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

26 April–5 May 2016

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Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met 26 April-5 May 2015 at Thuenen Institute in Hamburg, Germany. There were 24 participants (+ one by correspondence) from 9 countries. The main terms of reference for the Working Group were: to update, quality check and report relevant data for the working group, to update and audit the assessment and forecasts of the stocks, to produce a first draft of the advice on the fish stocks and to prepare planning for benchmarks next year. Ecosystem changes have been analytically considered in the assessments for cod, haddock and whiting in the form of varying natural mortalities estimated by the ICES Working Group on Multi Species Assessment Methods (WGSAM).

Working procedures

WGNSSK has to deal with an increasing number of data limited stocks, formerly assessed by WGNEW. This increased substantially the workload. Therefore the working group met for 10 days instead of 8 days.

The progress initiated in late 2011 on the quality of the data collection process were pursued in 2016. Notably, a number of improvements were brought to the InterCatch data raising process in the last years, both through technical improvements of the InterCatch procedures and interface, and through the development of a number of exploratory scripts allowing rapid data screening and visualisation. Data were requested through a joint DCF-based data call for all assessment working groups, and the deadline for early data delivery were largely held.

The principle analytical models used for the stock assessments were SAM, XSA, TSA and the Aarts and Poos model (AAP), as well as SURBAR (for one data-limited stock).

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

Benchmarks in 2016

Saithe in 4, 3.a and 6 as well as dab in 4 and 3.a has been benchmarked in 2016. Major changes were made to the saithe assessment (change from XSA to SAM, replacement of three national CPUE indices by a combined fishable biomass index, usage of ages 6 to 8 from the 3rd quarter IBTS index). These changes led to a higher estimate of current SSB. Fishing mortality is still below the updated F_{MSY}. For dab, an age based assessment with SURBAR could be provided for the first time and has been accepted as category 3 assessment.

An Interbenchmark was carried out for whiting in 4 and 7.d. Because of updated natural mortality estimates, the EU-Norway management strategy (fixed F without $B_{trigger}$ and TAC constraints) used in previous years' advice is no longer considered precautionary. Following ACOM guidelines, an F=0.15 when applied as part of the MSY approach (with $B_{trigger}$) leads to <5% probability of falling below B_{lim}. In general, the stock dynamics of North Sea whiting are largely driven by recruitment and natural mortality and alternative management strategies should be evaluated for this stock.

WGNSSK rejected the update assessment for haddock in 4, 3.a and 6.a. An Interbenchmark will be carried out over the summer and advice is postponed to the autumn.

State of the Stocks

The main impression in 2016 is that fishing mortality has been reduced significantly for many North Sea stocks of roundfish and flatfish compared to the beginning of the century. All fish stocks with agreed biomass reference points are above B_{lim}, and only the SSB of cod in 4,3.a and 7.d and sole in 7.d is below MSY $B_{trigger}$ at the beginning of 2016. The assessment of haddock has been rejected by WGNSSK and stock status will be re-evaluated in autumn after an Interbenchmark. Several North Sea stocks are exploited around F_{msy} levels. Exceptions are cod in 4,3.a and 7.d and sole in 7.d. An important feature is that recruitment still remains poor compared to historic average levels for most gadoids. For whiting, the most recent recruitments are estimated to be higher but still do not reach historically observed high recruitment levels; however, the decreasing trend in SSB has stopped and the whiting stock has increased in recent years. The stock status of saithe has been revised during the 2016 benchmark process. According to the latest assessment, the saithe stock has fluctuated without trend above $B_{trigger}$ since 1997. The southern North Sea and eastern channel areas are currently experiencing a steep increase of the plaice stock, with SSB values higher than ever observed in the assessment time series.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries. For all of these stocks, catch advice was provided in 2015 for the first time. The trends in abundance/biomass indices is decreasing for some of these stocks and increasing for others. In 2016 it was only necessary to determine whether the perception of the stock has changed compared to 2015; because perceptions have not changed compared to 2015, no reopening of the advice was needed.

The stock status of *Nephrops* stocks differs between functional units but globally a decrease compared to earlier years is observed for *Nephrops* in the North Sea.

The summary of stock status is as follows:

1) *Nephrops*: Abundance globally decreased compared to former years in the North Sea. The abundance of *Nephrops* in FU 6 and 7 has decreased further while the abundance in FU 8 and FU 9 has been stable in recent years. The abundance of *Nephrops* in 3.a is stable and at a high level. The 2015 harvest rates were in accordance with F_{MSY} in FU 7, FU 9 and in 3.a. In contrast, harvest rates in FU 6 exceeded F_{MSY} in 2015. For FU 8 the harvest rate was very close to F_{MSY}. Because the TAC is set for the whole North Sea and not at a functional unit level, this contributes to F_{MSY} reference points being exceeded in some FUs. The FUs 5, 32, 33 and 34 are data limited. For these FUs, densities have to be assumed, along with other variables (e.g. discard rates, mean weights) and/or TV-survey estimates are uncertain. Given these assumptions, current harvest rates seem not to be problematic, apart from those for FU5.

2) Norway Pout: Will be assessed in autumn

3) Cod in area 4, 3.a.20 and 7.d: Fishing mortality (F) has been declining since 2000 and is estimated to be above F_{MSY}. Spawning-stock biomass (SSB) has increased from the historical low in 2006 and close to MSY $B_{trigger}$. Recruitment since 1998 remains poor.

4) Haddock in 3.a.20, 4 and 7.d: Assessment has been rejected. Will be re-evaluated in the autumn after an Interbenchmark

5) Whiting in 4 and 7.d: Spawning-stock biomass (SSB) has fluctuated around MSY $B_{trigger}$. Fishing mortality (F) has been above F_{MSY} throughout the time-series. Recruitment (R) has been low since 2003, with recruitment in 2014 and 2015 above previous years.

6) Saithe in 3.a, 4 and 6: Recruitment (R) has generally been below the long-term average since 2008. Fishing mortality (F) has been below F_{MSY} since 2013. Spawning-stock biomass (SSB) has fluctuated without trend, above MSY $B_{trigger}$ since 1997.

7) Plaice in 4 and 3.a.20: The combined North Sea and Skagerrak stock is well above MSY $B_{trigger}$, increased in the past ten years, and has been at a record high for the last 5 years. Recruitment has been around the long-term average since the mid-90s. In recent years, fishing mortality (F) has been estimated around F_{MSY}.

8) Sole in 4: The spawning stock biomass (SSB) has increased since 2007 and has been estimated to be above MSY $B_{trigger}$ since 2012. Fishing mortality (F) has declined since 1997 and is estimated to be at F_{MSY} in 2015. Recruitment (R) has fluctuated without trend since the early 1990s

9) Plaice in 7.d: Fishing mortality (F) has declined since the mid-1990s and has been below F_{MSY} since 2009. Spawning–stock biomass (SSB) has increased since 2008 and has been above MSY $B_{trigger}$ since 2009. Recruitment (R) has been high since 2009.

10) Sole in 7.d: The spawning-stock biomass (SSB) has fluctuated without trend and is predicted to drop below MSY $B_{trigger}$ in 2016. Fishing mortality (F) has always been above F_{MSY} and increased over the years 2012–2015. Recruitment has been fluctuating without trend, and was among the lowest of the time series in 2012–2014, which has resulted in the decrease in recent SSB.

11) Category 3–6 stocks: In 2016 a new advice has been produced for Pollack in 4 and 3.a as well as grey gurnard in 4, 7.d and 3.a. Pollack is a category 5 stock. However, information available suggest that the stock is at a low level compared to historic times. The time series of mature biomass index of grey gurnard from the IBTS-Q1 survey showed a strong increase from the beginning of 90's, and has since fluctuated at a high level. Advice on other category 3 stocks will be updated next year. New survey information has not changed the perception of the stocks.

1 General

1.1 Terms of Reference

Generic TORs

2015/2/ACOM05 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on ecosystem overviews where available;

b) For the fisheries relevant to the working group consider and comment on:

  i) descriptions of ecosystem impacts of fisheries where available

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries overview, and

  iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising 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) For relevant stocks estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area by year in the recent three years.

  iv) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

  v) The state of the stocks against relevant reference points;

  vi) Catch options for next year;

  vii) Historical performance of the assessment and catch options and brief description of quality issues with these;

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

The working group is furthermore requested to:

e) Consider and propose stocks to be benchmarked;

f) Review progress on benchmark processes of relevance to the expert group;

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

h) Prepare the data calls for the next year update assessment and for the planned data evaluation workshops;

i) Update, quality check and report relevant data for the stock:
   i) Load fisheries data on effort and catches into the INTERCATCH database by fisheries/fleets;
   ii) Abundance survey results;
   iii) Environmental drivers.
j) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database.
k) Identify research needs of relevance for the expert group.

Specific TORs

2015/2/ACOM14 The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), chaired by Alexander Kempf, Germany, and Jose De Oliveira*, UK, in meet in Hamburg, 26 April–5 May 2016 and by correspondence in September 2016 to:

a) Address generic ToRs for Regional and Species Working Groups. The Norway pout assessments shall be developed by correspondence;
b) Check the relevance of the reopening procedure and report on reopened advice if appropriate.

Material and data relevant for the meeting must be available to the group no later than 12 April 2016 according to the Data Call 2016.

WGNSSK will report by 12 May 2016, and by 28 September 2016 (Norway pout) for the attention of ACOM. Concerning ToR b) the group will report on the ACOM guidelines on reopening procedure of the advice before 12 October and will report on reopened advice before 28 October.

1.2 InterCatch

1.2.1 Metier-based data call for WGNSSK (and other working groups)

The year 2012 represented a major change in the process of data collection for WGNSSK. Following an initiative launched by ICES WGMIXFISH in August 2011, it had been decided to merge the data calls and data collection of both groups WGNSSK and WGMIXFISH, on the basis of

1) improving the availability of metier-based data and their consistency with the stock-based data used for single-stock assessment.
2) allowing WGMIXFISH to meet earlier and as such integrate the mixed-fisheries advice within the single-stocks advice sheets.

In 2014 data limited stocks were included in the data call for the first time to improve the knowledge base for these stocks. Under the landing obligation these stocks become more important and discard information is a prerequisite to give catch advice and to carry out mixed fisheries scenarios under the landing obligation. In 2015, for the first time a joint data call for all relevant assessment working groups was launched.

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

In 2016, despite a new format of the data call the procedure for data submission was practically the same as in 2015. An official data call was issued by ICES, with a deadline for data delivery by 12th April 2016. No major issues occurred at that stage, and only few data were delayed compared to this date and some errors needed to be corrected before the working group without having a major impact on the work.

1.2.2 Data raising and allocation to unsampled strata

Major changes occured in recent years with the raising of data within InterCatch. Different initiatives can be mentioned here.

3) **Technical improvements in the InterCatch interface:**

- Allocation Group Setup: Define a group of unsampled catch/strata for which each distribution will be calculated according to the (for the group) allocated sampled catches/strata
- Automatic allocation 'same' strata: Automatically find and allocate identically sampled strata from other countries to unsampled catches/strata (with the identical stratum)
- Discard Group setup: Define a group of raised discards for which each discard weight will be calculated according to the (for the group) selected landing-discard ratios
- CATON and age/length data overviews: it is possible to examin all imported data in detail
- Allocation overview for pivot table/matrix: All unsampled strata are shown in the first column and all sampled strata are shown as the first row, then all the selected combinations are shown in the matrix.
- Possibility to save allocation schemes

4) **Summary outputs and inspection of data before raising**: the new features included in InterCatch allowed improved inspection and visualization of the data submitted by national data providers and a comparison with data from previous years. A generic R script has been developed in 2016 by Y. Vermard (IFREMER) mapping out the raw data, through e.g. quantification of the proportion of catches covered by sampling, identification of major gaps and outliers, plot of the age distribution and discards ratio of the various strata etc.

5) **Raising procedures**. Based on statistical principles discussed within WKPICS, RCMs, PGCCDBS and DC-MAP etc, the suggestions for the basis on which to proceed regarding raising of age distributions and discards ratio have been revisited. In 2012, the raising and allocating was based on finding similar strata from other countries, but this was judged not fully defendable in terms of statistical integrity. In 2016 the underlying principles applied were thus:

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

b) Therefore, the suggestion was that by default, unsampled strata should be raised by all sampled strata, unless there is a good and informed reason for chosing differently after the data inspection process. Each stock coordinator developed general principles for the allocation scheme. The main principles are mentioned in the the respective report sections.

Ultimately, all these changes have triggered in-depth investigation and understanding of the data submitted, and are hopefully contributing to improved consistency and transparency in the assessment data. However, if more than one year needs to be raised the Intercatch procedure is still very time consuming. The saving of allocations schemes does not always function, especially when the metiers differ between years, and currently, only the age allocation scheme can be copied (not the discard ratio allocation scheme). It would be beneficial to allow for more flexible automatic matching based on e.g., gear type or area only. Also the possibility of entering allocation schemes via scripts (instead of the need to click through the options and metiers) would allow for fast sensitivity checks and would make Intercatch much more user-friendly.

Because of the landing obligation new catch categories need to be reported from 2016 onwards. There is currently little guidance about how the different catch categories should be reported, and how they should be used in raising discards where discard information is not provided. This is an issue that affects all Expert Groups that have to provide catch advice, so a common approach is needed. BMS landings, observer discards and log-book recorded discards should sum up to discard data provided so far (i.e. double-counting should be avoided), and when performing raising procedures, these three categories should be combined to provide raising factors, and the raising procedure in Intercatch should be adapted as necessary. This provides a robust approach, independent of how countries categorize catches when providing catch data. WGNSSK recommends that ICES provides a harmonized approach across all Expert Groups.

InterCatch summary data have been made available on the SharePoint, and will be investigated further during ICES WGMIXFISH.

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

Stocks for which data are imported	DataY	Extracted (work started in InterCatc	Exported (work finished in InterCatch	Status of Data filled in
bll-nsea	2015	Extracted	Exported	DataNOTusedForAssessment
cod-347d	2015	Extracted	Exported	DataUsedForAssessment
dab-nsea	2015	Extracted	Exported	Notfilled
fle-nsea	2015	Extracted	No	Notfilled
gug-347d	2015	Extracted	No	DataNOTusedForAssessment
had-346a	2015	Extracted	Exported	DataUsedForAssessment
lem-nsea	2015	Extracted	Exported	DataUsedForAssessment
mur-347d	2015	Extracted	Exported	DataUsedForAssessment
nep-10	2015	Extracted	No	DataUsedForAssessment
nep-32	2015	Extracted	No	DataNOTusedForAssessment
nep-33	2015	Extracted	No	Notfilled
nep-34	2015	Extracted	Exported	DataUsedForAssessment
nep-3-4	2015	Extracted	No	DataNOTusedForAssessment
nep-5	2015	Extracted	Exported	DataUsedForAssessment
nep-6	2015	Extracted	Exported	DataUsedForAssessment
nep-7	2015	Extracted	Exported	DataUsedForAssessment
nep-8	2015	Extracted	Exported	DataUsedForAssessment
nep-9	2015	Extracted	Exported	DataUsedForAssessment
nep-IVnotFU	2015	Extracted	No	Notfilled
nop-34	2015	Extracted	Exported	Notfilled
ple-eche	2015	Extracted	Exported	DataNOTusedForAssessment
ple-nsea	2015	Extracted	Exported	Notfilled
ple-skag	2015	Extracted	Exported	DataUsedForAssessment
pol-nsea	2015	Extracted	No	Notfilled
sai-3a46	2015	Extracted	Exported	DataUsedForAssessment
sol-eche	2015	Extracted	Exported	DataUsedForAssessment
sol-nsea	2015	Extracted	Exported	DataUsedForAssessment
tur-kask	2015	Extracted	No	DataUsedForAssessment
tur-nsea	2015	Extracted	Exported	DataUsedForAssessment
whg-47d	2015	Extracted	Exported	DataUsedForAssessment
whg-kask	2015	Extracted	Exported	DataUsedForAssessment
wit-nsea	2015	Extracted	Exported	DataUsedForAssessment

1.3 General uncertainty considerations

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

Assessment working groups are in many ways end users of data and it would be preferable to have such information presented as point estimates together with estimates of uncertainty or confidence bands and with a description of potential sources of bias and qualitative remarks related to specific observations. Intercatch is still not fully operational in this respect.

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

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

1.4 Survey corrections during 2015 and 2016

During the last year no major resubmissions occurred for IBTS data and the indices produced by DATRAs as tuning indices only showed very minor changes compared to last year.

In contrast, the French and UK beam trawl surveys in area 7.d have been corrected and made more consistent between years. These corrections were related both to a modernization of calculation procedures (e.g. from Excel spreadsheets to R-scripts), and a more consistent use of data (e.g. use of a consistent set of prime stations, cleaning up an errors found, and harmonization of calculation methods with the way samples were collected, e.g. for age-length keys). Working documents are available under Annex 08 that describe in more detail the work done by national institutes. The final impact on the results of the plaice and sole in 7.d assessments is limited (see respective stock sections in this report).

1.5 Internal auditing and external reviews

ICES removed in general the external review process that had been in place for some years, and replaced it by an internal audit process within the Working Group itself. WGNSSK understands the motivations and reasoning behind this choice, and recognizes also that the process has certainly some merits and direct benefits such as increased participation and collaboration within the group across countries and stocks. However, WGNSSK wishes to underline that this audit is another heavy task pending on group members, and it was not possible to accomplish all audits during the meeting itself. WGNSSK operates with seldom more than one scientist per stock (sometimes even one scientist is responsible for two or more stocks), and there was simply not always enough time to have the reports finalized in time in order to carry out their subsequent audit within the WG meeting. Audits had to be conducted by correspondence after the WG time, which is neither very efficient nor very motivating given the heavy workload most members usually operate with back in home institutes. WGNSSK recommends to explore alternative ways to strengthen the audit process (e.g., professional auditors as part of the ICES secretariat, external audit).

Finally, all WGNSSK stocks with an updated advice in 2016 could be covered by the internal audit (Table 1.5.1). The audit sheets can be found on the WGNSSK SharePoint.

Table 1.5.1. Fish stocks covered by the internal audit and external reviews:

Fish Stock	Internal audit	External review
cod-347d	x	
had-34	Advice postponed	x
nep-5	x	
nep-6	x	
nep-7	x	
nep-8	x	
nep-9	x	
nep-10	x	
nep-32	x	
nep-33	x	
nep-34	x	
nep-iiia	x	
nop-34	no assessment in spring	
ple-eche	x	
ple-nsea	x	
sai-3a46	x	x
sol-eche	x	
sol-nsea	x	
whg-47d	x	
whg-kask	no new advice in 2016	
bll-nsea	no new advice in 2016	
dab-nsea	no new advice in 2016	
fle-nsea	no new advice in 2016	
lem-nsea	no new advice in 2016	
wit-nsea	no new advice in 2016	
Tur-nsea	no new advice in 2016	
Tur-kask	no new advice in 2016	
Mur-347d	no new advice in 2016	
POL	x	
GUR	x	

1.6 Mixed Fisheries

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

The two groups have developed and issued a common data call since 2012, which greatly improved the quality and scheduling of data delivery. WGMIXFISH will meet in late May 2016 in order to integrate mixed-fisheries advice for the North Sea into single stock advice.

It is therefore referred to the ICES WGMIXFISH 2016 report for any further description of mixed-fisheries context.

However, the group discussed mixed fisheries issues under the landing obligation in the last years. There is a potential problem with choke species in the North Sea. Target species as well as bycatch species can become choke species for certain fleet segments. One way to deal with the situation could be to use the recently defined ranges for F_{msy} instead of point estimates (see ICES WKMSYREF III and IV, 2014-16). Ranges can introduce the flexibility needed to minimize the discrepancies in available quotas for species in a mixed fishery. However, further objectives are needed to determine which F inside the range should be applied. Ideas exist for an algorithm that minimises the discrepancy between TACs and ensures that a maximum of TACs can be fished out. It should be avoided that TACs are blindly set at the upper range for all stocks by managers. In the long-term there is no gain to fish stocks above F_{MSY} as the yield becomes lower and the risk for the stocks increases. Selectivity in mixed fisheries should be improved instead to avoid choke effects.

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

1.7 Multi species considerations

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

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

Already in 2013 the group discussed the progress achieved under various initiatives such as ICES WGSAM (2011, 2012), ICES WKM-TRADE (2012) and the EU project MYFISH. The group noted that a multispecies benchmark as in the Baltic may be needed where the North Sea SMS model and keyrun settings are reviewed by external experts before a final multi species advice can be given.

There are many direct and indirect interactions between species, making it difficult to reach a single and robust best solution. Optimization scenarios carried out so far show that the result (target F) depends very much on the objectives (objective function) and SSB constraints used. The exact combination of species target F depends also on the weighting factors (e.g. price per kg when optimizing value) actually used for calculating these objectives. During a stakeholder workshop organized by ICES and MYFISH (ICES WKM-TRADE 2012) it has been agreed that when offering trade-offs, ICES can provide scenarios below F_{MSY} for the exploitation of some populations. This will allow a policy choice to be made within the limits defined and explained by ICES. F_{MSY} rnages (see also under mixed fisheries) could also help here to reach consenus based on a pretty good yield concept instead of trying to reach the absolute maximum for each stock, which is impossible given the biological interactions between predator and prey.

1.8 Frequency of assessments

ACOM provided for the first time criteria to test whether a category 1 stock could be a candidate for biennial assessments. The criteria are summarized in table 1.8.1.

Table 1.8.1 Criteria to be applied to identify candidate stocks for less frequent assessment.

Stock Category	Criteria to be used to identify candidate stocks for less frequent assessment.
Cat. 1 and 2	Stocks are considered candidates for biennial assessment if: The advice for the stock has been 0-catch or equivalent for the latest three advice years. Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously: Life span (i.e. maximum normal age) of the species is larger than 5 years The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x Fmsy OR if Fmsy range has been defined: F(latest assessment year) is <= Fupper (upper bound in F range) AND SSB(start of intermediate year) >= MSY Btrigger The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year. The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by less than 20% The formula to be used in the calculations is: $\rho = \frac{1}{7}\sum_{u=Y-7}^{Y-1}\left(1 - \frac{F_{u,u}}{F_{u,Y}}\right)$. The result should be < 0.20, where $F_{u,u}$ is F in year u estimated from an assessment that ends in year u, and $F_{u,Y}$ is the F in year u estimated from the most recent assessment (which ends in year Y)
Cat. 3	By default all stocks in this category are considered candidates for biennial or triennial assessment.
Cat 4-5-6	By default all stocks in this category are considered candidates for triennial assessment.

Results of the criteria check for cateogry 1 stocks can be found in the respective stock sections. In conclusion, saithe, plaice in 4 and 7.d as well as sole in 4 are currently candidates for biennial assessments based on the ACOM criteria alone (table 1.8.2). In general, only if the criteria based on the status of the stock are met, the other criteria need to be tested.

Table 1.8.2 Information on whether criteria for a biennial assessment are met.

Fish Stock	Live span >= 5 years	Stock status: Fcur <=1.1x Fmsy or inside F MSY ranges	Stock status: SSB (start of the intermediate year) >= MSY Btrigger	Contribution of first age to total catches in the last 5 years < 25%	Mohn's Rho index shows that F is not consistently underestimated by less than 20%	Potential candidate for less frequent assessments ?
cod-347d	Yes	Yes	No	No	Yes	No
had-346a*	Yes	Yes	No	Yes	No	No
ple-eche	Yes	Yes	Yes	Yes	Yes	Yes
ple-nsea	Yes	Yes	Yes	Yes	Yes	Yes
sai-3a46	Yes	Yes	Yes	Yes	Yes	Yes
sol-eche	Yes	No	Yes	?	?	No
sol-nsea	Yes	Yes	Yes	Yes	Yes	Yes
whg-47d	Yes	No	Yes	No	Yes	No

*** Based on the rejected update assessment. Needs to be re-evaluated in autumn after the Interbenchmark!**

Although saithe passes all criteria in table 1.8.2, WGNSSK argues that it still may not be a good candidate for less frequent assessments. The reason is that the stock assessment suffers from structural uncertainties. The input data for the assessment is uncertain (i.e. year effects in the IBTS q3 survey), as shown during the benchmark (WKNSEA 2016) and work following the benchmark. Minor modifications to the weighting of tuning series can greatly change perception of the stock. This, coupled with the uncertainties in the forecast (a substatial part of the adviced catch comes from year classes where year class strength needs to be assumed) questions a reduction in the frequency of assessments.

In general, WGNSSK members expressed during their discussion in 2015 that relatively simple tests would generally be insufficient to determine the risk of unwanted outcomes, should the frequency of assessments for a particular stock be reduced. Such an exercise requires a simulation analysis of the type used to evaluate management plans and strategies. An approach of this kind takes considerable time that is not available during the WG meeting.

The working group would also like to point out as in previous years that time spent at the yearly assessment meetings represent only a modest fraction of the work related to collect and prepare the information needed in these meetings. WGNSSK is of the opinion that "new information" is best assessed by using the information directly in an assessment model (update run), which is usually quick to produce once the necessary data have been put together.

As an important point, WGNSSK underlines that stock assessment and corresponding advice is an integrated part of long term management strategies and the management system in general. Any change in the frequency of assessments represents a change to the management strategy/system itself (or at least the implementation of it) and needs to be evaluated in the same way as management strategies in general (e.g., Management Strategy Evaluations, MSE).

1.9 Special requests

No larger special requests have been received during 2015 and beginning of 2016 for North Sea stocks.

1.10 References

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2 Overview

2.1 Introduction

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

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

For some stocks, the North Sea assessment area may also cover other regions adjacent to ICES Subarea 4. Thus, combined assessments are made for cod including 3.aN (Skagerrak) and 7d, for haddock including VIa and 3.a, Norway pout including 3.a, for whiting including 7d, and for saithe including 3.a and 6.a. Since the benchmark in 2015 also plaice in 3.a is now assessed together with plaice in area 4. The state of *Nephrops* stocks are evaluated on the basis of discrete Functional Units (FU) on which estimates of appropriate removals are founded. Quota management for *Nephrops* is still carried out at the Subarea and Division level, however.

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

The analysis of biological interactions (predator-prey relationships) among species has been a central theme in ICES over the last 30 years, primary for the Baltic Sea and the North Sea. The2011 and 2014 North Sea key run performed by the multispecies group WGSAM represents the ultimate state of the art in terms of multispecies assessment, with the dynamic estimation of predation mortality. This has led to the publication of the first multispecies advice by ICES in 2013 (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf) . The single-stock assessments and advice presented in this report are not produced by the multispecies assessment model, but time variant values of natural mortalities estimated by multispecies assessments for cod, haddock, and whiting are incorporated in the assessments of these species. Flatfish are not part of the current multi species assessment and more work is needed to incorporate also information on flatfish in the multi species advice.

Gear types vary between fisheries. Human consumption fisheries use otter trawls, pair trawls, *Nephrops* trawls, seines, gill nets, or beam trawls, while industrial fisheries use small meshed otter trawls. Trends in reported effort in the major fleets fishing in the North Sea are described annually by the ICES WG on Mixed Fisheries Advice for the North Sea (ICES WGMIXFISH 2016), which meets straight after the WGNSSK. Both WG share a joint data call issued by ICES for fulfilling the data needs of both groups.

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 EC's Data Collection Framework (DCF, Reg. (EC) No 949/2008), which we adopt here*:*

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

Fleets and métiers were defined to match with the available economic data and the cod long term management plan. In 2013 and 2014 WGMIXFISH included new stocks in its analyses (plaice and sole in the Eastern Channel as full analytical stocks; hake in the North Sea and plaice in Skagerrak as additional "lpue" stocks as well as turbot, see WGMIXFISH 2013 and 2014 report). Plaice in the Skagerrak has been merged with plaice in 4 in 2015. In 2015 and 2016 WGMIXFISH focused again on the full analytical assessed stocks as well as *Nephrops* only but no longer on turbot and hake. This will most likely change in the near future again as a lot of the stocks without full analytical assessment (e.g., turbot, hake, witch, lemon sole) are important by-catch and can become potential "choke species" once under the landing obligation.

Ultimately, WGMIXFISH has identified 43 national demersal fleets (combination of country, main gear and vessel size category, plus an "others" OTH fleet) from nine countries. These fleets engage in one to four different métiers each, resulting in 118 demersal fisheries (country*fleet*métier*area) in the North Sea, Skagerrak and Eastern Channel.

ICES WGMIXFISH produces a number of synthetic Figures describing main trends, of effort and catches and landings by fleet and stock. The effort time series is not 100% consistent. It is planned to issue a data call and ask countries to resubmit a full time series of effort data. The following paragraph is based on data from WGMIXFISH 2015 and will be updated once a more consistent time series becomes available:

Overall nominal effort (kW-days) by EU demersal trawls regulated in the cod management (TR1, TR2, TR3, GN1, GT1, LL1,BT1,BT2) in the North Sea, Skagerrak, and Eastern Channel had been substantially reduced since the implementation of the two successive effort management plans in 2004 and 2008 (−30% between 2004 and 2014, −12% between 2008 and 2014). Following the introduction of days-at-sea regulations in 2003, there was a substantial switch from the larger mesh (>100 mm, TR1) gear to the smaller mesh (70–99 mm, TR2) gear. Subsequently, effort by TR1 has been relatively stable, whereas effort in TR2 and in small-mesh beam trawl (80–120 mm, BT2) has shown a pronounced decline (+2%, −43%, and −49%, respectively, between 2004 and 2014). Gill- and trammelnet fisheries have increased (+20%, +13%). Effort in large-meshed beam trawl (≥120 mm, BT1) has increased significantly in 2012 and 2013 after a decade of continuous decline. Nominal effort reported by Norway has increased since 2011 due to the generalization of electronic logbooks. For 2014 the same effort had to be assumed as observed in 2013 because of data quality issues.

Technical interactions appear between stocks when they are caught by the same gear during a fishing operation (mixed fisheries). Ideally the technical interaction should then be studied at the scale of the fishing operation to prevent artificially creating technical interaction between stocks that might only be caught at day/night or in different areas/timing of the year. However, the finest available information is per stock/gear/area/season from the WGMIXFISH data base, aggregating the catches at an already quite high level.

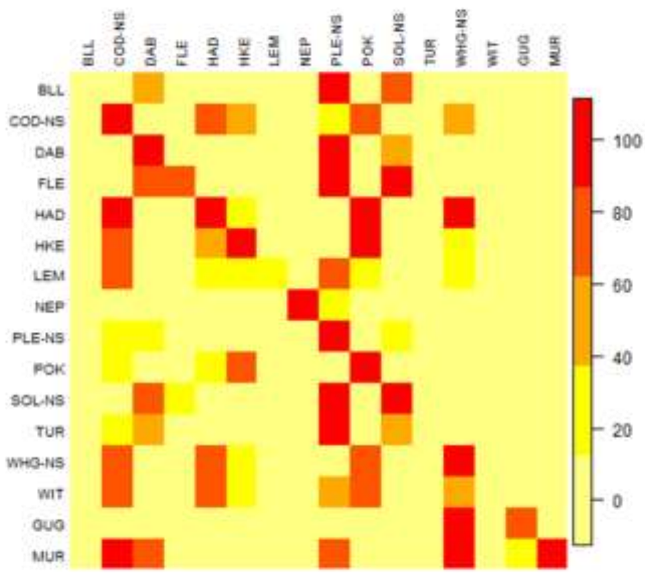
Knowing these limitations, this database can still be used to provide information on technical interactions. The methodology used here consists in computing the sum of catches per strata of one species given that a second species is also present in the total catches of this stratum. This value is then divided by the total catches of the first species:

$$TechnicalInter_{i,j} = \frac{\sum_{strata=0}^{n} Landings_{strata,i} * PresInLandings_{strata,j}}{\sum_{strata=0}^{n} Landings_{strata,i}} * 100$$

Where i and j are the two species for which the technical interaction is assessed.

$PresInLandings_{strata,j}$ is a Boolean and equals 0 if the total landings of species j for a given strata is less than 5% the total landings for that strata and 1 otherwise to remove the by catch effect. *Strata* corresponds to the provided disaggregation of the landings in WGMIXFISH. The minimum level being Season=Quarter, Metier=Metier level 6, Area=ICES division.

The following table shows the technical interaction between stocks. Red cells indicate that the species are caught together to a large extent. Orange cells indicate less strong interactions while yellow cells indicate a weak interaction.



2.2 Main management regulations

The near-collapse of the North Sea cod stock in the beginning of the 2000s led to the introduction of effort restrictions alongside TACs as a management measure within EU fisheries. There has also been an increasing use of single-species multi-annual management plans, partly in relation to cod recovery, but also more generally. With the implementation of the landing obligation in 2016 mixed fisheries multi species plans are under development but have not yet been agreed

The management frames can be summarised as such:

2.2.1 Landings obligation

Fisheries in Norwegian waters have been subject to a landing obligation for cod and haddock from 1987 and for most species since 2009. A landing obligation for EU fisheries on demersal species in the North Sea is implemented from 2016 in a phased approach with all quota stocks subject to the landings obligation from 2019 onwards. Detailed definitions of the landing obligation can be found in Article 15 of regulation 1380/2013. For 2016 discard plans have been agreed defining for which species, gear and mesh size combinations the landing obligation applies in 2016. Table 2.2.1, 2.2.2 and 2.2.3 show these combinations relevant for WGNSSK stocks in areas 4, 3.a, 6a and 7d. The discard plans will be amended to define which additional species and gear combinations will fall under the landing obligation in 2017 and 2018. Until 2019 it is expected that the landing obligation is fully implemented.

Table 2.2.1. Fisheries under the landing obligation in area 4 and 3.a (from Comission delegated regulation (EU) 2015/2440).

Fishing gear (1) (2)	Mesh size	Species concerned
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	> 100 mm	All catches of saithe (if caught by a saithe targeting vessel (3)), plaice and haddock. All by-catches of Northern prawn.
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	In ICES Subarea IV and in Union waters of ICES Division IIa: 80-99 mm	In all areas, all catches of Norway lobster and common sole (4). All by-catches of Northern prawn.
	In ICES Division IIIa: 70-99 mm	In ICES Division IIIa: all catches of haddock.
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	32-69 mm	All catches of Northern prawn.
Beam trawls: TBB	> 120 mm	All catches of plaice. All by-catches of Northern prawn.
Beam trawls: TBB	80-119 mm	All catches of common sole. Any by-catches of Northern prawn.
Gillnets, trammel nets and entangling nets: GN, GNS, GND, GNC, GTN, GTR, GEN, GNF		All catches of common sole. All by-catches of Northern prawn.
Hooks and lines: LLS, LLD, LL, LTL, LX, LHP, LHM		All catches of hake. All by-catches of Northern prawn.
Traps: FPO, FIX, FYK, FPN		All catches of Norway lobster. All by-catches of Northern prawn.

(1) Gear codes used in this Table refer to those codes in Annex XI to Commission Implementing Regulation (EU) No 404/2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common fisheries policy.

(2) For the vessels whose LOA is less than 10 metres gear codes used in this table refer to the codes from the FAO gear classification.

(3) Vessels are considered as saithe targeting if, when using trawls with mesh size ≥ 100 mm, they have had annual average landings of saithe of ≥ 50 % of all landings by the vessel taken in both EU and third country zone of the North Sea over the period of x-4 to x-2 where x is the year of application; i.e. 2012-2014 for 2016 and 2013-2015 for 2017.

(4) Except in ICES division IIIa when fishing with trawls with a mesh size of at least 90 mm equipped with a top panel of at least 270 mm mesh size (diamond mesh) or at least 140 mm mesh size (square mesh) or 120 mm square mesh panel placed 6 to 9 meters from the cod-end.

Table 2.2.2. Fisheries under the landing obligation in area 6a (from Comission delegated regulation (EU) 2015/2438).

(a) Fisheries in ICES division VIa and Union waters of ICES division Vb

Fishery	Gear Code	Fishing gear description	Mesh Size	Landing Obligation
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, OT, PT, TX	Trawls & Seines	All	Where total landings per vessel of all species in 2013 and 2014 consist of more than 10 % of the following gadoids: cod, haddock, whiting and saithe combined, the landing obligation shall apply to haddock.
Norway lobster (*Nephrops norvegicus*)	OTB, SSC, OTT, PTB, SDN, SPR, FPO, TBN, TB, TBS, SX, SV, FIX, OT, PT, TX	Trawls, Seines, Pots, Traps & Creels	All	Where the total landings per vessel of all species in 2013 and 2014 consist of more than 30 % of Norway lobster, the landing obligation shall apply to Norway lobster.

Table 2.2.3. Fisheries under the landing obligation in area 7d (from Comission delegated regulation (EU) 2015/2438).

Fishery	Gear Code	Fishing gear	Mesh Size	Landing Obligation
Common Sole (*Solea solea*)	TBB	All Beam trawls	All	All catches of common sole are subject to the landing obligation.
Common Sole (*Solea solea*)	OTT, OTB, TBS, TBN, TB, PTB, OT, PT, TX	Trawls	< 100 mm	Where the total landings per vessel of all species in 2013 and 2014 consist of more than 5 % of common sole, the landing obligation shall apply to common sole.
Common Sole (*Solea solea*)	GNS, GN, GND, GNC, GTN, GTR, GEN	All Trammel nets & Gill nets	All	All catches of common sole shall be subject to the landing obligation.
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, OT, PT, TX	Trawls and Seines	All	Where total landings per vessel of all species in 2013 and 2014 consist of more than 25 % of the following gadoids: cod, haddock, whiting and saithe combined, the landing obligation shall apply to whiting.

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

In 2016 a high survival exemption has been granted for the main metiers catching *Nephrops* in 3.a and discarding of *Nephrops* below the minimum conservation reference size (MCRS) up to a deminins of 6% is still allowed in area 4. Also the MCRS has been reduced substantially in 3.a. WGNSSK tries to take this into account in the forecasts for *Nephrops* by assuming the 2015 selection pattern in the respective fisheries but that only discards below the agreed MCRS continue under the landing obligation.

Also for sole and haddock several de-minims exemptions have been agreed. The default ICES assumption is that the same exploitation patterns as observed in recent years will continue and former discards are now called unwanted catch. How much of this unwanted catch will be landed in the future (catch cateogry BMS) and how much will still be discarded is pure speculation. Given that stocks are impacted by the total F independent of how the total catch is split up (at least under the assumption of no survival of discards), the results of forecasts are robust to assumptions regarding which fraction of the total catch will be landed. In contrast, the landing obligation will mean a serious change and therefore exploitation patterns of fleets will most likely change in the future. Predicting these changes is impossible at the current stage what leads to an increased uncertainty in short term forecasts until more information becomes available (from 2017 onwards).

2.2.2 Effort limitations

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

In 2008 the system was radically redesigned. From 2009, a total effort limit (measured in kW days) is set and divided up between the various nation's fleet effort categories. The baselines assigned in 2009 were based on track record per fleet effort category averaged over 2004–2006 or 2005–2007 depending on national preference, and the effort ceilings were updated in 2010. After some reductions based on the cod management plan to support the recovery of the cod stock, an effort roll over was decided for 2013, 2014 and 2015.

The areas are Kattegat, the part of 3.a not covered by Skagerrak and Kattegat, ICES zone 4, EC waters of ICES zone 2a, ICES zone 7d, ICES zone 7.a, ICES zone 6a and EC waters of ICES zone 5b. The grouping of fishing gear concerned are: Bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≤ 100 mm) – TR2 (≤ 70 and < 100 mm) – TR3 (≤ 16 and < 32 mm); Beam trawl of mesh size: BT1 (≤ 120 mm) – BT2 (≤ 80 and < 120 mm); Gill nets excluding trammel nets: GN1; Trammel nets: GT1 and Longlines: LL1. The respective effort limitations per area per gear can be found in annex IIa and Appendix 1 to Annex IIa in the annual TAC and quota regulations

Table 2.1.1 Maximum allowable fishing effort in kilo watt days in 2013, 2014, 2015 and 2016.

Geographical area: Skagerrak, that part of ICES division 3.a not covered by the Skagerrak and the Kattegat; ICES subarea 4 and EU waters of ICES division 2a; ICES division 7d

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

The STECF and ICES WGMIXFISH has performed annual monitoring of deployed effort trends since 2002. In addition, a more detailed overview and analyses of the various measures implemented in the frame of the cod recovery plan can be found in the 2011 joint STECF/ICES evaluation of this plan (ICES WKROUNDMP 2011, Kraak *et al.*, 2013).

2.2.3 Stock-based management plans

Cod, saithe, whiting, plaice and sole are currently subject to multi-annual management strategies (the latter two, being EU strategies, not EU-Norway agreements). These plans all consist of harvest rules to derive annual TACs depending on the state of the stock relative to biomass reference points and target fishing mortality. The harvest rules also impose constraints on the annual percentage change in TAC. These plans have been discussed, evaluated and adopted on a stock-by-stock basis, involving different timing, procedures, stakeholders and scientists involved, disregarding mixed-fisheries interactions (ICES WGMIXFISH 2012). The technical basis of the individual management plans is detailed in the relevant stock section. Most of these plans are no longer used as basis of advice and to set TACs due to benchmarks and the general change from individual target fishing mortalities to F_{MSY}.

With the new CFP, the demand for mixed fisheries management plans covering all species caught in a fishery is increasing. However, so far no multi species (fishery based) management plans have been agreed for the greater North Sea. With the implementation of the landing obligation by 2016 for the North Sea demersal fisheries, problems caused by the management of mixed fisheries with single species plans will become more evident. In addition, benchmarks have caused major changes in the assessment and reference points in the last years.

2.2.4 Additional Technical measures

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

2.2.4.1 Minimum landing size/ Minimum conservation reference 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)). After the implementation of the landing obligation minimum landing sizes have been transformed into Minimum Conservation Reference Sizes (MCRS) that apply from 2016 onwards. The current MCRS can be found in table 2.2.4.1. Individuals below MCRS have to be landed now but are not allowed to be sold for human consumption.

Table 2.2.4.1. Current MCRS

Species	MCRS region 1–5	MCRS Skagerrak and Kattegat
Cod	35 cm	30 cm
Haddock	30 cm	27 cm
Saithe	35 cm	30 cm
Pollack	30 cm	----
Whiting	27 cm	23 cm
Sole	24 cm	24 cm
Plaice	27 cm	27 cm
Nephrops	85 mm (25 mm)	105 mm (32 mm)

2.2.4.2 Minimum mesh size

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

Towed nets excluding beam trawls

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

- ***Nephrops* fishing.** It is possible to use a mesh size in range 70–99 mm, provided catches retained on board consist of at least 30% of *Nephrops*. However, the net needs to be equipped with a 80 mm square-meshed panel if a mesh size of 70–99 mm is to be used in the North Sea and if a mesh size of 90 mm is to be used in the Skagerrak and Kattegat 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 4 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, which is when the proportion of cod catches retained exceeds 30% of total catches.

2.2.4.3 Closed areas

Twelve mile zone

Beam trawling is not allowed in a 12 nm wide zone along the British coast, except for vessel having an engine power not exceeding 221 kW and an overall length of 24 m maximum. In the 12 mile zone extending from the French coast at 51°N to Hirtshals in Denmark trawling is not allowed to vessels over 8m overall length. However, otter trawling is allowed to vessels of maximum 221 kW and 24 m overall length, provided that catches of plaice and sole do not exceed 5% of the total catch. Beam trawling is only allowed to vessels included in a list that has been drawn up for the purposes. The number of vessels on this list is bound to a maximum, but the vessels on it may be replaced by other ones, provided that their engine power does not exceed 221 kW and their overall length is 24 m maximum. Vessels on the list are allowed to fish within the twelve miles zone with beam trawls having an aggregate width of 9 m maximum. To this rule there is a further derogation for vessels having shrimping as their main occupation. Such vessels may be included in annually revised second list and are allowed to use beam trawls exceeding 9 m total width.

Plaice box

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

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.

Natura 2000

To protect habitats several Natura 2000 areas have been defined. It is still under negotiation which fisheries will be prohibited in these areas exactly. It is likely that for each of these areas different rules will apply.

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 are described in the stock sections to which they pertain.

2.3 Environmental considerations

WGNSSK welcomes the progress made to provide ecosystem overviews. These overviews give a good overview on environmental factors influencing the current development of fish and shellfish stocks. However, from these overviews it is still difficult to relate certain changes to observations made in the assessments. Therefore, the WG considers that although it is clear that the North Sea ecosystem is undergoing change and this will affect fish stocks, the causal mechanisms linking the environment with fish stock dynamics are in most cases not yet clearly-enough understood. However, for gadoids the choice of appropriate reference points takes now into account the current low productivity of the stocks although the exact causes of this low productivity are not fully understood. F_{msy} is estimated based on shortened stock recruitment time series and the upper range of F_{msy} is constraint by Fp05 estimated for the current low recruitment period. To improve the situation, ICES may provide a database with all available environmental data and indicators from the various working and study groups to make them available to the scientific community. The longer the time series and the higher the contrast in these time series, the more likely that causal relationships can be identified.

Next to this WGNSSK made the following observations during the discussion on the ecosystem overviews:

1) The current low productivity of gadoids in the North Sea is not mentioned in the document. In general, under impact on commercial stocks an overview figure showing recruitment trends for the different guilds could provide valuable information.
2) The word crustaceans should be replaced with *Nephrops* in Figure 6.1.1.7. Only for *Nephrops* assessments are available and *Nephrops* constitutes only a small part of the crustacean biomass.
3) No flatfish are in the figure showing the North Sea food web. This is questionable for a flatfish dominated system .
4) The OSPAR table on threatened and declining species needs a review. Some of the species should not be mentioned any more (e.g., thornback ray, cod)
5) The ranking of the strength of interactions between pressure and state are pure qualitative (Figure 6.1.1.3). It is also unclear who has decided on the ranking. There are excellent expert elicitation methods available that could be applied to get an objective ranking based on the opinions of ICES experts.
6) The overviews need to be a living document. New knowledge needs to be incorporated when becoming available.

2.4 Human consumption fisheries

2.4.1 Data

Estimates of discarding rates provided by a number of countries through observer sampling programme were used in the assessments of various roundfish and flatfish as well as *Nephrops* FUs, to raise landings to catch (see also section 01 on Intercatch). During recent benchmarks discards could be included in the assessments of sole in 4, saithe in 4, 3.a and 6a as well as plaice in 7d. Discards could be also estimated for bycatch species (e.g., dab, flounder, lemon sole, witch, brill, turbot). Finally, catch advice could be given for all WGNSSK stocks.

In the EU, national sampling programs are defined and implemented as part of the Data Collection Framework (DCF). Other sampling programmes (e.g. industry self-sampling for discards and biological data) have been in place in recent years and the data are increasingly entering the assessment process in some instances (e.g., plaice in 4, haddock). In general, some discarding occurred in most human-consumption fisheries until 2015. As TACs have become more restrictive for some species (e.g. cod), an increase in discarding of marketable fish (i.e. over minimum landing size) has been observed. In 2013, a landing obligation has been agreed between the EU Parliament and the Council of Ministers, as one of the most important aspects of the reform of the Common Fishery Policy (CFP), and this is going to have fundamental implications for the demersal fisheries and associated data collection program (see above).

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

Several research-vessel survey indices are available for most species, and were used both to calibrate population estimates from catch-at-age analyses, and in exploratory analyses based on survey data only. Commercial CPUE series were available for a number of fleets and stocks, but for various reasons few of them could be used for assessment purposes (although they are presented and discussed). The use of commercial CPUE indices has been phased out where possible and only the saithe and sole in 7d assessment still relies on a commercial index.

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

2.4.2 Summary of stock status

The main impression in 2016 is that fishing mortality has been reduced significantly for many North Sea stocks of roundfish and flatfish compared to the beginning of the century. All fish stocks with agreed biomass reference points are above B_{lim}, and only the SSBs of haddock in 4, 6.a and 3.a.20 and sole in 7d are below MSY $B_{trigger}$ at the beginning of 2016 (the update assessment for cod, given in Annex 04, shows it is now above MSY $B_{trigger}$). The assessment of haddock was initially rejected by WGNSSK and the stock status was re-evaluated in autumn after an Interbenchmark. Several North Sea stocks are exploited around or below F_{msy} levels. Exceptions are cod in 4, 3.a.20 and 7d, haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d and sole in 7d. An important feature is that recruitment still remains poor compared to historic average levels for most gadoids. For whiting, the most recent recruitments are estimated to be higher but still do not reach historically observed high recruitment levels; however, the decreasing trend in SSB has stopped and the whiting stock has increased in recent years. The stock status of saithe has been revised during the 2016 benchmark process. According to the latest assessment, the saithe stock has fluctuated without trend above MSY $B_{trigger}$ since 1997. The southern North Sea and eastern channel areas are currently experiencing a steep increase of the plaice stock, with SSB values higher than ever observed in the assessment time series. Following new survey information during the summer, advice was re-opened for cod in 4, 3.a.20 and 7.d, saithe in 4, 6 and 3.a, and *Nephrops* FUs 6, 7 and 8, and this are given in Annex 04.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries. For all of these stocks, catch advice was provided in 2015 for the first time. The trends in abundance/biomass indices is decreasing for some of these stocks and increasing for others. In 2016 it was only necessary to determine whether the perception of the stock has changed compared to 2015; because perceptions have not changed compared to 2015, no reopening of the advice was needed.

The stock status of *Nephrops* stocks differs between functional units but globally a decrease compared to earlier years is observed for *Nephrops* in the North Sea, although a strong increase has been observed in the latest UWTV survey for FU7, which may be related to a strong recruitment event.

The summary of stock status is as follows:

1) *Nephrops*: Abundance globally decreased compared to former years in the North Sea. The abundance of *Nephrops* in FU 6 remains low, but there have been recent increases in FU7 and 8, while FU9 has been stable in recent years. The abundance of *Nephrops* in 3.a is stable and at a high level. The 2015 harvest rates were in accordance with F_{MSY} in FU 7, FU 9 and in 3.a. In contrast, harvest rates in FU 6 exceeded F_{MSY} in 2015. For FU 8 the harvest rate was very close to F_{MSY}. Because the TAC is set for the whole North Sea and not

at a functional unit level, this contributes to F_{MSY} reference points being exceeded in some FUs. The FUs 5, 32, 33 and 34 are data limited. For these FUs, densities have to be assumed, along with other variables (e.g. discard rates, mean weights) and/or TV-survey estimates are uncertain. Given these assumptions, current harvest rates seem not to be problematic, apart from those for FU6.

2) Norway Pout in 4 and 3.a: The stock size is highly variable from year to year, due to recruitment variability and a short life span. Stock size has increased and is above B_{pa} in 2016. Fishing mortality has been below the long-term average F (0.45) since 1995. Recruitment in 2014 and 2016 are high, while recruitment in 2015 is around average.

3) Cod in 4, 3.a.20 and 7d: Fishing mortality has been declining since 2000 and is estimated to be above F_{MSY}. Spawning-stock biomass has increased from the historical low in 2006 and is just above MSY $B_{trigger}$. Recruitment since 1998 remains poor.

4) Haddock in 4, 6.a and 3.a.20: Fishing mortality is above F_{MSY} and spawning-stock biomass has fallen below MSY $B_{trigger}$. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing. The 2014 recruitment estimate is higher than recent poor recruitment years, but is still below the long-term average.

5) Whiting in 4 and 7d: Spawning-stock biomass has fluctuated around MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} throughout the time-series. Recruitment has been low since 2003, with recruitment in 2014 and 2015 above previous years.

6) Saithe in 3.a, 4 and 6: Recruitment has fluctuated over time and has generally been below the long-term average since 2008. Fishing mortality has been below F_{MSY} since 2013. Spawning-stock biomass has fluctuated without trend, remaining above MSY $B_{trigger}$ since 1997.

7) Plaice in 4 and 3.a.20: The combined North Sea and Skagerrak stock is well above MSY $B_{trigger}$, has increased in the past ten years, and has been at a record high for the last 5 years. Recruitment has been around the long-term average since the mid-90s. In recent years, fishing mortality has been estimated around F_{MSY}.

8) Sole in 4: The spawning stock biomass has increased since 2007 and has been estimated at above MSY $B_{trigger}$ since 2012. Fishing mortality has declined since 1997 and is estimated at F_{MSY} in 2015. Recruitment has fluctuated without trend since the early 1990s

9) Plaice in 7d: Fishing mortality has declined since the mid-1990s and has been below F_{MSY} since 2009. Spawning–stock biomass has increased since 2008 and has been above MSY $B_{trigger}$ since 2009. Recruitment has been high since 2009.

10) Sole in 7d : The spawning-stock biomass has fluctuated without trend and is predicted to drop below MSY $B_{trigger}$ in 2016. Fishing mortality has always been above F_{MSY} and increased over the years 2012–2015. Recruitment has been fluctuating without trend, and was in 2012–2014 among the lowest of the time series, which has resulted in the decrease in recent SSB.

11) Category 3–6 stocks: In 2016 a new advice has been produced for Pollack in 4 and 3.a as well as grey gurnard in 4, 7d and 3.a. Pollack is a category 5 stock. However, information available suggests that the stock is at a low

level compared to historic times. The time series of mature biomass index of grey gurnard from the IBTS-Q1 survey showed a strong increase from the beginning of 90's, and has since fluctuated at a high level. Advice on other category 3 stocks will be updated next year. New survey information has not changed the perception of the stocks.

2.5 Industrial fisheries

The Norway Pout assessment was benchmarked in 2012 through an inter-benchmark protocol (IBPNPOUT), resulting in changes in biological parameters (growth, maturity and natural mortality), and again in 2016 (WKPOUT) during which the assessment model was changed, but the general perception of the stock hasn't changed substantially. Fishery has fluctuated considerably in recent years with full or partial closures in 2005, 2006, 2007 and 2011. The stock is largely driven by natural process, particularly recruitment. Stock size has increased and is above B_{pa} in 2016. Fishing mortality has been below the long-term average F (0.45) since 1995. Recruitment in 2014 and 2016 are high, while recruitment in 2015 is around average.

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

The WGFTFB provided fishery development information specific to the various assessment Expert Groups every second year, based on annual questionnaires to a number of FTFB members (ICES 2012, WGFTFB). Unfortunately in 2015 and 2016 no information was provided. The information specific to WGNSSK in 2013 was the following:

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

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

Fleet dynamics

- It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively). A total of 42 licences have been given out by the Dutch Ministry for pulse trawling. The majority of these licences are for flatfish beam trawls although 2–3 vessels are involved in trials to test the Belgium "HOVERCRAN" system. (Netherlands: Implications: Switch from beam trawling to pulse trawling).
- Measures to reduce fuel costs in the Dutch fleet have been continuing since 2008 from 35% (now 50 M€) to 25% in 2009 due to adaptations in gear and operation. Reports show that the use of the SumWing can save up to 300 tonnes of fuel per year per boat (Loa = 40 m), and with the pulse trawl up to 800–1000 tonnes annually. Up to 78 Dutch beam trawlers now used the SumWing with 28 of these using the Pulse/Wing trawl. A further 12 Dutch registered vessels in the UK, 2 in Germany and 5 in Belgium are also using the Sum Wing with 3 of these using the dual Pulse/Wing. (Netherlands: Implications: Switch to more fuel efficient gear).

- The use of the SumWing, Pulse Trawl and Pulse/Wing beam trawls are reported to have resulted in a shift in grounds in ICES Area 4, and also add fishing time, due to faster hauling speed. This is not well documented but may result in increased a change in effort patters and increased fishing time (Netherlands: Implications: Improved fuel efficiency).
- A recent analysis carried out in the Netherlands has measured the relative changes in catching efficiency between the pulse trawl and the standard beam trawl in numbers caught per hour. This analysis has shown a reduction in catching efficiency for plaice of around 25–30%; for sole 20–25% with a reduction in discards of 55–60% and a reduction in benthos of 35–40-%. (Netherlands: Implications: Changes in catching efficiency).
- There are a smaller number of vessels in Belgium, Germany and the UK (Dutch owned) using the pulse trawl. However, the derogation only allows it to be used in the south of the North Sea and this has hindered the uptake of the gear in Belgium as they have only a limited sole quota in this area. (Belgium: Implications: Lower uptake of pulse trawl).
- The shift to Danish/Scottish seining has continued in a number of countries. This is driven by high fuel prices: There are now around 16 Dutch vessels operating in the North and the South North Sea, while there are around 12 French vessels now converted to Danish seining. (France: Implications: Shift from trawling to Seining).
- At least two Dutch beam trawlers have been converted into dual purpose vessels with the capability of fishing with twin-rigs and beam trawls. The idea is to increase the fishing opportunities for these vessels and allow them to switch between fisheries at different time of the year. (Netherlands: Implications: Dual purpose fishing vessels).
- In Norway there has not been any removal of fishing effort through decommissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3–4 new large whitefish trawlers, 4–5 pursers, 7–9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010–2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).

Technology Creep

- As reported the use of the SumWing and Pulse trawl are widespread now in the Netherlands. This is driven by high fuel costs with reported savings ranging from 10–50% from a combination of the gear and lower towing speeds. (Netherlands: Implications: Improved fuel efficiency).
- Since 2010 one large Belgium beam trawler is now using the energy-efficient SumWing as a replacement for standard beam trawl gear. In addition some 25 other beam trawlers are using the SumWing seasonally. Additional there is growing interest in using the electric pulse trawl amongst the Belgium beam trawl fleet allthough none of them are using as yet as they are awaiting authorisation to do so from the EU. These changes are driven by high fuel prices. (Belgium: Implications: Changes in gear type).
- There have been continued efforts by many countries to reduce fuel costs through the use of more energy efficient gears. Modifications tested include

hydrodynamic/low impact trawl doors, dynex warps, low drag twines and reductions in the size of trawls used. In addition there have been changes in fishing operations through slower steaming to and from grounds, fishing closer to home ports and other fuel saving measures. The actual impacts on fishing effort are difficult to predict but this is likely to be a continuing trend. However, as a result of one project in France (EFFICHALUT) an energy efficient trawl has been developed and is now being used by 15 whitefish trawls. The anticipated annual savings from these 15 vessels is estimated at €800 000 per year. (Multiple countries: Implications: Improved energy efficiency)

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

Technical Conservation Measures

- The Dutch government closed the Botany Gut in December 2011 and 2011 for three months to all trawling to protect cod. The *Nephrops* fishermen have looked for an exemption from this closure on the basis of low cod impact although observer data suggest catches of 2–5/hour Pilot studies will be carried out in 2012 to test selective gears to reduce cod catches. (Netherlands: Implications: Reduction of cod catches).
- At the Dutch Shipyard, Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. Trials will be carried out during 2012 and 2013. (Netherlands: Implications: Improved survival of discarded fish).
- In Sweden the use of rigid sorting grids has continued to increase in the Skagerrak and Kattegat. In Skagerrak the use of sorting grid has increased from 50% 2009 to 53% 2010 of total TR2 effort. The TR2 effort is by far the most important gear category in both Skagerrak and Kattegat constituting 80-90% of total effort. Almost 100% have opted to use this device due primarily to national legislation allocating 50% of the total *Nephrops* quota to grid vessels (Sweden: Implications: Widespread use of sorting grid).
- Extensive testing has been carried out in the North Sea by the UK (Scotland) with a new design of trawl called the Flip-flap netting grid (FFG) which has been developed by a Scottish netmaker for reducing cod catches in the *Nephrops* fishery. The results show a large and significant decrease in the number of the three main whitefish species retained by the FFG gear. The reductions by weight of cod, haddock and whiting were 73, 67 and 82% respectively. There are indications that will be introduced as a regulated gear across the Scottish fleet during 2012. (UK (Scotland): Implications: Widespread use of selective gear)
- Trials with sorting grids in the Norway pout fishery were completed in 2011, with further tests of flexible grid designs. In 2011 grids with a 40mm bar

spacing were made mandatory for Norwegian vessels on the basis of these and earlier trials for blue whiting and Norway pout in the Barents Sea. From mid-2013 all vessels with have to use in these small mesh fisheries in the Norwegian Economic Zone in the North Sea. (Norway: Implications: Mandatory use of sorting grids).

- Experiments from the North Sea carried out by Denmark during 2011have indicated that 50% of *Nephrops* above MLS are lost through the codend in nominal 120 mm codends used in the North Sea indicated a general increase in mesh size is not applicable in this fishery. (Denmark: Implications: Loss of marke Table catch)
- In July 2011 Denmark introduced a mandatory regulation requiring the use of the SELTRA trawl in the demersal fisheries in the Kattegat. This selective device comprises a 180mm square mesh panel or 270mm diamond mesh panel contained in a 4 panel section laced 4m from the codend. This on the basis of trials with this device which showed very good reductions in cod catches. The L50 for the 180mm panel is around 64cm. (Denmark: Implications: Mandatory introduction of a selective gear)

Ecosystem effects

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

Development of New Fisheries

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

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3 Norway lobster (*Nephrops* spp.) in Division 3.a (Skagerrak and Kattegat)

3.1 General comments relating to all *Nephrops* stocks (3.a and 4)

3.1.1 Introduction

Nephrops stocks have previously been identified by WGNEPH on the basis of their population distribution and characteristics, and established as separate Functional Units. The Functional Units (FU) are defined by the groupings of ICES statistical rectangles given in Table 3.1.1 and illustrated in Figure 3.1.1. The statistical rectangles making up each FU encompass the distribution of mud sediment on which *Nephrops* live. There are two FUs in Division 3.a and nine FUs in Subarea 4. At the 2010 WG, it was noted that a significant and increasing proportion of *Nephrops* landings were being taken outside the previously defined FUs in Subarea 4. This has led to the introduction of a new FU (FU 34) covering the Devil's Hole. Additional catches of *Nephrops* are also taken from smaller, isolated pockets of mud distributed throughout the ICES divisions (e.g. off the east coast of Scotland at Arbroath). Management of *Nephrops* currently operates at the ICES Subarea/Division level.

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

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

3.1.2 A new approach for data poor *Nephrops* stocks

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

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

In 2014 the working group introduced a different approach to previous years in order to provide an estimated guidance of the biomass in FUs 5, 10, 32, 33, and 34 and consider different harvest rates. Using FU area (calculated from information on the extension of suitable habitat and/or extent of *Nephrops* fisheries), mean discard percentage from all years of data, and mean weight in catches, tables of harvest rates were calculated for each of the five data poor functional units, using a range of landings (100 t to maximum landings observed for each stock) and densities (0.05–0.8 animals m^{-2}). The density range comes from the North Sea/Skagerrak stocks for which UWTV surveys exist. For each data poor FU, the mean and maximum of the landings time series is marked in the table. Harvest rates larger than 10 % are marked red. For each stock the most likely densities are considered based on information from neighbouring FUs.

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

The presentation of specific data and assessments relating to the Divisions 3.a and 4 FUs can be found in the WGNSSK report sections 3 and 4, respectively.

3.2 *Nephrops* in Division 3.a

3.2.1 General

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

Ecosystem aspects

Nephrops live in burrows in suitable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder in the burrows (Loo *et al*., 1993). This ability may contribute to maintaining a high production of this species in 3.a, due to increased organic production. *Nephrops* have recently been found to have a high prevalence of plastics which may have implications for the health of the stock (Murry and Cowie, 2011).

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of 3.a 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 3.a (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 3.a was given in 2015. ICES concluded that:

´Stock size is considered to be stable. The estimated harvest ratios suggest that the fishing mortality (F) for this stock is currently below FMSY.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area 3.a was increased from 5318 t in 2015 to 11001 t in 2015. The large increase in quota was due to the fact that the EU shifted from providing landings advice to providing catch advice. The minimum conservation reference size (previously referred to as minimum landings size) for *Nephrops* in area 3.a was reduced in 2016 from 40 to 32 mm carapace length. The historically large MLS led to a high discard ratios (discards/ discards+landings), and during 2015 41% of the catch (in numbers) in 3.a consisted of undersized individuals (Figure 3.2.1.1). The reduction in MLS is expected to reduce the proportion of the catch discarded considerably. Furthermore, it is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. A discard ban was implemented in EU waters from the 1st January 2015. The discard ban became applicable to *Nephrops* from the 1st January 2016, however an exemption for high survivability was introduced for one year. New technical measures have also been agreed upon and have been implemented since the 1st February 2013.

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

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

Landings

Division 3.a includes FU 3 and 4, which are assessed together. Total *Nephrops* landings by FU and country are shown in Table 3.2.1.1 and Table 3.2.1.2.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 58 % and 38 % by weight of the landings in 2015, respectively. Landings by the Swedish creel fishery represented 13–18 % of the total Swedish *Nephrops* landings from the Skagerrak in the period 1991 to 2002. Since 2002 creel catches have been steadily increasing and have in 2009 to 2014 accounted for more than 30%, and in 2015 for more than 40% of Swedish Skagerrak landings (Table 3.2.2.1). In the early 1980s, total *Nephrops* landings from the Skagerrak increased from around 1000 t to just over 2670 t. Since then they have been fluctuating around a mean of 2500 t (Figure 3.2.2.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2015, Denmark accounted for about 73 % of total landings in FU4, while Sweden took 27 % (Table 3.2.2.5). Minor landings have been taken by Germany (< 1%).

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

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991–2015. In the beginning of the time series, the Swedish data 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 landings are fluctuating without trend. Mean size for undersized show an increasing trend since 2005.

For Kattegat, size distributions of both the landings and discards are available from Sweden for 1990–2015, and from Denmark for 1992–2015. The at-sea-sampling intensity has generally increased since 1999. The Danish sampling intensity was low in 2007 and 2008, but was normalized in 2009 to 2015. Information on mean size is shown in Figure 3.2.2.5 and Table 3.2.2.8. Notice, that except for small mean sizes from 1993 to 1996 all categories have since been fluctuating without trend.

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

Natural mortality, maturity at age and other biological parameters

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

Growth parameters are as follows:

Males:	L_∞ = 73 mm CL, k = 0.138.
Immature females:	L_∞ = 73 mm CL, k = 0.138.
Mature females:	L_∞ = 65 mm CL, k = 0.10, Size at 50% maturity = 29 mm CL.

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

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

Catch and effort data – FU3

Effort data for the Swedish fleet are available from logbooks for 1978-2015 (Figure 3.2.2.1 and Table 3.2.2.2). During the period 1998 to 2005, twin trawlers shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in LPUE during this period (Table 3.2.2.2). Since 2005, LPUE for twin trawls has increased. The LPUE for single trawls has shown and increasing trend throughout the entire time series. The long term trend in LPUEs is similar in the Swedish and Danish fisheries (Figure 3.2.2.1). Total Swedish trawl effort shows a decreasing trend since 1992 and has been fluctuating without trend since 2003. From 2007 onwards, total Swedish trawl effort has been estimated from LPUEs from the single trawl with a grid (targeting only *Nephrops*).

Danish effort 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 1994–98, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2015. Also the trend in LPUE is similar to that in the Swedish single trawl fishery, however with a much more marked increase in the Danish LPUE for 2007 and 2008. This high LPUE level is likely to be a consequence of the national (Danish) management system introduced in 2007.

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

Catch and effort data – FU4

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

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

3.2.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

"No major issues. It was noted that it would be useful to show confidence intervals around the UWTV estimates. The LPUE considerations were moved to additional considerations."

3.2.3.1 TV survey in 3.a

In 2008 and 2009, an exploratory UWTV survey was carried out by Denmark. In 2010, the TV survey was expanded covering the main *Nephrops* grounds in the western part of Skagerrak (subarea 1) and Northern part of Kattegat (subarea 2). Since 2011, the TV survey has been carried out in collaboration between Denmark and Sweden and covers the main *Nephrops* fishing grounds in 3.a (subarea 1–6). In 2014, subarea 1 was extended to the west (subarea 7; Figure 3.2.3.2). However, important parts of the assumed distributional range of *Nephrops* were still not covered in 2015. The survey is still developing and improved spatial coverage is expected to be raised during the 2016 benchmark. Figure 3.2.3.4 presents the distribution of stations with valid density estimates from 2008 to 2015. A similar survey design has been applied for both national surveys: a fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in 3.a. VMS data from the Swedish and Danish fishery from 2010 were used (Figure 3.2.3.3) and are described in more detail in ICES (2011). The area estimates for each subarea are defined in Table 3.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS (ICES, 2013).

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in 3.a divided into subareas Figure 3.2.3.2 is shown in Table 3.2.3.1 and Figure 3.2.3.4.

In WK*NEPH* (2009) a number of bias sources were highlighted relating to the "counted" density from the TV surveys. These bias sources are not easily estimated and are largely based on expert opinion. For the *Nephrops* stock in 3.a 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 biases result in a correction factor to take the raw counts to absolute densities. The correction factor for 3.a was set to be 1.1, meaning that the raw TV survey is likely to overestimate *Nephrops* abundance by 10 %. TV survey results are presented as absolute values (i.e. the bias already taken into account)

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

3.2.3.2 2015 Assessment.

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2015. Additional used information was trends in total combined (Denmark and Sweden) LPUE, and discards (numbers) as a proxy for recruitment during the period 1990–2015.

Combined relative effort declined slightly over the period 1990 to 2015 (Figure 3.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level in the recent 7 years (Figure 3.2.4.2). This high level may be attributed to the change in the Danish management system (Individual Transferable Quotas) in 2007. Technical creep, changes in targeting behaviour, stock size and catchability may also be responsible for some of this increase. High LPUEs attributable to sudden changes in catchability (caused by e.g. poor oxygen conditions) are known to occur but are generally of short duration.

Since the abundance of small *Nephrops* (typically discards of specimens below minimum landing size) may also be regarded as an index of recruitment, they can be used to further explain the current developments in the stock. The large amounts of discards in the periods 1993–95 and 1999–2000 reflect strong recruitment during these years (Figure 3.2.4.3). The high levels of discards in 1993–95 are believed to have significantly contributed to the high LPUE in 1998–99. The high amount of discards observed in 2007, 2008 and 2009 would then indicate high recruitment in these years, as could the low amount of discards in 2014 and 2015 indicate a low recruitment. The discards in 2015 is the lowest since 1991 and may be due to a very low recruitment and/or an increase in gear size selectivity.

MSY consideration (TV-survey)

There are no precautionary reference points defined for *Nephrops*. Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yields (and low probability of stock overfishing) have been explored and proposed for Division 3.a. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} are determined. WGNSSK (2010) developed a framework for proposing F_{MSY} proxies for the various *Nephrops* stocks based upon their biological and historical characteristics, and is described in section 1 of that report. Three candidates for F_{MSY} are $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}. There may be strong differences in relative exploitation rates between the sexes in many stocks. To account for this, values for each of the candidates have been determined for males, females and the two sexes combined. An appropriate F_{MSY} candidate has been selected according to the perception of stock resilience, factors affecting recruitment, population density, knowledge of biological parameters and the nature of the fishery (relative exploitation of the sexes and historical harvest rate vs stock status).

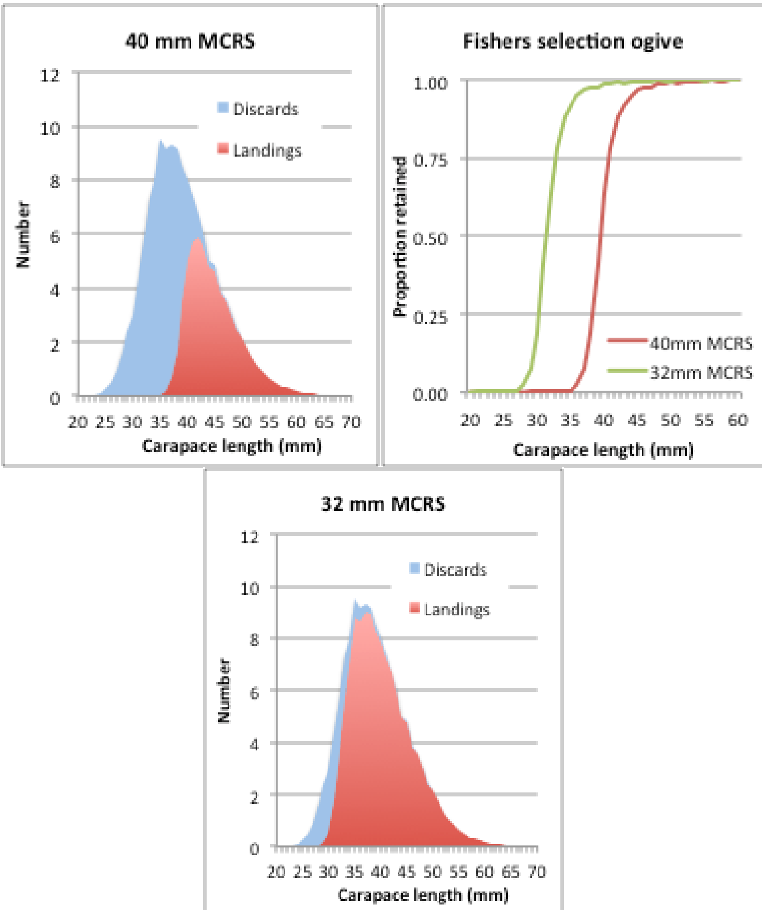
A decision-making framework based on the table below was used in the selection of preliminary stock-specific F_{MSY} proxies (ICES, 2010a). These proxies may be modified following further data exploration and analysis. The combined sex F_{MSY} proxy should be considered appropriate if the resulting percentage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

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

The absolute burrow density in Division 3.a is medium (0.3–0.8/m^2), the observed harvest rate is below $F_{0.1}$ and historically the fishery is stable both spatially and temporally. This means that $F_{0.1}$ may be selected as a proxy for F_{MSY}. As the MLS has been decreased in 2016 and this stock will be benchmarked during 2016, it is recommended to use Fmax as a proxy for F_{MSY} as in last years. For 2017 this corresponds to a TAC of 13 099 tonnes if a landing obligation is applied. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with F_{MSY} as total catches would be subjected to 100% mortality (current discard survival is estimated to be 25 %).

A mismatch between mesh size in trawl fisheries and minimum landing size (carapace length 40 mm, which is higher than North Sea FUs) has historically resulted in a high discard proportion for this stock. However, since 1st January 2016 the MCRS/MLS was lowered from 40 to 32 mm carapace length for EU countries. This is expected to reduce the proportion of the catch discarded considerably. Norway still apply 40 mm MCRS and a Norwegian discard ban was implemented in the Skagerrak since 1st of January 2015.

To simulate the effect of a decreased MCRS on the proportion of discards, the average (2013–2015) total sampled length distribution (graph left below) was first used to estimate fisher's selection when sorting the catch at a MCRS of 40 mm carapace length (red line in middle graph below). This selection ogive was then shifted down to 32 mm MCRS (assuming that fishers selection is equally effective at the new MCRS) in order to predict the new composition of landings and discards (see graph right below). The following mean weight in discards and landings, discard proportion and dead discard rate was used in this year's assessment.



Recent Swedish discard survival experiments indicate that the trawl discard survival may be higher (around 50%) compared to the 25% currently used in the assessment. This has caused a possibility to continue discard Nephrops <MCRS (high survivability exemption) during 2016. Effects of discard survival estimates will be discussed during the coming benchmark meeting in 2016.

Harvest rate as proxy for F_{MSY} for 3.a from length cohort analysis 2011 (2008–2010):

	MALE	FEMALE	COMBINED
Fmax	6.8 %	10.0 %	7.9 %
F0.1	4.9 %	7.6 %	5.6 %
F35%SpR	8.1 %	12.9 %	10.5 %

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

Norway lobster in Division 3.a. The catch options.

VARIABLE	VALUE	SOURCE	NOTES
Abundance in TV assessment	3857 million	ICES 2016a	UWTV 2015
Mean weight in landings*	46.2g	ICES 2016a	Average 2013–2015
Mean weight in discards*	20.5g	ICES 2016a	Average 2013–2015
Discard proportion*	12.5%	ICES 2016a	Average (proportion by number) 2013–2015
Discard survival rate	25%	ICES 2016a	Proportion by number. Only applies in scenarios where discarding allowed.
Dead discard rate*	9.7%	ICES 2016a	Average 2013–2015 (proportion by number), Only applies in scenarios where discarding allowed

*** Simulated that MCRS was 32 mm carapace length during 2013–2015.**

Landings obligation

BASIS	TOTAL CATCH*	WANTED CATCH	UNWANTED CATCH	HARVEST RATE*
	L+D	L	D	for L + DD
F2015	3399	3196	203	2.1%
Fcurrent (2013–2015)	6019	5660	359	3.6%
F0.1 = FmsyLower	9284	8731	553	5.6%
MSY Approach	13099	12318	781	7.9%
F35SpR	17410	16372	1038	10.5%

Weights in tonnes

*** as calculated for dead removals**

Discarding allowed

Basis	Total catch*	Dead removals	Landings	Dead discards*	Surviving discards*	Harvest rate**
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	13521	13319	12715	604	201	7.9%

Weights in tonnes.

***Total discard ratio is assumed to be 12.5% of the catches (by number, average of last three years, 2013–2015), MCRS is changed to 32 mm carapace length, discard survival (SD) is assumed to be 25% (WKNEPH; ICES, 2009).**

**** as calculated for dead removals**

A summary of the results from the TV survey 2015 is presented in Table 3.2.3.1. The estimated abundance index was 0.393 resulting in a total abundance of 3857 million individuals. Total removals (landings + dead discards) were estimated to 79 million individuals resulting in a harvest rate of 2.0%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased by 50 % since 2002 and is currently at a low level while LPUE shows an increasing trend and is at a long term high level in recent years (Figures 3.2.4.1 and 3.2.4.2). Mean sizes are fluctuating without trend. There are no signs of overexploitation in 3.a.

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

The UWTV survey 2015 was conducted in all 7 defined subdivisions in 3.a. A correction factor of 1.1 was used. A total weighted mean density was estimated based on density estimates from each subdivision and weighted by the size of each subdivision. The estimated F_{msy} proxies for this stock provide a relatively low harvest rate which may be a result of the high discards ratios (31% in weight) which occur due to the high minimum landing size (40 mm). These removals do not increase the yield from the stock.

The Danish LPUE data used as indicators for stock development have been standardised regarding engine size. However, LPUE is also influenced by changes in catchability due to sudden changes in the environmental conditions or/and changes in selectivity, gear efficiency or a change in targeting behaviour due to the cod management plan in 3.a. Also the changes in management systems (indicated by the broken red line in Figure 3.2.4.2), which occurred in 2007 in Denmark, caused a general increase in LPUE. In 3.a, fluctuations in catches of small *Nephrops* are used as indicators of recruitment (Figure 3.2.4.3).

3.2.6 Status of the Stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the fifth year (2011–2015; new subarea 7 only in 2014–2015) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 3.3.6.1).

The 2015 harvest rate was estimated to be relatively low (2.0% from UWTV survey) implying the stock appears to be exploited sustainably.

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

3.2.7 Division 3.a *Nephrops* Management Considerations

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

The UWTV- survey in 3.a suggests that the harvest rate 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 the lowest level in the time series while LPUE has increased and is at a relatively high level in the last ten years (Figures 3.2.4.1 and 3.2.4.2). Mean sizes are fluctuating without trend (Figures 3.2.2.2 and 3.2.2.5). There are no signs of overexploitation in 3.a.

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

The WG encourages the work on size selectivity in *Nephrops* trawls to reduce the large amount of discarded undersized *Nephrops* in 3.a.

Mixed fishery aspects

Cod and sole are significant by-catch species in these fisheries in 3.a, and even if data on catches, including discards, of the by-catch gradually become available, they have not yet been used in the management. The WG has for many years recommended the use of species selective grids in the fisheries targeting *Nephrops* as legislated for Swedish national waters. New technical measures (Swedish grid and SELTRA trawl) have recently been agreed upon for the *Nephrops* directed fishery and have been implemented since the 1st February 2013. The European Union and Norway have also agreed that a discard ban will be implemented in EU waters from the 1st January 2015. The discard ban will be applicable to *Nephrops* from the 1st January 2016 but preliminary results indicating high discard survival has resulted in an exception of landing obligation for *Nephrops* in 3.a during 2016.

Table 3.1.1. Definition of *Nephrops* Functional Units in 3.a and 4 in terms of ICES statistical rectangles.

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

Table 3.2.1.1. Division 3.a: Total *Nephrops* landings (tonnes) by Functional Unit, 1981–2015.

YEAR	FU 3	FU 4	TOTAL
1981	992	1728	2720
1982	1470	1828	3298
1983	2205	1472	3677
1984	2675	2036	4711
1985	2191	1798	3989
1986	2018	1807	3825
1987	2441	1605	4046
1988	2363	1364	3727
1989	2564	1313	3877
1990	2866	1475	4341
1991	2924	1304	4228
1992	1893	1012	2905
1993	2288	924	3212
1994	1981	893	2874
1995	2429	998	3427
1996	2695	1285	3980
1997	2612	1594	4206
1998	3248	1808	5056
1999	3194	1755	4949
2000	2894	1816	4710
2001	2282	1774	4056
2002	2977	1471	4448
2003	2126	1641	3767
2004	2312	1653	3965
2005	2546	1488	4034
2006	2392	1280	3672
2007	2771	1741	4512
2008	2851	2025	4876
2009	3004	1842	4846
2010	2938	2185	5123
2011	2511	1475	3986
2012	2536	1893	4429
2013	2147	1613	3760
2014	2856	1294	4150
2015	2123	1228	3350

Table 3.2.1.2. Division 3.a: Total *Nephrops* landings (tonnes) by country, 1991–2015.

Year	Denmark	Norway	Sweden	Germany	Total landings	Total Disc.	Total Catch
1991	2824	185	1219		4228	5183	9411
1992	2052	104	749		2905	2523	5428
1993	2250	103	859		3212	8493	11705
1994	2049	62	763		2874	6450	9324
1995	2419	90	918		3427	4464	7891
1996	2844	102	1034		3980	2148	6128
1997	2959	117	1130		4206	3469	7675
1998	3541	184	1319	12	5056	1944	7000
1999	3486	214	1243	6	4949	4108	9057
2000	3325	181	1197	7	4710	5664	10374
2001	2880	138	1037	1	4056	3767	7823
2002	3293	116	1032	7	4448	4311	8760
2003	2757	99	898	13	3767	2208	5975
2004	2955	95	903	12	3965	2532	6497
2005	2901	83	1048	2	4034	3014	7048
2006	2432	91	1143	6	3672	2926	6598
2007	2887	145	1467	13	4512	6524	11036
2008	3174	158	1509	19	4860	4746	9606
2009	3372	128	1331	15	4846	6129	10975
2010	3721	124	1249	29	5123	3548	8671
2011	2937	87	945	17	3986	2847	6833
2012	2970	104	1355	0	4429	4771	9200
2013	2550	73	1134	3	3760	4010	7770
2014	2785	88	1269	7	4150	1854	6004
2015	2121	91	1138	0	3350	1038	4389

Table 3.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2015.

YEAR	DENMARK	NORWAY			SWEDEN			GERMANY	TOTAL
		Trawl	Creel	Sub-total	Trawl	Creel	Sub-total		
1991	1639	185	0	185	949	151	1100	0	2924
1992	1151	104	0	104	524	114	638	0	1893
1993	1485	101	2	103	577	123	700	0	2288
1994	1298	62	0	62	531	90	621	0	1981
1995	1569	90	0	90	659	111	770	0	2429
1996	1772	102	0	102	708	113	821	0	2695
1997	1687	117	0	117	690	118	808	0	2612
1998	2055	184	0	184	864	145	1009	0	3248
1999	2070	214	0	214	793	117	910	0	3194
2000	1877	181	0	181	689	147	836	0	2894
2001	1416	125	13	138	594	134	728	0	2282
2002	2053	99	17	116	658	150	808	0	2977
2003	1421	90	9	99	471	135	606	0	2126
2004	1595	85	10	95	449	173	622	0	2312
2005	1727	71	12	83	538	198	736	0	2546
2006	1516	80	11	91	583	201	784	0	2391
2007	1664	127	18	145	709	253	962	0	2771
2008	1745	124	34	158	675	273	948	0	2851
2009	2012	101	27	128	605	260	864	0	3004
2010	1981	105	20	125	563	266	829	4	2938
2011	1801	74	12	87	432	188	621	2	2510
2012	1516	80	24	104	592	324	916	0	2536
2013	1309	57	16	73	484	279	763	0	2146
2014	1868	68	20	88	594	305	899	0	2856
2015	1226	66	25	91	479	327	806	0	2123

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, 1991–2015. (*Include only** ***Nephrops*** **trawls with grid and square mesh codend).**

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	676	401	71.4	9.5	5.6
1992	360	231	73.7	4.9	3.1
1993	614	279	72.6	8.4	3.8
1994	441	246	60.1	7.3	4.1
1995	501	336	60.8	7.8	5.2
1996	754	488	51.1	14.8	9.6
1997	643	437	44.4	14.4	9.8
1998	794	557	49.7	16.0	11.2
1999	605	386	34.5	17.5	9.3
2000	486	329	32.7	14.9	10.9
2001	446	236	26.2	17.0	10.4
2002	503	301	29.4	17.1	8.8
2003	310	254	21.5	13.9	11.4
2004*	474	257	20.1	23.6	13.4
2005*	760	339	29.7	25.6	12.7
2006*	839	401	37.5	22.4	12.2
2007*	894	314	24.1	37.0	13.0
2008*	605	264	20.0	30.3	13.2
2009*	482	285	19.6	24.5	14.5
2010*	476	286	20.7	23.0	13.8
2011*	334	198	16.8	19.9	11.8
2012*	542	238	16.0	33.8	14.9
2013*	251	137	11.3	22.2	12.1
2014*	240	157	11.0	21.7	14.2
2015*	187	133	9.5	19.6	14.0
Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1
2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3
2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6
2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8
2014*	484	316	16.0	30.3	19.8
2015*	328	234	11.3	28.9	20.6

Table 3.2.2.3. *Nephrops* Skagerrak (FU 3): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2015.

YEAR	KW DAYS	DAYS AT SEA	FISHING DAYS	LPUE
1991	5501223	21043	18762	87
1992	4043742	16125	13970	82
1993	3728965	13698	11958	124
1994	3276355	12324	10778	120
1995	3024232	12070	10448	150
1996	3020019	11871	10385	171
1997	3053570	11950	10509	161
1998	3353072	12131	10899	189
1999	3967797	13767	12376	167
2000	4371006	14849	13307	141
2001	3970228	13337	11579	122
2002	4693962	16575	14197	145
2003	3476385	11589	10333	138
2004	3871974	13149	11694	136
2005	3757466	12560	11166	155
2006	3296744	10825	9725	156
2007	2424063	8026	7294	228
2008	2332056	8016	7300	239
2009	2549895	8814	8058	250
2010	2668904	9027	8338	238
2011	2666680	9767	8912	202
2012	2183682	8330	7507	202
2013	1738286	6770	6332	207
2014	2094860	8060	7653	244
2015	1592065	6337	5923	207

Table 3.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2015.

	Catches					
	Undersized		Full sized		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.2	30.9	41.2	42.7	30.9	29.8
1992	33.3	32.3	43.3	44.7	33.3	32.2
1993	33.0	31.5	42.0	43.6	33.0	31.5
1994	31.7	29.6	41.7	43.6	31.7	29.6
1995	30.0	28.5	41.6	41.3	32.9	29.8
1996	33.2	31.9	42.9	44.0	37.6	37.0
1997	35.8	34.5	44.6	44.1	39.8	39.1
1998	34.8	34.4	46.1	43.9	40.7	37.3
1999	34.6	33.9	44.9	43.8	39.3	36.1
2000	30.6	30.5	45.6	45.0	32.5	34.1
2001	33.6	33.6	45.5	43.6	37.3	36.4
2002	33.9	33.7	44.0	42.5	37.2	37.3
2003	33.5	32.6	43.2	43.4	38.0	36.7
2004	34.3	33.4	44.6	45.2	38.7	36.6
2005	33.5	32.4	43.7	43.0	36.4	35.3
2006	33.2	32.9	44.7	42.7	37.1	36.1
2007	32.6	31.9	44.4	42.4	34.9	33.5
2008	33.6	32.3	44.0	42.7	36.5	34.5
2009	35.0	33.8	45.3	42.8	39.8	35.9
2010	34.2	33.8	46.2	44.8	38.9	36.6
2011	33.8	33.1	44.5	43.3	38.4	36.5
2012	34.8	34.1	44.2	42.5	38.2	36.2
2013	35.1	34.8	45.0	42.9	38.6	36.9
2014	35.7	35.3	45.5	43.7	41.7	39.1
2015	35.5	36.2	47.2	44.1	43.6	41.1

Table 3.2.2.5. *Nephrops* Kattegat (FU 4): Landings (tonnes) by country, 1991–2015.

Year	Denmark	Sweden			Germany	Total
		Trawl	Creel	Sub-total		
1991	1185	119	0	119	0	1304
1992	901	111	0	111	0	1012
1993	765	159	0	159	0	924
1994	751	142	0	142	0	893
1995	850	148	0	148	0	998
1996	1072	213	0	213	0	1285
1997	1272	319	3	322	0	1594
1998	1486	306	4	310	12	1808
1999	1416	329	4	333	6	1755
2000	1448	357	4	361	7	1816
2001	1464	304	6	309	1	1774
2002	1240	219	5	224	7	1471
2003	1336	287	5	292	13	1641
2004	1360	270	11	281	12	1653
2005	1175	303	8	311	2	1488
2006	916	347	11	358	6	1280
2007	1223	491	15	505	13	1741
2008	1429	561	16	577	19	2025
2009	1360	450	16	467	15	1842
2010	1740	403	17	420	25	2185
2011	1136	308	16	324	15	1475
2012	1454	406	33	439	0	1893
2013	1241	341	27	368	3	1612
2014	917	335	34	369	7	1294
2015	895	301	31	333	0	1228

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, 1991–2015 (*Include only *Nephrops* trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	66	39	10.3	6.4	3.7
1992	44	28	11.6	3.8	2.4
1993	128	58	14.9	8.6	3.9
1994	95	53	16.2	5.7	3.2
1995	79	53	9.6	7.8	5.5
1996	207	134	13.7	15.1	9.8
1997	269	183	18.0	15.0	10.2
1998	181	127	13.1	13.8	9.7
1999	146	93	8.1	17.9	11.4
2000	114	77	8.5	13.4	9.1
2001	117	62	7.6	15.4	8.2
2002	42	25	3.7	11.2	6.7
2003	49	40	4.6	10.7	8.7
2004	70	44	4.3	16.2	10.1
2005	147	100	12.3	11.9	8.1
2006	234	154	15.1	15.5	10.2
2007*	107	51	4.1	25.7	12.3
2008*	121	57	4.4	27.6	13.0
2009*	157	81	5.1	30.9	16.1
2010*	181	102	7.6	23.8	13.4
2011*	75	45	3.8	20.0	12.0
2012*	80	45	3.4	23.5	13.3
2013*	44	26	2.3	19.5	11.6
2014*	35	25	2.2	15.8	11.6
2015	43	29	2.6	16.6	11.0
Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	8.9	7.3
2004	253	158	16.5	15.4	9.6
2005	198	135	15.3	12.9	8.8
2006	183	121	12.7	14.4	9.5
2007*	112	54	3.6	30.9	14.8
2008*	164	78	4.8	34.1	16.1
2009*	309	161	11.0	28.2	14.6
2010*	297	167	9.2	32.2	18.1
2011*	266	159	9.7	27.3	16.3
2012*	406	231	12.4	32.8	18.6
2013*	354	210	15.0	23.7	14.0
2014*	282	206	14.4	19.6	14.4
2015	262	173	11.3	23.2	15.4

Table 3.2.2.7. *Nephrops* Kattegat (FU 4): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2015.

Year	kW days	Days at sea	Fishing days	LPUE
1991	4223351	23040	16770	71
1992	3689413	20184	14240	63
1993	2827025	15392	10598	72
1994	2480847	13989	10985	68
1995	2330909	13023	10028	85
1996	2707363	14856	11688	92
1997	2807943	14389	11558	110
1998	2957280	15264	12380	120
1999	3417242	16734	13536	105
2000	3642120	18307	14661	99
2001	3826693	18764	15294	96
2002	3258819	16568	13325	93
2003	3173969	15345	12507	107
2004	2929407	14229	11289	120
2005	2452852	11814	9337	126
2006	2147461	10431	8467	108
2007	2022910	9883	7897	155
2008	2148132	10538	8469	169
2009	2219200	11120	8726	156
2010	2438736	12055	9707	179
2011	2009409	10286	8099	140
2012	2292229	11800	9661	150
2013	2221959	11669	9226	135
2014	1908170	10393	7865	117
2015	1847763	10094	7704	116

Table 3.2.2.8. ***Nephrops*** **Kattegat (FU 4): Mean sizes (mm CL) of male and female** ***Nephrops*** **in discards, landings and catches, 1991–2015. Since 2005 based on combined Danish and Swedish data.**

	Catches					
	Discards		Landings		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.7	31.1	42.4	42.5	32.5	32.9
1992	33.0	30.3	44.4	43.2	36.7	34.9
1993	30.5	29.3	42.3	43.1	31.3	30.1
1994	29.7	28.3	40.8	40.2	31.2	28.9
1995	30.8	30.5	42.4	42.0	33.7	33.2
1996	32.7	31.3	42.0	44.0	36.7	37.3
1997	33.6	33.2	45.0	44.5	37.1	35.0
1998	34.2	33.2	45.6	44.1	41.3	36.8
1999	32.9	33.8	45.3	40.9	37.8	34.9
2000	35.1	35.2	45.7	42.1	40.4	36.9
2001	32.2	33.0	44.1	41.9	35.9	36.5
2002	34.4	33.3	44.4	43.8	37.2	36.2
2003	33.0	33.2	43.5	42.2	37.1	36.0
2004	34.7	34.2	45.1	43.2	39.9	37.5
2005	33.5	33.9	45.8	43.1	38.7	38.7
2006	33.2	33.6	45.1	42.8	37.9	37.4
2007	33.9	33.2	44.8	43.5	37.2	35.5
2008	32.6	32.4	44.0	43.9	37.5	35.9
2009	33.8	33.1	44.7	44.1	36.8	35.2
2010	34.6	33.8	45.9	44.5	39.8	36.9
2011	33.7	32.9	44.7	43.3	38.1	35.5
2012	33.8	33.2	44.3	42.9	37.1	35.7
2013	34.4	34.6	44.8	42.9	38.0	36.5
2014	35.0	34.8	45.6	42.9	40.4	37.4
2015	34.5	34.8	45.6	42.7	40.9	38.3

Table 3.2.3.1. Summary output of the TV-survey in 3.a from 2015.

Subarea	Area (km2)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)
1	2044	34	0.319	0.119	653
2	1982	24	0.392	0.354	777
3	2462	36	0.398	0.143	980
4	676	14	0.630	0.228	426
5	670	12	0.430	0.380	288
6	973	19	0.541	0.188	527
7	1019	15	0.203	0.100	207
Total	9826	154	0.393	0.203	3857
				Harvest rate	0.0205
Removals 2015 (landings + dead discards**)				79*	

*** In millions**

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

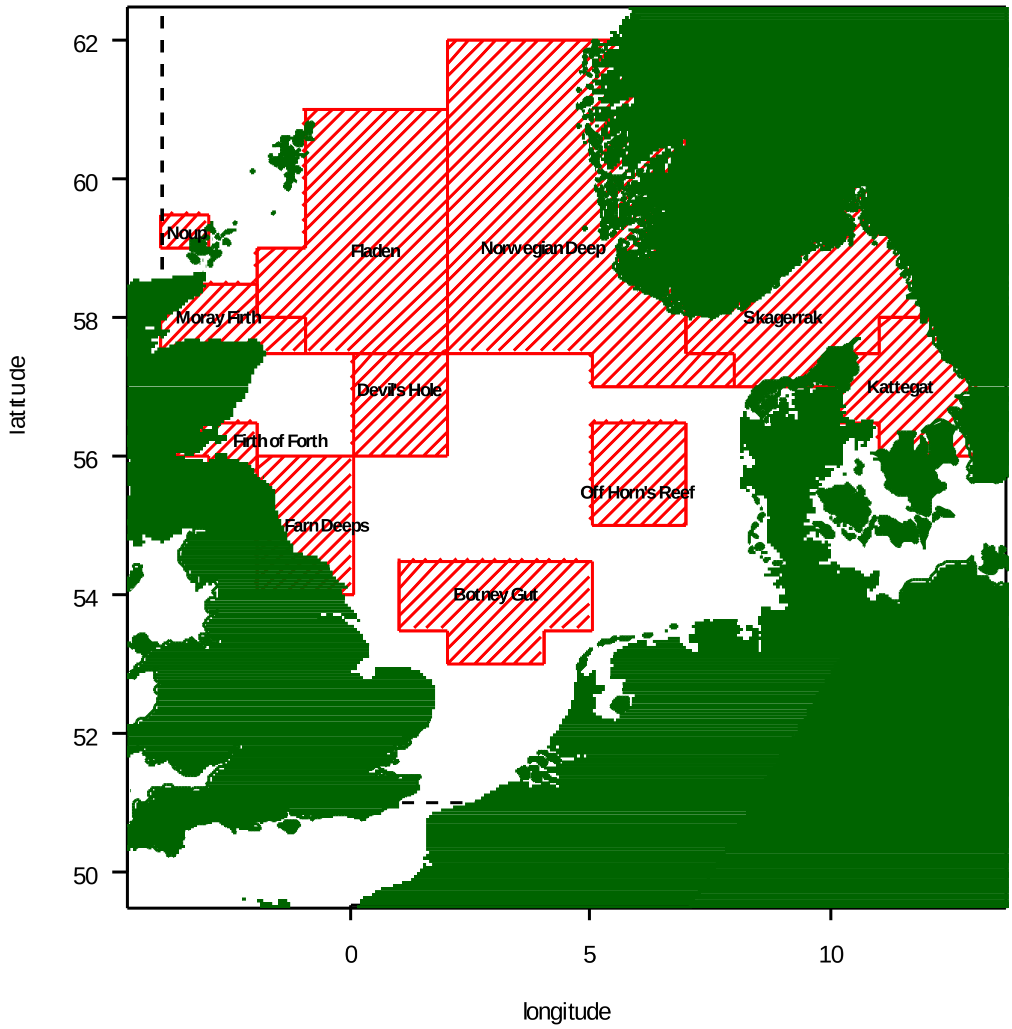


Figure 3.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

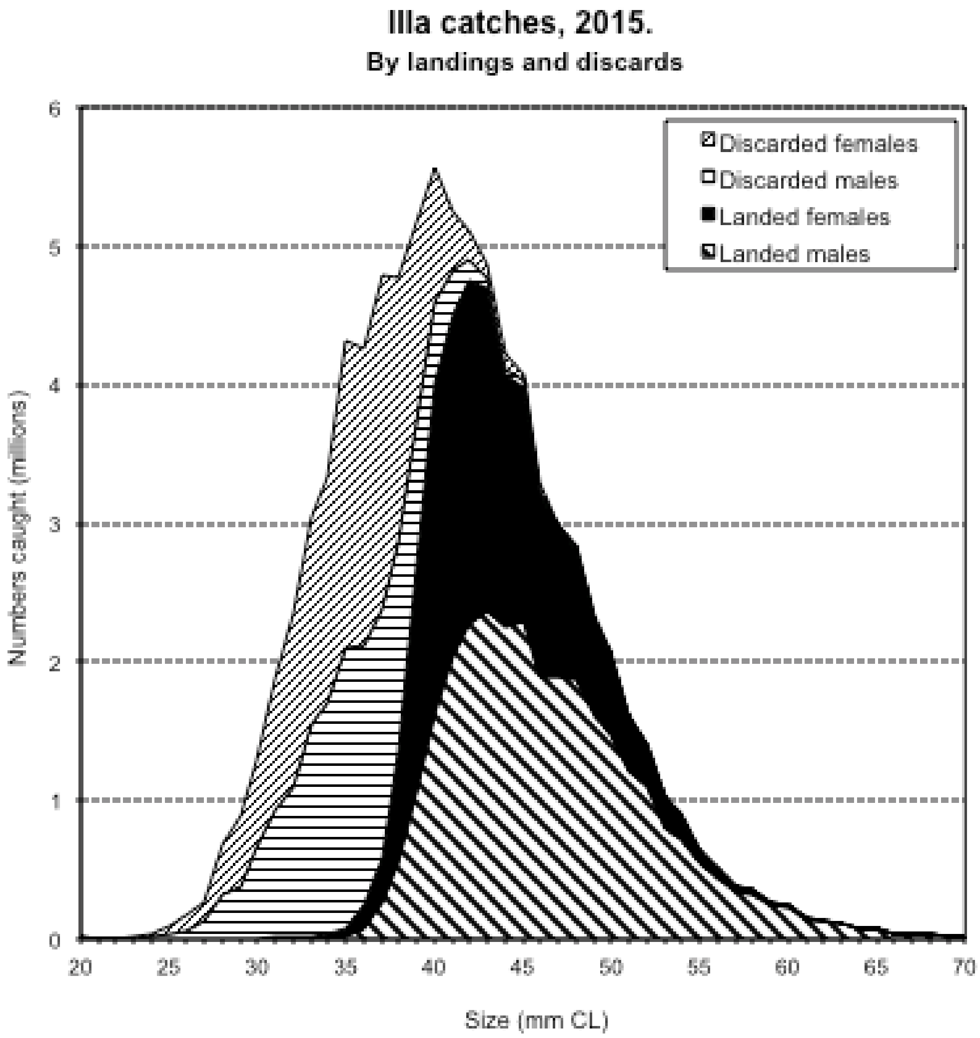


Figure 3.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2015.

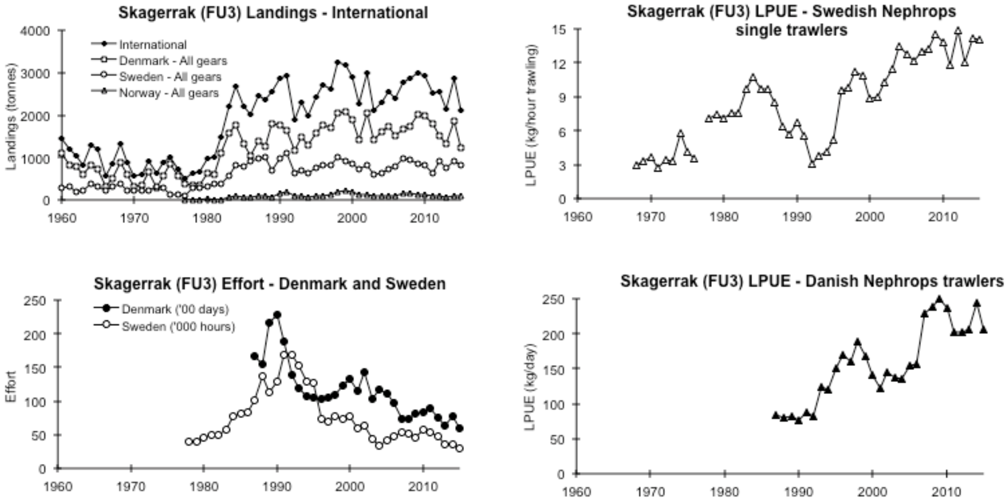


Figure 3.2.2.1. ***Nephrops*** **Skagerrak (FU 3): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.**

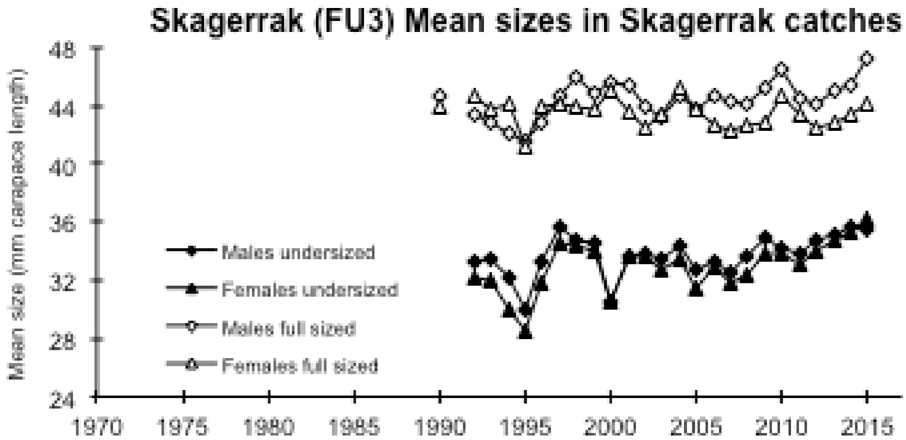


Figure 3.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

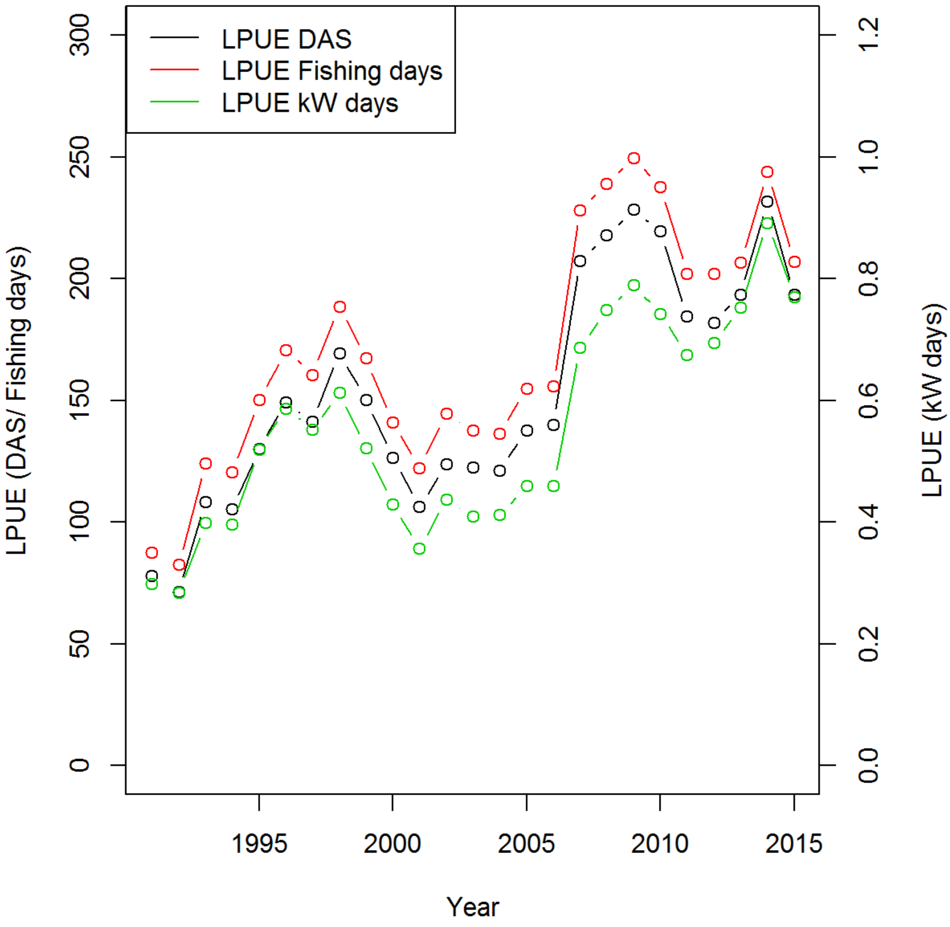


Figure 3.2.2.3. ***Nephrops*** **in FU 3. Danish LPUE trends.**

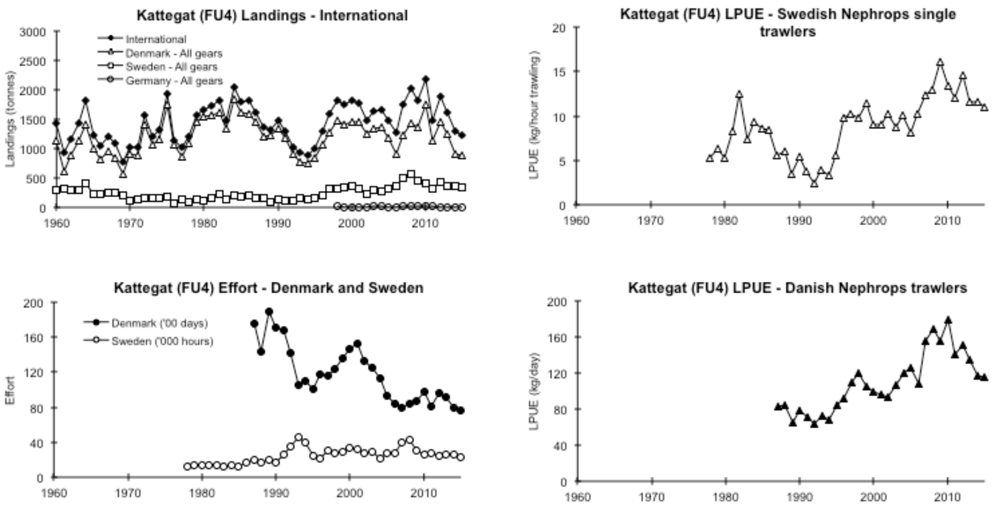


Figure 3.2.2.4. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort, LPUEs.**

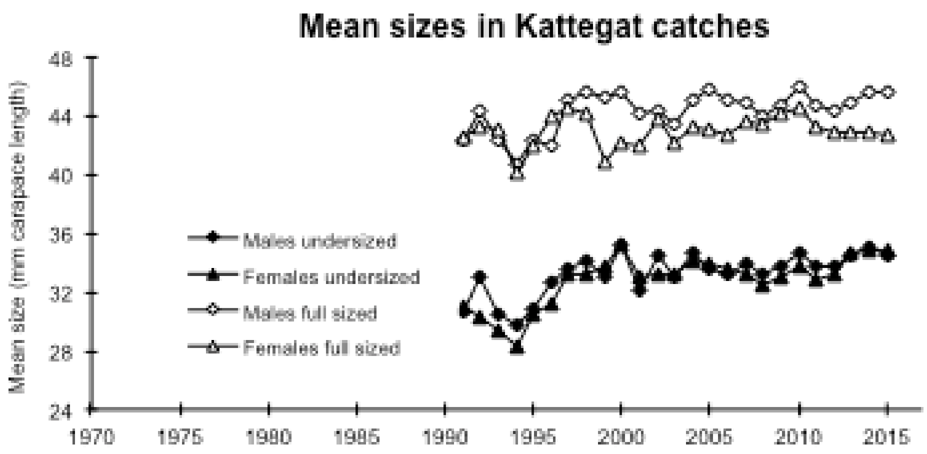


Figure 3.2.2.5. ***Nephrops*** **in FU 4. Mean sizes in the catches.**

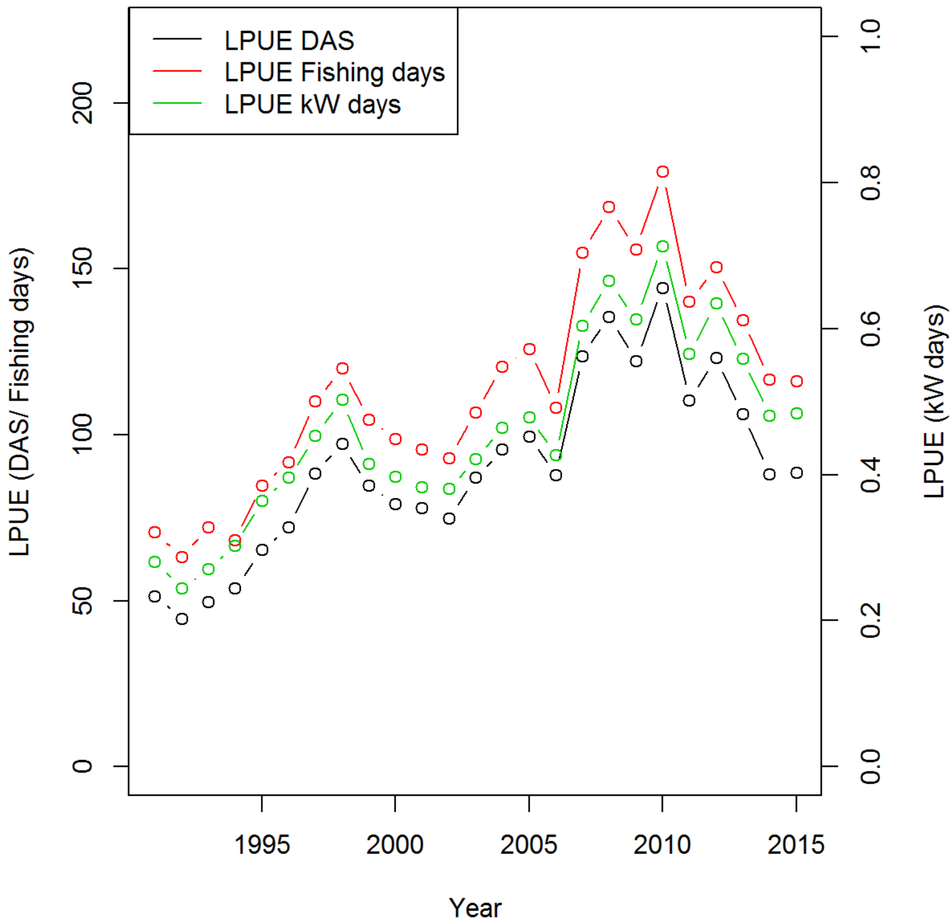


Figure 3.2.2.6. ***Nephrops*** **in FU 4. Danish LPUE trends.**

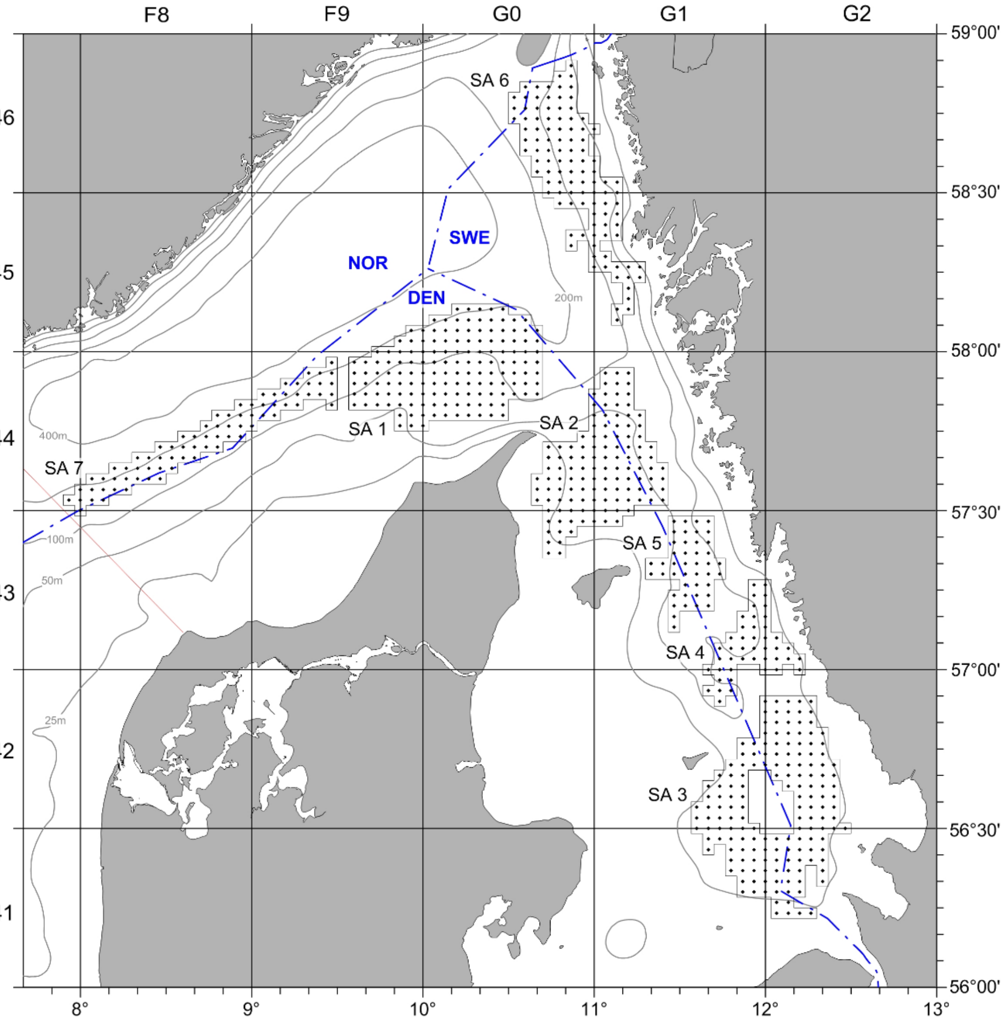


Figure 3.2.3.2. The defined sub areas of the *Nephrops* stock in 3.a.

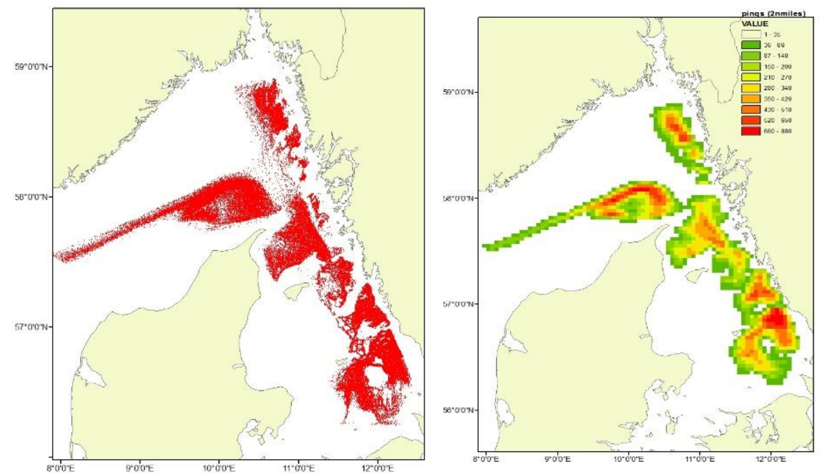


Figure 3.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010. Left map shows VMS pings and the right map shows density of VMS pings.

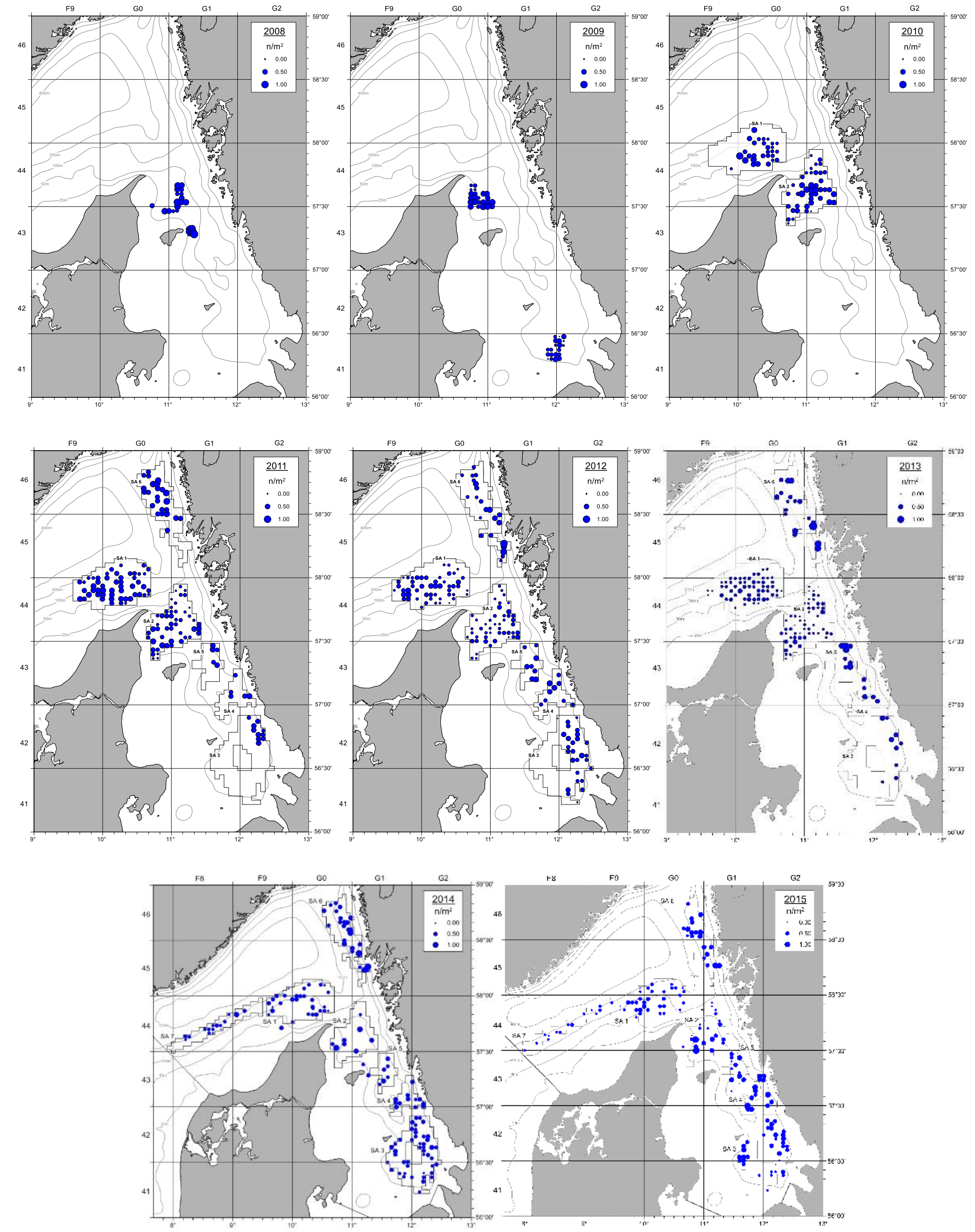


Figure 3.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2008 (26 stations, Denmark only), 2009 (47 stations, Denmark only), 2010 (72 stations, Denmark only), 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations) and 2015 (154 stations).

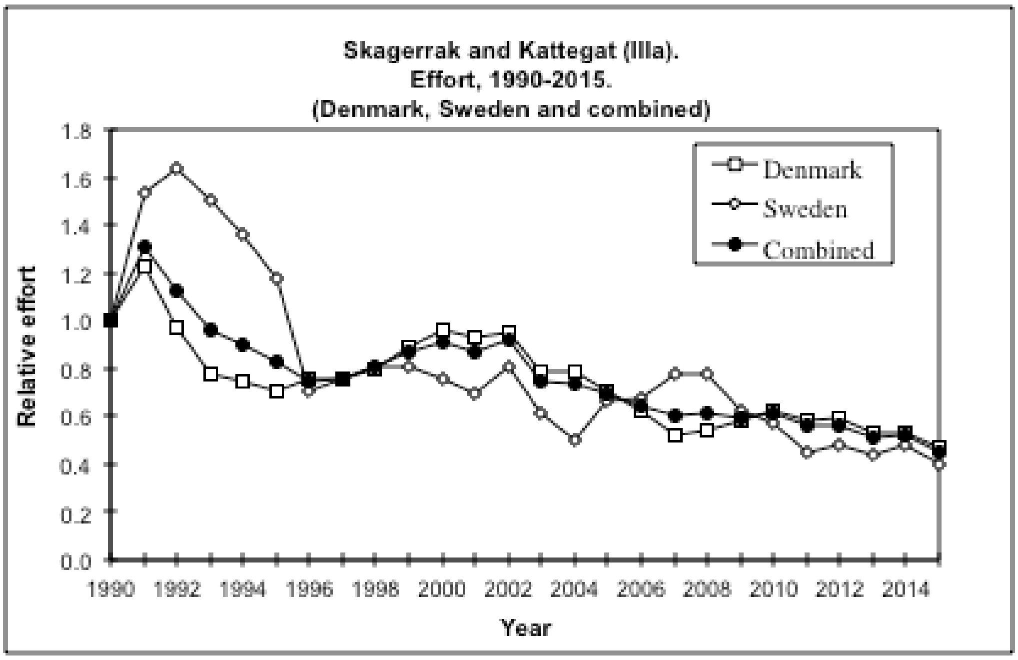


Figure 3.2.4.1 *Nephrops* in Area 3.a. Combined Effort for FU 3&4

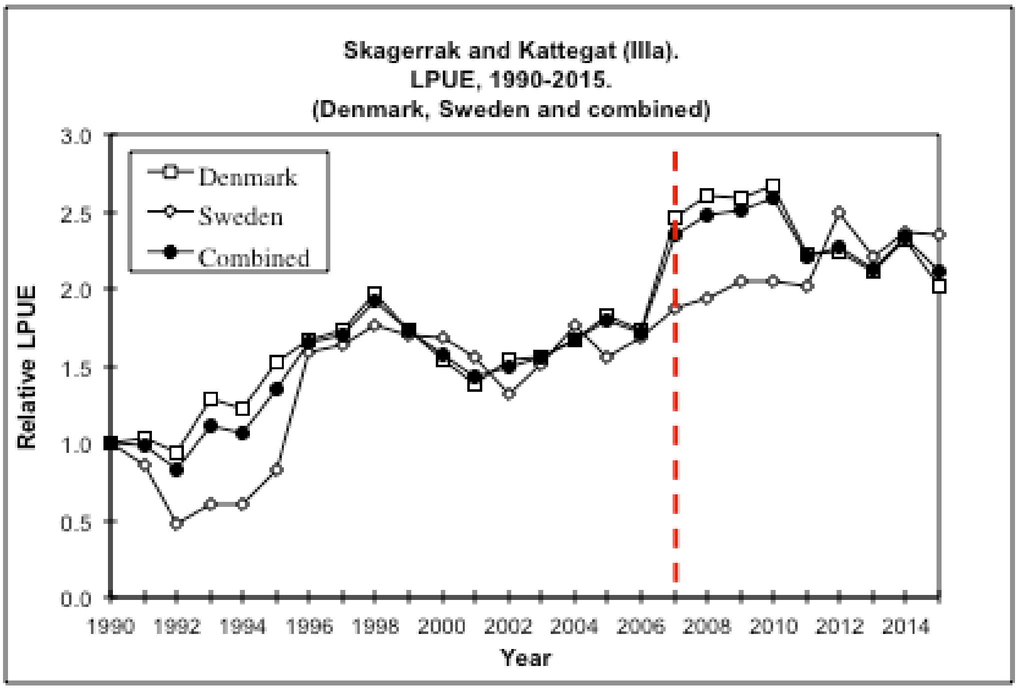


Figure 3.2.4.2 *Nephrops* in Area 3.a. Combined LPUE for FU 3&4. Red dotted line shows the year at the shift in Danish management system.

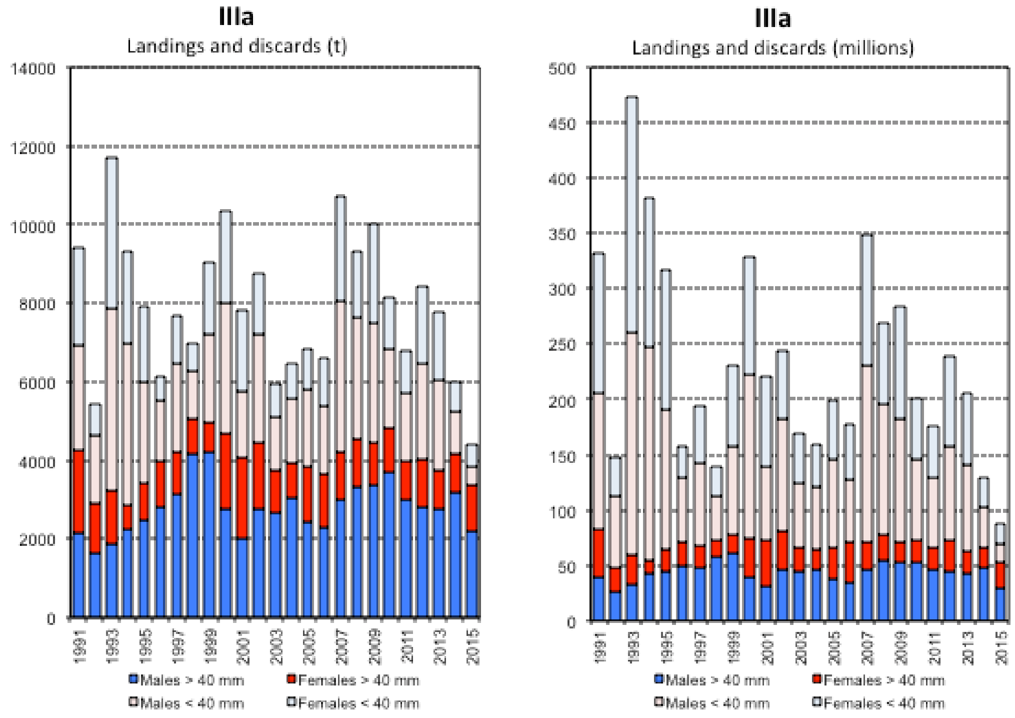


Figure 3.2.4.3 ***Nephrops*** **in 3.a FUs 3&4. Catch by sex and size category in numbers and biomass.**

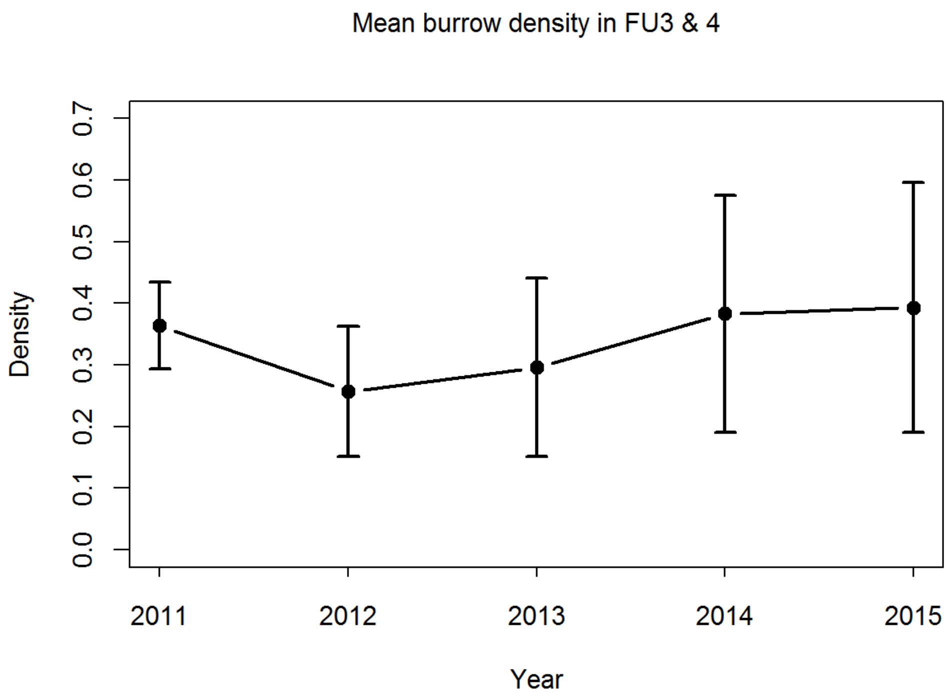


Figure 3.2.4.4. Mean burrow density in 3.a by year. Error bars indicate the 95 % confidence intervals.

4 Norway lobster (*Nephrops* spp.) in Subarea 4 (North Sea)

4.1 General comments relating to all *Nephrops* stocks

See section 3.1

4.2 *Nephrops* in Subarea 4

Subarea 4 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 relatively new functional unit having been designated in 2010 (SGNepS 2010). The forecasts for FUs 6, 7 and 8 were re-run in the Autumn because new information from UWTV surveys held during the summer triggered the re-opening criterion – the updated forecasts are provided in Annex 04.

Management at ICES Subarea Level

The 2014 EC TAC for *Nephrops* in ICES Subarea 2.a and 4 was 15 499 tonnes in EC waters (plus 1000 tonnes in Norwegian waters). For 2015, this was increased to 17 843 tonnes in EC waters and 1000 tonnes in Norwegian waters.

A major change in the management of *Nephrops* fisheries in ICES Subarea 4 for 2016 is the introduction of the landing obligation for *Nephrops* fisheries in the 80–99mm trawl fisheries. This does not affect the historical assessments presented here, but should affect the forecasts for 2017 fishing opportunities. A *de minimis* excemption for catches below the Minimum Conservation Reference Size (MCRS) of up to 6% was permitted for the fishery in Subarea 4. Where discard length frequencies and rates were available, the proportion of catch (in biomass) of animals below the MCRS was always below 6% and therefore no change in fishing behaviour would be expected from this rule. Discards above MCRS are generally for reasons of quality (damaged/soft) and these would be expected to now be landed. Catch options therefore are presented in four categories, "wanted landings", "unwanted landings" (catch historically discarded but above MCRS), "de minimis discards" and surviving discards (as not all discards die).

The minimum landings size (MLS) for *Nephrops* in Subarea 4 (EC) is 25 mm carapace length. Denmark, Sweden and Norway applied a national MLS of 40 mm up to 2015 but this was changed to 32 mm from 01/01/2016.

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 4 are presented in Table 3.3.1. The preliminary officially reported landings in 2014 are around 9600 tonnes, representing a decline of over 50% from the peak observed in 2009 (24 500t). The decline has been almost entirely from within the UK which typically represents 80% of the landings. Overall quota uptake for 2015 was 51%.

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 4 come from outside the defined *Nephrops* FUs. This value increased to nearly 10 % of the total in 2009 and as a response, a new Functional Unit at the Devil's Hole (FU 34) was designated in 2011. The trends observed in the 2012 Fishers' North Sea stock survey for *Nephrops* are discussed in the Quality of Assessment sections for each FU but there was no update to this survey in 2016.

4.3 Botney Gut (FU5)

4.3.1 The fishery in 2014 and 2015.

Landings from FU5 have been increasing from a low point in 2009 and were the highest on record in 2015 at 1516t (more than double the 2009 landings). 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. Since 2004, the Netherlands and UK have consistently taken between 78–82% of the landings. Danish activity has been at a low level but erratic since 2006.

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

4.3.2 Data Available

Landings

Landings by country for FU 5, including Belgium, Denmark, Netherlands, Germany and UK are available since 1991 (Table 4.3.1). Landings increased from ~800t in the early 1990s to ~1200t in the early 2000s, peaking at ~1400t in 2001. There then followed a period of general decline to a low in 2009 but landings have subsequently increased and in 2015 were 1516, the highest on record. Between 1991 and 1995, the Belgian fleet took more than 75% of the international *Nephrops* landings from this FU, but since then, the Belgian landings have declined drastically, and since 2006 there has been no directed Belgian *Nephrops* fishery by Belgian operated vessels. Some Belgian owned vessels operating as Dutch vessels have a directed fishery and trebled the landings between 2009 and 2014. Danish landings have been sporadic since 2006. In the most recent years UK and Netherlands have accounted for most of the landings from this FU, the large increase in landings 2014–2015 being driven entirely by these two fleets.

Annual discard data for 2015 were available from the Dutch self sampling program. 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. Three different discarding patterns were observed in the Dutch sampling. The 70–99 mm otter trawl fleet had a very high discard rate (93% by number), the 70–99 mm beam trawl fleet reported a 2.8% discard rate by number and all other gears reported zero discarding.

Length compositions

Length compositions in the Dutch landings are available from 2004 to 2015 with the exception of 2013 (Figure 4.3.1). Length composition for the 2015 discard data from the Dutch self-sampling program were also available. Data for 2013 were not considered of sufficient quality for inclusion due to a large SOP error (SOP=sum of products, the sum of number landed at length * weight at length should be close to the total landing biomass). Both mean sizes of males and females showed an increasing trend over time up to around 2012 but have been stable since (Table 4.3.2), although the intensity of sampling is fairly low in FU 5 and as a result samples may not be fully representative of actual removals. Between 2005 and 2009 the average numbers measured were >10 000 individuals a year, while between 2010 and 2012 the sampling measurements dropped to around 2500–3000 individuals. Sampling intensity in 2011 and 2012 was particularly low in the third quarter which is the main period of the fishery.

4.3.3 Natural mortality, maturity at age and other biological parameters

No analytical assessment has been performed this year.

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

Growth parameters are as follows:

Males: L_∞ = 62mm CL, k = 0.165.

Immature females: L_∞ = 62 mm CL, k = 0.165.

Mature females: L_∞ = 60 mm CL, k = 0.080, Size at 50% maturity = 27 mm CL.

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

4.3.4 Commercial catch-effort data and research vessel surveys

Effort and LPUE data have been presented for this FU for several years as indicator indices however in 2015 it was discovered that there were serious concerns regarding the way in which effort had been reported for the Dutch, Belgian and English fleets.

- Historic Belgian effort data claimed to be from vessels targeting *Nephrops* however it transpired that the effort data were for the whole towed gear fleets operating in this area. It was not possible to reconstruct a new effort series in time for the 2015 assessment meeting but this should be completed in time for the 2016 assessment.
- Dutch data had always stated that effort was being reported for all vessels catching *Nephrops* but closer investigation showed that the majority of the

landings were made from TR2 gears whilst the effort figures were dominated by TBB gears where *Nephrops* are picked up as bycatch. Revised LPUE indices will be developed in time for the next assessment in 2016.

- English effort data purported to represent hours fished, however there were discovered to be a large number of inconsistent entries in the effort fields on the database. It was decided that reporting effort in hours fished was not a viable option and therefore days fishing for targeted *Nephrops* activity have been reported instead. A landing targeting *Nephrops* is defined as using 70–99 mm otter trawl with at least 25% by weight of *Nephrops* per record. Changes to the way in which fishing activities were recorded in 2006 significantly sharply changing the level of landings and targeted reported.
- In addition to the erroneous data in the Dutch, Belgian and English data, Danish activity in the area has become sporadic with only one or two vessels prosecuting the fishery, therefore LPUE data for this sector is not used as an index of abundance.

Changes to the way in which gear is specified in the English fishery since 2014 necessitates a re-calculation of the landings and effort for the directed fishery. The basic premise of the calculation remains the same, otter trawl gears in the 70–99 mm category in which >25% of the total landing comprises *Nephrops*, but the number of days fishing included in this categorisation has increased since the previous data extraction however there are minimal changes to the resulting LPUE. The only LPUE series considered to be an appropriate abundance proxy is the English LPUE series since 2006 (Table 4.3.3 and Figure 4.3.2.)

Effort by English vessels targeting *Nephrops* (targeting being classed as trips where *Nephrops* comprise >=25% of landings by biomass) in FU5 , has been generally falling since 2006 but was relatively stable between 2013–2015. LPUE has fluctuated without trend over the period 2006–2015.

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

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

Intercatch

FU5 data were available from Intercatch for all nationalities for 2011, 2012, 2013 and 2014. Quarterly landings by metier were available for all countries fishing the functional unit. Length composition data were not available for 2013 as the sample rate was considered insufficient to raise the distributions. Discards were raised for non-sampled strata on a fleet by fleet basis, matching the Dutch raising factors for the three different gear types (70–99 Otter, 70–99 Beam and other). This approach gave an overall discard rate of 73% by number (57% by weight), which is substantially higher than the 25% by number assumed in previous assessments. As a bounding exercise, the non-observed fleets had discard rates set to zero resulting in a total international discard rate of 45%, indicating that discard data for other fisheries is highly desirable (although with the inclusion of *Nephrops* into the landing obligation in 2016 this need should reduce).

4.3.5 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. The advent of discard data from the Dutch fleet for 2015 indicates that harvest rates have been significantly higher than previously assumed.

In previous assessments there had been concern regarding conflicting signals in LPUE series, however this was most likely due to the inclusion of non-targeted behaviours and there is now only one LPUE series presented which shows no trends.

Following the procedure outlined in section 3.1.2, an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in this functional unit. Mean weight in landings component came from the 3 year average whilst the mean weight of discards and the discard proportion came from the 2015 data as they were the only ones available. Discard survival was set to zero in line with the protocol for data limited *Nephrops* stocks. The 2012 survey shows that density is relatively high on this ground at 0.7 burrows per metre squared.

Under the assumption that the landing obligation applies (i.e. no discarding) and that the abundance is around 0.7 burrows per metre squared, the 2016 catch advice should result in a Harvest Rate of around 3.6%. Even a 20% increase in the 2016 catch advice should result in a Harvest Rate of less than 7.5% (the lowest MSY harvest rate for the analytically assessed stocks in area 4).

Basis	Total Catch	Wanted Catch	Unwanted Catch	Dead discards	Surviving discards	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.2*2015	837	303	534	-	-	40.0%	20.0%	10.0%	6.7%	5.0%	4.0%	3.3%	2.9%	2.5%
2016 Catch advice	1155	419	737	-	-	55.2%	27.6%	13.8%	9.2%	6.9%	5.5%	4.6%	3.9%	3.5%
0.3*2015	1256	455	801	-	-	60.0%	30.0%	15.0%	10.0%	7.5%	6.0%	5.0%	4.3%	3.8%
2016 Catch adv * 1.2	1386	502	884	-	-	66.3%	33.1%	16.6%	11.0%	8.3%	6.6%	5.5%	4.7%	4.1%
0.5*2015	2093	758	1335	-	-	100.1%	50.0%	25.0%	16.7%	12.5%	10.0%	8.3%	7.1%	6.3%
Fmsy	2195	795	1400	-	-	104.9%	52.5%	26.2%	17.5%	13.1%	10.5%	8.7%	7.5%	6.6%
0.8*10 yr av	2304	834	1469	-	-	110.1%	55.1%	27.5%	18.4%	13.8%	11.0%	9.2%	7.9%	6.9%
0.8* 2016 land advice	2472	895	1576	-	-	118.2%	59.1%	29.5%	19.7%	14.8%	11.8%	9.8%	8.4%	7.4%
2016 landings advice	2880	1043	1837	-	-	137.7%	68.8%	34.4%	22.9%	17.2%	13.8%	11.5%	9.8%	8.6%
10 year av	3089	1119	1970	-	-	147.7%	73.9%	36.9%	24.6%	18.5%	14.8%	12.3%	10.6%	9.2%
0.8*2015	3348	1213	2136	-	-	160.1%	80.0%	40.0%	26.7%	20.0%	16.0%	13.3%	11.4%	10.0%
2015	4186	1516	2670	-	-	#####	#####	50.0%	33.4%	25.0%	20.0%	16.7%	14.3%	12.5%

Under the scenario in which the landing obligation applies but discarding is permitted on a di minimis basis (i.e. catch below MCRS is permitted to be discarded up to 6% of total catch weight), the same 20% increase in total catch advice from the 2016 value results in a harvest rate below the 7.5% level.

Basis	Total Catch	Wanted Catch	Unwanted Catch >MCRS	De minimis discards <MCRS	Surviving discards	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.2*2015	837	303	500	34	0	40.0%	20.0%	10.0%	6.7%	5.0%	4.0%	3.3%	2.9%	2.5%
2016 Catch advice	1156	419	691	46	0	55.2%	27.6%	13.8%	9.2%	6.9%	5.5%	4.6%	3.9%	3.5%
0.3*2015	1256	455	751	50	0	60.0%	30.0%	15.0%	10.0%	7.5%	6.0%	5.0%	4.3%	3.8%
2016 Catch adv * 1.2	1386	502	828	56	0	66.3%	33.1%	16.6%	11.0%	8.3%	6.6%	5.5%	4.7%	4.1%
0.5*2015	2093	758	1251	84	0	100.1%	50.0%	25.0%	16.7%	12.5%	10.0%	8.3%	7.1%	6.3%
Fmsy	2195	795	1312	88	0	104.9%	52.5%	26.2%	17.5%	13.1%	10.5%	8.7%	7.5%	6.6%
0.8*10 yr av	2304	834	1377	93	0	110.1%	55.1%	27.5%	18.4%	13.8%	11.0%	9.2%	7.9%	6.9%
0.8* 2016 land advice	2472	895	1477	99	0	118.2%	59.1%	29.5%	19.7%	14.8%	11.8%	9.8%	8.4%	7.4%
2016 landings advice	2880	1043	1721	116	0	137.7%	68.8%	34.4%	22.9%	17.2%	13.8%	11.5%	9.8%	8.6%
10 year av	3090	1119	1847	124	0	147.7%	73.9%	36.9%	24.6%	18.5%	14.8%	12.3%	10.6%	9.2%
0.8*2015	3349	1213	2002	135	0	160.1%	80.0%	40.0%	26.7%	20.0%	16.0%	13.3%	11.4%	10.0%
2015	4186	1516	2502	168	0	200.1%	100.1%	50.0%	33.4%	25.0%	20.0%	16.7%	14.3%	12.5%

4.3.6 Management considerations for FU 5.

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock. Given the paucity of metrics available for monitoring stock development, the exploitation of this stock should monitored closely.

4.4 Farn Deeps (FU6)

An updated assessment based on the 2015 TV survey is available in Annex 04.

4.4.1 Fishery in 2014 & 2015

Since the beginning of the time-series, the UK fleet has accounted for virtually all landings from the Farn Deeps (Table 4.4.1). The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2015 data comprise the end of the 2014–2015 fishery and the start of the 2015–2016 fishery.

Landings in 2014 were 2503t, close to the 10 year average whilst landings in 2015 dropped to 1371, the lowest since 2008 and the second lowest on record (Figure 4.4.1). The majority of this reduction occurred in the second half of 2015, the winter fishery of 2015–2016 being particularly poor.

The introduction of the buyers and sellers legislation in 2006 means direct comparison with previous years should be viewed with caution because the suspected resulting improvement in reporting levels will have created a discontinuity in the data.

Directed effort (i.e. days fishing by vessels fishing with *Nephrops* gears) from English vessels during 2015 declined from the 2014 level, particularly for the <10m sector, although the 10–15 m sectors also declined substantially. Only in the >15 m sector did effort remain relatively constant.

Historically the fishery has been prosecuted by a combination of local English boats (smaller vessels undertaking day–trips) and larger vessels from Scotland with occasional influxes of effort by Northern Irish vessels. The total number of vessels in the fishery has generally been decreasing since 2007 although 2013 and 2014 saw increases again in all sectors (Figure 4.4.2). The majority of the dynamic in fleet size is due to Scottish boats, likely to be a response of vessels moving away from reduced catch rates in FU7.

ICES Advice in 2015

The last assessment of *Nephrops* in FU6 was in 2014

ICES advises that when the MSY approach is applied, catches in 2016 (assuming a landing obligation applies) should be no more than 738 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 680 tonnes.

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

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

4.4.2 Assessment

Review of the 2015 assessment

The assessment has been performed correctly with no deviations from the standard procedure for this stock. The update assessment gives a valid basis for advice.

Data available

Catch, effort and research vessel data

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

Discards

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

Length Frequency

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

A bi-modal length frequency distribution for landed females had been present since 2009 and become steadily more pronounced until 2014. This could be the result of a large year class, but a similar phenomenon is not observed in the male part of the population, in fact the mean size in the males decreased in 2012 and 2013. The mean annual increment of the female second mode is only around 2 mm whereas interannual growth would be expected to be more and therefore year class strength is unlikely to be the cause of this feature. The predominance of large females in the catches means they were foraging for food on the surface at a time when they would have been expected to be brooding eggs within their burrows. Given that there are very few males of similar size appearing in the catches it is possible that there is a physical size differential constraint in mating patterns of *Nephrops*. This may either be an inability of the males to successfully transfer spermatophores, or alternatively large females may be able to resist the (usually quite aggressive) approaches of the smaller males when they try to mate with large females. The reduction in the bi-modal nature of the female length distribution in 2015 implies a lower relative availability of females at larger sizes and may indicate a better spawning success. The alternative hypothesis is that this part of the population was removed by the fishery and would therefore suggest continued low recruitment.

There is therefore considerable concern that this stock is likely to be suffering from reduced recruitment and may continue to do so for at least the next two years (assuming that recruits enter the fishery between age 2 and 3). Whether the change in proportion of large mature females in the landings is a result of improved mating conditions remains to be seen and will not be evident for a further 12–24 months in the form of improved recruitment.

Effort and LPUE

The metric of fishing effort (hours fished by *Nephrops* targeting vessels) produced for 2014 using the standard raising process was sharply different to the 2013 metric. On closer inspection it transpired that changes to reporting mechanisms (more uptake of e-log systems) had caused a discontinuity in how data were reported. Further analysis of historic data also highlighted serious inconsistency in the way that fishing hours had been reported back through time. The number of days fished is considered to be more reliably captured by the official statistics and therefore the effort metrics were reworked from 2000 onwards.

The way in which data regarding both landings and effort were collected within the UK changed in 2006 (Buyers and Sellers legislation) which had a noticeable change in the level of reported metrics. Comparison between these two time periods is therefore inadvisable.

Directed effort fell for the under 10m sector has remained constant from 2006 onwards, whilst for the larger vessels this dropped from 2006. 2006 saw a large influx of larger vessels from other areas of the UK including Scotland and Northern Ireland. There has been an increase in the number of Scottish boats, particularly the large >15m sector in 2013 and 2014. (Figure 4.4.2).

The use of LPUE as an index of stock abundance for *Nephrops* is confounded by changes in availability of *Nephrops* to fishing gears depending upon environmental factors such as tide and light levels, plus changes to emergence behaviour induced by mating and predator avoidance. There is a general level of agreement between LPUE for the different gears and a decline in stock abundance from around 2006 to 2008.

Effort and LPUE show distinct differences between vessel size classes, twin-rig being more efficient for a size class of vessel than single-rigs (figure 4.4.5). There remain some consistency issues between periods pre and post 2006, but despite this there appears to be a difference in the trajectory of LPUE between the vessel size classes. Small (<10m) single-rig vessels have seen a sharp drop from ~300kg per day in 2006 to around 150kg per day in 2014 and this level had remained fairly constant between 2009 and 2014, vessels larger than this on the other hand appeared to be experiencing increasing LPUE, particularly for the >15m vessel sector. This may represent a spatial difference in stock development as the smaller vessels are restricted to more inshore areas, however there may be some fleet changes (larger vessels) or reporting changes (issues with data from e-logs) which are driving some of these differences. For 2015 however, all fleet sectors experienced their lowest recorded catch rates.

Traditionally, males tend to predominate the landings, averaging about 70% (range 64%–79%) by biomass in the period 1992–2005. Towards the end of the fishing season (February-March) there is usually an increase in female availability as mature females emerge from their burrows having released their eggs. There has been a marked change in the seasonal pattern of sex-ratio for Farn Deeps *Nephrops* since the winter of 2005. Prior to this the ratios were generally smooth with small (~10%) seasonal fluctuations, but since then the fishery has observed very large swings, with whole years being dominated by landings of females (2006, 2010, 2012 and 2013–2014, Figure 4.4.4). The sex ratio for 2015 returned to a generally male dominated fishery and can be explained by the lack of large females in the catches (figure 4.4.7).

Effort in the 2014–2015 winter fishery was markedly lower than the same period 12 months previously but no lower than that observed in the early 2000s when abundance was estimated to be much higher. The relative strength of effort within a season (i.e. the fourth quarter compared to the first quarter) fluctuates without trend.

Female LPUE in the fourth quarters of 2000, 2006, 2009, 2001 and 2013 have been higher than one might expect given that they are supposed to have reduced availability due to egg-brooding.

UWTV

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

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

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

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

Intercatch

All data for 2015 were entered onto Intercatch. Landings data by fleet were provided by Scotland, England, Denmark, Belgium and the Netherlands, whilst England provided length distributions for landings and discards by fleet where available.

Discard ratios for all unsampled fleets were raised on the combined annual data from England. Quarterly length distributions were imported for England which represetned 84% of the landings. Consequently, length frequencies for the remaining metiers were generated from the pooled data (i.e. irrespective of metier or quarter) for both landing and discard components.

Natural mortality, maturity at age and other biological parameters

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

Exploratory analyses of RV data

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

Final Assessment

The estimated abundance in 2015 was 549 million individuals (95% confidence interval of ±13 million), significantly below the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2015 was 11%, well above the MSY proxy level of 8.1% but lower than the 2014 Harvest Rate of 13%.

The stock therefore remains in a vulnerable state. The dominance of large females in the landings again for the 2012–2014 fishery suggests that they had not successfully mated and therefore there remains the potential for poor recruitment for 2016 and 2017 (recruits to the fishery are estimated to be ~ 2–3 years old)

4.4.3 Historical stock trends.

The time series of TV surveys is 14 consecutive years although the new geostatistical method has only been applied retrospectively to 2007. Whilst there is expected to have been a small over-estimation of abundance using the previous technique it is likely that the reduction in stock abundance observed between the two periods of estimation procedure is real.

Estimates of historical harvest ratio (the proportion of the stock which is removed) range from 6.1% to 25.5% (Table 4.4.5). The harvest ratio jumped from around 12% in 2004–2005 to 25.5% in 2006 when the new reporting legislation came in. The harvest rate has only been below the MSY level once in 13 years.

4.4.4 MSY considerations

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

- Average density in the stock is at a medium level, above the level of the FU 7 but below that of FU 8.
- Density has varied through time but does not appear to undergo large scale interannual fluctuations. Spatially there is a good degree of consistency in the pattern of high and low density between the years.
- Estimated growth rates are at a moderate level although the data supporting them are quite old. Natural mortality estimates are standard.
- The fishery in the Farn Deeps is a winter fishery (October – March) with typically male dominated catches. The intra-annual pattern of sex ratios in

the catches has changed in 2006 and 2009 possibly due to sperm limitation leading to more mature but unfertilised females being available to the fishery. This may lead to reduced recruitment to the fishery.

- Although the time series of observed harvest rates is relatively short, there has been a fair degree of fluctuation (7–25%). The observed harvest rate is, of course, confounded by the change in reporting levels considered to have occurred around 2006. The average harvest rate since 2006 is 15.7% which is above the most recent estimate of F_{max} for males.

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

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

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

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

Short term forecasts.

Catch and landing predictions for 2017 are given in the text table below. This assumes that the absolute abundance estimate made in June 2015 is relevant to the stock status for 2017. The ICES MSY approach dictates that where the stock status is below the trigger point, the maximum advised fishing rate should be the MSY rate adjusted by the ratio of the current stock status to the Btrigger level. For 2017 this gives

HR_{2017} = HR_{MSY} (8.12%) * Abundnace 2015 (569) / Btrigger (858) = 5.3%

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given for 2017 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea) allowed. Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU6 is assumed to be 15%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2017 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (15% survival rate is still assumed).

Variable	Value	Source	Notes
Abundance in TV assessment	565	ICES (2016a)	UWTV 2015
Mean weight in landings	28.96	ICES (2016a)	Average 2013–2015
Mean weight in discards	11.098	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCRS	13.63	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCRS	6.765	ICES (2016a)	Average 2013–2015
Discard rate (total)	24.56%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCRS)	14.14%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (<MCRS)	10.45%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Only applies in scenarios where discarding is allowed.
Dead discard rate (total)	21.67%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	9.03%	ICES (2016a)	Average (proportion by number) 2013–2015, only applies in scenarios where when discarding allowed for de minimus exemptions.

***Nephrops* in FU6: Catch options assuming the landing obligation applies.**

	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
FMSY ApproachComb	791	769	703	66
FmsyLower	1036	1007	921	86
F0.1Male	1052	1023	935	87
FmsyUpper	1183	1151	1052	98
F35%Male = FMSY	1201	1168	1068	100
F0.1Comb	1284	1248	1142	107
F35%Comb	1648	1602	1465	137
FmaxMale	1716	1668	1526	143
F0.1Female	2074	2017	1844	172
F35%Female	2247	2185	1998	187
FmaxComb	2263	2201	2012	188
Fcurrent	2530	2460	2249	210
FmaxFemale	3195	3107	2841	266

***Nephrops* in FU6: Catch options assuming that discarding continues at historic patterns.**

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
FMSY Approach	759	754	678	60	16	5
FmsyLower	994	987	887	78	22	7
F0.1Male	1010	1002	901	79	22	7
FmsyUpper	1136	1128	1014	89	25	8
F35%Male = FMSY	1153	1145	1029	91	25	8
F0.1Comb	1232	1224	1100	97	27	9
F35%Comb	1582	1570	1412	125	34	11
FmaxMale	1647	1635	1470	130	36	12
F0.1Female	1991	1976	1777	157	43	14
F35%Female	2157	2141	1925	170	47	16
FmaxComb	2172	2157	1939	171	47	16
Fcurrent	2428	2411	2167	191	53	18
FmaxFemale	3067	3045	2737	241	66	22

***Nephrops* in FU6: Catch options assuming the landing obligation applies with the di minimis rules for animals below MCRS.**

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
FMSY Approach	759	754	678	60	16	5	5.35%
FmsyLower	994	987	887	78	22	7	7.00%
F0.1Male	1010	1002	901	79	22	7	7.11%
FmsyUpper	1136	1128	1014	89	25	8	8.00%
F35%Male = FMSY	1153	1145	1029	91	25	8	8.12%
F0.1Comb	1232	1224	1100	97	27	9	8.68%
F35%Comb	1582	1570	1412	125	34	11	11.14%
FmaxMale	1647	1635	1470	130	36	12	11.60%
F0.1Female	1991	1976	1777	157	43	14	14.02%
F35%Female	2157	2141	1925	170	47	16	15.19%
FmaxComb	2172	2157	1939	171	47	16	15.30%
Fcurrent	2428	2411	2167	191	53	18	17.10%
FmaxFemale	3067	3045	2737	241	66	22	21.60%

4.4.5 BRPs

Suggestions for proxies of biological reference points are shown in the catch option table and discussed in 4.3.4.

4.4.6 Quality of assessment

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

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

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

The spatial distribution of the 2014 survey results continues the pattern observed in other years, although at a lower overall level. The spine of high density on the western edge of the ground remains a regular feature. The main features of the survey series are peaks in abundance 2001 and 2005, with reasonably constant series since 2007.

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

Without suitable controls on the movement of effort between Functional Units there is nothing to prevent the effort in 2016 continuing to inflict fishing mortality above the F35%SprR level and indeed above the level of F_{max}. Prior to the introduction of "Buyers and Sellers" legislation in 2006 reporting rates are considered to have been low and hence the estimated Harvest Ratios prior to 2006 are also likely to have been underestimated.

4.4.7 Status of stock

The 2015 TV survey indicates the stock continues to be in a depleted state and is in further decline, below the level of MSY $B_{trigger}$ with harvest rates well in excess of the MSY advised rate. There are no indications of strong recruitments coming into the stock and the appearance of large females appearing in the catches up to 2014 suggests that the situation may continue for some years yet.

4.4.8 Management considerations

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

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

During the December council meeting in 2015, the UK undertook to instigate a package of national technical measures in an attempt to bring the level of fishing mortality down. The measures to be put in place in time for the winter fishery in 2016 include:

- Vessel owners will be required to use a minimum mesh size of 90 mm using single twine of 5 mm.
- The use of a lifting bag will continue to be permitted
- Only single-rig vessels of 350 kW (476 hp) or less will be permitted to fish within 12 nm of the coast.
- Multi-rig vessels (vessels with three or more rigs) will be prohibited from operating within the Farn Deeps. Twin rig vessels will be permitted to operate outside 12 nm.
- No vessel will be permitted to use gear with more than one codend per rig.
- The Farn Deeps will be defined as ICES rectangle 38E8, 38E9, 39E8, 38E9, 40E8 and 40E9.

The majority of the impact of these measures is expected to be a deterrent effect in terms of the number of vessels using the ground. The next ICES assessment in 2017 will have a partial year's data where these rules are in place and therefore will be in a limited position to evaluate their impacts. These rules also only apply to UK registered vessels, however the UK removals from FU6 are in excess of 95% of the historic landings.

4.5 Fladen Ground (FU7)

4.5.1 Ecosystem aspects

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

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the Fladen Ground FU these substrates are distributed more or less continuously over a very large area (approx. 30 000km^2). Figure 4.5.5 shows the distribution of sediment in the area. Sandy mud and muddy sand are the dominant sediment types, with patches of mud in the south west area of the FU. Numerous fish species occur in in the same area as *Nephrops* with demersal fish more prevalent in the northern area. In the softest areas of mud, *Pandalus borealis* is also found.

4.5.2 The Fishery in 2015

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (1774 tonnes in 2015), with England taking 4 tonnes and Denmark 8 tonnes (Table 4.5.1). Around 80 vessels participated in the Fladen fishery at various times throughout the year. The majority are Scottish vessels fishing out of and landing to Fraserburgh and Peterhead. Catch consisted of *Nephrops*, haddock, whiting, cod, monkfish and megrim. A number of vessels have installed freezer capabilities to enable longer trips, but the average trip is around seven days. The fishery is seasonal and the fleet nomadic, moving between Fladen, Moray Firth, Firth of Forth, Devil's

Hole, Farn Deeps and west coast of Scotland according with the time of the year and catch rates. Fishing in 2015 was generally poor in Fladen with landings reaching its lowest figure since the late eighties. A reduced number of trips were registered in 2015 with large areas of FU 7 not visited, mostly to the north of the ground. In the second quarter of 2015, low catch rates lead to a significant exodus from the Fladen grounds to the Firth of Forth, Farn Deeps and the west coast of Scotland. Information on the fishery suggests that due to poor fishing in the Minches, some vessels moved further through the west to the South of England, fishing off the Scilly Islands (FU 20–21) between April and July. Some vessels also spent some time during summer in the Silver Pits (FU 5). The fishery in Fladen improved slightly in the second half of 2015 when most landings took place, but remained low compared with recent years.

Most vessels fishing in FU 7 traditionally use twin rigs with 80/90 mm mesh. Recently, to reduce catches of whitefish (e.g. cod), mandatory measures implied that any vessel using gear with a mesh size of less than 100 mm (TR2) in Area 4.a in the North Sea must fish exclusively with any of the Highly Selective Gears (HSGs). Examples of these are the Gamrie Bay Trawl or Faithlie Cod Avoidance Panel. This made a significant portion of the fleet to switch to 100 mm mesh, as they can target both *Nephrops* and fish. This confirms anecdotal information suggesting that in recent years, vessels fishing in Fladen have become more dual purpose in the sense that more vessels are now targeting fish (using TR1 gears) and no longer solely dependent on *Nephrops*. This implies that these vessels have to buy both quota and days. Further general information on the fishery can be found in the Stock Annex.

4.5.3 ICES advice in 2015

The ICES conclusions in 2015 in relation to State of the Stock were as follows:

"The stock size has declined from the highest observed value in 2008 and is just below the MSY Btrigger. The 2015 abundance estimate is the lowest of the time-series. The harvest rate has declined in recent years and remains well below FMSY. "

The ICES advice in 2015 (for 2016) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, catches in 2016 (assuming zero discards) should be no more than 6856 tonnes. If instead discard rates continue at recent values (average of 2012–2014), and there is no change in assumed discard survival rate, this implies landings of no more than 6847 tonnes.

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

4.5.4 Management

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

4.5.5 Assessment

Approach in 2016

The assessment of *Nephrops* in 2016 is based on examining trends in the UWTV survey data (1992–2015) and utilising an extensive series of commercial fishery data and follows the process defined by the benchmark WG 2009. The assessment approach is further described in the stock annex.

The provision of advice in 2016 followed the process of 2015, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

4.5.6 Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with small contributions from Denmark and England, and are presented in Table 4.5.1 and Figure 4.5.1. Total international landings (as reported to the WG) in 2015 were 1786 tonnes (over 2000 tonnes lower than the 2014 total), consisting mostly of Scottish landings with only 12 tonnes landed by other countries.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas, particularly Fladen. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to 2015 and only annual summaries are available.

Trends in Scottish effort of *Nephrops* trawlers and LPUE are shown in Figure 4.5.1 and Table 4.5.2. From 2015, effort data for this stock is expressed both in days fishing and kW days (there are no major differences in effort trends between those different units). Effort has been relatively stable from 2002 to 2010 but fell markedly in the last five years because of poor fishing and part the fleet relocating to other areas. The spatial contraction of the fishery is further confirmed by the VMS distribution of otter trawlers fishing in Fladen (2010–2015) shown in Figure 4.5.8. In recent years a decreasing numbers of trips have been taking place in FU 7 and in 2015, the south of the ground was the area where most fishing took place. LPUE has gradually increased since 2000 to a peak of over 620 kg/day in 2009. It has fallen since then until 2013 followed by a slight increase in 2014 and a further decrease in 2015. Danish LPUE data (1991–2015) are presented in Table 4.5.3. Effort has generally decreased over the time whilst LPUE has gradually increased to a high in 2009 followed by a decreasing trend until 2013. In 2014–2015, the Danish LPUE showed a very slight increase but remains much lower than in previous years.

Males consistently make the largest contribution to the landings (Figure 4.5.2). This is likely to be due to the varying seasonal pattern in the fishery and associated relative catchability (due to different burrow emergence behaviour) of male and female *Nephrops*. This is confirmed by the quarterly landings as shown in Figure 4.5.2. In 2014–2015 the landings were much lower in the second quarter of the year, a period when females would be expected to be more available for capture. In 2013–2015 landings were larger in the third and fourth quarters. Figure 4.5.7 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is apparent with males dominating catches, in particular during winter time (quarters 1 and 4). In quarters 2 and 3, females become more active and are more available to the fishery, although in FU 7 (unlike FU 8 and 9) the sex ratio is less seasonal and closer to 50:50 all year round. In the last three years the male proportion in quarter 2 is much higher than previously. This may be related with sampling noise associated with the recent decrease in landings (and sampling opportunities) in that quarter. Sex ratio data does not seem to show an overall increase of female proportion in catches in the time series, except for the last two winters (2014 and 2015) where male percentage in catches decreased to less than 50%. Increased female catchability has 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). It is unclear if this is the case in FU 7 but sex ratio monitoring in catches will continue to inform on potential shifts in the balance of the population.

Discarding of undersized and unwanted *Nephrops* has occurred in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 2000. The discarding rate average (2000–2015) is approximately 8% by number in this FU. From 2008 discard rates have dropped below the long term average and in the last five years the discard rates have been close to zero. In 2015 no discards have been recorded in the observer trips conducted. This reduction in discard rate appears to be due to a change in the discard pattern with lower numbers of small individuals being caught and could also signal reduced recruitment and a tendency towards the use of larger mesh gears (see below on length compositions).

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

Intercatch

Scottish data for 2015 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2016 WG and output length compositions were obtained in formats suitable for running the assessment.

Length compositions

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

Figure 4.5.3 shows a series of annual length frequency distributions for the period 2000 to 2015. Catch (removals) length compositions are shown for each sex with the mean catch and landings lengths shown in relation to MLS (25 mm) and 35 mm. In both sexes the mean sizes have been generally stable over time except for the last five years where a noticeable shift in the length distribution and an increase in the mean size has been observed for males and to a lesser extent, females.

Figure 4.5.1 and Table 4.5.4 show the series of mean sizes of larger *Nephrops* (>35 mm) in the landings. This parameter might be expected to reduce in size if overexploitation were taking place but there is no evidence of this. The mean size of smaller animals (<35 mm) in the catch is also fairly stable through time until 2010 when an increase is noticeable which may be associated with lower recruitments. In the last five years the landings mean size increased but discarding stopped, this may signal a period of reduced recruitment but could possibly reflect the increasing use of more selective gears. The discard rate in 2015 was estimated to be zero (as in 2011–2013). Quantitative information on trends in gear changes is not currently available. A further difficulty in the interpretation of these size observations is that the ground extends over a wide area and the distributional pattern of fleet activity is known to vary over time. This may lead to exploitation of sub-areas within the ground, where size compositions may be slightly different.

Mean weights in the landings through time (1990–2015) are shown in Figure 4.5.4 and Table 4.5.5. The variability in mean size is greater in Fladen (and Devil's Hole) than in other areas. In 2015 the mean weight in landings decreased to 36.7g (following the mentioned reduction in the mean size of males).

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 4.5.6. On average, approximately 65 stations have been considered valid each year (71 stations in 2015). Data are raised to a stock area of 28153 km^2 based on the stratification (by sediment type). General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in more detail in the Stock Annex.

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

4.5.7 Data analyses

Exploratory analyses of survey data

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

Figure 4.5.5 shows the distribution of stations in recent UWTV surveys (2010–2015), with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground. Table 4.5.6 and Figure 4.5.6 show the time series estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. Following the recent low UWTV estimated densities and the apparent *Nephrops* fleet preference for the fishing grounds located to the south of Fladen (Figure 4.5.8), the 2016 WG looked closely at the spatial distribution of the UWTV survey in the last seven years. It was suggested (as a hypothesis) that the north of the ground has been more affected by the recent decline (from 2009) in abundance than the areas in the south where most fishing took place in 2015. To test this, the TV surveys from 2009–15 were re-worked by sediment type, splitting the ground in two areas, north and south of the 58.75 N latitude line. Results seem to support that the areas mostly affected by the reduction in the mean *Nephrops* burrow density from 2009 were in fact located in the south, especially those made of finer sediments located in the central south region (Figure 4.5.9). In the north of Fladen, where coarser sediments (<40% silt and clay) dominate, a decrease in density was also observed but to a lesser extent when compared with those in the south. This analysis also shows that despite the recent decrease in density in the south, the mean densities remain in average higher than in the north.

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

Final assessment

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

The 2015 UWTV survey data shows that the abundance has decreased 14% from the 2014 estimate. The stock remains at a low level and (below the average abundance over the time series) and is currently below the biomass trigger. The harvest ratio in 2015 (2%, calculated as dead removals/TV abundance) is well below FMSY. The effort by *Nephrops* trawlers and respective LPUE declined from 2010 and this appears to be consistent with the abundance trends from the UWTV survey. The LPUE in recent years is still higher than the period prior to 2006 but this may be due the under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The relatively high LPUEs calculated for the period 2010–15, after the stock have declined could also be explained by the fishing fleet targeting areas where the density of *Nephrops* is higher. The mean size of individuals > 35 mm in the catch shows a clear increase. The discard rate remain at a very low level (average of 0.8% by number in 2013–2015) and the mean size of individuals below 35 mm shows an increasing trend from 2010, which may suggest a period of lower recruitment. Larger square mesh panels and new, more selective

TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme in Division 4a may also have improved the exploitation pattern and reduced catches of smaller individuals.

Historical Stock trends

The UWTV survey estimates of abundance for *Nephrops* in the Fladen suggest that the population has fluctuated over the 20 year period of the surveys. From 1997 to 2008 the abundance has generally increased and reached a peak of 7360 million individuals in 2008. Since 2008 the abundance has fallen until 2012 and increased slightly in the following two years. In 2015 the abundance has fallen again to 2569 million which is the lowest point of the time series (Table 4.5.8).

Table 4.5.8 also shows the estimated harvest ratios from 2003–2015. These range from 2–10% over this period and are all below $F_{0.1}$. It is unlikely that prior to 2006, the estimated harvest ratios are representative of actual harvest ratios due to under-reporting of landings. In 2015, due to a 57% reduction in landings in relation to the previous year, the harvest ratio was estimated to be 2%, which is also the lowest value recorded.

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

4.5.8 Recruitment estimates

Recruitment estimates from surveys are not available for this FU. However, the increase in mean size of small animals <35 mm (i.e. a lower proportion of small animals in this component of the catch) observed in recent years (2010–2015) may be indicative of lower recent recruitment.

4.5.9 MSY considerations

FMSY proxies for *Nephrops* are obtained from the per-recruit analysis as documented in the WGNSSK 2015 report. The most recent analysis used 2012–14 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. Length frequency data in Fladen have clearly shifted towards larger animals since 2010 (see section 4.5.5 and Figure 4.5.3) suggesting a different selection pattern in the fishery. In addition, the discard rate has declined (average of 7% by number in 2008-10 and around 0% in recent years), potentially due to a shift to larger meshes (TR1) and the increase in the use of the use of Highly Selective Gears for reducing fish bycatch. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit FMSY proxies is given in the table below and the basis for choosing an appropriate FMSY proxy remains the same and is described in WGNSSK 2010 report.

WGNSSK 2015		Fbar(20–40 mm)		HR (%)	SPR (%)		
		M	F		M	F	T
F0.1	M	0.07	0.07	6.4	47.4	58.3	51.9
	F	0.14	0.15	10.6	33.3	40.8	36.4
	T	0.08	0.09	7.5	43.0	53.1	47.2
Fmax	M	0.21	0.22	13.8	26.6	31.6	28.7
	F	0.44	0.46	21.2	17.5	18.7	18.0
	T	0.27	0.29	16.4	22.8	26.1	24.2
F35%SpR	M	0.13	0.13	10.0	34.8	42.9	38.1
	F	0.18	0.19	12.6	29.0	34.9	31.4
	T	0.15	0.16	11.2	31.9	39.0	34.8

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

For this FU, the absolute density observed on the UWTV survey remains low (average of just below 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 conservative proxy is chosen for FMSY such as $F_{0.1(T)}$.

The FMSY proxy harvest ratio is 7.5%.

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

4.5.10 Short-term forecasts

A catch prediction for 2017 was made for the Fladen Ground (FU7) using the approach agreed at the Benchmark Workshop in 2009 and outlined in the introductory section of the 2010 WGNSSK report. The table below shows catch 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 2015 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections).

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2016 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea) allowed. Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU8 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2017 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2017 at the FMSY proxy harvest ratio under a *de minimis* exemption is 6844 tonnes. It should be noted that the FMSY proxy harvest ratio for Fladen is based on a combined Length Cohort Analysis (data 2012–2014) using dead removals (landings + dead discards). This value is expected to be updated in the future (using updated length information) to account for the landings obligation where no discard survival is assumed. A discussion of FMSY reference points for *Nephrops* is provided in Section 3.1.

The inputs to the landings forecast were as follows:

VARIABLE	VALUE	SOURCE	NOTES
Abundance in TV assessment	2569 million	ICES (2016a)	UWTV 2015
Mean weight in landings	38.24g	ICES (2016a)	Average 2013–2015
Mean weight in discards	15.30g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCRS	16.13g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCRS	7.58g	ICES (2016a)	Average 2013–2015
Discard rate (total)	0.83%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCRS)	0.67%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (<MCRS)	0.16%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (total)	0.62%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	0.12%	ICES (2016a)	Average (proportion by number) 2013–2015, only applies in scenarios where when discarding allowed for de minimus exemptions.

Catch options assuming zero discards

	TOTAL CATCH	WANTED CATCH*	UNWANTED CATCH*	HARVEST RATE**
MSY approach	6843	6821	22	7%
Fmsy	7332	7308	24	7.5%
F2015	1955	1949	6	2%
F2013–2015	2835	2826	9	2.9%
F35%SpR	10949	10914	35	11.2%
Fmax	16033	15981	52	16.4%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	6858	6852	6835	17	6	7%

*** Calculated for dead removals.**

Discarding allowed for de minimis excemptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	6844	6843	6822	19	2	1	7.0%
Fmsy	7334	7333	7310	21	2	1	7.5%
F2015	1955	1955	1949	6	0	0	2.0%
F2013–2015	2835	2835	2826	8	1	0	2.9%
F35%SpR	10951	10950	10916	31	3	1	11.2%
Fmax	16035	16034	15984	46	4	1	16.4%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

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

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

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

Biological Reference points

Biological reference points have not been defined for this stock.

4.5.11 Quality of assessment

The TV surveys results show that the abundance has fallen in recent years, but not to the extent that would cause such a loss of fishing opportunity as observed. It is necessary to consider the biology of *Nephrops* (and indeed other crustaceans using cryptic, or burrow orientated behaviours) that are only available to trawling when they emerge from burrows. One explanation for the low emergence in 2013 (and to some extent in 2012) is that bottom temperatures appear to have been unusually low and for longer. Other environmental variables such as light levels, strength of tides are also known to exert an effect in the emergency behaviour of *Nephrops*. Exploratory analysis of the UWTV survey by sediment type (split by north and south of the ground) have shown that, despite the recent decrease in density, the mean densities remain in average higher in the south than in the north of FU 7 (see section 4.5.6). Taking into account the fact that the south of Fladen is located closer to the ports of Fraserburgh and Peterhead, where most of the fleet is based, this may explain why, in a period of lower densities, the south of FU 7 remains the area where most fishing activity takes place. Another factor that may play a role is that fishing in Fladen has become mixed in recent years and vessels may look for areas where economic returns are more favourable targeting both *Nephrops* and whitefish, while reducing fuel costs.

The recent low landings in Fladen may be the result of a complex interplay of factors combined with reduced average densities in the population as confirmed by the recent TV survey results.

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately. Discard data covered 80% of the landings in 2015 (no discards were recorded).

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

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

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

The Fishers' North Sea stock survey suggests that moderate or high amounts of recruits were apparent in Area 1 (which Fladen FU lies largely within) in 2011 compared to 2009. The time series of perceived abundance in Area 1 increases up to 2011. Opinion on discards appears to be split fairly evenly between lower, higher and no change. There are no Fishers' North Sea survey data available for 2013–2015.

4.5.12 Status of the stock

The stock has declined 63% in size in the period 2008–2012, then increased slightly in the 2013–2014 and in 2015 decreased again to the lowest point in the time series. The abundance is currently below the MSY $B_{trigger}$ level. Landings taken from this FU in 2015 (1786 tonnes) were much lower than the 2014 advice (for 2015) of 10759 tonnes. The harvest rate decreased in 2015 to 2% and remains well below F_{MSY}. Length frequencies in the caches have evolved towards larger animals over the last five years suggesting a selectivity change and/or lower recruitment.

4.5.13 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management implemented at the Functional Unit level could provide controls to ensure that catch opportunities and effort were in line with the scale of the resource and that other FUs do not suffer from displacement from unused catch options from this FU.

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

4.5.14 References

ICES. 2012. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 4 - 10 May 2011, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:13. 1197 pp.

ICES. 2015. Report of the Joint ICES-MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 156 pp.

4.6 Firth of Forth (FU 8)

4.6.1 Ecosystem aspects

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

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

4.6.2 The Fishery in 2015

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 4.6.1). In recent years around 40 vessels worked regularly in the Firth of Forth. Most vessels are under 12m in length with about 10 in 12–15m category and a few above 15m. Engine power ranges from just under 100kw to around the 300kw. The trip length for most of the fleet is one day. In the winter, most vessels fish from around dawn till 16:00–19:00. In spring/summer, vessels switch to nights, working from around 19:00 to 07:00–10:00. The few larger vessels (over 15m) fishing in FU 8, undertake trips of around 2–3 days. The overall number of boats operating varies seasonally as vessels move around the UK in response to varying catch rates. In 2015 some large Fraserburgh boats, which usually operate in FU 7, moved into the area, fishing mostly to the east grounds of the Firth. Visitor boats come generally from the Northeast of Scotland (FU 7 and FU 9) in periods of poor fishing in those grounds. A few English vessels visited FU 8, mostly during summer, with landings from the rest of UK increasing from 22 tonnes in 2014 to 68 tonnes in 2015. Catches were generally reported as good with considerable market demand and a slight increase in prices for all sizes of *Nephrops* caught. Fuel prices have been reported as lower than in previous years. The predominant trawl gear mesh sizes are 80 mm and 95 mm (TR2 gears with several vessels working with twin rigs). A few vessels have been involved with FDF (Fully documented Fisheries) getting some benefits in days at sea because of this. The fishery continues to be characterised by catches of small *Nephrops* which often leads to higher discard rates than in other east coast Functional Units. There was an increase in the amount of landings by creel vessels in this area to 43 tonnes in 2015 (14 tonnes in 2014) although typically the main target species of these vessels are crabs and lobsters.

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

4.6.3 Advice in 2015

The ICES conclusions in 2015 in relation to State of the Stock were as follows:

"The stock size is above MSY Btrigger. The harvest rate increased in 2014 to 29.1% and is now above FMSY."

The ICES advice in 2015 (for 2016) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, catches in 2016 (assuming zero discards) should be no more than 2040 tonnes. If instead discard rates continue at recent values (average of 2012–2014), and there is no change in assumed discard survival rate, this implies landings of no more than 1866 tonnes.

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

4.6.4 Management

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

4.6.5 Assessment

Approach in 2016

The assessment in 2016 is based on a combination of examining trends in fishery indicators and underwater TV using an extensive data series for the Firth of Forth Ground FU 8. The assessment of *Nephrops* through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice in 2016 followed the process of 2015, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involving collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 4.6.1 and Figure 4.6.1. Most of the landings are made by trawlers with creels accounting for just 2%. Reported landings rose from 1100 to over 2650 tonnes between 2003 and 2009 and has fluctuated since then around 2000 tones. The value for 2009 of over 2,663 tonnes was the highest in the available time series whilst the 2015 landings (1892 tonnes) are below the ten year average (2200 tonnes).

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

Trends in Scottish effort and LPUE are shown in Figure 4.6.1 and Table 4.6.2. From 2015, effort data for this stock is expressed both in days fishing and kW days (there are no major differences in effort trends between those different units). Effort has shown a gradual decline over the time period. Some of this is recently attributable to the EU effort management regime although, as part of the Scottish conservation credits scheme, *Nephrops* vessels have been eligible for effort 'buy-backs'. LPUE rose in the early 2000s and since 2006 has stabilised at a relatively high level.

Males consistently make the largest contribution to the landings by weight (Figure 4.6.2), although the sex ratio does vary and in 2011 more females in the catches moved the ratio closer to 1:1. This situation continued in 2012–2013. The proportion of females in the landings has increased in other years too (for example 2008). This may be due to the change in seasonal effort distribution with greatest effort in the 3rd quarter in 2008 when females are likely to be more available to the fishery (compared with a more evenly distributed seasonal effort pattern in 2007 – Figure 4.6.2). Figure 4.6.6 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is evident with males dominating catches during winter time. In quarters 2 and 3 females become more active and are more available to the fishery. These data suggest a gradual increase of female proportion in catches in recent years. Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This does not appear to be the case here.

Discarding of undersized and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Historically, discard rates have been higher in this stock than the more northerly North Sea FUs for which Scottish discard estimates are also available. This could arise from the fact that the use of larger meshed nets is not so prevalent in this fishery (80–95 mm is more common) and in addition, the population appears to consist of smaller individuals due to slower growth. Discarding rates in this FU have varied between 19%

and 55 % of the catch by number (2006 –2015 average 31 %). In the last five years, discard rates appear to have dropped to below this value (25 % on average by number). This appears to be due to increased retention of *Nephrops* rather than an absence of small *Nephrops* from the catches.

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

Intercatch

Scottish data for 2015 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2016 WG and output length compositions obtained in formats suitable for running the assessment.

Length compositions

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

Figure 4.6.3 shows a series of annual length frequency distributions for the period 2000 to 2015. Size information on catches (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35 mm. There is little evidence of change in the mean size of either sex 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 4.6.1 and Table 4.6.3. This parameter might be expected to reduce in size if overexploitation were taking place but over the last 20 years has in fact been quite stable. The mean size in the catch in the < 35 mm category (Figure 4.6.1) also shows no particular trend although it has risen slightly in the period 2009–2014, followed by a small decrease in 2015. The recent increase in the lower tail of discarded length frequencies (Figure 4.6.3), the decrease in the mean size of animals below 35 mm (Figure 4.6.1) and a slight increase in the discard rate in 2015 suggest possible a better recruitment in 2015. .

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

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 4.6.4. On average, about 44 stations have been considered valid each year. In 2015, there were 51 valid stations. Abundance data are raised to a stock area of 915 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

A further non-surveyed area of sediment (Lunan Bay) exists just north of the Firth of Forth FU. There is a small *Nephrops* fishery in this area (off Arbroath), but the area is only surveyed on an irregular basis and therefore is not included in any estimates of abundance. The WG wishes to emphasise that this area is out-with the Firth of Forth functional unit, is considered as part of the 'other' North Sea *Nephrops* area and hence not further considered in this section.

Data analyses

Exploratory analyses of survey data

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

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

Final assessment

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

The UWTV abundance was relatively high in the period 2003 to 2008 but has shown a decreasing trend in 2008–2012. In the last 3 years the stock has fluctuated around 600 million individuals. The stock is currently above the average abundance over the time series and remains above the biomass trigger. The calculated harvest ratio in 2015 (dead removals/TV abundance) decreased markedly and is just above FMSY. This is the result of an increase in stock abundance combined with a 20% decrease in landings in 2015. The mean size of individuals > 35 mm in the catch show no strong trend in recent years but the mean size of individuals below 35 mm has shown a slight increase from 2009. Larger square mesh panels and new, more selective TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme may have improved the exploitation pattern. The effect of these changes are not however, as evident as those observed in FU 7 and length frequencies in recent years remain relatively stable in the Firth of Forth.

4.6.6 Historical Stock trends

The TV survey estimate of abundance for *Nephrops* in the Firth of Forth suggests that the population decreased between 1993 and 1998 and then began a steady increase up to 2003. Abundance is estimated to have fluctuated without trend in the years since then. The abundance estimates from 2003–2015 (the period over which the survey estimates have been revised) are shown in Table 4.6.6. The stock is currently estimated to consist of 664 million individuals.

Table 4.6.6 also shows the estimated harvest ratios over this period. These range from 12–29 % over this period, with the upper range being the estimated value for 2014 (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 2015 is 16.8% which is just above the estimated value at F_{MSY} (16.3 %).

In addition to the discard rate, Table 4.6.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.6.7 Recruitment estimates

Survey recruitment estimates are not available for this stock.

4.6.8 MSY considerations

A number of potential FMSY proxies were obtained from the per-recruit analysis for *Nephrops* as documented in the WGNSSK 2010 report. The most recent analysis (in 2011) used 2008–10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit FMSY proxies is given in the table below and the process for choosing an appropriate FMSY proxy is described in WGNSSK 2010 report.

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

For this FU, the absolute density observed in the UWTV survey is relatively high (average of ~ 0.7 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) have been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that the sexes combined $F_{max(T)}$ is chosen as the FMSY proxy.

The FMSY proxy harvest ratio is 16.3 %.

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

4.6.9 Short-term forecasts

A catch prediction for 2017 was made for the Firth of Forth (FU8) using the approach agreed at the Benchmark Workshop and outlined in the introductory section to this chapter (Section 3.1). The table below shows catch 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 2015 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections).

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2016 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea) allowed. Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU8 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2017 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2017 at the FMSY proxy harvest ratio under a *de minimis* exemption is 2122 tonnes. It should be noted that the FMSY proxy harvest ratio in the Firth of Forth is still based on a combined Length Cohort Analysis (data 2008–2010) using dead removals (landings + dead discards). A discussion of FMSY reference points for *Nephrops* is provided in Section 3.1.

The inputs to the landings forecast were as follows:

VARIABLE	VALUE	SOURCE	NOTES
Abundance in TV assessment	664 million	ICES (2016a)	UWTV 2015
Mean weight in landings	21.81g	ICES (2016a)	Average 2013–2015
Mean weight in discards	10.74g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCRS	13.71g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCRS	7.25g	ICES (2016a)	Average 2013–2015
Discard rate (total)	24.9%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCRS)	13.3%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (<MCRS)	11.6%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (total)	19.9%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	9.0%	ICES (2016a)	Average (proportion by number) 2013-2015, only applies in scenarios where when discarding allowed for de minimus exemptions.

Catch options assuming zero discards

BASIS	TOTAL CATCHES	WANTED CATCHES*	UNWANTED CATCHES*	HARVEST RATE**
MSY approach	2062	1773	289	16.3%
F0.1	1189	1022	167	9.4%
F35SpR	1607	1381	226	12.7%
F2015	2125	1827	298	16.8%
F2013_2015	2594	2230	364	20.5%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

BASIS	TOTAL CATCHES	DEAD REMOVALS	LANDINGS	DEAD DISCARDS	SURVIVING DISCARDS	HARVEST RATE*
	L+DD+SD	L+DD	L	DD	SD	for L+DD

MSY approach	2199	2122	1890	232	77	16.3%

*** Calculated for dead removals.**

Discarding allowed for *de minimis* exemptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	2122	2099	1826	203	70	23	16.3%
F0.1	1225	1211	1053	117	41	14	9.4%
F35SpR	1653	1635	1422	158	55	18	12.7%
F2015	2187	2163	1882	209	72	24	16.8%
F2013_2015	2669	2640	2296	256	88	29	20.5%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

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

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

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

Biological Reference points

Biological reference points have not been defined for this stock.

4.6.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. Discard data covered 92% of the landings in 2015 (88% of the discards were imported and 12% were raised discards).

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

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

The Fishers' North Sea Stock survey does not include specific information for the Firth of Forth. Area 3 shows a perception of decreased abundance over the period 2007 – 2012, but this covers the Firth of Forth and parts of the Devil's Hole in addition to the Moray Firth. There are no Fishers' North Sea survey data available for 2013–2015.

4.6.11 Status of the stock

The stock has declined in size since 2008 when it was at the highest point in the series but is still above the average abundance and well above the MSY $B_{trigger}$ level. The UWTV abundance was relatively high in the period 2003 to 2010. The value calculated for 2015 (664 million) is about the same abundance to that recorded in 2013. Landings taken from this FU in 2015 (1892 tonnes) were higher than the 2014 advice (for 2015) of

1769 tonnes. The harvest rate decreased in 2015 to 16.8% and is just above F_{MSY}. Length frequencies in the catches have been stable.

4.6.12 Management considerations

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

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

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

4.7 Moray Firth (FU 9)

4.7.1 Ecosystem aspects

The Moray Firth Functional Unit is located in the east of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 3.1.1). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to seaward, narrowing towards the coast with river basins draining into the area. Muddy sand deposits are the most widespread sediment, particularly towards the outer areas of the Firth, with smaller areas of sandy mud. Overall the ground covers an area of 2195km^2. In the inner parts of the Firth the sediment is more patchy and there are several areas of sand and of gravel.

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

4.7.2 The Fishery in 2015

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 4.7.1). Vessels targeting this fishery typically conduct day trips from the nearby ports along the Moray Firth coast. Around 15–20 local vessels (all single riggers) regularly fish in Moray Firth area, mostly out of Burghead. The majority of the Moray Firth fleet is under 10m and are not affected by Cod Recovery Measures. The fleet have been consistent in their grounds throughout the years, with smaller vessels fishing locally from Burghead and larger and more powerful vessels venturing further out with good weather and reports of good catch rates in 2015. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. These larger (typically over 15m) twin riggers fished mainly in the outer areas of the Firth during the winter months and unlike the smaller local vessels, they can continue to operate in periods of poor weather. In 2012, a new voluntary code of conduct for *Nephrops* trawlers (Moray Firth Prawn Agreement) has been agreed amongst fishermen for the Inner Moray Firth so as to protect the viability of smaller vessels based in the area. The agreement proposes that an area in the most westerly part of the Moray Firth be reserved for vessels under 300HP with a further small area reserved for vessels under 400HP. Prices of *Nephrops* have been reported as similar to the previous years but fuel costs decreased considerably in 2015. Anecdotal evidence suggests some by-catch of monkfish and haddock occurred but vessels under 10m, which make most of the fleet, are generally limited by quota restrictions. *Nephrops* creeling in the Moray Firth is not common (no landings in 2015) as grounds are in open water and gear conflicts with trawl vessels are likely to happen. A squid fishery usually takes place in the Moray Firth in the late summer, starting in the Southern Trench when squid moves inshore. The majority of the local *Nephrops* fleet participated in the squid fishery between September and October 2015. Further general information on the fishery can be found in the Stock Annex.

4.7.3 Advice in 2015

The ICES conclusions in 2015 in relation to State of the Stock were as follows:

"*The stock has declined in 2006 and has remained stable since then. The harvest rate has fluctuated around FMSY for the last decade*"

The ICES advice in 2015 (for 2016) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, catches in 2016 (assuming a landing obligation applies) should be no more than 943 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 923 tonnes.

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

4.7.4 Management

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

4.7.5 Assessment

Approach in 2016

The assessment in 2016 is based on a combination of examining trends in fishery indicators and UWTV using an extensive data series for the Moray Firth FU 9. The assessment of *Nephrops* through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice in 2016 followed the process of 2015, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 4.7.1. Total landings (as reported to the WG) in 2015 for Scotland were 828 tonnes (a 33% decrease in relation to 2014) and England landed 2 tonnes. Landings in recent years (post 2006) are more reliable due to the introduction of 'buyers and sellers' legislation. The long term landings trends are shown in Figure 4.7.1.

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

Trends in Scottish effort and LPUE are shown in Figure 4.7.1 and Table 4.7.2. From 2015, effort data for this stock is expressed both in days fishing and kW days (there are no major differences in effort trends between those different units). Effort has shown a gradual decline over the time period. Some of this is attributable to the EU effort management regime although *Nephrops* vessels have generally been allocated exemptions. LPUE rose in the early 2000s and since 2006 it has fluctuated with a slightly downwards trend.

Males generally make the largest contribution to the landings by weight (Figure 4.7.2), although in 2011 the proportion of females is higher than in the recent past. In 2012–2015 males dominate again. The high contribution of females appears to be due to a much higher proportion of the fishery taking place in the second and third quarter when females are more available. This observation has been made a number of times before in the Moray Firth (particularly for example in 1994 when female catches exceeded those of males). Figure 4.7.6 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is evident with males dominating catches during winter time. In quarters 2 and 3, females become more active and are more available to the fishery. These data suggest a fairly stable sex ratio in quarterly catches throughout the time series. Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This is not the case here.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates in this FU appear to be highly variable with rates over the time series of 3 to 33 % of the catch by number. In 2013 the observed rate by number was at its lowest level, approximately 3% by number but it increased to 15% in recent years (a similar level to that observed in 2010–2012). Discards rates were generally higher in the past and now appear to be generally lower but with occasional high annual levels which may be associated with occasional high recruitments (e.g. 2002 and 2004).

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

Intercatch

Scottish data for 2015 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2016 WG and output length compositions were obtained in formats suitable for running the assessment.

Length compositions

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

Figure 4.7.3 shows a series of annual length frequency distributions for the period 2000 to 2015. Catch (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35 mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35 mm shows no evidence of reductions in relative numbers of larger animals. Occasional large year classes can be observed in these length frequency data (2002 and 2004). This is consistent with the occasional high discard rates observed for this FU.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35 mm) in the landings shown in Figure 4.7.1 and Table 4.7.3. This parameter might be expected to reduce in size if overexploitation were taking place, but it appears to be stable throughout the time series. In 2013–2015, length frequencies seem to suggest a slight increase in the retention of larger males, which given the larger male contribution to the catches, caused an increase in the mean weight in the landings (Figure 4.5.4 and Table 4.5.5).

The mean size in the catch in the < 35 mm category (Figure 4.7.1) shows no particular trend over the time series although it has risen slightly in the period 2011–2013, followed by a small decrease in males in 2014 and both sexes in 2015, which is consistent with the recent (2014–2015) increase in the discard rate.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 4.7.4. On average, 41 stations have been considered valid each year, 52 stations were sampled in 2015. Abundance data are raised to a stock area of 2195 km². General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 4.7.5 shows the basic analysis for the three most recent UWTV surveys conducted in FU 9. 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, the variance in the survey seems to be evenly split among the different strata in recent years. The densities typically observed in this FU are lower than those observed in FU 8.

Figure 4.7.4 shows the distribution of stations in UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In 2015, the abundance appears to be highest at the western end of the FU, with lower densities in the central and eastern areas. Table 4.7.4 and Figure 4.7.5 show the time series of estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

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

Final assessment

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

The abundance in the Moray Firth has gradually decline since 2007 having increased in 2013 followed by a further decrease in 2014 and increased again slightly in 2015 (5%) to 347 million. The stock is currently below the average abundance over the time series but remains above the biomass trigger. The calculated harvest ratio in 2015 (dead removals/TV abundance) is just below FMSY as a result of decreasing landings and a slight increase in stock abundance in 2015. The mean size of individuals > 35 mm in the catch shows no strong trend in recent years but the mean size of individuals below 35 mm has shown a slight increase from 2011. Larger square mesh panels and new, more selective TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme may have improved the exploitation pattern as shown by a small increase in the proportion of large males in caches in 2013–2015. The effect of these changes are not however, as evident as those observed in FU 7 and length frequencies in recent years remain relatively stable in the Moray Firth.

4.7.6 Historical Stock trends

The UWTV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased between 1997 and 2005 but has gradually fallen since then (with the exception of 2007, 2013 and 2015). The abundance estimates from 2003–2015 are shown in Table 4.7.6.

Table 4.7.6 also shows the estimated harvest ratios over this period. These range from 7–20 % over the period 2003–2015. Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The estimated harvest rate has decreased in 2015 to 9.1% and is now below the FMSY proxy value of 11.8 %.

In addition to the discard rate, Table 4.7.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.7.7 Recruitment estimates

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

4.7.8 MSY considerations

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

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

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

Moderate absolute densities are generally observed on the UWTV survey of this FU (average of ~ 0.2 m^{-2}). 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 ~ 1300 tonnes, above those predicted by currently fishing at $F_{35\%SPR}$). For these reasons, it is suggested that $F_{35\%SPR(T)}$ is used as the FMSY proxy.

The FMSY proxy harvest ratio is 11.8 %.

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

4.7.9 Short-term forecasts

A catch prediction for 2017 was made for the Moray Firth (FU9) using the approach agreed at the Benchmark Workshop. The table below shows catch predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed in Section 3.1 of this report and the harvest ratio in 2015 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections).

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2016 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea) allowed. Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU8 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2017 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2017 at the FMSY proxy harvest ratio under a *de minimis* exemption is 1070 tonnes. It should be noted that the FMSY proxy harvest ratio in the Moray Firth is still based on a combined Length Cohort Analysis (data 2008–2010) using dead removals (landings + dead discards. A discussion of FMSY reference points for *Nephrops* is provided in Section 3.1.

The inputs to the landings forecast were as follows:

VARIABLE	VALUE	SOURCE	NOTES
Abundance in TV assessment	347 million	ICES (2016a)	UWTV 2015
Mean weight in landings	27.66 g	ICES (2016a)	Average 2013–2015
Mean weight in discards	11.45 g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCRS	14.37g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCRS	6.63g	ICES (2016a)	Average 2013–2015
Discard rate (total)	11.0%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCRS)	6.9%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (<MCRS)	4.1%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (total)	8.5%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	3.1%	ICES (2016a)	Average (proportion by number) 2013–2015, only applies in scenarios where when discarding allowed for de minimus exemptions.

Catch options assuming zero discards

BASIS	TOTAL CATCH	WANTED CATCH*	UNWANTED CATCH**	HARVEST RATE**
MSY approach	1060	1008	52	11.8%
F0.1	700	666	34	7.8%
F2015	817	777	40	9.1%
F2013_2015	889	846	43	9.9%
Fmax	1338	1273	65	14.9%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

Basis	Total catches	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	1089	1076	1036	40	13	11.8%

*** calculated for dead removals**

Discarding allowed for *de minimis* excemptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	1070	1067	1018	41	8	3	11.8%
F0.1	708	706	673	27	6	2	7.8%
F2015	826	824	785	32	7	2	9.1%
F2013_2015	897	895	854	34	7	2	9.9%
Fmax	1353	1349	1286	52	11	4	14.9%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

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

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

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

Biological Reference points

Biological reference points have not been defined for this stock.

4.7.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. Discard data covered 44% of the landings in 2015 (50% of the discards were imported and 50% were raised discards). The reduction in the proportion of landings covered by discard data relates to missing sampling events in quarter 2 of the main metier (*Nephrops* trawlers, TR2 gears).

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

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

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. Area 3 covers the Moray Firth, Firth of Forth and areas of the Devil's Hole and there appears to be some inconsistencies between the report in 2011 and 2012. In 2011 the report documented a perceived increase in the *Nephrops* abundance in this area since 2008; however the 2012 report appears to show a perceived decrease since 2008. There are no Fishers' North Sea survey data available for 2013–2015.

4.7.11 Status of the stock

The evidence from the UWTV survey suggests that following a continuous decrease from 2007 to 2012 the abundance has fluctuacted around 400 million in recent years. The abundance has increased 5% in 2015 (to 347 million) remaining approximately at the same level as the late 2000's. The stock size is above the MSY $B_{trigger}$ level. Landings taken from this FU in 2015 (830 tonnes) were lower than the 2014 advice (for 2015) of 1185 tonnes. The harvest rate decreased in 2014 to 9.1% and is now below F_{MSY} (11.8%). Length frequencies in the catches have been relatively stable.

4.7.12 Management considerations

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

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

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

4.8 Noup (FU 10)

4.8.1 Ecosystem aspects

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

4.8.2 The Fishery in 2014 and 2015

The Noup currently supports a relatively small fishery. Few vessels target *Nephrops* regularly in this area. In Orkney there is currently only one part-time (summer) vessel fishing for *Nephrops* as most of the local fleet targets crabs and lobsters. *Nephrops* boats from Orkney spend most of the year fishing in the Moray Firth (FU 9). In recent years, vessels from Scrabster landing *Nephrops* use 120 mm mesh twin rigs (targeting whitefish). Landings from Noup have decreased steadily since 2002 and in 2015 only 15 tonnes of *Nephrops* were landed (Table.4.8.1). Further general information on the fishery can be found in the Stock Annex.

4.8.3 Advice in 2014

The advice provided in 2014 was biennial and valid for 2015 and 2016.

"ICES advises on the basis of the ICES approach for data-limited stocks that catches should be no more than 33 t. If discard rates do not change from the assumed rate of 7.9%, this implies landings of no more than 32 t.

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

Data available

Commercial catch and effort data

Landings from this fishery are reported only from Scotland and are presented in Table 4.8.1 and Figure 4.8.1. Total landings (as reported to the WG) in 2015 were only 15 tonnes, the same as in the previous year and an increase of 2 tonnes from 2012 which was the lowest landing reported in the time series (1997–2015). *Nephrops* are almost exclusively landed by 'non-*Nephrops'* vessels. This supports the anecdotal information received from the fishing industry that this area is rarely fished by *Nephrops* vessels due to the high catch rates of whitefish in the area.

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

Trends in Scottish effort and LPUE are shown in Figures 4.8.1 and Table 4.8.2. Effort on *Nephrops* trawlers (TR2) has declined over the time period and is more marked than on other *Nephrops* grounds owing to the dominance of trawlers targeting demersal fish in the area. LPUE remained approximately at the same level of 2014. From 2000 onwards landings, effort and LPUE have been split by TR1 and TR2 gears (Figure 4.8.2). Effort from TR1 in the last 10 years has remained relatively contstant but TR1 LPUE has declined from 2008 to 2010 remaining at a low level in the last 5 years.

Length compositions

Levels of market sampling are low and discard sampling is not available. Mean sizes in the landings in previous years are shown in Figure 4.8.1 and Table 4.8.3. There are no sampling data available for 2015. The low levels of sampling for this fishery mean it is not realistic to draw conclusions from changes in size composition or sex ratio.

InterCatch

Scottish data for 2015 were successfully uploaded into InterCatch prior the 2016 WG meeting according with the deadline proposed. Data for this stock is limited to official landings (classified as "Landing only" in Intercatch with no sampling data) provided by Scotland, therefore, length frequencies were not raised.

Natural mortality, maturity at age and other biological parameters

No data available.

Research vessel data

An underwater TV (UWTV) survey of this FU has been conducted sporadically (1994, 1999, 2006 and 2007). In 2014 Noup was re-visited by the summer Scotia UWTV survey after seven years past the previous survey. Figure 4.8.3 shows the distribution of stations in the UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In 2014, 12 stations were successfully surveyed. The most recent survey gives an estimate of population size (51 million) similar to that found in 2006 and 2007 which is slightly lower than the 1999 value. All of these are lower than the very high value observed in 1994. The results of the UWTV surveys are shown in Figure 4.8.4 and Table 4.8.4.

4.8.4 Historical stock trends

The TV survey estimate of abundance for *Nephrops* in the Noup suggests that the population declined from the first survey in 1994 to 1999 and remained at a lower level on the following surveyed years. Landings fluctuated between 200 and 400 tonnes between 1995 and 2002, and declined markedly from then. Recent landings for this FU have been low, approximately 16 tonnes in 2013 and 15 tonnes in 2014–2015.

4.8.5 Recruitment estimates

There are no recruitment estimates for this FU.

4.8.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.8.7 Status of the stock

The current state of the stock is unknown.

4.8.8 Management considerations

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

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

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES, 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (WKNEPH, 2013). Following the procedure outlined (section 3.1.2), the spatial extent of the *Nephrops* grounds were estimated (based on BGS sediment maps) to provide a likely envelope for the total abundance of *Nephrops* in FU 10 (see table below). UWTV survey information on the mean density of *Nephrops* (0.13 *Nephrops*/m^2), from the 2014 survey, was used together with discard percentages, and mean weights taken from FU 9 (Moray Firth). The same advice as provided in 2014 of 33 tonnes (catch) results in a harvest ratio of 2.4% which is below the range of harvest ratios observed for other North Sea functional units (7.5–16%) and therefore considered precautionary. Additional options including an increase in 20% in catches (uncertainty cap) and the medium term (10 year) average were included in the table. All the options (with the exception of the time series maximum landing value) result in a harvest ratio lower than 7.5%, reflecting the low exploitation level in recent years in FU 10. The proposed advice (given in 2016) for 2017 and 2018 was that catches should be no more than 40 tonnes (2014 advice + 20%). In line with the advice for other stocks, total catches, wanted catches and unwanted catches expected under the landing obligation policy were added to the table. A second catch options table allowing for discarding under *the de minimis exemption* (6% < MCRS by weight for North Sea *Nephrops*) is also included below. This assumes the discard patterns do not change from average values previously observed, and the total catch is split in wanted catch, unwanted catch > MCRS, unwanted catch < MCRS and surviving discards. For data limited stocks the discard survival is assumed to be zero.

Catch options assuming zero discards

Basis	Total Catch	Wanted Catch	Unwanted Catch	Range of potential densities (Nephrops per m^2)								
				0.05	0.1	0.13	0.15	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	16	15	1	2.98%	1.49%	1.15%	0.99%	0.74%	0.50%	0.37%	0.25%	0.19%
2014 Advice - 20%	26	25	1	4.97%	2.48%	1.91%	1.66%	1.24%	0.83%	0.62%	0.41%	0.31%
2014 Advice	33	31	2	6.16%	3.08%	2.37%	2.05%	1.54%	1.03%	0.77%	0.51%	0.38%
2014 Advice + 20%	40	38	2	7.55%	3.77%	2.90%	2.52%	1.89%	1.26%	0.94%	0.63%	0.47%
Average (2006-2015)	75	71	4	14.10%	7.05%	5.42%	4.70%	3.53%	2.35%	1.76%	1.18%	0.88%
	102	97	5	19.27%	9.63%	7.41%	6.42%	4.82%	3.21%	2.41%	1.61%	1.20%
Maximum	519	494	25	98.13%	49.06%	37.74%	32.71%	24.53%	16.35%	12.27%	8.18%	6.13%

Catch options assuming discarding allowed for de minimis exemptions

Basis	Total Catch	Wanted Catch	Unwanted Catch >MCRS	de minimis discards <MCRS	Surviving discards	Range of potential densities (Nephrops per m2)								
						0.05	0.1	0.13	0.15	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	16	15	1	0	0	2.98%	1.49%	1.15%	0.99%	0.74%	0.50%	0.37%	0.25%	0.19%
2014 Advice - 20%	26	25	1	0	0	4.97%	2.48%	1.91%	1.66%	1.24%	0.83%	0.62%	0.41%	0.31%
2014 Advice	32	31	1	0	0	6.16%	3.08%	2.37%	2.05%	1.54%	1.03%	0.77%	0.51%	0.38%
2014 Advice + 20%	40	38	2	0	0	7.55%	3.77%	2.90%	2.52%	1.89%	1.26%	0.94%	0.63%	0.47%
Average (2006-2015)	75	71	3	1	0	14.10%	7.05%	5.42%	4.70%	3.53%	2.35%	1.76%	1.18%	0.88%
	102	97	4	1	0	19.27%	9.63%	7.41%	6.42%	4.82%	3.21%	2.41%	1.61%	1.20%
Maximum	519	494	20	5	0	98.13%	49.06%	37.74%	32.71%	24.53%	16.35%	12.27%	8.18%	6.13%

Basis for the catch options.

VARIABLE	VALUE	SOURCE	NOTES
Density in TV assessment	0.13 *Nephrops* m2	ICES (2016a)	UWTV 2014
Mean weight in landings	27.66g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in discards	11.45g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in unwanted catch >MCRS	14.37g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in unwanted catch <MCRS	6.63g	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard rate (total)	11.0%	ICES (2016a)	Average 2013–2015 (from FU 9, proportion by number)
Discard rate (>MCRS)	6.9%	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard rate (<MCRS)	4.1%	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard survival rate	0%	ICES (2016a)	Discard survival is assumed to be zero.
Surface area estimate	409 km2	ICES (2007)	Benchmark estimate WKNEPH (2007)

4.9 Norwegian Deep (FU 32)

4.9.1 Ecosystem aspects.

See stock annex (section A.3).

4.9.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2). Maps showing the annual geographic distribution of the Danish fishery in FU 32 were provided for the first time in 2015. Maps showing the annual geographic distribution of the Norwegian trawl fishery (vessels ≥ 15 m) in FU 32 (2011–2015) were provided for the first time in 2016.

4.9.3 Advice in 2015

Advice for *Nephrops* was updated in 2015.

In 2015, ICES noted for this stock that:

- The perceptions of this stock (FU 32) are based on Danish landings and effort data as well as mean sizes (CL) in landings and discards.
- The new Danish LPUE index shows a stepwise declining trend from the mid-1990s until present. However, it is not possible to determine whether this decrease in LPUE is due to changes in management or whether the decrease to some extent also reflects stock changes.
- The recent Danish landings from the stock are very small, but are fished in a restricted area. The low LPUE in both 2013 and 2014 might therefore imply stock size changes in the southern part of FU 32.

- Trends in mean size in landings and catches (discards from 2015 onwards), and overall size distribution in catches have for many years indicated that the *Nephrops* stock in FU 32 is not over-exploited. However, trends in mean size of landings in 2013 and 2014 are difficult to interpret as are the highly varying discard ratios during the last two years.
- The WG concludes that the available data give a non-conclusive perception of stock status. The average annual landings over the last ten years are 554 t (2005–2014), while the short-term average landings are 302 t (2010–2014). The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 1%), even in years when landings were highest.

4.9.4 Management

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

4.9.5 Assessment

Data available

Landings data for the 2016 assessment (all fleets in 2015) have been uploaded using InterCatch.

Catch

Dutch landings from FU 32 were incorporated in the report for the first time in 2010, but it was only in 2006 that the Netherlands landed more than a ton of *Nephrops* from this FU. International landings from the Norwegian Deep increased from less than 20 t in the mid-1980s to 1190 t in 2001 (Table 4.9.1, Figure 4.9.1). Since then, landings have declined due to a reduction of Danish landings, and total landings in 2013 amounted to only 191 t, the lowest Figure since 1992. In 2014, total landings increased slightly, but decreased again in 2015 to 192 t. The decreased Danish landings can be explained by increasing fuel costs, fewer vessels, and *Nephrops* landings now occurring mainly as bycatch in mixed fisheries. Danish vessels used to take 80–90% of the total landings, but since 2008 this percentage has decreased. In 2015, Denmark landed 57% of the total landings. Norwegian landings decreased from 2009 to 2014, but increased in 2015 to 82 t.

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Table 4.9.1). Danish discards are low due to the legislated 120 mm mesh size. The Danish discard ratio (discard as percentage of catch) was high in 2004–2005 (21–24%), but decreased to 10–17% in the years 2006–2012. In 2013, estimated Danish discards were 68 t, and the Danish discard ratio increased to 35%, while in 2014 and 2015 estimated Danish discards were only 5 and 6 t, respectively, resulting in very low discard ratios of 3% and 5%. The low discards the last two years may indicate low recruitment to the stock. It should be noted that the 2014– and 2015-discards in FUs 3-4 also were low. There are no Norwegian discard data, and Norwegian discards are assumed to be zero.

Length composition

Figure 4.9.1 was changed in the 2015 report. Previously, average sizes in catches and landings have been presented. In 2015, this was changed to average sizes in landings ≥ 40 mm (MLS) and in discards < 40 mm. When considering recruitment mean size of individuals < MLS is more informative than mean size in catches. The average size of *Nephrops* in Danish landings (≥ 40 mm) showed a general increasing trend for both males and females in the period 2005–2012 (Figure 4.9.1). This increase coincides with a sharp decrease in landings and may imply a lower exploitation pressure. However, the mean size of both males and females in the Danish landings decreased sharply from 2012 to 2013. In 2014, the mean size of landed males jumped back to the high 2012–level, and remained at this level in 2015. The average size of landed females, on the other hand, has remained at the low 2013-level both in 2014 and 2015. The mean size of discards (< 40 mm) has fluctuated without trend since 2002. In the 2014-report it was suggested that a possible explanation for the decreased mean size of large *Nephrops* could be that the declining Danish fishery in 2013 contracted into an area with small *Nephrops*, possibly in the southern part of FU 32. However, the maps of the annual distribution of the Danish fishery show that there was no change in the distribution from 2012 to 2013 (Figure 4.9.2). The Danish fishery has been located in the southernmost part of FU 32 since 2011. It is unclear why the mean size of landings has varied so much in recent years. The Norwegian time series of mean size in catches was removed from Figure 4.9.l in 2015, but will be updated with additional length data (total lengths converted to CL) at the upcoming benchmark in 2016 and will be included in the report in 2017.

The length frequency distributions of the Danish catches from the years 2007, 2010, 2012 and 2014 had a greater proportion of large *Nephrops* compared with former years (Figure 4.9.3). The 2013 and 2015 length frequency distributions, on the other hand, had a relatively smaller proportion of large specimens. In general, there are few individuals below the MLS of 40 mm due to the legislated 120 mm mesh size. Size distributions of catches from Norwegian coast guard inspections of Danish and Norwegian trawlers (Figure 4.9.4), have not been updated since 2012 due to lack of CL data. Total lengths converted to CL will be included in the Figure at the upcoming benchmark. Danish and Norwegian length frequency distributions in catches have been compared for 2006, 2007 and 2012, years for which data exist from both countries (Figure 4.9.5). Trends are similar.

Natural mortality, maturity at age and other biological parameters

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

Catch, effort and research vessel data

Effort and LPUE Figures for the period 1989–2015 are available from Danish logbooks (Table 4.9.2, Figure 4.9.1). In 2013, the Danish effort index was changed to kW days (formerly fishing days) (see stock annex, section B.4), as kW days account for temporal differences in vessel size. Days at sea and fishing days are presented in addition to kW days (Table 4.9.2). The time series of fishing days (earlier years' effort index) was updated in 2013. In 2016, all efforts numbers back to 1987 changed slightly due to some minor adjustments to the métier codes for the whole time series. The LPUE values thus also changed slightly but the trend remained the same. The Danish LPUE index based on kW days shows a decreasing trend (Figure 4.9.1). This is in contrast to the former LPUE index based on fishing days that fluctuated without trend around a mean level of approximately 200 kg day^{-1}. As kW days is a more representative effort index, the new LPUE index is a more representative catch rate index. However, due to changes in the management regime, changes in the LPUE index do not necessarily imply stock size changes (see below).

In the beginning of the 1990s, vessel size increased in the Danish fleet fishing in FU 32. This increase, and more directed fisheries for *Nephrops* in areas with previously low exploitation levels are probably partly responsible for the observed increase in the Danish LPUE in those years (Table 4.9.2, Figure 4.9.1). The Norwegian mesh size legislation was changed in 2002 (see stock annex, section A.2). The introduction of the larger mesh size of 120 mm may explain the decrease in LPUE (catch rate) from 1999 to 2001 with a subsequent stabilizing at a lower level relative to the late 1990s. However, the lower LPUE may also reflect a stock decrease as Danish landings in 1999 increased to > 1000 t and remained at this level until 2006. In 2007, individual vessel quotas were introduced in the Danish fishery. This resulted in the vessels buying up a lot of fish quotas and shifting their effort to fin fish rather than *Nephrops*. To get good catches of *Nephrops* vessels need to target this species by fishing at dusk/dawn when the animals are out of their burrows, as opposed to fin fish fisheries where good catches can be obtained around the clock. This change in management coincided with a decreasing LPUE (2008–2009) and the onset of steadily falling Danish landings. From 2012 to 2013 the Danish LPUE decreased by approximately 40% and remained at this low level also in 2014 and 2015. As there has been no change in the distribution of the Danish fishery since 2011 the low LPUE in 2013–2015 might imply an increased fishing pressure in the southern part of FU 32. Environmental changes resulting in lower *Nephrops* densities cannot be ruled out. The likely low recruitment to the stock in 2014 and 2015 may imply continued low catch rates.

The Danish effort increased from 2004 to 2006, but showed a strong decline in 2007 and has since continued decreasing to 576 kW days in 2015, the lowest observed effort since 1990. It has not been possible to incorporate 'technological creep' in the evaluation of the effort data. However, the use of twin trawls has been widespread for many years.

The 2013 benchmark (WKNEPH 2013) analysed the Norwegian LPUE Figures from bottom and shrimp trawls. The data from bottom trawls and shrimp trawls prior to 2011 are considered unsuitable for LPUE analyses (see stock annex, section B.4). With the introduction of Norwegian electronic logbooks, compulsory for all vessels ≥ 15 m length in 2011, two new time series from respectively bottom and shrimp trawls (single and twin) have been established. These new indices will be considered for inclusion in the assessment at the upcoming 2016 benchmark. As a large portion of the Norwegian fleet landing *Nephrops* in FU 32 consists of vessels < 15 m, especially north of 60 °N, the Norwegian logbook data still only cover part of the fleet. The electronic logbook data show that the Norwegian large vessel trawl fishery for *Nephrops* in FU 32 declined from 2012 to 2013 (Figure 4.9.6). In 2013–2014, the fishery was confined to the southernmost part of the functional unit as well as an area just west of Stavanger, while in 2015 some trawling also took place along the western rim of the Norwegian Trench.

The Norwegian annual shrimp survey shows that *Nephrops* is distributed in areas deeper than 100 m in FU 32 (Figure 4.9.7). (Areas shallower than 100 m are not covered by the survey). In 2016, most trawl stations in FU 32 had catches of *Nephrops* of less than 1 kg per trawled nm. No *Nephrops* was caught on the northernmost trawl stations. Catch rates were similar in FU 32 and FU 3 (Skagerrak).

Data analysis

Review of last year's assessment

"Technical comments

The stock annex contains text on two options for further work: the Nephrops benchmark in 2013 (WKNEPH 2013) suggested that the data from the shrimp survey should be investigated more closely, And two new time series from Norwegian bottom and shrimp trawls will be established from 2011 onwards. These new data have not been presented yet.

The stock annex does not explain how the calculations from the advice catch option table are performed. It is recommended to add this using a working example, so that the audit can be performed correctly.

It is unclear why a 10 years discard rate is used (15.9% according to the catch option table), given the changes in the Danish fishery. The discard rate in 2014 is 5/(143+5)= 3.3%, which is very low compared to before. This should be mentioned and explained in the advice sheet?

It guess it is linked to how the years with missing discards are treated in the calculation, but the 2005–2014 average of catches from table Table 6.3.20.6 from the advice sheet (using "total" + Danish discards) is 636 and not 642 in my calculation.

Conclusions

The advice is the average catch of the last ten years. It seems OK but the variability of discards ratio and the low value in 2014 merits discussion."

Exploratory analysis of catch data

There was no age based analysis carried out

Exploratory analysis of survey data

Catches of *Nephrops* from the annual Norwegian shrimp trawl survey (back to 1997) are small and variable. The benchmark in 2013 (WKNEPH 2013) suggested that although small, these catches should be explored with the aim of establishing a biomass index time series for *Nephrops* in FU 32. This is now work in progress and will be presented at the upcoming 2016 benchmark.

Final assessment

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

4.9.6 Historic stock trends

The increase in mean size in landings from 2006 to 2012 in females and from 2005 to 2012 in males could indicate a lower exploitation pressure as this increase coincided with decreasing landings. Mean sizes in landings in 2013–2015 are difficult to interpret. The introduction of a new effort index (kW days) in 2013 resulted in a stepwise declining trend in the new LPUE index, from the mid-1990s until present.

4.9.7 Recruitment estimates

There are no recruitment estimates for this stock. Fluctuations in catches of small *Nephrops* are used as a proxy for recruitment.

4.9.8 Forecasts

There were no forecasts for this stock.

4.9.9 Biological reference points

No reference points are defined for this stock.

4.9.10 Quality of assessment

The data available for this stock remain limited.

4.9.11 Status of stock

The perceptions of this stock (FU 32) are based on Danish landings and effort data as well as mean sizes (CL) in landings and discards. A new Danish effort index which accounts for temporal differences in vessel size was introduced in 2013 (kW days as opposed to former fishing days). The effect of technological creep on the effective effort of the fishery is still not known. The new Danish LPUE index shows a stepwise declining trend from the mid-1990s until present. However, it is not possible to determine whether this decrease in LPUE is due to changes in management or whether the decrease to some extent also reflects stock changes. The recent Danish landings from the stock are very small, but are fished in a restricted area. The low LPUE in 2013–2015 might therefore imply stock size changes in the southern part of FU 32. Trends in mean size in Danish landings and discards and overall size distribution in catches have for many years indicated that the *Nephrops* stock in FU 32 is not over-exploited. However, trends in mean size of landings in 2013– 2015 are difficult to interpret. The low catches of small *Nephrops* during the last two years indicate low recruitment to the stock.

The WG concludes that the available data give a non-conclusive perception of stock status. The average annual landings over the last ten years are 464 t (2006–2015), while the short-term average landings are 259 t (2011–2015). The biomass estimates indicate that harvest ratios for this stock have always been very low (< 1%), even in years when landings were highest.

4.9.12 Management considerations

For 2006–2008 the agreed TAC for EU vessels was 1300 t. This decreased to 1200 t in 2009–2012 and 1000 t in 2013–2016. The WG notes that there is no TAC for the Norwegian vessels fishing in FU 32.

The Danish at-sea-sampling programme provided a satisfactory number of observer trips in 2015. However, quarters 1 and 2 were not sampled. Possibilities for obtaining biological data from the at-sea-sampling programme are explored. Norwegian sampling of catches by the Norwegian coast guard should be improved. Sample weights are not recorded, not allowing calculation of catches by length. Discard and landings components are not sampled separately and discards can therefore not be estimated.

ICES provide catch advice for FU 32. Advice is given for two scenarios: with and without a discard ban. Following the procedure outlined in the stock annex (section H) a table of harvest ratios (see table below) was calculated.

The biomass estimates imply very low harvest ratios in FU 32 (< 1%), even in former years with high landings (1000–1200 t). ICES advise that when the precautionary approach is applied, catches in 2016 (assuming a landing obligation applies) should be no more than 496 t.

									2015-values			mean (2006-2015)	
	FU32 : Norwegian Deep						55 500	Area (km2	101	land wt		22 %	percentage discards
									25	disc wt			
Landing obligation									Density				
Basis	**Total catch**	**Wanted catch**	**Unwanted catch**		**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	248	232	16		0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	496	464	32		0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Maximum	1273	1190	83		0.5%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
						Fladen (FU7) density							
Discarding allowed													
Basis	**Dead removals**	**Landings**	**Dead discards**	**Live discards**	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	244	232	12	4	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	488	464	24	8	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Maximum	1252	1190	62	21	0.5%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
						Fladen (FU7) density							

4.10 Off Horns Reef (FU 33)

4.10.1 Data available

Catch

The landings from FU 33 were marginal for many years. However, from 1997 to 2004, Danish landings increased considerably, from 274 to 1,097 t. Denmark dominated the fishery during this period. Since 2004, Danish landings have gradually decreased and in 2015 were 371 t. The other countries reporting landings from the area are Belgium, Netherlands, Germany and the UK. Dutch landings show an increasing trend from the start of the time series until 2007 when landings were almost 500 t. Since 2007, Dutch landings show a decreasing trend and in 2015 were the lowest landings recorded over the last decade (187 t). Belgium and German landings having increased throughout the time period and were around 300 and 140 t respectively in 2015. UK landings were highest in 2009 (170 t) and have since decreased dramatically. In 2007, total landings were the highest on record (1467 t). Since 2007, total landings have remained relatively stable and fluctuated without trend, and were 1003 t in 2015 (Table 4.10.1 and Figure 4.10.1). Discard weights are only available for a portion of the fishery (Denmark and the Netherlands) and have been used to raise discards.

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 to 2015 are shown in Figure 4.10.2. Notice, that except for 2005 and 2011 they are rather similar. Figure 4.10.1 shows the development of the mean size of *Nephrops* in catches. The drop in the mean CL in the catches in 2005 and 2013 reflects an increase in numbers at around 30 mm CL and could indicate a large recruitment in these years, see also Figure 4.10.1

In the period 2001–2005, and in 2009–2015 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples do not cover all quarters.

Natural mortality, maturity at age and other biological parameters

No data available

Catch and effort data

Table 4.10.2 and Figure 4.10.1 show the development in Danish effort and LPUE. Notice that the 10-fold increase in fishing effort from 1996 to 2004 seems to correspond to the increase in landings during the same period and the LPUE was relatively stable. After 2004 the Danish effort decreased markedly, and since 2009 has remained stable at around 300 000 kW days. Dutch effort data are available from 2005–2015 and shows an increasing trend over the time period. However, Dutch effort decreased from around 1 300 000 kW days in 2013 to 1 000 000 kW days in 2014 and 2015. The Danish LPUE shows an increasing trend during the whole period, and since 2011 has remained above 1.0 kg/ kW day). This increase in LPUE could reflect an increase in gear efficiency (technological creep) or in fishers' ability to exploit the stock. LPUE from the Netherlands increased from 0.3 kg/kW day in 2005 to around 0.7 kg/kW day in 2007, and has since fluctuated between 0.2 and 0.5 kg/kW day.

Data analysis

Exploratory analyses of catch data

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

Exploratory analyses of survey

No survey data were available

4.10.2 Historic stock trends

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

Danish effort began decreasing after 2004. Since then, the LPUE has steadily increased, except for 2010 when LPUE declined slightly. In 2013, new data from the Netherlands became available for the last nine years, and shows a more stable effort. LPUE has increased for Denmark and decreased for the Netherlands in 2015.

In 2015, the size distribution in the catches is similar to those in 2001–04, 2009–2010 and 2012–2013. The smaller individuals in the 2005 and 2011 catches could reflect a high recruitment in these years. The decrease in mean size could indicate either high recruitment or a decline in the stock, reflected by fewer large individuals. However, there are no recruitment estimates for this FU.

Forecasts: Forecasts were not performed.

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

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

4.10.3 Management considerations for FU 33.

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

4.10.4 Status of the stock

The state of this stock is unknown. Based on the assumed low density (based on lowest observed density at FU 7 (Fladen Ground), harvest rates are considered low for this stock.

The size of the Off Horns Reef *Nephrops* grounds are 5700 km2 and are believed to have a density similar to the Fladen Grounds (FU 7) of 0.1 *Nephrops* m−2. The mean individual weight in landings and discards are 40.57 and 17.19 g respectively and the survival rate of discards is 25 %. Discards are known to take place for the entire fishery, however only length measured discard data exist for the Danish fishery. These data are believed to be representative for the entire fishery and have been used to calculate the values in the catch options table.

4.11 Devil's Hole (FU 34)

The Devil's Hole was designated as a functional unit in 2010, after recommendation from SGNEPS because of increasing landings in the area. The latest advice for this functional unit was provided in 2014 using the data limited approach.

4.11.1 Ecosystem aspects

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

4.11.2 The Fishery in 2014 and 2015

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. Effort in FU 34 by vessels with *Nephrops* gears has decreased from 2009 and fewer boats were reported to be operating in the *Nephrops* offshore grounds. In contrast, landings and effort from TR1 vessels have increased in recent years.

Advice in 2014

Advice provided in 2014 was biennial for 2015 and 2016.

"*ICES advises on the basis of ICES approach to data-limited stocks that catches should be no more than 410 t. If discard rates do not change from the recent average (2008–2011), this implies landings of no more than 383 t.*

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

4.11.3 Management

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

4.11.4 Assessment

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

4.11.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2015 are presented in Table 4.11.1 and Figure 4.11.2. Landings gradually increased from 378 tonnes in 2005 to approximately 1305 tonnes in 2009 followed by a decline in the following years to 121 tonnes in 2013. In 2015 landings increased to 439 tonnes. This is explained by an increase in both landings from TR1 (which target mostly whitefish) and TR2 vessels.

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

Trends in Scottish effort and LPUE are shown in Figure 4.11.3 and Table 4.11.2. TR2 effort has fluctuated over the time period showing generally a downwards trend from 2003, reaching its lowest point in 2013. The decrease may partly be explained as a result of reductions in available effort imposed by the effort management regime and partly because this ground is more remote than a number of other *Nephrops* grounds and costs of steaming to and from the ground are likely to be high. In 2014–2015 TR2 effort increased again to a similar level to that recorded in 2012. TR1 effort decreased sharply in the early 2000's and has fluctuated ever since.

LPUE for Scottish *Nephrops* trawlers (TR2) showed an increasing trend from 2003 to 2009 followed by a slight drop in 2011 and has remained relatively stable in the last four of years. LPUE for TR1 trawlers has been fluctuating without trend over the time series.

Length compositions

Levels of both market and discard sampling are low and data are only available from the Scottish fleet. Most observer sampling in FU 34 took place in the period 2008–2011. No market samples were taken in 2012–2013 and in the last two years only three fishing trips were sampled. Mean sizes in the catch and landings for 2006 to 2011 are shown Table 4.11.3. Sampling has not been conducted in all quarters, so there is potential bias in these results.

InterCatch

Scottish data for 2015 were successfully uploaded into InterCatch prior the 2016 WG meeting according with the deadline proposed. Both landings and discard sampling have been very limited in recent years and Intercatch was used only to record official landings data (no raising) from counties who submitted data into FU 34 (Scotland, England and Denmark).

Natural mortality, maturity at age and other biological parameters

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

Research vessel data

Marine Scotland Science (MSS) have carried out UWTV surveys of the Devil's Hole area opportunistically over the past 10 years. Since 2009, VMS data have been used to define the location of the survey stations. It is not known how station locations were selected on the earlier surveys in this area. It was not possible to survey FU 34 in 2013 but the survey has continued in recent years. The TV surveys in the period 2009–2014 were re-worked to exclude any station lying outside the VMS strata that was adopted in the 2013 benchmark (WKNEPH, 2013). Overall, 6 stations were excluded in the 5 year period and this had little impact on the new abundance values which are very similar to previous estimates. In 2015, FU 34 was visited by the summer Scotia UWTV survey and 17 stations were successfully surveyed. A decline was observed in the *Nephrops* density from 2009 to 2012 followed by a slight increase in recent years. The most recent survey give estimates of density (0.16 burrows/m^2) similar to those found in 2011. A density distribution map of these surveys is shown in Figure 4.11.4 with the size of the symbol reflecting the *Nephrops* burrow density. Table 4.11.4 and Figure 4.11.5 show the time series of mean burrow densities and 95 % confidence intervals.

4.11.6 Historical stock trends

Scottish landings from this area have risen substantially from 2005 to 2009 followed by a general decreasing trend until 2013 and increased again in the last 2 years. Estimates of mean density in the stock have declined from 2009 to 2014 but increased slightly in 2015, remaining higher than in 2003, although this may be due to the change is survey sampling design, with a greater proportion of stations in the western trenches since 2009, producing the high densities.

4.11.7 Recruitment estimates

There are no recruitment estimates for this FU.

4.11.8 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.

4.11.9 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.11.10 Status of the stock

The current state of the stock is unknown.

4.11.11 Management considerations

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

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

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES, 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (WKNEPH, 2013). Following the procedure outlined (section 3.1.2), an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in the FU 34 (see text table below). UWTV survey information on the mean density of *Nephrops* (0.16 *Nephrops*/m^2) from the UWTV survey (2015), was used together with the mean weight (average 2007–2010) and discard percentage (average 2008–2011). The same advice as provided in 2014 of 410 tonnes (catch) results in a harvest ratio of 4.9% which is below the range of harvest ratios observed for other North Sea functional units (7.5–16%). The 10 year average (2006–2015) results in a higher harvest ratio (8.0%). Additional options were added to the table including an increase in 20% in catches (uncertainty cap) and a 20% reduction (precautionary buffer) on the 10 year average. These two options yield a harvest ratio of 5.9% and 6.4% respectively, both below the 7.5% threshold. The proposed advice (given in 2016) for 2017 and 2018 was that catches should be no more than 492 tonnes (2014 advice + 20%). In line with the advice for other stocks, total catches, wanted catches and unwanted catches expected under the landing obligation policy were added to the table. A second catch options table allowing for discarding under *the de minimis exemption* (6% < MCRS by weight for North Sea *Nephrops*) is also included below. This assumes the discard patterns do not change from average values previously observed, and the total catch is split in wanted catch, unwanted catch > MCRS, unwanted catch < MCRS and surviving discards. For data limited stocks the discard survival is assumed to be zero.

Catch options assuming zero discards

Basis	Total Catch	Wanted Catch	Unwanted Catch	Density (Nephrops per m2)							
				0.05	0.1	0.16	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	314	293	21	12.08%	6.04%	3.78%	3.02%	2.01%	1.51%	1.01%	0.76%
2014 Advice - 20%	328	306	22	12.62%	6.31%	3.94%	3.16%	2.10%	1.58%	1.05%	0.79%
2014 Advice	410	383	27	15.80%	7.90%	4.94%	3.95%	2.63%	1.97%	1.32%	0.99%
2014 Advice + 20%	492	459	33	18.93%	9.47%	5.92%	4.73%	3.16%	2.37%	1.58%	1.18%
Average (2006-2015) - 20%	529	494	35	20.39%	10.20%	6.37%	5.10%	3.40%	2.55%	1.70%	1.27%
	612	571	41	23.55%	11.77%	7.36%	5.89%	3.92%	2.94%	1.96%	1.47%
Average (2006-2015)	662	618	44	25.49%	12.74%	7.97%	6.37%	4.25%	3.19%	2.12%	1.59%
Maximum	1398	1305	93	53.82%	26.91%	16.82%	13.46%	8.97%	6.73%	4.49%	3.36%

Catch options assuming discarding allowed for de minimis excemptions

Basis	Total Catch	Wanted Catch	Unwanted Catch >MCRS	de minimis discards <MCRS	Surviving discards	Density (Nephrops per m2)							
						0.05	0.1	0.16	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	314	293	20	1	0	12.08%	6.04%	3.78%	3.02%	2.01%	1.51%	1.01%	0.76%
2014 Advice - 20%	328	306	21	1	0	12.62%	6.31%	3.94%	3.16%	2.10%	1.58%	1.05%	0.79%
2014 Advice	410	383	26	1	0	15.80%	7.90%	4.94%	3.95%	2.63%	1.97%	1.32%	0.99%
2014 Advice + 20%	492	459	31	2	0	18.93%	9.47%	5.92%	4.73%	3.16%	2.37%	1.58%	1.18%
Average (2006-2015) - 20%	529	494	33	2	0	20.39%	10.20%	6.37%	5.10%	3.40%	2.55%	1.70%	1.27%
	612	571	39	2	0	23.55%	11.77%	7.36%	5.89%	3.92%	2.94%	1.96%	1.47%
Average (2006-2015)	662	618	42	2	0	25.49%	12.74%	7.97%	6.37%	4.25%	3.19%	2.12%	1.59%
Maximum	1398	1305	88	5	0	53.82%	26.91%	16.82%	13.46%	8.97%	6.73%	4.49%	3.36%

Basis for the catch options.

VARIABLE	VALUE	SOURCE	NOTES
Density in TV assessment	0.16 *Nephrops* m2	ICES (2016a)	UWTV 2015
Mean weight in landings	31.76 g	ICES (2016a)	Average 2007–2010 (benchmark estimate WKNEPH, 2013)
Mean weight in discards	15.3 g	ICES (2016a)	Average 2013–2015 (from FU 7)
Mean weight in unwanted catch >MCRS	16.13g	ICES (2016a)	Average 2013–2015 (from FU 7)
Mean weight in unwanted catch <MCRS	7.58g	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard rate (total)	12.9%	ICES (2013)	Average 2008–2011 (benchmark estimate WKNEPH, 2013; proportion by number)
Discard rate (>MCRS)	11.6%	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard rate (<MCRS)	1.3%	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard survival rate	0%	ICES (2016a)	Discard survival is assumed to be zero.
Surface area estimate	1753 km2	ICES (2013)	Benchmark estimate WKNEPH (2013)

Table 4.2.1. Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984 – 2013, as officially reported to ICES.

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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	350	252	283	284	229	213	180	214	205	200	265	115	295	374
Denmark	1963	1747	1935	2154	2128	2244	2339	2024	1408	1078	875	603	828	728
Faeroe Islands	1	0	-	-	-	-	-	-	-	-	-	-		
France	0	0	-	-	-	-	-	-	-	-	-	+		+
Germany	104	79	140	125	50	50	109	288	602	266	410	373	552	385
Netherlands	662	572	851	966	940	918	1019	982	1147	737	882	701	1012	1024
Norway	144	147	115	130	100	93	132	96	99	143	139	123	70	75
Sweden	4	37	26	14	1	1	3	1	5	26	2	1	1	1
UK (Eng + Wales + NI)	2431	2210	2691	1964	2295	2241	3236	4937	3295	1679	3437	-		
UK (Scotland)	10715	9834	9681	11045	10094	12912	10565	16165	17930	17960	18587	-		
UK	-	-	-	-	-	-		-	-	-	-	18941	14190	10976
Total	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20857	16948	13541

	2013	2014	2015
Belgium	303	494	349
Denmark	387	624	515
Faeroe Islands	0	0	0
France	0	0	0
Germany	425	418	435
Ireland	0	1	0
Netherlands	910	1154	1113
Norway	63	63	81
Sweden	0		0
UK (Eng + Wales + NI)	-		
UK (Scotland)	-		
UK	8625	11211	6825
Total	10713	13965	9318

* **Landings data for 2015 are preliminary.**

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

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981		1073	373	1006	1416	36				76	3980
1982		2524	422	1195	1120	19				157	5437
1983		2078	693	1724	940	15				101	5551
1984		1479	646	2134	1170	111				88	5628
1985		2027	1148	1969	2081	22				139	7386
1986		2015	1543	2263	2143	68				204	8236
1987		2191	1696	1674	1991	44				195	7791
1988		2495	1573	2528	1959	76				364	8995
1989		3098	2299	1886	2576	84				233	10176
1990		2498	2537	1930	2038	217				222	9442
1991	862	2063	4223	1404	1519	196				560	10827
1992	612	1473	3363	1757	1591	188				401	9385
1993	721	3030	3493	2369	1808	376	339	160		434	12730
1994	503	3683	4569	1850	1538	495	755	137		703	14233
1995	869	2569	6440	1763	1297	280	489	164		844	14715
1996	679	2483	5217	1688	1451	344	952	77		808	13699
1997	1149	2189	6171	2194	1446	316	760	276		662	15163
1998	1111	2177	5136	2145	1032	254	836	350		694	13735
1999	1244	2391	6521	2205	1008	279	1119	724		988	16479
2000	1121	2178	5569	1785	1541	275	1084	597		900	15050
2001	1443	2574	5541	1528	1403	177	1190	791		1268	15915
2002	1231	1954	7247	1340	1118	401	1170	861		1383	16705
2003	1144	2245	6294	1126	1079	337	1089	929		1390	15633
2004	1070	2153	8729	1658	1335	228	922	1268		1224	18587
2005	1099	3094	10685	1990	1605	165	1089	1050		1120	21897
2006	974	4903	10791	2458	1803	133	11033	1288		1249	24627
2007	1294	2966	11910	2652	1842	155	755	1467		1637	24678
2008	963	1218	12240	2450	1514	173	675	1444		1673	22350
2009	728	2703	13327	2662	1067	89	477	1163		2367	24583
2010	959	1443	12825	1871	1032	38	407	806	757	709****	20847
2011	1053	2070	7558	1888	1391	69	395	1191	433	1166*****	17214
2012	1240	2460	4369	2091	860	13	310	1084	597	608****	13632
2013	1050	2982	2951	1503	623	16	191	946	120	409	10791
2014	1416	2503	4147	2370	1252	15	205	1146	320	392	13766
2015	1516	1371	1786	1892	830	15	192	1003	439	612	9656

*** Provisional**

**** Includes 3.a.**

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

***** *695t in IV and 14t in 3.a**

******4 only**

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

	Belgium	Denmark	Netherlands	Germany	UK	Total**	Catch***
1991	682	176	na		4	862	
1992	571	22	na		19	612	
1993	694	20	na		7	721	
1994	494	0	na		9	503	
1995	641	77	148		3	869	
1996	266	41	317		55	679	
1997	486	67	540		56	1149	
1998	372	88	584	39	28	1111	
1999	436	53	538	59	158	1244	
2000	366	83	402	52	218	1121	
2001	353	145	553	114	278	1443	
2002	281	94	617	88	151	1231	
2003	265	36	661	24	158	1144	
2004	171	39	646	16	198	1070	
2005	109	87	654	51	198	1099	
2006	77	24	444	99	330	974	
2007	75	3	464	201	551	1294	
2008	49	29	268	108	509	963	
2009	52	3	288	98	287	728	
2010	48	5	354	140	411	959	
2011	60	18	480	145	350	1053	
2012	129	0	497	121	493	1240	
2013	142	1	447	168	292	1050	
2014	131	41	645	139	460	1416	
2015	146	0	681	184	505	1516	3562

*** provisional na = not available**

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

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

	Mean length (mm)	
Year	Females	Males
2003	38.43	38.43
2004	37.68	39.21
2005	36.85	37.47
2006	37.33	37.85
2007	38.05	38.9
2008	38.71	39.81
2009	38.18	39.91
2010	41.1	41.1
2011	41.2	41.1
2012	39.7	40.8
2013	na	na
2014	40.2	40.2
2015	39.43	39.8

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

	ENGLAND		
	Landings	Effort	LPUE
	tons	Boat Days Fished	T/Day
2000	53.2184	36	1.48
2001	104.1648	73	1.43
2002	7.3549	10	0.74
2003	21.4591	24	0.89
2004	32.4969	21	1.55
2005	66.7731	35	1.91
2006	176.7924	214	0.83
2007	208.698	177	1.18
2008	267.7608	292	0.92
2009	193.9114	188	1.03
2010	176.1818	152	1.16
2011	181.6175	147	1.24
2012	204.7108	185	1.11
2013	111.6035	142	0.79
2014	147.0582	138	1.07
2015	136.1702	147	0.93

*** provisional na = not available**

Logbook records from vessels operating in FU 5, with mesh size >=70 mm with *Nephrops* in catches

Table 4.4.1 *Nephrops* in FU 6. Nominal Landings (tonnes) of *Nephrops*, 1981–2015, as reported to the WG.

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
1981	1006	67	1073	0	1073
1982	2443	81	2524	0	2524
1983	2073	5	2078	0	2078
1984	1471	8	1479	0	1479
1985	2009	18	2027	0	2027
1986	1987	28	2015	0	2015
1987	2158	33	2191	0	2191
1988	2390	105	2495	0	2495
1989	2930	168	3098	0	3098
1990	2306	192	2498	0	2498
1991	1884	179	2063	0	2063
1992	1403	60	1463	10	1473
1993	2941	89	3030	0	3030
1994	3530	153	3683	0	3683
1995	2478	90	2568	1	2569
1996	2386	96	2482	1	2483
1997	2109	80	2189	0	2189
1998	2029	147	2176	1	2177
1999	2197	194	2391	0	2391
2000	1947	231	2178	0	2178
2001	2319	255	2574	0	2574
2002	1739	215	1954	0	1954
2003	2031	214	2245	0	2245
2004	1952	201	2153	0	2153
2005	2936	158	3094	0	3094
2006	4430	434	4864	39	4903
2007	2525	437	2962	4	2966
2008	976	244	1220	0	1220
2009	2299	414	2713	0	2713
2010	1258	185	1443	0	1443
2011	1806	250	2056	14	2070
2012	2177	256	2433	27	2460
2013	2666	305	2971	11	2982
2014	2104	345	2449	54	2503
2015*	1186	174	1360	11	1371

*** provisional na = not available**

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

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

Year	<10m			10–15m			>15m		
	Landings	Days	LPUE (kg/d)	Landings	Days	LPUE (kg/d)	Landings	Days	LPUE (kg/d)
2000	124	591	210	368	1611	228	552	1465	377
2001	139	665	209	306	1264	242	460	1363	338
2002	125	654	191	354	1376	257	456	1320	346
2003	319	958	333	483	1614	299	517	1461	354
2004	384	1088	353	456	1604	284	371	863	430
2005	581	1472	395	511	1669	306	647	1276	507
2006	778	2296	339	489	1372	356	1324	2062	642
2007	523	2067	253	259	1034	251	568	1571	362
2008	299	2181	137	152	798	190	163	611	266
2009	449	2279	197	314	1103	285	574	1195	480
2010	340	1773	192	176	650	271	322	969	332
2011	401	2320	173	235	827	285	414	1006	412
2012	388	2174	178	333	1263	264	406	1014	400
2013	465	2374	196	402	1246	323	484	899	539
2014	399	2160	185	280	870	322	420	917	458
2015	197	1567	125	126	647	195	242	901	269

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

Year	Catches		Landings	
	Males	Females	Males	Females
1985	30.1	28.5	35.4	33.8
1986	31.7	30.2	35.3	33.7
1987	28.6	27	35.3	33.3
1988	28.7	27.3	35	33.9
1989	29	28.2	32.4	31.9
1990	27.1	27.4	31.8	31.3
1991	28.9	27.1	33.5	33.1
1992	30.8	29	33	31.9
1993	32.1	28.7	33.4	30.1
1994	30.5	27.7	33.8	30.5
1995	28.4	27.4	33.8	31.6
1996	29.8	28.2	34.5	32.1
1997	29.9	29.6	33.5	32.1
1998	30	28.9	34.9	33.7
1999	29.6	27.5	35.1	33.6
2000	27.2	26.8	31.1	31.3
2001	26.2	26.3	30.6	31.3
2002	28.0	26.9	30.9	30.0
2003	29.0	27.1	31.7	30.6
2004	29.2	27.0	32.3	30.6
2005	29.7	29.4	32.1	32.2
2006	29.0	30.3	31.4	32.4
2007	31.3	30.7	33.3	32.6
2008	31.5	31.1	33.5	33.3
2009	30.0	31.0	32.1	33.3
2010	31.2	31.4	32.8	33.2
2011	32.0	31.6	33.7	33.6
2012	30.8	32.0	33.2	34.5
2013	29.6	32.4	32.0	35.3
2014	31.8	35.4	32.9	36.6
2015	31.5	31.7	33.9	34.9
	* provisional na = not available			

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

Year	Stations	Season	Mean density	Absolute Abundance	95% confidence interval	Method
			burrows/m²	millions	millions	
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	73	Autumn	0.33	1085	90	Box
2004	76	Autumn	0.43	1377	101	Box
2005	105	Autumn	0.49	1657	148	Box
2006	105	Autumn*	0.37	1244	114	Box
2007	105	Autumn*	0.28	858	23	Geostatistics
2008	95	Autumn*	0.31	987	39	Geostatistics
2009	76	Autumn*	0.22	682	38	Geostatistics
2010	95	Autumn*	0.25	785	21	Geostatistics
2011	97	Autumn*	0.28	878	17	Geostatistics
2012	97	Autumn*	0.24	758	13	Geostatistics
2013	110	Summer	0.23	706	18	Geostatistics
2014	110	Summer	0.24	755	18	Geostatistics
2015	110	Summer	0.18	565	13	Geostatistics

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

Year	TV abundance index	Landings (t)	Discard rate	Mean Weight Landings(g)	Mean Weight Discards (g)	N removed	Observed Harvest Rate
2001	1685	2574	66.60%	20.67	9.62	373	22.1%
2002	1048	1953	46.10%	20.00	9.50	181	17.3%
2003	1085	2245	42.10%	21.89	9.56	177	16.3%
2004	1377	2152	41.70%	23.14	9.22	160	11.6%
2005	1657	3094	34.50%	23.58	10.32	200	12.1%
2006	1244	4858	31.30%	22.53	10.58	314	25.2%
2007	858	2966	25.00%	24.95	10.89	159	18.5%
2008	987	1213	24.90%	26.63	10.97	61	6.1%
2009	682	2711	29.30%	24.45	10.54	157	23.0%
2010	785	1443	23.00%	25.18	11.74	74	9.5%
2011	878	2072	22.60%	27.05	11.02	99	11.3%
2012	758	2457	27.42%	27.30	10.16	124	16.4%
2013	706	2982	29.80%	27.60	9.80	154	21.8%
2014	755	2503	14.90%	29.90	13.50	98	13.0%
2015	565	1371	28.97%	29.39	9.99	66	11.6%

Table 4.5.1 ***Nephrops*****, Fladen (FU 7), Nominal Landings (tonnes) of** ***Nephrops*****, 1981–2015, as reported to the WG.**

Year	UK Scotland					Other	Total
	Nephrops trawl	Other trawl	Creel	Sub-total	Denmark	countries **	
1981	304	68	0	372	0	0	372
1982	381	40	0	421	0	0	421
1983	588	105	0	693	0	0	693
1984	552	94	0	646	0	0	646
1985	1020	120	0	1140	7	0	1147
1986	1401	92	0	1493	50	0	1543
1987	1023	349	0	1372	323	0	1695
1988	1309	185	0	1494	81	0	1575
1989	1724	410	0	2134	165	0	2299
1990	1703	598	0	2301	236	3	2540
1991	3021	772	0	3793	424	6	4223
1992	1809	1164	0	2973	359	31	3363
1993	2031	1234	0	3265	224	3	3492
1994	1816	2356	0	4172	390	6	4568
1995	3568	2389	19	5976	439	4	6419
1996	2338	2578	7	4923	286	1	5210
1997	2712	3221	0	5933	235	2	6170
1998	2290	2673	0	4963	173	0	5136
1999	2860	3546	0	6406	96	16	6518
2000	2916	2546	0	5462	103	5	5570
2001	3540	1936	0	5476	64	2	5542
2002	4511	2546	0	7057	173	15	7245
2003	4175	2033	0	6208	82	4	6294
2004	7274	1319	1	8594	136	0	8730
2005	8849	1508	5	10362	321	1	10684
2006	9470	1026	1	10497	283	11	10791
2007	11055	734	0	11789	119	3	11911
2008	11432	666	0	12098	133	8	12239
2009	12688	499	0	13187	130	10	13327
2010	12544	288	0	12832	124	12	12968
2011	7367	128	0	7495	64	<0.5	7559
2012	4257	81	0	4338	75	2	4415
2013	2275	663	0	2938	5	8	2951
2014	2164	1970	0	4134	10	3	4147
2015	806	968	0	1774	8	4	1786

*** provisional na = not available**

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

Table 4.5.2 *Nephrops*, Fladen (FU 7): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2015.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	5462	35367	154.4
2001	5476	28558	191.8
2002	7057	28586	246.9
2003	6208	21960	282.7
2004	8593	21562	398.5
2005	10357	23555	439.7
2006	10496	22836	459.6
2007	11789	21603	545.7
2008	12098	22856	529.3
2009	13187	21153	623.4
2010	12832	20968	612.0
2011	7495	15273	490.7
2012	4338	11994	361.7
2013	2938	11933	246.2
2014	4134	12629	327.3
2015*	1774	10562	168.0

*** provisional**

Table 4.5.3 *Nephrops*, Fladen (FU 7): Logbook recorded effort (kW days) and LPUE (kg/kW day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2015.

Year	Logbook data	
	Effort	LPUE
1991	2487464	0.170
1992	1952431	0.184
1993	653665	0.343
1994	1029253	0.379
1995	696951	0.630
1996	524375	0.545
1997	278210	0.845
1998	207196	0.835
1999	144720	0.663
2000	236941	0.435
2001	142562	0.449
2002	217053	0.797
2003	105864	0.775
2004	196984	0.690
2005	430272	0.746
2006	363866	0.778
2007	160590	0.741
2008	106969	1.243
2009	92461	1.406
2010	125830	0.985
2011	65646	0.975
2012	129719	0.578
2013	130458	0.038
2014	171105	0.058
2015	71790	0.111

Table 4.5.4 *Nephrops*, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1993–2015.

	CATCHES		LANDINGS			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
YEAR	Males	Females	Males	Females	Males	Females
1993	na	na	30.4	29.6	38.7	38.2
1994	na	na	30.0	28.9	39.2	37.8
1995	na	na	30.6	29.8	39.9	38.1
1996	na	na	30.4	29.1	40.6	38.8
1997	na	na	30.2	29.1	40.9	38.8
1998	na	na	30.8	29.4	40.7	38.3
1999	na	na	30.9	29.6	40.5	38.5
2000	30.7	30.1	31.2	30.5	41.3	38.7
2001	30.1	29.4	30.7	29.7	39.6	38.0
2002	30.6	30.0	31.3	30.7	39.5	38.3
2003	30.9	29.8	31.2	30.1	40.0	38.1
2004	30.8	29.9	31.1	30.2	40.1	38.7
2005	30.9	30.0	31.2	30.1	40.1	38.2
2006	30.3	29.7	30.8	30.0	40.7	38.2
2007	29.8	29.2	30.4	29.5	40.8	38.8
2008	29.7	28.6	29.8	28.7	41.8	39.1
2009	30.7	29.5	31.2	29.9	39.7	38.7
2010	30.4	29.0	30.5	29.0	39.8	38.4
2011	31.7	29.6	31.7	29.6	41.2	38.6
2012	31.9	30.6	31.9	30.6	41.8	38.5
2013	31.4	30.2	31.4	30.2	42.2	39.0
2014	30.4	30.1	30.8	30.2	44.5	39.2
2015	32.3	31.2	32.3	31.2	41.5	40.0

na = not available

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

Year	Fladen	Firth of Forth	Moray Firth	Devil's Hole	Noup
1990	31.59	20.29	20.05	na	na
1991	26.50	20.03	18.53	na	na
1992	29.61	20.96	23.49	na	na
1993	25.38	24.30	23.42	na	na
1994	23.72	19.51	22.25	na	na
1995	27.51	19.55	20.59	na	na
1996	29.82	20.81	21.40	na	na
1997	32.08	18.87	20.43	na	23.94
1998	31.37	18.23	20.47	na	20.58
1999	30.55	20.05	21.79	na	21.23
2000	36.35	21.83	25.44	na	30.81
2001	25.10	21.22	24.18	na	25.30
2002	27.93	19.62	27.68	na	27.95
2003	30.15	22.31	23.32	na	20.05
2004	30.98	22.45	27.57	na	28.98
2005	29.05	22.33	23.84	na	24.13
2006	29.25	21.43	22.34	22.93	25.97
2007	26.63	20.97	23.04	26.27	25.58
2008	28.18	17.23	25.29	30.08	33.18
2009	28.20	19.41	23.46	39.62	49.38
2010	26.38	19.76	26.94	31.08	51.93
2011	36.17	19.75	21.63	42.05	45.73
2012	36.91	21.66	23.16	na	34.48
2013	34.90	19.30	24.95	na	43.56
2014	43.11	24.30	28.94	50.09	68.31
2015	36.70	21.84	29.10	48.75	na
Mean (13–15)	38.24	21.81	27.66	31.76*	-

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

na = not available

Table 4.5.6. *Nephrops*, Fladen (FU 7): Results of the 1992–2015 TV surveys.

Year	Stations	Abundance	Mean density	95% confidence interval
		millions	burrows/m2	millions
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996	No survey			
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	336
2014	70	2990	0.11	412
2015	71	2569	0.09	320

Table 4.5.7. *Nephrops*, Fladen Ground (FU 7):Summary of TV results for most recent 3 years (2013–2015) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.

Stratum (ranges of % silt clay)	Area (km2)	Number of Stations	Mean burrow density (no./m2)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2013 TV survey							
>80	3248	9	0.183	0.001	593	1867	0.049
55<80	4967	14	0.166	0.007	823	11739	0.309
40<55	4304	15	0.115	0.005	493	5982	0.158
<40	15634	33	0.064	0.002	993	18347	0.484
Total	28153	71			2902	37934	1
2014 TV survey							
>80	3248	9	0.197	0.007	639	7993	0.188
55<80	4967	15	0.143	0.004	709	6387	0.15
40<55	4304	12	0.112	0.004	481	6643	0.156
<40	15634	34	0.074	0.003	1162	21432	0.505
Total	28153	70			2990	42455	1
2015 TV survey							
>80	3248	10	0.201	0.002	652	2450	0.096
55<80	4967	15	0.124	0.002	613	4043	0.158
40<55	4304	12	0.096	0.004	414	6174	0.241
<40	15634	34	0.057	0.002	889	12974	0.506
Total	28153	71			2569	25642	1

Table 4.5.8 *Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2015.

Year	Adjusted abundance (millions)	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
2003	5547	4.1	209	24	226	6294	349	10.1	30.15	14.83	7.8
2004	5725	5.4	282	34	307	8730	506	10.6	30.98	15.06	8.2
2005	4325	9.3	368	46	403	10684	823	11.2	29.05	17.74	8.6
2006	4862	8.4	369	54	409	10791	798	12.7	29.25	14.87	9.8
2007	7017	7	447	55	488	11911	747	10.9	26.63	13.67	8.4
2008	7360	6.1	434	18	448	12239	257	3.9	28.18	14.54	3.0
2009	5457	9.4	473	51	511	13327	707	9.7	28.20	13.85	7.5
2010	5224	9.9	492	34	517	12968	560	6.5	26.38	16.44	4.9
2011	3382	6.2	209	0	209	7559	0	0	36.17	NA	0
2012	2748	4.7	128	0	128	4415	0	0	36.91	NA	0
2013	2902	3.1	89	0	89	2951	0	0	34.90	NA	0
2014	2990	3.5	102	3	104	4147	37	2.5	43.11	13.9	1.9
2015	2569	2	51	0	51	1786	0	0	36.7	NA	0

Table 4.6.1 *Nephrops*, Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981–2015, as reported to the WG.

YEAR	UK SCOTLAND				UK	
		Other			(E, W & NI)	
	Nephrops trawl	trawl	Creel	Sub-total		TOTAL **
1981	947	60	0	1007	0	1007
1982	1138	57	0	1195	0	1195
1983	1681	43	0	1724	0	1724
1984	2078	56	0	2134	0	2134
1985	1907	61	0	1968	0	1968
1986	2204	59	0	2263	0	2263
1987	1583	90	2	1675	0	1675
1988	2455	74	0	2529	0	2529
1989	1834	53	0	1887	1	1888
1990	1900	30	0	1930	1	1931
1991	1362	43	0	1405	0	1405
1992	1715	41	0	1756	0	1756
1993	2349	17	0	2366	2	2368
1994	1827	17	0	1844	6	1850
1995	1707	53	0	1760	2	1762
1996	1621	66	0	1687	0	1687
1997	2136	55	0	2191	2	2193
1998	2105	37	0	2142	2	2144
1999	2193	10	1	2204	3	2207
2000	1775	9	0	1784	1	1785
2001	1484	34	0	1518	9	1527
2002	1302	31	1	1334	6	1340
2003	1116	8	0	1124	3	1127
2004	1650	4	0	1654	3	1657
2005	1974	0	4	1978	11	1989
2006	2438	3	12	2453	5	2458
2007	2627	10	7	2644	7	2651
2008	2435	2	8	2445	5	2450
2009	2620	8	26	2654	9	2663
2010	1923	5	13	1941	9	1950
2011	1789	6	89	1884	5	1889
2012	1944	17	126	2087	42	2129
2013	1409	24	58	1491	12	1503
2014	2313	33	14	2360	22	2382
2015*	1677	104	43	1824	68	1892

*** provisional na = not available**

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

Table 4.6.2 *Nephrops*, Firth of Forth (FU 8): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2015

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	1784	10508	169.8
2001	1518	11513	131.9
2002	1333	10394	128.2
2003	1124	8279	135.8
2004	1654	9505	174.0
2005	1974	7704	256.2
2006	2441	6174	395.4
2007	2637	6409	411.5
2008	2437	6440	378.4
2009	2628	5852	449.1
2010	1928	5054	381.5
2011	1795	4614	389.0
2012	1961	5058	387.7
2013	1433	4029	355.7
2014	2346	6812	344.4
2015*	1781	6024	295.7

*** provisional na = not available**

Table 4.6.3 *Nephrops*, Firth of Forth (FU 8): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1981–2015

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	28.9	27.8	29.8	28.6	38.3	38.8
1991	28.7	27.5	29.8	28.7	38.3	38.7
1992	29.5	27.9	30.2	28.7	38.1	38.7
1993	28.7	28.0	30.3	29.5	39.0	38.6
1994	25.7	25.1	29.1	28.5	38.8	37.8
1995	27.9	27.1	29.4	28.9	38.7	37.9
1996	28.0	27.4	29.8	28.8	38.6	38.6
1997	27.2	27.0	29.2	28.7	38.8	38.2
1998	27.7	26.4	29.0	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38.0	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011	28.6	27.5	30.0	28.3	38.8	38.2
2012	28.4	28.0	30.4	29.3	39.0	38.1
2013	28.3	27.4	29.6	28.8	38.8	37.9
2014	29.6	29.1	31.1	30.3	38.6	38.1
2015	27.9	28.3	29.5	29.3	39.6	38.5
	na = not available					

Table 4.6.4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1993–2015 TV surveys.**

Year	Stations	Mean Density burrows/m²	Abundance millions	95% conf interval millions
1993	37	0.61	555	142
1994	30	0.49	448	78
1995	no survey			
1996	27	0.41	375	88
1997	no survey			
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125
2014	51	0.47	428	80
2015	51	0.73	664	127

Table 4.6.5. ***Nephrops*****, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2013–2015) 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
2013 TV survey							
M & SM	170	10	0.477	0.342	81	992	0.213
MS(west)	139	8	0.568	0.214	79	518	0.111
MS(mid)	211	12	1.051	0.381	221	1409	0.302
MS(east)	395	21	0.725	0.235	286	1744	0.374
Total	915	51			668	4663	1
2014 TV survey							
M & SM	170	10	0.317	0.081	54	236	0.147
MS(west)	139	7	0.198	0.010	28	27	0.017
MS(mid)	211	12	0.725	0.134	153	496	0.309
MS(east)	395	22	0.491	0.119	194	847	0.527
Total	915	51			428	1606	1
2015 TV survey							
M & SM	170	9	0.613	0.447	105	1444	0.357
MS(west)	139	8	0.462	0.200	64	482	0.119
MS(mid)	211	12	0.955	0.243	201	898	0.222
MS(east)	395	22	0.746	0.173	295	1226	0.303
Total	915	51				4050	1

Table 4.6.6 ***Nephrops*****, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2015.**

YEAR	ADJUST	HARVE	LANDI	DISCA	REMO	LANDINGS	DISCA	DISCA	MEAN	MEAN	DEAD
2003	767	12.4	51	59	95	1127	546	53.9	22.31	9.25	46.7
2004	630	16.4	74	40	103	1657	406	34.9	22.45	10.25	28.7
2005	710	19.4	89	65	138	1989	602	42.1	22.33	9.28	35.3
2006	827	26.7	115	142	221	2458	1510	55.2	21.43	10.67	48.1
2007	692	22.9	126	43	159	2651	614	25.3	20.97	14.34	20.3
2008	881	21.1	142	58	186	2450	796	29.1	17.23	13.65	23.5
2009	732	26	137	71	190	2663	573	34.1	19.41	8.09	27.9
2010	682	19.2	99	43	131	1950	407	30.2	19.76	9.55	24.5
2011	533	22.1	100	24	118	1889	231	19.5	19.75	9.56	15.3
2012	522	24.6	100	38	129	2129	379	27.2	21.66	10.10	21.9
2013	668	15.6	81	31	104	1501	301	27.4	19.30	9.82	22.0
2014	428	29.1	102	30	124	2382	353	22.9	24.30	11.66	18.3
2015	664	16.8	90	29	112	1892	311	24.4	21.84	10.74	19.5

Table 4.7.1 *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981–2015, as reported to the WG.

	UK Scotland				UK*	
Year		Other			England	
	Nephrops trawl	trawl	Creel	Sub-total		Total **
1981	1299	117	0	1416	0	1416
1982	1033	86	0	1119	0	1119
1983	850	91	0	941	0	941
1984	960	209	0	1169	0	1169
1985	1908	173	0	2081	0	2081
1986	1932	211	0	2143	0	2143
1987	1724	268	0	1992	0	1992
1988	1637	322	0	1959	0	1959
1989	2102	474	0	2576	0	2576
1990	1698	339	0	2037	0	2037
1991	1285	235	0	1520	0	1520
1992	1285	306	0	1591	0	1591
1993	1505	304	0	1809	0	1809
1994	1179	358	0	1537	0	1537
1995	967	312	0	1279	0	1279
1996	1084	364	1	1449	2	1451
1997	1103	343	0	1446	1	1447
1998	739	289	4	1032	0	1032
1999	813	194	2	1009	0	1009
2000	1341	196	2	1539	0	1539
2001	1186	213	2	1401	0	1401
2002	883	247	2	1132	0	1132
2003	873	196	11	1080	0	1080
2004	1222	103	8	1333	0	1333
2005	1526	64	12	1602	3	1605
2006	1751	42	11	1804	1	1805
2007	1818	17	6	1841	2	1843
2008	1444	68	3	1515	0	1515
2009	1033	31	2	1066	1	1067
2010	1026	28	9	1063	0	1063
2011	1358	23	9	1390	1	1391
2012	834	24	8	866	0	866
2013	497	116	7	620	3	623
2014	890	348	2	1240	12	1252
2015*	604	224	0	828	2	830

*** provisional na = not available**

**** No landings by non UK countries from this FU**

Table 4.7.2 *Nephrops*, Moray Firth (FU 9): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2015.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	1537	7943	193.5
2001	1399	7219	193.8
2002	1130	7495	150.8
2003	1069	5934	180.1
2004	1325	6200	213.7
2005	1590	4805	330.9
2006	1793	4588	390.8
2007	1835	4758	385.7
2008	1512	4328	349.4
2009	1064	3546	300.1
2010	1054	3589	293.7
2011	1381	3880	355.9
2012	858	3079	278.7
2013	613	2954	207.5
2014	1238	4099	302.0
2015*	828	3755	220.5

*** provisional na = not available**

Table 4.7.3 *Nephrops*, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1991–2015.

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	28.8	28.1	30.3	29.1	38.4	38.7
1991	28.3	27.4	30.1	28.6	38.2	38.2
1992	29.4	28.6	31.0	30.5	38.3	38.0
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31.0	39.4	37.5
1995	25.8	25.0	29.9	29.3	39.1	38.0
1996	29.3	28.4	30.6	29.7	38.5	38.0
1997	28.5	27.9	29.5	28.9	38.8	38.2
1998	28.7	28.2	30.1	29.3	38.8	38.2
1999	29.5	28.8	30.4	29.7	38.9	37.6
2000	29.8	29.1	31.5	30.6	39.2	38.3
2001	30.0	29.2	30.9	30.2	39.5	37.9
2002	27.2	27.0	31.2	30.9	41.0	38.7
2003	29.3	29.2	30.3	30.1	39.8	38.0
2004	29.3	28.4	31.3	30.8	39.0	39.2
2005	30.0	28.7	31.0	29.6	39.2	38.5
2006	29.7	28.9	30.6	29.6	39.3	38.6
2007	30.1	28.8	30.3	29.0	39.4	38.6
2008	29.3	27.7	30.2	28.2	39.8	40.2
2009	29.7	28.9	30.7	29.3	39.6	38.5
2010	29.7	29.1	31.1	30.5	40.0	38.9
2011	28.6	28.4	29.4	29.0	39.5	38.4
2012	29.5	29.1	30.5	29.9	39.2	38.5
2013	30.7	29.3	30.9	29.5	39.6	38.4
2014	30.2	29.8	31.6	30.8	40.3	39.0
2015	29.8	29.4	31.5	30.6	40.6	39.1

na = not available

Table 4.7.4 *Nephrops*, Moray Firth (FU 9): Results of the 1993–2015 TV surveys.

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995	no survey			
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84

Table 4.7.5 *Nephrops*, Moray Firth (FU 9):Summary of TV results for most recent 3 years (2013–2015) 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
2013 TV survey							
M & SM	169	3	0.22	0.06	37	580	0.17
MS(west)	682	18	0.22	0.06	148	1576	0.463
MS(mid)	698	18	0.23	0.01	160	300	0.088
MS(east)	646	16	0.19	0.04	124	950	0.279
Total	2195	55			469	3406	1
2014 TV survey							
M & SM	169	3	0.19	0.04	33	412	0.202
MS(west)	682	16	0.14	0.03	98	851	0.417
MS(mid)	698	17	0.15	0.02	103	436	0.213
MS(east)	646	16	0.15	0.01	97	344	0.168
Total	2195	52			331	2042	1
2015 TV survey							
M & SM	169	3	0.30	0.03	51	235	0.134
MS(west)	682	19	0.11	0.02	75	542	0.309
MS(mid)	698	17	0.22	0.02	151	456	0.259
MS(east)	646	13	0.11	0.02	71	525	0.299
Total	2195	52			347	1757	1

Table 4.7.6 *Nephrops*, Moray Firth (FU 9): Adjusted TV survey abundance, landings, discard rate (proportion by number), dead discard rate (proportion by number) and estimated harvest ratio 2003–2015.

Year	Adjusted abundance	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
2003	730	7.1	46	7	52	1080	70	13.7	23.32	9.51	10.6
2004	626	10.5	48	23	66	1333	272	32.6	27.57	11.62	26.6
2005	869	8.8	67	12	76	1605	122	15.0	23.84	10.31	11.7
2006	445	20.1	81	12	90	1805	117	12.8	22.34	9.86	9.9
2007	531	16	80	7	85	1843	95	7.9	23.04	13.95	6.0
2008	481	13.7	60	8	66	1515	74	11.4	25.29	9.60	8.8
2009	415	11.6	45	4	48	1067	33	7.6	23.46	8.72	5.8
2010	406	11.5	39	10	47	1063	104	19.8	26.94	10.63	15.7
2011	372	18.9	63	10	70	1391	102	13.9	21.63	10.12	10.8
2012	299	13.7	37	6	41	866	54	13.2	23.16	9.72	10.3
2013	469	5.8	26	1	27	655	10	3.3	24.95	11.21	2.5
2014	331	14.7	43	7	49	1252	87	14.6	28.94	11.79	11.3
2015	347	9.1	28	5	32	830	56	15.1	29.1	11.35	11.8

Table 4.8.1 *Nephrops*, Noup (FU 10), Nominal Landings (tonnes) of *Nephrops*, 1981–2015, as reported to the WG.

Year	*Nephrops* Trawl	Other trawl	Creel	Sub Total	Other UK	Total
1981	12	23	0	35	0	35
1982	12	7	0	19	0	19
1983	10	6	0	16	0	16
1984	76	35	0	111	0	111
1985	1	21	0	22	0	22
1986	45	22	0	67	0	67
1987	13	32	0	45	0	45
1988	23	53	0	76	0	76
1989	24	60	0	84	0	84
1990	101	117	0	218	0	218
1991	111	86	0	197	0	197
1992	58	130	0	188	0	188
1993	200	176	0	376	0	376
1994	307	187	0	494	0	494
1995	163	116	0	279	0	279
1996	181	164	0	345	0	345
1997	185	131	1	317	0	317
1998	184	72	0	256	0	256
1999	211	67	0	278	0	278
2000	196	78	0	274	0	274
2001	88	89	0	177	0	177
2002	246	157	0	403	0	403
2003	258	78	0	336	0	336
2004	174	54	0	228	0	228
2005	81	84	0	165	0	165
2006	44	89	0	133	0	133
2007	46	107	0	153	0	153
2008	74	98	0	172	0	172
2009	24	63	0	87	0	87
2010	4	35	0	39	0	39
2011	27	41	0	68	0	68
2012	2	11	0	13	0	13
2013	4	12	0	16	0	16
2014	5	9	1	15	0	15
2015	5	10	0	15	0	15

*** provisional**

Table 4.8.2 *Nephrops*, Noup (FU 10): landings (tonnes), effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2015.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	274	1622	168.9
2001	177	1383	128.0
2002	403	2036	197.9
2003	336	1434	234.3
2004	228	899	253.6
2005	165	730	226.0
2006	133	612	217.3
2007	153	591	258.9
2008	172	746	230.6
2009	87	871	99.9
2010	39	813	48.0
2011	68	776	87.6
2012	13	574	22.6
2013	16	454	35.2
2014	14	673	20.8
2015*	15	514	29.2

*** provisional**

Table 4.8.3 *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997–2015. No females in samples in 2010 and no sampling in 2015.

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
1997	29.7	28.3	40.4	38.2
1998	30.4	29.8	38.8	38.6
1999	30.4	30.1	39.2	37.8
2000	31.8	30.1	38.2	39.1
2001	31.4	29.5	38.7	37.9
2002	30.8	29.9	39.7	38.5
2003	29.3	30.4	39.9	38.5
2004	31.4	30.0	40.2	38.8
2005	31.0	29.3	39.3	38.4
2006	30.8	30.2	40.4	38.7
2007	30.7	29.4	40.2	38.7
2008	31.9	30.6	40.3	39.3
2009	33.2	33.2	42.6	42.7
2010	33.3	na	42.6	na
2011	32.8	32.7	43.3	40.1
2012	32.4	31.8	40.7	40.1
2013	34.0	32.4	43.7	39.7
2014	33.3	33.0	46.6	43.2
2015	na	na	na	na
	na = not available			

Table 4.8.4 *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006, 2007 & 2014 TV surveys (absolute conversion factor =1.35, from Fladen).

		Mean		95%
		density		confidence
			Abundance	interval
Year	Stations	burrows/m²	millions	millions
1994	10	0.47	185	67
1995	no survey			
1996	no survey			
1997	no survey			
1998	no survey			
1999	10	0.22	89	31
2000	no survey			
2001	no survey			
2002	no survey			
2003	no survey			
2004	no survey			
2005	2	poor visibility, limited survey - see text		
2006	7	0.13	55	35
2007	9	0.11	44	19
2008	no survey			
2009	no survey			
2010	no survey			
2011	no survey			
2012	no survey			
2013	no survey			
2014	12	0.13	51	22
2015	no survey			

Table 4.9.1 *Nephrops* Norwegian Deep (FU 32). Landings (tonnes) by country, 1993–2015, estimated Danish discards (2003–2015), and TAC (EU). The 2005 discards numbers were updated in 2015.

		Danish discards		Norway							
Year	Denmark	dead	live	Trawl	Creel	Sub-total	Sweden	UK	Netherlands	Total	TAC
1993	220			102	1	103		16		339	
1994	584			161	0	161		10		755	
1995	418			68	1	69		2		489	
1996	868			73	1	74		10		952	
1997	689			56	8	64		7		760	
1998	743			88	1	89		4		836	
1999	972			119	15	134		13		1119	
2000	871			143	0	143	37	34		1085	
2001	1026			72	13	85	26	53		1190	
2002	1043			42	21	63	13	52		1171	
2003	996	145	48	68	11	79	1	14		1090	
2004	835	200	67	72	8	80	1	6		922	1000
2005	979	194	65	89	13	102	2	6		1089	1000
2006	939	126	42	62	19	81	1	7	5	1033	1300
2007	652	64	21	77	20	97	5	1		755	1300
2008	505			112	30	142	24	4		675	1300
2009	331	29	10	107	31	138	2	6		477	1200
2010	282	36	12	82	41	123	1	1		407	1200
2011	322			29	40	69	1	3		395	1200
2012	234	35	12	25	50	75	1	0		310	1200
2013	128	51	17	18	45	63	0	0		191	1000
2014	143	4	1	15	47	62	0	0		205	1000
2015*	110	5	2	8	74	82	0	0		192	1000

*** provisional**

Table 4.9.2 *Nephrops* Norwegian Deep (FU 32). Danish effort (kW days, days at sea, fishing days) and LPUE (kg/kW day) for bottom trawlers catching *Nephrops*, 1993–2015. Effort values were updated in 2016.

Year	kW days ('1000)	Days at sea	Fishing days	LPUE
1993	891	1980	1536	247
1994	1439	3574	2793	406
1995	1009	2464	1936	414
1996	1734	4000	3229	501
1997	1962	4162	3410	351
1998	1471	3251	2644	505
1999	2262	4658	3763	430
2000	2662	5068	4152	327
2001	3511	6429	5464	292
2002	3105	5743	4791	336
2003	3494	6287	5404	285
2004	2443	4297	3653	342
2005	2787	5076	4348	351
2006	3023	5274	4514	311
2007	1782	3052	2557	366
2008	1589	2521	2123	318
2009	1351	2160	1793	245
2010	1151	1903	1612	245
2011	1152	1863	1543	280
2012	907	1474	1224	258
2013	862	1450	1200	149
2014	747	1224	1054	191
2015	576	927	784	191

Table 4.10.1 *Nephrops* in FU 33. (Off Horns Reef) Landings (tonnes) by country, 1993–2013.

	Belgium	Denmark	Germany	Netherl.	UK	Total **
1993	0	159		na	1	160
1994	0	137		na	0	137
1995	3	158		3	1	164
1996	1	74		2	0	77
1997	0	274		2	0	276
1998	4	333	8	12	1	350
1999	22	683	14	12	6	724
2000	13	537	12	39	9	597
2001	52	667	11	61	+	791
2002	21	772	13	51	4	861
2003	15	842	4	67	1	929
2004	37	1097	24	109	1	1268
2005	16	803	31	191	9	1050
2006	97	710	151	314	15	1288
2007	118	610	201	496	42	1467
2008	130	362	160	386	58	1096
2009	121	231	150	491	170	1163
2010	56	180	206	295	69	806
2011	163	396	202	403	28	1191
2012	181	394	132	376	2	1084
2013	156	310	174	304	2	946
2014	229	387	161	360	9	1146
2015*	299	371	142	187	4	1003

*** provisional na = not available**

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

Table 4.10.2 *Nephrops* in FU 33. (Off Horns Reef): Danish logbook recorded effort (kW days, Days at sea and fishing days) and LPUE (kg/kW day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, 1991–2015.

Year	kW days	Days at sea	Fishing days	LPUE*
1991	596367.7	1363	1087	0.12
1992	533565	1382	1068	0.14
1993	628812.5	1441	1141	0.25
1994	387571.7	997	782	0.35
1995	376068.1	1068	813	0.42
1996	212737.4	634	494	0.35
1997	490267.8	1446	1126	0.56
1998	752999.4	2254	1741	0.44
1999	1168914	3400	2714	0.58
2000	1039983	3200	2473	0.52
2001	1251480	3836	3049	0.53
2002	1610003	4544	3533	0.48
2003	1598038	4722	3795	0.53
2004	1900555	5626	4407	0.58
2005	1084823	3276	2624	0.74
2006	959737.6	2703	2146	0.74
2007	773976.6	1972	1548	0.79
2008	445158.7	926	722	0.81
2009	274715.9	647	547	0.84
2010	246931.1	528	425	0.73
2011	346294.2	760	608	1.14
2012	298139	700	589	1.32
2013	238654.1	560	492	1.30
2014	374372.2	882	752	1.03
2015	279017.5	663	586	1.33

***kg/ kW days**

Table 4.11.1. ***Nephrops*, Devil's Hole (FU 34). Nominal landings (tonnes) of *Nephrops* 1986–2015 as reported to the WG. Scottish data only from 1986 to 2009.**

	UK Scotland							
Year	*Nephrops* trawl	Other trawl	Creel	Sub-total	UK (E, W & NI)	Denmark	Netherlands	Total
1986	20	3	0	23				23
1987	2	3	0	5				5
1988	1	1	0	2				2
1989	15	13	0	28				28
1990	20	6	0	26				26
1991	64	21	0	85				85
1992	78	28	0	106				106
1993	23	21	0	44				44
1994	79	50	0	129				129
1995	37	95	0	132				132
1996	40	89	0	129				129
1997	30	70	0	100				100
1998	15	73	0	88				88
1999	80	122	0	202				202
2000	89	95	0	184				184
2001	159	112	0	271				271
2002	240	103	0	343				343
2003	518	157	0	675				675
2004	398	90	0	488				488
2005	253	125	0	378				378
2006	359	89	0	448				448
2007	649	68	0	717				717
2008	844	93	0	937				937
2009	1297	8	0	1305				1305
2010	816	22	0	838	25	1	1	865
2011	406	16	0	422	6	4		432
2012	546	4	0	550	37	10		597
2013	65	41	0	106	11	3		120
2014	81	226	0	307	13			320
2015*	218	182	0	400	39	<0.5		439

*** provisional**

Table 4.11.2 *Nephrops*, Devils Hole (FU 34): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2015.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	184	3391	54.3
2001	271	3142	86.3
2002	343	2022	169.6
2003	675	2614	258.2
2004	488	1551	314.6
2005	378	1545	244.7
2006	448	1440	311.1
2007	717	1824	393.1
2008	937	1673	560.1
2009	1305	1921	679.3
2010	838	1465	572.0
2011	422	1041	405.4
2012	550	1255	438.2
2013	106	438	242.0
2014	307	758	405.0
2015	400	1222	327.3

*** provisional**

Table 4.11.3. *Nephrops*, Devil's Hole (FU 34). Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 2006–2015. Samples not available in 2012 and 2013.

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
2006	29.7	29.8	39.7	38.1
2007	30.4	28.7	40.5	39.2
2008	31	30.5	40.3	39.6
2009	31.7	31.1	41.3	40.6
2010	32.1	29.7	39.1	38.8
2011	31.7	30.7	43.7	40.4
2012	na	na	na	na
2013	na	na	na	na
2014	33.0	34.0	42.0	41.4
2015	na	na	na	na
	na = not available			

Table 4.11.4. ***Nephrops*****, Devil's Hole (FU 34). Results of the 2003, 2005, 2009–12 and 2014–2015 surveys.**

Year	Stations	Mean density burrows/m²	95% confidence interval burrows/m²
2003	20	0.09	0.02
2004	no survey		
2005	29	0.09	0.04
2006	no survey		
2007	no survey		
2008	no survey		
2009	12	0.28	0.13
2010	19	0.24	0.08
2011	14	0.16	0.09
2012	15	0.14	0.06
2013	no survey		
2014	13	0.13	0.04
2015	17	0.16	0.06

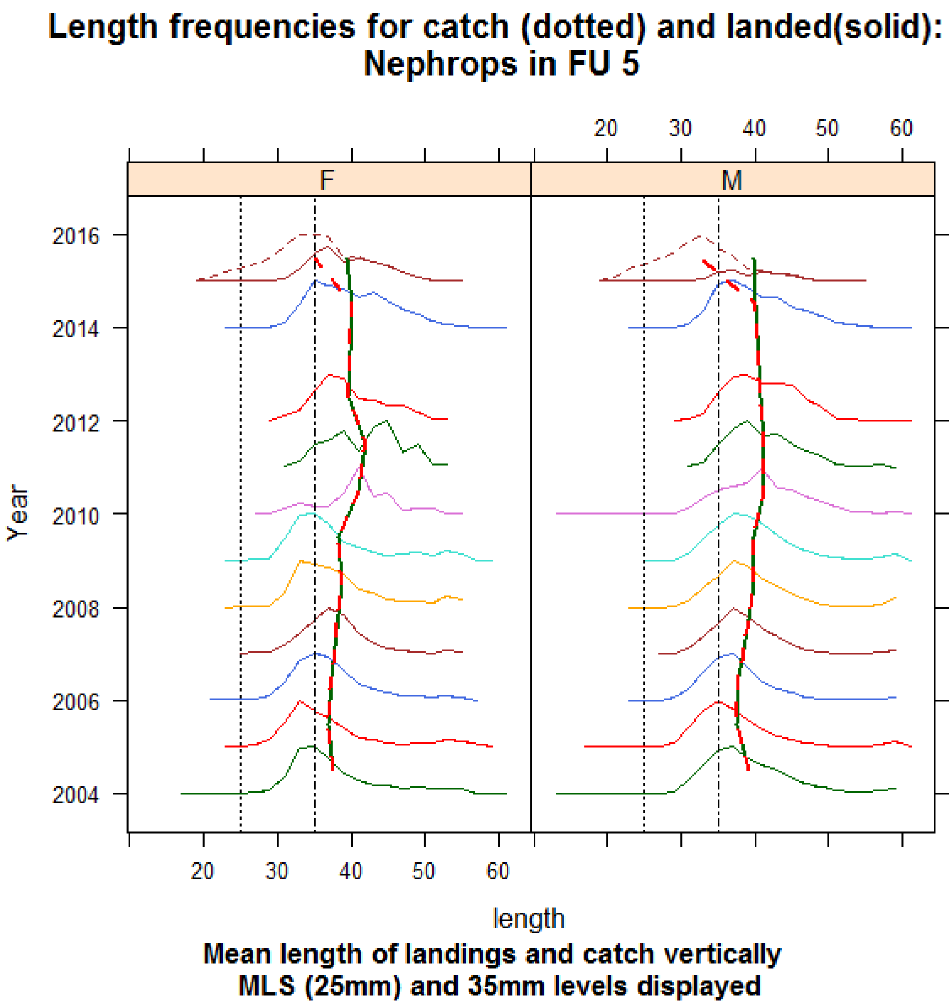


Figure 4.3.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2004 to 2011.

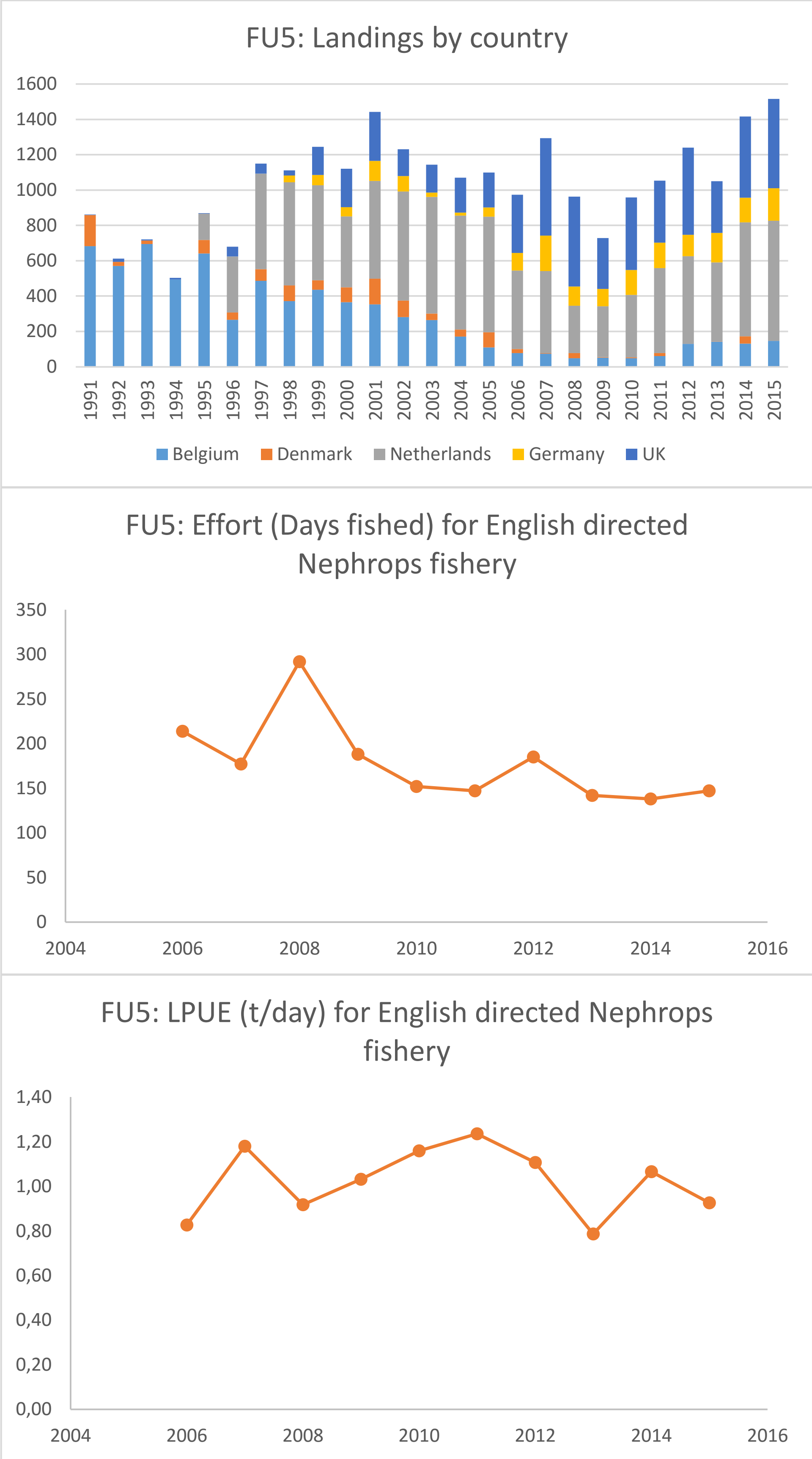


Figure 4.3.2 FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUE.

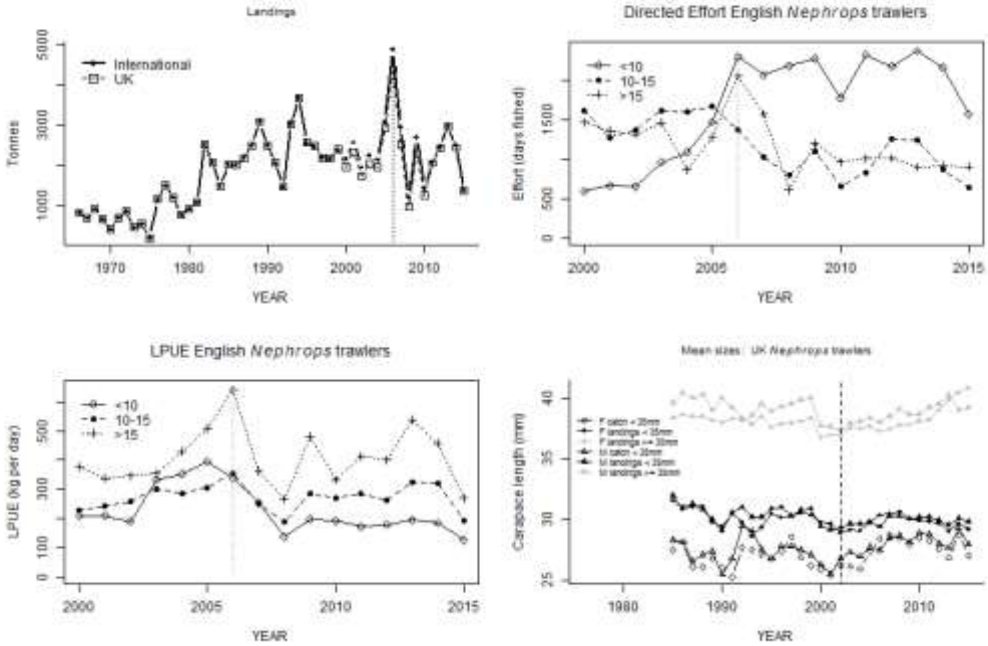


Figure 4.4.1 ***Nephrops*** **in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.**

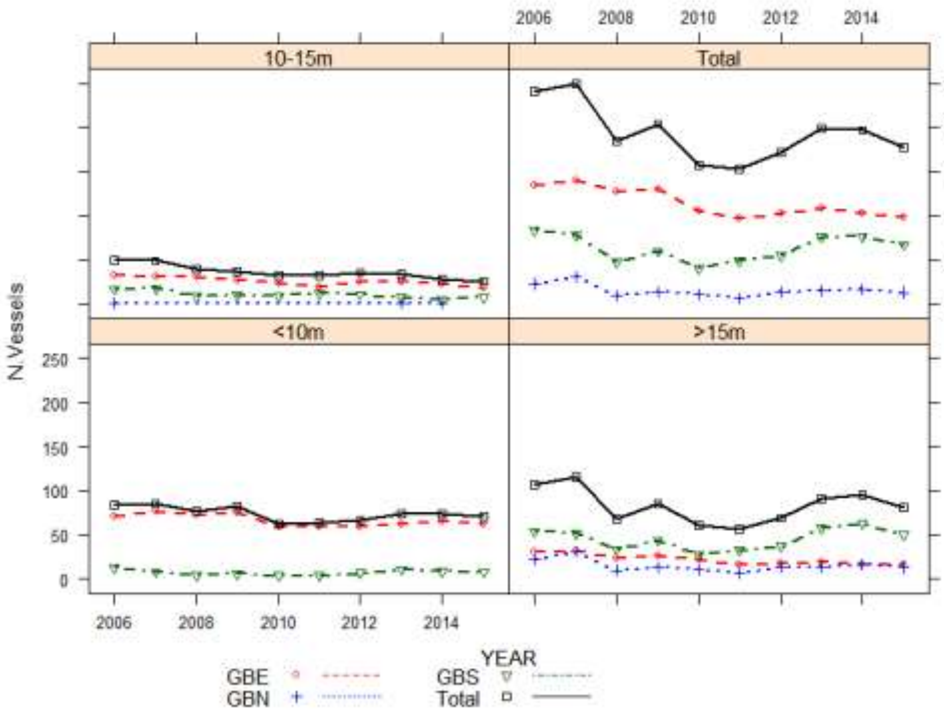


Figure 4.4.2 ***Nephrops*** **in FU6, Number of participating vessels (from UK) by vessel size category.**

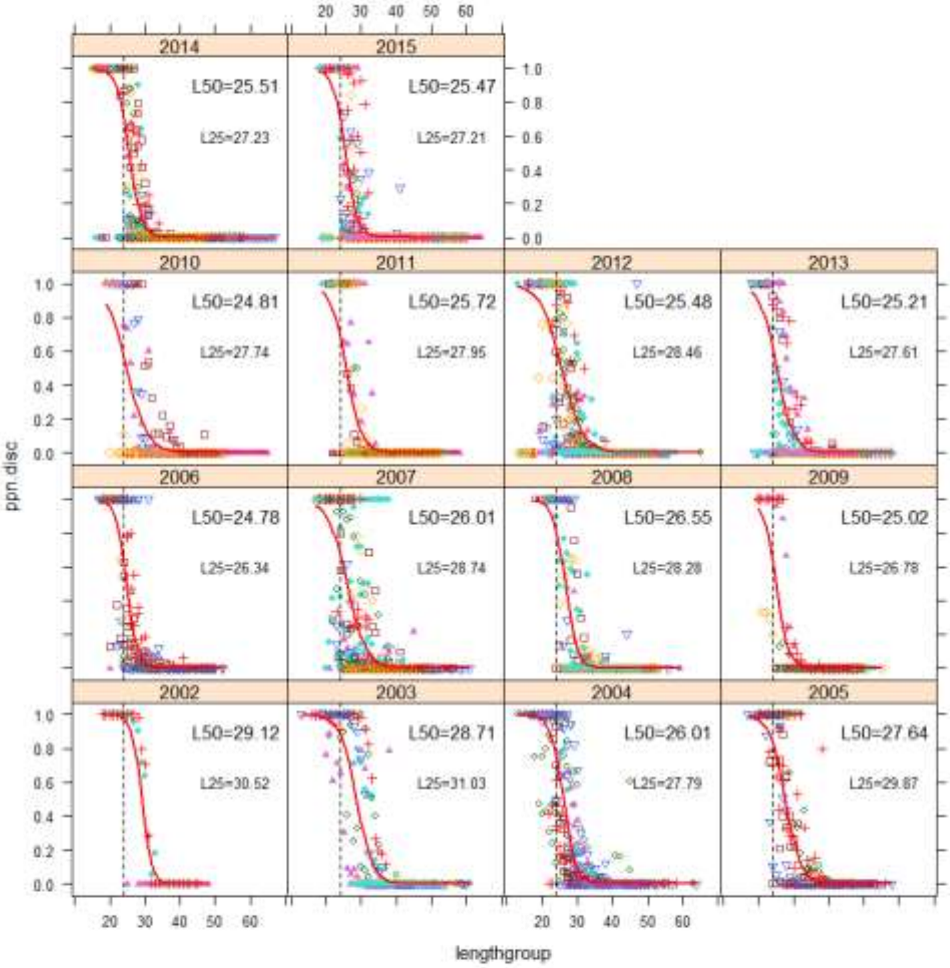


Figure 4.4.3 ***Nephrops*** **in FU6, annual discard ogives. The different point shapes represent different sampling trips within any year.**

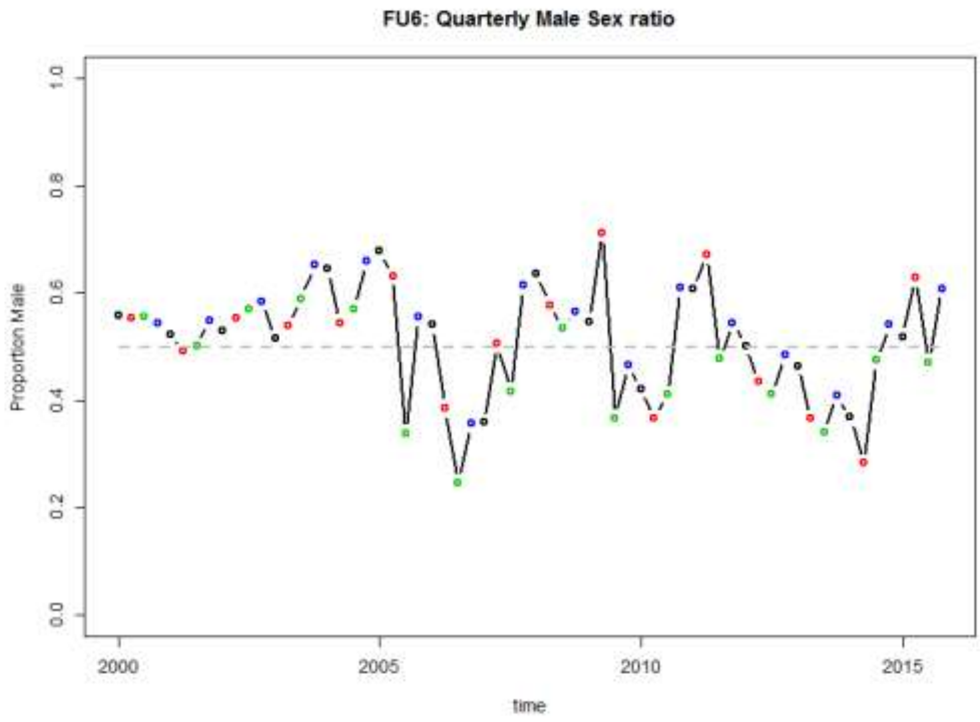


Figure 4.4.4 ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

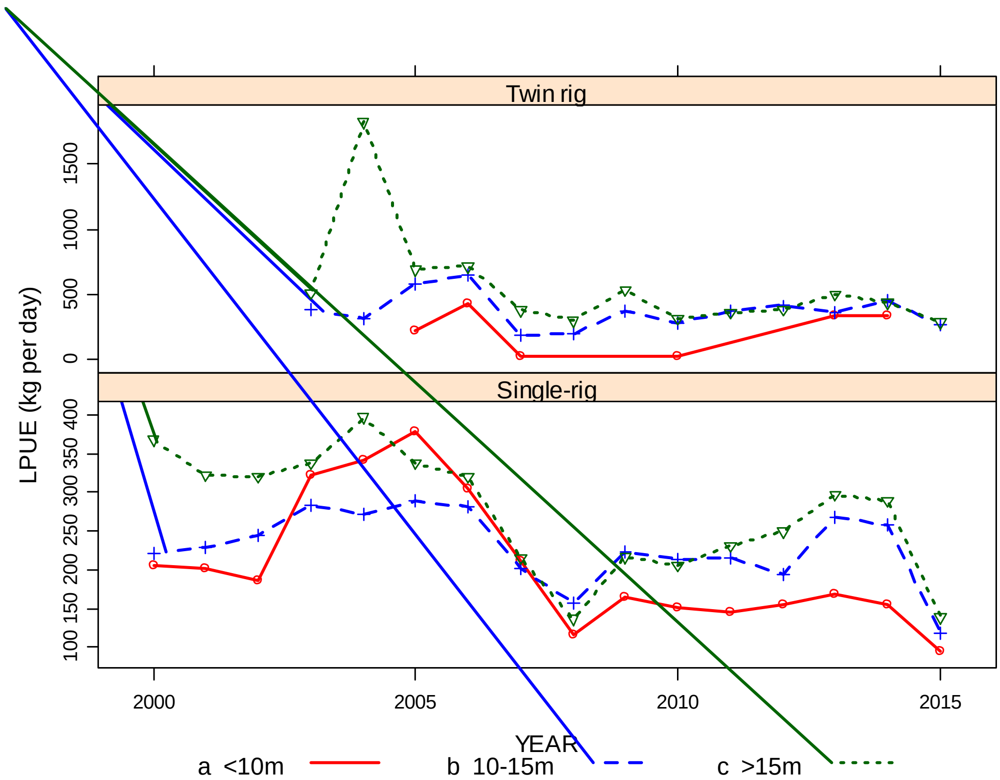


Figure 4.4.5 ***Nephrops*** **in FU6: LPUE for directed English trawlers by gear type and vessel size**

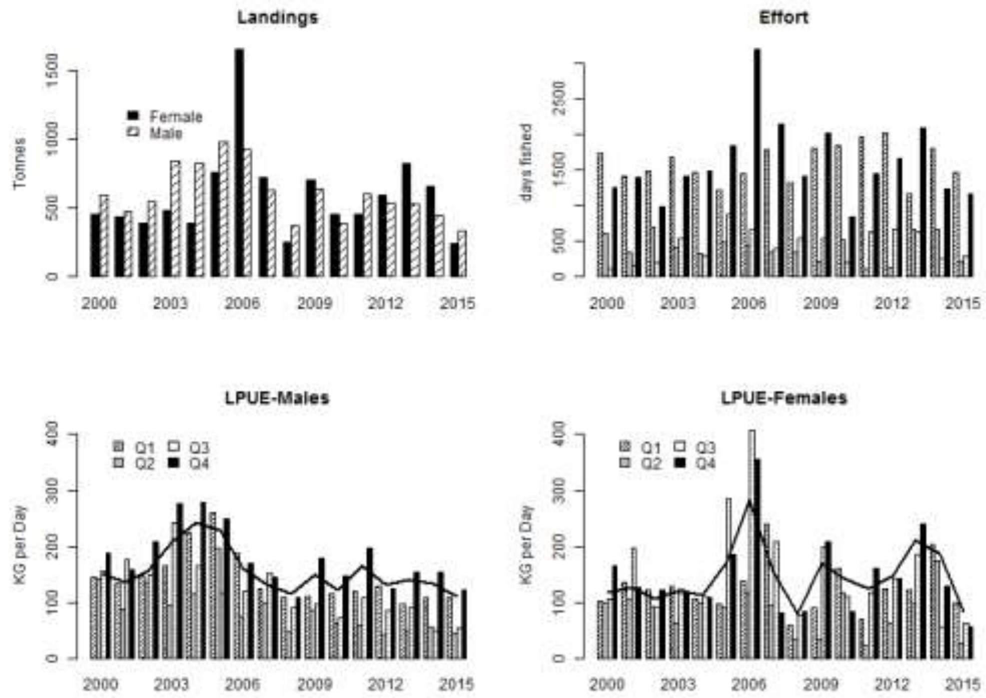


Figure 4.4.6 *Nephrops* in FU6: LPUE by sex and quarter.

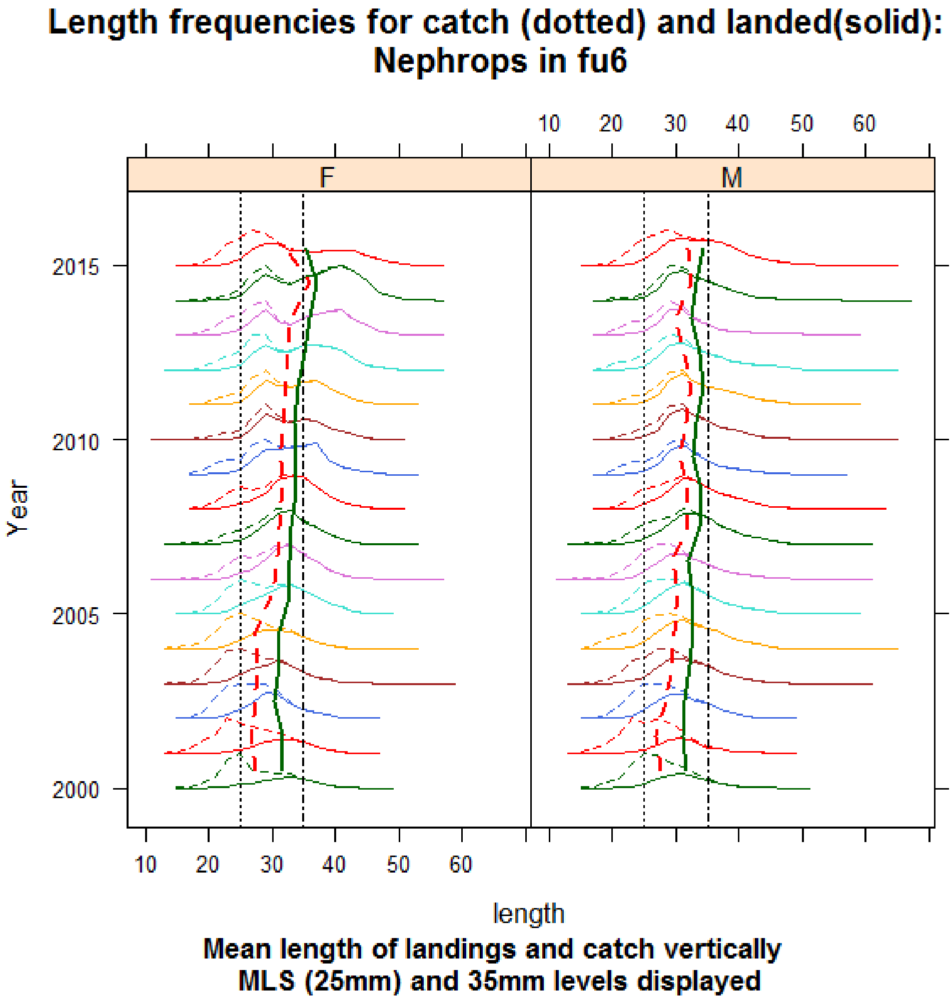


Figure 4.4.7 ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

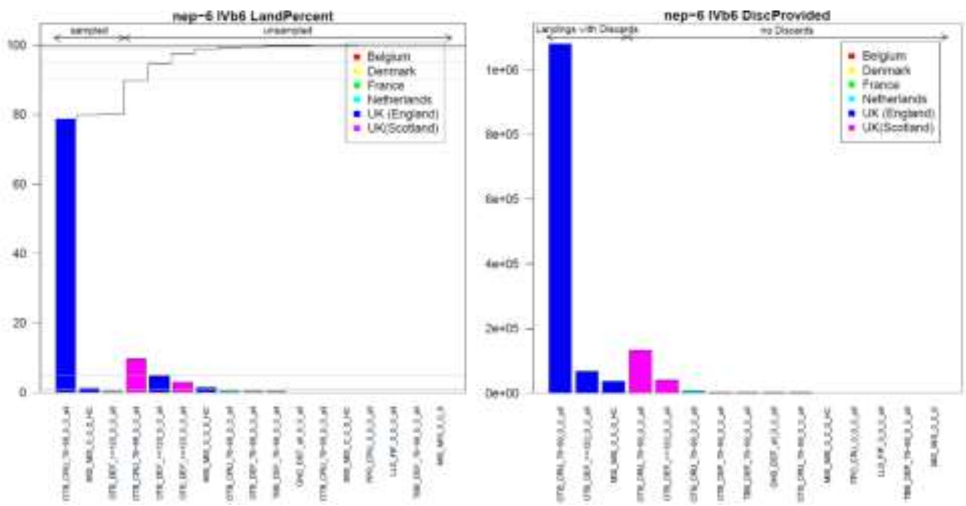


Figure 4.4.8 ***Nephrops*** **in FU6: Breakdown of landings by gear, country and sample availibilty.**

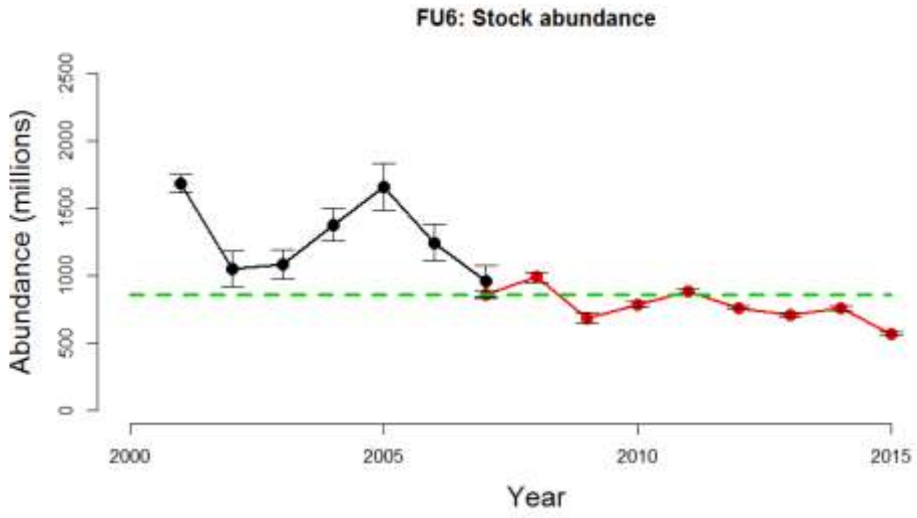


Figure 4.4.9 *Nephrops* in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the Geostatsistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.

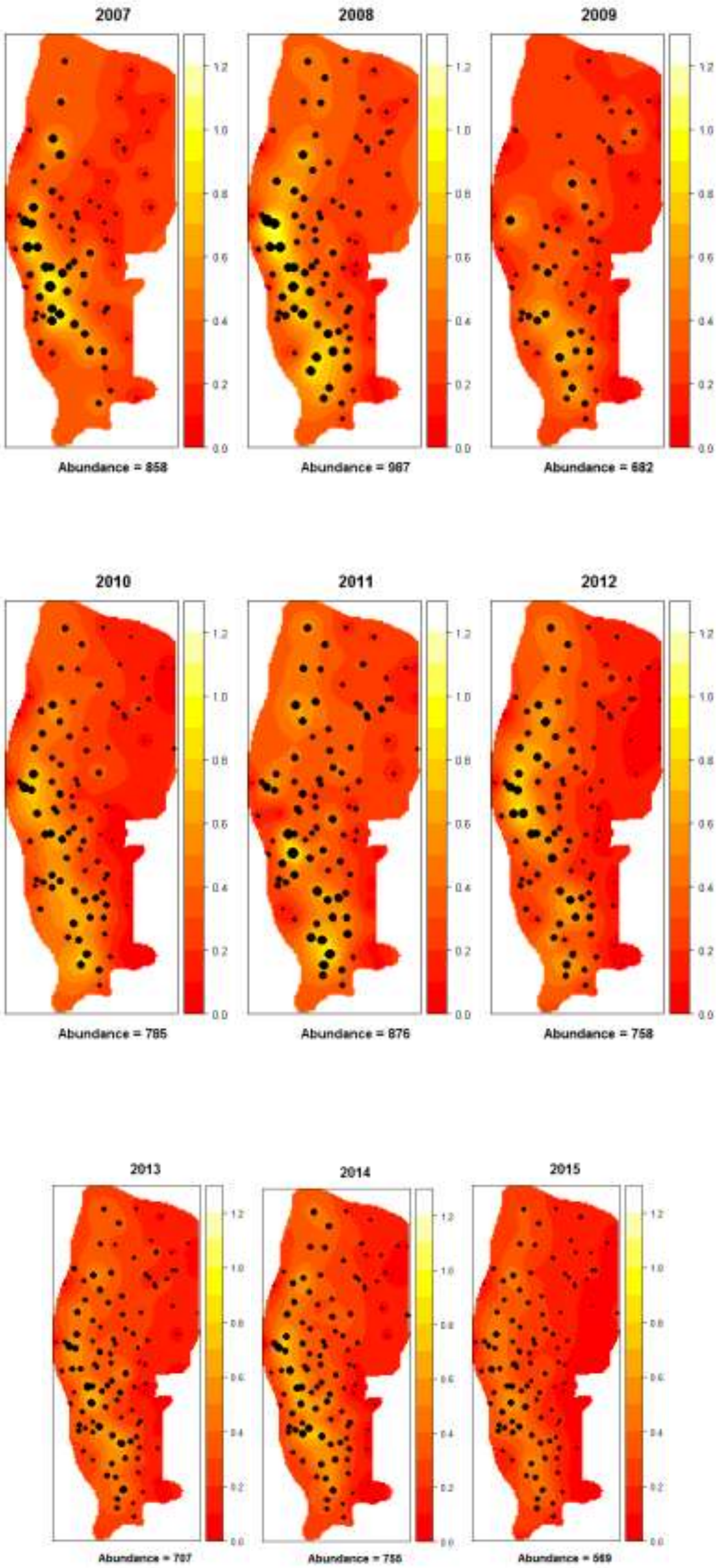


Figure 4.4.10 *Nephrops* in FU6: Results of the UWTV survey.

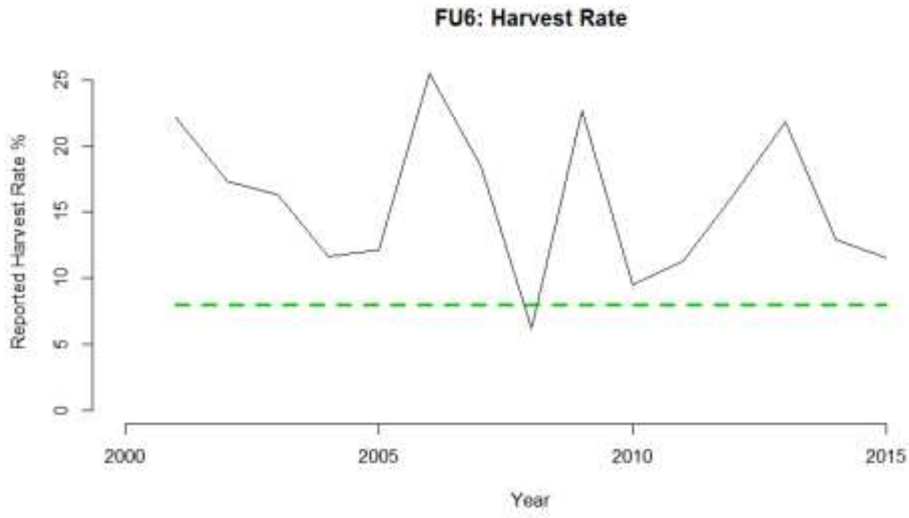


Figure 4.4.11 *Nephrops* in FU6: Observed harvest ratio (removals divided by abundance estimate).

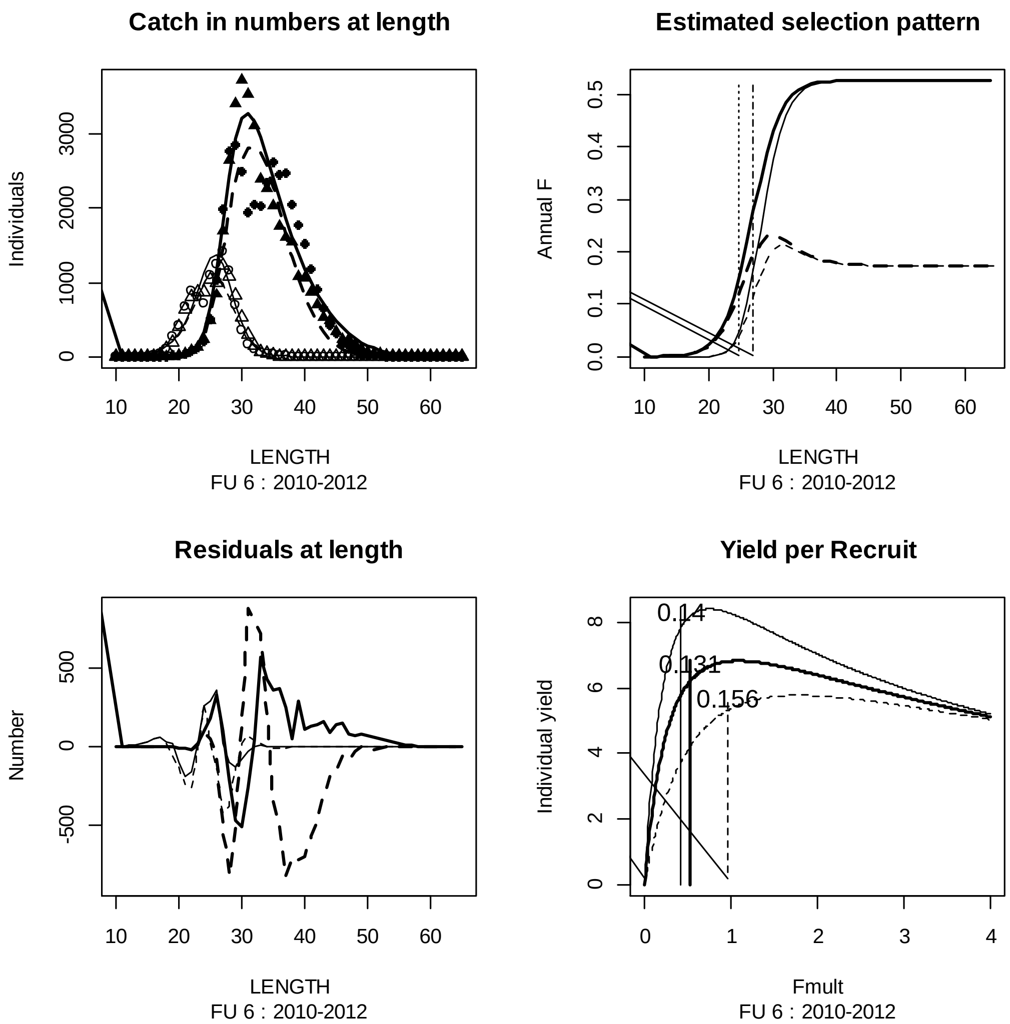


Figure 4.4.12 *Nephrops* in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed – expected) at length. The bottom right gives the Yield Per recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent $F_{0.1}$ for the three curves.

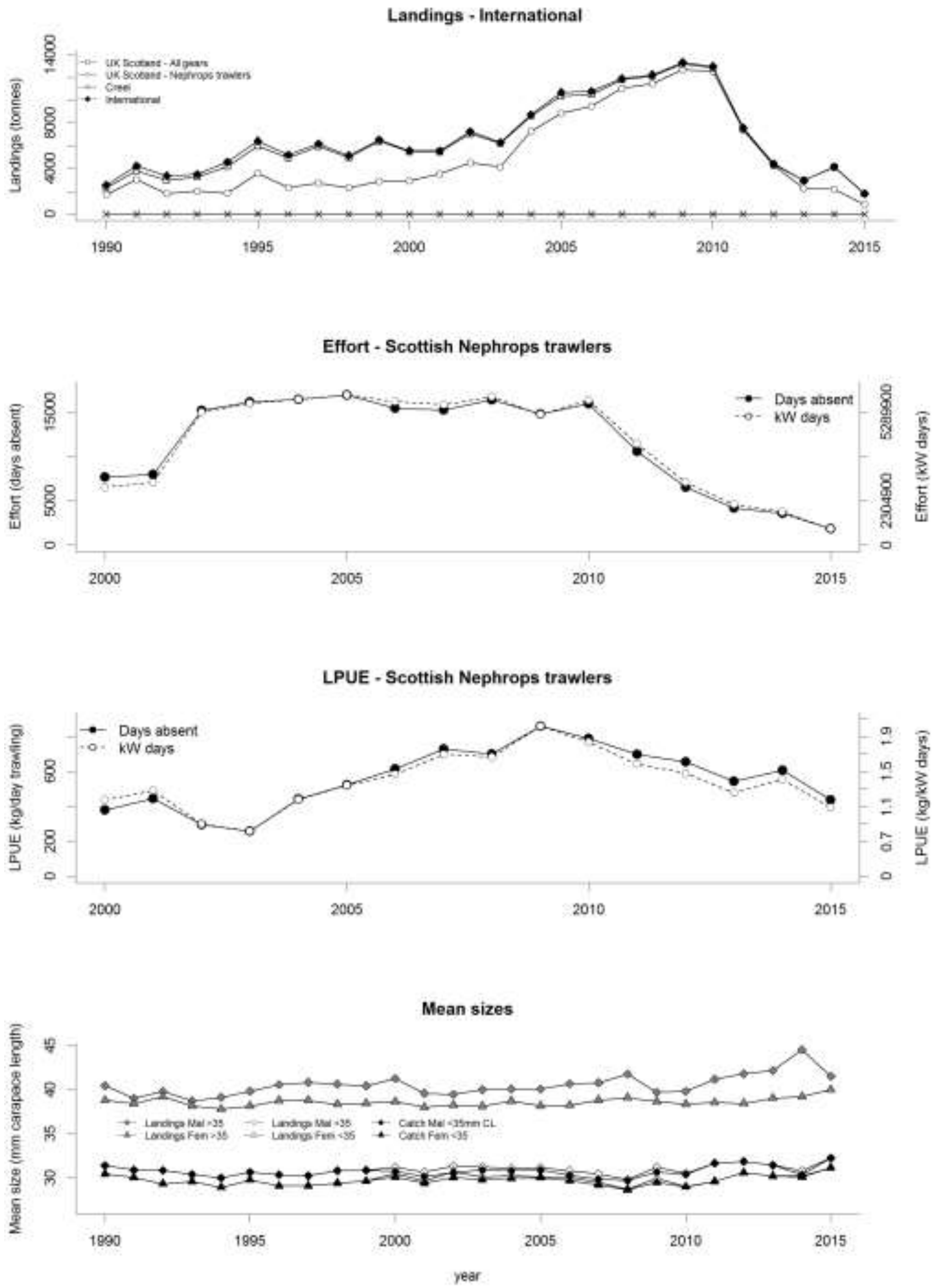
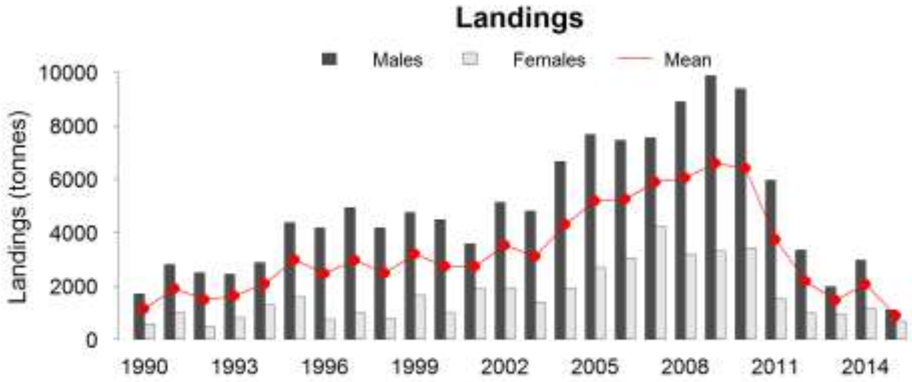


Figure 4.5.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2015.**



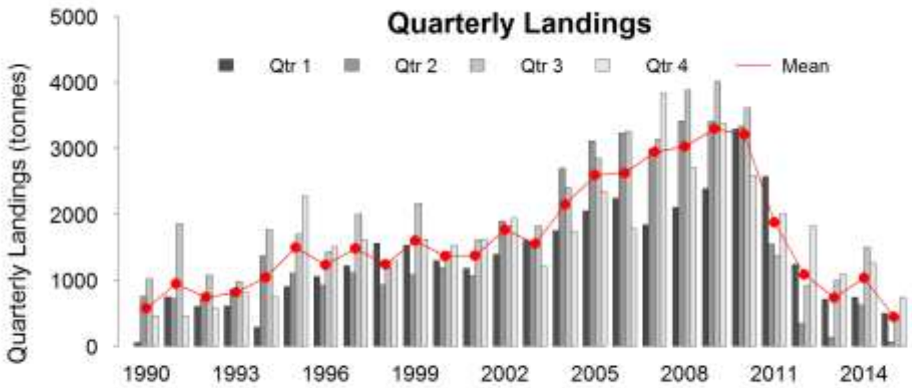


Figure 4.5.2 *Nephrops*, Fladen (FU 7), Landings by quarter and sex from Scottish *Nephrops* trawlers.

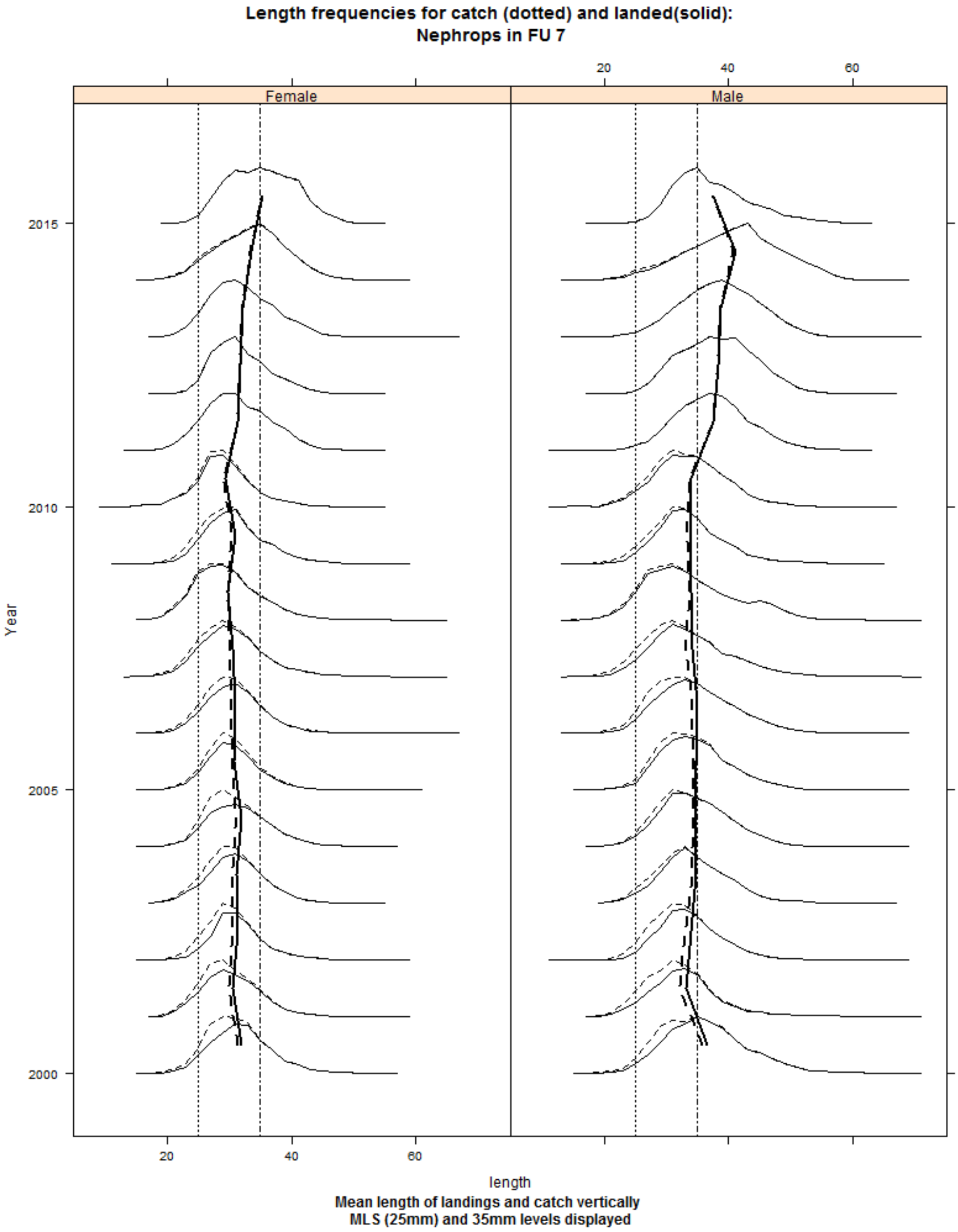
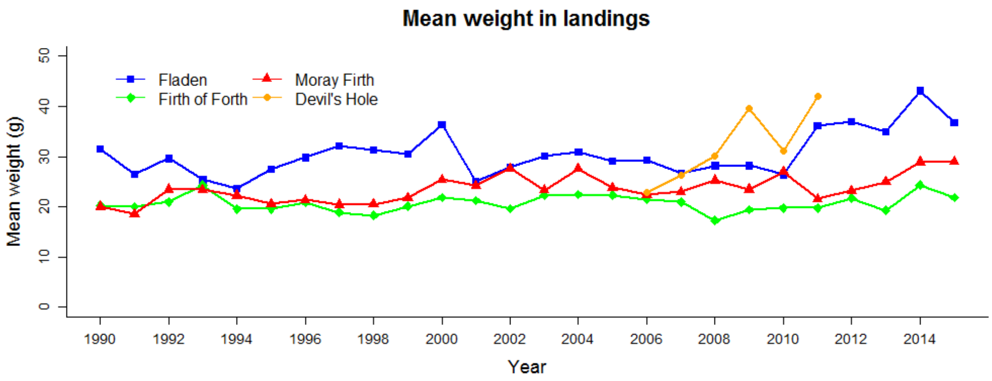


Figure4.5.3 *Nephrops* Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2015 (top). Mean sizes of catch and landings are displayed vertically.



4.5.4 *Nephrops*, (FUs 7–9 and 34, Fladen, Firth of Forth, Moray Firth and Devil's Hole). Individual mean weight (g) in the landings from 1990–2015 (Scottish market sampling data). FU 34 data only shown for 2006–2011.

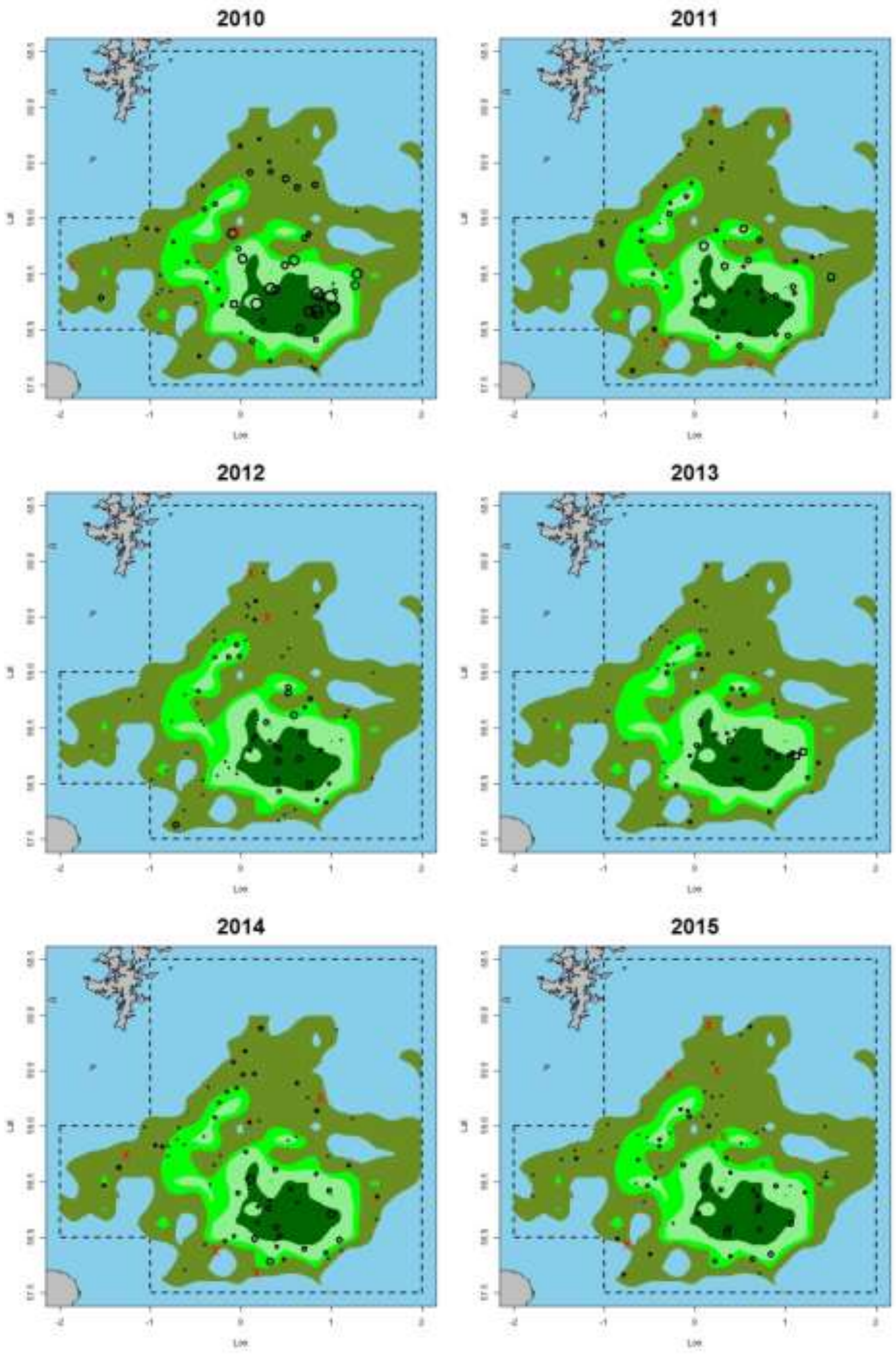


Figure 4.5.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2010–2015). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

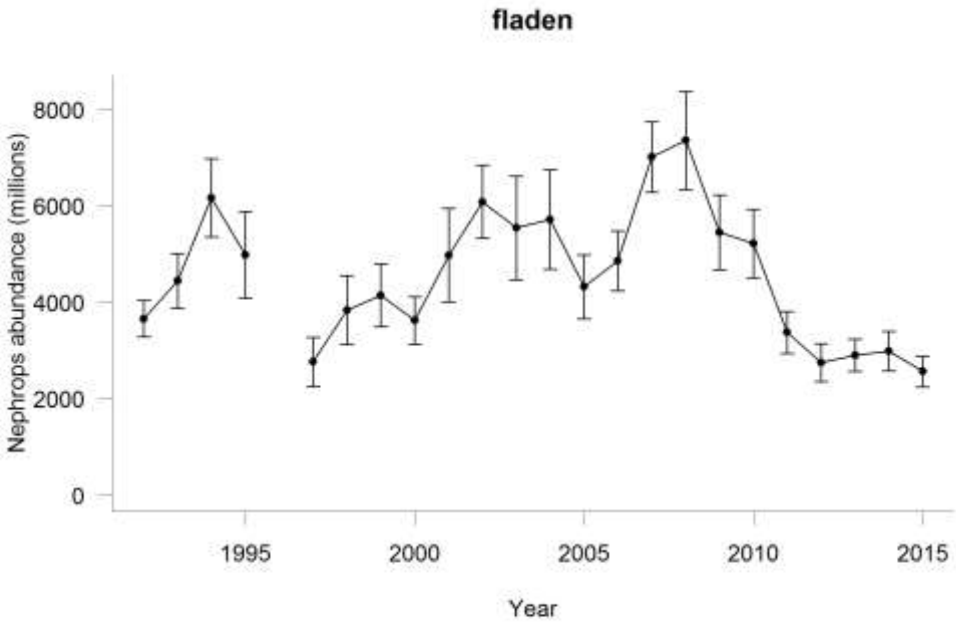


Figure 4.5.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates with 95% confidence intervals, 1992 – 2015.**

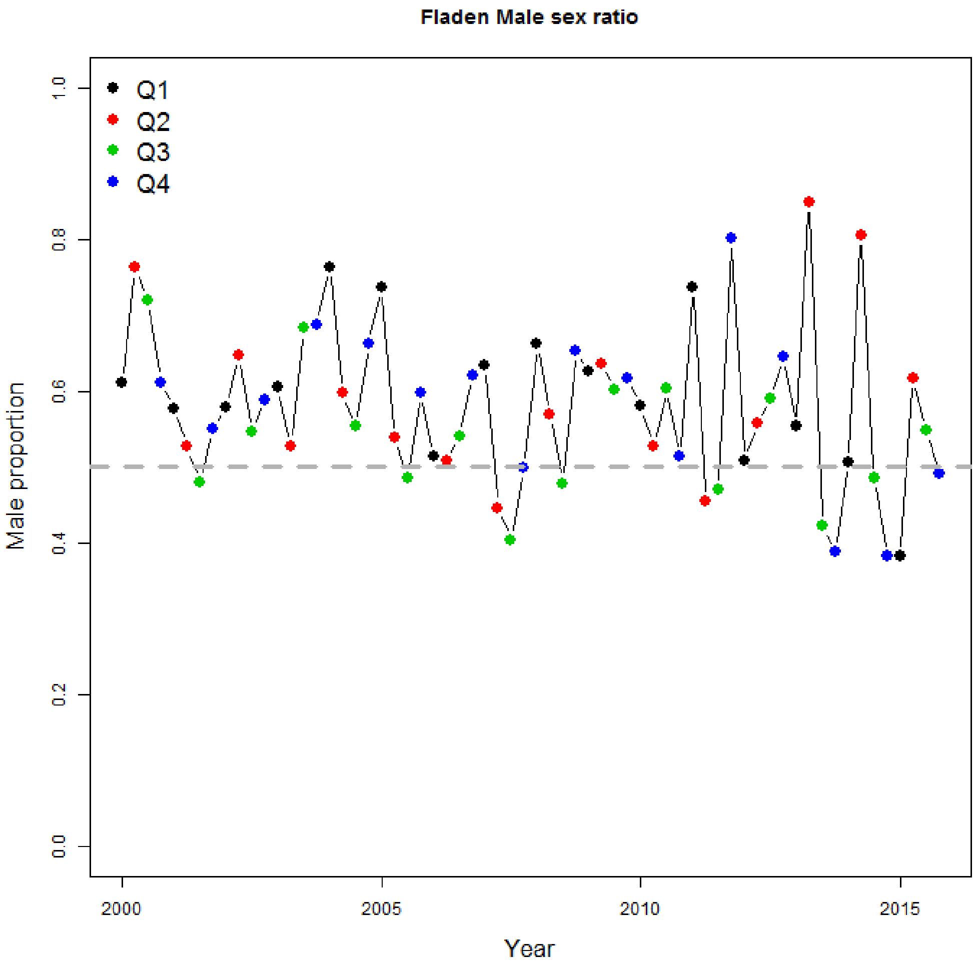


Figure 4.5.7 ***Nephrops*****, Fladen (FU 7), Quarterly sex ratio (by number) in catches.**

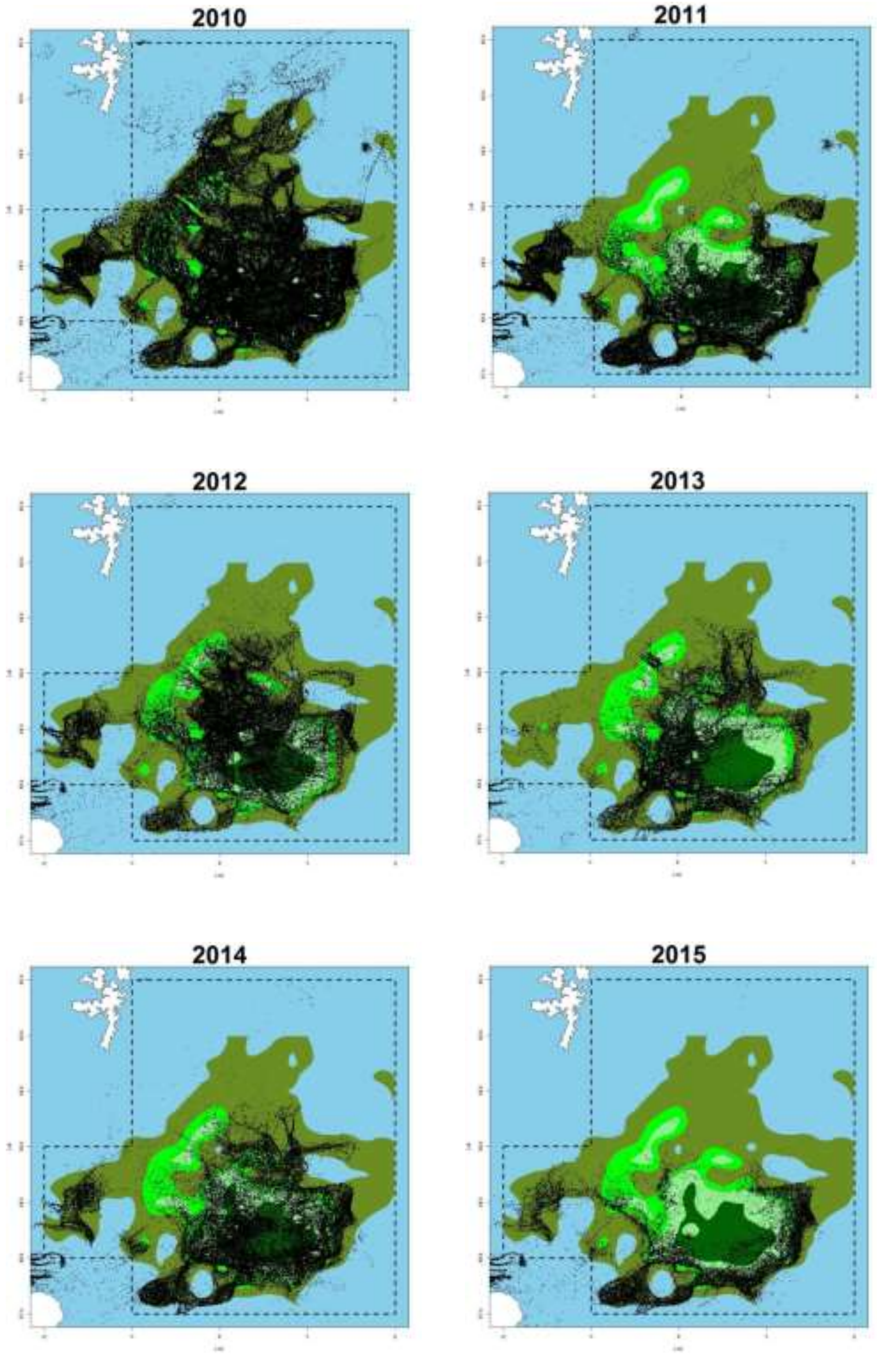


Figure 4.5.8 ***Nephrops*****, Fladen (FU 7), VMS distribution of vessels in Fladen (2010–2015). Points in figure correspond to fishing pings (speed<5 kn) associated with trips made by otter trawlers landing more than 25% of** ***Nephrops*** **by weight.**

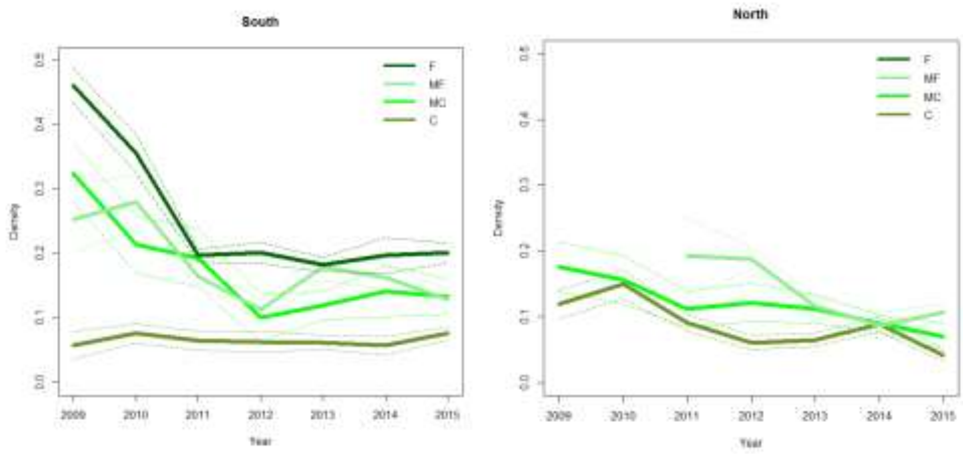


Figure 4.5.9 ***Nephrops*****, Fladen (FU 7), UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt & clay >80%); MF: medium fine sediment (55%< silt & clay< 80); MC: medium coarse sediment (40%< silt & clay< 55); C: coarse sediment (silt & clay <40%).**

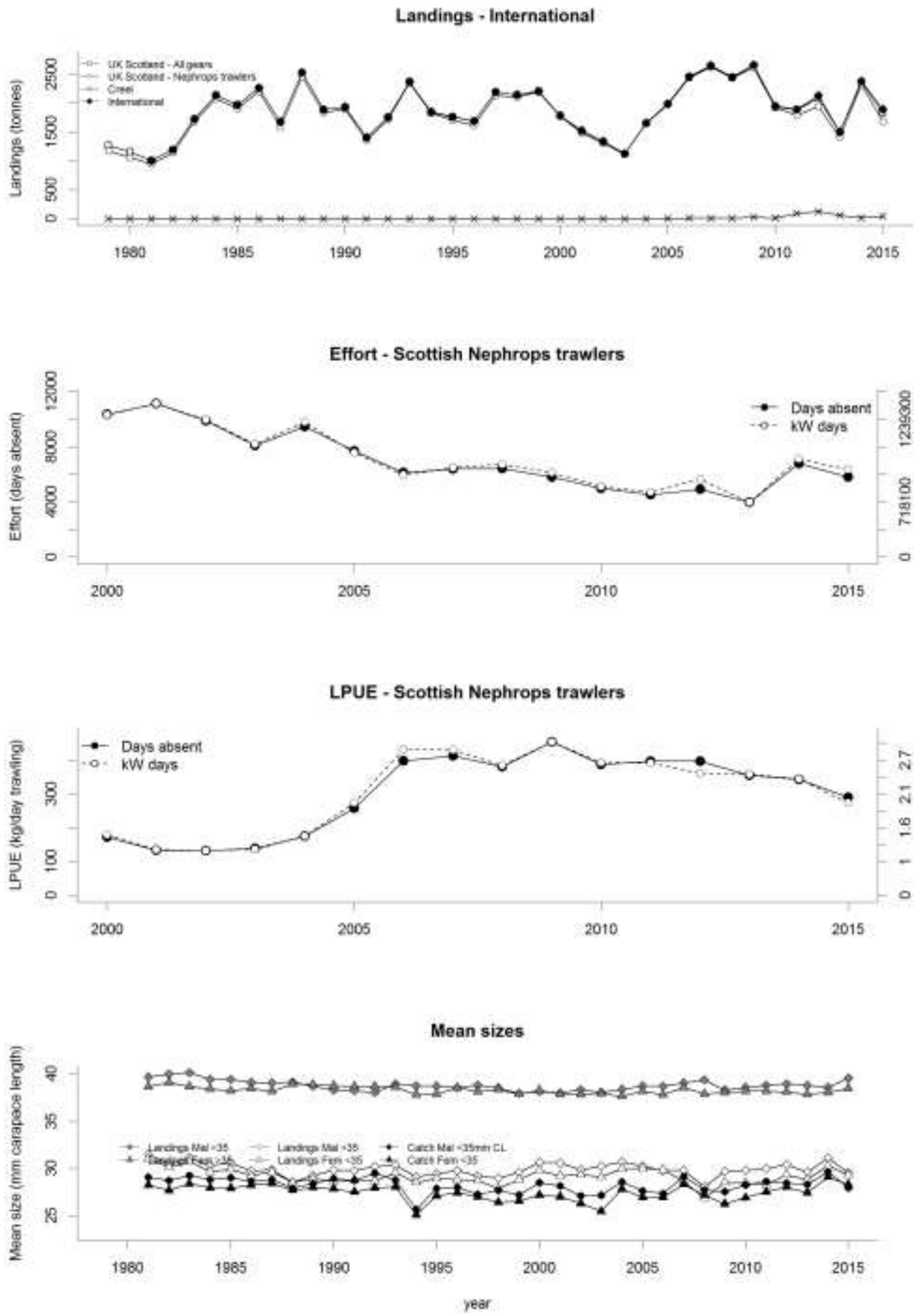
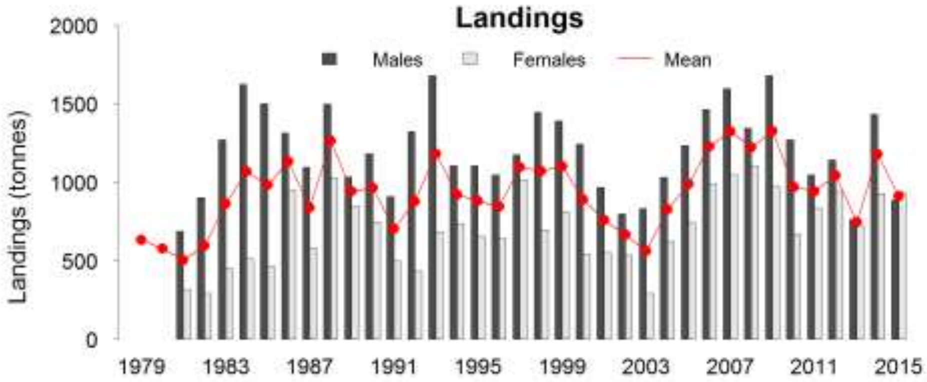


Figure 4.6.1 ***Nephrops*****, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2015.**



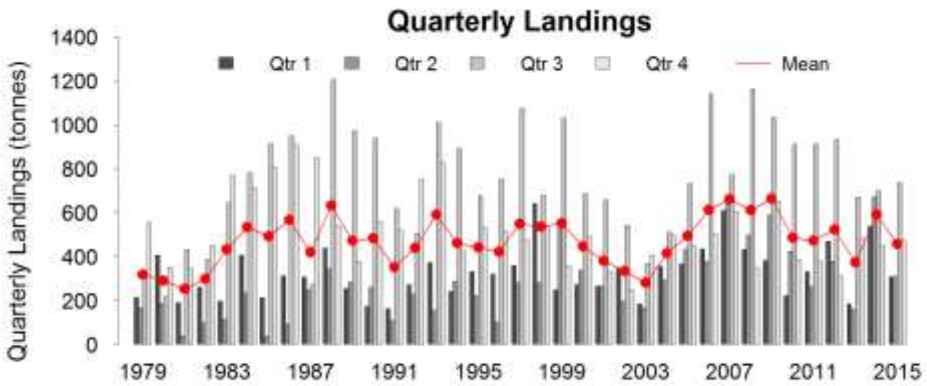


Figure 4.6.2 ***Nephrops*****, Firth of Forth (FU 8), Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

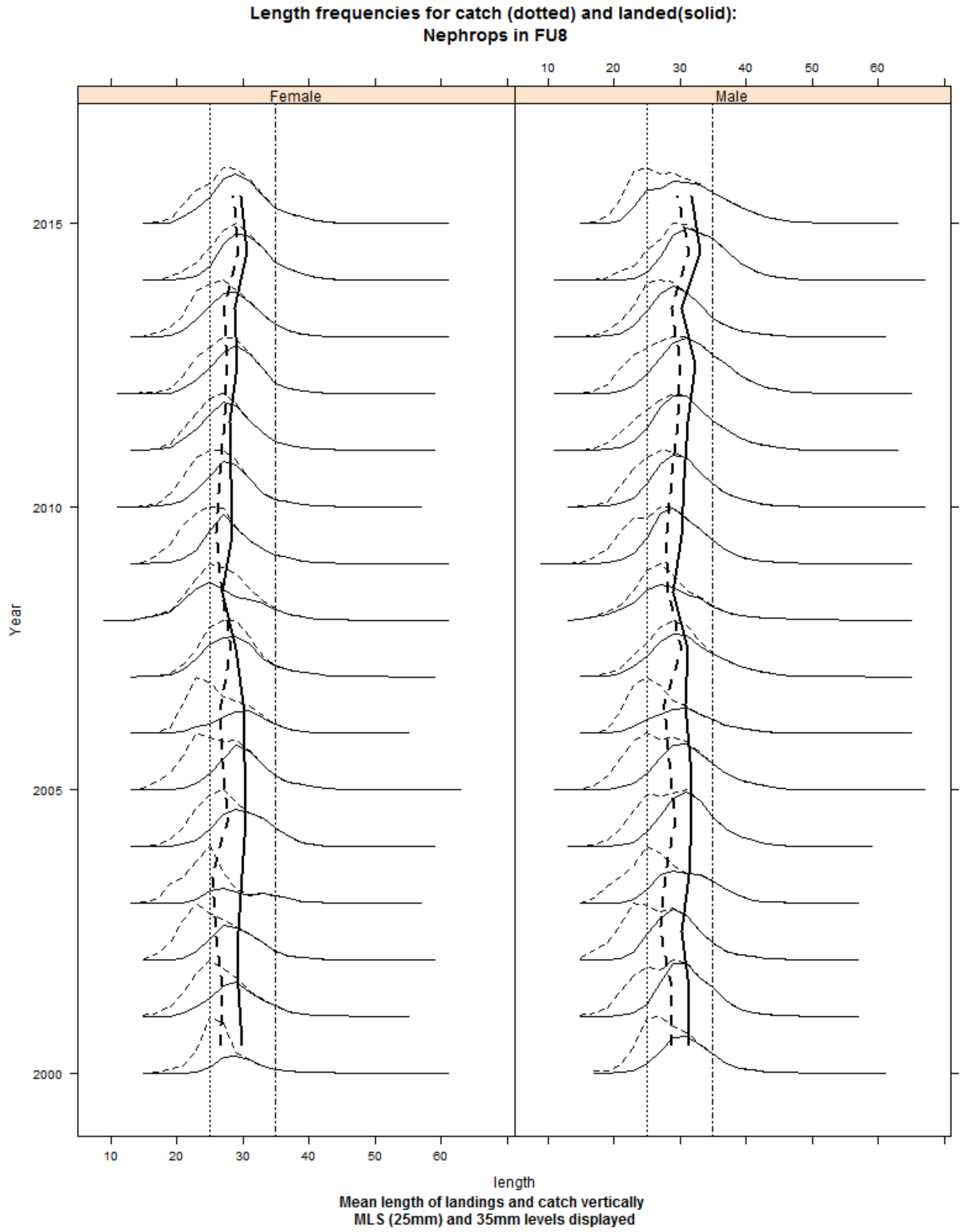


Figure 4.6.3 ***Nephrops*** **Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2015 (top). Mean sizes of catch and landings are displayed vertically.**

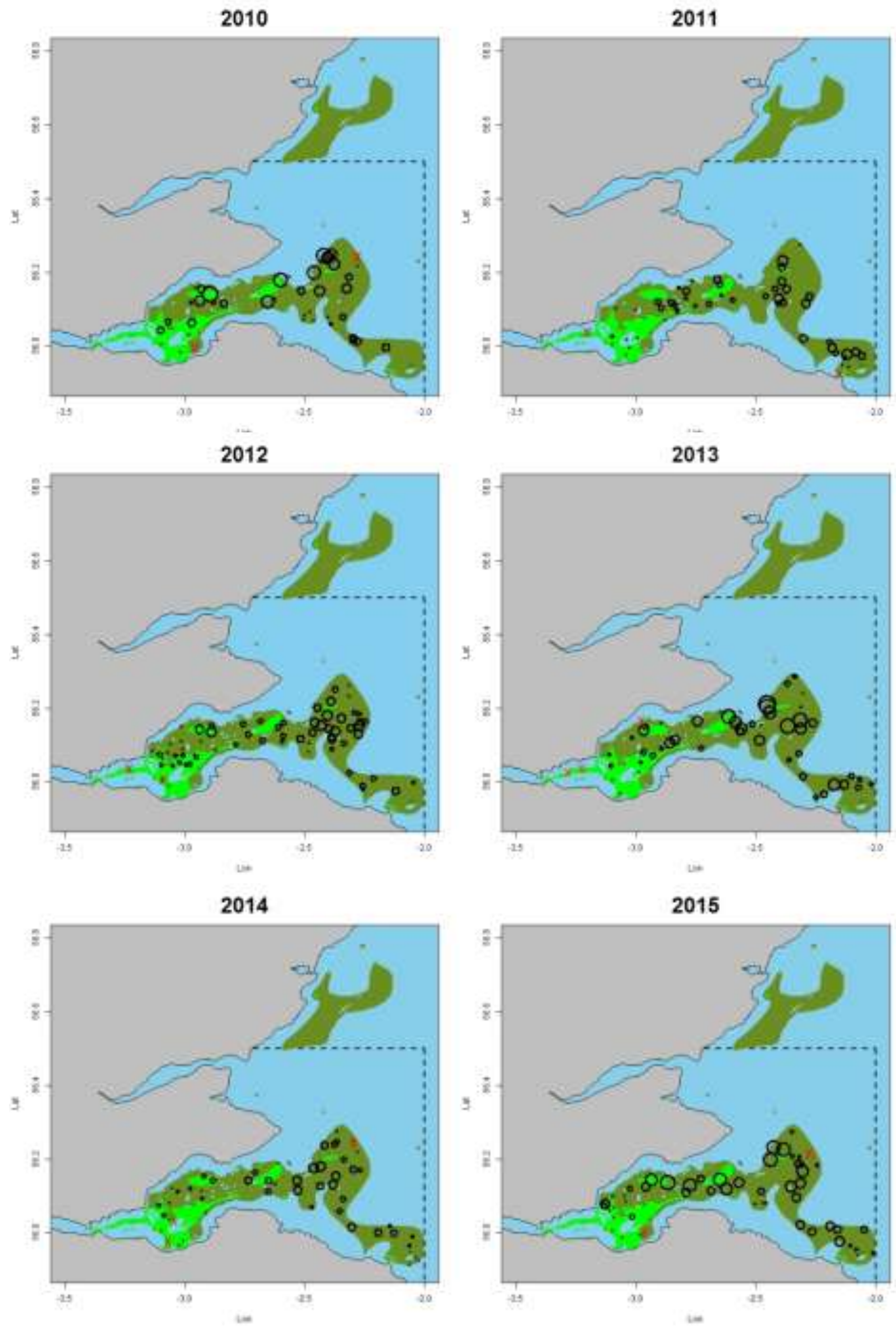


Figure 4.6.4 ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2010–2015). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

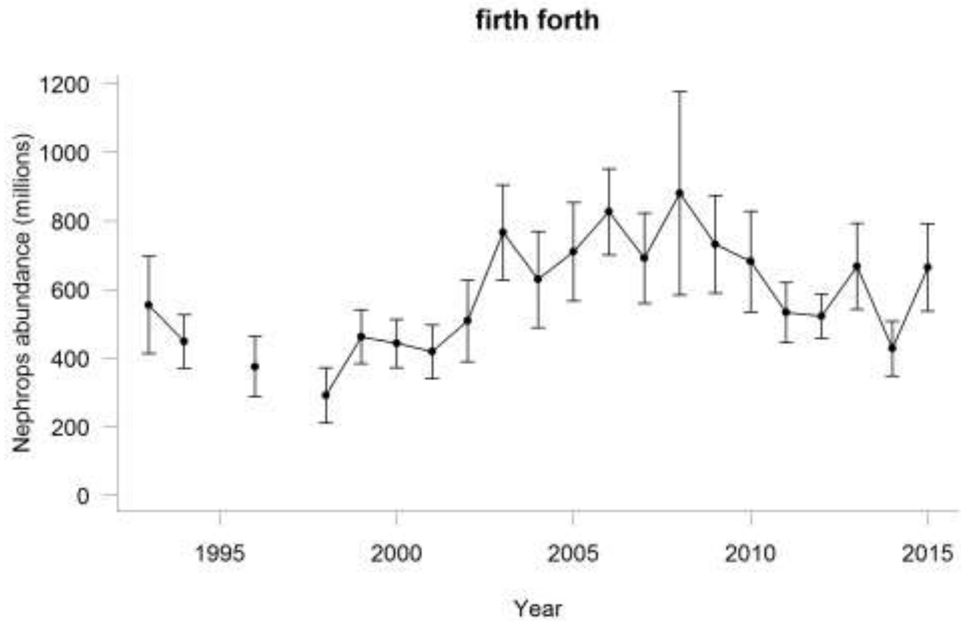


Figure 4.6.5 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates with 95% confidence intervals, 1993 – 2015.**

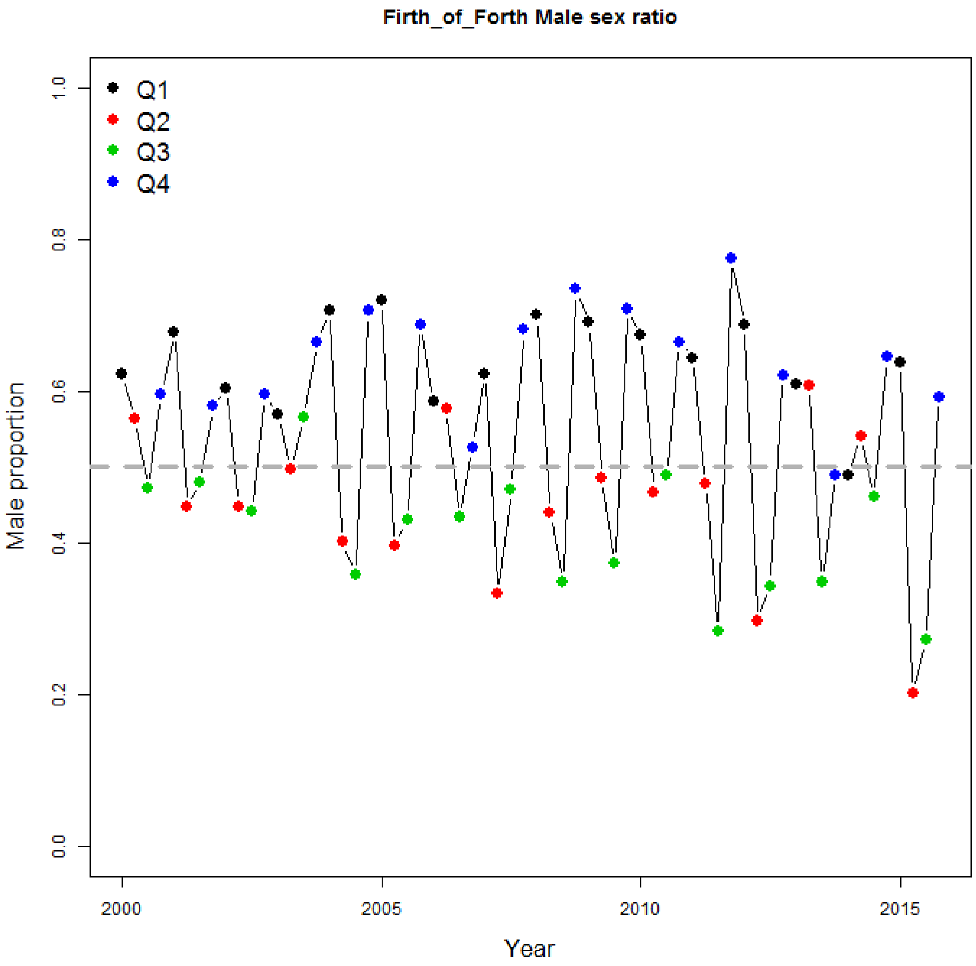


Figure 4.6.6 ***Nephrops*****, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.**

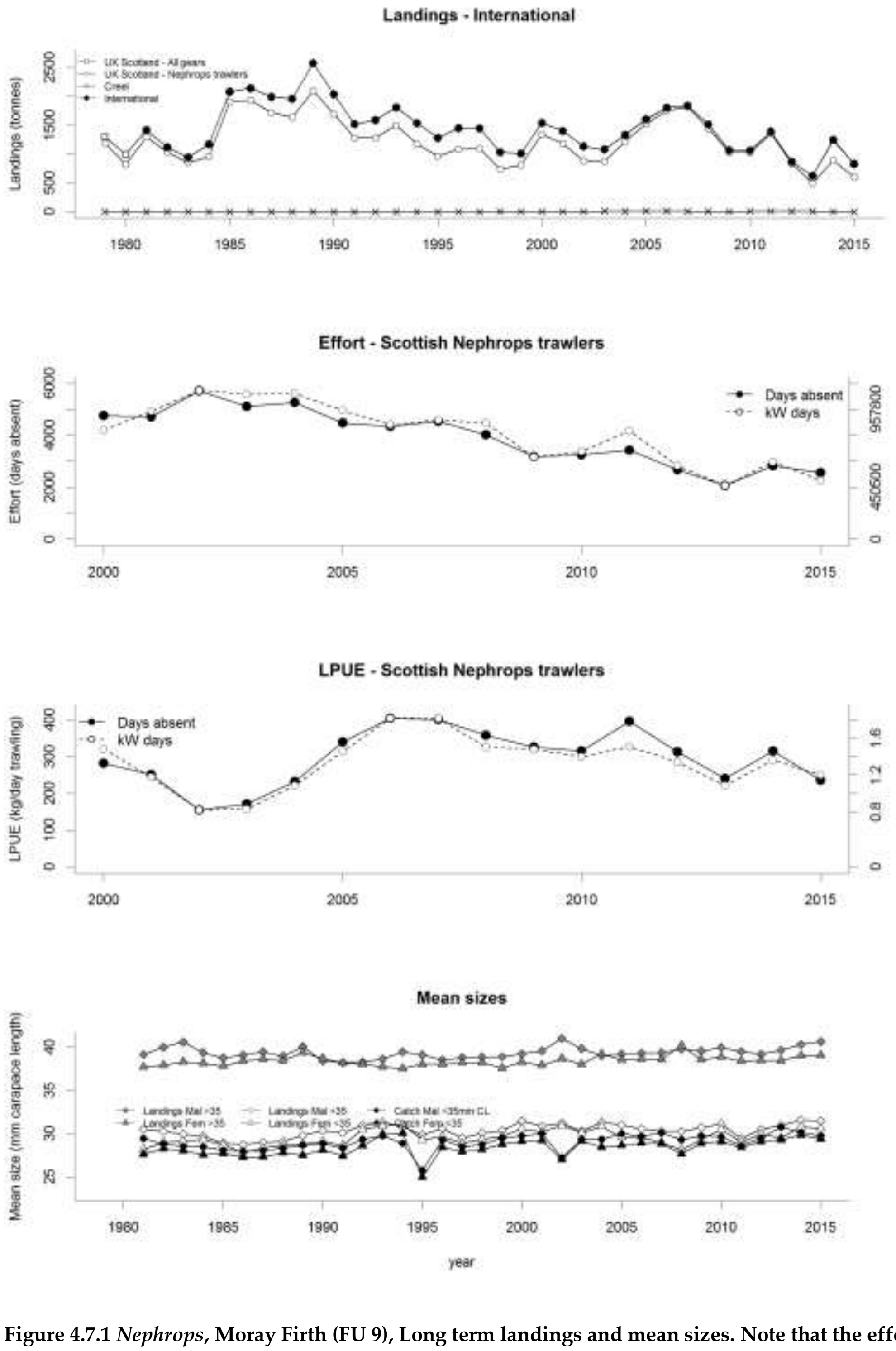
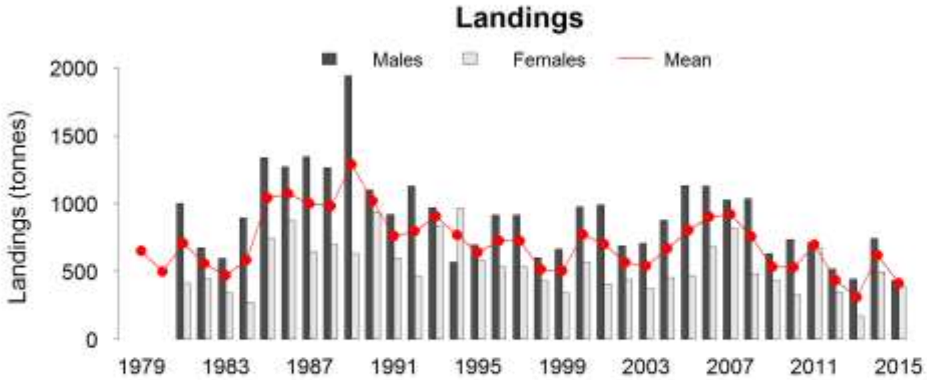


Figure 4.7.1 *Nephrops*, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2015.



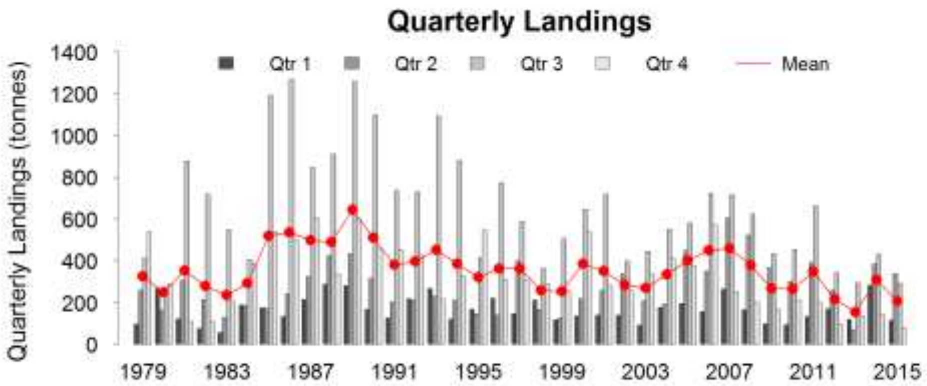


Figure 4.7.2 ***Nephrops*****, Moray Firth (FU 9), Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

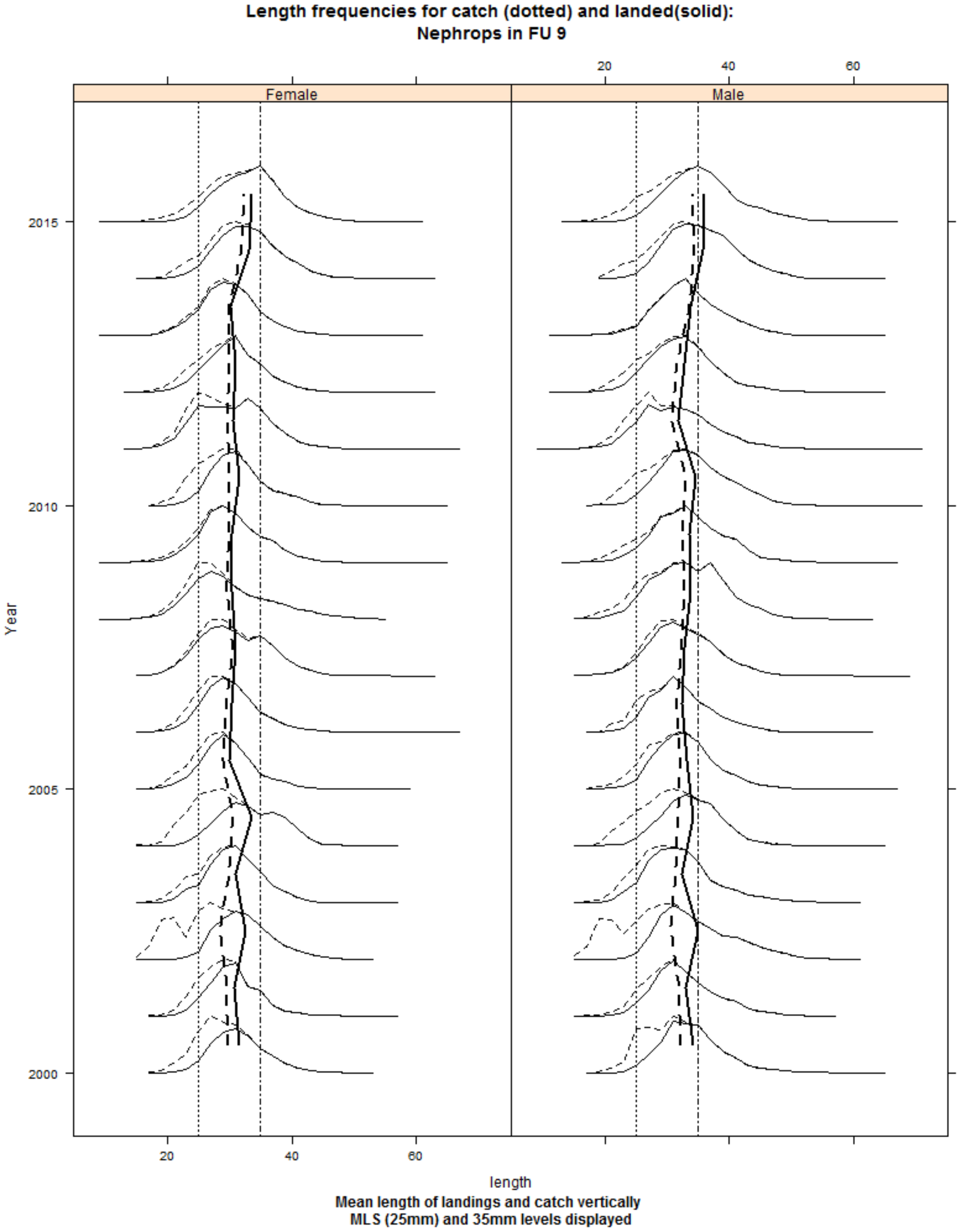


Figure 4.7.3 *Nephrops* Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2015 (top). Mean sizes of catch and landings are displayed vertically.

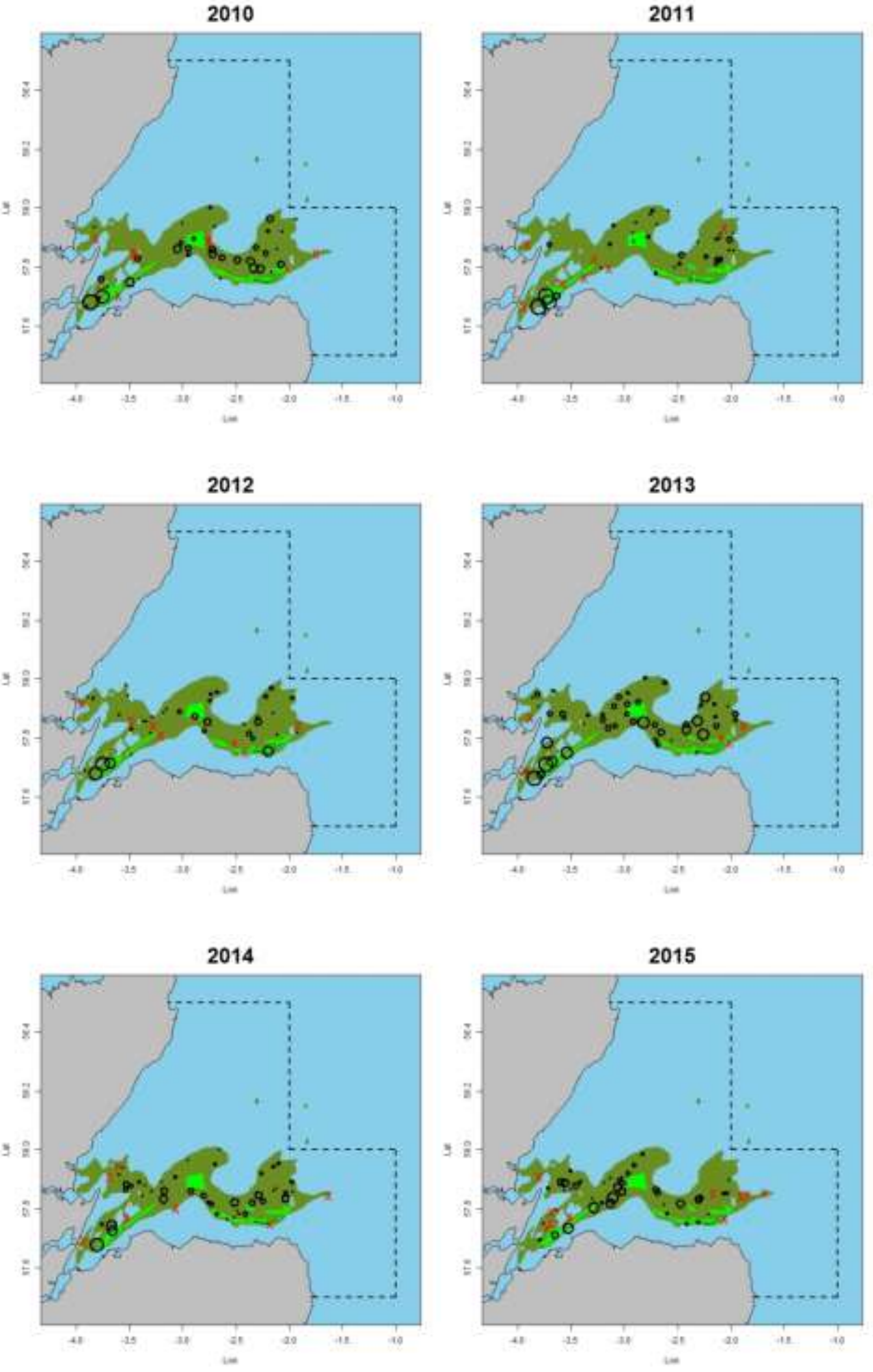


Figure4.7.4 *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2010–2015). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

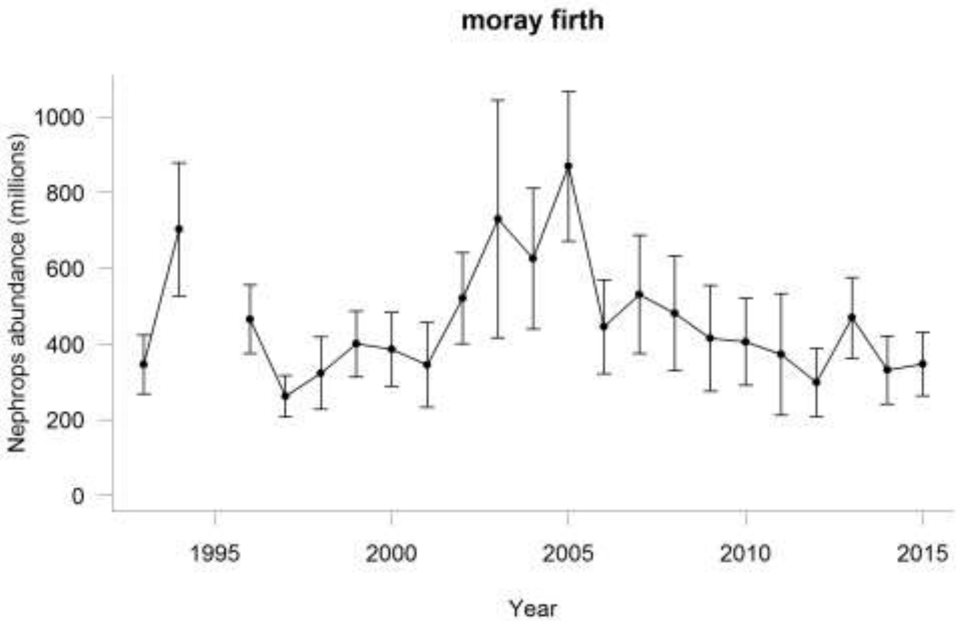


Figure 4.7.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates with 95% confidence intervals, 1993 – 2015.

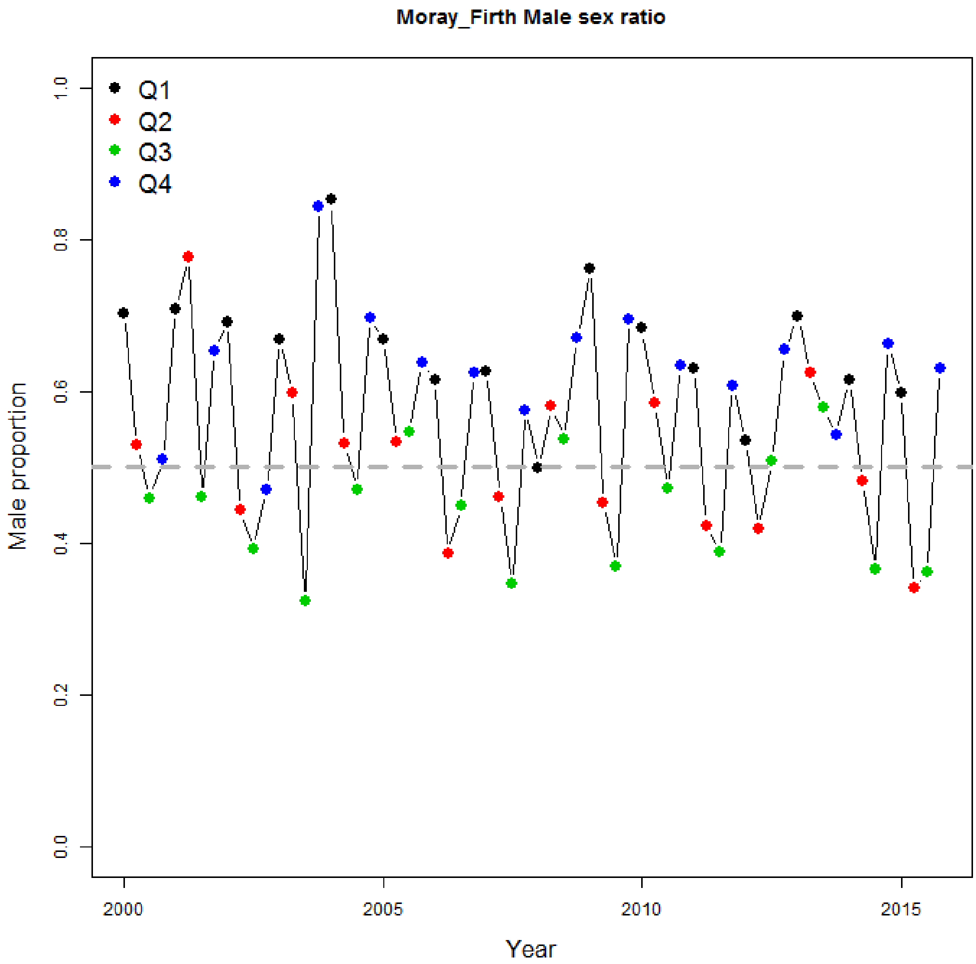


Figure 4.7.6 *Nephrops*, Moray Firth (FU 9), Quarterly sex ratio (by number) in catches.

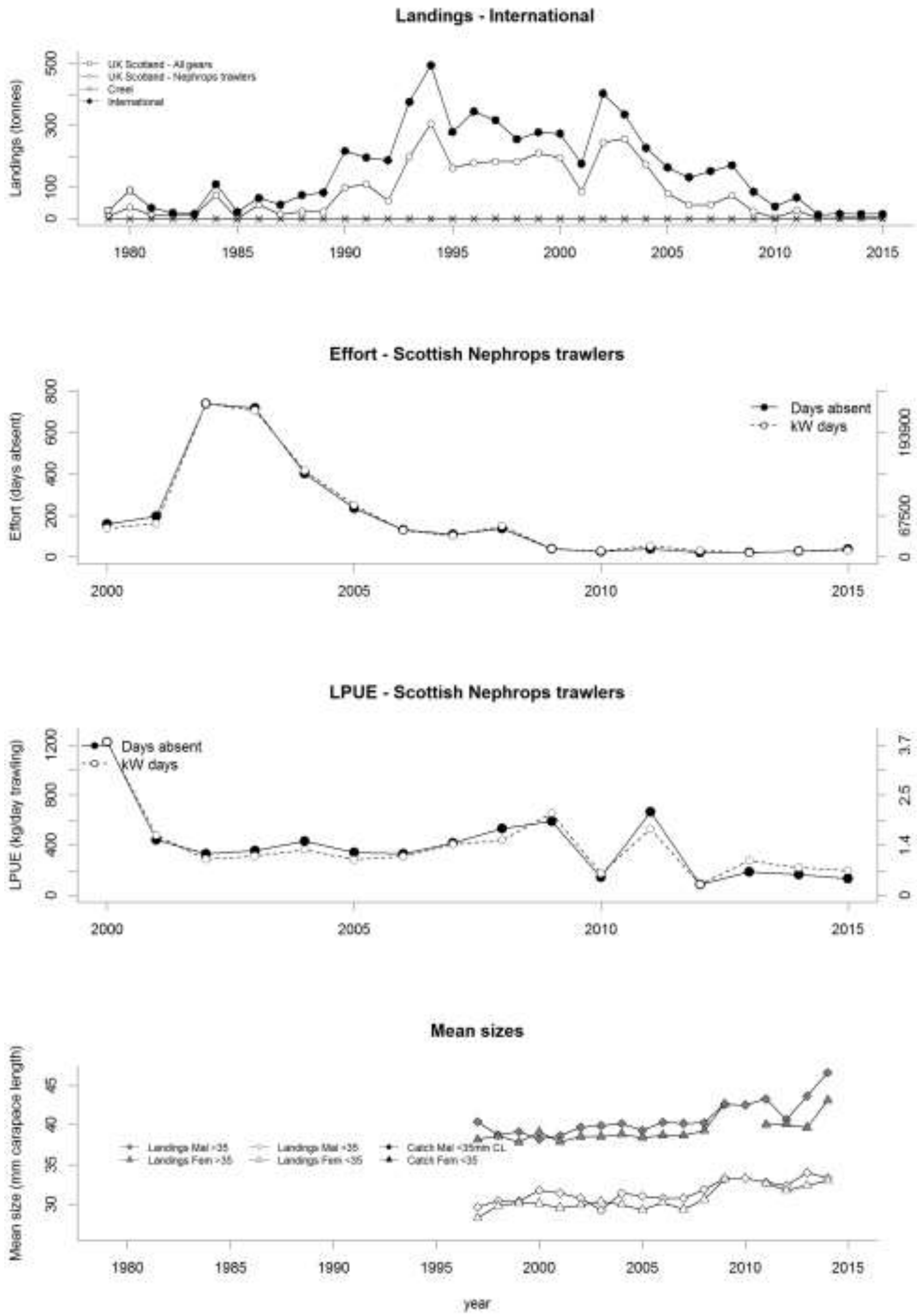


Figure 4.8.1 ***Nephrops*, Noup (FU 10), Long term landings, effort, LPUE and mean sizes (no females in samples in 2010 and no samples in 2015).**

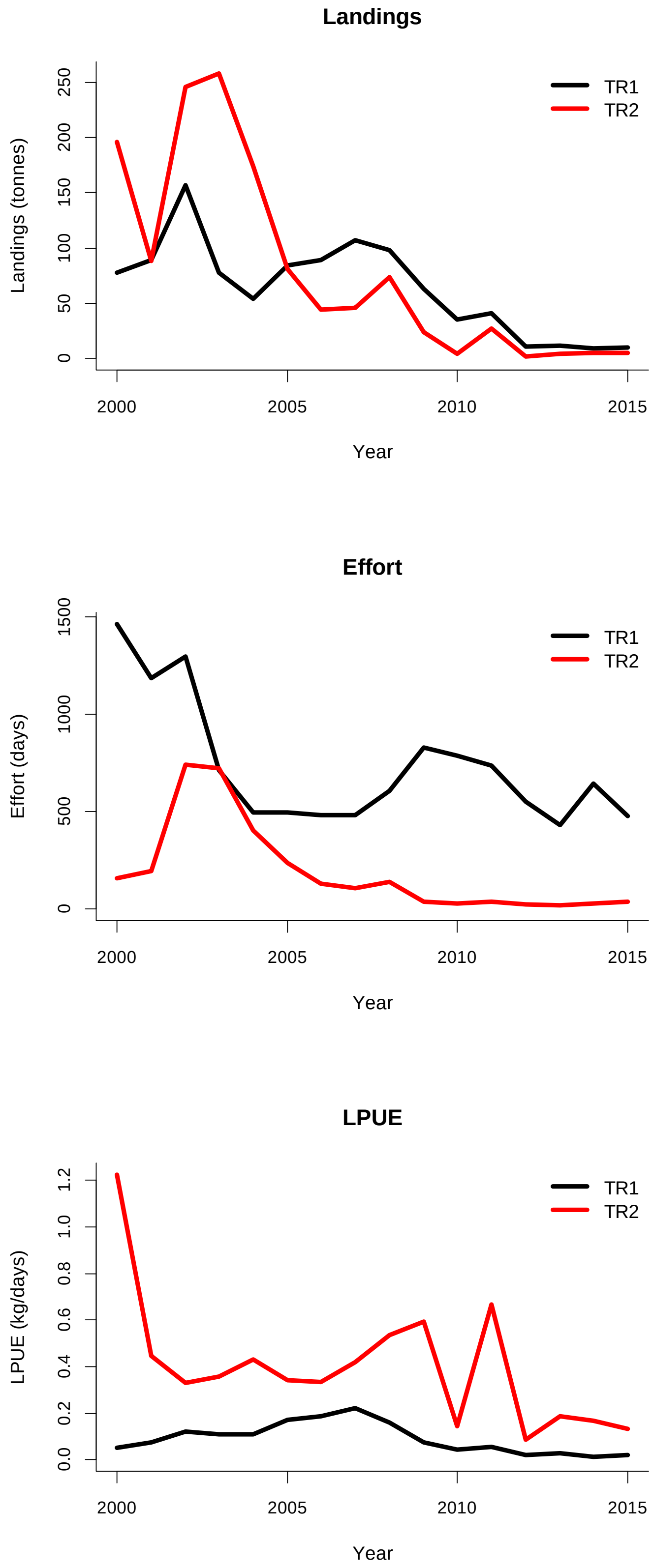


Figure 4.8.2 ***Nephrops*****, Noup (FU 10), Landings, effort (days) and LPUE (kg/day) split by TR1 and TR2 gears, data from year 2000.**

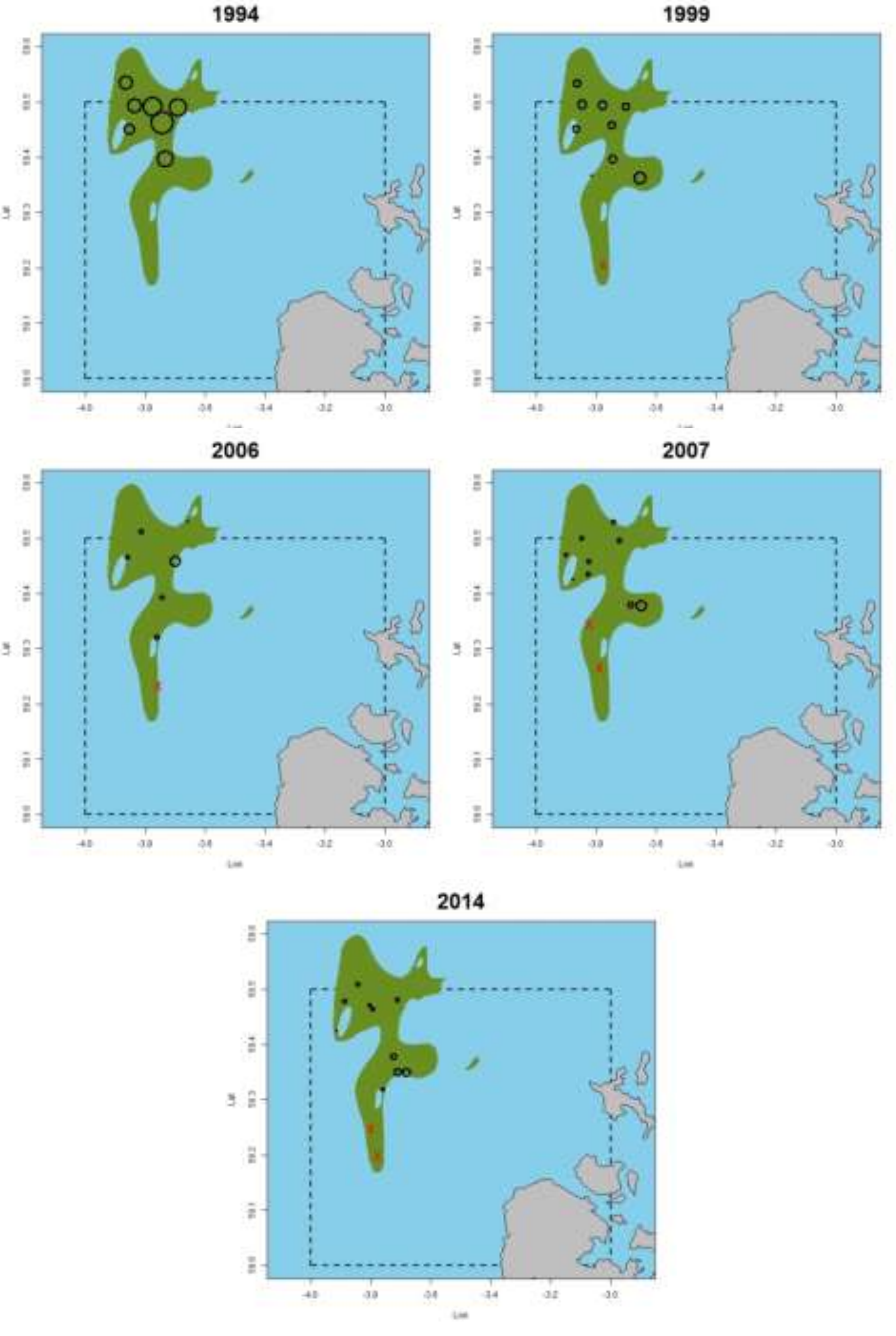


Figure 4.8.3 *Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007 & 2014). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

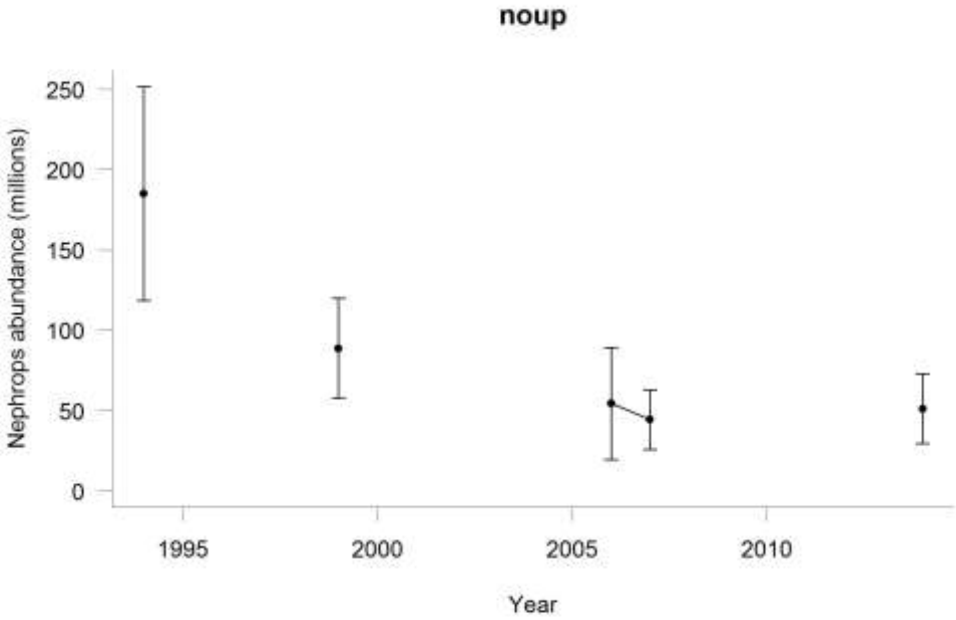


Figure 4.8.4 ***Nephrops*****, Noup (FU 10), Time series of TV survey abundance estimates (absolute conversion factor =1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007 & 2014.**

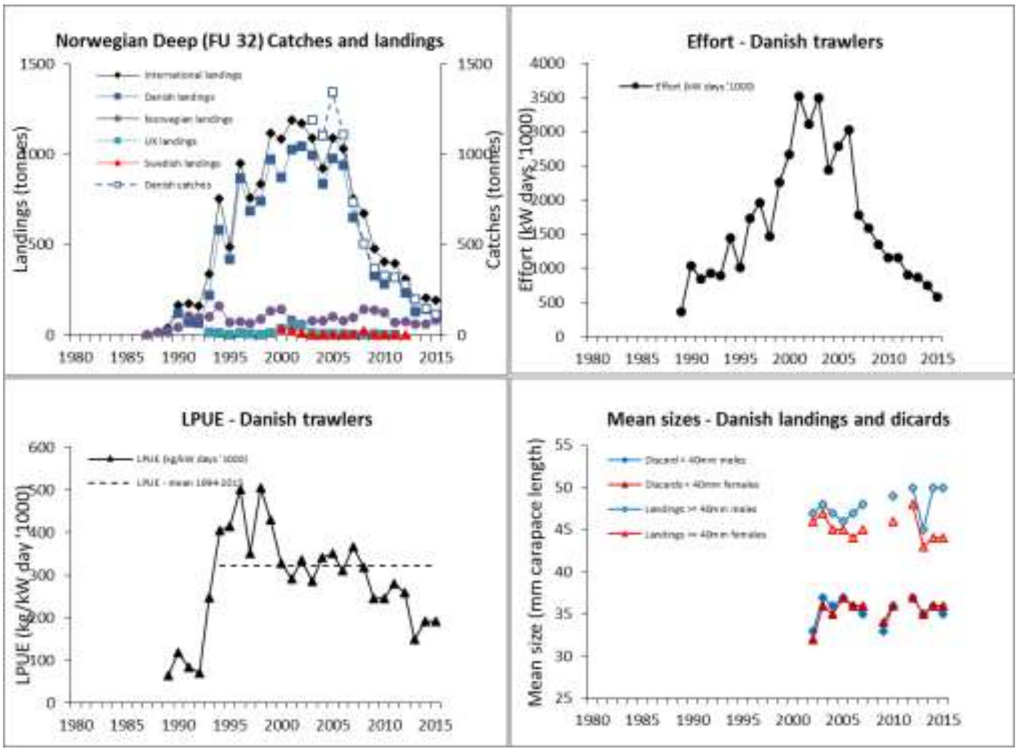
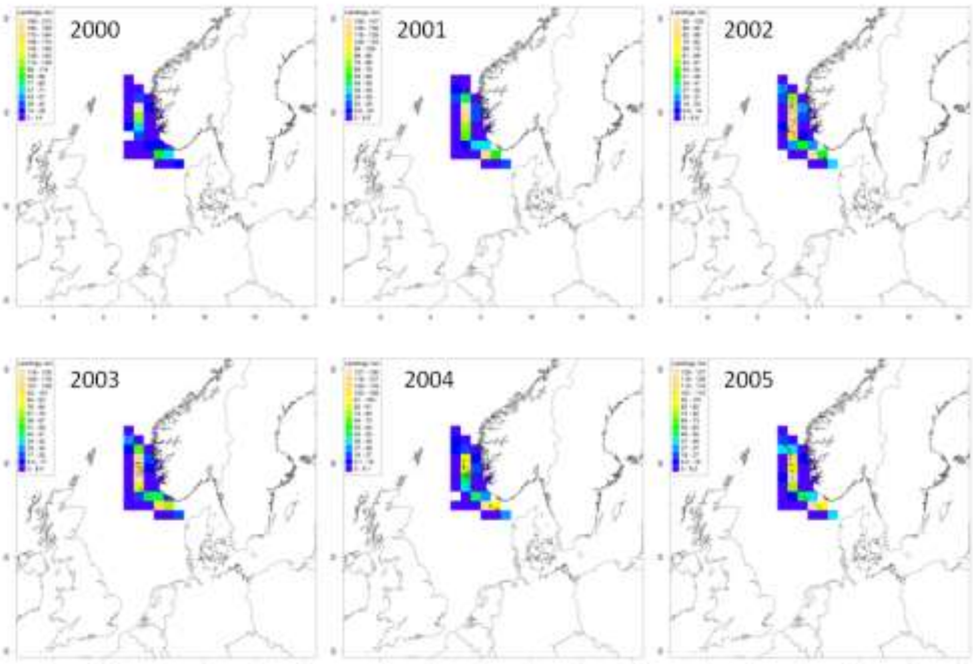
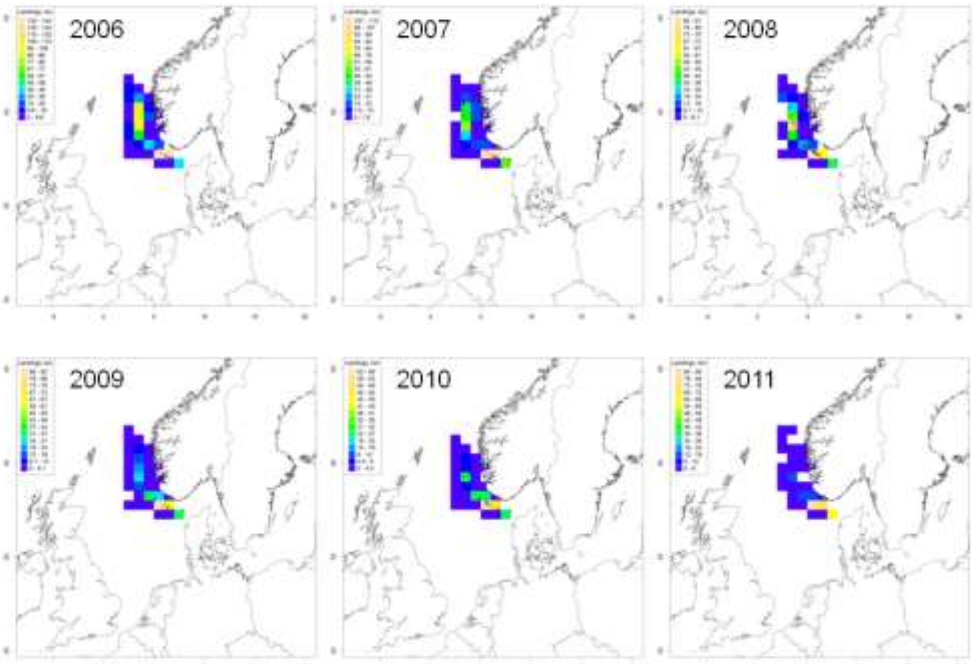


Figure 4.9.1. ***Nephrops*** **Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards and landings.**


2000
2001
2002
2003
2004
2005


2006
2007
2008
2009
2010
2011

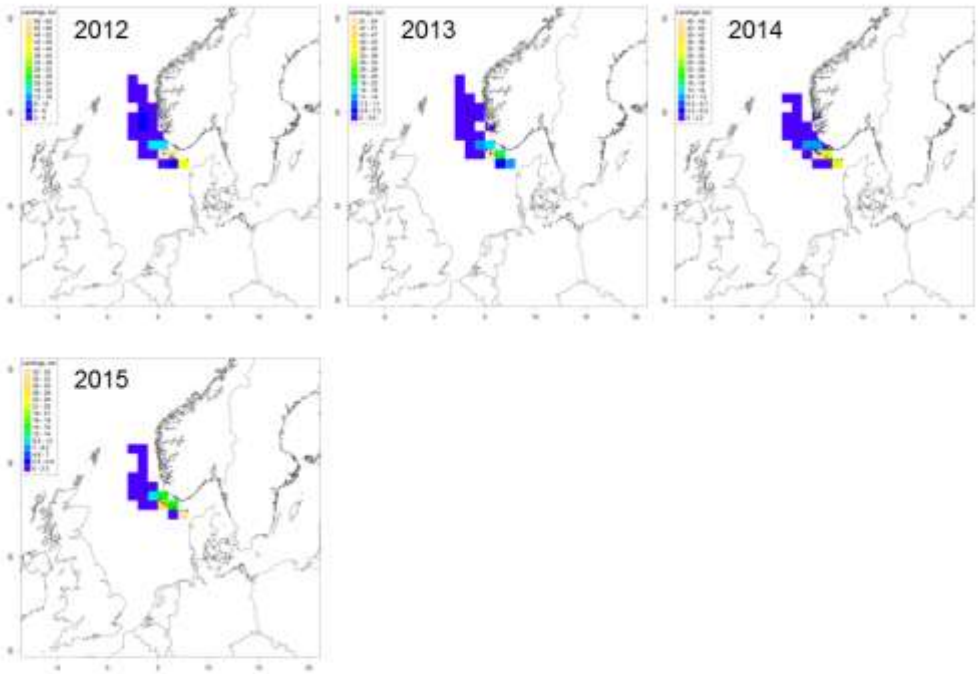


Figure 4.9.2. *Nephrops* Norwegian Deep (FU 32). Danish landings of *Nephrops* per ICES square. Dots represent hauls with *Nephrops* in at-sea-sampling program.

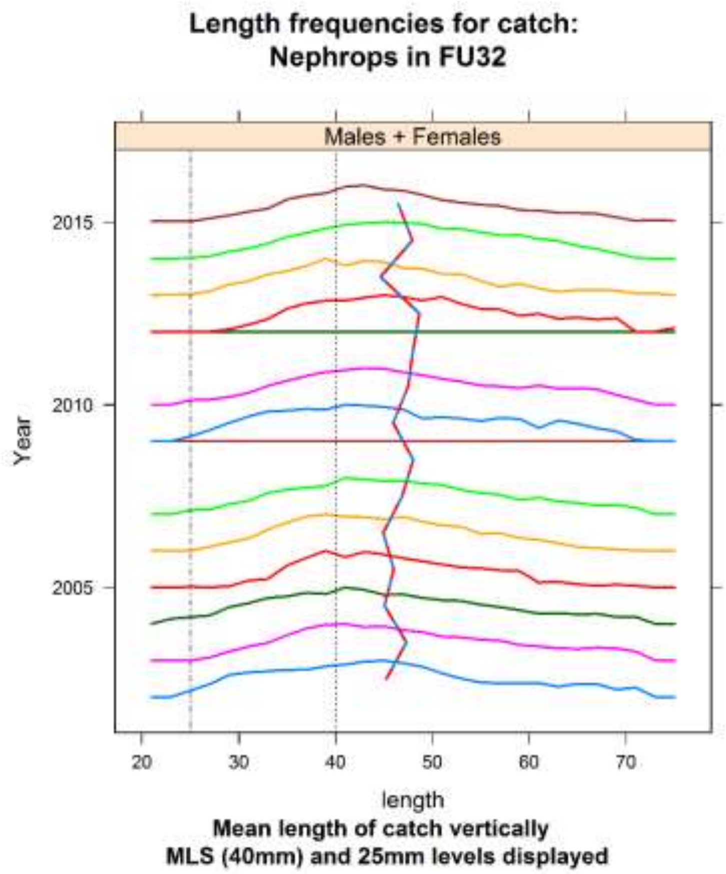


Figure 4.9.3. ***Nephrops*** **Norwegian Deep (FU 32). Size distribution in Danish catches.**

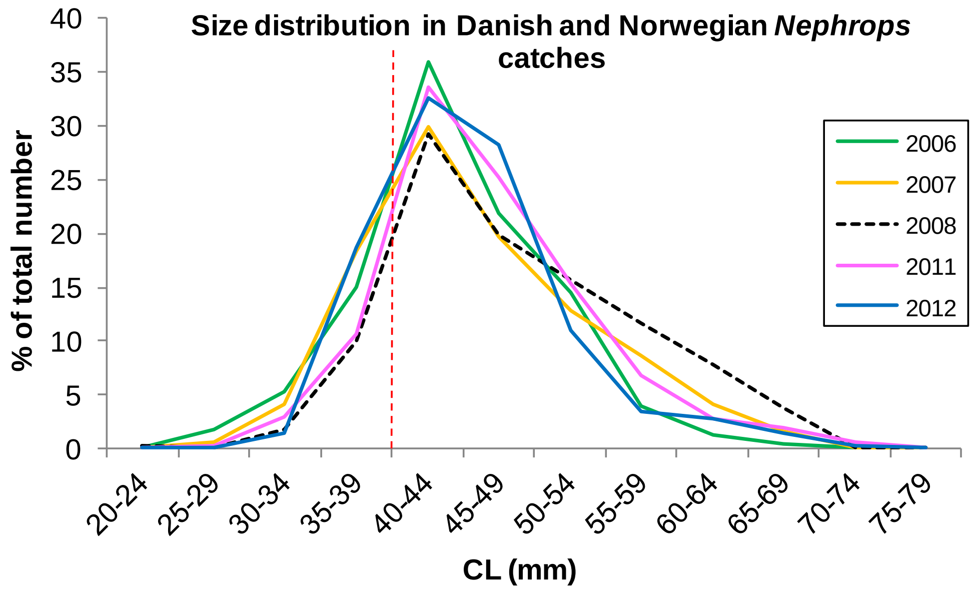


Figure 4.9.4. ***Nephrops*** **Norwegian Deep (FU 32). Size distribution of Danish and Norwegian catches. Vertical line indicates MLS (40 mm CL). Data from the Norwegian coast guard.**

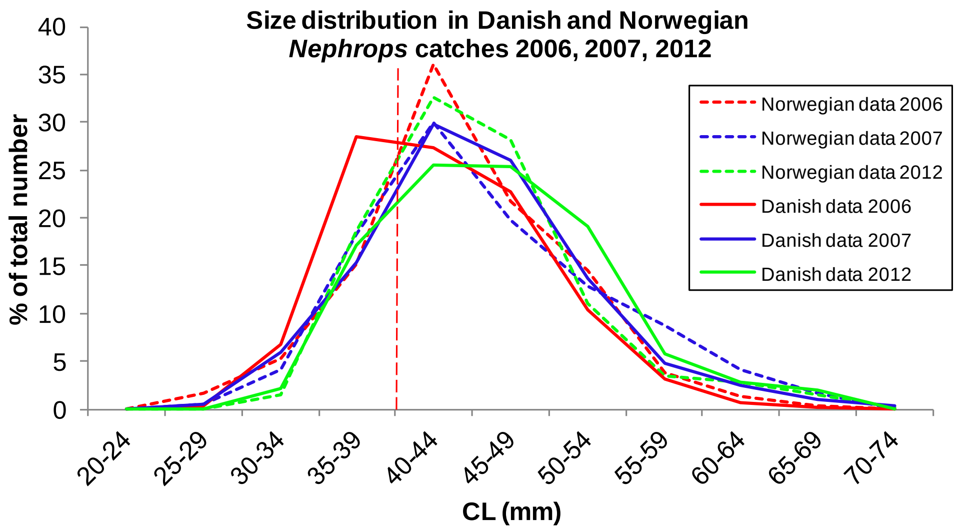


Figure 4.9.5. ***Nephrops*** **Norwegian Deep (FU 32). Comparison of size distribution in catches (2006, 2007, 2012) from Danish and Norwegian data sources. Vertical line indicates MLS (40 mm CL).**

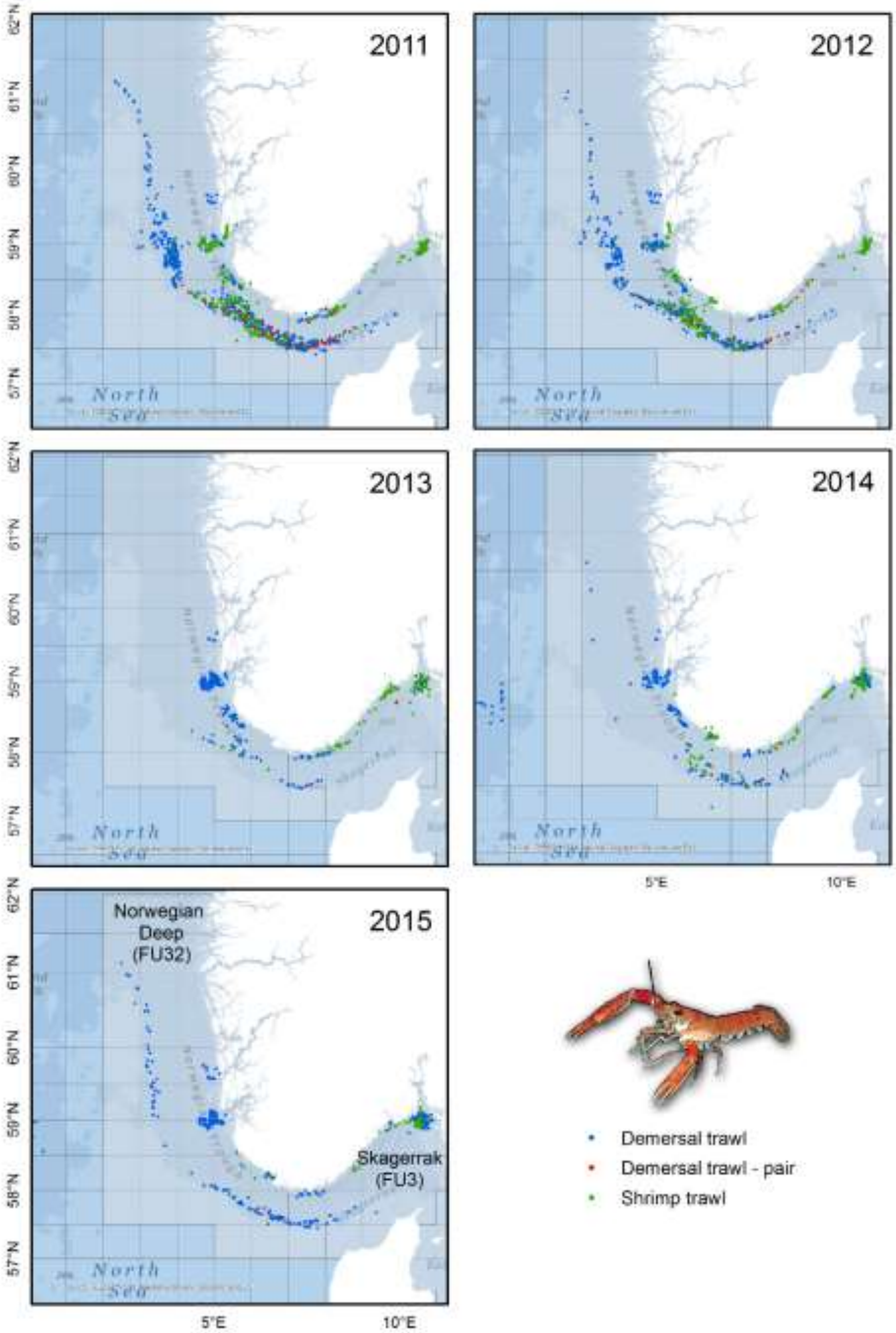


Figure 4.9.6. *Nephrops* Norwegian Deep (FU 32). Positions of single trawl hauls with *Nephrops* in the catch from Norwegian bottom trawlers ≥ 15 m, 2011–2015.

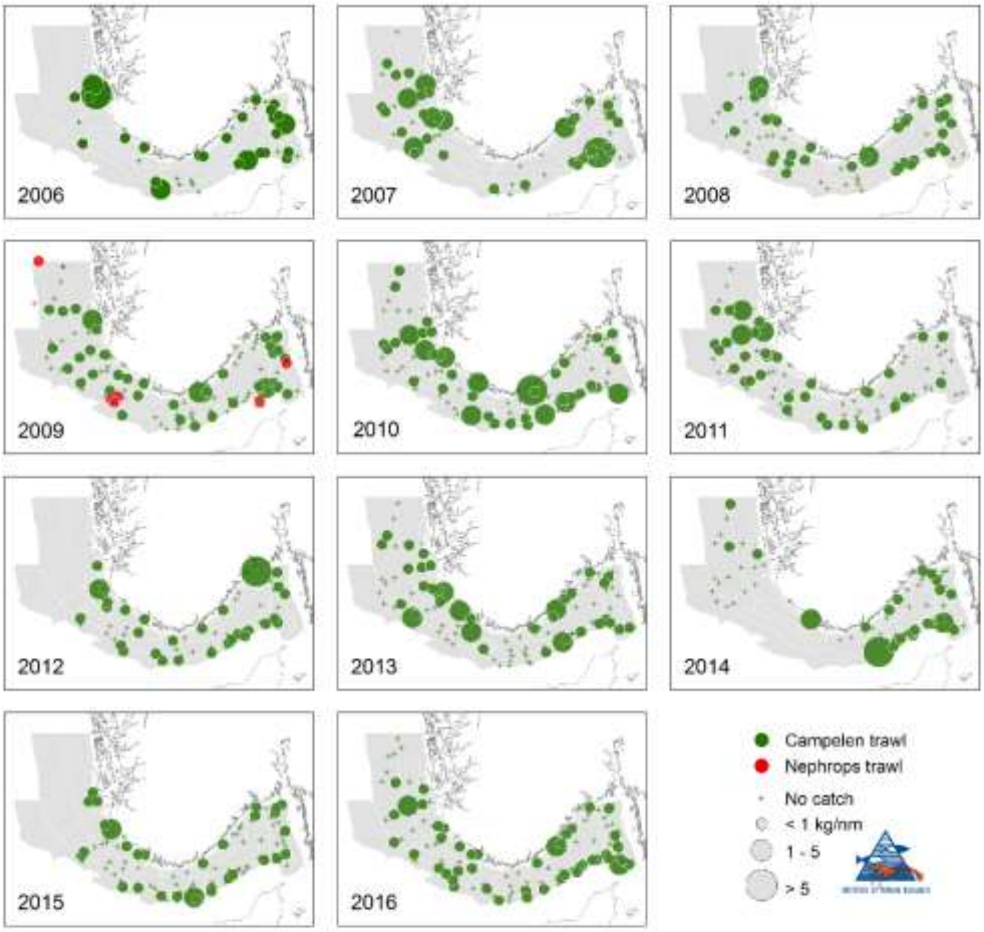


Figure 4.9.7. *Nephrops* Norwegian Deep (FU 32). Distribution of *Nephrops* in Norwegian shrimp survey, 2006–2016.

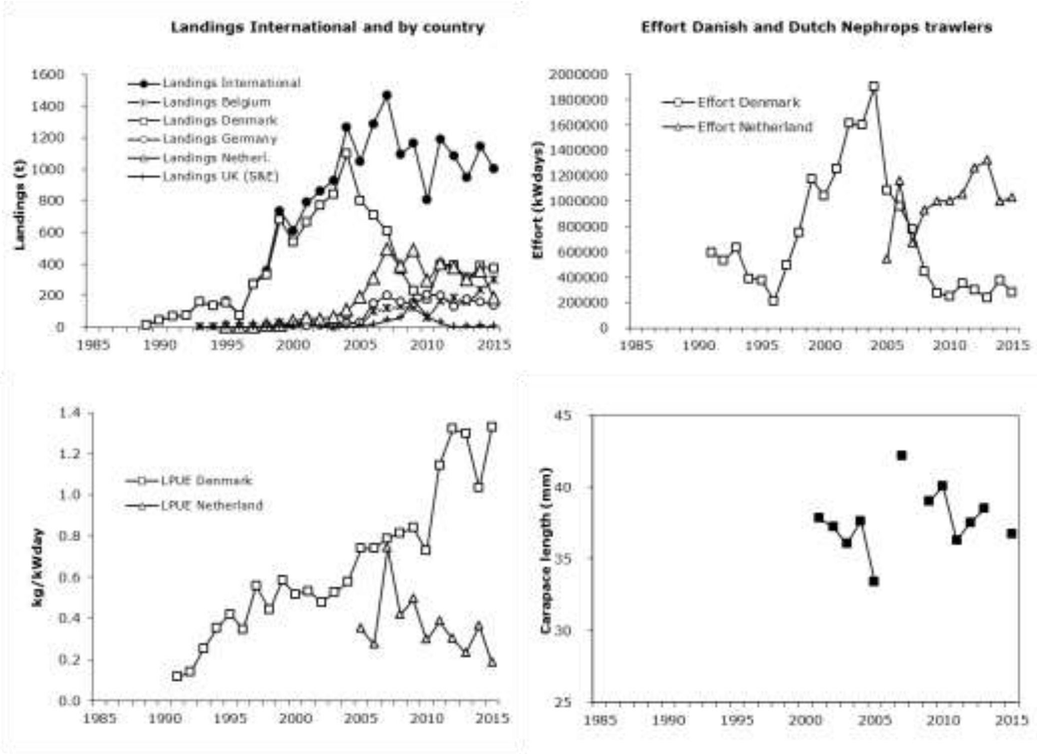


Figure 4.10.1 ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

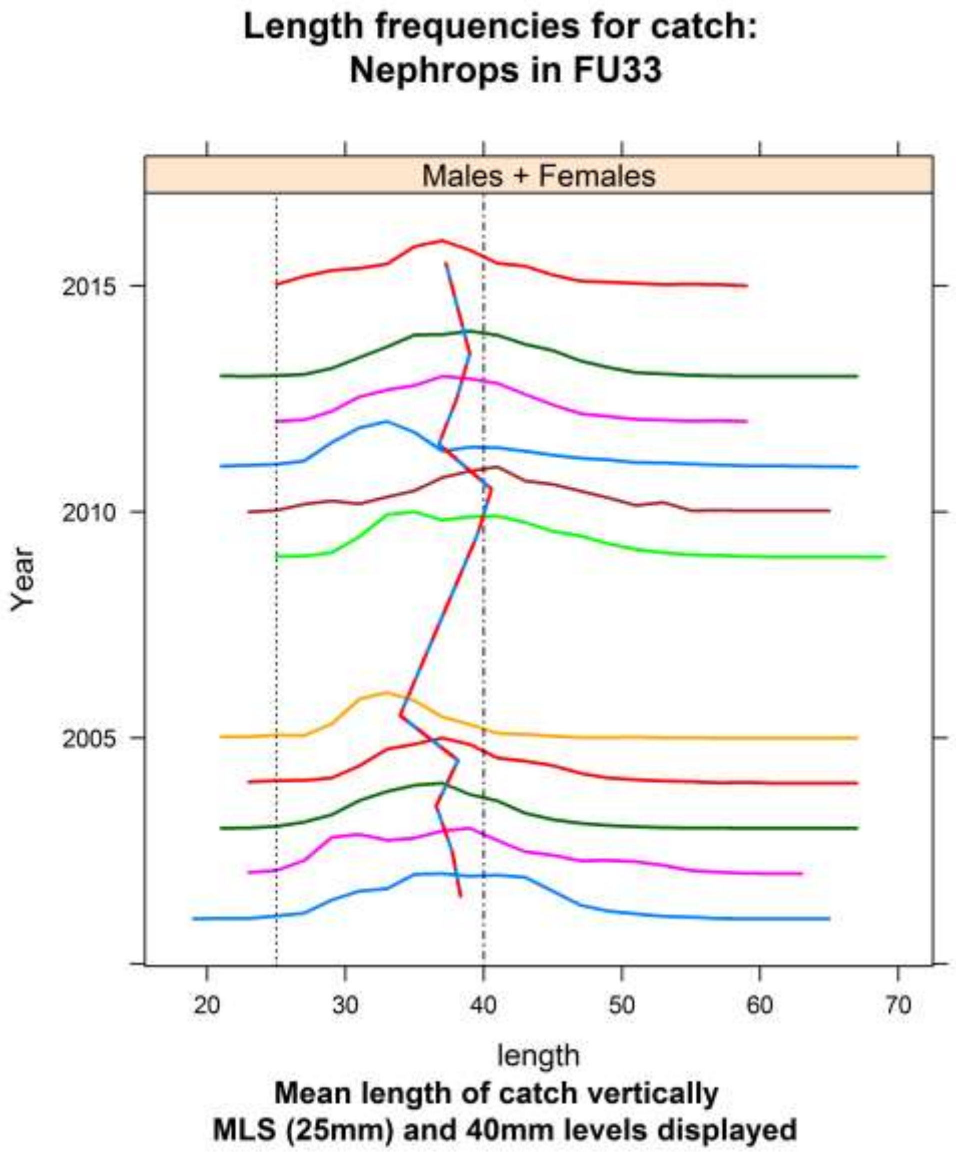


Figure 4.10.2 ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

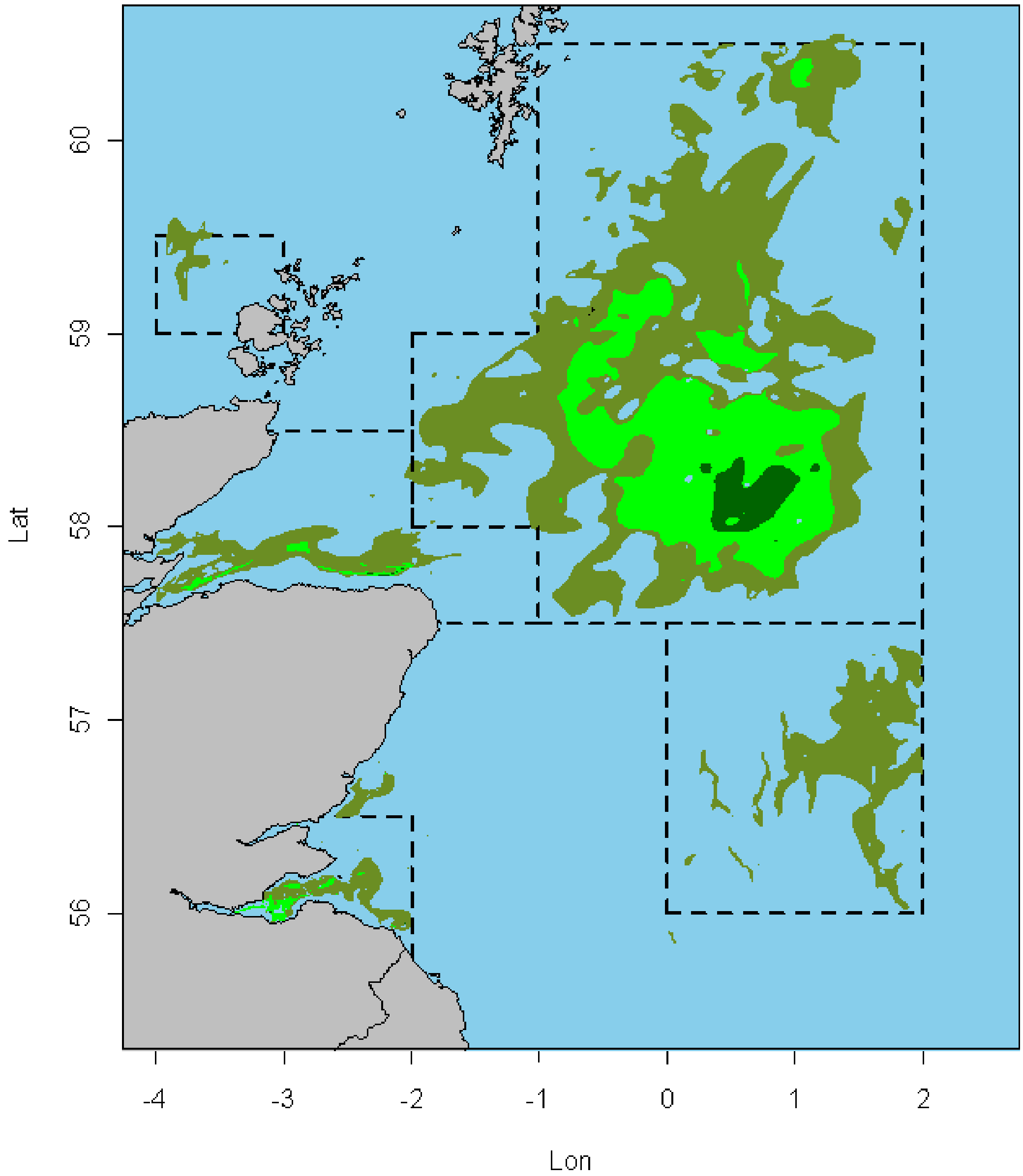
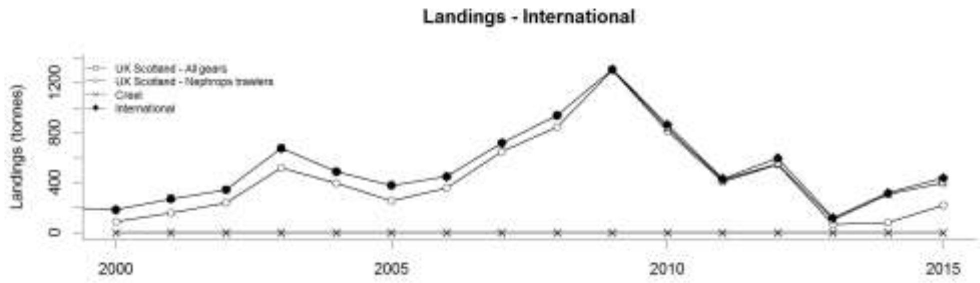


Figure 4.11.1. ***Nephrops*, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**



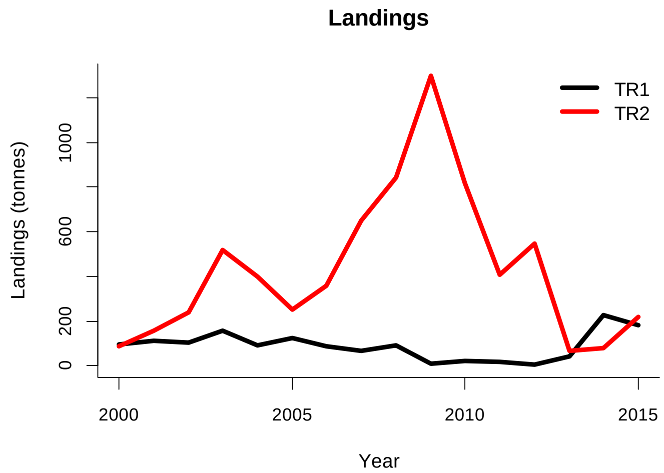


Figure 4.11.2. ***Nephrops*****, Devil's Hole (FU 34). International landings (top) and Scottish landings split by TR1 and TR2 (bottom).**

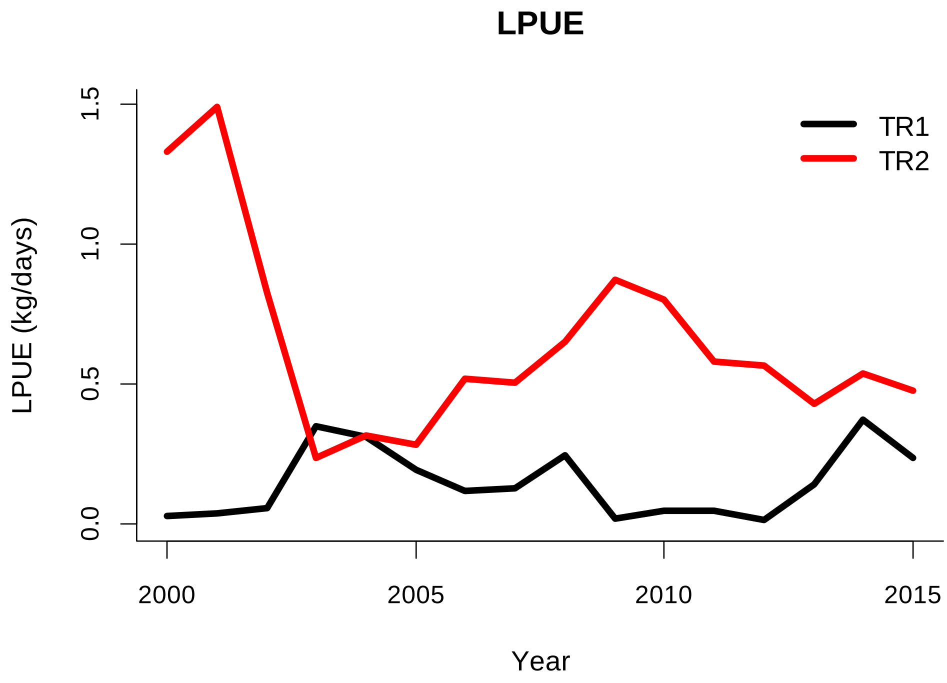


Figure 4.11.3. ***Nephrops*****, Devil's Hole (FU 34). Effort (days) and LPUE (kg/day) by Scottish trawlers split by TR1 and TR2 gears.**

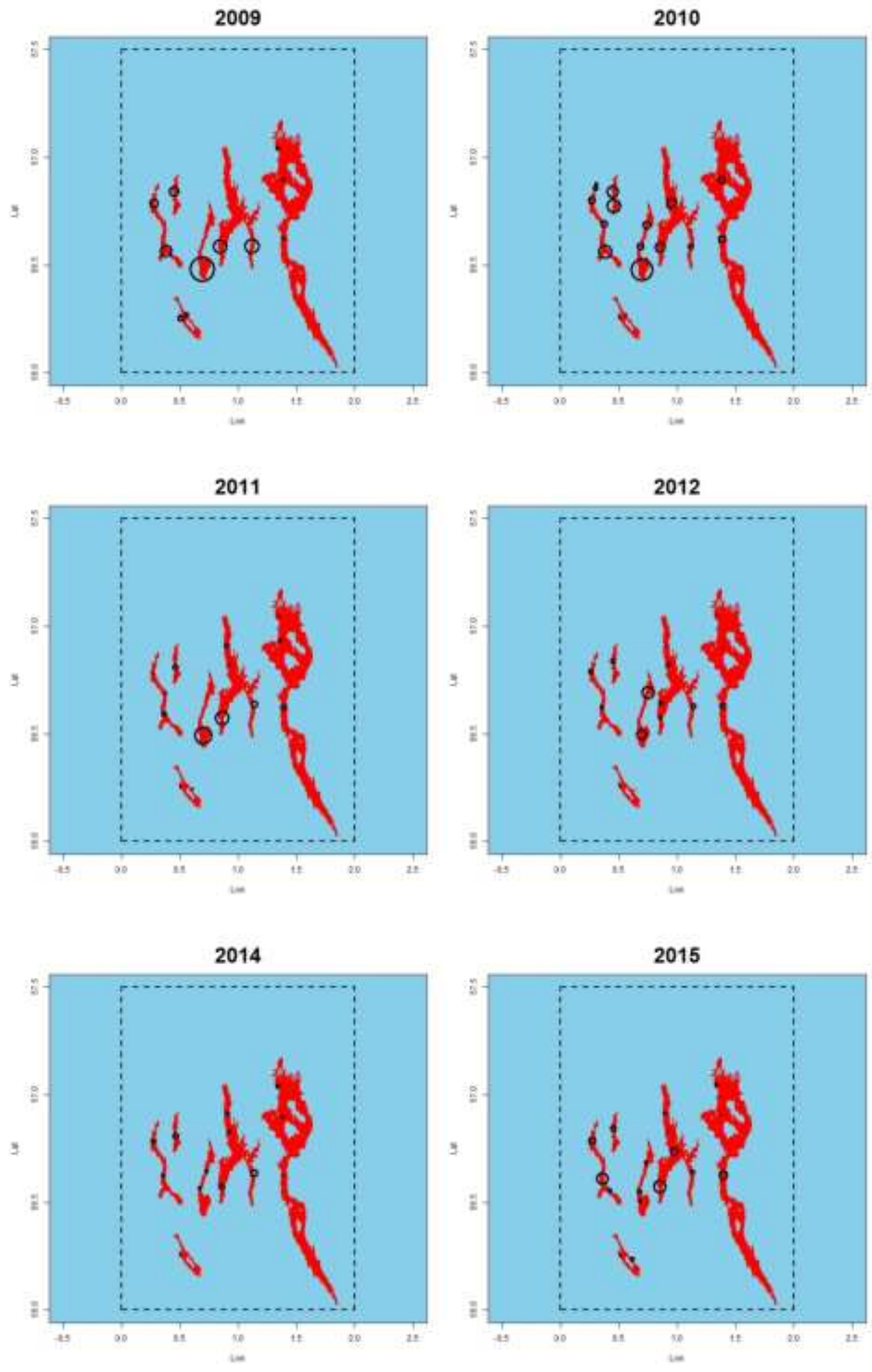


Figure 4.11.4. ***Nephrops*, Devil's Hole (FU 34). UWTV survey distribution and relative density (2009–2015). Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

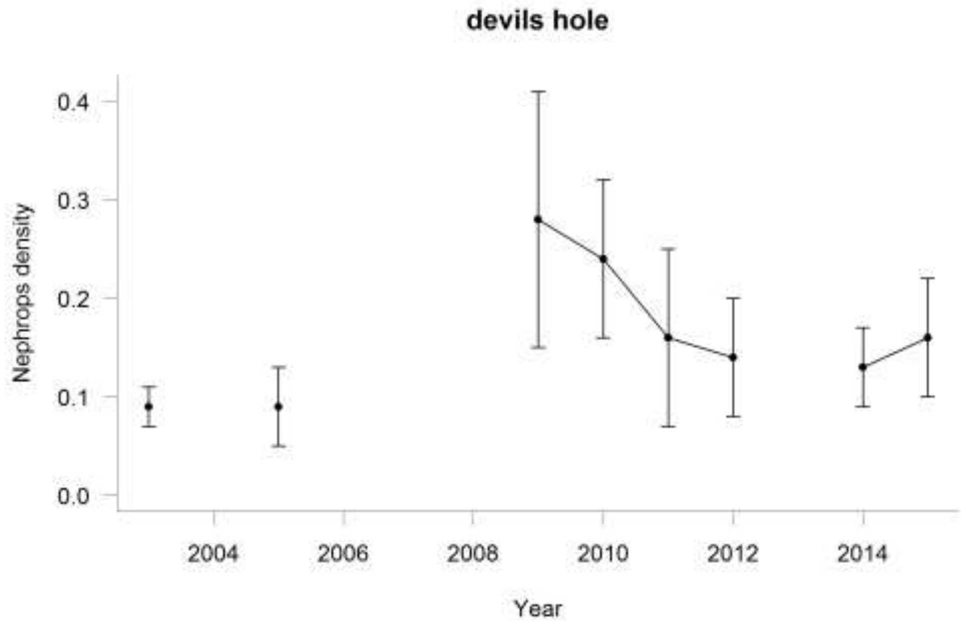


Figure 4.11.5. ***Nephrops*****, Devil's Hole (FU 34). Time series of UWTV survey density estimates with 95 % confidence intervals, 2003, 2005, 2009–2015.**

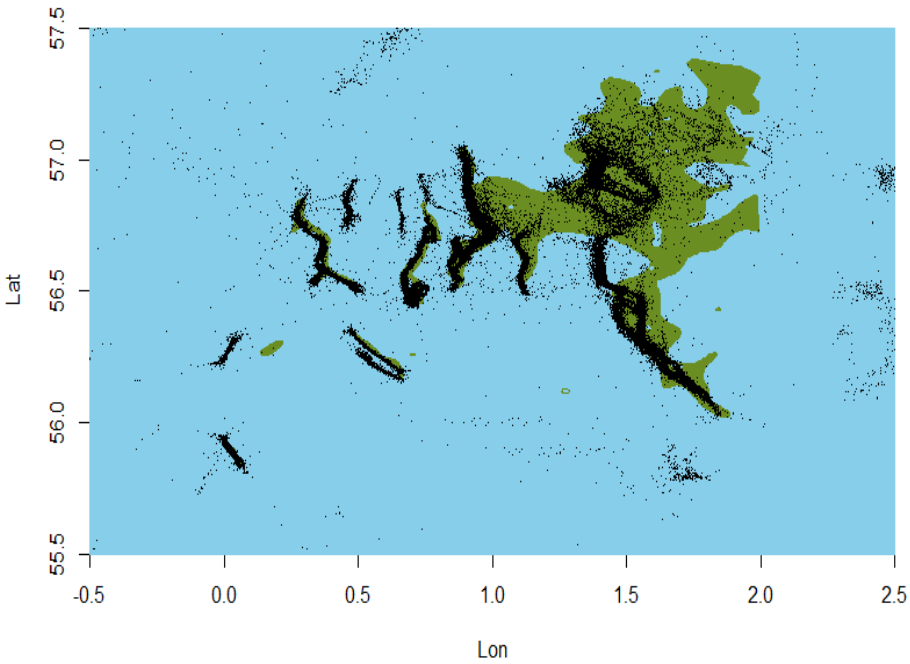


Figure 4.11.6. ***Nephrops*****, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for *Nephrops* landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.**

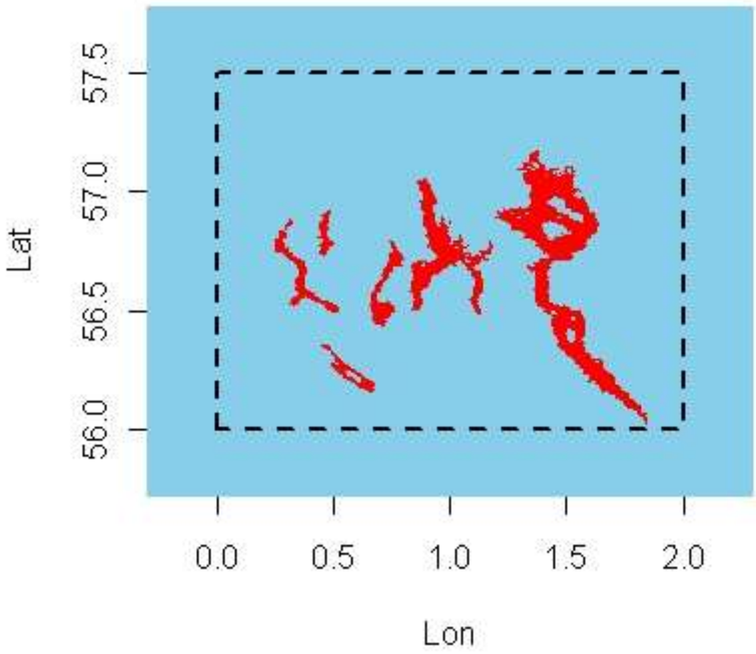


Figure 4.11.7. ***Nephrops*, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for *Nephrops* landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.**

5 Norway Pout (*Trisopterus esmarkii*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)

The advice, as well as the report, on Norway Pout will be released on the 11 November 2016.

6 Plaice (*Pleuronectes platessa*) in Division 7.d (Eastern English Channel)

This stock is in category 1. This year, the assessment of plaice in Division 7.d was made following methodological information described in the Stock Annex revised during ICES WKPLE 2015 and WGNSSK 2015.

6.1 General

6.1.1 Stock definition

A summary of available information can be found in the stock annex.

6.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2016. All available information on ecological aspects can be found in the Stock Annex.

6.1.3 Fisheries

Plaice is mainly caught in two offshore fisheries, i.e. the beam trawl sole fishery and the mixed demersal fishery 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. All available information on the fisheries can be found in the Stock Annex.

6.1.4 ICES advices for previous years

2014 advice*: Based on the ICES approach for data limited stocks, ICES advises that landings of plaice in Division 7.d plaice stock should be no more than 2811 tonnes. Assuming the same proportion of the Division 7.e and Subarea IV plaice stocks is taken in Division 7.d as during the last decade (2001–2012), this will correspond to total landings of plaice in Division 7.d of no more than 3469 tonnes.*

2015 advice*: ICES advises that when the MSY approach is applied, catches of the Division 7.d plaice stock in 2016 should be no more than 16 923 tonnes. If discard rates do not change from the average (2012–2014), this implies landings of the Division 7.d plaice stock of no more than 10 855 tonnes. Assuming the same proportion of the Division 7.e and Subarea IV plaice stocks is taken in Division 7.d as during 2003–2014, this will correspond to catches of plaice in Division 7.d in 2016 of no more than 19 506 tonnes. If discard rates do not change from the average (2012–2014), this implies landings of plaice in Division 7.d of no more than 12 512 tonnes.*

6.1.5 Management

There are no explicit management objectives for this stock.

The TACs have been set to **for the combined ICES Divisions 7.d & 7.e**.

The minimum landing size for plaice is 27 cm, which is not in accordance with the minimum mesh size of 80 mm, permitted for catching plaice by beam and otter trawling. Fixed nets are required to use 90-mm mesh as an absolute minimum.

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 are shown in Figure 6.2.1.1 as well as in Table 6.2.1.1 together with the total landings estimated by the Working Group. The 2015 landings of 3727 t (2956 t attributed to the resident stock and 771 t removed from the first quarter as estimated to be resulting from catches coming from 7.e and IV to spawn) are in the catch level of the past 10 years (between 3500 and 4500 t). Unlike previous years, France (45%) and Belgium (43%) contributed almost equally to the total 7.d landings in 2015, with UK contributing for 11%.

Routine discard monitoring has recently begun following the introduction of the EU data collection regulations. Based on the sampling intensity (WKPLE 2015), a discards time series starting in 2006 has been included in the assessment.

Following the ICES WKFLAT 2010 and WKPLE 2015 conclusions, 65% of the first quarter catches were removed. These 65% were estimated during ICES WKFLAT 2010, based on published tagging results and some previous studies (e.g. Burt *et al.* 2006, Hunter *et al.* 2004, Kell *et al.* 2004) showing that 50% of the fish caught during the first quarter are fish coming from area IV to spawn. The same study also shown that 15% of the fish caught during the first quarter were fishes from area 7.e. Following the ICES WKPLE 2015 conclusions, only mature individuals are removed, both from landings and discards. Table 6.2.1.2 shows the Quarter 1 landings and discards and the corresponding removals. Removing this part of the catches allows for assessing the stock resident biomass**. All the following figures will take into account this Quarter 1 removal.**

6.2.2 Intercatch

UK, France, the Netherlands and Belgium have been providing landings data under the ICES InterCatch format since 2011, and InterCatch was used to produce the input data. Age distributions were provided by France, Belgium and England, accounting for 85% of the landings (Figure 6.2.2.1). Belgium has not always been able to provide landings data per quarter (for 2004, 2005, 2006, 2011, 2013, catch data were provided per semester or year), but they now provide it at least for quarter 1 on a separate excel spreadsheet. Allocations to calculate age structures for the remaining landings were done per quarter, using the groups below.

UNSAMPLED FLEET*	SAMPLED FLEET**
All nets	All nets
All OTB, TBB and Seines	All OTB, TBB and Seines
Others (MIS and LLS)	All métiers

* Unsampled fleet are those fleets for which no age structure is known.

** Sampled fleet are those fleets for which the age structure is known.

Discards data have also been provided under the ICES InterCatch format by France, Belgium, and the UK since WKPLE (ICES, 2015). In 2015, 87% of landings had associated discards data imported to Intercatch. The discard volumes of the remaining strata have been raised using the grouping below (all quarters were pooled). As a result, the raised discards account for 14% of the total discards.

Unsampled fleet*	Sampled fleet**
TBB	TBB
GNS	GNS except 2 UK strata with high discards ratios
GTR	GTR
OTB	OTB
Seines (SDN and SSC)	Seines
Others (MIS and LLS)	All métiers

* Unsampled fleet are those fleets for which no discards data have been provided.

** Sampled fleet are those fleets for which the discards volumes are known.

Age distributions were provided by France, Belgium and England, accounting for 79% of the total discards (imported + raised).

6.2.3 Age compositions

Age compositions of the landings and of the discards are presented in Table 6.2.3.1 and Figure 6.2.3.1, and Table 6.2.3.3 and Figure 6.2.3.2 respectively.

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2015 in Figure 6.2.3.3, with recruits at age 0 and 1 starting to be caught and age 1 landed after summer.

Figure 6.2.3.4 presents the discards at age ratios (i.e. discards numbers/landings numbers) per age over the sampled period 2006–2015. From 2012, the ratio is higher for the ages 1 to 4. The ratio for age 5 also increased to more than 20% in 2015.

6.2.4 Weight at age

Weights at age in the landings, in the discards and in the stock are presented in Table 6.2.3.2, 6.2.3.4 and 6.2.3.5 respectively and in Figure 6.2.3.1. Stock weights are assumed to be the Q2 landings weights. These weights at age do not show specific trends, apart from a general decrease in stock weights in 2013–2015.

6.2.5 Maturity and natural mortality

The maturity ogive used in the assessment is given in the table below.

Age	1	2	3	4	5	6	7
Proportion of mature	0	0.15	0.53	0.96	1	1	1

New age-specific natural mortality rates have been estimated from Peterson and Wroblewski's relationship during the 2015 WKPLE benchmark, as detailed in the Stock Annex.

AGE	1	2	3	4	5	6	7
Natural mortality	0.3531	0.3132	0.292	0.2749	0.2594	0.2474	0.2329

6.2.6 Surveys

The survey series used in the assessment are the French Ground Fish Survey (FR GFS) and the UK beam trawl survey (UK BTS) (Figure 6.2.6.1 and Table 6.2.6.1). The International Young fish survey is also presented, although not used in the assessment. They are fully described in the stock annex.

New time series have been provided for both the FR GFS (Travers-Trolet et al, 2016; see Annex 08 under Working documents) and the UK BTS (Silva, 2016; see Annex 08 under Working documents).

The differences between the old and new time series are presented in Figure 6.2.6.2. The differences are very small for the UK BTS, while ages 1, 2 and 6 of the FR GFS changed a bit more. In the case of age 1, the FR GFS indices is now closer to the UK BTS (Figure Figure 6.2.6.1). The consistencies of the two new surveys are presented in Figure 6.2.6.3. They are increased for ages 1 to 2 and 4 to 5 but slightly decreased for ages 2 to 3 and 3 to 4 of the FR GFS survey. They are increased for all ages but 1 to 2 of the UK BTS survey.

The effect of the changes in the survey indices on 2015 the assessment is presented in Figure 6.2.6.4. The use of the new indices leads to a slight change in the perception of the stock with a reduced recruitment, an increased fishing mortality, and a reduced SSB (around -15% in 2014).

6.3 Assessment

The model used is the Art and Poos model (AAP, Aarts and Poos, 2009, for more details please refer to the Stock Annex).

YEAR OF ASSESSMENT:		2016
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
UK Beam Trawl Survey	Age range	1–6
Year range		1988 onwards
FR Ground Fish Survey	Age range	1–6
Year range		1988 onwards
Catch/Landings		
Age range:		1–7+
Landings data:		1980–2015
Discards data		2006–2015
Model settings		
Fbar:		3–6
Age from which F is constant (qplat.Fmatrix)		6
Dimension of the F matrix (Fage.knots)		4
Ftime.knots		14
Wtime.knots		5
Age from which q is constant (qplat.surveys)		5

6.3.1 Results

The landings and discards estimated by the model are presented in Figure 6.3.1.1 and the residuals in Tables 6.3.1.1 and 6.3.1.2. As last year, given the observed trend in the discard at age ratio (see section 6.2.3), the actual discard at age ratio (rather than the average one, i.e. the black line on the left panel of Figure 6.2.1.3) are used in the assessment to estimate the discards for the last 3 years (2012 to 2015).

The survey residuals are shown in Figure 6.3.1.2 and Table 6.3.1.3for the two surveys. There are opposite trends in the residuals of the UK BTS and French GFS (the two surveys covering the entire geographical area of the stock) appearing in the late 2000s, particularly for ages 1 and 2.

The final outputs are given in Table 6.3.1.4 (fishing mortalities) and Table 6.3.1.5 (stock numbers). A summary of the assessment results is given in Table 6.3.1.6 and trends in fishing mortality, recruitment, spawning stock and total catches are shown in Figure 6.3.1.3. Retrospective patterns for the final run are shown in Figure 6.3.1.4. The model tends to underestimate the recruitment.

The 1986 year class dominated the history of this stock until the late 2000s (Figure 6.3.1.5 and 6.3.1.3). A second peak occurred with the 1997 year class, although estimated to be at 75% of the 1986 year class. The ephemeral peak of SSB in 1999 has been followed by years of stability at a low level. This low SSB situation was confirmed by the fisher's perception and assessed by a survey in France in 2006. The SSB has now been increasing for the last 5 years. From 2006 onwards, a series of high recruitments occurred, reaching a maximum in 2010, which caused to biomass to increase until now (Figure 6.3.1.5).

6.4 Biological reference points

F_{MSY} was estimated last year using the procedure advised during WKMSYREF3 2014 (WGNSSK, 2015). Three stock-recruitment relationships were assessed which led to the selection of the hockey-stick and the Beverton and Holt models. Then, F_{MSY} was determined using the eqsim method from the R library MSY.

6.4.1 Calculation of additional reference points

This year, F_{lim} (Figure 6.4.1.1) and F_{pa} were calculated according to the recommendations from ACOM (ICES, 2016).

References points	Value	Notes
F_{lim}	0.50	The fishing mortality (F) that in equilibrium will maintain the stock above B_{lim} with a 50% probability.
F_{pa} default	0.36	$F_{lim}/1.4$
F_{pa}	0.40	$F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$ where σ is the standard error of ln(F) in the final assessment year.

6.5 Short-term forecasts

Weight-at-age in the stock and in the catch were taken to be the average over the last 3 years. The exploitation pattern, as well as the discards/landings numbers ratio, were taken to be the mean value of the last three years. Population numbers at age 2 and older in 2014 are AAP survivors estimates.

6.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated.

For 2016 and the previsions (2017 and 2018), the recruitment was calculated as the geometric mean recruitment over the period 2010–2013 (taking into account the higher recruitment in the recent years

6.5.2 Calculation of the 7.d resident stock

F for the intermediate year is set such as landings equal the TAC for that year. However, TAC is combined for area 7.d and 7.e. The long term proportion of catches taken in area 7.d over the total catches is used to compute a TAC 7.d (Figure 6.5.2.1).

As catch numbers and AAP survivors in 2015 are computed from the resident population (catches made on fishes from area 7.e and IV are removed), the TAC in 7.d and resulting F in intermediate year were also modified to take into account this first quarter removal. The first quarter removal was also estimated as the long term average, and TAC reduced by this average (Figure 6.5.2.1).

6.5.3 Management options tested

6.5.3.1 Calculation of STF

Potential TACs for 2017 were calculated using F_{MSY} and the newly estimated Fpa. Alternative options were also tested. Results are presented in Table 6.5.3.1.1

Following the MSY approach would lead to a TAC in 2017 for the resident stock of 12805 t, corresponding to an estimated wanted catch of 7550 t, i.e. an increase compared to the 2015 landings.

6.6 Quality of the assessment

The sampling for plaice in 7.d are considered to be at a reasonable level.

The quality of the assessment is considered to have improved in 2015 following the change of assessment model and the inclusion of discards. Some concerns however were expressed during the group about the change of natural mortality rate values which leads to a significant change in the perception of this stock. The assessment was therefore externally reviewed, and the new mortality rates maintained.

A fishery on the spawners takes place during the first quarter of the year, 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.

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 4.c.

6.7 Status of the stock

Results of the assessment indicate that F is stable at a low level, while SSB has been increasing in recent years.

6.8 Management considerations

The stock identity of plaice in the Channel is unclear and may raise some issues.

The TAC is combined for Divisions 7.d and 7.e. Plaice in 7.e is considered at risk of being harvested unsustainably (F above F_{msy}, although the ssb is estimated to be increasing as in 7.d).

The plaice stock in 7.d is mostly harvested in a mixed fishery with sole in 7.d.

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.

6.9 Frequency of assessment

In this section, the criteria defining whether a stock is candidate for less frequent assessments (ACOM, 2014) are assessed for ple-eche.

<table>
<tr><th>STOCKS ARE CONSIDERED CANDIDATES FOR BIENNIAL ASSESSMENT IF:</th><th>PLE-ECHE</th></tr>
<tr><td>The advice for the stock has been 0-catch or equivalent for the latest three advice years</td><td>No</td></tr>
<tr><td>The following criteria are fulfilled simultaneously:</td><td></td></tr>
<tr><td>Life span (i.e. maximum normal age) of the species is larger than 5 years</td><td>Yes</td></tr>
<tr><td>The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x Fmsy OR if F_{msy} range has been defined: F(latest assessment year) is <= Fupper (upper bound in F range) AND SSB (start of intermediate year) >= MSY $B_{trigger}$</td><td>Yes
<table>
<tr><td>F(2015)</td><td>1.1 x F_{msy}</td></tr>
<tr><td>0.12</td><td>1.1x0.25=0.275</td></tr>
</table></td></tr>
<tr><td>The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.</td><td>Yes
<table>
<tr><td>Year</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td></tr>
<tr><td>% age 1 caught / total catch</td><td>10%</td><td>5%</td><td>7%</td><td>16%</td><td>15%</td></tr>
</table></td></tr>
<tr><td>The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by less than 20%
The formula to be used in the calculations is:
$\rho = \frac{1}{7}\sum_{u=Y-7}^{Y-1}\left(1-\frac{F_{u,u}}{F_{u,Y}}\right)$. The result should be < 0.20,
where $F_{u,u}$ is F in year u estimated from an assessment that ends in year u, and $F_{u,Y}$ is the F in year u estimated from the most recent assessment (which ends in year Y)</td><td>Results from WGNSSK 2015
Yes, ρ=0.11
<table>
<tr><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td></tr>
<tr><td>0.35</td><td>0.16</td><td>-0.03</td><td>0.11</td><td>0.17</td><td>-0.03</td><td>0.03</td></tr>
</table>
Results from WGNSSK 2016
Yes, ρ=0.04
<table>
<tr><td>2011</td><td>2012</td><td>2013</td><td>2014</td></tr>
<tr><td>0.24</td><td>0.12</td><td>-0.03</td><td>-0.16</td></tr>
</table>
The model cannot be used to run simulations prior to 2011 due to a small change in the code to account for trends in discards at age ratio.</td></tr>
</table>

6.10 Sources

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Table 6.2.1.1 - Plaice in 7d. Nominal landings (tonnes) as officially reported to ICES, 1976-2014.

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7d (3)	Estim.discards 7d (4)	Tot. land. rep. in 7e	Agreed TAC (5)
1976	147	1439	376	1(1)	1963	-	1963		640	
1977	149	1714	302	81(2)	2246	-	2246		702	
1978	161	1810	349	156(2)	2476	-	2476		784	
1979	217	2094	278	28(2)	2617	-	2617		977	
1980	435	2905	304	112(2)	3756	-1106	2650		1215	
1981	815	3431	489	-	4735	34	4769		1746	
1982	738	3504	541	22	4805	60	4865		1938	
1983	1013	3119	548	-	4680	363	5043		1754	
1984	947	2844	640	-	4431	730	5161		1813	
1985	1148	3943	866	-	5957	65	6022		1751	
1986	1158	3288	828	488 (2)	5762	1072	6834		2161	
1987	1807	4768	1292	-	7867	499	8366		2388	8300
1988	2165	5688 (2)	1250	-	9103	1317	10420		2994	9960
1989	2019	3265 (1)	1383	-	6667	2091	8758		2808	11700
1990	2149	4170 (1)	1479	-	7798	1249	9047		3058	10700
1991	2265	3606 (1)	1566	-	7437	376	7813		2250	10700
1992	1560	3099	1553	20	6232	105	6337		1950	9600
1993	877	2792	1075	27	4771	560	5331		1691	8500
1994	1418	3199	993	23	5633	488	6121		1471	9100
1995	1157	2598 (2)	796	18	4569	561	5130		1295	8000
1996	1112	2630 (2)	856	+	4598	795	5393		1321	7530
1997	1161	3077	1078	+	5316	991	6307		1654	7090
1998	854	3603 (2)	700	+	5157	605	5762		1430	5700
1999	1306	3388 (1)	743	+	5437	889	6326		1616	7400
2000	1298	3183	752	+	5233	782	6015		1678	6500
2001	1346	2962	655	+	4963	303	5266		1379	6000
2002	1204	3454	841		5499	278	5777		1608	6700
2003	998	2893	756	3	4650	-564	4086		1478	6000
2004	954	2766	582	10	4312	438	4750		1402	6060
2005	832	2432	421	21	3706	285	3991		1370	5150
2006	1024	1935	550	16	3525	121	3646	749	1466	5080
2007	1355	2017	463	10	3845	156	4001	1252	1184	5050
2008	1386	1740	471	12	3609	255	3864	936	1144	4646
2009	1002	1892	612	16	3522	38	3560	1528	1043	4274
2010	1123	2190	517	62	3892	519	4411	2511	2240	4665
2011	1067	1994	472	56	3589	60	3649	2025	1192	4665
2012	1045	1962	542	63	3612	111	3723	3336	1339	5092
2013	1295	2159	641	87	4182	-55	4127	2955	1526	6400
2014	1389	2229	633	76	4327	-7	4320	3886	1339	5322
2015	1605	1664	390	53	3712	15	3727	2821		6223

Estimated by the working group from combined Division 7d+e

Includes Division 7e

As provided to ICES through InterCatch

Raised with InterCatch from BE, UK and FR estimated discards data.

TAC´s for Divisions 7 d,e

Table 6.2.1.2 - Plaice in 7.d. Nominal landings, estimated discards, and Quarter 1 removals

Year	Total Landings	Q1 Remov.	Landings as used by WG (1)	Estim. discards	Discards Q1 remov.	Discards as used by WG (1)
1980	2650	427	2223			
1981	4769	760	4009			
1982	4865	825	4040			
1983	5043	950	4093			
1984	5161	912	4249			
1985	6022	1022	5000			
1986	6834	1161	5673			
1987	8366	1360	7006			
1988	10420	1635	8785			
1989	8758	1665	7093			
1990	9047	1698	7349			
1991	7813	1451	6362			
1992	6337	1118	5220			
1993	5331	852	4479			
1994	6121	1074	5047			
1995	5130	934	4196			
1996	5393	963	4430			
1997	6307	1127	5180			
1998	5762	931	4832			
1999	6326	1058	5268			
2000	6015	1494	4522			
2001	5266	886	4380			
2002	5777	931	4846			
2003	4086	476	3610			
2004	4750	544	4206			
2005	3991	506	3485			
2006	3646	421	3225	749	21	727
2007	4001	620	3381	1252	32	1220
2008	3864	586	3278	936	48	888
2009	3560	436	3124	1528	56	1473
2010	4411	501	3910	2511	99	2412
2011	3649	358	3291	2025	99	1926
2012	3723	544	3179	3336	293	3043
2013	4127	523	3604	2955	260	2696
2014	4320	645	3675	3886	561	3325
2015	3727	771	2956	2821	453	2368

1. **takes into account the removal of 65% of the Quarter 1 landings or discards.**

Table 6.2.3.1. Plaice in 7.d. Landings in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

AGE							
year	1	2	3	4	5	6	7
1980	53	2598	1253	370	324	50	133
1981	16	2403	5866	1643	192	106	238
1982	265	1369	5964	2262	505	138	179
1983	92	2977	2761	4048	617	151	214
1984	350	1838	6310	1928	1242	356	312
1985	142	5614	5347	3346	274	409	300
1986	679	4799	6072	2510	965	375	247
1987	25	8350	6481	2379	833	287	512
1988	16	4923	16239	3357	741	362	561
1989	826	3574	6238	6477	1770	392	497
1990	1632	2581	7550	4099	2386	535	572
1991	1542	5758	4700	3099	1614	1123	429
1992	1665	6085	3841	1183	786	697	745
1993	740	7473	3295	863	359	313	581
1994	1242	3570	6015	2131	563	280	781
1995	2592	4264	2532	2006	611	152	591
1996	1119	4762	3113	1060	951	326	585
1997	550	4168	6184	2382	724	506	722
1998	464	4323	7467	2335	360	94	289
1999	741	1737	10493	4583	696	121	223
2000	1383	6177	3432	3992	752	150	142
2001	2682	4070	3589	1385	1253	203	145
2002	902	6876	4553	1390	1144	603	288
2003	0	3597	2103	1380	350	356	758
2004	922	2718	4573	760	400	219	527
2005	86	2602	2153	1975	449	245	508
2006	191	2801	3081	1626	987	166	379
2007	529	2986	2379	1237	534	395	274
2008	293	3844	2512	1125	584	218	258
2009	491	2975	3112	848	402	242	240
2010	530	4238	3367	1465	392	278	287
2011	93	4436	3557	964	316	59	119
2012	18	1266	3780	1845	524	195	171
2013	9	756	3666	3294	1158	247	156
2014	76	759	2015	3731	1848	468	202
2015	3	600	1523	1483	1933	940	642

Table 6.2.3.2. Plaice in 7.d. Weights in the landings.

	1	2	3	4	5	6	7
1980	0.309	0.312	0.499	0.627	0.787	1.138	1.413
1981	0.224	0.280	0.349	0.434	0.666	0.814	1.000
1982	0.226	0.250	0.325	0.397	0.589	0.732	1.134
1983	0.239	0.267	0.314	0.378	0.488	0.740	1.112
1984	0.201	0.255	0.290	0.347	0.438	0.595	0.812
1985	0.235	0.257	0.278	0.395	0.464	0.527	0.798
1986	0.226	0.306	0.331	0.406	0.546	0.486	0.806
1987	0.245	0.275	0.351	0.465	0.563	0.764	0.947
1988	0.269	0.247	0.296	0.398	0.517	0.606	0.892
1989	0.187	0.250	0.299	0.345	0.441	0.604	1.008
1990	0.197	0.251	0.319	0.370	0.473	0.597	1.030
1991	0.217	0.267	0.299	0.375	0.437	0.535	0.978
1992	0.179	0.273	0.347	0.422	0.501	0.576	0.783
1993	0.219	0.270	0.334	0.429	0.504	0.587	0.860
1994	0.241	0.268	0.286	0.354	0.463	0.572	0.968
1995	0.214	0.266	0.307	0.382	0.476	0.675	0.927
1996	0.225	0.306	0.296	0.404	0.485	0.656	1.102
1997	0.194	0.246	0.291	0.324	0.431	0.562	0.990
1998	0.163	0.249	0.273	0.389	0.513	0.779	1.140
1999	0.196	0.244	0.234	0.305	0.460	0.749	1.093
2000	0.208	0.246	0.262	0.284	0.376	0.578	0.914
2001	0.225	0.263	0.317	0.387	0.467	0.671	1.093
2002	0.248	0.250	0.301	0.367	0.427	0.548	0.825
2003	NA	0.282	0.371	0.478	0.633	0.644	0.859
2004	0.246	0.298	0.400	0.499	0.690	0.788	0.997
2005	0.285	0.312	0.345	0.444	0.557	0.653	1.088
2006	0.259	0.277	0.304	0.361	0.444	0.552	0.843
2007	0.173	0.303	0.379	0.454	0.520	0.583	0.913
2008	0.231	0.282	0.338	0.418	0.529	0.623	0.939
2009	0.234	0.283	0.341	0.486	0.513	0.643	1.046
2010	0.225	0.296	0.348	0.438	0.497	0.639	0.822
2011	0.156	0.259	0.347	0.478	0.625	0.805	1.056
2012	0.198	0.287	0.346	0.437	0.540	0.691	1.026
2013	0.140	0.254	0.309	0.381	0.480	0.712	1.038
2014	0.169	0.249	0.283	0.357	0.492	0.674	0.945
2015	0.122	0.220	0.295	0.336	0.401	0.522	0.817

Table 6.2.3.3. Plaice in 7.d. Discards in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

YEAR	1	2	3	4	5	6	7
2006	553	2541	1826	70	10	1	0
2007	1227	5531	1776	278	0	2	0
2008	2368	2893	631	163	38	8	1
2009	2032	5679	1988	114	17	26	3
2010	2023	11797	3243	336	28	3	2
2011	2480	8872	1559	155	14	19	1
2012	1423	10296	7943	1235	52	0	0
2013	2040	5395	9367	1818	89	9	1
2014	4380	6222	8481	3445	493	79	10
2015	4420	8316	4958	1478	761	276	40

Table 6.2.3.4. Plaice in 7.d. Weights in the discards.

YEAR	1	2	3	4	5	6	7
2006	0.100	0.138	0.165	0.205	0.258	0.563	NA
2007	0.103	0.139	0.157	0.163	0.284	0.214	NA
2008	0.118	0.153	0.189	0.222	0.219	0.384	NA
2009	0.125	0.137	0.169	0.449	0.729	1.298	0.267
2010	0.103	0.135	0.167	0.180	0.237	0.381	0.369
2011	0.096	0.154	0.173	0.215	0.214	0.227	1.348
2012	0.092	0.129	0.165	0.192	0.211	0.602	NA
2013	0.081	0.125	0.151	0.184	0.243	0.453	0.411
2014	0.092	0.126	0.139	0.236	0.252	0.307	0.392
2015	0.039	0.105	0.155	0.173	0.219	0.273	0.618

Table 6.2.3.5. Plaice in 7.d. Weights in the stock.

YEAR	1	2	3	4	5	6	7
1980	0.171	0.332	0.482	0.622	0.751	0.870	1.197
1981	0.110	0.216	0.317	0.414	0.506	0.594	0.924
1982	0.105	0.208	0.308	0.406	0.502	0.596	0.869
1983	0.097	0.192	0.286	0.379	0.470	0.560	0.854
1984	0.082	0.164	0.248	0.333	0.420	0.507	0.738
1985	0.084	0.171	0.259	0.348	0.440	0.533	0.778
1986	0.101	0.205	0.311	0.420	0.532	0.646	0.850
1987	0.122	0.242	0.361	0.479	0.596	0.712	0.929
1988	0.084	0.168	0.254	0.340	0.427	0.514	0.715
1989	0.079	0.162	0.250	0.342	0.439	0.541	0.855
1990	0.085	0.230	0.322	0.346	0.465	0.549	1.118
1991	0.143	0.219	0.275	0.335	0.375	0.472	0.958
1992	0.088	0.241	0.336	0.421	0.477	0.521	0.725
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.727
1994	0.165	0.198	0.276	0.331	0.383	0.493	0.866
1995	0.124	0.257	0.286	0.354	0.442	0.707	0.855
1996	0.178	0.229	0.263	0.347	0.354	0.474	0.934
1997	0.059	0.202	0.256	0.266	0.417	0.530	0.902
1998	0.072	0.203	0.273	0.361	0.530	0.670	0.873
1999	0.072	0.172	0.213	0.351	0.429	0.644	0.904
2000	0.068	0.184	0.204	0.246	0.355	0.554	0.928
2001	0.093	0.206	0.274	0.338	0.404	0.624	1.104
2002	0.102	0.206	0.281	0.379	0.467	0.558	0.809
2003	NA	0.306	0.403	0.528	0.673	0.592	0.961
2004	0.280	0.366	0.508	0.571	0.701	0.788	0.861
2005	0.174	0.299	0.377	0.489	0.672	0.683	1.010
2006	0.220	0.270	0.343	0.419	0.506	0.637	0.938
2007	0.063	0.247	0.391	0.543	0.579	0.656	0.825
2008	0.121	0.245	0.301	0.368	0.448	0.462	1.005
2009	NA	0.268	0.358	0.487	0.476	0.719	1.036
2010	NA	0.280	0.354	0.415	0.455	0.561	0.719
2011	0.189	0.238	0.402	0.535	0.737	0.791	0.908
2012	NA	0.253	0.298	0.424	0.517	0.629	0.938
2013	0.174	0.252	0.277	0.479	0.454	0.886	0.995
2014	0.157	0.256	0.243	0.381	0.518	0.756	1.042
2015	0.154	0.253	0.256	0.287	0.363	0.436	0.782

Table 6.2.6.1. Plaice in 7.d. Tuning fleets

UK BTS						
1989 2015						
1 1 0.5 0.75						
1 6						
1	3.8	15.8	28.9	31.7	4.0	1.7
1	9.2	9.4	11.1	11.7	12.6	1.5
1	16.8	14.5	11.5	8.7	8.6	4.6
1	22.4	21.3	6.6	6.6	7.2	5.4
1	4.6	20.2	8.0	2.8	2.9	2.4
1	9.4	8.5	10.1	6.0	2.0	0.6
1	14.5	6.2	3.8	5.7	2.2	0.8
1	22.1	17.3	1.7	1.0	2.0	1.3
1	48.2	28.6	11.0	1.3	1.6	0.5
1	30.6	37.9	12.1	5.0	0.6	0.6
1	12.8	10.7	28.8	4.6	1.6	0.3
1	19.5	30.2	18.8	20.5	5.0	1.3
1	27.9	20.3	14.1	9.8	14.8	2.7
1	37.9	25.9	12.5	5.5	2.6	5.3
1	10.6	39.7	9.8	4.4	2.3	1.1
1	52.9	22.5	20.7	4.8	1.2	0.3
1	15.6	36.2	12.8	10.0	3.2	1.1
1	30.1	28.9	16.8	5.9	4.3	1.3
1	53.1	28.9	12.2	6.2	3.2	2.9
1	39.6	40.6	10.5	4.3	3.8	1.8
1	77.7	39.5	20.9	5.9	3.2	2.3
1	64.2	64.7	17.7	9.2	3.1	1.7
1	115.1	112.2	39.6	10.3	7.0	2.9
1	24.7	81.1	56.0	18.7	4.2	3.3
1	32.3	61.0	88.2	45.0	10.2	3.4
1	145.3	156.5	50.7	62.1	26.8	9.0
1	38	178.7	63.2	30.2	33.4	15.7

Table 6.2.6.1.(cont.) Plaice in 7.d. Tuning fleets

FR GFS						
1993 2015						
1 1 0.75 1						
1 6						
1	232.04	867.4	345	125.8	32	8.66
1	468.69	347.5	148	67.6	26.2	11.65
1	30.31	336.5	364	142.1	101.1	27.19
1	772.65	243.8	181	26.6	12.9	15.07
1	537.67	800.7	267	245.8	20.8	8.55
1	551.31	415.3	406	93.7	29.3	0
1	66.49	529.1	254	392	76.1	12.41
1	2347.63	653.6	655	201.1	192.6	50.45
1	62.33	290.8	187	81.6	75.1	35.37
1	36.13	584.9	303	189.7	69.8	51.4
1	698.12	304	460	81.8	16.8	17.21
1	67.8	388.3	281	137	40	4.34
1	105.13	405.9	746	360	114.2	32.07
1	2163.19	684.3	447	152	61.4	32.69
1	46.64	446	395	237.2	105.1	33.52
1	120.29	235	642	140.1	46.8	12.23
1	48.65	293.8	223	94.6	27.8	6.82
1	36.36	745.5	467	109.5	29	7.46
1	729.93	1973.9	2370	734.3	116.8	12.96
1	224.96	557.3	1504	1282	257.9	97.02
1	304.35	716.4	567	1148.2	288.4	88.07
1	75.67	556.2	470	542.7	708.6	172.21
1	4.18	96.8	683	556.5	152.8	173.23

Table 6.3.1.2 Plaice in 7.d. Landings Residuals

AGE	1	2	3	4	5	6	7
1980	-0.7317623	0.7566031	-0.4537843	-0.2965485	0.2433267	-0.0335535	-0.1074725
1981	-1.3342082	0.2234025	0.3884756	0.3356951	-0.1290887	-0.1795775	0.2904463
1982	0.656489	0.2266889	-0.0949777	-0.0819194	0.0580407	0.3417678	-0.3046804
1983	-0.4874645	0.193992	-0.3108887	0.092499	-0.3021358	-0.203802	-0.0610599
1984	0.6120163	-0.4227322	-0.1980962	0.1460666	0.1639283	0.1455761	0.2762606
1985	-0.5629748	0.5532505	-0.2708043	0.2638308	-0.5253418	-0.0645073	0.004894
1986	0.564304	0.3181647	-0.0784105	0.1795455	0.1592601	0.5011414	-0.5382334
1987	-1.8573791	0.4775731	-0.1468664	0.0219268	0.0649163	-0.3826158	0.2550488
1988	-1.9362587	0.5622501	0.1174346	-0.0546161	-0.1904098	-0.006112	0.1022216
1989	1.4967842	0.3512363	-0.381461	-0.1915061	0.3214279	0.0243125	-0.0475156
1990	0.9707152	-0.0580355	0.2106991	-0.0707438	-0.1352495	-0.037476	0.1482987
1991	-0.4267999	0.4580829	0.2665366	0.2942429	0.0548876	-0.0771983	-0.1433432
1992	-0.6884845	0.0970929	0.32322	0.0181352	-0.0345705	0.0667483	0.0146508
1993	-0.554017	0.2589953	-0.1474135	-0.0869141	-0.183979	-0.09832	-0.1391778
1994	0.3271496	0.2645401	0.2026866	0.3248958	0.3548035	0.2960378	0.168455
1995	0.6418369	0.5444338	-0.113989	-0.1056738	-0.1372602	-0.3433138	-0.1683983
1996	-0.1084539	0.1492848	0.1480712	-0.177267	0.0116047	-0.061425	-0.1399089
1997	-1.0029445	0.1346697	0.3188984	0.7181046	0.491243	0.3930009	0.2718472
1998	-0.1416657	-0.1406508	0.438704	0.0357727	-0.0100945	-0.2434586	-0.2862662
1999	0.3337157	-0.3589311	0.1752386	0.4552492	0.0199685	0.3350789	0.0663487
2000	0.1027707	0.6558747	-0.3740824	-0.270096	-0.1172459	-0.1161922	0.0812366
2001	0.4033466	-0.2864938	-0.2256259	-0.4253859	-0.1481753	-0.227334	-0.0580562
2002	-0.45984	0.4543747	0.0182458	0.0827547	0.6207151	-0.0086562	0.0951584
2003	-5.1954149	-0.0223658	-0.5396951	0.2000351	-0.1894234	0.0299125	0.1707002
2004	2.6741098	0.8517705	-0.2293421	-0.3987292	-0.0474681	-0.1843397	-0.2454659
2005	0.5785501	0.662106	-0.4892391	-0.1555769	0.0535073	0.0429811	-0.0076851
2006	0.6946995	0.5427154	-0.4395654	0.1117793	0.197065	-0.2228395	0.0757119
2007	0.7945855	0.3292781	-0.5980723	-0.3150248	0.1285787	0.053215	0.0347295
2008	-0.1588189	0.3007986	-0.4355213	-0.1080558	0.1208411	-0.0346606	-0.2510059
2009	0.2858867	-0.1065306	-0.3539347	-0.1597542	0.0746052	-0.0553035	-0.2098879
2010	0.3328369	0.0897623	-0.4613077	0.2484095	0.2786715	0.4786274	0.0363171
2011	-1.4481915	0.0072165	-0.6669212	-0.514388	-0.1009961	-0.6833003	-0.5897582
2012	-0.0079514	-0.022589	-0.0711335	0.0119617	0.0574442	0.4348787	-0.0366851
2013	-0.0597915	0.0724931	-0.1075138	0.0076288	0.1831061	0.2289692	-0.2414452
2014	-0.0200016	0.0153136	0.4397213	0.0495386	0.1542901	0.1470297	-0.4317627
2015	-0.0762711	-0.1305248	-0.0294269	-0.1150904	-0.1566889	0.0556973	-0.0255026

Table 6.3.1.2 (cont.) Plaice in 7.d. Discards Residuals

	1	2	3	4	5	6	7
2006	-0.00908802	0.00031716	-0.08771148	-0.82880826	-0.7855614	0.08560163	0.42011066
2007	-0.12960469	0.50044144	-0.01494139	0.39017146	-2.63289603	0.09618416	0.57302124
2008	0.16434532	-0.42821622	-0.94066635	0.16185145	0.92037458	1.65224772	0.94337154
2009	-0.06134169	0.09480914	0.07303661	0.03767075	0.50453007	2.60064971	1.8307582
2010	-0.09358731	0.66840533	0.37618488	0.9739187	1.17859469	1.12768993	1.76332543
2011	0.05630504	0.2552561	-0.61659755	-0.13914334	0.37563609	3.03444045	1.41390177
2012	0.01264133	-0.02219619	-0.07090686	0.01297867	0.07705162	1.56638513	3.97886867
2013	-0.02371232	0.07318064	-0.10730794	0.00829163	0.19462398	0.33090886	0.52945203
2014	-0.01485282	0.01597445	0.44002571	0.04992961	0.15651739	0.16043345	-0.33074677
2015	0.02012124	-0.12977373	-0.02897518	-0.11415927	-0.15517922	0.05971473	-0.0003182

Table 6.3.1.3 Plaice in 7.d. Survey residuals

UK BTS

age	1	2	3	4	5	6
1989	-1.43148745	-0.62624065	-0.02135472	0.38638918	-0.07116134	0.13027007
1990	-0.53547634	-0.61966855	-0.45519266	-0.15493513	0.17307268	-0.32496766
1991	-0.37975962	-0.01601455	0.17993733	0.05080842	0.19403026	-0.19334254
1992	-0.25173593	0.01525521	-0.13088954	0.38830939	0.4711237	0.30405314
1993	-1.10447529	-0.21383867	-0.28839183	-0.21891379	0.16725896	-0.06463491
1994	-0.29294124	-0.40667679	-0.23559149	0.2023231	0.07457078	-0.69917606
1995	-0.43951373	-0.62824213	-0.49359842	0.06902363	-0.04921443	-0.20408029
1996	-0.14796569	-0.2428682	-1.14305435	-0.74808974	-0.11848734	0.12857335
1997	0.06546143	0.04718776	-0.05637104	-0.44775196	0.53670304	-0.5801213
1998	0.34397762	-0.30119526	-0.29034675	0.08261055	-0.16197706	0.42278586
1999	-0.36692911	-0.83552111	-0.10786985	-0.41604123	-0.19430781	-0.02637398
2000	-0.14318957	0.44197261	0.25354944	0.32081673	0.36853388	0.18878627
2001	0.31586228	0.0164717	0.36631755	0.39036214	0.64879427	0.34510529
2002	0.2890561	0.36695719	0.32498023	0.25111136	-0.27776436	0.16742688
2003	-0.35590819	0.26018649	0.10035136	0.13234092	0.0286	-0.49352247
2004	1.01125291	0.18404982	0.13944107	0.16901792	-0.51335679	-1.21151257
2005	-0.08409085	0.40893837	0.08348681	0.14898737	0.40269139	0.01515998
2006	0.60743401	0.3347427	0.11918789	0.03029914	-0.09382152	0.13105584
2007	0.94953223	0.43026296	0.00034771	-0.16285356	-0.00967448	0.06150179
2008	0.34571173	0.5625445	-0.01437182	-0.32238223	-0.0865295	-0.04344882
2009	0.56902137	0.19737558	0.44053244	0.10107347	-0.07526721	-0.11131366
2010	-0.08160808	0.19337409	-0.1395587	0.27676884	-0.01037471	-0.21412174
2011	0.20545346	0.24716936	0.07082351	-0.07531371	0.49768285	0.34072371
2012	-0.64787945	-0.39057798	-0.14675079	-0.12537556	-0.47304607	0.18974073
2013	-0.42180968	0.00502969	-0.04178826	0.15013855	-0.25475869	-0.2598642
2014	0.92208764	0.91618134	0.07301929	0.10070953	0.09262729	0.04141455
2015	0.3689431	0.91530687	0.26546319	0.03628505	-0.05467066	0.00813469

Table 6.3.1.3 (cont.) Plaice in 7.d. Survey Residuals

FR GFS						
age	1	2	3	4	5	6
1993	1.353593	0.0210181	0.0548124	-0.0089883	-0.612795	-0.5389702
1994	0.5411788	-0.1679686	-0.717743	-0.4907609	-0.1001986	0.7926329
1995	-0.077728	0.8099477	0.7236571	0.7416236	0.4452086	2.0290029
1996	-0.5347635	-0.5160409	-0.7795479	-0.3547855	-0.0282261	0.9151427
1997	0.073288	-0.3668155	0.6459888	0.1960825	0.3875457	1.7552893
1998	0.1434398	-0.6015105	-0.6620311	-0.2870276	-1.1096102	1.2627494
1999	0.5408585	-0.3405981	0.0625838	0.1792969	-0.0923184	1.6330874
2000	0.5781173	0.8820428	0.2112203	0.3447399	0.6531712	1.0170063
2001	-0.098032	-0.3372665	-0.2423324	0.2072461	-0.492258	-0.2842516
2002	0.2373909	0.2318073	0.6757749	0.5673839	0.6286002	-0.1522591
2003	0.1732396	0.0508293	-0.1632947	-0.6841587	0.0525786	0.2300011
2004	0.179822	0.0174283	-0.3888267	0.0795215	-0.9397006	1.1059182
2005	0.3427379	0.7374616	0.9816194	0.3378208	0.6768258	1.0192598
2006	0.9064749	0.39293	-0.0978014	0.1265211	-0.0892722	0.6352713
2007	0.2594098	0.3835484	0.5537636	0.4075869	0.2970984	-0.6784026
2008	-0.6873221	0.6642244	0.166533	-0.1824748	-0.8778031	0.2159958
2009	-0.9186273	-0.7361389	-0.4567317	-0.5629428	-1.175137	-0.2468969
2010	-0.4549106	-0.5149893	-0.7538173	-0.7906015	-1.0126621	0.0176862
2011	0.2211274	0.597396	0.5175538	0.0763692	-0.8416741	1.5953954
2012	-0.3587013	-0.1774395	0.4899349	0.2131379	0.5573373	0.3428993
2013	-0.1473372	-0.4719367	0.0211648	-0.2817425	-0.1847234	-0.5596347
2014	-0.5533869	-0.6841747	-0.0623705	0.2397628	-0.1292369	-0.7164262
2015	-1.487909	-0.4383178	-0.0667455	-0.6293846	-0.4904655	-0.6884282

Table 6.3.1.4 Plaice in 7.d. Fishing mortality (F) at age

	1	2	3	4	5	6	7
1980	0.0138004	0.13028	0.400872	0.311596	0.170516	0.0990706	0.0990706
1981	0.0151641	0.135083	0.437482	0.397358	0.238643	0.139975	0.139975
1982	0.0171941	0.147522	0.485567	0.474815	0.30375	0.185111	0.185111
1983	0.020738	0.178502	0.557166	0.498611	0.320219	0.21464	0.21464
1984	0.0254172	0.230258	0.646873	0.460697	0.281243	0.216699	0.216699
1985	0.0266535	0.262725	0.69836	0.417941	0.244133	0.208412	0.208412
1986	0.0204471	0.221842	0.64647	0.416047	0.248993	0.209747	0.209747
1987	0.0144166	0.158761	0.539217	0.449105	0.293379	0.225642	0.225642
1988	0.0155992	0.139092	0.469054	0.474335	0.341244	0.251207	0.251207
1989	0.0371468	0.195869	0.476332	0.451333	0.343745	0.278126	0.278126
1990	0.125351	0.349958	0.528068	0.398773	0.30541	0.285281	0.285281
1991	0.300703	0.534324	0.565018	0.349383	0.255481	0.250255	0.250255
1992	0.357016	0.567657	0.552624	0.322504	0.21723	0.190575	0.190575
1993	0.285807	0.503979	0.538842	0.329737	0.20742	0.155333	0.155333
1994	0.224973	0.466191	0.577294	0.390106	0.244557	0.168853	0.168853
1995	0.193077	0.459784	0.657503	0.505823	0.338275	0.236151	0.236151
1996	0.156364	0.413831	0.684624	0.623074	0.456956	0.325213	0.325213
1997	0.108013	0.303888	0.580475	0.645404	0.511905	0.348459	0.348459
1998	0.0803795	0.223953	0.458886	0.58061	0.472692	0.296764	0.296764
1999	0.0927587	0.230864	0.427367	0.497773	0.380464	0.22703	0.22703
2000	0.17698	0.370834	0.522322	0.436218	0.286588	0.1753	0.1753
2001	0.277201	0.584372	0.677027	0.395369	0.225355	0.151152	0.151152
2002	0.162058	0.530115	0.720835	0.371445	0.206725	0.159852	0.159852
2003	0.0386855	0.274851	0.605675	0.358628	0.220226	0.19884	0.19884
2004	0.0108886	0.144628	0.489654	0.348596	0.238685	0.240121	0.240121
2005	0.0094362	0.130815	0.458758	0.334538	0.232605	0.236526	0.236526
2006	0.019186	0.183017	0.491297	0.315021	0.204328	0.196747	0.196747
2007	0.0382231	0.261727	0.538045	0.291185	0.172489	0.15843	0.15843
2008	0.0402568	0.281089	0.54885	0.264552	0.147148	0.135287	0.135287
2009	0.0276595	0.23487	0.503962	0.237242	0.127529	0.115886	0.115886
2010	0.0179739	0.169381	0.40778	0.211011	0.11191	0.0917004	0.0917004
2011	0.0141284	0.118259	0.299842	0.187506	0.100218	0.0679323	0.0679323
2012	0.0145018	0.0910184	0.221664	0.168244	0.0937239	0.0543524	0.0543524
2013	0.0205087	0.0869097	0.181579	0.153926	0.0934989	0.0539198	0.0539198
2014	0.037611	0.101204	0.165418	0.143336	0.0985855	0.0655779	0.0655779
2015	0.0785829	0.130216	0.15898	0.134663	0.106881	0.088364	0.088364

Table 6.3.1.4 Plaice in 7.d. Stock number from the assessment.

	1	2	3	4	5	6	7
1980	66487.2	30226.8	9931.93	2438.46	1978.16	670.93	1875.38
1981	34816.7	46067.5	18640.7	4672.91	1254.42	1171.81	1620.07
1982	65693.4	24090.9	28273.5	8455.08	2206.32	694.15	1705.13
1983	59878.4	45363.3	14602.8	12222.2	3694.53	1143.94	1400.68
1984	61544.2	41201.6	26658.4	5876.41	5215.04	1884.26	1442.3
1985	77470	42150.2	22991.4	9807.33	2604.26	2765.45	1881.63
1986	155094	52991.8	22769.3	8033.81	4536.2	1433.21	2650.44
1987	94476	106749	29820.5	8379.96	3722.93	2484.31	2325.99
1988	61809.7	65420.1	63983.4	12217.6	3757.07	1950.4	2696.67
1989	41183.8	42749.6	39990.3	28119.7	5341.16	1876.29	2539.41
1990	42485.5	27876.9	24689.8	17447.6	12579.1	2660.72	2348.88
1991	73290.6	26330	13801	10229	8226.26	6511.22	2645.81
1992	88777.8	38115.8	10840.5	5510.32	5066.96	4476.09	5008.65
1993	41775.9	43642.1	15178.4	4382.25	2803.92	2864.55	5506.95
1994	35888.6	22052.2	18521.7	6220.99	2213.83	1600.79	5034.93
1995	62768.2	20132.7	9719.39	7304.92	2958.62	1217.83	3937.38
1996	69714.6	36352.8	8930.41	3537.85	3094.5	1481.94	2859.81
1997	118778	41885.8	16883.6	3163.69	1332.88	1376.53	2203.32
1998	56203.8	74899.5	21714	6637.7	1165.6	561.21	1774.93
1999	48589.6	36434.1	42059.9	9640.48	2609.23	510.4	1219.74
2000	62202.8	31110.7	20318.7	19271.5	4116.89	1252.94	968.58
2001	59642.8	36610	15083.7	8466.51	8752.24	2171.48	1309.69
2002	77267.3	31755.7	14337.1	5384.31	4005.42	4907.94	2102.48
2003	38573.7	46159.9	13129.5	4898.43	2608.94	2288.33	4197.32
2004	47696.9	26070	24634.8	5033.34	2404.13	1470.52	3734.64
2005	42294.8	33144.5	15848.2	10605.9	2495.24	1330.29	2876.09
2006	40842.5	29433.3	20429.1	7037.11	5332.23	1389.14	2332.58
2007	51775.4	28146.9	17219	8780.79	3607.73	3053.66	2147.58
2008	70735	35008.5	15220	7062.97	4610.25	2132.91	3118.54
2009	110054	47731.1	18567.3	6175.94	3808.42	2795.56	3222.37
2010	173358	75204.9	26512.4	7880.11	3422.32	2355.1	3765.04
2011	232267	119615	44600	12388.1	4482.72	2149.66	3922.72
2012	117472	160880	74658.4	23214.9	7214.74	2848.84	3985.72
2013	122771	81336.9	103187	42020.6	13783.2	4614.96	4547.33
2014	145350	84496.6	52383.4	60452.6	25308.3	8818.48	6098.7
2015	67953	98340.4	53646	31189.2	36797.3	16110.1	9814.25

Table 6.3.1.6 Plaice in 7.d. Summary table (Outputs from the model)

	Recruitment	SSB	Catch	Landings	Total Biomass	Fbar
1980	66487.2	8180.7	2292	1826	28372	0.24551
1981	34816.7	10781	3814	3074	29819	0.30336
1982	65693.4	13150	5260	4444	32644	0.36231
1983	59878.4	13256	5339	4386	33028	0.39766
1984	61544.2	13273	6160	4893	33303	0.40138
1985	77470	13237	6144	4783	34214	0.39221
1986	155094	13121	5965	4514	44787	0.38031
1987	94476	15623	6920	5168	49410	0.37684
1988	61809.7	20628	8921	7190	47644	0.38396
1989	41183.8	22361	8804	7347	39909	0.38738
1990	42485.5	19277	7418	5952	32203	0.37938
1991	73290.6	15254	6989	4597	29840	0.35503
1992	88777.8	12404	7138	3916	30215	0.32073
1993	41775.9	11262	5778	3567	25238	0.30783
1994	35888.6	10631	4838	3391	20947	0.3452
1995	62768.2	9206.1	4797	3267	21283	0.43444
1996	69714.6	7848.7	5156	3382	23498	0.52247
1997	118778	7922.4	5486	3552	31773	0.52156
1998	56203.8	10351	5768	4043	33533	0.45224
1999	48589.6	14138	6629	5137	32941	0.38316
2000	62202.8	15533	7182	5343	32473	0.35511
2001	59642.8	14013	7421	4921	31052	0.36223
2002	77267.3	12501	6248	4198	31158	0.36471
2003	38573.7	11918	4735	3587	28297	0.34584
2004	47696.9	12561	4449	3747	28343	0.32926
2005	42294.8	13136	4068	3459	28496	0.31561
2006	40842.5	13652	4480	3705	28902	0.30185
2007	51775.4	13865	4606	3676	30014	0.29004
2008	70735	13691	4734	3476	33613	0.27396
2009	110054	14375	4912	3561	42916	0.24615
2010	173358	17278	5374	3933	61236	0.2056
2011	232267	24231	6530	4702	87194	0.16387
2012	117472	36661	6118	2977	95269	0.1345
2013	122771	49924	6400	3674	96915	0.12073
2014	145350	55810	6134	3288	97071	0.11823
2015	67953	54378	5788	3253	86361	0.12222

Table 6.5.3.1.1 Plaice in 7.d. Management options for 2016 and their effects on the resident stock.

Variable	Value	Source	Notes
F ages 3-6 (2016)	0.27	AAP	Assuming that the 7d proportion of the TAC 2016 is fully landed
SSB (2017)	61116	AAP	Short term forecast (STF), tonnes
Rage1 (2017)	155235	GM 2010-2013	Thousands individuals
Rage1 (2017)	155235	GM 2010-2013	Thousands individuals
Catch (2016)	14074	AAP	t (resident stock)
Landings (2016)	8223	AAP	t (resident stock)
Discards (2016)	5851	AAP	projection based on the 2013-2015 discard ratio (by age)

Rationale	Basis	Catch (2017)	Wanted catch (2017)	Unwanted catch (2017)	F total catch (2017)	%SSB change (2018/2017)	% change in wanted catch (2017/2015)
MSY Approach	Fmsy	12805	7550	5255	0.25	-3%	+155%
Other options	Fpa	17607	10402	7205	0.36	-12%	+252
	Fsq (Fbar 2015)	6502	3824	2678	0.12	+9%	+29%
	Landings 2015 roll over	5030	2957	2073	0.09	+12%	+0%
	Landings 2015 + 20%	6034	3548	2486	0.11	+10%	+20%
	Landings 2015 -20%	4025	2365	1660	0.07	+14%	-20%

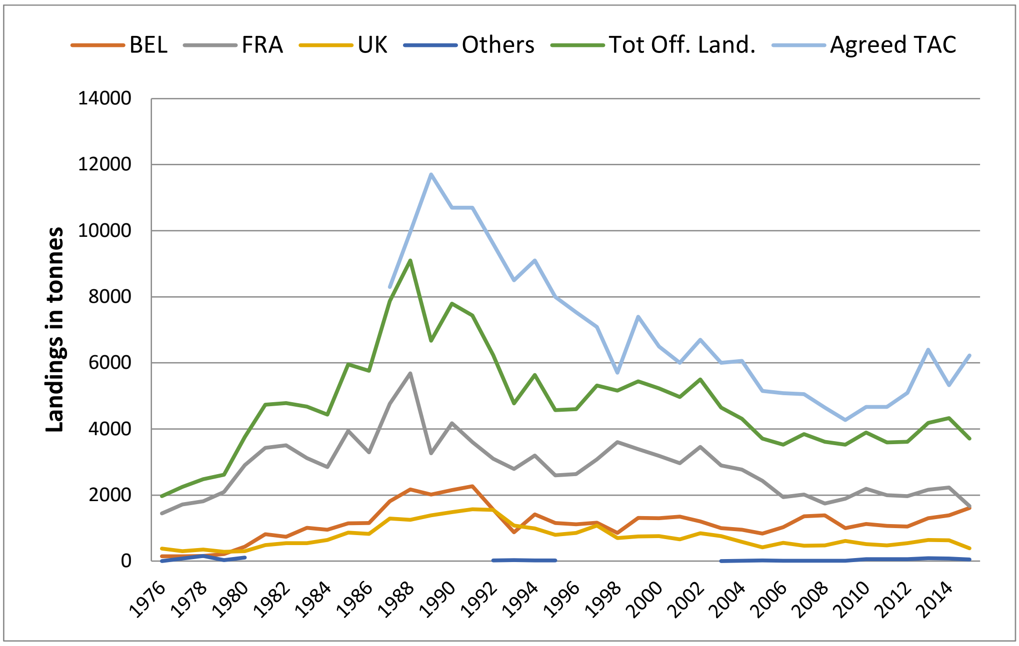


Figure 6.2.1.1. Plaice in 7.d. Official landings.

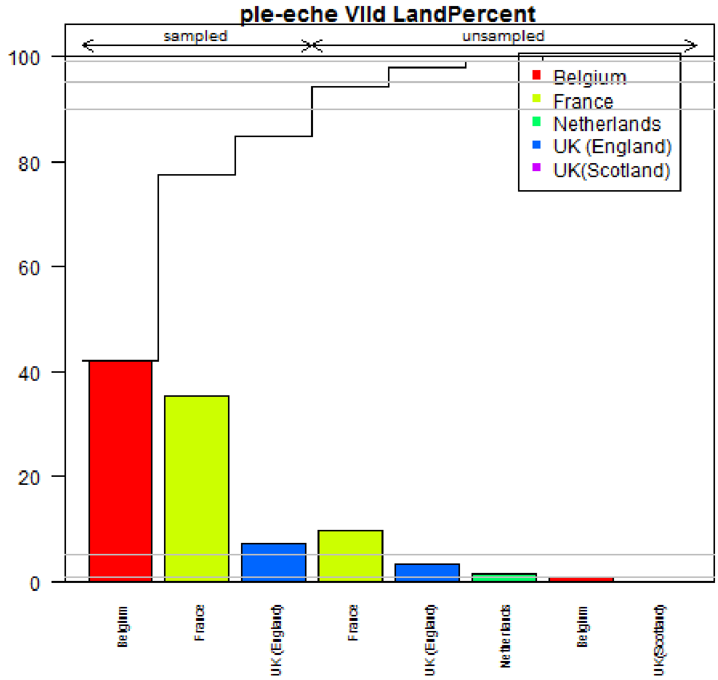


Figure 6.2.2.1: Plaice in 7.d. Proportions of total landings per country with and without age distribution provided.

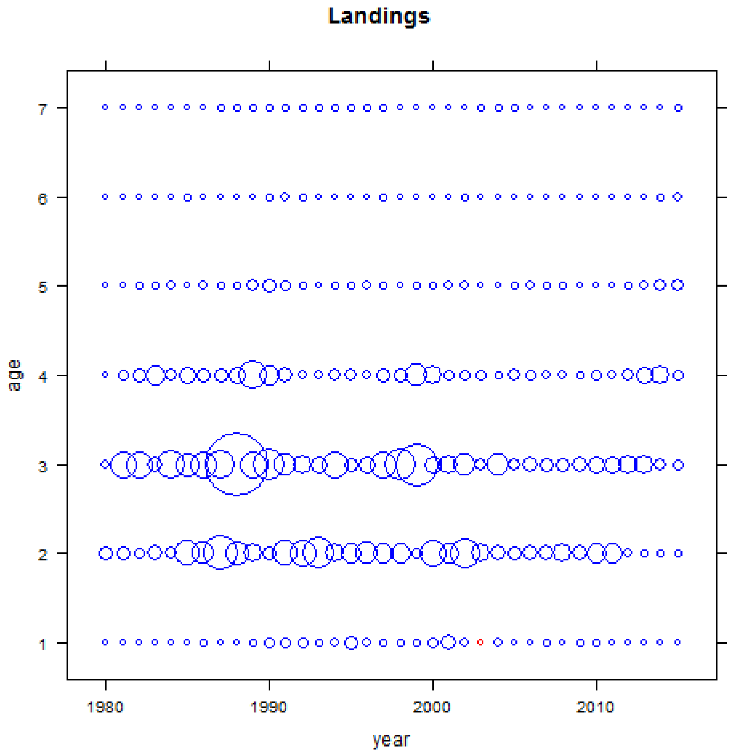


Figure 6.2.3.1. Plaice in 7.d. Age composition of the landings.

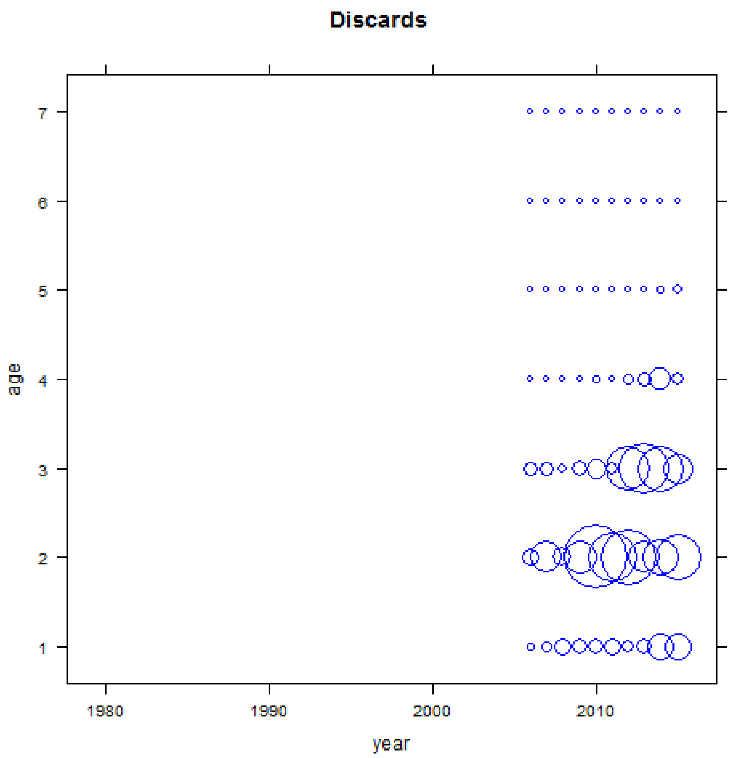
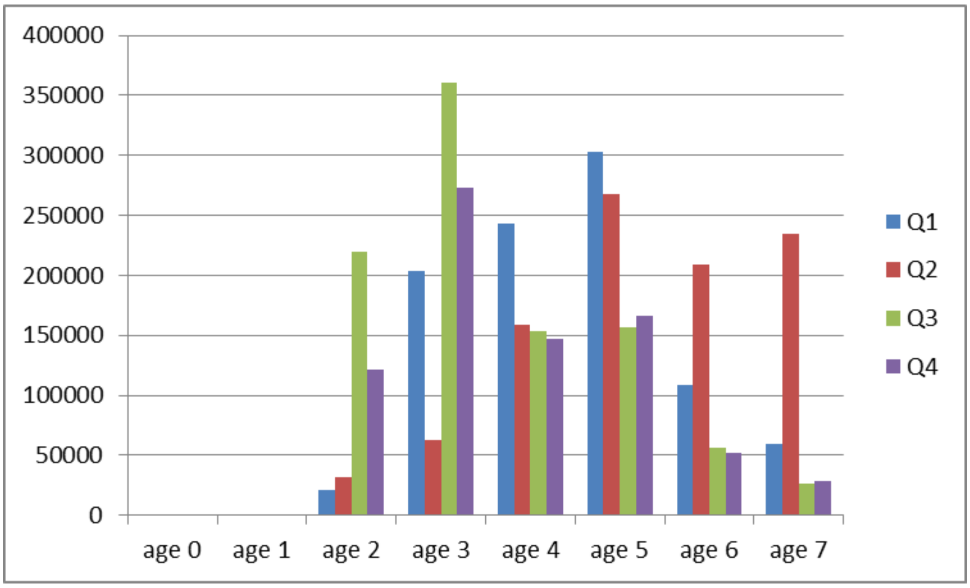


Figure 6.2.3.2. Plaice in 7.d. Age composition of the discards.

Landings



Discards

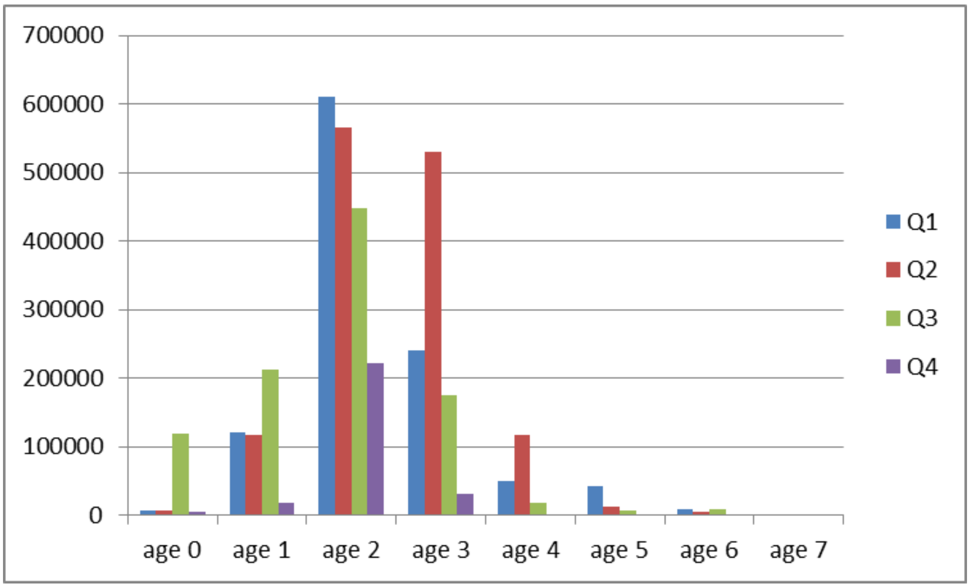


Figure 6.2.1.2. Plaice in 7.d. 2015 Age distribution in the sampled landings and discards per quarter. (Number of individuals)

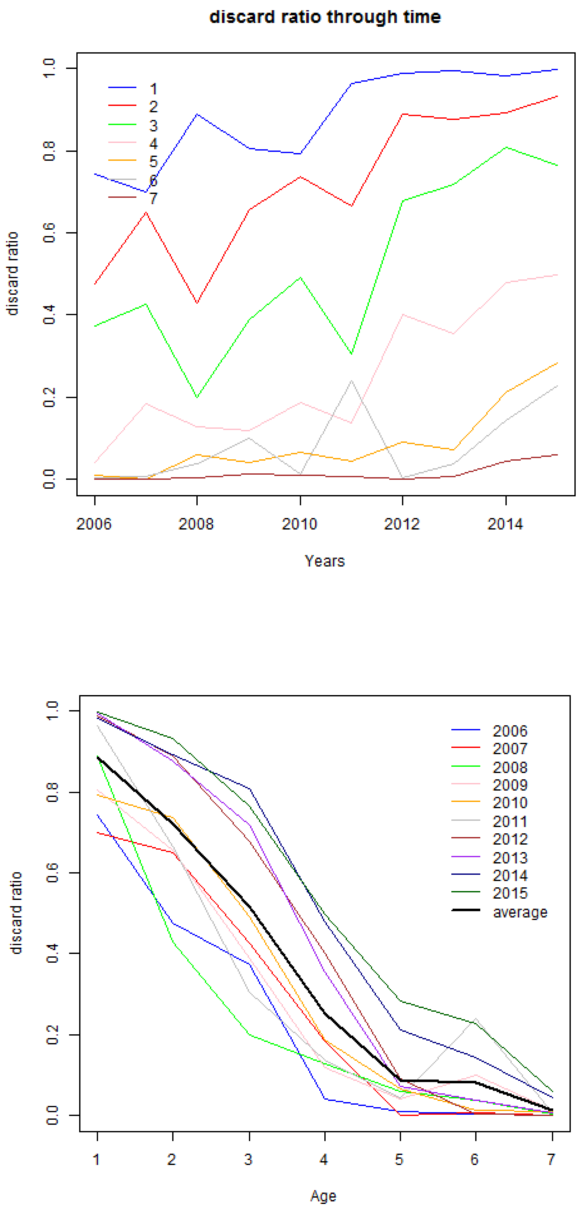


Figure 6.2.1.3. Plaice in 7.d. Discards at age ratio (discards numbers/landings numbers) per age and through time.

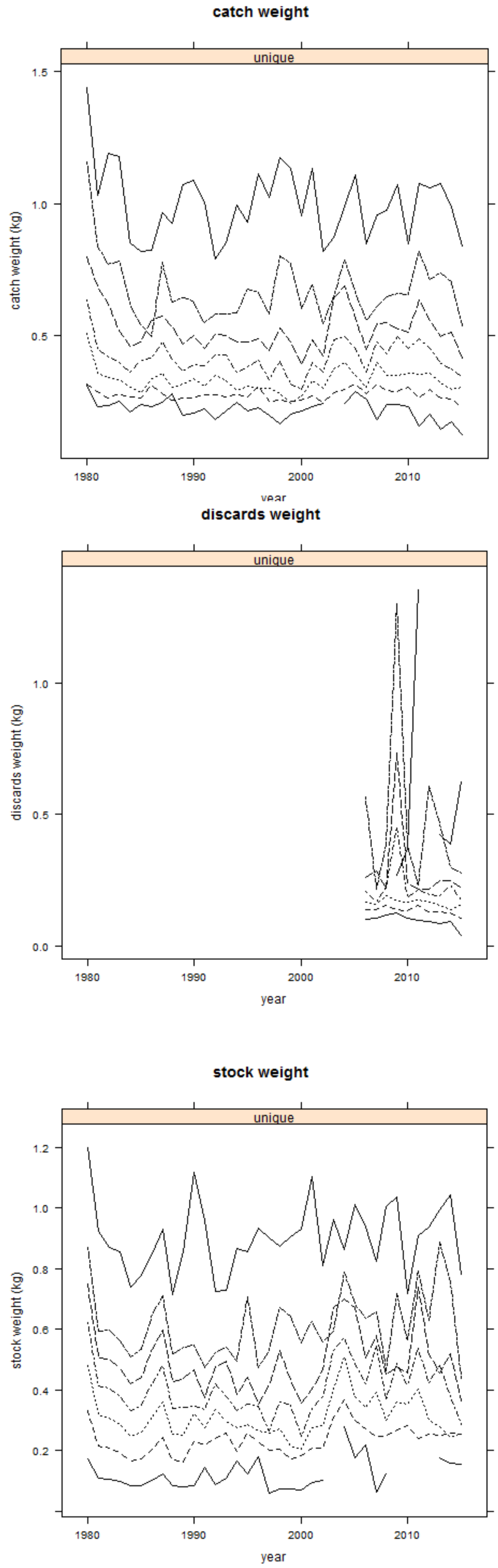


Figure 6.2.3.1. Plaice in 7.d. Stock, Catch weight and discard weight.

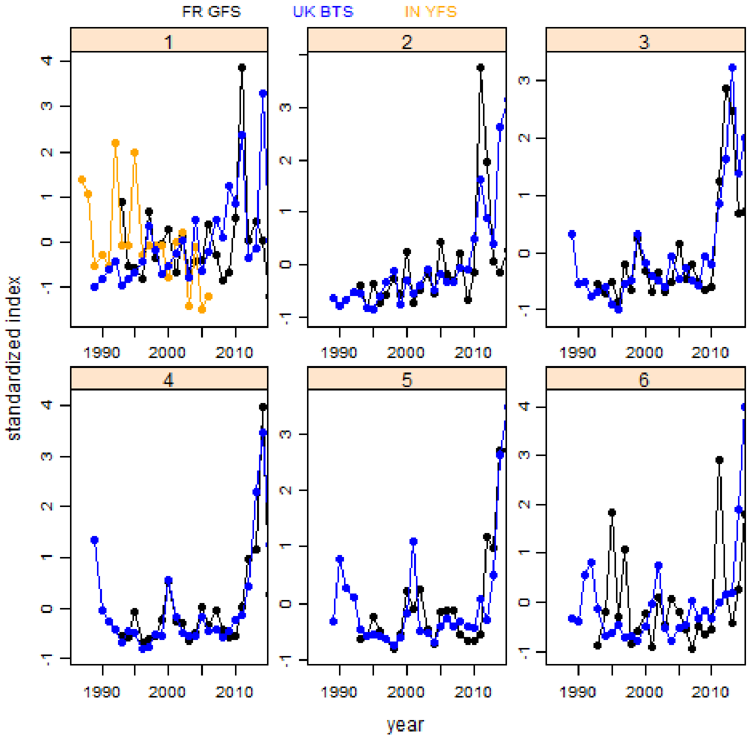
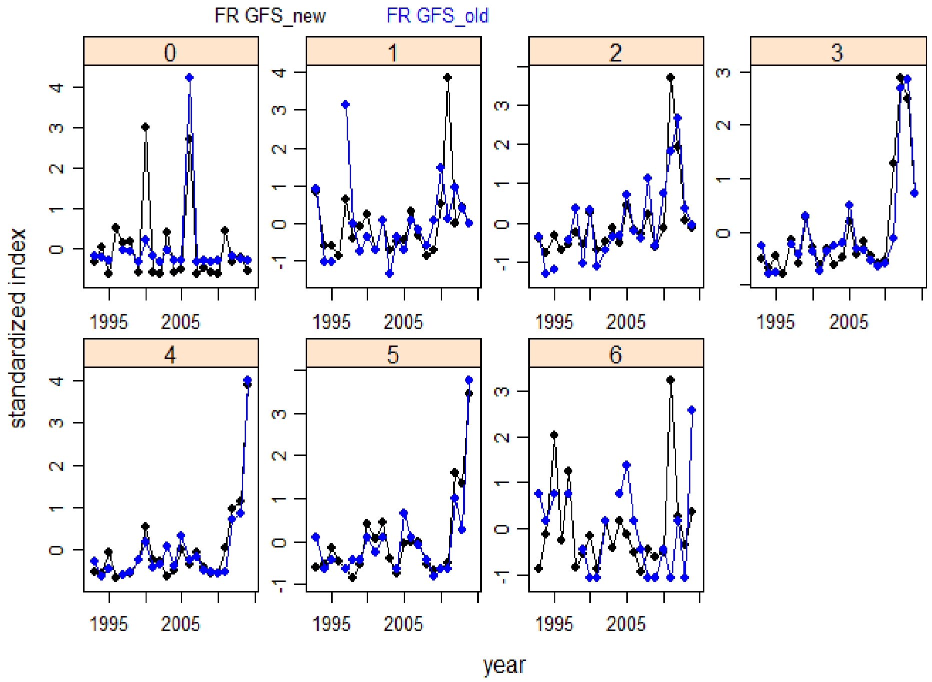


Figure 6.2.6.1 Plaice in 7.d. Consistency between surveys: Mean standardised indices by surveys for each age.



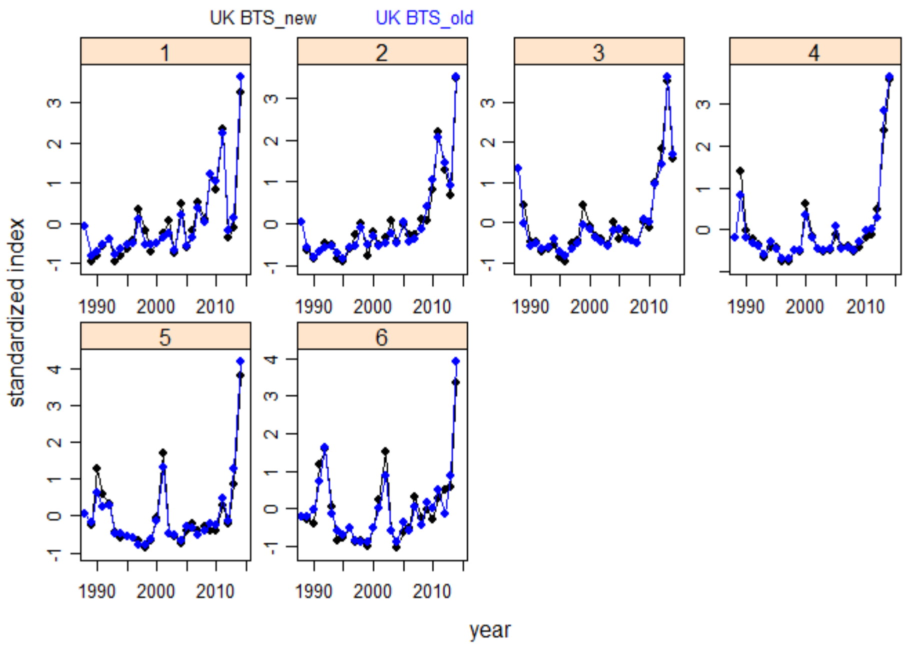


Figure 6.2.6.2: Old and new UK BTS and FR GFS indices.

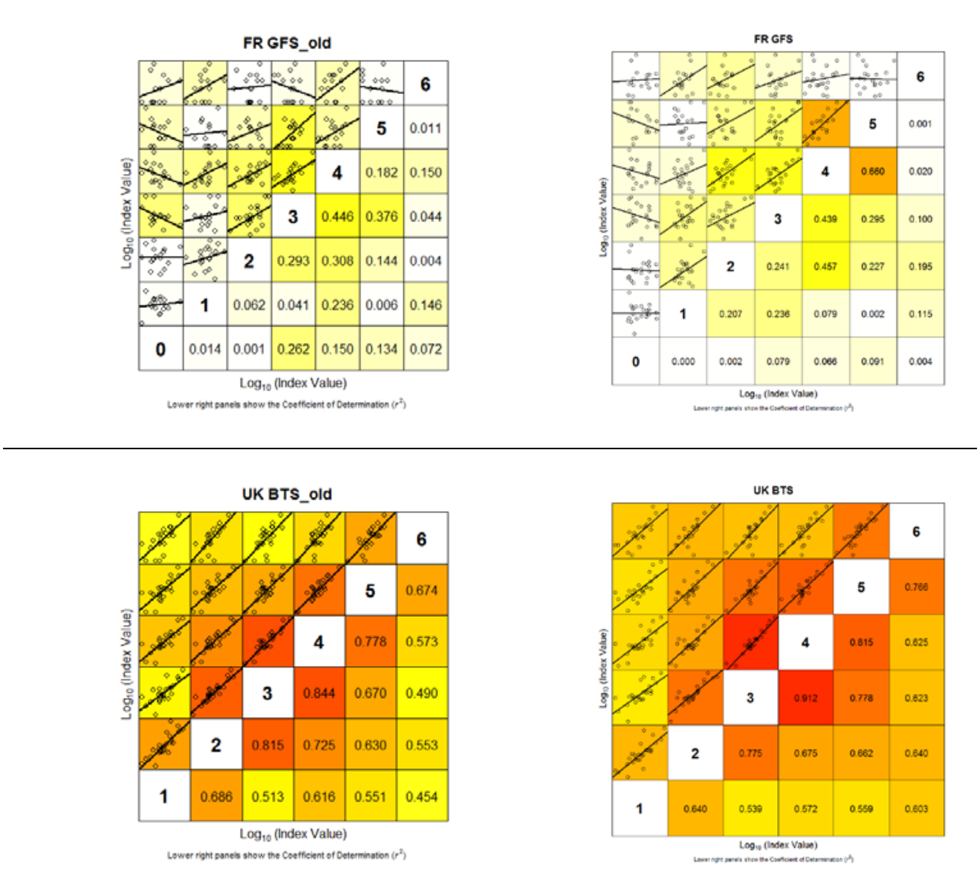


Figure 6.2.6.3: Old and new UK BTS and FR GFS indices consistencies

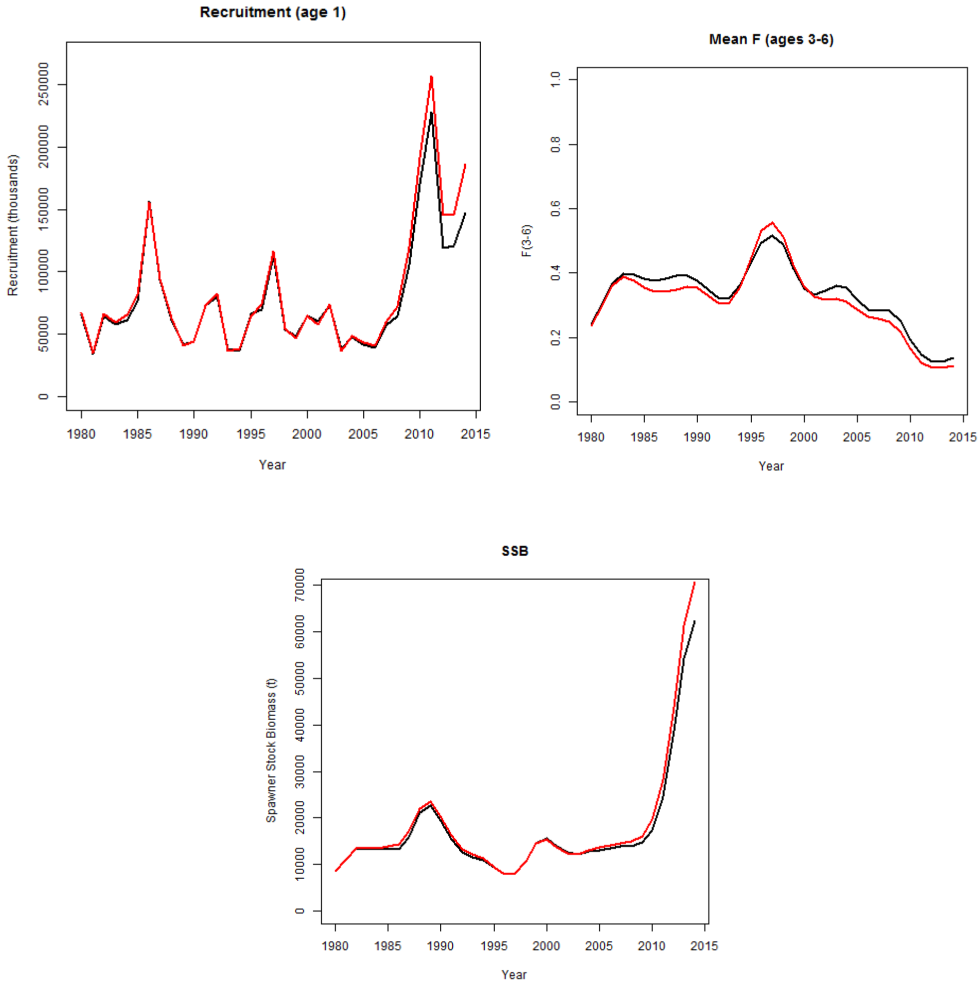


Figure 6.2.6.4: Effect of the changes in the survey indices on the 2015 assessment. Red: assessment with old indices, black: assessment with new indices.

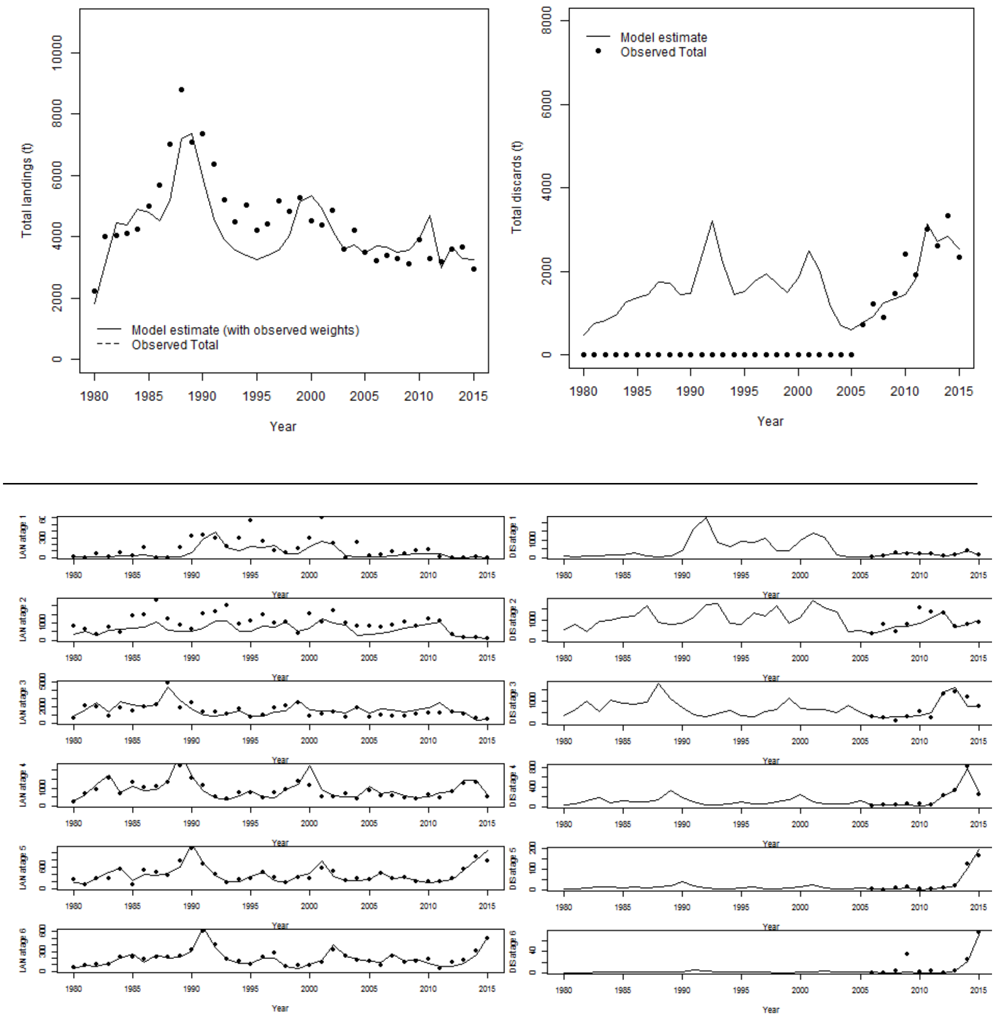


Figure 6.3.1.1. Plaice in 7.d. Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).

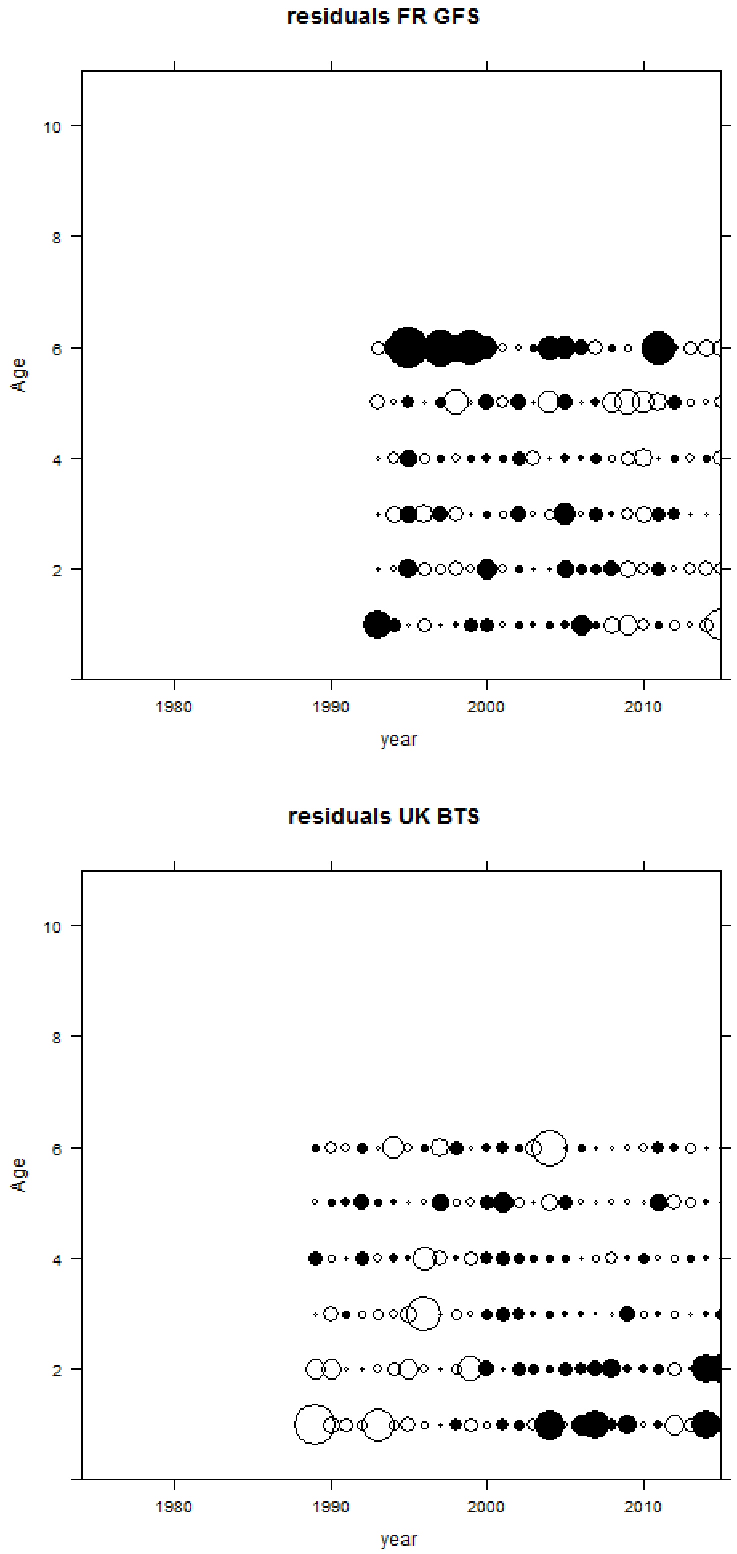


Figure 6.3.1.2. Plaice in 7.d. Survey residuals from the AAP assessment.

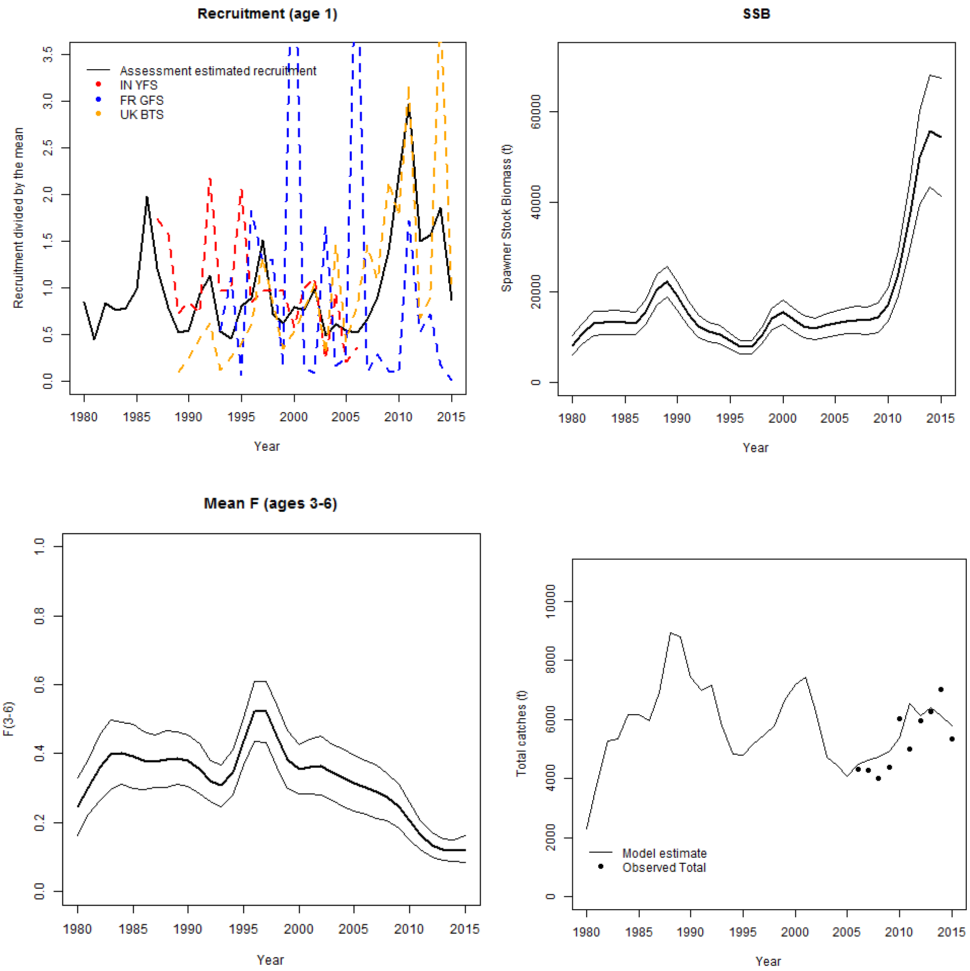


Figure 6.3.1.3. Plaice in 7.d. Summary of assessment results.

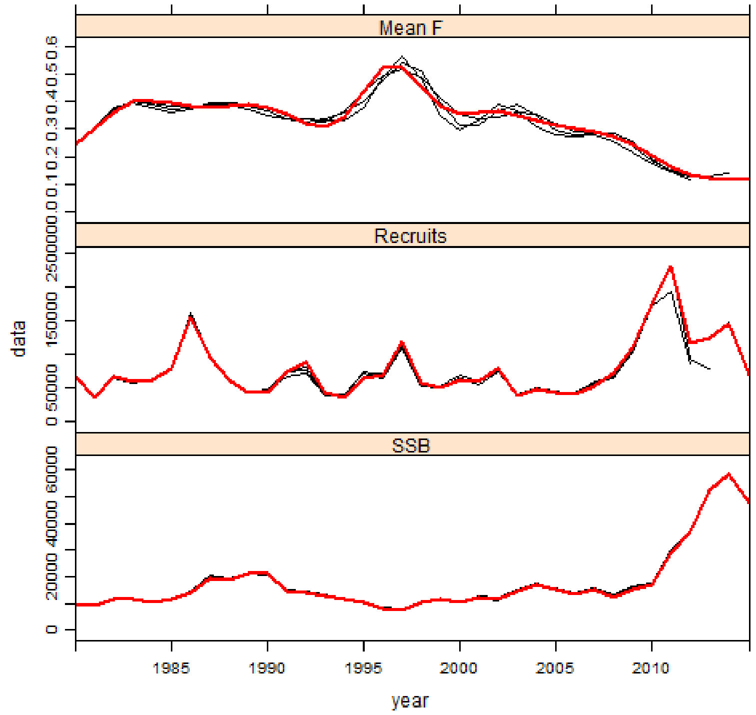


Figure 6.3.1.4. Plaice in 7.d. Retrospective patterns.

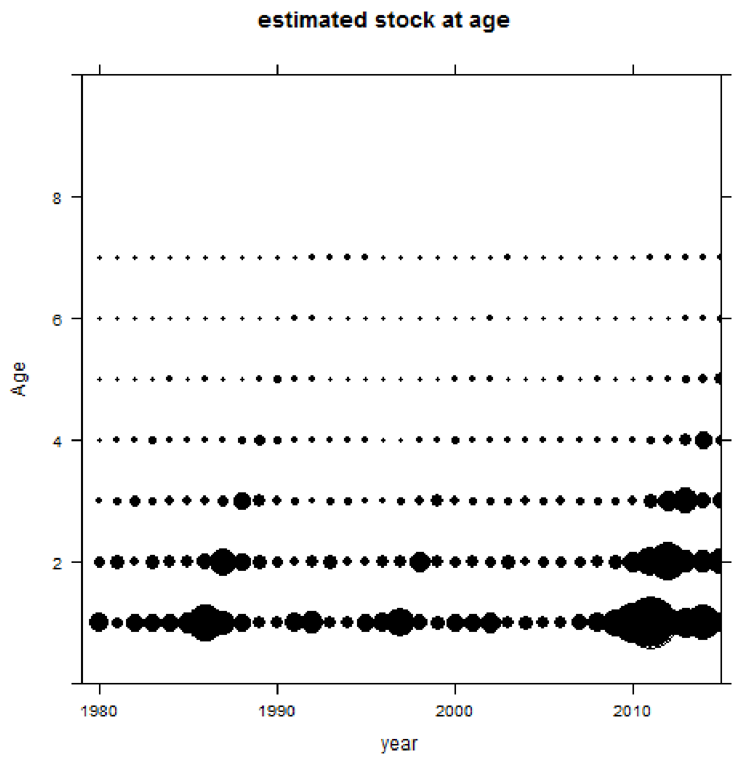


Figure 6.3.1.5. Plaice in 7.d. Estimated stock numbers.

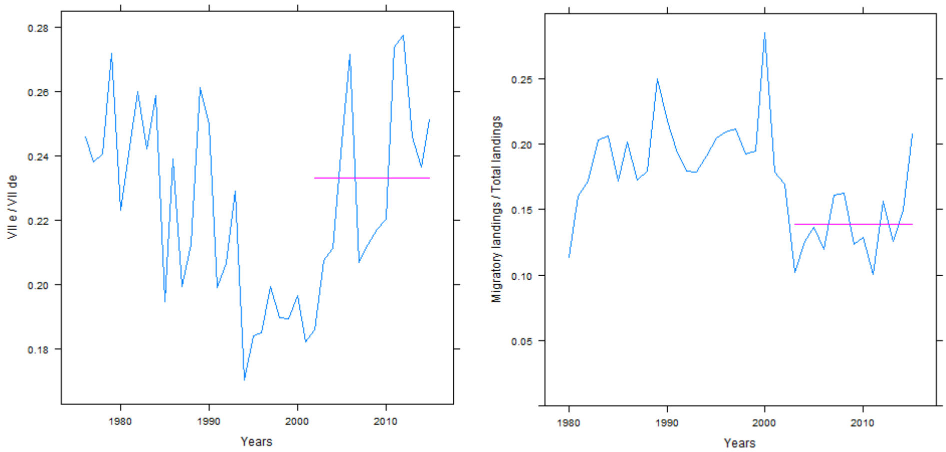


Figure 6.5.2.1 Plaice in 7.d. Time series of (left) proportion of the catch taken in 7.e over the total catch for 7.d-e, and (right) proportion of the catch of fish coming from .7e and 4 over the 7.d catch, and the averages used.

7 Plaice (*Pleuronectes platessa*) in Subdivision 3.aN (Skagerrak)

The plaice in Skagerrak has been benchmarked in February 2015 (ICES WKPLE), and is now assessed together with the North Sea Plaice (see details in ICES WGNSSK 2015 report). All information related to the assessment of the combined stock is found in section 8. But the current section on Plaice in Skagerrak is maintained to display the relevant indicators.

The existence of a resident plaice population in Skagerrak, with a distinct genetic print has been demonstrated (Ulrich *et al.*, in press). However, this population is importantly mixed with the North Sea population, also during spawning season, indicating that the Skagerrak area also belongs to the natural distribution area of North Sea plaice.

During summer, there is likely an important inflow from the North Sea population, entering Skagerrak to feed. This inflow has increased over the recent years, consistently with the increase of abundance of the North Sea stock. The largest part of the fishery occurs in this period, and in the most westerly part of the Skagerrak close to the North Sea border (Jammer Bay). Therefore, much (and likely most) of the commercial catches recorded for Skagerrak may belong to the North Sea component, although the geographical patterns of mixing with the local Skagerrak component is not known in detail at present.

There is thus no scope for a stock assessment of the Skagerrak population alone at present. Nevertheless, WGNSSK suggested a number of indicators to monitor fisheries trends in the Skagerrak. This routine scrutiny could potentially detect a departure from the current situation and an increased risk of local depletion of the resident population. In the medium-term, other actions could be undertaken to improve the monitoring of the local component in Skagerrak. Such actions have not been launched at present, but could motivate future research efforts.

7.1 Ecosystem aspects

7.1.1 Fisheries

Technical Conservation Measures

Minimum Landing Size is 27 cm.

Changes in fleet dynamics

A detailed description of the fishing activities in area 3.a is available in STECF (2015)[1], separated by area (Skagerrak= area 3.b1).

In 2015, the share of landings coming from Fully Documented Fisheries in the Skagerrak reduced sensibly compared with previous years, down to 586 t (against 1500 tonnes

1 https://stecf.jrc.ec.europa.eu/documents/43805/1040968/2015-07_STECF+15-12+-+FDI+2015_JRC97365.pdf

and http://datacollection.jrc.ec.europa.eu/dd/effort/graphs in 2014), corresponding to around 6% of total landings in the area (17% in 2014). (InterCatch data). There are less Danish landings operating under that scheme, but some Dutch flyshooters have been recorded in FDF.

7.1.2 Management

According to the agreed records of EU-Norway negotiations in December 2015, the North Sea plaice long-term management plan was not used as the basis for TAC for the combined stock. An interim agreement was reached to keep the TAC in 2016 at the 2015 level in both areas. These TACs were adjusted by 2.6% in the North Sea and by 17% in the Skagerrak in order to take into account the inclusion of plaice (trawls and beam trawls with mesh size equal to or greater than 100 mm) in the EU landing obligation, resulting in a TAC of 11 766 tonnes in the Skagerrak.

7.2 Data available

7.2.1 Catch

The official landings reported to ICES are not distinguished between Skagerrak (3.asN) and Kattegat (3.aS) in the FAO areas definitions used by Eurostat, so this information is not presented.

The annual landings used by the Working Group, available since 1972, are given by country in Tables 7.1.1. Denmark stands for the largest part of landings (80% in 2015). Misreporting is not considered an issue.

As in previous years, information was provided by DCF metier as specified in the data call and InterCatch was used to raise catch-at-age information.

Age information is provided by Denmark, and discards information is provided by Denmark, Sweden and Germany (Tables 7.3.1 and 7.3.2)

The small issue in the older Swedish InterCatchdata discovered during WGNSSK 2015 will still have to be reprocessed during the benchmark next year.

For 2015, landings strata for which discards ratios are available summed up to 78% of all landings weight (Figure 7.3.1). Discards raising was performed as in previous years, by grouping all static gears together, small mesh size fishery 32–69 mm together, and demersal fisheries >90 mm together. Age information was used to raise to international catches all metiers together, on a quarter basis for landings and on a yearly basis for discards.

Overall 2015 discards were estimated at 677 tonnes, corresponding to a discards ratio to catches of 6,4%, which is lower than estimations from previous years.

7.2.2 Weight at age

Weight at age in landings is presented in Table 7.3.4 and Figure 7.3.2.

7.2.3 Catch, effort and research vessel data

Landings and effort data by gear were computed at the level of the ICES rectangle. 2002–2014 Data for the European fleet was available from the STECF online data [http://datacollection.jrc.ec.europa.eu/dd/effort/graphs], on the basis of the main "cod plan categories". Provisional 2015 data from Sweden and Denmark were added in the same format.

IBTS data are available in the area 3.aN. Since 2007 the WG discussed the limited spatial coverage of the surveys with regards to main fishing grounds. The IBTS sampling in Skagerrak has only few hauls in the Western Skagerrak. Since 2014, the Danish part of IBTS has added one haul in Skagerrak, located more coastally (43F9) than usual IBTS hauls, and thus more directly into the expected plaice distribution area. In 2014, this haul yielded the most important density ever recorded in the Skagerrak, and WKPLE suggested to remove that haul from the index until more coastal hauls were taken in order to disentangle possible effects of depth from just an outlier. In 2015 and 2016, hauls in shallow waters were also performed and obtained also a high CPUE, though less extreme than in 2014 (Figure 7.3.5).

7.3 Data analyses

7.3.1 Catch-at-age matrix

There are almost no landings from age 1 plaice, and generally poor tracking of the cohorts in the landings. (Figure 7.3.2). There has been a shift in the age distribution in 2003, from predominantly age 4–5 to now mainly age 3–4. Weight at age has been increasing over the decade for the main ages. Discards are mainly on ages 2 and 3 (Figure 7.3.3)

7.3.2 Spatial information on catches

Information of commercial catches is still presented accordingly for the purpose of the monitoring of the situation (Figure 7.4.1). Nearly all catches are taken in the Western area (~ 98% in 2015), while plaice by-catches in the targeted *Nephrops* fishery in the Eastern area have dropped to very low levels with the increased adoption of more selective gears.

Catches trends in fishing patterns by the main gear groups across both areas were computed. 2015 lpue for the main fishery (TR1 in Western Skagerrak, 54% of total landings for the stock in 2015) is slightly higher than in 2014.

Since 2012, the fishing pattern has moved slightly away from the North Sea boundary rectangle (43F8) towards the more central Skagerrak (44F9) (Figure 7.4.2).

Plaice in Skagerrak is fished in the relatively shallow waters of the Western Skagerrak (<50m), where it is the main target species. Therefore, CPUE trends were also computed for the small vessels separately (<10m, without VMS) as these fish closer to the shore, and the trends were also pointing upwards for this segment. (Figure 7.4.3).

7.3.3 Survey series

The benchmark WKPLE recommended to remove the haul with high CPUE from the survey index, until enough additional coastal hauls are taken to account for the effect of depth on the index, for example using Berg *et al.* GAM model.

Trends in IBTS are different between spring and autumn (Figure 7.4.5). The autumn survey seems to show consistent high signals for some year classes, and in particular at age 3 the picks correspond to the large year classes 2007, 2004 and 2002 observed in the North Sea. Based on the additional analyses of seasonal patterns performed during WKPLE, this confirms the hypothesis of summer inflow from the North Sea into the Skagerrak, indicating that Skagerrak belongs to the distribution area of North Sea plaice. The spring survey is less consistent, and does not track populations over time very well (Figure 7.4.6). The improper IBTS sampling design for plaice might explain part of the issue, but it is also hypothesised that spawning in Skagerrak is not very regular, and that the densities of populations may vary from year to year. This is also supported by the hydrodynamic simulations presented in WKPLE, which demonstrated large variability from year to year of the inflow of North Sea water into the Skagerrak. Nevertheless, there is a significant correlation between the estimated recruitment of the combined stock and the observed recruitment in Skagerrak in IBTS Q1 age 1 (Figure 7.4.7).

7.4 Assessment

The analytical assessment of the combined stock of plaice in the North Sea and Skagerrak is presented in section 8.

7.5 References

ICES. 2015. Report of the Benchmark Workshop on Plaice (WKPLE), 23–27 February 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015\ACOM:33. 200 pp.

Ulrich, C., Boje, J., Cardinale, M., Gatti, P., LeBras, Q., Andersen, M., Hemmer-Hansen, J., Hintzen, N.T., Jacobsen, J.B., Jonsson, P., Miller, D.C.M., Nielsen, E.E., Rijnsdorp, A.D., Sköld, M., Svedäng, H., Wennhage, H. 2013. Variability and connectivity of plaice populations from the Eastern North Sea to the Western Baltic Sea, and implications for assessment and management, Journal of Sea Research, 10.1016/j.seares.2013.04.007.

Ulrich, C., Hemmer-Hansen, J., Boje, J., Christensen, A., Hüssy, K., Clausen, L.A.W., in press, Variability and connectivity of plaice populations from the Eastern North Sea to the Baltic Sea, Part II. Biological evidence of population mixing. Journal of Sea Research..

Table 7.1.1 Plaice in Subdivision 20 (Skagerrak). ICES estimates of landings by country in tonnes.

Year	Denmark	Sweden	Germany	Belgium	Norway	Netherlands	Total	Disc rat	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		11 200
1993	9 125	287	37	326	79		9 854		11 200
1994	8 783	315	37	325	91		9 551		11 200
1995	8 468	337	48	302	224		9 379		11 200
1996	7 304	260	11		428		8 003		11 200
1997	7 306	244	14		249		7 813		11 200
1998	6 132	208	11		98		6 449		11 200
1999	6 473	233	7		336		7 049		11 200
2000	6 680	230	5		67		6 982		11 200
2001	9 045	125			61		9 231		9 400
2002	6 773	141	3		164	3	7 084		6 400
2003	5 079	143	8		385	1 484	7 098		10 400
2004	5 999	545	67		111	1 288	8 011		9 500
2005	4 684	554	14		9	823	6 084		7 600
2006	6 563	366	21		352	1 059	8 361		7 600
2007	5 656	281	21		166	1 503	7 626		8 500
2008	7 163	220	17		117	775	8 292		9 300
2009	5 828	92	13		62	506	6 500		9 300
2010	7 101	127	13		103	1 331	8 676		9 300
2011	7 746	179	13		230	15	8 183		7 900
2012	7 338	155	12		136	10	7 651	12%	7 900
2013	6 326	160	10		138	181	6 815	14%	9 142
2014	7 484	240	46		48	506	8 981	10%	10 056
2015	7 808	274	14		69	1 639	9 804		10 056
2016									11 766

Table 7.3.3 Summary of data provided to InterCatch 2002–2015

	previous landings	revised landings	revision	discards provided to IC	total discards after raising	discards ratio	share of landings with discards provided	share of landings with age information provided
	t	t	%	t	t	%		
2002	6671	7087	6%	517	574	7%	0.89	0.96
2003	6656	7100	7%	748	1437	17%	0.51	0.72
2004	7513	8013	7%	1761	2873	26%	0.59	0.75
2005	5690	6084	7%	1200	2081	25%	0.62	0.77
2006	7855	8360	6%	1309	2243	21%	0.53	0.78
2007	7406	7626	3%	1714	2862	27%	0.55	0.74
2008	7607	8295	9%	811	1043	11%	0.72	0.86
2009	6035	6502	8%	520	610	9%	0.87	0.9
2010	9187	8676	-6%	661	842	9%	0.81	0.82
2011	8342	8183	-2%	919	1040	11%	0.94	0.95
2012	7627	7651	0%	734	846	10%	0.86	0.96
2013	6825	6815	0%	949	1161	15%	0.81	0.93
2014		8981		836	1022	10%	0.8	0.83
2015		9804		524	677	6%	0.78	

Table 7.3.4. Plaice in Skagerrak. Landings number at age.

	1	2	3	4	5	6	7	8	9	10+
1984	1	809	8059	9177	3915	1760	375	73	25	23
1985	1	142	3816	17915	5815	1633	624	154	116	97
1986	1	3	2172	12185	17220	3886	509	214	107	152
1987	1	16	1814	8845	16315	9804	1983	293	167	121
1988	1	33	1922	10081	12460	6358	2512	803	254	148
1989	1	296	2256	6024	5530	2404	1032	468	194	216
1990	1	1311	6462	7785	9284	3084	888	436	319	358
1991	1	851	5312	8195	4480	2810	828	268	129	162
1992	1	54	1406	9159	16174	4146	932	260	89	71
1993	1	224	2369	9351	12579	6392	1381	309	82	43
1994	1	19	5087	7295	9521	7596	2129	292	91	34
1995	1	0	655	5404	11006	6475	4848	843	119	69
1996	1	863	3517	6322	4849	4609	1768	1318	137	25
1997	1	0	541	4647	8783	4875	2985	1332	832	121
1998	1	198	4783	5307	5991	2700	685	348	210	200
1999	1	0	1160	6174	7456	7234	1239	361	71	129
2000	1	0	1114	7270	10566	3276	854	109	10	22
2001	1	1035	5422	8212	10722	4540	288	76	8	33
2002	0	70	1642	6928	7508	5106	1848	458	49	38
2003	11	2497	3005	6189	7784	4396	1057	145	19	12
2004	0	1661	16204	3693	3105	1930	320	133	13	16
2005	34	2330	3707	9036	3186	1401	597	145	64	12
2006	0	770	10525	7991	7264	1304	480	185	46	16
2007	146	2080	4306	8357	5113	4441	569	133	53	14
2008	18	2109	8966	6659	4224	1736	1170	60	55	28
2009	0	1074	8310	6529	2654	1085	217	90	1	6
2010	78	1795	8819	10703	3102	735	261	81	62	14
2011	183	3022	4299	6794	5139	1770	310	166	65	20
2012	162	1668	8012	5105	2820	1696	248	157	101	89
2013	0	2753	9401	4436	1102	777	365	94	49	42
2014	0	653	11091	9280	3522	895	481	245	64	50
2015	0	1406	9947	11611	3853	1059	223	170	58	23

Table 7.2.2. Plaice in Skagerrak. Landings weight at age.

CW	1	2	3	4	5	6	7	8	9	10+
1984		0.276	0.299	0.301	0.373	0.423	0.548	0.817	1.029	1.319
1985		0.212	0.294	0.309	0.351	0.434	0.55	0.759	0.872	0.993
1986		0.395	0.26	0.28	0.304	0.379	0.543	0.736	0.94	1.041
1987		0.205	0.245	0.266	0.285	0.358	0.525	0.728	0.911	1.127
1988		0.22	0.251	0.261	0.285	0.343	0.466	0.551	0.746	1.111
1989		0.216	0.24	0.274	0.315	0.372	0.465	0.639	0.703	0.876
1990		0.267	0.28	0.289	0.333	0.389	0.484	0.667	0.756	1.077
1991		0.27	0.26	0.248	0.27	0.361	0.49	0.577	0.653	1.032
1992		0.274	0.318	0.265	0.278	0.334	0.506	0.67	0.85	0.872
1993		0.229	0.25	0.266	0.291	0.338	0.456	0.581	0.669	0.884
1994		0.365	0.246	0.265	0.286	0.33	0.41	0.586	0.653	0.785
1995			0.297	0.296	0.286	0.325	0.366	0.498	0.726	0.767
1996		0.225	0.252	0.282	0.384	0.399	0.437	0.428	0.559	1.013
1997			0.248	0.266	0.291	0.335	0.408	0.458	0.441	0.492
1998		0.226	0.242	0.273	0.328	0.401	0.468	0.513	0.574	0.655
1999			0.277	0.294	0.287	0.292	0.33	0.357	0.661	0.585
2000			0.24	0.273	0.301	0.351	0.38	0.489	0.857	0.911
2001		0.257	0.282	0.292	0.322	0.306	0.423	0.604	0.876	0.658
2002	0	0.221	0.285	0.276	0.277	0.317	0.39	0.459	0.751	1.064
2003	0.217	0.239	0.258	0.272	0.292	0.296	0.401	0.424	0.669	1.064
2004	0	0.238	0.269	0.324	0.348	0.381	0.481	0.654	0.791	0.97
2005	0.227	0.251	0.259	0.292	0.325	0.359	0.397	0.529	0.659	1.087
2006	0	0.255	0.264	0.287	0.326	0.32	0.343	0.424	0.686	1.063
2007	0.246	0.249	0.271	0.304	0.309	0.334	0.34	0.47	0.476	1.073
2008	0.239	0.282	0.314	0.315	0.356	0.412	0.466	0.558	0.579	0.533
2009	0	0.241	0.281	0.332	0.393	0.488	0.529	0.658	1.121	0.872
2010	0.102	0.247	0.31	0.334	0.404	0.538	0.681	0.693	0.677	1.08
2011	0.258	0.302	0.322	0.354	0.431	0.484	0.679	0.733	0.585	1.356
2012	0.236	0.276	0.347	0.368	0.437	0.519	0.606	0.6	0.828	0.916
2013	0	0.287	0.319	0.376	0.47	0.595	0.631	0.767	0.778	0.825
2014	0	0.274	0.301	0.352	0.406	0.486	0.634	0.676	0.757	0.902
2015	0	0.289	0.326	0.354	0.401	0.473	0.639	0.753	0.715	0.961

Table 7.2.1. Plaice in Skagerrak. Discards number at age

	1	2	3	4	5	6	7	8	9	10+
2002	620	828	2050	1827	1263	57	2	0	0	0
2003	80	5695	3998	1054	515	33	5	0	0	0
2004	746	3947	12130	4036	928	218	4	0	0	0
2005	351	7413	3157	4323	396	39	140	5	0	0
2006	481	3094	10099	652	44	2	4	1	0	0
2007	448	6579	6429	4911	858	56	20	0	0	0
2008	165	4484	2923	745	132	6	7	0	0	0
2009	27	1105	2754	299	33	2	2	0	0	0
2010	1473	2218	1458	131	23	10	1	2	1	0
2011	606	3291	1919	529	158	0	0	0	0	0
2012	823	2850	1717	360	31	12	0	0	0	0
2013	511	5531	2563	690	21	6	0	0	0	0
2014	474	3632	3741	831	119	0	0	0	0	0
2015	66	1050	2134	996	120	35	14	1	0	0

Table 7.2.2. Plaice in Skagerrak. discard weight at age.

CW	1	2	3	4	5	6	7	8	9	10+
2002	0.03	0.063	0.089	0.094	0.115	0.058	0.176	0.218	0.151	0
2003	0.055	0.105	0.149	0.143	0.156	0.119	0.15	0.237	0	0
2004	0.066	0.097	0.134	0.155	0.169	0.133	0.118	0	0	0
2005	0.075	0.134	0.139	0.155	0.153	0.119	0.187	0.11	0	0
2006	0.047	0.115	0.175	0.142	0.157	0.251	0.186	0.223	0	0
2007	0.051	0.125	0.155	0.176	0.172	0.142	0.17	0	0	0
2008	0.047	0.105	0.134	0.174	0.166	0.148	0.445	0	0	0
2009	0.032	0.126	0.151	0.162	0.169	0.139	0.128	0	0	0
2010	0.098	0.158	0.195	0.258	0.393	0.385	0.8	0.618	0.474	0
2011	0.084	0.156	0.175	0.19	0.235	0	0	0	0	0
2012	0.083	0.145	0.169	0.183	0.212	0.209	0.6	0	0.633	0
2013	0.071	0.113	0.147	0.172	0.203	0.23	0	0	0	0
2014	0.049	0.076	0.151	0.165	0.174	0	0	0.418	0	0
2015	0.043	0.11	0.16	0.179	0.217	0.248	0.189	0.562	0	0

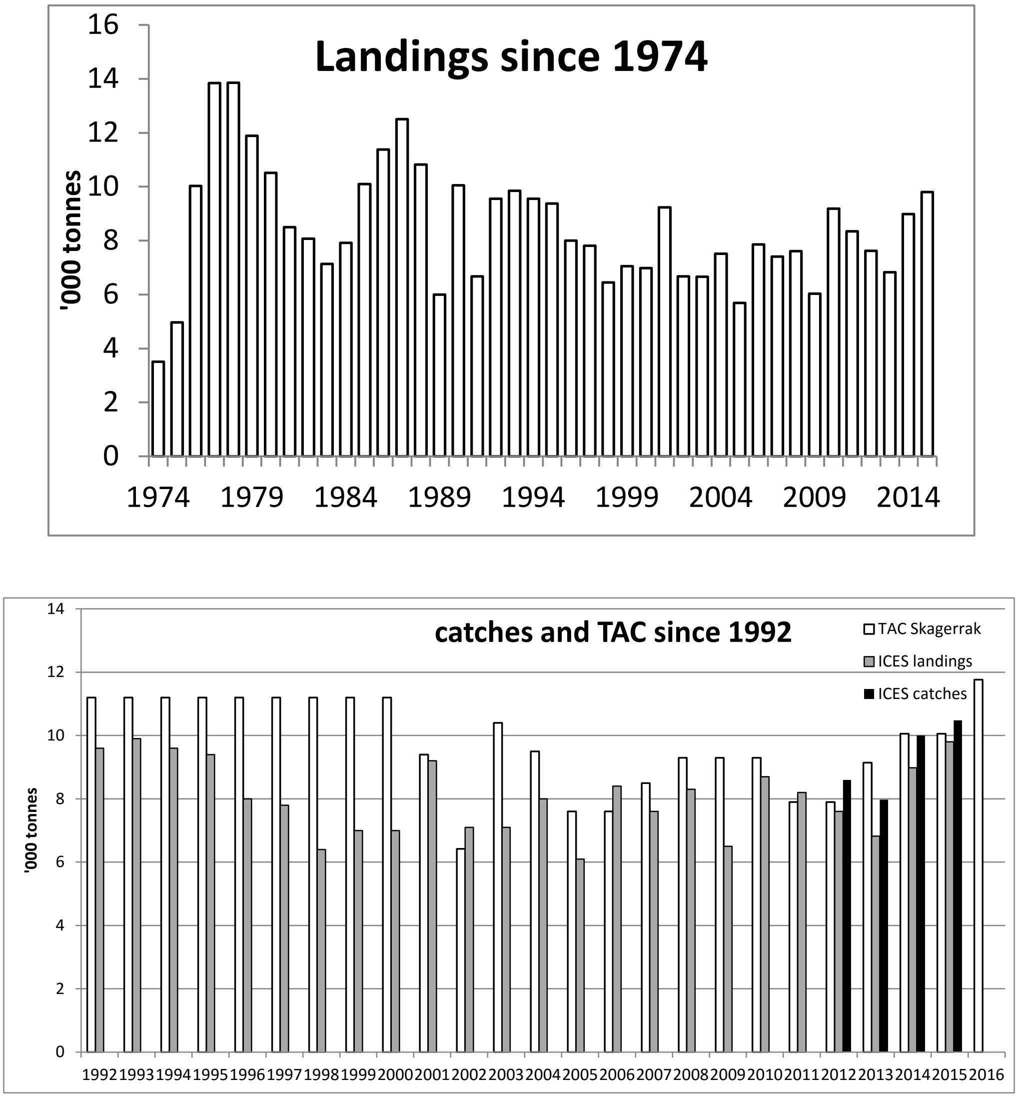


Figure 7.1.1. Plaice Skagerrak. Upper: total landings 1974–2015. Lower: Landings vs. TAC in Skagerrak, 1992–2016.

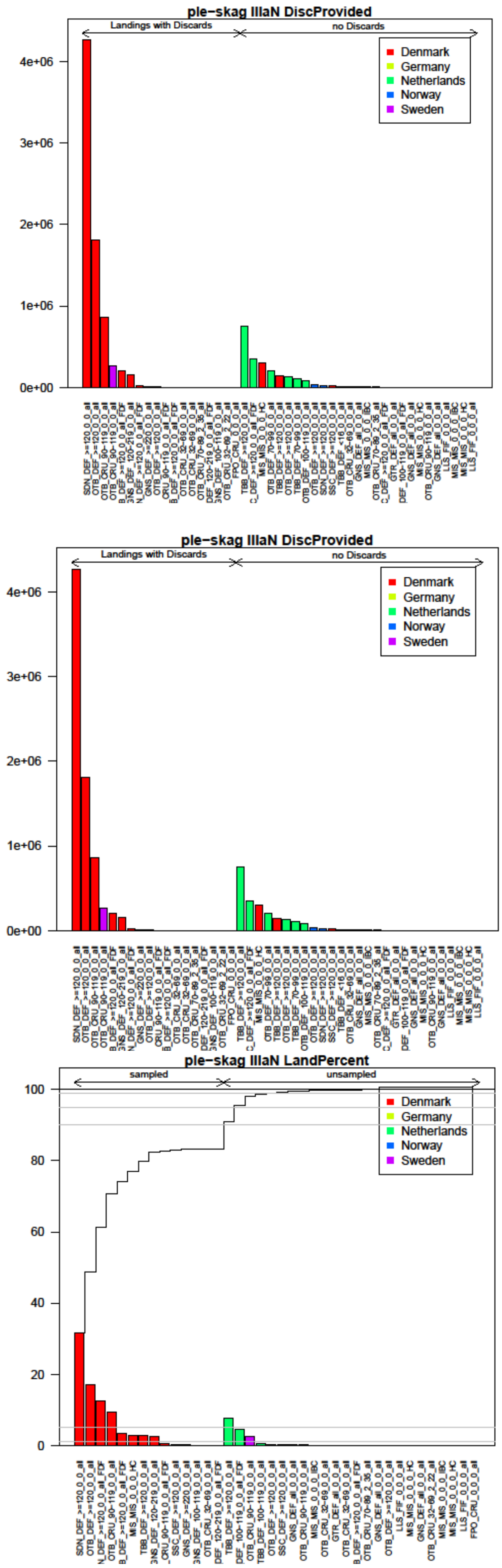
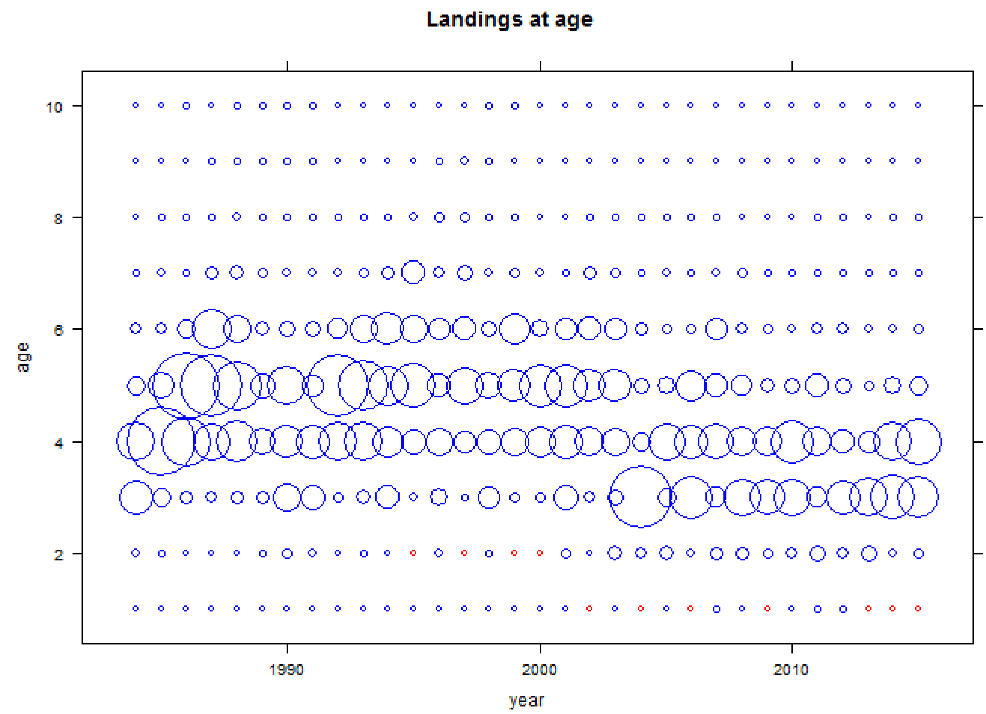


Figure 7.3.1. Landings strata with discards ratios available (top) and with age information available (down) as provided to InterCatch before raising.



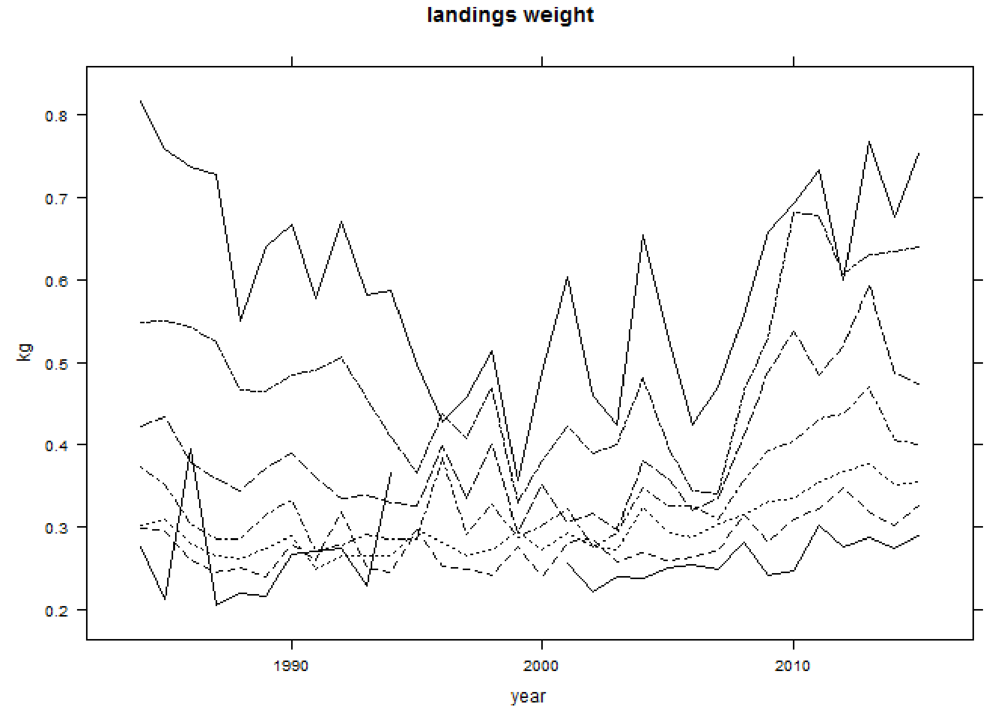
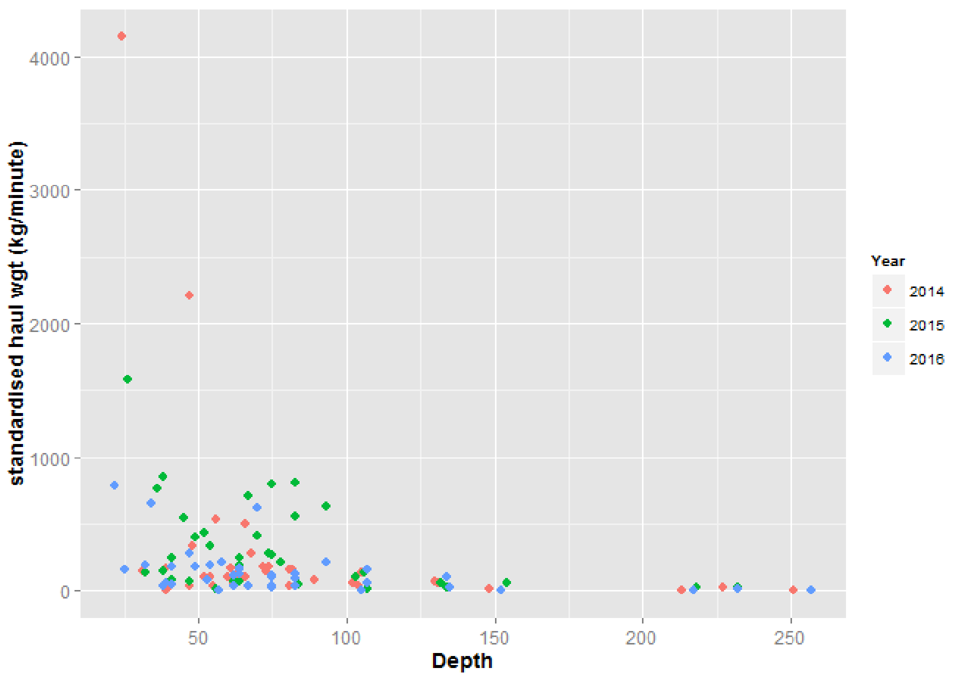


Figure 7.3.2. Landings at age and mean weight at age in the landings.

Figure 7.3.3. Discards number in Skagerrak


standardised haul wgt (kg/minute)
4000
3000
2000
1000
0
50
100
150
200
250
Depth
Year
2014
2015
2016

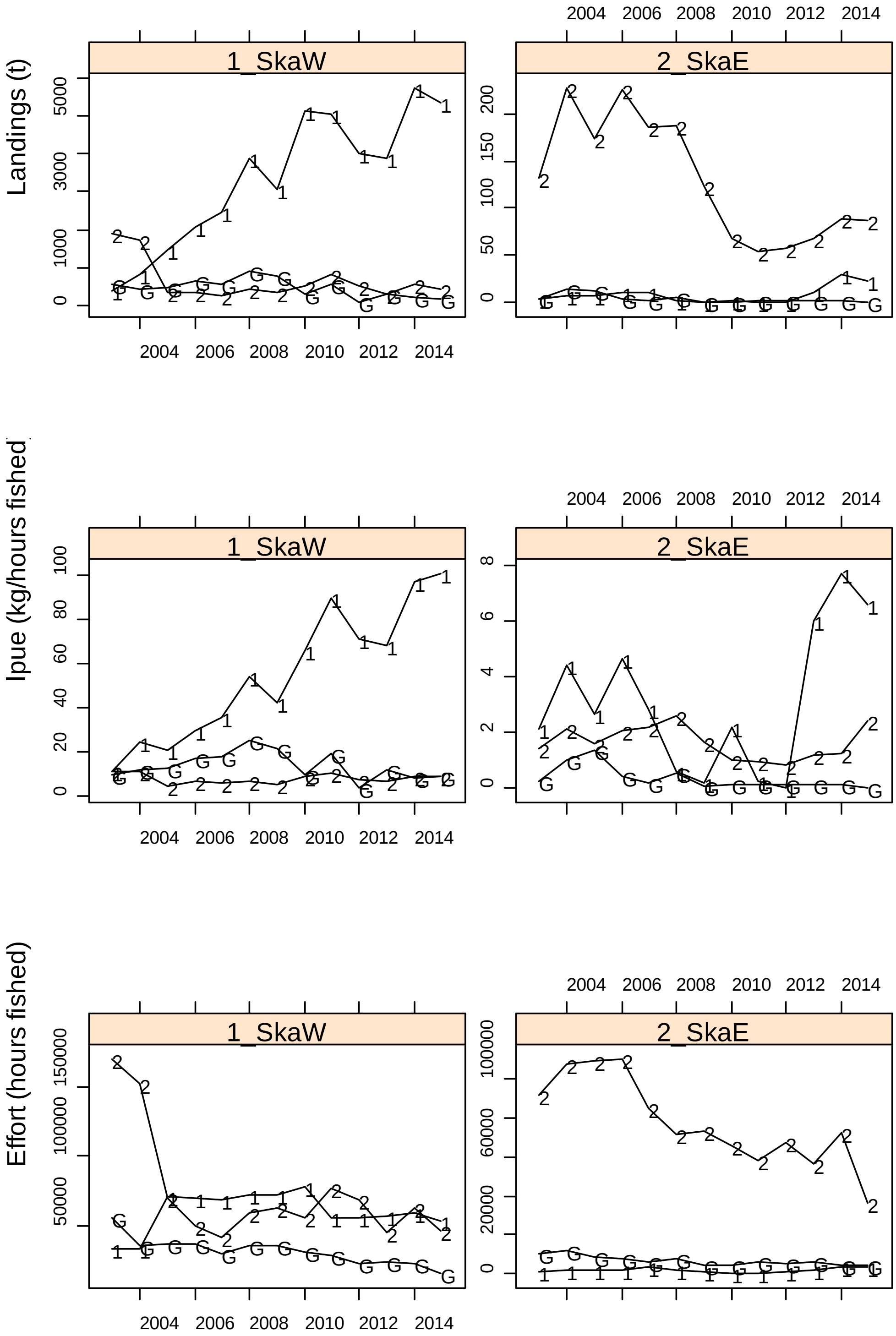


Figure 7.4.1 Trends in EU Landings, effort and lpue by gear and Skagerrak area. G=Gillnets , 1 = TR1, 2= TR2.(STECF data)

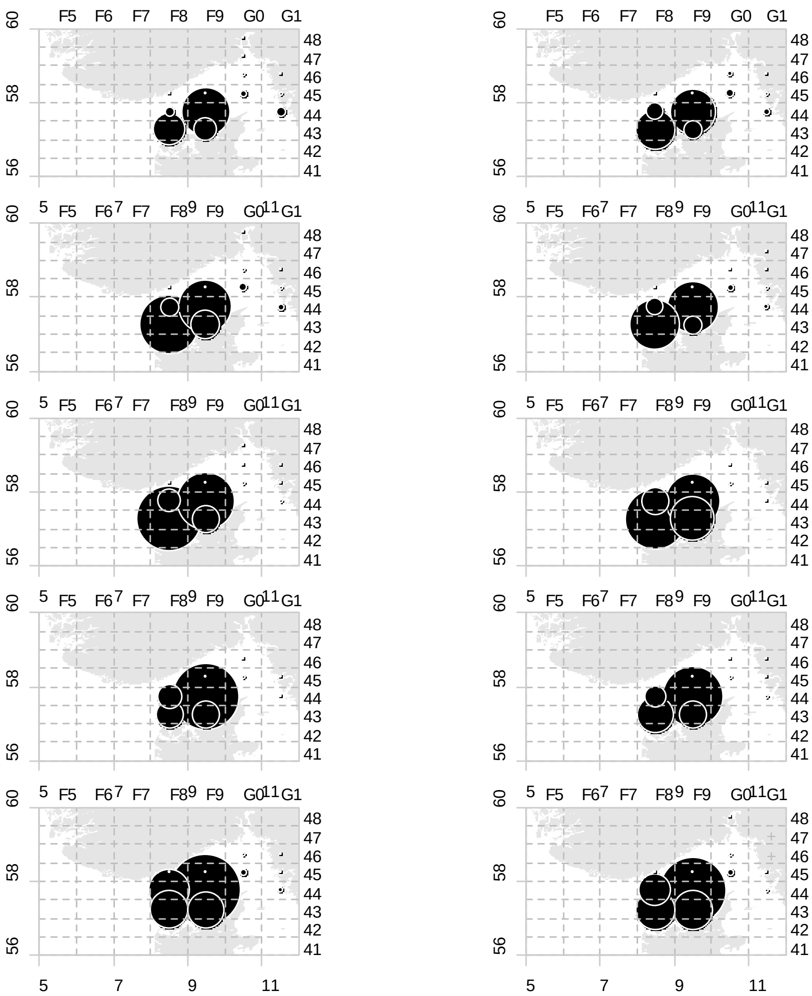


Figure 7.4.2. EU plaice Landings 2006–2015 (from left to right then top to bottom) for the main fisheries (TR1, TR2, GN1) all gears (STECF data). Bubble max size= 3200 tonnes.

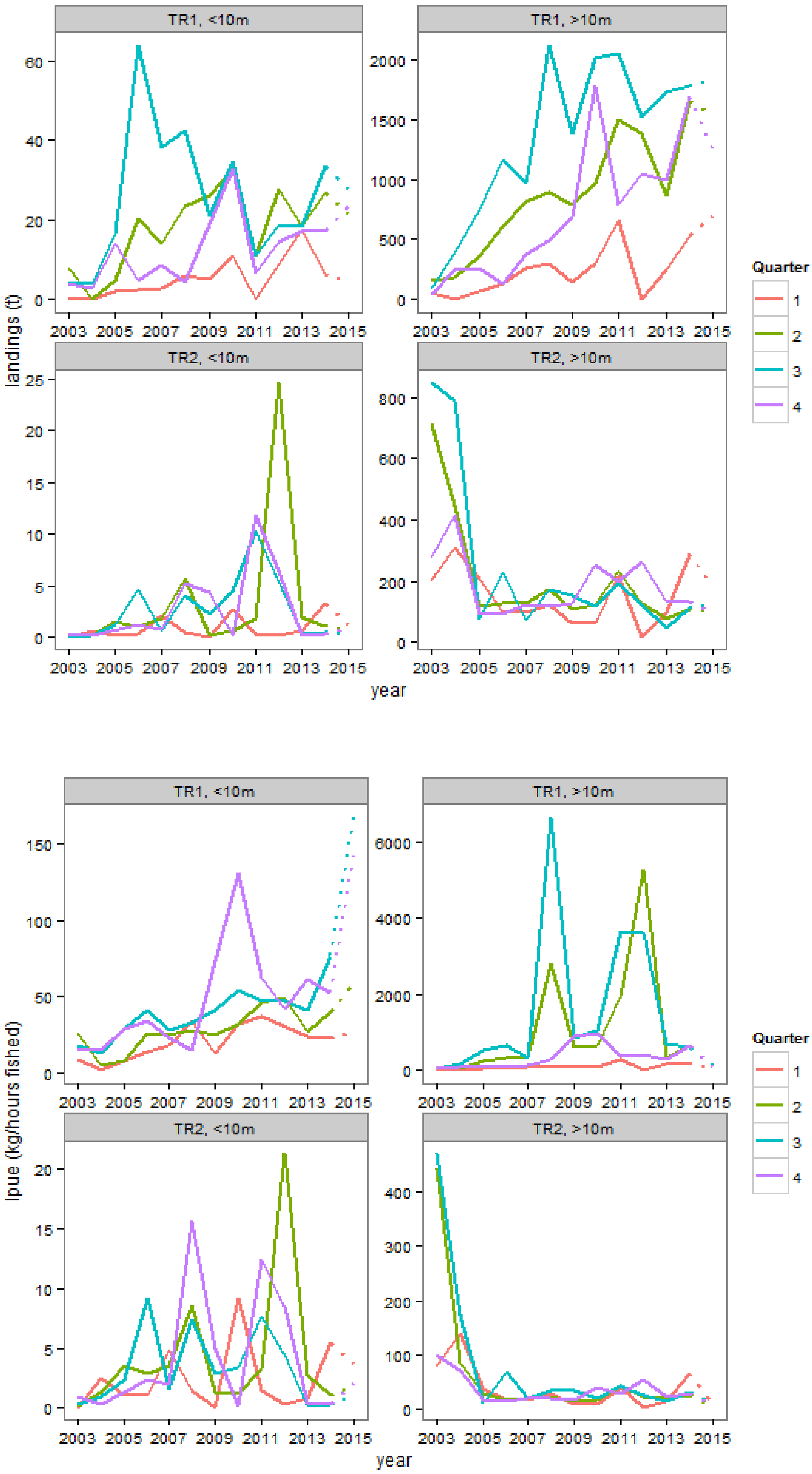


Figure 7.4.3. Landings and lpue by quarter and fleet segment showing both target fishery (TR1) and bycatch fishery (TR2), for small inshore vessels (<10m) and larger vessels (>10m). STECF data. 2014 provisional.

Figure 7.4.5. Standardized mean CPUE by haul, IBTS Q1 and Q3, for Skagerrak only and for the combined area North Sea plus Skagerrak.

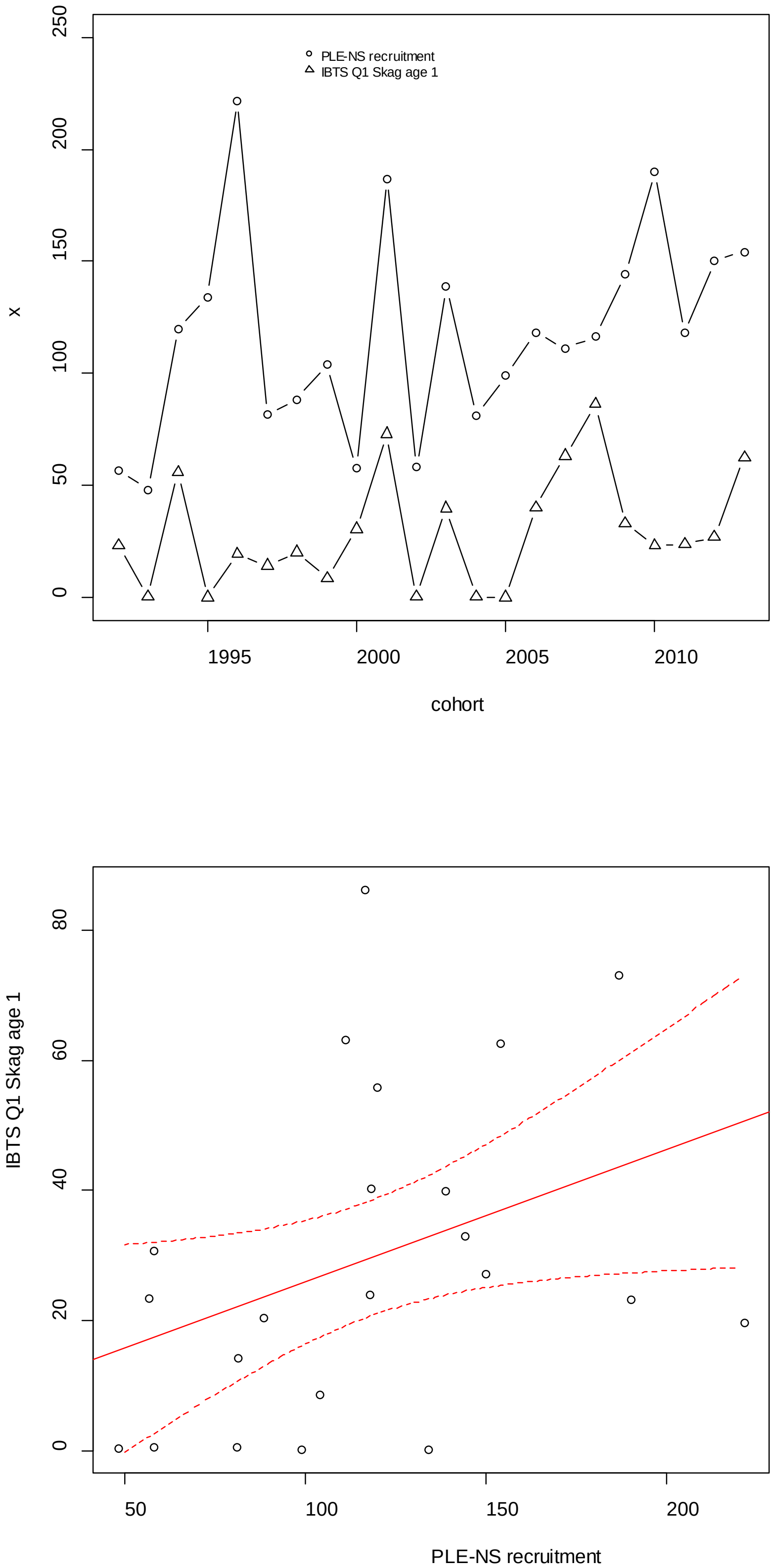


Figure 7.4.7 Correlation between IBTS Q1 at age 1 and the estimated recruitment of the combined stock.

8 Plaice (*Pleuronectes platessa*) in Subarea 4 (North Sea) and Division 3.a (Skagerrak)

A Stock Annex is available for North Sea plaice. Therefore only a comprehensive description of the methods and deviations from the stock annex are presented within this Section of the report. In 2015, the stock annex was updated and two significant changes took place: 1) the North Sea stock is now assessed in a combined assessment with the Skagerrak and 2) the SNS survey is now split into two surveys, from 1982–1999 and from 2000–present (2015).

8.1 General

8.1.1 Stock structure

The flatfish benchmark group (WKFLAT, ICES, 2010) recommended to explore the potential to perform an integrated assessment of the continuum of plaice stocks from the Baltic to the English Channel. ICES evaluated the stock identity of plaice in the Skagerrak and Kattegat during a dedicated workshop (WKPESTO; ICES 2012b) for which until now combined advice was given.

Plaice in the Skagerrak is considered to have two components: an Eastern and Western. The latter occurs in a mix with plaice migrating in from the North Sea (Ulrich et al 2013) and the predominance of catches occurs on summer feeding aggregations in the Western Skagerrak. In a benchmark (WKPLE 2015, ICES 2015) it was decided that plaice in the Skagerrak would be assessed together with the North Sea stock.

In addition, as in previous years, part of the catches in the 7.d area in the first quarter are included in the North Sea plaice assessment, since North Sea plaice migrates into the area in that season (ICES 2010). This year, 50% of the mature animals from 7.d in Q1 were added to the North Sea stock, whereas before, 50% of the total catches were added. Moreover, this year 50% of the mature discards in Q1 were also added to the North Sea stock.

8.1.2 Ecosystem considerations

Available information on ecosystem aspects can be found in the Stock Annex. In addition, the ICES Working Group on the Ecosystem Effects of Fishing Activities (WGECO, ICES 2014b) met in April 2014 and addressed a specific question in relation to North Sea plaice, in response to a request from WGNSSK in 2013:

"According to WGNSSK estimates, the North Sea is currently ongoing a plaice outburst without precedent. However, plaice is not included in multispecies models, so the consequences of this outburst on the North Sea ecosystem are unclear and would potentially require additional focus".

WGECO addressed the trends shown in the stock assessment of plaice, which show how increasing fishing pressure on the stock has progressively moved SSB away from the desired state (in the 1980s and 1990s), and then how management has rectified this situation in recent years, which has brought the North Sea plaice stock in a situation unlike any other over the whole 58 year period for which data is available. The group investigated a possible relationship of these trends with abundance of benthic biomass, which is a predominant food source for plaice. Q1 IBTS data showed a two-fold increase in demersal benthivore biomass over the last 29 year period of the survey, and that species composition of the demersal benthivore guild has changed as well. The data showed that predation loading by plaice on benthic invertebrates increased by a factor of 8.8 in just eleven years (2000–2011).

The increase in the consumption of benthic invertebrate prey by the whole demersal benthivore guild, and particularly by plaice, raises the question as to whether the abundance of benthic invertebrate prey might be becoming limiting. If the biomass of demersal benthivorous fish is approaching its carrying capacity, then growth rates in the dominant species in the guild might start to decline (which is in this case plaice growth rates). Computed growth coefficients for the 1956 to 2002 cohorts showed a strong declining linear trend over the whole period (albeit with clear systematic variation in the residuals), and this has been related to increasing water temperature in the North Sea. However, fitting a 4th order polynomial function to the data suggested a marked decline in cohort growth towards the end of the time-series. This is perhaps indicative of plaice becoming food limited, possibly suggesting that B_{MSY} targets for the stock might be marginally too high to be supported by available benthic invertebrate food supplies. However, this evidence is by no means conclusive as polynomial functions are known to show a tendency for marked swings at the extremes of the data range. The situation will become clearer in a few years' time when data for more recent cohorts can be added to the analysis.

On another issue, moving towards better informed estimations of natural mortality (M) may be timely, since fishing mortality now is at a relatively low level, and the assessment model will become more sensitive to the assumption of M. Plaice is not usually included in multi-species models, since it is commonly assumed that plaice is not a common prey species. Another source of natural mortality may be disease outbreaks. Such outbreaks may be more severe when population density and thus population size is high. McVicar and McLay (1985) showed that plaice are relatively susceptible to *Ichthyophonus*. Patterson (1996) showed that an outbreak of this fungus was responsible for the mortality of approximately 10% of the North Sea herring population between 1991 and 1994. In order to obtain more realistic estimates of M for plaice in the near future it may be worthwhile to consider the impact of diseases.

8.1.3 Fisheries

A basic description of the fisheries is available in the Stock Annex. In recent years, the adoption of innovative gears – which are often aimed at reduction of fuel consumption and reduction of bottom disturbance – may be contributing to changes in fishing patterns however. In 2011, approximately 30 derogation licenses for Pulse trawls were taken into operation, which increased to 42 in 2012. An additional 42 derogation licenses have been extended in spring 2014. At the same time, possible amendments to EU regulations which would permanently legalize the use of pulse gears for the whole fleet are ongoing. Potential future impact either on the plaice stock itself or the stock assessment is unknown. ICES recommends that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls are undertaken.

8.1.4 ICES Advice

The information in this section is taken from the ICES advice sheet 2015, section 6.3.31:

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2016 should be no more than 213 440 tonnes in Subarea 4 and Division 3.a (Skagerrak part) combined. If this stock is not under the

EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 159 197 tonnes.

Management plan

The plan consists of two stages and is now in stage two; implementation of this second stage (as stipulated in article 5 of the EC regulation) is not yet defined. Application of stage two of the plan is based on transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). ICES is using the existing management plan for advice on the combined stock.

8.1.5 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages of which the first stage should be deemed a recovery plan and its second stage a management plan. ICES has evaluated the plan as in agreement with the precautionary approach (Miller and Poos 2010; Simmonds 2010). A subsequent evaluation in 2012 (Coers *et al*, 2012) addressed amendments to the plan in the context of moving towards stage two of the plan. These amendments do not affect the current advice for plaice.

8.2 Data available

8.2.1 Landings

During the benchmark of the eastern channel (7.d) plaice stock (WKFLAT) it was decided that 50% of Q1 mature fish catches taken in the eastern channel are actually plaice from the North Sea stock migrating in and out of the area. Before 2015, 50% of the Q1 eastern channel (7.d) plaice landings were included in the assessment of the North Sea plaice stock. Since 2015, 50% of the mature fish in the landings in Q1 and of the mature fish in the discards in Q1 were added to the North Sea stock and the time series was updated, such that in previous years also 50% of the mature catches from Q1 were added. See the stock annex for plaice in division 7.d for further details.

During the benchmark on plaice (WKPLE, ICES 2015) it was decided that plaice from the Skagerrak would be added to the North Sea stock. Since, the assessment is a combined assessment with Skagerrak plaice.

Total landings (including 7.d and Skagerrak) of North Sea plaice in 2015 were estimated by the WG at 85 360t. Of these 74 963t came from the North Sea (excluding Skagerrak). This is an increase of 6% from the 2014 landings and only 58% of the 128 376t TAC for 2015. Total landings (in tonnes) are presented in Table 8.2.1 and landings in numbers at age in Table 8.2.2.

8.2.2 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2015, as is described in the stock annex. From Belgium, discards data have been available as well but were only used in the assessment since 2012, since it became available through InterCatch. See section 8.2.7 for more information on the use of InterCatch for raising discards rates across metiers and countries. The Dutch discards data for 2009 and 2010 were derived from a combination of the observer programme that has been running since 2000, and a new self-sampling programme. The estimates from both programmes were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet. Since 2011, estimates were derived exclusively from the self-sampling data. There is an on-going project within IMARES to validate these estimates by examining matched (same vessel and haul) trips where both observer estimates and self-sampling estimates are derived.

To reconstruct the number of plaice discards at age before 2000, catch numbers at age data was reconstructed in 2005 based on a model-based analysis of growth, selectivity of the 80-mm beam trawl gear, and the availability of undersized plaice on the fishing grounds. Discards numbers at age are presented in Table 8.2.3. Figure 8.2.1 presents a time series of landings, catches and discards from these different sources.

8.2.3 Catch

The total catch at age as used in the assessment including all landings and all discards are presented in Table 8.2.4. These include catch of NS plaice in the 1st quarter from division 7.d and catch from the Skagerrak. Landings-at-age, discards-at-age and catch-at-age plots are presented in figures 8.2.2 and 8.2.3.

8.2.4 Weight at age

Stock weights at age are presented in Table 8.2.5. Stock weight at age has varied considerably over time, especially for the older ages. Landing, discards and catch weights at age are presented in Table 8.2.6, 8.2.7 and 8.2.8 respectively. Catch weights at age are derived from the discards and landings weights at age according to the relative contributions of each to the overall catch for each age. Figure 8.2.4 presents the stock, discards, landings and catch weights at age. Notably, there has been a long-term decline in the observed stock weight at age.

8.2.5 Maturity and natural mortality

Natural mortality is assumed to be 0.1 for all age groups and constant over time. A fixed maturity ogive (Table 8.2.9) is used for the estimation of SSB in North Sea plaice.

8.2.6 Catch, effort and survey data

Three survey indices are used as tuning indices, as decided during an Inter Benchmark Protocol, in March 2013 (Miller and Coers 2013). For some additional explanation, see also the WGNSSK report of 2013 (ICES 2013). This year, the SNS survey was split into two timeseries.

Table 8.2.10 and Figure 8.2.5 show the index values for the years that they are used in the assessment:

Beam Trawl Survey combined for RV Tridens and ISIS (BTS-combined); (1996–2015)

Beam Trawl Survey RV Isis (BTS–Isis) for the older part of the time series; (1985–1995)

Sole Net Survey 1 (SNS1); (1982–1999)

Sole Net Survey 2 (SNS2); (2000–2015)

Of the BTS-combined survey index, ages 1–9 are used for tuning the North Sea plaice assessment. Of the BTS-Isis older survey index, ages 1–8 are used. And of the Sole Net Survey (SNS1 & SNS2) ages 1–3 are used in the assessment, while the 0-group index is used in the RCT3 analysis for recent recruitment estimates. The internal consistency of the survey indices used for tuning appears relatively high for the Beam trawl surveys, but low for the SNS surveys (Figures 8.2.6–8.2.8).

Since 2011 there is an annual survey of plaice and sole using commercial vessels and gears (Reijden *et al.* 2016). This survey takes place in the same season as the BTS surveys. Length structured catch per unit effort estimates and age-length keys are collected during this survey.

An additional survey index is used for recruitment estimates in the RCT3 analysis (Table 8.5.1):

Demersal Fish Survey (DFS) age-0

Several commercial LPUE series consisting of an effort series and landings-at-age series are available for usage as tuning fleets. These include time series for the Dutch beam trawl fleet and the UK beam trawl fleet (excluding all flag vessels). Because WKFLAT 2009 recommended to exclude LPUE series from the final assessment run upon which management advice is based, they have not been included in the assessment.

8.2.7 InterCatch

Since 2012, national research institutes submitted landings and discard estimates by métier and quarter in InterCatch. Figure 8.2.9 shows the landings and discards by country and by métier in area 4. Approximately 54% of the landings in weight are sampled to obtain information on age-composition (Note that the UK vessels of the TBB_DEF_70–99_mm metier are exclusively Dutch owned flag vessels and de facto are thus sampled in the Dutch market sampling programme). Of the metiers for which discards are monitored in sampling programmes, the largest part of these discards is covered in the TBB_DEF_70–99_mm fleet. In most discards monitoring programmes, age composition information is also collected. Approximately 94% of the discards (in weight) were sampled. To raise the amount of discards for landings that had no discards allocated and to raise the landings and discards for which no age distribution was known, the same following allocation scheme was used. Allocations to calculate the age structure were done separately for discards and landings. The métiers that covered most of the catches each had their own group (OTB 70–119, OTB > 120, TBB 70–119, TBB > 120 and OTB & TBB CRU, see table below). Other countries that had sampled the métiers were used to allocate discard and age structure to the unsampled fleets. All other métiers were grouped into one group. All métiers except the métiers for crustaceans (_CRU) were used to allocate discards and age structure to this group. All allocations were done per quarter. If age structures were present for data for the whole year only, these were added to all quarters. If there were no samples in a specific quarter, all other quarters were used. No discards were sampled for TBB > 120, therefore OTB > 120 was used for this group.

Allocation scheme to raise discards and age structures to unsampled fleets.

Unsampled fleet*	Sampled fleet**
OTB 70–119	OTB 70–119
OTB > 120	OTB > 120
TBB 70–119	TBB 70–119
TBB > 120	TBB > 120 (OTB > 120)
OTB & TBB CRU	OTB & TBB CRU
Others	All métiers, excluding métiers for crustaceans (_CRU)

* Unsampled fleet are those fleets for which no dicards or age structure is known.

** Sampled fleet are those fleets for which the discard rate or age structure is known.

8.2.8 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.

Since 2013, ICES does not operate with external review groups anymore. Audits were done by internal reviewers (members of the WGNSSK group) and potential issues were directly discussed between the auditors and the stock assessor. Therefore there is no written review to be presented here.

8.3 Assessment

8.3.1 Exploratory catch-at-age-based analyses

Additional exploratory assessments were run. Since 2011, there is a survey using commercial vessels held annually in the Netherlands (van der Reijden *et al.* 2016). The indices from this survey were used in an exploratory assessment, combined with the 4 tuning indices that are currently used. The index values per age are given in Figure 8.3.1. The results for the two assessments are compared in Figure 8.3.2. Although the two assessments are very much alike, the survey with the commercial gears results in lower SSB estimates in the most recent 10 years, and slightly higher F values.

Conclusions exploratory runs

The group agreed that incorporation of the survey with the commercial gears and vessels should be considered at the next benchmark.

Final XSA assessment

The settings for the final assessment that is used for the catch option table is given below:

STOCK	NORTH SEA AND SKAGERRAK COMBINED
Year	2016
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + DE fleets and BE (since 2012)
Fleets (years; ages)	BTS-Isis-early 1985–1995; 1–8 BTS-combined 1996–2015; 1–9 SNS1 1982–1999; 1–3 SNS2 2000-2015 (excl. 2003); 1–3
Plus group	10
First tuning year	1982
Last data year	2015
Time series weights	No taper
Catchability dependent on stock size for age <	1
Catchability independent of ages for ages >=	6
Survivor estimates shrunk towards the mean F	5 years / 5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

The full diagnostics are presented in Table 8.3.1. The XSA model converged after 39 iterations. The model fits well to the combined BTS tuning indices (small residuals and no clear patterns), and also to the early SNS1 tuning index. The later SNS2 time series still shows a pattern with more positive residuals in the earlier years and more negative residuals in the later years, apart from the final year (Figure 8.3.3).

Fishing mortality and stock numbers are shown in Tables 8.3.2 and 8.3.3 respectively. Figure 8.3.4 shows retrospective pattern of the final XSA run with respect to SSB, recruitment and F. Retrospective analyses indicate that each year F and recruitment are corrected upwards and SSB is corrected downwards. It is unknown what causes these patterns. The overall reduction in fishing mortality leads to more uncertain assessments because the share of natural mortality in the total mortality increases. Therefore it is advised to study the impact of varying natural mortalities on the assessment.

8.3.2 Final XSA results

Table 8.4.1 shows the stock summary table. Figure 8.4.1 presents the trends in landings, mean F(2–6), SSB, and recruitment since 1957. Reported landings gradually increased up to the late 1980s and then rapidly declined until 1995, in line with the decrease in TAC. The landings show a general decline from 1987 onwards, increasing slowly but steadily in recent years, although in 2014 the landings were slightly lower than in 2013. Discards were particularly high in 1997 and 1998 (reconstructed), and in 2001 and 2003 (observed), resulting from strong year classes. Fishing mortality increased until the late 1990s and reached its highest observed level in 1997. Since the early 2000's, fishing mortality has been rapidly decreasing. Since 2007 it has been below the fishing mortality target established in the management plan. It is currently (2015) estimated at 0.17. Over the last five years SSB has been rapidly increasing and is currently (2015) estimated at 754 812 kt. Recruitment varies inter-annually around the long term geometric mean of approximately 1 million recruits. It appears to have been lower on average during the 1960's and 1970's, then above average in the 1980's and fluctuating around the average since the 1990's. In recent years, it is higher than average (1.6 million average 2011–2015).

The stock dynamics are affected by the occurrence of strong year classes, but increased stock size in recent years is most likely the direct consequence of reduced fishing mortality, given that no exceptionally strong year classes have been observed in recent years.

The predominant age in the landings is currently age-4 (in 2014 as well as in the past decade, see figure 8.2.2). Notably, during the time series, this was only also observed in the 1960's. In contrast, the predominant age in the landings in the 1970's, 1980's and 1990's, was age-3. The age distribution in the landings in recent years furthermore shows more similarity with the 1960's in that age-5 and age-6 fish are relatively abundant in the landings in comparison to the rest of the time series and age-2 fish are notably underrepresented in the landings. These shifts in age distribution may be explained by the still relatively low exploitation level in the 1960's, which subsequently substantially increased over the next three decades and since the early 2000's has shown a dramatic decline. Changes in spatial distribution of fishing effort and shifts in spatial distribution of the fish may also have affected these changes. The 'lack' of age-2 fish in the landings in the 1960's as well as in recent years may be for a number of reasons. When considering the age distribution in the catches age-2 fish were also lacking in the catches in the 1960's, while this is not the case in 2014. One possible explanation may be the occurrence of high grading (discarding of smaller fish in order to allow for landing higher numbers of large fish for which a higher price may be received or to avoid exhaustion of quota. The latter seems unlikely since the TAC has not been fully utilised in recent years. Another explanation may be that plaice have become mature at younger ages than in the past since this shift in maturation also leads to mature fish being of a smaller size at age, because growth rate diminishes after maturation. Grift *et al.* 2003 observed that this may occur due to fisheries-induced genetic change: those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This could cause age-2 fish to be discarded more abundantly in recent years because a larger fraction of them being under the minimum size in comparison to the past.

8.3.3 The Fishers' North Sea Stock Survey

The Fishers' North Sea Stock Survey (FNSSS) was carried out using a questionnaire circulated to North Sea fishermen in five countries: Belgium, Denmark, England, the Netherlands, and Scotland. Fishermen were asked to record their perceptions of changes in their economic circumstances, as well as in the state of selected fish stocks. No real relationship was apparent between the plaice abundance index derived from the Fishers' North Sea Stock Survey and the ICES estimates of the North Sea plaice spawning stock biomass.

8.4 Recruitment estimates

In the short term forecasts, assumptions are made on a number of things (see also section 8.5). One of the more difficult things to predict is the strength of incoming year classes (abundance of ages 0-2) in the assessment year. A number of options are considered as follows:

Age-0: More specifically, the abundance estimate of age-1 fish in the year after the assessment year, i.e. in the TAC-year) needs to be assumed and no data is available from surveys or otherwise. Therefore, the geometric mean of the time series is used.

Age-1: The RCT3 analysis is run which combines DFS and SNS survey data and the assessment results to predict the abundance of age-1. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise, the geometric mean is used.

Age-2: The RCT3 analysis is run which combines DFS, BTS and SNS survey data and the assessment results to predict the abundance of age-2. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise the XSA survivors estimate is used.

Input to the RCT3 analysis is presented in Table 8.4.1. The results for age-1 and age-2 abundance estimates are presented in Table 8.4.2, and in Table 8.4.3 respectively. For year class 2014 (age 1 in 2015) the values predicted by the DFS-0 and the SNS-0 survey estimates in RCT3 have similar values and are both lower than the VPA mean respectively. The SNS-0 has a low prediction standard error and the DFS-0 has a high standard error. The WG decided that because the DFS-0 and the SNS-0 had similar values, the RCT3 value was used for the short-term forecasts. For year class 2013 (age 2 in 2015), the estimates from BTS 1-group (comparable to the VPA mean) has a relatively low standard error (compared to the other surveys). However, a retrospective analysis for age-2 survivors shows that the XSA is relatively strong in predicting age-2 survivors (see retrospective plot, Figure 8.11.1). Hence, the WG decided to use the XSA estimate rather than the RCT3 estimate for the 2014 year class. The recruitment estimates from the different sources are summarized in the text table below. Underlined values were used in the forecast.

Year class	Age in 2016	XSA survivors	RCT3	GM 1957–2013	Accepted estimate
2014	2	952366	704951	726298	XSA survivors
2015	1		907736	980962	RCT3
2016	0			980962	GM 1957–2013

8.5 Short-term forecasts

Short-term prognoses were carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2015 (the last data year) into 2016 (the intermediate year in which the assessment is done); into 2016 (the TAC year) and finally into 2017 (the 'result' of the TAC year). For these years, a number of assumptions were made. Weight-at-age in the stock, weight-at-age in the catch and weight at age in the discards are taken to be the average over the last 3 years. The exploitation pattern (selectivity of the fishery) was taken to be the mean value of the last three years. The relative proportions of landings versus discards in the catch were taken to be the mean of the last three years.

In the intermediate year F is assumed to be equal to the estimate for F in 2015 ("F-status quo" or F_{sq}). The option of assuming F to correspond to the TAC being fully landed was considered, but abandoned as an option to pursue considering the fact that the TAC has not been fully utilised in previous years. No results for this option are presented here further for that reason. Population numbers in the intermediate year for ages 2 and older are taken from the XSA survivor estimates. Numbers at age 1 in 2016 are taken from the RCT3 output and age 1 from 2017 are taken from the long-term geometric mean (1957–2013). Input to the short term forecast is presented in Table 8.5.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	F2016	SSB2017	Landings2016
F2016 = F2015 (Fsq)	0.17	1033466t	109277 t

Resulting management options for 2017 are given in Table 8.5.2.

8.6 Biological reference points

8.6.1 Precautionary approach reference points

The current precautionary approach reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks (Figure 8.4.2). 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 A multiplier of 1.44. $\mathbf{F_{lim}}$ was set at $\mathbf{F_{loss}}$ (0.74). $\mathbf{F_{pa}}$ was proposed to be set at 0.6 which is the 5th percentile of $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 t.

8.6.2 F_{MSY} reference points

In 2010 ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 2014 the joint ICES-MYFISH Workshop (WKMSYREF3, ICES 2014) held place to consider the basis for FMSY ranges. The workshop was convened in response to a request from the European Commission for advice on potential intervals above and below FMSY. This resulted in an Fmsy range for North Sea plaice of 0.13 – 0.27. The point value of Fmsy was set at 0.19.

This values differs from the previous value of Fmsy = 0.25 (range 0.2 – 0.3, Miller and Poos 2010).

8.6.3 Update of F_{lim} and F_{pa} values

The original F_{lim} and F_{pa} values were established by the WGNSSK in 2004. In 2016, an updated calculation of F_{lim} is proposed as the F that, in equilibrium from a long-term stochastic projection, gives 50% probability of SSB>B_{lim}. The value of F_{pa} is estimated as the F value such that when F is estimated to be at F_{pa}, the probability that true F<F_{lim} is at least 95%. Thus F_{pa}= F_{lim} /exp(1.645*σ), where σ is estimated standard deviation of ln(F) in the final assessment year. In case of plaice where a σ is not available, a default value is used F_{pa}= F_{lim} /1.4. The last 10 years of the 2014 stock assessment object (data year 2004–2013) was retrieved and the distribution of recruitment at SSB was simulated using EqSIM, setting B_{lim}=160000 (Figure 8.6.1). The estimated 10 years plaice SSB are all far higher than $B_{lim.}$ The estimated F_{lim} is 0.63 (Fig. 8.6.1) and the corresponding F_{pa}= 0.45 using the default ratio of 1.4. The updated values of both F_{lim} and F_{pa} deviate from their original values, most likely due to the inclusion of Skagerrak (3.a) data in the recent years where the original reference point was not derived from. A full update of the reference points (for the stock that now includes 3.a) should be carried out in Benchmark.

8.7 Quality of the assessment

Although discards form a substantial part of total plaice catches, for which estimates are less certain than for landings, the assessment at present includes 14 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years. Discards data are now for instance available from Denmark (beamtrawls, ottertrawls, Scottish seines and Danish seines, gillnets and longliners); the United Kingdom (for beamtrawls up to 2007); Germany (beamtrawls, ottertrawls, gillnets); Belgium (beamtrawls, ottertrawls, Scottish seines) and the Netherlands (beamtrawls and ottertrawls). The improvement of retrospective patterns observed in the recent years might have beneficiated from increased coverage of discards estimates from the main fishing nations, through self-sampling and observers programs.

A self-sampling programme by the Dutch beam-trawl fleet has been in place since 2004. This sampling programme indicates spatial and temporal trends in discarding (higher discards are observed in coastal regions and late summer), but it was considered inappropriate for overall estimates of discarding because of differences in the implementations of sampling methods. In 2009, a new self-sampling programme was launched to address this. For the 2009 and 2010 assessments, discarded numbers-at-age for the Netherlands have been estimated using data from both the self-sampling and the observer programmes. It is noted that estimates of discard numbers in 2010 differed between the two programmes. Mid 2011 the programme was redesigned again, to allow for better comparison between self-sampling and observer estimates through paired measurements. From 2011 onwards, Dutch discard estimates are derived exclusively from the self-sampling programme, while observer estimates are used for validation of the self-sampling data only. Preliminary analyses suggest that the self-sampling estimates are as reliable as those from the observer programme. Further analyses will be conducted in 2013 as more data from 'matched trips' (self-sampling and observer estimates from the same vessel trip) become available.

If the introduction of the landing obligation for the fisheries on sole and plaice in 2016 will affect the quality of catch data available to ICES, the quality of the assessment and advice by ICES may particularly be affected in the case of plaice, given that (substantial) discards are included in the assessment. It is unclear how these programs will continue under a landing obligation.

8.8 Status of the Stock

The stock is well within precautionary boundaries. SSB in 2015 is estimated around 754812 thousand tonnes which is well above Bpa (230 000 t). Fishing mortality in 2015 is estimated to be at a value of 0.17 (below Fpa of 0.45, below the long term management target F of 0.30, and below Fmsy of 0.19). Fishing mortality of the human consumption part of the catch is estimated to be 0.08.

8.9 Management Considerations

Plaice is mainly taken by beam trawlers in a mixed fishery with sole in the southern and central part of the North Sea. There are a number of EC regulations that affect the fisheries on plaice and sole in the North Sea, e.g. as a basis for setting the TAC, limiting effort, minimum landing size and minimum mesh size.

8.9.1 Multiannual plan North Sea

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007). This plan is written for the North Sea stock and does not take the merging with the Skagerrak into account. The plan describes two stages: to be deemed a recovery plan during its first stage and a management plan during its second stage. ICES has evaluated this management plan in 2010 and considers it to be precautionary (ICES 2010a). Objectives are defined for these two stages; to rebuild the stocks to within safe biological limits and to exploit the stocks at MSY respectively. In 2015 WKMSYREF3 estimated Fmsy to be between 0.13 and 0.27. ICES identified the point estimate for the North Sea stock to be 0.19 (ADGMSYREF3).

Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years. The plaice stock has been within safe biological limits (F = 0.6) as defined by the plan since 2005. The sole stock has been within safe biological limits in terms of fishing mortality and SSB has been above the biomass limit (Bpa = 35 kt) in the latest years. According to the management plan (Article 3.2), this signals the end of stage one. Consequently, utilisation of the plan as a basis for advice is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). In 2012, ICES evaluated a proposal by the Netherlands for an amended management plan, which could serve as the 'stage 2' plan (Coers *et al.* 2012). ICES concluded that the plan – subject to those amendments –

is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY). However, implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Since the management plan is now in stage 2, the EU regulation stipulates that the stocks should be managed on the basis of MSY. For plaice, the ICES Fmsy estimate is 0.19, which is below the target F (0.3) defined in the plan. Considering that the plan specifies that fishing mortality in stage 2 should not be below the target of 0.3 (which coincides with the upper bound of a range of Fmsy values suggested by ICES), the current advice for plaice is still on the basis of moving towards the target of 0.3, rather than on the basis of Fmsy point estimate of 0.19 (albeit that the TAC change is restricted to a maximum 15% change). This apparent conflict in the basis for TAC setting in the management plan should be addressed.

This management plan is written for the North Sea stock. No specific management plan exists for the Skagerrak. The North Sea management plan should be updated including the Skagerrak. The forecast and advice are given for both areas with a combined TAC.

8.9.2 Effort regulations (North Sea)

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In 2009, the effort management programme switched from a days-at-sea to a kW-day system (EC regulation 43/2009), in which different amounts of kW-days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. A minor part of the fleets exploiting sole, i.e. otter trawls (OTB) with a mesh size equal to or larger than 100 mm included in TR1, have since 2009 been affected by the regulation. The beam trawl fleet (BT2) was affected by this regulation only once in 2009 but not afterwards.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, likely due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. 25 vessels were decommissioned in 2008. In addition, the current sole and plaice long-term management plan specifically reduces effort as a management measure. However, the evaluation of amendments to the plan in 2012 showed that the plan is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY) also without reductions of effort (Coers *et al*. 2012).

Fishing effort of the beamtrawl fleet has shifted towards the southern North Sea to target sole over the past decade. Juvenile plaice tend to be relatively abundant there, leading to relatively high discarding rates of small plaice. This shift was amongst others driven by a number of economic factors, such as the prices for sole and plaice respectively and fuel costs, which meant that the sole fishery was the most profitable fishery. With the recent substantial increases in biomass of the plaice stock, and thus to be expected increased catch rates, targeting plaice further North may become more economically favourable again. With the relatively low fishing mortality levels in recent years, it is also to be expected that a larger proportion of the population will be made up of older fish, of which the fishery could potentially benefit, since larger plaice receive higher prices on the market than small plaice. However, this benefit may be reduced if weight at age are decreasing, which seems to be the case in the plaice stock. At present, the beam trawl fleet is limited in its ability to move northwards (where larger plaice are more abundant) by effort restrictions for the BT1 fleet, which are imposed on the basis of the North Sea cod management plan. This trade-off between objectives in the cod and flatfish plans deserves some attention. Ongoing work in the Netherlands on the levels of cod catch rates (which are considered to be low) in the beam trawl fisheries should help quantification of this trade-off. The introduction of the landing obligation will likely provide an additional strong driver for at least part of the beam trawl fleet to focus on a more northerly plaice fishery, to avoid the complications of the high unwanted bycatches of undersized plaice in the South. For effort regulations in the Skagerrak see section 07.

8.9.3 Technical measures

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea where sole has become relatively more abundant, affect both sole and plaice. The minimum mesh size of 80 mm selects sole at the minimum landing size. However, this mesh size generates high discards of plaice with a larger minimum landing size than sole. For the overall fleet the discards ratio has been slightly decreasing since 2003 and at present is approximately 40% by weight. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. Furthermore, the size selectivity of the fleet may lead to a shift in the age and size at maturation. For example, in recent years plaice and sole have become mature at younger ages and at smaller sizes than in the past (Grift *et al.*, 2003). The introduction of the Omega (mesh size) meter in 2010 has led to a slight increase in the effective mesh size in the fishery.

Technical management measures have caused a shift towards two categories of vessels: 2000 HP (the maximum engine power allowed) and 300 HP. The 300 HP vessels are allowed to fish within the 12-nautical mile coastal zone and in the Plaice Box. The Plaice Box is a partially closed area along the continental coast that was implemented in phases, starting in 1989. The area has been closed to most categories of vessels >300 HP all year round since 1995. The most recent EU-funded evaluation by Beare *et al.* (2010) reported the Plaice Box as having very little impact on the plaice stock.

Large scale adoption of innovative gears, for instance if EU regulations would permanently legalize the use of pulse gears could cause changes in fishing patterns in the near future (see section 8.1.3).

8.9.4 Frequency of assessment

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment.

The North Sea Plaice assessment succeeded in all four criteria when evaluated in 2015 (ICES WGNSSK 2015). Therefore the North Sea Plaice stock is a candidate for less frequent assessments. The perception of the stock and the retrospective pattern in the stock did not change since last year.

8.10 References

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Table 8.2.1 North Sea (7.d Q1 not included) and Skagerrak Plaice. Nominal landings.

	North Sea													Skagerrak	
YEAR	Belgium	Denmark	France	Ger-many	Netherlands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
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	7921	
1985	9965	28236	1010	2197	90950	23	18	15912		148311	11527	159838	200000	10095	
1986	7232	26332	751	1809	74447	21	16	17294		127902	37445	165347	180000	11378	
1987	8554	21597	1580	1794	76612	12	7	20638		130794	22876	153670	150000	12503	
1988	11527	20259	1773	2566	77724	21	2	24497	43	138412	16063	154475	175000	10820	
1989	10939	23481	2037	5341	84173	321	12	26104		152408	17410	169818	185000	5997	
1990	13940	26474	1339	8747	78204	1756	169	25632		156261	-21	156240	180000	10048	
1991	14328	24356	508	7926	67945	560	103	27839		143565	4438	148003	175000	6679	
1992	12006	20891	537	6818	51064	836	53	31277		123482	1708	125190	175000	9554	11200
1993	10814	16452	603	6895	48552	827	7	31128		115278	1835	117113	175000	9854	11200
1994	7951	17056	407	5697	50289	524	6	27749		109679	713	110392	165000	9551	11200
1995	7093	13358	442	6329	44263	527	3	24395		96410	1946	98356	115000	9380	11200
1996	5765	11776	379	4780	35419	917	5	20992		80033	1640	81673	81000	8003	11200
1997	5223	13940	254	4159	34143	1620	10	22134		81483	1565	83048	91000	7814	11200
1998	5592	10087	489	2773	30541	965	2	19915	1	70365	1169	71534	87000	6449	11200
1999	6160	13468	624	3144	37513	643	4	17061		78617	2045	80662	102000	7049	11200
2000	7260	13408	547	4310	35030	883	3	20710		82151	-1001	81150	97000	6989	11200
2001	6369	13797	429	4739	33290	1926	3	19147		79700	2147	81847	78000	9231	9400
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000	7102	6400
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250	7143	1400
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000	8033	9500
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000	6099	7600
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441	8345	7600
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261	7621	8500
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000	8356	9300
2009	3474	N/A*	N/A*	2931	29142	1116	1	13143	-	N/A*	-	54973	55500	6514	9300
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825	8700	9300
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400	8218	7900
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410	7680	7900
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070	6812	9142
2014	7105	12003	276	4203	29306	577	5	17370	-	69179	1668	70847	111631	9213	10056
2015	5522	14401	223	5171	32074	169	7	17240	-	74807	156	74963	128376	10480	10056
2016													131714		11766

*** Official estimates not available.**

Table 8.2.2 Plaice in 4 and 3.a. Landings in numbers by age (including 1st quarter of 7.d NS plaice catches) in thousands

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1957	0	4792	66428	49659	35282	9867	12248	10026	5522	12059
1958	0	7581	23612	65979	36274	20836	8696	8507	6497	13981
1959	0	16914	31085	26040	41988	23432	14173	6547	6739	16530
1960	0	5998	62285	51359	21462	27510	14280	9073	5121	15253
1961	0	2299	33913	68965	33209	12958	14909	9900	6089	14889
1962	0	2075	34677	64548	48387	19939	8757	8733	5081	12373
1963	0	4424	21886	78412	55414	32413	13096	6965	7183	16912
1964	0	14818	40789	65219	57837	37368	15937	6644	4010	17012
1965	0	9913	42438	53486	43919	30320	18464	8602	4237	17686
1966	0	4220	66196	52428	37336	27870	16801	10981	6585	15201
1967	0	6101	30905	115157	42204	22490	16496	8163	6861	11397
1968	0	9750	41883	39251	127220	17638	10642	10396	4039	13754
1969	3	15892	47819	38185	37657	107955	11016	6440	8669	17029
1970	74	16850	49861	54712	39642	34174	76862	6149	4078	14459
1971	20	30568	49876	34580	26919	23659	17471	30711	6626	17468
1972	2296	37561	63958	54402	23695	17479	14787	11211	19111	16094
1973	1332	33342	62095	76769	44397	14517	9335	10347	6392	25194
1974	2305	23972	57595	43677	42588	20391	8300	6554	5773	22790
1975	1042	29877	65465	33211	27004	22509	12613	6292	4362	20923
1976	2892	34497	79621	98846	14129	10156	9352	6553	3022	12871
1977	3225	57061	43359	66120	83841	9157	5922	5030	4068	9206
1978	1102	58412	60114	52398	48310	34240	5728	3232	2333	7201
1979	1316	57933	118662	48879	47805	39864	24187	4154	2802	9272
1980	996	66095	136274	79035	25548	18321	14018	8621	1898	5497
1981	259	103354	125928	59565	36670	12750	9805	8295	5005	6091
1982	3373	48354	212188	71167	29191	16975	7704	5551	4539	8775
1983	1214	119696	115332	100473	29591	12960	8238	4224	3013	8308
1984	108	63507	280481	62835	41492	15417	6842	5593	2729	6551
1985	120	72806	146839	201629	37939	17106	7441	3780	2813	5830
1986	1669	66935	165986	106461	101684	27971	9839	4704	2834	7083
1987	1	85153	118416	120782	81304	44590	13539	4669	2346	5610
1988	1	15200	253815	85347	59950	31492	19347	6198	3434	6402
1989	1254	46810	108272	238243	58767	21667	11605	8025	2321	5806
1990	1546	33766	104796	119829	169465	29946	9053	4689	3803	4206
1991	1425	43064	87196	122233	76075	78728	15410	5390	3215	5634
1992	3386	43769	86358	81470	88534	37542	30444	7229	3295	6976
1993	3416	53555	99805	80856	63275	35042	14745	11500	3704	5883
1994	1375	44554	105863	86992	47577	27680	17279	6661	5449	5458
1995	7779	36761	82649	84778	47911	24572	14746	5285	2495	3896
1996	1103	43346	68155	52961	37285	19160	12400	5881	2799	4989
1997	897	43122	88687	49362	31750	18673	9518	5037	3054	4400
1998	197	30594	74441	62339	22793	9151	5703	2870	1983	3360

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1999	549	8690	158088	47391	31778	14077	4038	2625	1597	3234
2000	2603	15656	40819	171994	25935	12586	2979	1135	953	2121
2001	4523	37095	58678	57195	101524	11492	4739	1212	650	2364
2002	1229	15868	60204	55511	44243	43066	6527	2256	794	1638
2003	700	44801	50607	54864	34689	20311	18128	1774	689	880
2004	544	12049	119093	39053	23766	13309	5152	4774	460	569
2005	2948	18885	29734	90989	20175	10900	5905	2760	2303	647
2006	363	20214	79934	34221	51057	8057	5589	2301	1318	1408
2007	1436	21357	41941	55949	20379	21837	3095	2011	604	1303
2008	400	13190	52382	45336	34035	7566	8066	978	735	936
2009	1563	12420	61907	42545	24886	18544	3400	4260	587	821
2010	2114	19874	49030	69702	25181	12622	9766	1866	2520	1267
2011	407	12977	45353	62017	51581	14815	6643	6984	1261	2743
2012	163	6164	60603	62070	44968	32037	7556	3402	3482	1924
2013	550	10530	63366	77056	42315	29486	15349	3955	2468	3795
2014	7	5384	40649	77966	52266	21932	12955	8387	2472	3440
2015	0	3844	42673	67065	60967	32309	12793	8902	4055	4834

Table 8.2.3 Plaice in 4 and 3.a. Discards in numbers by age (including 1st quarter of 7.d NS plaice catches) in thousands

	AGE							
YEAR	1	2	3	4	5	6	7	8
1957	32356	45596	9220	909	961	25	0	0
1958	66199	73552	23655	2572	2137	65	0	0
1959	116086	127771	46402	11407	4737	106	0	0
1960	73939	167893	44948	997	1067	519	0	0
1961	75578	144609	89014	538	1612	130	0	0
1962	51265	181321	87599	21716	799	186	0	0
1963	90913	136183	129778	9964	2112	188	0	0
1964	66035	153274	64156	33825	3011	323	0	0
1965	43708	426021	59262	3404	923	267	0	0
1966	38496	163125	349358	14399	1402	125	0	0
1967	20199	133545	87532	152496	623	260	0	0
1968	73971	72192	46339	26530	22436	58	0	0
1969	85192	67378	16747	19334	773	2024	0	0
1970	123569	152480	27747	1287	5061	161	0	0
1971	69337	96968	42354	2675	426	81	0	0
1972	70002	55470	33899	5714	567	73	0	0
1973	132352	49815	4008	673	1289	67	0	0
1974	211139	308411	3652	285	611	109	0	0
1975	244969	280130	190536	4807	253	123	0	0
1976	183879	140921	71054	18013	174	41	0	0
1977	256628	103696	79317	33552	9317	129	0	0
1978	226872	154113	27257	10775	1244	570	0	0
1979	293166	215084	57578	18382	589	310	0	0
1980	226371	122561	932	687	193	86	0	0
1981	134142	193241	1850	373	431	55	0	0
1982	411307	204572	4624	1109	216	98	0	0
1983	261400	436331	30716	2235	804	72	0	0
1984	310675	313490	52651	24529	1492	69	0	0
1985	405385	229208	35566	2221	200	78	0	0
1986	1117345	490965	48510	26470	1451	146	0	0
1987	361519	1374202	180969	1427	1348	248	0	0
1988	348597	608109	459385	61167	882	177	0	0
1989	213291	485845	193176	85758	7224	115	0	0
1990	145314	279298	168674	28102	5011	177	0	0
1991	183126	301575	141567	40739	5528	939	0	0
1992	138755	219619	94581	34348	4307	880	0	0
1993	96371	154083	48088	11966	1635	216	0	0
1994	62122	95703	35703	1038	822	144	0	0
1995	118863	82676	15753	860	663	120	0	0
1996	111250	331065	27606	3930	451	116	0	0
1997	128653	510918	193828	588	271	108	0	0
1998	104538	646250	191631	53354	297	33	0	0

	AGE							
YEAR	1	2	3	4	5	6	7	8
1999	127321	208401	231769	54869	278	58	0	0
2000	103468	171213	51092	64971	1230	241	263	167
2001	30346	352452	186900	74744	54276	152	45	1
2002	310442	178402	78296	13940	2834	718	109	1
2003	67798	523336	56580	20184	4358	419	5756	1
2004	233682	183508	127876	10650	1975	450	41	1
2005	93936	332157	46454	23763	4494	6007	287	6
2006	220982	226944	117342	9785	2369	251	736	195
2007	77687	210407	73043	13942	1594	7028	190	1644
2008	135504	255948	37983	5356	1785	336	8852	885
2009	148666	193174	68975	9471	2007	1108	138	3220
2010	167387	180364	59943	22776	2699	1736	2074	283
2011	117902	153773	62696	37050	12949	2924	143	2273
2012	91961	313013	123821	32986	9439	1547	226	7
2013	128227	156837	125878	24797	4679	1033	219	15
2014	293515	192537	116178	55315	19141	2610	478	67
2015	83433	288990	130826	38858	12591	2367	521	209

Table 8.2.4 Plaice in 4 and 3.a. Catch in numbers by age (including 1st quarter of 7.d NS plaice catches) in thousands

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1957	32356	50388	75648	50568	36243	9892	12248	10026	5522	12059
1958	66199	81133	47267	68551	38411	20901	8696	8507	6497	13981
1959	116086	144685	77487	37447	46725	23538	14173	6547	6739	16530
1960	73939	173891	107233	52356	22529	28029	14280	9073	5121	15253
1961	75578	146908	122927	69503	34821	13088	14909	9900	6089	14889
1962	51265	183396	122276	86264	49186	20125	8757	8733	5081	12373
1963	90913	140607	151664	88376	57526	32601	13096	6965	7183	16912
1964	66035	168092	104945	99044	60848	37691	15937	6644	4010	17012
1965	43708	435934	101700	56890	44842	30587	18464	8602	4237	17686
1966	38496	167345	415554	66827	38738	27995	16801	10981	6585	15201
1967	20199	139646	118437	267653	42827	22750	16496	8163	6861	11397
1968	73971	81942	88222	65781	149656	17696	10642	10396	4039	13754
1969	85195	83270	64566	57519	38430	109979	11016	6440	8669	17029
1970	123643	169330	77608	55999	44703	34335	76862	6149	4078	14459
1971	69357	127536	92230	37255	27345	23740	17471	30711	6626	17468
1972	72298	93031	97857	60116	24262	17552	14787	11211	19111	16094
1973	133684	83157	66103	77442	45686	14584	9335	10347	6392	25194
1974	213444	332383	61247	43962	43199	20500	8300	6554	5773	22790
1975	246011	310007	256001	38018	27257	22632	12613	6292	4362	20923
1976	186771	175418	150675	116859	14303	10197	9352	6553	3022	12871
1977	259853	160757	122676	99672	93158	9286	5922	5030	4068	9206
1978	227974	212525	87371	63173	49554	34810	5728	3232	2333	7201
1979	294482	273017	176240	67261	48394	40174	24187	4154	2802	9272
1980	227367	188656	137206	79722	25741	18407	14018	8621	1898	5497
1981	134401	296595	127778	59938	37101	12805	9805	8295	5005	6091
1982	414680	252926	216812	72276	29407	17073	7704	5551	4539	8775
1983	262614	556027	146048	102708	30395	13032	8238	4224	3013	8308
1984	310783	376997	333132	87364	42984	15486	6842	5593	2729	6551
1985	405505	302014	182405	203850	38139	17184	7441	3780	2813	5830
1986	1119014	557900	214496	132931	103135	28117	9839	4704	2834	7083
1987	361520	1459355	299385	122209	82652	44838	13539	4669	2346	5610
1988	348598	623309	713200	146514	60832	31669	19347	6198	3434	6402
1989	214545	532655	301448	324001	65991	21782	11605	8025	2321	5806
1990	146860	313064	273470	147931	174476	30123	9053	4689	3803	4206
1991	184551	344639	228763	162972	81603	79667	15410	5390	3215	5634
1992	142141	263388	180939	115818	92841	38422	30444	7229	3295	6976
1993	99787	207638	147893	92822	64910	35258	14745	11500	3704	5883
1994	63497	140257	141566	88030	48399	27824	17279	6661	5449	5458
1995	126642	119437	98402	85638	48574	24692	14746	5285	2495	3896
1996	112353	374411	95761	56891	37736	19276	12400	5881	2799	4989
1997	129550	554040	282515	49950	32021	18781	9518	5037	3054	4400
1998	104735	676844	266072	115693	23090	9184	5703	2870	1983	3360

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1999	127870	217091	389857	102260	32056	14135	4038	2625	1597	3234
2000	106071	186869	91911	236965	27165	12827	3242	1302	953	2121
2001	34869	389547	245578	131939	155800	11644	4784	1213	650	2364
2002	311671	194270	138500	69451	47077	43784	6636	2257	794	1638
2003	68498	568137	107187	75048	39047	20730	23884	1775	689	880
2004	234226	195557	246969	49703	25741	13759	5193	4775	460	569
2005	96884	351042	76188	114752	24669	16907	6192	2766	2303	647
2006	221345	247158	197276	44006	53426	8308	6325	2496	1318	1408
2007	79123	231764	114984	69891	21973	28865	3285	3655	604	1303
2008	135904	269138	90365	50692	35820	7902	16918	1863	735	936
2009	150229	205594	130882	52016	26893	19652	3538	7480	587	821
2010	169501	200238	108973	92478	27880	14358	11840	2149	2520	1267
2011	118309	166750	108049	99067	64530	17739	6786	9257	1261	2743
2012	92124	319177	184424	95056	54407	33584	7782	3409	3482	1924
2013	128777	167367	189244	101853	46994	30519	15568	3970	2468	3795
2014	293522	197921	156827	133281	71407	24542	13433	8454	2472	3440
2015	83433	292834	173499	105923	73558	34676	13314	9111	4055	4834

Table 8.2.5 Plaice in 4 and 3.a. Stock weight at age (kg).

	AGE									
YEAR	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	0.918
1958	0.041	0.093	0.180	0.272	0.303	0.442	0.577	0.778	0.793	0.945
1959	0.045	0.106	0.173	0.264	0.329	0.470	0.650	0.686	0.908	0.897
1960	0.038	0.111	0.181	0.272	0.364	0.469	0.633	0.726	0.845	0.918
1961	0.037	0.098	0.185	0.306	0.337	0.483	0.579	0.691	0.779	0.911
1962	0.036	0.096	0.173	0.301	0.424	0.573	0.684	0.806	0.873	1.335
1963	0.041	0.103	0.176	0.273	0.378	0.540	0.663	0.788	0.882	0.961
1964	0.024	0.113	0.184	0.296	0.373	0.477	0.645	0.673	0.845	0.973
1965	0.031	0.068	0.198	0.294	0.333	0.43	0.516	0.601	0.722	0.578
1966	0.031	0.099	0.127	0.305	0.403	0.455	0.503	0.565	0.581	0.848
1967	0.029	0.104	0.179	0.205	0.442	0.528	0.585	0.650	0.703	0.833
1968	0.055	0.094	0.175	0.287	0.344	0.532	0.592	0.362	0.667	0.746
1969	0.047	0.158	0.188	0.266	0.344	0.390	0.565	0.621	0.679	0.635
1970	0.043	0.113	0.236	0.274	0.369	0.410	0.468	0.636	0.732	0.747
1971	0.051	0.109	0.251	0.344	0.413	0.489	0.512	0.583	0.696	0.707
1972	0.056	0.158	0.218	0.407	0.473	0.534	0.579	0.606	0.655	0.759
1973	0.037	0.134	0.237	0.308	0.468	0.521	0.566	0.583	0.617	0.690
1974	0.049	0.105	0.217	0.416	0.437	0.524	0.570	0.629	0.652	0.690
1975	0.063	0.141	0.187	0.388	0.483	0.544	0.610	0.668	0.704	0.762
1976	0.082	0.169	0.226	0.308	0.484	0.550	0.593	0.658	0.694	0.743
1977	0.064	0.184	0.265	0.311	0.405	0.551	0.627	0.690	0.667	0.759
1978	0.064	0.151	0.319	0.373	0.411	0.467	0.547	0.630	0.704	0.773
1979	0.062	0.179	0.258	0.365	0.414	0.459	0.543	0.667	0.764	0.826
1980	0.049	0.163	0.289	0.428	0.444	0.524	0.582	0.651	0.778	1.025
1981	0.041	0.140	0.239	0.421	0.473	0.536	0.570	0.624	0.707	0.849
1982	0.048	0.128	0.250	0.351	0.490	0.589	0.631	0.679	0.726	0.828
1983	0.045	0.128	0.242	0.381	0.494	0.559	0.624	0.712	0.754	0.791
1984	0.048	0.129	0.216	0.413	0.464	0.571	0.649	0.692	0.787	0.898
1985	0.048	0.146	0.232	0.320	0.452	0.536	0.635	0.656	0.764	0.869
1986	0.043	0.126	0.245	0.311	0.440	0.533	0.692	0.779	0.888	0.971
1987	0.036	0.105	0.200	0.383	0.401	0.503	0.573	0.711	0.747	0.817
1988	0.036	0.097	0.172	0.264	0.426	0.467	0.547	0.644	0.706	0.897
1989	0.039	0.101	0.192	0.247	0.362	0.484	0.553	0.616	0.759	0.837
1990	0.043	0.108	0.176	0.261	0.343	0.422	0.555	0.647	0.701	0.760
1991	0.048	0.131	0.184	0.260	0.342	0.401	0.463	0.633	0.652	0.744
1992	0.043	0.121	0.199	0.270	0.318	0.403	0.500	0.573	0.683	0.730
1993	0.050	0.119	0.208	0.315	0.330	0.391	0.490	0.587	0.633	0.723
1994	0.053	0.141	0.214	0.290	0.360	0.404	0.462	0.533	0.653	0.702
1995	0.050	0.142	0.254	0.336	0.399	0.448	0.509	0.584	0.678	0.789
1996	0.044	0.117	0.229	0.368	0.390	0.462	0.488	0.554	0.660	0.791
1997	0.035	0.115	0.233	0.359	0.439	0.492	0.521	0.543	0.627	0.734
1998	0.038	0.081	0.207	0.333	0.474	0.577	0.581	0.648	0.656	0.642
1999	0.044	0.091	0.150	0.319	0.437	0.524	0.586	0.644	0.664	0.620

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
2000	0.051	0.106	0.165	0.219	0.408	0.467	0.649	0.695	0.656	0.744
2001	0.061	0.122	0.202	0.233	0.331	0.452	0.560	0.641	0.798	0.816
2002	0.048	0.118	0.213	0.301	0.319	0.403	0.446	0.612	0.685	0.781
2003	0.057	0.111	0.227	0.269	0.344	0.391	0.464	0.600	0.714	0.960
2004	0.047	0.116	0.201	0.306	0.384	0.430	0.489	0.495	0.780	0.921
2005	0.053	0.106	0.216	0.237	0.378	0.422	0.434	0.527	0.621	0.815
2006	0.052	0.130	0.190	0.316	0.354	0.424	0.439	0.506	0.583	0.688
2007	0.047	0.093	0.235	0.238	0.337	0.394	0.458	0.412	0.526	0.512
2008	0.048	0.114	0.196	0.274	0.355	0.429	0.484	0.627	0.598	0.449
2009	0.052	0.114	0.194	0.344	0.373	0.412	0.472	0.540	0.565	0.576
2010	0.053	0.116	0.179	0.340	0.361	0.401	0.448	0.572	0.568	0.655
2011	0.039	0.100	0.187	0.209	0.355	0.483	0.438	0.422	0.530	0.580
2012	0.052	0.093	0.142	0.188	0.331	0.393	0.484	0.479	0.480	0.518
2013	0.043	0.107	0.153	0.208	0.320	0.354	0.434	0.493	0.662	0.468
2014	0.048	0.104	0.158	0.202	0.312	0.380	0.439	0.484	0.458	0.615
2015	0.024	0.065	0.120	0.207	0.279	0.323	0.379	0.435	0.465	0.457

Table 8.2.6 Plaice in 4 and 3.a. Landings weight at age (kg).

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	0.000	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	0.000	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.750	1.000
1960	0.000	0.200	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.094
1961	0.000	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.071
1962	0.000	0.211	0.248	0.300	0.400	0.541	0.570	0.692	0.777	1.127
1963	0.000	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.028
1964	0.000	0.250	0.273	0.312	0.388	0.487	0.628	0.700	0.737	1.005
1965	0.000	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.887
1966	0.000	0.232	0.270	0.348	0.436	0.484	0.559	0.624	0.690	0.933
1967	0.000	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.978
1968	0.000	0.267	0.298	0.331	0.366	0.517	0.590	0.596	0.686	0.911
1969	0.217	0.294	0.310	0.333	0.359	0.412	0.573	0.655	0.658	0.893
1970	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.892
1971	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.891
1972	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.939
1973	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.842
1974	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.926
1975	0.249	0.300	0.330	0.420	0.495	0.587	0.636	0.703	0.783	1.019
1976	0.265	0.295	0.338	0.375	0.513	0.594	0.641	0.705	0.741	0.980
1977	0.254	0.323	0.353	0.380	0.418	0.556	0.647	0.721	0.715	0.978
1978	0.244	0.315	0.369	0.397	0.438	0.491	0.609	0.687	0.776	0.950
1979	0.235	0.311	0.349	0.388	0.429	0.474	0.550	0.675	0.796	0.960
1980	0.238	0.286	0.344	0.401	0.473	0.545	0.588	0.662	0.772	1.013
1981	0.237	0.274	0.329	0.416	0.505	0.558	0.604	0.642	0.725	1.007
1982	0.279	0.262	0.311	0.424	0.514	0.608	0.664	0.712	0.738	0.984
1983	0.200	0.250	0.300	0.383	0.515	0.604	0.677	0.771	0.815	0.984
1984	0.231	0.263	0.283	0.364	0.480	0.591	0.677	0.726	0.839	1.036
1985	0.245	0.264	0.290	0.335	0.445	0.563	0.667	0.730	0.807	1.021
1986	0.221	0.269	0.303	0.339	0.405	0.473	0.668	0.750	0.856	1.014
1987	0.000	0.249	0.299	0.345	0.378	0.472	0.574	0.728	0.835	0.993
1988	0.000	0.254	0.278	0.341	0.418	0.478	0.590	0.680	0.808	1.017
1989	0.236	0.280	0.308	0.331	0.385	0.515	0.591	0.668	0.785	0.940
1990	0.271	0.284	0.297	0.315	0.364	0.441	0.586	0.690	0.761	1.010
1991	0.227	0.286	0.292	0.302	0.360	0.452	0.526	0.666	0.743	0.924
1992	0.251	0.263	0.290	0.312	0.330	0.415	0.530	0.607	0.719	0.891
1993	0.249	0.273	0.288	0.319	0.343	0.408	0.512	0.630	0.720	0.856
1994	0.229	0.263	0.284	0.333	0.375	0.417	0.491	0.610	0.731	0.906
1995	0.272	0.277	0.301	0.335	0.375	0.420	0.474	0.593	0.734	0.906
1996	0.240	0.279	0.304	0.346	0.415	0.465	0.490	0.553	0.712	0.858
1997	0.208	0.271	0.313	0.355	0.410	0.474	0.541	0.574	0.616	0.912
1998	0.151	0.260	0.306	0.384	0.452	0.546	0.613	0.673	0.687	0.899
1999	0.245	0.253	0.280	0.347	0.415	0.416	0.538	0.637	0.748	0.804

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
2000	0.228	0.267	0.283	0.312	0.378	0.461	0.597	0.689	0.752	0.888
2001	0.238	0.267	0.291	0.307	0.360	0.412	0.582	0.701	0.796	0.799
2002	0.237	0.264	0.289	0.311	0.336	0.430	0.477	0.644	0.760	0.904
2003	0.232	0.252	0.285	0.320	0.353	0.389	0.482	0.635	0.763	0.857
2004	0.214	0.246	0.281	0.328	0.391	0.429	0.508	0.560	0.797	0.872
2005	0.272	0.265	0.280	0.330	0.382	0.426	0.465	0.555	0.617	0.910
2006	0.253	0.267	0.282	0.322	0.383	0.389	0.457	0.477	0.531	0.748
2007	0.263	0.268	0.303	0.343	0.364	0.432	0.507	0.486	0.587	0.632
2008	0.249	0.269	0.309	0.341	0.400	0.446	0.531	0.720	0.640	0.638
2009	0.176	0.260	0.308	0.355	0.415	0.481	0.531	0.608	0.668	0.792
2010	0.206	0.265	0.308	0.348	0.418	0.476	0.516	0.625	0.682	0.649
2011	0.235	0.242	0.281	0.341	0.414	0.504	0.604	0.521	0.556	0.804
2012	0.236	0.258	0.305	0.351	0.380	0.436	0.518	0.558	0.558	0.680
2013	0.031	0.242	0.281	0.313	0.364	0.417	0.494	0.600	0.607	0.680
2014	0.207	0.252	0.285	0.318	0.368	0.418	0.479	0.543	0.628	0.650
2015	NA	0.251	0.284	0.321	0.359	0.409	0.473	0.487	0.582	0.600

Table 8.2.7 Plaice in 4 and 3.a. Discards weight at age (kg).

	AGE									
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	0.000	0.000
1958	0.047	0.096	0.158	0.188	0.200	0.244	0.000	0.000	0.000	0.000
1959	0.051	0.107	0.155	0.186	0.197	0.231	0.000	0.000	0.000	0.000
1960	0.045	0.112	0.159	0.188	0.204	0.212	0.244	0.000	0.000	0.000
1961	0.044	0.100	0.160	0.194	0.204	0.220	0.220	0.000	0.000	0.000
1962	0.042	0.098	0.155	0.193	0.213	0.221	0.221	0.231	0.000	0.000
1963	0.048	0.105	0.156	0.188	0.205	0.231	0.221	0.231	0.000	0.000
1964	0.032	0.114	0.160	0.192	0.204	0.221	0.244	0.231	0.000	0.000
1965	0.038	0.072	0.166	0.192	0.212	0.221	0.231	0.000	0.000	0.000
1966	0.038	0.101	0.125	0.194	0.205	0.231	0.231	0.244	0.000	0.000
1967	0.036	0.105	0.158	0.169	0.220	0.220	0.244	0.244	0.000	0.000
1968	0.060	0.096	0.156	0.191	0.192	0.244	0.220	0.000	0.000	0.000
1969	0.052	0.146	0.162	0.186	0.211	0.212	0.000	0.231	0.000	0.000
1970	0.049	0.114	0.179	0.189	0.196	0.000	0.220	0.231	0.000	0.000
1971	0.057	0.110	0.183	0.200	0.212	0.000	0.000	0.231	0.000	0.000
1972	0.061	0.147	0.173	0.211	0.211	0.244	0.000	0.000	0.000	0.000
1973	0.043	0.131	0.179	0.195	0.211	0.244	0.000	0.000	0.000	0.000
1974	0.054	0.106	0.173	0.212	0.220	0.231	0.244	0.000	0.000	0.000
1975	0.068	0.136	0.162	0.206	0.221	0.244	0.244	0.000	0.000	0.000
1976	0.085	0.153	0.176	0.195	0.220	0.000	0.244	0.000	0.000	0.000
1977	0.069	0.160	0.186	0.196	0.198	0.220	0.000	0.000	0.000	0.000
1978	0.069	0.143	0.197	0.205	0.211	0.213	0.231	0.000	0.000	0.000
1979	0.066	0.158	0.185	0.204	0.220	0.231	0.221	0.244	0.000	0.000
1980	0.055	0.149	0.191	0.212	0.231	0.000	0.000	0.000	0.000	0.000
1981	0.048	0.135	0.179	0.212	0.220	0.000	0.000	0.000	0.000	0.000
1982	0.054	0.126	0.182	0.203	0.231	0.244	0.244	0.000	0.000	0.000
1983	0.051	0.126	0.180	0.205	0.211	0.244	0.000	0.000	0.000	0.000
1984	0.053	0.127	0.172	0.211	0.205	0.000	0.244	0.000	0.000	0.000
1985	0.054	0.139	0.177	0.197	0.231	0.244	0.000	0.000	0.000	0.000
1986	0.049	0.124	0.181	0.196	0.220	0.244	0.244	0.000	0.000	0.000
1987	0.043	0.105	0.166	0.205	0.220	0.231	0.000	0.000	0.000	0.000
1988	0.043	0.098	0.153	0.185	0.220	0.244	0.000	0.000	0.000	0.000
1989	0.046	0.102	0.163	0.181	0.196	0.000	0.000	0.000	0.000	0.000
1990	0.051	0.111	0.157	0.186	0.212	0.231	0.000	0.000	0.000	0.000
1991	0.055	0.130	0.161	0.185	0.203	0.221	0.231	0.231	0.000	0.000
1992	0.050	0.122	0.167	0.188	0.204	0.212	0.231	0.244	0.000	0.000
1993	0.056	0.121	0.171	0.197	0.211	0.231	0.244	0.000	0.000	0.000
1994	0.060	0.140	0.175	0.194	0.213	0.244	0.244	0.221	0.000	0.000
1995	0.058	0.141	0.186	0.201	0.220	0.232	0.232	0.244	0.000	0.000
1996	0.052	0.122	0.179	0.205	0.221	0.232	0.000	0.000	0.000	0.000
1997	0.044	0.117	0.178	0.203	0.221	0.244	0.000	0.000	0.000	0.000
1998	0.047	0.086	0.170	0.199	0.220	0.000	0.244	0.000	0.000	0.000
1999	0.053	0.097	0.143	0.197	0.220	0.000	0.000	0.000	0.000	0.000

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
2000	0.059	0.110	0.151	0.174	0.244	0.000	0.203	0.000	0.000	0.000
2001	0.068	0.122	0.167	0.178	0.197	0.244	0.000	0.244	0.000	0.000
2002	0.056	0.119	0.170	0.182	0.172	0.208	0.003	0.000	0.000	0.000
2003	0.064	0.113	0.174	0.185	0.198	0.204	0.221	0.000	0.000	0.000
2004	0.054	0.117	0.164	0.183	0.189	0.192	0.196	0.000	0.000	0.000
2005	0.061	0.109	0.170	0.175	0.215	0.205	0.210	0.176	0.000	0.000
2006	0.060	0.128	0.164	0.193	0.198	0.204	0.212	0.220	0.000	0.000
2007	0.055	0.098	0.177	0.178	0.188	0.199	0.225	0.200	0.000	0.000
2008	0.056	0.116	0.163	0.186	0.187	0.230	0.220	0.191	0.000	0.000
2009	0.060	0.116	0.164	0.199	0.202	0.212	0.210	0.220	0.000	0.000
2010	0.060	0.117	0.159	0.199	0.190	0.198	0.211	0.234	0.001	0.000
2011	0.047	0.104	0.162	0.171	0.192	0.196	0.199	0.211	0.000	0.000
2012	0.052	0.093	0.142	0.188	0.198	0.206	0.215	0.215	0.000	0.000
2013	0.051	0.081	0.127	0.151	0.170	0.194	0.228	0.346	0.000	0.000
2014	0.025	0.089	0.132	0.162	0.180	0.212	0.300	0.370	0.255	0.000
2015	0.026	0.078	0.122	0.149	0.164	0.185	0.173	0.218	0.404	0.291

Table 8.2.8 Plaice in 4 and 3.a. Catch weight at age (kg).

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.110	0.194	0.257	0.349	0.455	0.533	0.589	0.396	0.998
1958	0.047	0.106	0.189	0.256	0.329	0.452	0.513	0.615	0.665	0.992
1959	0.051	0.120	0.192	0.260	0.345	0.472	0.592	0.623	0.750	1.000
1960	0.045	0.115	0.204	0.287	0.377	0.480	0.601	0.683	0.724	1.094
1961	0.044	0.101	0.180	0.301	0.402	0.506	0.604	0.671	0.812	1.071
1962	0.042	0.099	0.181	0.273	0.397	0.538	0.570	0.692	0.777	1.127
1963	0.048	0.110	0.175	0.304	0.392	0.531	0.624	0.667	0.715	1.028
1964	0.032	0.126	0.204	0.271	0.379	0.485	0.628	0.700	0.737	1.005
1965	0.038	0.076	0.214	0.313	0.381	0.469	0.539	0.663	0.726	0.887
1966	0.038	0.104	0.148	0.315	0.428	0.483	0.559	0.624	0.690	0.933
1967	0.036	0.111	0.190	0.235	0.422	0.543	0.597	0.662	0.738	0.978
1968	0.060	0.116	0.223	0.275	0.340	0.516	0.590	0.596	0.686	0.911
1969	0.052	0.174	0.272	0.284	0.356	0.408	0.573	0.655	0.658	0.893
1970	0.049	0.131	0.268	0.352	0.394	0.441	0.499	0.672	0.744	0.892
1971	0.057	0.160	0.277	0.388	0.444	0.512	0.542	0.607	0.699	0.891
1972	0.067	0.207	0.290	0.407	0.486	0.540	0.608	0.646	0.674	0.939
1973	0.045	0.205	0.334	0.403	0.478	0.538	0.605	0.627	0.677	0.842
1974	0.056	0.121	0.343	0.404	0.472	0.552	0.609	0.693	0.707	0.926
1975	0.069	0.152	0.205	0.393	0.492	0.585	0.636	0.703	0.783	1.019
1976	0.088	0.181	0.262	0.347	0.509	0.592	0.641	0.705	0.741	0.980
1977	0.071	0.218	0.245	0.318	0.396	0.551	0.647	0.721	0.715	0.978
1978	0.070	0.190	0.315	0.364	0.432	0.486	0.609	0.687	0.776	0.950
1979	0.067	0.190	0.295	0.338	0.426	0.472	0.550	0.675	0.796	0.960
1980	0.056	0.197	0.343	0.399	0.471	0.542	0.588	0.662	0.772	1.013
1981	0.048	0.183	0.327	0.415	0.502	0.556	0.604	0.642	0.725	1.007
1982	0.056	0.152	0.308	0.421	0.512	0.606	0.664	0.712	0.738	0.984
1983	0.052	0.153	0.275	0.379	0.507	0.602	0.677	0.771	0.815	0.984
1984	0.053	0.150	0.265	0.321	0.470	0.588	0.677	0.726	0.839	1.036
1985	0.054	0.169	0.268	0.333	0.444	0.562	0.667	0.730	0.807	1.021
1986	0.049	0.141	0.275	0.311	0.402	0.472	0.668	0.750	0.856	1.014
1987	0.043	0.113	0.219	0.343	0.375	0.471	0.574	0.728	0.835	0.993
1988	0.043	0.102	0.197	0.276	0.415	0.477	0.590	0.680	0.808	1.017
1989	0.047	0.118	0.215	0.291	0.364	0.512	0.591	0.668	0.785	0.940
1990	0.053	0.130	0.211	0.290	0.360	0.440	0.586	0.690	0.761	1.010
1991	0.056	0.149	0.211	0.273	0.349	0.449	0.526	0.666	0.743	0.924
1992	0.055	0.145	0.226	0.275	0.324	0.410	0.530	0.607	0.719	0.891
1993	0.063	0.160	0.250	0.303	0.340	0.407	0.512	0.630	0.720	0.856
1994	0.064	0.179	0.257	0.331	0.372	0.416	0.491	0.610	0.731	0.906
1995	0.071	0.183	0.283	0.334	0.373	0.419	0.474	0.593	0.734	0.906
1996	0.054	0.140	0.268	0.336	0.413	0.464	0.490	0.553	0.712	0.858
1997	0.045	0.129	0.220	0.353	0.408	0.473	0.541	0.574	0.616	0.912
1998	0.047	0.094	0.208	0.299	0.449	0.544	0.613	0.673	0.687	0.899
1999	0.054	0.103	0.199	0.267	0.413	0.414	0.538	0.637	0.748	0.804

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
2000	0.063	0.123	0.210	0.274	0.372	0.452	0.565	0.601	0.752	0.888
2001	0.090	0.136	0.197	0.234	0.303	0.410	0.577	0.701	0.796	0.799
2002	0.057	0.131	0.222	0.285	0.326	0.426	0.469	0.644	0.760	0.904
2003	0.066	0.124	0.226	0.284	0.336	0.385	0.419	0.635	0.763	0.857
2004	0.054	0.125	0.220	0.297	0.376	0.421	0.506	0.560	0.797	0.872
2005	0.067	0.117	0.213	0.298	0.352	0.347	0.453	0.554	0.617	0.910
2006	0.060	0.139	0.212	0.293	0.375	0.383	0.428	0.457	0.531	0.748
2007	0.059	0.114	0.223	0.310	0.351	0.375	0.491	0.357	0.587	0.632
2008	0.057	0.123	0.248	0.325	0.389	0.437	0.368	0.469	0.640	0.638
2009	0.061	0.125	0.232	0.327	0.399	0.466	0.518	0.441	0.668	0.792
2010	0.062	0.132	0.226	0.311	0.396	0.442	0.463	0.574	0.682	0.649
2011	0.048	0.115	0.212	0.277	0.369	0.453	0.595	0.445	0.556	0.804
2012	0.052	0.096	0.196	0.294	0.348	0.425	0.509	0.557	0.558	0.680
2013	0.051	0.091	0.179	0.274	0.345	0.409	0.490	0.599	0.607	0.680
2014	0.025	0.093	0.172	0.253	0.318	0.396	0.473	0.542	0.628	0.650
2015	0.026	0.080	0.162	0.258	0.326	0.394	0.461	0.481	0.582	0.600

Table 8.2.9 North Sea plaice (including Skagerrak). Natural mortality at age and maturity ate age

AGE	1	2	3	4	5	6	7	8	9	10
natural mortality	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
maturity	0	0.5	0.5	1	1	1	1	1	1	1

Table 8.2.10 North Sea plaice. Survey tuning indices

BTS-Isis	age								
year	1	2	3	4	5	6	7	8	9
1985	137	173.9	36.1	11	1.27	0.973	0.336	0.155	0.091
1986	667	131.7	50.2	9.21	3.78	0.4	0.418	0.147	0.07
1987	226	764.2	33.8	4.88	1.84	0.607	0.252	0.134	0.078
1988	680	147	182.3	9.99	2.81	0.814	0.458	0.036	0.112
1989	468	319.3	38.7	47.3	5.85	0.833	0.311	0.661	0.132
1990	185	146.1	79.3	26.35	5.47	0.758	0.189	0.383	0.239
1991	291	159.4	34	13.57	4.31	5.659	0.239	0.204	0.092
1992	361	174.5	29.3	5.96	3.75	2.871	1.186	0.346	0.05
1993	189	283.4	62.8	8.27	1.13	1.13	0.584	0.464	0.155
1994	193	77.1	34.5	10.59	2.67	0.6	0.8	0.895	0.373
1995	266	40.6	13.2	7.53	1.11	0.806	0.33	1.051	0.202

BTS-Combined	1	2	3	4	5	6	7	8	9
1996	143.9	99.6	13.3	4.27	3.04	1.65	0.676	0.442	0.214
1997	386.8	28.7	14.9	4.01	2.04	1.54	0.428	0.797	0.327
1998	131.2	177.6	25.5	7.27	2.5	1.35	0.955	0.808	0.323
1999	117	53.6	96.3	6.49	3	1.93	0.659	0.756	0.314
2000	108.4	38.9	22.9	23.68	3.02	1.73	1.113	0.797	0.219
2001	80.3	39.8	15.7	8.75	9.3	1.08	0.624	0.42	0.511
2002	217.3	26.7	14	7.62	4.79	4.64	0.754	0.765	0.385
2003	53.6	94.4	15.9	10.3	5.36	3.08	4.007	0.732	0.76
2004	101.4	30.3	51.2	11.21	4.96	2.88	1.538	3.402	0.391
2005	70.8	45.6	13.8	20.39	3.04	6.94	1.568	0.571	3.57
2006	54.9	42.9	29.2	11.75	12.05	2.11	3.938	0.844	0.767
2007	139.4	44.4	24.6	26.58	5.68	11.69	2.091	3.947	0.364
2008	98.9	89.7	33.8	20.73	20.61	6.33	13.054	2.727	6.718
2009	170.8	76.5	54.1	21.48	12.83	12.19	3.139	10.254	1.585
2010	144.8	69.5	47.9	40.35	17.91	6.84	15.841	3.179	8.306
2011	226.5	126	58.1	32.75	33.17	15.09	5.808	11.94	1.124
2012	118.4	149.6	79.8	35.86	22.17	16.39	7.216	3.544	8.696
2013	192.8	90.5	90.3	46.71	27.6	15.37	11.273	4.523	3.224
2014	155.2	123.2	83.3	58.53	34.74	14.87	10.569	6.607	7.591
2015	116.5	156.6	102.5	57.4	49.2	25.5	9.7	7.0	7.4

SNS1						SNS2					
	age						age				
year	1	2	3	4	5	year	1	2	3	4	5
1970	9311	9732	3273	770	170	2000	22855	2493	891	983	17
1971	13538	28164	1415	101	50	2001	11511	2898	370	176	691
1972	13207	10780	4478	89	84	2002	30809	1103	265	65	69
1973	65643	5133	1578	461	15	2003	NA	NA	NA	NA	NA
1974	15366	16509	1129	160	82	2004	18202	1350	1081	51	27
1975	11628	8168	9556	65	15	2005	10118	1819	142	366	8
1976	8537	2403	868	236	0	2006	12164	1571	385	52	54
1977	18537	3424	1737	590	213	2007	14175	2134	140	52	0
1978	14012	12678	345	135	45	2008	14706	2700	464	179	34
1979	21495	9829	1575	161	17	2009	14860	2019	492	38	20
1980	59174	12882	491	180	24	2010	11947	1812	529	55	10
1981	24756	18785	834	38	32	2011	18349	1143	308	75	60
1982	69993	8642	1261	88	8	2012	5893	2929	682	82	30
1983	33974	13909	249	71	6	2013	15395	3021	1638	428	89
1984	44965	10413	2467	42	0	2014	17313	2258	514	458	58
1985	28101	13848	1598	328	17	2015	16727	5040	1882	478	200
1986	93552	7580	1152	145	30						
1987	33402	32991	1227	200	30						
1988	36609	14421	13153	1350	88						
1989	34276	17810	4373	7126	289						
1990	25037	7496	3160	816	422						
1991	57221	11247	1518	1077	128						
1992	46798	13842	2268	613	176						
1993	22098	9686	1006	98	60						
1994	19188	4977	856	76	23						
1995	24767	2796	381	97	38						
1996	23015	10268	1185	45	47						
1997	95901	4473	497	32	0						
1998	33666	30242	5014	50	10						
1999	32951	10272	13783	1058	17						

Table 8.3.1 North Sea plaice (4, 3.a and 7.dQ1). XSA diagnostics from final run

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FLR XSA Diagnostics 2016-04-28 10:15:08
CPUE data from indices
Catch data for 59 years. 1957 to 2015. Ages 1 to 10.

      fleet first age last age first year last year alpha beta
1 BTS-Isis-early     1    8    1985   1995 0.66 0.75
2  BTS-Combined     1    9    1996   2015 0.66 0.75
3      SNS1     1    3    1982   1999 0.66 0.75
4      SNS2     1    3    2000   2015 0.66 0.75

Time series weights :
  Tapered time weighting not applied

Catchability analysis :
  Catchability independent of size for all ages
  Catchability independent of age for ages >=  6

Terminal population estimation :
  Survivor estimates shrunk towards the mean F
  of the final  5 years or the 5 oldest ages.

  S.E. of the mean to which the estimates are shrunk =  2

  Minimum standard error for population
  estimates derived from each fleet = 0.3

  prior weighting not applied

Regression weights
    year
 age  2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
  all  1  1  1  1  1  1  1  1  1  1

Fishing mortalities
  year
age  2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
 1 0.271 0.075 0.143 0.153 0.134 0.068 0.079 0.083 0.171 0.080
 2 0.526 0.447 0.349 0.297 0.280 0.170 0.235 0.180 0.159 0.230
 3 0.433 0.440 0.279 0.254 0.227 0.214 0.256 0.191 0.229 0.182
 4 0.420 0.238 0.314 0.229 0.257 0.295 0.264 0.196 0.179 0.213
 5 0.242 0.340 0.165 0.243 0.165 0.256 0.234 0.180 0.184 0.127
 6 0.239 0.178 0.176 0.115 0.177 0.135 0.183 0.178 0.121 0.115
 7 0.109 0.125 0.135 0.100 0.085 0.107 0.073 0.109 0.100 0.080
 8 0.298 0.076 0.087 0.073 0.073 0.080 0.065 0.043 0.071 0.082
 9 0.163 0.097 0.018 0.032 0.029 0.050 0.035 0.055 0.031 0.040
 10 0.163 0.097 0.018 0.032 0.029 0.050 0.035 0.055 0.031 0.040

XSA population number (Thousand)
      age
year     1     2     3    4    5    6    7    8    9    10
2006 979159 635267 590473 134811 261313 41158 64566 10197  9220  9832
2007 1143879 675430 339709 346628 80123 185625 29338 52405  6852 14779
2008 1071558 959761 390694 198006 247160 51596 140503 23421 43941 55932
2009 1110840 840310 612415 267556 130943 189566 39169 111040 19420 27170
2010 1419551 862227 564777 429637 192616 92901 152833 32077 93358 46909
2011 1892434 1123228 589703 407373 300783 147766 70403 127027 26980 58621
2012 1274853 1599807 857721 430806 274371 210777 116830 57248 106134 58598
2013 1703575 1065903 1143954 600668 299390 196508 158773 98310 48558 74607
2014 1966051 1418962 805264 855078 446622 226197 148777 128855 85178 118469
2015 1140208 1499750 1095662 579455 646926 336195 181327 121842 108551 129321

Estimated population abundance at 1st Jan 2016
   age
year  1   2    3    4    5    6    7    8    9  10
 2016 0 952367 1078524 826403 423588 515435 271247 151425 101595 94378

Fleet: BTS-Isis-early
Log catchability residuals.
  year
age 1985  1986  1987  1988  1989  1990  1991  1992  1993  1994  1995
 1-1.127 -0.461 -0.707 0.481 0.470 -0.344 0.281 0.647 0.362 0.507 -0.110
 2 0.027 -0.553 0.323 -0.528 0.297 -0.206 0.067 0.314 0.904 -0.045 -0.601
 3-0.269 0.212 -0.397 0.415 -0.390 0.329 -0.238 -0.171 0.702 0.213 -0.407
 4-0.366 -0.226 -0.600 -0.091 0.542 0.652 0.023 -0.531 0.007 0.374 0.216
```

```
 5-0.495 0.063 -0.292 0.405 0.828 -0.163 0.232 0.279 -0.743 0.270 -0.384
 6 0.293 -0.710 -0.746 -0.027 0.186 -0.278 0.856 0.714 0.127 -0.424 0.008
 7 0.056 0.096 -0.282 -0.212 -0.207 -0.601 -0.649 -0.015 -0.314 0.719 -0.201
 8-0.102 -0.074 -0.423 -1.162 0.918 0.654 0.235 0.559 -0.435 0.544 1.811

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 -8.1508 -8.1708 -8.9547 -9.7115 -10.4000 -10.5928 -10.5928 -10.5928
S.E_Logq  0.5047 0.5047 0.5047 0.5047  0.5047  0.5047  0.5047  0.5047

Fleet: BTS-Combined
Log catchability residuals.
  year
age  1996 1997 1998 1999 2000 2001  2002 2003 2004 2005 2006 2007
 1 -0.02 0.44 0.42 0.24 -0.04 0.22 0.13 -0.15 -0.33 -0.19 -0.55 0.09
 2 0.44 -0.79 0.31 0.17 -0.28 -0.24 -0.19 0.05 0.04 -0.46 0.01 -0.07
 3 -0.01 -0.54 0.11 0.36 -0.17 -0.29 -0.58 0.02 0.09 -0.10 -0.30 0.09
 4 -0.46 -0.41 -0.15 -0.13 -0.33 -0.27 -0.13 -0.25 0.39 -0.27 0.34 0.09
 5 -0.23 -0.29 -0.14 -0.13 -0.03 -0.41 0.01 0.36 -0.53 -0.31 -0.37 0.13
 6 -0.27 -0.07 -0.05 0.38 -0.04 -0.43 -0.50 0.32 0.41 0.09 -0.32 -0.15
 7 -0.64 -0.82 0.18 -0.25 0.41 -0.54 -0.10 -0.11 0.15 0.38 -0.23 -0.06
 8 -0.37 0.29 0.44 0.54 0.28 -0.23 0.05 0.36 0.04 -0.47 0.21 -0.04
 9 -0.21 0.21 0.01 0.02 -0.27 0.08 -0.04 0.29 -0.02 0.27 0.12 -0.38
   year
age 2008  2009 2010 2011 2012 2013 2014  2015
 1 -0.14 0.38 -0.05 0.07 -0.18 0.02 -0.28 -0.08
 2 0.21 0.15 0.02 0.27 0.13 -0.01 0.00 0.24
 3 0.15 0.16 0.10 0.24 0.21 -0.00 0.30 0.16
 4 0.45 0.13 0.30 0.17 0.19 0.07 -0.07 0.33
 5 0.16 0.38 0.27 0.51 0.18 0.28 0.11 0.04
 6 0.51 -0.17 0.01 0.30 0.06 0.07 -0.15 -0.01
 7 0.21 0.04 0.28 0.07 -0.24 -0.08 -0.09 -0.38
 8 0.40 0.19 0.23 0.18 -0.25 -0.56 -0.43 -0.31
 9 0.62 0.01 0.09 -0.65 0.01 -0.19 0.09 -0.18


Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

        1   2   3   4   5   6   7   8   9
Mean_Logq -8.979 -9.172 -9.241 -9.324 -9.369 -9.326 -9.326 -9.326 -9.326
S.E_Logq  0.284 0.284 0.284 0.284 0.284 0.284 0.284 0.284 0.284

Fleet: SNS1
Log catchability residuals.
   year
age 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
 1 0.16 -0.14 0.24 -0.62 -0.34 -0.53 -0.35 -0.06 -0.26 0.74 0.69 0.30
 2 0.12 -0.20 -0.04 0.31 -0.59 -0.00 -0.03 0.23 -0.36 0.23 0.60 0.34
 3 -0.12 -1.67 -0.15 -0.20 -0.37 -0.53 0.98 0.62 0.30 -0.16 0.46 -0.24
  year
age  1994  1995  1996  1997 1998 1999
 1 0.286 -0.394 -0.597 0.308 0.319 0.230
 2 0.030 -0.461 -0.022 -0.833 0.356 0.335
 3 -0.293 -0.765 0.474- 1.034 1.391 1.314

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 -3.3312 -4.0788 -5.2354
S.E_Logq  0.5496 0.5496 0.5496


Fleet: SNS2
 Log catchability residuals.
   year
age 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
 1 0.60 0.46 0.37  NA 0.15 0.05 0.14 -0.01 0.14 0.13 -0.35 -0.26 -0.99
 2 0.42 0.59 0.07  NA 0.37 -0.24 0.15 0.34 0.15 -0.04 -0.19 -0.99 -0.36
 3 0.95 0.33 -0.16  NA 0.60 -0.32 -0.27 -0.72 0.23 -0.18 -0.05 -0.64 -0.19
  year
age 2013 2014 2015
 1 -0.32 -0.28 0.17
 2 0.04 -0.55 0.25
```

```
 3 0.35 -0.43 0.53
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 -4.2612 -5.7091 -6.6948
S.E_Logq  0.4200 0.4200 0.4200

Terminal year survivor and F summaries:

 Age 1 Year class =2014
source    scaledWts survivors yrcls
BTS-Combined   0.637  876187 2014
SNS2       0.348  1124545 2014
fshk       0.016  702304 2014

 Age 2 Year class =2013
source    scaledWts survivors yrcls
BTS-Combined   0.657  1367991 2013
SNS2       0.325  1379092 2013
fshk       0.019  1223062 2013

 Age 3 Year class =2012
source    scaledWts survivors yrcls
BTS-Combined   0.717  971970 2012
SNS2       0.264  1399519 2012
fshk       0.019  657784 2012

 Age 4 Year class =2011
source    scaledWts survivors yrcls
BTS-Combined   0.973  586494 2011
fshk       0.027  373713 2011

 Age 5 Year class =2010
source    scaledWts survivors yrcls
BTS-Combined   0.975  538707 2010
fshk       0.025  308947 2010

 Age 6 Year class =2009
source    scaledWts survivors yrcls
BTS-Combined   0.975  268765 2009
fshk       0.025  191093 2009

 Age 7 Year class =2008
source    scaledWts survivors yrcls
BTS-Combined   0.968  103395 2008
fshk       0.032  127524 2008

 Age 8 Year class =2007
source    scaledWts survivors yrcls
BTS-Combined   0.969   74789 2007
fshk       0.031  126027 2007

 Age 9 Year class =2006
source    scaledWts survivors yrcls
BTS-Combined   0.977   79219 2006
fshk       0.023   29288 2006
```

Table 8.3.2 Plaice in 4 and 3.a. Harvest (F)

	Age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.077	0.228	0.271	0.325	0.370	0.224	0.293	0.336	0.311	0.311
1958	0.105	0.250	0.308	0.373	0.389	0.336	0.280	0.303	0.337	0.337
1959	0.152	0.31	0.356	0.379	0.416	0.389	0.355	0.314	0.372	0.372
1960	0.108	0.317	0.353	0.385	0.366	0.419	0.383	0.359	0.384	0.384
1961	0.096	0.288	0.345	0.362	0.423	0.334	0.365	0.443	0.386	0.386
1962	0.095	0.316	0.366	0.385	0.417	0.409	0.347	0.336	0.380	0.380
1963	0.148	0.361	0.415	0.435	0.425	0.476	0.452	0.454	0.450	0.450
1964	0.031	0.394	0.443	0.464	0.536	0.484	0.400	0.387	0.455	0.455
1965	0.068	0.264	0.391	0.407	0.350	0.501	0.411	0.347	0.404	0.404
1966	0.071	0.352	0.382	0.426	0.475	0.341	0.503	0.406	0.432	0.432
1967	0.054	0.347	0.400	0.403	0.472	0.501	0.307	0.432	0.425	0.425
1968	0.195	0.283	0.342	0.359	0.366	0.323	0.410	0.289	0.350	0.350
1969	0.146	0.312	0.336	0.348	0.327	0.445	0.304	0.414	0.369	0.369
1970	0.218	0.424	0.473	0.482	0.441	0.481	0.567	0.247	0.445	0.445
1971	0.191	0.325	0.383	0.387	0.407	0.394	0.427	0.411	0.406	0.406
1972	0.227	0.373	0.394	0.409	0.416	0.44	0.404	0.474	0.43	0.43
1973	0.113	0.391	0.438	0.548	0.553	0.419	0.393	0.487	0.482	0.482
1974	0.220	0.396	0.494	0.517	0.598	0.455	0.397	0.467	0.489	0.489
1975	0.355	0.503	0.535	0.577	0.624	0.642	0.498	0.524	0.575	0.575
1976	0.334	0.410	0.432	0.441	0.393	0.444	0.53	0.463	0.456	0.456
1977	0.323	0.473	0.497	0.503	0.670	0.423	0.444	0.537	0.517	0.517
1978	0.302	0.422	0.452	0.456	0.445	0.501	0.445	0.411	0.453	0.453
1979	0.418	0.627	0.655	0.666	0.672	0.696	0.693	0.596	0.667	0.667
1980	0.233	0.459	0.662	0.621	0.511	0.515	0.491	0.501	0.530	0.530
1981	0.170	0.476	0.572	0.604	0.585	0.456	0.506	0.536	0.539	0.539
1982	0.231	0.489	0.678	0.659	0.597	0.519	0.485	0.531	0.560	0.560
1983	0.225	0.487	0.514	0.709	0.568	0.510	0.450	0.476	0.545	0.545
1984	0.290	0.513	0.537	0.588	0.649	0.563	0.489	0.556	0.571	0.571
1985	0.257	0.447	0.443	0.656	0.488	0.518	0.513	0.485	0.534	0.534
1986	0.281	0.590	0.585	0.596	0.730	0.718	0.560	0.632	0.729	0.729
1987	0.213	0.632	0.647	0.694	0.821	0.726	0.819	0.501	0.664	0.664
1988	0.223	0.603	0.646	0.678	0.800	0.775	0.711	1.028	0.752	0.752
1989	0.199	0.549	0.584	0.608	0.660	0.664	0.643	0.644	1.356	1.356
1990	0.154	0.438	0.537	0.563	0.689	0.638	0.567	0.515	0.642	0.642
1991	0.226	0.563	0.587	0.631	0.617	0.693	0.703	0.698	0.715	0.715
1992	0.204	0.510	0.578	0.592	0.806	0.587	0.549	0.752	1.145	1.145
1993	0.205	0.453	0.533	0.586	0.694	0.733	0.414	0.364	1.008	1.008
1994	0.149	0.437	0.565	0.622	0.615	0.643	0.882	0.296	0.261	0.261
1995	0.118	0.408	0.553	0.710	0.746	0.653	0.752	0.650	0.154	0.154
1996	0.092	0.525	0.591	0.638	0.700	0.665	0.715	0.682	0.769	0.769
1997	0.064	0.749	0.858	0.626	0.811	0.816	0.725	0.633	0.823	0.823
1998	0.145	0.476	0.896	0.954	0.587	0.504	0.550	0.438	0.485	0.485

	Age									
year	1	2	3	4	5	6	7	8	9	10
1999	0.165	0.444	0.491	0.955	0.671	0.777	0.383	0.467	0.412	0.412
2000	0.114	0.343	0.303	0.556	0.634	0.550	0.354	0.182	0.273	0.273
2001	0.066	0.673	0.900	0.825	0.776	0.544	0.359	0.193	0.117	0.117
2002	0.194	0.541	0.473	0.609	0.704	0.453	0.607	0.256	0.167	0.167
2003	0.133	0.565	0.575	0.450	0.737	0.688	0.424	0.284	0.103	0.103
2004	0.197	0.594	0.453	0.508	0.243	0.552	0.320	0.124	0.099	0.099
2005	0.135	0.448	0.430	0.349	0.451	0.222	0.456	0.251	0.073	0.073
2006	0.271	0.526	0.433	0.420	0.242	0.239	0.109	0.298	0.163	0.163
2007	0.075	0.447	0.440	0.238	0.340	0.178	0.125	0.076	0.097	0.097
2008	0.143	0.349	0.279	0.314	0.165	0.176	0.135	0.087	0.018	0.018
2009	0.153	0.297	0.254	0.229	0.243	0.115	0.100	0.073	0.032	0.032
2010	0.134	0.280	0.227	0.257	0.165	0.177	0.085	0.073	0.029	0.029
2011	0.068	0.170	0.214	0.295	0.256	0.135	0.107	0.080	0.050	0.050
2012	0.079	0.235	0.256	0.264	0.234	0.183	0.073	0.065	0.035	0.035
2013	0.083	0.180	0.191	0.196	0.180	0.178	0.109	0.043	0.055	0.055
2014	0.171	0.159	0.229	0.179	0.184	0.121	0.100	0.071	0.031	0.031
2015	0.080	0.230	0.182	0.213	0.127	0.115	0.080	0.082	0.04	0.040

Table 8.3.3 Plaice in 4 and 3.a. Stock numbers (thousands)

	AGE									
year	1	2	3	4	5	6	7	8	9	10
1957	460518	260189	335426	191663	123254	51719	50633	36912	21748	47346
1958	700350	385916	187499	231548	125322	77050	37388	34164	23863	51185
1959	864891	570733	272015	124694	144305	76859	49836	25558	22821	55784
1960	760716	672161	378792	172422	77206	86127	47154	31612	16898	50156
1961	866067	617992	442786	240742	106211	48429	51269	29084	19973	48657
1962	593498	711758	419439	283718	151719	62981	31371	32208	16899	41003
1963	694671	488254	469573	263211	174662	90494	37844	20055	20836	48855
1964	2254825	542085	308041	280620	154097	103320	50871	21785	11522	48678
1965	701920	1977435	330605	178901	159702	81552	57635	30870	13392	55694
1966	594050	593547	1374584	202403	107760	101849	44696	34587	19750	45407
1967	407196	500900	377880	848488	119574	60657	65528	24461	20850	34495
1968	438895	349233	320398	229259	513144	67457	33243	43601	14369	48764
1969	658811	326766	238053	205988	144870	321955	44204	19957	29562	57869
1970	664222	515077	216461	153983	131672	94527	186702	29519	11931	42135
1971	420331	483400	304989	122040	86061	76619	52872	95822	20860	54789
1972	374300	314358	316083	188234	74988	51860	46745	31221	57490	48221
1973	1320356	269909	195949	192919	113137	44774	30229	28231	17585	69002
1974	1136000	1067543	165123	114422	100895	58912	26640	18472	15702	61709
1975	864714	824861	649780	91149	61716	50201	33806	16209	10480	50010
1976	691691	548413	451477	344430	46311	29915	23896	18591	8681	36821
1977	990829	448206	329361	265187	200493	28299	17369	12726	10588	23851
1978	920713	649359	252636	181325	145140	92799	16773	10083	6730	20692
1979	905430	616240	385404	145485	103978	84190	50856	9729	6049	19898
1980	1148883	539147	297895	181084	67660	48049	37964	23009	4851	13982
1981	901574	823274	308386	139032	88018	36735	25968	21017	12619	15283
1982	2111275	687932	462799	157493	68787	44350	21059	14169	11126	21400
1983	1368338	1515904	381875	212521	73755	34268	23889	11726	7541	20691
1984	1299663	988318	842738	206610	94598	37823	18611	13779	6593	15745
1985	1880989	880358	535656	445656	103845	44708	19494	10332	7148	14743
1986	4797263	1316261	509296	311173	209338	57683	24107	10560	5753	14286
1987	1979144	3276305	660311	256795	155113	91312	25449	12454	5081	12078
1988	1830953	1446915	1576342	312691	116109	61731	39972	10148	6828	12646
1989	1250820	1325118	716313	747916	143566	47195	25731	17765	3286	8129
1990	1084035	927707	692339	361401	368543	67131	21984	12244	8440	9281
1991	959797	841178	541628	366321	186293	167504	32089	11281	6618	11527
1992	811532	692911	433298	272479	176437	90942	75783	14377	5080	10650
1993	565366	599095	376429	219950	136380	71334	45739	39612	6133	9656
1994	480910	416644	344572	199927	110724	61658	31007	27361	24903	24879
1995	1197928	374746	243579	177120	97165	54149	29324	11620	18421	28716
1996	1339279	963465	225472	126796	78804	41713	25508	12506	5486	9713
1997	2212118	1104956	515628	112925	60614	35409	19408	11286	5721	8185
1998	813659	1878375	472787	197823	54665	24386	14175	8508	5420	9144

	AGE									
year	1	2	3	4	5	6	7	8	9	10
1999	882903	636602	1055790	174700	68947	27499	13329	7401	4968	10022
2000	1035754	677250	369519	584475	60803	31893	11436	8220	4199	9318
2001	577074	836291	435045	246925	303446	29177	16656	7265	6199	22518
2002	1857519	488990	386159	160044	97923	126368	15324	10521	5419	11151
2003	579018	1384282	257662	217666	78750	43823	72693	7553	7373	9401
2004	1375294	458760	712121	131183	125565	34113	19934	43056	5146	6360
2005	803930	1021614	229084	409430	71420	89130	17779	13097	34417	9658
2006	979159	635267	590473	134811	261313	41158	64566	10197	9220	9832
2007	1143879	675430	339709	346628	80123	185625	29338	52405	6852	14779
2008	1071558	959761	390694	198006	247160	51596	140503	23421	43941	55932
2009	1110840	840310	612415	267556	130943	189566	39169	111040	19420	27170
2010	1419551	862227	564777	429637	192616	92901	152833	32077	93358	46909
2011	1892434	1123228	589703	407373	300783	147766	70403	127027	26980	58621
2012	1274853	1599807	857721	430806	274371	210777	116830	57248	106134	58598
2013	1703575	1065903	1143954	600668	299390	196508	158773	98310	48558	74607
2014	1966051	1418962	805264	855078	446622	226197	148777	128855	85178	118469
2015	1140208	1499750	1095662	579455	646926	336195	181327	121842	108551	129321

Table 8.3.4 Plaice in 4 and 3.a. Stock summary table.

YEAR	RECRUITS	SSB	CATCH	LANDINGS	DISCARDS	FBAR2-6	FBAR HC2-6	FBAR DIS2-3	Y/SSB
1957	460518	274522	78443	70563	7880	0.28	0.23	0.12	0.26
1958	700350	285276	88191	73354	14837	0.33	0.25	0.19	0.26
1959	864891	290983	109164	79300	29864	0.37	0.24	0.24	0.27
1960	760716	300102	117334	87541	29793	0.37	0.27	0.23	0.29
1961	866067	313758	118474	85984	32490	0.35	0.24	0.27	0.27
1962	593498	373171	125375	87472	37903	0.38	0.24	0.29	0.23
1963	694671	359434	148376	107118	41258	0.42	0.27	0.35	0.30
1964	2254825	353366	147571	110540	37031	0.46	0.30	0.32	0.31
1965	701920	330960	140223	97143	43080	0.38	0.28	0.24	0.29
1966	594050	360172	166552	101834	64718	0.40	0.24	0.33	0.28
1967	407196	416311	163365	108819	54546	0.42	0.25	0.31	0.26
1968	438895	404080	139521	111534	27987	0.33	0.21	0.21	0.28
1969	658811	372570	142820	121651	21169	0.35	0.26	0.17	0.33
1970	664222	330537	159982	130342	29640	0.46	0.34	0.28	0.39
1971	420331	315802	136939	113944	22995	0.38	0.29	0.21	0.36
1972	374300	319302	142475	122843	19632	0.41	0.32	0.18	0.38
1973	1320356	269028	143783	130429	13354	0.47	0.41	0.13	0.48
1974	1136000	276144	157485	112540	44945	0.49	0.41	0.20	0.41
1975	864714	288327	195235	108536	86699	0.58	0.39	0.43	0.38
1976	691691	302097	166917	113670	53247	0.42	0.30	0.27	0.38
1977	990829	308977	176689	119188	57501	0.51	0.34	0.31	0.39
1978	920713	296206	159639	113984	45655	0.46	0.35	0.22	0.38
1979	905430	294824	213282	145347	67935	0.66	0.48	0.35	0.49
1980	1148883	274888	171844	140764	31080	0.55	0.49	0.15	0.51
1981	901574	264149	174264	141233	33031	0.54	0.47	0.16	0.53
1982	2111275	265691	205280	156153	49127	0.59	0.50	0.20	0.59
1983	1368338	325094	220262	145779	74483	0.56	0.45	0.25	0.45
1984	1299663	346523	236588	165772	70816	0.57	0.43	0.26	0.48
1985	1880989	377342	232387	171838	60549	0.51	0.42	0.21	0.46
1986	4797263	408832	308831	178878	129953	0.64	0.49	0.33	0.44
1987	1979144	481620	359283	168759	190524	0.70	0.50	0.49	0.35
1988	1830953	411146	324975	168552	156423	0.70	0.44	0.50	0.41
1989	1250820	429704	286684	178891	107793	0.61	0.39	0.44	0.42
1990	1084035	393180	240678	169453	71225	0.57	0.40	0.36	0.43
1991	959797	365941	238212	157277	80935	0.62	0.41	0.43	0.43
1992	811532	308734	193776	136727	57049	0.61	0.42	0.36	0.44
1993	565366	273504	163522	128506	35016	0.60	0.48	0.25	0.47
1994	480910	251627	145710	121925	23785	0.58	0.48	0.22	0.48
1995	1197928	236939	131176	109348	21828	0.61	0.54	0.19	0.46
1996	1339279	209525	143435	91386	52049	0.62	0.49	0.32	0.44
1997	2212118	234011	193103	92958	100145	0.77	0.51	0.64	0.40
1998	813659	254039	183561	79810	103751	0.68	0.37	0.55	0.31
1999	882903	230508	160702	89726	70976	0.67	0.42	0.36	0.39

YEAR	RECRUITS	SSB	CATCH	LANDINGS	DISCARDS	FBAR2-6	FBAR HC2-6	FBAR DIS2-3	Y/SSB
1957	460518	274522	78443	70563	7880	0.28	0.23	0.12	0.26
2000	1035754	256904	135065	90754	44311	0.48	0.34	0.24	0.35
2001	577074	303421	193221	92912	100309	0.74	0.34	0.65	0.31
2002	1857519	226008	134277	79178	55099	0.56	0.37	0.38	0.35
2003	579018	261400	153997	74722	79275	0.60	0.39	0.41	0.29
2004	1375294	242136	127989	70511	57478	0.47	0.28	0.40	0.29
2005	803930	284394	119046	62796	56250	0.38	0.20	0.34	0.22
2006	979159	295586	131303	67143	64160	0.37	0.20	0.37	0.23
2007	1143879	300157	100949	58576	42373	0.33	0.17	0.34	0.20
2008	1071558	391203	105329	58336	46993	0.26	0.16	0.22	0.15
2009	1110840	431357	108262	62360	45902	0.23	0.13	0.21	0.14
2010	1419551	523991	116910	70340	46570	0.22	0.13	0.19	0.13
2011	1892434	507330	118100	76507	41593	0.21	0.12	0.14	0.15
2012	1274853	555199	141932	82018	59914	0.23	0.13	0.20	0.15
2013	1703575	619281	126247	86222	40025	0.19	0.11	0.15	0.14
2014	1966051	774978	133623	80686	52937	0.17	0.08	0.16	0.10
2015	1140208	754812	134460	85360	49100	0.17	0.08	0.18	0.11

Table 8.4.1. Plaice in 4 and 3.a. Input table for RCT3 analysis.

YEARCLASS	AGE 1 XSA	AGE 2 XSA	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1974	864714	548413	NA	NA	2402.6	NA	NA	NA
1975	691691	448206	NA	NA	3423.8	NA	NA	NA
1976	990829	649359	NA	NA	12678	NA	NA	NA
1977	920713	616240	NA	NA	9828.8	NA	NA	NA
1978	905430	539147	NA	NA	12882.3	NA	NA	NA
1979	1148883	823274	NA	NA	18785.3	NA	NA	NA
1980	901574	687932	NA	NA	8642.0	NA	NA	NA
1981	2111275	1515904	NA	NA	13908.6	NA	NA	NA
1982	1368338	988318	NA	NA	10412.8	NA	NA	NA
1983	1299663	880358	NA	NA	13847.8	NA	NA	NA
1984	1880989	1316261	NA	NA	7580.4	NA	NA	NA
1985	4797263	3276305	NA	NA	32991.1	NA	NA	NA
1986	1979144	1446915	NA	NA	14421.1	NA	NA	NA
1987	1830953	1325118	NA	NA	17810.2	NA	NA	NA
1988	1250820	927707	NA	NA	7496.0	NA	NA	NA
1989	1084035	841178	NA	NA	11247.2	NA	NA	NA
1990	959797	692911	NA	NA	13841.8	NA	NA	439.6
1991	811532	599095	NA	NA	9685.6	NA	NA	332.4
1992	565366	416644	NA	NA	4976.6	NA	NA	180.3
1993	480910	374746	NA	NA	2796.4	NA	NA	217.0
1994	1197928	963465	NA	NA	10268.2	NA	99.6	283.4
1995	1339279	1104956	NA	NA	4472.7	143.9	28.7	146.1
1996	2212118	1878375	NA	NA	30242.2	386.8	177.6	619.6
1997	813659	636602	NA	NA	10272.1	131.2	53.6	229.2
1998	882903	677250	NA	NA	2493.4	117.0	38.9	NA
1999	1035755	836291	NA	22855	2898.5	108.4	39.8	NA
2000	577074	488990	24213.5	11510.5	1102.7	80.3	26.7	124.9
2001	1857519	1384282	99628.0	30809.2	NA	217.3	94.4	313.2
2002	579018	458760	31202.0	NA	1349.7	53.6	30.3	122.9
2003	1375294	1021614	NA	18201.6	1818.9	101.4	45.6	238.6
2004	803930	635267	13537.2	10118.4	1571.0	70.8	42.9	126.7
2005	979159	675430	27390.6	12164.2	2133.9	54.9	44.4	85.9
2006	1143879	959761	51124.2	14174.5	2700.4	139.4	89.7	168.0
2007	1071558	840310	40580.9	14705.8	2018.7	98.9	76.5	98.3
2008	1110840	862227	50179.3	14860	1811.5	170.8	69.5	129.7
2009	1419551	1123228	53258.8	11946.9	1142.5	144.8	126.0	141.9
2010	1892434	1599807	49347.2	18348.6	2928.6	226.5	149.6	179.6
2011	1274853	1065903	52643.0	5893.4	3021.3	118.4	90.5	93.0
2012	NA	NA	45027.1	15394.9	2258.3	192.8	123.2	181.1
2013	NA	NA	44327.5	17312.7	5040.4	155.2	156.6	168.5
2014	NA	NA	11722.3	16726.5	NA	116.5	NA	108.0
2015	NA	NA	30494.5	NA	NA	NA	NA	100.2

Table 8.4.2. Plaice in 4 and 3.a. RCT3 results for age 1 in 2016 (yearclass 2015).

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 42 years : 1974 - 2015
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:2015
index  slope intercept  se rsquare n indices pred se.pred WAP.weights
SNS0   1.006  3.230 0.368 0.5665 11  10.33 13.62  0.430    0.5039
DFS0   2.775  -0.631 1.446 0.0835 20  4.61 12.15  1.614    0.0358
VPA Mean  NA    NA  NA   NA 38   NA 13.95  0.450    0.4603

         WAP logWAP int.se
yearclass:2015 907736 13.72 0.3052
```

Table 8.4.3. Plaice in IV and 3.a. RCT3 results for age 2 in 2015 (yearclass 2013).

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 42 years : 1974 - 2015
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as  .00
Minimum of  3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014
index  slope intercept se rsquare n indices pred se.pred WAP.weights
SNS0   1.012  2.939 0.371 0.5645 11  9.37 12.42  0.524   0.1488
SNS1   2.085  -6.227 0.851 0.1421 12  9.73 14.05  0.976   0.0428
BTS1   0.893  9.404 0.238 0.7418 17  4.76 13.65  0.261   0.6006
DFS0   3.128  -2.716 1.641 0.0715 20  4.68 11.93  1.818   0.0124
VPA Mean  NA    NA  NA   NA 38   NA 13.65  0.457   0.1955

         WAP logWAP int.se
yearclass:2014 704951 13.47 0.202
```

Table 8.5.1. Plaice in 4 and 3.a. Input to the short term forecast (F values presented are for Fsq)

2016 SSB	2016 F2-6	2016 F_DIS2-3	2016 F_HC2-6	2016 RECRUITS	2016 LANDINGS	2016 DISCARDS	2016 CATCH	2016 TAC
945709	0.173	0.16	0.089	907736	109277	42090	151362	138432

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2016	0.109	0.11	0	907736	0.03	0.08	0.03	0.04	0	0.1
2	2016	0.185	0.18	0.01	952339	0.09	0.25	0.08	0.09	0.5	0.1
3	2016	0.196	0.14	0.05	1078478	0.17	0.28	0.13	0.14	0.5	0.1
4	2016	0.192	0.07	0.13	826358	0.26	0.32	0.15	0.21	1	0.1
5	2016	0.16	0.03	0.13	423556	0.33	0.36	0.17	0.3	1	0.1
6	2016	0.135	0.01	0.13	515392	0.4	0.41	0.2	0.35	1	0.1
7	2016	0.094	0	0.09	271217	0.47	0.48	0.23	0.42	1	0.1
8	2016	0.064	0	0.06	151406	0.54	0.54	0.31	0.47	1	0.1
9	2016	0.041	0	0.04	101580	0.61	0.61	0.22	0.53	1	0.1
10	2016	0.041	0	0.04	206784	0.64	0.64	0	0.51	1	0.1
1	2017	0.109	0.11	0	980962	0.03	0.08	0.03	0.04	0	0.1
2	2017	0.185	0.18	0.01	NA	0.09	0.25	0.08	0.09	0.5	0.1
3	2017	0.196	0.14	0.05	NA	0.17	0.28	0.13	0.14	0.5	0.1
4	2017	0.192	0.07	0.13	NA	0.26	0.32	0.15	0.21	1	0.1
5	2017	0.16	0.03	0.13	NA	0.33	0.36	0.17	0.3	1	0.1
6	2017	0.135	0.01	0.13	NA	0.4	0.41	0.2	0.35	1	0.1
7	2017	0.094	0	0.09	NA	0.47	0.48	0.23	0.42	1	0.1
8	2017	0.064	0	0.06	NA	0.54	0.54	0.31	0.47	1	0.1
9	2017	0.041	0	0.04	NA	0.61	0.61	0.22	0.53	1	0.1
10	2017	0.041	0	0.04	NA	0.64	0.64	0	0.51	1	0.1
1	2018	0.109	0.11	0	980962	0.03	0.08	0.03	0.04	0	0.1
2	2018	0.185	0.18	0.01	NA	0.09	0.25	0.08	0.09	0.5	0.1
3	2018	0.196	0.14	0.05	NA	0.17	0.28	0.13	0.14	0.5	0.1
4	2018	0.192	0.07	0.13	NA	0.26	0.32	0.15	0.21	1	0.1
5	2018	0.16	0.03	0.13	NA	0.33	0.36	0.17	0.3	1	0.1
6	2018	0.135	0.01	0.13	NA	0.4	0.41	0.2	0.35	1	0.1
7	2018	0.094	0	0.09	NA	0.47	0.48	0.23	0.42	1	0.1
8	2018	0.064	0	0.06	NA	0.54	0.54	0.31	0.47	1	0.1
9	2018	0.041	0	0.04	NA	0.61	0.61	0.22	0.53	1	0.1
10	2018	0.041	0	0.04	NA	0.64	0.64	0	0.51	1	0.1

Table 8.5.2. Plaice in 4 and 3.a. Results from the short term forecast assuming $F_{2016} = F_{2015}$ (rescaled)

BASIS	LANDINGS 2017*	F2-6	F_HC2-6	F_DIS2-3	DISCARDS 2017*	CATCH 2017	SSB 2017	SSB 2018	SSB_CHANGE**	TAC_CHANGE***
Fmp	184384	0.3	0.15	0.28	55227	239611	1033466	983389	-5	28
Ftar	184384	0.3	0.15	0.28	55227	239611	1033466	983389	-5	28
Fmsy	121523	0.19	0.1	0.18	36678	158201	1033466	1065323	3	-15
Fmsy_low	84850	0.13	0.07	0.12	25656	110506	1033466	1113470	8	-41
Fmsy_high	167778	0.27	0.14	0.25	50370	218148	1033466	1004958	-3	17
Fpa	261819	0.45	0.23	0.41	77428	339247	1033466	883590	-15	82
Flim	343667	0.63	0.32	0.58	100022	443689	1033466	779638	-25	139
SSB>Bpa	815440	2.754	1.41	2.54	203288	1018728	1033466	230000	-78	465
SSB>Blim	886406	3.57	1.83	3.29	212409	1098815	1033466	160000	-85	514
SSB>MSYBtrig	815440	2.754	1.41	2.54	203288	1018728	1033466	230000	-78	465
TACsq	143480	0.227	0.12	0.21	43207	186687	1033466	1036616	0	0
15%_TAC_inc	165142	0.265	0.14	0.24	49596	214738	1033466	1008386	-2	15
15%_TAC_dec	121818	0.19	0.1	0.18	36766	158584	1033466	1064937	3	-15
Fsq*0	0	0	NA	NA	0	0	1033466	1227002	19	-100
Fsq*0.25	28442	0.043	0.02	0.04	8437	36879	1033466	1187986	15	-80
Fsq*0.5	57463	0.087	0.04	0.08	17336	74799	1033466	1149580	11	-60
Fsq*0.9	100957	0.156	0.08	0.14	30514	131471	1033466	1092293	6	-29
Fsq*1	111309	0.173	0.09	0.16	33623	144932	1033466	1078707	4	-22
Fsq*1.1	122119	0.191	0.1	0.18	36856	158975	1033466	1064542	3	-15
Fsq*1.25	137462	0.217	0.11	0.2	41423	178885	1033466	1044474	1	-4

Wanted catch of plaice in Subarea 4 and Subdivision 3.a.20, calculated as the projected total stock wanted catch less the wanted catch of plaice from Subarea 4 taken in Division 7.d. The subtracted value (934 t) is estimated based on the plaice catch advice for Division 7.d for 2016, using the recent 10-year average (2006–2015) proportion of plaice from Subarea 4 in the annual plaice landings in Division 7.d. Similarly, 652 t of unwanted catch of plaice from Subarea 4 are projected to be taken in Division 7.d. These are removed from the unwanted catch. TAC change restrictions of 15% are applied after subtracting the Division 7.d catches.

****SSB 2018 relative to SSB 2017**

*****landings2017/(131714+11766), where 131714 and 11766 are the TAC for 2016 Subarea 4 and Division 7.d.**

Table 8.5.3. Plaice in 4 and 3.a. Detailed STF table by age, assuming F = Fsq, rescaled.

AGE	F	F DISC	F LAN	STOCK .N	CATCH .WT	LAN .WT	DISC .WT	ST .WT	CATCH .N	CATCH	LAN .N	LAND	DISC .N	DISC	SSB	TSB
2016																
1	0.11	0.11	0	907736	0.03	0.08	0.03	0.04	88934	3021	127	10	88806	3019	0	34797
2	0.19	0.18	0.01	952339	0.09	0.25	0.08	0.09	153345	13537	5277	1311	148067	12240	43808	87615
3	0.20	0.14	0.05	1078478	0.17	0.28	0.13	0.14	182933	31225	51221	14513	131713	16727	77471	154941
4	0.19	0.07	0.13	826358	0.26	0.32	0.15	0.21	137307	35916	90379	28680	46929	7227	169954	169954
5	0.16	0.03	0.13	423556	0.33	0.36	0.17	0.30	59670	19649	48953	17803	10716	1836	128620	128620
6	0.14	0.01	0.13	515392	0.4	0.41	0.20	0.35	61902	24745	57600	23885	4301	847	181590	181590
7	0.09	0	0.09	271217	0.47	0.48	0.23	0.42	23171	11000	22486	10838	686	160	113188	113188
8	0.06	0	0.06	151406	0.54	0.54	0.31	0.47	8939	4831	8836	4801	103	32	71262	71262
9	0.04	0	0.04	101580	0.61	0.61	0.22	0.53	3883	2352	3883	2352	0	0	53668	53668
10	0.04	0	0.04	206784	0.64	0.64	0	0.51	7904	5085	7904	5085	0	0	106149	106149
2017																
1	0.11	0.11	0	980962	0.03	0.08	0.03	0.04	96108	3265	138	11	95970	3263	0	37604
2	0.19	0.18	0.01	736869	0.09	0.25	0.08	0.09	118650	10474	4083	1014	114567	9471	33896	67792
3	0.20	0.14	0.05	716131	0.17	0.28	0.13	0.14	121471	20734	34012	9637	87460	11107	51442	102884
4	0.19	0.07	0.13	802191	0.26	0.32	0.15	0.21	133292	34865	87735	27841	45556	7016	164984	164984
5	0.16	0.03	0.13	617372	0.33	0.36	0.17	0.3	86974	28641	71354	25949	15620	2676	187475	187475
6	0.14	0.01	0.13	326589	0.40	0.41	0.20	0.35	39225	15680	36500	15135	2726	537	115068	115068
7	0.09	0	0.09	407554	0.47	0.48	0.23	0.42	34819	16529	33789	16286	1030	241	170086	170086
8	0.06	0	0.06	223392	0.54	0.54	0.31	0.47	13189	7129	13037	7083	152	47	105143	105143
9	0.04	0	0.04	128503	0.61	0.61	0.22	0.53	4912	2975	4912	2975	0	0	67893	67893
10	0.04	0	0.04	267815	0.64	0.64	0	0.51	10237	6586	10237	6586	0	0	137479	137479
2018																
1	0.11	0.11	0	980962	0.03	0.08	0.03	0.04	96108	3265	138	11	95970	3263	0	37604
2	0.19	0.18	0.01	796312	0.09	0.25	0.08	0.09	128222	11319	4413	1096	123809	10235	36630	73261
3	0.20	0.14	0.05	554104	0.17	0.28	0.13	0.14	93988	16043	26316	7456	67672	8594	39803	79606
4	0.19	0.07	0.13	532671	0.26	0.32	0.15	0.21	88508	23151	58258	18487	30250	4659	109553	109553
5	0.16	0.03	0.13	599317	0.33	0.36	0.17	0.30	84430	27803	69267	25190	15163	2598	181992	181992
6	0.14	0.01	0.13	476033	0.40	0.41	0.20	0.35	57174	22856	53202	22061	3973	783	167722	167722
7	0.09	0	0.09	258255	0.47	0.48	0.23	0.42	22064	10474	21411	10320	653	153	107778	107778
8	0.06	0	0.06	335689	0.54	0.54	0.31	0.47	19819	10712	19590	10644	229	71	157997	157997
9	0.04	0	0.04	189600	0.61	0.61	0.22	0.53	7248	4390	7248	4390	0	0	100172	100172
10	0.04	0	0.04	344204	0.64	0.64	0	0.51	13157	8465	13157	8465	0	0	176691	176691

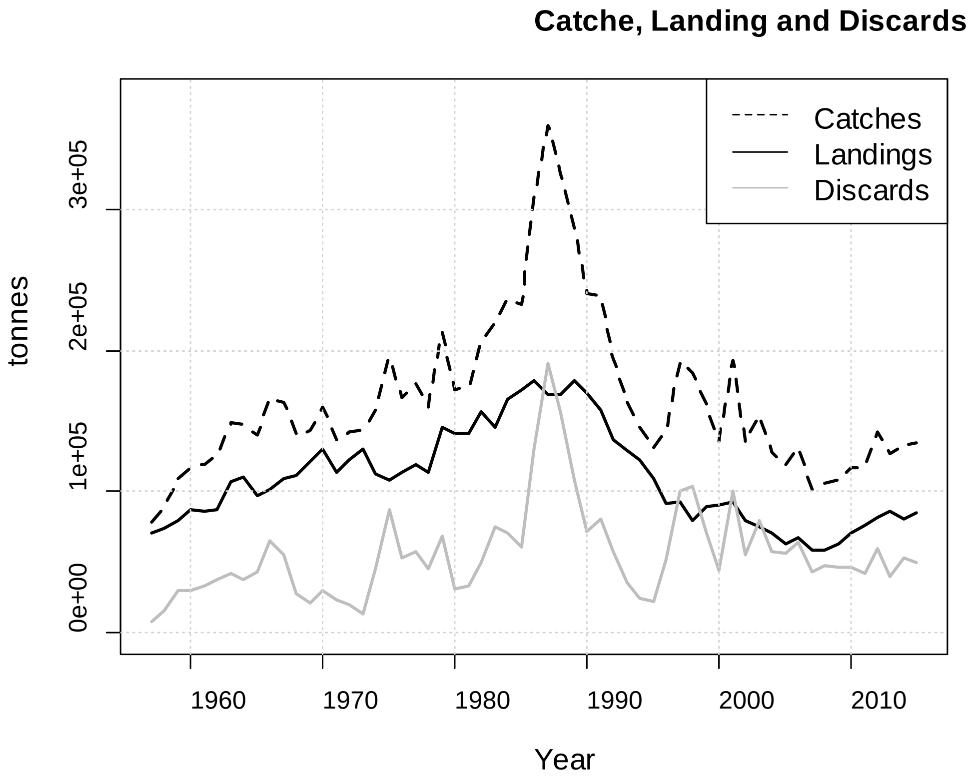


Figure 8.2.1 North Sea plaice (including Skagerrak and 7.d Q1). Time series of catch (dashed line), landings (solid line) and discards (gray line) estimates.

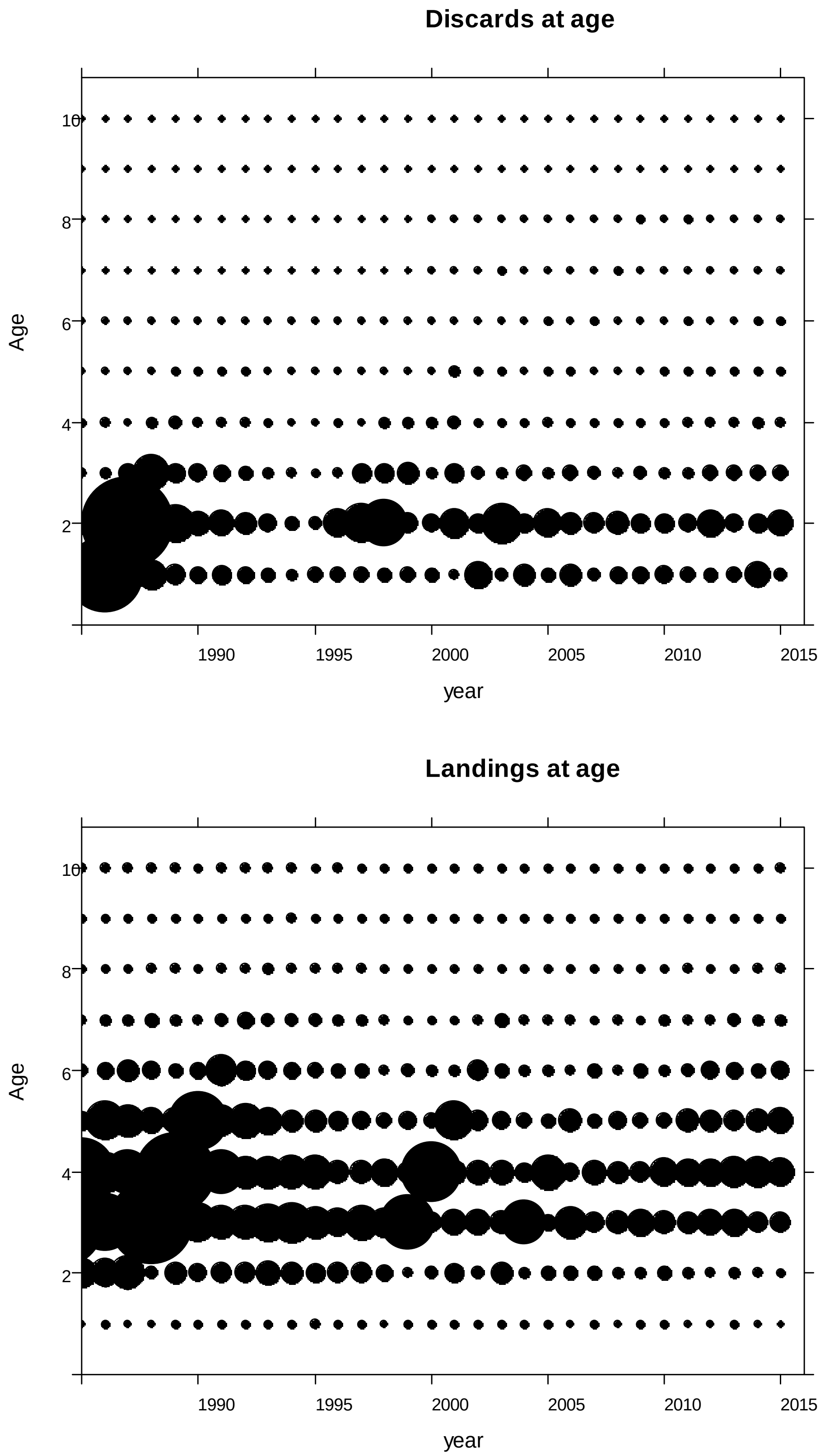


Figure 8.2.2 North Sea and Skagerrak plaice (including 7.dQ1). Discards numbers-at-age (top) and landing numbers-at-age (down).

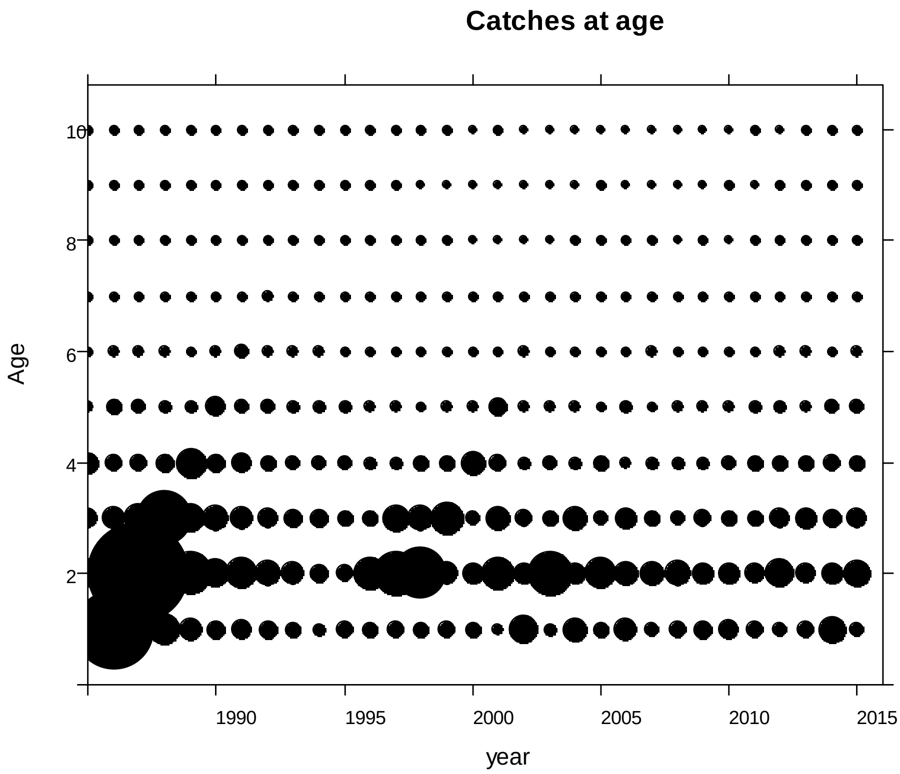


Figure 8.2.3 North Sea and Skagerrak plaice (including 7.dQ1). Catch numbers-at-age.

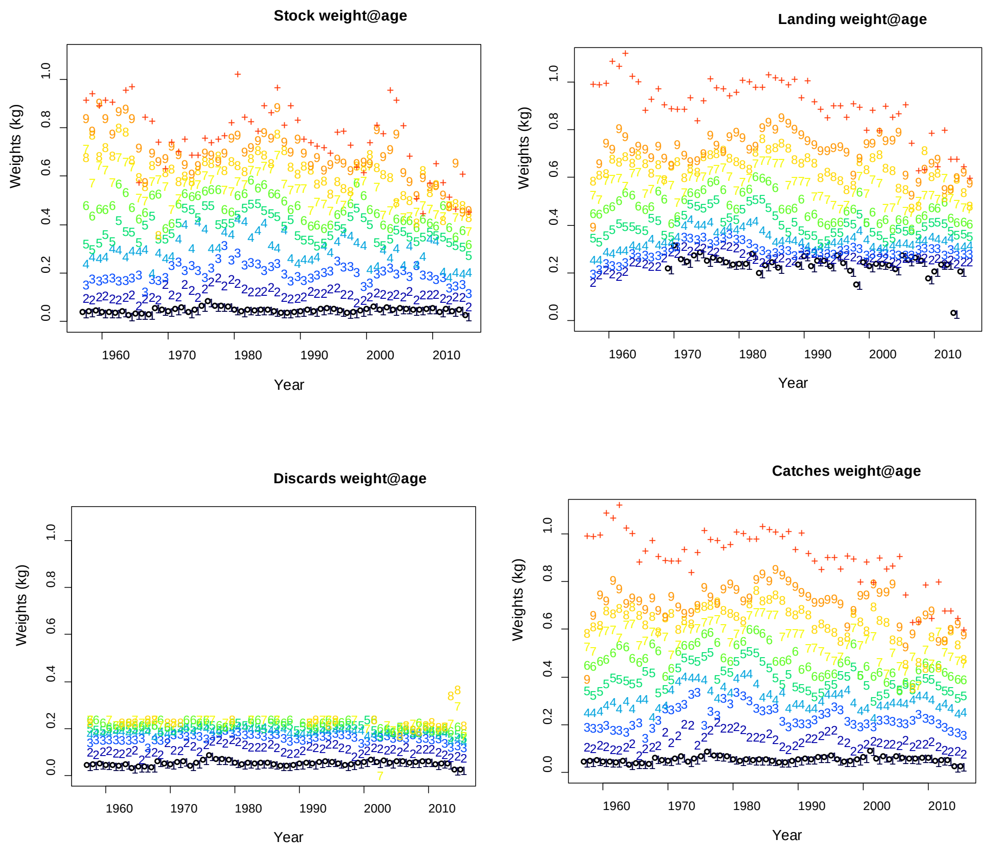


Figure 8.2.4 North Sea and Skagerrak plaice. Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

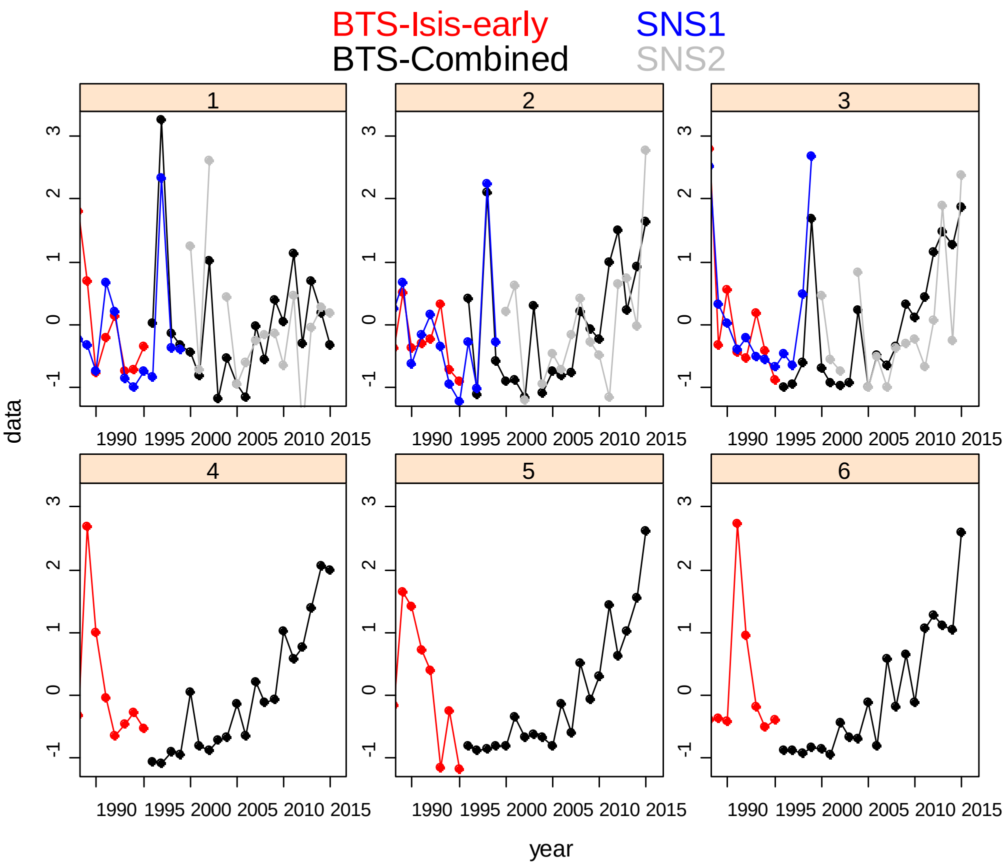


Figure 8.2.5 North Sea and Skagerrak plaice. Standardized survey tuning indices used for tuning XSA: BTS-combined (red), BTS-Isis-old (black) SNS-1 (1984-1999, blue) and SNS-2 (2000-2015, grey). Note: only ages used in the assessment are presented. The BTS-combined index combines BTS-Tridens and BTS-Isis indices.

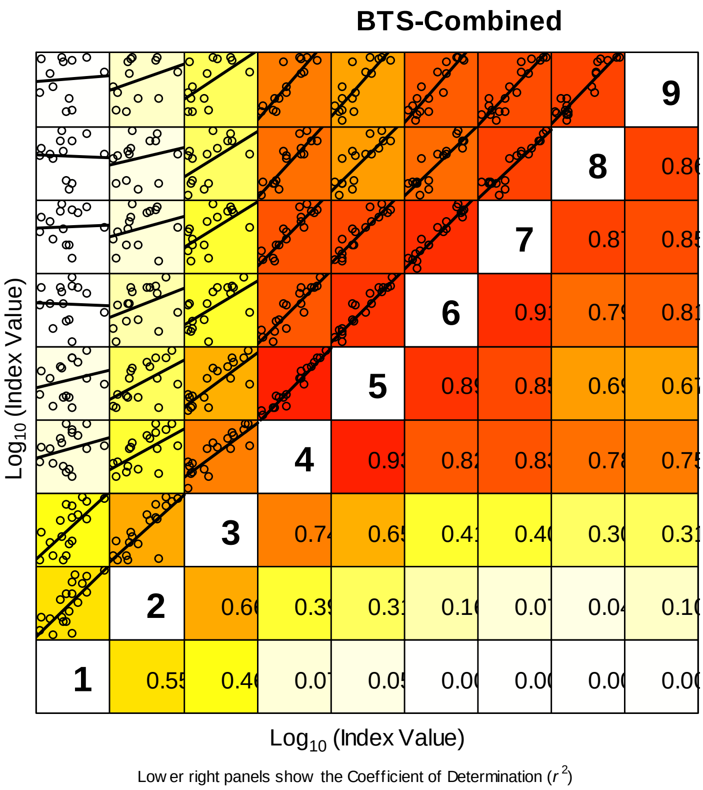


Figure 8.2.6 Plaice in 4 and 3.a. Internal consistency plot for the BTS-combined survey index.

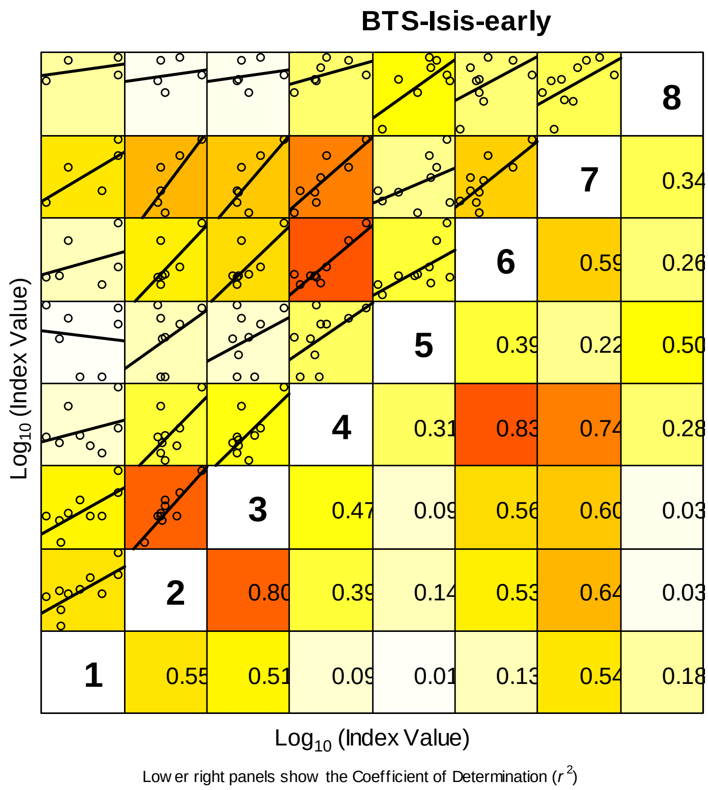
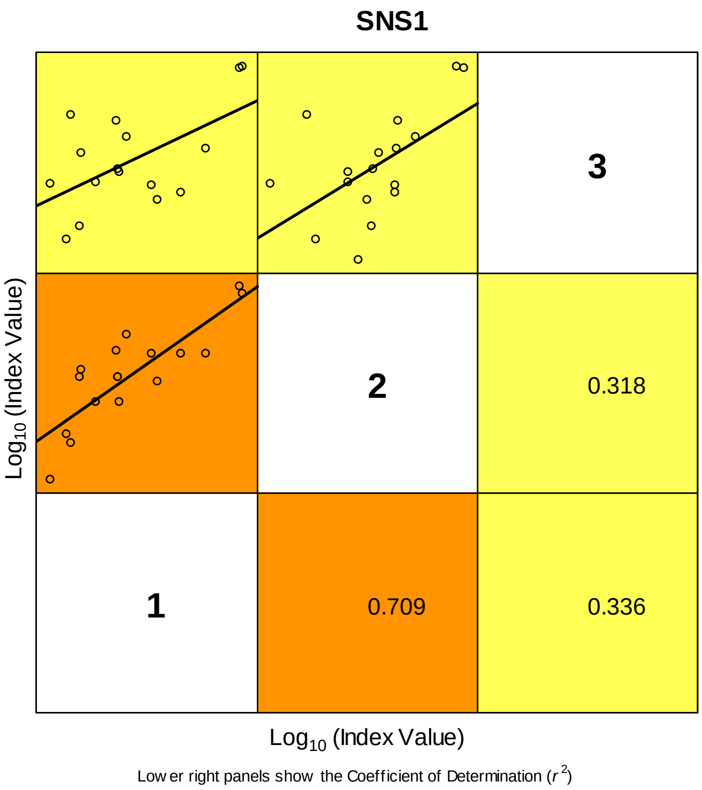


Figure 8.2.7. Plaice in 4 and 3.a. Internal consistency plot for the BTS-Isis-early survey index.



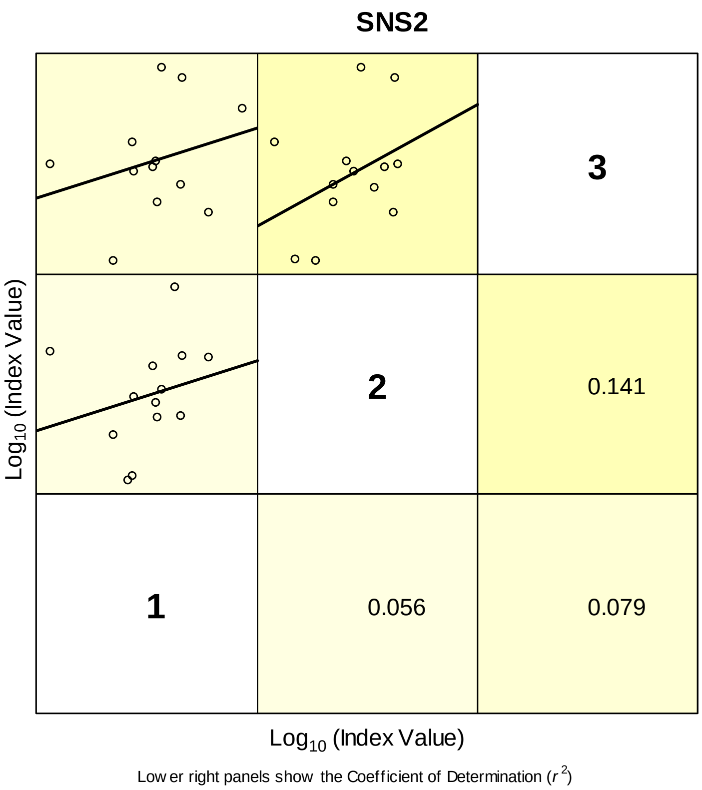
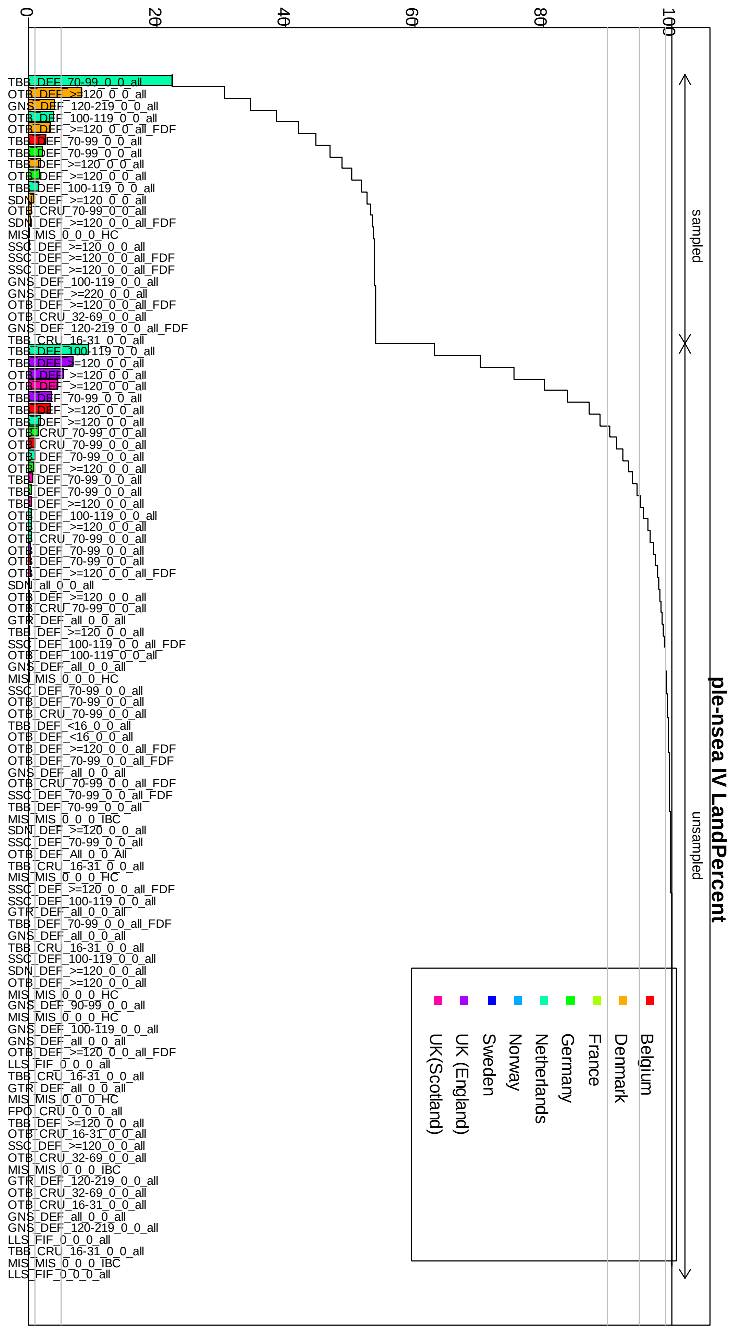
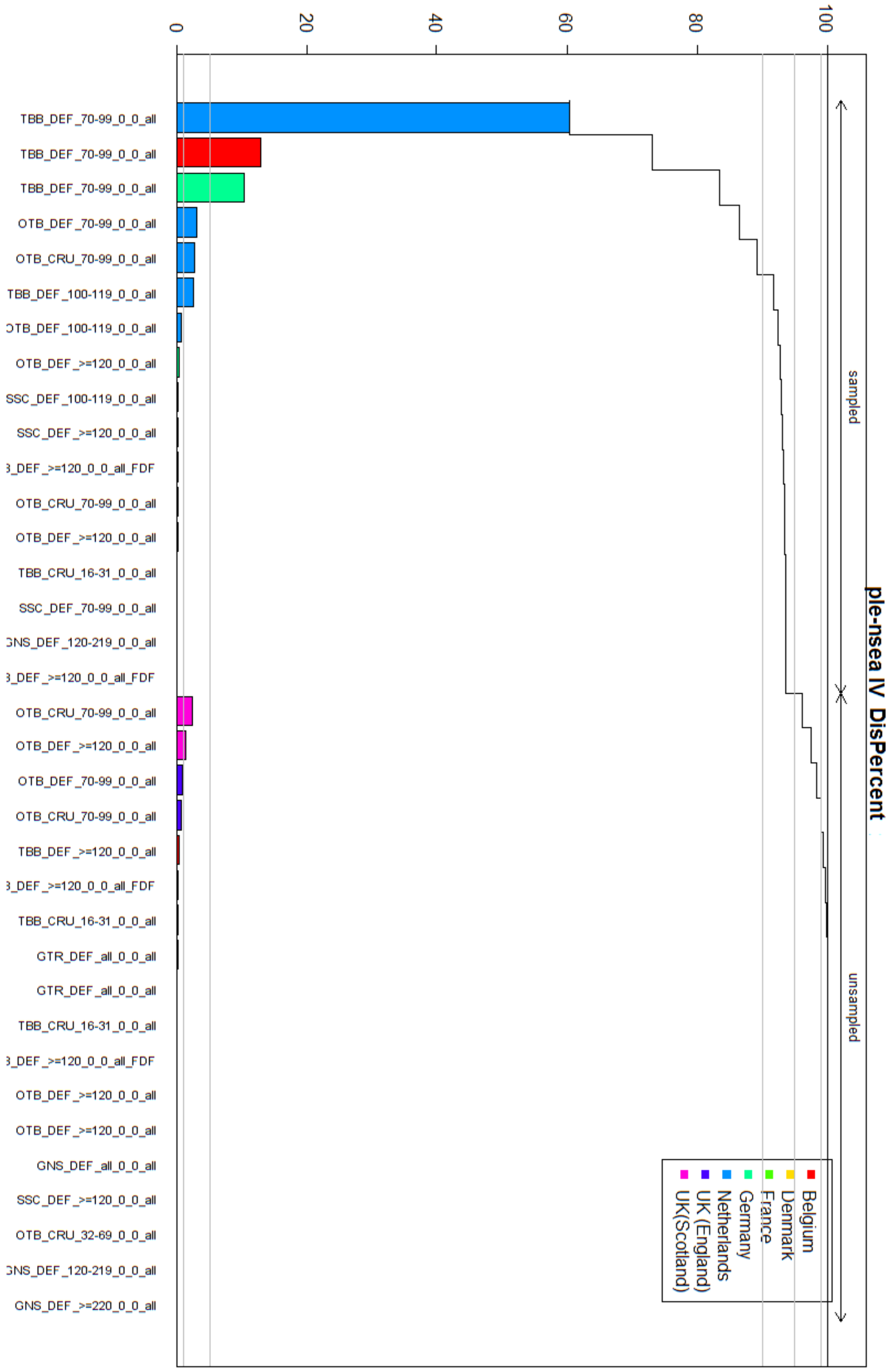


Figure 8.2.8. Plaice in 4 and 3.a. Internal consistency plot for the SNS-1 (1984–1999, left) and the SNS-2 (2000–2015, right) survey indices.


ple-nsea.IV LandPercent
sampled
unsampled
0
20
40
60
80
100
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(a)



(b)

Figure 8.2.9. Data upload in Intercatch: percentage of landings (a) and discards (b) (%) by country by métier. Sampled and unsampled refers to availability of age-composition information. This data is for North Sea plaice only (excluding Skagerrak).

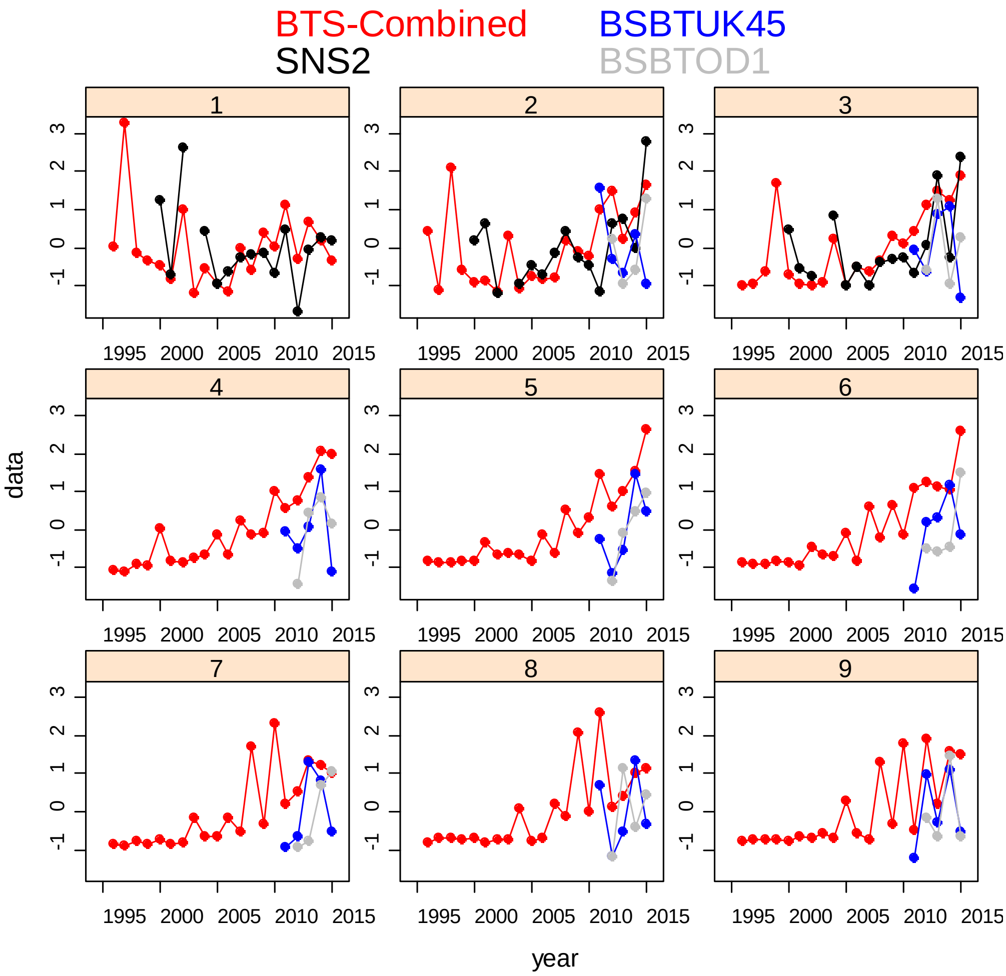


Figure 8.3.1 North Sea and Skagerrak plaice. Standardized survey tuning indices for the surveys used in the recent part of the assessment and the two vessels participating in the industry survey.

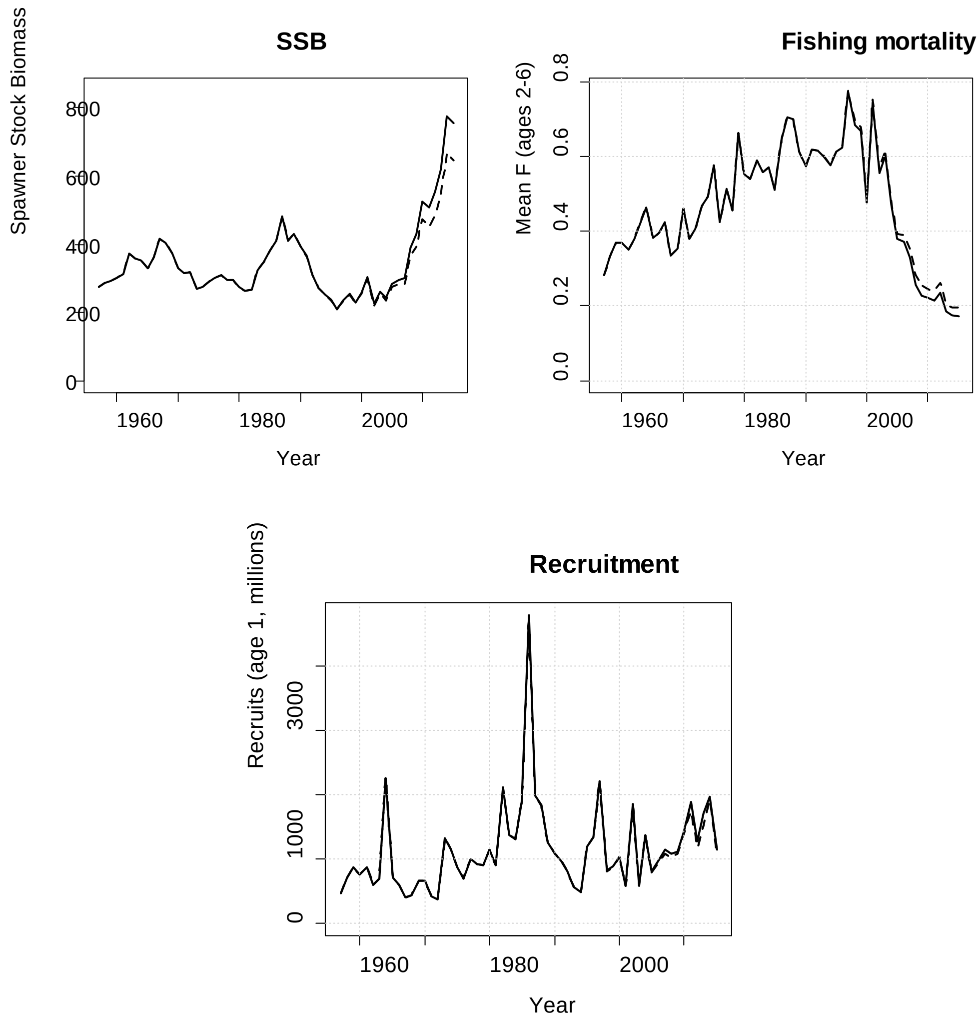


Figure 8.3.2 North Sea and Skagerrak plaice. SSB(top left), fishing mortality(top right), and recruitment (bottom left) estimates of the assessment with the inclusion of the industry survey (dashed line), compared with the assessment with the indices as used in WGNSSK2015 (drawn line.

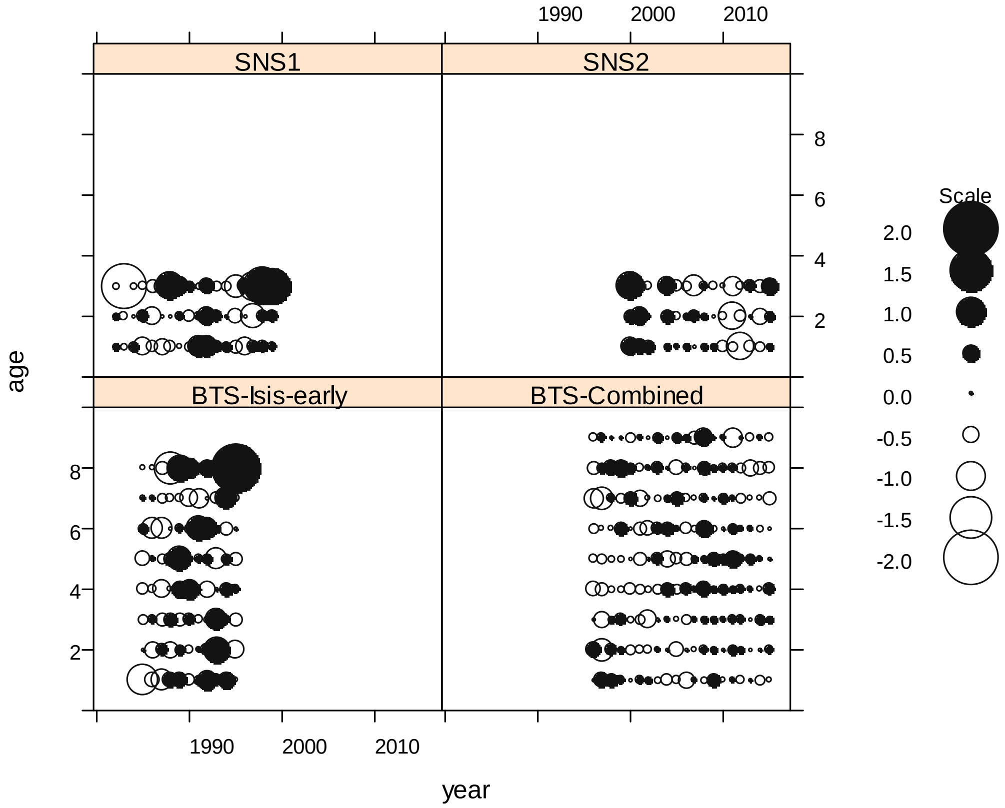


Figure 8.3.3. Plaice in 4 and 3.a. Log catchability residuals for the final XSA run from the three tuning series.

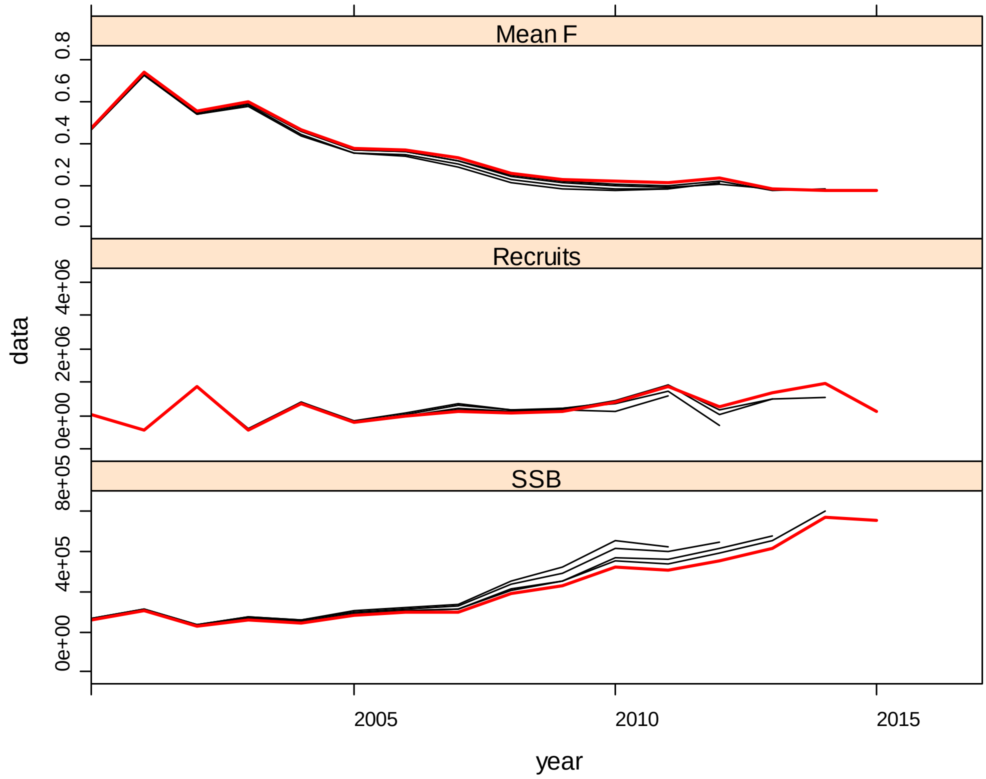


Figure 8.3.4. North Sea and Skagerrak plaice. Retrospective pattern of the final XSA run with respect to SSB, recruitment and F.

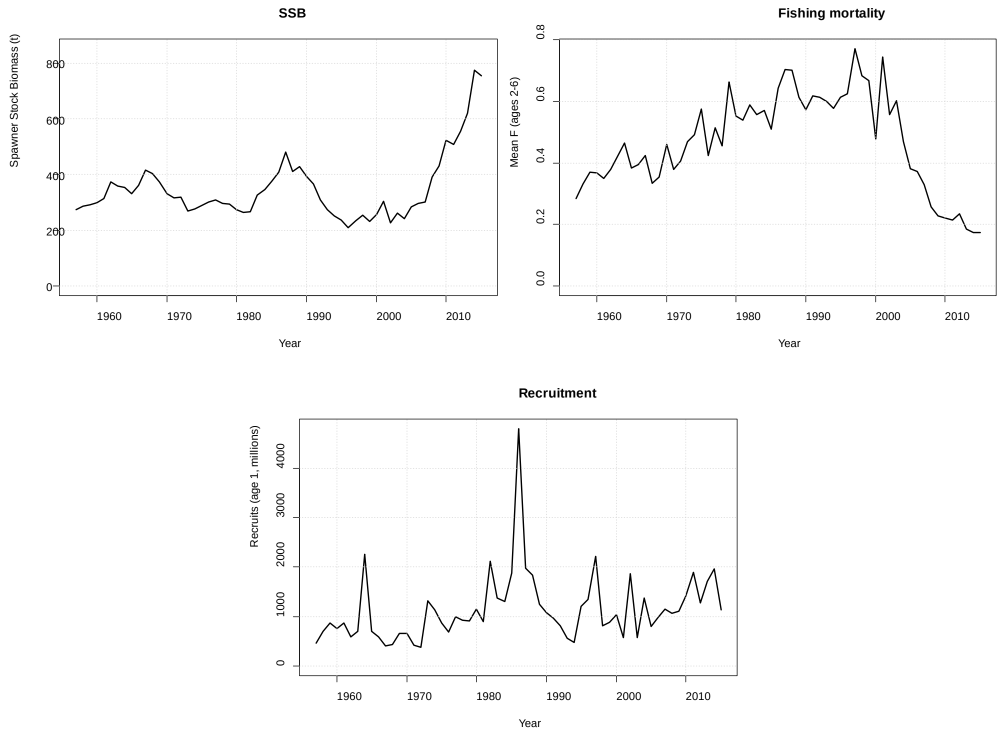


Figure 8.4.1. North Sea and Skagerrak plaice. Stock summary figure, time series on SSB (top left), fishing mortality for ages 2–6 (top right), and recruitment (bottom left).

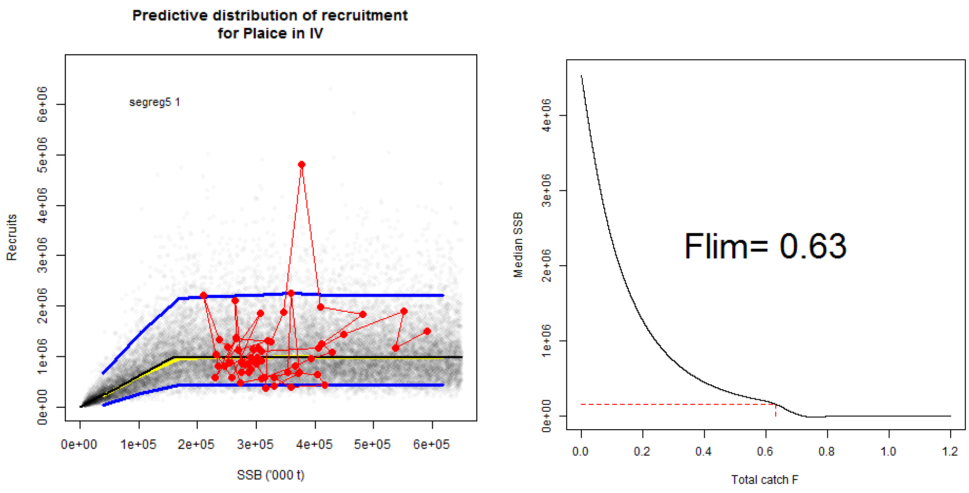


Figure 8.6.1. North Sea and Skagerrak plaice. Stock summary figure, time series on SSB (top left), fishing mortality for ages 2–6 (top right), and recruitment (bottom left).

9 Sole (*Solea solea*) in Division 7.d (Eastern English Channel)

The assessment of sole in sub-area 7.d 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 Biology and ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2016.

All available information on ecological aspects can be found in the Stock Annex.

9.1.2 Stock identity and possible assessment areas

Reflections on the stock identity of Eastern Channel sole can be consulted in the Stock Annex.

More recently, Cuveliers *et al*. (2012) showed genetic differences (using neutral microsatellite markers and a mitochondrial marker) at a large scale, along a latitudinal gradient from the Skagerrak/Kattegat to the Bay of Biscay. At a smaller spatial scale within the North Sea Ecoregion however, subpopulations seemed genetically homogeneous, probably due to a high level of gene flow and/or the high effective population size preventing strong effects of genetic drift. With respect to the temporal aspect, a remarkable high genetic stability was found from the 1950s up to present (Cuveliers *et al*. 2011). The large scale genetic differentiation supports the approach in which sole is treated as several different assessment and management units within the North Sea Ecoregion, whereas the homogeneity suggests it may be one population.

9.1.3 Management regulations

Management of sole in 7.d is by TAC and technical measures. The minimum landing size for sole is 24 cm. Mesh size restrictions in place 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.

TACs have been defined for sole in 7.d. A historical overview since 2000 is presented in the table below.

Historical overview of the TACs for sole *Solea solea* in Division 7.d, 2000–2015

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	4100	4600	5200	5400	5900	5700	5720	6220	6590
Year	2009	2010	2011	2012	2013	2014	2015	2016	
TAC	5274	4219	4852	5580	5900	4838	3483	3258*	

*** Catch TAC (see below)**

Except for 2010, the TAC was not restrictive for France, Belgium or the UK since 1997. In 2014 it became restrictive for Belgium, and in 2015 this was the case for Belgium and France (see 9.2.1 Landings).

In the second half of 2015, the North Western Waters Advisory Council (in this case mainly driven by France and Belgium) approached the Commission with a management strategy in which it was found to be appropriate (STECF evaluation) to set a TAC of 3000 tonnes for 2016 (the ICES advice was for landings of 2376 tonnes in 2016), corresponding to a 14% decrease as compared to 2015. The Commission and the Member States concerned agreed that the following additional rules should be considered in future years unless scientific advice indicates that they are no longer appropriate: i) keep the TAC constant at 3000 tonnes in 2016–2020, ii) if the biomass in any year before 2020 is below the precautionary level (Bpa), then the TAC will be set at a level corresponding to a fishing mortality equal to F_{MSY} and iii) if ICES indicates in 2019 that the fishing mortality in 2020 risks being above F_{MSY}, then the TAC will be set at a level corresponding to a fishing mortality in line with F_{MSY}. If the fishing mortality is below F_{MSY} for any 2 consecutive years before 2020 then the Commission will request the STECF to provide advice on the situation of this stock.

As 7.d sole is under the landing obligation in 2016, the landings TAC of 3000 tonnes was topped up to a catch TAC of 3258 tonnes based on a discard ratio of 8,6%. It is however unclear to the stock coordinator and the WGNSSK 2016 how this discard ratio was derived, as it differs from the values estimated by the WG in 2015. So far, this management strategy is not anchored in EU legislation, and was not brought to the attention of ICES. Therefore, it cannot be used as the basis for the ICES advice. The corresponding catch options are not included in the advice sheet.

In response to the drop in SSB and the poor recruitment in 2012–2014, the two main countries participating in the fishery have also implemented additional conservation measures. For Belgian beam trawlers in 7.d (and 7fg, 7a) it is mandatory since 1 April 2015 to incorporate a 3 m long section with 120 mm mesh size before the codend, in order to reduce the catches of small sole. France engaged in 2016 to i) strengthen the protection of the nursery areas, ii) increase the area closed to fishing within the nursery areas, and iii) increase the minimum conservation reference size to 25 cm for French vessels in accordance with EU legislation, where appropriate.

9.1.4 ICES advice

In 2014 the stock status was presented as follows:

	Fishing pressure			
	2011	2012	2013	
MSY (F_{MSY})	✗	✗	✗	Above target
Precautionary approach (F_{pa},F_{lim})	O	O	O	Increased risk
	Stock size			
	2012	2013	2014	
MSY ($B_{trigger}$)	✓	✓	✓	Above trigger
Precautionary approach (B_{pa},B_{lim})	✓	✓	✓	Full reproductive capacity

The ICES advice for 2015 was:

ICES advises on the basis of the MSY approach but cannot quantify the resulting catches. The implied landings should be no more than 1 931 t.

In 2015 the stock status was presented as follows:

		Fishing pressure					Stock size			
		2012	2013	2014			2013	2014	2015	
Maximum Sustainable Yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✓	At trigger
Precautionary approach	F_{pa}, F_{lim}	O	O	✗	Harvested unsustainably	B_{pa}, B_{lim}	✓	✓	✓	Full reproductive capacity
Management Plan	F_{MGT}	-	-	-	Not applicable	SSB_{MGT}	-	-	-	Not applicable

The ICES advice for 2016 was:

ICES advises that when the MSY approach is applied, catches in 2016 should be no more than 2685 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from 2014, this implies landings of no more than 2376 tonnes.

9.2 Data

A detailed description of the fishery can be found in the Stock Annex.

There were no revisions to the landings data provided last year.

9.2.1 Landings

Table 9.1 and Figure 9.1 summarise the official sole landings by country for Division 7.d, as consulted in ICES Fishstat, and the total ICES estimated landings (for 2012–2015, these are the landings uploaded to InterCatch by the countries involved in the fishery). The landings have steadily increased over the '70s – '90s, fluctuated around an average of 4815 t (range: 3832 t – 6247 t) in 2000–2014, and dropped to 3372 tonnes in 2015. Over the last ca 30 years, the contribution to the landings of the three main countries involved in this fishery has remained rather stable over time (around 30% Belgium, 20% UK, and 50% France) (Figure 9.2).

Since 1997, full uptake of the 7.d sole TAC has not been realized, and also the national quota have not been restrictive. In 2014 however, the national Belgian quotum was overshot by 15%. In 2015 both Belgium and France overshot their national quota (Belgium by 12%, France by 3%). The total uptake was 99% in this year (for comparison: 73% in 2012, 74% in 2013, 95% in 2014). The 2015 uptake percentages (both national and total) are presented in Table 9.2 and Figure 9.3.

The increase in Belgian effort (mainly due to Belgian beam trawlers trying to 'escape' the sharp increase in Dutch pulse trawler effort in the southern North Sea) also becomes apparent when comparing the landings by gear type between 2013 and 2014, that show an increase from 26% to 35% for TBB, the gear mainly used by Belgian fishermen. In 2015, the relative importance of the different métiers landing sole from 7.d remained almost identical to 2014 (Table 9.3).

The 2016 ICES Data Call detailed that biological data accompanying the landings should be uploaded to InterCatch for the year 2015. In this way, biological data (age and length distributions) were available for 87% of the landings. Figures 9.4 and 9.5 illustrate the distribution of these data by métier/country and country respectively.

9.2.2 Discards

Until the 2014 meeting of the WGNSSK, it was decided not to include discards in the assessment of 7.d sole due to the scarcity of the data. Furthermore, with an estimated overall discard rate of around 10% (2011–2013), discards were considered not to be a substantial part of the catch for this high valued species (ICES 2014a).

In 2015, quarterly discard data from the different countries contributing to the sole fisheries in 7.d were requested through InterCatch for the years 2012–2014, and gaps were filled by allocating discard percentages from similar métiers/quarters to the unsampled strata. Only discard data obtained through InterCatch have been used in the WGNSSK 2015, making 2015 the first year in which InterCatch was effectively used for the collection and raising of 7.d sole discards (details on older available discard information for this stock can be consulted in ICES 2014a). In the assessment year 2016, discard data for 2015 were added in the same way. 42% of the discards were observed discards, 58% was raised (Table 9.4 – this table indicates 43% observed discards (3% with sampled distribution, 40% with estimated distribution) but this is a rounding effect).

Discard rates (based on weight data) that were evaluated as reliable for the three countries (Belgium, France and UK) in 2012–2015 are summarized in Table 9.5. From this table it becomes clear that the different métiers contributing to this fishery were not well covered for the years 2012 and 2013 (mainly for France and UK), so only the 2014 discard rate (all main métiers sampled by all countries) was used for topping up the landings advice to catch advice in 2015. Because of sufficient coverage in 2014 and 2015, the average discard rate 2014–2015 was used for the same purpose during WGNSSK 2016 (overall discard rate of 9,25%).

9.2.3 Catch at age / Weigth at age

Catch proportions at age and standardized catch proportions at age are depicted in Figures 9.6 and 9.7 respectively.

Weight at age in the catch is presented in Table 9.6 and Figure 9.8 and weight at age in the stock in Table 9.7 and Figure 9.9. The procedure for calculating mean weights is described in the Stock Annex.

9.2.4 Maturity and natural mortality

As in previous assessments, a knife-edged maturity-ogive was used at age 3.

Natural mortality is assumed to be a fixed value (0.1) for all ages across all years.

9.2.5 Tuning series

Two commercial (both beam trawl: Belgian CBT and UK(E&W)-CBT) and three survey (UK(E&W)-BTS-Q3, UK(E&W)-YFS, FR-YFS) data series are used for the calibration of the assessment of 7.d sole. The full series are presented in Tables 9.8–12.

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 (ICES 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.

Two revisions of previously submitted data were received in 2016:

UK(E&W)-BTS-Q3

This revision affected the entire time series, and was performed after CEFAS carried out investigations in relation to the survey data quality, selection of prime stations, age-at-length keys and ultimately the indices calculations. More details, including results for revisited index and previous index are shown in Silva (2016) in Annex 08 to facilitate a better comparison and further inform on temporal differences to the year class abundance.

Belgian CBT

This revision affected the years 2012–2014, and was necessary as it was discovered that the tuning data for these years were not based on the exact same set of vessels as was the case previously. This was corrected, and the 2015 data were calculated in the same way.

To gain insight in the impact of these revisions on the assessment results, separate assessment runs were carried out using the same data and settings as in WGNSSK 2015 (so only data up to data year 2014, only differing from the original input data in the tuning series).

Run 1 : revision of UK(E&W)-Q3-BTS – corresponding residual patterns, assessment summary graphs and retrospective patterns are shown in Figures 9.10 – 9.12, and the corresponding assessment summary numbers in Table 9.13 (WGNSSK 2015 = OLD ; WGNSSK 2015 + update = NEW).

Results: impact generally only detectable in recent years, retros similar

recruitment 2014 was revised downwards

F 2014 was revised upwards

SSB 2014 was revised downwards

Run 2 : revision of BEL-CBT – corresponding residual patterns, assessment summary graphs and retrospective patterns are shown in Figures 9.13 – 9.15, and the corresponding assessment summary numbers in Table 9.14 (WGNSSK 2015 = OLD ; WGNSSK 2015 + update = NEW).

Results: impact generally only detectable in recent years, retros similar

recruitment 2014 was revised downwards

F 2014 was revised downwards

SSB 2014 was revised upwards

Run 3 : both revisions – corresponding residual patterns, assessment summary graphs and retrospective patterns are shown in Figures 9.16 – 9.18, and the corresponding assessment summary numbers in Table 9.15 (WGNSSK 2015 = OLD ; WGNSSK 2015 + update = NEW).

Results: impact generally only detectable in recent years, retros similar

recruitment 2014 was revised downwards (25732 -> 20574)

F 2014 was revised downwards (0.55 -> 0.48)

SSB 2014 was revised upwards (9052 t -> 9968 t)

9.3 Analyses of stock trends

9.3.1 Review of last year's assessment

No major deficiencies for the sole assessment in the Eastern English Channel were reported.

9.3.2 Exploratory catch at age analysis

Catch at age analysis was carried out according to the specifications in the Stock Annex. The model used was XSA.

The time series of the standardized indices for ages 1 to 10 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 9.19. All tuning fleets appear to track the year classes reasonably well for ages 2 to 6.

Internal consistency plots for the 2 commercial fleets and the UK beam trawl survey are presented in Figures 9.20–22. The internal consistency of these three fleets is high for the entire age-range.

The catchability residuals for the proposed final XSA (see below) are shown in Figure 9.23. Some concern rises around the UK(E&W)-BTS-Q3, that shows an age effect for Age 1 (that is more effectively estimated by the UK(E&W)-YFS and the FR-YFS) and a year effect in 2014 (note that these are persistent effects, that were not affected by the revision of this tuning series).

In this year's assessment the estimates for the recruiting year class 2014 were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of 44,2% and 44,1% respectively in the final survivor estimates (Table 9.16). Shrinkage takes 11,7% of the weighting. Although it should be noted that the internal standard errors of both surveys are around 1.0, indicating a high variability and therefore an uncertain estimate providing for this year class strength, the Expert group decided to use this estimate in the forecast.

At age 2, the 2013 year-class is predominantly estimated by the UK beam trawl survey and the commercial UK beam trawl fleet, with weightings of 41,5% and 42,4% respectively (Table 9.16). Especially the UK commercial tuning fleet estimates the survivors of that year class to be relatively weak 8277). The Belgian commercial beam trawl fleet estimate this year class to be even weaker (3719) with a weighting of 13,1%.

F shrinkage gets low weights for all ages older than 2. The weighting of the 3 surveys decreases for the older ages as the commercial fleets are given more weight.

Deviation from the stock annex : change of F-range

WGNSSK 2015 decided to change the F_{bar}-range from 3–8 to 3–7 in the final XSA, and as such deviated from the stock annex. The reason was that F increased to a very high value of almost 0,8 in 2014 (steep increase compared to the already high F in the previous years), and this could not be explained by any anomalies in the analyses, but was identified to be due to the yearclass 2006 (8 years old in 2014) that had almost disappeared from the stock.

This approach was followed again in WGNSSK 2016. It was decided that the discussion to go back to the old age range, and around whether the reference points should be re-estimated under this new setup (or whether stronger shrinkage would help out), are questions to be addressed during the benchmark of this stock in 2017.

9.3.3 Final assessment

The final settings used in this year's assessment are specified as in the stock annex and are detailed below:

	2016 ASSESSMENT		
Fleets	Years	Ages	α-β
BE-CBT commercial	86–15	2–10	0–1
UK(E&W)-CBT commercial	86–15	2–10	0–1
UK(E&W)-BTS survey	88–15	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	87–15	1–1	0.5–0.75
-First data year	1982		
-Last data year	2015		
-First age -Last age	1 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 diagnostics of this run (including fishing mortalities and stock numbers by age and year) are presented in Table 9.16. A summary of the XSA results is given in Table 9.17 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 9.26.

Retrospective patterns for the final run are shown in Figure 9.27. There is a small retrospective pattern in F (that was overestimated in 2012–2013), but the consistency between estimates in successive years for fishing mortality and SSB was found to be generally good.

9.3.4 Historical stock trends

Trends in landings, SSB, F(3–8) and recruitment are presented in Table 9.17 and Figure 9.26.

For most of the time series, fishing mortality has been fluctuating between F_{pa} (0.4) and F_{lim} (0.55). 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 9 years fishing mortality has fluctuated again but consistently remained above F_{pa} (with an especially strong increase in 2013–2014).

Recruitment has fluctuated around 24 million recruits with occasional strong year classes. Five of the highest values in the time series have been recorded in the last 12 years. The 2011 and 2012 year classes were predicted to be very weak.

The spawning stock biomass has been stable for most of the time series. Since 2001 SSB has increased to well above B_{pa} (8000 t) due to average and above average year classes. The incoming very weak year classes of 2011 and 2012 have reversed the increasing trend in SSB, that is predicted to drop below MSY $B_{trigger}$ in 2016.

9.4 Recruitment estimates and short-term forecast

9.4.1 Recruitment estimates

The table below summarizes the recruitment estimates for the year classes 2014–2016 from the XSA, an RCT3-analysis and the long-term geometric mean recruitments. The stock annex prescribes that the XSA value should be taken for the initial stock size for age 2 (in 2015) and older, and from RCT3 for age 1, if appropriate. Otherwise the XSA value for age 1 is used. The long-term geometric mean recruitment is used for age 0 in all projection years.

The RCT3 input for Ages 1 and 2 is presented in Tables 9.18 and 9.19 respectively, and the corresponding outputs in Tables 9.20 and 9.21, but the results have not been used for prediction.

After discussion, the WGNSSK decided to follow the stock annex and use the XSA result for yearclass 2014, the fallback option of the XSA result for yearclass 2015 (and not the RCT3), and the GM for yearclass 2016.

Since 2004 initial stock size for age 2 was taken from XSA.

Year class	Age in 2015	XSA survivors	RCT3	GM1982-2012	Accepted estimate
2014	2	23301	25234	21074	XSA
2015	1	NA	22439	23722	XSA
2016	0	NA	NA	23722	GM

9.4.2 Short-term forecast

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 2013–2015.

2016 was the second year in which the short-term forecast was performed using an R-script that uses the output files from the XSA (and the RCT3-analysis, when used) as input files, so no separate input files for the short-term forecast are presented in this report.

As the TAC was nearly fully taken in 2015 (uptake of 99%), the TAC-constraint scenario was used for the forecast. The results for different management options under this scenario are presented in Table 9.22, and the accompanying relative contributions of year-classes to the landings in 2017 and to SSB in 2018 are shown in Figures 9.28 and 9.29.

ICES advice 2016

Assuming a TAC-constraint scenario and an overall discard rate of 9,25%, ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2487 tonnes.

9.5 Medium- and long-term forecasts

This year, no medium- and long-term forecasts have been carried out for this stock.

9.6 Biological reference points

The table below summarizes all known reference points for sole in 7.d, and their technical basis.

Framework	Reference point	Value	Technical basis
MSY approach	MSY BTrigger	8 000 t	Bpa
	FMSY	0.3	Stochastic simulations assuming a smooth hockey-stick relationship. Calculated on ages 3–8.
Precautionary approach	Blim	Not defined.	Poor biological basis for definition.
	Bpa	8 000 t	This is the 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 shown continued decline.
	Fpa	0.4	Between Fmed and 5th percentile of Floss; SSB>Bpa and probability (SSBmt<Bpa), 10%: 0.4.
Management plan	SSBMGT	Undefined	
	FMGT	Undefined	

Note that the MSY reference points have been redefined, and that F_{msy} was changed for this stock from 0.29 to 0.3 (ICES 2014b). $MSYB_{trigger}$ remained unchanged.

9.7 Quality of the assessment

The main quality issue related to the evaluation of the stock status of sole in 7.d is that the UK component of the YFS index is not available since 2007, resulting in the unavailability of the combined YFS-index. This combined index estimated the incoming year class strength very consistently and provided reliable estimates for the forecasts. Although results of using the YFS indices separately (FR-YFS for 1987-present and UK-YFS for 1987–2006), did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. The Working Group suggests that the assessment could benefit if the French Young Fish survey could be extended to include some of the sampling points from the former UK Young Fish survey along the English coast. The extended French survey might then mimic the earlier available combined Young Fish survey which was an excellent estimator of the incoming recruitment.

Other quality-issues have been thoroughly listed in the report of WGNSSK 2014 (ICES 2014).

9.8 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 7.d) were re-allocated to 7e on a quarterly basis, (based on information provided to the Working Group by the fishing industry) and the age compositions raised accordingly.

- There is a less than 5% probability that SSB will decrease to B_{pa} in the short term due to the strong 2008 and 2009 year classes.
- EU Council Regulation (EC) N°43/2014 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. This regime has only slightly reduced effort directed at sole in this area.
- Due to the minimum mesh size (80 mm) in the mixed beam trawl fishery, a large number of (undersized) plaice are discarded. The 80-mm mesh size is matched to the minimum landing size of sole but not matched to the minimum landing size of plaice. Measures to reduce discarding of plaice in the sole fishery would greatly benefit the plaice stock and future yields. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. An increase in the minimum landing size of sole could provide an incentive to fish with larger mesh sizes and therefore mean a reduction in the discarding of plaice.

9.9 References

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Silva, J.F. 2016. Plaice (*Pleuronectes platessa*) and sole (*Solea solea*) in the UK Beam trawl survey in the Eastern English Channel (7.d). Working document to the WGNSSK, April 2016.

Table 9.1 Sole 7.d. Nominal landings (tonnes) by country over the period 1974–2015, as officially reported to ICES and used by the Working Group.

							Total used
Year	Belgium	France	UK(E+W)	other	reported	Unallocated*	by WG
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
1988	667	2057	578	.	3302	551	3853
1989	646	1610	689	.	2945	860	3805
1990	996	1255	785	.	3036	611	3647
1991	904	2054	826	.	3784	567	4351
1992	891	2187	706	10	3794	278	4072
1993	917	2322	610	13	3862	437	4299
1994	940	2382	701	14	4037	346	4383
1995	817	2248	669	9	3743	677	4420
1996	899	2322	877	.	4098	699	4797
1997	1306	1702	933	.	3941	823	4764
1998	541	1703	803	.	3047	316	3363
1999	880	2251	769	.	3900	235	4135
2000	1021	2190	621	.	3832	-356	3476
2001	1313	2482	822	.	4617	-592	4025
2002	1643	2780	976	.	5399	-666	4733
2003	1657	3475	1114	1	6247	-1209	5038
2004	1485	3070	1112	.	5667	-841	4826
2005	1221	2832	567	.	4620	-236	4384
2006	1547	2627	678	.	4852	-18	4834
2007	1530	2981	801	1	5313	-147	5166
2008	1368	2880	724	.	4972	-455	4517
2009	1475	2886	754	6	5121	145	5266
2010	1294	2407	674		4374	17	4391
2011	1181	2283	686		4150	-17	4133
2012	920	2475	623	0,25	4018	29	4047
2013	954	2865	605		4424	-34	4390
2014	1495	2477	648		4620	0	4620
2015 **	1048	1856	468		3372	69	3441

*** Unallocated mainly due to misreporting**

**** Preliminary**

Table 9.2 Uptake of the national quota and the total TAC of sole *Solea solea* in 7.d in 2015 (ICES estimated landings).

	BEL	FRA	UK(E&W)	TOTAL
Landings (t)	1048	1856	468	3372
TAC (t)	938	1875	670	3258
	12%	3%	-30%	-1%
	over	over	under	under

Table 9.3 Landings percentages of 7.d sole *Solea solea* by gear type (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB = otter trawls) in 2013–2015.

LANDINGS BY GEAR	2013	2014	2015
GNS/GTR	52%	47%	45%
TBB	26%	35%	34%
OTB	17%	12%	14%
OTHER	6%	6%	7%

Table 9.4 Summary of the Intercatch data for 7.d sole *Solea solea* in 2015 (imported vs. raised data; sampled vs. estimated data).

CATCH CATEGORY	RAISEDOR IMPORTED	SAMPLED OR ESTIMATED	CATON	PERC
Landings	Imported Data	Sampled Distribution	2986657	89
Landings	Imported Data	Estimated Distribution	379502	11
Discards	Raised Discards	Estimated Distribution	147021	58
Discards	Imported Data	Estimated Distribution	100816	40
Discards	Imported Data	Sampled Distribution	7244	3

Table 9.5 Discard rates of 7.d sole *Solea solea* by country in 2012–2015.

	OVERALL	BEL	FRA	UK
Discard rate 2012	0,09	0,09		
Discard rate 2013	0,11	0,11		
Discard rate 2014	0,115	0,08	0,18	0,01
Discard rate 2015	0,07	0,09	0,06	0,04

Table 9.6 Catch weights at age for 7.d sole.

YEAR	1982	1983	1984	1985
AGE				
1	0,102	0	0,100	0,090
2	0,171	0,173	0,178	0,182
3	0,225	0,23	0,234	0,230
4	0,312	0,302	0,314	0,281
5	0,386	0,404	0,380	0,368
6	0,428	0,436	0,436	0,394
7	0,439	0,435	0,417	0,516
8	0,509	0,524	0,538	0,543
9	0,502	0,537	0,529	0,594
10	0,463	0,583	0,565	0,595
+gp	0,6729	0,6283	0,7135	0,8005

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE										
1	0,135	0,095	0,102	0,106	0,12	0,114	0,103	0,085	0,099	0,129
2	0,180	0,175	0,152	0,154	0,178	0,161	0,153	0,147	0,150	0,176
3	0,212	0,236	0,226	0,192	0,238	0,208	0,203	0,197	0,186	0,179
4	0,306	0,295	0,278	0,271	0,289	0,266	0,267	0,247	0,235	0,230
5	0,363	0,353	0,360	0,293	0,349	0,354	0,29	0,335	0,288	0,255
6	0,387	0,407	0,409	0,358	0,339	0,394	0,403	0,384	0,355	0,333
7	0,437	0,411	0,459	0,388	0,47	0,421	0,391	0,537	0,381	0,357
8	0,520	0,482	0,514	0,472	0,465	0,43	0,462	0,553	0,505	0,385
9	0,502	0,465	0,553	0,515	0,487	0,434	0,459	0,515	0,484	0,490
10	0,523	0,538	0,563	0,547	0,518	0,478	0,463	0,766	0,496	0,494
+gp	0,6015	0,6176	0,6647	0,7014	0,5621	0,5656	0,5661	0,6666	0,6156	0,6536

YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE										
1	0,142	0,139	0,132	0,130	0,145	0,108	0,120	0,114	0,120	0,135
2	0,165	0,153	0,159	0,151	0,142	0,152	0,162	0,170	0,179	0,172
3	0,178	0,188	0,172	0,189	0,176	0,211	0,204	0,208	0,205	0,208
4	0,229	0,233	0,235	0,215	0,223	0,283	0,253	0,257	0,255	0,253
5	0,269	0,292	0,286	0,260	0,332	0,288	0,316	0,277	0,296	0,303
6	0,324	0,343	0,343	0,280	0,377	0,334	0,375	0,357	0,304	0,337
7	0,361	0,390	0,383	0,290	0,424	0,367	0,376	0,381	0,348	0,368
8	0,405	0,404	0,417	0,341	0,427	0,374	0,393	0,438	0,403	0,433
9	0,435	0,503	0,484	0,358	0,384	0,493	0,469	0,482	0,492	0,570
10	0,465	0,474	0,435	0,374	0,459	0,511	0,420	0,494	0,509	0,445

+gp	0,5854	0,6509	0,6162	0,5354	0,68	0,5445	0,5308	0,5274	0,525	0,5369

YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AGE										
1	0,139	0,163	0,148	0,143	0,124	0,123	0,173	0,076	0,017	0,083
2	0,162	0,190	0,164	0,177	0,161	0,161	0,179	0,150	0,134	0,144
3	0,192	0,202	0,201	0,203	0,195	0,204	0,204	0,189	0,175	0,191
4	0,249	0,227	0,244	0,260	0,239	0,252	0,245	0,245	0,217	0,228
5	0,284	0,276	0,262	0,279	0,287	0,295	0,288	0,297	0,267	0,266
6	0,328	0,294	0,321	0,358	0,340	0,326	0,301	0,315	0,326	0,280
7	0,353	0,315	0,435	0,321	0,342	0,342	0,377	0,389	0,344	0,323
8	0,402	0,378	0,411	0,464	0,355	0,399	0,355	0,446	0,389	0,345
9	0,457	0,441	0,377	0,406	0,512	0,352	0,467	0,406	0,403	0,419
10	0,450	0,439	0,498	0,476	0,438	0,441	0,365	0,441	0,470	0,357
+gp	0,557	0,5206	0,5127	0,6185	0,4504	0,5216	0,5169	0,5381	0,462	0,401

Table 9.7 Stock weights at age for 7.d sole.

YEAR	1982	1983	1984	1985
AGE				
1	0,059	0,07	0,067	0,065
2	0,114	0,135	0,131	0,129
3	0,167	0,197	0,192	0,192
4	0,217	0,255	0,249	0,254
5	0,263	0,309	0,304	0,315
6	0,306	0,359	0,355	0,376
7	0,347	0,406	0,403	0,436
8	0,384	0,448	0,448	0,495
9	0,418	0,487	0,490	0,554
10	0,45	0,522	0,5290	0,6110
+gp	0,53	0,6008	0,6265	0,7798

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE										
1	0,070	0,072	0,050	0,050	0,05	0,05	0,05	0,05	0,050	0,050
2	0,136	0,139	0,145	0,113	0,138	0,138	0,144	0,13	0,116	0,126
3	0,198	0,203	0,223	0,182	0,232	0,225	0,199	0,189	0,161	0,129
4	0,256	0,262	0,268	0,269	0,305	0,279	0,277	0,246	0,215	0,220
5	0,309	0,318	0,365	0,323	0,4	0,38	0,305	0,366	0,273	0,234
6	0,358	0,370	0,425	0,335	0,361	0,384	0,454	0,377	0,316	0,333
7	0,403	0,417	0,477	0,480	0,476	0,41	0,405	0,545	0,368	0,357
8	0,443	0,461	0,498	0,504	0,535	0,449	0,459	0,56	0,530	0,330

9	0,480	0,500	0,572	0,586	0,571	0,474	0,43	0,559	0,461	0,614
10	0,5120	0,5360	0,6360	0,5360	0,507	0,451	0,528	0,813	0,470	0,382
+gp	0,5761	0,6156	0,7498	0,7135	0,5765	0,6203	0,5269	0,5664	0,6122	0,6292

YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE										
1	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,144
2	0,155	0,139	0,140	0,128	0,122	0,127	0,136	0,151	0,137	0,157
3	0,176	0,165	0,158	0,180	0,148	0,157	0,179	0,207	0,185	0,203
4	0,258	0,220	0,233	0,205	0,208	0,216	0,209	0,249	0,236	0,241
5	0,286	0,264	0,299	0,253	0,402	0,226	0,258	0,314	0,265	0,267
6	0,308	0,317	0,374	0,277	0,440	0,223	0,254	0,376	0,267	0,309
7	0,366	0,376	0,363	0,298	0,395	0,231	0,301	0,399	0,273	0,349
8	0,391	0,404	0,357	0,324	0,554	0,253	0,234	0,418	0,331	0,401
9	0,438	0,563	0,450	0,336	0,443	0,256	0,326	0,446	0,504	0,608
10	0,466	0,494	0,372	0,323	0,420	0,301	0,404	0,444	0,409	0,425
+gp	0,6304	0,6536	0,5768	0,5118	0,6822	0,4204	0,4170	0,5032	0,4501	0,5602

YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AGE										
1	0,141	0,139	0,131	0,141	0,143	0,050	0,172	0,085	0,014	0,048
2	0,161	0,163	0,158	0,169	0,149	0,142	0,165	0,133	0,089	0,125
3	0,185	0,195	0,191	0,186	0,185	0,189	0,182	0,168	0,132	0,176
4	0,246	0,239	0,250	0,243	0,210	0,244	0,243	0,253	0,181	0,215
5	0,272	0,286	0,294	0,278	0,267	0,277	0,259	0,324	0,253	0,263
6	0,326	0,297	0,368	0,352	0,316	0,318	0,284	0,357	0,311	0,285
7	0,339	0,340	0,401	0,341	0,341	0,336	0,365	0,432	0,298	0,303
8	0,394	0,400	0,476	0,430	0,326	0,375	0,344	0,518	0,335	0,321
9	0,416	0,433	0,463	0,449	0,440	0,386	0,338	0,461	0,317	0,498
10	0,461	0,446	0,402	0,456	0,416	0,501	0,521	0,472	0,399	0,379
+gp	0,5553	0,5182	0,5663	0,6598	0,4192	0,5147	0,4788	0,5709	0,367	0,462

Table 9.8 Tuning series 1: Belgian commercial beam trawl.

	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
1980	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
1981	19	640.7	161.4	82.1	312.8	229.6	44.7	32.9	33.1	6.9	9	18.4	9.3	0.8	51.9
1982	23.9	148.7	980.9	128	93.4	155.9	112.6	38.8	60.1	15.2	14	7.4	12.5	5.9	54.3
1983	23.6	190.4	373	818.9	65.5	54	81.7	73.2	23.5	20.2	27	5	1	7.1	33
1984	28	603.8	347.2	311.2	436	53.7	38.5	104.9	59.9	25.4	23.2	25.3	9	8.2	42.4
1985	25.3	382.9	612.1	213	209.1	260.2	58.2	34.1	48	31	16.9	19.6	9.2	7.7	21.3
1986	23.4	215	1522.3	675	233.7	170.6	194	30.1	53.1	64.2	32.6	12.7	2.6	43	29.3
1987	27.1	843.6	451	739.3	724.4	344.5	232.4	152.7	25.3	86.5	56	56.1	54.5	9.3	109
1988	38.5	131.6	990.4	243.3	362.9	216.7	111.8	41.8	73.8	47	9.8	22.3	35.8	8.6	25.3
1989	35.7	47.5	512.6	543.6	748	276.6	225	53.1	36.4	12.7	4.7	0	0	4.7	27
1990	30.3	1011.4	1375.2	218.1	366.2	85.3	198.2	65.5	39	22.4	22.2	25.4	2.8	24	18.2
1991	24.3	320.2	1358.6	710.1	125.6	283.9	60.6	56.2	21	19.8	22.2	18	5.6	0.3	21.4
1992	22	499.3	1613.7	523.3	477.7	36.9	67.9	28.2	31.7	11.2	11.4	6	5.7	3.2	16.7
1993	20	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	22.4
1994	22.2	196.9	1183.2	1598.5	912.9	201	160	39.5	33.8	46.2	16	10.2	14.9	8.8	18.6
1995	24.2	206.2	542.7	671.3	590.9	409.4	100.6	40.3	25.4	14.2	9.3	5	11.9	3.4	8
1996	25	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
1997	30.9	196	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
1998	18.1	254.1	450.3	375.4	175.1	54.8	116.1	95.9	59.1	12.4	16	7.7	2.9	4.4	19.2
1999	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
2000	30.5	569.1	1170.7	1225.1	239.1	139.4	68.4	66.6	74.4	46	26.9	7.6	6.6	0.3	1.9
2001	32.4	1055.5	1385.4	375	617.9	351.1	105.4	31.6	15.2	18.7	35.5	11.6	6.9	12.3	4.6
2002	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	6	2.6
2003	47.5	2157.2	1848.1	1368.5	737	395.3	191.8	97.9	15	47.9	33.5	30.8	37.9	0	1.2
2004	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
2005	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
2006	48.8	1341	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
2007	57.9	1736.5	1888.6	808.5	415.2	550.6	207.8	258	117.2	47.6	36.6	21.5	9.2	5.5	31.4
2008	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	24.7
2009	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
2010	35.9	1470.6	1380.4	442.1	726.2	492.4	142.6	66	137.3	39.5	76.7	25.5	17.1	0	36.4
2011	34.8	1303.1	2102.8	861.5	289.3	292.6	138.9	47.4	48.4	37.3	7.7	37.6	3.9	0	10.3
2012	31.2	139.6	1554.9	1147.3	427.5	178.9	169.4	172.4	51.5	6.6	34.6	14.2	35.6	19.5	29.8
2013	35.8	146.7	1633.2	1205.1	449.1	187.9	177.9	181.1	54.1	6.9	36.3	14.9	37.4	20.4	31.3
2014	48.1	210.9	796.8	1332.9	1423.2	705.4	227.8	111.4	123.4	78.1	8.4	19.6	16.7	20.3	24.0
2015	43.4	144.8	384.1	541.2	652.1	907.5	624.1	197.4	42.0	118.9	63.8	30.3	6.2	13.4	21.5

Table 9.9 Tuning series 2: UK(E&W) commercial beam trawl.

	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
1986	2.79	30	144.8	100.5	28	28.8	39.4	1.2	2.4	5.2	2.5	2.8	1.5	1.7	5.3
1987	5.64	251.8	106	143.5	99.2	18.6	14.6	37.6	1.4	0.4	3.3	1.1	1.5	3.3	2.4
1988	5.09	112.3	281.3	56.4	62.9	39.6	9	11.5	16.2	2	0.2	4.6	4.9	0	0.2
1989	5.65	162.3	78.1	144.2	18.2	31.7	23.1	5.1	4.2	16.3	1	0.6	2.2	2.7	12.9
1990	7.27	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
1991	7.67	349	139.2	195.2	8.4	30.7	5.1	7.4	10.9	2.7	1.9	8.4	0.3	0	5
1992	8.78	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
1993	6.4	174.9	222.5	218.9	34.6	52.7	5.2	10.7	4.5	3	3.3	1.1	1.3	2.1	2.8
1994	5.43	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
1995	6.89	181.1	106.9	220.4	107.6	94.6	18.3	37.5	5.4	9.4	2	4.3	4.4	0.9	7.7
1996	10.31	295.8	251.3	79.5	169	84.6	67.4	17.5	33.2	4.1	8.8	4.2	5.4	3.6	11.9
1997	10.25	268.5	331.1	158.5	42.4	125.2	50.8	48.7	11.6	23	2.7	7.1	1.1	3.8	7.6
1998	7.31	252.6	169.4	97.5	65.2	22.1	51.7	28.8	22.4	5.8	12.5	2	5.3	1.5	9
1999	5.86	170	300	105.6	43.6	31.8	12.3	26.3	12.9	7.3	3.4	3.8	0.7	2.5	4.1
2000	5.65	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
2001	7.64	284.3	268	101	111.9	44	19	19.6	5.8	14.7	12.1	5	1.4	3	4.7
2002	7.9	314.6	449	222.2	71.7	54.9	22.9	18.6	6	3.1	5.2	2.3	2.4	0.4	2.9
2003	6.69	386	220.8	149.5	64.8	27.2	32	15	5.6	5.8	0.9	4.2	2.8	1.9	5.1
2004	4.87	111.94	440.41	103.2	62.24	32.62	9.61	18.18	4.33	3.21	2.89	0.54	3.32	1.2	4.22
2005	6	170.74	178.27	376.44	69.41	72.25	35.36	17.41	15.58	11.22	4.26	7.89	2.68	3.2	10.94
2006	5.94	395.17	350.51	113.46	188.96	31.71	28.12	13.55	9.03	5.42	2.76	0.81	1.49	0.26	2.92
2007	5	167.78	303.67	114.86	34.62	102.76	23.99	23.55	9.39	1.33	4.14	2.77	0.93	1.83	5.95
2008	6.21	152.52	612.94	184.74	40.66	24.66	34.21	12.57	4.41	6.36	4.55	1.27	2.28	0.11	3.56
2009	6.21	289.96	113.51	272.97	98.85	15.33	12.47	26.55	7.68	13.8	2.69	0.27	1.86	1.9	0.89
2010	4.35	153.05	151.85	50.86	101.02	33.93	11.9	7.8	14.04	4.89	3.38	3.7	0.63	0.57	2.79
2011	3	227.03	121.43	59.61	16.54	37.19	10.8	2.5	2.51	2.57	0.85	2.13	0.57	0.07	0.81
2012	3.31	44.70	323.85	59.64	34.35	5.88	15.99	8.54	1.41	1.42	3.68	0.68	0.28	0.88	1.56
2013	2.88	15.57	109.60	200.66	36.49	21.35	6.73	9.04	2.68	0.84	0.43	2.17	0.50	0.30	1.06
2014	3.02	75.63	72.96	164.94	95.63	14.27	8.56	1.03	5.96	2.25	1.18	0.24	0.66	0.00	0.52
2015	4.19	57.68	54.11	28.85	55.41	41.61	5.80	3.73	0.98	1.53	1.04	0.31	0.25	0.39	0.57

Table 9.10 Tuning series 3 : UK(E&W)-BTS-Q3.

	Effort	Age1	Age2	Age3	Age4	Age5	Age6
1989	1	3.01	22.09	4.62	2.45	0.56	0.35
1990	1	17.96	5.55	5.55	1.24	1.01	0.33
1991	1	12.14	31.17	3.19	2.82	0.48	0.67
1992	1	1.33	15.29	13.47	1.07	1.61	0.34
1993	1	0.82	22.96	11.42	9.97	1.14	1.52
1994	1	8.33	4.26	11.07	4.65	4.30	0.28
1995	1	5.89	16.09	2.22	3.51	1.67	2.12
1996	1	5.30	10.79	5.97	1.07	1.86	1.15
1997	1	24.75	10.85	4.42	1.94	0.26	0.82
1998	1	3.27	24.11	3.67	1.47	0.83	0.19
1999	1	35.99	8.22	11.33	1.59	0.73	1.02
2000	1	14.98	27.45	5.52	4.85	1.48	0.68
2001	1	10.19	27.88	11.55	1.67	2.33	0.75
2002	1	53.56	16.11	8.60	5.11	0.45	1.04
2003	1	11.03	45.65	5.87	3.20	2.05	0.42
2004	1	12.67	11.81	10.97	2.08	2.02	1.34
2005	1	43.27	6.91	3.50	5.18	1.90	1.15
2006	1	10.84	42.62	4.51	2.68	2.59	0.55
2007	1	2.57	28.97	15.45	1.47	1.04	1.56
2008	1	3.77	7.35	9.14	5.82	0.40	0.68
2009	1	51.25	19.16	7.10	5.81	5.02	0.44
2010	1	16.59	30.76	5.14	1.66	2.70	2.73
2011	1	13.66	28.60	14.70	1.66	0.54	2.62
2012	1	1.75	9.72	7.51	3.53	0.92	0.39
2013	1	0.72	8.91	15.09	9.72	3.23	1.12
2014	1	25.39	16.35	12.38	11.92	5.09	2.73
2015	1	25.24	21.36	6.04	2.29	4.51	2.08

Table 9.11 Tuning series 4 : UK(E&W)-YFS.

	Effort	Age1
1987	1	1.38
1988	1	1.87
1989	1	0.62
1990	1	1.9
1991	1	3.69
1992	1	1.5
1993	1	1.33
1994	1	2.68
1995	1	2.91
1996	1	0.57
1997	1	1.12
1998	1	1.12
1999	1	1.47
2000	1	2.47
2001	1	0.38
2002	1	4.15
2003	1	1.44
2004	1	2.72
2005	1	4.07
2006	1	2.21

Table 9.12 Tuning series 5 : FR-YFS.

	Effort	Age1
1987	1	0.07
1988	1	0.17
1989	1	0.14
1990	1	0.54
1991	1	0.38
1992	1	0.22
1993	1	0.03
1994	1	0.7
1995	1	0.28
1996	1	0.15
1997	1	0.03
1998	1	0.1
1999	1	0.35
2000	1	0.31
2001	1	1.21
2002	1	0.11
2003	1	0.32
2004	1	0.15
2005	1	0.82
2006	1	0.83
2007	1	0.08
2008	1	0.06
2009	1	2.78
2010	1	0.1
2011	1	0.32
2012	1	0.35
2013	1	0.05
2014	1	0.04
2015	1	0.09

Table 9.13 Impact of revision of UK(E&W)-Q3-BTS: comparison of the 2015 assessment results (OLD) and a new run with the revised index (NEW).

	RECRUITS		SSB		FBAR3-7		Y/SSB	
	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW
1986	25724	25725	10574	10562	0.39	0.39	0.37	0.37
1987	10979	10982	8974	8967	0.62	0.62	0.53	0.53
1988	25750	25731	10128	10117	0.44	0.44	0.38	0.38
1989	16820	16821	8415	8394	0.59	0.59	0.45	0.45
1990	44185	44147	9579	9568	0.39	0.39	0.38	0.38
1991	34859	34820	8760	8759	0.47	0.47	0.50	0.50
1992	33621	33580	11144	11135	0.38	0.38	0.37	0.37
1993	16791	16783	13108	13097	0.31	0.31	0.33	0.33
1994	26554	26526	12543	12528	0.37	0.37	0.35	0.35
1995	19403	19373	11088	11066	0.40	0.40	0.40	0.40
1996	18907	18886	12135	12106	0.50	0.51	0.40	0.40
1997	27739	27726	10511	10467	0.62	0.62	0.45	0.46
1998	17994	18000	8106	8069	0.49	0.49	0.41	0.42
1999	26250	26253	9002	8954	0.57	0.57	0.46	0.46
2000	31357	31356	8512	8456	0.45	0.46	0.41	0.41
2001	26528	26535	7600	7560	0.43	0.43	0.53	0.53
2002	46268	46286	8549	8532	0.40	0.41	0.55	0.56
2003	20950	20953	10395	10363	0.39	0.39	0.48	0.49
2004	19301	19308	11381	11360	0.40	0.40	0.42	0.43
2005	33804	33805	11416	11405	0.39	0.39	0.38	0.38
2006	40790	40779	9887	9888	0.44	0.44	0.49	0.49
2007	19899	19900	10388	10398	0.51	0.51	0.50	0.50
2008	19921	19899	12675	12683	0.43	0.43	0.36	0.36
2009	31058	30868	11540	11546	0.54	0.54	0.46	0.46
2010	40616	40367	8990	8995	0.49	0.49	0.49	0.49
2011	25227	24314	10186	10164	0.43	0.43	0.41	0.41
2012	11073	10381	12207	12136	0.42	0.42	0.33	0.33
2013	14271	13572	13384	13168	0.46	0.47	0.32	0.32
2014	25732	20342	9052	8772	0.55	0.58	0.48	0.50

Table 9.14 Impact of revision of BEL-CBT: comparison of the 2015 assessment results (OLD) and a new run with the revised index (NEW).

	RECRUITS		SSB		FBAR3-7		Y/SSB	
	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW
1986	25724	25736	10574	10596	0.39	0.39	0.37	0.37
1987	10979	10976	8974	8988	0.62	0.62	0.53	0.53
1988	25750	25829	10128	10149	0.44	0.44	0.38	0.38
1989	16820	16826	8415	8439	0.59	0.59	0.45	0.45
1990	44185	44210	9579	9625	0.39	0.39	0.38	0.38
1991	34859	34865	8760	8790	0.47	0.47	0.50	0.49
1992	33621	33649	11144	11184	0.38	0.38	0.37	0.36
1993	16791	16783	13108	13145	0.31	0.31	0.33	0.33
1994	26554	26566	12543	12579	0.37	0.37	0.35	0.35
1995	19403	19409	11088	11120	0.40	0.40	0.40	0.40
1996	18907	18915	12135	12161	0.50	0.50	0.40	0.39
1997	27739	27768	10511	10575	0.62	0.61	0.45	0.45
1998	17994	17995	8106	8124	0.49	0.49	0.41	0.41
1999	26250	26268	9002	9028	0.57	0.57	0.46	0.46
2000	31357	31347	8512	8530	0.45	0.45	0.41	0.41
2001	26528	26536	7600	7628	0.43	0.43	0.53	0.53
2002	46268	46292	8549	8553	0.40	0.40	0.55	0.55
2003	20950	20954	10395	10416	0.39	0.39	0.48	0.48
2004	19301	19271	11381	11398	0.40	0.40	0.42	0.42
2005	33804	33760	11416	11437	0.39	0.39	0.38	0.38
2006	40790	41101	9887	9906	0.44	0.44	0.49	0.49
2007	19899	19997	10388	10385	0.51	0.51	0.50	0.50
2008	19921	20355	12675	12727	0.43	0.43	0.36	0.36
2009	31058	31266	11540	11597	0.54	0.54	0.46	0.45
2010	40616	42712	8990	9123	0.49	0.49	0.49	0.48
2011	25227	28942	10186	10377	0.43	0.42	0.41	0.40
2012	11073	12666	12207	12705	0.42	0.40	0.33	0.32
2013	14271	15954	13384	14501	0.46	0.43	0.32	0.29
2014	25732	25295	9052	10229	0.55	0.46	0.48	0.43

Table 9.15 Impact of revisions of UK(E&W)-Q3-BTS and BEL-CBT: comparison of the 2015 assessment results (OLD) and a new run with the revised indices (NEW).

	RECRUITS		SSB		FBAR3-7		Y/SSB	
	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW
1986	25724	25741	10574	10582	0.39	0.39	0.37	0.37
1987	10979	10982	8974	8981	0.62	0.62	0.53	0.53
1988	25750	25812	10128	10137	0.44	0.44	0.38	0.38
1989	16820	16827	8415	8418	0.59	0.59	0.45	0.45
1990	44185	44169	9579	9614	0.39	0.39	0.38	0.38
1991	34859	34820	8760	8791	0.47	0.47	0.50	0.49
1992	33621	33603	11144	11176	0.38	0.38	0.37	0.36
1993	16791	16775	13108	13140	0.31	0.31	0.33	0.33
1994	26554	26535	12543	12561	0.37	0.37	0.35	0.35
1995	19403	19377	11088	11099	0.40	0.40	0.40	0.40
1996	18907	18887	12135	12132	0.50	0.51	0.40	0.40
1997	27739	27753	10511	10528	0.62	0.62	0.45	0.45
1998	17994	18002	8106	8081	0.49	0.49	0.41	0.42
1999	26250	26271	9002	8974	0.57	0.57	0.46	0.46
2000	31357	31340	8512	8466	0.45	0.46	0.41	0.41
2001	26528	26541	7600	7583	0.43	0.43	0.53	0.53
2002	46268	46317	8549	8532	0.40	0.41	0.55	0.56
2003	20950	20958	10395	10379	0.39	0.39	0.48	0.49
2004	19301	19276	11381	11373	0.40	0.40	0.42	0.43
2005	33804	33756	11416	11422	0.39	0.39	0.38	0.38
2006	40790	41098	9887	9906	0.44	0.44	0.49	0.49
2007	19899	19999	10388	10393	0.51	0.51	0.50	0.50
2008	19921	20333	12675	12734	0.43	0.43	0.36	0.36
2009	31058	31040	11540	11600	0.54	0.54	0.46	0.45
2010	40616	42538	8990	9128	0.49	0.49	0.49	0.48
2011	25227	28205	10186	10355	0.43	0.42	0.41	0.40
2012	11073	11878	12207	12640	0.42	0.40	0.33	0.32
2013	14271	14588	13384	14315	0.46	0.43	0.32	0.30
2014	25732	20574	9052	9968	0.55	0.48	0.48	0.44

Table 9.16 XSA diagnostics.

FLR XSA Diagnostics 2016–06–08 12:18:43

CPUE data from indices

Catch data for 34 years. 1982 to 2015. Ages 1 to 11.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE-CBT	2	10	1986	2015	0	1
2	UK(E&W)-CBT	2	10	1986	2015	0	1
3	UK(E&W)-BTS-Q3	1	6	1989	2015	0.5	0.75
4	UK(E&W)-YFS	1	1	1987	2006	0.5	0.75
5	FR-YFS	1	1	1987	2015	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 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

year										
age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

	year									
age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.016	0.009	0.008	0.008	0.004	0.000	0.000	0.001	0.003	0.001
2	0.294	0.209	0.170	0.190	0.217	0.140	0.045	0.112	0.152	0.167
3	0.416	0.471	0.407	0.410	0.419	0.379	0.276	0.285	0.445	0.305
4	0.483	0.607	0.471	0.623	0.539	0.466	0.445	0.389	0.623	0.574
5	0.479	0.456	0.494	0.481	0.535	0.450	0.377	0.420	0.461	0.586
6	0.414	0.518	0.446	0.589	0.478	0.452	0.539	0.354	0.499	0.461
7	0.429	0.490	0.322	0.599	0.453	0.333	0.334	0.667	0.497	0.687
8	0.379	0.428	0.400	0.446	0.500	0.424	0.482	0.430	1.084	0.608
9	0.486	0.393	0.231	0.551	0.392	0.507	0.518	0.437	0.553	0.952
10	0.566	0.885	0.324	0.582	0.343	0.182	0.343	0.676	0.460	0.653
11	0.566	0.885	0.324	0.582	0.343	0.182	0.343	0.676	0.460	0.653

XSA population number (Thousand)

	age										
year	1	2	3	4	5	6	7	8	9	10	11
2006	40884	30438	11600	7740	9481	3419	2400	1344	522	506	743
2007	20200	36415	20531	6926	4320	5313	2045	1414	833	291	410
2008	20361	18111	26740	11600	3415	2478	2864	1134	834	509	935
2009	31721	18282	13819	16102	6557	1886	1436	1878	688	599	1070
2010	41504	28483	13680	8298	7817	3669	947	713	1088	359	1047
2011	29433	37422	20755	8144	4380	4141	2058	545	392	665	1403
2012	12001	26632	29449	12851	4624	2527	2384	1335	323	213	1403
2013	9866	10855	23045	20220	7452	2869	1333	1546	746	174	368
2014	16902	8922	8782	15674	12400	4431	1822	619	910	436	664
2015	25774	15243	6938	5090	7609	7074	2435	1003	189	474	498

Estimated population abundance at 1st Jan 2016

age

year 1 2 3 4 5 6 7 8 9 10 11

2016 1 23301 11671 4627 2593 3832 4037 1109 494 66 223

Fleet: BE-CBT

Log catchability residuals.

year

age 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

2 0.114 0.660 -0.648 -2.484 1.197 -0.685 0.048 1.389 -0.214 -0.672 -0.034 -0.649 -0.259 0.462 0.142 0.565

3 0.758 -0.177 -0.400 0.032 0.124 0.863 0.129 0.287 0.009 -0.256 -0.015 0.422 -0.178 0.069 0.457 0.072

4 0.214 0.385 -0.703 -0.375 -0.122 0.095 0.422 -0.019 0.590 -0.313 0.298 0.380 0.305 0.549 0.363 -0.319

5 -0.043 0.634 -0.179 1.054 -0.038 0.005 0.295 0.014 0.316 -0.017 -0.070 0.515 -0.100 0.526 -0.258 0.169

6 -0.127 0.891 -0.231 0.264 -0.204 0.625 -0.508 -0.857 0.395 0.064 0.115 0.134 -0.274 -0.086 0.089 0.704

7 -0.215 0.570 -0.004 0.306 0.516 0.009 -0.265 -0.037 -0.001 -0.067 0.208 0.191 -0.257 -0.039 -0.256 0.140

8 -0.022 -0.102 -0.788 -0.126 -0.283 -0.072 -0.222 -0.294 0.255 -1.131 -0.077 -0.238 0.039 -0.241 0.481 -0.671

9 0.702 0.223 -0.739 -0.364 0.269 -0.683 -0.078 0.611 -0.232 0.133 -0.163 0.012 -0.089 -0.030 -0.292 -0.648

10 0.024 2.103 1.254 -2.073 -0.127 0.446 -0.670 -0.610 1.283 -0.810 1.054 -0.975 -0.147 -0.575 -0.366 -1.388

year

age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

2 0.927 0.545 0.642 1.084 0.333 0.201 -0.881 0.666 0.763 0.363 -1.467 -0.625 -0.342 -1.144

3 0.122 0.164 -0.314 0.111 -0.191 -0.321 -0.749 -0.173 0.225 0.243 -0.348 -0.187 -0.161 -0.617

4 -0.092 0.020 -0.203 -0.170 0.060 -0.167 0.007 -0.258 -0.504 0.181 0.111 -0.457 -0.291 0.013

5 -0.217 -0.075 0.301 -0.606 -0.370 -0.523 -0.065 0.123 -0.044 -0.392 0.020 -0.526 -0.158 -0.291

6 -0.842 0.439 -0.121 -0.562 0.034 -0.295 -0.316 0.344 0.424 -0.198 -0.048 -0.347 0.311 0.181

7 -0.253 -0.433 -0.599 -0.321 0.149 -0.413 -0.205 0.156 0.441 -0.385 -0.225 0.418 -0.017 0.887

8 -0.341 -0.190 -0.554 -0.102 -0.215 0.144 -0.102 -0.305 -0.025 -0.090 0.441 0.183 0.597 0.589

9 -0.609 -1.476 -0.882 -0.793 0.156 -0.132 -0.469 -0.166 0.237 0.299 0.669 -0.294 0.089 0.854

10 0.313 0.099 0.227 -0.991 0.178 0.236 -0.074 -0.064 0.078 -0.641 -1.052 -0.791 0.325 0.851

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 10

Mean_Logq -7.1528 -5.8516 -5.7069 -5.6125 -5.7380 -5.6514 -5.6514 -5.6514 -5.6514

S.E_Logq 0.8552 0.3560 0.3274 0.3654 0.4212 0.3408 0.3804 0.5223 0.8719

Fleet: UK(E&W)-CBT

Log catchability residuals.

year

age 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

2 -0.346 0.403 0.600 -0.029 -0.188 -0.063 -0.383 -0.336 -1.191 -0.163 0.274 0.152 0.025 0.368 -0.109 0.080

3 0.506 -0.081 0.338 -0.032 0.090 -0.288 -0.117 -0.522 -0.120 -0.650 -0.511 0.145 -0.275 0.091 0.238 -0.152

4 0.528 0.408 -0.049 0.234 -0.122 0.050 -0.429 -0.189 -0.315 -0.078 -0.791 -0.231 -0.044 0.135 0.175 -0.094

5 0.285 0.539 0.415 -0.495 0.000 -1.223 0.488 -0.353 -0.039 -0.141 -0.059 -0.526 0.141 0.188 0.276 0.228

6 0.454 -0.225 0.327 0.175 -0.343 -0.212 -0.557 0.118 0.047 0.089 -0.198 0.255 -0.042 0.352 0.322 0.305

7 0.703 -0.242 -0.113 0.260 -0.245 -0.926 -0.168 -0.523 0.536 -0.128 -0.067 -0.099 0.227 0.267 0.492 0.258

8 -0.731 0.452 0.332 -0.239 0.063 -0.560 -0.400 -0.107 -0.145 0.440 -0.167 0.163 0.129 0.204 0.286 0.682

9 0.118 -0.716 0.155 -0.293 -0.170 0.200 0.451 0.009 0.393 0.227 0.260 -0.083 0.234 -0.015 0.544 0.219

10 0.024 -1.318 0.507 0.407 0.579 -0.007 -0.191 -0.411 0.408 0.420 0.205 0.273 0.387 -0.245 0.150 0.202

year

age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

2 0.367 0.167 0.021 0.345 0.600 -0.304 0.065 0.707 -0.007 0.449 -0.980 -0.965 0.783 -0.344

3 0.268 -0.026 0.372 0.001 0.791 0.274 0.467 -0.558 0.103 -0.184 0.301 -0.394 0.190 -0.265

4 0.165 -0.142 0.015 0.501 0.073 0.424 0.105 0.236 -0.463 0.053 -0.510 0.363 0.480 -0.488

5 0.172 -0.224 -0.058 0.009 0.514 -0.235 -0.039 0.191 0.417 -0.480 0.065 -0.193 0.233 -0.096

6 0.041 -0.043 -0.060 0.431 -0.245 0.710 -0.204 -0.342 0.093 0.424 -0.986 0.232 -0.587 -0.330

7 0.154 0.122 -0.215 0.364 0.062 0.263 -0.012 -0.205 0.454 -0.102 0.045 0.050 -0.144 -1.067

8 0.608 0.280 0.340 0.620 -0.112 0.585 -0.051 0.213 0.337 -0.195 0.066 0.092 -0.932 -0.656

9 -0.191 -0.115 -0.310 0.490 0.477 0.179 -0.870 0.025 0.454 0.177 -0.299 -0.393 0.213 -0.179

10 -0.072 0.335 -0.011 0.802 0.033 -0.506 0.034 0.763 0.486 -0.479 0.041 0.010 -0.068 -0.778

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 10

Mean_Logq -6.5355 -5.8256 -5.7995 -5.9355 -5.9716 -6.0377 -6.0377 -6.0377 -6.0377

S.E_Logq 0.4808 0.3462 0.3328 0.3752 0.3667 0.3858 0.4152 0.3475 0.4541

Fleet: UK(E&W)-BTS-Q3

Log catchability residuals.

year

age 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

1 -0.689 0.141 -0.022 -2.204 -1.990 -0.132 -0.137 -0.245 0.910 -0.681 1.343 0.294 0.074 1.179 0.396 0.642 1.275

2 0.244 -0.671 0.101 -0.432 0.029 -1.046 -0.123 -0.175 -0.204 0.185 -0.347 0.447 0.340 0.028 0.493 -0.094 -0.523

3 0.551 -0.371 -0.377 0.040 -0.015 0.034 -0.956 -0.258 -0.169 -0.461 0.239 0.154 0.378 0.031 -0.114 -0.104 -0.505

4 -0.063 0.224 -0.129 -0.585 0.579 -0.041 -0.283 -0.741 -0.238 -0.216 -0.251 0.364 -0.173 0.474 -0.089 -0.310 0.014

5 -0.167 -0.171 -0.022 0.045 0.102 0.405 -0.350 -0.200 -1.202 -0.185 -0.085 0.417 0.438 -0.796 0.243 0.126 0.217

6 -0.658 -0.201 -0.048 0.051 0.328 -0.930 0.153 -0.219 -0.505 -0.861 0.644 0.348 0.205 0.050 -0.381 0.263 0.010

year

age 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

1 -0.292 -1.031 -0.656 1.510 0.111 0.258 -0.900 -1.592 1.435 1.005

2 0.709 0.091 -0.606 0.355 0.401 0.007 -0.791 0.062 0.889 0.631

3 -0.145 0.549 -0.279 0.130 -0.178 0.432 -0.654 0.295 1.161 0.592

4 0.123 -0.289 0.486 0.251 -0.391 -0.417 -0.132 0.393 0.997 0.442

5 0.040 -0.101 -0.798 1.071 0.309 -0.774 -0.341 0.464 0.436 0.881

6 -0.583 0.083 -0.029 -0.102 0.989 0.810 -0.546 0.266 0.813 0.049

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

Mean_Logq -7.8708 -7.0345 -7.3856 -7.7281 -7.8839 -7.8315

S.E_Logq 1.0101 0.4751 0.4455 0.3982 0.5112 0.4938

Fleet: UK(E&W)-YFS

Log catchability residuals.

year

age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1 0.641 0.094 -0.578 -0.415 0.477 -0.393 0.184 0.424 0.848 -0.784 -0.495 -0.062 -0.165 0.182 -1.525 0.312 0.05 0.794

year

age 2005 2006

1 0.602 -0.192

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

1

Mean_Logq -9.5614

S.E_Logq 0.5902

Fleet: FR-YFS

Log catchability residuals.

year

age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1 -0.254 -0.218 0.02 0.413 0.29 -0.227 -1.522 1.167 0.593 -0.033 -2.029 -0.392 0.486 0.192 1.719 -1.233 0.632 -0.018

year

age 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

1 1.085 0.915 -0.724 -1.02 2.372 -1.224 0.28 1.267 -0.443 -1.242 -0.855

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

1

Mean_Logq -11.6473

S.E_Logq 1.0130

Terminal year survivor and F summaries:

Age 1 Year class =2014

source

scaledWts survivors yrcls

UK(E&W)-BTS-Q3 0.442 63665 2014

FR-YFS 0.441 9912 2014

fshk 0.117 13068 2014

Age 2 Year class =2013

source

scaledWts survivors yrcls

BE-CBT 0.131 3719 2013

UK(E&W)-CBT 0.415 8277 2013

UK(E&W)-BTS-Q3 0.424 21931 2013

fshk 0.029 14911 2013

Age 3 Year class =2012

source

scaledWts survivors yrcls

BE-CBT 0.365 2497 2012

UK(E&W)-CBT 0.386 3550 2012

UK(E&W)-BTS-Q3 0.232 8364 2012

fshk 0.016 3783 2012

Age 4 Year class =2011

source

scaledWts survivors yrcls

BE-CBT 0.372 2628 2011

UK(E&W)-CBT 0.360 1592 2011

UK(E&W)-BTS-Q3 0.250 4034 2011

fshk 0.018 3150 2011

Age 5 Year class =2010

source

scaledWts survivors yrcls

BE-CBT 0.397 2863 2010

UK(E&W)-CBT 0.376 3481 2010

UK(E&W)-BTS-Q3 0.202 9243 2010

fshk 0.025 5369 2010

Age 6 Year class =2009

source

scaledWts survivors yrcls

BE-CBT 0.321 4840 2009

UK(E&W)-CBT 0.423 2904 2009

UK(E&W)-BTS-Q3 0.233 4242 2009

fshk 0.023 3981 2009

Age 7 Year class =2008

source

scaledWts survivors yrcls

BE-CBT 0.543 2692 2008

UK(E&W)-CBT 0.424 381 2008

fshk 0.032 1883 2008

Age 8 Year class =2007

source

scaledWts survivors yrcls

BE-CBT 0.505 890 2007

UK(E&W)-CBT 0.457 256 2007

fshk 0.038 518 2007

Age 9 Year class =2006

source

scaledWts survivors yrcls

BE-CBT 0.280 156 2006

UK(E&W)-CBT 0.665 55 2006

fshk 0.054 170 2006

Age 10 Year class =2005

source

scaledWts survivors yrcls

BE-CBT 0.199 523 2005

UK(E&W)-CBT 0.726 103 2005

fshk 0.076 219 2005

Table 9.17 Sole 7.d. XSA summary

	RECRUITS	SSB	CATCH	LANDINGS	FBAR3-7	Y/SSB
1982	12686	7732	3190	3190	0.34	0.41
1983	21296	9532	3458	3458	0.38	0.36
1984	21545	8957	3575	3575	0.47	0.4
1985	12943	9985	3837	3837	0.34	0.38
1986	25756	10623	3932	3932	0.39	0.37
1987	10993	9016	4791	4791	0.62	0.53
1988	25806	10136	3853	3853	0.44	0.38
1989	16819	8404	3805	3805	0.59	0.45
1990	44324	9619	3647	3647	0.39	0.38
1991	34875	8837	4351	4351	0.47	0.49
1992	33667	11242	4072	4072	0.38	0.36
1993	16788	13228	4299	4299	0.31	0.32
1994	26539	12620	4383	4383	0.37	0.35
1995	19397	11164	4420	4420	0.4	0.4
1996	18880	12200	4797	4797	0.5	0.39
1997	27805	10586	4764	4764	0.61	0.45
1998	18041	8139	3363	3363	0.49	0.41
1999	26314	9081	4135	4135	0.57	0.46
2000	31229	8532	3476	3476	0.45	0.41
2001	26510	7648	4025	4025	0.43	0.53
2002	46410	8545	4733	4733	0.4	0.55
2003	20955	10385	5038	5038	0.39	0.49
2004	19274	11390	4826	4826	0.4	0.42
2005	33856	11439	4383	4383	0.39	0.38
2006	40884	9950	4833	4833	0.44	0.49
2007	20200	10436	5166	5166	0.51	0.5
2008	20361	12732	4517	4517	0.43	0.35
2009	31721	11555	5266	5266	0.54	0.46
2010	41504	9142	4409	4409	0.48	0.48
2011	29433	10542	4133	4133	0.42	0.39
2012	12001	12619	4048	4048	0.39	0.32
2013	9866	14439	4390	4390	0.42	0.3
2014	16902	10017	4620	4620	0.51	0.46
2015	25774	7899	3441	3441	0.52	0.44

Table 9.18 Sole 7.d. RCT3-input for Age 1.

Sole 7.d Age1

4 35 2

1981	12686		3.33	0.07	-11	-11
1982	21296		1.04	0.02	-11	-11
1983	21545		0.79	-11	-11	-11
1984	12943		-11	-11	-11	-11
1985	25756		-11	-11	-11	-11
1986	10993		-11	0.07	-11	14.20
1987	25806		0.75	0.17	8.20	22.09
1988	16819		0.04	0.14	3.01	5.55
1989	44324		17.43	0.54	17.96	31.17
1990	34875		0.57	0.38	12.14	15.29
1991	33667		1.04	0.22	1.33	22.96
1992	16788		0.48	0.03	0.82	4.26
1993	26539		0.27	0.70	8.33	16.09
1994	19397		4.04	0.28	5.89	10.79
1995	18880		3.50	0.15	5.30	10.85
1996	27805		0.28	0.03	24.75	24.11
1997	18041		0.07	0.10	3.27	8.22
1998	26314		10.52	0.35	35.99	27.45
1999	31229		2.84	0.31	14.98	27.88
2000	26510		2.41	1.21	10.19	16.11
2001	46410		4.32	0.11	53.56	45.65
2002	20955		0.94	0.32	11.03	11.81
2003	19274		0.21	0.15	12.67	6.91
2004	33856		7.29	0.82	43.27	42.62
2005	40884		0.05	0.83	10.84	28.97
2006	20200		1.04	0.08	2.57	7.35
2007	20361		0.03	0.06	3.77	19.16
2008	31721		6.58	2.78	51.25	30.76
2009	41504		2.47	0.10	16.59	28.60
2010	29433		0.20	0.32	13.66	9.72
2011	12001		2.78	0.35	1.75	8.91
2012	-11	0.44	0.052	0.72	16.35	
2013	-11	0.72	0.04	25.39	21.36	
2014	-11	1.08	0.09	25.24	-11	
2015	-11	0.26	-11	-11	-11	

FRYF0

FRYF1

BTS1

BTS2

Table 9.19 Sole 7.d. RCT3-input for Age 2.

Sole 7.d Age1

4 35 2

1981	11335		3.33	0.07	-11	-11
1982	19269		1.04	0.02	-11	-11
1983	19472		0.79	-11	-11	-11
1984	11665		-11	-11	-11	-11
1985	23258		-11	-11	-11	-11
1986	9938	-11	0.07	-11	14.20	
1987	23260		0.75	0.17	8.20	22.09
1988	15064		0.04	0.14	3.01	5.55
1989	38922		17.43	0.54	17.96	31.17
1990	31191		0.57	0.38	12.14	15.29
1991	30364		1.04	0.22	1.33	22.96
1992	15110		0.48	0.03	0.82	4.26
1993	23984		0.27	0.70	8.33	16.09
1994	16754		4.04	0.28	5.89	10.79
1995	17075		3.50	0.15	5.30	10.85
1996	25136		0.28	0.03	24.75	24.11
1997	16293		0.07	0.10	3.27	8.22
1998	23650		10.52	0.35	35.99	27.45
1999	28126		2.84	0.31	14.98	27.88
2000	23827		2.41	1.21	10.19	16.11
2001	41321		4.32	0.11	53.56	45.65
2002	18600		0.94	0.32	11.03	11.81
2003	16462		0.21	0.15	12.67	6.91
2004	30438		7.29	0.82	43.27	42.62
2005	36415		0.05	0.83	10.84	28.97
2006	18111		1.04	0.08	2.57	7.35
2007	18282		0.03	0.06	3.77	19.16
2008	28483		6.58	2.78	51.25	30.76
2009	37422		2.47	0.10	16.59	28.60
2010	26632		0.20	0.32	13.66	9.72
2011	10855		2.78	0.35	1.75	8.91
2012	-11	0.44	0.052	0.72	16.35	
2013	-11	0.72	0.04	25.39	21.36	
2014	-11	1.08	0.09	25.24	-11	
2015	-11	0.26	-11	-11	-11	

FRYF0

FRYF1

BTS1

BTS2

Table 9.20 Sole 7.d. RCT3-output for Age 1.

Analysis by RCT3 ver4.0

Data for 4 surveys over 35 years : 1981 - 2015

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2012

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9509	10.176	1.6278	0.04773	28	-0.8210	9.396	1.7252	0.01658
FRYF1	0.8007	11.394	0.8714	0.17130	28	-2.9565	9.027	0.9414	0.05569
BTS1	0.4715	9.131	0.4073	0.43349	25	-0.3285	8.976	0.4743	0.21935
BTS2	0.7893	7.941	0.3408	0.56507	26	2.7942	10.146	0.3615	0.37774
VPA Mean	NA	NA	NA	NA	31	NA	10.074	0.3864	0.33064

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9509	10.176	1.6278	0.04773	28	-0.3285	9.864	1.7199	0.01618
FRYF1	0.8007	11.394	0.8714	0.17130	28	-3.2189	8.817	0.9504	0.05300
BTS1	0.4715	9.131	0.4073	0.43349	25	3.2344	10.656	0.4406	0.24658
BTS2	0.7893	7.941	0.3408	0.56507	26	3.0615	10.357	0.3629	0.36352

VPA Mean	NA	NA	NA	NA	31	NA	10.074	0.3864	0.32072

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9509	10.176	1.6278	0.04773	28	0.07696	10.250	1.7193	0.02534
FRYF1	0.8007	11.394	0.8714	0.17130	28	-2.40795	9.466	0.9277	0.08702
BTS1	0.4715	9.131	0.4073	0.43349	25	3.22843	10.653	0.4405	0.38590
BTS2	0.7893	7.941	0.3408	0.56507	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	31	NA	10.074	0.3864	0.50174

yearclass:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9509	10.176	1.6278	0.04773	28	-1.347	8.895	1.7363	0.04718
FRYF1	0.8007	11.394	0.8714	0.17130	28	NA	NA	NA	NA
BTS1	0.4715	9.131	0.4073	0.43349	25	NA	NA	NA	NA
BTS2	0.7893	7.941	0.3408	0.56507	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	31	NA	10.074	0.3864	0.95282

	WAP	logWAP	int.se
yearclass:2012	17871	9.791	0.2222
yearclass:2013	28296	10.250	0.2188
yearclass:2014	28259	10.249	0.2737
yearclass:2015	22439	10.019	0.3771

Table 9.21 Sole 7.d. RCT3-output for Age 2.

Analysis by RCT3 ver4.0

Data for 4 surveys over 35 years : 1981 - 2015

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9650	10.067	1.6531	0.04642	28	-0.3285	9.750	1.7466	0.01565
FRYF1	0.8087	11.296	0.8820	0.16766	28	-3.2189	8.693	0.9619	0.05159
BTS1	0.4771	9.008	0.4153	0.42479	25	3.2344	10.551	0.4493	0.23648
BTS2	0.7829	7.848	0.3348	0.57323	26	3.0615	10.245	0.3566	0.37543
VPA Mean	NA	NA	NA	NA	31	NA	9.965	0.3857	0.32086

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9650	10.067	1.6531	0.04642	28	0.07696	10.141	1.7461	0.02496
FRYF1	0.8087	11.296	0.8820	0.16766	28	-2.40795	9.349	0.9390	0.08632
BTS1	0.4771	9.008	0.4153	0.42479	25	3.22843	10.548	0.4492	0.37717
BTS2	0.7829	7.848	0.3348	0.57323	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	31	NA	9.965	0.3857	0.51155

yearclass:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.9650	10.067	1.6531	0.04642	28	-1.347	8.767	1.7633	0.04567
FRYF1	0.8087	11.296	0.8820	0.16766	28	NA	NA	NA	NA
BTS1	0.4771	9.008	0.4153	0.42479	25	NA	NA	NA	NA
BTS2	0.7829	7.848	0.3348	0.57323	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	31	NA	9.965	0.3857	0.95433

	WAP	logWAP	int.se
yearclass:2013	25322	10.14	0.2185
yearclass:2014	25234	10.14	0.2759
yearclass:2015	20128	9.91	0.3768

Table 9.22 Sole 7.d. Short-term forecast. Management options under the TAC-constraint scenario.

BASIS	LANDINGS	F3-7	SSB2017	SSB2018	SSB_CHANGE	TAC_CHANGE
Ftar	2294	0.3	7853	9400	20	-22
Fmsy	2257	0.294	7853	9440	20	-24
Fmsy_low	1304	0.16	7853	10472	33	-56
Fmsy_high	3503	0.5	7853	8093	3	18
Fpa	2926	0.4	7853	8716	11	-1
Flim	3773	0.55	7853	7803	-1	28
SSB>Bpa	3590	0.516	7853	8000	2	21
TACsq	2957	0.405	7853	8683	11	0
15%_TAC_inc	3401	0.482	7853	8204	4	15
15%_TAC_dec	2513	0.334	7853	9162	17	-15
Fsq*0	0	0	7853	11887	51	-100
Fsq*0.25	933	0.112	7853	10874	38	-68
Fsq*0.5	1765	0.223	7853	9972	27	-40
Fsq*0.9	2932	0.401	7853	8710	11	-1
Fsq*1	3198	0.446	7853	8423	7	8
Fsq*1.1	3453	0.491	7853	8147	4	17
Fsq*1.25	3815	0.558	7853	7757	-1	29
Fsq*1.5	4368	0.669	7853	7162	-9	48
Fsq*1.75	4869	0.78	7853	6623	-16	65
Fsq*2	5329	0.892	7853	6131	-22	80

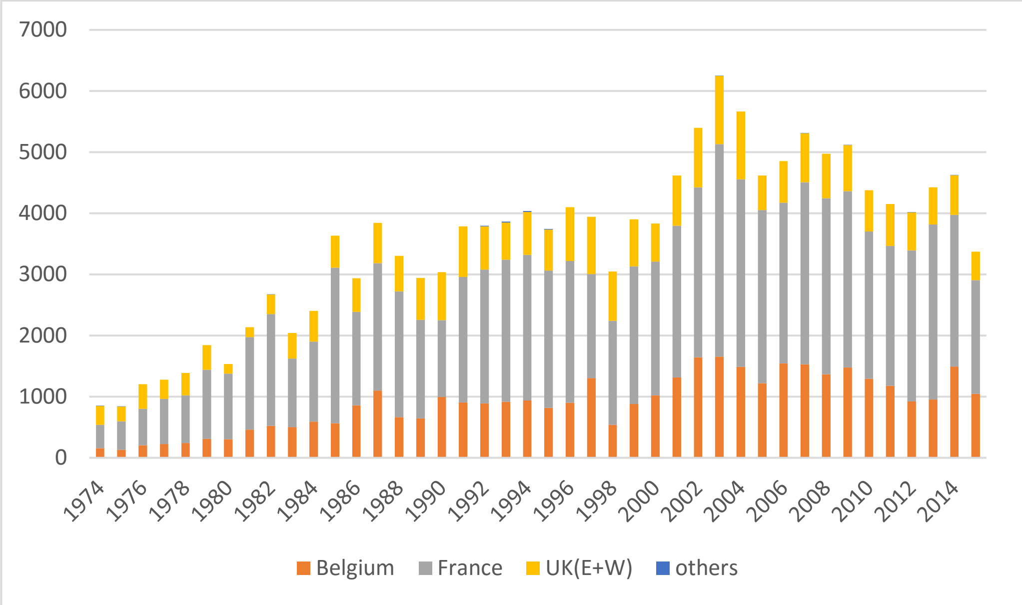


Figure 9.1 Sole 7.d. Official landings (tonnes) by country over the period 1974–2015, as officially reported to ICES.

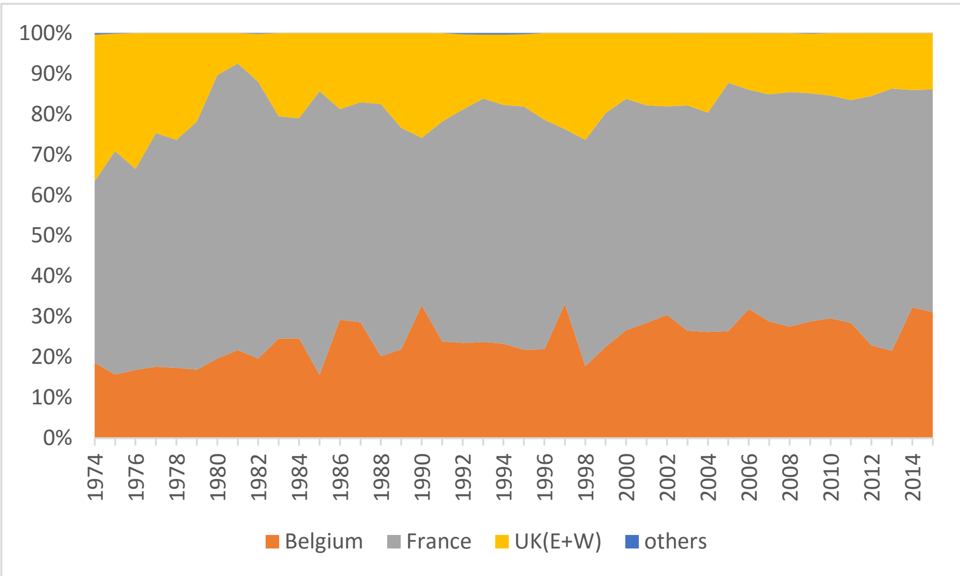


Figure 9.2 Relative contribution to the official landings of sole *Solea solea* from Division 7.d for the main countries involved over the period 1974–2015.

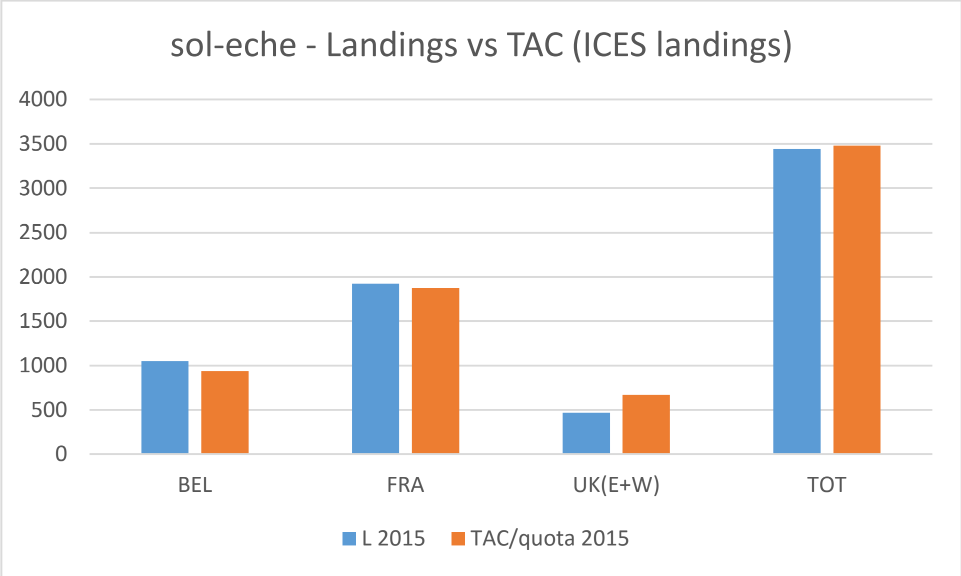


Figure 9.3 Uptake of the national quota and the total TAC of sole *Solea solea* in 7.d in 2015 (ICES landings as uploaded to InterCatch).

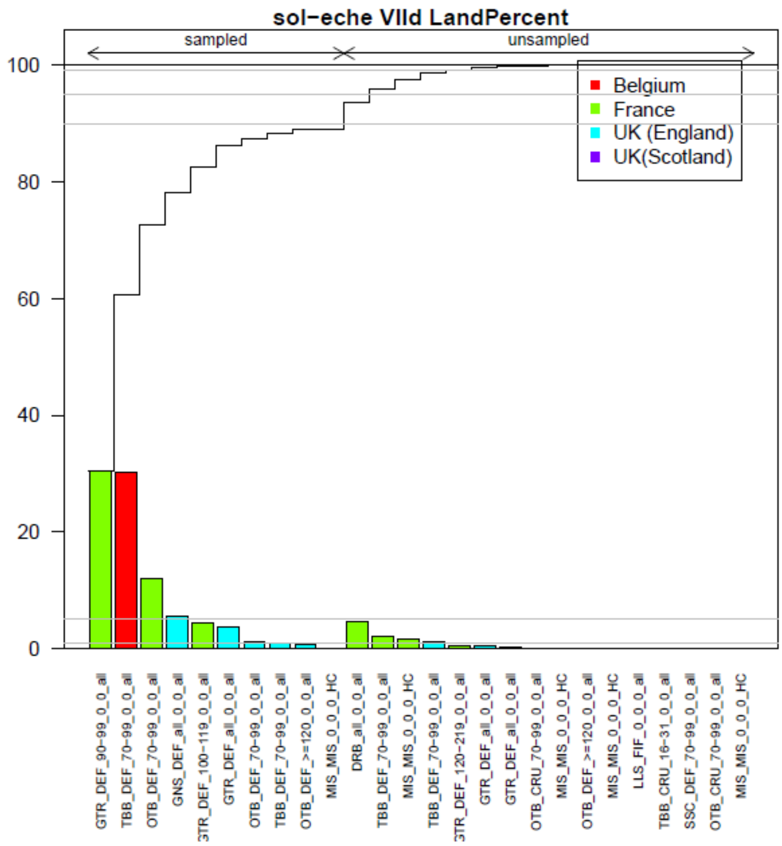


Figure 9.4 Overview of 2015 7.d sole *Solea solea* landings (and corresponding percentages) by métier and country, for which biological data were uploaded (8 left blocks; totaling to 87%) or not available (rest of plot) in InterCatch.

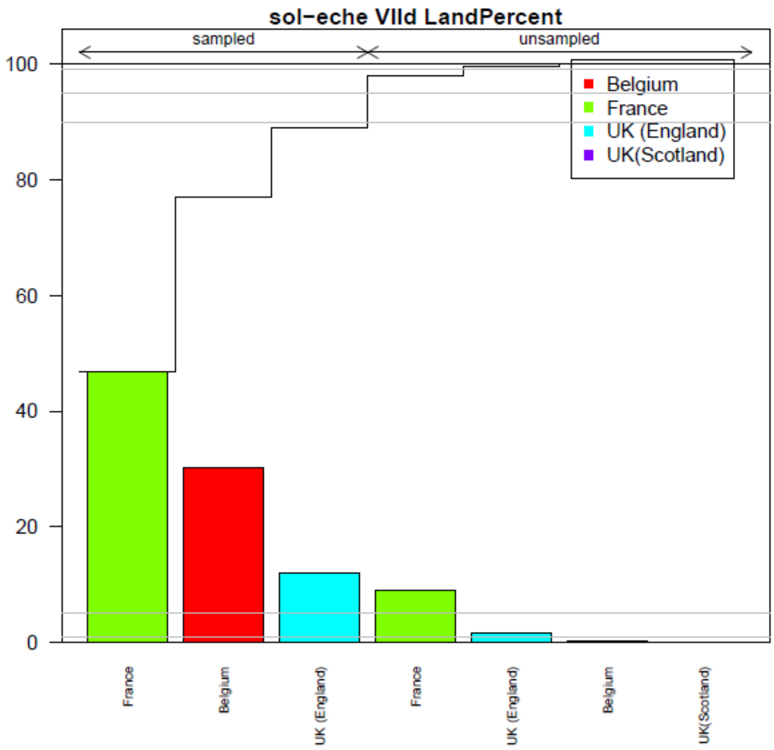


Figure 9.5 Overview of 2015 7.d sole *Solea solea* landings (and corresponding percentages) by country, for which biological data were uploaded (3 left blocks; totaling to 87%) or not available (rest of plot) in InterCatch.

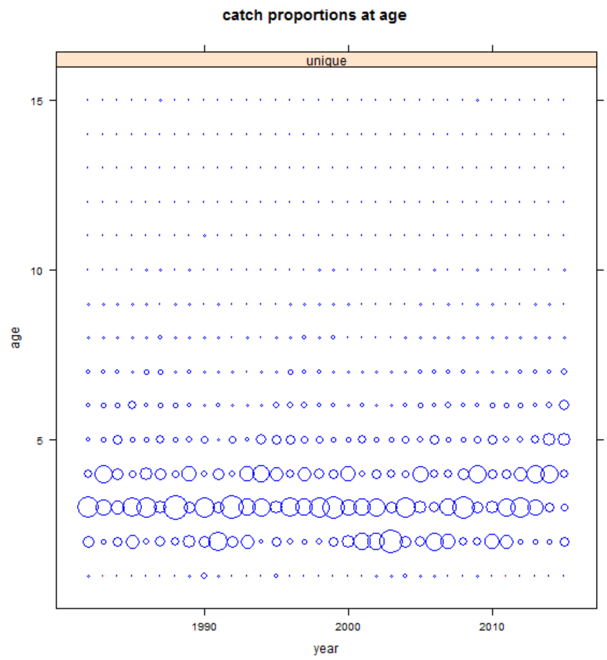


Figure 9.6 Catch proportions at age for 7.d sole.

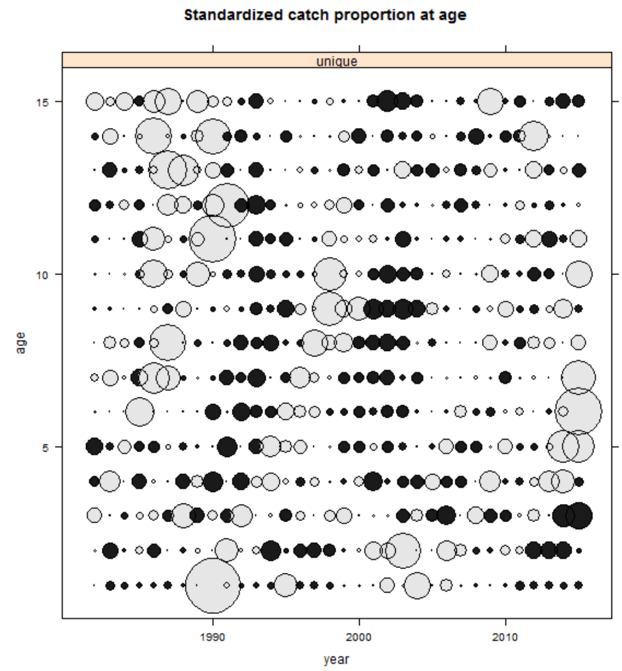


Figure 9.7 Standardised catch proportions at age for 7.d sole.

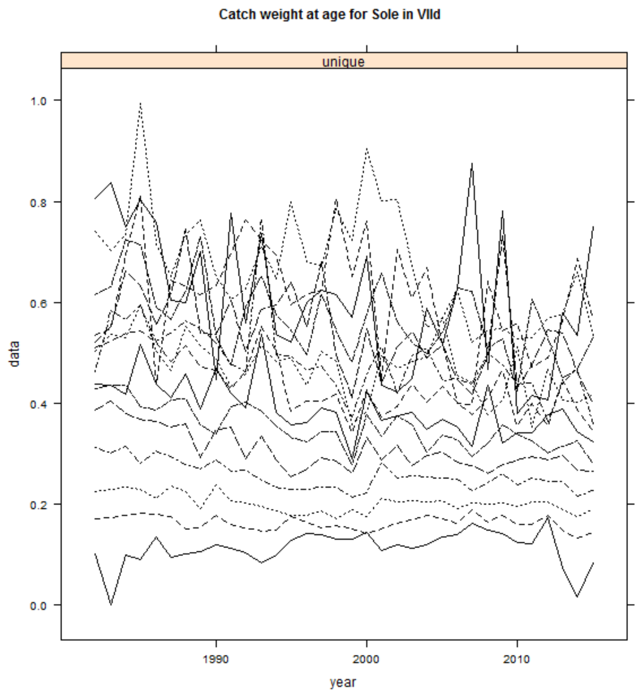


Figure 9.8 Catch weights at age for 7.d sole.

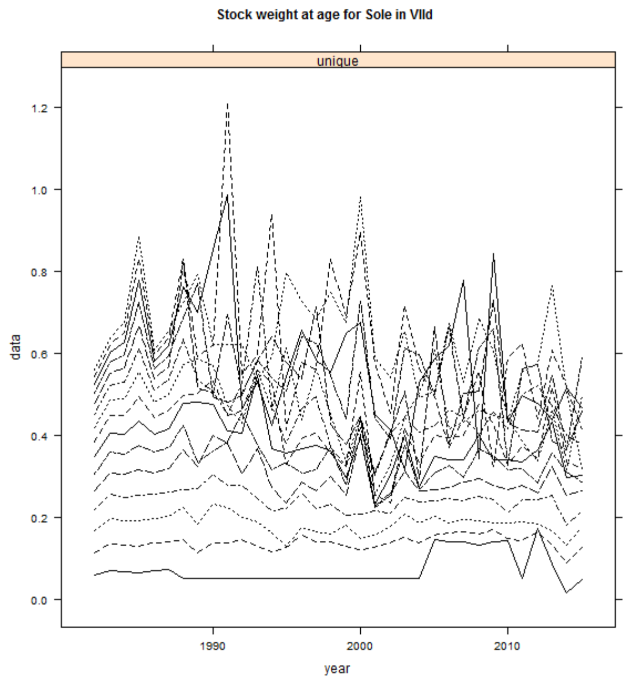


Figure 9.9 Stock weights at age for 7.d sole.

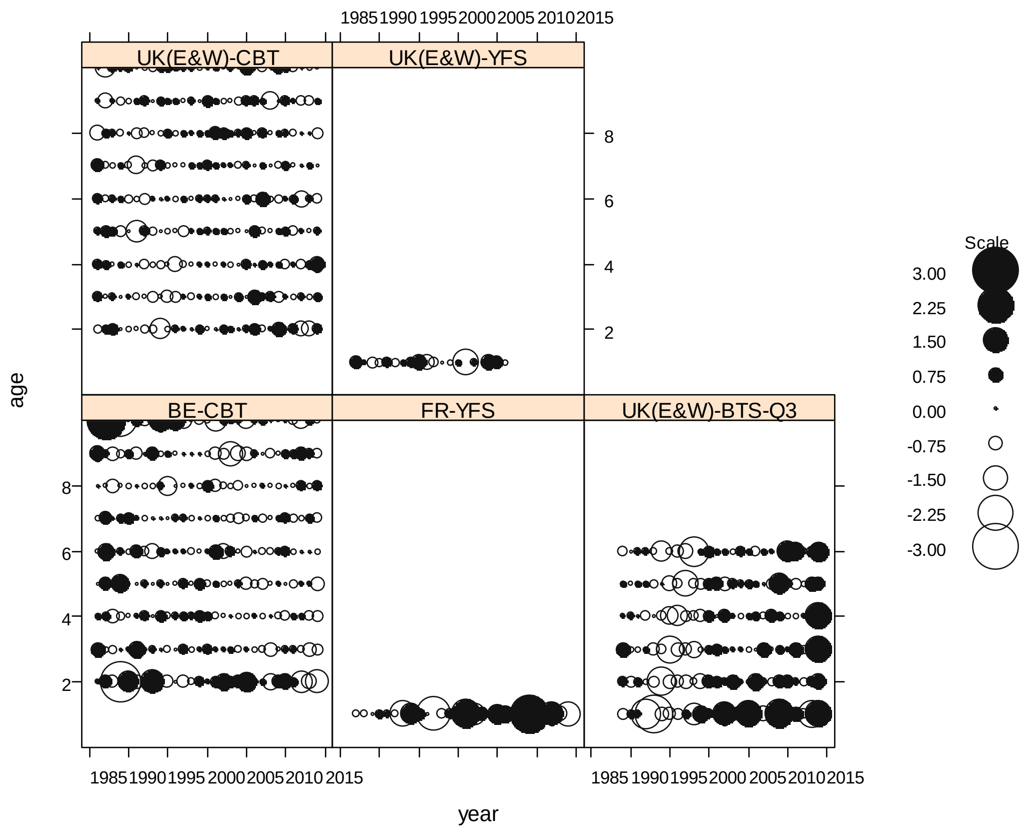


Figure 9.10 Impact of revision of UK(E&W)-Q3-BTS : catchability residuals for all tuning fleets used in the assessment of 7.d sole.

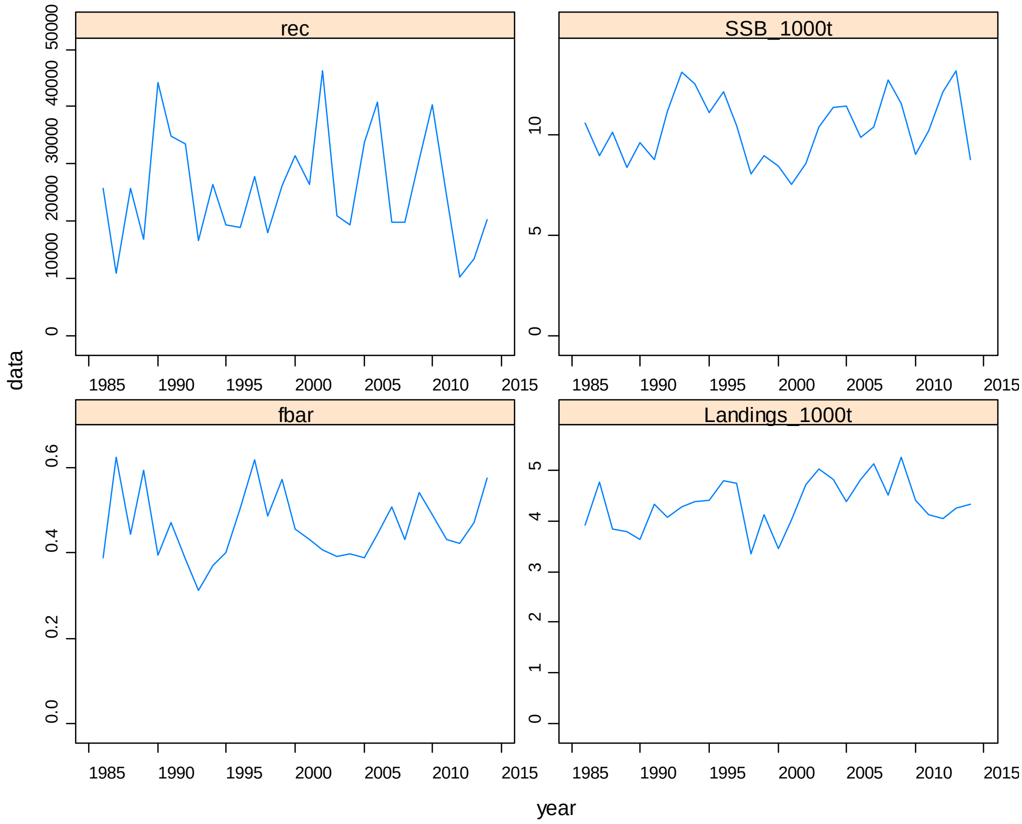


Figure 9.11 Impact of revision of UK(E&W)-Q3-BTS : assessment summary.

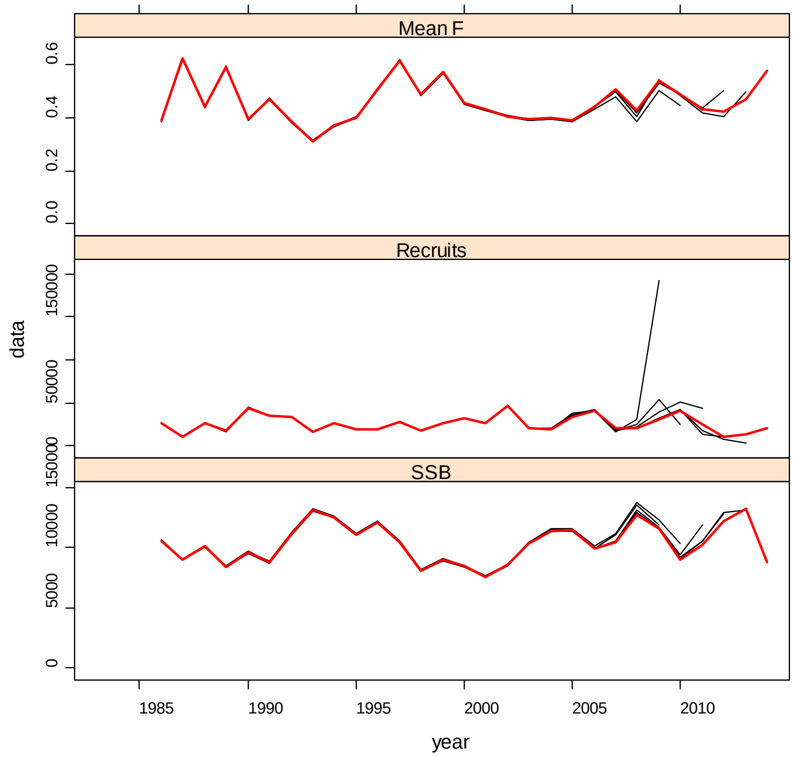


Figure 9.12 Impact of revision of UK(E&W)-Q3-BTS : retrospective pattern.

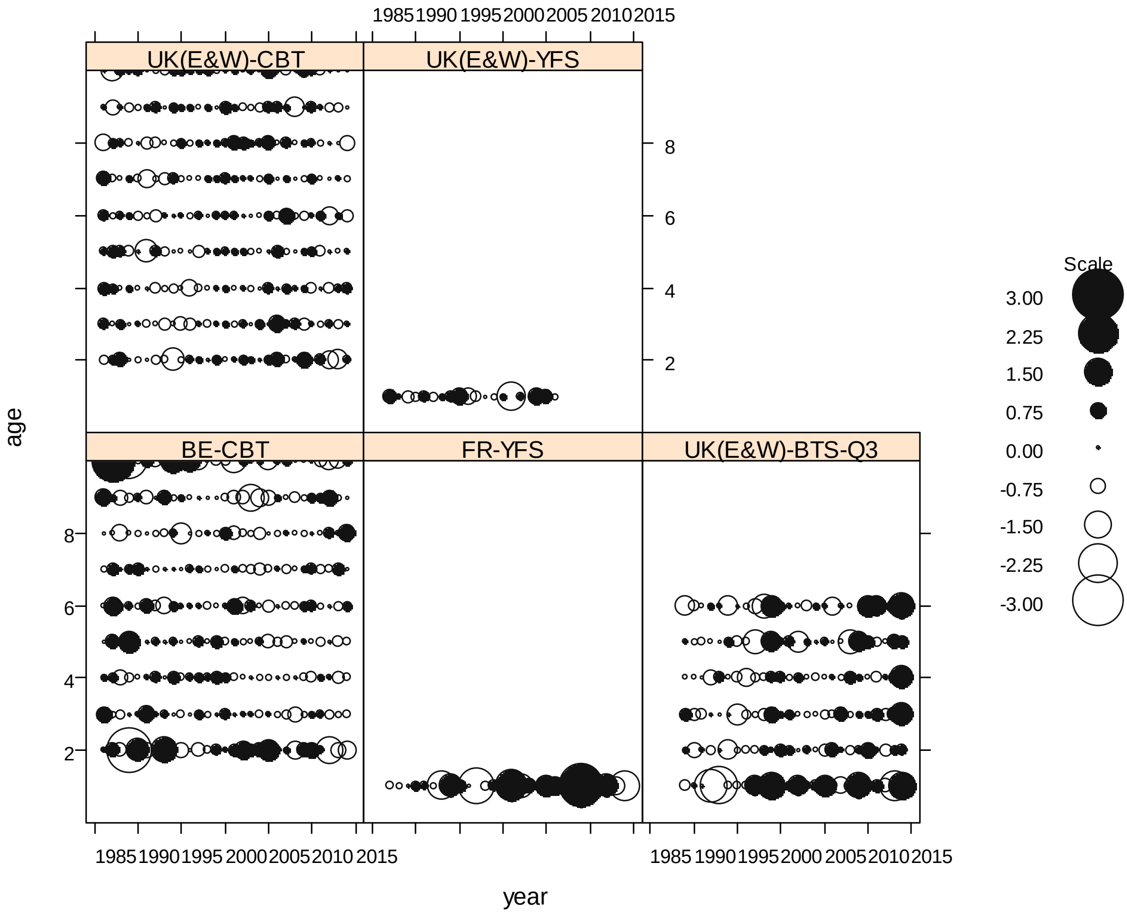


Figure 9.13 Impact of revision of BEL-CBT : catchability residuals for all tuning fleets used in the assessment of 7.d sole.

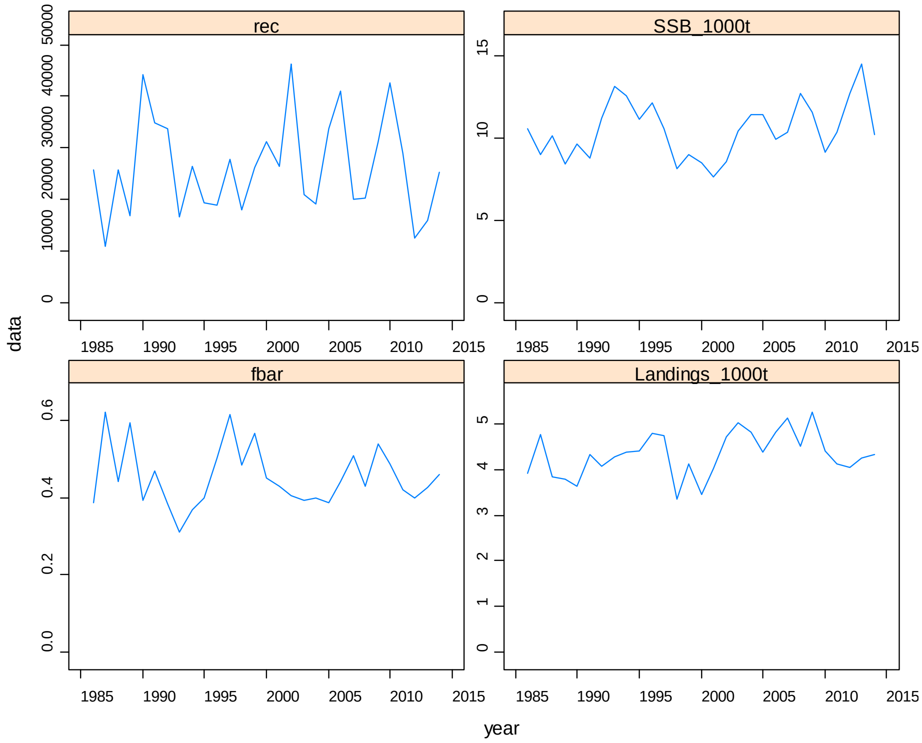


Figure 9.14 Impact of revision of BEL-CBT : assessment summary.

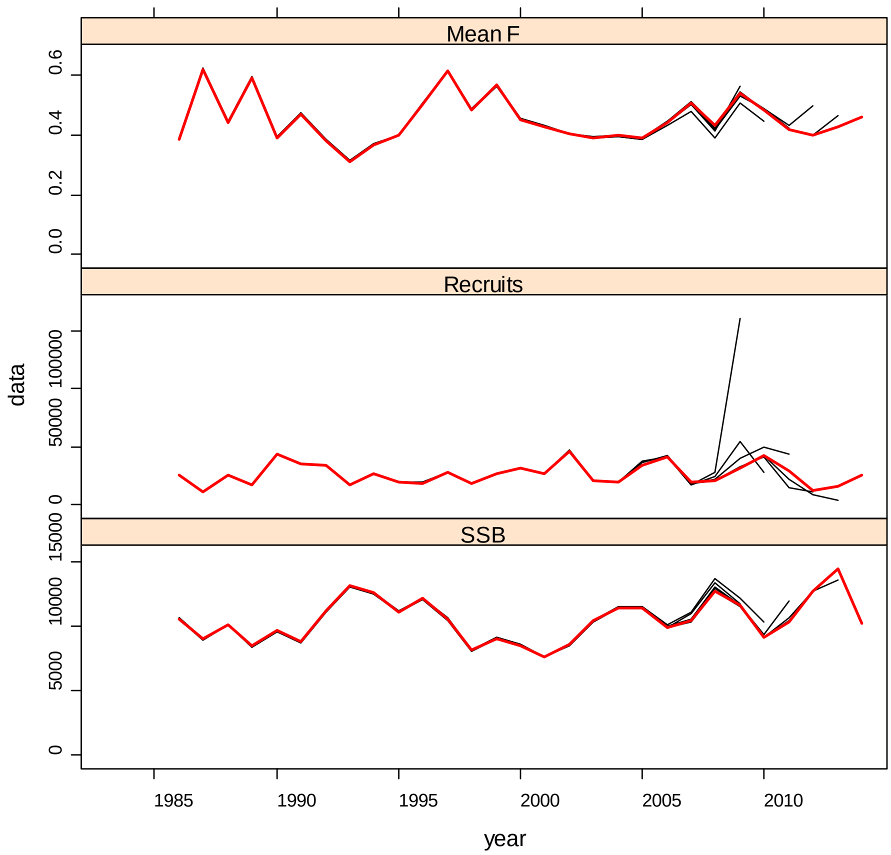


Figure 9.15 Impact of revision of BEL-CBT : retrospective pattern.

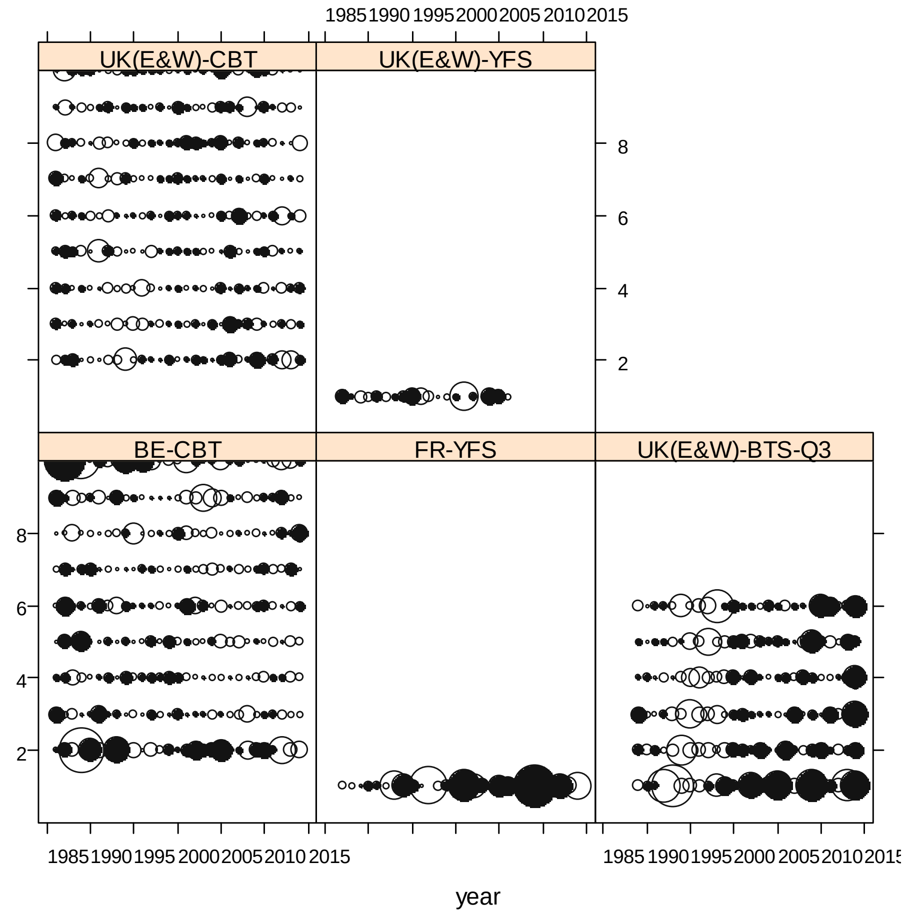


Figure 9.16 Impact of revisions of UK(E&W)-Q3-BTS AND BEL-CBT : catchability residuals for all tuning fleets used in the assessment of 7.d sole.

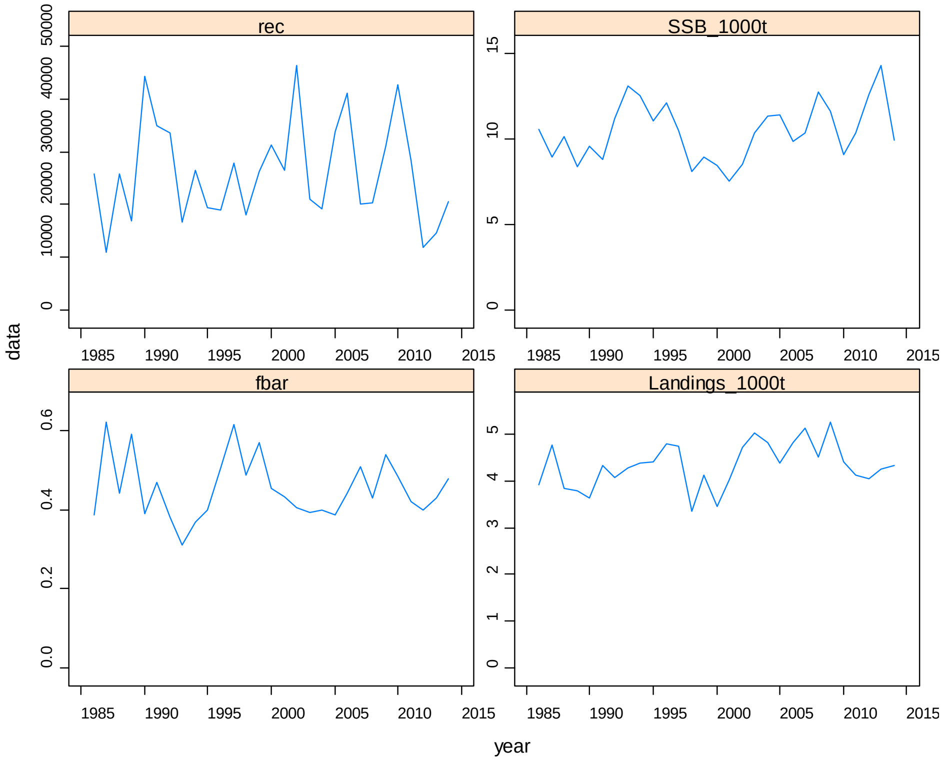


Figure 9.17 Impact of revisions of UK(E&W)-Q3-BTS AND BEL-CBT : assessment summary.

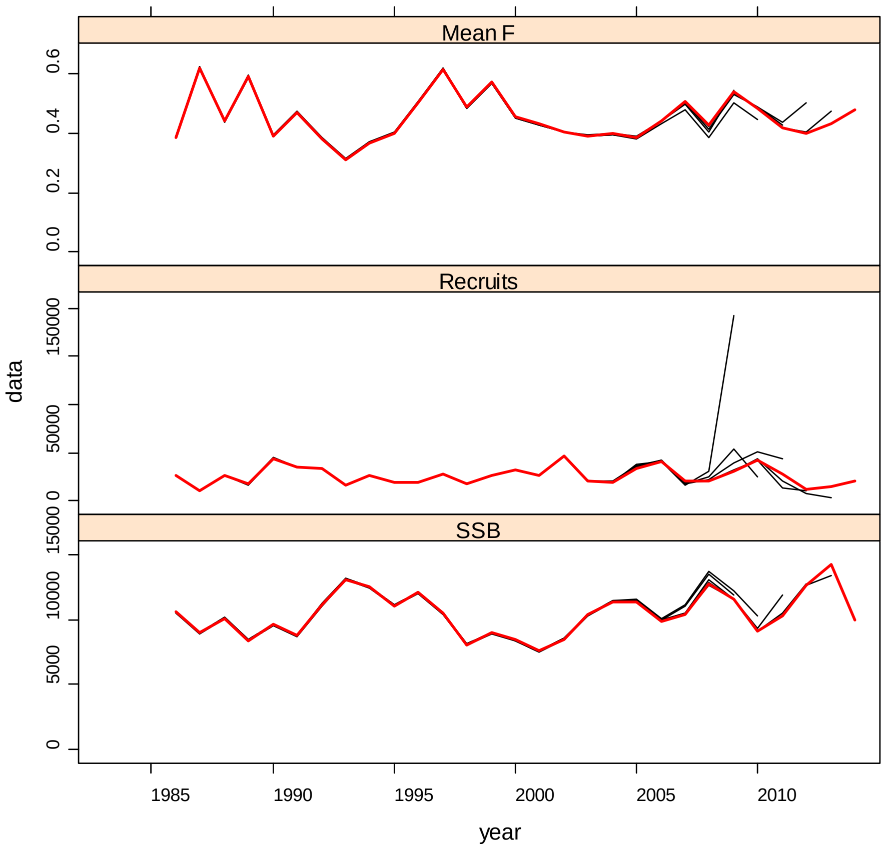


Figure 9.18 Impact of revisions of UK(E&W)-Q3-BTS AND BEL-CBT: retrospective pattern.

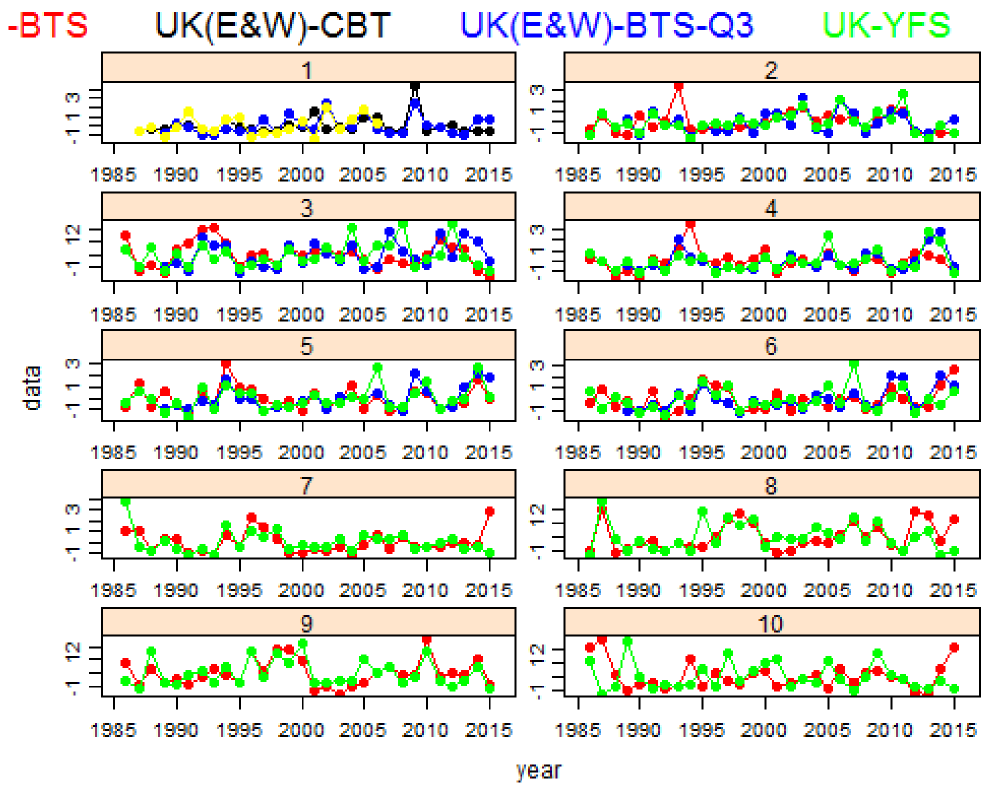


Figure 9.19 Standardised tuning indices at age for 7.d sole.

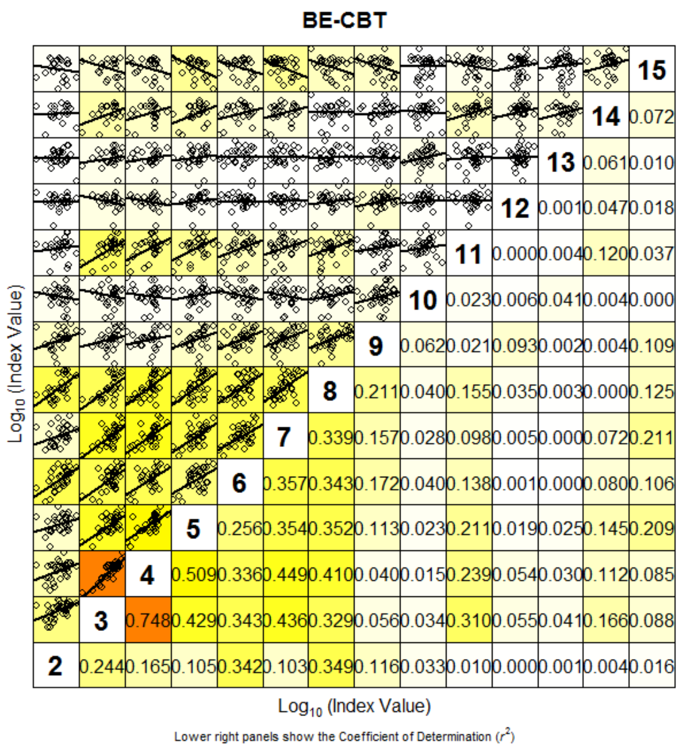


Figure 9.20 Internal consistency plot of the BEL-CBT tuning series for 7.d sole.

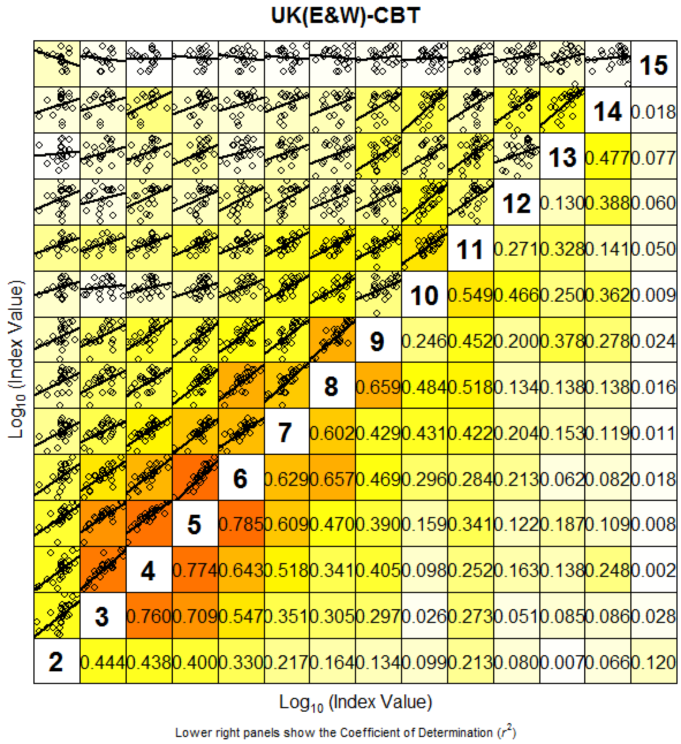


Figure 9.21 Internal consistency plot of the UK(E&W)-CBT tuning series for 7.d sole.

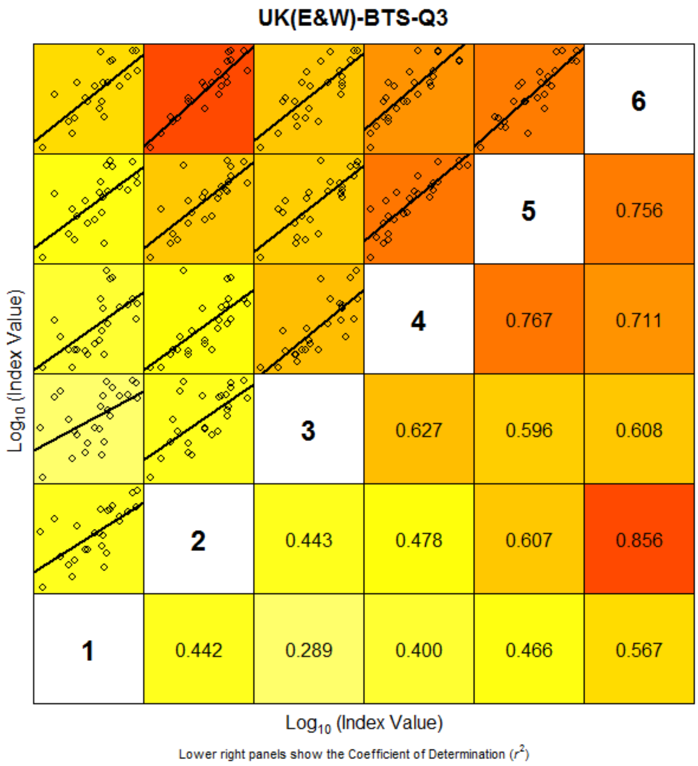


Figure 9.22 Internal consistency plot of the UK(E&W)-BTS-Q3 tuning series for 7.d sole.

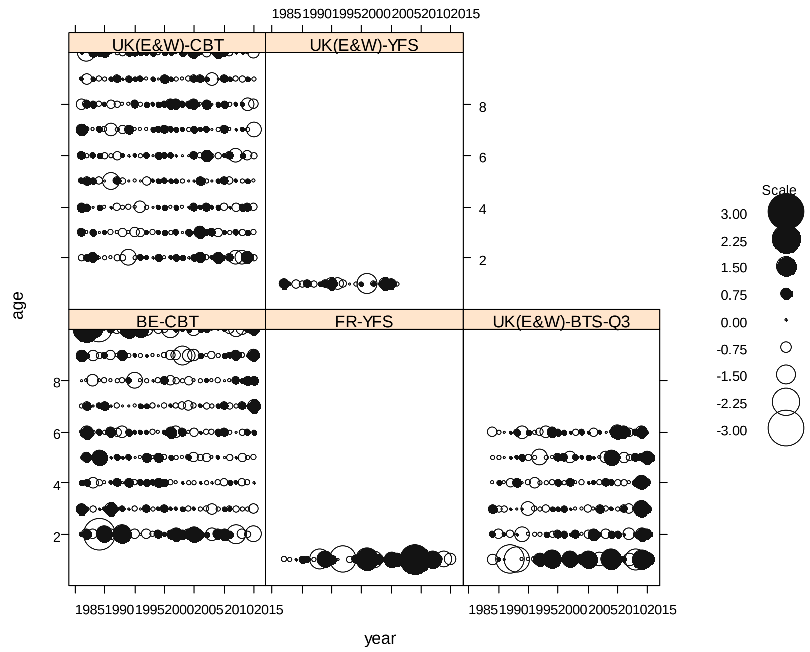


Figure 9.23 Catchability residuals for all tuning fleets used in the 2016 assessment of 7.d sole.

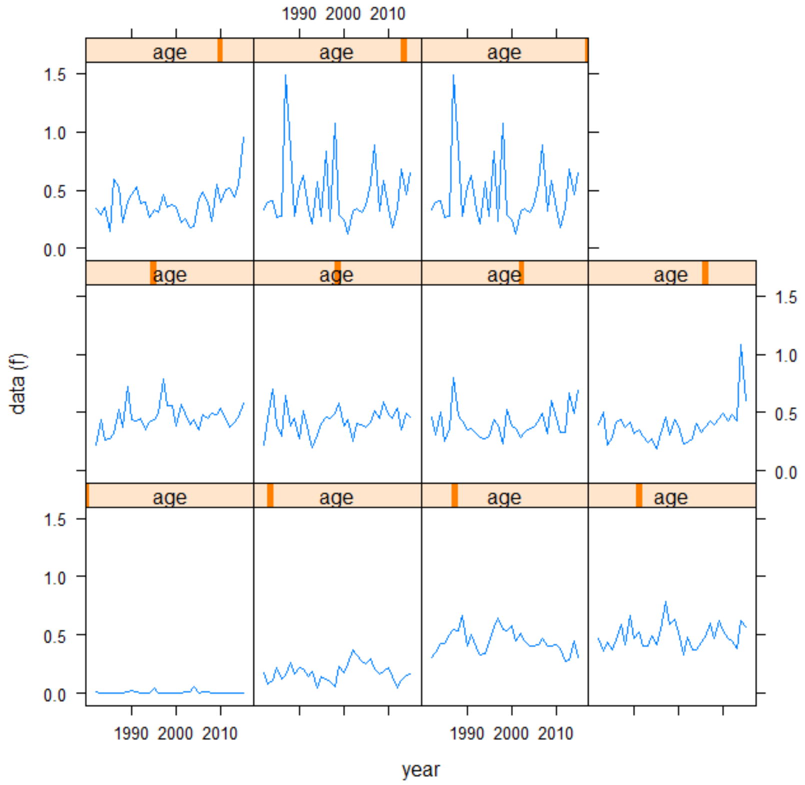


Figure 9.24 Sole 7.d. F at age.

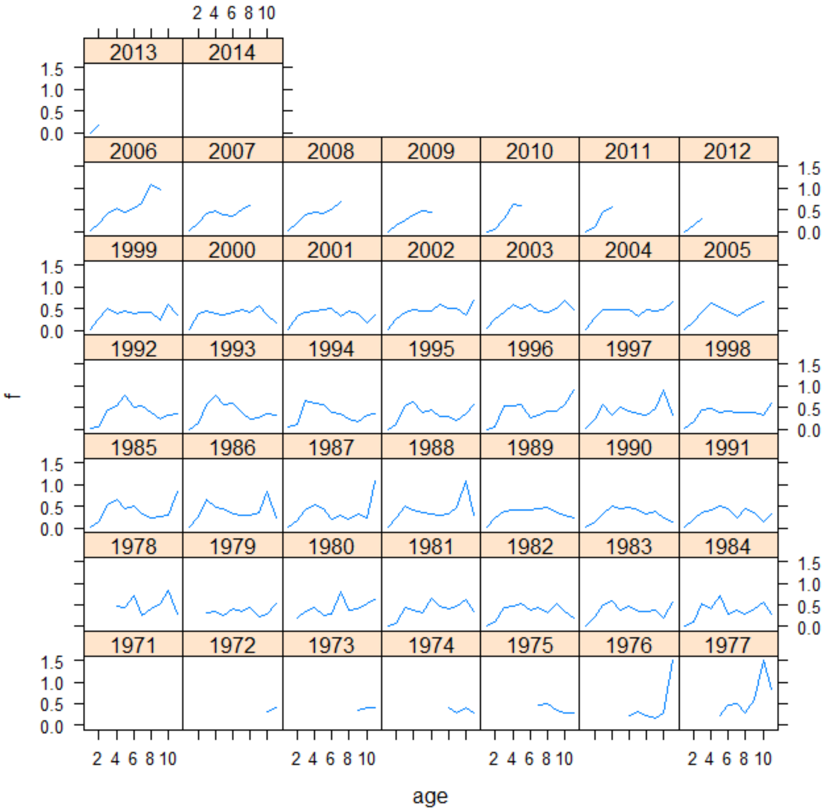


Figure 9.25 Sole 7.d. F per cohort.

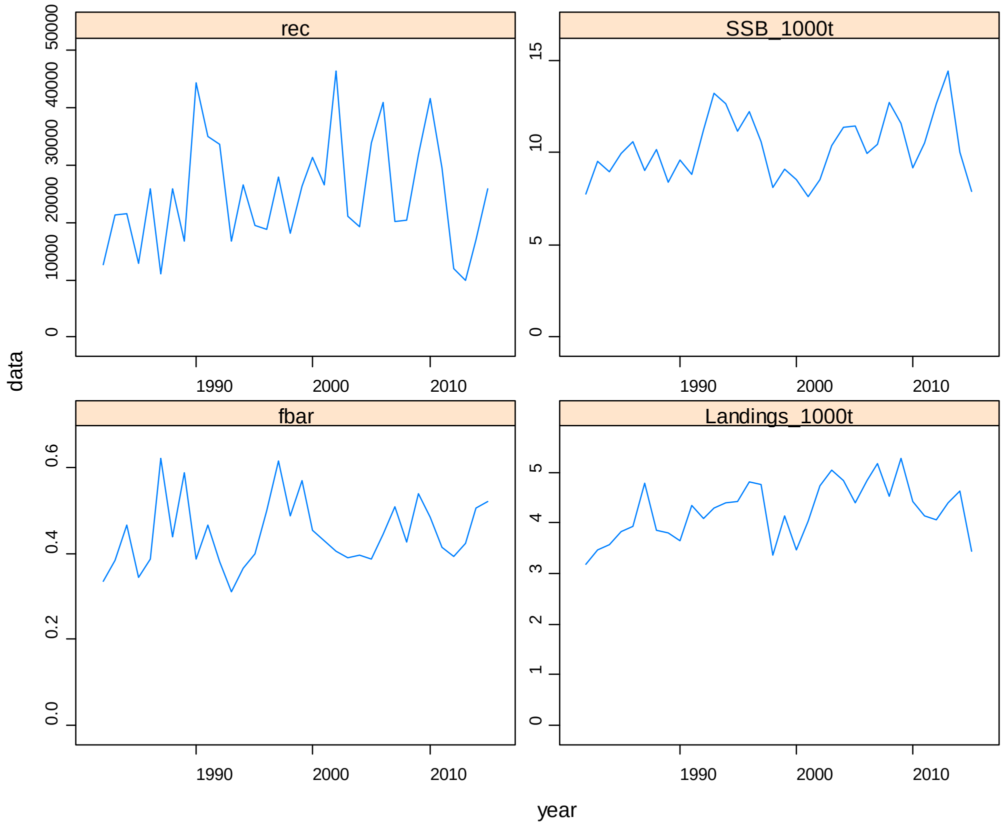


Figure 9.26 Sole 7.d. XSA Summary: trends in recruitment (rec), spawning stock biomass (SSB), fbar and landings.

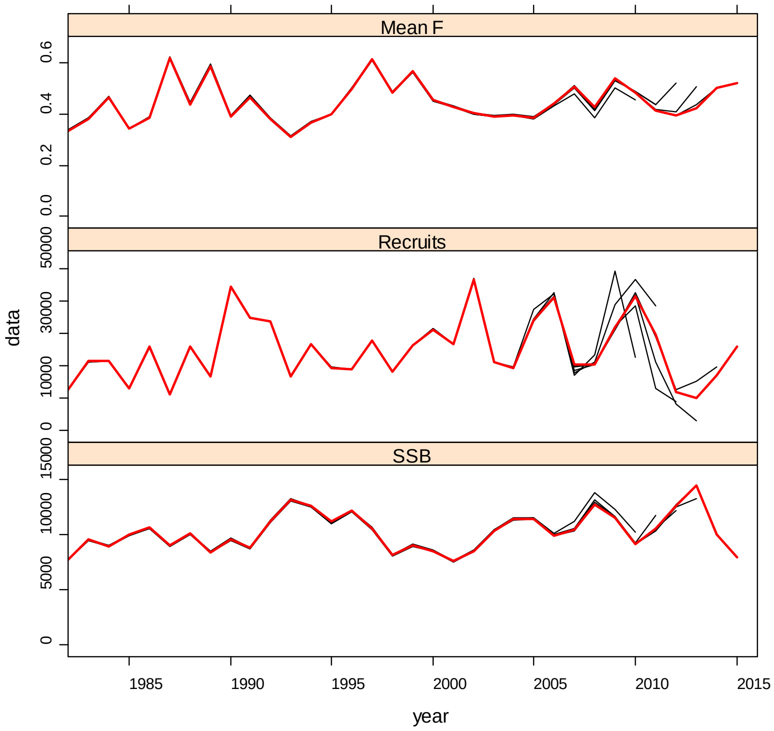


Figure 9.27 Sole 7.d. Restrospective patterns in F, recruitment and SSB.

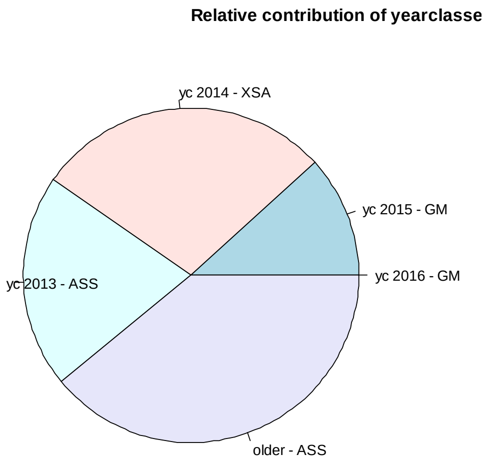


Figure 9.28 Sole 7.d. Relative contribution of year classes to landings in 2017.

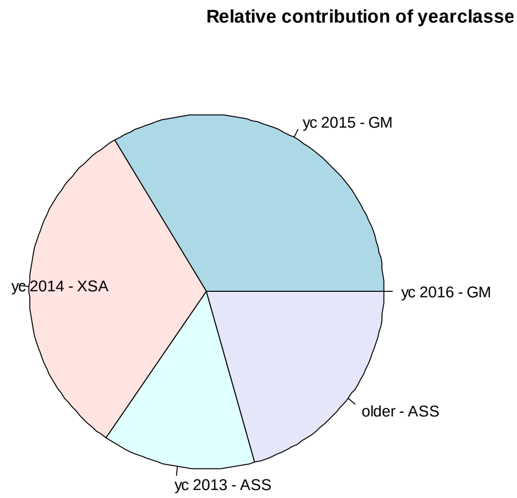


Figure 9.29 Sole 7.d. Relative contribution of year classes to SSB in 2018.

10 Sole (*Solea solea*) in Subarea 4 (North Sea)

The assessment of sole in Subarea 4 is presented as an update assessment. The most recent benchmark assessment was carried out in February 2015 (ICES WKNSEA 2015). More details can be found in the most recent Stock Annex. Only a comprehensive description of the methods and deviations from the stock annex are presented within this Section of the report.

10.1 General

10.1.1 Stock definition

See Stock Annex.

10.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK (2016). All available information on ecological aspects can be found in the Stock Annex.

10.1.3 Fisheries

See Stock Annex for a general comprehensive description of the fishery.

Many vessels in the beam trawl fleet, that is mainly catching sole in the North Sea, have adopted technological developments to their gears. The catch composition of these "advanced" gears are different from the traditional beam trawl (van Marlen *et al.*, 2014). The operational use of these new gears cannot be distinguished using current logbook data.

10.1.4 ICES Advice

The information in this section is taken from the update advice from section 6.3.46 in the Advice summary sheet 2015.

Advice for 2016

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2016 should be no more than 13 031 tonnes. If discard rates do not change from the average (2012–2014), this implies landings of no more than 12 066 tonnes.

Management plan

An evaluation of the management plan (ICES, 2010) concluded that the management plan is precautionary. The stocks are in stage two of the EU multiannual plan (EU, 2007). Application of stage two of the plan is based on transitional arrangements until an evaluation of the plan has been conducted. ICES assumes that harvesting the stock with the newest estimate of FMSY is in accordance with stage two of the current plan.

10.1.5 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages; of which the first stage should be deemed a recovery plan and its second stage a management plan.

The plan was implemented in 2007. ICES has evaluated the plan and found it to be in agreement with the precautionary approach (ICES, 2010). A subsequent evaluation in 2012 (Coers *et al.*, 2012) addressed amendments to the plan in the context of moving towards stage two of the plan.

As of December 2014, the management plan has officially moved to the stage two (EU, 2014).

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 – 2016.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a by-catch. The exploitation of sole and plaice are closely connected as they are caught together in fisheries mainly targeting sole, which are more valuable. This means that the minimum mesh size is decided on the basis of the more valuable species (sole), resulting in substantial discards of undersized plaice. The mixed fisheries for flatfish are dominated by a mixed beam trawl fishery using 80 mm mesh in the southern North Sea where up to 80% in number of all plaice caught are being discarded. Additionally, a shift in the age and size at maturation of plaice has been observed (Grift et al., 2004): plaice become mature at younger ages and at smaller sizes in recent years than in the past. There is a risk that this is caused by a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This shift in maturation also leads to mature fish being of a smaller size-at-age. Measures to reduce discarding in the mixed beam trawl fishery would greatly benefit the plaice stock and future yields. In order to improve the selection pattern, mesh size increases or configuration changes (i.e. square mesh) would help reduce the discards. However, this would result in a short-term loss of marketable sole. Readjustment of minimum landing sizes corresponding to an improved selection pattern could be considered.

Improvements to gear selectivity, which would contribute to a reduction in catches of small fish, must take into account the effect on the other species within the mixed fishery. For instance, mesh enlargement in the flatfish fishery would reduce the catch of undersized plaice, but would also result in loss of marketable sole.

10.2 Data available

10.2.1 Landings

Annual landings by country and TACs are presented next to the landings submitted to InterCatch in Table 10.2.1. The TAC of 11 900 t in 2015 was fully taken and slightly overshot compared to official landings of 12 203 t, and landings reported to ICES of 12 867 t. Landings in numbers by age that are input for the assessment model are presented in Table 10.2.2. A time series of total landings is shown on Figure 10.2.1.

10.2.2 Discards

Discards were included in the assessment after the most recent benchmark (WKNSEA, 2015). A time series from national discard monitoring programmes from 2002 onwards is used since then. Discards in numbers by age from 2002 until present are shown in Table 10.2.3. A time series of total discards is shown on Figure 10.2.2.

10.2.3 InterCatch

Since 2012, InterCatch is used for raising the catch. Age distributions were provided by Denmark, Germany, UK, and the Netherlands, accounting for 86% of the landings in 2105 (Figure 10.2.3).

Discards estimates for 2015 were available from Belgium, Denmark, Germany, the Netherlands, and the UK (Figure 10.2.3.) for 88% of the landings weight. This implies that 78% of the discards were imported and 22% was raised.

First metiers for which yearly discard estimates had been imported were grouped with the same metiers with quarterly landings estimates. Then, discards were raised by grouping metiers with small meshes apart from metiers with larger mesh sizes, and by grouping static gears apart from towed gears. In the towed gear group a distinction was made between otter trawlers and seines, and beam trawlers. Beam trawlers and otter trawlers targeting crustaceans (CRU) with a mesh size smaller than 99mm were grouped together. The remainder, which consisted of metiers which did not fit in any of the above groups or, were then raised with all available discard estimates.

Discard estimates from Scotland (UK) were not included in any of the groups for raising unsampled strata since they held strangely high discard ratios.

Allocation scheme to raise discards and age structures to unsampled fleets

UNSAMPLED FLEET*	SAMPLED FLEET**
Quarterly landings	Yearly discards
GN/GTR/GNS	GN/GTR/GNS
OTB 70 – 99	OTB 70 – 99
OTB 100 – >120	OTB 100 – >120
TBB 70 – 99	TBB 70 – 99
TBB 100 – >120	TBB 100 – >120
OTB & TBB CRU <99	OTB & TBB CRU <99
Others	All métiers, excluding métiers for crustaceans (_CRU)

* Unsampled fleet are those fleets for which no discards or age structure is known.

** Sampled fleet are those fleets for which the discard rate or age structure is known.

10.2.4 Age compositions

In 2015, the age compositions of landings and discards were raised in and exported from InterCatch. The age composition of the landings and discards is presented in numbers in Table 10.2.2–3., and Figure 10.2.4.

For metiers where no age was available, age compositions were allocated using the same method as for the discard raising (described above). These allocations were done separately for discards and landings.

Both catch categories were separately exported from InterCatch. The SOP correction for the landings was 1.000 and was 1.008 for discards.

10.2.5 Weight at age

Since 2012 weights at age in the landings for both sexes combined (Table 10.2.4) are measured weights from the various national market sampling programmes. Discard weights at age (Table 10.2.5) are derived from the various national discard programmes (observer and self-sampling).

Mean stock weights at age (Table 10.2.6.) are the average weights from the 2nd Quarter landings and discards and are derived from the InterCatch (CatchAndSampleDataTable).

Landing, discard, and mean stock weights at age are presented on Figure 10.2.5.

At WGNSSK 2016 the mean weights in quarter 2 for 2015 seemed to be on the low side and sharply contrasted with mean stock weights before 2012. It seems that some countries had submitted strangely low weights for age 1 and 2. After revision of the weight sample data in quarter two, the sample data with unrealistically low weights were taken out of the InterCatch final datafile.

However, stock weights of younger ages after 2012 are still slightly lower than stock weights before 2012. This is because before deriving the mean stock weights from InterCatch (since 2012), these weights were manually raised based on landings only. In that time series (1957–2011) a constant value (0.05) was taken for age 1 and age 2 of that time series only consisted of landings.

Efforts were made at WGNSSK 2016 to revise the stock weights from 2012 but because of unrealistic submitted sample data from some countries this exercise was unsuccessful and only 2015 was corrected.

10.2.6 Maturity and natural mortality

A knife-edged maturity-ogive with full maturation at age 3 is assumed for North Sea sole (Table 10.2.7.).No new data was presented at WGNSKK 2016.

Natural mortality at age (Table 10.2.7.) has been assumed to be constant at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962−1963) (ICES-FWG 1979). The estimate of 0.9 was based on an analysis of CPUE in the fisheries before and after the severe winter (CM 1979/G:10).

10.2.7 Catch, effort and survey data

Two tuning series that take place in quarter 3 are used in the assessment. The BTS-ISIS (Beam Trawl Survey on the RV ISIS) and the SNS (Sole Net Survey) are both surveys conducted by the Netherlands. Catches of sole in the 2012 survey were extremely low and contradicted with the BTS, indicating problems with operating the gear properly on board of the vessel. The data from the SNS survey for the years 2003 and 2012 were not made available.

The BTS-ISIS and SNS 2015 surveys show large yearclasses of 2009–2011 coming through in ages 6–9.

A standardised comparison of the two surveys that are used as tuning indices over the available time series is given in Figure 10.2.7.1. The internal consistency of the year class cohorts in these two surveys is presented in Figure 10.2.7.2.

An additional survey index (the combined Belgian, German, and Dutch DFS0) is used for recruitment estimates in the RCT3 analysis.

All survey indices of importance for the advice are presented in Table 10.2.8.

In autumn, when new data becomes available from the surveys in quarter 3, the advice can be revised if significant changes in the assumptions of recruitment made at WGNSSK 2016 are observed.

10.3 Assessment

The model used is the Art and Poos model (AAP, Aarts and Poos (2009), for more details please refer to the Stock Annex).

Year of assessment:		2016
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
BTS-ISIS	Age range	1–9
	Year range	1985-present
SNS	Age range	1–6
	Year range	1970-present
Catch/Landings		
Age range:		1–10+
Landings data:		1957-present
Discards data		2002-present
Model settings		
Fbar:		2–6
Age from which F is constant (qplat.Fmatrix)		8
Dimension of the F matrix (Fage.knots)		6
Ftime.knots		22
Wtime.knots		5
Age from which q is constant (qplat.surveys)		7

This is an update assessment with, in principle, only an update of historical data and addition of the commercial and survey data in the most recent year. The model settings, defined in the most recent benchmark by WKNSEA (2015), were applied.

The assessment summary is presented in Table 10.3.1. and in Figure 10.3.1. The retrospective performance of the assessment is shown in Figure 10.3.2.

10.4 Recruitment estimates

Recruitment estimation was carried out using RCT3. Input to the RCT3 model is presented in Table 10.4.1. Results are presented in Table 10.4.2. for age 1 and Table 10.4.3. for age 2. Average recruitment of 1-year old fish in the period 1957–2012 was around 111 million (geometric mean).

The results are summarized in the table below and the estimates used for the short-term forecast are underlined.

Year Class	Age in 2016	AAP thousands	RCT3 thousands	GM(1957–2012) thousands
2014	2	163431	137233	99023
2015	1		59248	111851
2016	Recruit (0)			111851

Additional recruitment information will be available from the 3rd quarter surveys (BTS-ISIS, SNS, and DFS) carried out in 2016. ICES will only issue an updated advice if these surveys provide a very different perspective on the short-term developments.

10.5 Short-term forecasts

The short-term forecasts were carried out with FLR. The exploitation pattern (F) was taken to be the mean value of the last three years. Weight-at-age in the stock and weight-at-age in the catch were taken to be the mean of the last three years. Population numbers at ages 2 and older are AAP survivor estimates. Numbers at age 1 are taken from the RCT3 analysis and recruitment of the 2015 and later year-classes are taken from the long-term geometric mean (1957–2011: 94 million). Input to and results from the short term forecast are presented in Table 10.5.1.–3. for F = Fsq and Table 10.5.4–6. for catch = TAC.

For the intermediate year 2016, it was assumed that catches equal the TAC at WGNSSK 2016 (since North Sea sole is under the landings obligation in 2016). The expected landings in 2015 of 12 761 t are close to the agreed TAC of 2015 (12 262 t). Therefore the landings in 2016 are assuming that the TAC will be fully taken. This corresponds with the observations in recent years.

Figure 10.5.1 – 2. shows the relative contribution of assumptions under both scenario's.

10.6 Medium-term forecasts

No medium term projections were done this year.

10.7 Biological reference points

	Type	Value	Technical basis
MSY Approach	MSY Btrigger	37 000 t	Default to value of Bpa
	FMSY	0.2	Median of stochastic MSY analysis assuming a Hockeystick stock-recruit relationship.
	Fmsy-upper	0.37	
	Fmsy-lower	0.11	
Precautionary Approach	Blim	26 300 t	Breakpoint of segmented regression (WKNSEA 2015)
	Bpa	37 000 t	Bpa = 1.4 * Blim
	Flim	0.63	EqSim run with no MSY Btrigger, realistic assessment.advice error, biological parameters (2003–2012) and fishery parameters (2009–2012)
	Fpa	0.44	Fpa = Flim / 1.4

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 2014 the joint ICES-MYFISH Workshop (WKMSYREF3, ICES 2014) held place to consider the basis for FMSY ranges of, among others, SOL4. The workshop convened again under the auspices of WKLIFE in March 2015. This eventually resulted in an F_{msy} range for sole of 0.13–0.27. The point value of F_{msy} was set at 0.2.

At WGNSSK 2016, F_{pa} and F_{lim} were defined according to ICES reference points guidelines (ACOM). An additional F_{pa}(sigma) was estimated by: F_{pa} = F_{lim} / exp(1.645 * sigma), where sigma is the standard deviation of ln(F) in the final assessment year. F_{pa}(sigma) was estimated as 0.48.

10.8 Quality of the assessment

The assessment was benchmarked recently in February 2015 (WKNSEA, 2015). Inclusion of discards in the catches and adding uncertainty estimates were the main goals. This was attained using the AAP-model.

Discards form a minor part of total sole catches, rates have stabilised in the last years. The assessment at present includes 15 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years.

Most of the discards originate from the Netherlands. A self-sampling programme by the Dutch beam-trawl fleet has been in place since 2004. This sampling programme indicates spatial and temporal trends in discarding (higher discards are observed in coastal regions and late summer), but it was considered inappropriate for overall estimates of discarding because of differences in the implementations of sampling methods.

In 2009, a new self-sampling programme was launched to address this. Since 2011, Dutch discard estimates are derived exclusively from the self-sampling programme, while observer estimates are used for validation of the self-sampling data only. Preliminary analyses suggest that the self-sampling estimates are as reliable as those from the observer programme (Chen *et al*. (in press)).

At WGNSSK 2016 the newest data year (2015) was added to the assessment. The assessment performed well and modelled landings, discards, and catch fitted well to observed landings, and discards (Figure 10.8.1–3.). It is apparent that the AAP-model estimates of the landings are slightly overestimated in the recent years. Whereas discards are slightly underestimated.

Residual plots of landings and discards are shown in Figure 10.8.4.–5. Residuals are small for younger ages in discards but tend to be higher for older ages. This is normal since older North Sea sole are not seen in discards.

Sigmas of the different data time series are shown in Figure 10.8.6.

10.9 Status of the Stock

Fishing mortality was estimated at 0.20 in 2015 which is well within biological limits and on F_{msy} (0.2). The SSB in 2015 was estimated at about 49142t which is well above both B_{lim} and B_{pa}.

10.10 Management Considerations

Sole is mainly taken by beam trawlers in a mixed fishery for sole and plaice in the southern and central part of the North Sea. The long term management plan for plaice and sole in the North Sea specifies two distinct phases. The objective of stage one of the flatfish management plan was to bring both sole and plaice stocks within safe biological limits. This objective has been achieved for both stocks. The plaice stock is estimated above B_{pa} since 2005 and the sole stock is above B_{pa} since 2012. Also fishing mortalities are well below F_{pa} for both stocks for a number of years.

The management plan foresees a re-evaluation of the biological objectives and introduction of economic and social objectives after stage 1 is completed. The management plan states that when the stocks of plaice and sole have been found for two years in succession to have returned to within safe biological limits, the Council shall decide on the basis of a proposal from the Commission on the amendment of Articles 4(2) and 4(3) and the amendment of Articles 7, 8 and 9 that will, in the light of the latest scientific advice from the STECF, permit the exploitation of the stocks at a fishing mortality rate compatible with maximum sustainable yield.

The management plan is in stage 2 now and action should be taken to specify the implementation in this stage. The multiannual plan states that, in its second stage, it shall ensure the exploitation of the stocks of plaice and sole on the basis of maximum sustainable yield. An overall objective of the CFP is to aim exploitation of all fish stocks at F_{msy}.

The majority of the sole catches are taken by beam trawlers in a mixed fishery with other flatfish and roundfish species. In general discards of other species in beam trawls are rather high. Due to measures resulting from the flatfish management plan, actions taken to reduce bycatch, disturbance to the sea bottom, and economic incentives (reduce fuel costs), overall effort in the beam fishery has been reduced in the past 16 years by 70%. The significant reduction of effort in the fleet must have contributed to reduce the impact of this fishery on the marine ecosystem.

10.11 Frequency of assessment

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment.

At WGNSSK 2015 the four criteria were assessed. The North Sea sole assessment succeeded in all four criteria. Although the North Sea sole stock is consequently a candidate for less frequent assessments some precautions should be taken in to account:

- North Sea sole is subject to the landing obligation as of 2016, this implies careful proceeding with discard data that are input for the model.
- Furthermore, the main fleet targeting sole is subject to technological changes in their gears. How this technological change affects the selectivity of the fishing gears catching sole and subsequently the age composition of the stock has not been quantified.
- Finally, the assessment currently holds two tuning indices that are not encompassing the whole sole stock in the North Sea and are missing out on the main grounds where sole is found. The positive trend in the assessment and its basis thereof for the second criterion on the frequency of assessment should be therefore taken with caution.

CRITERION	NORTH SEA SOLE
(1) Life span (i.e. maximum normal age) of the species is larger than 5 years	Life span larger than 5 years
(2) The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) is <= F_{upper} (upper bound in F range) AND SSB (start of intermediate year) >= MSY $B_{trigger}$	F(2015) = 0.20 < F_{upper} SSB(2015) = 49142 > $B_{trigger}$= B_{pa}= 37 000
(3) The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers.	The average contribution to the catch in numbers of the recruiting year class in latest 5 years is 19% of the total catch in numbers
(4) The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently overestimated by less than 20%	Rho = -0.1 i.e. F is overestimated by 10%

Table 10.2.1 North Sea sole. Landings per country, total reported landings, ICES total landings, and TAC

Year	BE	DK	FR	GE	NL	UK	Other	Total reported landings	ICES Total landings	TAC
1982	1900	524	686	266	17686	403	2	21467	21579	21000
1983	1740	730	332	619	16101	435		19957	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	26839	20000
1985	2390	692	875	303	14897	774	3	19934	24248	22000
1986	1833	443	296	155	9558	647	2	12934	18201	20000
1987	1644	342	318	210	10635	676	4	13829	17368	14000
1988	1199	616	487	452	9841	740	28	13363	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	21805	14000
1990	2389	1427	352	2296	18202	1614	263	26543	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	22651	23000
1997	1519	689	99	510	10241	479	204	13741	14901	18000
1998	1844	520	510	782	15198	549	339	19742	20868	19100
1999	1919	828	NA	1458	16283	645	501	21634	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	22641	22000
2001	1874	772	411	958	13345	597	394	18351	19944	19000
2002	1437	644	266	759	12120	451	292	15969	16945	16000
2003	1605	703	728	749	12469	521	363	17138	17920	15850
2004	1477	808	655	949	12860	535	544	17828	18757	17000
2005	1374	831	676	756	10917	667	357	15579	16355	18600
2006	980	585	648	475	8299	910	0	11933	12594	17670
2007	955	413	401	458	10365	1203	5	13800	14635	15000
2008	1379	507	714	513	9456	851	15	13435	14071	12800
2009	1353	NA	NA	555	12038	951	1	NA	13952	14000
2010	1268	406	621	537	8770	526	1.38	12129	12603	14100
2011	857	346	539	327	8133	786	2	10990	11485	14100
2012	593	418	633	416	9089	599	3	11752	11602	16200
2013	697	497	680	561	9987	867	0	13291	13137	14000
2014	920	314	675	642	9569	840	0	12547	13060	11900
2015	933	271	532	765	8899	804	0	12203	12867	11900

Table 10.2.2. North Sea sole. Landings in numbers by age (in thousands) as input for the assessment model, age 10 is a plusgroup

	1	2	3	4	5	6	7	8	9	10+
1957	0	1472	10556	13150	3913	3041	6780	1803	529	6541
1958	0	1863	8482	14240	9547	3501	3023	4461	2264	6590
1959	0	3694	12139	10499	9060	5823	1217	2044	2598	5668
1960	0	11965	14043	16691	9248	8313	4815	1583	1049	7851
1961	0	972	50470	19403	12574	4760	3998	4338	847	7355
1962	0	1584	6173	58836	15254	10478	4797	4087	2074	7450
1963	0	670	8271	8485	45823	8420	6603	2403	3365	8316
1964	53	150	2041	5518	3680	16749	3020	1749	790	2913
1965	0	45180	1045	1534	4798	2381	11990	1494	1463	3077
1966	0	12145	132170	979	1168	3649	736	6255	694	2424
1967	0	3769	26260	87039	1998	548	1962	777	5160	2978
1968	1034	17093	13852	24894	48417	461	244	1639	323	6502
1969	404	24404	21884	5433	12638	25646	338	249	1214	5379
1970	1299	6141	25996	8236	1784	3231	11961	246	140	5234
1971	425	33765	14596	12909	4538	1459	2355	7300	194	4649
1972	354	7511	36356	6997	4911	1548	517	1218	4654	2772
1973	716	12459	13025	16493	4101	2368	1013	779	1241	5899
1974	100	15171	21248	5412	6965	1896	1563	649	396	4750
1975	267	23193	28833	11839	2110	3870	798	916	513	3481
1976	1064	3619	28571	14316	4923	987	1950	562	434	2721
1977	1780	22747	12299	15593	7580	1812	325	1133	261	2155
1978	27	24921	29163	6102	6610	4231	1730	608	643	1595
1979	9	8280	41681	16259	3033	3262	1769	826	244	1546
1980	650	1233	12762	18138	7444	1479	2241	1437	374	1227
1981	434	29983	3344	7046	8439	3757	973	909	786	932
1982	2697	26799	46375	1868	3584	4855	1701	623	613	1295
1983	391	34545	41551	21273	626	1383	1958	982	388	1181
1984	192	30839	44081	22631	8821	744	857	1047	526	897
1985	163	16449	42773	20079	9307	3520	207	375	631	965
1986	372	9304	18381	17591	7698	5480	2256	109	281	1671
1987	93	28896	21927	8851	6477	3102	1559	898	81	690
1988	10	13206	47135	15217	4377	3878	1549	890	523	317
1989	115	45652	17973	22295	4551	1627	1414	637	451	459
1990	854	11816	103380	9667	9099	3315	1032	1186	548	837
1991	118	12938	24985	76580	6609	3612	1706	707	718	1072
1992	965	6730	43713	15961	37745	2440	2995	730	393	1163
1993	53	49870	16575	31047	13709	23758	1472	1170	456	833
1994	709	7710	86349	13387	18513	5642	11174	458	905	897
1995	4766	12674	16700	68073	6262	7254	1981	5971	293	665
1996	170	18609	16005	16770	26946	3814	4725	932	3267	976
1997	1574	5987	23418	7253	5058	12667	1189	2303	330	1672
1998	242	56162	15011	14806	3466	1924	4727	787	1022	838

	1	2	3	4	5	6	7	8	9	10+
1999	284	15601	71730	8103	6049	1200	657	1964	328	804
2000	2329	14929	32425	42394	3257	2453	796	431	922	708
2001	857	25045	20925	19260	16211	1383	808	266	163	701
2002	1046	10958	32570	12185	8145	6393	667	592	88	362
2003	1047	32295	17479	16072	5814	3902	2427	400	128	451
2004	516	14960	48003	9531	7462	2167	902	962	389	389
2005	1131	7254	22633	28875	4168	3861	1491	602	768	392
2006	7008	9966	10397	9606	10943	1617	1577	724	373	553
2007	315	39643	10820	6407	5706	5479	819	725	498	541
2008	1959	6325	37427	5996	2928	2393	2613	448	491	459
2009	1630	10417	10771	26548	3278	1652	1591	1532	312	864
2010	371	11659	13354	8530	13623	1817	907	809	1196	690
2011	44	11992	19788	8379	5070	6436	983	431	283	765
2012	1	6439	28605	11069	4285	2146	4072	587	286	1028
2013	0	2741	28189	21500	5643	2042	1532	2246	242	471
2014	371	8111	6916	22942	11440	2591	1808	620	840	459
2015	201	10512	16589	4738	14756	6157	1470	562	393	545

Table 10.2.3. North Sea sole. Discards in numbers by age (in thousands) as input for the assessment model, age 10 is a plusgroup

	1	2	3	4	5	6	7	8	9	10+
2002	6461	12606	5212	1029	272	0	0	0	0	0
2003	1156	7152	5059	1212	381	0	0	0	0	0
2004	2936	12832	7449	1719	518	12	0	0	0	0
2005	2256	5622	4796	1258	375	63	22	0	0	0
2006	2390	5727	2705	654	197	28	18	7	0	0
2007	818	4923	3010	619	226	57	4	0	0	0
2008	1230	2704	1764	371	106	0	8	0	0	0
2009	2695	6480	3652	999	266	5	9	0	0	0
2010	5687	12164	6670	1544	493	31	10	2	2	0
2011	3457	10298	5482	1273	354	33	0	0	0	0
2012	1132	19556	9444	984	230	232	36	4	7	1
2013	4653	5733	12558	3649	340	125	19	3	0	0
2014	7162	5836	2371	3488	1366	238	198	6	0	0
2015	9454	9166	3913	1991	1528	415	15	50	8	1

Table 10.2.4. North Sea sole. Landings weights (kg) at age as input for the assessment model, age 10 is a plusgroup

	1	2	3	4	5	6	7	8	9	10+
1957	0.155	0.154	0.177	0.204	0.248	0.279	0.29	0.335	0.436	0.40813
1958	0.155	0.145	0.178	0.22	0.254	0.273	0.314	0.323	0.388	0.41344
1959	0.155	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.42621
1960	0.155	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.4177
1961	0.155	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.41932
1962	0.155	0.155	0.165	0.208	0.241	0.295	0.32	0.321	0.334	0.41186
1963	0.155	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.48463
1964	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.4805
1965	0.155	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.47972
1966	0.155	0.177	0.19	0.18	0.301	0.332	0.429	0.399	0.449	0.50148
1967	0.155	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.49123
1968	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.50752
1969	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.52271
1970	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.5326
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.42	0.49	0.534	0.54714
1972	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.62907
1973	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.58575
1974	0.164	0.192	0.233	0.338	0.418	0.448	0.52	0.559	0.609	0.65327
1975	0.129	0.182	0.225	0.32	0.406	0.456	0.529	0.595	0.629	0.66935
1976	0.143	0.19	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.66472
1977	0.147	0.188	0.236	0.307	0.369	0.424	0.43	0.52	0.562	0.6194
1978	0.152	0.196	0.231	0.314	0.37	0.426	0.466	0.417	0.572	0.66635
1979	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.76296
1980	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.55	0.598	0.68412
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.63022
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.65568
1983	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.64225
1984	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.63382
1985	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.64476
1986	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.60955
1987	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.65696
1988	0.127	0.175	0.217	0.27	0.354	0.428	0.484	0.521	0.559	0.71241
1989	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.47	0.61107
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.61975
1991	0.127	0.186	0.21	0.263	0.315	0.436	0.443	0.467	0.507	0.55809
1992	0.146	0.178	0.213	0.258	0.298	0.38	0.409	0.46	0.487	0.55569
1993	0.097	0.167	0.196	0.239	0.264	0.3	0.338	0.441	0.496	0.60312
1994	0.143	0.18	0.202	0.228	0.257	0.3	0.317	0.432	0.409	0.51009
1995	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.59158
1996	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.37	0.39	0.59428
1997	0.151	0.18	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.4396
1998	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.50367

	1	2	3	4	5	6	7	8	9	10+
1999	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.45268
2000	0.145	0.17	0.2	0.248	0.29	0.299	0.323	0.368	0.402	0.42761
2001	0.143	0.185	0.202	0.27	0.275	0.333	0.391	0.414	0.433	0.49344
2002	0.14	0.183	0.211	0.243	0.281	0.312	0.366	0.319	0.571	0.53635
2003	0.136	0.182	0.214	0.256	0.273	0.317	0.34	0.344	0.503	0.43054
2004	0.127	0.18	0.209	0.252	0.263	0.284	0.378	0.367	0.327	0.42456
2005	0.172	0.185	0.207	0.243	0.241	0.282	0.265	0.377	0.318	0.40057
2006	0.156	0.19	0.22	0.263	0.291	0.322	0.293	0.358	0.397	0.39622
2007	0.154	0.18	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.32644
2008	0.15	0.181	0.223	0.24	0.265	0.324	0.314	0.297	0.307	0.41748
2009	0.138	0.185	0.202	0.256	0.275	0.278	0.325	0.334	0.303	0.39787
2010	0.163	0.181	0.22	0.236	0.273	0.308	0.283	0.311	0.361	0.38068
2011	0.152	0.162	0.194	0.233	0.242	0.274	0.272	0.293	0.335	0.34695
2012	0.095	0.169	0.185	0.233	0.256	0.234	0.27	0.26	0.283	0.269
2013	0.125	0.169	0.185	0.224	0.253	0.266	0.297	0.278	0.309	0.466
2014	0.155	0.191	0.212	0.228	0.263	0.273	0.249	0.279	0.319	0.351
2015	0.145	0.169	0.205	0.24	0.263	0.274	0.304	0.293	0.33	0.31934

Table 10.2.5. North Sea sole. Discard weights (kg) at age as input for the assessment model, age 10 is a plusgroup

	1	2	3	4	5	6	7	8	9	10+
2002	0.046	0.068	0.084	0.091	0.096	0.11	0.124	0.137	0.137	0
2003	0.054	0.087	0.1	0.107	0.114	0.11	0.124	0.137	0.137	0
2004	0.065	0.089	0.103	0.111	0.118	0.095	0.124	0.137	0.137	0
2005	0.068	0.089	0.104	0.109	0.114	0.103	0.107	0.137	0.137	0
2006	0.066	0.082	0.099	0.109	0.108	0.115	0.113	0.121	0.137	0
2007	0.066	0.087	0.098	0.102	0.107	0.104	0.121	0.136	0.136	0
2008	0.064	0.086	0.101	0.112	0.124	0.11	0.111	0.137	0.137	0
2009	0.066	0.089	0.101	0.106	0.114	0.126	0.104	0.137	0.137	0
2010	0.066	0.083	0.096	0.105	0.109	0.111	0.113	0.121	0.121	0
2011	0.053	0.081	0.093	0.104	0.113	0.104	0.11	0.122	0.126	0
2012	0.059	0.075	0.09	0.096	0.111	0.08	0.115	0.122	0.121	0.14
2013	0.041	0.075	0.086	0.1	0.117	0.09	0.112	0.117	0.121	0
2014	0.051	0.079	0.089	0.097	0.106	0.1	0.117	0.099	0.147	0
2015	0.032	0.076	0.095	0.087	0.105	0.117	0.132	0.124	0.159	0.199

Table 10.2.6. North Sea sole. Stock weights (kg) at age (kg) as input for the assessment model, age 10 is a plusgroup. Mean weights of sampled catches in quarter 2 are exported from InterCatch. Danish weights were not extracted for quarter 2 at WGNSSK 2016

	1	2	3	4	5	6	7	8	9	10+
1957	0.025	0.07	0.147	0.187	0.208	0.253	0.262	0.355	0.39	0.36517
1958	0.025	0.07	0.164	0.205	0.226	0.228	0.297	0.318	0.393	0.4215
1959	0.025	0.07	0.159	0.198	0.239	0.271	0.292	0.276	0.303	0.42579
1960	0.025	0.07	0.163	0.207	0.234	0.24	0.268	0.242	0.36	0.43132
1961	0.025	0.07	0.148	0.206	0.235	0.232	0.259	0.274	0.281	0.39639
1962	0.025	0.07	0.148	0.192	0.24	0.301	0.293	0.282	0.273	0.44136
1963	0.025	0.07	0.148	0.193	0.243	0.275	0.311	0.363	0.329	0.46536
1964	0.025	0.07	0.159	0.214	0.24	0.291	0.305	0.306	0.365	0.47387
1965	0.025	0.14	0.198	0.223	0.251	0.297	0.337	0.358	0.526	0.46044
1966	0.025	0.07	0.16	0.149	0.389	0.31	0.406	0.377	0.385	0.50451
1967	0.025	0.177	0.164	0.235	0.242	0.399	0.362	0.283	0.381	0.45912
1968	0.025	0.122	0.171	0.248	0.312	0.28	0.629	0.416	0.41	0.48561
1969	0.025	0.137	0.174	0.252	0.324	0.364	0.579	0.415	0.469	0.52107
1970	0.025	0.137	0.201	0.275	0.341	0.367	0.423	0.458	0.39	0.55442
1971	0.034	0.148	0.213	0.313	0.361	0.41	0.432	0.474	0.483	0.53254
1972	0.038	0.155	0.218	0.313	0.419	0.443	0.443	0.443	0.508	0.60178
1973	0.039	0.149	0.226	0.322	0.371	0.433	0.452	0.472	0.446	0.53554
1974	0.035	0.146	0.218	0.329	0.408	0.429	0.499	0.565	0.542	0.61804
1975	0.035	0.148	0.206	0.311	0.403	0.446	0.508	0.582	0.58	0.6501
1976	0.035	0.142	0.201	0.301	0.379	0.458	0.508	0.517	0.644	0.66481
1977	0.035	0.147	0.202	0.291	0.365	0.409	0.478	0.487	0.531	0.64434
1978	0.035	0.139	0.211	0.29	0.365	0.429	0.427	0.385	0.542	0.64441
1979	0.045	0.148	0.211	0.3	0.352	0.429	0.521	0.562	0.567	0.74343
1980	0.039	0.157	0.2	0.304	0.345	0.394	0.489	0.537	0.579	0.64513
1981	0.05	0.137	0.2	0.305	0.364	0.402	0.454	0.522	0.561	0.62226
1982	0.05	0.13	0.193	0.27	0.359	0.411	0.429	0.476	0.583	0.64223
1983	0.05	0.14	0.2	0.285	0.329	0.435	0.464	0.483	0.51	0.63619
1984	0.05	0.133	0.203	0.268	0.348	0.386	0.488	0.591	0.567	0.66346
1985	0.05	0.127	0.185	0.267	0.324	0.381	0.38	0.626	0.554	0.64227
1986	0.05	0.133	0.191	0.278	0.345	0.423	0.495	0.487	0.587	0.68625
1987	0.05	0.154	0.191	0.262	0.357	0.381	0.406	0.454	0.332	0.61971
1988	0.05	0.133	0.193	0.26	0.335	0.409	0.417	0.474	0.486	0.65433
1989	0.05	0.133	0.195	0.29	0.35	0.34	0.411	0.475	0.419	0.59444
1990	0.05	0.148	0.203	0.294	0.357	0.447	0.399	0.494	0.481	0.65279
1991	0.05	0.139	0.184	0.254	0.301	0.413	0.447	0.522	0.548	0.57344
1992	0.05	0.156	0.194	0.257	0.307	0.398	0.406	0.472	0.5	0.54009
1993	0.05	0.128	0.184	0.229	0.265	0.293	0.344	0.482	0.437	0.58327
1994	0.05	0.143	0.174	0.209	0.257	0.326	0.349	0.402	0.494	0.45895
1995	0.05	0.151	0.179	0.24	0.253	0.321	0.365	0.357	0.545	0.54526
1996	0.05	0.147	0.178	0.208	0.274	0.268	0.321	0.375	0.402	0.54643
1997	0.05	0.15	0.19	0.225	0.252	0.303	0.319	0.325	0.36	0.42402
1998	0.05	0.14	0.173	0.234	0.267	0.281	0.328	0.273	0.336	0.4546

	1	2	3	4	5	6	7	8	9	10+
1999	0.05	0.131	0.187	0.216	0.259	0.296	0.34	0.322	0.369	0.46388
2000	0.05	0.139	0.185	0.226	0.264	0.275	0.287	0.337	0.391	0.3763
2001	0.05	0.144	0.185	0.223	0.263	0.319	0.327	0.421	0.41	0.53023
2002	0.05	0.145	0.197	0.245	0.267	0.267	0.299	0.308	0.435	0.43536
2003	0.05	0.146	0.194	0.24	0.256	0.288	0.33	0.312	0.509	0.46973
2004	0.05	0.137	0.195	0.24	0.245	0.305	0.316	0.448	0.356	0.60138
2005	0.05	0.15	0.189	0.234	0.237	0.258	0.276	0.396	0.369	0.42863
2006	0.05	0.148	0.197	0.25	0.27	0.319	0.286	0.341	0.409	0.45521
2007	0.05	0.152	0.179	0.216	0.242	0.245	0.275	0.252	0.257	0.36401
2008	0.05	0.154	0.198	0.212	0.239	0.302	0.282	0.231	0.274	0.40044
2009	0.05	0.142	0.185	0.232	0.255	0.279	0.283	0.333	0.302	0.39017
2010	0.05	0.149	0.2	0.23	0.272	0.307	0.336	0.336	0.361	0.41003
2011	0.05	0.141	0.179	0.223	0.261	0.276	0.32	0.36	0.444	0.39082
2012	0.025	0.058	0.144	0.205	0.23	0.209	0.251	0.235	0.334	0.223
2013	0.034	0.068	0.117	0.186	0.254	0.258	0.309	0.241	0.325	0.562
2014	0.022	0.079	0.136	0.188	0.212	0.227	0.228	0.29	0.343	0.603
2015	0.07	0.075	0.142	0.148	0.227	0.244	0.263	0.288	0.37	0.38939

Table 10.2.7. North Sea sole. Natural mortality at age and maturity ate 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	1	1	1	1	1	1	1	1

Table 10.2.8. North Sea sole. Survey tuning indices

BTS-ISIS	1	2	3	4	5	6	7	8	9
1985	7.031	7.121	3.695	1.654	0.688	0.276	0	0	0
1986	7.168	5.183	1.596	0.987	0.623	0.171	0.158	0	0.018
1987	6.973	12.548	1.834	0.563	0.583	0.222	0.228	0.058	0
1988	83.111	12.512	2.684	1.032	0.123	0.149	0.132	0.103	0.014
1989	9.015	68.084	4.191	4.096	0.677	0.128	0.242	0	0.051
1990	37.839	24.487	21.789	0.778	1.081	0.77	0.12	0.115	0.025
1991	4.035	28.841	6.872	6.453	0.136	0.135	0.063	0.045	0.013
1992	81.625	22.284	10.449	2.529	3.018	0.09	0.162	0.078	0.02
1993	6.35	42.345	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	7.66	7.121	19.743	0.124	1.636	0.088	0.983	0.009	0
1995	28.125	8.458	6.268	5.129	0.363	0.805	0.316	0.734	0.039
1996	3.975	7.634	1.955	1.785	2.586	0.326	0.393	0.052	0.264
1997	169.343	4.919	2.985	0.739	0.71	0.38	0.096	0.035	0.042
1998	17.108	27.422	1.862	1.242	0.073	0.015	0.391	0	0
1999	11.96	18.363	15.783	0.584	1.92	0.31	0.218	0.604	0.003
2000	14.594	6.144	4.045	1.483	0.263	0.141	0.06	0.007	0.15
2001	7.998	9.963	2.156	1.564	0.684	0.074	0.037	0.028	0
2002	20.989	4.182	3.428	0.886	0.363	0.361	0.032	0.069	0
2003	10.507	9.947	2.459	1.67	0.36	0.187	0.319	0	0.02
2004	4.192	4.354	3.553	0.644	0.626	0.118	0.07	0.073	0
2005	5.534	3.395	2.377	1.303	0.167	0.171	0.077	0.047	0
2006	17.089	2.332	0.278	0.709	0.479	0.151	0.088	0	0.007
2007	7.498	19.504	1.464	0.565	0.315	0.537	0.031	0.009	0
2008	15.247	9.062	12.298	1.313	0.222	0.279	0.202	0.028	0.047
2009	15.95	4.999	2.858	4.791	0.252	0.124	0.272	0.079	0
2010	54.811	10.707	2.027	0.774	1.252	0.143	0.122	0.005	0.027
2011	26.166	17.387	4.006	1.094	0.778	0.828	0.013	0	0.141
2012	5.149	18.212	8.863	1.692	0.764	0.257	0.229	0.046	0
2013	6.844	3.558	12.566	5.385	0.871	0.197	0.105	0.078	0.019
2014	18.926	15.576	3.373	6.763	3.208	0.377	0.101	0.02	0
2015	21.099	25.601	9.66	1.294	4.576	1.502	0.419	0.122	0.15

SNS	1	2	3	4	5	6
1970	5410	734	238	35	4	0
1971	903	1831	113	3	28.9	0
1972	1455	272	149	NA	28.3	0
1973	5587	935	84	37	13	0
1974	2348	361	65	NA	0	4.4
1975	525	865	177	18	0	17.1
1976	1399	74	229	27	5.7	0
1977	3743	776	104	43	31.7	3.9
1978	1548	1355	294	28	99.4	13.3
1979	94	408	301	78	0	16.7
1980	4313	89	109	61	3.3	0
1981	3737	1413	50	20	0	0
1982	5857	1146	228	7	10	0
1983	2621	1123	121	40	0	19.7
1984	2493	1100	318	74	8	0
1985	3619	716	167	49	4.4	0
1986	3705	458	69	31	16.7	0
1987	1948	944	65	21	0	0
1988	11227	594	282	82	10.2	15.5
1989	2831	5005	208	53	18.2	18.6
1990	2856	1120	914	100	49.6	12.5
1991	1254	2529	514	624	27.2	35.8
1992	11114	144	360	195	284.8	20
1993	1291	3420	154	213	0	191.7
1994	652	498	934	10	59.3	0
1995	1362	224	143	411	7.1	31.1
1996	218	349	30	36	90	10
1997	10279	154	190	27	58.1	230
1998	4095	3126	142	99	0	10
1999	1649	972	456	10	20.7	0
2000	1639	126	166	118	0	2
2001	970	655	107	36	56.2	0
2002	7548	379	195	NA	30.8	19.2
2003	NA	NA	NA	NA	NA	NA
2004	1370	624	393	69	53.1	7.5
2005	568	163	124	NA	21.3	6.7
2006	2726	117	25	30	0	0
2007	849	911	33	40	14.4	0
2008	1259	259	325	NA	10	0
2009	1932	344	62	103	0	0
2010	2637	237	67	42	23.2	0
2011	1248	884	211	112	0	38
2012	NA	NA	NA	NA	NA	NA
2013	967	427	491	179	50.8	7.6
2014	2849	448	45	60	34	0
2015	3192	2334	138	160	162	151

DFS0	nl	be	de	combined
1970	21.56			
1971	20.35			
1972	0.76			
1973	6.52			
1974	1.06		0.21	
1975	9.65		3.79	
1976	4.23		0.55	
1977	1.12		2.80	
1978	5.80		3.10	
1979	12.76		1.33	
1980	26.17		3.56	
1981	15.61		2.10	
1982	12.75		1.11	
1983	4.31	2.67	2.14	
1984	7.27	5.40	1.14	
1985	12.03	16.98	0.03	
1986	4.41	2.56	0.31	
1987	30.82	2.29	1.27	
1988	1.67	0.70	3.17	
1989	3.02	1.00	0.43	
1990	0.44	0.36	0.23	6.38
1991	14.52	2.17	0.87	167.56
1992	0.76	0.16	0.19	9.27
1993	1.26	0.45	0.12	15.32
1994	1.82	0.69	0.15	22.06
1995	0.28	1.57	0.09	7.06
1996	2.45	4.95	0.55	40.27
1997	2.14	1.40	0.03	26.94
1998	1.26	3.48	0.18	
1999	1.34	2.31	0.10	
2000	0.72	0.53	0.12	9.50
2001	2.65	9.45	0.05	51.42
2002	2.43	13.39	0.18	58.58
2003	0.62	1.50	0.10	10.61
2004	0.59	10.52	0.05	31.25
2005	2.24	5.66	0.99	40.99
2006	1.04	0.34	0.12	12.57
2007	0.86	1.74	0.05	13.73
2008	0.97	0.43	0.02	11.77
2009	1.22	5.52	0.31	27.33
2010	2.24	7.72	0.024	42.86
2011	0.98	0.48	0.07	12.13
2012	0.92	0.43	0.05	11.23
2013	3.46	1.94	0.72	44.82
2014	1.98	0.69	0.07	23.62
2015	0.56	0.46	0.05	7.45

Table 10.3.1. North Sea sole. Assessment summary

Year	Recruitment	SSB	Landings	Discards	Fbar
	Age 1				Ages 2-6
	thousands	tonnes	tonnes	tonnes	
1957	133173	62928	13181	739	0.213
1958	120070	65375	13235	701	0.216
1959	446825	68284	15479	937	0.228
1960	41799	69492	17466	1260	0.257
1961	68261	103720	27981	2777	0.305
1962	11057	87064	28290	1481	0.347
1963	12754	70159	22572	778	0.338
1964	611539	51556	14772	280	0.291
1965	151219	41217	10450	895	0.265
1966	55092	109817	32060	4723	0.297
1967	85651	106122	32749	2668	0.389
1968	120554	91237	34733	1819	0.501
1969	86543	69397	23590	2116	0.542
1970	203014	63714	21091	2200	0.522
1971	57000	56001	21295	2700	0.504
1972	110647	65080	25195	2221	0.525
1973	146093	47830	20773	1631	0.556
1974	122131	46208	20616	2120	0.551
1975	59092	46806	19338	2178	0.505
1976	138917	45552	16824	1631	0.464
1977	172911	37143	15510	1658	0.458
1978	63381	43159	18781	2233	0.483
1979	17880	52765	23045	2133	0.517
1980	181294	39168	16474	1040	0.531
1981	218640	25990	13339	1740	0.536
1982	204054	37887	20355	3565	0.558
1983	203846	49563	25889	4071	0.604
1984	95271	51530	27521	3874	0.646
1985	111974	47927	25123	2846	0.644
1986	163489	38037	18051	1841	0.593
1987	84106	34507	15870	1950	0.534
1988	686583	42206	17661	1996	0.499
1989	135009	38607	21383	3764	0.489
1990	247976	125120	48929	6398	0.491
1991	88638	91008	38715	3537	0.494
1992	442592	88799	34069	2956	0.506
1993	88109	59020	29598	3671	0.534
1994	64572	85156	34753	4031	0.573
1995	113851	64557	30630	2296	0.618
1996	76031	38480	20241	1749	0.654

Year	Recruitment	SSB	Landings	Discards	Fbar
1997	326152	32375	16388	2045	0.666
1998	150896	24075	18008	3556	0.662
1999	116975	48060	24942	3937	0.647
2000	140444	40595	20461	2610	0.627
2001	72200	34640	18453	2247	0.612
2002	217842	35489	16617	1817	0.603
2003	96079	27520	16691	3007	0.596
2004	52786	39574	17420	2800	0.575
2005	51243	31191	12936	1535	0.53
2006	188203	25213	10577	1078	0.485
2007	69450	18415	9460	1576	0.458
2008	79121	36219	13352	1836	0.451
2009	103169	31630	12399	1480	0.447
2010	217368	31029	11971	1596	0.425
2011	228790	30767	11997	2015	0.384
2012	58439	38452	14339	2147	0.335
2013	132788	48012	15059	1602	0.286
2014	240457	45163	13302	1398	0.24
2015	194127	49142	12630	1663	0.201
2016	59248	64312			
Average	150624	53168	20587	2257	0.475

Table 10.4.1. North Sea sole. Input table for RCT3 analysis

yearclass	N_Age_1	N_Age_2	DFS0	SNS0	SNS1	BTS1
1974	59092	52591	NA	174.4	525.4	NA
1975	138917	122596	NA	577.5	1399.4	NA
1976	172911	153675	NA	464.6	3742.9	NA
1977	63381	56908	NA	1585	1547.7	NA
1978	17880	16108	NA	10370.5	93.8	NA
1979	181294	163061	NA	3922.7	4312.9	NA
1980	218640	195134	NA	5145.8	3737.2	NA
1981	204054	179807	NA	3240.7	5856.5	NA
1982	203846	179488	NA	2147	2621.1	NA
1983	95271	84715	NA	769.1	2493.1	NA
1984	111974	100418	NA	3334	3619.4	7.031
1985	163489	147256	NA	2713.4	3705.1	7.168
1986	84106	75889	NA	742	1947.9	6.973
1987	686583	619725	NA	13610.1	11226.7	83.111
1988	135009	121800	NA	522.7	2830.7	9.015
1989	247976	223426	NA	1743.4	2856.2	37.839
1990	88638	79701	6.38	50.8	1253.6	4.035
1991	442592	396755	167.56	3639.7	11114	81.625
1992	88109	78597	9.27	302.9	1290.8	6.35
1993	64572	57149	15.32	231.3	651.8	7.66
1994	113851	99840	22.06	4692.7	1362.1	28.125
1995	76031	66385	7.06	1374.9	218.4	3.975
1996	326152	285876	40.27	2322.3	10279.3	169.343
1997	150896	133132	26.94	803	4094.6	17.108
1998	116975	103693	NA	327.9	1648.9	11.96
1999	140444	124684	NA	2187.9	1639.2	14.594
2000	72200	63920	9.5	70	970.3	7.998
2001	217842	190844	51.42	8340	7547.5	20.989
2002	96079	82677	58.58	1127.7	NA	10.507
2003	52786	45003	10.61	NA	1369.5	4.192
2004	51243	44337	31.25	162	568.1	5.534
2005	188203	165500	40.99	305	2726.4	17.089
2006	69450	61423	12.57	16	848.6	7.498
2007	79121	69716	13.73	466.9	1259.1	15.247
2008	103169	90232	11.77	754.7	1931.6	15.95
2009	217368	189870	27.33	2291	2636.9	54.811
2010	228790	201060	42.86	333.9	1248	26.166
2011	58439	51568	12.13	136.3	226.6	5.149
2012	NA	116775	11.23	144.7	967.4	6.844
2013	NA	NA	44.82	237.3	2849	18.926
2014	NA	NA	23.62	126	3192	21.099
2015	NA	NA	7.45	109.7	NA	NA

Table 10.4.2. North Sea sole. RCT3 results for age 1 in 2016 (yearclass 2015)

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years : 1974 - 2015

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0005	8.590	0.5719	0.5608	20	3.162	11.75	0.6180	0.1577
SNS0	1.0228	4.783	1.4378	0.1860	37	4.836	9.73	1.5307	0.0257
SNS1	0.7542	6.049	0.4127	0.7425	37	8.068	12.13	0.4316	0.3233
BTS1	0.7590	9.754	0.3838	0.7476	28	3.049	12.07	0.4066	0.3642
VPA Mean	NA	NA	NA	NA	38	NA	11.71	0.6827	0.1292

yearclass:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0005	8.590	0.5719	0.5608	20	2.008	10.599	0.6409	0.48648
SNS0	1.0228	4.783	1.4378	0.1860	37	4.698	9.588	1.5354	0.08477
SNS1	0.7542	6.049	0.4127	0.7425	37	NA	NA	NA	NA
BTS1	0.7590	9.754	0.3838	0.7476	28	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	38	NA	11.710	0.6827	0.42875

	WAP	logWAP	int.se
yearclass:2014	152290	11.93	0.2454
yearclass:2015	59248	10.99	0.4470

Table 10.4.3. North Sea sole. RCT3 results for age 2 in 2016 (yearclass 2014)

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years : 1974 – 2015

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0295	8.410	0.6056	0.5224	21	3.162	11.666	0.6522	0.15029
SNS0	1.0249	4.700	1.4534	0.1790	38	4.836	9.656	1.5430	0.02685
SNS1	0.7575	5.918	0.4180	0.7333	38	8.068	12.030	0.4368	0.33505
BTS1	0.7719	9.617	0.4052	0.7226	29	3.049	11.971	0.4286	0.34794
VPA Mean	NA	NA	NA	NA	39	NA	11.590	0.6760	0.13987

yearclass:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0295	8.410	0.6056	0.5224	21	2.008	10.478	0.6743	0.45774
SNS0	1.0249	4.700	1.4534	0.1790	38	4.698	9.514	1.5475	0.08691
SNS1	0.7575	5.918	0.4180	0.7333	38	NA	NA	NA	NA
BTS1	0.7719	9.617	0.4052	0.7226	29	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	39	NA	11.590	0.6760	0.45535

	WAP	logWAP	int.se
yearclass:2014	137233	11.83	0.2528
yearclass:2015	54213	10.90	0.4562

Table 10.5.1. North Sea sole. Input and assumptions for 2016 to the short term forecast (F values presented are assuming F = Fsq)

ssb	f2-6	f_dis1-3	f_hc2-6	recruits	landings	discards	catch	TAC			
64312	0.201	0.052	0.171	59248	14823	1543	16366	13262			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2016	0.04	0.03	0.01	59248	0.07	0.14	0.04	0.04	0	0.1
2	2016	0.1	0.05	0.06	163431	0.13	0.18	0.08	0.07	0	0.1
3	2016	0.22	0.06	0.16	165908	0.17	0.2	0.09	0.13	1	0.1
4	2016	0.26	0.03	0.23	69351	0.21	0.23	0.09	0.17	1	0.1
5	2016	0.22	0.01	0.21	20511	0.25	0.26	0.11	0.23	1	0.1
6	2016	0.2	0	0.2	48812	0.27	0.27	0.1	0.24	1	0.1
7	2016	0.21	0	0.2	27755	0.28	0.28	0.12	0.27	1	0.1
8	2016	0.21	0	0.21	8087	0.28	0.28	0.11	0.27	1	0.1
9	2016	0.21	0	0.21	3861	0.32	0.32	0.14	0.35	1	0.1
10	2016	0.21	0	0.21	5512	0.38	0.38	0.07	0.52	1	0.1
1	2017	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1
2	2017	0.1	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2017	0.22	0.06	0.16	NA	0.17	0.2	0.09	0.13	1	0.1
4	2017	0.26	0.03	0.23	NA	0.21	0.23	0.09	0.17	1	0.1
5	2017	0.22	0.01	0.21	NA	0.25	0.26	0.11	0.23	1	0.1
6	2017	0.2	0	0.2	NA	0.27	0.27	0.1	0.24	1	0.1
7	2017	0.21	0	0.2	NA	0.28	0.28	0.12	0.27	1	0.1
8	2017	0.21	0	0.21	NA	0.28	0.28	0.11	0.27	1	0.1
9	2017	0.21	0	0.21	NA	0.32	0.32	0.14	0.35	1	0.1
10	2017	0.21	0	0.21	NA	0.38	0.38	0.07	0.52	1	0.1
1	2018	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1
2	2018	0.1	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2018	0.22	0.06	0.16	NA	0.17	0.2	0.09	0.13	1	0.1
4	2018	0.26	0.03	0.23	NA	0.21	0.23	0.09	0.17	1	0.1
5	2018	0.22	0.01	0.21	NA	0.25	0.26	0.11	0.23	1	0.1
6	2018	0.2	0	0.2	NA	0.27	0.27	0.1	0.24	1	0.1
7	2018	0.21	0	0.2	NA	0.28	0.28	0.12	0.27	1	0.1
8	2018	0.21	0	0.21	NA	0.28	0.28	0.11	0.27	1	0.1
9	2018	0.21	0	0.21	NA	0.32	0.32	0.14	0.35	1	0.1
10	2018	0.21	0	0.21	NA	0.38	0.38	0.07	0.52	1	0.1

Table 10.5.2. North Sea sole. Results from the short term forecast assuming F = Fsq.

basis	landings	f2-6	f_hc2-6	f_dis1-3	discards	catch	ssb2017	ssb2018	ssb_change	tac_change
Fmp	16165	0.2	0.17	0.05	1232	17397	74186	70778	-5	31
Ftar	16165	0.2	0.17	0.05	1232	17397	74186	70778	-5	31
Fmsy	16165	0.2	0.17	0.05	1232	17397	74186	70778	-5	31
Fmsy_low	9326	0.11	0.09	0.03	707	10032	74186	78026	5	-24
Fmsy_high	27393	0.37	0.31	0.09	2111	29505	74186	58925	-21	122
Fpa	31449	0.44	0.37	0.11	2435	33885	74186	54660	-26	156
Fpasig	33633	0.48	0.41	0.12	2611	36245	74186	52367	-29	173
Flim	40580	0.62	0.53	0.16	3180	43760	74186	45099	-39	230
SSB>Bpa	48371	0.807	0.68	0.21	3836	52207	74186	37000	-50	294
SSB>Blim	58778	1.132	0.96	0.29	4759	63537	74186	26300	-65	379
SSB>MSYBtrig	48371	0.807	0.68	0.21	3836	52207	74186	37000	-50	294
TACsq	12326	0.148	0.13	0.04	936	13262	74186	74844	1	0
15%_TAC_inc	14173	0.173	0.15	0.04	1078	15251	74186	72887	-2	15
15%_TAC_dec	10478	0.125	0.11	0.03	795	11273	74186	76803	4	-15
Fsq*0	0	0	NA	NA	0	0	74186	87936	19	-100
Fsq*0.25	4378	0.05	0.04	0.01	330	4709	74186	83279	12	-64
Fsq*0.5	8604	0.101	0.09	0.03	652	9256	74186	78791	6	-30
Fsq*0.9	14777	0.181	0.15	0.05	1125	15901	74186	72248	-3	20
Fsq*1	16237	0.201	0.17	0.05	1238	17475	74186	70701	-5	32
Fsq*1.1	17737	0.222	0.19	0.06	1354	19091	74186	69114	-7	44
Fsq*1.25	19822	0.252	0.21	0.06	1516	21338	74186	66911	-10	61
Fsq*1.5	23149	0.302	0.26	0.08	1776	24925	74186	63398	-15	88
Fsq*1.75	26300	0.352	0.3	0.09	2025	28325	74186	60076	-19	114
Fsq*2	29344	0.403	0.34	0.1	2267	31610	74186	56873	-23	138

Table 10.5.3. North Sea sole. Detailed STF table by age, assuming F = Fsq, rescaled

AGE	YEAR	F	FDISC	FLAND	STOCKN	CATCHWT	LANDINGSWT	DISCARDSWT	STOCKWT	MAT	M	CATCHN	CATCH	LANDINGSN	LANDINGS	DISCARDSN	DISCARDS	SSB	TSB
1	2016	0.04	0.03	0.01	59248	0.07	0.14	0.04	0.04	0	0.1	2191	163	719	102	1472	61	0	2488
2	2016	0.105	0.05	0.06	163431	0.13	0.18	0.08	0.07	0	0.1	15521	2030	8425	1486	7096	544	0	12094
3	2016	0.215	0.06	0.16	165908	0.17	0.2	0.09	0.13	1	0.1	30572	5264	22707	4557	7865	708	21845	21845
4	2016	0.262	0.03	0.23	69351	0.21	0.23	0.09	0.17	1	0.1	15234	3256	13335	3076	1900	180	12067	12067
5	2016	0.222	0.01	0.21	20511	0.25	0.26	0.11	0.23	1	0.1	3898	980	3682	956	216	24	4738	4738
6	2016	0.203	0	0.2	48812	0.27	0.27	0.1	0.24	1	0.1	8545	2282	8344	2261	201	21	11861	11861
7	2016	0.206	0	0.2	27755	0.28	0.28	0.12	0.27	1	0.1	4918	1386	4870	1380	48	6	7401	7401
8	2016	0.209	0	0.21	8087	0.28	0.28	0.11	0.27	1	0.1	1452	410	1446	410	6	1	2208	2208
9	2016	0.209	0	0.21	3861	0.32	0.32	0.14	0.35	1	0.1	693	221	692	221	1	0	1336	1336
10	2016	0.209	0	0.21	5512	0.38	0.38	0.07	0.52	1	0.1	990	375	989	375	1	0	2856	2856
1	2017	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1	4136	307	1357	192	2779	115	0	4698
2	2017	0.105	0.05	0.06	51527	0.13	0.18	0.08	0.07	0	0.1	4894	640	2656	468	2237	172	0	3813
3	2017	0.215	0.06	0.16	133133	0.17	0.2	0.09	0.13	1	0.1	24533	4224	18221	3656	6311	568	17529	17529
4	2017	0.262	0.03	0.23	121103	0.21	0.23	0.09	0.17	1	0.1	26603	5685	23285	5371	3317	314	21072	21072
5	2017	0.222	0.01	0.21	48298	0.25	0.26	0.11	0.23	1	0.1	9179	2307	8671	2252	508	56	11157	11157
6	2017	0.203	0	0.2	14860	0.27	0.27	0.1	0.24	1	0.1	2601	695	2540	688	61	6	3611	3611
7	2017	0.206	0	0.2	36055	0.28	0.28	0.12	0.27	1	0.1	6389	1800	6327	1793	63	8	9615	9615
8	2017	0.209	0	0.21	20445	0.28	0.28	0.11	0.27	1	0.1	3671	1038	3656	1036	15	2	5581	5581
9	2017	0.209	0	0.21	5939	0.32	0.32	0.14	0.35	1	0.1	1066	340	1065	340	2	0	2055	2055
10	2017	0.209	0	0.21	6884	0.38	0.38	0.07	0.52	1	0.1	1236	468	1235	468	1	0	3567	3567
1	2018	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1	4136	307	1357	192	2779	115	0	4698
2	2018	0.105	0.05	0.06	97275	0.13	0.18	0.08	0.07	0	0.1	9238	1208	5015	884	4223	324	0	7198

AGE	YEAR	F	FDISC	FLAND	STOCKN	CATCHWT	LANDINGSWT	DISCARDSWT	STOCKWT	MAT	M	CATCHN	CATCH	LANDINGSN	LANDINGS	DISCARDSN	DISCARDS	SSB	TSB
3	2018	0.215	0.06	0.16	41975	0.17	0.2	0.09	0.13	1	0.1	7735	1332	5745	1153	1990	179	5527	5527
4	2018	0.262	0.03	0.23	97179	0.21	0.23	0.09	0.17	1	0.1	21347	4562	18685	4310	2662	252	16909	16909
5	2018	0.222	0.01	0.21	84339	0.25	0.26	0.11	0.23	1	0.1	16028	4029	15141	3932	887	97	19482	19482
6	2018	0.203	0	0.2	34990	0.27	0.27	0.1	0.24	1	0.1	6126	1636	5982	1621	144	15	8503	8503
7	2018	0.206	0	0.2	10976	0.28	0.28	0.12	0.27	1	0.1	1945	548	1926	546	19	2	2927	2927
8	2018	0.209	0	0.21	26559	0.28	0.28	0.11	0.27	1	0.1	4769	1348	4750	1346	19	2	7251	7251
9	2018	0.209	0	0.21	15015	0.32	0.32	0.14	0.35	1	0.1	2696	860	2691	859	5	1	5195	5195
10	2018	0.209	0	0.21	9417	0.38	0.38	0.07	0.52	1	0.1	1691	640	1690	640	1	0	4879	4879

Table 10.5.4. North Sea sole. Input and assumptions for 2016 to the short term forecast (F values presented are for TAC=landings)

ssb	f2-6	f_dis1-3	f_hc2-6	recruits	landings	discards	catch	TAC			
64312	0.16	0.041	0.136	59248	12021	1247	13269	13262			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2016	0.03	0.02	0.01	59248	0.07	0.14	0.04	0.04	0	0.1
2	2016	0.08	0.04	0.05	163431	0.13	0.18	0.08	0.07	0	0.1
3	2016	0.17	0.04	0.13	165908	0.17	0.2	0.09	0.13	1	0.1
4	2016	0.21	0.03	0.18	69351	0.21	0.23	0.09	0.17	1	0.1
5	2016	0.18	0.01	0.17	20511	0.25	0.26	0.11	0.23	1	0.1
6	2016	0.16	0	0.16	48812	0.27	0.27	0.1	0.24	1	0.1
7	2016	0.16	0	0.16	27755	0.28	0.28	0.12	0.27	1	0.1
8	2016	0.17	0	0.17	8087	0.28	0.28	0.11	0.27	1	0.1
9	2016	0.17	0	0.17	3861	0.32	0.32	0.14	0.35	1	0.1
10	2016	0.17	0	0.17	5512	0.38	0.38	0.07	0.52	1	0.1
1	2017	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1
2	2017	0.1	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2017	0.22	0.06	0.16	NA	0.17	0.2	0.09	0.13	1	0.1
4	2017	0.26	0.03	0.23	NA	0.21	0.23	0.09	0.17	1	0.1
5	2017	0.22	0.01	0.21	NA	0.25	0.26	0.11	0.23	1	0.1
6	2017	0.2	0	0.2	NA	0.27	0.27	0.1	0.24	1	0.1
7	2017	0.21	0	0.2	NA	0.28	0.28	0.12	0.27	1	0.1
8	2017	0.21	0	0.21	NA	0.28	0.28	0.11	0.27	1	0.1
9	2017	0.21	0	0.21	NA	0.32	0.32	0.14	0.35	1	0.1
10	2017	0.21	0	0.21	NA	0.38	0.38	0.07	0.52	1	0.1
1	2018	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1
2	2018	0.1	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2018	0.22	0.06	0.16	NA	0.17	0.2	0.09	0.13	1	0.1
4	2018	0.26	0.03	0.23	NA	0.21	0.23	0.09	0.17	1	0.1
5	2018	0.22	0.01	0.21	NA	0.25	0.26	0.11	0.23	1	0.1
6	2018	0.2	0	0.2	NA	0.27	0.27	0.1	0.24	1	0.1
7	2018	0.21	0	0.2	NA	0.28	0.28	0.12	0.27	1	0.1
8	2018	0.21	0	0.21	NA	0.28	0.28	0.11	0.27	1	0.1
9	2018	0.21	0	0.21	NA	0.32	0.32	0.14	0.35	1	0.1
10	2018	0.21	0	0.21	NA	0.38	0.38	0.07	0.52	1	0.1

Table 10.5.5. North Sea sole. Results from the short term forecast assuming landings = TAC.

basis	landings	f2-6	f_hc2-6	f_dis1-3	discards	catch	ssb2017	ssb2018	ssb_change	tac_change
Fmp	16800	0.2	0.17	0.05	1264	18064	77202	73429	-5	36
Ftar	16800	0.2	0.17	0.05	1264	18064	77202	73429	-5	36
Fmsy	16800	0.2	0.17	0.05	1264	18064	77202	73429	-5	36
Fmsy_low	9693	0.11	0.09	0.03	725	10417	77202	80960	5	-21
Fmsy_high	28467	0.37	0.31	0.09	2165	30631	77202	61113	-21	131
Fpa	32680	0.44	0.37	0.11	2496	35177	77202	56683	-27	165
Fpasig	34949	0.48	0.41	0.12	2677	37625	77202	54302	-30	184
Flim	42164	0.62	0.53	0.16	3258	45422	77202	46753	-39	242
SSB>Bpa	51550	0.84	0.71	0.22	4040	55589	77202	37000	-52	319
SSB>Blim	61971	1.166	0.99	0.3	4955	66927	77202	26300	-66	405
SSB>MSYBtrig	51550	0.84	0.71	0.22	4040	55589	77202	37000	-52	319
TACsq	12337	0.142	0.12	0.04	925	13262	77202	78155	1	0
15%_TAC_inc	14187	0.166	0.14	0.04	1065	15251	77202	76196	-1	15
15%_TAC_dec	10488	0.12	0.1	0.03	785	11273	77202	80116	4	-15
Fsq*0	0	0	NA	NA	0	0	77202	91259	18	-100
Fsq*0.25	3660	0.04	0.03	0.01	273	3933	77202	87366	13	-70
Fsq*0.5	7164	0.08	0.07	0.02	535	7699	77202	83644	8	-42
Fsq*0.9	12460	0.144	0.12	0.04	934	13394	77202	78025	1	1
Fsq*1	13727	0.16	0.14	0.04	1030	14757	77202	76682	-1	11
Fsq*1.1	14973	0.176	0.15	0.05	1124	16097	77202	75363	-2	21
Fsq*1.25	16800	0.2	0.17	0.05	1264	18064	77202	73429	-5	36
Fsq*1.5	19742	0.24	0.2	0.06	1489	21231	77202	70317	-9	60

Table 10.5.6. North Sea sole. Detailed STF table by age, assuming landings=TAC, rescaled

AGE	YEAR	F	FDISC	FLAND	STOCKN	CATCHWT	LANDINGSWT	DISCARDSWT	STOCKWT	MAT	M	CATCHN	CATCH	LANDINGSN	LANDINGS	DISCARDSN	DISCARDS	SSB	TSB
1	2016	0.031	0.02	0.01	59248	0.07	0.14	0.04	0.04	0	0.1	1748	130	573	81	1174	49	0	2488
2	2016	0.083	0.04	0.05	163431	0.13	0.18	0.08	0.07	0	0.1	12462	1630	6764	1193	5697	437	0	12094
3	2016	0.171	0.04	0.13	165908	0.17	0.2	0.09	0.13	1	0.1	24806	4272	18424	3697	6382	574	21845	21845
4	2016	0.208	0.03	0.18	69351	0.21	0.23	0.09	0.17	1	0.1	12416	2653	10868	2507	1548	147	12067	12067
5	2016	0.177	0.01	0.17	20511	0.25	0.26	0.11	0.23	1	0.1	3165	796	2990	776	175	19	4738	4738
6	2016	0.161	0	0.16	48812	0.27	0.27	0.1	0.24	1	0.1	6926	1849	6763	1833	163	17	11861	11861
7	2016	0.163	0	0.16	27755	0.28	0.28	0.12	0.27	1	0.1	3987	1123	3948	1119	39	5	7401	7401
8	2016	0.166	0	0.17	8087	0.28	0.28	0.11	0.27	1	0.1	1177	333	1173	332	5	1	2208	2208
9	2016	0.166	0	0.17	3861	0.32	0.32	0.14	0.35	1	0.1	562	179	561	179	1	0	1336	1336
10	2016	0.166	0	0.17	5512	0.38	0.38	0.07	0.52	1	0.1	803	304	802	304	1	0	2856	2856
1	2017	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1	4136	307	1357	192	2779	115	0	4698
2	2017	0.105	0.05	0.06	51948	0.13	0.18	0.08	0.07	0	0.1	4934	645	2678	472	2255	173	0	3844
3	2017	0.215	0.06	0.16	136038	0.17	0.2	0.09	0.13	1	0.1	25068	4317	18619	3736	6449	580	17912	17912
4	2017	0.262	0.03	0.23	126567	0.21	0.23	0.09	0.17	1	0.1	27803	5942	24336	5614	3467	328	22023	22023
5	2017	0.222	0.01	0.21	50967	0.25	0.26	0.11	0.23	1	0.1	9686	2435	9150	2376	536	59	11773	11773
6	2017	0.203	0	0.2	15554	0.27	0.27	0.1	0.24	1	0.1	2723	727	2659	721	64	7	3780	3780
7	2017	0.206	0	0.2	37590	0.28	0.28	0.12	0.27	1	0.1	6661	1877	6596	1869	65	8	10024	10024
8	2017	0.209	0	0.21	21327	0.28	0.28	0.11	0.27	1	0.1	3829	1082	3814	1081	16	2	5822	5822
9	2017	0.209	0	0.21	6199	0.32	0.32	0.14	0.35	1	0.1	1113	355	1111	355	2	0	2145	2145
10	2017	0.209	0	0.21	7185	0.38	0.38	0.07	0.52	1	0.1	1290	488	1289	488	1	0	3723	3723
1	2018	0.04	0.03	0.01	111851	0.07	0.14	0.04	0.04	0	0.1	4136	307	1357	192	2779	115	0	4698
2	2018	0.105	0.05	0.06	97275	0.13	0.18	0.08	0.07	0	0.1	9238	1208	5015	884	4223	324	0	7198

3	2018	0.215	0.06	0.16	42318	0.17	0.2	0.09	0.13	1	0.1	7798	1343	5792	1162	2006	181	5572	5572
4	2018	0.262	0.03	0.23	99299	0.21	0.23	0.09	0.17	1	0.1	21813	4662	19093	4404	2720	257	17278	17278
5	2018	0.222	0.01	0.21	88144	0.25	0.26	0.11	0.23	1	0.1	16752	4210	15825	4109	927	101	20361	20361
6	2018	0.203	0	0.2	36924	0.27	0.27	0.1	0.24	1	0.1	6464	1726	6312	1711	152	16	8973	8973
7	2018	0.206	0	0.2	11489	0.28	0.28	0.12	0.27	1	0.1	2036	574	2016	571	20	2	3064	3064
8	2018	0.209	0	0.21	27690	0.28	0.28	0.11	0.27	1	0.1	4972	1405	4952	1403	20	2	7559	7559
9	2018	0.209	0	0.21	15663	0.32	0.32	0.14	0.35	1	0.1	2812	897	2808	897	5	1	5419	5419
10	2018	0.209	0	0.21	9830	0.38	0.38	0.07	0.52	1	0.1	1765	668	1764	668	1	0	5093	5093

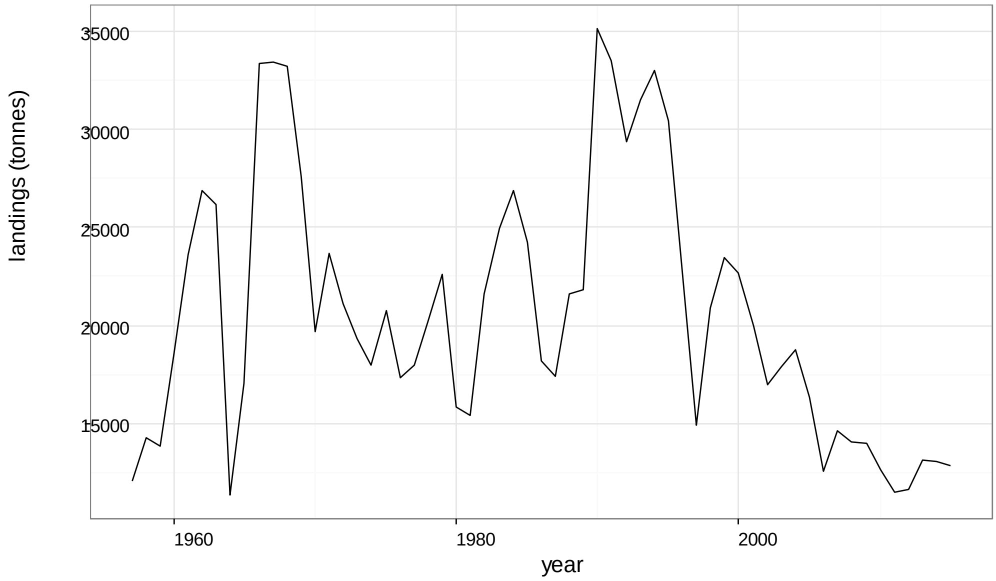


Figure 10.2.1. North Sea sole. Time series of landings (reported to ICES) (1957 – present)

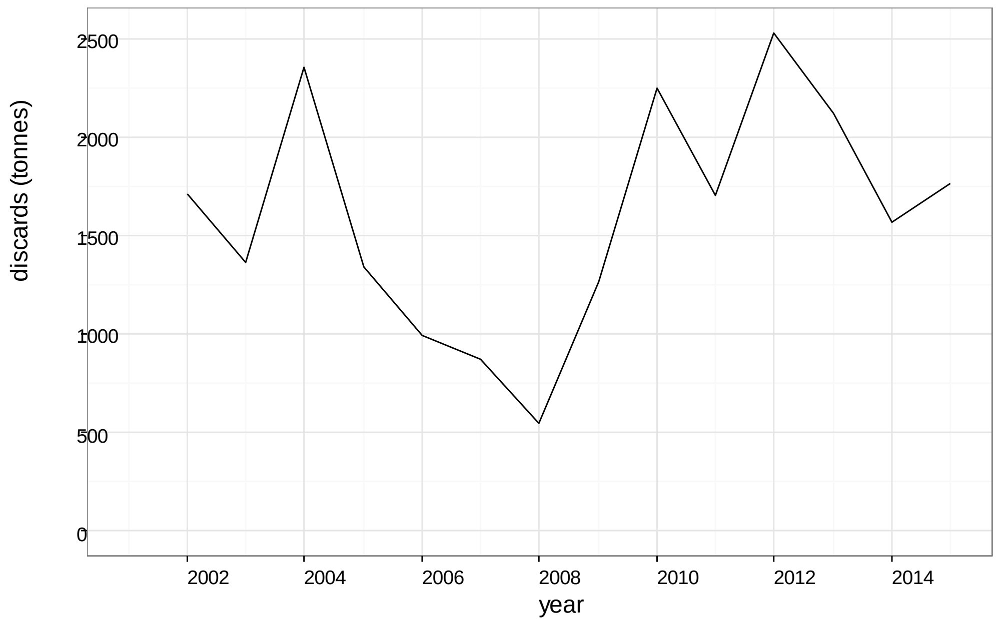


Figure 10.2.2. North Sea sole. Time series of discards (reported to ICES) (2002 – present)

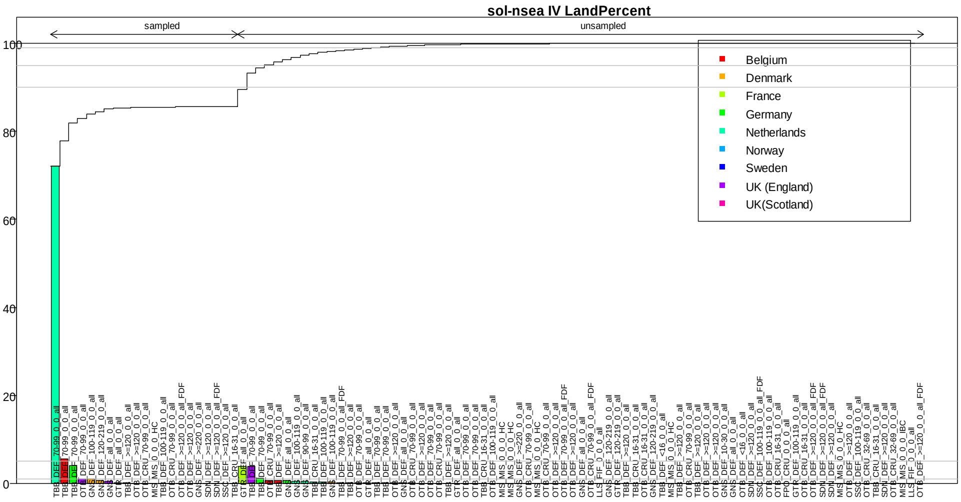


Figure 10.2.3. North Sea sole. Data upload in Intercatch: landings % by country by metier (top); discards in weight (kg) by country by metier (bottom). Sampled and unsampled refers to availability of age-composition information

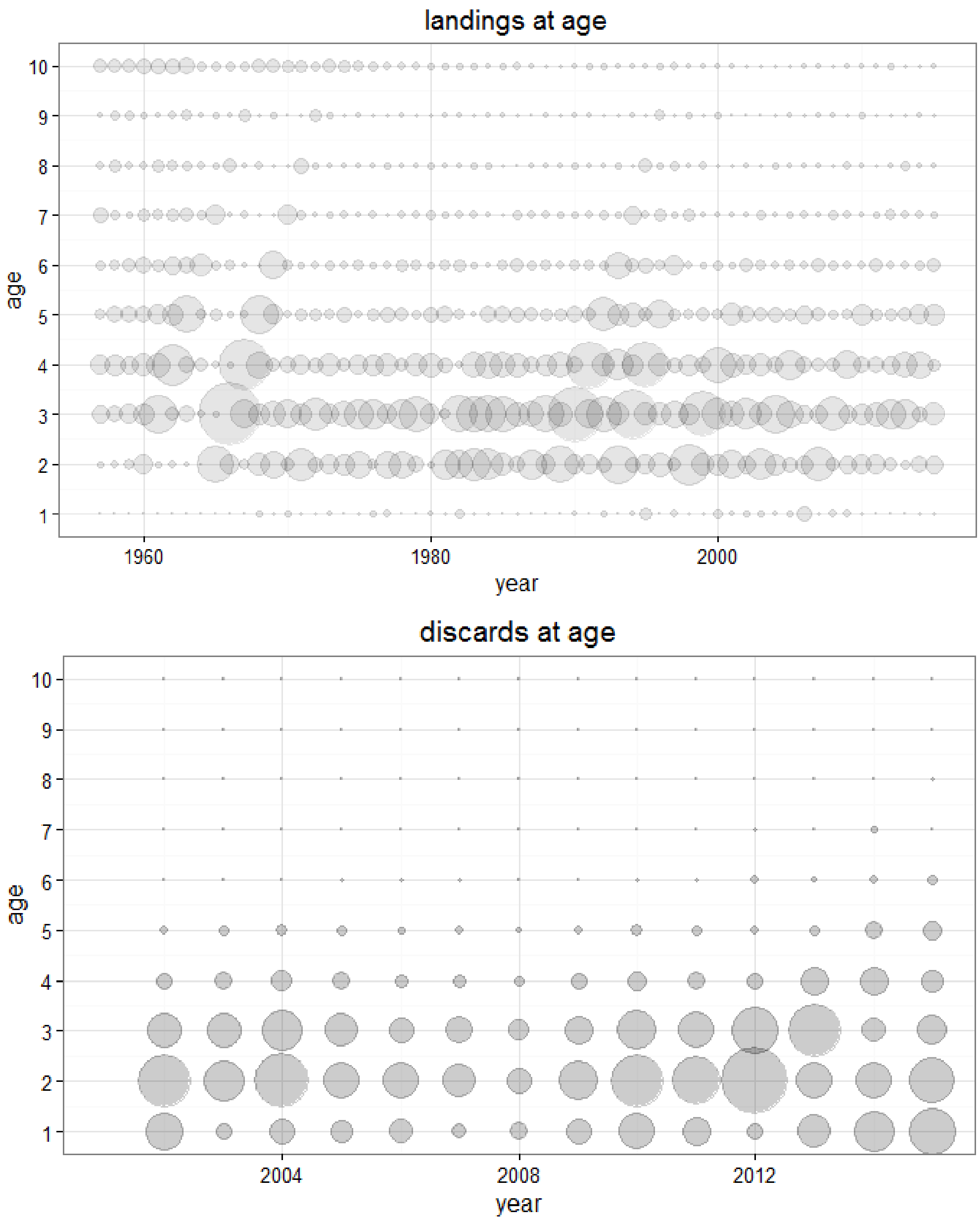
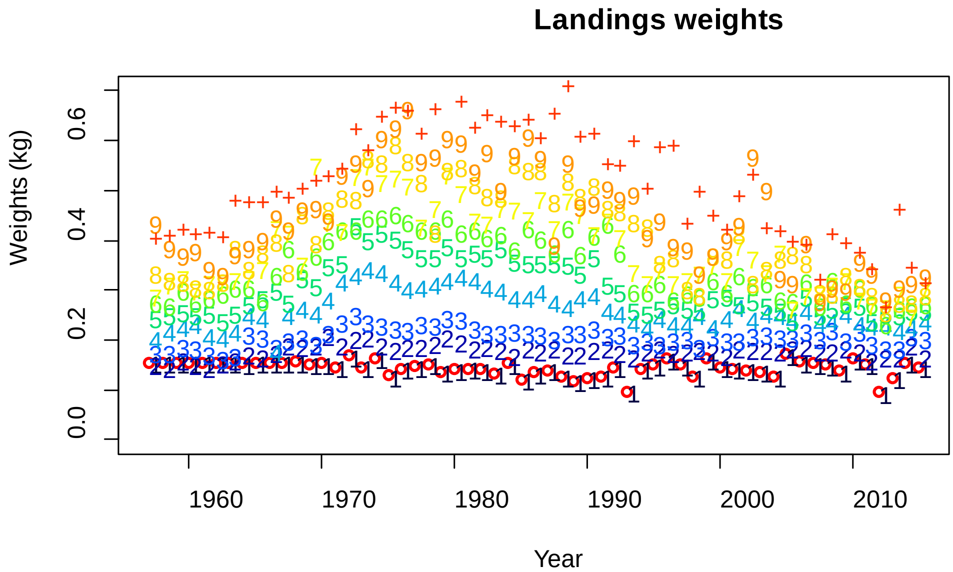
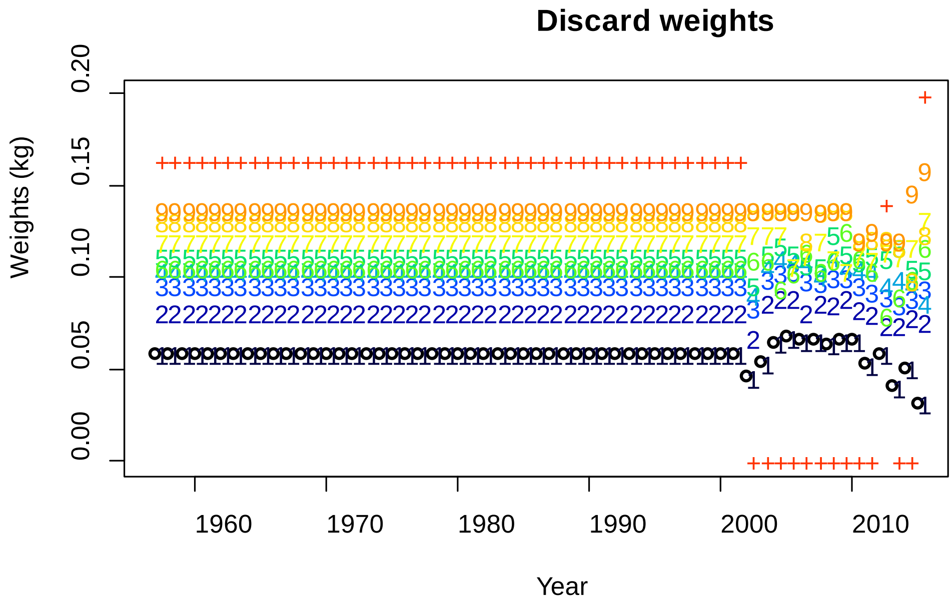
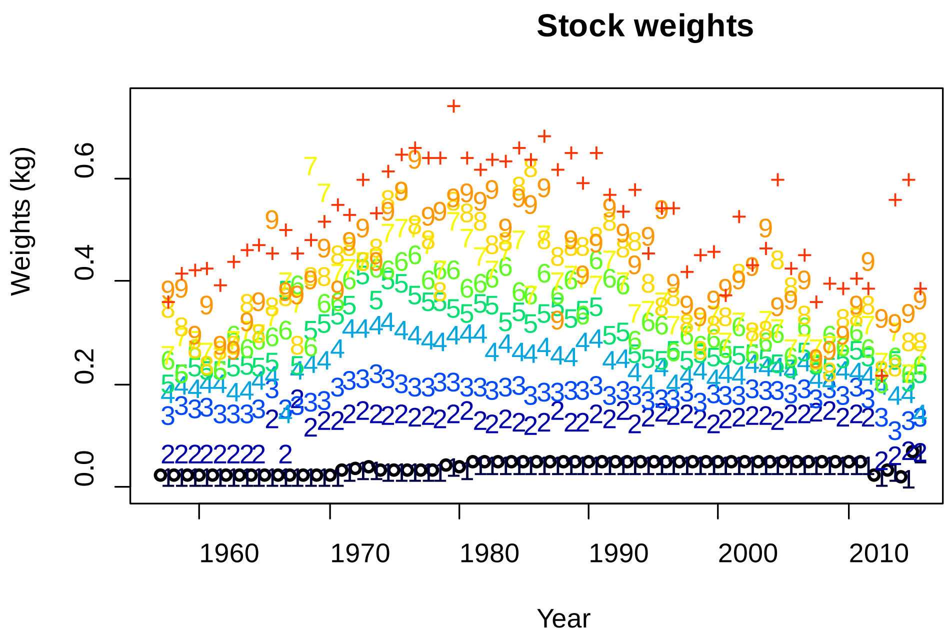
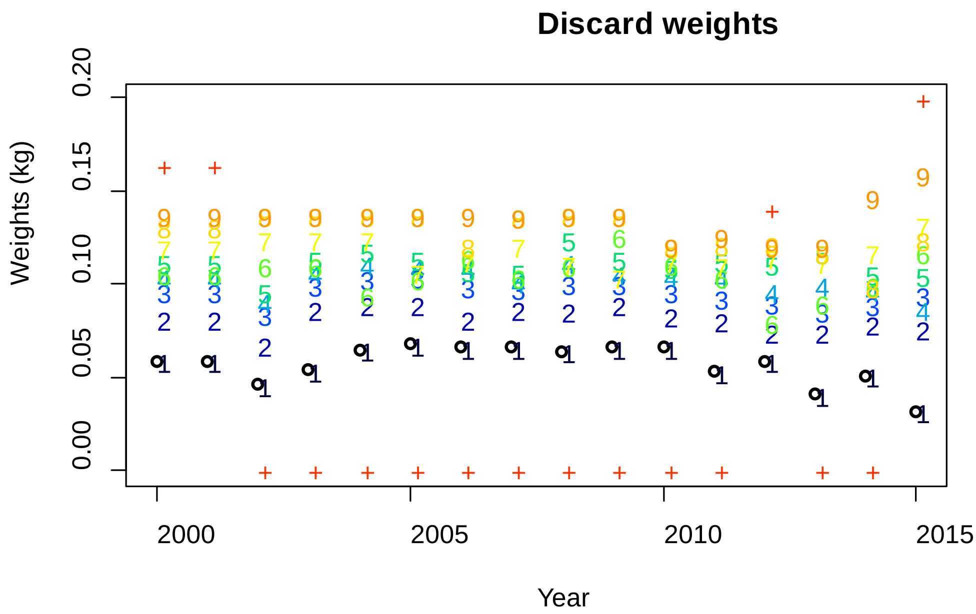


Figure 10.2. North Sea sole. Landings and discards numbers-at-age


Landings weights
Weights (kg)
Year


Discard weights
Weights (kg)
Year


Stock weights
Weights (kg)
0.0
0.2
0.4
0.6
1960
1970
1980
1990
2000
2010
Year


Discard weights
Weights (kg)
0.00
0.05
0.10
0.15
0.20
2000
2005
2010
2015
Year

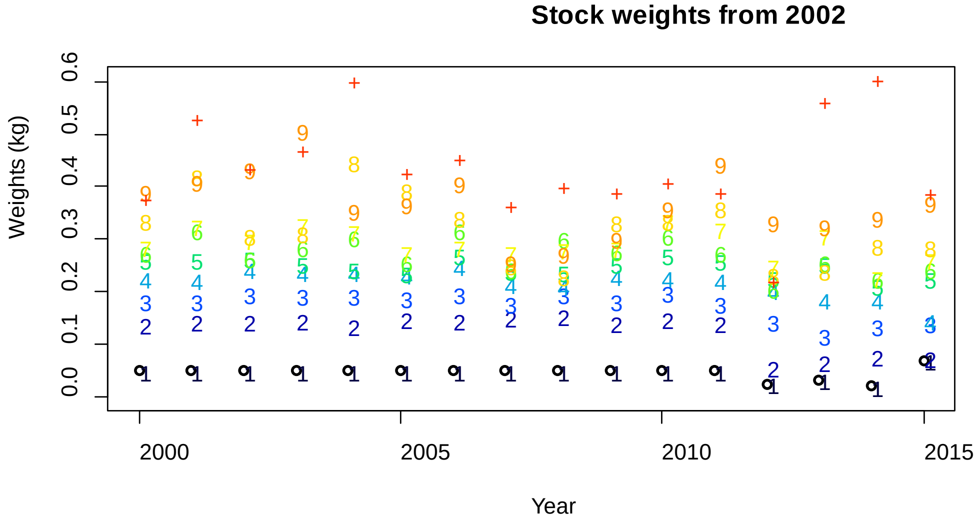


Figure 10.2.5. North Sea sole. Landing, discard, and mean stock weights at age for the whole time series (top), and for the most recent years (only discard and mean stock weights, 2002 - present)

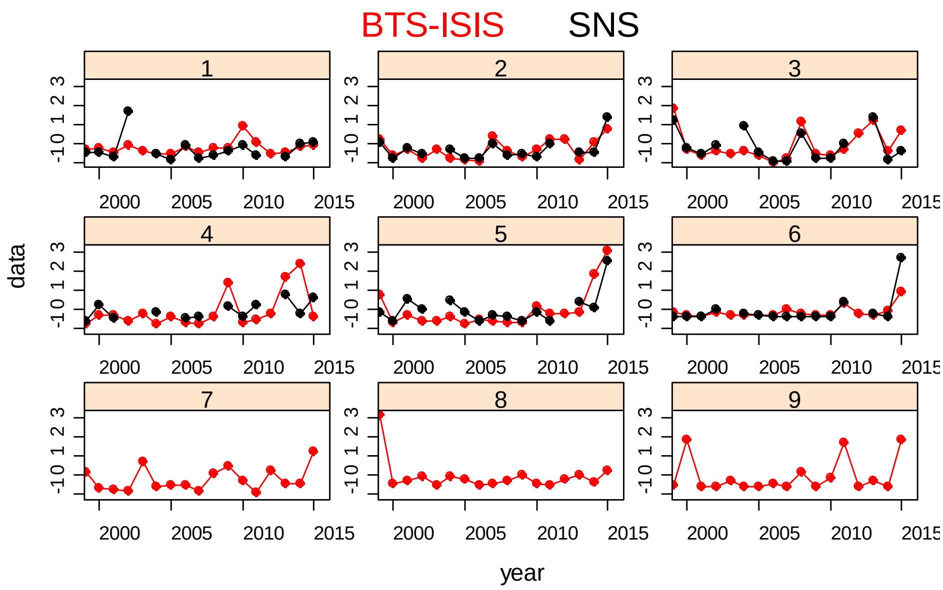
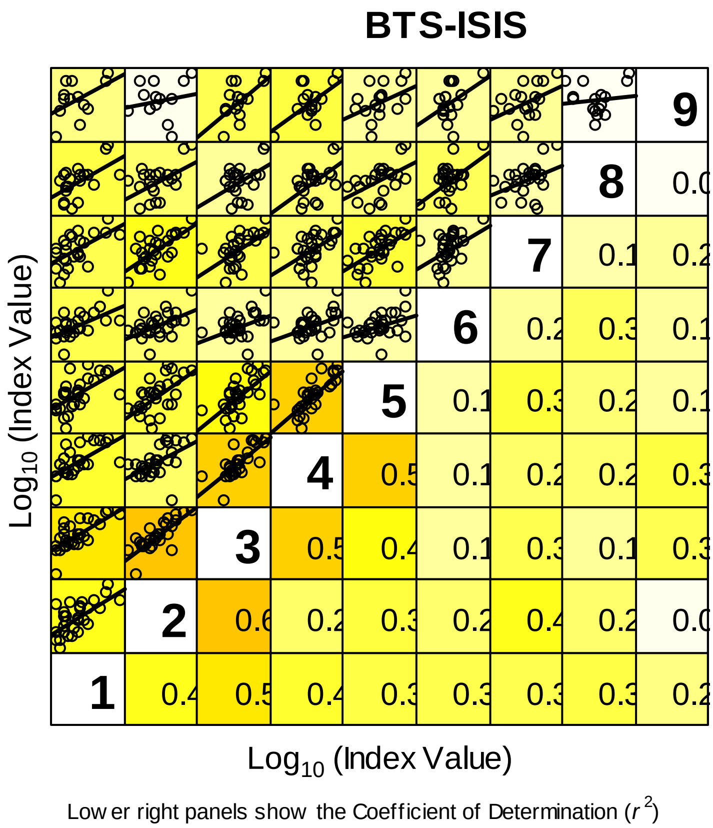


Figure 10.2.7.1. North Sea sole. Standardized survey tuning indices. BTS-Isis (red), SNS (black)



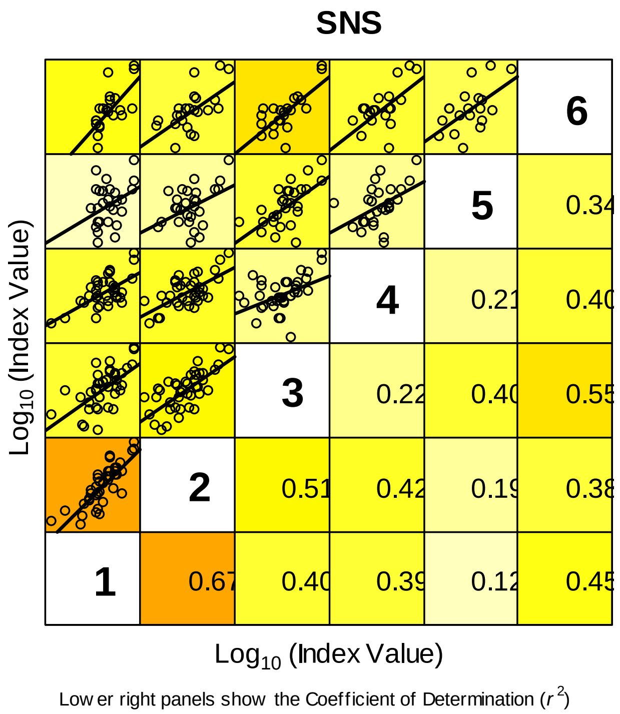


Figure 10.2.7.1. North Sea sole. Correlation plots for both tuning indices

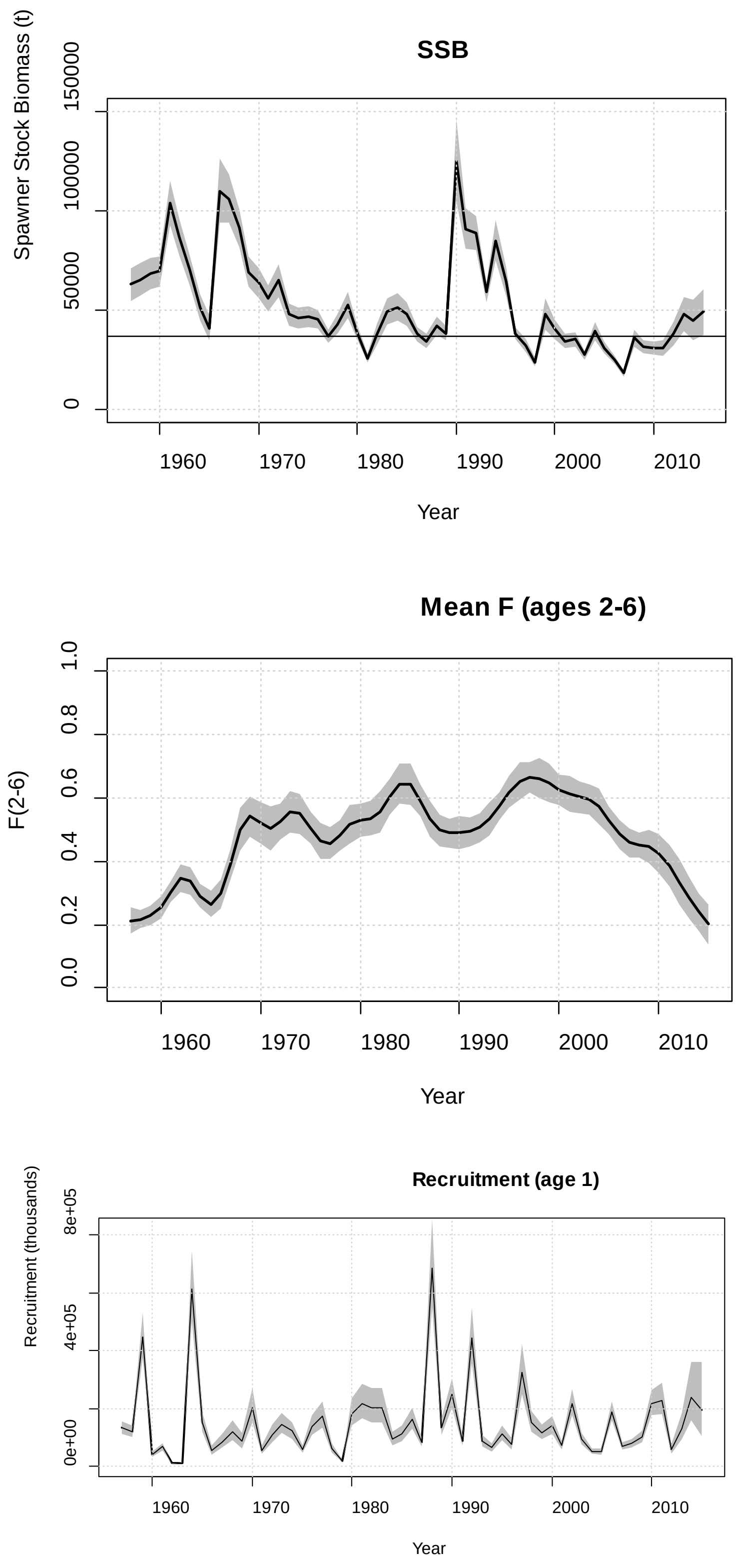


Figure 10.3.1. North Sea sole. Assessment summary WGNSSK 2016

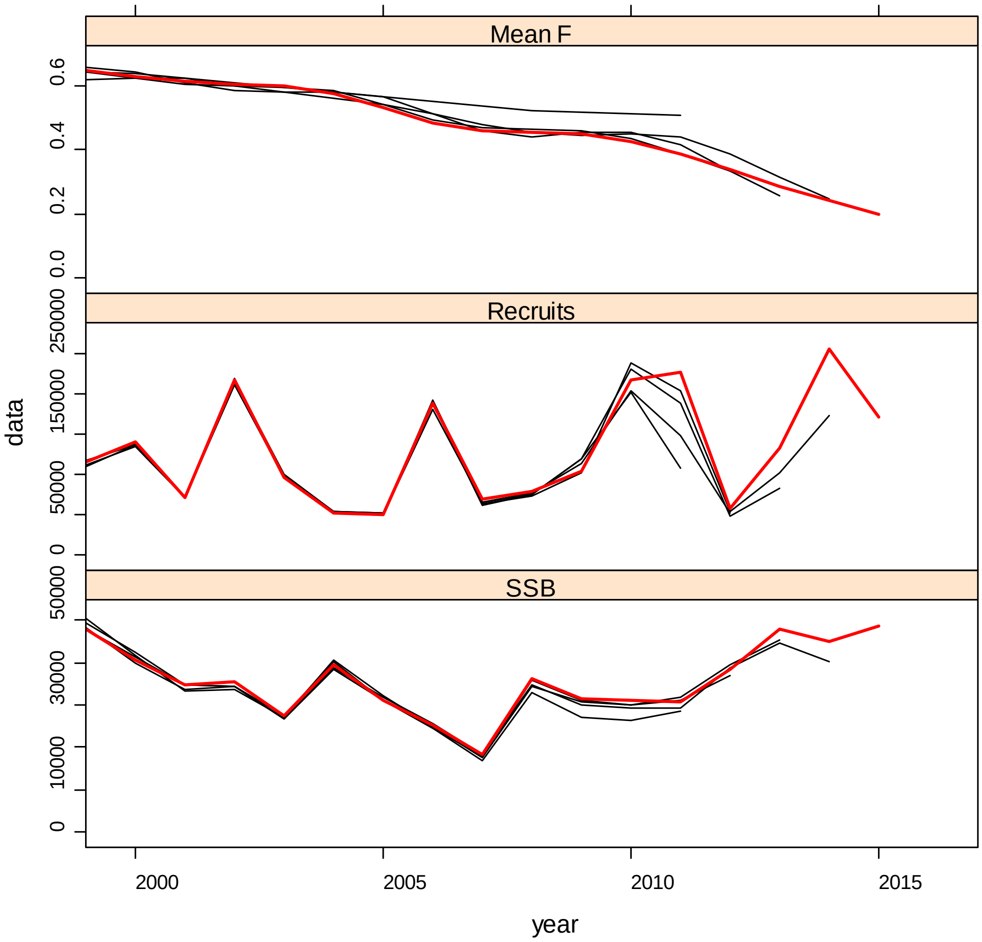


Figure 10.3.2. North Sea sole. Retrospective performance of assessment summary

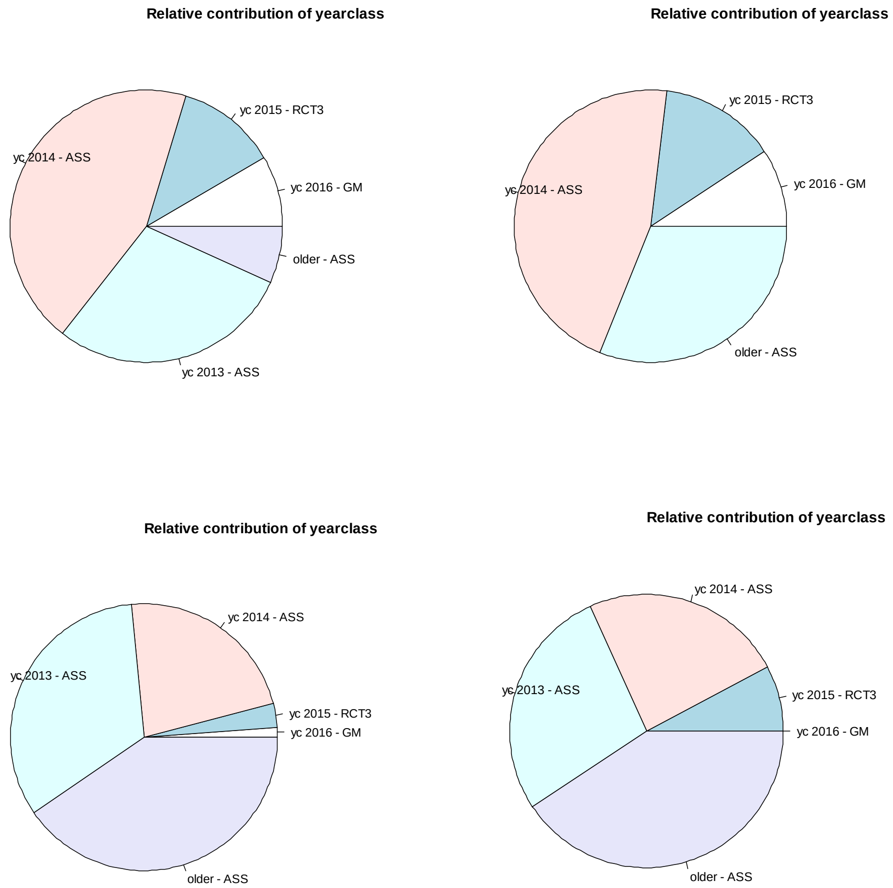


Figure 10.5.1. North Sea sole. Pieplots showing relative contribution of intermediate year assumptions for both F = Fsq scenario

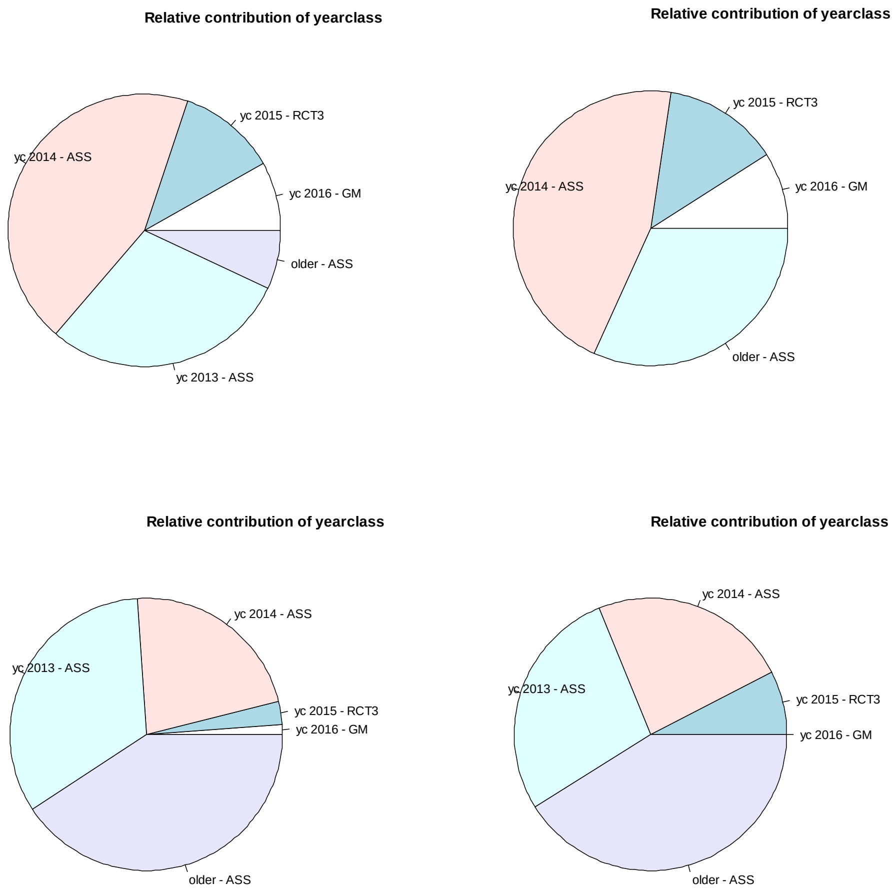


Figure 10.5.1. North Sea sole. Pieplots showing relative contribution of intermediate year assumptions for both F = Ftac=catch scenario

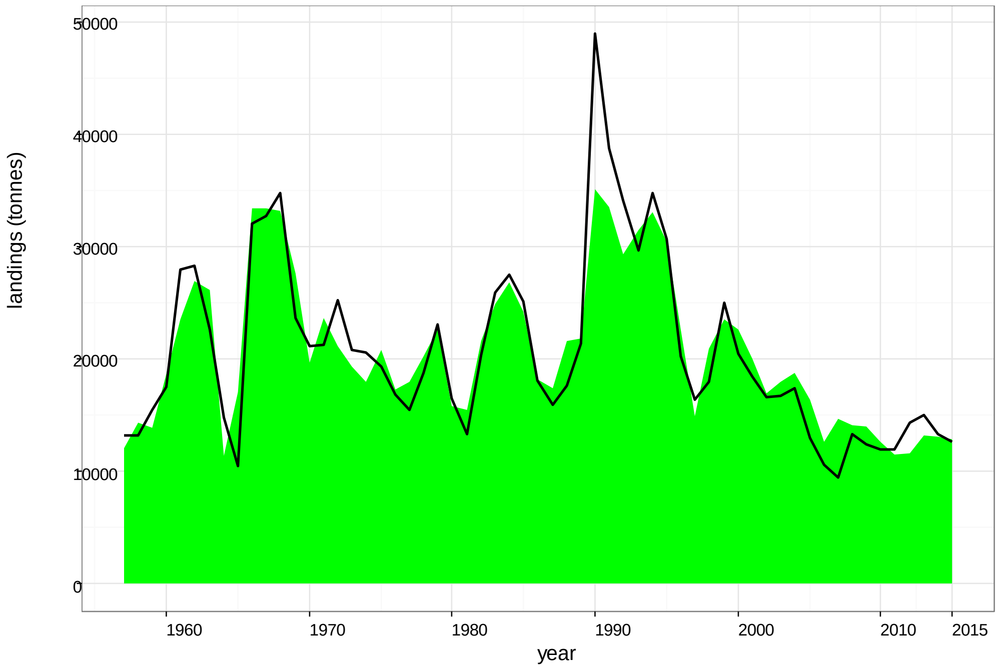


Figure 10.8.1. North Sea sole. Modelled landings (black line) versus observed landings (green area)

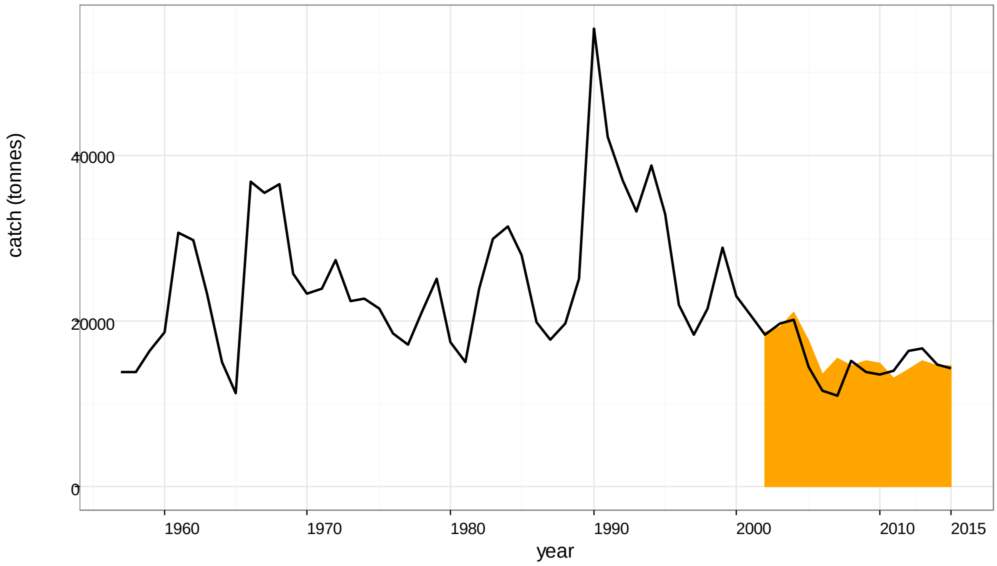


Figure 10.8.2. North Sea sole. Modelled catch (black line) versus observed catches (orange area)

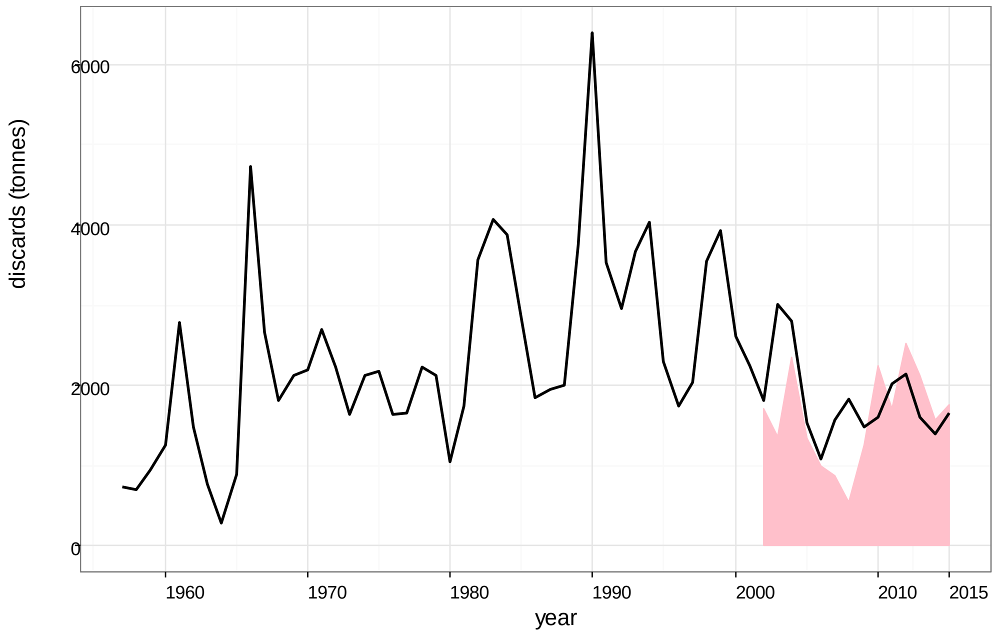


Figure 10.8.3. North Sea sole. Modelled discards (black line) versus observed discards (pink area)

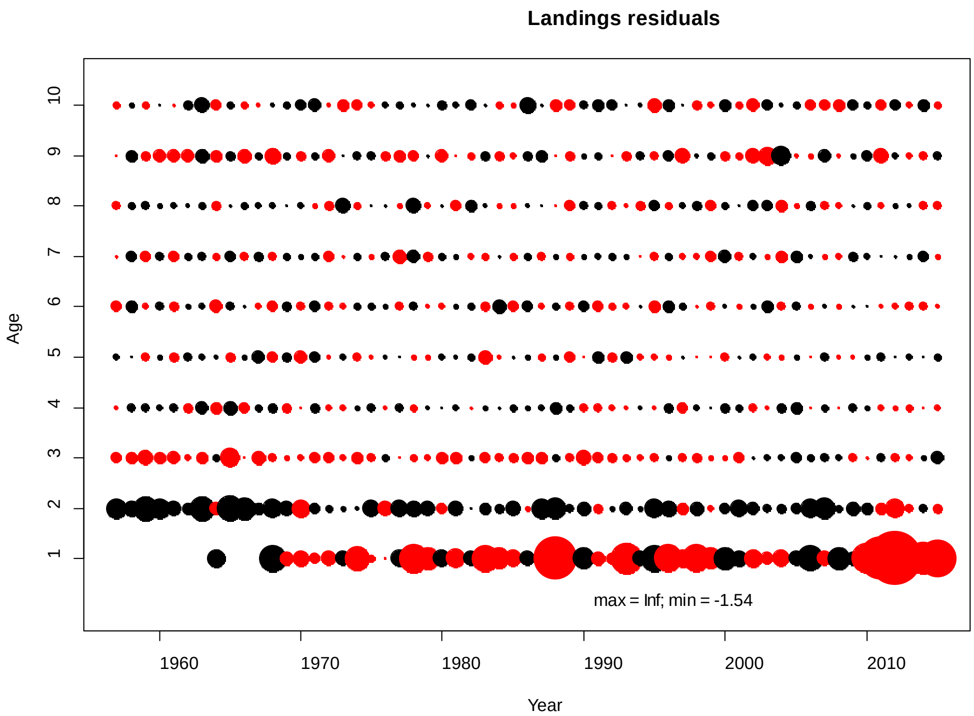


Figure 10.8.4. North Sea sole. Landings residuals

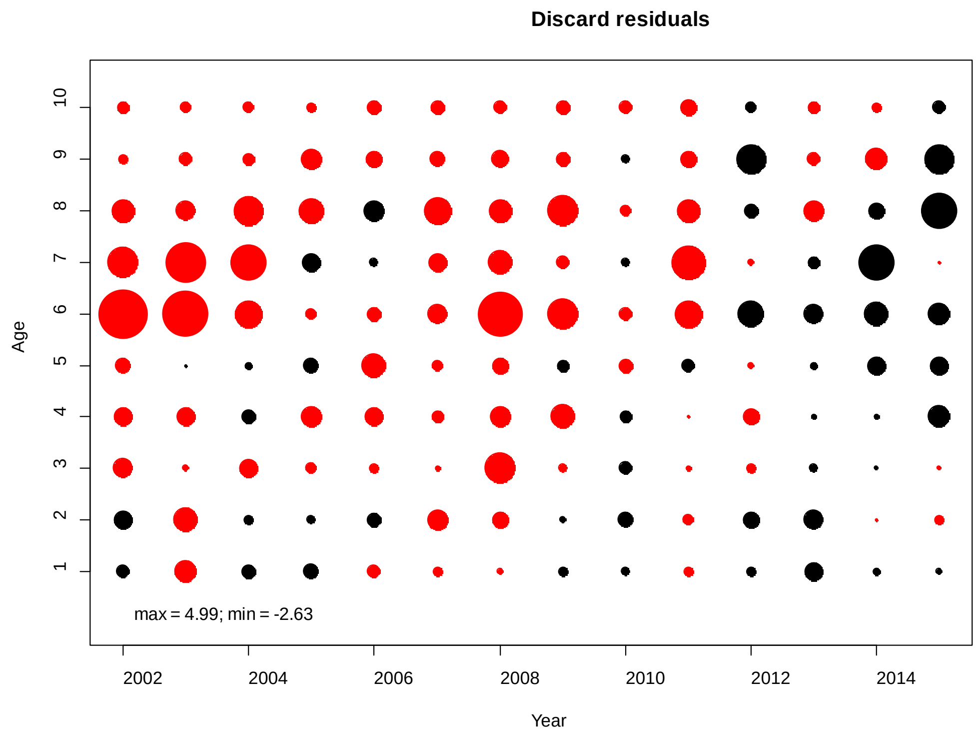


Figure 10.8.5. North Sea sole. Discard residuals

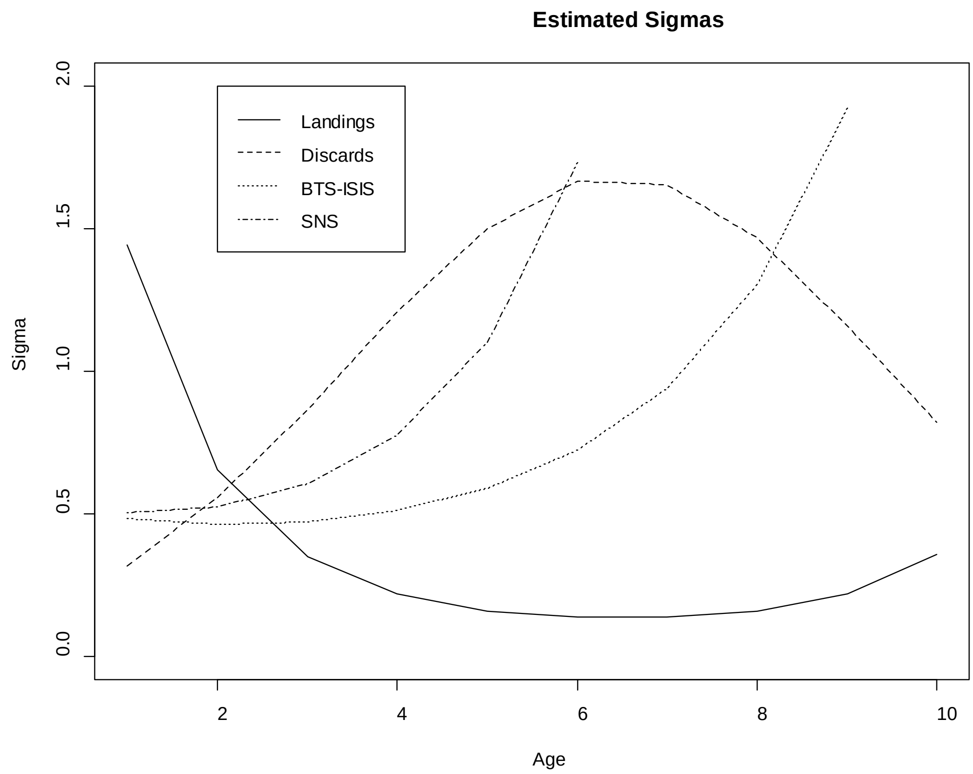


Figure 10.8.6. North Sea sole. Sigmas of different input time series

11 Saithe (*Pollachius virens*) in Subarea 4, 6 and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)

The assessment of saithe in Division 3.a and Subareas 4 and 6 is presented as a benchmarked assessment based on the revised assessment protocol specified by the 2016 meeting of WKNSEA (ICES-WKNSEA 2016) and a further revision, put forward after the WGNSSK 2016 meeting to provide a solution to the uncertainty in the assessment and forecast due to the highly uncertain and fluctuating survey indices. The forecast for this stock was re-run in the Autumn because new information from the IBTS Q3 survey triggered the re-opening criterion – the updated forecast is provided in Annex 04.

11.1 General

11.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

11.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK in 2016. A summary of available information, prepared during WKBENCH 2011, can be found in the Stock Annex. No ecosystem aspects were discussed during WKNSEA 2016.

11.1.3 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex.

Saithe are predominantly taken in the trawler fisheries by Norway, Germany, and France. Changes in the fishing pattern of these three fleets began in 2009, but all fleets appear to have largely reverted back to their original fishing patterns (see Stock Annex). For the German and Norwegian fleets, this is mainly along the shelf edge in Subarea 4 and Division 3.a, while French fleets fish along the northern shelf and west of Scotland (Subareas 4 and 6). The Scottish fleets also catch a large amount of saithe in Subareas 4 and 6, which is then discarded due to lack of quota. Discards can also be high in a few Danish and Swedish fisheries in the Skagerrak because these fleets do not have quota allocations.

11.1.4 ICES Advice

The information in this section is taken from the Advice summary sheet 2015, section 6.3.35.

Advice for 2016

ICES advises that when the EU–Norway management strategy is applied, catches in 2016 should be no more than 75 049 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 68 601 tonnes.

Management plan

Since SSB is marginally below 200 000 tonnes in 2015, paragraph 3 of the EU–Norway management strategy applies, resulting in an F of 0.298.

11.2 Management

In 2012, an EU–Norway request was made to ICES on options to revise the long-term management strategy for saithe (ICES, 2012). Based upon the evaluations, the EU and Norway agreed to keep the existing management strategy. Because the long-term performance was not clear, ICES advised that the strategy should be re-evaluated within four years (i.e. no later than 2016) and revised if necessary.

In 2013, the effects of interannual quota flexibility in the management strategy for saithe were evaluated (ICES, 2013). ICES concluded that the management strategy evaluated is robust to inclusion of interannual quota flexibility in terms of the probability of the stock biomass falling below B_{lim}. This conclusion is conditional on the interannual quota flexibility being suspended when the stock is estimated to be outside safe biological limits. SSB was estimated to be 199 270 tonnes for 2015, which was below B_{pa} (200 000 tonnes).

Changes to the stock assessment and reference points in 2016 imply a need to re-evaluate the management plan in order to ascertain if it can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice will follow protocol, i.e., given according to the ICES MSY approach.

11.3 Data available

11.3.1 Catch

Official landings data for each country participating in the fishery are presented in Table 11.3.1, together with the corresponding WG estimates and the agreed international quota (“total allowable catch” or TAC). During WKNSEA 2016, catch data were updated in InterCatch for the years 2002–2014. Figures 11.3.1 to 11.3.5 and Tables 11.3.2 to 11.3.4 summarise the proportion of landings and discards, for which samples have been provided. Although a large number of fleets do not provide samples for the landings, these do not contribute a large proportion of the catch; 86% of the landings have been sampled. The amount of samples taken, especially in the targeted trawl fisheries, is an issue (see ICES-WKNSEA 2016). Age compositions for the remaining landings have been determined by averaging within an area (Division 3.a or combined Subareas 4/6) and a quarter, similar to previous years. This is because the fleets, particularly the target trawl fishery, are targeted the spawning fish in the first two quarters, while a wider range of age classes is captured in the latter part of the year. Discard observations are not available for the fleets landing the vast majority of saithe (Figure 11.3.5). While Norway has a no discarding policy, discarding is not monitored and discard information is not collected. Norwegian discards for the trawler fleet were raised using discard information from the French and German trawler fleets (i.e., the targeted fishery), while discards for other fleets (all counties) were raised similar to landings (stratification by quarter and area). Raised discards accounted for 2% of the total catch (Table 11.3.2). Discards were raised for all previous years (1967–2014) during WKNSEA 2016 (Figure 11.3.6; ICES-WKNSEA 2016). Details can be found in the Stock Annex and relevant benchmark working documents.

The full time series of catch, landings, and discards is summarized in Table 11.3.5 and illustrated in Figure 11.3.7. Catch has been relatively stable from 1990 through 2008 and then declined. The WG estimates of saithe discarding (as a proportion of total catch) has declined from early 2000. Discard estimates were lowest for the period when the saithe trawler fleet changed its exploitation pattern (2009–2011). Prior to 2002, discards were estimated using a constant discarding rate (age specific, Figure 11.3.6; see benchmark WD documentation for details). high discards in 2002–2003, 2007 and 2012 were due to reported discarding by Scottish fisheries.

11.3.2 Age compositions

International catch and discard data was collated and catch-at-age was generated using InterCatch. Age composition in the landings was based on samples, provided by Denmark, France, Scotland, Germany, and Norway, which account for 86% of the total landings (also see Table 11.3.4).

Total catch-at-age data are given in Table 11.3.6, while catch-at-age data for each catch component are given in Tables 11.3.7 and 11.3.8. Age 3 fish make up a smaller portion of the landings in recent years (Figure 11.3.8). The last strong year class in the catch appears to be the 2009 year class as seen in the discards in 2012 at age 3 and landings in 2013 at age 4. From 2016 onwards, saithe fishing in the bottom trawl fleet is covered by the EU Landing Obligation.

11.3.3 Weight at age

Weight-at-age from the catch and catch components for ages 3–10+ are presented in Tables 11.3.9–11.3.11 and Figure 11.3.9. Catch weights are also used as stock weights. There was a decreasing trend in mean weight for ages 6 and older, but that has stopped or been reversed (Figure 11.3.9). Weights-at-age for ages 3–5 have been relatively stable, with some variation, over the last decade. Discard weights since 2009 appear to be increasing.

11.3.4 Maturity and natural mortality

The following maturity ogive, revised during the 2016 benchmark, is used for all years (see Stock Annex for details):

Age	1	2	3	4	5	6	7	8+
Proportion mature	0.0	0.0	0.0	0.2	0.65	0.84	0.97	1.0

A natural mortality rate of 0.2 is used for all ages and years.

11.3.5 Catch, effort and research vessel data

Indices used in the assessment are include as Table 11.3.12. Data for the Norwegian, French, and German commercial trawler fleets were combined into one standardized CPUE index, which is then tuned to the exploitable biomass (see Stock Annex for details). One fisheries-independent survey index was included for tuning of the assessment; the survey is the IBTS quarter 3, ages 3–8, 1992–2015 (“IBTS-Q3”).

11.4 Data analyses

The assessment of North Sea saithe was carried out using a state-space stock assessment model (SAM; stockassessment.org). Alternate models were run after the benchmark and are summarized in the Stock Annex. An exploratory model is included, which uses the combined standardized cpue index and IBTS Q3 index for tuning, but where stock weights equal catch weights only for those age classes where stock weights were estimated to be larger than catch weights (ages 7+; see ICES-WKNSEA 2016).

11.4.1 Exploratory survey-based analyses

Numbers-at-age for saithe ages 3 to 8 (IBTS Q3) on the log-scale, linked by cohort is shown in Figure 11.4.1. A strong year effect is apparent in 2007, 2011, and 2013; this is reflected in the sharp increase in age 4 when compared to earlier cohorts. Within-cohort correlations between ages for the survey index is also presented in Figure 11.4.2. The catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages.

Trends by age for the IBTS Q3 index are shown in Figure 11.4.3. Abundance of age 3 and 4 is very low in 2014, but have increased again in 2015.

11.4.2 Exploratory catch-at-age-based analyses

The catch curves for total catches are shown in Figure 11.4.4. The curves show that age 3 is only partially recruited to the fishery for the latter cohorts (around the mid 1990s), but fully recruited for many of the earlier cohorts. The catch curves in recent years are less steep than for earlier cohorts, which indicates a change in exploitation occurred. This may be partially explained by declines in catches by the Norwegian purse seine fishery, which occurred in the early 1990s; purse seiners mainly target younger fish. The minimum landing size (40 cm in the North Sea) changed around this time, which would also cause a change in exploitation.

The outcome of WKNSEA 2016 was to remove the 3 cpue series for the targeted trawl fisheries, partially due to concerns over using information in the catch-at-age matrix in both the cpue and in the catch-at-age and because more weight was given to 3 indices within the former assessment model (artificially higher weighting to the cpue indices). A standardized combined cpue index was created for the French, German, and Norwegian trawl fleet targeting saithe, which was then tuned to the exploitable biomass, removing the need to use the information in the catch-at-age matrix twice (see WD 2 from WKNSEA 2016 for details). This index is given in Table 11.3.13 and plotted in Figure 11.4.5.

11.4.3 Assessments

The benchmark assessment (ICES-WKNSEA) was rejected by WGNSSK. The benchmark model included GAM-derived survey indices for IBTS Q1 and IBTS Q3, plus the combined cpue index. It was subsequently shown that the IBTS Q1 survey did not adequate cover the stock because of movement in and out of the survey area, which was unrelated to abundance (see working documents in Annex 08) . It was also questioned whether the IBTS Q3 survey was useful or if the signal was over-ridden by noise and uncertainty in the index. An external review (see technical minutes under Annex 09) helped clarify that the IBTS Q3 index did contain useful information, but that the GAM model used to generate the index was contributing to the noise/uncertainty. This was because the GAM model used a constant spatial effect for all years, whereas year effects were in the data (see Stock Annex and WGNSSK additional working documents in Annex 08). Because of this, the standard Q3 index (derived by using ALKs created annually by roundfish area) was used, but extended to include ages 3–8 (see working documents in Annex 08).

The external review also questioned the use of generating stock weights from survey indices. Stock weights were generally lower than catch weights before age 7, after which, they were generally higher than catch weights. The benchmark group discussed that this was plausible; fish that are larger for a given age would be selected by the fisheries up to a certain age, after which, selection should drop (i.e., selection is towards an "average" sized fish). The external review advocated the replacement of stock weights with catch weights for all ages as there was some concern over how stock weights were generated (may not be representative of the population). An alternate (exploratory) assessment has been run using stock weights, generated from survey information (see WKNSEA WD 7) for ages 3–6, and catch weights for ages 7+ (the ages where stock weights are greater than catch weights).

Settings used in the assessment are given in Table 11.4.1. SOP correction of the catches has been done on all revised catches (2002–current assessment year).

11.4.4 Exploratory assessment with alternative stock weights

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 360.27. Estimated catchabilities for the Q3 index were higher than the cpue index (Q3 range 0.031 to 0.091; cpue 0.004). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.798).

Estimated fishing mortality-at-age are given in Table 11.4.2 and illustrated in Figure 11.4.6; estimated population numbers-at-age are in Table 11.4.3.

The log catchability residuals from the exploratory assessment are shown in Figure 11.4.7 and the retrospective analysis is in Figure 11.4.8.

The historic stock and fishery trends, including 95% confidence intervals for the exploratory assessment are in Figure 11.4.9. Because fish aged 3–6 make up a high proportion of the total catch, using a lower average weight as stock weights results in lower SSB than in the final assessment model; in 2015, SSB was 5% lower. The differences in F_{4-7} and recruitment were negligible.

11.4.5 Final assessment

Settings used in the final assessment are as in Table 11.4.1.

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 358.89. Estimated catchabilities for the Q3 index were higher than the cpue index, and not that different from the exploratory model (Q3 range 0.031 to 0.091; cpue 0.003). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.796).

Estimated fishing mortality-at-age are given in Table 11.4.4 and Figure 11.4.6. Estimated population numbers-at-age are in Table 11.4.5.

The residuals are shown in Figure 11.4.10. After accounting for the correlation between ages within years, the IBTS Q3 residuals show less of a pattern; however, the series is still largely positive at the end of the series, when the series is beginning to show an increase in abundance for most ages. The retrospective analysis shows that F tends to be overestimated, while SSB and recruitment tend to be underestimated (Figure 11.4.11).

The SSB estimates over the entire series for the final model are higher than that for the exploratory model (Figure 11.4.9). This is because stock weights are now heavier for the younger age classes, despite these fish making up only a proportion of the mature biomass.

11.5 Historic Stock Trends

The historic stock and fishery trends from the final assessment are presented in Figure 11.5.1 and Table 11.5.1. Because of the benchmark, historic perception of the stock has changed. Recruitment has been highly variable, but shows an overall decline since the mid 1990s. Recruitment is well below the median for the period 2002–2015, used in the forecast. The decline in SSB reversed in 2010 and SSB is now approaching levels seen in the mid-2000s. The final year estimate of SSB is well above B_{pa} and MSY $B_{trigger}$. Fishing mortality has generally declined since the mid 1980s. Currently, fishing mortality is below F_{MSY}.

11.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The 2002–2015 median value (102 million) used in the short-term forecast is below the estimated recruitment for 2015, but below estimates for 2013 and 2014.

11.7 Short-term forecasts

A short-term forecast was carried out based on the final assessment.

Weight-at-age in the stock and catch were the mean values for the last 3 years. The exploitation pattern (selectivity pattern) was chosen as the mean exploitation pattern over the last three years. A TAC constraint for the intermediate year was chosen, i.e., the fishing mortality for 2016 was determined such that the landings in 2015 matched the TAC (which was based on landings without the adjustment). Population numbers-at-age for ages 4 and older in 2015 were survivor estimates, while numbers at age 3 were the median estimate of recruitment for the years 2002–2015. The short-term projection was run in SAM.

The input data for the short term forecast are given in Table 11.7.1.

The management options are given in Table 11.7.2. Assuming that the landings in 2016 are scaled to the TAC in 2016 results in an F_{2015} of 0.24 and a SSB in 2016 of 239 561 t. Because reference points were re-estimated after the benchmark, the management plan is no longer valid; therefore the MSY approach is used. Total catch in 2017 is 116 605 t, where landings (wanted catch) is 110 917 t; this is a 62% increase in TAC

The contribution of the 2008–2014 year classes to landings in 2017 are shown in Table 11.7.3. The 2012 and 2013 year classes contribute the most to the forecasts; the 2013 year class was large because it was estimated from the resampled median from 2002–2015.

11.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

11.9 Biological reference points

The biological reference points were re-estimated following the benchmark in 2016 (Table 11.9.1) and further changes during WGNSSK 2016. Data used in the MSY interval analysis were taken from the FLStock object created from the SAM final assessment model presented above. Data represent the latest assessment input and output data, reflecting the changes in data and model as decided upon at the benchmark and a second external review.

The interval analysis was based on a segmented regression, where the inflection point was set to B_{loss}. (107 000; Figure 11.9.1). Recruitment is fairly flat with increasing SSB; this is considered a Type 5 stock recruitment characteristic (distinct plateau, wide range of SSB) and for these stocks, B_{lim} is recommended to be B_{loss}. $B_{lim} = B_{loss} = 107\ 000$. B_{pa} was estimated to be 150 000, from the equation $B_{pa} = B_{lim} * 1.4$.

The alternate equation of $B_{pa} = B_{lim} * \exp(1.645 * \sigma)$, where σ is the standard deviation of ln(SSB) in the final the assessment year, was not used based on the outcome of WGNSSK 2016. The argument against this was that B_{pa}, could be overly influenced by the standard deviation for stocks where retrospective patterns are strong, while for stocks that use state-space models, estimating uncertainty that accounts for both the process and observation error is often not straightforward; a more precautionary approach (across stocks) was recommended.

The time period for the interval analysis was truncated to 2003-present. Recruitment per SSB showed signs of a cyclic trend over time (Figure 11.9.2). Whether the low productivity observed in recent years is part of cyclic changes or reflects that the stock has entered a new productivity regime is unknown. A change-point analysis, conducted using the *changepoint* library (Killick *et al*. 2016) in R, identified three distinct periods: high recruitment in the first years of the series, mid-level recruitment from 1969-2002, and low recruitment 2003–2015. Although the low recruitment period was used in the interval analysis, B_{loss} was estimated from the entire time series because no low levels of SSB have been observed during the truncated period.

11.10 Estimation of F_{MSY}

All analyses were conducted with Eqsim. The assessment error in the advisory year (F_{cv}) and the autocorrelation (F_{phi}) were set to values agreed at WKMSYREF4 for stocks where these uncertainties cannot be estimated (ICES-WKMSYREF4 2016). These values, which are normally derived by comparing F values from the latest assessment with forecasted F values in year^{-1}, could not be estimated for North Sea saithe because the assessment model, input data, and age range for F_{bar} were changed during the benchmark. Table 11.10.1 shows the model and data selection settings.

A landings obligation is soon to be mandatory for the North Sea and Skagerrak. Because of this, adjustments had to be made to the landings weights- and numbers-at-age for ages 4+. Discard numbers-at-age were added to the landings and catch weights-at-age were used for landings weights-at-age.

The results of Eqsim simulations run with and without $MSYB_{trigger}$ are shown in Figures 11.10.1 and 11.10.2, respectively.

The median F_{MSY} estimated by Eqsim applying a fixed F harvest strategy was 0.36 (Figure 11.10.3, Table 11.9.1). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to be above both $F_{P.05}$ and F_{pa}, and therefore must be constrained $F_{P.05}$. F_{pa} was estimated as $F_{lim}/1.4$ (again opting for the more precautionary approach when estimating F_{pa}). The median of the SSB estimates at F_{MSY} was 233163 (Figure 3.8.5.4). Median SSB is also shown in Figure 11.10.3.

$B_{trigger}$ was set to B_{pa} because F was below FMSY for only the last 4 years. When applying the ICES MSY harvest control rule with a $B_{trigger}$ of 150 000 tonnes, median F_{MSY} increased to 0.37. The upper bound must be again restricted to $F_{P.05}$. Median SSB values are lower than under the constant F scenario because of the higher F_{MSY} values (Figure 11.10.4).

11.11 Quality of the assessment and forecast

Although the benchmark attempted to address some of the issues with the previous year's assessments, several issues still remain.

The poor reliability of the recruitment estimate is a major problem for the saithe assessment. There is no survey that adequately covers the recruiting age class.

The commercial CPUE indices may introduce biases into the assessment if changes in fishing patterns occur, as seen in 2009–2011. There are conflicting signals between the survey and fishable biomass index.

The scientific survey used in the assessment does not cover the entire distribution of the stock, however, it is considered generally representative. The number of observations (trawl stations) with saithe is low and the resulting survey index is uncertain.

The fraction of fish age 3 migrating into the survey area (and the fishery) is low and varying between years with no obvious trend. Observations of saithe at age 3 are not suitable for predicting year class strength. This means that assumed recruitment values are highly uncertain and a substantial portion (30%) of the advised wanted catch in 2017 is based on the recruitment assumptions for 2016 and 2017.

Status of the Stock

The general perception of the status of the saithe stock is more positive than last year.

11.12 Management Considerations

The assessment is sensitive to relatively small changes in the input data. Because this stock suffers from 'poor data', the assessment is relatively uncertain. Recruitment is currently at a low level and it appears the strong recruitment pulses are more sporadic than in the past.

The reported landings have been relatively stable since the early 1990s. Landings have been lower than the TAC since 2002, even with reductions in the TAC were in place 2013–2015. The TAC was taken fully in 2015. Information from fishers' survey (Napier, 2014) has been moved to the Stock Annex.

Bycatch of other demersal fish species does occur in the target trawl fishery for saithe. Saithe is also taken as unintentional bycatch in other fisheries, and discards do occur. Bycatch of saithe in all fisheries in 2015 was estimated to be approximately % of the official landings; this included estimates of the Norwegian discards.

11.12.1 Evaluation of the Management plan

Because reference points were re-estimated after the benchmark, the management plan is no longer valid; therefore the MSY approach is used. The catch option for 2017 based on the EU-Norway management strategy has a lower F than the corresponding F_{MSY} option and is considered precautionary.

The assessment, if run in terms with the management plan, is consistent with the precautionary approach in the short term, conditional on the absence of major changes in the productivity and the absence of measurement and implementation error (ICES Advice 2008, Book 6, Paragraph 6.3.3.3). The EU–Norway management plan was reconsidered in February 2013, but no modification was implemented. It was previously evaluated by ICES (ICES, 2012a) and considered to be consistent with the precautionary approach in the short term (< 4 years). Because the long-term performance was not clear, ICES advised that the strategy should be re-evaluated within four years (i.e. no later than 2016) and revised if necessary.

11.13 Criteria for identification of candidate stocks for less frequent assessments

The following criteria were applied to determine whether saithe is a stock that may be subject to a change in the frequency by which it is assessed.

CRITERIA TO BE USED TO IDENTIFY CANDIDATE STOCKS FOR LESS FREQUENT ASSESSMENT.	CRITERIA FOR SAI_3.A46
Stocks are considered candidates for biennial assessment if:	
The advice for the stock has been 0-catch or equivalent for the latest three advice years.	False
Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously:	
Life span (i.e. maximum normal age) of the species is larger than 5 years	True
The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x FMSY OR if FMSY range has been defined: F(latest assessment year) is <= Fupper (upper bound in F range) AND SSB(start of intermediate year) >= MSY Btrigger	True: F=0.301 <= 1.1*FMSY OR F=0.301 <= MSY Fupper (0.403) AND SSB2016 (239561) is >= MSY Btrigger (150 000)
The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.	True. The average over the latest five years (in numbers) = 14%. Avg. contribution: 2011: 19%, 2012: 16%, 2013: 10%, 2014: 8%, 2015: 15%
The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by less than 20%.	True; p<0.01

Saithe is a stock that meets the criteria for biennial assessment. However, the input data for the assessment is highly uncertain, as shown during the benchmark (ICES-WKNSEA 2016) and work following the benchmark. Minor modifications to the input data can greatly change perception of the stock. This, coupled with the uncertainties in the forecast, mean that saithe should continue to be assessed annually.

11.14 References

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Table 11.3.1. Saithe in Subareas 4 and 6 and Division 3.a. Nominal landings (tonnes) of saithe, 2004–2015, as officially reported to ICES and estimated by the Working Group.

Subarea 4 and Division 3.a

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*
Belgium	22	28	15	18	7	27	15	2	1	3	4	6
Denmark	7991	7498	7470	5443	8066	8802	8018	6331	5171	5691	5056	4508
Faroe Isl.	558	463	60	15	108	841	146	2	8	3	0	0
France	13628	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7906	11612
Germany	9589	12401	14397	12791	14140	13410	11193	10234	8052	9687	8562	7954
Greenland	403	1042	924	564	888	927	0	0	0	0	0	0
Ireland	1	0	0	0	0	1	0	0	0	0	0	0
Lithuania	0	149	0	0	0	0	0	0	0	0	0	0
Netherlands	3	40	28	5	3	16	3	24	34	168	0	64
Norway	62783	68122	61318	45396	61464	57708	52712	46809	33288	35701	37463	35691
Poland	0	1100	1084	1384	1407	988	654	584	0	0	0	0
Russia	0	35	2	5	5	13	0	0	0	0	0	0
Sweden	2249	2132	1745	1381	1639	1363	1545	1335	1306	1401	1272	1157
UK (E/W/NI)	457	960									687	8888**
UK (Scotland)	5924	6170	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	7686	
Total reported	103608	111970	113124	91710	115412	103883	90755	89427	69240	71508	68318	69879
Unallocated	−3646	−427	3988	1908	−3979	1646	4345	277	645	317	319	726
ICES estimate	99962	111543	117112	93618	111433	105529	95100	89704	70510	71825	68662	69153
TAC	190000	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006

***Preliminary.**

****Scotland+E/W/NI combined.**

Subarea 6

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*
Denmark	0	0	0	0	0	0	0	0	0	0	20	0
Faroe Islands	34	25	76	32	23	60	24	5	6	25	0	3
France	3053	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484
Germany	4	373	532	580	148	298	257	0	9	0	0	0
Ireland	95	168	267	322	288	407	520	359	364	313	128	105
Netherlands	0	0	3	36	1	0	0	0	0	0	0	6
Norway	16	20	28	377	78	68	121	240	5	715	442	677
Russia	6	25	7	2	50	4	2	0	0	0	0	1
Spain	2	3	6	3	4	8	18	31	13	21	0	15
UK (E/W/NI)	37	133									97	
UK (Scotland)	1563	2922	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	3191	3286**
Total reported	4810	7623	9759	7103	7717	6438	6118	7492	7558	8534	6842	7577
Unallocated	−296	−1884	−1191	−317	−483	525	722	−92	−351	−472	−60	-1578
ICES estimate	4514	5739	8568	6786	7234	6963	6840	7400	7162	8062	6831	9155
TAC	20000	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848

***Preliminary.**

****Scotland+E/W/NI combined.**

Subarea 4, Division 3.a, and Subarea 6

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ICES estimate	108418	119593	125680	100404	118667	112492	101940	97104	77672	79887	75419	78307
TAC	210000	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854

Table 11.3.2. Saithe in Subareas 4 and 6 and Division 3.a. Proportion of sampling strata for discards imported into InterCatch and proportion of discards raised from averaged discard rates.

Catch Category	Raised Or Imported	Weight (tonnes)	Proportion
Discards	Raised_Discards	94.9	2
Discards	Imported_Data	4913.8	98
Landings	Imported_Data	76936.3	100

Table 11.3.3. Saithe in Subareas 4 and 6 and Division 3.a. Proportion of distributions for landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch Category	Raised Or Imported	Sampled Or Estimated	Weight (tonnes)	Proportion
Landings	Imported_Data	Sampled_Distribution	66398.8	86
Landings	Imported_Data	Estimated_Distribution	10537.5	14
Discards	Imported_Data	Sampled_Distribution	4644.6	93
Discards	Imported_Data	Estimated_Distribution	269.2	5
Discards	Raised_Discards	Estimated_Distribution	94.9	2

Table 11.3.4. Saithe in Subareas 4 and 6 and Division 3.a. Proportion by area of distributions for landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch Category	Raised or Imported	Sampled Or Estimated	Area	Weight (tonnes)	Proportion
Landings	Imported_Data	Sampled_Distribution	6	6160	82
Landings	Imported_Data	Estimated_Distribution	6	1373	18
Discards	Imported_Data	Sampled_Distribution	6	269	66
Discards	Imported_Data	Estimated_Distribution	6	134	33
Discards	Raised_Discards	Estimated_Distribution	6	2	0
Landings	Imported_Data	Sampled_Distribution	4	59406	88
Landings	Imported_Data	Estimated_Distribution	4	8404	12
Discards	Imported_Data	Sampled_Distribution	4	4266	98
Discards	Raised_Discards	Estimated_Distribution	4	56	1
Discards	Imported_Data	Estimated_Distribution	4	35	1
Landings	Imported_Data	Sampled_Distribution	3.aN	832	52
Landings	Imported_Data	Estimated_Distribution	3.aN	760	48
Discards	Imported_Data	Sampled_Distribution	3.aN	109	44
Discards	Imported_Data	Estimated_Distribution	3.aN	100	41
Discards	Raised_Discards	Estimated_Distribution	3.aN	37	15

Table 11.3.5. Saithe in Subareas 4 and 6 and Division 3.a. Working Group estimates of catch components by weight (000 tonnes).

Year	Catches	Landings	Discards	Proportion discards
1967	126743	113751	12992	10
1968	109144	88326	20818	19
1969	150301	130588	19713	13
1970	270779	234962	35817	13
1971	309202	265381	43821	14
1972	296444	261877	34567	12
1973	275150	242499	32651	12
1974	337025	298351	38674	11
1975	304619	271584	33035	11
1976	423416	343967	79449	19
1977	239915	216395	23520	10
1978	176868	155141	21727	12
1979	142655	128360	14295	10
1980	145300	131908	13392	9
1981	148249	132278	15971	11
1982	202126	174351	27775	14
1983	203022	180044	22978	11
1984	240557	200834	39723	17
1985	273671	220869	52802	19
1986	232786	198596	34190	15
1987	192391	167514	24877	13
1988	154248	135172	19076	12
1989	124584	108877	15707	13
1990	124419	103800	20619	17
1991	130950	108048	22902	17
1992	115534	99742	15792	14
1993	132610	111491	21119	16
1994	126760	109622	17138	14
1995	141205	121810	19395	14
1996	128925	114997	13928	11
1997	120082	107327	12755	11
1998	117219	106123	11096	9
1999	119652	110716	8936	7
2000	99336	91322	8014	8
2001	106160	95042	11118	10
2002	143580	122036	21544	15
2003	123821	112383	11438	9
2004	115472	107384	8088	7
2005	127069	118873	8196	6
2006	130235	121650	8585	7
2007	111883	99470	12413	11
2008	130207	121848	8359	6
2009	118052	113756	4296	4
2010	107488	103004	4484	4
2011	101960	97598	4362	4
2012	87143	77865	9278	11
2013	88224	80447	7777	9
2014	81830	75493	6337	8
2015	83310	78307	5003	6

Table 11.3.6. Saithe in Subareas 4 and 6 and Division 3.a. Catch numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	26948	19395	16672	2358	1610	299	203	185
1968	36111	25387	14153	6166	433	247	127	147
1969	47014	21142	11869	7790	5795	810	642	151
1970	57920	91668	16102	12416	3932	1834	326	270
1971	108549	69105	35143	4848	4290	2910	1922	782
1972	74755	79033	27178	21711	3709	3014	1682	1625
1973	84484	45078	28822	16443	8511	2047	1391	2407
1974	104086	40345	15160	21179	14810	5321	1514	1977
1975	88613	30927	11077	7746	13792	9577	3591	2717
1976	323156	63447	12556	6401	4016	5488	3678	3528
1977	42701	65727	15839	5620	3814	3528	3909	4753
1978	54515	32608	19389	3390	1149	1057	788	3522
1979	25395	16999	12004	8906	2833	750	554	2112
1980	27203	14757	9677	6878	5714	1177	522	2327
1981	40705	9971	7235	3763	3368	3475	674	2564
1982	49595	48533	9848	6120	2166	1489	1007	1268
1983	43916	24637	27924	5813	4942	1529	1062	1342
1984	125848	38470	13910	13320	1673	1281	344	653
1985	208401	66489	14257	4878	3034	698	409	750
1986	86198	109080	16302	5509	2629	1490	457	910
1987	48545	116551	15019	3233	1829	1269	933	707
1988	50657	31577	37919	3918	1927	1130	796	687
1989	34408	36772	14156	11211	1572	757	430	493
1990	63454	23416	12154	4826	2803	762	288	368
1991	71710	35719	8016	3669	1733	976	376	463
1992	28617	40193	13691	3269	1539	712	531	426
1993	58813	24905	12715	3199	1583	1547	835	1037
1994	31034	48062	13992	4399	957	354	438	803
1995	41461	31130	15884	3864	3529	690	566	809
1996	17208	46468	12653	7915	3194	827	215	496
1997	23380	23077	32395	3763	2666	1036	299	292
1998	16113	37088	17570	16459	2253	1234	581	280
1999	14661	16588	28645	8588	10169	2401	914	665
2000	10985	20680	9597	12632	3190	3302	657	446
2001	24961	21100	24068	3429	3621	1814	1655	248
2002	17570	37489	14736	13731	2309	2544	1321	1575
2003	28296	31752	20631	6836	6855	1535	2000	2042
2004	13642	24479	15649	15220	2037	2164	1300	1066
2005	12690	15473	19060	20042	7956	1628	1188	1151
2006	17313	31972	10381	11286	8395	3824	1008	1281
2007	24614	13314	20919	7175	5564	3610	1218	930
2008	7620	30911	12540	14941	5088	3285	3551	3118
2009	7438	15507	14222	5847	8512	2994	1519	2945
2010	8766	9249	9440	6511	2671	4773	1679	2707
2011	12786	24269	8980	3674	2867	1208	1564	3877
2012	14334	13053	16948	4075	1977	1268	541	2611
2013	7267	30318	5312	7869	1890	1241	616	1658
2014	4055	14322	15195	3957	4124	1040	429	1389
2015	8369	8323	14259	8254	1862	1623	715	977

Table 11.3.7. Saithe in Subareas 4 and 6 and Division 3.a. Landings numbers (thousands) at age for the age range used in the assessment.

Year/Age	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	55435	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	9131	31779	12286	13307	2245	2220	1199	1479
2003	13009	24646	20397	6836	6855	1535	2000	2042
2004	8037	20071	15649	15220	2037	2164	1300	1066
2005	9191	15473	19060	20042	7956	1628	1188	1151
2006	12200	26690	9986	11286	8395	3824	1008	1281
2007	15181	10163	19157	7078	5564	3610	1218	930
2008	6924	23230	10930	14196	4977	3276	3551	3118
2009	6607	14349	13827	5817	8419	2978	1505	2934
2010	7880	8859	9174	6394	2670	4762	1679	2669
2011	10150	22799	8852	3630	2860	1183	1563	3869
2012	7029	11712	15572	4016	1971	1267	537	2610
2013	4999	25516	4974	7645	1886	1241	616	1658
2014	3099	12117	13380	3737	4047	1036	429	1388
2015	6206	7392	13555	8021	1844	1621	715	975

Table 11.3.8. Saithe in Subareas 4 and 6 and Division 3.a. Dicards numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	9617	3175	1141	55	16	7	5	2
1968	12888	4156	969	143	4	6	3	2
1969	16779	3461	813	181	57	19	16	2
1970	20671	15007	1102	288	38	42	8	3
1971	38741	11313	2406	112	42	67	48	9
1972	26680	12938	1861	504	36	69	42	18
1973	30152	7380	1973	381	83	47	35	26
1974	37148	6605	1038	491	144	122	38	22
1975	31626	5063	758	180	135	220	89	30
1976	115333	10387	860	148	39	126	92	38
1977	15240	10760	1084	130	37	81	97	52
1978	19456	5338	1327	79	11	24	20	38
1979	9063	2783	822	207	28	17	14	23
1980	9709	2416	662	160	56	27	13	25
1981	14527	1632	495	87	33	80	17	28
1982	17700	7945	674	142	21	34	25	14
1983	15673	4033	1912	135	48	35	26	15
1984	44915	6298	952	309	16	29	9	7
1985	74378	10885	976	113	30	16	10	8
1986	30764	17857	1116	128	26	34	11	10
1987	17326	19080	1028	75	18	29	23	8
1988	18079	5169	2596	91	19	26	20	7
1989	12280	6020	969	260	15	17	11	5
1990	22647	3833	832	112	27	18	7	4
1991	25593	5847	549	85	17	22	9	5
1992	10213	6580	937	76	15	16	13	5
1993	20990	4077	871	74	15	36	21	11
1994	11076	7868	958	102	9	8	11	9
1995	14797	5096	1087	90	34	16	14	9
1996	6141	7607	866	184	31	19	5	5
1997	8344	3778	2218	87	26	24	7	3
1998	5751	6072	1203	382	22	28	14	3
1999	5233	2716	1961	199	99	55	23	7
2000	3920	3386	657	293	31	76	16	5
2001	8908	3454	1648	80	35	42	41	3
2002	8439	5710	2451	425	64	324	121	96
2003	15288	7106	234	0	0	0	0	0
2004	5605	4407	0	0	0	0	0	0
2005	3498	0	0	0	0	0	0	0
2006	5114	5282	394	0	0	0	0	0
2007	9433	3152	1762	97	0	0	0	0
2008	696	7682	1610	745	111	9	0	0
2009	831	1158	395	30	93	16	14	11
2010	886	390	266	117	1	11	0	38
2011	2636	1470	129	44	7	25	1	8
2012	7305	1341	1377	58	7	1	4	1
2013	2268	4801	339	224	4	0	0	1
2014	955	2205	1816	220	77	4	0	1
2015	2163	931	704	232	17	3	0	2

Table 11.3.9. Saithe in Subareas 4 and 6 and Division 3.a. Catch weight-at-age (kg) .

Year/Age	3	4	5	6	7	8	9	10+
1967	0.898	1.339	2.094	3.183	3.753	5.316	5.891	7.719
1968	1.234	1.624	1.979	3.007	4.039	4.428	6.136	7.406
1969	0.933	1.530	2.251	2.711	3.558	4.406	5.220	6.767
1970	0.908	1.416	2.049	2.716	3.599	4.463	5.687	6.845
1971	0.811	1.325	2.167	2.934	3.765	4.634	5.172	6.163
1972	0.780	1.175	1.952	2.367	3.793	4.228	4.630	6.326
1973	0.792	1.382	1.633	2.569	3.356	4.684	4.814	6.445
1974	0.831	1.534	2.372	2.751	3.428	4.498	5.713	7.857
1975	0.862	1.472	2.479	3.298	3.764	4.296	5.540	7.562
1976	0.678	1.287	2.250	3.068	4.034	4.383	5.112	7.147
1977	0.733	1.234	1.926	3.108	4.161	4.605	4.859	6.542
1978	0.793	1.304	2.145	3.338	4.521	4.900	5.449	7.400
1979	1.069	1.595	2.228	3.093	4.049	5.274	6.308	7.955
1980	0.921	1.790	2.380	3.028	4.089	5.126	5.939	8.148
1981	0.927	1.790	2.705	3.584	4.535	5.478	6.980	8.724
1982	1.048	1.548	2.518	3.218	4.206	5.125	5.905	8.823
1983	0.992	1.688	2.139	3.135	3.690	4.632	5.505	8.453
1984	0.767	1.586	2.286	2.688	3.895	4.665	6.183	8.474
1985	0.640	1.244	1.941	2.769	3.406	4.950	5.865	8.854
1986	0.670	1.018	1.786	2.430	3.571	4.209	5.651	8.218
1987	0.650	0.861	1.815	3.072	4.209	5.330	6.128	8.603
1988	0.751	0.964	1.379	2.789	4.023	5.254	6.322	8.649
1989	0.864	1.018	1.413	1.997	3.913	5.017	6.430	8.431
1990	0.815	1.175	1.575	2.245	3.241	4.858	6.315	8.416
1991	0.764	1.138	1.744	2.363	3.165	4.222	6.066	8.191
1992	0.930	1.169	1.599	2.240	3.667	4.330	5.412	7.045
1993	0.868	1.239	1.746	2.634	3.184	3.980	5.080	6.891
1994	0.911	1.100	1.594	2.432	3.617	4.787	6.548	8.326
1995	0.967	1.272	1.807	2.560	3.554	4.767	5.267	7.891
1996	0.933	1.167	1.798	2.366	2.951	4.705	6.092	8.382
1997	0.873	1.125	1.445	2.585	3.555	4.525	6.158	8.866
1998	0.861	0.949	1.386	1.743	2.948	3.883	4.996	7.227
1999	0.850	1.042	1.206	1.752	2.337	3.493	4.844	6.745
2000	0.992	1.107	1.532	1.683	2.593	3.084	4.773	7.461
2001	0.774	1.053	1.307	2.093	2.546	3.485	4.141	6.141
2002	0.776	1.014	1.495	1.791	2.961	3.761	4.638	5.750
2003	0.636	0.889	1.167	1.810	2.368	3.176	3.768	5.065
2004	0.794	1.010	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.715	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.904	1.012	1.489	1.906	2.424	3.058	4.318	5.734
2007	0.769	1.124	1.286	1.834	2.328	2.887	3.600	4.975
2008	0.916	1.065	1.488	1.692	2.210	2.792	3.206	4.565
2009	1.033	1.333	1.672	1.994	2.566	3.086	3.651	4.790
2010	1.037	1.474	2.033	2.597	3.163	3.488	3.968	5.223
2011	0.955	1.192	1.787	2.571	3.068	3.418	3.718	4.289
2012	0.910	1.287	1.383	2.196	3.221	3.536	4.181	4.482
2013	0.878	1.132	1.586	1.957	3.076	3.841	4.541	5.648
2014	1.091	1.265	1.568	2.334	2.607	4.010	5.530	6.679
2015	0.951	1.253	1.621	2.180	3.037	3.793	4.228	7.285

Table 11.3.10. Saithe in Subareas 4 and 6 and Division 3.a. Landings weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.9305	1.3620	2.1035	3.1858	3.7541	5.3162	5.8905	7.7190
1968	1.2784	1.6521	1.9886	3.0093	4.0404	4.4278	6.1355	7.4055
1969	0.9663	1.5568	2.2614	2.7133	3.5588	4.4063	5.2203	6.7675
1970	0.9414	1.4408	2.0587	2.7180	3.5995	4.4632	5.6871	6.8452
1971	0.8399	1.3480	2.1775	2.9360	3.7657	4.6339	5.1725	6.1630
1972	0.8082	1.1958	1.9610	2.3687	3.7941	4.2276	4.6304	6.3263
1973	0.8212	1.4061	1.6410	2.5709	3.3571	4.6844	4.8138	6.4449
1974	0.8608	1.5606	2.3834	2.7527	3.4286	4.4977	5.7128	7.8570
1975	0.8928	1.4977	2.4904	3.3002	3.7647	4.2957	5.5396	7.5620
1976	0.7024	1.3092	2.2604	3.0706	4.0347	4.3833	5.1117	7.1470
1977	0.7598	1.2560	1.9348	3.1107	4.1618	4.6045	4.8589	6.5419
1978	0.8215	1.3267	2.1545	3.3401	4.5221	4.9005	5.4494	7.4000
1979	1.1072	1.6228	2.2381	3.0950	4.0504	5.2742	6.3077	7.9551
1980	0.9546	1.8212	2.3911	3.0300	4.0895	5.1262	5.9393	8.1476
1981	0.9608	1.8211	2.7175	3.5868	4.5360	5.4776	6.9804	8.7237
1982	1.0857	1.5746	2.5293	3.2202	4.2069	5.1251	5.9049	8.8232
1983	1.0276	1.7178	2.1493	3.1377	3.6906	4.6317	5.5053	8.4529
1984	0.7948	1.6139	2.2966	2.6899	3.8959	4.6647	6.1830	8.4735
1985	0.6632	1.2654	1.9505	2.7715	3.4067	4.9499	5.8649	8.8543
1986	0.6943	1.0353	1.7944	2.4316	3.5717	4.2094	5.6506	8.2184
1987	0.6739	0.8763	1.8236	3.0747	4.2098	5.3300	6.1284	8.6026
1988	0.7787	0.9810	1.3859	2.7907	4.0238	5.2544	6.3221	8.6489
1989	0.8954	1.0362	1.4196	1.9984	3.9139	5.0175	6.4298	8.4308
1990	0.8441	1.1958	1.5828	2.2472	3.2419	4.8583	6.3149	8.4162
1991	0.7913	1.1579	1.7523	2.3646	3.1653	4.2221	6.0661	8.1914
1992	0.9641	1.1893	1.6066	2.2417	3.6677	4.3296	5.4125	7.0455
1993	0.8994	1.2603	1.7544	2.6363	3.1851	3.9798	5.0802	6.8909
1994	0.9439	1.1188	1.6010	2.4337	3.6175	4.7869	6.5479	8.3256
1995	1.0022	1.2937	1.8159	2.5619	3.5549	4.7670	5.2674	7.8907
1996	0.9668	1.1873	1.8068	2.3678	2.9518	4.7053	6.0922	8.3821
1997	0.9047	1.1448	1.4522	2.5867	3.5556	4.5251	6.1575	8.8663
1998	0.8917	0.9660	1.3925	1.7440	2.9486	3.8829	4.9955	7.2273
1999	0.8808	1.0605	1.2112	1.7537	2.3374	3.4934	4.8438	6.7452
2000	1.0274	1.1266	1.5389	1.6843	2.5936	3.0842	4.7733	7.4615
2001	0.8023	1.0717	1.3130	2.0950	2.5461	3.4848	4.1410	6.1410
2002	0.9233	1.0348	1.4777	1.7691	2.9469	3.4261	4.4066	5.6741
2003	0.8327	0.9801	1.1732	1.8103	2.3683	3.1761	3.7684	5.0647
2004	0.9182	1.0839	1.3915	1.8959	2.8599	3.6872	4.8135	7.0589
2005	0.9211	1.1553	1.3252	1.7095	2.1315	3.0262	3.6217	5.7133
2006	0.9445	1.0687	1.5137	1.9060	2.4242	3.0581	4.3175	5.7338
2007	0.8369	1.1427	1.3168	1.8401	2.3283	2.8874	3.6002	4.9754
2008	0.9444	1.1925	1.5650	1.7199	2.2264	2.7948	3.2060	4.5654
2009	1.0357	1.3396	1.6638	1.9920	2.5627	3.0845	3.6483	4.7929
2010	1.0359	1.4786	2.0343	2.5974	3.1636	3.4884	3.9677	5.1988
2011	1.0072	1.2065	1.7828	2.5727	3.0682	3.4043	3.7174	4.2837
2012	1.0151	1.3207	1.4080	2.2014	3.2230	3.5363	4.1772	4.4822
2013	0.8978	1.1563	1.6141	1.9761	3.0780	3.8405	4.5407	5.6475
2014	1.1264	1.3004	1.6074	2.3842	2.6172	4.0126	5.5301	6.6790
2015	0.9770	1.2441	1.6253	2.1899	3.0431	3.7957	4.2282	7.2869

Table 11.3.11. Saithe in Subareas 4 and 6 and Division 3.a. Discards weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.748	1.076	1.818	2.972	3.590	5.316	5.891	7.719
1968	1.028	1.306	1.719	2.808	3.864	4.428	6.136	7.406
1969	0.777	1.230	1.955	2.531	3.403	4.406	5.220	6.767
1970	0.757	1.139	1.780	2.536	3.442	4.463	5.687	6.845
1971	0.676	1.065	1.882	2.739	3.601	4.634	5.172	6.163
1972	0.650	0.945	1.695	2.210	3.628	4.228	4.630	6.326
1973	0.660	1.111	1.419	2.399	3.210	4.684	4.814	6.445
1974	0.692	1.233	2.060	2.568	3.279	4.498	5.713	7.857
1975	0.718	1.184	2.153	3.079	3.600	4.296	5.540	7.562
1976	0.565	1.035	1.954	2.865	3.858	4.383	5.112	7.147
1977	0.611	0.993	1.673	2.902	3.980	4.605	4.859	6.542
1978	0.661	1.049	1.862	3.116	4.325	4.900	5.449	7.400
1979	0.890	1.283	1.935	2.888	3.873	5.274	6.308	7.955
1980	0.768	1.439	2.067	2.827	3.911	5.126	5.939	8.148
1981	0.773	1.439	2.349	3.346	4.338	5.478	6.980	8.724
1982	0.873	1.245	2.186	3.004	4.023	5.125	5.905	8.823
1983	0.826	1.358	1.858	2.927	3.529	4.632	5.505	8.453
1984	0.639	1.276	1.985	2.510	3.726	4.665	6.183	8.474
1985	0.533	1.000	1.686	2.586	3.258	4.950	5.865	8.854
1986	0.558	0.818	1.551	2.269	3.416	4.209	5.651	8.218
1987	0.542	0.693	1.576	2.869	4.026	5.330	6.128	8.603
1988	0.626	0.775	1.198	2.604	3.848	5.254	6.322	8.649
1989	0.720	0.819	1.227	1.865	3.743	5.017	6.430	8.431
1990	0.679	0.945	1.368	2.097	3.100	4.858	6.315	8.416
1991	0.636	0.915	1.515	2.206	3.027	4.222	6.066	8.191
1992	0.775	0.940	1.389	2.092	3.508	4.330	5.412	7.045
1993	0.723	0.996	1.517	2.460	3.046	3.980	5.080	6.891
1994	0.759	0.884	1.384	2.271	3.459	4.787	6.548	8.326
1995	0.806	1.023	1.570	2.390	3.400	4.767	5.267	7.891
1996	0.778	0.938	1.562	2.209	2.823	4.705	6.092	8.382
1997	0.728	0.905	1.255	2.413	3.400	4.525	6.158	8.866
1998	0.717	0.764	1.204	1.627	2.820	3.883	4.996	7.227
1999	0.708	0.838	1.047	1.636	2.235	3.493	4.844	6.745
2000	0.826	0.890	1.330	1.571	2.480	3.084	4.773	7.461
2001	0.645	0.847	1.135	1.955	2.435	3.485	4.141	6.141
2002	0.616	0.896	1.580	2.483	3.469	6.058	6.935	6.927
2003	0.469	0.571	0.641	1.689	2.265	3.176	3.768	5.065
2004	0.617	0.676	1.203	1.769	2.735	3.687	4.814	7.059
2005	0.741	0.913	1.146	1.595	2.038	3.026	3.622	5.713
2006	0.808	0.724	0.859	1.778	2.318	3.058	4.318	5.734
2007	0.660	1.062	0.949	1.365	2.227	2.887	3.600	4.975
2008	0.633	0.680	0.967	1.161	1.495	1.820	3.206	2.797
2009	1.010	1.253	1.946	2.403	2.838	3.388	3.934	3.911
2010	1.046	1.374	1.987	2.561	3.025	3.351	3.968	6.895
2011	0.756	0.971	2.054	2.445	3.170	4.072	4.369	6.618
2012	0.808	0.997	1.101	1.831	2.675	3.411	4.804	5.313
2013	0.835	1.003	1.180	1.300	2.298	3.841	4.541	5.861
2014	0.977	1.072	1.274	1.487	2.077	3.223	5.530	7.568
2015	0.877	1.326	1.531	1.848	2.410	2.184	4.228	5.911

Table 11.3.12. Saithe in Subareas 4 and 6 and Division 3.a. Data available for calibration of the assessment. Indices include one commercial standardized CPUE indices (year effects), tuned to the exploitable biomass within SAM, and one research survey.

	IBTS Q3 (DATRAS STANDARD INDEX)						CPUE
Year	3	4	5	6	7	8	
1992	1.077	2.76	0.516	0.098	0.057	0.05	
1993	7.965	2.781	1.129	0.197	0.011	0.04	
1994	1.117	1.615	0.893	0.609	0.091	0.04	
1995	13.959	2.501	1.559	0.533	0.172	0.049	
1996	3.825	6.533	1.112	0.971	0.212	0.069	
1997	3.756	3.351	7.461	0.698	0.534	0.181	
1998	1.181	4.134	1.351	1.58	0.149	0.179	
1999	2.086	1.907	3.155	0.619	0.632	0.074	
2000	3.479	8.836	1.081	0.868	0.114	0.152	0.217
2001	21.614	6.206	3.959	0.357	0.446	0.114	0.3368
2002	10.748	18.974	1.327	1.09	0.162	0.264	0.1296
2003	19.272	23.802	13.402	0.393	0.439	0.168	0.05785
2004	4.93	6.727	3.237	0.921	0.064	0.085	0.2981
2005	8.916	7.512	4.428	1.914	1.082	0.104	0.391
2006	10.553	29.579	2.835	1.177	0.445	0.242	0.4279
2007	34.006	5.578	11.7	1.016	0.743	0.358	0.2428
2008	3.312	5.584	0.907	1.997	0.254	0.254	0.4292
2009	1.346	1.703	0.568	0.101	0.229	0.2	0.1744
2010	1.361	0.964	0.471	0.205	0.045	0.166	0.1069
2011	4.52	8.451	1.059	1.114	0.426	0.08	0.0939
2012	11.134	2.497	2.968	0.503	0.483	0.344	-0.0428
2013	14.701	16.279	1.83	1.858	0.308	0.146	0.05277
2014	1.649	3.923	2.822	0.481	0.52	0.114	-0.01323
2015	11.001	5.613	4.611	1.581	0.289	0.285	0.1663

Table 11.4.1. Saithe in Subareas 4 and 6 and Division 3.a. Model configuration for both the final and the exploratory SAM assessment.

Min Age: 3

Max Age: 10

Max Age considered a plus group (Yes)

The following matrix describes the coupling of fishing mortality STATES, where rows represent fleets and columns represent ages:

1	2	3	4	5	6	7	7
0	0	0	0	0	0	0	0

Use correlated random walks for the fishing mortalities: (2=AR1)

2

Coupling of catchability PARAMETERS

0	0	0	0	0	0	0	0
1	2	3	4	5	6	0	0

Coupling of power law model EXPONENTS (if used)

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Coupling of fishing mortality RW VARIANCES

1	2	2	2	2	2	2	2
0	0	0	0	0	0	0	0

Coupling of log N RW VARIANCES

1	2	2	2	2	2	2	2

Coupling of OBSERVATION VARIANCES

1	1	1	1	1	1	1	1
2	2	2	2	2	2	0	0

Stock recruitment model code (random walk)

Years in which catch data are to be scaled by an estimated parameter

0

Fbar range: 4 to 7

Observation correlation coupling (0 = uncorrelated). Rows represent fleets, columns represent adjacent age groups, i.e. the first column is the correlation between the first and 2nd age group. An NA in all non-empty age groups for a fleet specifies unstructured correlation. NA's and positive numbers cannot be mixed within fleets.

0	0	0	0	0	0	0
NA	**NA**	**NA**	**NA**	**NA**	**0**	**0**

Table 11.4.2. Saithe in Subareas 4 and 6 and Division 3.a. Fishing mortalities at age for the exploratory assessment model: cpue + DATRAS Q3, sw=cw for ages 7+. Fs for ages 9 and 10+ were coupled in the model configuration.

Year\Age	3	4	5	6	7	8	9+
1967	0.268	0.385	0.355	0.350	0.311	0.281	0.310
1968	0.238	0.344	0.301	0.284	0.245	0.221	0.247
1969	0.257	0.371	0.324	0.311	0.276	0.252	0.273
1970	0.305	0.418	0.351	0.326	0.282	0.253	0.266
1971	0.370	0.467	0.377	0.345	0.308	0.284	0.295
1972	0.445	0.521	0.405	0.368	0.331	0.306	0.310
1973	0.520	0.572	0.429	0.381	0.345	0.319	0.317
1974	0.631	0.662	0.497	0.436	0.398	0.364	0.350
1975	0.655	0.695	0.537	0.476	0.442	0.409	0.385
1976	0.743	0.775	0.609	0.531	0.486	0.445	0.409
1977	0.633	0.714	0.598	0.541	0.510	0.473	0.430
1978	0.501	0.586	0.492	0.439	0.416	0.388	0.355
1979	0.419	0.523	0.459	0.422	0.408	0.380	0.346
1980	0.405	0.522	0.479	0.453	0.447	0.423	0.386
1981	0.366	0.500	0.473	0.459	0.464	0.452	0.416
1982	0.432	0.586	0.553	0.521	0.508	0.481	0.436
1983	0.515	0.705	0.674	0.626	0.597	0.554	0.493
1984	0.586	0.793	0.725	0.628	0.561	0.504	0.444
1985	0.626	0.869	0.772	0.625	0.541	0.483	0.436
1986	0.592	0.897	0.821	0.654	0.565	0.511	0.478
1987	0.540	0.845	0.794	0.632	0.553	0.509	0.490
1988	0.528	0.832	0.804	0.647	0.567	0.521	0.503
1989	0.517	0.813	0.783	0.628	0.538	0.483	0.464
1990	0.500	0.784	0.749	0.591	0.501	0.439	0.422
1991	0.463	0.745	0.719	0.565	0.479	0.418	0.408
1992	0.410	0.694	0.695	0.559	0.482	0.419	0.413
1993	0.389	0.681	0.710	0.603	0.559	0.501	0.499
1994	0.319	0.595	0.630	0.539	0.512	0.466	0.472
1995	0.275	0.553	0.618	0.559	0.561	0.529	0.536
1996	0.218	0.466	0.545	0.507	0.506	0.481	0.483
1997	0.184	0.403	0.476	0.446	0.436	0.419	0.419
1998	0.184	0.403	0.485	0.461	0.440	0.423	0.419
1999	0.182	0.410	0.512	0.506	0.484	0.471	0.461
2000	0.155	0.360	0.450	0.444	0.407	0.388	0.377
2001	0.147	0.341	0.418	0.410	0.364	0.342	0.334
2002	0.143	0.335	0.420	0.438	0.400	0.388	0.401
2003	0.149	0.337	0.416	0.456	0.426	0.415	0.435
2004	0.133	0.309	0.372	0.406	0.374	0.360	0.365
2005	0.135	0.316	0.381	0.415	0.380	0.360	0.354
2006	0.150	0.341	0.400	0.425	0.388	0.366	0.357
2007	0.143	0.335	0.389	0.402	0.364	0.341	0.332
2008	0.157	0.383	0.459	0.470	0.426	0.399	0.385
2009	0.152	0.382	0.467	0.480	0.438	0.413	0.397
2010	0.137	0.359	0.445	0.459	0.429	0.413	0.398
2011	0.143	0.372	0.454	0.455	0.418	0.402	0.385
2012	0.123	0.339	0.414	0.417	0.381	0.367	0.355
2013	0.103	0.299	0.367	0.375	0.347	0.338	0.330
2014	0.089	0.265	0.332	0.344	0.321	0.317	0.319
2015	0.088	0.263	0.328	0.335	0.309	0.301	0.304

Table 11.4.3. Saithe in Subareas 4 and 6 and Division 3.a. Estimated population numbers-at-age for the exploratory assessment model: cpue + DATRAS Q3, sw=cw for ages 7+.

Year\Age	3	4	5	6	7	8	9	10+
1967	140963	81613	57347	7177	4923	1158	759	694
1968	160362	91876	50370	31878	3747	2547	665	793
1969	283740	90417	54375	31055	20519	2842	1966	835
1970	293388	215022	49090	35300	18682	11735	1805	1646
1971	354167	191110	118659	24662	19415	11927	7836	2520
1972	224084	209036	102790	67090	14503	11360	7303	6511
1973	201100	111374	105146	63086	35662	8668	6336	8605
1974	199243	90766	48379	62491	41760	20472	5383	8537
1975	234909	76841	35525	24203	35998	24968	11932	8471
1976	403670	102762	29696	17386	12851	19027	13191	11534
1977	149927	148828	35701	12435	8653	7165	10688	13908
1978	120345	72388	58174	14262	5124	4006	3384	13088
1979	87539	53928	34763	29293	7801	2815	2207	9519
1980	85562	47065	25688	18703	16078	4041	1667	7666
1981	162508	41887	24867	12280	9624	8280	2144	5881
1982	140911	107955	22924	15011	6271	4820	3773	4076
1983	148652	69639	54668	11311	8240	3131	2523	3824
1984	255031	76154	29993	23769	4726	3472	1333	2793
1985	354922	108294	29490	12780	9453	2220	1591	2299
1986	289819	141896	32321	11783	6357	4473	1190	2257
1987	149255	163455	36430	10225	5136	3280	2284	1798
1988	137966	71459	61357	11450	4549	2588	1737	1932
1989	102533	69267	27683	21756	4710	2088	1241	1651
1990	151040	48014	25676	11125	8371	2305	1025	1408
1991	174004	71654	17403	10254	5255	3794	1234	1389
1992	104092	88513	26170	6805	5173	2850	2056	1478
1993	175788	59386	33946	9200	2916	3126	1797	2250
1994	117944	97068	28730	13421	3471	1415	1469	2149
1995	215510	66620	41962	13047	6409	1628	921	1926
1996	119756	148954	29830	19658	7027	2509	714	1347
1997	148944	79834	90061	13274	9296	3443	1126	982
1998	87526	120579	45524	48976	7257	4650	1879	1057
1999	111322	55243	73734	22718	26719	4238	2396	1626
2000	97469	92533	29131	36771	11085	12764	2024	1754
2001	206934	67506	63561	14255	17763	6384	6987	1640
2002	163709	146677	35470	34643	8349	9787	3913	5082
2003	166719	122905	85574	17033	17451	5394	5375	5071
2004	117472	111331	77223	50204	8253	8455	3389	4873
2005	143050	74983	66865	49658	28050	5048	4602	4481
2006	101651	123281	41985	37019	26768	14191	3093	4943
2007	154444	55618	77627	24460	19767	14839	7168	4395
2008	73363	96788	30967	47554	15269	11026	9835	8026
2009	58434	51655	43768	14616	24627	9469	5785	10120
2010	89669	37942	28176	20182	7126	12960	5475	9362
2011	82872	78852	22687	14450	10156	3689	6496	9785
2012	141079	48363	48369	12264	7600	5065	2011	9273
2013	97500	107400	23753	27583	7048	4113	2707	6485
2014	58354	72343	59010	13537	15405	4165	2127	5301
2015	102967	42975	49233	33743	7913	8428	2648	4327

Table 11.4.4. Saithe in Subareas 4 and 6 and Division 3.a. Fishing mortalities at age for the final assessment model: cpue + DATRAS Q3, sw=cw for all ages. Fs for ages 9 and 10+ were coupled in the model configuration.

Year\Age	3	4	5	6	7	8	9+
1967	0.267	0.384	0.356	0.352	0.312	0.281	0.312
1968	0.238	0.343	0.301	0.283	0.244	0.220	0.247
1969	0.256	0.369	0.324	0.311	0.276	0.252	0.274
1970	0.305	0.418	0.351	0.326	0.282	0.252	0.265
1971	0.371	0.467	0.377	0.345	0.307	0.283	0.295
1972	0.446	0.521	0.404	0.367	0.330	0.306	0.310
1973	0.522	0.572	0.428	0.379	0.344	0.318	0.316
1974	0.633	0.663	0.495	0.435	0.397	0.364	0.349
1975	0.655	0.696	0.535	0.475	0.442	0.409	0.385
1976	0.746	0.778	0.609	0.532	0.486	0.445	0.408
1977	0.633	0.715	0.599	0.542	0.512	0.476	0.431
1978	0.501	0.585	0.490	0.438	0.415	0.388	0.353
1979	0.420	0.521	0.457	0.421	0.408	0.380	0.345
1980	0.405	0.520	0.477	0.453	0.448	0.424	0.387
1981	0.364	0.496	0.470	0.458	0.466	0.454	0.418
1982	0.431	0.583	0.552	0.521	0.510	0.482	0.436
1983	0.514	0.704	0.675	0.629	0.601	0.558	0.495
1984	0.586	0.794	0.726	0.628	0.561	0.504	0.443
1985	0.627	0.873	0.773	0.624	0.539	0.481	0.435
1986	0.591	0.902	0.823	0.654	0.564	0.511	0.478
1987	0.538	0.848	0.795	0.631	0.551	0.509	0.490
1988	0.527	0.834	0.805	0.646	0.566	0.521	0.504
1989	0.516	0.815	0.784	0.628	0.537	0.482	0.464
1990	0.500	0.787	0.750	0.590	0.499	0.437	0.420
1991	0.464	0.747	0.720	0.563	0.478	0.416	0.406
1992	0.410	0.696	0.696	0.558	0.481	0.417	0.411
1993	0.389	0.683	0.712	0.603	0.560	0.501	0.501
1994	0.318	0.596	0.630	0.537	0.511	0.464	0.472
1995	0.274	0.553	0.620	0.559	0.564	0.531	0.540
1996	0.218	0.465	0.546	0.507	0.508	0.483	0.486
1997	0.184	0.402	0.476	0.445	0.437	0.419	0.420
1998	0.184	0.403	0.486	0.461	0.441	0.424	0.419
1999	0.182	0.411	0.515	0.509	0.487	0.474	0.464
2000	0.157	0.362	0.453	0.447	0.408	0.388	0.377
2001	0.149	0.344	0.421	0.412	0.365	0.343	0.335
2002	0.144	0.334	0.420	0.440	0.404	0.394	0.412
2003	0.151	0.339	0.418	0.461	0.433	0.423	0.449
2004	0.131	0.302	0.364	0.404	0.377	0.368	0.382
2005	0.135	0.315	0.379	0.416	0.381	0.361	0.358
2006	0.151	0.340	0.397	0.425	0.388	0.365	0.359
2007	0.141	0.331	0.383	0.399	0.361	0.338	0.331
2008	0.159	0.386	0.461	0.473	0.425	0.394	0.377
2009	0.151	0.381	0.464	0.481	0.437	0.410	0.393
2010	0.137	0.360	0.445	0.462	0.429	0.411	0.393
2011	0.143	0.373	0.454	0.457	0.419	0.403	0.385
2012	0.121	0.335	0.410	0.416	0.381	0.371	0.361
2013	0.100	0.292	0.360	0.372	0.345	0.340	0.334
2014	0.086	0.257	0.323	0.338	0.316	0.314	0.317
2015	0.086	0.255	0.319	0.328	0.301	0.293	0.295

Table 11.4.5. Saithe in Subareas 4 and 6 and Division 3.a. Estimated population numbers-at-age for the final assessment model: cpue + DATRAS Q3, sw=cw for all ages.

Year\Age	3	4	5	6	7	8	9	10+
1967	141049	81578	57358	7176	4929	1159	757	692
1968	160710	92026	50466	31866	3738	2543	665	789
1969	283767	90491	54478	31103	20546	2848	1970	832
1970	292893	215642	49165	35409	18699	11735	1808	1644
1971	354179	190991	118938	24641	19442	11948	7845	2527
1972	224067	209003	102729	67251	14508	11379	7314	6521
1973	201256	111280	105107	63144	35705	8679	6341	8626
1974	199522	90691	48306	62588	41888	20497	5397	8547
1975	234962	76745	35444	24189	36071	25047	11950	8493
1976	405133	102883	29664	17380	12852	19037	13210	11555
1977	149577	148834	35651	12423	8657	7176	10698	13931
1978	120502	72360	58123	14222	5106	4000	3381	13098
1979	87444	53914	34796	29302	7798	2810	2207	9524
1980	85530	47002	25721	18732	16090	4034	1666	7680
1981	162536	41815	24883	12288	9626	8277	2138	5895
1982	140877	108200	22975	15059	6273	4813	3759	4072
1983	148454	69524	54870	11340	8270	3131	2519	3813
1984	255733	76151	29972	23833	4723	3472	1328	2782
1985	356446	108526	29471	12768	9452	2220	1590	2299
1986	289571	142393	32268	11778	6363	4475	1192	2262
1987	149017	163930	36324	10186	5136	3286	2287	1801
1988	137951	71414	61486	11410	4548	2593	1741	1931
1989	102546	69331	27663	21785	4703	2090	1243	1649
1990	151294	48055	25651	11118	8374	2307	1026	1408
1991	174125	71728	17404	10236	5256	3795	1237	1393
1992	103944	88437	26152	6814	5170	2852	2059	1483
1993	176170	59297	33829	9173	2924	3131	1803	2259
1994	118110	97290	28687	13381	3461	1415	1468	2153
1995	215385	66737	41948	13018	6409	1626	924	1926
1996	119594	148907	29844	19650	7022	2502	711	1344
1997	148952	79763	90043	13262	9285	3434	1121	977
1998	87723	120609	45472	48923	7258	4639	1876	1051
1999	111435	55318	73745	22656	26645	4242	2389	1621
2000	97569	93077	29145	36652	11023	12662	2018	1741
2001	205817	67645	64004	14178	17604	6338	6919	1624
2002	163051	144410	35250	34548	8264	9667	3869	5009
2003	166920	123163	84968	16953	17419	5312	5279	4971
2004	117267	109637	75898	49011	8134	8300	3297	4664
2005	143615	75797	67544	50201	27953	5015	4533	4336
2006	102098	123653	42273	37337	26978	14160	3083	4859
2007	155694	55604	77448	24534	19864	14928	7164	4360
2008	73631	98547	31326	48339	15436	11156	10003	8123
2009	58640	51468	43732	14673	24714	9554	5849	10255
2010	90077	38225	28299	20281	7153	13075	5547	9542
2011	83142	79213	22793	14433	10139	3685	6511	9913
2012	141320	48196	48019	12244	7547	5027	1995	9212
2013	99244	107991	23823	27572	7055	4095	2676	6408
2014	60074	74017	60189	13739	15563	4201	2124	5287
2015	107275	44478	51242	34913	8110	8579	2696	4373

Table 11.5.1. Saithe in Subareas 4 and 6 and Division 3.a. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 7 (F_{4-7}), 1967–2015. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F47	Low	High
1967	141049	100250	198451	413262	338348	504762	152998	120865	193674	0.351	0.273	0.451
1968	160710	116066	222527	579708	477847	703282	211139	169304	263312	0.292	0.229	0.374
1969	283767	204666	393440	711592	589975	858279	277606	225538	341693	0.320	0.257	0.399
1970	292893	212488	403722	909561	761892	1085851	346525	286158	419627	0.344	0.279	0.425
1971	354179	259600	483214	1054929	892982	1246247	461416	382154	557118	0.374	0.306	0.458
1972	224067	165369	303600	958361	819372	1120927	489786	408228	587638	0.406	0.334	0.493
1973	201256	148578	272612	893771	770064	1037351	521616	434824	625732	0.431	0.357	0.520
1974	199522	147024	270768	925363	802180	1067462	576364	483023	687744	0.498	0.417	0.595
1975	234962	174191	316934	856816	742955	988126	516418	431858	617535	0.537	0.451	0.640
1976	405133	294824	556715	812452	695827	948624	398488	331298	479304	0.601	0.504	0.717
1977	149577	110052	203296	612857	526548	713314	324904	269650	391480	0.592	0.491	0.714
1978	120502	88940	163265	520026	446249	606000	297101	245483	359575	0.482	0.401	0.580
1979	87444	64322	118876	483643	417009	560924	278838	232998	333698	0.452	0.375	0.544
1980	85530	62915	116273	439786	381075	507543	261217	219895	310303	0.474	0.397	0.567
1981	162536	118618	222716	492231	424278	571068	249741	211263	295227	0.473	0.395	0.566
1982	140877	104073	190695	530535	456292	616858	220175	188876	256661	0.542	0.459	0.640
1983	148454	109546	201183	508661	439507	588696	219844	188123	256914	0.652	0.553	0.769
1984	255733	188128	347633	515910	442169	601949	188332	161822	219185	0.677	0.578	0.794
1985	356446	259219	490140	528538	445297	627341	165787	143176	191968	0.702	0.600	0.822
1986	289571	213267	393176	492068	418570	578471	156686	135587	181069	0.736	0.623	0.869
1987	149017	109846	202158	403968	348185	468688	165372	143091	191122	0.706	0.602	0.828
1988	137951	102124	186347	348791	302157	402623	154711	132423	180750	0.713	0.608	0.836
1989	102546	75795	138739	292599	253392	337871	126303	108491	147039	0.691	0.588	0.812
1990	151294	111597	205111	301775	258308	352555	114398	98053	133468	0.657	0.558	0.772
1991	174125	128779	235437	320712	272751	377107	107444	92600	124667	0.627	0.533	0.738
1992	103944	77394	139602	310066	265901	361567	113008	97945	130387	0.608	0.514	0.718
1993	176170	130913	237072	356091	303049	418417	119604	103024	138852	0.640	0.540	0.757
1994	118110	87926	158656	339647	290514	397090	124892	107626	144928	0.569	0.480	0.674
1995	215385	158167	293303	452910	380876	538567	144156	123579	168159	0.574	0.482	0.684
1996	119594	88101	162346	433610	367185	512051	156161	134128	181813	0.507	0.424	0.606
1997	148952	108749	204016	448334	381481	526903	194461	164217	230273	0.440	0.365	0.530
1998	87723	64226	119818	394657	338703	459856	191216	162071	225601	0.448	0.373	0.537
1999	111435	81226	152879	380582	327806	441854	200392	169437	237003	0.480	0.398	0.580
2000	97569	71444	133248	396396	340283	461762	190854	161980	224874	0.417	0.344	0.507
2001	205817	150447	281565	449464	381999	528844	197732	167145	233915	0.385	0.316	0.471
2002	163051	119401	222659	495044	421179	581864	222354	188292	262579	0.399	0.330	0.483
2003	166920	122148	228102	448660	383297	525170	214089	181229	252908	0.413	0.341	0.500
2004	117267	86123	159673	505127	433222	588965	270812	228497	320963	0.362	0.296	0.442
2005	143615	104908	196603	481555	414121	559969	261942	221625	309592	0.373	0.307	0.453
2006	102098	73248	142312	501405	432072	581862	273621	231611	323252	0.388	0.320	0.470
2007	155694	111085	218216	463624	397626	540575	250461	211198	297023	0.369	0.303	0.448
2008	73631	53979	100438	435243	373892	506662	253402	213685	300502	0.436	0.359	0.529
2009	58640	42995	79978	394907	338948	460104	247285	207172	295164	0.441	0.363	0.535
2010	90077	65627	123636	400029	341318	468838	232304	192935	279706	0.424	0.348	0.517
2011	83142	59367	116439	362141	305198	429708	186024	153989	224722	0.426	0.345	0.525
2012	141320	99521	200674	375622	308204	457788	169156	138898	206007	0.385	0.305	0.486
2013	99244	67079	146832	386907	308665	484982	179454	144785	222425	0.342	0.260	0.451
2014	60074	37288	96785	390110	297856	510939	210261	163439	270496	0.309	0.220	0.434
2015	107275	56905	202231	417385	290382	599934	228761	165879	315480	0.301	0.197	0.460

Table 11.7.1. Saithe in Subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Source	Notes
F ages 4–7 (2016)	68601 t	ICES (2016a)	TAC constraint (F=0.24)
SSB (2016)	239561 t	ICES (2016a)	SSB in the intermediate year
SSB (2017)	277948 t	ICES (2016a)	SSB at the beginning of the TAC year
Rage3 (2016)	102 billion	ICES (2016a)	Median recruitment re-sampled from 2003-2015
Rage3 (2017)	102 billion	ICES (2016a)	Median recruitment re-sampled from 2003–2015
Total catch (2016)	72442 t	ICES (2016a)	Assuming 2015 landings fraction by age
Commercial landings (2016)	68601 t	ICES (2016a)	TAC 2015
Discards (2016)	3841 t	ICES (2016a)	Assuming 2015 discard fraction by age

*** TAC was based on landings without adjustment.**

Table 11.7.2. Saithe in Subareas 4 and 6 and Division 3.a. All weights in tonnes.

Rationale	Total catch (2017)	Wanted catch* (2017)	Unwanted catch* (2017)	Wanted catch 3.a & 4 2017 **	Wanted catch 6 2017 **	Basis	Ftotal (2017)	Fwanted (2017)	Funwanted (2017)	SSB (2018)	%SSB Change **	% TAC Change wanted catch^
MSY approach	116605	110917	5688	100491	10426	FMSY	0.36	0.34	0.02	278294	0	62
EU-Norway management strategy	82747	78850	3897	71438	7412	Paragraph 5 of management strategy	0.24	0.23	0.01	310717	12	15
Zero catch	0	0	0	0	0	F = 0	0	0	0	390077	40	-100
Other options	81833	77982	3851	70652	7330	F2016	0.24	0.23	0.01	311578	12	14
	72171	68601	3570	62153	6448	TAC2016	0.21	0.2	0.01	321351	16	0
	128157	121919	6237	110459	11460	Fpa	0.40	0.38	0.02	267579	-4	78
	167792	159522	8270	144527	14995	Flim	0.56	0.54	0.02	229799	-17	133
	73497	70040	3457	63456	6584	Flower (w/AR)	0.21	0.2	0.01	319442	15	2
	128157	121919	6237	110459	11460	Fupper (w/AR)	0.49	0.47	0.02	246040	-11	109
	304748	287277	17470	260273	27004	SSB2018 = Blim	1.40	1.33	0.07	107000	-62	319
	255135	241105	14030	218441	22664	SSB2018 = Bpa	1.02	0.98	0.04	150000	-46	251
	255135	241105	14030	218441	22664	SSB2018 = Btrigger***	1.02	0.98	0.04	150000	-46	251
	75678	72117	3560	65338	6779	F in 0.01 increments (0.22)	0.22	0.21	0.01	317383	14	5
	78769	75063	3706	68007	7056	F = 0.23	0.23	0.22	0.01	314466	13	9
	81833	77982	3851	70652	7330	F = 0.24	0.24	0.23	0.01	311578	12	14
	84869	80865	4004	73264	7601	F = 0.25	0.25	0.24	0.01	308717	11	18
	87877	83722	4155	75852	7870	F = 0.26	0.26	0.25	0.01	305884	10	22
	90859	86552	4307	78416	8136	F = 0.27	0.27	0.26	0.01	303073	9	26
	93830	89356	4474	80957	8399	F = 0.28	0.28	0.27	0.01	300222	8	30
	96777	92134	4644	83473	8661	F = 0.29	0.29	0.28	0.01	297377	7	34
	99699	94891	4809	85971	8920	F = 0.30	0.3	0.29	0.01	294542	6	38
	102597	97623	4973	88446	9177	F = 0.31	0.31	0.3	0.01	291762	5	42
	105450	100331	5119	90900	9431	F = 0.32	0.32	0.31	0.01	289031	4	46
	108276	103014	5262	93331	9683	F = 0.33	0.33	0.31	0.02	286287	3	50
	111078	105672	5405	95739	9933	F = 0.34	0.34	0.32	0.02	283557	2	54
	113854	108307	5547	98126	10181	F = 0.35	0.35	0.33	0.02	280912	1	58
	116605	110917	5688	100491	10426	F = 0.36	0.36	0.34	0.02	278294	0	62
	119331	113503	5828	102834	10669	F = 0.37	0.37	0.35	0.02	275701	-1	65
	122033	116079	5954	105168	10911	F = 0.38	0.38	0.36	0.02	273161	-2	69
	124711	118633	6078	107481	11152	F = 0.39	0.39	0.37	0.02	270719	-3	73
	127365	121164	6201	109775	11389	F = 0.40	0.4	0.38	0.02	268300	-3	77
	129995	123673	6322	112048	11625	F = 0.41	0.41	0.39	0.02	265886	-4	80
	132602	126160	6442	114301	11859	F = 0.42	0.42	0.4	0.02	263414	-5	84
	135185	128625	6560	116534	12091	F = 0.43	0.43	0.41	0.02	260899	-6	87
	137745	131061	6684	118741	12320	F = 0.44	0.44	0.42	0.02	258408	-7	91
	140290	133465	6824	120919	12546	F = 0.45	0.45	0.43	0.02	255942	-8	95
	142812	135847	6965	123077	12770	F = 0.46	0.46	0.44	0.02	253500	-9	98
	145313	138208	7105	125216	12992	F = 0.47	0.47	0.45	0.02	251113	-10	101
	147791	140546	7245	127335	13211	F = 0.48	0.48	0.46	0.02	248794	-10	105

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rates estimates for 2015.**

**** Wanted catch split according to the average in 1993–1998, i.e. 90.6% in Subarea 4 and Subdivision 3.a.20 and 9.4% in Subarea 6.**

***** $B_{trigger} = B_{pa}$**

^ Wanted catch 2017 relative to the 2016 wanted catch (without adjustment) TAC.

Table 11.7.3. Saithe in Subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2017.

Year class	Contribution to landings (%)
2014	7
2013	20
2012	23
2011	10
2010	14
2009	12
2008	4

Table 11.9.1. Saithe in Subareas 4 and 6 and Division 3.a. Reference points estimated using the FBI + DATRAS Q3 model, where catch weights = stock weights for all ages.

Reference point	Value
Blim	107 000
Bpa (1.4)	150 000
Bpa (sigma)	139 000
Btrigger	150 000
Flim	0.564
Fpa (1.4)	0.403
Fpa (sigma)	0.398
FMSY without Btrigger	0.36
FMSY lower without Btrigger	0.21
FMSY upper without Btrigger	0.498
New FP.05 (5% risk to Blim without Btrigger)	0.419
FMSY upper precautionary without Btrigger	0.419
FP.05 (5% risk to Blim with Btrigger)	0.492
FMSY with Btrigger	0.395
FMSY lower with Btrigger	0.213
FMSY upper with Btrigger	0.647
FMSY upper precautionary with Btrigger	0.492
MSY (without HCR)	89 305
Median SSB at FMSY (without HCR)	206 513
Median SSB lower precautionary (median at FMSY upper precautionary; without HCR)	179 497
Median SSB upper (median at FMSY lower; without HCR)	368 806

Sigma (F) = 0.2114521, sigma (SSB) = 0.1607088.

Table 11.10.1. Saithe in Subareas 4 and 6 and Division 3.a. Model and data selection settings

DATA AND PARAMETERS	SETTING	COMMENTS
Recruitment model	Segmented regression, where the inflection point was forced to be Bloss from the entire time series	Recruitment vs. SSB for the entire times series showed a distinct plateau across a wide range of SSB. For stocks showing this characteristic, Bloss is recommended to be the inflection point in the segmented regression.
SSB-recruitment data	(a) Truncated time series, based on changepoint analysis (year classes 2000 to 2011)	Changepoint analysis of R per SSB showed distinct periods in recruitment: higher R per SSB in 1969–2002 and lower in 2003 to present (see also section sensitivity/discussion).
	(b) Full data series (year classes 1967 to 2011)	R per SSB shows signs of cyclic changes in productivity over time. Whether the current low productivity of the stock can be explained by cyclic changes or whether the stock is in a new productivity regime remains unclear (see also section sensitivity/discussion).
Exclusion of extreme values (option extreme.trim)	No	
Mean weights and proportion mature; natural mortality	Default (2005–2014)	During the last ten years mean weight at age was noisy without trend or declined and increased again in recent years for some ages.
Exploitation pattern	Default (2005–2014)	Exploitation pattern noisy without clear trends. Selectivity for age 4 increased in the last 2 years. Based on only 2 years it is not possible to judge whether this is a longer-lasting change in the fishery.
Assessment error in the advisory year. CV of F	0.212	Default value for stocks where these uncertainties cannot be estimated
Autocorrelation in assessment error in the advisory year	0.423	Default value for stocks where these uncertainties cannot be estimated

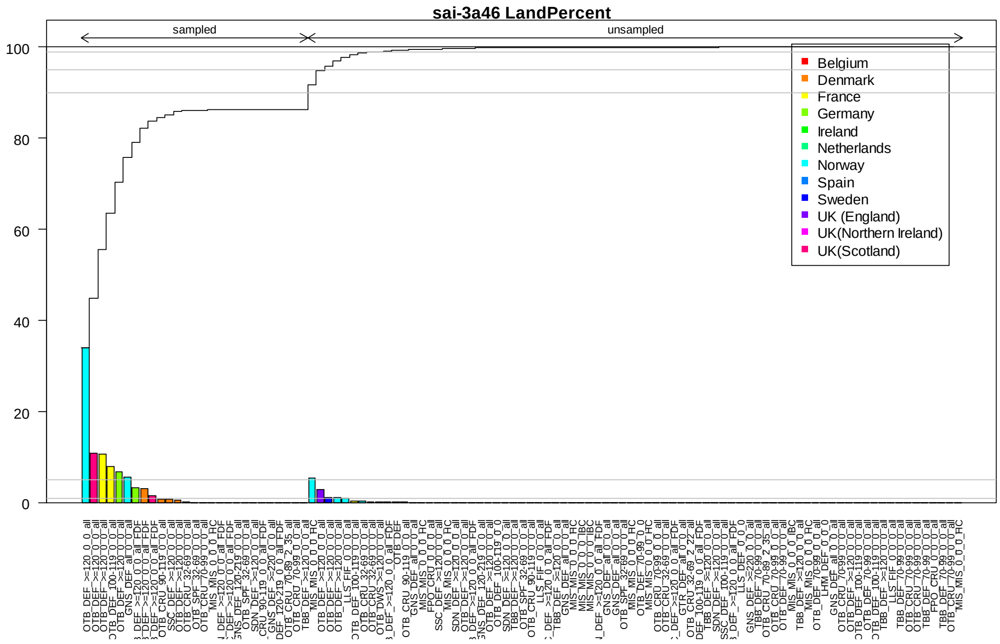

Figure 11.3.1. Saithe in Subareas 4 and 6 and Division 3.a. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

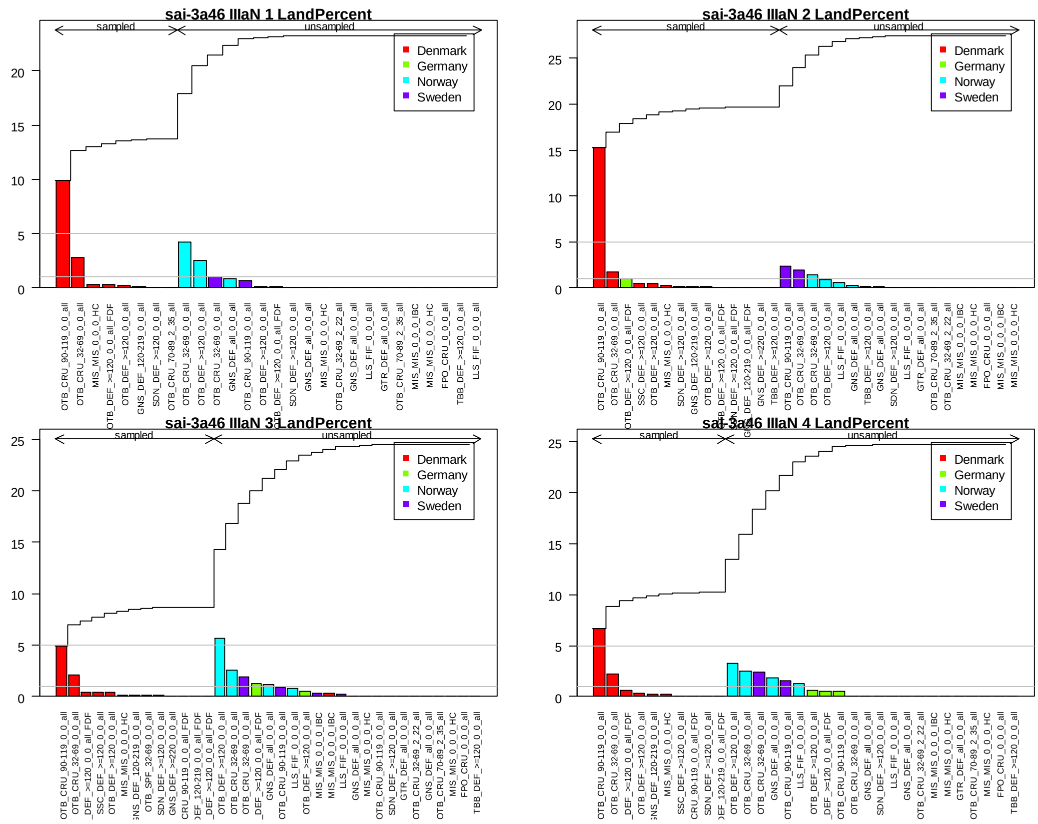

Figure 11.3.2. Saithe in Subareas 4 and 6 and Division 3.a. Overview of percent of catch sampled and unsampled by country, fleet, and quarter for saithe catches in Subdvision 3.a.

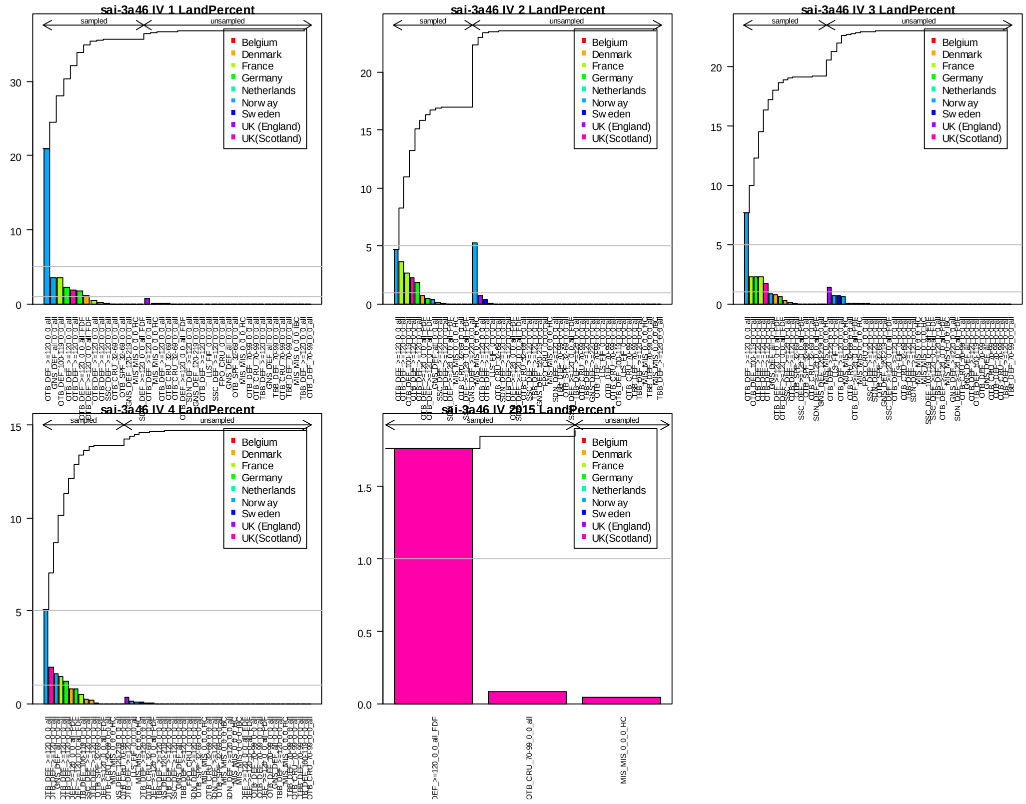

Figure 11.3.3. Saithe in Subareas 4 and 6 and Division 3.a. Overview of percent of catch sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 4. Scotland reported by year, not quarter.

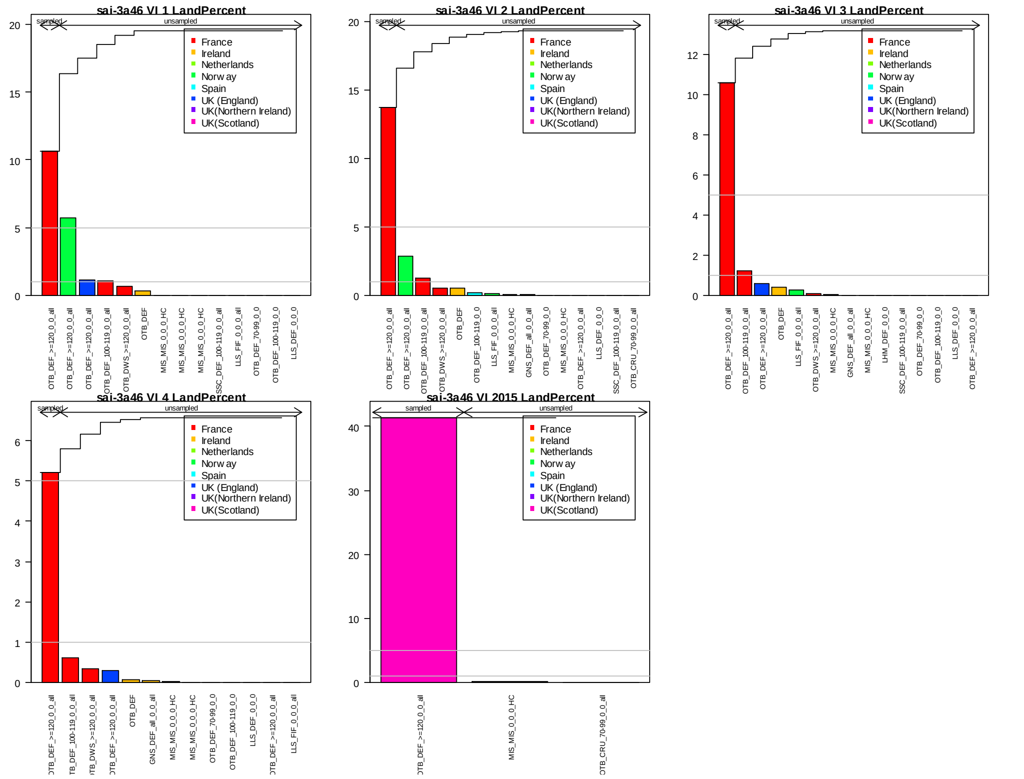

Figure 11.3.4. Saithe in Subareas 4 and 6 and Division 3.a. Overview of percent of catch sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 6. Scotland reported by year, not quarter.

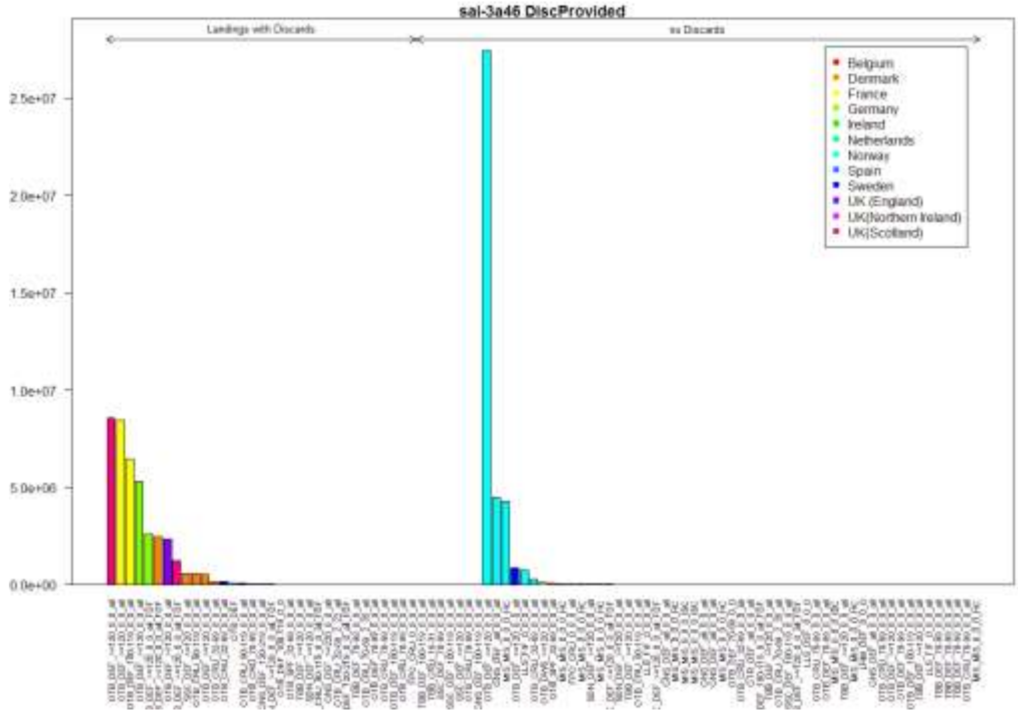

Figure 11.3.5. Saithe in Subareas 4 and 6 and Division 3.a. Summary of landings for fleets with and without discard estimates.

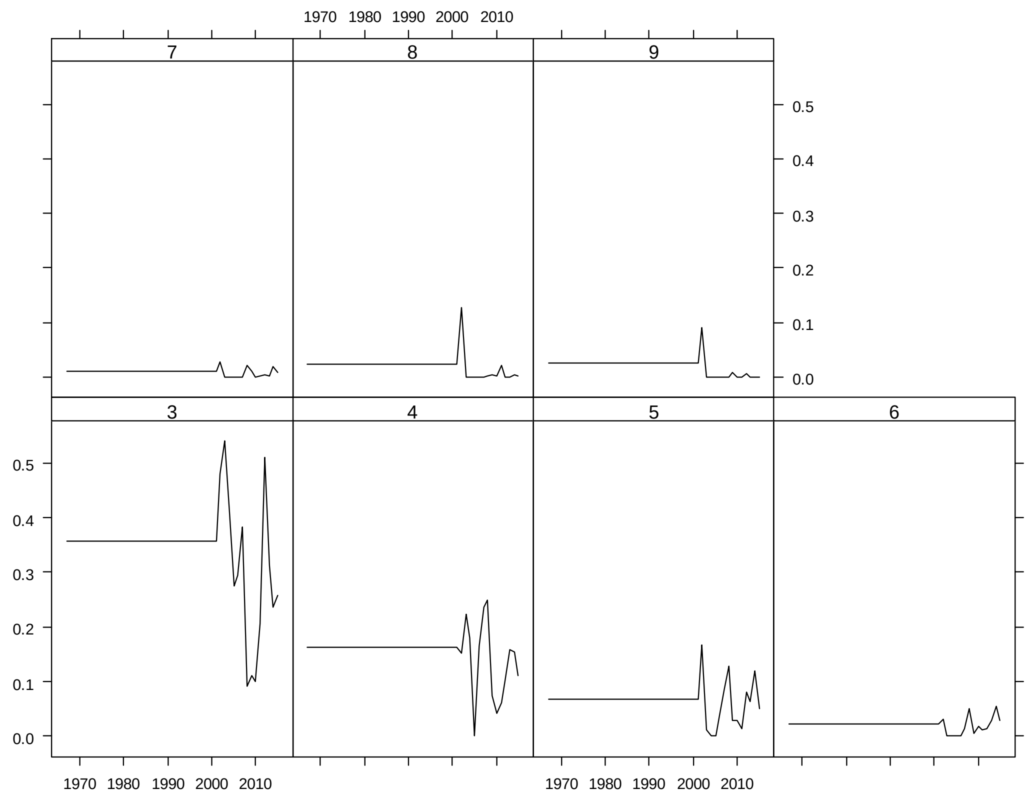

Figure 11.3.6. Saithe in Subareas 4 and 6 and Division 3.a. Proportion of total catch discarded by age and year.

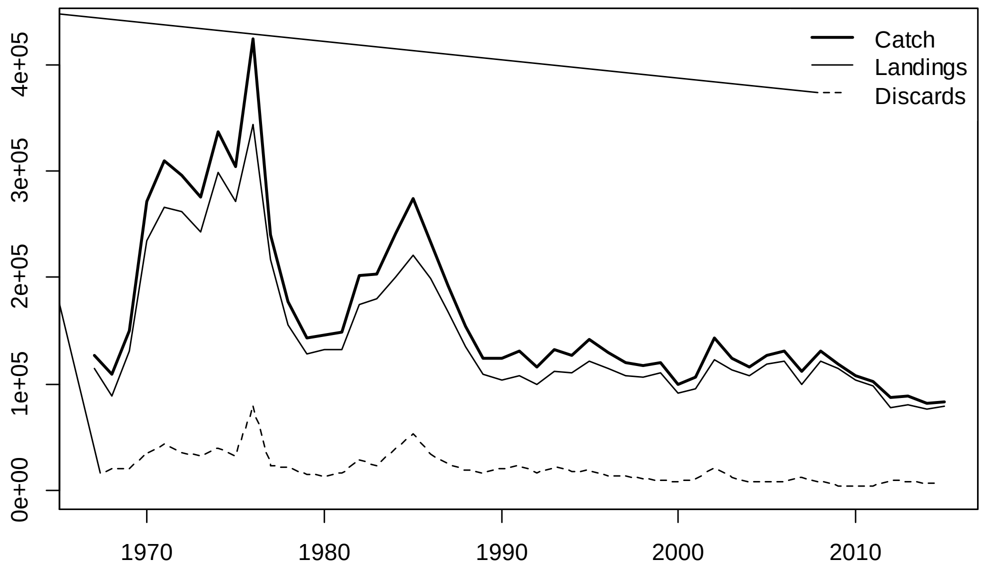

Figure 11.3.7. Saithe in Subareas 4 and 6 and Division 3.a. Yield by catch component.

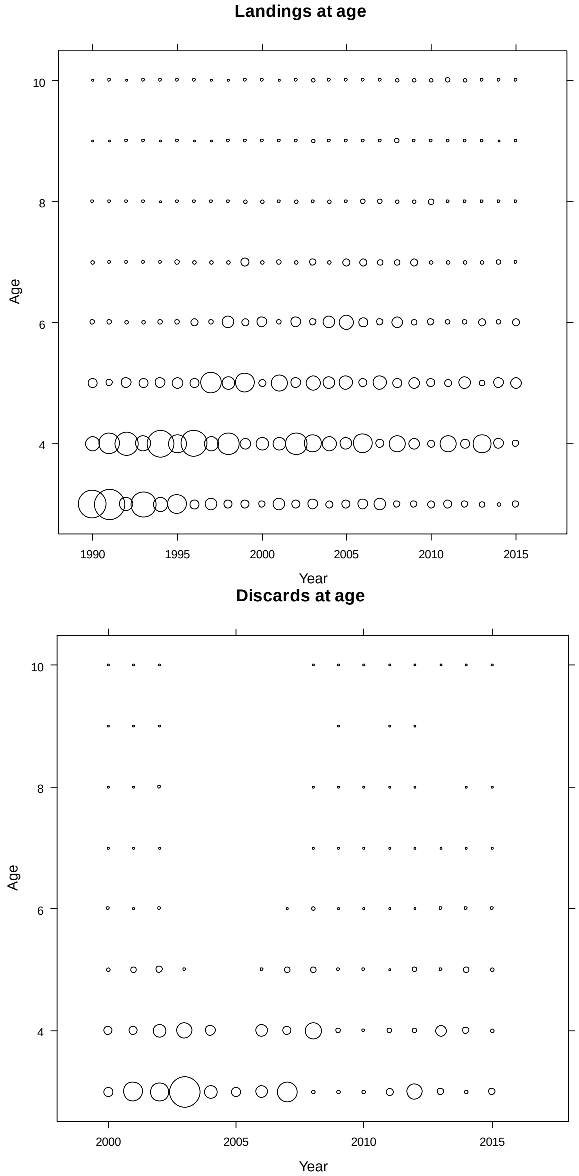

Figure 11.3.8. Saithe in Subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990-2015; smallest bubble corresponds to 210 thousand individuals and largest to 46 million individuals. (right) Discard weights at age for saithe ages 3–10+, 2000–2015 (min: 0, max: 15 million individuals).

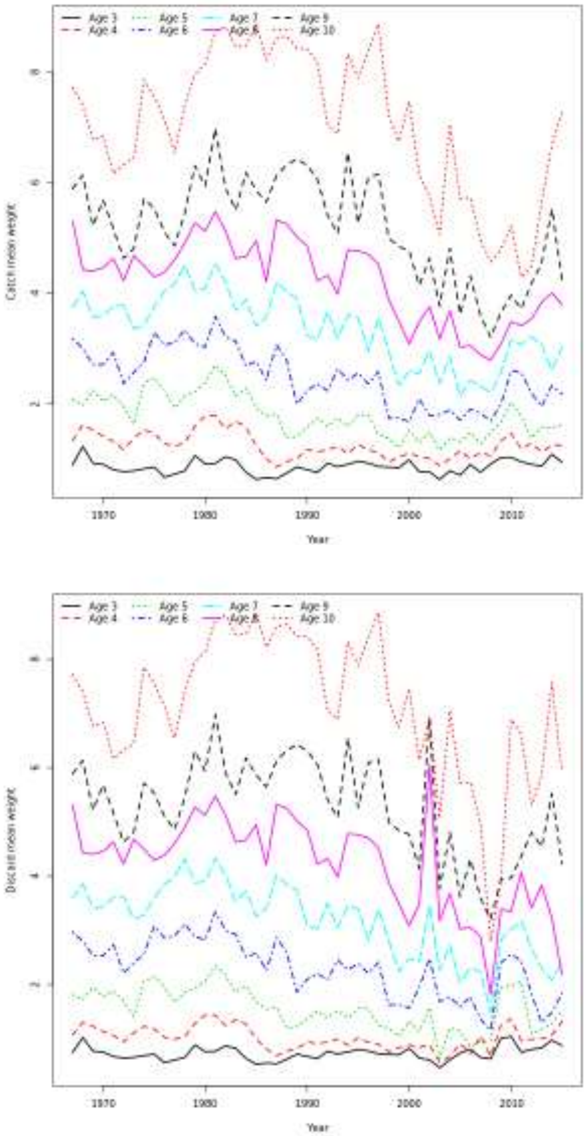

Figure 11.3.9. Saithe in Subareas 4 and 6 and Division 3.a. (left) Catch weight-at-age (kg) for saithe ages 3–10+, 1967–2015. Catch weight-at-age are also stock weight-at-age in the assessment. (right) Discard weights-at-age (kg) for saithe ages 3–10+, 1967–2015.

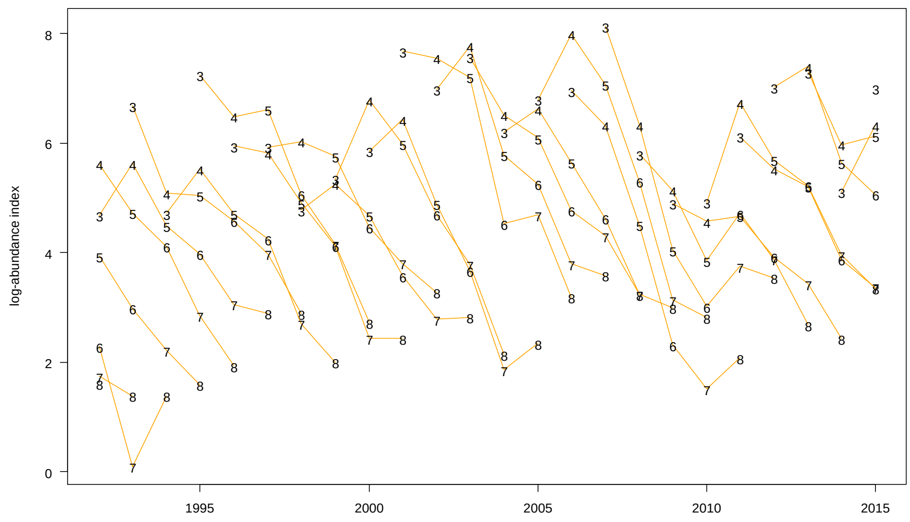

Figure 11.4.1. Saithe in Subareas 4 and 6 and Division 3.a. Log catch curves by cohort from the research survey index, IBTS Q3, for total catches for ages 3 to 8.

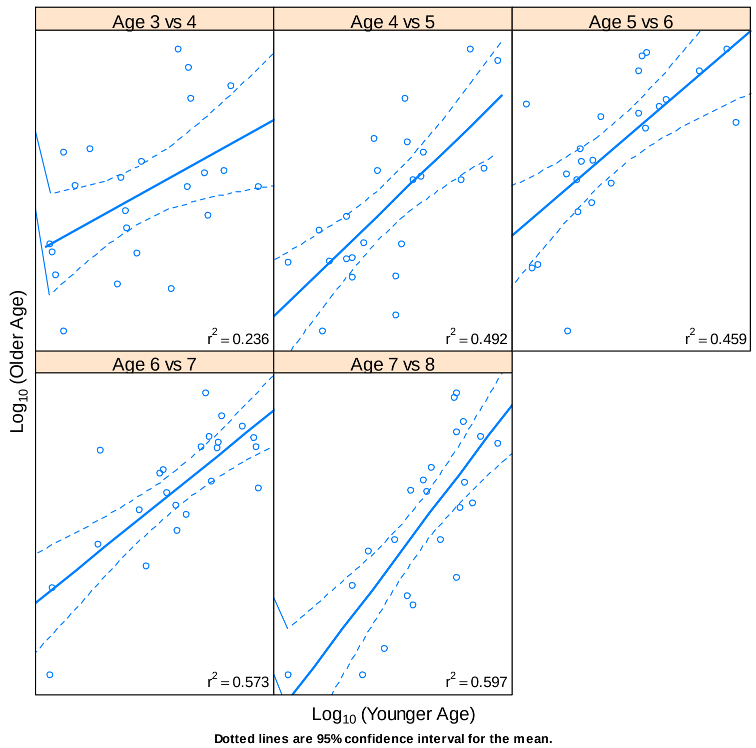

Figure 11.4.2. Saithe in Subareas 4 and 6 and Division 3.a. Internal consistencies for IBTS Q3, ages 3 to 8.

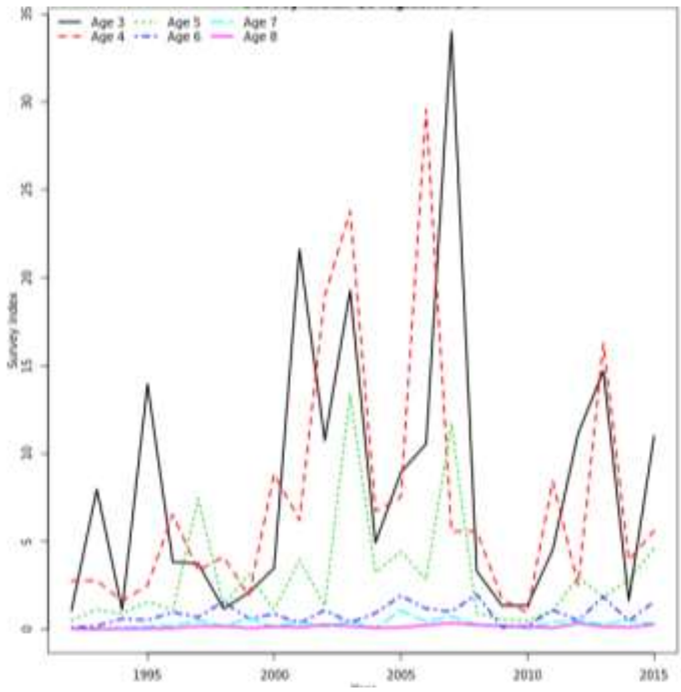

Figure 11.4.3. Saithe in Subareas 4 and 6 and Division 3.a. Standardised IBTS Q3 research tuning series index.

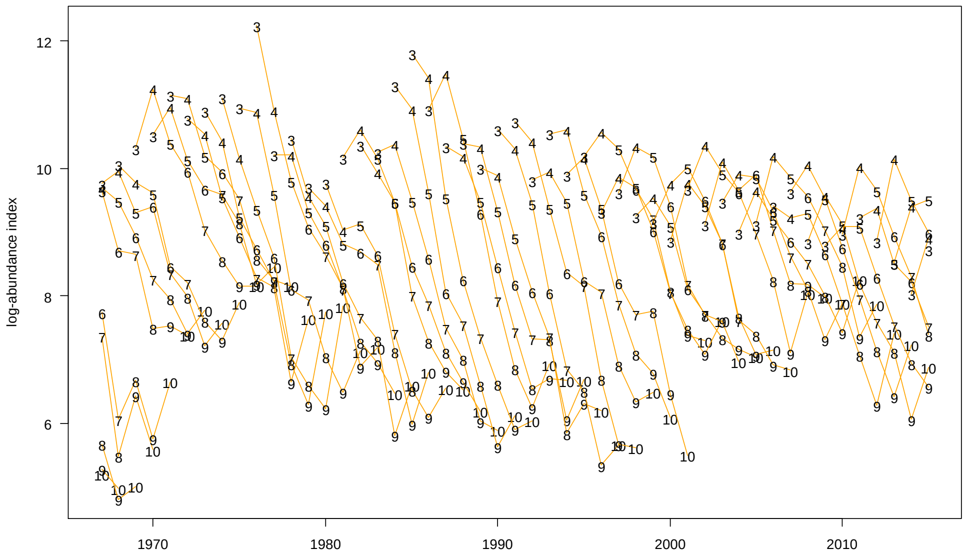

Figure 11.4.4. Saithe in Subareas 4 and 6 and Division 3.a. Log catch curves by cohort for landings for ages 3 to 9.

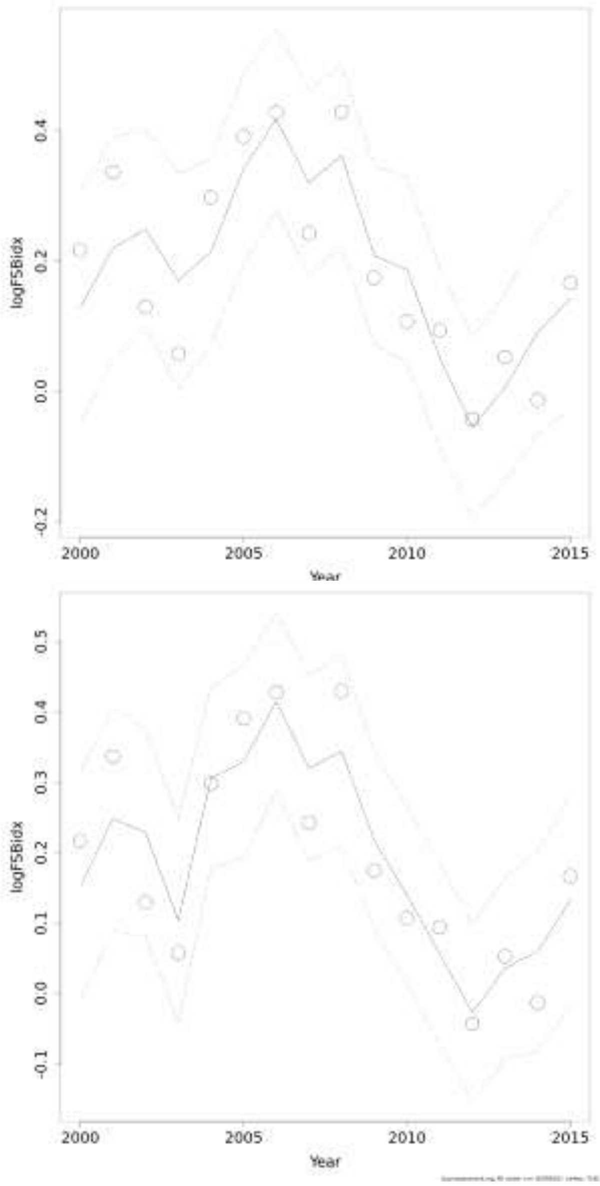

Figure 11.4.5. Saithe in Subareas 4 and 6 and Division 3.a. Standardized combined cpue index (year effects) and fit of model after tuning to the biomass. Left: Fit for the exploratory assessment model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for ages 7+. Right: Fit for the final model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages.

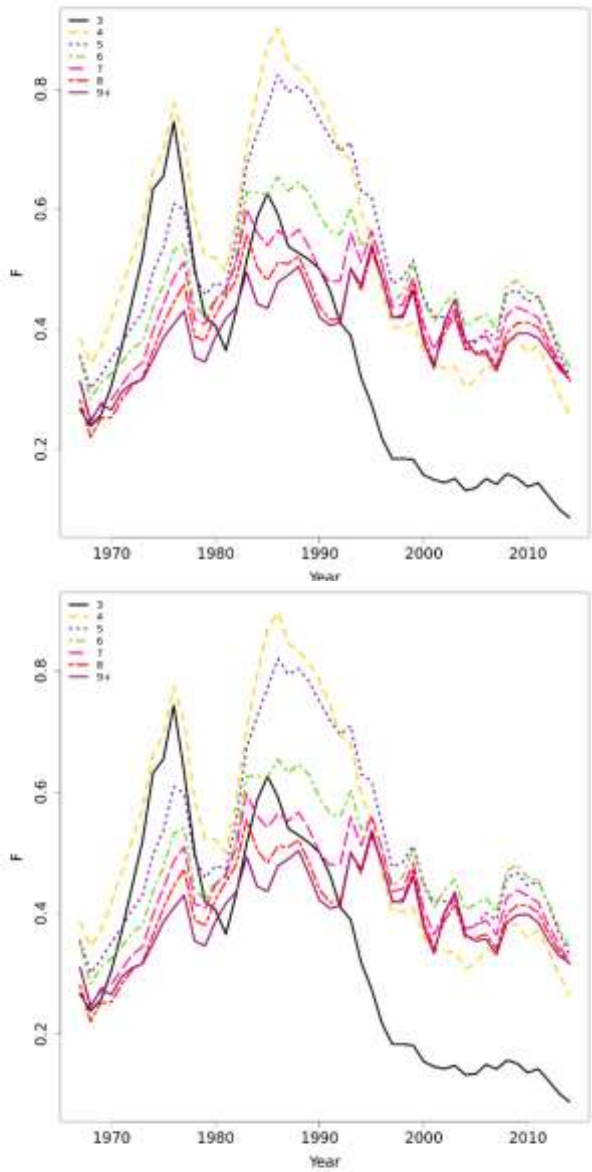

Figure 11.4.6. Saithe in Subareas 4 and 6 and Division 3.a. Fishing mortality at age. Left: Assessment model is combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for ages 7+. Right: Assessment model is combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages.

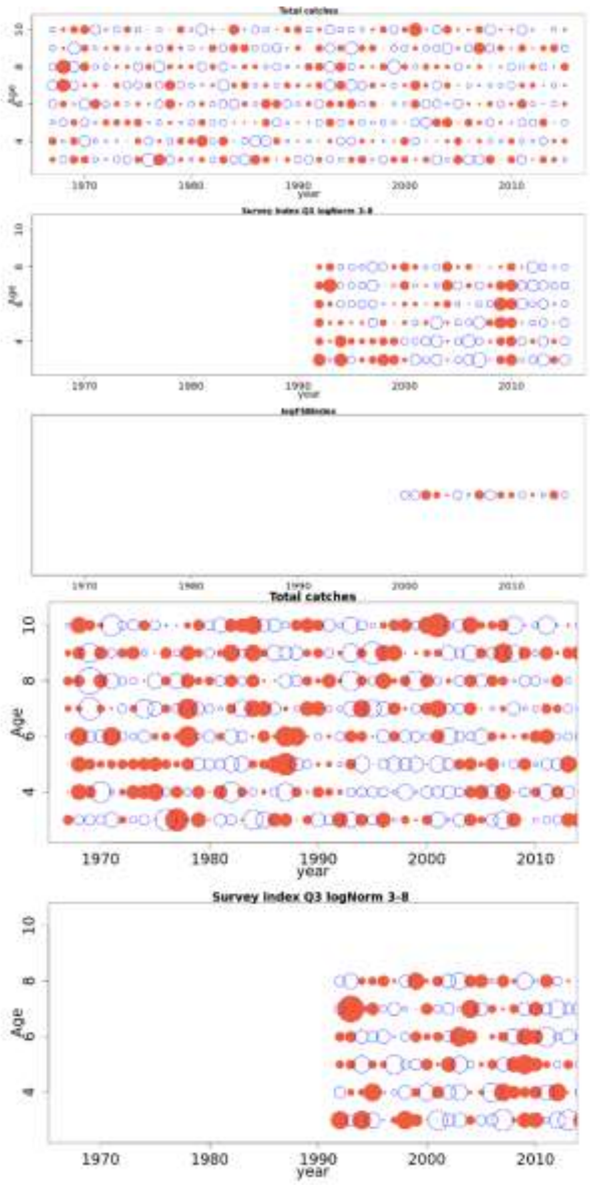

Figure 11.4.7. Saithe in Subareas 4 and 6 and Division 3.a. Residual patterns for the exploratory assessment model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for ages 7+. (left) Before correlation taken into account between ages; (right) after accounting for the correlation between ages within years (residuals are one-step ahead). Open circles (blue) indicate positive residuals and filled red circles indicate negative residuals.

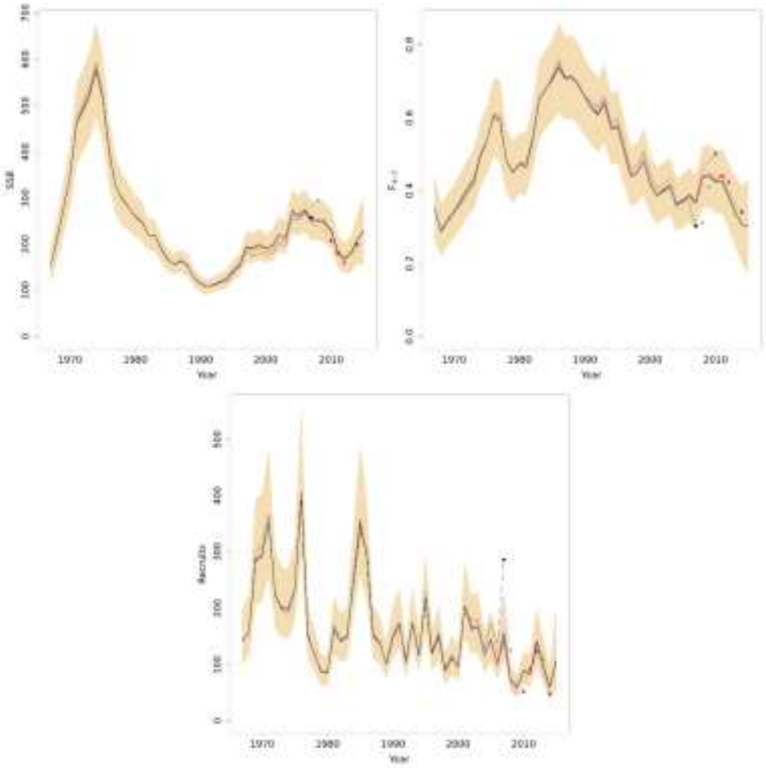

Figure 11.4.8. Saithe in Subareas 4 and 6 and Division 3.a. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment for the exploratory model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for ages 7+.

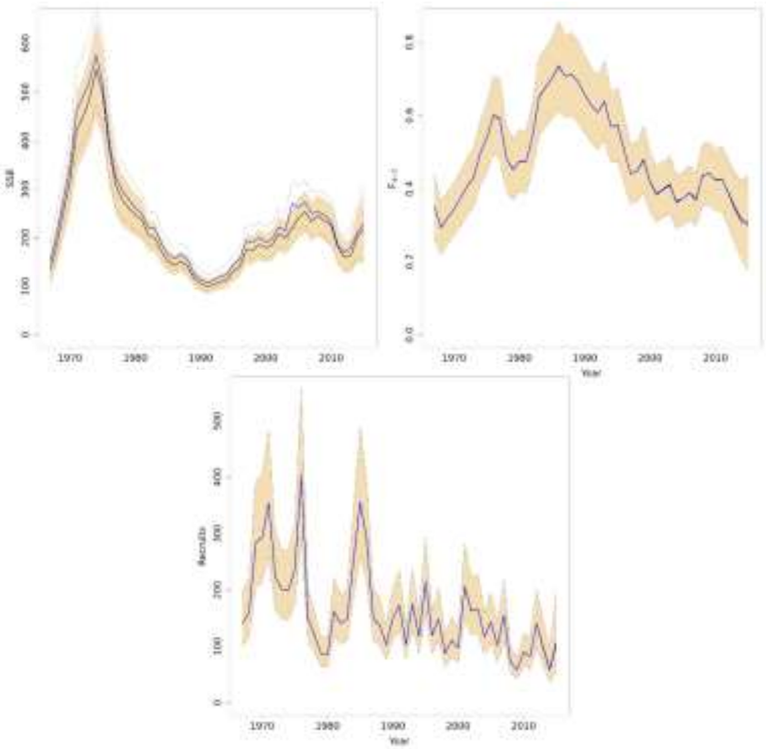

Figure 11.4.9. Saithe in Subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, and recruitment for the exploratory model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for ages 7+. Blue line and grey dashed confidence interval pertains to the final assessment model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages.

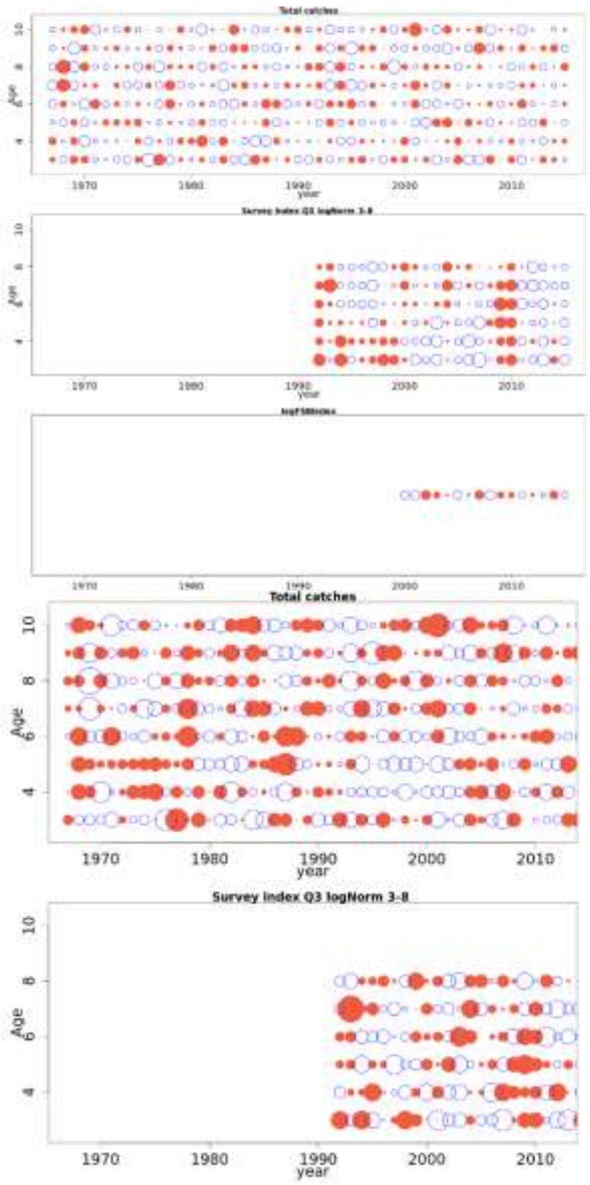

Figure 11.4.10. Saithe in Subareas 4 and 6 and Division 3.a. Residual patterns for the final SAM model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages. Left: Before correlation taken into account between ages, within years in the Q3 index. Right: After accounting for the correlation between ages within years in the Q3 index. Open circles (blue) indicate positive residuals and filled red circles indicate negative residuals.

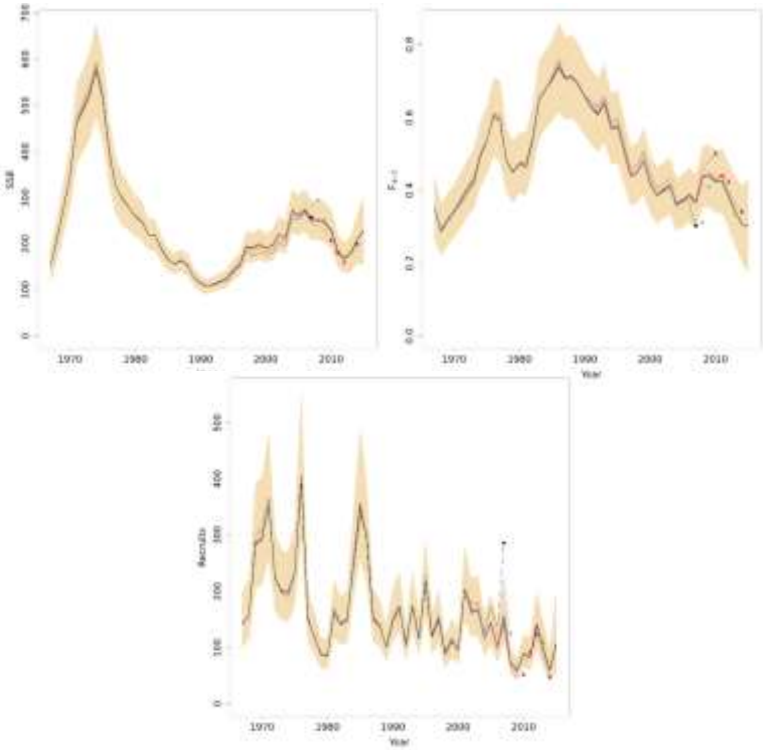

Figure 11.4.11. Saithe in Subareas 4 and 6 and Division 3.a. Eight year retrospective pattern in SSB, F_{4-7}, and recruitment for the final assessment model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages.

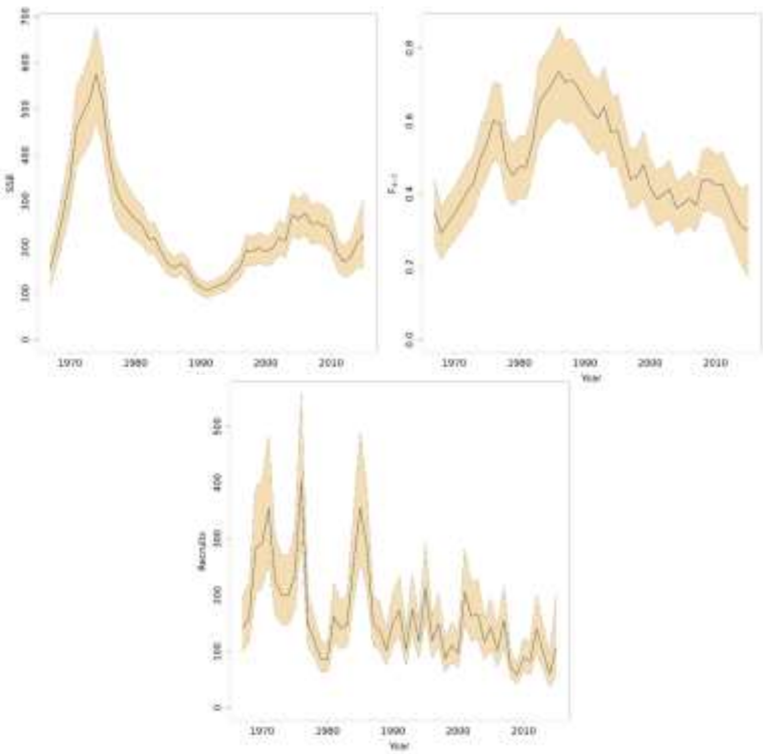

Figure 11.5.1. Saithe in Subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, and recruitment for the final assessment model: combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat), stock weights=catch weights for all ages.

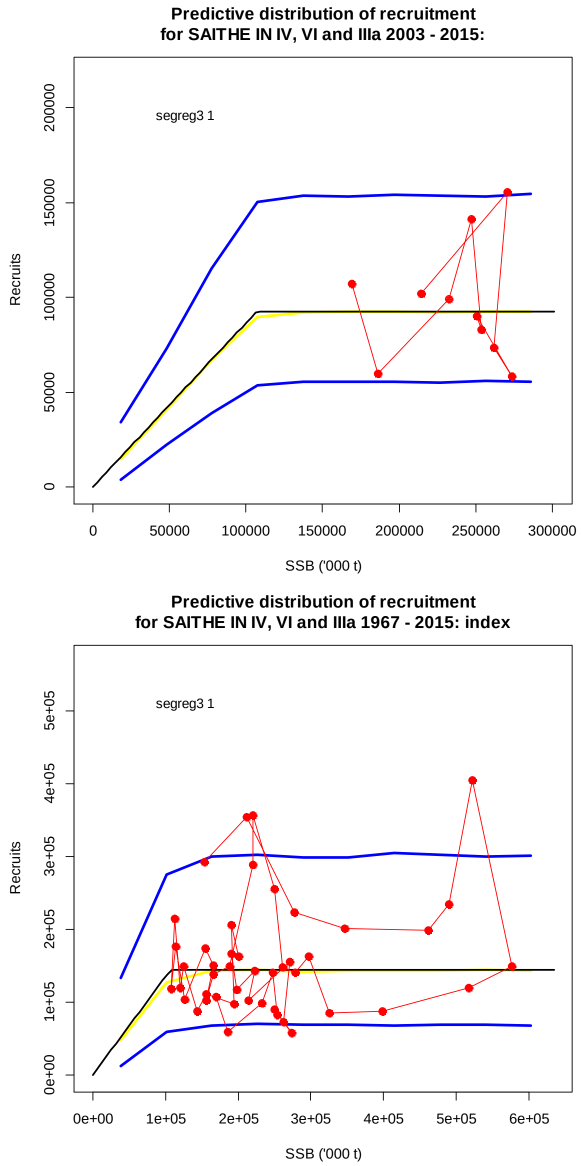

Figure 11.9.1. Saithe in Subareas 4 and 6 and Division 3.a. Left: Stock recruitment relationship based on segmented regression over the truncated time period (2003–2015), where the inflection point was forced to be B_{loss} from the complete time series 1967–2014. Right: Stock recruitment relationship based on segmented regression over the entire time series.

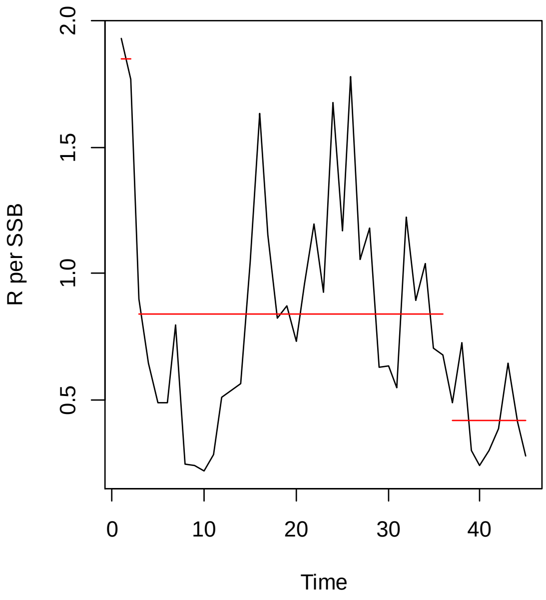

Figure 11.9.2. Saithe in Subareas 4 and 6 and Division 3.a. Recruitment per SSB over time and periods identified in the change-point analysis as having different levels of recruitment.

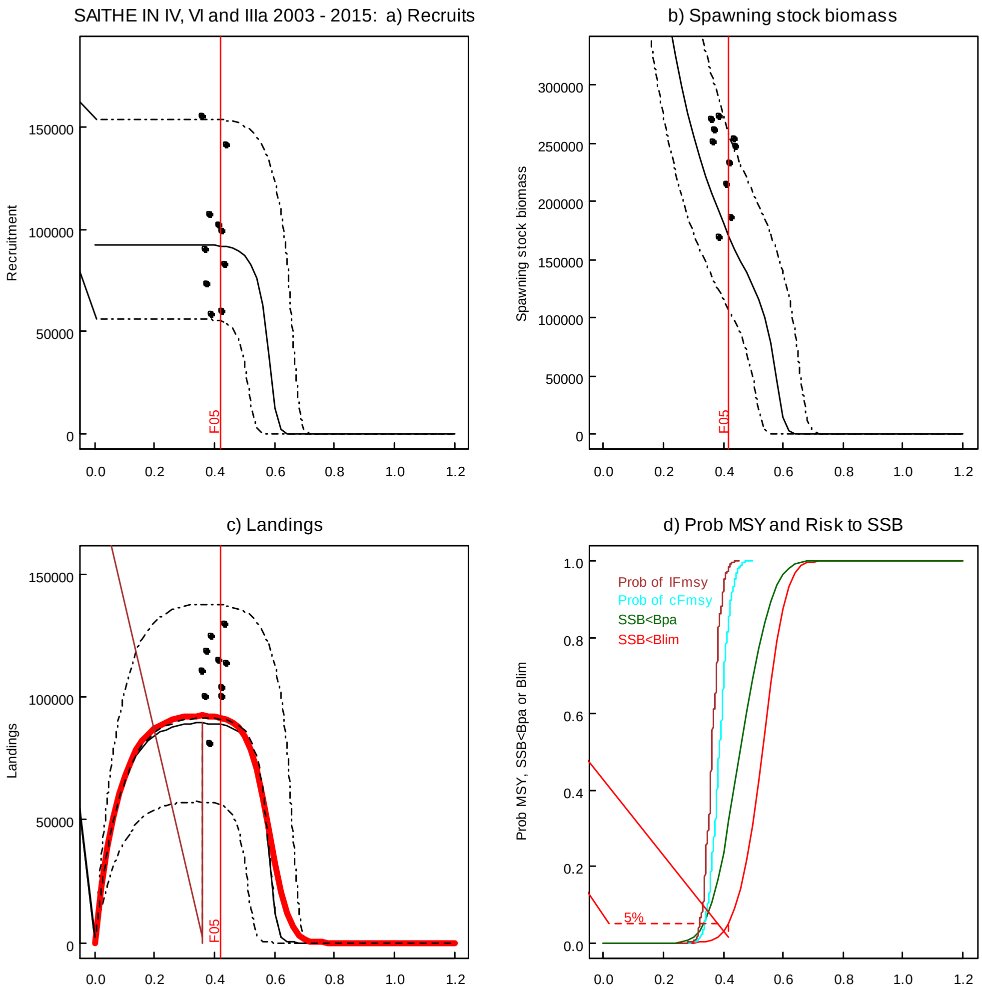

Figure 11.10.1. Saithe in Subareas 4 and 6 and Division 3.a. Eqsim results: no trim, no $B_{trigger}$, segmented regression with B_{loss} forced to be the inflection point. Panels a-c: historic values (dots), median (solid black), and 90% intervals (dotted black) for recruitment, SSB, and landings for exploitation at fixed values of F. Panel c also shows mean landings (red solid line). Panel d shows the probability of SSB<B_{lim} (red), SSB<B_{pa} (green), and the cumulative distribution of F_{MSY} based on yield as landings (brown) and catch (cyan).

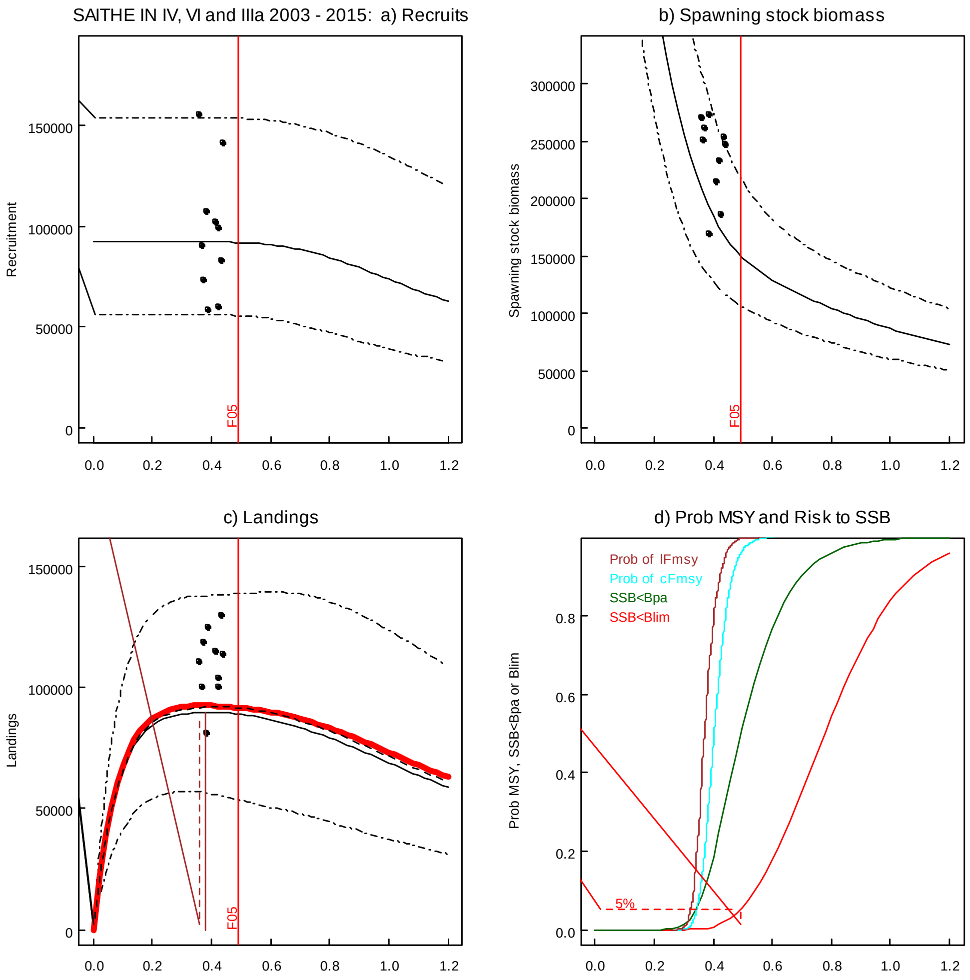

Figure 11.10.2. Saithe in Subareas 4 and 6 and Division 3.a. Eqsim results: no trim, with $B_{trigger}$, segmented regression with B_{loss} forced to be the inflection point). Panels a-c: historic values (dots), median (solid black), and 90% intervals (dotted black) for recruitment, SSB, and landings for exploitation at fixed values of F. Panel c also shows mean landings (red solid line). Panel d shows the probability of SSB<B_{lim} (red), SSB<B_{pa} (green), and the cumulative distribution of F_{MSY} based on yield as landings (brown) and catch (cyan).

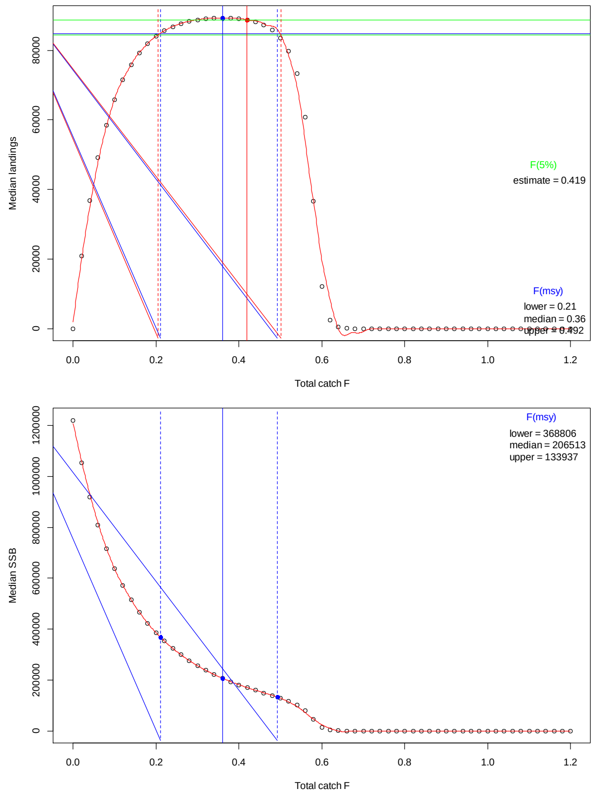

Figure 11.10.3. Saithe in Subareas 4 and 6 and Division 3.a. Eqsim results with a fixed F exploitation from F = 0 to 1.2 (no $B_{trigger}$). Left: median landing yield curve: blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield, with the upper bound restricted to $F_{P0.05}$ (dotted); green lines: F(5%) estimate (solid). Right: median SSB: blue lines show the location of F_{MSY} (solid) with the (dotted) lower 95% F_{MSY} and the upper precautionary bound (restricted to $F_{P0.05}$).

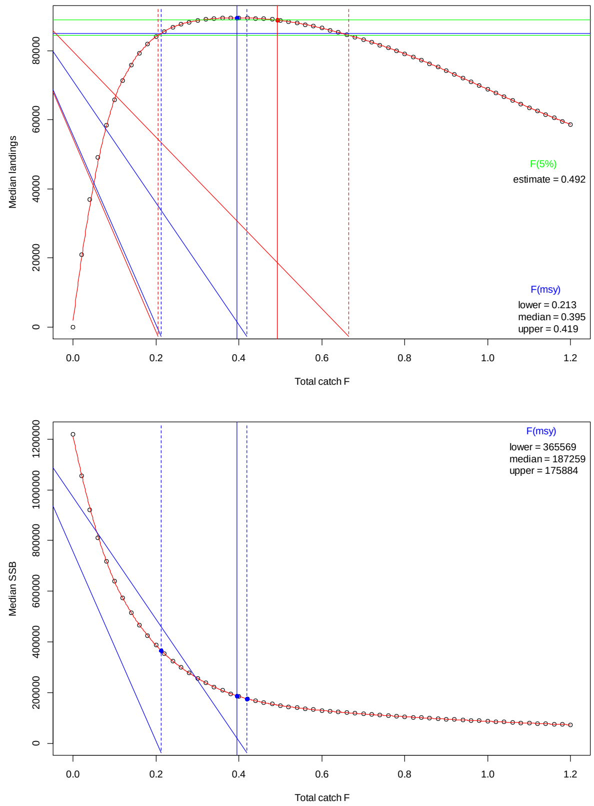

Figure 11.10.4. Saithe in Subareas 4 and 6 and Division 3.a. Eqsim results with a fixed F exploitation from F = 0 to 1.2 and applying the ICES MSY harvest control rule with a $B_{trigger}$ at 150 000 tonnes. Left: median landing yield curve: blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield, with the upper bound restricted to $F_{P0.05}$ (dotted); green lines: F(5%) estimate (solid). Right: median SSB: blue lines show the location of F_{MSY} (solid) with the (dotted) lower 95% F_{MSY} and the upper precautionary bound (restricted to $F_{P0.05}$).

12 Whiting (*Merlangius merlangus*) in Subarea 4 (North Sea), Division 7.d (Eastern English Channel) and 3.a (Skagerrak and Kattegat)

12.1 Whiting in Subarea 4 and Divisions 7.d

This Section contains the assessment relating to whiting in the North Sea (ICES Subarea 4) and eastern Channel (ICES Division 7.d). The current assessment is formally classified as an update assessment. The most recent benchmark for this stock was conducted in January 2013 (WKROUND 2013). An Interbenchmark was conducted in March 2016 (ICES 2016) to test new natural mortalities from the 2014/2015 key run from of the SMS multispecies model (WGSAM 2014).

Available information on whiting in Division 3.a (Skagerrak and Kattegat) is presented in Section 12.2.

12.1.1 General

12.1.1.1 Stock definition

No new information was presented at the WG. A summary of available information on stock definition can be found in the Stock Annex prepared by ICES-WKROUND (2013).

12.1.1.2 Ecosystem aspects

No new information was presented at the WG. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared by ICES-WKROUND (2013).

12.1.2 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES-WKROUND (2013).

12.1.3 ICES advice

ICES advice for 2014

In November 2013, ICES concluded as follows:

ICES advises on the basis of precautionary considerations that total catches should be no more than 31 553 tonnes. If rates of discards and industrial bycatch do not change from the average of the last three years (2010–2012), this implies human consumption landings of no more than 21 199 tonnes (16 092 tonnes in the North Sea and 5 106 tonnes in Division 7.d). Management for Division 7.d should be separated from the rest of Subarea 7.

ICES advice for 2015

In November 2014, ICES concluded as follows:

ICES advised on the basis of the EU-Norway management plan that total catches should be no more than 30 579 tonnes. If rates of discards and industrial bycatch do not change from the average of the last three years (2011–2013), this implies human consumption of no more than 17 190 tonnes (13 678 tonnes in the North Sea and

3 512 tonnes in Division 7.d). Management for Division 7.d should be separated from the rest of Subarea 7.

ICES advice for 2016

In November 2015, ICES concluded as follows:

ICES advised on the basis of the EU-Norway management plan that total catches should be no more than 30 510 tonnes. If rates of discards and industrial bycatch do not change from the average of the last three years (2012–2014), this implies human consumption of no more than 14 853 tonnes (12 373 tonnes in the North Sea and 2 480 tonnes in Division 7.d). Management for Division 7.d should be separated from the rest of Subarea 7.

12.1.4 Management

Management of whiting is by TAC and technical measures. The TACs for this stock are split between two areas: (i) Subarea 4 and Division 2.a (EU waters), and (ii) Divisions 7b-k. Since 1996 the North Sea and eastern Channel whiting assessments have been combined into one.

The agreed TACs for whiting in Subarea 4 and Division 2.a (EU waters) were 16 092 t in 2014 and 13 678 t in 2015. The TAC in 2016 was set as a Roll-over TAC at 13 678t. There is no separate TAC for Division 7.d; landings from this Division are counted against the TAC for Divisions 7b-k combined (20 668 t in 2014, 17 742 t in 2015 and 22 778 t in 2016). There are no means to control how much of the Division 7b-k TAC is taken from Division 7.d. By comparison, a specific TAC for Division 7.d was established for cod in 2009, and the same procedure for whiting may be appropriate.

In previous years, the human consumption landings in Subarea 4 and Division 7.d were calculated as 70% and 30% of the combined area totals. Since 2006, the landings data have been collated separately for each area. In 2015, 77% of the total catches originated in Subarea 4.

The minimum landing size for whiting in Subarea 4 and Division 7.d is 27 cm. The minimum mesh size for whiting in Division 7.d is 80 mm.

Whiting are a by-catch in some *Nephrops* fisheries that use a smaller mesh size, although landings are restricted through by-catch regulations. They are also caught in flatfish fisheries that use a smaller mesh size. Industrial fishing with small-meshed gear is permitted, subject to by-catch limits of protected species. Regulations also apply to the area of the Norway pout box, preventing industrial fishing with small meshes in an area where the by-catch limits are likely to be exceeded.

Conservation credit scheme

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), 166 (2013), 94 (2014) and 97 (2015). In 2016, 34 closures had been implanted by 4th 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 whiting.

Studies tracking Scottish vessels during 2009–2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behavior on the whiting stock is still under investigation.

In 2015, 24 Scottish demersal whitefish vessels (although 6 left during the year) participated in a trial Fully Documented Fishery (FDF) scheme, following similar schemes during 2010–2014. Trials of similar schemes have been conducted during various periods by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF scheme, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on whiting fisheries of an enforceable discard ban for cod, and in data collation for the whiting assessment it was assumed that FDF vessels would have similar whiting discard patterns as other vessels, but this remains to be verified. The Scottish FDF scheme for 2016 began in January, and is being run along similar lines to previous years. Currently, 12 vessels are participating in the scheme in 2016. The uptake of the scheme has declined due to concerns about the monitoring of discards under the Landing Obligation.

12.1.5 Data available

12.1.5.1 Catch

Since 2012, international data on landings and discards have been collated through the InterCatch system.

The 70% of the landings had associated discard data imported to Intercatch. The discard data provided for landings in 2015 are illustrated in Figure 12.1. Discards were raised from discard ratios for all strata from Subarea 4 and Division 7.d combined. Industrial bycatch landings were excluded from the discard raising, as now discards occur in that fleet. Minor whiting bycatch landings of 12 t from a miscellaneous fleet (originating from a Dutch pelagic métier under landing obligation) imported as BMS landing (below minimum landing size) into InterCatch were treated as discards throughout.

Figure 12.2.1 shows fleet-specific landings in percent of the total landings in 2015 for whiting in Subarea 4 and Division 7.d, for fleets sampled for age compositions in landings and for fleets which were not sampled. The Figure also shows the cumulative landings when sampled and unsampled fleets are ordered by landings yield. Sampled fleets comprise around 69% of the overall landings, from 9 métiers. Sampled and unsampled métiers are listed in Figure 12.2.1. However, although the unsampled fleets provide considerable landings overall (30%), most métiers provide less than 5% of the overall landings each. A métier summarized as miscellaneous landing industrial bycatch provides about 11% of the landings, occurred in the Danish fishery and was not sampled. It would therefore make little difference to the final data collation to segregate fleets on the basis of gear type or quarter before applying age compositions. Age compositions were applied to landings without any splitting of fleets on the basis of area, quarter or gear type. For consistency, the same approach was taken for raising discard rates from sampled to unsampled discard fleets.

Of the total discards, 83% were imported into InterCatch. 59% of the imported discards were sampled for age distributions. The 11 métiers providing discard samples and unsampled métiers are listed in Figure 12.2.2.

Discard rates for unsampled whiting fleet components were obtained from samples provided by France and UK (England, Scotland) for Subarea 4 and in Division 7.d by France.

Official reported landings by country, WG estimates of total catch and catch component yields, as well as TACs covering the respective areas are given in Table 12.1 for the North Sea (Subarea 4) and in Table 12.2 for the Eastern Channel (Division 7.d).

WG estimates of numbers and weights at age for the defined catch components (total catch, landings, discards and industrial bycatch) are given in Tables 12.4 to 12.11. The estimated tonnages of the Subarea 4 catch components remained low but is higher than in most recent years, and whiting industrial by-catch remains low similar to last year (6% of the total catches). Discards have increased to 40 % of the total catches, discards in both catch components increased. Figure 12.3 plots the trends in the commercial catch for each component in both Subarea 4 and Division 7.d combined. Recent years have seen these time series stabilize to a certain extent. There has been a slight increase in discards for age 1 in recent years. Compared to last year, the discard increased for all age groups except age 1, 4, 6 (Figure 12.4).

12.1.5.2 Age compositions

Age compositions in the landings and discards were based on samples provided by France, UK(England) and UK(Scotland). Limited sampling of the industrial bycatch component resulted in the 2006 data appearing as an outlier and the 2007 to 2010 data were deemed unreliable. This applies to both the age compositions and the estimates of mean weights at age. Thus the data for 2006 to 2010 were replaced with estimates derived from the years 1990 to 2005 (as described in the Stock Annex).

For the industrial bycatch in 2011 and 2012, age compositions were inferred in InterCatch from corresponding age samples taken from small-mesh fisheries of France and the UK.

Total international catch numbers at age (Subarea 4 and Division 7.d combined) are presented in Table 12.4. Numbers for human consumption landings, discards, and industrial bycatch are given in Tables 12.5 to 12.7.

12.1.5.3 Weight at age

Mean weights at age (Subarea 4 and Division 7.d combined) in the catch are presented in Table 12.8. These are also used as stock weights at age. Mean weights at age (both areas combined) in human consumption landings are presented in Table 12.9, and for the discards and industrial by-catch in the North Sea in Tables 12.10 and 12.11 respectively. Weights-at-age are depicted graphically in Figure 12.5, which indicates an increasing trend (with annual fluctuations) in mean weight-at-age in the landings, discards and total catch for ages >2.

Unrepresentative sampling of industrial bycatch in 2006 to 2010 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values). For 2012 to

2015, the weights at ages of total catches were used for weights at ages of industrial bycatches.

12.1.5.4 Maturity and natural mortality

Values for maturity remain unchanged from those used in recent assessments and are given in Table 12.12. Their origin is discussed in the Stock Annex.

Estimates of natural mortality (M) are taken from the 2014/2015 update key run from of the SMS multispecies model (ICES-WGSAM 2014) (Table 12.13 and Figure 12.6). It was decided by WGNSSK to use the most recent estimates of natural mortality values from the 2014/2015 model key run, because recruitment estimates in the assessment changed significantly with the new estimates, while SSB and F were hardly impacted. The SMS keyrun is mainly based on stomach data sampled in the years 1981, 85–87 and 1991. In addition, data on the diet of marine mammals (seals, harbour porpoise) are available from sporadic samples during the last 30 years. In general, the new keyrun in is an update of the 2011 keyrun. But in comparison, the time series of grey gurnard and raja abundances were revised. In addition, the cod assessment changed between 2011 and 2014 leading to lower abundances of cod in SMS. The predation mortalities for age 1 and 2 are systematically lower than in the 2011 keyrun. The assessment results using the new natural mortalities questioned the current reference points and an Inter-benchmark was done to test the new natural mortality estimates (ICES 2016). As a result, it was decided to use these new mortality values. The new natural mortality values are constant for ages 5+ (Figure 6). Reference points were updated accordingly (Table 12.19).

12.1.5.5 Research vessel data

Survey tuning indices are presented in Table 12.14. The indices used in the assessment are ages 1 to 5 from the IBTS-Q1 and IBTS-Q3 surveys, from 1990 to 2016 and 1991 to 2015, respectively. The report of the 2001 meeting of WGNSSK (ICES-WGNSSK 2002), and the ICES advice for 2002 (ICES-ACFM 2001) provide arguments for the exclusion of commercial CPUE tuning series from calibration of the catch-at-age analysis. Such arguments remain valid and only survey data have been considered for tuning purposes. All available tuning series are presented in the Stock Annex prepared at ICES-WKROUND (2013).

In Figure 12.7 survey distribution maps, based on the IBTS-Q1 survey in the North Sea, for ages 1–3+ of the first quarter (Q1) 2012–2016 are presented. Figure 12.8, the third quarter is represented (Q3) for ages 0–3+ for the years 2012–2015. The figures illustrate the CPUE is high along the UK east coast in quarter 1 and in the Northern North Sea and Scottish east coast and in the German Bight in quarter 3 for age 0–2. For age3+ the CPUE is highest along the UK East Coast. In 2015/2016 CPUE generally remained high as the last year.

12.1.6 Data analyses

The benchmark meeting for whiting in Subarea 4 and Division 7.d was held in Galway and Aberdeen in early 2013 (ICES-WKROUND 2013). Analyses focused on a number of key issues: these are listed below, along with relevant recommendations for future work (and steps taken by WGNSSK to address them):

CCTV-based discard-rate estimation

Several participating countries have now installed CCTV cameras on a subset of vessels, and the issue is whether footage from these can be used to improve discard- rate estimation for assessments. The WKROUND meeting concluded that further work is needed to integrate CCTV with existing observer programs, and work is ongoing to improve length measurements accordingly (new camera and annotation systems, automated image analysis, and length-based assessments).

Length of assessment time-series

Considerable effort was put into the evaluation of the pre-1990 catch and survey data which were previously used in the assessment, but which were removed in recent years due to discrepancies between catch and survey information. WKROUND found that pre-1990 catch data would need to be reduced by at least 75% for the FLXSA SSB estimates (catch-based) to resemble those from SURBAR (survey-based). It did not seem possible to resolve this discrepancy, and WKROUND concluded that 1990 should be retained as the starting point for the update assessment.

Stock identity

The issue of how to define stock units for whiting that are biologically relevant remains a difficult one to address. WKROUND evaluated the available evidence, and produced area-specific SURBAR analyses to determine whether estimated time-series of biomass and mortality were correlated between different areas. Although the northern North Sea appeared to be linked with the areas immediately to the south and with no others, the analysis was not sufficiently conclusive. There is some evidence for north-south split in the North Sea, and some evidence for links between Divisions 4.a and 6.a (Holmes *et al*. 2014), but full stock determination is hindered by data availability. It would be very difficult to subdivide historical landings and discards time-series from all participating nations between any new areas. WKROUND 2013 concluded that the issue of stock identity needs to be considered as a matter of high priority, and as a parallel process with the existing data collation and assessment approach.

Assessment models

WKROUND concluded that the update assessment model should continue to be FLXSA, with supporting exploratory runs using SURBAR (and, time permitting, SAM). A full investigation of the appropriate SAM run settings was not possible due to lack of time, although WKROUND recommended that this be done in the near future.

12.1.6.1 Exploratory survey-based analyses

Figure 12.9 presents time-series of survey log CPUE at age, and suggests that while broad trends are captured in a consistent way by the two surveys, finer-scale details of year-class strength may not be.

Catch-curve analyses for the surveys are shown in Figures 12.10. These show consistent tracking of year classes (since catch curves are mostly smooth) and consistent selection with some recent exceptions. The catchability of the IBTS Q1 seems to have changed since 2007, underestimating the size of the 2006 year class at age 1. The 2007 to 2010 and 2012 year classes also seem to have been underestimated at age 1. The IBTS-Q3 survey shows low mortality for the 2006 year class, and a potential under estimate of the 2007 year class at age 1; however, numbers at age 2 in the 2007 yearclass may well be an overestimate. There does not appear to be a problem estimating age 1 in the 2008 or subsequent year classes in the IBTS-Q3 survey.

The consistency within surveys is assessed using correlation plots in Figures 12.11 and 12.12. These indicate that the IBTS Q1 and Q3 surveys both show good internal consistency across ages. The log CPUE plots by survey (Figure 12.13) support the conclusion of good internal consistency.

Figures 12.14 to 12.16 summarize the results of a SURBAR analysis using the available whiting surveys. These show a well-specified analysis in which the data agree broadly with the separability assumptions in the model and uncertainty bounds are fairly tight.

12.1.6.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 12.17 and show numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 2 for some cohorts. Also evident is the persistence of the 1999 to 2001 year classes in past catches and the recent low catches of the 2002–2010 year classes.

The negative gradients of log catches per cohort, averaged over ages 2-6 and interpreted here as a rough proxy for fishing mortality over those ages, are given in Figure 12.18. The gradients (since the 2002 year class) appear to be fluctuating around a mean level that is lower than the mean level before the 1998 year-class, which suggests that recent fishing mortality is likely to be lower than in the past.

Within cohort correlations between ages are presented in Figure 12.19. In general, catch numbers correlate well between cohorts with the relationship breaking down as cohorts are compared across increasing age gaps.

Single fleet XSA runs were conducted to compare trends in the catch data with using survey data for quarter 1 and 3 separately. These used the same procedure as this year's final assessment. Summary plots of these runs are presented in Figure 12.20. The population trends from each survey are consistent; however, the mean F estimates differ considerably throughout the time-series. In recent years estimates in SSB, fishing mortality and recruitment have been similar. Residual patterns (Figure 12.21) show that the 2006 year class has a large negative residual at age 1 for both surveys (and particularly IBTS Q1). In quarter 1, residuals for age 1 have been larger in some years (2006, 2013).

12.1.6.3 Conclusions drawn from exploratory analyses

Catch curve analysis and correlation plots show that in general both surveys and catch data track cohorts well and are internally consistent. However, beginning with the 2006 year class, the IBTS Q1 appears to be underestimating the abundance of age 1 and 2 whiting. In previous assessments, this had implications for the estimation of recruitment at age 1 in 2007 and resulted in a considerable retrospective bias in recruitment.

12.1.6.4 Final assessment

The final assessment used an FLXSA model fitted to the combined landings, discard and industrial bycatch data for the period 1990–2015. This is the same procedure as last year and that agreed at WKROUND (ICES-WKROUND 2013). The settings are provided in the table below.

Catch-at-age data	1990–2015
	Ages 1–8+
Calibration period	1990–2015

Survey: IBTS Q1	1990–2016
Ages 1–5	
Survey: IBTS Q3	1991–2015
Ages 1–5	
Catchability independent of stock size from	Age 1
Catchability plateau	Age 4
Weighting	No taper weighting
Shrinkage	Last 3 years and 4 ages
Shrinkage SE	2.0
Minimum SE for survivors' estimates	0.3

Diagnostics for the final XSA run are given in Tables 12.15. Residual plots are presented in Figure 12.23. These show that the IBTS Q3 survey fits more closely to the model and the catch data, than the IBTS Q1 survey which demonstrated considerable year effects towards the end of the time series. This indicates that the model is effectively paying less attention to the Q1 survey than to the Q3 survey, and this is borne out by Figure 12.24 which shows the contribution of each tuning fleet to the estimation of survivors in the most recent year.

Finally, Figure 12.22 compares the SURBAR results with the final XSA assessment. The mean Z (total mortality) estimates show year-to-year variation, but the trends in all outputs are very similar.

Fishing mortality estimates are presented in Table 12.16, estimated stock numbers in Table 12.17 and the assessment summary in Table 12.18 and Figure 12.25.

A retrospective analysis is shown in Figure 12.26.1. This shows a consistent bias in recruitment from 2006 to 2010. The largest revision in recruitment is for recruitment in 2008 (the 2007 year class) which coincides with large negative residuals and the flat catch curve in the IBTS-Q1 survey (Figure 12.10). This translates directly to a large revision of SSB in 2008. However, the last four retrospective runs are very consistent for SSB and fishing mortality. This may indicate that previous data problems have been corrected, although it may be too early to say whether the retrospective bias has actually been eliminated. Relative differences are illustrated in Figure 12.26.2, they are calculated as a percentage difference per year from the final year assessment. For each of the retrospective percentage difference plots, the terminal values of the past 7 years are used to calculate Mohn's rho, (ϱ(SSB)= -0.026, ϱ(F) = 0.026, ϱ(Rec) = -0.01).

12.1.7 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 12.25. These show that mean F has been declining and has reached the minimum of the post-1990 time-series in 2012, but is increasing in the recent years. The SSB has decreased after recent increases; and recruitment is fluctuating around a recent low average. In the most recent year, landings, discards and industrial bycatch have also all remained at or around a recent average. The stock-recruitment plot in Figure 12.27 shows some evidence of a weak positive relationship between SSB and subsequent recruitment, although such evidence is not compelling.

12.1.8 Biological reference points

Due to the shape of the yield per recruit (YPR) curve, a maximum is often not reached, and F_{max} has therefore not been defined for several years. The WG considers that YPR F reference points are not applicable to this stock since F_{max} is undefined in most years, and the estimate of $F_{0.1}$ is very variable in recent years (see ICES-WGNSSK, 2009). A long-term average selection pattern could be used to stabilize $F_{0.1}$ or a long term average of $F_{0.1}$ could be interpreted as a sensible reference point. The 2013 benchmark meeting (ICES-WKROUND 2013) attempted to calculate F_{msy} for North Sea whiting, but concluded that this value was inestimable using standard equilibrium considerations and would need to be determined as part of a management strategy evaluation.

After the considerable revisions in the 2012 assessment, caused by new estimates of natural mortality, the target F of 0.3 was no longer considered applicable. The management plan was re-evaluated in October 2013 (ICES 2013) and ICES advised that updating the target F from 0.3 to 0.15 within the management plan.

New revisions of natural mortalities were presented at WGSAM 2014. The new natural mortality values from the 2014/2015 key run are used in the current assessment. Due to the new natural mortalities, the recruitment estimates and SSB decreased in the assessment, an Interbenchmark was performed for whiting in the North Sea and Division 7.d (ICES 2016). This included a comparison of assessment results, Eqsim runs and MSE. On the basis of the 2015 assessment using the new natural mortalities the target F of 0.15 leads to maximum probabilities above 5% of SSB falling below B_{lim}, which is considered precautionary. This is under the assumption that recruitment stays within a medium-low range. Therefore, a target F of 0.15 together with a TAC constraint of 15% according to the EU-Norway Management Plan may not be sufficient to keep SSB above B_{lim}. It was concluded to use an MSY approach with FMSY of 0.15 and an additional check of SSB relative to $B_{lim.}$ The target fishing mortality can then be adapted at very low biomass levels. Until additional information becomes available, it is considered that the lowest observed SSB (SSB in 2007, 172 741 t in the 2015 assessment) can be used as a B_{lim} reference point. As a result new reference points are listed in Table 12.19.

12.1.9 Recruitment estimates

RCT3 input data are presented in Table 12.20, and RCT3 output is presented in Table 12.21. The RCT3 estimate of recruitment at age 1 in 2016 (that is, the 2015 year-class) was 2900 million. Following the approach taken last year, and subsequently formalized in the benchmark report (ICES-WKROUND 2013), the WG agreed to use the RCT3 estimates for recruitment in 2016, and the long-term geometric mean for recruitment in 2017 and beyond in the short-term forecast. The geometric mean of all recruitments excluding the most recent year is 2443 million (Table 12.22).

12.1.10 Short-term forecasts

A short-term forecast was carried out based on the final FLXSA assessment. FLXSA survivors from 2015 were used as input population numbers for ages 2 and older in 2016. Recruitment assumptions are detailed in the preceding section.

The exploitation pattern was chosen as the mean exploitation pattern over the years 2013–2015. A simple mean F would have led to bias in forecast F, given the recent changes in $F_{2\text{-}6}$, so this exploitation pattern was scaled to the mean $F_{2\text{-}6}$ in 2015 for forecasts. Partial F at age for each catch component was estimated by splitting the forecast F at age using the mean proportion in the catch of each catch component over the years 2013–2015. The F at age used in the forecast is compared with the F at age estimates for 2013–2015 in Figure 12.27.

Mean weights at age are generally consistent over the recent period but there are trends at several ages (Figure 12.5). To avoid introducing bias, therefore, the 2015 estimates were used for the purposes of forecasting.

The inputs to the short-term forecast are given in Tables 12.22 to 12.23, and results are presented in Table 12.24. The MFDP program was used to carry out the forecasts, since there is no available function currently within FLR to account for industrial bycatch in forecasts and WGNSSK could not complete the coding required to address this in the time available.

No TAC constraint was applied in the intermediate year since it is not considered that fishing will stop when the TAC is reached.

Assuming mean F_{2016} to equal mean F_{2015}, results in human consumption landings in 2016 of 18 537 t from a total catch of 33 601 t, giving an SSB in 2017 of 310 363 t (Table 12.24).

Carrying the same fishing mortality forward into 2017 (the status quo F option) would result in landings of 19 926 t out of total catches of 35 900 t, and would result in an SSB of 317 115 t in 2018 (a 2% increase in SSB relative to 2017). Applying the F_{msy} of 0.15 in 2017 would generate landings of 12 679 t out of total catches of 23 679 t, and result in an SSB of 327 559 t in 2018 (a 5.5% increase in SSB relative to 2017). In 2018, SSB would be above B_{lim}. F of 0.15 would also cause the TAC to be changed by -29%.

12.1.11 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting.

12.1.12 Quality of the assessment

Previous meetings of WGNSSK and the benchmark workshop (ICES-WKROUND 2009, ICES-WKROUND 2013) have concluded that the historical survey data and commercial catch data contain different signals concerning the stock. Analyses by Working Group members and by the ICES Study Group on Stock Identity and Management Units of Whiting (ICES-SGSIMUW 2005) indicate that data since the early- to mid-1990s are sufficiently consistent to undertake a catch-at-age analysis calibrated against survey data 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, WGNSSK considers that it is not possible categorically to classify the current state of the stock with reference to precautionary reference points as the biomass reference points are derived from a consideration of the stock dynamics dating from a time when the commercial catch-at-age data and the survey data conflict. Precautionary reference points must be reconsidered following the ongoing management strategy evaluation.

The IBTS-Q1 survey is showing a step change in catchability of young fish (especially age 1). The reason for this is unclear, but it appears to have happened after the 2006 survey. This represents a model misspecification, as the current model (FLXSA) assumes constant catchability through time.

Due to the likely population structuring in the North Sea and Eastern Channel, it is probable that the overall stock estimates may not reflect trends in more localized areas.

Given the spatial structure of the whiting stock and of the fleets exploiting it, it is important to have data that covers all fleets. Considering that age 1 and age 2 whiting make up a large proportion of the total stock biomass, good information of the discarding practices of the major fleets is important.

The survey information for Division 7.d were not available in a form that could be used by WGNSSK. Due to the recent changes in distribution of the stock, tuning information from this area would be extremely useful, and could improve the estimate of recruitment in the most recent year. However, previous analyses of the survey in Division 7.d showed it did not track cohorts well (ICES-WKROUND 2009).

Age distributions and mean weights at age have been estimated for the industrial bycatch from 2006 to 2010. This was due to low sampling levels of the Danish industrial bycatch fisheries. In recent years no samples of industrial bycatch were available. Age distributions and weights at age were inferred from sampling of landings and discards from other fleets.

There have been issues with regard to the whiting age reading of Norwegian samples. The readings did not correlate well with readings from the Netherlands. The issue mainly affects age readings for the IBTS survey. Until the issue is resolved, the IBTS survey data is used as in previous years.

The historical performance of the assessment is summarized in Figure 12.29. The difference in recruitment estimates in the current assessment is caused by the new natural mortality estimates.

12.1.13 Status of the stock

For North Sea whiting, SSB has a generally downwards trend since the start of the assessment time-series. SSB is estimated to be well above B_{lim} since 2008 (Figure 12.24). The stock, at the level of the entire North Sea and Eastern Channel, was at an historical low level during 2005 to 2008 (relative to the period since 1990), and the recent increase in SSB is in large part due to relatively improved perception of recruitment in 2008 and 2011. All indications are that fishing mortality has been declining over most of the time-series, currently fluctuating around a low level with a small increase in recent years. The level of recruitment has been generally low since 2003, with recruitment since 2014 above the average of the recent years. Recruitment is varying around a recent mean, but that mean is low relative to the rest of the time series and whiting biomass is likely to decline in future (even at low fishing mortality rates) until the appearance of the next good year class.

12.1.14 Management considerations

In 1997, 2003 to 2007 and 2012 to 2013, the whiting stock produced the lowest recruitments in the series. Whiting recruitment (estimated largely from the IBTS-Q1 and IBTS-Q3 surveys) was underestimated substantially in 2007 and 2008 resulting in low forecasts of recruitment and recommendations of reduced TACs due to the perception of critically low recruitment. Subsequent recruitment is below the long-term average.

Whiting mature at age 2 and grow quickly at young ages; therefore an increase in SSB is seen the year immediately after a good recruitment. Managers should consider the age structure of the population as well as the SSB since at low stock sizes short term forecasts are highly sensitive to recruitment assumptions.

Catches of whiting have been declining since 1980 (from 243 570 t in 1979 to 25 078 t in 2012, including discards and industrial bycatch). Catch rates from localized fleets may not represent trends in the overall North Sea and English Channel population. The localized distribution of the population is known to be resulting in substantial differences in the quota uptake rate. This is likely to result in localized discarding problems that should be monitored carefully.

Whiting are caught in mixed demersal roundfish fisheries, fisheries targeting flatfish, the *Nephrops* fisheries, and the Norway pout fishery. The current minimum mesh-size in the targeted demersal roundfish fishery in the northern North Sea has resulted in reduced discards from that sector compared with the historical discard rates. Mortality may have increased on younger ages due to increased discarding in recent years as a result of recent changes in fleet dynamics of *Nephrops* fleets and small mesh fisheries in the southern North Sea. The bycatch of whiting in the Norway pout and sandeel fisheries is dependent on activity in that fishery, which has recently declined after strong reductions in the fisheries. Industrial bycatches are considered low in the forecast. A larger catch allocation for bycatch may be required if industrial effort increases.

Catches of whiting in the North Sea are also likely to be affected by the effort reduction seen in the targeted demersal roundfish and flatfish fisheries, although this will in part be offset by increases in the number of vessels switching to small mesh fisheries. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. WGMIXFISH monitors the consistency of the various single-species management plans and TAC advice under current effort schemes, in order to estimate the potential risks of quota over- and under shooting for the different stocks, and it was demonstrated that the current basis for whiting advice was not consistent with other single-stock management objectives. It is recommended that the ongoing discussions about the whiting management plan takes into account such mixed-fisheries considerations before implementation.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear in the North Sea and Skagerrak, should be encouraged for whiting. There is a mismatch between quota allocations, derived from relative stability criteria, and the access of the various fisheries to the resource which has changed because of changes in the distribution of whiting.

ICES has developed a generic approach to evaluate whether new survey in-formation that becomes available in September forms a basis to update the advice. ICES will publish new advice in November 2016 if this is the case for this year.

12.1.15 Frequency of assessment

Stocks are considered candidates for biennial assessment if:

- The advice for the stock has been 0-catch or equivalent for the latest three advice years.

Does not apply for North Sea whiting

Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously:

- Life span (i.e. maximum normal age) of the species is larger than 5 years

YES

The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x F_{msy} OR if F_{msy} range has been defined: F(latest assessment year) is <= F_{upper} (upper bound in F range)

NO, F(2015) = 0.227 F_{MSY} x 1.1 = 0.165

AND SSB(start of intermediate year) >= MSY $B_{trigger}$

YES, SSB(2015) = 246870 >= 241 837

- The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.

NO, the average contribution of recruits (age 1) in numbers in the last 5 years is 65%.

- The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by less than 20%

YES, $\rho =$ 0.026< 0.2

The formula to be used in the calculations is:

$\rho = \frac{1}{7}\sum_{u=Y-7}^{Y-1}\left(1 - \frac{F_{u,u}}{F_{u,Y}}\right)$. The result should be < 0.20,

where $F_{u,u}$ is F in year u estimated from an assessment that ends in year u, and $F_{u,Y}$ is the F in year u estimated from the most recent assessment (which ends in year Y)

Results of the frequency of assessment analysis are summarized in Table 12.24.

In conclusion, North Sea whiting does not qualify for a change in assessment frequency.

12.1.16 References

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Table 12.1: Whiting in Subarea 4 and Division 7.d. Whiting in Subarea 4. Nominal landings (in tonnes) as officially reported to ICES, WG estimates of catch components, and TACs.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
belgium.4	1040	913	1030	944	1042	880	843	391	268	529	536	454	270
denmark.4	1206	1528	1377	1418	549	368	189	103	46	58	105	105	96
france.4	4951	5188	5115	5502	4735	5963	4704	3526	1908	NA	2527	3455	3314
germany.4	692	865	511	441	239	124	187	196	103	176	424	402	354
netherlands.4	3273	4028	5390	4799	3864	3640	3388	2539	1941	1795	1884	2478	2425
norway.4	55	103	232	130	79	115	66	75	65	68	33	44	47
sweden.4	16	48	22	18	10	1	1	1	0	9	4	6	7
england.wales.4	2338	2676	2528	2774	2722	2477	2329	2638	2909	2268	1782	1301	1322
scotland.4	23486	31257	30821	31268	28974	27811	23409	22098	16696	17206	17158	10589	7756
uk.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.4	41057	46606	47026	47295	42214	41379	35116	31567	23936	NA	24453	18834	15591
unallocated.landings.4	-1123	396	1816	685	344	829	-434	627	246	NA	173	-426	721
wg.landings.4	42180	46210	45210	46610	41870	40550	35550	30940	23690	25700	24280	19260	14870
wg.discards.4	52270	30840	28470	41400	31840	28940	27130	16660	12480	22110	21931	16130	17144
wg.ibc.4	51337	39755	25045	20723	17473	27379	5116	6213	3494	5038	9160	940	7270
wg.catch.4	145787	116805	98725	108733	91183	96869	67796	53813	39664	52848	55371	36330	39284
tac.4.2.a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30000	29700	41000

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
belgium.4	248	144	105	93	45	115	162	147	74	45	33	46	69
denmark.4	89	62	57	251	78	42	79	156	135	131	124	160	215
france.4	2675	1721	1261	2711	3336	3076	2305	2644	2794	1925	942	1887	1130
germany.4	334	296	149	252	76	76	124	156	111	25	44	31	73
netherlands.4	1442	977	805	702	618	656	718	614	514	471	495	466	548
norway.4	39	23	16	17	11	92	73	118	28	94	560	916	1088
sweden.4	10	2	0	2	1	2	4	8	6	4	1	2	5
england.wales.4	680	1209	2560	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
scotland.4	5734	5057	3441	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
uk.4	NA	NA	NA	11632	12110	10391	8853	7845	8892	9893	11162	10248	9970
total.landings.4	11251	9491	8394	15660	16275	14451	12318	11690	12554	12588	13361	13756	13098
unallocated.landings.4	801	541	-2286	563	609	972	544	-591	-751	-341	-2023	-1860	-510
wg.landings.4	10450	8950	10680	15097	15666	13479	11774	12281	13305	12929	15384	15616	13608
wg.discards.4	26135	18142	10300	14018	5206	8356	5223	7853	8180	5929	4198	8326	10468
wg.ibc.4	2730	1210	890	2190	1240	0	1020	1350	1750	78	1530	1479	2053
wg.catch.4	39315	28302	21870	31305	22112	21835	18017	21484	23235	18936	21119	25421	24076
tac.4.2.a	16000	16000	28500	23800	23800	17850	15173	12897	14832	17056	18932	16092	13678

Table 12.2: Whiting in Subarea 4 and Division 7.d. Whiting in Division 7.d. Nominal landings (in tonnes) as officially reported to ICES, WG estimates of catch components, and TACs.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
belgium.7.d	83	83	66	74	61	68	84	98	53	48	65	75	58
france.7.d	NA	NA	5414	5032	6734	5202	4771	4532	4495	NA	5875	6338	5172
netherlands.7.d	0	0	0	0	0	0	1	1	32	6	14	67	19
england.wales.7.d	239	292	419	321	293	280	199	147	185	135	118	134	112
scotland.7.d	0	0	24	2	0	1	1	1	0	0	0	0	0
uk.7.d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.7.d	NA	NA	5923	5429	7088	5551	5056	4779	4765	NA	6072	6614	5361
unallocat.landings.7.d	NA	NA	203	219	468	161	106	159	165	NA	1772	814	-439
wg.landings.7.d	3480	5720	5740	5210	6620	5390	4950	4620	4600	4430	4300	5800	5800
wg.discards.7.d	3330	4220	4090	2970	3850	3240	3370	3000	3210	3570	4129	3109	1356
wg.catch.7.d	6810	9940	9830	8180	10470	8630	8320	7620	7810	8000	8429	8909	7156
tac.7b.k	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22000	21000	31700

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
belgium.7.d	67	46	45	73	75	69	71	88	78	66	95	89	121
france.7.d	6654	5006	4638	3487	3135	2875	6248	5512	4833	3093	3076	2115	3065
netherlands.7.d	175	132	128	117	118	162	112	275	282	437	650	663	558
england.wales.7.d	109	99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
uk.7.d	NA	NA	90	72	63	87	138	258	271	261	472	345	365
total.landings.7.d	7005	5283	4901	3749	3391	3193	6569	6133	5464	3857	4293	3212	4109
unalloc.landings.7.d	1295	933	111	306	137	-1278	-77	194	400	-246	343	82	11
wg.landings.7.d	5710	4350	4790	3443	3254	4471	6646	5939	5064	4103	3950	3130	4098
wg.discards.7.d	604	907	2219	2291	1763	1943	2477	3727	3538	2446	1778	2125	2960
wg.catch.7.d	6314	5257	7009	5734	5017	6414	9123	9666	8602	6549	5728	5255	7059
tac.7b.k	31700	27000	21600	19940	19940	19940	16949	14407	16568	19053	24500	20668	17742

Table 12.3.1: Whiting in Subarea 4 and Division 7.d. Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. SOP.

CatchCategory	SOP
Discards	1.002
Landings	1.032

Table 12.3.2: Whiting in Subarea 4 and Division 7.d. Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of imported and raised data.

CatchCategory	RaisedOrImported	CATON	percent
Discards	Raised	2292643	17
Discards	Imported	11100197	83
Landings	Imported	19396023	100

Table 12.3.3: Whiting in Subarea 4 and Division 7.d. Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of the imported/Raised/SampledOrEstimated data.

CatchCategory	RaisedOrImported	SampledOrEstimated distribution	CATON	perc
Landings	Imported	Sampled	13744977	69
Landings	Imported	Estimated	6265110	31
Discards	Imported	Sampled	6637692	49
Discards	Imported	Estimated	4451738	33
Discards	Raised	Estimated	2338849	17

Table 12.3.4: Whiting in Subarea 4 and Division 7.d. Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of the imported/Raised/SampledOrEstimated data by area.

CatchCategory	RaisedOrImported	SampledOrEstimated distribution	Area	CATON	percent
Landings	Imported	Sampled	7.d	2676203	65
Landings	Imported	Estimated	7.d	1421845	35
Discards	Imported	Sampled	7.d	1631383	55
Discards	Raised	Estimated	7.d	966053	33
Discards	Imported	Estimated	7.d	363286	12
Landings	Imported	Sampled	4	11068775	70
Landings	Imported	Estimated	4	4843266	30
Discards	Imported	Sampled	4	5006309	48
Discards	Imported	Estimated	4	4088452	39
Discards	Raised	Estimated	4	1372796	13

Table 12.4: Whiting in Subarea 4 and Division 7.d. Total catch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	687238	418910	313391	242370	90047	7563	7565	1851	253	11	9	4	0	0	0	0	277
1979	476383	615524	467537	218283	100975	29267	3111	1657	264	35	1	4	0	0	0	0	304
1980	332209	265359	416008	286077	90718	52969	10751	1152	689	58	14	5	1	0	0	0	767
1981	516869	162899	346343	266517	102295	27776	12297	3540	244	45	37	1	0	0	0	0	326
1982	101058	192640	114444	245246	88137	26796	6909	2082	400	53	26	4	1	0	0	0	484
1983	668604	205646	184746	118412	131508	37231	8688	1780	794	101	35	0	0	0	0	0	930
1984	157819	323408	175965	124886	49505	59817	13860	2964	410	182	21	0	0	0	0	0	613
1985	186723	203321	141716	82037	37847	14420	17445	3328	805	89	9	1	0	0	0	0	904
1986	225201	576731	167077	169577	46517	13367	3487	3975	497	71	0	1	0	0	0	0	569
1987	84863	267051	368229	122748	85240	11392	4556	928	929	98	7	0	0	0	0	0	1035
1988	416924	430344	307429	179502	39635	17901	2175	544	59	72	37	0	0	0	0	0	168
1989	87325	331672	173676	191942	78464	14367	5050	516	291	36	6	1	0	0	0	0	334
1990	289174	258102	501372	127966	84147	31102	1934	719	93	16	0	0	0	0	0	0	109
1991	1058000	135797	194921	184960	36290	25554	5339	526	249	17	1	0	0	0	0	0	268
1992	259390	230302	167478	87819	91081	11654	6634	2546	104	7	1	0	0	0	0	0	112
1993	628301	223425	172048	125599	46181	45300	3899	1501	682	56	15	0	0	0	0	0	754
1994	218286	191544	158369	97559	51040	18683	17905	1258	441	73	0	0	0	0	0	0	514
1995	1597900	148170	144023	112416	35649	15062	5117	4472	315	101	54	0	0	0	0	0	470
1996	96515	86318	118910	99644	48303	14088	4638	1281	897	166	24	6	2	0	0	0	1095
1997	19001	60946	80471	84336	41975	18304	3333	1012	304	135	16	0	0	0	0	0	456
1998	72289	92557	50361	43423	36295	17627	6343	1416	306	66	33	0	0	0	0	0	405
1999	76976	189162	95416	45920	33921	18271	7443	2021	565	95	12	0	0	0	0	0	672
2000	1970	82545	129582	63706	23913	16198	8758	4309	969	244	47	3	0	0	0	0	1264
2001	18011	52567	83086	52076	20799	9256	4826	2233	896	246	124	2	0	0	0	0	1268
2002	135848	51338	62462	84600	34659	8098	2048	1461	621	102	13	9	9	0	0	0	755
2003	60744	83680	111144	55866	41840	14218	2358	473	329	50	16	1	0	0	0	0	397
2004	34210	47967	23009	32557	30401	21755	8342	1351	197	93	12	1	4	0	0	0	307
2005	17621	47805	34627	12204	18146	14931	8979	3041	540	83	29	1	0	0	0	0	654
2006	15673	73908	42198	21651	8642	15077	11822	4618	1300	142	14	0	0	0	0	0	1457
2007	2490	39041	34001	24900	9905	4009	7657	5267	2559	476	82	0	0	0	0	0	3117
2008	5631	62164	28301	22741	13571	4305	1848	3954	2134	631	143	43	0	0	0	0	2951
2009	2362	19919	56301	14922	11605	5331	1409	613	1504	942	341	49	1	0	0	0	2837
2010	1224	26266	60426	24826	8016	5394	2867	518	650	567	239	54	1	0	0	0	1510
2011	612	32894	59451	27509	14825	3331	2179	1032	119	47	92	55	0	0	0	0	312
2012	1854	28438	29366	22034	17656	6541	2406	1215	330	86	52	18	55	0	5	0	546
2013	4979	19972	17442	30164	16063	11179	3598	781	366	132	3	0	0	0	0	0	501
2014	5540	43756	20633	21001	21876	10837	4167	1269	242	119	16	0	0	0	0	0	377
2015	3746	39951	60807	14005	9152	13356	4488	1423	441	15	29	4	0	0	0	0	489

Table 12.5: Whiting in Subarea 4 and Division 7.d. Landings numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0	14793	99836	155424	76829	6693	7202	1837	253	11	9	4	0	0	0	0	277
1979	8	8488	108548	144343	89093	26584	3011	1617	250	35	1	4	0	0	0	0	290
1980	0	3656	62405	152570	68422	41430	9911	1135	689	58	14	5	1	0	0	0	767
1981	6	4240	69211	104348	78253	23698	12036	3530	244	45	37	1	0	0	0	0	326
1982	0	10890	46703	124656	59393	21376	5664	2058	400	53	26	4	1	0	0	0	484
1983	1	10568	68640	67312	101342	31266	8330	1730	784	101	35	0	0	0	0	0	921
1984	0	14388	62693	99204	41277	51745	12735	2813	410	182	21	0	0	0	0	0	613
1985	1	2288	51194	57049	32340	12974	16361	3238	805	89	9	1	0	0	0	0	904
1986	29	12879	44500	111527	37287	11285	3379	3912	485	71	0	1	0	0	0	0	557
1987	22	11074	72372	70504	73742	10808	4506	928	899	98	7	0	0	0	0	0	1004
1988	0	7462	61360	94163	29147	16556	2158	544	56	72	37	0	0	0	0	0	164
1989	52	8636	28406	77009	44307	9249	3888	420	208	35	6	1	0	0	0	0	249
1990	23	6910	52533	43850	48537	16845	1341	605	91	16	0	0	0	0	0	0	107
1991	410	11565	42525	88974	25738	21261	4581	396	249	17	1	0	0	0	0	0	268
1992	298	9565	44697	47843	59208	9784	6099	1453	99	7	1	0	0	0	0	0	107
1993	720	5957	28935	63383	32819	33741	2932	1339	682	56	15	0	0	0	0	0	753
1994	77	17124	31351	45492	36289	13920	14407	914	366	73	0	0	0	0	0	0	439
1995	277	8829	28027	58046	27775	13652	4911	4359	308	101	54	0	0	0	0	0	463
1996	1015	12517	26611	47125	35828	11861	4396	1103	897	166	24	6	2	0	0	0	1095
1997	608	6511	23436	47717	31503	15615	2931	1010	289	135	15	0	0	0	0	0	439
1998	1202	17071	19828	24860	24473	14579	5395	1204	219	64	16	0	0	0	0	0	299
1999	68	16661	26669	25504	23465	14483	6554	1854	514	61	12	0	0	0	0	0	587
2000	0	15384	31808	28283	14241	11775	6618	3758	862	244	47	3	0	0	0	0	1157
2001	150	12260	28476	27293	17491	8633	4503	2091	877	246	124	2	0	0	0	0	1249
2002	0	2610	10346	30890	22353	6712	1710	1330	511	99	10	9	9	0	0	0	639
2003	20	403	11613	13990	18974	9513	1861	443	329	50	16	0	0	0	0	0	396
2004	0	3973	2812	9629	13302	11846	4409	747	174	84	12	1	4	0	0	0	274
2005	74	11009	10414	5669	10926	10283	5933	2343	321	78	29	1	0	0	0	0	429
2006	11	11055	11023	8494	5362	12259	10161	4118	1080	105	6	0	0	0	0	0	1192
2007	140	10378	14740	16491	7666	3310	6681	4227	2179	383	77	0	0	0	0	0	2638
2008	0	13234	12334	14120	9106	3564	1519	2505	1481	568	143	43	0	0	0	0	2235
2009	2	2462	31910	9615	9516	4318	1252	548	1156	876	304	49	1	0	0	0	2386
2010	9	3593	27147	15341	4885	4063	1746	363	391	489	230	54	1	0	0	0	1165
2011	0	4679	22858	14952	10821	2333	1484	729	114	42	76	48	0	0	0	0	280
2012	213	4872	13111	13014	11490	4726	1590	860	247	76	28	13	49	0	4	0	417
2013	7	2596	7176	17656	12699	9914	3208	705	328	122	3	0	0	0	0	0	453
2014	0	4594	9508	12019	13943	8219	3006	1009	198	102	15	0	0	0	0	0	314
2015	295	5293	22924	7381	5945	8494	3348	1084	307	13	27	4	0	0	0	0	350

Table 12.6: Whiting in Subarea 4 and Division 7.d. Discards numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	28587	52684	114965	37682	7154	255	110	0	0	0	0	0	0	0	0	0	0
1979	4577	473830	126724	31601	7322	1263	27	7	0	0	0	0	0	0	0	0	0
1980	3144	103203	250735	88399	14135	10795	786	0	0	0	0	0	0	0	0	0	0
1981	867	50407	96509	57403	7313	1285	149	10	0	0	0	0	0	0	0	0	0
1982	18639	53753	26922	52349	18230	2972	343	22	0	0	0	0	0	0	0	0	0
1983	71016	152488	85318	33325	23442	4309	295	25	9	0	0	0	0	0	0	0	9
1984	16724	200589	82563	16814	4437	4495	1034	151	0	0	0	0	0	0	0	0	0
1985	8497	154232	48791	15117	2985	761	801	65	0	0	0	0	0	0	0	0	0
1986	7966	404604	120492	43479	5242	627	108	63	12	0	0	0	0	0	0	0	12
1987	9978	158531	202154	34824	9776	582	49	0	31	0	0	0	0	0	0	0	31
1988	21321	65021	87197	51135	5877	846	16	0	3	0	0	0	0	0	0	0	3
1989	6898	150598	36712	61442	21267	3276	103	8	12	0	0	0	0	0	0	0	12
1990	147764	83152	241924	33084	23009	11665	246	85	0	0	0	0	0	0	0	0	0
1991	7208	81678	82053	75035	5176	1885	91	60	0	0	0	0	0	0	0	0	0
1992	7587	105838	63830	27659	23115	1231	355	1064	2	0	0	0	0	0	0	0	2
1993	48873	128248	104844	51054	9205	10727	521	131	0	0	0	0	0	0	0	0	0
1994	8352	96890	102020	37751	9867	2885	2338	7	0	0	0	0	0	0	0	0	0
1995	33363	53830	81783	50019	7136	1336	206	113	6	0	0	0	0	0	0	0	6
1996	4575	43126	86878	49817	11506	2205	240	179	0	0	0	0	0	0	0	0	0
1997	11525	26188	34948	32473	9398	2412	400	2	16	0	1	0	0	0	0	0	17
1998	6098	50703	24200	17053	11076	2987	936	213	87	2	18	0	0	0	0	0	106
1999	14762	96413	56365	15228	9016	3104	862	167	51	34	0	0	0	0	0	0	85
2000	1682	48162	81086	24082	3075	2311	1560	478	107	0	0	0	0	0	0	0	107
2001	17352	39826	52156	23055	2795	471	283	142	19	0	0	0	0	0	0	0	19
2002	1158	10597	33371	45125	10136	1182	218	131	110	3	3	0	0	0	0	0	116
2003	3584	65829	94497	39301	21654	4314	449	30	0	0	0	1	0	0	0	0	1
2004	10478	31169	15698	21879	16951	9909	3922	605	24	9	0	0	0	0	0	0	33
2005	5499	25753	23486	6041	7192	4616	2992	688	211	5	0	0	0	0	0	0	216
2006	15662	51961	25906	10935	2474	2595	1598	493	219	37	8	0	0	0	0	0	265
2007	2350	22508	16283	7153	1784	572	940	1037	380	93	5	0	0	0	0	0	478
2008	5631	48929	15967	8621	4465	741	328	1449	653	63	0	0	0	0	0	0	716
2009	2360	12411	21950	4277	1715	910	128	62	347	66	37	0	0	0	0	0	450
2010	1215	15988	30046	8121	2637	1194	1082	151	258	77	9	0	0	0	0	0	344
2011	612	28024	34431	11770	3314	866	641	274	5	3	9	5	0	0	0	0	22
2012	1635	23479	16165	8953	6112	1796	809	352	82	10	23	5	6	0	0	0	128
2013	4972	17154	9653	10997	2277	417	116	15	10	0	0	0	0	0	0	0	10
2014	5540	38754	10281	7915	6697	1889	895	171	26	9	0	0	0	0	0	0	35
2015	3280	32739	34337	5720	2568	3938	808	232	102	1	0	0	0	0	0	0	103

Table 12.7: Whiting in Subarea 4 and Division 7.d. Industrial bycatch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	658651	351432	98590	49263	6064	616	252	14	0	0	0	0	0	0	0	0	0
1979	471798	133206	232266	42339	4561	1420	73	33	14	0	0	0	0	0	0	0	14
1980	329065	158500	102869	45108	8162	744	55	18	0	0	0	0	0	0	0	0	0
1981	515996	108252	180623	104766	16729	2793	112	0	0	0	0	0	0	0	0	0	0
1982	82418	127998	40818	68242	10514	2448	902	2	0	0	0	0	0	0	0	0	0
1983	597587	42591	30789	17774	6723	1656	63	25	0	0	0	0	0	0	0	0	0
1984	141095	108431	30709	8868	3790	3577	91	0	0	0	0	0	0	0	0	0	0
1985	178224	46801	41731	9871	2522	685	284	26	0	0	0	0	0	0	0	0	0
1986	217207	159249	2086	14572	3987	1456	0	0	0	0	0	0	0	0	0	0	0
1987	74863	97446	93704	17420	1722	1	0	0	0	0	0	0	0	0	0	0	0
1988	395603	357861	158872	34205	4611	500	0	0	0	0	0	0	0	0	0	0	0
1989	80375	172438	108558	53491	12890	1842	1060	89	71	2	0	0	0	0	0	0	72
1990	141387	168040	206916	51033	12601	2592	346	29	2	0	0	0	0	0	0	0	2
1991	1050381	42554	70343	20951	5376	2408	667	70	0	0	0	0	0	0	0	0	0
1992	251505	114899	58952	12318	8758	639	180	29	3	0	0	0	0	0	0	0	3
1993	578708	89219	38270	11162	4157	832	445	31	0	0	0	0	0	0	0	0	0
1994	209858	77530	24998	14316	4885	1878	1160	337	75	0	0	0	0	0	0	0	75
1995	1564260	85510	34213	4351	738	73	0	0	0	0	0	0	0	0	0	0	0
1996	90925	30675	5421	2702	970	21	2	0	0	0	0	0	0	0	0	0	0
1997	6868	28247	22087	4146	1074	276	2	0	0	0	0	0	0	0	0	0	0
1998	64989	24782	6334	1511	746	62	12	0	0	0	0	0	0	0	0	0	0
1999	62145	76088	12381	5188	1440	684	27	0	0	0	0	0	0	0	0	0	0
2000	288	19000	16688	11341	6597	2113	580	73	0	0	0	0	0	0	0	0	0
2001	510	481	2453	1728	514	152	40	0	0	0	0	0	0	0	0	0	0
2002	134690	38131	18745	8585	2170	205	120	0	0	0	0	0	0	0	0	0	0
2003	57140	17448	5034	2575	1213	390	49	0	0	0	0	0	0	0	0	0	0
2004	23732	12824	4499	1049	147	0	11	0	0	0	0	0	0	0	0	0	0
2005	12049	11043	726	494	28	32	54	10	8	0	0	0	0	0	0	0	8
2006	0	10892	5270	2222	806	223	63	7	1	0	0	0	0	0	0	0	1
2007	0	6155	2978	1256	456	126	36	4	1	0	0	0	0	0	0	0	1
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	5046	2441	1030	374	103	29	3	1	0	0	0	0	0	0	0	1
2010	0	6685	3234	1364	495	137	39	4	1	0	0	0	0	0	0	0	1
2011	0	191	2162	787	691	132	54	30	0	1	7	2	0	0	0	0	11
2012	6	87	90	67	54	20	7	4	1	0	0	0	0	0	0	0	2
2013	1	222	614	1511	1087	848	275	60	28	10	0	0	0	0	0	0	39
2014	0	407	843	1066	1237	729	267	89	18	9	1	0	0	0	0	0	28
2015	172	1919	3546	905	638	924	331	106	32	1	2	0	0	0	0	0	35

Table 12.8: Whiting in Subarea 4 and Division 7.d. Total catch mean weights at age (kg). Age 8 is a plus-group. These estimates are also used as stock mean weights at age. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.010	0.074	0.182	0.234	0.322	0.427	0.428	0.466	0.615	0.702	1.539	0.589	0.000	0.000	0.000	0.000	0.649
1979	0.009	0.098	0.166	0.259	0.301	0.411	0.455	0.492	0.578	0.617	0.737	0.515	0.000	0.000	0.000	0.000	0.582
1980	0.013	0.075	0.176	0.252	0.328	0.337	0.458	0.458	0.568	0.539	0.790	0.688	1.711	0.000	0.000	0.000	0.572
1981	0.011	0.083	0.168	0.242	0.321	0.379	0.411	0.444	0.651	0.833	1.041	0.695	0.000	0.000	0.000	0.000	0.720
1982	0.029	0.061	0.184	0.253	0.314	0.376	0.478	0.504	0.702	0.772	1.141	0.853	1.081	0.000	0.000	0.000	0.736
1983	0.015	0.107	0.191	0.273	0.325	0.384	0.426	0.452	0.520	0.677	0.516	0.000	0.000	0.000	0.000	0.000	0.537
1984	0.020	0.089	0.188	0.271	0.337	0.382	0.391	0.463	0.575	0.514	0.871	0.000	0.000	0.000	0.000	0.000	0.567
1985	0.014	0.094	0.192	0.284	0.332	0.402	0.435	0.494	0.426	0.507	0.852	0.976	0.000	0.000	0.000	0.000	0.438
1986	0.015	0.105	0.183	0.255	0.318	0.378	0.475	0.468	0.540	1.226	0.990	0.535	0.000	0.000	0.000	0.000	0.626
1987	0.013	0.077	0.148	0.247	0.297	0.375	0.379	0.542	0.555	0.857	0.603	1.193	0.000	0.000	0.000	0.000	0.584
1988	0.013	0.054	0.146	0.223	0.301	0.346	0.423	0.506	0.854	0.585	0.648	0.000	0.000	0.000	0.000	0.000	0.694
1989	0.023	0.070	0.157	0.225	0.267	0.318	0.391	0.431	0.369	0.517	0.857	0.609	0.000	0.000	0.000	0.000	0.394
1990	0.016	0.084	0.137	0.210	0.252	0.279	0.411	0.498	0.636	0.351	0.918	0.000	0.000	0.000	0.000	0.000	0.594
1991	0.018	0.104	0.168	0.217	0.289	0.306	0.339	0.365	0.385	0.589	0.996	2.756	0.000	0.000	0.000	0.000	0.401
1992	0.013	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.480	0.763	1.728	0.000	0.000	0.000	0.000	0.000	0.506
1993	0.012	0.073	0.174	0.250	0.316	0.328	0.346	0.400	0.376	0.417	0.359	0.000	0.000	0.000	0.000	0.000	0.379
1994	0.013	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.438	0.392	0.499	0.000	0.000	0.000	0.000	0.000	0.431
1995	0.010	0.089	0.180	0.257	0.340	0.384	0.429	0.434	0.445	0.346	0.406	0.000	0.000	0.000	0.000	0.000	0.419
1996	0.018	0.094	0.167	0.235	0.302	0.388	0.407	0.431	0.439	0.404	0.376	0.398	0.287	0.000	0.000	0.000	0.432
1997	0.028	0.096	0.178	0.242	0.295	0.334	0.384	0.387	0.394	0.479	0.458	0.000	0.000	0.000	0.000	0.000	0.422
1998	0.018	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.335	0.495	0.433	0.600	0.000	0.000	0.000	0.000	0.369
1999	0.023	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.286	0.316	0.344	0.000	0.000	0.000	0.000	0.000	0.292
2000	0.034	0.117	0.182	0.238	0.287	0.286	0.276	0.275	0.268	0.264	0.280	0.321	0.000	0.000	0.000	0.000	0.268
2001	0.024	0.101	0.192	0.244	0.282	0.267	0.298	0.284	0.286	0.301	0.315	0.505	0.000	0.000	0.000	0.000	0.292
2002	0.010	0.069	0.155	0.218	0.273	0.303	0.350	0.343	0.327	0.412	0.288	0.231	0.304	0.643	0.000	0.000	0.336
2003	0.012	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.342	0.462	0.620	0.000	0.000	0.000	0.000	0.000	0.368
2004	0.031	0.111	0.150	0.213	0.253	0.286	0.285	0.286	0.347	0.351	0.352	1.463	0.337	0.000	0.000	0.000	0.350
2005	0.032	0.124	0.199	0.239	0.250	0.282	0.305	0.298	0.271	0.376	0.316	0.337	0.670	0.000	0.000	0.000	0.286
2006	0.093	0.131	0.180	0.231	0.274	0.288	0.360	0.345	0.318	0.299	0.289	0.000	0.000	0.000	0.000	0.000	0.316
2007	0.059	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.325	0.288	0.328	0.350	0.000	0.000	0.000	0.000	0.320
2008	0.027	0.104	0.218	0.282	0.315	0.402	0.407	0.317	0.359	0.337	0.334	0.433	0.000	0.000	0.000	0.000	0.354
2009	0.042	0.092	0.220	0.289	0.381	0.401	0.465	0.393	0.336	0.310	0.342	0.321	0.436	0.000	0.000	0.000	0.328
2010	0.022	0.088	0.226	0.305	0.376	0.448	0.422	0.458	0.380	0.376	0.351	0.355	0.272	0.000	0.000	0.000	0.373
2011	0.046	0.106	0.185	0.315	0.379	0.443	0.499	0.460	0.568	0.606	0.396	0.437	0.894	0.000	0.000	0.000	0.501
2012	0.021	0.086	0.191	0.275	0.376	0.391	0.403	0.413	0.437	0.583	0.223	0.473	0.616	0.489	0.288	0.000	0.458
2013	0.045	0.090	0.186	0.244	0.397	0.481	0.497	0.522	0.465	0.567	1.027	0.000	0.000	0.000	0.000	0.000	0.496
2014	0.023	0.111	0.212	0.289	0.328	0.472	0.499	0.527	0.606	0.623	0.611	1.754	0.000	0.000	0.000	0.000	0.612
2015	0.044	0.122	0.201	0.305	0.372	0.384	0.474	0.511	0.509	0.803	0.758	0.778	0.000	0.000	0.000	0.000	0.535

Table 12.9: Whiting in Subarea 4 and Division 7.d. Landings mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.000	0.185	0.233	0.250	0.334	0.426	0.434	0.466	0.615	0.702	1.539	0.589	0.000	0.000	0.000	0.000	0.649
1979	0.113	0.206	0.231	0.277	0.304	0.416	0.456	0.491	0.583	0.617	0.737	0.515	0.000	0.000	0.000	0.000	0.587
1980	0.000	0.204	0.239	0.273	0.335	0.358	0.473	0.457	0.568	0.539	0.790	0.688	1.711	0.000	0.000	0.000	0.572
1981	0.144	0.194	0.242	0.292	0.331	0.378	0.411	0.445	0.651	0.833	1.041	0.695	0.000	0.000	0.000	0.000	0.720
1982	0.000	0.186	0.230	0.282	0.340	0.396	0.461	0.507	0.702	0.772	1.141	0.853	1.081	0.000	0.000	0.000	0.736
1983	0.132	0.199	0.240	0.282	0.332	0.383	0.429	0.452	0.522	0.677	0.516	0.000	0.000	0.000	0.000	0.000	0.538
1984	0.000	0.194	0.231	0.279	0.346	0.391	0.403	0.472	0.575	0.514	0.871	0.000	0.000	0.000	0.000	0.000	0.567
1985	0.137	0.187	0.248	0.307	0.337	0.408	0.443	0.498	0.426	0.507	0.852	0.976	0.000	0.000	0.000	0.000	0.438
1986	0.131	0.189	0.230	0.279	0.327	0.376	0.484	0.472	0.546	1.226	0.990	0.535	0.000	0.000	0.000	0.000	0.632
1987	0.135	0.188	0.226	0.286	0.310	0.381	0.381	0.542	0.564	0.857	0.603	1.193	0.000	0.000	0.000	0.000	0.593
1988	0.117	0.194	0.226	0.256	0.328	0.351	0.425	0.506	0.887	0.585	0.648	0.000	0.000	0.000	0.000	0.000	0.702
1989	0.171	0.178	0.226	0.253	0.288	0.345	0.370	0.440	0.373	0.522	0.857	0.609	0.000	0.000	0.000	0.000	0.405
1990	0.167	0.206	0.222	0.263	0.296	0.337	0.455	0.533	0.640	0.351	0.918	0.000	0.000	0.000	0.000	0.000	0.597
1991	0.139	0.202	0.249	0.252	0.308	0.317	0.349	0.387	0.385	0.589	0.996	2.756	0.000	0.000	0.000	0.000	0.401
1992	0.145	0.194	0.246	0.289	0.306	0.340	0.356	0.383	0.473	0.763	1.728	0.000	0.000	0.000	0.000	0.000	0.501
1993	0.153	0.194	0.248	0.284	0.345	0.358	0.385	0.418	0.376	0.417	0.359	0.000	0.000	0.000	0.000	0.000	0.379
1994	0.132	0.182	0.248	0.297	0.346	0.392	0.382	0.412	0.414	0.392	0.499	0.000	0.000	0.000	0.000	0.000	0.410
1995	0.140	0.171	0.256	0.299	0.367	0.397	0.437	0.437	0.448	0.346	0.406	0.000	0.000	0.000	0.000	0.000	0.421
1996	0.143	0.169	0.222	0.274	0.329	0.408	0.415	0.452	0.439	0.404	0.376	0.398	0.287	0.000	0.000	0.000	0.432
1997	0.149	0.171	0.206	0.260	0.315	0.349	0.401	0.386	0.398	0.479	0.437	0.000	0.000	0.000	0.000	0.000	0.424
1998	0.138	0.164	0.208	0.259	0.304	0.331	0.361	0.348	0.392	0.504	0.603	0.600	0.000	0.000	0.000	0.000	0.427
1999	0.135	0.184	0.237	0.271	0.281	0.303	0.316	0.320	0.292	0.368	0.344	0.000	0.000	0.000	0.000	0.000	0.301
2000	0.000	0.166	0.227	0.272	0.299	0.292	0.313	0.276	0.269	0.264	0.280	0.321	0.000	0.000	0.000	0.000	0.269
2001	0.138	0.160	0.216	0.268	0.285	0.267	0.301	0.288	0.287	0.301	0.315	0.505	0.000	0.000	0.000	0.000	0.293
2002	0.000	0.183	0.214	0.260	0.293	0.313	0.364	0.350	0.325	0.390	0.311	0.231	0.304	0.643	0.000	0.000	0.333
2003	0.128	0.208	0.228	0.258	0.308	0.311	0.374	0.391	0.342	0.462	0.620	0.000	0.000	0.000	0.000	0.000	0.369
2004	0.000	0.210	0.216	0.242	0.290	0.326	0.330	0.334	0.366	0.351	0.352	1.463	0.337	0.000	0.000	0.000	0.363
2005	0.164	0.205	0.253	0.277	0.270	0.308	0.339	0.313	0.296	0.381	0.316	0.337	0.670	0.000	0.000	0.000	0.313
2006	0.133	0.217	0.254	0.285	0.295	0.298	0.377	0.353	0.334	0.306	0.290	0.000	0.000	0.000	0.000	0.000	0.331
2007	0.202	0.199	0.264	0.280	0.351	0.361	0.319	0.332	0.342	0.318	0.334	0.000	0.000	0.000	0.000	0.000	0.338
2008	0.000	0.223	0.265	0.324	0.356	0.431	0.424	0.359	0.389	0.339	0.334	0.433	0.000	0.000	0.000	0.000	0.374
2009	0.148	0.205	0.246	0.318	0.386	0.404	0.464	0.404	0.347	0.313	0.311	0.321	0.436	0.000	0.000	0.000	0.329
2010	0.359	0.221	0.255	0.331	0.416	0.470	0.479	0.541	0.439	0.374	0.337	0.355	0.272	0.000	0.000	0.000	0.388
2011	0.000	0.182	0.237	0.374	0.416	0.506	0.569	0.504	0.582	0.634	0.406	0.465	0.894	0.000	0.000	0.000	0.523
2012	0.021	0.135	0.236	0.337	0.468	0.443	0.501	0.478	0.478	0.584	0.256	0.514	0.621	0.489	0.288	0.000	0.498
2013	0.066	0.181	0.224	0.275	0.421	0.487	0.508	0.526	0.464	0.567	1.027	0.000	0.000	0.000	0.000	0.000	0.496
2014	0.000	0.177	0.256	0.323	0.359	0.513	0.547	0.546	0.634	0.647	0.613	1.754	0.000	0.000	0.000	0.000	0.638
2015	0.047	0.166	0.240	0.359	0.414	0.437	0.510	0.528	0.579	0.834	0.758	0.778	0.000	0.000	0.000	0.000	0.604

Table 12.10: Whiting in Subarea 4 and Division 7.d. Discards mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.036	0.145	0.158	0.185	0.209	0.222	0.239	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.080	0.104	0.158	0.191	0.189	0.234	0.265	0.295	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.030	0.107	0.166	0.202	0.244	0.253	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.071	0.131	0.164	0.197	0.230	0.289	0.252	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.047	0.091	0.182	0.211	0.225	0.241	0.244	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.036	0.114	0.167	0.235	0.264	0.290	0.317	0.277	0.365	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.365
1984	0.038	0.101	0.162	0.216	0.246	0.265	0.248	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.022	0.105	0.169	0.213	0.238	0.242	0.253	0.255	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.028	0.123	0.166	0.190	0.208	0.227	0.194	0.217	0.311	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.311
1987	0.016	0.090	0.149	0.206	0.205	0.263	0.257	0.000	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292
1988	0.030	0.063	0.146	0.181	0.210	0.219	0.235	0.000	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.284
1989	0.033	0.083	0.164	0.191	0.213	0.227	0.241	0.351	0.221	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.221
1990	0.024	0.095	0.130	0.183	0.186	0.196	0.249	0.302	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.041	0.089	0.154	0.177	0.213	0.230	0.253	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.037	0.093	0.173	0.210	0.215	0.241	0.245	0.220	1.183	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.183
1993	0.023	0.087	0.160	0.205	0.237	0.235	0.225	0.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.040	0.090	0.151	0.203	0.230	0.244	0.254	0.332	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.032	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.290
1996	0.031	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.031	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.320	0.601	0.773	0.000	0.000	0.000	0.000	0.000	0.352
1998	0.026	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.191	0.180	0.284	0.000	0.000	0.000	0.000	0.000	0.206
1999	0.062	0.100	0.166	0.197	0.201	0.225	0.231	0.212	0.231	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.227
2000	0.033	0.127	0.167	0.195	0.226	0.209	0.219	0.222	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.264
2001	0.023	0.084	0.183	0.217	0.259	0.248	0.240	0.225	0.243	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.243
2002	0.039	0.130	0.167	0.196	0.224	0.224	0.225	0.272	0.334	1.120	0.217	0.000	0.000	0.000	0.000	0.000	0.352
2003	0.048	0.062	0.105	0.170	0.214	0.262	0.257	0.293	0.237	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.055
2004	0.079	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.204	0.351	0.000	0.000	0.000	0.000	0.000	0.000	0.245
2005	0.070	0.124	0.177	0.207	0.221	0.223	0.235	0.245	0.222	0.293	0.000	0.000	0.000	0.000	0.000	0.000	0.224
2006	0.093	0.131	0.161	0.193	0.229	0.233	0.247	0.273	0.239	0.279	0.289	0.000	0.000	0.000	0.000	0.000	0.246
2007	0.050	0.065	0.170	0.214	0.225	0.247	0.237	0.215	0.229	0.166	0.241	0.350	0.000	0.000	0.000	0.000	0.217
2008	0.027	0.072	0.181	0.213	0.230	0.265	0.328	0.244	0.291	0.317	0.057	0.000	0.000	0.000	0.000	0.000	0.293
2009	0.042	0.089	0.193	0.243	0.376	0.393	0.484	0.286	0.300	0.268	0.596	0.000	0.000	0.000	0.000	0.000	0.319
2010	0.019	0.075	0.211	0.272	0.319	0.384	0.330	0.254	0.290	0.390	0.730	0.000	0.000	0.000	0.000	0.000	0.323
2011	0.046	0.093	0.147	0.242	0.271	0.285	0.339	0.344	0.246	0.291	0.304	0.167	0.000	0.000	0.000	0.000	0.256
2012	0.021	0.076	0.155	0.184	0.204	0.254	0.211	0.252	0.313	0.574	0.183	0.374	0.580	0.489	0.288	0.000	0.325
2013	0.045	0.076	0.158	0.196	0.262	0.326	0.207	0.335	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.508
2014	0.023	0.103	0.170	0.237	0.263	0.295	0.340	0.418	0.393	0.343	0.509	0.000	0.000	0.000	0.000	0.000	0.381
2015	0.044	0.115	0.175	0.236	0.275	0.270	0.326	0.431	0.299	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.301

Table 12.11: Whiting in Subarea 4 and Division 7.d. Industrial bycatch mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2015 are included in the final assessment.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.009	0.059	0.158	0.220	0.295	0.529	0.351	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.008	0.069	0.141	0.249	0.428	0.477	0.467	0.605	0.482	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.482
1980	0.013	0.051	0.164	0.281	0.412	0.380	0.389	0.561	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
1981	0.011	0.056	0.141	0.218	0.318	0.433	0.596	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800
1982	0.025	0.038	0.133	0.232	0.320	0.366	0.674	0.284	0.800	1.000	1.200	0.000	0.000	0.000	0.000	0.000	0.840
1983	0.012	0.058	0.148	0.311	0.431	0.651	0.565	0.602	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.802
1984	0.018	0.053	0.173	0.289	0.343	0.390	0.228	0.600	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.896
1985	0.014	0.054	0.150	0.263	0.382	0.454	0.504	0.584	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.809
1986	0.014	0.054	0.150	0.262	0.381	0.455	0.500	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800
1987	0.012	0.043	0.085	0.173	0.262	0.400	0.500	0.600	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.822
1988	0.012	0.050	0.115	0.197	0.245	0.380	0.500	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800
1989	0.022	0.053	0.137	0.224	0.285	0.344	0.482	0.396	0.385	0.401	0.000	0.000	0.000	0.000	0.000	0.000	0.385
1990	0.007	0.073	0.123	0.181	0.201	0.280	0.355	0.335	0.472	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.472
1991	0.018	0.105	0.136	0.215	0.272	0.265	0.279	0.322	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.012	0.068	0.151	0.235	0.244	0.364	0.219	0.256	0.282	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.282
1993	0.011	0.045	0.156	0.260	0.264	0.307	0.235	0.392	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.012	0.055	0.131	0.259	0.388	0.521	0.555	0.440	0.555	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.555
1995	0.009	0.072	0.160	0.312	0.373	0.511	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.016	0.064	0.151	0.239	0.233	0.347	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.012	0.051	0.145	0.252	0.321	0.348	0.588	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.015	0.049	0.115	0.220	0.304	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.013	0.027	0.077	0.144	0.194	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.038	0.051	0.166	0.242	0.289	0.339	0.000	0.588	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.012	0.055	0.118	0.225	0.320	0.351	0.386	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.010	0.044	0.101	0.185	0.294	0.415	0.380	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.010	0.035	0.102	0.189	0.302	0.418	0.462	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.010	0.032	0.083	0.143	0.264	0.000	0.380	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.014	0.043	0.133	0.196	0.205	0.366	0.438	0.541	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2006	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2007	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2008	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	0.000	0.000	0.000	0.000
2009	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2010	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2011	0.000	0.188	0.242	0.305	0.321	0.371	0.464	0.436	0.628	0.421	0.393	0.480	0.000	0.000	0.000	0.000	0.419
2012	0.021	0.087	0.193	0.279	0.385	0.398	0.413	0.421	0.443	0.583	0.225	0.478	0.618	0.489	0.288	0.000	0.462
2013	0.045	0.090	0.186	0.244	0.397	0.481	0.497	0.522	0.465	0.567	1.027	0.000	0.000	0.000	0.000	0.000	0.497
2014	0.023	0.111	0.212	0.289	0.328	0.472	0.499	0.527	0.606	0.623	0.611	1.754	0.000	0.000	0.000	0.000	0.613
2015	0.044	0.122	0.201	0.305	0.372	0.384	0.474	0.511	0.509	0.803	0.758	0.778	0.000	0.000	0.000	0.000	0.538

Table 12.12: Whiting in Subarea 4 and Division 7.d. Estimated proportion mature at age as used in the assessment.

Age	1	2	3	4	5	6	7	8+
Mat	0.11	0.92	1	1	1	1	1	1

Table 12.13: Whiting in Subarea 4 and Division 7.d. Natural mortality at age from ICES-WGSAM (2014).

Age	1	2	3	4	5	6	7	8+
1990	1.248	0.608	0.549	0.545	0.478	0.478	0.478	0.478
1991	1.242	0.604	0.547	0.544	0.487	0.487	0.487	0.487
1992	1.237	0.603	0.546	0.543	0.496	0.496	0.496	0.496
1993	1.233	0.603	0.546	0.543	0.506	0.506	0.506	0.506
1994	1.233	0.605	0.547	0.544	0.515	0.515	0.515	0.515
1995	1.238	0.607	0.549	0.545	0.523	0.523	0.523	0.523
1996	1.246	0.609	0.551	0.547	0.531	0.531	0.531	0.531
1997	1.258	0.610	0.553	0.549	0.538	0.538	0.538	0.538
1998	1.274	0.612	0.556	0.551	0.544	0.544	0.544	0.544
1999	1.292	0.614	0.558	0.552	0.549	0.549	0.549	0.549
2000	1.314	0.619	0.562	0.555	0.554	0.554	0.554	0.554
2001	1.338	0.626	0.567	0.559	0.559	0.559	0.559	0.559
2002	1.362	0.637	0.574	0.565	0.566	0.566	0.566	0.566
2003	1.380	0.651	0.583	0.573	0.573	0.573	0.573	0.573
2004	1.386	0.668	0.592	0.582	0.579	0.579	0.579	0.579
2005	1.379	0.686	0.601	0.591	0.584	0.584	0.584	0.584
2006	1.362	0.704	0.608	0.599	0.586	0.586	0.586	0.586
2007	1.338	0.722	0.613	0.605	0.585	0.585	0.585	0.585
2008	1.312	0.739	0.617	0.610	0.580	0.580	0.580	0.580
2009	1.288	0.755	0.620	0.615	0.574	0.574	0.574	0.574
2010	1.271	0.771	0.624	0.620	0.567	0.567	0.567	0.567
2011	1.261	0.790	0.629	0.627	0.561	0.561	0.561	0.561
2012	1.257	0.809	0.636	0.635	0.557	0.557	0.557	0.557
2013	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553
2014	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553
2015	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553

Table 12.14: Whiting in Subarea 4 and Division 7.d. Tuning series used in the assessment and forecast. Note that only years from 1990 onwards are used in the final assessment.

	IBTS-Q1				
Age	1	2	3	4	5
1978	5.472	2.629	0.919	0.220	0.042
1979	4.439	2.307	1.143	0.335	0.050
1980	6.750	4.037	1.250	0.254	0.088
1981	2.297	4.635	2.285	0.460	0.091
1982	1.515	2.173	2.581	0.686	0.101
1983	1.266	1.250	1.100	0.764	0.322
1984	4.345	1.780	0.890	0.303	0.254
1985	3.392	3.623	0.659	0.186	0.071
1986	4.687	2.683	1.946	0.321	0.066
1987	6.849	5.611	0.904	0.455	0.049
1988	4.480	8.657	3.143	0.330	0.126
1989	14.476	5.328	4.055	1.073	0.119
1990	5.189	8.624	1.982	0.916	0.169
1991	10.076	6.864	4.796	0.709	0.376
1992	9.073	6.657	2.402	1.508	0.127
1993	10.756	5.228	2.446	0.655	0.590
1994	7.217	6.274	1.810	0.681	0.119
1995	6.786	4.485	2.394	0.581	0.119
1996	5.024	4.860	2.447	0.697	0.231
1997	2.878	3.422	1.624	0.604	0.180
1998	5.431	1.607	1.254	0.540	0.155
1999	6.763	3.054	0.947	0.575	0.258
2000	7.658	5.444	1.835	0.536	0.202
2001	6.487	5.984	2.991	0.983	0.258
2002	5.574	3.433	2.632	0.633	0.208
2003	1.316	2.988	2.370	1.334	0.484
2004	1.844	0.901	1.727	0.999	0.487
2005	1.127	0.978	0.456	0.601	0.390
2006	1.844	1.251	0.455	0.183	0.270
2007	0.645	1.473	0.673	0.186	0.084
2008	2.686	2.058	0.655	0.221	0.075
2009	2.112	2.958	0.936	0.272	0.119
2010	3.262	2.248	2.441	0.948	0.285
2011	1.849	3.371	1.575	0.926	0.197
2012	2.313	5.883	1.147	0.464	0.324
2013	0.544	1.630	2.413	0.883	0.269
2014	2.652	1.845	0.992	0.659	0.227
2015	3.150	2.126	0.598	0.287	0.240

2016	2.813	3.122	0.884	0.197	0.111

	IBTS-Q3				
Age	1	2	3	4	5
1991	7.034	1.586	0.790	0.146	0.052
1992	6.009	2.961	0.725	0.575	0.103
1993	6.387	1.774	0.661	0.147	0.159
1994	6.776	2.195	0.747	0.195	0.047
1995	6.198	2.912	1.072	0.215	0.060
1996	5.457	2.782	1.294	0.340	0.069
1997	3.330	1.807	1.090	0.280	0.107
1998	3.306	1.502	0.528	0.310	0.112
1999	12.035	1.906	0.539	0.245	0.095
2000	9.417	3.269	0.641	0.136	0.065
2001	6.450	2.823	0.949	0.193	0.043
2002	7.321	2.374	1.251	0.340	0.053
2003	2.462	3.021	1.348	0.661	0.165
2004	1.506	0.590	0.663	0.457	0.271
2005	1.714	0.683	0.314	0.456	0.340
2006	1.746	0.863	0.326	0.135	0.233
2007	0.955	0.636	0.376	0.115	0.084
2008	3.623	0.689	0.309	0.138	0.041
2009	5.855	3.848	0.410	0.123	0.080
2010	2.243	1.457	0.546	0.128	0.060
2011	4.468	1.444	0.472	0.162	0.069
2012	2.567	1.935	0.570	0.201	0.106
2013	0.675	0.601	0.658	0.175	0.071
2014	2.234	0.980	0.656	0.333	0.103
2015	3.125	2.226	0.431	0.240	0.184

Table 12.15: Whiting in Subarea 4 and Division 7.d. FLXSA tuning diagnostics.

FLR XSA Diagnostics 2016-04-27 10:43:51

CPUE data from indices

Catch data for 26 years 1990 to 2015. Ages 1 to 8.

	fleet	first age	last age	first year	last year	alpha	beta
1	IBTS-Q1	1	5	1990	2015	0	0.25
2	IBTS-Q3	1	5	1991	2015	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 4

Terminal population estimation :

Survivor estimates shrunk towards the mean F of the final 3 years or the 4 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

	year									
age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

	year									
age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.096	0.051	0.044	0.017	0.021	0.020	0.034	0.033	0.039	0.036
2	0.172	0.140	0.114	0.122	0.156	0.148	0.053	0.061	0.105	0.169
3	0.287	0.242	0.219	0.134	0.121	0.169	0.129	0.124	0.174	0.170

4 0.235 0.327 0.321 0.263 0.155 0.156 0.251 0.210 0.201 0.171

5 0.272 0.251 0.362 0.313 0.291 0.134 0.144 0.397 0.339 0.284

6 0.389 0.336 0.268 0.294 0.431 0.275 0.200 0.161 0.379 0.343

7 0.311 0.478 0.461 0.200 0.251 0.417 0.369 0.134 0.113 0.320

8 0.311 0.478 0.461 0.200 0.251 0.417 0.369 0.134 0.113 0.320

XSA population number (Thousand)

age

year 1 2 3 4 5 6 7 8

2006 1600655 378759 117641 55773 84754 49206 23139 7091

2007 1526369 372725 157644 48077 24232 35919 18564 10585

2008 2767240 380572 157399 67050 18927 10511 14301 10298

2009 2263468 712972 162272 68204 26413 7372 4501 20362

2010 2335777 613547 296593 76312 28336 10876 3095 8802

2011 3053030 641257 242598 140727 35158 12007 4008 1175

2012 1612011 847298 251084 109229 64338 17538 5203 2269

2013 1140360 443461 357534 116920 45021 31910 8227 5185

2014 2155672 314523 181826 166056 49755 17412 15621 4562

2015 2097757 591352 123504 80344 71345 20393 6852 2291

Estimated population abundance at 1st Jan 2016

age

year 1 2 3 4 5 6 7 8

2016 0 576879 217676 54763 35559 30899 8324 2862

Fleet: IBTS-Q1

Log catchability residuals.

year

age 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1 0.055 0.721 0.660 0.696 0.361 0.407 0.446 0.159 0.471 0.209 0.155 0.171 0.175 -0.210 0.108

2 -0.132 0.516 0.411 0.266 0.283 0.001 0.178 0.159 -0.324 0.023 0.150 0.022 -0.336 -0.280 -0.306

3 0.054 0.132 0.293 0.183 0.005 0.050 0.115 -0.220 -0.170 -0.197 0.239 0.229 -0.195 -0.104 -0.119

4 -0.005 0.285 0.008 0.085 0.116 -0.013 -0.102 -0.240 -0.312 -0.028 0.241 0.643 -0.466 0.022 -0.103

5 -0.484 0.416 -0.383 0.091 -0.448 -0.407 0.068 -0.433 -0.642 -0.129 -0.075 0.491 -0.067 0.070 -0.182

year

age 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

1 -0.655 -0.161 -1.171 -0.344 -0.389 0.012 -0.825 0.039 -1.062 -0.114 0.085

2 -0.288 -0.336 -0.158 0.155 -0.107 -0.225 0.137 0.406 -0.227 0.246 -0.236

3 -0.321 -0.301 -0.206 -0.233 0.083 0.437 0.206 -0.150 0.241 0.034 -0.086

4 -0.337 -0.356 -0.183 -0.343 -0.157 0.967 0.333 -0.092 0.478 -0.167 -0.274

5 -0.270 -0.383 -0.306 -0.153 -0.032 0.765 0.161 0.055 0.256 -0.019 -0.330

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

1 2 3 4 5

Mean_Logq -13.3366 -12.1779 -12.0530 -12.1675 -12.1675

S.E_Logq 0.3385 0.3385 0.3385 0.3385 0.3385

Fleet: IBTS-Q3

Log catchability residuals.

year

age 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

1 0.245 0.159 0.073 0.191 0.205 0.413 0.193 -0.126 0.704 0.262 0.074 0.369 0.406 -0.135 -0.289

2 -0.307 0.203 -0.193 -0.181 0.152 0.193 0.087 0.158 0.137 0.212 -0.202 -0.177 0.322 -0.165 -0.044

3 -0.788 0.001 -0.155 0.052 0.156 0.370 0.256 -0.214 0.110 0.078 -0.122 -0.118 0.135 -0.286 0.113

4 -0.274 0.035 -0.342 -0.029 -0.015 0.181 -0.041 0.077 0.099 -0.149 -0.072 -0.194 0.210 -0.008 0.247

5 -0.400 0.378 -0.142 -0.195 0.005 -0.137 0.058 0.018 -0.125 -0.140 -0.307 -0.537 -0.121 0.146 0.477

year

age 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

1 -0.261 -0.859 -0.141 0.509 -0.490 -0.075 0.015 -0.977 -0.413 -0.052

2 -0.102 -0.401 -0.348 0.760 -0.030 -0.076 -0.109 -0.613 0.246 0.476

3 0.244 0.070 -0.137 0.064 -0.257 -0.169 -0.037 -0.245 0.458 0.423

4 0.247 0.294 0.143 -0.021 -0.154 -0.528 0.004 -0.221 0.064 0.447

5 0.388 0.607 0.198 0.508 0.127 -0.045 -0.217 -0.113 0.127 0.313

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-12.5625	-12.3436	-12.4826	-12.6584	-12.6584
S.E_Logq	0.2959	0.2959	0.2959	0.2959	0.2959

Terminal year survivor and F summaries:

,Age 1 Year class =2014

source

	scaledWts	survivors	yrcls
IBTS-Q1	0.378	627890	2014
IBTS-Q3	0.596	547604	2014
fshk	0.026	555439	2014

,Age 2 Year class =2013

source

	scaledWts	survivors	yrcls
IBTS-Q1	0.498	171990	2013
IBTS-Q3	0.489	350195	2013
fshk	0.013	511705	2013

,Age 3 Year class =2012

source

	scaledWts	survivors	yrcls
IBTS-Q1	0.493	50254	2012
IBTS-Q3	0.493	83584	2012
fshk	0.013	64962	2012

,Age 4 Year class =2011

source

	scaledWts	survivors	yrcls
IBTS-Q1	0.432	27044	2011

IBTS-Q3 0.553 55575 2011

fshk 0.015 26094 2011

,Age 5 Year class =2010

source

scaledWts survivors yrcls

IBTS-Q1 0.415 22205 2010

IBTS-Q3 0.568 42267 2010

fshk 0.017 28964 2010

,Age 6 Year class =2009

source

scaledWts survivors yrcls

fshk 1 11872 2009

,Age 7 Year class =2008

source

scaledWts survivors yrcls

fshk 1 3851 2008

Table 12.16: Whiting in Subarea 4 and Division 7.d. Final fishing mortality estimates from FLXSA.

Age	1	2	3	4	5	6	7	8+
1990	0.144	0.378	0.605	0.760	0.983	0.710	0.786	0.786
1991	0.074	0.349	0.359	0.523	0.865	0.625	0.608	0.608
1992	0.133	0.270	0.407	0.458	0.464	0.876	1.131	1.131
1993	0.112	0.310	0.534	0.607	0.668	0.394	0.740	0.740
1994	0.102	0.236	0.457	0.683	0.851	0.984	0.301	0.301
1995	0.087	0.226	0.410	0.455	0.679	0.963	1.215	1.215
1996	0.071	0.204	0.375	0.473	0.495	0.707	1.160	1.160
1997	0.066	0.192	0.338	0.404	0.502	0.299	0.482	0.482
1998	0.073	0.155	0.228	0.358	0.449	0.491	0.294	0.294
1999	0.094	0.225	0.322	0.429	0.471	0.532	0.429	0.429
2000	0.034	0.193	0.362	0.424	0.588	0.693	1.226	1.226
2001	0.026	0.096	0.168	0.287	0.440	0.538	0.589	0.589
2002	0.030	0.088	0.206	0.241	0.257	0.242	0.475	0.475
2003	0.148	0.199	0.164	0.225	0.221	0.164	0.119	0.119
2004	0.082	0.131	0.128	0.191	0.266	0.298	0.200	0.200
2005	0.061	0.190	0.150	0.148	0.204	0.254	0.257	0.257
2006	0.096	0.172	0.287	0.235	0.272	0.389	0.311	0.311
2007	0.051	0.140	0.242	0.327	0.251	0.336	0.478	0.478
2008	0.044	0.114	0.219	0.321	0.362	0.268	0.461	0.461
2009	0.017	0.122	0.134	0.263	0.313	0.294	0.200	0.200
2010	0.021	0.156	0.121	0.155	0.291	0.431	0.251	0.251
2011	0.020	0.148	0.169	0.156	0.134	0.275	0.417	0.417
2012	0.034	0.053	0.129	0.251	0.144	0.200	0.369	0.369
2013	0.033	0.061	0.124	0.210	0.397	0.161	0.134	0.134
2014	0.039	0.105	0.174	0.201	0.339	0.379	0.113	0.113
2015	0.036	0.169	0.170	0.171	0.284	0.343	0.320	0.320

Table 12.17: Whiting in Subarea 4 and Division 7.d. Final abundance estimates from FLXSA.

Age	1	2	3	4	5	6	7	8+
1990	3602988	2158961	370932	207681	63125	4829	1677	245
1991	3561689	895596	805842	116943	56315	14652	1472	724
1992	3429482	955318	345389	325450	40238	14574	4818	201
1993	3911169	871714	398905	133160	119663	15403	3696	1781
1994	3665192	1019106	349554	135406	42163	36986	6262	2499
1995	3286257	964585	439502	128009	39711	10754	8262	815
1996	2338049	873564	419423	168388	47053	11937	2434	1957
1997	1785364	626229	387550	166060	60680	16865	3462	1508
1998	2473817	474935	280846	158888	64011	21448	7301	2037
1999	4023722	643315	220454	128218	64059	23727	7617	2453
2000	4784856	1006166	277821	91393	48072	23107	8045	2207
2001	3996189	1243444	446909	110298	34365	15347	6641	3623
2002	3432777	1021342	604257	214279	47360	12646	5125	2557
2003	1210399	853244	494886	276781	95664	20796	5639	4640
2004	1225220	262589	364723	234492	124607	43274	9957	2208
2005	1599745	282356	118192	177496	108247	53525	18000	3768
2006	1600655	378759	117641	55773	84754	49206	23139	7091
2007	1526369	372725	157644	48077	24232	35919	18564	10585
2008	2767240	380572	157399	67050	18927	10511	14301	10298
2009	2263468	712972	162272	68204	26413	7372	4501	20362
2010	2335777	613547	296593	76312	28336	10876	3095	8802
2011	3053030	641257	242598	140727	35158	12007	4008	1175
2012	1612011	847298	251084	109229	64338	17538	5203	2269
2013	1140360	443461	357534	116920	45021	31910	8227	5185
2014	2155672	314523	181826	166056	49755	17412	15621	4562
2015	2097757	591352	123504	80344	71345	20393	6852	2291

Table 12.18: Whiting in Subarea 4 and Division 7.d. Final FLXSA summary table. Units are millions of individuals and tonnes.

Year	Recruitment	TSB	SSB	Catch	Landings	Discards	Bycatch	Yield /SSB	Mean F(2-6)
1990	3602988	747248	455397	152602	45662	55603	51337	0.100	0.687
1991	3561689	751778	411205	126742	51929	35058	39755	0.126	0.544
1992	3429482	665749	393038	108555	50946	32564	25045	0.130	0.495
1993	3911169	625893	359374	116911	51818	44370	20723	0.144	0.503
1994	3665192	645577	357759	101650	48486	35692	17473	0.136	0.642
1995	3286257	646234	372599	105494	45938	32176	27379	0.123	0.547
1996	2338049	540570	332860	76123	40503	30505	5116	0.122	0.451
1997	1785364	453710	292840	61435	35563	19660	6213	0.121	0.347
1998	2473817	450586	244557	47475	28288	15693	3494	0.116	0.336
1999	4023722	538961	250537	60845	30130	25677	5038	0.120	0.396
2000	4784856	856619	344713	63806	28583	26063	9160	0.083	0.452
2001	3996189	801579	421586	45242	25061	19237	944	0.059	0.306
2002	3432777	606256	383340	46450	20675	18501	7275	0.054	0.207
2003	1210399	376566	307048	45640	16161	26745	2734	0.053	0.194
2004	1225220	364002	239720	33557	13295	19048	1214	0.055	0.202
2005	1599745	380442	199482	28883	15471	12525	888	0.078	0.189
2006	1600655	373156	180601	37038	18535	16310	2193	0.103	0.271
2007	1526369	310686	171915	27125	18915	6971	1239	0.110	0.259
2008	2767240	456552	193429	28247	17951	10296	0	0.093	0.257
2009	2263468	461318	262550	27139	18418	7705	1016	0.070	0.225
2010	2335777	484244	291072	31147	18224	11577	1346	0.063	0.231
2011	3053030	595720	298456	32626	18899	11977	1750	0.063	0.176
2012	1612011	446216	309860	25078	17032	7968	78	0.055	0.155
2013	1140360	363584	265474	26841	19335	5976	1530	0.073	0.191
2014	2155672	455526	237652	30675	18746	10451	1479	0.079	0.239
2015	2097757	484595	246870	33188	17707	13428	2053	0.072	0.227

Table 12.19: Whiting in Subarea 4 and Division 7.d. Reference points as determined in the Inter-benchmark 2016 (ICES 2016).

Reference point	value
Blim	172 741 (Bloss)
Flim	0.39
Bpa	241 837 (Btrigger)
Fpa	0.28
Fp.05 (without Btrigger)	0.12
Fp.05 (with Btrigger)	0.15 (final Fmsy , with SSB > Blim)

Table 12.20: Whiting in Subarea 4 and Division 7.d. RCT3 input table.

Year class	Recruitment	IBTSQ11	IBTSQ12	IBTSQ30	IBTSQ31	IBTSQ32
1989	3602988	518.936	686.445	NA	NA	158.594
1990	3561689	1007.621	665.714	NA	703.368	296.100
1991	3429482	907.297	522.811	536.990	600.867	177.377
1992	3911169	1075.624	627.406	1379.459	638.722	219.541
1993	3665192	721.709	448.484	919.193	677.645	291.180
1994	3286257	678.590	485.968	610.743	619.786	278.218
1995	2338049	502.361	342.246	729.246	545.708	180.681
1996	1785364	287.779	160.695	316.501	332.968	150.205
1997	2473817	543.117	305.445	2062.670	330.600	190.643
1998	4023722	676.266	544.367	2631.690	1203.501	326.943
1999	4784856	765.844	598.356	2498.550	941.658	282.320
2000	3996189	648.657	343.308	1968.070	645.003	237.372
2001	3432777	557.353	298.849	3031.442	732.137	302.054
2002	1210399	131.599	90.134	264.063	246.155	59.032
2003	1225220	184.399	97.824	363.406	150.623	68.259
2004	1599745	112.663	125.057	714.270	171.386	86.336
2005	1600655	184.411	147.304	169.321	174.625	63.592
2006	1526369	64.530	205.798	198.949	95.495	68.886
2007	2767240	268.598	295.812	822.902	362.299	384.777
2008	2263468	211.202	224.795	764.759	585.529	145.671
2009	2335777	326.192	337.096	593.801	224.321	144.439
2010	3053030	184.867	588.309	510.123	446.812	193.523
2011	1612011	231.255	162.985	247.085	256.718	60.102
2012	1140360	54.431	184.517	306.812	67.451	97.962
2013	NA	265.226	212.642	334.257	223.400	222.551
2014	NA	315.019	312.194	1401.008	312.453	NA
2015	NA	281.272	NA	2091.636	NA	NA

Table 12.21: Whiting in Subarea 4 and Division 7.d. RCT3 output.

ANALYSIS BY RCT3 VER4.0

Whiting

Data for 5 surveys over 26 years : 1989 -2015

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:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.5962	11.25	0.2624	0.7444	24	5.639	14.61	0.2800	0.6581
IBTSq12	0.7692	10.34	0.2099	0.8199	24	NA	NA	NA	NA
IBTSq30	0.6419	10.49	0.3495	0.6273	22	7.646	15.4	0.3885	0.3419
IBTSq31	0.660	10.8	0.2273	0.7972	23	NA	NA	NA	NA
IBTSq32	0.8380	10.47	0.2526	0.7587	24	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	24	NA	14.72	0.438	0

	WAP	logWAP	int.se
yearclass:2015	2900142	14.88	0.2017

Table 12.22: Whiting in Subarea 4 and Division 7.d. Recruitment estimates as used in the short-term forecast (RCT3 estimate year class 2015, geometric mean).

Year class	RCT3 estimate	Geometric mean of Time series (since 1990)
2015	2900	
2016		2443
2017		2443

Table 12.23: Whiting in Subarea 4 and Division 7.d. Short-term forecast inputs.

MFDP version 1a						
Run: run2						
Time and date: 09:59 02/05/2016						
Fbar age range (Total) : 2–6						
Fbar age range Fleet 1 : 2–6						
Fbar age range Fleet 2 : 2–6						
2016						
Age	N	M	Mat	PF	PM	SWt
1	2900142	1.255	0.11	0	0	0.122
2	577051	0.830	0.92	0	0	0.201
3	217732	0.643	1	0	0	0.305
4	54767	0.644	1	0	0	0.372
5	35558	0.553	1	0	0	0.384
6	30883	0.553	1	0	0	0.474
7	8322	0.553	1	0	0	0.511
8	3818	0.553	1	0	0	0.535
Catch						
Age	Sel	CWt	DSel	DCWt		
1	0.00459	0.166	0.03202	0.115		
2	0.04739	0.240	0.06132	0.175		
3	0.09043	0.359	0.06172	0.236		
4	0.14135	0.414	0.04956	0.275		
5	0.27359	0.437	0.06074	0.270		
6	0.23451	0.510	0.04246	0.326		
7	0.16056	0.528	0.02069	0.431		
8	0.15999	0.604	0.02112	0.301		
IBC						
Age	Sel	CWt				
1	0.00085	0.122				
2	0.0051	0.201				
3	0.00888	0.305				
4	0.01319	0.372				
5	0.02546	0.384				
6	0.0213	0.474				
7	0.01446	0.511				
8	0.01459	0.538				
2017						
Age	N	M	Mat	PF	PM	SWt

1	2442840	1.255	0.11	0	0	0.122
2	.	0.83	0.92	0	0	0.201
3	.	0.643	1	0	0	0.305
4	.	0.644	1	0	0	0.372
5	.	0.553	1	0	0	0.384
6	.	0.553	1	0	0	0.474
7	.	0.553	1	0	0	0.511
8	.	0.553	1	0	0	0.535

Catch				
Age	Sel	CWt	DSel	DCWt
1	0.00459	0.166	0.03202	0.115
2	0.04739	0.240	0.06132	0.175
3	0.09043	0.359	0.06172	0.236
4	0.14135	0.414	0.04956	0.275
5	0.27359	0.437	0.06074	0.270
6	0.23451	0.510	0.04246	0.326
7	0.16056	0.528	0.02069	0.431
8	0.15999	0.604	0.02112	0.301

IBC		
Age	Sel	CWt
1	0.00085	0.122
2	0.0051	0.201
3	0.00888	0.305
4	0.01319	0.372
5	0.02546	0.384
6	0.0213	0.474
7	0.01446	0.511
8	0.01459	0.538

2018						
Age	N	M	Mat	PF	PM	SWt
1	2442840	1.255	0.11	0	0	0.122
2	.	0.830	0.92	0	0	0.201
3	.	0.643	1	0	0	0.305
4	.	0.644	1	0	0	0.372
5	.	0.553	1	0	0	0.384
6	.	0.553	1	0	0	0.474
7	.	0.553	1	0	0	0.511
8	.	0.553	1	0	0	0.535

Catch				
Age	Sel	CWt	DSel	DCWt
1	0.00459	0.166	0.03202	0.115

2	0.04739	0.240	0.06132	0.175
3	0.09043	0.359	0.06172	0.236
4	0.14135	0.414	0.04956	0.275
5	0.27359	0.437	0.06074	0.270
6	0.23451	0.510	0.04246	0.326
7	0.16056	0.528	0.02069	0.431
8	0.15999	0.604	0.02112	0.301

IBC		
Age	Sel	CWt
1	0.00085	0.122
2	0.0051	0.201
3	0.00888	0.305
4	0.01319	0.372
5	0.02546	0.384
6	0.0213	0.474
7	0.01446	0.511
Input units are thousands and kg - output in tonnes		

Table 12.23: Whiting in Subarea 4 and Division 7.d. MFDP output table for short-term forecasts.

MFDP version 1a; Run: run2. Time and date: 09:59 02/05/2016, Fbar age range: 2–6; 2015 landings: total 17 706; 4: 13 608 (0.769); 7.d: 4098 (0.231)

2016																
		Catch			Landings				Discards		IBC					
Biomass	SSB	FMult	FBar	Yield	FBar	4+7.d yield	4 yield	7.d yield	FBar	Yield	FMult	FBar	Yield		0.75*Fbar	1.25*Fbar
591174	266998	1	0.2275	33601	0.1575	18537	14247	4290	0.0552	13424	1	0.0148	1640		0.171	0.284375

2017														2018		2016 TAC 4	13678	
		Catch			Landings				Discards		IBC	Landings						
Biomass	SSB	FMult	FBar	Yield	FBar	4+7.d yield	4 yield	7.d yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	4 TAC change	SSB change	
588412	310363	0	0.015	1887	0.000	0	0	0	0.000	0	1	0.015	1887	622258	345826	-100%	11%	No HC fishery
.	310363	0.1	0.036	5481	0.016	2128	1635	493	0.006	1479	1	0.015	1874	619163	342772	-88%	10%	
.	310363	0.2	0.057	9028	0.032	4224	3246	978	0.011	2944	1	0.015	1860	616111	339761	-76%	9%	
.	310363	0.3	0.079	12534	0.047	6290	4834	1456	0.017	4397	1	0.015	1847	613101	336791	-65%	9%	
.	310363	0.4	0.100	15996	0.063	8325	6398	1927	0.022	5837	1	0.015	1834	610132	333863	-53%	8%	
.	310363	0.5	0.121	19415	0.079	10330	7939	2391	0.028	7264	1	0.015	1821	607204	330975	-42%	7%	
.	310363	0.6	0.142	22791	0.095	12305	9457	2848	0.033	8678	1	0.015	1808	604316	328127	-31%	6%	
.	310363	0.7	0.164	26129	0.110	14252	10953	3299	0.039	10081	1	0.015	1796	601466	325317	-20%	5%	
.	310363	0.8	0.185	29425	0.126	16171	12428	3743	0.044	11471	1	0.015	1783	598655	322546	-9%	4%	
.	310363	0.9	0.206	32683	0.142	18062	13882	4180	0.050	12850	1	0.015	1771	595882	319812	1%	3%	
.	310363	1	0.228	35900	0.158	19926	15314	4612	0.055	14216	1	0.015	1758	593145	317115	12%	2%	Fsq
.	310363	1.1	0.249	39080	0.173	21763	16726	5037	0.061	15571	1	0.015	1746	590445	314455	22%	1%	
.	310363	1.2	0.270	42223	0.189	23574	18118	5456	0.066	16915	1	0.015	1734	587781	311830	32%	0%	
.	310363	1.3	0.291	45329	0.205	25359	19490	5869	0.072	18247	1	0.015	1723	585152	309240	42%	0%	
.	310363	1.4	0.312	48397	0.220	27119	20842	6277	0.077	19567	1	0.015	1711	582558	306685	52%	-1%	
.	310363	1.5	0.334	51431	0.236	28854	22176	6678	0.083	20877	1	0.015	1700	579998	304163	62%	-2%	
.	310363	1.6	0.355	54428	0.252	30564	23490	7074	0.088	22176	1	0.015	1688	577471	301675	72%	-3%	
.	310363	1.7	0.376	57392	0.268	32251	24787	7464	0.094	23464	1	0.015	1677	574977	299220	81%	-4%	

.	310363	1.8	0.398	60321	0.283	33914	26065	7849	0.099	24741	1	0.015	1666	572515	296796	91%	-4%	
.	310363	1.9	0.419	63218	0.299	35555	27326	8229	0.105	26008	1	0.015	1655	570085	294405	100%	-5%	
.	310363	2	0.440	66080	0.315	37172	28569	8603	0.110	27264	1	0.015	1644	567686	292044	109%	-6%	
.	310363	0.75	0.174	27184	0.118	14796	11371	3424	0.041	10596	1	0.015	1791	600627	324495	-17%	5%	0.75 * Fsq
.	310363	0.64	0.150	23527	0.100	12679	9744	2935	0.035	9042	1	0.015	1805	603735	327559	-29%	5.5%	Fmsy
.	310363	1.25	0.281	43213	0.197	24075	18503	5572	0.069	17408	1	0.015	1731	587002	311068	35%	0%	1.25 * Fsq
.	310363	0.77	0.178	27759	0.121	15128	11626	3501	0.042	10842	1	0.015	1789	600139	324015	-15%	4%	15% TAC decrease (4)
.	310363	1.06	0.239	36980	0.166	20467	15730	4737	0.058	14759	1	0.015	1754	592300	316289	15%	2%	15% TAC increase (4)
.	310363	0.91	0.209	32369	0.144	17797	13678	4119	0.050	12800	1	0.015	1772	596219	320152	0%	3%	Rollover TAC
.	310363	1.00	0.227	35137	0.157	19399	14909	4490	0.055	13976	1	0.015	1761	593867	317834	9%	2%	Fsq
.	310363	1.25	0.280	43128	0.196	24025	18465	5561	0.069	17372	1	0.015	1731	587075	311140	35%	0%	Fpa
.	310363	1.76	0.390	59714	0.278	33626	25843	7783	0.097	24420	1	0.015	1668	572977	297247	89%	-4%	Flim
.	310363	3.82	0.828	125742	0.602	71846	55218	16629	0.211	52478	1	0.015	1418	516856	241837	304%	-22%	Bpa, MSY Btrigger
.	310363	6.39	1.374	208120	1.007	119531	91866	27665	0.353	87484	1	0.015	1106	446838	172741	572%	-44%	Blim

Output units in tonnes

Table 24. Frequency of assessment

stock	Life span	Fsq>=1.1Fmsy	SSB(2016) >=MSY Btrigger	conribution age 1 to total catches <25%	F under-estimated (<20%)	qualifies
Whg47.d	yes	no	yes	no	yes	NO

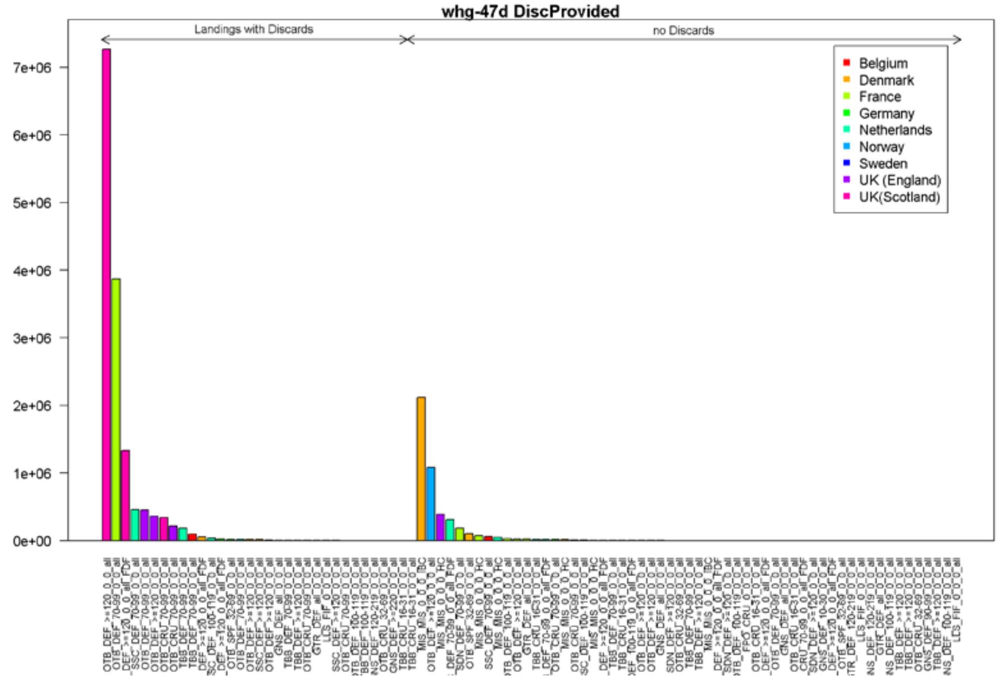


Figure 12.1: Whiting in Subarea 4 and Division 7.d. Landings with discards. Metier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

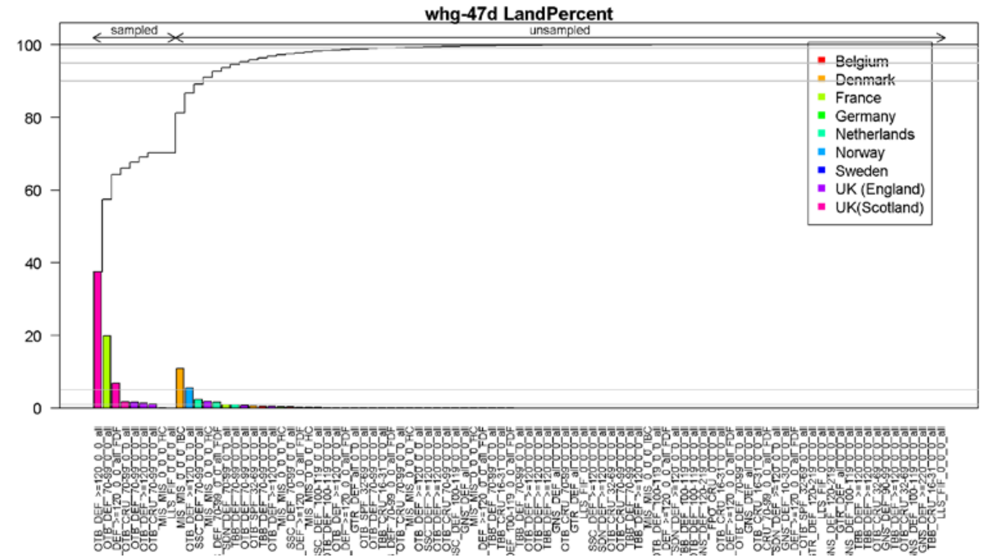


Figure 12.2.1: Whiting in Subarea 4 and Division 7.d. Reported landings (in percent, coloured bars)) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

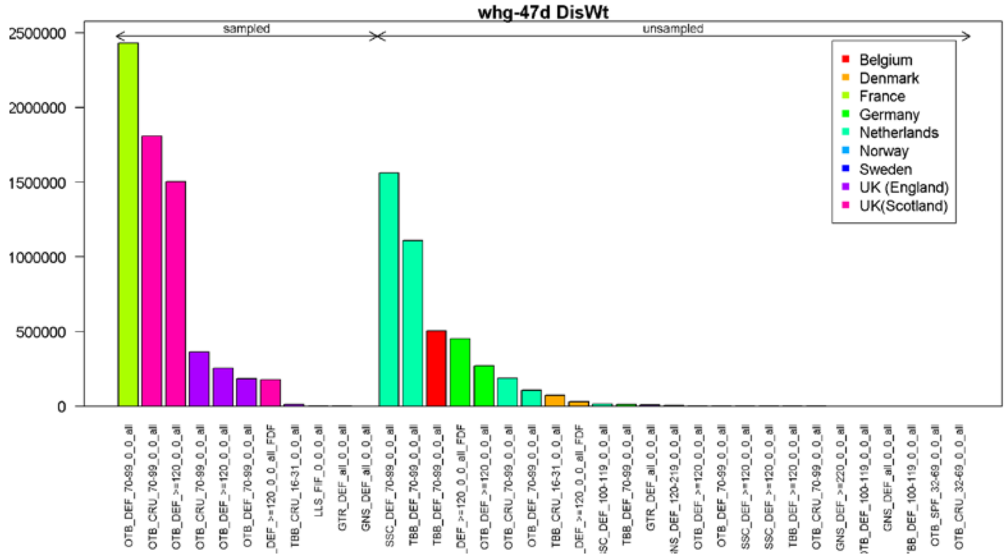


Figure 12.2.2: Whiting in Subarea 4 and Division 7.d. Reported discards (in tonnes, coloured bars)) for each sampled and unsampled fleet, along with cumulative discards (black line) for fleets in descending order of yield.

Figure 12.3: Whiting in Subarea 4 and Division 7.d. Yield by catch component.

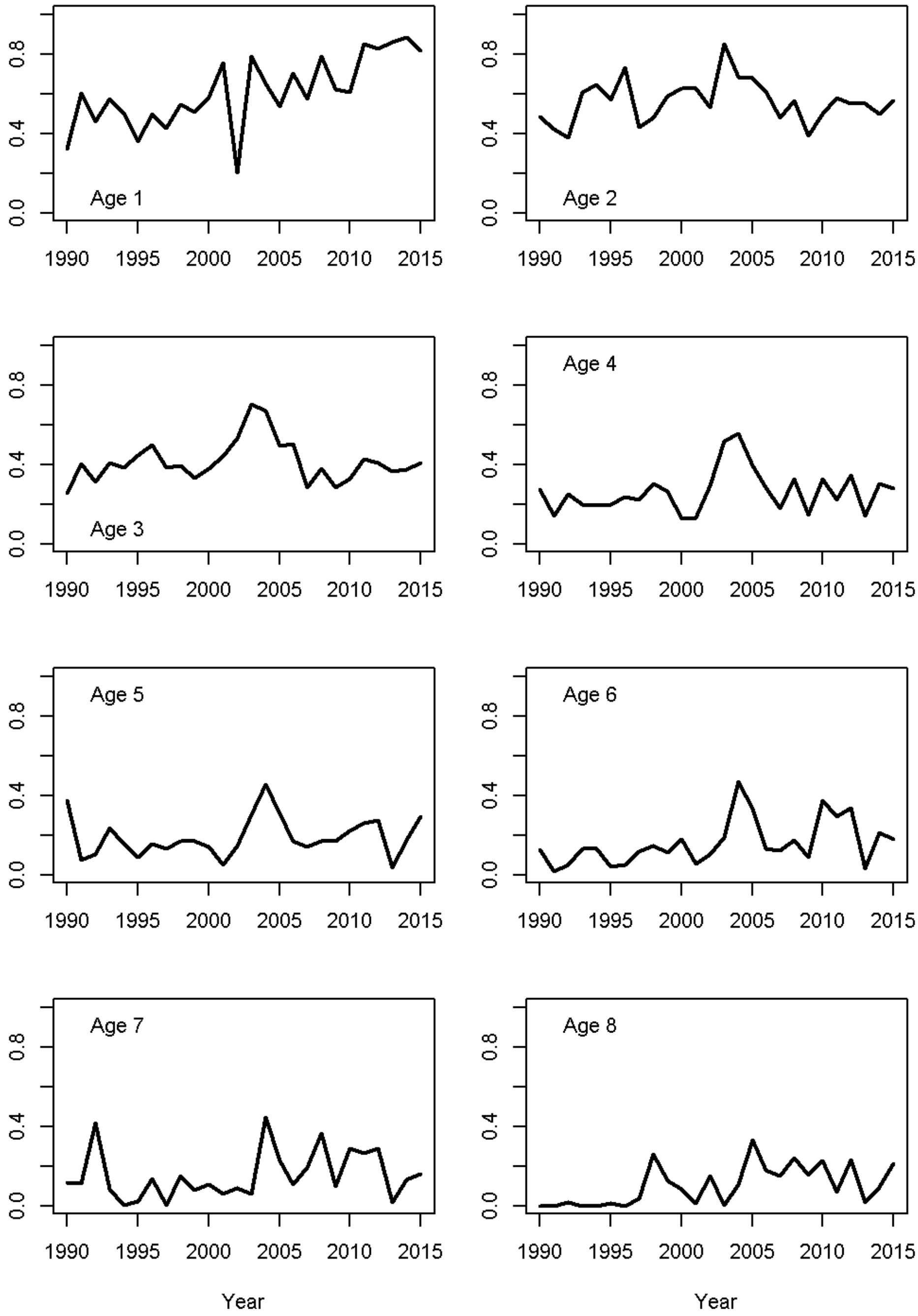


Figure 12.4: Whiting in Subarea 4 and Division 7.d. Proportion of total catch discarded, by age and year.

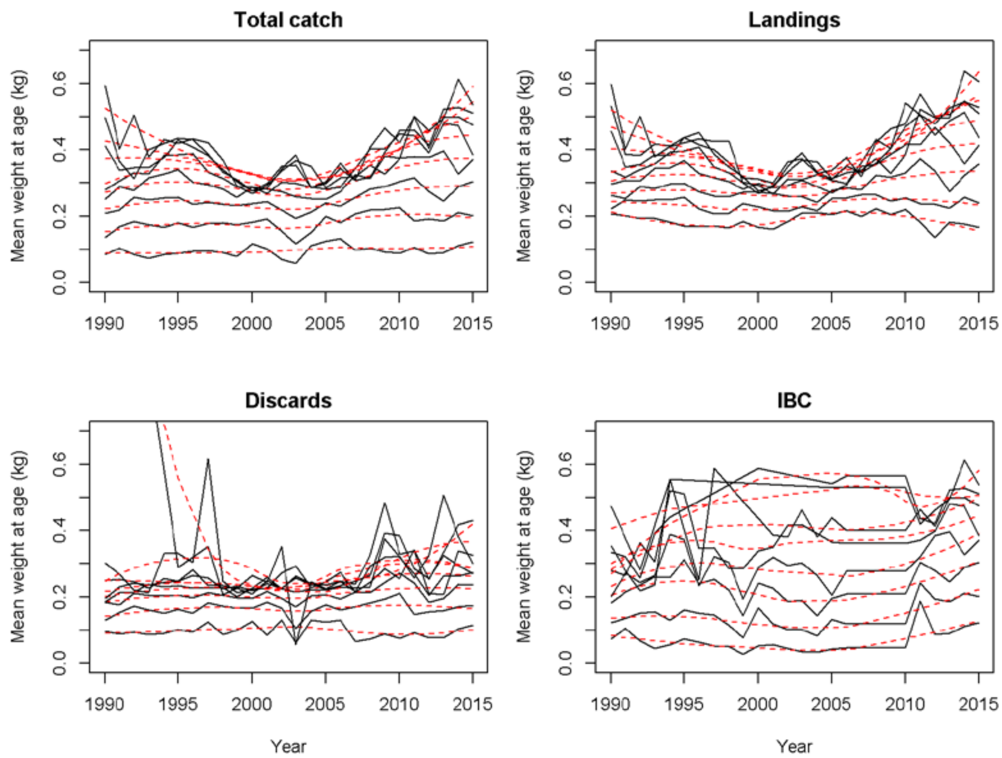


Figure 12.5: Whiting in Subarea 4 and Division 7.d. Mean weights-at-age (kg) by catch component (black lines) and LOESS smoothers through each time-series of mean weights-at-age (red dashed lines). Catch mean weights are used as stock mean weights.

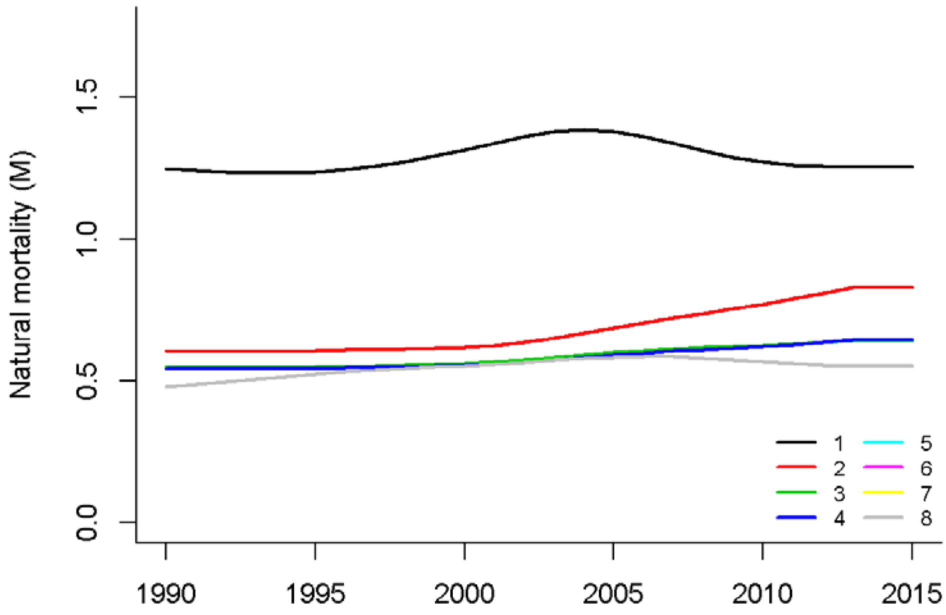


Figure 12.6: Whiting in Subarea 4 and Division 7.d. Natural mortality estimates from the 2011 SMS key run, used in this year's assessment.

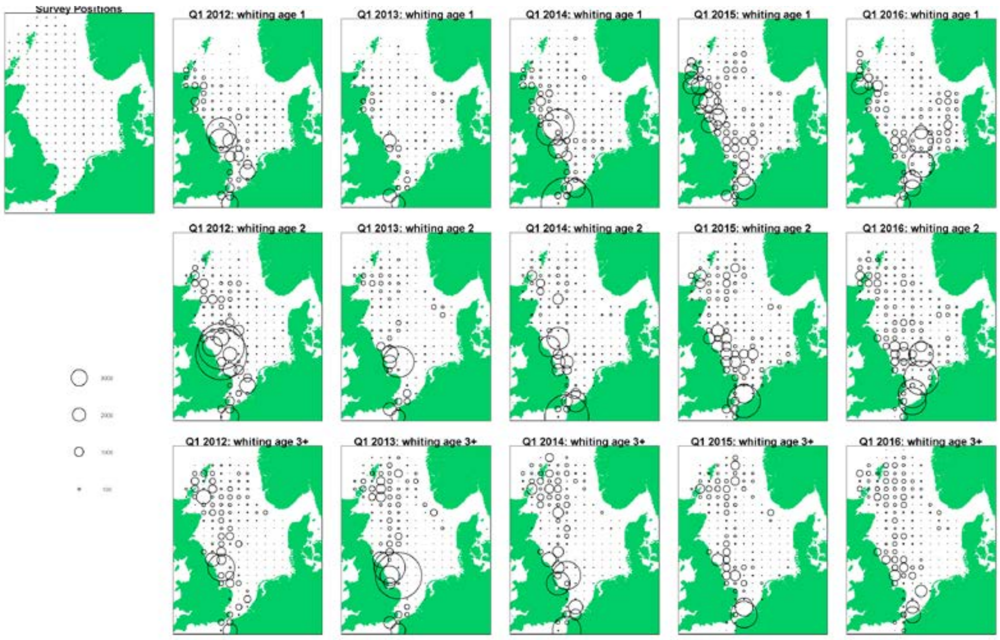


Figure 12.7: Whiting in Subarea 4 and Division 7.d. Survey distribution maps for Ages 1–3+ Q1 2011–2016. Size of the bubbles indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q1 survey in the North Sea.

Figure 12.8: Whiting in Subarea 4 and Division 7.d. Survey distribution maps for ages 0–3+ Q3 2011–2015. Size of the bubbles indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q3 survey in the North Sea.

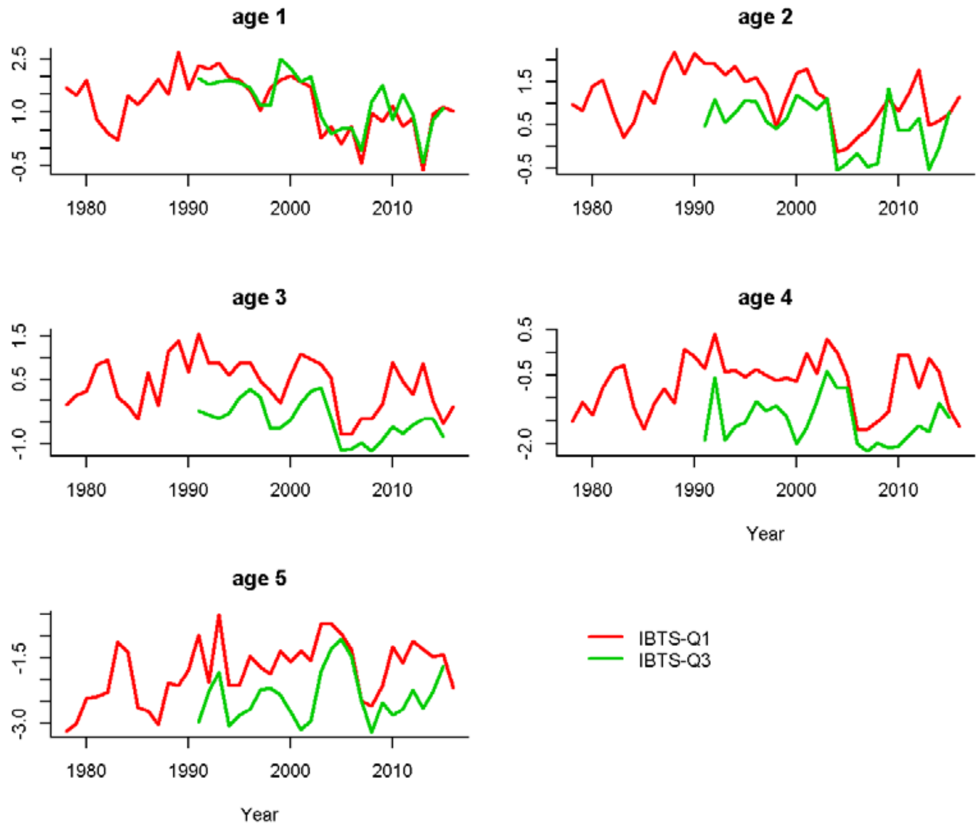


Figure 12.9: Whiting in Subarea 4 and Division 7.d. Survey log CPUE (catch per unit effort) at age.

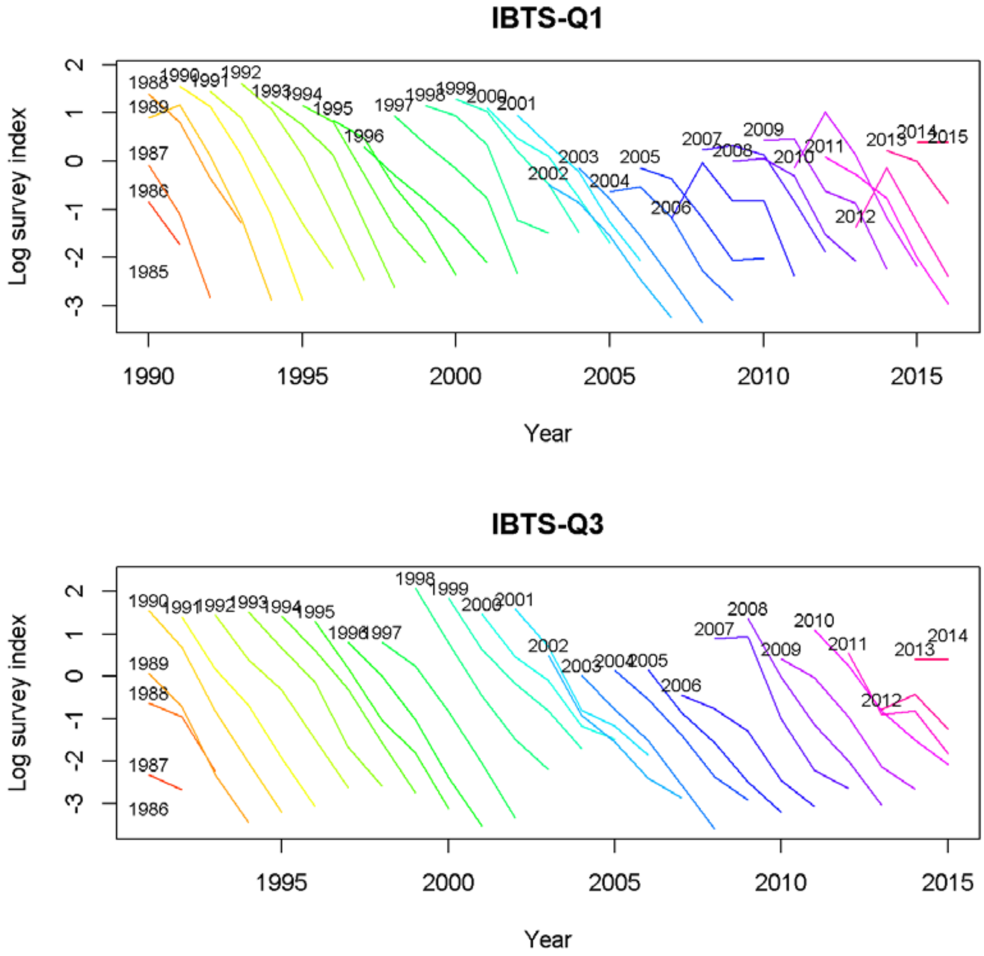


Figure 12.10: Whiting in Subarea 4 and Division 7.d. Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

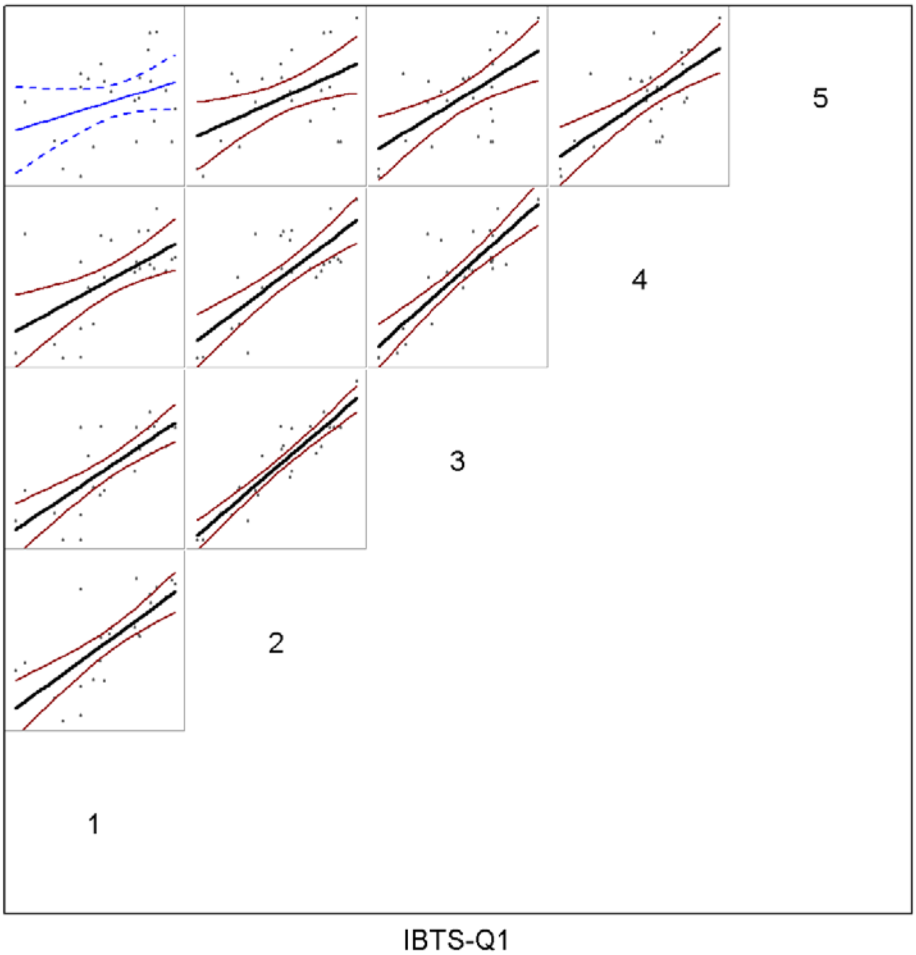


Figure 12.11: Within-survey correlations for the IBTS Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

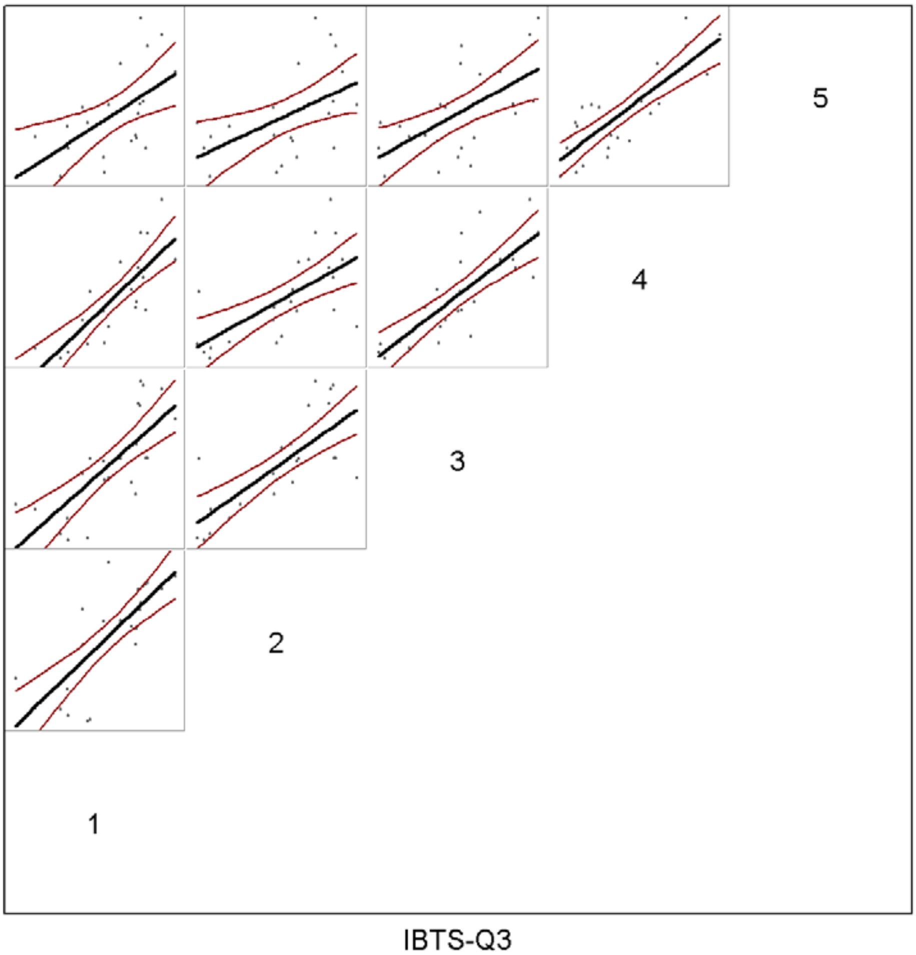


Figure 12.12: Within-survey correlations for the IBTS Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

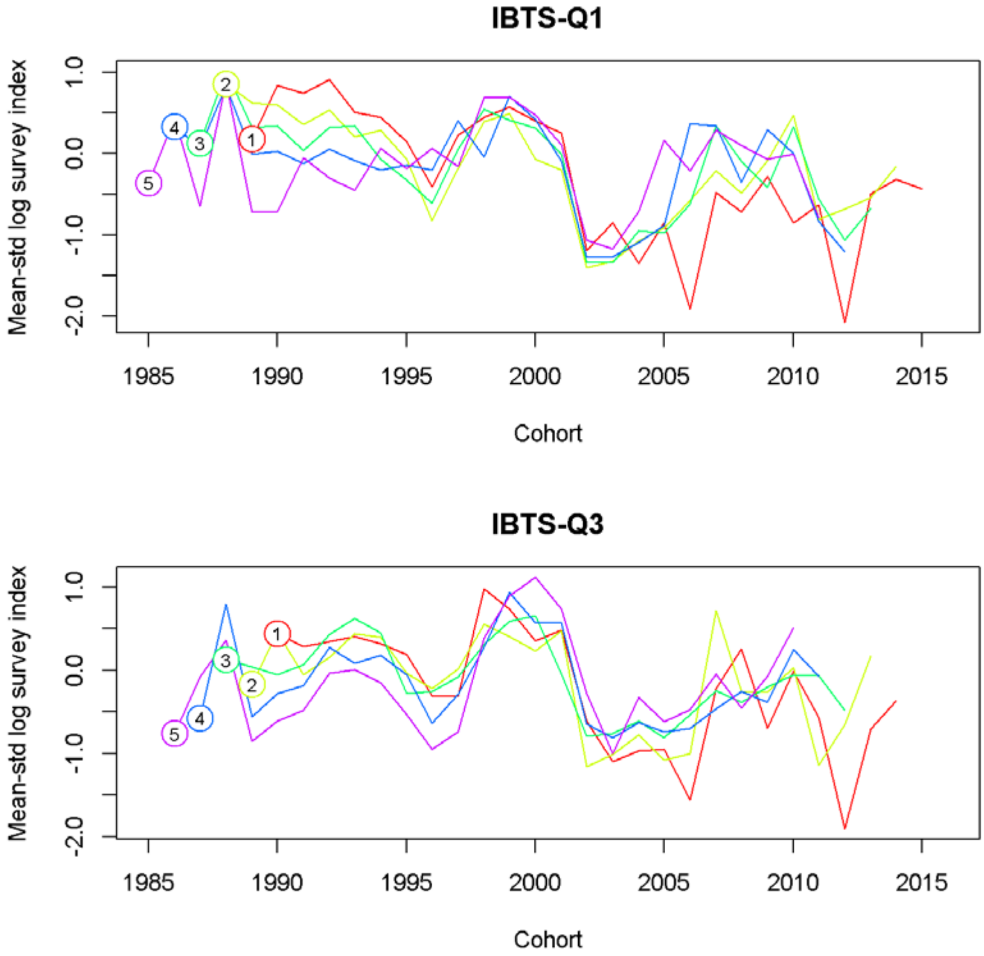


Figure 12.13: Whiting in Subarea 4 and Division 7.d. Survey log CPUE (catch per unit effort) for the IBTS Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

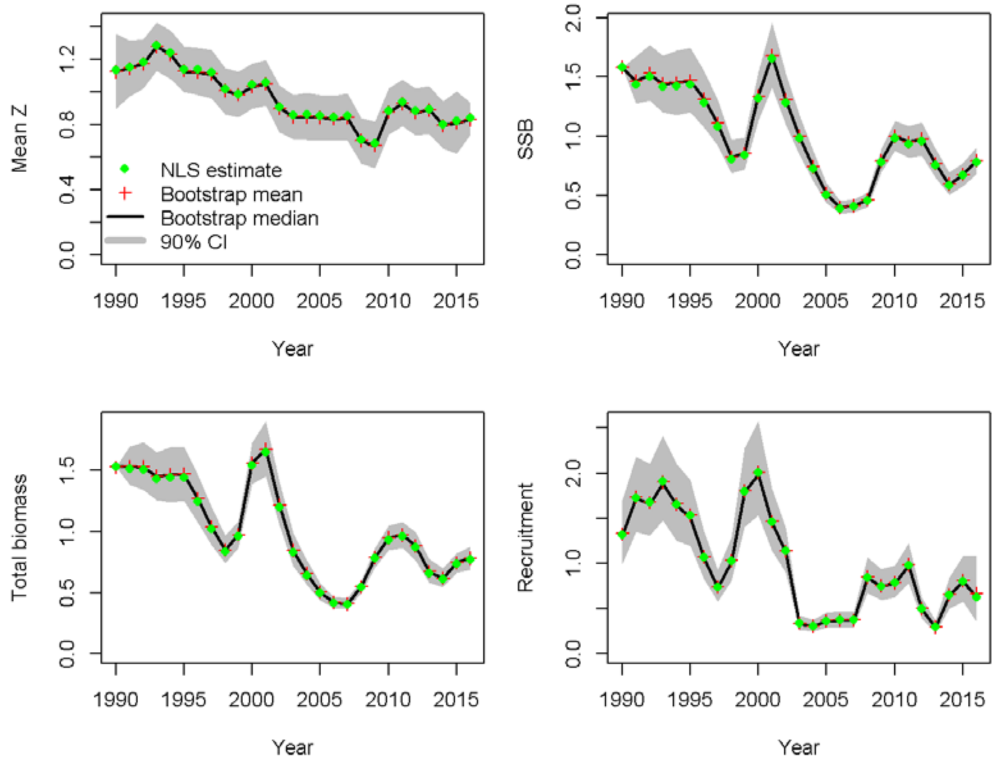


Figure 12.14: Whiting in Subarea 4 and Division 7.d. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

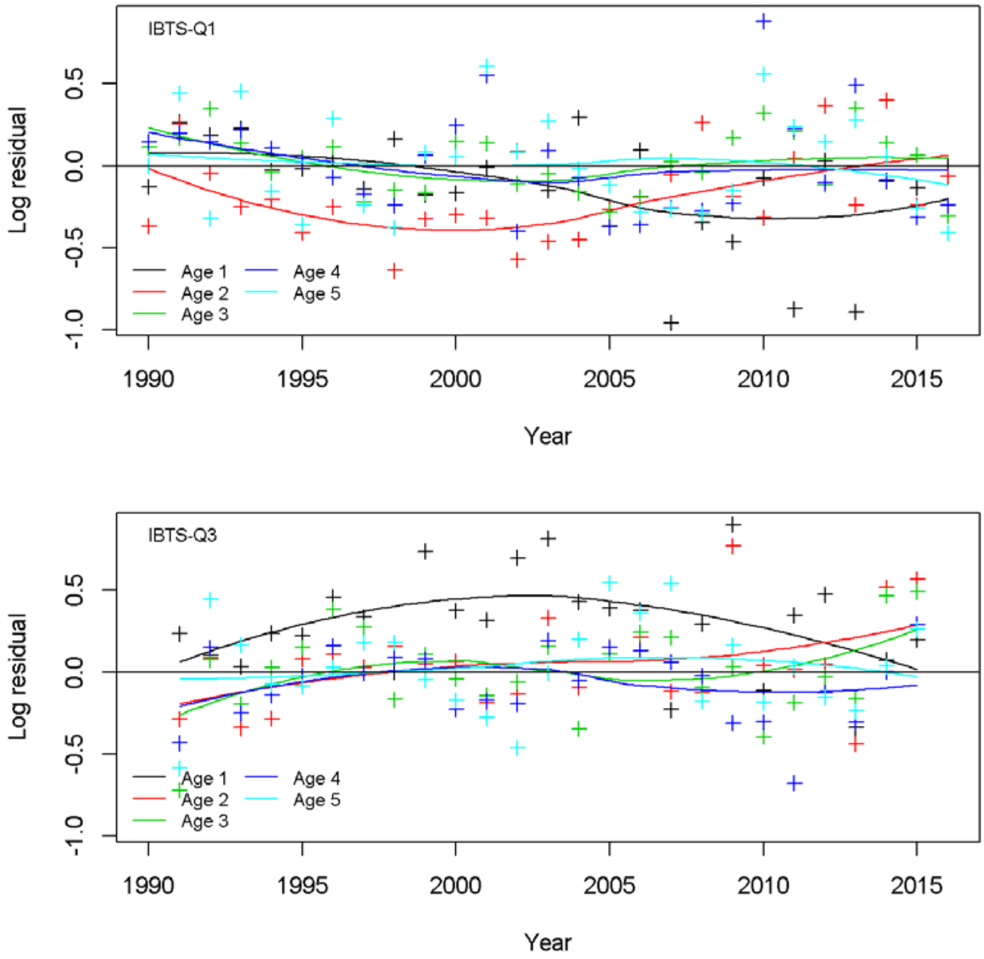


Figure 12.15: Whiting in Subarea 4 and Division 7.d. Log survey residuals from the SURBAR analysis. Ages are colour-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

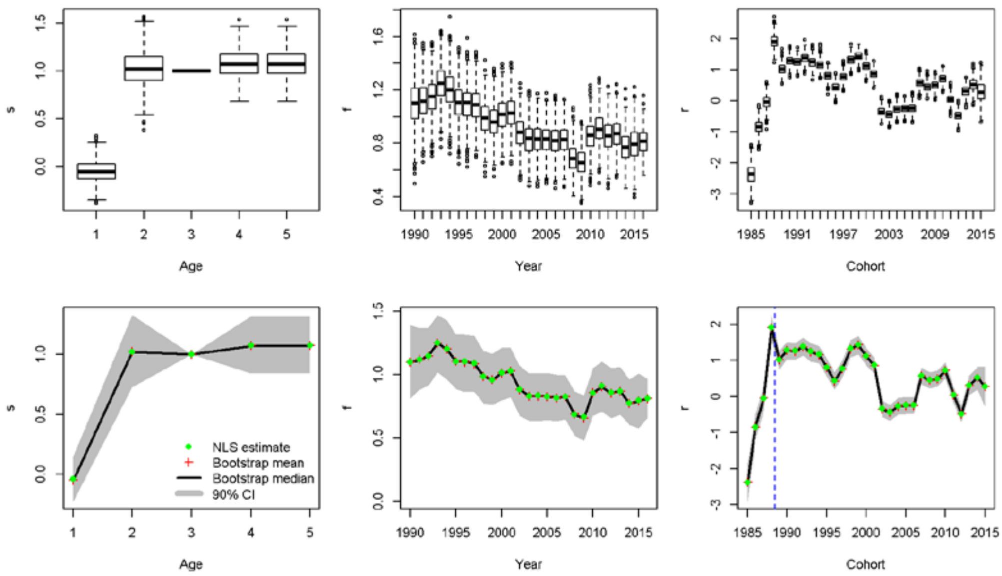


Figure 12.16: Whiting in Subarea 4 and Division 7.d. Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

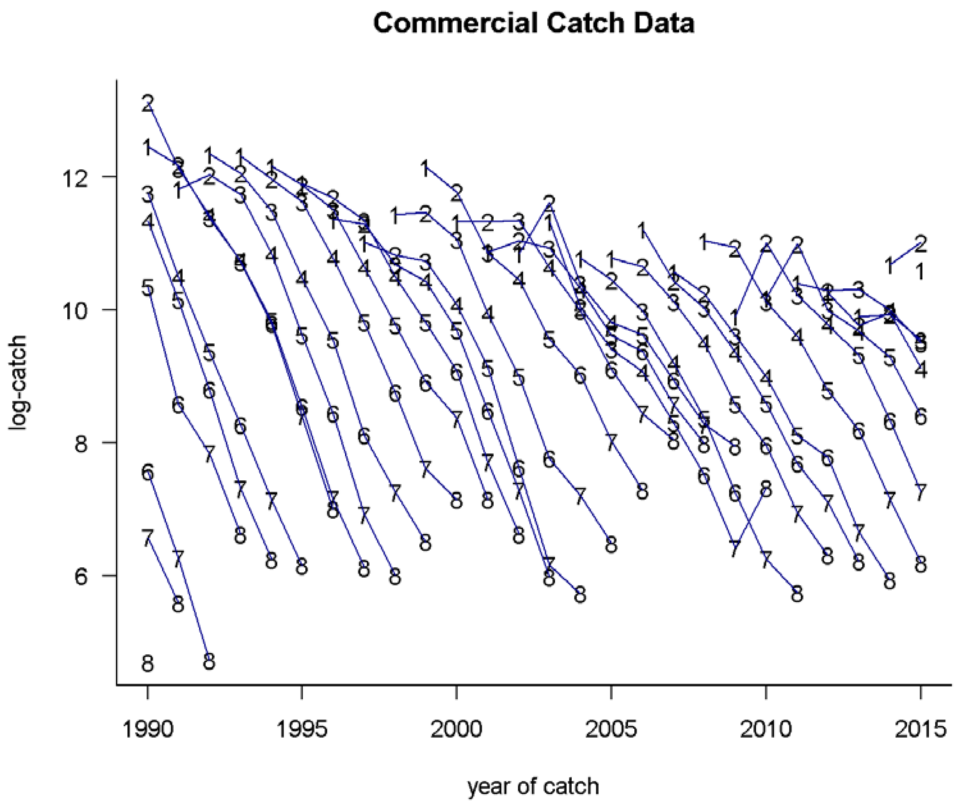


Figure 12.17: Whiting in Subarea 4 and Division 7.d. Log catch curves by cohort for total catches.

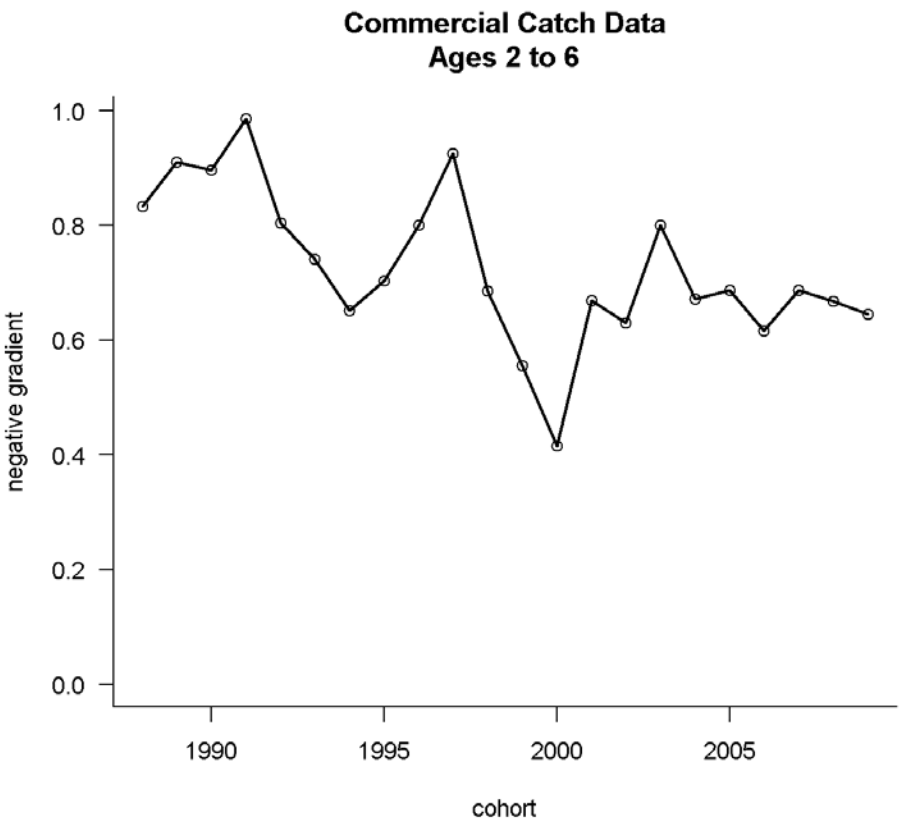


Figure 12.18: Whiting in Subarea 4 and Division 7.d. Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

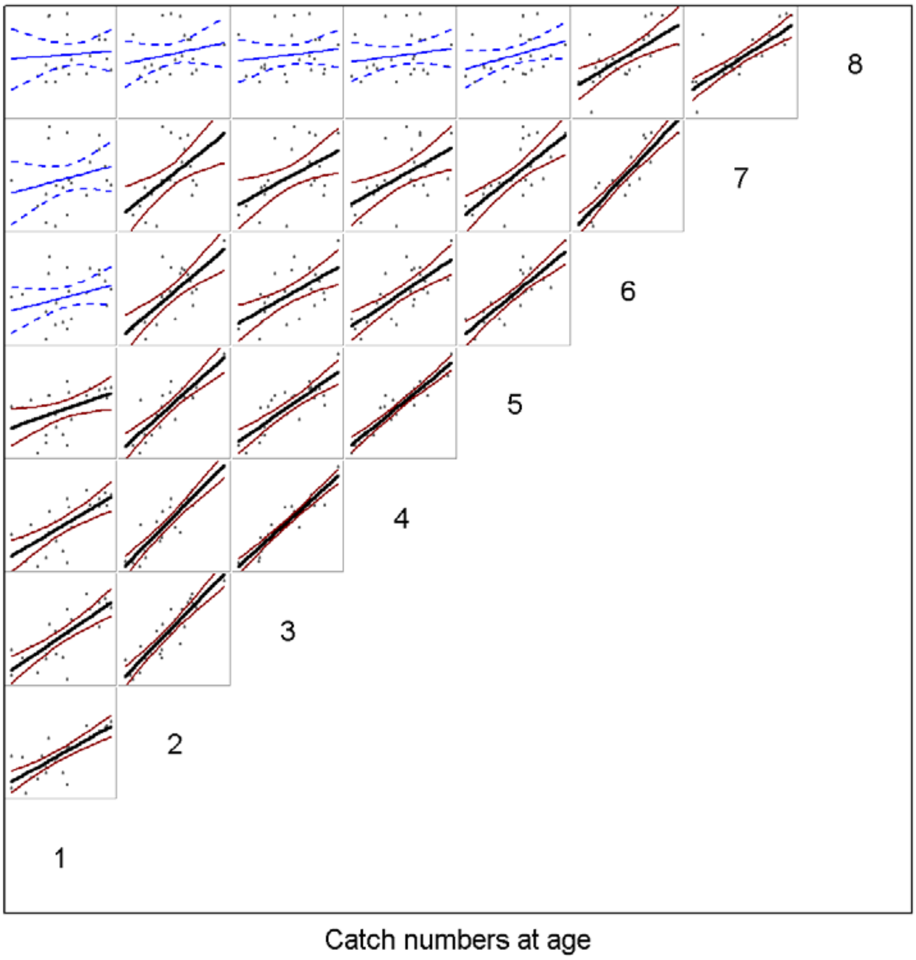


Figure 12.19: Whiting in Subarea 4 and Division 7.d. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

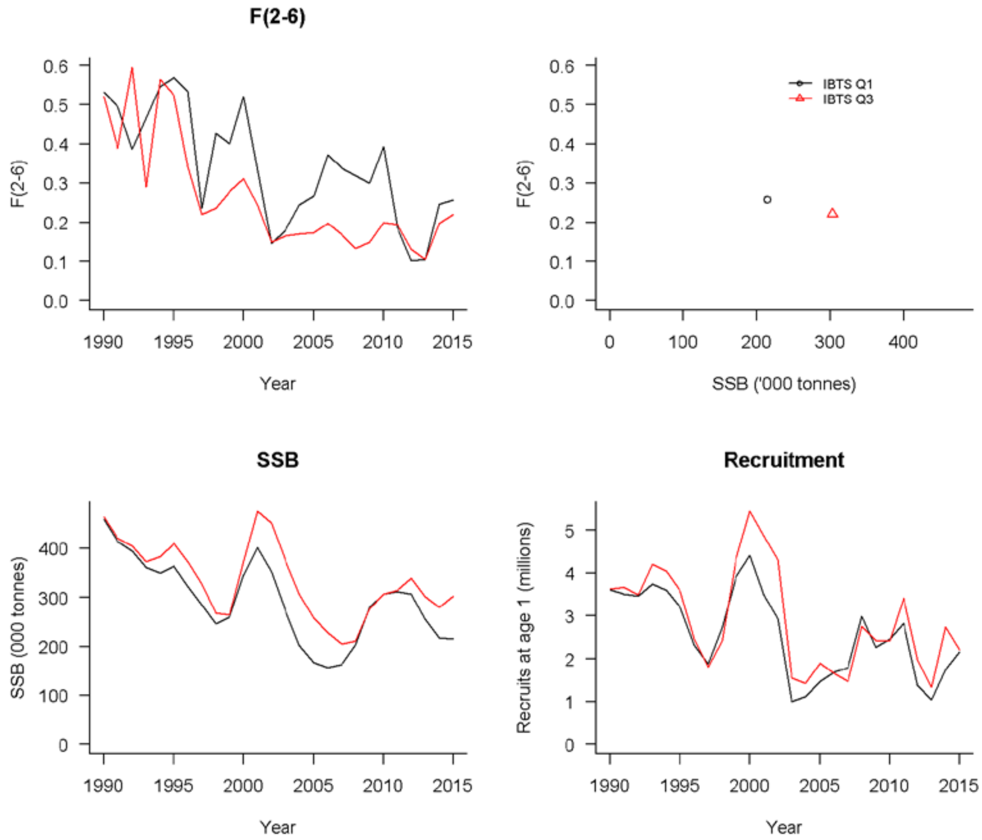


Figure 12.20: Whiting in Subarea 4 and Division 7.d. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2015) values of SSB and mean F(2–4) are plotted against each other in the upper right plot.

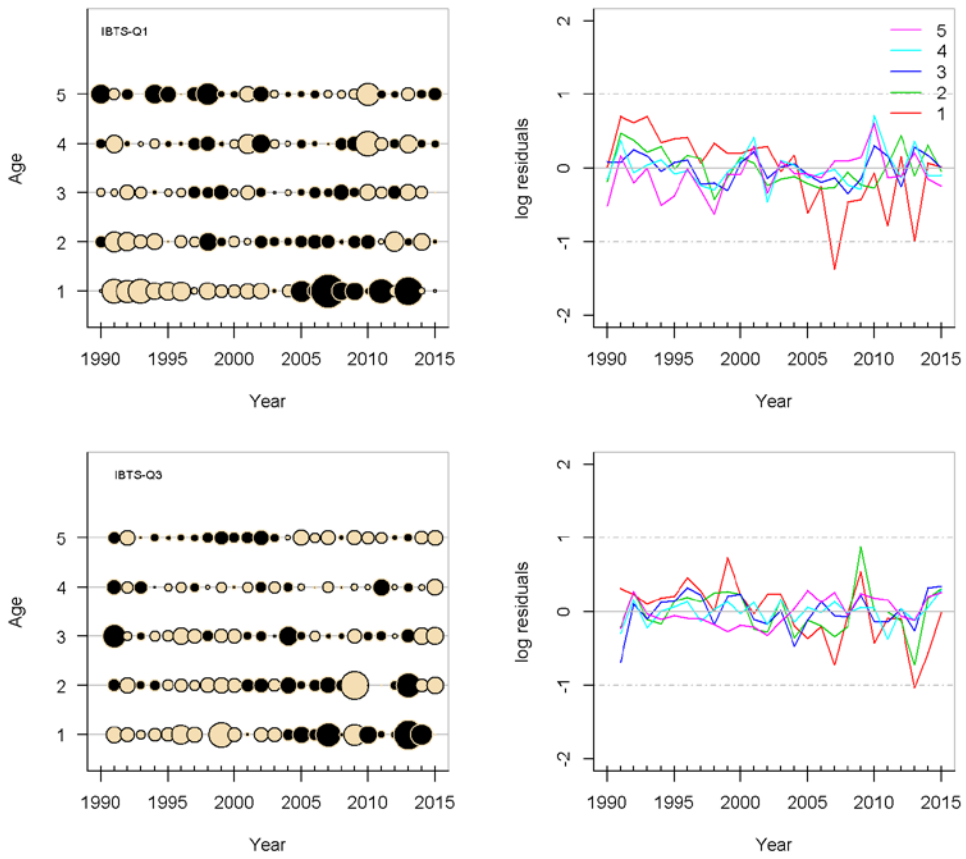


Figure 12.21: Whiting in Subarea 4 and Division 7.d. Log catchability residuals for single-fleet FLXSA assessments (negative values as black bubbles, positive values as yellow bubbles).

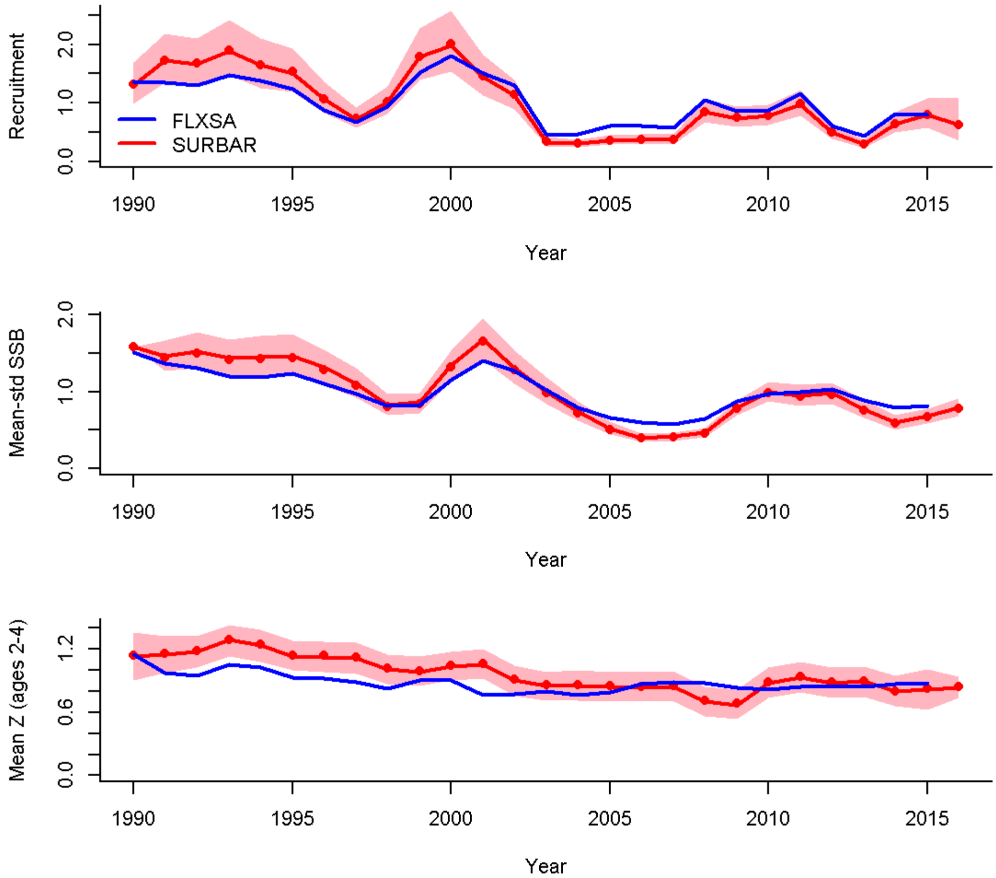


Figure 12.22: Whiting in Subarea 4 and Division 7.d. Comparisons of stock summary estimates from the final XSA (blue) and SURBAR (red) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models. The SURBAR estimates are plotted along with their 90% confidence bounds (shaded pink regions).

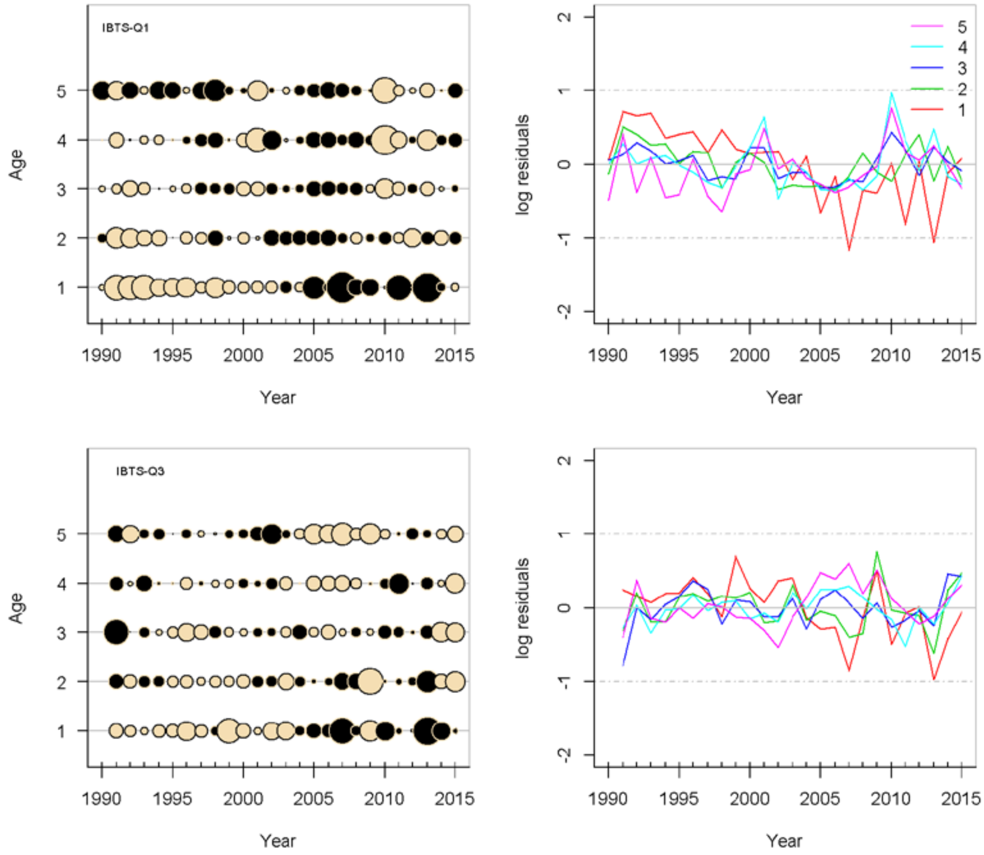


Figure 12.23: Whiting in Subarea 4 and Division 7.d. Log catchability residuals for final FLXSA assessment (negative values as black bubbles, positive values as yellow bubbles).

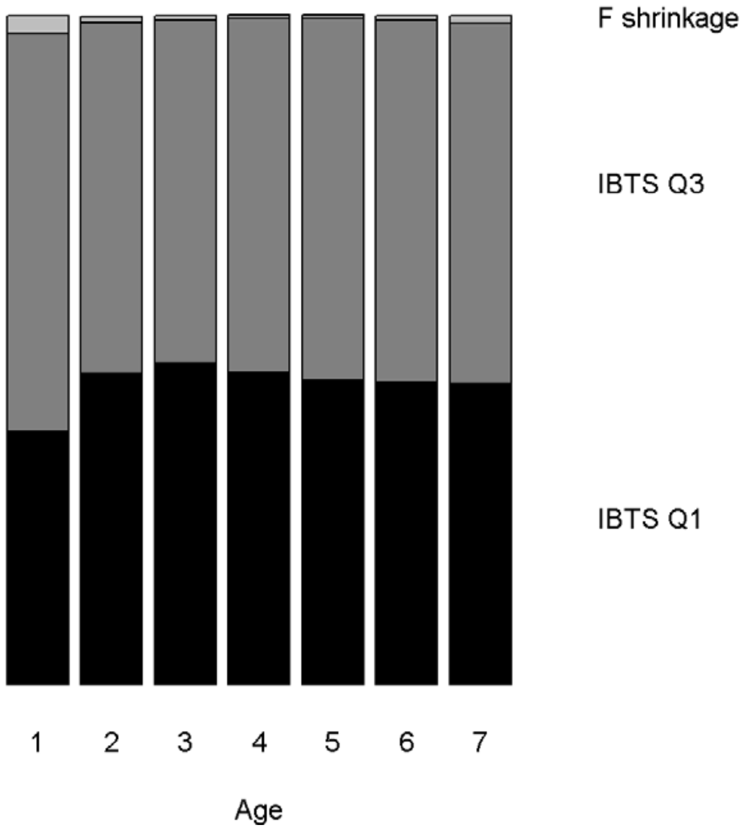


Figure 12.24: Whiting in Subarea 4 and Division 7.d. Contribution to survivors' estimates in final FLXSA assessment.

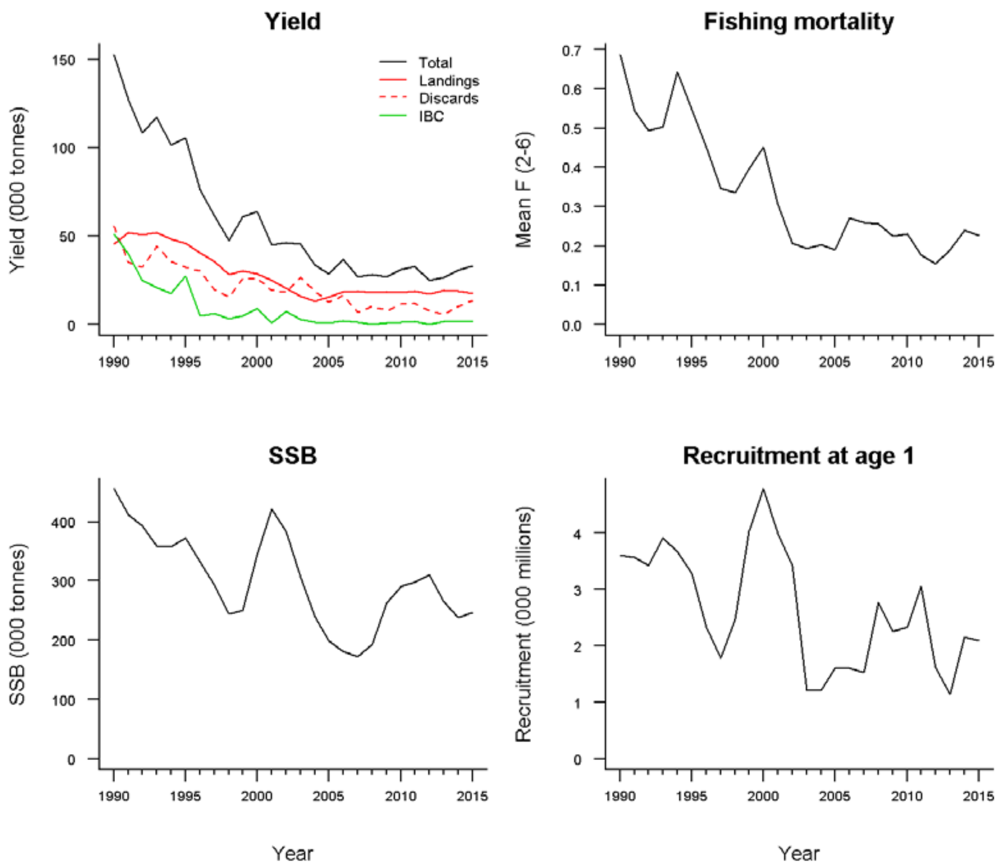


Figure 12.25: Whiting in Subarea 4 and Division 7.d. Summary plots for final FLXSA assessment.

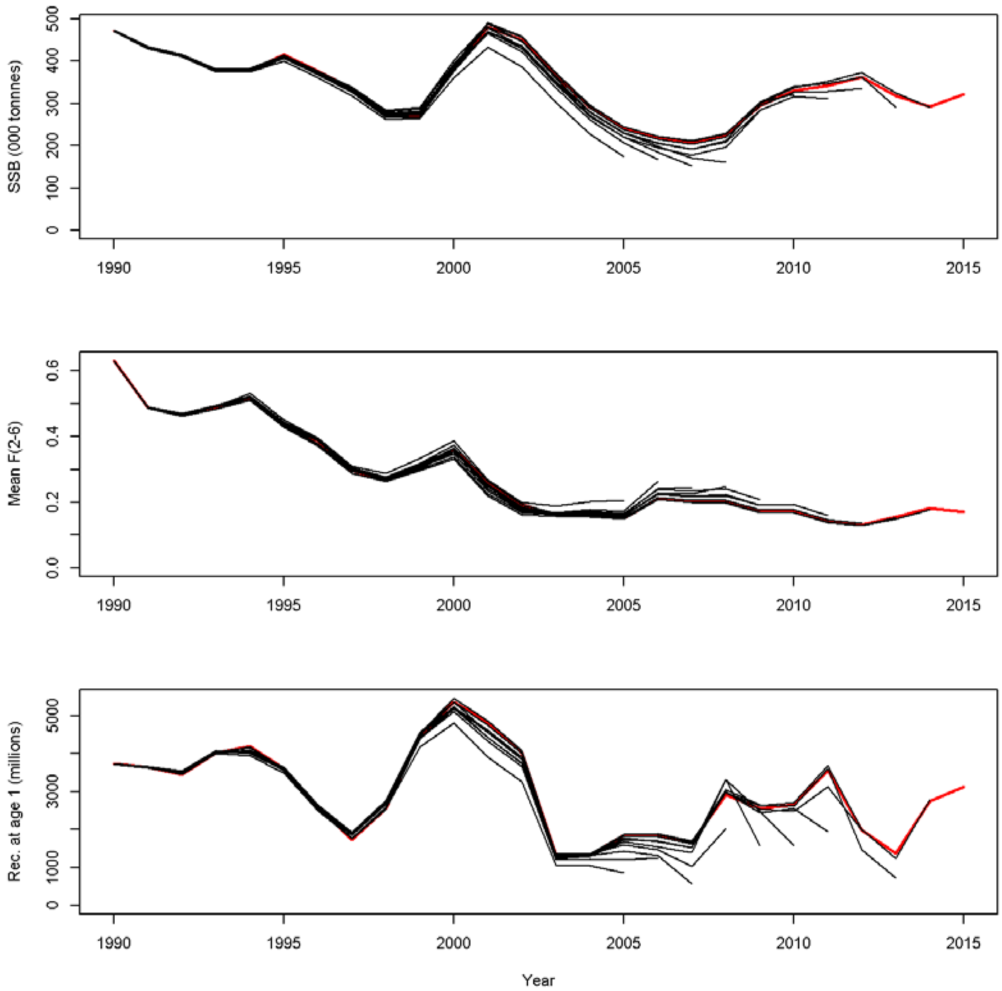


Figure 12.26.1: Whiting in Subarea 4 and Division 7.d. Retrospective plots for final FLXSA assessment.

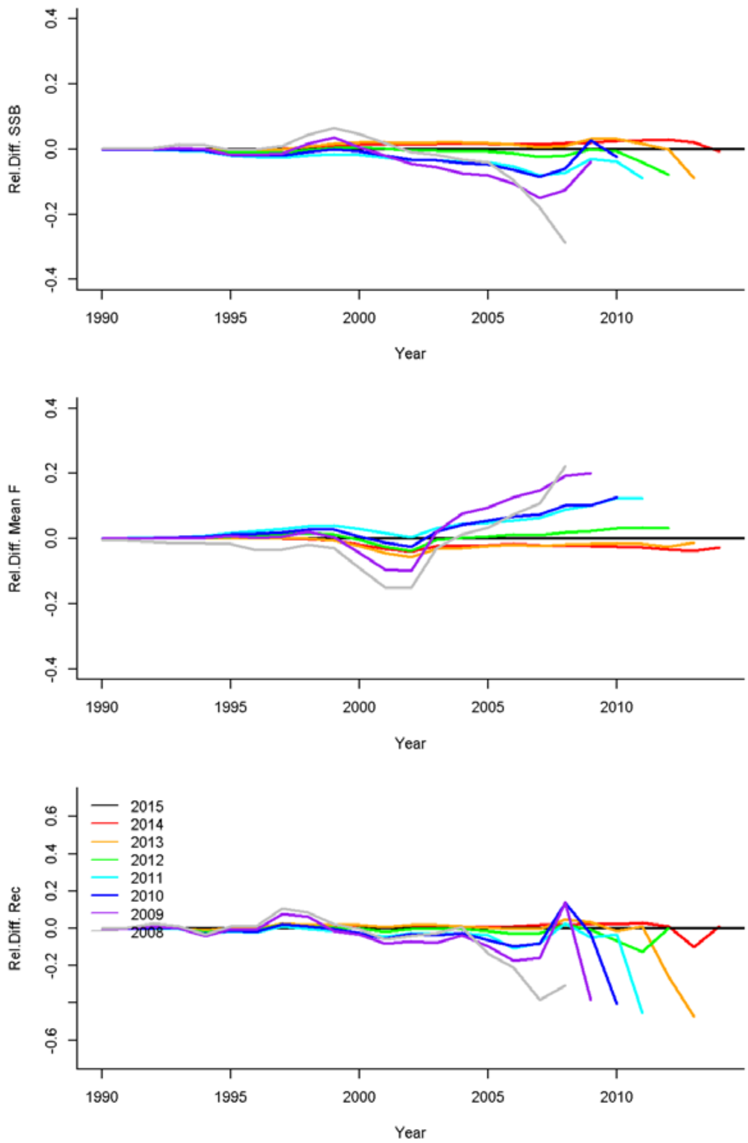


Figure 12.26.2: Whiting in Subarea 4 and Division 7.d. Retrospective plots for final FLXSA assessment, relative differences.

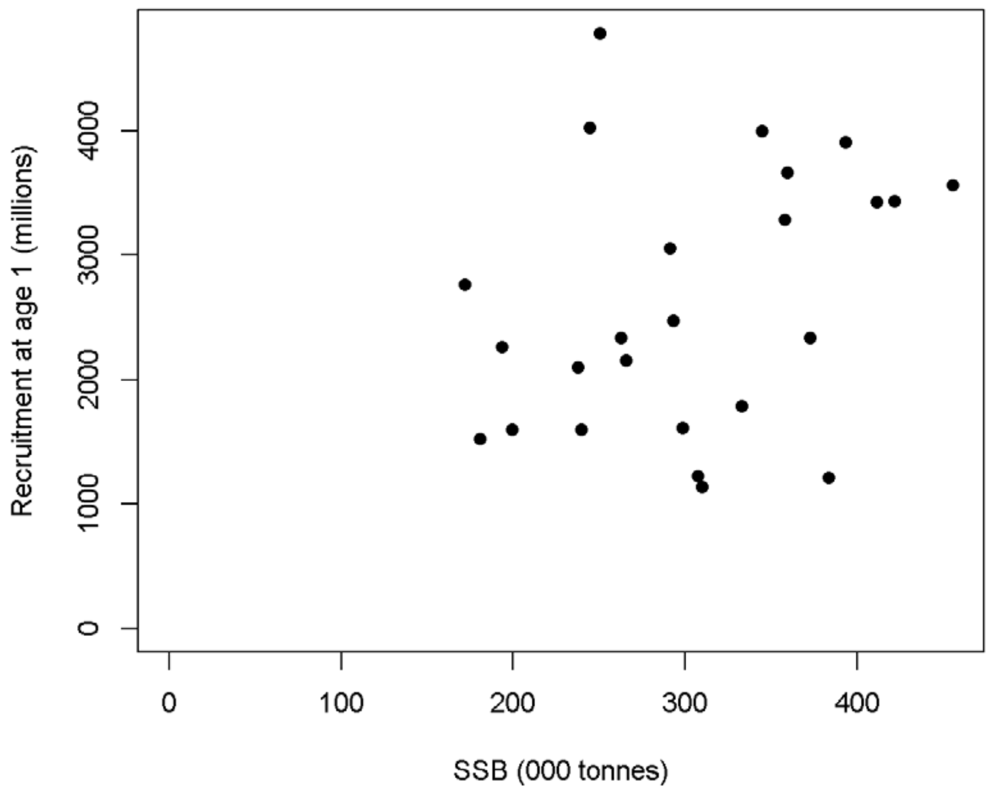


Figure 12.27: Whiting in Subarea 4 and Division 7.d. Stock-recruitment plot from final FLXSA assessment.

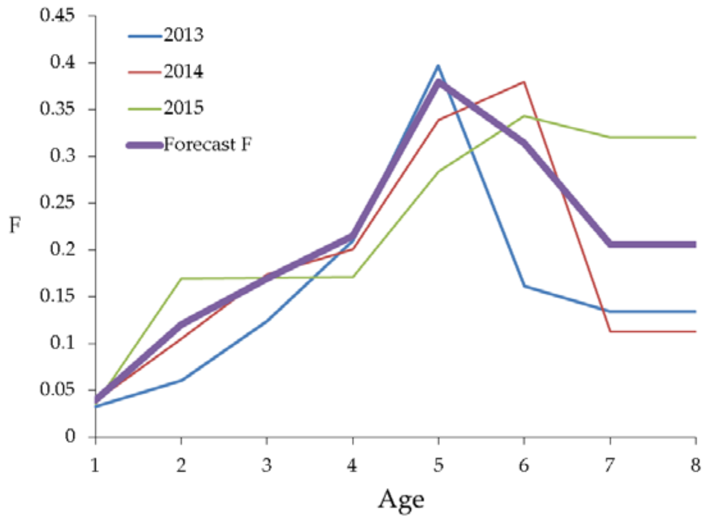


Figure 12.28: Whiting in Subarea 4 and Division 7.d. FLXSA F at age estimates for 2012–2015, along with scaled mean exploitation used for the forecast.

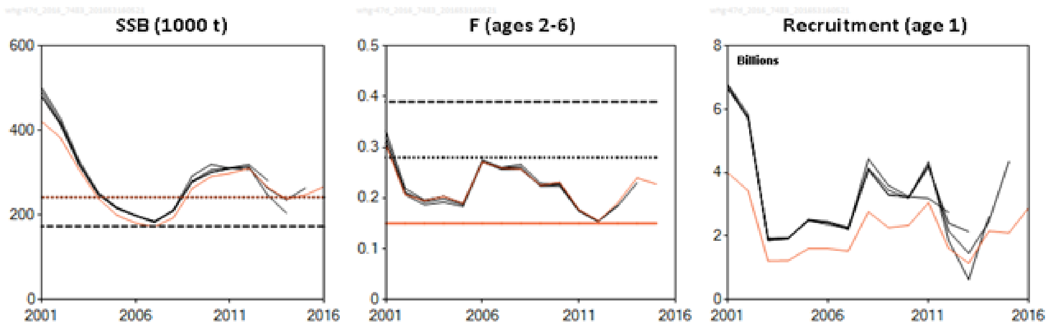


Figure 12.29: Whiting in Subarea 4 and Division 7.d. Historical assessment comparison plot.

12.2 Whiting in Division 3.a

12.2.1 General

12.2.1.1 Stock definition

There is a paucity of information on the population structure of whiting in Division 3.a (the Skagerrak-Kattegat area). No genetic surveys have been conducted, nor otolith based surveys. Tagging of whiting has previously been undertaken, yet these data need to be re-examined. Results from modelled survey data (SURBAR) are inconclusive regarding independent population dynamics in Division 3.a in comparison with the North Sea, presumably due to the need of age readings in 3.a. The drop in landings in the beginning of the 1990s gives however an indication of local stock structure, as this reduction was not paralleled by any similar event in the North Sea.

12.2.1.2 Ecosystem aspect

No new information was presented at the Working Group. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.2.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the spatial distribution of the Swedish landings in 2015 using logbooks information. The plot is reported in Figure 12.1.1 and showed that higher landings were taken along the Swedish coastline than in the offshore Skagerrak. A summary of available information on fisheries is presented in the Stock Annex prepared at ICES-WKROUND (2009). Discards estimates are available since 2003. Information on derivation of discards is presented in the Stock Annex.

12.2.1.4 Data available

According to the WKLIFE categorisation of various levels of available data for assessment, whiting in Division 3.a can be considered to be a stock for which survey based indices are available, indicating trends. This survey data have been used for an exploratory assessment.

Total landings are shown in Table 12.1.1.

The WGNSSK in 2015 used IBTS indices per area (Skagerrak and Kattegat) and BITS indices (Kattegat) for plotting CPUE per quarter of fish of total length > 21 cm, which corresponds to the 50% point of the maturity ogive of whiting in the North Sea. Plots of the IBTS Q1 and IBTS Q3 per area are shown in Figures 12.1.2 and BITS Q1 and Q4 in Figure 12.1.3. IBTS Q3 indicate high inter-annual variability in recruitment. IBTS Q1 in Kattegat shows a marked increase in CPUE in 2015. This is assigned to one single haul dominating the data series. Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 12.1.4a for the IBTS Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS Q3 survey in Figure 12.1.4b. Year effects occur (top left) and the importance of cohorts fluctuate through the time-series (top right) indicating migratory behaviour. No clear pattern of total mortality (bottom right).

12.2.2 Data analyses

12.2.2.1 Exploratory survey-based analysis

Based on the information provided by the IBTS mean age indices for Q1 and Q3 a SURBAR analysis was performed. The summary plot from this run is given is Figure 12.1.5 and indicated great uncertainties in all parameter values of relative spawning stock biomass (SSB), relative total biomass (TSB) and mean mortality (Z) with highly erratic patterns.

The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year are shown in Figure 12.1.6. For both IBTS Q1 and IBTS Q3 surveys the different plots indicated that internal consistency was virtually absent, impeding cohort analysis in the stock for the present. Log residual estimates per age class for IBTS Q1 and IBTS Q3 are shown in Figure 12.1.7.

12.2.2.2 Conclusions drawn from exploratory analysis

The lack of internal consistency in the available survey indices prevents analytical assessment. This internal inconsistency could be related to a) age reading problems, and/or b) a mixture of several stock components leading to unaccounted migrations. As the survey-based assessment cannot be used as a basis for advice, the stock is thus classified, according to the ICES rules for data limited stocks, as belonging to category 5.2. No new data were presented at the WGNSSK 2016 to change the perception of the stock. WGH 3.a is up for Benchmark in 2017 and the suggested workplan was updated.

12.2.2.3 Advice

DLS-category 5.2, which is based catch information only.. Multi-annual advice is given (2016). There are no new data that change the perception of the stock status.

Table 12.1.1 Nominal landings (t) of Whiting from Division 3.a as supplied by the Study Group on Division 3.a Demersal Stocks (ICES 1992b) and updated by the Working Group, and WG estimate of Discards.

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
1975	19,018			57	611	4	19,690	
1976	17,870			48	1,002	48	18,968	
1977	18,116			46	975	41	19,178	
1978	48,102			58	899	32	49,091	
1979	16,971			63	1,033	16	18,083	
1980	21,070			65	1,516	3	22,654	
	Total consumption	Total industrial	Total					
1981	1,027	23,915	24,942	70	1,054	7	26,073	
1982	1,183	39,758	40,941	40	670	13	41,664	
1983	1,311	23,505	24,816	48	1,061	8	25,933	
1984	1,036	12,102	13,138	51	1,168	60	14,417	
1985	557	11,967	12,524	45	654	2	13,225	
1986	484	11,979	12,463	64	477	1	13,005	
1987	443	15,880	16,323	29	262	43	16,657	
1988	391	10,872	11,263	42	435	24	11,764	
1989	917	11,662	12,579	29	675	-	13,283	
1990	1,016	17,829	18,845	49	456	73	19,423	
1991	871	12,463	13,334	56	527	97	14,041	
1992	555	3,340	3,895	66	959	1	4,921	
1993	261	1,987	2,248	42	756	1	3,047	
1994	174	1,900	2,074	21	440	1	2,536	
1995	85	2,549	2,634	24	431	1	3,090	
1996	55	1,235	1,290	21	182	-	1,493	
1997	38	264	302	18	94	-	414	
1998	35	354	389	16	81	-	486	
1999	37	695	732	15	111	-	858	
2000	59	777	836	17	138	1	992	
2001	61	9701	1,0311	27	126	+	1,1841	
2002	101	9751	1,0761	23	127	1	1,2271	
2003	93	6541	7471	20	71.9	2	840.91	429
2004	93	1,1201	1,2131	17	74	1	1,3051	909
2005	49	9071	9561	13	73	0	1,0421	299
2006	591	2901	3491	n/a	85.92	n/a	434.92	331
2007	532	2782	3312	14	82	1	4282	561
2008	522	2882	3402	14	52	n/a	4062	241
2009	712	1732	2442	10.3	33.82	-	288.12	128
2010	41	165	206	9.7	29.7	-	245.4	291
2011	40	44	84	8.3	20.4	0.2	112.9	794
2012	30	6.8	37	15.5	9.6	0.8	62.9	277
2013	29	102	131	8.4	14.5	1.0	155	591
2014	49	346	395	4.8	37.6	1.3	439	579
2015	74	572	646	5.9	55.681	5.1	713.4	604

[1] Values from 1992 updated by WGNSSK (2007).

[2] Values updated by WGNSSK (2011).

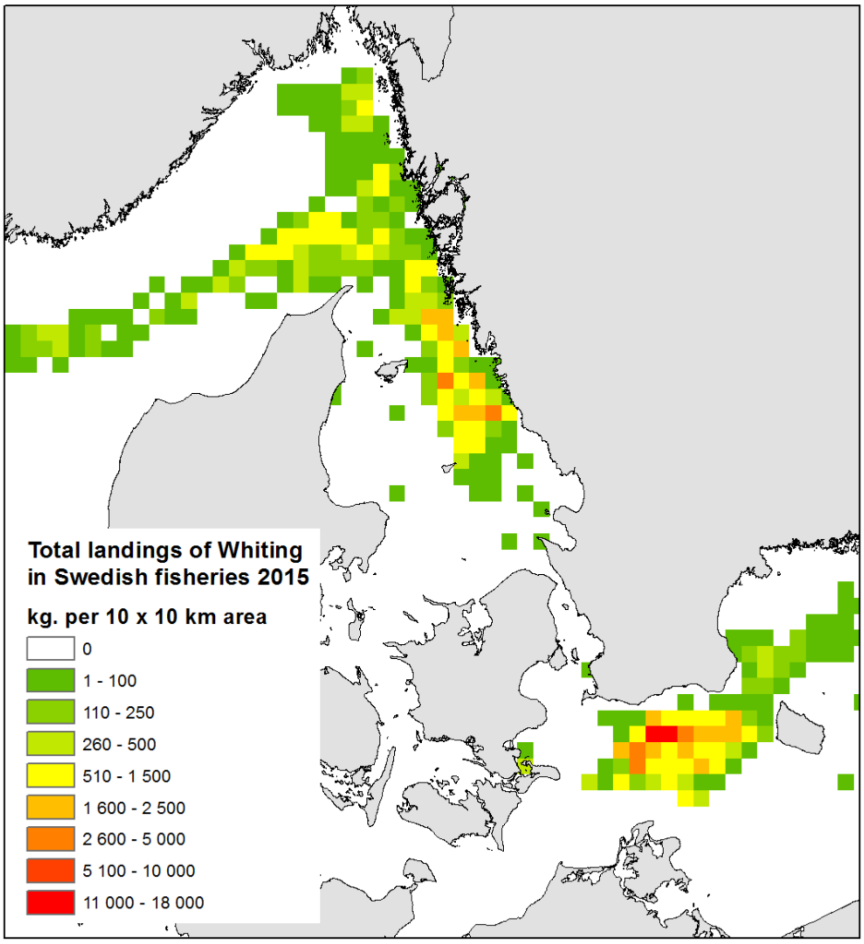
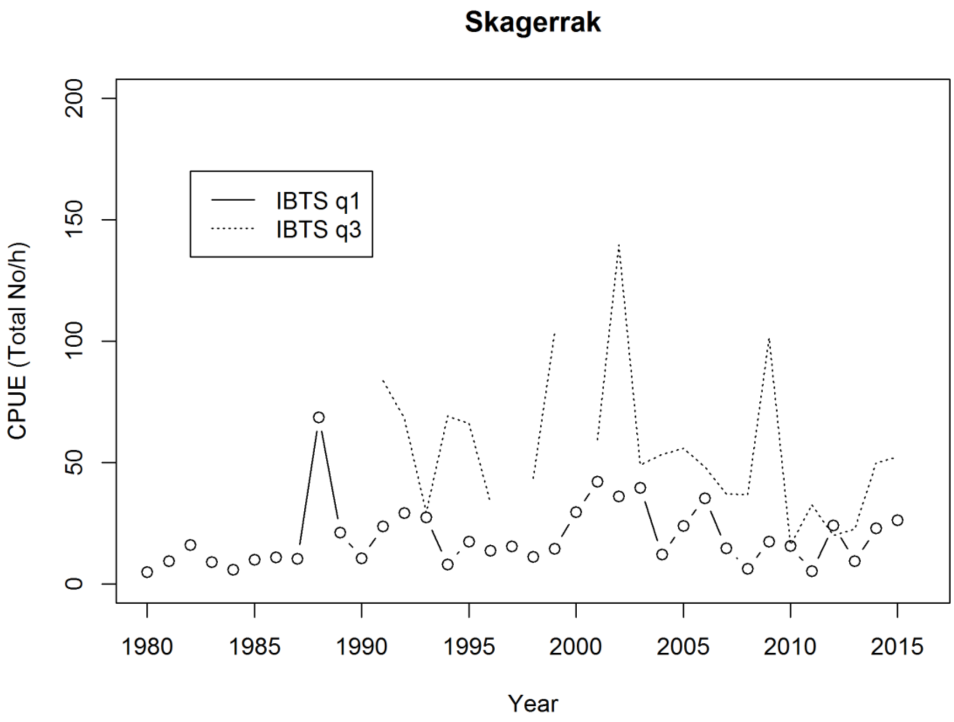


Figure 12.1.1. Whiting in Division 3.a. Spatial distribution of the total landings of whiting 3.a in Swedish fisheries 2014 from logbooks information.



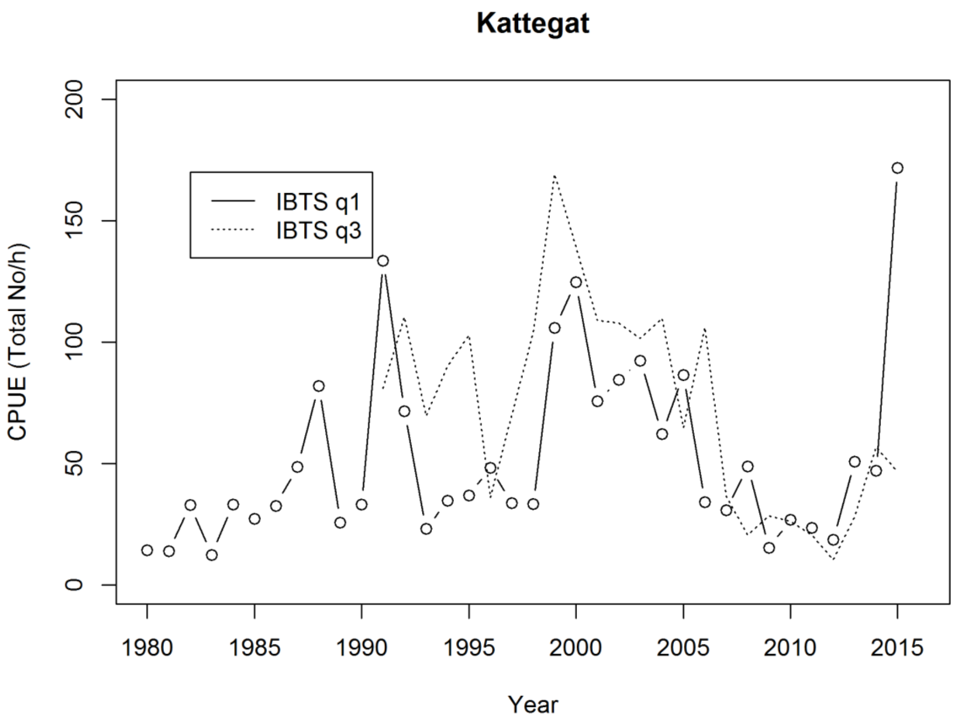


Figure 12.1.2. Whiting in Division 3.a (Skagerrak and Kattegat). IBTS CPUE per area Q1 covering the years 1967–2015 and Q3 covering the years 1991–2014.

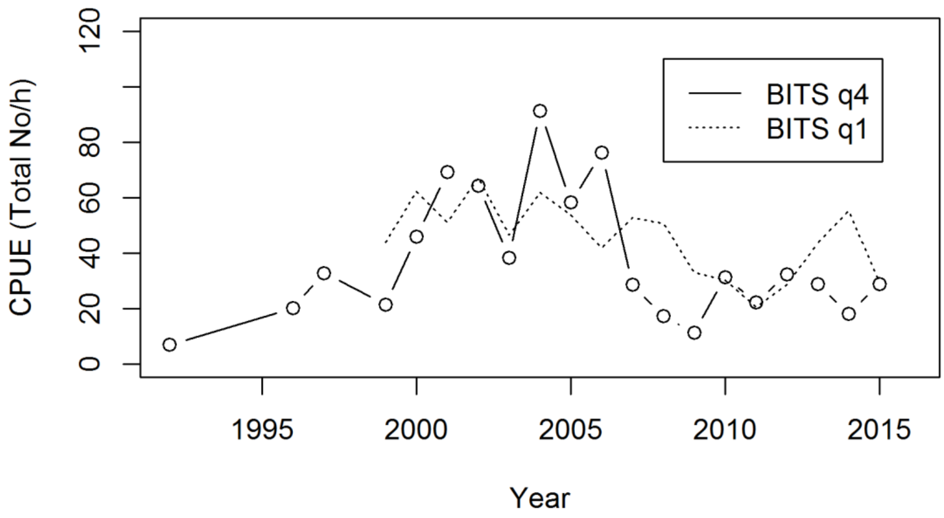


Figure 12.1.3. Whiting in Division 3.a S (Kattegat). BITS CPUE per Q1 and Q4 covering the years 1992–2015 and 1992–2014, respectively.

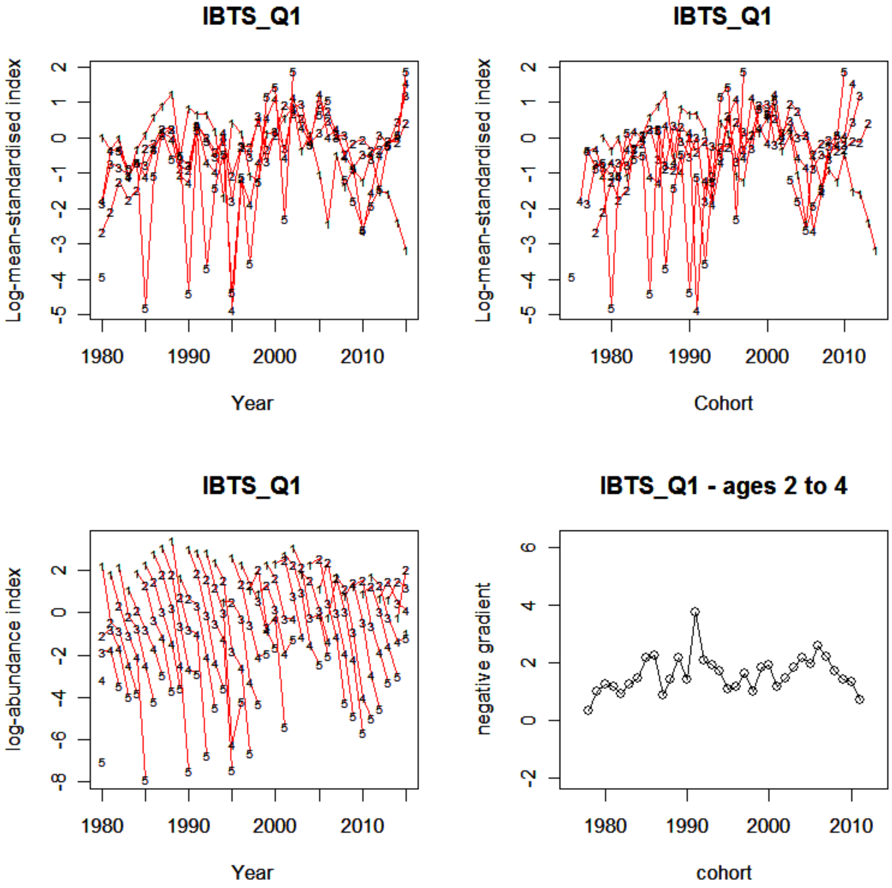


Figure 12.1.4a Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTSQ1 groundfish survey (NS-IBTS Delta-GAM index)

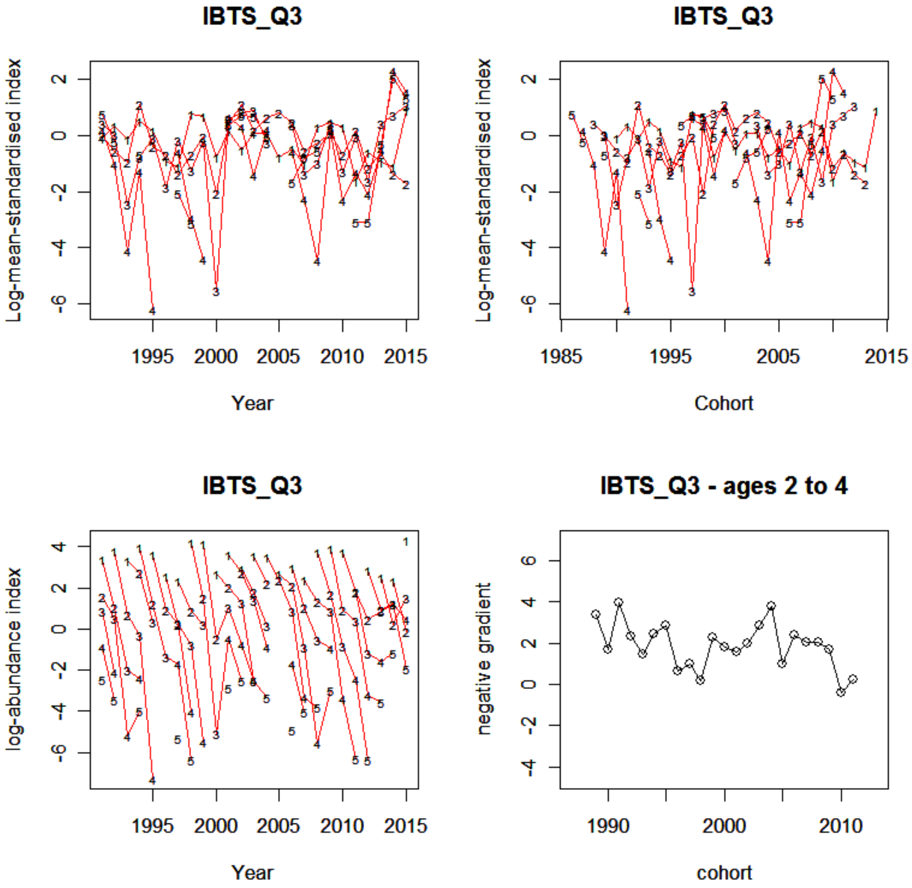


Figure 12.1.4b Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTSQ3 groundfish survey (NS-IBTS Delta-GAM index)

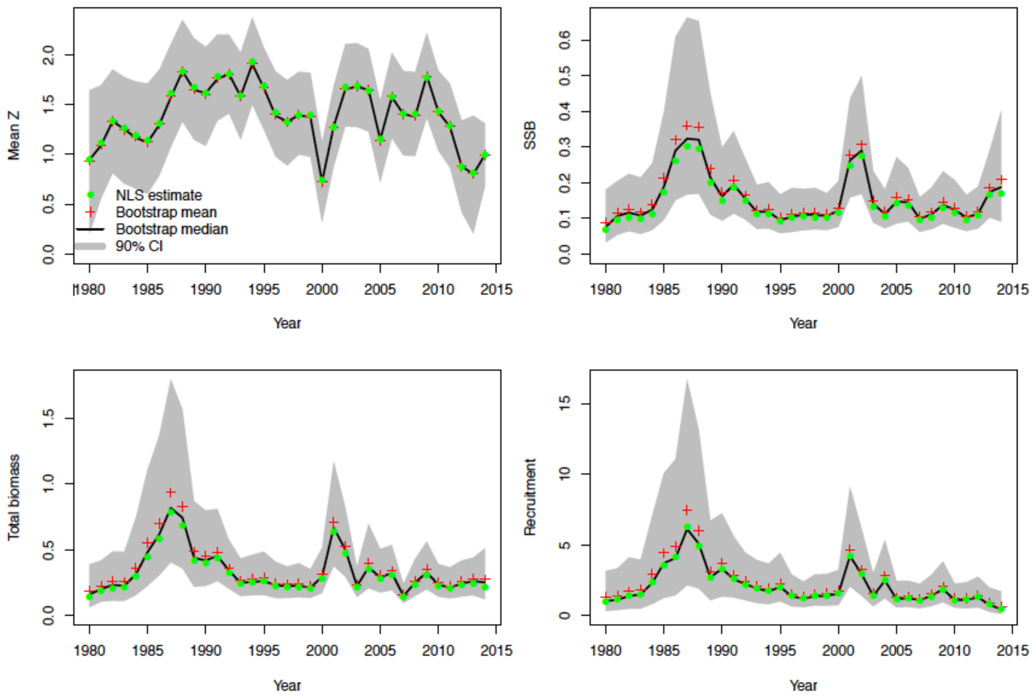
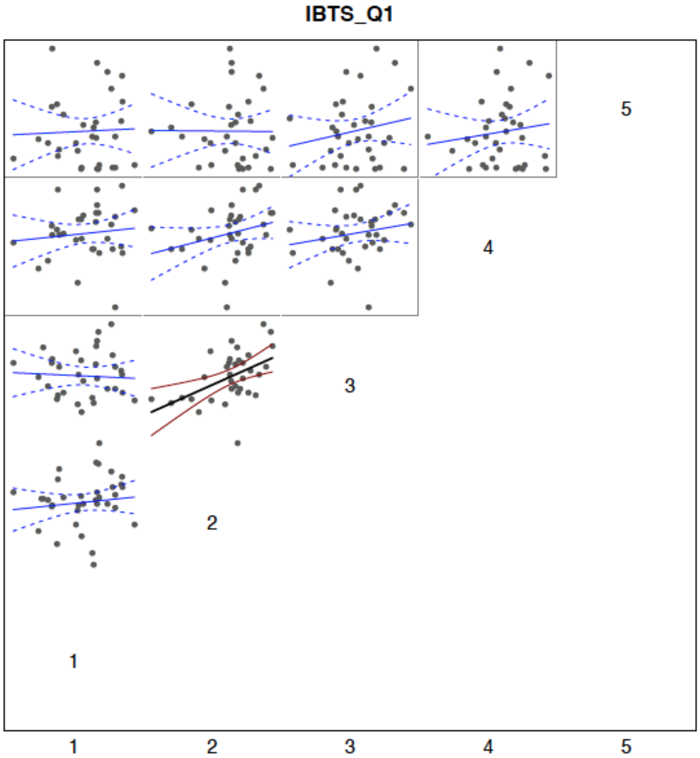


Figure 12.1.5. Whiting in Division 3.a. SURBAR analysis. Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootst



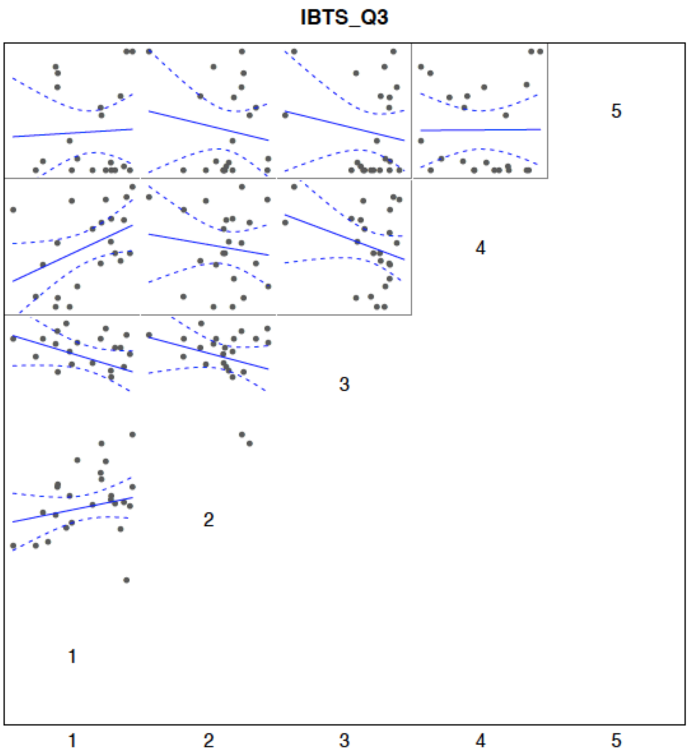


Figure 12.1.6 Whiting in Division 3.a. SURBAR analysis. IBTS indices per age class 1–5 for Q1 covering the years 1980–2015 and Q3 covering the years 1991–2014. The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year.

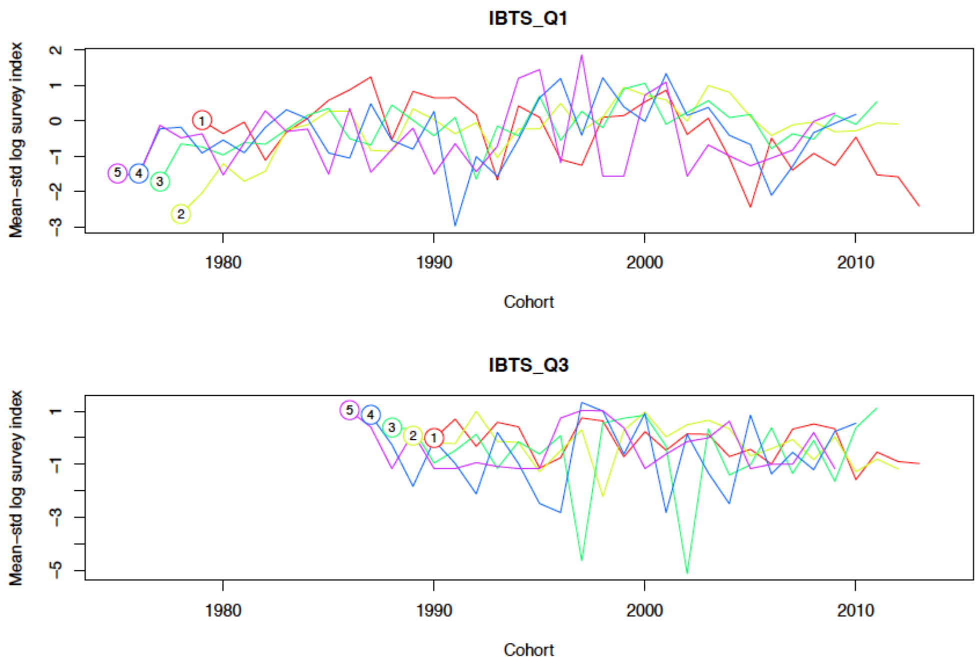


Figure 12.1.7 Whiting in Division 3.a. SURBAR analysis. Log residual estimates per age class for IBTS Q1 (upper line plots) and IBTS Q3 (lower line plots).

13 Haddock in Subarea 4 and Divisions 3.a.20 and 6.a (North Sea, Skagerrak and West of Scotland)

Until 2014, haddock in Subarea 4 and Divisions 3.a.20 and 6.a (referred to hereafter as Northern Shelf haddock) were assessed as two separate stocks: Subarea 4 and Division 3.a.20 by WGNSSK, and Division 6.a by WGCSE. The 2014 Benchmark Workshop for Northern Haddock Stocks (ICES-WKHAD 2014) concluded that the two notional haddock stocks should be assessed as one stock. This section presents the third annual ICES assessment of Northern Shelf haddock.

During the 2016 WGNSSK meeting, problems were identified with the update haddock assessment. These could not be rectified during the meeting, and a separate Interbenchmark Group (IBPHaddock) was convened to address the issue during the summer of 2016 (ICES-IBPHaddock 2016). IBPHaddock concluded that a) the existing TSA model code contained an error (and had done so since 2015), and that b) the corrected code produced a retrospective bias, which was addressed by modifying the treatment of recent above-average year-classes. The following Section reports the results of the corrected model produced during the IBPHaddock process, which was used as the basis for the 2017 advice (and revised 2016 advice) published in November 2016.

13.1 General

13.1.1 Ecosystem aspects

Ecosystem aspects are summarised in the Stock Annex.

13.1.2 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex. Most of the information presented below and in the Stock Annex pertains to the Scottish fleet, which takes the largest proportion of the haddock stock. This fleet is not just confined to the Northern Shelf area, as vessels will sometimes operate in Divisions 6.b (Rockall) and 5.b (Faroes).

13.1.2.1 Changes in fleet dynamics

There have been no decommissioning schemes affecting haddock fisheries since the major rounds in 2002 and 2004. A number of Scottish vessels have been taking up opportunities for oil support work during recent years with a view to saving quota and days at sea.

With the relatively limited cod and whiting quotas in recent years, many vessels have tended to concentrate more on the haddock fishery, with others taking the opportunity to move between the *Nephrops* and demersal fisheries (particularly during 2006 and 2007 – there may have been fewer boats changing focus in this way from 2008 to 2015). 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 have improved selectivity for haddock. Fish from the 2009 year-class still form the bulk of haddock catches (although the modestly large 2014 year-class started to contribute to landings towards the end of 2015), and discarding rates for the 2009 year-class fish declined during 2012 and 2013 as they grew beyond the minimum landings size. The decline may also have been due to other measures related to the Scottish Conservation

Credits scheme (CCS; see Section 13.1.4). Discard rates in 2015 increased once again, although the reasons for this are not clear.

Specific information on changes in the Scottish fleet during 2011-2015 was not provided to WGNSSK in 2016. It is difficult to reach a firm conclusion on the likely effect of recent fishery changes on haddock mortality. Changes in gear that were required to qualify for the Scottish CCS are likely to have reduced bycatch (and therefore discards) of haddock in the *Nephrops* fishery in particular. The inclusion of Scottish vessels in the CCS has been mandatory since the beginning of 2009, and compliance has been close to 100%. Cod avoidance under the real-time closures scheme (which is a component of the CCS) could also have moved vessels away from haddock concentrations, but the extent of this depends on how closely cod and haddock distributions are linked, and on how successful the avoidance strategies have been. On the other hand, vessels catching fewer cod may have increased their exploitation of haddock in order to maintain economic viability. It is unclear what changes in fleet dynamics and fishing behaviour may be caused by the impending EU landings obligation, due to be implemented for the majority of fleets catching Northern Shelf haddock in January 2016.

Following trials during 2010-2013, 26 Scottish demersal whitefish vessels participated in the 2014 Fully Documented Fishery (FDF) scheme (although 3 vessels left the scheme during the year). Similar trials have been conducted during various periods by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on haddock fisheries of an enforceable discard ban for cod, and in data collation for the haddock assessment it was assumed that FDF vessels would have similar haddock discard patterns as other vessels, but this remains to be verified. It should be noted that the Scottish FDF schemes implemented to date have all been restricted to the North Sea: cod discarding from CCTV vessels has remained legal in Division 6.a, and indeed has been mandatory for over-quota cod. The Scottish FDF scheme for 2015 continued without a break from the end of 2014, and included 24 vessels (although 6 left during the year). Currently, 12 vessels are participating in the scheme in 2016: the uptake of the scheme has declined due to concerns about monitoring of discards under the EU Landing Obligation.

13.1.2.2 Additional information provided by the fishing industry

Haddock are still the mainstay of the Scottish whitefish fleet, and have become increasingly so following cod-avoidance initiatives under the Scottish Conservation Credits scheme.

13.1.3 ICES advice

13.1.3.1 3.a.20 ICES advice for 2015

13.1.3.1.1 Subarea 4 and Divisions 3.a.20 and 6.a

From 2014 onwards, ICES advice is provided on the basis of the assessment stock unit, rather than the component management units. Hence, in November 2014 (following the application of the AGCREFA (ICES-AGCREFA 2008) update protocol, ICES concluded the following for the Northern Shelf haddock stock:

> *ICES advises on the basis of the MSY approach that catches should be no more than 68 690 t for the whole assessment area. If rates of discards and industrial bycatch do not change from the average of the last three years (2011–2013), this implies human*

consumption landings of no more than 50 163 t. Measures to reduce discards should be taken in order to protect the incoming recruitment.

13.1.3.2 ICES advice for 2016

13.1.3.2.1 Subarea 4 and Divisions 3.a.20 and 6.a

In June 2015, ICES concluded the following:

ICES advises that when the MSY approach is applied, catches in 2016 should be no more than 74 854 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 61 930 tonnes.

The application of the update protocol in September 2015 did not lead to a revision of the advice for this stock.

13.1.4 Management

Until 2014, North Sea haddock (Subarea 4 and Division 3.a.20) were jointly managed by the EU and Norway under an agreed management plan, the details of which are given in the Stock Annex. However, the validity and sustainability of the management plan when applied to the wider Northern Shelf area had not been evaluated by ICES, and advice could not be provided on the basis of the plan as a consequence. A separate management plan for Division 6.a was evaluated by ICES in 2008 to be precautionary, but similarly cannot be used to provide advice for the full stock area. A management plan for Northern Shelf haddock was to have been developed during 2015, but this has not yet occurred as the basis for management of shared EU-Norway stocks has still to be agreed. In the meantime the stock is managed according to advice based on the ICES MSY approach.

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), 166 (2013), 94 (2014) and 97 (2015). 114 closures were implanted during 2016, although the scheme was suspended on 20th November and there are no plans for its reintroduction. The CCS had 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 were also being made to reduce discards generally. Although the scheme was intended to reduce mortality on cod, it undoubtedly had an effect on the mortality of associated species such as haddock.

Studies tracking Scottish vessels during 2009-2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the haddock stock is still under investigation.

In 2015, 24 Scottish demersal whitefish vessels participated in a trial Fully Documented Fishery (FDF) scheme, following similar schemes during 2010-2014. The Scottish FDF scheme for 2016 began in April, and is being run along similar lines to previous years. At the time of writing, in May 2016, 12 vessels were included in the scheme, with each receiving an increase in cod quota and extra days at sea in return for landing all cod caught.

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. The remaining technical conservation measures in place for the haddock fisheries in Subarea 4 and Division 3.a.20 and 6.a are summarised in the Stock Annex.

Annual management of the fishery operates through TACs for three discrete areas. The first is Subarea 4 (and EU Waters of 2.a). The 2015 and 2016 TACs for haddock in this area were 40711 t and 61933 t respectively. The second is Division 3.a (EU waters), for which the TACs for 2015 and 2016 were 2504 t and 3926 t respectively. The third is Division 6.a, for which the TACs in 2015 and 2016 were 4536 t and 6462 t respectively.

13.2 Data available

13.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 13.2.1, together with the corresponding WG estimates and the agreed international quota (listed as "total allowable catch" or TAC). Since 2012, international data on landings and discards have been collated through the InterCatch system (see Section 1.2). Figure 13.2.1 and Tables 13.2.2 to 13.2.4 summarise the proportion of landings in the combined Northern Shelf area, for which samples have been provided. While there are a large number of fleets for which landings have not been sampled, the overall contribution of these fleets to total landings is small and more than 90% of landings by weight have been sampled appropriately. Age compositions for the remaining landings have therefore been determined by averaging across the available sampling (as for last year), without consideration of quarter, country or gear type. Similarly, discard observations are available for the fleets landing the vast majority of haddock (see Figure 13.2.2), so discard rates for the remaining fleets have also been inferred using simple averaging.

The full time series of landings, discards and industrial by-catch (IBC) is presented in Table 13.2.5. These data are illustrated further in Figure 13.2.3. The total landed yield of the international fishery has been relatively stable since 2007. The WG estimates (Table 13.2.5) suggest that haddock discarding (as a proportion of the total catch) decreased significantly during 2013, and the discard rate for that year was the lowest in the time series at 7.2% by weight. This may have been due in part to fleet behaviour changes related to cod avoidance measures, but also to the weak year-classes since 2009 (implying that the bulk of the catch was large, mature fish that are less likely to be discarded). The discard rate increased once more to around 11% by weight in 2014 and around 15% in 2015, although the reasons for this are not known. The recent changes in discarding are not consistent across ages (Figure 13.2.4).

Subarea 4 discard estimates are derived from data submitted by Denmark, Germany, England and Scotland. As Scotland is the principal haddock fishing nation in that area, Scottish discard practices dominate the overall estimates. DCF regulations oblige only the UK (Scotland and England) and Denmark to submit discard age-composition data for Subarea 4. Division 3.a discard estimates are derived from data submitted by Denmark. Division 6.a discard estimates are provided by UK (Scotland) and Ireland. Industrial bycatch (IBC) has declined considerably from the high levels observed until the late 1970s.

Estimated discard rates can be calculated using video data from Scottish vessels carrying cameras (as part of the FDF scheme described in Section 13.1.2). Neither fish ages nor weights can be measured directly using video, but a method has been developed in Scotland for estimating discard rates by measuring numbers and lengths of discarded fish and applying existing weight-length relationships to obtain a discarded weight, which can then be compared with the total landed weight (see Needle et al 2015). The lack of age information currently impedes the use of these estimates in the ICES assessment process, but work is underway in Scotland and elsewhere to address this.

13.2.2 Age compositions

Total catch-at-age data are given in Table 13.2.6, while catch-at-age data for each catch component are given in Tables 13.2.7 to 13.2.9. The fishery in 2015 (landings for human consumption) was still strongly reliant on the 2009 and 2012 year-classes. In the past, vessels have very seldom exhausted their quota in this fishery, and previous discarding behaviour is thought to be driven by a complicated mix of economic and other market-driven factors. From 2016 onwards, haddock fishing is covered by the EU Landing Obligation.

13.2.3 Weight at age

Weight-at-age for the total catch in the North Sea is given in Table 13.2.10. 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 13.2.11 to 13.2.13 and are illustrated in Figure 13.2.5: this shows the declining trend in weights-at–age for older ages in total catch and landings, as well as increasing trends for younger ages and 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 in the short-term forecast (Section 13.6).

13.2.4 Maturity and natural mortality

Maturity is assumed to be fixed over time and knife-edged at age 3 (that is, all fish aged 0-2 are assumed to be immature, all fish aged 3 and older are assumed to be fully mature). Natural mortality varies with age and year as shown in Figure 13.2.6 and Table 13.2.14. The general basis for these estimates is described in the Stock Annex, and these values shown here are derived from the WGSAM 2014 key run (as revised in 2015).

13.2.5 Catch, effort and research vessel data

The survey data available are summarised in the following table: data used in the final assessment are highlighted in bold.

Area	Country	Quarter	Code	Year range	Age range
Subarea 4	Scotland	Q3	ScoGFS Aberdeen Q3	1982-1997	0-8
Subarea 4	Scotland	Q3	ScoGFS Q3 GOV	1998-present	0-8
Subarea 4	England	Q3	EngGFS Q3 GRT	1977-1991	0-9
Subarea 4	England	Q3	EngGFS Q3 GOV	1992-present	0-9
Subarea 4 and Division 3.a	International	Q1	IBTS Q1	1983-present	1-5
Subarea 4 and Division 3.a	International	Q3	IBTS Q3	1991-present	0-5
Subarea 6.a	Scotland	Q1	ScoGFS-WIBTS Q1	1985-2010	1-8
Subarea 6.a	Scotland	Q1	New ScoGFS-WIBTS Q1	2011-present	1-8
Subarea 6.a	Scotland	Q4	ScoGFS-WIBTS Q4	1996-2009	0-7
Subarea 6.a	Scotland	Q4	New ScoGFS-WIBTS Q4	2011-present	0-7
Subarea 6.a	Ireland	Q4	IGFS-WIBTS-Q4	1993-2002	0-8
Subarea 6.a	Ireland	Q4	New IGFS-WIBTS-Q4	2003-present	0-8

The 2014 benchmark meeting (ICES-WKHAD 2014) concluded that only the North Sea IBTS Q1 and Q3 survey indices should be used to tune the Northern Shelf assessment. The West of Scotland surveys conducted by Scotland and Ireland covered too small a proportion of the overall stock area to be considered reliable indicators of overall stock dynamics, and the separate English and Scottish North Sea indices were only used previously because of the historical timing of the working group (WGNSSK met in early October when IBTS Q3 was not yet available). ICES-WKHAD (2014) recommended that the IBTS working group consider whether the North Sea IBTS Q1 and West of Scotland ScoGFS Q1 indices could be combined, but this is for future consideration.

Data used for the calibration of the assessment are presented in Table 13.2.15. Survey-based abundance distributions by age and year are given in Figures 13.2.7 (North Sea IBTS Q1), 13.2.8 (North Sea IBTS Q3) and 13.2.9 (Scottish West Coast IBTS Q4)). These demonstrate the concentration of North Sea haddock towards the north and west of the North Sea, quite widely along the continental shelf to the west of Scotland. The modestly large 2014 year-class is evident in all three surveys. Abundance trends in survey indices are shown in Figure 13.2.10. These indicate reasonably good consistency in stock signals from the two North Sea surveys, and support the perception of a modestly large 2014 year-class.

13.3 Data analyses

The assessment has been carried out using TSA (Fryer 2002) as the main assessment method. The results of SURBAR and SAM analyses are also shown, to corroborate (or otherwise) the main assessment.

13.3.1 Exploratory catch-at-age-based analyses

The catch-at-age data, in the form of log-catch curves linked by cohort (Figure 13.3.1), indicates partial recruitment to the fishery for most cohorts up to age 2. Gradients between consecutive values within a cohort have reduced considerably for some recent cohorts, reflecting a reduction in fishing mortality, although catch curves are considerably more variable in recent years suggesting less consistent catch data (which may reflect the lower sample size available from reduced landings). Figure 13.3.2 plots the negative gradient of straight lines fitted to each cohort over the age range 2–4, which can be viewed as a rough proxy for average total mortality for ages 2–4 in the cohort. These negative gradients are also lower in most recent cohorts, and the negative gradient measure for the 2010 cohort is the lowest in the time-series: it is itself negative, which in the absence of other information would indicate that the 2010 was increasing in size over time. As this cannot be the case, it suggests potential problems with recent catch data. It can also be seen that the negative gradient for the 2010 cohort (from ages 2-4) rises sharply, which suggests that fishing mortality may have increased in the most recent time-period.

Cohort correlations in the catch-at-age matrix (plotted as log-numbers) are shown in Figure 13.3.3. These correlations show good consistency within cohorts up to the plus-group, verifying the ability of the catch-at-age data over the full time-series to track relative cohort strengths (although data for ages 0 and 1 are slightly more variable, and recent years may be problematic as discussed above).

An exploratory SAM assessment was conducted, using the run settings stipulated in ICES-WKHAD (2014). The stock summary and residual plots from this run are given in Figure 13.3.4. The SAM assessment follows similar trends to the final TSA assessment, although the F estimates are less variable (see also Figure 13.3.10). There is evidence of some retrospective underestimation of mean F in the SAM runs, with a corresponding retrospective overestimation of SSB.

13.3.2 Exploratory survey-based analyses

A SURBAR run (ICES-WKADSAM 2010, Needle 2015) was carried out using the same combination of tuning indices as the TSA and SAM assessments. The summary plot from this run is given is Figure 13.3.5, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The SURBAR residual plot in Figure 13.3.6 shows that the surveys agree more closely in recent years than was the case at the 2014 WGNSSK meeting, although there remains an indication of some conflict (mostly negative residuals for Q1 and a more even spread for Q3. The plot of survey catch curves also shows reasonable consistency (Figure 13.3.7). The plots of mean-standardised log survey indices by age and cohort (Figure 13.3.8) and the pairwise within-survey correlations (Figure 13.3.9) show that both surveys track year-class strength well through the population overall. The results are discussed further in Section 13.3.4 below.

13.3.3 Assessment problems (May 2016)

During the May 2016 WGNSSK meeting, the update TSA assessment methodology was applied to the available catch and survey data, as stipulated in the Stock Annex. However, analysis of retrospective TSA runs revealed that, unlike for previous FLXSA, SAM and SURBAR retrospective analyses from previous WGs for North Sea haddock, and the 2014 and 2015 TSA assessments for Northern Shelf haddock, there was significant retrospective bias in this year's assessment. This bias caused an annual upwards adjustment in fishing mortality and a corresponding reduction in SSB. During the May meeting, WGNSSK hypothesised that this bias was caused by the way in which TSA partitions the variance in F estimates between transitory and persistent effects, but could not identify the precise cause with any certainty. The final assessment was also significantly different to the final assessment presented last year, with much lower SSB estimates and much higher F estimates in many years. The combination of internal problems (retrospective bias) and lack of consistency with last year's assessment led WGNSSK to recommend that the final assessment produced in May **not** be used as the basis for advice. This suggestion was subsequently confirmed by the Advice Drafting Group for the North Sea (ADGNS), which convened in June. A Review Group also met, which rejected the XSA model that had been proposed as a stop gap remedy, and the assessment was finally rejected. ICES then initiated an Interbenchmark Procedure for Haddock (IBPHaddock), which met by correspondence during the summer of 2016 to address the problems with the assessment.

13.3.4 Assessment revisions from IBPHaddock (November 2016)

The report of the IBP (ICES-IBPHaddock 2016) provides detailed information on the analyses performed and conclusions reached. The Executive Summary reads as follows:

> The Interbenchmark Workshop on Haddock in Subarea 4, Division 6.a and Subdivision 3.a.20 (IBPHaddock), chaired by José De Oliveira (UK) took place by correspondence during 4 meetings spread over several weeks (29 June – 29 September 2016). There were eight participants, including two external reviewers (both from the USA) and scientists from the UK and Germany. The main focus of the IBP was to investigate the cause of the apparent failure of the TSA model, to remedy this failure, if possible, or to consider alternative models, if not, and to re-estimate reference points based on the newly selected model. The IBP identified the problem as a retrospective pattern caused by the way in which the larger post-1999 recruitment events were treated, and was able to find a TSA model configuration that remedied this problem; this was achieved by not treating any of the post-1999 year-classes as "outstanding". The post-1999 period was then used as a basis for estimating reference points, apart from B_{lim} which was taken to be the lowest SSB that produced an outstanding year-class (1979).

In addition to a revision of the way that post-1999 larger year-classes were treated, the new configuration also limited the assumption of flat-topped selectivity to ages 7 and 8+ (thus allowing for dome-shaped selectivity in recent years, as indicated by exploratory SAM and XSA runs), and used external (data-driven) estimates for the CVs of the landings and discards data (rather than simpler assumptions used in previous implementations).

The outcome of the analysis was a newly-configured TSA model which presented greatly reduced retrospective bias, when compared to the update TSA model produced at the May 2016 WGNSSK meeting. This was used in turn to generate revised reference points (see Section 13.8) and an updated short-term forecast, which in addition incorporated the available 2016 Q3 IBTS survey data (thus removing the need for the usual update protocol).

During the IBP, it also became apparent that an error had arisen in the TSA code developed for the assessment presented by the 2015 WG. The error was related to the indexing of matrices and was very difficult to discover – it also only affected assessments which included age-0 data (and thus did not impinge on the TSA assessments used for other ICES stocks). The effect of the error was to overestimate SSB and underestimate *F*, leading to a falsely optimistic impression of the stock. ICES accordingly issued revised advice for the 2016 fishing year in November 2016, replacing the previous F(msy)-based advice of a 30% catch increase with advice for a 2% catch increase. The revised 2015 assessment is now much more consistent with the corresponding 2014 and 2016 assessments. It has also transpired that the updated advice is more in line with the available fishing opportunities for the year: as of mid-November 2016, the quota uptake for the year was still under 50%, indicating that the high quota advised for 2016 was not supported by the actual stock.

Mean-standardising SSB and recruitment estimates (using a common year-range for the mean) and generating TSA and SAM estimates of Z by adding F and M enables the comparison between TSA, SAM and SURBAR shown in Figure 13.3.10. SSB and recruitment estimates are very similar from the three models, although it is noticeable that the SURBAR estimates for large year-classes in particular tend to be higher, and the swings between high and low SURBAR SSB estimates are more pronounced than for TSA and SAM: the final year SSB estimate from SAM is very similar to that from TSA. The mean Z time-series from SURBAR is consistent with that from TSA, while the SAM mean Z estimates tend to be smoother, but the overall trends are not significantly different: again, we note that the final year mean Z estimate from SAM is lower than that from TSA. Overall, the SAM and SURBAR assessments concur with and support the final TSA assessment, with some relatively minor variations.

13.3.5 Final assessment

Table 13.3.1 gives the final TSA assessment settings, while Table 13.3.2 gives the corresponding parameter estimates from the completed run. A full description of the TSA method and the purposes of each parameter are given in the Stock Annex, and the ICES-WKHAD (2014) report. Note that, for assessment purposes, total catch is divided into human consumption landings (referred to as "landings") and a composite of discards and industrial bycatch (referred to as "discards" or "discards+bycatch"), as the selectivity characteristics of these latter components are similar.

The stock summary is given in Figure 13.3.11, with the stock-recruit plot in Figure 13.3.12 and the recruitment time-series in Figure 13.3.13. The latter plot shows that the underlying mean level of recruitment has declined from the early seventies until today, and recruitment remains low in general. Furthermore, the size of sporadic, larger year classes has diminished since the large 1999 year-class. Figure 13.3.14 summarises the observed and fitted discard+bycatch proportions by age, from which the decline in discard+bycatch rates across ages 2 to 4 in recent years can be seen.

Standardised prediction errors are given in Figures 13.3.15 (landings), 13.3.16 (discard+bycatch), 13.3.17 (the IBTS Q1 survey) and 13.3.18 (the IBTS Q3 survey). These are the principal diagnostic tools for fitting time-series Kalman filter models like TSA, and indicate the discrepancy between the model prediction and observation as the model steps through the data from the start to the end. They are a useful guide to suggest observations which might need to be downweighted, but as TSA also includes a backwards smoothing step they cannot be considered to be residuals in the usual sense.

The time-series of observed and fitted values for total catch (Figure 13.3.19), the IBTS Q1 survey (Figure 13.3.20) and the IBTS Q3 survey (Figure 13.3.21) are more interpretable in that context. The estimate of total catch at age-0 prior to 1991 is based on quite noisy discard+bycatch data where they are available, or on model inference where they are not (1973-1977), so for the earlier period model fits are not necessarily very close to observations. The other notable feature is that total catch tends to be overestimated for larger year-classes, whereas survey indices tend to be slightly underestimated for these year-classes: the TSA model fit is a compromise between the two.

Figure 13.3.22 summarises the results of TSA retrospective analyses for Northern Shelf haddock. As discussed in detail in the IBP report (ICES-IBPHaddock 2016), these show considerably less bias than the equivalent plots from the May 2016 assessment, due principally to a different treatment of recent larger year-classes.

Fishing mortality estimates for the final TSA assessment are presented in Table 13.3.3, the stock numbers in Table 13.3.4, and the assessment summary in Table 13.3.5.

13.4 Historical Stock Trends

The historical stock and fishery trends are presented in Figure 13.3.11.

Landings yields have stabilised since 2000, partly due (until 2014) to the limitation of inter-annual TAC variation to ±15% in the EU-Norway management plan for the North Sea. Discards have fluctuated in the same period due to the appearance and subsequent growth of the 1999, 2005 and 2009 year-classes, while industrial bycatch (IBC) is now at a very low level for haddock (see also Figure 13.2.3).

Estimated fishing mortality for 2008 to 2015 appears to fluctuate between 0.2 and 0.4 and remains above the new value of F(msy) of 0.19 (see Section 13.7) in 2015. Fluctuations around the previous target-F rate (0.3) 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 did not work. The 2006-2008 and 2010-2013 year-classes are estimated to have been very weak, and the fishery has been sustained in recent years by the 2005 and 2009 year-classes. The 2014 year-class is modest in size compared to the previous sporadic larger year classes and is below the long-term average for recruitment. Therefore, it is expected to make a smaller contribution to the stock compared to other "larger" year classes over the next few years.

13.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2016) and in the quota year (IY + 1 = 2017) are based on the TSA estimate of forecasted recruits at age 0 in the intermediate year, as this ensures consistency between assessment and forecast. At the time of the final assessment (November 2016), the results of the IBTS Q3 survey were available, and these were included in the TSA run.

The following table summarises the recruitment, age 1 and age 2 assumptions for the short term forecast.

Year class	Age in 2016	TSA estimate (millions)	TSA forecast (millions)
2014	2	618	
2015	1	541	
2016	0		3279
2017	Age 0 in 2017		3279
2018	Age 0 in 2018		3279

13.6 Short-term forecasts

Weights-at-age

Mean weights-at-age are forecast using the method proposed by Jaworski (2011) and discussed by ICES-WKHAD (2014). The method is also summarised in the Stock Annex, and involves fitting straight lines to cohort-based weight estimates and extrapolating forward in time.

The outcomes are summarized in Figures 13.6.1 (total catch), 13.6.2 (landings) and 13.6.3 (discards). There is insufficient data to allow for cohort-based modeling of weights-at-age in the industrial bycatch component, so simple three-year (2013-2015) means by age are used for all forecast years.

Fishing mortality

ICES-WKHAD (2014) concluded that fishing mortality estimates for the intermediate year should be taken to be the same as the final year, considering that F is smoothed within the TSA model. When this approach results in landings that overshoot the TAC, a TAC constraint should be considered: however, this is not the case for the 2016 intermediate year as the quota will not be fully utilised.

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 2013-2015) of each component to the total catch.

Splitting catch forecasts between management units

The haddock assessment presented in this section is for the combined Northern Shelf stock, following the conclusion from ICES-WKHAD (2014) that this was biologically appropriate. However, catch advice is still required for the extant management units. ICES-WKHAD (2014) proposed a survey-based method for splitting forecast catch into sub-units on the basis of a time-smoothed survey-based estimate of the proportion of the fishable stock in each area in each year. This is summarised in the Stock Annex.

However, the survey-based proportions were not accepted by ACOM (in June 2014) as the basis for advice, due to concerns over the comparability of survey catchability between the three management areas covered by the assessment area. As a consequence, the catch forecasts provided in Table 13.6.2 are provided for the full stock area only (Subarea 4 and Divisions 3.a and 6.a).

Forecast results

The inputs to the short-term forecast (conducted using the MFDP program) are presented in Table 13.6.1. Results for the short-term forecasts are presented in Table 13.6.2.

Assuming TSA-smoothed F in both 2016 and 2017, SSB is expected to decrease to 119 477 t in 2016, before rising in 2017 to 235 113 t. In this case, human consumption yield in 2016 would will be 62 993 t with associated discards of 15 985 t.

Several alternative options have been highlighted in Table 13.6.2. Among these are a forecast with total fishing mortality fixed to the level specified in the previous EU-Norway North Sea management plan (F = 0.3), a revised estimate of F_{msy} = 0.19 (see Section 13.7), and forecasts using a range of multipliers of F_{sq} as the basis. Under the assumption of F_{msy}, the 2017 total catch is forecast to be 39 461 t, which corresponds (if 2015 discard rates remain unchanged) to a wanted-catch yield of 33 385 t and unwanted catch of 6 071 t. This exploitation is forecast to lead in turn to SSB in 2018 of 205 595 t, a decrease of 13% on the 2017 forecast.

Table 13.6.2 includes an additional column, summarizing the percentage change between the wanted catch in 2015 and the forecast total catch in 2017. The WG proposes that this may be a more indicative comparison, as it circumvents the problem of the overly optimistic and incorrect forecast used as the basis for the 2016 advice issued in June 2015, while accounting for the inclusion in 2016 of haddock in the EU Landing Obligation regulation.

13.7 Medium-term forecasts

No specific medium-term forecasts have been carried out for this stock. Management simulations over the medium-term period were performed for North Sea haddock (Needle 2008a, b) and West of Scotland haddock (Needle 2010), as discussed briefly in Section 13.1.4 above.

13.8 Biological reference points

Following the estimation of revised F_{MSY} reference points at the 2014 WKMSYREF3 meeting, WGNSSK conducted further analysis using the EqSIM software to check that the estimated points remained valid following the update assessment. These analyses were repeated by the IBP following the modifications made to the assessment (ICES-IBPHaddock 2016). Figure 13.8.1 summarises the output from this analysis, which indicates that an appropriate value of F_{MSY} for Northern Shelf haddock is now 0.19. This is a reduction from the value set at WKMSYREF3 (0.37): the key difference in the estimates is that the calculation is based on the recruitment time-series from 2000-2015, rather than the full 1972-2015 time series. WGNSSK proposes that the former period is more appropriate, as recruitment does appear to be declining (see Figure 13.3.11) and it would be unwise to assume that a very large recruitment is likely in the near future.

Using the ICES guidelines for sporadic spawners, B_{lim} was revised to 94 kt (the estimated SSB for 1979, the smallest stock size to produce a good recruitment), and B_{pa} was revised to 1.4 x Blim = 132 kt (which was also used as the MSY $B_{trigger}$ value). An EqSim run with no advice error or rule generated F_{lim} = F_{p50} = 0.38, and F_{pa} = F_{lim}/1.4 = 0.27. A second EqSim run with advice error but no advice rule produced an estimate of F_{MSY} = 0.24 with the range of 0.18 to 0.30 (Figure 13.8.1, top plot). However, an EqSim run with advice error and rule showed that F_{p05} = 0.19 < F_{MSY} (Figure 13.8.1, bottom plot) so both F_{MSY} and the upper limit of the F_{MSY} range were constrained resulting in an F_{MSY} estimate of 0.19 and associated range of 0.18–0.19.

The reference points in full from this analysis are given below:

Variable	WKHAD (2014)	IBPHaddock (2016)
B_{lim}	63 kt	94 kt
B_{pa}	88 kt	132 kt
F_{lim}	n/a	0.38
F_{pa}	n/a	0.27
F_{MSY}	0.37	0.19

13.9 Quality of the assessment

Survey data are consistent both within and between surveys, and the catch data are internally consistent. Trends in mortality from catch data and survey indices are similar. Retrospective bias in the TSA model has been significantly reduced in the current implementation, and a previous coding error has been identified and removed.

13.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2015 and is now fluctuating around the historical minimum, although this remains above the most recent estimate of F_{msy} (0.19). Discard rates have increased slightly above the historical minimum observed in 2013, but remain low. The 2010-2013 year-classes were estimated to be weak, following the relatively strong 2009 year-class, but the 2014 year-class is slightly larger than the recent average. Recruitment since the very large 1999 year-class has generally been low, compared with the historical time series. Spawning stock biomass is predicted to decrease during 2016 to below B_{pa} (132kt) before increasing in 2017 as the 2014 year-class matures.

13.11 Management Considerations

The previous EU-Norway management plan for North Sea haddock, and the EU management plan for Division 6.a haddock, are not appropriate for the Northern Shelf stock, as they relate to only a part of the full stock area. Discussions are ongoing between the EU and Norway which may establish a new management strategy on the basis of the Northern Shelf stock. However, even if agreed this will require evaluation, and in the meantime the principal basis for management of this haddock stock is the MSY approach. The survey-based proposal for splitting catch advice into management subunits, which was proposed by WGNSSK in 2014, has not been agreed by ACOM, and the split of quota into management units remains based on historical landings. It is unlikely, therefore, to follow any future changes in stock distribution across the Northern Shelf.

Considering the Northern Shelf as a whole, fishing mortality declined significantly in the early 2000s and has fluctuated around a relatively low level since. However, the current estimate remains above the proposed new value of F_{msy}. Spawning stock biomass is estimated to have reached a historical peak in 2002 with the growth of the large 1999 year-class, but declined again rapidly and is now driven strongly by occasional moderate year-classes. The most recent of these occurred in 2005, 2009 and 2014: other recent cohorts have been very weak. SSB is likely to decline further in the future, even with low fishing mortality, until the maturation of the 2014 year-class in 2017. However, the impact on SSB of the 2014 year class is expected to be less than previous moderate year classes.

Keeping fishing mortality close to the target MSY level would be preferable to encourage the sustainable exploitation of the 2009 and 2014 year-classes. Estimated discard rates are now low, which may be due partly to the lack of small fish in the population, and partly due to an increased awareness of discard problems following public campaigns and (particularly) the installation of CCTV monitoring cameras on a number of vessels. However, discard rates do remain high in certain small-mesh fisheries (such as the TR2 *Nephrops* fleets in Division 6.a). 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 included in the EU Landings Obligation regulation from 2016, though the impacts on fishing and on the stock are as yet unknown.

Haddock is a specific target for some fleets, but is also caught as part of a mixed fishery catching cod, whiting and *Nephrops*. It is important to consider both the species-specific assessments of these species for effective management, as well as the latest developments in the mixed fisheries approach. This is not straightforward when stocks are managed via a series of single-species, single-area management plans that do not incorporate mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another and the implications of any change need to be considered carefully.

13.12 Assessment frequency

Regarding the Northern Shelf haddock assessment, the following summarises the WGNSSK responses to each of the criteria:-

- Stocks are considered candidates for biennial assessment if the advice for the stock has been 0-catch or equivalent for the latest three advice years.
    - This **does not apply** for haddock.

Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously.

- Life span (i.e. maximum normal age) of the species is larger than 5 years.
    - This **applies** to haddock.
- The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x Fmsy OR if Fmsy range has been defined: F(latest assessment year) is <= Fupper (upper bound in F range) AND SSB(start of intermediate year) >= MSY Btrigger
    - This **does not apply** to haddock.
- The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.
    - The first age in the assessment of haddock is zero. Applying the method given here, 2% of the catch is at age zero. Using age-1 instead (which would be the recruiting age for most comparable stocks) gives 3%. So the criterion **applies** to haddock as given.
- The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by more than 20%. The formula to

be used in the calculations is: $\rho = \frac{1}{7}\sum_{u=Y-7}^{Y-1}\left(1 - \frac{F_{u,u}}{F_{u,Y}}\right)$. The result should be < 0.20, where F_(u,u) is F in year u estimated from an assessment that ends in year u, and F_(u,Y) is the F in year u estimated from the most recent assessment (which ends in year Y)

- Mohn's rho for haddock is 0.22, so this criterion **does not apply**.

The stability table is difficult to complete for this stock, because the stock definition changed in 2014 and the predicted catch from original component stocks is not directly comparable. In addition, neither the 2011 nor the 2012 advice included a catch prediction for 2014 – such a prediction was not made until the 2013 advice. A further complication for haddock is that the forecast must still be run using the MFDP program, because the corresponding FLR function does not yet allow for a third catch component (industrial bycatch, in this case). This should be possible within FLR, but the required development work has not yet been completed and MFDP is the only option in the meantime. The problem for this exercise is that MFDP can only carry out a standard one-year ahead forecast, rather than the two-year ahead forecast required for the frequency analysis.

Therefore, Northern Shelf haddock does not pass all the given criteria. In 2015, the stock did pass all the criteria, but WGNSSK argued that it still may not be a good candidate for less frequent assessment in any case. The reason is that stock dynamics are driven very strongly by the occasional (and completely unpredictable) appearance of large year-classes, and an assessment schedule that was unable to respond sufficiently quickly to these recruitment events would rapidly lead to a serious disjunction between the stock abundance and the available quota. In the context of the EU Landings Obligation, this would be particularly problematic. On the other hand, it generally takes two years for the recruits observed at age 0 in the IBTS Q3 survey to *fully* recruit to the human consumption fishery, so a two-year quota *may* be sufficient to account for large incoming year-classes. It is hard to be certain what the outcome would be, however, without more comprehensive risk analyses.

This leads to the more general point. One further opinion expressed during the WGNSSK discussion on this issue was that relatively simple tests would generally be insufficient to determine the risk of unwanted outcomes, should the frequency of assessments for a particular stock be reduced. Such an exercise would require a simulation analysis of the type used to evaluate management plans and strategies. An approach of this kind would take considerable time that would not be available during the WG meeting itself, and would thus require the implementation of a directed Expert Group or coordinated intersessional work. Several members of WGNSSK have tried to set up such a Group within ICES in recent years to no avail, and the difficulty of instigating this work should not be underestimated. There remains a real concern that the simple application of the criteria could lead rapidly to very undesirable outcomes which cannot be predicted without a more robust risk analysis.

13.13 References

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Table 13.2.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Nominal landings (000 t) during 2006–2015, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2015 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota. Note that the United Kingdom did not provide official landings for 2012.

Division 3.a										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
DE	186	206	87	105	65	102	120	90	114	103
DK	1001	1054	1052	1263	1139	1661	1916	1456	1763	1057
NL	0	0	0	0	1	0	0	5	6	4
NO	113	152	170	121	81	125	239	223	81	63
PT	30	37	0	0	0	0	0	0	0	0
SE	246	278	276	166	126	198	210	217	219	202
UK	0	0	0	0	0	0	0	3	0	0
Subarea 4										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BE	106	178	112	108	78	106	78	78	98	45
DE	726	727	393	657	634	575	548	677	677	599
DK	759	645	501	552	725	697	947	1283	1079	1426
ES	0	0	0	0	0	0	0	0	0	0
FO	4	0	3	32	5	0	0	0	0	0
FR	444	498	448	135	276	320	175	177	209	101
GL	5	8	0	4	0	0	0	0	0	0
IE	0	0	0	0	0	0	0	0	0	0
IS	0	0	0	0	0	0	0	0	0	0
NL	33	55	29	24	41	71	191	172	99	43
NO	1798	1706	1482	1278	1126	1195	1069	1661	2705	2004
PL	8	8	16	0	0	0	0	0	0	0
PT	76	0	0	0	0	0	0	0	0	0
SE	100	130	83	141	90	128	103	113	154	135
UK	32390	26717	27365	28393	24983	23343	0	32993	29758	25852
Division 6.a										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
DE	7	0	1	0	1	0	0	0	0	0
ES	44	5	10	21	28	36	15	0	19	9
FO	1	2	0	0	0	0	0	0	0	0
FR	291	211	151	136	89	73	32	51	67	41
IE	526	759	879	297	396	290	845	746	653	768
NO	17	16	28	18	9	4	0	6	15	7
UK	4947	2780	1776	2380	2415	1364	0	3878	3230	3051
Northern Shelf										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Official landings	43858	36172	34862	35831	32308	30288	6488	43830	40945	35520
ICES landings	43334	34672	33058	35590	31940	36570	38162	43681	41143	35316
ICES discards	23094	32651	14503	12326	13071	13067	5032	3038	5090	6255
ICES IBC	535	48	199	52	431	24	1	54	65	21
ICES total catch	66962	67371	47759	47968	45442	49661	43195	46772	46295	41571
TAC 4	51850	54640	46444	42110	35794	34057	39000	45041	38284	40711
TAC 3.a	3189	3360	2856	2590	2201	2100	2095	2770	2355	2504
TAC 6.a	7810	7200	6120	3520	2670	2005	6015	4211	3988	4536
Total TAC	62849	65200	55420	48220	40665	38162	47110	52022	44627	47751
ICES quota uptake	69%	53%	60%	74%	79%	96%	81%	84%	92%	74%

Table 13.2.2. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Proportion of sampling strata for discards imported into InterCatch and proportion of discards raised from averaged discard rates.

Catch category	Raised or imported	Weight (tonnes)	Proportion
DISCARDS	RAISED	610622	10
DISCARDS	IMPORTED	5583761	90
LANDINGS	IMPORTED	35490794	100

Table 13.2.3 Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Proportion of age distributions for landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Weight (tonnes)	Proportion
LANDINGS	IMPORTED	SAMPLED	31776693	90
LANDINGS	IMPORTED	ESTIMATED	3539434	10
DISCARDS	IMPORTED	SAMPLED	5508464	88
DISCARDS	RAISED	ESTIMATED	616607	10
DISCARDS	IMPORTED	ESTIMATED	130143	2

Table 13.2.4 Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Proportion by area of distributions for landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Area	Weight (tonnes)	Proportion
Landings	Imported	Sampled	IIIaN	1041917	73
Landings	Imported	Estimated	IIIaN	380466.8	27
Discards	Raised	Estimated	IIIaN	58622.38	41
Discards	Imported	Sampled	IIIaN	50341.03	35
Discards	Imported	Estimated	IIIaN	35591.27	2
Landings	Imported	Sampled	IV	25595184	90
Landings	Imported	Estimated	IV	2877496	10
Discards	Imported	Sampled	IV	4128573	90
Discards	Raised	Estimated	IV	452611	10
Discards	Imported	Estimated	IV	15566.43	0
Landings	Imported	Sampled	IVa	1180255	99
Landings	Imported	Estimated	IVa	15471.65	1
Discards	Raised	Estimated	IVa	34601.67	58
Discards	Imported	Sampled	IVa	18180.07	30
Discards	Imported	Estimated	IVa	6959.729	12
Landings	Imported	Estimated	IVb	195995.6	71
Landings	Imported	Sampled	IVb	80037.57	29
Discards	Raised	Estimated	IVb	13529.61	39
Discards	Imported	Estimated	IVb	11143.41	32
Discards	Imported	Sampled	IVb	9786.963	28
Discards	Imported	Estimated	IVc	0	NA
Landings	Imported	Sampled	VIa	3879299	98
Landings	Imported	Estimated	VIa	70003.73	2
Discards	Imported	Sampled	VIa	1301582	92
Discards	Raised	Estimated	VIa	57241.97	4
Discards	Imported	Estimated	VIa	60882.39	4

Table 13.2.5. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Working Group estimates of catch components by weight (000 tonnes). *Note that Subarea 4 and Division 3.a.20 data are collated together in 2013, and are listed here only in the Subarea 4 section.

	Subarea 4				Division 3.a			Division 6.a			Combined			
Year	Landings	Discards	IBC	Total	Landings	Discards	Total	Landings	Discards	Total	Landings	Discards	IBC	Total
1965	161.7	62.3	74.6	298.6	0.7		0.7	32.5	3.4	35.9	194.9	65.7	74.6	335.2
1966	225.6	73.5	46.7	345.8	0.6		0.6	29.9	0.7	30.6	256.1	74.2	46.7	377.0
1967	147.4	78.2	20.7	246.3	0.4		0.4	20.3	7.4	27.7	168.1	85.6	20.7	274.4
1968	105.4	161.8	34.2	301.4	0.4		0.4	20.5	25.3	45.8	126.3	187.1	34.2	347.6
1969	331.1	260.1	338.4	929.5	0.5		0.5	26.3	25.2	51.5	357.9	285.3	338.4	981.6
1970	524.1	101.3	179.7	805.1	0.7		0.7	34.1	6.2	40.3	558.9	107.5	179.7	846.1
1971	235.5	177.8	31.5	444.8	2		2	46.3	12.2	58.5	283.8	190.0	31.5	505.3
1972	193	128	29.6	350.5	2.6		2.6	41.1	16.4	57.5	236.7	144.4	29.6	410.7
1973	178.7	114.7	11.3	304.7	2.9		2.9	28.8	11.4	40.2	210.4	126.1	11.3	347.8
1974	149.6	166.4	47.5	363.5	3.5		3.5	18.0	15.4	33.3	171.1	181.8	47.5	400.3
1975	146.6	260.4	41.5	448.4	4.8		4.8	13.7	33.0	46.6	165.1	293.4	41.5	499.9
1976	165.7	154.5	48.2	368.3	7		7	18.8	15.3	34.1	191.5	169.8	48.2	409.5
1977	137.3	44.4	35	216.7	7.8		7.8	19.3	4.4	23.7	164.4	48.8	35	248.2
1978	85.8	76.8	10.9	173.5	5.9		5.9	17.2	1.1	18.3	108.9	77.9	10.9	197.7
1979	83.1	41.7	16.2	141	4		4	14.8	6.5	21.3	101.9	48.2	16.2	166.3
1980	98.6	94.6	22.5	215.7	6.4		6.4	12.8	4.8	17.5	117.8	99.4	22.5	239.6
1981	129.6	60.1	17	206.7	6.6		6.6	18.2	7.1	25.3	154.4	67.2	17	238.6
1982	165.8	40.6	19.4	225.8	7.5		7.5	29.6	7.7	37.3	202.9	48.3	19.4	270.6
1983	159.3	66	12.9	238.2	6		6	29.4	3.4	32.8	194.7	69.4	12.9	277.0
1984	128.2	75.3	10.1	213.6	5.4		5.4	30.0	8.1	38.1	163.6	83.4	10.1	257.1
1985	158.6	85.2	6	249.8	5.6		5.6	24.4	10.7	35.1	188.6	95.9	6	290.5
1986	165.6	52.2	2.6	220.4	2.7		2.7	19.6	5.2	24.7	187.9	57.4	2.6	247.8
1987	108	59.1	4.4	171.6	2.3		2.3	27.0	11.1	38.1	137.3	70.2	4.4	211.9
1988	105.1	62.1	4	171.2	1.9		1.9	21.1	5.0	26.1	128.1	67.1	4	199.2
1989	76.2	25.7	2.4	104.2	2.3		2.3	16.7	2.5	19.2	95.2	28.2	2.4	125.8
1990	51.5	32.6	2.6	86.6	2.3		2.3	10.1	0.8	11.0	63.9	33.4	2.6	100.0
1991	44.7	40.2	5.4	90.2	3.1		3.1	10.6	4.8	15.3	58.4	45.0	5.4	108.7
1992	70.2	47.9	10.9	129.1	2.6		2.6	11.3	3.5	14.9	84.1	51.4	10.9	146.5
1993	79.6	79.6	10.8	169.9	2.6		2.6	19.1	7.0	26.1	101.3	86.6	10.8	198.7
1994	80.9	65.4	3.6	149.8	1.2		1.2	14.2	5.0	19.2	96.3	70.4	3.6	170.3
1995	75.3	57.4	7.7	140.4	2.2		2.2	12.4	7.7	20.0	89.9	65.1	7.7	162.6
1996	76	72.5	5	153.5	3.1		3.1	13.5	7.8	21.3	92.6	80.3	5	177.9
1997	79.1	52.1	6.7	137.9	3.4		3.4	12.9	7.5	20.4	95.4	59.6	6.7	161.7
1998	77.3	45.2	5.1	127.6	3.8		3.8	14.4	7.0	21.4	95.5	52.2	5.1	152.8
1999	64.2	42.6	3.8	110.7	1.4		1.4	10.4	3.9	14.3	76.0	46.5	3.8	126.3
2000	46.1	48.8	8.1	103	1.5		1.5	7.0	6.3	13.2	54.6	55.1	8.1	117.7
2001	39	118.3	7.9	165.2	1.9		1.9	6.7	8.5	15.2	47.6	126.8	7.9	182.3
2002	54.2	45.9	3.7	103.8	4.1		4.1	7.1	9.4	16.5	65.4	55.3	3.7	124.4
2003	40.1	23.5	1.1	64.8	1.8	0.2	2	5.3	4.5	9.8	47.2	28.2	1.1	76.5
2004	47.3	15.4	0.6	63.2	1.4	0.1	1.6	3.2	4.5	7.7	51.9	20.0	0.6	72.5
2005	47.6	8.4	0.2	56.2	0.8	0.2	1	3.1	3.8	6.9	51.5	12.4	0.2	64.1
2006	36.1	16.9	0.5	53.6	1.5	1	2.5	5.7	5.2	10.9	43.3	23.1	0.5	66.9
2007	29.4	27.8	0	57.3	1.5	0.8	2.3	3.7	4.0	7.8	34.6	32.6	0	67.3
2008	28.9	12.5	0.2	41.6	1.4	0.6	2	2.8	1.3	4.1	33.1	14.4	0.2	47.7
2009	31.3	10	0.1	41.3	1.5	0.6	2.1	2.8	1.8	4.6	35.6	12.4	0.1	48.1
2010	27.8	9.5	0.4	37.7	1.3	0.6	1.9	2.9	2.9	5.8	32.0	13.0	0.4	45.4
2011	26.3	10.2	0	36.5	9.9	1.7	11.6	1.7	1.5	3.3	37.9	13.4	0	51.4
2012	30.3	3.7	1.2	35.0	2.6	0.7	3.4	5.1	0.5	5.6	38.0	4.9	1.2	44.1
2013*	38.9	2.0	0.1	41.0				4.7	1.1	5.8	43.7	3.0	0.1	46.8
2014	34.9	4.1	0.1	39.1	2.3	0.1	2.4	4.0	0.8	4.8	41.1	5.1	0.1	46.3
2015	30.2	4.2	0.0	34.3	1.4	0.1	1.5	3.9	1.3	5.2	35.3	6.3	0.0	41.6

Table 13.2.6. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Numbers at age data (thousands) for total catch. Ages 0-7 and 8+ and years 1972-2015 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	650218	368560	16491	721514	36301	4954	2245	626	118	97	47	0	0	0	0	0	262
1966	1672925	1007517	26186	7536	459941	11903	1109	633	222	90	23	2	0	0	0	0	337
1967	345371	856339	108401	5814	3850	202830	2843	223	231	61	34	0	0	0	0	0	326
1968	11133	1226448	477603	22671	2303	3210	60034	1052	84	22	5	0	0	0	0	0	111
1969	75301	20554	3736629	313593	9029	2678	2894	23704	392	32	7	0	0	0	0	0	431
1970	941790	272467	218881	2003201	60200	1350	1285	401	6539	81	13	19	0	0	0	0	6652
1971	337277	1881729	74866	50845	480381	10916	589	201	167	1767	176	3	5	0	0	0	2119
1972	255110	696714	671965	43309	23547	211817	4067	241	53	27	475	11	0	0	0	0	566
1973	79461	412305	587335	260080	6450	5689	72652	1406	140	34	234	49	5	0	0	0	462
1974	665110	1283252	187149	342628	60523	1956	1795	22380	345	57	63	4	7	4	0	0	480
1975	51796	2276937	673960	62175	112242	17691	1078	718	6168	339	70	11	0	8	0	0	6596
1976	171400	192030	1127520	225532	11538	32677	5864	228	84	1863	64	3	5	0	0	0	2019
1977	119506	263702	109480	426291	45756	4984	6757	1608	163	40	460	8	0	1	0	0	672
1978	281785	223294	130963	31141	144703	11791	1582	2322	740	122	33	275	16	2	0	0	1188
1979	844410	261156	220200	45487	7978	38097	3069	377	629	181	57	13	52	3	0	0	935
1980	374573	439674	374310	80225	11364	2040	11143	827	143	168	96	34	9	7	1	0	457
1981	645352	116229	430149	180553	17044	2225	497	3320	164	78	26	32	5	1	4	0	311
1982	275508	217834	89989	390347	49835	4275	820	551	1072	60	28	8	2	2	0	0	1172
1983	513034	148158	222772	83199	166812	20055	2365	338	255	385	93	21	4	4	0	0	763
1984	95862	483045	139887	143821	29321	56077	6238	967	127	84	185	19	5	1	1	0	423
1985	127003	161400	441785	80605	41508	7082	18393	1929	296	56	29	144	9	0	0	1	535
1986	45703	137091	144075	328016	29497	10595	1686	4421	581	156	56	47	37	16	4	1	898
1987	10249	253236	259369	56407	92705	6214	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	16679	33092	424014	96795	17161	27728	2030	874	368	1076	95	21	12	13	17	1	1603
1989	19587	51743	43162	216359	21015	4189	7671	763	285	170	469	69	8	3	2	1	1007
1990	19286	82571	78881	17811	60888	4373	1104	1839	254	100	54	13	12	1	4	2	439
1991	128703	188087	101425	24822	4706	17618	1388	684	1024	171	65	11	11	1	2	2	1287
1992	277933	166550	255051	43257	7162	1486	6376	611	337	401	149	22	6	2	0	0	918
1993	136841	302610	269220	123469	11822	1986	669	2050	215	210	188	84	4	4	0	0	706
1994	89104	91674	339428	106673	35056	3381	601	366	746	132	48	36	26	5	0	0	992
1995	200151	336460	119210	182969	33802	9237	898	161	155	151	21	8	6	2	1	0	345
1996	167032	46797	505401	73987	66245	11159	4058	1080	75	72	37	9	8	3	1	0	205
1997	36954	162449	107657	251339	18037	18288	2762	937	121	16	18	5	4	4	2	0	170
1998	21919	88387	224037	60861	128348	7110	4590	850	263	60	7	8	3	2	1	1	345
1999	90634	69455	119094	110046	28510	45221	2700	2047	438	53	8	3	3	2	0	0	507
2000	12630	397390	110381	61263	33137	7254	9935	765	367	53	13	2	1	1	0	0	438
2001	3518	95086	633162	34548	12078	5573	2094	1611	257	89	28	3	4	0	0	0	382
2002	50927	36063	99685	372036	7812	2801	1615	729	603	283	25	8	5	0	0	0	923
2003	7082	13136	15234	48729	127241	2166	786	339	144	100	48	5	1	0	0	0	299
2004	3758	25698	24627	8958	38784	97827	1010	248	82	42	37	12	1	0	0	0	174
2005	8779	17695	24596	15085	5446	27745	61457	371	132	38	11	8	4	1	0	0	193
2006	3229	122537	30995	20657	11284	6078	16415	32978	156	56	20	7	4	1	0	0	243
2007	2046	20565	171600	16796	8187	4782	2237	6876	7254	75	8	14	3	1	0	0	7355
2008	3780	15005	31864	75341	4757	2050	1516	566	1432	2570	5	8	1	1	0	0	4017
2009	10483	11042	15303	20764	78513	1860	845	567	239	276	569	6	2	0	0	0	1092
2010	2930	108139	17377	17834	11301	38134	853	416	160	83	85	148	9	0	0	3	488
2011	3003	6082	66355	17091	14138	11495	23124	677	282	95	17	5	60	0	0	0	459
2012	1319	3389	5260	66109	5388	3670	2416	7900	157	178	68	44	57	24	4	0	532
2013	1285	11998	4394	4838	68899	2269	1539	879	3896	37	7	8	2	2	2	0	3954
2014	3537	7504	19838	4818	7799	46760	1104	980	390	1706	14	6	1	1	0	2	2121
2015	3820	27637	15799	17624	1730	5166	22109	1059	433	437	782	107	0	0	0	0	1759

Table 13.2.7. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
1965	0	2670	3908	396363	30232	4358	2126	620	118	97	47	0	0	0	0	0	262
1966	0	13034	6899	5332	419437	11113	1082	631	222	90	23	2	0	0	0	0	337
1967	0	55548	40030	4627	3607	198991	2821	223	231	61	34	0	0	0	0	0	326
1968	0	22108	151474	17130	2160	3176	59110	1051	84	22	5	0	0	0	0	0	111
1969	0	143	759680	175763	7965	2282	2760	23452	392	32	7	0	0	0	0	0	431
1970	0	2428	52031	1211535	53570	1184	1220	398	6539	81	13	19	0	0	0	0	6652
1971	0	35945	27011	37832	448352	10551	582	201	167	1767	176	3	5	0	0	0	2119
1972	0	13354	233966	35440	22165	210167	4054	241	53	27	475	11	0	0	0	0	566
1973	0	7277	211018	209961	6085	5459	72528	1406	140	34	234	49	5	0	0	0	462
1974	0	25699	55734	236624	53054	1868	1679	22156	345	57	63	4	7	4	0	0	480
1975	0	28773	211495	41030	93617	17406	1073	718	6163	339	70	11	0	8	0	0	6591
1976	0	3045	246027	155162	11292	29594	5846	228	84	1863	64	3	5	0	0	0	2019
1977	0	8934	33058	278741	42737	4737	6516	1608	163	40	460	8	0	1	0	0	672
1978	0	13913	55636	26119	123655	11479	1496	2317	740	122	33	275	16	2	0	0	1187
1979	0	16077	120456	38247	7752	37353	3052	377	629	181	57	13	52	3	0	0	935
1980	0	11487	154765	67241	9978	1985	11057	820	143	166	96	34	9	7	1	0	456
1981	0	1959	174018	128102	16447	2219	494	3320	164	78	26	32	5	1	4	0	311
1982	0	7623	40161	282492	45732	3811	820	551	1072	60	28	8	2	2	0	0	1172
1983	0	7669	114118	57151	152477	19147	2201	338	255	385	93	21	4	4	0	0	763
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706
1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381
2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284
2008	0	299	6472	50965	4461	1986	1378	563	1402	2566	5	8	1	1	0	0	3983
2009	0	486	4605	9666	61972	1775	793	521	239	276	566	6	2	0	0	0	1088
2010	0	1089	5150	12597	10176	35718	828	416	146	83	85	147	9	0	0	3	473
2011	0	224	16505	15260	13321	11383	22889	677	282	95	16	5	60	0	0	0	458
2012	0	261	3286	52091	4884	3660	2408	7885	157	178	68	44	57	24	4	0	532
2013	0	983	2493	4338	66123	2240	1526	867	3868	37	6	8	2	2	2	0	3924
2014	0	232	12630	3832	7626	42509	1100	965	382	1703	14	6	1	1	0	2	2110
2015	0	717	10574	16080	1636	5135	21121	1059	433	437	780	107	0	0	0	0	1758

Table 13.2.8. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
1965	5757	111654	4897	141863	3704	4	1	0	0	0	0	0	0	0	0	0	0
1966	13832	445648	12742	1197	24643	35	2	0	0	0	0	0	0	0	0	0	0
1967	46372	408281	62831	1032	219	1576	9	0	0	0	0	0	0	0	0	0	0
1968	67	741402	244976	3512	97	15	186	0	0	0	0	0	0	0	0	0	0
1969	4475	5234	1273332	39179	432	16	8	0	0	0	0	0	0	0	0	0	0
1970	68905	99125	78340	306391	2663	13	4	0	0	0	0	0	0	0	0	0	0
1971	14189	1275394	37883	9623	25648	66	2	0	0	0	0	0	0	0	0	0	0
1972	18446	444794	380988	6846	1236	1212	13	0	0	0	0	0	0	0	0	0	0
1973	38129	287558	363916	50108	354	33	123	0	0	0	0	0	0	0	0	0	0
1974	88456	982287	99148	59143	2869	6	4	0	0	0	0	0	0	0	0	0	0
1975	7479	1653311	377845	16385	13423	143	0	0	0	0	0	0	0	0	0	0	0
1976	6418	122012	698428	41183	200	137	0	0	0	0	0	0	0	0	0	0	0
1977	16364	107748	47070	79922	664	9	0	0	0	0	0	0	0	0	0	0	0
1978	1193	83683	63997	4214	19568	248	80	0	0	0	0	0	0	0	0	0	0
1979	4795	119245	82074	5734	142	365	0	0	0	0	0	0	0	0	0	0	0
1980	258	146751	197725	4726	96	0	0	0	0	0	0	0	0	0	0	0	0
1981	442	15023	225773	47838	157	1	0	0	0	0	0	0	0	0	0	0	0
1982	505	36063	35089	94315	2293	0	0	0	0	0	0	0	0	0	0	0	0
1983	24327	76672	94323	20914	12092	905	164	0	0	0	0	0	0	0	0	0	0
1984	3275	361946	48893	23714	1623	3317	0	0	0	0	0	0	0	0	0	0	0
1985	4924	146668	156400	3624	115	1	16	0	0	0	0	0	0	0	0	0	0
1986	13007	84333	75071	39219	23	1	0	0	0	0	0	0	0	0	0	0	0
1987	1996	159860	134988	9142	2795	2	0	0	0	0	0	0	0	0	0	0	0
1988	7399	27412	244105	10535	427	10	0	0	24	0	0	0	0	0	0	0	24
1989	10673	43756	23611	67102	1048	23	35	0	2	0	2	0	0	0	0	0	4
1990	16290	69073	30530	1772	4932	28	25	0	0	0	0	0	0	0	0	0	0
1991	11794	143967	40697	1163	17	107	0	0	0	0	0	0	0	0	0	0	0
1992	36231	82605	115933	4063	97	0	6	0	0	0	0	0	0	0	0	0	0
1993	12346	191714	163172	17474	170	1	0	3	0	0	0	0	0	0	0	0	0
1994	19197	75840	254112	20271	2069	30	0	0	0	0	0	0	0	0	0	0	0
1995	2118	231490	84163	67644	2539	199	0	0	0	0	0	0	0	0	0	0	0
1996	22563	35010	413599	28996	10344	36	0	0	0	0	0	0	0	0	0	0	0
1997	15260	114893	69948	106789	1700	425	0	0	0	0	0	0	0	0	0	0	0
1998	2936	77065	162251	15801	20732	88	11	0	0	0	0	0	0	0	0	0	0
1999	20814	57336	83205	46764	1905	2561	49	0	0	0	0	0	0	0	0	0	0
2000	8472	320463	55818	24661	5703	321	201	0	0	0	0	0	0	0	0	0	0
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0
2004	3758	24613	21221	3967	14548	19811	5	4	0	0	0	0	0	0	0	0	0
2005	8779	16730	18722	6181	1258	4826	4496	1	1	0	0	0	0	0	0	0	1
2006	3229	118636	19862	8636	2634	823	1596	2520	6	1	1	0	0	0	0	0	8
2007	2045	19393	142509	5585	826	97	38	103	71	0	0	0	0	0	0	0	71
2008	3768	14623	25111	24195	243	46	134	2	30	4	0	0	0	0	0	0	34
2009	10468	10521	10601	11050	16522	79	50	46	0	1	4	0	0	0	0	0	5
2010	2930	102881	11872	5201	1125	2415	25	0	14	0	0	1	0	0	0	0	15
2011	3002	5858	49830	1817	806	105	224	0	0	0	1	1	0	0	0	0	2
2012	1319	3128	1973	14017	503	11	7	15	0	0	0	0	0	0	0	0	0
2013	1285	11014	1898	494	2695	26	11	12	24	0	1	0	0	0	0	0	25
2014	3537	7272	7187	980	161	4185	2	14	7	1	0	0	0	0	0	0	8
2015	3820	26920	5225	1545	94	31	989	0	0	0	2	0	0	0	0	0	2

Table 13.2.9. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
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	0
1988	9280	3309	12819	2462	620	202	0	0	0	0	0	0	0	0	0	0	0
1989	8914	2541	1751	2789	460	37	86	10	0	0	0	0	0	0	0	0	0
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0
1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198033	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0
2004	0	590	265	84	258	753	8	4	0	0	0	0	0	0	0	0	0
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	0	1
2007	1	27	218	6	1	0	0	0	0	0	0	0	0	0	0	0	0
2008	12	82	280	180	52	18	4	1	0	0	0	0	0	0	0	0	0
2009	15	36	97	48	19	6	2	0	0	0	0	0	0	0	0	0	0
2010	0	4169	355	36	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	19	14	11	7	12	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	1	3	5	82	3	2	1	5	0	0	0	0	0	0	0	5
2014	0	0	20	6	12	67	2	2	1	3	0	0	0	0	0	0	3
2015	0	6	9	1	3	12	1	0	0	0	0	0	0	0	0	0	0

Table 13.2.10. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
1965	0.010	0.070	0.227	0.370	0.655	0.846	1.170	1.190	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.088	0.247	0.394	0.536	0.962	1.254	1.512	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.014	0.116	0.278	0.478	0.591	0.641	1.072	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.129	0.254	0.516	0.743	0.827	0.829	1.483	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.012	0.064	0.217	0.410	0.817	0.905	1.029	1.074	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.013	0.075	0.222	0.353	0.738	0.925	1.195	1.246	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000
1971	0.012	0.109	0.246	0.359	0.509	0.888	1.269	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.025	0.117	0.242	0.383	0.503	0.585	0.987	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.043	0.118	0.239	0.369	0.578	0.611	0.648	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.025	0.129	0.226	0.339	0.536	0.867	0.828	0.863	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.023	0.105	0.240	0.353	0.442	0.678	1.190	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.014	0.129	0.225	0.394	0.505	0.578	0.916	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.020	0.111	0.238	0.339	0.586	0.612	0.787	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000
1978	0.011	0.104	0.254	0.396	0.424	0.707	0.784	0.921	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.009	0.093	0.287	0.417	0.611	0.669	0.931	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.012	0.081	0.276	0.464	0.693	0.985	0.908	1.264	1.511	1.501	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.009	0.060	0.264	0.445	0.726	1.055	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.010	0.074	0.286	0.423	0.759	1.109	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.011	0.132	0.303	0.431	0.612	0.904	1.211	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.010	0.142	0.303	0.461	0.645	0.736	1.077	1.205	1.821	2.030	1.732	1.950	2.422	2.822	4.995	0.000
1985	0.010	0.148	0.296	0.466	0.649	0.835	0.934	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.023	0.123	0.261	0.406	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.010	0.125	0.264	0.405	0.594	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.042	0.163	0.232	0.411	0.581	0.731	1.203	1.363	1.281	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.036	0.200	0.282	0.367	0.590	0.770	0.935	1.259	1.586	1.507	1.034	1.534	2.431	2.559	2.307	0.980
1990	0.040	0.187	0.313	0.422	0.506	0.795	0.995	1.179	1.495	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.030	0.175	0.308	0.454	0.574	0.644	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.019	0.102	0.306	0.466	0.717	0.923	0.903	1.382	1.514	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.010	0.110	0.282	0.454	0.660	0.877	1.053	1.062	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.018	0.121	0.247	0.435	0.599	0.846	1.240	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.012	0.107	0.290	0.369	0.581	0.774	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.022	0.126	0.241	0.382	0.484	0.746	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.029	0.138	0.280	0.360	0.585	0.634	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.027	0.153	0.255	0.396	0.444	0.665	0.777	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.025	0.166	0.250	0.356	0.477	0.510	0.735	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.052	0.121	0.256	0.355	0.480	0.605	0.656	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.029	0.111	0.219	0.321	0.466	0.658	0.735	0.945	1.690	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.017	0.109	0.255	0.311	0.527	0.703	0.829	0.818	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.024	0.082	0.221	0.327	0.400	0.681	0.758	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.039	0.139	0.238	0.378	0.395	0.440	0.686	0.926	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.054	0.160	0.271	0.364	0.495	0.479	0.522	0.925	1.054	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.042	0.126	0.283	0.352	0.442	0.507	0.538	0.550	1.048	1.395	2.031	2.525	1.834	3.532	5.274	2.580
2007	0.042	0.159	0.227	0.407	0.478	0.538	0.657	0.700	0.745	0.902	2.272	0.971	1.712	2.348	4.244	0.000
2008	0.030	0.170	0.256	0.366	0.593	0.662	0.714	0.928	0.924	0.878	1.689	1.970	0.988	0.224	3.792	3.024
2009	0.048	0.175	0.305	0.323	0.388	0.677	0.799	0.839	1.308	1.318	1.025	1.045	1.150	3.091	2.115	0.000
2010	0.016	0.078	0.288	0.411	0.454	0.466	0.710	0.899	1.269	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.017	0.140	0.260	0.399	0.434	0.466	0.534	0.661	0.864	0.558	1.484	1.787	1.593	0.000	0.000	0.000
2012	0.035	0.160	0.439	0.408	0.576	0.706	0.711	0.654	1.278	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.034	0.172	0.425	0.599	0.487	0.727	0.854	0.796	0.758	1.085	1.842	2.191	2.607	1.810	2.512	0.000
2014	0.042	0.139	0.433	0.589	0.656	0.537	0.780	0.831	0.923	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.031	0.145	0.417	0.561	0.752	0.698	0.631	0.685	0.970	0.725	0.715	0.719	1.448	2.954	0.000	0.000

Table 13.2.11. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
1965	0.000	0.308	0.348	0.413	0.680	0.904	1.211	1.197	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.000	0.300	0.382	0.445	0.554	1.001	1.275	1.515	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.000	0.260	0.399	0.530	0.610	0.646	1.077	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.000	0.256	0.360	0.595	0.769	0.832	0.835	1.484	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.000	0.178	0.302	0.508	0.878	0.989	1.058	1.081	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.000	0.249	0.309	0.402	0.787	0.997	1.235	1.250	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000
1971	0.000	0.256	0.332	0.393	0.525	0.905	1.280	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.000	0.243	0.325	0.415	0.518	0.587	0.989	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.000	0.228	0.310	0.400	0.596	0.621	0.649	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.000	0.268	0.314	0.381	0.567	0.882	0.866	0.867	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.000	0.254	0.336	0.400	0.476	0.683	1.193	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.000	0.243	0.331	0.452	0.509	0.601	0.917	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.000	0.272	0.344	0.381	0.595	0.625	0.800	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000
1978	0.000	0.257	0.333	0.427	0.456	0.717	0.812	0.922	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.000	0.262	0.348	0.447	0.620	0.675	0.932	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.000	0.274	0.347	0.501	0.706	0.992	0.907	1.261	1.511	1.499	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.000	0.334	0.364	0.503	0.734	1.056	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.000	0.299	0.349	0.478	0.788	1.153	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.000	0.320	0.375	0.464	0.624	0.914	1.242	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.000	0.280	0.350	0.493	0.666	0.764	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000
1985	0.000	0.279	0.348	0.478	0.651	0.844	0.935	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.000	0.277	0.348	0.428	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.000	0.265	0.335	0.440	0.603	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.000	0.236	0.322	0.437	0.594	0.732	1.203	1.363	1.370	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.000	0.319	0.356	0.413	0.602	0.769	0.934	1.256	1.579	1.507	1.025	1.534	2.431	2.559	2.307	0.980
1990	0.000	0.260	0.372	0.439	0.525	0.796	1.015	1.196	1.504	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.000	0.269	0.363	0.462	0.576	0.645	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.000	0.287	0.367	0.486	0.723	0.924	0.904	1.382	1.515	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.000	0.293	0.372	0.484	0.666	0.878	1.053	1.067	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.000	0.269	0.378	0.473	0.617	0.851	1.241	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.000	0.316	0.400	0.424	0.600	0.782	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.000	0.326	0.364	0.471	0.519	0.747	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.000	0.344	0.410	0.418	0.615	0.641	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.000	0.271	0.370	0.441	0.470	0.670	0.778	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.000	0.297	0.349	0.422	0.490	0.523	0.746	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.000	0.334	0.368	0.421	0.515	0.617	0.663	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.000	0.379	0.352	0.448	0.483	0.675	0.735	0.946	1.695	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.000	0.427	0.446	0.397	0.569	0.713	0.829	0.901	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.000	0.283	0.377	0.464	0.441	0.684	0.759	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.000	0.366	0.383	0.474	0.454	0.468	0.688	0.932	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.000	0.399	0.399	0.428	0.548	0.516	0.536	0.926	1.056	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.000	0.392	0.386	0.418	0.493	0.546	0.574	0.583	1.093	1.431	2.109	2.643	1.926	3.592	5.292	2.709
2007	0.000	0.379	0.385	0.466	0.497	0.542	0.662	0.705	0.748	0.902	2.272	0.971	1.712	2.348	4.244	0.000
2008	0.000	0.357	0.408	0.414	0.607	0.668	0.754	0.931	0.935	0.879	1.703	1.970	0.988	0.224	3.792	3.024
2009	0.000	0.443	0.434	0.410	0.416	0.691	0.830	0.882	1.309	1.321	1.029	1.045	1.150	3.091	2.115	0.000
2010	0.000	0.278	0.473	0.457	0.471	0.476	0.721	0.899	1.364	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.016	0.266	0.358	0.411	0.442	0.468	0.535	0.661	0.864	0.559	1.456	1.698	1.593	0.000	0.000	0.000
2012	0.000	0.358	0.525	0.445	0.606	0.707	0.712	0.654	1.279	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.000	0.437	0.564	0.625	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000

Table 13.2.12. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
1965	0.062	0.131	0.203	0.335	0.607	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.053	0.141	0.208	0.245	0.309	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.043	0.170	0.210	0.273	0.306	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.054	0.181	0.212	0.257	0.317	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.049	0.129	0.216	0.238	0.300	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.057	0.131	0.210	0.239	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.052	0.135	0.202	0.244	0.264	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.045	0.140	0.207	0.239	0.261	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.051	0.135	0.201	0.237	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.046	0.146	0.201	0.234	0.259	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.041	0.126	0.201	0.257	0.275	0.348	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.053	0.172	0.198	0.239	0.291	0.337	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.062	0.191	0.198	0.220	0.306	0.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.042	0.175	0.199	0.222	0.225	0.265	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.037	0.128	0.221	0.245	0.259	0.314	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.051	0.147	0.232	0.276	0.325	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.074	0.160	0.199	0.296	0.621	0.727	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.055	0.194	0.247	0.265	0.289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.066	0.184	0.237	0.343	0.458	0.711	0.792	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.047	0.160	0.245	0.315	0.309	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.040	0.154	0.221	0.271	0.356	0.423	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.057	0.140	0.185	0.246	0.337	0.329	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.026	0.160	0.201	0.227	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.072	0.167	0.172	0.239	0.256	0.352	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.054	0.188	0.229	0.266	0.336	0.708	0.844	0.000	2.572	0.000	3.048	0.000	0.000	0.000	0.000	0.000
1990	0.047	0.189	0.229	0.248	0.264	0.290	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.059	0.179	0.238	0.341	0.464	0.480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.136	0.246	0.282	0.345	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.028	0.139	0.237	0.287	0.355	0.369	0.000	0.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.042	0.130	0.212	0.273	0.310	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.044	0.132	0.250	0.276	0.356	0.384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.047	0.133	0.218	0.279	0.297	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.060	0.159	0.250	0.286	0.322	0.374	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.075	0.159	0.232	0.293	0.317	0.391	0.428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.047	0.182	0.217	0.273	0.308	0.304	0.227	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.049	0.129	0.245	0.278	0.316	0.355	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.049	0.115	0.206	0.300	0.301	0.300	0.000	0.411	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.044	0.125	0.223	0.267	0.334	0.382	0.000	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.042	0.124	0.223	0.261	0.327	0.536	0.630	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.039	0.135	0.218	0.263	0.299	0.330	0.639	0.650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.054	0.150	0.232	0.273	0.318	0.301	0.342	0.499	0.493	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.042	0.121	0.231	0.265	0.279	0.274	0.217	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.042	0.146	0.195	0.291	0.314	0.358	0.375	0.356	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.030	0.166	0.217	0.262	0.365	0.456	0.317	0.454	0.427	0.596	0.321	0.000	0.000	0.000	0.000	0.000
2009	0.048	0.162	0.250	0.248	0.282	0.394	0.315	0.357	0.366	0.409	0.452	0.000	0.000	0.000	0.000	0.000
2010	0.016	0.076	0.209	0.303	0.307	0.315	0.350	0.523	0.284	0.000	0.000	1.445	0.000	0.000	0.000	0.000
2011	0.017	0.135	0.227	0.297	0.310	0.352	0.351	0.000	0.000	0.000	2.027	2.215	0.000	0.000	0.000	0.000
2012	0.035	0.143	0.295	0.271	0.286	0.406	0.353	0.392	0.633	0.488	0.316	0.000	0.000	0.000	0.000	0.000
2013	0.034	0.148	0.243	0.362	0.345	0.498	1.355	0.533	0.842	0.000	2.113	0.000	0.000	0.000	0.000	0.000
2014	0.042	0.133	0.298	0.336	0.394	0.340	0.572	0.617	0.475	0.885	0.000	0.000	0.000	0.000	0.000	0.000
2015	0.031	0.141	0.261	0.347	0.377	0.411	0.407	0.634	0.634	0.000	1.082	0.000	0.000	0.000	0.000	0.000

Table 13.2.13. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. 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+
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000
2012	0.451	0.762	1.045	1.498	1.854	2.098	2.188	2.317	2.541	2.173	2.324	2.121	2.452	2.368	0.000	0.000
2013	0.000	0.437	0.564	0.626	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.830
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000

Table 13.2.14. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Estimates of natural mortality from the most recent key run of SMS (ICES-WGSAM 2014).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1966	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1967	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1968	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1969	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1970	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1971	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1972	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1973	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1974	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1975	1.511	1.528	0.820	0.511	0.441	0.314	0.264	0.238	0.217	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1976	1.551	1.547	0.798	0.494	0.417	0.306	0.261	0.233	0.215	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1977	1.583	1.565	0.775	0.477	0.393	0.297	0.257	0.230	0.212	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1978	1.605	1.578	0.753	0.462	0.372	0.287	0.252	0.226	0.210	0.206	0.200	0.232	0.232	0.232	0.232	0.232
1979	1.618	1.583	0.731	0.447	0.351	0.277	0.246	0.222	0.208	0.205	0.200	0.231	0.231	0.231	0.231	0.231
1980	1.624	1.579	0.708	0.433	0.333	0.269	0.240	0.219	0.207	0.205	0.200	0.230	0.230	0.230	0.230	0.230
1981	1.622	1.566	0.685	0.420	0.318	0.261	0.235	0.217	0.205	0.205	0.200	0.228	0.228	0.228	0.228	0.228
1982	1.616	1.539	0.662	0.409	0.306	0.256	0.230	0.215	0.204	0.204	0.200	0.226	0.226	0.226	0.226	0.226
1983	1.609	1.500	0.637	0.398	0.297	0.253	0.226	0.214	0.203	0.204	0.200	0.224	0.224	0.224	0.224	0.224
1984	1.603	1.452	0.612	0.387	0.291	0.251	0.224	0.213	0.202	0.204	0.200	0.222	0.222	0.222	0.222	0.222
1985	1.597	1.404	0.589	0.376	0.287	0.249	0.222	0.212	0.202	0.203	0.200	0.219	0.219	0.219	0.219	0.219
1986	1.589	1.358	0.567	0.366	0.284	0.248	0.221	0.211	0.201	0.203	0.200	0.217	0.217	0.217	0.217	0.217
1987	1.577	1.318	0.545	0.357	0.282	0.247	0.220	0.210	0.201	0.202	0.200	0.215	0.215	0.215	0.215	0.215
1988	1.555	1.285	0.525	0.349	0.281	0.246	0.220	0.209	0.201	0.202	0.200	0.213	0.213	0.213	0.213	0.213
1989	1.525	1.257	0.507	0.341	0.281	0.246	0.220	0.209	0.201	0.201	0.200	0.211	0.211	0.211	0.211	0.211
1990	1.487	1.234	0.489	0.333	0.280	0.245	0.220	0.209	0.201	0.201	0.200	0.210	0.210	0.210	0.210	0.210
1991	1.444	1.215	0.472	0.325	0.280	0.244	0.220	0.209	0.201	0.201	0.200	0.208	0.208	0.208	0.208	0.208
1992	1.401	1.203	0.458	0.319	0.279	0.243	0.220	0.209	0.202	0.200	0.200	0.207	0.207	0.207	0.207	0.207
1993	1.364	1.196	0.446	0.313	0.278	0.241	0.220	0.209	0.202	0.200	0.200	0.207	0.207	0.207	0.207	0.207
1994	1.333	1.194	0.437	0.309	0.278	0.240	0.220	0.210	0.203	0.200	0.200	0.206	0.206	0.206	0.206	0.206
1995	1.311	1.197	0.430	0.306	0.277	0.240	0.220	0.210	0.203	0.200	0.200	0.205	0.205	0.205	0.205	0.205
1996	1.298	1.202	0.425	0.305	0.277	0.240	0.221	0.211	0.204	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1997	1.292	1.211	0.422	0.305	0.276	0.241	0.221	0.211	0.205	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1998	1.292	1.222	0.421	0.305	0.275	0.241	0.222	0.211	0.205	0.200	0.200	0.203	0.203	0.203	0.203	0.203
1999	1.299	1.238	0.420	0.306	0.274	0.241	0.223	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2000	1.310	1.260	0.421	0.306	0.272	0.240	0.223	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2001	1.320	1.289	0.424	0.306	0.271	0.241	0.224	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2002	1.322	1.320	0.430	0.306	0.271	0.241	0.225	0.212	0.205	0.201	0.200	0.204	0.204	0.204	0.204	0.204
2003	1.313	1.346	0.437	0.306	0.271	0.243	0.226	0.213	0.205	0.202	0.200	0.205	0.205	0.205	0.205	0.205
2004	1.291	1.362	0.446	0.305	0.271	0.246	0.228	0.214	0.205	0.202	0.200	0.206	0.206	0.206	0.206	0.206
2005	1.259	1.361	0.456	0.303	0.272	0.248	0.229	0.215	0.205	0.202	0.200	0.208	0.208	0.208	0.208	0.208
2006	1.222	1.346	0.466	0.303	0.274	0.252	0.231	0.216	0.205	0.203	0.201	0.209	0.209	0.209	0.209	0.209
2007	1.183	1.320	0.479	0.304	0.277	0.256	0.232	0.216	0.205	0.203	0.201	0.212	0.212	0.212	0.212	0.212
2008	1.147	1.288	0.492	0.308	0.283	0.263	0.233	0.216	0.204	0.203	0.201	0.214	0.214	0.214	0.214	0.214
2009	1.115	1.257	0.507	0.313	0.290	0.273	0.235	0.216	0.204	0.202	0.201	0.216	0.216	0.216	0.216	0.216
2010	1.089	1.231	0.523	0.321	0.300	0.286	0.238	0.216	0.203	0.202	0.201	0.219	0.219	0.219	0.219	0.219
2011	1.067	1.212	0.541	0.332	0.312	0.301	0.242	0.217	0.202	0.201	0.201	0.219	0.219	0.219	0.219	0.219
2012	1.046	1.199	0.561	0.344	0.326	0.319	0.247	0.218	0.201	0.201	0.201	0.219	0.219	0.219	0.219	0.219
2013	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219
2014	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219
2015	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219

Table 13.2.15. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS Q1					
1983	2016				
1	1	0.00	0.25		
1	5				
100	302.278	403.079	89.463	116.447	13.182
100	1072.285	221.275	127.77	20.41	20.9
100	230.968	833.257	107.598	32.317	3.575
100	573.023	266.912	303.546	17.888	6.49
100	912.559	328.062	45.201	58.262	4.345
100	101.691	677.641	97.149	12.684	13.965
100	219.06	97.372	273.008	16.604	2.114
100	217.448	139.114	32.997	50.367	3.163
100	680.231	134.076	25.032	4.26	8.476
100	1141.396	331.044	17.035	3.026	0.664
100	1242.121	519.521	152.384	8.848	1.076
100	227.919	491.051	97.656	23.308	1.566
100	1355.485	201.069	176.165	24.354	5.286
100	267.411	813.268	65.869	46.691	7.734
100	848.966	354.766	466.823	24.987	15.238
100	357.597	420.926	103.531	112.632	8.758
100	211.139	222.907	127.063	48.217	36.649
100	3734.174	107.12	48.609	24.497	15.58
100	901.378	2216.722	75.408	14.506	7.244
100	57.312	473.628	1309.589	9.179	6.886
100	89.991	39.267	241.529	532.024	5.354
100	71.745	79.256	36.962	176.352	324.91
100	70.189	51.885	38.458	14.057	54.576
100	1158.194	46.081	28.477	9.896	4.837
100	109.44	963.393	35.962	14.956	3.019
100	61.357	107.39	241.221	14.886	1.592
100	75.068	141.444	102.986	135.595	2.528
100	674.962	71.132	68.015	51.48	90.942
100	46.068	781.507	101.666	35.942	47.87
100	14.006	66.409	390.588	21.18	15.108
100	58.227	24.55	32.549	93.814	6.488
100	24.066	104.024	18.339	49.978	126.068
100	388.205	32.597	29.955	3.879	9.103
100	104.434	282.372	15.419	11.375	1.905

Table 13.2.15. (cont.) **Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Data available for calibration of the assessment. Only those data used in the final assessment are shown here. Note that these pertain to the assessment produced by IBPHaddock in November 2016, so the Q3 2016 data is included (as it was used in that assessment).**

North Sea IBTS Q3						
1991	2016					
1	1	0.50	0.75			
0	5					
100	718.479	233.55	22.921	2.842	0.507	1.561
100	2741.14	595.235	189.015	10.529	1.583	0.396
100	577.382	605.99	140.146	37.604	2.36	0.372
100	1781.191	195.331	262.643	32.423	8.383	0.381
100	520.855	1019.607	106.642	97.383	8.06	3.131
100	627.502	247.469	428.471	30.426	20.215	2.649
100	195.255	347.567	123.793	149.048	6.672	5.282
100	276.401	257.14	164.853	53.69	42.66	3.093
100	6904.537	176.457	94.108	47.947	13.268	9.904
100	1092.83	2511.127	44.361	19.494	10.29	4.276
100	34.751	360.531	1100.248	30.305	6.377	3.653
100	138.204	49.504	223.792	583.061	10.079	2.601
100	163.924	69.356	31.171	199.252	368.656	2.942
100	183.977	69.539	40.556	23.119	82.685	154.82
100	1412.973	67.605	45.54	16.254	9.845	37.095
100	191.608	547.284	27.543	11.709	3.612	3.352
100	111.475	149.743	385.791	10.354	5.35	1.126
100	126.428	86.627	89.934	174.968	5.206	2.253
100	909.334	77.703	79.994	38.131	73.972	1.643
100	30.294	557.39	59.017	34.214	25.186	53.33
100	30.64	77.035	344.508	27.159	12.209	9.196
100	68.068	31.515	40.248	132.237	7.344	4.397
100	86.249	58.345	25.17	18.291	82.779	2.515
100	747.522	48.207	58.51	5.216	9.093	51.625
100	104.274	463.428	22.807	15.993	1.662	2.307
100	351.819	94.546	219.874	8.057	3.669	0.400

Table 13.3.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. TSA final assessment: Model settings. ω is a multiplier on the permitted variance of the estimated value: a higher setting for ω indicates greater downweighting of that value in the overall assessment.

LANDINGS	AGES	0–8+
	Years	1972-2015
Discards	Ages	0-8+
	Years	1972, 1978-2015
Industrial bycatch	Ages	0-8+
	Years	1972, 1978-2015
Survey: NS IBTS Q1	Ages	1-5
	Years	1983-2016
Survey: NS IBTS Q3	Ages	0-5
	Years	1991-2016
Maturity		Knife-edge at age 3 (interim measure)
Natural mortality		Age- and time-varying from North Sea SMS key runs
Catch weights		Catch abundance-weighted average of North Sea and West of Scotland catch weights
Stock weights		Set equal to catch weights (interim measure)
Large year-classes ($\lambda = 5$)		1974, 1979, 1999
Age-dependent F variability		$H(a) = (2,1,1,1,1,1,1,1,1)$
F plateau		$a_m = 5$
Measurement-error multiplier for landings		$B_{landings}(a) = (*, 3.7, 1.3, 1, 1.1, 1.4, 1.6, 2.7, 2.8)$
Measurement-error multiplier for discards+bycatch		$B_{discards}(a) = (2.0, 1.7, 1, 1.5, 1.8, 2.4, *, *, *)$
Downweighted landings outliers		1996, age 7 (ω = 3)
Downweighted discards+bycatch outliers		1982, age 5; 2012, age 2 (ω = 3 for both)
Downweighted survey outliers		NS IBST Q1: 2011, age 5 (ω = 3)

Table 13.3.2. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. TSA final assessment: Parameter estimates.

	estimate	lower bound	upper bound	Estimated	on bound
F age 0	0.0351	0.005	0.1	TRUE	FALSE
F age 1	0.0795	0.05	0.15	TRUE	FALSE
F age 2	0.8515	0.6	1	TRUE	FALSE
F age 7	1.306	1	1.4	TRUE	FALSE
sd F	0.1621	0.01	0.2	TRUE	FALSE
sd U	0.069	0.01	0.15	TRUE	FALSE
sd V	0.1446	0.01	0.2	TRUE	FALSE
sd Y	0.1544	0.01	0.25	TRUE	FALSE
cv landings	0.1492	0.1	0.3	TRUE	FALSE
cv discards	0.2874	0.2	0.4	TRUE	FALSE
log mean recruitment at start	7.2937	7	9	TRUE	FALSE
sd of random walk	0.0713	0	0.25	TRUE	FALSE
recruitment cv	0.5236	0.3	0.6	TRUE	FALSE
discards sd transitory	0.0091	0	0.35	TRUE	FALSE
discards sd persistent	0.3378	0.25	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2527	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.6436	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.7099	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5823	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4609	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.3469	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.2138	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.0898	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2248	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3717	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5643	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.4903	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3858	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.3477	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.2382	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.083	0	0.3	TRUE	FALSE
NSQ3 omega	0.0925	0	0.3	TRUE	FALSE
NSQ3 beta	0	0	0.1	FALSE	TRUE

Table 13.3.3. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Estimates of fishing mortality at age from the final TSA assessment. Estimates refer to the full year (January – December) except for age 0, for which the mortality rate given refers to the second half-year only (July – December). The 2016 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	Mean F(2-4)
1972	0.033	0.077	0.607	0.998	0.953	0.917	1.011	1.055	0.997	0.852
1973	0.029	0.079	0.606	0.872	0.847	0.893	0.995	1.037	1.101	0.775
1974	0.027	0.080	0.613	0.720	0.835	0.759	0.893	0.961	0.965	0.723
1975	0.030	0.081	0.696	0.883	0.965	0.928	1.089	1.080	1.069	0.848
1976	0.028	0.083	0.554	0.966	0.857	1.035	0.969	0.996	1.001	0.792
1977	0.027	0.091	0.602	0.748	1.057	0.965	0.969	0.944	0.968	0.802
1978	0.023	0.113	0.647	0.943	1.079	1.072	1.065	1.075	1.111	0.890
1979	0.027	0.095	0.688	1.049	0.990	1.012	1.027	1.042	1.048	0.909
1980	0.029	0.078	0.489	1.045	1.101	0.798	0.912	0.958	0.959	0.878
1981	0.025	0.069	0.321	0.779	0.893	0.740	0.475	0.729	0.698	0.664
1982	0.018	0.069	0.372	0.579	0.695	0.591	0.600	0.700	0.624	0.548
1983	0.017	0.079	0.442	0.837	0.852	0.893	0.750	0.746	0.761	0.710
1984	0.020	0.108	0.483	0.937	1.075	0.818	0.829	0.802	0.802	0.832
1985	0.020	0.108	0.441	0.909	1.010	0.864	0.821	0.768	0.772	0.787
1986	0.016	0.112	0.628	0.922	1.102	0.820	0.684	0.685	0.727	0.884
1987	0.021	0.091	0.720	1.002	0.948	0.877	0.882	0.814	0.790	0.890
1988	0.020	0.109	0.578	1.153	1.087	0.939	0.855	0.780	0.817	0.939
1989	0.018	0.111	0.625	0.939	1.102	0.870	0.845	0.776	0.781	0.888
1990	0.015	0.108	0.708	0.967	0.982	0.858	0.733	0.686	0.702	0.886
1991	0.016	0.150	0.686	1.014	0.925	0.785	0.780	0.734	0.701	0.875
1992	0.018	0.114	0.630	0.993	0.997	0.667	0.857	0.699	0.722	0.874
1993	0.020	0.149	0.784	0.997	1.014	0.969	0.841	0.817	0.833	0.932
1994	0.014	0.118	0.721	1.032	0.981	1.031	0.976	0.901	0.827	0.911
1995	0.018	0.095	0.588	0.922	0.948	0.827	0.921	0.712	0.708	0.820
1996	0.016	0.093	0.521	0.879	1.014	0.979	0.965	0.704	0.700	0.805
1997	0.013	0.108	0.485	0.645	0.758	0.902	0.792	0.607	0.594	0.629
1998	0.013	0.133	0.619	0.702	0.883	0.834	0.809	0.617	0.604	0.735
1999	0.011	0.119	0.675	0.926	0.871	1.092	0.892	0.677	0.649	0.824
2000	0.011	0.096	0.732	0.974	0.972	0.844	0.875	0.615	0.592	0.893
2001	0.010	0.078	0.419	0.700	0.723	0.681	0.612	0.435	0.422	0.614
2002	0.006	0.095	0.281	0.380	0.499	0.484	0.433	0.294	0.292	0.387
2003	0.004	0.045	0.218	0.235	0.279	0.344	0.288	0.188	0.184	0.244
2004	0.004	0.050	0.216	0.252	0.261	0.317	0.254	0.161	0.158	0.243
2005	0.003	0.055	0.280	0.356	0.284	0.337	0.311	0.172	0.168	0.307
2006	0.005	0.052	0.426	0.534	0.551	0.533	0.399	0.262	0.225	0.503
2007	0.005	0.054	0.237	0.517	0.514	0.499	0.386	0.220	0.215	0.423
2008	0.003	0.036	0.181	0.230	0.338	0.318	0.263	0.143	0.142	0.250
2009	0.002	0.030	0.128	0.194	0.263	0.251	0.188	0.110	0.104	0.195
2010	0.003	0.031	0.160	0.234	0.229	0.268	0.185	0.107	0.102	0.208
2011	0.003	0.035	0.130	0.381	0.384	0.377	0.273	0.139	0.122	0.298
2012	0.002	0.032	0.124	0.166	0.243	0.234	0.165	0.094	0.084	0.178
2013	0.002	0.036	0.162	0.160	0.247	0.229	0.159	0.086	0.086	0.189
2014	0.002	0.036	0.267	0.312	0.319	0.395	0.198	0.117	0.109	0.299
2015	0.004	0.040	0.412	0.453	0.355	0.503	0.367	0.166	0.146	0.407
2016*	0.004	0.051	0.317	0.397	0.421	0.493	0.316	0.154	0.154	0.378

Table 13.3.4. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Estimates of stock numbers at age (thousands) from the final TSA assessment. Estimates refer to January 1st, except for age 0 for estimates refer to July 1st. *TSA estimated survivors.

	0	1	2	3	4	5	6	7	8+
1972	9334178	13726648	2123425	79500	45151	396642	7157	435	1167
1973	35028610	2087849	2828264	489139	17647	11305	117984	2057	456
1974	69453988	7834434	428189	672552	122488	4968	3486	34581	716
1975	4607792	15672055	1593991	109338	192870	33908	1681	1108	10685
1976	7190961	993133	3137669	353684	28542	49142	10193	461	3440
1977	15430704	1619883	225956	832447	85267	8446	13555	3196	1256
1978	31724047	3120387	301522	65069	259274	21528	2655	4539	1534
1979	64106952	6217948	574825	78136	16580	63750	5474	754	1763
1980	11637362	12466923	1161388	141710	18194	4724	18826	1693	789
1981	19582587	2237958	2384127	343941	33952	4727	1645	6253	825
1982	11819198	3813036	439659	795156	101210	10819	1789	637	2590
1983	38209077	2324212	762113	162897	296137	37801	4737	802	1401
1984	7549963	7486807	479856	262509	48580	93661	12301	1830	841
1985	12359046	1661260	1563731	161127	71547	12746	30364	4346	919
1986	23436516	2528814	366927	552250	45553	20118	4283	10792	1961
1987	511175	4506975	581486	112248	151249	11673	6798	1636	4756
1988	1442810	387952	1100841	163695	29628	43666	3861	2322	2353
1989	2623166	613286	109440	365889	36268	7742	13456	1347	1747
1990	11049117	840994	154510	35488	103842	9321	2616	4787	1207
1991	12277185	2520843	218902	42619	9778	30428	3229	1042	2522
1992	20621156	2846325	639791	69374	11512	2738	9664	1171	1352
1993	5212195	4992663	758672	216064	17893	3175	1058	3312	1030
1994	20248492	1308150	1287523	220415	58795	4917	970	371	1618
1995	5600800	5262795	352600	401403	58323	16679	1396	304	734
1996	7872209	1485968	1446139	127912	118251	17208	5784	462	432
1997	4641366	2116660	407633	561384	39399	32835	5159	1820	370
1998	3468782	1260358	564725	165040	217714	14089	10510	1913	996
1999	52278672	953361	324020	196827	60412	68813	4828	3753	1317
2000	10186254	14101149	245511	105836	55346	19108	17971	1599	2163
2001	958698	2719783	3632203	77821	28614	15542	6415	5971	1732
2002	1341073	372385	693827	1568301	27767	10464	6126	2798	4154
2003	1508352	424676	90586	341421	791523	12671	5058	3192	4294
2004	1460362	455286	105751	47188	198856	455819	6998	3024	5104
2005	14398949	453617	110862	54434	26973	116413	256715	4286	5653
2006	3033564	4076445	110164	53040	28103	15483	64525	147431	6806
2007	1992846	891430	1007711	45343	23037	12369	7092	34341	95103
2008	1374472	629101	225611	492626	20040	10472	5852	3846	84705
2009	10329091	492743	167007	115138	286885	10799	5881	3582	62850
2010	952186	3379676	136053	88640	69487	165175	6407	3867	49088
2011	113917	370349	956680	68779	50960	41009	95146	4209	39121
2012	1300389	129841	106505	489231	33375	25425	20882	57038	31377
2013	576257	477482	37955	53689	293098	18851	14655	13867	65554
2014	5885774	268002	140311	17819	32041	162858	10719	9727	59499
2015	1488346	2108931	78915	60264	8929	16608	78677	6862	50690
2016*	3279669	541246	617993	29394	26822	4460	7211	42575	40651

Table 13.3.5. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Stock summary table. Both estimates (EST) and standard errors (SE) are given. *TSA model fits or projections.

year	catch	catch.est	catch.se	landings	landings.est	landings.se	discards	discards.est	discards.se	meanF.est	meanF.se	SSB.est	SSB.se	TSB.est	TSB.se	recruit.est	recruit.se
1972	408148	384782	40729	233286	229555	24740	173903	155227	28552	0.852	0.064	294835	29279	2648076	264743	9334178	2149032
1973	344574	383454	52636	206808	217530	21257	137198	165924	41299	0.775	0.070	276958	18789	2705509	250240	35028610	4382995
1974	397035	250556	29034	167410	159239	14229	229503	91318	22137	0.723	0.071	331762	23871	3175524	315271	69453988	9853342
1975	494390	300148	41267	159640	161042	14059	334009	139106	35223	0.848	0.081	161530	11149	2295633	261002	4607792	1839161
1976	402046	344062	52660	181758	206412	23035	217725	137650	40566	0.792	0.080	196822	16286	1131585	129510	7190961	1732580
1977	240292	200014	21973	155748	163026	18214	83726	36989	9142	0.802	0.084	353701	30047	895899	72118	15430704	2137114
1978	146664	138616	13473	102222	102560	10026	43760	36056	7139	0.890	0.085	159401	13687	909472	58978	31724047	2439629
1979	149126	143546	16046	97389	86482	9183	51376	57064	10363	0.909	0.087	93894	10621	1414100	78246	64106952	5640228
1980	202624	189849	19295	110832	106225	10345	91263	83625	14195	0.878	0.080	103563	10442	1573575	94418	11637362	1266833
1981	226556	225290	21210	147673	151454	14970	78665	73836	12176	0.664	0.062	193503	12682	1133434	58852	19582587	1993292
1982	256280	208783	15508	195359	167041	13241	60730	41742	6834	0.548	0.046	432650	20208	958749	39914	11819198	1042453
1983	253314	226786	16637	187963	178615	12875	64451	48170	7615	0.710	0.053	294486	15147	1252502	50836	38209077	2639044
1984	247209	227552	22634	157631	150013	11103	89057	77539	16956	0.832	0.060	238292	14740	1522315	79209	7549963	1647606
1985	247401	226526	18400	182552	165805	13901	64375	60721	9878	0.787	0.056	168059	8494	1000381	43200	12359046	1491235
1986	223837	206451	15059	184520	164171	12518	38735	42280	6754	0.884	0.060	288815	16382	1234667	62711	23436516	2152177
1987	195048	178828	14848	133892	125167	9518	60046	53661	9367	0.890	0.062	163463	8896	885459	45447	511175	1352857
1988	179912	168320	13929	124800	122018	10852	53729	46303	7396	0.939	0.067	126941	8558	506170	95818	1442810	2089310
1989	127674	117973	9869	91927	93147	8565	34872	24827	4388	0.888	0.067	178229	11191	426183	60207	2623166	1530656
1990	86734	78217	7472	61187	56924	5138	25159	21293	4070	0.886	0.066	85310	5813	732903	67940	11049117	1587267
1991	97213	91860	12597	54731	45418	4557	41993	46442	10219	0.875	0.066	52414	3953	929299	46914	12277185	942659
1992	135092	126306	11938	80479	71615	7209	53421	54691	8322	0.874	0.054	55814	2850	933717	41636	20621156	1497217
1993	180233	210707	21101	97867	109840	10529	81509	100867	16260	0.932	0.058	119014	7469	934274	46750	5212195	469606
1994	169501	233408	21969	94708	129957	13396	74297	103451	14983	0.911	0.060	139261	9711	980038	42277	20248492	1367437
1995	168825	176392	17266	89581	104415	10806	79035	71977	11667	0.820	0.059	197825	14114	930407	44504	5600800	447773
1996	204701	201451	18802	92422	98385	8892	112055	103066	14684	0.805	0.057	124912	7260	833852	36272	7872209	659512
1997	170055	164910	14764	95341	95272	8938	74603	69638	10377	0.629	0.050	253112	14918	793948	36658	4641366	460477
1998	161962	159278	13704	95387	92507	7704	66457	66770	9456	0.735	0.057	182752	9800	613248	27410	3468782	326372
1999	123449	128048	11106	75872	73363	6129	47446	54685	7637	0.824	0.063	141729	8884	1687959	100450	52278672	3809693
2000	126876	169990	30586	54358	55577	5125	72395	114414	28199	0.893	0.067	91483	6414	2390258	136384	10186254	697739
2001	173525	279235	38737	47383	100043	14749	125978	179192	31339	0.614	0.054	61624	4379	1186775	68898	958698	749473
2002	155164	190651	22550	64778	100630	12406	89745	90021	16451	0.387	0.038	523362	36523	763676	41012	1341073	390034
2003	74412	101470	11681	46991	78392	9735	27149	23078	4491	0.244	0.026	450852	27870	541895	30070	1508352	365457
2004	72510	78848	9545	51760	67481	8680	20586	11367	2029	0.243	0.026	312235	22259	457643	25547	1460362	228366
2005	64115	65826	7768	51437	56352	7117	12573	9474	1487	0.307	0.031	234038	19910	1114204	48479	14398949	763580
2006	66955	66908	8192	43185	45981	5509	23622	20927	4530	0.503	0.044	163429	16391	835647	35576	3033564	209238
2007	67437	76402	8112	34572	45800	5253	32751	30603	4741	0.423	0.039	136082	16431	590269	29061	1992846	354733
2008	47730	56603	5846	30755	41562	4420	14694	15041	2623	0.250	0.026	282911	19532	488849	24422	1374472	308960
2009	47943	44874	4484	34614	36609	3805	12372	8266	1287	0.195	0.021	236544	18807	869507	34393	10329091	526309
2010	45411	44321	4631	31460	35427	3638	13473	8895	1731	0.208	0.022	221500	18310	539533	27284	952186	747724
2011	49677	57960	5572	36392	40482	3712	13082	17479	3027	0.298	0.030	158629	12012	461151	21473	113917	557619
2012	43200	45180	4530	37619	39652	3971	5032	5528	1133	0.178	0.020	332903	18651	445947	21569	1300389	248483
2013	47068	42278	4399	43631	38898	4071	3352	3380	699	0.189	0.020	262506	14008	380357	18312	576257	235123
2014	46316	50618	5049	39765	45473	4636	5149	5145	1020	0.299	0.031	184867	11635	530077	30181	5885774	606801
2015	41596	50330	5206	34376	40719	3911	6285	9611	2417	0.407	0.045	146053	10656	530895	36692	1488346	301125
2016*		77855	19990		62463	16889		15392	5431	0.378	0.098					3279669	896276

Table 13.6.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Short-term forecast input.

MFDP version 1a						
RUN: IBP02						
TIME AND DATE: 12:09 14/10/2016						
FBAR AGE RANGE (TOTAL) : 2-4						
FBAR AGE RANGE FLEET 1 : 2-4						
FBAR AGE RANGE FLEET 2 : 2-4						
2016						
Age	N	M	Mat	PF	PM	SWt
0	3279669	1.02	0	0	0	0.036
1	541246	1.19	0	0	0	0.152
2	617993	0.58	0	0	0	0.425
3	29394	0.36	1	0	0	0.580
4	26822	0.34	1	0	0	0.760
5	4460	0.34	1	0	0	0.958
6	7211	0.25	1	0	0	0.936
7	42575	0.22	1	0	0	0.763
8	40651	0.2	1	0	0	0.948
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.000	0.000	0.004	0.036		
1	0.002	0.356	0.048	0.141		
2	0.198	0.523	0.119	0.267		
3	0.344	0.620	0.052	0.369		
4	0.405	0.654	0.016	0.479		
5	0.475	1.016	0.018	0.497		
6	0.311	0.857	0.006	0.551		
7	0.153	0.708	0.001	0.491		
8	0.154	0.83	0.001	0.714		
IBC						
Age	Sel	CWt				
0	0.000	0				
1	0.000	0.3562				
2	0.000	0.5228				
3	0.000	0.6205				
4	0.000	0.6425				
5	0.001	0.6619				
6	0.000	0.7576				
7	0.000	0.7728				
8	0	1.41				

Table 13.6.1 (cont). Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Short-term forecast input.

2017						
Age	N	M	Mat	PF	PM	SWt
0	3279669	1.020	0	0	0	0.036
1	.	1.190	0	0	0	0.152
2	.	0.580	0	0	0	0.425
3	.	0.360	1	0	0	0.583
4	.	0.340	1	0	0	0.771
5	.	0.340	1	0	0	0.944
6	.	0.250	1	0	0	1.148
7	.	0.22	1	0	0	1
8	.	0.2	1	0	0	1

Catch				
Age	Sel	CWt	DSel	DCWt
0	0.000	0.000	0.004	0.036
1	0.002	0.356	0.048	0.141
2	0.198	0.523	0.119	0.267
3	0.344	0.620	0.052	0.348
4	0.405	0.642	0.016	0.482
5	0.475	0.726	0.018	0.587
6	0.311	1.197	0.006	0.588
7	0.153	0.957	0.001	1
8	0.154	0.87	0.001	1

IBC		
Age	Sel	CWt
0	0.000	0
1	0.000	0.3562
2	0.000	0.5228
3	0.000	0.6205
4	0.000	0.6425
5	0.001	0.6619
6	0.000	0.7576
7	0	0.7728
8	0	1.41

Table 13.6.1 (cont). Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Short-term forecast input.

2018						
Age	N	M	Mat	PF	PM	SWt
0	3279669	1.02	0	0	0	0.036
1	.	1.19	0	0	0	0.152
2	.	0.58	0	0	0	0.425
3	.	0.36	1	0	0	0.583
4	.	0.34	1	0	0	0.632
5	.	0.34	1	0	0	0.963
6	.	0.25	1	0	0	1
7	.	0.22	1	0	0	1
8	.	0.2	1	0	0	1

Catch				
Age	Sel	CWt	DSel	DCWt
0	0	0	0.004	0.036
1	0.002	0.356	0.048	0.141
2	0.198	0.523	0.119	0.267
3	0.344	0.62	0.052	0.348
4	0.405	0.642	0.016	0.372
5	0.475	0.662	0.018	0.596
6	0.311	0.799	0.006	0.696
7	0.153	1.379	0.001	0.679
8	0.154	0.966	0.001	0.888

IBC		
Age	Sel	CWt
0	0	0.000
1	0	0.356
2	0	0.523
3	0	0.621
4	0	0.643
5	0.001	0.662
6	0	0.7576
7	0	0.7728
8	0	1.41

Input units are thousands and kg - output in tonnes

Table 13.6.2. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Short-term forecast output. A number of management options are highlighted.

Rationale	Total catch 2017	Wanted catch 2017*	Unwanted catch 2017*	IBC 2017**	Basis	Total F 2017	F(land) 2017	F(disc) 2017	F(IBC) 2017	SSB 2018	% SSB change (1)	% TAC change (2)	% change from 2015 landings (3)
MSY	39.461	33.385	6.071	0.006	New F(msy) estimate	0.190	0.159	0.031	0.000	205.595	-13%	-45%	12%
Management plan	60.003	50.653	9.344	0.006	MP target F	0.300	0.251	0.049	0.000	187.292	-20%	-17%	70%
IBC only	0.007	0.000	0.000	0.007	No HC fishery	0.000	0.000	0.000	0.000	241.562	3%	-100%	-100%
Other options	57.029	48.159	8.864	0.006	0.75 * F(sq)	0.284	0.237	0.047	0.000	189.932	-19%	-21%	61%
	73.469	61.914	11.549	0.006	Fsq	0.378	0.316	0.062	0.000	175.332	-25%	2%	108%
	88.817	74.691	14.118	0.005	1.25 * F(sq)	0.473	0.395	0.078	0.000	161.934	-31%	23%	151%
	64.940	54.789	10.145	0.006	15% TAC decrease	0.328	0.274	0.054	0.000	182.918	-22%	-15%	84%
	75.903	63.949	11.947	0.006	Rollover TAC	0.392	0.327	0.065	0.000	173.245	-26%	0%	115%
	86.290	72.594	13.689	0.005	15% TAC increase	0.456	0.381	0.075	0.000	164.140	-30%	15%	144%
	55.300	46.708	8.586	0.006	F(pa)	0.274	0.229	0.045	0.000	191.468	-19%	-24%	57%
	72.196	60.856	11.334	0.006	F(msy) long time-series	0.370	0.309	0.061	0.000	176.509	-25%	0%	104%
	135.308	112.682	22.625	0.005	F(pa) long time-series	0.830	0.693	0.137	0.000	122.389	-48%	87%	283%
	73.882	62.263	11.612	0.006	F(lim)	0.380	0.317	0.063	0.000	175.024	-26%	2%	109%
	146.572	121.590	24.985	0.005	B(lim)	0.946	0.790	0.156	0.000	94.000	-52%	103%	315%
	119.463	99.898	19.561	0.005	B(trigger)	0.692	0.578	0.114	0.000	132.000	-42%	65%	238%

*** "Wanted" and "unwanted" catch are used to described fish that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for 2013–2015.**

**** Industrial bycatch (IBC) also based on average proportion of the total catch for 2013–2015.**

[1] SSB 2018 relative to SSB 2017.

[2] Total catch in 2017 relative to the combined TACs 2016 (TAC 4 = 61.933; TAC 3.a = 3.926; TAC 6.a = 6.462; Total = 72.321).

[3] Total catch in 2017 relative to WG estimates of wanted catch in 2015

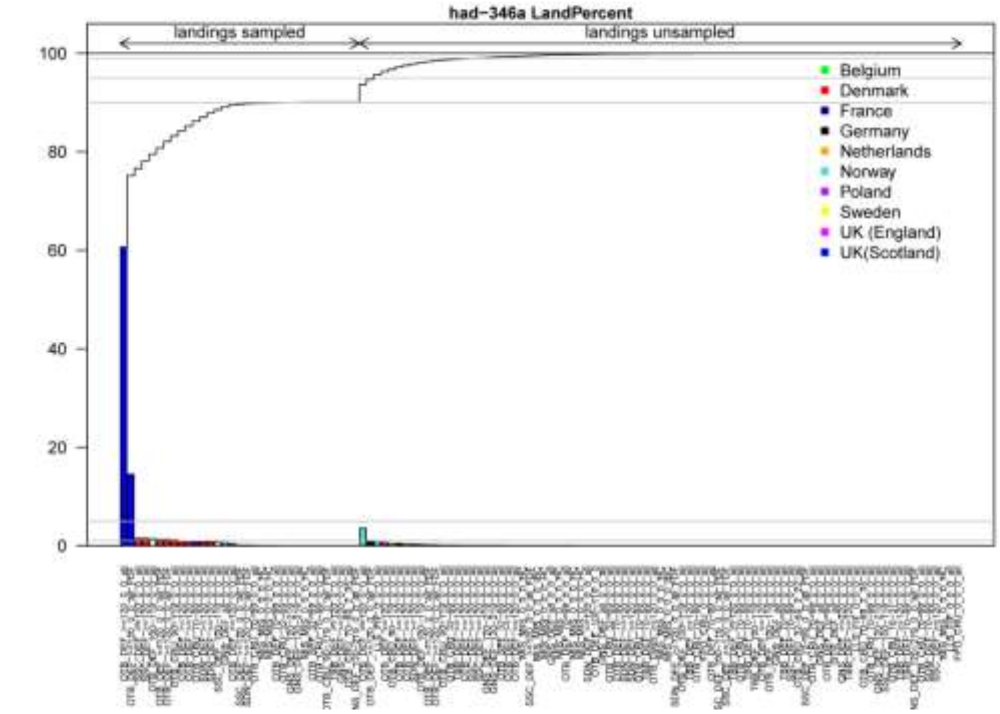


Figure 13.2.1: Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

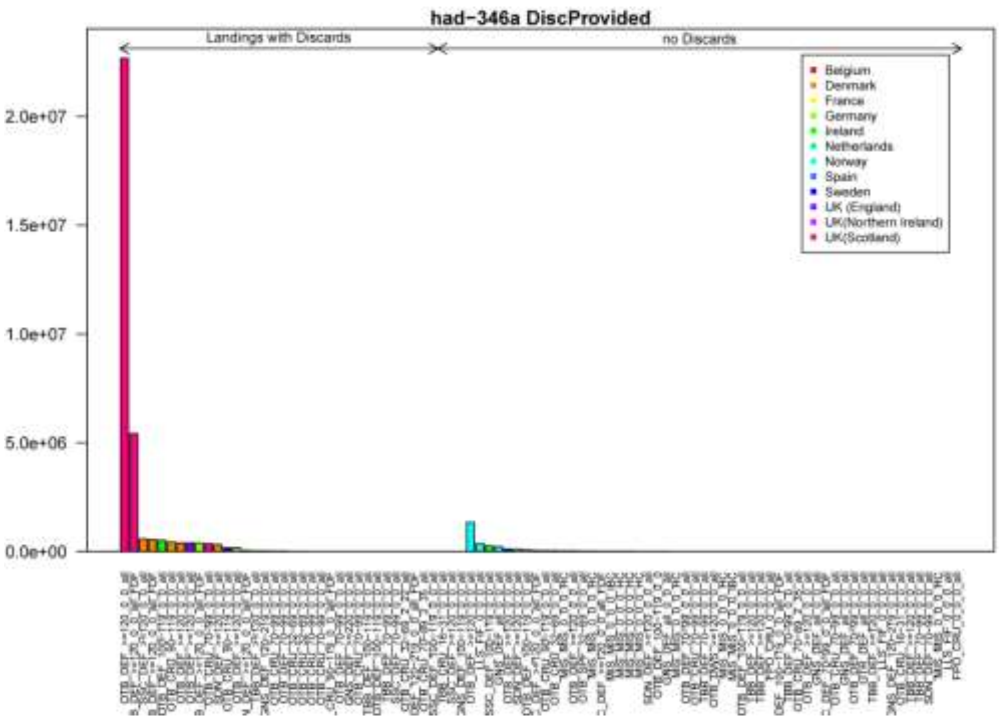


Figure 13.2.2: Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Summary of landings for fleets with and without discard estimates.

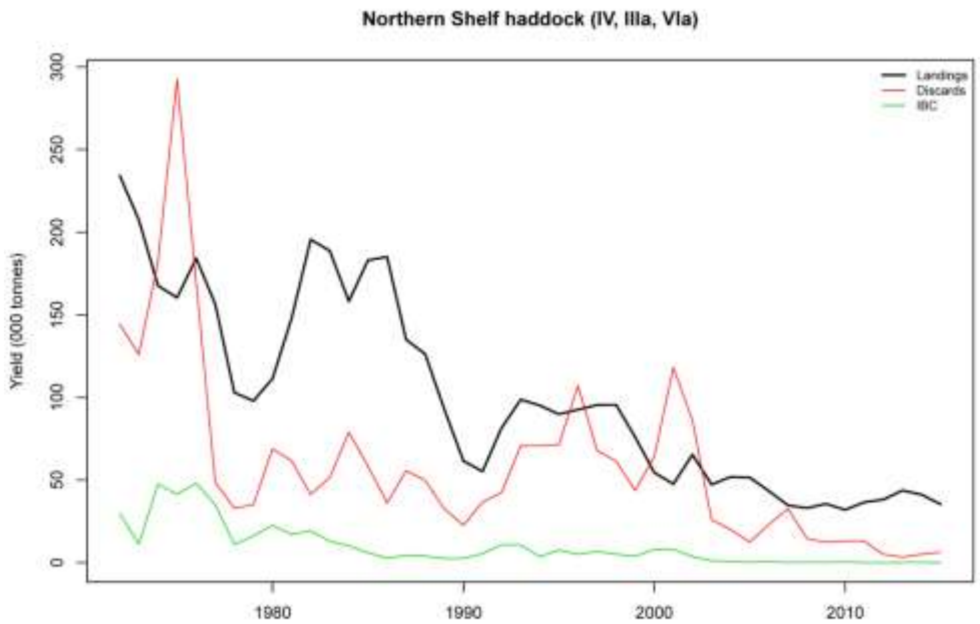


Figure 13.2.3. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Yield by catch component.

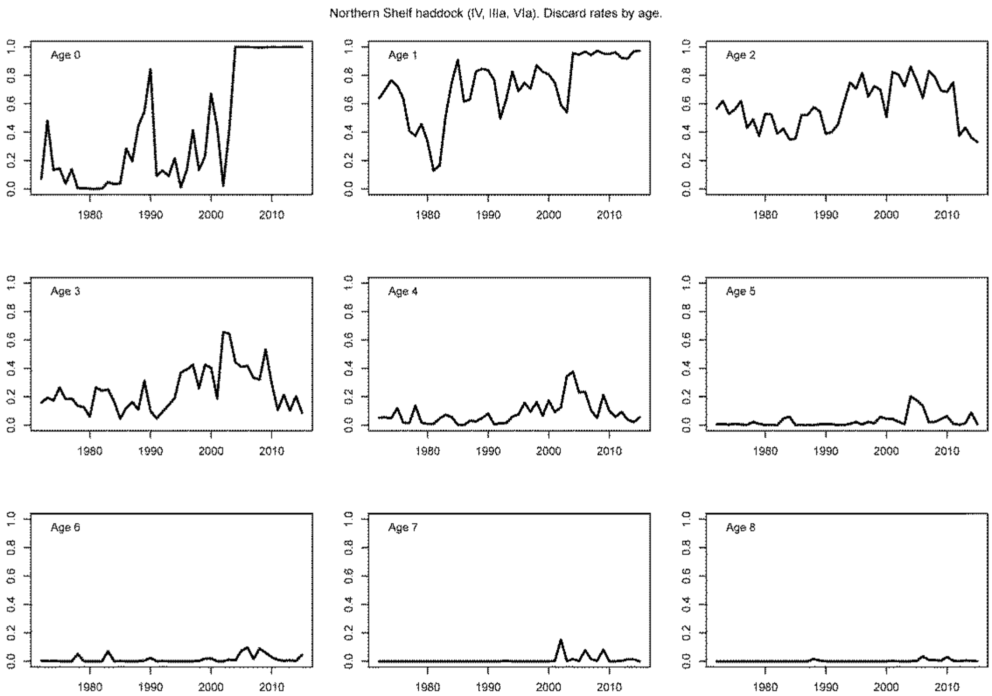


Figure 13.2.4. Haddock in Subarea 4 and Divisions 3.a. Proportion of total catch discarded, by age and year.

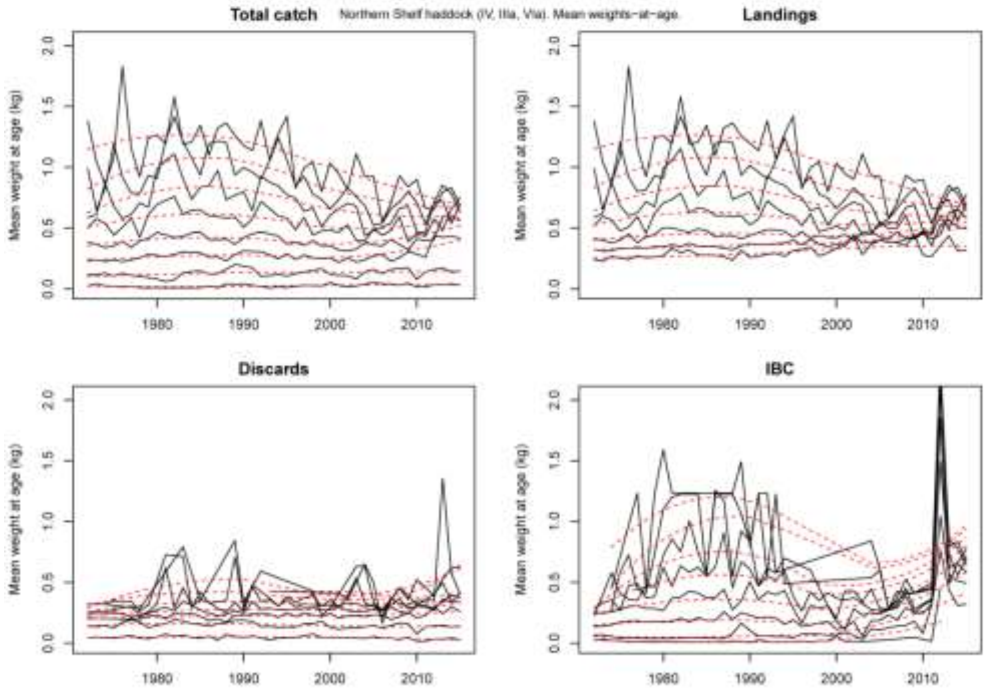


Figure 13.2.5. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

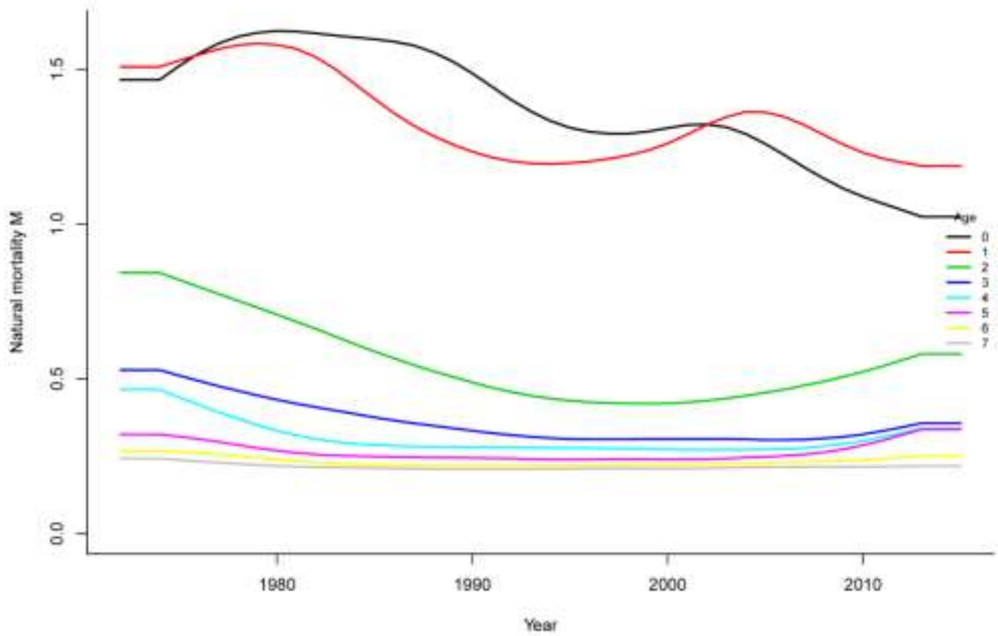


Figure 13.2.6. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Time series of estimated natural mortality at age, from ICES-WGSAM (2014).

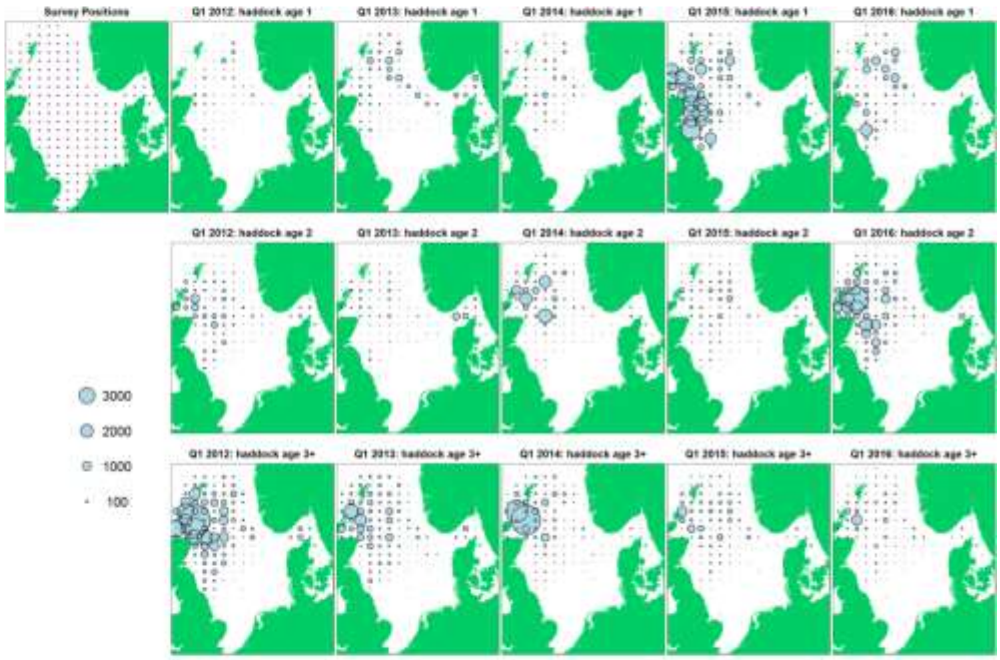


Figure 13.2.7. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Survey distributions by age for the international IBTS Q1 survey (North Sea).

Figure 13.2.8. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Survey distributions by age for the international IBTS Q3 survey (North Sea).

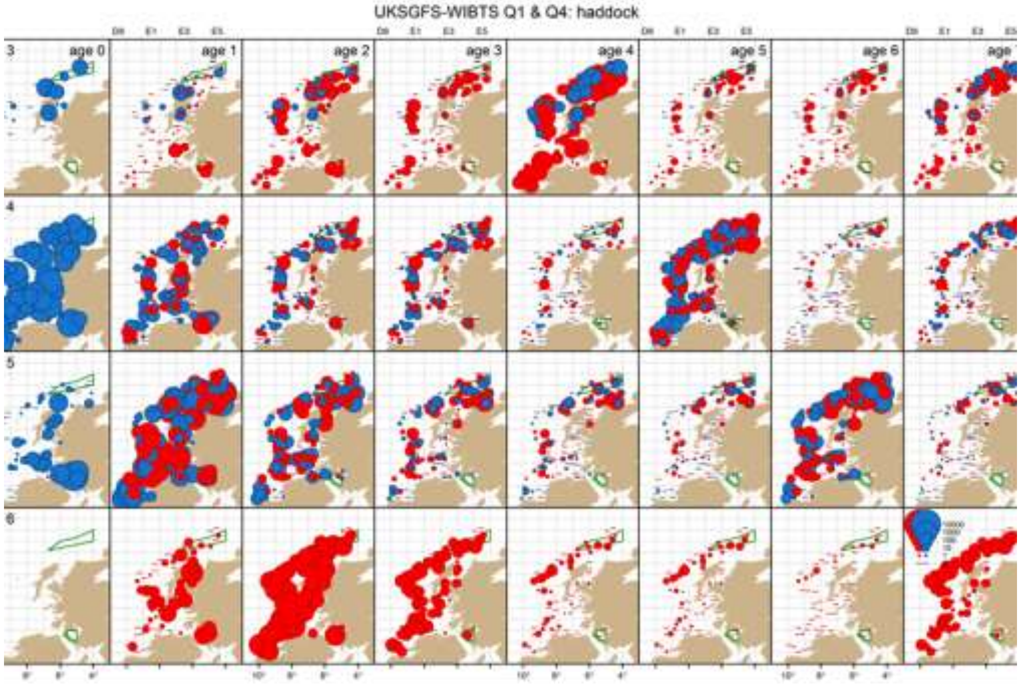


Figure 13.2.9. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Survey distributions by age and quarter for the Scottish West Coast Q1 survey (West of Scotland). Rows show years 2013-2016 (from top to bottom).

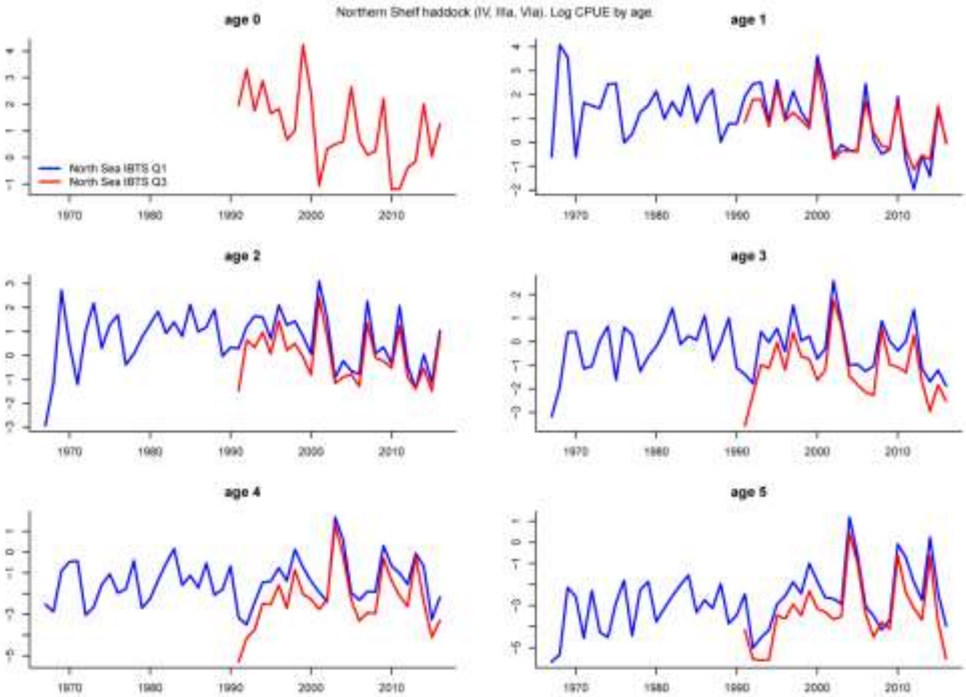


Figure 13.2.10. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Survey log CPUE (catch per unit effort) at age.

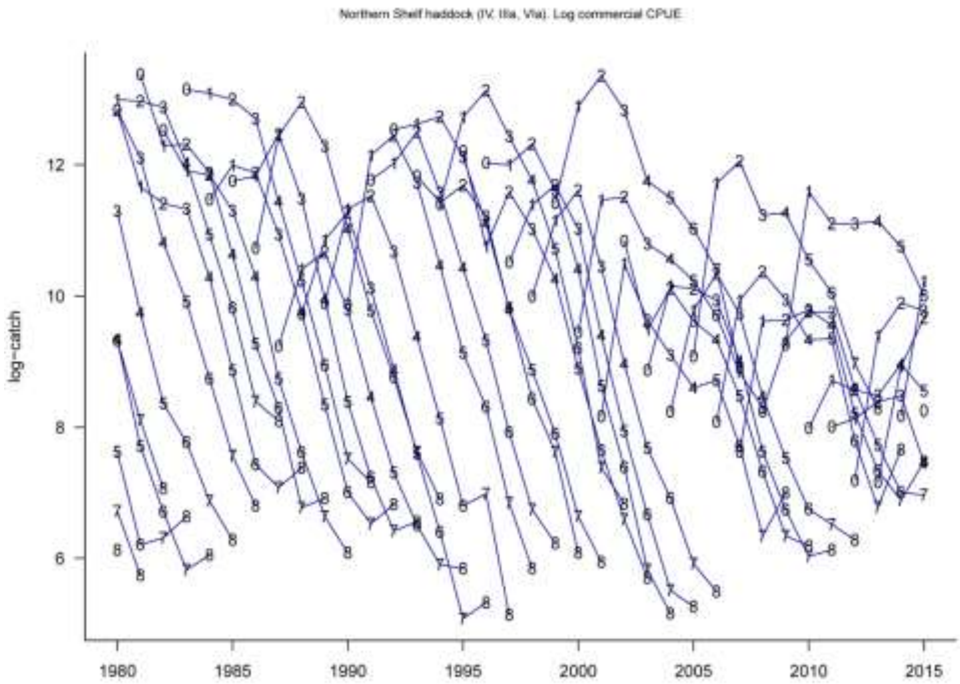


Figure 13.3.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Log catch curves by cohort for total catches.

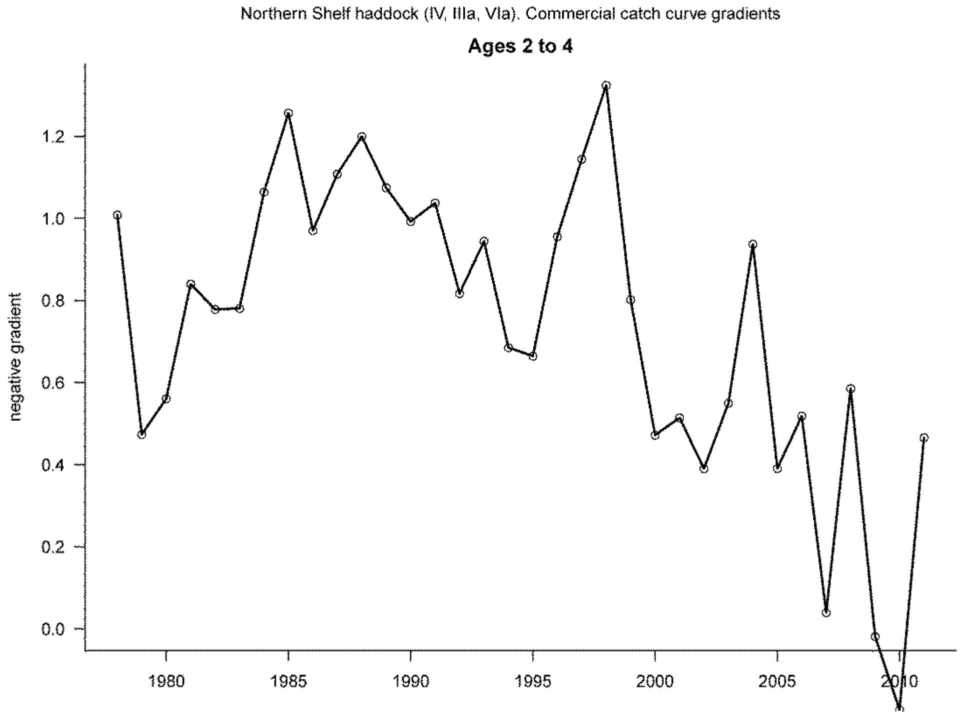


Figure 13.3.2. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Negative gradients of log catches per cohort, averaged over ages 2-4. The x-axis represents the spawning year of each cohort.

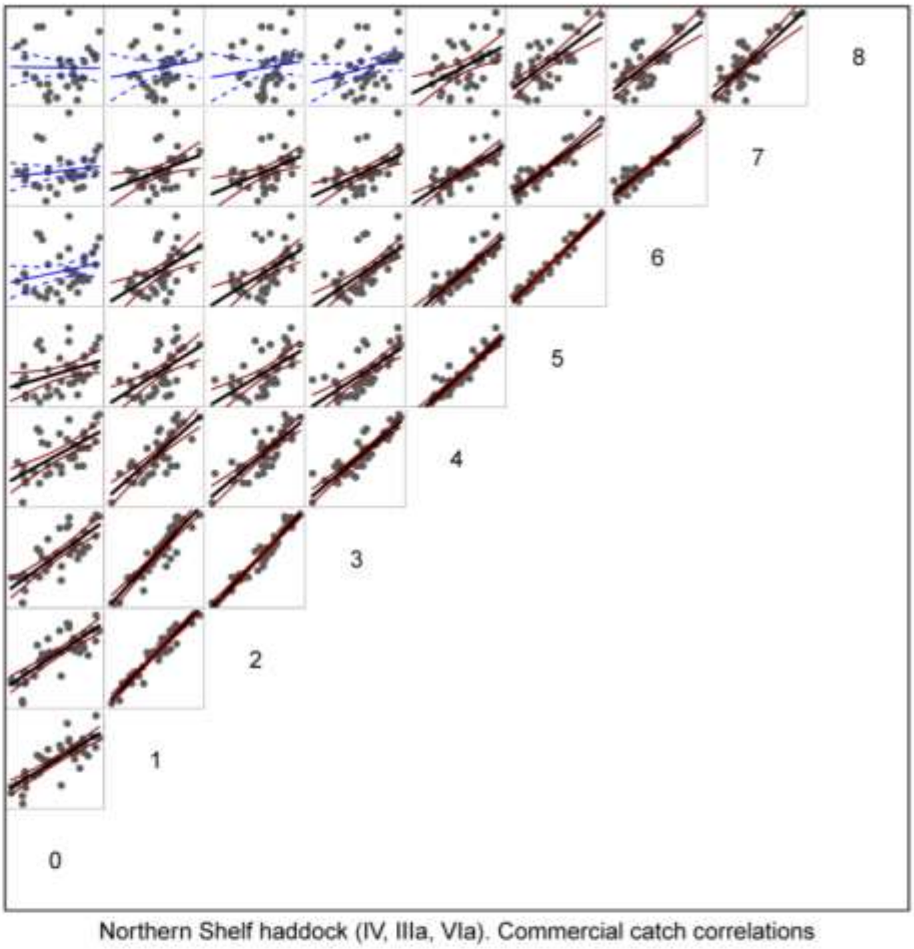


Figure 13.3.3. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

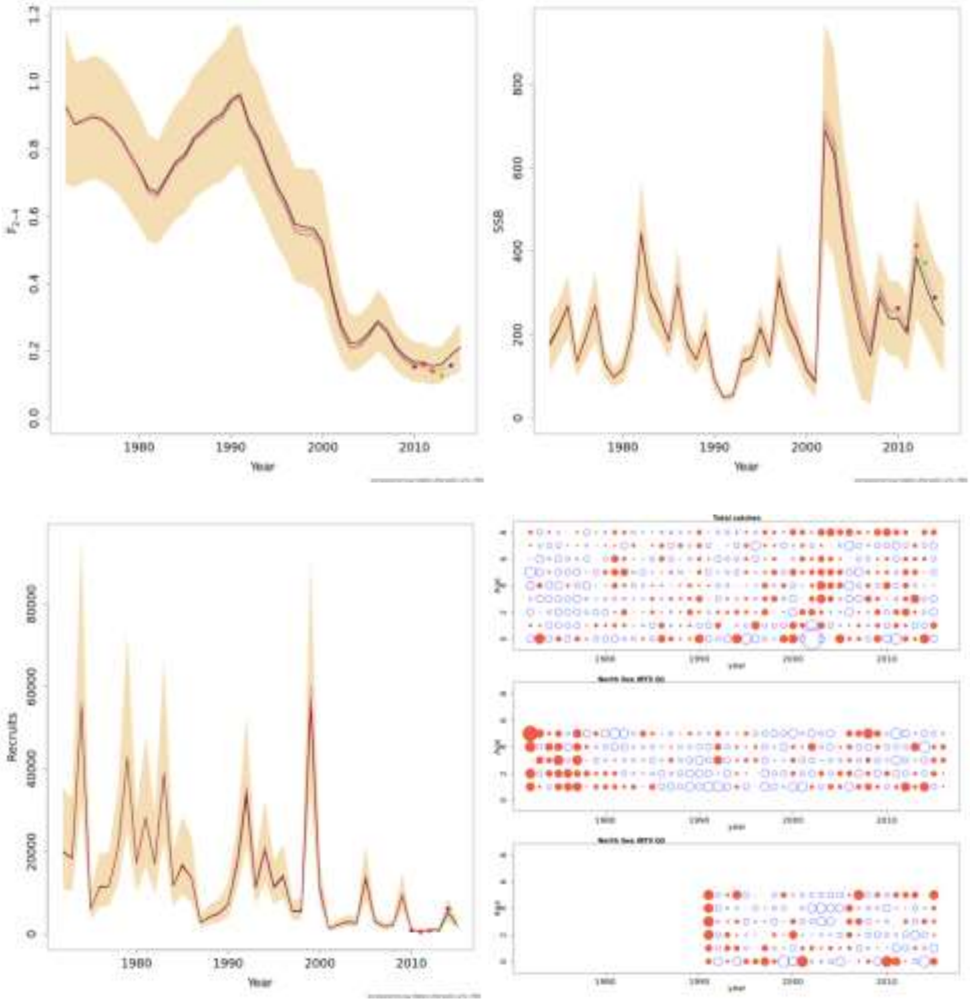


Figure 13.3.4. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Summary plots from an exploratory SAM assessment. Time-series of estimated SSB (top left), mean F(2-4) (top right) and recruitment (bottom right) are shown with approximate pointwise 95% confidence intervals. Retrospective runs are included in these plots. Model residuals (bottom left) are depicted with a clear blue circle for a positive residual, and a solid red circle for a negative residual.

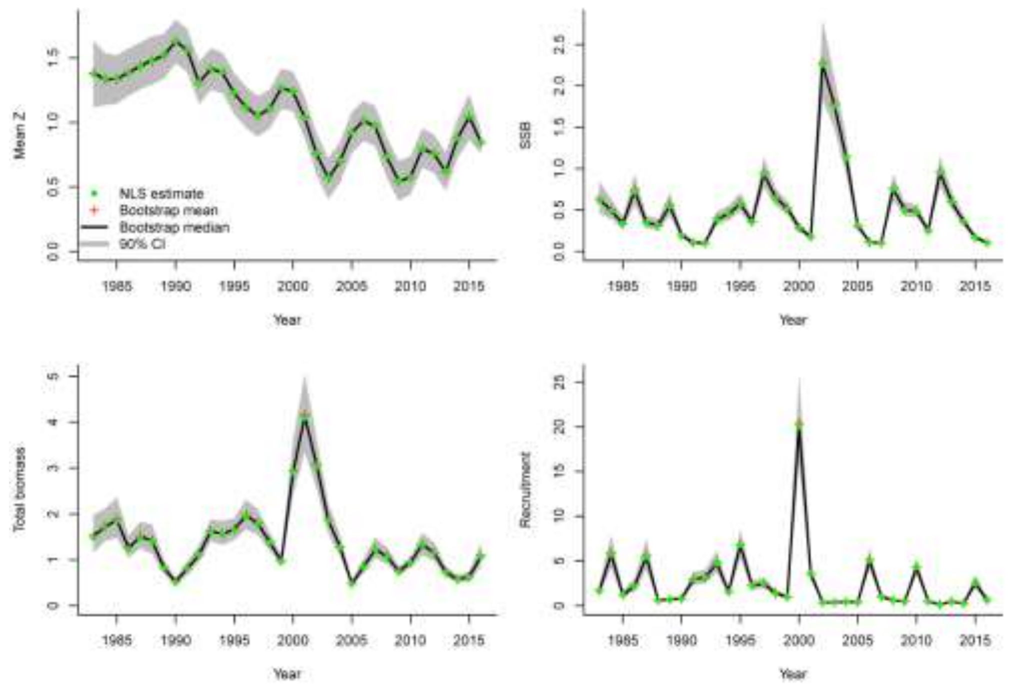


Figure 13.3.5. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

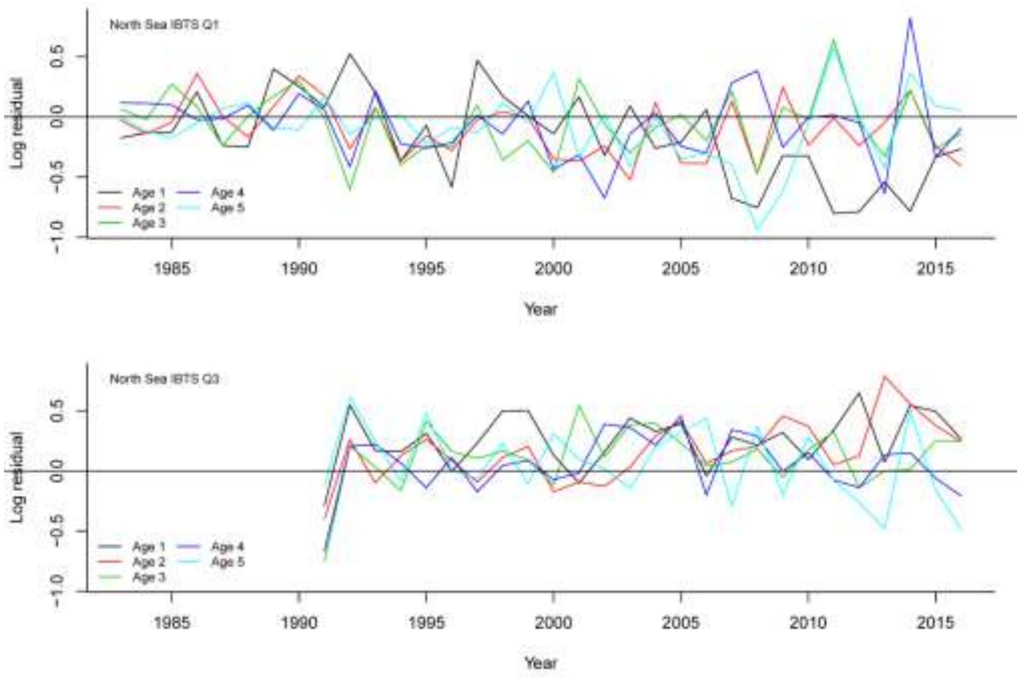


Figure 13.3.6. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).

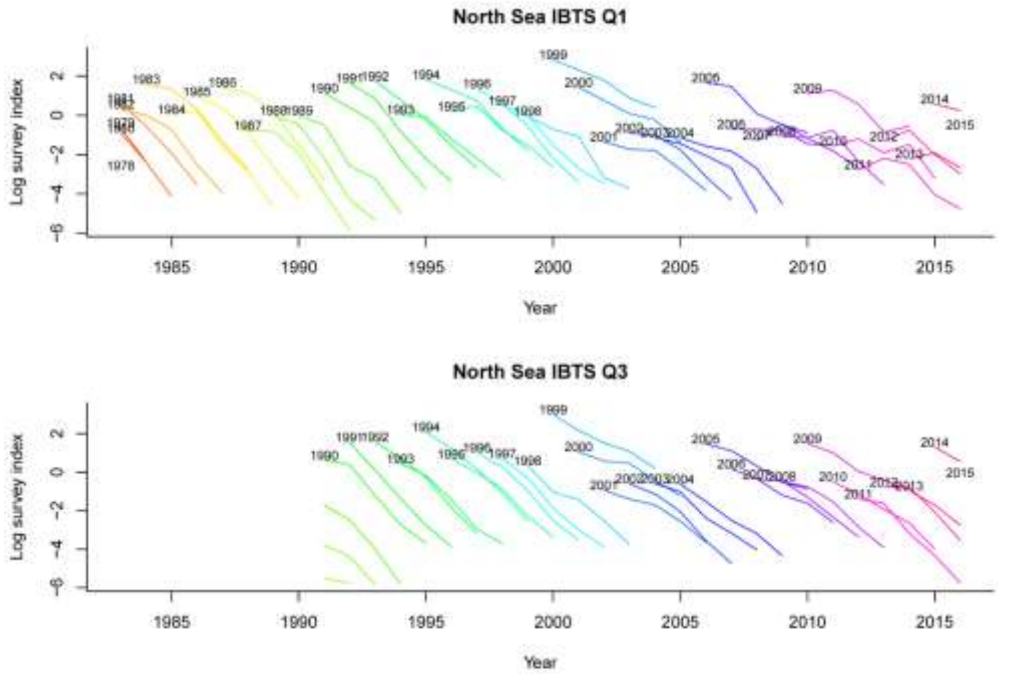


Figure 13.3.7. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

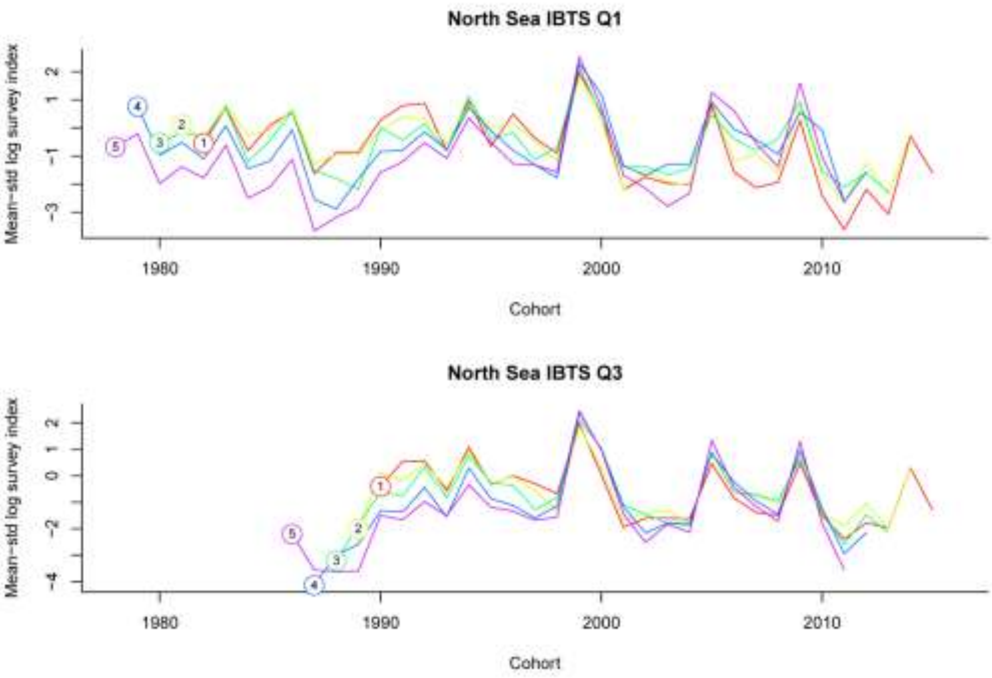
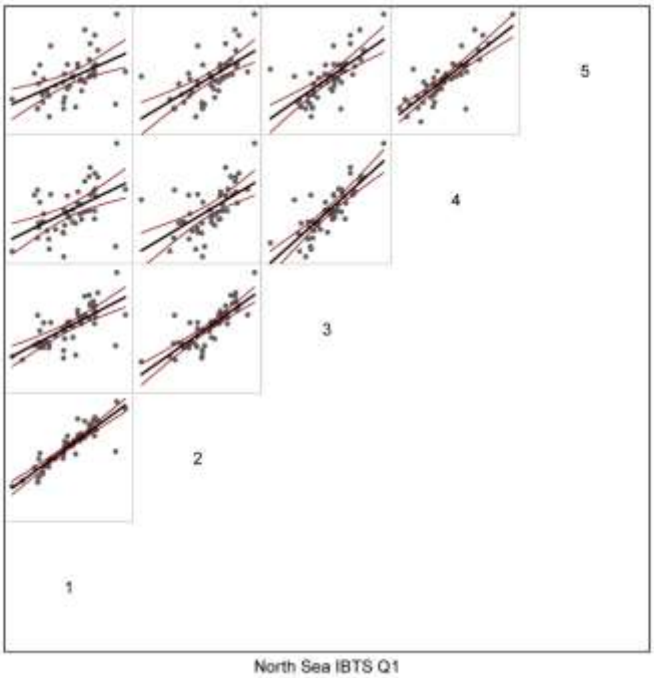


Figure 13.3.8. Haddock in Subarea 4, Division 3.a20 and Division 6.a. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.



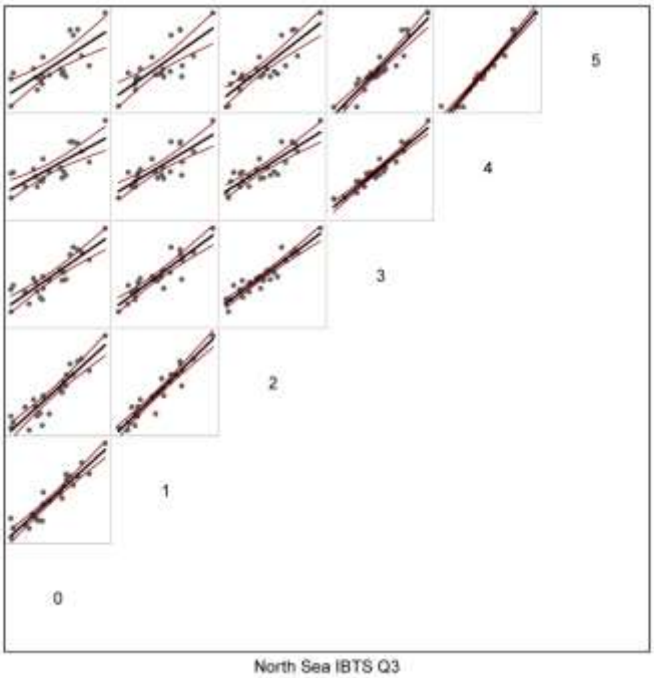


Figure 13.3.9. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

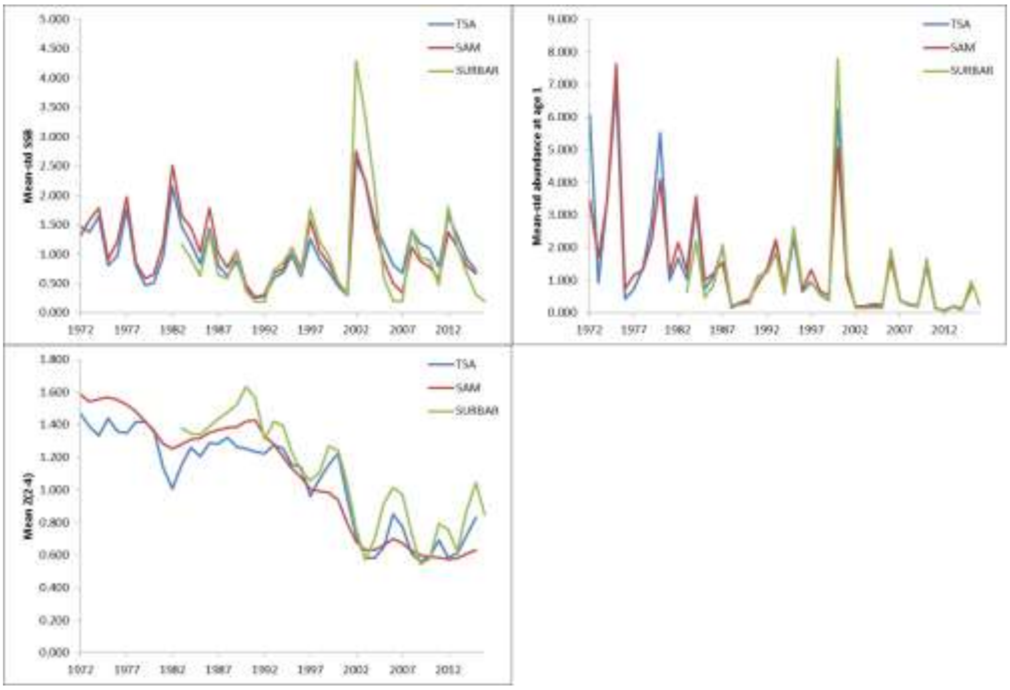


Figure 13.3.10. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Comparisons of stock summary estimates from TSA (blue), SAM (red) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models, and a composite Z estimate has been made for TSA and SAM by adding natural and fishing mortality estimates.

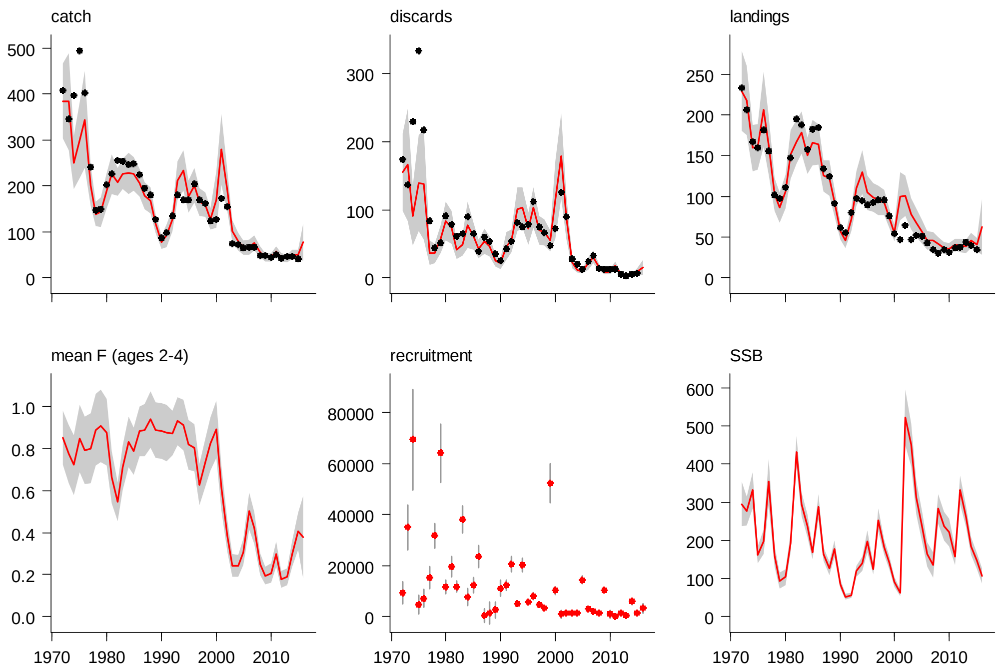


Figure 13.3.11. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Stock summary from final TSA assessment (including forecasts for 2016). Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for catch, discards+IBC, and landings).

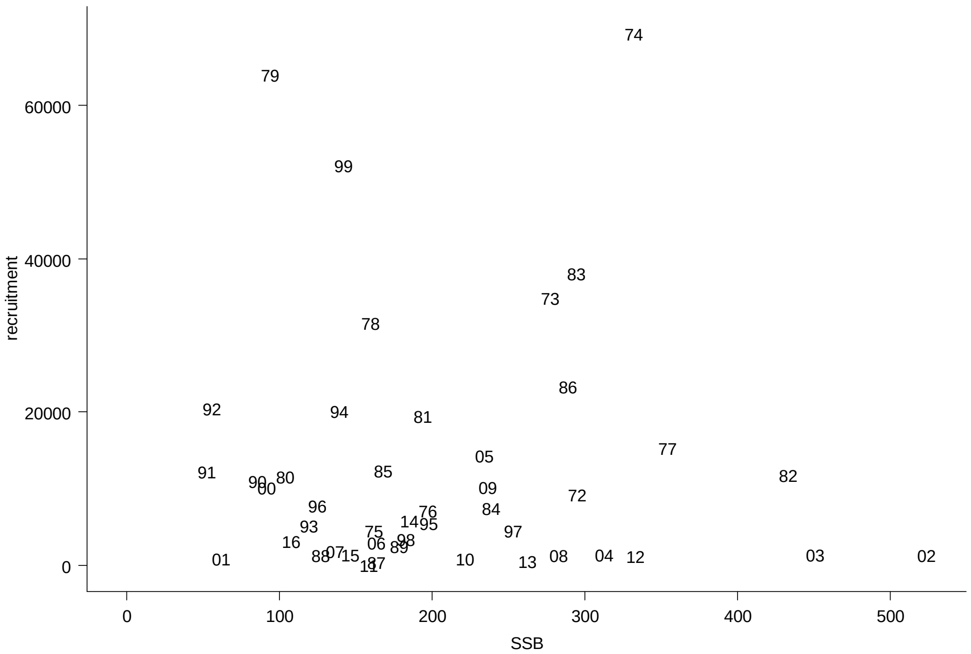


Figure 13.3.12. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

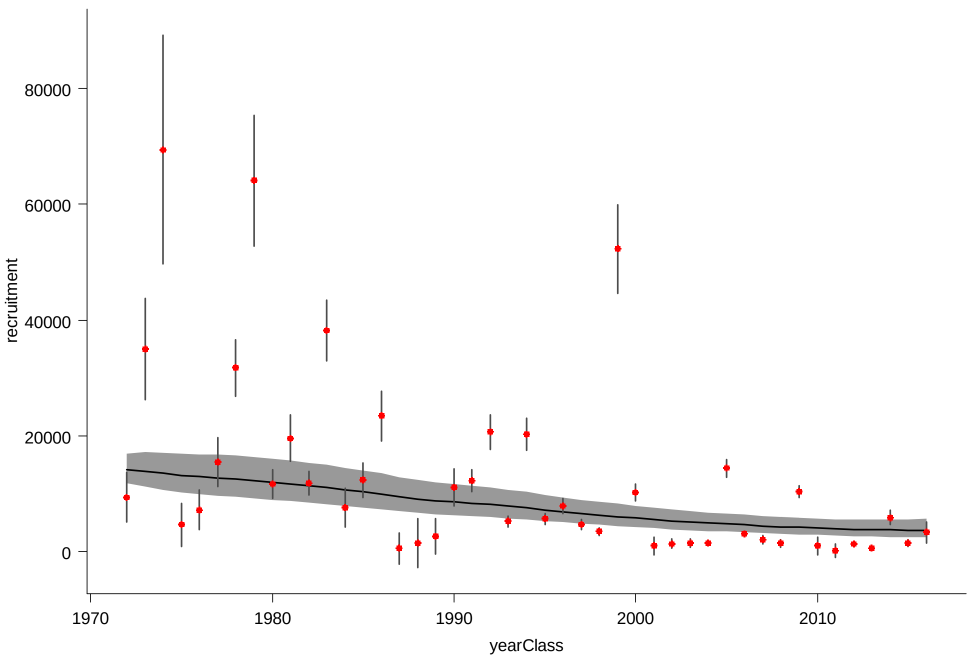


Figure 13.3.13. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk recruitment model estimated by TSA.

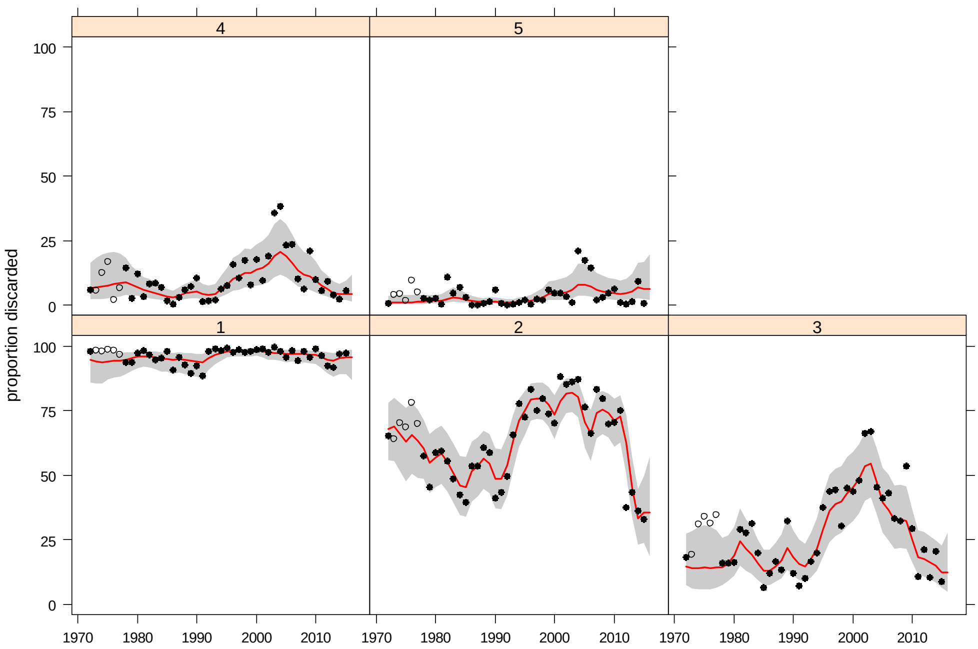


Figure 13.3.14. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch. The open points for the years 1973-1977 indicate that these values are treated as missing in the TSA estimation. All haddock of age 0 are assumed to be either discarded or caught as industrial bycatch.

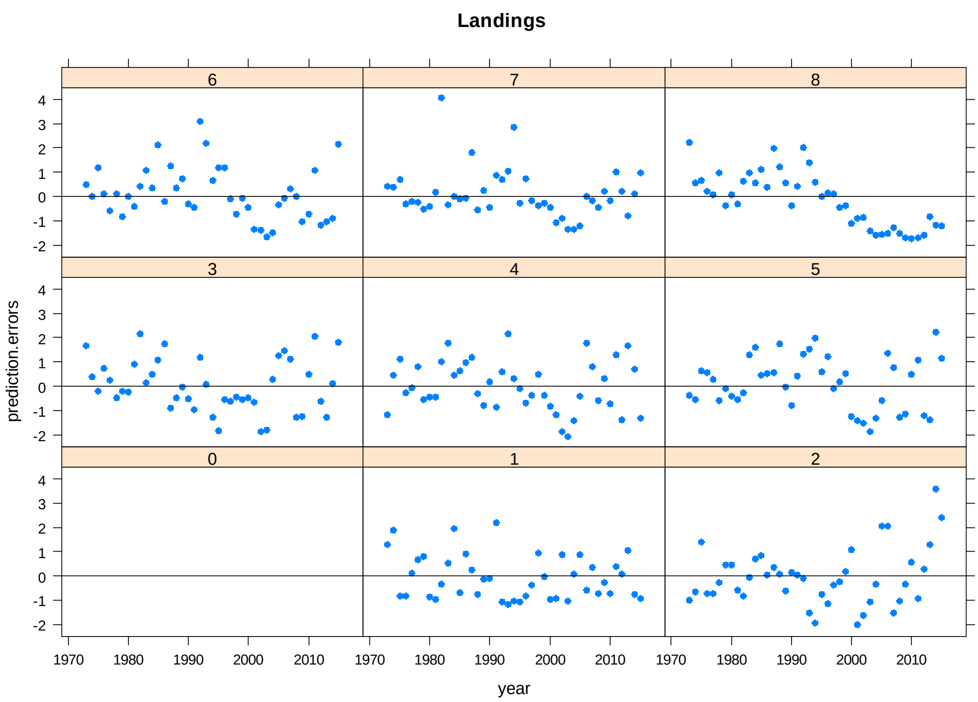


Figure 13.3.15. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Standardised TSA landings prediction errors by age.

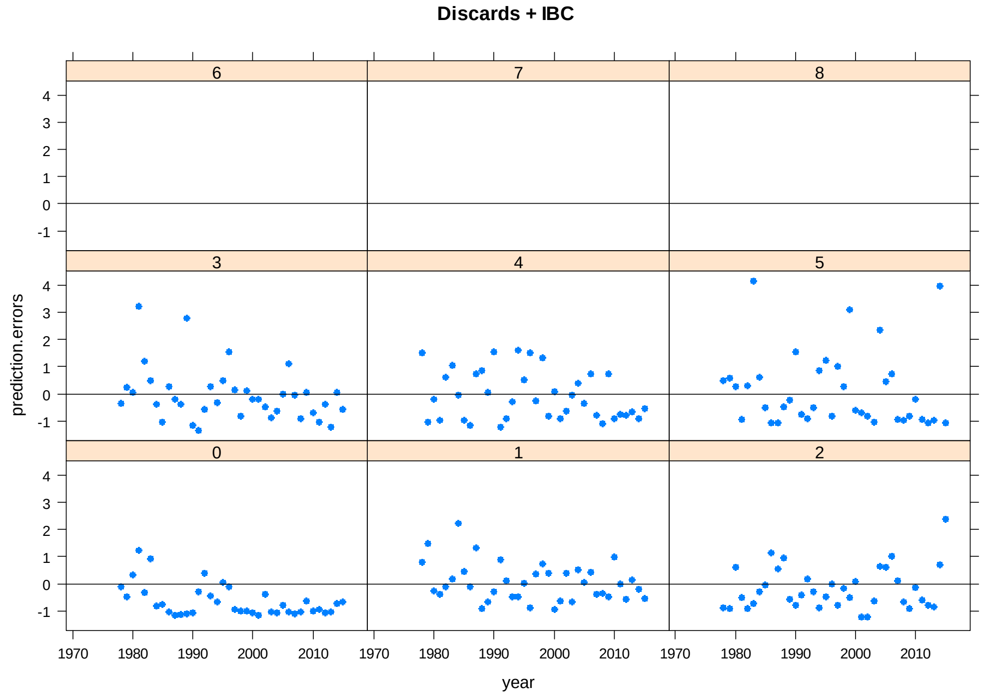


Figure 13.3.16. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Standardised TSA discards + IBC prediction errors by age.

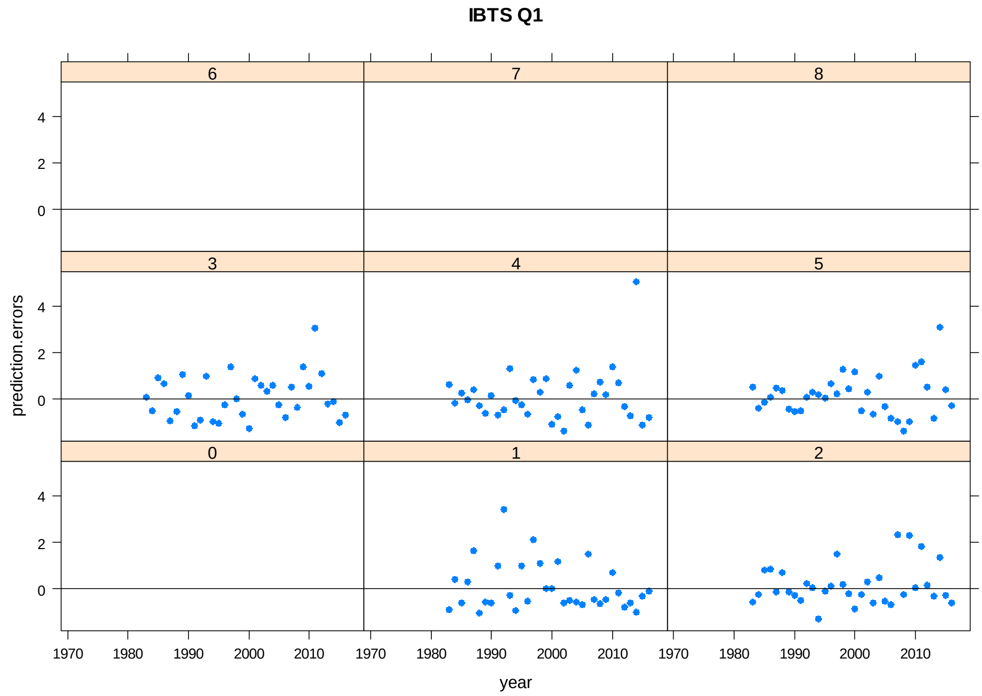


Figure 13.3.17. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Standardised TSA prediction errors by age for the IBTS Q1 survey index.

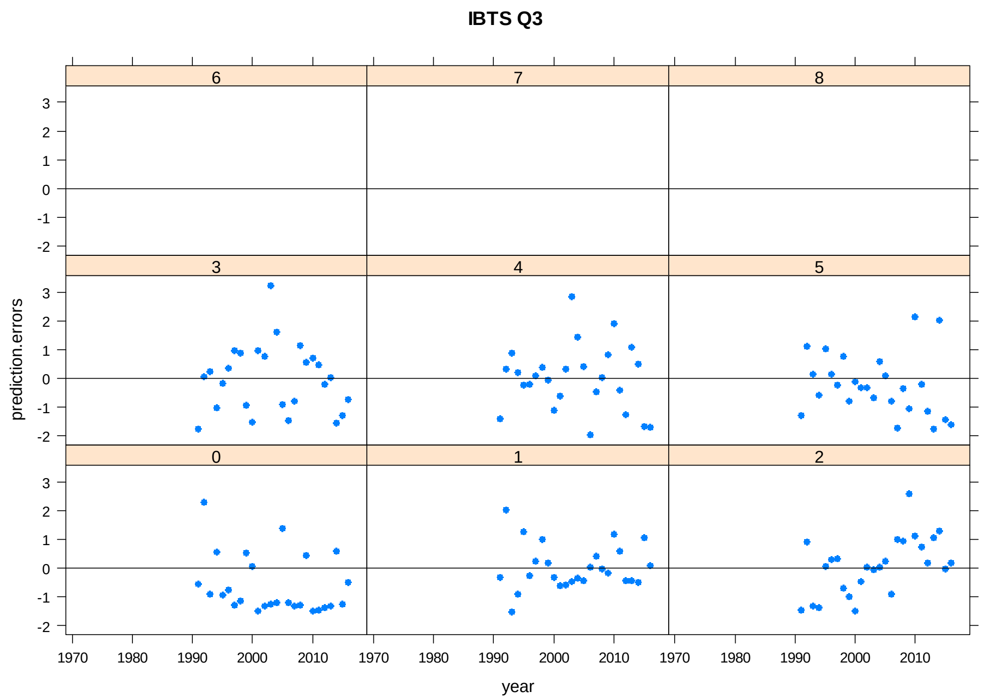


Figure 13.3.18. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Standardised TSA prediction errors by age for the IBTS Q3 survey index.

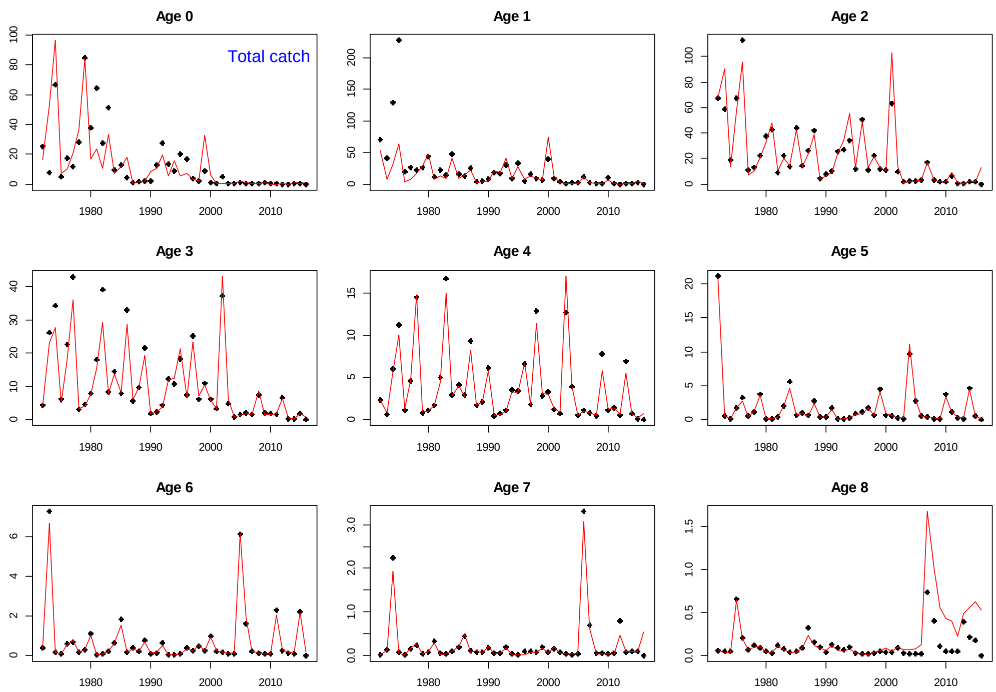


Figure 13.3.19. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Time-series of observed (points) and fitted (lines) values for total catch, by age.

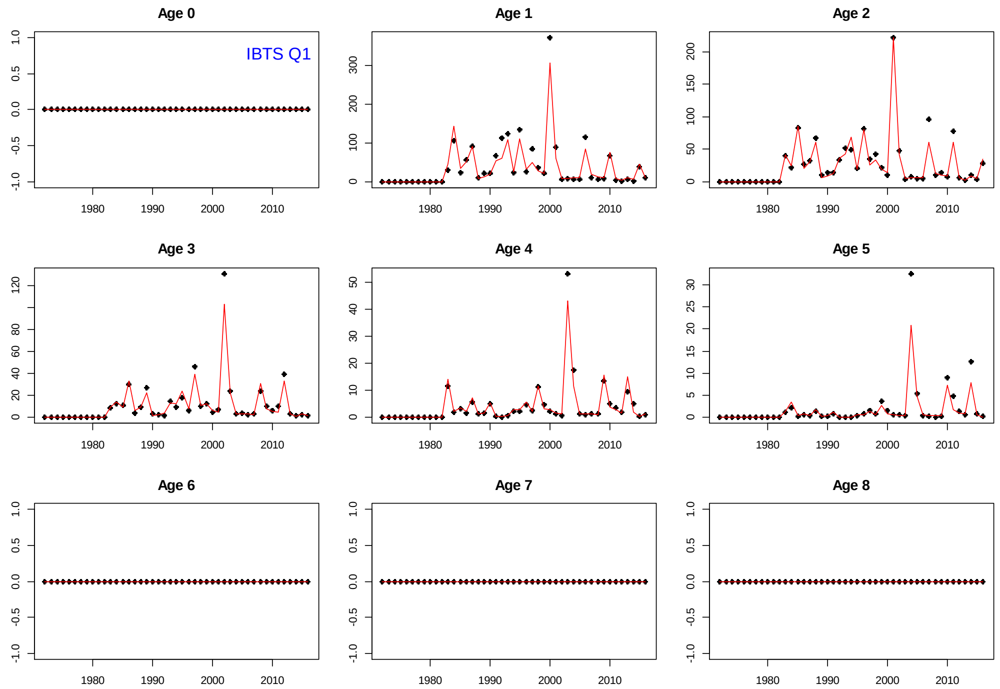


Figure 13.3.20. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

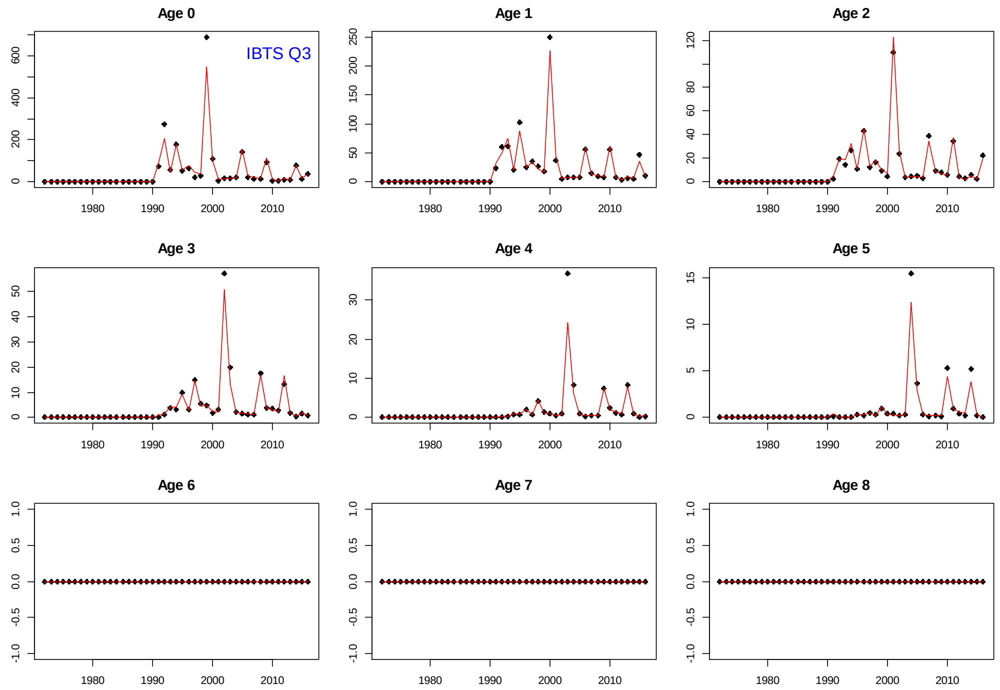


Figure 13.3.21. Haddock in Subarea 4, Division 3.a.20 and Division 6.a Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.

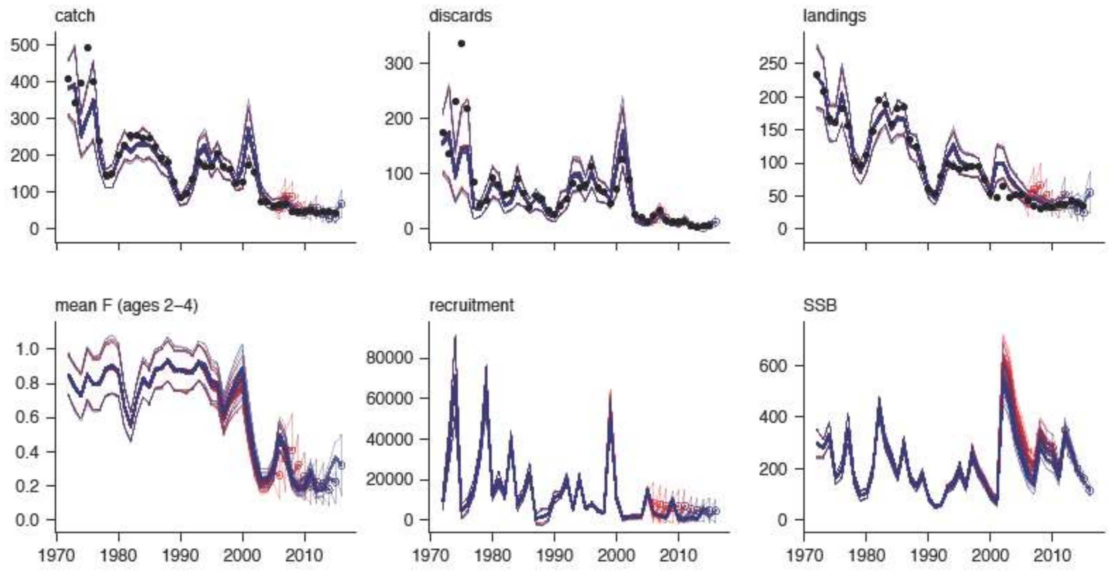


Figure 13.3.22. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Retrospective plots for the TSA assessment. The best estimates for each retrospective run end in an open circle, and each run is shown with the approximate pointwise 95% confidence interval. Estimates and CIs are colour-coded, with older runs becoming progressively more red.

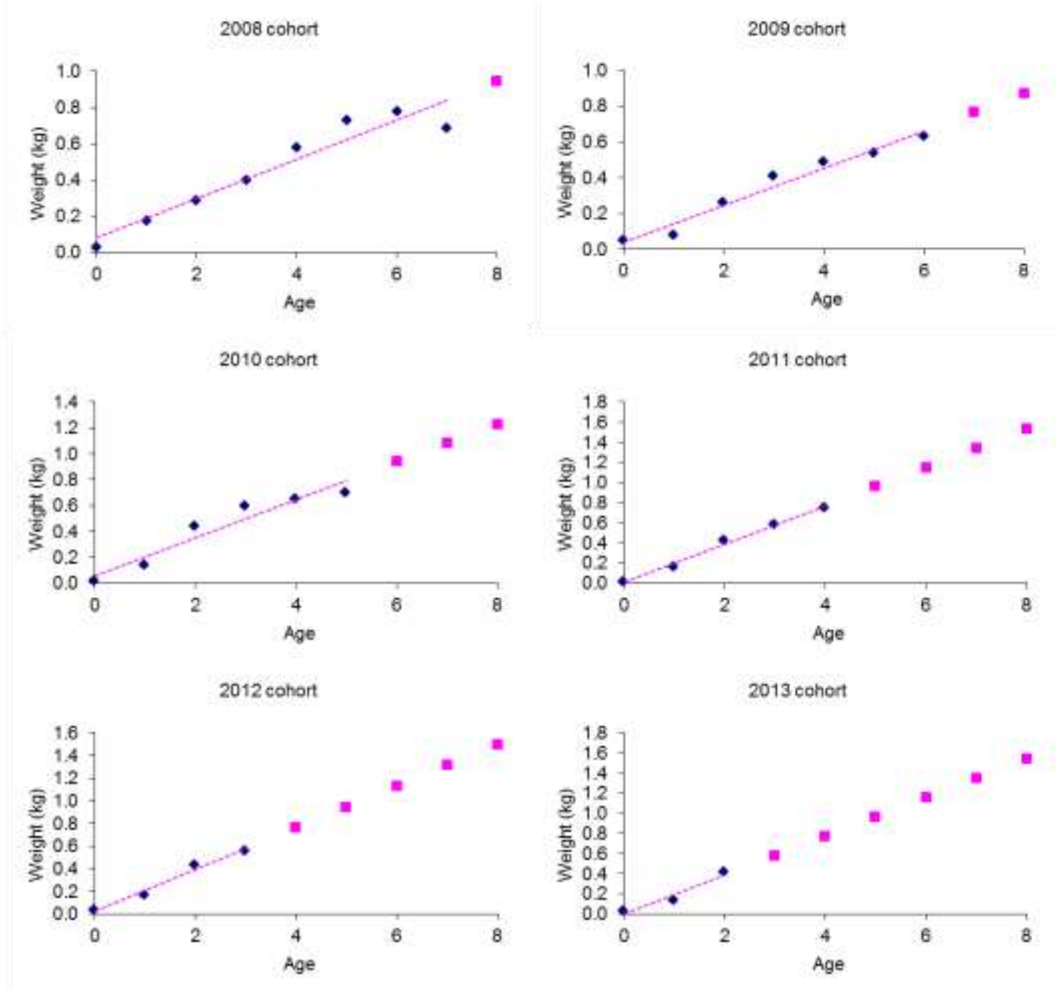


Figure 13.6.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski 2011). Cohorts 2008-2013 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

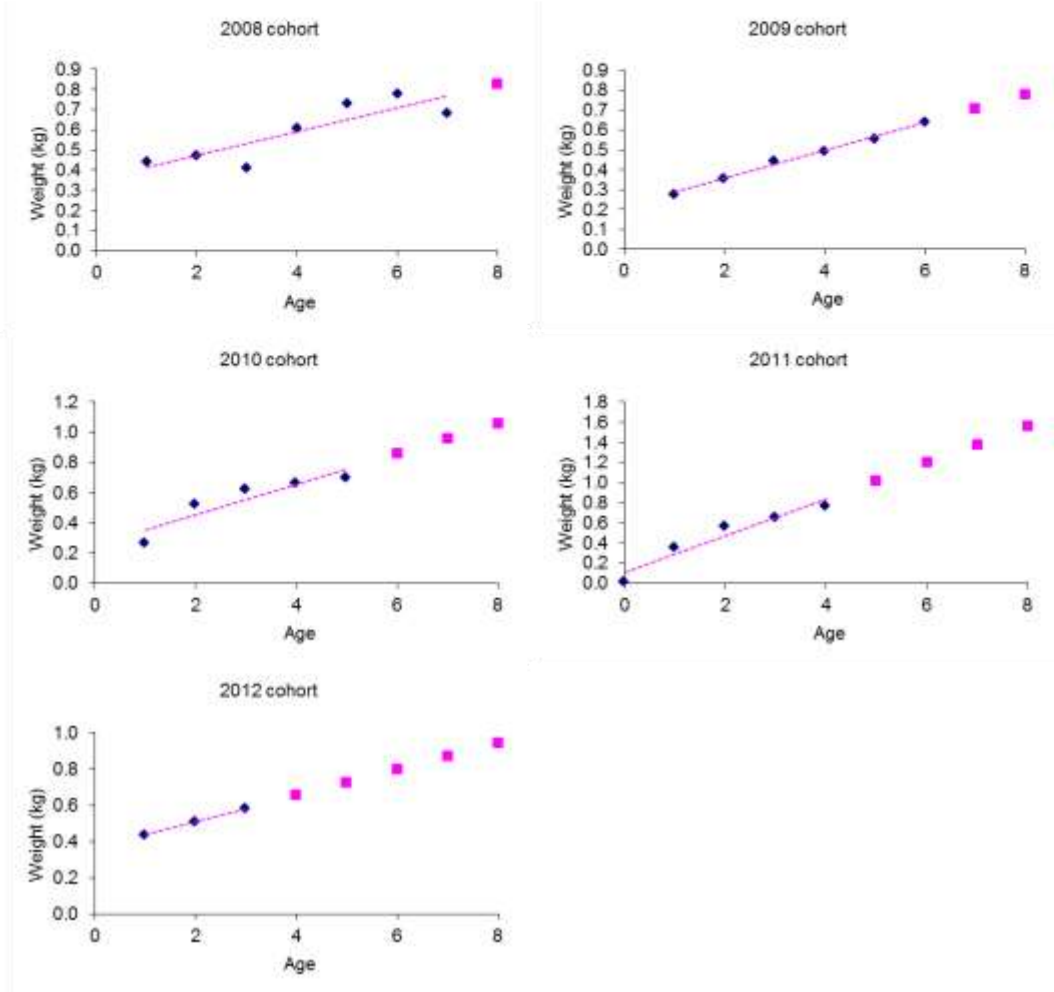


Figure 13.6.2. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Results of growth modelling for landings weights using cohort-based linear models (Jaworski 2011). Cohorts 2008-2012 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

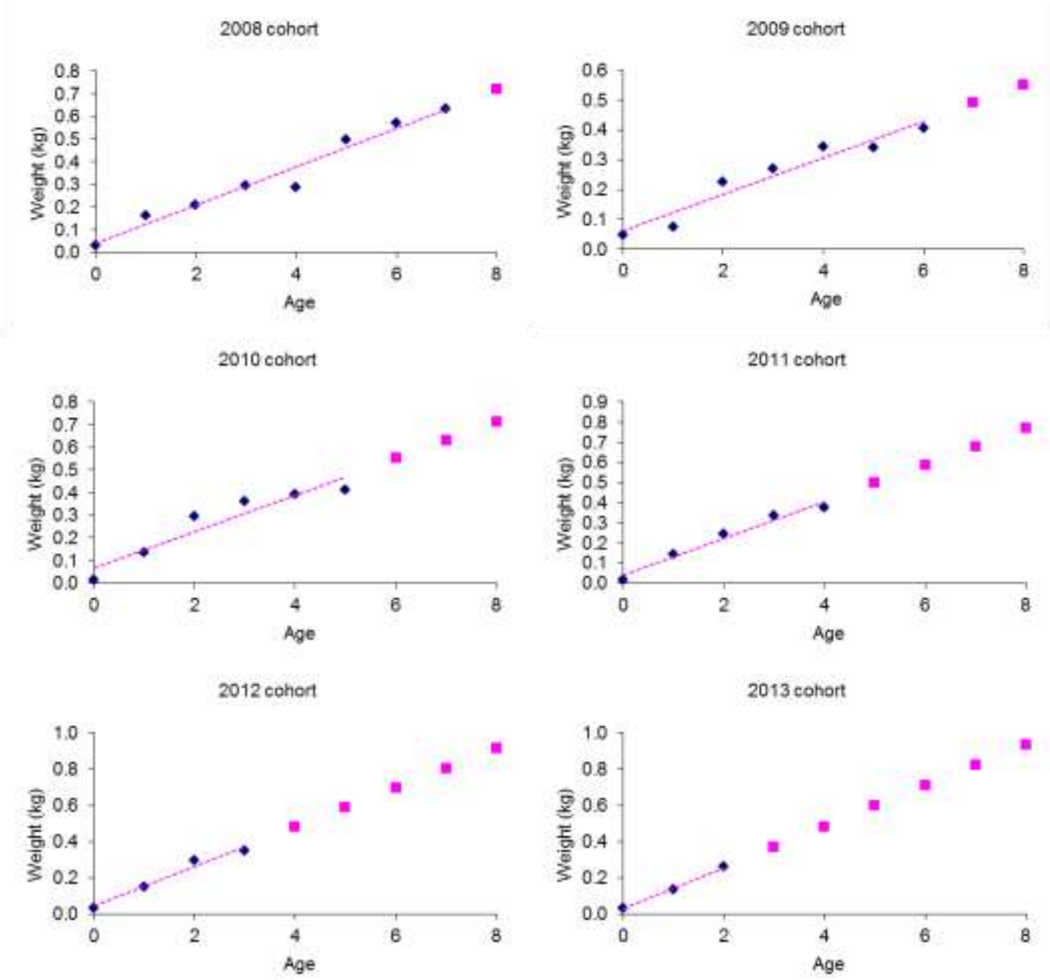


Figure 13.6.3. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Results of growth modelling for discard weights using cohort-based linear models (Jaworski 2011). Cohorts 2008-2013 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

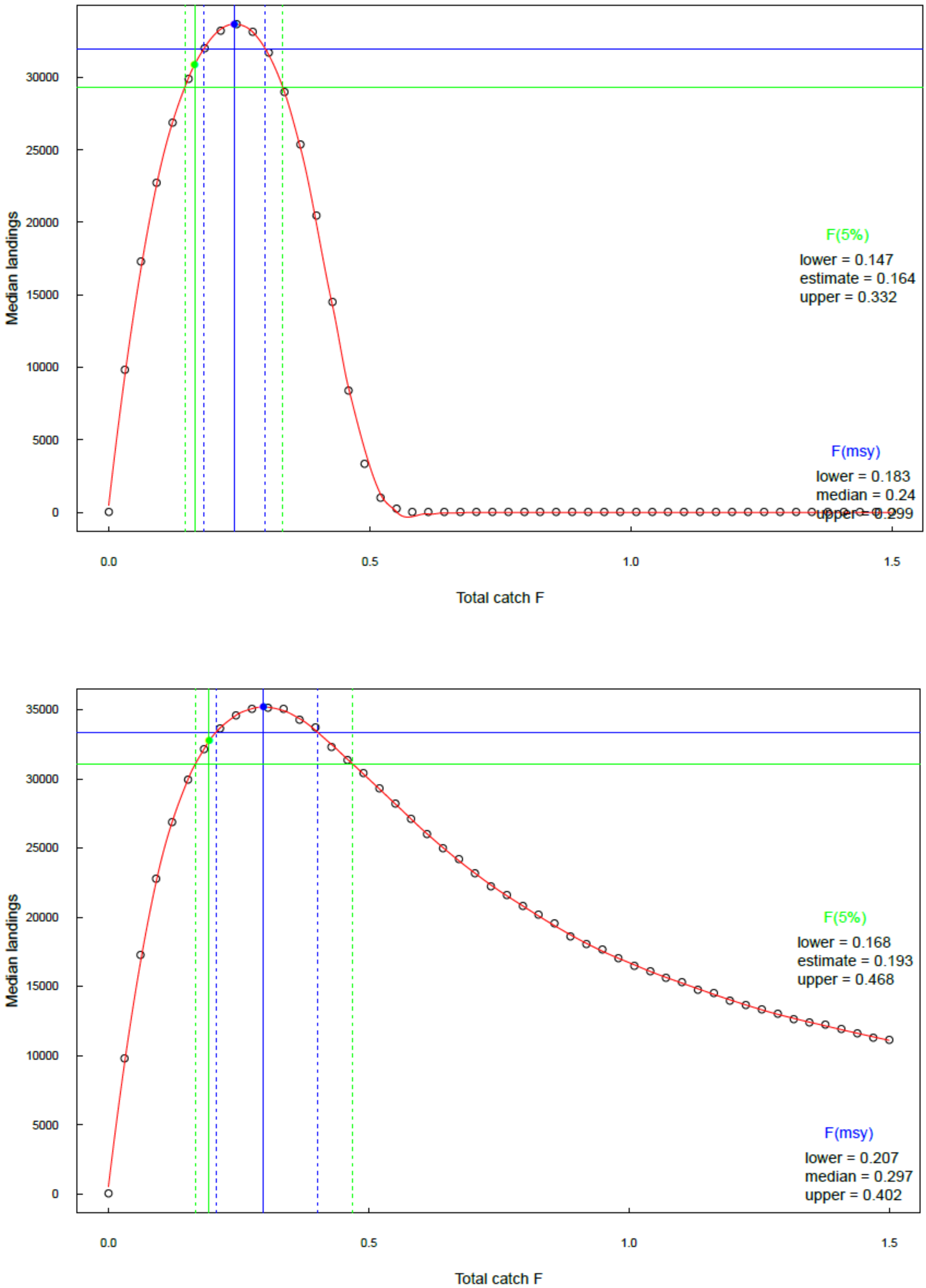


Figure 13.8.1. Haddock in Subarea 4, Division 3.a.20 and Division 6.a. Results of EqSIM estimation of F(MSY) with the advice error but no rule (top) and of Fp05 with both advice error and rule (bottom).

14 Cod (*Gadus morhua*) in Subarea 4 and Divisions 7.d and 3.a West (North Sea, Eastern English Channel, Skagerrak)

This assessment relates to the cod stock in the North Sea (Subarea 4), the Skagerrak (the western section of Division 3.a) and the eastern Channel (Division 7.d). This assessment is presented as an update from last year.

A stock annex 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. The forecast for this stock was re-run in the Autumn because new information from the IBTS Q3 survey triggered the re-opening criterion – the updated forecast is provided in Annex 04.

14.1 General

14.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

14.1.2 Ecosystem aspects

The North Sea is characterised by episodic changes in productivity of key components of the ecosystem. Phytoplankton, zooplankton, demersal and pelagic fish have all exhibited such cycles in variability. Managers should expect long-term change, and ensure that management plans have the potential to respond to new circumstances. Examples of these changes include the gadoid outburst in the 1970s. The contracted range of the North Sea cod stock can be linked to reduced abundance as well as environmental factors. A summary of available information on ecosystem aspects is presented in the Stock Annex.

14.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d, including beam trawls, otter trawls, seine nets, gill nets, trammel nets and lines. Most of these gears take a mixture of species. In some of them, cod are considered to be a bycatch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, some of the fixed gear fisheries). The main gears landing cod in the EU are primarily TR1 (mainly operated by Scotland, Denmark and Germany), but also GN1 (mainly Denmark), BT1 (mainly Denmark, Belgium and England), BT2 (mainly Netherlands, Belgium and Germany), and TR2. The overall effort by demersal trawls/seines has shown a reduction since 2003, especially in the North Sea. The effort by larger mesh (TR1) had remained relatively stable over the previous cod plan (2004–2009) but has been declining since the full implementation of the new cod plan in 2010 (STECF, 2014). A summary of historic information on the directed and by-catch cod fisheries and past and current technical measures used for the management of cod is presented in the Stock Annex.

Technical Conservation Measures

In 2009 a new system of effort management, by setting effort ceilings (kilowatt-days), was introduced in accordance with the new cod management plan (EC 1342/2008). The number of kw-days utilized was estimated for the different metiers of the national fleets during a reference period selected by each nation (2004–2006 or 2005–2007). From these reference values, the effort in the primary métiers catching cod (with discard and bycatch taken into account) would be reduced in direct proportion to reductions in fishing mortality until the new cod management plan target fishing mortality of 0.4 was achieved for levels of SSB at or above B_{pa}. EC 1342/2008 specifies that the reductions in effort shall be applied to metiers using Otter Trawls, Danish Seines or similar gears with mesh size 80 mm and larger and Gill Nets. However, if certain national fleet segments can provide proof that they use highly selective gears and/or that their catches per fishing trip comprise less than 5% cod, the reductions will not pertain. National fleet segments with less than 1.5% cod catches can apply to be excluded from the effort management regime completely. There has been no reduction in effort ceiling in 2013–2016 compared to 2012.

In 2008, Scotland introduced a voluntary programme known as "Conservation Credits", which involved seasonal closures, real-time closures (RTCs) and various selective gear options. This was designed to reduce mortality and discarding of cod. The scheme was incentivised by rewarding participating skippers with additional days at sea. The real-time closures system (15 were implemented in 2008) discouraged vessels from operating in areas of high cod abundance. In 2009, the number of closures implemented was increased substantially (to 144 for all areas subject to the cod management plan) and made mandatory, with up to 12 being implemented at any one time. Closures are determined by landings per unit effort, based on fine scale VMS data and daily logbook records and also by on-board inspections. Based on new in-year information on cod movement from tagging, the dimensions of the RTCs were increased by just over four times (from 50 square nautical miles to 225) from July 2010. The use of more species and size selective gears (some trialled by the Marine Laboratory in Aberdeen) formed a further series of options within the scheme. These included the 'Orkney' trawl, the use of nets with 130mm codends and larger meshes in the square meshed panels of Nephrops trawls. The scheme has delivered a total of 165, 185, 173, 166, 94 and 97 closures in 2010, 2011, 2012, 2013 2014 and 2015 respectively. ICES notes that from the initial year of operation (2008) cod discarding rates in Scotland have decreased from 61% to 24% in 2012, but have increased again to 31% in 2013, 27% in 2014 and 34% in 2015; it is hypothesised that this recent increase may be due in part to FDF (fully documented fisheries) vessels putting upward pressure on the lease price of cod, resulting in non-FDF vessels increasing the amount of cod they discard because they are unwilling to pay an above-market price for cod quota.

The expansion of the closed-circuit TV (CCTV) and FDF programmes in 2010–2015 in Scotland, Denmark, Germany, England and the Netherlands is expected to have contributed to the reduction of cod mortality. Under this scheme, UK vessels are not permitted to discard any cod, while Danish, German and Dutch vessels are still permitted to discard undersized cod. For participating vessels, all cod caught are counted against the quota, and in return fishers are permitted additional catches of cod. No effect of changed fishing behaviour has been observed for small vessels (<221kWh), though changes in fishing behaviour and increased marketable landings have been observed for the larger vessels. Though analyses are still underway, no high grading issues have been detected as yet. Landings by FDF métiers comprised less than 2% of total landings in 2009, rising to 27% in 2012, but has since declined to 22% in 2013 and 21% in 2014 and 2015 (Intercatch data).

Changes in national fleet dynamics

The ICES WGFTFB report now only provides a description of changes in EU fishing fleets and effort relevant to assessment working groups every second year; there is no such information in recent ICES-WGFTFB (2014, 2015) reports.

The Fishers' North Sea Stock Survey

A fishers' North Sea stock survey for 2015 was not available at the time of the Working Group. Historic comparisons between the fishers' North Sea stock survey and the IBTS survey data are given in previous WGNSSK reports.

14.1.4 Management

Management of cod is by TAC and technical measures. The agreed TACs for Cod in Division 3.a (Skagerrak), 7.d and Subarea 4 were as follows:

TAC(000T)	2009	2010	2011	2012	2013	2014	2015	2016
3.a (Skagerrak)	4.1	4.8	3.8	3.8	3.8	4.0	4.2	4.8
2.a + 4	28.8	33.6	26.8	26.5	26.5	27.8	29.2	33.7
7.d	1.7	2.0	1.6	1.5	1.5	1.6	1.7	2.0

For 2009 Council Regulation (EC) N°43/2009 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size (see section 2.1.2 for more details). For 2010–2016, Council Regulations (EC) N°219/2010, N°57/2011, N°44/2012, N°297/2013, N°432/2014, N°2015/104 and N°2016/72 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.

Cod recovery and management plans

A Cod Recovery Plan which detailed the process of setting TACs for the North Sea cod was in place until 2008. Details of it are given in EC 423/2004 and previous working group reports. ICES considered the recovery plan as not consistent with the precautionary approach because it did not result in a closure of the fisheries for cod at a time of very low stock abundance and until an initial recovery of the cod SSB had been proven.

In April 2008, the European Commission adopted a proposal to amend the cod recovery plan, based on input from stakeholders, and on scientific advice from both ICES and STECF that current measures have been inadequate to reduce fishing pressure on cod to enable stock recovery. The main changes proposed were replacing targets in terms of biomass levels with new targets expressed as optimum fishing rates intended to provide high sustainable yield, and introducing a new system of effort management by setting effort ceilings (kilowatt-days) for groups of vessels or fleet segments to be managed at a national level by Member States. The new system was intended to be simpler, more flexible and more efficient than the previous one, allowing effort reductions to be proportionate to targeted reductions in fishing mortality for the segments that contribute the most to cod mortality, while for other segments effort will be frozen at the average level for either 2004–2006 or 2005–2007.

In December 2008 the European Commission and Norway agreed on a new cod management plan that aimed to be consistent with the precautionary approach and was intended to achieve sustainable fisheries and high yield, leading to a target fishing mortality of 0.4. In addition to the EU-Norway agreement, the EU has implemented effort restrictions, reducing KW-days available to EU vessels in the main métiers catching cod in direct proportion to reductions in fishing mortality until the long-term phase of the plan is reached, for which the target F is 0.4 if SSB is above B_{pa}. Details of European Commission plan are given in EC 1342/2008.

A joint ICES–STECF group met during 2011 to conduct a historical evaluation of the effectiveness of these plans (ICES-WKROUNDMP, 2011; Kraak *et al*., 2013), and concluded that for North Sea cod, although there had been a gradual reduction in F and discards, the plans had not controlled F as envisaged, and that following the current regime was unlikely to deliver F_{msy} by 2015. However, there have been positive contributions under Article 13c of the EC plan towards achieving the cod plan targets. The EC plan is currently subject to deliberation between the European Commission, Council and Parliament.

The management plan HCR for setting TAC for North Sea cod stock are as follows (extracts from EC 1342/2008):

Article 7: Procedure for setting TACs for cod stocks in the Kattegat the west of Scotland and the Irish Sea

1. Each year, the Council shall decide on the TAC for the following year for each of the cod stocks in the Kattegat, the west of Scotland and the Irish Sea. The TAC shall be calculated by deducting the following quantities from the total removals of cod that are forecast by STECF as corresponding to the fishing mortality rates referred to in paragraphs 2 and 3:

(a) a quantity of fish equivalent to the expected discards of cod from the stock concerned;

(b) as appropriate a quantity corresponding to other sources of cod mortality caused by fishing to be fixed on the basis of a proposal from the Commission.

4. [assumed to apply to North Sea cod as well] When giving its advice in accordance with paragraphs 2 and 3, STECF shall assume that in the year prior to the year of application of the TAC the stock is fished with an adjustment in fishing mortality equal to the reduction in maximum allowable fishing effort that applies in that year.

Article 8: Procedure for setting TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel

1. Each year, the Council shall decide on the TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel. The TACs shall be calculated by applying the reduction rules set out in Article 7 paragraph 1(a) and (b).

2. The TACs shall initially be calculated in accordance with paragraphs 3 and 5. From the year where the TACs resulting from the application of paragraphs 3 and 5 would be lower than the TACs resulting from the application of paragraphs 4 and 5, the TACs shall be calculated according to the paragraphs 4 and 5.

3. Initially, the TACs shall not exceed a level corresponding to a fishing mortality which is a fraction of the estimate of fishing mortality on appropriate age groups in 2008 as follows: 75 % for the TACs in 2009, 65 % for the TACs in 2010, and applying successive decrements of 10 % for the following years.

4. Subsequently, if the size of the stock on 1 January of the year prior to the year of application of the TACs is:

(a) above the precautionary spawning biomass level, the TACs shall correspond to a fishing mortality rate of 0,4 on appropriate age groups;

*(b) between the minimum spawning biomass level and the precautionary spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate on appropriate age groups equal to the following formula: 0,4 – (0,2 * (Precautionary spawning biomass level – spawning biomass) / (Precautionary spawning biomass level – minimum spawning biomass level))*

(c) at or below the limit spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate of 0,2 on appropriate age groups.

5. Notwithstanding paragraphs 3 and 4, the Council shall not set the TACs for 2010 and subsequent years at a level that is more than 20 % below or above the TACs established in the previous year.

6. Where the cod stock referred to in paragraph 1 has been exploited at a fishing mortality rate close to 0,4 during three successive years, the Commission shall evaluate the application of this Article and, where appropriate, propose relevant measures to amend it in order to ensure exploitation at maximum sustainable yield.

Article 9: Procedure for setting TACs in poor data conditions

Where, due to lack of sufficiently accurate and representative information, STECF is not able to give advice allowing the Council to set the TACs in accordance with Articles 7 or 8, the Council shall decide as follows:

(a) where STECF advises that the catches of cod should be reduced to the lowest possible level, the TACs shall be set according to a 25 % reduction compared to the TAC in the previous year;

(b) in all other cases the TACs shall be set according to a 15 % reduction compared to the TAC in the previous year, unless STECF advises that this is not appropriate.

Article 10: Adaptation of measures

1. When the target fishing mortality rate in Article 5(2) has been reached or in the event that STECF advises that this target, or the minimum and precautionary spawning biomass levels in Article 6 or the levels of fishing mortality rates given in Article 7(2) are no longer appropriate in order to maintain a low risk of stock depletion and a maximum sustainable yield, the Council shall decide on new values for these levels.

2. In the event that STECF advises that any of the cod stocks is failing to recover properly, the Council shall take a decision which:

(a) sets the TAC for the relevant stock at a level lower than that provided for in Articles 7, 8 and 9;

(b) *sets the maximum allowable fishing effort at a level lower than that provided for in Article 12;*

(c) *establishes associated conditions as appropriate.*

Changes to the stock assessment and reference points in 2015 imply a need to re-evaluate the management plans in order to ascertain if they can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice is given according to the ICES MSY approach.

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 landings estimate for 2015 is 37.2 thousand tonnes, split as follows for the separate areas (thousand tonnes):

	TAC	Landings	Discards
3.a-Skagerrak	4.2	4.6	2.9
4	29.2	31.2	9.7
7.d	1.7	1.4	0.02
Total	35.1	37.2	12.6

WG estimates of discards are also shown in the above table.

Prior to the use of Intercatch for discard estimation, discard numbers-at-age were estimated for areas 4 and 7.d by applying the Scottish discard ogives to the international landings-at-age, and were based on observer sampling estimates for area 3.a-Skagerrak. Discard raising for 2002–2015 was performed in Intercatch, with the different nations providing information by area, quarter and métier. Prior to the reform of the EU's data collection framework in 2008 (see http://datacollection.jrc.ec.europa.eu/), sampling for discards and age compositions was poor in area 7.d, and this necessitated combining areas 4 and 7.d for 2002–2008 in order to facilitate computations in Intercatch. The provision of discard information has vastly improved since 2009 and covered 70% of the landings by weight in 2015, with all nations (apart from Norway) now providing discard information. Figure 14.1a plots reported landings and estimated discards used in the assessment. Discard ratio sampling coverage by area and season for 2015 is provided in Table 14.2e, along with the contributions to total landings and discards from each area prior to raising.

Norwegian discarding is illegal, so although this nation has accounted for 7–14% of cod landings over the period 2002–2015 (Intercatch data), it does not provide discard estimates. Nevertheless, the agreed procedure applied in Intercatch is that discards raising should include Norway (i.e. Norway will be allocated discards associated with landings in reported métiers). Furthermore, tagging and genetic studies have indicated that Norwegian coastal cod are different to North Sea cod and do not generally move into areas occupied by North Sea cod. Therefore, Norwegian coastal cod data have been removed from North Sea cod data by uploading only North Sea cod data into Intercatch for 2002 onwards, and by adjusting catches prior to 2002 to reflect the removal of Norwegian coastal cod data (an annual multiplicative adjustment of no more than 2.5% was made using Norwegian coastal cod data – see ICES-WKNSEA 2015 for more details).

For cod in 4, 3.a-Skagerrak and 7.d, ICES first raised concerns about the mis-reporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid-1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3 000t of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment (apart from the adjustment for Norwegian coastal cod).

For 1999 and 2000, the WG has no *a priori* reason to believe that there was significant under-reporting of landings. However, the substantial reduction in fishing effort implied by the 2001, 2002 and 2003 TACs is likely to have resulted in an increase in unreported catch in those years. Anecdotal information from the fisheries in some countries indicated that this may indeed have been the case, but the extent of the alleged under-reporting of catch varies considerably.

Marine Scotland-Compliance, a department in the Scottish government responsible for monitoring the Scottish fishing industry, operated a system intended to detect unreported or otherwise illegal fish landings (known as "blackfish"). Records show that blackfish landings have declined significantly since 2003, and is likely to be extremely low since 2006 (ICES-WKCOD, 2011). While the UK Registration of Buyers and Sellers regulation, introduced towards the end of 2005, may have had an important impact on the declining levels of blackfish landings, it is unlikely to be solely responsible, with other factors including large-scale decommissioning, and the development of targeting and monitoring systems that has substantially increased the pressure on the fleet.

The Danish Fisheries Directorate expressed the view that there is no indication of a lack of reporting of cod of any significance for vessels of ten meters and more. This view is based both on the analysis of six indicators of missing reports of landed cod, and a calculation of the difference between the total quantity of cod registered in logbooks and cod registered in sales receipts for Danish vessels over ten meters per quarter over the period 2008–2010, which has been shown to vary between approx. 0.5% and 2.5% (ICES-WKCOD, 2011).

Since the WG has no basis to judge the overall extent of under-reported catch over time, it has no alternative but to use its best estimates of landings, which in general are in line with the officially reported landings. An attempt is made to incorporate a catch multiplier to the sum of reported landings and discards data in the assessment of this stock for the period 1993–2005, but the figures shown in Table 14.2c and Figure 14.1a nevertheless comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations in 2015, althougth there are gaps from some nations in the years in 2002–2014 (e.g. France prior to 2009, Norway in 2011 and prior to 2005 and the Netherlands prior to 2015). The sampling coverage for landings and discards age compositions for 2015 are reported in Table 14.2e.

Landings in numbers at age for age groups 1–11+ and 1963–2015 are given in Table 14.2a. These data form the basis for the catch at age analysis but do not include industrial fishery by-catches landed for reduction purposes prior to 2002 (values from 2002 onwards were entered into Intercatch for all relevant nations except Norway, and were included in the raising, although the numbers were very small). By-catch estimates are available for the total Danish small-meshed fishery in Division 3.a and Subarea 4 and separately for the Skagerrak (Table 14.1). During the last five years, an average of 74% of the international landings in number were accounted for by juvenile cod aged 1–3; this average rises to 87% when considering landings and discards combined. In 2015, age 1 cod comprised 16% of the total catch by number, age 2, 50% and age 3, 22%.

Discard numbers-at-age are shown in Table 14.2b. The proportions of the estimated numbers discarded for ages 1–4 are plotted in Figure 14.1b. The proportion of the estimated total discards by weight are shown in Figure 14.1c, and by number in Figure 14.1d. Estimated proportion of total numbers caught that were discarded (Figure 14.1d) has varied between 35 and 70% from 1995 to 2005, but has shown an increase to between 70 and 85% in 2006–8, due to the stronger 2005 year class entering the fishery (estimated to be almost the size of the 1999 year class), and a mismatch between the TAC and effort. The total numbers discarded has decreased to between 50 and 60% in 2012–15. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% with no decline apparent after the introduction of the 120mm mesh in 2002. Since 2003, it has been at or above 90%, except for a brief decrease to 78% in 2011 and again in 2014, rising to 86% in 2015. At ages 2 to 4 discard proportions increased to a maximum around 2006–10, but have subsequently declined to give 58% for age 2, 29% for age 3 and 8% for 4 year old cod in 2015. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 14.2c. Landings, discards and total catch numbers at age are given by season in Table 14.2d for 2015. Reported landings, estimated discards and total catch (sum of landings and discards), given in tonnage, are shown in Table 14.4.

Intercatch

Intercatch was used for estimation of landings, discards and total catch at age and mean weight at age in 2015, and updates performed for 2014 (due to data revisions by UK-England and Wales). Data co-ordinators from each nation were tasked to input data into Intercatch, disaggregated to quarter and métier. The data from Norway excluded Norwegian coastal cod. Allocations of discard ratios and age compositions for unsampled strata were then performed in order to obtain the data required for the assessment. This is the fifth year that Intercatch is used for this purpose for North Sea cod. The approach used for discard ratio allocations was to do it by area (3.a.20, 4 and 7.d) and treat FDF métiers separately, giving six broad categories. Annual discards were first matched to quarterly landings. Then, within each of these six categories, ignoring country and season, where métiers had some samples these were pooled and allocated to unsampled records within that métier. At the end of this process, any remaining métiers were allocated an all-samples pooled discard ratio for the given category.

The landings and discards imported or raised for 2015 are as follows (thousand tonnes; note any differences in landings and discards values to those given above are due to SOP correction):

Catch Category	Raised or Imported	CATON	Percentage
Discards	Raised	2.7	22
Discards	Imported	9.9	78
Landings	Imported	37.4	100

A similar approach was used for allocating age compositions, except that there were 12 broad categories because discards were treated separately to landings.

The landings and discards imported or raised, with age distribution sampled or estimated for 2015 are as follows (thousand tonnes; note any differences in landings and discards values to those given above are due to SOP correction):

Catch Category	Raised or Imported	Sampled or Estimated	CATON	Percentage
Landings	Imported	Sampled	30.3	81
Landings	Imported	Estimated	7.1	19
Discards	Imported	Sampled	9.5	75
Discards	Raised	Estimated	2.7	22
Discards	Imported	Estimated	0.4	3

Intercatch is discussed in section 1.2, and all results are available on the WGNSSK sharepoint. Further work is ongoing, analysing the Intercatch data (cf ICES WGMIXFISH meeting during 2016).

14.2.2 Weight at age

Mean weight at age data for landings, discards and catch, are given in Tables 14.3a-c. Landings, discards and catch mean weights at age are given by season in Table 14.3d for 2015. 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 and above now seems to have been reversed. Ages 1 and 2 show little absolute variation over the long-term.

14.2.3 Maturity and natural mortality

Until 2015 the maturity values applied to all years were left unchanged from year to year, and were based on NS-IBTS Q1 data from 1981–1985. However, ICES-WKNSEA (2015) noted a change in maturity-at-age in the North Sea cod stock, with fish maturing at a younger age and smaller size. In order to address these changes in the stock, an area-weighted maturity age key was constructed from NS-IBTS Q1 data. As variation in sampling intensity added to the inter-annual variation, a smoother was applied to the maturity age key. This smoothed maturity age key was then applied to the estimation of spawning stock biomass. Maturity in 2016 was based on very low sample sizes (8 fish sampled for age 3 in the south), and the WG therefore rejected these maturity estimates and instead smoothed maturities to 2015 and assumed the 2015 maturity values to estimate SSB in 2016. The time-varying maturity ogive used in the assessment is given in Table 14.5a, and the ogives smoothed to either 2015 or 2016 are illustrated in Figure 14.2b.

Table 14.5b and Figure 14.2c show estimates of M, based on multi species considerations adopted for the assessment. ICES-WKROUND (2009) noted that as new stomach data (e.g. on seal predation) become available, a revision of more recent M2 values to reflect the current status of the food web, should be considered. Estimates of natural mortality, derived from multi-species analyses, are updated by the Working Group on Multi Species Stock Assessment Methods (WGSAM) every three years in so called "key runs" to account for improved knowledge of predation on cod by other species (mainly seals, harbour porpoises and gurnards) and cannibalism; the last update occurred in 2014 with the new key run (ICES-WGSAM 2014). The values presented in Table 14.5b are different to the ones presented by ICES-WGSAM (2014) and ICES-WKNSEA (2015) because an error in the input data to the multi species model was found after WKNSEA that led to a shift in parameters influencing the estimated natural mortalities for cod to a small extent. Between ICES-WGSAM (2014) and ICES-WKNSEA (2015) already unrealistically high predation mortalities on age 3 cod caused by harbour porpoise were corrected in an updated keyrun (see ICES-WKNSEA 2015).

14.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable as it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed. The WG has previously argued that, although they are in general agreement with the survey information, commercial CPUE tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES-WGNSSK 2001), and also changes in gear design and usage, as discussed by ICES-WGFTFB (2006, 2007). Therefore, although the commercial fleet series are available, only survey and combined commercial landings and discard information are analysed within the assessment presented.

ICES-WKCOD (2011) analysed UK commercial landings per unit of effort (days fishing) to the northeast and west of Shetland compared to the south and east. Analyses were conducted by gear type and vessel length. Landings per unit of effort (lpue) do not contain discard information or allow for reductions in catch/landings rates resulting from changes in fisher behaviour as part of the Scottish Conservation Credits programme; recent values are therefore likely to be underestimates of the catches and potential catch rates. Vessels from 19–23 m had a slightly greater increase in their catch rates to the north and west of Shetland, by a factor of 4 compared to 3.5 in the east. When catch rates were averaged across other vessel lengths and across all vessels, the WKCOD analysis could not identify differing rates of increase to either side of the Shetlands but did demonstrate that all vessels have had strong increases in lpue around the Shetlands in recent years.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS Q1): ages 1–6+, covering the period 1976–2016. 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 1991–2015. 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.

Maps showing the IBTS distribution of cod are presented in Figures 14.3a-b (ages 1-3+). The recent dominant effect of the size and distribution of the 1996 and, to a lesser extent, the 1999, 2005, 2009 and 2013 year-classes are clearly apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 2000, 2002 and

2004 year classes, but have subsequently begun to increase, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels but is increasing. The 2013 year class seems to be distributed more widely when compared to other year classes at the same age, indicating a slightly stronger year class, while the 2014 year class appears to be weak (Figure 14.3a and b), and the 2015 year class even weaker, based on only one survey (the 2016 IBTS Q1 survey; Figure 14.3a; Figure 14.6).

The 2011 benchmark of North Sea Cod resulted in the exclusion of the IBTS Q3 survey index, because divergent trends in recent years were observed when the Q3 index was applied independently of the Q1 index (ICES-WKCOD 2011). At that time it was decided that until the reasons for the discrepancies were resolved, the Q1 was more likely to reflect the stock, and hence the Q3 index was dropped from the assessment. The indices were calculated using the standard stratified mean methodology (mean by rectangle within year, followed by mean over rectangles by year), applied to an extended area (referred to below as the NS-IBTS extended index; ICES-WKROUND 2009; Figure 14.3c). This simple design-based estimator is unable to account for systematic changes in experimental conditions (e.g. change of survey gear). Given these issues, an alternative methodology that calculates standardized age-based survey indices based on GAMs and Delta-distributions (see also Berg WD3, ICES-WKNSEA 2015) has now been adopted (referred to as the NS-IBTS Delta-GAM index), and has led to both the Q1 and Q3 indices being incorporated into the assessment. The general methodology is described in Berg and Kristensen (2012) and Berg et al. (2014) and is implemented in R based on the DATRAS package (http://rforge.net/DATRAS/).

More details of the method used to produce the NS-IBTS Delta-GAM index is provided in the stock annex and can be found in ICES-WKNSEA (2015), as well as the above-mentioned publications. In summary the final Delta-GAM models selected for NS-IBTS Q1 and Q3 comprised a stationary spatial model, and included ship, year, depth, time-of-day and haul-duration effects. In addition, the Q3 model also included a gear effect (Q1 only has a single gear, GOV, so this effect is not an issue). The NS-IBTS Delta-GAM indices used in the assessment are given in Table 14.6. Figure 14.3d compares the Q1 and Q3 NS-IBTS extended indices to the corresponding NS-IBTS Delta-GAM indices.

14.3 Data analyses

14.3.1 Assessment audit

The assessment audit for North Sea cod was completed and no significant issues found. Additional checks on the forecast are carried out during the ICES WGMIXFISH meeting in 2016.

14.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 14.4a for the IBTS Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS Q3 survey in Figure 14.4b. The log-mean standardised curves indicate no obvious year effects (top-left plots), and tracks cohort signals well (top right). The log abundance curves for each survey series indicate consistent gradients (bottom left), with less steep gradients in recent years (bottom right).

Figures 14.5a and b show within-survey consistency (in cohort strength) for the NS-IBTS Q1 and Q3 Delta-GAM surveys indices, while Figure 14.5c shows between-survey consistency (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning. Correlations deteriorate for age 5 for the IBTS Q3 survey.

The SURBAR survey analysis model was fitted to both the Q1 and Q3 NS-IBTS Delta-GAM survey indices. The summary plots are presented in Figure 14.6.

Biomass –Spawning stock biomass reached the lowest level in the time series in 2005 caused by a series of poor recruitments coupled with high fishing mortality and discard rates at the youngest ages, but SSB has subsequently increased again because of the stronger 2005, 2009 and 2013 year classes and recent reductions in fishing mortality. This increase can also be seen in the time series for total stock biomass.

Total mortality –The SURBAR analysis indicates an overall gradual decline in total mortality with a slight increase in the most recent years.

Recruitment –The SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, but that the 2005, 2009 and 2013 year classes are among the highest of the recent low values.

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, 1999, 2005 and 2009 year classes to catches in recent years, with the larger 1996 year class disappearing more rapidly from the catches compared to the 1999, 2005 and 2009 year classes. It also shows the greater proportion of older fish in the catches at the start of the time series relative to recent years, but with the most recent years indicating a relative increase in the number of older fish in the catches. The 2005 and 2009 year classes feature strongly in the catch in the most recent period.

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, with the last three values being the lowest in the time series.

Assessment model

SAM

SAM (State-space Assessment Model, Nielsen and Berg 2014) has been used as the assessment model for North Sea cod since 2011, following acceptance at the 2011 benchmark meeting held for the stock (ICES-WKCOD 2011, ICES-WGNSSK 2011). More details can be found in Nielsen and Berg (2014) and in the ICES-WKCOD 2011 report, but essentially SAM models recruitment from a stock–recruitment relationship, with random variability estimated around it, or as a random walk in log-space. Starting from recruitment, each cohort's abundance decreases over time following the usual exponential equation involving natural and fishing mortality. Instead of assuming catches to be known without error and simply subtracting those, SAM assumes that catches include observation noise, and that the survival process along cohorts is a random process. This has the consequence that estimated F-at-age paths display less interannual variability with SAM than with deterministic assessment models, because part of the observed fluctuations in catch-at-age are arising from observation noise instead of from changes in F.

SAM puts random distributions on the fishing mortalities F(y,a), where (y,a) denotes year and age. SAM considers a random walk over time for log [F(y,a)], for each age, allowing for correlation in the increments of the different ages. It has observation equations for both survey indices-at-age and observed catch-at-age, so catch-at-age data are never considered to be known without error. Additionally, in order to deal with the uncertain overall catch levels over the period 1993–2005, SAM estimates annual catch multipliers for this period.

An extension to allow for varying correlation between different ages is achieved by setting the correlation of the log F annual increments to be a simple function of the age difference (AR(1) process over the ages). By doing this, individual log F processes will develop correlated in time, but in such a way that neighbouring age classes have more similar fishing mortalities than more distant ones. This correlation structure does not introduce additional parameters to the model, and is referred to as an AR correlation structure (see Nielsen and Berg 2014 for more details).

SAM is considered more appropriate than VPA approaches such as B-Adapt, because the additional variability/uncertainty considered in various components of SAM seems realistic and gives rise to results that are less reactive to noise in the catch or survey data or to potential changes in survey catchability.The fact that SAM considers random variability of the annual survival process along cohorts separately from fishing mortality produces smoother estimated F paths over time. Because the current management regime for the North Sea cod stock is strongly focused on F estimates in the final assessment year, it is important that these estimates do not change too suddenly in response to some data values which may represent noise. Additionally, SAM utilizes the age structure of the observed catch even in years when the overall catch value is considered biased. SAM was considered by recent benchmarks of North Sea cod (ICES-WKCOD 2011; ICES-WKNSEA 2015) to be the most appropriate modelling approach for the stock assessment.

The assessement uses a time-varying maturity ogive, obtained by smoothing through an area-weighted maturity age key derived from the NS-IBTS Q1 survey data. The WG rejected the 2016 maturity estimates on the basis of low sample size and instead smoothed maturities to 2015 and assumed the 2015 maturity values to estimate SSB in 2016. This affects estimates of SSB, but has no impact in the assessment because recruitment is modelled as a random-walk process independent of SSB. An additional run of SAM using a maturity ogive smoothed to the 2016 maturity values is presented as a sensitivity check on SSB.

Figure 14.9a shows the SAM assessment with maturities smoothed to 2015, and Figure 14.9b the SSB plot with maturities smoothed to 2016; the final assessment from last year (2015) is given in light grey for comparison. Rejecting the 2016 maturity estimates results in a SSB almost 15 thousand tonnes higher than had they been included, but has no further impact on the assessment.

Normalised residual plots are shown in Figure 14.10 , indicating no serious model misspecification. Retrospective plots for SSB, average fishing mortality and recruitment at age 1 are shown with Mohn's r statistics in Figure 14.11, indicating no serious retrospective patterns. A summary of the SAM final assessment run in terms of population trends is provided in Figure 14.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 14.13.

14.3.4 Final assessment

The SAM update run with maturity smoothed to 2015 is accepted as the final assessment. The data used in the assessment are given in Tables 14.2–3 and 14.5–6, and the model configuration in Table 14.7a. Model fitting diagnostics, parameter estimates and associated correlation matrix are given in Table 14.7b, while normalised residual plots and retrospective runs are shown in Figures 14.10 and 14.11 respectively. Estimates of fishing mortality at age, stock numbers at age and total removals at age are given in Tables 14.8–10 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, total removals and Fbar (2–4) are given in Table 14.11a (along with 95% confidence bounds), and estimates of landings, discards, catch, the catch multiplier and total removals (combining all these components) are given in Table 14.11b (and can be compared to the corresponding data in Table 14.4). Table 14.11c provides estimates of the catch multiplier along with 95% confidence bounds. Summary plots of the final assessment in terms of population trends is provided in Figure 14.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into age is shown in Figure 14.13. A comparison with last year's assessment is provided in Figure 14.14.

14.4 Historic Stock Trends

The historic stock and fishery trends are presented in Figures 14.12–13 and Table 14.11a–c.

Recruitment has fluctuated at a relatively low level since 1998. The 1996 year class was the last large year class that contributed to the fishery, and subsequent year classes have been the lowest in the time series apart from the 1999, 2005, 2009 and 2013 year classes. The 2006–8, 2010–12 and 2014 year classes are estimated to be weak.

Fishing mortality increased until the early 1980's, remained high until 2000 after which it has declined, and is now just below 0.4, the target for the management plan when $SSB>B_{pa}$.

SSB declined steadily during the 1970's and 80's. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the mid 1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline. SSB is estimated to have increased in recent years from the lowest level in the time series in 2006. TSB estimates have been increasing for slightly longer than SSB because of the 2005 year class, but have not experienced as rapid an improvement as SSB because of continued low recruitment.

Figure 14.15 indicates that the age structure in the population is gradually improving (number of fish aged 5 and older in the population appears to be increasing), and the survival of fish to age 5 is at its highest level in the time series.

Biomass indices by subregion (Figure 14.16a with subregions given in Figure 14.16c) highlight differing rates of change in cod biomass, with a general decline in all areas prior to the mid-2000s, and a general increase in all areas thereafter, apart from the southern area, where biomass has not increased following the decline. Recruitment indices by subregion (Figure 14.16b with subregions given in Figure 14.16c) show similar trends in all areas. Management measures ensuring sustainable exploitation of sub-stocks may be needed in addition to management for the stock as a whole.

14.5 Recruitment estimates

Estimates of recruitment were sampled from the 1997–2014 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005, 2009 and 2013 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 is performed with the EQSIM software (ICES-WGMG 2013), in accordance with the guidelines provided in ICES-WKMSYREF3 (2014). MSY estimation for North Sea cod was performed during the WKMSYREF3 meeting in late 2014 (ICES-WKMSYREF3 2014) and repeated during WKNSEA (ICES-WKNSEA 2015) and WGNSSK (ICES-WGNSSK 2015) in 2015; the B_{lim} used in the analysis was taken as the SSB associated with the 1996 year class (the last reasonably-sized recruitment; Section 14.9). MSY ranges for NS cod were pulished during 2015 following an EU request to provide plausible values around F_{MSY} (ICES-Special Request Advice 2015).

Assessment error in the advisory year and associated autocorrelation was derived from MSE evaluations of the current EU management plan for both assessments. There were three choices for recruitment periods, namely the full time series, only recruitment from 1988 onwards (reflecting the period of known productivity change in the North Sea), and only recruitment from 1998 onwards (reflecting the recent low period of recruitment for North Sea cod). The second of these (1988 onwards) was selected for the analysis because it was a period that included the SSB used for B_{lim}, reflected the productivity change in the North Sea, and excluded the "gadoid outburst" of the 1960s and 1970s that could be considered an exception. Nevertheless, there are indications that recruitment from 1998 onwards has been lower than would be explained by SSB alone, so an EQSIM analysis based on the very low recruitment period of 1998 onwards was used as a precautionary check on the F_{MSY} range. Further investigation is needed to evaluate whether this very low recruitment period is just due to short-term environmental effects, or whether it is likely to continue in the long term; such changes may influence both the recovery rate of SSB and the values for biomass reference points.

A summary of the resultant biological reference points based on the recruitment period 1988–2014 (not including the advisory HCR in all but FP.05) is provided in the following table.

Stock	
FMSY	0.33
FMSY lower	0.22
FMSY upper	0.49
FP.05 (5% risk to Blim, no HCR included)	0.62
FP.05 (5% risk to Blim, with HCR included)	0.75
FMSY upper precautionary	0.49*
MSY	102 903 t
Median SSB at FMSY	466 778 t
Median SSB at FMSY upper precautionary	351 435 t
Median SSB at FMSY lower	687 971 t

*Note that for the recruitment period 1998–2014, the $F_{P.05}$ value is 0.42 for an EQSIM run with no HCR included, and 0.52 for an EQSIM run with HCR included, so in the case where the HCR is included, the F_{MSY} upper value is not constrained.

14.7 Short-term forecasts

The May forecast

Forecasting takes the form of short-term stochastic projections. A total of 1 000 samples are generated from the estimated distribution of survivors, with recruitment being sampled with replacement from the year 1998 to the final year of catch data (a period during which recruitment has been low). These replicates are then simulated forward according to model and forecast assumptions (see Table below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios.

Forecasts are presented for the final SAM run with maturities smoothed to 2015 (Table 14.12a) and for the sensitivity run with maturites smoothed to 2016 (Table 14.12b). Forecast assumptions are as follows. [Note that the values that appear in the catch options Tables 14.12a and b are medians from the distributions that result from the stochastic forecast.]

Initial stock size	Starting populations are simulated from the estimated distribution at the start of the intermediate year (including co-variances).
Maturity	Maturity for the intermediate year is taken from the smoothed maturity ogive. Maturity for the TAC year onwards is the 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	Average of final three years of assessment data.
Weight at age in the stock	Assumed to be the 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, assumed to be 1 to reflect a status quo intermediate year assumption.
Stock recruitment model used	Recruitment for the intermediate year onwards (the year the WG meets) is sampled, with replacement, from 1998 to the final year of catch data.
Procedures used for splitting projected catches	The final year landing fractions are used in the forecast period.

Large differences in SSB in the intermediate year between the assessment and the forecast resulted from assuming the final year of assessment data in 2016 for the assessment and the average of the final three years assessment data in 2016 for the forecast. This divergence had not presented itself to this extent in previous years, and was solved by using three year averages for stock weights and natural mortality to calculate SSB in the intermediate year for the assessment, and by using the smoothed maturity estimates to calculate SSB in the intermediate year for the forecast (which were set equal to 2015 maturity estimates in the final assessment) so the two calculations are consistent.

This is the first year that maturity data has been available in the assessment year and, for the sensitivity run where the 2016 maturity estimates were retained, necessitated increasing the forecast assumption for maturity from a three to a four year average. This is consistent with the start of the period over which the other data are averaged and allows inclusion of the most recent maturity estimate.

The October forecast

Since the NS-IBTS Q3 index has been re-introduced into the assessment, there is an opportunity to update the forecast in October following the NS-IBTS Q3 survey. ICES-WKNSEA (2015) recommended that the usual procedure be used to establish whether to re-open advice in the autumn (as described in ICES-AGCREFA 2008). Once it has been established that advice should be re-opened for North Sea cod, the recommended procedure is to then re-run the assessment and forecast with the new Q3 data included, but to use the actual SAM estimate of recruitment for the intermediate year (the year following the final year of catch data), with recruitment for the years following the intermediate year being re-sampled, with replacement, from the period 1998 to the final year of catch data.

The ICES-WKNSEA (2015) recommendations on conducting the North Sea cod forecast deviated from the ICES norm in that the October forecast implies re-running the SAM assessment, and was therefore presented to the ICES ACOM leadership who have given it their approval. The forecasting procedure will therefore follow the ICES-WKNSEA (2015) recommended approach.

The current May forecast

A number of scenarios were considered as follows [note, $B_{trigger}$ = B_{pa} = 165 000t, and F_{MSY} = 0.33; see Section 14.9]:

1. EU Management plan: the Longterm Phase of the plan, applying the sliding rule with former B_{lim} and B_{pa} values (70 000t and 150 000t respectively) (paragraph 4 of Article 8 of EC 1342/2008), ensuring that TAC (2017) is within 20% of TAC (2016)
2. EU-Norway agreement plan: the Longterm Phase of the plan, applying the same sliding rule as for the EU Management plan, but using the new B_{lim} and B_{pa} values (118 000t and 165 000t respectively) (see Section 14.9), ensuring that TAC (2017) is within 20% of TAC (2016)
3. MSY framework: Fbar (2017) = F_{MSY}×min{1; $SSB_{2017}/B_{trigger}$}
4. Zero catch: Fbar (2017) = 0
5. MSY: Fbar (2017) = F_{MSY}
6. F_{pa}: Fbar (2017) = F_{pa} = F_{lim}/1.4 = 0.41
7. F_{pa}: Fbar (2017) = F_{pa} = $F_{lim} \times \exp(-\sigma \times 1.645)$ = 0.47
8. F_{lim}: Fbar (2017) = F_{lim}
9. SSB (2018) = B_{lim}: F corresponding to SSB (2018) = B_{lim}
10. SSB (2018) = B_{pa}: F corresponding to SSB (2018) = B_{pa}
11. SSB (2018) = $B_{trigger}$: F corresponding to SSB (2018) = $B_{trigger}$
12. Lower TAC constraint: Fbar (2017) such that TAC (2017) = 0.8×TAC (2016)
13. Rollover TAC - 15%: Fbar (2017) such that TAC (2016) = 0.85×TAC (2016)
14. Rollover TAC - 10%: Fbar (2017) such that TAC (2017) = 0.9×TAC (2016)
15. Rollover TAC - 5%: Fbar (2017) such that TAC (2017) = 0.95×TAC (2016)
16. Rollover TAC: Fbar (2017) such that TAC (2017) = TAC (2016)

17. Rollover TAC + 5%: Fbar (2017) such that TAC (2017) = 1.05×TAC (2016)
18. Rollover TAC + 10%: Fbar (2017) such that TAC (2017) = 1.1×TAC (2016)
19. Rollover TAC + 15%: Fbar (2017) such that TAC (2017) = 1.15×TAC (2016)
20. Upper TAC constraint: Fbar (2017) such that TAC (2017) = 1.2×TAC (2016)
21. Status quo – constant F: Fbar (2016) = Fbar (2015)

The reason two management plan options (1 and 2 above) are supplied is because both plans were based on B_{lim} and B_{pa} as part of the sliding rule, but with the revision of these reference points in 2015, the two plans now differ from one another. The EU management plan continues to be based on the previous values for B_{lim} and B_{pa} (formerly 70 000t and 150 000t respectively) while the EU-Norway agreement has the flexibility to accommodate the revised values for these quantities (118 000t and 165 000t respectively). Furthermore, both management plans switched into their long-term phases (when they were still based on the same values for B_{lim} and B_{pa}) in 2013.

Two catch options (6 and 7 above) are supplied for F_{pa}. The first relates to the value of F_{pa} derived from F_{lim}/1.4 while the second relates to the F_{pa} value based on assessment uncertainty in fishing mortality in the terminal year (Section 14.9).

Forecasts for the SAM final run and associated scenarios are given in Table 14.12a. For completeness, Table 14.12b provides the corresponding forecasts for the SAM sensitivity run with maturities smoothed to 2016, excluding options 8–11.

14.8 Medium-term forecasts

Medium-term projections are not carried out for this stock.

14.9 Biological reference points

Biological reference points were calculated in 2015 on the basis of the SAM final assessment (ICES-WGNSSK 2015). The choice for B_{lim} was to take the last SSB to have produced a reasonably-sized recruitment (the 1996 year class); the reason the changepoint in a segemented regression fitted to the whole time period was not used was because this time period spans different environmental and recruitment regimes, and such a changepoint would therefore not be appropriate for deriving B_{lim}. The SSB in 1996 produced the last outstanding year class (1 162 403 thousands recruits based on the 2015 assessment) that was above the average observed between 1963 and 1996 (1 029 484 thousands based on the 2015 assessment) when the stock produced relatively high recruitment compared to recently observed values. Therefore, it can be argued that a SSB above the one observed in 1996 has the potential to produce high recruitment under sufficiently good environmental conditions, and therefore impaired recruitment because of a too-low SSB is avoided. Bpa was simply calculated as 1.4×B_{lim}.

F_{lim} was calculated on the basis of the SAM final assessment from 2015, for consistency with existing reference points. F_{lim} estimation was performed with the EQSIM software on the basis of the very low recruitment period from 1998, consistent with the calcualtion of $F_{P.05}$ used as a precautionary check on the F_{MSY} range (as opposed to the period 1988 onwards used for calculation of B_{lim} and B_{pa}). The changepoint of the segmented regression was estimated rather than forced at B_{lim}. This deviation from the ICES guidelines avoids use of a stock-recruit curve that falls below the majority of observed stock-recruit pairs and is consistent with the curve used for calculating the existing $F_{P.05}$ value. F_{pa} was simply calculated as F_{lim}/1.4, and an alternative F_{pa} value was calculated on the basis of assessment uncertainty in fishing mortality in the final assessment year (σ = 0.12; F_{pa} = 0.47) following the ICES guidelines. Biological reference points are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Btrigger	165 000 t.	The default option of Bpa.(=1.4×Blim)	
	FMSY	0.33	EQSim analysis based on recruitment period 1988–2014	2015 assessment
Precautionary approach	Blim	118 000 t.	SSB associated with the 1996 year class	2015 assessment
	Bpa	165 000 t.	Blim multiplied by 1.4. This is the current ICES default approach.	
	Flim	0.58	EQSim analysis based on recruitment period 1998–2014	2015 assessment
	Fpa	0.41	Flim/1.4	
EU Management plan	SSBlower	70 000 t.	Former Blim	EC 1342/2008
	SSBupper	150 000 t	Former Bpa	
	Flower	0.2	Fishing mortality when SSB <SSBlower.	
	Fupper	0.4	Fishing mortality when SSB>SSBupper	
EU-Norway agreement	SSBlower	118 000 t.	Revised Blim	2008 EU-Norway agreement
	SSBupper	165 000 t	Revised Bpa	
	Flower	0.2	Fishing mortality when SSB <SSBlower.	
	Fupper	0.4	Fishing mortality when SSB>SSBupper	

14.10 Quality of the assessment

The quality of the commercial landings and catch-at-age data for this stock deteriorated in the 1990s following reductions in the TAC without associated control of fishing effort. The WG considers the international landings figures from 1993 onwards to have inaccuracies that lead to retrospective underestimation of fishing mortality and over estimation of spawning stock biomass and other problems with an analytical assessment. The mismatch between reported and actual landings is assumed to be negligible since 2006.

Prior to 2002 estimates of discards for areas 4 and 7.d 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. Intercatch has been used to raise data for discards ratios and landings and discard age compositions from 2002 onwards. The provision of discard information has vastly improved since 2009.

Comparing the assessment this year with last year gives the following (Figure 14.14): historical SSB trends are similar; the stock is above B_{lim} and approaching B_{pa}; fishing mortality continues to decline, and is now just below the management plan target of 0.4, but still above F_{msy}; there is hardly any difference in fishing mortality compared to last year.

The estimated CVs for observed catch at age 1, for the NS-IBTS Q1 and Q3 survey indices at age 1 and for the stock–recruitment relationship are all large: 61%, 46%, 36% and 75%, respectively. These large CVs suggest that these sources of information are somewhat 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 non-recruiting ages (estimated at 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.

Finally, the high correlation (0.89) 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.

Changes to the assessment in 2015 include a reduction of the plusgroup from 7+ to 6+. This reduces the cohort information for ages 6+; these ages represent around 26% of the SSB (by weight), and if the SSB continues to increase, this proportion should also increase as more fish aggregate in the plusgroup, with an associated increasing loss in cohort signal for ages in the plusgroup, potentially undermining the assessment. Furthermore, this change introduced increasingly domed selection in the latter half of the time series that was not present in previous assessments; although there are reasons why such increasingly domed selection might occur, such as some evidence that larger cod inhabit less accessible rocky areas or simply move away from areas fishing vessels operate in, these reasons remain largely speculative.

The SAM model estimates the quantity of additional "unaccounted removals" that would be required to be added or removed from the catch-at-age data in order to remove any persistent trends in survey catchability. The unaccounted removals figures given by SAM could potentially include components due to increased natural mortality and discarding as well as misreported landings.

There is general agreement across all models presented (SAM and SURBAR) of an increasing SSB since the mid-2000s, declining fishing mortality (total mortality for SURBAR) since around 2000, and slightly stronger 2005, 2009 and 2013 year classes in recent years. The decline in fishing mortality is evident from the shallower gradients of log-catch curves, and the stronger 2013 year class is evident from this year class being slightly more widespread in the North Sea compared to other recent year classes at the same age.

The annually varying maturity-at-age estimates are derived from an area-weighted maturity age key based on NS-IBTS Q1 data from the period 1977–2015, to which a smoother is applied to get rid of the effects of variations in sampling intensity. Maturity sampling in the southern North Sea was poor in 2016, leading the WG to reject the 2016 maturity estimates. This increased the estimate of SSB in 2016 by almost 15 thousand tonnes but had no further impact on the assessment.

Values for natural mortality were updated in 2015, following the key run conducted by WGSAM (ICES-WGSAM, 2014); they are smoothed annual model estimates from a multi-species model. A Delta-GAM approach, assuming a stationary spatial model with ship effect, has been used to derive both Q1 and Q3 NS-IBTS indices.

14.11 Status of the Stock

There has been a strong improvement of the status of the stock in the last few years. SSB has increased from the historical low in 2006, and is now above B_{lim} and approaching B_{pa}. This increasing trend is expected to continue in the short term under current fishing mortality levels, because of improved survival of incoming year classes.

Fishing mortality has declined from 2000, and is now just below the target for the management plan when SSB>B_{pa}, but still estimated to be above the level that achieves the long-term objective of maximum yield.

Recruitment of 1 year old cod has varied considerably since the 1960s, but since 1998, average recruitment has been lower than any other time. The 2009 and 2013 year classes are stronger but the 2010–12 and 2014 year classes appear to be weak, with some indication (based on one survey only) of a weak 2015 year class. Recent sharp increases in the rate of discarding have been reversed are are stabilising at lower levels.

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, 2009 and 2013 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 may have been some difficulties with the effectiveness of the cod recovery plans; despite the objective to reduce fishing mortality and to increase the SSB by combined TAC control and effort management, estimated total removals have until recently been much higher than intended. The situation has been improving, however, and fishing mortality is now just below the management plan target when SSB>B_{pa}. Discarding currently contributes around a quarter of the total catch by weight, a substantial improvement compared to recent years (when the average was almost half of the total). There have been considerable efforts to reduce discards by some countries, and the impact of these reductions are starting to be felt (e.g. reduced discarding leading to improved survival of incoming year classes).

Rejecting the 2016 maturity estimates has no impact on the catch advice when following the ICES MSY approach as SSB in 2017 is above MSY $B_{trigger}$ for both assessment runs. It does however impact the management plans because rejecting the 2016 maturity estimates results in an intermediate SSB that is either above or closer to B_{pa} defined in the management plans, which then impacts the F set following the sliding rule.

Cod is caught by a large variety of gears and together with many other species. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, in order to estimate the potential risks of quota over- and undershooting for the different stocks.

There is a need to reduce fishing induced mortality on North Sea cod further, particularly for younger ages, in order to allow more fish to reach maturity and increase the probability of good recruitment. Incidence of discarding remain high, with the proportion of fish discarded by number in 2015 being 86% of 1 year old (compared to 78% in 2014), 58% of 2 year old (61% in 2014), 29% of 3 year old (24% in 2014) and 8% of 4 year old cod (9% in 2014).

Because the fishery is at present so dependent on incoming year classes, fishing mortalities on these year classes remain high, and only a small proportion of 2 year olds currently survive to maturity. At the same time, the unbalanced age structure of the stock reduces its reproductive capacity even if a sufficient SSB were reached, as first-time spawners reproduce less successfully than older fish. Both factors are believed to have contributed to the reduction in recruitment of cod. However, there are indications that, although still low, survival to age 5 is improving, and is currently at the highest level in the time series.

The recruitment of the relatively more abundant year classes to the fishery may have no beneficial effect on the stock if they are caught and heavily discarded. 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. Furthermore, the 2014 years class is estimated to be weak, and there are some indications, based on one survey only, of a weak 2015 year class.

The availability of discard rate estimates has vastly improved since 2009, and catch estimates (landings and discards) are now provided by Intercatch from 2002 onwards.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear such as the now widespread use of sorting grids in the Skagerrak, should be encouraged.

The reported landings in 2015 were 37.2 thousand tonnes and the estimated discards in 2015 were 12.6 thousand tonnes, giving a total of 49.8 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 d was previously managed by a TAC for Divisions b-k, 8, 9,10, and CECAF 34.1.1, (i.e. the TAC covered a small proportion of the North Sea cod stock together with cod in Divisions7.e-k). Division 7.d is now allocated a separate TAC (since 2009), which is adjusted in line with the revision to the North Sea TAC.

14.13 Assessment frequency

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment. The assessment failed to meet two of the four criteria (highlighted in grey). Therefore the North Sea cod stock is not a candidate for less frequent assessments.

CRITERION	
(1) Life span (i.e. maximum normal age) of the species is larger than 5 years	Life span larger than 5 years
(2) The stock status in relation to the reference points is according to the MSY criteria F (latest assessment year) is <= Fupper (upper bound in F range) AND SSB (start of intermediate year) >= MSY Btrigger	F(2015) = 0.385 < Fupper= 0.42 SSB(2016) = 161 135 < Btrigger= 165 000
(3) The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers.	The average contribution to the catch in numbers of the recruiting year class in latest 5 years is 28% of the total catch in numbers
(4) The retrospective pattern, based on a seven years peel of Mohn's rho index, shows that F is consistently underestimated by less than 20%	ϱ = -0.035 i.e. F is overestimated by 4%

14.14 References

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Table 14.1 Nominal landings (in tons) of COD in 3.a (Skagerrak), 4 and 7.d, as officially reported to ICES, and as used by the Working Group.

Table 14.1.

Sub-area IV

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	3,458	4,642	5,799	3,882	3,304	2,470	2,616	1,482	1,627	1,722
Denmark	23,573	21,870	23,002	19,697	14,000	8,358	9,022	4,676	5,889	6,291
Faroe Islands	44	40	102	96	-	9	34	36	37	34
France	1,934	3,451	2,934	.	1,222	717	1,777	620	294	664
Germany	8,344	5,179	8,045	3,386	1,740	1,810	2,018	2,048	2,213	2,648
Greenland	.	.	.	.	.	.	.	.	.	35
Netherlands	9,271	11,807	14,676	9,068	5,995	3,574	4,707	2,305	1,726	1,660
Norway	5,869	5,814	5,823	7,432	6,410	4,369	5,217	4,417	3,223	2,900
Poland	18	31	25	19	18	18	39	35	-	-
Sweden	617	832	540	625	640	661	463	252	240	319
UK (E/W/NI)	15,930	13,413	17,745	10,344	6,543	4,087	3,112	2,213	1,890	1,270
UK (Scotland)	35,349	32,344	35,633	23,017	21,009	15,640	15,416	7,852	6,650	4,936
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Others	0	0	0	0	0	0	0	0	0	0
Danish industrial by-catch *	.	.	.	.	.	.	105	22	17	21
Norwegian industrial by-catch	.	.	.	.	.	.	.	.	.	.
Total Nominal Catch	104,407	99,423	114,324	77,566	60,881	41,713	44,526	25,958	23,806	22,500
Unallocated landings	2,161	2,746	7,779	826	-1,114	-740	-226	-111	-1,277	356
WG estimate of total landings	**106,568**	**102,169**	**122,103**	**78,392**	**59,767**	**40,973**	**44,300**	**25,847**	**22,529**	**22,855**
Agreed TAC	**130,000**	**115,000**	**140,000**	**132,400**	**81,000**	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**

Division VIId

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	321	310	239	172	110	93	51	54	47	51
Denmark	-	-	-	-	-	-	-	-	-	-
France	2,808	6,387	7,788	.	3,084	1,677	1,361	1,730	810	986
Netherlands	-	-	19	3	4	17	6	36	14	9
UK (E/W/NI)	414	478	618	454	385	249	145	121	103	184
UK (Scotland)	4	3	1	-	-	-	-	-	-	-
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Nominal Catch	3,547	7,178	8,665	629	3,583	2,036	1,563	1,941	974	1,230
Unallocated landings	-44	-135	-85	6,229	-1,258	-463	1,534	-707	40	29
WG estimate of total landings	**3,503**	**7,043**	**8,580**	**6,858**	**2,325**	**1,573**	**3,097**	**1,234**	**1,014**	**1,259**

Division IIIa (Skagerrak)**

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Denmark	14,573	12,159	12,339	8,681	7,684	5,900	5,525	3,067	3,038	3,019
Germany	259	81	54	54	54	32	83	49	99	86
Norway	1,046	1,323	1,293	1,146	926	762	645	825	856	759
Sweden	1,986	2,173	1,900	1,909	1,293	1,035	897	510	495	488
Others	-	-	-	-	-	-	-	27	24	21
Danish industrial by-catch *	676	205	97	62	99	687	20	5	4	2
Total Nominal Catch	17,864	15,736	15,586	11,790	9,957	7,729	7,170	4,483	4,516	4,375
Unallocated landings	-1,615	-790	-255	-816	-680	-643	298	-692	-602	-376
WG estimate of total landings	**16,249**	**14,946**	**15,331**	**10,974**	**9,277**	**7,086**	**7,468**	**3,791**	**3,914**	**3,998**
Agreed TAC	**23,000**	**16,100**	**20,000**	**19,000**	**11,600**	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Nominal Catch	125,818	122,337	138,575	89,985	74,421	51,478	53,260	32,382	29,296	28,104
Unallocated landings	502	1,821	7,439	6,240	-3,052	-1,846	1,605	-1,510	-1,839	9
WG estimate of total landings	**126,320**	**124,158**	**146,014**	**96,225**	**71,369**	**49,632**	**54,865**	**30,872**	**27,457**	**28,113**

** Skaggerak/Kattegat split derived from national statistics

* The Danish industrial by-catch (up to 2001) 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	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Danish industrial by-catch *	676	205	97	62	99	687	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	.	.	.	.	.
Total	**676**	**205**	**97**	**62**	**99**	**687**	**0**	**0**	**0**	**0**

Table 14.1 cont. Nominal landings (in tons) of COD in 3.a (Skagerrak), 4 and 7.d, as officially reported to ICES, and as used by the Working Group.

Table 14.1. Cont'd.

Sub-area IV										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Belgium	1,309	1,009	894	946	666	653	862	1,076	1,257	1,187
Denmark	5,105	3,430	3,831	4,402	5,686	4,863	4,803	4,536	5,457	6,026
Faroe Islands	3	0	16	45	32	0	0	0	0	.
France	354	659	573	950	781	619	368	287	638	521
Germany	2,537	1,899	1,736	2,374	2,844	2,211	2,385	1,921	2,257	2,133
Greenland	23	17	17	11	0	0	0	0	0	.
Netherlands	1,585	1,523	1,896	2,649	2,657	1,928	1,955	1,344	1,242	1,349
Norway	2,749	3,057	4,128	4,234	4,496	4,898	4,601	4,079	4,590	5,486
Poland	0	1	2	3	0	2	0	0	0	.
Sweden	309	387	439	378	363	315	472	332	401	417
UK (E/W/NI)	1,491	1,588	1,546	2,384	2,553	2,169	1,630	2,129	2,963	.
UK (Scotland)	6,857	6,511	7,185	9,052	11,567	10,141	10,565	10,619	10,517	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	13,480	14,839
Others	786	0	0	0	0	0	0	0	0	0
Danish industrial by-catch	11	23	1	72	12	0	0	2	24	0
Norwegian indust by-catch *	48	101	22	4	201	1	.	.	.	.
Total Nominal Catch	23,119	20,104	22,264	27,500	31,657	27,799	27,641	26,325	29,346	31,959
Unallocated landings	-2,041	-1,047	-607	134	-677	-1,124	-1,014	-1,010	-796	-715
WG estimate of total landings	**21,078**	**19,056**	**21,657**	**27,634**	**30,980**	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**
Agreed TAC	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**

Division VIId										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Belgium	80	84	154	73	57	56	40	53	72	79
Denmark	-	.	.	.	.	.	.	.	.	.
France	1,124	1,743	1,326	1,779	1,606	1,078	885	768	1,270	1,100
Netherlands	9	59	30	35	45	51	40	38	50	47
UK (E/W/NI)	267	174	144	133	127	125	99	100	156	.
UK (Scotland)	1	12	7	3	1	1	0	0	0	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	156	161
Total Nominal Catch	1,481	2,072	1,661	2,023	1,836	1,311	1,064	959	1,548	1,387
Unallocated landings	-2	75	-32	-136	-128	8	56	-43	-112	11
WG estimate of total landings	**1,479**	**2,147**	**1,629**	**1,887**	**1,708**	**1,319**	**1,120**	**916**	**1,436**	**1,398**
Agreed TAC				**1,678**	**1,955**	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**

Division IIIa (Skagerrak)**										
Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Denmark	2,513	2,246	2,553	3,024	3,286	3,118	3,178	3,033	3,430	3,344
Germany	84	67	52	55	56	60	78	69	84	87
Norway	628	681	779	440	375	421	615	575	528	499
Sweden	372	370	365	459	458	518	520	529	570	576
Others	373	385	13	2	26	0	0	33	28	24
Danish industrial by-catch	3	2	7	2	10	0	1	1	5	5
Total Nominal Catch	3,973	3,751	3,769	3,982	4,211	4,117	4,392	4,240	4,645	4,536
Unallocated landings	-715	-731	-376	-188	-154	-161	-65	-86	42	27
WG estimate of total landings	**3,258**	**3,020**	**3,393**	**3,794**	**4,057**	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**
Agreed TAC	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total Nominal Catch	28,573	25,927	27,694	33,505	37,705	33,227	33,097	31,524	35,538	37,882
Unallocated landings	-2,759	-1,704	-1,015	-190	-959	-1,277	-1,023	-1,139	-865	-676
WG estimate of total landings	**25,815**	**24,223**	**26,679**	**33,315**	**36,746**	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**

** Skaggerak/Kattegat split derived from national statistics

* The Norwegian industrial by-catch 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	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Danish indust by-catch	-	-	-	-	-	-	-	-	-	-
Norwegian indust by-catch *	48	101	22	4	201	1	.	.	.	.
Total	**48**	**101**	**22**	**4**	**201**	**1**	**-**	**-**	**-**	**-**

Table 14.2a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Landings numbers at age (Thousands).

Landings numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	3198	5004	15734	18133	10749	5800	2932	54219	44599	3813	25836
2	42377	22373	51628	62202	70539	83416	22561	33747	154565	186744	31596
3	6995	20003	17557	29695	32529	42373	31419	18395	17132	47885	54655
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103
7	81	596	655	475	884	866	585	956	888	1671	1055
8	489	117	297	368	353	307	420	208	455	609	487
9	13	93	51	125	137	150	147	185	227	388	79
10	6	11	75	56	40	111	46	97	77	112	57
+gp	0	4	8	83	17	24	77	40	93	17	161
TOTALNUM	60659	56203	98460	121923	131671	152829	79251	129139	234508	252789	131226
TONSLAND	115893	125393	180120	220197	251687	286948	199746	224993	326492	352161	237874
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	15484	33210	5695	75130	29593	34627	62394	20131	66220	25488	64358
2	58624	46907	99779	50926	174912	91143	104356	187626	64755	128396	66026
3	11347	18849	18481	25525	17178	44384	34938	34567	59907	21456	31087
4	15745	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238
5	4601	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415
6	956	2057	3056	833	1103	708	1269	779	2048	1246	1013
7	436	447	920	1140	408	396	494	599	425	589	434
8	393	195	130	370	403	139	197	133	234	179	243
9	330	228	67	262	152	157	73	64	77	89	59
10	80	95	63	26	36	42	55	36	27	28	44
+gp	188	63	43	96	44	17	25	21	16	23	19
TOTALNUM	108183	114215	136672	161191	236214	178997	218034	256998	206643	192083	170937
TONSLAND	213215	204249	233007	208318	294640	266019	293753	333616	302365	257634	227070
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	8795	99841	24816	21362	22072	11629	13288	27162	4688	15366	15486
2	117383	32308	127774	55025	36084	53783	23145	31472	54171	24969	62650
3	18888	33973	9761	43712	18056	11795	16554	8523	11134	20885	12753
4	7779	5791	8689	3117	9791	4299	3267	4916	3126	3045	5223
5	1369	2981	1528	2543	994	2445	1372	1041	1546	859	790
6	1257	602	1071	652	1028	307	1039	482	426	513	282
7	371	554	234	293	249	307	222	323	200	140	148
8	172	170	215	66	139	54	137	51	106	57	41
9	78	69	55	63	27	60	27	39	17	32	14
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	9	9	13	16	5
TOTALNUM	156139	176355	174203	126873	88481	84698	59065	74034	75437	65889	97405
TONSLAND	214354	201279	216041	183202	139578	124835	101442	112740	119947	109915	136397
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4871	23443	1243	5831	8087	2164	4425	438	1470	1009	1286
2	36303	28793	80948	9549	22457	20309	8029	8893	3511	8175	4401
3	23046	18390	16794	31624	6310	6044	13831	3552	5453	3036	4410
4	3125	6409	5909	3959	6529	1114	2787	3072	1527	1714	969
5	1834	1221	2379	1419	996	1053	395	397	939	479	520
6	393	690	504	614	375	140	384	68	155	339	187
7	159	151	233	219	135	82	58	61	29	52	120
8	87	47	41	89	39	27	38	15	19	13	23
9	42	14	16	14	18	13	18	5	6	9	4
10	4	15	4	10	5	6	4	2	2	1	1
+gp	8	10	12	2	1	1	1	0	0	1	0
TOTALNUM	69872	79183	108083	53329	44952	30953	29971	16505	13111	14830	11921
TONSLAND	124721	122434	144637	94108	69567	48440	53152	30426	27748	28165	25665
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	776	338	519	1120	1099	665	683	2240	706
2	6334	3268	4833	5037	4540	2230	2688	4207	6430
3	2264	4130	2839	4578	4046	5367	3063	4376	4892
4	1562	1146	2888	1582	1408	1963	2592	1605	1939
5	398	706	596	1315	610	633	865	1286	744
6	137	213	237	198	451	248	190	332	583
7	40	70	44	65	48	139	84	64	144
8	39	26	19	16	27	15	38	38	22
9	6	13	17	6	5	4	5	6	6
10	1	1	8	4	2	4	1	2	1
+gp	1	1	3	2	2	1	1	0	1
TOTALNUM	11558	9911	12003	13923	12237	11269	10208	14156	15470
TONSLAND	24215	26814	33177	36762	31979	32124	30474	34651	37373
SOPCOF %	100	100	100	100	100	100	100	100	100

Table 14.2b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Discard numbers at age (Thousands).

Discards numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	16150	8049	97921	108375	50214	31115	2502	52958	258920	38250	85915
2	19902	6168	6599	22125	24736	22957	10279	8656	37224	59342	17387
3	33	115	89	71	160	197	113	152	47	177	246
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	36085	14332	104609	130570	75110	54268	12894	61766	296192	97768	103548
TONSDISC	12198.57	4655.611	28972.64	37861.71	23284.92	17468.34	4756.776	17662.66	84006.59	33602.62	29965.76
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	124151	136651	226781	472599	28908	581071	1185689	155732	181946	54949	537521
2	15878	16214	83210	48009	78114	5270	17692	34307	8377	11130	12518
3	71	0	192	464	0	0	0	79	98	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	140100	152866	310182	521072	107022	586341	1203381	190118	190421	66103	550043
TONSDISC	39532.68	36840.85	72396.83	139026.6	32433.69	162278.1	294208.1	57075.62	54007.83	21430.4	151003.9
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	63301	563506	24634	15376	176920	33875	47473	102410	33433	320725	44756
2	36573	5761	61948	17084	8685	48244	8383	9881	28538	16804	43434
3	115	303	0	216	489	78	448	2	11	160	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	99989	569571	86583	32676	186094	82197	56304	112293	61983	337689	88220
TONSDISC	31297.6	138603.8	27706.11	10504.47	61655.63	26747.11	18198.97	36192.59	21411.61	98208.27	31706.81
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	14254	86109	15458	30962	37031	5460	26267	5696	20336	10213	26890
2	23058	13701	90259	5630	5509	33094	13236	6082	8941	8303	35342
3	764	40	1500	8280	0	753	3181	775	2007	1795	1965
4	0	0	0	0	0	0	17	55	122	149	51
5	0	0	0	0	0	0	0	0	6	66	4
6	0	0	0	0	0	0	0	0	0	12	1
7	0	0	0	0	0	0	0	0	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	2	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	38075	99851	107216	44872	42540	39307	42702	12608	31413	20540	64253
TONSDISC	14030	33183.67	40102.32	13641.52	13359.94	13519.42	11900.56	4007.44	8721.211	9931.799	11923
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	16171	10847	9608	9867	3936	11149	6188	7756	4271
2	23047	9331	9055	9151	7851	5190	6055	6504	8988
3	2657	7591	2655	1254	925	1422	856	1434	1960
4	481	223	650	65	81	115	397	163	179
5	52	14	50	30	6	5	83	58	54
6	24	11	17	0	4	1	40	5	63
7	0	0	9	0	1	1	16	0	15
8	2	0	0	0	1	0	0	0	5
9	0	0	0	0	0	0	0	0	3
10	0	0	2	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0
TOTALNUM	42433	28017	22047	20366	12804	17884	13635	15921	15538
TONSDISC	30422	24984	20846	12341	8711	8638	10289	10538	12609
SOPCOF %	100	100	100	100	100	100	100	100	100

Table 14.2c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Catch numbers at age (Thousands).

Catch numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	19347	13052	113655	126508	60962	36915	5434	107177	303519	42062	111751
2	62280	28541	58227	84327	95275	106373	32840	42403	191789	246086	48983
3	7028	20118	17646	29766	32689	42569	31532	18547	17179	48062	54901
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103
7	81	596	655	475	884	866	585	956	888	1671	1055
8	489	117	297	368	353	307	420	208	455	609	487
9	13	93	51	125	137	150	147	185	227	388	79
10	6	11	75	56	40	111	46	97	77	112	57
+gp	0	4	8	83	17	24	77	40	93	17	161
TOTALNUM	96744	70535	203069	252494	206780	207098	92145	190905	530700	350558	234774
TONSLAND	128092	130049	209092	258059	274972	304417	204503	242656	410498	385764	267840
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	139635	169862	232476	547729	58501	615698	1248084	175863	248166	80437	601879
2	74502	63121	182989	98935	253025	96413	122048	221933	73132	139526	78543
3	11418	18849	18672	25989	17178	44384	34938	34646	60005	21480	31092
4	15745	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238
5	4601	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415
6	956	2057	3056	833	1103	708	1269	779	2048	1246	1013
7	436	447	920	1140	408	396	494	599	425	589	434
8	393	195	130	370	403	139	197	133	234	179	243
9	330	228	67	262	152	157	73	64	77	89	59
10	80	95	63	26	36	42	55	36	27	28	44
+gp	188	63	43	96	44	17	25	21	16	23	19
TOTALNUM	248283	267081	446854	682263	343235	765338	1421415	447116	397064	258186	720980
TONSLAND	252748	241089	305404	347345	327074	428297	587962	390691	356372	279065	378074
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	72096	663347	49451	36738	198992	45504	60761	129572	38121	336092	60242
2	153957	38069	189722	72109	44768	102027	31528	41353	82709	41773	106084
3	19003	34277	9761	43929	18544	11873	17002	8525	11145	21045	12783
4	7779	5791	8689	3117	9791	4299	3267	4916	3126	3045	5223
5	1369	2981	1528	2543	994	2445	1372	1041	1546	859	790
6	1257	602	1071	652	1028	307	1039	482	426	513	282
7	371	554	234	293	249	307	222	323	200	140	148
8	172	170	215	66	139	54	137	51	106	57	41
9	78	69	55	63	27	60	27	39	17	32	14
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	9	9	13	16	5
TOTALNUM	256129	745925	260786	159550	274574	166895	115368	186327	137419	403578	185625
TONSLAND	245651	339883	243747	193706	201233	151582	119641	148932	141358	208123	168104
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	19124	109552	16701	36793	45118	7624	30692	6135	21807	11222	28177
2	59360	42494	171206	15180	27965	53403	21265	14975	12452	16478	39743
3	23809	18430	18293	39904	6310	6797	17012	4328	7460	4831	6375
4	3125	6409	5909	3959	6529	1114	2805	3127	1650	1863	1020
5	1834	1221	2379	1419	996	1053	395	397	944	546	524
6	393	690	504	614	375	140	384	68	155	351	187
7	159	151	233	219	135	82	58	61	29	52	121
8	87	47	41	89	39	27	38	15	19	13	23
9	42	14	16	14	18	13	18	5	6	11	4
10	4	15	4	10	5	6	4	2	2	1	1
+gp	8	10	12	2	1	1	1	0	0	1	0
TOTALNUM	107947	179034	215299	98201	87491	70260	72673	29113	44524	35370	76174
TONSLAND	138751	155618	184740	107749	82927	61960	65053	34433	36469	38097	37589
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	16947	11185	10127	10987	5035	11815	6871	9995	4977
2	29381	12599	13887	14188	12391	7420	8743	10711	15418
3	4921	11721	5494	5831	4970	6789	3919	5810	6853
4	2043	1369	3539	1646	1489	2077	2989	1768	2118
5	451	720	646	1344	616	638	949	1345	799
6	161	224	254	199	455	249	229	337	647
7	40	70	53	65	49	139	100	64	159
8	41	26	19	16	28	15	38	38	27
9	6	13	17	6	5	4	5	6	9
10	1	1	10	4	2	4	2	2	1
+gp	1	1	3	2	2	1	1	0	1
TOTALNUM	53992	37928	34050	34288	25041	29153	23844	30076	31008
TONSLAND	54637	51798	54023	49103	40689	40762	40763	45190	49983
SOPCOF %	100	100	100	100	100	100	100	100	100

Table 14.2d Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Landings, discards and catch numbers at age (Thousands) by season (quarter or annual, depending on data stratification) from Intercatch for 2015.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	40	34	125	496	11	706
2	1287	1110	2081	1341	611	6430
3	1004	1067	1130	1041	651	4893
4	427	502	437	386	187	1939
5	188	207	182	118	48	743
6	154	161	121	73	75	584
7	30	50	31	17	16	144
8	6	5	4	2	5	22
9	1	1	1	1	3	7
10	0	1	0	0	0	1
+gp	0	0	1	1	0	2
TOTALNUM	3137	3138	4113	3476	1607	15471

Discards numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	470	372	1542	1117	770	4271
2	1287	1336	1804	1787	2774	8988
3	359	575	320	344	362	1960
4	46	40	34	31	28	179
5	31	7	4	4	8	54
6	39	7	6	4	7	63
7	10	2	1	1	0	14
8	4	0	0	0	0	4
9	1	0	1	0	0	2
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	2247	2339	3712	3288	3949	15535

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	510	405	1667	1614	781	4977
2	2574	2446	3885	3128	3385	15418
3	1363	1642	1451	1385	1013	6854
4	473	543	470	416	215	2117
5	219	215	187	123	56	800
6	194	168	127	77	82	648
7	40	52	32	18	17	159
8	10	5	4	3	5	27
9	2	1	2	1	3	9
10	0	1	0	0	0	1
+gp	0	0	1	1	0	2
TOTALNUM	5385	5478	7826	6766	5557	31012

Table 14.2e Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2015, calculated as the weight in each area-season-métier stratum covered by the relevant sampling, then summed over métiers and expressed as a proportion of the total for the area-season (note the country dimension is not used). Also provided is the contribution of landings and discards in each area (by weight) to the total for that catch category (before raising is conducted).

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	75%	66%	65%	69%	96%
IIIaN	78%	75%	57%	87%	-
VIId	84%	89%	84%	77%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	81%	78%	75%	77%	96%
IIIaN	94%	95%	77%	90%	-
VIId	84%	87%	87%	87%	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	98%	90%	96%	93%	100%
IIIaN	99%	100%	100%	92%	-
VIId	100%	100%	100%	100%	-

Contribution to total (before raising)

Area/Type	Landings	Discards
IV	84%	76%
IIIaN	12%	23%
VIId	4%	0%

Table 14.3a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. 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	0.626	0.573	0.726	0.747	0.793
2	1.117	0.960	0.922	0.935	1.021	1.004	0.996	1.079	1.072	1.160	1.200
3	2.147	2.120	1.724	1.663	1.747	2.303	1.844	1.895	2.089	1.952	2.239
4	4.034	3.821	3.495	3.305	3.216	3.663	3.735	3.347	3.252	3.647	3.894
5	6.637	6.228	5.387	5.726	4.903	5.871	5.537	5.757	5.184	5.244	5.676
6	8.494	8.394	7.563	7.403	7.488	7.333	8.006	6.694	7.438	7.225	7.234
7	9.729	9.979	9.628	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.243
8	11.080	11.424	10.643	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477
9	12.264	12.300	11.499	11.600	10.894	12.062	11.888	11.518	11.857	12.015	12.325
10	12.756	12.761	13.085	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.830	1.06679	0.78826	0.71481	0.862	0.938	0.883	0.699	0.594
2	1.182	1.38884	1.41193	1.29224	1.328	1.369	1.240	1.213	1.198
3	2.365	2.45605	2.67433	2.67091	2.525	2.354	2.461	2.390	2.290
4	4.050	4.06299	4.14457	4.22308	4.596	4.175	4.164	4.180	4.111
5	6.053	6.22405	6.11913	6.04897	6.481	6.391	6.187	5.678	5.935
6	8.250	7.39317	7.48963	8.29925	7.843	8.115	8.347	7.435	6.923
7	9.262	9.65076	8.96797	9.47215	9.681	9.092	9.817	9.191	8.774
8	10.015	11.48868	11.44744	11.63072	9.629	11.799	9.486	9.180	9.627
9	12.282	11.38721	11.29135	12.82728	10.845	12.548	11.364	11.469	10.654
10	14.559	12.72507	11.71648	12.08332	14.436	11.436	10.935	16.456	13.838
+gp	17.522	15.38134	18.764	10.05238	12.421	20.644	29.764	34.656	30.079

Table 14.3b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. 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	0.243	0.262	0.236	0.302	0.224
2	0.380	0.453	0.375	0.389	0.422	0.361	0.314	0.345	0.270	0.565	0.116
3	0.515	0.616	0.481	0.422	0.000	0.406	0.413	0.498	0.686	0.814	0.827
4	0.000	0.000	0.000	0.000	0.000	0.000	2.205	0.528	0.864	2.223	2.557
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.852	4.255	4.208
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.300	6.509	5.437
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.048
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	8.100	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	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.288	0.404	0.385	0.292	0.277	0.234	0.334	0.311	0.321
2	0.814	0.735	0.984	0.785	0.677	0.556	0.796	0.742	0.756
3	1.690	1.699	2.013	1.533	2.057	1.867	1.493	1.772	1.616
4	3.949	3.002	3.485	3.137	4.099	3.803	3.375	3.128	3.157
5	6.609	5.311	6.565	5.323	5.576	6.456	4.048	3.826	3.983
6	10.198	9.341	8.521	8.369	6.071	8.579	8.419	4.642	5.303
7	5.900	5.128	13.464	6.728	8.264	9.733	7.086	4.423	6.940
8	15.906	0.000	0.000	0.000	6.213	0.000	0.000	0.000	8.390
9	0.000	0.000	0.000	0.000	11.617	0.000	0.000	0.000	4.081
10	0.000	0.000	12.014	0.000	0.000	16.370	16.370	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 14.3c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. 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	0.312	0.313	0.326	0.327	0.417	0.449	0.314	0.300	0.335
2	0.809	0.761	0.900	0.836	0.868	0.848	0.755	0.845	0.834	0.729	0.700
3	2.647	2.366	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.913
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	0.198	0.294	0.432	0.291	0.257	0.330	0.358	0.403	0.305
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	1.834	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	0.393	0.395	0.326	0.305	0.420
2	0.800	0.782	0.773	0.753	0.932	0.690	0.889	0.970	0.846	0.788	0.768
3	2.132	1.822	1.955	1.975	1.810	2.165	1.995	2.546	2.477	2.188	2.206
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	0.318	0.354	0.372	0.298	0.285	0.269	0.342	0.250
2	0.831	0.797	0.634	0.732	0.903	0.606	0.572	0.781	0.496	0.860	0.236
3	2.095	2.117	1.622	1.405	1.747	2.093	1.576	1.645	1.712	1.529	1.804
4	4.034	3.821	3.495	3.305	3.216	3.663	3.726	3.298	3.075	3.533	3.828
5	6.637	6.228	5.387	5.726	4.903	5.871	5.537	5.757	5.175	5.124	5.665
6	8.494	8.394	7.563	7.403	7.488	7.333	8.006	6.694	7.449	7.201	7.229
7	9.729	9.979	9.628	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.262
8	11.080	11.424	10.643	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477
9	12.264	12.300	11.499	11.600	10.894	12.062	11.888	11.518	11.857	11.384	12.325
10	12.756	12.761	13.085	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887

AGE/YEAI	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.313	0.424	0.406	0.33483	0.405	0.274	0.388	0.398	0.360
2	0.893	0.904	1.133	0.964822	0.915	0.800	0.932	0.927	0.941
3	2.001	1.966	2.355	2.426207	2.438	2.252	2.249	2.237	2.097
4	4.026	3.890	4.023	4.180381	4.569	4.154	4.060	4.083	4.031
5	6.117	6.207	6.154	6.032982	6.472	6.392	5.999	5.598	5.802
6	8.543	7.491	7.560	8.299303	7.829	8.117	8.360	7.392	6.764
7	9.255	9.644	9.733	9.47205	9.656	9.095	9.385	9.190	8.603
8	10.293	11.489	11.447	11.63072	9.461	11.799	9.486	9.180	9.416
9	12.282	11.387	11.291	12.82728	10.853	12.548	11.364	11.469	8.670
10	14.559	12.725	11.786	12.08332	14.436	11.754	11.680	16.456	13.838
+gp	17.522	15.381	18.764	10.05238	12.421	20.644	29.764	34.656	30.079

Table 14.3d Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Landings, discards and catch weights at age (kg) by season (quarter or annual, depending on data stratification) from Intercatch for 2015 (note, any differences in the +gp values between Tables 14.3a-c and Table 14.3d is due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.555	0.595	0.593	0.593	0.803	0.594
2	1.009	1.12	1.235	1.427	1.115	1.198
3	1.903	2.004	2.596	2.867	1.901	2.29
4	3.421	3.782	4.71	4.849	3.655	4.111
5	5.159	5.784	6.497	6.673	5.671	5.935
6	6.266	6.936	7.685	7.842	6.131	6.923
7	8.889	8.315	9.464	9.765	7.607	8.774
8	8.751	10.901	9.762	11.634	8.379	9.627
9	12.07	11.699	11.276	11.994	9.336	10.654
10	12.631	12.838	15.512	15.483	12.665	13.838
+gp	33.87	23.635	26.772	37.213	30.642	30.079

Discards weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.215	0.286	0.33	0.412	0.254	0.321
2	0.592	0.687	0.842	1.061	0.615	0.756
3	1.345	1.451	1.791	2.09	1.541	1.616
4	3.269	3.193	3.039	3.162	3.061	3.157
5	3.823	4.597	4.033	4.386	3.765	3.983
6	5.733	4.466	5.553	5.502	3.405	5.303
7	7.562	4.49	6.94	6.94	6.94	6.94
8	8.39	8.39	8.39	8.39	8.39	8.39
9	7.2	4.516	0.805	4.774	6.051	4.081
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0

Catch weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.242	0.312	0.35	0.468	0.262	0.36
2	0.8	0.883	1.052	1.218	0.705	0.941
3	1.756	1.811	2.418	2.674	1.772	2.097
4	3.406	3.738	4.591	4.724	3.577	4.031
5	4.973	5.743	6.439	6.59	5.413	5.802
6	6.158	6.834	7.583	7.718	5.896	6.764
7	8.563	8.132	9.366	9.608	7.595	8.603
8	8.624	10.767	9.634	11.258	8.379	9.416
9	9.524	10.375	5.486	10.692	9.294	8.67
10	12.631	12.838	15.512	15.483	12.665	13.838
+gp	33.87	23.635	26.772	37.213	30.642	30.079

Table 14.4 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Reported landings, estimated discards and total catch (landings + discards) in tonnes. Note any differences in values between Table 14.4 and those given in the report and advice are due to SOP correction.

year	landings	discards	catch
1963	115893	12199	128092
1964	125393	4656	130049
1965	180120	28973	209092
1966	220197	37862	258059
1967	251687	23285	274972
1968	286948	17468	304417
1969	199746	4757	204503
1970	224993	17663	242656
1971	326492	84007	410498
1972	352161	33603	385764
1973	237874	29966	267840
1974	213215	39533	252748
1975	204249	36841	241089
1976	233007	72397	305404
1977	208318	139027	347345
1978	294640	32434	327074
1979	266019	162278	428297
1980	293753	294208	587962
1981	333616	57076	390691
1982	302365	54008	356372
1983	257634	21430	279065
1984	227070	151004	378074
1985	214354	31298	245651
1986	201279	138604	339883
1987	216041	27706	243747
1988	183202	10504	193706
1989	139578	61656	201233
1990	124835	26747	151582
1991	101442	18199	119641
1992	112740	36193	148932
1993	119947	21412	141358
1994	109915	98208	208123
1995	136397	31707	168104
1996	124721	14030	138751
1997	122434	33184	155618
1998	144637	40102	184740
1999	94108	13642	107749
2000	69567	13360	82927
2001	48440	13519	61960
2002	53152	11901	65053
2003	30426	4007	34433
2004	27748	8721	36469
2005	28165	9932	38097
2006	25665	11923	37589
2007	24215	30422	54637
2008	26814	24984	51798
2009	33177	20846	54023
2010	36762	12341	49103
2011	31979	8711	40689
2012	32124	8638	40762
2013	30474	10289	40763
2014	34651	10538	45190
2015	37373	12609	49983

Table 14.5a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Proportion mature by age-group.

	Age					
	1	2	3	4	5	6+
1963	0.010	0.050	0.230	0.620	0.860	1.000
1964	0.010	0.050	0.230	0.620	0.860	1.000
1965	0.010	0.050	0.230	0.620	0.860	1.000
1966	0.010	0.050	0.230	0.620	0.860	1.000
1967	0.010	0.050	0.230	0.620	0.860	1.000
1968	0.010	0.050	0.230	0.620	0.860	1.000
1969	0.010	0.050	0.230	0.620	0.860	1.000
1970	0.010	0.050	0.230	0.620	0.860	1.000
1971	0.010	0.050	0.230	0.620	0.860	1.000
1972	0.010	0.050	0.230	0.620	0.860	1.000
1973	0.008	0.030	0.228	0.628	0.859	1.000
1974	0.007	0.035	0.223	0.616	0.846	1.000
1975	0.007	0.040	0.220	0.603	0.833	1.000
1976	0.006	0.046	0.217	0.591	0.820	1.000
1977	0.005	0.051	0.215	0.580	0.809	1.000
1978	0.005	0.056	0.215	0.570	0.799	1.000
1979	0.004	0.061	0.216	0.560	0.791	1.000
1980	0.003	0.067	0.219	0.551	0.785	1.000
1981	0.003	0.072	0.225	0.544	0.782	1.000
1982	0.002	0.078	0.233	0.539	0.780	1.000
1983	0.002	0.084	0.245	0.538	0.781	1.000
1984	0.002	0.090	0.262	0.541	0.785	1.000
1985	0.001	0.096	0.283	0.549	0.791	1.000
1986	0.001	0.103	0.309	0.564	0.800	1.000
1987	0.001	0.110	0.339	0.586	0.812	1.000
1988	0.001	0.117	0.371	0.612	0.825	1.000
1989	0.001	0.124	0.402	0.643	0.840	1.000
1990	0.002	0.132	0.431	0.675	0.856	1.000
1991	0.002	0.141	0.454	0.706	0.872	1.000
1992	0.003	0.149	0.471	0.734	0.887	1.000
1993	0.003	0.158	0.483	0.757	0.901	1.000
1994	0.004	0.167	0.489	0.774	0.913	1.000
1995	0.005	0.177	0.492	0.787	0.923	1.000
1996	0.006	0.187	0.495	0.794	0.931	1.000
1997	0.008	0.197	0.501	0.798	0.937	1.000
1998	0.009	0.208	0.511	0.799	0.941	1.000
1999	0.011	0.218	0.525	0.799	0.943	1.000
2000	0.013	0.230	0.545	0.798	0.944	1.000
2001	0.015	0.241	0.569	0.798	0.944	1.000
2002	0.017	0.252	0.596	0.798	0.944	1.000
2003	0.019	0.264	0.624	0.800	0.943	1.000
2004	0.022	0.276	0.651	0.804	0.943	1.000
2005	0.024	0.287	0.676	0.810	0.943	1.000
2006	0.027	0.299	0.697	0.818	0.944	1.000
2007	0.030	0.310	0.714	0.828	0.945	1.000
2008	0.033	0.322	0.725	0.839	0.946	1.000
2009	0.036	0.333	0.729	0.850	0.947	0.990
2010	0.039	0.345	0.727	0.859	0.947	0.970
2011	0.041	0.357	0.718	0.867	0.945	1.000
2012	0.044	0.368	0.702	0.872	0.943	1.000
2013	0.047	0.380	0.682	0.875	0.939	1.000
2014	0.050	0.392	0.659	0.877	0.934	1.000
2015	0.053	0.403	0.634	0.878	0.929	1.000

Table 14.5b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Natural mortality by age-group.

	Age					
y	1	2	3	4	5	6
1963	1.215	0.777	0.221	0.2	0.2	0.2
1964	1.215	0.777	0.221	0.2	0.2	0.2
1965	1.215	0.777	0.221	0.2	0.2	0.2
1966	1.215	0.777	0.221	0.2	0.2	0.2
1967	1.215	0.777	0.221	0.2	0.2	0.2
1968	1.215	0.777	0.221	0.2	0.2	0.2
1969	1.215	0.777	0.221	0.2	0.2	0.2
1970	1.215	0.777	0.221	0.2	0.2	0.2
1971	1.215	0.777	0.221	0.2	0.2	0.2
1972	1.215	0.777	0.221	0.2	0.2	0.2
1973	1.215	0.777	0.221	0.2	0.2	0.2
1974	1.208	0.767	0.211	0.2	0.2	0.2
1975	1.233	0.746	0.211	0.2	0.2	0.2
1976	1.260	0.729	0.211	0.2	0.2	0.2
1977	1.286	0.715	0.211	0.2	0.2	0.2
1978	1.311	0.705	0.211	0.2	0.2	0.2
1979	1.332	0.701	0.211	0.2	0.2	0.2
1980	1.349	0.702	0.211	0.2	0.2	0.2
1981	1.360	0.706	0.211	0.2	0.2	0.2
1982	1.362	0.710	0.211	0.2	0.2	0.2
1983	1.357	0.715	0.212	0.2	0.2	0.2
1984	1.344	0.717	0.212	0.2	0.2	0.2
1985	1.325	0.718	0.213	0.2	0.2	0.2
1986	1.301	0.718	0.213	0.2	0.2	0.2
1987	1.274	0.718	0.214	0.2	0.2	0.2
1988	1.247	0.718	0.215	0.2	0.2	0.2
1989	1.220	0.720	0.215	0.2	0.2	0.2
1990	1.196	0.722	0.216	0.2	0.2	0.2
1991	1.174	0.723	0.216	0.2	0.2	0.2
1992	1.157	0.725	0.217	0.2	0.2	0.2
1993	1.144	0.727	0.217	0.2	0.2	0.2
1994	1.136	0.730	0.217	0.2	0.2	0.2
1995	1.129	0.734	0.218	0.2	0.2	0.2
1996	1.122	0.740	0.219	0.2	0.2	0.2
1997	1.115	0.748	0.220	0.2	0.2	0.2
1998	1.106	0.756	0.222	0.2	0.2	0.2
1999	1.097	0.767	0.224	0.2	0.2	0.2
2000	1.088	0.779	0.226	0.2	0.2	0.2
2001	1.084	0.795	0.229	0.2	0.2	0.2
2002	1.085	0.814	0.232	0.2	0.2	0.2
2003	1.091	0.835	0.235	0.2	0.2	0.2
2004	1.100	0.854	0.237	0.2	0.2	0.2
2005	1.112	0.871	0.238	0.2	0.2	0.2
2006	1.126	0.884	0.239	0.2	0.2	0.2
2007	1.141	0.893	0.238	0.2	0.2	0.2
2008	1.159	0.900	0.237	0.2	0.2	0.2
2009	1.180	0.907	0.236	0.2	0.2	0.2
2010	1.208	0.916	0.235	0.2	0.2	0.2
2011	1.242	0.929	0.234	0.2	0.2	0.2
2012	1.283	0.945	0.233	0.2	0.2	0.2
2013	1.326	0.962	0.233	0.2	0.2	0.2
2014*	1.326	0.962	0.233	0.2	0.2	0.2
2015*	1.326	0.962	0.233	0.2	0.2	0.2

***A new key run was performed in 2014 with data up to 2013 (ICES-WGSAM 2014), so 2014–2015 M-values are assumed equal to 2013.**

Table 14.6 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Survey tuning indices for IBTS Q1 and Q3 (NS-IBTS Delta-GAM indices). Data used in the assessment are highlighted in bold font.

IBTS_Q1_gam							
1983	2016						
1	1	0	0.25				
1	5						
1	**3741.78**	**14132.13**	**1724.21**	**941.86**	**384.66**	377.18	1983
1	**11153.10**	**5497.36**	**2343.07**	**449.14**	**437.52**	181.72	1984
1	**544.18**	**14312.28**	**1967.92**	**741.63**	**240.04**	271.17	1985
1	**11081.92**	**2284.09**	**3338.45**	**883.19**	**449.11**	250.91	1986
1	**4343.54**	**13889.45**	**703.16**	**740.47**	**219.12**	195.82	1987
1	**2537.07**	**3376.75**	**3512.02**	**184.41**	**358.84**	213.01	1988
1	**8362.17**	**3247.15**	**2622.34**	**1092.07**	**154.26**	242.90	1989
1	**1770.07**	**7058.47**	**1148.25**	**427.25**	**487.25**	79.49	1990
1	**1537.86**	**2119.94**	**1874.37**	**492.86**	**271.26**	264.44	1991
1	**8175.95**	**2843.91**	**724.79**	**490.88**	**164.19**	67.02	1992
1	**2820.51**	**7559.90**	**931.68**	**324.35**	**248.62**	76.59	1993
1	**6187.10**	**2041.72**	**1528.11**	**465.48**	**236.70**	125.76	1994
1	**6769.18**	**8786.29**	**1633.26**	**539.54**	**158.52**	71.91	1995
1	**1639.53**	**4144.51**	**2101.74**	**325.73**	**234.19**	81.02	1996
1	**13784.83**	**2498.59**	**1156.42**	**506.59**	**169.80**	115.96	1997
1	**1578.96**	**9421.22**	**904.93**	**449.40**	**223.89**	105.38	1998
1	**1305.47**	**859.71**	**4033.23**	**362.04**	**212.58**	87.47	1999
1	**3481.66**	**2042.73**	**418.88**	**958.79**	**194.87**	126.99	2000
1	**920.90**	**3624.01**	**812.00**	**162.67**	**162.18**	50.59	2001
1	**2474.57**	**1411.18**	**1497.13**	**248.10**	**53.35**	64.21	2002
1	**364.51**	**2066.03**	**555.69**	**428.01**	**134.33**	34.97	2003
1	**2486.79**	**1139.14**	**1155.09**	**215.67**	**183.72**	73.08	2004
1	**943.49**	**1458.11**	**476.54**	**403.32**	**69.40**	110.93	2005
1	**3493.36**	**857.28**	**747.85**	**155.34**	**88.82**	58.63	2006
1	**1202.53**	**2644.71**	**701.81**	**232.04**	**87.09**	67.69	2007
1	**1910.62**	**1051.92**	**1194.02**	**299.30**	**208.04**	51.91	2008
1	**961.17**	**1775.10**	**873.44**	**398.22**	**130.54**	75.95	2009
1	**2508.88**	**1583.70**	**1191.47**	**330.12**	**208.62**	85.72	2010
1	**662.54**	**2898.17**	**628.04**	**359.33**	**237.31**	140.38	2011
1	**1343.47**	**1542.92**	**1963.47**	**442.23**	**250.25**	86.58	2012
1	**1404.72**	**1367.10**	**804.77**	**591.39**	**401.67**	101.03	2013
1	**2357.56**	**1723.23**	**790.62**	**302.22**	**370.83**	115.97	2014
1	**1510.25**	**3623.29**	**1278.42**	**465.31**	**205.98**	162.89	2015
1	**878.73**	**1107.19**	**2015.79**	**665.88**	**369.41**	137.22	2016
IBTS_Q3_gam							
1992	2015						
1	1	0.50	0.75				
1	4						
1	**16659.55**	**1668.03**	**379.05**	**328.82**	109.27	39.70	1992
1	**4734.55**	**4283.37**	**441.09**	**134.85**	79.57	11.90	1993
1	**16986.96**	**2205.09**	**917.32**	**154.23**	44.60	34.19	1994
1	**9089.09**	**6754.62**	**656.67**	**291.25**	45.05	20.24	1995
1	**4982.21**	**2881.26**	**972.41**	**208.60**	111.74	13.60	1996
1	**29172.47**	**1940.78**	**710.92**	**251.72**	55.20	39.71	1997
1	**845.78**	**8731.51**	**705.17**	**189.67**	114.94	38.66	1998
1	**3261.62**	**461.16**	**2348.48**	**152.85**	40.78	17.98	1999
1	**6320.26**	**915.81**	**111.73**	**334.77**	35.15	32.31	2000
1	**1380.10**	**2145.59**	**362.00**	**74.17**	56.05	35.73	2001
1	**3817.10**	**830.28**	**742.27**	**204.51**	54.31	25.45	2002
1	**980.98**	**1205.45**	**263.92**	**176.23**	84.68	57.54	2003
1	**3148.20**	**753.56**	**468.06**	**93.26**	68.88	25.32	2004
1	**1075.17**	**716.81**	**281.62**	**115.61**	25.03	43.83	2005
1	**5461.72**	**682.03**	**581.09**	**115.39**	27.80	17.89	2006
1	**1835.00**	**2275.05**	**425.92**	**167.70**	93.09	43.57	2007
1	**2455.73**	**1127.97**	**1084.04**	**219.96**	114.25	30.28	2008
1	**1917.58**	**922.39**	**291.62**	**234.33**	50.64	25.19	2009
1	**4570.25**	**1661.53**	**540.67**	**179.22**	105.49	21.96	2010
1	**1205.34**	**2767.19**	**864.61**	**358.71**	98.39	95.45	2011
1	**2064.47**	**974.01**	**1239.32**	**364.15**	100.85	18.89	2012
1	**3098.67**	**1073.44**	**501.20**	**527.55**	141.27	63.70	2013
1	**3391.89**	**1481.11**	**597.75**	**291.73**	201.08	95.81	2014
1	**1834.02**	**3110.39**	**1085.68**	**466.09**	143.51	141.77	2015

Table 14.7a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run model specification (model.cfg file).

```
# Min Age (should not be modified unless data is modified accordingly)
1
# Max Age (should not be modified unless data is modified accordingly)
6
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality
# Rows represent fleets.
# Columns represent ages.
1	2	3	4	5	6
0	0	0	0	0	0
0	0	0	0	0	0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
2
# Coupling of catchability PARAMETERS
0	0	0	0	0	0
1	2	3	4	5	0
6	7	8	9	0	0
# Coupling of power law model EXPONENTS (if used)
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
# Coupling of fishing mortality RW VARIANCES
1	2	2	2	2	2
0	0	0	0	0	0
0	0	0	0	0	0
# Coupling of log N RW VARIANCES
1	2	2	2	2	2
# Coupling of OBSERVATION VARIANCES
1	2	3	3	3	3
4	5	5	5	5	0
6	7	7	7	0	0
```

Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)

0

Years in which catch data are to be scaled by an estimated parameter

first the number of years

13

Then the actual years

1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Them the model config lines years cols ages

1 1 1 1 1 1

2 2 2 2 2 2

3 3 3 3 3 3

4 4 4 4 4 4

5 5 5 5 5 5

6 6 6 6 6 6

7 7 7 7 7 7

8 8 8 8 8 8

9 9 9 9 9 9

10 10 10 10 10 10

11 11 11 11 11 11

12 12 12 12 12 12

13 13 13 13 13 13

Define Fbar range

2 4

Table 14.7b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run model fitting diagnostics, parameter estimates and correlation matrix (.par and .cor files)

 # Number of parameters = 34 Objective function value = 144.135 Maximum gradient component = 0.00930897

The logarithm of the determinant of the hessian = 164.414

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	logq Q1_1	-4.8806	0.089253	1																																	
2	logq Q1_2	-3.3305	0.051103	0.23	1																																
3	logq Q1_3	-2.701	0.04935	0.16	0.31	1																															
4	logq Q1_4	-2.6496	0.054999	0.17	0.31	0.4	1																														
5	logq Q1_5	-2.3479	0.069018	0.17	0.32	0.41	0.54	1																													
6	logq Q3_1	-3.6109	0.08697	0.21	0.28	0.21	0.21	0.22	1																												
7	logq Q3_2	-2.9581	0.066092	0.19	0.35	0.32	0.33	0.34	0.25	1																											
8	logq Q3_3	-2.7008	0.069188	0.16	0.3	0.39	0.42	0.44	0.21	0.32	1																										
9	logq Q3_4	-2.6677	0.079191	0.17	0.31	0.39	0.52	0.58	0.21	0.33	0.43	1																									
10	logSd LogF1	-1.894	0.22265	-0	-0	-0	-0.1	-0.1	-0	-0	-0	-0.1	1																								
11	logSd LogF2+	-2.3871	0.1305	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	0.4	1																							
12	logSd LogN1	-0.28161	0.1186	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	1																						
13	logSd LogN2+	-2.1866	0.14571	0.02	0.02	0.01	0.03	0.08	0	0.03	0	0.02	-0.1	-0.1	0.22	1																					
14	logSd LogC1	-0.49104	0.11338	-0	0	0.01	0.02	0.02	-0	0.01	0.02	0.02	-0.1	-0	-0.1	-0	1																				
15	logSd LogC2	-1.4242	0.13149	0.01	0.01	0.03	0.03	0.03	0.01	0.02	0.03	0.03	-0	-0	-0	-0.1	0.06	1																			
16	logSd LogC3+	-2.7396	0.25102	-0	-0	-0	-0	-0.1	-0	-0	-0	-0.1	-0	-0.1	-0.1	-0.5	0.06	-0	1																		
17	logSd LogQ1_1	-0.77307	0.13553	0.01	0.03	0.03	0.04	0.03	0.05	0.04	0.04	0.04	0.02	-0	-0.1	-0.1	0.01	0.02	0.05	1																	
18	logSd LogQ1_2+	-1.4928	0.071059	0.03	0.07	0.08	0.09	0.1	0.03	0.06	0.09	0.11	0.03	-0	-0.1	-0.1	0.01	-0	-0.1	0.03	1																
19	logSd LogQ3_1	-1.0091	0.16857	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	-0.2	-0.2	0.03	-0	0.05	0.11	0.06	1															
20	logSd LogQ3_2+	-1.3573	0.096731	0.01	0.02	0.03	0.05	0.06	0.01	0.02	0.04	0.06	0.01	-0	-0.1	-0.1	-0	-0	-0.1	0.02	0.08	0.07	1														
21	rho	0.89466	0.054397	-0	0	0.01	0.03	0.07	-0	0.02	0.01	0.04	-0	0.09	0.05	0.25	0.12	0.05	0.19	-0	-0.1	-0	-0.1	1													
22	log Cmult 93	-0.06718	0.089509	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	0.01	0.06	0.01	0	-0	-0	0.05	-0	-0.1	-0	0.02	0.03	1												
23	log Cmult 94	0.035709	0.096308	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.04	0.09	0.02	0.03	0	-0	0.01	-0	-0.1	-0.1	0.03	0.02	0.39	1											
24	log Cmult 95	0.1587	0.098548	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.03	0.14	0.01	-0	0	0	0.04	-0	-0.1	-0.1	0.01	0.05	0.19	0.42	1										
25	log Cmult 96	0.012358	0.09837	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.01	0.13	0.02	-0	-0	-0	0.03	-0	-0	-0.1	-0	0.03	0.12	0.21	0.43	1									
26	log Cmult 97	-0.15563	0.09646	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.01	0.07	0	-0.1	-0	-0	0.02	-0	0.04	-0.1	0	-0.1	0.1	0.12	0.19	0.4	1								
27	log Cmult 98	-0.34224	0.096725	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.04	0.11	0	-0.1	-0	-0	0.02	-0	0.02	-0	-0	-0	0.11	0.13	0.15	0.21	0.41	1							
28	log Cmult 99	-0.1536	0.098936	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.08	0.24	0.02	0.03	-0	-0.1	-0	-0.1	-0.1	-0	-0.1	0.01	0.12	0.15	0.15	0.15	0.19	0.4	1						
29	log Cmult 00	-0.05531	0.098888	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.06	0.21	-0	-0	-0	-0	0	-0	-0.1	0.01	0.04	-0	0.13	0.16	0.16	0.15	0.13	0.19	0.42	1					
30	log Cmult 01	0.25665	0.097081	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.01	0.06	-0	-0	-0	0.03	0	-0	-0.1	0	0.08	-0.1	0.12	0.15	0.16	0.14	0.12	0.13	0.18	0.4	1				
31	log Cmult 02	-0.13797	0.096256	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.02	0.05	0.01	0.02	-0	-0	-0	-0	-0.1	-0	0.04	-0	0.1	0.14	0.14	0.13	0.13	0.11	0.12	0.19	0.4	1			
32	log Cmult 03	0.39605	0.098303	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.03	0.11	-0	-0.1	-0	-0	0.07	-0	-0.1	0.01	0.04	-0	0.13	0.15	0.17	0.16	0.14	0.14	0.14	0.15	0.21	0.41	1		
33	log Cmult 04	0.12548	0.097358	-0.1	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	0.05	0.13	0	-0	-0	-0	0.02	-0	-0.1	0.01	0.05	0.02	0.12	0.14	0.16	0.15	0.13	0.13	0.14	0.14	0.13	0.19	0.42	1	
34	log Cmult 05	-0.02969	9.00E-02	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-0.1	0.03	0.11	0.01	0.02	-0	-0.1	0.01	-0	-0.1	0.01	0.03	0.06	0.08	0.1	0.11	0.1	0.09	0.09	0.11	0.11	0.08	0.1	0.17	0.38	1

Table 14.8 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and VIId. SAM final run estimated fishing mortality at age.

Fishing mortality (F) at age

Year\Age	1	2	3	4	5	6+	Fbar 2-4
1963	0.079	0.443	0.511	0.465	0.461	0.473	0.473
1964	0.089	0.478	0.562	0.507	0.500	0.509	0.516
1965	0.104	0.528	0.623	0.549	0.531	0.533	0.567
1966	0.109	0.541	0.631	0.544	0.528	0.533	0.572
1967	0.119	0.575	0.673	0.580	0.571	0.574	0.609
1968	0.131	0.612	0.711	0.615	0.602	0.596	0.646
1969	0.123	0.586	0.671	0.581	0.576	0.572	0.613
1970	0.143	0.638	0.711	0.601	0.586	0.570	0.650
1971	0.182	0.737	0.800	0.668	0.644	0.617	0.735
1972	0.215	0.812	0.860	0.716	0.689	0.660	0.796
1973	0.222	0.815	0.836	0.692	0.661	0.625	0.781
1974	0.219	0.793	0.789	0.651	0.630	0.599	0.744
1975	0.251	0.861	0.848	0.696	0.673	0.631	0.802
1976	0.288	0.934	0.908	0.726	0.701	0.650	0.856
1977	0.273	0.896	0.866	0.682	0.675	0.631	0.815
1978	0.307	0.972	0.969	0.765	0.756	0.693	0.902
1979	0.283	0.908	0.917	0.713	0.689	0.628	0.846
1980	0.313	0.974	1.005	0.783	0.737	0.667	0.921
1981	0.312	0.979	1.029	0.803	0.738	0.668	0.937
1982	0.350	1.071	1.159	0.917	0.833	0.747	1.049
1983	0.340	1.057	1.149	0.920	0.826	0.737	1.042
1984	0.306	0.985	1.066	0.871	0.783	0.700	0.974
1985	0.285	0.945	1.022	0.852	0.762	0.680	0.940
1986	0.297	0.978	1.078	0.923	0.820	0.726	0.993
1987	0.280	0.952	1.058	0.918	0.812	0.718	0.976
1988	0.283	0.964	1.085	0.941	0.823	0.719	0.997
1989	0.290	0.979	1.101	0.962	0.844	0.734	1.014
1990	0.262	0.918	1.018	0.884	0.768	0.664	0.940
1991	0.251	0.896	1.007	0.890	0.785	0.673	0.931
1992	0.241	0.877	0.999	0.888	0.778	0.652	0.921
1993	0.240	0.883	1.027	0.907	0.790	0.649	0.939
1994	0.241	0.890	1.065	0.931	0.808	0.651	0.962
1995	0.249	0.923	1.130	0.973	0.842	0.662	1.009
1996	0.232	0.895	1.136	0.994	0.889	0.693	1.008
1997	0.212	0.847	1.113	0.996	0.902	0.690	0.985
1998	0.209	0.843	1.139	1.030	0.933	0.696	1.004
1999	0.215	0.863	1.210	1.113	1.016	0.741	1.062
2000	0.211	0.855	1.217	1.136	1.032	0.730	1.069
2001	0.190	0.798	1.133	1.068	0.963	0.665	1.000
2002	0.176	0.751	1.073	1.013	0.909	0.616	0.946
2003	0.171	0.735	1.056	0.977	0.862	0.568	0.923
2004	0.166	0.716	1.030	0.919	0.812	0.526	0.888
2005	0.153	0.674	0.963	0.839	0.758	0.486	0.825
2006	0.134	0.611	0.858	0.728	0.673	0.428	0.732
2007	0.119	0.561	0.798	0.672	0.619	0.384	0.677
2008	0.108	0.525	0.761	0.637	0.597	0.369	0.641
2009	0.102	0.505	0.746	0.628	0.587	0.352	0.626
2010	0.083	0.437	0.647	0.544	0.505	0.298	0.543
2011	0.062	0.356	0.527	0.446	0.416	0.246	0.443
2012	0.054	0.324	0.481	0.406	0.371	0.216	0.404
2013	0.052	0.314	0.472	0.394	0.352	0.199	0.393
2014	0.052	0.314	0.479	0.394	0.344	0.192	0.396
2015	0.050	0.305	0.466	0.383	0.339	0.19	0.385

Table 14.9 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run estimated population numbers at age. [Note, the recruitment value in the final year relies on a single data point only, and is therefore considered preliminary only, and is ignored for projections.]

Stock numbers at age (start of year) (thousands)

Year\Age	1	2	3	4	5	6+	Total
1963	487478	184241	20339	10330	8251	5229	715868
1964	802109	133653	51741	11535	5261	7059	1011358
1965	1042362	229120	40336	22948	6212	5602	1346580
1966	1271872	275130	67711	16487	9513	6184	1646897
1967	1074107	338067	72693	28739	8039	8202	1529847
1968	544161	289816	89859	28739	14327	7123	974025
1969	480220	141210	72620	34166	11439	10048	749703
1970	1561254	130875	38754	32370	15432	8536	1787221
1971	2034987	414571	33591	14955	16036	10721	2524861
1972	509406	518658	90490	12157	5981	12826	1149518
1973	740440	119372	105873	29912	4964	7216	1007777
1974	726505	177194	23861	36680	11073	5634	980947
1975	1236753	169397	36901	9666	16455	7232	1476404
1976	846614	285501	33996	13639	3812	9945	1193507
1977	2092772	171442	51226	10937	5137	6186	2337700
1978	1333077	443743	30792	18834	5598	4652	1836696
1979	1636385	271577	80258	9005	7374	3572	2008171
1980	2623448	313013	58806	24711	3982	4721	3028681
1981	1056001	494350	58747	17678	8882	3660	1639318
1982	1727179	191760	92042	17024	6599	5632	2040236
1983	946949	320937	33090	21245	5434	4533	1332188
1984	1709993	177371	51896	8047	6790	3887	1957984
1985	415817	332701	32958	14820	2806	4265	803367
1986	1861699	84881	57815	10212	5661	3037	2023305
1987	709276	387317	16365	15466	3034	3409	1134867
1988	490411	151752	70263	5234	4986	2410	725056
1989	827364	107689	30394	17499	1832	2993	987771
1990	327420	180593	20296	7972	5228	1729	543238
1991	374370	75132	30669	6111	2741	3047	492070
1992	856834	90400	14979	8947	2073	2140	975373
1993	434521	201995	17910	5104	2918	1661	664109
1994	1018661	107259	36534	5594	1778	1797	1171623
1995	596002	248451	23318	10440	1823	1379	881413
1996	372876	141775	39577	5710	3344	1449	564731
1997	1160081	96568	25848	9548	1868	1723	1295636
1998	141210	300740	20613	7003	3011	1280	473857
1999	251450	37272	54285	5519	2072	1623	352221
2000	457257	67914	8617	10507	1578	1150	547023
2001	167042	127389	14258	2296	2420	810	314215
2002	246965	48388	25540	4067	626	1033	326619
2003	123254	68186	10749	7506	1153	589	211437
2004	201793	37459	14371	3257	2172	650	259702
2005	154508	53960	8150	3628	1066	1171	222483
2006	358255	45388	12417	2326	1170	1027	420583
2007	168552	100609	10064	4366	1043	918	285552
2008	196025	46490	23742	3432	1780	1123	272592
2009	193300	54122	11460	8139	1539	1326	269886
2010	296262	55160	13354	4308	3591	1296	373971
2011	148153	80902	13808	4803	2007	2619	252292
2012	203211	41689	21047	6704	2297	2377	277325
2013	263024	52892	11685	9939	3509	2362	343411
2014	391601	66836	15902	5772	5136	3012	488259
2015	169058	104925	20228	7482	3032	5274	309999
2016	145365	41357	30152	10075	4168	5339	236456

Table 14.10 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run estimated total removals at age (including catches due to unaccounted mortality)

Total removals at age (thousands)

Year\Age	1	2	3	4	5	6+
1963	21689	47321	7397	3507	2785	1800
1964	39807	36523	20249	4191	1892	2573
1965	60409	67833	17038	8865	2341	2115
1966	76726	82975	28889	6330	3569	2337
1967	70841	107087	32461	11577	3199	3276
1968	39211	96221	41719	12080	5934	2928
1969	32725	45374	32377	13780	4584	4005
1970	122578	44860	18000	13377	6262	3394
1971	200426	158055	16906	6681	6971	4522
1972	58513	211758	47777	5700	2731	5676
1973	87571	48850	54852	13694	2200	3072
1974	84669	71168	11903	16073	4741	2325
1975	161765	72533	19313	4442	7390	3100
1976	124033	130027	18572	6458	1762	4356
1977	289179	76321	27152	4957	2311	2650
1978	202805	209190	17506	9245	2724	2131
1979	229349	122602	44135	4208	3364	1526
1980	400713	147798	34190	12315	1905	2107
1981	160171	233935	34641	8964	4255	1635
1982	289526	95894	58070	9404	3426	2719
1983	154848	158832	20787	11760	2807	2168
1984	256145	83952	31245	4302	3386	1795
1985	58924	153169	19341	7808	1374	1929
1986	275709	39971	34989	5662	2910	1438
1987	100881	179333	9796	8549	1550	1601
1988	71083	70785	42689	2937	2568	1133
1989	123624	50701	18596	9953	959	1428
1990	45143	81528	11869	4302	2573	769
1991	50071	33360	17815	3313	1368	1368
1992	111035	39525	8658	4841	1029	940
1993	56449	88610	10525	2800	1463	726
1994	133226	47259	21929	3119	905	788
1995	80443	112005	14466	5981	953	612
1996	47448	62442	24637	3313	1811	664
1997	136189	40864	15893	5545	1021	788
1998	16444	126475	12828	4151	1681	588
1999	30170	15878	34902	3420	1218	779
2000	54090	28598	5549	6585	936	547
2001	17978	50808	8822	1390	1378	360
2002	24629	18370	15307	2386	344	435
2003	11953	25276	6376	4311	612	234
2004	19026	13525	8389	1802	1109	243
2005	13408	18522	4568	1892	520	412
2006	27203	14393	6467	1103	525	326
2007	11364	29747	5000	1957	441	267
2008	12003	13020	11428	1481	733	316
2009	11140	14653	5445	3477	626	359
2010	13774	13201	5742	1652	1302	304
2011	5121	16233	5093	1577	623	521
2012	6079	7658	7229	2042	650	419
2013	7376	9375	3958	2955	949	388
2014	10986	11854	5446	1713	1364	478
2015	4556	18129	6779	2172	794	830

Table 14.11a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run estimated stock and management metrics, together with the lower and upper bounds of the point-wise 95% confidence intervals.

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), total removals (including catches due to unaccounted mortality) and average fishing mortality for ages 2 to 4 (Fbar 2-4).

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	487478	358327	663179	511959	438909	597167	151903	116620	197861	117830	104453	132921	0.473	0.41	0.546
1964	802109	590710	1089163	661986	563847	777207	163081	128015	207752	144929	131184	160114	0.515	0.453	0.587
1965	1042362	770073	1410931	834009	718024	968731	199187	161242	246062	199187	177659	223324	0.567	0.498	0.645
1966	1271872	940738	1719562	996496	858764	1156316	221239	180297	271479	240867	215473	269254	0.572	0.505	0.648
1967	1074107	793636	1453696	1051786	916308	1207294	249946	204164	305994	287506	256711	321996	0.609	0.541	0.687
1968	544161	401563	737396	879404	784009	986407	260928	219902	309608	293608	266422	323568	0.646	0.572	0.729
1969	480220	352625	653985	735275	650773	830750	257816	215292	308739	226840	209423	245706	0.613	0.545	0.689
1970	1561254	1151735	2116385	1191829	989256	1435885	270222	226747	322033	252206	221705	286903	0.65	0.581	0.727
1971	2034987	1494855	2770283	1330413	1125138	1573140	274032	230490	325799	349410	300289	406565	0.735	0.66	0.819
1972	509406	373697	694398	921723	816093	1041025	242559	204115	288243	362580	317364	414237	0.796	0.714	0.887
1973	740440	543432	1008869	738222	654242	832983	209190	181178	241534	259627	236256	285309	0.781	0.701	0.87
1974	726505	532203	991744	710696	628630	803476	227521	197185	262526	235626	210477	263779	0.744	0.668	0.829
1975	1236753	898049	1703201	806936	687318	947373	208147	178992	242051	245242	213679	281467	0.802	0.722	0.89
1976	846614	610455	1174132	636029	558694	724069	177549	150733	209135	245242	212833	282586	0.856	0.77	0.952
1977	2092772	1517872	2885417	987567	804712	1211973	152512	129838	179147	259367	213325	315347	0.815	0.733	0.906
1978	1333077	964302	1842880	1126921	939155	1352228	153430	135157	174173	355045	291999	431704	0.902	0.814	1
1979	1636385	1187309	2255315	1040280	885178	1222558	155438	138265	174743	340102	290766	397808	0.846	0.764	0.937
1980	2623448	1894717	3632458	1255444	1040773	1514394	171785	153907	191740	391601	324430	472680	0.921	0.834	1016
1981	1056001	764334	1458968	1037163	896985	1199249	186839	168927	206650	395933	337515	464462	0.937	0.851	1032
1982	1727179	1266440	2355539	1132570	947803	1353356	181861	163890	201804	386930	327705	456860	1.049	0.954	1154
1983	946949	705301	1271388	885582	761846	1029414	153737	138111	171131	324811	276910	380999	1.042	0.949	1144
1984	1709993	1276254	2291140	908000	761709	1082388	132191	118318	147690	278173	236185	327626	0.974	0.887	107
1985	415817	306386	564333	586542	519056	662802	134054	120046	149698	241832	209515	279134	0.939	0.854	1033
1986	1861699	1392122	2489668	817495	671484	995255	117948	106247	130938	227749	190592	272150	0.993	0.905	1089
1987	709276	531862	945870	748630	644155	870050	124368	111732	138432	257558	217457	305054	0.976	0.889	1071
1988	490411	367376	654653	550730	481387	630062	122394	111714	134095	206076	182711	232429	0.997	0.909	1093
1989	827364	617442	1108657	555154	469661	656209	109754	99560	120993	179154	154255	208071	1.014	0.924	1113
1990	327420	245925	435923	371759	327466	422042	99409	89727	110136	138275	120905	158140	0.94	0.853	1035
1991	374370	282954	495320	342491	299039	392256	95607	85764	106579	118302	105025	133259	0.931	0.847	1025
1992	856834	651596	1126719	534988	446930	640396	91400	82417	101362	140084	118184	166044	0.921	0.838	1012
1993	434521	333421	566278	414571	364768	471175	98815	89788	108748	148301	127906	171948	0.939	0.855	1032
1994	1018661	774196	1340321	529136	447527	625626	101722	93173	111056	153430	132162	178121	0.962	0.878	1054
1995	596002	455413	779993	564107	487180	653183	121297	111138	132385	190232	162909	222137	1.009	0.92	1105
1996	372876	286009	486124	420837	371918	476190	116658	107364	126756	155593	137976	175460	1.008	0.921	1104
1997	1160081	873759	1540226	643064	525791	786494	101519	93269	110499	153430	128317	183458	0.985	0.901	1078
1998	141210	107355	185739	328076	288902	372562	102847	93052	113674	135673	116389	158151	1.004	0.919	1097
1999	251450	193327	327047	226840	203275	253136	85819	78573	93734	94845	86633	103836	1.062	0.972	1161
2000	457257	351456	594907	289526	246955	339435	68255	62000	75140	84965	73561	98138	1.069	0.978	117
2001	167042	128335	217423	198590	176133	223911	63513	57588	70047	72186	63669	81843	1	0.911	1098
2002	246965	190137	320777	168890	148613	191932	56387	51162	62146	56444	51043	62416	0.946	0.86	104
2003	123254	94570	160637	142344	127825	158512	56783	51588	62503	53316	47825	59439	0.923	0.834	1022
2004	201793	155640	261634	123995	108845	141254	46212	41454	51516	39419	35863	43328	0.888	0.801	0.985
2005	154508	117922	202444	139107	121516	159244	47620	41866	54164	40055	35433	45280	0.825	0.742	0.918
2006	358255	276697	463852	146679	123856	173707	43261	37523	49876	31761	28205	35766	0.732	0.652	0.822
2007	168552	130595	217540	195048	172164	220974	72766	64232	82433	53104	46487	60662	0.677	0.6	0.763
2008	196025	151700	253303	205664	180468	234378	81227	71691	92031	52313	47548	57555	0.641	0.564	0.728
2009	193300	149561	249831	220356	193500	250939	90944	79475	104068	54830	49572	60647	0.627	0.548	0.716
2010	296262	228415	384262	236097	203918	273355	93060	79738	108608	48728	44262	53644	0.542	0.469	0.627
2011	148153	114403	191860	223910	194119	258273	105662	88341	126379	44802	40440	49634	0.443	0.379	0.518
2012	203211	157358	262425	199586	172234	231281	106831	88281	129277	40336	37275	43648	0.404	0.344	0.473
2013	263024	203288	340313	259886	223095	302746	117477	97190	142000	41606	38211	45303	0.393	0.338	0.458
2014	391601	295327	519260	329391	278089	390156	126880	105516	152570	45936	41634	50682	0.395	0.341	0.459
2015	169058	118172	241857	288082	245194	338472	151146	125031	182714	52313	46831	58436	0.385	0.327	0.453
2016							161135	129713	200170						

Table 14.11b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run estimated landings, discards, catch (=landings + discards) and total removals in tonnes. Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch (after removing unaccounted mortality), while total removals are the SAM estimate of catch, including a catch multiplier incorporated from 1993 to 2005 only.

Year	Landings	Discards	Catch	Catch multiplier	Total Removals
1963	106938	10849	117830		117830
1964	135131	9788	144929		144929
1965	182043	17057	199187		199187
1966	214701	26239	240867		240867
1967	260667	26662	287506		287506
1968	276509	17127	293608		293608
1969	217075	9664	226840		226840
1970	232350	19897	252206		252206
1971	291560	57873	349410		349410
1972	328076	34372	362580		362580
1973	234685	24959	259627		259627
1974	209609	26160	235626		235626
1975	209190	36243	245242		245242
1976	201390	43871	245242		245242
1977	181680	77964	259367		259367
1978	306202	48728	355045		355045
1979	278173	62131	340102		340102
1980	290977	100912	391601		391601
1981	342148	53960	395933		395933
1982	323191	63577	386930		386930
1983	287794	37235	324811		324811
1984	209819	68050	278173		278173
1985	213844	28029	241832		241832
1986	168890	59042	227749		227749
1987	225032	32565	257558		257558
1988	191377	14707	206076		206076
1989	138968	40296	179154		179154
1990	115151	23086	138275		138275
1991	102437	15755	118302		118302
1992	108554	31414	140084		140084
1993	130115	28543	158606	0.94	148301
1994	106116	41910	148048	1.04	153430
1995	130522	31930	162316	1.17	190232
1996	132275	21451	153682	1.01	155593
1997	133070	46149	179267	0.86	153430
1998	147449	43575	191040	0.71	135673
1999	96722	13843	110592	0.86	94845
2000	73373	16493	89798	0.95	84965
2001	44416	11411	55846	1.29	72186
2002	53422	11395	64794	0.87	56444
2003	31131	4750	35881	1.49	53316
2004	27269	7503	34770	1.13	39419
2005	29902	11366	41262	0.97	40055
2006	22629	9121	31761		31761
2007	24005	29144	53104		53104
2008	27038	25261	52313		52313
2009	33223	21610	54830		54830
2010	36207	12545	48728		48728
2011	34372	10443	44802		44802
2012	32728	7632	40336		40336
2013	30822	10808	41606		41606
2014	34822	11121	45936		45936
2015	38638	13654	52313		52313

Table 14.11c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM final run estimated catch multipliers, together with the lower and upper bounds of the point-wise 95% confidence intervals.

Year Catch multiplier

year	Catch multiplier	Low	High
1993	0.94	0.78	112
1994	1.04	0.85	126
1995	1.17	0.96	143
1996	1.01	0.83	123
1997	0.86	0.71	104
1998	0.71	0.59	0.86
1999	0.86	0.70	105
2000	0.95	0.78	115
2001	1.29	106	157
2002	0.87	0.72	106
2003	1.49	122	181
2004	1.13	0.93	138
2005	0.97	0.81	116

Table 14.12a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Catch options based on the final SAM assessment run with maturities smoothed to 2015, where SSB in the intermediate year is 161135 tonnes. Units are '000t (SSB, landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2016) = F(2015) =	**0.39**
Recruitment resampled from 1998-2015 =	**196**
SSB(2017) =	**174300**
HC landings (2016) =	**44837**
Discards (2016) =	**11465**

Rationale	Catch (2017)	Landings (2017)	Discards (2017)	Basis	Ftotal (2017)	F land (2017)	F disc (2017)	SSB (2018)	SSB 5% (2018)	%SSB change	%TAC change	Ftotal (2018)	Ftotal (2019)	Catch (2018)	Catch (2019)	Landings (2018)	Landings (2019)	Discards (2018)	Discards (2019)	SSB (2019)	SSB (2020)	%change SSB 19:17	%change SSB 20:17
Management Plan	55959	45612	10347	EU MP	0.40	0.28	0.12	173495	134519	0	13	0.40	0.40	53176	51087	42900	39989	10276	11098	171376	168355	-2	-3
Management Plan	54046	44091	9955	EU-Norway	0.38	0.27	0.11	175637	136324	1	9	0.40	0.40	53806	51541	43466	40319	10340	11222	173013	169678	-1	-3
MSY approach	47431	38691	8740	FMSY *SSB2017/Btrigger	0.33	0.23	0.10	182807	142585	5	-4	0.33	0.33	47361	47155	38465	37311	8896	9844	188515	191706	8	10
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	237118	188285	36	-100	0	0	0	0	0	0	0	0	307740	372686	77	114
MSY	47431	38691	8740	FMSY	0.33	0.23	0.10	182807	142585	5	-4	0.33	0.33	47361	47155	38465	37311	8896	9844	188515	191706	8	10
Fpa 0.41	57140	46551	10589	Flim/1.4	0.41	0.29	0.12	172171	133416	-1	15	0.41	0.41	53895	51541	43421	40320	10474	11221	169103	165281	-3	-5
Fpa 0.47	63993	52118	11875	$F_{lim} \times \exp(-\sigma \times 1.645)$	0.47	0.33	0.14	164628	127030	-6	29	0.47	0.47	58068	54061	46306	41819	11762	12242	155630	148788	-11	-15
Flim	75810	61629	14181	Flim	0.58	0.41	0.17	151846	116043	-13	52	0.58	0.58	63649	56608	50331	43092	13318	13516	134929	123262	-23	-29
SSB(2018)=Blim	107401	87011	20390	SSB(2018)=Blim	0.94	0.66	0.28	118000	88722	-32	115	0.94	0.94	72088	56978	54797	40803	17291	16175	88170	72950	-49	-58
SSB(2018)=Bpa	63653	51839	11814	SSB(2018)=Bpa	0.47	0.33	0.14	165000	127386	-5	28	0.47	0.47	57877	53933	46163	41770	11714	12163	156282	149569	-10	-14
SSB(2018)=Btrigger	63653	51839	11814	SSB(2018)=Btrigger	0.47	0.33	0.14	165000	127386	-5	28	0.47	0.47	57877	53933	46163	41770	11714	12163	156282	149569	-10	-14
TAC constraint	39518	32335	7183	TAC2016 - 20%	0.27	0.19	0.08	191608	144116	10	-20	0.26	0.25	39895	40043	32335	32335	7560	7708	207709	218101	19	25
TAC constraint	41995	34356	7639	TAC2016 - 15%	0.29	0.20	0.09	188858	141560	8	-15	0.28	0.28	42456	42690	34356	34356	8100	8334	201598	208834	16	20
TAC constraint	44478	36377	8101	TAC2016 - 10%	0.31	0.22	0.09	186052	139029	7	-10	0.3	0.31	45026	45374	36377	36377	8649	8997	195584	198896	12	14
TAC constraint	46962	38398	8564	TAC2016 - 5%	0.33	0.23	0.10	183206	136365	5	-5	0.33	0.34	47616	48076	38398	38398	9218	9678	189451	189490	9	9
TAC constraint	49454	40419	9035	TAC2016	0.35	0.24	0.11	180305	133707	3	0	0.35	0.37	50214	50814	40419	40419	9795	10395	183390	180231	5	3
TAC constraint	51939	42440	9499	TAC2016 + 5%	0.37	0.26	0.11	177556	131054	2	5	0.38	0.41	52811	53576	42440	42440	10371	11136	177101	170508	2	-2
TAC constraint	54425	44461	9964	TAC2016 + 10%	0.39	0.27	0.12	174736	128407	0	10	0.41	0.45	55444	56375	44461	44461	10983	11914	171028	160715	-2	-8
TAC constraint	56914	46482	10432	TAC2016 + 15%	0.41	0.29	0.12	171902	125766	-1	15	0.44	0.5	58084	59233	46482	46482	11602	12751	165080	151676	-5	-13
TAC constraint	59410	48503	10907	TAC2016 + 20%	0.43	0.30	0.13	169100	123082	-3	20	0.47	0.55	60721	62110	48503	48503	12218	13607	159094	142343	-9	-18
Status quo	54214	44226	9988	Fsq	0.39	0.27	0.12	175459	136166	1	9	0.39	0.39	52065	50407	42063	39461	10002	10946	174721	172896	0	-1

Table 14.12b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Catch options based on the SAM sensitivity run with maturities smoothed to 2016, where SSB in the intermediate year is 146386 tonnes. Units are ‘000t (SSB, landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2016) = F(2015) = 0.39
Recruitment resampled from 1998-2015 = 196
SSB(2017) = 169745
HC landings (2016) = 44837
Discards (2016) = 11465

Rationale	Catch (2017)	Landings (2017)	Discards (2017)	Basis	Ftotal (2017)	F land (2017)	F disc (2017)	SSB (2018)	SSB 5% (2018)	%SSB change	%TAC change	Ftotal (2018)	Ftotal (2019)	Catch (2018)	Catch (2019)	Landings (2018)	Landings (2019)	Discards (2018)	Discards (2019)	SSB (2019)	SSB (2020)	%change SSB 19:17	%change SSB 20:17
Management Plan	54886	44765	10121	EU MP	0.39	0.27	0.12	170316	132251	0	11	0.40	0.40	53538	51346	43211	40171	10327	11175	167312	164268	-1	-3
Management Plan	46297	37766	8531	EU-Norway	0.32	0.23	0.09	179905	139873	6	-7	0.39	0.40	56181	53218	45319	42345	10862	10873	175789	170413	4	0
MSY approach	47431	38691	8740	FMSY *SSB2017/Btrigger	0.33	0.23	0.10	178571	138809	5	-4	0.33	0.33	47361	47155	38465	37311	8896	9844	183513	186034	8	10
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	232404	184104	37	-100	0	0	0	0	0	0	0	0	302253	367831	78	117
MSY	47431	38691	8740	FMSY	0.33	0.23	0.10	178571	138809	5	-4	0.33	0.33	47361	47155	38465	37311	8896	9844	183513	186034	8	10
Fpa 0.41	57140	46551	10589	Flim/1.4	0.41	0.29	0.12	167931	129950	-1	15	0.41	0.41	53895	51541	43421	40320	10474	11221	164001	160562	-3	-5
Fpa 0.47	63993	52118	11875	$F_{lim} \times \exp(-\sigma \times 1.645)$	0.47	0.33	0.14	160372	123405	-6	29	0.47	0.47	58068	54061	46306	41819	11762	12242	151108	143886	-11	-15
TAC constraint	39518	32335	7183	TAC2016 - 20%	0.27	0.19	0.08	187141	141055	10	-20	0.26	0.25	39895	40043	32335	32335	7560	7708	202853	212934	20	25
TAC constraint	41995	34356	7639	TAC2016 - 15%	0.29	0.20	0.09	184301	138452	9	-15	0.28	0.28	42456	42690	34356	34356	8100	8334	196760	203453	16	20
TAC constraint	44478	36377	8101	TAC2016 - 10%	0.31	0.22	0.09	181585	135855	7	-10	0.3	0.31	45026	45374	36377	36377	8649	8997	190613	194023	12	14
TAC constraint	46962	38398	8564	TAC2016 - 5%	0.33	0.23	0.10	178769	133267	5	-5	0.33	0.34	47616	48076	38398	38398	9218	9678	184580	184844	9	9
TAC constraint	49454	40419	9035	TAC2016	0.35	0.24	0.11	176028	130629	4	0	0.35	0.37	50214	50814	40419	40419	9795	10395	178460	174997	5	3
TAC constraint	51939	42440	9499	TAC2016 + 5%	0.37	0.26	0.11	173324	128107	2	5	0.38	0.41	52811	53576	42440	42440	10371	11136	172411	165421	2	-3
TAC constraint	54425	44461	9964	TAC2016 + 10%	0.39	0.27	0.12	170534	125450	0	10	0.41	0.45	55444	56375	44461	44461	10983	11914	166597	156134	-2	-8
TAC constraint	56914	46482	10432	TAC2016 + 15%	0.41	0.29	0.12	167778	122504	-1	15	0.44	0.5	58084	59233	46482	46482	11602	12751	160659	146885	-5	-13
TAC constraint	59410	48503	10907	TAC2016 + 20%	0.43	0.30	0.13	165080	119729	-3	20	0.47	0.55	60721	62110	48503	48503	12218	13607	154588	137236	-9	-19
Status quo	54214	44226	9988	Fsq	0.39	0.27	0.12	171078	132810	1	9	0.39	0.39	52065	50407	42063	39461	10002	10946	169860	168006	0	-1

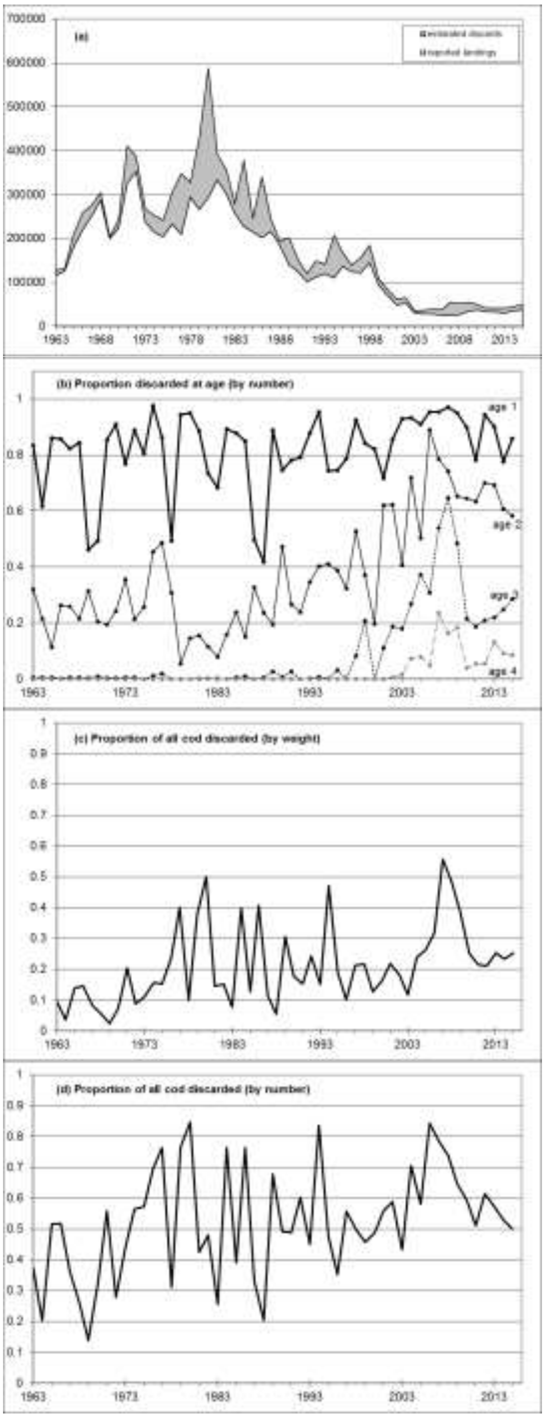


Figure 14.1 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d: (a) stacked area plot of reported landings and estimated discards (in tons); (b) proportion of total numbers caught at age that are discarded; (c) proportion of total weight caught that is discarded; (d) and proportion of the total numbers caught that are discarded.

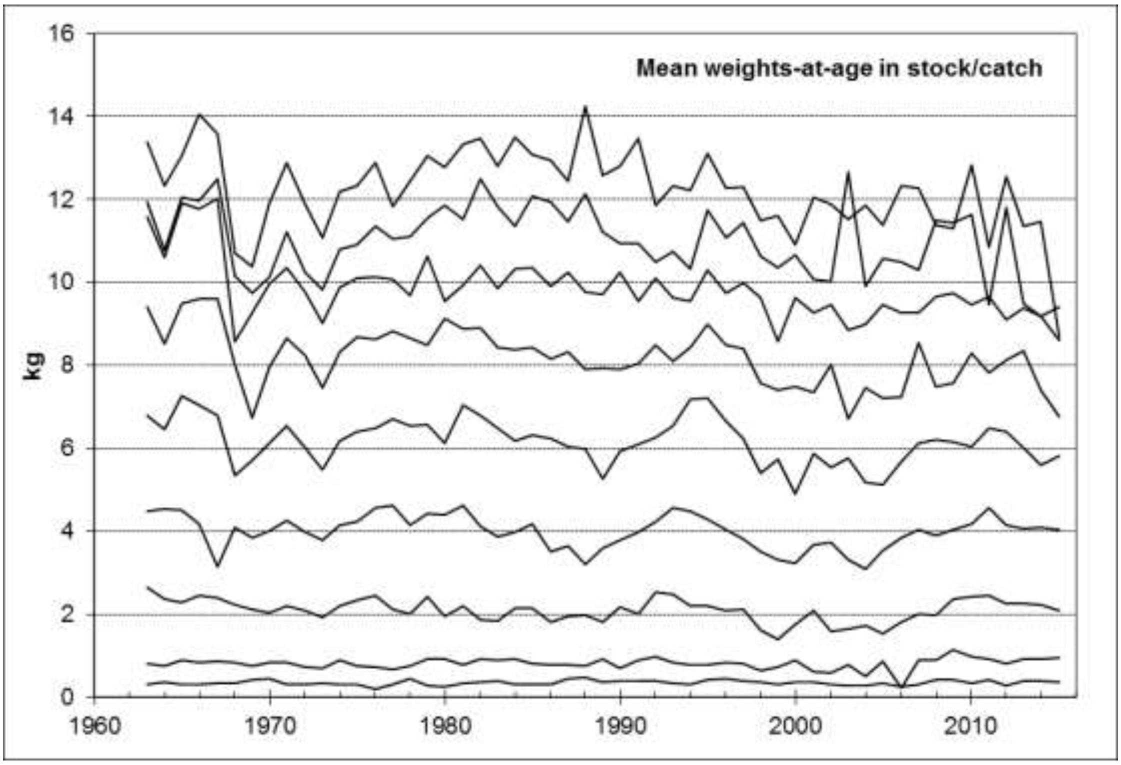


Figure 14.2a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d: Mean weight at age in the catch for ages 1–9.

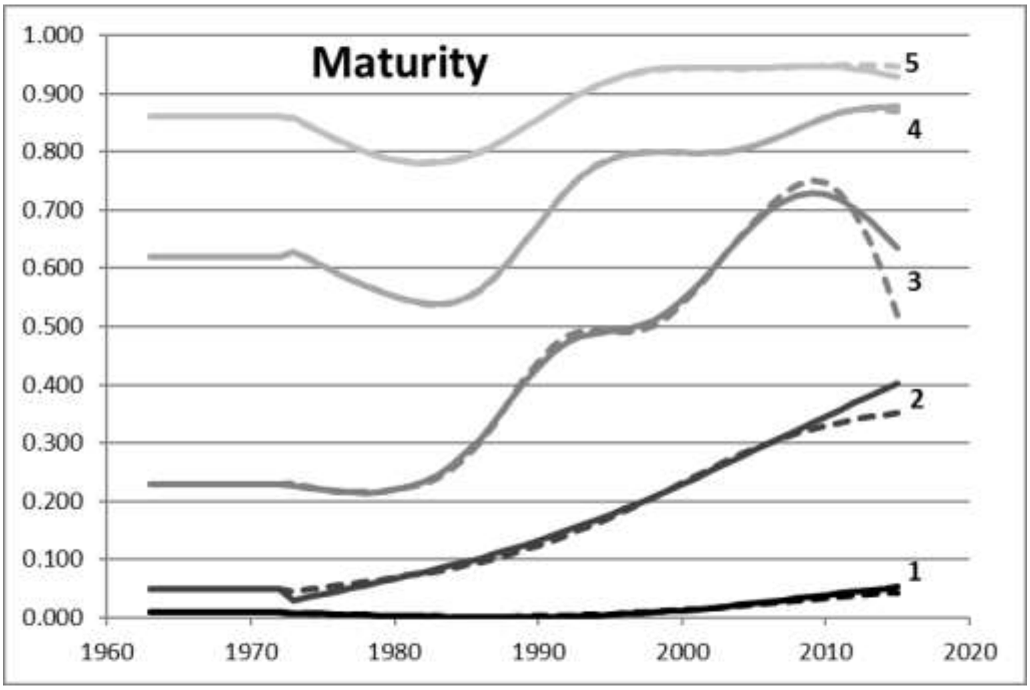


Figure 14.2b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d: Annually varying maturity-at-age smoothed to 2015 (solid line) or 2016 (dashed line). Values for 1963–1972 are the former constant maturity values used for cod.

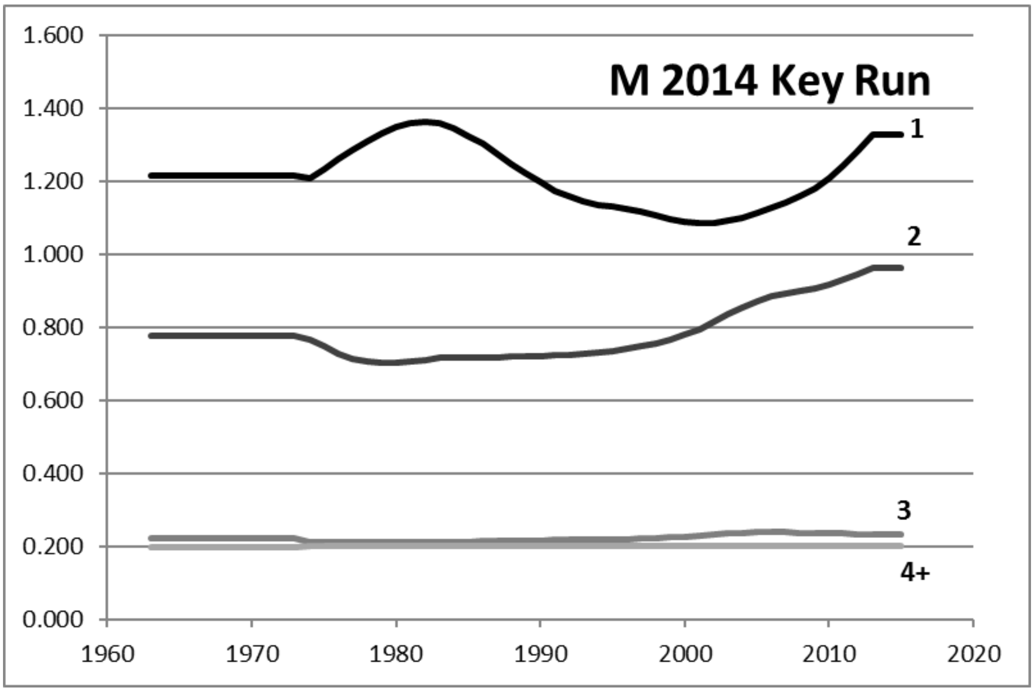


Figure 14.2c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d: Smoothed, annually varying natural mortality from the 2014 key run (ICES-WGSAM 2014). Values for 1963–1972 are set equal to the 1973 value, while 2014 and 2015 are set equal to 2013.

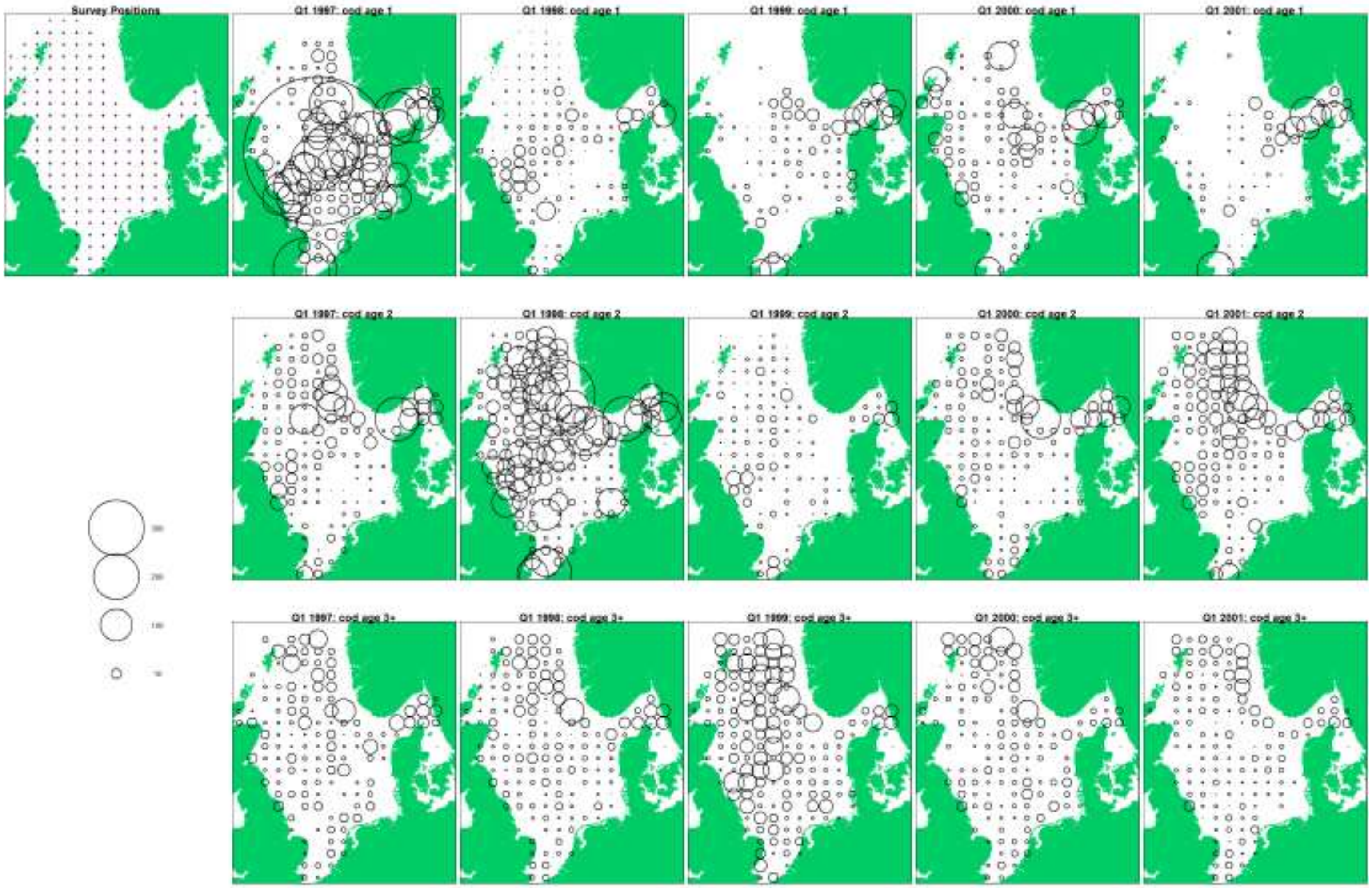


Figure 14.3a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q1 survey 1997–2016 in the North Sea.

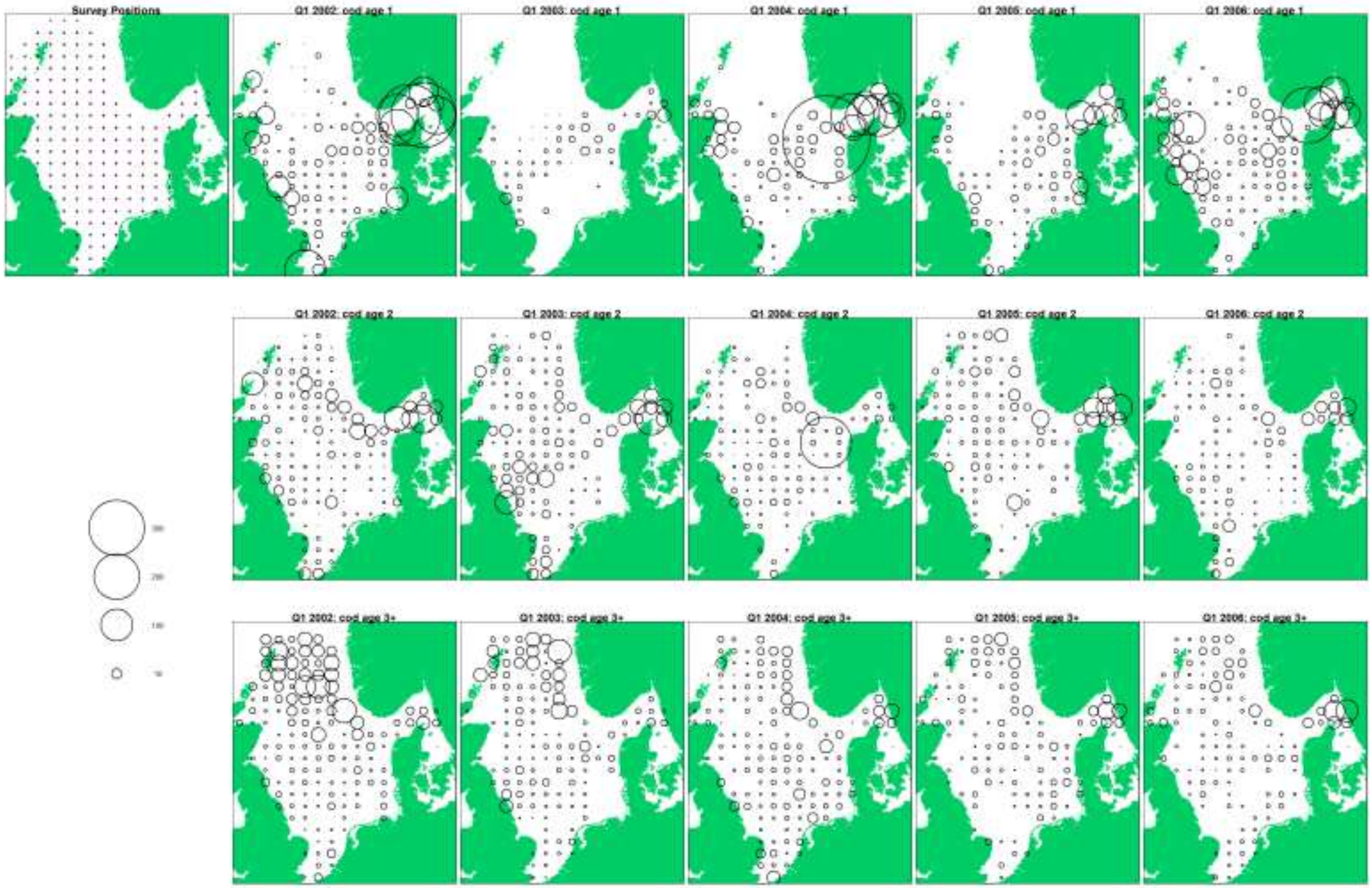


Figure 14.3a contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q1 survey 1997–2016 in the North Sea.

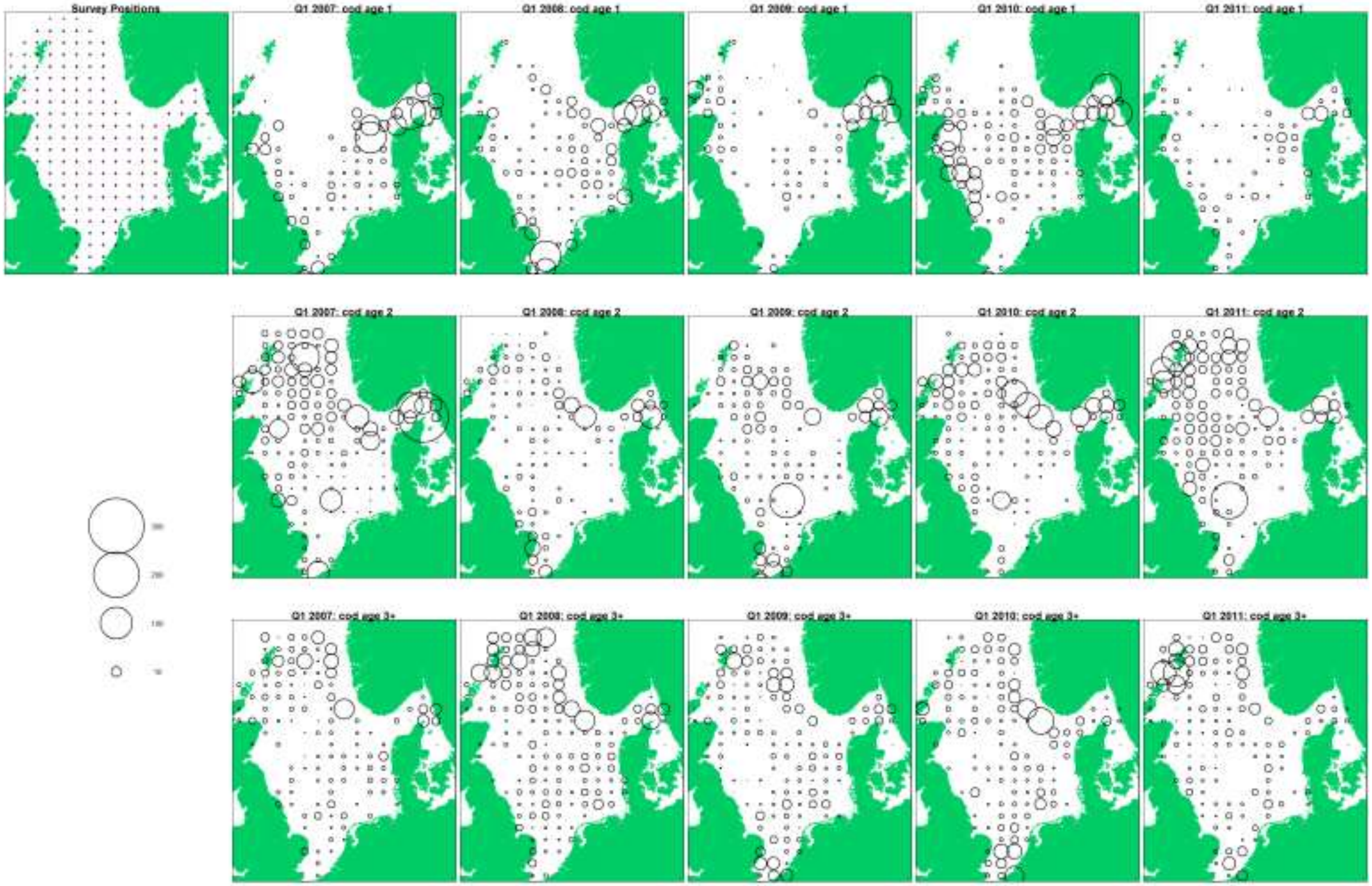


Figure 14.3a contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q1 survey 1997–2016 in the North Sea.

Figure 14.3a contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q1 survey 1997–2016 in the North Sea.

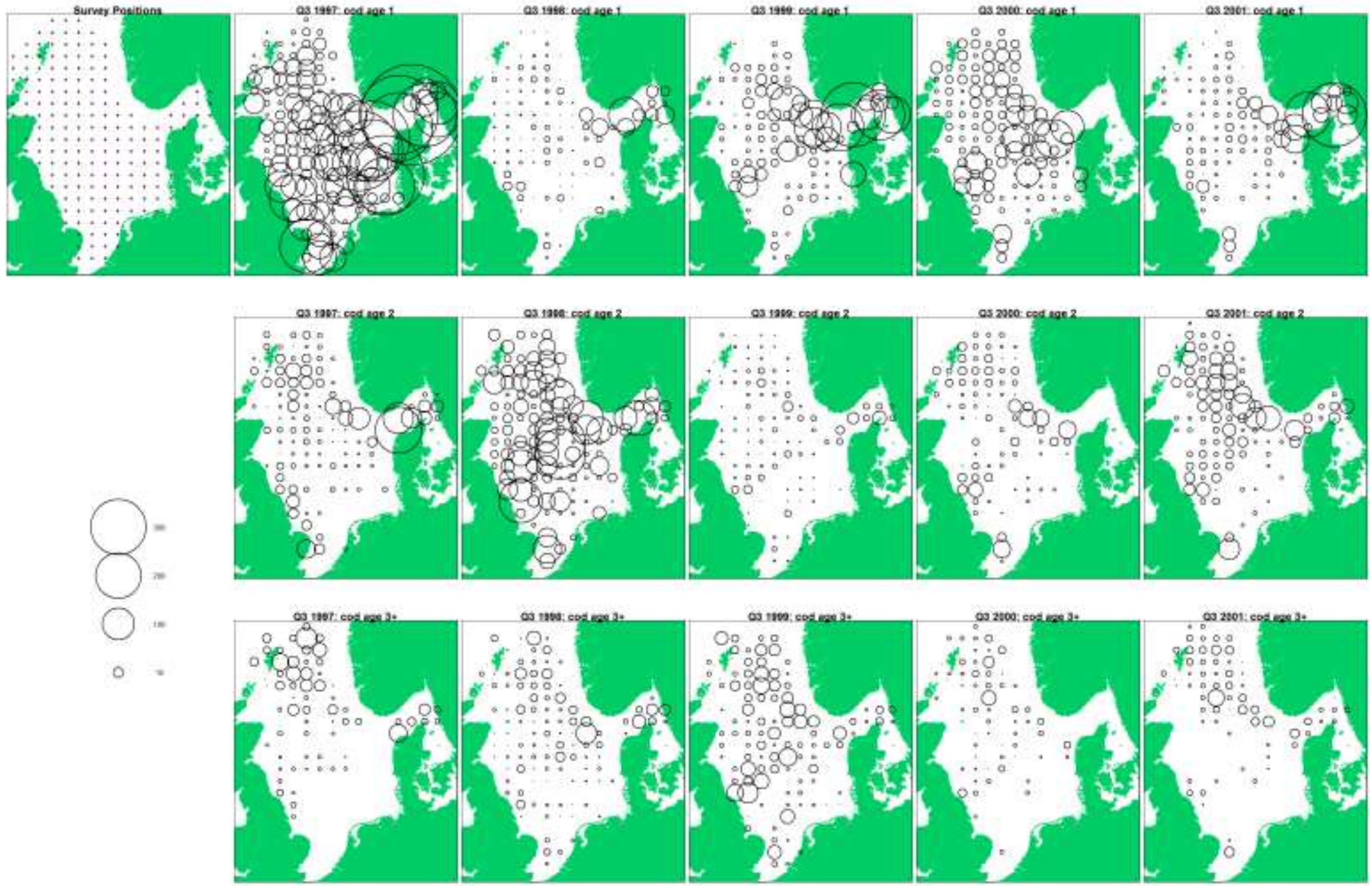


Figure 14.3b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q3 survey 1997–2015 in the North Sea.

Figure 14.3b contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q3 survey 1997–2015 in the North Sea.

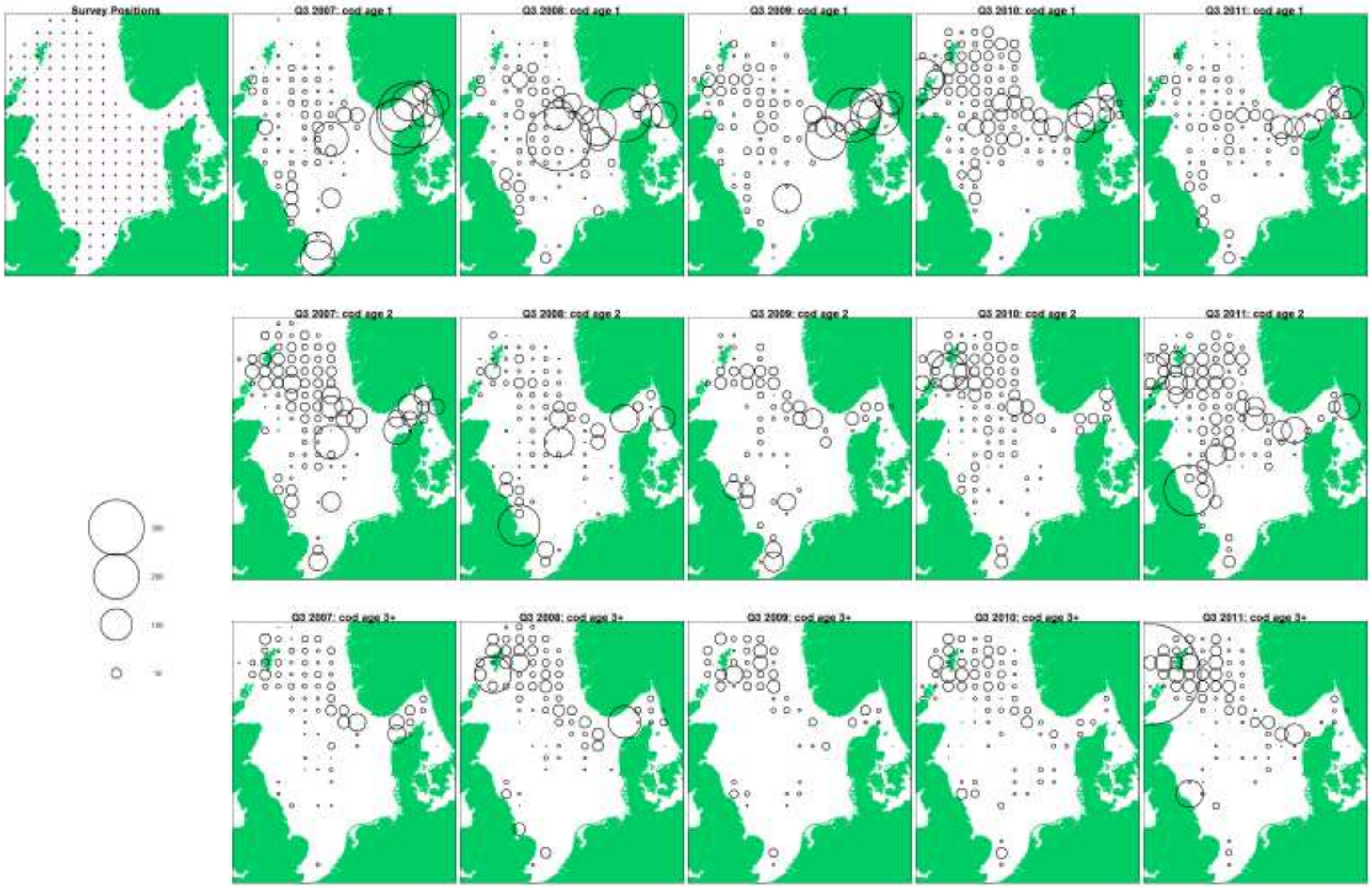


Figure 14.3b contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q3 survey 1997–2015 in the North Sea.

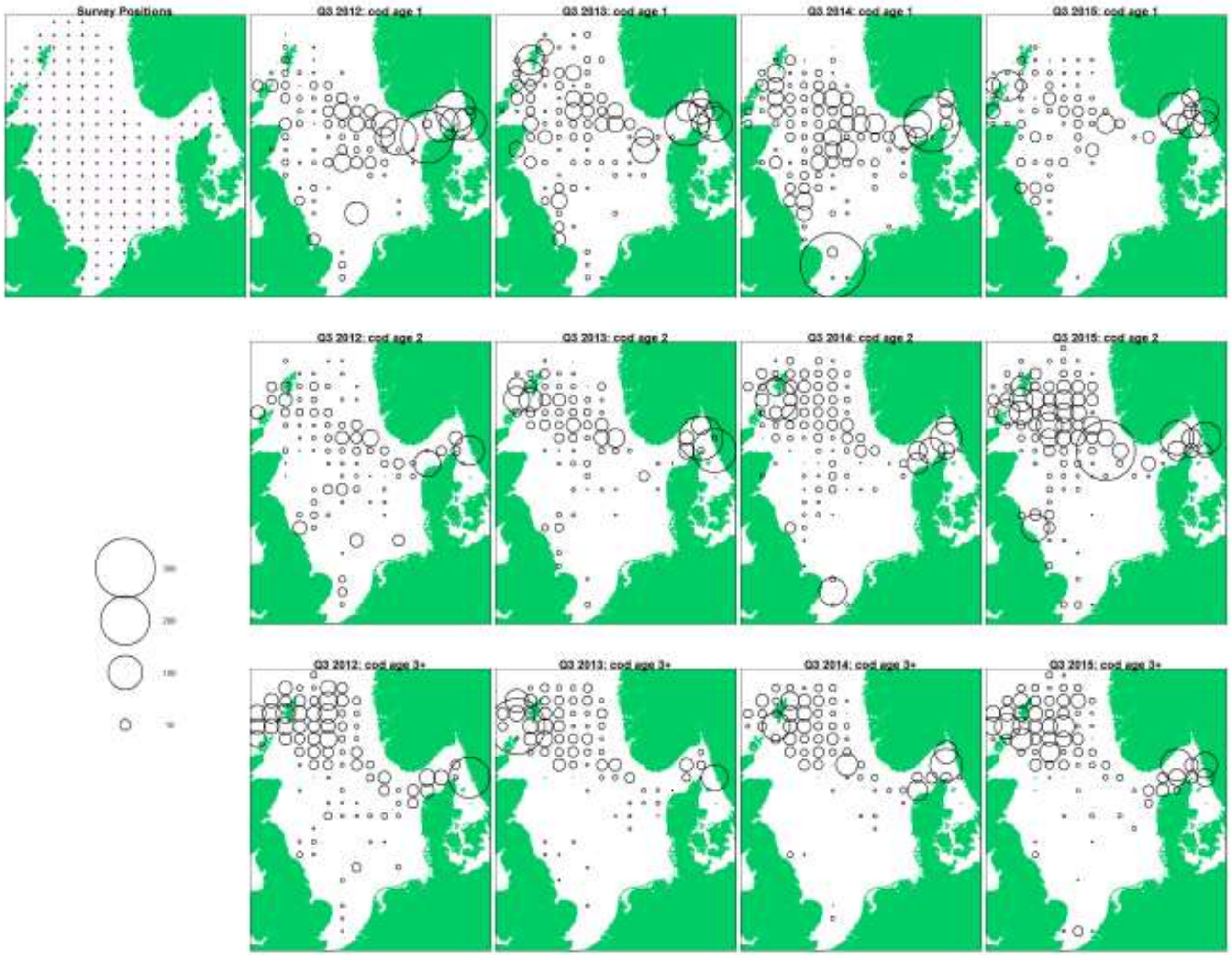


Figure 14.3b contd. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Distribution charts of cod ages 1–3+ caught in the IBTS Q3 survey 1997–2015 in the North Sea.

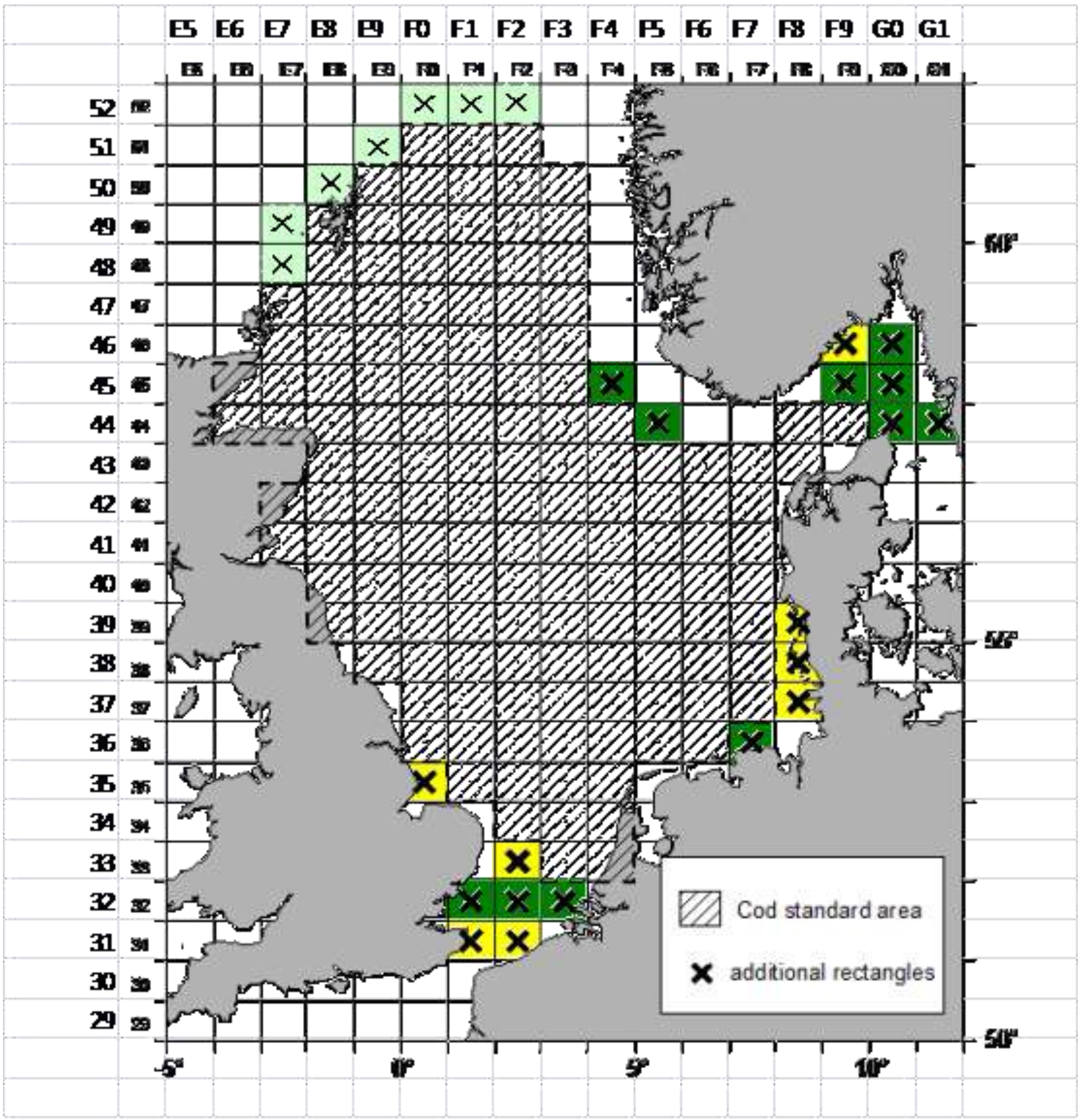


Figure 14.3c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Extension of cod standard area used for the NS-IBTS extended index. Crosses indicate suggested extensions to the survey (ICES-WKROUND, 2009; ICES-WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is available; yellow squares indicate where intermittent coverage does not allow inclusion and the IBTS WG considered should be omitted; light green squares indicate the recommended extension around Shetland (ICES-WKCOD, 2011).

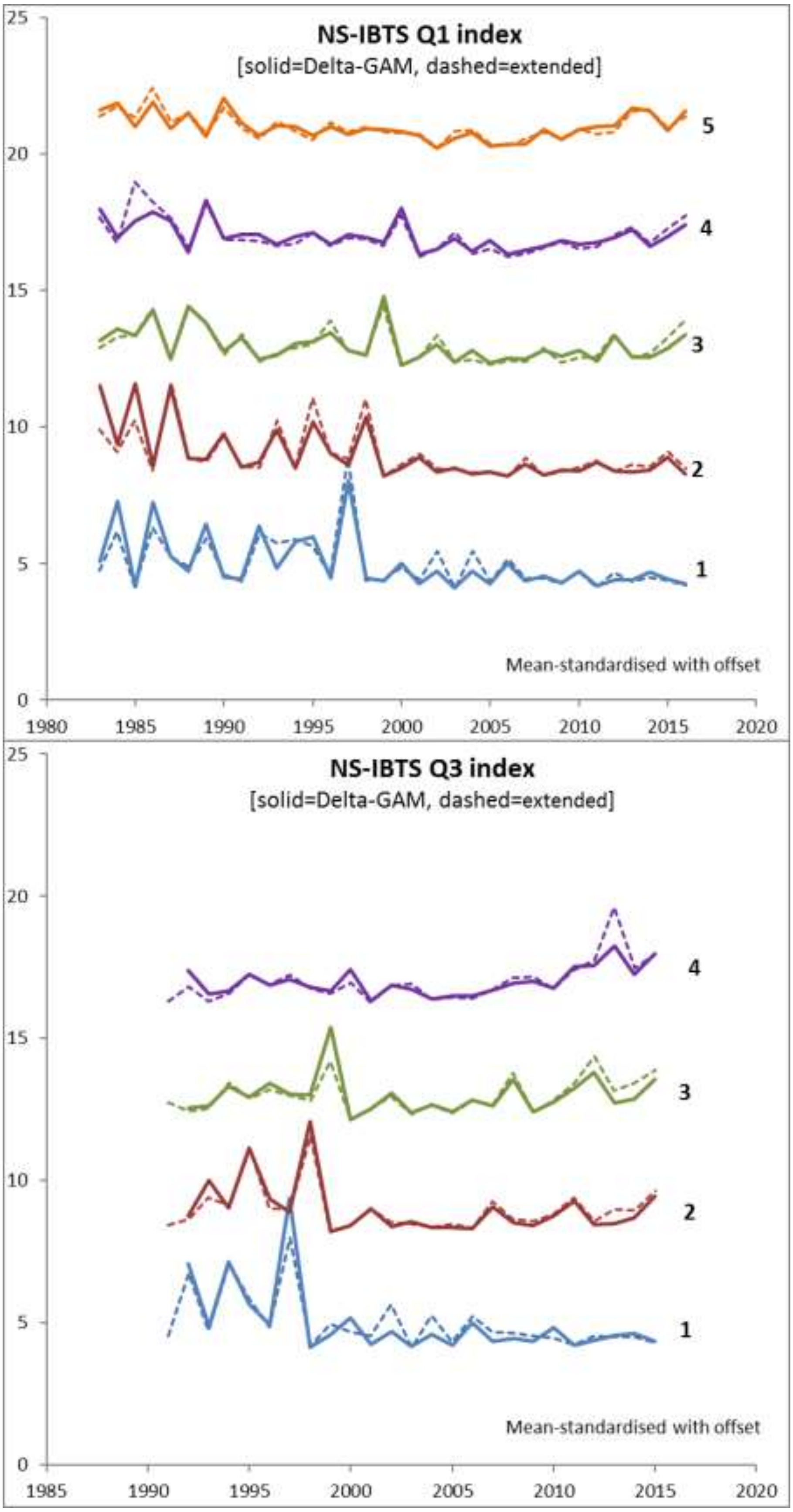


Figure 14.3d Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Comparison of the Q1 and Q3 NS-IBTS extended indices to the corresponding NS-IBTS Delta GAM indices used in the assessment. The indices are mean-standardised with an offset for ease of presentation.

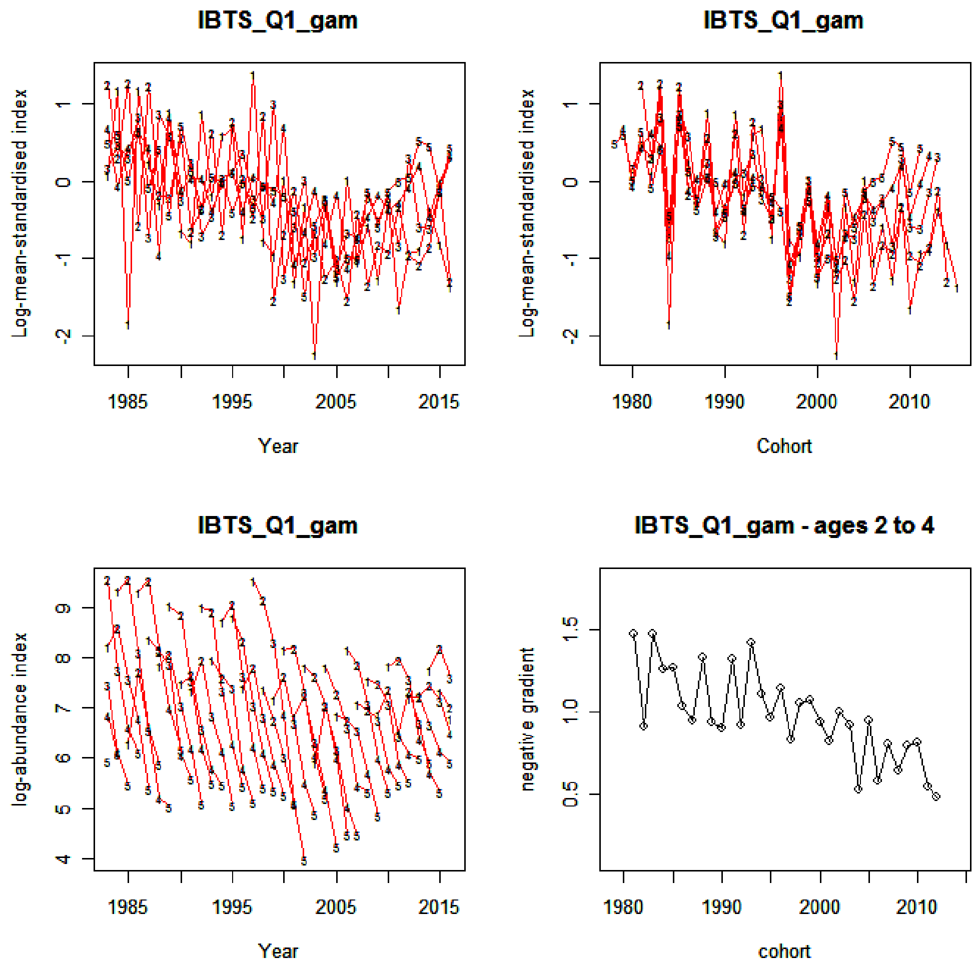


Figure 14.4a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ1 groundfish survey (NS-IBTS Delta-GAM index).

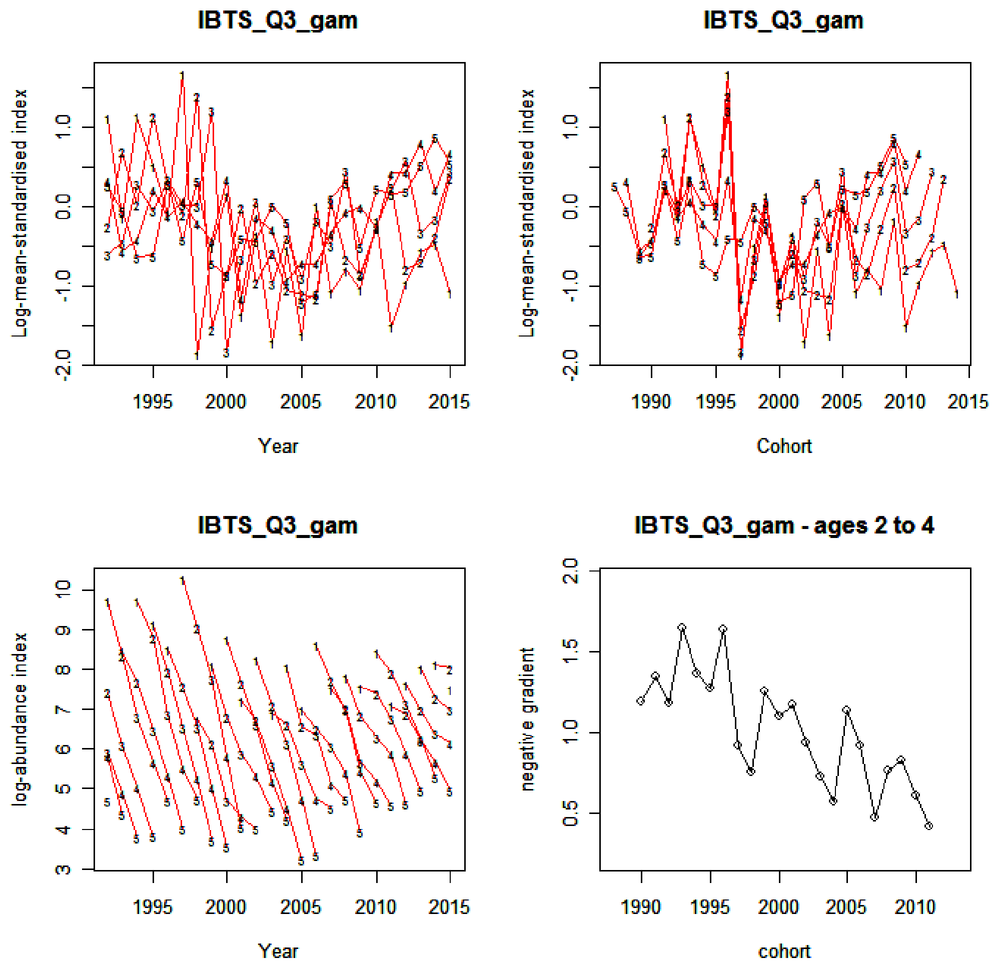


Figure 14.4b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTSQ3 groundfish survey (NS-IBTS Delta-GAM index).

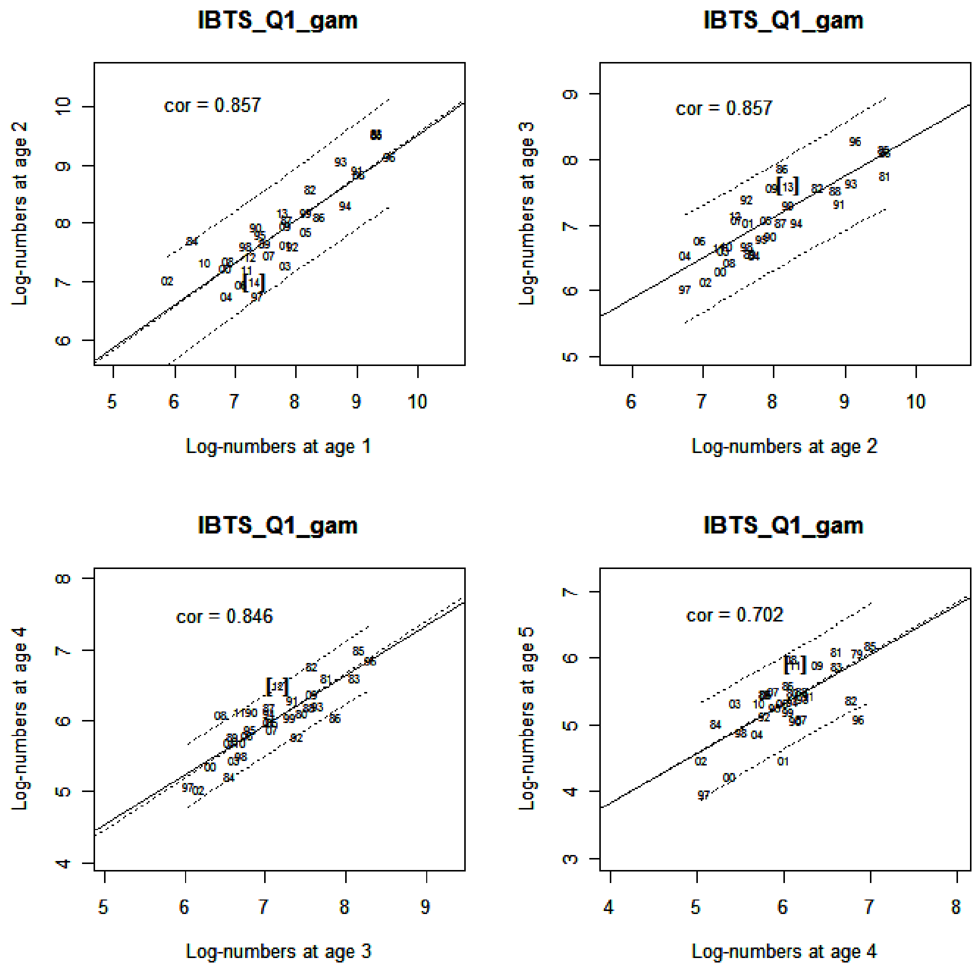


Figure 14.5a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Within-survey correlations for IBTSQ1 (NS-IBTS Delta-GAM index) for the period 1983–2016. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust 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.

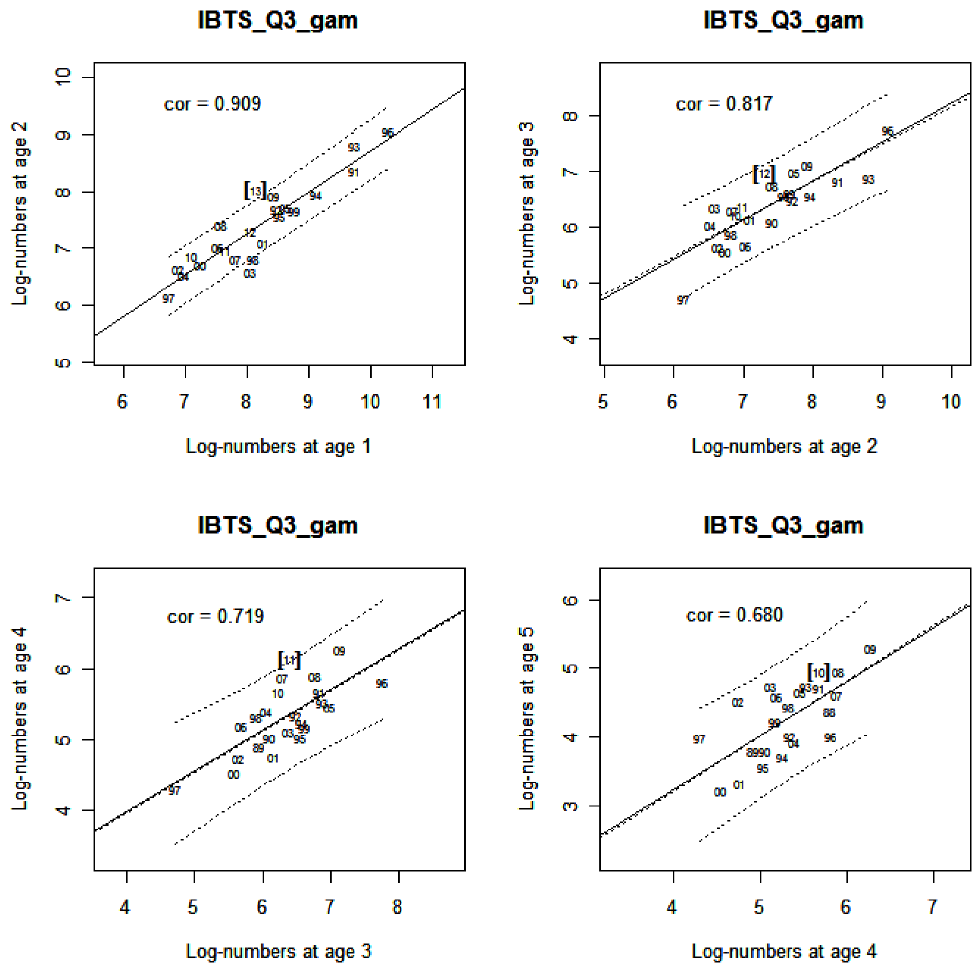


Figure 14.5b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Within-survey correlations for IBTSQ3 (NS-IBTS Delta-GAM index) for the period 1992–2015. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust 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.

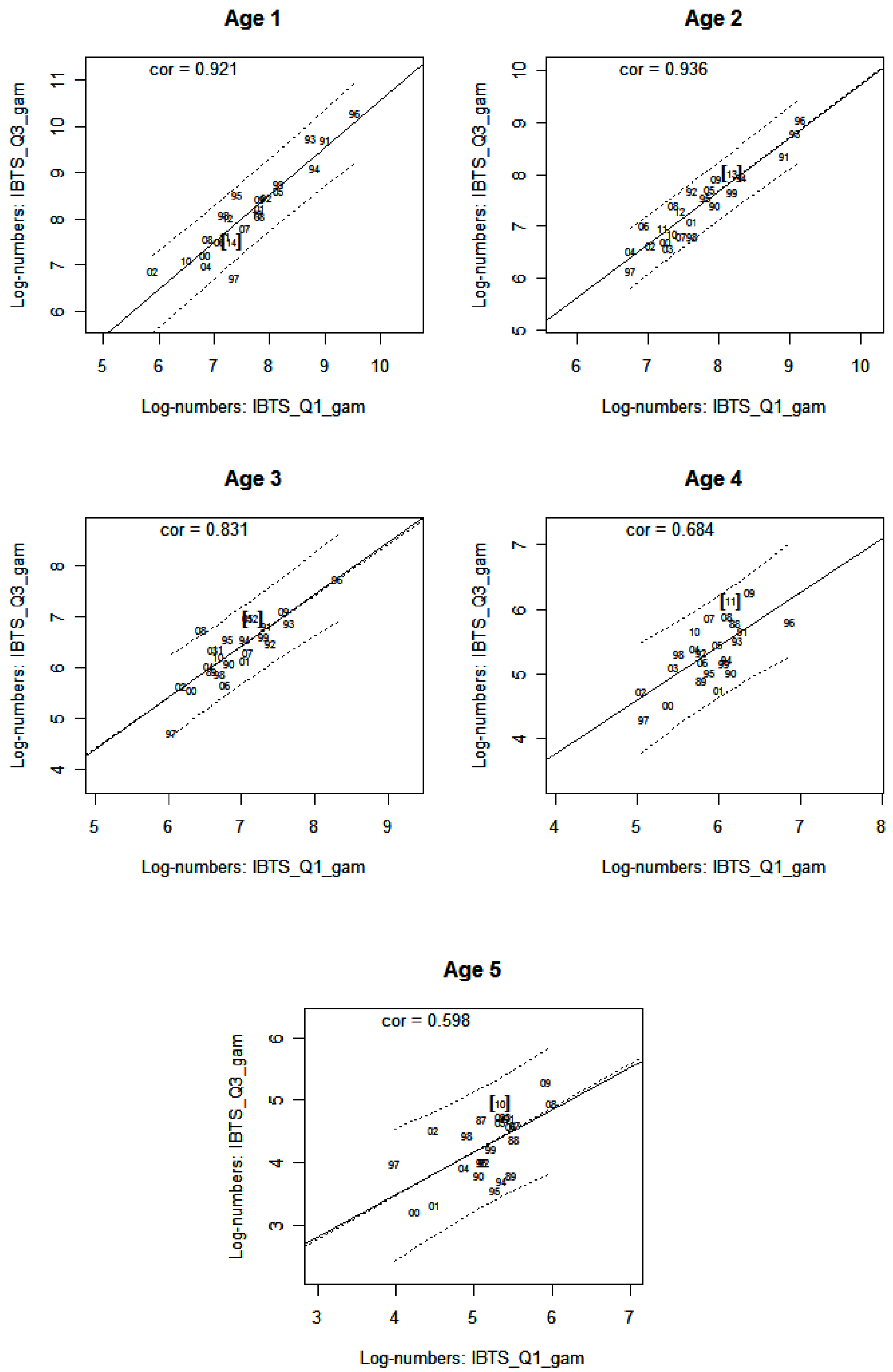


Figure 14.5c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Between-survey correlations for IBTSQ1 and Q3 surveys (NS-IBTS Delta-GAM indices) for the period 1992–2015. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line 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.

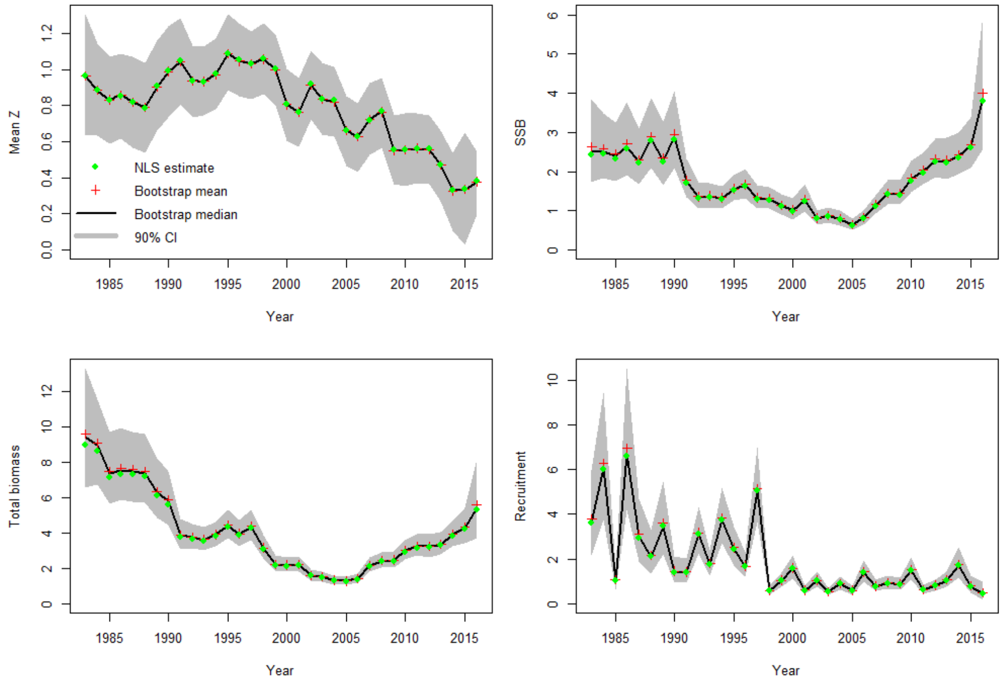


Figure 14.6 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (IBTSQ1 and Q3 NS-IBTS Delta-GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3. The shaded area represents 90% confidence bounds.

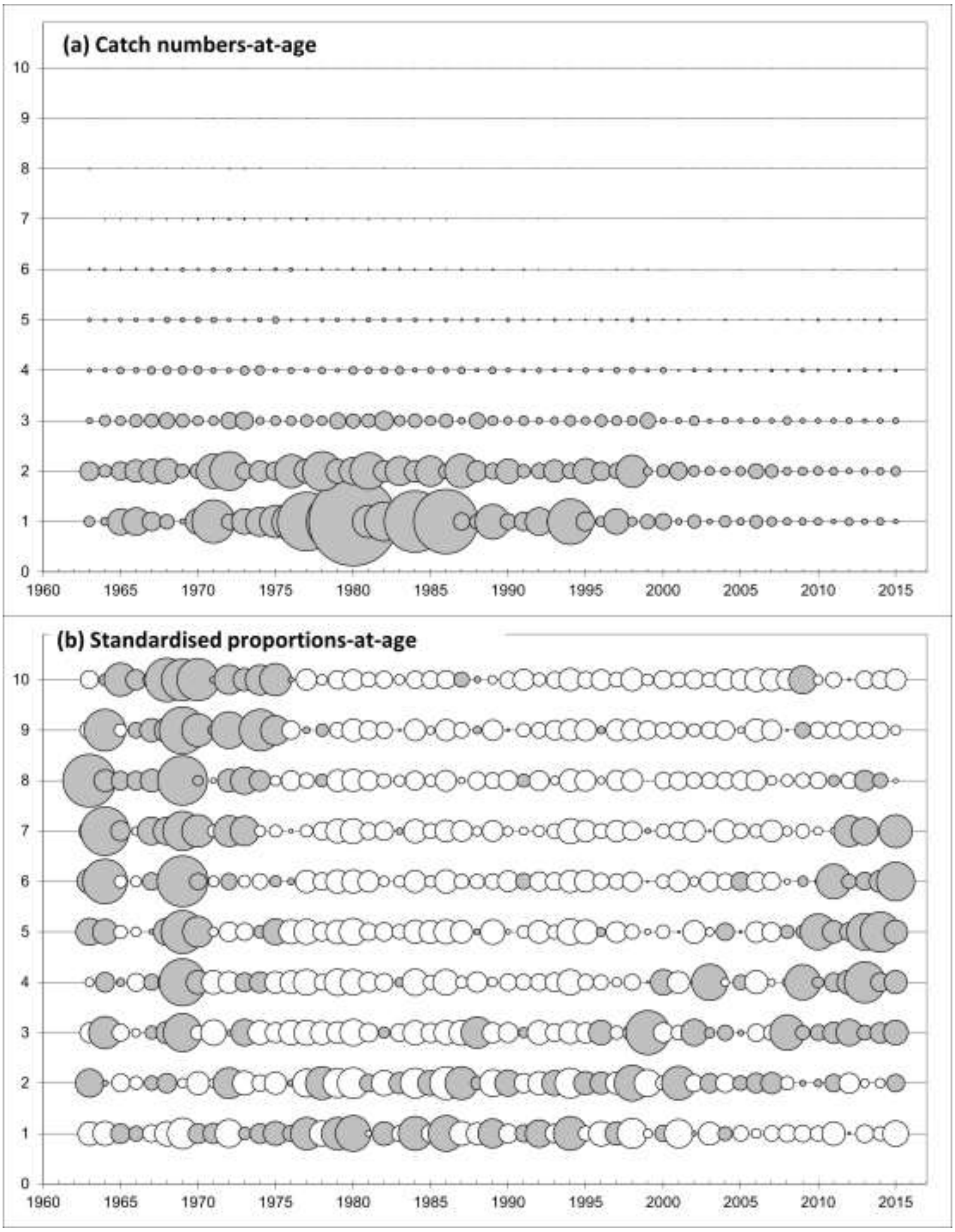
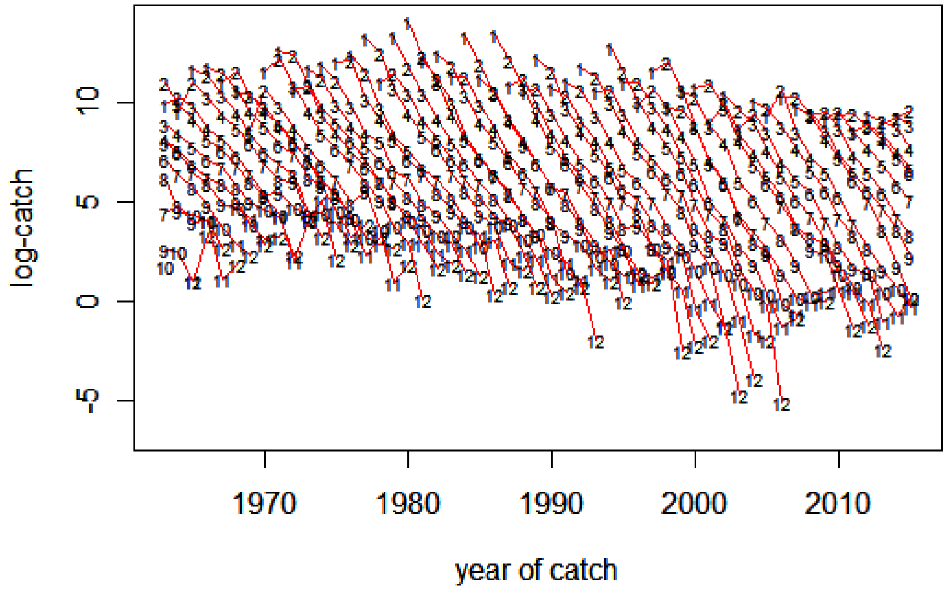


Figure 14.7 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.



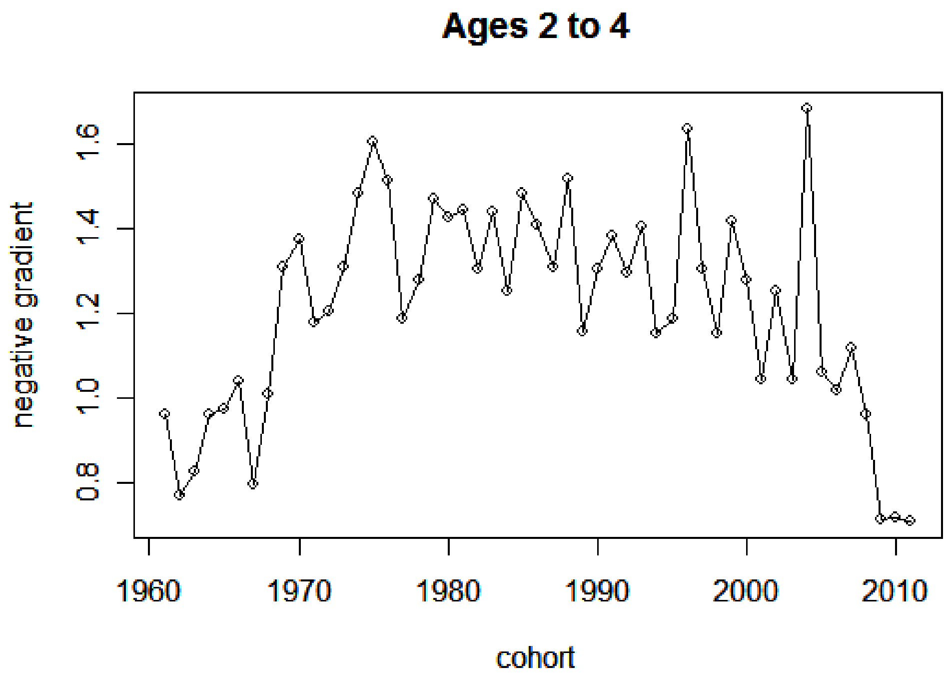


Figure 14.8 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2-4.

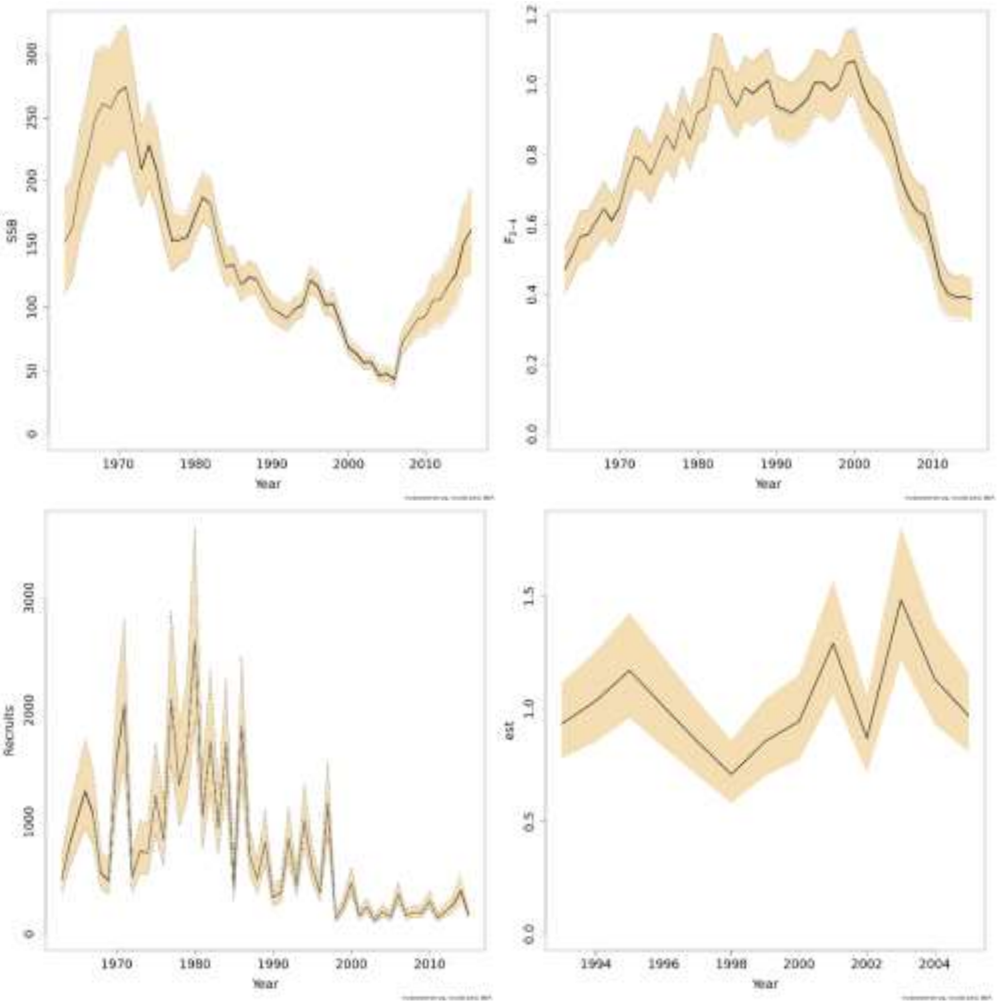


Figure 14.9a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Estimated SSB, F (2–4), recruitment (age 1) and the catch multiplier from the SAM assessment with maturities smoothed to 2015 (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The final SAM assessment for last year (2015) is plotted in light grey for the SSB, F and recruitment plots for comparison.

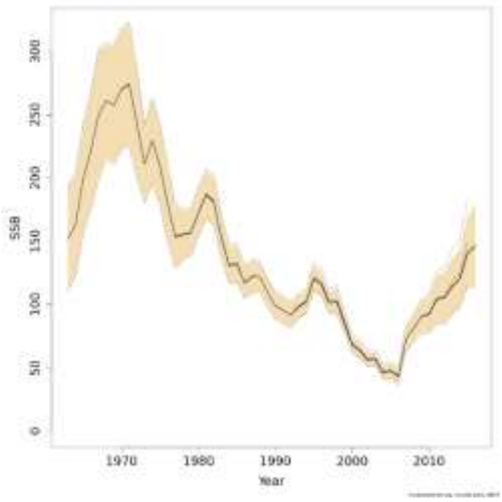


Figure 14.9b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Estimated SSB from the SAM assessment with maturities smoothed to 2016 (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The SAM assessment for last year (2015) is plotted in light grey.

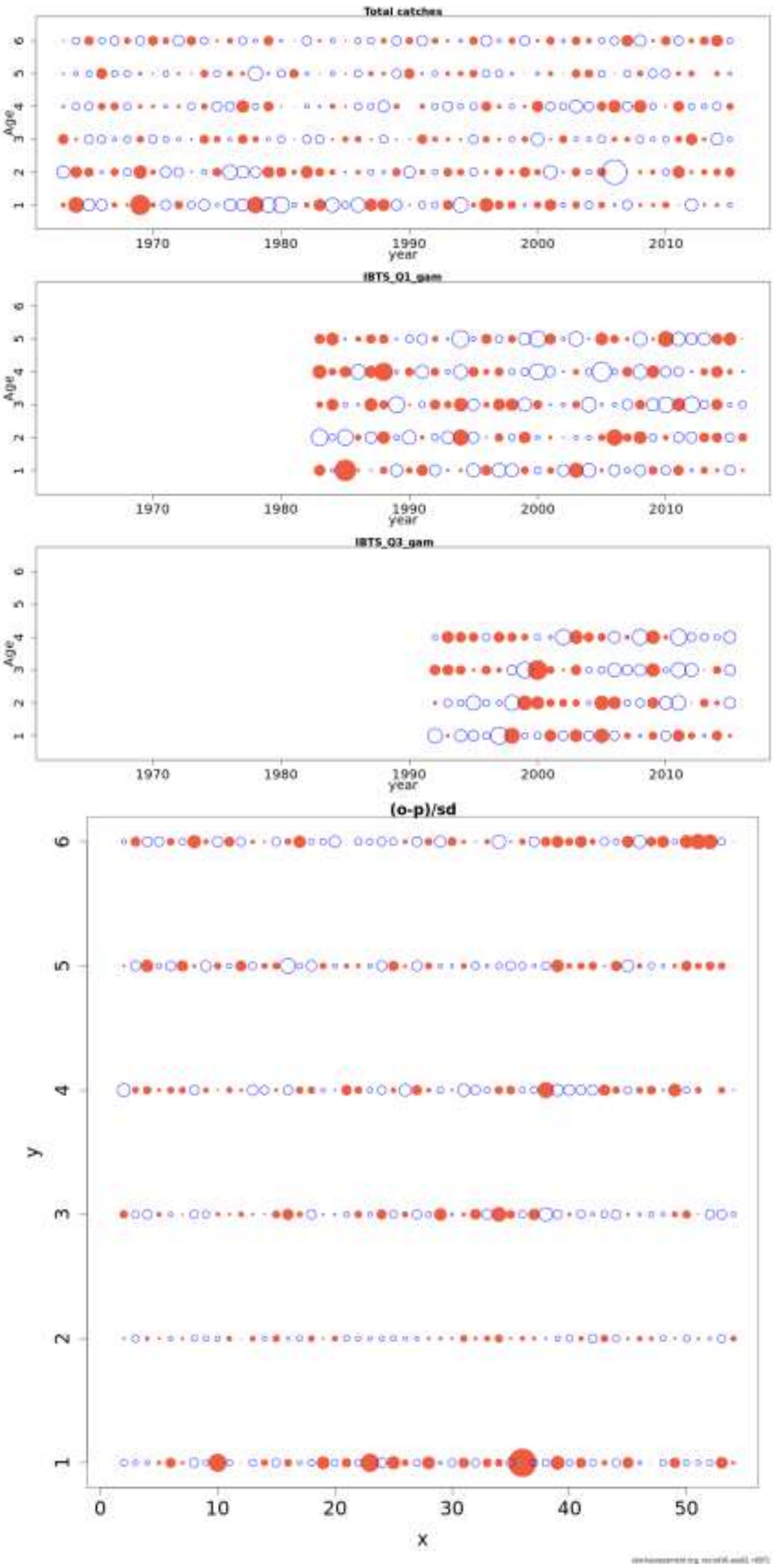


Figure 14.10 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Normalized residuals for the SAM assessment, for total catch, IBTSQ1, IBTSQ3, and the recruitment and survival process error. Empty circles indicate a positive residual and filled circles negative residual.

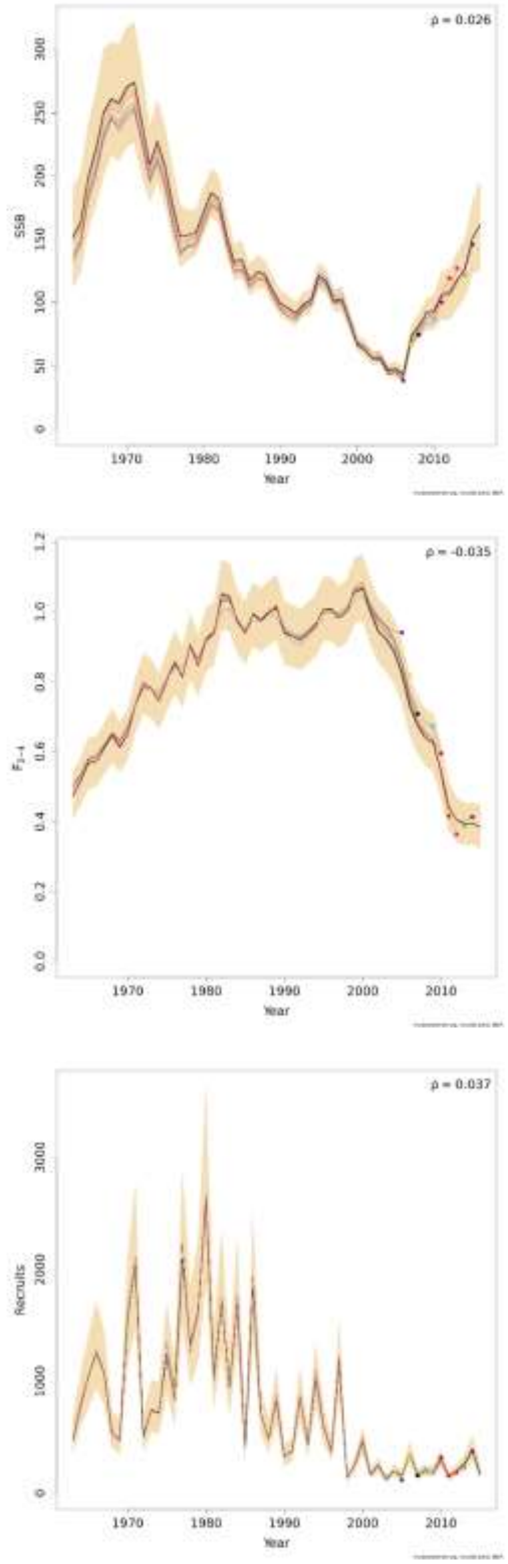


Figure 14.11 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Retrospective estimates (10 years) from the SAM assessment. Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals. Mohn's r given in each plot is calculated as: $=\frac{1}{n}\sum_{y=Y-n}^{Y-1}(1-X_{y,y}/X_{y,Y})$, where the first subscript indicates the year X (SSB, F or R) pertains to, and the second subscript the final full data year for the given assessment, with Y indicating the most recent assessment.

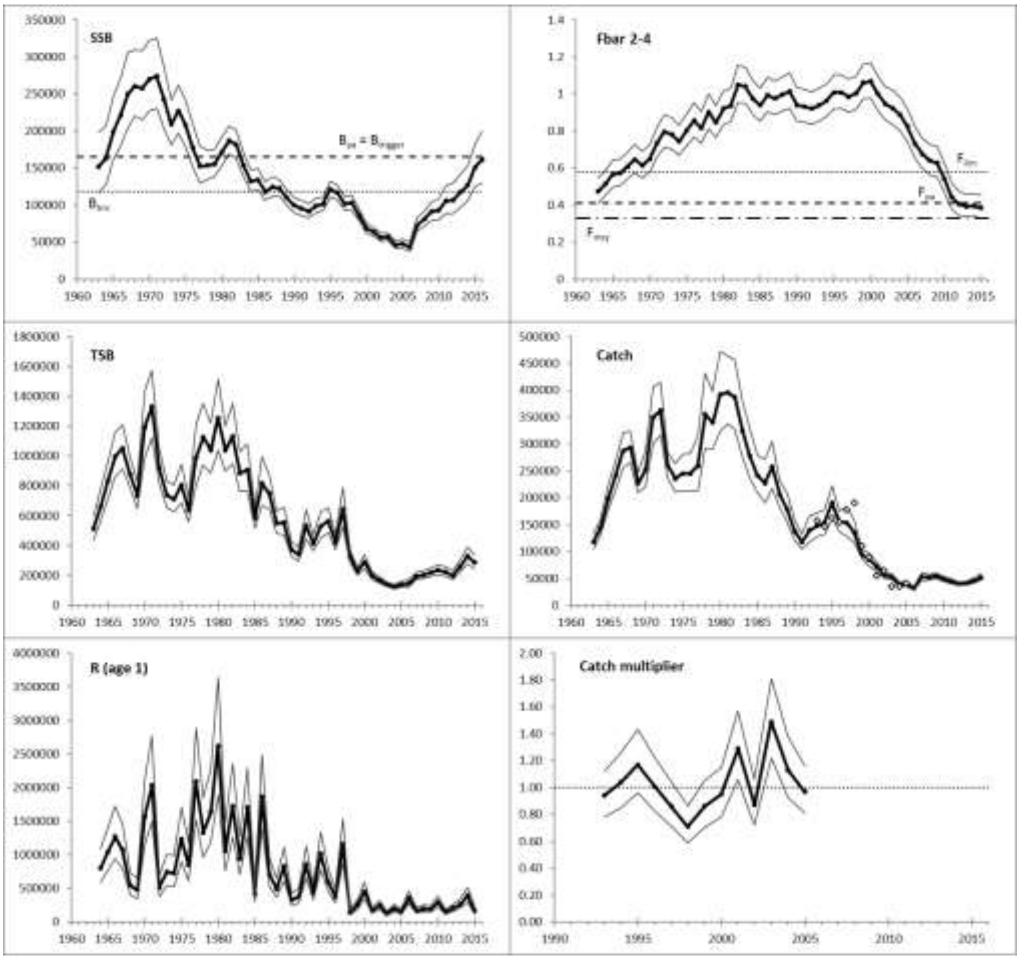


Figure 14.12 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Anticlockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2–4 (F(2–4)), from the SAM final run (catch multiplier estimated for 1993–2005 only). The heavy lines represent the point-wise estimate, and the light lines point-wise 95% confidence intervals. The open diamonds given in the catch plot represent model estimates of the total catch excluding unaccounted mortality, while the solid lines represent the total catch including unaccounted mortality for 1993–2005. The horizontal broken lines in the SSB plot indicate Blim=118 000t and Bpa=165 000t, and in the Fbar plot Flim=0.58, Fpa=0.41 and Fmsy=0.33. 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.

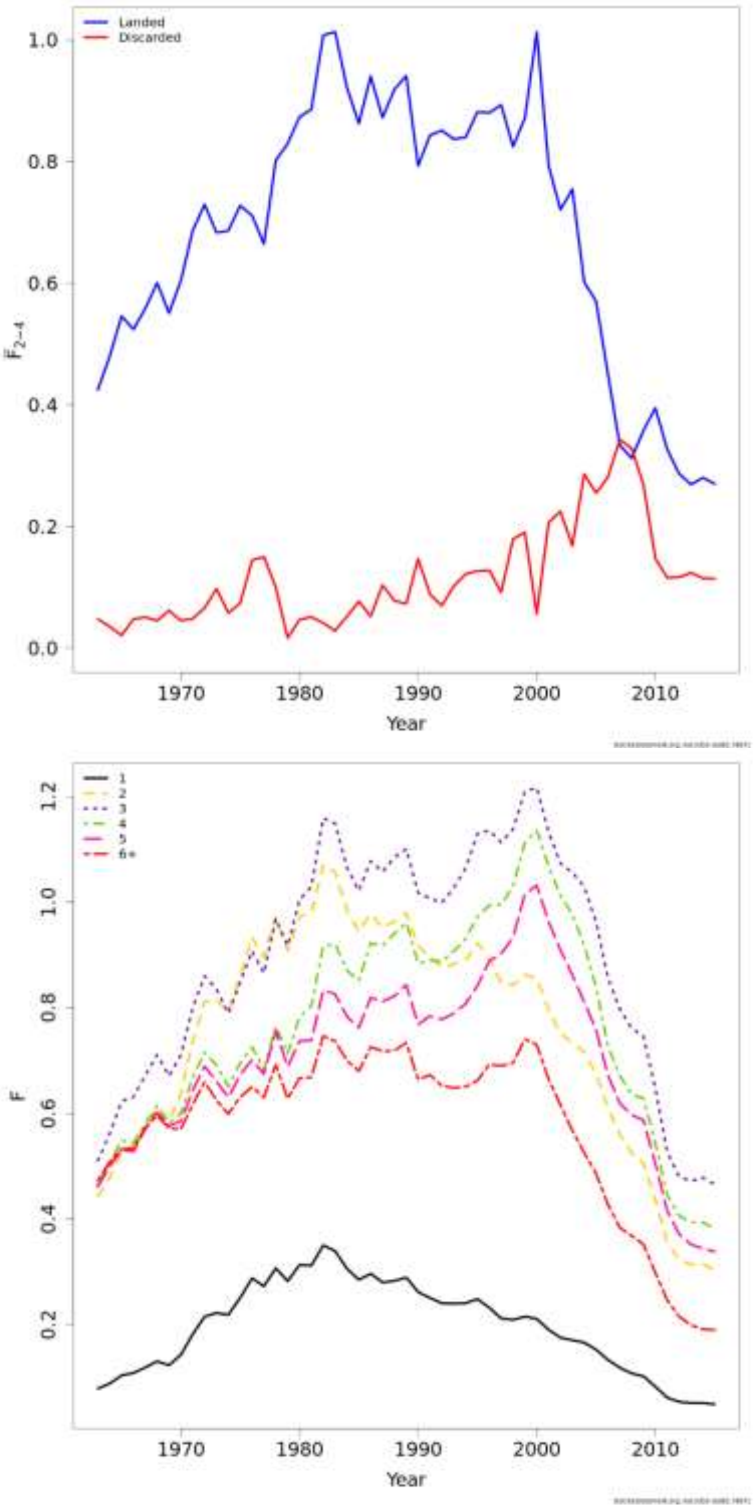


Figure 14.13 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. SAM estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2–4 (shown in Figure 14.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

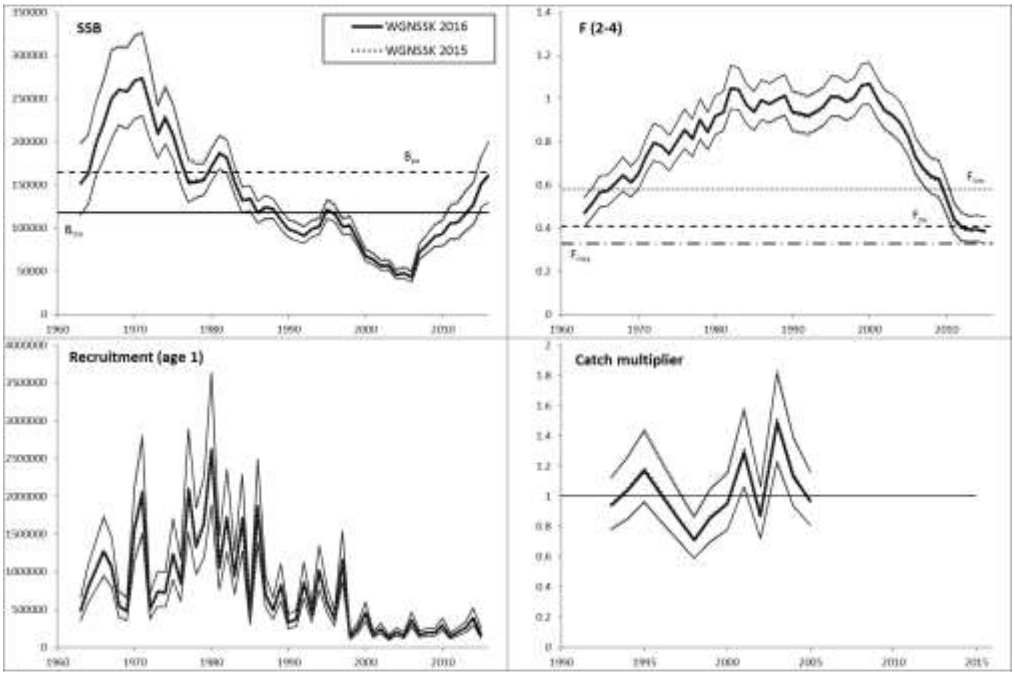


Figure 14.14 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Comparison of final SAM assessment for 2016 with the final SAM assessment for 2015. Plots are as described in Figure 14.12.

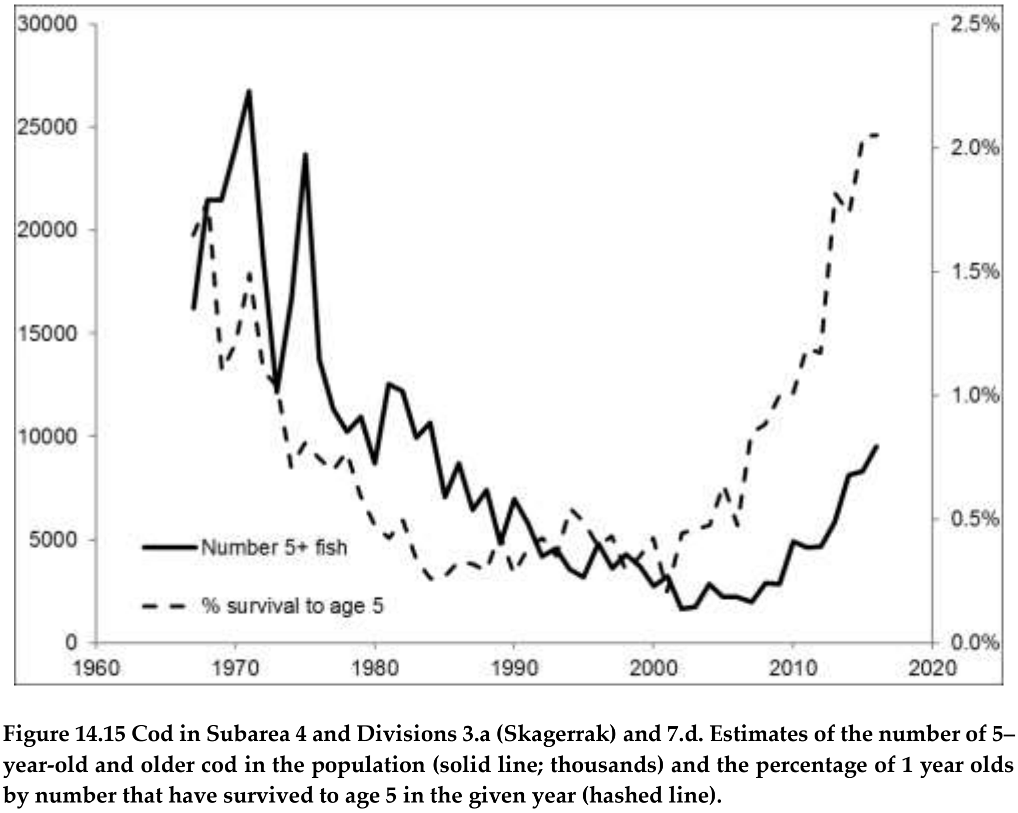


Figure 14.15 Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Estimates of the number of 5–year-old and older cod in the population (solid line; thousands) and the percentage of 1 year olds by number that have survived to age 5 in the given year (hashed line).

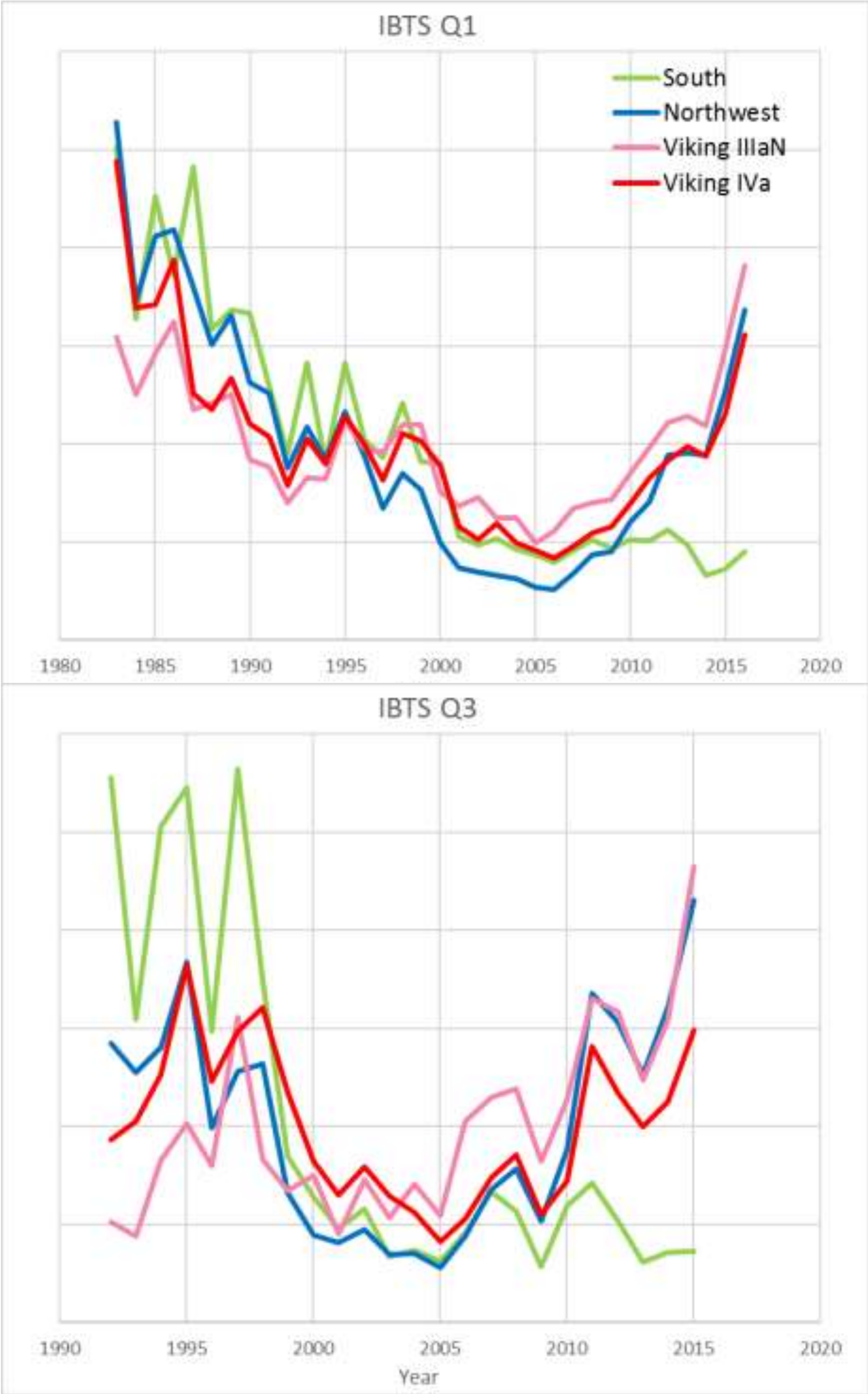


Figure 14.16a Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Biomass indices by subregion (see Figure 14.16c), based on NS-IBTS Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta-GAM model (including ship effects) to numbers-at-age for the entire dataset and integrating the fitted abundance surface over each of the Subareas to obtain indices-at-age by area. These are then multiplied by smoothed weight-at-age estimates and summed to get the biomass indices.

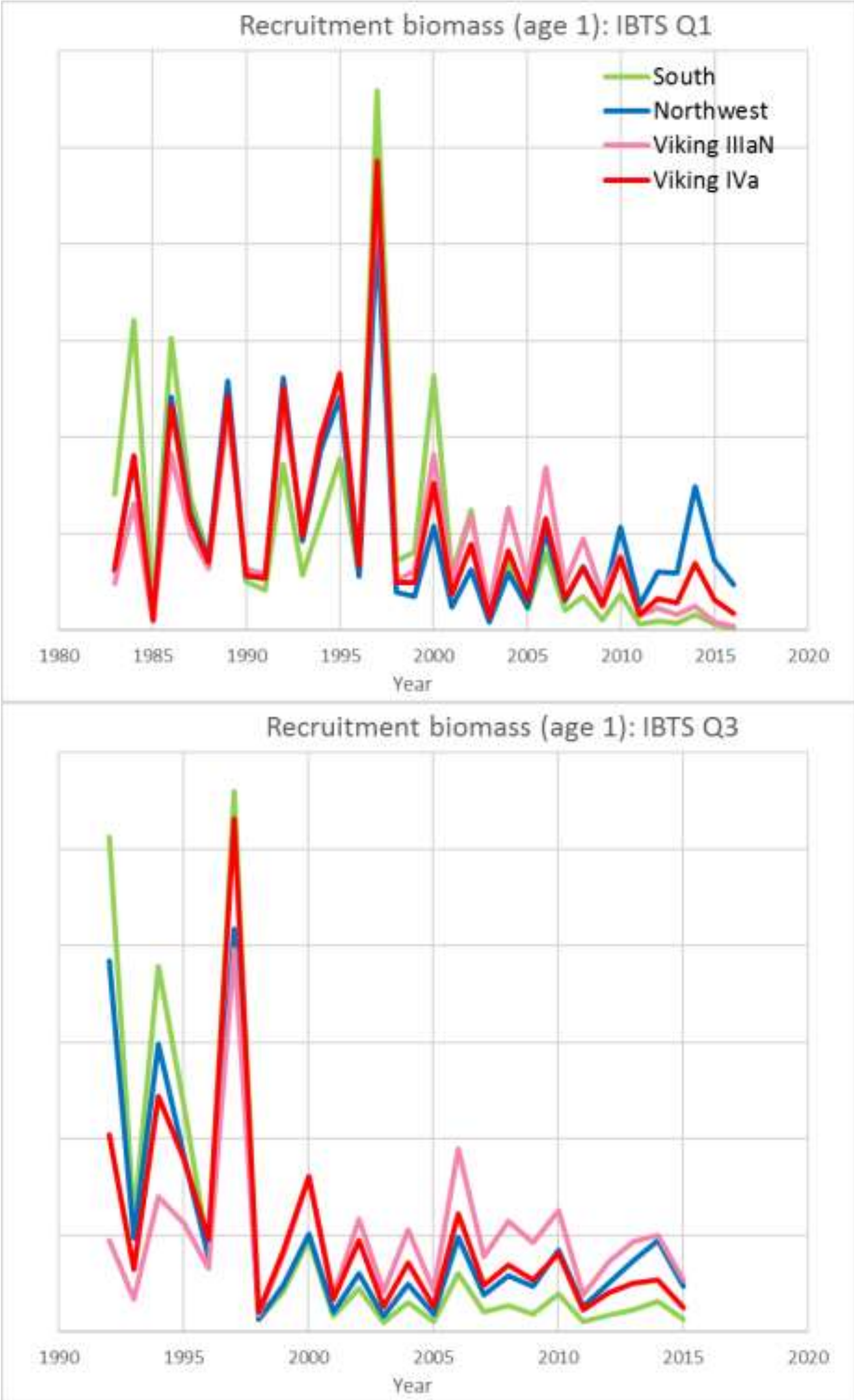


Figure 14.16b Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Recruitment indices by sub-region (see Figure 14.16c), based on NS-IBTS Q1 and Q3 data.

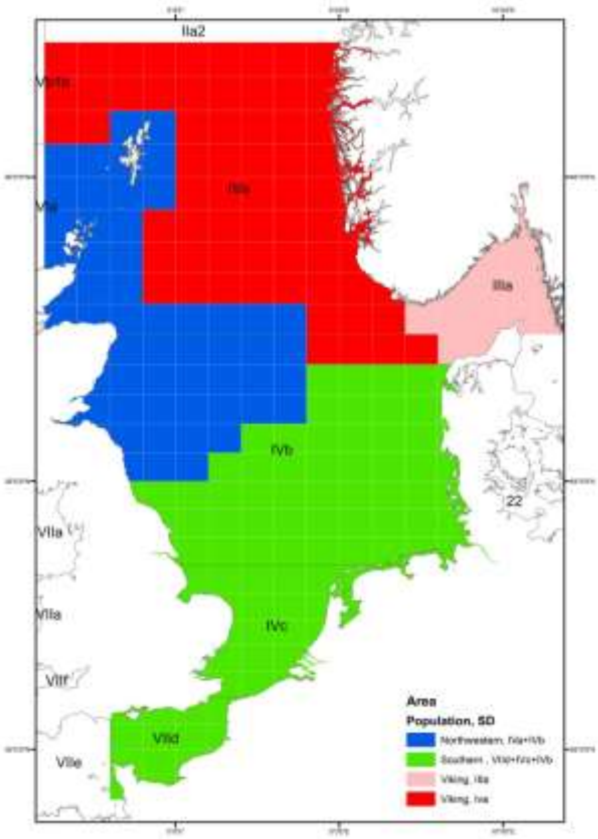


Figure 14.16c Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Subregions used to derive area-specific biomass indices based on NS-IBTS Q1 and Q3 data.

15 Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea and Skagerrak)

15.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >35cm, at 3–4years of age and growth after age 3 is about 7 cm per year (Heino *et al.* 2012). Pollack feeds mainly on fish, and incidentally on crustaceans and cephalopods.

15.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including 7.d and 3.a). In the ICES advice, it was, however, decided to include 7.d Pollack in the Celtic Seas Ecoregion.

15.3 Management

For 4 and 3.a there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

15.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2015 in Division 3.a (Skagerrak/Kattegat) and Subarea 4 (North Sea) are shown in Table 15.1. Figure 15.1 shows total landings in Subarea 4 and Division 3.a from 1977–2015. Two periods with high landings can be seen, and over the entire period total landings for both areas have declined. In Division 3.a landings have been low but stable since 2000, while in Subarea 4 landings have fluctuated over the same period and stabilised the last four years. Swedish fishers targeted pollack from the 1940s until mid-1980s when landings sometimes amounted to over 1000 tonnes. From the 1980s pollack started to decline severely and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast.

Nowadays, no fishery is targeting pollack, and it is mainly, possibly exclusively, a bycatch in various commercial fisheries. Norwegian catches peak in the months of March and April, and this may be associated with spawning aggregations. In 2015, 47% of the total landings were caught with gillnet and 39% with otter trawls in Division 3.a. In Subarea 4 18% of the total landings were made with gillnets and 72?% with otter trawls. The geographical distribution of Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower. Discards are now considered by ICES to be known to take place and raised discards were estimated at 5.7 tonnes in total between area 3 and 4 in 2015 (see Table 15.2 for total catches and Table 15.3 for estimated discards). Discard numbers were raised for all nations. 72 % of the discards were reported by bottom trawl fleets with UK-Scotland the country reporting the largest number of discards (30 % of total).

Pollack is also frequently caught in recreational fisheries. Regularly collected data about these catches are not available to the working group. Norwegian recreational fishing data collected in 2009 suggests that catches of pollack south of 62^0 north may range between 13 – 30 tonnes (Vølstad *et al.* 2011)

15.5 Survey data / recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the cpue was much higher in the 1970s. They are distributed mainly over the northern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat. Time series of abundance (average number per hour) in the IBTS are shown for Subarea 4 and Division 3.a separately, for quarter 1 (from 1983 onwards) and quarter 3 (from 1996 onwards) (Figure 15.2). The catches are small, and rather irregular, and no clear patterns emerge in 3 and 4.

15.5.1 Biological sampling

There has been some collection of length data in Subarea 4 and Division 3.a by Norway in the most recent years. Preliminary analysis of this data indicates that length ranges of pollack caught in gill net fisheries differ with meshsize and location. The majority of fish caught in western Norwegian fjords had a size range of 60–80 cm (Figure 15.3) compared to 50–70 cm in the Skagerrak (Figure 15.4).

15.5.2 Analysis of stock trends

In previous years the study by Cardinale *et al.* (2012), which analysed the spatial distribution and stock trends for the period 1906–2007, based on IBTS Q1 and commercial catches, was used to assess the stock for Division 3.a (Skagerrak and Kattegat) and it was found that there had a been large decline in stock size from approximately 1960 to 2000. However, during routine IBTS surveys in Subarea 4 and Subarea 3, pollack catches seem rather irregular and with no clear pattern. A spatial analysis of Norwegian fisheries data from 2013, showing total Pollack catches by ICES rectangle, indicates that the surveys do not cover the geographic distribution of the species adequately in both Subarea 4 and subdivision 3.a (Figures 15.5 and 15.6). The surveys may therefore not be very well suited for monitoring this species as trends in standardised CPUE likely are not a reliable indicator for the status of the stock. However, if the stock increases, it is arguably expected that present trawl survey (e.g. IBTS) would be able to detect such a stock trend in a consistent manner (Cardinale *et al.*, 2012).

15.5.3 Data requirements

In order to get a better understanding of growth and maturity WGNEW recommended that the collection of otoliths and maturity should be continued during these surveys for a few years. WGNSSK recommends also that the Norwegian biological data from commercial catches should be processed.

15.6 References

Cardinale, M., H. Svedäng, V. Bartolino, L. Maiorano, M. Casini and H. Linderholm, 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. J. Appl. Ichthyol. 28(2): 200-208

Council Regulation (EU) No 850/1998. Conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

ICES 2012. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

Heino, M., Svåsand, T., Nordeide, J. T., Otterå, H., 2012. Seasonal dynamics of growth and mortality suggest contrasting population structure and ecology for cod, pollack, and saithe in a Norwegian fjord. – ICES Journal of Marine Science 69: 537–546

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S.,Wienerroither, R., 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery. ICES Journal of Marine Science. 68: 1785–1791

Table 15.1. Pollack in Subarea 4 and Division 3.a. Landings (tonnes) by country as officially reported to ICES 1977–2015.

ICES Division 3.a								
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Official Total
1977	10	1764	4	3	449	706		2936
1978	1	2077	4		556	794		3432
1979	13	1898	<0.5		824	1066		3801
1980	13	1860			987	1584	<0.5	4444
1981	5	1661			839	1187	1	3693
1982	1	1272			575	417	<0.5	2265
1983	2	972			438	288		1700
1984	2	930	<0.5		371	276		1579
1985	-	824	<0.5		350	356		1530
1986	4	759	<0.5		374	271		1408
1987	6	665			342	246		1259
1988	4	494			350	136		984
1989	3	554			313	152		1022
1990	8	1842	<0.5		246	253		2349
1991	2	1824			324	281		2431
1992	8	1228			391	320		1947
1993	6	1130	1		364	442		1943
1994	5	645	<0.5		276	238		1164
1995	10	497			322	271		1100
1996		680			309	273		1262
1997		364	<0.5		302	178		844
1998		299			330	105		734
1999		192			342	88		622
2000		199			268	33		500
2001		201	1		253	46		501
2002		228	3		202	44		477
2003		168	3	1	236	17		425
2004		140	2	4	179	34		359
2005		160	5	7	173	153		498
2006		103	10	3	178	36		330
2007		172	9		245	38		464
2008		166	5		247	33		451
2009		208	7		220	38		473
2010		313	8	1	195	35		552
2011		193	7		168	28		395
2012		200	7		171	37		414
2013		210	3		172	35		420
2014		191	5	1	156	30		383
2015		190	14	1	138	48		389*

***Preliminary**

ICES Subarea 4											
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
1977	121	275		75	142	38	419	9	0	442	1521
1978	102	249		98	154	21	492	2	0	471	1589
1979	62	333		72	64	8	563	11	31	429	1573
1980	82	407		66	58	2	1095		38	355	2103
1981	59	500		173	21	2	1261		12	362	2390
1982	46	431		59	40	1	1169	33	23	270	2072
1983	58	481		79	44	1	1081		57	300	2101
1984	52	402		108	37	0	880	2	106	315	1902
1985	14	308		69	23	0	686		51	363	1514
1986	44	550		45	21	0	602		67	362	1691
1987	21	427		988	21	0	471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273		0	21	4	568		37	269	1203
1990	44	924		0	34	3	651		126	366	2148
1991	31	1464		0	48	4	887		153	684	3271
1992	49	794		18	59	7	1051		141	1310	3429
1993	46	1161		8	161	19	1429		217	1561	4602
1994	42	635		12	55	14	845		113	872	2588
1995	56	532	1	7	84	18	1203		175	1525	3601
1996	13	366		4	99	13	909		82	945	2431
1997	20	272	1	1	115	11	733		82	1185	2420
1998	21	265		7	44	5	567		75	780	1764
1999	21	288		0	62	5	768		72	636	1852
2000	45	291		24	38	5	880		91	877	2251
2001	36	156		6	40	1	860		63	809	1971
2002	27	234		6	112	0	879		68	711	2037
2003	13	191		9	82	1	971		36	837	2140
2004	28	162		5	57	0	517		16	612	1397
2005	26	173		3	128	3	511		46	477	1367
2006	18	152		4	80	1	545		12	587	1399
2007	18	192		130	137	2	754		43	905	2181
2008	15	150		129	114	1	840		46	999	2294
2009	13	121	2	6	50	1	668		32	658	1551
2010	12	163		10	129	0	599		32	540	1485
2011	12	106	0	10	67	0	580	0	35	489	1299
2012	17	123	0	3	102	1	433		42	443	1164
2013	17	128	0	2	66	4	371	0	29	463	1080
2014	24	121		32	145	1	476		40	377	1215
2015	19	183		2	237	2	473		50	625	1591*

*** Preliminary**

Table 15.2. Pollack in Subarea 4 and Division 3.a. Catches (tonnes) by country as estimated by the Working Group 2013 – 2015.

ICES Division 3.a			
	2013	2014	2015
Denmark	214	192	192
Germany	11	6	35
Netherlands	<0.5	0	0
Norway	174	156	138
Sweden	36	30	46
ICES Total	435	384	413
Official Total	420	383	389*
Diff Ices-Off	15	1	24

*** Preliminary**

ICES Subarea 4			
	2013	2014	2015
Belgium	17	24	20
Denmark	150	122	183
France	2	32	2
Germany	59	145	216
Netherland.	3	1	2
Norway	379	481	466
Sweden	29	41	50
UK	456	377	626
Ices Total	1103	1227	1567
Official Total	1080	1215	1591*
Diff Ices-Off	23	12	-22

*** Preliminary**

Table 15.3. Pollack in Subarea 4 and Division 3.a. Discards (tonnes) by country estimated by the Working Group, 2015.

ICES Division 3.a								
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Total
2013		1.949	0.139		1.795	1.528		5.41
2014		0.62	0.008		0.441	0.473		1.54
2015		2.026	0.385		0.667	0.094		3.17

*** Preliminary**

ICES Subarea 4											
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
2013	0.111	22.785		0.050	0.229	1.320	7.967		0.662	8.923	42.05
2014	0.181	0.973		0.241	0.154	0.009	5.200		0.309	4.461	12.16
2015		0.069		0.005	0.075	0.001	0.691		0.090	1.59	2.52

*** Preliminary**

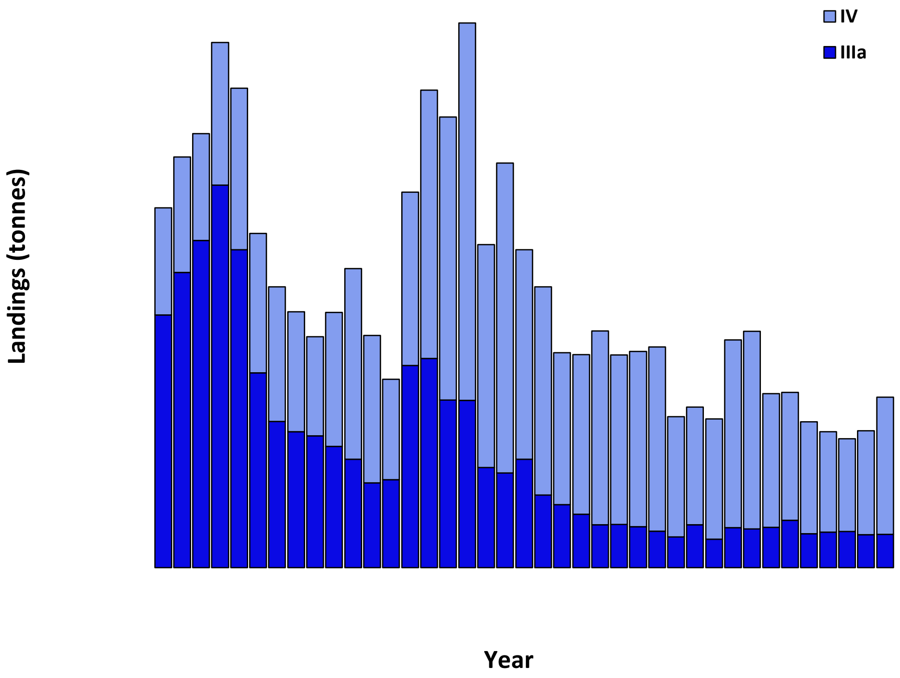


Figure 15.1. Pollack. Total landings of pollack from 2007–2015 in Division 3.a and Subarea 4 as officially reported to ICES.

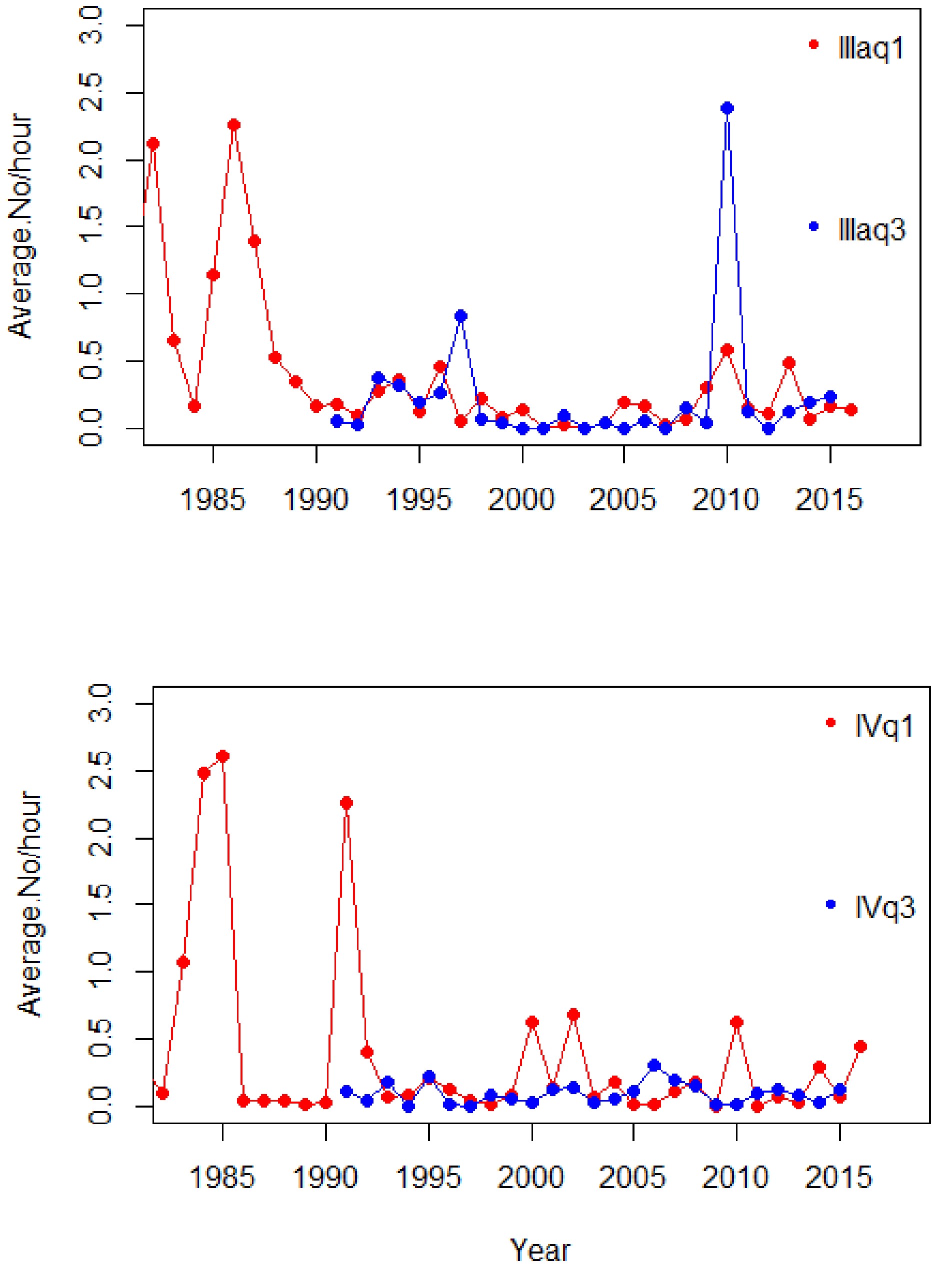


Figure 15.2. Time series of catches of pollack from 1983–2015 in ICES divison 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV-trawl. Data from Datras.

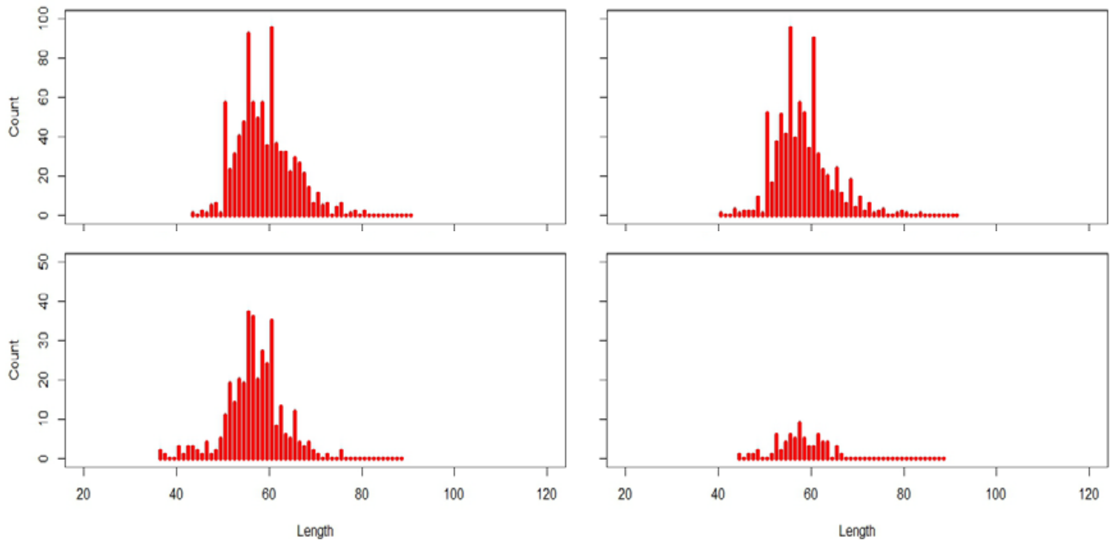


Figure 15.3 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a . The data is aggregated for gillnets with a 63mm meshsize.

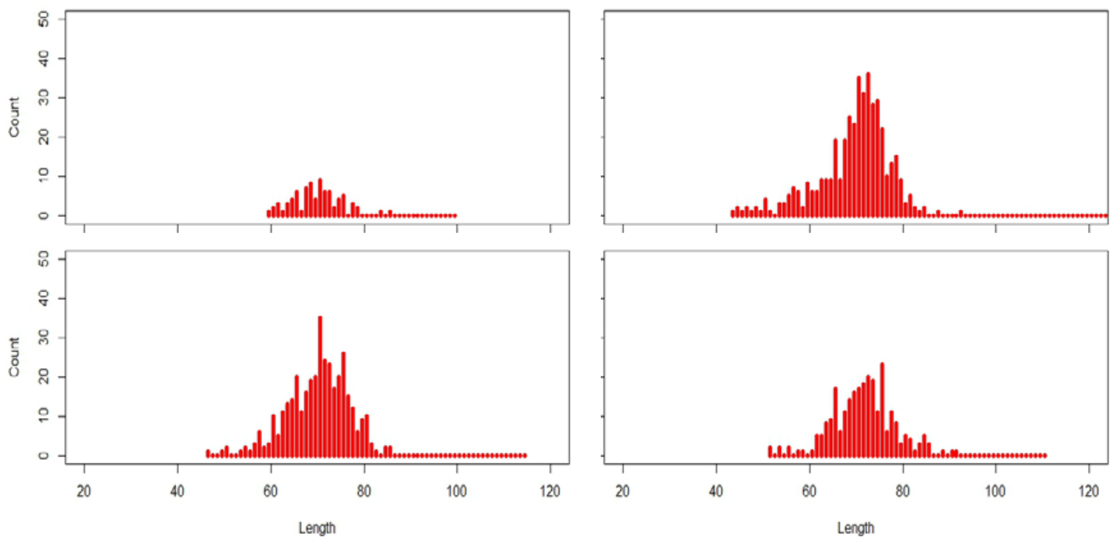


Figure 15.4 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70mm mesh size.

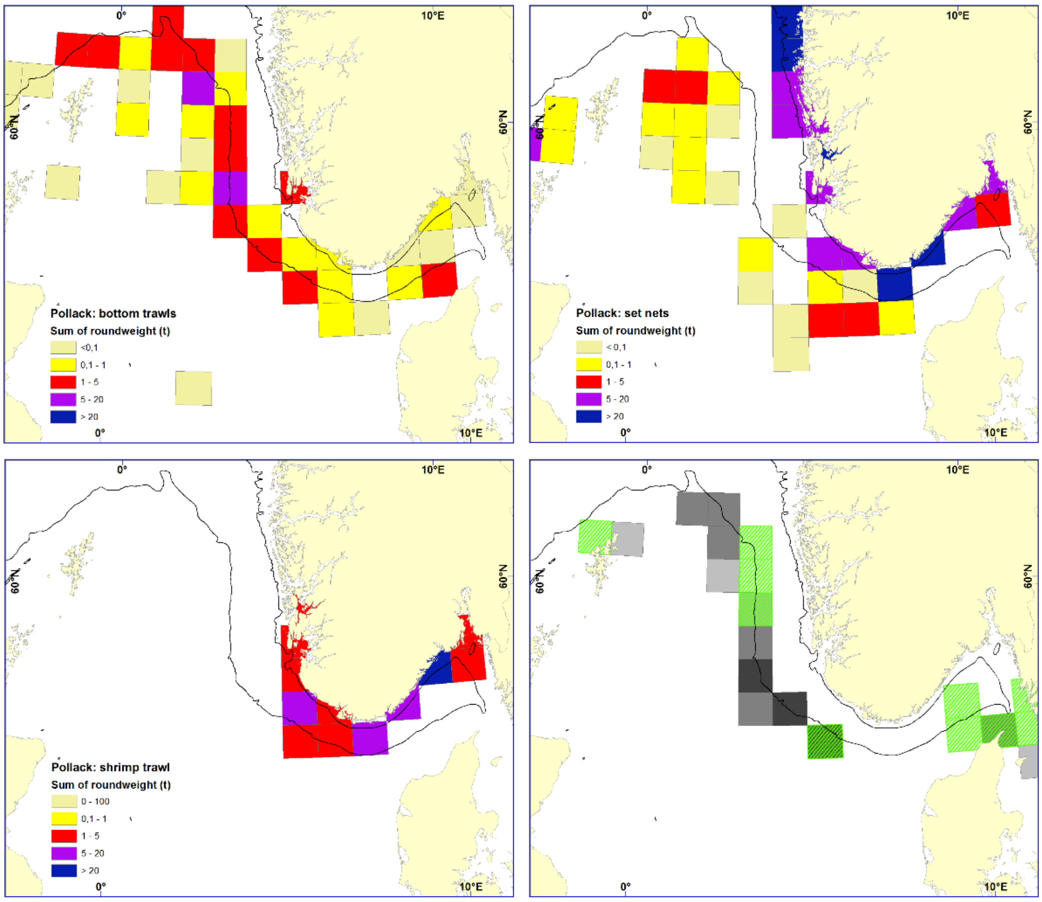


Figure 15.5 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

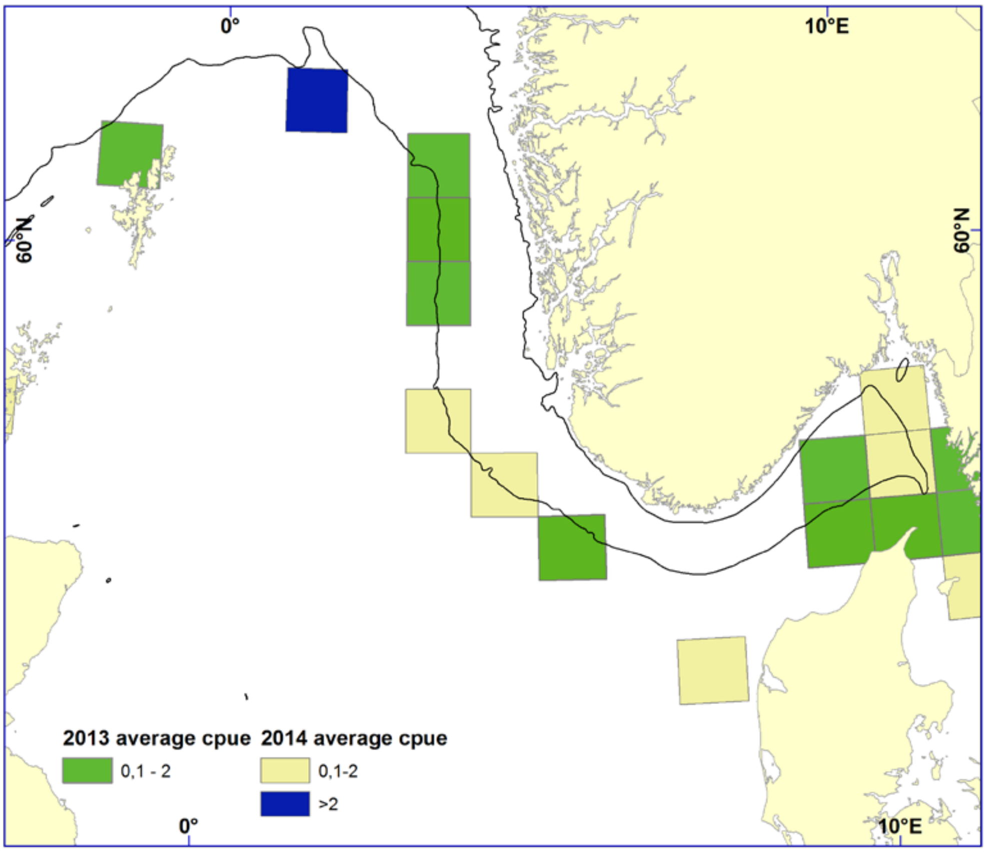


Figure 15.6 Pollack catches from IBTS surveys in 2013 (green) and 2014.

16 Grey gurnard (*Eutrigla gurnardus*) in Subarea 4 and Divisions 7.d and 3.a (North Sea, Eastern English Channel, Skagerrak and Kattegat)

16.1 General

Grey gurnard (*Eutrigla gurnardus*) was assessed in the Working Group on the Assessment of New MoU Species (ICES, 2014) until 2014. Biennal advice was given for the years 2015 and 2016. In 2015 the stock was assessed by the WGNSSK. For this stock several survey data were available. Available official landings data are incomplete or were not reported specifically for grey gurnard in the past. Only survey trends were used as a stock indicator (mature biomass index IBTS Q1). Based on the updated assessment the advised total catch should not be more than 8813 t for 2017 and 2018. This corresponds to landings not higher than 1763 t if the average discard rate (80%) does not change.

16.1.1 Biology and ecosystem aspects

Grey gurnard occurs in the Eastern Atlantic from Iceland, Norway, southern Baltic, and North Sea to southern Morocco and Madeira. It is also found in the Mediterranean and Black Seas. In the North Sea and in Skagerrak/Kattegat, grey gurnard is an abundant demersal species. In the North Sea, the species may form dense semi-pelagic aggregations in winter to the northwest of the Dogger Bank, whereas in summer it is more widely distributed. The species is less abundant in the Channel, the Celtic Sea and in the Bay of Biscay.

Spawning takes place in spring and summer. There do not seem to be clear nursery areas. Grey gurnard can reach a maximum length of approximately 50 cm.

Grey gurnard is considered a predator on a number of commercially important demersal stocks (cod, whiting, haddock, sandeel, and Norway pout) in the North Sea (de Gee & Kikkert, 1993). The steep increase in abundance of grey gurnard has led to an increase in mortality especially of North Sea cod (age-0) and whiting (age-0 and age-1) in recent years (ICES, 2011). The multi species model SMS estimated that grey gurnard can cause up to 50% of the predation mortality on 0-group cod and whiting. Therefore, the abundance and distribution pattern of grey gurnard and its prey size preferences are highly relevant from an ecological point of view (Floeter and Temming, 2005; Kempf *et al*. 2013).

16.1.2 Stock ID and possible assessment areas

No studies are known of the stock ID of grey gurnard. In a pragmatic approach for advisory purposes and in order to facilitate addressing ecosystem considerations, the population is currently split among 3 Ecoregions: North Sea including 7.d, Celtic Seas and South European Atlantic. This proposal should be discussed considering the low levels of catches reported in recent years in Celtic Seas and South European Atlantic (ICES, 2011; ICES, 2012).

16.1.3 Management regulations

There is no minimum landing size for this species and there is no TAC.

16.2 Fisheries data

16.2.1 Historical landings

Historically, grey gurnard is taken as a by-catch species in mixed demersal fisheries for flatfish and roundfish. Grey gurnard from the North Sea is mainly landed for human consumption purposes. A high amount of grey gurnard is landed as industrial bycatch in the Danish fishery for sandeel and sprat (MIS_MIS_0_0_0_IBC). However, the market is limited and the largest part of the catch is discarded (see also stock Annex). Owing to the low commercial value of this species, landings data do not reflect the actual catches.

In the past, gurnards were often not sorted by species when landed and were reported as one generic category of "gurnards". Further, catch statistics are incomplete for some years, e.g. the Netherlands did not report gurnards during the years 1984–1999. In recent years, the official statistics seem to improve gradually. However, some countries continue to report "gurnards" landings and do not provide information on grey gurnard separately (e.g. Germany) or the data imported into InterCatch are based on a gurnard mix (e.g. UK England).

Since the early 1980s specific landings data for grey gurnard are available from the official catch statistics. Before that, these data occurred only sporadically in the statistics. Most of gurnard catches are taken in area IV and to a much lesser extent in areas 7.d and 3.a (Fig. 16.2.1.1.–16.2.2.3.; Table 16.1.1.–16.1.3.). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46 598 t in 1987 (Fig. 16.2.1.2; Table 16.1.2.) because of Danish landings for reduction purposes. After this peak, the Danish landings dropped again to a low level. Recent international landings for the last 5 years have been low ranging between 388 to 558 t per year. The average official landings for the period 2000-2014 was at 449 t. Data from 1950 to 2005 were taken from the "ICES catch statistics 1950 to 2010". Data from 2006 to 2014 were taken from the "ICES catch statistics 2006 to 2014". Data for 2015 were taken from the preliminary catch statistics.

16.2.2 InterCatch data

InterCatch contains now data for the years 2012–2015. Similar as for 2014, the largest amount of landings in 2015 was reported by Denmark for the MIS_MIS_0_0_0_IBC metier (1188t) which is mainly industrial fishery for sand eel and sprat. These landings are not included in the official landings which is the main reason for the large discrepancy between the official landings and the InterCatch estimate. Considerable amounts of landings were also reported by Scotland (297t, OTB_DEF_>=120_0_0_all) and Norway (171t, OTB_DEF_>=120_0_0_all). For all other metiers the landings were below 100 t (Fig. 16.2.2.1). For all countries the amount of discards exceeded by far the amount of landings, with the exception of Denmark (Fig. 16.2.2.3). The largest amounts of discards were reported for the Scottish OTB_DEF_>=120_0_0_all (926 t), Scottish OTB_CRU_70–99_0_0_all (743 t) and the Dutch TBB_DEF_70–99_0_0_all (803 t) metiers. Not all countries reported grey gurnard discards (Norway, Belgium, Germany, France). The largest amount of discards was estimated for the OTB_DEF_>120_0_0_all fleet (~1638 t reported plus raised discards). The total catch estimated with Inter Catch for the year 2015 was 7316 t from which 1999 t were landings (27%) and 5290t estimated discards (73% of total catch). In total The Netherlands take the largest proportion of the total catch with a high amount of discards, followed by Scotland. In 2015 landings were 15% lower compared to 2014 and total catches were 9% lower.

The estimate of the previous year InterCatch landings and discards were revised this year by including German data and splitting UK England data to get an estimate for grey gurnard only. Germany does not report officially grey gurnard data separately, but rather reports a combined group of gurnards. Thus, it was not possible to upload German data into InterCatch. The uploaded InterCatch data from UK England were also based on a gurnard mix for which a ratio obtained by survey data was applied. This latter approach will lead to a bias because gurnard landings are usually dominated by tub gurnards (*Chelidonichthys lucerna*) while the largest part of grey gurnard is discarded. In order to estimate the grey gurnard proportion of these data the grey gurnard proportion of all gurnards from Dutch and Belgian official landings was used. This resulted in an average of 20% grey gurnards in landings for the three recent years (2014–2012). This ratio was then applied to the German and UK England data. Table 16.2.2.1 displays the change in total catch due to this correction.

16.2.3 Other information on Discards

In Table 16.2.3.1. the numbers per hour of discarded grey gurnard in Dutch bottom-trawl fisheries in North Sea and Eastern Channel are shown for 2006–2012 (Uhlmann *et al*., 2013). The rates are highly variable depending on the specific métiers, with highest values observed for the SSC_DEF métiers. German discard data from an observer programme indicate that the proportion of discarded gurnard in German demersal trawl fisheries ranges between 76.6% and 93.0% (Ulleweit *et al*., 2010).

16.3 Survey data / recruit series

For the North Sea and Skagerrak/Kattegat, data are available from the International Bottom Trawl survey. The IBTS-Q1 and IBTS-Q3 can provide information on distribution and the length composition of the catches. Grey gurnard occurs throughout the North Sea and Skagerrak/Kattegat. During winter, grey gurnards are concentrated to the northwest of the Dogger Bank at depths of 50–100 m, while densities are lower off the Danish coast, in the German Bight and eastern part of the Southern Bight (Figure 16.3.1. and 16.3.2.). The distribution pattern changes substantially in spring, when the whole area south of 56°N becomes densely populated and the high concentrations in the central North Sea disappear until the next winter (Daan *et al.* 1990).

The nearly absence of grey gurnard in the southern North Sea during winter and the marked shift in the centre of distribution between winter and summer suggests a preference for higher water temperatures (Hertling, 1924; Daan *et al.* 1990).

During winter, grey gurnard occasionally form dense aggregations just above the sea bed (or even in midwater, especially during night time) which may result in extremely large catches. Within one survey, these large hauls may account for 70% or more of the total catch of the species. Bottom temperatures in high-density areas usually range from 8 to 13°C (Sahrhage, 1964).

16.4 Biological sampling

Individual biological data for this species are still scarce (see also the stock annex). In the North Sea, individual data have been collected sporadically during some years of the IBTS-Q1 and IBTS-Q3 survey. An ALK from collected otoliths has shown that the age span of grey gurnard collected in Q1 is large (age 2 to age 14), but not many individuals were aged.

Available data on grey gurnard individual weights and maturity were analysed in order to estimate a mature biomass index (Figure 16.4.1). A maturity ogive based on all the available grey gurnard maturity data from IBTS Q1 was used to calculate the mature biomass index. The obtained maturity ogive shows that above 19.5 cm more than 90% of all the individuals can be considered mature (Figure 16.4.1.a). The corresponding Lmat50% value was 15.6 cm. Proportion mature at length was calculated by the obtained model PropMat = 0.995/(1+exp(-1*(LngtClass-15.611)/2.073)). The obtained weight-length relation was Weight = (0.007 * LngtClass ^ 3.062).

The available age and maturity data suggest that grey gurnard is early maturing in North Sea and a certain proportion of fish at age 1 are mature.

16.5 Analysis of stock trends / assessment

Information from landings is very poor, due to poor reporting (gurnard species are not always identified in the data, and probably also misreporting has occurred) and also because the low value of the species leads to massive discarding.

The status of the populations in the Ecoregions which cover the Northern European Shelf is not known but some indications of trend are delivered by the survey series available.

To analyse stock trends a mature biomass index was calculated applying a length weight relationship and a maturity ogive which were obtained from all data available.

According to van Heesen and Daan (1996), outliers were excluded from the IBTS-Q1 time series since grey gurnards tend to form dense concentrations during winter. Outliers were defined as hauls which accounted for more than 90% of the total gurnard weight caught in the respective year. However, such extreme outliers were only identified in the time period before 1983 which is not displayed here. The time series of mature biomass index of grey gurnard of the IBTS-Q1 survey has shown a strong increase pattern from the beginning of 90's (Figure 16.5.1.; Table 16.5.1). Since then it was fluctuating on a high level. The mature biomass index for the IBTS-Q3 does not show this pronounced increasing trend but the 2014 value was the highest observed in the time series ever. In 2015 the IBTS-Q3 index dropped quite sharply again. In general lower biomass and abundance values were observed for the IBTS-Q3 survey time series. Compared to the North Sea/Skagerrak (area IV/3.a) the mature biomass values recorded by the Channel Ground Fish Survey (CGFS) in the Eastern Channel (area 7.d) were extremely low (not shown in this report). No trend could be detected in the CGFS index. Therefore, the advice for grey gurnard in area 4, 3.a and 7.d should be based on the IBTS survey, which covers by far the largest part of the stock.

16.5.1 DLS 3.2. approach

Grey gurnard was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2012). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. A mature biomass index in kg per hour was estimated from the IBTS Q1 survey, because this survey covers most of the distribution area of grey gurnard. The stock size indicator (mature biomass kg/hour) in the last two years (2015–2016) is 10% higher than the average of the three previous years (2012–2014). This results in an advised total catch of no more than 8813 t and no more than 1763 t landings given that the average discard rate of the previous three years does not change.

16.6 Data requirements

For management purposes, information should be available on catches and landings. Traditionally the quality of landings data has been poor for this species because in the past often only landings of "gurnards" were reported which is still the case for some countries today (e.g. Germany, UK England). Further, this species is highly discarded and discard data are only available for the recent years (2012–2015).

Given the high level of discarding, observation at sea under DCF is the main source of information to better estimate the total catches.

For a better understanding of this species an increase in our knowledge of biological parameters is required. In the context of ecosystem considerations, it would be useful to obtain more information on age composition of the stock and its diet composition.

From the information presented here, it can be concluded that grey gurnard is currently of very limited commercial interest.

16.7 References

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Table 16.2.2.1 InterCatch revision of landings, discards and total catch.

Year	old Catch (WGNSSK2015)	updated Catch (WGNSSK2016)	Change
2012	8345	7262	-13%
2013	10230	8710	-15%
2014	8596	8009	-7%
2015	8343	7316	-6%

Table 16.2.3.1 Grey gurnard. Discards per hour of grey gurnard by different metiers in the Netherlands 2006–2012.

Métier	TBB_DEF	TBB_DEF*	TBB_DEF	SSC_DEF	SSC_DEF	OTB_MCD	OTB_DEF	OTB_DEF
Mesh	70-99	70-99	100-119	100-119	>120	70-99	70-99	100-119
2006	68.3							
2007	60.2							
2008	34.3							
2009	55	17	37			111	77	15
2010	81	10	109			47	52	110
2011	61	27	10	NA	119	27	55	70
2012	41	24	30	317	307	110	75	12

*≤300 hp segment

Table 16.5.1.1. Summary of the assessment

Year	Official landings	ICES Landings	ICES catches	ICES discards	Discard rate	Index
1983	589					5.00
1984	265					14.31
1985	301					3.75
1986	326					9.42
1987	44422					4.61
1988	37445					2.61
1989	26470					6.85
1990	22303					9.04
1991	14741					8.74
1992	8365					9.76
1993	1060					11.19
1994	254					10.61
1995	211					11.73
1996	301					18.71
1997	253					25.75
1998	145					21.45
1999	254					45.24
2000	661					25.83
2001	690					20.34
2002	499					24.85
2003	525					20.35
2004	452					21.29
2005	378					23.97
2006	267					22.24
2007	279					25.42
2008	273					24.68
2009	285					20.18
2010	388					30.87
2011	440					29.86
2012	632	904	7262	6358	0.88	32.47
2013	526	975	8710	7735	0.89	25.47
2014	499	1761	8009	6248	0.78	25.63
2015	777	2026	7316	5290	0.72	28.96
2016						32.29

Table 16.1.1. Official grey gurnard landings in area 3.a.

Year	BE	DK	NL	NO	SE	Total
1980	0	0	0	0	36	36
1981	0	0	0	0	46	46
1982	0	86	0	0	43	129
1983	0	29	0	0	7	36
1984	0	62	0	0	6	68
1985	0	3	0	0	9	12
1986	0	6	0	0	10	16
1987	1	13	0	0	6	20
1988	0	59	0	0	2	61
1989	0	19	0	0	4	23
1990	0	34	0	0	3	37
1991	0	25	0	0	5	30
1992	0	22	0	0	10	32
1993	0	18	0	0	9	27
1994	0	12	0	0	12	24
1995	0	10	0	0	5	15
1996	0	18	0	0	3	21
1997	0	13	0	0	5	18
1998	0	27	0	0	8	35
1999	0	23	0	0	5	28
2000	0	32	0	0	5	37
2001	0	30	0	0	3	33
2002	0	18	0	0	1	19
2003	0	32	0	0	1	33
2004	0	24	2	0	2	28
2005	0	21	4	0	1	26
2006	0	19	0	0	2	21
2007	0	21	1	0	3	25
2008	0	24	0	0	5	29
2009	0	15	0	0	3	18
2010	0	10	1	0	2	13
2011	0	5	0	0	1	6
2012	0	5	0	0	1	6
2013	0	5	0	0	1	6
2014	0	3	0	0	1	4
2015	0	4	0	1	2	7

Table 16.1.2. Official grey gurnard landings in area IV.

YEAR	BE	DK	FR	NL	NO	SE	UK	TOTAL
1980	0	0	43	0	0	0	0	43
1981	0	0	0	0	0	0	0	0
1982	0	0	100	0	0	0	0	100
1983	0	0	64	0	0	0	0	64
1984	0	0	71	0	0	0	0	71
1985	88	0	85	0	0	0	0	173
1986	0	27	66	0	0	0	0	93
1987	63	44205	56	0	0	0	0	44324
1988	72	36887	43	0	0	0	22	37024
1989	73	26230	45	0	0	0	0	26348
1990	85	22041	42	0	0	0	0	22168
1991	70	14514	28	0	0	0	0	14612
1992	98	8113	21	0	0	0	10	8242
1993	106	822	27	0	0	0	24	979
1994	63	87	21	0	0	0	22	193
1995	43	63	26	0	0	0	21	153
1996	108	52	18	0	0	0	54	232
1997	49	23	22	0	0	0	57	151
1998	33	29	13	0	0	0	0	75
1999	35	63	0	0	0	127	0	225
2000	28	63	5	452	0	0	0	548
2001	22	258	20	277	0	1	33	611
2002	23	45	10	285	0	1	29	393
2003	16	60	5	307	0	6	26	420
2004	21	59	6	264	0	3	23	376
2005	16	52	5	213	0	8	22	316
2006	10	46	2	133	2	0	7	200
2007	11	16	4	155	5	0	14	205
2008	8	24	2	104	5	3	12	158
2009	15	6	2	154	1	1	22	201
2010	14	8	10	218	1	0	13	264
2011	26	6	7	263	1	0	31	334
2012	49	3	4	467	2	0	77	602
2013	30	4	2	268	34	0	131	469
2014	35	4	3	252	56	0	128	478
2015	20	7	2	209	172	4	345	760

Table 16.1.3. Official grey gurnard landings in area 7.d.

Year	BE	FR	NL	UK	Total
1980	0	950	0	0	950
1981	0	0	0	0	0
1982	0	380	0	0	380
1983	0	489	0	0	489
1984	0	126	0	0	126
1985	14	102	0	0	116
1986	0	217	0	0	217
1987	12	66	0	0	78
1988	14	346	0	0	360
1989	9	90	0	0	99
1990	6	92	0	0	98
1991	5	94	0	0	99
1992	6	85	0	0	91
1993	7	47	0	0	54
1994	4	33	0	0	37
1995	7	36	0	0	43
1996	4	44	0	0	48
1997	3	81	0	0	84
1998	1	34	0	0	35
1999	1	0	0	0	1
2000	9	67	0	0	76
2001	6	40	0	0	46
2002	32	54	1	0	87
2003	18	42	12	0	72
2004	14	3	31	0	48
2005	13	2	21	0	36
2006	8	2	22	14	46
2007	3	1	9	36	49
2008	1	3	16	66	86
2009	1	1	3	61	66
2010	6	2	39	64	111
2011	11	5	53	33	102
2012	11	5	11	23	50
2013	23	4	11	14	52
2014	7	5	4	2	18
2015	2	6	2	0	10

Table 16.5.1. Grey gurnard mature biomass indices (kg/hour) from IBTS Q1 and IBTS Q3.

Year	IBTS Q1	IBTS Q3
1983	5.00	
1984	14.31	
1985	3.75	
1986	9.42	
1987	4.61	
1988	2.61	
1989	6.85	
1990	9.04	
1991	8.74	2.62
1992	9.76	5.98
1993	11.19	3.79
1994	10.61	4.92
1995	11.73	5.22
1996	18.71	9.26
1997	25.75	7.45
1998	21.45	12.41
1999	45.24	13.44
2000	25.83	9.40
2001	20.34	11.15
2002	24.85	7.81
2003	20.35	8.36
2004	21.29	3.98
2005	23.97	3.28
2006	22.24	3.52
2007	25.42	4.10
2008	24.68	7.00
2009	20.18	6.15
2010	30.87	5.16
2011	29.86	10.41
2012	32.47	5.78
2013	25.47	7.08
2014	25.63	12.14
2015	28.96	
2016	32.29	

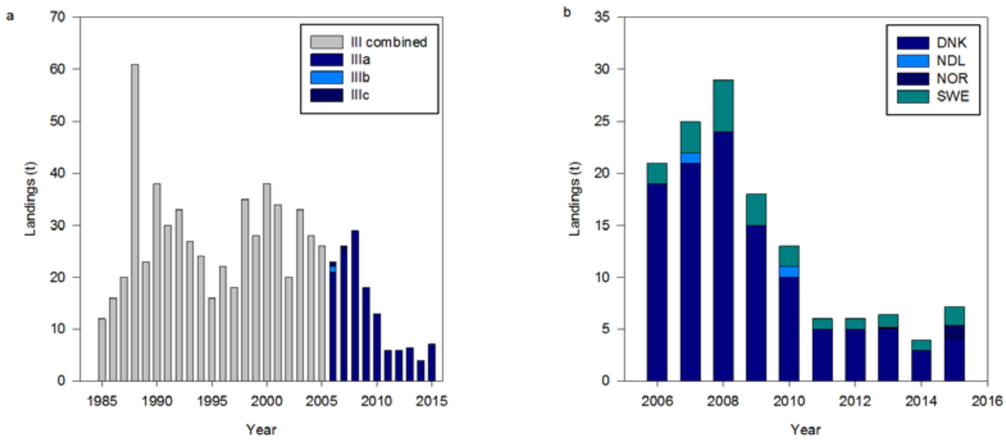


Figure 16.2.1.1: Gurnards. Official landings of grey gurnard in area 3.a, 3b and 3c 1985 – 2015 (a) , official landings of grey gurnards by country only in area 3.a 2006 – 2015 (b).

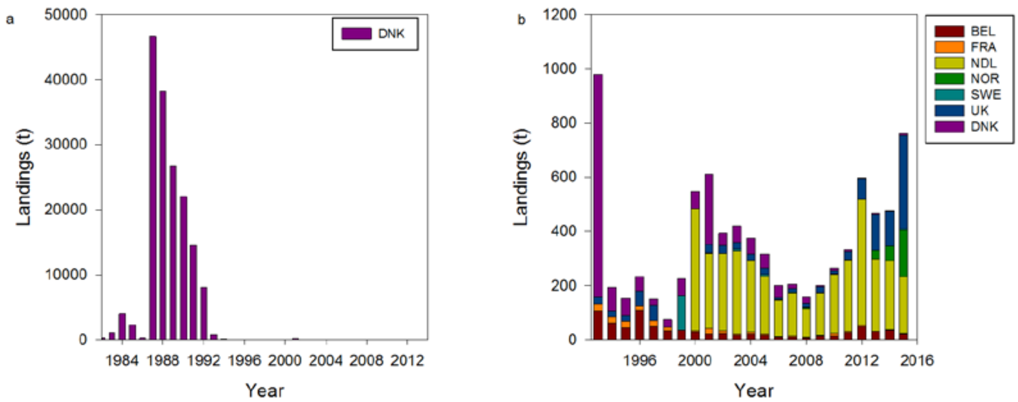


Figure 16.2.1.2: Gurnards. Official landings of grey gurnard in area IV for Denmark only(a) , official landings of grey gurnards by country in area IV since 1993 (b).

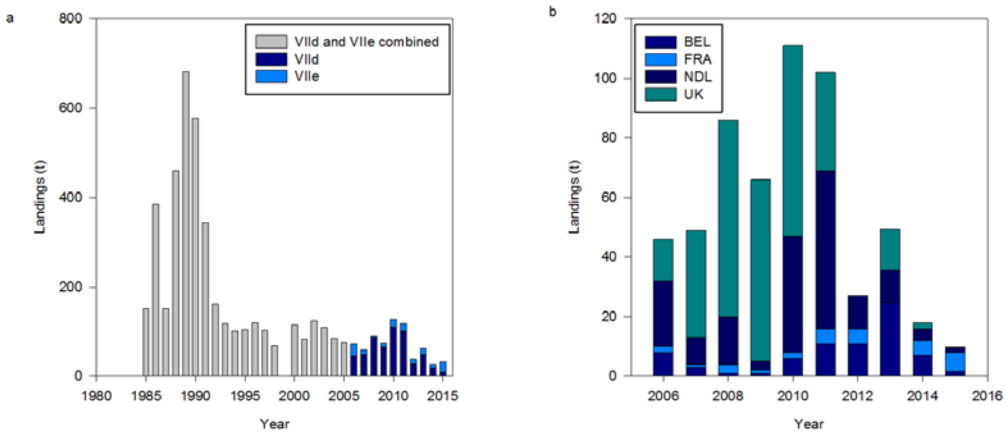


Figure 16.2.1.3: Gurnards. Official landings of grey gurnard in area 7.d and 7e (a) , official landings of grey gurnards by country only in area 7.d by country since 2006 (b).

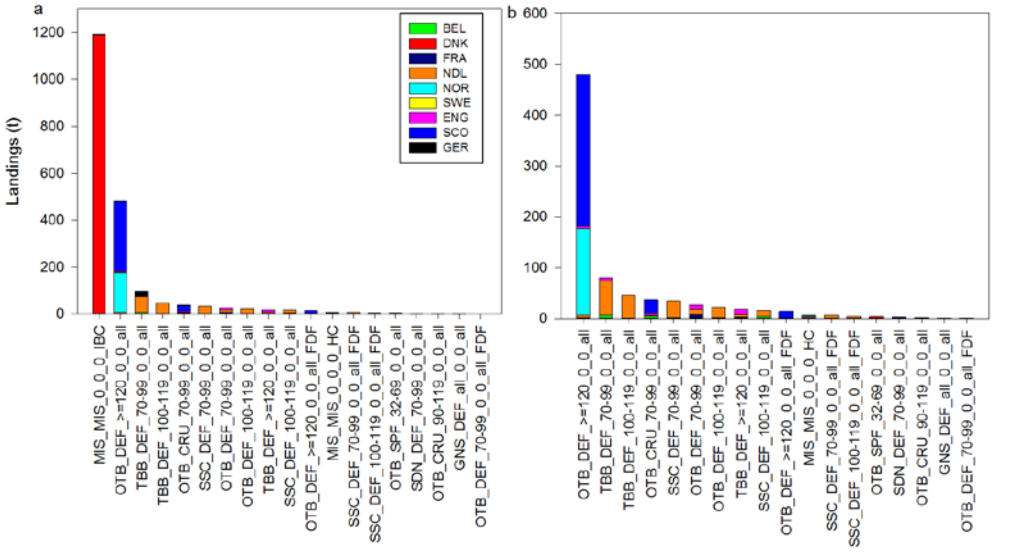


Figure 16.2.2.1 Inter Catch. Grey gurnard landings in 2015 by metier and country as uploaded to InterCatch. Panel (a) and (b) showing the same data, but y-axis in panel (b) is downscaled to better visualize details.

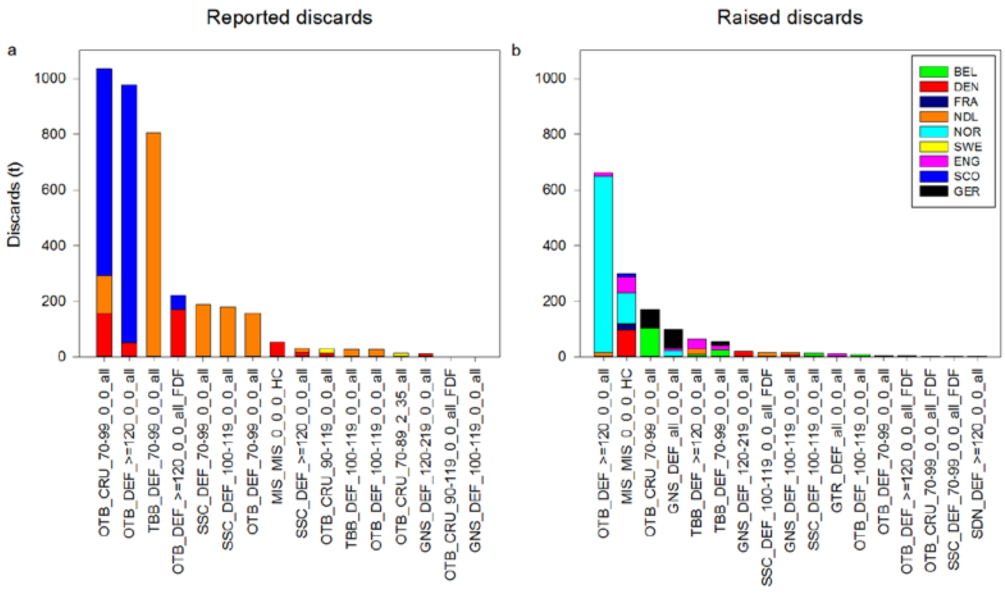


Figure 16.2.2.2 Inter Catch. Grey gurnard discards in 2015 by metier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

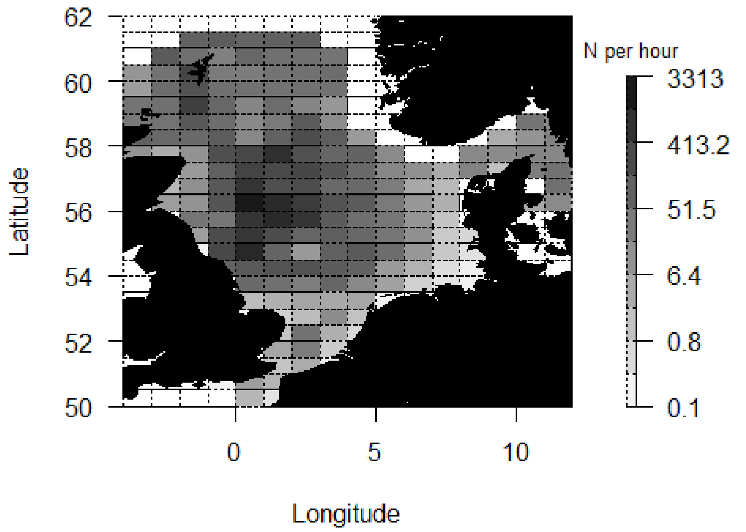


Figure 16.3.1: Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q1 survey in area IV and 3.a.

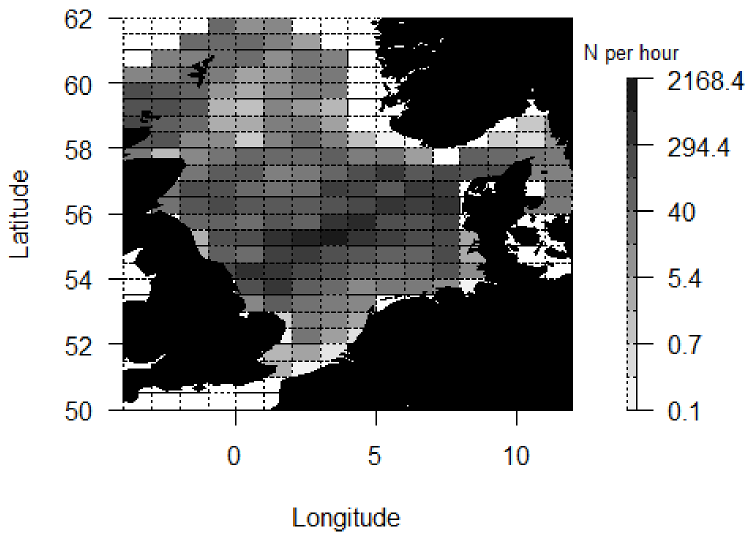


Figure 16.3.2: Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q3 survey in area IV and 3.a.

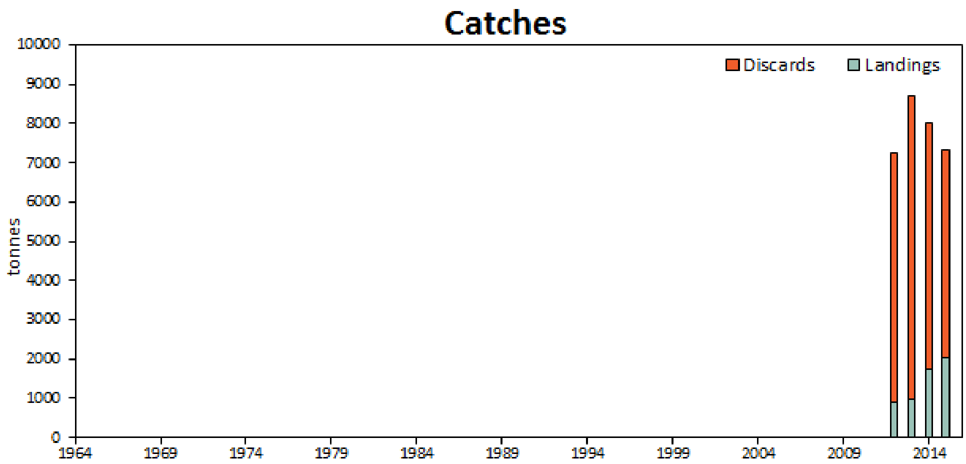


Figure 16.5.1.1: Estimated total catches and landings (upper panel) and stock indicator (lower panel).

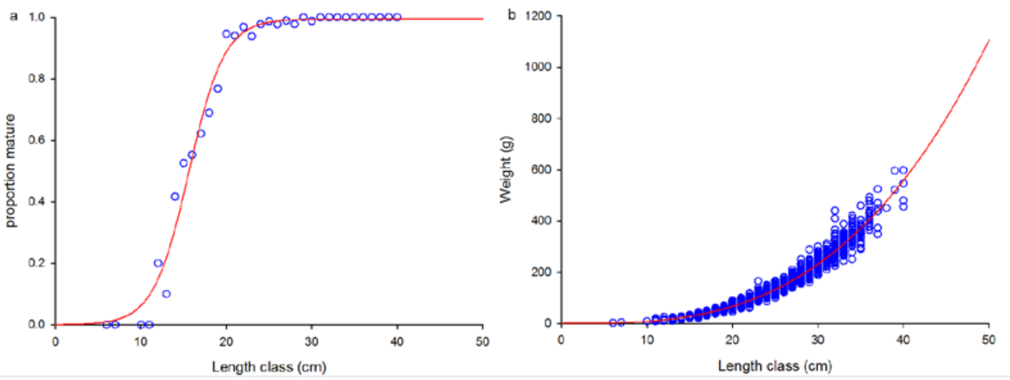


Figure 16.4.1. (a) Maturity ogive of Grey gurnard sampled during IBTS Q1 surveys (n=1501), (b) length weight relationship of Grey gurnard sampled during IBTS Q1 surveys.

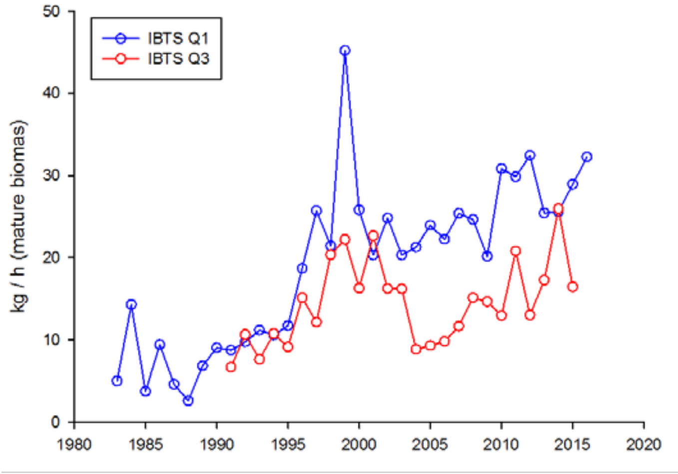


Figure 16.5.1. IBTS Q1 and IBTS Q3 grey gurnard mature biomass index.

17 Striped red mullet (*Mullus surmuletus*) in Subarea 4 and Divisions 7.d and 3.a (North Sea, Eastern English Channel, Skagerrak and Kattegat)

17.1 General

Striped red mullet has been benchmarked in 2015 (ICES 2015).

The main issues addressed during the benchmark were the quantity and representativeness of the observational data. Analyses suggested the extrapolation of the assessment results from the eastern English Channel to the southern North Sea had merit. It was less clear whether the assessment was valid for the other areas within the stock region, because the fishery catches were small and data were sparse.

The conclusion of the benchmark were, that the agreed stock assessment seemed reasonable given the available information and that it could be used for providing fisheries advice under the ICES Stock Category 3 framework. Ecosystem aspects

Striped red mullet (*Mullus surmuletus*) is a benthic species. Young fish are distributed in coastal areas, while adults have a more offshore distribution. Benzinou *et al*, (2013) conducted stock identification studies based on otolith and fish shape in European waters and showed that striped red mullet can be geographically divided into two units: Western Unit (Subareas 6 and 8, and Divisions 7.a–c, 7.e–k, and 9.a) and Northern Unit (Subarea 4 (North Sea) and Divisions 7.d (Eastern English Channel) and 3.a (Skagerrak–Kattegat))..

In the English Channel, this species matures at approximately 16 cm.

Juveniles are found in waters of low salinity, while adults are found at high salinity. Striped red mullet prefers sandy sediments.

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud.

17.2 Fisheries

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (>90% of landings). This French fishery targeting striped red mullet is conducted by bottom trawlers using a mesh size of 70–99 mm in the eastern English Channel and in the southern North Sea.

The eastern English Channel and southern North Sea areas are also fished by trawlers of various types targeting a variety of species. Striped red mullet might be a bycatch in these fisheries.

From 2000 a Dutch targeted fishery, using flyshooters, and a UK fisheries have also developed. Landings are shared by these three fleets in the latter years.

17.3 ICES advice

Advice for 2016 and 2017

ICES advises that when precautionary approach is applied, catches should be no more than 552 tonnes in each of the years 2016 and 2017.

All catch are assumed to be landed. Selectivity in the fishery should be improved to avoid fishing on juvenile recruits and to protect the strong 2014 year class.

17.4 Management

No specific management objectives are known to ICES. There is no TAC for this species.

There is no minimum landing size for this species.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

17.5 Data available

17.5.1 Catch

Official landings data are shown by country in Table 17.5.1.1 and by area in Table 17.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 17.5.1.3 presents total official landings and ICES estimates over the period 2006–2015 as well as the predicted catch corresponding to advice. In 2015 53% of the catches were made using demersal seines and 30% using demersal trawls.

Total landings were provided under the ICES InterCatch format for the period 2003–2013 during the benchmark. However only France provided age composition for the period 2006–2013. 2014 and 2015 landings were provided under the ICES InterCatch format. Figure 17.5.1.1 shows that only landings from France in the Eastern Channel (representing around 30% of the total landings) were provided in 2014 and 2015 with an age structure. Figure 17.5.1.2 shows that IC data and official landings are consistent over years and countries.

Age composition of the landing were provided under the ICES InterCatch format for the period 2006–2013 for the benchmark in 2015 but only for the Fench Otter Trawlers in the Eastern Channel. All other fleets were raised using this stratum. Figure 17.5.1.3 and table 17.5.1.1 show the age structure of the landings provided in 2015.

Prior to 2009, no landings of age 0 were observed. Most of the landings are made on age 1.

17.5.2 Weight at age

Mean weight at age were computed as described in the stock annex and are presented in figures 17.5.2.1 and 17.5.2.2 and table 17.5.2.1.

Weights at age in the landings show a slight decrease for the oldest ages. However sampling intensity for these ages is very low due to the low number of fishes in the catches. Stock weight do not show this slight decrease of age 3 and 4+ but as for landings weight, the sampling is very low due to the low number of fishes in the landings.

17.5.3 Maturity and natural mortality

Information about maturity per age class is given with the table included in this section. At an age of one year more than 50 percent of the striped red mullet are mature.

Age	0	1	2	3	4	5	6
Maturity	0	0.54	0.65	1	1	1	1

As defined during WKNSEA (ICES 2015), natural mortality was derived from Gislason first estimator (Gislason *et al* ., 2010) leading, as expected for this species, to high natural mortality for the youngest ages (see table included below).

Age	M_Gislason
0	1.426
1	0.6641
2	0.4888
3	0.4164
4	0.3616
5	0.3275
6	0.3421

17.5.4 Survey data

The Channel Ground Fish Survey (CGFS) and the IBTS-Q3 surveys were estimated to be good indicators of the population trends as they cover the spatial distribution of this stock. However none of them have an exhaustive coverage of the spatial distribution.

In 2015, a change in the research vessel used for the CGFS was realised. The consequences of these changes were assessed via an intercalibraton in 2014 and some analysis of the catch data (see WGIBTS report). It appeared that for red mullet indices seem to be used without correcting factor.

Only CGFS survey allowed deriving age structured indices. Internal consistencies of the survey (Fig. 17.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 17.5.4.2.

17.6 Trend based assessment

As agreed during WKNSEA (ICES 2015), the assessment model was used for trend as the SSB estimated by the model was considered to be a more reliable indicator of stock status than the direct use of survey indices.

The settings used are described on the following table.

SETTING/DATA	VALUES/SOURCE
Catch at age	Landings (since 2004, ages 0– 4+) InterCatch Discards are assumed neglictible
Tuning indices	FR CGFS (since 2004 ages 0–4+)
Plus group	4
First tuning year	2004
Fishing mortality	~ s(year, k=5) + factor(age)
Survey catchability	~ factor(age)
Recruitment	~ factor(year)

Results from the assessment are presented in figures 17.6.1. Log residuals of the model are presented in Figure 17.3.6.2 and observed and predicted catches in figures 17.6.3 and 17.6.4.

As observed during WKNSEA, there is still a relatively high uncertainty in this assessment but the SSB is still at a very low level and the recruitment seems to be the highest observed during this limited time series. The slight increase in SSB in mostly due to the few age 1 fishes left in the population. Trends show a very low level of biomass and a very high fishing mortality. Most of the catches rely only on the recruitment (age 0) and age 1 fishes.

17.7 Conclusions drawn from analyses

The very good recruitment observed in 2014 was confirmed by the catches in 2015 and the remaining age 1 seen in 2015 during CGFS. There is no TAC on that species so the advice was not followed and the catches overshot the advice for 2015 (4487 Tonnes against 460 Tonnes in the advice).

Basis for the advice:

For the previous reason and the poor recruitment observed in 2015, the advice was not reopened in 2016:

Striped red mullet in Subarea 4 and Divisions 7.d and 3.a. For stocks in ICES data categories 3–6, one catch option is possible. This is highlighted in bold.

Indicator (2013–4) : SSB	914	
Indicator (2010–2012) : SSB	621	
Indicator ratio	1.47	
Recent advice catch	460	
Recent advice catch * indicator ratio	676	
Uncertainty cap applied	Yes	552
Precautionary buffer applied	Yes	2013

A good recruitment has been observed in the different surveys and landings have increased in 2014. However, the increase in landings and in indices only rely on the recruitment (age 0) and age 1.

Instead of using the average catches of the last three years, recent advice catch was taken as a basis for the calculation because ICES advice has never been implemented despite a substantial over exploitation of the stock.

The uncertainty cap has to be applied leading to an increase in TAC by 20%

17.8 Sources:

Benzinoua, A., Carbinia, S., Nasreddinea, K., Elleboode, R., Mahé K., Discriminating stocks of striped red mullet (Mullus surmuletus) in the Northwest European seas using three automatic shape classification methods

ICES 2015. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 2-6 February 2015. ICES CM 2015/ACOM:32

Table 17.5.1.1 Striped red mullet in Subarea 4 and Divisions 7.d and 3.a. Official and ICES landings by country (tonnes).

.YEAR	BELGIUM	DENMARK	FRANCE	NETHERLANDS	UK	TOTAL
1975	0	0	140	0	0	140
1976	0	0	156	3	1	160
1977	0	0	279	12	1	292
1978	0	0	207	25	3	235
1979	0	0	212	32	11	255
1980	0	0	86	25	4	115
1981	0	0	44	19	1	64
1982	0	0	32	18	2	54
1983	0	0	232	15	1	248
1984	0	0	204	0	3	207
1985	0	0	135	0	4	140
1986	0	0	84	0	3	88
1987	0	1	40	0	3	46
1988	0	1	35	0	4	41
1989	0	0	37	0	5	42
1990	0	0	524	0	13	537
1991	0	0	208	0	11	219
1992	0	0	458	0	17	475
1993	0	0	576	0	21	597
1994	0	0	362	0	18	380
1995	0	0	2537	0	69	2606
1996	0	2	2039	2	44	2087
1997	0	2	856	0	61	919
1998	0	2	2966	0	117	3085
19991)	0	4	NA	0	103	107
2000	0	4	3201	464	133	3802
2001	0	10	1789	915	183	2897
2002	0	24	1658	560	141	2383
2003	28	0	3256	626	177	4087
2004	31	0	4137	1148	129	5445
2005	29	0	1918	914	136	2997
2006	126	0	1030	293	116	1451
2007	13	0	3475	906	292	4686
2008	15	0	3250	873	606	4744
2009	14	0	736	562	428	1740
2010	62	0	879	567	466	1974
2011	83	0	650	540	338	1611
2012	39	0	155	367	187	748
2013	33	0	112	180	42	367
2014	71		720	700	242	1732
2015	211		1598	1997	356	4162

[1)] No data reported by France in 1999.

[2)] ICES estimates.

Table 17.2.1.2 Striped red mullet in Subarea 4 and Divisions 7.d and 3.a. Official landings by area (tonnes). Note: Most of the Subarea 4 catches are made in Division 4.c.

YEAR	4	3.A	7.D	TOTAL
1975	0	0	140	140
1976	4	0	156	160
1977	19	0	273	292
1978	30	0	205	235
1979	49	0	206	255
1980	29	0	86	115
1981	20	0	44	64
1982	21	0	33	54
1983	41	0	207	248
1984	22	0	185	207
1985	10	0	130	140
1986	6	0	82	88
1987	7	0	38	46
1988	7	0	33	41
1989	5	0	37	42
1990	33	0	504	537
1991	26	0	193	219
1992	60	0	415	475
1993	126	0	471	597
1994	116	0	264	380
1995	1054	0	1552	2606
1996	528	0	1559	2087
1997	278	0	641	919
1998	778	0	2307	3085
19991)	70	0	37	107
2000	1764	0	2038	3802
2001	1600	0	1297	2897
2002	1234	0	1149	2383
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	338	0	1113	1451
2007	787	0	3899	4686
2008	946	0	3798	4744
2009	471	0	1269	1740
2010	359	0	1615	1974
2011	307	0	1304	1611
2012	196	0	552	748
2013	99	0	268	367
2014	263	0	1469	1732
2015	770		3392	4162

[1)] No data reported by France in 1999.

Table 17.3. 1.3 Striped red mullet in Subarea 4 and Divisions 7.d and 3.a. History of ICES advice, the agreed TAC, and ICES estimates of landings.

Year	ICES Advice	Predicted catch corresp. to advice	Official landings	ICES Estimates
2006		-	1451	1483
2007		-	4686	4610
2008		-	4744	2066
2009		-	1740	1518
2010		-	1974	1920
2011		-	1611	1512
2012	No increase in catch	-	748	725
2013	No increase in catches (average 2009–2010)	< 1700	367	409
2014	Reduce catches by 36% compared to 2012	< 460	1732	1717
2015	No new advice, same as for 2014	< 460	4162	4487
2016	Precautionary approach	<552		
2017	Precautionary approach	<552		

Weights in tonnes.

Table 17.5. 1.1 Striped red mullet landing numbers at age (thousands).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0	0	0	0	0	55	14734	0	6	1384	10124	1832
1	43375	16606	3912	37013	1323	16259	15203	9317	1335	2771	10790	37485
2	1839	2455	2332	1124	10518	1319	674	1454	1244	467	1329	6310
3	947	263	1679	553	1255	662	142	639	1477	289	14	19
4	187	256	188	127	537	102	102	80	183	0	29	36

Table 17.5. 2.1 Striped red mullet stock weights (kg).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0	0	0	0	0	0.046	0.042	0	0.02	0.02	0.029	0.038
1	0.09	0.105	0.15	0.107	0.096	0.07	0.077	0.05	0.09	0.06	0.093	0.1
2	0.222	0.172	0.19	0.313	0.139	0.16	0.112	0.15	0.17	0.12	0.144	0.114
3	0.27	0.3	0.24	0.422	0.226	0.177	0.24	0	0.25	0.12	0.259	0.37
4	0.569	0.411	0.37	0.506	0.361	0.423	0.209	0.02	0.23	0	0.309	0.2

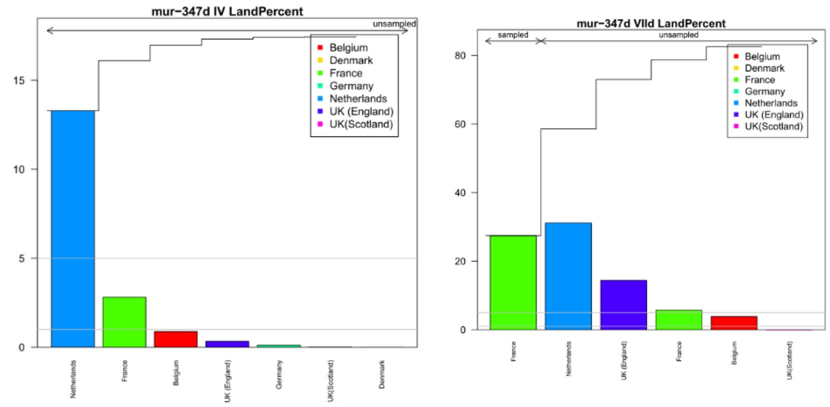
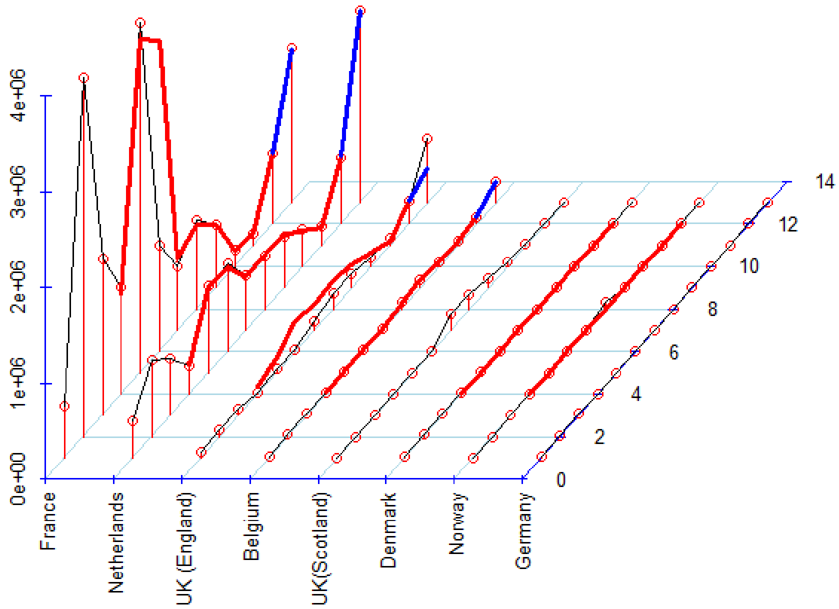


Figure 17.5. 1 Striped red mullet in Subarea 4 and Divisions 7.d ICES landings by country (percentage over the total area).



[redacted]

Figure 17.5. 2 Striped red mullet in Subarea 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional)

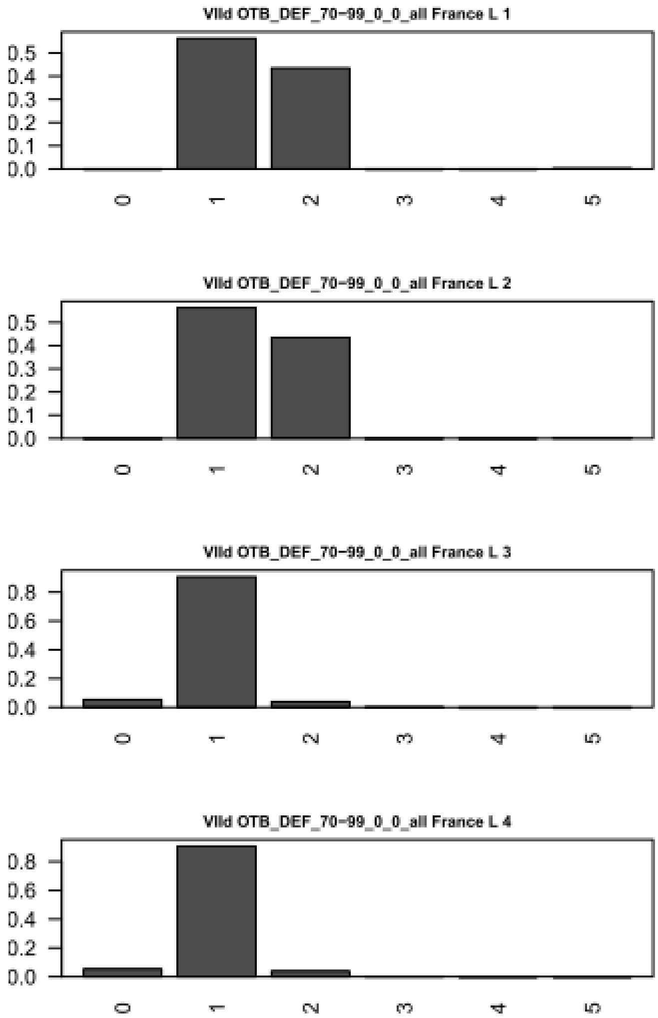


Figure 17.5.1.3 Striped red mullet age structure as provided in 2014 for the Feench

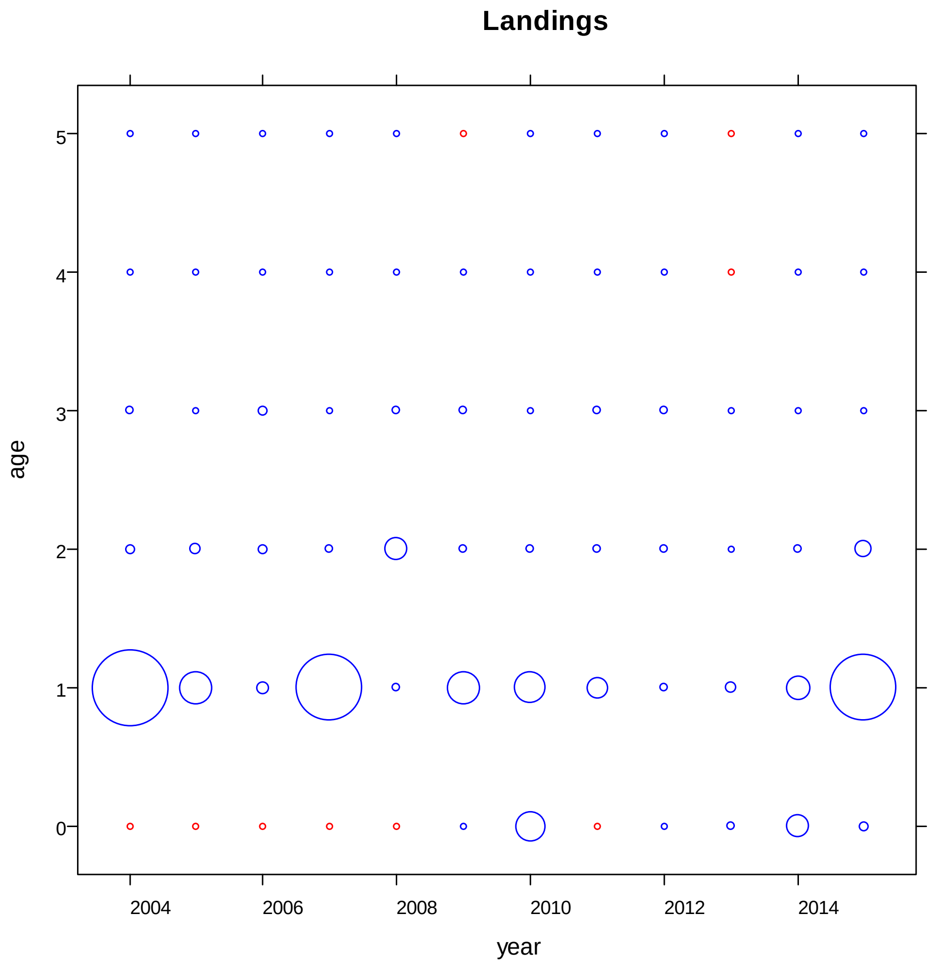


Figure 17.5.1.3 Striped red mullet age structure (in numbers) as provided in the landings

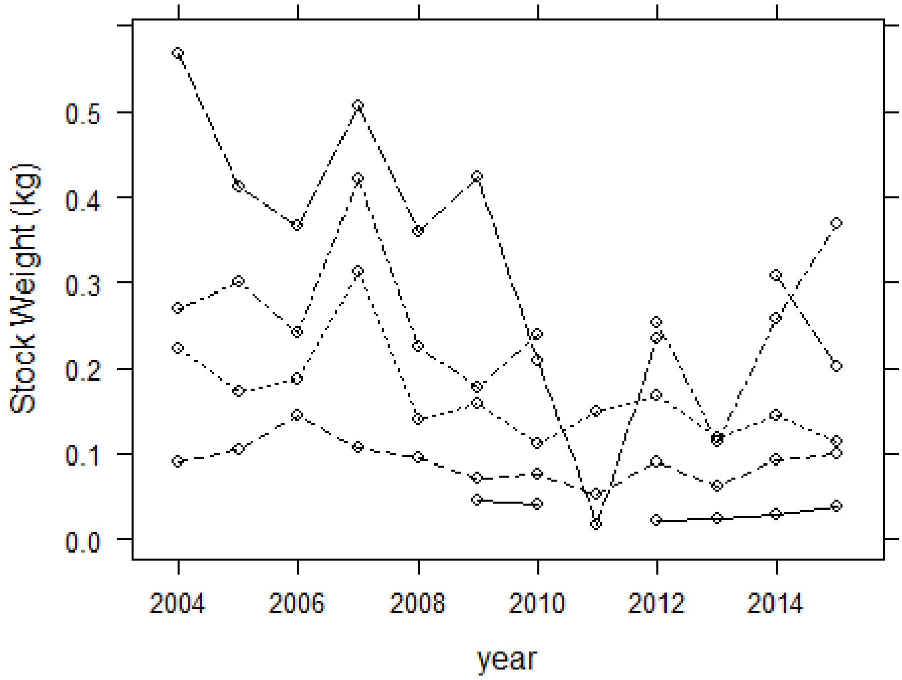


Figure 17.5.2.1 Weight at age in the stock

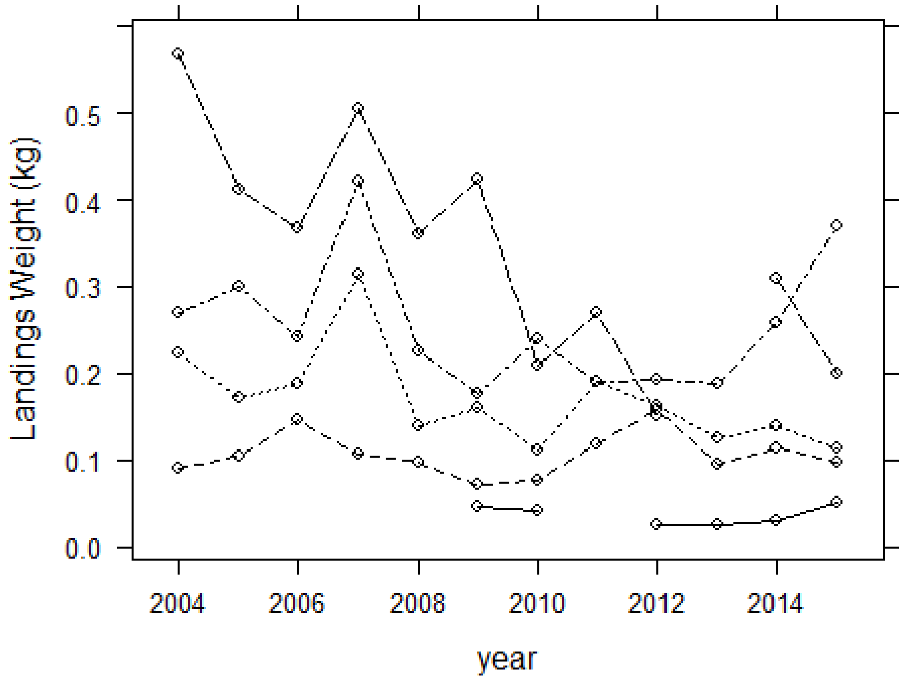


Figure 17.5.2.2 Weight at age in the landings

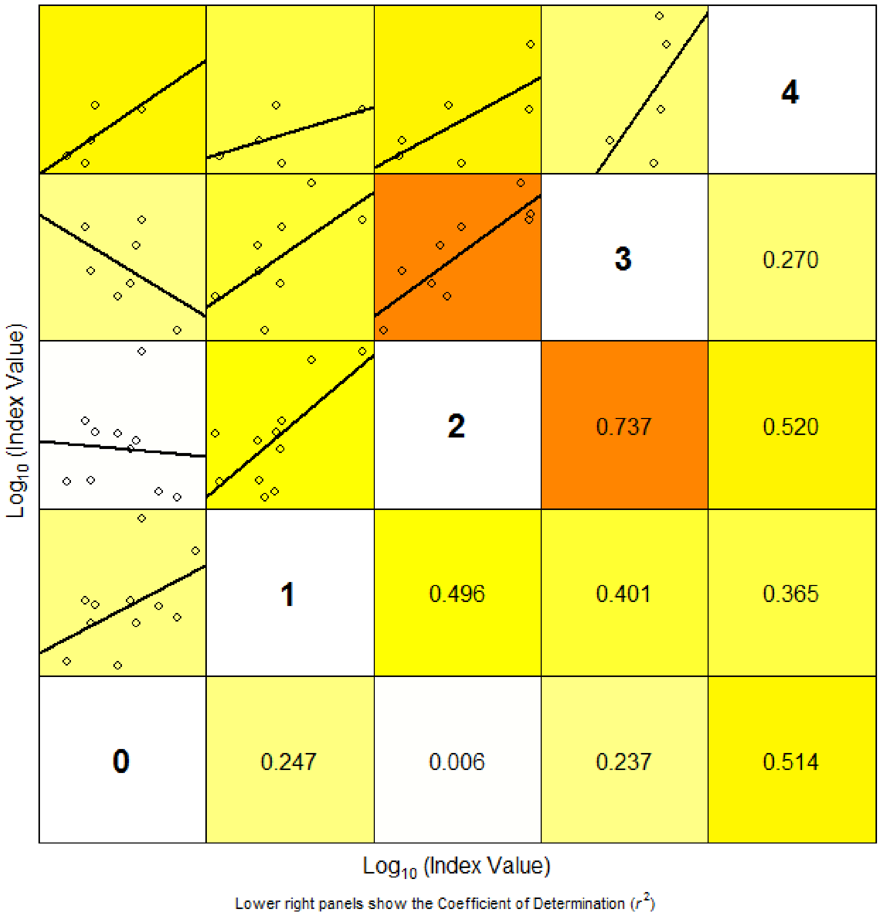


Figure 17.5.4.1 CGFS internal consistencies

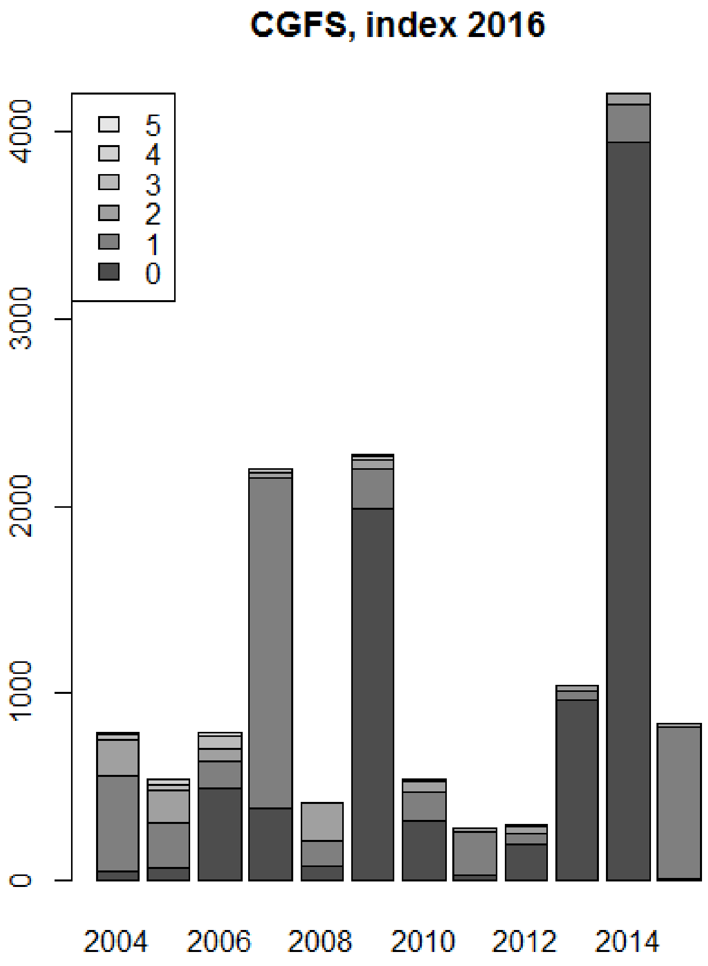


Figure 17.5.4.2 CGFS catch age composition

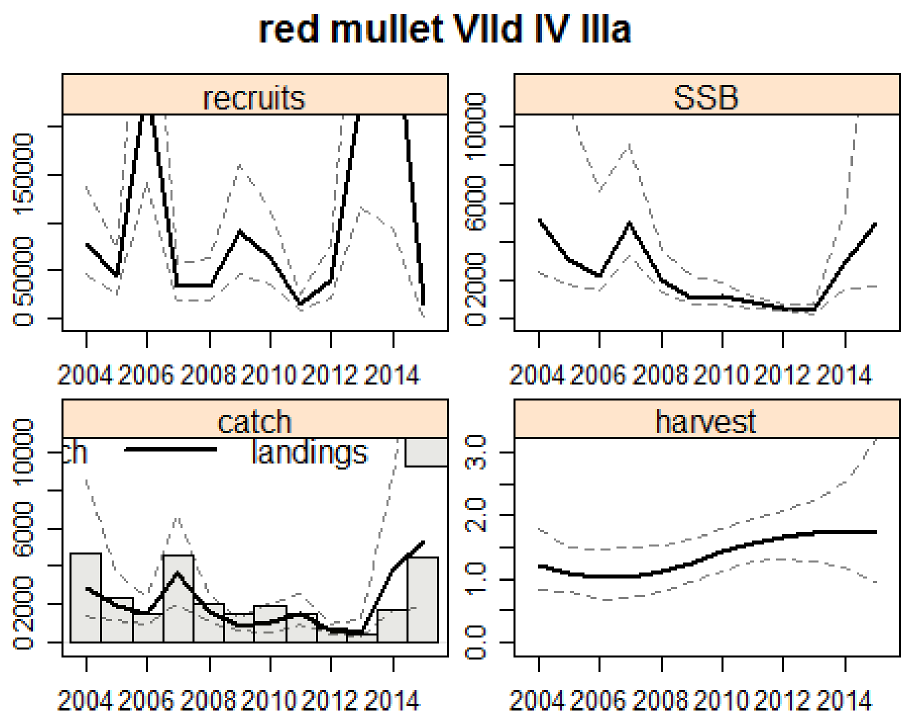


Figure 17.6.1 **CGFS internal consistencies**

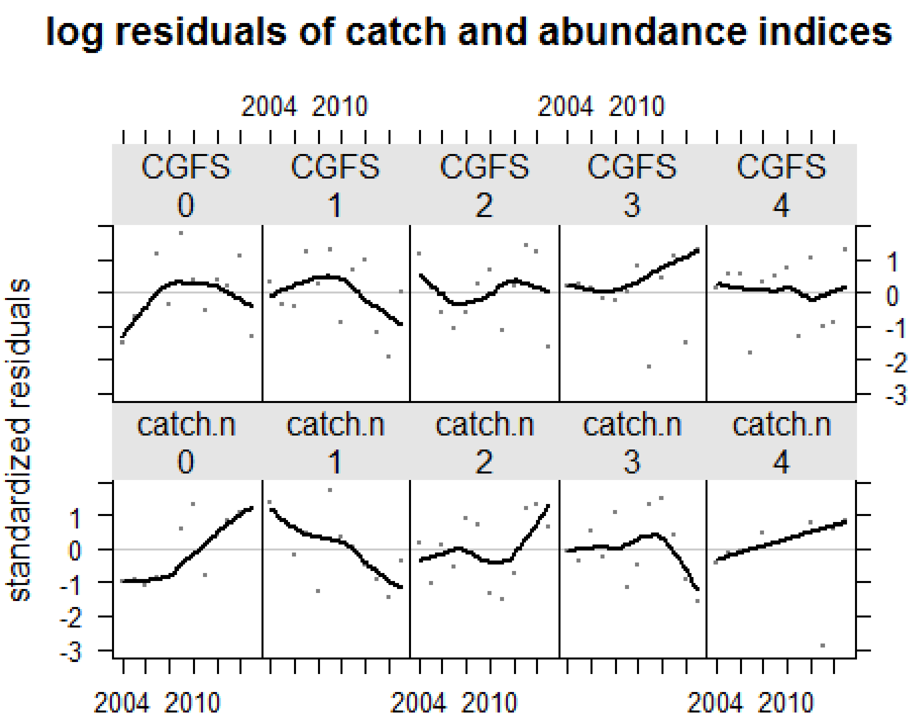


Figure 17.6.2 **Log residuals of the assessment**

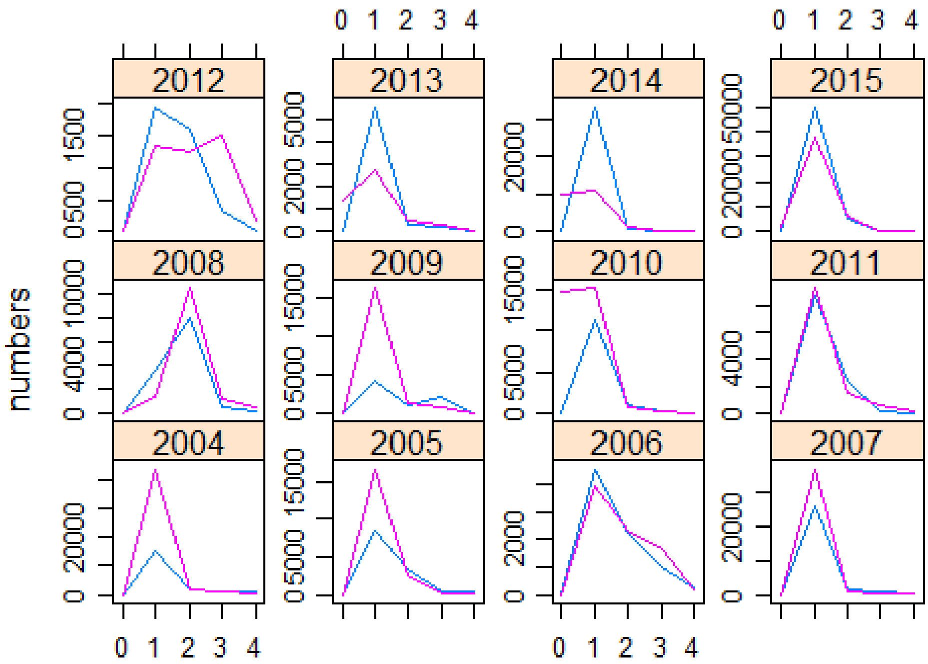


Figure 17.6.3 **observed (pink) and estimated (blue) catch number-at-age**

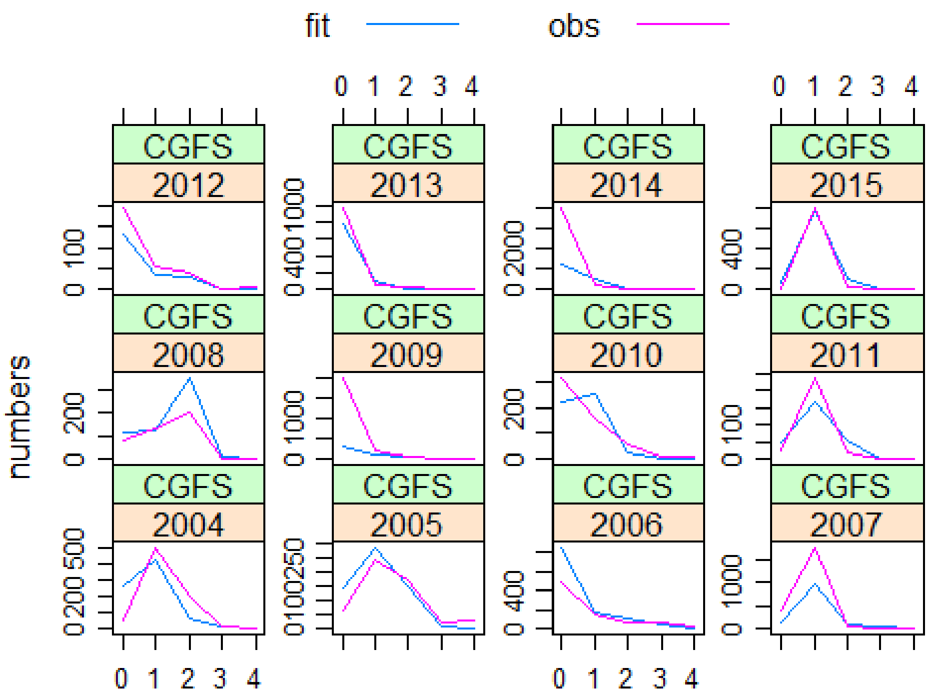


Figure 17.6.4 **observed (pink) and estimated (blue) indices at age**

18 Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2015. Following an inter-benchmark procedure for this stock, a new assessment model (SAM) was used since 2015. More details on the data used, assumptions made and the assessment model settings can be found in the stock annex.

Turbot was assessed at WGNSSK for the first time in 2013. At IBPNEW 2012 (ICES, 2012) an assessment model was developed for turbot in Subarea 4. While the assessment model developed for turbot represented a big step forward, there was still much work to be done to fine tune the model settings to improve the reliability and consistency of outputs. This lead to an Inter-benchmark procedure in 2014–15 (IBPturbot; ICES 2015). Following IBPturbot, a new technique for modelling weights at age has been developed, a plusgroup (10+) was added to the assessment and the assessment methodology was changed.

At WGNSSK 2013 (ICES, 2013a) it was decided to categorise turbot as a 'Category 2' stock under the ICES data-limited stocks (DLS) framework (ICES, 2013b). Category 2 stocks have quantitative assessments that are treated as indicative of trends rather than absolute values. The assessment model adapted during IBPturbot is proposed as a Category 1 assessment, but numerous data quality issues and poor diagnostics mean that the assessment of this stock is still highly uncertain. After an external review highlighting the many issues with the assessment, the advice drafting group North Sea finally decided to treat the assessment output (SSB) as indicative of trends and to use this as the basis for deriving advice under category 3 of the ICES DLS approach.

18.1 General

18.1.1 Biology and ecosystem aspects

Turbot is broadly distributed from Iceland in the North, along the European coastline, to the Mediterranean and Adriatic Sea in the south. In general, turbot is a rather sedentary species, but there are some indications of migratory patterns. For example in the North Sea, migrations from the nursery grounds in the south-eastern part to more northerly areas have been recorded. IBPNEW (ICES, 2012) concluded that Turbot in the North Sea (Subarea 4) can be considered as a distinct stock for management purposes.

Turbot is typically found at a depth range of 10 to 70 m, on sandy, rocky or mixed bottoms and is one of the few marine fish species that inhabits brackish waters. It is a typical visual feeder and could be regarded as a top predator. Turbot feeds mainly on bottom living fishes (e.g. common gadoids, sandeels, gobies, sole, dab, dragonets, sea breams etc.) and small pelagic fish (e.g. herring, sprat, boarfish, sardine) but also, to a lesser extent, on larger crustaceans and bivalves. Despite its role as a top predator in the North Sea ecosystem, at present turbot is not included as a species in the WGSAM multispecies assessment (ICES, 2014a).

18.1.2 Fisheries

In the 1950s the UK was the biggest contributor to the landings (~50% of the landings). In recent years most of the landings stem from the Netherlands (~50–60%). In most countries turbot is caught in mixed fisheries trawls, with most of the landings in the Netherlands coming from the 80 mm beam trawl fleet (BT2) fishing for sole and plaice.

In Denmark, the second largest contributor to the landings in recent times, there is a directed fishery for turbot using gillnets (~10% of the total landings).

See the stock annex (section A.2) for more details.

18.1.3 ICES advice for 2016

The information in this section is taken from the ICES advice sheet 2015, section 6.3.54. This stock is managed under a biennial TAC (together with brill), but ICES has provided advice individually for each of these stocks.

Advice for 2016:

ICES advises that when the precautionary approach is applied, catches should be no more than 1995 tonnes in each of the years 2016 and 2017. If discard rates do not change from 2014, this implies landings of no more than 1925 tonnes.

Management of turbot and brill under a combined species TAC prevents effective control of the single species exploitation rates and could lead to the overexploitation of either species.

18.1.4 Management

A combined EU TAC for turbot and brill is set for EU waters in areas IIa and 4. This TAC only applies to the EU fisheries. This management area (particularly the inclusion of area IIa) does not correspond to either of the stock areas defined by ICES for turbot and brill.

No specific management objectives or plans are known to ICES. Following IBPturbot precautionary reference points (B_{lim} and B_{pa}) have been proposed for the stock.

As a primarily bycatch species, regulations relating to effort restrictions for the primary metiers catching turbot (e.g. beam trawlers) are likely to impact on the stock. Fishing effort has been restricted for demersal fleets in a number of EC regulations (e.g. EC Council Regulation Nos. 2056/2001, 51/2006, 41/2007, and 40/2008).

The Dutch Producer Organisations have introduced a minimum landings size of 27 cm in 2015, and 30 cm in 2016 in order to maintain the landings within the national quota.

See the stock annex (section A.2) for more details.

18.2 Data used

To estimate the trends in abundance and exploitation over time, the assessment of the turbot stock requires three main types of data:

Catch data: estimates of removals of turbot by the fishery.

Survey data and commercial LPUE (landings per unit effort): indices of trends in population abundance over time from fisheries independent and fisheries dependent sources, respectively.

Biological data: estimates and/or assumptions on growth, maturation and natural mortality.

Since the assessment is age-based, data for the above is required for each age. See the stock annex (section B) for more details on the data used in the assessment, sources and historical values.

18.2.1 Catch data

The assessment model only uses catch numbers at age and does not utilise total landings (tonnage per year). InterCatch was used for the first time for the North Sea turbot stock at WGNSSK 2014, and has been used since.

Age structure of the landings for 2004–2015 has been estimated from Dutch samples accounting for auctions, quarters and market categories. Prior to 2014, all samples were taken from the 80mm beam trawl fishery (TBB_DEF_70–99). In 2012, 11 samples were taken and a total of 596 fish were aged. In 2013, 8 samples were taken and a total of 426 fish were aged. In 2014, 9 samples (503 aged fish) were taken from the TBB_DEF_70–99 metier and 2 samples (120 aged fish) were taken from otter trawl metier (OTB_DEF_70–99). In 2015, 14 samples (781 aged fish) were taken from the TBB_DEF_70–99 metier.

Figure 18.2.1 shows the metiers with numbers at age samples for the landings and the age distributions by season observed in these metiers. The only usable samples were those from the Dutch TBB_DEF_70–99 (beamtrawl) metier, and these samples were used to raise all the unsampled métiers in 2014.

Raising was done by quarter. The TBB_DEF_70–99 samples were evenly spread over the seasons,. All beam trawl fleets were raised using the age distributions calculated form the TBB samples. There are a wide variety of métiers that land turbot, including a significant amount from the Danish >220mm gillnet fleet. **More samples of landings at age are required from other métiers to more accurately raise the total landings at age**.

Figure 18.2.2 shows the trend in total landings over time and Figure 18.2.3 shows the breakdown of landings by country for 2014 (from the EuroStat database). Landing of turbot decreased during the 1990s and for the last ten years have been stable in the region of 3000t. Over this time effort by the Dutch beam trawl fleet, which contributes the most of the landings, has decreased notably. Since turbot is primarily a bycatch species, this indicates that abundance of turbot has likely increased over this period.

Landings at age are presented in Table 18.2.1 and Figure 18.2.4. The 2005 yearclass shows up clearly in the landings data, but since then there have been no notably large year classes observed. Following a decrease in minimum market size for turbot in the Netherlands in 2002, there has been a notable increase in the amount of age 1 and 2 turbot landed, accounting for half of the catch in some years but this proportion has been decreasing in recent years due to some poor year classes in 2012 and 2013. Since turbot are only fully mature at age 4, indicates a high proportion of immature fish in the landings. However, the last 5 years have also seen an increase in the proportion of age 5+ fish in the landings compared to the five years prior to that, though still lower than observed in the 1970s and 1980s. This could reflect a reduction in F recently leading to an increasing proportion of older fish in the landings. However, since the catch data is raised using only the Dutch 80 mm TBB fleet, signals in catch at age data may not be accurate reflections of true removals from the population over time.

18.2.1.1 Discard data

The assessment of this stock assumes that discarding of catches for this stock is negligible. However, there was a sudden increase in the landing of age two turbot following the decrease in minimum market size in the Netherlands in 2002. Given that there was no known change in the fishing behaviour of the main fleets at this time, this could indicates that previously more age 2 fish must have been caught than were actually landed. These were either discarded or, as a much sought after fish, kept by the fishermen for personal use. **This would mean that the discards could be underestimated in the period up to 2002 relative to the period following this, potentially causing a bias in the assessment outputs.** Alternatively, subsequent to the change in MLS, more targeting of small turbot may have occurred. Without a useable time series of discards before and after this change it is difficult to determine which of these explanations holds.

However, the impact on the final year estimates is likely to be small because with the reduction in minimum market size in 2002, the assumption of negligible discards probably holds for the last 10 years. Discard data were submitted to Intercatch by various nations. However, there is very limited age sampling of the discards. Very few fish were sampled in the discards of some of the Danish métiers (<10 per métier, fewer than the number of ages in the assessment model), not enough to be used in the raising of international landings.

In 2016, most countries provided estimates of discards in 2015 to Intercatch. Out of the 2925 t that were landed, 2012 t (86%) had associated reported discards (totalling 92 t). When the rest of the discards were raised for the unsampled landings an extra 27 t of discards is estimated. In total this gives an estimate of 92+20 = 112 t discarded, implying a discard rate of 3.7% in 2014. No useable age structure information was submitted for the discard estimates.

Overall, discard rates estimated from the available data suggest less than 5% of the catch is discarded and are therefore discarding is considered negligible.

18.2.2 Survey data and commercial LPUE

Two survey abundance indices, the Sole Net Survey (SNS) and the Beam Trawl Survey (BTS ISIS), and one commercial LPUE abundance index, the Dutch 80 mm beam trawl fleet (BT2), are used to tune the assessment (Table 18.2.2 and Figure 18.2.5). Prior to IBPturbot the Dutch BT2 LPUE index was used as an age-structured index of abundance. Following IBPturbot and WGNSSK 2015 it was decided to rather use this index and age-aggregated index of exploitable biomass. This was decided upon since the same catch at age data was used to raise the catch at age matrix and the Dutch BT2 index. It was felt that feeding the same data into the model for both the catch and the index would inherently bias the assessment in favour of this index since it follows very close the catch information used in the model. The new age-aggregated exploitable biomass per unit effort index is shown in Figure 18.2.5b.

All abundance indices indicate an increase in the number of fish aged 4 and older in late 2000s compared to the past. An increase in the amount of older fish would indicate either strong recruitment or a decrease in mortality (e.g. fishing pressure) exerted on the stock. However, following 2010 the indices indicate a decrease in some of the older ages and there are no clear indications of strong year classes in the most recent years. In particular, estimates of numbers at age 2 are low in 2014. Both fisheries independent surveys however, show large numbers of age 1 and age 2 fish in 2015.

There is fairly close agreement between the three indices on the general trends in abundance at age, but the data are noisy from year to year. This can be seen in the low R^2 values in the internal consistency correlations in the BTS_ISIS and SNS surveys (Figure 18.2.9). The SNS survey is particularly poor at picking up cohort signals, with low R^2 values on the correlations between numbers at consecutive ages. Though all correlations between successive ages are positive, estimated numbers at age, particularly for the younger ages, fluctuate a lot from year to year. The BTS-ISIS is more internally consistent for ages 3 and up. The almost non-existent relationship between the numbers estimated at age 1 and the numbers estimated at age 2 in the following year suggest that in future removing age 1, and potentially age 2, from this index may be appropriate. The internal consistency of the NL_BT2 LPUE index is significantly better, though the removal of age 1 from this index could also be considered. However, this index is no longer used as an age-structured index.

Noisy indices that are more indicative of general trends are best used in an assessment model that is able to smooth over the noise in the data. The SAM model used for this stock is able do this, but nevertheless inputting noisy data into the assessment will increase uncertainty in the outputs. By removing the age-structure from the NL BT2 LPUE index, the clearest cohort signals in the assessment of this stock are coming from the catch at age matrix.

18.2.3 Biological data

All biological data used in the assessment are presented in Table 18.2.3.

Weight at age

Constant annual catch and stock weights at age (long term means of all available data) were previously used in the assessment because of large gaps in the time series of weight at age data for turbot in the North Sea (Figure 18.2.7). What data is available is also very noisy, due to low sample sizes for most ages. The data that are available, and trends in other flatfish species in the same areas suggest that there have been potentially significant changes in weight at age over time. At IBPturbot a method was developed to model the growth parameters over time, allowing smooth changes over the time series (see stock annex for full details). The results indicate an increase in weight at age from the start of the time series, peaking in the early 1990s. Since then weights at age have decreased again to slightly lower than the 1970s, and have been fairly stable in recent years.

Maturity

At IBPNEW (ICES, 2012) turbot maturity data from the Netherlands was used to study some reproductive characteristics of turbot from the North Sea. A female maturity ogive constructed from derived from a General Linear Model fit using the maturity data from the recent time period was chosen for the stock.

Natural mortality

There are currently no accepted estimates of turbot natural mortality over time. A number of alternative methods, using different estimates of growth parameters, were used to estimate the level of natural mortality by age for turbot in the North Sea at IBPNEW (ICES, 2012). Since turbot grows relatively fast compared to other flatfish species in the same areas, results indicate that natural mortality is higher. However, due to high variability for recorded values of K (an estimated growth parameter) for turbot, it proved difficult to find agreement on natural mortality values. Hence, after performing assessment test runs, a constant value of M=0.2 for all ages and years was chosen for this stock. This is twice the level used in the sole and plaice assessments in the North Sea.

18.3 Stock assessment model

Turbot in Subarea 4 was previously assessed using a custom designed age-structured assessment model. Following IBPturbot, a SAM model is now used for this stock. The basic SAM set up was modified to allow the inclusions of an exploitable biomass index (see stock annex).

18.3.1 Model settings

The assessment model was conducted using the settings and configuration given below. Details of the assessment model can be found in the stock annex.

Assessment settings used in the final assessment

YEAR	2015 (IBPTURBOT PROPOSAL)
Model	SAM
First tuning year	1975
Last data year	2014
Ages	1–10+
Plus group	Yes
Stock weights at age	Von Bertalanffy growth curve with time varying Linf
Catch weights at age	Von Bertalanffy growth curve with time varying Linf
Total Landings	Not used
Landings at age	1975–1978, 1981–1990, 1998, 2000-present
Discards	Not used (assumed 0)
Abundance indices	BTS-Isis 1985−2013 SNS 1975−2002, 2004–2013
	NL-BT2 LPUE age-aggregated catchable biomass 2002–2014
Catchability independent of age for ages >=	7

SAM configuration file (see stock annex for details)

\# **Min Age**
1
\# **Max Age**
10
\# **Max Age considered a plus group (0=No, 1=Yes)**
1
\# The following matrix describes the coupling of fishing mortality STATES
\# Row represent Catch, Columns represent ages.

1	2	3	4	5	6	7	7	7	7

\# Use correlated random walks for the fishing mortalities
\# (0 = independent, 1 = correlation estimated, 2=AR1)
2
\# **Coupling of catchability PARAMETERS (Surveys)**
\# Row represent fleets (SNS and BTS only; LPUE age-aggregated), Columns represent ages.

1	2	3	4	5	6	6	0	0	0
7	8	9	10	11	12	12	0	0	0

\# **Coupling of power law model EXPONENTS**
(not used)
\# **Coupling of fishing mortality RW VARIANCES**

1	2	1	1	1	1	1	1	1	1

\# **Coupling of log N RW VARIANCES**

1	2	2	2	2	2	2	2	2	2

\# **Coupling of OBSERVATION VARIANCES**
\# Row represent fleets (Catch, SNS, BTS), Columns represent ages.

1	2	3	3	3	3	3	3	4	4
5	6	7	7	7	7	7	0	0	0
8	9	10	10	10	10	10	0	0	0

\# **Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)**
0
\# **Years in which catch data are to be scaled by an estimated parameter**
(Catch not scaled)
\# **Define Fbar range**
2 6

18.4 Assessment model results

Abundance at age and fishing mortality at age estimated by the assessment model are presented in Tables 18.4.1 and 18.4.2, respectively. Key stock and fishery metrics are given in Table 18.4.3 and plotted in Figure 18.4.1.

18.4.1 Status of the stock

Fishing mortality was estimated at 0.99 in 2015, a sharp increase from 2013 (0.74). This is well above the long term geometric mean (0.49). The SSB in 2014 was estimated to be 3 469 t, decreasing sharply to 2 569 t in 2015. Both years are lower than the long term geometric mean (7177 t). The estimated recruitment (age 1) for 2015 is higher than the geometric mean of the time series. However, this estimate is based on very little data and is unlikely to be a reliable estimate.

18.4.2 Historic stock trends

Spawning stock biomass since 2000 has been at a low level compared to the period before this.

SSB peaked in the early 1980s, at a time when F was estimated to be at the lowest level of the time series. From the mid-1980s up until the early 2000s SSB declined gradually and F increased gradually. The lowest observed SSB was in 2005, SSB subsequently increased until 2010 and has remained between 3500 t and 400t since then. However, SSB at the start of 2015 is estimated to have declined sharply since 2014 to 2610 t, below B_{pa}. This is because recruitment in 2013 is estimated to be the lowest in the time series. Likewise, the 2014 and 2012 year classes are estimated to be poor.

Mean F peaked in 2003 at 0.93, but then declined sharply to 0.46 in 2006 before gradually increasing again. This corresponds to a period of reduction in effort by the NL BT2 fleet and allowed SSB to gradually increase from its lowest observed level. The perceived increase in mean F (ages 2–6) in the early 2000s is the result of an increase in the amount of age 2 turbot landed following the change in MLS in the Netherlands. Since the mean F range covers ages 2–6, this increase in F on age 2 fish lead to a sharp increase in mean F over this period.

There are no clear patterns in recruitment, though values are estimated at a slightly higher level, but with more uncertainty, during the years of missing landings at age data (1990s). Recent recruitment has been poor, with the exception of the most recent year class .

18.4.3 Retrospective assessments

The results of five retrospective assessments, run using the same model settings but removing one year of data from the end of the time series, are plotted in Figure 18.4.2. In most years F has been severely overestimated and SSB has been underestimated.. For SSB only one of the retrospective peels falls within the confidence bounds of the most recent assessment. For F, three retrospective peels are well above the confidence bounds of the latest assessment. Recruitment shows no clear retrospective pattern and all peels fall within the confidence bounds of the latest assessment.

The disagreement between retrospective assessments is large, and though not clearly biased, are still problematic. This is due to the quality of the data used by the assessment rather than the model itself.

18.5 Model diagnostics

Diagnostic tests are carried out on the assessment model fit and outputs to identify any irregularities or potential biases that should be taken into account when interpreting the assessment results. **The diagnostics for the turbot SAM model are poor.**

Table 18.5.1 shows the observation and process error estimates from the SAM model. The process error is not particularly large. The process error on numbers at age for age 1 is estimated to be three times as high as that for the other ages. This means that the dynamics between age1 and age 2 are uncertain, potentially diminishing the meaning of the recruitment estimates (since year class strength as estimated at age 1 may not correlate very strongly with year class strength as estimated at age 2). The observation variance for almost all ages of the SNS and BTS-ISIS indices are very large. This is unsurprising given the poor internal consistency found in these indices. Observation variances on the catch are particularly high for age 1 (2.19), indicating that estimates for catches at age one are significantly down weighted by the model. The estimates for age 9 and the plusgroup are also high (0.61), while the observations variance for all the other ages are lower than those for the survey indices (with the exception of age 2 for the BTS-ISIS).

For the fishery there is a clear periods of negative or positive residuals for age 1 and the model has consistently estimated more age 2 catches in recent years than were raised. Ages 2–4, which contribute to the vast majority of the landings, are estimated by the model to be most similar to the observed values. The increase in age 3+ fish observed in the 2014 catch at age results in negative residuals for most of these ages in 2014 (model predicts less than reported).

The residuals for the three tuning indices are presented Figure 18.5.3. There are some year effects present in the SNS index. In 2014 all residuals are negative, while in 2012 and 2013 most of the residuals were positive. The BTS-ISIS index has clear groupings of negative or positive residuals over certain ages and years. The NL BT2 exploitable biomass index has positive residuals until 2005 and negative residuals since then indicating that the index suggests a more rapid increase in biomass over this time period than the model. The fact that all indices (with the exception of age 2 in the BTS-ISIS) have negative residuals in the final year suggests that the indices are have a limited impact on the

To evaluate the impact of each of the tuning indices on the model fit, leave-one-out (LOO) runs were conducted (Figure 18.5.4). Excluding the SNS index leads to higher SSB and lower F in the last 7 years. SSB in particular is estimated to be well above the confidence bounds of the full assessment. During the period when no catch at age data are available (the 1990s), leaving out the SNS leads to lower SSB and higher F, while leaving out the BTS-ISIS leads to higher SSB and lower F. Leaving out the NL BT2 exploitable biomass index does a very negligible effect on SSB, F and recruitment estimation. This suggests that this index is down weighted strongly in the model, hence the very poor residual pattern for this index. Recruitment values do not change significantly is any of the indices are removed. The indicates that the catch at age matrix is the major source of data contributing to the models estimates of year class strength.

18.5.1 Data Limited Stocks (DLS) approach

Given the poor diagnostics of the assessment, an alternative approach to deriving advice for this stock is to use the ICES framework for category 3 stocks (ICES 2012a). An SSB index from the age based assessment treated as indicative of trends can be applied as the indicator of stock development. The perception of the stock has not changed with the inclusion of the new data.

18.6 Management considerations

There are a number of EC regulations that affect the flatfish fisheries in the North Sea, e.g. as a basis for setting the TAC, limiting effort, and minimum mesh size.

18.6.1 Effort regulations

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In 2009, the effort management programme switched from a days-at-sea to a kW-day system (EC regulation 43/2009), in which different amounts of kW-days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. The most important fleet catching turbot in the North Sea, the Dutch 80mm beam trawl fleet (BT2), was affected by this regulation only once in 2009 but not since.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. In 2008, 25 vessels were decommissioned.

18.6.2 Technical measures

Turbot is mainly taken by beam trawlers in a mixed fishery directed at sole and plaice in the southern and central part of the North Sea. Technical measures (EC Council Regulation 1543/2000) applicable to the mixed flatfish fishery affect the catching of turbot. The minimum mesh size of 80 mm in the beam trawl fishery selects sole at the minimum landing size (24 cm). However, this mesh size is likely to catch immature turbot (age 1 and 2 fish). Mesh enlargement would reduce the catch of smaller turbot at the same time potential increasing the yield per recruit, but would also result in loss of marketable sole catches.

A closed area has been in operation since 1989 (the plaice box) and since 1995 this area has been closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation. An additional technical measure concerning the fishing gear is the restriction of the aggregated beam length of beam trawlers to 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9 m.

18.6.3 Combined TAC

At present the EU provides a combined TAC for turbot and brill in the North Sea. It is unclear how the quantitative single species advice for turbot and the qualitative single species advice for brill can/will be used to formulate a combined TAC for these two stocks. In this situation, improving the brill assessment may be necessary in order to ensure efficient management of both of these stocks. Ideally, a combined TAC would not be used.

18.7 References

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ICES, 2013b. (DRAFT) ICES Implementation of Advice for Data-limited Stocks in 2013. ICES CM 2012/ACOM: 68. 42pp.

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ICES. 2015. Report of the Inter-Benchmark Protocol for Turbot in Subarea IV (IBP Turbot), May 2015, By correspondence. ICES CM 2015/ACOM:XXX. Xxx pp.

Table 18.2.1 Turbot in Subarea 4: Landings at age estimates (abundance, thousands) used in the assessment.

	1	2	3	4	5	6	7	8	9	10+
1975	1.15	427.35	1012.35	239.35	108.35	124.55	90.35	47.25	42.05	146.55
1976	0.35	350.35	1346.35	392.35	114.35	76.25	57.75	50.55	38.55	174.15
1977	18.55	895.35	644.35	531.35	166.35	44.15	30.85	42.35	36.95	142.35
1978	0.35	1324.35	1273.35	309.35	268.35	76.35	37.95	29.35	20.75	65.05
1979-1980	NO DATA									
1981	0.35	299.35	755.35	532.35	458.35	175.35	67.35	35.35	40.35	32.35
1982	0.35	169.35	1046.35	267.35	167.35	292.35	98.35	49.35	41.35	65.35
1983	0.35	402.35	673.35	479.35	110.35	113.35	180.35	91.35	31.35	81.35
1984	0.35	1296.35	1223.35	311.35	157.35	60.35	57.35	74.35	51.35	70.35
1985	0.35	795.35	2415.35	654.35	179.35	109.35	26.35	38.35	48.35	74.35
1986	0.35	371.35	1470.35	697.35	183.35	67.35	29.35	16.35	18.35	90.35
1987	13.35	648.35	546.35	676.35	158.35	52.35	19.35	5.35	5.35	60.35
1988	36.35	1084.35	897.35	178.35	176.35	90.35	28.35	42.35	10.35	25.35
1989	0.35	594.35	1037.35	315.35	139.35	73.35	28.35	22.35	10.35	29.35
1990	43.35	957.35	1032.35	305.35	160.35	73.35	98.35	58.35	13.35	39.35
1991–1997	NO DATA									
1998	0.35	540.35	1158.35	476.35	97.35	39.65	11.65	10.45	1.26	8.35
1999	NO DATA									
2000	4.85	255.35	938.35	270.35	315.35	145.05	116.45	51.65	59.14	72.7
2001	0.35	478.35	1642.35	357.35	64.35	75.85	55.45	65.05	21.93	61.49
2002	468.35	1283.35	1237.35	265.35	123.35	32.45	16.75	17.65	3.62	9.87
2003	267.35	2429.35	586.35	378.35	90.35	42.25	26.65	9.35	8.02	9.43
2004	491.15	2234.35	894.35	156.35	93.35	11.25	8.85	4.45	1.37	1.73
2005	291.45	1678.35	611.35	195.35	21.35	18.85	2.55	12.15	1.38	3.42
2006	706.05	1312.35	644.35	95.35	28.35	6.65	13.25	3.45	1.05	10.66
2007	80.25	2829.35	627.35	290.35	41.35	29.95	8.75	9.85	0.35	6.34
2008	184.85	1404.35	854.35	229.35	203.35	49.35	13.75	1.55	7.16	2.62
2009	117.25	1076.35	1005.35	434.35	92.35	26.25	11.75	8.15	2	9.71
2010	237.15	1193.35	328.35	263.35	146.35	75.25	26.35	6.35	4.83	6.14
2011	219.45	2017.35	626.35	115.35	143.35	80.35	33.85	16.65	3.72	4.84
2012	0.35	1949.35	793.35	272.35	43.35	65.25	74.55	13.65	6.88	4.71
2013	161.68	1480.55	1013.13	304.82	85.22	24.34	39.35	16.95	2.76	4.54
2014	94.56	548.41	620.09	461.38	162.79	78.15	24.22	21.31	11.21	32.21
2015	57.39	1911.06	531.05	347.21	354.88	111.12	34.10	12.59	11.60	17.554

Table 18.2.2 Turbot in Subarea 4: Relative abundance indices used in the assessment. SNS.

SNS							
start	0.66	end	0.75				
	1	2	3	4	5	6	7
1975	92.7765	80.0575	19.9635	6.8025	2.5955	2.9235	0.6775
1976	43.9395	53.5585	12.8505	4.5435	2.2625	1.5405	0.4575
1977	406.4435	212.4895	43.5875	12.0325	8.4625	3.3085	1.7745
1978	27.5655	121.5145	49.0915	17.3695	7.5775	4.5425	2.3125
1979	14.5295	107.7745	45.9225	13.9525	8.0695	4.8685	2.4875
1980	109.9805	66.3845	24.5475	8.4455	3.7515	2.5315	1.6905
1981	23.6485	65.2125	23.7685	7.4655	8.0285	5.1455	4.2085
1982	87.7025	40.0155	7.5965	1.7605	1.2525	0.3035	0.7955
1983	151.5805	146.6065	27.7185	8.7335	2.7935	2.9135	1.1675
1984	88.7745	76.0395	24.9595	9.5415	5.1865	3.1565	1.3265
1985	42.6505	93.7175	21.9185	6.8335	3.9385	3.0565	0.7115
1986	24.1895	15.9245	4.9955	1.8845	2.7715	3.3135	1.2595
1987	62.2215	16.8645	3.2955	1.0885	0.2885	0.6675	0.4785
1988	166.6585	101.5035	17.9345	4.2315	1.1895	0.6835	0.6684
1989	62.5885	44.8695	13.2645	5.7775	3.4475	1.1415	0.7695
1990	231.0075	102.8355	22.3815	4.7845	2.2265	0.2685	2.7135
1991	37.5065	75.4595	21.0285	6.2545	2.6065	2.5775	0.6465
1992	249.0995	106.4985	33.3155	14.6285	7.5245	4.7545	0.7845
1993	146.6255	154.4875	33.8125	9.1675	3.8695	2.8315	0.8465
1994	94.9145	47.8945	16.5355	9.2765	4.5725	0.9505	1.3515
1995	189.3095	58.2185	5.2265	2.5675	0.8135	0.8495	0.6245
1996	80.0705	79.0695	17.8295	4.7915	1.1525	2.1045	0.8065
1997	31.3715	27.4255	9.3865	5.3905	4.1575	0.5675	1.6635
1998	53.3635	41.9375	9.8765	2.5165	1.6535	0.9105	0.5725
1999	156.4185	97.0725	28.3925	9.1855	3.7725	2.0645	1.3765
2000	147.8075	41.0165	5.4855	2.2645	1.0855	0.9295	0.7035
2001	45.5375	31.4445	19.1445	4.7515	3.5365	1.2165	1.6635
2002	127.0935	53.1605	14.2155	3.2315	0.4025	1.0425	0.0895
2003	-1	-1	-1	-1	-1	-1	-1
2004	186.5145	27.0285	18.7565	4.0895	2.9985	3.4225	0.0895
2005	75.3905	155.5475	23.6635	0.0895	0.0895	0.0895	0.0895
2006	196.1535	97.4725	14.8685	3.6135	1.0895	0.0895	0.0895
2007	89.7415	55.6055	33.7815	11.8455	1.3245	0.0895	0.0895
2008	52.0905	99.7425	40.8285	11.8675	10.9225	1.2005	7.4825
2009	26.2675	20.3115	5.6455	14.4675	5.0895	0.0895	0.0895
2010	96.0185	35.8115	9.2565	5.3675	3.7005	6.7565	1.2005
2011	116.6895	36.8895	0.0895	0.0895	0.0895	1.6895	0.0895
2012	39.8585	33.5115	9.4645	1.2325	0.0895	0.0895	0.0895
2013	110.1595	16.1155	15.6395	0.4405	0.0895	0.0895	0.0895
2014	102.7143	18.3059	9.4471	6.1647	4.7412	1.2	0.9412
2015	273.794	45.873	2.000	2.000	0.0895	0.0895	0.0895

Table 18.2.2 cont. Turbot in Subarea 4: Relative abundance indices used in the assessment. BTS-ISIS.

BTS-ISIS							
Start	0.66	End	0.75				
	1	2	3	4	5	6	7
1985	0.39545	1.28365	0.26525	0.11355	0.05375	0.02135	0.00955
1986	0.22755	0.90425	0.27645	0.10075	0.04255	0.01925	0.00745
1987	0.26385	1.08715	0.27415	0.11135	0.05005	0.03425	0.00765
1988	0.58935	1.19375	0.30315	0.08525	0.03035	0.02755	0.00745
1989	0.37815	1.35885	0.39915	0.12165	0.03985	0.02615	0.01545
1990	2.08255	1.24465	0.25975	0.12565	0.06665	0.02745	0.00965
1991	1.22675	1.66485	0.21705	0.02365	0.01415	0.00025	0.01215
1992	1.36115	1.17845	0.31985	0.03375	0.01545	0.01055	0.00335
1993	1.67955	1.40555	0.18545	0.05225	0.04505	0.00175	0.00075
1994	1.83025	1.58005	0.10225	0.03125	0.00625	0.00325	0.00325
1995	1.83265	0.60705	0.10125	0.01185	0.00895	0.00345	0.00025
1996	0.61465	1.90125	0.11255	0.07465	0.04045	0.00025	0.00915
1997	0.66885	1.30755	0.37765	0.02625	0.03805	0.01335	0.01155
1998	1.91495	0.91595	0.23285	0.15245	0.00475	0.00025	0.00135
1999	1.24255	1.18095	0.19545	0.09545	0.01665	0.00265	0.00115
2000	4.21375	0.84715	0.38565	0.16375	0.05395	0.05465	0.00025
2001	1.04385	1.40955	0.12875	0.15225	0.00025	0.00025	0.04025
2002	2.81445	0.49315	0.14595	0.04625	0.03195	0.02175	0.00095
2003	1.54345	0.87475	0.10115	0.05435	0.00025	0.01215	0.01145
2004	2.16585	0.63995	0.35895	0.00025	0.06855	0.01715	0.00025
2005	1.14255	1.53825	0.52595	0.11575	0.03595	0.00625	0.01215
2006	1.70525	0.79935	0.27315	0.11375	0.00475	0.00025	0.00025
2007	1.34235	0.90235	0.56285	0.27955	0.09035	0.06005	0.00025
2008	1.19555	1.12475	0.43125	0.14325	0.07615	0.01735	0.07975
2009	0.97165	0.41985	0.34585	0.28145	0.15225	0.04955	0.00505
2010	1.69095	0.34825	0.09925	0.07015	0.08895	0.01465	0.01465
2011	1.84005	0.89155	0.16335	0.06325	0.06535	0.01665	0.00025
2012	0.97725	0.93035	0.24015	0.23555	0.02135	0.04495	0.08375
2013	0.66795	0.58505	0.45565	0.15835	0.01775	0.03735	0.04055
2014	2.26954	0.17582	0.22454	0.32127	0.12045	0.04955	0.01422
2015	4.312	1.179	0.173	0.070	0.087	0.00025	0.00025

Table 18.2.2 cont. Turbot in Subarea 4: Relative abundance indices used in the assessment. Dutch 80mm beam trawl (BT2) LPUE: age-aggregated index of exploitable biomass per unit effort (top) and the age-disaggregated index of abundance per unit effort.

DUTCH_BT2_LPUE	
start	0
end	1
	Exploitable biomass
2002	66.545
2003	68.835
2004	70.225
2005	67.795
2006	69.505
2007	89.185
2008	102.285
2009	105.585
2010	86.595
2011	97.285
2012	93.515
2013	105.955
2014	89.775
2015	94.895

DUTCH_BT2_LPUE_AGES									
Start	0								
End	1								
	1	2	3	4	5	6	7	8	9
2002	1.833	13.993	30.153	8.703	6.053	2.083	0.753	0.963	0.173
2003	2.383	25.533	14.613	15.043	4.173	2.643	1.573	0.533	0.723
2004	3.103	27.583	23.873	5.273	5.903	1.223	0.953	0.333	0.153
2005	1.413	23.213	25.313	10.863	1.793	2.793	0.173	0.483	0.193
2006	4.193	20.453	27.443	8.333	4.073	1.263	1.583	0.403	0.053
2007	0.993	42.923	20.493	13.743	3.793	2.753	0.483	0.703	0.023
2008	2.733	30.313	34.123	11.163	11.983	3.563	2.523	0.283	0.743
2009	0.903	17.133	37.753	28.783	8.503	4.113	1.953	1.313	0.153
2010	2.793	22.883	14.933	15.733	11.893	5.613	2.623	1.133	0.903
2011	4.523	29.833	25.053	8.823	10.633	8.713	3.473	1.393	0.563
2012	4.343	35.973	22.713	11.723	3.823	5.573	5.073	0.893	0.913
2013	3.693	24.553	39.023	17.583	7.613	4.623	6.373	3.813	0.633
2014	1.855	14.615	26.725	23.185	10.465	6.155	2.025	2.575	2.175
2015	0.875	33.225	17.015	12.325	19.635	6.835	2.055	1.295	1.635

Table 18.2.3 Turbot in Subarea 4: Biological data used in the assessment. Maturity and natural mortality values are constant over years.

	AGE									
	1	2	3	4	5	6	7	8	9	10+
Maturity	0	0.04	0.47	0.95	1	1	1	1	1	1
Natural Mortality (M)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stock W@A	1	2	3	4	5	6	7	8	9	10
1975	0.27	0.58	1.01	1.53	2.12	2.75	3.41	4.08	4.75	5.39
1976	0.28	0.60	1.04	1.57	2.18	2.84	3.52	4.21	4.90	5.56
1977	0.29	0.62	1.07	1.63	2.25	2.93	3.64	4.35	5.06	5.75
1978	0.30	0.64	1.11	1.68	2.33	3.03	3.76	4.50	5.23	5.94
1979	0.31	0.67	1.15	1.74	2.41	3.14	3.89	4.66	5.42	6.15
1980	0.32	0.69	1.19	1.80	2.50	3.25	4.03	4.82	5.61	6.37
1981	0.33	0.71	1.23	1.87	2.59	3.37	4.18	5.00	5.81	6.60
1982	0.34	0.74	1.28	1.93	2.68	3.48	4.32	5.17	6.01	6.83
1983	0.36	0.76	1.32	2.00	2.77	3.60	4.47	5.35	6.22	7.06
1984	0.37	0.79	1.36	2.07	2.86	3.72	4.62	5.53	6.42	7.30
1985	0.38	0.81	1.41	2.13	2.95	3.84	4.76	5.70	6.63	7.53
1986	0.39	0.84	1.45	2.19	3.04	3.95	4.90	5.87	6.82	7.75
1987	0.40	0.86	1.49	2.25	3.12	4.06	5.04	6.02	7.00	7.96
1988	0.41	0.88	1.52	2.31	3.20	4.16	5.16	6.17	7.17	8.15
1989	0.42	0.90	1.55	2.35	3.26	4.24	5.26	6.30	7.32	8.32
1990	0.43	0.91	1.58	2.39	3.32	4.32	5.35	6.41	7.45	8.46
1991	0.43	0.93	1.60	2.43	3.36	4.37	5.42	6.49	7.54	8.57
1992	0.44	0.93	1.62	2.45	3.39	4.41	5.47	6.55	7.61	8.64
1993	0.44	0.94	1.62	2.46	3.40	4.43	5.49	6.57	7.64	8.68
1994	0.44	0.94	1.62	2.45	3.40	4.42	5.48	6.56	7.63	8.67
1995	0.43	0.93	1.61	2.44	3.37	4.39	5.45	6.52	7.58	8.61
1996	0.43	0.92	1.59	2.40	3.33	4.33	5.38	6.43	7.48	8.50
1997	0.42	0.90	1.56	2.36	3.27	4.26	5.28	6.32	7.34	8.34
1998	0.41	0.88	1.52	2.31	3.20	4.16	5.16	6.17	7.18	8.15
1999	0.40	0.86	1.48	2.25	3.11	4.05	5.02	6.01	6.99	7.94
2000	0.39	0.83	1.44	2.18	3.02	3.93	4.87	5.83	6.78	7.70
2001	0.38	0.80	1.39	2.11	2.92	3.80	4.71	5.64	6.55	7.44
2002	0.36	0.78	1.34	2.03	2.82	3.66	4.54	5.44	6.32	7.18
2003	0.35	0.75	1.29	1.96	2.71	3.53	4.38	5.23	6.09	6.91
2004	0.34	0.72	1.24	1.88	2.61	3.39	4.21	5.04	5.85	6.65
2005	0.32	0.69	1.19	1.81	2.51	3.26	4.05	4.84	5.63	6.39
2006	0.31	0.66	1.15	1.74	2.41	3.14	3.89	4.65	5.41	6.15
2007	0.30	0.64	1.11	1.67	2.32	3.02	3.74	4.48	5.21	5.92
2008	0.29	0.62	1.06	1.61	2.23	2.91	3.61	4.31	5.02	5.70
2009	0.28	0.59	1.03	1.56	2.16	2.81	3.48	4.16	4.84	5.50
2010	0.27	0.58	0.99	1.51	2.09	2.72	3.37	4.03	4.69	5.32
2011	0.26	0.56	0.97	1.46	2.03	2.64	3.27	3.91	4.55	5.17
2012	0.25	0.54	0.94	1.42	1.97	2.57	3.19	3.81	4.43	5.03
2013	0.25	0.53	0.92	1.39	1.93	2.51	3.12	3.73	4.34	4.93

2014	0.24	0.52	0.91	1.37	1.90	2.47	3.07	3.67	4.26	4.84
2015	0.24	0.52	0.90	1.36	1.88	2.44	3.03	3.63	4.22	4.79

Landings W@A	1	2	3	4	5	6	7	8	9	10
1975	0.28	0.61	1.05	1.59	2.20	2.86	3.55	4.25	4.94	5.61
1976	0.29	0.63	1.08	1.64	2.27	2.95	3.66	4.38	5.09	5.79
1977	0.30	0.65	1.12	1.69	2.34	3.05	3.78	4.53	5.26	5.98
1978	0.31	0.67	1.16	1.75	2.42	3.15	3.91	4.68	5.44	6.18
1979	0.32	0.69	1.20	1.81	2.51	3.26	4.05	4.84	5.63	6.40
1980	0.33	0.72	1.24	1.88	2.60	3.38	4.19	5.02	5.83	6.63
1981	0.35	0.74	1.28	1.94	2.69	3.50	4.34	5.20	6.04	6.86
1982	0.36	0.77	1.33	2.01	2.79	3.62	4.50	5.38	6.25	7.10
1983	0.37	0.79	1.37	2.08	2.88	3.75	4.65	5.56	6.47	7.35
1984	0.38	0.82	1.42	2.15	2.98	3.87	4.80	5.75	6.68	7.59
1985	0.40	0.85	1.46	2.22	3.07	3.99	4.95	5.93	6.89	7.83
1986	0.41	0.87	1.51	2.28	3.16	4.11	5.10	6.10	7.09	8.06
1987	0.42	0.89	1.55	2.34	3.25	4.22	5.24	6.27	7.28	8.28
1988	0.43	0.92	1.58	2.40	3.32	4.32	5.36	6.42	7.46	8.47
1989	0.44	0.94	1.62	2.45	3.39	4.41	5.47	6.55	7.61	8.65
1990	0.44	0.95	1.64	2.49	3.45	4.49	5.57	6.66	7.74	8.80
1991	0.45	0.96	1.67	2.52	3.50	4.55	5.64	6.75	7.85	8.91
1992	0.45	0.97	1.68	2.54	3.53	4.59	5.69	6.81	7.91	8.99
1993	0.46	0.98	1.69	2.55	3.54	4.60	5.71	6.83	7.94	9.03
1994	0.46	0.97	1.68	2.55	3.53	4.60	5.70	6.82	7.93	9.01
1995	0.45	0.97	1.67	2.53	3.51	4.57	5.66	6.78	7.88	8.95
1996	0.45	0.96	1.65	2.50	3.47	4.51	5.59	6.69	7.78	8.84
1997	0.44	0.94	1.62	2.46	3.40	4.43	5.49	6.57	7.64	8.68
1998	0.43	0.92	1.58	2.40	3.33	4.33	5.37	6.42	7.47	8.48
1999	0.42	0.89	1.54	2.34	3.24	4.21	5.22	6.25	7.27	8.25
2000	0.40	0.87	1.50	2.27	3.14	4.08	5.07	6.06	7.05	8.01
2001	0.39	0.84	1.45	2.19	3.04	3.95	4.90	5.86	6.81	7.74
2002	0.38	0.81	1.40	2.11	2.93	3.81	4.73	5.65	6.57	7.47
2003	0.36	0.78	1.34	2.03	2.82	3.67	4.55	5.44	6.33	7.19
2004	0.35	0.75	1.29	1.96	2.71	3.53	4.38	5.24	6.09	6.92
2005	0.34	0.72	1.24	1.88	2.61	3.39	4.21	5.03	5.85	6.65
2006	0.32	0.69	1.19	1.81	2.51	3.26	4.05	4.84	5.63	6.39
2007	0.31	0.67	1.15	1.74	2.41	3.14	3.89	4.66	5.41	6.15
2008	0.30	0.64	1.11	1.68	2.32	3.02	3.75	4.49	5.22	5.93
2009	0.29	0.62	1.07	1.62	2.24	2.92	3.62	4.33	5.04	5.72
2010	0.28	0.60	1.03	1.57	2.17	2.82	3.50	4.19	4.87	5.54
2011	0.27	0.58	1.00	1.52	2.11	2.74	3.40	4.07	4.73	5.37
2012	0.26	0.57	0.98	1.48	2.05	2.67	3.31	3.96	4.61	5.24
2013	0.26	0.55	0.96	1.45	2.01	2.61	3.24	3.88	4.51	5.12
2014	0.25	0.54	0.94	1.43	1.98	2.57	3.19	3.81	4.43	5.04
2015	0.25	0.54	0.93	1.41	1.95	2.54	3.15	3.77	4.38	4.98

Table 18.4.1 Turbot in Subarea 4: Estimates of stock numbers at age (thousands) from the SAM assessment.

N@A	1	2	3	4	5	6	7	8	9	10+
1975	4744	4913	2827	881	545	540	430	261	231	918
1976	6898	3766	3573	1466	501	341	338	278	170	749
1977	8518	5899	2665	1885	835	309	218	221	182	598
1978	4683	7212	4269	1472	1103	530	207	148	147	513
1979	3195	3892	5298	2346	882	679	354	138	99	438
1980	3815	2594	2789	2896	1347	557	427	238	91	354
1981	3453	3153	1808	1422	1629	823	359	273	159	291
1982	5017	2801	2256	836	724	971	514	236	180	298
1983	6274	4173	2027	1072	411	418	587	333	149	306
1984	5207	5286	2916	991	508	223	241	354	204	279
1985	2888	4424	3709	1303	500	266	124	148	218	298
1986	3050	2310	3040	1399	530	259	132	74	88	311
1987	3974	2608	1525	1281	605	269	154	76	45	250
1988	4523	3417	1826	710	659	355	168	112	52	199
1989	4756	3711	2249	837	382	385	217	109	72	162
1990	6091	4017	2446	976	428	217	248	147	70	151
1991	5664	4957	2576	988	455	214	120	144	85	128
1992	6289	4715	3066	984	453	229	118	70	84	125
1993	5761	5144	2927	1027	410	219	123	68	41	121
1994	4852	4685	2977	923	386	183	115	70	39	92
1995	5915	3807	2668	814	336	163	93	65	40	74
1996	4270	4939	2243	832	316	160	86	55	38	67
1997	3430	3516	2945	876	385	166	98	52	35	67
1998	4401	2774	2165	1224	445	217	103	65	33	67
1999	3967	3710	1670	943	626	276	144	72	45	69
2000	4697	3094	2159	632	419	316	167	87	44	70
2001	2979	3844	1686	691	217	145	127	70	35	47
2002	4345	2285	1988	424	225	82	51	44	24	29
2003	3878	3519	1031	605	133	90	39	22	19	23
2004	5608	2985	1477	218	179	42	38	17	10	18
2005	4855	4591	1195	378	68	79	20	22	9	16
2006	6069	3842	1947	383	156	33	47	11	13	15
2007	5215	4965	1803	835	190	94	20	30	7	17
2008	2974	4376	2401	771	400	105	56	11	18	14
2009	3362	2254	2011	1080	370	191	54	32	6	19
2010	4951	2712	919	807	522	200	107	31	19	15
2011	5339	4060	1206	364	382	283	104	60	17	19
2012	3591	4419	1754	523	171	201	155	56	33	20
2013	2699	2950	2027	740	246	96	110	83	31	30
2014	5061	1991	1350	853	332	134	57	62	48	36
2015	8038	4073	833	504	293	135	58	29	30	41

Table 18.4.2. Turbot in Subarea 4: Estimates of fishing mortality at age from the SAM assessment.

F@A	1	2	3	4	5	6	7+
1975	0.000	0.131	0.449	0.363	0.279	0.255	0.234
1976	0.000	0.132	0.444	0.363	0.280	0.248	0.230
1977	0.000	0.126	0.396	0.327	0.252	0.217	0.206
1978	0.000	0.127	0.398	0.328	0.256	0.218	0.205
1979	0.000	0.130	0.421	0.354	0.271	0.232	0.208
1980	0.000	0.138	0.469	0.397	0.296	0.252	0.215
1981	0.000	0.147	0.532	0.458	0.329	0.275	0.221
1982	0.000	0.150	0.543	0.488	0.360	0.318	0.256
1983	0.001	0.157	0.553	0.520	0.399	0.362	0.297
1984	0.001	0.173	0.600	0.536	0.414	0.368	0.288
1985	0.001	0.207	0.766	0.682	0.503	0.431	0.317
1986	0.001	0.208	0.705	0.624	0.456	0.363	0.270
1987	0.001	0.197	0.579	0.477	0.341	0.257	0.185
1988	0.001	0.210	0.597	0.467	0.364	0.292	0.233
1989	0.001	0.219	0.616	0.474	0.375	0.290	0.235
1990	0.001	0.248	0.718	0.569	0.484	0.401	0.344
1991	0.001	0.265	0.765	0.595	0.492	0.398	0.336
1992	0.002	0.295	0.873	0.673	0.537	0.420	0.347
1993	0.002	0.323	0.968	0.755	0.593	0.449	0.362
1994	0.002	0.355	1.078	0.823	0.637	0.471	0.372
1995	0.002	0.346	0.971	0.740	0.561	0.415	0.331
1996	0.002	0.309	0.759	0.575	0.434	0.320	0.262
1997	0.002	0.297	0.676	0.502	0.370	0.270	0.222
1998	0.002	0.293	0.623	0.459	0.328	0.234	0.192
1999	0.003	0.338	0.748	0.597	0.474	0.361	0.324
2000	0.004	0.409	0.969	0.865	0.804	0.697	0.700
2001	0.005	0.484	1.128	0.951	0.840	0.788	0.845
2002	0.006	0.526	1.041	0.892	0.733	0.595	0.606
2003	0.009	0.659	1.317	1.083	0.895	0.672	0.639
2004	0.009	0.671	1.158	0.917	0.643	0.450	0.388
2005	0.009	0.607	0.890	0.686	0.479	0.360	0.331
2006	0.007	0.528	0.626	0.479	0.352	0.306	0.305
2007	0.008	0.557	0.632	0.505	0.396	0.361	0.347
2008	0.009	0.583	0.639	0.526	0.438	0.388	0.334
2009	0.010	0.651	0.705	0.540	0.411	0.363	0.330
2010	0.010	0.651	0.699	0.552	0.426	0.398	0.359
2011	0.010	0.648	0.694	0.574	0.444	0.420	0.392
2012	0.010	0.622	0.665	0.578	0.432	0.414	0.388
2013	0.010	0.625	0.674	0.612	0.447	0.402	0.353
2014	0.011	0.693	0.831	0.856	0.674	0.631	0.523
2015	0.013	0.772	1.077	1.184	0.966	0.929	0.761

Table 18.4.3. Turbot in Subarea 4: Summary of assessment results. Values by year with the geometric mean over all years. Biomass values are in tons (t).

	Rec	TSB	SSB	Official Land	Mean F (ages 2–6)
1975	4744	19573	13952	4589	0.295
1976	6898	19649	13452	4816	0.293
1977	8518	20967	13304	4486	0.263
1978	4683	22697	14204	5036	0.265
1979	3195	23272	16352	6365	0.282
1980	3815	22382	17407	5486	0.31
1981	3453	20986	16360	4756	0.348
1982	5017	20177	14854	4454	0.372
1983	6274	20384	13559	4576	0.398
1984	5207	20810	12676	5297	0.418
1985	2888	20309	12851	6188	0.518
1986	3050	17320	11782	5264	0.471
1987	3974	15511	10413	4272	0.37
1988	4523	16411	10104	4042	0.386
1989	4756	17382	10228	4927	0.395
1990	6091	18907	10611	5751	0.484
1991	5664	19357	10189	6340	0.503
1992	6289	19887	10164	5934	0.56
1993	5761	19467	9667	5547	0.617
1994	4852	17912	8903	5244	0.673
1995	5915	16102	7757	4672	0.607
1996	4270	15349	7172	3644	0.479
1997	3430	14904	7875	3382	0.423
1998	4401	14426	8375	3087	0.387
1999	3967	14452	8387	3187	0.503
2000	4697	13549	7536	4026	0.749
2001	2979	10771	5366	4101	0.838
2002	4345	8634	3899	3750	0.757
2003	3878	7744	3100	3375	0.925
2004	5608	7303	2365	3319	0.768
2005	4855	7620	2213	3195	0.604
2006	6069	8220	2665	2977	0.458
2007	5215	9193	3460	3510	0.49
2008	2974	8966	4104	3007	0.515
2009	3362	7818	4417	3091	0.534
2010	4951	7309	3933	2692	0.545
2011	5339	7633	3419	2807	0.556
2012	3591	7521	3388	2914	0.542
2013	2699	6790	3570	3084	0.552
2014	5061	6414	3469	2834	0.737
2015	8038	6967	2569	2925	0.986
Geo.Mean	4586	13451	7177		

Table 18.5.1. Standard deviation estimates for random walks and observations.

Age	1	2	3	4	5	6	7	8	9	10
Random walk log(F) SDs										
	0.29	0.18	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Random walk log(N) SDs										
	0.37	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Rho correlation parameter for random walks on F at age										
	0.86									
Observation SDs										
Landings	2.19	0.55	0.31	0.31	0.31	0.31	0.31	0.31	0.61	0.61
SNS	0.64	0.50	1.10	1.10	1.10	1.10	1.10			
BTS	0.62	0.32	1.43	1.43	1.43	1.43	1.43			

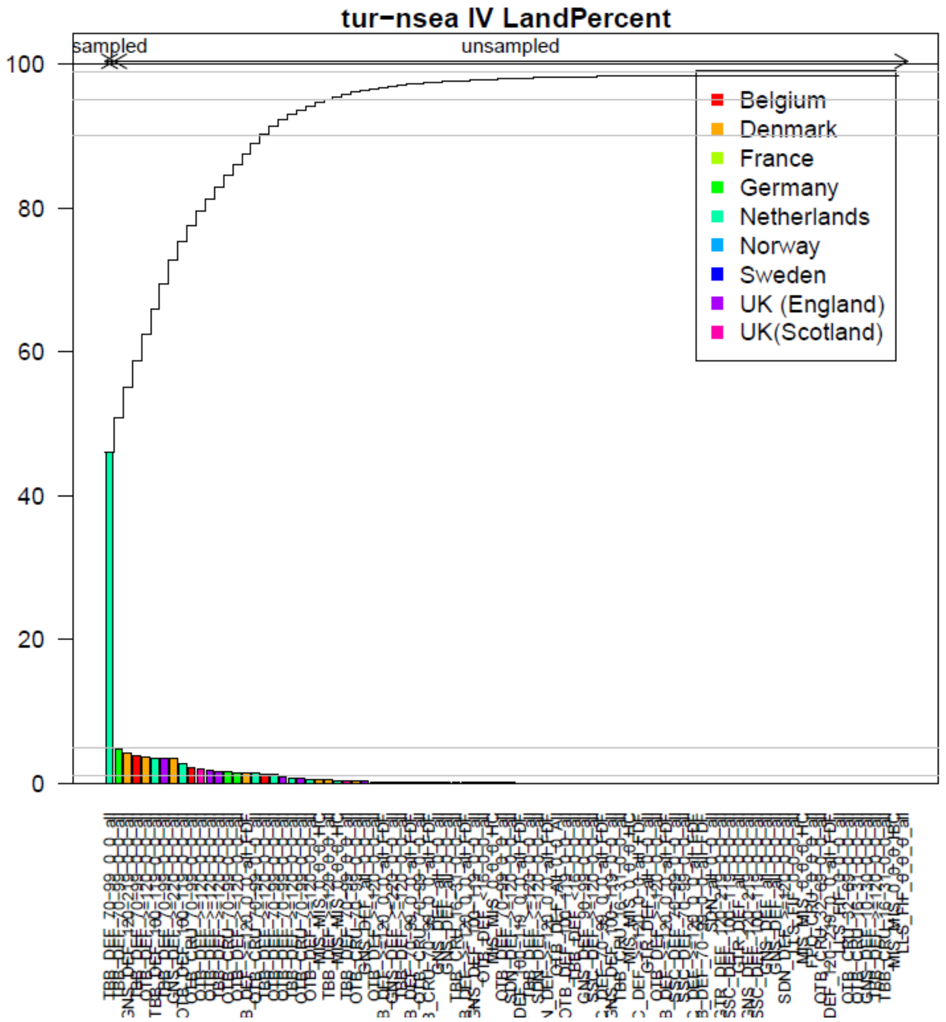


Figure 18.2.1. Turbot in Subarea 4. Top: Total landings by metier in 2014 sorted by sampled/unsampled for numbers at age in InterCatch. Bottom: Distributions of numbers at age by quarter for the two metiers with available samples – NL TBB_DEF_70–99 (left) and NL OTB_DEF_70–99 (right).

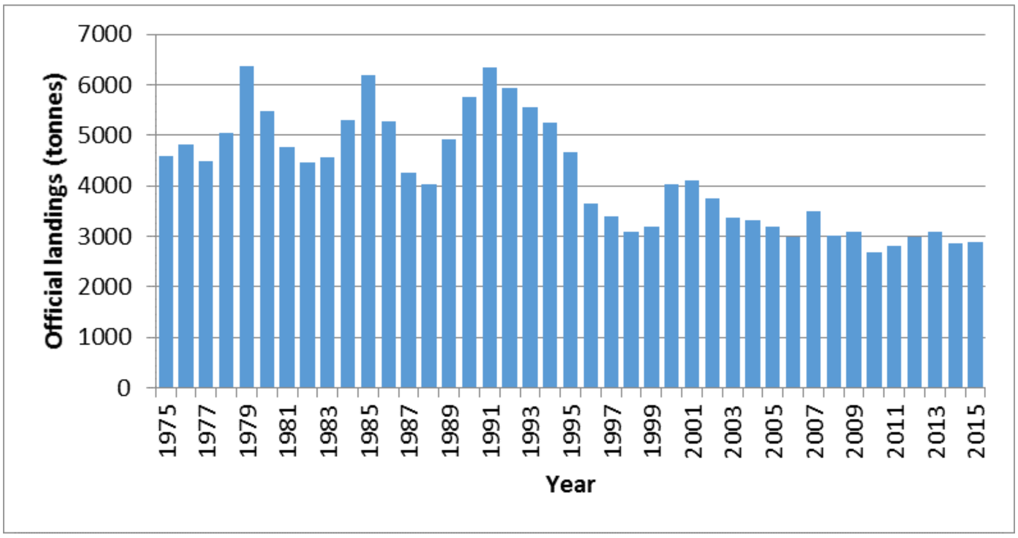


Figure 18.2.2. Turbot in Subarea 4. Total landings 1957–2014 (from the ICES database of official landings).

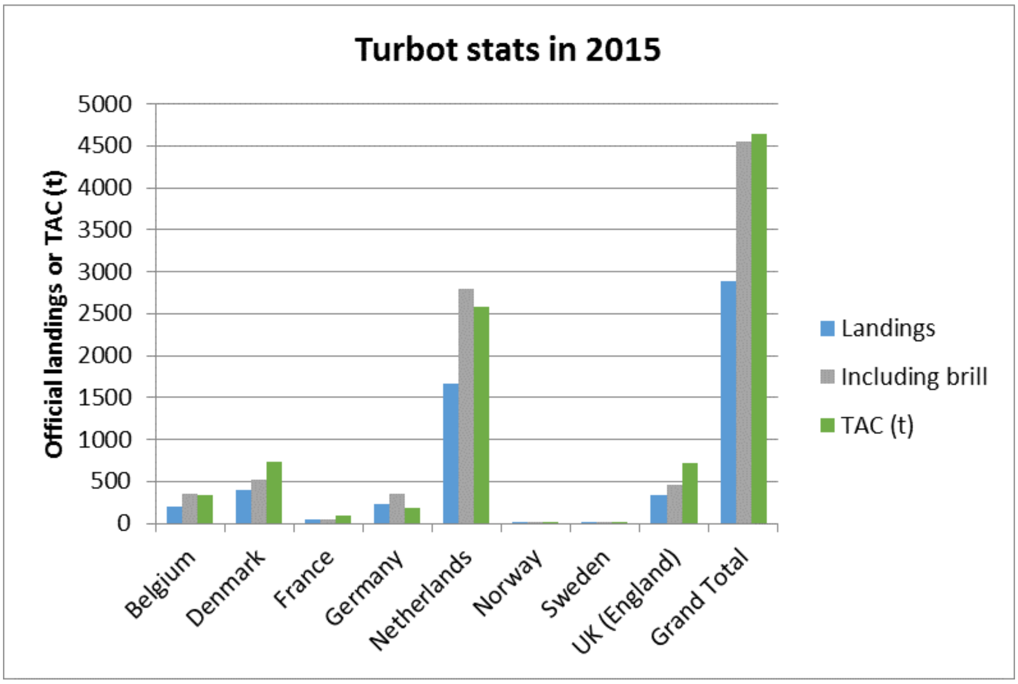


Figure 18.2.3. Turbot in Subarea 4. Official landings by country in 2014 (from the ICES database of official landings) for turbot (blue), turbot and brill combined (green) compared to the combined TAC for turbot and brill (orange).

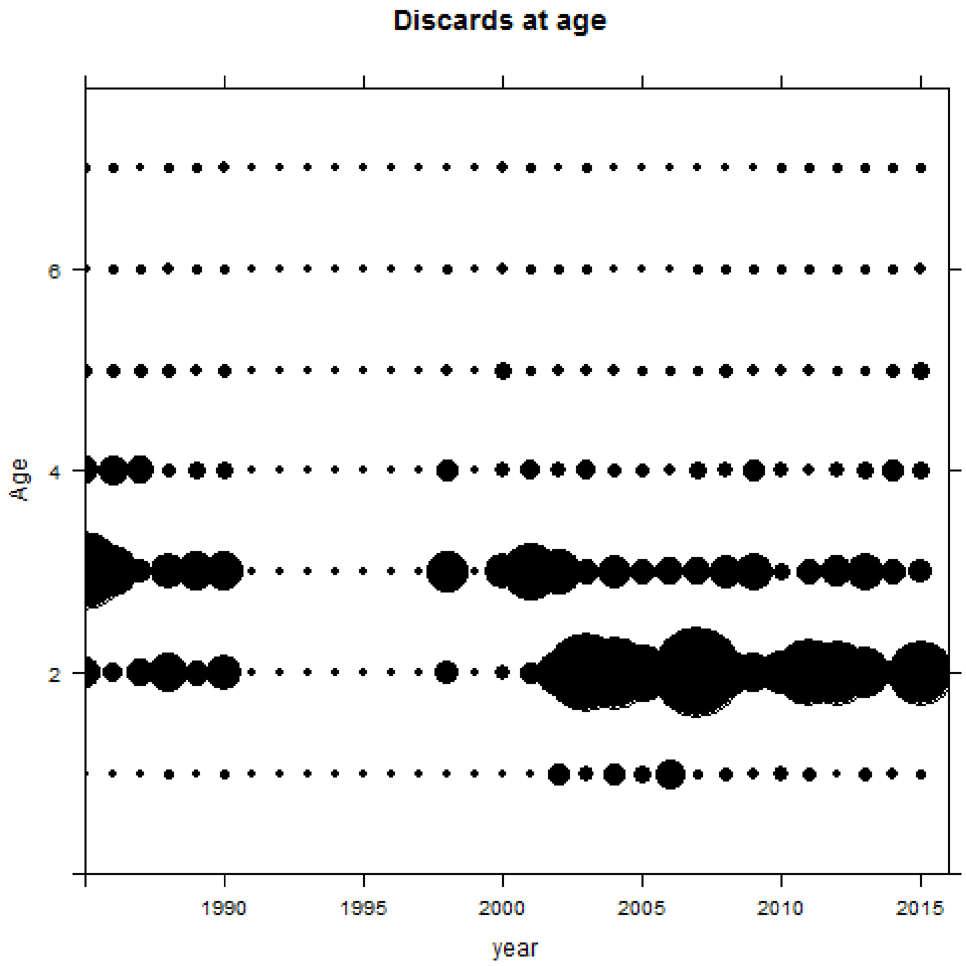


Figure 18.2.4. Turbot in Subarea 4. Landings at age for the years with available data between 1985–2014.

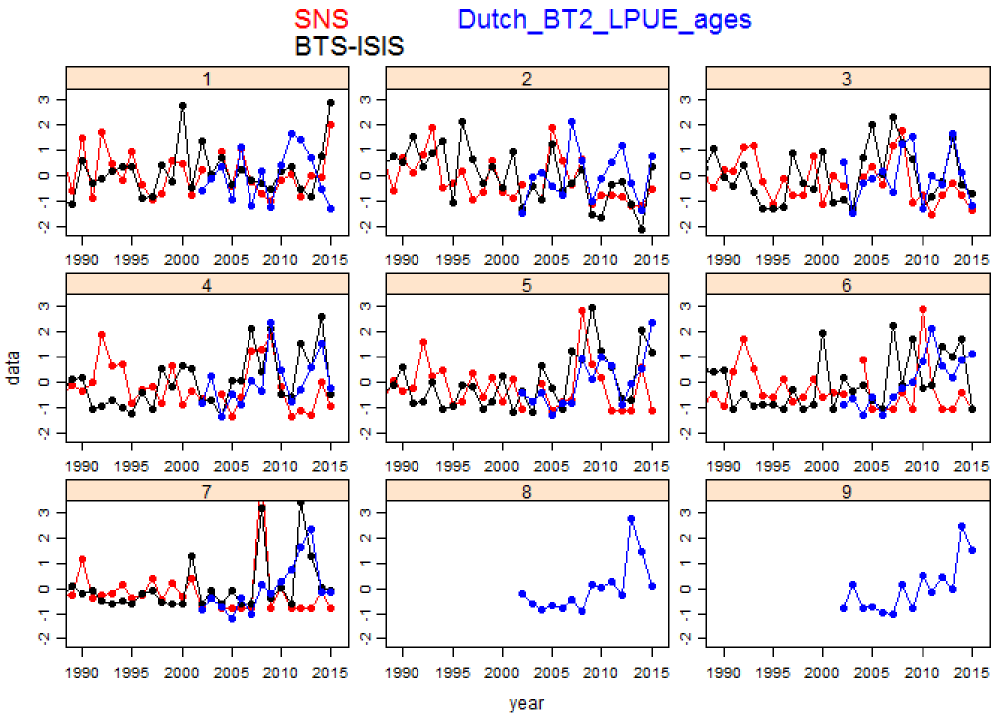


Figure 18.2.5a. Turbot in Subarea 4. Time series of the standardized indices for ages 1 to 9 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE (blue; not used in the final assessment).

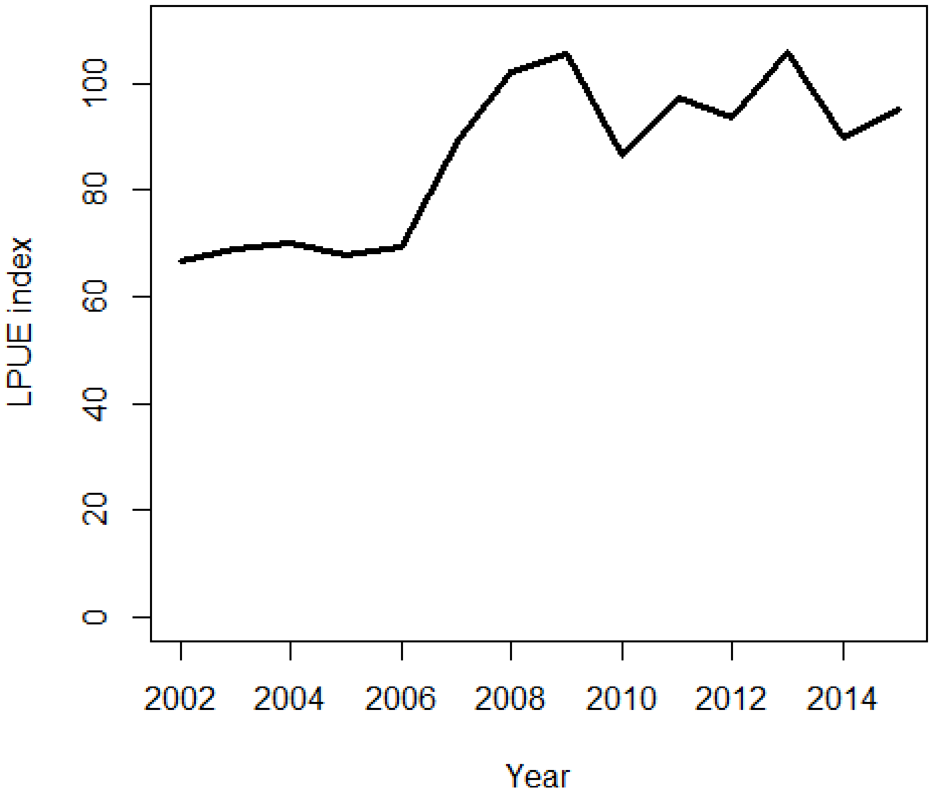
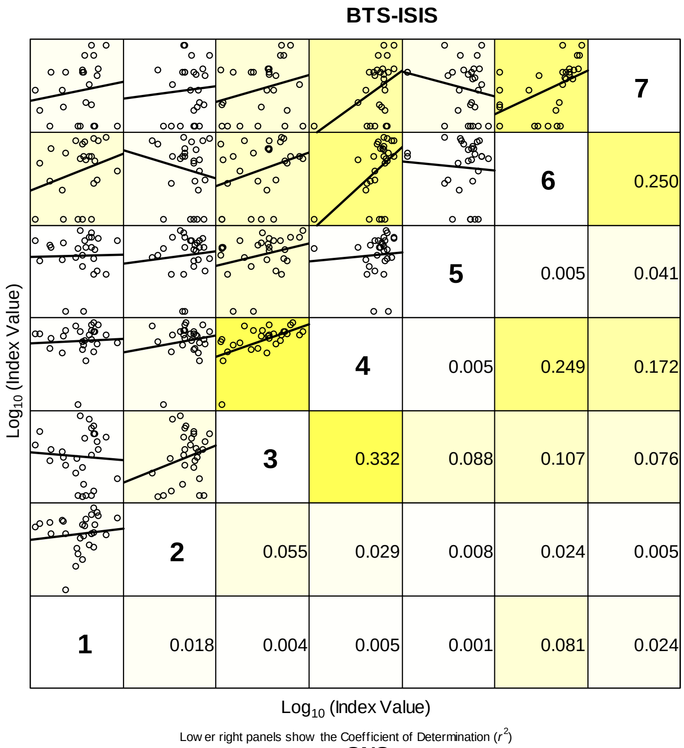


Figure 18.2.5b. Turbot in Subarea 4. Time series of exploitable biomass per unit effort from the NL 80mm beam trawl fleet.



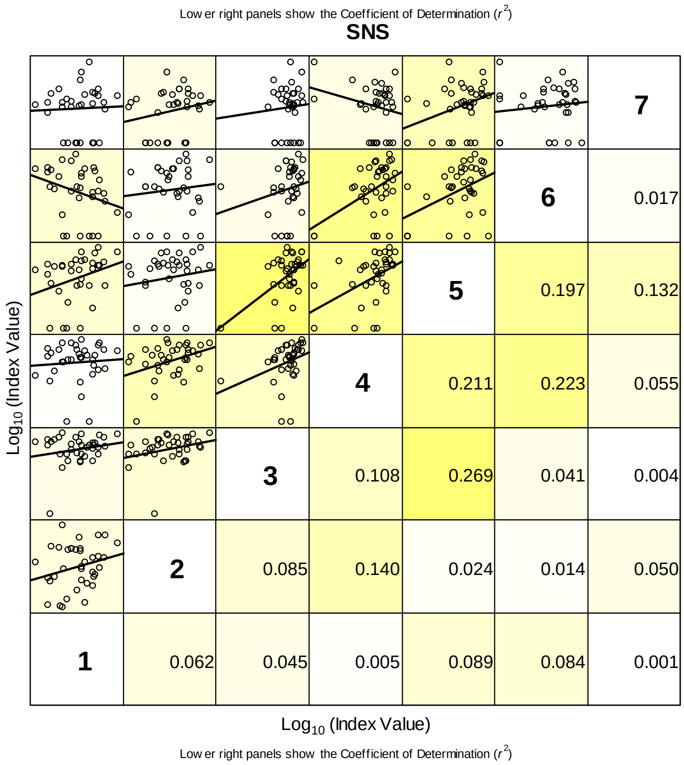


Figure 18.2.6 Turbot in Subarea 4. Internal consistency of the three tuning indices available for the assessment : BTS-ISIS (top), SNS (bottom) and NL beam trawl LPUE (next page, not used in the final assessment).

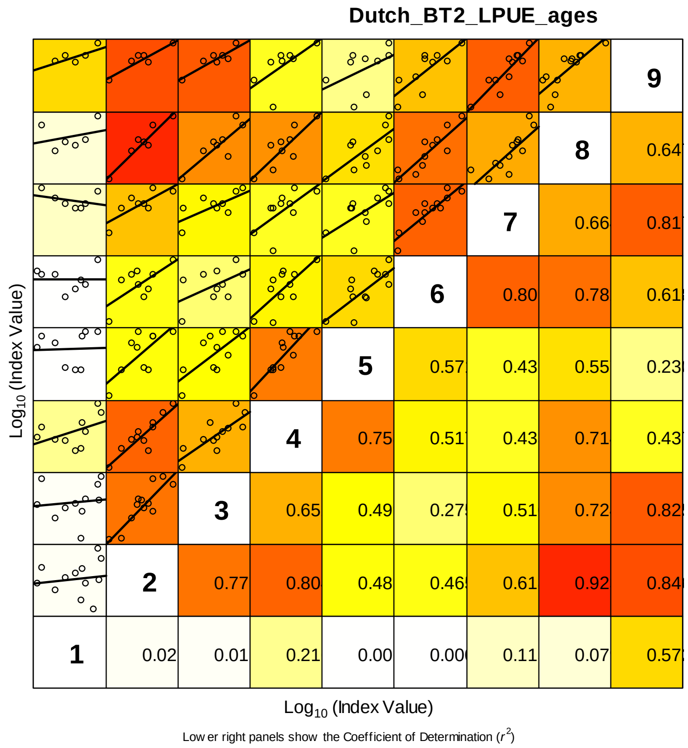


Figure 18.2.6 cont. Turbot in Subarea 4. Internal consistency of the three tuning indices available for the assessment: BTS-ISIS, SNS (previous page) and NL beam trawl LPUE (not used in the final assessment).

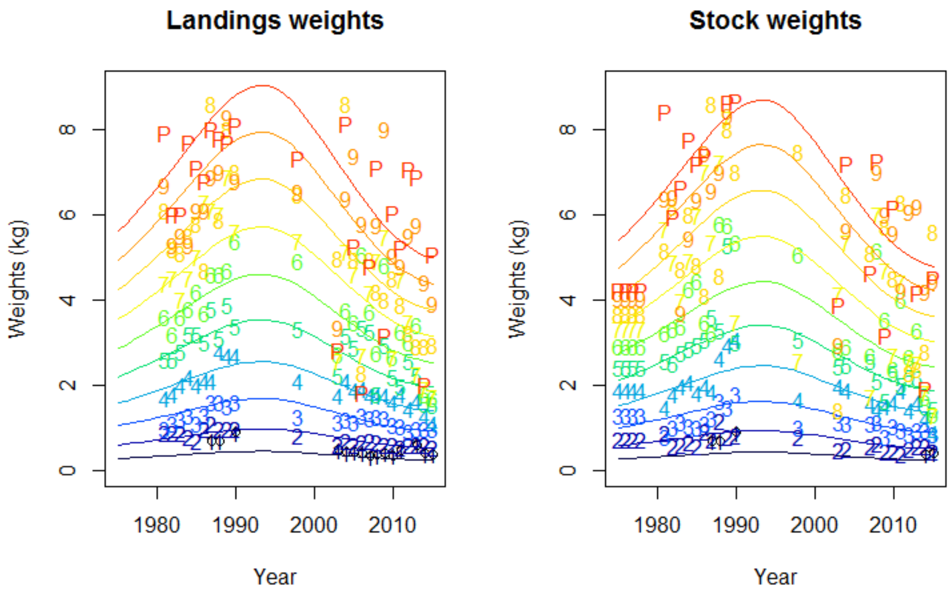


Figure 18.2.7. Landings (left) and stock (right) weight at age from observations (points) and modelled values (lines).

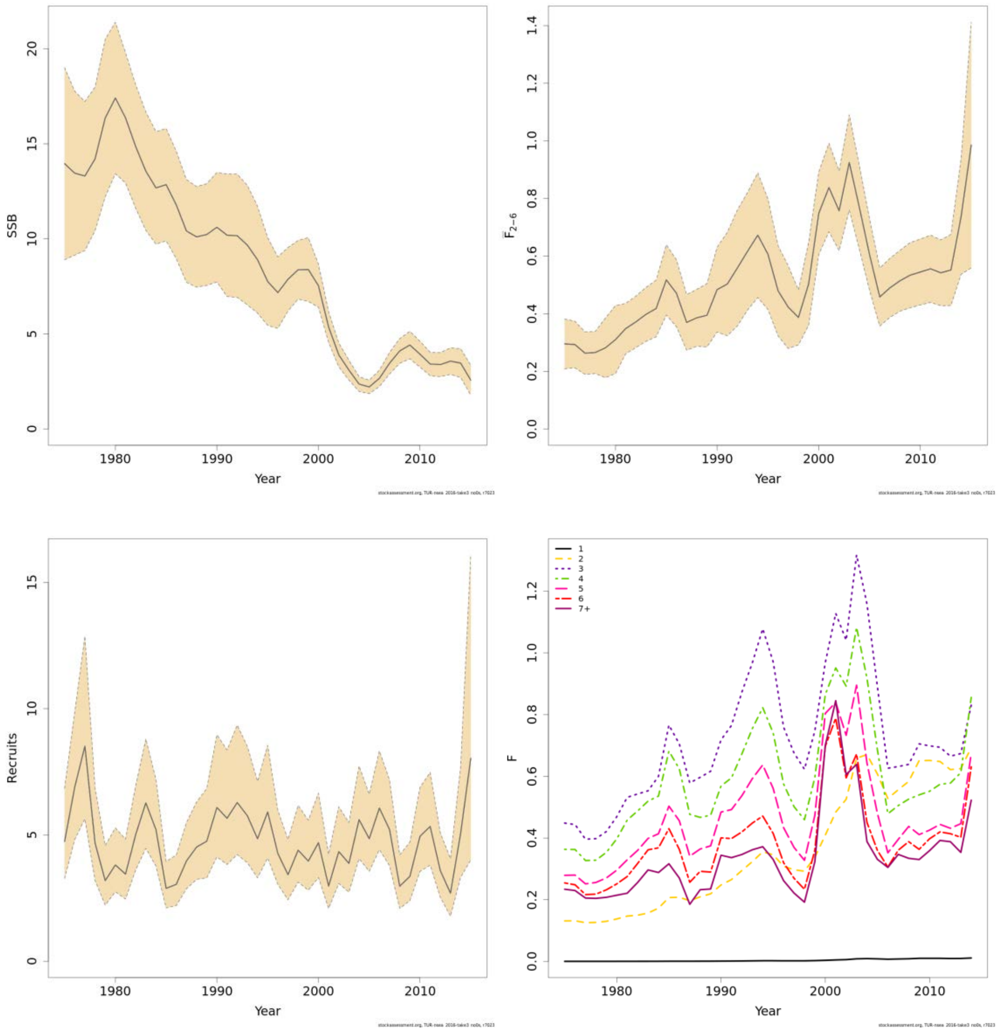


Figure 18.4.1 Turbot in Subarea 4. Key metrics from the assessment model results: spawner stock biomass (top left), mean fishing mortality (ages 2–6; top right), fishing mortality at age (bottom right) and recruitment (bottom left). The best estimate (solid line) and 95% confidence limits (dashed lines, shaded area) are plotted (except for F at age).

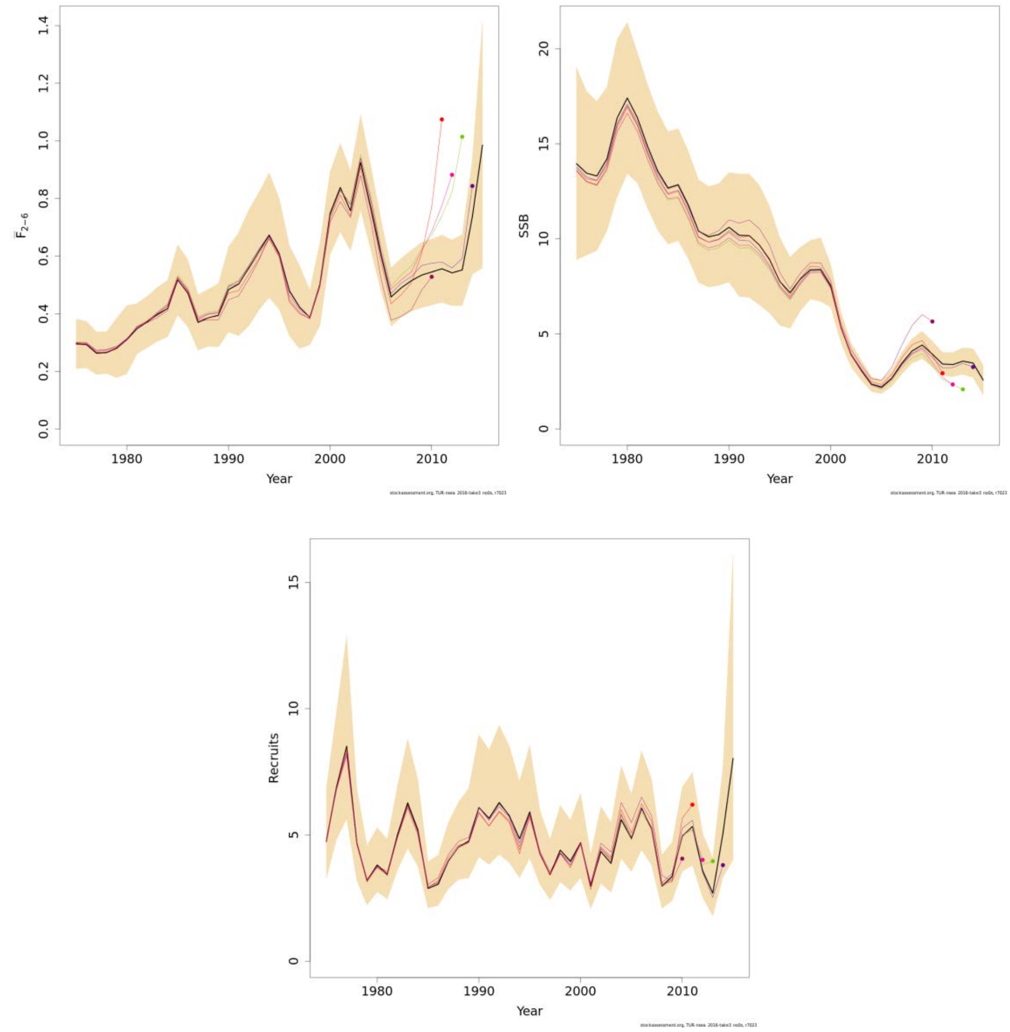


Figure 18.4.2 Turbot in Subarea 4. Retrospective analysis of the key metrics from the assessment model results: spawner stock biomass (top left), fishing mortality (top right) and recruitment (bottom). The current assessment (black line and shaded area for 95% uncertainty bounds) and five retrospective 'peels' (coloured lines) are shown.

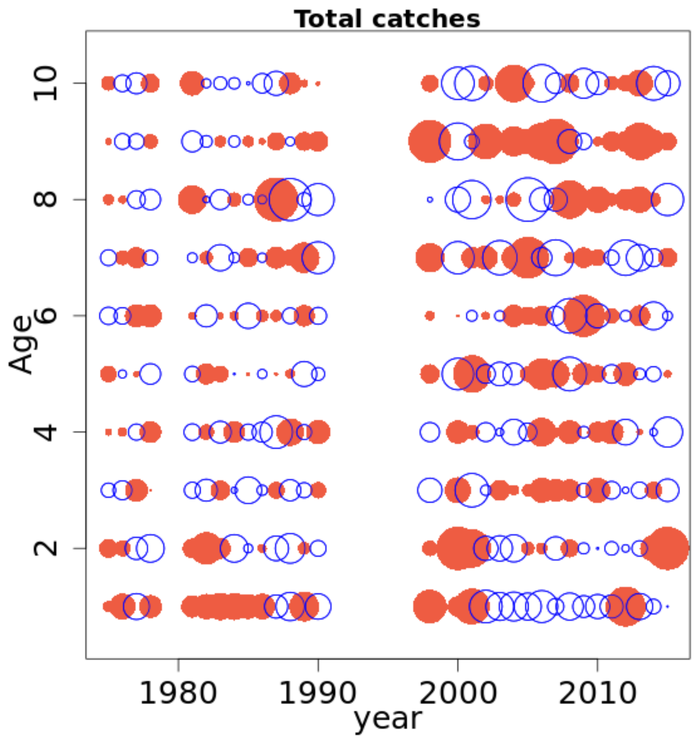


Figure 18.5.1. Turbot in Subarea 4. Log catchability residuals for the landings. Red solid bubbles indicate that the model estimates higher values than observed, hollow blue bubbles indicate that the model estimates lower values than observed.

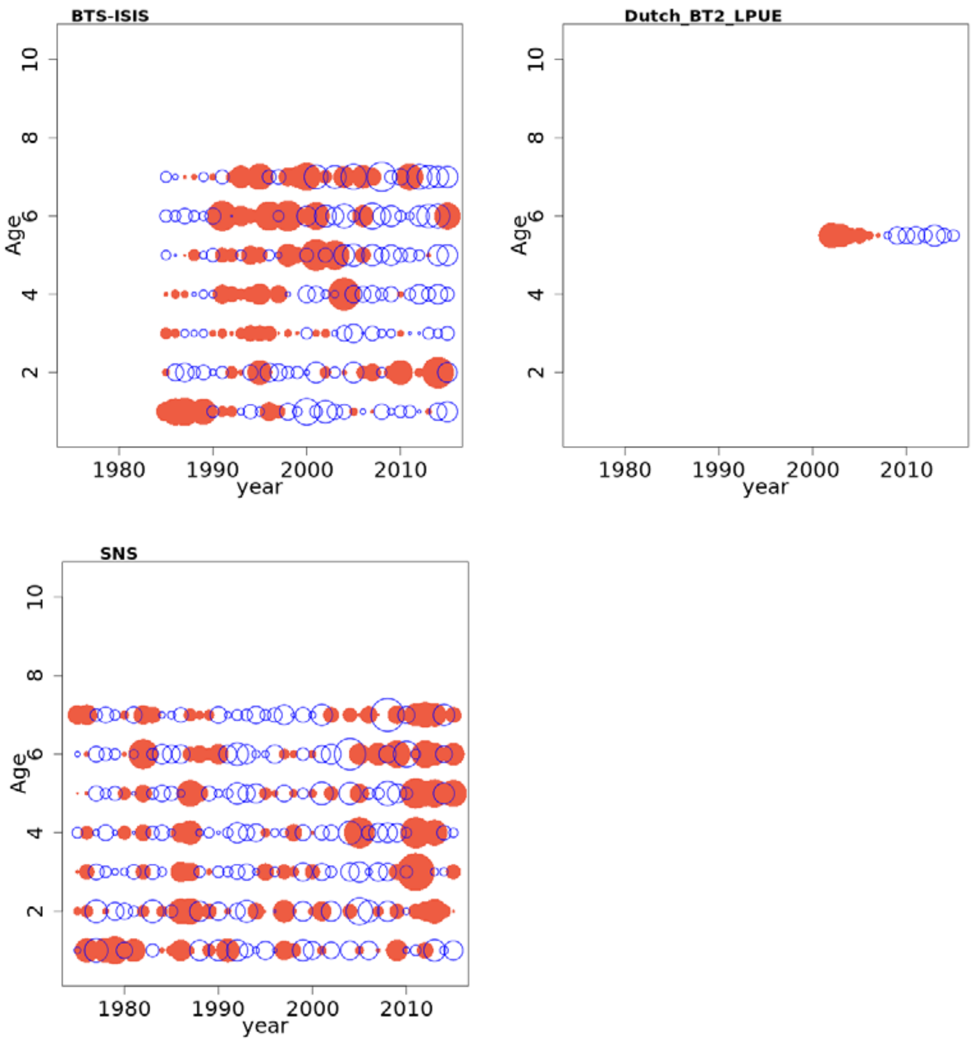


Figure 18.5.2. Turbot in Subarea 4. Log catchability residuals for the three tuning fleets: BTS-ISIS (top left), NL beam trawl LPUE (top right), and SNS (top). Red solid bubbles indicate that the model estimates higher values than observed, hollow blue bubbles indicate that the model estimates lower values than observed.

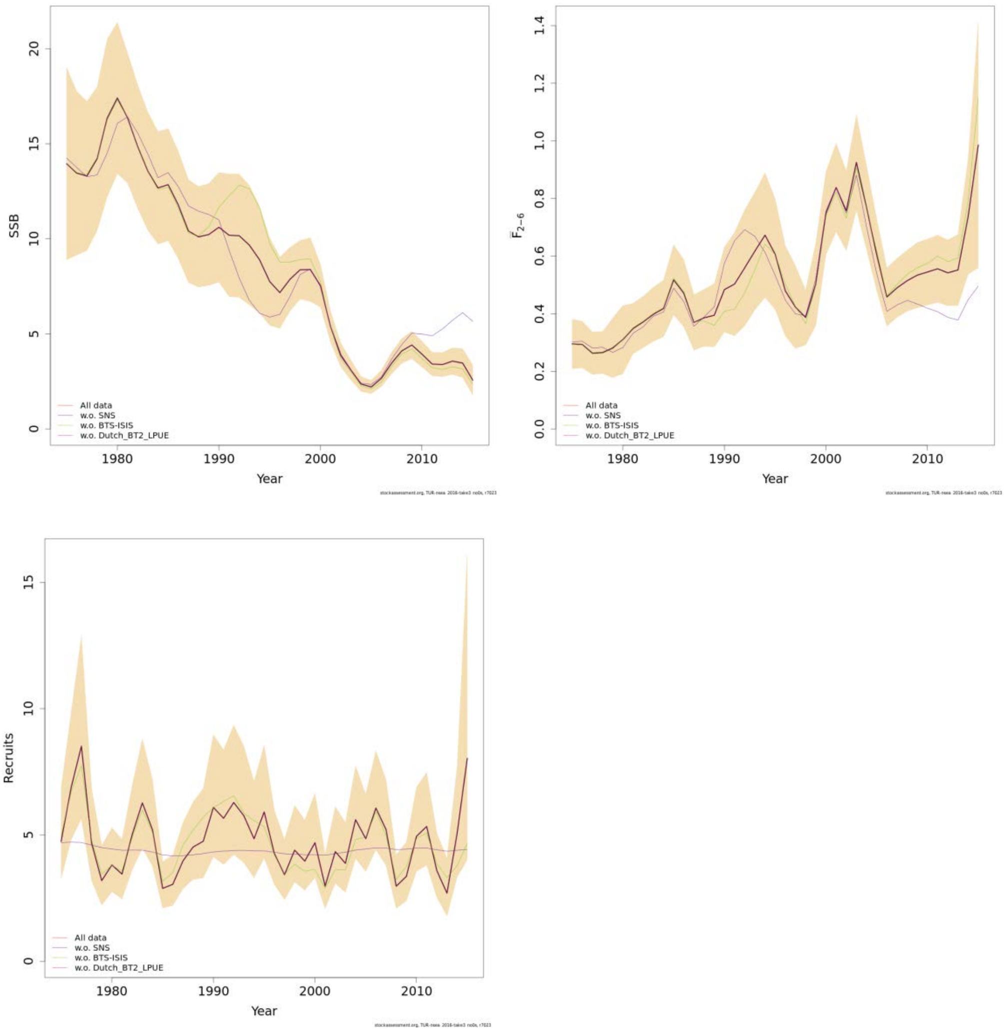


Figure 18.5.3. Turbot in Subarea 4. Leave-one-out (LOO) assessment results: spawner stock biomass (top left), fishing mortality (top right) and recruitment (bottom). The full assessment (black line and shaded area for 95% uncertainty bounds) and three alternative assessments, each leaving out one of the tuning indices: no SNS (purple), no BTS-ISIS (green) and no NL BT2 LPUE (pink).

19 Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)

In 2016, no advice was scheduled for this stock, which is under a biennial advice. So this section only reviews the latest information available (2015 catches, 2015 Quarter 3 and 2016 Quarter 1 surveys).

The general perception is that landings have increased, and that the latest survey estimates are also somehow higher than in the past few years. But these estimates are very noisy with large variations from year to year. WGNSSK considered that the perception of the stock had not changed and did not re-open the advice.

Discards ratio in Kattegat have increased in 2015.

19.1 Management regulations

There are no TACs in place for turbot in area 3.a. So far, no analytical assessments leading to fisheries advice have been carried out for turbot in 3.a by ICES, but some work is ongoing, testing various methods for the assessment of data limited stocks. No precautionary reference points have been proposed, and no management plans are in place for this stock.

There is no official EC minimum landing size.

19.2 Fisheries data

In 3.a, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale *et al.*, 2009), while today turbot is only caught as by-catch in the trawl and gillnet fisheries. Table 19.1 and Figure 19.1 summarize turbot landings in ICES area 3.a. Over the period 1950 – 2015, total landings (3.a) ranged from 64 t to 736 t per year, with the lowest landings during the end of 1960´s and the beginning of the 1970s, and the highest peaks in 1977 and in the early nineties. In the last decade, the total landings of turbot in 3.a had declined from around 350 t pr year to around 100 t per year, but landings in 2015 were higher (175 tonnes).

2015 catch data for turbot-kask were uploaded into InterCatch, according to the specification of the data call. This allowed compiling information by area and metier. Length-based information was provided (mainly for Kattegat), but no ages.

Discard ratios were provided for strata summing up to 72% of the reported landings (71% in Skagerrak, 79% in Kattegat). For those strata where information exist, discards ratios were estimated at 31% of catches in the Kattegat, but only 4% in the Skagerrak. Overall, this discard ratio is almost twice as high as last year in Kattegat (16% in 2014), but at the same level as before for the Skagerrak.

The raising of discards was performed by groups of métiers: all passive gears together (discards ratio close to zero), all trawled gears with mesh size >=120 mm together (medium discards ratio). After raising, the discard ratio for the entire stock area was estimated at 9.1%, which is an slightly increasing trend (6% in 2013, 8% in 2014) (Table 19.2).

19.3 Survey data, recruit series and analysis of stock trends

Two survey series catching turbot are available: the International Bottom Trawl Survey (IBTS), with two research vessels (Argos and Dana), and the Baltic International Trawl

Survey (BITS) with the Danish vessel Havfisken (KASU survey). But since the initial investigations of ICES WGNEW, only the Havfisken trawl survey (BITS) is used to derive an index of abundance of turbot in 3.a. The estimated CPUE is computed in n/hour, and a biomass proxy is calculated using a fixed length-weight relationship from www.fishbase.org (a=0.00802, b=3.260).

Indices are noisy (Table 19.3), but in both surveys the last CPUE estimate (2016 for BITS Q1, and 2015 for BITS Q4) is higher than the last two years. In all four cases (for the two seasons and both in biomass and in number), the 2:3 ratio is above 1. The index used for advice is BITS Q1 in number, and for this one the DLS 2:3 ratio is at 1.196, indicating an increase of 20% in the average of the last two years compared to the previous 3 years.

The length frequency distribution estimated from BITS surveys and aggregated every 5 years does not show major variations since 1990. Most of the fish caught are under 30 cm (Figure 19.2).

19.4 Re-opening of advice

According to the 2:3 rule, the advice in 2016 is more optimistic than the advice in 2015, which called for a reduction of 20%. Nevertheless, WGNSSK notes that the indices available are quite noisy. The average number of fish caught per hour is very small, and with relatively few hauls in the survey. Therefore small variations in the survey catches lead to large differences when expressed in relative changes from year to year. In reality, the BITS Q1 index in number fluctuates around the mean, with a slightly decreasing trend over the time. Therefore, the relatively higher value in 2016 cannot be considered as an increase of the stock at this stage. A few more years would be necessary to confirm this point for being either a noisy estimate or indicative of a real trend.

On this basis, WGNSSK decided not to re-open the advice.

19.5 Biological sampling

WGNEW (2013) noted that turbot is classified as a Group 2 species under the DCF, and detailed some issues limiting the ability of member states to collect biological information for that stock.

19.6 Data recommendations

WGNEW (2013) formulated a number of recommendations for improving the biological knowledge on this stock:

In order to meet the DCF-requirements for sampling of biological parameters for turbot in the Kattegat- Skagerrak, the following countries could be valid candidates to fill current data gaps, according to their importance in turbot fisheries;

- Denmark in the Kattegat-Skagerrak
- Sweden in Kattegat-Skagerrak

General recommendations

- EU to upgrade turbot from Group 2 to Group 1, forcing relevant Member States to collect biological information on a yearly basis
- Relevant Member States to include market sampling for turbot in their National Proposals, thus generating the required funds through the DCF.

19.7 References

ICES. 2013. Report of the Working Group on Assessment of New MoU Species (WGNEW), 18 - 22 March 2013, ICES HQ, Copenhagen, Denmark. ACOM .

Cardinale, M., Linder, M., Bartolino, V., Maiorano, L., and Casini, M. 2009. Conservation value of historical data: Reconstructing stock dynamics of turbot during the last century in the Kattegat-Skagerrak. Marine Ecology Progress Series, 386: 197–206.

Table 19.1. Turbot in 3.a: Official landings by country from 1950 to 2014.

Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total
1950	0	13	212	0	0	1	73	299
1951	0	6	191	0	0	6	62	265
1952	0	6	114	0	0	3	58	181
1953	0	4	80	0	0	4	51	139
1954	0	0	78	0	0	1	61	140
1955	0	4	77	0	0	0	49	130
1956	0	7	75	0	0	0	41	123
1957	0	3	108	0	0	0	30	141
1958	0	7	112	0	0	0	41	160
1959	0	6	132	0	0	3	43	184
1960	0	11	115	0	0	2	46	174
1961	0	4	130	0	0	0	45	179
1962	0	5	157	0	0	0	0	162
1963	0	4	124	0	0	0	0	128
1964	0	5	89	0	0	0	0	94
1965	0	6	79	1	0	0	0	86
1966	0	2	104	0	0	0	0	106
1967	0	4	68	1	0	0	0	73
1968	0	0	64	0	0	0	0	64
1969	0	1	75	0	0	0	0	76
1970	0	1	76	0	0	0	0	77
1971	0	1	100	0	0	0	0	101
1972	0	2	130	0	0	0	0	132
1973	0	2	98	0	0	0	0	100
1974	0	1	116	0	0	0	0	117
1975	0	2	167	0	7	0	7	183
1976	7	2	178	0	190	0	6	383
1977	7	4	331	0	389	0	5	736
1978	2	4	327	0	186	0	6	525
1979	8	0	307	0	87	0	4	406
1980	7	0	205	1	14	0	6	233
1981	2	0	183	2	12	0	8	207
1982	1	0	164	1	9	0	7	182
1983	4	0	171	0	24	0	10	209
1984	0	0	176	0	0	0	12	188
1985	1	0	224	0	0	0	16	241
1986	2	0	180	0	0	0	11	193
1987	5	0	147	0	0	0	9	161
1988	2	0	115	0	11	0	10	138
1989	2	0	173	0	0	0	9	184
1990	5	0	363	0	0	0	18	386
1991	4	0	244	0	0	7	21	276
Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total

YEAR	BEL	DEU	DNK	GBR	NLD	NOR	SWE	TOTAL
1992	4	0	278	0	0	8	19	309
1993	3	0	336	0	0	10	0	349
1994	2	0	313	0	0	15	22	352
1995	4	0	268	0	0	17	11	300
1996	0	0	185	0	0	13	11	209
1997	0	0	200	0	0	9	11	220
1998	0	0	148	0	0	7	8	163
1999	0	0	139	0	0	10	6	155
2000	0	0	180	0	0	6	6	192
2001	0	0	227	0	0	8	3	238
2002	0	0	205	0	0	11	5	221
2003	0	0	128	0	13	14	4	159
2004	0	0	119	0	14	7	7	147
2005	0	0	108	0	7	6	6	127
2006	0	1	95	0	8	8	9	121
2007	0	1	138	0	15	7	12	173
2008	0	1	121	0	4	6	11	143
2009	0	1	94	0	2	6	17	120
2010	0	0	72	0	6	4	13	95
2011	0	1	78	0	0	7	13	99
2012	0	0	168	0	0	8	14	189
2013	0	0	91			5	15	111
2014	0	1	94	0	2	6	17	120
2015	0	0	135	0	20	8	11	175

Table 19.2. Turbot in 3.a: Landings and discards (in kg) after raising in InterCatch.

	Discards	Landings	Grand Total	Discard Ratio
2013	7365.87	112960	120325.87	6.1%
3.aN	1904.79	78830	80734.79	2.4%
3.aS	5461.08	34130	39591.08	13.8%
2014	10508.24	120240.6	130748.84	8.0%
3.aN	2712.3	80968.9	83681.2	3.2%
3.aS	7795.94	39271.7	47067.64	16.6%
2015	18274	183501.8	201775.8	9.1%
3.aN	4639	145083.9	149722.9	3.1%
3.aS	13635	38417	52052	26.2%

Table 19.3. Turbot in 3.a: Average CPUE (n/h) estimated from BITS (KASU) surveys for quarter 1 and quarter 4 between 1996 and 2016, and DLS calculations using 2:3 rule

	Q1	Q1	Q4	Q4
Year	wt	number	wt	number
1992				
1993			1.294	2.000
1994			0.744	2.000
1996	0.860	1.955	0	0.000
1997	0.557	0.422		
1998	1.033	2.500		
1999	1.121	1.227	0.962	1.727
2000	0.430	1	0.207	0.667
2001	0.689	1.818	0.597	1.185
2002	0.254	0.621	0.683	1.515
2003	0.732	1.848	0.236	0.515
2004	0.445	1.030	4.088	2.258
2005	0.393	0.894	0.636	1.197
2006	0.884	1.227	0.362	0.470
2007	0.361	0.894	0.427	1.000
2008	0.809	1.788	0.517	0.867
2009	0.336	0.633	0.303	0.606
2010	0.717	1.533	0.783	2.233
2011	0.400	0.803	0.437	0.712
2012	0.416	0.591	0.304	0.742
2013	0.944	1.455	0.216	0.545
2014	0.190	0.482	0.227	0.377
2015	0.458	0.652	0.926	1.167
2016	1.200	1.364		
2 yrs average	0.829	1.008	0.577	0.772
3 previous	0.517	0.843	0.319	0.666
2:3	1.605	1.196	1.807	1.159

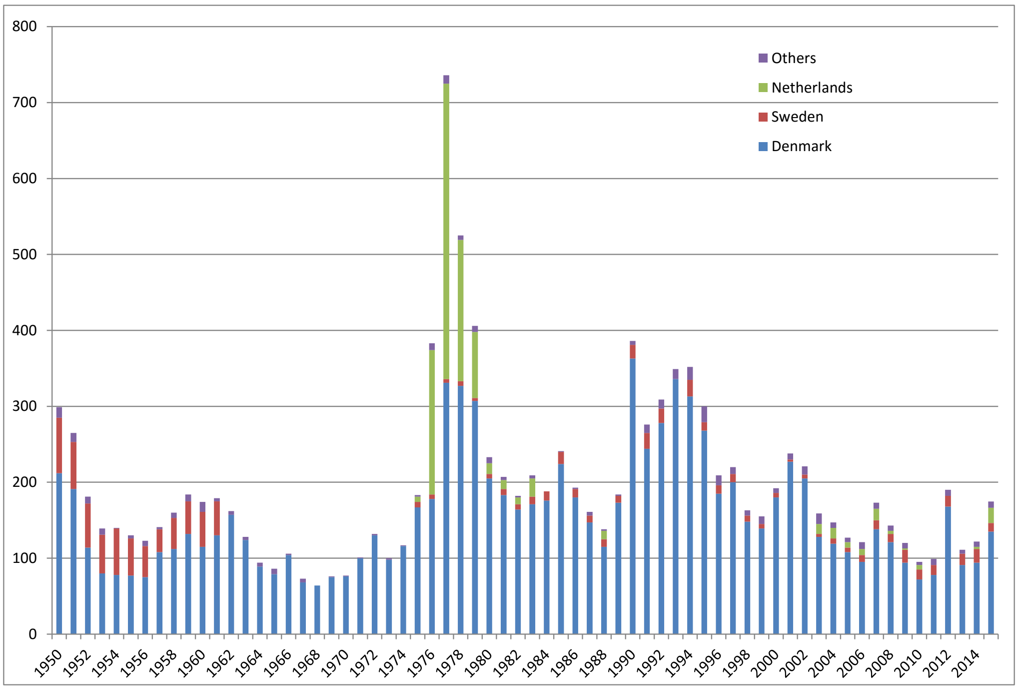


Figure 19.1. Turbot in 3.a: official landings by country from 1950 to 2015.

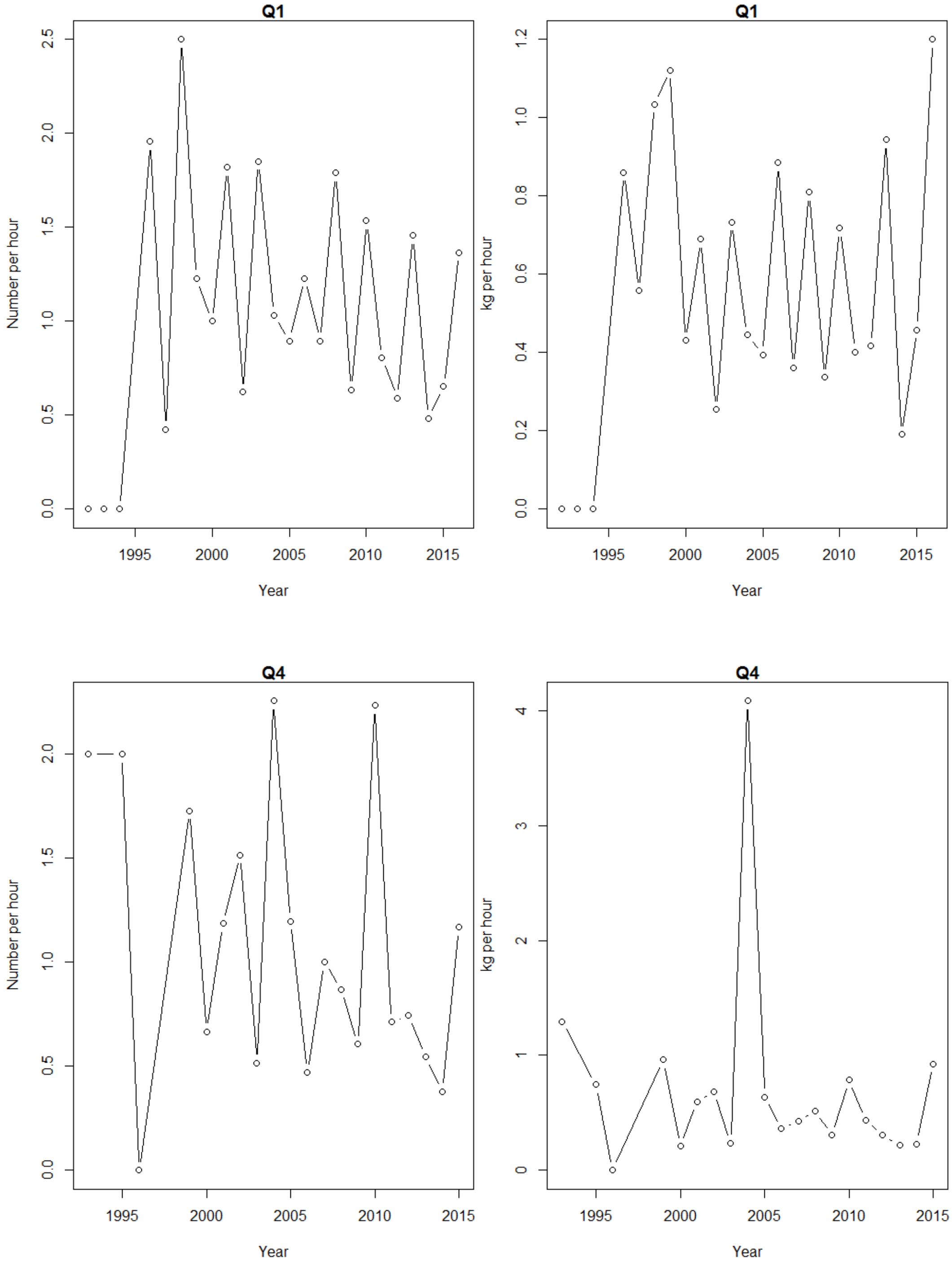


Figure 19.2. Turbot in 3.a. Trend in cpue (in kg/h, left or in n/h, right) estimated from BITS surveys between 2004 and 2016 in quarter 1 (top) and quarter 4 (bottom).

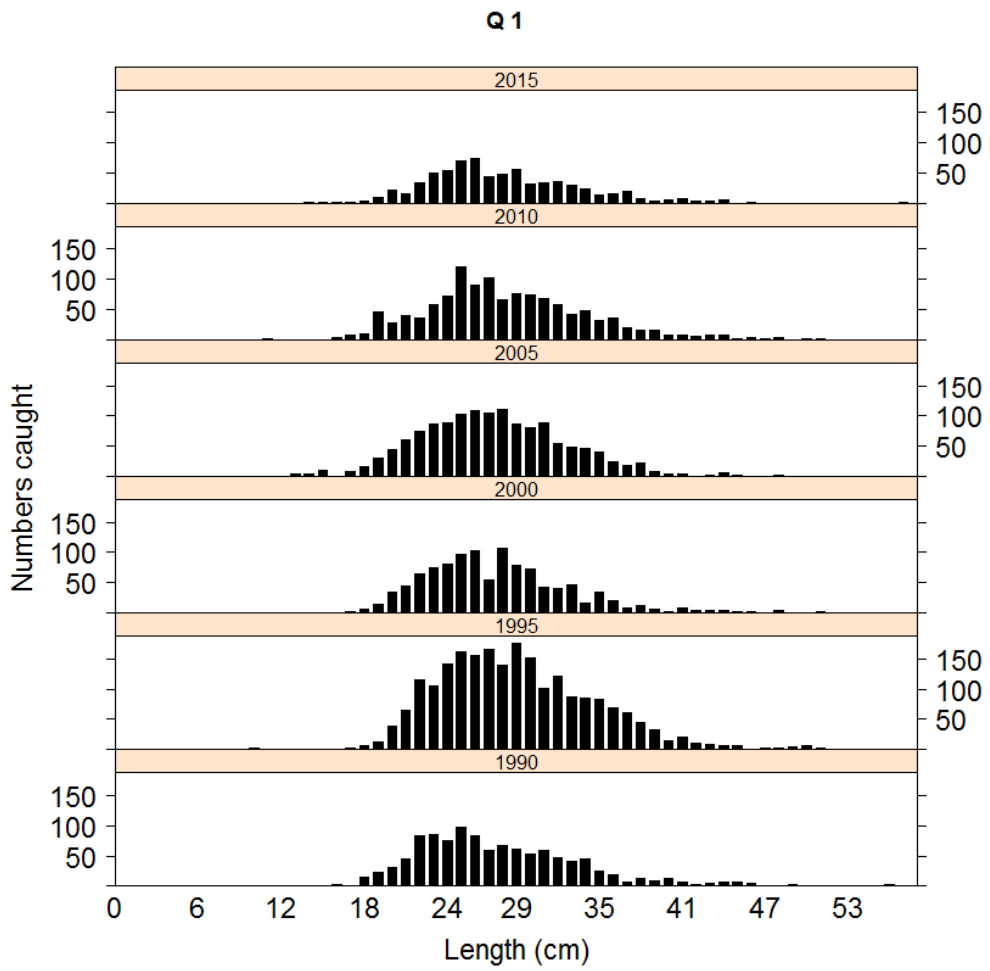


Figure 19.7. Turbot in 3.a. Length frequency distribution derived from BITS surveys in quarter 1 and aggregated every 5 years.

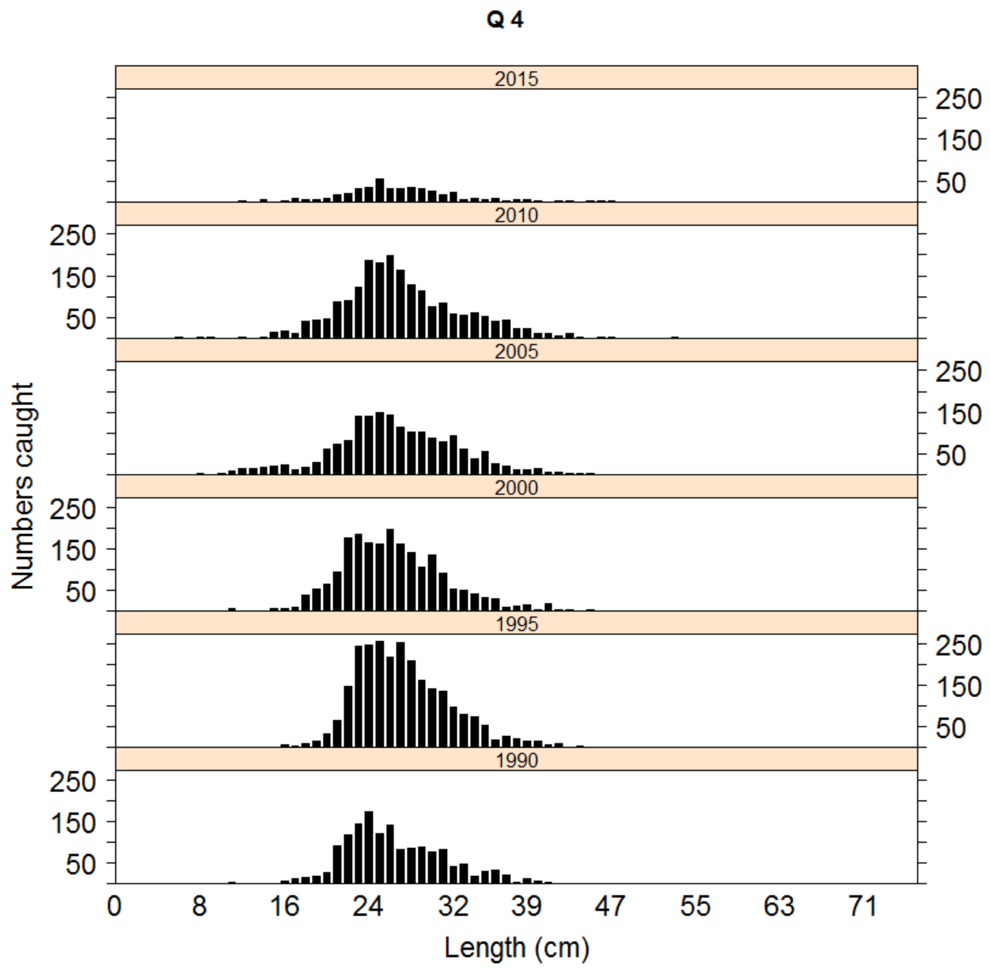


Figure 19.8. Turbot in 3.a. Length frequency distribution derived from BITS surveys in quarter 4 and aggregated every 5 years.

20 Brill (*Scophthalmus rhombus*) in Subarea 4 and Divisions 3.a and 7.d-e (North Sea, Skagerrak and Kattegat, English Channel)

Brill (*Scophthalmus rhombus*) was assessed in the Working Group on Assessment of New MoU Species until 2013 (ICES, 2013a). Because only official landings and survey data were available, brill in the Greater North Sea was defined as a category 3 stock according to the ICES guidelines for data limited stocks (ICES, 2012a). WGNSSK refined the WGNEW-advice in this final year (ICES, 2013b), and biennial advice was given in 2013 (ICES, 2013c) on the basis of LPUE-trends of the Dutch beam trawl fleet (vessels > 221 kW). In 2014–2016, the stock was included in the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group. 2015 and 2016 were the first years in which landings and discards by metier were requested from all countries contributing to the North Sea brill fishery through InterCatch.

20.1 General

20.1.1 Biology and ecosystem aspects

Brill is a shallow-water flatfish mainly found in areas close inshore. It prefers sandy bottoms, but can sometimes also be found on gravel and muddy grounds. Its vertical distribution ranges from 4 meters to 73 meters, although small juvenile fish are often common in sand shore pools. Mature brill are rarely observed inshore, whereas immature specimens are often caught near the coast and even in estuaries.

The distribution of brill in the North Eastern Atlantic ranges along the European coastline from 64° N (the Lofotes) down to 30° N, extending into the Mediterranean and even into the Black Sea (Nielsen, 1986). Brill is also found in the Skagerrak, the Kattegat, and small quantities in the Baltic Sea. The western limit of its distribution area is reached in southern Iceland.

The feeding habits of this species closely resemble those of turbot and were extensively reviewed by de Groot (1971) and Wetsteijn (1981). The pelagic larvae feed primarily on copepod nauplii, decapod and mollusc larvae. With increasing size, this diet gradually changes from larger invertebrate prey and larvae of several fish species to small fish. Larger brill (> 40 cm) are primarily piscivorous.

More information on the biology of brill can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.1.2 Stock identity and possible assessment areas

The oldest study that could be found containing information on the genetic structure of brill was carried out by Blanquer *et al*. (1992), using allozyme electrophoresis. No genetic differentiation could be found between Atlantic and Mediterranean populations, suggesting that there are also very low levels of differentiation in brill from different areas.

In the EU funded study on 'Stock discrimination in relation to the assessment of the brill fishery' the following was concluded (Delbare and De Clerck, 1999): "As a final conclusion, biological parameters (composition of Belgian brill landings, growth rate and reproduction characteristics) and the sequencing of the D-loop resulted in insignificant differences between brill from the different areas. Therefore, arguments favour the hypothesis that brill from the NE Atlantic might be considered to be only one population: the North-eastern Atlantic brill population. Further research on spawning areas and migration through respectively egg surveys and tagging experiments, could generate valuable information about (sub-)population structures of brill throughout its entire distribution area. Therefore it is advisable to extend the sampling area to the Mediterranean Sea and the Black Sea."

Recently, the genetic structure of brill over its entire distribution area has being characterized by Vandamme (2014). Genetic variation was found to be of mean to high levels, but the results show almost no differentiation between potential biological populations and/or management units. Therefore, we still feel confident in treating brill in 3.a, 4 and 7.de as a single stock, which could potentially have an even wider geographical spread.

Further research on brill spawning areas (egg surveys), and of migration of adult (tagging experiments) and especially immature brill (tagging experiments and genetic analysis of the immature population components) could still generate valuable information about (sub-)population structure of brill throughout its entire distribution area.

More information on the delineation of potential brill stocks can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.1.3 Management regulations

Although several EC regulations affect the flatfish fisheries in the North Sea (e.g. effort restrictions, minimum mesh sizes), no explicit management objectives have been defined for the stock of brill in the Greater North Sea, and no management plans are in place. However, for the EU-waters in Division 2.a and Subarea 4, precautionary TACs have been defined for brill and turbot (combined). It is unclear how the quantitative single species advices for turbot and brill are used to formulate a combined TAC, that belongs entirely to the EU-fisheries. A historical overview is presented in the table below.

Historical overview of combined TACs for brill *Scophthalmus rhombus* and turbot *Scophthalmus maximus* in Division 2.a and Subarea 4

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	9000	9000	6750	5738	4877	4550	4323	4323	5263
Year	2009	2010	2011	2012	2013	2014	2015	2016	
TAC	5263	5263	4642	4642	4642	4642	4642	4488	

No restriction on the minimum length for landing brill is imposed by the EC. Some authorities have however installed Minimum Landing Sizes (MLS) for brill. The most frequently applied MLS is 30 cm (e.g., in Belgium, the Baltic, the English Sea Fisheries District Cornwall, …).

20.2 Fisheries data

20.2.1 Landings

Tables 20.1–3 summarize the official brill landings by country for Subarea 4, Division 3.a and Divisions 7.d-e respectively (Source: ICES Fishstat). The total international landings can be consulted in Table 20.4 and Figure 20.1. Over the period 1950–1970, total landings ranged from 582 t to 947 t per year, followed by a gradual increase to 2121 t in 1977. During 1978–2014, total landings varied between 1517 t (in 1980) and

3141 t (in 1993). In 2000–2014, annual total landings fluctuated around an average of 2112 t (range: 1781 t–2409 t). The higher value of The North Sea (4) accounts for the major part of these landings (Figure 20.2), on average generating 68% of the totals over the time series (range: 50–86%). In 2015, landings increased to the third highest value in the time series (2489 t). The English Channel and the Skagerrak are responsible for average contributions to the international brill landings of 19% and 13% respectively. The Skagerrak was responsible for a higher relative importance in the total landings during the first two decades of the time series, and the English Channel has gained importance since the late seventies. No trend towards a higher or lower mean relative contribution of a certain Subarea or Division is apparent in the data for the more recent years. It is however possible that these trends (or lack thereof) are influenced by incomplete statistics for the early part of the time series.

Uptake percentages for brill in the Greater North Sea assessment area cannot be reliably calculated, as the TAC is set combined with turbot. Additionally, there is a mismatch between the assessment and the management areas, as the TAC is set for Subareas 4 and Division 2.a.

More details on the Belgian, Dutch, French and UK fisheries catching brill, and information on length- and age-distributions of Belgian brill landings can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.2.2 Discards

Due to its high value and the absence of a European Minimum Landing Size, brill is not expected to be discarded easily by fishermen catching the species as long as the quota have not been fully taken. The fact that the species is characterized by a fast growth, quickly reaching commercially interesting lengths (unfortunately at relatively young ages and while still immature), explains why smaller individuals are rather rare in commercial catches, contributing to the low numbers of discards. Therefore, earlier evaluations resulted in the labelling of this stock as one with negligible discards, and landings were considered to be a reliable proxy for total catch. The amount of discarding of brill was not thought to be a substantial problem for the assessments of the state of the species's stocks in terms of data completeness. From a biological perspective however, it's a very different story, as most of the discarded fish have not reached sexual maturity yet, and as such have not had the chance to reproduce and contribute to the future generations and future fisheries.

In 2014, discard rates and/or discard data that were raised to fleet levels were available for the first time through InterCatch, for some countries participating in the brill fishery. However, these were not analyzed or incorporated in the assessment, or to top up the landings in order to issue a catch advice, as 2014 was an update year. Under the 2015 data call, 8 countries (Belgium, Denmark, France, Germany, Ireland, The Netherlands, Sweden and the United Kingdom) were expected to upload quarterly discard data by métier and Division in InterCatch, for the years 2012–2014. The response to this data call can be evaluated as very good for this stock. Five countries delivered data for all three years (Belgium, Germany, Netherlands, Norway – that was not in the call, and United Kingdom – both England and Scotland), three countries for 2013 and 2014 (Denmark, France and Sweden), and Ireland for 2014. All subdivisions and the main métiers catching brill (gear types: TBB, OTB, GNS, GTR) were covered in this way, and quarter/country-combinations for which discard information was lacking could be easily filled by allocating discard rates of similar/identical métiers or quarters. The 2016 data call listed the same data demands, and also the response of the different countries can be evaluated as good (both quantitatively and qualitatively).

The resulting overall overview of the raised discard rates in 2012–2015 is shown in Table 20.5, and broken down by country and Subarea/Division for the years 2014–2015 (years with the most complete coverage) respectively in Tables 20.6–7. The overall discard rates in these years (7% in 2012, 4% in 2013, 8% in 2014, 9% in 2015) show no trend (Table 20.5), but may have gone up compared to the years prior to 2012. The overall average discard rate over 2012–2014 is 7%. A comparison can be made with the discard rate time series 2008–2012 for the Belgian TBB_DEF in WGNEW 2013 (ICES, 2013.a). At that time, 7% (in 2011 in 4) was the highest value ever documented in this programme.

The overview by country (Table 20.6, listing discard rates for 2014 and 2015) shows discard rates that are well above the average for Sweden (29–35%) and Denmark (21–22%) in both years, corresponding to the higher discard rates in the North of the assessment area (up to 38% in 3.a; Table 20.7). These higher numbers in the North are largely caused by gillnet and trammel net fisheries taking place there. Remarkable is that the high discard rate of 16% for Germany in 2014 dropped to only 1% in 2015, and that the rather low discard rate of 4% for France in 2014 increased to 24% in 2015.

Length and/or age distributions of brill discards were not requested in the 2015 and 2016 data calls. Details on the numbers at length discarded per hour in the Dutch beam trawl fleet (North Sea) can be found in Annex 5 of WGNEW 2010 (ICES, 2010), and length distributions for the Belgian beam trawl fleet (4, 7.d and 7.e, for the years 2008 – 2012) are presented in WGNEW 2013 (ICES, 2013.a).

20.3 Tuning series

20.3.1 Survey Data

General

Catches of brill are generally very low on surveys. These low catch numbers very often result in an underrepresentation of some year- or length-classes (mainly the older or bigger ones), leading to a poor quality of the resulting survey abundance series and indices, and poor agreement among different surveys.

WGNEW 2012 (ICES, 2012b) tested four surveys for their potential use in describing stock trends of brill in the greater North Sea. Three of these surveys take place in the North Sea (IBTS_TRI_Q1, BTS_TRI_Q3 and BTS_ISI_Q3) and one in the English Channel (CGFS_Q4). Time series of total numbers of brill caught by the three North Sea surveys and the Channel are depicted in WGNEW 2012 (ICES, 2012b), but only the BTS_ISI_Q3 was found to catch a sufficient number of individuals to be useful in the context of evaluating stock trends of North Sea brill. WGNEW 2013 and the following WGNSSK-meetings did not go into these surveys again, with exception for the BTS_ISI_Q3 and BITS_HAF_Q1&4 that were updated because of their use as indicators in the advice that was issued in 2013 (ICES, 2013c) in the North Sea and the Skagerrak respectively. Plots and tables for these surveys were also updated during WGNSSK 2016.

North Sea (Subarea 4)

The abundance indices (numbers per hour) for brill in the BTS_ISI_Q3 in 4 are spatially plotted per rectangle in Figure 20.3 and over time in Figure 20.4 and Table 20.8. These seem to illustrate a recovery of the species in 4 since 2009 after a period of consistent lower catches during 2001–2008, followed by a drop in abundance in 2012–2013, a steep increase in 2014 and again a drop in 2015. The inter-annual variation between all other years is so big that no real trend is apparent over the entire time series. Therefore, the lower catches per hour in 2012 (1.04/hr) in comparison with the higher values in the three preceding years (1.42–2.41/hr), were not yet considered to represent an alarming signal by WGNEW 2013 (ICES 2013.a). The confirmation of the low abundance by the survey in 2013 (0.76/hr, even lower than in 2012 and the 6th lowest value in the time series) raised some concerns during WGNSSK 2013 (ICES 2013b), that appears to be no longer relevant as the abundance index jumped up to 3.04/hr in 2014 (3rd highest value of the time series). The lower value in 2015 (1.84/hr) is still higher than the long term average (1.55/hr).

The corresponding ALK, length distributions (per 5 years) and length-at-maturity are illustrated in Figures 20.5–7. These show that mainly brill of ages 1–2 and lengths of 20–45cm are caught in this survey and that no obvious shifts in length distributions are apparent over the time series (1987–2015). All brill under 30 cm were immature, and all above 40 cm were mature, with a mix of mature and immature individuals between 30 and 40 cm.

Skagerrak/Kattegat (Division 3.a)

Data on brill from the Danish BITS-survey in the Kattegat (BITS_HAF_Q1&4) were analysed separately for the two quarters in which this survey runs by WGNEW 2013 (ICES, 2013.a), revealing almost identical patterns for Q1 and Q4. Therefore, it was decided to combine the data from both quarters for the evaluation of the brill substock in 3.a, and only the results of this combined analysis are updated and presented in this report. The fact that this survey only covers the Kattegat (3.aS) and not the Skagerrak (3.aN) was not considered to be a problem by WGNEW 2013 as the deeper northern waters don't harbour important numbers or densities of brill, that generally prefers more shallow waters.

The abundance indices (numbers per hour) for brill in the BITS_HAF_Q1&4 are spatially plotted per rectangle in Figure 20.8 and over time in Figure 20.9 and Table 20.9. These illustrate a period with higher catches (2006–2011) after a period of consistent lower catches (1996–2005). In 2012, the numbers caught per hour dropped to the level of 2004–2005 again but given the noise in the data (large inter-annual variations) it was considered to be preliminary to interpret this as a sign of a decreasing stock. However, as in the survey used as an indicator for brill in the North Sea, the lower abundance of 2012 (2.27/hr) in 3.a was also followed by an even lower abundance in 2013 (2.13/hr), and a steep increase in 2014 (3.86/hr) up to the highest value ever documented in this survey in 2015 (4.47/hr). Although the survey index values are generally higher in 3.a compared to 4, the trends are remarkably similar in the past few years, except for 2015 (decrease in 4, increase in 3.a).

The corresponding length distributions (per 5 years) for the BITS_HAF_Q1&4 in 3.a are shown in Figure 20.10. As in Subarea 4, no alarming shifts in length distributions (no obvious loss of larger/older individuals from the population) are apparent over the time series (1996–2014). A much bigger overlap in length between the immature and mature stages compared to the North Sea, with mature individuals of lengths lower than 20 cm, was documented in WGNEW 2013 (ICES 2013.a). This illustrates the general phenomenon of slower growth at higher lattitudes that was also published for brill by Delbare & Declerck (1999), that didn't include the Skagerrak/Kattegat in their overview.

English Channel (Divisions 7.d–e)

Unfortunately, no useful survey index could be identified for the evaluation of the brill substock in the English Channel during previous WGNEW meetings (ICES, 2010, 2012b, 2013.a).

20.3.2 Commercial LPUE series

Although the survey indices presented above are useful indicators when evaluating the state of the brill stock in (parts of) the Greater North Sea area, the spatial coverage of both surveys was evaluated as insufficiently spanning the stock area, and the catches too low, to use these surveys as a basis for catch advice, by previous WGNEW and WGNSSK meetings.

A corrected Landings Per Unit of Effort (LPUE) series from the Dutch beam trawl fleet > 221 kW was presented to and discussed for the first time during WGNEW 2013 (see ICES, 2013.a for interpretation), and has been used as the basis for the advice since. These LPUE's were standardized for engine power and corrected for targeting behavior in a way similar to the one used to analyze commercial LPUE data for North Sea plaice. The standardization for engine power is relevant as trawlers are likely to have higher catches with higher engine powers, as they can trawl heavier gear or fish at higher speeds. The correction for targeting behavior relies on reducing the effects of spatial shifts in fishing effort by calculating the fishing effort by ICES rectangle and subsequently averaging these over the entire fishing area. More information on the data that were used (EU logbook auction data and market sampling data), the calculation of the LPUEs, the standardization of engine power, the correction for targeting behavior and the results can be found in van der Hammen *et al*. (2011).

In 2015, a revised LPUE series was delivered to the Working Group, containing fewer years than in the past. Both the old (delivered to WGNSSK 2014) and new (delivered to WGNSSK 2015) series were presented in the corresponding report (ICES 2015). Given the facts that the majority of the brill landings from the greater North Sea originate from Subarea 4, and that around 70% (on average) of these are landed by the Netherlands, this LPUE series may be considered a more reliable time series when evaluating the stock trend of brill in the Greater North Sea. Differences between the two series are discussed in the report of WGNSSK 2015 (ICES 2015), in 2016 only the new series – the one used for the advice - is presented. This series showed a consistently increasing LPUE (kg/day) up to 2012, dropping slightly over 2013–2014 (6% decrease between 2010–2012 and 2013–2014) but increasing again in 2015. As a result, applying the 2:3 rule leads to an increase of 1% between 2011–2013 and 2014–2015.

20.4 Biological sampling and population biology parameters

No new information was obtained compared to previous WGNEW and WGNSSK reports.

20.5 Analyses of stock trends and potential status indicators

So far, no analytical assessments leading to fisheries advice have been carried out for brill in the Greater North Sea by ICES. In the absence of collated and analyzed biological data, Category 3 of the ICES Data Limited Stocks Methodology (ICES, 2012a) is currently the highest attainable category for this stock. Method 3.2.0 specifies that catch advice can be derived from the survey-adjusted status-quo catch in situations where there are survey data on abundance (e.g. CPUE over time), but survey-based proxies for MSY $B_{trigger}$ and F values are not known. Also other indicators of stock size can be used.

WGNEW and WGNSSK tested several surveys for their information content regarding brill in the Greater North Sea over the last few years, and decided to retain only the BTS_ISI_Q3 in 4 and the BITS_HAF_Q1&4 in 3.a as useful indicators for this stock, and to use the commercial LPUE series from the Dutch beam trawl fleet > 221kW as a more reliable time series and basis for the advice.

As brill in the Greater North Sea is a stock for which biennial catch advice was issued in 2015 (valid for 2016 and 2017), and the perception of the stock hasn't changed since, the WG decided not te reopen this advice and stick to the advice issued in 2015.

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Table 20.1 Landings (t) of brill *Scophthalmus rhombus* in Subarea IV (North Sea) by country, over the period 1950–2015 (Source: ICES Fishstat).

YEAR	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1950	34	0	39	0	183	108	1	19	384
1951	23	0	53	0	322	93	1	19	511
1952	21	0	65	0	350	117	3	9	565
1953	23	0	49	0	376	130	0	11	589
1954	19	0	53	0	330	106	14	7	529
1955	23	0	51	0	357	137	3	0	571
1956	28	0	47	0	276	156	0	9	516
1957	32	0	27	0	247	154	0	8	468
1958	43	0	42	0	223	162	0	10	480
1959	41	0	30	0	219	125	0	9	424
1960	55	0	37	0	235	150	1	8	486
1961	102	0	40	0	264	166	0	9	581
1962	97	0	42	0	238	214	0	0	591
1963	79	0	59	0	307	175	0	0	620
1964	79	0	46	0	161	279	0	0	565
1965	71	0	56	0	127	281	0	0	535
1966	100	0	63	0	119	264	0	0	546
1967	138	0	29	0	105	137	0	0	409
1968	152	0	43	0	110	274	0	0	579
1969	145	0	47	0	102	364	0	0	658
1970	114	0	42	0	76	386	0	0	618
1971	187	0	72	0	94	720	0	0	1073
1972	213	0	65	0	51	665	0	0	994
1973	185	0	55	0	39	710	0	0	989
1974	135	0	68	0	44	905	0	0	1152
1975	164	0	76	13	44	925	0	0	1222
1976	148	0	65	10	45	940	0	0	1208
1977	166	0	88	17	60	1079	0	0	1410
1978	175	0	123	26	84	967	0	0	1375
1979	188	0	154	10	103	908	0	0	1363
1980	129	0	104	8	45	747	0	0	1033
1981	148	0	66	5	42	957	0	0	1218
1982	182	0	53	11	41	1007	0	0	1294
1983	182	0	62	23	28	1153	0	0	1448
1984	190	0	73	30	29	1200	0	0	1522
1985	187	0	71	35	46	1370	0	0	1709
1986	131	0	76	4	46	950	0	0	1207
1987	140	0	50	17	48	715	0	0	970
1988	102	0	33	18	52	880	0	0	1085
1989	112	0	43	9	58	1080	0	0	1302
1990	168	0	139	24	82	480	0	0	893
1991	205	38	145	28	147	1111	8	0	1682

YEAR	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1992	203	59	77	34	218	1196	22	1	1810
1993	291	63	118	38	268	1647	14	0	2439
1994	208	90	109	28	235	1235	11	0	1916
1995	194	67	55	24	145	943	6	0	1434
1996	206	47	64	15	175	732	8	0	1247
1997	129	48	38	1	135	590	16	0	957
1998	160	58	58	11	172	808	16	0	1283
1999	161	51	91	0	156	805	16	0	1280
2000	167	77	93	16	141	998	16	0	1508
2001	182	66	67	12	158	1075	13	0	1573
2002	145	58	52	10	120	907	10	0	1302
2003	145	70	57	9	119	934	12	0	1346
2004	140	66	77	7	168	772	19	0	1249
2005	120	62	89	7	138	716	28	0	1160
2006	105	55	75	9	154	765	12	0	1175
2007	110	47	52	12	156	854	9	0	1240
2008	117	42	86	5	93	650	11	0	1004
2009	109	54	96	8	105	786	4	0	1162
2010	104	75	97	12	136	1072	4	0	1500
2011	101	57	122	13	137	1061	6	0	1497
2012	110	71	126	12	102	1084	7	0	1512
2013	100	63	123	10	117	972	4	0	1389
2014	98	69	96	9	116	811	9	4	1212
2015	149	115	122	7	136	1124	1	0	1655

Table 20.2 Landings (t) of brill *Scophthalmus rhombus* in Subdivision 3.a (Skagerrak) by country, over the period 1950–2015 (Source: ICES Fishstat).

YEAR	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
1950	0	0	234	0	0	85	319
1951	0	0	260	0	4	73	337
1952	0	0	170	0	1	65	236
1953	0	0	175	0	0	71	246
1954	0	0	155	0	1	78	234
1955	0	0	150	0	0	62	212
1956	0	0	163	0	0	50	213
1957	0	0	110	0	0	38	148
1958	0	0	166	0	0	37	203
1959	0	0	175	0	0	58	233
1960	0	0	272	0	0	46	318
1961	0	0	255	0	0	50	305
1962	0	0	207	0	0	0	207
1963	0	0	120	0	0	0	120
1964	0	0	106	0	0	0	106
1965	0	0	155	0	0	0	155
1966	0	0	187	0	0	0	187
1967	0	0	106	0	0	0	106
1968	0	0	100	0	0	0	100
1969	0	0	99	0	0	0	99
1970	0	0	97	0	0	0	97
1971	0	0	104	0	0	0	104
1972	0	0	120	0	0	0	120
1973	0	0	131	0	0	0	131
1974	0	0	200	0	0	0	200
1975	0	0	167	1	0	19	187
1976	1	0	185	26	0	12	224
1977	1	0	276	99	0	12	388
1978	0	0	178	27	0	11	216
1979	0	0	156	17	0	11	184
1980	2	0	69	1	0	10	82
1981	0	0	54	0	0	5	59
1982	1	0	64	1	0	8	74
1983	0	0	73	3	0	7	83
1984	0	0	89	0	0	8	97
1985	0	0	100	0	0	10	110
1986	0	0	94	0	0	13	107
1987	0	0	93	0	0	12	105
1988	0	0	91	0	0	10	101
1989	0	0	88	0	0	9	97
1990	1	0	116	0	0	11	128
1991	1	0	81	0	7	10	99

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
1992	1	0	123	0	7	15	146
1993	2	0	184	0	10	16	212
1994	0	0	191	0	12	19	222
1995	0	0	124	0	13	14	151
1996	0	0	94	0	12	6	112
1997	0	0	83	0	11	12	106
1998	0	0	108	0	10	14	132
1999	0	0	126	0	13	18	157
2000	0	0	112	0	12	17	141
2001	0	0	73	0	13	12	98
2002	0	0	66	0	12	12	90
2003	0	0	99	1	12	16	128
2004	0	0	119	4	15	18	156
2005	0	0	101	3	16	13	133
2006	0	1	105	3	16	15	140
2007	0	1	119	3	15	20	158
2008	0	2	138	1	13	30	184
2009	0	1	98	1	14	33	147
2010	0	1	95	1	9	16	122
2011	0	1	103	0	15	12	131
2012	0	0	89	0	16	15	120
2013	0	0	70	0	9	13	92
2014	0	0	59	0	8	11	79
2015	0	0	104	11	8	19	143

Table 20.3 Landings (t) of brill *Scophthalmus rhombus* in Subdivisions 7.de (English Channel) by country, over the period 1950–2015 (Source: ICES Fishstat).

YEAR	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
1950	11	0	0	48	0	0	0	59
1951	8	0	0	70	0	0	0	78
1952	6	0	0	66	0	0	0	72
1953	2	0	0	60	0	0	0	62
1954	1	0	0	59	0	0	0	60
1955	4	0	0	57	0	0	0	61
1956	2	0	0	58	0	0	0	60
1957	4	0	0	66	0	0	0	70
1958	2	0	0	65	0	0	0	67
1959	1	0	0	58	0	0	0	59
1960	6	0	0	46	0	0	0	52
1961	1	0	0	46	0	0	0	47
1962	3	0	0	52	0	0	0	55
1963	1	0	0	50	0	0	0	51
1964	0	0	0	60	0	0	0	60
1965	2	0	0	46	0	0	0	48
1966	0	0	0	53	0	0	0	53
1967	1	0	0	66	0	0	0	67
1968	3	0	0	54	0	0	0	57
1969	2	0	121	67	0	0	0	190
1970	10	0	0	49	0	0	0	59
1971	18	0	0	48	0	0	0	66
1972	20	0	0	52	0	3	0	75
1973	20	0	0	70	0	0	0	90
1974	25	0	0	56	0	0	0	81
1975	24	0	55	56	0	0	2	137
1976	41	0	170	72	0	0	2	285
1977	45	0	197	77	0	0	4	323
1978	58	3	227	120	0	0	3	411
1979	55	0	262	140	0	0	2	459
1980	64	2	213	118	3	0	2	402
1981	83	0	271	130	0	0	6	490
1982	105	0	225	149	0	1	7	487
1983	107	0	234	181	0	1	3	526
1984	114	0	226	186	0	0	5	531
1985	94	0	213	177	0	0	10	494
1986	115	0	183	147	0	0	11	456
1987	126	0	216	141	0	0	10	493
1988	112	0	202	133	0	0	5	452
1989	89	0	213	121	0	0	2	425
1990	99	0	249	187	0	0	8	543
1991	81	0	249	140	0	0	0	470

YEAR	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
1992	82	0	223	151	0	0	7	463
1993	78	0	256	152	0	0	4	490
1994	88	0	227	170	0	0	5	490
1995	91	0	248	200	1	0	18	558
1996	105	0	240	253	0	0	10	608
1997	107	0	185	198	1	0	10	501
1998	70	0	196	173	0	2	10	451
1999	97	0	0	127	0	3	13	240
2000	164	0	260	232	1	4	17	678
2001	212	0	256	251	0	2	17	738
2002	204	0	268	227	0	1	16	716
2003	217	0	287	238	1	1	15	759
2004	165	0	259	223	1	3	15	666
2005	138	0	267	183	0	2	21	611
2006	180	0	281	170	0	3	15	649
2007	205	0	325	199	0	1	11	741
2008	154	0	225	199	0	2	13	593
2009	131	0	278	171	0	1	10	591
2010	145	0	340	198	0	1	11	695
2011	141	0	277	204	0	0	0	622
2012	121	0	263	232	0	1	0	617
2013	143	0	237	214	0	1	6	601
2014	165	0	243	232	0	1	10	651
2015	162	0	274	250	0	0	5	691

Table 20.4 Total international landings (t) of brill *Scophthalmus rhombus* in the Greater North Sea over the period 1950–2015, subdivided into Subarea 4 and Subdivisions 3.a and 7.d-e (Source: ICES Fishstat).

Year	3.a	4	7.de	TOTAL
1950	319	384	59	762
1951	337	511	78	926
1952	236	565	72	873
1953	246	589	62	897
1954	234	529	60	823
1955	212	571	61	844
1956	213	516	60	789
1957	148	468	70	686
1958	203	480	67	750
1959	233	424	59	716
1960	318	486	52	856
1961	305	581	47	933
1962	207	591	55	853
1963	120	620	51	791
1964	106	565	60	731
1965	155	535	48	738
1966	187	546	53	786
1967	106	409	67	582
1968	100	579	57	736
1969	99	658	190	947
1970	97	618	59	774
1971	104	1073	66	1243
1972	120	994	75	1189
1973	131	989	90	1210
1974	200	1152	81	1433
1975	187	1222	137	1546
1976	224	1208	285	1717
1977	388	1410	323	2121
1978	216	1375	411	2002
1979	184	1363	459	2006
1980	82	1033	402	1517
1981	59	1218	490	1767
1982	74	1294	487	1855
1983	83	1448	526	2057
1984	97	1522	531	2150
1985	110	1709	494	2313
1986	107	1207	456	1770
1987	105	970	493	1568
1988	101	1085	452	1638
1989	97	1302	425	1824
1990	128	893	543	1564
1991	99	1682	470	2251

Year	3.a	4	7.de	TOTAL
1992	146	1810	463	2419
1993	212	2439	490	3141
1994	222	1916	490	2628
1995	151	1434	558	2143
1996	112	1247	608	1967
1997	106	957	501	1564
1998	132	1283	451	1866
1999	157	1280	240	1677
2000	141	1508	678	2327
2001	98	1573	738	2409
2002	90	1302	716	2108
2003	128	1346	759	2233
2004	156	1249	666	2071
2005	133	1160	611	1904
2006	140	1175	649	1964
2007	158	1240	741	2139
2008	184	1004	593	1781
2009	147	1162	591	1900
2010	122	1500	695	2317
2011	131	1497	622	2250
2012	120	1512	617	2249
2013	92	1389	601	2082
2014	79	1212	651	1942
2015	143	1655	691	2489

Table 20.5 Overall discard rates (all countries and métiers) for brill *Scophthalmus rhombus* in the Greater North Sea over the period 2012–2015 (Source: InterCatch).

Year	Discard rate
2012	0,07
2013	0,04
2014	0,08
2015	0,09

Table 20.6 Discard rates for brill *Scophthalmus rhombus* in the Greater North Sea in 2015 by country (Source: InterCatch).

Country	Discard rate 2014	Discard rate 2015
Belgium	0,01	0,03
Denmark	0,21	0,22
France	0,04	0,24
Germany	0,16	0,01
Ireland	0	0
Netherlands	0,09	0,05
Norway	0	0
Sweden	0,35	0,29
UK (England)	0,01	0,02
UK(Scotland)	0,1	0,2
Overall	0,08	0,09

Table 20.7 Discard rates for brill *Scophthalmus rhombus* in the Greater North Sea in 2014 by Sub-area/Division (Source: InterCatch).

Subarea/ Division	Discard rate 2014	Discard rate 2015
3.a	0,38	0,33
4	0,08	0,04
7.d	0,02	0,1
7.e	0,01	0,14
Overall	0,08	0,09

Table 20.8 Survey index (N°/hr) for brill *Scophthalmus rhombus* in the BTS_ISI_Q3, Subarea 4.

Year	N/hr	Year	N/hr
1987	1.9957265	2002	0.7947304
1988	0.6666667	2003	1.0000000
1989	0.9362745	2004	0.8214286
1990	2.2962963	2005	0.6060606
1991	1.8710526	2006	0.8716931
1992	3.6793860	2007	1.0952381
1993	3.3062753	2008	0.5138889
1994	2.3622590	2009	1.4246488
1995	1.8011775	2010	2.1853733
1996	0.7647059	2011	2.4057061
1997	2.0000000	2012	1.0411007
1998	1.4301503	2013	0.7586207
1999	0.7523810	2014	3.0445977
2000	2.1945342	2015	1.8429119
2001	0.6913580		

Table 20.9 Survey index (N°/hr) for brill *Scophthalmus rhombus* in the BITS_HAF_Q1&4, Division 3.a.

Year	N/hr
1996	1.9090909
1997	0.3888889
1998	0.5000000
1999	1.8333333
2000	0.5555556
2001	1.0416667
2002	1.8030303
2003	1.3636364
2004	2.2045455
2005	2.0833333
2006	3.8181818
2007	3.6196970
2008	4.0500000
2009	3.0912698
2010	3.8893939
2011	3.6136364
2012	2.2651515
2013	2.1390227
2014	3.8551515
2015	4.4682540

Table 20.10 Commercial LPUE (kg/day) for brill *Scophthalmus rhombus* in the Dutch beam trawl fleet > 221kW, Subarea 4.

Year	LPUE (kg/day)
2007	33.38
2008	41.14
2009	40.65
2010	50.1
2011	52.39
2012	55.52
2013	52.97
2014	47.78
2015	60.74

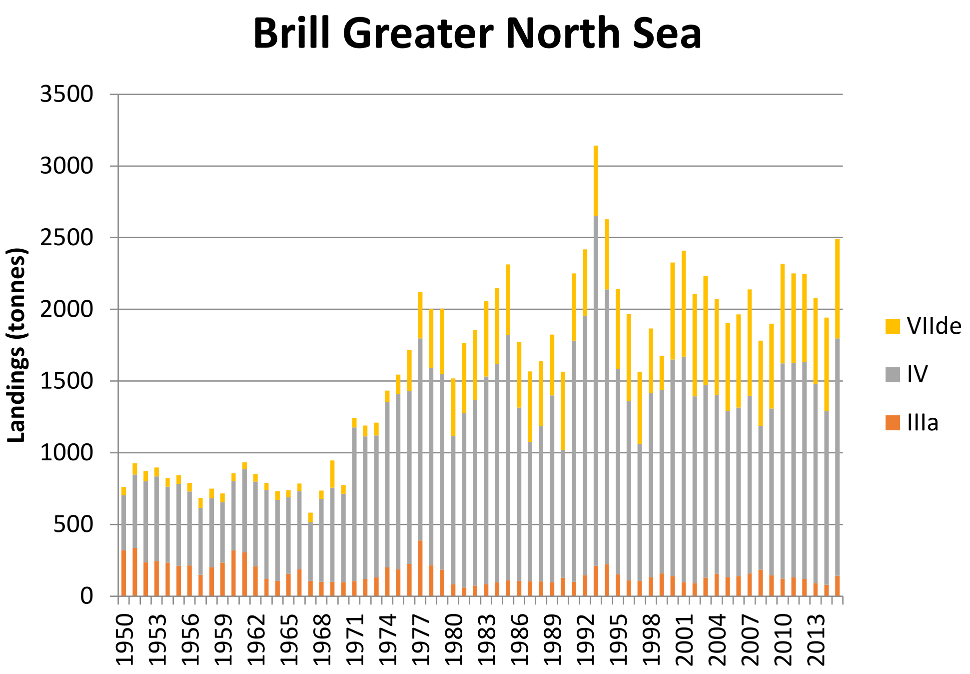

Figure 20.1 Total international landings (t) of brill *Scophthalmus rhombus* in the Greater North Sea over the period 1950–2015, subdivided into Subarea 4, Division 3.a and Divisions 7.de (Source: ICES Fishstat).

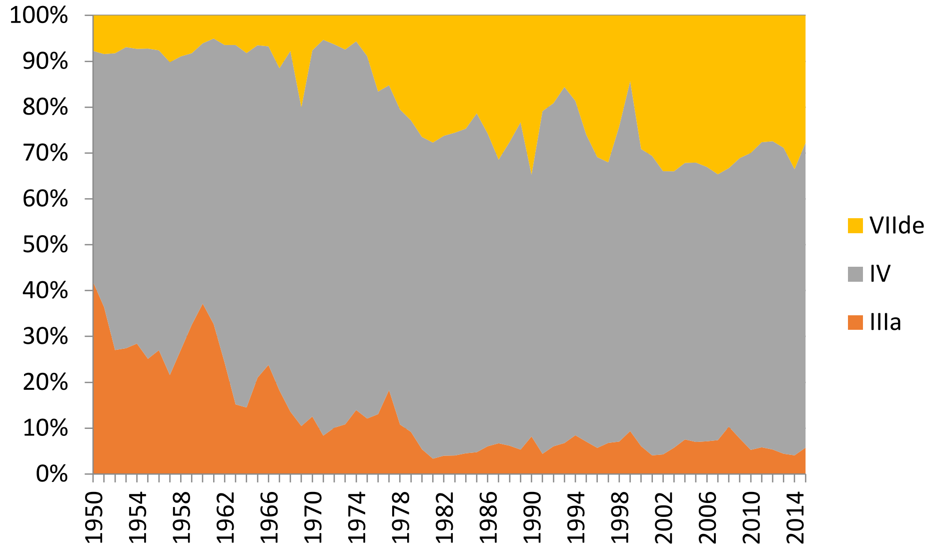

Figure 20.2 Relative contribution of landings of brill *Scophthalmus rhombus* from Subarea 4, Division 3.a and Divisions 7.de to the total international landings (t) in the Greater North Sea over the period 1950–2015 (Source: ICES Fishstat).

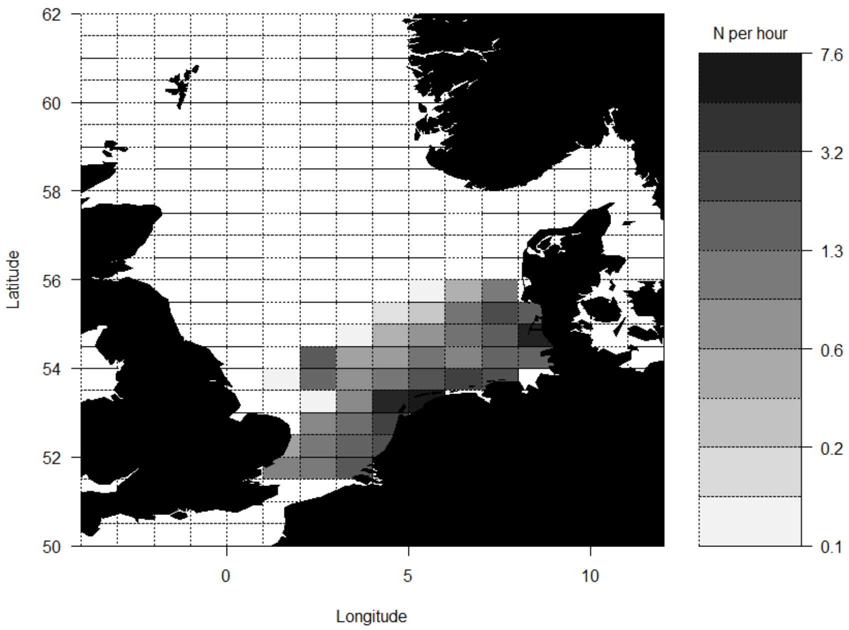

Fig. 20.3 Numbers of brill *Scophthalmus rhombus* caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (4) over the period 1987–2015.

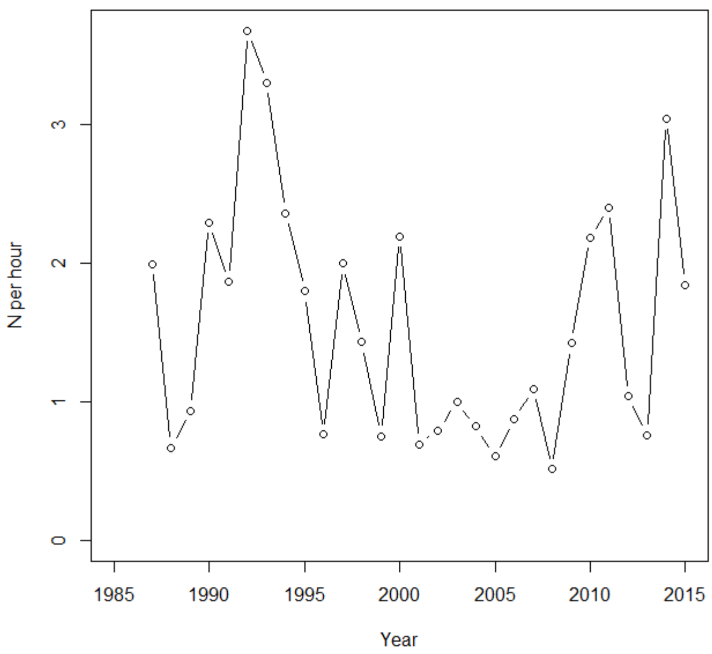

Fig. 20.4 Abundance index (numbers caught per hour) of brill *Scophthalmus rhombus* for the BTS_ISI_Q3 in the North Sea (4) over the period 1987–2015.

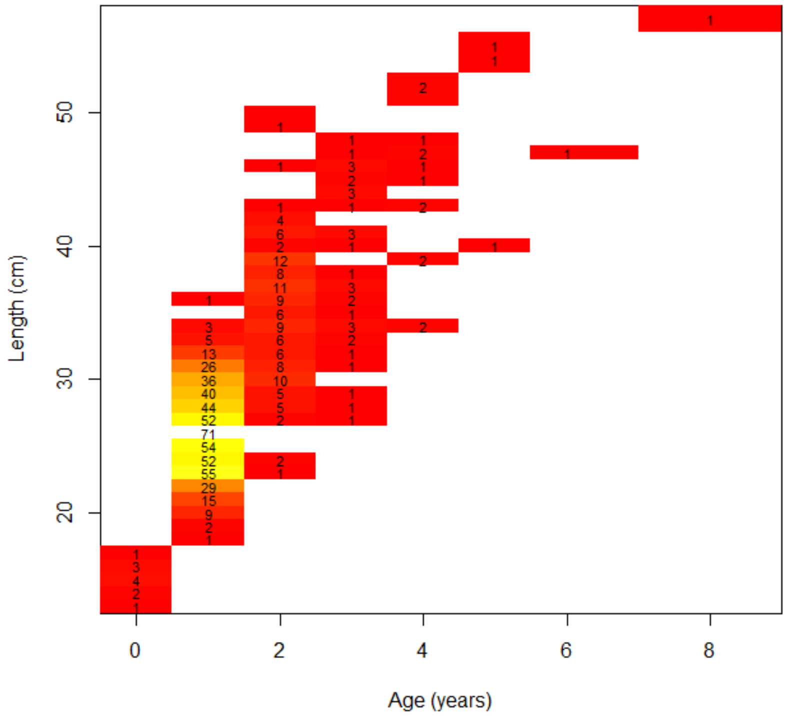

Figure 20.5 ALK of brill *Scophthalmus rhombus* in the North Sea (4) as documented in the BTS_ISI_Q3.

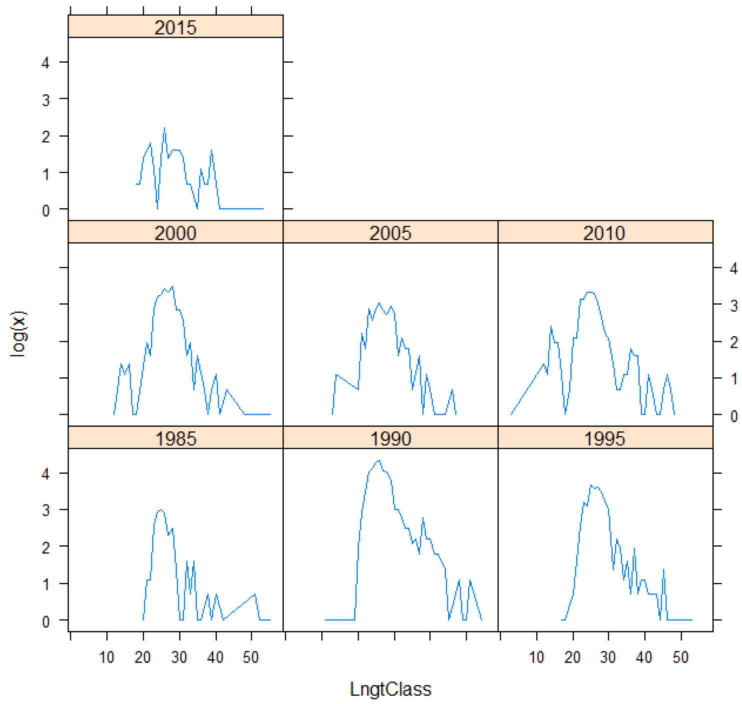

Figure 20.6 Length distributions (per 5 years) of brill *Scophthalmus rhombus* in the North Sea (4) as documented in the BTS_ISI_Q3.

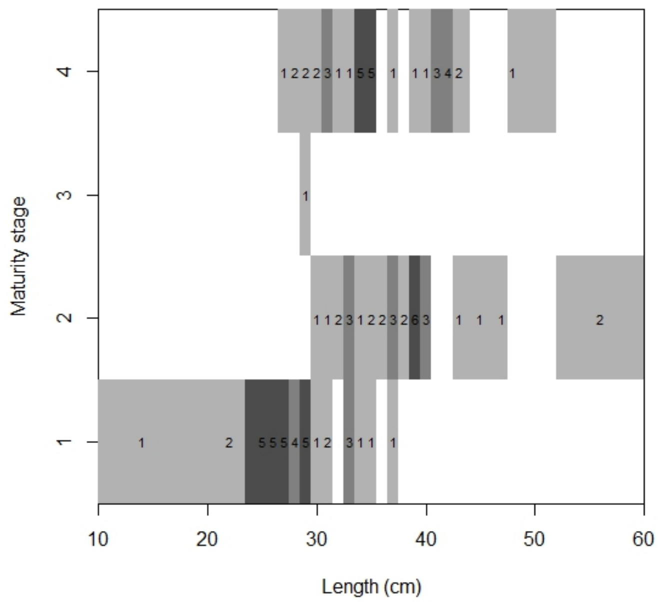

Figure 20.7 Maturity at length of brill *Scophthalmus rhombus* in the North Sea (4) as documented in the BTS_ISI_Q3.

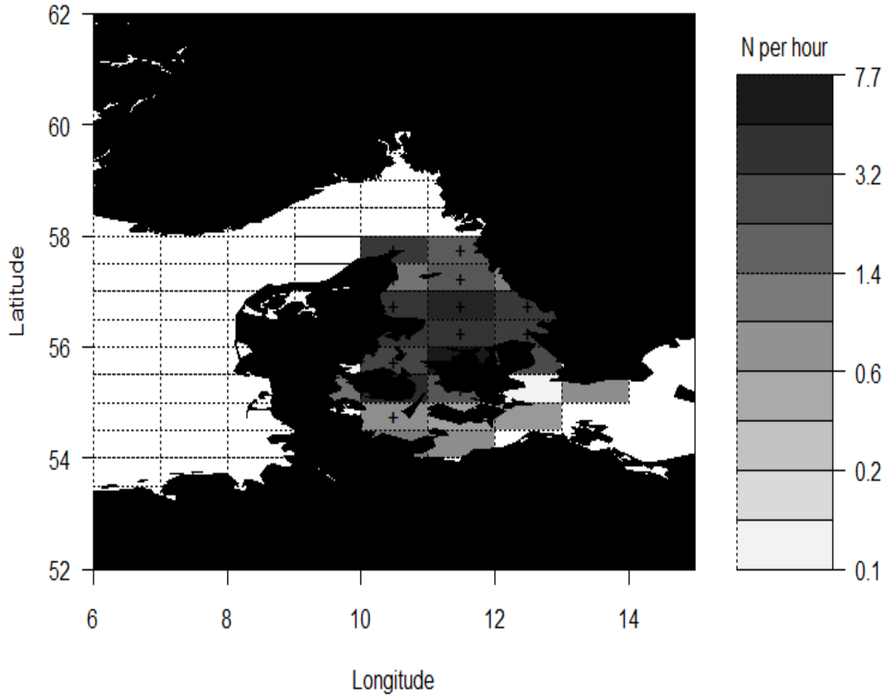

Fig. 20.8 Numbers of brill *Scophthalmus rhombus* caught per hour and rectangle by BITS_HAF_Q1&4 in the Kattegat (3.aS) over the period 1996–2015.

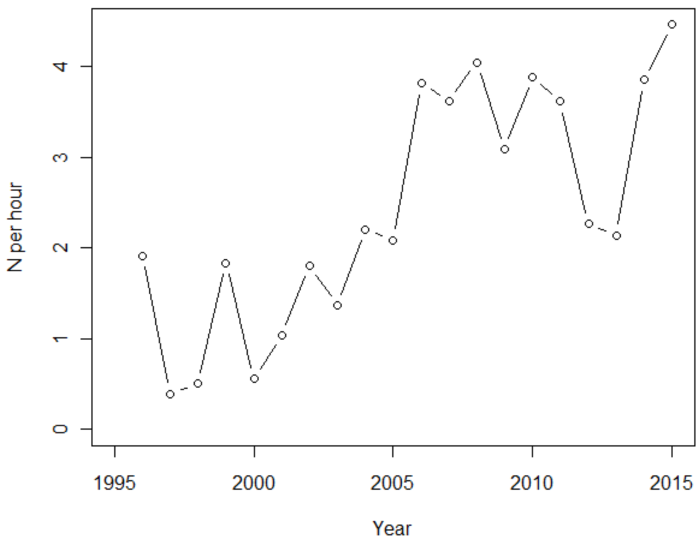

Fig. 20.9 Abundance index (numbers caught per hour) of brill *Scophthalmus rhombus* for the BITS_HAF_Q1&4 in the Kattegat (3.aS) over the period 1996–2015.

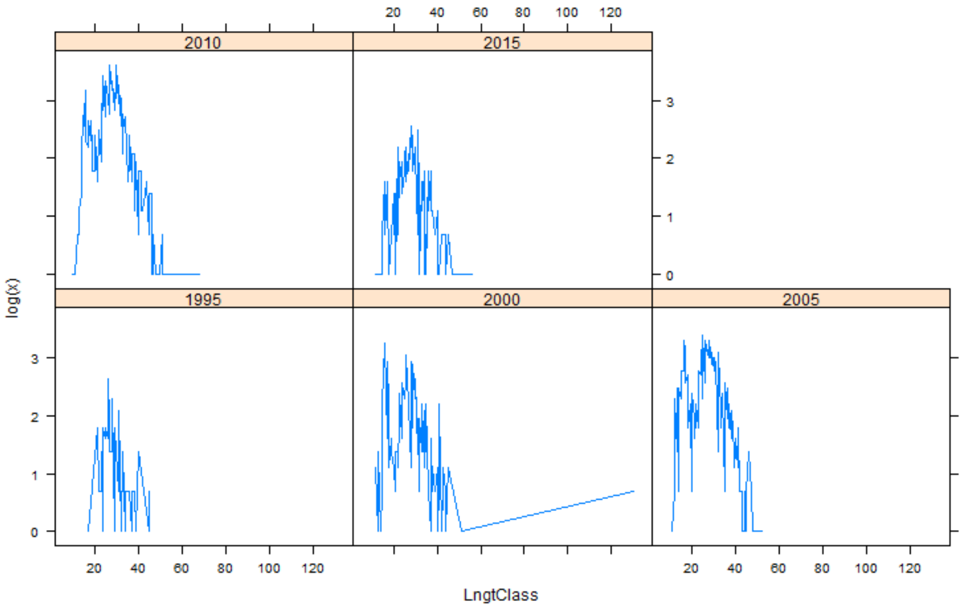

Figure 20.10 Length distributions (per 5 years) of brill *Scophthalmus rhombus* in the Kattegat (3.aS) as documented in the BITS_HAF_Q1&4.

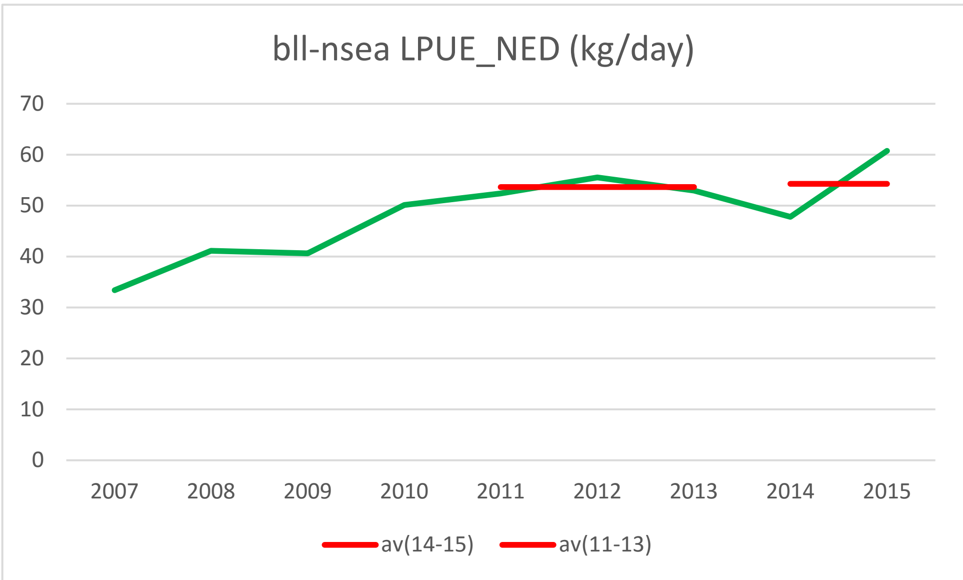

Fig. 20.11 Commercial LPUE (kg/day) of brill *Scophthalmus rhombus* in the Dutch beam trawl fleet > 221kW (standardized for engine power and corrected for targeting behaviour). The bright red lines are the averages of the last two (2014–2015) and the previous three (2011–2013) years.

21 Dab (*Limanda limanda*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)

21.1 General

Dab (*Limanda limanda*) was assessed for the first time by the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) in 2014. Until 2013 it was assessed by the Working Group on Assessment of New MoU Species (ICES, 2013.a). This group was dissolved in 2014. Because only official landings and survey data were available at that time, dab was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Since 2015 dab was included in the official data call for the WGNSSK and discard estimates were included into the dab assessment. Based on survey trends and total catch data (2012–2014) biennial advice for dab was given in 2015 (ICES, 2015). In 2016 a benchmark assessment of dab was conducted by ICES. For this benchmark assessment catch data from 2002 were requested and uploaded into the InterCatch data portal by all relevant countries (ICES, 2016). The benchmark agreed on the use of a survey based assessment model (SURBA) to inform stock status of North Sea dab (ICES, 2016). Based on these results the perception of the stock did not change and the WGNSSK agreed on not to reopen the advice for dab.

21.1.1 Biology and ecosystem aspects

Dab is a widespread demersal species on the Northeast Atlantic shelf and distributed from the Bay of Biscay to Iceland and Norway, including the Barents Sea and the Baltic. In the North Sea it is one of the most abundant species distributed over the whole area in depths down to 100m, but it was also found occasionally down to depths of 150m. The main concentration of dab can be found in the south eastern North Sea, especially the younger age groups 1–2. Older age groups are more distributed in the central and more Northern parts of the North Sea (Fig. 21.1.1.1). Dab abundance decreases towards the northern parts of the North Sea. Dab feeds on a variety of small invertebrates, mainly polychaete worms, shellfish and crustaceans. Early sexual maturation was reported for dab, maturing at ages of 2 to 3 years corresponding to approximately 11 to 14cm total length. Peak spawning in the south eastern North Sea occurs from February to April.

21.1.2 Stock ID and possible assessment areas

The several spawning grounds and the wide distribution of dab indicate the presence of more than one stock. Meristic data (Lozán 1988) corroborate the hypothesis of several stocks for dab, distinguishing significantly between populations from western British waters, the North Sea and the Baltic Sea.

21.1.3 Management regulations

According to EU-Regulations a precautionary TAC is given in EU waters of 2a and 4 together with flounder (*Plathichthys flesus*). Since 2011 the TAC of 18434t did not change. No minimum landing size is defined. Dab is mainly a bycatch species in fisheries for plaice and sole. The discard rates for dab can be extremely high (~90%). TACs may not be appropriate as a management tool for bycatch species.

21.2 Fisheries data

21.2.1 Historical landings

Dab is a by-catch species in fisheries for plaice, sole and demersal round fish. According to ICES catch statistics, annual landings of dab in ICES Divisions 4 and 3.a has been well above 10000t since 1973 (Figure 21.2.1.1). The apparent decreases in official landings in the 1980's and 1990's are due to unreported catches by the Netherlands and Norway. However, since 1999 landings in area 4 and area 3.a steadily decreased. This trend continued in 2015 with total official landings of 4321 t.

The main fishing gear in the North Sea is the beam trawl with mesh sizes between 80 and 100mm. Large effort reductions took place in this fishery over the last decade. The largest part of the landings in area 4 is taken by the Netherlands, followed by UK and Denmark (Figure 21.2.1.2). In division 3.a Denmark is landing the largest amount of dab (Figure 21.2.1.3). Dab is among the most discarded fish species in ICES Division 4. In the beam trawl fishery on plaice and sole and the otter trawl fishery on plaice up to 95% of the catches on dab are discarded (e.g. van Helmond *et al*. 2012).

21.2.2 InterCatch

For the WGNSSK2016 dab landing and discard data from 2002–2015 were available in the InterCatch web portal. Norway did not report any discards because of the official discard ban. Discard information in 2015 was provided for 56% of total landings in relation to weight calculated for the most disaggregated level of data (59% in 2014, 59% in 2013, 49% in 2012).

In 2015 the largest amount of landings and discards was again reported by The Netherlands for the TBB_DEF_70–99_0_0_all metier (Fig. 21.2.2.2 and Fig. 21.2.2.3). Consequently, by far the largest catch is taken by the Netherlands (27 258 t in total). All other countries catch less than 10 000 t (Figure 21.2.2.4). The total dab catch estimated with InterCatch for 2015 was 52 454 t from which 5082t were landings and 47 372 t discards (90% of total catch). It should be noted that not all metiers were sampled in every quarter and that raising procedure may not be adequate in all cases. However, the Dutch TBB_DEF_70–99_0_0_all metier is by far the most important one in terms of landings and information on discard weights was provided for every quarter.

21.3 Survey data / recruit series

Surveys providing information on distribution, abundance and length frequency for dab in area 4 and division 3.a are the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3 (Figure 21.3.1.), the Beam Trawl Surveys (BTS; only area 4) in quarter 3 and the BITS (only in division 3.a). To estimate a mature biomass index a length weight relationship derived from IBTS Q1 data was estimated in previous years to apply the DLS 3.2. method. The same data set was used to create a length based maturity ogive. The obtained length weight relationship and the maturity ogive were then applied to estimate the mature biomass index in kg per hour (Fig. 21.3.3.). From 1983 onwards the abundance index showed an increasing trend (Figure 21.4.2). Since the beginning of the 1990s the stock abundance index is fluctuating on a rather stable level. After a quite low index in 2012 the index was much higher for the last three years. This index served as an input for a survey based assessment model (SURBA) to inform the stock status of North Sea dab.

Only the beam trawl surveys provide data on age and weight for dab. During the benchmark in 2016 it was agreed to use an age based survey index combining data from the Dutch and German beam trawl surveys taking into account a ship effect (Berg *et al.*, 2014).

21.4 Survey Based Assessment (SURBA)

In spring 2016 a benchmark assessment was carried out for dab (ICES, 2016; see a summary in Annex 6). During this benchmark it was agreed to make use of the available data from the beam trawl surveys and to run a survey based assessment model taking the age structure into account. The final SURBAR (Needle, 2015) model run resulted in an overall decreasing total mortality while the spawning stock biomass (relative biomass) and the recruitment showed increasing trends (Fig. 21.4.1). The recruitment increased by a factor of 2.6 from 2003 to 2014 but dropped in 2015. However, there is a strong retrospective pattern in recruitment with a general underestimation of recruitment for the terminal years (Fig. 21.4.4.). This might indicate a lower catchability of the survey for the youngest age group. No pattern was detected in the log residual pattern of the age based survey indices (Fig. 21.4.2.).

21.5 Analysis of stock trends

Dab is defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2013). Consequently, the basis of the advice is a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and *I* is the stock index. By default x=2 and z=5.

Table 21.4.2. displays the summary of the DLS 3.2. approach using the results of the updated and benchmarked assessment. However, the increasing trend in the SURBA SSB did not change the perception of this stock compared to the previous year. Therefore it was agreed not to reopen the advice for 2017.

21.6 References

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ICES 2013.a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM:21.

ICES 2013b. Dab in Subarea IV and Division 3.a, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.28.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Lozán J.L., 1988. Verbreitung, Dichte, und Struktur der Population der Klieschen (*Limanda limanda* L.) in der Nordsee mit Vergleichen zu Popualtionen um Island und in der Ostsee anhand meristischer Merkmale. Arch. Fischereiwiss. 38: 165-189.

Table 21.4.1: Settings and input data used for the final SURBA assessment run.

SETTING/DATA	VALUES/SOURCE
Survey index	Combined beam trawl survey index 2003 – current assessment year (BTS-Isis, BTS-Tridens, German BTS) . Delta GAM Method by Berg *et al*., 2014.
Ages	1–6
Lambda	3
zbar	1–6
Spawning time	0.4
Maturity ogive	Fixed ogive, age 1 = 60%, age 2 = 80%, age 3 and older 100%
Weight at age	Data from Dutch Beam Trawl Surveys (2003 – current assessment year)

Table 21.4.1. Summary of the assessment.

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS Q1 index	Discard rate
1983	14771				12.15	
1984	8251				11.96	
1985	7047				13.04	
1986	4813				18.02	
1987	6189				22.52	
1988	9321				22.09	
1989	8162				29.97	
1990	4275				32.28	
1991	5057				20.86	
1992	4101				30.91	
1993	5004				32.95	
1994	5822				22.35	
1995	5395				28.31	
1996	6239				20.97	
1997	6271				18.92	
1998	13720				21.61	
1999	13949				19.56	
2000	11249				16.18	
2001	10564				16.32	
2002	9655	8588	35219	26631	25.22	0.76
2003	9873	9433	54363	44930	26.04	0.83
2004	9387	8647	42920	34273	29.98	0.80
2005	10238	9537	44828	35291	23.51	0.79
2006	9914	10236	48214	37977	25.13	0.79
2007	10127	9881	43208	33328	33.09	0.77
2008	8551	8645	36024	27379	31.36	0.76
2009	7060	7040	40461	33421	22.81	0.83
2010	7830	8279	50765	42486	23.72	0.84
2011	7372	7422	51882	44460	25.32	0.86
2012	6749	7047	59679	52632	27.65	0.88
2013	6084	6611	60087	53476	20.28	0.89
2014	4957	5047	58780	53733	34.56	0.91
2015	4321	5082	52454	47372	33.59	0.90
2016					34.87	

Table 21.4.2: Results of applying the DLS 3.2.

Indicator (2011–2013)	189.98
Indicator (2014–2015)	254.51
Indicator ratio	1.34
Uncertainty cap	Yes
Average catch (2013–2015)	57107 (tonnes)
Discard rate (2013–2015)	0.9
Precautionary buffer	No
Catch advice	No new advice for 2017

Table 21.6.1 Official dab landings by ICES area 4 and division 3.a.

Year	4	3.a	total
1950	5971	1287	7258
1951	8190	1332	9522
1952	7976	1294	9270
1953	5915	1123	7038
1954	5652	1237	6889
1955	6623	1257	7880
1956	5468	2081	7549
1957	6127	2724	8851
1958	6342	2210	8552
1959	5239	1943	7182
1960	5168	1314	6482
1961	4602	1367	5969
1962	4082	1683	5765
1963	4615	1565	6180
1964	4982	1575	6557
1965	5519	2052	7571
1966	5862	1755	7617
1967	4324	1115	5439
1968	3995	1548	5543
1969	4122	1430	5552
1970	5183	1079	6262
1971	6546	1242	7788
1972	7901	1669	9570
1973	9657	1449	11106
1974	7146	2003	9149
1975	7033	2049	9082
1976	5917	1583	7500
1977	6702	2318	9020
1978	6407	2630	9037
1979	8243	2716	10959
1980	8357	2333	10690
1981	8454	2679	11133
1982	9565	2902	12467
1983	11865	2906	14771
1984	5482	2769	8251
1985	5502	1545	7047
1986	3205	1608	4813
1987	3931	2258	6189
1988	7067	2254	9321
1989	5816	2346	8162
1990	2701	1574	4275
1991	3448	1609	5057
1992	2647	1454	4101

YEAR	4	3.A	TOTAL
1993	3309	1695	5004
1994	3861	1961	5822
1995	3865	1530	5395
1996	4834	1405	6239
1997	5259	1012	6271
1998	12759	961	13720
1999	13276	673	13949
2000	10595	654	11249
2001	9799	765	10564
2002	8678	977	9655
2003	9008	865	9873
2004	8608	779	9387
2005	9402	836	10238
2006	9190	725	9915
2007	9434	694	10128
2008	8029	522	8551
2009	6561	498	7059
2010	7240	589	7829
2011	6824	545	7369
2012	6095	653	6748
2013	5214	871	6085
2014	4344	611	4955
2015*	3595	726	4321

*** preliminary catch statistics**

Table 21.6.2 Official dab landings by country in area 4.

YEAR	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	4
1950	254	92	900	139	0	2555	2031	0	0	5971
1951	462	114	1800	90	0	3503	2221	0	0	8190
1952	386	74	1562	227	0	2823	2904	0	0	7976
1953	357	58	1337	189	0	2591	1383	0	0	5915
1954	255	62	1666	177	0	2393	1099	0	0	5652
1955	305	92	2923	161	0	1993	1149	0	0	6623
1956	338	99	1766	138	0	1660	1368	0	99	5468
1957	336	73	1983	154	0	1785	1669	0	127	6127
1958	290	71	2320	175	0	1885	1517	0	84	6342
1959	285	93	1433	146	0	2011	1265	0	6	5239
1960	246	70	1833	154	0	1813	1052	0	0	5168
1961	227	67	1497	161	0	1734	916	0	0	4602
1962	205	54	1357	147	0	1524	795	0	0	4082
1963	306	40	1660	128	0	1481	1000	0	0	4615
1964	424	48	1612	672	0	1177	1049	0	0	4982
1965	432	64	1841	734	0	1099	1349	0	0	5519
1966	507	65	1589	719	0	1215	1767	0	0	5862
1967	384	77	659	716	0	1147	1341	0	0	4324
1968	334	57	861	350	0	877	1516	0	0	3995
1969	302	69	984	448	0	689	1630	0	0	4122
1970	338	71	1476	588	0	752	1958	0	0	5183
1971	409	46	1546	618	0	986	2941	0	0	6546
1972	638	46	1816	727	0	1057	3617	0	0	7901
1973	678	41	1899	873	0	1349	3638	1179	0	9657
1974	281	59	1168	310	0	1227	4101	0	0	7146
1975	600	45	944	418	0	992	4031	0	3	7033
1976	489	52	852	306	0	816	3402	0	0	5917
1977	652	70	743	371	0	907	3959	0	0	6702
1978	520	64	799	513	0	1038	3473	0	0	6407
1979	484	87	1366	630	0	951	4724	0	1	8243
1980	518	24	1376	639	0	777	5023	0	0	8357
1981	542	31	1968	447	0	737	4729	0	0	8454
1982	460	42	2356	594	0	1002	5111	0	0	9565
1983	541	49	4428	495	0	1034	5318	0	0	11865
1984	603	35	3438	486	0	920	0	0	0	5482
1985	509	24	3535	404	0	1030	0	0	0	5502
1986	445	34	1400	289	0	1036	0	0	1	3205
1987	514	36	1574	434	0	1373	0	0	0	3931
1988	697	72	1324	349	0	1221	3404	0	0	7067
1989	443	117	1280	223	0	1232	2521	0	0	5816
1990	416	162	1103	214	0	802	0	0	4	2701
1991	491	290	1160	258	0	1249	0	0	0	3448
1992	464	218	699	217	0	1049	0	0	0	2647

YEAR	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	4
1993	548	493	1016	235	0	1017	0	0	0	3309
1994	397	626	1307	133	0	1398	0	0	0	3861
1995	410	0	1306	155	1	1993	0	0	0	3865
1996	527	718	1484	177	0	1928	0	0	0	4834
1997	507	945	1399	124	0	2284	0	0	0	5259
1998	757	796	1024	126	0	2085	7971	0	0	12759
1999	802	758	1101	0	0	1964	8651	0	0	13276
2000	684	892	785	124	0	1534	6527	49	0	10595
2001	575	878	839	206	0	1368	5886	47	0	9799
2002	516	582	1126	228	0	1224	4951	51	0	8678
2003	396	642	1580	154	0	1204	4955	77	0	9008
2004	382	767	1136	121	0	1158	4989	55	0	8608
2005	372	1105	1128	121	0	1193	5352	131	0	9402
2006	369	1149	949	130	0	1415	5071	107	0	9190
2007	436	526	634	195	0	1212	6313	118	0	9434
2008	371	375	670	161	0	847	5544	61	0	8029
2009	349	262	489	196	0	648	4588	29	0	6561
2010	337	365	523	178	0	724	5097	16	0	7240
2011	243	312	622	165	0	645	4808	29	0	6824
2012	454	252	421	126	0	665	4136	41	0	6095
2013	404	333	404	84	0	647	3316	26	0	5214
2014	299	282	253	73	0	505	2910	23	0	4344
2015*	242	244	250	75	0	336	2438	10	0	3595

Table 21.6.3 Official dab landings in ICES division 3.a.

YEAR	BEL	DEU	DNK	FRA	NLD	NOR	SWE	3.A
1950	0	34	1253	0	0	0	0	1287
1951	0	17	1315	0	0	0	0	1332
1952	0	21	1273	0	0	0	0	1294
1953	0	9	1114	0	0	0	0	1123
1954	0	4	1233	0	0	0	0	1237
1955	0	3	1254	0	0	0	0	1257
1956	0	5	1462	0	0	0	614	2081
1957	0	5	2025	0	0	0	694	2724
1958	0	4	1578	0	0	0	628	2210
1959	0	2	1307	0	0	0	634	1943
1960	0	1	1313	0	0	0	0	1314
1961	0	0	1367	0	0	0	0	1367
1962	0	2	1681	0	0	0	0	1683
1963	0	0	1565	0	0	0	0	1565
1964	0	1	1574	0	0	0	0	1575
1965	0	1	2051	0	0	0	0	2052
1966	0	0	1755	0	0	0	0	1755
1967	0	0	1115	0	0	0	0	1115
1968	0	0	1535	13	0	0	0	1548
1969	0	0	1430	0	0	0	0	1430
1970	0	0	1079	0	0	0	0	1079
1971	0	0	1242	0	0	0	0	1242
1972	0	0	1669	0	0	0	0	1669
1973	0	0	1449	0	0	0	0	1449
1974	0	0	2003	0	0	0	0	2003
1975	0	0	1959	0	2	0	88	2049
1976	10	0	1493	0	80	0	0	1583
1977	11	0	2105	0	142	0	60	2318
1978	2	0	2515	0	39	0	74	2630
1979	3	0	2616	0	15	0	82	2716
1980	3	0	2218	0	3	0	109	2333
1981	0	0	2574	0	5	0	100	2679
1982	1	0	2823	0	22	0	56	2902
1983	1	0	2759	0	34	0	112	2906
1984	0	0	2695	0	0	0	74	2769
1985	1	0	1486	0	0	0	58	1545
1986	5	0	1551	0	0	0	52	1608
1987	19	0	2182	0	0	0	57	2258
1988	13	0	2150	0	15	0	76	2254
1989	4	0	2302	0	0	0	40	2346
1990	3	0	1535	0	0	0	36	1574
1991	5	1	1556	0	0	0	47	1609
1992	10	0	1412	0	0	0	32	1454

YEAR	BEL	DEU	DNK	FRA	NLD	NOR	SWE	3.A
1993	7	0	1656	0	0	0	32	1695
1994	9	0	1917	0	0	0	35	1961
1995	3	0	1482	0	0	0	45	1530
1996	0	0	1387	0	0	0	18	1405
1997	0	0	990	0	0	0	22	1012
1998	0	0	942	0	0	0	19	961
1999	0	0	661	0	0	0	12	673
2000	0	0	647	0	0	1	6	654
2001	0	0	751	0	0	7	7	765
2002	0	0	968	0	0	3	6	977
2003	0	0	674	0	173	14	4	865
2004	0	0	637	0	138	1	3	779
2005	0	0	738	0	95	0	3	836
2006	0	20	566	0	117	18	4	725
2007	0	9	547	0	126	3	9	694
2008	0	12	475	0	26	2	7	522
2009	0	4	478	0	3	1	12	498
2010	0	4	426	0	151	0	8	589
2011	0	10	517	0	0	11	7	545
2012	0	5	632	0	0	10	6	653
2013	0	11	654	0	174	26	6	871
2014	0	12	501	0	75	2	21	611
2015*	0.0	7.6	687.2	0.0	0.0	8.0	23.2	726

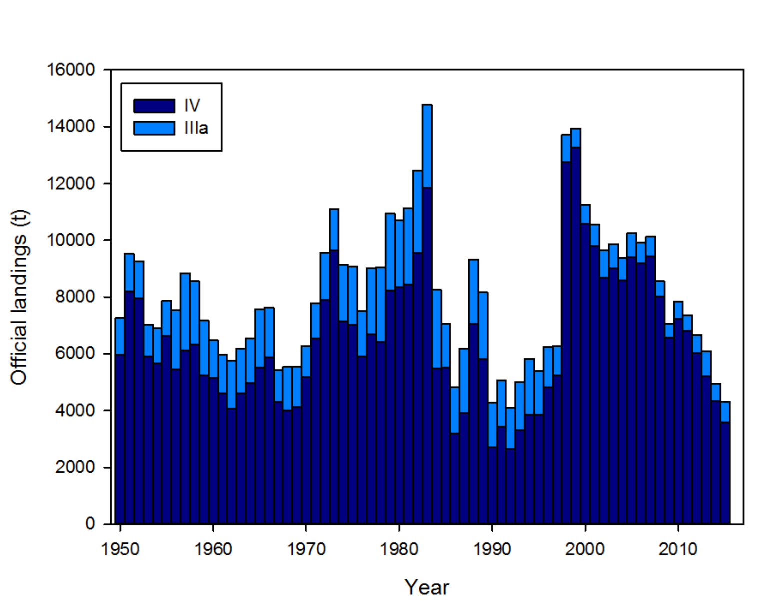

Figure 21.2.1.1 Total official landings of dab in area 4 and division 3.a in 1950–2015.

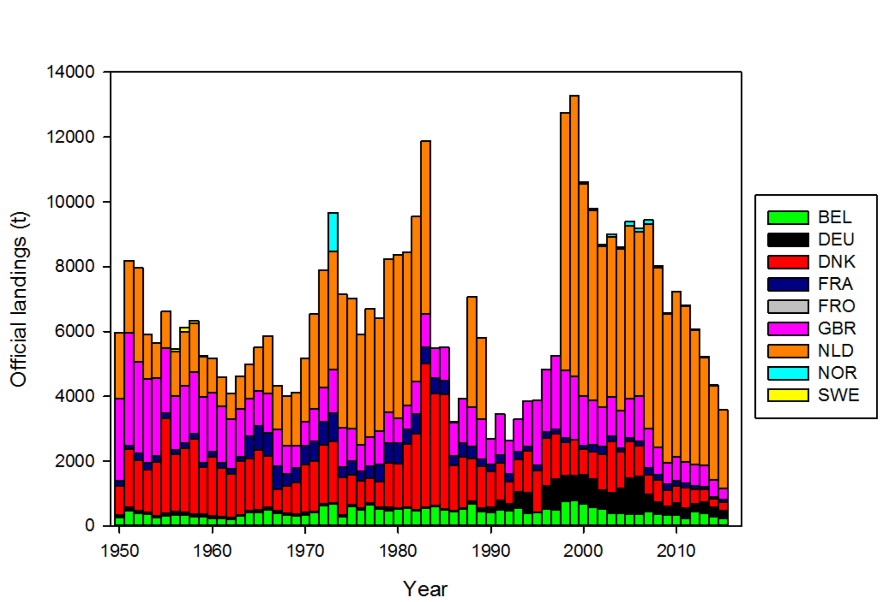

Figure 21.2.1.2 Official landings of dab in area 4 by country up to 2015.

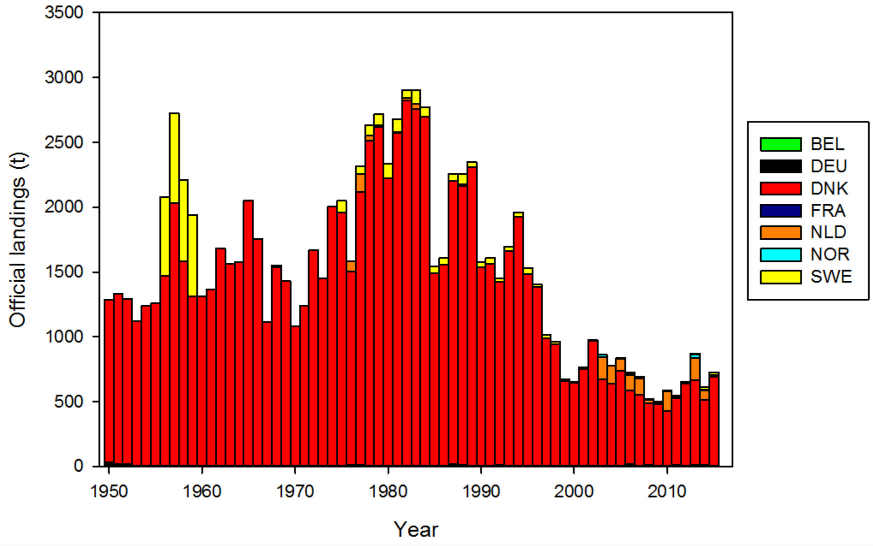

Figure 21.2.1.3 Official landings of dab in division 3.a by country in 1950–2015.

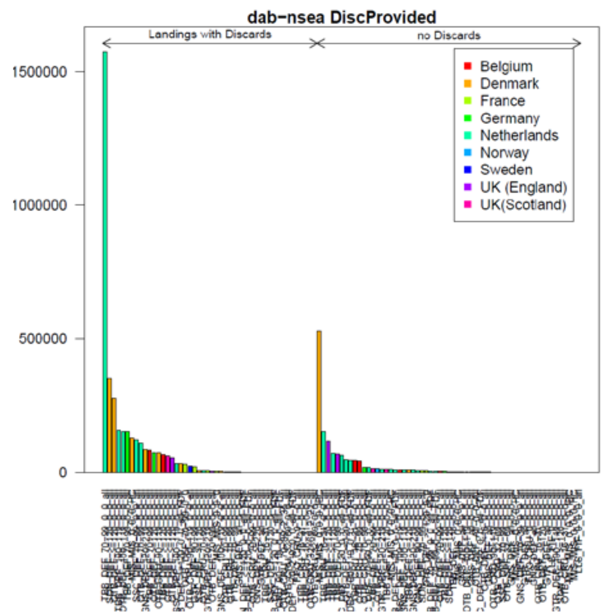

Figure 21.2.2.1 InterCatch. Dab landings and discards (kg) provision for sub-area 4 and division 3.a by metier and country in 2015 as uploaded to InterCatch.

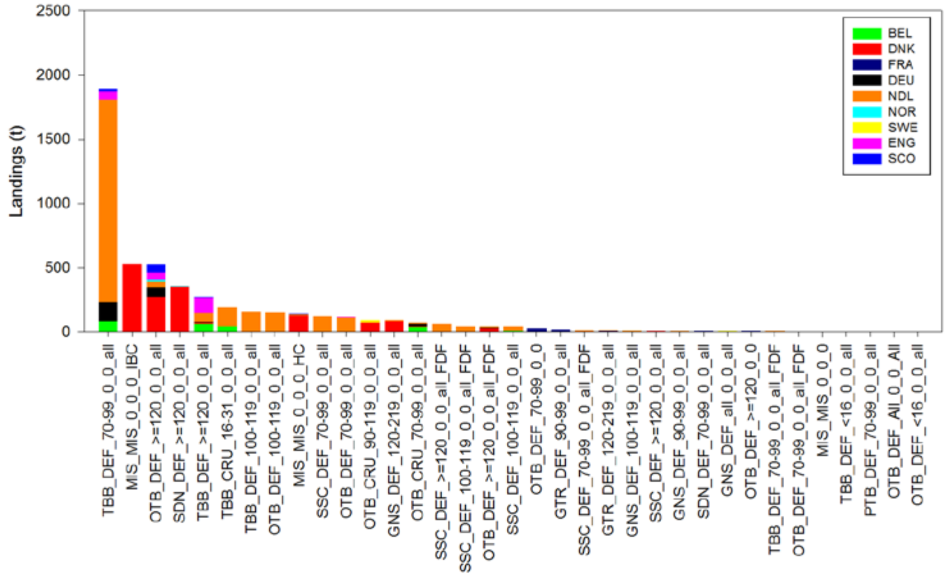

Figure 21.2.2.2 InterCatch. Dab landings (t) for sub-area 4 and division 3.a by metier and country in 2015 as uploaded to InterCatch.

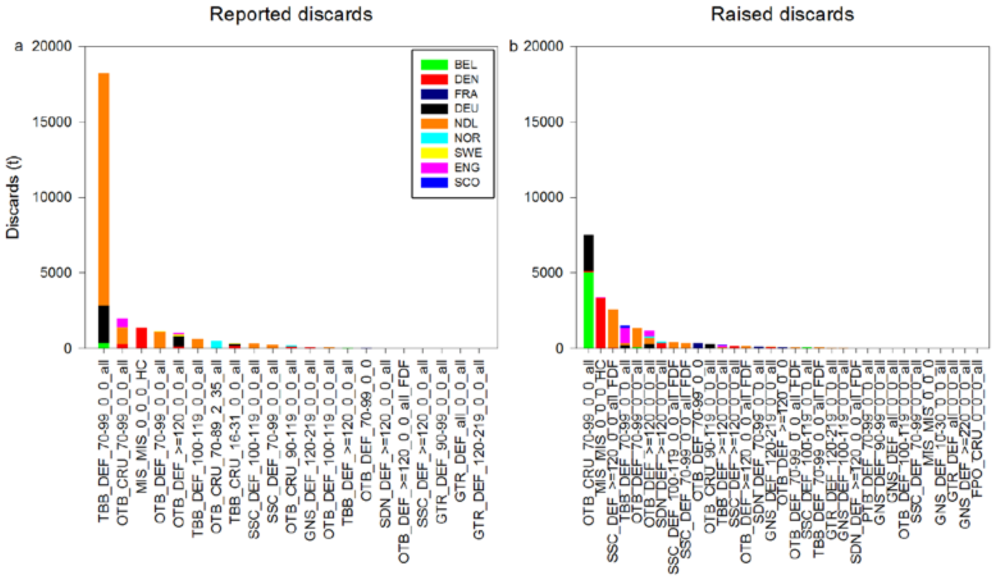

Figure 21.2.2.3 InterCatch. Dab discards for sub-area 4 and division 3.a by metier and country in 2015. Reported discards (a), raised discards (b).

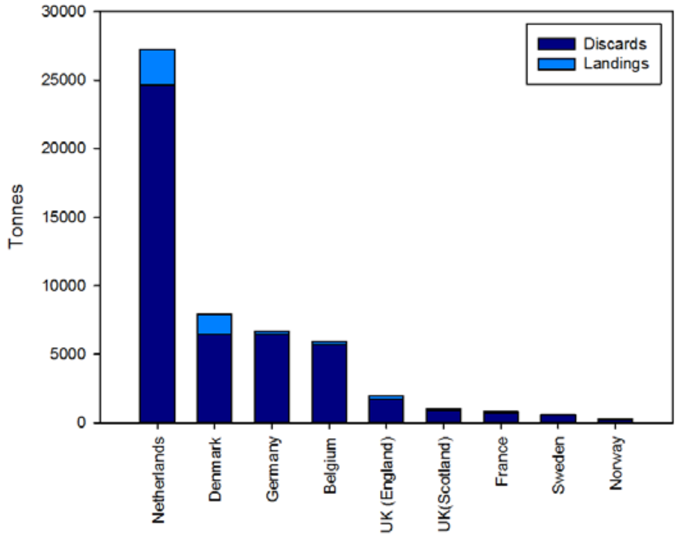

Figure 21.2.2.4 InterCatch. Dab landings and estimated discards for sub-area 4 and division 3.a by countries in 2015.

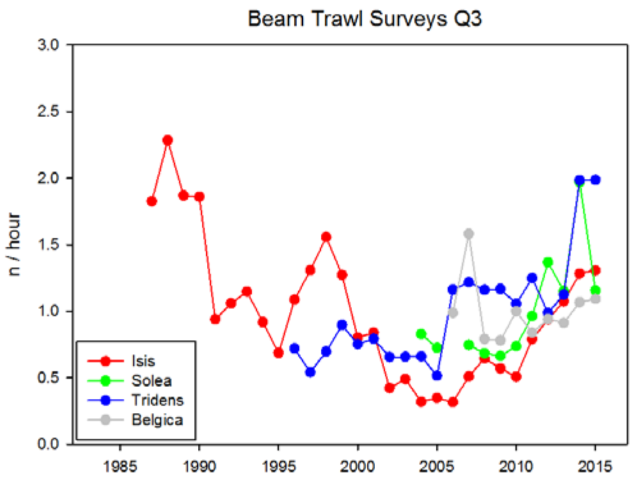

Fig. 21.3.1. Standardized dab survey indices (n/hour) from the beam trawl surveys.

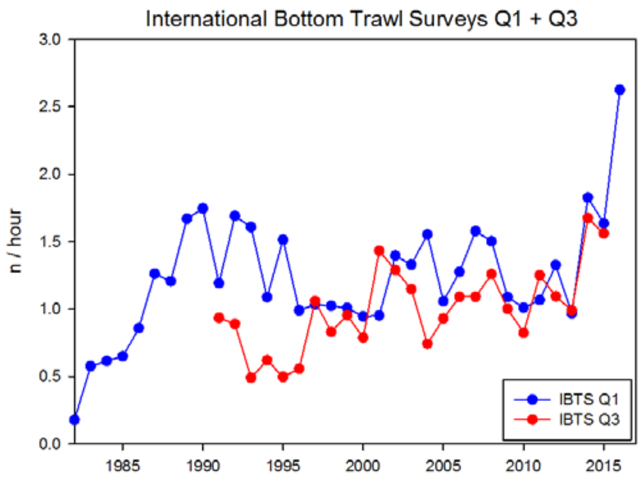

Fig. 21.3.2. Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

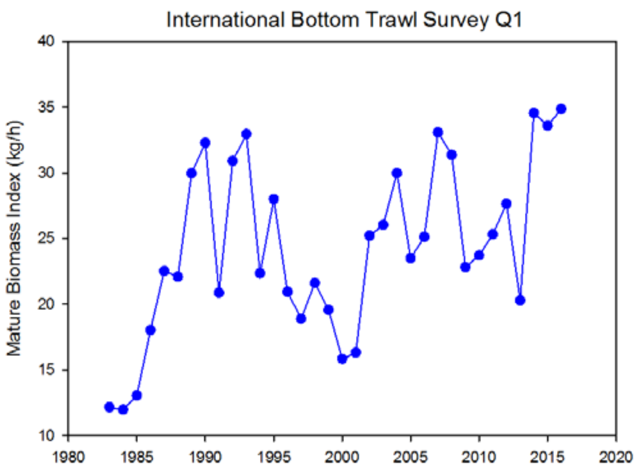

Fig. 21.3.3. Updated mature biomass index (kg/h) as previously used for the DLS 3.2. method.

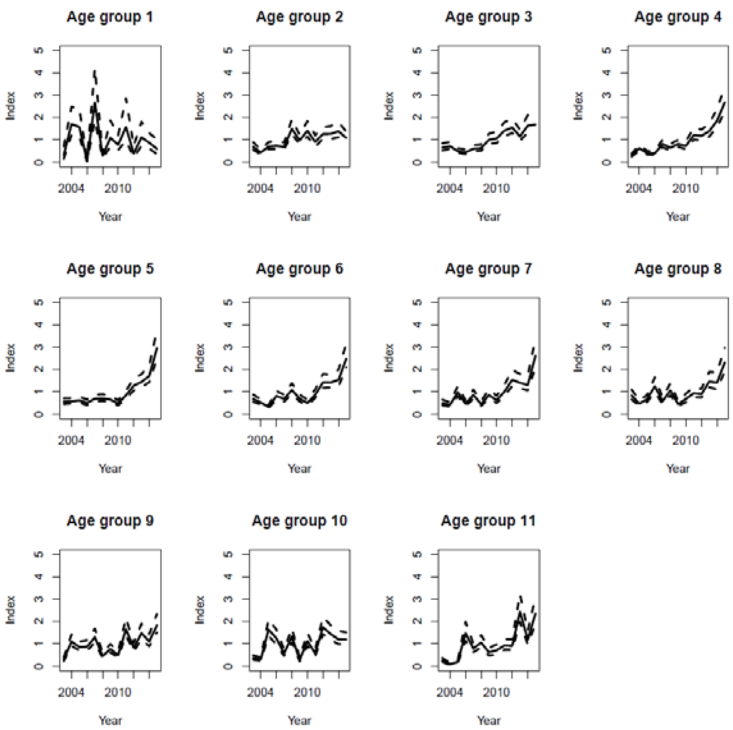

Fig. 21.3.4. Combined beam trawl index by age groups.

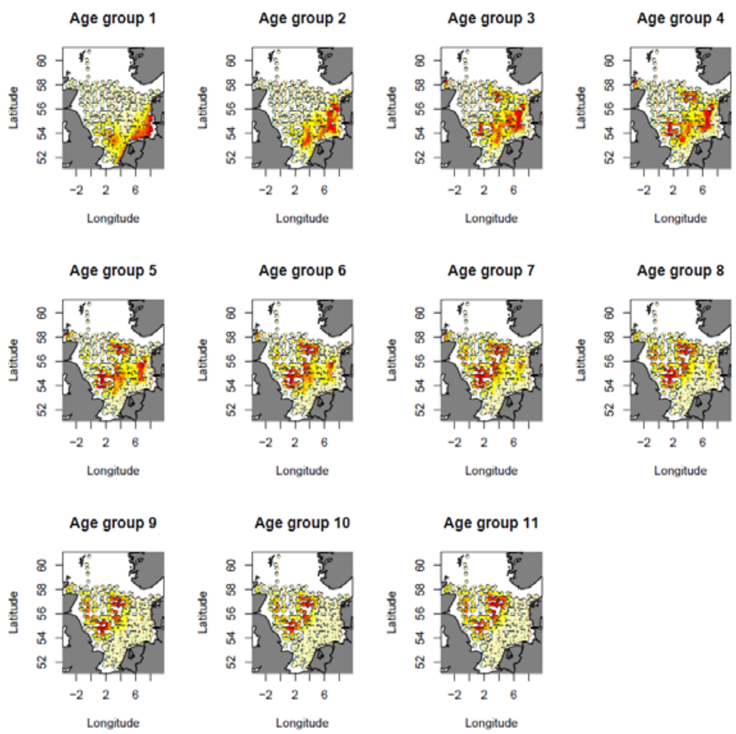

Fig. 21.3.3. Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys.

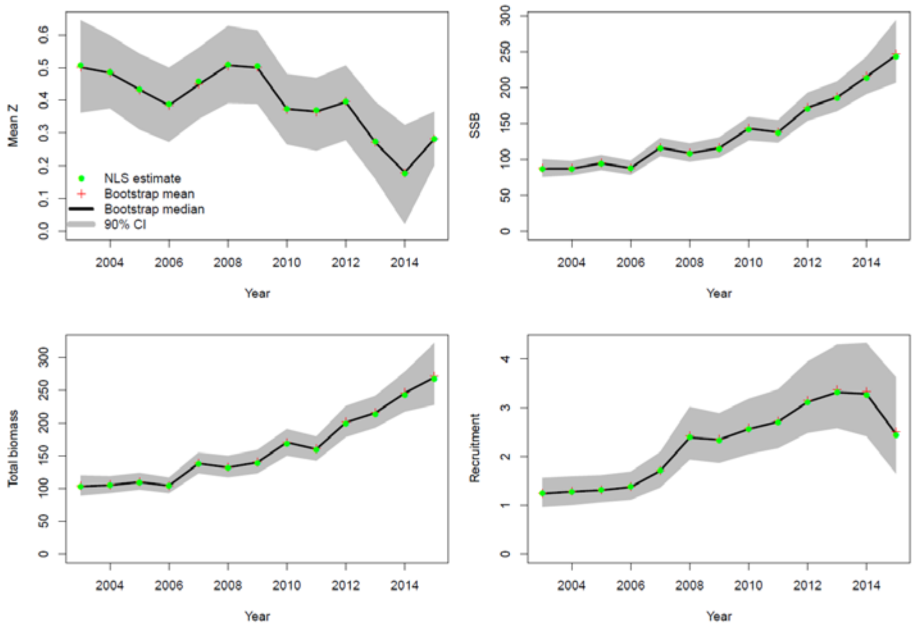

Fig. 21.4.1. SURBA model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

Fig. 21.4.2. SURBA model results of log residuals.

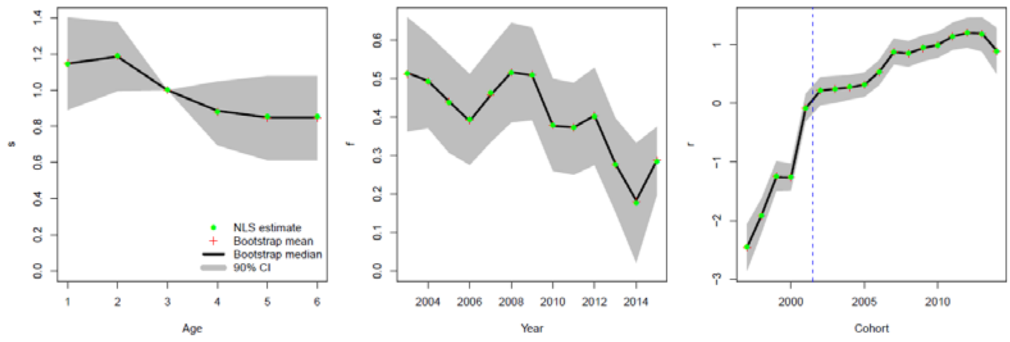

Fig. 21.4.3. SURBA model results displaying the age, year and cohort effects.

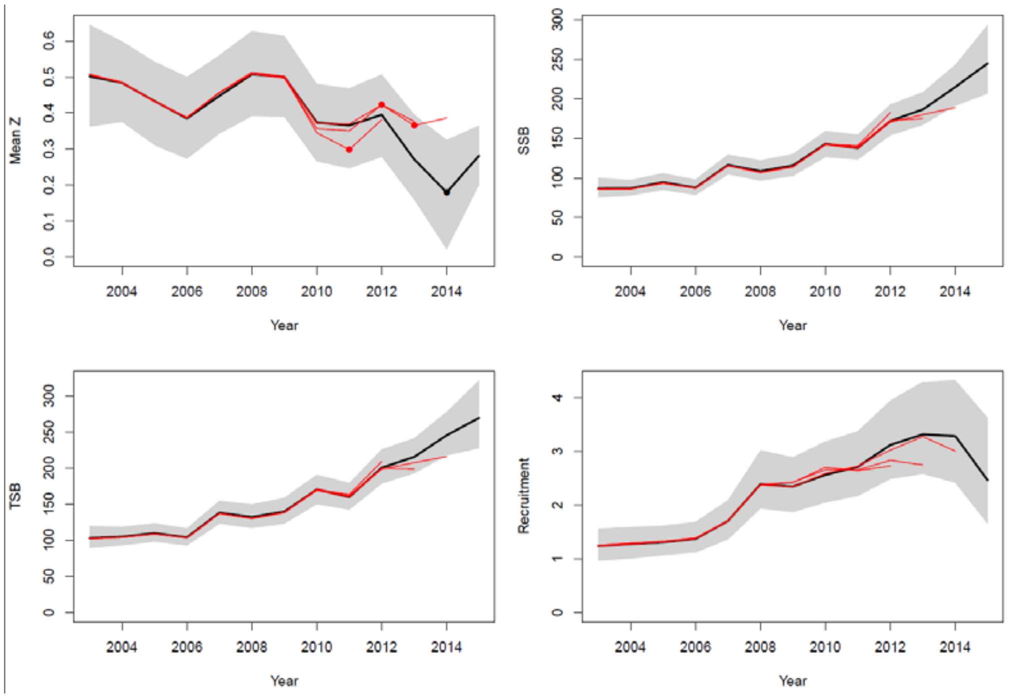

Fig. 21.4.4. SURBA model results. Retrospective runs.

22 Flounder (*Platichtys flesus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)

22.1 General

Flounder (*Platichthys flesus*) was assessed until 2013 in the Working Group on Assessment of New MoU Species (ICES, 2013.a). Because only official landings and survey data were available, flounder was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for flounder was given in 2013 by ICES (ICES, 2013b) based on survey trends. In 2014, flounder was included into the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group. The last biennial advice was that catches should be no more than 5228 tonnes in each of the years 2016 and 2017 (ICES, 2015). If discard rates do not change from the average of the last three years (2012–2014), this implies landings of no more than 2876 tonnes. The WGNSSK 2016 updated official landings, InterCatch raisings and the survey indices for flounder. The used survey index did not change the perception of the stock and thus it was concluded not to reopen the advice for 2017.

22.1.1 Biology and ecosystem aspects

Flounder is an euryhaline flatfish: the life cycle of each individual usually includes marine, brackish, and freshwater habitats. It has a coastal distribution in the Northeast Atlantic, ranging from the White Sea and the Baltic in the north, to the Mediterranean and Black Sea in the south. Flounder can live in low salinity water but they reproduce in water of higher salinity. In the North Sea, Skagerrak and Kattegat flounder spawn between February and April.

Flounder feeds on a wide variety of small invertebrates (mainly polychaete worms, shellfish, and crustaceans), but locally the diet may include small fish species like smelt and gobies. The most intensive feeding occurs in the summer, while food is sparse in the winter.

During autumn, both mature and immature flounder withdraw from the inshore and estuarine feeding areas. Immature flounder migrate into coastal areas, where they spend the winter. The adults move further offshore to the 25–40 m deep spawning grounds, the most important of which are situated along the coasts of Belgium, the Netherlands, Germany, and Denmark.

More details on available data and knowledge can be found in the flounder stock annex.

22.1.2 Stock ID and possible assessment areas

There is no information about stock identity and possible stock assessment areas in the North Sea, Skagerrak and Kattegat. Within the North Sea there may exist a number of sub-populations (WGNEW, 2013).

22.1.3 Management regulations

There is no minimum landing size for this species in EC waters.

In the EC waters of area 2 a and 4 there is a combined TAC for flounder and dab. The TAC for both species of 18.434 t was not changed in the last three years.

22.2 Fisheries data

22.2.1 Historical landings

In the North Sea and in Skagerrak-Kattegat flounder is mainly a by-catch in the fishery for commercially more important flatfish such as sole and plaice and in the mixed demersal fisheries. The largest part of official landings is reported for Subarea 4, especially for the last decade (Fig. 22.2.1.1; Table 22.2.1.3). Landings in ICES Subarea 4 and Division 3.a by country are shown in Figures 22.2.1.2 and 22.2.1.3 and in Tables 22.2.1.1 and 22.2.1.2. From Figure 22.2.1.1 it can be seen that the landings data are not complete: there is a gap in Dutch landings data for the time period 1984 to 1997.

Since 1950, annual landings from the North Sea have fluctuated, without a clear pattern (Figure 22.2.1.1). In the last decade, landings declined considerably. This decline goes hand in hand with a reduction in fishing effort of bottom trawl fleets in the North Sea. For 2015, total official landings were reported with 1883 t, compared to 2062 t in 2014. In area 3.a, annual landings have decreased sharply from 194 t in 2014 to 77 t in 2015 (Figure 22.2.1.3). In the beginning of the time series the landings seem to be fluctuating without a clear trend, however in last two decades the trend is declining. Flounder is of relatively little commercial importance in the North Sea and the Skagerrak-Kattegat. In the North Sea and the Skagerrak-Kattegat the landings data may be misreported in years that quota for commercially more important species are limited. The amount of misreporting however is not known. In addition, the North Sea landings may not reflect the catches very well. Flounder is often discarded and discarding is influenced by the prices and the availability of other, commercially more important species.

22.2.2 Inter Catch

In 2014 flounder was included for the first time into the data call for WGNSSK 2014. In 2016 data to cover the years 2012 – 2015 are available in InterCatch. From all countries data were uploaded to the Inter Catch data portal. Norway, France, and Scotland did only report landings but no discards for flounder. For the year 2012 The Netherlands provided only discard data. In general it was tried only to use equivalent or similar metiers for the raising procedure. Discard information was provided for 88% in relation to weight of total landings in 2015 (90% in 2014; 90% in 2013).

In 2015 by far the largest proportion of landings (1365 t, ~72% of total landings) was reported by the Netherlands and Belgium beam trawlers (TBB_DEF_70_99_0_0_all). Other metiers landing flounder in considerable amounts did not land more than 100t. These metiers were also dominated by Dutch landings (Fig. 22.2.2.1). The highest amount of discard in 2015 comes again from the MIS_MIS_0_0_0_HC metier (Fig. 22.2.2.2.).

A problem in the estimation of total flounder discards maybe the TBB_CRU_16-32_0_0_all metier targeting brown shrimps in more coastal areas. For this metier relatively high discards but extremely low landings were reported by Germany. The Netherlands and Belgium reported landings but no discards. It was not meaningful to use the German fleet to raise the Belgium and Dutch landings which would probably have resulted in unrealistic high discards for these fleets. However, given the amount discarded by Germany and the similar effort in this metier by The Netherlands this might lead to a substantial underestimation of the total discard estimation. It might be useful in the future to raise discard by effort for these fleets and also for some metiers with zero landings for which no discards can be raised although they might occur in these metiers.

The highest total catch is taken by the Netherlands, followed by Scotland (nearly all reported discards for Scotland). Belgium and Denmark also take a considerable part of the catch while all other countries catch less than 100t (Fig. 22.2.2.3). The total catch estimated with Inter Catch was 3045 t from which 1762t were landings (compared to 1883t reported official landings) and 1283 t discards (42% of total catches which is the same value as for the last year). However, it should be noted that not all metiers were sampled in every quarter and that the raising procedure may not be adequate in all cases.

22.3 Survey data / recruit series

Several surveys in the North Sea, Skagerrak and Kattegat provide information on distribution, abundance and length composition of flounder. The most relevant survey for flounder is probably the International Bottom Trawl Survey IBTS in quarter 1 (Figure 22.3.1 and Figure 22.4.3). However, the IBTS Q1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. The BTS surveys use a beam trawl, but they are carried out in quarter 3, in a time of year in which flounder is usually distributed in more coastal, shallow and brackish waters. Therefore, it was decided by WGNEW2013 to use the IBTS Q1 to analyse survey trends for this species. It should be noted here that for the IBTS the gear in use was fully standardized since 1983. Therefore, index data before this year should be interpreted with caution and are not presented in this report.

22.4 Analysis of stock trends / assessment

In 2013 flounder was assessed in the Working Group on Assessment of New MoU Species (ICES, 2013). Until then, only landings data and survey trends were available for this species. Therefore, flounder was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2012). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. A mature biomass index in kg per hour was estimated from the IBTS Q1 survey (excluding round fish areas 1 and 2), because this survey covers most of the distribution area of flounder in area 4 and 3.a.

As the used index for flounder did not change the perception of the stock it was agreed by the WGNSSK2016 that the advice was not reopened.

Estimated indices

The mature biomass index (kg/hour) estimated by WGNSSK2016 was based on the IBTS Q1 survey which covers most of the distribution area of flounder in area 4 and 3.a. Roundfish areas 1 and 2 were excluded from analyses because flounder does only occur very occasionally in these areas (Fig. 22.3.1). To estimate a mature biomass index (kg/hour) a length weight relationship derived from IBTS Q1 data was applied. The same data set shows that above 20cm probably most flounder are mature (Fig. 22.4.1).

The biomass index shows a rather stable trend from 1983 onwards with two major peaks between 1985 and 1995 (Fig. 22.4.3). From 1996 to 2001 the index declined, followed by an increase until 2005. Since then it fluctuated without a clear trend up to 2010. A declining trend can be observed from 2010 to 2014, while the values of 2015 and 2016 are again somewhat higher.

22.5 References

ICES 2015. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK),

ICES 2013.a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM 21.

ICES 2013b. Flounder in Subarea IV and Division 3.a, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.29.

ICES. 2013c. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24–30 April 2013. ICES CM 2013/ACOM:13.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Table 22.2.1.1 Flounder official landings by country in ICES area 4.

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1950	67	1514	0	641	937	0	67	241	3467
1951	119	1143	0	329	949	0	81	127	2748
1952	91	1210	0	257	841	0	71	186	2656
1953	270	1372	0	397	886	0	92	203	3220
1954	142	1225	0	281	696	0	71	121	2536
1955	145	1244	0	353	871	0	88	109	2810
1956	132	1389	0	277	1097	0	102	2	2999
1957	81	910	0	250	825	0	112	0	2178
1958	99	784	0	257	1088	0	94	0	2322
1959	62	533	0	424	857	0	79	1	1956
1960	82	614	0	540	733	0	49	8	2026
1961	68	776	0	390	579	0	81	13	1907
1962	37	1146	0	313	717	0	53	2	2268
1963	16	501	0	263	467	0	65	0	1312
1964	30	1141	0	305	563	0	48	6	2093
1965	121	1349	0	248	549	0	54	3	2324
1966	32	946	0	229	573	0	71	2	1853
1967	43	540	0	193	331	0	57	25	1189
1968	75	894	0	152	160	0	43	1	1325
1969	54	582	0	158	161	0	33	0	988
1970	50	316	0	135	405	0	57	0	963
1971	60	685	0	173	297	0	70	0	1285
1972	63	991	0	159	275	0	60	0	1548
1973	63	290	0	172	1424	0	53	0	2002
1974	115	766	0	190	2661	0	58	0	3790
1975	68	437	0	155	2191	0	87	1	2939
1976	94	575	0	209	2077	0	70	54	3079
1977	107	320	0	208	1732	0	127	11	2505
1978	122	203	0	198	1519	0	169	0	2211
1979	129	181	31	275	1260	0	201	0	2077
1980	190	300	33	229	806	0	140	0	1698
1981	164	669	14	200	1068	0	133	0	2248
1982	110	630	31	200	1597	0	121	0	2689
1983	88	564	36	197	2059	0	125	0	3069
1984	272	518	15	103	0	0	122	0	1030
1985	163	379	14	128	0	0	109	0	793
1986	155	456	1	91	0	0	111	0	814
1987	132	394	32	106	0	0	90	0	754
1988	160	509	44	105	682	0	98	0	1598
1989	200	632	28	95	916	0	80	0	1951
1990	153	467	69	147	0	0	45	0	881
1991	260	377	51	902	0	0	69	0	1659
1992	152	492	35	521	0	0	76	0	1276

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1993	194	1812	47	356	0	0	136	0	2545
1994	196	642	57	921	0	0	247	0	2063
1995	301	628	103	843	0	0	250	0	2125
1996	262	1439	68	43	0	0	193	0	2005
1997	110	988	10	25	0	0	157	0	1290
1998	283	154	40	13	4938	0	132	0	5560
1999	326	123	0	11	3158	0	54	0	3672
2000	289	100	46	17	2656	5	52	0	3165
2001	241	92	42	4	2608	3	32	0	3022
2002	165	83	51	2	3531	3	55	0	3890
2003	206	94	33	3	3172	9	120	0	3637
2004	335	96	46	5	3720	18	74	0	4294
2005	241	171	17	5	3363	38	111	0	3946
2006	168	152	19	2	4020	39	216	0	4616
2007	298	166	56	45	2925	11	119	0	3620
2008	306	228	30	39	2231	3	57	0	2894
2009	272	273	38	46	2124	3	59	0	2815
2010	251	126	20	58	2612	6	87	0	3160
2011	262	112	17	25	2566	1	65	0	3048
2012	348	100	11	23	1672	0	38	0	2192
2013	346	93	13	28	1199	0	24	0	1703
2014	366	107	15	30	1318	1	31	0	1868
2015*	301	97	18	19	1356	15	0	0	1806

***Preliminary catch statistics**

Table 22.2.1.2 Flounder official landings by country in ICES division 3.a.

YEAR	DENMARK	GERMANY	NETHERLANDS	NORWAY	SWEDEN	TOTAL
1950	1632	92	0	0	657	2381
1951	1548	88	0	0	759	2395
1952	1161	48	0	0	683	1892
1953	1135	17	0	0	724	1876
1954	1138	13	0	0	528	1679
1955	1265	11	0	0	667	1943
1956	1229	6	0	0	0	1235
1957	1331	12	0	0	0	1343
1958	1099	12	0	0	0	1111
1959	1003	3	0	0	0	1006
1960	875	10	0	0	566	1451
1961	821	9	0	0	442	1272
1962	812	3	0	0	0	815
1963	554	0	0	0	0	554
1964	822	1	0	0	0	823
1965	1016	0	0	0	0	1016
1966	1027	0	0	0	0	1027
1967	811	3	0	0	0	814
1968	808	2	0	0	0	810
1969	721	0	0	0	0	721
1970	667	0	0	0	0	667
1971	611	1	0	0	0	612
1972	365	0	0	0	0	365
1973	346	0	0	0	0	346
1974	1656	2	0	0	0	1658
1975	1377	1	0	0	89	1467
1976	949	2	4	0	144	1099
1977	1036	0	19	0	64	1119
1978	1560	10	14	0	64	1648
1979	1219	0	0	0	100	1319
1980	426	0	0	0	135	561
1981	1831	0	0	0	74	1905
1982	1236	0	0	0	75	1311
1983	2352	0	0	0	160	2512
1984	2463	0	0	0	283	2746
1985	1203	0	0	0	102	1305
1986	1585	0	0	0	166	1751
1987	1050	0	0	0	119	1169
1988	1164	0	0	0	149	1313
1989	996	0	0	0	133	1129
1990	650	1	0	0	57	708
1991	574	0	0	0	50	624
1992	455	0	0	0	52	507

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
1993	673	3	0	0	67	743
1994	865	1	0	0	77	943
1995	403	19	0	0	76	498
1996	429	9	0	0	104	542
1997	367	2	0	0	68	437
1998	637	5	0	0	83	725
1999	558	6	0	0	24	588
2000	609	17	0	0	30	656
2001	672	2	0	1	30	705
2002	493	0	0	1	30	524
2003	452	3	0	0	18	473
2004	462	2	0	0	14	478
2005	467	0	0	0	15	482
2006	380	0	0	0	13	393
2007	419	3	1	0	22	445
2008	326	4	0	0	16	346
2009	238	2	0	0	33	273
2010	188	0	0	0	17	205
2011	129	0	0	0	16	145
2012	110	0	0	0	8	118
2013	162	0	0	0	11	173
2014	190	0	0	0	4	194
2015*	74	0	0	0	3	77

*preliminary catch statistics

Table 22.2.1.3 Flounder total official landings by ICES areas.

Year	3.a	4	Total
1950	2381	3467	5848
1951	2395	2748	5143
1952	1892	2656	4548
1953	1876	3220	5096
1954	1679	2536	4215
1955	1943	2810	4753
1956	1235	2999	4234
1957	1343	2178	3521
1958	1111	2322	3433
1959	1006	1956	2962
1960	1451	2026	3477
1961	1272	1907	3179
1962	815	2268	3083
1963	554	1312	1866
1964	823	2093	2916
1965	1016	2324	3340
1966	1027	1853	2880
1967	814	1189	2003
1968	810	1325	2135
1969	721	988	1709
1970	667	963	1630
1971	612	1285	1897
1972	365	1548	1913
1973	346	2002	2348
1974	1658	3790	5448
1975	1467	2939	4406
1976	1099	3079	4178
1977	1119	2505	3624
1978	1648	2211	3859
1979	1319	2077	3396
1980	561	1698	2259
1981	1905	2248	4153
1982	1311	2689	4000
1983	2512	3069	5581
1984	2746	1030	3776
1985	1305	793	2098
1986	1751	814	2565
1987	1169	754	1923
1988	1313	1598	2911
1989	1129	1951	3080
1990	708	881	1589
1991	624	1659	2283
1992	507	1276	1783

Year	3.a	4	Total
1993	743	2545	3288
1994	943	2063	3006
1995	498	2125	2623
1996	542	2005	2547
1997	437	1290	1727
1998	725	5560	6285
1999	588	3672	4260
2000	656	3165	3821
2001	705	3022	3727
2002	524	3890	4414
2003	473	3637	4110
2004	478	4294	4772
2005	482	3946	4428
2006	393	4616	5009
2007	445	3620	4065
2008	346	2894	3240
2009	273	2815	3088
2010	205	3160	3365
2011	145	3048	3193
2012	118	2192	2310
2013	173	1703	1876
2014	194	1868	2062
2015*	77	1806	1883

***preliminary catch statistics**

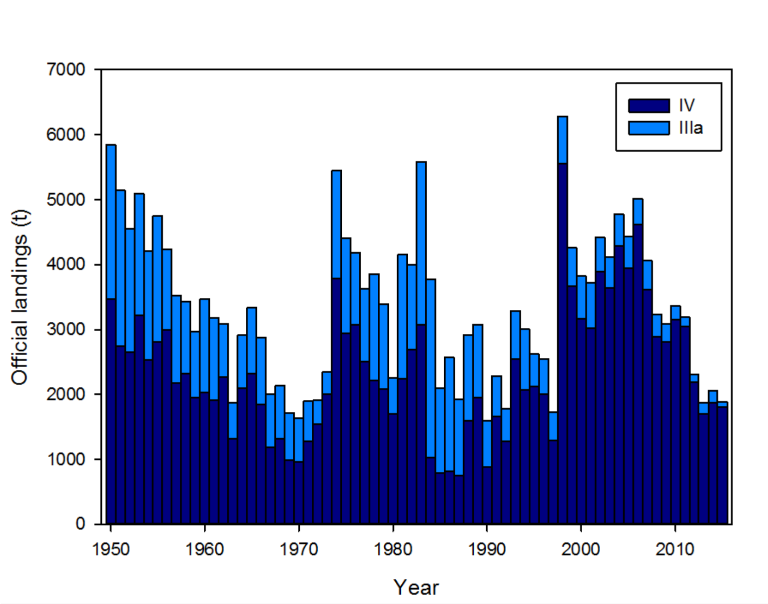

Fig. 22.2.1.1 Official landings of flounder by area.

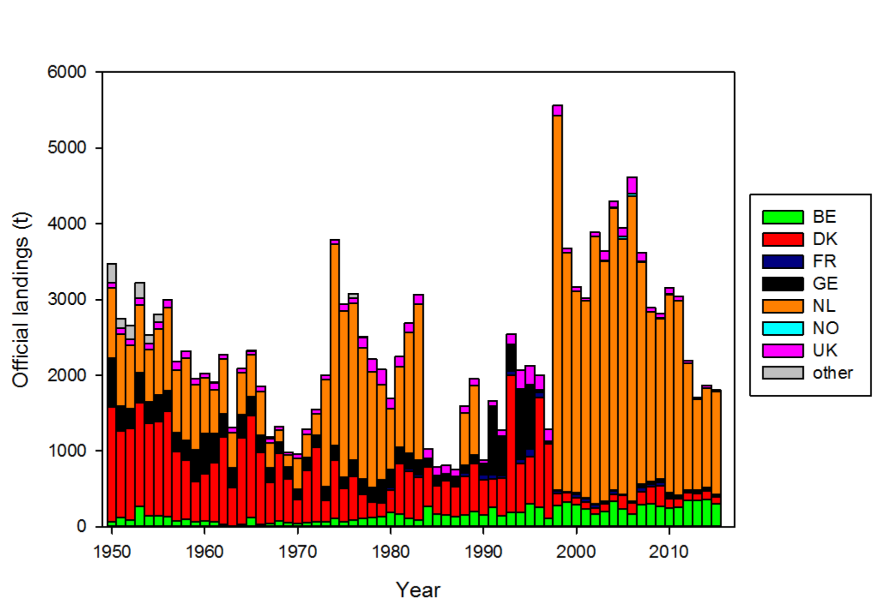

Fig. 22.2.1.2 Official landings of flounder in ICES area 4 by country.

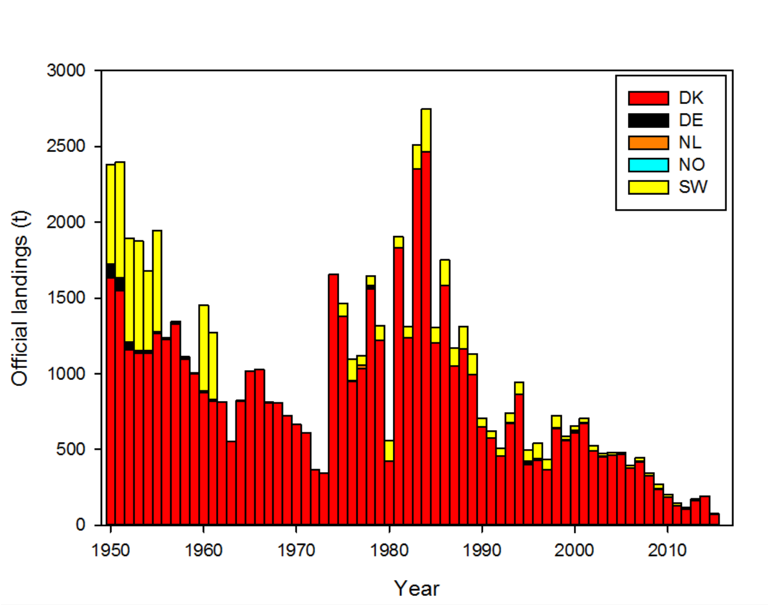

Fig. 22.2.1.3 Official landings of flounder in ICES division 3.a by country.

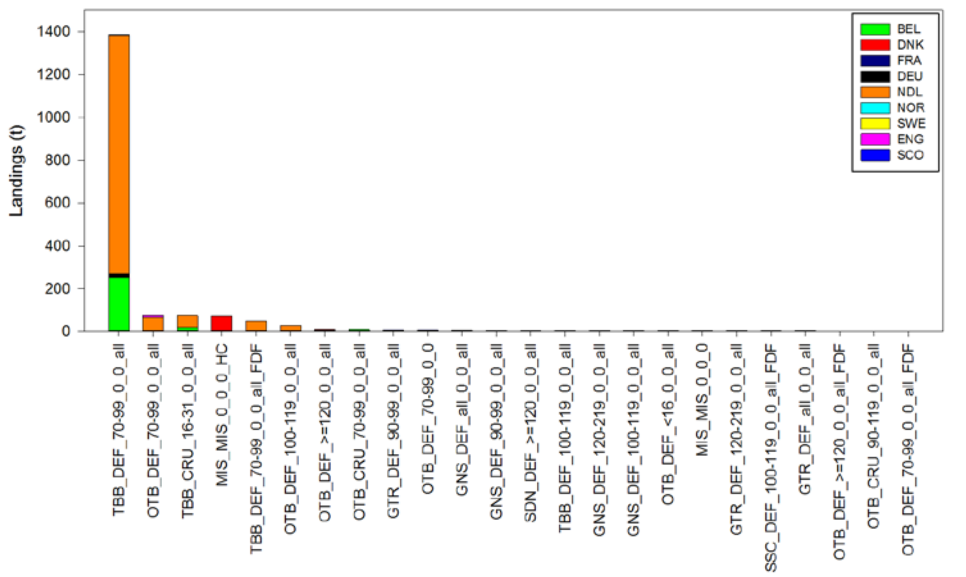

Fig. 22.2.2.1 Inter Catch. Flounder landings by metier and country in 2015 as uploaded to Inter Catch.

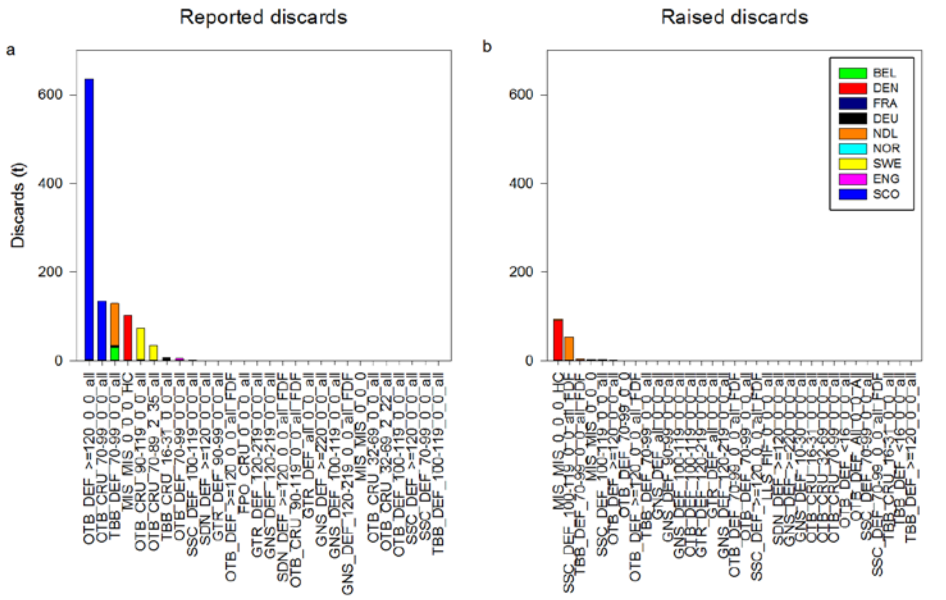

Fig. 22.2.2.2 Inter Catch. Flounder discards by metier and country in 2015. Reported discards panel (a), raised discards panel (b).

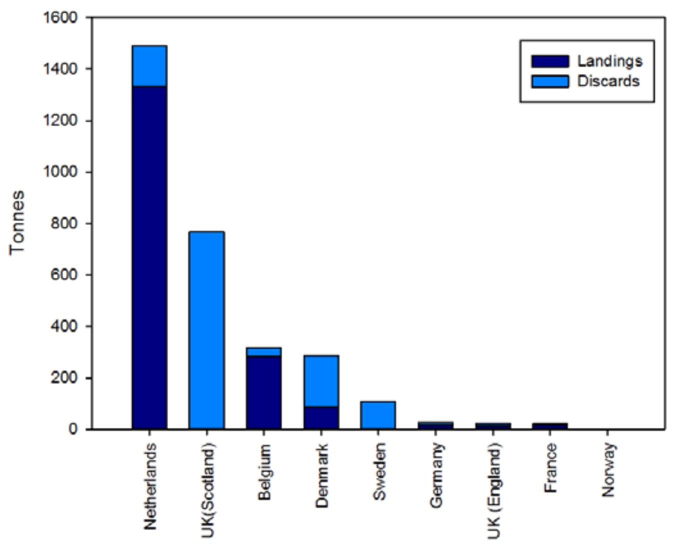

Fig. 22.2.2.3 Inter Catch. Flounder landings and discards by country in 2014.

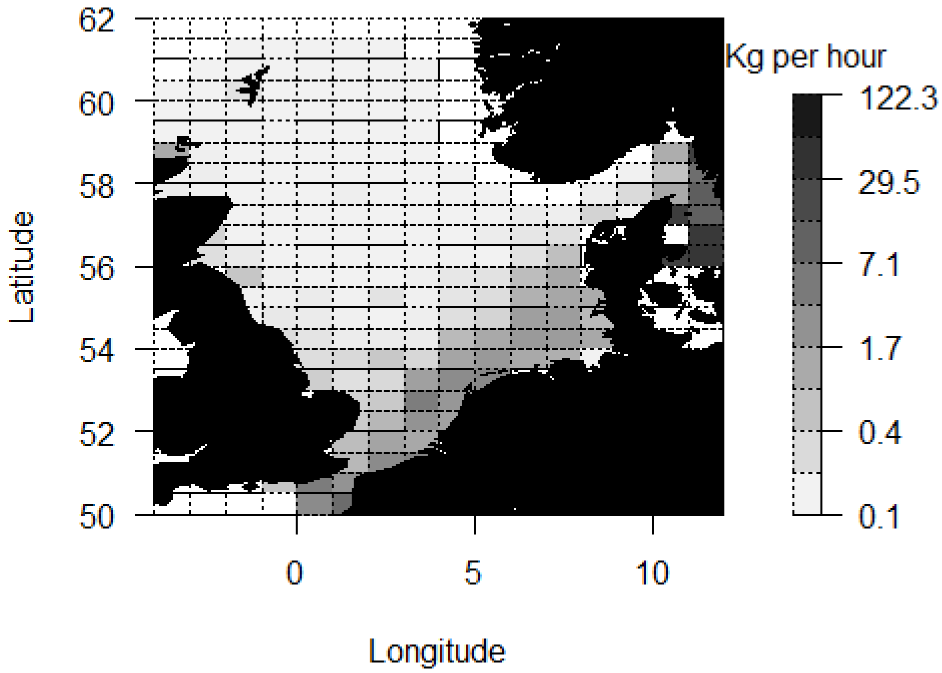

Fig. 22.3.1 Distribution of flounder derived from the IBTS Q1 survey in area 4 and division 3.a for the whole time series.

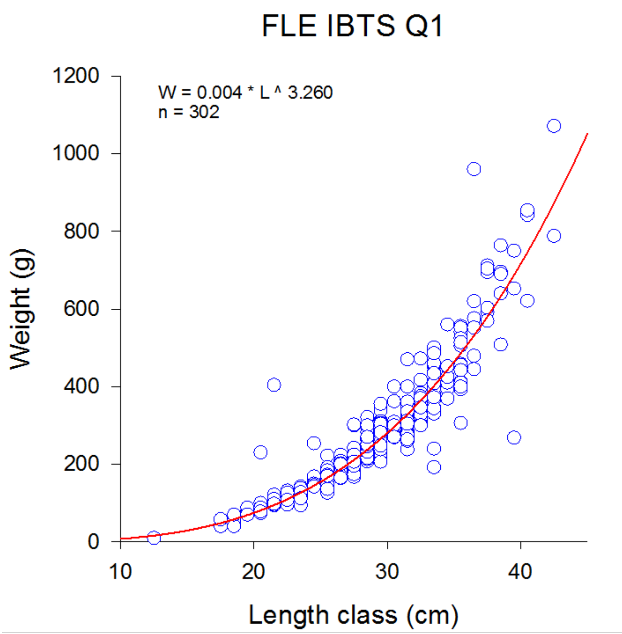

Fig. 22.4.1 Length weight relationship of flounder derived from IBTS Q1 data.

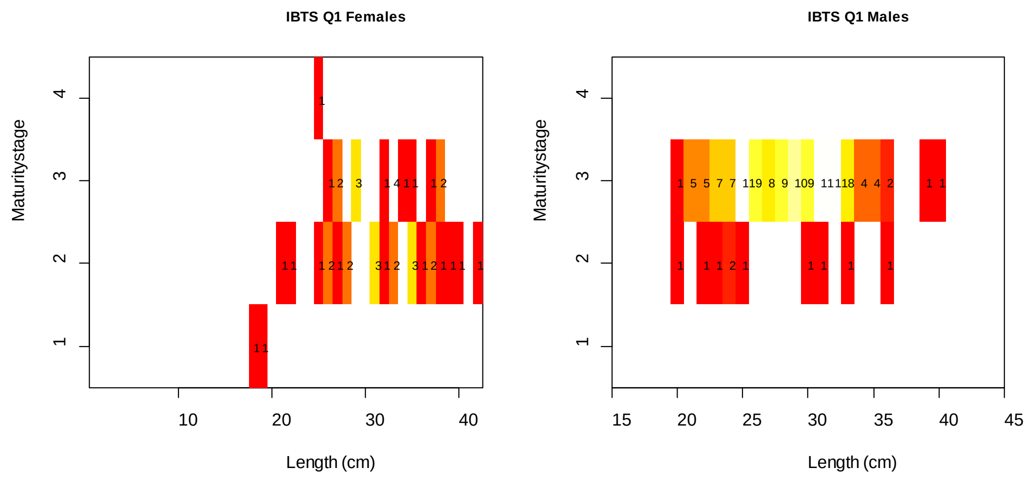

Fig. 22.4.2 Maturity at length of female and male flounder derived from IBTS Q1 data.

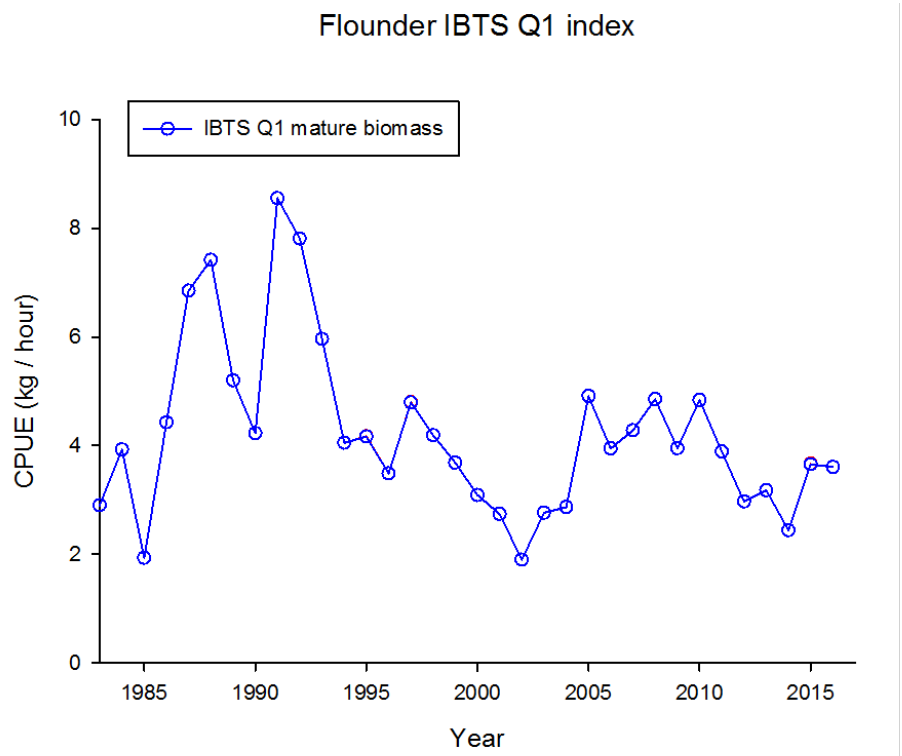

Fig. 22.4.3 Mature biomass index of flounder in area 4 and division 3.a derived from IBTS Q1 data 1983–2016.

23 Lemon sole (*Microstomus kitt*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, Eastern English Channel)

23.1 General

Until 2014, lemon sole (*Microstomus kitt*) was assessed in the Working Group on Assessment of New MoU Species (ICES, 2013). Lemon sole has been defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for lemon sole was given in 2013 (ICES, 2013b), based on survey trends. In 2014, lemon sole was included to the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). This is the third year in which the stock status for lemon sole has been evaluated by WGNSSK.

23.1.1 Biology and ecosystem aspects

Lemon sole is a commercially important flatfish that is found in the shelf waters of the North Atlantic from the White Sea and Iceland southwards to the Bay of Biscay. In Scottish waters, lemon sole spawn in the northwest of the North Sea in April and spawning spreads north and east as the season progresses (Rae, 1965). In the western English Channel, lemon sole spawn in April and May (Jennings *et al.* 1993). In the English Channel, investigations of habitat association for plaice, sole and lemon sole indicated that distribution is restricted to a few sites and that lemon soles appear to prefer sandy and gravely strata, living deeper and at a higher salinity and lower temperature than plaice or sole (Hinz *et al*., 2006). Lemon sole feeds on small invertebrates, mainly polychaete worms, bivalves and crustaceans.

23.1.2 Stock ID and possible assessment areas

There is little information available on lemon sole stock identity for the greater North Sea.

23.1.3 Management regulations

No specific management objectives are known to ICES. An EU TAC is set for EU waters of ICES Division 2.a and Subarea 4 together with witch flounder (ICES, 2013).

23.2 Fisheries data

23.2.1 Historical landings

In the North Sea and in Skagerrak-Kattegat lemon sole is mainly a by-catch species in the fishery for plaice and in the mixed demersal fisheries. Landings in ICES Division 7.d, and sub-area 4 and division 3.a are shown in Figures 23.2.1 to 23.2.4, and in Tables 23.2.1 to 23.2.4. The time-series of landings are not fully complete, and a number of countries have gaps in data provision.

23.2.2 Discards

Catch yields and age compositions for lemon sole for 2013 and 2014 were submitted for the first time to the InterCatch system prior to the 2015 WGNSSK meeting, enabling the estimation of discard rates (by weight) for those years. However, no age-sampled landings or discards were submitted for the 2016 WGNSSK meeting. Previously, only around 10% of metiers landing lemon sole were age-sampled for landings and discards, and all such sampling was carried out by England. In 2016, age samples were not available. However, the majority of landings have estimates of total discards by weight associated with them. The time-series of official landings for the full stock area, along with WG estimates of landings and discards for 2013, 2014 and 2015, are given in Figure 23.2.5. Discard rates by weight in 2015 (29%) remain similar to that of 2013 (28%) and 2014 (31%).

23.3 Survey data / recruit series

Surveys providing information on distribution, abundance and length frequency for lemon sole in area 4, division 7.d and division 3.a are the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3, and the Beam Trawl Survey (BTS; only area 4) in quarter 3. The IBTS Q1 was used in the case of lemon sole to analyse stock trends. This survey uses a GOV demersal trawl which may not be the optimal gear to catch flatfish such as lemon sole. However, the beam trawl surveys do not cover the whole distribution area of lemon sole (missing the northern area in particular, see Figure 23.3.1) and catches of lemon sole are relatively high in the IBTS. It should be noted here that for the IBTS the gear in use was fully standardized since 1983. Therefore, index data before this year (although available) should be interpreted with caution. Figure 23.3.1 displays the distribution of lemon sole in the greater North Sea obtained from IBTS Q1 data in 2016, in which year the stock was widely distributed across the central North Sea.

23.4 Analysis of stock trends / assessment

In 2013, lemon sole was assessed within the Working Group on the Assessment of MoU New Species (ICES, 2013). Only landings data and survey trends were available for this species. Therefore, lemon sole was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2013). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = \bar{C}_{y-1,y}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{x-1} I_i/(z-x)}\right).$$

Here $C_{y+1}$is the advised catch for the next year, $\bar{C}_{y-1,y}$ is the average catch of the last three years , and *I* is the stock index (see below). By default x=2 and z=5, and this setting was used by WGNSSK in 2016.

The index of mature biomass (Figure 23.4.1.) was calculated annually from the IBTS Q1 data. For mature biomass index, the total weight per hour by centimetre length group was calculated using the length-weight relationship from Bedford *et al*. (1986):

$W = 0.00756L^{3.142}$.

The length-maturity ogive (Figure 23.4.2.) was then applied to calculate the mature biomass index. Lemon sole are reported to spawn in the west central North Sea during the period May to November with peak spawning during July-August (Rae, 1965). Therefore most spawning occurs between the Q1 and Q3 IBTS surveys. For this reason, the maturity ogive shown in Figure 23.4.2 was derived from the age at maturity data (2006–2012) from both of these surveys (see stock annex for maturity-length key). Information from the spawning time would improve the accuracy of these estimates.

From WGNSSK 2015 the 2:3 ratio of the abundance index was estimated to be -9%, resulting in an advised decrease in catch from 4833 t (the average of 2013 and 2014) to 4399 t in 2016. The perception of the stock remains unchanged at WGNSSK 2016 with the discard rate and the estimate of SSB in 2015 being similar to that of 2013 and 2014 (Figure 23.4.1). Therefore, WGNSSK concludes that the extant biennial advice remains appropriate.

23.5 Conclusions

Discard estimates were made available for the lemon sole stock for the first time in 2015. These make the application of the DLS 3.2 advice method more justifiable than was the case when only landings data were provided. However, the new data are only available from 2013 onwards, and further backwards extension of the discard time-series would be beneficial.

The use of only the IBTS Q1 survey is also a limitation, as the gear used is not optimum for catching flatfish and there may thus be catchability problems. Information on stock structure, biological data and catch at age information would be needed to be able to perform an analytic assessment. Age readings and maturity status evaluation techniques are still uncertain and under development.

WGNSSK concludes, on the basis of available catch and survey data, that the extent biennial advice (for 2016 and 2017) remains appropriate.

23.6 References

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Jennings, S., Howlett, G. J., Flatman, S. (1993). The distribution, migration and stock integrity of lemon sole *Microstomus kitt* in the western English Channel. Fisheries Research 18: 377–388.

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Table 23.6.1 Official lemon sole landings by area.

Year	3.a	4	7.d	Total
1950	307	3754	208	4269
1951	248	4710	314	5272
1952	243	4922	298	5463
1953	132	5440	386	5958
1954	128	3972	534	4634
1955	102	3836	141	4079
1956	96	3395	103	3594
1957	78	3419	102	3599
1958	94	3104	82	3280
1959	130	3647	82	3859
1960	153	4035	66	4254
1961	161	4900	108	5169
1962	93	4630	101	4824
1963	99	3791	66	3956
1964	134	4121	77	4332
1965	164	4949	105	5218
1966	159	5415	201	5775
1967	191	6188	331	6710
1968	185	6270	337	6792
1969	215	4470	315	5000
1970	169	3434	256	3859
1971	173	3967	357	4497
1972	168	3672	475	4315
1973	214	4568	451	5233
1974	183	4227	351	4761
1975	317	5029	33	5379
1976	361	4830	42	5233
1977	627	5661	36	6324
1978	705	6108	139	6952
1979	833	6428	260	7521
1980	722	6424	152	7298
1981	793	5933	290	7016
1982	735	7168	584	8487
1983	759	8257	491	9507
1984	595	6930	586	8111
1985	793	6435	347	7575
1986	639	5047	251	5937
1987	669	5516	310	6495
1988	642	5898	258	6798
1989	693	5967	364	7024
1990	872	6190	423	7485
1991	734	6618	428	7780
1992	952	6126	364	7442

YEAR	3.A	4	7.D	TOTAL
1993	1152	5839	422	7413
1994	801	5262	695	6758
1995	712	4712	877	6301
1996	634	4737	1151	6522
1997	766	4727	563	6056
1998	865	6466	346	7677
1999	841	6316	140	7297
2000	802	5980	388	7170
2001	583	5389	483	6455
2002	518	3827	474	4819
2003	537	3688	491	4716
2004	602	3543	424	4569
2005	669	3444	350	4463
2006	417	3627	246	4290
2007	432	3892	164	4488
2008	276	3465	234	3975
2009	262	2691	441	3394
2010	351	2627	223	3201
2011	254	3365	403	4022
2012	483	3084	459	4026
2013	290	2980	491	3761
2014	315	3017	357	3689
2015	269	2873	253	3394

Table 23.6.2 Official lemon sole landings in area 7.d by country.

YEAR	BEL	DNK	FRA	NED	UK	OTHER	TOTAL
1950	10	0	174	0	24	0	208
1951	5	0	262	0	47	0	314
1952	10	0	188	0	100	0	298
1953	7	0	196	0	183	0	386
1954	9	0	361	0	164	0	534
1955	9	0	0	0	132	0	141
1956	4	0	0	0	99	0	103
1957	7	0	0	0	95	0	102
1958	1	0	0	0	81	0	82
1959	2	0	0	0	80	0	82
1960	4	0	0	0	62	0	66
1961	1	0	0	0	106	1	108
1962	2	0	0	0	99	0	101
1963	3	0	0	0	63	0	66
1964	5	0	0	0	72	0	77
1965	16	0	0	0	89	0	105
1966	7	0	0	0	194	0	201
1967	6	0	0	0	325	0	331
1968	8	0	0	0	329	0	337
1969	12	0	0	0	303	0	315
1970	16	0	0	0	240	0	256
1971	22	0	0	0	335	0	357
1972	18	0	0	0	457	0	475
1973	25	0	0	0	426	0	451
1974	16	0	0	1	334	0	351
1975	19	0	0	0	14	0	33
1976	24	0	0	0	18	0	42
1977	21	1	0	0	15	0	37
1978	45	2	63	0	31	0	141
1979	60	0	165	0	35	0	260
1980	33	0	109	0	10	0	152
1981	66	0	212	0	12	0	290
1982	96	0	406	1	81	0	584
1983	108	0	298	0	85	0	491
1984	110	0	367	0	109	0	586
1985	117	0	164	0	66	0	347
1986	77	0	133	0	41	0	251
1987	81	0	185	0	44	0	310
1988	74	0	155	0	29	0	258
1989	68	0	252	0	44	0	364
1990	68	0	272	0	83	0	423
1991	83	0	272	0	73	0	428
1992	66	0	176	0	122	0	364

Year	BEL	DNK	FRA	NED	UK	Other	Total
1993	36	0	311	0	75	0	422
1994	97	0	505	0	93	0	695
1995	138	0	584	0	155	0	877
1996	213	0	720	0	218	0	1151
1997	143	0	305	0	115	0	563
1998	53	0	198	0	95	0	346
1999	50	0	0	0	90	0	140
2000	62	0	200	0	126	0	388
2001	104	0	191	0	188	0	483
2002	101	0	256	0	117	0	474
2003	128	0	251	0	112	0	491
2004	120	0	198	1	105	0	424
2005	90	0	187	2	71	0	350
2006	98	0	100	0	48	0	246
2007	70	0	72	1	21	0	164
2008	140	0	46	3	45	0	234
2009	149	0	176	9	108	0	442
2010	101	0	85	5	32	0	223
2011	153	0	178	15	57	0	403
2012	171	0	167	20	0	0	358
2013	176	0	179	26	110	0	491
2014	162	0	108	14	72	0	357
2015	123	0	84	5	41	0	253

Table. 23.6.3 Official lemon sole landings in ICES sub-area 4 by country.

YEAR	BEL	DNK	FRA	GER	NED	NOR	UK	OTHER	TOTAL
1950	112	435	139	31	156	0	2855	26	3754
1951	115	845	90	21	167	0	3430	42	4710
1952	98	391	227	26	168	0	3953	59	4922
1953	73	409	189	18	132	0	4590	29	5440
1954	2	272	177	24	112	0	3368	17	3972
1955	49	311	0	15	78	0	3374	9	3836
1956	48	222	0	19	58	0	3034	14	3395
1957	39	249	0	24	64	0	3032	11	3419
1958	30	171	0	13	43	0	2835	12	3104
1959	85	242	0	40	43	0	3226	11	3647
1960	155	577	0	46	67	0	3178	12	4035
1961	286	488	0	79	102	0	3934	11	4900
1962	175	501	0	54	106	0	3794	0	4630
1963	365	222	0	36	71	0	3097	0	3791
1964	484	358	0	62	75	0	3142	0	4121
1965	562	385	0	91	93	0	3818	0	4949
1966	594	548	0	98	65	0	4110	0	5415
1967	601	791	0	136	61	0	4599	0	6188
1968	422	775	0	96	34	0	4943	0	6270
1969	292	639	0	80	36	0	3423	0	4470
1970	241	307	0	52	58	0	2776	0	3434
1971	348	514	0	54	122	0	2929	0	3967
1972	423	530	0	59	130	0	2530	0	3672
1973	566	478	0	73	217	16	3218	0	4568
1974	486	447	0	59	269	0	2966	0	4227
1975	748	521	0	83	299	0	3367	11	5029
1976	493	506	0	68	308	0	3443	12	4830
1977	618	321	0	71	262	0	4387	2	5661
1978	760	517	28	54	231	0	4518	0	6108
1979	674	876	136	41	390	0	4308	3	6428
1980	484	599	102	49	303	0	4885	2	6424
1981	555	605	237	39	412	0	4084	1	5933
1982	879	670	419	52	759	0	4386	3	7168
1983	1122	735	402	28	1009	0	4957	4	8257
1984	1144	567	344	22	0	0	4850	3	6930
1985	989	555	157	26	0	0	4703	5	6435
1986	511	577	103	16	0	0	3839	1	5047
1987	448	742	174	14	0	0	4137	1	5516
1988	539	639	184	14	301	0	4220	1	5898
1989	441	828	176	40	397	0	4083	2	5967
1990	491	1007	208	49	0	0	4431	4	6190
1991	544	1099	250	41	0	12	4666	6	6618
1992	577	1149	177	30	0	13	4175	5	6126

YEAR	BEL	DNK	FRA	GER	NED	NOR	UK	OTHER	TOTAL
1993	525	966	240	37	0	9	4059	3	5839
1994	436	597	436	27	0	11	3754	1	5262
1995	588	585	412	70	0	9	3046	2	4712
1996	592	547	534	67	0	18	2976	3	4737
1997	504	499	224	76	0	29	3391	4	4727
1998	815	796	197	149	838	23	3643	5	6466
1999	662	1015	0	62	681	24	3866	6	6316
2000	711	1277	184	72	492	17	3222	5	5980
2001	694	1281	191	77	451	22	2666	7	5389
2002	604	971	190	116	402	17	1521	6	3827
2003	517	1008	239	136	369	16	1399	4	3688
2004	667	1113	120	81	355	12	1192	3	3543
2005	595	1057	102	85	402	13	1188	2	3444
2006	552	968	57	183	412	13	1440	2	3627
2007	542	1136	65	143	367	23	1610	6	3892
2008	527	925	47	120	434	26	1383	4	3466
2009	389	898	88	64	294	31	927	2	2693
2010	375	821	32	102	323	35	935	2	2625
2011	387	999	56	96	641	27	1157	2	3365
2012	406	999	34	61	587	30	0	2	2119
2013	527	649	27	67	479	16	1214	2	2981
2014	648	626	27	63	425	23	1202	3	3017
2015	425	794	16	82	423	12	1116	3	2873

Table 23.6.4 Official landings in area 3.a by country.

Year	BEL	DNK	GER	NED	SWE	Other	Total
1950	0	100	1	0	206	0	307
1951	0	74	1	0	173	0	248
1952	0	64	0	0	179	0	243
1953	0	35	0	0	97	0	132
1954	0	33	0	0	95	0	128
1955	0	29	0	0	73	0	102
1956	0	33	0	0	63	0	96
1957	0	27	0	0	51	0	78
1958	0	38	0	0	56	0	94
1959	0	71	0	0	59	0	130
1960	0	95	1	0	57	0	153
1961	0	90	0	0	71	0	161
1962	0	92	1	0	0	0	93
1963	0	99	0	0	0	0	99
1964	0	133	1	0	0	0	134
1965	0	163	1	0	0	0	164
1966	0	159	0	0	0	0	159
1967	0	189	1	0	0	1	191
1968	0	184	0	0	0	1	185
1969	0	215	0	0	0	0	215
1970	0	169	0	0	0	0	169
1971	0	173	0	0	0	0	173
1972	0	168	0	0	0	0	168
1973	0	214	0	0	0	0	214
1974	0	183	0	0	0	0	183
1975	0	263	1	1	52	0	317
1976	10	294	1	19	37	0	361
1977	9	528	2	37	51	0	627
1978	4	628	2	12	59	0	705
1979	7	704	1	10	111	0	833
1980	12	622	0	0	87	1	722
1981	1	710	0	3	75	4	793
1982	2	647	0	9	77	0	735
1983	3	636	0	10	110	0	759
1984	6	525	0	0	64	0	595
1985	0	729	0	0	64	0	793
1986	7	576	0	0	56	0	639
1987	24	577	0	0	68	0	669
1988	11	569	0	6	56	0	642
1989	8	610	0	0	75	0	693
1990	16	782	0	0	74	0	872
1991	11	640	0	0	83	0	734
1992	22	793	0	0	120	17	952

Year	BEL	DNK	GER	NED	SWE	Other	Total
1993	14	980	4	0	141	17	1156
1994	10	648	2	0	127	16	803
1995	27	576	2	0	91	18	714
1996	0	513	1	0	97	24	635
1997	0	628	2	0	115	23	768
1998	0	743	3	0	100	22	868
1999	0	731	3	0	88	22	844
2000	0	722	1	0	65	15	803
2001	0	511	1	0	53	19	584
2002	0	457	4	0	41	20	522
2003	0	451	6	30	35	21	543
2004	0	472	5	82	29	19	607
2005	0	468	5	147	38	16	674
2006	0	321	8	40	32	16	417
2007	0	374	5	16	18	19	432
2008	0	239	7	3	15	12	276
2009	0	233	4	1	15	9	262
2010	0	286	3	35	19	7	350
2011	0	223	0	0	12	16	254
2012	0	446	3	0	15	18	482
2013	0	259	3	5	10	12	289
2014	0	276	7	12	14	6	315
2015	0	250	4	0	9	6	269

Table 23.6.5 Mature biomass index (g/hour) calculated from IBTS Q1 data by WGNSSK in 2016.

Year	Biomass index
1983	1.61
1984	1.629
1985	1.273
1986	1.467
1987	1.313
1988	1.357
1989	1.583
1990	1.548
1991	1.171
1992	1.542
1993	1.927
1994	1.185
1995	1.157
1996	1.381
1997	1.223
1998	1.733
1999	1.787
2000	1.702
2001	1.377
2002	1.819
2003	1.707
2004	1.683
2005	1.22
2006	1.02
2007	1.331
2008	1.331
2009	0.862
2010	0.954
2011	1.265
2012	1.895
2013	1.249
2014	0.968
2015	1.019
2016	1.097

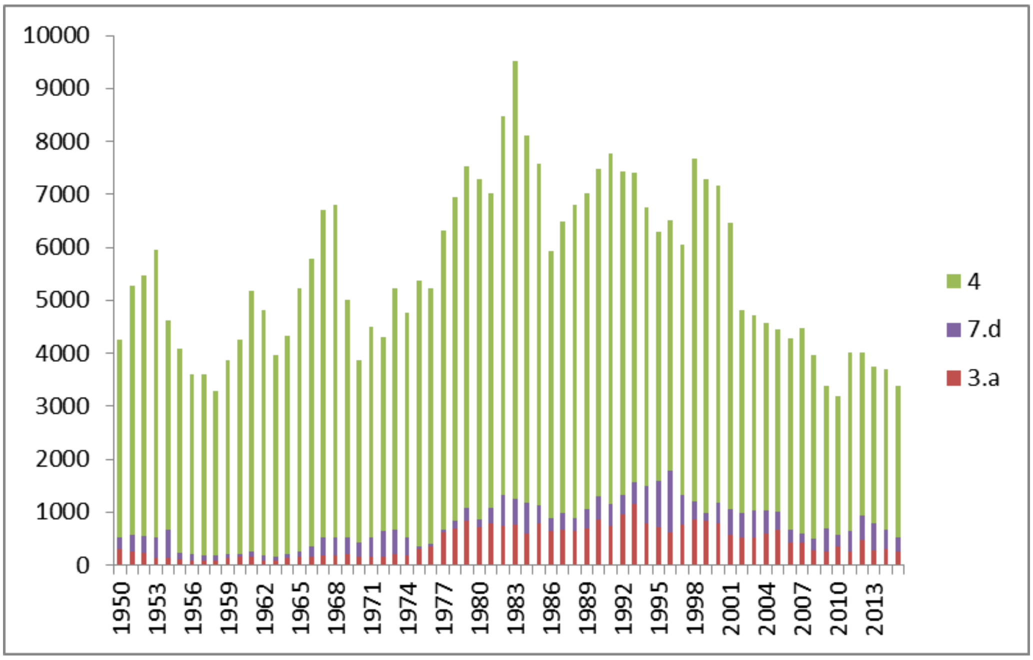

Figure 23.2.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tonnes) of lemon sole by area in the greater North Sea, 1950–2015.

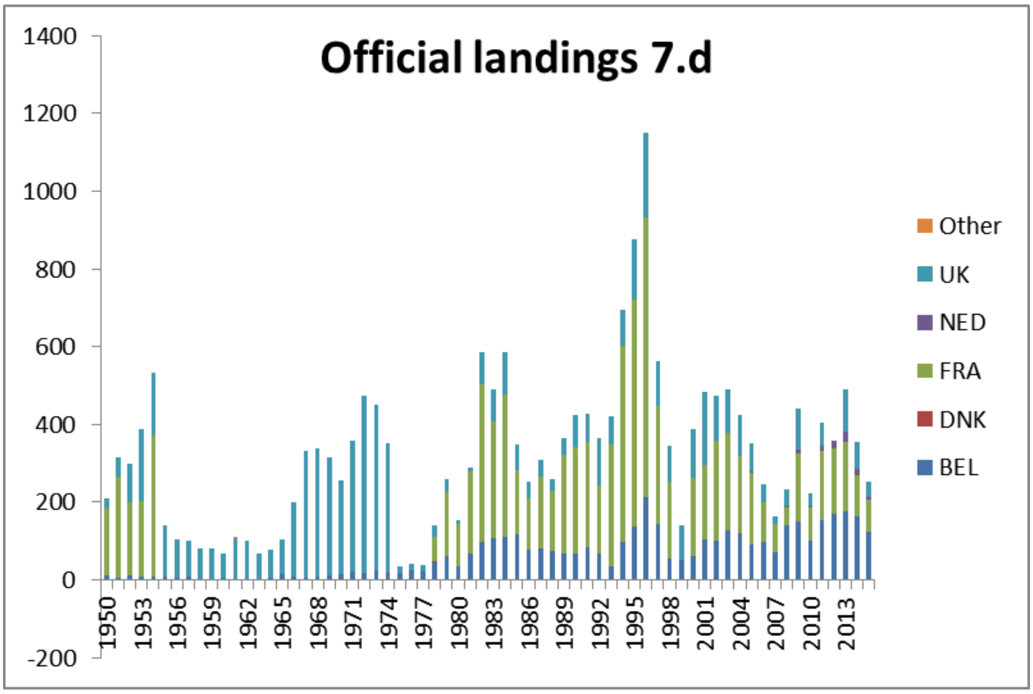

Figure 23.2.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 7.d by country for 1950–2015. Note that official landings data for UK are missing for 2012.

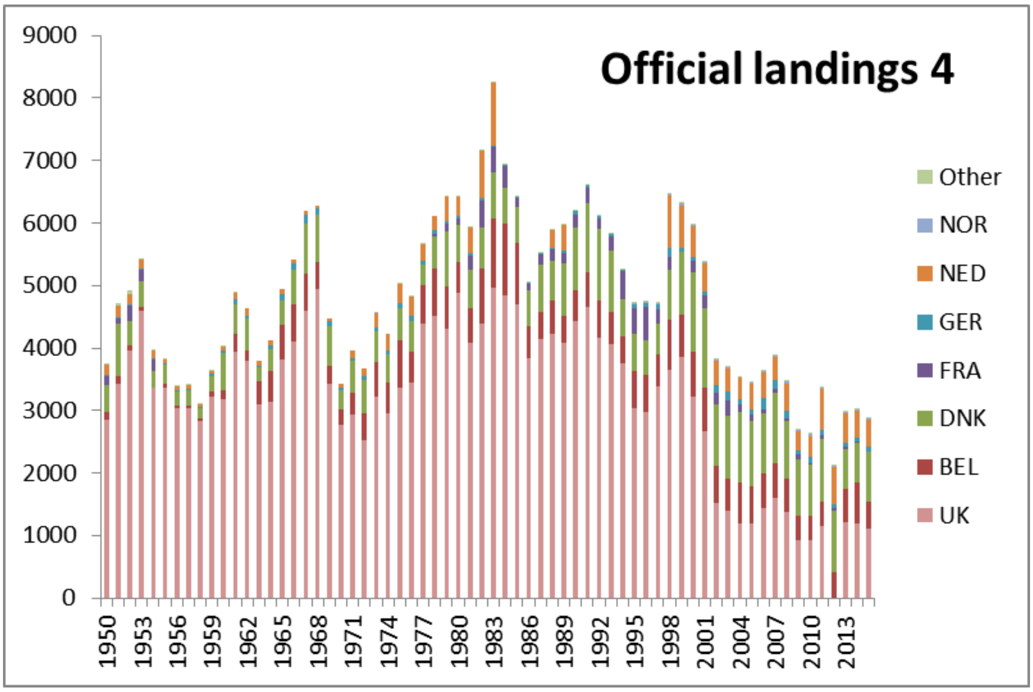

Figure 23.2.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 4 by country, for 1950–2015. Note that official landings data for UK are missing for 2012.

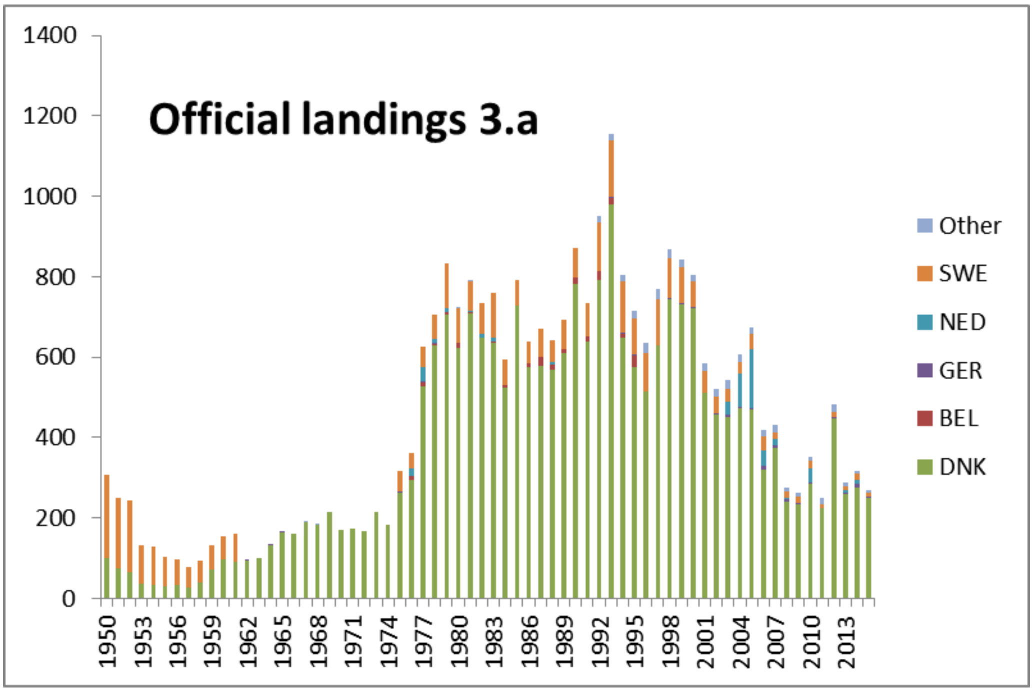

Figure 23.2.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 3.a by country, for 1950–2015.

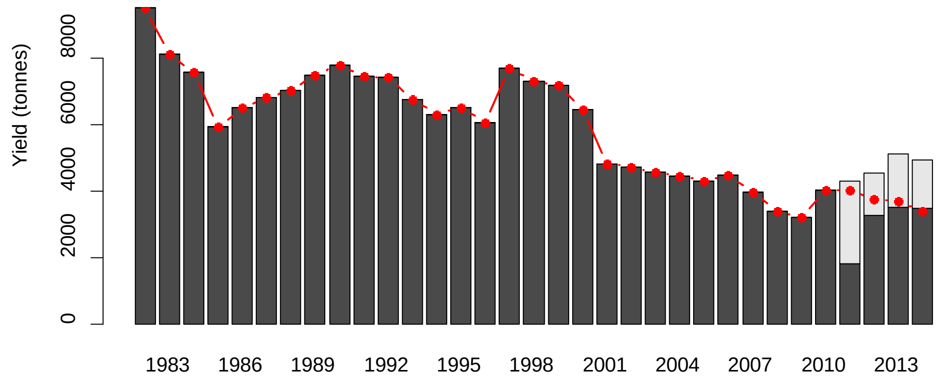

Figure 23.2.5. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of official landings (red dots) along with WG estimates of landings (dark bars) and discards (light bars). Note that the discard-rate estimate for 2012 was based on data submissions from a small subset of countries only, and is unlikely to be representative.

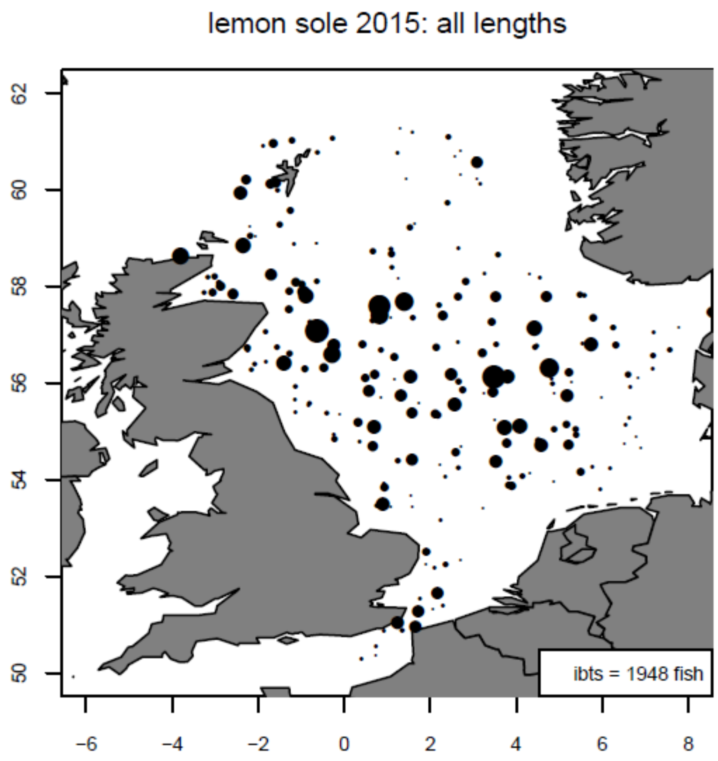

Figure 23.3.1. Distribution of lemon sole in the greater North Sea derived from IBTS Q1 data (2015).

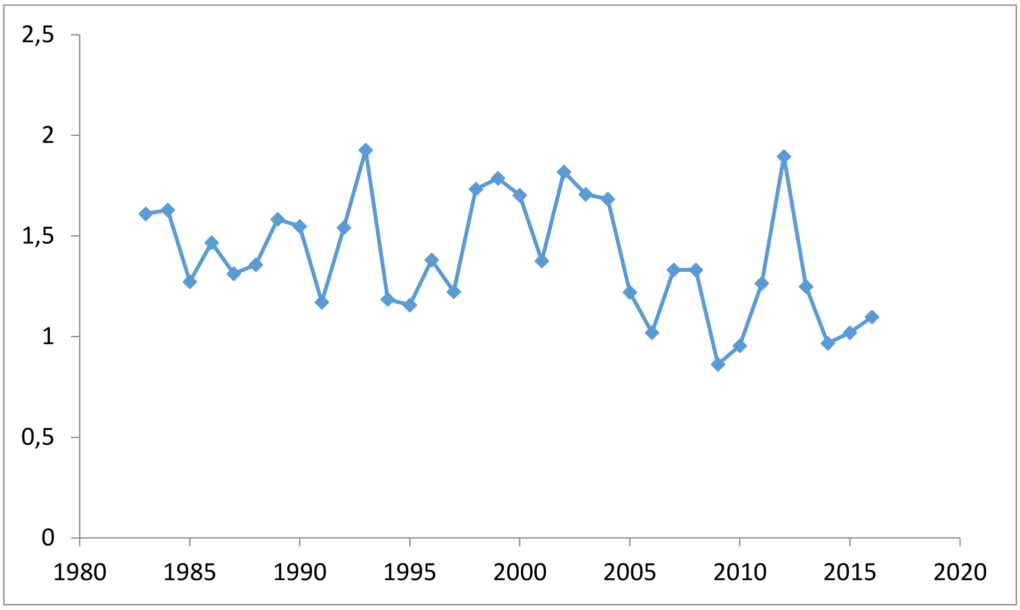

Figure 23.4.1. Index of mature biomass (kg/hr)for Subarea 4 derived from IBTS Q1 data

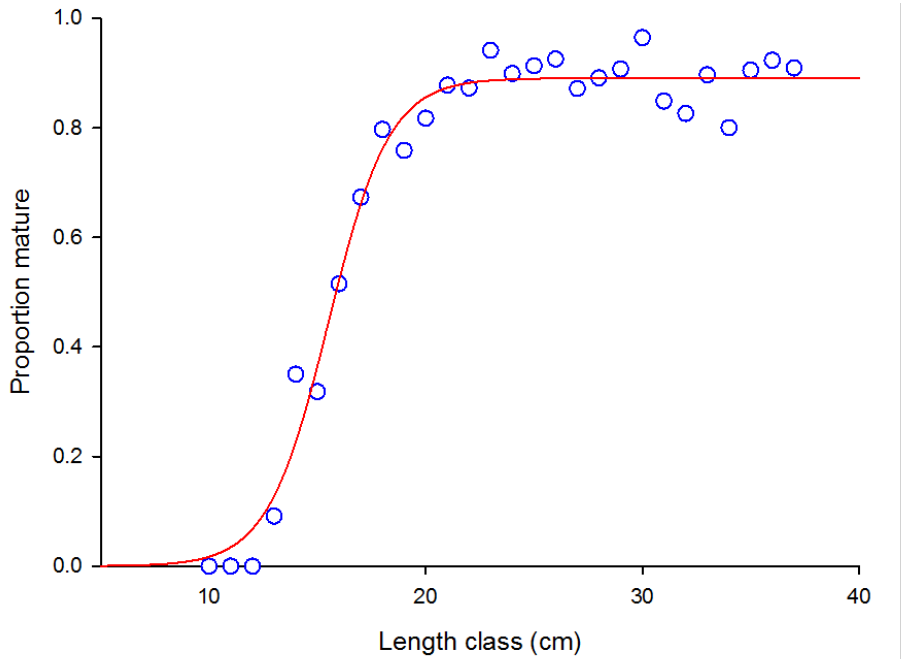

Figure 23.4.2. Length based maturity ogive for Lemon sole derived from IBTS Q1 data.

23 Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, Eastern English Channel)

23.1 General

Witch flounder (*Glyptocephalus cynoglossus*) was assessed, between 2010 and 2013, by the Working Group on Assessment of New MoU Species (WGNEW, ICES 2013.a). Since 2014 WGNEW was dissolved thus this species ´was included in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).
Following the ICES guidelines for data limited stocks (ICES, 2012) witch was defined as a category 3 species as only official landings and survey data were available. The biennial advice, drafted in 2013 (ICES, 2013b), was based on stock size indicators (standardized CPUE in number/hour) derived from IBTS (both Q1 and Q3) and exploratory estimates (merely indicative of trends and not used for catch forecast) suggesting that fishing mortality is above potential F_{MSY} proxies. In 2015, witch flounder was included into the official data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated by this group. The new data call for the WGNSSK 2016 included landing and discard data for the years 2012–2015 for attempting to give catch advice for this species.

23.1.1 Biology and ecosystem aspects

The existing knowledge of witch biology is summarized in the Stock Annex.

In 2009, witch flounder has been included as a mandatory species in the EU Data Collection Framework (DCF). Accordingly, Denmark and Sweden started the regular sampling of biological data, i.e. length, weight, maturity status and age, in 3.a and 4 both in discards and landings. Scotland has also been collecting biological samples since 2009 but only from the landings.

Age readings techniques are now well established while the macroscopic evaluation of maturity status is still uncertain and a histological analysis of the gonads is under development and it is planned to be ready before the benchmark scheduled in 2017.

23.1.2 Management regulations

According to EU-Regulations a precautionary TAC is given in EU waters of 3.a and 4 together with lemon sole (*Microstomus kitt*). The TACs have been stable, varying around 6000 t since 2006. There is no official Minimum Landing Size (MLS) specified in EU waters. However, in most of the countries reporting catches the landing of witch below 28 cm is prohibited. Currently, lemon sole and witch flounder are managed under a combined species TAC, which prevents the effective control of the single species exploitation rates and could potentially lead to the overexploitation of either species. Furthermore, witch flounder is mainly a bycatch species in a mixed fisheries (although some limited seasonal target fisheries occurs) thus a TAC alone may not be appropriate as a management tool.

23.2 Fisheries data

23.2.1 Historical landings

North Sea witch flounder's landings have declined in the last decade, but from 2011 a general increasing trend is observed. This species is nowadays mainly landed by Denmark, Norway, Sweden and Germany in both areas (3.a and 4) and UK mainly in Subarea 4. The Netherlands reports only a small fraction of the total landings in subarea 4 as this species it is mostly discarded. In division 3.a, Denmark is landing the largest amount of witch flounder, while in Subarea 4 it is Scotland having the largest portion of the landings.

23.2.2 InterCatch

In 2014, witch flounder was included for the first time into the data call for WGNSSK 2014 and since 2015 the data call was extended to obtain landing and discard data for the years 2012–2015. From all countries data were uploaded to the InterCatch data portal. Norway did not report any discards.

Discards could thus be raised for the period 2012–2015 and catches estimated. In general, the discard rate is moderately low and it has been decreasing from 23% in 2012 to 11 and 10% respectively in 2013 and 2014 and increased again in 2015 (18%). However, it should be noted that not all metiers were sampled in every quarter and that raising procedure may not be adequate in all cases. Thus for some metiers the applied raising procedure might introduce some bias to the total discard estimates. An overview of the reported landings and discards and the resulting discard rates for all fleets is given in table 24.4.1. Landings showed a slight decrease from 2014 to 2015, around 2300t.

For 2015, the largest amount of landings and discards was reported by Denmark in Division 3.a using the OTB_CRU_90–119_0_0_all metier and by Scotland in Subarea 4 using the OTB_DEF_>=120_0_0_all métier (Figures 26.2.2.1–3). The total catch estimated with InterCatch was 2649 t, of which only 410 t were discards (18% of total catch).

23.3 Survey data / recruit series

The International Bottom Trawl Survey (IBTS) performed every year during the first and third quarter since 1975 provides indices for the North Sea and 3.a. Furthermore a time series of Dutch Beam Trawl Survey (BTS) data (1985–2008) in 4 is also available but it was not explored during the current assessment. The IBTS seem to be the most valuable and promising data source to be used as tuning fleet for the assessment, particularly during Q1 when more stations are usually fished and the time series is longer (Figure 24.3.1).

23.4 Analysis of stock trends / assessment

Witch flounder has been classified as category 3 stocks following the guidelines of the ICES Data Limited Stocks (DLS) methodological document (ICES 2012). This category includes stocks for which survey indices (or other indicators of stock size) are available and provide reliable indications of trends in stock metrics.

Consequently, the basis of the biennial advice in 2013 was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and *I* is the stock index. By default x=2 and z=5. A mature biomass index in kg per hour was estimated from the IBTS Q1 and Q3 survey. The choice to compare three versus five rather than two versus three years index values applied for the advice 2013 was made for accounting the inter-annual variability of surveys. Recent more detailed analysis of the gonads (i.e. ongoing work at the Swedish Institute for Marine Research) revealed that this species becomes reproductively mature at age 5 and therefore considering a three versus five years average will include at least one generation.

A logistic regression applied in 2014 on the DATRAS CA records showed that L_{50}, i.e. the length at which 50% of the stock is mature, corresponds to 34 cm (ICES 2015). Thus, as in 2015, the mature biomass indices were estimated including all specimens larger than 34 cm and the LW relationship as in 2015 was used (ICES 2015).

For IBTS Q1 survey the three most recent year indices of the mature biomass (in kg per hour) (2014–2016) were more than 300% higher than five previous year index although it declined in 2016, while for IBTS Q3, the three most recent year indices (2013–2015) were more than 40% higher than five previous year index.

During WGNSSK 2016, a mature biomass index in kg per hour as derived from both surveys (IBTS Q1 and Q3) was estimated in accordance with the DLS guidelines and thus the mean of the two most recent year (2015–2016 and 2014–2015 for IBTS Q1 and Q3, respectively) index was compared to the mean of the three previous years (2012–2014 and 2011–2013 for IBTS Q1 and Q3, respectively) indices. The stock size indicator (i.e. the mature biomass index) in the last two years was 3% higher for IBTS Q1 but about 17% less for IBTS Q3 than the average of the three previous years.

Based on these information, WGNSSK 2016 consider that the biannual advice issued by ICES in 2015 and valid for 2016 and 2017 should be maintained and total catches in 2017 should be no more than 3107 tonnes.

23.5 References

ICES 2013.a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM.

ICES 2013b. Witch in Subarea IV and Division 3.a and VIId, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.35.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

ICES 2015. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 28 April-7 May, ICES HQ, Copenhagen, Denmark. ICES CM 2015/ACOM:13. 1229 pp.

Table 24.4.1. Witch flounder in area 4 and division 3.a. Summary of the assessment. Landings, discards and catches are in tonnes. The IBTS indices indicate mature biomass in kg/hour.

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS Q1 index	IBTS Q3 index	Discard rate
1968	1174				0.08		
1969	891				0.04		
1970	597				0.15		
1971	843				0.01		
1972	908				0.01		
1973	1494				0.06		
1974	1138				0.04		
1975	1841				0.03		
1976	1496				0.13		
1977	1618				0.04		
1978	1664				0.05		
1979	1572				0.07		
1980	1883				0.03		
1981	1933				0.38		
1982	3155				0.06		
1983	3606				0.15		
1984	3903				0.11		
1985	3979				0.16		
1986	3579				0.17		
1987	3700				0.21		
1988	3290				0.07		
1989	3841				0.30		
1990	3862				0.12		
1991	3641				0.10	0.11	
1992	3164				0.39	0.12	
1993	2673				0.28	0.06	
1994	2696				0.09	0.08	
1995	2810				0.25	0.13	
1996	2790				0.09	0.10	
1997	3494				0.25	0.17	
1998	3786				0.25	0.08	
1999	4024				0.19	0.12	
2000	4422				0.24	0.04	
2001	4206				0.13	0.11	
2002	3640				0.16	0.09	
2003	3281				0.12	0.05	
2004	3029				0.12	0.08	
2005	2813				0.14	0.05	
2006	2303				0.06	0.08	
2007	2236				0.08	0.12	
2008	1953				0.11	0.06	
2009	1818				0.06	0.05	
2010	1490				0.04	0.06	
2011	1530				0.05	0.09	
2012	1895	1953	2544	592	0.09	0.13	0.303
2013	1993	2020	2272	252	0.08	0.13	0.125
2014	2646	2669	2950	281	0.29	0.08	0.105
2015	2359	2238	2649	410	0.19	0.12	0.183
2016					0.13		

Table 24.6.1. Witch flounder in area 4 and division 3.a. Official ICES landings by area 4 and division 3.a.

Year	3.a	4	Tot
1950	902	1477	2379
1951	923	1645	2568
1952	713	1841	2554
1953	767	1496	2263
1954	463	1127	1590
1955	450	1577	2027
1956	502	1434	1936
1957	643	1348	1991
1958	559	2119	2678
1959	752	1581	2333
1960	640	1923	2563
1961	594	1499	2093
1962	148	1271	1419
1963	209	1314	1523
1964	288	1472	1760
1965	260	1096	1356
1966	175	962	1137
1967	152	973	1125
1968	185	989	1174
1969	156	735	891
1970	118	479	597
1971	162	681	843
1972	235	673	908
1973	277	1217	1494
1974	304	834	1138
1975	972	869	1841
1976	778	718	1496
1977	738	880	1618
1978	719	945	1664
1979	678	894	1572
1980	874	1009	1883
1981	1044	889	1933
1982	1453	1702	3155
1983	1598	2008	3606
1984	1796	2107	3903
1985	1921	2058	3979
1986	1426	2153	3579
1987	1252	2448	3700
1988	1210	2080	3290
1989	1520	2321	3841
1990	1498	2364	3862
1991	1301	2340	3641

Year	3.a	4	Tot
1992	1237	1927	3164
1993	950	1723	2673
1994	771	1925	2696
1995	939	1871	2810
1996	902	1888	2790
1997	1502	1992	3494
1998	1986	1800	3786
1999	2239	1785	4024
2000	2477	1945	4422
2001	1939	2267	4206
2002	2006	1634	3640
2003	1646	1635	3281
2004	1788	1241	3029
2005	1605	1208	2813
2006	1043	1260	2303
2007	949	1287	2236
2008	783	1170	1953
2009	773	1045	1818
2010	675	815	1490
2011	693	837	1530
2012	1107	788	1895
2013	1000	993	1993
2014	1562	1085	2646
2015	1282	956	2238

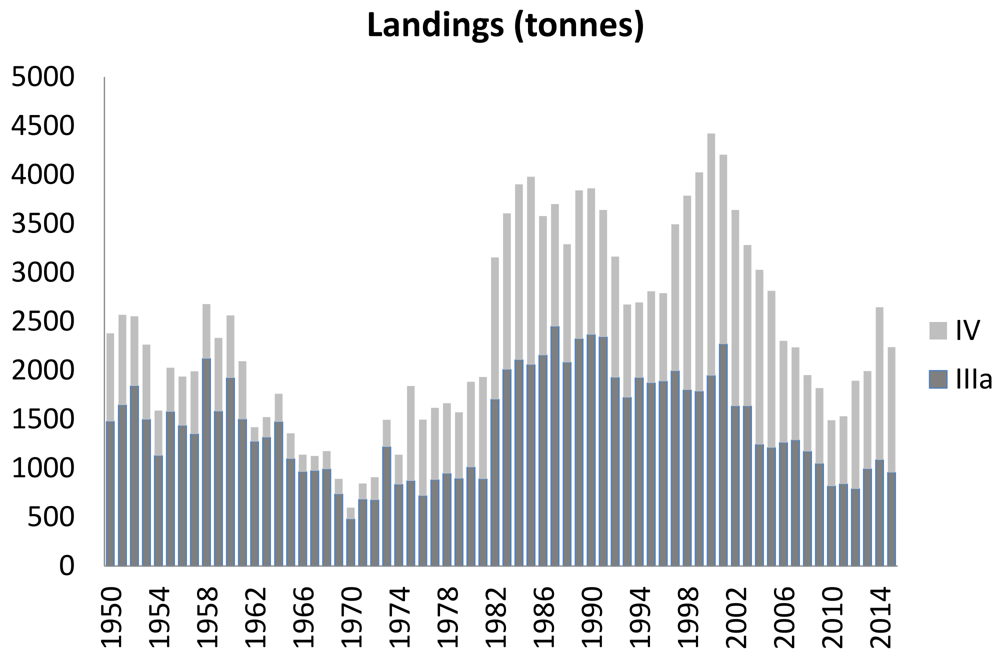

Figure 24.2.1.1. Witch flounder in area 4 and division 3.a. Total official landings (in tonnes).

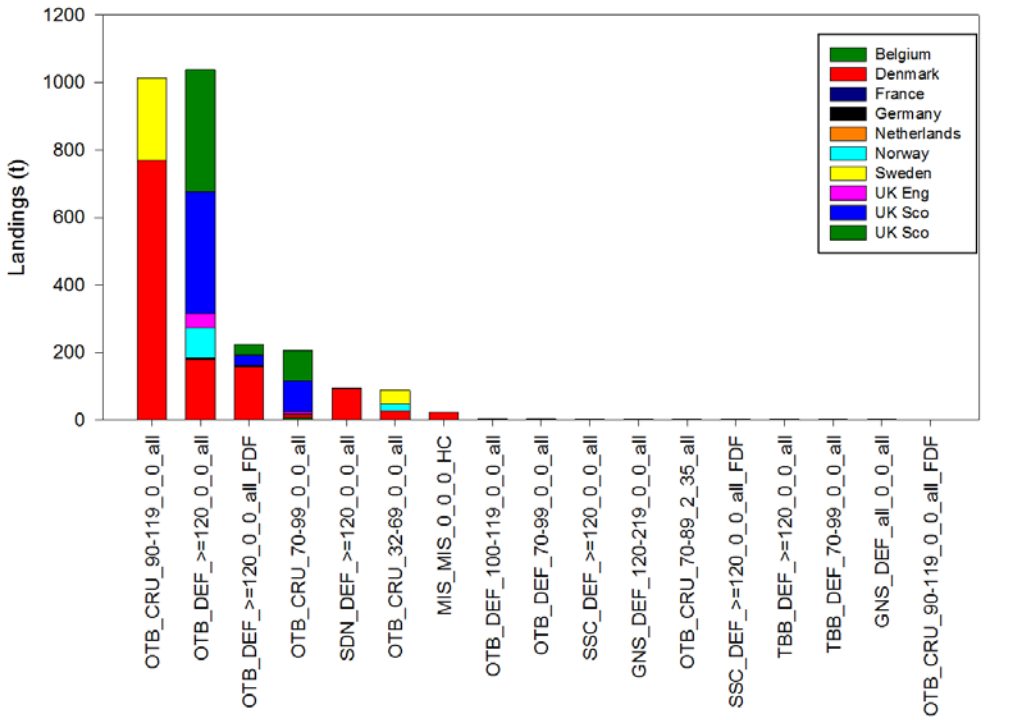

Figure 24.2.2.1. Witch flounder in Subarea 4 and division 3.a. Landings by metier and country in 2015.

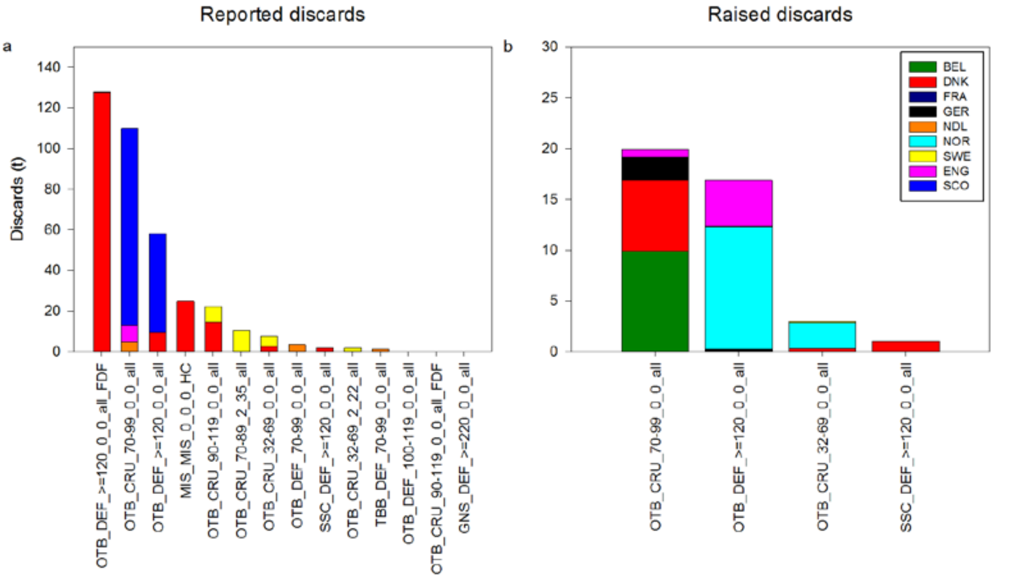

Figure 24.2.2.2. Witch flounder in Subarea 4 and division 3.a. Discards by metier and country in 2015. Reported discards panel (a), raised discards panel (b).

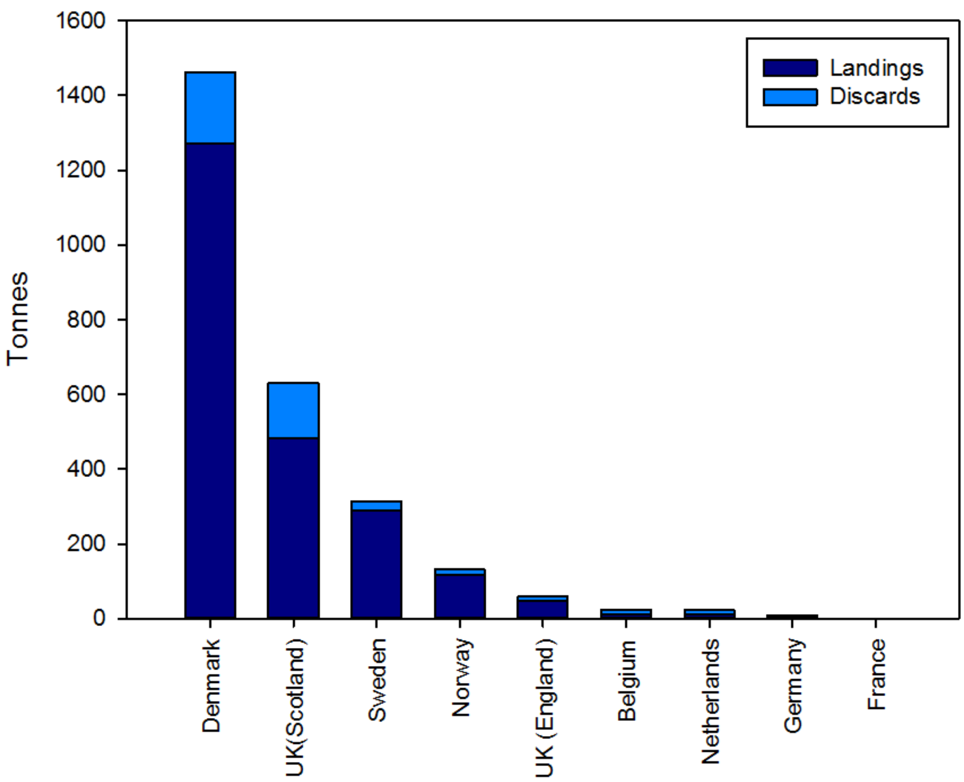

Figure 24.2.2.3. Witch flounder in Subarea 4 and division 3.a. Estimated landings and discards by countries in 2015.

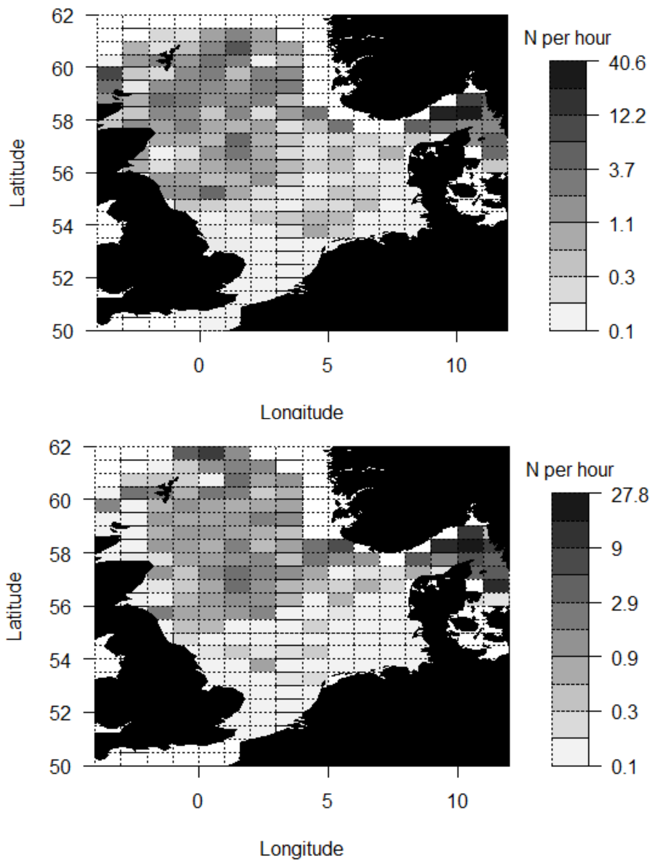

Figure 24.3.1. Witch flounder in Subarea 4 and division 3.a. Aggregated distribution over the entire time series in the North Sea derived from IBTS Q1 (upper) and Q3 (lower) using data collected between 1968 and 2015.

Annex 01 List of participants

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Massimiliano Cardinale (by correspondence)	SLU	Sweden

Annex 02 Recommendations

The following table summarises the main recommendations arising from the WGNSSK and identifies suggested responsibilities for action.

Recommendation	For follow up by:
WGNSSK evaluated the guidelines for reference points and made the following observations: The current guidelines propose to use the sigma on ln(F_{bar}) and ln(SSB) from the final year in the assessment to derive F_{pa} and B_{pa} from F_{lim} and B_{lim}. For many stocks in WGNSSK this would bring B_{pa} and F_{pa} closer to the limit reference points compared to the default used so far (1.4* B_{lim} and F_{lim}/1.4). Furthermore, the current guidelines do not take into account retrospective uncertainty/bias in the calculation of the uncertainty in the last assessment year, and the interpretation of the latter can vary between assessment methods because they handle it in different ways. More careful thinking is needed about what uncertainty in the final year in the assessment means. The guidelines are also still only draft and have not been finally agreed by ACOM. Until final guidelines are agreed by ACOM, WGNSSK recommends the use of the estimated sigmas from assessments only if the precautionary reference points that result from their application are larger for biomass or lower for F than the ones derived by the default settings (1.4* B_{lim} and F_{lim}/1.4). Such an approach is also used in the US when taking scientific uncertainty into account in the setting of buffers between the OFL and ABC (Dichmont *et al*. in press, Ralston *et al*. 2011). A decision is needed about whether F_{pa} and/or Fp.05 restrict the upper limit of FMSY ranges as both reference points differ from one another in most cases. A clear decision is needed about whether the MSY approach or the precautionary approach is the leading principle behind reference points. In general, the increasing number of reference points is worrying, also making the communication to stakeholders difficult. WGNSSK suggests to keep the number of reference points to a minimum, and to keep methodology as consistent and concise as possible (e.g. F_{pa}=Fp.05).	ACOM

The last step in the $B_{trigger}$ decision tree in the current draft guidelines is unclear. It can happen that the 5th percentile of the current SSB is below B_{pa} (e.g., if there is a depleted stock and/or where there is large uncertainty in the assessment). WGNSSK suggests to make clear in the guidelines that B_{pa} is the lower limit for $B_{trigger}$ in all cases. References: Dichmont, C.M., Punt, A.E., Dowling, N., De Oliveira, J.A.A., Little, L.R., Sporcic, M., Fulton, E., Gorton, R., Klaer, N., Haddon, M. and D.S. Smith. In press. Is risk consistent across tier-based harvest control rule management systems? A comparison of four case-studies. Fish and Fisheries, doi: 10.1111/faf.12142. Ralston, S., Punt, A.E., Hamel, O.S., DeVore, J. and Conser, R.J. (2011) An approach to quantifying scientific uncertainty in stock assessment. Fishery Bulletin 109, 217–231.	
Underwater TV surveys for *Nephrops* are carried out in summer after WGNSSK. This questions an assessment in spring and leads to a high probability that the advice needs to be reopened once the latest TV survey estimates are available. WGNSSK recommends postponing the final *Nephrops* assessment and advice to autumn. Analyses of catch data from the previous year and a preliminary assessment can still be conducted during the spring meeting to support mixed fishery advice. But the final assessment and advice could be produced either by correspondence or in a meeting together with the Celtic Sea *Nephrops* stocks. However, the timing of TV surveys needs to ensure that at least in autumn the most recent data are available.	ACOM, Scotland, England, Denmark
There is currently little guidance about how catch categories should be reported, and how they should be used in raising discards where discard information is not provided. This is an issue that affects all Expert Groups that have to provide catch advice, so a common approach is needed. BMS landings, observer discards and log-book recorded discards should sum up to discard data provided so far (i.e. double-counting should be avoided), and when performing raising procedures, these three categories should be combined to provide raising factors, and the raising procedure in Intercatch should be adapted as necessary. This pro-	ACOM, ICES Data Center

vides a robust approach, independent of how countries categorize catches when providing catch data. WGNSSK recommends that ICES provides a harmonized approach across all Expert Groups.	
The French FRGFS survey does not currently receive funding from DCF and may be discontinued. This survey provides tuning series used in the assessment of red mullet and 7d plaice. This survey needs to be maintained in order to maintain the integrity of current assessments for these stocks.	ACOM, France
The current guidelines for reopening advice for DLS stock is vague, referring to a "change in perception" of stock status. It is not entirely clear what this means, and what constitutes a perception that would be different enough to lead to re-opening. It is recommended that clearer guidelines are provided in this regard.	ACOM

Annex 03 ToRs for next meeting

WGNSSK – Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

2016/2/ACOMXX The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), chaired by José De Oliveira, UK, in meet in Copenhagen, 25 April – 4 May 2017 and by correspondence in September 2017 to:

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

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 11 April 2017 according to the Data Call 2017.

WGNSSK will report by 11 May 2017, and by 28 September 2017 (Norway pout) for the attention of ACOM.

Annex 04 Update Forecasts and Assessments

4.1 Summary

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chairs: Alexander Kempf, DE and Jose de Oliveira, UK) met by correspondence at the beginning of October 2016 to evaluate new information from the fisheries independent surveys carried out during 2016 subsequent to the meeting of the group in April/May. Also this year a deviation from the manual occurred during the IBTS q3 survey. It was tested whether the CPUE from 15 min. hauls does not significantly differ from 30 min. hauls. In most ICES rectangles one 30 min. and one 15 min. haul was conducted instead of two 30 min. hauls. Analyses of theIBTS working group do not show significant differences between 15 min and 30 min hauls. Therefore, all hauls were used for the IBTS q3 index calculations (relevant for cod, whiting, haddock and saithe). However, Verena Trenkel (IFREMER) has also analysed 15 and 30 min hauls in comparison and found systematic differences in CPUE values (higher in the 15 min hauls when standardized to 1 hour). This needs further investigation to derive final conclusions taking also the second year of data into account.

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 2016 survey information to estimate the recent recruitment abundance and then comparing the prediction and its associated uncertainty with the assumptions made in forecasts used as the basis for the ACOM spring advice.

As every year, the indices used in the current update must be considered as provisional and may be revised for the assessment in May next year.

An update is also presented for the *Nephrops* stocks, given that UTV surveys usually take place over summer. This allows for a considerably smaller time lag between the last abundance observations and their use for next year's advice.

The comparisons indicated that there is potential for re-opening of the June advice for cod in IV, IIIa and VIId, saithe in IV, IIIa and VI as well as *Nephrops in* FUs 6, 7 and FU 8. For Nephrops FU6, the new catch advice would be 1125t compared to 740t in June. If the discarding exemptions for 2016 continue to apply for 2017 then the wanted landings would be 1020t (compared to 671t in June). For *Nephrops* FU7, the new catch advice would be 11852t compared to 6844t in June. If the discarding exemptions for 2016 continue to apply for 2017 then the wanted landings would be 11813t (compared to 6821t in June). The strong increase may be related to a strong recruitment. These recruits will not show up immediately in the fishery given the current selectivity. Given that the TAC has not been taken in recent years caution is needed when increasing the TAC for FU7 further. It has to be ensured this does not lead to overexploitation in other FUs. For FU 8 the catch advice would change from 2123t to 2548t. If the discarding exemptions for 2016 continue to apply for 2017 then the wanted landings would be 2190t (compared to 1825t in June). For cod in IV, IIIa and VIId the advice for total catch would change from 47431 tonnes to 47359 tonnes . Despite a considerably lower 2016 recruitment estimate, the change in TAC is small because the 2016 indices (for the older ages) lead to higher abundances for older age groups at the start of the intermediate year in the SAM modelling framework. For saithe in IV, IIIa and VI the advice would change from 116605 to 134962 tonnes. A very strong incoming year class and significantly higher age 4 index has been detected in the IBTS q3 survey. However, the age 3 survey index is highly uncertain and the internal consistency between age 3 and age 4 is extremely poor. Therefore, the perception of the incoming year class strength may change considerably in the next years. In addition age 3 is not fully recruited to the survey/fishery area. Therefore, age 4 has been treated as fully recruited and only the indices from age 4 and higher have been taken into account in the reopening.

Additional TOR on the historic performance of the reopening protocol

WGNSSK was asked to start with an analysis on the historic performance of the reopening protocol. WGNSSK analysed whether the recruitment assumptions used in June were farer away from assessment estimates in the following years compared to the recruitment assumptions used in autumn incorporating quarter 3 survey information. The recruitment assumptions were compared to assessment estimates in year+1 after the reopening, year+2 and to estimates from the latest assessment. Recruitment estimates may change over time when more information about the cohort becomes available. In addition, benchmarks often lead to changes in assessment results. In total 7 reopening events were analysed for plaice, sole and whiting. The advice for cod and saithe has not been reopened in recent years based on the reopening protocol.

In all cases analysed, the recruitment used for the intermediate year in the October forecasts was closer to the recruitment estimates from assessments in the following years (table 4.1.1). This perception does not change when looking at different assessments (e.g., before and after benchmarks). However, the analysis also revealed the general high uncertainty in recruitment assumptions.

For whiting the 0 group index has been used to update also recruitment assumptions for the TAC year. The analysis revealed that the updated recruitment was farer away from the assessment estimates in the following years compared to the June assumption not using the information from the 0 group index (table 4.2.2). Therefore, the 0 group index seems not to be a reliable proxy for the incoming year class.

Table 4.1.1 Comparison of the performance of intermediate year recruitment assumptions between June and October forecasts

Intermediate year recruitment:

Stock	Benchmarks since 2009	Year of the Reopening	Recruitment for intermediate year used in spring forecast	Recruitment for intermediate year used in autumn forecast	Corresponding recruitment estimate in the assessment carried out in reopening year +1	Corresponding recruitment estimate in the assessment carried out in reopening year +2	Corresponding recruitment estimate in the 2016 assessment	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the assessment carried out in reopening year+1	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the assessment carried out in reopening year+1	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the assessment carried out in reopening year+2	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the assessment carried out in reopening year+2	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the 2016 assessment	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the 2016 assessment
sol (age2)	2015	2014	54268	65474	78062	116775	116775	30.5	16.1	53.5	43.9	53.5	43.9
sol (age1)	2015	2015	103741	135220	194127		194127	46.6	30.3	x	x	46.6	30.3
plaice (age1)	2015 (merged with 3a)	2014	936981	1309243	1542295	1966051	1966051	39.2	15.1	52.3	33.4	52.3	33.4
plaice (age1)	2015 (merged with 3a)	2015	650882	826318	1140208	x	1140208	42.9	27.5	x	x	42.9	27.5
WHG47d	2013	2013	2139711	1119366	624701	1453422	1140360	242.52	79.18	47.22	22.98	87.63	1.84
WHG47d	2013	2014	2613817	2497236	2446622	2155672	2155672	6.83	2.07	21.25	15.84	21.25	15.84
WHG47d	2013	2015	4352809	3836431	2097757	x	2097757	107.50	82.88	x	x	107.50	82.88

Table 4.1.2 Comparison of the performance of TAC year recruitment assumptions between June and October forecasts

TAC year:

Stock	Benchmarks since 2009	Year of the reopening	Recruitment for TAC year used in spring forecast	Recruitment for TAC year used in autumn forecast	Corresponding recruitment estimate in the assessment carried out in reopening year +1	Corresponding recruitment estimate in the assessment carried out in reopening year +2	Corresponding recruitment estimate in the 2016 assessment	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the assessment carried out in reopening year+1	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the assessment carried out in reopening year+1	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the assessment carried out in reopening year+2	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the assessment carried out in reopening year+2	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the 2016 assessment	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the 2016 assessment
WHG47d	2013	2014	3687000	6038870	4352809	2097757	2097757	15.30	38.74	75.76	187.87	75.76	187.87
WHG47d	2013	2015	3781580	8066061	2900142	x	2900142	30.39	178.13	x	x	30.39	178.13

4.2 Cod in Subarea 4, 7.d and 3.a

4.2.1 New survey information

New survey information, in the form of the IBTS Q3 2016 data, has come to light, subjecting this assessment to the AGCREFA protocol for re-opening advice in the autumn. The Delta-GAM model was re-applied to the full IBTS Q3 time series of North Sea cod data from DATRAS to provide a Q3 index for this stock. The new Delta-GAM Q3 index time series is given in Table 4.2.1.

4.2.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2015) year-class at age 1. The RCT3 input and output files are given in Tables 4.2.2 and 4.2.3, respectively

4.2.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2015 year-class at age 1	
Log WAP from RCT3 (R)	11.93
Log of recruitment assumed in spring (A)	12.19
Int SE of log WAP (S)	0.158
Distance D $\left(D = \frac{R-A}{S}\right)$	-1.623

4.2.4 Conclusions from Protocol

As the distance D < -1.0, the protocol concludes that **the advisory process for North Sea cod should be reopened**. The autumn indices suggest that the size of the incoming year-class is significantly lower than what had been assumed in the forecast produced by WGNSSK in May 2016.

4.2.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea cod. The assessment and forecast were re-run with the new Q3 data included, but using the SAM estimate of recruitment for the intermediate year, with recruitment for the years following the intermediate year being resampled, with replacement, from the period 1998 to the final year of catch data. Otherwise the settings and assumptions were unchanged from those used by WGNSSK in May 2016.

Outputs from the assessment re-run with the new Q3 data included are given in Table 4.2.4 and Figure 4.2.1, and the updated catch options Table 4.2.5.

Following the ICES MSY approach, the new short term forecasts lead to a **decrease in advised catch from 47 431 tonnes to 47 359 tonnes** (a decrease of 72 tonnes).

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

Table 4.2.1. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Survey tuning indices for Q3 (NS-IBTS Delta-GAM indices). Data used in the assessment are highlighted in bold font. (The equivalent Q1 index can be found in Section 14, Table 14.6 of this report).

North Sea Cod Survey Index Q3 (DG) calculated 2016-10-07 15:51:58

1992	2016						
1	1	0.5	0.75				
1	6						
1	**16735.79**	**1731.95**	**377.1426**	**351.607**	114.3897	41.0668	1992
1	**4811.725**	**4431.508**	**455.9923**	**140.285**	82.6421	12.1088	1993
1	**17041.4**	**2325.414**	**931.0293**	**158.3623**	45.2002	33.703	1994
1	**9108.123**	**6943.744**	**668.6729**	**299.2365**	45.5765	19.79	1995
1	**5134.213**	**2997.462**	**988.2882**	**214.3392**	115.8488	13.538	1996
1	**29167.53**	**2038.199**	**713.1794**	**255.8751**	56.2559	38.5853	1997
1	**888.1424**	**9069.842**	**711.9355**	**188.9126**	117.6698	39.2174	1998
1	**3323.758**	**477.5959**	**2387.595**	**154.8905**	41.9148	17.8443	1999
1	**6500.347**	**964.8445**	**112.883**	**342.6196**	35.6253	31.1427	2000
1	**1406.542**	**2200.953**	**369.8287**	**76.2315**	56.9098	35.6339	2001
1	**4011.908**	**875.171**	**751.6024**	**194.3245**	52.0673	23.4956	2002
1	**983.716**	**1288.772**	**247.1028**	**179.8112**	85.9206	59.7055	2003
1	**3226.685**	**791.2897**	**468.9025**	**92.6942**	70.6532	25.0133	2004
1	**1109.156**	**743.255**	**283.6082**	**118.2981**	26.1665	45.9766	2005
1	**5580.464**	**714.2858**	**598.6245**	**118.2994**	28.9897	17.7059	2006
1	**1900.15**	**2337.798**	**432.9355**	**173.7437**	100.4404	46.1546	2007
1	**2569.835**	**1155.259**	**1106.6**	**226.6009**	123.8025	31.7938	2008
1	**1983.084**	**974.0072**	**295.1983**	**238.9074**	52.7604	25.8237	2009
1	**4672.705**	**1694.437**	**541.0272**	**181.3279**	110.8881	22.7705	2010
1	**1247.59**	**2828.731**	**870.4958**	**373.7392**	104.391	99.4266	2011
1	**2127.912**	**1004.978**	**1283.637**	**369.0733**	103.3943	18.3627	2012
1	**3246.6**	**1053.988**	**503.8285**	**527.7289**	142.6192	63.9869	2013
1	**3498.95**	**1479.747**	**618.4551**	**297.9765**	198.7568	96.4452	2014
1	**1906.228**	**3095.226**	**1108.364**	**466.0012**	141.7069	136.9022	2015
1	**1453.662**	**1144.704**	**1715.091**	**840.9669**	204.0186	134.7918	2016

Table 4.2.2. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. RCT3 Inputs.

"yearclass"	"recruitment"	"DeltaGAMq11"	"DeltaGAMq31"
1982	946949	3741.7822	NA
1983	1709993	11153.0972	NA
1984	415817	544.1801	NA
1985	1861699	11081.9228	NA
1986	709276	4343.5409	NA
1987	490411	2537.0711	NA
1988	827364	8362.1714	NA
1989	327420	1770.0654	NA
1990	374370	1537.8647	NA
1991	856834	8175.9454	16735.7875
1992	434521	2820.5127	4811.7253
1993	1018661	6187.1008	17041.4007
1994	596002	6769.1817	9108.1228
1995	372876	1639.532	5134.2129
1996	1160081	13784.828	29167.5344
1997	141210	1578.9563	888.1424
1998	251450	1305.4656	3323.7578
1999	457257	3481.6615	6500.3466
2000	167042	920.8996	1406.5418
2001	246965	2474.5739	4011.9079
2002	123254	364.5132	983.716
2003	201793	2486.7931	3226.6848
2004	154508	943.4926	1109.156
2005	358255	3493.3633	5580.4643
2006	168552	1202.5336	1900.1495
2007	196025	1910.6205	2569.8349
2008	193300	961.1721	1983.0844
2009	296262	2508.875	4672.7046
2010	148153	662.5383	1247.5896
2011	203211	1343.4717	2127.9124
2012	263024	1404.7233	3246.5997
2013	391601	2357.5571	3498.9504
2014	169058	1510.2513	1906.2281
2015	NA	878.7259	1453.6621

Table 4.2.3. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. RCT3 Outputs.

```
Analysis by RCT3 ver4.0

Cod

Data for 2 surveys over 34 years : 1982 - 2015
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:2015
       index   slope  intercept       se  rsquare   n  indices  prediction
se.pred WAP.weights
 DeltaGAMq11  0.9635      5.334  0.4462   0.7445  33    6.778       11.86
0.4756       0.115
 DeltaGAMq31  0.7144      6.736  0.1579   0.9447  24    7.282       11.94
0.1715       0.885
    VPA Mean      NA          NA      NA       NA  33       NA      12.81
0.7496       0.000

                 WAP  logWAP  int.se
yearclass:2015 151785  11.93 0.1577
```

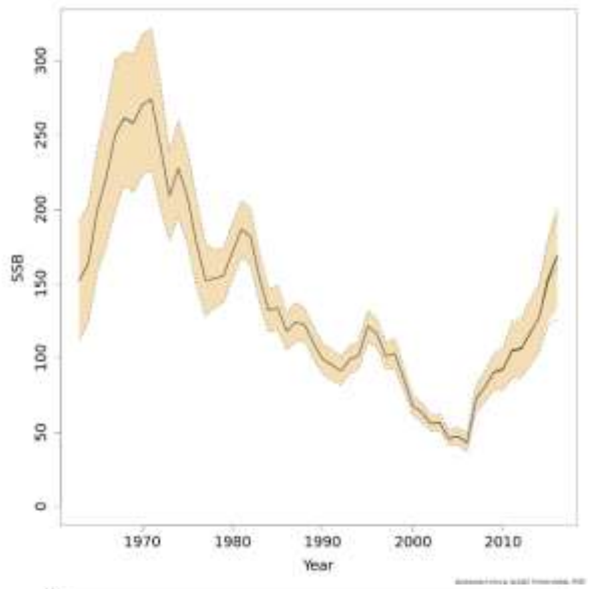
Table 4.2.4. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Assessment summary. Weights are in tonnes.

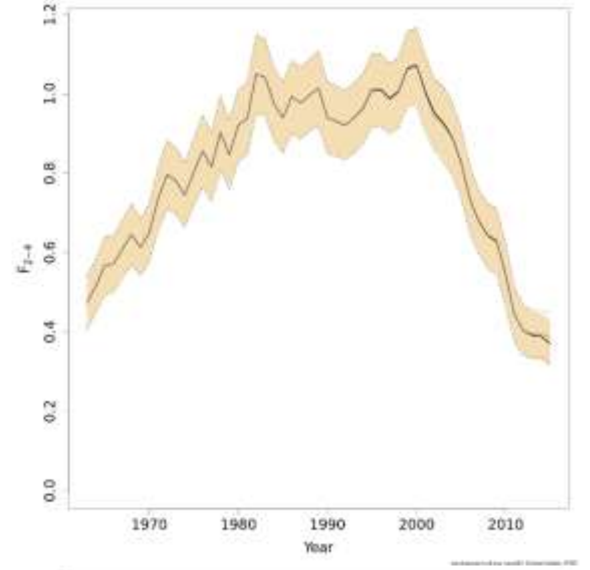
Year	Recruits age 1 ('000)	Low	High	TSB (tonnes)	Low	High	SSB (tonnes)	Low	High	Fbar 2-4	Low	High	Landings	Discards	Catch	Unaccounted	Total Removals	Low	High
1963	487478	357668	664400	512471	439164	598016	152207	116938	198114	0.473	0.410	0.546	106938	10880	117830		117830	104458	132914
1964	802109	589683	1091060	661986	563467	777731	163407	128333	208068	0.515	0.452	0.587	135131	9818	145074		145074	131312	160278
1965	1043405	769595	1414632	834009	717597	969306	199386	161487	246180	0.567	0.498	0.645	182225	17125	199187		199187	177647	223339
1966	1273144	940099	1724176	997493	859127	1158143	221682	180741	271897	0.572	0.505	0.648	214701	26318	241108		241108	215680	269534
1967	1074107	792335	1456082	1052838	916799	1209063	250446	204671	306459	0.609	0.540	0.687	260928	26742	287506		287506	256698	322012
1968	544161	400873	738665	879404	783787	986687	261450	220439	310091	0.646	0.572	0.729	276509	17168	293608		293608	266424	323565
1969	479740	351653	654482	735275	650537	831051	258074	215584	308937	0.613	0.545	0.689	217075	9685	226840		226840	209438	245688
1970	1561254	1149940	2119689	1193022	989390	1438564	270222	226848	321890	0.650	0.581	0.727	232582	19944	252458		252458	221946	287164
1971	2034987	1492585	2774497	1330413	1124452	1574100	274032	230600	325643	0.735	0.660	0.819	291851	57931	349759		349759	300632	406914
1972	508897	372786	694703	921723	815909	1041260	242802	204436	288368	0.796	0.714	0.887	328404	34338	362580		362580	317387	414207
1973	739700	542119	1009292	738222	654023	833261	209190	181291	241384	0.781	0.700	0.870	234451	24884	259367		259367	236089	284941
1974	725053	530396	991149	710696	628446	803710	227521	197289	262387	0.744	0.668	0.830	209400	26056	235390		235390	210316	263453
1975	1234282	895108	1701975	806130	686338	946829	208147	179111	241890	0.802	0.722	0.890	208981	36062	244997		244997	213581	281033
1976	845768	609101	1174391	636029	558569	724231	177371	150699	208764	0.856	0.770	0.952	201189	43695	244997		244997	212673	282233
1977	2090680	1514446	2886167	986580	803329	1211633	152512	129976	178956	0.815	0.733	0.906	181498	77575	258849		258849	213081	314447
1978	1329083	960376	1839345	1125795	937873	1351371	153430	135286	174008	0.903	0.814	1001	305896	48533	354336		354336	291550	430642
1979	1634749	1184629	2255901	1039240	883871	1221920	155282	138233	174435	0.846	0.764	0.938	277895	61821	339762		339762	290618	397215
1980	2623448	1892369	3636965	1254189	1039136	1513749	171785	154018	191602	0.921	0.834	1017	290686	100509	391210		391210	324295	471933
1981	1056001	763433	1460691	1037163	896687	1199647	186652	168862	206315	0.937	0.851	1032	342148	53745	395933		395933	337559	464401
1982	1727179	1265098	2358037	1132570	947363	1353984	181680	163854	201444	1.049	0.954	1154	323191	63450	386544		386544	327558	456151
1983	945057	703385	1269762	885582	761752	1029541	153584	138097	170807	1.042	0.949	1144	287794	37123	324811		324811	277021	380847
1984	1709993	1275387	2292698	908000	761430	1082784	132058	118313	147400	0.974	0.887	1070	209819	67914	277895		277895	236097	327093
1985	413743	304376	562406	586542	518972	662910	133920	120029	149419	0.939	0.854	1033	213844	27945	241832		241832	209545	279095
1986	1863562	1392512	2493954	818313	671822	996747	117830	106244	130680	0.993	0.905	1089	168721	58924	227749		227749	190730	271953
1987	709276	531469	946570	749379	644652	871119	124244	111709	138184	0.976	0.890	1072	225258	32598	257816		257816	217746	305259
1988	490411	367096	655150	550730	481290	630188	122394	111793	134000	0.997	0.909	1093	191377	14698	206076		206076	182779	232342
1989	829850	618777	1112923	556265	470358	657862	109754	99649	120884	1.014	0.924	1113	138968	40336	179333		179333	154475	208191
1990	327093	245507	435792	371759	327430	422088	99310	89729	109914	0.940	0.853	1035	115151	23063	138275		138275	120936	158100
1991	374370	282733	495707	342491	298970	392346	95511	85782	106344	0.931	0.846	1024	102437	15709	118184		118184	104964	133070
1992	861991	655465	1133590	537132	448600	643136	91309	82439	101132	0.921	0.838	1012	108662	31477	140225		140225	118377	166104
1993	435827	334516	567820	415817	365903	472539	98913	89968	108748	0.940	0.855	1033	130180	28557	158843	-9947	148896	128471	172568
1994	1022744	777610	1345155	531256	449397	628027	101926	93458	111160	0.963	0.879	1056	106186	41938	148146	5899	154045	132790	178703
1995	598990	457760	783793	565802	488675	655103	121419	111338	132412	1.010	0.922	1107	130522	31962	162478	28517	190995	163662	222891
1996	374745	287478	488503	422101	373015	477646	116658	107469	126632	1.011	0.923	1107	132366	21522	153941	2276	156217	138561	176122
1997	1171740	881976	1556702	647582	529009	792732	101417	93291	110251	0.988	0.903	1081	133460	46610	180153	-25800	154353	129050	184619
1998	141351	107469	185914	329062	289708	373760	102847	93115	113597	1.007	0.921	1100	148023	43876	191975	-55622	136353	116955	158968
1999	252458	194125	328319	227067	203490	253376	85648	78533	93407	1.064	0.974	1163	96833	13896	110718	-15683	95035	86812	104037
2000	459089	352851	597315	290106	247415	340162	68118	61981	74863	1.073	0.981	1173	73539	16615	90091	-4785	85306	73852	98536
2001	166542	127920	216824	198392	175980	223659	63386	57568	69792	1.005	0.915	1102	44499	11451	55950	16453	72403	63868	82078
2002	249447	191925	324208	169228	148815	192440	56050	50967	61640	0.951	0.865	1046	53494	11512	65012	-8399	56613	51180	62623
2003	122516	93928	159807	141917	127458	158017	56444	51365	62025	0.927	0.838	1026	31280	4788	36088	17282	53370	47856	59519
2004	202805	156392	262992	123871	108727	141125	45844	41235	50968	0.890	0.803	0.987	27316	7546	34865	4514	39379	35829	43282
2005	154353	117795	202258	138690	121207	158696	47335	41742	53677	0.828	0.744	0.920	29923	11382	41291	-1236	40055	35443	45266
2006	359331	277468	465348	146679	123851	173714	43002	37440	49390	0.734	0.654	0.824	22652	9136	31793		31793	28245	35787
2007	168721	130724	217762	194853	172032	220701	72475	64100	81944	0.678	0.602	0.764	24029	29144	53157		53157	46548	60704
2008	197402	152732	255138	205870	180652	234608	80822	71493	91368	0.643	0.566	0.730	27065	25311	52365		52365	47603	57604
2009	193300	149564	249826	219916	193230	250288	90490	79262	103309	0.629	0.551	0.719	33290	21673	54940		54940	49673	60766
2010	297450	229280	385887	235861	203787	272984	92411	79388	107570	0.544	0.471	0.629	36207	12565	48776		48776	44312	53691
2011	148153	114375	191906	223463	193941	257479	104925	87982	125131	0.444	0.380	0.518	34372	10446	44846		44846	40490	49672
2012	203618	157642	263003	198988	171971	230249	106085	87951	127958	0.403	0.344	0.472	32696	7618	40336		40336	37289	43632
2013	267533	206741	346203	260928	224014	303924	116891	97007	140852	0.391	0.336	0.455	30792	10777	41564		41564	38186	45241
2014	399113	302761	526128	333701	282322	394430	127262	106149	152573	0.389	0.335	0.451	34787	11086	45844		45844	41567	50561
2015	174905	127145	240607	294785	252701	343877	153584	127598	184861	0.371	0.316	0.434	38561	13558	52104		52104	46732	58094
2016	134054						168552	137278	206952										

Table 4.2.5. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Catch options. Units are '000t (SSB landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2016) = F(2015) = 0.37
Recruitment resampled from 1998-2015 = 197
SSB(2017) = 176299
HC landings (2016) = 46031
Discards (2016) = 10930

Rationale	Catch (2017)	Landings (2017)	Discards (2017)	Basis	Ftotal (2017)	F land (2017)	F disc (2017)	SSB (2018)	SSB 5% (2018)	%SSB change	%TAC change	Ftotal (2018)	Ftotal (2019)	Catch (2018)	Catch (2019)	Landings (2018)	Landings (2019)	Discards (2018)	Discards (2019)	SSB (2019)	SSB (2020)	%change SSB 19:17	%change SSB 20:17
Management Plan	55876	46754	9122	EU MP	0.40	0.28	0.12	171971	137734	-2	16	0.40	0.40	51685	48948	41834	38355	9851	10593	168267	162985	-5	-8
Management Plan	55876	46754	9122	EU-Norway	0.40	0.28	0.12	171971	137734	-2	16	0.40	0.40	51685	48948	41834	38355	9851	10593	168267	162985	-5	-8
MSY approach	47359	39651	7708	FMSY *SSB2017/Btrigger	0.33	0.23	0.10	181374	146059	3	-2	0.33	0.33	46112	45035	37545	35727	8567	9308	185027	185341	5	5
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	236794	192601	34	-100	0.00	0.00	0	0	0	0	0	0	299892	356630	70	102
MSY	47359	39651	7708	FMSY	0.33	0.23	0.10	181374	146059	3	-2	0.33	0.33	46112	45035	37545	35727	8567	9308	185027	185341	5	5
Fpa	57039	47740	9299	Flim/1.4	0.41	0.29	0.12	170652	136590	-3	18	0.41	0.41	52391	49363	42409	38673	9982	10690	166166	160137	-6	-9
Flim	75481	63192	12289	Flim	0.58	0.41	0.17	149955	118849	-15	56	0.58	0.58	61568	54295	49196	41415	12372	12880	132551	120002	-25	-32
SSB(2018)=Blim	105033	87793	17240	SSB(2018)=Blim	0.91	0.64	0.27	118000	91689	-33	117	0.91	0.91	69219	55548	53523	39560	15696	15988	88774	73717	-50	-58
SSB(2018)=Bpa	61928	51863	10065	SSB(2018)=Bpa	0.45	0.32	0.13	165000	131881	-6	28	0.45	0.45	55208	51159	44551	39696	10657	11463	156600	148228	-11	-16
SSB(2018)=Btrigger	61928	51863	10065	SSB(2018)=Btrigger	0.45	0.32	0.13	165000	131881	-6	28	0.45	0.45	55208	51159	44551	39696	10657	11463	156600	148228	-11	-16
TAC constraint	38404	32335	6069	TAC2016 - 20%	0.26	0.18	0.08	192162	151192	9	-20	0.26	0.26	39313	40286	32335	32335	6978	7951	204463	211131	16	20
TAC constraint	40813	34356	6457	TAC2016 - 15%	0.28	0.20	0.08	189519	148841	7	-15	0.28	0.29	41844	42950	34356	34356	7488	8594	198587	202280	13	15
TAC constraint	43224	36377	6847	TAC2016 - 10%	0.30	0.21	0.09	186772	146198	6	-10	0.31	0.32	44394	45633	36377	36377	8017	9256	192462	192448	9	9
TAC constraint	45635	38398	7237	TAC2016 - 5%	0.32	0.22	0.10	184025	143430	4	-5	0.33	0.35	46951	48338	38398	38398	8553	9940	186436	183751	6	4
TAC constraint	48049	40419	7630	TAC2016	0.33	0.24	0.09	181234	140614	3	0	0.36	0.39	49517	51069	40419	40419	9098	10650	180418	174460	2	-1
TAC constraint	50464	42440	8024	TAC2016 + 5%	0.35	0.25	0.10	178427	138147	1	5	0.39	0.43	52094	53858	42440	42440	9654	11418	174548	165199	-1	-6
TAC constraint	52879	44461	8418	TAC2016 + 10%	0.37	0.26	0.11	175714	135682	0	10	0.42	0.47	54685	56669	44461	44461	10224	12208	168533	156066	-4	-11
TAC constraint	55295	46482	8813	TAC2016 + 15%	0.39	0.28	0.11	173027	133064	-2	15	0.45	0.52	57281	59528	46482	46482	10799	13046	162639	146886	-8	-17
TAC constraint	57713	48503	9210	TAC2016 + 20%	0.42	0.29	0.13	170353	130529	-3	20	0.48	0.57	59906	62430	48503	48503	11403	13927	156576	137768	-11	-22
Status quo	52735	44156	8579	Fsq	0.37	0.26	0.11	175461	140750	0	9	0.37	0.37	49727	47606	40346	37455	9381	10151	174146	170958	-1	-3


SSB
0
50
100
150
200
250
300
1970
1980
1990
2000
2010
Year


0.0
0.2
0.4
0.6
0.8
1.0
1.2
1970
1980
1990
2000
2010
Year

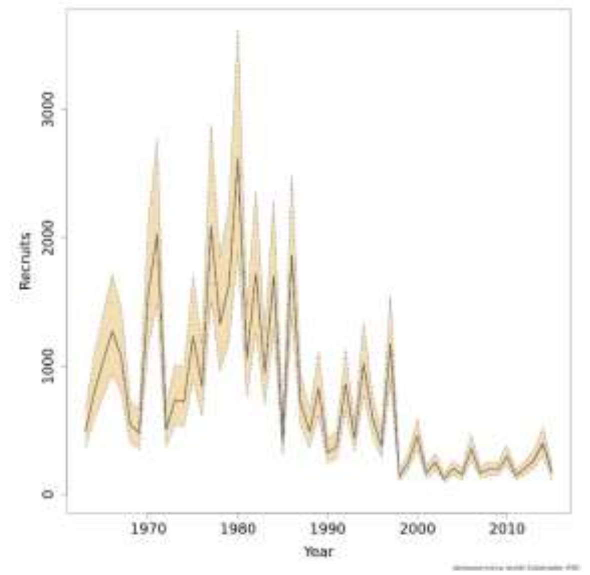

Recruits
0
1000
2000
3000
1970
1980
1990
2000
2010
Year

Figure 4.2.4. Cod in Subarea 4 and Divisions 3.a (Skagerrak) and 7.d. Summary of stock assessment with point-wise 95% confidence intervals. The SAM assessment produced by WGNSSK in May 2016 is plotted in grey for comparison.

4.3 Haddock in Sub-Area IV and Divisions IIIa and Via

The reopening protocol has not been applied because the final assessment carried out in October already includes the 3rq quarter survey information from 2016.

4.4 Saithe in Subarea 4, 6 and Division 3a

4.4.1 New survey information

New survey data are available from the 2016 international third quarter IBTS survey (IBTS Q3) for a potential autumn forecast. The following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2016), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

4.4.2 RCT3 analysis

An RCT3 analysis, following the protocol outlined by AGCREFA (ICES-AGCREFA 2008), was run to provide an estimate of the abundance of the incoming age 3 and age 4 year-classes. The RCT3 input and output files are given in Tables 4.4.1 to 4.4.3.

4.4.3 Update protocol calculation

The outcome of following the protocol was:

Calculation of 2013 year-class at:	Age 3	Age 4
Log WAP from RCT3 (R)	11.94	11.55
WAP	153277	103777
Log of recruitment assumed in spring (A)	11.53	11.29
Int SE of log WAP (S)	0.24	0.26
Distance D $=(R-A)/S$	1.71	1.00

4.4.4 Conclusions from protocol

As the distance D > 1.71, the protocol concludes that the advisory process for North Sea saithe should be reopened. The autumn indices suggest that the size of the incoming year-class is considerably larger than the median value assumed in the forecast produced by WGNSSK in May 2016. However, caution is warranted because the internal consistency of the Q3 survey between age 3 and age 4 were very poor (correlation = 0.24; Figure 4.4.1). This indicates that the age 3 index value is very uncertain and the perception of the year class strength can change considerably in the following year when information at age 4 becomes available. Age 3 is only partially recruited to the survey/fishing area, which explaines the low internal consistency to some extent. Age 4 can be seen as first fully recruited year class although the assessment starts with age 3. Therefore, an RCT3 analysis for age 4 was also explored and D = 1, indicating that age 4 is also marginally larger than expected. Therefore, just following the protocol would imply a reopening of the advice.

4.4.5 Updated forecast

The assessment was revised for North Sea saithe, incorporating the new survey data for 2016. The forecast was updated, but the 2016 recruitment estimate from the IBTS Q3 2016 survey was not used in the forecast for the reasons stated above. Instead, recruitment in 2016 was resampled from the period between 2003 and 2015. The settings and assumptions for the forecast are in Table 4.4.4.

Table 4.4.5 gives the draft advice table for the October 2016 update. On this basis, predicted North Sea total catch in 2017 increases from 116605 t (June Advice) to 134962 t (October results), while the corresponding TAC change increases from 62% to 88%. The very optimistic forecast that results from this reopening has very high uncertainties associated with it (Figure 4.4.2), which are largely ignored in the way the current advice is set up. A 62% TAC increase has been advised in June together with additional consideration that TAC constraints should be taken into account given the high uncertainty in the assessment and forecast. An even higher increase in the advised TAC would contradict the TAC constraint statement given that the former saithe EU- Norway management strategy had a 15% TAC constraint.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2016). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 26 April-5 May 2016, Hamburg, Germany. ICES CM 2016/ ACOM:14. 1023 pp.

Table 4.4.1. Saithe in Subareas 4 and 6 and Division 3a. RCT3 data input file for the age 3 and age 4 year-classes.

	Age3		Age 4	
Year class	Recruitment	IBTS Q3	Recruitment	IBTS Q3
1987	–	–	71728	0.402
1988	174125	1.946	88437	2.76
1989	103944	1.077	59297	2.781
1990	176170	7.965	97290	1.615
1991	118110	1.117	66737	2.501
1992	215385	13.959	148907	6.533
1993	119594	3.825	79763	3.351
1994	148952	3.756	120609	4.134
1995	87723	1.181	55318	1.907
1996	111435	2.086	93077	8.836
1997	97569	3.479	67645	6.173
1998	205817	21.494	144410	18.974
1999	163051	10.748	123163	23.802
2000	166920	19.272	109637	6.727
2001	117267	4.93	75797	7.512
2002	143615	8.916	123653	29.579
2003	102098	10.553	55604	5.578
2004	155694	34.006	98547	5.584
2005	73631	3.312	51468	1.703
2006	58640	1.346	38225	0.964
2007	90077	1.361	79213	8.451
2008	83142	4.52	48196	2.497
2009	141320	11.134	107991	16.279
2010	99244	14.701	74017	3.923
2011	60074	1.649	44478	5.613
2012	107275	11.001	NA	17.307
2013	NA	37.74	–	–

Table 4.4.2. Saithe in Subareas 4 and 6 and Division 3a. RCT3 data output file for the age 3 year-class.

```
Analysis by RCT3_R ver3.1 of data from file:
RCT3 Saithe AGE 3 2016.txt
RCT3 input for D calculations for Saithe in Subareas IV VI and Division IIIa
Data for 1 surveys over 26 years:  1988 - 2013
Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.
yearclass = 2013
          I-----------Regression----------I  -----------Prediction---------
I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series          cept   Error          Pts  Value  Value    Error  Weights
  IBTSQ3   0.51  10.51   0.26  0.665     25   3.66   12.36    0.344    0.507
                                         VPA Mean =   11.51    0.348    0.493

 Year     Weighted      Log      Int      Ext      Var      VPA      Log
 Class     Average      WAP      Std      Std    Ratio               VPA
          Prediction             Error    Error
 2013      153445     11.94    0.24     0.42     3.01
```

Table 4.4.3. Saithe in Subareas 4 and 6 and Division 3a. RCT3 data output file for the age 4 year-class.

```
Analysis by RCT3_R ver3.1 of data from file :
RCT3 Saithe AGE 4 2016.txt
RCT3 input for D calculations for  Saithe in Subareas IV VI and Division
IIIa
Data for 1 surveys over 26 years :  1987 - 2012
Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.
yearclass = 2012
          I-----------Regression----------I   I-----------Prediction-------
--I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series          cept   Error          Pts  Value  Value    Error  Weights
  IBTSQ3   0.62   9.97   0.28  0.704     25   2.91   11.78    0.338    0.610
                                         VPA Mean =   11.19    0.422    0.390

 Year     Weighted      Log      Int      Ext      Var      VPA      Log
 Class     Average      WAP      Std      Std    Ratio               VPA
          Prediction             Error    Error
 2012      103538       11.55   0.26     0.29    1.20
```

Table 4.4.4. Saithe in Subareas 4 and 6 and Division 3a. The basis for the catch options.

Variable	Value	Notes
F ages 4–7 (2016)	F = 0.20	TAC constraint (68601 tonnes)*
SSB (2016)	275345 t	SSB in the intermediate year, tonnes
SSB (2017)	337973 t	SSB at the beginning of the TAC year, tonnes
Rage3 (2016)	109 million	Median recruitment re-sampled from the years 2003–2015
Rage3 (2017)	109 million	Median recruitment re-sampled from the years 2003–2015
Total catch (2016)	72335 t	Assuming 2015 landings fraction by age, tonnes
Commercial landings (2016)	68601 t	TAC 2015, tonnes
Discards (2016)	3734 t	Assuming 2015 discard fraction by age, tonnes

*** TAC was based on landings without adjustment.**

Table 4.4.5. Saithe in Subareas 4 and 6 and Division 3a. Draft advice table; all weights are in tonnes.

Rationale	Total catch (2017)	Wanted catch* (2017)	Unwanted catch* (2017)	Wanted catch 3.a & 4 (2017) **	Wanted catch 6 (2017) **	Basis	Ftotal (2017)	Fwanted (2017)	Funwanted (2017)	SSB (2018)	% SSB change ***	% TAC change wanted catch^
MSY approach	140653	134792	5861	122122	12670	FMSY	0.36	0.34	0.02	333297	−1	96
EU–Norway management strategy	82455	78976	3479	71552	7424	Paragraph 5 of management strategy	0.2	0.19	0.01	390772	16	15
Zero catch	0	0	0	0	0	F = 0	0	0	0	470855	39	−100
Other options	83984	80439	3544	72878	7561	F2016	0.2	0.19	0.01	389271	15	17
	71912	68601	3311	62153	6448	TAC2016	0.17	0.16	0.01	400429	18	0
	152927	146546	6381	132771	13775	Fpa	0.4	0.38	0.02	321560	−5	114
	201882	193230	8651	175066	18164	Flim	0.56	0.54	0.02	273675	−19	182
	385729	365782	19946	331398	34384	SSB2018 = Blim	1.58	1.5	0.08	107000	−68	433
	335831	319572	16259	289532	30040	SSB2018 = Bpa	1.2	1.15	0.05	150000	−56	366
	335831	319572	16259	289532	30040	SSB2018 = MSY Btrigger	1.2	1.15	0.05	150000	−56	366

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rates estimates for 2015.**

**** Wanted catch split according to the average in 1993–1998, i.e. 90.6% in Subarea 4 and Subdivision 3.a.20 and 9.4% in Subarea 6.**

***** SSB 2018 relative to SSB 2017**

^ Wanted catch 2017 relative to the 2016 wanted catch (without adjustment) TAC.

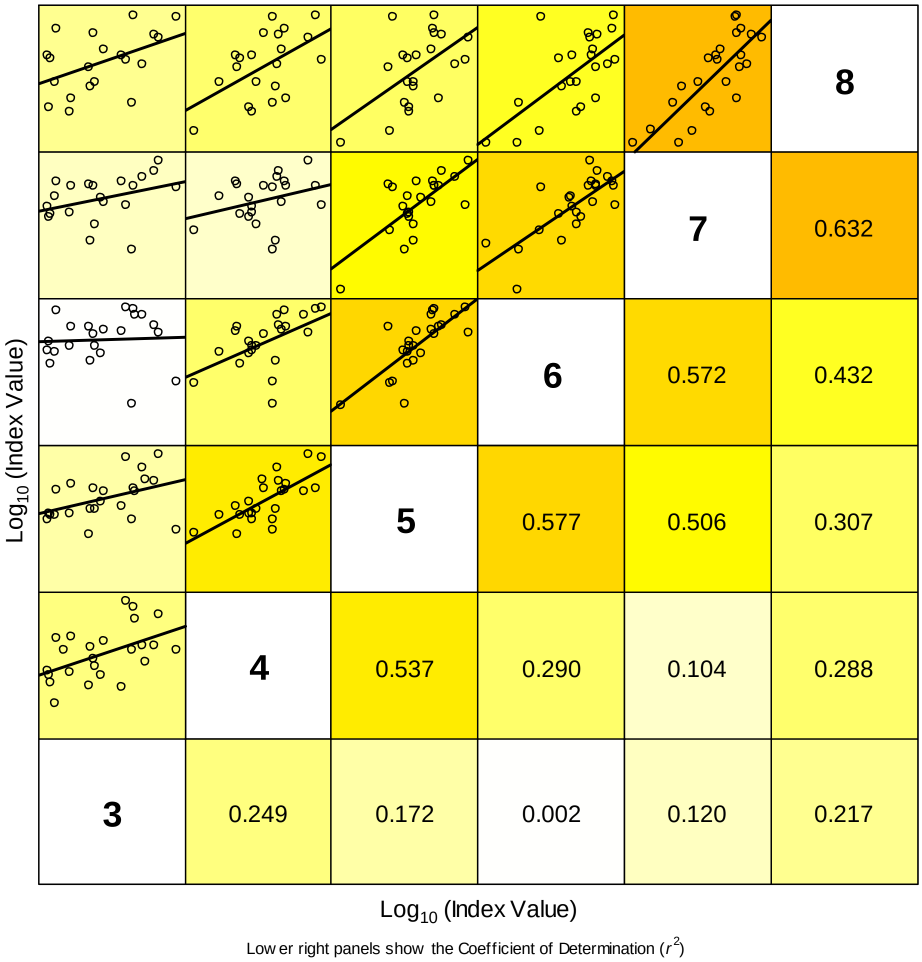


Figure 4.4.1. Saithe in Subareas 4 and 6 and Division 3a. Internal consistencies between subsequent ages in the IBTS Q3 survey.

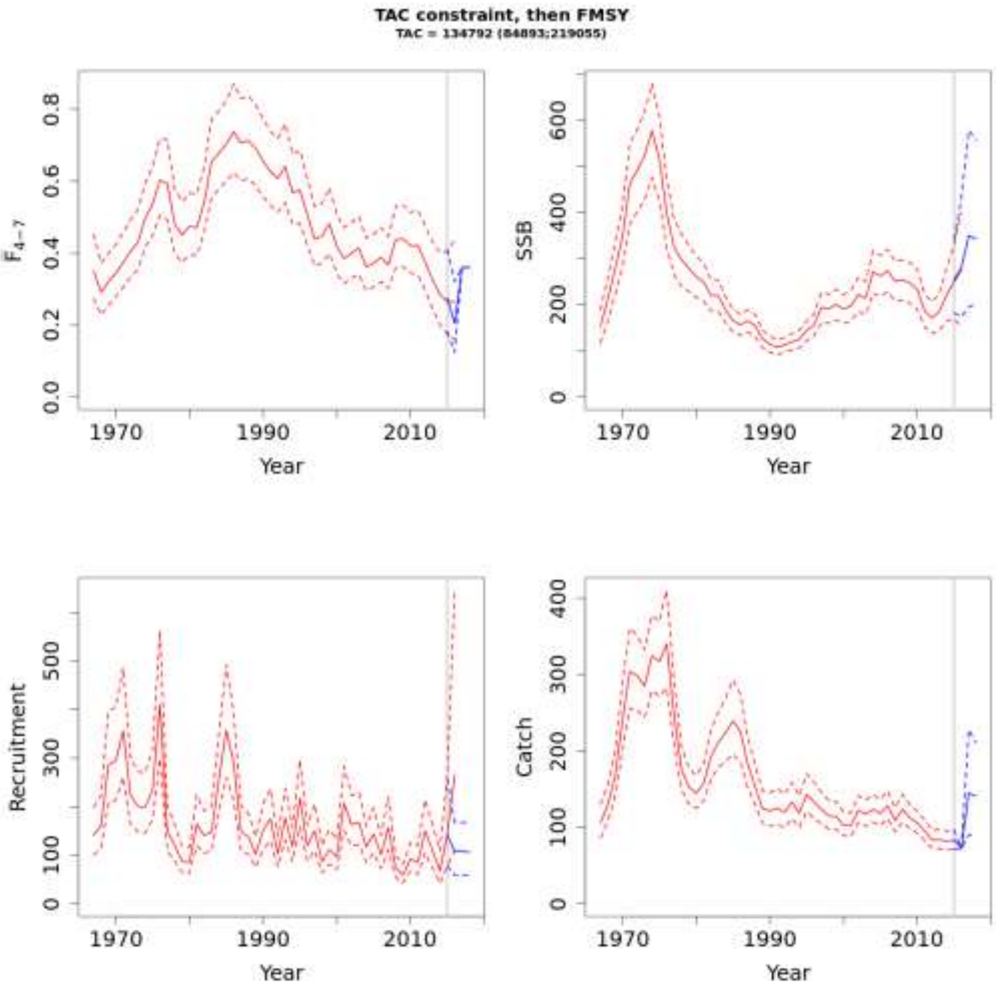


Figure 4.4.2. Saithe in Subareas 4 and 6 and Division 3a. Historic trend and three-year projection in $F_{4\text{-}7}$, SSB, recruitment, and catch including the associated uncertainties in the estimates.

4.5 Whiting in Sub-Area IV and Division VIId

4.5.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 4.5.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2016), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

4.5.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the 2015 year-class at age 0, and the incoming (2016) year-class at age 0. The RCT3 input and output files are given in Tables 4.5.2 and 4.5.3.

4.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2015 year-class at age 1 (in 2016)	
Log WAP from RCT3 (R)	14.73
Log of recruitment assumed in spring (A)	14.88
Int SE of log WAP (S)	0.154
Distance D $\left(D = \frac{R-A}{S}\right)$	-0.97

Calculations for 2016 year-class at age 1 (in 2017)	
Log WAP from RCT3 (R)	14.92
Log of recruitment assumed in spring (A)	14.71
Int SE of log WAP (S)	0.284
Distance D $\left(D = \frac{R-A}{S}\right)$	0.74

4.5.4 Conclusions from protocol

- 2015 year class at age 1 (in 2016): as the distance -1.0 < D < 1.0, the protocol concludes that the RCT3 estimate used for 2015 recruitment was appropriate and need not be changed.
- 2016 year class at age 1 (in 2017): in the spring advice, a geometric mean value was used for this year class. As the distance -1.0 < D < 1.0 for this year-class, the protocol concludes that the original geometric mean appropriate and need not be changed.

The overall conclusion is that **the advisory process for North Sea whiting does not have to be reopened based on the RCT3 analysis.**

4.5.5 Reopening performance

Since 2009, the advice had to be reopened and updated three times (in 2013, 2014 and 2015). Generally the autumn update for the intermediate year improved the forecast from spring relative to the values estimated in the following years (reopening year+1, reopening year +2 or 2016). The percentage difference relative to 2016 could be reduced from 88, 21 and 108% in spring to 2, 16 and 83% in autumn, respectively.

In contrast for the TAC year, the spring forecast using the geometric mean of recruitment of recent years was better in forecasting the recruitment estimated in the following years than the autumn update. In 2014 and 2015 when recruitment for the TAC year was updated, the percentage difference to the respective estimate in the final year 2016 increased from 76 and 30% to 188 and 179%, respectively.

4.5.6 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2016). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2015/ACOM:13.

Table 4.5.1. Whiting in Sub-Area IV and Division VIId. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2016 are highlighted.

	Age						
Year	0	1	2	3	4	5	6
1991	536.99	703.368	158.594	79.024	14.568	5.183	1.018
1992	1379.459	600.867	296.1	72.451	57.498	10.273	6.212
1993	919.193	638.722	177.377	66.118	14.711	15.904	3.039
1994	610.743	677.645	219.541	74.71	19.506	4.722	3.16
1995	729.246	619.786	291.18	107.195	21.512	6.013	3.464
1996	316.501	545.708	278.218	129.356	34.003	6.893	4.1
1997	2062.67	332.968	180.681	108.985	28.006	10.711	4.245
1998	2631.69	330.6	150.205	52.766	31.01	11.179	4.695
1999	2498.55	1203.501	190.643	53.932	24.452	9.529	4.179
2000	1961.467	940.784	326.515	64.396	13.597	6.534	4.861
2001	3548.815	668.907	283.081	93.978	19.076	4.279	6.023
2002	269.285	811.915	257.157	131.47	35.034	5.45	2.835
2003	356.523	257.637	292.805	128.67	67.944	17.313	4.767
2004	714.27	150.623	59.032	66.326	45.724	27.103	9.711
2005	169.321	171.386	68.259	31.433	45.616	33.96	28.704
2006	198.949	174.625	86.336	32.619	13.511	23.287	25.714
2007	822.902	95.495	63.592	37.636	11.482	8.405	20.747
2008	764.759	362.299	68.886	30.907	13.774	4.081	14.791
2009	593.801	585.529	384.777	40.984	12.295	8.037	6.808
2010	510.123	224.321	145.671	54.635	12.844	5.996	7.795
2011	247.085	446.812	144.439	47.243	16.217	6.929	4.635
2012	306.812	256.718	193.523	57.001	20.081	10.644	5.384
2013	334.257	67.451	60.102	65.787	17.504	7.08	3.725
2014	1401.008	223.4	97.962	65.552	33.278	10.311	6.849
2015	2091.636	312.453	222.551	43.072	24.038	18.433	10.853
2016	971.324	297.483	243.642	77.638	12.211	8.053	9.947

Table 4.5.2 Whiting in Sub-Area IV and Division VIId. RCT3 input file. Data from surveys in autumn 2016 are highlighted.

Year class	VPA Recruits at age 1	IBTS Q1 Age 1	IBTS Q1 Age 2	IBTS Q3 Age 0	IBTS Q3 Age 1	IBTS Q3 Age 2
1989	3602988	518.936	686.445	-11	-11	158.594
1990	3561689	1007.621	665.714	-11	703.368	296.1
1991	3429482	907.297	522.811	536.99	600.867	177.377
1992	3911169	1075.624	627.406	1379.459	638.722	219.541
1993	3665192	721.709	448.484	919.193	677.645	291.18
1994	3286257	678.59	485.968	610.743	619.786	278.218
1995	2338049	502.361	342.246	729.246	545.708	180.681
1996	1785364	287.779	160.695	316.501	332.968	150.205
1997	2473817	543.117	305.445	2062.67	330.6	190.643
1998	4023722	676.266	544.86	2631.69	1203.501	326.515
1999	4784856	767.887	592.395	2498.55	940.784	283.081
2000	3996189	614.174	342.774	1961.467	668.907	257.157
2001	3432777	558.505	298.408	3548.815	811.915	292.805
2002	1210399	131.588	90.134	269.285	257.637	59.032
2003	1225220	184.399	97.824	356.523	150.623	68.259
2004	1599745	112.663	125.057	714.27	171.386	86.336
2005	1600655	184.411	147.304	169.321	174.625	63.592
2006	1526369	64.53	205.798	198.949	95.495	68.886
2007	2767240	268.598	295.812	822.902	362.299	384.777
2008	2263468	211.202	224.795	764.759	585.529	145.671
2009	2335777	326.192	337.096	593.801	224.321	144.439
2010	3053030	184.867	588.309	510.123	446.812	193.523
2011	1612011	231.255	162.985	247.085	256.718	60.102
2012	1140360	54.431	184.517	306.812	67.451	97.962
2013	2155672	265.226	212.642	334.257	223.4	222.551
2014	-11	315.019	312.194	1401.008	312.453	243.642
2015	-11	281.272	-11	2091.636	297.483	-11
2016	-11	-11	-11	971.324	-11	-11

Table 4.5.3. Whiting in Sub-Area IV and Division VIId. RCT3 output file.

Analysis by RCT3 ver4.0

Whiting

Data for 5 surveys over 28 years : 1989 - 2016

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:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.5980	11.24	0.2580	0.7433	25	5.639	14.61	0.2745	0.3622
IBTSq12	0.7673	10.35	0.2067	0.8184	25	NA	NA	NA	NA
IBTSq30	0.6311	10.58	0.3520	0.6130	23	7.646	15.40	0.3899	0.1795
IBTSq31	0.6539	10.84	0.2285	0.7883	24	5.695	14.56	0.2440	0.4583
IBTSq32	0.8437	10.42	0.2607	0.7392	25	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	25	NA	14.71	0.4297	0.0000

	WAP	logWAP	int.se
yearclass:2015	2493212	14.73	0.1542

yearclass:2016

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.5980	11.24	0.2580	0.7433	25	NA	NA	NA	NA
IBTSq12	0.7673	10.35	0.2067	0.8184	25	NA	NA	NA	NA
IBTSq30	0.6311	10.58	0.3520	0.6130	23	6.879	14.92	0.3778	1
IBTSq31	0.6539	10.84	0.2285	0.7883	24	NA	NA	NA	NA
IBTSq32	0.8437	10.42	0.2607	0.7392	25	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	25	NA	14.71	0.4297	0

	WAP	logWAP	int.se
yearclass:2016	3005768	14.92	0.2837

4.6 North Sea plaice

4.6.1 Short term forecast and June advice

At WGNSSK 2016 (ICES 2016), the following short term forecast settings were used:

Year class	Age in 2016	XSA survivors	RCT3	GM 1957–2013	Accepted estimate
2014	2	952366	704951	726298	XSA survivors
2015	1		907736	980962	RCT3
2016	0			980962	GM 1957-2013

4.6.2 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS), that was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea. Since IBPplaice (ICES 2013), the assessment uses the combined BTS-Isis and BTS-Tridens index. This index have a shorter time series due to the BTS-Tridens only starting in 1996.

4.6.3 RCT3 Analysis

The RCT3 analysis on the BTS-combined survey indices for ages 1 and 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 42 years including the assessment estimates for the two ages are presented in Table 2.6.1. In 2016, the new data comprises age 1 of year class 2015 and age 2 of year class 2014. The last 4 years from the assessment estimates were removed from the time series.

Table 2.6.1 North Sea plaice RCT3 input data

yc	N_Age_1	N_Age_2	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1974	864714	548413	NA	NA	2402.6	NA	NA	NA
1975	691691	448206	NA	NA	3423.8	NA	NA	NA
1976	990829	649359	NA	NA	12678	NA	NA	NA
1977	920713	616240	NA	NA	9828.8	NA	NA	NA
1978	905430	539147	NA	NA	12882.3	NA	NA	NA
1979	1148883	823274	NA	NA	18785.3	NA	NA	NA
1980	901574	687932	NA	NA	8642	NA	NA	NA
1981	2111275	1515904	NA	NA	13908.6	NA	NA	NA
1982	1368338	988318	NA	NA	10412.8	NA	NA	NA
1983	1299663	880358	NA	NA	13847.8	NA	NA	NA
1984	1880989	1316261	NA	NA	7580.4	NA	NA	NA
1985	4797263	3276305	NA	NA	32991.1	NA	NA	NA
1986	1979144	1446915	NA	NA	14421.1	NA	NA	NA
1987	1830953	1325118	NA	NA	17810.2	NA	NA	NA
1988	1250820	927707	NA	NA	7496	NA	NA	NA
1989	1084035	841178	NA	NA	11247.2	NA	NA	NA
1990	959797	692911	NA	NA	13841.8	NA	NA	439.6
1991	811532	599095	NA	NA	9685.6	NA	NA	332.4
1992	565366	416644	NA	NA	4976.6	NA	NA	180.3
1993	480910	374746	NA	NA	2796.4	NA	NA	217
1994	1197928	963465	NA	NA	10268.2	NA	99.6	283.4
1995	1339279	1104956	NA	NA	4472.7	143.9	28.7	146.1
1996	2212118	1878375	NA	NA	30242.2	386.8	177.6	619.6
1997	813659	636602	NA	NA	10272.1	131.2	53.6	229.2
1998	882903	677250	NA	NA	2493.4	117	38.9	NA

1999	1035755	836291	NA	22855	2898.5	108.4	39.8	NA
2000	577074	488990	24213.5	11510.5	1102.7	80.3	26.7	124.9
2001	1857519	1384282	99628	30809.2	NA	217.3	94.4	313.2
2002	579018	458760	31202	NA	1349.7	53.6	30.3	122.9
2003	1375294	1021614	NA	18201.6	1818.9	101.4	45.6	238.6
2004	803930	635267	13537.2	10118.4	1571	70.8	42.9	126.7
2005	979159	675430	27390.6	12164.2	2133.9	54.9	44.4	85.9
2006	1143879	959761	51124.2	14174.5	2700.4	139.4	89.7	168
2007	1071558	840310	40580.9	14705.8	2018.7	98.9	76.5	98.3
2008	1110840	862227	50179.3	14860	1811.5	170.8	69.5	129.7
2009	1419551	1123228	53258.8	11946.9	1142.5	144.8	126	141.9
2010	1892434	1599807	49347.2	18348.6	2928.6	226.5	149.6	179.6
2011	1274853	1065903	52643	5893.4	3021.3	118.4	90.5	93
2012	NA	NA	45027.1	15394.9	2258.3	192.8	123.2	181.1
2013	NA	NA	44327.5	17312.7	5040.4	155.2	156.6	168.5
2014	NA	NA	11722.3	16726.5	NA	116.5	68.8	108
2015	NA	NA	30494.5	NA	NA	112.02	NA	100.2

4.6.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 4.6.2.

For age 1, the D value for this age indicates 0.61, a small positive signal but not significantly different from spring assumptions. For age 2 the D value=0.04 indicating a small positive signal, but not significantly different from spring assumptions. Therefore, a reopening is not warranted.

Table 2.6.2 North Sea plaice RCT3 output for age 1 and 2 and D calculation

D calculation North Sea plaice age 1

```
nalysis by RCT3 ver4.0

Plaice

Data for 1 surveys over 42 years : 1974 - 2015
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:2015
    index slope intercept     se rsquare  n indices prediction se.pred
WAP.weights
     BTS1 0.909     9.559 0.2699  0.6791 17   4.719      13.85  0.2959       1
 VPA Mean    NA        NA     NA      NA 38      NA      13.95  0.4498       0

                   WAP logWAP int.se
yearclass:2015 1064735  13.85 0.2472

Spring assumption for age 1: 907736; log(907736) = 13.72
```

Calculations for 2013 year-class at age 1	
Log WAP from RCT3 (R)	13.85
Log of recruitment assumed in spring (A)	13.72
Int SE of log WAP (S)	0.25
Distance D $\left(D = \frac{R-A}{S}\right)$	0.61

A positive signal, but not substantially different from spring assumptions.

D calculation North Sea plaice age 2

```
Analysis by RCT3 ver4.0

Plaice

Data for 1 surveys over 42 years : 1974 - 2015
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014
    index  slope intercept    se rsquare  n indices prediction se.pred
WAP.weights
     BTS2 0.8255     10.29 0.301  0.6277 18   4.231      13.78  0.3282      1
 VPA Mean     NA        NA    NA      NA 38      NA      13.65  0.4568      0

                  WAP logWAP int.se
yearclass:2014 923678  13.78 0.2666
```

```
Spring assumption for age 2: 952366; log(952366) = 13.77
```

Calculations for 2012 year-class at age 2	
Log WAP from RCT3 (R)	13.78
Log of recruitment assumed in spring (A)	13.77
Int SE of log WAP (S)	0.27
Distance D $\left(D = \frac{R-A}{S}\right)$	0.04

```
A negative signal, but not substantially different from spring assumptions.
```

4.6.5 Revised forecast

Since none of the new survey indices indicates a substantial difference in perceived recruitment (compared to the spring assumptions), no further STF was done.

4.6.6 Reopening performance

A review of reopened advice since 2009 reveals that the advice was reopened twice: in 2014 and in 2015. In 2014 the recruitment estimate was increased from 936981 to 1309243. In 2015 the recruitment estimate was increased from 650882 to 826318. For both years, the autumn update of the recruitment corresponded more closely to the assessment outcomes for those ages and years. The absolute difference between recruitment used in the spring forecast and the estimate in 2016 for 2014 and 2015 was 52.3 % and 42.9%, respectively, The difference for the recruitment used in the autumn forecast and the 2016 was smaller, with 33.4% and 27.5% respectively.

4.6.7 References

ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2013. Report of the Inter-Benchmark Protocol for Plaice in Subarea IV (IBP Plaice), April 2013, By correspondence. ICES CM 2013/ACOM:63. 78 pp.

ICES. 2016. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM.

4.7 North Sea sole

4.7.1 Short term forecast and June advice

At WGNSSK 2016 (ICES, 2016), the following short term forecast settings were used:

Year Class	Age in 2016	AAP thousands	RCT3 thousands	GM(1957-2012) thousands
2014	2	163431	137233	99023
2015	1		59248	111851
2016	Recruit (0)			111851

4.7.2 New survey information

There is new survey information available from the quarter three 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.

4.7.3 RCT3 Analysis

The RCT3 analysis on the BTS ISIS survey indices for ages 1 and 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 42 years including the assessment estimates for the two ages are presented in Table 2.6.1. In autumn 2016, the new data derived from the recently conducted surveys comprises age 1 of year class 2015 and age 2 of year class 2014. The last 4 years from the assessment estimates were removed from the time series.

Table 2.7.1. North Sea sole RCT3 input data (shaded cells are new values from 2016 surveys, age 1 and age 2 estimated in separate analysis).

yc	N_Age_1	N_Age_2	SNS0	SNS1	BTS1	BTS2	DFS0
1974	59092	52591	174.4	525.4	NA	NA	NA
1975	138917	122596	577.5	1399.4	NA	NA	NA
1976	172911	153675	464.6	3742.9	NA	NA	NA
1977	63381	56908	1585	1547.7	NA	NA	NA
1978	17880	16108	10370.5	93.8	NA	NA	NA
1979	181294	163061	3922.7	4312.9	NA	NA	NA
1980	218640	195134	5145.8	3737.2	NA	NA	NA
1981	204054	179807	3240.7	5856.5	NA	NA	NA
1982	203846	179488	2147	2621.1	NA	NA	NA
1983	95271	84715	769.1	2493.1	NA	7.121	NA
1984	111974	100418	3334	3619.4	7.031	5.183	NA
1985	163489	147256	2713.4	3705.1	7.168	12.548	NA
1986	84106	75889	742	1947.9	6.973	12.512	NA
1987	686583	619725	13610.1	11226.7	83.111	68.084	NA
1988	135009	121800	522.7	2830.7	9.015	24.487	NA
1989	247976	223426	1743.4	2856.2	37.839	28.841	NA
1990	88638	79701	50.8	1253.6	4.035	22.284	6.38
1991	442592	396755	3639.7	11114	81.625	42.345	167.56
1992	88109	78597	302.9	1290.8	6.35	7.121	9.27
1993	64572	57149	231.3	651.8	7.66	8.458	15.32
1994	113851	99840	4692.7	1362.1	28.125	7.634	22.06
1995	76031	66385	1374.9	218.4	3.975	4.919	7.06
1996	326152	285876	2322.3	10279.3	169.343	27.422	40.27
1997	150896	133132	803	4094.6	17.108	18.363	26.94
1998	116975	103693	327.9	1648.9	11.96	6.144	NA
1999	140444	124684	2187.9	1639.2	14.594	9.963	NA
2000	72200	63920	70	970.3	7.998	4.182	9.5
2001	217842	190844	8340	7547.5	20.989	9.947	51.42
2002	96079	82677	1127.7	NA	10.507	4.354	58.58
2003	52786	45003	NA	1369.5	4.192	3.395	10.61
2004	51243	44337	162	568.1	5.534	2.332	31.25
2005	188203	165500	305	2726.4	17.089	19.504	40.99
2006	69450	61423	16	848.6	7.498	9.062	12.57
2007	79121	69716	466.9	1259.1	15.247	4.999	13.73
2008	103169	90232	754.7	1931.6	15.95	10.707	11.77
2009	217368	189870	2291	2636.9	54.811	17.387	27.33
2010	228790	201060	333.9	1248	26.166	18.212	42.86
2011	58439	51568	136.3	226.6	5.149	3.558	12.13
2012	NA	116775	144.7	967.4	6.844	15.576	11.23
2013	NA	NA	237.3	2849	18.926	25.601	44.82
2014	NA	NA	126	3192	21.099	11.982	23.62
2015	NA	NA	109.7	NA	6.307	NA	7.45

2.7.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 2.6.2.

The D value for age 1 is 0.46 (Table 2.7.2), a weak positive signal, not significantly different from the spring assumption (D<1). For age 2 the D value is -0.74 (Table 2.7.2), a weak negative signal, not significantly different from the spring assumption (D<1). Hence, **the short term forecast does not need to be re-run**.

Table 2.7.2 North Sea sole RCT3 output for age 1 and 2 and D calculation

D calculation North Sea sole age 1

Analysis by RCT3 ver4.0: Sole

Data for 1 surveys over 42 years : 1974 - 2015

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:2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
BTS1	0.759	9.754	0.3838	0.7476	28	1.842	11.15	0.4099	1
VPA Mean	NA	NA	NA	NA	38	NA	11.71	0.6827	0

	WAP	logWAP	int.se
yearclass:2015	69691	11.15	0.3514

Spring assumption for age 1: 59248; log(59248) = 10.99

Calculations for 2013 year-class at age 1	
Log WAP from RCT3 (R)	11.15
Log of recruitment assumed in spring (A)	10.99
Int SE of log WAP (S)	0.35
Distance D $\left(D = \frac{R-A}{S}\right)$	0.46

D calculation North Sea sole age 2

Analysis by RCT3 ver4.0: Sole

Data for 1 surveys over 42 years : 1974 - 2015

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
BTS2	0.9157	9.463	0.3869	0.7349	30	2.483	11.74	0.4073	1
VPA Mean	NA	NA	NA	NA	39	NA	11.59	0.6760	0

	WAP	logWAP	int.se
yearclass:2014	125057	11.74	0.3489

Spring assumption for age 2: 163431 ; log(163431) = 12.00

Calculations for 2013 year-class at age 2	
Log WAP from RCT3 (R)	11.74
Log of recruitment assumed in spring (A)	12.00
Int SE of log WAP (S)	0.35
Distance D $\left(D = \frac{R-A}{S}\right)$	-0.74

2.7.5 Reopening performance

A review of reopened advice since 2009 reveals that the advice was reopened twice: in 2014 and in 2015. In 2014 the age 2 estimate was increased from 54268 to 65474. In 2015 the recruitment estimate was increased from 103741 to 135220. For both years, the autumn update of the recruitment corresponded more closely to the assessment outcomes for those ages and years. The absolute difference between recruitment used in the spring forecast and the estimate in 2016 for 2014 and 2015 was 53.5 and 46.6%, respectively, The difference for the recruitment used in the autumn forecast and the 2016 was smaller, with 43.9% and 30.3% respectively.

2.7.6 References

ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2016. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM.

4.8 North Sea Nephrops

Nephrops FU6

The annual underwater TV survey of the Farn Deeps area was undertaken 21st – 28th June 2016.

The survey was completed without any technical issues and the visibility was excellent. All 110 stations were completed with valid counts generated using the standard protocols for counting and quality assurance. The survey results show the usual pattern to the densities as with previous years of a higher density spine down the western side of the ground. There does appear to be a slight southward shift in stock densities with an absence of *Nephrops* in the far north and a higher relative abundance in the far south (figure 1).

Total abundance in 2016 is estimated to be 697 million with a 95% CI of 19 million. The advice in June 2016 was based upon the 2015 survey which showed 565 million with a 95% CI of 13 million. The increase in abundance from 2015 to 2016 was 132 million, well beyond the confidence envelope of the 2015 survey (table 1 and figure 2).

It is therefore recommended that the advice be reopened.

Btrigger for FU6 Nephrops is 858 million and the MSY harvest rate is 8.1%. Following ICES procedures, when the abundance index is below Btrigger, the target harvest rate is reduced linearly by the ratio of current abundance: Btrigger. This results in a target Harvest Rate of 6.6%.

Mean weights and discard rates have not been updated (as this update only has new survey data), so the updated advice is only based upon the change in abundance estimate.

Nephrops in IV: FU6 updated survey results. Table 1 survey result history

Year	Stations	Season	Mean density	Absolute Abundance	95% confidence interval	Method
			burrows/m²	millions	millions	
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	73	Autumn	0.33	1085	90	Box
2004	76	Autumn	0.43	1377	101	Box
2005	105	Autumn	0.49	1657	148	Box
2006	105	Autumn*	0.37	1244	114	Box
2007	105	Autumn*	0.28	858	23	Geostatistics
2008	95	Autumn*	0.31	987	39	Geostatistics
2009	76	Autumn*	0.22	682	38	Geostatistics
2010	95	Autumn*	0.25	785	21	Geostatistics
2011	97	Autumn*	0.28	878	17	Geostatistics
2012	97	Autumn*	0.24	758	13	Geostatistics
2013	110	Summer	0.23	706	18	Geostatistics
2014	110	Summer	0.24	755	18	Geostatistics
2015	110	Summer	0.18	565	13	Geostatistics
2016	110	Summer	0.22	697	19	Geostatistics

Nephrops in IV: FU6 updated survey results. Table 2 revised catch advice tables

Catch options assuming zero discards

Rationale	Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
MSY approach	MSY approach	1125	1004	121	6.60%
Other options	FMSY	1385	1236	149	8.12%
	Fcurrent (2013–2015)	2641	2357	284	15.48%

*** Wanted" and "unwanted" catch are used to described Norway lobster that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

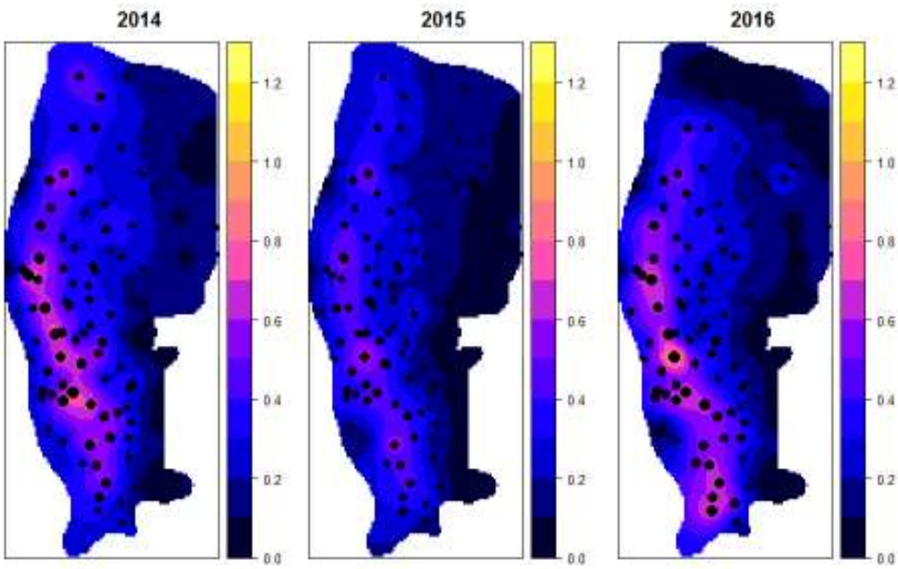
Discarding assumed below MCS only*

Rationale	Basis	Total catch	Dead removals	Landings (Wanted catch)	Unwanted >MCS**	Dead discards <MCS	Surviving discards	Harvest rate***
		L+U+DD+SD	L+U+DD	L	U	DD	SD	for L+U+DD
MSY approach	MSY approach	1143	1138	1020	90	28	5	6.60%
Other options	FMSY	1407	1401	1256	111	35	6	8.12%
	Fcurrent (2013–2015)	2683	2671	2394	211	66	12	15.48%

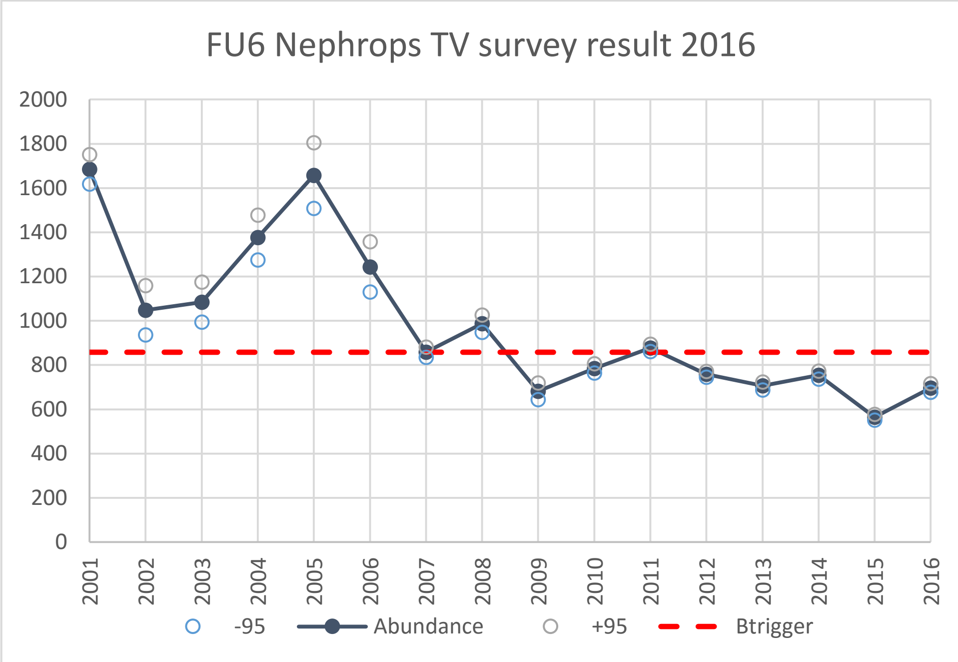
*** Assumed for all fleets**

**** Unwanted landings (U) are those animals >MCS but historically discarded**

***** Calculated for dead removals**



Nephrops in IV: FU6 survey update. Figure 1. Abundance maps.



Nephrops in IV: FU6 survey update. Figure 2. Abundance time series.

Fladen (FU7)

The most recent UWTV survey for this stock was carried out in June 2016. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2016 advice and based on the 2015 survey is 2569 million with a 95 % CI of 320 million (Table 1; Figure 1 & 2). The estimate from the 2016 summer survey is 4449 million (73% increase on the 2015 value). The 2016 value is significantly different from that of 2015 (ACOM specifies 1 SD, this is well over the specified threshold) and therefore the advice for FU7 may be reopened.

The advice for 2017 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2017 under the landing obligation and assuming discarding below MCS only (Table 2) following the MSY approach is 11852 tonnes (the June advice was 6844 tonnes). Mean weights and discard rates have not been revised in October 2016 (as this update only has new 2016 summer survey data), so the update of the advice is only due to the change in the abundance estimate. Discards survival for *Nephrops* in FU7 is assumed to be 25%. ICES was also requested to provide a second catch options table assuming zero discards (Table 3).

The large abundance increase in 2016 may be be related with a strong recruitment event. The size of Nephrops burrows is not quantified in the TV surveys but burrow counters participating in the last survey reported a large number of small burrows in FU 7. If the increase is dominated by small Nephrops, it is unlikely they will appear in the fishery straight away given the selectivity observed for this FU. It should be noted that in recent years the catch in this FU has been lower than advised. The increase in the 2016 abundance is substantial and this translates into a large increase in the advice for 2017 compared with that released in June. In the event that this advice is updated it should be emphasized that if the large difference between advice and catches remains, it may be transferred to other FUs in the North Sea which could result in non-precautionary exploitation of those FUs.

Table 1. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2016 TV surveys.**

Year	Stations	Abundance millions	Mean density burrows/m2	95% confidence interval millions
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996	No survey			
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	335
2014	70	2990	0.11	412
2015	71	2569	0.091	320
2016	78	4449	0.158	662

FU7 basis for the catch options

Variable	Value	Source	Notes
Stock abundance	4449 million individuals	ICES (2016a)	UWTV 2015
Mean weight in landings	38.24g	ICES (2016a)	Average 2013–2015
Mean weight in discards	15.30g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCS	16.13g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCS	7.58g	ICES (2016a)	Average 2013–2015
Discard rate (total)	0.83%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCS)	0.75%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (<MCS)	0.08%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Proportion by number, only applies in scenarios when discarding is allowed.
Dead discard rate (total)	0.62%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios when discarding is allowed.
Dead discard rate (<MCS)	0.12%	ICES (2016a)	Average (proportion by number) 2013–2015, only applies in scenarios when discarding is allowed below MCS.

Table 2. Revised Advice table assuming discarding below MCS only*

Rationale	Basis	Total catch	Dead removals	Landings (Wanted catch)	Unwanted >MCS**	Dead discards <MCS	Surviving discards	Harvest rate***
		L+U+DD+SD	L+U+DD	L	U	DD	SD	for L+U+DD
MSY approach	MSY approach	11852	11852	11813	38	1	0	7.0%
Other options	FMSY	12699	12698	12656	40	2	1	7.5%
	F2015	3386	3386	3375	11	0	0	2.0%
	F2013–2015	4911	4911	4894	16	1	0	2.9%
	F35%SpR	18963	18962	18900	60	2	1	11.2%
	Fmax	27767	27766	27675	88	3	1	16.4%

*** Assumed for all fleets**

**** Unwanted landings are those animals >MCS but historically discarded**

***** Calculated for dead removals**

Table 3. Revised Advice table assuming zero discards

Rationale	Basis	Total catches	Wanted catches*	Unwanted catches*	Harvest rate**
MSY approach	MSY approach	11850	11810	40	7.0%
Other options	Fmsy	12696	12654	42	7.5%
	F2015	3385	3374	11	2.0%
	F2013–2015	4909	4893	16	2.9%
	F35%SpR	18959	18896	63	11.2%
	Fmax	27763	27670	93	16.4%

*** "Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

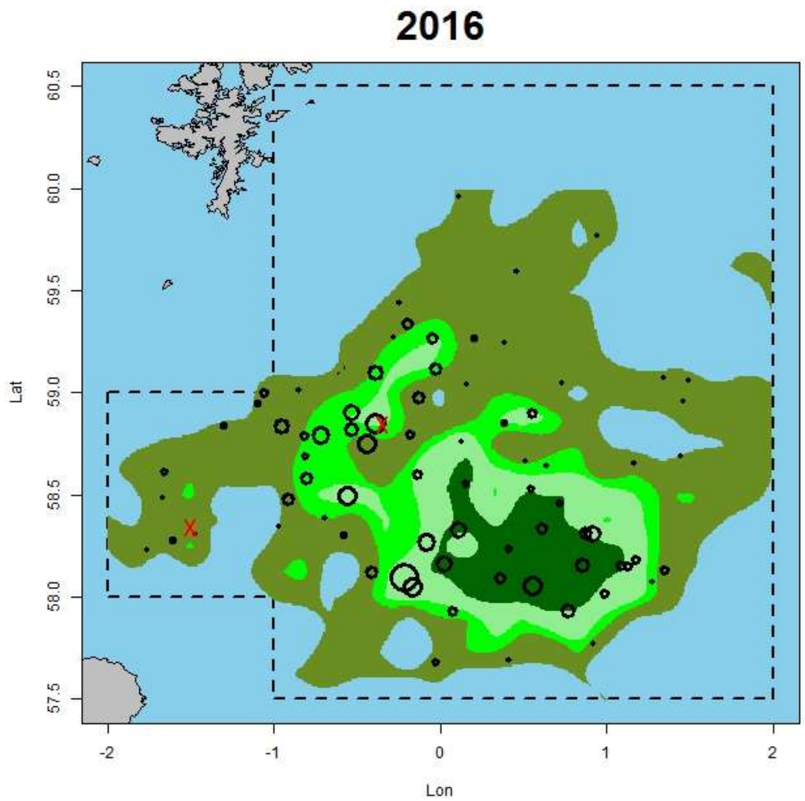


Figure 1. *Nephrops*, Fladen (FU 7). TV survey distribution and relative density in 2016. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

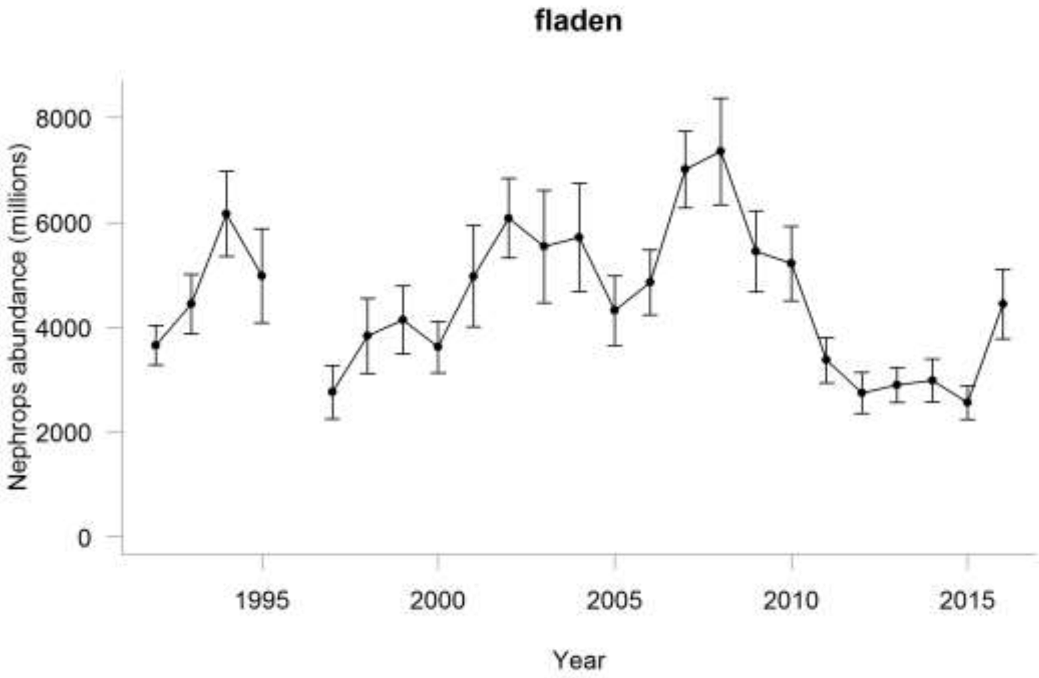


Figure 2. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2016 TV surveys.**

Firth of Forth (FU8)

The most recent UWTV survey for this stock was carried out in August 2016. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2016 advice and based on the 2015 survey is 664 million with a 95 % CI of 127 million (Table 4; Figure 3 & 4). The estimate from the 2016 summer survey is 797 million (20% increase on the 2015 value). The 2015 value is significantly different from that of 2015 (ACOM specifies 1 SD, this is over 2 SD) and therefore the advice for FU8 may be reopened.

The advice for 2017 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2017 under the landing obligation and assuming discarding below MCS only (Table 5) following the MSY approach is 2548 tonnes (the June advice was 2123 tonnes). Mean weights and discard rates have not been revised in October 2016 (as this update only has new 2016 summer survey data), so the update of the advice is only due to the change in the abundance estimate. Discards survival for *Nephrops* in FU8 is assumed to be 25%. ICES was also requested to provide a second catch options table assuming zero discards (Table 6).

Table 4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1993-2016 TV surveys.**

Year	Stations	Mean Density	Abundance	95% conf interval
		burrows/m²	millions	millions
1993	37	0.61	555	142
1994	30	0.49	448	78
1995	no survey			
1996	27	0.41	375	88
1997	no survey			
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125
2014	51	0.47	428	80
2015	51	0.73	664	127
2016	50	0.87	797	146

FU8 basis for the catch options

Variable	Value	Source	Notes
Stock abundance	797 million individuals	ICES (2016a)	UWTV 2015
Mean weight in landings	21.81g	ICES (2016a)	Average 2013–2015
Mean weight in discards	10.74g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch >MCS	13.71g	ICES (2016a)	Average 2013–2015
Mean weight in unwanted catch <MCS	7.25g	ICES (2016a)	Average 2013–2015
Discard rate (total)	24.9%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard rate (>MCS)	13.5%	ICES (2016a)	Average 2013–2015 (proportion by number)

Discard rate (<MCS)	11.4%	ICES (2016a)	Average 2013–2015 (proportion by number)
Discard survival rate	25%	ICES (2016a)	Average 2013–2015 (proportion by number), only applies in scenarios when discarding is allowed.
Dead discard rate (<MCS)	8.8%	ICES (2016a)	Average (proportion by number) 2013–2015, only applies in scenarios when discarding is allowed below MCS.

Table 5. Revised Advice table assuming discarding below MCS only*

Rationale	Basis	Total catch	Dead removals	Landings (wanted catch)	Unwanted >MCS**	Dead discards <MCS	Surviving discards	Harvest rate***
		L+U+DD+SD	L+U+DD	L	U	DD	SD	for L+U+DD
MSY approach	MSY approach	2548	2520	2190	247	83	28	16.3%
Other options	F0.1	1470	1454	1263	143	48	16	9.4%
	F35SpR	1987	1965	1707	193	65	22	12.7%
	F2015	2625	2597	2257	255	85	28	16.8%
	F2013-2015	3205	3170	2755	311	104	35	20.5%

Table 6. Revised Advice table assuming zero discards

Rationale	Basis	Total catches	Wanted catches*	Unwanted catches*	Harvest rate**
MSY approach	MSY approach	2475	2128	347	16.3%
Other options	F0.1	1427	1227	200	9.4%
	F35SpR	1929	1658	271	12.7%
	F2015	2551	2193	358	16.8%
	F2013-2015	3113	2676	437	20.5%

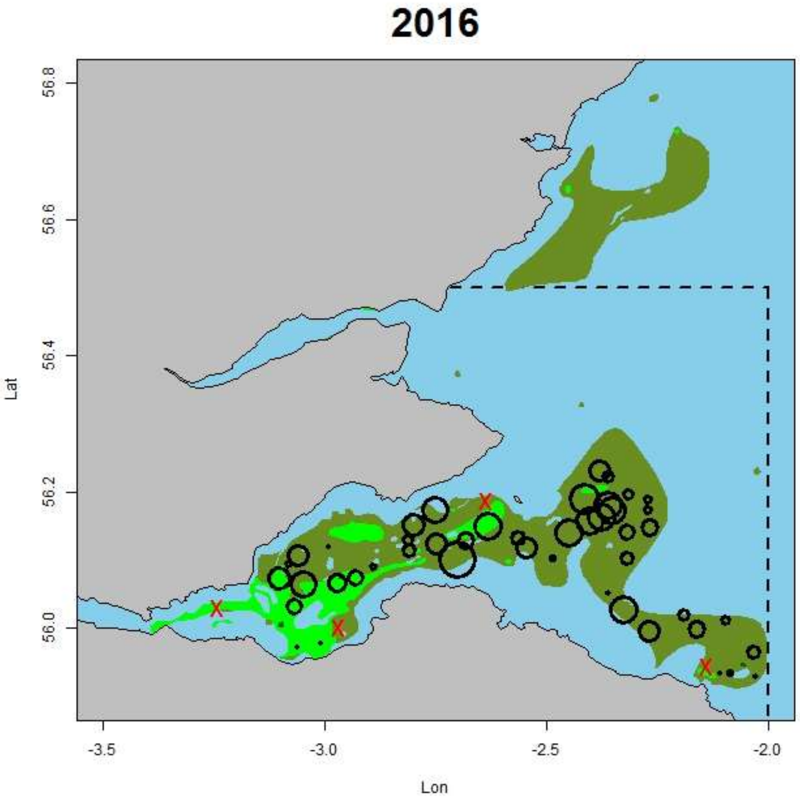


Figure 3. ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density in 2016. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

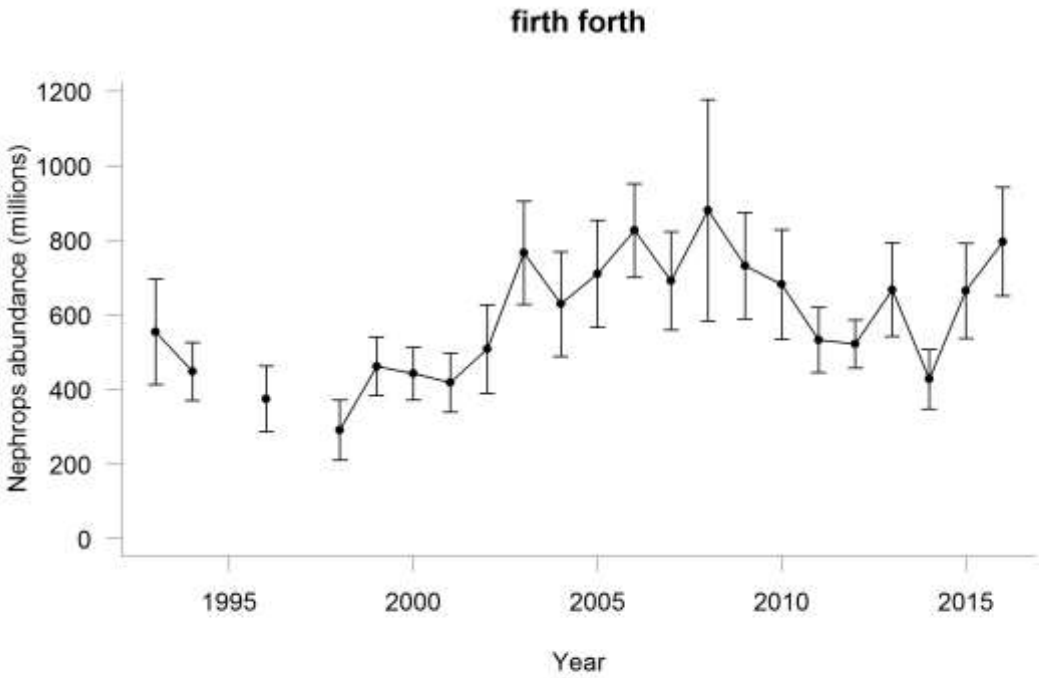


Figure 4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1992-2016 TV surveys.**

Moray Firth (FU9)

The most recent UWTV survey for this stock was carried out in August 2016. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2016 advice and based on the 2015 survey is 347 million with a 95 % CI of 84 million (Table 7; Figure 5 & 6). The estimate from the 2016 summer survey is 388 million (12% increase on the 2015 value). The 2016 value is just within 1 SD of the 2015 abundance estimate and therefore the advice for FU9 should not be reopened.

Table 7. *Nephrops*, Moray Firth (FU 9): Results of the 1993-2015 TV surveys.

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995	no survey			
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84
2016	53	0.18	388	87

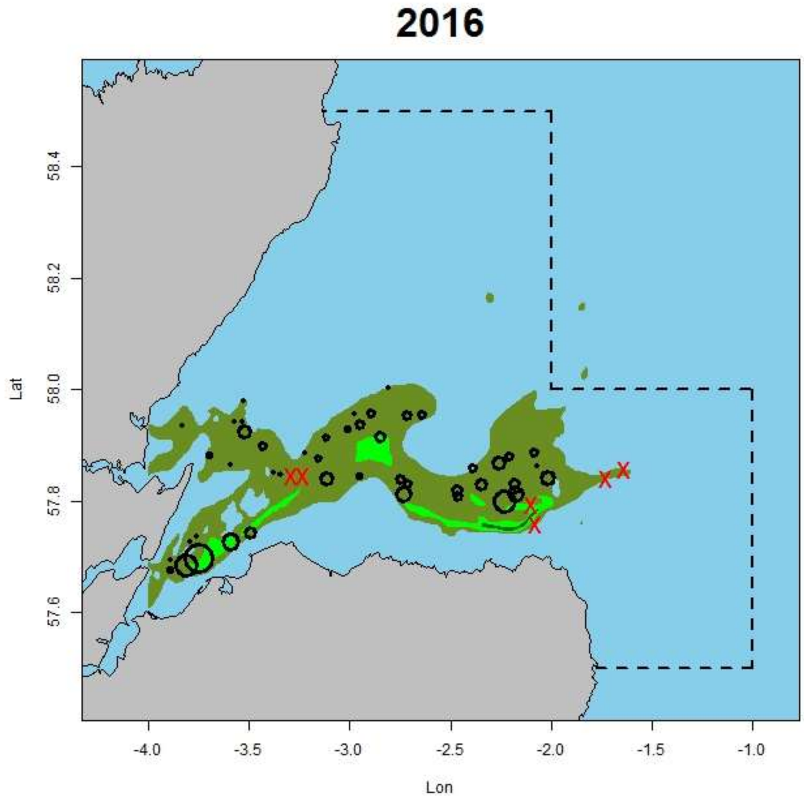


Figure 5. ***Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density in 2016. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

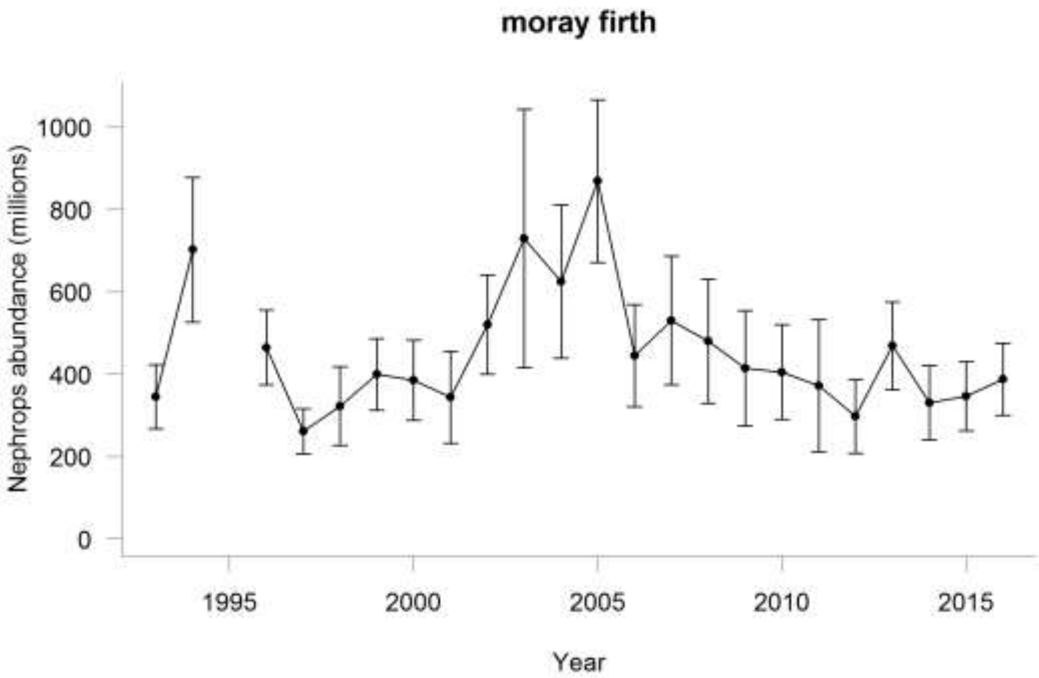


Figure 6. ***Nephrops*, Moray Firth (FU 9): Results of the 1992-2016 TV surveys.**

Annex 05 List of Stock Annexes

The table below provides an overview of the WGBFAS Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock Name	Modified	Link
bll-nsea_SA	Brill in Subarea 4 and divisions 3.a and 7.d–e	07-12-2015 13:46	bll-nsea_SA.docx
cod-347d_SA	Cod in Subarea 4 and divisions 7.d and 3.a West	29-06-2015 16:27	cod-347d_SA.doc
dab-nsea_SA	Dab in Subarea 4 and Division 3.a	04-07-2016 13:59	dab-nsea_SA.docx
fle-nsea_SA	Flounder in Subarea 4 and Division 3.a	29-06-2015 16:29	fle-nsea_SA.docx
gug-347d_SA	Grey gurnard in Subarea 4 and divisions 7.d and 3.a	28-10-2014 13:28	gug-347d_SA.docx
had-346a_SA	Haddock in Subarea 4 and divisions 6.a and 3.a West	28-10-2014 13:26	had-346a_SA.docx
lem-nsea_SA	Lemon sole in Subarea 4 and divisions 3.a and 7.d	29-06-2015 16:30	lem-nsea_SA.docx
mur-347d_SA	Striped red mullet in Subarea 4 and divisions 7.d and 3.a	14-04-2015 14:57	mur-347d_SA.docx
nep-10_SA	Norway lobster in Division 4.a, FU 10	04-11-2014 12:04	nep-10_SA.docx
nep-32_SA	Norway lobster in Division 4.a, FU 32	04-11-2014 12:03	nep-32_SA.docx
nep-33_SA	Norway lobster in Division 4.b, FU 33	05-07-2016 12:11	nep-33_SA.docx
nep-34_SA	Norway lobster in Division 4.b, FU 34	04-11-2014 12:03	nep-34_SA.docx
nep-3-4_SA	Norway lobster in Division 3.a	29-06-2015 16:32	nep-3-4_SA.docx
nep-5_SA	Norway lobster in divisions 4.b and 4.c, FU 5	06-07-2016 09:23	nep-5_SA.docx
nep-6_SA	Norway lobster in Division 4.b, FU 6	04-11-2014 12:02	nep-6_SA.docx
nep-7_SA	Norway lobster in Division 4.a, FU 7	29-06-2015 16:38	nep-7_SA.docx
nep-8_SA	Norway lobster in Division 4.b, FU 8	04-11-2014 12:02	nep-8_SA.docx
nep-9_SA	Norway lobster in Division 4.b, FU 9	04-11-2014 12:01	nep-9_SA.docx
nop-34_SA	Norway pout in Subarea 4 and Division 3.a	04-11-2014 14:26	nop-34_SA.docx
ple-eche_SA	Plaice in Division 7.d	29-06-2015 16:40	ple-eche_SA.docx
ple-kask_SA		04-11-2014 15:03	ple-kask_SA.docx

ple-nsea_SA	Plaice in Subarea 4 (North Sea) and Division 3.a (Skagerrak)	04-11-2014 15:02	ple-nsea_SA.docx
pol-nsea_SA	Pollack in Subarea 4 and Division 3.a	04-11-2014 15:02	pol-nsea_SA.docx
sai-3a46_SA	Saithe in subareas 4–5 and Division 3.a	06-07-2016 15:52	sai-3a46_SA.docx
sol-eche_SA	Sole in Division 7.d	04-11-2014 12:47	sol-eche_SA.docx
sol-nsea_SA	Sole in Subarea 4	14-04-2015 14:58	sol-nsea_SA.docx

Annex 6 Benchmark Planning and Data Problems by Stock

Part A

Benchmarks planning WGNSSK

A.1.1 Latest benchmark results

The ICES Benchmark Workshop on North Sea Stocks (WKNSEA-2016) convened at two meetings in Copenhagen, one data compilation workshop (23–25 November 2015) and the final benchmark meeting (14–18 March 2016).

In WKNSEA-2016, two stocks were benchmarked: Saithe in IV, VI and IIIa, and Dab in IV and IIIa. Furthermore, an inter-benchmark meeting was held by correspondence just prior to WGNSSK-2016 for Whiting in IV and VIId. The most important conclusions for each stock are given below.

Saithe in IV, VI and IIIa (WKNSEA-2016):

A benchmark for North Sea saithe (Subareas 4 and 6, Division 3a) took place in March 2016. The official data call requested landings and discards to be uploaded by métier, quarter, and area into InterCatch; tagging or data that could assist in stock differentiation; maturity and national survey indices not held within DATRAS; national cpue indices; data on natural mortality; and recreational fishery catches by age, year, and quarter.

Landings and discards from commercial fleets

Discards were raised for all fleets that did not submit information. Discards were raised two ways: treating Norwegian fleets as operating like other fleets and treating Norwegian OTB_DEF fleets as operating like French and German OTB_DEF fleets. A bug in InterCatch resulted in the re-raising of data after the WG met in May for four years. To estimate discards weights- and numbers-at-age prior to 2002, a constant ratio landings/discards by age was applied. Discard weights for age 8+ were set to 1.

Ages were allocated using 3 different stratification scenarios: no stratification, by area, and by quarter and area. The 'by quarter and area' stratification was used for the final data set. Discard age allocations were unstratified for most years due to lack of samples; it was only the most recent years which had enough samples to allow for the 'by area and quarter' stratification.

Survey data

The North Sea IBTS Q1 and Q3 and Scottish West Coast Q1 and Q4 surveys were investigated to see if they could be used as a survey index. A delta-GAM approach was initially used to estimate the index for ages 1-10+, but not all ages were included in the assessment model. At the benchmark, the North Sea IBTS Q1 (ages 3-5) and North Sea IBTS Q3 (ages 3-8), estimated using the delta-GAM approach (Berg et al. 2014), were used in the assessment. It was after an external review post-WGNSSK (end of May) that only the NS-IBTS Q3 (ages 3-8), estimated as the standard DATRAS output, was used. The Q1 survey was eliminated due to movement of fish in and out of the survey area, unrelated to abundance. The delta-GAM approach for estimating the indices was also removed because the method uses one age-length key for all years, whereas the survey data were showing year effects existed.

Changes to other input data

The benchmark explored an alternate rate for natural mortality rate of 0.26 based on longevity (Then et al. 2014), but opted to remain with the 0.2 value (noting that this deserved exploration in the near future).

Stock weights, estimated from the NS-IBTS Q1 and Q3 and the Scottish West Coast Q1 and Q4 surveys, were used initially in the benchmark model. These were replaced with catch weights for all ages following the external review post-WGNSSK.

The maturity ogive was revised using all available survey data (NS-IBTS and SWC-IBTS) from the 1st and 4th quarters. After much discussion, it was agreed that the ogive including cohort showed too much variability that was unlikely over such a short time period, even after smoothing was applied within the SAM model. Therefore the newly estimated static ogive was used, with some modification based on expert knowledge within the group. This modification was to use a slightly conservative approach for setting the proportions mature at age 3 and 4 to less than that estimated by the model. This was because of variability in the amount of age 3 and 4 year old fish that migrate into the survey area varies annually and those that are present tend to be the larger (and thus faster maturing) fish.

Combined cpue index

Data for the Norwegian, French, and German commercial trawler fleets were combined into one standardized CPUE index, which is then tuned to the exploitable biomass. A single combined index was estimated to avoid using the same information twice: the information in the catch-at-age matrix and in the three individual cpue fleets in the assessment. There were concerns that using the information twice gave too much weight in the tuning.

Assessment model

A state-space assessment model (SAM; Nielsen and Berg 2014) was used, where the correlation between age groups within years was included in the model, following the method of Berg and Nielsen (2016). The final model includes the standard DATRAS IBTS Q3 index (ages 3-8), a combined cpue index tuned to the exploitable biomass, a new maturity ogive, discard information, and revised catch data for 2002-2015.

References

Berg, CW, Nielsen, A. 2016. Accounting for correlated observations in an age-based state-space stock assessment model. ICES Journal of Marine Science. doi:10.1093/icesjms/fsw046

Berg, C., Nielsen, A., Christensen, K., 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research 151: 91-99.

Nielsen, A. and C.W. Berg. 2014. Estimation of time-varying selectivity in stock assessments using state–space models. Fisheries Research, 158: 96–101.

Then, A., Hoenig, J. M., Hall, N.,G., Hewitt, D.,A., (2014). Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science 72 (1) 82-92.

Dab in IV and IIIa (WKNSEA-2016)

A benchmark assessment for North Sea dab was carried out in spring 2016 (14.03. – 18.03.2016, ICES HQ Copenhagen). The official data call for this benchmark requested landings and discard data from 2002 – 2014. All relevant countries loaded up these data into the InterCatch data portal which was subsequently used to raise discards and to estimate the total catch for dab. Besides landing and discard data also biological sampling data such as age readings and weight at age data were uploaded and were analysed during the benchmark. The suitability of these data to set up an age based assessment for dab were tested. Further, the suitability of different survey data and indices was tested to set up a survey based assessments model (SURBA).

Data on landings, discards and biological sampling from commercial fleets

The amount of imported discard data was lower for the earlier years of the time series and the InterCatch raising procedure introduces some uncertainty. However, in general discard data for the most important fleet, the Dutch TBB_DEF_70-99_0_0_all metier, was provided and most of the amount of discard estimates was therefore based on imported data. Thus, it was possible to create a time series on total catch for the years 2002 to 2014. The discard ratio increased from 76% in 2002 up to 91% for the last year of this time series. Some countries provided also catch at age (numbers) and weight at age data based on samples from commercial fleets. The age distribution pattern seems to be odd for the years 2002 – 2005 and 2008 – 2010 with age group 5 always showing higher numbers compared to younger age groups. The estimated results of weight at age from the commercial samplings are also poor for the years 2002 – 2005. This can probably be explained by the comparatively low sample sizes for these years. Therefore, the use of these data as input for any age based assessment model is questionable.

The use of survey data and application of SURBA

Probably the most suitable survey for dab is the International Beam Trawl Survey (BTS) targeting especially flat fish species in the North Sea. The problem with this survey is that it is not fully standardized and not all data are currently available via the DATRAS data portal. Furthermore, the geographical coverage is more limited compared to the International Bottom Trawl Survey (IBTS). However, the IBTS never collected any biological parameters of dab in a consistent way or covering the whole distribution range of dab. Age-length keys were available for the two Dutch BTS and the German BTS. Different options were tested to make use of age based indices in a survey based assessment model (SURBA). During the benchmark it was then agreed to use a combined beam trawl survey index for further SURBA runs which was estimated by applying the delta GAM method of Berg et al. (2014). Other index options were also tested (e.g. using BTS indices separately), but the delta GAM index showed the best internal consistency among age classes. The final SURBAR model run resulted in an overall decreasing total mortality. The spawning stock biomass and the recruitment showed increasing trends, especially from 2009 onwards. These trends could be explained by a decrease in fishing effort. Still the CPUE for the commercial fleets, but also for the surveys, increased in recent years.

Exploratory SAM model

An exploratory assessment was done using the SAM model which is a state-space assessment model which takes the uncertainty of the assessment inputs and outputs into account. As input data for this model, the total catch weight, catch numbers at age and catch weight at age from commercial sampling data was used. Further, stock weight at age from survey data and the combined beam trawl survey index was used. The SAM model produced similar results as the SURBA model: decreasing F, increasing stock biomass and recruitment. This is due to the fact that the SAM model puts most weight on the survey data which are the same data as used for the SURBA model. Given the unrealistic age distribution of the catch samples the fishing mortality pattern for age 5 was not realistic.

Length based mortality estimator

The fishing mortality for dab was alternatively estimated by applying a modification of the original Gedamke-Hoenig mean length-based total mortality estimator (Gedamke and Hoenig, 2006) were total mortality Z is replaced by q*effort + M following Then et al. (2014). Furthermore, instead of assuming constant recruitment of cohorts, a recruitment index was taken into account as proposed by a method by Gedamke et al. (2008). For this purpose a time series of effort (STECF and InterCatch data) and a recruitment index based on survey data was used. The results of the length based mortality estimator confirmed the trends in dab population dynamics which were obtained by using the SURBA model.

Conclusion

It was agreed to keep dab a category 3.2. species according to the data limited stocks guidelines (ICES, 2012) and to use the SURBA model as future basis of advice. As input for the SURBA Dutch and German beam trawl survey data were used. A combined age based index was estimated taking into account a ship effect by applying the method by Berg et al. (2014). The weight at age data were only taken from Dutch surveys because no weight at age data were available from the German survey for most of the years. A maturity ogive was estimated by using available survey data. All data used are available in the DATRAS data base.

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Whiting in IV and VIId (IBPWhiting-2016)

The Inter-Benchmark workshop for North Sea Whiting (IBPWhiting), chaired by Alexander Kempf, Germany for ICES and Larry Alade, USA (External Chair) met by correspondence from February to March 2016.

During the workshop it has been tested whether updated natural mortality estimates available from the ICES multi species working group (WGSAM) have a larger impact on the assessment of North Sea whiting. In addition, reference points have been reviewed in the light of new assessment results and the up-to-date ACOM guidelines have been applied to estimate potential new reference points. The precautionarity of the management strategy (fixed F=0.15 and 15% TAC constraint) currently used as basis for advice has been tested using the same methodology (MSE simulation) as applied in 2013. The main conclusions from this work were:

1) The new M values do not lead to an increased impact on the XSA diagnostics, but recruitment and SSB are scaled downwards because of lower M values for ages 1 and 2.

2) Stock dynamics are driven principally by recruitment and natural mortality. F_{MSY} does not seem to be meaningful for this stock as long as B_{loss} is seen as reference point for B_{lim} and F_{p05} has had to be used as reference point according to the ACOM guidelines. This means the management target is to avoid SSB falling below $B_{lim}=B_{loss}$ instead of maximizing yield. Even at low fishing mortalities, there is a significant probability to fall below $B_{lim}=B_{loss}$ given the current low recruitment and high natural mortalities.

3) The currently used management strategy (target F of 0.15 and 15% TAC constraint) is not precautionary (defined as <5% risk to fall below B_{lim}) according to the MSE results. Even at a target fishing mortality of 0.1, there is a more than 5% probability to fall below $B_{lim}=B_{loss}$ in the short and in the medium term if low to medium recruitment is assumed. As expected, this probability increases under the assumption of low recruitment only. The current management strategy has no $B_{trigger}$ value and therefore does not allow for reduced fishing mortalities to safeguard the stock. The 15% TAC constraint may further preclude fast reactions to decreasing stock abundances. The reduced flexibility for downward adjustments of TAC is problematic. In contrast, the reduced flexibility for upward adjustments is not problematic from a conservation point of view.

4) Eqsim gives slightly more optimistic results (F_{p05} = 0.12) under current recruitment levels and no $B_{trigger}$ (fixed F exploitation independent of SBB) compared to the MSE simulations. This is caused by differences in how the recruitment is modelled. In addition, in Eqsim an assumed advice error is given as input while the MSE simulates error in the assessment and short-term forecast.

5) Overall, it seems to be impossible to derive an F reference point that is precautionary under all circumstances when setting $B_{lim}=B_{loss}$. Therefore, it may be best in the short term to use the standard ICES MSY advice rule (linear reduction of F below $B_{trigger}$!) and the associated F_{p05} of 0.15 estimated based on ACOM guidelines with Eqsim under the assumption of currently observed recruitment levels. An additional check of whether the stock is predicted in the short-term forecast to fall below B_{lim} is needed. If the stock is predicted to fall below B_{lim}, the F may be reduced further. However, whiting is fished in a mixed fishery and is considered to be a bycatch to some extent

in most North Sea demersal fisheries. There is a likely trade-off between a choke effect under the landing obligation and the target to keep the stock above B_{lim}=B_{loss} if recruitment stays at the current low level. In the longer term, the results from the inter-benchmark and the high natural mortalities estimated for this stock raise the question whether alternative management strategies (e.g. escapement strategy) are needed, and whether the currently used B_{lim}=B_{loss} (according to ACOM guidelines) is realistic. In the event that environmental factors drive the stock below B_{loss} despite low fishing mortalities in the near future, alternative reference points need to be explored (e.g. B_{pa}=B_{loss} and B_{lim}=B_{pa}/1.4). A full benchmark is needed in the next two years to improve the assessment but also to evaluate any proposed alternative management strategies.

A.1.2 Planning future benchmarks

Planning table [used for preparing the ACOM proposal of upcoming benchmarks]

Stock	Assessment status	Latest benchmark	Benchmark this year / next year	Planning Year +2	Further planning	Comments
cod-347d	Accepted SAM model	WKNSEA 2015	No	No		Stock definition issues and area based assessments
had-34	Accepted TSA model but continued exploratory assessments with SAM and SURBAR	WKHAD 2014	IBP 2016	No		May need an interbenchmark to check whether benchmark decisions are still appropiate and rules are needed to split TAC between IV, VIa and IIIa
nep-34	OK	NA	No	No		
nep-5	Data-limited.	NA	No	No		TV surveys under developement
nep-6	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	no	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-7	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-8	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-9	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-10	Data limited		No	No		

Stock	Assessment status	Latest benchmark	Benchmark this year / next year	Planning Year +2	Further planning	Comments
nep-32	Data limited	2013	2016	No		Exploration of all available data, incl new Norw electronic logbooks
nep-33	Data limited	No benchmark ever on this stock, mainly due to lack of data	no	No		More data should be made available for this stock before a new benchmark
nep-IIIa	OK	No benchmark ever on this stock, 2009 WKNEPH - only benchmarked the UWTV survey process.	2016	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-34	Data limited		no	no		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nop-34	OK	2012	2016	No		Assessment method, Reference levels in ecosystem / multi-species context, commercial fishyer tuning time series, average recruitment used in forecast for forecast year.
ple-eche	ok	WKPLE 2015	No	No		Stock definition and mixing with North Sea stock still unclear

Stock	Assessment status	Latest benchmark	Benchmark this year / next year	Planning Year +2	Further planning	Comments
ple-nsea	OK	2009, Inter-benchmark procedure in 2013	2017	No	-	Changes in catchability for indices of young ages (1–3) may need to be addressed again in a future benchmark. Potential removal of the SNS index now that the two BTS indices (Isis and Tridens) have been combined. Possible inclusion of the IBTS survey.
sai-3a46	Accepted FLXSA assessment but exploratory assessments with SAM.	WKNSEA 2016	no	no		stock identity, discards data, revised CPUE indices, investigation of research surveys (whether they are adequate for use as tuning indices), investigate the lack of 3-year olds in the Q3 survey (fish not appearing until age 4). Test alternative models
sol-eche	OK	2009	2017	no		Evaluating available Tuning series and alternative models
sol-nsea	OK	WKNSEA 2015	no	no		Inclusion of Belgium BTS and new CPUE time series when available.

Stock	Assessment status	Latest benchmark	Benchmark this year / next year	Planning Year +2	Further planning	Comments
tur-nsea	In development	IBP 2015	no	no	.	Still hihgly uncertain assessment. More data and better survey information needed
whg-47d	Update deviating from benchmark	2009, 2013 IBP 2016	no	2018		Change in catchability of young fish in IBTS surveys – requires application of different but extant method. New natural mortalites tested in IBP2016
whg-kask	Data limited stock	No	IBP 2016/17	No		Aim to move from Cat 5 to Cat 3 stock by developing biomass index, review historical catch data and run SPiCT-model
Pol-nsea	Data limited stock	no	no	no		
mur-347d	quantitative advice for data-limited stocks	WKNSEA 2015	no	no		Length based assessment methods should be further investigated
bll-nsea	Data-limited	No/WGNEW	no	no		
dab-nsea	Data-limited	WKNSEA 2016	no	no		Test analytical assessment methods
Fle-nsea	Data-limited	No/WGNEW	no	2018		Collate length and age based data, test analytical assessment methods.
Lem-nsea	Data-limited	No/WGNEW	no	2018		Collate length and age based data, test analytical assessment methods.

Stock	Assessment status	Latest benchmark	Benchmark this year / next year	Planning Year +2	Further planning	Comments
Wit-nsea	Data-limited	No/WGNEW	no	2018		Test analytical assessment methods
Tur-kask	Data-limited	No/WGNEW	No	no	2019	IBP may be needed to check current stock definition
GUR	Data-limited	No/WGNEW	No	no		

A.1.3 Issue lists, workplans and progress reports for stocks with upcoming benchmarks

Benchmarks 2016

Apart from the benchmarks for Norway Pout and Nephrops in IIIa and 32, detailed below, interbenchmarks are planned for Northern Shelf haddock in the summer of 2016 to deal with the retrospective pattern problem that caused a delay in the assessment and advice for this stock, and for whiting in 3.a prior to WGNSSK in 2017 to attempt to upgrade the assessment to a category 3 stock.

Norway pout

Terms of Reference were issued by ACOM, as follows:

2015/2/ACOM36 A **Benchmark Workshop on Norway Pout** (WKPout), chaired by External Chair XX, xx and ICES Chair José De Oliveira, UK, and attended by two invited external experts Jerry Ault, USA, Verena Trenkel, France and Daniel Hennen, USA will be established 18–19 May 2016 for a data evaluation meeting at ICES Headquarters and in tbc., 22–26 August 2016 for a Benchmark meeting, to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:
   - i) Stock identity and migration issues;
   - ii) Life-history data;
   - iii) Fishery-dependent and fishery-independent data;
   - iv) Further inclusion of environmental drivers, multi-species information, and ecosystem impacts for stock dynamics in the assessments and outlook

b) Agree and document the preferred method for evaluating stock status and (where applicable) short term forecast and update the stock annex as appropriate. Knowledge about environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology

If no analytical assessment method can be agreed, then an alternative method (the former method, or following the ICES approach for stocks without analytical assessments) should be put forward;

c) Re-examine and update, if necessary, MSY and PA reference points according to ICES guidelines (see reports of WKMSYREF 2-4 and the Technical document on reference points);

d) Bearing in mind that the catch advice for Norway pout is for the period November 1 of the assessment year to October 31 of the following year, evaluate the settings of the escapement strategy used in the ICES MSY approach and the value of $F_{cap.}$

e) Develop recommendations for future improving of the assessment methodology and data collection;

f) As part of the evaluation:
   - i) Conduct a 3 day data evaluation workshop. Stakeholders are invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of

the data evaluation workshop consider the quality of data including discard and estimates of misreporting of landings;

ii) Following the data evaluation correspondence work, produce working documents to be reviewed during the Benchmark meeting; these documents should be available at least 7 days prior to the meeting

Stocks	Stock leader
Nop-34	J. Rasmus Nielsen

The Benchmark Workshop will report by 15 September 2016 for the attention of ACOM.

Proposed working papers/analyses

1) Seasonal SAM assessment development, including 3-5-year back comparison with SXSA, and sensitivity analysis [led by Rasmus Nielsen]

2) Forecast methodology, and MSY and PA reference points, including implications of sensitivity analysis and ecosystem considerations [led by Rasmus Nielsen]

3) Norwegian fishery description and CPUE analysis [led by Espen Johnsen]

4) Danish fishery description and CPUE analysis [led by Rasmus Nielsen]

5) Existing supporting documents on historic catches (Industrial fisheries Expert Group, EU-Norway negotiations) [co-ordinated by Rasmus Nielsen]

6) Age-reading data comparisons [co-ordinated by Rasmus Nielsen]

7) Norwegian Shrimp survey estimates east of Norwegian trench (comparing perceptions with IBTS surveys), as supplementary information only (not as a tuning series) [led by Espen Johnsen]

Workplan (recommendations from DCWKPOUT)

- Keep current data sets (current catch, current historic CPUE and current IBTS Q1, Q3 and UK-Q3-EGFS and UK-Q3-SGFS) and develop SAM assessment
    - Check whether discards can be included or not (include if yes)
    - Keep SXSA assessment as an alternative assessment for comparison at the benchmark
- Develop forecast methodology
- Develop MSY and PA reference points (including ecosystem considerations)
- Conduct sensitivity analyses:
    - Remove historic commercial CPUE from the assessment
- Compile time series of effort and compare to changes in F
    - Norwegian and Danish data available

Stock	Nop-34	
Benchmark	Year: 2016	
Stock coordinator	Name: J. Rasmus Nielsen	Email: rn@aqua.dtu.dk
Stock assessor	Name: J. Rasmus Nielsen	Email: rn@aqua.dtu.dk
Data contact	Name: J. Rasmus Nielsen, Espen Jonssen	Email: rn@aqua.dtu.dk

Nephrops in IIIa

Data needed

Genetic information

- VMS information
- Sediment type maps
- Landings data
- Discard data
- Growth data
- Size and sex distribution
- Maturity information
- Length-weight data
- UWTV survey data

Current assessment issues

- Redefine *Nephrops*' spatial distribution in IIIa and update population estimates retrospectively based on the new area estimate.
- Create UWTV survey reference footage
- Update Length Cohort Analysis (LCA)

Proposed working papers/analyses

- The current spatial distribution of *Nephrops* grounds is based on Danish and Swedish VMS data from 2008–2010. The boarders to the grounds have been arbitrarily defined using two different methods. The most recent VMS data (2013–2015) together with Swedish logbook data from creel and < 12 m vessels and sediment maps will be combined to establish a new distribution of *Nephrops* suitable habitats. The new area estimates will be used to update the *Nephrops* stock population time series.
- Following the same protocol for other FU's where UWTV surveys exist, reference footage will be compiled, comprising footage of poor, average and high quality as well as different burrow densities (low, medium and high density). A manual will complement the footage, describing how to use the footage.
- The current LCA is based on length frequency data from 2008–2010 and assumes a discard survival of 25%. Under a landing obligation, survivability will be zero as all individuals are to be landed. Therefore, the LCA needs to be updated with new data as well as different survival rates (0, 25 and 50%). There are also discussions around lowering the MLS (MCRS) for *Nephrops* in the Skagerrak and Kattegat from 40 mm carapace length to 30 mm. This would change the discard pattern in the fisheries and would also require an update to the LCA. Therefore, the sensitivity of the LCA to different MLSs will be assessed.

Workplan

- Redefine spatial distribution. (Jordan - November/December 2015 - WGNEPS)

- Create UWTV survey reference footage (Mats – November/December 2015 - WGNEPS)
- Update Length Cohort Analysis (LCA) (Helen Dobby/Mats – February 2016)
-

STOCK	NEP IIIA	
Stock coordinator	Name: Mats Ulmestrand	Email: mats.ulmestrand
Stock assessor	Name: Jordan P. Feekings	Email: jpfe@dtu.aqua.dk
Data contact	Name:	Email:

ISSUE	PROBLEM/AIM	WORK NEEDED / POSSIBLE DIRECTION OF SOLUTION	DATA NEEDED TO BE ABLE TO DO THIS: ARE THESE AVAILABLE / WHERE SHOULD THESE COME FROM?	EXTERNAL EXPERTISE NEEDED AT BENCHMARK TYPE OF EXPERTISE / PROPOSED NAMES
(New) data to be considered and/or quantified1	Redefine area of all subareas using up to date information.	Compile available data sources from all available years.	DK & SW VMS data, SW logbook data from < 12 m vessels and creel vessels, sediment maps etc. Data are available.	
	Create UWTV reference footage.	Review selection of UWTV footage and establish consensus counts	UWTV survey footage. Data are available	
Tuning series	Standardize Swedish lpue.		Logbook data are available.	
Discards	Effects of changing the MLS Effects of a landing obligation	Bio-economic analysis of changing the MLS for Nephrops.	VMS, landings, discards, stock estimates, price data, biological data (e.g. size and sex distribution, female and male maturity).	

[1] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Parameters	Growth parameter update Length-weight update			
Assessment method	The UWTV survey method is not possible for creel areas. Possible inclusion of a length based assessment model to compliment the UWTV survey.	Develop and finalize a length based model for Nephrops.	Catch data. Data are available for trawled and creeled areas.	Anders Nielsen, DTU Aqua
Biological Reference Points		Model work should provide these reference points.	Proxies for Fmsy exist from LCA. Btrigger estimate requires a longer UWTV time series.	

Nephrops 32

Data needed

- Danish data from at-sea-observers (discard, lfd, sex ratio)
- Norwegian shrimp survey data
- Norwegian electronic log book data
- Norwegian data from recreational *Nephrops* fishery
- Norwegian Coast Guard data from vessel inspections

Current assessment issues

Danish data

- Investigate possibilities for obtaining biological data (maturity, weight, length) from the Danish at-sea-observer program
- Analyze discard data (strange values in recent years), document old and new sampling procedures, agree on standard sampling procedure

Norwegian data

- Explore possibilities for obtaining a *Nephrops* biomass index from the survey data
- Analyze biological data from recent studies on recreational fishery along Norwegian coast (sex ratio, length)
- Analyze so far unused total length data (TL) from Coast Guard inspections
- Investigate possibilities for obtaining discard data from Coast Guard inspections
- Explore the area calculations used for estimating harvest rates. Is the current estimated area too large?
- Explore electronic logbook data from 2011 onwards and establish new LPUE time series from respectively shrimp and *Nephrops* trawls.

Proposed working papers/analyses

Working paper 1: Danish at-sea-observer program: documentation of procedures and possibilities for obtaining biological data.

Working paper 2: New biomass index time series from Norwegian electronic logbook data.

Working paper 3: A new biomass index from the Norwegian annual shrimp survey in the Norwegian Deep?

Working paper 4: Exploration of Norwegian Coast Guard inspections data: discard and length frequency distributions.

Working paper 5: Biological data from recent studies of the Norwegian recreational fishery – does the coastal *Nephrops* differ from animals on offshore fishing grounds?

Workplan

Most of the work will be done autumn 2015, before the data workshop. Jordan Feekings will work on the Danish discard data and participate in discussions on the area estimates. Guldborg Søvik will analyze the Norwegian data, with the aid of colleagues at IMR.

Stock	Nephrops in FU 32	
Stock coordinator	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no
Stock assessor	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no
Data contact	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
New data to be considered	Current stock definition is based on spatial distribution. The level of larval exchange with Skagerrak is unknown.	Work is ongoing at IMR on collecting/analysing new genetic data from Kattegat, Skagerrak and the Norwegian Deep, as part of a Scandinavian Interreg project	New information will be available by end of 2014/beginning of 2015	Relevant Nephrops experts. The benchmark should be arranged together with the planned benchmark for FU 3 and 4
New analyses to be considered	At WKNEPH 2013 it was suggested that the Nephrops data in the Norwegian annual shrimp survey should be analysed in order to determine if they can be used to provide a fishery independent biomass index	Analyse annual Nephrops catches from shrimp survey	Nephrops data from Norwegian shrimp survey exist back to 1997	Time series experts
Biological Parameters	No biological data exist for this stock	Collection of biological data from stock component along the Norwegian coast	Collection of data from the Norwegian recreational fishery was initiated in 2012. It is expected that by 2016 data on sex ratio, length frequency distribution and life cycle will be available	relevant Nephrops experts

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Parameters	No biological data exist for this stock	Collection of biological data from stock component along the western part of the Norwegian Deep	Investigate possibilities for obtaining biological data from the Danish at-sea-sampling-programme	relevant Nephrops experts
Fishery patterns	How much does spatial and temporal variation in the fishery influence stock biomass indices (LPUE)?	The Danish fishery (1990s until present) has gone through large changes. Spatial and temporal patterns in the fishery need to be explored.	Annual Danish VMS data exist	relevant Nephrops experts

Benchmarks 2017

Plaice in IV and IIIaN

Data needed

Natural mortality data

Maturity data

Landings and discards data per fleet

Tuning series of plaice from IBTS, SNS, BTS-Tridens, and BTS-ISIS

Current assessment and forecast issues

XSA

Proposed working papers/analyses

TBA

Workplan

TBA

Stock	Plaice–North Sea Skagerrak	
Stock coordinator	Name: Chun Chen/Jan Jaap Poos/Ruben Verkempynck	Email: chun.chen@wur.nl/janjaap.poos@wur.nl
Stock assessor	Name: Chun Chen	Email: chun.chen@wur.nl
Data contact	Name: Chun Chen/Ruben Verkempynck	Email: chun.chen@wur.nl/ruben.verkempynck@wur.nl

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified	Additional M - predator relations	Review of basis for natural mortality		
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Tuning series	Exclusion of SNS or combine SNS with BTS	Make a combined index SNS/BTS and explore assessments with or without SNS and combined index	SNS, BTS indices	Chun Chen
Tuning series	Inclusion of IBTS as tuning fleet	IBTS index	IBTS index	Clara Ulrich, Chun Chen, Casper Berg
Discards				
Biological Parameters	Natural mortality Maturity	Review of basis for natural mortality. Literature review, model estimates of M Review of basis for maturity. Literature review, model estimates of maturity		Chun Chen, Jan Jaap Poos, Ruben Verkempynck
Assessment method	Explore other models (SCAA, SAM, Aarts and Poos).			Chun Chen, Jan Jaap Poos, Ruben Verkempynck
Biological Reference Points	Revision Fmsy and MSYBtrigger after inclusion of Skagerrak			Chun Chen, Jan Jaap Poos, Ruben Verkempynck
Management plan	Revision of the North Sea management plan after adding SK AND Implementation of stage 2 of the MP			Chun Chen, Jan Jaap Poos, Ruben Verkempynck

Sole in VIId

Data needed

- Discard time series from BEL, FRA and UK
- Belgian discard data at quarterly scale
- Alternative fishery-independent recruitment data
- National commercial CPUE indices
- Maturity at age/length data not already included in DATRAS
- Any tagging data/information or genetic analysis

Current assessment issues

See Table below.

Proposed working papers/analyses

Working paper on maturity (Lies Vansteenbrugge, Bart Vanelslander, Sofie Nimmegeers)

Workplan

- Discard time series (at quarterly scale) ready for the Data Evaluation Workshop
- Alternative fishery-independent recruitment data and national commercial CPUE indices ready for the Data Evaluation Workshop
- Alternative maturity ogive and corresponding working paper ready by the actual benchmark
- Comparative runs using different assessment models (XSA, AAP and SAM) at the benchmark
- Simulation model runs to calculate reference points (especially Blim and Fbar) at the benchmark
-

Other working groups to be involved

Not applicable

STOCK	SOL-ECHE	
Stock coordinator	Name: Lies Vansteenbrugge	Email: lies.vansteenbrugge@ilvo.vlaanderen.be
Stock assessor	Name: Lies Vansteenbrugge and Bart Vanelslander	Email: lies.vansteenbrugge@ilvo.vlaanderen.be bart.vanelslander@ilvo.vlaanderen.be
Data contact	Name: Bart Vanelslander	Email: bart.vanelslander@ilvo.vlaanderen.be

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified2	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	As the UK Young Fish Survey (YFS) stopped in 2006, the French YFS and the UK(E&W)-BTS-Q3 are the two remaining fishery-independent sources of information on age 1. There is however doubt around to what extent the BTS, that fishes with a mesh size of 40 mm in the codend, catches 1 year old sole in a quantitative way (BTS tuning series used in other assessments often start at age 2). Furthermore , the French YFS is probably not providing the correct recruitment estimates as it only covers part of VIId (potential impact on forecast).	Analysis : test runs with UK(E&W)-BTS-Q3 for ages 2 and older only. New data : Long-term : UK to consider picking up the YFS in VIId again, or FRA to consider extending the French YFS into UK waters. Short-term : FRA/UK to check for other data sources that could inform WKNSEA 2017 on the strength of incoming year classes (especially ages 1–2), so it can be evaluated to what extent	Data are delivered annually by CEFAS. If the UK-YFS is reinstated, this will not lead to a time series that will already be useful at the time of WKNSEA 2017. FRA and UK	Potentially people from FRA and/or UK to present new data. No specific extra expertise needed for analysis of these data.

[2] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
		these data correspond to the views presented by the French YFS.		
Discards	Discards are not included in the assessment.	BEL, FRA and UK to compose time series of raised discard data (as long as possible).	Data available from Belgian, French and English discard sampling programmes.	No specific expertise needed from countries delivering the discard time series.
	FRA and UK upload quarterly discard data for all sampled métiers to Intercatch, whereas Belgium only uploads annual estimates. As Belgium only samples the métier TBB_DEF_70-99, a métier with a high share in the total effort/landings of sol-eche and that is generally characterised by high discard rates and discard patterns that can be very different compared to the other métiers that are predominant in the FRA and UK sampling programmes, it would be desirable to also obtain quarterly discard estimates from Belgium for this metier.	Belgium to compute quarterly discard estimates for sol-eche (TBB_DEF_70-99) based on the available data (some countries have a comparable sampling level, but deliver quarterly data with a low qualitative self-evaluation, where Belgium chooses to only compute annual estimates with a higher self-evaluation)	Data available in Belgium (ILVO), but need to be processed differently and delivered so the impact on the assessment can be evaluated. Not relevant to WKNSEA 2017.	ILVO (Lies Vansteenbrugge, Bart Vanelslander, Sofie Nimmegeers)
Biological Parameters	A knife-edged maturity ogive, with full maturation from age 3 onwards is used in the assessment. No new data have been explored for a long time.	Investigate all available trawl survey maturity data to come up with a maturity ogive that is supported by recent data.	Data available in DATRAS.	ILVO (Lies Vansteenbrugge, Bart Vanelslander, Sofie Nimmegeers)

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	The current XSA behaves well, but when discard time series get included as input data, other models need to be tested: AAP, potentially SAM.	Carry out comparative runs using different models.	/	Experts in running AAP, SAM. This expertise is currently not available at ILVO-Belgium.
Biological Reference Points	Revision of reference points. Preliminary analyses during WGNSSK 2014 already suggested that a revision of Fmsy could be considered. No Blim is identified and Fbar is calculated on other ages than Fmsy is.	Computation of potential new reference points.	Data available from assessment.	Experts in computation of reference points. This expertise is currently not available at ILVO-Belgium.

Proposed Benchmarks 2018

Whiting in 4 and 7.d

Data needed

- Catch (landings, discards, IBC) data back to 2002 (BEL, DNK, FR, GER, NDL, NOR, SWE, UK ENG, UK SCO).
- Biological data available from commercial sampling and IBTS surveys (including (maturity, length distributions, age distributions, individual weights, sex ratios)
- IBTS survey data

Current assessment and forecast

Currently, assessment is done using a FLXSA, assuming catches to be exact. And for comparison a SURBAR analysis is run. The IBTS survey indices quarter 1 and 3 are used in the analysis. Advice is given on ICES area Subdivision IV and Division VIId combined. The advice per area is then split between areas based on the landings ratios. The TAC is given for Subdivision IV separately, and for Division VIId in combination with VIIb-k.

Proposed analysis

A more detailed stock structure has been proposed dividing a northern North Sea stock from a southern North Sea stock (Holmes *et al* 2014, SGSIMUW 2005). It needs to be determined whether differences in biological characteristics, such as growth maturity, exist between suggested new substocks. Also, for the analysis it would be necessary to determine whether available historical landings and discard data is sufficient for a subdivision into new assessment areas.

Maturity values at age used in the XSA originate from analysis from the 1980ies. A check is suggested whether an update of the used values is necessary, also with regard to new stock units. National catch sampling and survey data may give those information.

Generally, an update of the assessment model is suggested. Available models include SAM or TSA. This would address issues with variability in catches, and catchability changes.

Within the framework of a benchmark the choice of input data into a short term forecast can be addressed (individual weights at age, recruitment estimates, fishing mortality at age estimates).

Holmes, S.J., Millar, C.P., Fryer, R.J., Wright, P.J., 2014. Gadoid dynamics: differing perceptions when contrasting stock vs. population trends and its implications to management. ICES J Mar Sci. 71: 1433-1442.

ICES, 2005. Report of the study group on stock identity and management units of whiting (SGSIMUW), 15 -17 March 2005, Aberdeen, UK. ICES CM 2005/G:03: 50pp.

Workplan

Compilation of Intercatch data for recent years of Landings, Discards and IBC

Compilation of IBTS survey data including biological information

Checking whether data with resolution based on stock structure is available

Exploratory assessment runs

(WG to be involved: IBTS WG, WGBIOP)

Stock	Whg47d	
Stock coordinator	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk
Stock assessor	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk
Data contact	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified3	Additional M - predator relations			
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			
Tuning series				
Discards				
Biological Parameters	Maturity (differences for areas, stock units)	Compile available data on maturity	IBTS Survey data (DATRAS), commercial sampling data	Coby Needle, Peter Wright (Scotland)
	Growth (differences for areas, stock units)	Compile available data on growth (length at age) from surveys	IBTS Survey data, commercial sampling data	Coby Needle, Peter Wright (Scotland)
Assessment method	XSA treats catch data as exact	Develop and test new assessment model (e.g. SAM, TSA)	Catch data, survey data	Anders Nielsen (DTUAqua) Rob Fryer (Scotland)
	Stock structure	Compile available data on catches by area or stock units	Catch data (landings, discards, IBC)	Liz Clarke (Scotland)

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Reference Points				
Short term forecast update	Check choice of input data to STF		Catch data(landings, discards, ibc), survey outputs	

Witch in IIIa, IV and VIId

Witch flounder (*Glyptocephalus cynoglossus*) in Subarea IV, Division IIIa and VIId is one of the stocks that were classified as category 3 stocks following the guidelines of the ICES Data Limited during WGNEW 2013.

In 2009 witch flounder has been included as a mandatory species in the EU Data Collection Framework (DCF). Accordingly, Denmark and Sweden started the regular sampling of biological data, i.e. length, weight, maturity status and age, in IIIa and IV both in discards and landings. Scotland has also been collecting biological samples since 2009 but only from the landings.

Abundance indices for witch flounder show a declining trend since the peak observed in 2000, followed by an increase in the most recent years both in landings and survey data. For this stock an exploratory Extended Survivors **Analysis (**XSA) was performed in 2013 which indicate that fishing mortality is above potential FMSY proxies (ICES WGNEW, 2013).

The model used in 2013 could be improved during the benchmark, given the inclusion of additional years and the availability of discards data allowing the use of catch data instead of only landings.

Tuning indices

In the XSA run in 2013 data, from IBTS Q1 were used as tuning index. During the benchmark those survey data will be updated and investigated by area, in order to check whether one of the areas, namely IIIa showing a larger number of fish caught per hour, is mostly driving the observed pattern. Concerning IBTS data Q3, data were not used in the previous assessment attempt, given the shorter time series. However, the abundance trend observed in Q3 did not reflect the one in Q1 possibly due to different spatial distribution of this species during the two periods. Given the scarce knowledge about the biological demographic dynamics of this stock it is not possible to define with certainty whether the observed difference is due to differential biological (feeding and reproductive) phases.

It was noticed that there is some difference in the coverage between the two surveys thus some statistical rectangles are not covered in one of the quarters. The next step is thus to consider a standardized area to ensure that the observed trends are mirroring the abundance of the same statistical rectangles and thus the detected difference is not due to a diverse coverage. The possibility of using Beam Trawl Survey (BTS) data in the same standardized area will also be investigated.

Assessment models to be investigated

The possibility of using a production model was discussed but the availability of discards data only from 2002 makes the use of this kind of model inappropriate, as a longer time series of catches is needed. Discards data will be used for the first time, mainly based on Swedish and Danish data, for running an updated XSA using catch data instead of only landings and an additional year. An a4a (Assessment for All Initiative) together with an SS3 will be also tested.

Working documents

Three working papers will be prepared:

1) Description of landings and discards raising procedure

2) Exploration of survey data to be used as tuning index

3) Assessment models trials

Stock	Witch IIIa, IV and VIId	
Stock coordinator	Name: Francesca Vitale	Email: francesca.vitale@slu.se
Stock assessor	Name: Max Cardinale	Email: massimiliano.cardinale@slu.se
Data contact	Name: Francesca Vitale	Email: francesca.vitale@slu.se

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified4	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	IBTS Q1 and Q3, BTS Q1 and Q3	The series are available and need just to be updated	DATRAS	None
Discards	Partially available on Intercatch only for Sweden, Netherland and Denmark in 2013	MS to submit discards information for the rest of the time series	Estimation of discards by country and by area	None
Biological Parameters survey	MO, WAA, NM	The series are available and need to be updated.	SLU AQUA will collate and update the biological data	None

		Ongoing maturity studies.		
Biological Parameters catch		MS to submit landings information (number at age and weight at age) for the rest of the time series	SLU AQUA will collate and compile the biological data	None
Assessment method	XSA, SS3, A4A			
Biological Reference Points	MSY library	It will be fitted after the assessment is ready	Final assessment model	

Progress towards benchmark

Tuning series: IBTS time series have been updated including 2016

Biological paramters, survey: Determination of maturity schedule and ageing technique almost finalised

Biological paramters, catch: Catch data submitted by MSs from 2009

Assessment method: To be conducted in 2016/2017

Biological reference points: To be conducted after the benchmark

Lemon sole in Subarea 4 and Divisions 3.a and 7.d

Data needed

- Catch (landings and discards) data back to 2002 (BEL, NDL, GER, DNK, SWE, NOR, UK ENG, UK SCO, FRA).
- Effort data by single métiers as potential additional source of information to estimate the amount of discards where no sufficient information from sampling programs is available.
- Available IBTS and BTS survey data on lemon sole.
- Available biological data from scientific surveys and sampling programs of the commercial fleets (length distributions, age distributions, spatial distributions, weight, maturity, sex ratios).

Current assessment issues

Currently lemon sole is treated as a data limited species and the stock perception is derived from simple survey trends and catch data. For the current assessment method the IBTS-Q1 index (mature biomass in kg) is used as basis for the trend based analysis (DLS 3.2. method). The IBTS surveys appear to cover the stock distribution well, but may not provide representative indices as the GOV gear is not optimized for flatfish sampling. The available beam-trawl surveys should provide a more representative index, but may not cover the full stock distribution. Survey data needs to be analysed to see if these issues can be circumvented. Further, it was often argued within the WGNSSK that the indices used for the DLS 3.2. method do not come along with uncertainty estimates and that these estimates should be calculated.

For commercial catches to be used in assessments, discards need to be quantified for lemon sole. Data are available to do this for 2012-2015, but more discard data sampled under the DCF should be available and should be uploaded into the InterCatch data portal by all relevant institutes.

Although lemon sole is treated as a data-limited stock, much data exist which are not utilized today. The available surveys can provide biological data for a number of years (including lengths, ages, maturity, weights and spatial location), and national catch-sampling programmes may be able to provide further valuable information. Age-based stock abundance indices can be generated from survey data, and could be used as the basis for survey-based assessment methods such as SURBAR. The distribution of age samples would need to be evaluated first, to ensure that they cover the likely stock distribution. If age-length keys can be generated for commercial data, then further work could explore the possibility of an age-based assessment model such as SAM. Concurrent developments in spatial length-based assessment methods (in Denmark and Scotland) could also be used to indicate stock trends in the absence of age estimates, and a variety of data-limited assessment methods could be explored as exploratory analyses.

No biological reference points are defined yet. The benchmark should explore if reference points can be defined or if the use of alternative indicators such as SSB proxies is possible.

The key first task of the benchmark will be to determine whether sufficient historical data exist to warrant a move towards a full analytic assessment, and to evaluate whether management of the stock on this basis would improve the efficacy of decision-making over the existing data-limited approach.

Workplan

Compilation of catch data in InterCatch format (years to be confirmed): all national institutes; prior to the benchmark.

Compilation of survey data (IBTS and BTS): probably via DATRAS, although would also need to check that biological information for lemon sole has been uploaded. Scotland in collaboration with contributing institutes; prior to the benchmark.

Evaluation of survey indices: Scotland; prior to the benchmark.

Compilation of input data for age- and length-based assessment models: relevant counties; prior to the benchmark.

Exploratory assessment runs: Scotland; during the benchmark.

Other working groups to be involved:

WGBEAM, IBTS-WG (age based indices, index uncertainty estimate, combination of IBTS and BTS indices).

STOCK	LEM-NSEA	
Stock coordinator	Name: Coby Needle	Email: needlec@marlab.ac.uk
Stock assessor	Name: Coby Needle	Email: needlec@marlab.ac.uk
Data contact	Name: Coby Needle	Email: needlec@marlab.ac.uk

Flounder in Subarea 4 and Divisions 3a

Data needed

- Catch (landings and discards) data back to 2002 (BEL, NDL, GER, DNK, SWE, NOR, UK ENG, UK, SCO, FRA).
- Effort data by single métiers as potential additional source of information to estimate the amount of discards where no sufficient information from sampling programs is available.
- Available IBTS, BTS and DYFS/DFS survey data on flounder.
- Available biological data from scientific surveys and sampling programs of the commercial fleets (length distributions, age distributions, spatial distributions, weight, maturity, sex ratios).

Current assessment issues

Currently flounder is treated as a data limited species and the stock perception is derived from simple survey trends and catch data. For the current assessment method the IBTS-Q1 index (excluding round fish area 1 and 2; mature biomass index in kg) is used as basis for the trend based analysis (DLS 3.2. method). The IBTS surveys appear to cover most of the stock distribution, but may not provide representative indices as the GOV gear is not optimized for flatfish sampling. The available beam-trawl surveys should provide a more representative index. Flounder is more distributed near coastal areas, therefore also the inshore surveys (DYFS/DFS) should be evaluated as a possible data source for a representative survey index. Survey data needs to be evaluated to estimate a reasonable survey index for flounder. Further, it was often argued within the WGNSSK that the indices used for the DLS 3.2. method do not come along with uncertainty estimates and that these estimates should be calculated.

For commercial catches to be used in assessments, discards need to be quantified for flounder. Data are available to do this for 2012-2015, but more discard data sampled under the DCF should be available and should be uploaded into the InterCatch data portal by all relevant institutes.

Although flounder is treated as a data-limited stock, much data may exist which are not utilized today. The compilation of such data can possibly provide biological data for a number of years (including lengths, ages, maturity, weights and spatial location), and national catch-sampling programmes may be able to provide further valuable information. The compilation of these data will be one of the major tasks during the proposed benchmark.

No biological reference points are defined yet. The benchmark should explore if reference points can be defined or if the use of alternative indicators such as SSB proxies is possible.

Workplan

Compilation of catch data in InterCatch format (years to be confirmed): all national institutes; prior to the benchmark.

Compilation of survey data (IBTS, BTS, DYFS/DFS): probably via DATRAS, although would also need to check that biological information for flounder has been uploaded: all national institutes.

Evaluation of survey indices; prior to the benchmark.

Compilation of input data for age- and/or length-based assessment models: relevant countries; prior to the benchmark.

Exploratory assessment runs: during the benchmark.

Other working groups to be involved:

WGBEAM, IBTS-WG (indices, index uncertainty estimate, combination of IBTS and BTS indices).

Stock	fle-nsea	
Stock coordinator	Name: Holger Haslob	Email:holger.haslob@thuenen.de
Stock assessor	Name: Holger Haslob	Email:holger.haslob@thuenen.de
Data contact	Name: Holger Haslob	Email:holger.haslob@thuenen.de

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
New) data to be considered and/or quantified	Lemon sole have never been the subject of a full analytic assessment. A key role of the benchmark is therefore to determine whether data exist to enable an assessment of this kind.	See below.	See below.	See below.
Tuning series	Tuning series do not yet exist for lemon sole.	Age- or lengthbased tuning series should be generated on the basis of DATRAS data.	Data should be available in DATRAS, but national institutes should also be approached to determine if all relevant data have been uploaded.	Coby Needle (Sco), Liz Clarke (Sco), ICES DATRAS staff.
Discards	Discard estimates from 2013-2015 indicate average rates of around 30%. Therefore, any catch-based assessment will need to account for discards.	Check availability of discard data from commercial sampling programmes and upload data to InterCatch for years prior to 2013.	Discard information from national sampling programmes. All relevant institutes (BEL, DNK, NDL, GER, ENG, SCO, FRA, SWE, NOR).	Coby Needle (Sco), Liz Clarke (Sco).
Biological Parameters	To collate and compile available data on weight, length, maturity, age, sex and spatial distribution.	Standard approaches currently applied to stocks such as haddock and plaice could be applied to collate these data.	Much of the required information can be obtained from DATRAS, but national institutes also need to be approached about the availability of relevant (and unsubmitted) data from survey and catch-sampling programmes.	Coby Needle (Sco), Liz Clarke (Sco), Rasmus Nielsen (Den).

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	Lemon sole are not currently assessed using an analytic method.	The applicability and utility of a range of candidate models to lemon sole needs to be evaluated.	The models to use depends on the data available (see previous row).	Coby Needle (Sco), Anders Nielsen (Den), Tanja Buch (Den), Colin Millar (ICES)
Biological Reference Points	No biological reference points exist for lemon sole.	The approach used to determine reference points will depend on the data available and the assessment methods used.	See above.	Coby Needle (Sco), Tanja Miethe (Sco), Alex Kempf (Ger).

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 for sole.	RCM-NS&EA, RBD-SG
Saithe in Subarea IV, VI and Division IIIa	No accoustic survey index for older year-classes, assessment heavily dependent on commercial CPUE	The NORACU can no longer be used in the assessment because of errors in sampling design and inconsistencies in the time series. Establish an acoustic survey in Q1 or Q3 to get fishery independent information on older age groups .	ACOM (Norway); ACOM (Germany); ACOM (France), ACOM (Denmark); ACOM (Scotland)
Saithe in Subarea IV, VI and Division IIIa	No recruitment index time series	The number of recruits is difficult to determine before they have been targeted by the fishery. Establish a recruitment survey .	ACOM (Norway)
Saithe in Subarea IV, VI and Division IIIa	Age sampling from commercial fleets	Possible cluster sampling due to few vessels in the reference fleet (Norway), needs review / redesign	ACOM (Norway); PGDATA

Stock	Data Problem	How to be addressed in	By who
Turbot in IIIa,	Small turbot stocks cannot be easily assessed because of potentially large migrations in and out the large areas IV and the Baltic.	Most knowledge about stocks connectivity is based on old and limited tagging experiments. New tagging studies would be necessary to improve the understanding of migratory patterns	SIMWG; ACOM (Denmark, Sweden)
Nep 32	Deficient Norwegian catch sampling	The coast guard sampling of Norwegian and Danish commercial catches is satisfactory in some years, but not in others. The main problems with these data are that catches are often measured by total length (whole cm) and sample weight is missing. As total length data have lower resolution compared with carapace length data, the two cannot be combined without losing accuracy. The coast guard is aware of these problems and strives to improve the data	ACOM (Norway)
Nep 32 & IIIa	Scarce Norwegian log book data	The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks compulsory for all vessels ≥ 15 m. In 2013 compulsory electronic logbooks for vessels ≥ 12 m were introduced in FU 3. As a large portion of the Norwegian fleet landing Nephrops in FU 3 and 32 consists of vessels < 12 m / < 15 m, the logbook data will continue to be limited. A growing part of the Norwegian Nephrops landings come from the trap fishery, but this part of the fleet is not required to fill in logbooks, probably because of the small size of the vessels. Logbooks from traps would provide data from the eastern (less exploited) part of FU 32. Log books should be introduced for vessels < 15 m, including trap fishers.	ACOM (Norway)
Pollack in Subarea IV and Division IIIa	General lack of biological data needed for better understanding of growth and maturity.	In routine surveys, such as the quarter 1 and quarter 3 IBTS in Subarea IV and Division IIIa, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity WGNEW recommended that otoliths and maturity information should be collected during these surveys for a few years. WGNSSK also recommends that biological data from commercial catches should be processed.	IBTSWG; RCM-NS&EA

Stock	Data Problem	How to be addressed in	By who
Whiting in Division IV and IIIa	General lack of stock identity and area specific age readings	Studies on whiting stock identity and connectivity in western Baltic, Division IIIa and Division IV should be encouraged In the routine surveys, IBTS quarter 1 and quarter 3 in Division IIIa, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity it is recommendable that otoliths and maturity (also in area IV) information should be collected during surveys.	National research services and IBTSWG
Cod in subdivision IIIaW, subarea IV, and division VIId	Perceived catchability problems in IBTS Q1 and Q3 indices,	Appropriate standardisation of IBTS Q1 and Q3 surveys was carried out during WKNSEA 2015. Inconsistencies were found between q1 and q3 in the Skagerrak area. However, so far only one vessel is fishing in the Skagerrak making it impossible to differentiate vessel, gear and crew effects from real changes in abundance. It is recommended that also in the Skagerrak two vessels fish in each ICES rectangle. This is the standard in all other areas covered by the IBTS.	IBTS-WG, ACOM (Danmark, Sweden, Germany, Norway).
Nephrops FU 33	Not enough discard information available to give catch advice	The sampling in this FU is insufficient. Samples are needed from the main fleets fishing in this FU.	ACOM (Denmark, Netherlands, Belgium, Germany)
Turbot in IV	Biological information is only available from the Netherlands. This is a serious concern leading to a potentially biased assessment	Age information is needed also from other countries. So far age distributions are mainly available from the Dutch BT2 fishery. However, these samples may not be representative for other fisheries and countries (e.g., gill net fishery, otter trawl fisheries). All available information needs to be uploaded to Intercatch as far back in time as possible. Future sampling effort needs to ensure a proper sampling coverage over the main fleets and countries.	ACOM (Denmark, UK, Germany, Belgium)

Stock	Data Problem	How to be addressed in	By who
Sole-eche	The UK YFS stopped in 2006 and 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. In RCT3 analysis the FR-YFS gets hardly any weight and the gemoetric mean has to be used instead. Possible solutions could be that either the UK YFS is conducted again in future years or the French Young Fish survey can be extended to include at least some of the sampling points from the former UK Young Fish survey.	ACOM (UK,France)
Nep 5	Incomplete catch sampling	Only Dutch catches are sampled, and discard data were only available for 2015. Length distributions and sex ratios are poorly defined due to limited sampling. Acknowledging that this is a difficult fishery to effectively sample, electronic capture of at-sea data could be developed.	ACOM (UK, Netherlands, Germany, Belgium)

Annex 07 WGNSSK data calls

No information provided for 2016.

Annex 08 Audit Reports

No information provided for 2016.

Annex 09 Working documents

Alternate SAM models

DATRAS standard Q3 index

The standard DATRAS Q3 indices (DATRAS indies), ages 3-8, 1992-2015 were used instead of the GAM generated indices in the SAM assessment model. Figure 1 shows the indices and the internal consistencies. The standard indices do not include the Skagerrak/Kattegat, but do include the southern North Sea (where saithe are no found). The truncated GAM-derived Q3 index (no Skagerrak/Kattegat or southern NS were compared with the DATRAS estimates for the expanded age range (Figure 2). The GAM and standard DATRAS indices are (generally) very similar. However, ages 4 and 5, especially in the last 2 years, are over-estimated by the GAM (especially age 5).

Results of the SAM assessment are in Figure 3. Estimated SSB using the DATRAS indices closely mirrors estimates from the cpue-only model until around 2010, unlike the model with Q3 indices estimated with the GAM model. The DATRAS model shows slightly lower SSB than the Q3 GAM indices in 2015. Retrospective patterns show that SSB has been consistently underestimated, while fishing mortality has been mostly over-estimated. The retrospective patterns in $F_{4\text{-}7}$ are not as poor as the model with the Q3 GAM indices. Residual plots are in Figure 5. Estimated catchabilities were very low for the DATRAS model, compared to the indices estimated with the GAM model.

GAM Q3 index but without 2015

Results of the SAM assessment are in Figure 6. Omitting the 2015 Q3 data resulted in SSB_{2015} estimates lying between those estimated by the cpue-only model and the GAM-estimated Q3 (with 2015) model. Retrospective patterns are in Figure 7; retrospectives are worse than the model including 2015 data (Figure 8). Residual patterns are in Figure 9.

GAM Q3 index but with stock weights=catch weights for ages 7-10+

Not finished – bounds for stock weights

Results of the SAM assessment are in Figure 10. Replacing stock weights with catch weights for ages 7-10+ (where stock weights were greater than catch weights) made a large difference in the SAM output. While SSB still increases in the last two years of the series, SSB is lower for this model until 2014 than all other models. Retrospective patterns are in Figure 11. Residual patterns are in Figure 12.

DATRAS Q3 index but with stock weights=catch weights for all ages

Results of the SAM assessment are in Figure 13; this is the model recommended as the final model based on the external review in early June. Replacing stock weights with catch weights for all ages had the effect of increasing SSB in comparison with the model where stock weights were replaced for ages 7-10+. This is because for ages 3-6, catch weights are higher than stock weights (Figure 14); these are the fish the make up the dominant part of the catch for the targeted trawl fisheries. Retrospective patterns are in Figure 15 and residuals are in Figure 16.

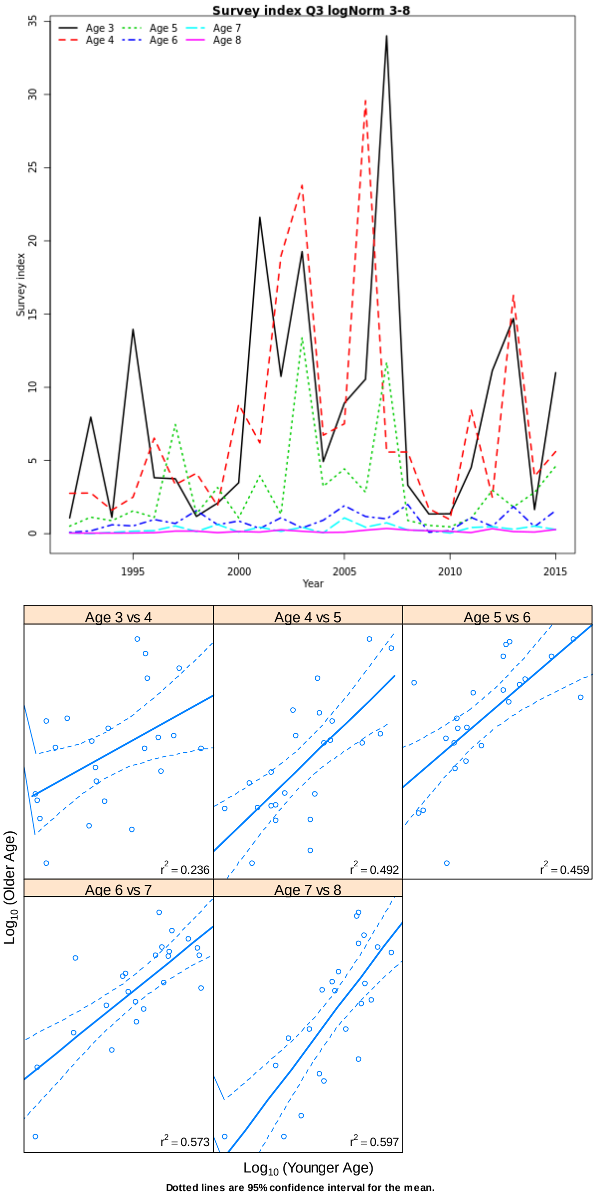

Figure 1. Standard DATRAS indices for Q3, 1992-2015, ages 3-8 and internal consistencies.

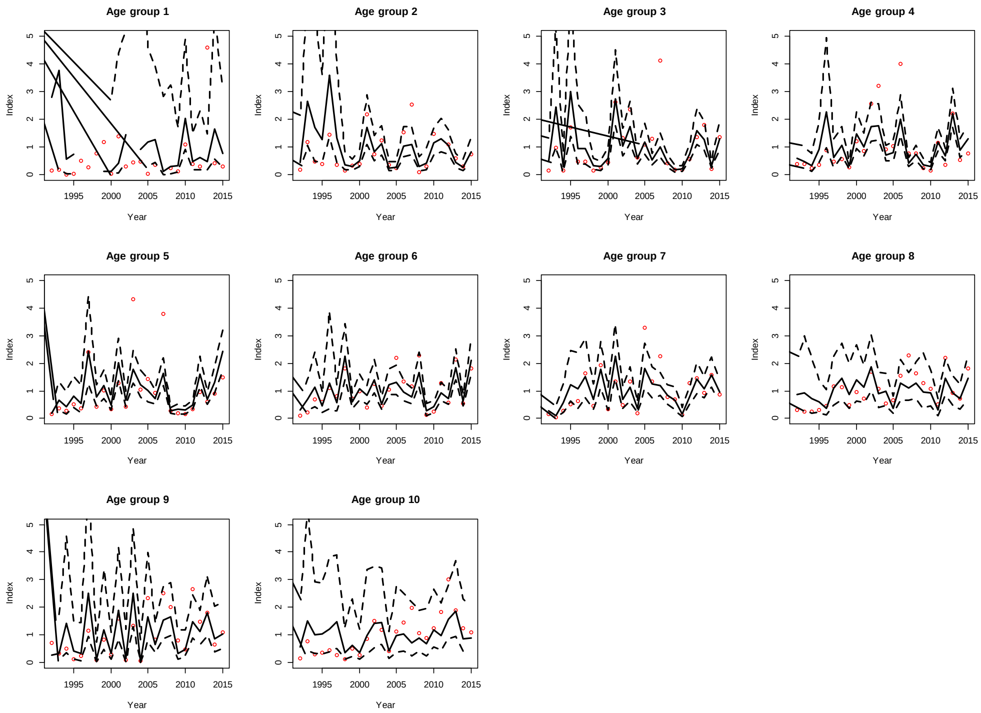

Figure 2. Standard DATRAS indices for Q3, 1992-2015, ages 3-8.

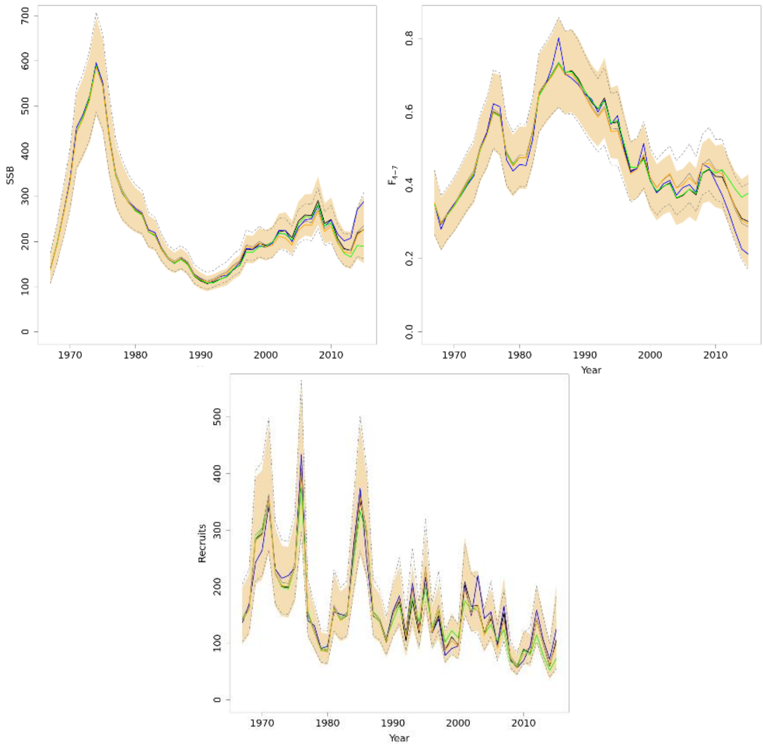

Figure 3. Trends in SSB, $F_{4\text{-}7}$, and recruitment for the 4 models. Blue line: Q1 + GAM-estimated Q3 + cpue index model; green line: cpue-only model; orange line: combined cpue + GAM-estimated Q3 (truncated to exclude Skagerrak/Kattegat and southern NS); black line: DATRAS Q3 + cpue model; orange/tan shaded region: 95% confidence interval for the DATRAS Q3 + cpue model; solid grey line (grey dashed confidence intervals) are the previously saved base model (unknown at this point).

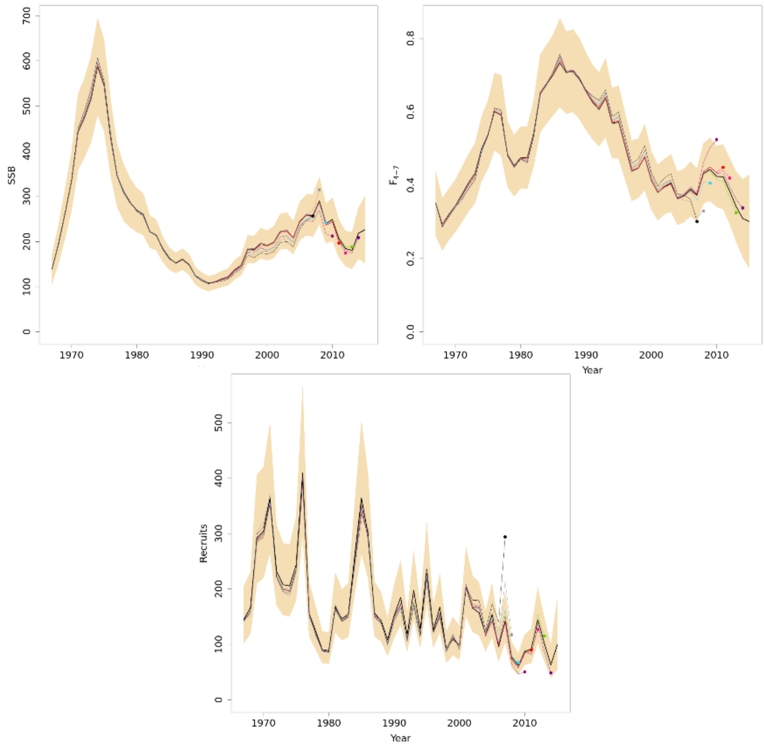

Figure 4. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is combined cpue + DATRAS Q3 and includes the discard revisions.

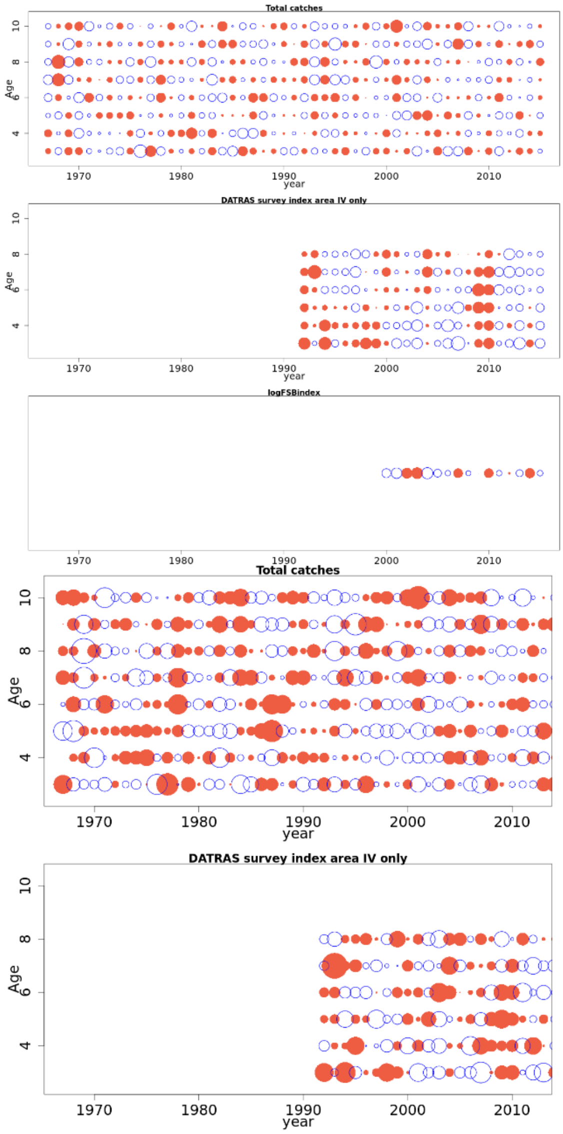

Figure 5. Residual patterns for the combined cpue + DATRAS Q3 assessment model. (left) Before correlation taken into account between ages, within years in the Q3 index; (right) after accounting for the correlation.

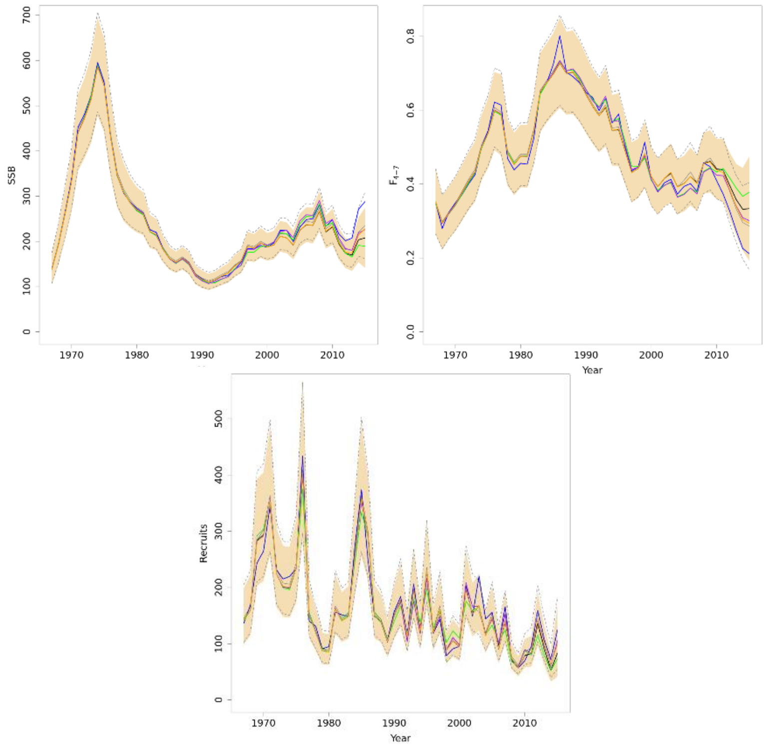

Figure 6. Trends in SSB, $F_{4\text{-}7}$, and recruitment for the 5 models. Blue line: Q1 + GAM-estimated Q3 + cpue index model; green line: cpue-only model; orange line: combined cpue + GAM-estimated Q3 (truncated to exclude Skagerrak/Kattegat and southern NS); purple line: DATRAS Q3 + cpue model; black line (orange/tan shaded region: 95% confidence interval): GAM-estimated Q3 indices without 2015 + cpue model; solid grey line (grey dashed confidence intervals) are the previously saved base model (unknown at this point).

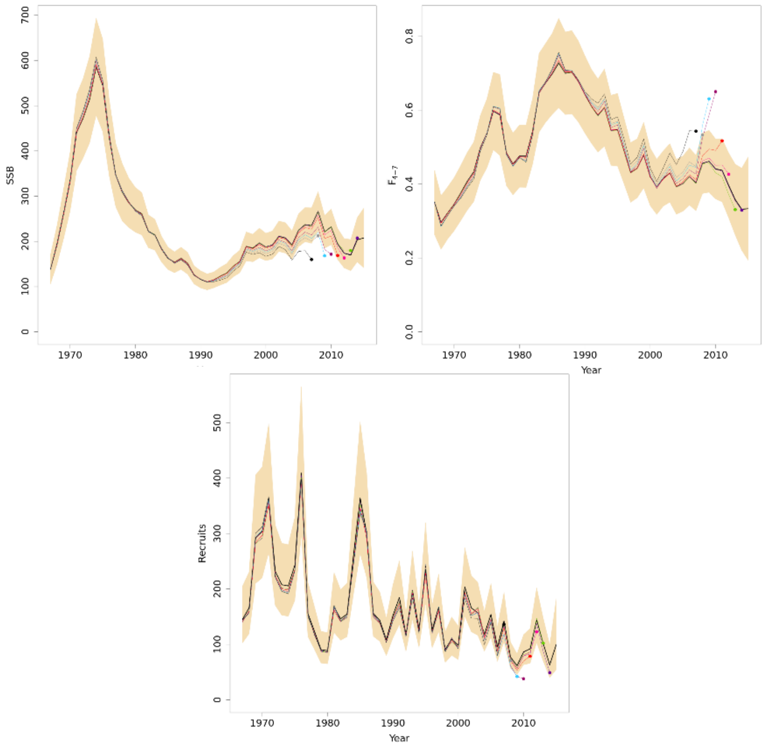

Figure 7. Eight year retrospective pattern in SSB, F_{4-7}, and recruitment. Model is combined cpue + GAM-estimated Q3 (without 2015, excludes Skagerrak/Kattegat and southern North Sea) and includes the discard revisions.

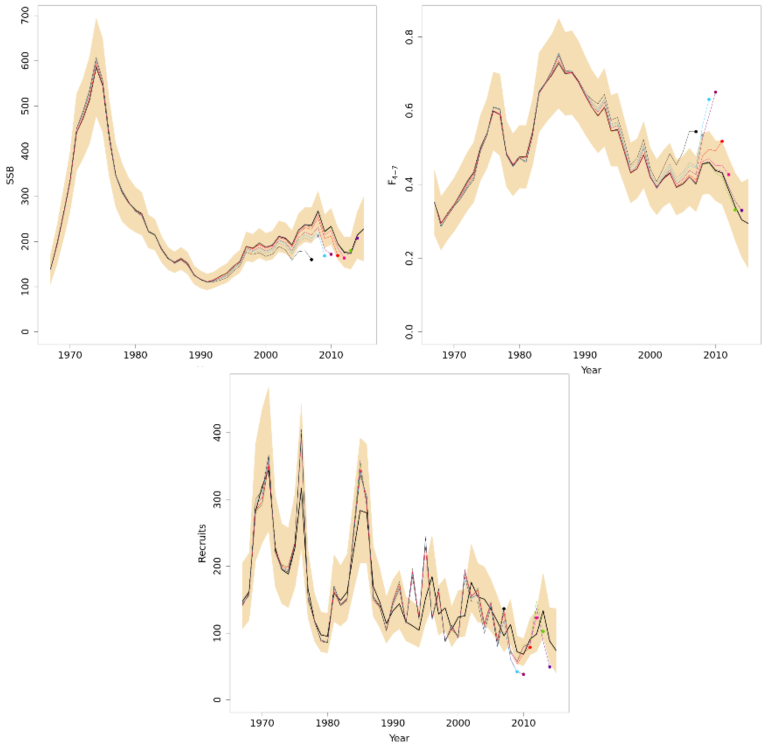

Figure 8. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is combined cpue + GAM-estimated Q3 (excludes Skagerrak/Kattegat and southern North Sea) and includes the discard revisions.

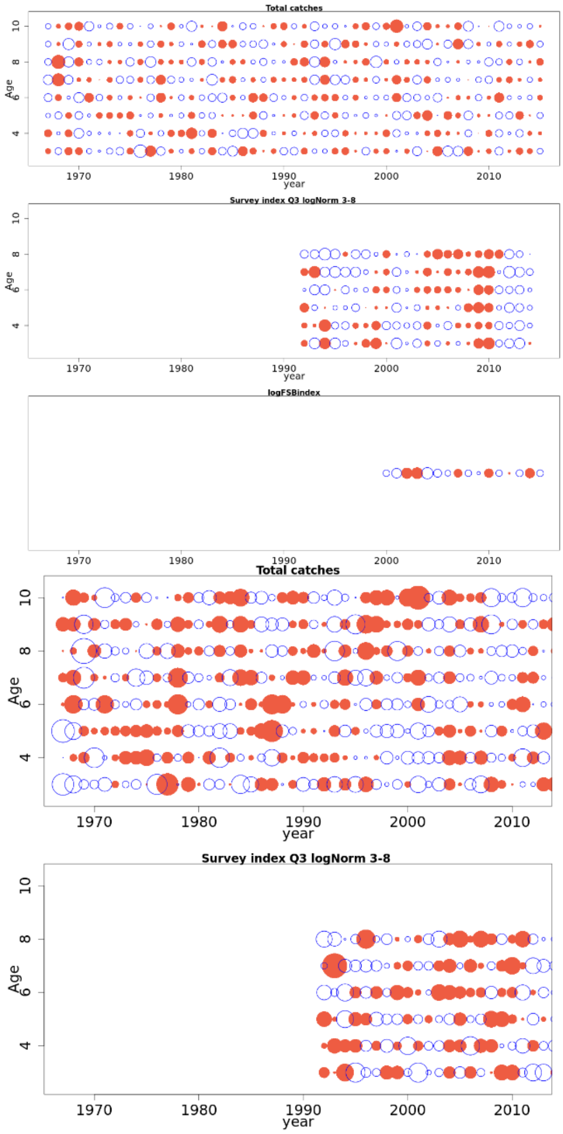

Figure 9. Residual patterns for the combined cpue + GAM-estimated Q3 assessment model (no 2015). (left) Before correlation taken into account between ages, within years in the Q3 index; (right) after accounting for the correlation.

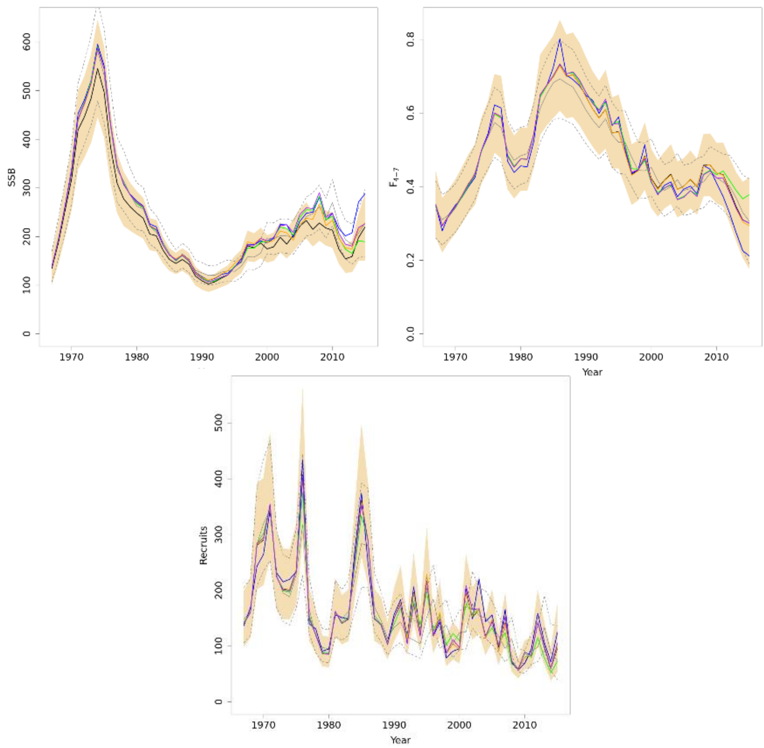

Figure 10. Trends in SSB, F_{4-7}, and recruitment for the 5 models. Blue line: Q1 + GAM-estimated Q3 + cpue index model; green line: cpue-only model; orange line: combined cpue + GAM-estimated Q3 (truncated to exclude Skagerrak/Kattegat and southern NS); purple line: DATRAS Q3 + combined cpue; black line (orange/tan shaded region: 95% confidence interval): GAM-estimated Q3 indices + cpue model + stock weights=catch weights for ages 7-10+; solid grey line (grey dashed confidence intervals) are the previously saved base model (unknown at this point).

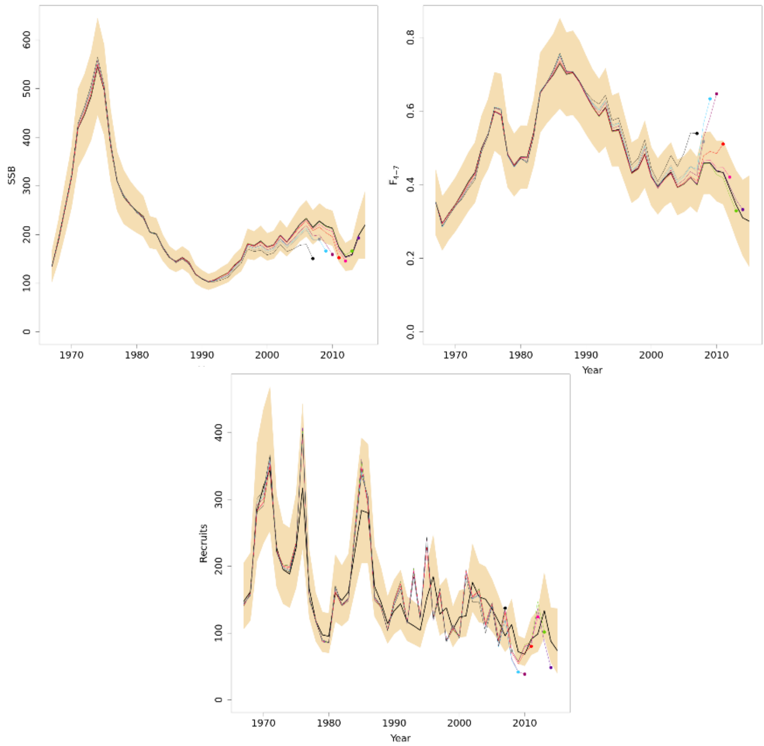

Figure 11. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is combined cpue + GAM-estimated Q3 (excludes Skagerrak/Kattegat and southern North Sea) + stock weights=catch weights for ages 7-10+ (includes discard revisions).

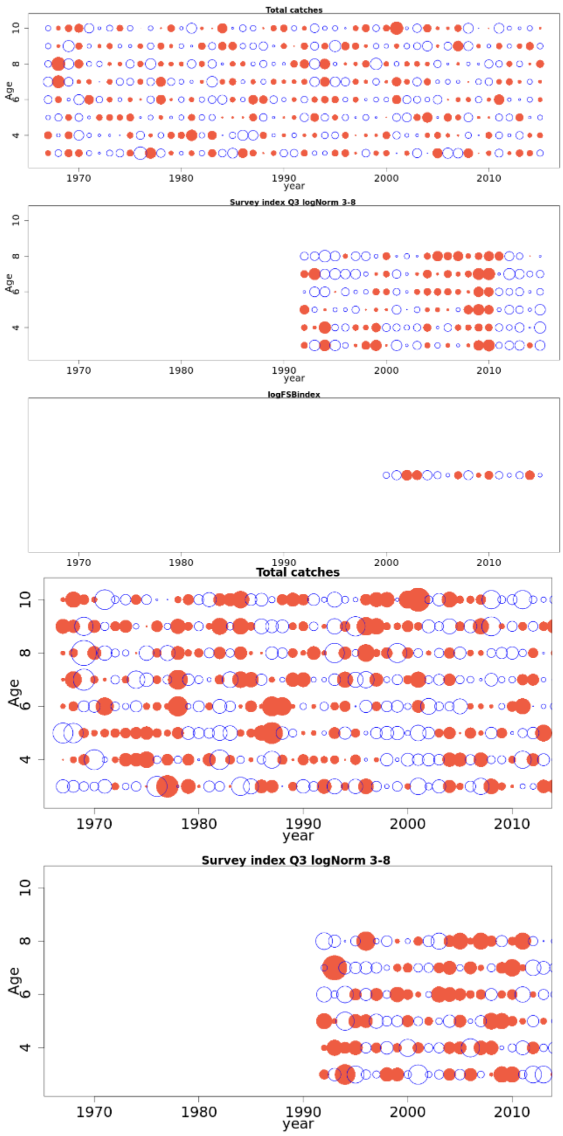

Figure 12. Residual patterns for the combined cpue + GAM-estimated Q3 + stock weights=catch weights for ages 7-10+ assessment model. (left) Before correlation taken into account between ages, within years in the Q3 index; (right) after accounting for the correlation.

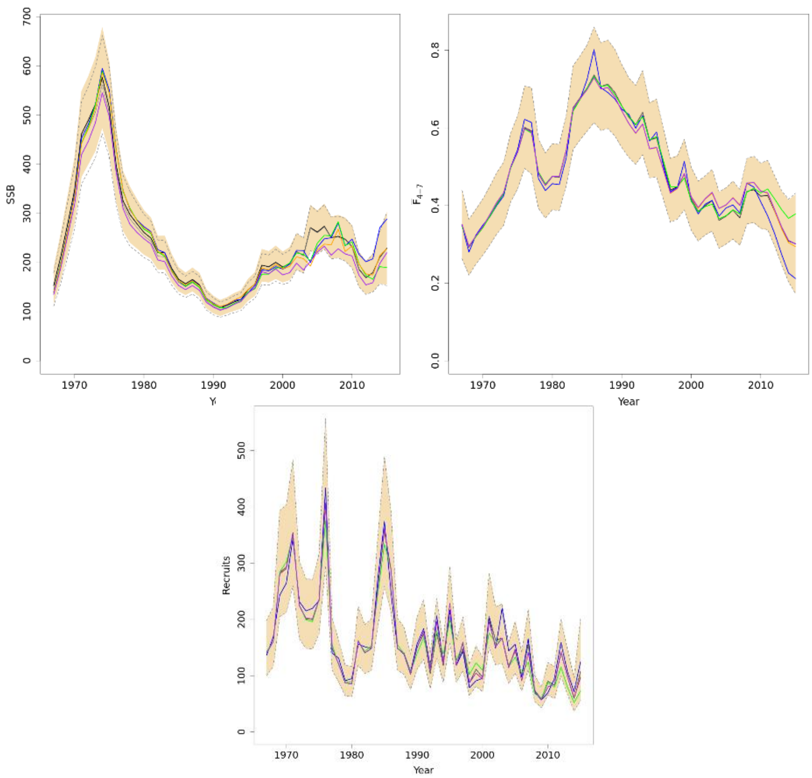

Figure 13. Trends in SSB, F_{4-7}, and recruitment for various models. Blue line: (benchmark model) Q1 + GAM-estimated Q3 + combined cpue index model; green line: combined cpue-only model; orange line: combined cpue + GAM-estimated Q3 (truncated to exclude Skagerrak/Kattegat and southern NS); purple line: GAM-estimated Q3 indices + combined cpue model + stock weights=catch weights for ages 7-10+; black line (orange/tan shaded region: 95% confidence interval): DATRAS Q3 indices + combined cpue, stock weights=catch weights for all ages.

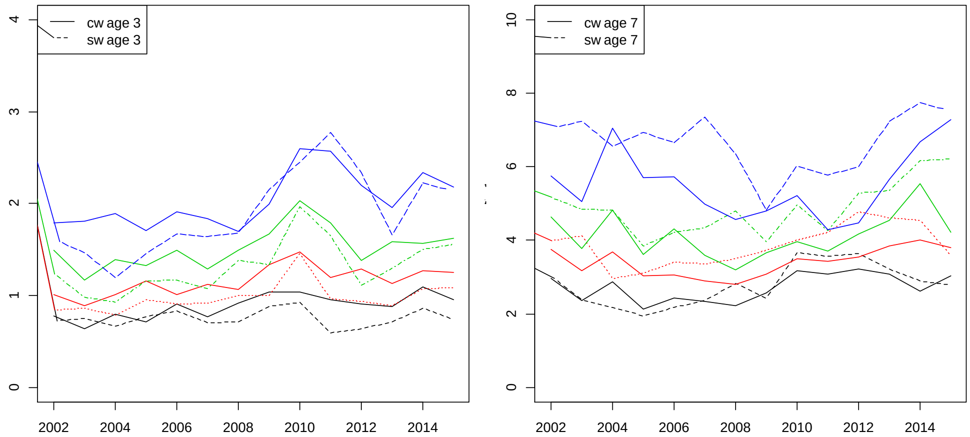

Figure 14. Stock weights (dashed lines) and catch weights (solid lines) for ages 1-10+. The left panel shows age 3 (black lines) to age 6 (light blue lines), while ages 7-10+ are in the right panel. This figure differs from the benchmark working document due to re-raising (InterCatch bug and changing of raising procedure for Norwegian discards).

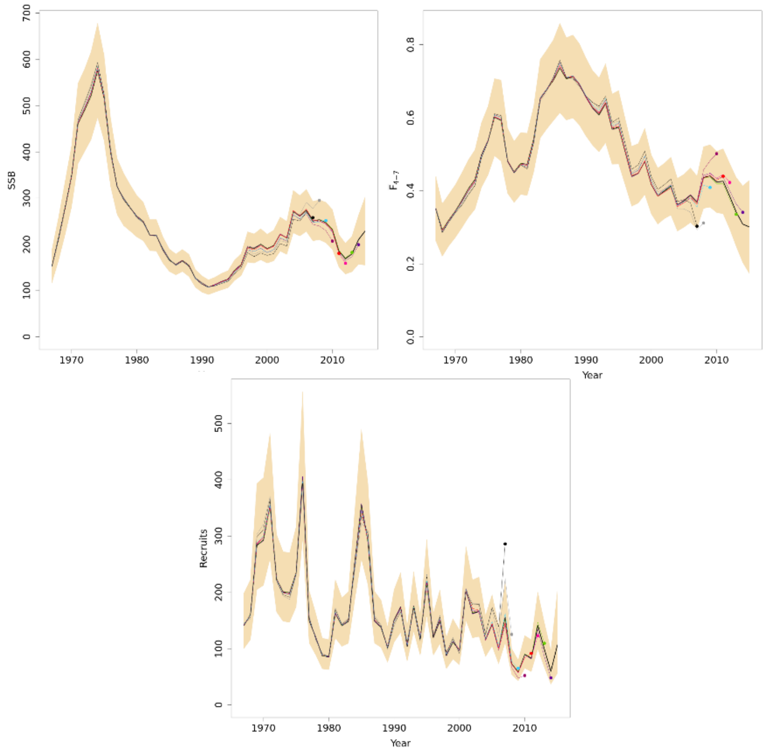

Figure 15. Eight year retrospective pattern in SSB, F_{4-7}, and recruitment. Model is combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat) + stock weights=catch weights for all ages (includes discard revisions).

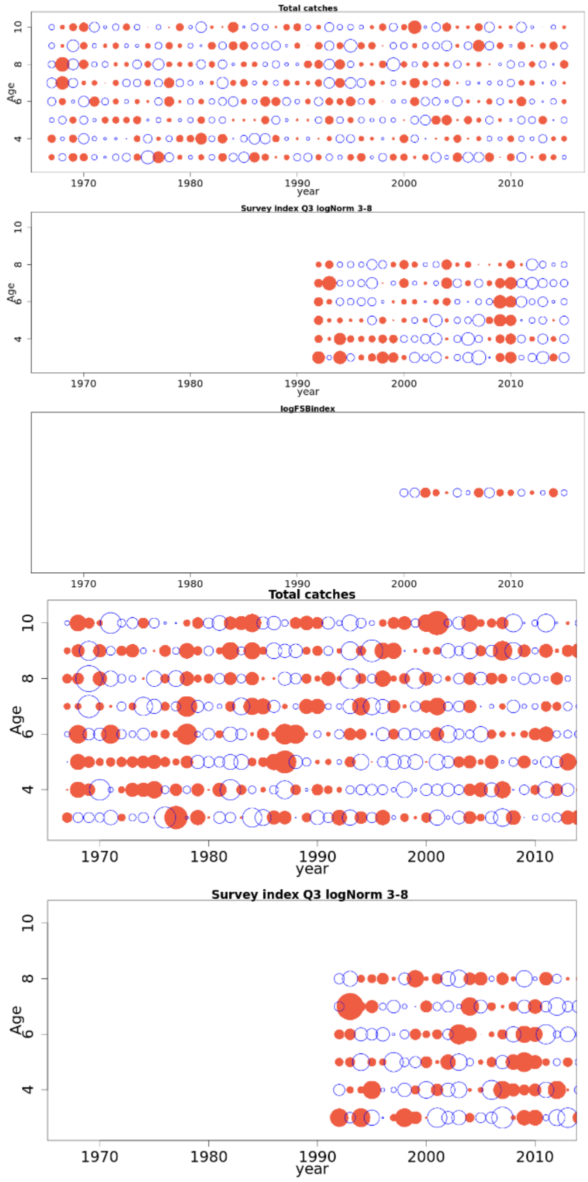

Figure 16. Residual patterns for the combined cpue + DATRAS Q3 (excludes Skagerrak/Kattegat) (stock weights=catch weights for all ages) assessment model. (left) Before correlation taken into account between ages, within years in the Q3 index; (right) after accounting for the correlation.

RBE
SIH Campagne

CGFS : Change of vessel from 2015 onwards and consequences on survey design and stock indices

Introduction

The Channel Ground Fish Survey (CGFS) has been conducted in the eastern English Channel yearly in October since 1988 with a systematic fixed sampling program. The CGFS was realized using a high opening (GOV) bottom trawl (20 mm meshsize coden) and 30 minutes trawls using the same RV Gwen Drez since 1988.

The RV Gwen Drez was decommissioned in 2015 but given the international importance of the CGFS it was decided to continue the time series using the RV Thalassa. In order to allow for a continuation of the time series an intercalibration was realized in 2014 by conducting paired tows, simultaneously with both vessels (see appendix of the WGIBTS 2015 report for description of the intercalibration results).

Adaptation of the sampling design

Rationale

Based on the characteristics of the new RV Thalassa (bigger draught), and the vessel time availability at this period of the year, three scenarios of reduction of the trawling stations set have been tested. For each scenario, a selection of hauls was made among the 89 hauls of original sampling scheme of the survey (Fig. 1) based on different criteria. The relevance of these subsets of hauls was assessed by resampling on the historical time series and computing the associated abundance indexes per age for plaice (*Pleuronectes platessa*) and red mullet (*Mullus surmuletus*) which are assessed using this survey as tuning fleet in the ICES WGNSSK (Working Group on North Sea, Skagerrak and Kattegat).

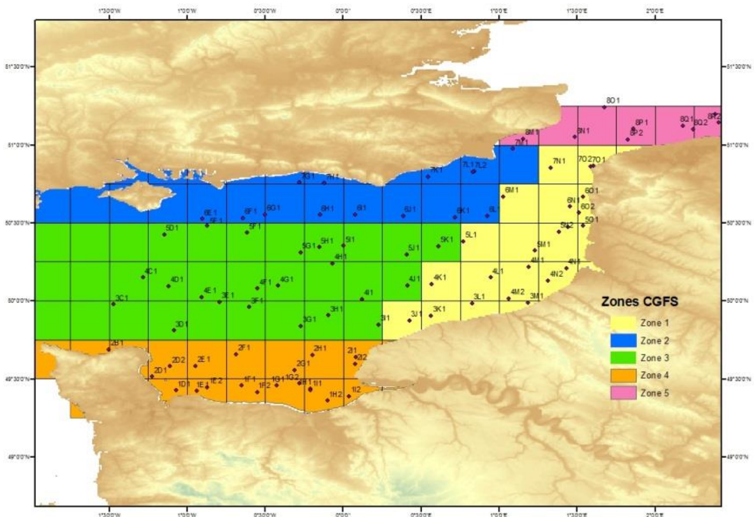

Figure 1 : Hauls of the original CGFS sampling scheme

Selected scenario

After a trial and error experiment on the haul selection, the selected sampling scheme include the areas easily fishable by the RV Thalassa (69 hauls that are always more than 15 meters deep) and some of the shallower hauls (limited to the ones which the average bathymetry over the time series is over 15 meters: 5 hauls). This selection allowed for covering 74 hauls (i.e. 83% of the initial sampling scheme, Ann.1). It excludes the hauls outside VIId which were not used.

To test the relevance of the selected hauls, the internal consistency of the indices was tested for two species (plaice and red mullet).

Red mullet

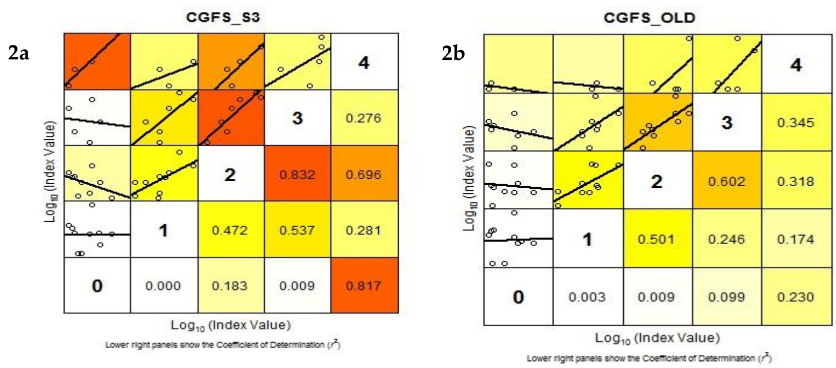

Figure 2 : Internal consistency ; 2a : New index based on the subset of hauls, 2b : reference index

Correlation coefficients appeared to be higher with this selection of hauls than with the original sampling scheme, improving the internal consistency of the index for red mullet.

Plaice

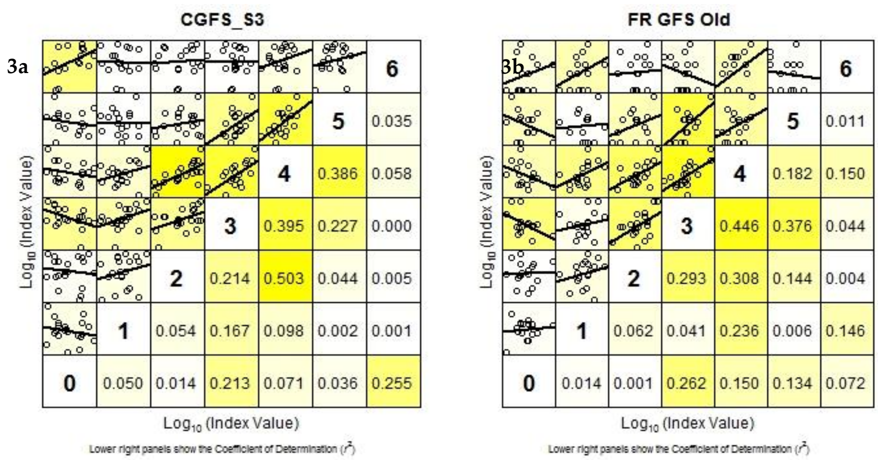

Figure 3 : Internal consistency ; 3a : New index based on the subset of hauls, 3b : reference index

The internal consistency of the original index was not completely satisfying. The new sampling scheme resulting from a subset of the original stations do not deteriorate this internal consistency further. The correlation coefficients are of the same order of magnitude for ages 2/3, 3/4 and slightly increased for ages 4/5.

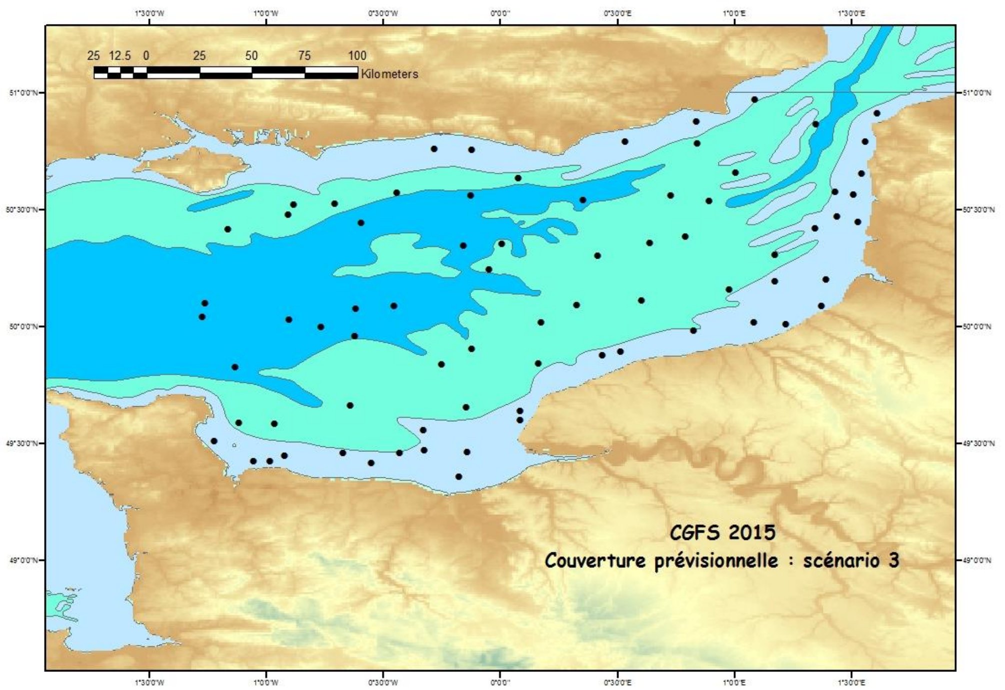

Figure 3 : New spatial coverage of the Channel Ground Fish Survey

From CPUE in number per hour fished to CPUE in number per km²

The original index provided was computed in number of fish per hour fished. In a first step an index was computed per ICES square (the stratum in this survey) and then elevated to the whole Eastern Channel to compute a number of fish per age class and hour fished.

As the surface trawled differed between the two RV (difference in trawling speed and width of the gear used (0.029 km² on average for the RV Gwen Drez over the period 2008-2014 against 0.052 km² for the RV Thalassa (average of the hauls realized in 2015)) a density index (number of fish per km²) was also tried in order to create a consistent index over the whole time series. This is in line with the current effort led by the IBTSWG to produce trawled surface and density indices for all the expert groups for 2017.

The index is then computed using the formula:

With :

$\overline{N_s}$ mean abundance in the strata s, expressed in number/km²

$$\overline{N} = \frac{\sum_s A_s . \overline{N_s}}{\sum_s A_s}$$

A_s Surface of the strata *s*, in km²

As the vertical opening of the gear used by the RV Thalassa was higher than the previous one, and in order to take into account any vessel effect on catchability, the CPUE were compared for all the species caught. Differences in CPUEs between the new and the old survey setting were found for 9 species (mostly pelagic species). In the case of plaice and red mullet, CPUEs were not significantly different, so no conversion factor was applied to these two species.

Differences in indices provided in 2015 and 2016

During the process of automatizing the computation of the index, some errors were found in the surface of some strata and ALK used for some species. These errors where corrected and the new indices (expressed in number of fish per km² instead of number of fish per hour fished) take these corrections into account.

In order to compare the "old" and "new" CGFS indices for plaice and red mullet they were first plotted against each other to get a visual comparison of the index values at age and assess the possible differences and inconsistencies. The correlations between indices at age time series were then computed to check for consistency between these two indices. The last step was to check the internal consistency to assess the impact of the new calculation on the indices.

Comparison Old/New index for plaice

Index at age

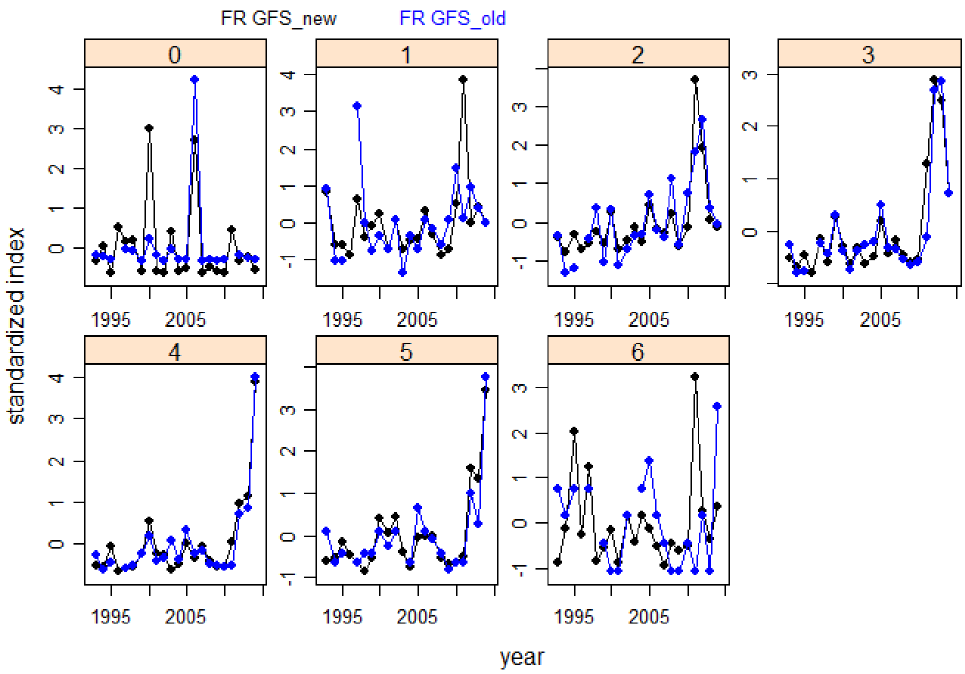

Figure 4 : CGFS old (blue) and new (black) standardized index at age

The main trends of the CGFS index at age remain very similar. The main differences are:

- for age 1 in 1997 where the peak observed is no longer observed with the new calculations;
- a new peak in the age 1 in 2011 which is in line with what was observed by the UK-BTS survey that year;
- the main differences are observed for age 6, where the two indices seem to be inconsistent ;
- for age 0 in 2000 and age 1 in 2011, two new peaks appeared with the new calculation.

In the assessment only the ages 1 to 6 are used.

Correlations between the two different indices at age time series

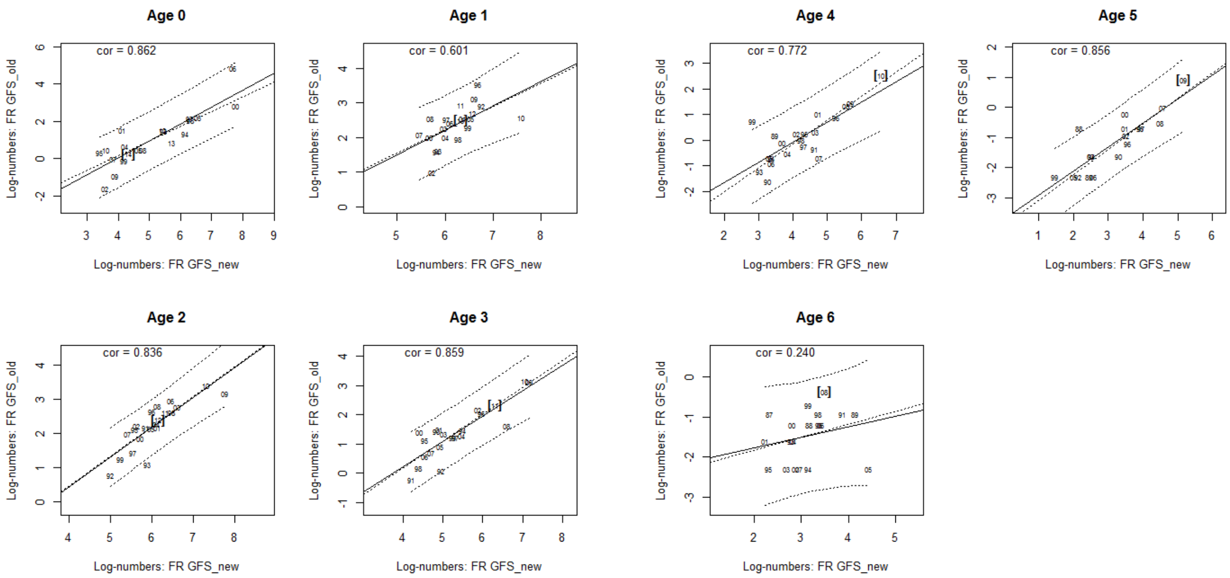

Figure 5 : Correlation between indices at age for the old and new indices

The correlations for ages 0, 2, 3, 4 and 5 are high, reflecting the coherence seen when plotting the old and new surveys against each other. Correlations for ages 1 and 6 are weaker, also reflecting the differences for some years for age 1 and a poor consistency between new and old indices for age 6.

Internal consistency

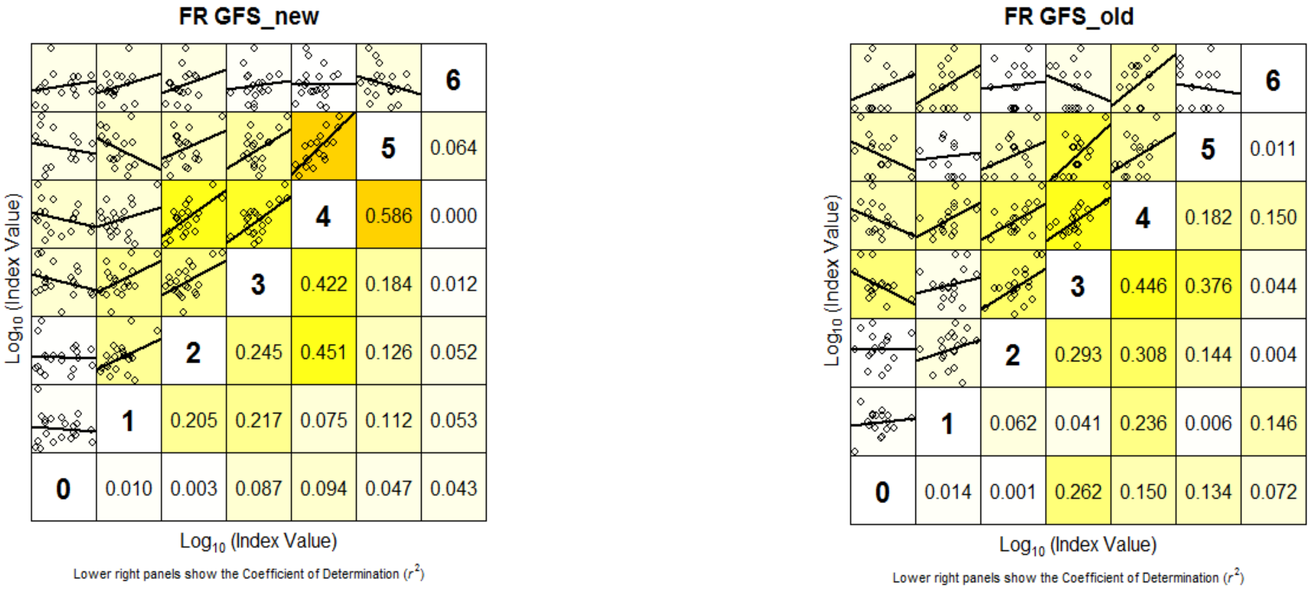

Figure 6: Internal consistency for new and old indices

The internal consistency is globally improved. Correlation coefficients are increased for ages 1/2 and 4/5 while they do not vary much for ages 2/3 and 3/4.

Comparison Old/New index for mullet

Index at age

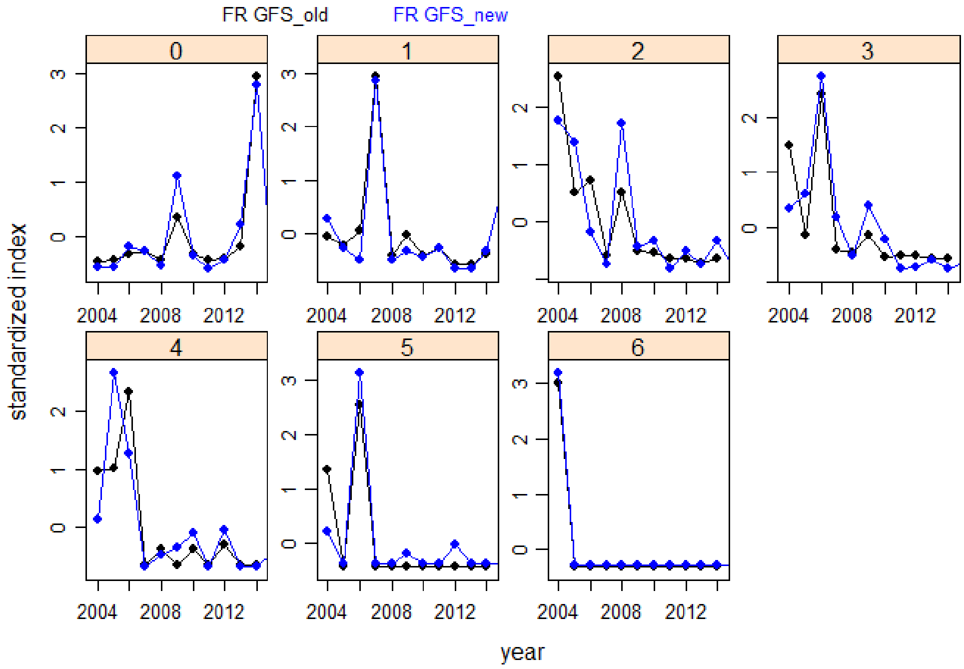

Figure 7: CGFS old (black) and new (blue) standardized index at age

The main trends of the CGFS index at age are remaining very similar. The main differences are for age 2 in 2008 where the peak observed in the new calculations is higher than the one from the old index. For Age 4 in 2004 and 2005, indices seem to be inconsistent with a decrease between 2005/2006 whereas the index increased with the old index.

Correlations between the two different indices at age time series

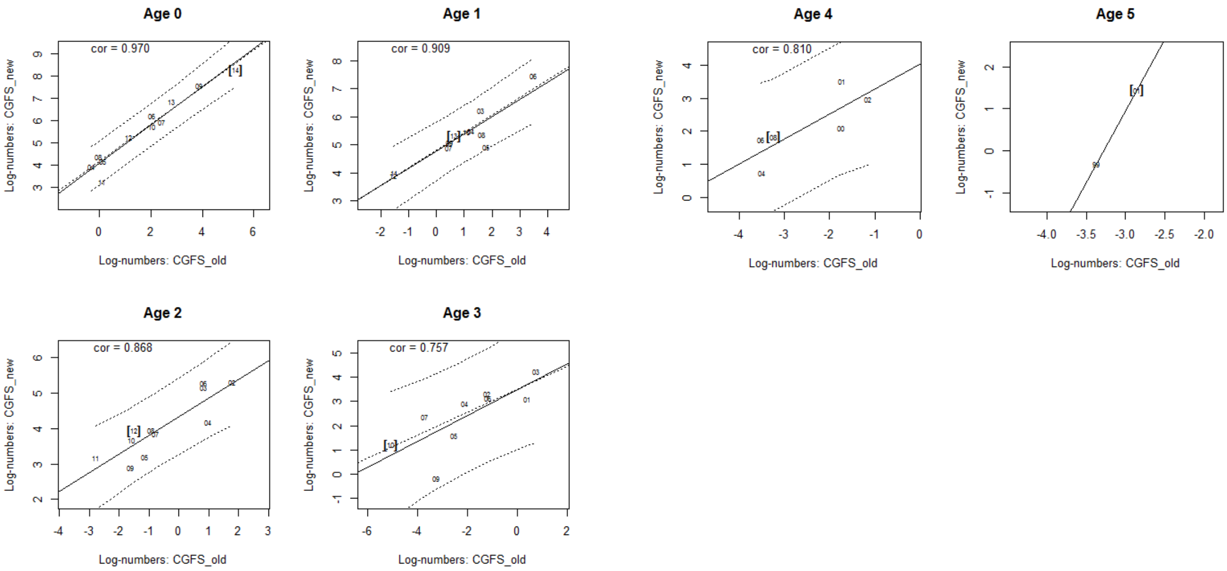

Figure 8

Correlation between indices at age for the old and new indices

The correlations for all ages are high but with very few data points after age 4.

Internal consistency

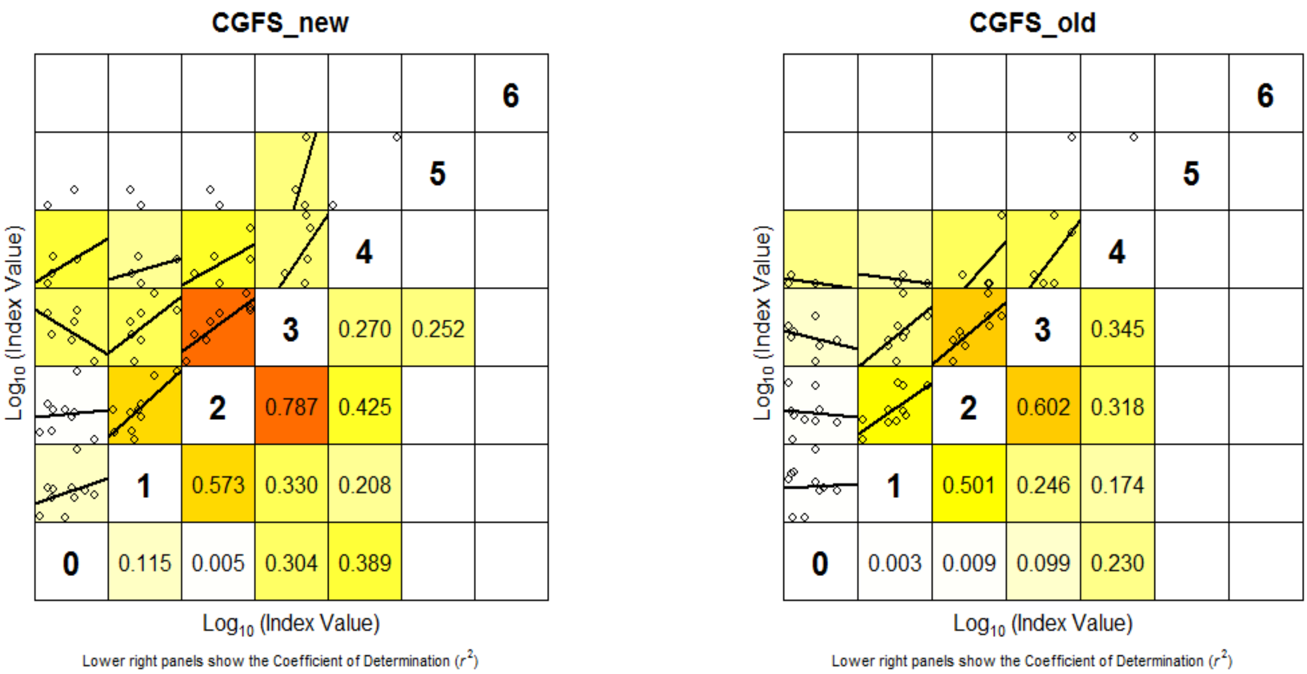

Figure 9: Internal consistency for new and old indices

The main patterns are maintained from the old to the new index. The higher correlation is between age 2 and 3 but increased with the new index.

Annex 1: Hauls kept in the new survey

TRAIT_SELECTION_CGFS_THALASSA_S3			
sta_Recodage	Latitude	Longitude	Trait2014
4M1	50.195	1.171667	62
4M2	50.01667	1.083333	67
5L1	50.385	0.7916667	84
5M1	50.305	1.171667	61
6J1	50.54	0.3533333	
6K1	50.56167	0.7283334	57
6L1	50.53667	0.89	59
2D2	49.59	-1.118333	32
2E1	49.58333	-0.9666666	34
3D1	49.82833	-1.135	1
3E1	49.99833	-0.7683333	2
3F1	49.96	-0.6216667	17
3H1	49.90333	-0.1216667	36
3I1	49.84333	0.1633333	71
3J1	49.87833	0.4333333	70
3K1	49.895	0.5116667	69
3L1	49.98167	0.825	68
4C1	50.04	-1.275	96
4D1	50.09833	-1.265	4
4E1	50.02833	-0.905	3
4F1	50.075	-0.6183333	15
4G1	50.08833	-0.4566667	14
4H1	50.245	-0.05	10
4I1	50.01833	0.175	37
4J1	50.09333	0.3266667	83
4K1	50.11333	0.6016667	41
5D1	50.415	-1.166667	76
5E1	50.47667	-0.9066667	74
5F1	50.44333	-0.5966667	72
5H1	50.34667	-0.1583333	12
5I1	50.355	0.005	11
5J1	50.30167	0.4133333	86
5K1	50.35833	0.6366667	85

TRAIT_SELECTION_CGFS_THALASSA_S3			
sta_Recodage	Latitude	Longitude	Trait2014
6E1	50.52333	-0.8833333	75
6F1	50.525	-0.71	73
6G1	50.57333	-0.4433333	80
1D1	49.42333	-1.058333	29
2D1	49.51167	-1.223333	97
2I1	49.64	8.166666E-02	88
2I2	49.60167	8.333334E-02	89
1E1	49.42333	-0.985	28
1E2	49.45	-0.9233333	27
1F1	49.46167	-0.675	26
1F2	49.41667	-0.5533333	25
1G1	49.45833	-0.43	24
1G2	49.47167	-0.325	23
2F1	49.66167	-0.6433333	35
2G1	49.55667	-0.3316667	20
2H1	49.65333	-0.145	19
3G1	49.84	-0.2533333	18
1H1	49.46333	-0.1433333	22
1H2	49.35833	-0.1766667	90
7O2	50.79	1.558333	49
7G1	50.76	-0.2833333	79
7K1	50.79167	0.5333334	54
7L1	50.87667	0.8366666	53
7L2	50.78167	0.84	56
7M1	50.97	1.085	51
6O1	50.655	1.541667	42
7O1	50.91333	1.61	48
7H1	50.755	-0.1216667	78
7N1	50.86666	1.346667	50
6H1	50.56	-0.1266667	81
6I1	50.635	7.666667E-02	
3M1	50.00834	1.218333	65
4N1	50.2	1.39	63
4N2	50.09	1.37	64
5N1	50.47167	1.438333	46
5N2	50.41833	1.345	47
5O1	50.44833	1.526667	
6M1	50.66	1.005	58

Trait_Selection_Cgfs_Thalassa_S3			
sta_Recodage	Latitude	Longitude	Trait2014
6N1	50.57667	1.43	44
6O2	50.56333	1.51	43
4L1	50.15667	0.9766667	60

Working Document to the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), April 2016

Not to be cited without prior reference to the author

Plaice (*Pleuronectes platessa*) and sole (*Solea solea*) in the UK Beam trawl survey in the Eastern English Channel (7d)

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Abstract

The present document describes the calculation of the plaice and sole survey indices in the Q3 UK beam trawl survey in the ICES division 7d. Further investigations were made in relation to the survey data quality, selection of prime stations, age-at-length keys and ultimately the indices calculations. Results for revisited index and previous index are shown in the present document to facilitate a better comparison and further inform on temporal differences to the year class abundance.

Survey indices

The present document describes the calculation of the plaice and sole indices in the UK Q3 beam trawl survey in the Eastern English Channel and Southern North Sea. The annual procedure is currently done automatically using the Cefas Fishing Survey System (FSS) and R software, and provides the index for the time-series since 1989 and 1996 (7d and 4c, respectively). Prior to 2016, survey indices were calculated using Cefas FSS, SAS code and Microsoft Excel® outputs. Whilst re-writing the code from SAS to R, discrepancies were found in the selection of valid primes used in the production of age-length keys (ALKs) and length-distributions (LDs), with survey data within Cefas FSS revisited and corrected accordingly, where possible. It should also be noted, current survey biological sampling targets (otoliths) for both species are set by sector (7d UK Inshore, 7d France Inshore and 4c North Sea), though previous indices had calculated ALKs by ICES rectangles.

Therefore, this document refers to an update of index calculations so that they are consistent with current survey data collection protocols. Data prior to 2005 presented for the 7d area should be viewed and used with some caution, since these data were not revisited and reviewed in terms of their quality, and historical data collection procedures may differ from the current one.

New results for survey area 4c were also provided to the 2016 ICES WGs, and although are not discussed in the present document, should be viewed only as provisional, because further investigations are required on the survey data and historical prime selection when current primes were not fished.

A total of 75 primes (39 in the UK and 36 in the FR sector), were selected from 1989-2015, with a few currently not fished, though historically relevant (Figure 1). Primes used for the length-distributions (LD) and fishing effort are within the UK sector, 22–27, 42–45, 47, 50–67, 73–75 and 94, with 1, 4, 6–12, 16–21, 29, 35–40, 68–72, 76–77 and 95 within the FR sector. Primes 2, 3, 5, 14, 15, 41 and 46 are included only in the age-length key (ALK) as they have not been fished in recent years, though historically were part of the survey primary grid. Similarly, only included in the ALKs calculations are primes 200, 201, 202 and 203 within the UK sector. These are set as additional and no longer fished since 2014, though historically, otoliths have been collected as part of the survey target. It should be noted that the prevalence of static gear around prime 49, currently on the main survey grid, has prevented the tow to be fished successfully in recent years. Therefore, data collected for the latter prime has been excluded from LDs and fishing effort, and only used as part of the ALK for the UK stratum.

R code procedures include an initial data retrieval from Cefas FSS, where data are electronically stored, for the relevant prime stations where fishing operations were considered valid. Numbers at length for each fishing station are standardized to 30 minute tows, with the raising factor dependent on the actual tow duration. The total number across stations within an ICES rectangle results in the LD for ICES rectangle within sector (UK and FR). The ALK derived from the biological sampling at sea (otolith collection) is produced separately by UK and FR sector and raised to the appropriate LDs, resulting in an age-length composition for each ICES rectangle-sector-sex combination. The ALKs and LDs for plaice are calculated by sex for all years, and for sole calculated by sex when measured and biologically sampled by sex (1993–2009), and combined when measured and biologically sampled unsexed (1989–1992, 2010–onwards). The LDs used are only from valid stations; meanwhile ALKs use all stations within the chosen primes, even when considered additional or invalid tows to accommodate the occasional biological sampling occurrence. The total numbers across lengths by age create the age composition (AC) for each ICES rectangle-sector-sex combination, with the sum as the AC for the survey year. These are divided by the total number of valid primes fished across UK and FR sectors, which may differ from the number of primes with plaice and/or sole catches. The results are further raised and multiplied by four to give the final index equivalent to one-hour tows with an 8-metre beam trawl (the factor four is because stations are standardised to 30 minute tows and conducted with a 4-metre beam trawl).

Furthermore, the R code is designed to reallocate, where possible, miss-matches where a fish at a given length has no associated record in the ALK, with code reallocating numbers at length (LD) up to a maximum of ± 2cm of the initial length. If there are age records either above or below the initial length group, the fish are reallocated to those respective length groups within the LD. However, if age records are found in both lengths above and below the initial length group, the fish are split between those two lengths groups, using the ratio of each value divide by the sum of both length groups. If code is unable to reallocate fish, data are not used for further index calculations.

Results

The revised survey indices for plaice and sole in 7d area are presented on Table 1 and 3. Previous index provided to the WG is presented on Table 2 and 4. A comparison between the two indices is presented on Figure 2 and 3 so as to better inform through visualization if there are any substantial temporal changes on year class abundance for fish aged one to six (ages currently used in the assessment).

Overall long-term trends for plaice are similar between the two indices for 1-year to 6-year class (Figure 2). Meanwhile, for sole, although the main increases and declines are being picked up by the two indices, there may be few discrepancies with historical data (e.g. 1999) (Figure 3).

References

R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

Table 1 – Revised index for plaice in the UK-7D BTS (1989 – 2015)

Age/Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	4.39	1.30	0.00	0.00	0.00	0.20	0.00	24.14	0.98	43.19	1.38	1.59	2.73	1.31
1	3.79	9.24	16.80	22.37	4.59	9.35	14.48	22.09	48.17	30.59	12.82	19.53	27.90	37.86
2	15.84	9.39	14.53	21.31	20.18	8.54	6.24	17.26	28.55	37.93	10.67	30.19	20.27	25.86
3	28.93	11.13	11.47	6.60	7.99	10.07	3.80	1.73	10.97	12.06	28.77	18.75	14.12	12.51
4	31.66	11.73	8.68	6.64	2.79	5.95	5.68	1.03	1.25	4.98	4.62	20.47	9.82	5.46
5	4.00	12.59	8.64	7.17	2.87	1.98	2.22	2.00	1.57	0.63	1.61	4.99	14.84	2.62
6	1.72	1.53	4.60	5.41	2.38	0.61	0.75	1.29	0.51	0.60	0.31	1.27	2.74	5.28
7	1.65	0.96	1.83	3.20	3.05	0.97	0.75	0.57	0.56	0.65	0.19	0.73	0.78	0.98
8	0.63	1.23	1.08	0.54	3.42	1.73	1.48	0.38	0.36	0.32	0.26	0.38	0.45	0.20
9	0.31	1.02	0.11	0.28	0.62	1.78	1.17	0.66	0.20	0.30	0.13	0.44	0.32	0.17
10 +	1.75	0.63	1.14	0.79	0.65	0.80	1.36	4.13	1.84	2.03	1.01	2.04	1.79	0.90
Total (ages 1-10+)	90.27	59.44	68.87	74.30	48.53	41.77	37.93	51.12	93.98	90.10	60.39	98.79	93.04	91.83
Age/Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
0	3.20	15.97	0.34	5.58	0.23	0.13	8.76	1.36	12.30	0.00	0.22	0.52	0.00	
1	10.62	52.93	15.62	30.06	53.11	39.58	77.73	64.24	115.07	24.69	32.26	145.33	37.99	
2	39.70	22.48	36.18	28.85	28.90	40.58	39.53	64.70	112.22	81.10	61.02	156.47	178.70	
3	9.81	20.72	12.80	16.80	12.17	10.51	20.92	17.74	39.55	55.98	88.19	50.67	63.19	
4	4.42	4.75	10.04	5.94	6.21	4.29	5.87	9.15	10.28	18.65	45.04	62.13	30.15	
5	2.28	1.15	3.19	4.27	3.17	3.84	3.23	3.12	7.00	4.24	10.24	26.75	33.42	
6	1.14	0.26	1.07	1.31	2.90	1.80	2.27	1.72	2.85	3.30	3.41	8.95	15.69	
7	2.67	0.84	0.64	1.08	0.82	0.90	0.77	1.27	1.09	1.06	1.13	1.96	3.30	
8	0.81	1.27	0.43	0.59	0.59	0.67	1.30	0.18	0.34	0.90	1.08	1.82	1.21	
9	0.20	0.23	0.99	0.33	0.19	0.16	0.33	0.35	0.70	0.66	0.13	0.92	0.27	
10 +	0.47	0.55	0.98	0.94	1.59	0.39	1.19	0.99	1.05	0.95	0.92	1.20	0.44	
Total (ages 1-10+)	72.12	105.18	81.96	90.17	109.64	102.73	153.13	163.47	290.15	191.52	243.43	456.19	364.37	

Table 2 – Previous index for plaice in the UK-7D BTS (1989 – 2014)

Age/Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	2.31	5.16	11.75	16.53	3.22	8.33	11.32	13.20	33.15	11.38	11.30	13.19	17.91
2	12.13	4.86	9.06	12.54	13.40	7.46	4.06	11.90	13.48	27.30	14.10	20.96	13.02
3	16.63	5.76	6.98	4.19	4.96	9.17	3.00	1.30	4.22	6.99	15.90	14.39	10.00
4	19.94	6.70	5.30	4.17	1.75	5.56	3.67	0.70	0.65	3.12	2.90	13.81	7.12
5	3.30	7.53	5.43	5.57	1.89	1.95	1.49	1.30	0.34	0.32	1.00	3.48	10.94
6	1.48	1.76	3.20	4.88	1.57	0.77	0.58	0.90	0.32	0.22	0.20	0.87	1.95
7	1.32	0.65	1.22	3.44	2.05	0.90	0.59	0.40	0.24	0.15	0.10	0.57	0.53
8	0.54	0.97	0.99	0.66	2.78	1.83	1.32	0.30	0.21	0.11	0.30	0.18	0.30
9	0.30	0.75	0.06	0.49	0.39	1.24	0.82	0.40	0.17	0.05	0.10	0.43	0.19
10 +	1.65	0.37	1.24	0.72	0.57	0.81	0.78	2.80	1.86	0.98	0.90	1.52	0.99
Total (ages 1-10+)	59.60	34.51	45.23	53.19	32.57	38.03	27.63	33.20	54.64	50.62	46.80	69.40	62.94
Age/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	20.66	6.18	36.18	10.84	17.21	42.61	30.28	71.62	65.25	105.55	23.23	34.33	153.63
2	15.95	22.79	14.97	31.21	16.11	18.81	26.52	42.88	63.83	95.31	76.07	59.27	140.96
3	7.73	6.00	13.15	13.77	9.22	8.70	7.20	19.15	17.27	35.70	45.26	87.99	50.67
4	3.55	2.94	3.44	10.28	3.35	3.87	2.97	5.74	8.90	9.25	12.73	45.47	55.50
5	1.80	1.61	0.91	2.95	2.64	1.75	2.32	3.20	3.04	6.68	3.53	10.58	25.08
6	3.46	0.79	0.16	1.17	0.77	1.95	1.11	2.17	1.90	2.82	1.61	3.54	9.13
7	0.72	1.77	0.66	0.77	0.57	0.80	0.50	0.78	1.38	1.40	0.42	1.03	2.32
8	0.14	0.60	1.16	0.42	0.31	0.30	0.41	1.24	0.30	0.19	0.41	1.37	1.88
9	0.11	0.11	0.17	0.86	0.14	0.10	0.09	0.37	0.36	0.57	0.43	0.14	1.01
10 +	0.61	0.28	0.17	0.65	0.46	1.11	0.25	1.31	0.89	0.95	0.12	0.20	1.36
Total (ages 1-10+)	54.71	43.06	70.97	72.91	50.79	80.01	71.66	148.46	163.10	258.41	163.82	243.92	441.55

Table 3 – Revised index for sole in the UK-7D BTS (1989 – 2015)

Age/Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0.16	0.00	0.00	0.00	0.00	0.00	0.06	5.55	0.06	0.13	2.56	0.00	1.27	0.00
1	3.01	17.96	12.14	1.33	0.82	8.33	5.89	5.30	24.75	3.27	35.99	14.98	10.19	53.56
2	22.09	5.55	31.17	15.29	22.96	4.26	16.09	10.79	10.85	24.11	8.22	27.45	27.88	16.11
3	4.62	5.55	3.19	13.47	11.42	11.07	2.22	5.97	4.42	3.67	11.33	5.52	11.55	8.60
4	2.45	1.24	2.82	1.07	9.97	4.65	3.51	1.07	1.94	1.47	1.59	4.85	1.67	5.11
5	0.56	1.01	0.48	1.61	1.14	4.30	1.67	1.86	0.26	0.83	0.73	1.48	2.33	0.45
6	0.35	0.33	0.67	0.34	1.52	0.28	2.12	1.15	0.82	0.19	1.02	0.68	0.75	1.04
7	0.26	0.06	0.16	0.50	0.34	0.90	0.28	1.55	0.52	0.37	0.19	0.34	0.63	0.59
8	0.05	0.15	0.20	0.11	0.34	0.09	0.53	0.20	0.96	0.08	0.54	0.00	0.48	0.17
9	0.00	0.00	0.07	0.30	0.07	0.46	0.20	0.65	0.07	0.13	0.43	0.34	0.12	0.00
10 +	0.72	0.16	0.26	1.11	0.40	0.46	0.32	0.59	0.62	0.35	0.54	1.06	0.86	0.72
Total (ages 1-10+)	34.11	32.00	51.14	35.15	48.98	34.80	32.84	29.14	45.21	34.48	60.59	56.70	56.46	86.36
Age/Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	
1	11.03	12.67	43.27	10.84	2.57	3.77	51.25	16.59	13.66	1.75	0.72	25.39	25.24	
2	45.65	11.81	6.91	42.62	28.97	7.35	19.16	30.76	28.60	9.72	8.91	16.35	21.36	
3	5.87	10.97	3.50	4.51	15.45	9.14	7.10	5.14	14.70	7.51	15.09	12.38	6.04	
4	3.20	2.08	5.18	2.68	1.47	5.82	5.81	1.66	1.66	3.53	9.72	11.92	2.29	
5	2.05	2.02	1.90	2.59	1.04	0.40	5.02	2.70	0.54	0.92	3.23	5.09	4.51	
6	0.42	1.34	1.15	0.55	1.56	0.68	0.44	2.73	2.62	0.39	1.12	2.73	2.08	
7	0.55	0.41	0.71	0.47	0.44	0.37	0.31	0.33	0.77	0.78	0.51	1.08	2.20	
8	0.27	0.64	0.08	0.66	0.21	0.37	0.63	0.06	0.24	0.67	0.89	0.32	0.20	
9	0.03	0.26	0.36	0.00	0.55	0.25	0.26	0.49	0.19	0.00	0.78	0.20	0.00	
10 +	0.92	0.88	0.35	0.40	0.53	0.26	0.59	0.31	0.12	0.70	0.17	0.70	0.67	
Total (ages 1-10+)	69.99	43.08	63.40	65.32	52.79	28.41	90.58	60.78	63.11	25.97	41.13	76.15	64.60	

Table 4 – Previous index for sole in the UK-7D BTS (1989 – 2014)

Age/Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	2.60	12.10	8.90	1.40	0.50	4.80	3.50	3.50	19.00	2.00	28.14	10.49	9.09
2	15.40	3.70	22.80	12.00	17.50	3.20	10.60	7.30	7.30	21.20	9.44	22.03	21.01
3	3.40	3.40	2.20	10.00	8.40	8.30	1.50	3.80	3.20	2.50	13.17	4.15	8.36
4	1.70	0.70	2.30	0.70	7.00	3.30	2.30	0.70	1.30	1.00	2.51	4.24	1.20
5	0.60	0.80	0.30	1.10	0.80	3.30	1.20	1.30	0.20	0.90	1.73	1.03	1.91
6	0.20	0.20	0.50	0.30	1.00	0.20	1.50	0.90	0.50	0.10	1.28	0.58	0.54
7	0.20	0.10	0.10	0.50	0.30	0.60	0.20	1.10	0.40	0.30	0.16	0.28	0.57
8	0.00	0.20	0.20	0.10	0.20	0.10	0.30	0.10	0.90	0.00	0.93	0.03	0.35
9	0.00	0.00	0.10	0.20	0.00	0.30	0.20	0.50	0.00	0.10	1.07	0.24	0.04
10 +	0.70	0.00	0.10	0.60	0.40	0.30	0.30	0.40	0.70	0.30	0.47	1.20	1.01
Total (ages 1-10+)	24.80	21.20	37.50	26.90	36.10	24.40	21.60	19.60	33.50	28.40	58.89	44.28	44.09
Age/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	31.76	6.47	7.35	25.00	6.30	2.14	2.86	30.54	15.90	11.92	1.77	0.78	25.53
2	11.42	28.48	8.49	5.04	29.18	21.86	6.46	13.33	30.12	23.54	9.28	9.20	13.93
3	5.42	4.13	7.71	2.86	2.83	12.90	7.24	5.44	5.32	11.56	6.57	15.54	9.87
4	3.45	2.46	1.57	3.47	1.99	1.22	4.82	4.34	1.66	1.25	3.41	8.91	11.31
5	0.27	1.58	1.45	1.63	1.95	0.80	0.25	3.76	2.82	0.57	0.88	2.95	5.22
6	0.71	0.30	0.99	1.02	0.34	1.20	0.49	0.37	2.38	2.56	0.39	1.35	3.52
7	0.44	0.39	0.20	0.66	0.44	0.32	0.38	0.20	0.35	0.60	0.66	0.37	1.40
8	0.09	0.20	0.44	0.06	0.57	0.17	0.27	0.31	0.16	0.16	0.52	0.97	0.85
9	0.00	0.07	0.21	0.31	0.00	0.59	0.24	0.23	0.55	0.21	0.00	0.75	0.23
10 +	0.56	0.52	0.57	0.35	0.34	1.02	0.20	0.48	0.31	0.06	0.66	0.10	0.26
Total (ages 1-10+)	54.12	44.60	28.98	40.40	43.93	42.22	23.21	59.01	59.56	52.44	24.16	40.92	72.11

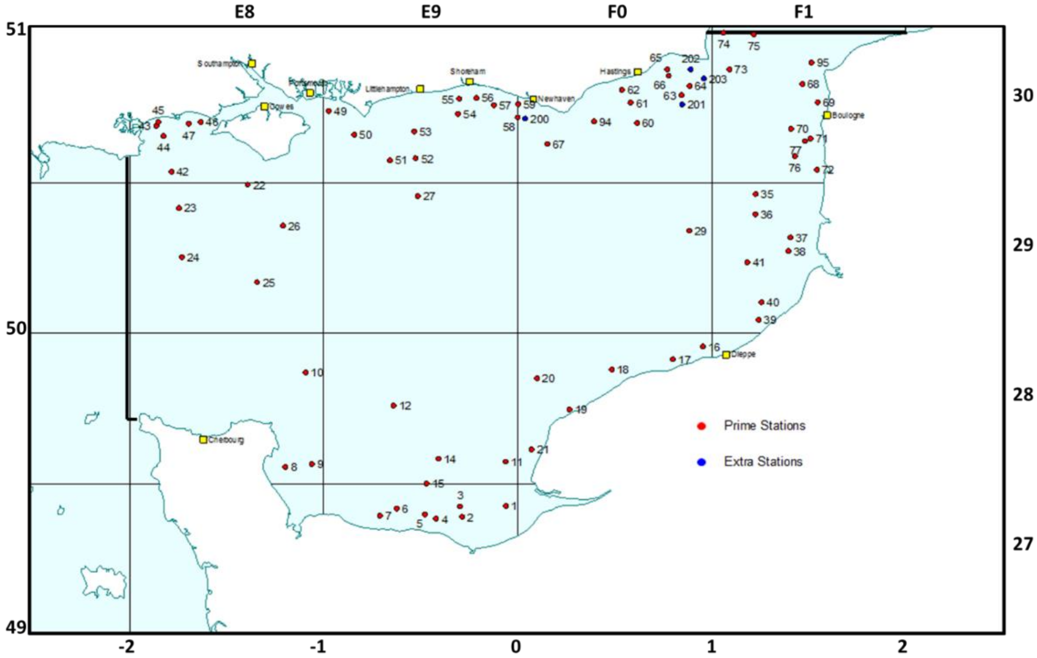

Figure 1 – Prime stations for Q3 UK beam trawl survey for survey index calculation (1989 – 2015)

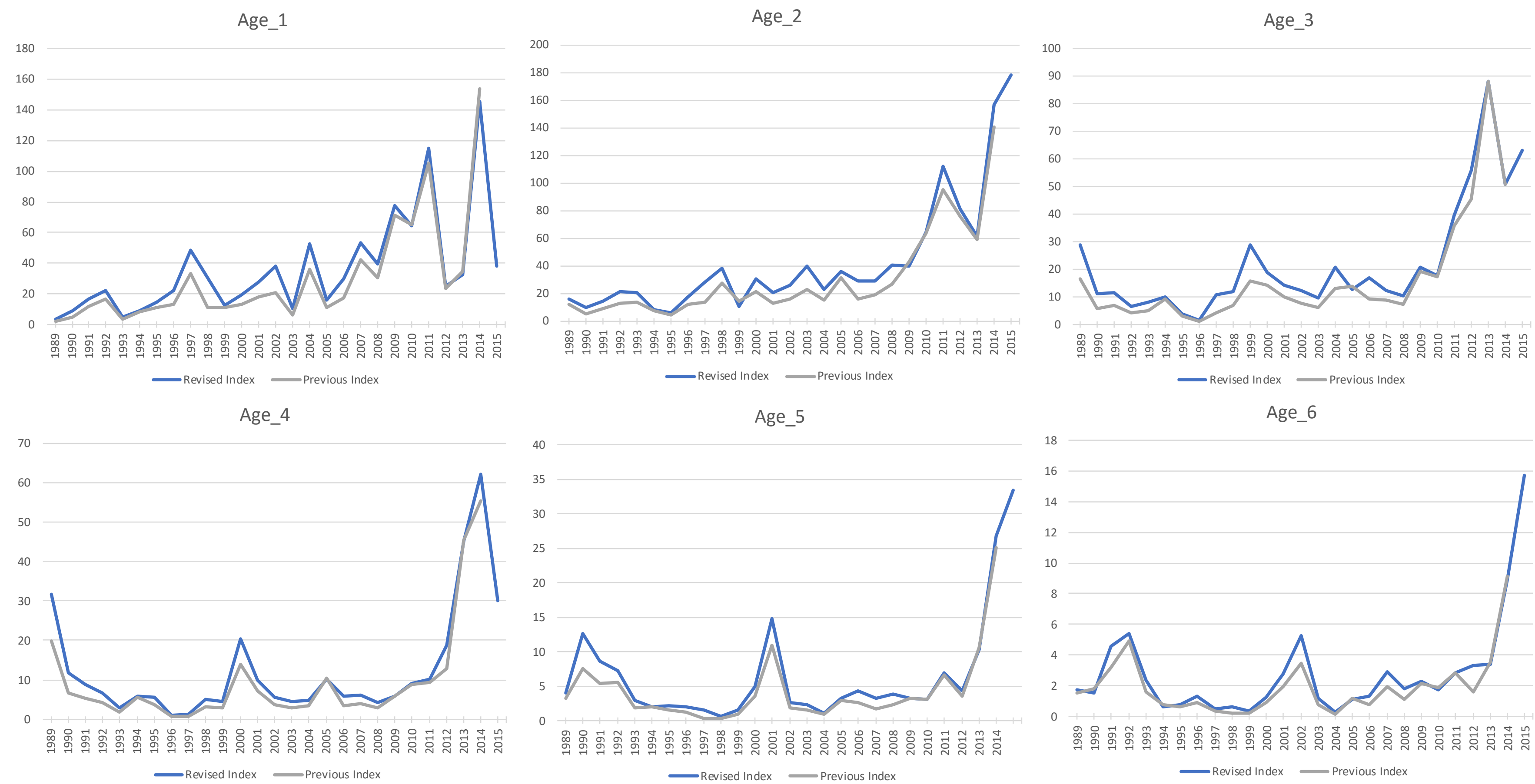

Figure 2 – Long-term trends of plaice survey index in the UK – 7D BTS (revised and previous index) for 1-year to 6–year class.

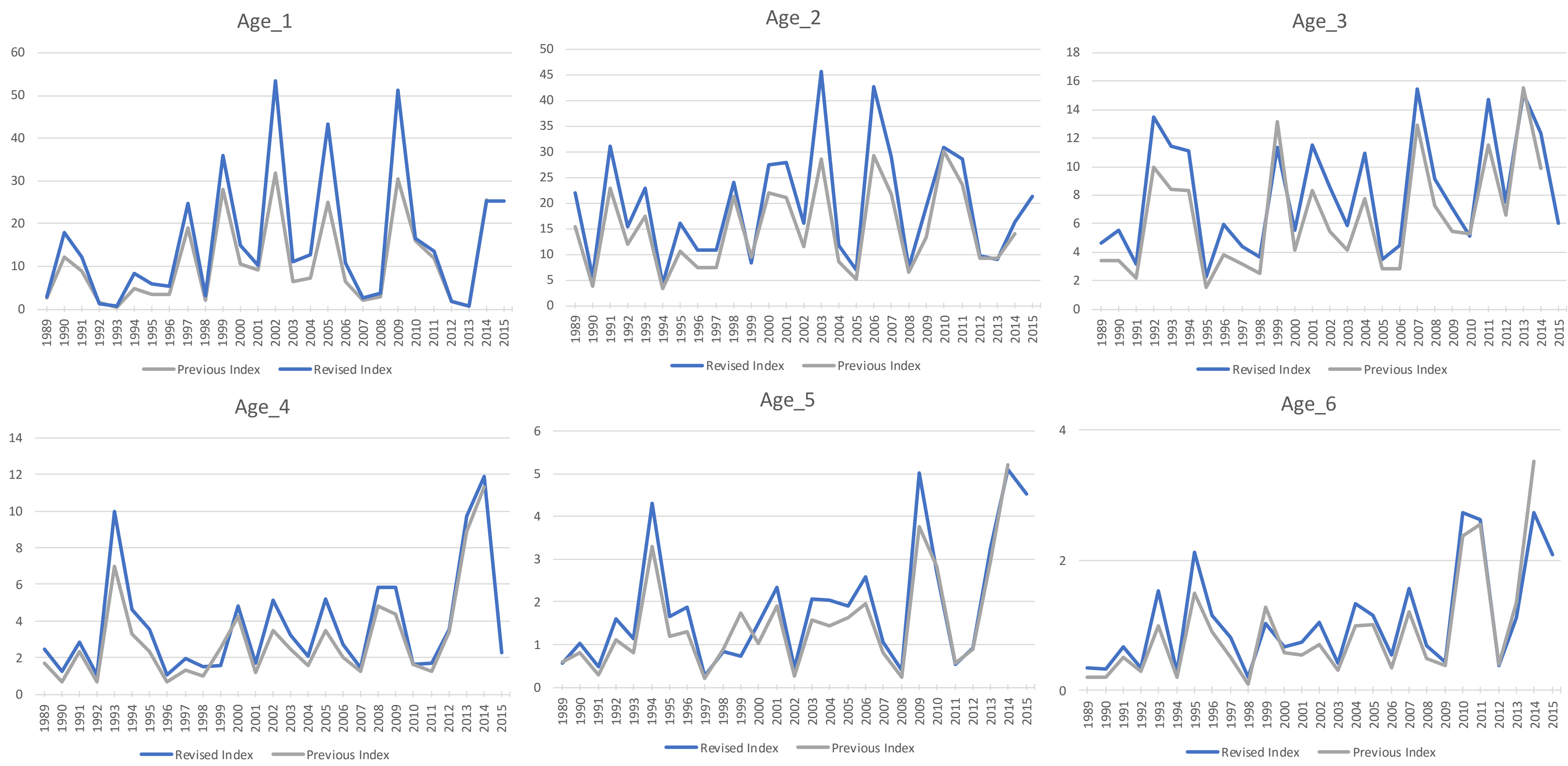

Figure 3 – Long-term trends of sole survey index in the UK – 7D BTS (revised and previous index) for 1-year to 6–year class.

WD 8: SAM Assessment – AMENDMENT

WGNSSK had some concerns about the saithe assessment model.

- Running the forecast with the benchmark-approved model resulted in unrealistically high increases in TAC for the advice (119% increase, MSY approach). The working group asked to review the model with only the standardized combined cpue index tuned to the exploitable biomass.
- A model using both the standardized combined cpue index (FBI) and the IBTS Q3 survey was put forward as an alternate model. Because this model diverges from the cpue-only model, properties of the survey were investigated (e.g., internal consistency, cross-consistency with other data, coverage).
- This prompted a more thorough exploration of the survey data to:
  - Determine if spatial changes had occurred in the survey that could be the result of fish moving in and out of the survey area (unrelated to stock size).
  - Investigate the Q3 index models.
    - Include a ship effect to determine whether a newly added ship at the end of the time series might be causing the problem (e.g., Dana in Skagerrak).
    - Modify the spatial grid over which the indices are estimated so that it is roughly representative of the population (do not include large areas where there are almost no saithe). Two potential indices were explored: one that removed the Skagerrak/Kattegat and southern North Sea (south of 57° N); one that kept the Skagerrak but removed the Kattegat and southern North Sea.
    - Investigate consistencies for each model option.
  - Determine the effect of various age groups.
- There were questions regarding the use of SAM vs. XSA. Discussions via email may have put this option to rest, but are summarized as:
  - When XSA and SAM are run with the same datasets, the XSA results fall more-or-less within the confidence limits of SAM (Figure 1).
  - Reverting to XSA would actually hamper our ability to investigate the uncertainties arising from the different datasets.
  - The 3 cpue indices get a very high weight and the IBTS q3 has hardly any influence; this hides the issue that the assessment relies nearly entirely on the commercial indices.
  - Would need to revert back to the age-based cpue indices because XSA cannot handle the combined standardized index, that is fit to the exploitable biomass (within the model). This reverts back to the issue of using the age information twice – once for the catch data, once for the cpue tuning indices.
  - The XSA cannot handle the correlation between ages with years in the survey indices; SAM can, as outlined in Berg & Nielsen (2016).

A bug in InterCatch resulted in the re-raising of discards for 2003, 2006, 2011, and 2014, which were done following the procedure in WD 5; 2002 was also re-raised as it seemed oddly high. After re-raising the data, several years still appeared to be atypical, so the raising for all years was re-done following a modification to the rules used for the benchmark:

- No discard ratio >= 25% was used in the raising of any fleet. Previously, ratios > 30% were omitted.
- Norwegian trawler fleet discards were raised using German or French (or both) discard information. Previously, they were raised with other OTB_DEF fleets, using discard information from all OTB_DEF fleets for a given area and quarter.

Results

Spatial changes in the surveys

Spatial plots of the catches (all ages combined) showed that, for the Q1 survey, saithe were mainly on the shelf edges and the survey was unlikely to be sampling much of the population (see Appendix: Q1 plots are catch weight per station per year, not age specific). At the time of the benchmark, this was discussed, but it was thought that, for the older ages, the amount of the population surveyed should be fairly consistent over time. A month parameter had been added to the delta-GAM model to account for changes in survey timing and any effect of fish movement in and out of the survey area. However, closer inspection of the figures showed that, in some years, fish are found further up on the shelf, while in other years, they are only along the shelf boundary (200 m contour). This does call into question using the Q1 index in the assessment.

For the Q3 surveys, saithe are found on the northern part of the shelf, along the shelf boundary, and in the Skagerrak (see Appendix: Q3 plots are catch weight per station per year, not age specific). The amount of saithe found within the area differs, but the distribution appeared fairly consistent. Stronger year classes are, for the most part, appearing in the survey when expected and persisting for at least 1 year (e.g., 1995, 2001, 2005).

Q3 index models

A ship effect was included in the index estimation. Sweden had begun using a new vessel in 2011 in the Skagerrak. Including ship in the model resulted in a higher AIC and BIC, and slightly worse internal consistencies (Tables 1, 2).

The spatial grid was truncated to a) exclude the area east of 8° E and south of 57° N, i.e., Skagerrak/Kattegat and southern North Sea information were removed, and b) exclude south of 57° N and the Kattegat (but include the Skagerrak). Saithe are not found in the southern North Sea; excluding this area mainly truncates the zeros and keeps the spatial spline of the GAM model from attempting to put fish where they are typically not found. Mainly young fish (the ages not included in the assessment model) are found in the Skagerrak, but the German fleet fishes in this area; therefore, datasets including and excluding this region were trialed. Ship was included in the final model.

Truncating the spatial area improved the model fit (Table 1). Removing the Skagerrak improved the fit of the model the most, but the indices were larger for a given age class and more variable for many of the age classes, especially at the beginning of the time series (Figure 2). Average internal consistencies were higher for the model including the Skagerrak, but the fit was not as good as the model excluding the Skagerrak (Tables 1, 2). Figure 3 shows the internal consistency plot, as given by FLR (note: correlations are reported differently using FLR); there is no evidence in the internal consistencies that something has gone wrong in the survey. The time series of indices by age (including confidence intervals and comparison to the DATRAS indices) for the full survey area, excluding the southern North Sea and Skagerrak/Kattegat, and excluding the southern North Sea and Kattegat are in Figures 4-6.

The effect seen at the start of the time series cannot be due to ship; it would have been captured within the model or also seen from 2001, when Sweden changed its research vessel. The indices (all ages) with and without the Skagerrak show similar trends and values.

Until 2003, Sweden did not take age samples, only lengths. This resulted in the age-length key for the North Sea (subarea 4) being applied to the Skagerrak. Whether fish in the Skagerrak were different from the North Sea was not thoroughly investigated, so it is questionable whether the age-length key from the North Sea should be applied to the Skagerrak. In addition, Sweden did not survey in 2000; this year had incomplete coverage of the entire survey area. Finally, the Skagerrak was never included in the old index estimation (in DATRAS). There is no documentation of why the Skagerrak was included and the IBTSWG was unable to answer this question.

Survey properties

Internal consistencies

Internal consistencies for the Q3 survey are decent, although slightly poorer for age 3 vs. age 4 (Table 2, Figure 3). There is no evidence in the internal consistencies that something has gone wrong in the survey.

Cross consistency with other data sources

Despite the Q1 survey having limited coverage of the stock, the external consistencies between the Q3 and Q1 (in the following year and age), as well as catch numbers at age, were used to see if tracking of cohorts was possible (Table 3). Cohorts can be tracked between surveys (and ages). The external consistencies are not as strong when comparing the catch numbers at age with the Q3 index, however, they still track cohorts reasonably well. The external consistency for age 4, the age when fish are expected to be fully recruited to the fishery, is the lowest of all the age class comparisons.

Coverage

The amount of saithe found within the survey area differs between years, but the distribution has not changed over the time period. Stronger year classes are, for the most part, appearing in the survey when expected and persisting for at least 1 year. The increase in the last 2 years appears to be related to stronger recruitment.

Effect of age groups and research surveys on the assessment

Only the Q3 index was used to assessing the influence of the different age classes. The decision was made that it is not appropriate to continue to include the Q1 indices in the assessment model (see above).

Q3 indices without truncating spatial grid or including ship in the model

The assessment results when including only the Q3 + FBI indices show SSB in the final years not as optimistic as the model including the Q1 index (Figure 7). It is, however, much more optimistic than the FBI-only model or the model using the DATRAS-estimated indices for ages 3-5. When looking at the effect of removing the oldest age classes one at a time, ages 5-8 have the largest effect on the assessment outcome (Figure 8). Using only the age ranges 3-4 or 3-9 has a large effect on the estimated SSB; ages 3-9 result in a lower SSB over the entire time series, while using only ages 3-4 has a mixed effect (lower SSB after 2010). The effect of changing the age range on F_{bar} and recruitment are shown in Figure 9.

Q3 indices with truncation of spatial grid + including ship in model

Figure 10 shows the effect of the Q3 (without Skagerrak) index on assessment model outputs. SSB and F are much closer to the DATRAS outputs and below that of the previous Q3 indices. Figures 11 and 12 detail the effects of changing the age range included in the Q3 index on SSB, $F_{4\text{-}7}$, and recruitment.

The effect of the Q3 with Skagerrak indices on the assessment model are in Figure 10. Including the Skagerrak in the Q3 index resulted in output that was similar to the model using the Q3 indices estimated from the entire North Sea dataset (Q3 + FBI model). Figures 13 and 14 show the effect of changing the age range included in the model on SSB, $F_{4\text{-}7}$, and recruitment.

Discard estimation

The change in discard amounts are in Table 4. The years that had the greatest percentage difference due to the modifications noted above were the years that had very few reported discards; Norwegian discards had to be estimated using poor data. Norway takes 50% of the catch and this therefore resulted in high raised discards amounts. Because there is no information on the discarding practices of Norwegian fleets, the truth is expected to lie somewhere between estimate (3) and estimate (2); these estimates should be treated as upper and lower bounds on discards. It is doubtful that Norwegian discards are at the low levels estimated in option 3. However, when low recruitment is seen (2008–2010), discards should be low. This is seen in Table 3 using raising option (3), but not in option (2). While raising option (3) may be under-estimating discards, it appears to be more likely than option (2).

The comparison of assessments (old raising procedure vs. option (3)) for the benchmark model (FBI + Q1 + Q3), FBI index-only model, and new Q3 model, where the Skagerrak/Kattegat/southern North Sea were truncated from the spatial grid are in Figures 15-17. Results of all 3 models using revised discards data are in Figure 18.

Retrospectives using the newly estimated catch are in Figure 19 for the benchmark model (FBI + Q1 + Q3) without discard revisions. Figure 20 is the benchmark model including discard revisions, Figure 21 is the FBI-only model (including discards revisions), and Figure 22 for the FBI+ new Q3 model (including discard revisions). The retrospective pattern is much worse for the benchmark model with the revised catch information. The retrospective pattern in F is particularly bad. The model with only the exploitable biomass index shows the best performance in the retrospective analysis.

All models converge to approximately similar F and SSB values for the 2005-2010 period (Figure 18). Therefore, by going back with the retro analysis before 2010 gives an idea which assessment would have been more in line with the final converged values. The assessment with FBI as only index would have assessed F around the converged values for 2005-2010. The retrospective indicates all other models would have assessed F well above the converged values for this period (with the FBI + new Q3 model being the worst)In recent years the retro patterns became less, however each of the assessments show F at a different level. It remains unclear whether the current FBI only assessment will be again closer to the converged estimates in a few years. Reference points and catch option tables are in the Appendix for the 3 models with revised catch information.

Conclusions

The Q1 index should not be included as a tuning series because the survey does not adequately cover the distribution of saithe. Saithe are spawning on the slope and their movement into (or out of) the survey area does not appear to be linked to recruitment or expected abundance.

For the Q3 index, the spatial distribution of saithe has not changed within the survey area. Truncating the spatial grid to be remove the southern North Sea (where saithe are not found) and the Skagerrak should be done. The arguments for excluding the Skagerrak include: no age-length key in the Skagerrak until after 2003, incomplete coverage of the survey area due to Skagerrak not surveyed in 2000, and exclusion of the Skagerrak in the previous (DATRAS) index estimation (even though the reason is not known).

Removing the Skagerrak and southern North Sea resulted in a less optimistic assessment when compared to the benchmark model. The assessment using Q3 indices that included the Skagerrak, but removing the Kattegat and southern North Sea, was (not surprisingly) similar to the benchmark assessment. The data from the Skagerrak appears to be creating an issue with the index estimation. The reason for this is not clear (biological or a survey effect, due to the lack of age information from this area). The reason for the large discrepancy in the indices including/excluding the Skagerrak for the beginning of the series should be investigated in the near future.

Because Norway lacks information on discards and takes 50% of the catch, the raising of discards in InterCatch must be handled carefully. Raising discards for the Norwegian trawlers based on reported discards from the French and German trawlers may result in underestimating the discards, but it is the best information available at this time. Germany, France and Norway have a targeted saithe fishery. Fisheries in countries like Scotland and Denmark are mixed demersal fisheries with higher discard rates compared to the sampled fisheries targeting saithe.

The pre-benchmark assessment included the Q3 indices for ages 3-5. The internal consistencies, coverage, and comparison with other data all show no reason to exclude the survey from the assessment. It is only in the last two years that the assessment has shown SSB is higher than the cpue-only model; prior to 2013, the cpue-only model had consistently higher SSB (Figure 18). There is a lot of uncertainty in the assessment regardless of the model chosen. The choice of survey data to include should be based on the properties of that survey (e.g., internal consistency, cross-consistency with other data, coverage).

The retrospective patterns, particularly for F, were very poor, especially for the assessments with IBTS data included. This is worrying as it casts doubt on our ability to assess the stock should conditions change again. Furthermore, the cause for the poor ability to estimate F is unknown (and could occur again). There is some doubt that the FBI + new Q3 model is the better model compared to the FBI-only model in light of the retrospective patterns.

Keeping the stipulation from the EU-Norway management plan, where the TAC is not allowed to deviate by more than 15% from the TAC in the previous year should protect the stock from the uncertainty in the assessment. Furthermore, including catch options based on probabilistic forecasts, e.g., 5% and 25% probability of being above F_{MSY} and F_{lim}, is another option for dealing with the uncertainty in the assessment.

Table 1. Model diagnostics for the Q3 indices. The models are the benchmark model (no truncation of spatial grid); benchmark model including Ship (no truncation of spatial grid); removing the Skagerrak/Kattegat and southern North Sea and including Ship; removing the Kattegat and southern North Sea and including Ship.

Model	AIC	BIC	IC (all ages)
Year+s(lon,lat)+s(Depth)+ HaulDur	34460	42834	0.3948
Year+Ship+s(lon,lat)+s(Depth)+HaulDur	34274	43476	0.4358
Truncated spatial range (57°N, 8°E): Year+Ship+s(lon,lat)+s(Depth)+HaulDur, ages 1-10	28122	36032	0.40527
Truncated spatial range (57°N, no Kattegat): Year+Ship+s(lon,lat)+s(Depth)+HaulDur, ages 1-10	32565	40590	0.4264

Table 2. Internal consistencies between ages classes for the four different Q3 indices.

Model/Data	IC	Average IC all ages	Average IC ages 3–8
Benchmark model: Year+s(lon,lat)+s(Depth)+ HaulDur, ages 0-10	Age 0 vs. 1 : 0.3231104 Age 1 vs. 2 : -0.1937066 Age 2 vs. 3 : 0.03960032 Age 3 vs. 4 : 0.4954253 Age 4 vs. 5 : 0.7447504 Age 5 vs. 6 : 0.7943942 Age 6 vs. 7 : 0.750217 Age 7 vs. 8 : 0.6407721 Age 8 vs. 9 : 0.4044236 Age 9 vs. 10 : -0.05130193	0.3948	0.6851
Benchmark model + Ship: Year+Ship+s(lon,lat)+s(Depth)+HaulDur, ages 0-10	Age 0 vs. 1 : 0.4646722 Age 1 vs. 2 : -0.1081123 Age 2 vs. 3 : 0.05023302 Age 3 vs. 4 : 0.4406976 Age 4 vs. 5 : 0.7406408 Age 5 vs. 6 : 0.8363853 Age 6 vs. 7 : 0.7676941 Age 7 vs. 8 : 0.5378916 Age 8 vs. 9 : 0.3850141 Age 9 vs. 10 : 0.2426996	0.4358	0.6647
Truncated spatial range (no Skagerrak/Kattegat or southern North Sea): Year+Ship+s(lon,lat)+s(Depth)+HaulDur, ages 1-10	Age 1 vs. 2 : 0.4287579 Age 2 vs. 3 : 0.1669562 Age 3 vs. 4 : 0.3777139 Age 4 vs. 5 : 0.759958 Age 5 vs. 6 : 0.7629555 Age 6 vs. 7 : 0.7211942 Age 7 vs. 8 : 0.6095779 Age 8 vs. 9 : 0.08241081 Age 9 vs. 10 : -0.262115	0.4053	0.6463
Truncated spatial range (no Kattegat or southern North Sea): Year+Ship+s(lon,lat)+s(Depth)+HaulDur, ages 1-10	Age 1 vs. 2 : -0.3264555 Age 2 vs. 3 : -0.02738525 Age 3 vs. 4 : 0.4273828 Age 4 vs. 5 : 0.7532319 Age 5 vs. 6 : 0.8270072 Age 6 vs. 7 : 0.7994671 Age 7 vs. 8 : 0.6195003 Age 8 vs. 9 : 0.3514482 Age 9 vs. 10 : 0.4138057	0.4264	0.6853

Table 3. External consistencies between Q3 (ages 1-9, 1992-2014) and Q1 (year+1, age+1), and between catch numbers at age and Q3 (in the same year). This is identifying if cohorts can be tracked from Q3 to the next survey in Q1. Numbers in bold refer to the ages included in the IBTS Q3 tuning index in the assessment model.

External consistencies: Q3 vs. Q1	External consistencies: catch vs. Q3
Q3 Age 1 vs. Q1 Age 2 : 0.3218696	Catch Age 1 vs. Q3 1 : -0.0165032
Q3 Age 2 vs. Q1 Age 3 : 0.4586471	Catch Age 2 vs. Q3 2 : -0.1492027
Q3 Age 3 vs. Q1 Age 4 : 0.8203473	Catch Age 3 vs. Q3 3 : 0.5044318
Q3 Age 4 vs. Q1 Age 5 : 0.8739198	Catch Age 4 vs. Q3 4 : 0.3768049
Q3 Age 5 vs. Q1 Age 6 : 0.8839688	Catch Age 5 vs. Q3 5 : 0.5894862
Q3 Age 6 vs. Q1 Age 7 : 0.7743481	Catch Age 6 vs. Q3 6 : 0.5557922
Q3 Age 7 vs. Q1 Age 8 : 0.696888	Catch Age 7 vs. Q3 7 : 0.5059279
Q3 Age 8 vs. Q1 Age 9 : 0.625716	Catch Age 8 vs. Q3 8 : 0.4097457
Q3 Age 9 vs. Q1 10 : 0.4047001	Catch Age 9 vs. Q3 9 : 0.05872988
	Catch Age 10 vs. Q3 10 : 0.4557988

Table 4. Amount of discards (estimated and reported) following 3 procedures: (1) as outlined in WD-5 during the benchmark, (2) after fixing the bug in InterCatch (bolded years), and (3) after the modification noted above. Differences are percentage.

Year	2015 assessment	(1) Benchmark estimate	(2) InterCatch bug correction	(3) Modification to Norway & reduced ratio estimate	Reported	Difference 2015 to (1)	Difference (1) to (2)	Difference (2) to (3)
2002		24812	21620	21544	21440	100	-13	0
2003		26377	12898	11438	11044	100	-51	-11
2004		9600	9656	8088	7850	100	1	-16
2005		8571	8571	8196	8072	100	0	-4
2006		15950	9498	8585	8340	100	-40	-10
2007		12050	12078	12413	11353	100	0	3
2008		9436	9436	8359	7891	100	0	-11
2009		14216	14216	4296	4170	100	0	-70
2010		10937	10937	4484	3009	100	0	-59
2011		12729	4951	4362	4285	100	-61	-12
2012	7585	9415	9415	9278	7471	24	0	-1
2013	8083	8173	8173	7777	7311	1	0	-5
2014	6289	6362	6356	6337	6068	1	0	0
2015		5060	5060	5003	4914		0	-1

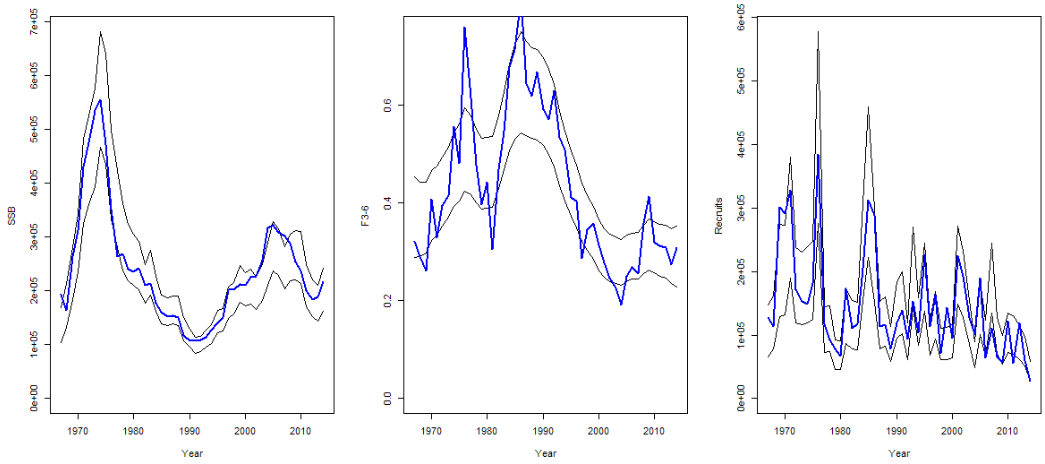

Figure 1. Comparison of the 2015 assessments. Blue lines: XSA assessment results. Black lines: 95% confidence interval of SAM assessment.

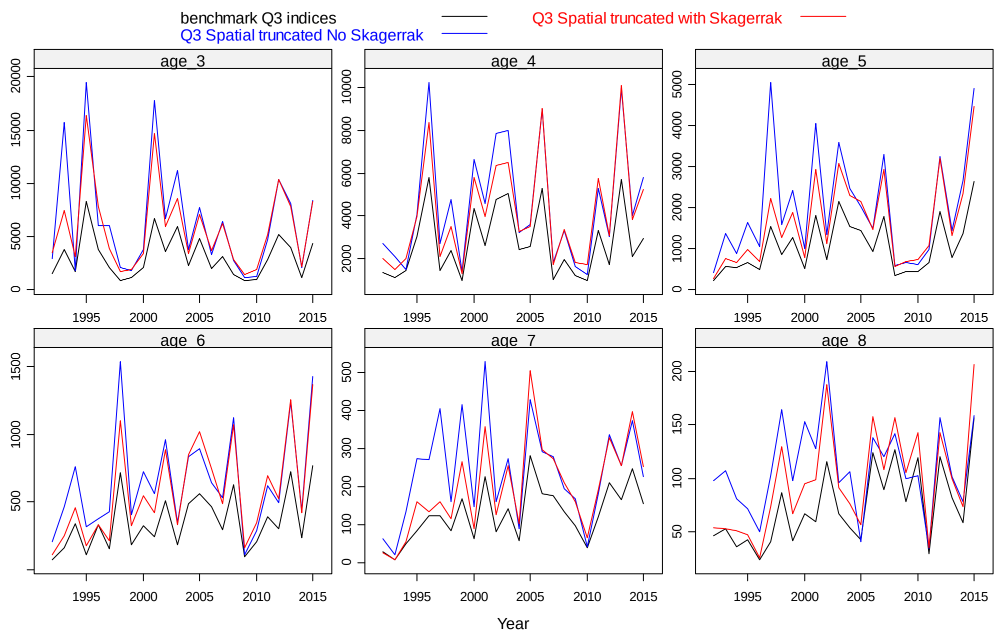

Figure 2. Comparison of IBTS Q3 indices, 1992-2015. Black lines: benchmark Q3 indices (no spatial truncation, without 'Ship' in model); blue lines: truncated spatial grid (No Skagerrak) + 'Ship' in model; red lines: truncated spatial grid (including Skagerrak) + 'Ship' in model.

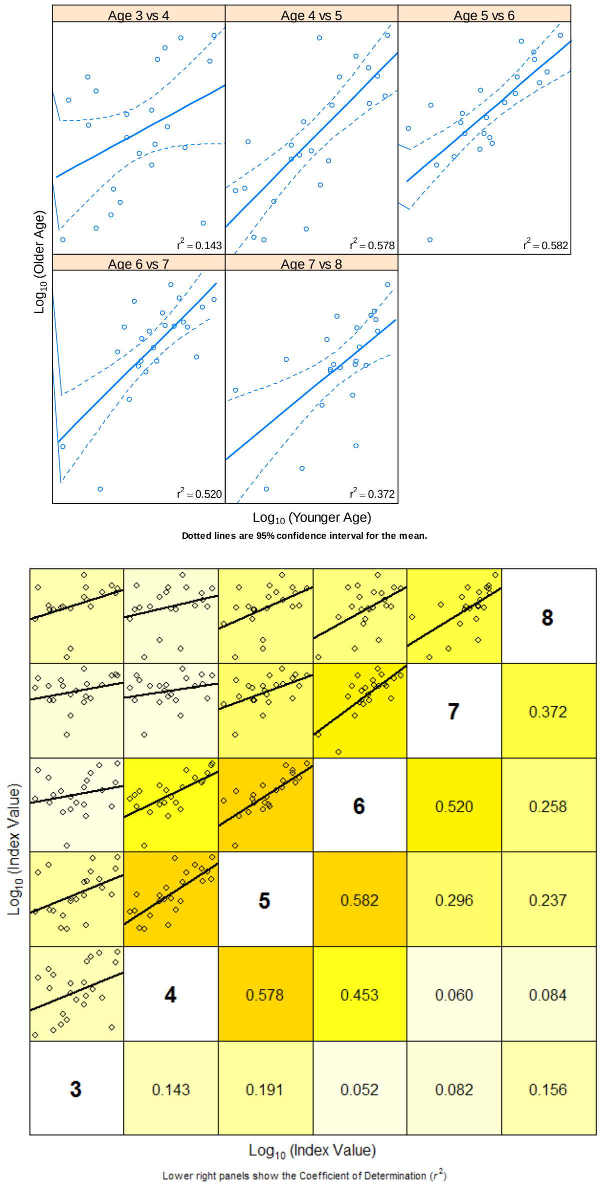

Figure 3. Internal consistencies as given by FLR. Note: FLR internal consistencies are estimated differently from Berg et al. 2014, as given in the amendment to WD 8.

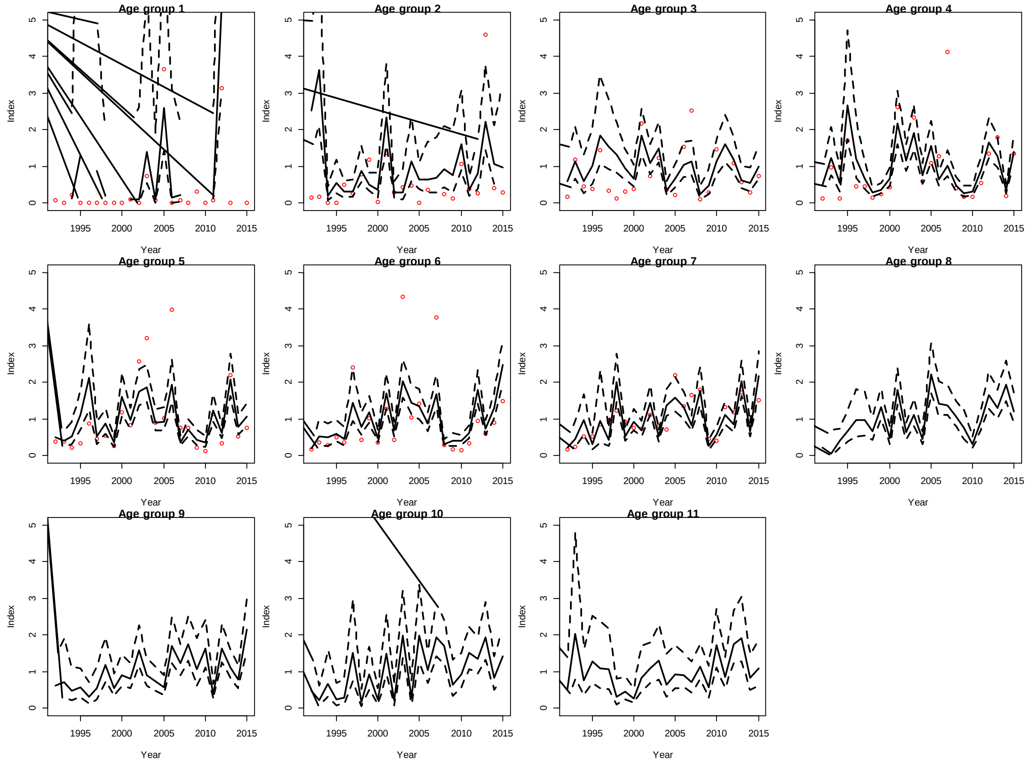

Figure 4. IBTS Q3 indices, ages 0-10, 1992-2015. Comparing survey indices by age (and confidence interval) to DATRAS indices for the full spatial range-no ship delta-GAM model (Q3 index as presented in the benchmark and WGNSSK).

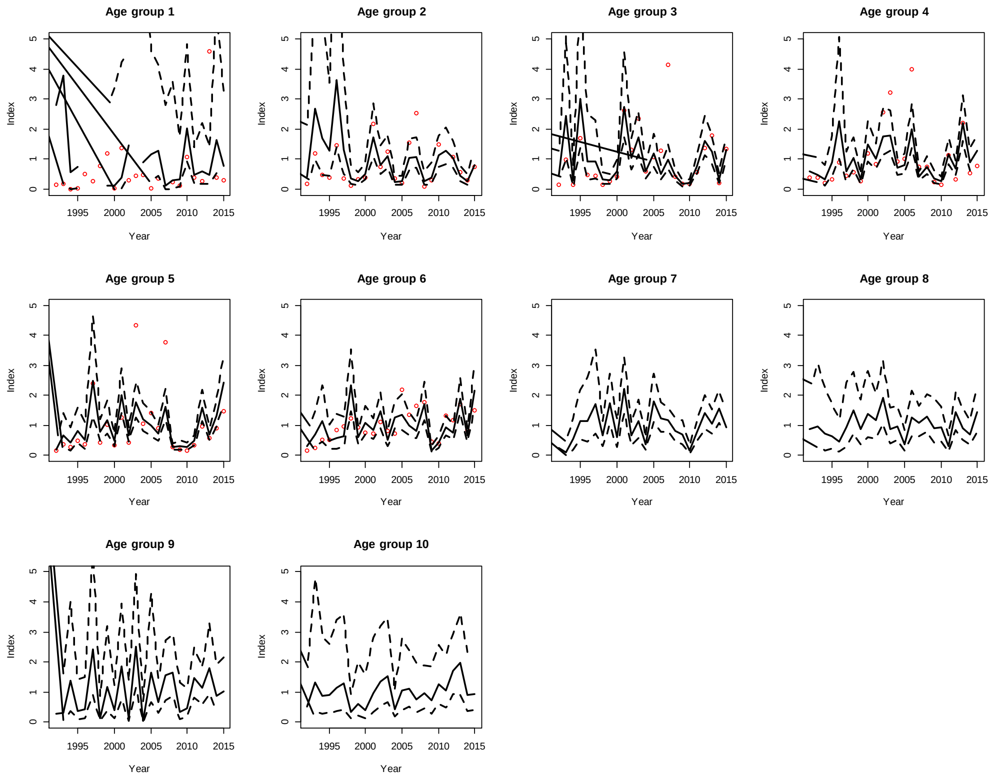

Figure 5. IBTS Q3 indices, ages 1-10+, 1992-2015. Comparing survey indices by age (and confidence interval) to DATRAS indices (ages 1-6+) for the truncated spatial grid-with ship delta-GAM model; this data excludes the Skagerrak-Kattegat and southern North Sea.

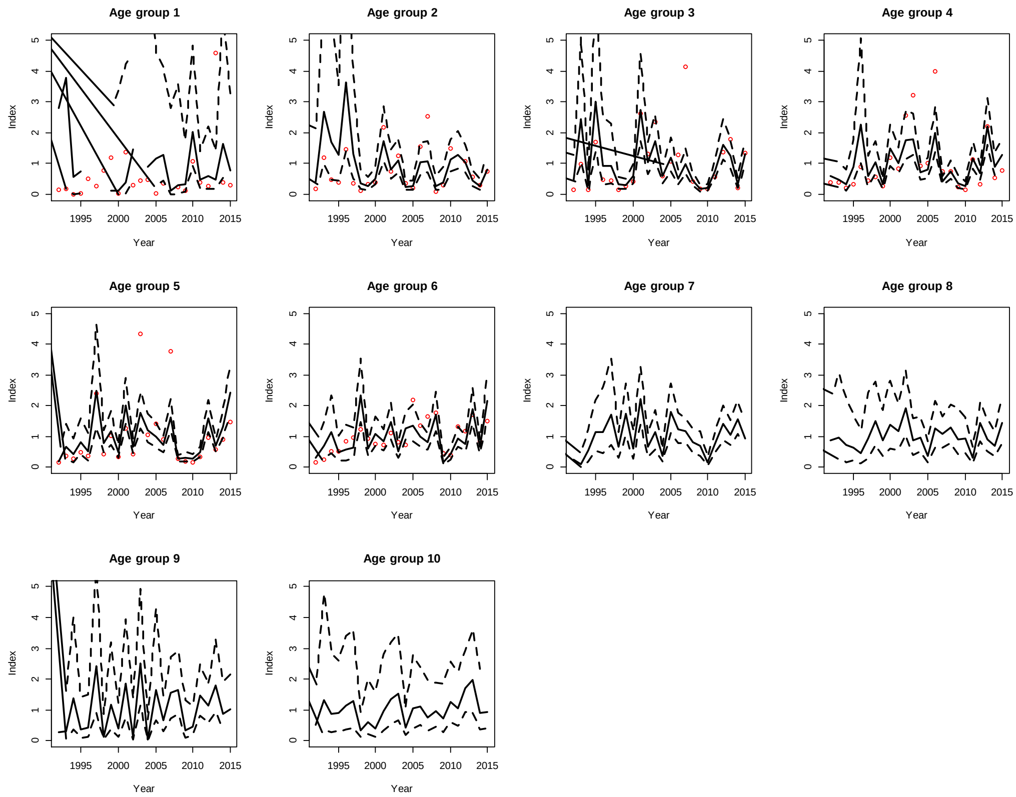

Figure 6. IBTS Q3 indices, ages 1-10+, 1992-2015. Comparing survey indices by age (and confidence interval) to DATRAS indices (ages 1-6+) for the truncated spatial grid-with ship delta-GAM model; this data includes the Skagerrak and excludes the southern North Sea and Kattegat.

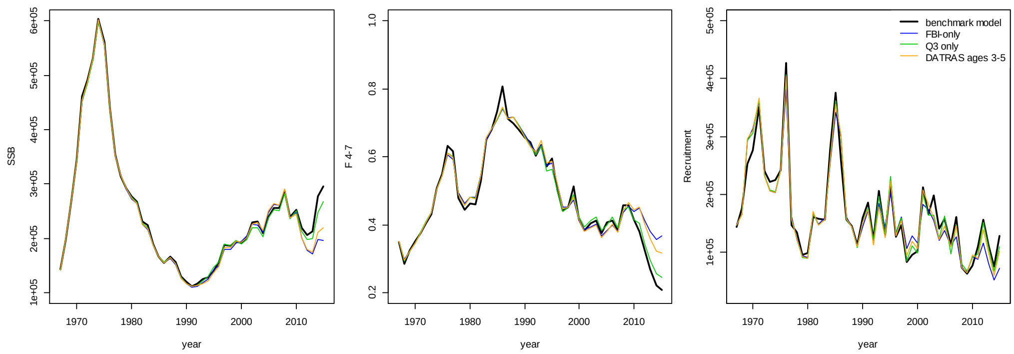

Figure 7. Affect of different indices on SAM assessment: black line = benchmark model (Q3 + Q1 + FBI indices); blue line = FBI index only (no surveys); green line = Q3 + FBI indices (no Q1); orange line = DATRAS Q3 (ages 3-5) + FBI indices. The Q3 indices estimated from the delta-GAM are those used in the benchmark meeting (no truncation of the survey area, without Ship in the model). Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

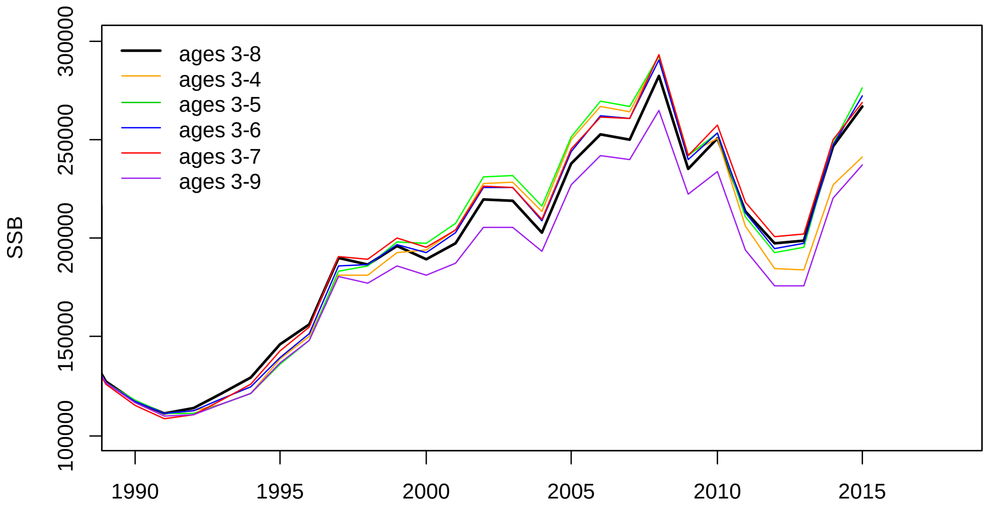

Figure 8. Effect of adding an changing age range of the Q3 index on estimated SSB. The Q3 indices were estimated using data from the entire North Sea. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

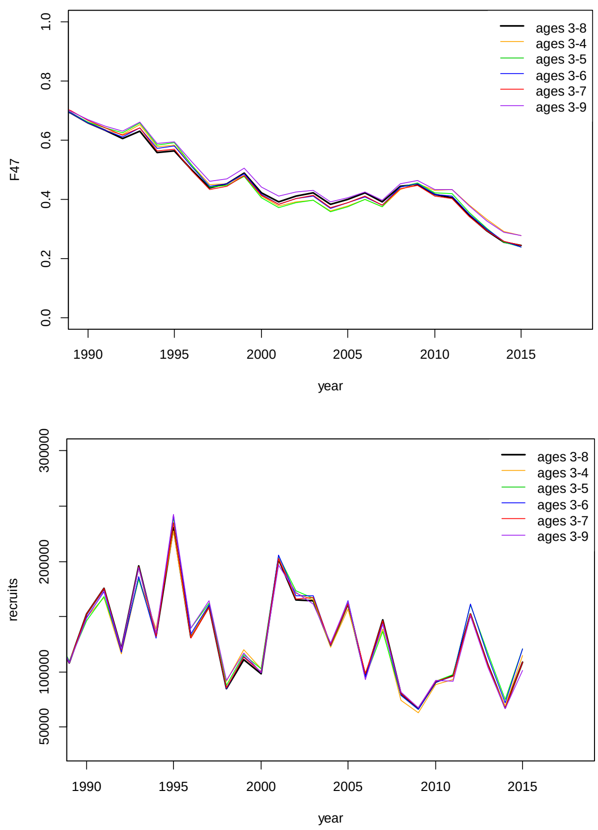

Figure 9. Effect of adding an changing age range of the Q3 index on estimated (left) $F_{bar\ 4\text{-}7}$ and (right) recruitment. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

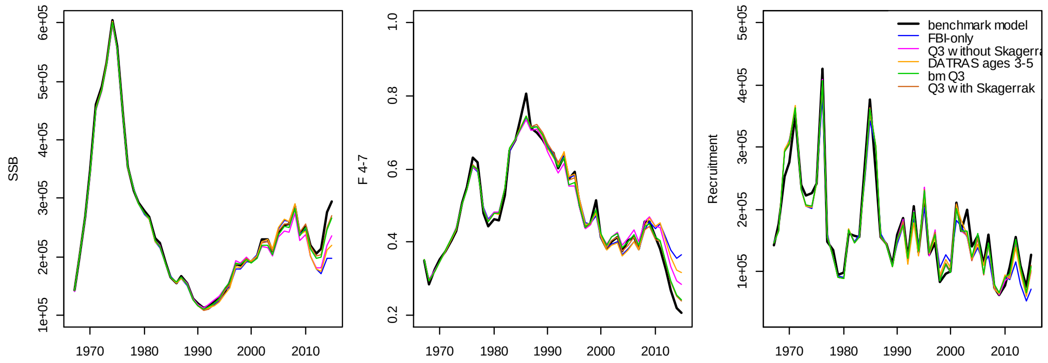

Figure 10. Affect of different indices on SAM assessment: black line = benchmark model (Q3 + Q1 + FBI indices); blue line = FBI index only (no surveys); green line = bm_Q3 + FBI indices (no Q1); orange line = DATRAS Q3 (ages 3-5) + FBI indices; magenta line = new Q3 + FBI indices (no Q1); brown line = Q3 including Skagerrak (without Kattegat or southern North Sea) + FBI. The bm_Q3 indices are those used in the benchmark meeting (no truncation of the survey area, without Ship in the model), while the new Q3 indices include truncating the spatial grid + ship in the delta-GAM model. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

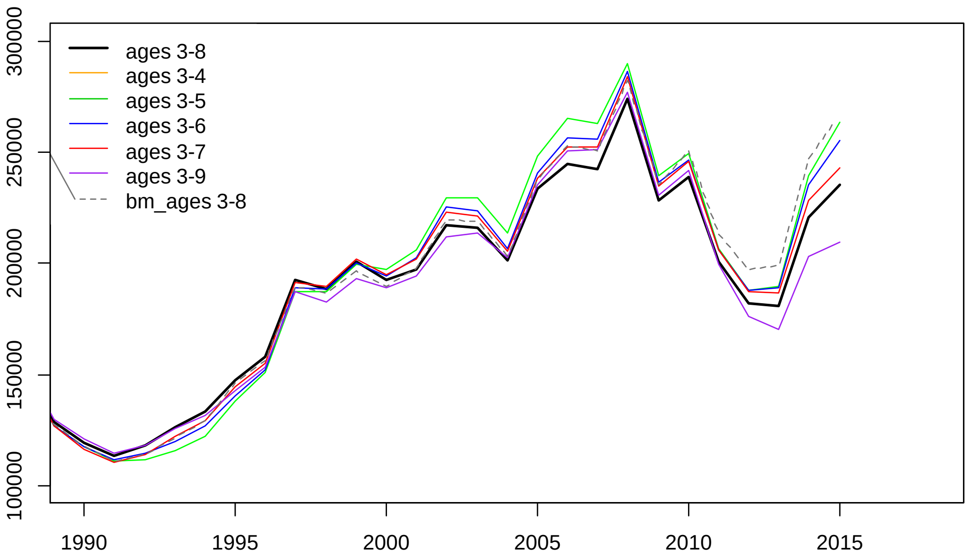

Figure 11. Effect of adding an changing age range of the Q3 index (truncated to remove the southern North Sea and Skagerrak/Kattegat) on estimated SSB. Model bm_ includes the Q3 indices estimated without truncation of the survey area or ship in the model. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

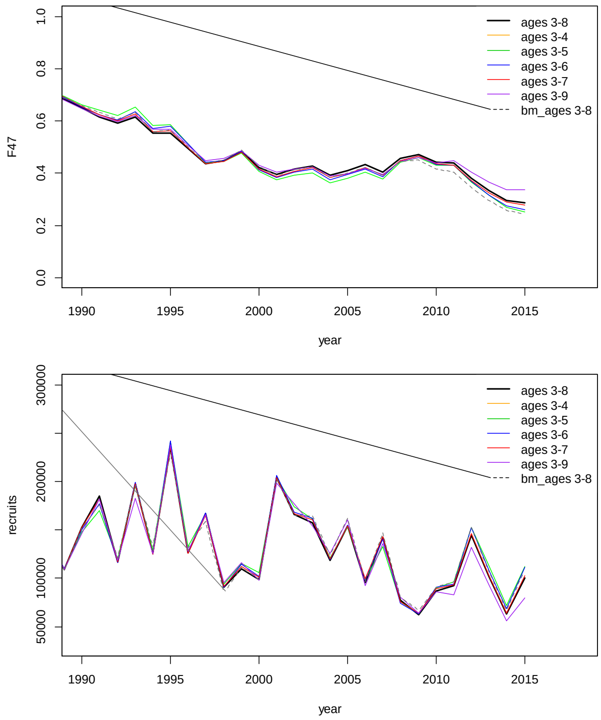

Figure 12. Effect of adding an changing age range of the Q3 indices (truncated to remove the southern North Sea and Skagerrak/Kattegat) on estimated (left) $F_{bar\ 4\text{-}7}$ and (right) recruitment. Model bm_ includes the Q3 indices estimated without truncation of the survey area or ship in the model. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

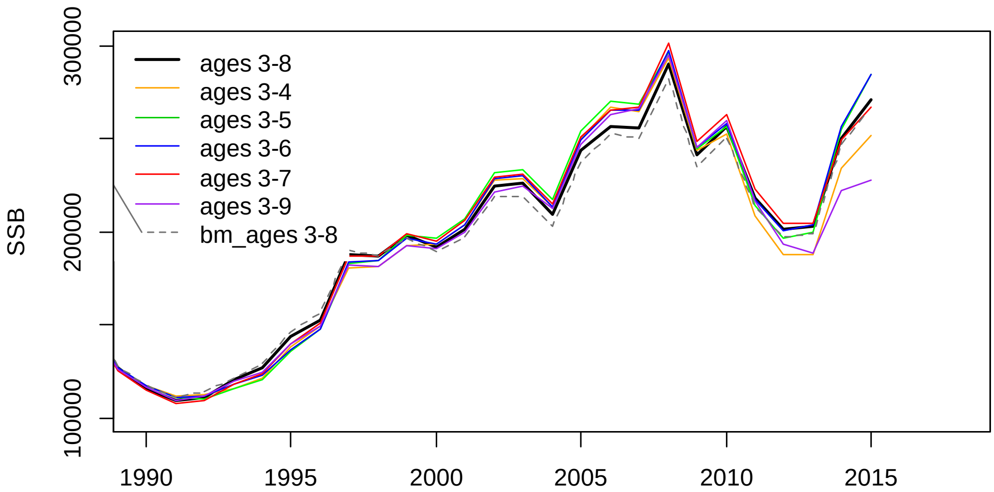

Figure 13. Effect of adding an changing age range of the Q3 indices (truncated to exclude the southern North Sea and Kattegat) on estimated SSB. Model bm_ includes the Q3 indices estimated without truncation of the survey area or ship in the model. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

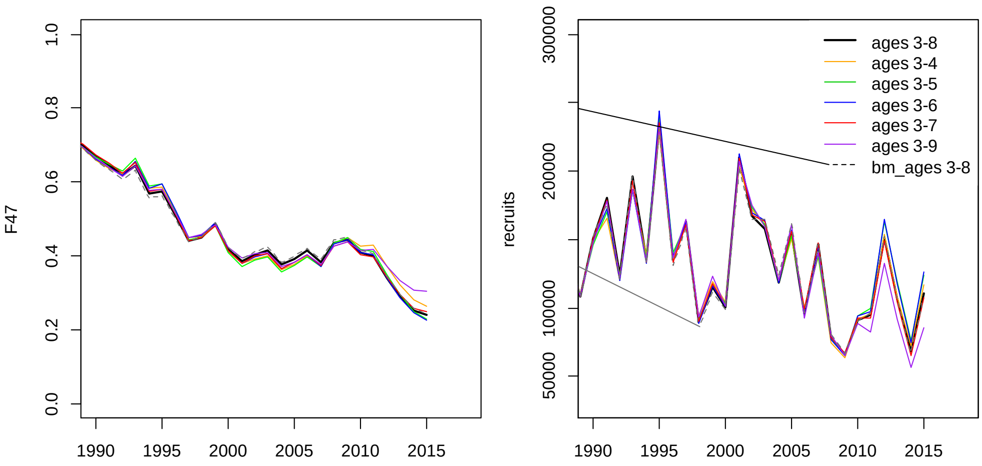

Figure 14. Effect of adding an changing age range of the Q3 indices (truncated to exclude the southern North Sea and Kattegat) on estimated (left) $F_{bar\ 4\text{-}7}$ and (right) recruitment. Model bm_ includes the Q3 indices estimated without truncation of the survey area or ship in the model. Note: this was conducted before the bug in InterCatch was found and discards had not been re-raised.

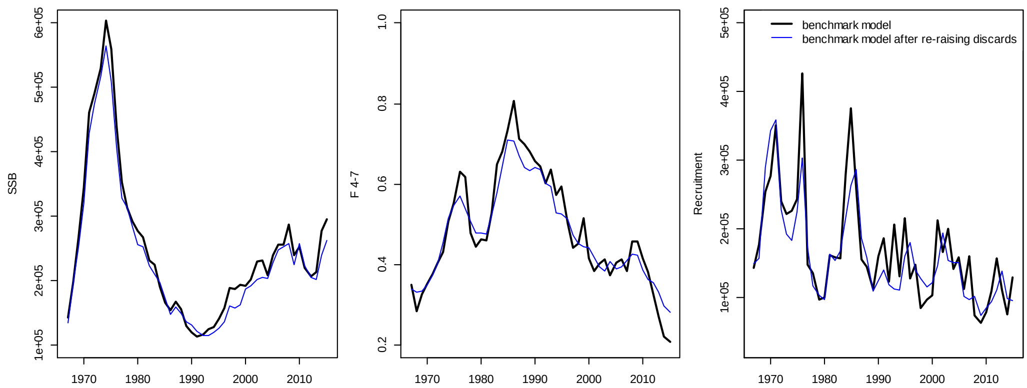

Figure 15. Effect of raising discards under assumption that Norway has low to zero discarding. Comparison of benchmark model (Q1 + Q3 + FBI) before and after changing raising procedure.

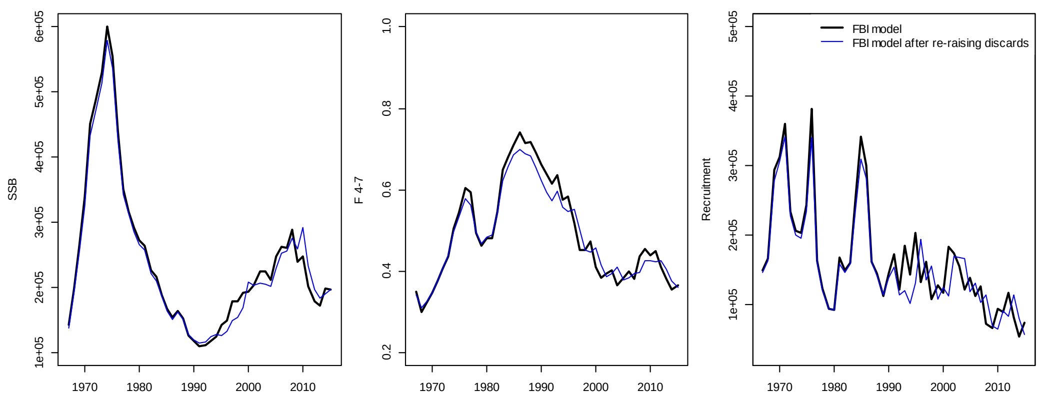

Figure 16. Effect of raising discards under assumption that Norway has low to zero discarding. Comparison of FBI index only model (no surveys) before and after changing raising procedure.

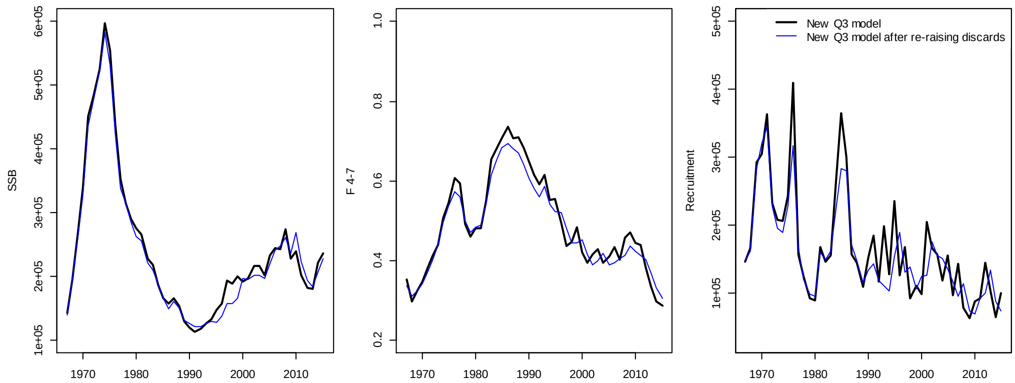

Figure 17. Effect of raising discards under assumption that Norway has low to zero discarding. Comparison of new Q3 model (FBI + Q3 - spatial truncation excludes Skagerrak/Kattegat and southern North Sea) before and after changing raising procedure.

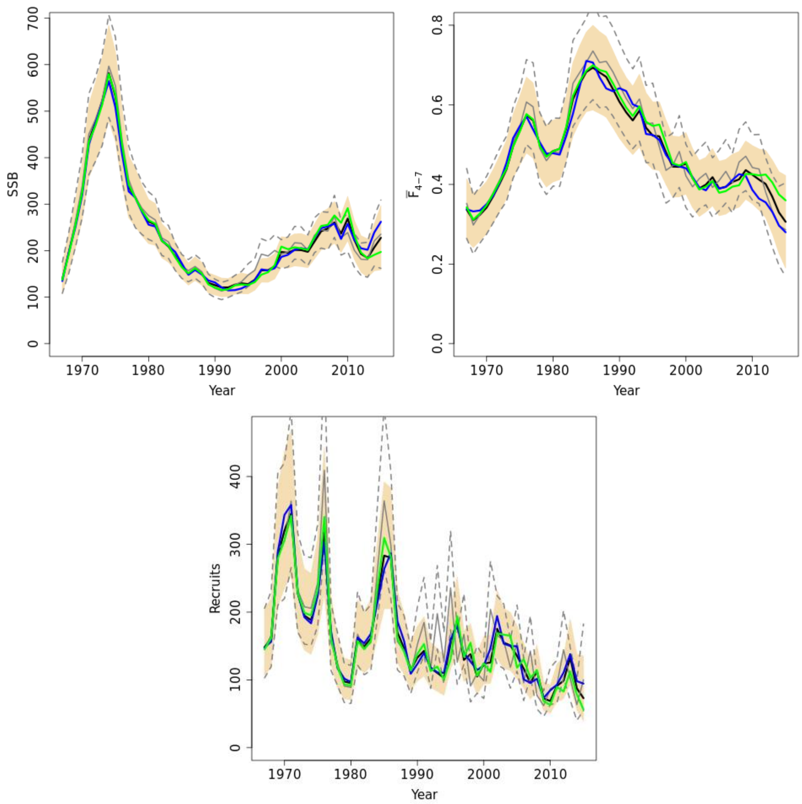

Figure 18. Trends in SSB, $F_{4\text{-}7}$, and recruitment for the 3 models. Blue line: Q1 + Q3 + cpue index model; green line: cpue-only model; black line: Q3 + cpue model; orange/tan shaded region: 95% confidence interval for the Q3 + cpue model; solid grey line (dashed): old Q3 + cpue model (95% confidence interval). The old Q3 model was estimated without removing the southern North Sea (where saithe are not found) and the Skagerrak (see amendment to WD 8 for details).

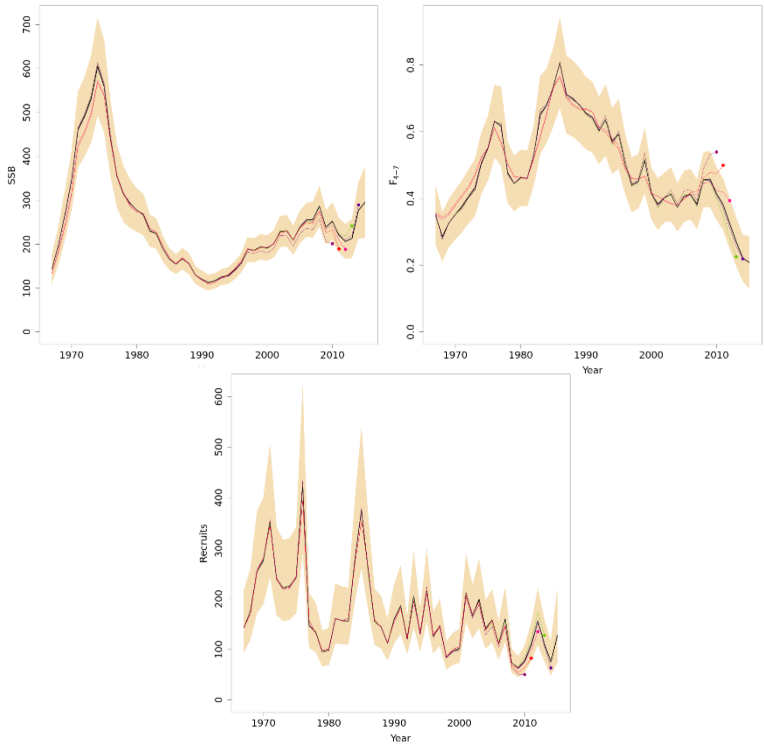

Figure 19. Five year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is FBI + Q1 + Q3 (untruncated spatial area) and does not include the discard revisions.

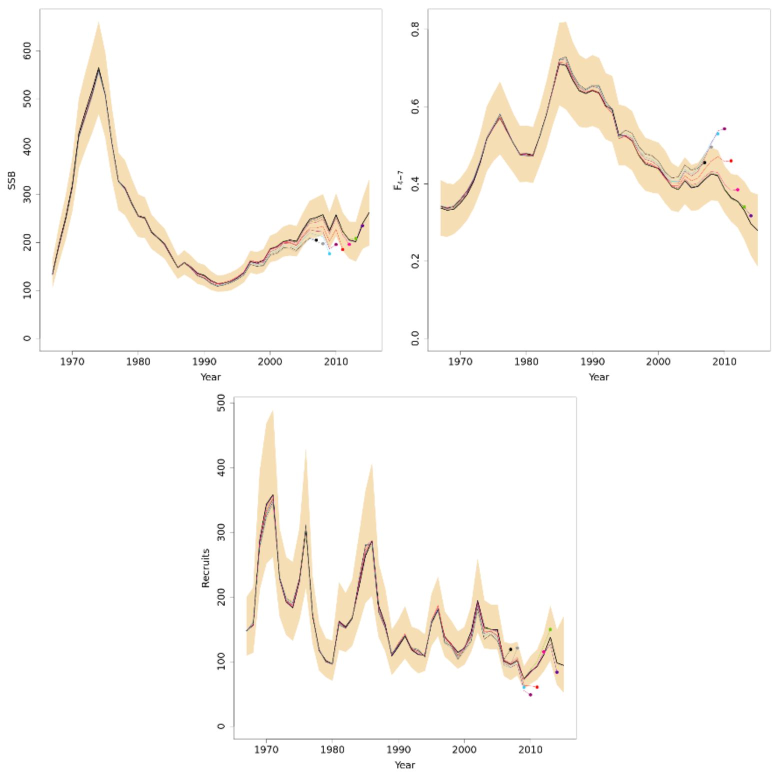

Figure 20. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is FBI + Q1 + Q3 (untruncated spatial area) and includes the discard revisions.

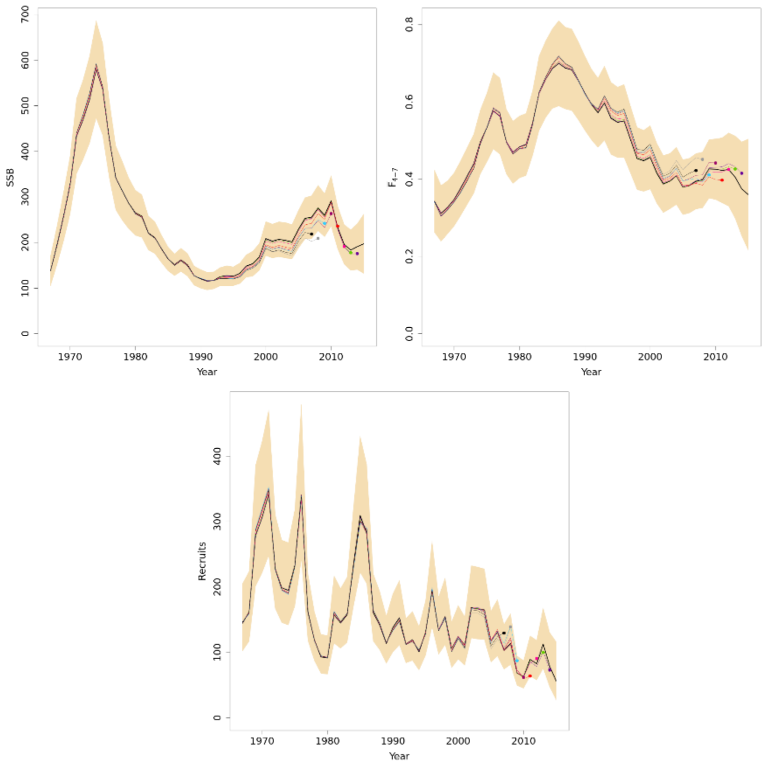

Figure 21. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is FBI index only (no surveys) and includes the discard revisions.

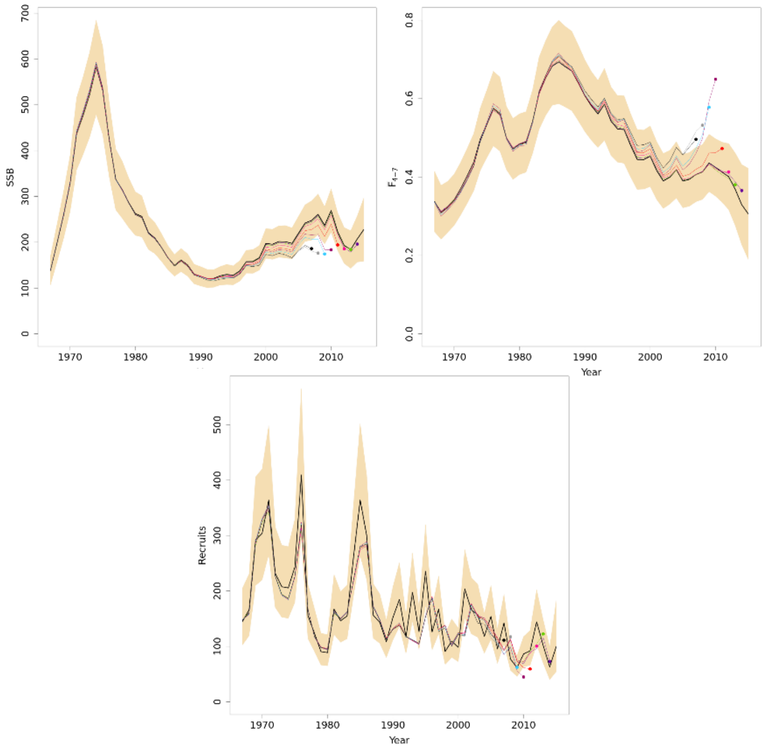

Figure 22. Eight year retrospective pattern in SSB, $F_{4\text{-}7}$, and recruitment. Model is FBI + new Q3 (excludes Skagerrak/Kattegat and southern North Sea) and includes the discard revisions.

APPENDIX

Reference Points and catch options

Reference Points estimated for the benchmark model, which includes the Q1, Q3 (untruncated spatially), and FBI indices are in Table A1; catch options are in Table A2 and basis for the catch options are in Table A3.

For the model that has only the FBI index (no surveys), reference points are in Table A4, catch options are in Table A5, and basis for the catch options are in Table A6.

Table A7 contains reference points estimated from the assessment model that includes the FBI and spatially truncated Q3 indices, where the Q3 indices do not include the southern North Sea or Skagerrak/Kattegat. Catch options are in Table A8 and basis for the catch options are in Table A9.

Table A1. Reference points estimated using the benchmark model (FBI + Q1+ Q3 no spatial truncation).

STOCK	
Reference point	Value
Blim	115 000
Bpa (1.4)	161 000
Bpa (sigma)	142 000
Btrigger	182 000
Flim	0.55
Fpa (1.4)	0.393
Fpa (sigma)	0.419
FMSY without Btrigger	0.359
FMSY lower without Btrigger	0.204
FMSY upper without Btrigger	0.492
New FP.05 (5% risk to Blim without Btrigger)	0.422
FMSY upper precautionary without Btrigger	0.393
FP.05 (5% risk to Blim with Btrigger)	0.534
FMSY with Btrigger	0. 396
FMSY lower with Btrigger	0.209
FMSY upper with Btrigger	0.694
FMSY upper precautionary with Btrigger	0.393
MSY (without HCR)	91 480
Median SSB at FMSY (without HCR)	220 827
Median SSB lower precautionary (median at FMSY upper precautionary; without HCR)	195 709
Median SSB upper (median at FMSY lower; without HCR)	420 907

Sigma (F) = 0.1653818, sigma (SSB) = 0.1300388.

Table A2. Saithe in Subareas 4 and 6 and Division 3a. The catch options. All weights in tonnes.

Rationale	Total catches 2017 *	Wanted catch 2017 *	Wanted catch 3a & 4 2017 **	Wanted catch 6 2017 **	Basis	F (total catch) 2017	F (wanted catch) 2017	SSB 2018	% SSB change ***	% TAC change wanted catch^
MSY approach	133332	127631	115634	11997	FMSY	0.36	0.34	322434	-3	86
EU-Norway management strategy	82261	78824	71415	7409	Paragraph 5 of management strategy	0.21	0.20	374902	13	15
Precautionary approach	298993	284409	257675	26734	SSB = min{1; SSB2017/Btrigger}	1.08	1.03	161000	-51	315
Zero catch	0	0	0	0	F = 0	0	0	461461	39	-100
Other options	79730	76405	69223	7182	F2016	0.20	0.19	377503	14	11
	71619	68601	62153	6448	TAC2016	0.18	0.17	386190	17	0
	143773	137641	124703	12938	Fpa	0.39	0.38	311808	-6	101

Table A3. Saithe in Subareas 4 and 6 and Division 3a. The basis for the catch options.

Variable	Value	Source	Notes
F ages 4–7 (2016)	68601 t	ICES (2016a)	TAC constraint (F=0.20)
SSB (2016)	284887 t	ICES (2016a)	SSB in the intermediate year
SSB (2017)	331048 t	ICES (2016a)	SSB at the beginning of the TAC year
Rage3 (2016)	101 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Rage3 (2017)	101 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Total catch (2016)	71775 t	ICES (2016a)	Assuming 2015 landings fraction by age
Commercial landings (2016)	68601 t	ICES (2016a)	TAC 2015
Discards (2016)	3174 t	ICES (2016a)	Assuming 2015 discard fraction by age

Table A4. Reference points estimated using the FBI index only model (no surveys).

Stock	
Reference point	Value
Blim	115 000
Bpa (1.4)	161 000
Bpa (sigma)	151 000
Btrigger	161 000
Flim	0.506
Fpa (1.4)	0.361
Fpa (sigma)	0.364
FMSY without Btrigger	0.361 (was 0.405)
FMSY lower without Btrigger	0.208
FMSY upper without Btrigger	0.454
New FP.05 (5% risk to Blim without Btrigger)	0.384
FMSY upper precautionary without Btrigger	0.361
FP.05 (5% risk to Blim with Btrigger)	0.447
FMSY with Btrigger	0. 38
FMSY lower with Btrigger	0.211
FMSY upper with Btrigger	0.595
FMSY upper precautionary with Btrigger	0.361
MSY (without HCR)	82 466
Median SSB at FMSY (without HCR)	197 952
Median SSB lower precautionary (median at FMSY upper precautionary; without HCR)	197 952
Median SSB upper (median at FMSY lower; without HCR)	377 258

Sigma (F) = 0.1651571, sigma (SSB) = 0.1997418.

Table A5. Saithe in Subareas 4 and 6 and Division 3a. The catch options. All weights in tonnes.

Rationale	Total catches 2017 *	Wanted catch 2017 *	Wanted catch 3a & 4 2017 **	Wanted catch 6 2017 **	Basis	F (total catch) 2017	F (wanted catch) 2017	SSB 2018	% SSB change ***	% TAC change wanted catch^
MSY approach	91749	85822	77755	8067	FMSY	0.36	0.34	221501	5	25
EU-Norway management strategy	84592	79134	71695	7439	Paragraph 5 of management strategy	0.33	0.31	228215	8	15
Precautionary approach	157658	147368	133515	13853	SSB = min{1; SSB2017/Btrigger}	0.71	0.68	161000	-24	115
Zero catch	0	0	0	0	F = 0	0	0	309384	47	-100
Other options	80442	75253	68179	7074	F2016	0.31	0.30	232171	10	10
	73037	68601	62153	6448	TAC2016	0.28	0.26	240108	14	0
	91749	85822	77755	8067	Fpa	0.36	0.34	221501	5	25

Table A6. Saithe in Subareas 4 and 6 and Division 3a. The basis for the catch options.

Variable	Value	Source	Notes
F ages 4–7 (2016)	68601 t	ICES (2016a)	TAC constraint (F=0.31)
SSB (2016)	199173 t	ICES (2016a)	SSB in the intermediate year
SSB (2017)	211158 t	ICES (2016a)	SSB at the beginning of the TAC year
Rage3 (2016)	103 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Rage3 (2017)	103 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Total catch (2016)	72518 t	ICES (2016a)	Assuming 2015 landings fraction by age
Commercial landings (2016)	68601 t	ICES (2016a)	TAC 2015
Discards (2016)	3917 t	ICES (2016a)	Assuming 2015 discard fraction by age

Table A7. Reference points estimated using the FBI + Q3 (spatially truncated, excludes southern North Sea and Skagerrak/Kattegat) model.

Reference point	Value
Blim	121 000
Bpa (1.4)	169 000
Bpa (sigma)	155 000
Btrigger	170 000
Flim	0.514
Fpa (1.4)	0.367
Fpa (sigma)	0.376
FMSY without Btrigger	0.363
FMSY lower without Btrigger	0.205
FMSY upper without Btrigger	0.461
New FP.05 (5% risk to Blim without Btrigger)	0.394
FMSY upper precautionary without Btrigger	0.367
FP.05 (5% risk to Blim with Btrigger)	0.455
FMSY with Btrigger	0. 382
FMSY lower with Btrigger	0.208
FMSY upper with Btrigger	0.607
FMSY upper precautionary with Btrigger	0.367
MSY (without HCR)	87 658
Median SSB at FMSY (without HCR)	209 632
Median SSB lower precautionary (median at FMSY upper precautionary; without HCR)	206 489
Median SSB upper (median at FMSY lower; without HCR)	402 573

Sigma (F) = 0.189643, sigma (SSB) = 0.1512602.

Table A8. Saithe in Subareas 4 and 6 and Division 3a. The catch options. All weights in tonnes.

Rationale	Total catches 2017 *	Wanted catch 2017 *	Wanted catch 3a & 4 2017 **	Wanted catch 6 2017 **	Basis	F (total catch) 2017	F (wanted catch) 2017	SSB 2018	% SSB change ***	% TAC change wanted catch^
MSY approach	114375	109057	98806	10251	FMSY	0.36	0.35	275385	0	59
EU-Norway management strategy	82766	78909	71492	7417	Paragraph 5 of management strategy	0.25	0.24	307208	12	15
Precautionary approach	224186	212434	192465	19969	SSB = min{1; SSB2017/Btrigger}	0.87	0.83	169000	-38	210
Zero catch	0	0	0	0	F = 0	0	0	391963	43	-100
Other options	79803	76084	68932	7152	F2016	0.24	0.23	310253	13	11
	72198	68601	62153	6448	TAC2016	0.21	0.20	315995	15	0
	115286	109922	99589	10333	Fpa	0.37	0.35	273885	0	60

Table A9. Saithe in Subareas 4 and 6 and Division 3a. The basis for the catch options.

Variable	Value	Source	Notes
F ages 4–7 (2016)	68601 t	ICES (2016a)	TAC constraint (F=0.24)
SSB (2016)	242142 t	ICES (2016a)	SSB in the intermediate year
SSB (2017)	274310 t	ICES (2016a)	SSB at the beginning of the TAC year
Rage3 (2016)	99 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Rage3 (2017)	99 billion	ICES (2016a)	Median recruitment resampled from 2003-2015
Total catch (2016)	72064 t	ICES (2016a)	Assuming 2015 landings fraction by age
Commercial landings (2016)	68601 t	ICES (2016a)	TAC 2015
Discards (2016)	3463 t	ICES (2016a)	Assuming 2015 discard fraction by age

Annex 10 Technical Minutes of the Review Group of Precautionary Approach Reference Points estimation

Review of ICES WGNSSK Report 2016

9 May 2016 – 31 May 2016

Reviewers: Chris Legault (chair)

Arni Magnusson

Colin Millar

Chair WG: Alexander Kempf (Germany) and José De Oliveira (UK)

Secretariat: Cristina Morgado

General

The RG acknowledges the intense effort expended by the working group to produce the report.

The Review Group considered estimation of PA reference points for the following stocks:

Cod in Subarea 4 and Divisions 7.d and 3.a (North Sea. Eastern English Channel. Skagerrak)

Haddock in Subarea 4 and Divisions 3.a and 6.a (North Sea. Skagerrak and West of Scotland)

Plaice in Division 7.d (Eastern Channel)

Sole in Subarea 4 (North Sea)

Whiting Subarea 4 (North Sea) and Division 7.d (Eastern Channel)

Plaice in Subarea 4(North Sea) and Division 3.a.20 (Skagerrak)

Cod in Subarea 4 and Divisions 7.d and 3.a (report section 14.9)

General comments

According to the advice sheet, B_{lim}=118 kt and B_{pa}=165 kt, and the basis of B_{lim} is the SSB associated with the last above-average recruitment (1996 year class). The use of 1.4 assumes σ_B =0.20.

According to the advice sheet, F_{lim}=0.58 and F_{pa}=0.41. The basis of F_{lim} is an EQSim analysis based on recruitment period 1998–2014, where the changepoint of the segmented regression was estimated rather than forced at $B_{lim,}$ this deviation from the ices guidelines is justified in the report. The use of 1.4 assumes σ_F =0.20. Estimation uncertainty in final year F gives σ_F =0.12, but the WG considered this too low.

The value 1.4 has historically been used to derive PA reference points, the underlying logic is an assumption of σ=0.20. For consistency with the guidelines on PA reference points, the value of σ_B and σ_F should be made explicit in the advice sheet along with the equation $B_{pa} = B_{lim} * \exp(1.645\ \sigma_B)$ or $F_{pa} = F_{lim} * \exp(-1.645\ \sigma_F)$.

The argument used to define B_{lim} is sound, but it was difficult to review without a stock-recruitment plot.

It was difficult to review the argument used to define F_{lim} without a stock-recruitment plot.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, (type 1 applied to recent time series)	OK	OK	No, value of σ_B not stated. Please state the formula $B_{pa} = B_{lim} * \exp(1.645\ \sigma)$ and state the value of σ used.
F_{pa}	OK, method a) stochastic simulation was used to estimate F_{lim}.	OK	OK	No, value of σ_F not stated. Please state the formula $F_{pa} = F_{lim} * \exp(-1.645\ \sigma)$ and state the value of σ used.

Conclusions

2/8 cells require attention. Small revisions to the advice sheet are required to address this.

Haddock in Subarea 4 and Divisions 3.a and 6.a (report section 13)

General comments

According to the advice sheet, B_{lim}=96 and B_{pa}=134. The basis of B_{lim} is the lowest estimated SSB which resulted in high recruitment (1972), and the basis of B_{pa} is 1.4*B_{lim}.

According to the advice sheet, F_{lim}=0.384 and F_{pa}=0.274. The basis of F_{lim} is estimation by application of EqSIM evaluation, and the basis of F_{pa} is stated in the advice sheet to be also estimation by application of EqSIM evaluation. From the values, however, it seems that the basis of F_{pa} is F_{lim}/1.4, and this is the basis stated in the report.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim} is the lowest biomass where large recruitment is observed (type 1)	Please state the equation $B_{pa}=B_{lim}*\exp(1.645\sigma_B)$ and the value of σ_B=0.20 in the refpt table of the advice sheet.	Almost, but B_{lim}*exp(1.645*0.20) will give a slightly different value.	Please state the value of σ_B=0.20 in the refpt table of the advice sheet.
F_{pa}	OK, method A (stochastic simulations) was used to evaluate F_{lim}.	Please state the equation $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$ and the value of σ_F in the refpt table of the advice sheet.	Almost, but F_{lim}*exp(-1.645*0.20) will give a slightly different value.	Please state the value of σ_F=0.20 in the refpt table of the advice sheet.

Conclusions

2/8 cells in the above matrix are OK. The remaining 6 should be improved.

Plaice in Division 7.d (report section 6)

General comments

According to the advice sheet, B_{lim}=18448 based on the break point of the segmented regression SRR and B_{pa}=25826 based on the relationship $B_{pa}=B_{lim}$*1.4.

According to the advice sheet, F_{lim}=0.5 based on EqSim that will maintain the stock above B_{lim} with a 50% probability and F_{pa}=0.36 based on the relationship $F_{pa}=F_{lim}$/1.4.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim} is estimated from segmented regression (Type 2)	Please state the equation $B_{pa}=B_{lim}*\exp(1.645\sigma_B)$ and the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.	Almost, but $B_{lim}*\exp(1.645*0.20)$ will give a slightly different value.	Please state the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.
F_{pa}	OK, method A (stochastic simulations) was used to evaluate F_{lim}.	Please state the equation $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$ and the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.	OK	Please state the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.

Conclusions

3/8 cells in the above matrix are OK. The remaining 5 should be improved.

Sole in Subarea 4 (report section 10.7)

General comments

According to the advice sheet, B_{lim}=26.3 and B_{pa}=37.0. The basis of B_{lim} is B_{loss} and the basis of B_{pa} is 1.4*B_{lim}. This implies σ_B=0.20 and B_{pa} has been rounded from 36.8 to 37.0.

According to the advice sheet, F_{lim}=0.63 and F_{pa}=0.44. The basis of F_{lim} is the F that in equilibrium will maintain the stock above B_{lim} with a 50% probability, and the basis of F_{pa} is F_{lim}/1.4. This implies that σ_F=0.20.

A closer examination of the F_{lim} analysis (Sharepoint file WGNSSK/Reference points Flim and Fpa/sol-nsea/Ref_points.7z) reveals that the F_{lim} was calculated as 0.623, which could be rounded to 0.62, but not 0.63.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, $B_{lim}=B_{loss}$ (type 5)	Please state the equation $B_{pa}=B_{lim}*\exp(1.645\sigma_B)$ and the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.	OK, if 0.20 is the best estimate of σ_B.	Please state the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.
F_{pa}	Method A (stochastic simulations) was used to evaluate F_{lim}. However, the resulting F_{lim} was probably 0.62, not 0.63.	Please state the equation $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$ and the value of σ_F in the refpt table of the advice sheet.	No, if F_{lim} is 0.62 (or 0.63, for that matter) then F_{pa} should be 0.45.	Please state the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.

Conclusions

2/8 cells in the above matrix are OK. The remaining 6 should be improved.

Whiting Subarea 4 and Division 7.d (report section 12.1.8)

General comments

According to the advice sheet, B_{lim}=173 kt and B_{pa}=242 kt. The basis of B_{lim} is B_{loss} (SSB in 2007 in the 2016 assessment) and the basis of B_{pa} is $1.4*B_{lim}$. This implies $\sigma_B=0.20$.

According to the advice sheet, F_{lim}=0.39 and F_{pa}=0.28. The basis of F_{lim} is Eqsim (F_{50}), and the basis of F_{pa} is $F_{lim}/1.4$. This implies that $\sigma_F=0.20$.

When using the value 1.4 to derive PA reference points, the underlying logic is an assumption of σ=0.20. For consistency with the guidelines on PA reference points, the value of σ_B and σ_F should be made explicit in the advice sheet along with the equation $B_{pa} = B_{lim} * \exp(1.645\ \sigma_B)$ or $F_{pa} = F_{lim} * \exp(-1.645\ \sigma_F)$.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, $B_{lim}=B_{loss}$ (type 5)	Please state the equation $B_{pa}=B_{lim}*\exp(1.645\sigma_B)$ and the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.	Almost, but $B_{lim}*\exp(1.645*0.20)$ will give a slightly different value (at 3rd sig. fig.).	Please state the value of $\sigma_B=0.20$ in the refpt table of the advice sheet.
F_{pa}	OK, method a) stochastic simulation was used to estimate F_{lim}.	Please state the equation $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$ and the value of σ_F in the refpt table of the advice sheet.	OK	Please state the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.

Conclusions

3/8 cells in the above matrix are OK. The remaining 5 should be improved.

Plaice in Subarea 4 and Division 3.a.20 (report section 8.6)

General comments

According to the advice sheet, B_{lim}=160 kt and B_{pa}=230 kt. The basis of B_{lim} is B_{loss}, the lowest observed biomass in 1997 as assessed in 2004, and the basis of Bpa is 1.44 × B_{lim}..

According to the advice sheet, F_{lim}=0.63 and F_{pa}=0.45. The basis of Fpa is the F that in equilibrium will maintain the stock above B_{lim} with a 50% probability, and the basis of F_{pa} is F_{lim}/1.4.

The value 1.4 is often used to derive PA reference points, the underlying logic is an assumption of σ=0.20. For consistency with the guidelines on PA reference points, the value of σ_B and σ_F should be made explicit in the advice sheet along with the equation $B_{pa} = B_{lim} * \exp(1.645\ \sigma_B)$ or $F_{pa} = F_{lim} * \exp(-1.645\ \sigma_F)$.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, $B_{lim}=B_{loss}$ (type 5)	Please state the equation $B_{pa}=B_{lim}*\exp(1.645\sigma_B)$ and the value of $\sigma_B=0.22$ in the refpt table of the advice sheet.	OK	Please state the value of σ_B in the refpt table of the advice sheet. 1.44 implies $\sigma_B=0.22$
F_{pa}	OK, method a) stochastic simulation was used to estimate F_{lim}.	Please state the equation $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$ and the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.	OK	Please state the value of $\sigma_F=0.20$ in the refpt table of the advice sheet.

Conclusions

4 out of 8 cells are OK, the remaining 4 should be addressed.

Saithe in Subareas 4 and 6 and Division 3.a (report section 11)

General comments

According to the advice sheet, B_{lim}=107 and B_{pa}=150. The basis of B_{lim} is B_{loss} and the basis of B_{pa} is $B_{lim}*\exp(1.645\sigma_B)$, where $\sigma_B=0.20$.

According to the advice sheet, F_{lim}=0.56 and F_{pa}=0.40. The basis of F_{lim} is the F that gives 50% probability to fall below Blim in the stochastic EqSim simulations, and the basis of F_{pa} is $F_{lim}*\exp(-1.645\sigma_F)$, where $\sigma_F=0.20$.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim}=B_{loss} (type 5)	OK	OK	OK
F_{pa}	OK, method A (stochastic simulations) was used to evaluate F_{lim}.	OK	OK	OK

Conclusions

8/8 cells in the above matrix are OK. The PA reference points have been evaluated according to the guidelines.