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

24 April - 3 May 2018

Oostende, Belgium

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Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met 24 April–3 May 2018 at ILVO, Oostende, Belgium. There were 28 full and part-time participants (+ two 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 in future years. An additional terms of reference requesting a Mohn's rho calculation for Category 1 stocks was completed; this request was to assist with a workshop that will consider catch forecasts from biased assessments. 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 met for 10 days to deal with the TORs, including one which required MSY proxy reference points to be derived for Category 3 and 4 stocks. WGNSSK was unable to make progress on MSY proxy reference points for Category 4 *Nephrops* stocks due to data quality issues, and this work has been deferred to a dedicated workshop to take place in early 2019. MSY proxy reference points were derived for the Category 3 grey gurnard stock and were reviewed.

Data were requested through a joint DCF-based data call for all assessment working groups, and the deadline for early data delivery was difficult to meet this year because the deadline was set one week earlier than expected; nevertheless, any delays did not significantly impede work progress.

The principle analytical models used for the stock assessments were SAM, XSA, TSA and the Aarts and Poos model (AAP), as well as SURBAR and a4a (for some Category 3 stocks, but advice not provided this year for these). For Category 3 stocks, SPiCT and the Length-based Indicator (LBI) approach developed within WKLIFE were used to estimate stock status relative to reference points.

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 and Inter-benchmarks in 2017/2018

Data compilation and benchmark workshops were held in November 2017 and February 2018 (respectively) for whiting (whg.27.47d), flounder (fle.27.3a4), lemon sole (lem.27.3a77d) and witch flounder (wit.27.3a47d).

For whiting, although a complex population structure has been identified in the North Sea, literature and available data did not provide a sufficient basis for revising the stock area. The feasibility of combining the Division 3.a with Subarea 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks. The new assessment was run for the North Sea and Eastern Channel (27.4 and 27.7d). As before, Subarea 27.4 represents the management unit with TAC advice to be given. No changes were made to the use of survey indices. The maturity ogive, stock weights-at-age, and natural mortality were updated with new information. Catch

data was updated in Intercatch with new data submissions for 2009–2016 and a new stratification design to allocate discard ratios and age distributions. The assessment model was changed from XSA to SAM and new reference points estimated.

For flounder, age data were sparse in the surveys and catch data. Survey indices were based on the catch weight per haul, applying a general length–weight relationship with the length distribution data by haul. Indices were generated using the delta-GAM method for Q1 from IBTS data and Q3 by combining information from three beam trawl surveys and the IBTS. Length-based data show that most flounder reach maturity above 20 cm in length. Lack of data prevented analyses of interannual trends in weight-at-age or growth. Natural mortality estimates were not available for flounder. A SPiCT model was agreed upon, which obtained robust results in terms of relative fishing mortality and relative biomass. The status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis by updating the SPiCT model, where the relative values of biomass and fishing mortality gives an indication for the stock status in relation to F_{MSY} and B_{MSY}.

For lemon sole, alternate survey indices were explored. The agreed-upon method was the GAM estimation for Q1 and Q3, where the Q3 incorporates both IBTS and BTS survey data. The length coverage of the surveys was concluded to be sufficiently representative of the stock as a whole, and therefore that advice could appropriately be based on survey data alone. SMALK data were used to determine the proportion mature-at-age, mean weight-at-age in the stock, and an annual length–weight relationship. Natural mortality estimates for lemon sole are not available; total mortality is an output of the survey-based assessment. Age data were sparse; therefore, an age-based assessment was not possible. The stochastic production model SPiCT was assessed but was deemed unsuitable for use as an assessment model for lemon sole at this time. The age- and survey-based assessment model SURBAR was agreed upon. No new reference points could be proposed by WKNSEA. It is proposed that the status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis through the LBI methodology.

For witch flounder, the delta-GAM approach was used to generate survey indices for IBTS Q1 and Q3 for years with age data, 2009–present. Total biomass indices were also estimated for use in the SPiCT model. Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. Stock weights-at-age and a new constant maturity ogive were estimated from survey data; natural mortality was left at 0.2. A SAM assessment model was used. The catch time-series was extended back in time by using landings from 1950 to 2008. Two new surveys of fishable stock biomass for Q1 (1983 to 2008) and Q3 (1991 to 2008) were included. Age-specific information for surveys and catches were available from 2009. The stock was upgraded to a Category 1 assessment, and new reference points estimated.

An inter-benchmark protocol meeting was held during the summer of 2017 (by correspondence) for turbot (tur.27.4). During this inter-benchmark, all available input data were screened again, including a new LPUE index from UK, a Delta-GAM survey index combining several BTS surveys and, for the first time, age-based catch data from Denmark for most recent years. Also, different models to standardise the Dutch LPUE time-series were tested. The SAM model settings were reviewed, and sensitivity runs were conducted with various combinations of input data, plus-group settings, highest age used in survey indices and different length of the assessment time-series. Decisions were made on final input data and model settings. In addition, reference point proxies were estimated. The assessment was left as a Category 3 assessment because of a strong retrospective pattern in F. During the WGNSSK 2018 meeting, a mistake was found in the assessment configuration (from the 2017 inter-benchmark) which led to questions on the persistence of the retrospective pattern on F and assessment category used to provide advice. For this reason, an inter-benchmark has been organised for the summer of 2018 to correct the mistake (the Dutch LPUE was treated as an SSB index, instead of an exploitable biomass index), re-check the model settings (plus-group, maximum age in surveys, assessment configuration), decide on the Categorisation of the stock (whether it should be upgraded to a Category 1 assessment in the light of the new results), estimate reference points, and agree a short-term forecast.

State of the Stocks

The main impression in recent years is that fishing mortality has been reduced substantially 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 cod in 4, 7.d and 20, and sole in 7.d are below MSY $B_{trigger}$ at the beginning of 2018. Several North Sea stocks are exploited around or below F_{MSY} levels; exceptions are cod in 4, 7.d and 20, haddock in 4, 6.a and 20, whiting in 4 and 7.d and sole in 4 (the latter only slightly above F_{MSY}). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries (brill, turbot in 4, turbot in 3a, witch, lemon sole, dab, flounder, striped red mullet, whiting in 3a), along with *Nephrops* in 4 outside functional units. For all of these stocks, catch advice was provided in 2015 for the first time, and again in 2017, but in 2018, it was only necessary to determine whether the perception of the stocks has changed compared to 2017; because these perceptions have not changed, no reopening was needed for any of these stocks. In 2018, assessments and advice was prepared for data-limited *Nephrops* stocks (FUs 5, 10, 32, 33 and 34), pollack and grey gurnard, along with the annual advice for Category 1 finfish and *Nephrops* stocks.

Reopening of advice was triggered for several stocks in the autumn, namely haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d, saithe in 4, 6 and 3.a, plaice in 4 and 3.a.20, and Nephrops in FU 6, 7, 8 and 34 (Annex 7).

The summary of stock status is as follows:

1) *Nephrops*: For FU 6, the stock has increased since 2015 and is currently just above MSY $B_{trigger}$, while harvest rates have dipped below F_{MSY} in 2017 after a long period of being above this level. The stock size for FU 7 declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015, but has since increased strongly and is currently above MSY $B_{trigger}$, while the harvest rate has declined since 2010 and remains well below F_{MSY}. For FU 8, the stock size has been above MSY $B_{trigger}$ for most of the time-series, and the harvest rate varying and now above F_{MSY}. For FU 9, the stock has been above MSY $B_{trigger}$ for the entire time-series, while the harvest rate has fluctuated around F_{MSY} and is now just below it. The stock size of *Nephrops* in 3.a is considered to be stable, while the harvest rate for this stock is currently below F_{MSY}.

   The FUs 5, 10, 32, 33 and 34 are data limited, and new catch advice was provided in 2018 (biennial advice, for 2019 and 2020). Furthermore, FU 34 was re-opened in the autumn of 2018 following a survey in June 2018 showing a significant increase compared to the previous year.

No new advice was provided for *Nephrops* outside the functional units in 2018.

A workshop is being planned for early 2019 to consider the framework for providing advice for *Nephrops* Category 1 and 4 stocks, including the estimation of reference points or proxies for them.

2) Cod in 4, 7.d and 20: Fishing mortality has declined since 2000, but remains above F_{MSY}. Spawning-stock biomass has increased from the historical low in 2006, but is still below MSY $B_{trigger}$. Recruitment since 1998 remains poor.

3) Haddock in 4, 6.a and 20: Fishing mortality has been fluctuating above F_{MSY} for most of the time-series and is above F_{MSY} in 2017. Spawning-stock biomass has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing.

4) Whiting in 4 and 7.d: Spawning-stock biomass has fluctuated around, and is now above, MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} throughout the time-series, apart from 2005. Since 2002 recruitment has been generally lower than in previous years. This stock was benchmarked in 2018, during which estimates of stock weights and maturity at age were updated, which resulted in a downward rescaling of the SSB. Furthermore, new natural mortality estimates were used, the recruitment age changed from age 0 to age 1, and the assessment model changed from XSA to SAM. Reference points were adapted accordingly.

5) Saithe in 3.a, 4 and 6: Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality has been decreasing, and it has been below F_{MSY} since 2013. Recruitment has fluctuated over time and has been below the long-term average since 2003.

6) Plaice in 4 and 20: The spawning-stock biomass is well above MSY $B_{trigger}$, and has markedly increased since 2008, following a substantial reduction in fishing mortality since 1999. Recruitment has been fluctuating around the long-term average since the mid-1990s. Since 2009, fishing mortality has been estimated at around F_{MSY}.

7) 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 1999 and is close to F_{MSY} in 2017. Recruitment has fluctuated without trend since the early 1990s, but without the large year classes that occurred in the preceding period.

8) Plaice in 7.d: The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now well above the MSY $B_{trigger}$. Fishing mortality has declined since the early 2000s and it has been below F_{MSY} since 2009. Recruitment is currently around the average of the time-series.

9) Sole in 7.d: The spawning-stock biomass has been fluctuating without trend since the 1980s, but has decreased and is now around B_{lim}. Fishing mortality has been decreasing since 2014 and is below F_{MSY} in 2017. Recruitment has been fluctuating without trend, and there has been no strong recruitment since 2011.

10) Category 3–6 finfish stocks: In 2018, new advice has been produced for pol.27.3a4 (Category 5) and gug.27.3a47d (Category 3), but not for several other stocks (bll.27.3a47de, dab.27.3a4, fle.27.3a4, lem.27.3a47d, mur.27.3a47d, tur.27.3a, tur.27.4, whg.27.3a, all Category 3 stocks, and wit.27.3a47d, now a Category 1 stock), for which biennial advice was given in 2017; it is expected that tur.27.4 will be upgraded to a Category 1 stock following the inter-benchmark meeting this summer.

i. Pollack (pol.27.3a4): Since 1977 there have been two periods of high catches. In recent years, catches have been low, albeit fairly stable.

ii. Grey gurnard (gug.27.3a47d): The time-series of mature biomass index of grey gurnard from the International Bottom Trawl Survey quarter 1 (IBTS-Q1) shows a strong increase from the beginning of 1990s and has since fluctuated at a high level.

11) Norway Pout in 3.a and 4: The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass has been above B_{pa} since 2007. Fishing mortality has been fluctuating at a lower level since 1995. Recruitment in 2018 was high, while recruitment in 2017 was slightly below the long-term average.

1 General

1.1 Terms of Reference

2017/2/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 and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

   i) descriptions of ecosystem impacts of fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2018 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 and examination of data quality;

   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 (i.e., all stocks with catches in the NEAFC area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2017.

   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(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

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

   viii) For the purpose of conducting further analyses relative to the issue of catch forecasts from biased assessment for category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

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

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

g) Identify research needs of relevance for the expert group.

Information of the stocks to be considered by each Expert Group is available here.

Specific ToRs

2017/2/ACOM:22. 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 Ostend, Belgium, 24 April – 3 May 2018 and by correspondence in September 2018 to:

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

b) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2018:

   i. Update the MSY proxy reference points for those category 3 and 4 stocks with existing proxy reference points using most recent data. For those stocks without reference points listed below, collate necessary data and information in order to estimate MSY proxy reference points prior to the Expert Group meeting. The official ICES data call included a call for length and life history parameters for each stock in the table below;

   ii. Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (ICES, 2017) along with available data and expert judgement.

Stock Code	Stock name description	EG	Data Category
nep.fu.32	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 32 (northern North Sea, Norway Deep)	WGNSSK	4.14
nep.fu.10	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 10 (northern North Sea, Noup)	WGNSSK	4.14
nep.fu.33	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 33 (central North Sea, Horn's Reef)	WGNSSK	4.14
nep.fu.34	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 34 (central North Sea, Devil's Hole)	WGNSSK	4.14
nep.fu.5	Norway lobster (*Nephrops norvegicus*) in divisions 4.b and 4.c, Functional Unit 5 (central and southern North Sea, Botney Cut–Silver Pit)	WGNSSK	4.14
tur.27.3a	Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)	WGNSSK	3.2
tur.27.4	Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)	WGNSSK	3.2

The assessments will be carried out on the basis of the stock annex. 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 14 days prior to the starting date. WGNSSK will report by 18 May 2018, and by 24 September 2018 (Norway pout) for the attention of ACOM.

Comments on and amendments to Specific ToRs

- It was not possible, during this meeting, to derive MSY proxy reference points for Category 4 Nephrops stocks. An attempt was made for one of the *Nephrops* stocks (FU 34) to run Length-Based Indicators (LBI) using length frequencies from 2014 to 2017, and borrowing life-history information from other stocks. However, results from application of the LBI method were not considered reliable because of data limitations. A workshop is being planned for the beginning of 2019, and this workshop will consider MSY proxy reference points for Category 4 *Nephrops* stocks in more detail.
- The two turbot stocks were erroneously placed on the list for WGNSSK to consider during 2018: advice is not due for either of these stocks. Furthermore, advice is due for the grey gurnard stock (gug.27.3a47d), and this stock should have been included in the list. MSY proxy reference points for this stock have been included in the corresponding chapter, and a review given in Annex 10.

1.2 InterCatch

1.2.1 Métier-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 métier-based data and their consistency with the stock-based data used for single-stock assessment.

2) Allowing WGMIXFISH to meet earlier in order to 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. With the landing obligation, these stocks become more important, and under these circumstances, discard information is a prerequisite for giving catch advice and carrying out mixed fisheries scenarios. 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 (métier) level for the data that 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. The ICES InterCatch database was chosen as the most appropriate tool to use until the planned Regional Data Bases are fully established and operational. Basic strata for the submission of catch and effort data were by country, quarter, area, and métier and catch category.

In 2018, the procedure for data submission was similar to previous years, including a requirement for life-history information and length compositions for historic landings and discards for stocks identified as "DLS" (essentially Category 3 stocks) from at least the three most recent consecutive years (only the most recent year for those stock for which length frequency data were already provided in a previous data call). The data call also required reporting to four catch categories, including BMS landings (landings below minimum size for stocks under the landing obligation). An official data call was issued by ICES, with a deadline for data delivery of the 27th March 2018. This deadline was four weeks prior to the start of the working group (instead of the usual three weeks) and caused great difficulty for labs trying to service the data call, with many missing the 4-week deadline. Despite delays in data submissions relative to the deadline and some errors needing to be corrected before the working group, these delays and corrections had no major impact on the work.

1.2.2 Data raising and allocation to unsampled strata

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

1) <u>Age and length data in parallel in InterCatch</u>

InterCatch can now work with age and length data in parallel, but it demands that length sample data have to be imported last for species with both age and length distribution data. This is due to InterCatch ignoring strata of other sample types. However, InterCatch will always take the latest imported strata without samples. Also, there is no problem with overwriting data in InterCatch as long as length data are imported latest, for stocks with both length and age samples. There is still no age-length-keys in InterCatch. It is important that when importing catches with and without age samples all strata have to be imported, all strata also have to be imported when importing catches with and without length samples.

2) <u>Technical improvements in the InterCatch interface</u>

- 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 examine 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.

3) <u>Summary outputs and inspection of data before raising</u>

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 and improved in subsequent years 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.

4) <u>Raising procedures</u>

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:

- 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. Even though there may be a great number of unsampled strata, in reality these should represent only a minor part of the catches. Large strata without sampling information would need to be investigated further.
- 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 choosing differently after the data inspection process. Each stock coordinator

has developed general principles for the allocation scheme. The main principles are mentioned in 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 métiers 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 have been reported since 2016. BMS landings, observer discards and logbook recorded discards should sum up to discard data provided prior to 2016 (i.e. double-counting should be avoided), and when performing raising procedures, the raising procedure in InterCatch should be adapted as necessary to provide a robust approach, independent of how countries categorize catches when providing catch data. The general approach adopted by WGNSSK is to raise discards using only the observed discards (catch category "D" from the datacall), and to allocate discard age compositions to BMS landings (category "B" from the datacall), if reported and given a "CATON" value.

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:

Stock	Data_year	Extracted	Exported	DataStatusFilled
bll.27.3a47de	2017	Extracted	Exported	Data used for the assessment
cod.27.47d20	2017	Extracted	Exported	Data used for the assessment
dab.27.3a4	2017	Extracted	Exported	Not filled
fle.27.3a4	2017	Extracted	Exported	Not filled
gug.27.3a47d	2017	Extracted	Exported	Not filled
had.27.46a20	2017	Extracted	Exported	Data used for the assessment
lem.27.3a47d	2017	Extracted	Exported	Data used for the assessment
mur.27.3a47d	2017	Extracted	Exported	Data used for the assessment
nep.27.4outFU	2017	Extracted	Exported	Data used for the assessment
nep.fu.10	2017	Extracted	Exported	Data used for the assessment
nep.fu.32	2017	Extracted	NO	Not filled
nep.fu.33	2017	Extracted	NO	Not filled
nep.fu.34	2017	Extracted	Exported	Data used for the assessment
nep.fu.3-4	2017	Extracted	NO	Not filled
nep.fu.5	2017	Extracted	Exported	Data used for the assessment
nep.fu.6	2017	Extracted	Exported	Data used for the assessment
nep.fu.7	2017	Extracted	Exported	Data used for the assessment
nep.fu.8	2017	Extracted	Exported	Data used for the assessment
nep.fu.9	2017	Extracted	Exported	Data used for the assessment
nop.27.3a4	2017	Extracted	NO	Not filled
ple.27.420	2017	Extracted	Exported	Data used for the assessment
ple.27.7d	2017	Extracted	Exported	Data used for the assessment
pok.27.3a46	2017	Extracted	Exported	Data used for the assessment
pol.27.3a4	2017	Extracted	Exported	Data used for the assessment
sol.27.4	2017	Extracted	Exported	Data used for the assessment
sol.27.7d	2017	Extracted	Exported	Data used for the assessment
tur.27.3a	2017	Extracted	Exported	Data used for the assessment
tur.27.4	2017	Extracted	Exported	Data used for the assessment
whg.27.3a	2017	Extracted	Exported	NOt filled
whg.27.47d	2017	Extracted	Exported	Not filled
wit.27.3a47d	2017	Extracted	Exported	Data used for the assessment

1.2.3 Treatment of BMS landings in advice sheets

There remain inconsistencies in the reporting of BMS landings between different nations, both in the official statistics (FAO) and in Intercatch. In general, WGNSSK has assumed that BMS landings are part of “unwanted” catch, and BMS landings are not shown separately in tables of ICES estimates given in the advice sheets; the only BMS estimates that appear in advice sheet tables are those from official statistics. The only exception to this treatment of BMS landings as “unwanted” catch is for the saithe stock (pok.27.3a46), for which the Norwegian component of BMS landings are included with the ICES estimates of landings or “wanted” catch.

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 sales slips 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 are a limiting factor in the amount of signal in data 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, for example, the Baranov catch equations do 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 gadoids 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 2017 and 2018

No major concerns about corrections to Datras data were raised during the working group.

1.5 Internal auditing and external reviews

ICES requested auditing procedures to be tightened to avoid unnecessary errors making their way into advice sheets, and an extra effort was made this year to achieve this. Although a very important quality assurance mechanism, internal audits do place an additional burden on group members, and it has not been possible to complete most audits during the meeting itself for a few years now. WGNSSK operates with seldom more than one scientist per stock (sometimes one scientist is responsible for two or more stocks), and there was in most cases not enough time to have the reports finalized in order to carry out the audit within the WG meeting itself. Audits had to be conducted by correspondence after the WG time, which is neither very efficient nor very motivating, given the heavy workload under which most members usually operate back in home institutes.

Finally, all WGNSSK stocks with an updated advice in 2018 could be covered by the internal audit (Table 1.5.1). The audits are given in Annex 5 of the report. An external review was also needed for the MSY proxy work for grey gurnard stock (see Annex 10). Furthermore, an external review will accompany the Inter-benchmark for North Sea turbot during the summer of 2018. In addition, any stock for which advice was re-opened in the Autumn was also subject to an audit (see Annex 7).

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

Stock	Internal Audit	External Review
bll.27.3a47de	no new advice in 2018	
cod.27.47d20	✓	
dab.27.3a4	no new advice in 2018	
fle.27.3a4	no new advice in 2018	
gug.27.3a47d	✓	✓
had.27.46a20	✓	
lem.27.3a47d	no new advice in 2018	
mur.27.3a47d	no new advice in 2018	
nep.27.4outFU	no new advice in 2018	
nep.fu.10	✓	
nep.fu.32	✓	
nep.fu.33	✓	
nep.fu.34	✓	
nep.fu.3-4	✓	
nep.fu.5	✓	
nep.fu.6	✓	
nep.fu.7	✓	
nep.fu.8	✓	
nep.fu.9	✓	
nop.27.3a4	no assessment in spring	
ple.27.420	✓	
ple.27.7d	✓	
pok.27.3a46	✓	
pol.27.3a4	✓	
sol.27.4	✓	
sol.27.7d	✓	
tur.27.3a	no new advice in 2018	
tur.27.4	no new advice in 2018	
whg.27.3a	no new advice in 2018	
whg.27.47d	✓	
wit.27.3a47d	no new advice in 2018	

1.6 Transparent Assessment Framework (TAF)

TAF is a new framework, currently in development, to organize all ICES stock assessments. Using a standard sequence of R scripts, it makes the data, analysis, and results available online, and documents how the data were preprocessed. Among the key benefits of this structured and open approach are improved quality assurance and peer review of ICES stock assessments. Furthermore, a fully scripted TAF assessment is easy to update and rerun later, with a new year of data. As of spring 2018, the first assessments are being scripted in standard TAF scripts. See http://taf.ices.dk for more information.

During the WGNSSK 2018 meeting, the following progress was made getting stocks into TAF:

1. North Sea cod (cod.27.47d20) assessment was run on Stockassessment.org (SAO), while TAF scripts were created to describe the preprocessing of survey indices and maturity at age. Future work (of TAF and SAO developers) will establish a connection between TAF and SAO to form a continuous pipeline for the workflow from the underlying to results.

2. North Sea sole (sol.27.4) has been fully scripted in TAF.

3. North Sea & West of Scotland haddock (had.27.46a20) has been fully scripted in TAF for the 2017 assessment. Work is underway to update this to the 2018 assessment.

The 2018 North Sea cod and North Sea sole analyses will become publicly available on https://github.com/ices-taf after ACOM has released the advice.

1.7 Mixed Fisheries

The mixed fisheries analyses for the North Sea are performed by the Working Group for Mixed Fisheries Advice for the North Sea (WGMIXFISH), which aims to evaluate the consistency of the ICES advice for the individual stocks in a mixed fisheries context, using the Fcube model (Ulrich *et al.*, 2011).

WGNSSK and WGMIXFISH have developed and issued a common data call since 2012, which has greatly improved the quality and scheduling of data delivery. WGMIXFISH meets directly after WGNSSK in late May 2018 in order to integrate mixed-fisheries advice for the North Sea into the single stock advice. We therefore refer to the ICES WGMIXFISH 2018 report for any further description of the mixed-fisheries context.

However, the group continues to discuss mixed fisheries issues under the landing obligation. There is a potential problem with choke species in the North Sea, where target as well as bycatch species can become choke species for certain fleet segments. One way to deal with this is to use the recently defined ranges for F_{MSY} instead of point estimates (see e.g. ICES WKMSYREF III 2014 and ICES WKMSYREF IV 2016). Ranges can introduce the flexibility needed to minimize the discrepancies in available quotas for species in a mixed fishery, and have been introduced as part of the proposed EU MAP, a mixed-fishery multiannual plan for demersal stocks in the North Sea. This plan allows fishing within the F_{MSY} range, but with more stringent conditions (related to the need to meet mixed fisheries objectives) for using the part of the range above F_{MSY}, referred to as the upper range. STECF undertook an evaluation of mixed-fishery multiannual plans for the North Sea (STECF EWG-15-02), following a European Commission proposal for such plans, and concluded in relation to the use of the upper range that (STECF PLEN-15-01):

> *There is an increased risk of over-exploitation if fishing opportunities are set in line with the upper limits of the F_{MSY} ranges, particularly if several stocks in a mixed fishery are involved.*

and furthermore that:

> *The use of the F_{MSY} range approach should only be employed when informed by objective mixed fishery advice which demonstrates that attaining F_{MSY} for the key driver*

species can not be achieved simultaneously and the the application of F_{MSY} ranges are necessary to better reconcile mixed fisheries issues. In the absence of such information, then fishing opportunities should be set in accordance with single species F_{MSY} advice.

Blindly setting TACs within the upper range for all stocks should be avoided 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 bycatch species (e.g. lemon sole, turbot) by TAC further complicates the situation. If the TAC management for these species continues and F_{MSY} proxies 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 bycatch 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 targets for target stocks are enough to ensure a sustainable exploitation of bycatch species.

1.8 Multispecies considerations

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

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

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

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 WKMTRADE 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} ranges (see also under mixed fisheries) could also help here to reach consensus 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.

1.9 Estimation of MSY proxies for Category 3 stocks

The new ToR introduced in 2017, which required the estimation of MSY proxies for Category 3 and 4 stocks, was carried over to 2018 to deal with the remaining Category

3 and 4 stocks. Due to data limitations, it was not possible to produce MSY proxies for Category 4 *Nephrops* stocks (although an attempt was made to apply the LBI methodology to FU34); instead a dedicated workshop to be held in early 2019 will deal with this issue. The group attempted the estimation of MSY proxies for the gug.27.3a47d, which can be found in the relevant chapter; a review of the MSY proxy work is included in Annex 10.

1.10 Special requests

In February 2018, ICES received the following Special Request from the Commission:

"ICES is requested to analyse for a list of stocks (as specified below) the role of the Total Allowable Catch instrument. It is asked to assess the risks of removing TAC for each case analysed in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of other conservation tools in absence of TACs to the requirement that the stock concerned remains within safe biological limits. In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs."

The list of stocks relevant to WGNSSK are: wit.27.3a47d, lem.27.3a47d, bll.27.3a47de, tur.27.4, whg.27.3a. Given data paucity, WGNSSK initially indicated that we were not in a position to provide a response for whg.27.3a, but that an attempt would be made to provide a response for the remaining 4 stocks. ICES suggested the same approach would be used as was done for dab and flounder in 2017, implying an attempt to answer the following six questions:

1) Was the TAC restrictive in the past?
2) Is there a targeted fishery for the stock or are the species mainly discarded?
3) Is the stock of large economic importance or are the species of high value?
4) How are the most important fisheries for the stock managed?
5) What are the fishing effort and stock trends over time?
6) What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

The work regarding this special request is given in Annex 11, which includes whg.27.3a, which the WG was able to complete in the autumn.

1.11 Presentations

Three presentations were made to WGNSSK in 2018, as follows:

Uncertainty estimation for NS IBTS Indices

Natoya Jourdain presented uncertainty estimation for North Sea IBTS indices. Several research vessels, using standardized fishing methods, participate in the North Sea International Bottom Trawl Survey (IBTS). The survey with these vessels, which allows fishing also on rough ground, provides information on seasonal distribution of stocks, abundance, hydrography and the environment, which is then used for stock assessments. Estimates of abundance indices based on age-length keys (ALK) are provided without any assessment of their accuracy. We present a model-based ALK estimator, and a stratified design-based ALK estimator for estimating abundance at age. Both estimators take into account the spatial differences in age-length structures. These estimators are compared with the designed-based ALK estimator proposed by ICES for IBTS, which does not account for spatial differences in the age-length structure. As the proposed ALK estimator by ICES is a combination of age data over a large area, this can result in strongly biased estimates of numbers-at-age. An example of cod (*Gadus morhua*) and saithe (*Pollachius virens*) is used to illustrate spatial differences in the proportions of age-at-length, and estimates of uncertainty are presented using nonparametric bootstrapping. Both haul-based and model-based ALK estimators provide a more accurate coverage probability compared with DATRAS.

MSE for Norway Pout

Mollie Brooks presented the management strategy evaluation (MSE) used to evaluate various harvest control rules (HCR) of the Norway pout fishery, including the presently-implemented HCR. The default is an escapement strategy. Other HCRs tested included TACmin and TACmax that would override the TAC from the escapement strategy. Also, Fcap values were considered such that they could override TACmax or the TAC from the escapement strategy. Overall, the reviewers (Martin Dorn and Manuela Azevedo) found that the MSE was carefully done, with the methods clearly described, and results reported in appropriate figures and tables. WKNPOUT members and reviewers discussed the reviewers' concerns about which risk is used (1 vs 3), potential imprecision of the stochastic forecast, the best way to simulate recruitment, changes to Blim, and random number consistency. It was agreed that an additional MSE should be run with 10000 replicates (10x the number in the study) to check if risk 3 will converge to risk 1. Also it was agreed that an additional MSE of the default strategy should be done with implementation error such that the maximum achievable Fbar is 0.89 as was done for most of the MSEs in the study. These additional analyses will be added as annexes to the WKNPOUT report.

Science-industry partnerships in the Netherlands

Wouter van Broekhoven presented current science-industry partnerships in the Netherlands investigating turbot, brill, plaice, sole, and *Nephrops*, jointly with Jurgen Batsleer.

The presentation was structured into three parts:

1. Turbot & brill, plaice, sole - discards quantified on commercial fishing trips

To date 16 research trips on which all discards of species subject to catch limits were carried out in the North Sea starting in 2015 and continuing presently on board commercial pulse trawling vessels, at 14 of which catches of commercial landings and discards were stored and subsequently analysed in detail on shore per haul. The collection of discards was carried out on regular commercial fishing trips by the regular crew plus one additional crew member, with an observer present.

Part A of the presentation showed catches of discards divided into seven species (groups): sole, plaice, dab (discontinued in 2018 after removal of catch limits), turbot & brill, rays, whiting, and other. Each was weighed to the nearest 0.1 kg per haul. Haul-based stacked bar charts showing the relative abundance in the catch were presented. CPUE (kg hr-1) of discards were shown geographically on the mid points of the hauls using a colour scale, for three species (groups): turbot&brill, sole, and plaice.

Part B of the presentation showed more detailed analysis of turbot, brill, plaice, and sole. A video showing an automated fish sorting machine employed at the Dutch fish auction of Den Helder was presented. The machine was used to count and weigh all individual plaice and, when volumes were large also sole, per 2-cm length bin, producing length-weight relations per haul. When volumes were low all sole were measured to the same specifications manually. Proportional distribution by weight of length classes of plaice and sole were shown together with length-weight relations. Turbot and brill were always measured individually: length to the nearest cm and weight to the nearest g. Length and weight frequency distributions were shown together with length-weight relations.

2. Turbot & brill, *Nephrops* – upcoming research project 2018–2020

Two main pillars of a new collaborative industry-science research project for which EMFF funding was recently confirmed were presented:

I. Survey using a commercial fishing vessel, targeting turbot & brill.

Current surveys show poor internal consistency performance for these species. The aim is to set up an annual survey using commercial fishing vessels fishing at predefined locations, aiming to deliver a data stream allowing the detection of trends and suitable for stock assessment use. Key pressure points relating to the design of the survey which was still under development were discussed among the group, and useful feedback was provided. Within the project lifetime three survey years are covered, but the project explicitly aims to secure the necessary continuation of the time series.

II. Fully catch-monitored fisheries *Nephrops norvegicus*

FU5, FU33, and outFU catches will be quantified using instruments such as a spring balance off the boom (total catch), and electronic discard valves in the chutes (total discards). A reference fleet will be equipped with the instruments and observer validation trips will be conducted. The aim is to contribute to improving the assessment of FU5 and FU33. After development time a monitoring period of 1.5 years is covered within the project lifetime, but the project explicitly aims to secure the necessary continuation of the time series.

3. Stock assessment data needs - exploring the data collection potential of the fishing fleet

Finally a brief discussion was held relating to the potential for data collection on the commercial fishing fleet. The group was invited to identify data collection needs that could potentially be addressed through collaborative approaches.

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 bycatch 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 1980s. 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 Greater North Sea peaked above 1.5 million tonnes in the 1980s, showed a strong decline from the mid to late 1990s, and is now just above 500 000 tonnes (ICES, 2017a).

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 Division 7.d and Subdivision 20 (i.e. Skagerrak), haddock including Division 6.a and Subdivision 20, whiting including Division 7.d, saithe including Subarea 6 and Division 3.a, plaice including Subdivision 20, and Norway pout including Division 3.a. The state of *Nephrops* stocks are evaluated on the basis of discrete Functional Units (FU) on which estimates of appropriate removals are based. However, quota management for *Nephrops* is still carried out at the Subarea and Division level.

The analysis of biological interactions (predator-prey relationships) among species has been a central theme in ICES over the last 30 years, primarily for the Baltic Sea and the North Sea. The 2011, 2014 and 2017 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-varying values of natural mortalities estimated by multispecies assessments for cod, haddock and whiting are incorporated in the assessments of these species. Given the new North Sea key run for 2017, reference points were evaluated for cod and haddock to see if they required revision, but differences were minor, so no revision was needed. Whiting underwent a benchmark, and results from the new key run were incorporated as part of this process. Flatfish are not part of the current multispecies assessment and more work is needed to incorporate information on flatfish in the multispecies 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 2018), which meets straight after the WGNSSK. Both WGs 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 Subdivision 20 has been merged with plaice in Subarea 4 in 2015. Mixed-fisheries considerations are based on the single-stock assessments, combined with information on the average catch composition and fishing effort of the demersal fleets and fisheries in the Greater North Sea catching cod (cod.27.47d20), haddock (had.27.46a20), whiting (whg.27.47d), saithe (pok.27.3a46), plaice (ple.27.420 and ple.27.7d), sole (sol.27.4 and sol.27.7d), and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4outFU). In the absence of specific mixed-fisheries management objectives, ICES does not advise on unique mixed-fisheries catch opportunities for the individual stocks but develops scenarios that might show potential discrepancies in the single stock advices in a mixed fisheries context.

In 2017, WGMIXFISH introduced a new scenario, the 'range' scenario taking advantage of the F_{MSY} ranges to reduce the potential inconsistencies in the single species advices. More effort will be put in the future in the inclusion of other stocks without analytical assessment and/or mostly distributed in other areas (i.e. hake) because many of them are important bycatch species and are potential "choke species" once under the landing obligation.

ICES WGMIXFISH also produces a number of figures describing main trends in effort, catches and landings by fleet and stock.

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 has 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.

ICES has evaluated technical interactions between species captured together in demersal fisheries by examining their co-occurrence in the landings at the scale of gear/mesh size range/ICES square/calendar quarter (hereafter referred to as 'strata'). The percentage of landings of species A, where species B is also landed and constitutes more than 5% of the total landings in that stratum, has been computed for each pair of species. Cases in which species B accounts for less than 5% of the total landings in a stratum were ignored.

To illustrate the extent of the technical interactions between pairs of species, a qualitative scale was applied to each interaction (Figure 2.1.1). In this figure, rows represent the share of each species A that was caught in fisheries where the B species (columns) accounted for at least 5% of the total landing of the fisheries. A high proportion of the catches of lemon sole was for example taken in fisheries where plaice landings where at least 5% of the total landings. The amounts of lemon sole caught in fisheries where cod, haddock, hake or saithe accounted for at least 5% of the total landings were medium. The amount of lemon sole caught in fisheries where lemon sole constituted 5% or more of the total landings were low, indicating that there is no (or very limited) target lemon sole fishery.

The vertical bars illustrate the degree of mixing. Fisheries where plaice (species B) constitute 5% or more of the total landings account for a high share (red cells) of the total landings of dab, lemon sole, plaice, sole, turbot, flounder, brill, haddock, and which, and a medium share (orange cells) of the landings of whiting, hake and *Nephrops*. The lemon sole column shows that the landings of lemon sole in fisheries where the species constituted 5% or more of the total landing were low and the relative landings of other species in these fisheries were also low. The columns can be used to identify the main fisheries (target fisheries) and the degree of mixing in these fisheries.

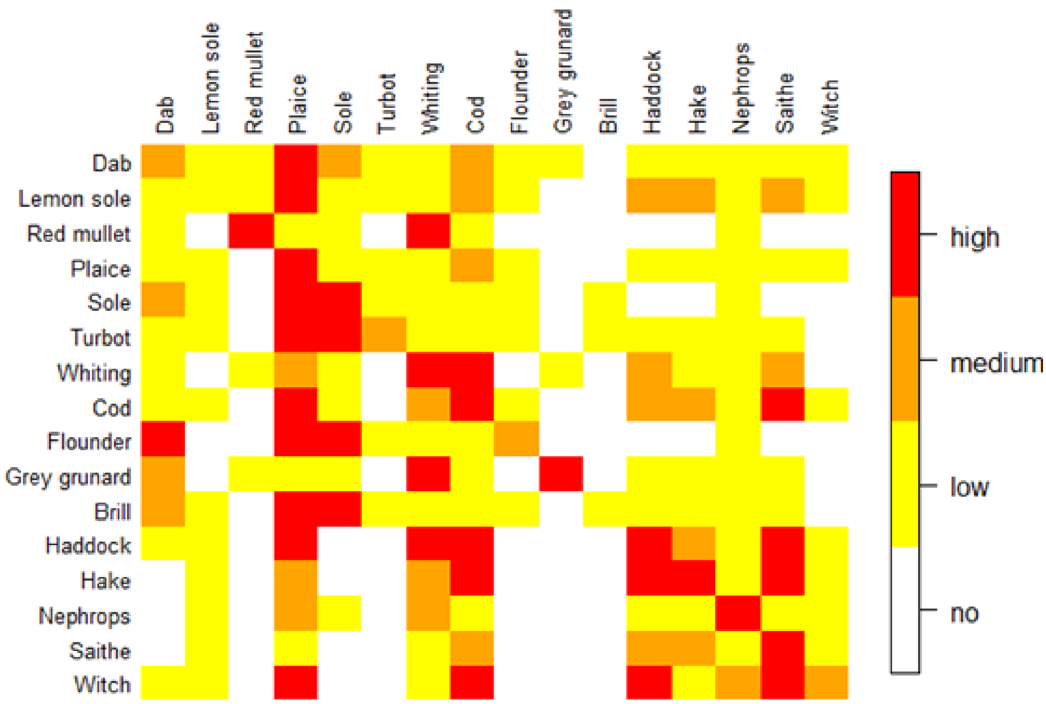

Figure 2.1.1. Technical interactions amongst North Sea demersal stocks. Horizontal lines of the figure represent the target species of the fishery (species A) for which the interaction with species in each column (species B) was assessed. Red cells indicate that the species are frequently caught together. Orange cells indicate medium interactions and yellow cells indicate weak interactions. For example, haddock sometimes occur in catches in the whiting fishery (a 'medium' interaction) but whiting often occur in catches in the haddock fishery (a 'high' 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 multiannual management plans, partly in relation to cod recovery, but also more generally. With the implementation of the landing obligation in 2016 mixed fisheries, EU multiannual plans have been under development, and one has now been proposed for the North Sea, and has been used as the basis for advice for North Sea sole for 2019.

The management frameworks can be summarised as such:

2.2.1 Landing 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. Discard plans have been agreed for 2018 in the North Sea (Subarea 4, Division 3.a and Union waters of Division 2.a; Table 2.2.1.1) and in Union and international waters of Subarea 6 and Division 5.b (Table 2.2.1.2), and in Division 7.d (Table 2.2.1.3), defining for which species, gear and mesh size combinations the landing obligation applies. The discard plans will be amended to define which additional species and gear combinations will fall under the landing obligation in future years until 2019, when it is expected that the landing obligation is fully implemented.

Table 2.2.1.1. Fisheries under the landing obligation in Subarea 4, Division 3.a and Union waters of Division 2.a (from Commission delegated regulation (EU) 2018/45).

Fishing gear (1) (2)	Mesh size	Species subject to the landing obligation
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	≥ 100 mm	All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting.
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	70-99 mm	All catches of cod (3), common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting.
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 cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting.
Beam trawls: TBB	≥ 120 mm	All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting.
Beam trawls: TBB	80-119 mm	All catches of cod, common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting.
Gillnets, trammel nets and entangling nets: GN, GNS, GND, GNC, GTN, GTR, GEN, GNF		All catches of cod (3), common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting.
Hooks and lines: LLS, LLD, LL, LTL, LX, LHP, LHM		All catches of cod, common sole, haddock, hake, plaice, saithe, Northern prawn, and Norway lobster and whiting.
Traps: FPO, FIX, FYK, FPN		All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting.

(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 (OJ L 112, 30.4.2011, p. 1).
(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) The landing obligation for cod shall not apply in ICES subdivision IIIaS.

Table 2.2.1.2. Fisheries under the landing obligation in Union and international waters of Subarea 6 and Division 5.b (from Commission delegated regulation (EU) 2018/46).

Fishery	Gear Code	Fishing gear description	Mesh Size	Species to be landed
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls & Seines	All	All catches of haddock and by-catches of sole, plaice and megrims where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 5 % of the following gadoids: cod, haddock, whiting and saithe combined
Norway lobster (*Nephrops norvegicus*)	OTB, SSC, OTT, PTB, SDN, SPR, FPO, TBN, TB, TBS, OTM, PTM, SX, SV, FIX, OT, PT, TX	Trawls, Seines, Pots, Traps & Creels	All	All catches of Norway lobster and by-catches of haddock, sole, plaice and megrim where the total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 5 % of Norway lobster.
Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls	≥ 100 mm	All catches of saithe where the total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 50 % of saithe.
Black scabbardfish (*Aphanopus carbo*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls & Seines	≥ 100 mm	All catches of black scabbardfish where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 20 % of black scabbardfish.
Blue ling (*Molva dypterygia*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls & Seines	≥ 100 mm	All catches of blue ling where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 20 % of blue ling.
Grenadiers (*Coryphaeides rupestris, Macrourus berglax*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls & Seines	≥ 100 mm	All catches of grenadiers where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 20 % of grenadiers.

(*) Vessels listed as subject to the landing obligation in this fishery in accordance with Commission Delegated Regulation (EU) 2016/2375 remain on the list indicated in Article 4 of this Regulation despite the change in the reference period and continue being subject to the landing obligation in this fishery.

Table 2.2.1.3. Fisheries under the landing obligation in Division 7.d (from Commission delegated regulation (EU) 2018/46).

Fishery	Gear Code	Fishing gear	Mesh Size	Species to be landed
Common Sole (*Solea solea*)	TBB	All Beam trawls	All	All catches of common sole
Common Sole (*Solea solea*)	OTT, OTB, TBS, TBN, TB, PTB, OT, PT, TX	Trawls	< 100 mm	All catches of common sole
Fishery	Gear Code	Fishing gear	Mesh Size	Species to be landed
Common Sole (*Solea solea*)	GNS, GN, GND, GNC, GTN, GTR, GEN	All Trammel nets & Gill nets	All	All catches of common sole
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls and Seines	All	All catches of whiting, where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than 10 % of the following gadoids: cod, haddock, whiting and saithe combined

(*) Vessels listed as subject to the landing obligation in this fishery in accordance with Commission Delegated Regulation (EU) 2016/2375 remain on the list indicated in Article 4 of this Regulation despite the change in the reference period and continue being subject to the landing obligation in this fishery.

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 may have serious implications for stocks dependent on the interpretation of the respective paragraphs in the regulation (STECF, 2014a, b). The possibility of using 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 because it is not possible to predict what will happen, at least in the first few years.

In 2016, a high survival exemption has been granted for the main métiers catching *Nephrops* in Division 3.a. Furthermore, the MCRS has been reduced substantially in Division 3.a. In 2017 the EU landing obligation was applied to all catches of Norway lobster fisheries in ICES Subarea 4. An exemption for high survival was granted for catches with pots (FPO), and for catches with bottom trawls (OTB, TBN) with a mesh size of at least 80 mm equipped with a netgrid selectivity device. In 2018, this second exemption was restricted to winter months (October to March), and to the functional units Farn Deeps (FU6), Firth of Forth (FU8) and Moray Firth (FU9), after evaluation of the scientific evidence by STECF. ICES notes that the landings information provided to ICES does not include information on the use of netgrid. Additionally, a *de minimis* exemption has been granted since 2016 for individuals below the 25 mm minimum conservation size (MCRS), up to a maximum of 6% of total annual catches of this species by vessels using bottom trawls (OTB, TBN, OTT, TB) of mesh size 80–99 mm. *De minimis* are not reported to ICES. There was no evidence presented to the Working Group that the introduction of the landing obligation had caused any change to discarding practices for the *Nephrops* fishery since 2016.

For sole and haddock, several *de minimis* 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 category BMS) and how much will still be discarded is 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, which leads to an increased uncertainty in short term forecasts until more information becomes available.

It would be expected that under the EU Landing Obligation fish caught under the minimum conservation reference size (MCRS) would be landed and recorded as BMS landings in log books rather than discarded as happened before the Landing Obligation. The log book records of BMS landings would then be reported to ICES. However, low BMS values may be seen if the fish caught below MCRS are either not landed, not recorded in log books, not reported to ICES, reported to ICES incorrectly, or a mixture of any of these. For all stocks where BMS landings were reported to ICES since 2016, these values were either zero or very low, substantially lower than the estimated discards.

2.2.2 Effort limitations

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

In 2008, the system was radically redesigned. From 2009, a total effort limit (measured in kW days) was 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 for the maximum allowable fishing effort was decided for 2013–2016 (Table 2.2.2.1). The effort management regime, which formed part of the long-term management plan for North Sea cod, has been revoked from 2017 onwards, but the effort management regime for plaice and sole remains in place; the maximum allowable fishing effort applied to beam trawls of mesh larger than or equal to 80 mm (BT1 and BT2) in Subarea 4 is shown in Table 2.2.2.2 for different countries.

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: GN; Trammel nets: GT and Longlines: LL.

Table 2.2.2.1. Maximum allowable fishing effort in kilo watt days in 2013–2016 for: Skagerrak, that part of Division 3.a not covered by the Skagerrak, and the Kattegat; Subarea 4 and EU waters of Division 2.a; Division 7.d. Note for 2016, TR1 and TR2 were combined.

Regulated gear	BE	DK	DE	ES	FR	IE	NL	SE	UK
TR1	895	3 385 928	954 390	1 409	1 505 354	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	5 037 332
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

Table 2.2.2.2. Maximum allowable fishing effort in kilowatt days in 2018 for Subarea 4.

Regulated gear	BE	DK	DE	NL	UK
BT1+BT2	5 693 620	1 432 092	1 972 158	39 475 162	10 568 178

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, haddock, whiting, saithe, plaice and sole are currently or have previously been subject to multiannual 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 mortalities. 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. All of these plans are no longer used as basis of advice and to set TACs for a variety of reasons, including benchmarks that have revised perceptions and reference points and the extension of stock areas, rendering these plans outdated.

With the new CFP, the demand for mixed fisheries management plans covering all species caught in a fishery is increasing. An EU multiannual management plan (EU MAP) for the North Sea has been developed and proposed, and is used as the basis for advice for North Sea sole for 2019; this plan has not been used for shared stocks in the North Sea (cod, haddock, whiting saithe, plaice) because Norway has not agreed to the EU MAP. Instead, Norway has proposed alternative single-species plans for these shared stocks, which ICES are in the process of evaluating. With the implementation of the landing obligation from 2016 onwards for the North Sea demersal fisheries, problems caused by the management of mixed fisheries with single species plans will become more evident.

2.2.4 Additional technical measures

The national management measures with regard to the implementation of the available quota in the fisheries differ between species and countries. The industrial fisheries are subject to regulations for the bycatches of other species (e.g. herring, whiting, haddock, cod). Technical measures relevant to each stock are listed in each stock section, along with additional management measures, 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 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-mesh 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-mesh 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-mesh 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 8 m 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 Ecosystem Overviews

WGNSSK welcomes the ecosystem overview available for the North Sea. It is a well-organized description of the ecosystem and highlights changes observed during the last decades. However, WGNSSK discussed the overviews and has some suggestions how to improve the next generation of overviews.

Discussions revealed that the overview currently does not provide sufficient information on the effects and impacts of observed changes. An example can be found on page 3: "The seabird population showed an overall increasing trend until 2000, after which it declined. Recent changes in fisheries management policy (e.g. reduction in effort and the landing obligation) will likely affect seabirds as well as other parts of the ecosystem". The second sentence is very general and does not contain useful information. Indications whether effects of management changes will be positive or negative or are relevant for certain parts of the ecosystem are missing. Similar examples can be found throughout the document.

A further issue is the description of the state of the ecosystem. In the absence of reference levels, conclusions on the current state of the ecosystem cannot be reached. In addition, the description of ecosystem states may be better combined with the description of main pressures influencing certain ecosystem states. A separation of natural fluctuations and/or changes from impacts caused by fishing and other pressures is needed to make the overview useful for managers. Otherwise it is unclear whether management actions are needed if a certain ecosystem state is changing.

Figure 6.1.3 is central to the ecosystem overview. The figure shows the main human activities, pressures and how they are linked to ecosystem states. The figure provides a good summary; however, it is unclear how the strength of the lines linking activities, pressures and states has been derived. Neither is it described how the ranking was performed, nor is an indication provided on which stakeholder groups, and how many people, were involved. This contradicts to some extent the ICES ambition to provide, as much as possible, transparent and objective advice. In addition, the thin line in the figure from selective extraction of species to food webs contradicts, at first sight, the sentences further down in the overview: "Fishing changes both community structure and food webs. The depletion of larger predatory species has likely perturbed the structure and functioning of the ecosystem". Maybe the figure and the text refer to different time scales or focus on different trophic levels. But such an explanation is missing.

Some of the figures in the current version are outdated. Longer time series are available for effort data, and the large fish indicator stops in 2011. Given the lower fishing mortality regime in recent years it would be most interesting to see whether the large fish indicator has responded or not. If it has not responded, a discussion on reasons and the indicator itself may be needed.

There is an overlap between the ecosystem and fisheries overviews, e.g. in relation to effort trends and status of stocks. Too much overlap should be avoided and the overviews may be linked in a way that updates in the fisheries overviews translate automatically into the ecosystem overviews. Ecosystem overviews could also focus more on general trends and, e.g., the naming of stocks above F_{MSY} is not needed. This would also reduce the update frequency of the ecosystem overviews.

The current low productivity of many gadoids in the North Sea is not discussed in the document. In general, an overview figure showing recruitment trends (similar to F/F_{MSY} and B/MSY $B_{trigger}$) for different guilds may provide valuable information.

The word "crustaceans" should be replaced with *Nephrops* in Figure 6.1.7. Only four *Nephrops* assessments are available, and *Nephrops* constitutes only a small part of the crustacean biomass.

WGNSSK does not fully follow the rationale behind the sentence: "The proportional impact of recreational fishing is increasing as commercial operations are restrained" (page 5). If commercial operations are restrained, the stocks are believed to increase. At a constant effort (and limited potential to increase CPUEs) of recreational fishing, this increase in stocks likely leads also to a decrease in mortality rates caused by recreational fishing. Next to this, the sentence on recreational fishing is closely linked to forage and industrial fish. However, recreational fishing is much more problematic for species like seabass and cod.

Bycatch of sensitive species is an important topic and highly relevant for managers and many stakeholders. Next to the text in the overview, a table highlighting which métiers/fisheries have the highest bycatch of a certain species could be an interesting addition for risk-based management approaches.

The paragraph on abrasion contains interesting information. It is stated "that mobile bottom trawling techniques used by commercial fisheries in the 12 m+ vessel category have been deployed over approximately 290 000 km^2 of the Greater North Sea in 2013, corresponding to ca. 42.5% of the ecoregion's spatial extent". However, does this also mean that 57.5% of the ecoregion's spatial extent is not impacted by bottom trawling with vessels 12 m+? This would be also an important message. If this conclusion is wrong, further explanation is needed for how the numbers have to be interpreted.

No flatfish are in the figure showing the North Sea food web. This is questionable for a flatfish-dominated system.

The list of threatened and declining species according to OSPAR may be updated after discussions with OSPAR. It is debatable whether species like cod (at least at a whole North Sea level), thornback and spotted ray still belong to this list.

2.4 Fisheries Overviews

ICES has published a Fisheries Overview for the Greater North Sea Ecoregion (ICES, 2017a). The Executive Summary is as follows:

Around 6600 fishing vessels are active in the Greater North Sea. Total landings peaked in the 1970s at 4 million tonnes and have since declined to about 2 million tonnes. Total fishing effort has declined substantially since 2003. Pelagic fish landings are greater than demersal fish landings. Herring and mackerel, caught using pelagic trawls and seines, account for the largest portion of the pelagic landings, while sandeel and haddock, caught using otter trawls/seines, account for the largest fraction of the demersal landings. Catches are taken from more than 100 stocks. Discards are highest in the demersal and benthic fisheries. The spatial distribution of fishing gear varies across the Greater North Sea. Static gear is used most frequently in the English Channel, the eastern part of the Southern Bight, the Danish banks, and in the waters east of Shetland. Bottom trawls are used throughout the North Sea, with lower use in the shallower southern North Sea where beam trawls are most commonly used. Pelagic gears are used throughout the North Sea.

In terms of tonnage of catch, most of the fish stocks harvested from the North Sea are being fished at levels consistent with achieving good environmental status (GES) under the EU's Marine Strategy Framework Directive; however, the reproductive capacity of the stocks has not generally reached this level. Almost all the fisheries in the North Sea catch more than one species; controlling fishing on one species therefore affects other species as well. ICES has developed a number of scenarios for fishing opportunities that take account of these technical interactions. Each of these scenarios results in different outcomes for the fish stocks. Managers may need to take these scenarios into account when deciding upon fishing opportunities. Furthermore, biological interactions occur between species (e.g. predation) and fishing on one stock may affect the population dynamics of another. Scenarios that take account of these various interactions have been identified by ICES and can be used to evaluate the possible consequences of policy decisions. The greatest physical disturbance of the seabed in the North Sea occurs by mobile bottom-contacting gear during fishery in the eastern English Channel, in nearshore areas in the southeastern North Sea, and in the central Skagerrak. Incidental bycatches of protected, endangered, and threatened species occur in several North Sea fisheries, and the bycatch of common dolphins in the western English Channel may be unsustainable in terms of population.

2.5 Human consumption fisheries

2.5.1 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 6, plaice in 7.d and sole in 7.d. Discards could also be estimated for bycatch species (e.g., dab, flounder, lemon sole, witch, brill, and 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 2016. 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 4) which estimated unallocated removals, potentially due to reporting problems, unrecorded discards, changes in natural mortality, or changes in survey catchability. In 2013, WGNSSK considered that the assumption of unallocated removals after 2006 could not be justified by any known factors (see 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 7.d 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.

2.5.2 Summary of stock status

The main impression in recent years is that fishing mortality has been reduced substantially 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 cod in 4, 7.d and 20, and sole in 7.d are below MSY $B_{trigger}$ at the beginning of 2018. Several North Sea stocks are exploited around or below F_{MSY} levels; exceptions are cod in 4, 7.d and 20, haddock in 4, 6.a and 20, whiting in 4 and 7.d and sole in 4 (the latter only slightly above F_{MSY}). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries (brill, turbot in 4, turbot in 3a, witch, lemon sole, dab, flounder, striped red mullet, whiting in 3a), along with *Nephrops* in 4 outside functional units. For all of these stocks, catch advice was provided in 2015 for the first time, and again in 2017, but in 2018, it was only necessary to determine whether the perception of the stocks has changed compared to 2017; because these perceptions have not changed, no reopening was needed for any of these stocks. In 2018, assessments and advice was prepared for data-limited *Nephrops* stocks (FUs 5, 10, 32, 33 and 34), pollack and grey gurnard, along with the annual advice for Category 1 finfish and *Nephrops* stocks.

Reopening of advice was triggered for several stocks in the autumn, namely haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d, saithe in 4, 6 and 3.a, plaice in 4 and 3.a.20, and Nephrops in FU 6, 7, 8 and 34 (Annex 7).

The summary of stock status is as follows:

1) *Nephrops*: For FU 6, the stock has increased since 2015 and is currently just above MSY $B_{trigger}$, while harvest rates have dipped below F_{MSY} in 2017 after a long period of being above this level. The stock size for FU 7 declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015, but has since increased strongly and is currently above MSY $B_{trigger}$, while the harvest rate has declined since 2010 and remains well below F_{MSY}. For FU 8, the stock size has been above MSY $B_{trigger}$ for most of the time-series, and the harvest rate varying and now above F_{MSY}. For FU 9, the stock has been above MSY $B_{trigger}$ for the entire time-series, while the harvest rate has fluctuated around F_{MSY} and is now just below it. The stock size of *Nephrops* in 3.a is considered to be stable, while the harvest rate for this stock is currently below F_{MSY}.

The FUs 5, 10, 32, 33 and 34 are data limited, and new catch advice was provided in 2018 (biennial advice, for 2019 and 2020). Furthermore, FU 34 was re-opened in the autumn of 2018 following a survey in June 2018 showing a significant increase compared to the previous year.

No new advice was provided for *Nephrops* outside the functional units in 2018.

A workshop is being planned for early 2019 to consider the framework for providing advice for *Nephrops* Category 1 and 4 stocks, including the estimation of reference points or proxies for them.

2) Cod in 4, 7.d and 20: Fishing mortality has declined since 2000, but remains above F_{MSY}. Spawning-stock biomass has increased from the historical low in 2006, but is still below MSY $B_{trigger}$. Recruitment since 1998 remains poor.

3) Haddock in 4, 6.a and 20: Fishing mortality has been fluctuating above F_{MSY} for most of the time-series and is above F_{MSY} in 2017. Spawning-stock biomass has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing.

4) Whiting in 4 and 7.d: Spawning-stock biomass has fluctuated around, and is now above, MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} throughout the time-series, apart from 2005. Since 2002 recruitment has been generally lower than in previous years. This stock was benchmarked in 2018, during which estimates of stock weights and maturity at age were updated, which resulted in a downward rescaling of the SSB. Furthermore, new natural mortality estimates were used, the recruitment age changed from age 0 to age 1, and the assessment model changed from XSA to SAM. Reference points were adapted accordingly.

5) Saithe in 3.a, 4 and 6: Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality has been decreasing, and it has been below F_{MSY} since 2013. Recruitment has fluctuated over time and has been below the long-term average since 2003.

6) Plaice in 4 and 20: The spawning-stock biomass is well above MSY $B_{trigger}$, and has markedly increased since 2008, following a substantial reduction in fishing mortality since 1999. Recruitment has been fluctuating around the long-term average since the mid-1990s. Since 2009, fishing mortality has been estimated at around F_{MSY}.

7) 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 1999 and is close to F_{MSY} in 2017. Recruitment has fluctuated without trend since the early 1990s, but without the large year classes that occurred in the preceding period.

8) Plaice in 7.d: The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now well above the MSY $B_{trigger}$. Fishing mortality has declined since the early 2000s and it has been below F_{MSY} since 2009. Recruitment is currently around the average of the time-series.

9) Sole in 7.d: The spawning-stock biomass has been fluctuating without trend since the 1980s, but has decreased and is now around B_{lim}. Fishing mortality has been decreasing since 2014 and is below F_{MSY} in 2017. Recruitment has been fluctuating without trend, and there has been no strong recruitment since 2011.

10) Category 3–6 finfish stocks: In 2018, new advice has been produced for pol.27.3a4 (Category 5) and gug.27.3a47d (Category 3), but not for several other stocks (bll.27.3a47de, dab.27.3a4, fle.27.3a4, lem.27.3a47d, mur.27.3a47d, tur.27.3a, tur.27.4, whg.27.3a, all Category 3 stocks, and wit.27.3a47d, now a Category 1 stock), for which biennial advice was given in 2017; it is expected that tur.27.4 will be upgraded to a Category 1 stock following the inter-benchmark meeting this summer.

   i. Pollack (pol.27.3a4): Since 1977 there have been two periods of high catches. In recent years, catches have been low, albeit fairly stable.

   ii. Grey gurnard (gug.27.3a47d): The time-series of mature biomass index of grey gurnard from the International Bottom Trawl Survey quarter 1 (IBTS-Q1) shows a strong increase from the beginning of 1990s and has since fluctuated at a high level.

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. Advice for Norway pout was released in the autumn 2018.

The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass has been above B_{pa} since 2007. Fishing mortality has been fluctuating at a lower level since 1995. Recruitment in 2018 was high, while recruitment in 2017 was slightly below the long-term average.

3 Brill in Subarea 27.4, Divisions 3.a, 27.7.d and 27.7.e

Brill (*Scophthalmus rhombus*) is assessed in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) since 2013. Because only official landings and survey data were available, brill in subarea 27.4, divisions 27.3.a, 27.7.d,e was defined as a category 3 stock (ICES 2012a). For this stock, biennial advice is provided based on the lpue trends of the Dutch beam trawl fleet (vessels > 221 kW). This year (working year 2018) no re-opening of the advice occurred. Consequently, the advice issued in 2017 for 2018 and 2019 is still valid for 2019.

3.1 General

3.1.1 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 mollusk 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).

3.1.2 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 Northeastern 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.d,e as a single stock that could potentially have an even wider geographical spread.

Further research on brill spawning areas (egg surveys), and of migration of adult (tagging experiments) and especially immature brill (tagging experiments and genetic analysis of the immature population components) could still generate valuable information about (sub)population structure of brill throughout its entire distribution area.

More information on the delineation of potential brill stocks can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

3.1.3 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 3.a 47d,e, and no management plans are in place. However, for the EU-waters in Division 27.2.a and Subarea 27.4, precautionary TACs have been defined for brill and turbot (combined) (see table below).

Historical overview of combined TACs for brill *Scophthalmus rhombus* and turbot *Scophthalmus maximus* in Division 27.2.a and Subarea 27.4.

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
TAC	9000	9000	6750	5738	4877	4550	4323	4323	5263	5263
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
TAC	5263	4642	4642	4642	4642	4642	4488	5924*	7102	

***the TAC was increased from 4937 to 5924 at the end of 2017**

Although turbot (27.4) and brill (27.3.a 47d,e) cover different stock areas, and have quantitative single species advice, there is a combined TAC. This impedes sustainable management of one or both stocks. Moreover, the advised catch for the entire brill stock seems to be used as the advice for Subarea 27.4 and Division 27.2a. This means that the application of the advice is applied in the wrong way, involving a great risk of overfishing the brill stock.

The combined TAC for brill and turbot has been restrictive in 2007, 2015 and 2016 (average overshoot 218 ± 197 tonnes). In 2016, some of the Member States with a share in the TAC, such as Belgium, Germany and The Netherlands asked for a an advance of their quota for 2017, in order to further prevent overshooting (±10%). The TAC in 2017 was 4937 tonnes, but at the end of the year, it was increased to 5924 tonnes (±20%; 10% to compensate for the advance from 2016 and 10% for 2017). There were several reasons to justify this increase: a) after the interbenchmark of Turbot, a new advice (for 2018) was given, which meant an 148% increase against the previous TAC (2017)[1], b) similar to 2016, member states were asking an advance of their quota for next year (2018), c)

[1] At WGNSSK 2018, a mistake was discovered in the final interbenchmark run of turbot. This involved an even higher increase.

observations and catches of fishermen did not seem to confirm the assessment (delay with data).

No restriction on the minimum length for landing brill is imposed by the EC. Some authorities or producer organizations have however installed Minimum Landing Sizes (MLS) for brill. The most frequently applied MLS is 30 cm (e.g. in Belgium).

3.2 Fisheries data

From 2015 onwards, also discards by metier were requested from all countries contributing to this stock through InterCatch. For the WGNSSK data call in 2017 all available age and length data were requested through InterCatch for three years back in time (2014–2016). For the WGNSSK data call in 2018, similarly both age and length data were requested.

3.2.1 Landings

Tables 3.1–3 summarizes the official brill landings by country for Division 3.a, Subarea 27.4, and divisions 27.7.de respectively (Source: ICES Fishstat). The total official landings can be consulted in Table 3.4 and Figure 3.1. Over the period 1950–1970, total landings ranged from 582 tons to 947 tons per year, followed by a gradual increase to 2 121 tons in 1977. During 1978–2014, total landings varied between 1 517 tons (in 1980) and 3 141 tons (in 1993). In 2000–2014, annual total landings fluctuated around an average of 2 112 tons (range: 1781 tons–2409 tons). In 2015, landings increased to the third highest value in the time series (2538 tons) and also in 2016, landings stayed in the same range (2409 tons). In 2017, landings decreased a little further to 2196 tonnes, but are still amongst the highest of the time series. Subarea 27.4 accounts for the major part of these landings (Figure 3.2), on average generating 68% of the total landings over the time series (range: 50–86%). The English Channel and Skagerrak are responsible for average contributions to the international brill landings of 20% and 13% respectively. 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 27.4 and Division 27.2.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). For the WGNSSK data call in 2017, available age and length data were requested through InterCatch for three years back in time (2014– 2016). The 2018 WGNSSK data call also asked for both age and length from 2017. An overview of what was received per country and métier is presented in Tables 3.5–6.

3.2.2 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, 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' stocks in terms of data completeness. However, it should be monitored whether brill ending up in the catch have already had the opportunity to spawn.

In 2014, discard data were uploaded to InterCatch for the first time. The 2017 WGNSSK data call asked for uploading brill data from 2014–2016. Together with this year's data call, discard data are available for 4 years. However, the data has not been used to issue advice or to top up the landings to issue catch advice, as discarding is assumed to be limited for this stock (see paragraph above).

Discard rates were calculated for 2014–2017 using the available data in InterCatch (Table 3.7). Table 3.8 and 3.9 show the discard rates broken down by country and Subarea/Division respectively for the years 2014–2017. The overall discard rates show no trend (Table 3.7). The discard rate overview by country (Table 3.8) shows rates that are well-above the average for e.g. Denmark (15% in 2017) and Sweden (17% in 2017), corresponding to the higher discard rates in the North of the stock area (up to 53% in 27.3.a in 2014; Table 3.9). These higher numbers in the North are largely caused by gillnet and trammel net fisheries taking place there. However, for both Denmark and Sweden, discard rates have gone down in 2016 and 2017, resulting in an overall discard rate for 27.3.a of 11 and 22 % for 2016 and 2017 respectively. Remarkably, the high discard rate of 16% for Germany in 2014 dropped to only 1% in 2015 and 3% in 2016, in 2017 the German discard rate was higher again (13%).

3.3 Tuning series

3.3.1 Survey Data

General

Catches of brill are generally very low during surveys. These low catch numbers 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 in the North Sea and the Skagerrak respectively. Plots and tables for these surveys were also updated during WGNSSK 2018.

North Sea (Subarea 27.4)

The abundance indices (numbers per hour) for brill in the BTS_ISI_Q3 in 27.4 are spatially plotted per rectangle in Figure 3.3 and over time in Figure 3.4 and Table 3.10.

These seem to illustrate a recovery of the species in 27.4 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 and 2016. In 2017, numbers per hour showed a further decrease. However, it should be noted that the recorded numbers per hour are low and that interannual variation over the years is large. Therefore, no real trend can be identified in this time series.

The corresponding age–length key and the length distributions (per 5 years) are illustrated in Figures 3.5–6. These show that mainly brill of ages 1–2 and lengths of 20–45 cm are caught in this survey and that no obvious shifts in length distributions are apparent over the time series (1987–2017).

Kattegat (Division 27.3.a22)

The abundance indices (numbers per hour) for brill in the BITS_HAF_Q1&4 are spatially plotted per rectangle in Figure 3.7 and over time in Figure 3.8 and Table 3.11. These illustrate a period with higher catches (2006–2011) after a period of consistent lower catches (1996–2005). In 2012 and 2013, 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. There was again a steep increase in 2014 (3.86/hr.) and this survey index remained high in 2015–2017. The survey index values for both the 3.a and 27.4 are considerably low and the indices show contrasting patterns.

The corresponding length distributions for the BITS_HAF_Q1&4 in 27.3.a are shown in Figure 3.9. As in Subarea 27.4, no alarming shifts in length distributions (no obvious loss of larger/older individuals from the population) are apparent over the time series (1996–2017).

Note that the BITS is performed using another research vessel since 2016. The term BITS_"HAF" could therefore cause confusion.

English Channel (Divisions 27.7.d,e)

Unfortunately, no useful survey index could be identified for the evaluation of the brill sub-stock in the English Channel during previous WGNEW meetings (ICES, 2010; 2012b; 2013a).

3.3.2 Commercial lpue series

Although the survey indices presented above are useful indicators when evaluating the state of the brill stock in (parts of) the stock 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, 2013a for interpretation), and has been used as the basis for the advice since. These lpue were standardised for engine power and corrected for targeting behaviour. The standardisation for engine power is relevant as trawlers are likely to have higher catches with higher engine powers, as they can trawl heavier gear or fish at higher speeds. The correction for targeting behaviour relies on reducing the effects of spatial shifts in fishing effort by calculating the fishing effort by ICES rectangle and subsequently averaging these over the entire fishing area. More information on the data that were used (EU logbook auction data and market sampling data), the calculation of the LPUEs, the standardization of engine power, the correction for targeting behavior and the results can be found in van der Hammen *et al*. (2011).

The Dutch lpue series investigated during the WGNSSK 2018 are shown in Table 3.12a–b and Figure 3.10. The 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. In 2016, a slight decrease is observed (from 61.11 to 55.68 kg/day). This decrease is continued in 2017.

During the Advice Drafting Group of the North Sea (June 2017), it was decided to use the extended Dutch lpue series (from 1995) instead of the shorter one. The longer time series confirms the increasing trend in lpue from the late 1990s onwards. The short and long time series do not fully overlap. This is due to the short series being age-structured and the sum over all ages is made, while the long series is not age-structured.

3.4 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. However, during the WGNSSK 2017, the ICES questionnaire to evaluate whether a stock could upgrade to a higher category was completed. It was concluded that this stock can be considered as a potential candidate for Category 1, but for an age or length based assessment more information is needed on available age and length samples and scientific resources to provide them. Additionally, an appropriate fisheries independent index series targeting large flatfish species such as brill and turbot, covering the entire stock area is currently missing and could provide better insight in the status of the stock.

During WGNSSK 2017, three different methods were used to get an idea of the stock trends and status. The ICES biennial advice was based on the Dutch commercial lpue series (see Section 3.4.1). Note that during the ADG North Sea, the extended Dutch commercial lpue series (from 1995) was preferred over the short series (from 2007).

3.4.1 Dutch commercial lpue series

As basis for the advice, the commercial lpue series from the Dutch beam trawl fleet > 221 kW was used being the most reliable time series currently available. As a result, applying the 2:3 rule led to a 15% increase in 2017 as advice for 2018 and 2019. This year (2018) applying the 2:3 rule showed a decrease of 2% (average 2013–2015 compared to average 2016–2017). The working group concluded not to re-open advice, because changes were not considered substantial.

3.4.2 Length-based indicator screening

Length-based indicators were calculated during the WGNSSK 2017. No similar analysis was executed during the WGNSSK 2018. Below is the analysis from 2017.

Length-based indicators (LBI) were estimated for three years of data (2014–2016), following the standard approach outlined by WKLIFE (ICES, 2017a) and WKPROXY (ICES, 2017b), using the length distributions provided through InterCatch.

Discards were raised and length compositions were allocated using InterCatch. Discard raising was performed on the gear level, regardless of season or country, using the following gear groups: TBB, OTB/SSC/SDN and GTR/GNS. All remaining strata were raised using all available data (overall). The weighting factor for raising the discards was ‘Landings CATON’. Two issues should be highlighted: 1) Dutch landings data were provided at quarterly level, while discards were provided at yearly level. Consequently, these discard strata were raised by matching them with the corresponding landings strata, prior to raising by gear group. 2) Some matched strata showed very large discard ratios. These were included in the raising process, which will have affected the final result of the raising. To allocate length compositions, landings and discards were handles separately. When length distributions had to be borrowed from other strata, allocations were completed using the same gear groups as for discard raising (TBB; OTB/SSC/SDN; GTR/GNS; overall). The weighting factor used was ‘Mean weight weighted by numbers at age’.

Life history parameters were obtained from van der Hammen *et al.* (2013). Note that sexually dimorphic growth is present in brill with females reaching larger maximum body sizes than males. Additionally, brill shows sex differences in size at 50% maturity. Assuming a 50:50 sex ratio (cf. turbot in lack of data on brill), L_{inf} and L_{mat} values were obtained by averaging sizes for males and females (Table 3.13). This was necessary as all data in InterCatch was provided for undetermined sex.

The following table summarised the output from the LBI analysis.

Traffic light indicators

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	>1	>1	>0.8	>30%	~1 (>0.9)	≥1
2014	0.84	0.88	1.07	0.2	1.00	1.19
2015	0.36	1.08	1.07	0.3	1.00	1.74
2016	1.33	1.20	1.09	0.4	1.19	1.07

Most of the indicators appeared closed to the established references.

- Length at first catch (Lc) and Length of 25% of catches (L25%) are both above $L_{maturity}$ (24.9 cm) in 2016 and have thus gradually improved from 2014 onwards. This indicates a low number of immature individuals in the catches.
- The ratio of the mean length of upper 5th percentile of catches to Linf (50.7 cm) is above 0.8 over all three years, which suggest enough large (and hence old) fish in the population.
- The Lmean/Lopt ratio of around 1 suggest that the exploitation targets the most productive length classes.
- Finally, Lmean/$L_{F=M}$ is greater than 1, which suggests this stock is exploited at MSY.
- Pmega (proportion of individuals above Lopt + 10%) only gave a value below the desired reference (30%) in 2014.

This indicates that the stock status has improved from 2014 onwards and may be considered to be exploited somehow sustainably and in the vicinity of MSY.

3.4.3 SPiCT MSY proxy reference points

A Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was applied during the WGNSSK 2017 to estimate MSY proxy reference points. No similar analysis was carried out during WGNSSK 2018.

More information on the WGNSSK 2017 analysis is provided below or in the WGNSSK 2017 report.

Three fishery independent survey time series (BTS_ISI_Q3, Baltic International Trawl Survey BITS_Q1 and _Q4), a standardized lpue from the Dutch beam-trawl fleet (with vessels > 221 kW), and a catch time series (1950–2016) were used as input for the model.

Eight exploratory SPiCT assessments were performed during the WGNSSK 2017. These different runs explored the effects of:

- The length of the time series of the official ICES landings (starting either in 1950 or in 1987 i.e. the start of the BTS_ISI_Q3 time series);
- The length of the time series of the standardized lpue from the Dutch beam trawl fleet (starting either in 1995 or 2007);
- Various combinations of BTS and BITS indices;
- The removal of age 0 and 1 fish from the standardized lpue from the Dutch beam-trawl fleet (vessels > 221 kW).

The final run used in the advice sheet uses the following settings:

- Landings data from 1987 onwards;
- Including BTS Q3 survey (1987–2016) and standardized lpue from the Dutch beam-trawl fleet (vessels > 221 kW) (1995–2016);
- Including age 0 and 1 for the standardized lpue from the Dutch beam trawl fleet with vessels > 221 kW;
- Excluding BITS_Q1 and BITS_Q4;
- Default priors.

We excluded the BITS_Q1 and BITS_Q4 from the final run because the landings from the 27.3.a are only 6.9% of the total landings for this stock. A longer time series for the Dutch lpue index was used for the SPiCT assessment than for the indicator used in the advice in order to increase coverage of the landings. Landings data were trimmed from 1987–2016 to have a full coverage of the landings time series by tuning series.

A summary of the final SPiCT assessment is given in Figure 3.11 and in Table 3.14. These results suggest that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is well above the reference B_{MSY}* 0.5 proxy. Therefore, the Precautionary Approach Buffer (PA Buffer) was not applied for the advice for this stock. The retrospective analysis shows a relative stability in the model outcomes. There is quiet some variation, but the model is performing relatively well. The trends are similar and the estimated status with respect to reference points is consistent.

Table 3.1: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivision 27.3a (Skagerrak) by country, over the period 1950–2017 (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**
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**

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
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	21	**145**
2016	0	0	124	7	8	25	**164**
2017	0	0	131	4	8	26	**169**

Table 3.2: BLL 27.3a47de – Official landings (tonnes) of brill in Subarea 27.4 by country, over the period 1950–2017 (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**

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1991	205	38	145	28	147	1111	8	0	**1682**
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	154	115	122	7	136	1159	1	0	**1695**
2016	175	90	131	8	156	965	1	0	**1526**
2017	138	69	122	0	115	920	2	0	**1366**

Table 3.3: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivisions 27.7.d,e (English Channel) by country, over the period 1950–2017 (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**

year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
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**
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	278	248	0	2	9	**698**
2016	143	0	286	284	0	1	5	**719**
2017	135	0	276	246	0	2	2	**661**

Table 3.4: BLL 27.3a47de – Total official landings (tonnes) of brill in the 27.3a47de (Greater North Sea) over the period 1950–2017, subdivided into Subarea 27.4 and Divisions 27.3.a and 27.7.d,e (Source: ICES Fishstat)

Year	3a	4	7de	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**

Year	3a	4	7de	TOTAL
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**
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	145	1695	698	**2537**
2016	164	1526	719	**2409**
2017	169	1366	661	**2196**

Table 3.5: BLL 27.3a47de – Overview of number of length measurements uploaded to InterCatch for the brill stock (per country and métier)

	D	L	Total
Belgium	**157**	**2561**	**2718**
TBB_DEF_>=120_0_0_all		49	49
TBB_DEF_70-99_0_0_all	157	2512	2669
Denmark	**123**	**335**	**458**
GNS_DEF_100-119_0_0_all	1	3	4
GNS_DEF_120-219_0_0_all	1	22	23
MIS_MIS_0_0_0_HC	1		1
OTB_CRU_90-119_0_0_all	104	290	394
OTB_DEF_>=120_0_0_all	16	20	36
France		**213**	**213**
OTB_DEF_100-119_0_0		94	94
OTB_DEF_70-99_0_0		119	119
Germany	**6**	**75**	**81**
OTB_CRU_70-99_0_0_all		37	37
TBB_DEF_70-99_0_0_all	6	38	44
Netherlands	**113**	**497**	**610**
OTB_DEF_70-99_0_0_all	4		4
OTB_MCD_70-99_0_0_all	4		4
TBB_DEF_70-99_0_0_all	105	497	602
Sweden		**72**	**72**
OTB_CRU_70-89_2_35_all		27	27
OTB_CRU_90-119_0_0_all		45	45
UK (England)		**2572**	**2572**
MIS_MIS_0_0_0_HC		33	33
OTB_CRU_70-99_0_0_all		69	69
OTB_DEF_>=120_0_0_all		130	130
OTB_DEF_70-99_0_0_all		407	407
TBB_DEF_70-99_0_0_all		1933	1933
UK(Scotland)	**1**	**228**	**229**
OTB_CRU_70-99_0_0_all		2	2
OTB_DEF_>=120_0_0_all	1	226	227
Total	**400**	**6553**	**6953**

Table 3.6: BLL 27.3a47de – Overview of number of age measurements uploaded to InterCatch for the brill stock (per country and métier)

	D	L	Total
Belgium	**81**	**288**	**369**
TBB_DEF_>=120_0_0_all		20	20
TBB_DEF_70-99_0_0_all	81	268	349
Netherlands		**497**	**497**
TBB_DEF_70-99_0_0_all		497	497
UK (England)		**466**	**466**
MIS_MIS_0_0_0_HC		69	69
OTB_CRU_70-99_0_0_all		0	0
OTB_DEF_>=120_0_0_all		39	39
OTB_DEF_70-99_0_0_all		179	179
TBB_DEF_70-99_0_0_all		179	179
Total	**81**	**1251**	**1332**

Table 3.7: BLL 27.3a47de – Overall discard rates (all countries and métiers) for brill over the period 2014–2017 (Source: InterCatch)

Year	Discard rate
2014	0.113
2015	0.095
2016	0.077
2017	0.086

Table 3.8: BLL 27.3a47de – Discard rates for brill by country for 2014–2017 (source: InterCatch)

Country	Discard rate 2014	Discard rate 2015	Discard rate 2016	Discard rate 2017
Belgium	0.024	0.043	0.102	0.045
Denmark	0.357	0.340	0.065	0.149
France	0.078	0.076	0.040	0.085
Germany	0.192	0.037	0.040	0.134
Netherlands	0.094	0.053	0.099	0.088
Norway	0.068	0.076	0.032	0.099
Sweden	0.350	0.298	0.138	0.169
UK (England)	0.055	0.035	0.033	0.048
UK(Scotland)	0.157	0.238	0.165	0.030
Overall	**0.113**	**0.095**	**0.077**	**0.086**

Table 3.9: BLL 27.3a47de – Discard rates for brill for 2014–2017 by Subarea/Division (Source: InterCatch)

Subarea/ Division	Discard rate 2014	Discard rate 2015	Discard rate 2016	Discard rate 2017
27.3.a	0.53	0.45	0.11	0.22
27.4	0.09	0.05	0.08	0.08
27.7.d	0.05	0.08	0.11	0.09
27.7.e	0.05	0.03	0.01	0.02
Overall	**0.11**	**0.09**	**0.08**	**0.09**

Table 3.10: BLL 27.3a47de – Survey index (N°/hr) for brill in the BTS_ISI_Q3, Subarea 27.4

Year	N/hr	Year	N/hr
1987	1.995726	2003	1.000000
1988	0.666667	2004	0.821429
1989	0.936275	2005	0.606061
1990	2.296296	2006	0.871693
1991	1.871053	2007	1.095238
1992	2.720614	2008	0.513889
1993	2.186977	2009	1.424649
1994	1.438705	2010	2.185373
1995	No data	2011	2.405706
1996	0.507353	2012	1.041101
1997	No data	2013	0.758621
1998	1.430150	2014	3.044598
1999	0.752381	2015	1.842912
2000	2.194534	2016	1.046875
2001	0.691358	2017	0.755542
2002	0.794730		

Table 3.11: BLL 27.3a47de – Survey index (N°/hr) for brill in the BITS_HAF_Q1&4, Division 27.3a.

Year	N/hr
1996	1.909091
1997	0.388889
1998	0.500000
1999	1.833333
2000	0.555556
2001	1.041667
2002	1.803030
2003	1.363636
2004	2.204545
2005	2.083333
2006	3.818182
2007	3.619697
2008	4.050000
2009	3.091270
2010	3.889394
2011	3.613636
2012	2.265152
2013	2.139023
2014	3.855152
2015	4.468254
2016	3.833333
2017	4.888889

Table 3.12: BLL 27.3a47de – Commercial LPUE (kg/day) for brill in the Dutch beam trawl fleet > 221 kW, Subarea 27.4 a) short series; b) long series (see report section 3.3.2);
*** the 2016 value was revised from 57.44 to 55.68**

a)

Year	LPUE (kg/day)
2007	33.73
2008	41.39
2009	41.02
2010	50.53
2011	52.80
2012	55.82
2013	53.07
2014	48.05
2015	61.11
2016*	55.68
2017	48.86

b)

Year	LPUE (kg/day)
1995	19.67
1996	19.19
1997	13.39
1998	23.75
1999	22.97
2000	24.08
2001	26.10
2002	21.99
2003	26.61
2004	27.25
2005	25.88
2006	26.67
2007	33.03
2008	39.66
2009	40.15
2010	50.54
2011	52.32
2012	55.82
2013	53.21
2014	46.04
2015	61.47
2016*	55.68
2017	48.86

Table 3.13: BLL 27.3a47de – Information for estimation of length-based indicators

Data type		Sex	Value	Source
von Bertalanffy growth parameter	*Linf*	females	58.0 cm	van der Hammen et al. (2013)
		males	43.3 cm	van der Hammen et al. (2013)
		used	50.7 cm	averaged, assuming 50:50 sex ratio
Length at maturity	*Lmat*	females	31.3 cm	van der Hammen et al. (2013)
		males	18.4 cm	van der Hammen et al. (2013)
		used	24.9 cm	Averaged, assuming 50:50 sex ratio
Catch at length			2014–2016	Discard raising by landing CATON using InterCatch
Length-weight relationship parameters for landings and discards			2014–2016	Length allocations by mean weight weighted by numbers at length using InterCatch

Table 3.14: BLL 27.3a47de – SPiCT summary output from the analyses performed last year during the WGNSSK 2017

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 14.213574
Euler time step (years):  1/16 or 0.0625
Nobs C: 30,  Nobs I1: 30,  Nobs I2: 22

Priors
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha1    9.1063919    0.7129254 1.163184e+02  2.2089766
 alpha2    1.4535591    0.0743938 2.840066e+01  0.3740151
 beta      0.1793337    0.0404432 7.952033e-01 -1.7185070
 r         0.6107734    0.2020882 1.845947e+00 -0.4930293
 rc        1.7398392    0.9487021 3.190717e+00  0.5537927
 rold      2.0502853    0.0840828 4.999441e+01  0.7179789
 m      2291.6417943 2114.6075115 2.483497e+03  7.7370238
 K      8635.3356122 3851.4348590 1.936136e+04  9.0636179
 q1        0.0006661    0.0003914 1.133600e-03 -7.3141141
 q2        0.0163524    0.0090961 2.939710e-02 -4.1133828
 n         0.7021032    0.2747997 1.793848e+00 -0.3536748
 sdb       0.0628935    0.0052205 7.577063e-01 -2.7663127
 sdf       0.2246388    0.1544822 3.266563e-01 -1.4932616
 sdi1      0.5727327    0.4385589 7.479559e-01 -0.5573362
 sdi2      0.0914194    0.0489262 1.708185e-01 -2.3922976
 sdc       0.0402853    0.0107614 1.508077e-01 -3.2117686

Deterministic reference points (Drp)
           estimate        cilow       ciupp    log.est
 Bmsyd 2634.3145191 1359.7118819 5103.737842  7.8763783
 Fmsyd    0.8699196    0.4743511    1.595359 -0.1393545
 MSYd  2291.6417943 2114.6075115 2483.497332  7.7370238

Stochastic reference points (Srp)
           estimate        cilow       ciupp    log.est  rel.diff.Drp
 Bmsys 2630.2300422 1352.5994632 5114.677525  7.8748266 -0.0015528972
 Fmsys    0.8700396    0.4744778    1.595373 -0.1392165  0.0001379415
 MSYs  2288.4048105 2104.1855646 2488.752259  7.7356103 -0.0014145154

States w 95% CI (inp$msytype: s)
                    estimate        cilow       ciupp    log.est
 B_2016.50      3256.0948581 1696.5061604 6249.404790  8.0882839
 F_2016.50         0.7474275    0.3846365    1.452405 -0.2911179
 B_2016.50/Bmsy    1.2379506    0.9532748    1.607639  0.2134573
 F_2016.50/Fmsy    0.8590730    0.6280398    1.175095 -0.1519014

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow       ciupp    log.est
 B_2017.00      3178.4669543 1599.8892524 6314.594691  8.0641543
 F_2017.00         0.7462458    0.3675975    1.514925 -0.2927003
 B_2017.00/Bmsy    1.2084369    0.9282380    1.573217  0.1893277
 F_2017.00/Fmsy    0.8577147    0.5882927    1.250525 -0.1534837
 Catch_2017.00  2339.3453683 1781.8445101 3071.276265  7.7576264
 E(B_inf)       3041.4778653           NA          NA  8.0200988
```

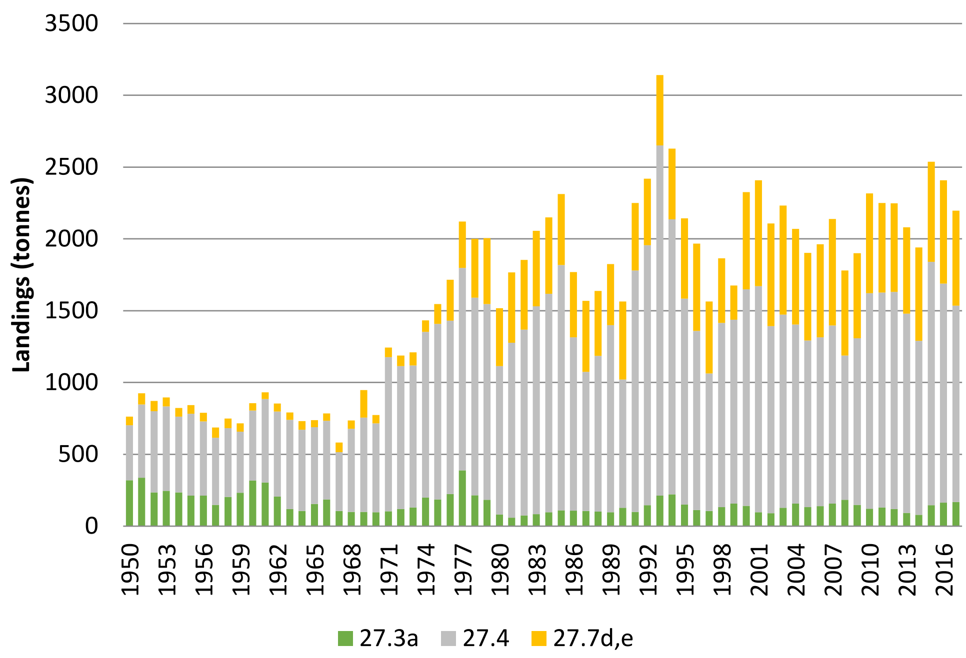

Figure 3.1: BLL 27.3a47de – Official landings (tonnes) over the period 1950-2017, as officially reported (Rec 12; ICES Fishstat).

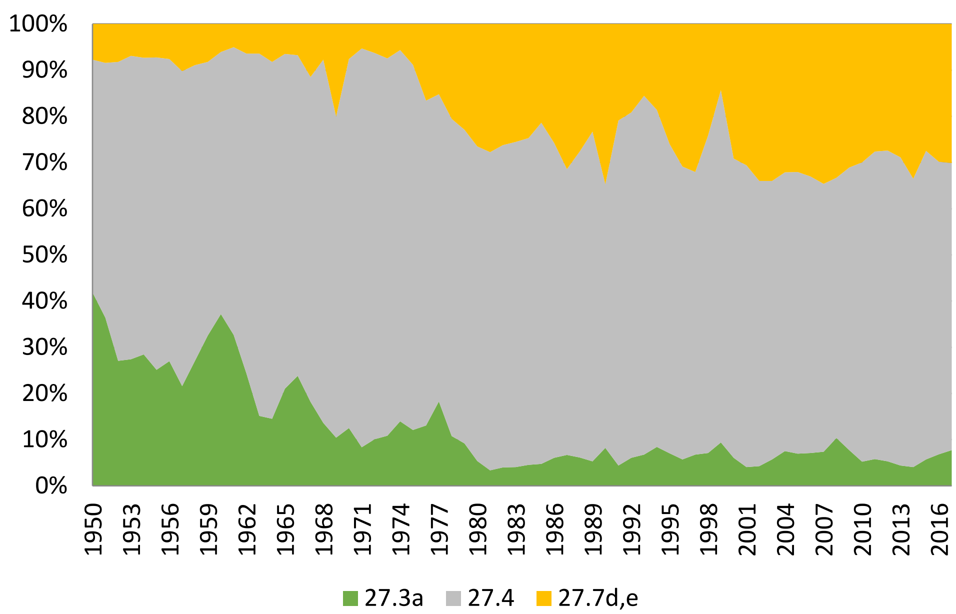

Figure 3.2: BLL 27.3a47de – Relative contribution to the official landings of brill from Subarea 27.4, Division 27.3a and 27.7.d,e to the total international landings (tonnes) in the Greater North Sea over the period 1950-2017 (Source: ICES Fishstat).

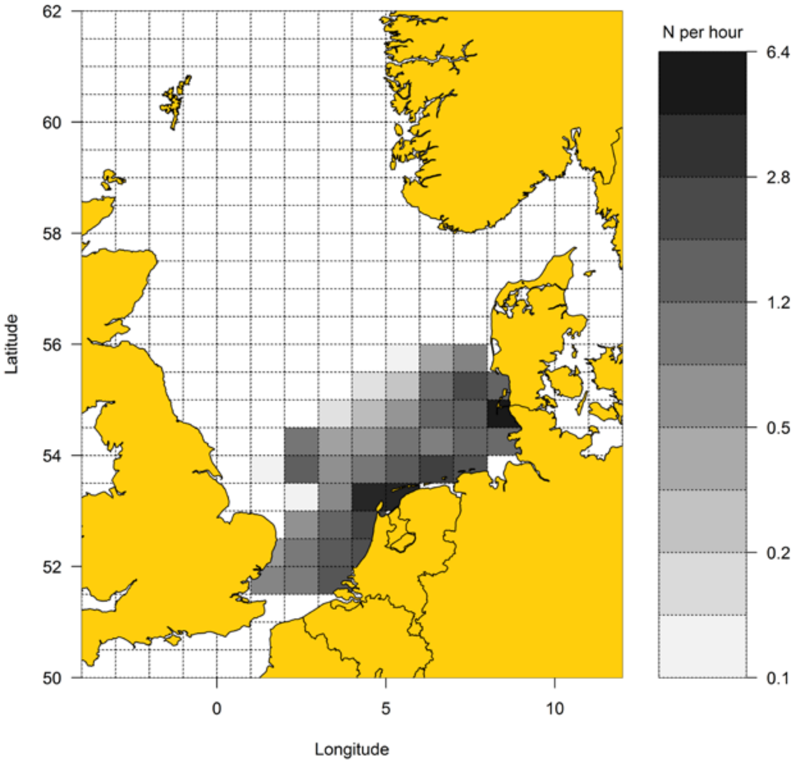

Figure 3.3: BLL 27.3a47de – Average numbers of brill caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2017.

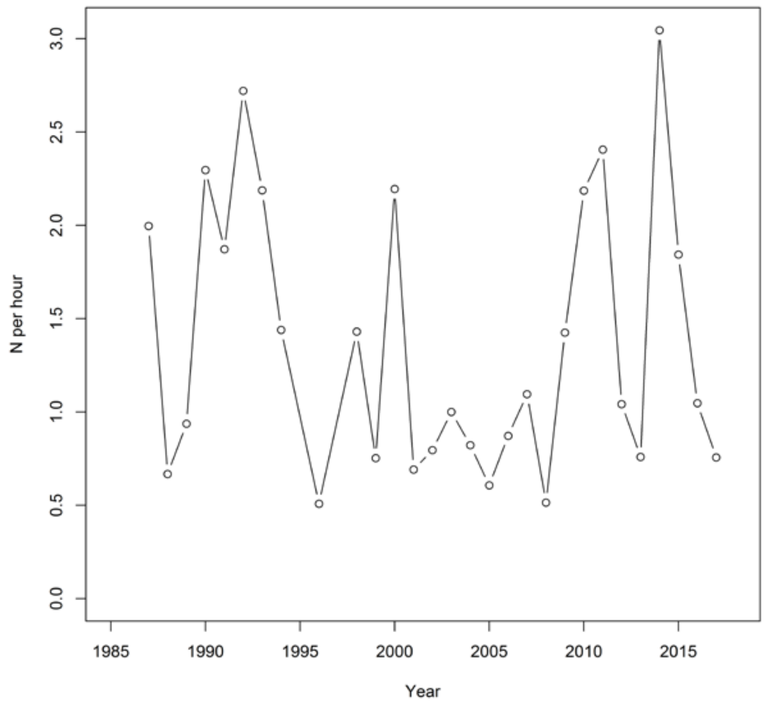

Figure 3.4: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2017.

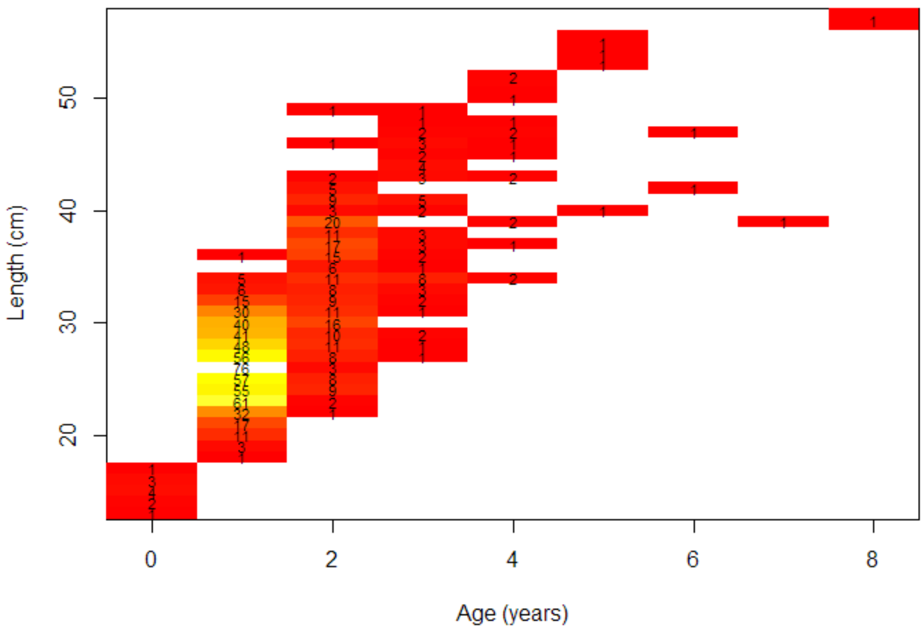

Figure 3.5: BLL 27.3a47de – Age-length key of brill in the North Sea (27.4) as documented by the BTS_ISI_Q3 (1992–2017).

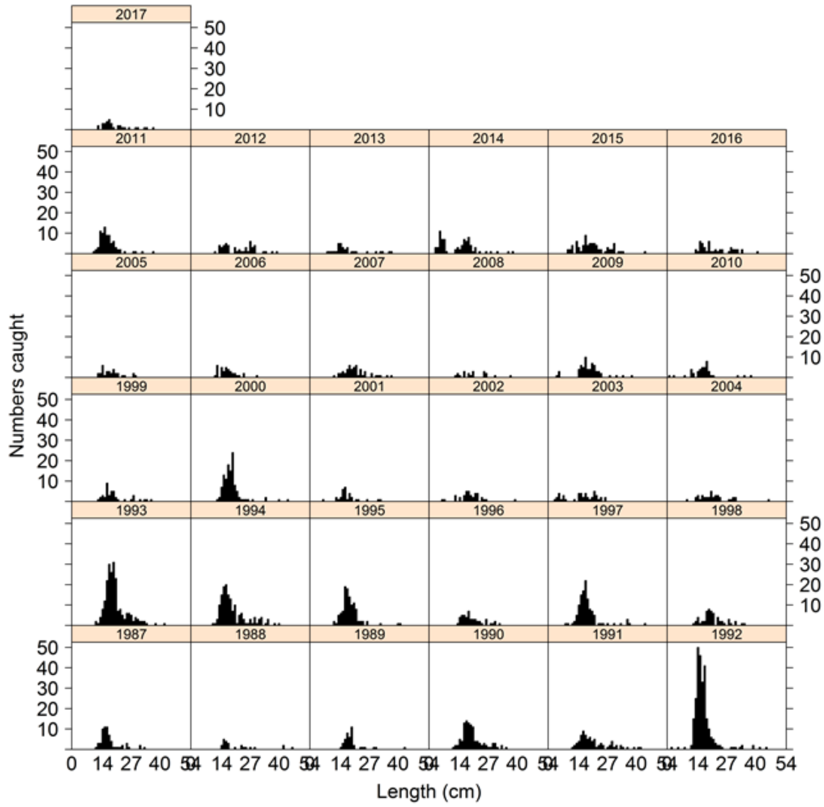

Figure 3.6: BLL 27.3a47de – Length distributions of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1987–2017)

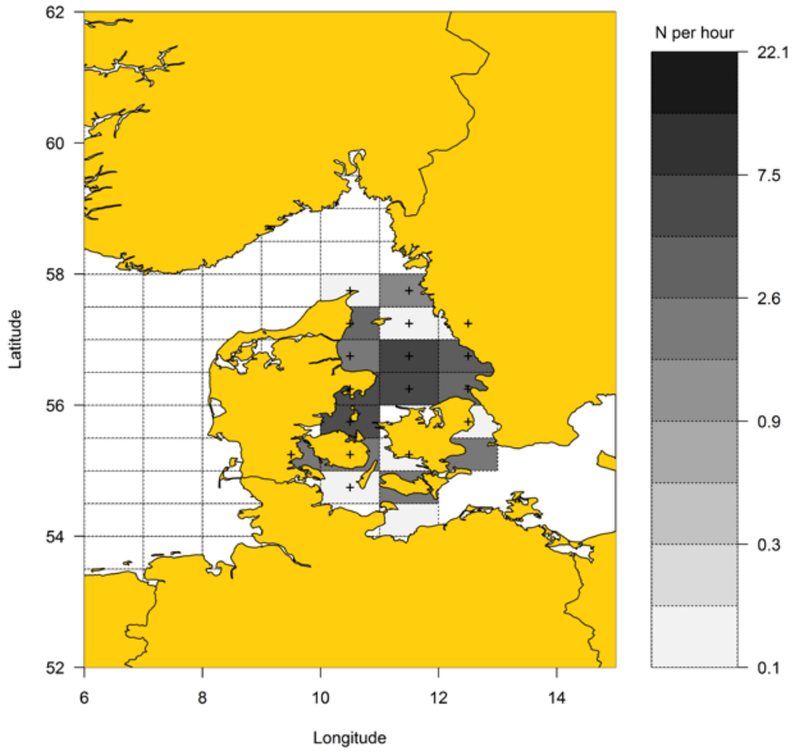

Figure 3.7: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q1&4 in the Kattegat (27.3.a22) in 2017.

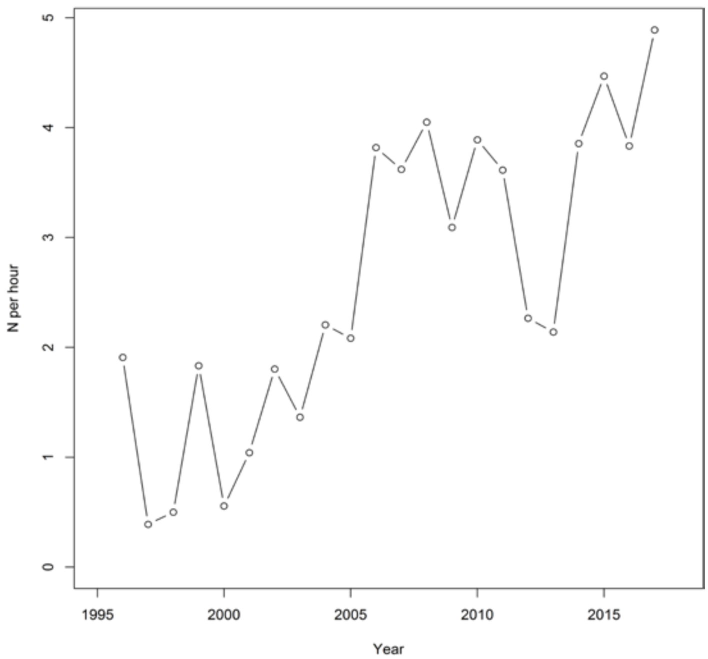

Figure 3.8: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q1+Q4) over the period 1996–2017.

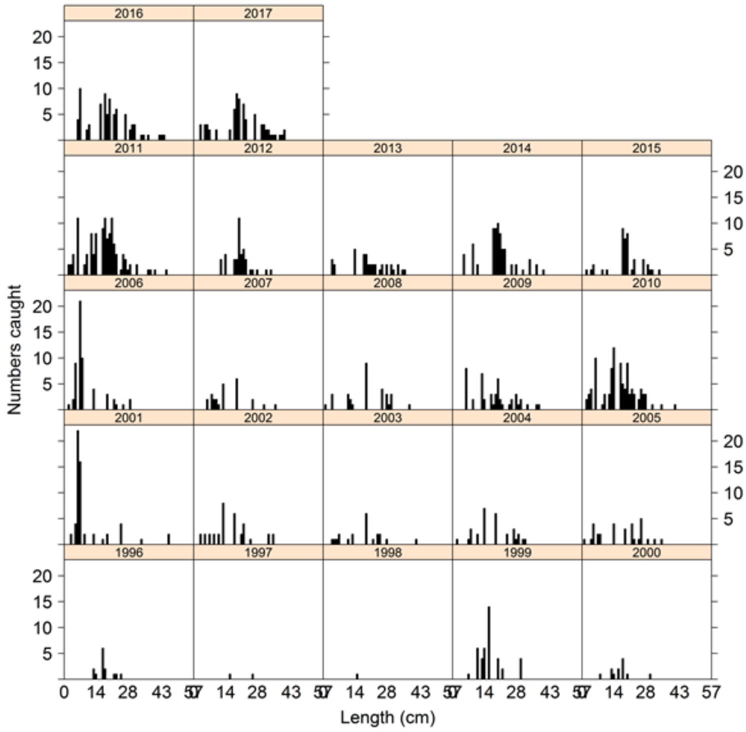

Figure 3.9: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q1&4 (1996–2017).

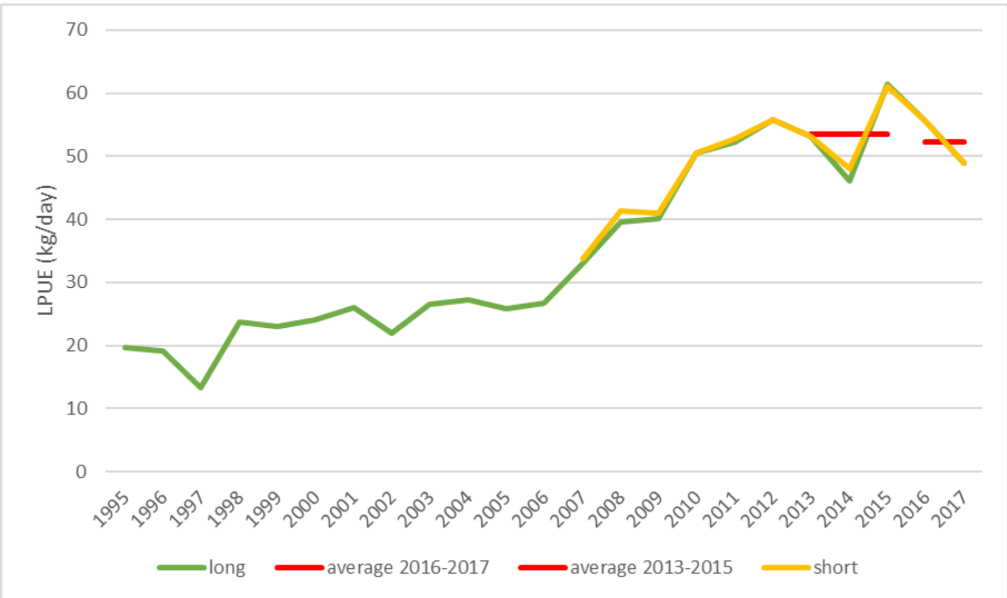

Figure 3.10: BLL 27.3a47de – Extended (long) commercial LPUE (kg/day) of brill in the Dutch beam trawl fleet > 221kW (standardized for engine power and corrected for targeting behavior) (green line) and shorter LPUE as used during the WGNSSK 2016 (yellow line). The red lines are the averages of the last two (2016–2017) and the previous three (2013–2015) years. From the WGNSSK 2017 onwards, the extended LPUE series is used as basis for the advice.

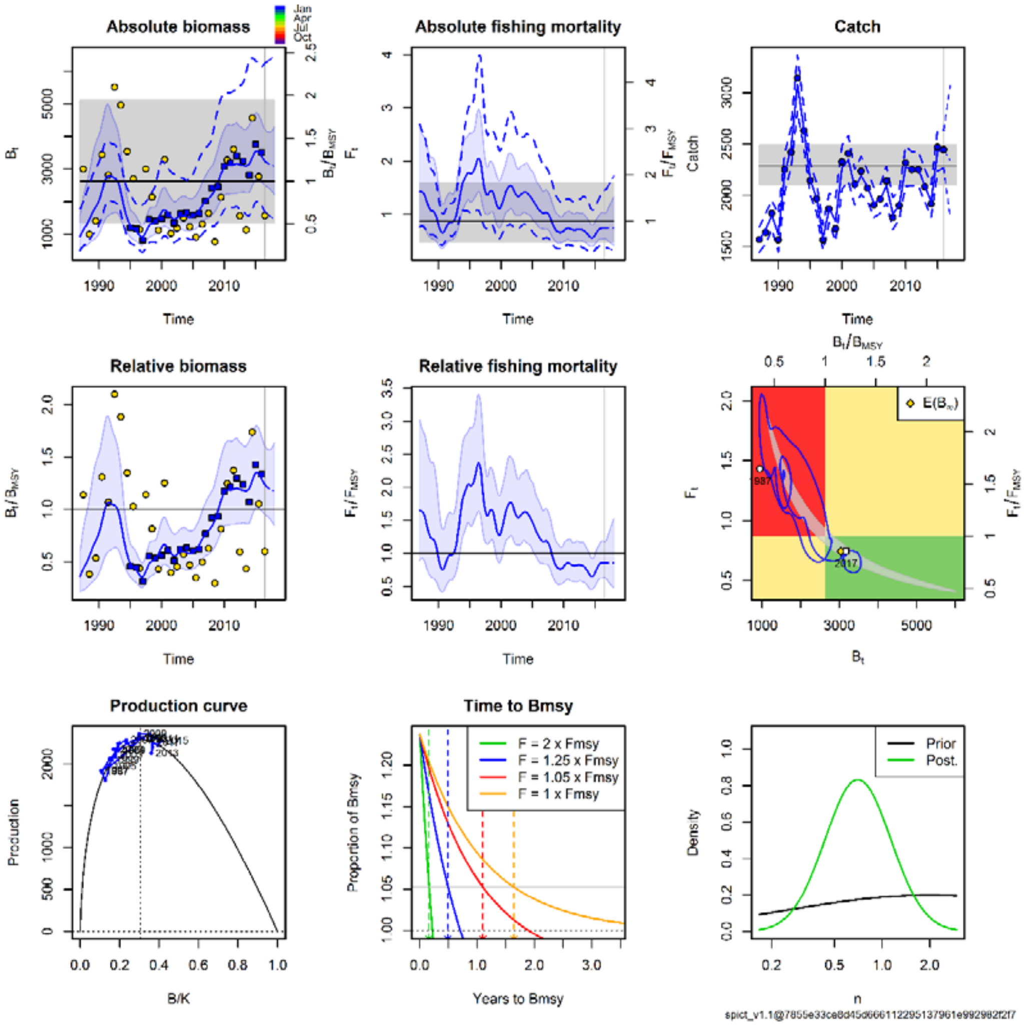

Figure 3.11: BLL 27.3a47de – SPiCT model results from WGNSSK 2017. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. Bottom row: production curve, estimated time to B_{MSY}, and prior and posterior parameter distributions. The dashed lines are 95% CI bounds for absolute estimated values, shaded blue regions are 95% CIs for relative estimates, shaded grey regions are 95% CIs for estimated absolute reference points (horizontal lines). The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates.

4 Cod (*Gadus morhua*) in Subarea 4, Division 7.d and Subdivision 20 (North Sea, Eastern English Channel, Skagerrak)

This assessment relates to the cod stock in the North Sea (Subarea 4), the Skagerrak (Subdivision 20) 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.

4.1 General

4.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

4.1.2 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.

4.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Subarea 4, Subdivision 20 (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 a bycatch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, in large-meshed otter trawls and some 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 and Norway), TR2, BT1 and BT2. 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

The recovery plan for cod (EC 1342/2008) triggered considerable improvements in selectivity and cod advoidance through incentives that were linked to the fishing effort regime and through national measures, such as the Scottish Conservation Credits scheme. The Conservation Credits scheme was suspended on 20th November 2016 and the fishing effort regime discontinued in 2017 (EC 2094/2016). Further details of these measures are presented in the Stock Annex.

The expansion of the closed-circuit TV (CCTV) and FDF programmes in 2010–2016 in Scotland, Denmark, Germany, England and the Netherlands is expected to have contributed to the reduction of cod mortality. The cod-specific FDF scheme terminated at the end of 2016. Further details are presented in the Stock Annex.

4.1.4 Management

Management of cod is by TAC and technical measures. The agreed TACs for Cod in Division 20 (Skagerrak), 7.d and Subarea 4 were as follows:

TAC(000t)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
20(Skagerrak)	4.1	4.8	3.8	3.8	3.8	4.0	4.2	4.8	5.7	8.0
2.a + 4	28.8	33.6	26.8	26.5	26.5	27.8	29.2	33.7	39.2	43.2
7.d	1.7	2.0	1.6	1.5	1.5	1.6	1.7	2.0	2.1	1.7

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. 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 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. The effort regime has now been discontinued, and the allocations for 2017 and 2018 are given in Council Regulations (EC) N°2017/127 and N°2018/120 respectively.

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 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 was 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 had been positive contributions under Article 13c of the EC plan towards achieving the cod plan targets.

In November 2016, the cod management plan was amended to discontinue the effort regime set out in EC 1342/2008 as it became an obstacle to the implementation of the landings obligation. Details of the amended cod management plan are given in EC 2016/2094. Since 2015, advice has been given according to the ICES MSY approach.

4.2 Data available

4.2.1 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 4.1.

The catch estimate for 2017 is 46 725 tonnes, split as follows for the separate areas (tonnes):

	TAC	Landings	Discards	BMS landings
20–Skagerrak	5744	4715	777	0
4	39220	33109	7945	20
7.d	2059	170	9	0
Total	47023	37994	8731	20

*** BMS landings are included in the discards as unwanted catch.**

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 20–Skagerrak. Discard raising for 2002–2017 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 to facilitate computations in InterCatch. The provision of discard information has vastly improved since 2009 and covered 75% of the landings in 2017, with all nations (apart from Norway) now providing discard information. Figure 4.1a plots reported landings and estimated discards (including BMS landings) used in the assessment. Discard ratio sampling coverage by area and season for 2017 is provided in Table 4.2e, 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 2002–2017 (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, 20–Skagerrak and 7.d, ICES first raised concerns about the misreporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid–1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3000 tons 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 4.2c and Figure 4.1a nevertheless comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations in 2017, although 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 2017 are reported in Table 4.2e.

Landings in numbers at age for age groups 1–11+ and 1963–2017 are given in Table 4.2a. These data form the basis for the catch at age analysis but do not include industrial fishery bycatches 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). Bycatch estimates are available for the total Danish small-meshed fishery in Subdivision 20 and Subarea 4 (Table 4.1). During the last five years, an average of 66% of the international landings in number were accounted for by juvenile cod aged 1–3; this average rises to 83% when considering landings and discards combined. In 2017, age 1 cod comprised 39% of the total catch by number, age 2, 19% and age 3, 17%.

Discard numbers-at-age (including BMS landings) are shown in Table 4.2b. The proportions of the estimated numbers discarded for ages 1–4 are plotted in Figure 4.1b. The proportion of the estimated total discards by weight are shown in Figure 4.1c, and by number in Figure 4.1d. Estimated proportion of total numbers caught that were discarded (Figure 4.1d) has decreased from a peak between 70 and 85% in 2006–2008, due to the stronger 2005 year class entering the fishery and a mismatch between the TAC and effort, to below 50% in 2015 and 2016. The total numbers discarded increased to 56% in 2017 due to a high proportion of the stronger 2016 year class being discarded at age 1. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% with no decline apparent after the introduction of the 120 mm 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 97% in 2017. At ages 2 to 4 discard proportions increased to a maximum around 2006–10, but have subsequently declined to give 56% for age 2, 28% for age 3 and 12% for 4-year-old cod in 2017. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 4.2c. Landings, discards (including BMS landings) and total catch numbers at age are given by season in Table 4.2d for 2017. Reported landings, estimated discards (including BMS landings) and total catch (sum of landings and discards), given in tonnage, are shown in Table 4.4.

InterCatch

InterCatch was used for estimation of landings, discards and total catch at age and mean weight at age in 2017. 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 seventh 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 (20, 4 and 7.d), giving three broad categories. Annual discards were first matched to quarterly landings. Then, within each of these three 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 2017 are as follows (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
BMS landing	Imported	16	100
Discards	Raised	1266	15
Discards	Imported	7449	85
Landings	Imported	37994	100
Logbook Registered Discard	Imported	0	NA

A similar approach was used for allocating age compositions, except that there were six broad categories because discards (including BMS landings) were treated separately to landings.

The landings and discards imported or raised, with age distribution sampled or estimated for 2017 are as follows (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
Logbook Registered Discard	Imported	Estimated	0	NA
Landings	Imported	Sampled	30785	81
Landings	Imported	Estimated	7209	19
Discards	Imported	Sampled	7422	85
Discards	Raised	Estimated	1266	15
Discards	Imported	Estimated	28	0
BMS landing	Imported	Estimated	16	100

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 2018).

4.2.2 Weight-at-age

Mean weight at age data for landings, discards (including BMS landings) and catch, are given in Tables 4.3a–c. Landings, discards and catch mean weights at age are given by season in Table 4.3d for 2017. 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 4.2, which indicates that there have been short-term trends in mean weight at age, currently showing a decline from 2010–2012 for ages 3 and above. Ages 1 and 2 show little absolute variation over the long-term.

4.2.3 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 is constructed from NS–IBTS–Q1 data. As variation in sampling intensity adds to the interannual variation, a smoother is applied to the maturity age key. This smoothed maturity age key is then applied to the estimation of spawning stock biomass. The smoothed time-varying maturity ogive used in the assessment is given in Table 4.5a, and illustrated in Figure 4.2b.

Table 4.5b and Figure 4.2c 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 multispecies 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 2017 with the new key run (ICES WGSAM 2018).

4.2.4 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.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS–Q1): ages 1–6+, covering the period 1976–2018. 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 1991–2017. 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 4.3a–b (ages 1–3+). The recent dominant effect of the size and distribution of the 1999, 2005, 2009, 2013 and 2016 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 increased, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels and appears to have declined in the past year. The 2017 year class appears to be weak (Figure 4.3a).

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 4.3c). 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 (http://rforge.net/DATRAS/) and surveyIndex packages.

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, and 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 4.6. Figure 4.3d compares the Q1 and Q3 NS–IBTS extended indices to the corresponding NS–IBTS Delta–GAM indices.

4.3 Data analyses

4.3.1 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 2018.

4.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 4.4a 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 4.4b. The log-mean standardised curves indicate no obvious year effects (top-left plots), and track cohort signals well (top right). The log abundance curves for each survey series indicate consistent gradients (bottom left), with an overall decrease in steepness, but an increase in the most recent years (bottom right).

Figures 4.5a and b show within-survey consistency (in cohort strength) for the NS-IBTS Q1 and Q3 Delta–GAM survey indices, while Figure 4.5c shows between survey consistencies (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning. The most recent data points for the NS-IBTS Q1 all fall below the linear regression line, so the 2018 data indicate weaker cohorts than observed in 2017.

The peak created by the strong 2013 year-class cannot be tracked from age 3 in 2016 to age 4 in 2017 in the NS-IBTS Q3 indices and from age 4 in 2017 to age 5 in 2018 in the NS-IBTS Q1 indices (Figure 4.3d). Figure 4.5d estimates total mortality along cohorts from the delta-GAM indices and shows low to negative values between 2016 and 2017 and high values between 2017 and 2018 in the NS-IBTS Q1 index, indicating possible year effects in 2017 and 2018.

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. SSB subsequently increased again because of the stronger 2005, 2009 and 2013 year classes and reductions in fishing mortality, reaching a peak in 2016. 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 until 2014, and a slight increase from 2014 to 2018.

Recruitment: the SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, and that the 2016 year class is the strongest and the 2017 year class the weakest since then.

4.3.3 Exploratory catch-at-age-based analyses

Catch-at-age matrix

The total catch-at-age matrix (Table 4.2c) is expressed as numbers at age, and proportions-at-age, standardised over time in Figure 4.7. It shows clearly the contribution of the 1999, 2005, 2009 and 2013 year classes to catches in recent years. 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 2009 year class features strongly in the catch in the most recent period.

Catch curve cohort trends

The top panel of Figure 4.8a 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 two values being the lowest in the time series.

Catch-survey consistency

Figures 4.8b and c show consistencies (in cohort strength) between the NS-IBTS Delta–GAM survey indices and the catch-at-age data (for each age). These show generally good consistency but with a deteriorated fit between the NS-IBTS Q3 index and catch data for older ages. Figure 4.8b shows the latest points (for 2017) to consistently fall below the linear regression line when looking at correlations between the NS-IBTS Q1 Delta-GAM index and the catch data, so the NS-IBTS Q1 is indicating stronger cohorts than observed in the catch.

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.

Figure 4.9 shows the assessment results. Normalised residual plots are shown in Figure 4.10, indicating no serious model misspecification, although residuals for the latest IBTS-Q1 and IBTS-Q3 (bar age 1) points are all negative. Retrospective plots for SSB, average fishing mortality and recruitment at age 1 are shown in Figure 4.11.Mohn's rho statistics are calculated as 0.104, -0.068 and 0.26 for SSB, $F_{2\text{-}4}$ and recruitment respectively, based on a five year peel. A summary of the SAM final assessment run in terms of population trends is provided in Figure 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 4.13.

4.3.4 Final assessment

The SAM update run is accepted as the final assessment. The data used in the assessment are given in Tables 4.2–3 and 4.5–6, and the model configuration in Table 4.7a. Model fitting diagnostics, parameter estimates and associated correlation matrix are given in Table 4.7b, while normalised residual plots and retrospective runs are shown in Figures 4.10 and 4.11 respectively. Estimates of fishing mortality at age, stock numbers at age and total removals at age are given in Tables 4.8–10 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, total removals and F_{bar} (2–4) are given in Table 4.11a (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 4.11b (and can be compared to the corresponding data in Table 4.4). Table 4.11c 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 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into age is shown in Figure 4.13. A comparison with last year's assessment (October update) is provided in Figure 4.14a. Differences between the assessments are due to the addition of one year of catch and NS–IBTS–Q1 data, as well as revisions to maturity, natural mortality and delta-GAM indices. Addition of the new data results in a downscaling of SSB and an upscaling of F, primarily caused by the lack of consistency in cohort strength for some cohorts at older ages in recent survey data (Figure 4.14b).

4.4 Historic Stock Trends

The historic stock and fishery trends are presented in Figures 4.12–13 and Table 4.11a–c.

Recruitment fluctuated at a relatively low level from 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, 2013 and 2016 year classes.

Fishing mortality increased until the early 1980s, remained high until 2000 after which it declined, and is now between the precautionary reference points F_{lim} and F_{pa}, but remains above F_{MSY}.

SSB declined steadily during the 1970s and 1980s. 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, reaching a peak in 2015. 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 4.15 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, although the survival of fish to age 5 has declined in the last year, it is at a high level in the time series.

Biomass indices by subregion (Figure 4.16a with subregions given in Figure 4.16c) 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 until 2017, apart from the southern area, where biomass has not increased following the decline. Recruitment indices by subregion (Figure 4.16b with subregions given in Figure 4.16c) show similar trends in all areas, but with indications of increased recruitment in the northern North Sea. Management measures ensuring sustainable exploitation of substocks may be needed in addition to management for the stock as a whole.

4.5 Recruitment estimates

Recruitment in the intermediate year (2018) was taken as the median from a normal distribution about the assessment estimate. Estimates of recruitment for subsequent years were resampled from the 1997–2016 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005, 2009, 2013 and 2016 year classes.

These re-sampled recruitments are only used for SAM forecasts in order to evaluate future stock dynamics.

4.6 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 last performed during ICES WGNSSK (2017) on the same basis as for ICES WKNSEA (2015) and ICES WGNSSK (2015). Details of the analysis are available in the expert group report (ICES WGNSSK 2017).

In 2018, reference points were recalculated based on new natural mortalities following the 2017 key-run (ICES WGSAM 2018). The final SAM assessment for 2017 (May assessment) was re-run with the new natural mortalities and fed into the EQSIM software, using the same rationale as ICES WGNSSK (2017). This did not change the estimate of F_{MSY} and made very little difference to the F_{MSY} range. Hence MSY reference points were not revised. A summary of the biological reference points (not including the advisory HCR in all but FP.05) is provided in the following table.

Stock	
F_{MSY}	0.31
F_{MSY} lower	0.198
F_{MSY} upper	0.46
FP.05 (5% risk to B_{lim}, with HCR included)	0.48
F_{MSY} upper precautionary	0.46*
MSY	77 651 t
Median SSB at F_{MSY}	346 032 t
Median SSB at F_{MSY} upper precautionary	219 876 t
Median SSB at F_{MSY} lower	510 886 t

*** Note that the FP0.5 value is 0.48 for an EQSIM run (with HCR included) based on the recruitment period 1998–2016, so the F_{MSY} upper value is not constrained.**

4.7 Short-term forecasts

The May forecast

Forecasting takes the form of short-term stochastic projections. A total of 1000 samples are generated from the estimated distribution of survivors. 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. Recruitment in the intermediate year (2018) is generated from the SAM assessment, as for other ages, while recruitment in subsequent years is sampled with replacement from the year 1998 to the final year of catch data (a period during which recruitment has been low).

Forecast assumptions are as follows. (Note that the values that appear in the catch scenarios Table 4.12 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 four 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 divided by the three-year average fishing mortality for ages 2–4, 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 (the year the WG meets) is taken from the SAM assessment. Recruitment for the TAC year onwards 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.

Maturity data are averaged over four years for consistency with the start of the period over which the other data are averaged and to include 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.

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

Several scenarios were considered as follows (note, $B_{trigger} = B_{pa}$ = 150 000 tonnes, and F_{MSY} = 0.31; see Section 4.9):

1) MSY framework: F_{bar} (2019) = $F_{MSY} \times \min\{1; SSB_{2019}/B_{trigger}\}$

2) EU-Norway agreement plan: the Long-term Phase of the plan, applying the sliding rule using the current B_{lim} and B_{pa} values (107 000 tonnes and 150 000 tonnes respectively) (see Section 4.9), ensuring that TAC (2019) is within 20% of TAC (2018)

3) EU Management plan: the long term Phase of the plan, applying the same sliding rule but with former B_{lim} and B_{pa} values (70 000 tonnes and 150 000 tonnes respectively) (paragraph 4 of Article 8 of EC 1342/2008), ensuring that TAC (2019) is within 20% of TAC (2018)

4) Zero catch: F_{bar} (2019) = 0

5) F_{pa}: F_{bar} (2019) = F_{pa} = F_{lim}/1.4 = 0.39

6) F_{lim}: F_{bar} (2019) = F_{lim} = 0.54

7) SSB (2020) = B_{lim}: F corresponding to SSB (2020) = B_{lim}

8) SSB (2020) = B_{pa}: F corresponding to SSB (2020) = B_{pa}

9) SSB (2020) = $B_{trigger}$: F corresponding to SSB (2020) = $B_{trigger}$

10) Lower TAC constraint: F_{bar} (2019) such that TAC (2019) = 0.8×TAC (2018)

11) Rollover TAC 15%: F_{bar} (2019) such that TAC (2019) = 0.85×TAC (2018)

12) Rollover TAC 10%: F_{bar} (2019) such that TAC (2019) = 0.9×TAC (2018)

13) Rollover TAC 5%: F_{bar} (2019) such that TAC (2019) = 0.95×TAC (2018)

14) Rollover TAC: F_{bar} (2019) such that TAC (2019) = TAC (2018)

15) Rollover TAC + 5%: F_{bar} (2019) such that TAC (2019) = 1.05×TAC (2018)

16) Rollover TAC + 10%: F_{bar} (2019) such that TAC (2019) = 1.1×TAC (2018)

17) Rollover TAC + 15%: F_{bar} (2019) such that TAC (2019) = 1.15×TAC (2018)

18) Upper TAC constraint: F_{bar} (2019) such that TAC (2019) = 1.2×TAC (2018)

19) Status quo – constant F: F_{bar} (2019) = F_{bar} (2018)

20) $F_{MSY\ lower}$: F_{bar} (2019) = $F_{FMY\ lower}$ = 0.198

21) F_{MSY}: F_{bar} (2019) = F_{FMY} = 0.31

22) $F_{MSY\ upper}$: F_{bar} (2019) = $F_{FMY\ upper}$ = 0.46

The reason two management plan options (2 and 3 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 and again in 2017, the two plans now differ from one another. The EU management plan continued to be based on the previous values for B_{lim} and B_{pa} (formerly 70 000 tonnes and 150 000 tonnes respectively) while the EU–Norway agreement has the flexibility to accommodate the revised values for these quantities (107 000 tonnes and 150 000 tonnes respectively). 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 but the effort regime was discontinued in 2017.

Forecasts for the SAM final run and associated scenarios are given in Table 4.12.

4.8 Medium-term forecasts

Medium-term projections are not carried out for this stock.

4.9 Biological reference points

The reference points for cod in Subarea 4, Division 7.d and Subdivision 20 were estimated at ICES WGNSSK 2017 following the procedures of ICES WGNSSK 2015 and ICES WGNSSK 2016. In 2018, reference points were recalculated based on new natural mortalities following the 2017 key-run (ICES WGSAM 2018). The final SAM assessment for 2017 (May assessment) was re-run with the new natural mortalities and fed into the EQSIM software, using the same rationale as ICES WGNSSK 2017. This made very little difference to the reference points so they were not revised. Biological reference points and their technical basis are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	150 000 t	The default option of B_{pa}.(=1.4×Blim)	
	F_{MSY}	0.31	EQSim analysis based on recruitment period 1988–2016	2017 assessment
Precautionary approach	B_{lim}	107 000 t	SSB associated with the 1996 year class	2017 assessment
	B_{pa}	150 000 t	B_{lim} multiplied by 1.4. This is the current ICES default approach.	
	F_{lim}	0.54	EQSim analysis based on recruitment period 1998–2016	2017 assessment
	F_{pa}	0.39	F_{lim}/1.4	
EU Management plan	SSB_{lower}	70 000 t	Former B_{lim}	EC 1342/2008
	SSB_{upper}	150 000 t	Former B_{pa}	
	F_{lower}	0.2	Fishing mortality when SSB < SSB_{lower}.	
	F_{upper}	0.4	Fishing mortality when SSB > SSB_{upper}	
EU–Norway agreement	SSB_{lower}	107 000 t	Revised B_{lim}	2008 EU-Norway agreement
	SSB_{upper}	150 000 t	Revised B_{pa}	
	F_{lower}	0.2	Fishing mortality when SSB < SSB_{lower}.	
	F_{upper}	0.4	Fishing mortality when SSB > SSB_{upper}	

4.10 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 4.14a): historical SSB trends are similar, but there is a downscaling of SSB from 2009 due to the lack of consistency in cohort strength for some cohorts at older ages in the NS-IBTS Q1 and Q3 survey data; the stock is below $B_{trigger}$; fishing mortality has increased slightly in the last year, and is between the precautionary reference points F_{lim} and F_{pa}, and above F_{MSY}.

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: 59%, 48%, 35% and 80%, 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 12%) and this might have an impact on recruitment estimates (and, hence, age 1 catch and survey residuals) because it constrains the changes permitted between abundance at ages 1 and 2 of a cohort.

Finally, the high correlation (0.86) 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. 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 plus group from 7+ to 6+. This reduces the cohort information for ages 6+; these ages represent 29% of the SSB (by weight) in 2018 (increasing from 20% in 2017), and if the SSB continues to increase, this proportion should also increase as more fish aggregate in the plus group, with an associated increasing loss in cohort signal for ages in the plus group, 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, overall declining fishing mortality (total mortality for SURBAR) since around 2000, and stronger 2005, 2009, 2013 and 2016 year classes in recent years. The decline in fishing mortality is evident from the shallower gradients of log-catch curves, and the stronger 2016 year class is evident from this year class being more widespread in the North Sea compared to other recent year classes at the same age.

Values for natural mortality were updated in 2018, following the key run conducted by WGSAM (ICES WGSAM 2018); they are smoothed annual model estimates from a multispecies model. 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 1978–2018, to which a smoother is applied to get rid of the effects of variations in sampling intensity. A Delta-GAM approach, assuming a stationary spatial model with ship effect, has been used to derive both Q1 and Q3 NS–IBTS indices.

4.11 Status of the Stock

There has been an improvement of the status of the stock in the last few years. SSB has increased from the historical low in 2006, and is now between B_{lim} and B_{pa}.

Fishing mortality has declined from 2000, and is now between the precautionary reference points F_{lim} and F_{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 2016 year class is stronger, just below the level of the strong 1999 year class, but the 2017 year class appears to be weak.

4.12 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, 2013 and 2016 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.

Discarding currently contributes less than a quarter of the total catch by weight, a substantial improvement compared to recent years (when the average was almost half of the total). There have been considerable efforts to reduce discards by some countries, and the impact of these reductions are starting to be felt (e.g. reduced discarding leading to improved survival of incoming year classes).

Cod is caught by a large variety of gears and together with many other species. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, in order to estimate the potential risks of quota over- and undershooting for the different stocks.

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 2017 being 97% of 1 year old (compared to 95% in 2016), 56% of 2 year old (71% in 2016), 28% of 3 year old (36% in 2016) and 12% of 4 year old cod (8% in 2016).

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 (1.5%), survival to age 5 is improving.

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. The forecast procedure uses the assessment estimate of recruitment in 2018. This remains to be confirmed by the IBTS-Q3 survey and a reopening of the advice may be triggered in October.

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.

The reported landings in 2017 were 37 994 tonnes and the estimated discards (including BMS landings) in 2017 were 8731 tonnes, giving a total of 46 725 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.

The change in advice (-47%) is due to a combination of: (a) a change in the perception of the stock with the addition of new data, including low estimates from the IBTS Q1 survey in 2018, (b) a reduction in the F needed below F_{MSY}, according to the MSY approach (SSB is now below MSY $B_{trigger}$), and (c) an extremely low recruitment estimated for 2018 (the lowest in the time-series).

4.13 References

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Table 4.1. Nominal landings (in tonnes) of COD in Subarea 4, Division 7.d and Subdivision 20, as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium	5,799	3,882	3,304	2,470	2,616	1,482	1,627	1,722	1,309	1,009
Denmark	23,002	19,697	14,000	8,358	9,022	4,676	5,889	6,291	5,105	3,430
Faroe Islands	102	96	-	9	34	36	37	34	3	0
France	2,934	.	1,222	717	1,777	620	294	664	354	659
Germany	8,045	3,386	1,740	1,810	2,018	2,048	2,213	2,648	2,537	1,899
Greenland	.	.	.	.	.	.	.	35	23	17
Netherlands	14,676	9,068	5,995	3,574	4,707	2,305	1,726	1,660	1,585	1,523
Norway	5,823	7,432	6,410	4,369	5,217	4,417	3,223	2,900	2,749	3,057
Poland	25	19	18	18	39	35	-	-	0	1
Sweden	540	625	640	661	463	252	240	319	309	387
UK (E/W/NI)	17,745	10,344	6,543	4,087	3,112	2,213	1,890	1,270	1,491	1,588
UK (Scotland)	35,633	23,017	21,009	15,640	15,416	7,852	6,650	4,936	6,857	6,511
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	786	0
Danish industrial by-catch *	.	.	.	.	105	22	17	21	11	23
Norwegian industrial by-catch *	.	.	.	.	.	.	.	.	48	101
Total Nominal Catch	114,324	77,566	60,881	41,713	44,526	25,958	23,806	22,500	23,119	20,104
Unallocated landings	7,779	826	-1,114	-740	-2,333	-1,875	-1,277	356	-2,041	-1,047
WG estimate of total landings	**122,103**	**78,392**	**59,767**	**40,973**	**42,193**	**24,083**	**22,529**	**22,855**	**21,078**	**19,056**
Agreed TAC	**140,000**	**132,400**	**81,000**	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**

Division VIId

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium	239	172	110	93	51	54	47	51	80	84
Denmark	-	-	-	-	-	-	-	-	-	.
France	7,788	.	3,084	1,677	1,361	1,730	810	986	1,124	1,743
Netherlands	19	3	4	17	6	36	14	9	9	59
UK (E/W/NI)	618	454	385	249	145	121	103	184	267	174
UK (Scotland)	1	-	-	-	-	-	-	-	1	12
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	8,665	629	3,583	2,036	1,563	1,941	974	1,230	1,481	2,072
Unallocated landings	-85	6,229	-1,258	-463	1,576	190	40	29	-2	75
WG estimate of total landings	**8,580**	**6,858**	**2,325**	**1,573**	**3,139**	**2,131**	**1,014**	**1,259**	**1,479**	**2,147**

Division IIIa (Skagerrak)**

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	12,339	8,681	7,684	5,900	5,525	3,067	3,038	3,019	2,513	2,246
Germany	54	54	54	32	83	49	99	86	84	67
Norway	1,293	1,146	926	762	645	825	856	759	628	681
Sweden	1,900	1,909	1,293	1,035	897	510	495	488	372	370
Others	-	-	-	-	-	27	24	21	373	385
Danish industrial by-catch *	97	62	99	687	20	5	4	2	3	2
Total Nominal Catch	15,586	11,790	9,957	7,729	7,170	4,483	4,516	4,375	3,973	3,751
Unallocated landings	-255	-816	-680	-643	-316	-504	-602	-376	-715	-731
WG estimate of total landings	**15,331**	**10,974**	**9,277**	**7,086**	**6,854**	**3,979**	**3,914**	**3,998**	**3,258**	**3,020**
Agreed TAC	**20,000**	**19,000**	**11,600**	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Nominal Catch	138,575	89,985	74,421	51,478	53,260	32,382	29,296	28,104	28,573	25,927
Unallocated landings	7,439	6,240	-3,052	-1,846	-1,074	-2,189	-1,839	9	-2,759	-1,704
WG estimate of total landings	**146,014**	**96,225**	**71,369**	**49,632**	**52,186**	**30,193**	**27,457**	**28,113**	**25,815**	**24,223**

** Skaggerak/Kattegat split derived from national statistics

* The Danish (up to 2001) and Norwegian industrial bycatch 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	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Danish industrial by-catch *	97	62	99	687	-	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	.	.	.	48	101
Total	**97**	**62**	**99**	**687**	**0**	**0**	**0**	**0**	**48**	**101**

Table 4.1 cont. Nominal landings (in tonnes) of COD in Subarea 4, Division 7.d and Subdivision 20, as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	894	946	666	653	862	1,076	1,257	1,223	1,103	696
Denmark	3,831	4,402	5,686	4,863	4,803	4,536	5,457	6,026	6,697	6,119
Faroe Islands	16	45	32	0	0	0	0	0	.	.
France	573	950	781	619	368	287	638	517	391	401
Germany	1,736	2,374	2,844	2,211	2,385	1,921	2,257	2,133	2,083	1,987
Greenland	17	11	0	0	0	0	0	0	2	1
Netherlands	1,896	2,649	2,657	1,928	1,955	1,344	1,242	1,403	1,365	645
Norway	4,128	4,234	4,496	4,898	4,601	4,079	4,600	5,404	5,592	5,521
Poland	2	3	0	2	0	0	0	0	.	.
Sweden	439	378	363	315	472	332	401	415	370	387
UK (E/W/NI)	1,546	2,384	2,553	2,169	1,630	2,129	2,963	.	.	.
UK (Scotland)	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	13,480	14,889	16,583	18,293
Others	0	0	0	0	0	0	0	0	0	0
Danish industrial by-catch	1	72	12	0	0	2	24	0	5	147
Norwegian indust by-catch *	22	4	201	1	.	.	.	.	.	.
Total Nominal Catch	22,264	27,500	31,657	27,799	27,641	26,325	29,356	32,012	34,192	34,198
Unallocated landings	-607	134	-677	-1,124	-1,014	-1,010	-806	-768	-1,157	-1,089
BMS landings	.	.	.	.	.	.	.	.	.	1
WG estimate of total landings	**21,657**	**27,634**	**30,980**	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**	**33,109**
Agreed TAC	**22,152**	**28,798**	**33,552**	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**33,651**	**39,220**

Division VIId										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	154	73	57	56	40	53	72	78	38	17
Denmark	.	.	.	.	.	.	.	.	.	.
France	1,326	1,779	1,606	1,078	885	768	1,270	1,142	279	92
Netherlands	30	35	45	51	40	38	50	52	40	22
UK (E/W/NI)	144	133	127	125	99	100	156	.	.	.
UK (Scotland)	7	3	1	1	0	0	0	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	156	162	101	48
Total Nominal Catch	1,661	2,023	1,836	1,311	1,064	959	1,548	1,434	459	179
Unallocated landings	-32	-136	-128	8	56	-43	-112	-36	-38	-9
WG estimate of total landings	**1,629**	**1,887**	**1,708**	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**	**170**
Agreed TAC		**1,678**	**1,955**	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**1,961**	**2,059**

Division IIIa (Skagerrak)**										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	2,553	3,024	3,286	3,118	3,178	3,033	3,430	3,344	3,695	3,663
Germany	52	55	56	60	78	69	84	87	94	63
Norway	779	440	375	421	615	575	533	500	549	486
Sweden	365	459	458	518	520	529	570	571	643	559
Others	13	2	26	0	0	33	28	26	25	37
Danish industrial by-catch	7	2	10	0	1	1	5	5	0	40
Total Nominal Catch	3,769	3,983	4,211	4,117	4,392	4,240	4,649	4,532	5,007	4,848
Unallocated landings	-376	-188	-154	-161	-65	-85	38	31	-233	-133
BMS landings	.	.	.	.	.	.	.	.	.	1
WG estimate of total landings	**3,393**	**3,794**	**4,057**	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**	**4,715**
Agreed TAC	**3,165**	**4,114**	**4,793**	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**4,807**	**5,744**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Nominal Catch	27,694	33,506	37,705	33,227	33,097	31,524	35,553	37,978	39,657	39,225
Unallocated landings	-1,015	-190	-959	-1,277	-1,024	-1,138	-880	-773	-1,427	-1,231
BMS landings	.	.	.	.	.	.	.	.	.	2
WG estimate of total landings	**26,679**	**33,315**	**36,746**	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**	**37,994**

*** WG estimates of total landings do not include BMS landings

** Skaggerak/Kattegat split derived from national statistics prior to 2017

* 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Norwegian indust by-catch *	22	4	201	1	.	.	.	.	.	.
Total	**22**	**4**	**201**	**1**	**0**	**0**	**0**	**0**	**0**	**0**

Table 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	2016	2017
1	776	338	519	1120	1099	665	683	2240	686	167	351
2	6334	3268	4833	5037	4540	2230	2688	4207	6384	2035	2240
3	2264	4130	2839	4578	4046	5367	3063	4376	4903	5644	3233
4	1562	1146	2888	1582	1408	1963	2592	1605	1933	3150	3495
5	398	706	596	1315	610	633	865	1286	745	1012	1660
6	137	213	237	198	451	248	190	332	584	277	385
7	40	70	44	65	48	139	84	64	144	188	94
8	39	26	19	16	27	15	38	38	22	44	78
9	6	13	17	6	5	4	5	6	6	9	24
10	1	1	8	4	2	4	1	2	1	5	9
+gp	1	1	3	2	2	1	1	0	2	2	2
TOTALNUM	11558	9911	12003	13923	12237	11269	10208	14156	15411	12534	11571
TONSLAND	24215	26814	33177	36762	31979	32124	30474	34651	37373	38104	37668
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

Table 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Discard numbers at age (including BMS landings from 2016; 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	2016	2017
1	16171	10847	9608	9867	3936	11149	6188	7756	3980	3067	9767
2	23047	9331	9055	9151	7851	5190	6055	6504	8935	4942	2814
3	2657	7591	2655	1254	925	1422	856	1434	1965	3110	1271
4	481	223	650	65	81	115	397	163	180	257	493
5	52	14	50	30	6	5	83	58	55	31	96
6	24	11	17	0	4	1	40	5	64	1	9
7	0	0	9	0	1	1	16	0	15	0	1
8	2	0	0	0	1	0	0	0	5	0	1
9	0	0	0	0	0	0	0	0	3	0	0
10	0	0	2	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	42433	28017	22047	20366	12804	17884	13635	15921	15201	11409	14453
TONSDISC	30422	24984	20846	12341	8711	8638	10289	10538	12537	12203	8702
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

Table 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	2016	2017
1	16947	11185	10127	10987	5035	11815	6871	9995	4666	3234	10118
2	29381	12599	13887	14188	12391	7420	8743	10711	15319	6977	5054
3	4921	11721	5494	5831	4970	6789	3919	5810	6869	8754	4504
4	2043	1369	3539	1646	1489	2077	2989	1768	2113	3408	3987
5	451	720	646	1344	616	638	949	1345	800	1044	1756
6	161	224	254	199	455	249	229	337	648	279	395
7	40	70	53	65	49	139	100	64	159	188	95
8	41	26	19	16	28	15	38	38	27	44	79
9	6	13	17	6	5	4	5	6	9	9	24
10	1	1	10	4	2	4	2	2	1	5	9
+gp	1	1	3	2	2	1	1	0	2	2	2
TOTALNUM	53992	37928	34050	34288	25041	29153	23844	30076	30612	23942	26024
TONSLAND	54637	51798	54023	49103	40689	40762	40763	45190	49910	50307	46371
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

Table 4.2d. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch numbers at age (Thousands) by season (quarter or annual, depending on data stratification) from InterCatch for 2017.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	15	24	43	238	31	351
2	475	502	519	704	39	2239
3	741	752	798	892	49	3232
4	969	873	839	780	33	3494
5	520	371	429	323	17	1660
6	59	140	117	65	4	385
7	14	37	27	14	1	93
8	10	15	22	31	1	79
9	2	1	3	17	1	24
10	1	3	4	0	0	8
+gp	0	1	1	0	0	2
TOTALNUM	2806	2719	2802	3064	176	11567

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	907	1722	1978	2456	2704	9767
2	709	953	554	324	275	2815
3	366	523	194	94	95	1272
4	191	199	41	25	37	493
5	43	24	21	5	3	96
6	2	7	0	0	0	9
7	1	1	0	0	0	2
8	0	0	0	0	1	1
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	2219	3429	2788	2904	3115	14455

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	922	1746	2021	2694	2735	10118
2	1184	1455	1073	1028	314	5054
3	1107	1275	992	986	144	4504
4	1160	1072	880	805	70	3987
5	563	395	451	327	20	1756
6	61	147	117	66	4	395
7	15	38	27	14	1	95
8	10	15	22	31	1	79
9	2	1	3	17	1	24
10	1	3	4	0	0	8
+gp	0	1	1	0	0	2
TOTALNUM	5025	6148	5591	5968	3290	26022

Table 4.2e. Cod in Subarea 4, Division 7.d and Subdivision 20: Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2017, 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). BMS landings are included with discards as unwanted catch.

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	78%	82%	73%	75%	45%
27.3.a.20	90%	86%	85%	74%	-
27.7.d	53%	50%	39%	73%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	87%	82%	78%	83%	45%
27.3.a.20	76%	64%	60%	75%	-
27.7.d	39%	10%	14%	38%	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	100%	100%	100%	99%	100%
27.3.a.20	100%	100%	100%	100%	-
27.7.d	-	-	-	-	-

Contribution to total (before raising)

Area/Type	Landings	Discards
27.4	87%	95%
27.3.a.20	12%	5%
27.7.d	0%	0%

Table 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	2016	2017
1	0.830	1.06679	0.78826	0.71481	0.862	0.938	0.883	0.699	0.596	0.800	0.753
2	1.182	1.38884	1.41193	1.29224	1.328	1.369	1.240	1.213	1.206	1.315	1.119
3	2.365	2.45605	2.67433	2.67091	2.525	2.354	2.461	2.390	2.291	2.342	2.379
4	4.050	4.06299	4.14457	4.22308	4.596	4.175	4.164	4.180	4.112	3.862	3.906
5	6.053	6.22405	6.11913	6.04897	6.481	6.391	6.187	5.678	5.935	5.744	5.393
6	8.250	7.39317	7.48963	8.29925	7.843	8.115	8.347	7.435	6.920	7.342	6.897
7	9.262	9.65076	8.96797	9.47215	9.681	9.092	9.817	9.191	8.775	7.928	8.906
8	10.015	11.48868	11.44744	11.63072	9.629	11.799	9.486	9.180	9.622	8.717	8.664
9	12.282	11.38721	11.29135	12.82728	10.845	12.548	11.364	11.469	10.654	10.367	9.586
10	14.559	12.72507	11.71648	12.08332	14.436	11.436	10.935	16.456	13.838	11.926	17.579
+gp	17.522	15.38134	18.764	10.05238	12.421	20.644	29.764	34.656	30.079	19.623	20.51895

Table 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Discard weights-at-age (includes BMS landings from 2016; 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	2016	2017
1	0.288	0.404	0.385	0.292	0.277	0.234	0.334	0.311	0.326	0.364	0.231
2	0.814	0.735	0.984	0.785	0.677	0.556	0.796	0.742	0.759	0.939	0.771
3	1.690	1.699	2.013	1.533	2.057	1.867	1.493	1.772	1.617	1.767	1.881
4	3.949	3.002	3.485	3.137	4.099	3.803	3.375	3.128	3.158	3.092	3.002
5	6.609	5.311	6.565	5.323	5.576	6.456	4.048	3.826	3.983	4.687	3.629
6	10.198	9.341	8.521	8.369	6.071	8.579	8.419	4.642	5.303	5.439	5.172
7	5.900	5.128	13.464	6.728	8.264	9.733	7.086	4.423	6.940	0.000	5.313
8	15.906	0.000	0.000	0.000	6.213	0.000	0.000	0.000	8.390	0.000	4.577
9	0.000	0.000	0.000	0.000	11.617	0.000	0.000	0.000	4.087	0.000	0.000
10	0.000	0.000	12.014	0.000	0.000	16.370	16.370	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

Table 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	2016	2017
1	0.313	0.424	0.406	0.33483	0.405	0.274	0.388	0.398	0.366	0.387	0.249
2	0.893	0.904	1.133	0.964822	0.915	0.800	0.932	0.927	0.945	1.049	0.925
3	2.001	1.966	2.355	2.426207	2.438	2.252	2.249	2.237	2.098	2.138	2.238
4	4.026	3.890	4.023	4.180381	4.569	4.154	4.060	4.083	4.031	3.803	3.794
5	6.117	6.207	6.154	6.032982	6.472	6.392	5.999	5.598	5.802	5.712	5.296
6	8.543	7.491	7.560	8.299303	7.829	8.117	8.360	7.392	6.761	7.332	6.857
7	9.255	9.644	9.733	9.47205	9.656	9.095	9.385	9.190	8.602	7.928	8.850
8	10.293	11.489	11.447	11.63072	9.461	11.799	9.486	9.180	9.410	8.717	8.618
9	12.282	11.387	11.291	12.82728	10.853	12.548	11.364	11.469	8.663	10.367	9.586
10	14.559	12.725	11.786	12.08332	14.436	11.754	11.680	16.456	13.838	11.926	17.579
+gp	17.522	15.381	18.764	10.05238	12.421	20.644	29.764	34.656	30.079	19.623	20.519

Table 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch weights at age (kg) by season (quarter or annual, depending on data stratification) from InterCatch for 2017 (note, any differences in the +gp values between Tables 4.3a–c and Table 4.3d is due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.796	0.7	0.777	0.75	0.763	0.753
2	0.905	0.961	1.248	1.286	1.104	1.12
3	1.972	2.186	2.583	2.727	1.844	2.379
4	3.371	3.841	4.087	4.445	3.854	3.905
5	4.79	5.22	5.848	5.989	4.938	5.394
6	6.994	6.378	6.862	8.076	6.264	6.905
7	8.678	8.507	9.17	9.662	9.014	8.906
8	10.616	9.421	9.959	6.788	8.512	8.674
9	10.271	9.568	10.041	9.487	8.168	9.587
10	12.918	23.364	13.64	17.111	17.676	17.57
+gp	25.395	12.605	25.102	28.339	20.545	20.605

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.122	0.18	0.251	0.328	0.193	0.23
2	0.574	0.705	1.002	0.81	0.986	0.77
3	1.506	1.937	2.115	2.383	2.031	1.88
4	2.504	3.302	2.909	3.426	3.796	3.004
5	3.472	4.368	2.818	4.206	4.883	3.63
6	4.208	5.419	5.172	5.172	5.172	5.172
7	5.418	5.215	5.313	5.313	5.313	5.313
8	6.501	4.84	4.702	4.741	3.956	4.565
9	0	0	0	0	0	0
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	0.133	0.187	0.263	0.365	0.199	0.248
2	0.707	0.793	1.121	1.136	1.001	0.925
3	1.818	2.084	2.492	2.695	1.967	2.238
4	3.229	3.741	4.032	4.414	3.823	3.794
5	4.689	5.169	5.704	5.964	4.929	5.298
6	6.916	6.335	6.856	8.06	6.243	6.865
7	8.535	8.447	9.161	9.645	8.931	8.85
8	10.539	9.413	9.952	6.786	6.03	8.628
9	10.271	9.568	10.041	9.487	8.168	9.587
10	12.918	23.364	13.64	17.111	17.676	17.57
+gp	25.395	12.605	25.102	28.339	20.545	20.605

Table 4.4. Cod in Subarea 4, Division 7.d and Subdivision 20: Reported landings, estimated discards (including BMS landings) and total catch (landings + discards) in tonnes. Note any differences in values between Table 4.4 and those given in the report and advice are due to SOP correction.

Tonnage landed, discarded and caught

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	12537	49910
2016	38104	12203	50307
2017	37668	8702	46371

Table 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	0.006	0.052	0.237	0.644	0.881	1.000
1974	0.006	0.053	0.229	0.619	0.849	1.000
1975	0.006	0.054	0.223	0.595	0.817	1.000
1976	0.006	0.055	0.217	0.572	0.787	1.000
1977	0.006	0.056	0.213	0.550	0.758	1.000
1978	0.006	0.057	0.211	0.530	0.732	1.000
1979	0.006	0.057	0.210	0.513	0.711	1.000
1980	0.006	0.057	0.210	0.499	0.695	1.000
1981	0.006	0.058	0.212	0.489	0.684	1.000
1982	0.007	0.059	0.215	0.483	0.681	1.000
1983	0.007	0.061	0.220	0.484	0.683	1.000
1984	0.007	0.064	0.228	0.490	0.693	1.000
1985	0.007	0.068	0.242	0.502	0.707	1.000
1986	0.008	0.073	0.262	0.520	0.726	1.000
1987	0.008	0.080	0.288	0.544	0.748	1.000
1988	0.009	0.086	0.319	0.571	0.772	1.000
1989	0.009	0.093	0.353	0.602	0.796	1.000
1990	0.009	0.100	0.387	0.633	0.819	1.000
1991	0.010	0.106	0.418	0.664	0.841	1.000
1992	0.010	0.112	0.444	0.693	0.860	1.000
1993	0.011	0.118	0.462	0.719	0.877	1.000
1994	0.012	0.126	0.472	0.741	0.891	1.000
1995	0.013	0.135	0.476	0.758	0.903	1.000
1996	0.014	0.146	0.478	0.772	0.914	1.000
1997	0.015	0.161	0.480	0.783	0.922	1.000
1998	0.016	0.178	0.487	0.792	0.929	1.000
1999	0.017	0.198	0.501	0.799	0.935	1.000
2000	0.019	0.220	0.524	0.806	0.939	1.000
2001	0.020	0.242	0.556	0.813	0.943	1.000
2002	0.022	0.265	0.593	0.821	0.946	1.000
2003	0.024	0.286	0.634	0.829	0.949	1.000
2004	0.026	0.305	0.674	0.837	0.951	1.000
2005	0.029	0.321	0.709	0.845	0.952	1.000
2006	0.031	0.334	0.737	0.853	0.953	1.000
2007	0.033	0.344	0.755	0.861	0.954	1.000
2008	0.036	0.352	0.764	0.868	0.955	1.000
2009	0.039	0.357	0.763	0.873	0.955	1.000
2010	0.041	0.360	0.752	0.877	0.955	1.000
2011	0.044	0.361	0.735	0.878	0.954	1.000
2012	0.046	0.360	0.712	0.877	0.953	1.000
2013	0.049	0.357	0.684	0.873	0.951	1.000
2014	0.051	0.351	0.653	0.866	0.948	1.000
2015	0.054	0.344	0.620	0.857	0.946	1.000
2016	0.056	0.334	0.586	0.845	0.943	1.000
2017	0.058	0.324	0.551	0.832	0.939	1.000

Table 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Natural mortality by age-group.

	Age					
y	1	2	3	4	5	6
1963	1.100	0.643	0.213	0.2	0.2	0.2
1964	1.100	0.643	0.213	0.2	0.2	0.2
1965	1.100	0.643	0.213	0.2	0.2	0.2
1966	1.100	0.643	0.213	0.2	0.2	0.2
1967	1.100	0.643	0.213	0.2	0.2	0.2
1968	1.100	0.643	0.213	0.2	0.2	0.2
1969	1.100	0.643	0.213	0.2	0.2	0.2
1970	1.100	0.643	0.213	0.2	0.2	0.2
1971	1.100	0.643	0.213	0.2	0.2	0.2
1972	1.100	0.643	0.213	0.2	0.2	0.2
1973	1.100	0.643	0.213	0.2	0.2	0.2
1974	1.100	0.643	0.213	0.2	0.2	0.2
1975	1.113	0.638	0.216	0.2	0.2	0.2
1976	1.127	0.634	0.218	0.2	0.2	0.2
1977	1.141	0.631	0.221	0.2	0.2	0.2
1978	1.154	0.629	0.223	0.2	0.2	0.2
1979	1.164	0.629	0.225	0.2	0.2	0.2
1980	1.172	0.631	0.228	0.2	0.2	0.2
1981	1.175	0.635	0.230	0.2	0.2	0.2
1982	1.174	0.639	0.232	0.2	0.2	0.2
1983	1.168	0.643	0.234	0.2	0.2	0.2
1984	1.157	0.646	0.236	0.2	0.2	0.2
1985	1.143	0.650	0.238	0.2	0.2	0.2
1986	1.127	0.653	0.240	0.2	0.2	0.2
1987	1.111	0.657	0.242	0.2	0.2	0.2
1988	1.095	0.663	0.244	0.2	0.2	0.2
1989	1.082	0.670	0.246	0.2	0.2	0.2
1990	1.070	0.677	0.247	0.2	0.2	0.2
1991	1.061	0.685	0.249	0.2	0.2	0.2
1992	1.054	0.693	0.251	0.2	0.2	0.2
1993	1.048	0.700	0.255	0.2	0.2	0.2
1994	1.045	0.708	0.259	0.2	0.2	0.2
1995	1.042	0.717	0.265	0.2	0.2	0.2
1996	1.040	0.728	0.274	0.2	0.2	0.2
1997	1.037	0.740	0.284	0.2	0.2	0.2
1998	1.035	0.755	0.295	0.2	0.2	0.2
1999	1.033	0.771	0.308	0.2	0.2	0.2
2000	1.033	0.790	0.322	0.2	0.2	0.2
2001	1.038	0.811	0.335	0.2	0.2	0.2
2002	1.047	0.834	0.348	0.2	0.2	0.2
2003	1.061	0.857	0.359	0.2	0.2	0.2
2004	1.077	0.880	0.366	0.2	0.2	0.2
2005	1.094	0.899	0.369	0.2	0.2	0.2
2006	1.110	0.914	0.368	0.2	0.2	0.2
2007	1.125	0.924	0.363	0.2	0.2	0.2
2008	1.139	0.929	0.356	0.2	0.2	0.2
2009	1.151	0.929	0.348	0.2	0.2	0.2
2010	1.163	0.927	0.340	0.2	0.2	0.2
2011	1.177	0.923	0.333	0.2	0.2	0.2
2012	1.193	0.918	0.327	0.2	0.2	0.2
2013	1.212	0.912	0.324	0.2	0.2	0.2
2014	1.233	0.907	0.321	0.2	0.2	0.2
2015	1.256	0.902	0.320	0.2	0.2	0.2
2016	1.280	0.897	0.320	0.2	0.2	0.2
2017*	1.280	0.897	0.320	0.2	0.2	0.2

***A new key run was performed in 2017 with data up to 2016 (ICES WGSAM 2017), so the 2017 M–value is assumed equal to 2016.**

Table 4.6. Cod in Subarea 4, Division 7.d and Subdivision 20: 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	2018						
	1	1	0	0.25				
	1	5						
	1	**4412.26**	**16117.23**	**1697.33**	**993.55**	**367.64**	393.24	1983
	1	**13407.82**	**6211.70**	**2371.71**	**463.77**	**426.27**	184.33	1984
	1	**628.75**	**16574.05**	**2008.68**	**792.24**	**225.26**	275.27	1985
	1	**12980.80**	**2679.22**	**3433.80**	**955.89**	**431.91**	231.91	1986
	1	**5256.87**	**15386.40**	**717.02**	**795.71**	**214.43**	200.68	1987
	1	**2960.81**	**3778.93**	**3464.10**	**200.22**	**347.64**	208.15	1988
	1	**9834.49**	**3629.38**	**2595.06**	**1245.19**	**157.25**	248.10	1989
	1	**2070.31**	**7957.21**	**1139.43**	**432.58**	**484.25**	81.63	1990
	1	**1744.39**	**2367.47**	**1934.32**	**509.51**	**270.47**	267.13	1991
	1	**9891.21**	**3068.09**	**739.24**	**511.53**	**158.27**	67.77	1992
	1	**3359.62**	**8413.28**	**973.70**	**349.03**	**248.55**	76.81	1993
	1	**7373.83**	**2210.07**	**1583.79**	**489.10**	**229.47**	126.06	1994
	1	**7224.15**	**9630.95**	**1829.80**	**526.26**	**184.28**	73.80	1995
	1	**1910.07**	**4140.18**	**2368.32**	**410.98**	**259.89**	68.84	1996
	1	**15792.85**	**3114.09**	**1244.03**	**535.73**	**154.99**	109.44	1997
	1	**660.18**	**9985.18**	**1171.28**	**493.41**	**289.65**	108.75	1998
	1	**1413.81**	**478.26**	**4290.43**	**577.62**	**291.16**	101.57	1999
	1	**3502.66**	**2171.49**	**506.02**	**964.19**	**175.69**	107.97	2000
	1	**886.84**	**3881.70**	**876.73**	**159.21**	**147.87**	55.28	2001
	1	**2974.63**	**1526.12**	**1568.61**	**248.51**	**57.24**	59.78	2002
	1	**363.45**	**2003.79**	**722.20**	**479.23**	**156.18**	31.10	2003
	1	**2762.97**	**1282.43**	**1154.17**	**187.99**	**183.46**	70.41	2004
	1	**1107.63**	**1483.20**	**494.02**	**401.35**	**68.90**	108.36	2005
	1	**3946.10**	**883.98**	**766.50**	**157.08**	**86.84**	57.27	2006
	1	**1441.51**	**2659.40**	**704.78**	**229.69**	**86.11**	66.64	2007
	1	**2313.64**	**1087.08**	**1185.27**	**292.00**	**200.32**	50.80	2008
	1	**1071.32**	**1763.10**	**816.68**	**388.63**	**126.47**	74.60	2009
	1	**2925.40**	**1617.34**	**1165.97**	**325.77**	**206.75**	83.81	2010
	1	**779.54**	**2910.73**	**608.46**	**333.14**	**206.75**	132.21	2011
	1	**1548.47**	**1551.43**	**1879.00**	**411.93**	**226.27**	81.00	2012
	1	**1639.64**	**1408.65**	**772.94**	**554.94**	**370.66**	100.01	2013
	1	**2681.55**	**1722.19**	**745.53**	**286.23**	**348.66**	112.42	2014
	1	**1680.24**	**3573.47**	**1244.35**	**441.16**	**195.03**	149.36	2015
	1	**898.21**	**1071.61**	**1919.20**	**615.35**	**356.29**	136.80	2016
	1	**8451.97**	**900.55**	**1198.14**	**999.61**	**560.80**	144.75	2017
	1	**469.41**	**2649.17**	**523.96**	**296.96**	**257.40**	215.76	2018
IBTS_Q3_gam								
	1992	2017						
	1	1	0.50	0.75				
	1	4						
	1	**16801.89**	**1689.75**	**388.93**	**338.49**	120.23	41.56	1992
	1	**4420.42**	**4451.69**	**604.44**	**126.50**	93.91	7.56	1993
	1	**17472.75**	**2317.34**	**947.96**	**162.93**	45.58	35.13	1994
	1	**9394.22**	**6857.73**	**718.34**	**307.73**	35.18	19.37	1995
	1	**4922.46**	**2947.06**	**1088.05**	**179.25**	146.54	13.02	1996
	1	**29259.80**	**2051.49**	**740.29**	**272.13**	53.18	37.37	1997
	1	**872.12**	**9222.68**	**724.31**	**196.88**	121.94	42.27	1998
	1	**3379.97**	**490.04**	**2497.37**	**155.75**	43.14	17.82	1999
	1	**6274.20**	**974.55**	**117.25**	**345.18**	38.91	33.15	2000
	1	**1374.87**	**2216.40**	**383.36**	**77.88**	60.84	35.89	2001
	1	**3751.87**	**912.98**	**770.34**	**195.54**	53.13	24.01	2002
	1	**935.85**	**1319.84**	**250.95**	**181.99**	87.25	63.01	2003
	1	**3084.57**	**785.62**	**487.31**	**95.64**	70.35	26.61	2004
	1	**1045.88**	**750.34**	**288.66**	**119.89**	26.85	48.06	2005
	1	**5435.67**	**717.36**	**611.30**	**120.15**	30.17	19.35	2006
	1	**1813.73**	**2307.71**	**435.12**	**175.73**	101.63	47.68	2007
	1	**2257.02**	**1189.96**	**1134.75**	**228.56**	125.27	32.22	2008
	1	**1847.98**	**964.61**	**298.77**	**241.94**	53.82	25.68	2009
	1	**4483.27**	**1637.97**	**544.61**	**182.07**	113.28	22.57	2010
	1	**1203.19**	**2814.01**	**885.44**	**372.99**	105.53	99.97	2011
	1	**2060.04**	**1003.83**	**1235.88**	**372.53**	104.71	18.77	2012
	1	**3000.33**	**1047.07**	**484.87**	**517.44**	139.25	64.52	2013
	1	**3278.76**	**1449.52**	**597.22**	**296.23**	198.12	95.94	2014
	1	**1780.40**	**2919.36**	**1051.48**	**460.16**	140.20	137.56	2015
	1	**1352.18**	**1102.76**	**1660.53**	**827.30**	202.15	131.99	2016
	1	**6691.09**	**591.44**	**463.64**	**413.39**	213.47	46.15	2017

Table 4.7a. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run model specification.

```
$minAge
[1] 1

$maxAge
[1] 6

$maxAgePlusGroup # (0=No, 1=Yes)
[1] 1

$keyLogFsta # Coupling of fishing mortality
     [,1] [,2] [,3] [,4] [,5] [,6]
[1,]    0    1    2    3    4    5
[2,]   -1   -1   -1   -1   -1   -1
[3,]   -1   -1   -1   -1   -1   -1

$corFlag # Use correlated random walks for fishing mortalities (0=independent, 1=correlation estimated)
[1] 2

$keyLogFpar # Coupling of catchability PARAMETERS
     [,1] [,2] [,3] [,4] [,5] [,6]
[1,]   -1   -1   -1   -1   -1   -1
[2,]    0    1    2    3    4   -1
[3,]    5    6    7    8   -1   -1

$keyQpow # Coupling of power law model EXPONENTS
     [,1] [,2] [,3] [,4] [,5] [,6]
[1,]   -1   -1   -1   -1   -1   -1
[2,]   -1   -1   -1   -1   -1   -1
[3,]   -1   -1   -1   -1   -1   -1

$keyVarF # Coupling of fishing mortality RW VARIANCES
     [,1] [,2] [,3] [,4] [,5] [,6]
[1,]    0    1    1    1    1    1
[2,]   -1   -1   -1   -1   -1   -1
[3,]   -1   -1   -1   -1   -1   -1

$keyVarLogN # Coupling of log N RW VARIANCES
[1] 0 1 1 1 1 1

$keyVarObs # Coupling of OBSERVATION VARIANCES
     [,1] [,2] [,3] [,4] [,5] [,6]
[1,]    0    1    2    2    2    2
[2,]    3    4    4    4    4   -1
[3,]    5    6    6    6   -1   -1

$obsCorStruct
[1] ID ID ID
Levels: ID AR US

$keyCorObs
     1-2 2-3 3-4 4-5 5-6
[1,]  NA  NA  NA  NA  NA
[2,]  NA  NA  NA  NA  -1
[3,]  NA  NA  NA  -1  -1

$stockRecruitmentModelCode # (0=RW, 1=Ricker, 2=BH)
[1] 0

$noScaledYears # Number of years catch to be scaled by estimated parameter
[1] 13

$keyScaledYears # Years catch to be scaled by an estimated parameter
 [1] 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

$keyParScaledYA # Model config lines for scaled years
      [,1] [,2] [,3] [,4] [,5] [,6]
 [1,]    0    0    0    0    0    0
 [2,]    1    1    1    1    1    1
 [3,]    2    2    2    2    2    2
 [4,]    3    3    3    3    3    3
 [5,]    4    4    4    4    4    4
 [6,]    5    5    5    5    5    5
 [7,]    6    6    6    6    6    6
 [8,]    7    7    7    7    7    7
 [9,]    8    8    8    8    8    8
[10,]    9    9    9    9    9    9
[11,]   10   10   10   10   10   10
[12,]   11   11   11   11   11   11
[13,]   12   12   12   12   12   12

$fbarRange
[1] 2 4

$keyBiomassTreat
[1] -1 -1 -1

$obsLikelihoodFlag
[1] LN LN LN
Levels: LN ALN

$fixVarToWeight
[1] 0
```

Table 4.7b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run model fitting diagnostics, parameter estimates and correlation matrix.

Model fitting

log(L)	#par	AIC
-169.785	34	407.5705

	value	std.dev	logq.Q1_1	logq.Q1_2	logq.Q1_3	logq.Q1_4	logq.Q1_5	logq.Q3_1	logq.Q3_2	logq.Q3_3	logq.Q3_4	logSd.LogF	logSd.LogF	logSd.LogN	logSd.LogN	logSd.LogC	logSd.LogC	logSd.Log3	logSd.logQ	logSd.LodQ	logSd.LogQ	LogSd.Log	itrans_rho	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2
logq Q1_1	-4.67	0.09	1																																	
logq Q1_2	-3.28	0.05	0.23	1																																
logq Q1_3	-2.66	0.05	0.17	0.31	1																															
logq Q1_4	-2.56	0.06	0.18	0.32	0.4	1																														
logq Q1_5	-2.28	0.08	0.19	0.34	0.43	0.57	1																													
logq Q3_1	-3.57	0.08	0.22	0.29	0.23	0.25	0.26	1																												
logq Q3_2	-2.93	0.07	0.2	0.36	0.33	0.35	0.37	0.28	1																											
logq Q3_3	-2.61	0.07	0.18	0.32	0.41	0.45	0.48	0.25	0.35	1																										
logq Q3_4	-2.55	0.09	0.19	0.34	0.42	0.55	0.63	0.26	0.37	0.48	1																									
logSd LogF1	-1.93	0.22	-0.05	-0.03	-0.05	-0.07	-0.09	-0.04	-0.05	-0.06	-0.07	1																								
logSd LogF2+	-2.49	0.14	-0.09	-0.17	-0.2	-0.25	-0.3	-0.12	-0.19	-0.22	-0.28	0.39	1																							
logSd LogN1	-0.22	0.11	0.02	-0.03	-0.02	-0.02	-0.02	-0.03	-0.01	-0.03	-0.03	-0.01	-0.02	1																						
logSd LogN2+	-2.12	0.14	0.01	0	-0.01	0	0.03	0	0.03	-0.02	-0.02	-0.08	-0.11	0.26	1																					
logSd LogC1	-0.53	0.11	0	0	0.01	0.02	0.02	0	0.01	0.02	0.02	-0.09	-0.01	-0.08	-0.08	1																				
logSd LogC2	-1.46	0.13	0	0.01	0.02	0.03	0.03	0.02	0.02	0.03	0.03	-0.01	-0.03	-0.04	-0.07	0.05	1																			
logSd Log3+	-2.82	0.29	-0.03	-0.04	-0.04	-0.07	-0.12	-0.03	-0.05	-0.05	-0.08	-0.03	-0.05	-0.11	-0.55	0.06	0.01	1																		
logSd logQ1_1	-0.73	0.14	-0.02	0.04	0.03	0.03	0.03	0.05	0.02	0.03	0.03	0.01	0.01	-0.22	-0.16	0.03	0.02	0.08	1																	
logSd LodQ1_2	-1.37	0.07	0.06	0.11	0.14	0.16	0.19	0.07	0.1	0.16	0.2	0.01	-0.08	-0.08	-0.16	0.02	-0.01	-0.01	0.04	1																
logSd LogQ3_1	-1.05	0.17	0.03	0.06	0.04	0.05	0.05	0.05	0.03	0.05	0.05	0.01	0	-0.21	-0.2	0.04	-0.04	0.09	0.2	0.08	1															
LogSd LogQ3_2	-1.31	0.09	0.02	0.05	0.07	0.11	0.15	0.03	0.05	0.09	0.14	-0.01	-0.11	-0.06	-0.08	0	-0.01	-0.08	0.04	0.1	0.07	1														
itrans_rho	1.31	0.24	-0.01	0	0	0	0.02	-0.01	0.01	-0.01	-0.01	-0.04	0.15	0.06	0.23	0.09	0.03	0.1	-0.04	-0.06	-0.05	-0.08	1													
log Cmult1993	-0.08	0.09	-0.12	-0.2	-0.23	-0.25	-0.27	-0.15	-0.2	-0.23	-0.25	0.02	0.08	0.02	0.02	-0.01	-0.04	0.05	-0.03	-0.09	-0.06	-0.01	0.03	1												
log Cmult1994	0.01	0.1	-0.14	-0.24	-0.27	-0.3	-0.31	-0.19	-0.25	-0.28	-0.3	0.04	0.11	0.03	0.03	0	-0.03	0.02	-0.04	-0.11	-0.08	0	0.02	0.44	1											
log Cmult1995	0.14	0.1	-0.16	-0.27	-0.31	-0.35	-0.37	-0.22	-0.29	-0.32	-0.36	0.03	0.17	0.03	0.02	0	0	0.04	-0.04	-0.12	-0.08	-0.02	0.05	0.25	0.49	1										
log Cmult1996	0.01	0.1	-0.16	-0.27	-0.31	-0.35	-0.36	-0.22	-0.29	-0.33	-0.36	0.02	0.16	0.04	0.04	-0.02	-0.02	0.02	-0.05	-0.1	-0.09	-0.03	0.04	0.17	0.27	0.5	1									
log Cmult1997	-0.15	0.1	-0.14	-0.25	-0.28	-0.3	-0.3	-0.2	-0.26	-0.29	-0.3	0.02	0.11	0.01	-0.04	-0.02	-0.03	0.04	-0.03	-0.03	-0.07	0.01	-0.04	0.12	0.17	0.26	0.47	1								
log Cmult1998	-0.33	0.1	-0.15	-0.26	-0.3	-0.33	-0.34	-0.21	-0.28	-0.32	-0.34	0.06	0.18	0.02	-0.01	-0.01	-0.02	0.03	-0.03	-0.09	-0.08	-0.03	0	0.14	0.16	0.2	0.28	0.48	1							
log Cmult1999	-0.17	0.1	-0.15	-0.26	-0.3	-0.32	-0.32	-0.2	-0.28	-0.31	-0.33	0.09	0.27	0.04	0.08	-0.02	-0.03	-0.04	-0.03	-0.19	-0.07	-0.07	0.05	0.14	0.17	0.19	0.2	0.25	0.48	1						
log Cmult2000	-0.12	0.1	-0.15	-0.26	-0.29	-0.32	-0.32	-0.2	-0.28	-0.31	-0.32	0.07	0.22	0	-0.03	-0.01	-0.01	0.03	0	-0.17	-0.02	0.01	0.01	0.14	0.17	0.19	0.18	0.17	0.27	0.49	1					
log Cmult2001	0.2	0.1	-0.14	-0.24	-0.27	-0.29	-0.29	-0.19	-0.26	-0.28	-0.3	0.02	0.09	0	-0.03	-0.02	0.04	0.03	0	-0.11	-0.01	0.05	-0.05	0.13	0.16	0.18	0.17	0.15	0.17	0.24	0.47	1				
log Cmult2002	-0.19	0.1	-0.13	-0.22	-0.24	-0.25	-0.23	-0.18	-0.23	-0.25	-0.24	0.02	0.06	0.02	0.03	-0.01	-0.02	-0.03	-0.01	-0.1	-0.01	0.03	-0.03	0.12	0.15	0.16	0.15	0.14	0.14	0.16	0.24	0.46	1			
log Cmult2003	0.35	0.1	-0.15	-0.26	-0.29	-0.32	-0.33	-0.2	-0.27	-0.3	-0.32	0.04	0.15	0	-0.03	-0.01	-0.04	0.07	0	-0.15	0	0.02	-0.01	0.15	0.18	0.2	0.2	0.17	0.18	0.17	0.2	0.27	0.47	1		
log Cmult2004	0.05	0.1	-0.14	-0.23	-0.25	-0.27	-0.27	-0.18	-0.24	-0.26	-0.27	0.04	0.12	0	0	0	-0.02	0.03	0	-0.14	0	0.03	0.01	0.13	0.16	0.18	0.17	0.15	0.16	0.16	0.16	0.17	0.24	0.48	1	
log Cmult2005	-0.08	0.09	-0.09	-0.15	-0.16	-0.15	-0.13	-0.12	-0.15	-0.16	-0.15	0.01	0.06	0	0.03	-0.01	-0.06	0	0	-0.09	0.01	0.04	0.03	0.08	0.1	0.11	0.11	0.1	0.1	0.11	0.1	0.09	0.13	0.21	0.42	1

Table 4.8. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated fishing mortality at age.

Year/Age	1	2	3	4	5	6+	Fbar 2-4
1963	0.091	0.475	0.519	0.475	0.476	0.523	0.490
1964	0.100	0.506	0.565	0.514	0.511	0.557	0.528
1965	0.118	0.557	0.626	0.555	0.541	0.580	0.579
1966	0.124	0.572	0.636	0.551	0.538	0.581	0.587
1967	0.134	0.604	0.673	0.583	0.578	0.620	0.620
1968	0.147	0.641	0.710	0.616	0.608	0.642	0.656
1969	0.139	0.618	0.675	0.587	0.586	0.620	0.627
1970	0.163	0.673	0.716	0.607	0.596	0.618	0.665
1971	0.208	0.772	0.799	0.669	0.647	0.660	0.747
1972	0.245	0.844	0.853	0.712	0.688	0.699	0.803
1973	0.256	0.853	0.836	0.693	0.664	0.667	0.794
1974	0.256	0.836	0.795	0.658	0.640	0.646	0.763
1975	0.291	0.899	0.848	0.699	0.679	0.675	0.815
1976	0.333	0.970	0.904	0.726	0.703	0.690	0.867
1977	0.317	0.935	0.867	0.686	0.682	0.675	0.829
1978	0.350	0.998	0.960	0.764	0.759	0.736	0.907
1979	0.328	0.942	0.919	0.720	0.700	0.676	0.860
1980	0.360	1.001	1.001	0.787	0.745	0.714	0.930
1981	0.358	1.006	1.027	0.810	0.749	0.717	0.948
1982	0.393	1.085	1.143	0.915	0.834	0.791	1.047
1983	0.384	1.077	1.139	0.923	0.833	0.784	1.046
1984	0.350	1.015	1.066	0.882	0.798	0.753	0.988
1985	0.326	0.976	1.023	0.865	0.780	0.735	0.955
1986	0.334	1.001	1.071	0.932	0.834	0.781	1.001
1987	0.313	0.973	1.051	0.928	0.826	0.774	0.984
1988	0.314	0.983	1.079	0.952	0.838	0.777	1.005
1989	0.319	0.993	1.092	0.972	0.857	0.792	1.019
1990	0.291	0.939	1.021	0.906	0.792	0.729	0.955
1991	0.275	0.910	1.006	0.911	0.808	0.739	0.942
1992	0.263	0.890	1.002	0.916	0.808	0.724	0.936
1993	0.256	0.883	1.020	0.930	0.815	0.717	0.944
1994	0.252	0.880	1.049	0.945	0.825	0.714	0.958
1995	0.253	0.898	1.101	0.978	0.851	0.720	0.992
1996	0.233	0.865	1.107	1.000	0.899	0.755	0.991
1997	0.213	0.822	1.093	1.009	0.919	0.756	0.975
1998	0.211	0.820	1.128	1.056	0.959	0.769	1.001
1999	0.211	0.823	1.182	1.127	1.030	0.807	1.044
2000	0.203	0.806	1.175	1.139	1.038	0.789	1.040
2001	0.182	0.752	1.096	1.079	0.979	0.727	0.976
2002	0.168	0.708	1.037	1.028	0.931	0.680	0.924
2003	0.163	0.692	1.024	0.998	0.891	0.636	0.905
2004	0.156	0.665	0.984	0.928	0.834	0.586	0.859
2005	0.143	0.626	0.921	0.849	0.786	0.548	0.799
2006	0.131	0.588	0.850	0.768	0.732	0.506	0.735
2007	0.118	0.544	0.801	0.721	0.690	0.465	0.689
2008	0.108	0.512	0.769	0.692	0.678	0.455	0.658
2009	0.103	0.496	0.761	0.693	0.681	0.444	0.650
2010	0.086	0.439	0.676	0.619	0.608	0.390	0.578
2011	0.067	0.367	0.564	0.524	0.521	0.336	0.485
2012	0.059	0.339	0.522	0.490	0.481	0.303	0.450
2013	0.057	0.329	0.514	0.483	0.466	0.286	0.442
2014	0.056	0.328	0.520	0.486	0.463	0.278	0.445
2015	0.054	0.317	0.504	0.479	0.463	0.278	0.433
2016	0.052	0.310	0.492	0.467	0.443	0.259	0.423
2017	0.055	0.323	0.517	0.491	0.458	0.263	0.444

Table 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated population numbers at age (start of year; thousands). Note, the recruitment value in the final year relies on a single data point only and is therefore considered preliminary.

Year/Age	1	2	3	4	5	6+	Total
1963	398864	168866	19936	10174	8047	4833	610720
1964	651351	120414	51604	11436	5170	6615	846589
1965	874233	206125	40395	22841	6152	5196	1154942
1966	1062544	252429	67683	16295	9283	5817	1414051
1967	890549	308618	72905	28452	7974	7792	1316290
1968	448728	263604	90202	28739	14252	6712	852237
1969	392556	127531	72084	33914	11280	9573	646938
1970	1321591	118706	38833	32100	15237	7971	1534438
1971	1734814	383929	33669	14944	16009	10157	2193522
1972	428894	479050	91128	12162	5974	12439	1029648
1973	635387	108827	106046	29993	4956	6829	892039
1974	631387	163635	23634	36351	10909	5358	871274
1975	1085420	157698	36863	9688	16372	6883	1312924
1976	752472	272031	34086	13702	3798	9531	1085620
1977	1832441	165820	51107	10786	5102	5918	2071174
1978	1121065	429170	30906	18831	5658	4448	1610078
1979	1400592	258282	80933	8893	7314	3366	1759379
1980	2261414	301022	59356	24553	3969	4506	2654820
1981	876555	482131	59290	17612	8746	3479	1447815
1982	1439757	182360	93919	17021	6584	5451	1745093
1983	800367	309568	33575	21257	5393	4342	1174503
1984	1481585	173319	52453	7963	6720	3703	1725742
1985	358913	328892	33230	14688	2751	4050	742524
1986	1625467	84325	58506	10151	5600	2883	1786933
1987	617457	384232	16688	15418	2985	3253	1040033
1988	426224	150481	71721	5278	4913	2271	660889
1989	745534	105605	30757	17344	1826	2861	903927
1990	295322	180489	20509	7862	5075	1609	510866
1991	339399	74565	30847	5992	2675	2882	456361
1992	792194	89639	15099	8783	2018	1979	909710
1993	394504	199790	18117	4976	2806	1520	621714
1994	955384	106267	36637	5438	1698	1645	1107068
1995	547278	248827	23766	10229	1774	1258	833132
1996	351284	140239	40775	5613	3319	1367	542597
1997	1089999	99755	26756	9504	1842	1628	1229484
1998	111936	302507	21852	7001	3025	1201	447523
1999	229672	32730	55172	5431	2033	1519	326557
2000	422524	66183	8561	9715	1472	1026	509482
2001	154024	126211	14307	2163	2238	711	299654
2002	233307	48149	25822	3828	587	916	312609
2003	115009	67079	11002	7139	1069	510	201809
2004	196468	37230	14436	3025	1981	556	253695
2005	154259	54466	8388	3366	992	1018	222490
2006	359929	47899	13076	2205	1096	901	425105
2007	168870	103686	10501	4170	971	775	288973
2008	190204	47819	24769	3180	1617	954	268542
2009	183318	54094	11737	7602	1387	1092	259230
2010	274919	54491	13421	3902	3165	1020	350918
2011	132904	77941	13614	4194	1675	2028	232355
2012	179434	39821	20252	5816	1860	1753	248935
2013	226194	50375	11318	8497	2804	1690	300878
2014	317568	63714	15629	4928	4048	2115	408003
2015	155316	91419	20260	6286	2330	3616	279227
2016	109912	41176	26396	9948	3178	2661	193272
2017	385593	27889	12759	11047	5242	2963	445493
2018	97383	97546	8246	5254	4867	4581	217878

Table 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated total removals at age (including catches due to unaccounted mortality; thousands).

Year/Age	1	2	3	4	5	6+
1963	21145	48287	7337	3517	2786	1800
1964	37913	36234	20274	4199	1891	2584
1965	59508	66889	17114	8894	2350	2092
1966	75744	83629	29024	6313	3534	2346
1967	68630	106602	32548	11506	3204	3297
1968	37648	95122	41829	12108	5947	2912
1969	31357	44792	32255	13780	4577	4048
1970	122551	44429	18112	13375	6263	3364
1971	200906	158538	16924	6684	6989	4498
1972	57704	210452	47817	5681	2723	5733
1973	89211	48151	54896	13753	2205	3047
1974	88541	71443	11839	16065	4721	2335
1975	169723	72394	19249	4468	7397	3095
1976	131858	131410	18519	6487	1758	4354
1977	306032	78309	27007	4910	2313	2663
1978	203116	211540	17398	9234	2761	2126
1979	238585	122669	44310	4186	3376	1516
1980	416861	148495	34208	12281	1913	2108
1981	160636	238379	34664	8978	4229	1633
1982	285927	94287	58327	9386	3423	2735
1983	155960	159090	20798	11790	2802	2167
1984	267986	85768	31267	4292	3393	1799
1985	61328	158597	19321	7819	1368	1934
1986	285560	41275	34912	5664	2911	1435
1987	103023	184373	9842	8580	1542	1609
1988	71836	72549	42917	2984	2561	1126
1989	127937	51109	18517	9927	966	1437
1990	46920	84025	11865	4308	2549	764
1991	51445	33905	17678	3297	1362	1382
1992	115686	40055	8625	4848	1027	935
1993	56318	88538	10445	2773	1436	713
1994	134792	46856	21435	3060	876	770
1995	77636	110802	14270	5878	934	592
1996	46266	60660	24471	3269	1810	665
1997	132350	41465	15879	5566	1019	792
1998	13494	124895	13146	4211	1718	591
1999	27702	13468	33904	3389	1205	773
2000	49141	26648	5216	6097	877	514
2001	16225	48023	8335	1317	1287	337
2002	22640	17372	14498	2266	327	414
2003	10810	23590	6102	4154	580	220
2004	17569	12611	7794	1683	1030	226
2005	12648	17494	4340	1770	496	393
2006	27038	14565	6425	1085	522	327
2007	11410	29579	4969	1965	443	263
2008	11747	12972	11438	1456	729	319
2009	10793	14299	5399	3486	627	357
2010	13544	13037	5700	1649	1319	301
2011	5059	16073	5066	1564	622	527
2012	6085	7681	7119	2058	649	418
2013	7273	9491	3940	2973	954	383
2014	10071	11998	5494	1734	1371	468
2015	4649	16764	6956	2185	789	799
2016	3143	7408	8897	3389	1039	552
2017	11702	5204	4469	3915	1758	623

Table 4.11a. Cod in Subarea 4, Division 7.d and Subdivision 20: 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 (TSB), 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 (tonnes)	Low	High	SSB (tonnes)	Low	High	Total removals (tonnes)	Low	High	Fbar 2-4	Low	High
1963	398864	289535	549476	464479	400776	538308	145056	114396	183934	118283	105076	133150	0.490	0.425	0.564
1964	651351	473524	895960	592619	508131	691155	157003	126165	195380	144210	131222	158484	0.528	0.465	0.601
1965	874233	637821	1198275	755618	653431	873787	192537	159332	232663	198155	177354	221395	0.579	0.511	0.657
1966	1062544	776067	1454771	905502	783949	1045901	213818	177765	257183	241231	216431	268873	0.587	0.520	0.662
1967	890549	650148	1219843	960932	840954	1098026	242898	202125	291894	286540	256729	319813	0.620	0.552	0.697
1968	448728	326969	615830	822668	736341	919116	255832	219047	298795	292477	266354	321163	0.656	0.583	0.738
1969	392556	284087	542441	681777	606480	766423	251522	213202	296728	225762	209300	243518	0.627	0.558	0.703
1970	1321591	962787	1814110	1067026	887916	1282266	261751	222799	307513	251899	221727	286176	0.665	0.596	0.743
1971	1734814	1258515	2391374	1205198	1021173	1422386	266191	226760	312478	350021	301095	406896	0.747	0.671	0.831
1972	428894	310617	592209	866122	768026	976747	237657	202254	279256	361880	317511	412450	0.803	0.721	0.894
1973	635387	460324	877028	693095	616576	779109	210703	185078	239875	259740	237046	284607	0.794	0.714	0.883
1974	631387	456634	873017	664154	588541	749481	225799	197922	257601	236937	211905	264926	0.763	0.686	0.849
1975	1085420	778290	1513751	747924	638274	876410	203488	176897	234076	247633	215654	284354	0.815	0.735	0.904
1976	752472	535390	1057572	604276	531257	687330	173152	148538	201844	247660	215240	284964	0.867	0.780	0.963
1977	1832441	1312566	2558226	903226	736279	1108028	146146	125714	169898	265383	217407	323947	0.829	0.747	0.920
1978	1121065	799291	1572378	1023448	855660	1224137	145892	129326	164581	356798	294383	432447	0.907	0.820	1.005
1979	1400592	1002243	1957266	957860	817614	1122163	145125	129715	162367	343305	293624	401391	0.860	0.778	0.952
1980	2261414	1609560	3177261	1149350	954507	1383966	158705	142629	176594	396357	327783	479276	0.930	0.843	1.025
1981	876555	625986	1227423	967040	838880	1114779	167149	151389	184549	399527	340931	468195	0.948	0.862	1.043
1982	1439757	1038977	1995138	1022740	859649	1216772	167389	150999	185559	384530	326278	453183	1.047	0.953	1.151
1983	800367	587331	1090675	815439	702431	946629	136979	123166	152341	325602	277335	382269	1.046	0.953	1.149
1984	1481585	1088119	2017329	833290	699088	993254	119012	106746	132688	283415	239632	335198	0.988	0.900	1.084
1985	358913	260702	494121	563672	497728	638354	117385	105134	131064	246901	213427	285625	0.955	0.869	1.049
1986	1625467	1197681	2206050	747370	613463	910506	108388	98046	119821	231527	192859	277948	1.001	0.914	1.098
1987	617457	456733	834739	704717	605923	819619	110237	99353	122313	262723	221467	311663	0.984	0.897	1.079
1988	426224	314860	576976	521073	456941	594205	110178	100818	120407	208250	184782	234698	1.005	0.917	1.101
1989	745534	548269	1013774	522512	441533	618343	101541	92366	111628	181081	155525	210836	1.019	0.928	1.118
1990	295322	218878	398465	357378	314380	406257	89913	81318	99416	140509	122752	160834	0.955	0.867	1.052
1991	339399	252176	456792	326378	283865	375258	88668	79517	98872	119036	105670	134093	0.942	0.853	1.041
1992	792194	588326	1066706	506750	416502	616553	85350	76304	95469	142253	119507	169329	0.936	0.841	1.041
1993	394504	295530	526625	397362	336036	469881	88375	75168	103903	147650	121299	179726	0.944	0.842	1.059
1994	955384	703812	1296879	506688	412073	623027	95545	80601	113260	151874	122456	188359	0.958	0.853	1.076
1995	547278	406514	736786	542476	448534	656094	110842	93376	131576	186984	149943	233174	0.992	0.883	1.116
1996	351284	262552	470004	411570	346486	488880	110348	93005	130925	153148	125348	187115	0.991	0.881	1.114
1997	1089999	795354	1493796	619309	490147	782508	99750	84553	117677	152485	120812	192463	0.975	0.869	1.093
1998	111936	82845	151243	319881	267389	382678	96772	81382	115072	134538	108631	166623	1.001	0.893	1.122
1999	229672	172285	306175	216366	183004	255810	82354	68841	98519	90641	74679	110014	1.044	0.930	1.172
2000	422524	317091	563014	271333	223384	329575	64321	54088	76489	78775	63890	97127	1.040	0.926	1.168
2001	154024	115180	205968	190857	161570	225452	61256	51786	72457	67840	55803	82473	0.976	0.869	1.095
2002	233307	175304	310502	163064	137357	193581	55558	46982	65700	53310	44178	64329	0.924	0.820	1.042
2003	115009	85932	153924	137246	117070	160899	56871	48072	67281	50427	41613	61106	0.905	0.801	1.021
2004	196468	149532	258136	120054	102114	141146	45670	38670	53936	36644	30406	44163	0.859	0.759	0.972
2005	154259	115848	205407	137277	118081	159594	48389	41744	56091	37840	31698	45172	0.799	0.702	0.909
2006	359929	275636	469998	146969	123544	174837	44507	39031	50752	31598	28097	35535	0.735	0.656	0.823
2007	168870	129567	220096	196233	172669	223012	76643	67842	86586	52945	46426	60379	0.689	0.612	0.775
2008	190204	145843	248057	203026	177835	231786	83653	74197	94314	52075	47510	57079	0.658	0.580	0.746
2009	183318	140233	239642	211742	185324	241925	89933	78842	102583	54216	49192	59753	0.650	0.569	0.743
2010	274919	209519	360733	221730	190344	258290	88828	75989	103836	48475	44203	53159	0.578	0.498	0.670
2011	132904	101506	174013	204854	176089	238319	96198	79729	116068	44569	40406	49161	0.485	0.412	0.571
2012	179434	137538	234092	177916	152215	207957	93960	76751	115029	40172	37311	43253	0.450	0.380	0.534
2013	226194	173181	295435	226431	192797	265933	99494	81167	121960	41713	38488	45209	0.442	0.375	0.521
2014	317568	242921	415153	279942	237238	330333	105714	86598	129050	45878	41936	50190	0.445	0.380	0.520
2015	155316	118799	203058	250908	214820	293057	119893	97172	147926	51334	46785	56326	0.433	0.371	0.506
2016	109912	82134	147083	218892	187046	256160	119699	97197	147411	51137	47714	54805	0.423	0.359	0.498
2017	385593	259272	573460	242908	197274	299098	113502	90267	142718	46702	43382	50276	0.444	0.373	0.528
2018	97383	40347	235049				118387	90333	155154						

Table 4.11b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated landings, discards, catch (=landings + discards) and total removals in tons. 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	107430	10847	118283		118283
1964	134769	9449	144210		144210
1965	181361	16807	198155		198155
1966	215189	26091	241231		241231
1967	260373	26136	286540		286540
1968	275773	16681	292477		292477
1969	216360	9424	225762		225762
1970	232054	19859	251899		251899
1971	292020	58017	350021		350021
1972	327803	34046	361880		361880
1973	234526	25206	259740		259740
1974	209859	27104	236937		236937
1975	209922	37671	247633		247633
1976	202162	45542	247660		247660
1977	183453	82031	265383		265383
1978	307773	48985	356798		356798
1979	278783	64566	343305		343305
1980	291866	104684	396357		396357
1981	345144	54320	399527		399527
1982	321748	62777	384530		384530
1983	288183	37468	325602		325602
1984	212301	71033	283415		283415
1985	217803	29104	246901		246901
1986	170475	61119	231527		231527
1987	229202	33415	262723		262723
1988	193235	14945	208250		208250
1989	139531	41591	181081		181081
1990	116636	23863	140509		140509
1991	102857	16145	119036		119036
1992	109586	32620	142253		142253
1993	131155	28888	160067	0.92	147650
1994	106816	43321	150152	1.01	151874
1995	131086	31863	162904	1.15	186984
1996	131082	21009	152119	1.01	153148
1997	132921	45101	177989	0.86	152485
1998	145364	41167	186600	0.72	134538
1999	94675	12943	107600	0.84	90641
2000	72967	16092	89053	0.88	78775
2001	44424	11364	55809	1.22	67840
2002	53283	11192	64473	0.83	53310
2003	31050	4611	35670	1.41	50427
2004	27272	7481	34754	1.05	36644
2005	29829	11339	41163	0.92	37840
2006	22506	9090	31598		31598
2007	23937	29014	52945		52945
2008	26944	25136	52075		52075
2009	32995	21216	54216		54216
2010	36089	12390	48475		48475
2011	34227	10349	44569		44569
2012	32571	7602	40172		40172
2013	30884	10838	41713		41713
2014	34886	10993	45878		45878
2015	38139	13199	51334		51334
2016	38589	12544	51137		51137
2017	37629	9079	46702		46702

Table 4.11c. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated catch multipliers, together with the lower and upper bounds of the point–wise 95% confidence intervals.

Year	Catch multiplier	Low	High
1993	0.92	0.77	1.10
1994	1.01	0.83	1.23
1995	1.15	0.94	1.40
1996	1.01	0.82	1.23
1997	0.86	0.71	1.04
1998	0.72	0.59	0.88
1999	0.84	0.69	1.03
2000	0.88	0.72	1.08
2001	1.22	1.00	1.48
2002	0.83	0.68	1.00
2003	1.41	1.16	1.73
2004	1.05	0.87	1.28
2005	0.92	0.77	1.09

Table 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios based on the SAM assessment. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2018)	0.449
SSB(2019)	116380
R(2018)	99387
R(2019)	186761
Catch(2018)	49278
Landings(2018)	37649
Discards(2018)	11629

Catch scenarios

Basis	Total catch (2019)	Wanted catch (2019)	Unwanted catch (2019)	F_{total} (2019)	F_{wanted} (2019)	$F_{unwanted}$ (2019)	SSB (2020)	%SSB change	% TAC change	% advice change
MSY approach	28204	22331	5873	0.24	0.170	0.070	141896	22	-47	-47
EU-Norway MP	42307	33357	8950	0.38	0.27	0.111	126249	8.5	-20	-20
EU-Norway old RPs	42307	33357	8950	0.38	0.27	0.111	126249	8.5	-20	-20
F=0	0	0	0	0.00	0.00	0.00	173375	49	-100	-100
F_{pa}	43081	33947	9134	0.39	0.28	0.113	125436	7.8	-18.5	-18.8
F_{lim}	56130	44231	11899	0.54	0.38	0.157	111247	-4.4	6.1	5.8
SSB(2020)=B_{lim}	60232	47418	12814	0.59	0.42	0.172	107000	-8.1	13.9	13.5
SSB(2020)=B_{pa}	20989	16647	4342	0.174	0.123	0.051	150000	29	-60	-60
SSB(2020)=$B_{trigger}$	20989	16647	4342	0.174	0.123	0.051	150000	29	-60	-60
TAC(2018)-20%	42307	33357	8950	0.38	0.27	0.111	126249	8.5	-20	-20
TAC(2018)-15%	44951	35414	9537	0.41	0.29	0.119	123296	5.9	-15.0	-15.3
TAC(2018)-10%	47596	37493	10103	0.44	0.31	0.127	120469	3.5	-10.0	-10.3
TAC(2018)-5%	50240	39556	10684	0.47	0.33	0.137	117588	1.04	-5.0	-5.3
Constant TAC	52884	41655	11229	0.50	0.36	0.146	114646	-1.49	0.00	-0.33
TAC(2018)+5%	55528	43760	11768	0.53	0.38	0.155	111869	-3.9	5.0	4.7
TAC(2018)+10%	58172	45801	12371	0.56	0.40	0.164	109085	-6.3	10.0	9.6
TAC(2018)+15%	60817	47895	12922	0.60	0.42	0.174	106397	-8.6	15.0	14.6
TAC(2018)+20%	63460	49989	13471	0.63	0.45	0.185	103620	-11.0	20.0	19.6
F=F(2018)	48422	38138	10284	0.45	0.32	0.131	119592	2.8	-8.4	-8.7
F=F_{lower}	23669	18765	4904	0.198	0.140	0.058	147011	26	-55	-55
F_{MSY}	35358	27950	7408	0.31	0.22	0.090	133964	15.1	-33	-33
F=F_{upper}	49414	38911	10503	0.46	0.33	0.134	118465	1.79	-6.6	-6.9

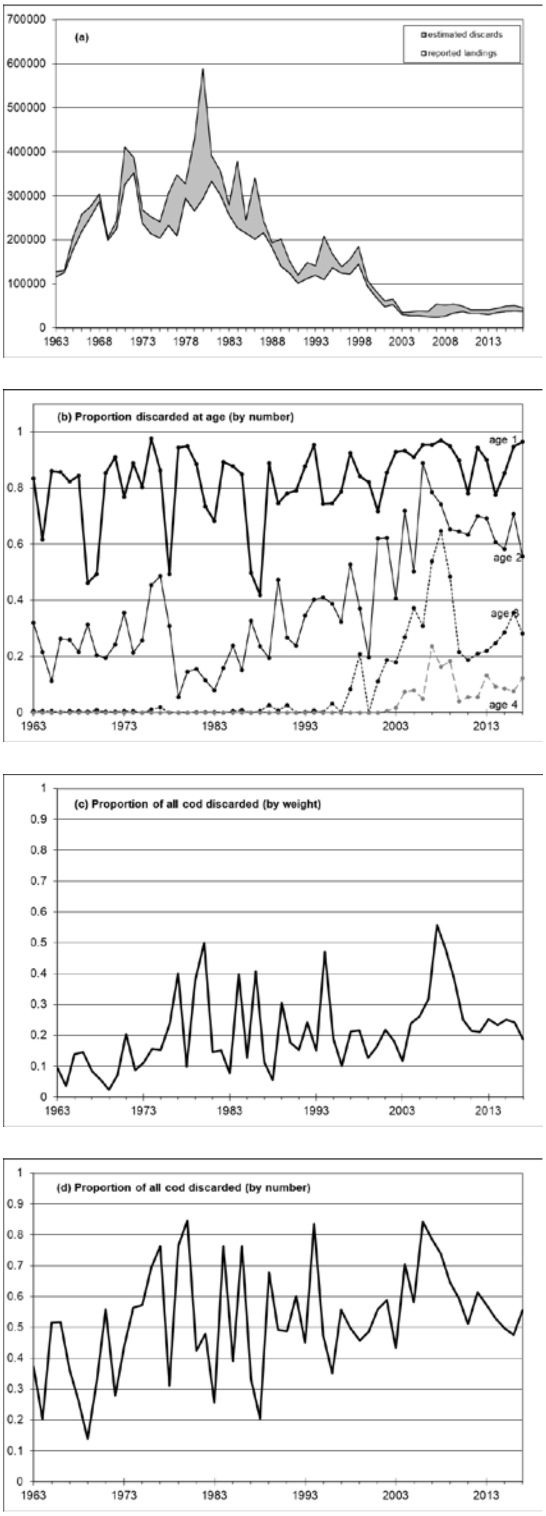


Figure 4.1. Cod in Subarea 4, Division 7.d and Subdivision 20: (a) stacked area plot of reported landings and estimated discards (including BMS landings; in tonnes); (b) proportion of total numbers caught at age that are discarded; (c) proportion of total weight caught that is discarded; (d) and proportion of the total numbers caught that are discarded.

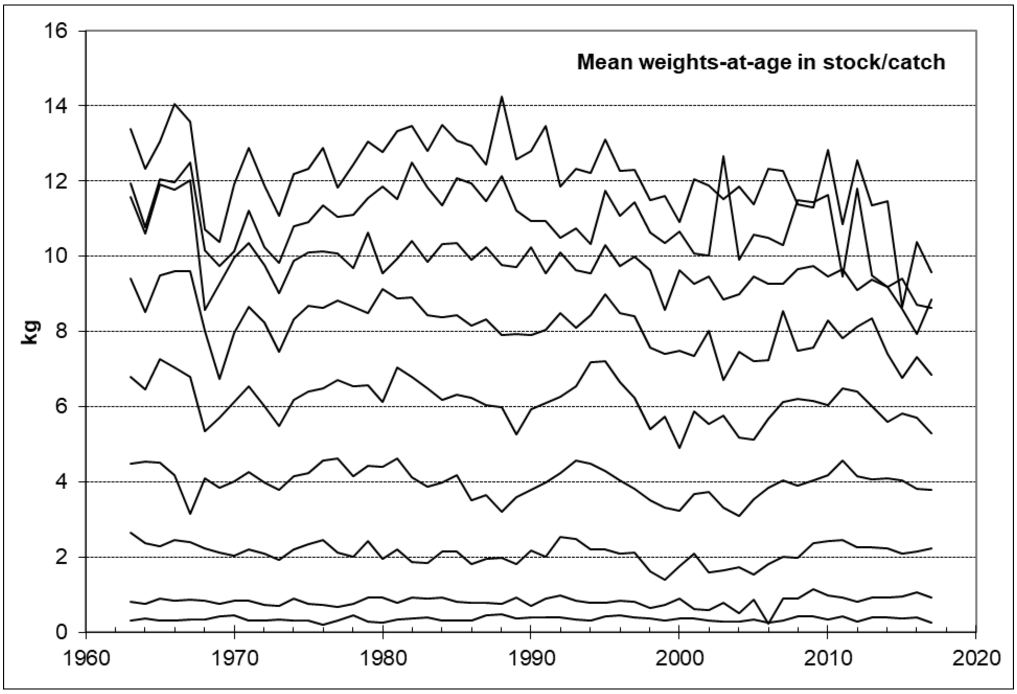


Figure 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weight at age in the catch for ages 1–9.

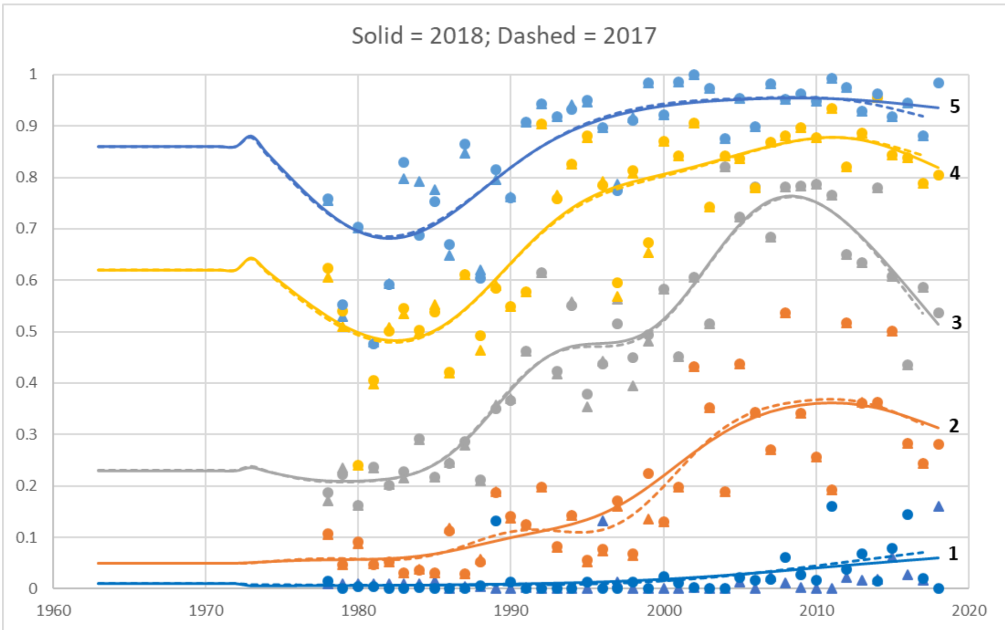


Figure 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Annually varying maturity-at-age used in the assessment compared to that used in 2017. Values for 1963–1972 are the former constant maturity values used for cod.

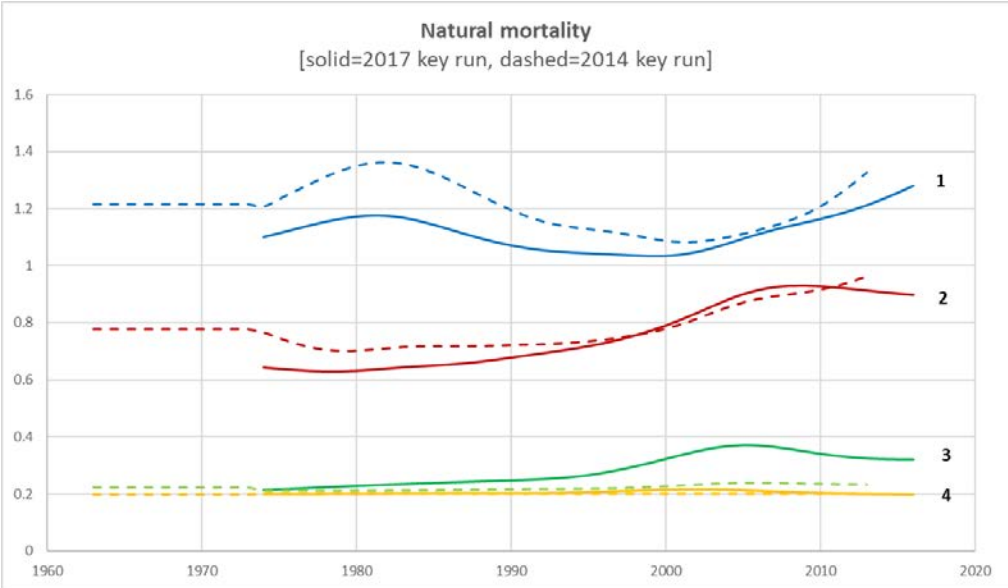


Figure 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2017 key run (ICES WGSAM 2017) compared to the smoothed annually varying natural mortality from the 2013 key run (ICES WGSAM 2013). Values for 1963–1972 are set equal to the 1973 value, while 2017 is set equal to 2016.

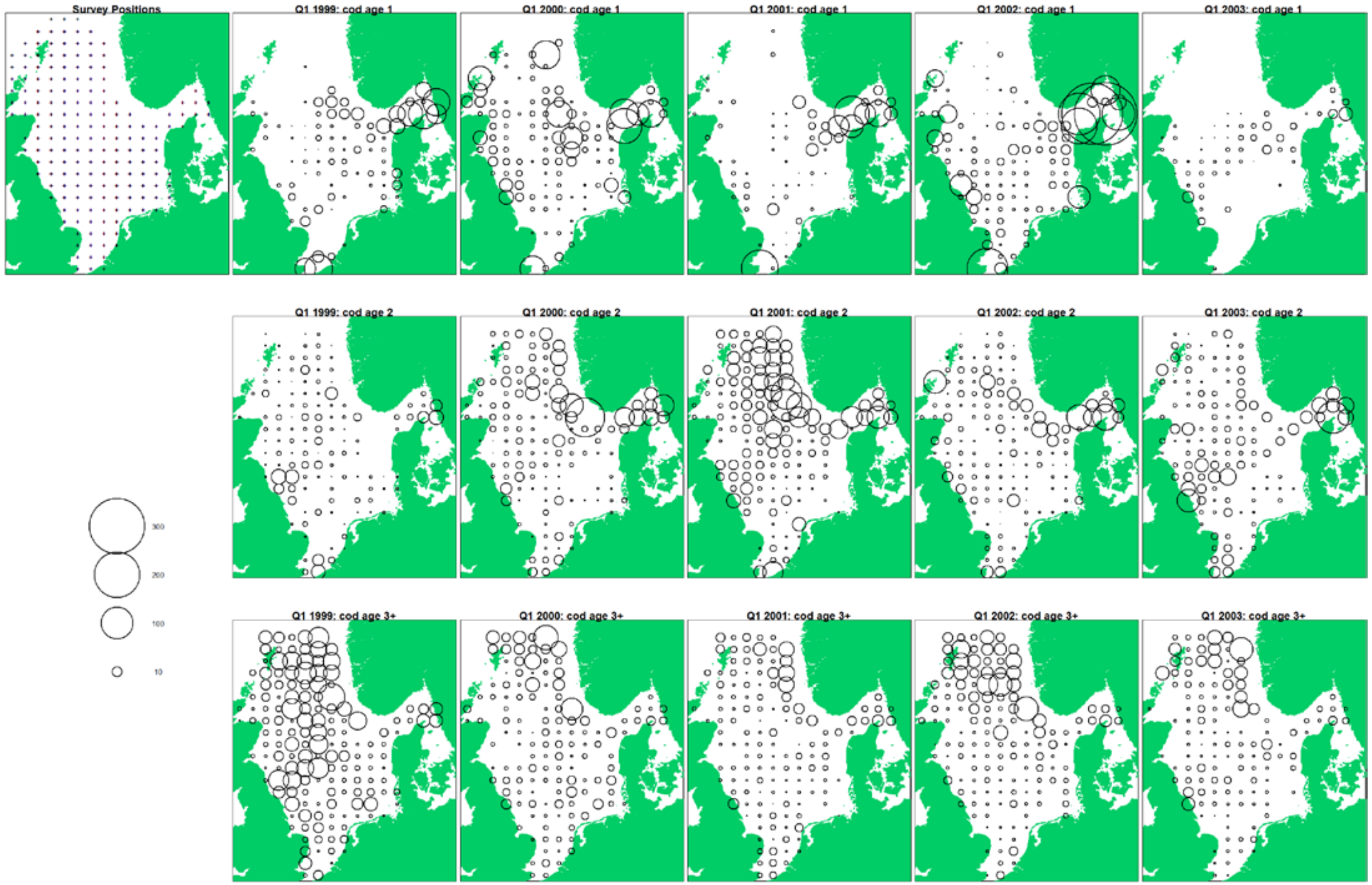


Figure 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1999–2018 in the North Sea.

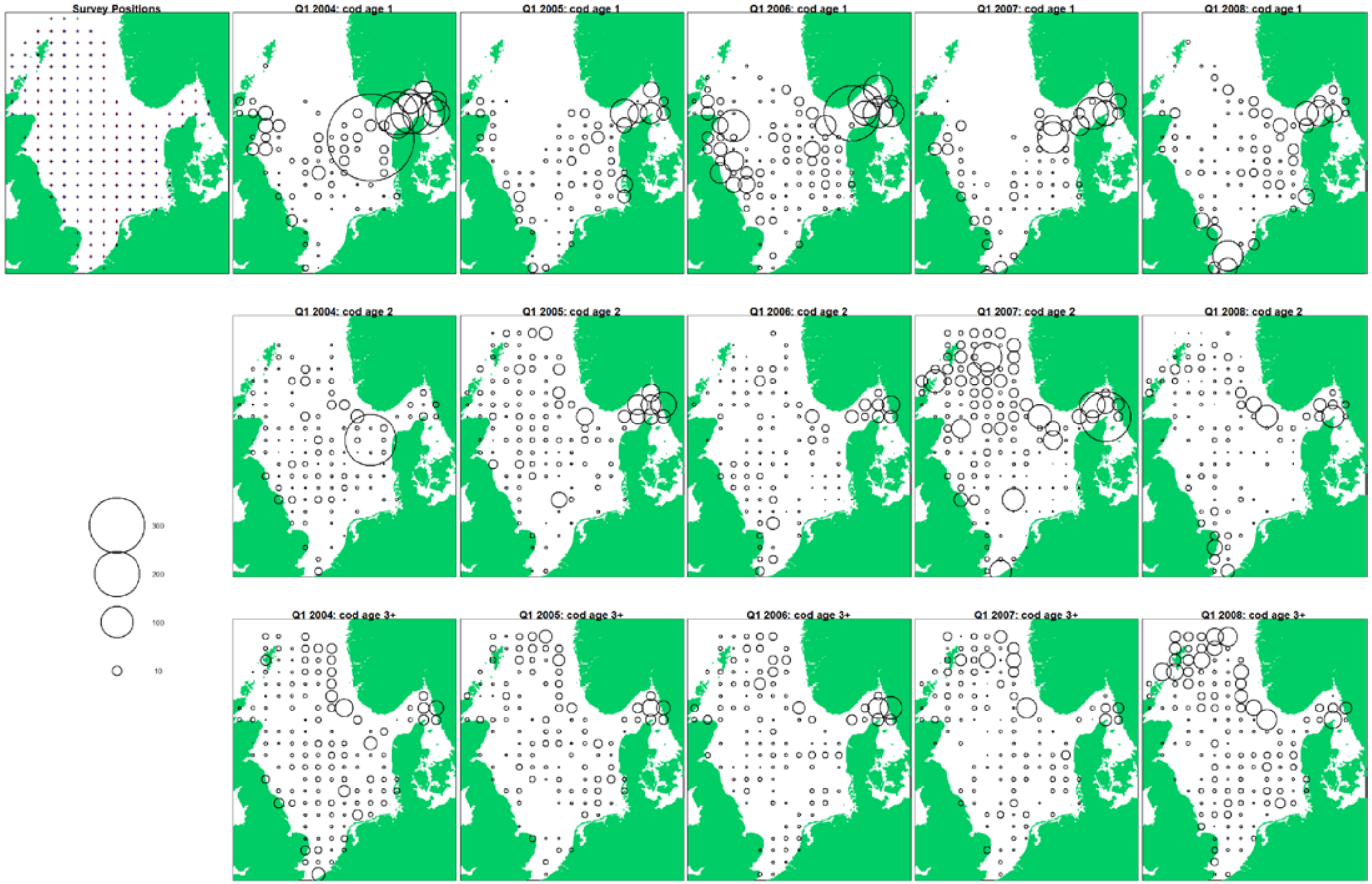


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1999–2018 in the North Sea.

Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1999–2018 in the North Sea.

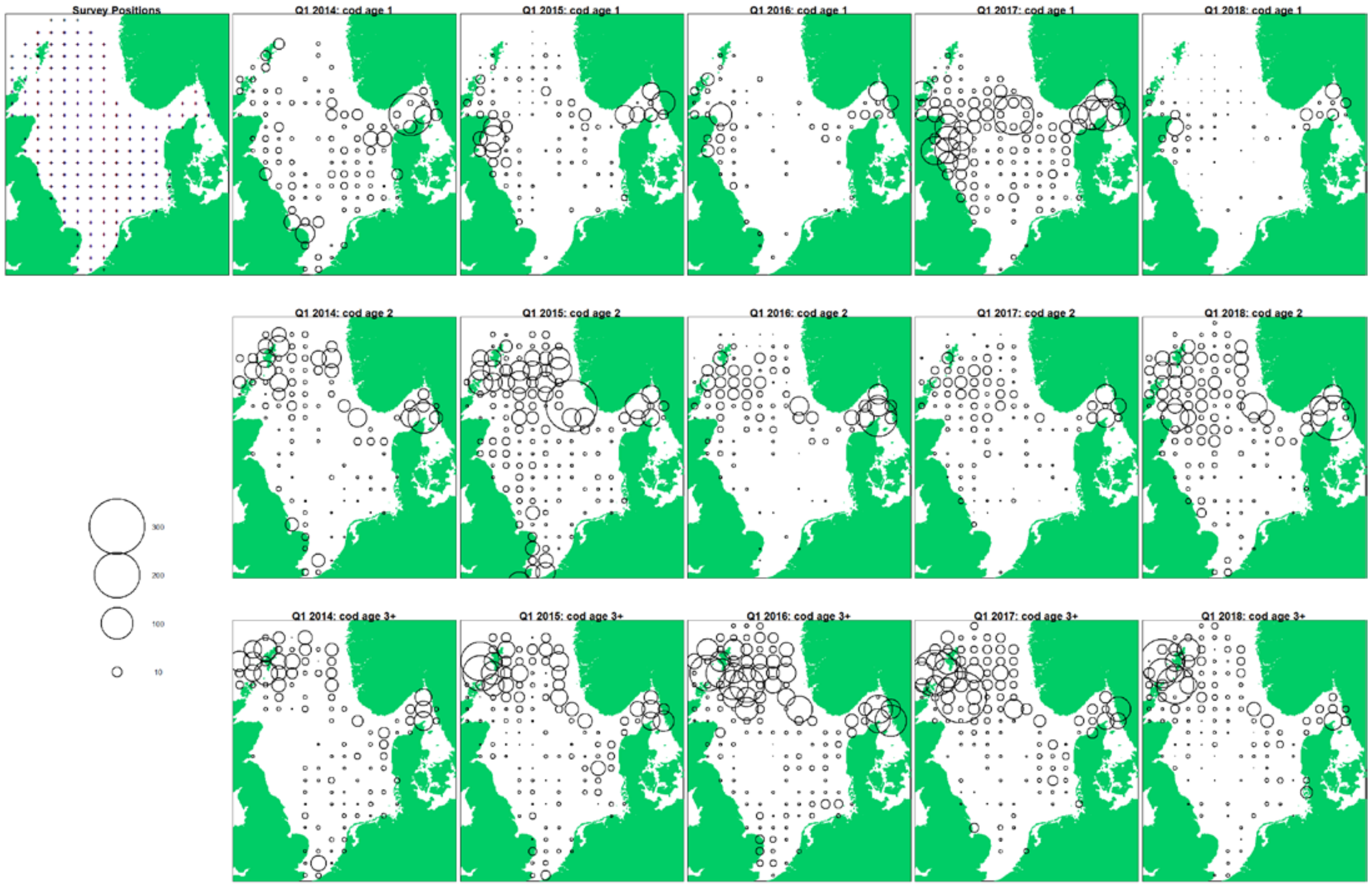


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1999–2018 in the North Sea.

Figure 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1999–2017 in the North Sea.

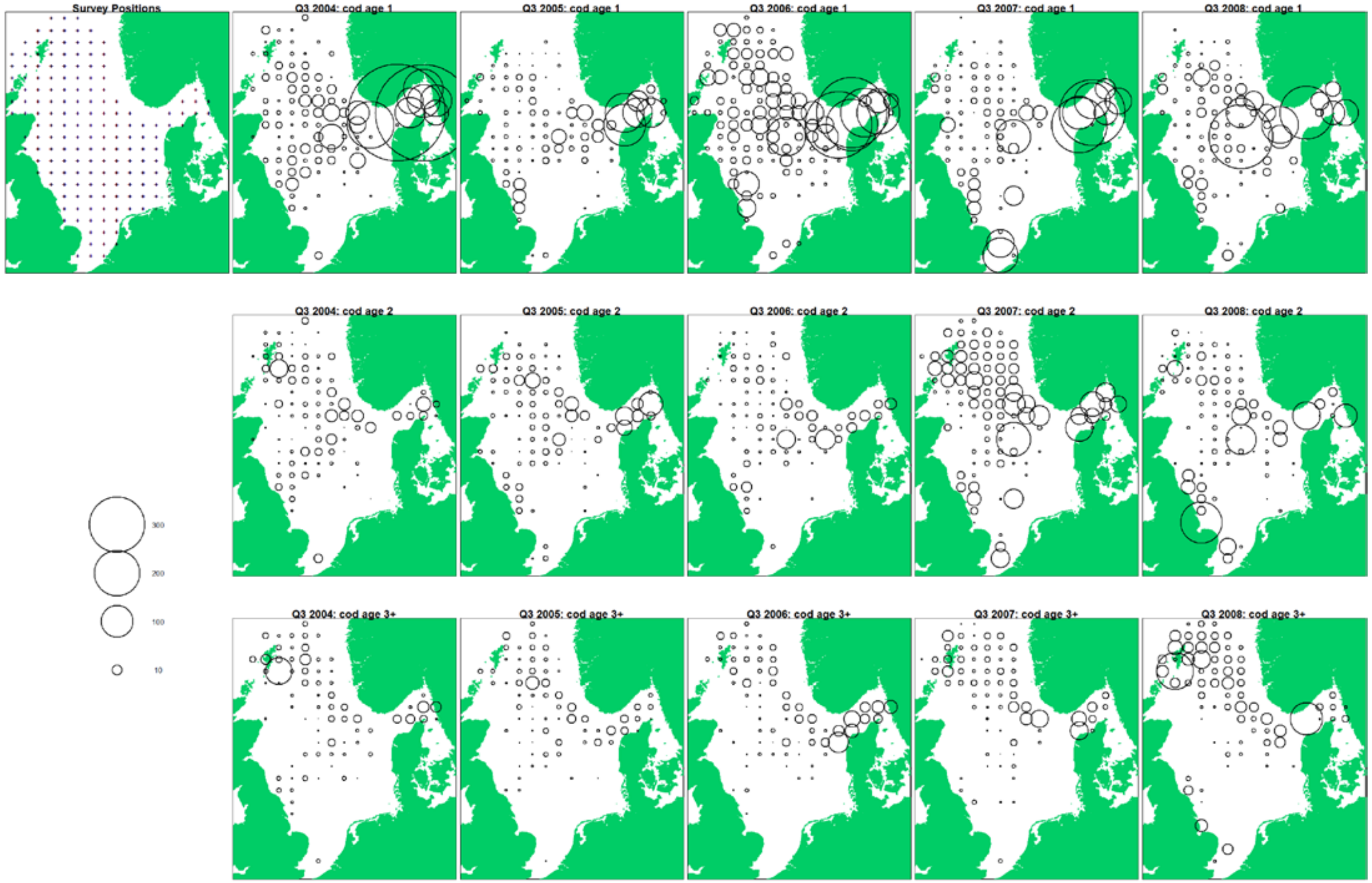


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1999–2017 in the North Sea.

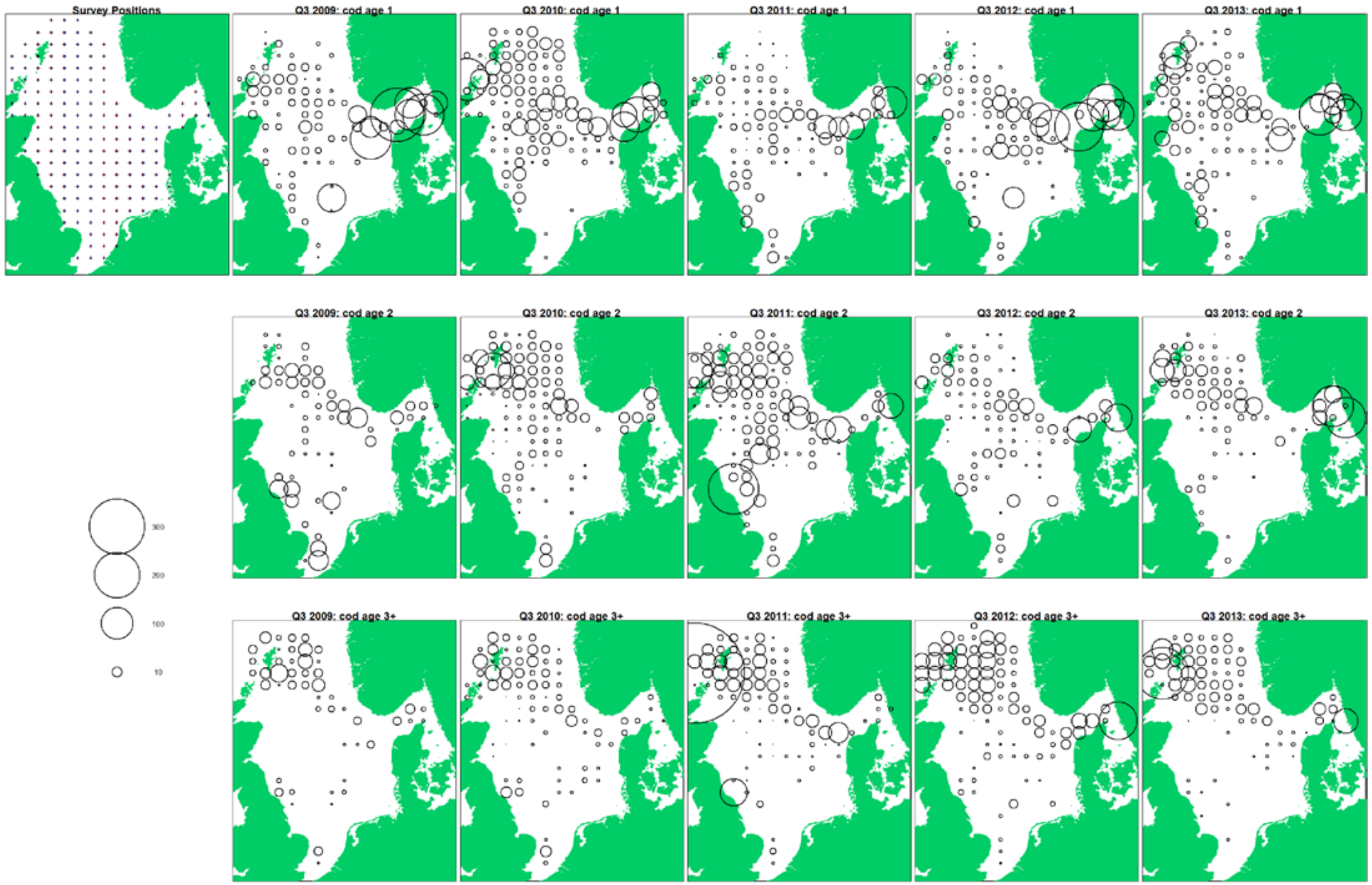


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1999–2017 in the North Sea.

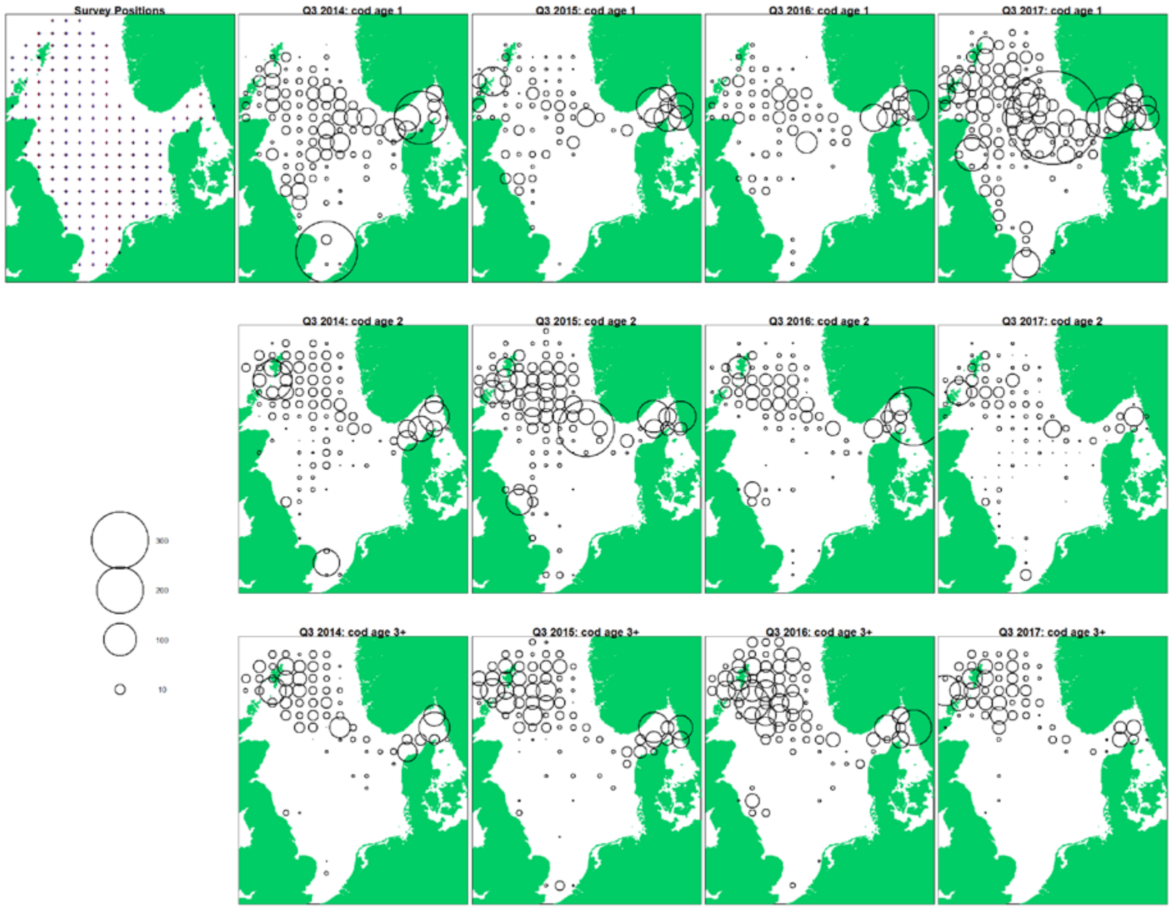


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1999–2017 in the North Sea.

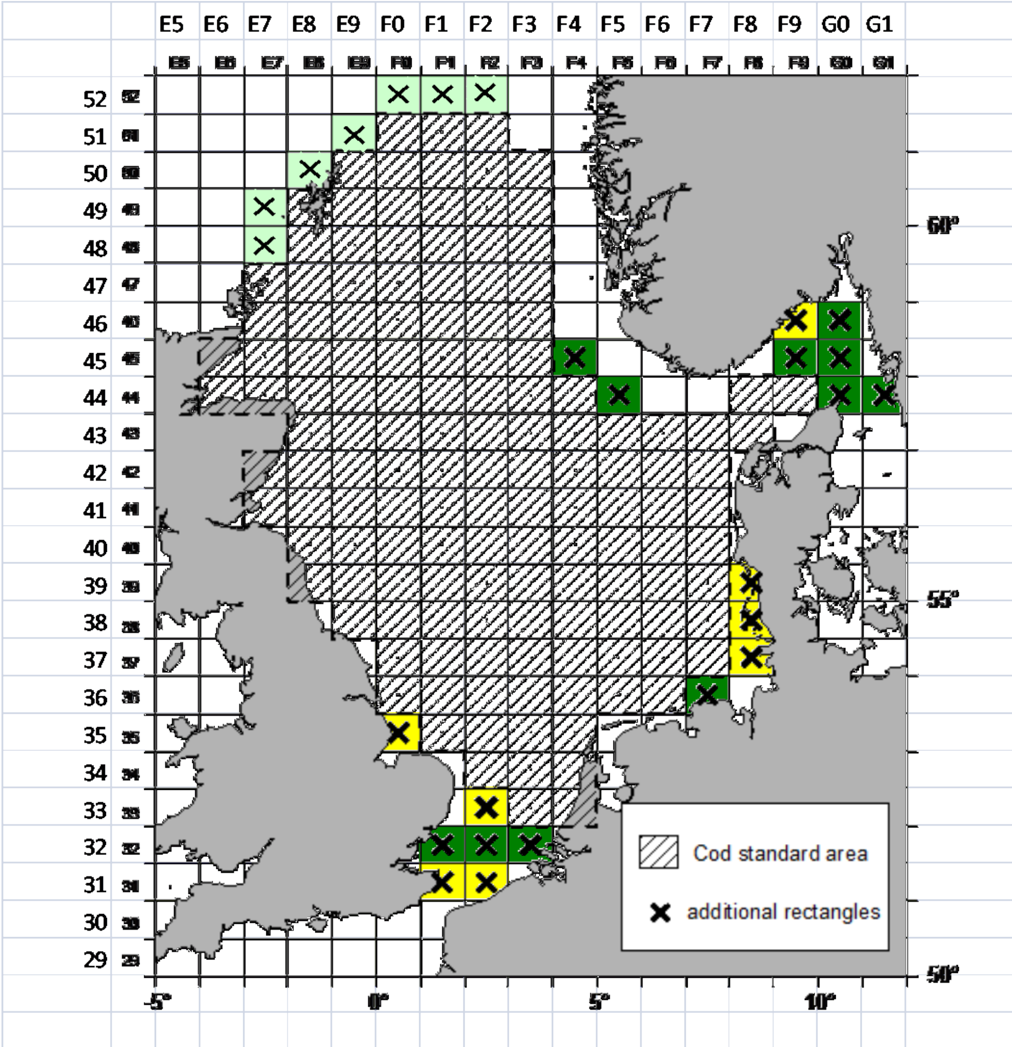


Figure 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND 2009; ICES WKCOD 2011); green squares (light and dark) indicate where the IBTS group indicate data is available; 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).

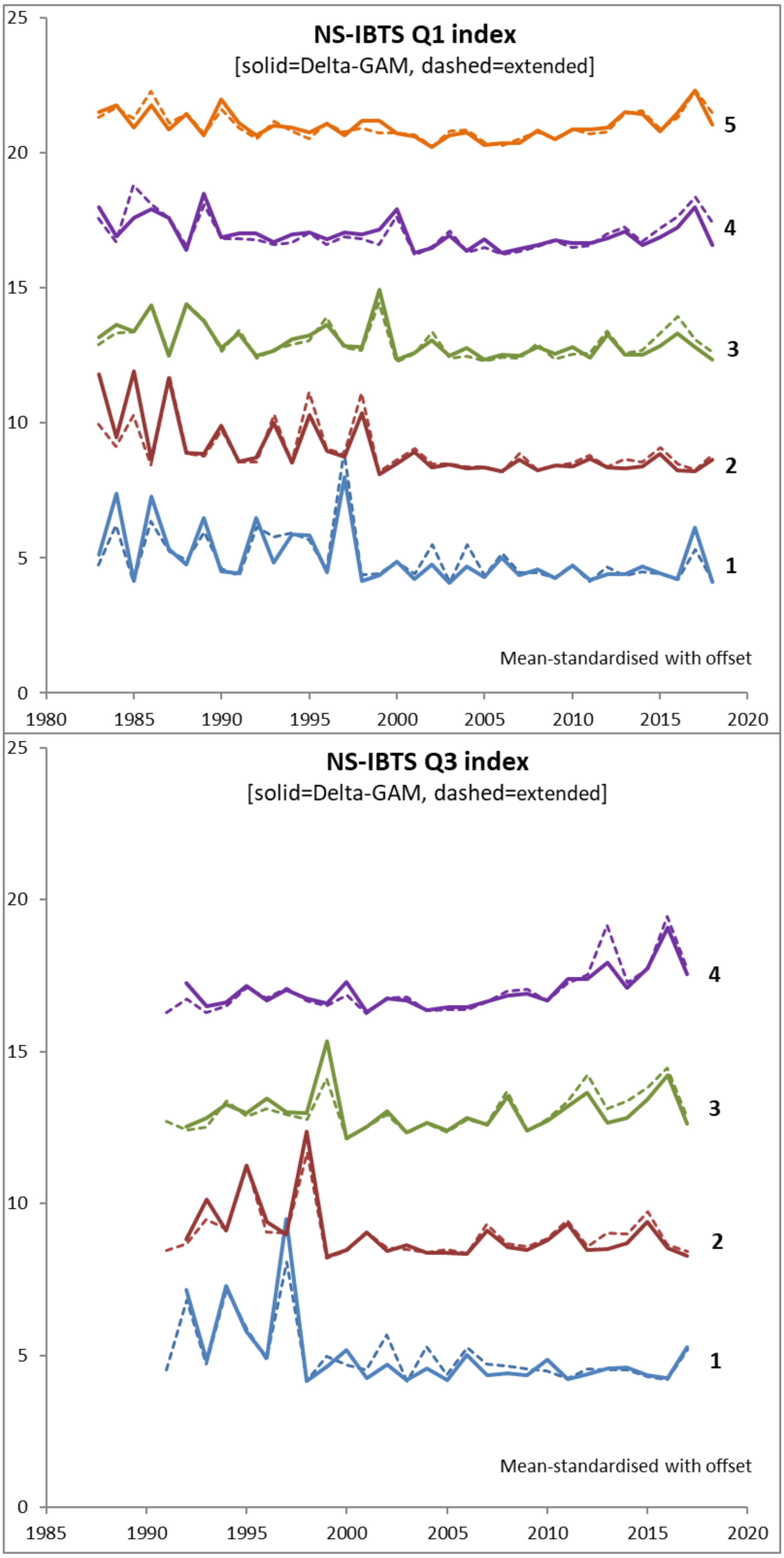


Figure 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS extended indices to the corresponding NS–IBTS Delta–GAM indices used in the assessment. The indices are mean-standardised with an offset for ease of presentation.

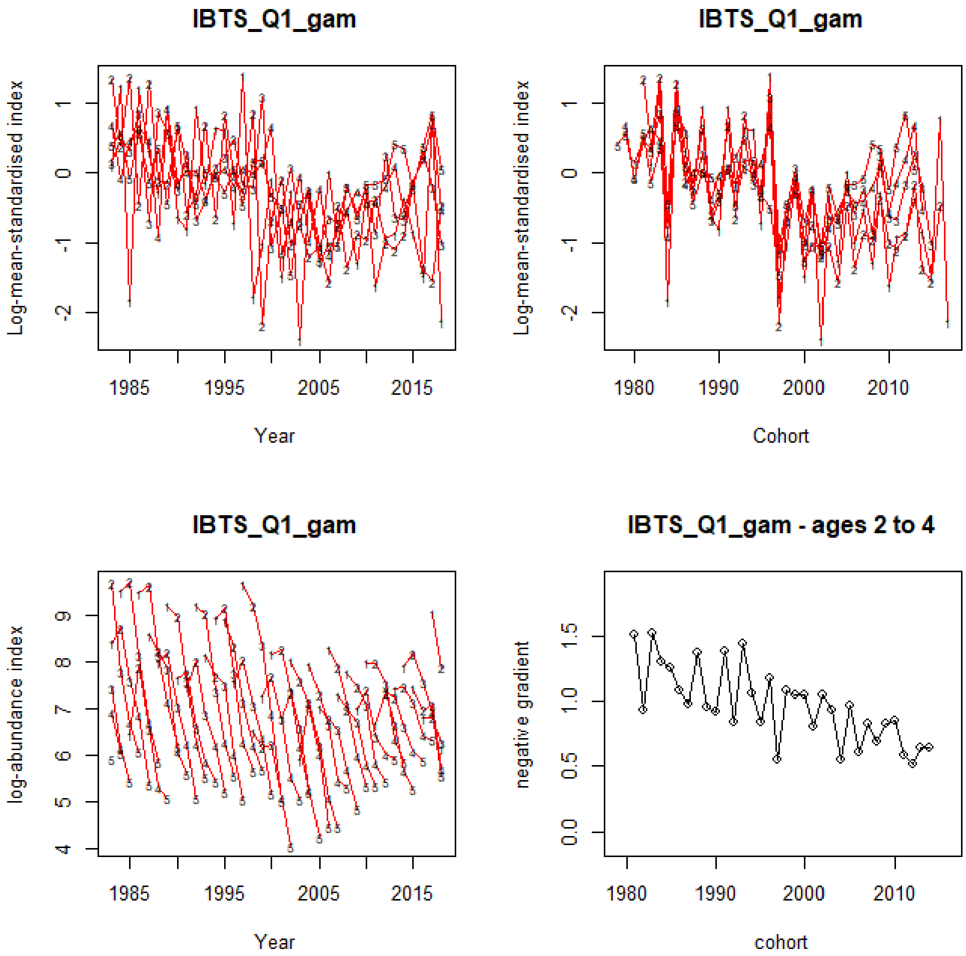


Figure 4.4a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta–GAM index).

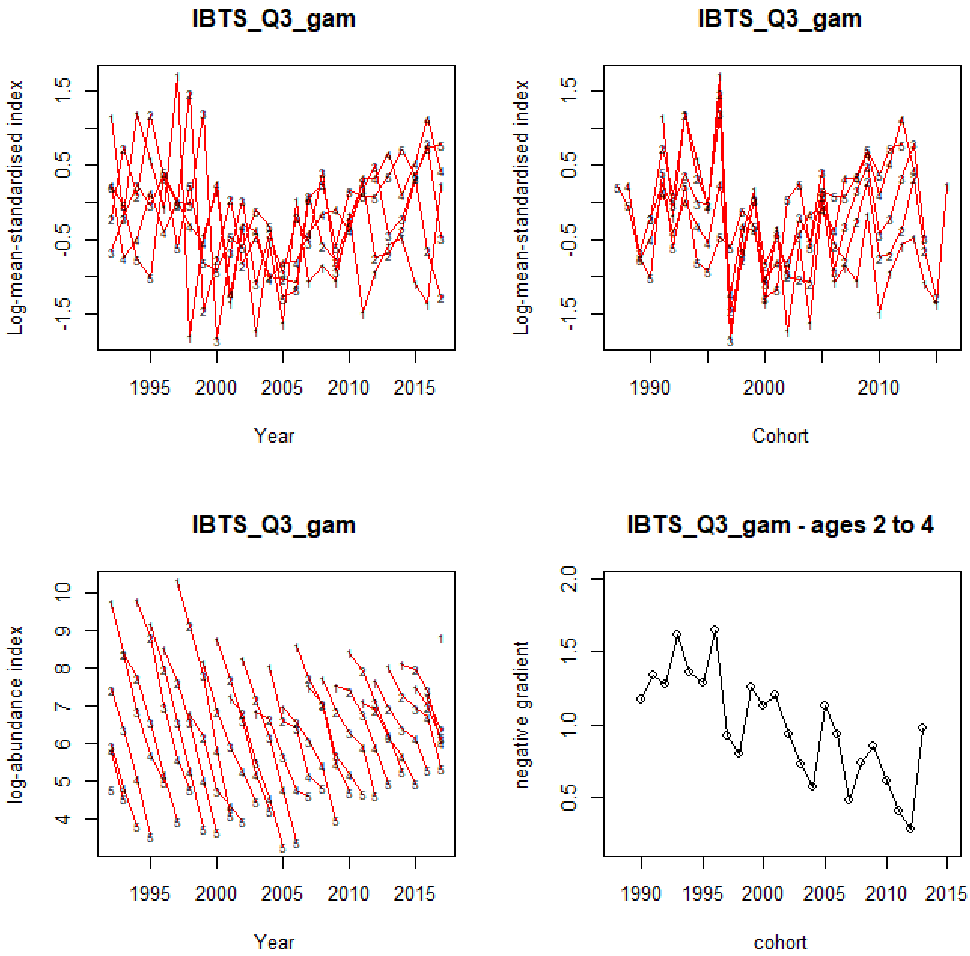


Figure 4.4b. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

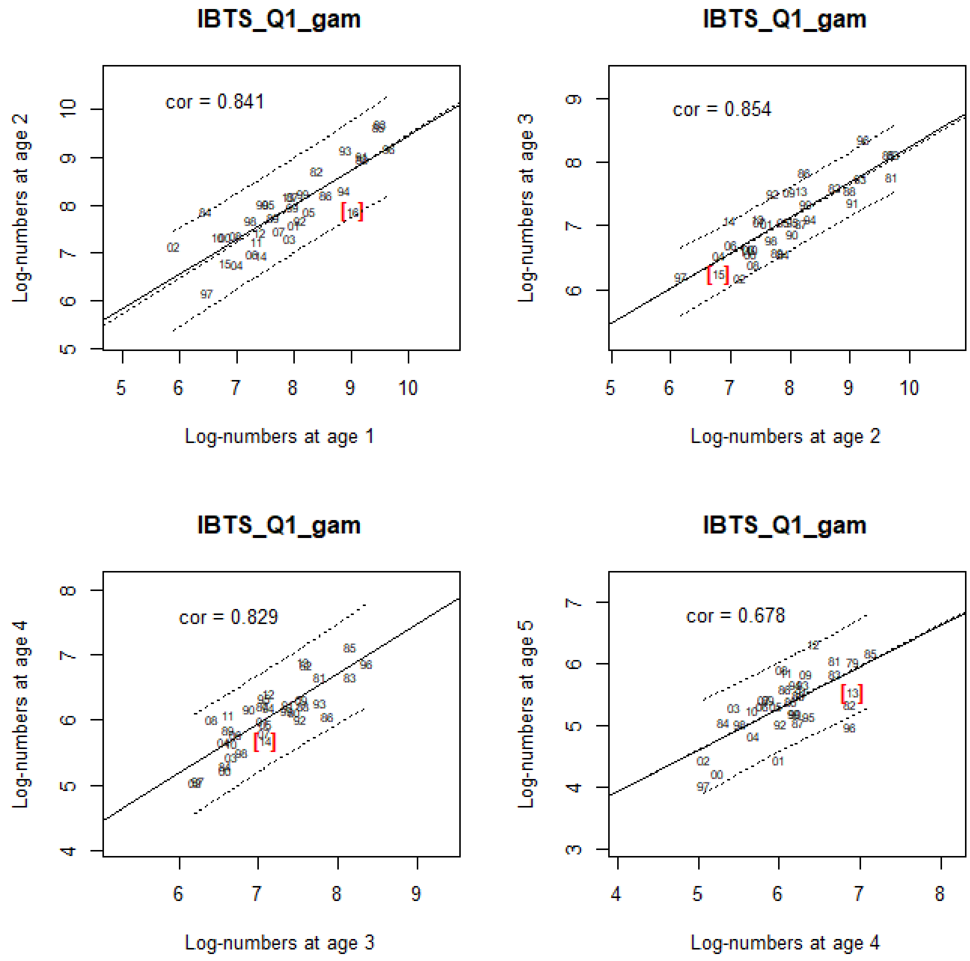


Figure 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2018. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear 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 red square brackets.

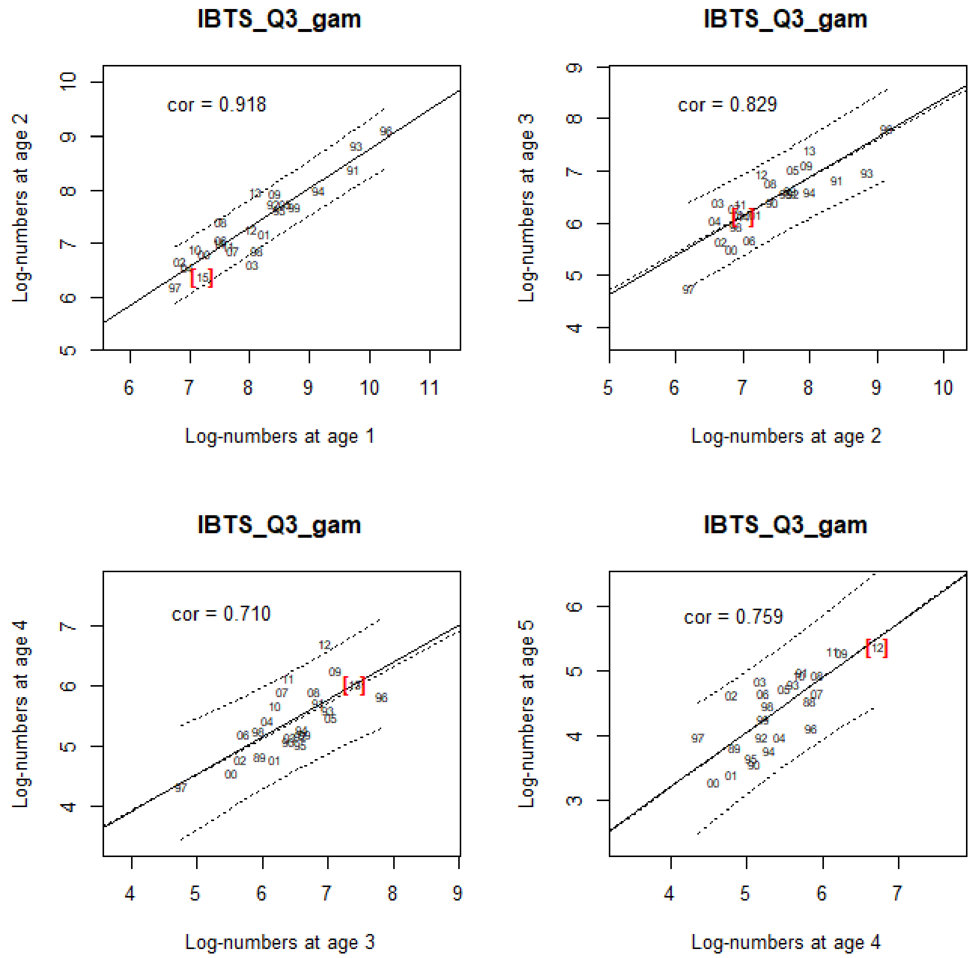


Figure 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2017. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear 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 red square brackets.

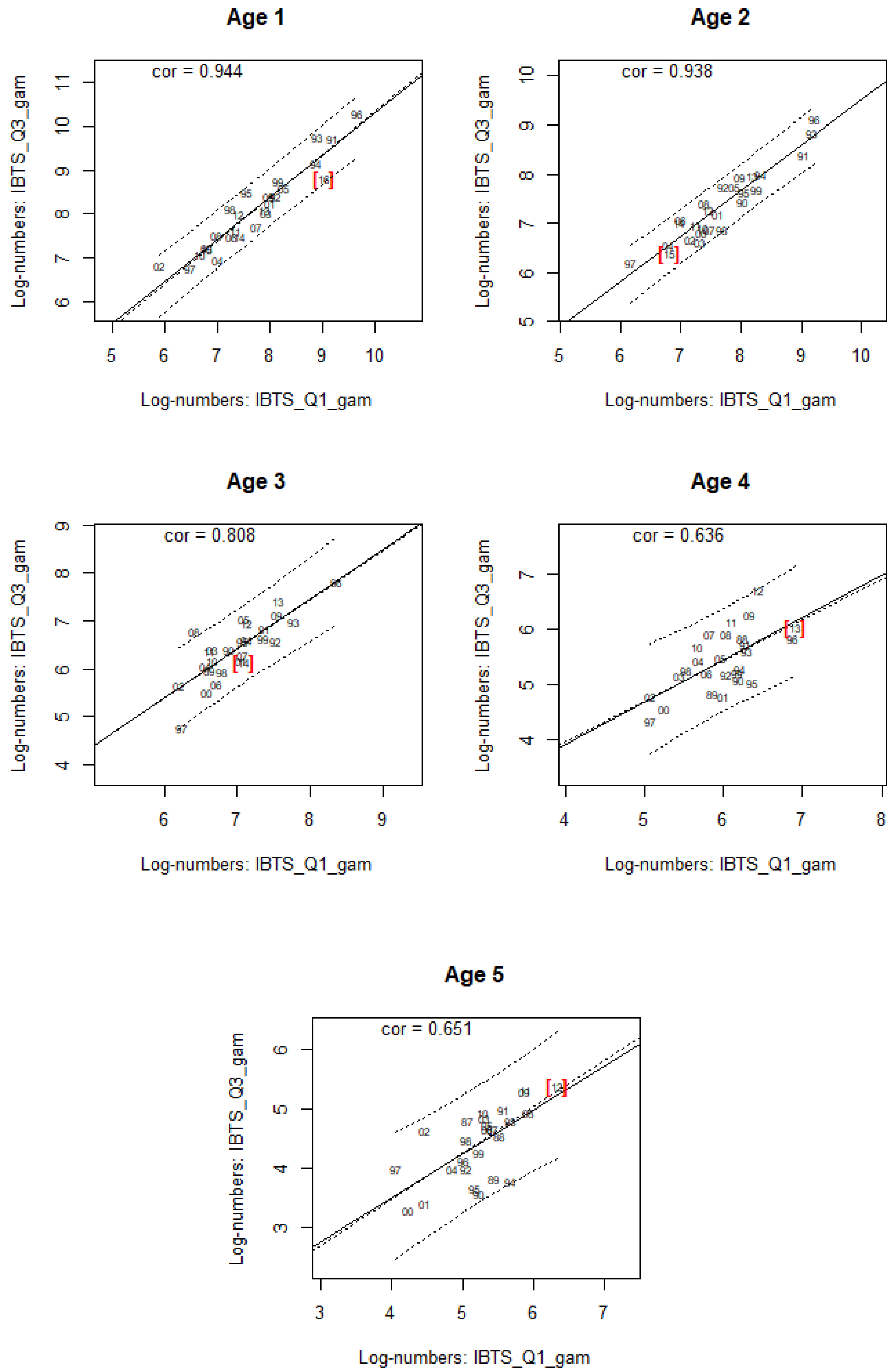


Figure 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2017. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest 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 red square brackets.

IBTS_Q1_gam											
1	1639.642	1408.649	772.9369	554.9358	370.6594	100.0117	2013	-0.02133	0.276335	0.431428	0.201845
1	2681.552	1722.186	745.5346	286.2303	348.6567	112.4163	2014	-0.1247	0.141136	0.22787	0.166624
1	1680.237	3573.473	1244.354	441.1619	195.0257	149.3608	2015	0.195333	0.269971	0.305818	0.09279
1	898.2148	1071.611	1919.198	615.3549	356.2936	136.7957	2016	-0.00113	-0.04847	0.283291	0.040314
1	8451.967	900.5503	1198.135	999.6061	560.8047	144.7514	2017	0.503848	0.235213	0.605805	0.589225
1	469.4061	2649.171	523.9565	296.9619	257.3971	215.7639	2018				
IBTS_Q3_gam											
1	3000.331	1047.069	484.8688	517.4426	139.2545	64.5158	2013	0.315946	0.243841	0.213998	
1	3278.757	1449.518	597.2191	296.2281	198.1247	95.9446	2014	0.050422	0.139423	0.113222	
1	1780.396	2919.356	1051.48	460.1626	140.1952	137.5579	2015	0.208037	0.24504	0.104137	
1	1352.184	1102.757	1660.532	827.3022	202.1454	131.9875	2016	0.359122	0.3763	0.603886	
1	6691.091	591.4438	463.6385	413.3914	213.4707	46.1505	2017				

Figure 4.5d. Cod in Subarea 4, Division 7.d and Subdivision 20: Survey tuning indices from 2013 for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices), highlighting the stronger 2013 year-class. Total mortality is calculated along cohorts as $\ln(I_{a,y}/I_{a+1,y+1})$ where I is the index value, the first subscript indicates age and the second subscript year.

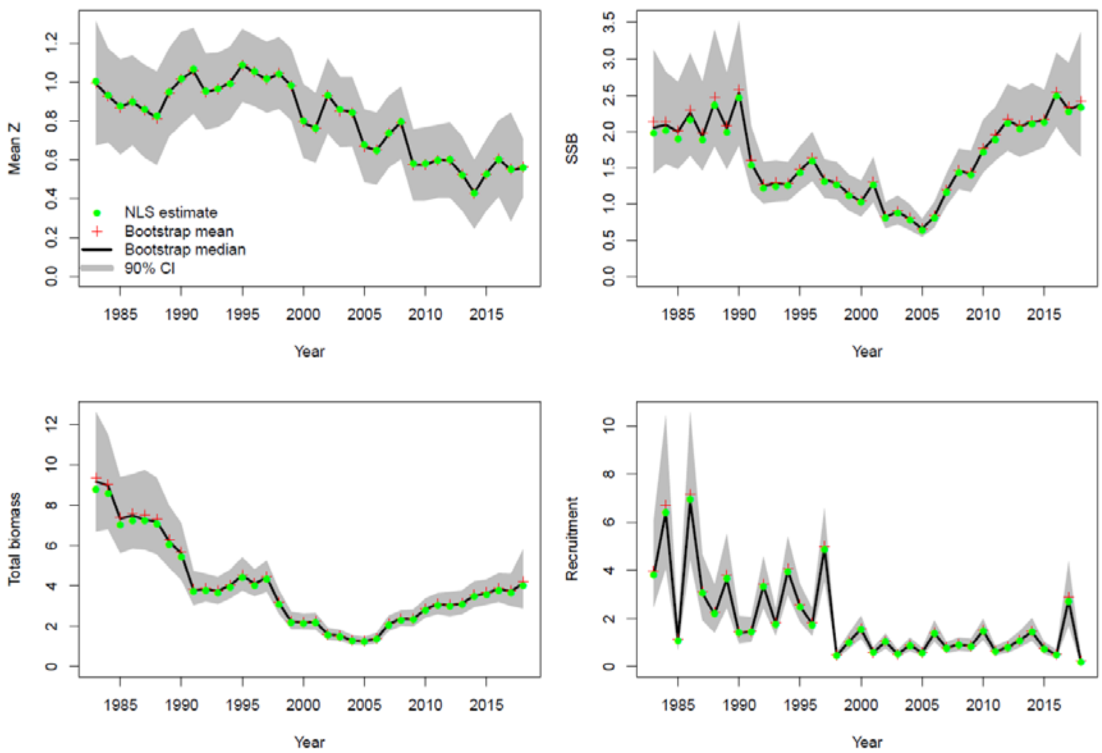


Figure 4.6. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (IBTS–Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3. The shaded area represents 90% confidence bounds.

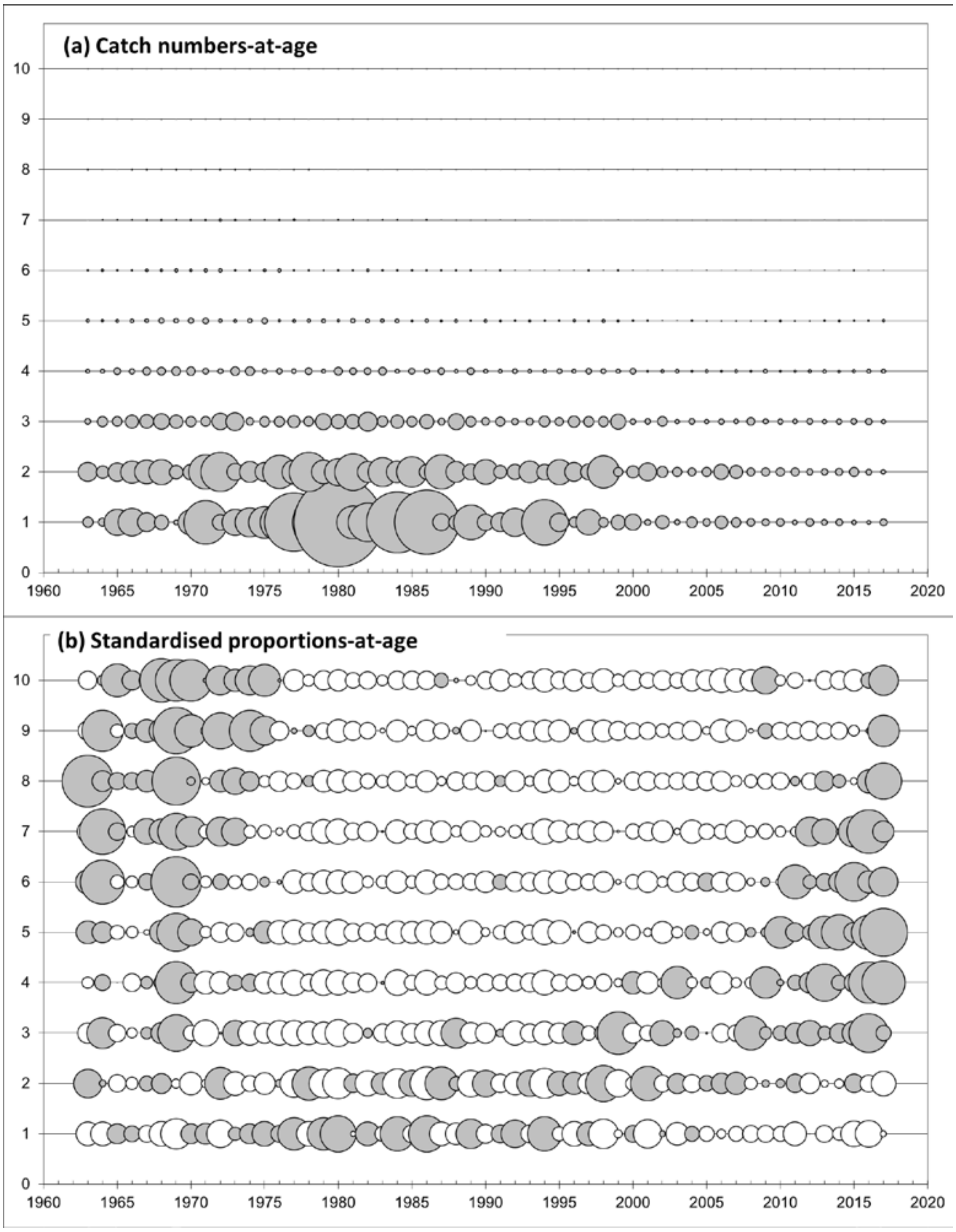


Figure 4.7. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

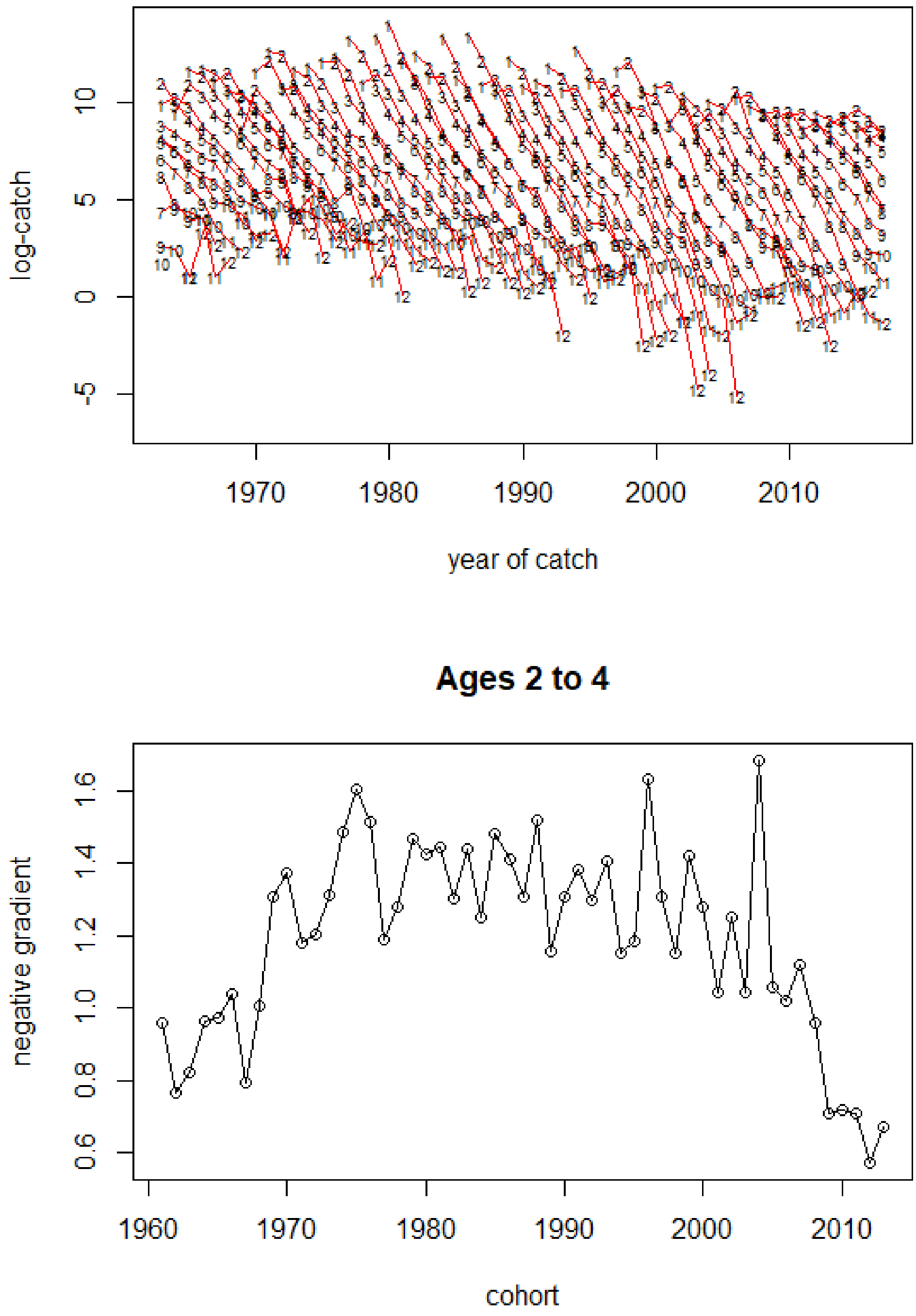


Figure 4.8a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

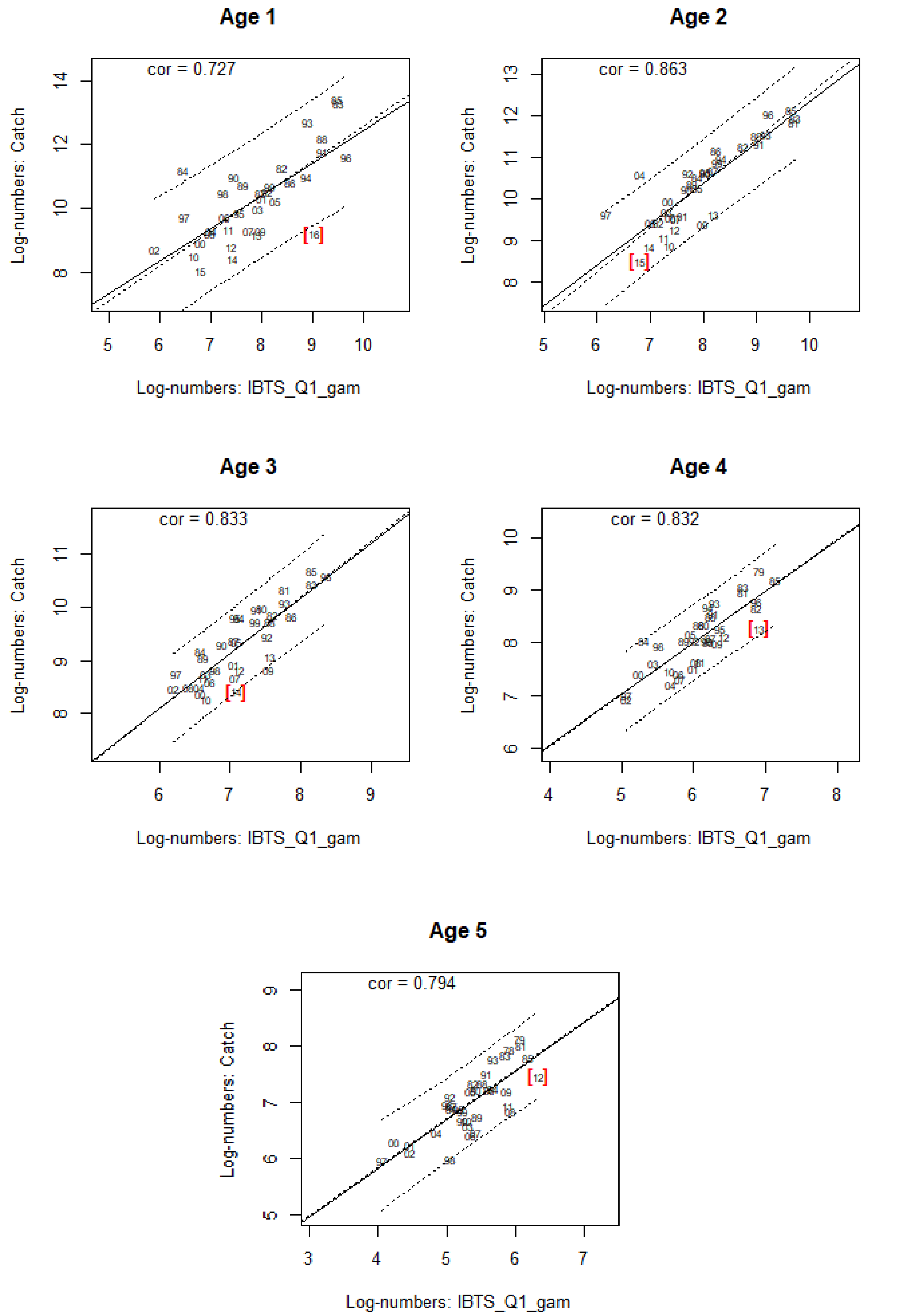


Figure 4.8b. Cod in Subarea 4, Division 7.d and Subdivision 20: Correlations between the IBTS–Q1 survey (NS–IBTS Delta–GAM index) and catch-at-age data for the period 1987–2017. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line 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 red square brackets.

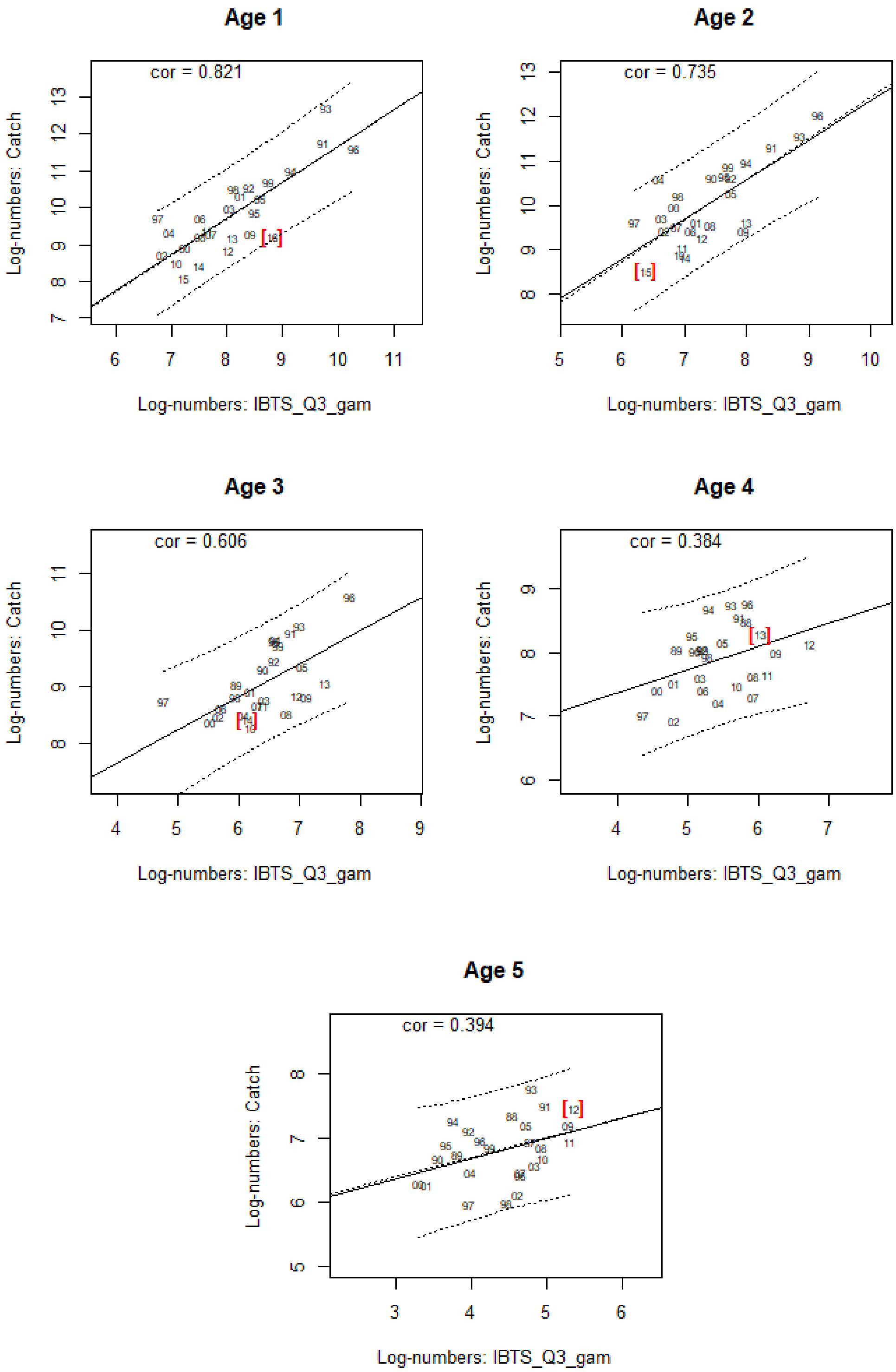


Figure 4.8c. Cod in Subarea 4, Division 7.d and Subdivision 20: Correlations between the IBTS–Q3 survey (NS–IBTS Delta–GAM index) and catch-at-age data for the period 1992–2017. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line 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 red square brackets.

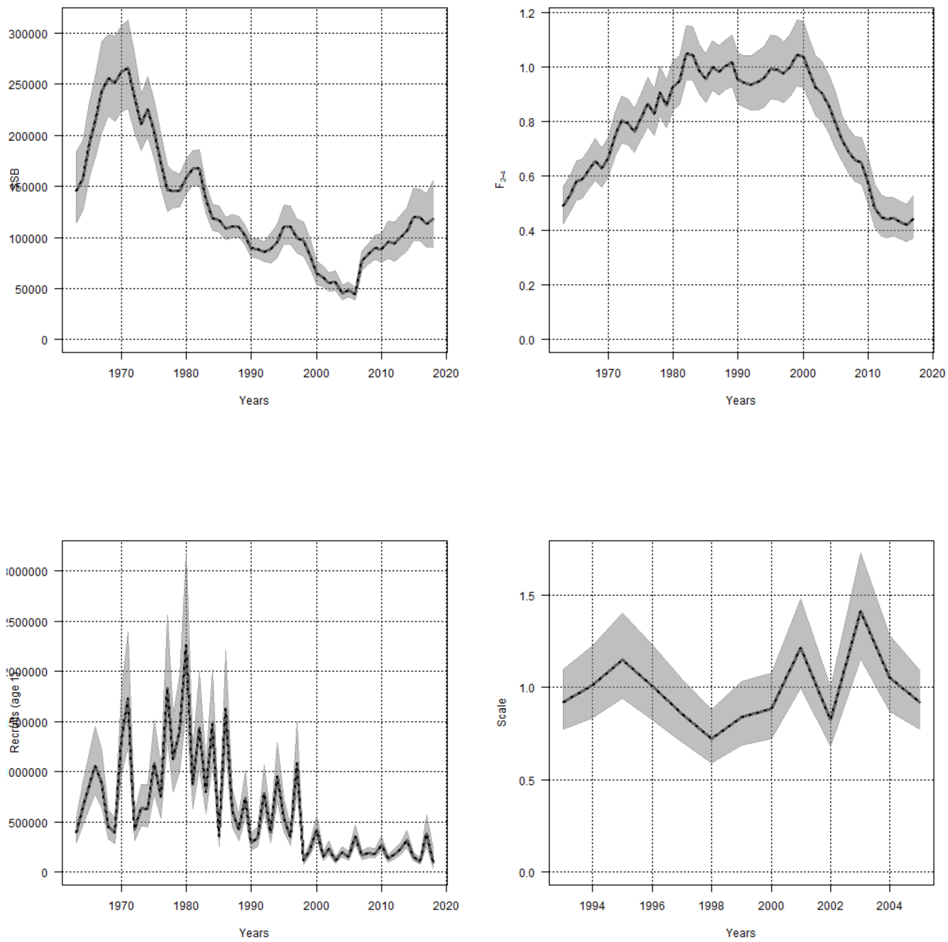
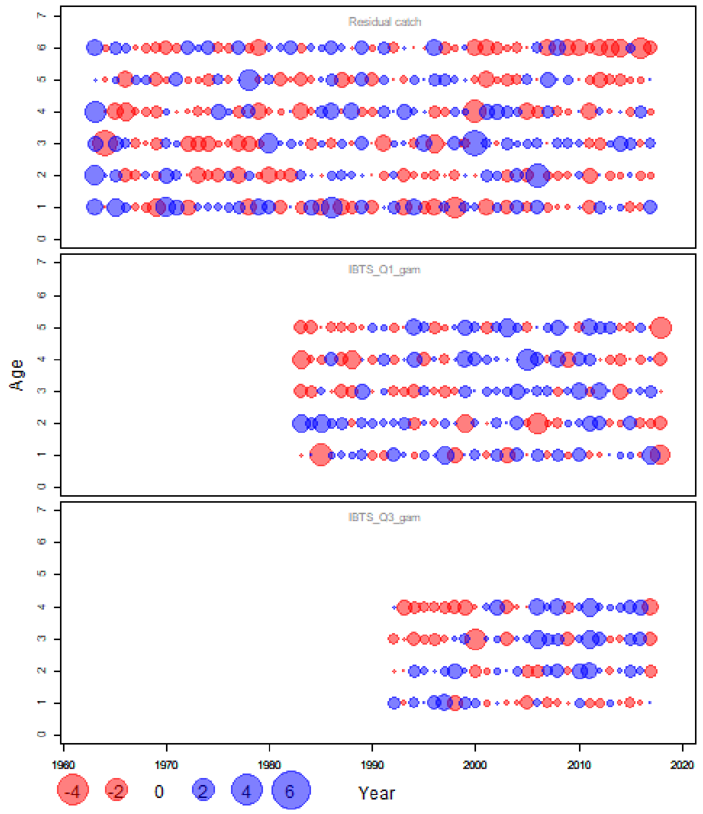


Figure 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and the catch multiplier from the SAM assessment (black lines = estimate and shaded area = corresponding point-wise 95% confidence intervals).



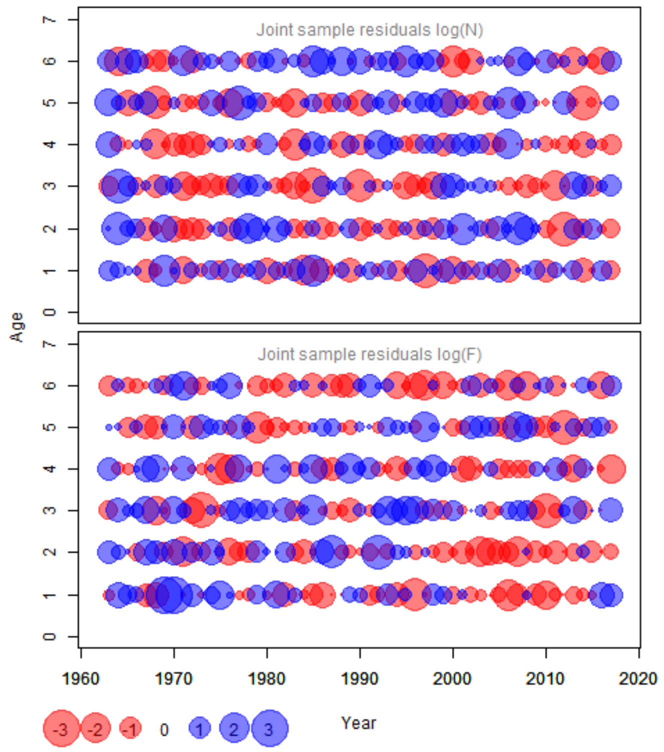


Figure 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: Normalized residuals for the SAM assessment, for total catch, IBTS–Q1, IBTS–Q3, and the recruitment and survival process error. Blue circles indicate a positive residual and red circles a negative residual.

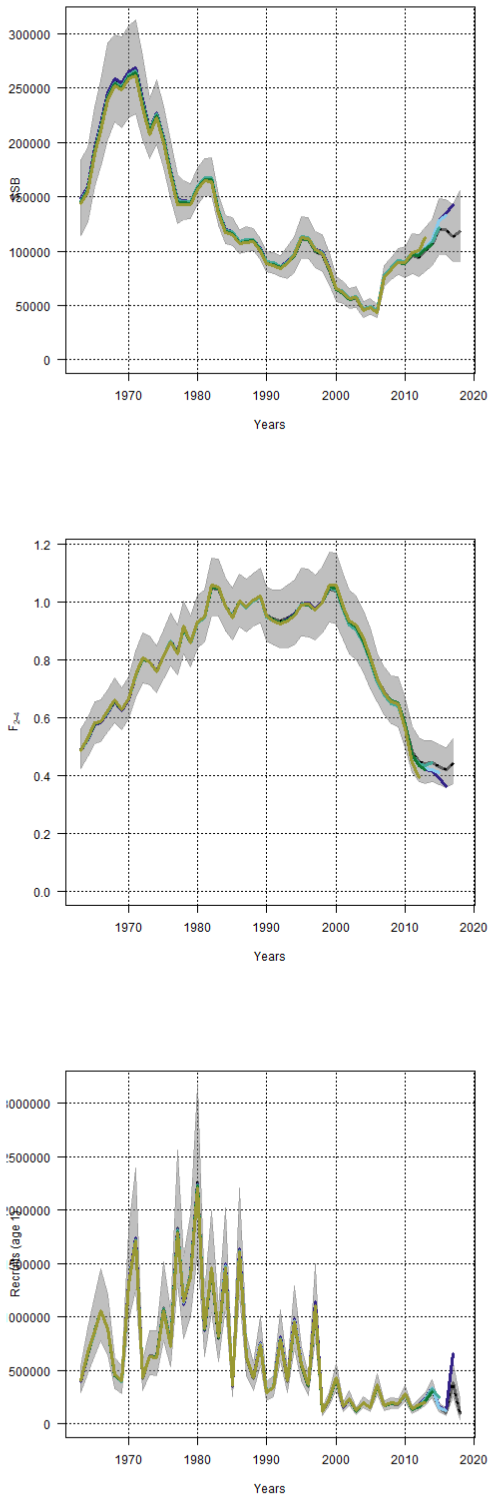


Figure 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: Retrospective estimates (5 years) from the SAM assessment. Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals.

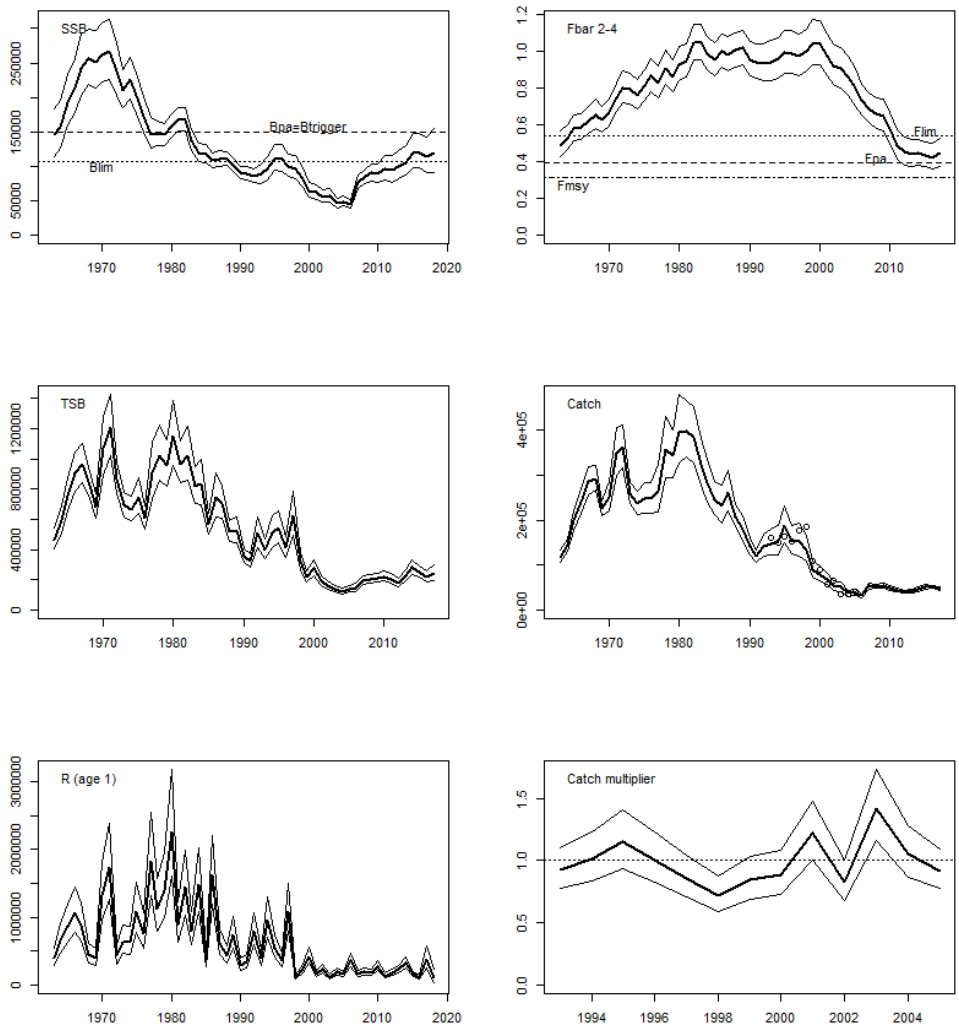


Figure 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Anticlockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2–4 (F(2–4)), 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 circles 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 B_{lim} = 107 000 t and B_{pa} = 150 000 t, and in the F_{bar} plot F_{lim} = 0.54, F_{pa} = 0.39 and F_{MSY} = 0.31. The horizontal broken line in the catch multiplier plot indicates a multiplier of 1. Catch, SSB and TSB are in tonnes, and R in thousands.

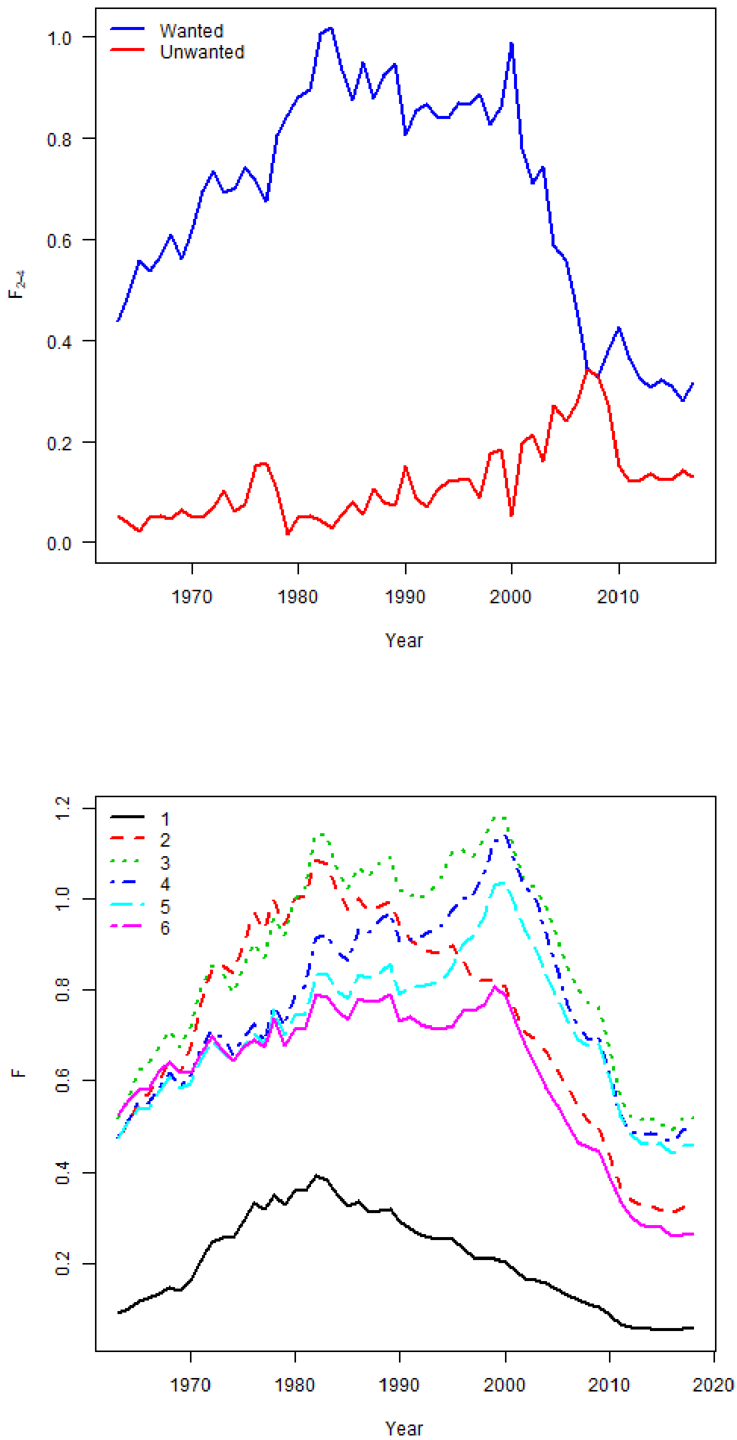


Figure 4.13. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

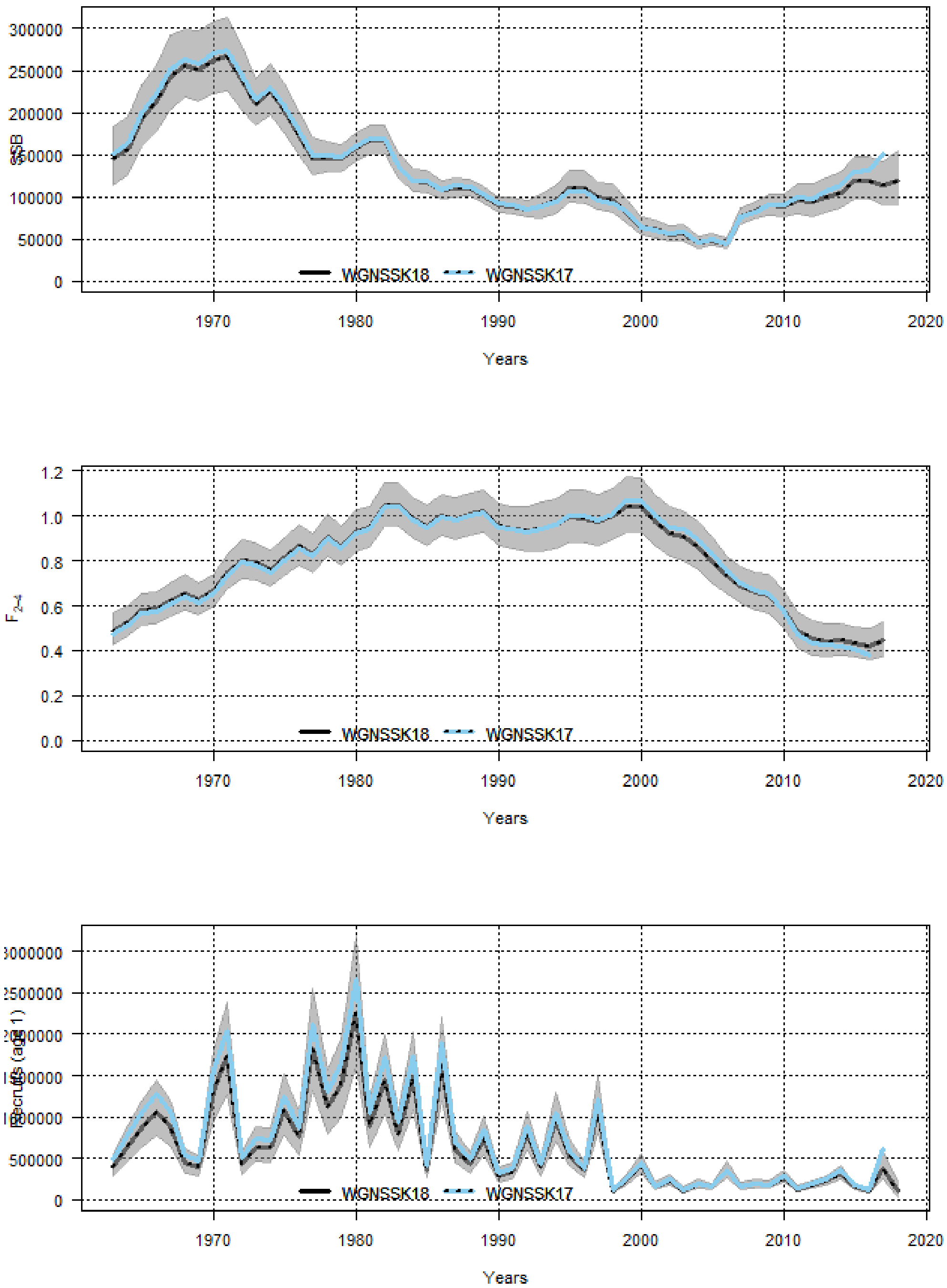
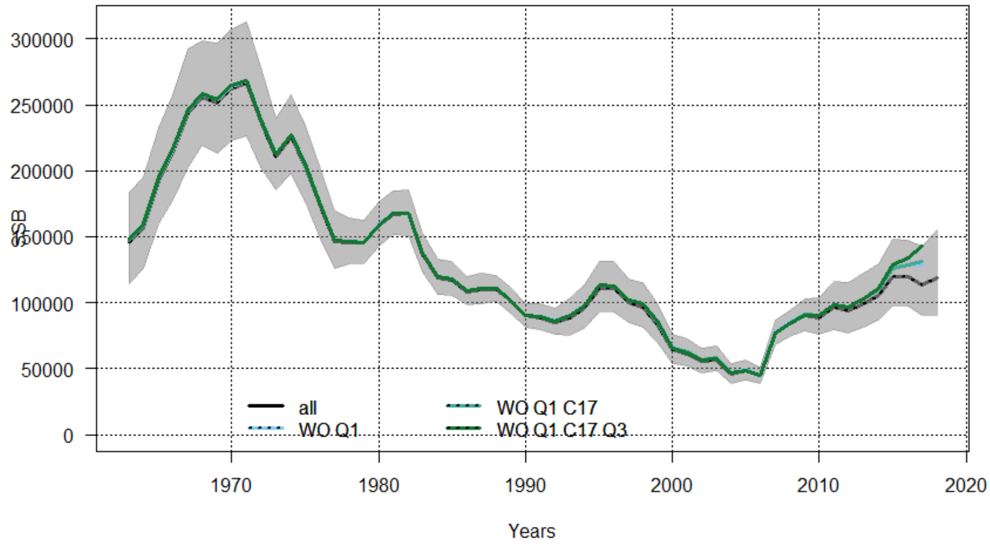


Figure 4.14a. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of final SAM assessment for 2018 with the final SAM assessment for 2017 (October update). Plots are as described in Figure 4.12.



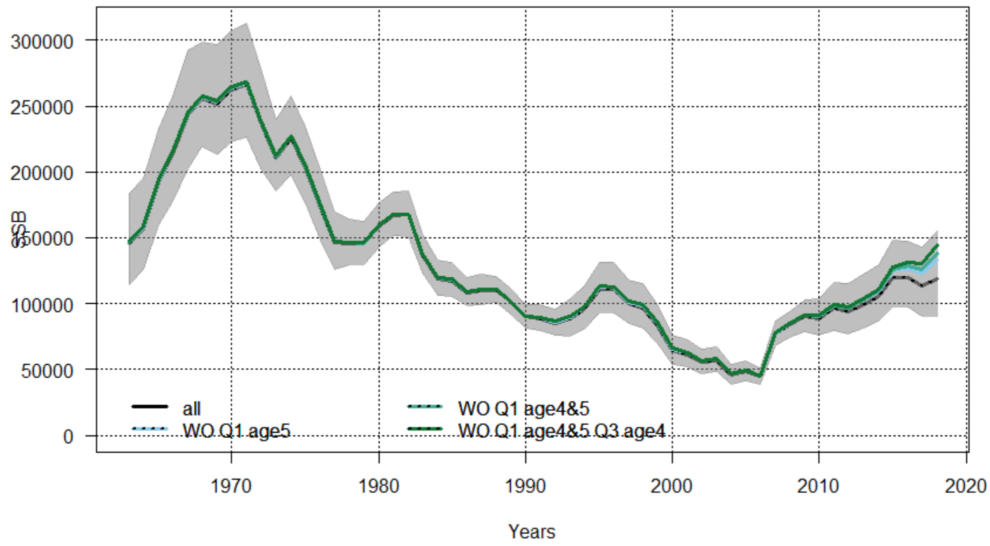


Figure 4.14b. Cod in Subarea 4, Division 7.d and Subdivision 20: Contribution of new data to the downscaling of SSB in the final SAM assessment for 2018. Top: Assessment runs without NS-IBTS Q1 data for 2018 (Q1), 2017 catch data (C17) and NS-IBTS Q3 data for 2017 (Q3). Bottom: Assessment runs excluding older ages from the NS-IBTS Q1 (2018) and Q3 (2017) survey indices.

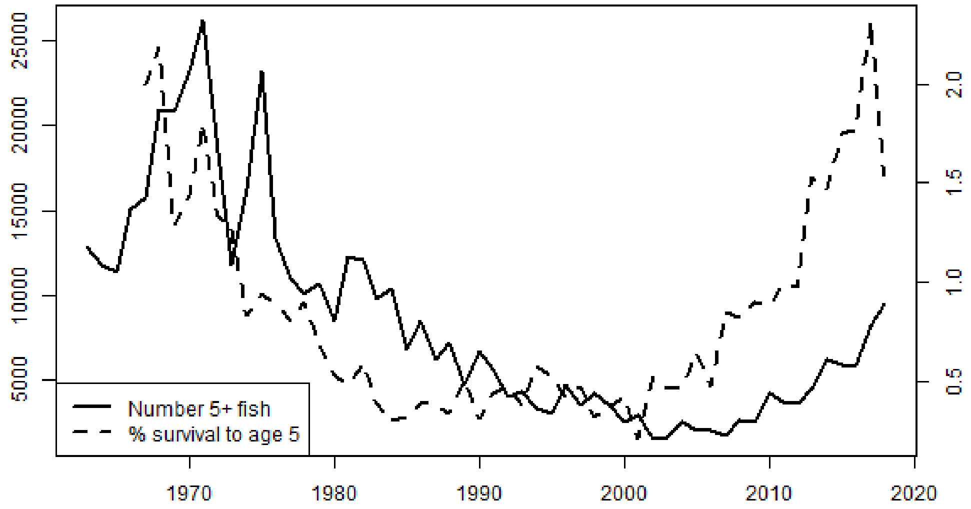


Figure 4.15. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimates of the number of 5-year-old and older cod in the population (solid line; thousands) and the percentage of 1 year olds by number that have survived to age 5 in the given year (hashed line).

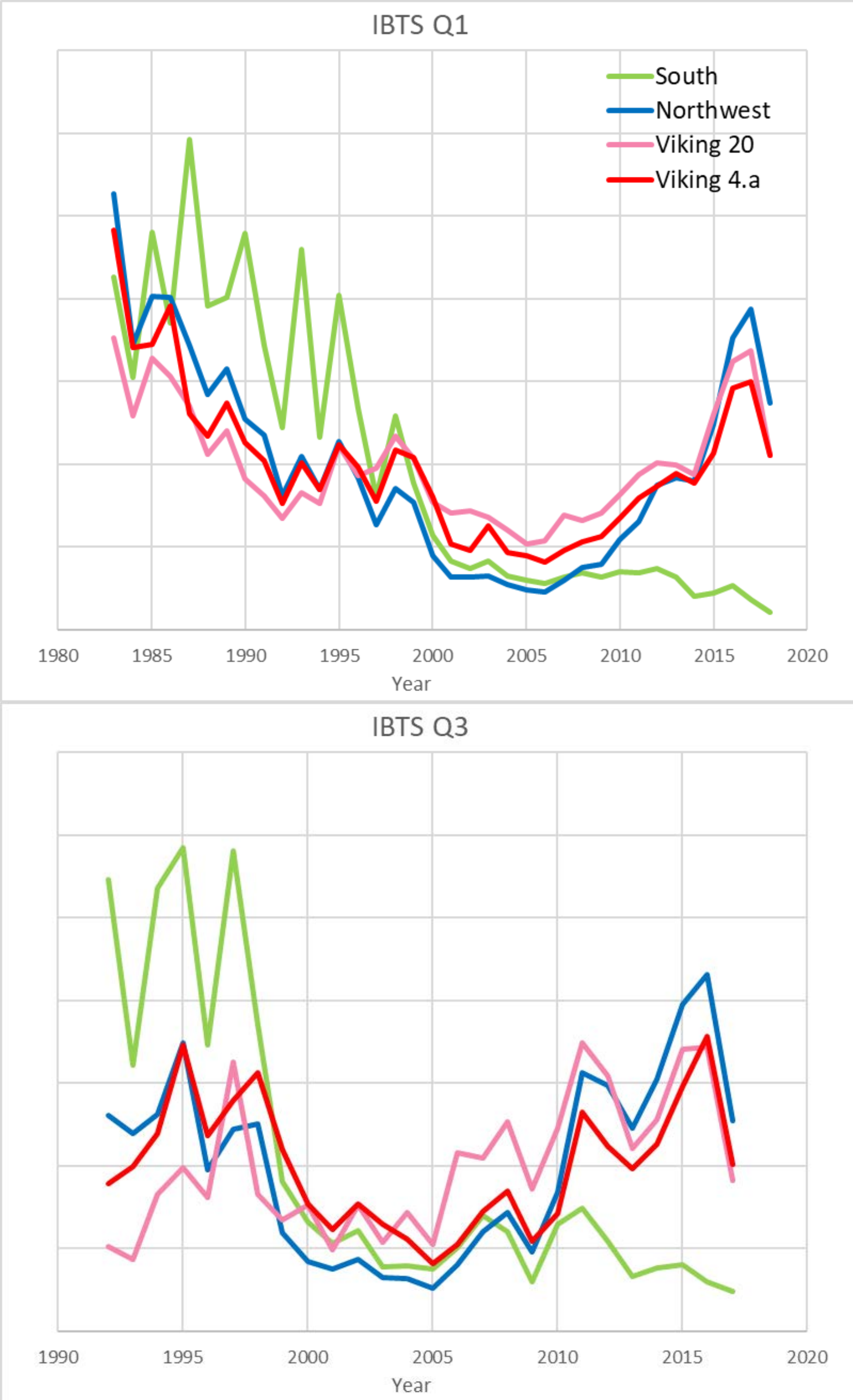


Figure 4.16a. Cod in Subarea 4, Division 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model (including ship effects) to numbers-at-age for the entire dataset and integrating 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.

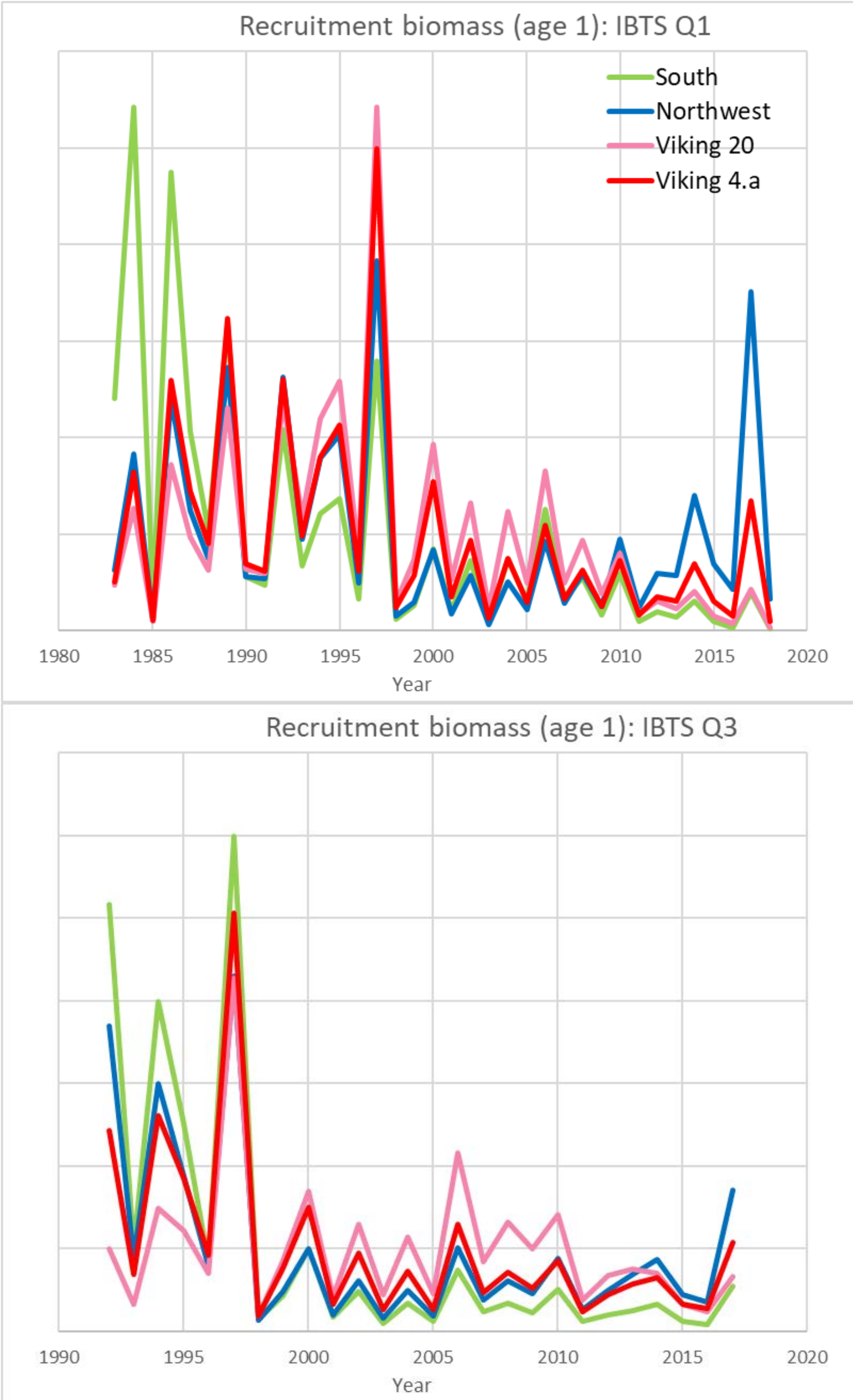


Figure 4.16b. Cod in Subarea 4, Division 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data.

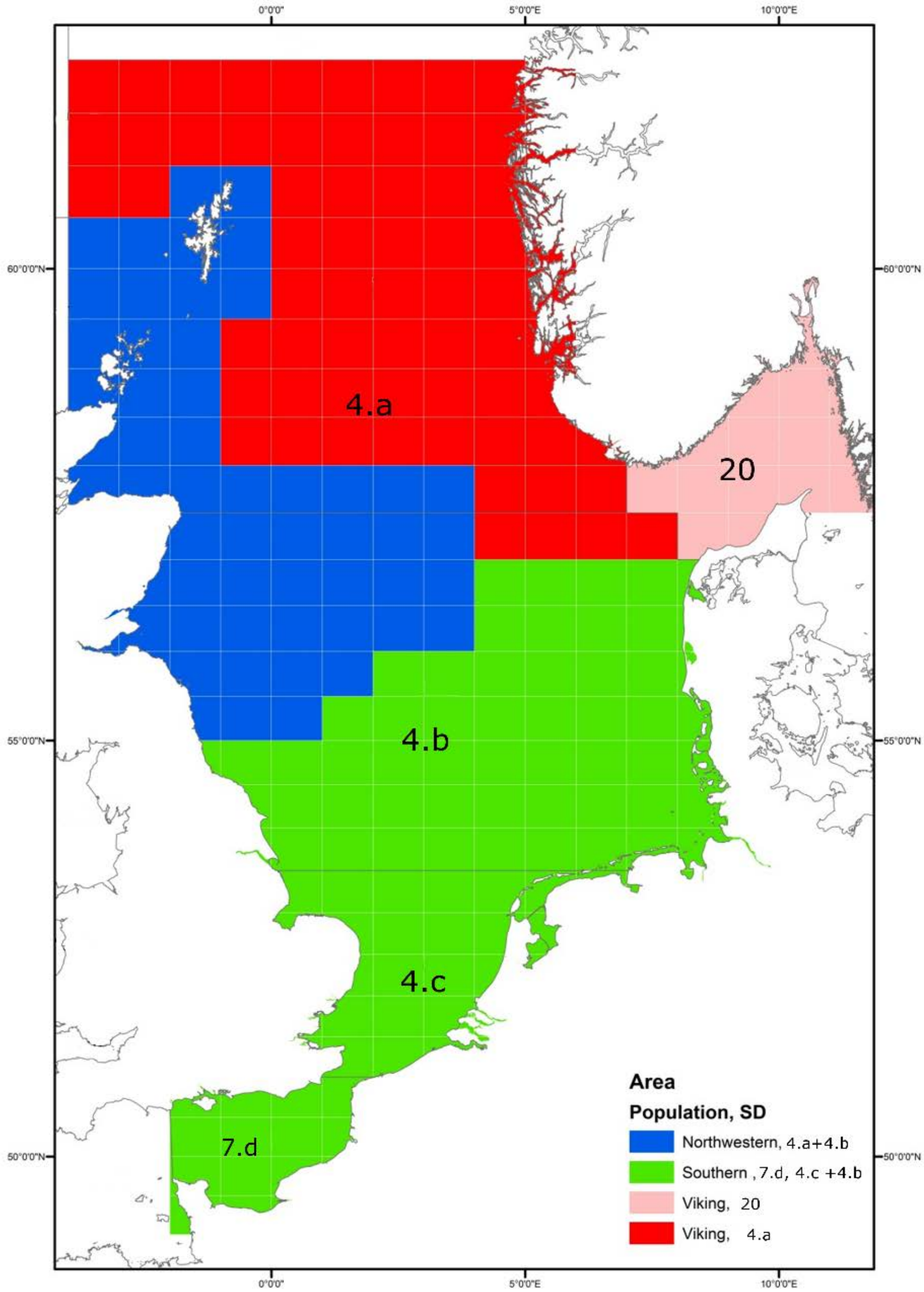


Figure 4.16c. Cod in Subarea 4, Division 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

5 Dab in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat)

5.1 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 dab was assessed by the Working Group on Assessment of New MoU Species (ICES, 2013a). 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 could be included into the dab assessment since then. 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 (SURBAR; Needle, 2015) to inform stock status of North Sea dab (ICES, 2016). This model provides relative estimates of the spawning stock, recruitment, and total mortality. During the WGNSSK 2017 MSY proxy reference points were determined applying the Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) and catch advice for dab was provided for 2017 and 2018. In 2017 the combined TAC for dab and flounder was removed (EU COM, 2017/595). North Sea dab has become a non-target species with no TAC since then and ICES has not been requested to provide advice on fishing opportunities for this stock. Therefore, there was no need to reopen the advice. However, catch data, indices and the SURBAR assessment were updated and also an updated SPiCT assessment was performed. Total catches were the lowest observed since 2002; in particular comparable low discards were reported and estimated for 2017. The SSB showed a decrease compared to the previous year but is still on a comparable high level. Recruitment showed a decreasing trend since 2015. This trend continued for 2017 but with only slightly lower value compared to 2016. The results of the SPiCT assessment for dab in Subarea 4 and Division 3.a showed that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is above the reference B_{MSY} proxy.

5.1.1 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 100 m, but it was also found occasionally down to depths of 150 m. The main concentration of dab can be found in the south eastern North Sea especially that of the younger age groups 1–2. Older age groups are more distributed in the central and more Northern parts of the North Sea (Figure 5.14). Generally, 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 cm to 14 cm total length. Peak spawning in the south eastern North Sea occurs from February to April.

5.1.2 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.

5.1.3 Management regulations

Dab is mainly a bycatch species in fisheries for plaice and sole. The discard rates for dab can be extremely high (~90%). No minimum landing size is defined for dab. According to EU–Regulations a precautionary TAC was given in EU waters of Division 2.a and Subarea 4 together with flounder (*Plathichthys flesus*). This combined TAC was never fully utilized. In 2017, the European Commission requested ICES to evaluate the possible effects on the stocks of dab and flounder having no TAC. ICES advised that given the current fishing patterns of the main fleets catching dab and flounder, which are the same fleets targeting plaice and sole, the risk of having no TAC for dab and flounder is considered to be low (ICES, 2017a). Therefore, the European Commission removed the combined TAC for these two stocks in 2017 (EU COM, 2017/595).

5.2 Fisheries data

5.2.1 Historical landings

Dab is a bycatch species mainly in the fisheries for plaice and sole but also in fisheries targeting demersal round fish. According to ICES catch statistics, annual landings of dab in ICES Subarea 4 and Division 3.a has been well above 10 000 tonnes since 1973 (Figure 5.1–5.3, Table 5.13). The apparent decrease in official landings in the 1980s and 1990s are due to unreported landings by the Netherlands and Norway. However, since 1999 total landings for both areas (Subarea 4 and Division 3.a) steadily decreased. This trend continued until 2015 with total official landings of 4512 tonnes. In 2016, official landings for both areas increased slightly and resulted in total landings of 4953 tonnes. In 2017, a strong decrease in official landings to 3529 tonnes was observed. This is the lowest record of official landings for the whole time series (1950–2017).

The main fishing gear in the North Sea is the beam trawl with mesh sizes between 80 and 100 mm. Large effort reductions took place in this fishery over the last decade. The largest part of the landings in Subarea 4 is taken by the Netherlands, followed by UK and Denmark (Figure 5.2, Table 5.14). In Division 3.a, Denmark lands the largest amount of dab (Figure 5.3, Table 5.15). Dab is among the most discarded fish species in ICES Subarea 4. In the beam trawl fishery on plaice and sole and the otter trawl fishery on plaice up to 95% of dab catches are discarded (e.g. van Helmond *et al*., 2012).

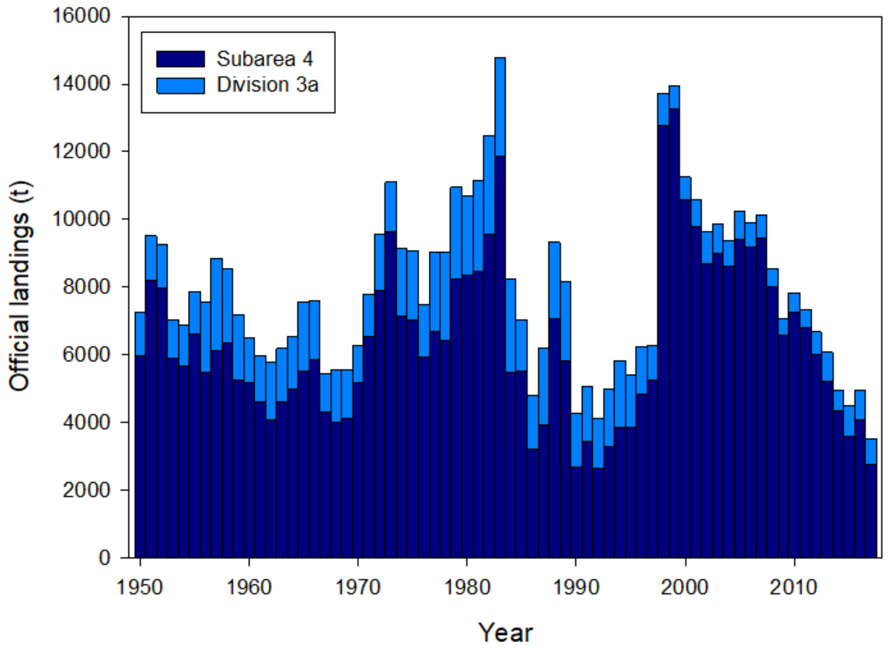


Figure 5.1. Dab in Subarea 4 and Division 3.a: Total official landings of dab in Subarea 4 and Division 3.a in 1950–2017.

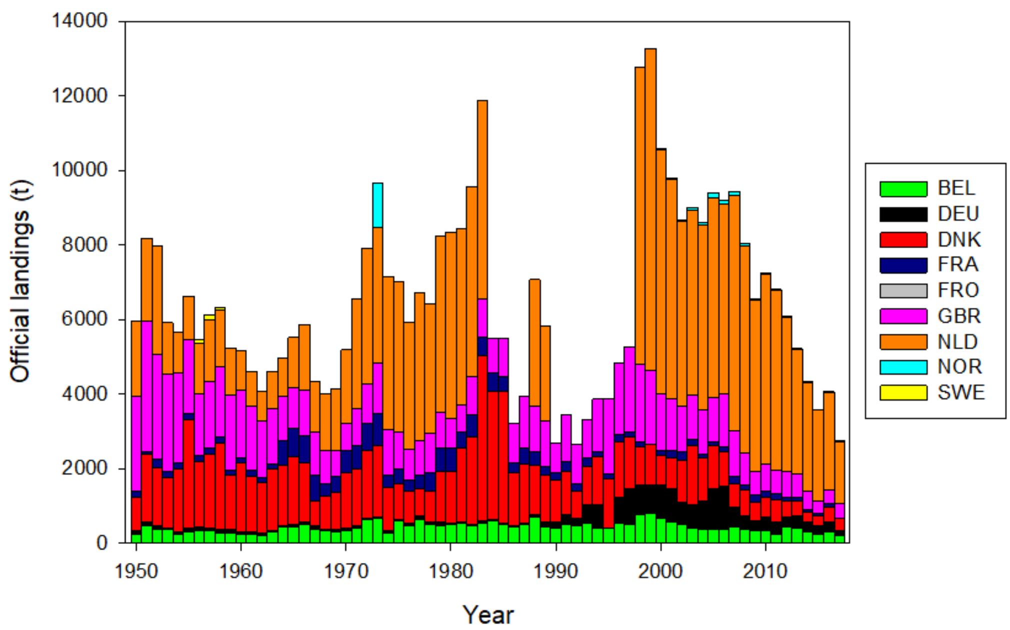


Figure 5.2. Dab in Subarea 4 and Division 3.a: Official landings of dab in Subarea 4 by country 1950 to 2017.

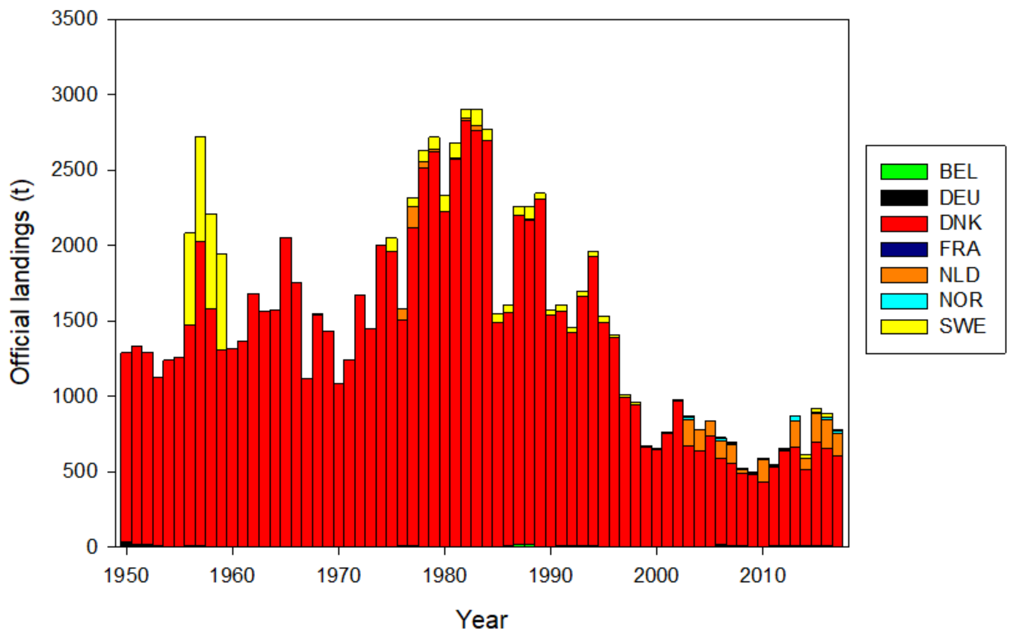


Figure 5.3. Dab in Subarea 4 and Division 3.a: Official landings of dab in Division 3.a by country 1950–2017.

5.2.2 InterCatch

For the WGNSSK, 2018 dab landing and discard data from 2002–2017 were available in the InterCatch system. Norway did not report any discards because of the official discard ban for the Norwegian fleet. Discard information for 2017 was provided for 79% of total landings in relation to weight (Figure 5.4).

In 2017, the largest amount of landings and discards was again reported by The Netherlands for the TBB_DEF_70-99_0_0_all metier (Figure 5.5 and Figure 5.6). Consequently, by far the largest catch in 2017 was taken by The Netherlands (19 394 tonnes in total). All other countries did not catch more than 5000 tonnes (Figure 5.7). The total dab catch estimated with InterCatch for 2017 was 35 113 tonnes (-14 783 tonnes compared to 2016) from which 3598 tonnes were landings and 31 515 tonnes discards (90% of total catch). It should be noted that not all metiers were sampled in every quarter and that the raising procedure with the InterCatch tool may not be adequate in all cases. Further, there are a number of metiers for which zero landings are reported and a discard raising for these fleets is not possible with the InterCatch tool, which is based on a discard ratio between landings and observed discards. Especially for bycatch species without economic interest zero landings do not necessarily imply zero discards. 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 for this métier.

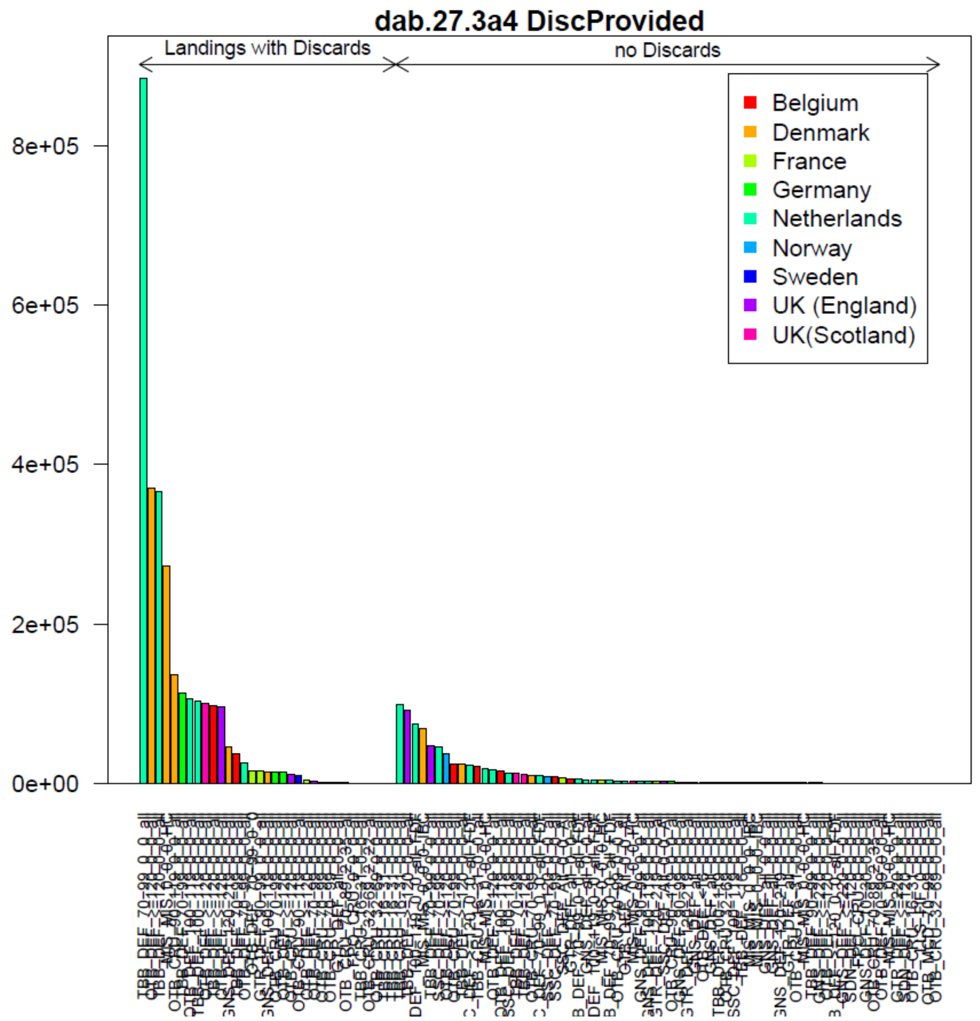


Figure 5.4. Dab in Subarea 4 and Division 3.a: Dab landings and discards (kg) provision for Subarea 4 and Division 3.a by métier and country in 2017 as uploaded into InterCatch.

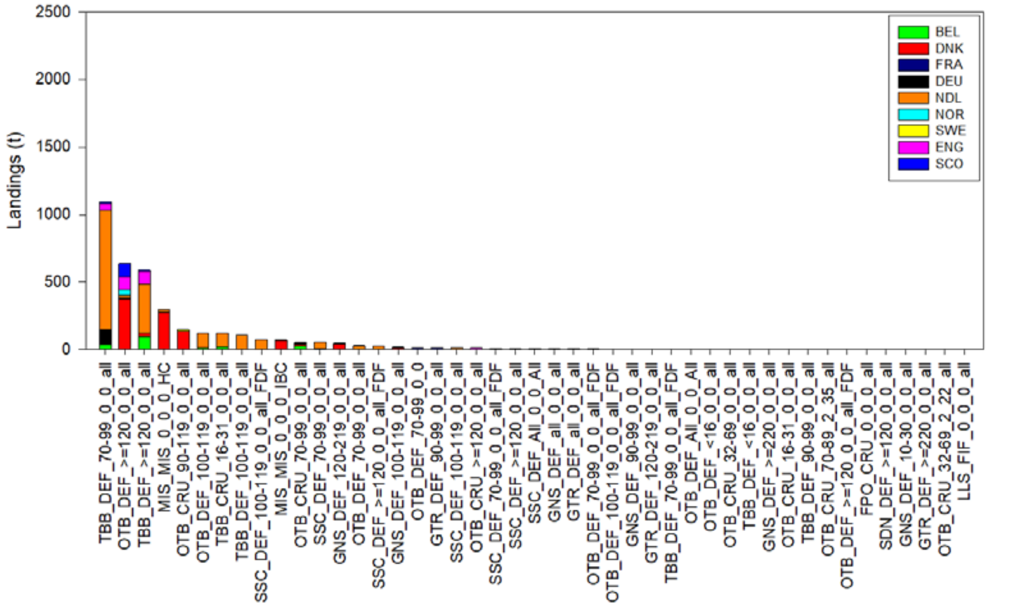


Figure 5.5. Dab in Subarea 4 and Division 3.a: Dab landings (tonnes) for Subarea 4 and Division 3.a by métier and country in 2017 as uploaded to InterCatch.

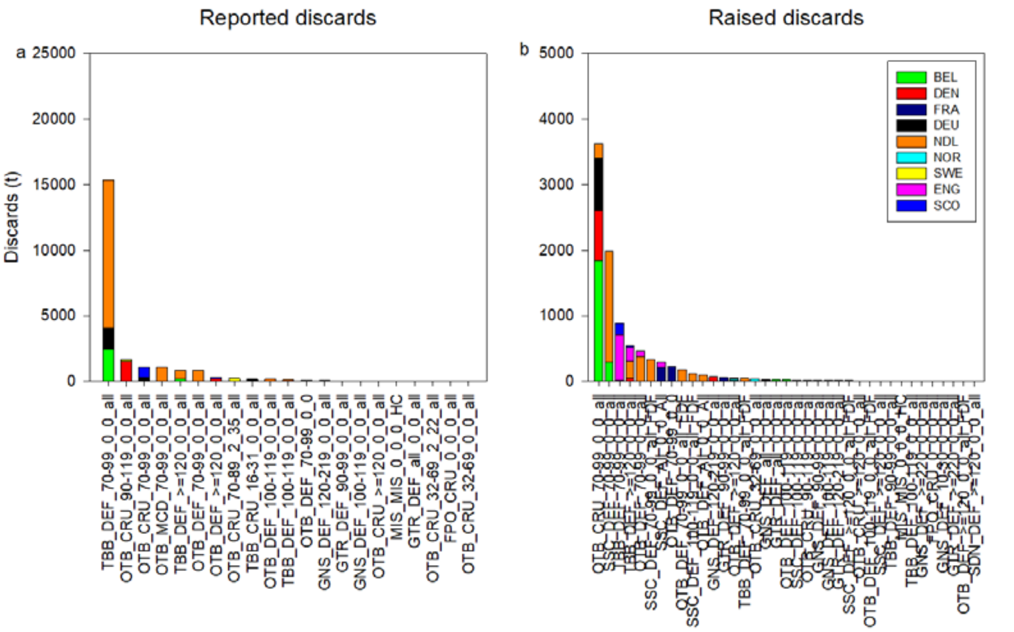


Figure 5.6. Dab in Subarea 4 and Division 3.a: Dab discards for Subarea 4 and Division 3.a by métier and country in 2017. Reported discards (a), raised discards (b).

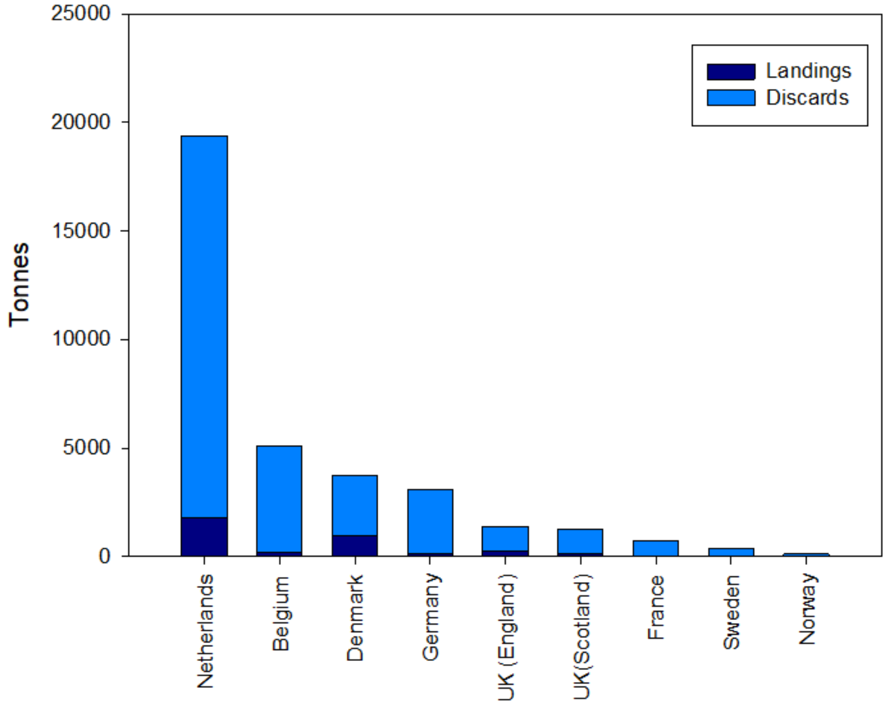


Figure 5.7. Dab in Subarea 4 and Division 3.a: Dab landings and estimated discards for Subarea 4 and Division 3.a by countries in 2017.

5.3 Survey data/recruit series

Surveys providing information on distribution, abundance and length frequency for dab in Subarea 4 and Division 3.a are the several Beam Trawl Surveys (BTS) in quarter 3 (Figure 5.8 and Figure 5.9) and the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3 (Figure 5.10).

The longest beam trawl survey time series exist for the RV Isis covering the south eastern part of the North Sea (Figure 5.9). This index showed high dab abundance in the early years (1987–1990) followed by a sharp decline until 1995. After a second peak in abundance in 1998 the abundance declined again until 2006, and afterwards increased again to such high values as were observed for the time period 1997–1999. The increasing abundance trend from 2005/2006 onwards was also observed for the RV Tridens beam trawl survey, and since 2010 also for the RV Solea beam trawl survey. No trend is visible in the RV Belgica survey data. The two Dutch time series showed a decrease in abundance for the two most recent years. A strong decrease was also observed for the RV Solea survey for the year 2015. Since 2017 RV Isis does not take part any more in the BTS and RV Tridens covers the whole survey area since then. A combined index of the two vessels also displays a declining trend in dab abundance for the last two years.

The International Bottom Trawl Survey in quarter 1 (IBTS–Q1) showed an increasing abundance trend from 1983 to 1990 and fluctuated since then without a clear trend until 2013. From 2013 to 2015 a rather strong increase in abundance was observed, followed by a strong decrease again in 2017 and 2018 (Figure 5.10). The IBTS Q3 also showed a highly variable abundance trend with a slight increase from the beginning of the time series in 1991 until 2014 (Figure 5.10). Since 2015 also this abundance index decreases.

In order to estimate a mature biomass index a length weight relationship and maturity data derived from IBTS–Q1 data was estimated in previous years to apply the DLS 3.2. method. The obtained length weight relationship and the maturity ogive (Figure 5.11) were then applied to estimate the mature biomass index in kg per hour. The mature biomass indices in kg/h (Figure 5.12) show the same trends as the IBTS abundance indices and for both quarters the decreasing trend is confirmed.

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 possible ship effect (i.e. gear effect; Berg *et al.*, 2014). For age group 0 the index is highly variable and does not show any trends, probably due to the low catchability of the offshore surveys to catch the 0–group. For the age groups 2–5 a decrease of the index is observed in 2017. The indices for older age groups are extremely variable for the most recent years. This index served as an input for the survey based assessment model (SURBAR) to inform the stock status of North Sea dab (Figure 5.13). The spatial distribution of dab age groups follows a clear pattern with the youngest age groups (0 and 1) located near the coast of the south eastern North Sea and the older age groups more distributed in the central North Sea (Figure 5.14). The weight at age data show a slightly decreasing trend for all age groups from 2002 to 2015, but a rather sharp increase in 2016 for the age groups 1–5 (Figure 5.15). In 2017, there was still an increase observed in weight at age for age group 1. For all other age groups the weight at age dropped again (ages 3–5) or stayed the same (age 6).

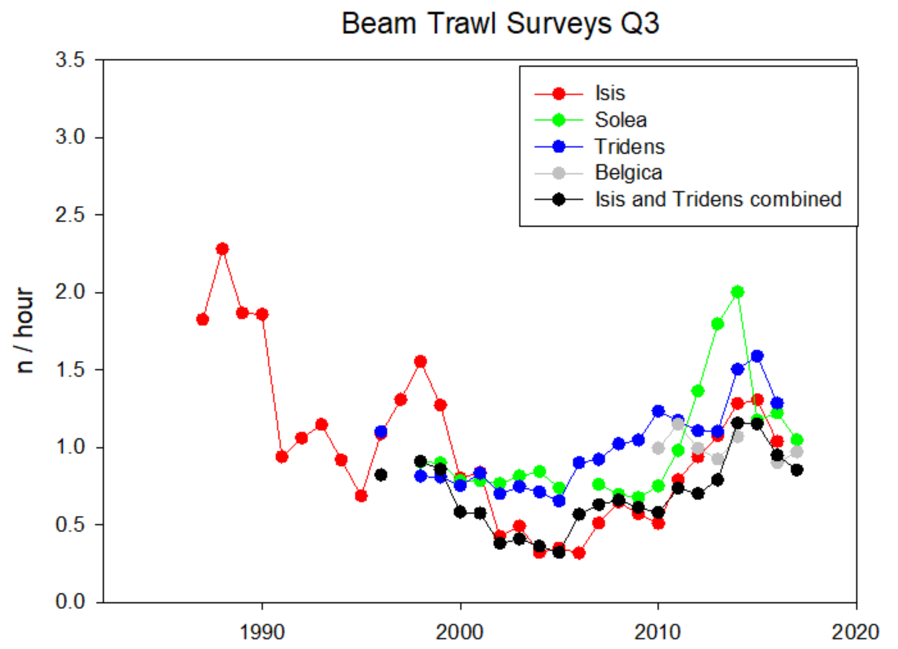


Figure 5.8. Dab in Subarea 4 and Division 3.a: Standardized dab beam trawl survey indices (n/hour) in Subarea 4.

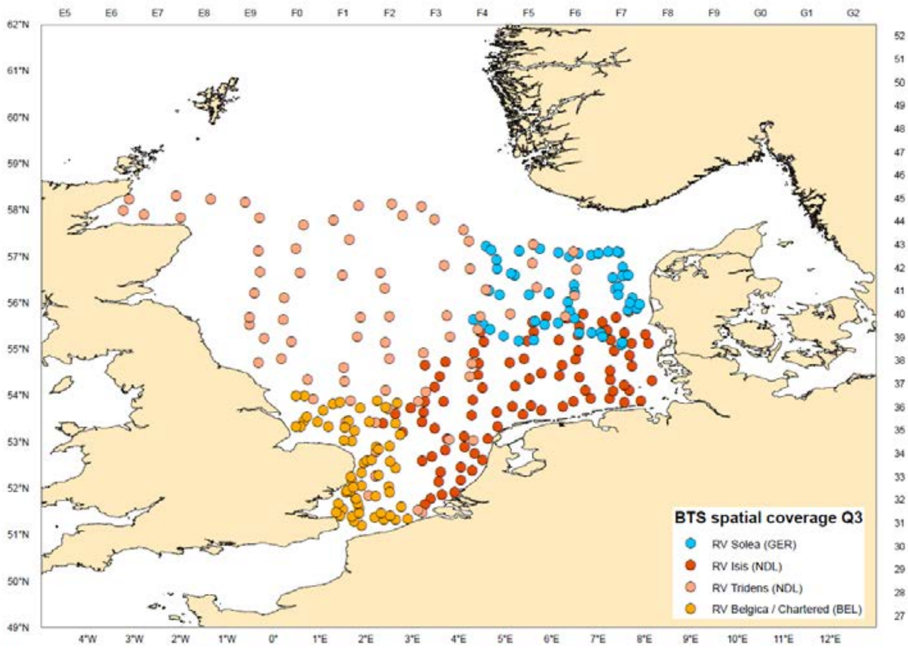


Figure 5.9. Dab in Subarea 4 and Division 3.a: Spatial coverage of the different beam trawl surveys in the North Sea (1987–2016). Since 2017, the survey area from RV Isis is also covered by RV Tridens.

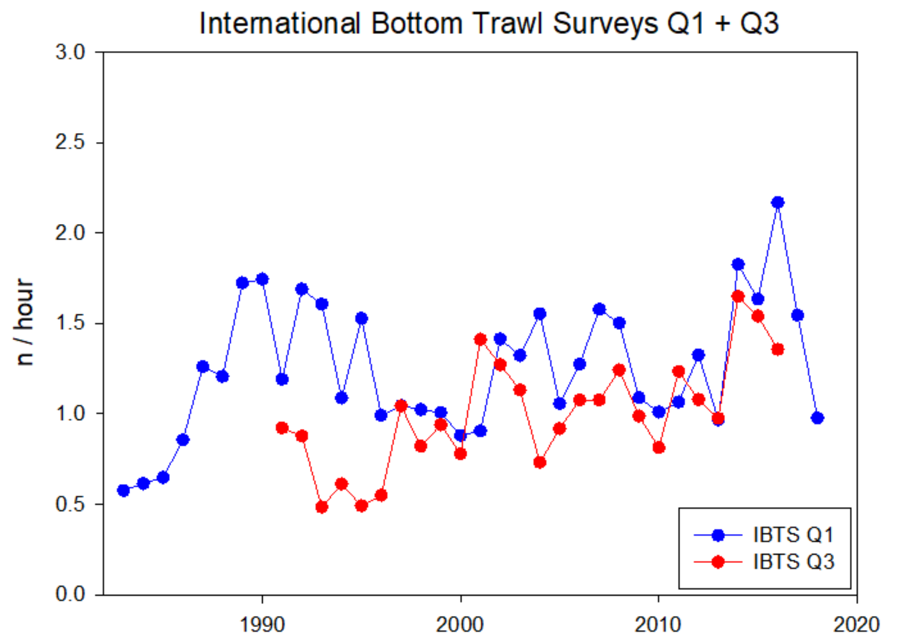


Figure 5.10. Dab in Subarea 4 and Division 3.a: Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

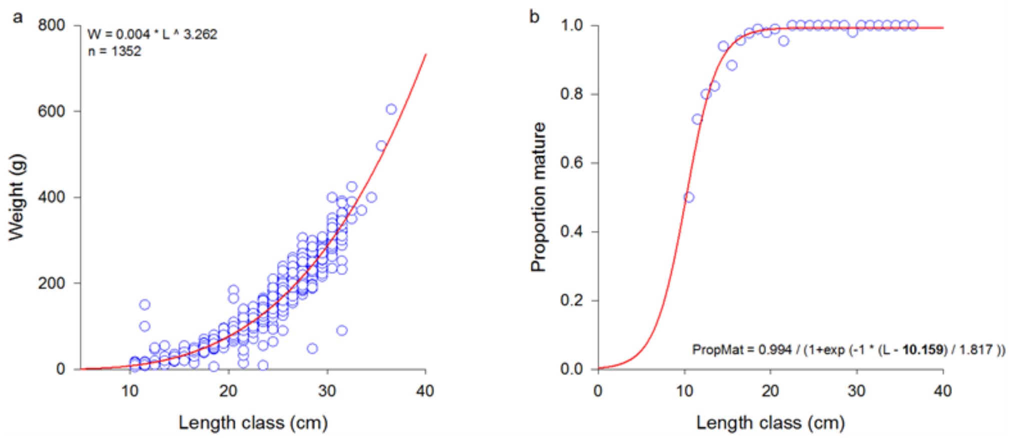


Figure 5.11. Dab in Subarea 4 and Division 3.a: Length weight relation (a) and length based maturity ogive (b) obtained from survey data (IBTS–Q1).

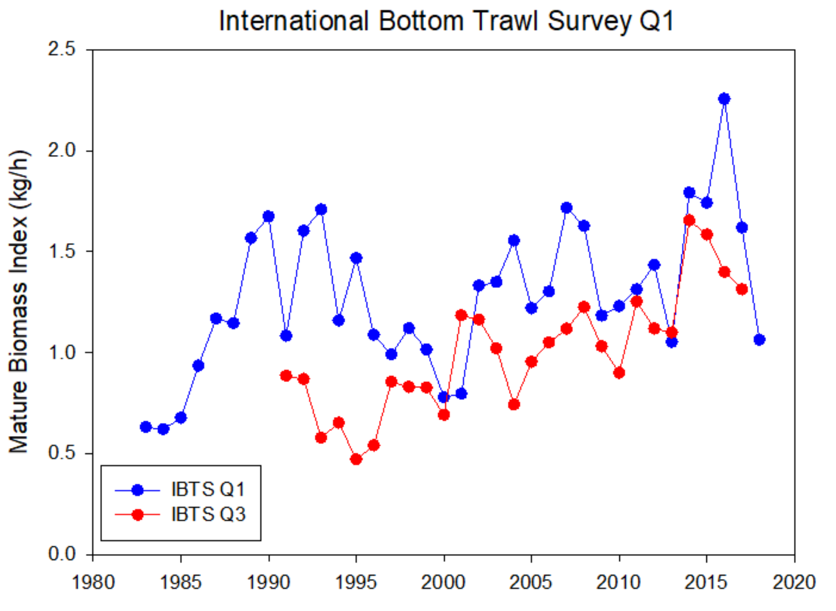


Figure 5.12. Dab in Subarea 4 and Division 3.a: Mature biomass index IBTS–Q1.

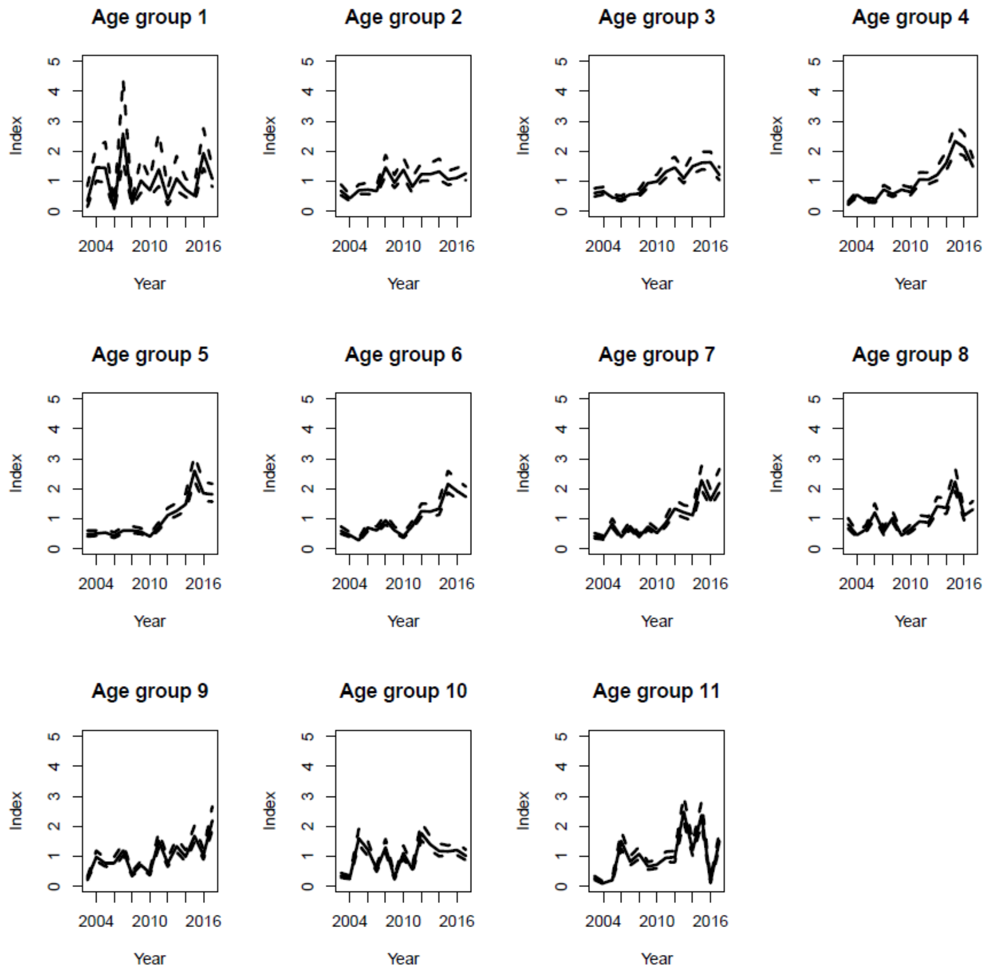


Figure 5.13. Dab in Subarea 4 and Division 3.a: Combined beam trawl index by age groups (2003–2017).

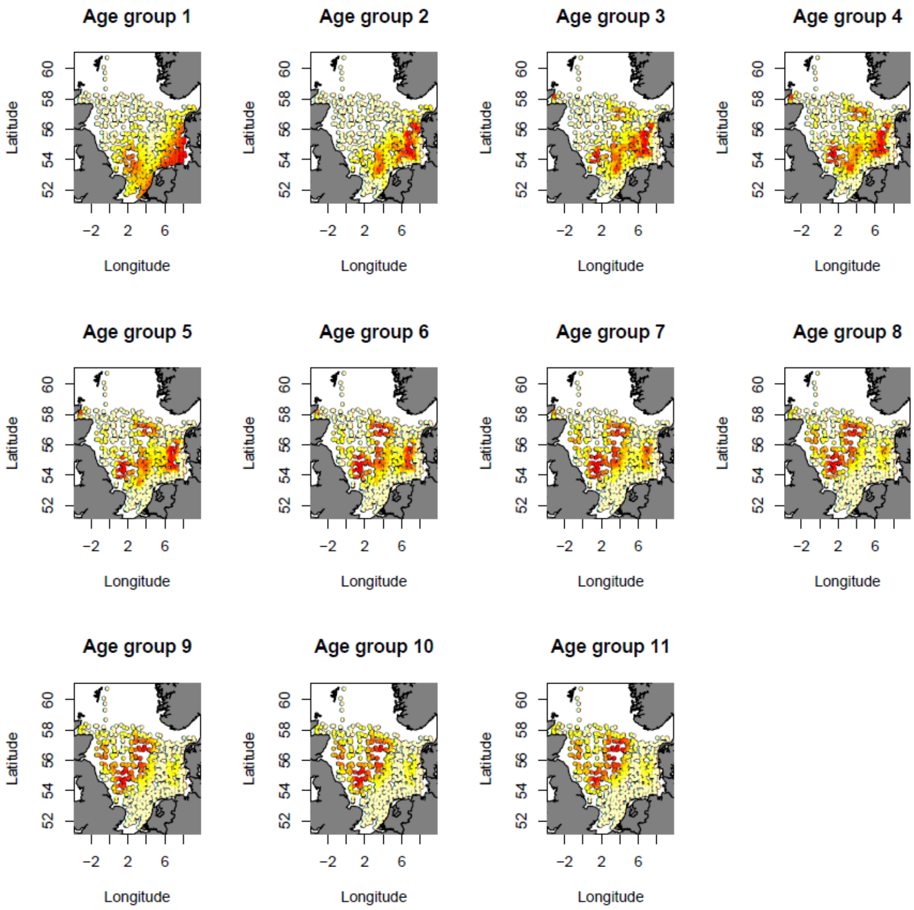


Figure 5.14. Dab in Subarea 4 and Division 3.a: Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys (age group = age group –1).

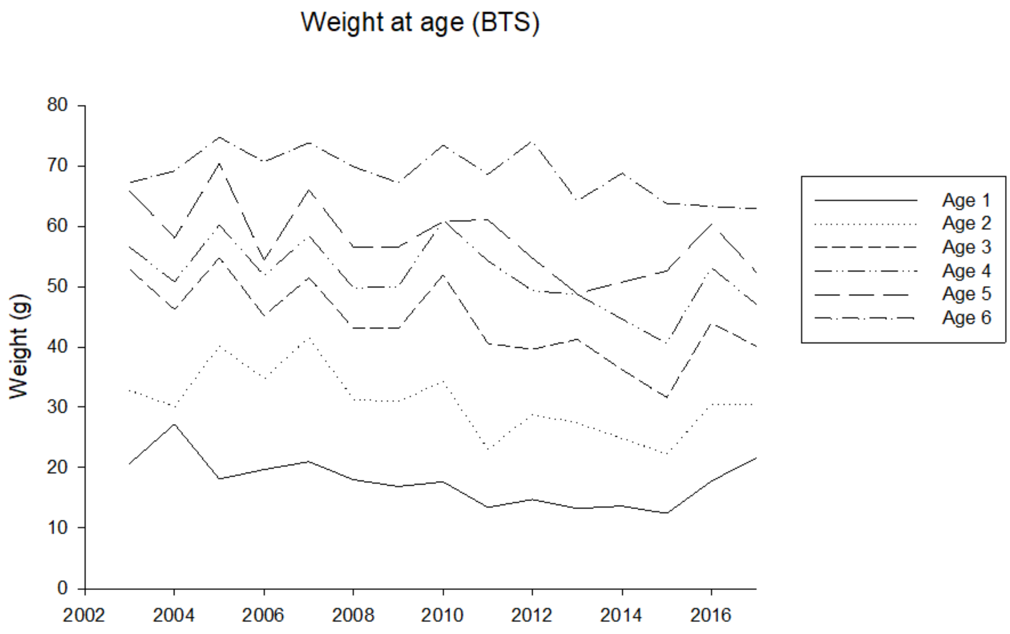


Figure. 5.15 Dab in Subarea 4 and Division 3.a: Weight at age derived from beam trawl survey data 2003–2017).

5.4 Survey Based Assessment (SURBAR)

In 2016, a benchmark assessment was carried out for dab (ICES, 2016). 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 (SURBAR; Needle, 2015) taking the age structure of dab into account. The SURBAR results of the update assessment showed an overall decreasing trend in total mortality for the years 2003–2014 (Figure 5.16, upper left panel) while the spawning stock biomass (relative biomass) continued to increase for the years 2003–2016 (Figure 5.16, upper right panel). Total mortality increased for the years 2015–2016, but dropped again slightly in 2017. The spawning stock biomass also dropped in 2017. The recruitment increased by a factor of 2.6 from 2003 to 2014 but dropped for the last three years (Figure 5.16, lower right panel). However, there is a strong retrospective pattern in recruitment with a general underestimation of recruitment for the terminal years (Figure 5.21). This might indicate a lower catchability of the survey for the youngest age group and a lower capability of the SURBAR model to track the young age groups. No pattern was detected in the log residual pattern of the age based survey indices (Figure 5.17).

Table 5.1. Dab in Subarea 4 and Division 3.a: Settings and input data used for the final SURBAR 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)

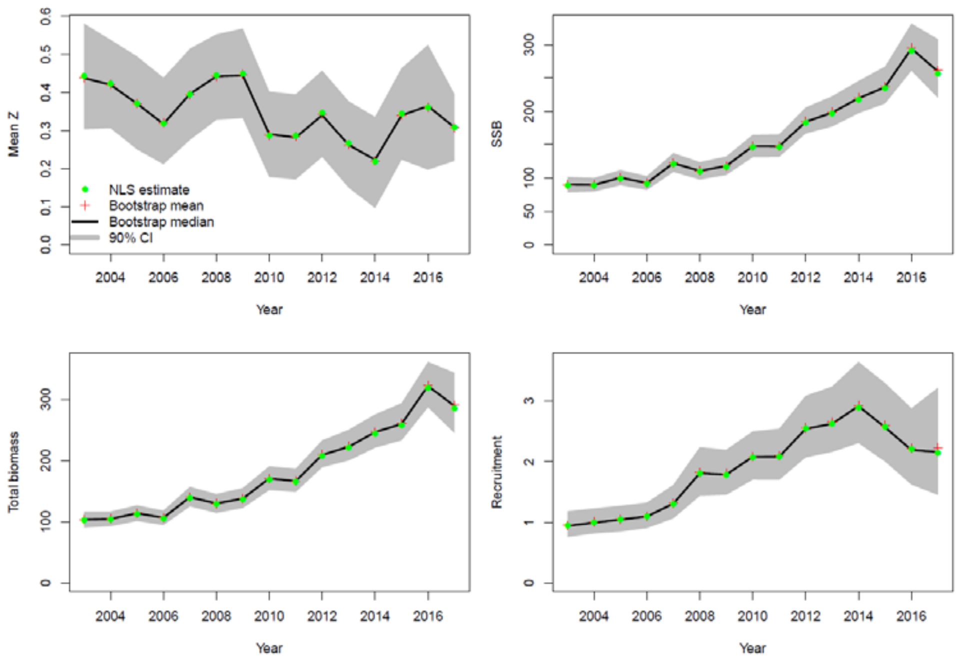


Figure 5.16. Dab in Subarea 4 and Division 3.a: SURBAR model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

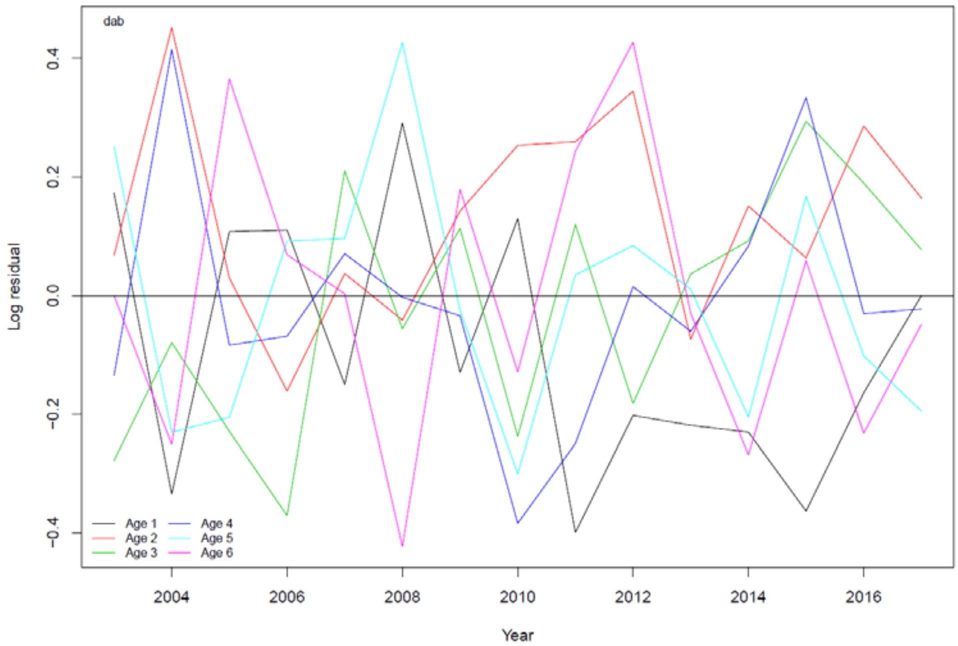


Figure 5.17. Dab in Subarea 4 and Division 3.a: SURBAR model results of log residuals.

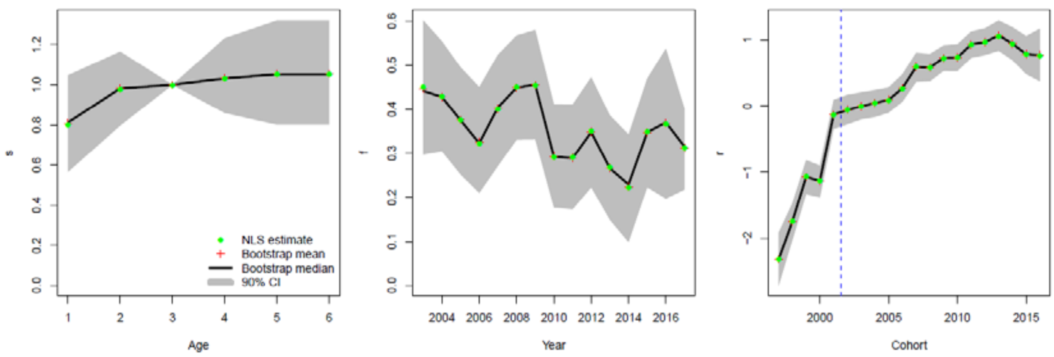


Figure 5.18. Dab in Subarea 4 and Division 3.a: SURBAR model results displaying the age, year and cohort effects.

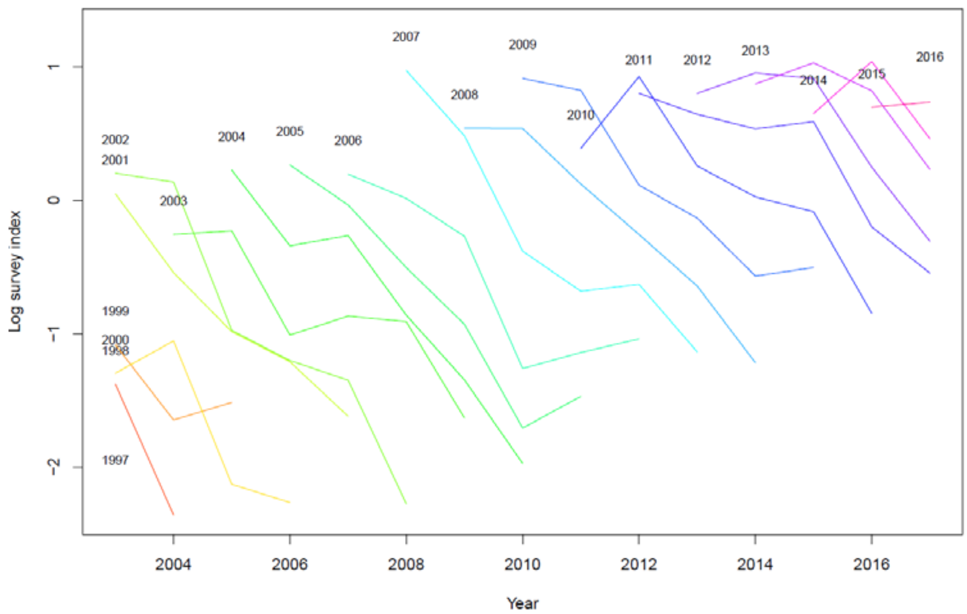


Figure 5.19. Dab in Subarea 4 and Division 3.a: SURBAR model results: catch curves.

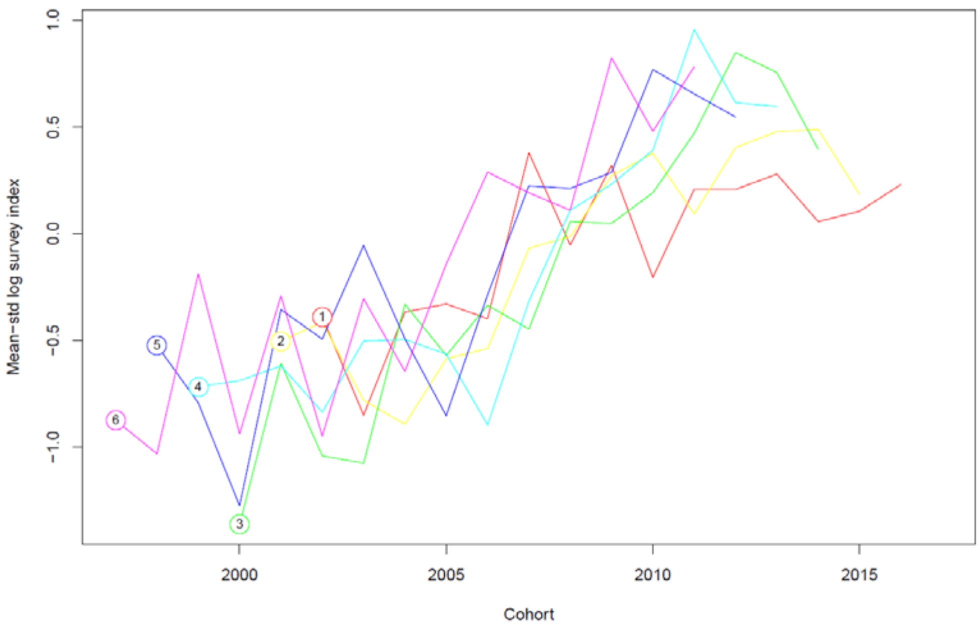


Figure 5.20. Dab in Subarea 4 and Division 3.a: SURBAR mean-standardized log survey index.

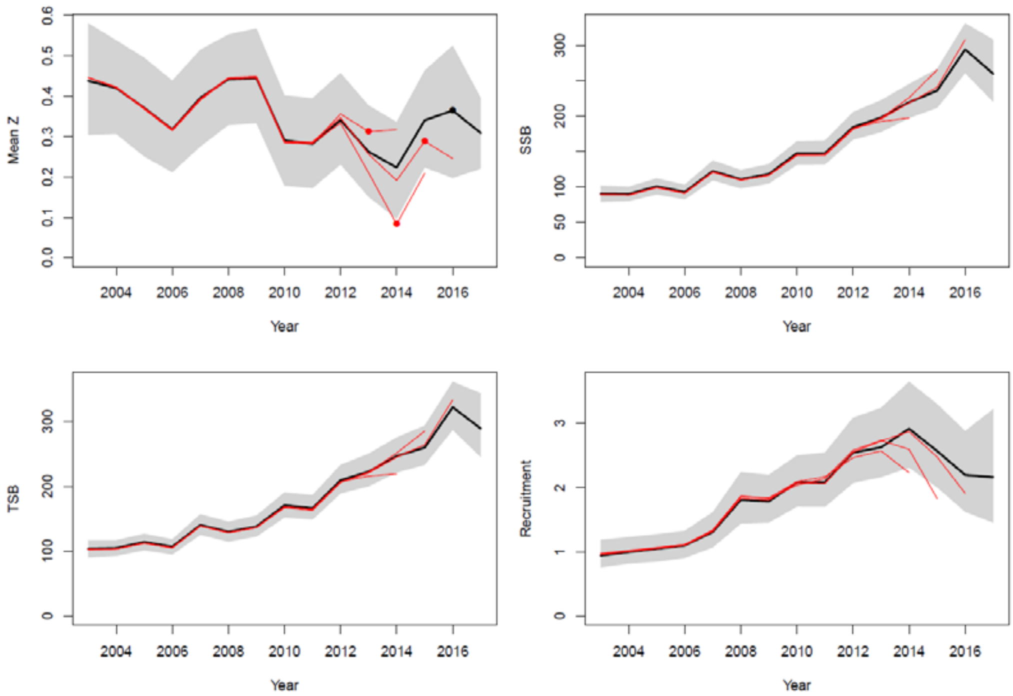


Figure 5.21. Dab in Subarea 4 and Division 3.a: SURBAR Retrospective runs.

5.5 MSY Proxy analyses for dab in Subarea 4 and Division 3.a.

5.5.1 Dab 27.3a4 Surplus Production Model in Continuous Time (SPiCT)

In order to estimate MSY proxy reference points for dab a Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was applied. Three fishery independent survey time series and a catch time series (2002–2017) were used as input for the model (details of model input and settings given in Table 5.2). The survey time series were reduced by the recruits (i.e. > 12 cm or > age 1) in order to obtain a better proxy for the exploitable biomass, which is a prerequisite for any production model.

Table 5.2. Dab in Subarea 4 and Division 3.a. SPiCT settings and input data.

SETTING/DATA	VALUES/SOURCE
Catch time series	InterCatch data 2002–2017
BTS Isis	1987–2002, >12 cm
BTS Tridens	1996–2002, >12 cm
Combined BTS (Isis, Tridens, Solea)	2003–2017, Age > 1yr
SPiCT settings	Default from stockassessment.org, no priors

The results of the SPiCT assessment for dab in Subarea 4 and Division 3.a showed that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is above the reference B_{MSY} * 0.5 proxy. Also the estimated uncertainty boundaries around the relative F values show that these are below the reference F_{MSY} proxy for recent years, and those estimated for the relative biomass are above the reference

BMSY* 0.5 for recent years. However, it has to be noted here that the absolute F and biomass estimates are highly uncertain and must not be used for any further analyses or conclusions. All results of the SPiCT assessment are given in figures 5.22–5.28.

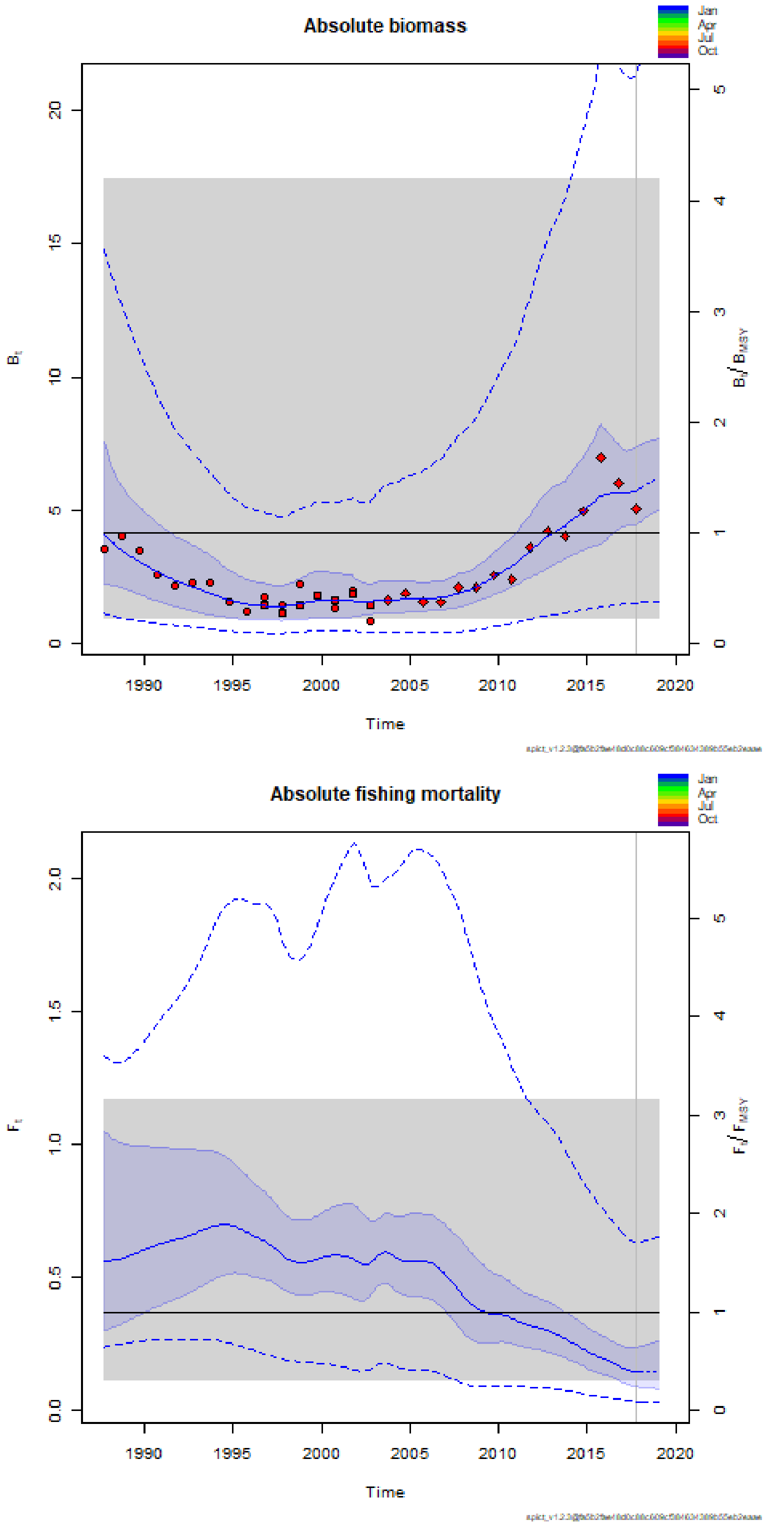


Figure 5.22. Dab in Subarea 4 and Division 3.a: SPiCT results. Absolute biomass (upper panel) and absolute fishing mortality (lower panel).

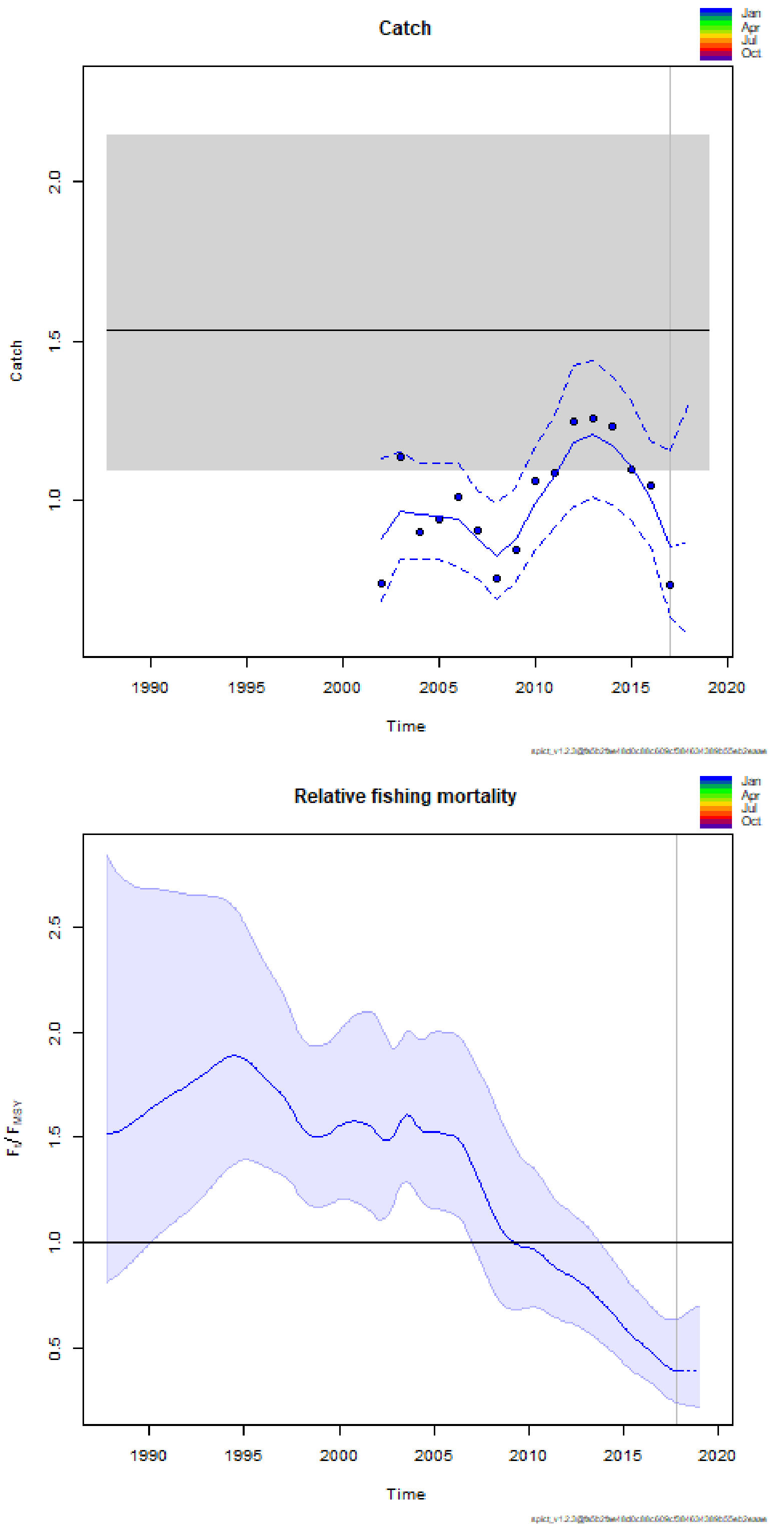


Figure 5.23. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch time series (upper panel) and relative fishing mortality (lower panel).

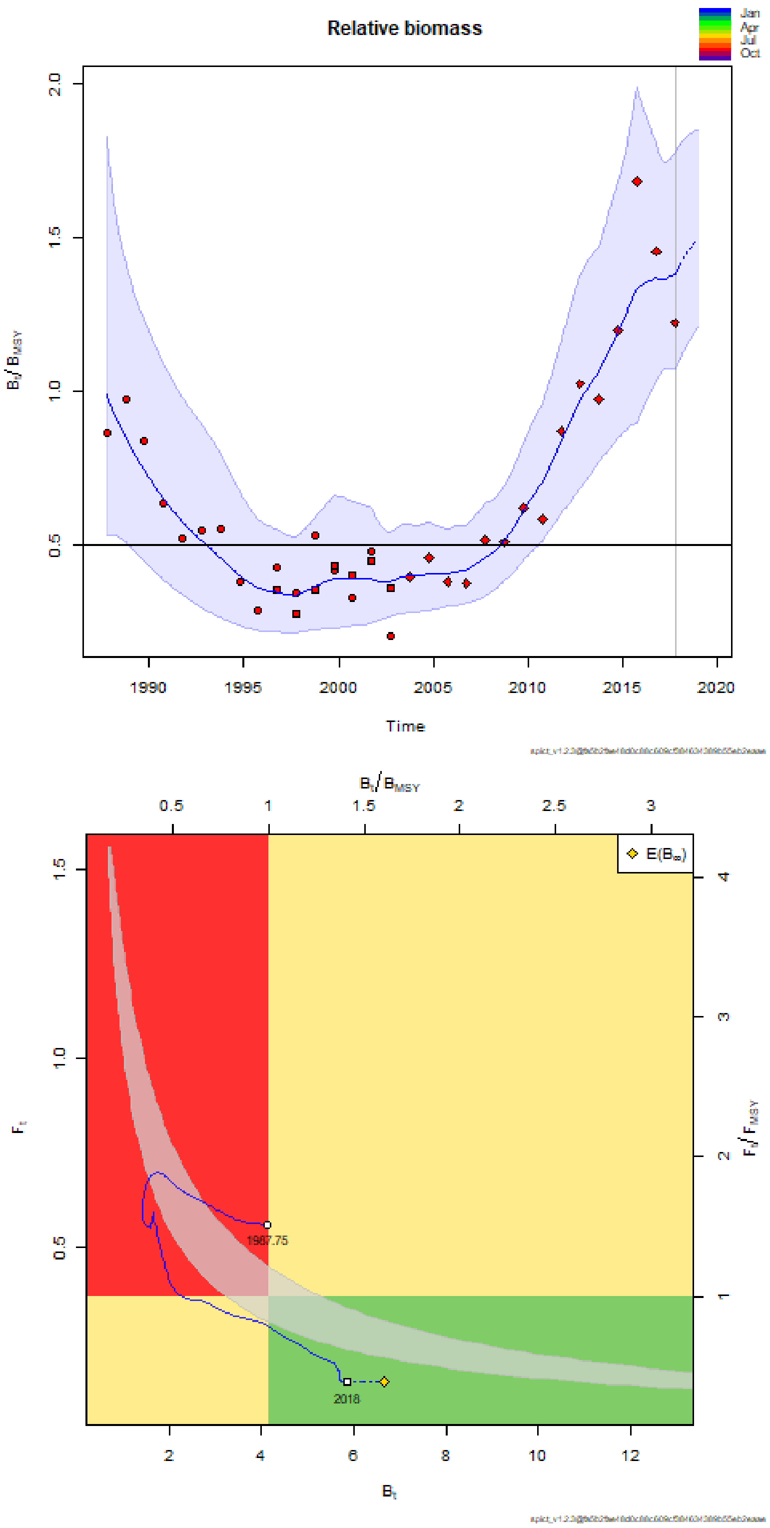


Figure 5.24. Dab in Subarea 4 and Division 3.a: SPiCT results. Relative biomass (left panel) and Kobe plot of relative fishing mortality over biomass estimate (right panel).

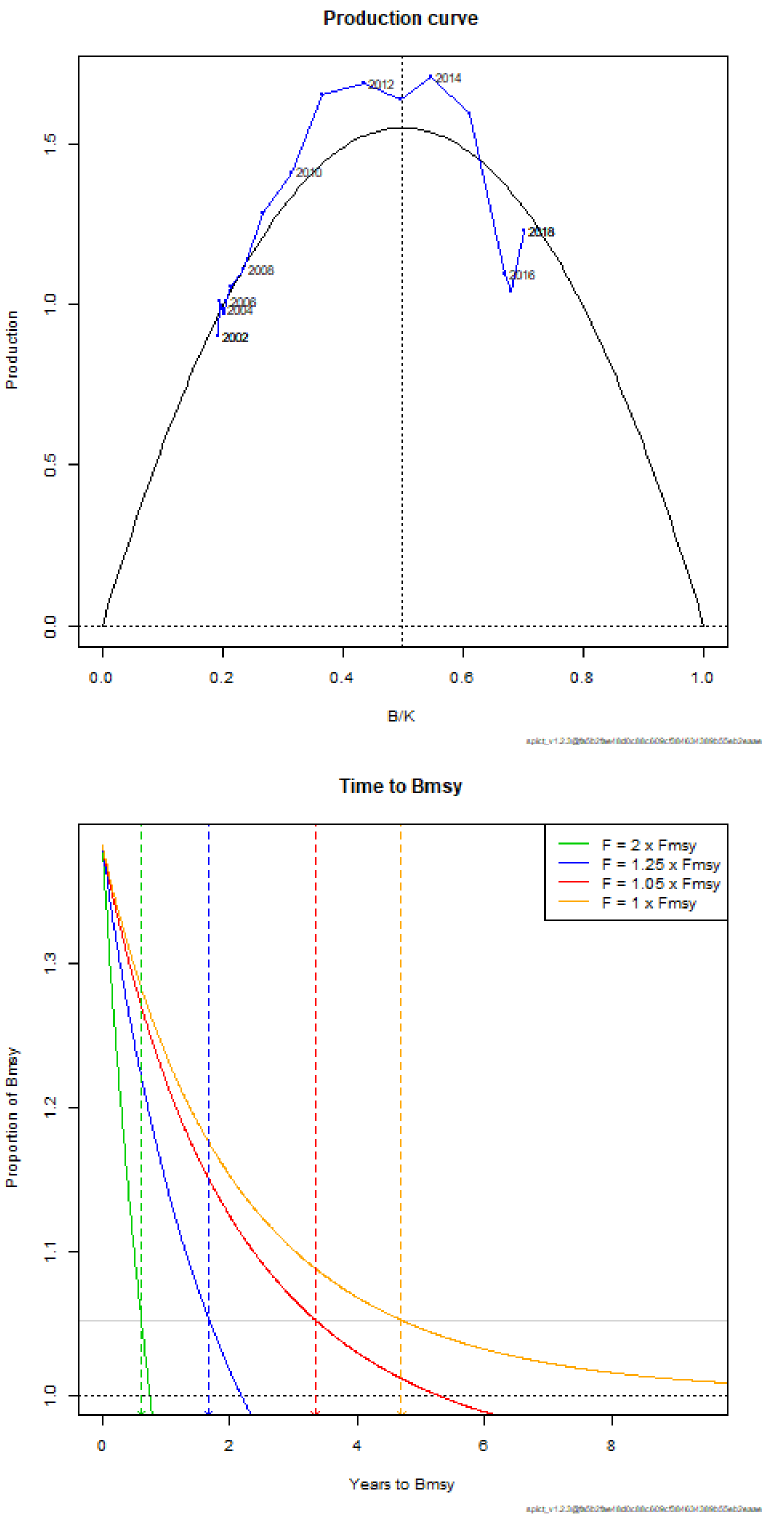


Figure 5.25. Dab in Subarea 4 and Division 3.a: SPiCT results. Production curve (upper panel) and estimated time to BMSY (lower panel).

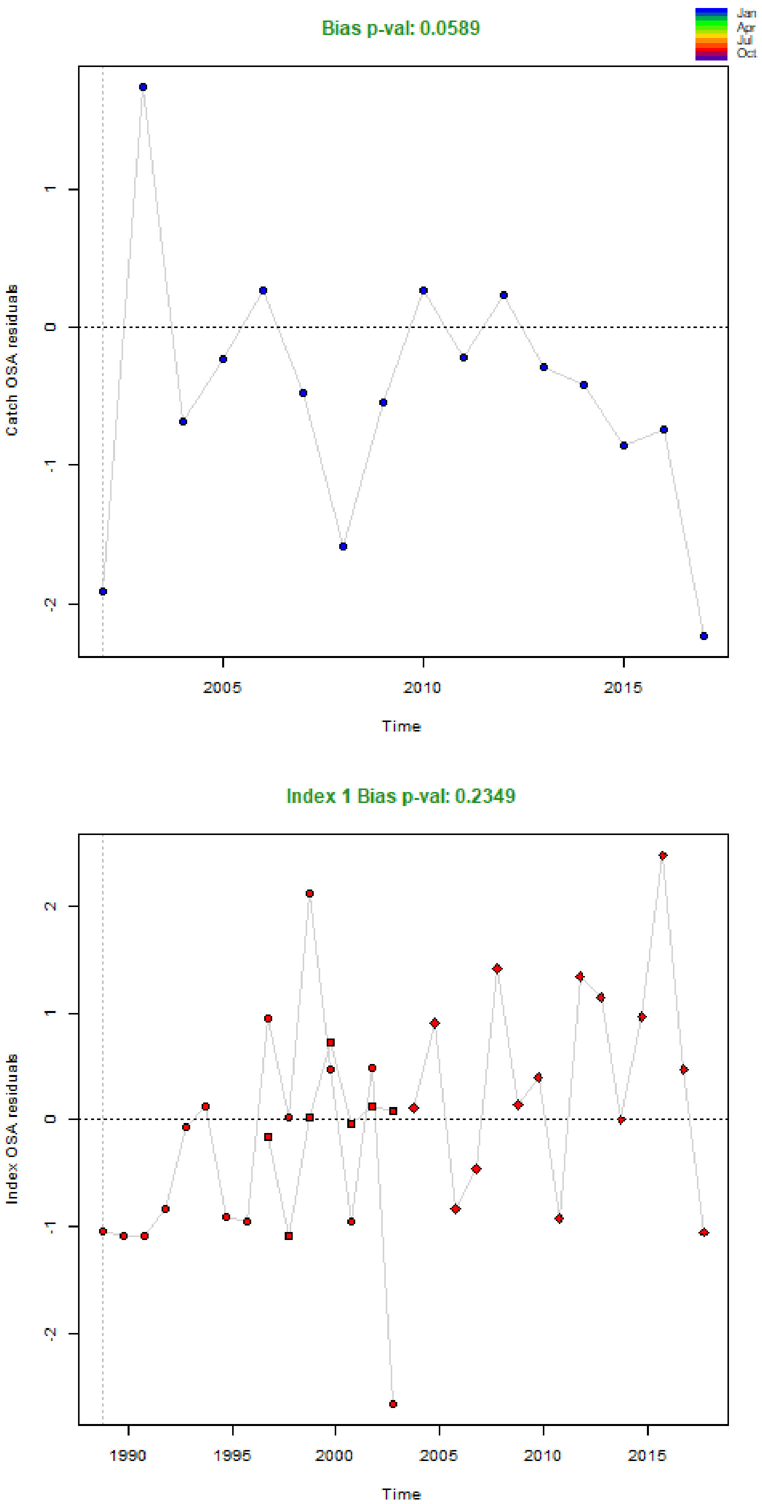


Figure 5.26. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch residuals (upper panel) and survey residuals (lower panel).

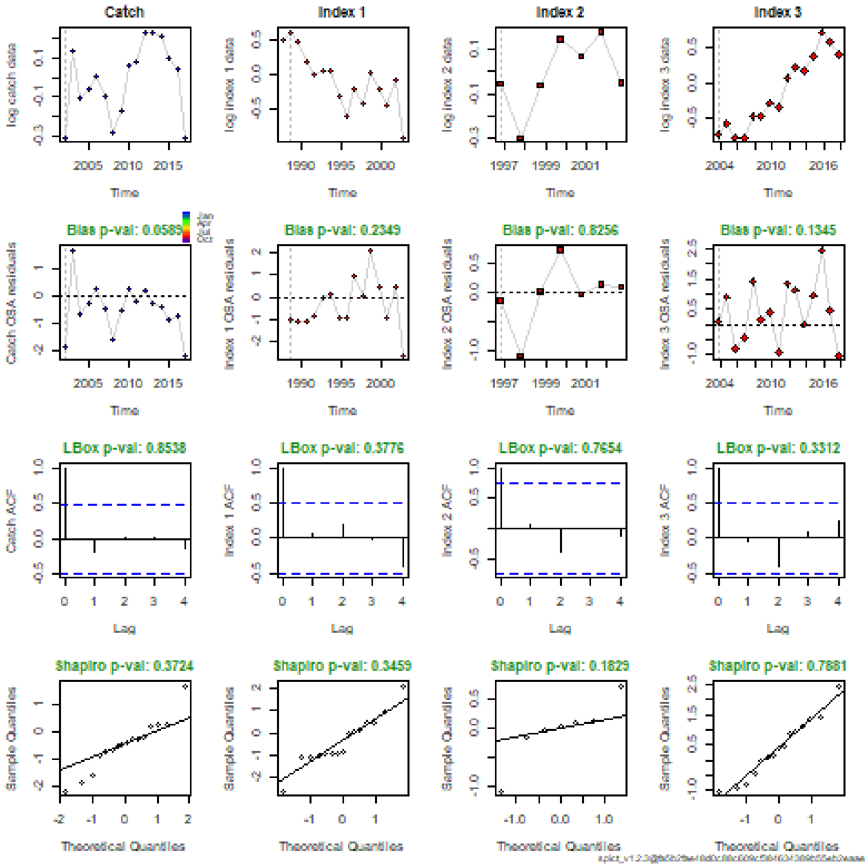


Figure 5.27. Dab in Subarea 4 and Division 3.a: SPiCT diagnostics.

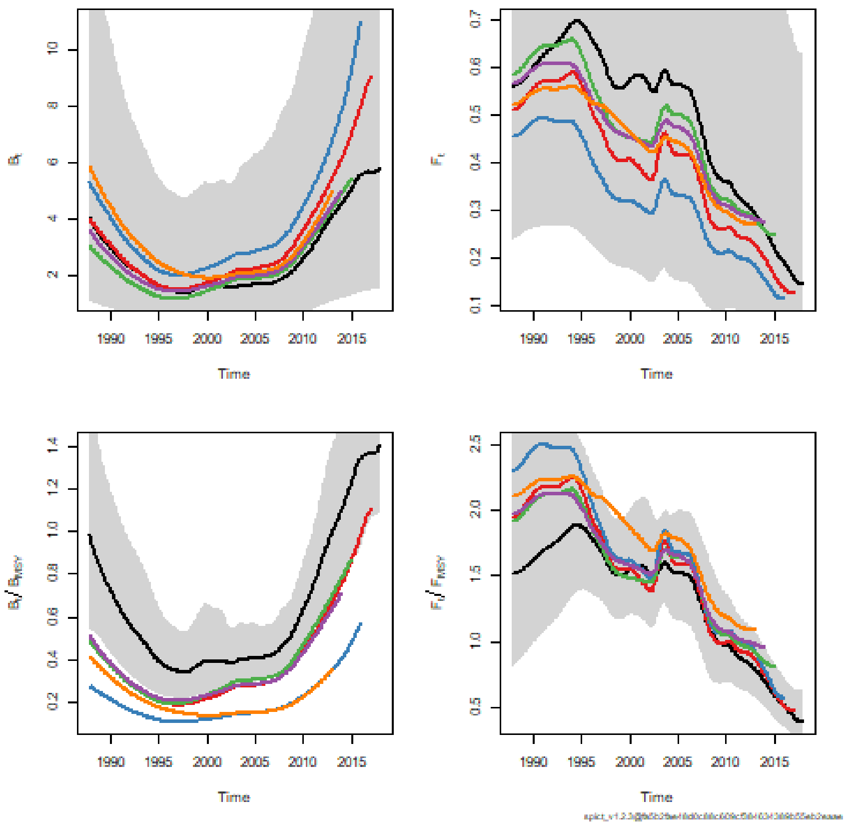


Figure 5.28. Dab in Subarea 4 and Division 3.a: SPiCT retrospective plots.

5.6 References

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5.7 Tables

Table 5.3. Official dab landings by ICES Subarea 4 and Division 3.a.

Year	Subarea 4	Division 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
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

Year	Subarea 4	Division 3.a	Total
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	917	4512
2016*	4070	883	4953
2017	2751	778	3529

*** preliminary catch statistics**

Table 5.4. Official dab landings by country in Subarea 4.

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Subarea 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
1993	548	493	1016	235	0	1017	0	0	0	3309

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Subarea 4
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
2016*	321	244	412	75	0	372	2611	35	0	4070
2017*	210	125	340	n.a.	0	379	1662	35	0	2751

*** preliminary catch statistics**

Table 5.5. Official dab landings in ICES Division 3.a.

Year	Bel	Deu	Dnk	Fra	Nld	Nor	Swe	Division 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
1993	7	0	1656	0	0	0	32	1695

Year	Bel	Deu	Dnk	Fra	Nld	Nor	Swe	Division 3.a
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	8	687	0	191	8	23	917
2016*	0	9	647	0	189	14	24	883
2017*	0	5	601	0	146	14	12	778

*** preliminary catch statistics**

Table 5.6. Dab in Subarea 4 and Division 3.a.: InterCatch landings, discards and total catch (2002–2017).

Year	Landings	Imported discards	Raised discards	Total discards	Total catch	% discards
2002	8588	14448	12183	26631	35219	76%
2003	9433	22152	22778	44930	54363	83%
2004	8647	18559	15714	34273	42920	80%
2005	9537	21295	13996	35291	44828	79%
2006	10236	16106	21871	37977	48214	79%
2007	9881	8936	24392	33328	43208	77%
2008	8645	14781	12598	27379	36024	76%
2009	7040	20652	12769	33421	40461	83%
2010	8279	23688	18798	42486	50765	84%
2011	7422	28227	16234	44460	51882	86%
2012	7047	33220	19412	52632	59679	88%
2013	6611	36855	16621	53476	60087	89%
2014	5047	35383	18350	53733	58780	91%
2015	5082	26468	20904	47372	52454	90%
2016	5085	29023	15788	44811	49896	90%
2017	3598	22241	9274	31515	35113	90%

6 Flounder in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat)

6.1 General

Flounder (*Platichthys flesus*) in Subarea 4 and Division 3.a was assessed until 2013 in the Working Group on Assessment of New MoU Species (ICES, 2013a). Because only official landings and survey data were available, flounder was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for flounder is given since 2013 by ICES (ICES, 2013b) based on survey trends. Since 2015 flounder was included in the official data call for the WGNSSK and discard estimates were included into the assessment. During the WGNSSK 2017 methods to determine MSY proxy reference points were tested. Only the Length Based Indicator method was accepted at that time and revealed that the North Sea flounder stock was fished at or below F_{MSY} proxy. The assessment for flounder in Subarea 4 and Division 3.a was benchmarked in 2018 and a SPiCT model was set up to evaluate the stock status of flounder relative to MSY proxies (ICES, 2018). Catch advice for dab was prepared for 2017 and 2018 during the WGNSSK 2017 (ICES, 2017a). However, in 2017 the combined TAC for dab and flounder was removed (EU COM, 2017/595), and North Sea flounder has become a non-target species with no TAC since then. ICES has not been requested to provide advice on fishing opportunities for these stocks. Therefore, there was no need to reopen the advice. However, catch data, survey indices and the SPiCT assessment were updated and presented.

6.1.1 Biology and ecosystem aspects

Flounder is a 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.

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.

In the North Sea, Skagerrak and Kattegat flounder spawn between February and April. 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. During autumn, both mature and immature flounder withdraw from the inshore and estuarine feeding areas. Juvenile flounder migrate into coastal areas, where they spend the winter.

6.1.2 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 (ICES, 2013a).

6.1.3 Management regulations

There is no minimum landing size for this species in EU waters.

Flounder is mainly a bycatch species in fisheries for plaice and sole. The discard rates for flounder can be (~40%). No minimum landing size is defined for flounder. According to EU-Regulations a precautionary TAC was given in EU waters of Division 2a and Subarea 4 together with dab (*Limanda limanda*). This combined TAC was never fully utilized. In 2017, the European Commission requested ICES to evaluate the possible effects on the stocks of flounder and dab having no TAC. ICES advised that given the current fishing patterns of the main fleets catching flounder and dab, which are the same fleets targeting plaice and sole, the risk of having no TAC for the flounder and dab stock is considered to be low (ICES, 2017b). Therefore, the European Commission removed the combined TAC for these two stocks (EU COM, 2017/595).

6.2 Fisheries data

6.2.1 Historical landings

In the North Sea and in the Skagerrak and Kattegat flounder is mainly a bycatch 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 (Figure 6.1; Table 6.1). Landings in ICES Subarea 4 and Division 3.a by country are shown in Figures 6.2 and 6.3 and in Tables 6.1 and 6.2. The apparent decrease in official landings between 1984 and 1997 is due to unreported landings by the Netherlands. Further, there seem to be an issue with Danish and German official landings in Subarea 4 which drastically dropped after 1997 (Figure 6.3, red and black bars). At least the drastic decline in Danish landings could be explained by a combined TAC for dab and flounder which was established in 1998, i.e. that before 1998 partly combined dab and flounder landings may have been reported by the Danish fishery. Another reason maybe misreporting to flounder from other quota species from the fishery in area 4 before the TAC came in force in 1998.

Since 1950, annual landings from the North Sea have fluctuated, without any clear pattern (Figure 6.1). During 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 2017, total official landings were reported with 1262 tonnes, compared to 1738 tonnes in 2016. This is the lowest value observed in the whole time series. In Area 3.a, annual landings in general have decreased sharply from mid of the 1980s until 2015. Official landings increased slightly in 2016 and also 2017 (159 tonnes), but they are still on historical low levels (108 tonnes in 2016; 77 tonnes in 2015; Figure 6.2).

Flounder is of relatively little commercial importance in the North Sea and the Skagerrak/Kattegat. Landings data may have been misreported in previous years. However, the amount of misreporting is not known. In addition, the official landings may not reflect the total catches, because flounder is often discarded and discarding is influenced by the prices and the availability of other, commercially more important species and therefore cannot be estimated for years without observations.

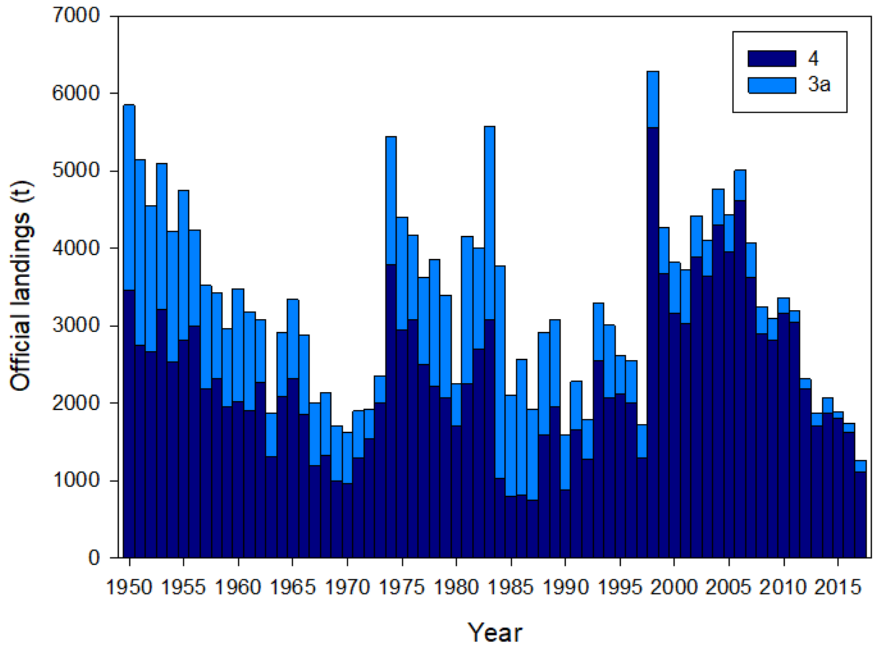

Figure. 6.1. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder by area.

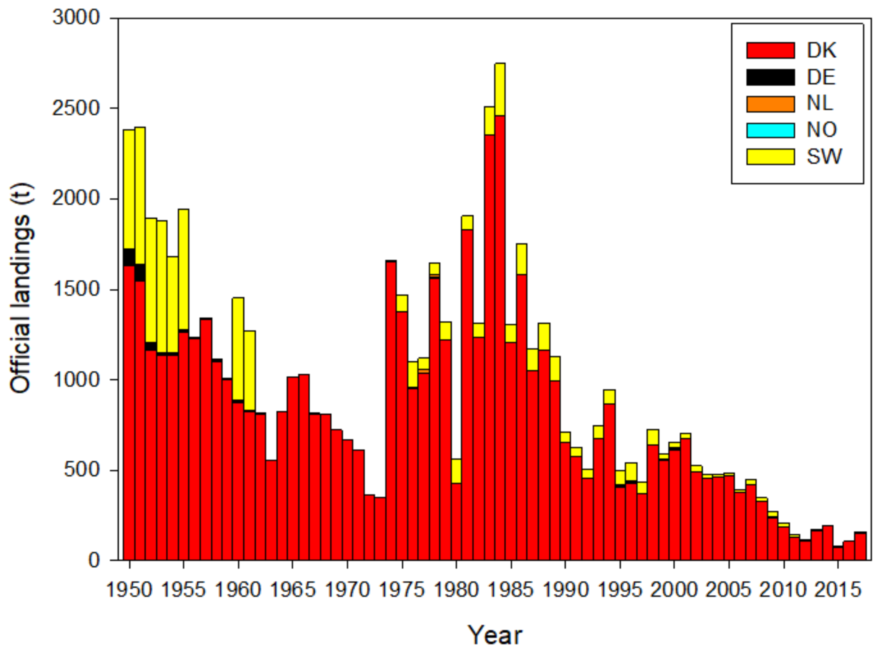

Figure 6.2. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder in ICES Division 3.a by country.

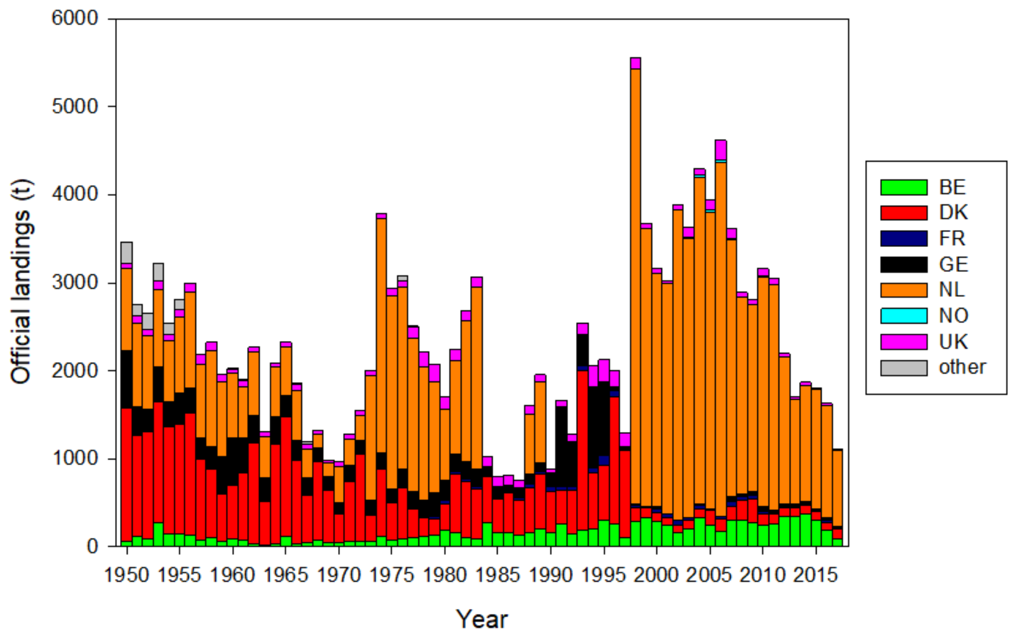

Figure 6.3. Flounder in Subarea 4 and Division 3.a: Official landings of flounder in ICES Subarea 4 by country.

6.2.2 InterCatch

For the WGNSSK 2018 flounder landings and discards data from 2002–2017 were available in the InterCatch system. Norway did not report any discards because of the official discard ban for the Norwegian fleet.

In general it was tried only to raise equivalent or similar métiers with each other in InterCatch. Discard information was provided for 90% of total landings in relation to weight in 2017 (Figure 6.4). However, for a number of métiers zero landings were reported. For these no raising with InterCatch was possible.

In 2017, by far the largest proportion of landings (754 tonnes, ~61% of total landings) was reported by Dutch beam trawlers (TBB_DEF_70_99_0_0_all), followed by the Danish MIS_MIS_0_0_0_HC métier (93 tonnes) and the Belgian TBB_DEF_70_99_0_0_all (90 tonnes). Other métiers landing flounder in considerable amounts did in general not land more than 65 tonnes each (Figure 6.5). The highest amount of discards in 2017 was reported for the Danish OTB_CRU_90-119_0_0_all (190 tonnes) and Belgian TBB_DEF_70_99_0_0_all (118 tonnes) métiers (Figure 6.6).

A problem in the estimation of total flounder discards maybe the TBB_CRU_16-32_0_0_all métier targeting brown shrimps in more coastal areas. For this métier relatively high discards but extremely low landings were reported by Germany. The Netherlands and Belgium reported landings but no discards. It is 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 métier by The Netherlands this might lead to an 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 métiers with zero landings for which no discards can be raised although they might occur in these métiers.

The largest total catch is taken by the Netherlands, followed by Belgium (233 tonnes) and Denmark (390 tonnes). All other countries catch less than 100 tonnes (Figure 6.7). The total catch estimated with InterCatch was 1832 tonnes from which 1244 tonnes were landings (compared to 1262 tonnes reported official landings) and 588 tonnes discards (32% of the total catch). However, it should be noted that not all métiers were sampled in every quarter and that the raising procedure may not be adequate for all cases.

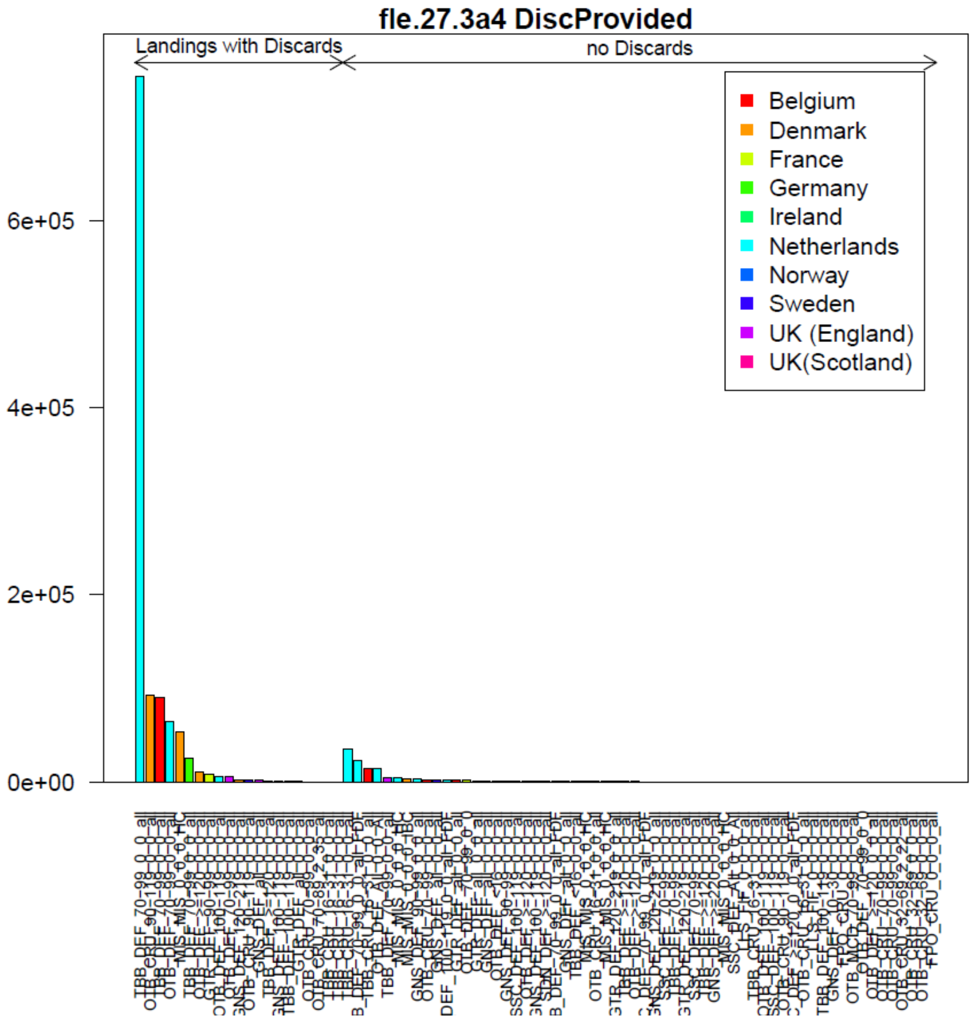

Figure 6.4. Flounder in Subarea 4 and Division 3.a: Provision of discards information by country and fleets.

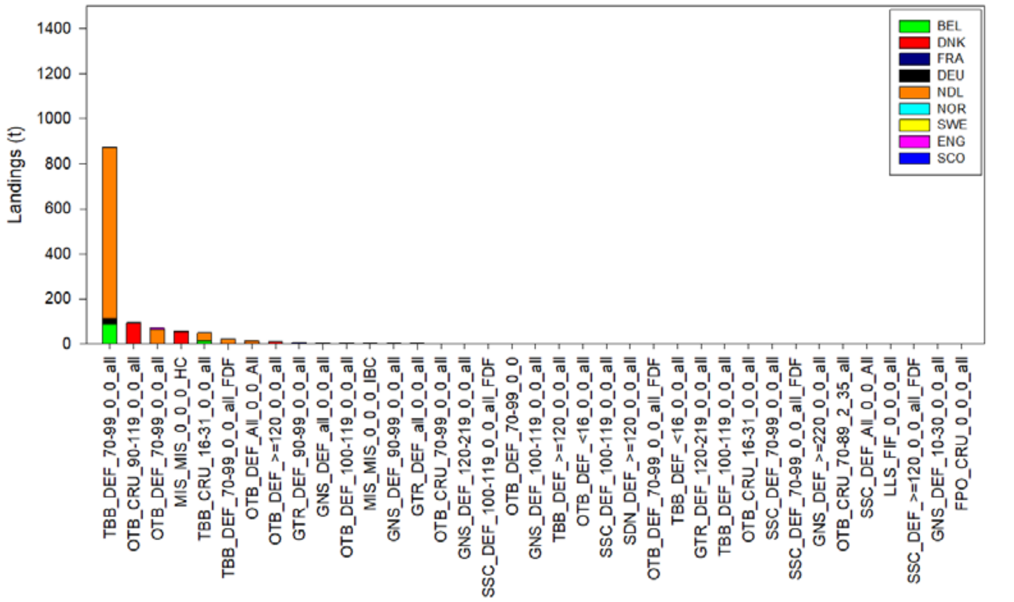

Figure 6.5. Flounder in Subarea 4 and Division 3.a: Flounder landings by métier and country in 2017 as uploaded to InterCatch.

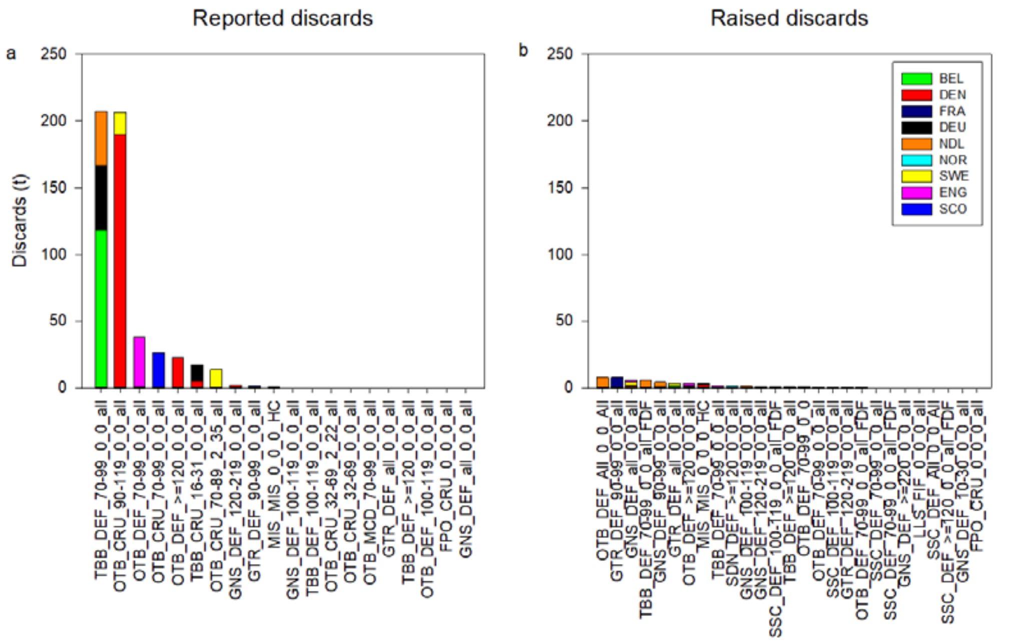

Figure 6.6. Flounder in Subarea 4 and Division 3.a: Flounder discards by métier and country in 2017. Reported discards panel (a), raised discards panel (b).

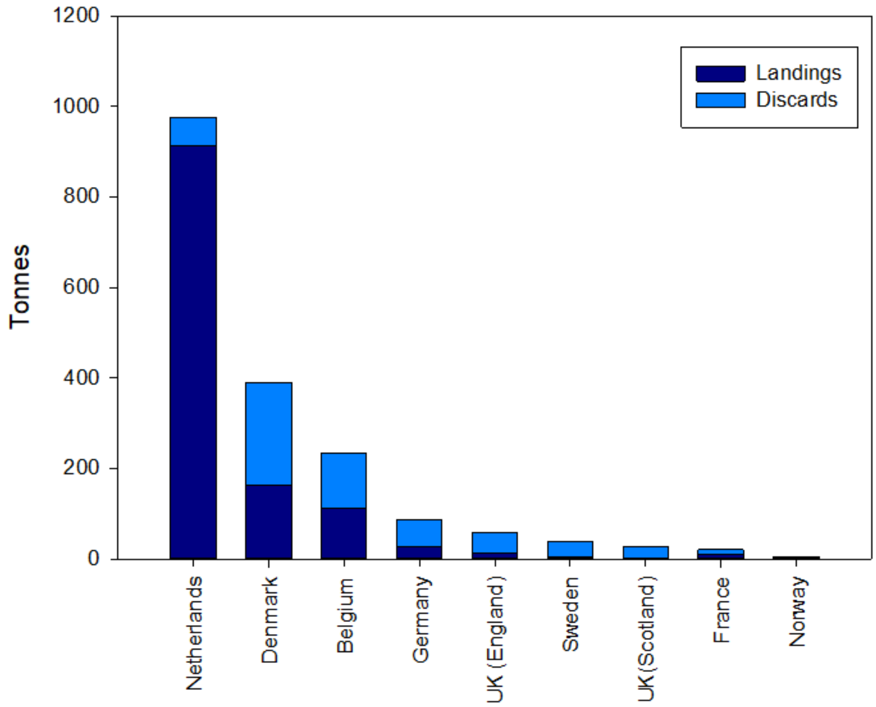

Figure 6.7. Flounder in Subarea 4 and Division 3.a: Flounder landings and discards by country in 2017 estimated with InterCatch.

6.3 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 because it covers the whole distribution area of the stock and shows a higher catchability compared to the beam trawl surveys. 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 WGNEW 2013 to use the IBTS–Q1 to analyse survey trends for this species. It should be noted here that the IBTS was not fully standardized before 1983. Therefore, index data before this year should be interpreted with caution and are not presented in this report.

The mature biomass index (kg/hour) was based on the IBTS–Q1 survey which covers most of the distribution area of flounder in Subarea 4 and Division 3.a. Roundfish areas 1 and 2 were excluded from the analyses because flounder does only occur very occasionally in these areas (Figure 6.8). To estimate a mature biomass index (kg/hour) a length weight relationship derived from IBTS–Q1 data was applied (Figure 6.9). The same data set shows that above 20 cm probably most flounder are mature (Figure 6.10). Therefore, only data > 20 cm were taken into account to calculate the index.

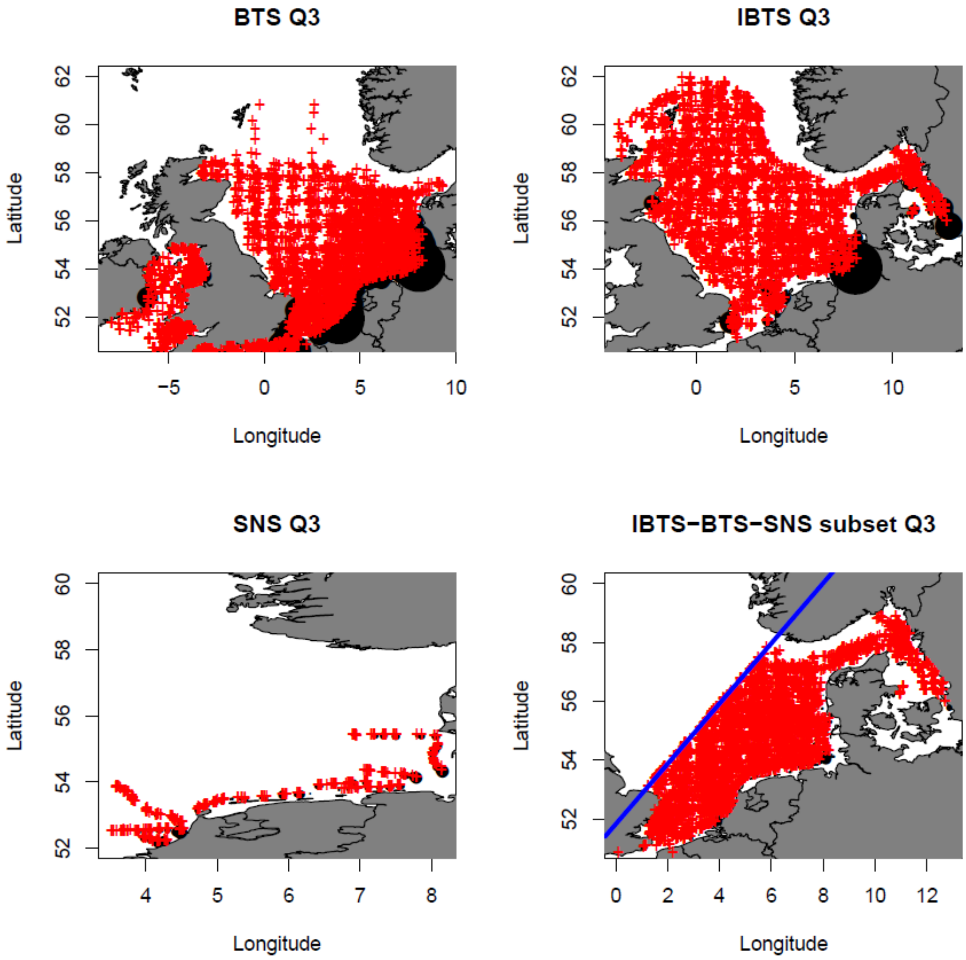

Figure 6.8. Flounder in Subarea 4 and Division 3.a: Distribution of flounder derived from different bottom trawl surveys in Subarea 4 and Division 3.a and the defined index area (lower right panel).

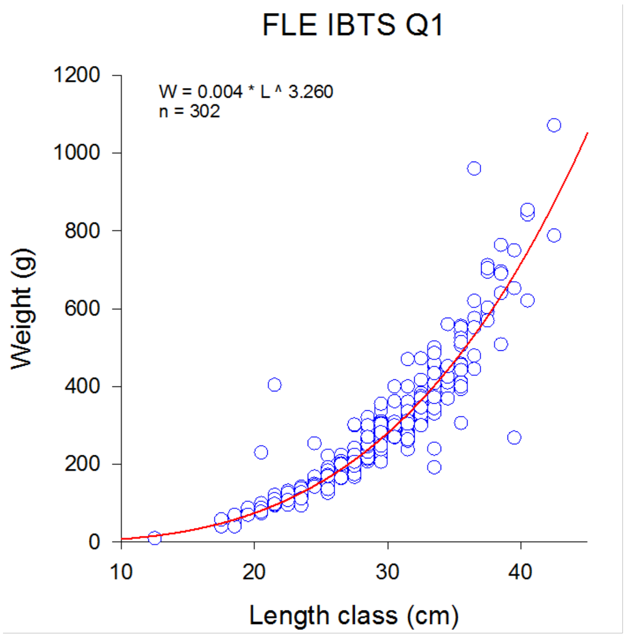

Figure 6.9. Flounder in Subarea 4 and Division 3.a: Length weight relationship of flounder derived from IBTS–Q1 data.

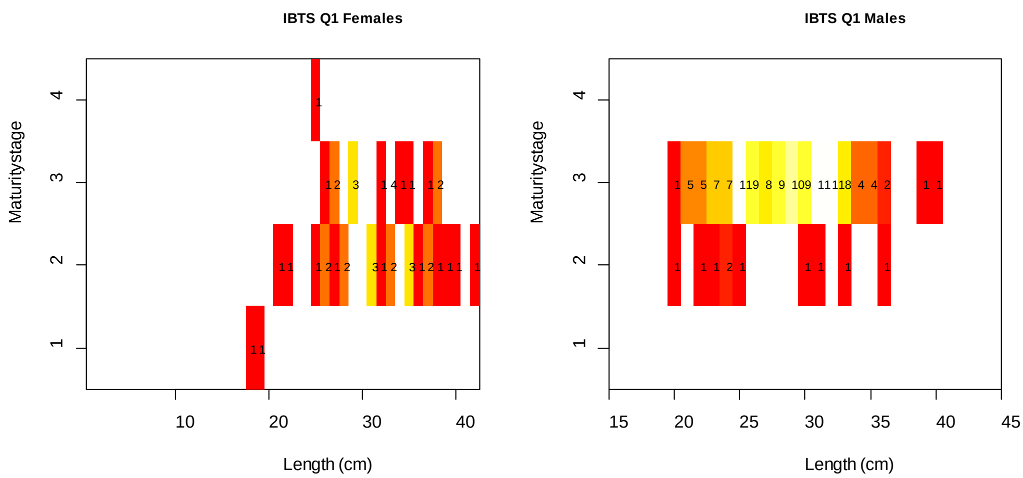

Figure 6.10. Flounder in Subarea 4 and Division 3.a: Maturity at length of female and male flounder derived from IBTS–Q1 data.

The biomass index shows a rather stable trend from 1983 onwards with two major peaks between 1985 and 1995 (Figure 6.11). From 1997 to 2002 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 from 2015 to 2017 are again somewhat higher. In 2018 again a decrease was observed.

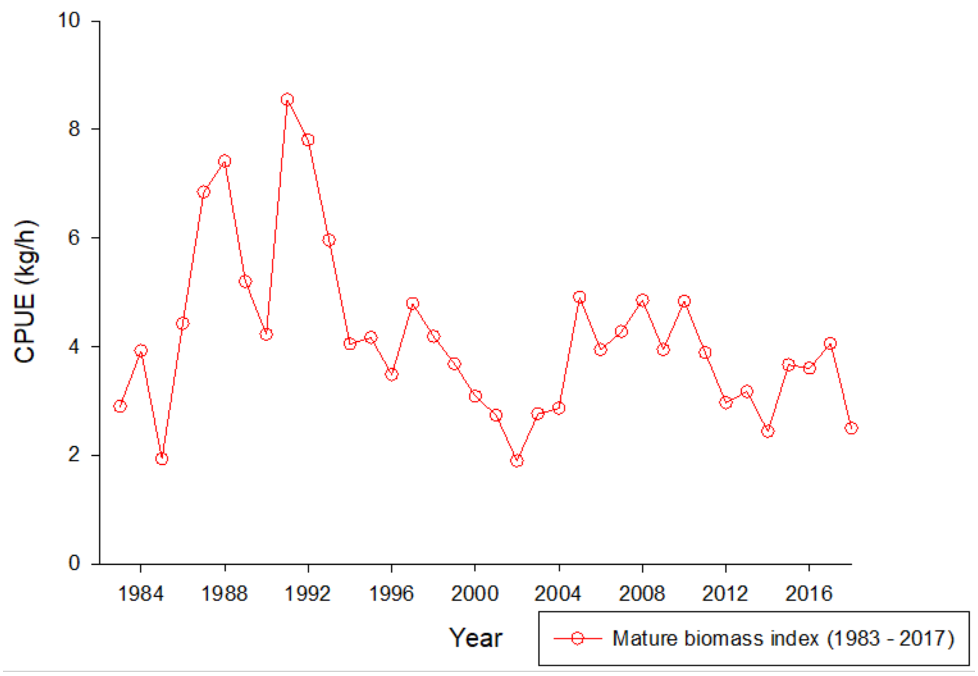

Figure 6.11. Flounder in Subarea 4 and Division 3.a: Mature biomass index of flounder in Subarea 4 and Division 3.a derived from IBTS–Q1 data 1983–2018.

New survey indices

The flounder assessment was benchmarked in 2018 and two new survey indices were constructed and used since then: the IBTS quarter 1 and a combined quarter 3 index (IBTS, BTS, SNS), both indices modelled with the deltaGAM method (Berg *et al.*, 2014). For both indices a new index area was defined (Figure 6.8 lower right panel) which is restricted to the south-eastern part of the North Sea and Division 3.a. In quarter 3, four gear types were used in the different beam trawl surveys (BT8, BT7, BT6, and BT4) and the GOV in the IBTS survey. Therefore, a gear effect was included to model a combined quarter 3 index for flounder.The following models where formulated:

Quarter 1

$$g(\mu_i) = Year(i) + f_1(lon_i + lat_i) + f_2(depth_i) + \log(HaulDur_i)$$

Quarter 3 – with gear effect

$$g(\mu_i) = Year(i) + Gear(i) + f_1(lon_i + lat_i) + f_2(depth_i) + log(HaulDur_i)$$

The new IBTS quarter 1 index shows very similar trends as the old IBTS quarter 1 based mature biomass index with some higher values at the beginning of the time series (compare Figures 6.11 and 6.12). Since 2000, the index is fluctuating without any clear trends. Since 2015, the index decreased. The combined quarter 3 index does not show any clear trends but has some higher values in the later part of the time series compared to the beginning. However, since 2014 the values decreased.

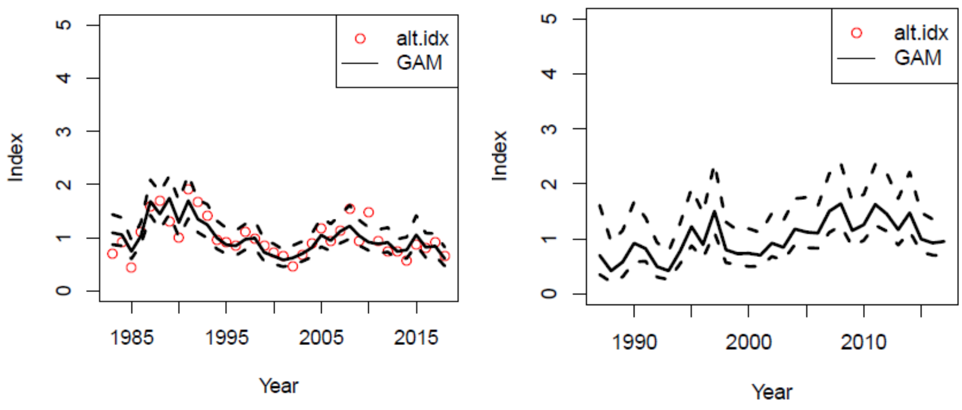

Figure 6.12. Flounder in Subarea 4 and Division 3.a: IBTS Quarter 1 biomass index (left panel; black line = deltaGAM index, red dots = stratified mean index) and combined quarter 3 biomass index (right panel).

6.4 MSY Proxy analyses for flounder in Subarea 4 and Division 3.a.

6.4.1 Surplus Production Model in Continuous Time (SPiCT)

During the benchmark assessment, a SPiCT model (Pedersen and Berg, 2017) for flounder was accepted to estimate MSY proxies for the North Sea flounder stock. The model was updated during the WGNSSK 2018 with the most recent catch and survey data. The results are summarized below. Details can be found in the benchmark report (ICES, 2018).

Input data

Based on the InterCatch raising procedure a catch time series for the years 2002–2016 was available and used (Figure 1a; WKNSEA, 2018). Prior to 2002, only official landings for flounder were available (1950–2001), but no discard information. To account for the missing discard information the average discard ratio of 0.48 (2002–2016) obtained from the InterCatch data was used to top up the official landings. However, Dutch landings for the time period 1984–1997 are not available and these landings had to be reconstructed. This was done by raising the available official landing with a factor. This factor was based on the proportion of Dutch landings to the total landings for the time period with full data available.

A biomass index from the IBTS quarter 1 (1983–2016) and a biomass index combining the quarter 3 surveys IBTS, BTS and SNS (1987–2016) were used. These indices were calculated by applying the deltaGAM method (Berg *et al.*, 2014).

Different runs and scenarios were tested during the benchmark assessment (ICES, 2018). In the final run both indices were kept in the model, but the combined quarter 3 index was truncated to the time period 2002–2016, i.e. the time period for which all of the used surveys provide data. This model only converged by setting the prior on sd log(n) to 1. However, the strong residual pattern of the indices disappeared and the retro runs revealed good results. Thus, it was decided to keep this model as final run because it produced the best results in terms of uncertainty and the retro analyses, while keeping most information possible from the different surveys without any issues in the model diagnostics. This run showed that the relative fishing mortality (F_t/F_{MSY}) was below 1.0 and the relative biomass (B_t/B_{MSY}) was above 0.5. It should be noted here that the use of the prior probably leads to an underestimation of the real uncertainties. However, all scenarios tested showed similar results with relative fishing mortality below the F_{MSY} proxy and relative biomass above the B_{MSY} proxy within their observed uncertainties.

Updated results WGNSSK 2018

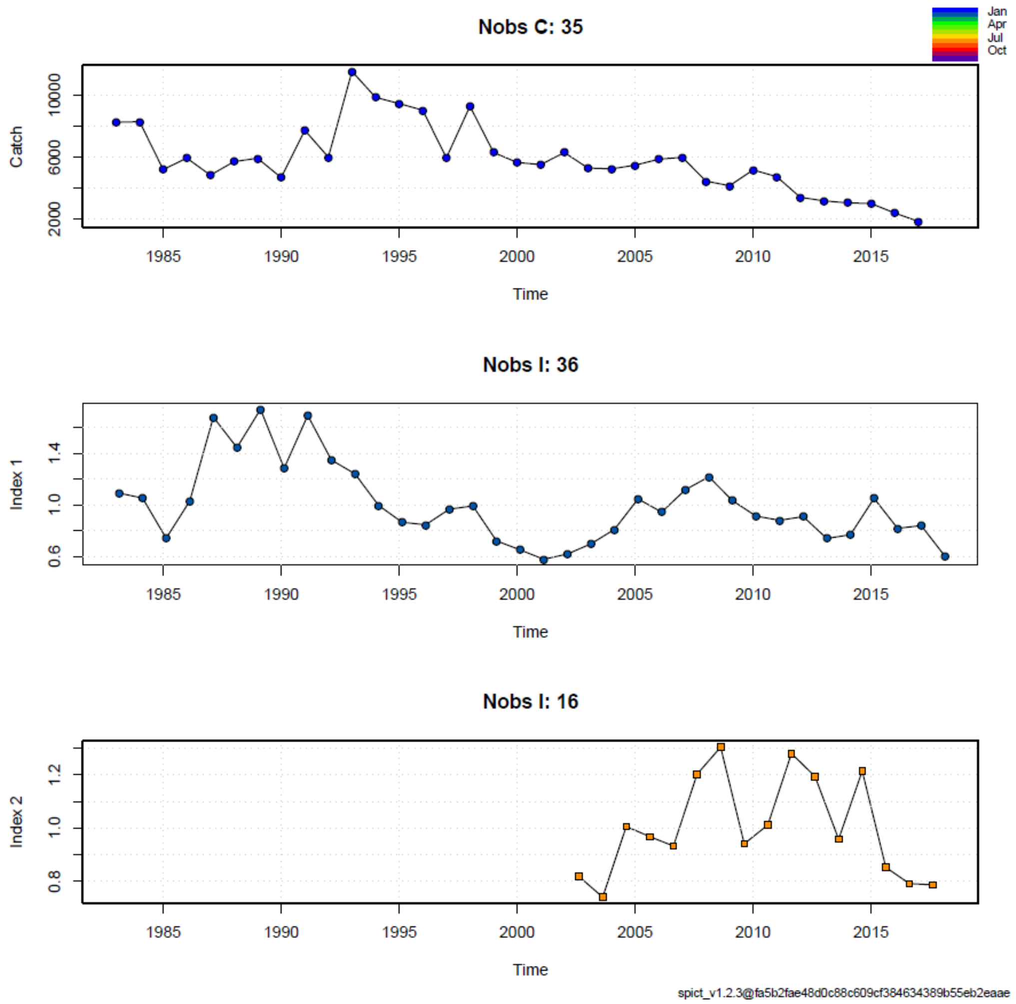

Figure 6.13. Flounder in Subarea 4 and Division 3.a: Input data for the SPiCT model: catch time series (upper panel), IBTS Q1 index (middle panel), and combined quarter 3 index (lower panel).

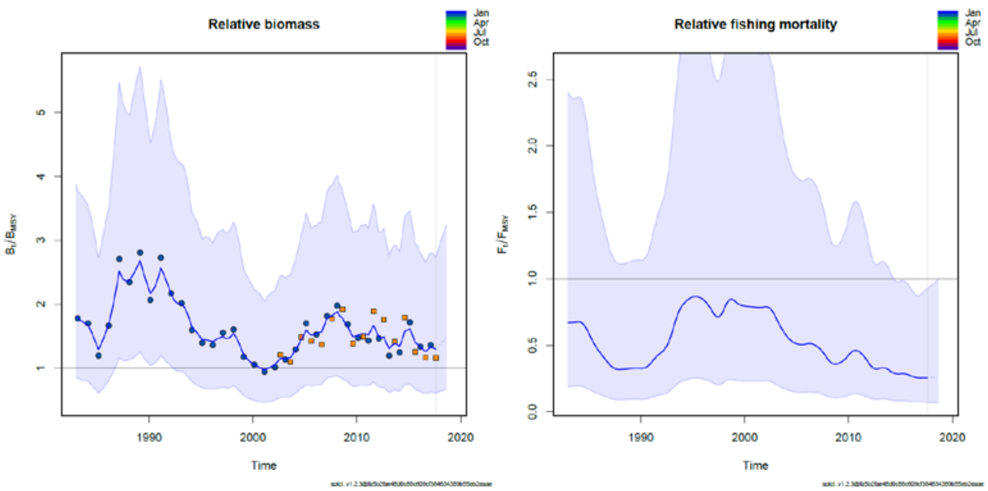

Figure 6.14. Flounder in Subarea 4 and Division 3.a: Relative biomass (left panel) and relative fishing mortality obtained from the SPiCT assessment.

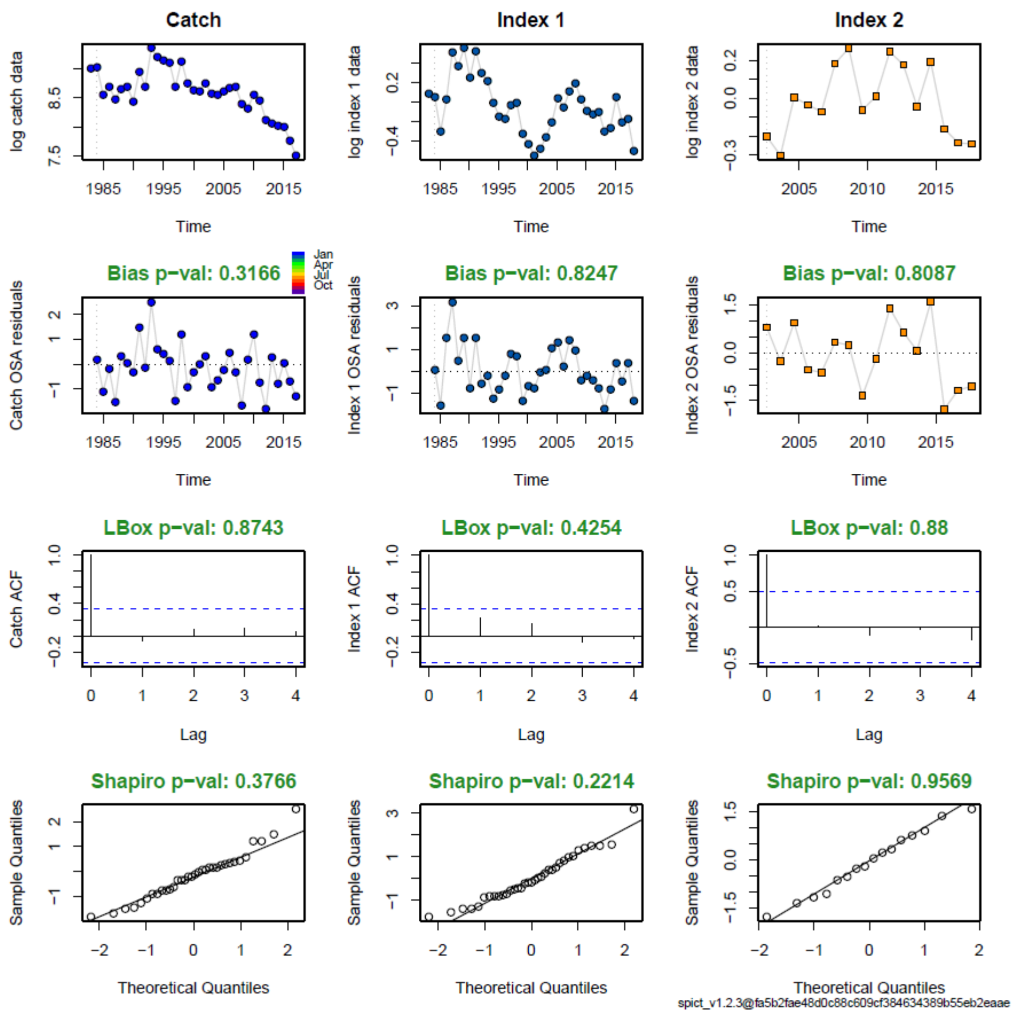

Figure 6.15. Flounder in Subarea 4 and Division 3.a: Model diagnostics of the SPiCT assessment.

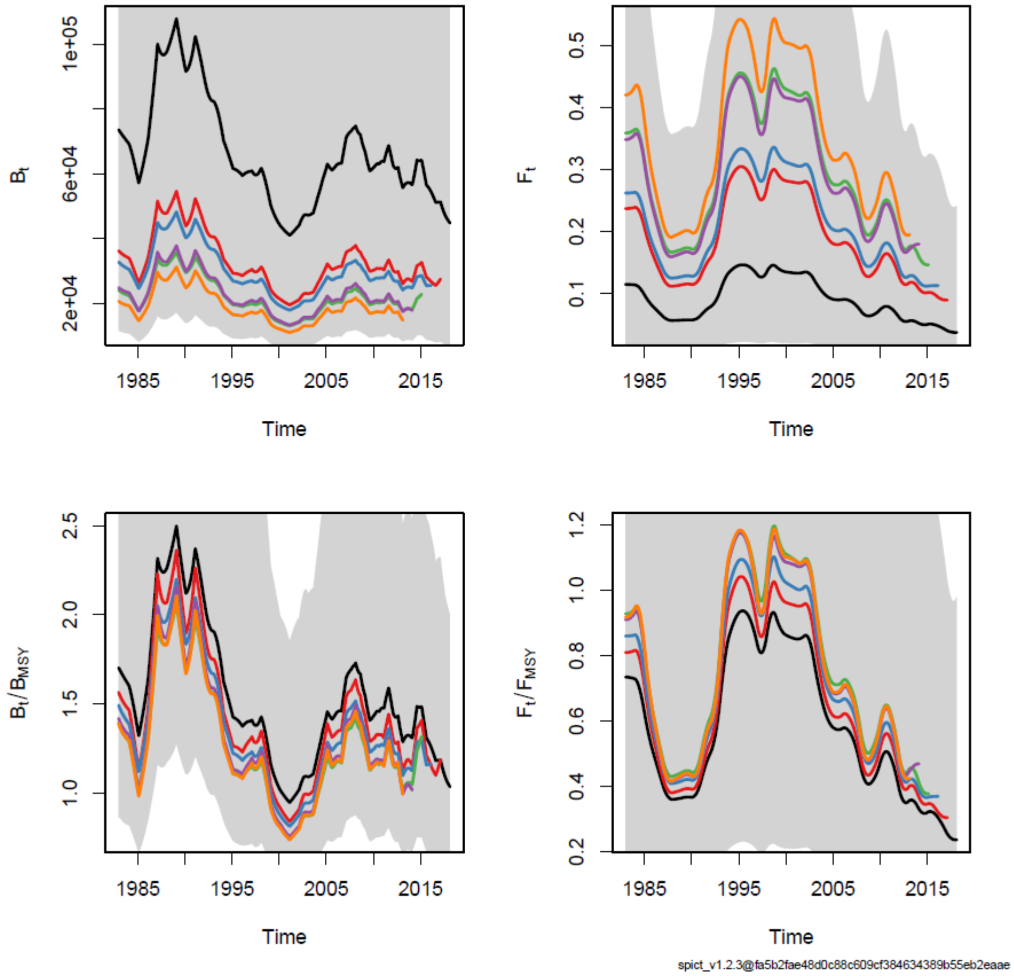

Figure 6.16. Flounder in Subarea 4 and Division 3.a: Retrospective diagnostics for the SPiCT model.

6.5 References

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6.6 Tables

Table 6.1. Flounder in Subarea 4 and Division 3.a: Flounder official landings by country in ICES Subarea 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
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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
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	376	107	15	30	1314	0	31	0	1873
2015	277	97	19	19	1409	0	15	0	1836
2016*	194	87	20	27	1277	0	25	0	1630
2017*	97	101	n.a.	28	862	1	14	0	1103

***Preliminary catch statistics**

Table 6.2. Flounder in Subarea 4 and Division 3.a: 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
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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
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
2016*	105	0	0	0	3	108
2017*	153	0	0	1	5	159

***preliminary catch statistics**

Table 6.3. Flounder in Subarea 4 and Division 3.a: Flounder total official landings by ICES areas.

Year	Division 3.a	Subarea 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
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

Year	Division 3.a	Subarea 4	Total
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	2068
2015	77	1806	1913
2016*	108	1630	1738
2017*	159	1103	1262

***preliminary catch statistics**

Table 6.4. Flounder in Subarea 4 and Division 3.a: Total official landings, InterCatch landings, discards and total catch.

Year	Official landings	IC landings	IC discards	IC total catch	Discard rate
2002	4414	4217	2084	6300	33.07%
2003	4110	3922	1370	5292	25.89%
2004	4772	4601	637	5239	12.16%
2005	4428	4214	1265	5479	23.09%
2006	5009	4837	1026	5863	17.50%
2007	4065	3908	2082	5991	34.76%
2008	3240	3067	1376	4444	30.97%
2009	3088	2804	1342	4146	32.38%
2010	3365	3166	3087	6254	49.37%
2011	3193	3041	1694	4735	35.77%
2012	2310	2189	1205	3394	35.49%
2013	1876	1750	1415	3165	44.71%
2014	2062	1907	1127	3035	37.15%
2015	1883	1762	1228	2990	41.07%
2016	1738	1750	628	2377	26.41%
2017	1262	1244	588	1832	32.10%

7 Grey gurnard (*Eutrigla gurnardus*) in Subarea 4, Divisions 7.d and 3.a (North Sea, Eastern English Channel, Skagerrak and Kattegat)

7.1 General

Grey gurnard (*Eutrigla gurnardus*) was assessed in the Working Group on the Assessment of New MoU Species (ICES, 2014) until 2014. Since 2015 the stock was assessed by the WGNSSK and defined as a category DLS 3.2 stock (ICES, 2015). For this stock only survey data and limited catch data (2012–2017) were available. Official landings data are incomplete or were not reported specifically for grey gurnard in the past. During the WGNSSK 2018 new available discard and landings data and IBTS mature biomass indices were updated. Length based methods were tested in order to define MSY proxy reference points for this stock. Given that the catch data are highly uncertain and only available for a short time period, the SPiCT model was not considered as an option for MSY proxies. Grey gurnard in Subarea 4, Divisions 7.d and 3.a is a non-target stock with no TAC. ICES has not been requested to provide advice on fishing opportunities for this stock.

7.1.1 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 ag-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 young age groups of a number of commercially important demersal stocks (cod, whiting, haddock, sandeel, and Norway pout) in the North Sea (de Gee and 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, 2017). The multispecies 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).

7.1.2 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 Division 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).

7.1.3 Management regulations

There is no minimum landing size for this species and there is no TAC.

7.2 Fisheries data

7.2.1 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 raised by survey information on the proportion of the specific gurnard species (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 Subarea 4 and to a much lesser extent in divisions 7.d and 3.a (Figure 7.1–7.3; Table 7.6–7.8). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46 598 tonnes in 1987 (Figure 7.2; Table 7.7) because of Danish landings for reduction purposes. After this peak, the Danish landings dropped again to a low level. Compared to 2016 the official landings in 2017 increased from 682 to 3203 tonnes. However, the comparatively low value from 2016 is probably due to the fact that in the official landings data from 2016 the Danish landings from the industrial bycatch were not included. The average official landings for the last ten years (2008–2017) was 889 tonnes. Official landings data from 1950 to 2005 were taken from the "ICES catch statistics 1950 to 2010" (http://ices.dk/marine-data/Documents/CatchStats/HistoricalLandings1950-2010.zip). Data from 2006 to 2015 were taken from the "ICES catch statistics 2006 to 2015" (http://ices.dk/marine-data/Documents/CatchStats/OfficialNominalCatches.zip). Data for 2016 and 2017 were taken from the preliminary catch statistics provided by ICES (http://data.ices.dk/rec12/login.aspx).

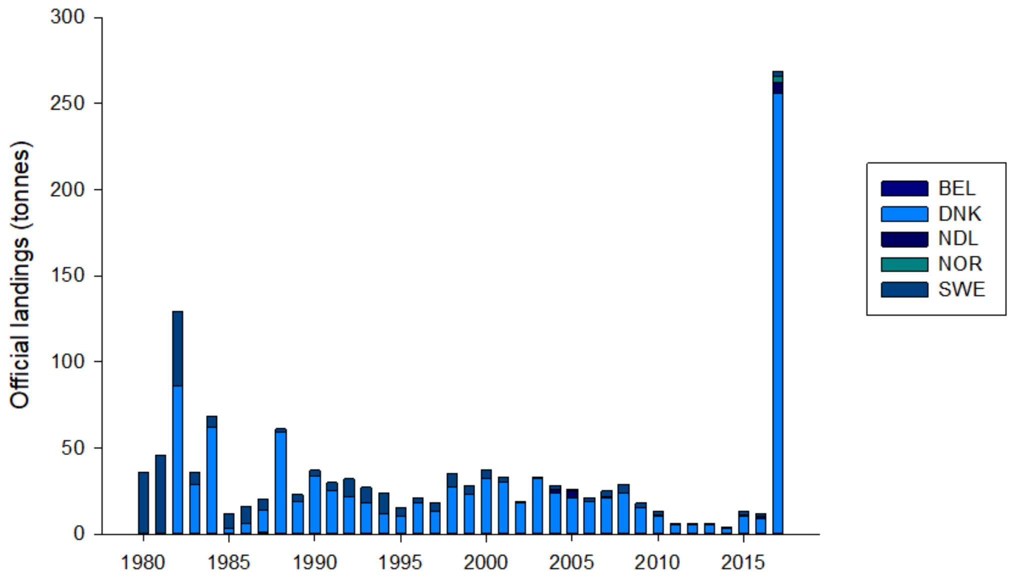

Figure 7.1. Grey gurnard in Subarea 4, Division 3.a and Division 7.d: Official landings of grey gurnard in Division 3.a 1980–2017.

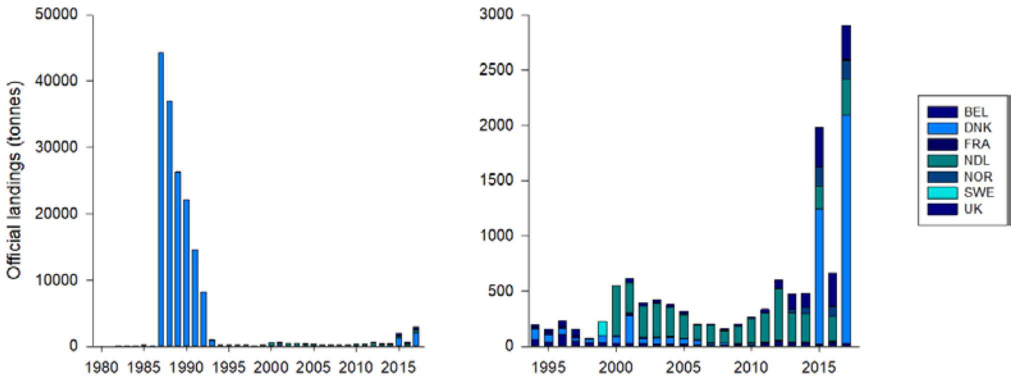

Figure 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Subarea 4 by country for the years 1980–2017 (a), and official landings of grey gurnard by country in Subarea 4 since 1993 only (b).

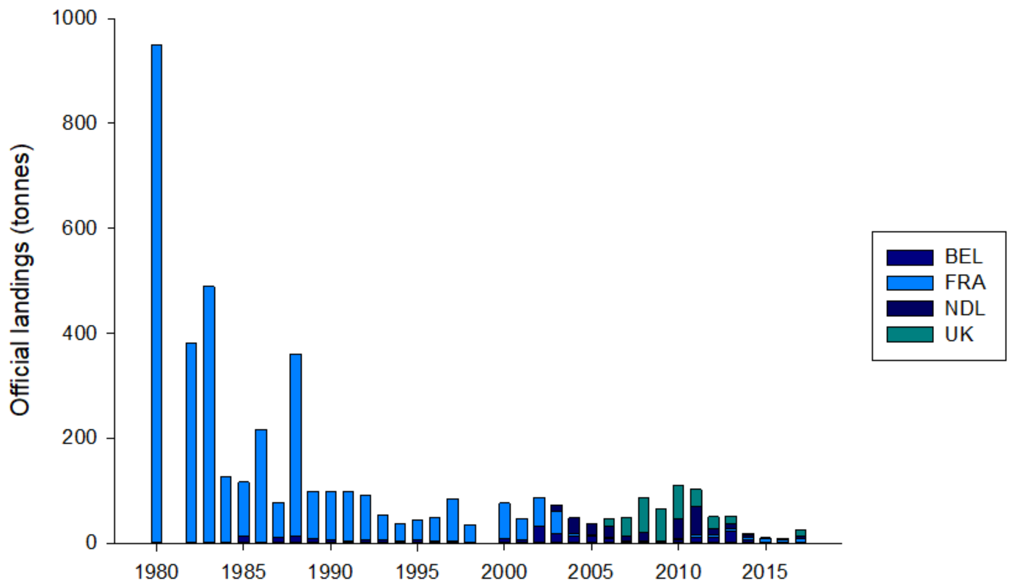

Figure 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings by country of grey gurnard in Division 7.d.

7.2.2 InterCatch data

InterCatch contains now data for the years 2012–2017. Similar as for 2016, the largest amount of landings in 2017 was reported by Denmark for the MIS_MIS_0_0_0_IBC metier (2305 tonnes), which is mainly industrial fishery for sand eel and sprat. Considerable amounts of landings were also reported by Scotland (236 tonnes, OTB_DEF_>=120_0_0_all) and Norway (165 tonnes, OTB_DEF_>=120_0_0_all). For all other metiers the landings were below 100 tonnes (Figure 7.4). For all countries the amount of discards exceeded by far the amount of landings, with the exception of Denmark because of the landings from the industrial bycatch (Figure 7.5). The largest amounts of discards were reported for the Scottish OTB_DEF_>=120_0_0_all (1918 tonnes), the Dutch TBB_DEF_70–99_0_0_all (814 tonnes), the Scottish OTB_CRU_70-99_0_0_all (312 tonnes), and the Danish OTB_DEF_>=120_0_0_all (297 tonmes). Norway, Belgium, and Germany did not report any grey gurnard discards.

The largest amount of discards was estimated for the UK England OTB_DEF_70-99_0_0_all metier in Division 7.d (4039 tonnes raised discards). The total catch estimated with InterCatch for the year 2017 was 17 121 tonnes from which 3451 tonnes were landings (20%) and 13 670 tonnes estimated discards (80% of total catch). In total UK England took the largest proportion of the total catch in 2017 with a high amount of discards, followed by Denmark and UK Scotland. In 2017 landings were 60% higher compared to 2016 and the total catch was 41% higher.

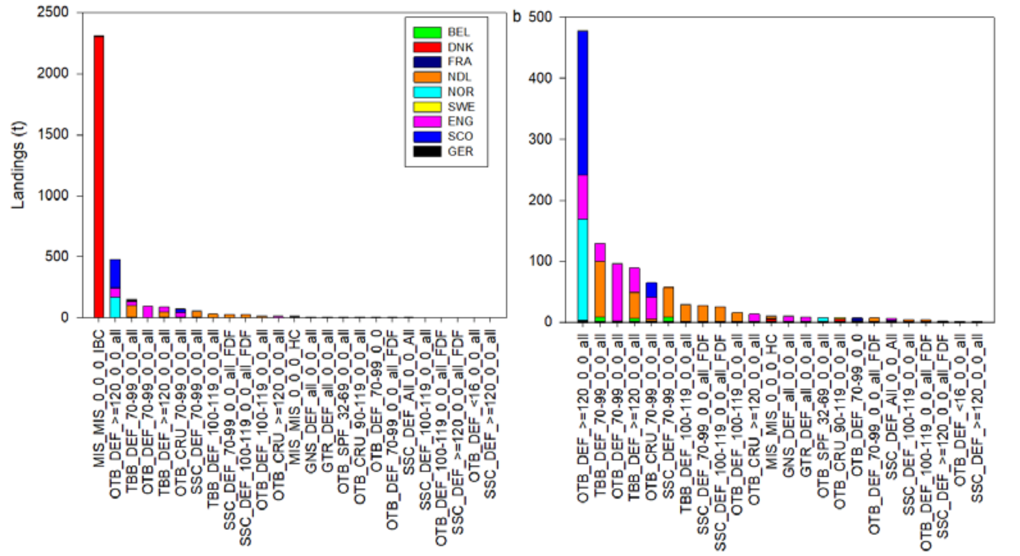

Figure 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard landings in 2017 by metier and country as uploaded into InterCatch. Panel (a) displays all metiers, while panel (b) excludes this metier for better visibility of other metiers.

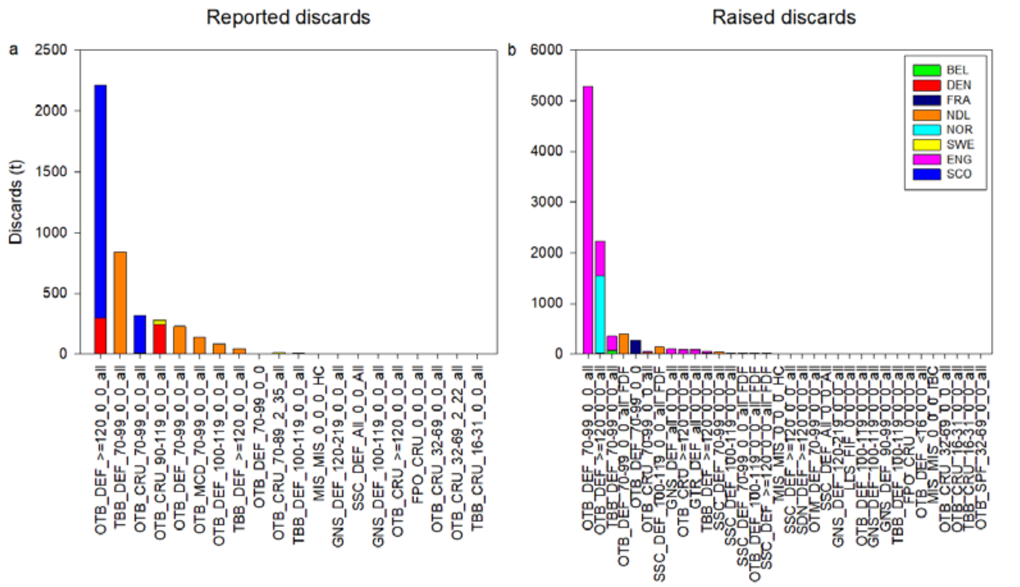

Figure 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard discards in 2017 by metier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

The estimate of the InterCatch landings and discards were revised by including German data. 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 grey gurnard data into InterCatch. 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 years 2012–2014. This ratio was applied to the German gurnard data. Further, it has to be noted here, that the uploaded InterCatch data from UK England were based on a gurnard mix for which a ratio obtained by survey data was applied. This latter approach will probably lead to a bias because gurnard landings are usually dominated by tub gurnards (*Chelidonichthys lucerna*) while the largest part of grey gurnard is discarded.

7.2.3 Other information on Discards

In Table 7.1 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).

Table 7.1 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: 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

7.3 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 stock. 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 7.6). 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; Figure 7.7).

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 all species. Bottom temperatures in high density areas usually range from 8 to 13°C (Sahrhage, 1964).

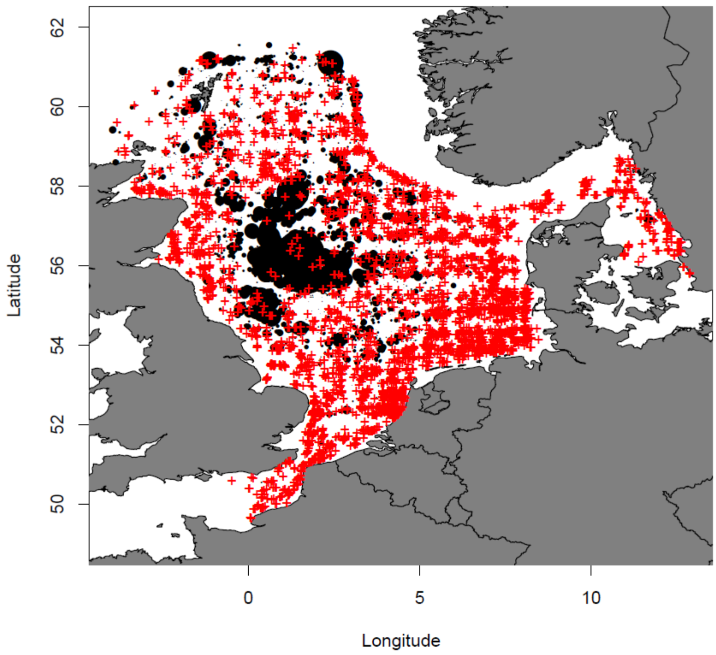

Figure 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Spatial distribution of grey gurnard from IBTS–Q1 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

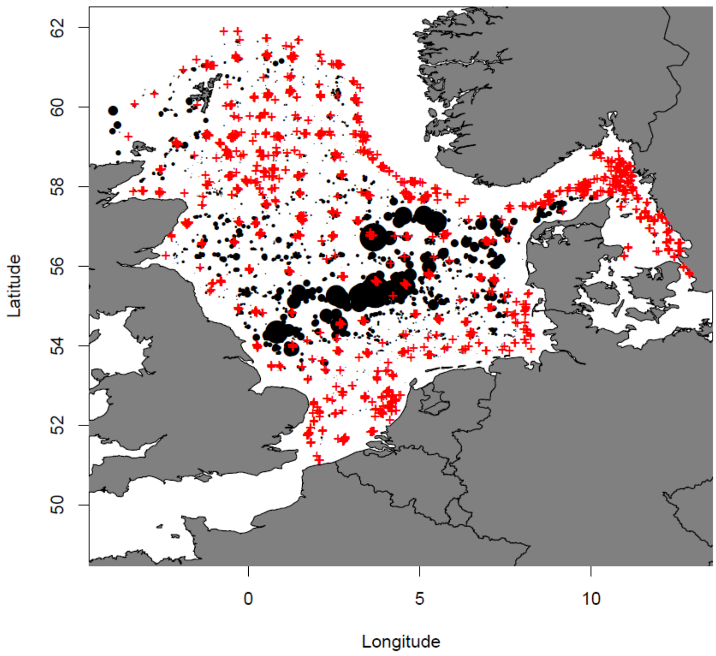

Figure 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q3 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

7.4 Biological sampling

Individual biological data for this species are 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. The age readings done on collected otoliths from IBTS–Q1 resulted in an age range from 2 to 14, but not many individuals were aged (n = 469, years 2010 and 2014).

Available data on grey gurnard individual weights and maturity were analysed in order to estimate a mature biomass index. The obtained weight–length relation was Weight = (0.006 * LngtClass ^ 3.082; Figure 7.8a). A maturity ogive based on all available grey gurnard maturity data from IBTS–Q1 was used to calculate this mature biomass index. The obtained maturity ogive shows that above 21.1 cm more than 95% of all the individuals can be considered mature (Figure 7.8b). The corresponding Lmat50% value was 16.3 cm. Proportion mature at length was calculated by the obtained model Prop-Mat = 0.991 / (1 + exp (-1 * (LngtClass - 16.273) / 2.105)).

The available age and maturity data suggest that grey gurnard is early maturing in the North Sea and a certain proportion of fish at age 1 are mature.

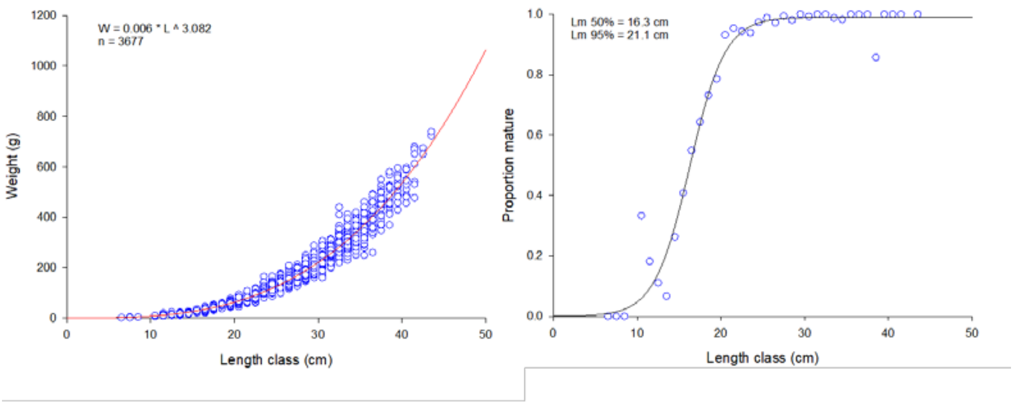

Figure 7.8 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length-weight relationship from IBTS CA data (left panel); maturity ogive obtained from IBTS CA data (right panel).

7.5 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 trends 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 available IBTS CA records (see section 4).

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 1990s (Figure 7.9; Table 7.9). Since then it was fluctuating on a high level. A strong decline of the index was observed for the year 2018. 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 (Subarea 4/Division 3.a) the mature biomass values recorded by the Channel Ground Fish Survey (CGFS) in the Eastern Channel (Division 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.

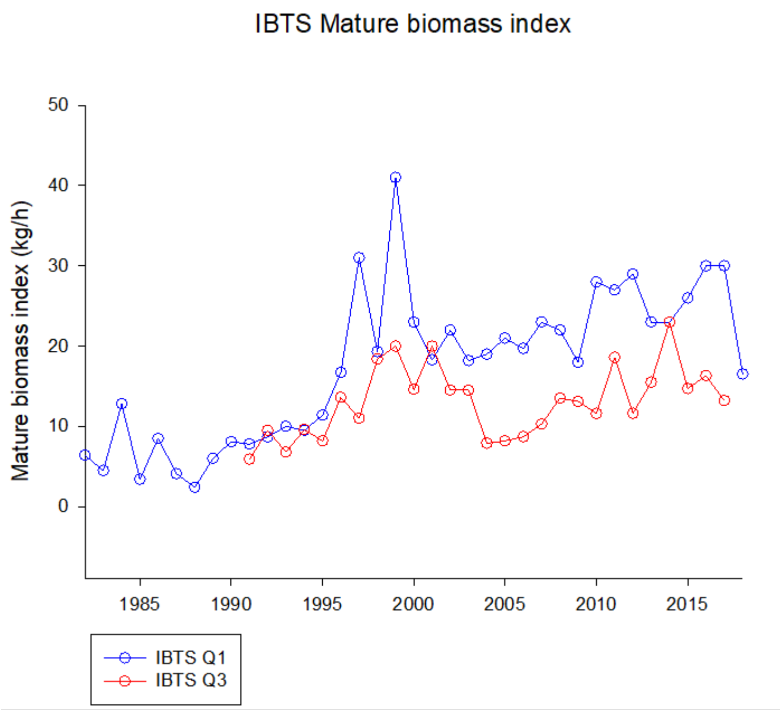

Figure 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: IBTS–Q1 and IBTS–Q3 grey gurnard mature biomass index.

7.6 MSY Proxies

Grey gurnard length samples from commercial catches were provided in InterCatch format for the years 2015–2017. These data were used for the analyses of MSY proxies applying the Mean Length Z Estimator, the Length Based Spawning Potential Ratio (LBSPR) and Length Based Indicators (LBI). Since the catch data time series is short (2012–2017) and these data are highly uncertain it was not attempted to set up a SPiCT (Pedersen and Berg, 2017) assessment for grey gurnard.

Length data

The length data submitted were most complete for the last data year 2017. For 2015 and 2016 length samples from landings were only provided by Sweden and UK England. For the 2017 data also Scotland and Denmark provided length samples for landings. A simple allocation scheme with only one landings group and one discard group was set up, because there were not enough data provided for a more complex allocation scheme taking into account also gear, season and métier. The length frequency distributions obtained are displayed in Figure 7.10 and show differences between years. For all years a unimodal distribution was observed. While the distribution of 2016 shows comparable high numbers, the distribution of 2017 contains more large individuals. The peak of the distribution increases from 17 to 20 cm (Figure 7. 11) and the mean length showed an increase for the most recent year.

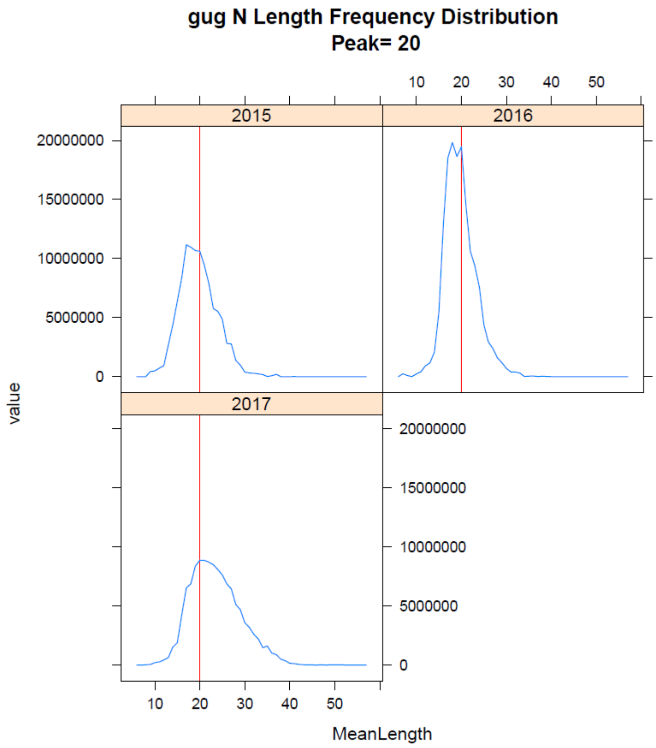

Figure 7.10 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length frequency distribution obtained from an InterCatch raising procedure using data of landings and discards samples. The red line indicates the overall mean.

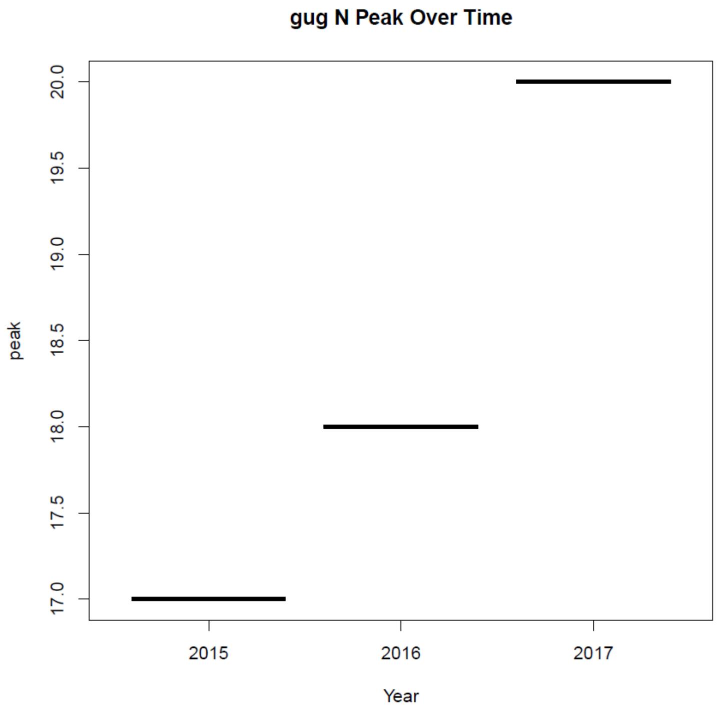

Figure 7.11 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Peak of the length distribution over the years.

Life history parameters

The length based methods presented here require some basic life history parameters: von Bertalanffy growth parameters, natural mortality, length-weight relationship, and length at maturity. Natural mortality is not known for grey gurnard. Thus, this parameter was kept constant 0.2 in all subsequent analyses where needed. There is only one reference available for the theoretical asymptotic length (L_{inf}) and the growth parameter K from the von Bertalanffy growth equation for grey gurnard in the North Sea (Jennings *et al.*, 1999). These values (L_{inf} = 46cm; K = 0.16) are based on a publication from Damm (1987) and unpublished data, and they differ largely from values obtained from more recent survey data (NS-IBTS CA data downloaded from DATRAS). However, survey data were only collected sporadically, i.e. in 2010 by the Netherlands (n = 240) and in 2014 by France (n = 224), and the results of these samplings in terms of von Bertalanffy growth parameters are not consistent. Additionally, the age range observed was very different between the two samplings which might indicate an age reading issue. It was also stated by Damm that the age reading for grey gurnard was extremely difficult and the obtained growth parameters from his study were not deemed reliable (Damm, 1987). Thus it was concluded to apply an empirical formula to obtain an estimate for L_{inf} based on L_{max} from the catches. L_{max} was defined as the 99^{th} percentile of the sampled average catch length distribution L_{max} = 35.5 cm. This resulted in L_{inf} = 37.2 cm and K = 0.41 applying the following formulae (Garcia *et al.*, 2016):

$$Log_{10}L_{inf} = 0.068260(\pm 0.010451) + 0.969112(\pm 0.006318) * log_{10}L_{inf} \quad (1)$$

$$K = 2.15\ (\pm 0.67) * L_{inf}^{-0.46(\pm 0.09)} \quad (2)$$

Length at maturity and a length-weight relationship were obtained from available survey data as described in Section 7.4 (Figure 7.8).

Table 7.2 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Parameters used as input for the length based methods.

Parameter	Sex combined	Source
von Bertalanffy L∞ (mm)	37.2 cm	Based on Lmax observed in the catch (99th percentile) and an empirical formula given by Garcia *et al*. (2016)
von Bertalanffy k (yr-1)	0.41	Based on empirical formula given by Garcia *et al*. (2016)
Length-weight a	0.006	IBTS CA data from DATRAS (n = 3677)
Length weight b	3.082	IBTS CA data from DATRAS (n = 3677)
Natural mortality M (yr-1)	0.2	M is not known and 0.2 was used as default input where needed
Length-at-maturity (mm)	L50% = 16.3 cm L95% = 21.1 cm	IBTS CA data from DATRAS (n = 2906)

7.6.1 Mean Length Z

For the Mean Length Z method only length frequency distributions from catch data (InterCatch) for the three most recent years were available, but no effort time series. Thus, only the Gedamke-Hoenig model was applied (Gedamke and Hoenig, 2006). M is not known for Grey gurnard and was assumed to be 0.2. L_{inf} was estimated with 37.2 cm. How the L_{inf} value was estimated is described above (see text on life history parameters and table 7.2). The mean length showed a strong increase from 2016 to 2017 (Figure 7.12), which can also be seen from the length distributions (Figure 7.10). It has to be noted here that for the last data year the data submissions to InterCatch where more complete. Thus, it is assumed that the estimates for the most recent data year (2017) are more robust compared to the estimates for the previous two years (2015, 2016).

Z obtained by the model was 0.76. Given the assumption on M this would result in F of 0.56 (Table 7.3). The YPR analysis (Figure 7.13) revealed $F_{0.1} = 0.18$ which is lower than F. This result would suggest that the stock is fished above F_{MSY}. However, since M is not known for this stock, but the result is heavily dependent on M, it was concluded that the Mean Length Z method is not appropriate for this stock. Unfortunately it was not possible to estimate M with the THoG-Model (Then *et al.*, 2015).

Table 7.3 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Results of the Mean Length Z method.

Model	Parameter	Value (sex combined)
Gedamke-Hoenig	Z estimate (yr^{-1})	0.76
	F (yr-1), derived from Z	0.56
	F0.1	0.18

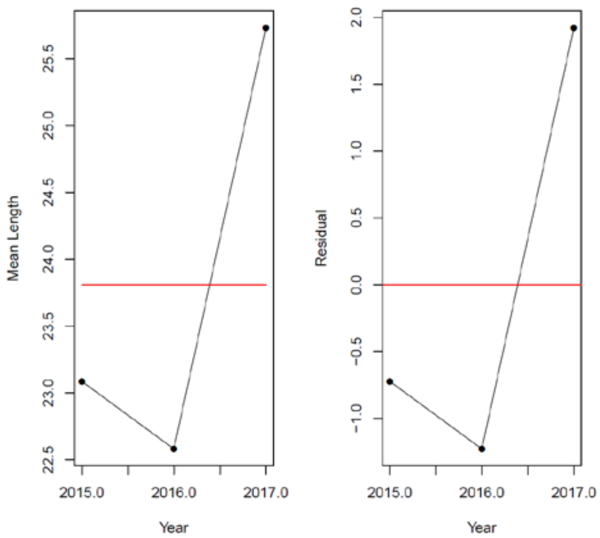

Figure 7.12 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Mean length and mean length residuals.

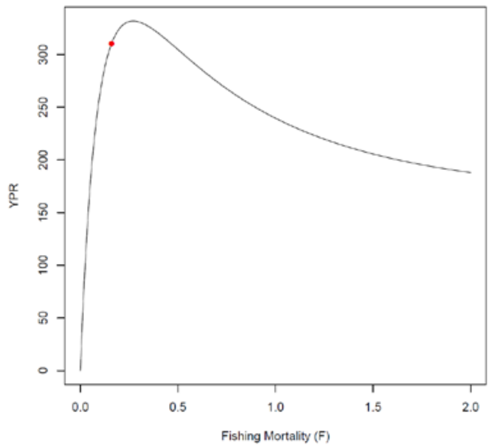

Figure 7.13 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Yield per recruit analysis.

7.6.2 Length Based Spawning Potential Ratio (LB-SPR)

Length frequency data from catch data (InterCatch) for the three most recent years were available for the length based Spawning Potential Ratio (LB-SPR) method. The following life history parameters were used as input values: L_{inf} = 37.2 cm, L50% = 16.3 cm, and L95% = 21.1 cm, M / K = 1.5 (default). How the life history parameters were estimated is described above (see text on life history parameters and Table 7.1).

The model fitted length distributions for the years 2015–2017 are shown in Figure 7.14 1-3. The fourth panel in Figure 7.14 displays the mean length frequency distribution. Figure 7.15 shows the estimated selectivity and the maturity ogive. The SPR values are below the SPR30–40% range for the years 2015–2016, but above for the most recent data year 2017 (Figure 7.16). The F/M ratios are above F/M = 1 for 2015–2016, and clearly below for 2017. This implies exploitation at or below F_{MSY} for the most recent year, but exploitation above F_{MSY} for the years 2015 and 2016. It has to be noted here that for the last data year the data submissions to InterCatch where more complete. Thus, it is assumed that the estimates for the most recent data year (2017) are more robust compared to the estimates for the previous two years (2015, 2016).

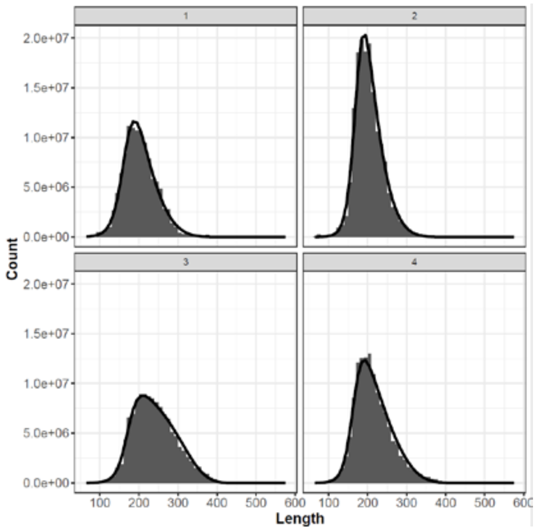

Figure 7.14 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length distributions from catch data (InterCatch) for the years 2015–2017 (1–3), and the mean length distribution (4).

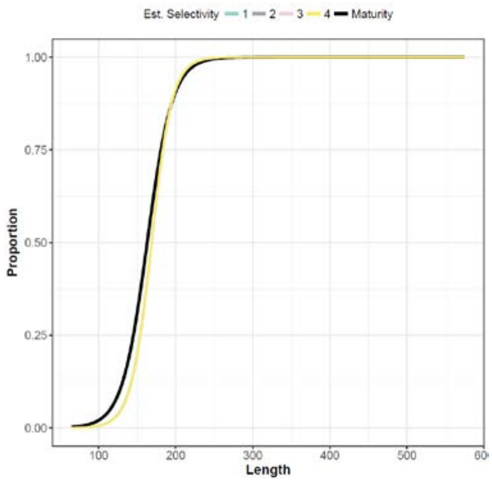

Figure 7.15 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Estimated selectivity for the years 2015–2017 (1–3), and for the mean length distribution (4).

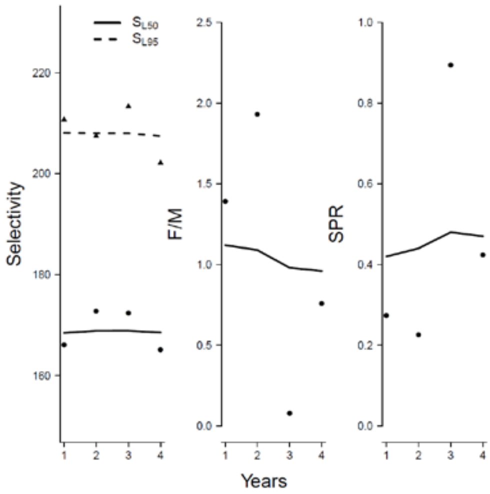

Figure 7.16 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Model output for the years 2015–2107 (1–3), and for the mean length distribution (4).

7.6.3 Length Based Indicators (LBI)

Results of the length based indicator method are sensitive to the assumed values of L_{inf} (37.2 cm) and L_{mat} (16.3 cm). How these values were estimated is described above (see text on life history parameters and Table 7.2). The length frequency distributions were binned into 20 mm size classes and all show a unimodal distribution (Figure 7.17). The results show that with respect to conservation the indicators are above the reference points for LC / L_{mat} and $L_{25\%}$ / L_{mat} for the recent three years (Figure 7.18 and Table 7.4 and Table 7.5). For the $L_{max5\%}$ / L_{inf} reference point the indicator is only above the reference point for the last year. The P_{mega} is for all three years below the reference of 30%, but is close to it for the last data year. With respect to optimum yield and MSY the indicators are only above the reference points for the last data year (Figure 7.19 and Figure 7.20), but quite close for the first two years (Table 7.5). It has to be noted here that for the last data year the data submissions to InterCatch were more complete. Thus, it is assumed that the estimates for the most recent data year (2017) are more robust compared to the estimates for the previous two years (2015, 2016). Therefore it was concluded that the exploitation for this stock is at or below F_{MSY}.

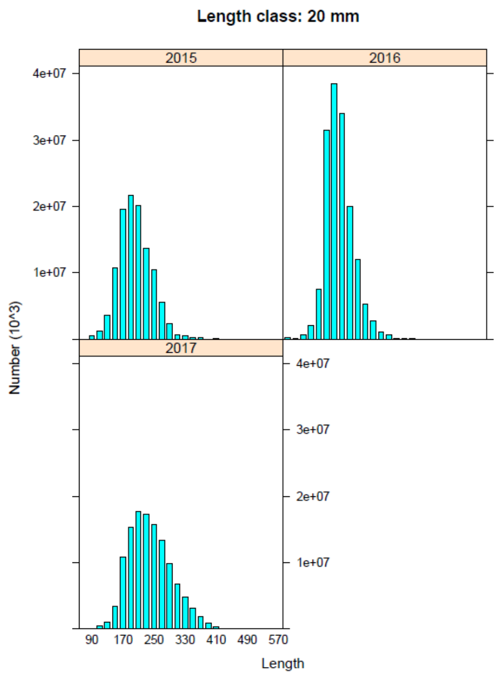

Figure 7.17 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Obtained length frequency distributions binned into 20 mm size classes.

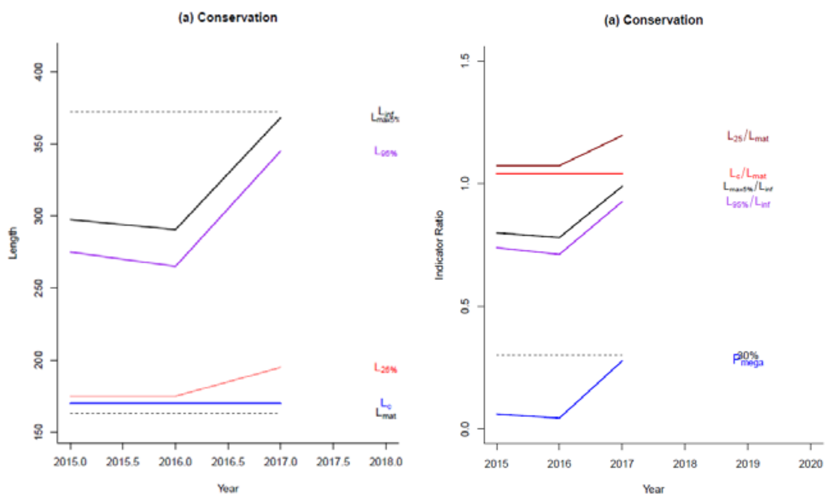

Figure 7.18 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Conservation indicators (left panel) and indicator ratios (right panel).

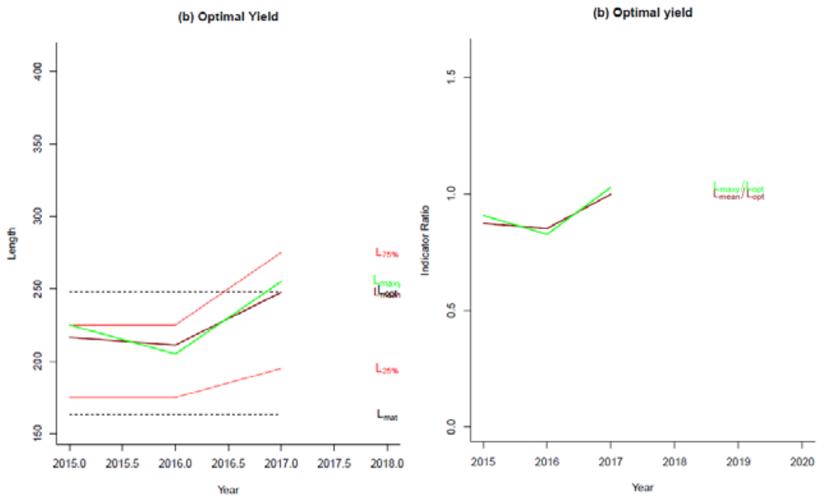

Figure 7.19 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Optimum yield indicators (left panel) and indicator ratios (right panel).

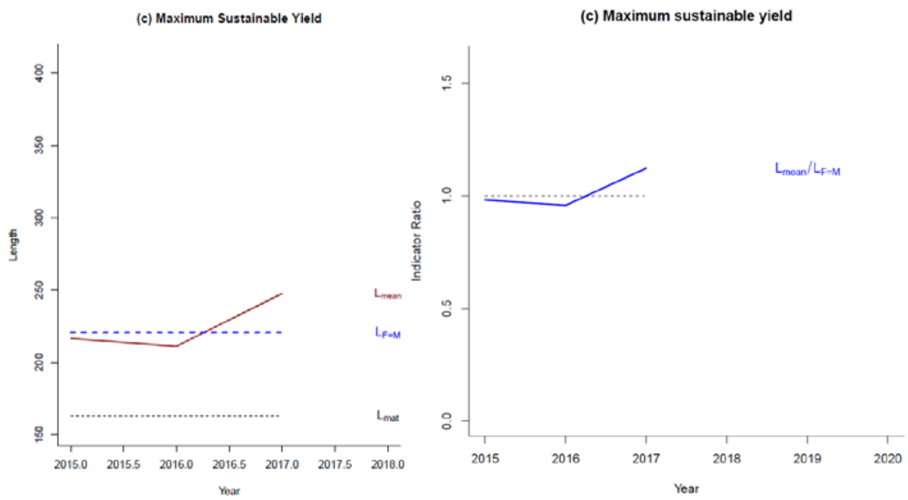

Figure 7.20 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

Table 7.4 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length based reference points.

Year	L75	L25	Lmed	L90	L95	Lmean	Lc	LFeM	Lmaxy	Lmat	Lopt	Linf	Lmax5
2015	225	175	195	255	275	216.5	170	220.5	225	163	248	372	297.58
2016	225	175	195	245	265	211.2	170	220.5	205	163	248	372	290.48
2017	275	195	235	315	345	247.6	170	220.5	255	163	248	372	368.10

Table 7.5 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length based indicators. Green colour indicate that the observed value is above the respective reference point, red colour indicates that it is below.

	Conservation				Optimizing Yield	MSY
	L_C/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1(>0.9)**	**≥1**
2015	**1.04**	**1.07**	0.80	0.06	0.87	0.98
2016	**1.04**	**1.07**	0.78	0.05	0.85	0.96
2017	**1.04**	**1.20**	**0.99**	0.28	**1.00**	**1.12**

7.6.4 Conclusion

The LBI and the LB-SPR method make use of the general assumption M/K = 1.5. Since M for Grey gurnard is unknown, it was concluded that the assumed ratio of M/K is a more robust assumption for this stock and thus the LBI and LB-SPR method might be more appropriate compared to the MLZ method in this case. The LBI and LB-SPR methods give consistent results for the most recent data year (2017) and suggest that the Grey gurnard stock in Subarea 4, Division 3.a and Division 7.d was exploited at or below F_{MSY}. Besides MSY and Optimal Yield indicators, the LBI method also gives information on conservation aspects and was thus preferred. Therefore, the LBI results were presented in the advice sheet for this Grey gurnard stock.

7.7 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 (2012–2017).

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.

7.8 References

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7.9 Catch and index tables

Table 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 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
2016	0	9	1	0	2	12
2017	0	256	6	4	3	269

Table 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Subarea 4.

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	3	155	5	0	14	204
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	14	266
2011	26	6	7	263	1	0	31	334
2012	49	3	4	467	2	0	77	602
2013	30	4	2	268	33	1	131	470
2014	35	4	3	252	56	0	128	478
2015	20	1220	2	229	172	5	354	2004
2016	31	7	6	232	83	5	297	661
2017	24	2067	4	320	172	8	314	2909

Table 7.8. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 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
2016	1	6	2	0	9
2017	1	8	4	12	25

Table 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Mature biomass indices (kg/hour) from IBTS–Q1 and IBTS–Q3.

Year	IBTS–Q1	IBTS–Q3
1983	4.5	
1984	12.8	
1985	3.4	
1986	8.5	
1987	4.1	
1988	2.4	
1989	6	
1990	8.1	
1991	7.8	5.9
1992	8.7	9.5
1993	10	6.8
1994	9.5	9.6
1995	11.4	8.2
1996	16.7	13.6
1997	31	11
1998	19.3	18.4
1999	41	20
2000	23	14.6
2001	18.3	20
2002	22	14.5
2003	18.2	14.5
2004	19	7.9
2005	21	8.2
2006	19.7	8.7
2007	23	10.3
2008	22	13.5
2009	18	13.1
2010	28	11.6
2011	27	18.6
2012	29	11.6
2013	23	15.5
2014	23	23
2015	26	14.7
2016	30	16.3
2017	30	13.2
2018	16.5	

Table 7.10. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Summary of the assessment done during the WGNSSK 2018 with updated values.

Year	Official landings	ICES Landings	ICES catches	ICES discards	Discard rate	IndexQ1
1983	589					4.5
1984	265					12.8
1985	301					3.4
1986	326					8.5
1987	44422					4.1
1988	37445					2.4
1989	26470					6
1990	22303					8.1
1991	14741					7.8
1992	8365					8.7
1993	1060					10
1994	254					9.5
1995	211					11.4
1996	301					16.7
1997	253					31
1998	145					19.3
1999	254					41
2000	661					23
2001	690					18.3
2002	499					22
2003	525					18.2
2004	452					19
2005	378					21
2006	267					19.7
2007	279					23
2008	273					22
2009	285					18
2010	390					28
2011	442					27
2012	658	689	8345	7656	0.92	29
2013	528	1180	10230	9050	0.88	23
2014	500	1892	8596	6704	0.78	23
2015	2028	2141	8451	6310	0.75	26
2016	682	2156	12129	9973	0.82	30
2017	3203	3451	17121	13670	0.80	30
2018						16.5

8 Haddock in Subarea 4, Division 6.a and Subdivision 20 (North Sea, West of Scotland and Skagerrak)

Until 2014, haddock in Subarea 4, Division 6.a and Subdivision 20 (referred to hereafter as Northern Shelf haddock) were assessed as two separate stocks: Subarea 4 and Subdivision 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.

8.1 General

8.1.1 Ecosystem aspects

Ecosystem aspects are summarised in the Stock Annex.

8.1.2 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).

8.1.2.1 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 and gas, and renewables sector 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 and 2014 year-classes form the bulk of haddock catches in 2017, 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 2017 decreased.

Specific information on changes in the Scottish fleet during 2011–2017 was not provided to WGNSSK in 2018. 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 have been caused by the EU landings obligation which was 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). In 2016, 14 vessels participated in the scheme: the uptake of the scheme declined due to concerns about monitoring of discards under the EU Landing Obligation. The cod-specific FDF scheme terminated at the end of 2016, due to the suspension of most aspects of the EU Cod Recovery plan which removed the opportunity for countries to provide additional quota for participants. However, a new Scottish FDF scheme has commenced, which is being run along similar lines and which is intended to monitor discarding of saithe and monkfish: there are currently three vessels participating in this new scheme in 2017.

8.1.2.2 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.

8.1.3 ICES advice

8.1.3.1 ICES advice for 2017

8.1.3.1.1 Subarea 4, Division 6.a and Subdivision 20

The advice for 2017 was delayed until November 2016 due to the issues found in the update assessment at WGNSSK 2016 and the need to initiate the IBPHaddock process. In November 2016, ICES concluded the following:

> *ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 39 461 tonnes*

8.1.3.2 ICES advice for 2018

8.1.3.2.1 Subarea 4, Division 6.a and Subdivision 20

> The advice for 2018 was delayed until December 2017 *ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 48 990 tonnes*

8.1.4 Management

Until 2014, North Sea haddock (Subarea 4 and Subdivision 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 20 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 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, Division 6.a and Subdivision 20 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 2017 and 2018 TACs for haddock in this area were 33 643 tonnes and 41 767 tonnes respectively. The second is Division 3.a (EU waters), for which the TACs for 2017 and 2018 were 2069 t and 2569t respectively. The third is Division 6.a, for which the TACs in 2017 and 2018 were 3697 tonnes and 4454 tonnes respectively.

8.2 Data available

8.2.1 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).

International data for below minimum size (BMS) landings and logbook registered discards (LRD) for Northern Shelf haddock have been collated through the InterCatch system from 2016. 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 89% 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 collation of BMS landings and logbook registered discards in InterCatch was introduced in 2016 in accordance with the implementation of the EU landing obligation. However, BMS data from Scotland was not submitted in 2017 resulting in no sampled of the BMS landings by weight (see Figure 13.2.3). Age compositions for the BMS landings were determined in a similar way to the landings without consideration of quarter, country or gear. Logbook registered discard observations were not available in 2017.

The full time series of landings, discards, BMS landings and industrial by-catch (IBC) is presented in Table 13.2.5. These data are illustrated further in Figure 13.2.4. 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, 15% in 2015 and around 18% in 2016 and 14% in 2017, although the reasons for this are not known. The recent changes in discarding are not consistent across ages (Figure 13.2.5).

It would be expected that under the EU Landing Obligation fish caught under the minimum conservation reference size (MCRS) would be landed and recorded as BMS landings in log books rather than discarded as happened before the Landing Obligation. The log book records of BMS landings would then be reported to ICES. However, low BMS values may be seen if the fish caught below MCRS are either not landed, not recorded in log books, not reported to ICES or a mixture of the three. BMS landings reported to ICES in 2017 are 0.28% of the total catch which is significantly lower than the discard estimate of 14.13% of total catch. This suggests that fish caught below MCRS are not being reported as BMS. The majority of the catch for Northern Shelf haddock comes from the Scottish fleet where no BMS landings were reported to ICES.

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. Subdivision 20 discard estimates are derived from data submitted by Denmark and Germany. Division 6.a discard estimates are provided by UK (Scotland). BMS landing estimates were provided for area Subarea 4 and Subdivision 20 by UK

(Scotland). 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.

8.2.2 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 13.2.10. The fishery in 2017 (landings for human consumption) was strongly reliant on the 2009, 2012 and 2014 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.

8.2.3 Weight at age

Weight-at-age for the total catch in the North Sea is given in Table 13.2.11. Weight-at-age in the total catch is a number-weighted average of weight-at-age in the human consumption landings, discards, BMS landings 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 13.2.12 to 13.2.15 and are illustrated in Figure 13.2.6: this shows the declining trend in weights-at–age for older ages in total catch and landings however in recent years there has been a slight increase in mean weight at age.. There is 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).

8.2.4 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 13.2.7 and Table 13.2.16. 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 2017).

8.2.5 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 13.2.17. Survey-based abundance distributions by age and year are given in Figures 13.2.8 (North Sea IBTS Q1), 13.2.9 (North Sea IBTS Q3) and 13.2.10 (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 13.2.11. 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.

8.3 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.

8.3.1 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.

8.3.2 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.

8.3.3 Conclusions drawn from exploratory analyses

Mean-standardising SSB and recruitment estimates (using a common year-range for the mean) and generating TSA and SAM estimates of Z by adding F and M enables the comparison between TSA, SAM and SURBAR shown in Figure 13.3.10. SSB and recruitment estimates are very similar from the three models, although it is noticeable that the SURBAR estimates for large year-classes in particular tend to be higher, 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 SAM is consistent with that from TSA, while the SAM mean Z estimates tend to be smoother, but the overall trajectory are not 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.

8.3.4 Final assessment

Table 13.3.1 gives the final TSA assessment settings, while Table 13.3.2 gives the corresponding parameter estimates from the completed run. A full description of the TSA method and the 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, BMS landings and industrial bycatch (referred to as "discards" or "discards+bycatch+BMS"), 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 discards (discard+bycatch+BMS) proportions by age, from which the decline in discard (discard+bycatch+BMS) 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+BMS), 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+BMS 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 summarizes the results of TSA retrospective analyses for Northern Shelf haddock.There is very little retrospective noise or bias: only one retrospective run falls outside an approximate pointwise 95% confidence intervals of the full time-series assessment, specifically in the mean *F* estimates. It may be hypothesized that the strong population signals from occasional large year-classes provide sufficient data contrast to obviate against retrospective noise.

Fishing mortality estimates for the final TSA assessment are presented in Table 13.3.3, the stock numbers in Table 13.3.4, and the assessment summary in Table 13.3.5.

8.4 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, 2009 and 2014 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 2017 appears to fluctuate between 0.2 and 0.4 and remains above the F_{MSY} value of 0.194 in 2017 (see Section 13.7). 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 recent "large" year classes over the next few years.

8.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2018) and in the quota year (IY + 1 = 2019) are based on the TSA estimate of forecasted recruits at age 0 in the intermediate year, as this ensures consistency between assessment and forecast.

The following table summarises the recruitment, age 1 and age 2 assumptions for the short term forecast.

Year class	Age in 2017	TSA estimate (millions)	TSA forecast (millions)
2016	2	257	
2017	1	305	
2018	0		3529
2019	Age 0 in 2019		3529
2020	Age 0 in 2020		3529

8.6 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 summarized in the Stock Annex, and involves fitting straight lines to cohort-based weight estimates and extrapolating forward in time.

The outcomes for the total catch and the landings (also referred to as wanted catch) are summarized in Figures 13.6.1 and 13.6.2 respectively. The weights-at-age for discards and BMS were combined into an unwanted catch category using the relative contribution of each component (in 2017) to the total catch. These combined weights were used in the extrapolation to calculate the forecast weights and are shown in Figure 13.6.3. There is insufficient data to allow for cohort-based modeling of weights-at-age in the industrial bycatch component, so simple three-year (2015–2017) 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. No TAC constraint was needed for the 2018. The combined-area TAC for 2018 was 46 538 tonnes.

Given the choice of fishing-mortality rates discussed above, partial fishing mortality values were obtained for each catch component (wanted catch (human consumption landings), unwanted catch (discards and BMS landings) and bycatch) by using the relative contribution (averaged over 2015–2017) 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, Division 6.a and Subdivision 20).

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 an F of 0.194 in 2018, SSB is expected to be 230 177 tonnes in 2018, before decreasing in 2019 to 216 979 tonnes. In this case, wanted catch (human consumption yield) in 2018 would be 54 509 tonnes with associated unwanted catch (discards + BMS) of 6331 t.

Several alternative options for 2019 have been highlighted in Table 13.6.2. These are based on various reference points including F_{MSY}, F_{pa}, F_{lim}, B_{pa}, B_{lim}, $B_{trigger}$ as well as F_{2018}, $F_{MSY\text{-}upper}$, $F_{MSY\text{-}lower}$. Under the assumption of F_{MSY}, the 2019 total catch is forecast to be 34 160 tonnes, which corresponds (if 2017 discard+BMS rates remain unchanged) to a wanted-catch yield of 29 729 tonnes and unwanted catch of 4431 tonnes. This exploitation is forecast to lead in turn to a SSB in 2019 of 193 817 tonnes, a decrease of 11% on the 2018 forecast.

8.7 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.

8.8 Biological reference points

Following the estimation of revised F_{MSY} reference points at the 2014 WKMSYREF3 meeting, WGNSSK 2016 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

0.194. 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 B_{lim} = 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 EqSim analysis was repeated by WGNSSK 2017 following the issuing of new guidelines (WKMSYREF4) that stated that the lower limit of the F_{MSY} range should be redefined when the F_{MSY} range is constrained by F_{p05}. The new guidelines define the lower limit of the F_{MSY} range as the F that delivers 95% of the yield at $F_{MSY} = F_{p05}$. The new EqSim run followed the same procedure as used in the IBP though with the new definition for the lower limit of the F_{MSY} range and resulted in a F_{MSY} range of 0.167–0.194. This rerun resulted in minor differences in the estimation of F_{MSY} (0.194 versus 0.193 from the IBP) which is thought to result from rounding.

Although there was updated natural mortality values for WGNSSK 2018, reference points have not been modified as a result of applying the revised smoothed natural mortality parameters to the 2017 assessment and also applying the previous natural mortality to the 2018 assessment. There were no discernible differences in assessment parameters, therefore it was assumed that the reference points previously derived at WGNSSK 2017 remain applicable.

The reference points in full from this analysis are given below:

Variable	WKHAD (2014)	IBPHaddock (2016)	WGNSSK 2017
B_{lim}	63 kt	94 kt	94 kt
B_{pa}	88 kt	132 kt	132 kt
F_{lim}	n/a	0.38	0.384
F_{pa}	n/a	0.27	0.274
F_{MSY}	0.37	0.19	0.194
$F_{MSY\ lower}$	n/a	0.18	0.167
$F_{MSYupper}$	n/a	0.19	0.194

8.9 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 (ICES IBPHaddock 2016).

8.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2016 and is now fluctuating around the historical minimum, although this remains above the estimate of F_{MSY} (0.194). 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 increase during 2018 to well above B_{pa} (132 kt) as the 2014 year-class matures.

8.11 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 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 expected to increase in 2018 as the 2014 year-class matures.

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.

8.12 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 F_{MSY} OR if F_{MSY} range has been defined: F(latest assessment year) is <= F_{upper} (upper bound in F range) AND SSB(start of intermediate year) >= MSY $B_{trigger}$
    - 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 0.13, 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.

8.13 References

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Table 13.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Nominal landings (000 t) during 2008–2017, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2017 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota before 2017. Quota uptake from 2017 is calculated as the WG estimates of total catch divided by available quota following the implementation of the Landing Obligation. Note that the United Kingdom did not provide official landings for 2012. Reporting of BMS landings started in 2016.

Subdivision 20										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
DE	87	105	65	102	120	90	114	103	125	0
DK	1052	1263	1139	1661	1916	1456	1763	1057	973	852
NL	0	0	1	0	0	5	6	4	2	20
NO	170	121	81	125	239	223	81	63	70	65
PT	0	0	0	0	0	0	0	0	0	0
SE	276	166	126	198	210	217	219	202	129	103
UK	0	0	0	0	0	3	0	0	0	0
Subarea 4										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BE	112	108	78	106	78	78	98	45	53	30
DE	393	657	634	575	548	677	677	599	554	534
DK	501	552	725	697	947	1283	1079	1426	1213	1185
ES	0	0	0	0	0	0	0	0	0	0
FO	3	32	5	0	0	0	0	0	0	0
FR	448	135	276	320	175	177	209	101	121	140
GL	0	4	0	0	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	29	24	41	71	191	172	99	43	146	75
NO	1482	1278	1126	1195	1069	1661	2705	2004	1484	2164
PL	16	0	0	0	0	0	0	0	0	0
PT	0	0	0	0	0	0	0	0	0	0
SE	83	141	90	128	103	113	154	135	117	179
UK	27365	28393	24983	23343	0	32993	29758	25852	26374	25376
Division 6.a										
Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
DE	1	0	1	0	0	0	0	0	0	o
DK	0	0	0	0	0	0	0	0	2	2
ES	10	21	28	36	15	0	19	9	33	28
FO	0	0	0	0	0	0	0	0	0	0
FR	151	136	89	73	32	51	67	41	62	68
IE	879	297	396	290	845	746	653	768	1033	641
NL	0	0	0	0	0	0	0	0	28	31
NO	28	18	9	4	0	6	15	7	5	1
UK	1776	2380	2415	1364	0	3878	3230	3051	3090	2492
Northern Shelf										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Official landings	34862	35831	32308	30288	6488	43830	40945	35520	35238	32290
ICES landings	33058	35590	31940	36570	38162	43681	41143	35316	35058	33538
ICES discards	14503	12326	13071	13067	5032	3038	5090	6255	7449	6933
ICES IBC	199	52	431	24	1	54	65	21	37	19
ICES BMS									201	93
ICES total catch	47759	47968	45442	49661	43195	46772	46295	41571	42745	40583
TAC 4	46444	42110	35794	34057	39000	45041	38284	40711	61933	33643
TAC 3.a	2856	2590	2201	2100	2095	2770	2355	2504	2069	2569
TAC 6.a	6120	3520	2670	2005	6015	4211	3988	4536	6462	6654
Total TAC	55420	48220	40665	38162	47110	52022	44627	47751	72321	46538
ICES quota uptake	60%	74%	79%	96%	81%	84%	92%	74%	59%	71%

Table 13.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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
BMS landings	Imported	93	100
Discards	Imported	6368	8
Discards	Raised	569	92
Landings	Imported	353556	100

Table 13.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of age distributions for landings, BMS 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	29743	89
Landings	Imported	Estimated	3813	11
Discards	Imported	Sampled	6339	91
Discards	Raised	Estimated	569	8
Discards	Imported	Estimated	29.2	0
BMS landings	Imported	Estimated	93	100

Table 13.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion by area of distributions for landings, BMS 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	27.6.a	2908	89
Landings	Imported	Estimated	27.6.a	349	11
Discards	Imported	Sampled	27.6.a	1549	98
Discards	Imported	Estimated	27.6.a	2	0
Discards	Raised	Estimated	27.6.a	32	2
BMS landings	Imported	Estimated	27.6.a	0	0
Landings	Imported	Sampled	27.4	26364	91
Landings	Imported	Estimated	27.4	2625	9
Discards	Imported	Sampled	27.4	4722	91
Discards	Raised	Estimated	27.4	470	9
Discards	Imported	Estimated	27.4	15	0
BMS landings	Imported	Estimated	27.4	93	100
Landings	Imported	Sampled	27.3.a.20	471	43
Landings	Imported	Estimated	27.3.a.20	630	57
Discards	Raised	Estimated	27.3.a.20	25	24
Discards	Imported	Sampled	27.3.a.20	68	65
Discards	Imported	Estimated	27.3.a.20	12	11

Table 13.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Working Group estimates of catch components by weight (000 tonnes). *Note that Subarea 4 and Subdivision 20 data are collated together in 2013, and are listed here only in the Subarea 4 section.

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	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

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
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

	Subarea 4					**Subdivision 20**				**Division 6.a**				**Combined**				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
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
2016	29.8	5.5	0.2	0.0	35.5	1.2	0.0	0.0	1.2	4.2	1.5	0.0	5.8	35.2	7.1	0.2	0.0	42.6
2017	29.2	5.2	0.1	0.0	34.5	1.1	0.1	0.0	1.2	3.3	1.5	0.0	4.8	33.5	6.9	0.1	0.0	40.6

Table 13.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers at age data (thousands) for total catch. Ages 0–7 and 8+ and years 1972–2017 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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
2016	1845	10258	61899	8780	5537	646	507	10150	262	151	9	146	8	0	0	1	57
2017	2593	12665	23033	55077	3214	1517	142	373	1482	509	5	20	5	1	0	1	2023

Table 13.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2015	0	716	10568	16070	1635	5132	21108	1058	433	437	779	107	0	0	0	0	1756
2016	1	158	36148	8540	5499	641	496	10104	261	150	9	146	8	0	0	1	576
2017	0	143	10793	46544	3020	1458	130	361	1430	495	5	19	5	1	0	1	1956

Table 13.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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
2016	1843	9910	24898	207	17	2	9	10	0	0	0	0	0	0	0	0	0
2017	2558	12352	11772	7098	106	17	8	2	11	0	0	0	0	0	0	0	11

Table 13.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers-at-age data (thousands) for BMS 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+
2016	0	189	725	2	1	0	0	0	0	0	0	0	0	0	0	0	0
2017	34	166	158	95	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 13.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2015	0	6	9	1	3	12	1	0	0	0	0	0	0	0	0	0	0
2016	0	0	38	9	6	1	1	11	0	0	0	0	0	0	0	0	1
2017	0	0	6	26	2	1	0	0	1	0	0	0	0	0	0	0	1

Table 13.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2016	0.048	0.154	0.362	0.642	0.776	0.886	0.989	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.836
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.803	2.670	0.678	0.890	1.514	0.909	0.000

Table 13.2.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2016	0.356	0.383	0.445	0.649	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.835
2017	0.000	0.249	0.448	0.469	0.783	0.963	1.295	1.034	1.022	0.647	2.744	0.910	2.824	2.333	4.673	5.558

Table 13.2.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2016	0.048	0.149	0.245	0.357	0.361	0.876	0.457	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.803	2.670	0.678	0.890	1.514	0.909	0.000

Table 13.2.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for BMS 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+
2016	0.068	0.239	0.213	0.386	0.000	0.000	0.481	0.000	0.991	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.000	2.67	0.000	0.000	1.514	0.000	0.000

Table 13.2.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2016	0.356	0.383	0.445	0.49	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	3.766
2017	0.000	0.249	0.448	0.469	0.783	0.963	1.295	1.034	1.022	0.647	2.744	0.910	2.824	2.333	4.673	5.558

Table 13.2.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimates of natural mortality from the most recent key run of SMS (ICES WGSAM, 2017).

	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	1.271	1.493	0.773	0.520	0.416	0.284	0.251	0.235	0.218	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1975	1.316	1.514	0.748	0.505	0.401	0.280	0.248	0.232	0.216	0.206	0.200	0.233	0.233	0.233	0.233	0.233

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	1.357	1.536	0.722	0.490	0.385	0.275	0.245	0.228	0.214	0.205	0.201	0.233	0.233	0.233	0.233	0.233
1977	1.394	1.555	0.696	0.476	0.369	0.270	0.242	0.225	0.212	0.205	0.201	0.233	0.233	0.233	0.233	0.233
1978	1.424	1.569	0.669	0.461	0.354	0.264	0.238	0.222	0.210	0.205	0.201	0.232	0.232	0.232	0.232	0.232
1979	1.449	1.574	0.642	0.446	0.339	0.259	0.235	0.219	0.208	0.205	0.201	0.231	0.231	0.231	0.231	0.231
1980	1.467	1.569	0.615	0.432	0.325	0.254	0.231	0.217	0.207	0.204	0.201	0.230	0.230	0.230	0.230	0.230
1981	1.478	1.550	0.588	0.417	0.313	0.249	0.227	0.215	0.206	0.204	0.202	0.228	0.228	0.228	0.228	0.228
1982	1.484	1.515	0.561	0.404	0.303	0.246	0.224	0.213	0.205	0.204	0.202	0.226	0.226	0.226	0.226	0.226
1983	1.485	1.464	0.534	0.390	0.295	0.243	0.221	0.212	0.204	0.204	0.202	0.224	0.224	0.224	0.224	0.224
1984	1.483	1.402	0.510	0.377	0.289	0.241	0.219	0.210	0.204	0.204	0.202	0.222	0.222	0.222	0.222	0.222
1985	1.479	1.337	0.487	0.365	0.284	0.239	0.218	0.209	0.204	0.204	0.202	0.219	0.219	0.219	0.219	0.219
1986	1.470	1.275	0.467	0.355	0.280	0.238	0.216	0.209	0.204	0.204	0.203	0.217	0.217	0.217	0.217	0.217
1987	1.455	1.222	0.451	0.345	0.277	0.237	0.215	0.208	0.203	0.204	0.203	0.215	0.215	0.215	0.215	0.215
1988	1.433	1.179	0.437	0.337	0.274	0.236	0.214	0.207	0.203	0.204	0.203	0.213	0.213	0.213	0.213	0.213
1989	1.404	1.146	0.426	0.329	0.272	0.235	0.214	0.207	0.203	0.204	0.203	0.211	0.211	0.211	0.211	0.211
1990	1.370	1.125	0.417	0.322	0.270	0.234	0.214	0.207	0.203	0.203	0.203	0.210	0.210	0.210	0.210	0.210
1991	1.334	1.113	0.409	0.316	0.268	0.234	0.213	0.207	0.203	0.203	0.202	0.208	0.208	0.208	0.208	0.208
1992	1.302	1.110	0.402	0.311	0.267	0.234	0.213	0.207	0.203	0.202	0.202	0.207	0.207	0.207	0.207	0.207
1993	1.278	1.112	0.397	0.308	0.266	0.235	0.213	0.207	0.203	0.202	0.201	0.207	0.207	0.207	0.207	0.207
1994	1.263	1.117	0.392	0.306	0.266	0.236	0.214	0.207	0.203	0.201	0.201	0.206	0.206	0.206	0.206	0.206
1995	1.257	1.125	0.388	0.305	0.267	0.238	0.215	0.208	0.203	0.201	0.201	0.205	0.205	0.205	0.205	0.205
1996	1.257	1.132	0.385	0.306	0.268	0.242	0.217	0.208	0.204	0.201	0.200	0.204	0.204	0.204	0.204	0.204
1997	1.263	1.138	0.382	0.309	0.270	0.246	0.220	0.209	0.204	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1998	1.272	1.144	0.381	0.313	0.273	0.250	0.224	0.209	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
1999	1.284	1.153	0.381	0.318	0.276	0.255	0.228	0.210	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2000	1.296	1.166	0.384	0.323	0.280	0.261	0.232	0.211	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2001	1.306	1.185	0.390	0.330	0.284	0.266	0.237	0.212	0.204	0.200	0.199	0.203	0.203	0.203	0.203	0.203

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2002	1.308	1.208	0.398	0.336	0.289	0.272	0.242	0.214	0.204	0.201	0.199	0.204	0.204	0.204	0.204	0.204
2003	1.300	1.232	0.407	0.340	0.293	0.277	0.248	0.216	0.205	0.201	0.199	0.205	0.205	0.205	0.205	0.205
2004	1.280	1.252	0.417	0.343	0.297	0.281	0.253	0.219	0.205	0.203	0.199	0.206	0.206	0.206	0.206	0.206
2005	1.251	1.263	0.427	0.344	0.299	0.283	0.257	0.222	0.206	0.204	0.199	0.208	0.208	0.208	0.208	0.208
2006	1.216	1.266	0.437	0.342	0.300	0.284	0.259	0.225	0.207	0.207	0.199	0.209	0.209	0.209	0.209	0.209
2007	1.181	1.261	0.448	0.338	0.299	0.283	0.261	0.228	0.208	0.209	0.200	0.212	0.212	0.212	0.212	0.212
2008	1.147	1.250	0.458	0.333	0.297	0.282	0.261	0.231	0.209	0.212	0.201	0.214	0.214	0.214	0.214	0.214
2009	1.118	1.238	0.470	0.327	0.295	0.280	0.261	0.235	0.210	0.216	0.202	0.216	0.216	0.216	0.216	0.216
2010	1.094	1.227	0.482	0.320	0.292	0.278	0.260	0.239	0.211	0.220	0.203	0.219	0.219	0.219	0.219	0.219
2011	1.074	1.221	0.496	0.314	0.288	0.276	0.258	0.243	0.213	0.223	0.205	0.219	0.219	0.219	0.219	0.219
2012	1.054	1.221	0.510	0.307	0.284	0.273	0.255	0.248	0.215	0.226	0.208	0.219	0.219	0.219	0.219	0.219
2013	1.035	1.225	0.526	0.302	0.279	0.269	0.252	0.252	0.217	0.229	0.211	0.219	0.219	0.219	0.219	0.219
2014	1.017	1.234	0.542	0.297	0.274	0.265	0.248	0.257	0.220	0.231	0.214	0.219	0.219	0.219	0.219	0.219
2015	0.999	1.245	0.560	0.292	0.268	0.260	0.244	0.262	0.223	0.233	0.217	0.219	0.219	0.219	0.219	0.219
2016	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
2017	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219

Table 13.2.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS Q1					
1983	2018				
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	3734.2	107.125	48.605	24.504	15.594
100	893.46	2220.593	76.321	14.493	6.385
100	57.309	473.459	1309.38	9.18	6.886
100	89.981	39.261	241.523	532.045	5.355
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	14.103	66.523	391.036	21.248	15.153
100	58.249	24.585	32.557	93.814	6.488
100	24.067	104.034	18.351	49.981	126.068
100	388.241	32.612	29.972	3.882	9.107
100	111.384	413.503	17.101	12.026	1.952
100	218.515	138.465	222.582	8.644	3.07
100	47.057	155.745	54.938	67.806	1.016

Table 13.2.17. (cont.) Haddock in Subarea 4, Division 6.a and Subdivision 20. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS Q3						
1991	2017					
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	6904.539	176.457	94.108	47.947	13.268	9.904
100	1092.754	2504.185	44.3	19.502	10.287	4.264
100	34.743	360.422	1099.293	30.29	6.371	3.648
100	137.709	45.969	237.732	573.754	9.826	2.485
100	163.931	69.348	31.171	199.259	368.665	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	352.014	94.977	220.721	8.166	3.731	0.41
100	146.171	167.605	72.398	130.786	2.896	1.29

Table 13.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA final assessment: Model settings. ω is a multiplier on the permitted variance of the estimated value: a higher setting for ω indicates greater down weighting of that value in the overall assessment.

Landings	**Ages**	**0–8+**
	Years	1972–2017
Discards	Ages	0–8+
	Years	1972, 1978–2017
Industrial bycatch	Ages	0–8+
	Years	1972, 1978–2017
BMS landings	Ages	0–8+
	Years	2016–2017
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		$H(a) = (2,2,1,1,1,1,1,1,1)$
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+bms		$B_{discards}(a) = (2.0, 1.7, 1, 1.5, 1.8, 2.4, *, *, *)$
Downweighted landings outliers		1996, age 7 ($\omega = 3$)
Downweighted discards+bycatch+bms outliers		1982, age 5; 2002, age 0; 2012, age 2 ($\omega = 3$ for all)
Downweighted survey outliers		NS IBST Q1: 2011, age 5 ($\omega = 3$)

Table 13.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA final assessment: Parameter estimates.

	Estimate	Lower bound	Upper bound	Estimated	On bound
F age 0	0.0384	0.005	0.1	TRUE	FALSE
F age 1	0.0881	0.05	0.15	TRUE	FALSE
F age 2	0.8525	0.6	1	TRUE	FALSE
F age 7	1.2893	1	1.4	TRUE	FALSE
sd F	0.1599	0.01	0.2	TRUE	FALSE
sd U	0.0721	0.01	0.15	TRUE	FALSE
sd V	0.1977	0.01	0.2	TRUE	FALSE
sd Y	0.1258	0.01	0.25	TRUE	FALSE
cv landings	0.1459	0.1	0.3	TRUE	FALSE
cv discards+bycatch+bms	0.2729	0.2	0.4	TRUE	FALSE
log mean recruitment at start	7.1087	7	9	TRUE	FALSE
sd of random walk	0.0803	0	0.25	TRUE	FALSE
recruitment cv	0.4834	0.3	0.6	TRUE	FALSE
discards sd transitory	0.0054	0	0.35	TRUE	FALSE
discards sd persistent	0.3375	0.25	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2869	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.7025	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.7202	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5925	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4529	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.3728	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.1745	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.073	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2685	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3919	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5931	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.5019	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3917	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.3492	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.2557	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.0818	0	0.3	TRUE	FALSE
NSQ3 omega	0.105	0	0.3	TRUE	FALSE
NSQ3 beta	0	0	0.1	FALSE	TRUE

Table 13.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. 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 2018 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
1972	0.039	0.084	0.614	1.016	0.962	0.920	1.012	1.050	0.989	0.864
1973	0.034	0.095	0.595	0.904	0.861	0.901	0.999	1.037	1.106	0.787
1974	0.032	0.090	0.635	0.721	0.864	0.769	0.901	0.968	0.971	0.740
1975	0.036	0.092	0.716	0.903	0.989	0.946	1.109	1.090	1.077	0.869
1976	0.033	0.093	0.574	0.982	0.871	1.062	0.976	1.001	1.005	0.809
1977	0.032	0.101	0.624	0.750	1.080	0.978	0.974	0.939	0.968	0.818
1978	0.027	0.121	0.668	0.946	1.094	1.084	1.068	1.071	1.111	0.903
1979	0.032	0.103	0.715	1.046	0.994	1.019	1.027	1.037	1.044	0.918
1980	0.036	0.086	0.516	1.050	1.115	0.805	0.923	0.965	0.967	0.894
1981	0.031	0.077	0.338	0.798	0.909	0.754	0.473	0.741	0.708	0.682
1982	0.022	0.077	0.396	0.590	0.708	0.599	0.613	0.719	0.636	0.565
1983	0.021	0.088	0.467	0.846	0.855	0.907	0.758	0.752	0.768	0.723
1984	0.024	0.121	0.507	0.945	1.083	0.822	0.835	0.805	0.806	0.845
1985	0.024	0.123	0.464	0.920	1.020	0.874	0.830	0.775	0.782	0.801
1986	0.018	0.127	0.664	0.937	1.113	0.828	0.680	0.685	0.732	0.905
1987	0.025	0.103	0.757	1.010	0.957	0.886	0.892	0.827	0.800	0.908
1988	0.024	0.121	0.608	1.160	1.097	0.952	0.860	0.788	0.829	0.955
1989	0.021	0.124	0.652	0.954	1.110	0.878	0.851	0.789	0.794	0.905
1990	0.017	0.120	0.734	0.973	0.990	0.866	0.730	0.690	0.709	0.899
1991	0.019	0.168	0.708	1.020	0.928	0.793	0.782	0.745	0.709	0.885
1992	0.021	0.126	0.653	0.998	1.002	0.664	0.865	0.710	0.735	0.884
1993	0.024	0.169	0.808	1.002	1.017	0.976	0.837	0.831	0.851	0.942
1994	0.016	0.127	0.738	1.029	0.982	1.034	0.981	0.922	0.839	0.916
1995	0.021	0.101	0.595	0.922	0.945	0.824	0.925	0.722	0.717	0.821
1996	0.019	0.099	0.524	0.875	1.011	0.978	0.972	0.715	0.711	0.803
1997	0.014	0.117	0.489	0.631	0.745	0.901	0.793	0.615	0.602	0.622
1998	0.014	0.145	0.627	0.690	0.871	0.821	0.806	0.624	0.609	0.729
1999	0.012	0.126	0.677	0.916	0.856	1.088	0.884	0.684	0.653	0.816
2000	0.012	0.100	0.736	0.958	0.963	0.821	0.869	0.617	0.593	0.886
2001	0.011	0.081	0.410	0.684	0.706	0.664	0.601	0.436	0.422	0.600
2002	0.007	0.105	0.275	0.362	0.484	0.469	0.427	0.295	0.293	0.374
2003	0.005	0.047	0.214	0.221	0.266	0.333	0.283	0.188	0.185	0.234
2004	0.004	0.052	0.211	0.239	0.251	0.311	0.249	0.161	0.158	0.234
2005	0.003	0.058	0.273	0.343	0.273	0.329	0.311	0.172	0.167	0.296
2006	0.005	0.052	0.425	0.524	0.550	0.531	0.398	0.272	0.226	0.500
2007	0.005	0.057	0.234	0.514	0.517	0.495	0.390	0.229	0.222	0.422
2008	0.004	0.038	0.183	0.224	0.336	0.310	0.262	0.148	0.146	0.248
2009	0.002	0.032	0.131	0.195	0.266	0.247	0.185	0.116	0.108	0.197
2010	0.003	0.033	0.169	0.244	0.233	0.268	0.181	0.113	0.107	0.215
2011	0.004	0.039	0.134	0.407	0.400	0.376	0.271	0.149	0.128	0.314
2012	0.002	0.036	0.135	0.177	0.254	0.230	0.159	0.101	0.088	0.189
2013	0.002	0.042	0.181	0.174	0.256	0.222	0.149	0.090	0.092	0.204
2014	0.002	0.038	0.316	0.353	0.338	0.360	0.176	0.121	0.114	0.336
2015	0.004	0.039	0.423	0.544	0.385	0.463	0.291	0.165	0.146	0.451
2016	0.003	0.034	0.195	0.412	0.357	0.317	0.170	0.131	0.108	0.321
2017	0.003	0.028	0.184	0.269	0.287	0.249	0.140	0.093	0.089	0.247
2018*	0.003	0.036	0.217	0.327	0.320	0.302	0.174	0.108	0.108	0.288

Table 13.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimates of stock numbers at age (thousands) from the final TSA assessment. Estimates refer to 1 January, except for age 0 for estimates refer to 1 July. *TSA estimated survivors.

	0	1	2	3	4	5	6	7	8+
1972	8943270	13347720	2102280	78990	45060	396930	7160	440	1160
1973	32931300	1989490	2732080	483960	17230	11220	118420	2070	460
1974	52623630	7324430	401620	646890	117830	4800	3440	34620	720
1975	3373420	14382110	1495140	107170	186200	33450	1670	1110	10720
1976	5452360	925140	2919750	348570	27620	48170	10230	460	3420
1977	11874670	1514310	212070	823440	83270	8320	13360	3230	1240
1978	24784890	2907060	280700	64390	256000	20980	2640	4490	1540
1979	49566390	5800200	536520	77010	16250	62980	5350	750	1750
1980	9101630	11396870	1084960	140360	17940	4690	18850	1670	790
1981	15398990	2033610	2193530	345670	33570	4650	1660	6290	820
1982	9254480	3443170	402960	799930	101510	10680	1770	650	2620
1983	30169940	2072210	698090	162110	296740	37660	4690	790	1410
1984	5827690	6671520	439850	260290	48380	93610	12210	1810	840
1985	9593360	1459430	1446070	160050	71290	12640	30530	4330	910
1986	18110550	2212260	339940	553550	45370	19950	4250	10810	1950
1987	265070	3918560	543840	110810	151750	11580	6800	1640	4810
1988	1044190	326340	1041870	161630	29410	43750	3840	2310	2360
1989	1978730	526400	101950	367550	35780	7670	13490	1350	1740
1990	8710820	730210	145760	34910	104120	9180	2600	4800	1190
1991	9817750	2228490	209270	41960	9650	30600	3190	1050	2520
1992	17033390	2532980	614710	69250	11400	2740	9820	1180	1370
1993	4304560	4534450	731630	214730	17860	3170	1070	3380	1030
1994	17004120	1173290	1246160	217910	58440	4950	970	380	1630
1995	4796300	4733570	338310	398970	58070	16770	1410	300	740
1996	6890100	1339980	1389490	127170	117740	17380	5850	470	430
1997	4149970	1924860	391800	560150	39270	33110	5210	1840	370
1998	3126270	1153240	547430	164480	219180	14300	10560	1930	1000
1999	46386980	869230	316500	197380	60570	70360	4920	3780	1320
2000	9058770	12694770	241990	107470	55660	19480	18240	1640	2170
2001	914490	2450500	3579030	79360	29200	15700	6560	6050	1750
2002	1222950	340490	691520	1612880	28270	10780	6160	2860	4200
2003	1362610	386060	91740	353580	804680	12930	5140	3180	4360
2004	1337620	408370	107460	49390	201780	459640	7000	3030	5130
2005	12763560	412890	110770	57320	27570	116470	252130	4210	5670
2006	2727540	3643970	110240	55020	28850	15590	62960	140980	6740
2007	1813230	804940	975360	46720	23250	12410	6950	32650	89460
2008	1269310	568940	215670	493200	20020	10330	5720	3650	78890
2009	9336940	450040	156600	113610	281490	10670	5730	3410	58000
2010	857280	3045050	126500	86020	67520	160680	6310	3690	44910
2011	64900	329510	863360	66020	48990	40020	93260	4070	35390
2012	1136960	107620	93530	459980	31690	24590	20920	55160	28030
2013	607300	417360	30650	49080	283070	18420	14900	13880	59780
2014	5711610	268290	117540	14710	30530	165680	11280	9990	53810
2015	1663010	2060560	75340	49530	7250	16530	88990	7390	45490
2016	2490960	611120	570830	28300	20940	3690	8020	52330	36390
2017	816110	931320	168060	264080	14070	11190	2090	5340	61320
2018*	3529010	305160	257490	78630	151670	8140	6780	1430	48530

Table 13.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary table. Both estimates (EST) and standard errors (SE) are given. *TSA model fits or projections. **Discards refers to disard+bycatch+BMS

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	408040	389760	41570	234140	230700	24790	173900	159060	29350	0.864	0.064	294770	29270	2588790	243640	8943270	1997460
1973	344580	378640	49900	207380	215530	20340	137200	163110	39440	0.787	0.070	275070	18920	2578840	225240	32931300	3908150
1974	397160	248550	28630	167650	156950	13350	229500	91600	22440	0.740	0.071	320420	21640	2671630	265710	52623630	8141150
1975	494390	302630	41560	160380	163940	13850	334010	138690	35890	0.869	0.081	157530	10630	2104070	253510	3373420	1517870
1976	401970	343770	52960	184240	211310	23900	217730	132460	39750	0.809	0.081	193770	15230	1046390	123270	5452360	1431570
1977	240260	199240	21840	156530	162500	18070	83730	36750	9070	0.818	0.085	349260	29440	805310	65360	11874670	1698740
1978	146700	137980	13380	102940	102260	9950	43760	35720	7110	0.903	0.086	157310	13390	803580	53980	24784890	1936410
1979	149260	142880	15960	97880	86160	9210	51380	56720	10300	0.918	0.089	92580	10730	1232080	68080	49566390	4386950
1980	202640	191300	19430	111370	106820	10420	91260	84480	14320	0.894	0.082	102720	10680	1434540	85660	9101630	1028390
1981	226590	227610	21350	147920	153370	15070	78660	74240	12090	0.682	0.065	193950	13040	1033650	55440	15398990	1616770
1982	256300	212690	15730	195570	169920	13440	60730	42770	6920	0.565	0.047	434790	20440	897380	37540	9254480	837450
1983	253190	227490	16700	188730	179180	12900	64450	48310	7620	0.723	0.054	294330	15180	1111260	45320	30169940	2145910
1984	247240	228200	22760	158180	150010	11040	89060	78190	17160	0.845	0.060	236970	14680	1375880	72540	5827690	1389620
1985	247430	227900	18360	183050	166760	13820	64380	61140	9840	0.801	0.057	167430	8420	907390	39380	9593360	1215040
1986	223850	208840	15220	185120	166170	12620	38740	42670	6840	0.905	0.061	289060	16470	1066440	53290	18110550	1741470
1987	195050	180210	14970	135000	125900	9560	60050	54310	9450	0.908	0.063	163170	8960	799220	40660	265070	1139920
1988	179910	170010	14160	126180	122990	10940	53730	47010	7490	0.955	0.068	126000	8580	464760	80010	1044190	1714840
1989	127680	119310	10130	92800	94440	8760	34880	24870	4400	0.905	0.068	178520	11460	383780	50960	1978730	1271090
1990	86740	78250	7550	61580	57060	5200	25160	21190	4100	0.899	0.067	85070	5880	615670	56270	8710820	1297500
1991	97200	92750	12790	55210	45520	4550	41990	47230	10430	0.885	0.067	52110	3920	801090	40930	9817750	772100
1992	134990	127520	12070	81570	72260	7210	53420	55260	8400	0.884	0.054	55850	2810	825950	36440	17033390	1245830
1993	180210	213810	21690	98700	110700	10540	81510	103110	16810	0.943	0.058	118470	7430	866630	43310	4304560	390870
1994	169470	233310	22130	95170	130440	13400	74300	102870	14970	0.916	0.060	138020	9640	893860	38630	17004120	1149860
1995	168890	174830	17100	89860	104010	10750	79040	70820	11470	0.820	0.059	196870	14150	859020	40560	4796300	389310
1996	204690	199000	18380	92630	97990	8760	112060	101010	14300	0.803	0.056	124570	7170	779850	33650	6890100	579940

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
1997	170050	162980	14530	95450	94210	8680	74600	68770	10210	0.622	0.049	252820	14700	748510	33600	4149970	395610
1998	161970	158880	13540	95510	92240	7560	66460	66640	9390	0.729	0.056	183380	9620	583830	25230	3126270	281800
1999	123420	127490	10900	75970	73520	6040	47450	53970	7470	0.816	0.062	142890	8770	1525980	88040	46386980	3332690
2000	126870	167370	29970	54480	55520	5030	72390	111860	27620	0.886	0.066	92660	6350	2161740	120720	9058770	611920
2001	173530	275050	37940	47550	99130	14430	125980	175920	30580	0.600	0.053	62710	4370	1145040	65140	914490	659540
2002	155140	187090	21900	65400	99440	12100	89750	87650	15800	0.374	0.037	537860	36590	772100	40550	1222950	330210
2003	74410	98390	11230	47270	76050	9340	27150	22340	4250	0.234	0.025	460410	27520	545040	28950	1362610	268290
2004	72510	76890	9270	51920	65720	8420	20590	11170	1940	0.233	0.025	315950	21690	450460	24220	1337620	187890
2005	64120	64130	7520	51540	54860	6880	12570	9270	1450	0.296	0.030	232970	18930	1018280	43240	12763560	671830
2006	66950	65540	7910	43330	45380	5380	23620	20160	4300	0.500	0.043	160040	15230	764930	32010	2727540	203700
2007	67430	74570	7830	34680	44790	5060	32750	29780	4560	0.422	0.038	131260	15050	556810	26670	1813230	328960
2008	47730	54850	5630	33040	40330	4270	14700	14520	2490	0.248	0.026	277520	18170	467540	22220	1269310	261080
2009	47940	44020	4370	35570	35980	3720	12370	8040	1240	0.198	0.021	227970	17200	802660	31210	9336940	473450
2010	45410	43550	4520	31940	34830	3560	13470	8720	1680	0.216	0.023	211370	16640	499030	24380	857280	631060
2011	49660	56420	5340	36570	39790	3610	13090	16620	2830	0.314	0.032	151640	11060	423350	19400	64900	484080
2012	43200	45110	4500	38160	39720	3970	5030	5380	1090	0.188	0.021	313510	17310	411590	19910	1136960	224380
2013	47070	42610	4430	43710	39350	4120	3350	3260	660	0.204	0.021	250330	13430	355790	16410	607300	195030
2014	46320	49630	4920	41170	44690	4520	5150	4940	890	0.336	0.032	179490	11350	507560	22150	5711610	410890
2015	41590	47820	4820	35310	38670	3660	6290	9160	2170	0.450	0.041	141520	10310	523270	26070	1663010	185720
2016	43050	48580	5190	35060	38290	4250	7990	10290	1880	0.321	0.035	120730	10390	541040	30850	2490960	403900
2017	39900	43520	4440	32840	37130	3890	7060	6390	1250	0.247	0.030	205170	14210	432570	34520	816110	426360
2018*		59450	14600		52470	13040		6980	2310	0.288	0.081	218270	17100	498520	93870	3529010	2189140

Table 13.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

MFDP version 1a

RUN: 15

TIME AND DATE: 14:33 23/05/2018

Fbar age range (Total) : 2–4

Fbar age range Fleet 1 : 2–4

Fbar age range Fleet 2 : 2–4

2018						
Age	N	M	Mat	PF	PM	SWt
0	3529010	0.98	0	0	0	0.039
1	305160	1.26	0	0	0	0.149
2	257490	0.58	0	0	0	0.372
3	78630	0.29	1	0	0	0.447
4	151670	0.26	1	0	0	0.775
5	8140	0.26	1	0	0	1.044
6	6780	0.24	1	0	0	1.144
7	1430	0.27	1	0	0	1.28
8	48530	0.23	1	0	0	1.224
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.356	0.003	0.039		
1	0.001	0.318	0.035	0.147		
2	0.124	0.462	0.093	0.247		
3	0.3	0.469	0.027	0.306		
4	0.31	0.783	0.01	0.516		
5	0.3	0.952	0.002	0.952		
6	0.167	1.05	0.007	0.543		
7	0.108	1.378	0	1.022		
8	0.108	1.162	0	0.641		
IBC						
Age	Sel	CWt				
0	0	0.178				
1	0	0.3177				
2	0	0.4623				
3	0	0.5667				
4	0	0.7777				
5	0	0.8497				
6	0	0.9783				
7	0	0.819				
8	0	0.937				

Table 13.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

2019						
Age	N	M	Mat	PF	PM	SWt
0	3529010	0.98	0	0	0	0.039
1	.	1.26	0	0	0	0.149
2	.	0.58	0	0	0	0.372
3	.	0.29	1	0	0	0.55
4	.	0.26	1	0	0	0.607
5	.	0.26	1	0	0	0.75
6	.	0.24	1	0	0	1.254
7	.	0.27	1	0	0	1.331
8	.	0.23	1	0	0	1.459
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.356	0.003	0.039		
1	0.001	0.318	0.035	0.147		
2	0.124	0.462	0.093	0.247		
3	0.3	0.567	0.027	0.337		
4	0.31	0.56	0.01	0.56		
5	0.3	0.634	0.002	0.634		
6	0.167	1.109	0.007	1.109		
7	0.108	1.181	0	0.62		
8	0.108	1.561	0	1.175		
IBC						
Age	Sel	CWt				
0	0	0.178				
1	0	0.3177				
2	0	0.4623				
3	0	0.5667				
4	0	0.7777				
5	0	0.8497				
6	0	0.9783				
7	0	0.819				
8	0	0.937				

Table 13.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

2020						
Age	N	M	Mat	PF	PM	SWt
0	3529010	0.98	0	0	0	0.039
1	.	1.26	0	0	0	0.149
2	.	0.58	0	0	0	0.372
3	.	0.29	1	0	0	0.55
4	.	0.26	1	0	0	0.768
5	.	0.26	1	0	0	0.788
6	.	0.24	1	0	0	0.893
7	.	0.27	1	0	0	1.464
8	.	0.23	1	0	0	1.518
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.356	0.003	0.039		
1	0.001	0.318	0.035	0.147		
2	0.124	0.462	0.093	0.247		
3	0.3	0.567	0.027	0.337		
4	0.31	0.778	0.01	0.419		
5	0.3	0.788	0.002	0.788		
6	0.167	0.708	0.007	0.708		
7	0.108	1.266	0	1.266		
8	0.108	1.313	0	0.698		
IBC						
Age	Sel	CWt				
0	0	0.178				
1	0	0.3177				
2	0	0.4623				
3	0	0.5667				
4	0	0.7777				
5	0	0.8497				
6	0	0.9783				
7	0	0.819				
8	0	0.937				

Input units are thousands and kg - output in tonnes

Table 13.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast output. A number of management options are highlighted.

Basis	Total catch (2019)	Wanted catch * (2018)	Unwanted catch * (2018)	IBC ** (2019)	F_{total} (2019)	F_{wanted} (2019)	$F_{unwanted}$ (2019)	F_{IBC} (2019)	SSB (2020)	% SSB change ***	% TAC change ****	% Advice change *****
ICES advice basis												
MSY approach: F_{MSY}	34160	29729	4431	0.000	0.194	0.165	0.029	0.000	193817	-11%	-30%	-30%
Other scenarios												
F = 0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	230113	6%	-100%	-100%
F_{pa}	46847	40672	6174	0.000	0.274	0.233	0.041	0.000	180621	-17%	-4%	-4%
F_{lim}	62397	53988	8409	0.000	0.380	0.323	0.057	0.000	164646	-24%	27%	27%
SSB (2020) = B_{lim}	123418	103971	19447	0.000	0.981	0.833	0.148	0.000	94000	-51%	153%	153%
SSB (2020) = B_{pa}	93876	80454	13422	0.000	0.635	0.539	0.095	0.000	132000	-39%	92%	92%
SSB (2020) = MSY $B_{trigger}$	93876	80454	13422	0.000	0.635	0.539	0.095	0.000	132000	-39%	92%	92%
F = F_{2018}	48983	42508	6474	0.000	0.288	0.245	0.043	0.000	178412	-18%	0%	0%
$F_{MSY\ upper}$	29694	25862	3832	0.000	0.167	0.142	0.025	0.000	198492	-9%	-39%	-39%
$F_{MSY\ lower}$	34160	29729	4431	0.000	0.194	0.165	0.029	0.000	193817	-11%	-30%	-30%

*** "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 rate estimates for 2015–2017. Unwanted catch includes discards and BMS landings.**

**** Industrial bycatch (IBC) is based on average proportion of the total catch for 2015–2017.**

***** SSB 2020 relative to SSB 2019.**

****** Total catch in 2019 relative to TAC in 2018 Subdivision 20 (2569) Subarea 4 (41 767) Division 6a (4454) = 48990t.**

*******Maximum level of permissible bycatches when the advice is "no targeted fisheries and bycatches should be minimized".**

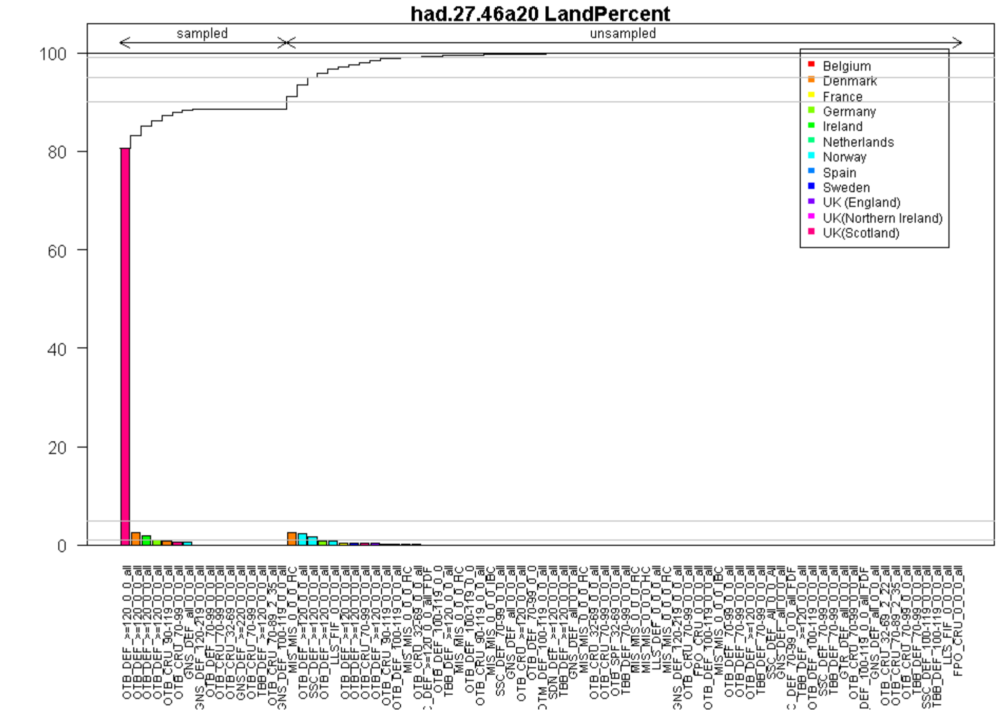


Figure 13.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

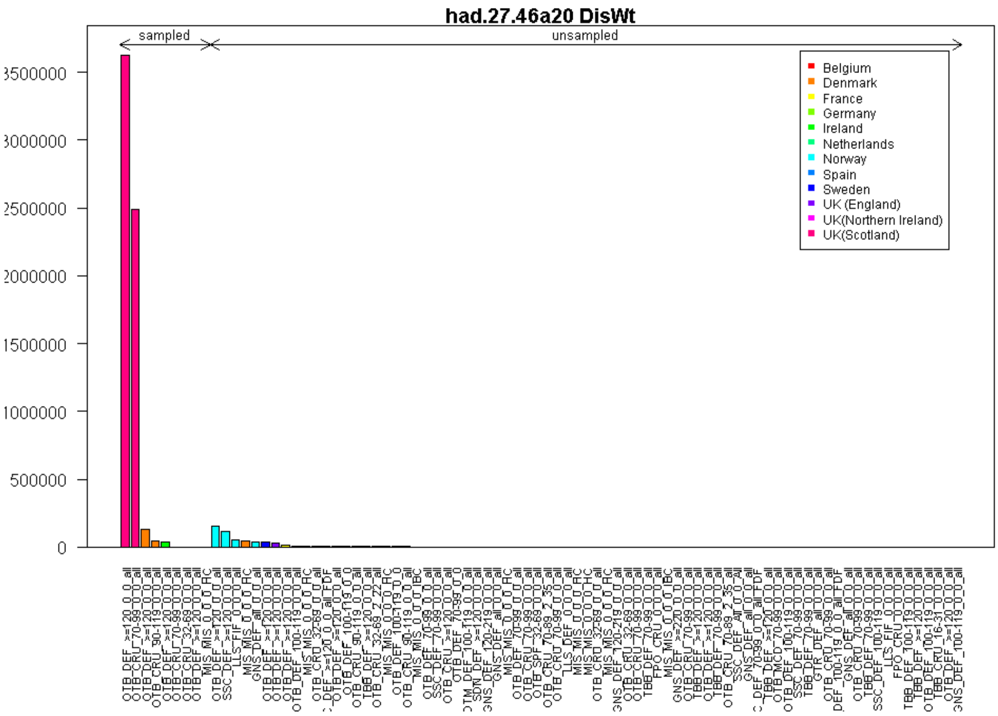


Figure 13.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary of landings for fleets with and without discard estimates.

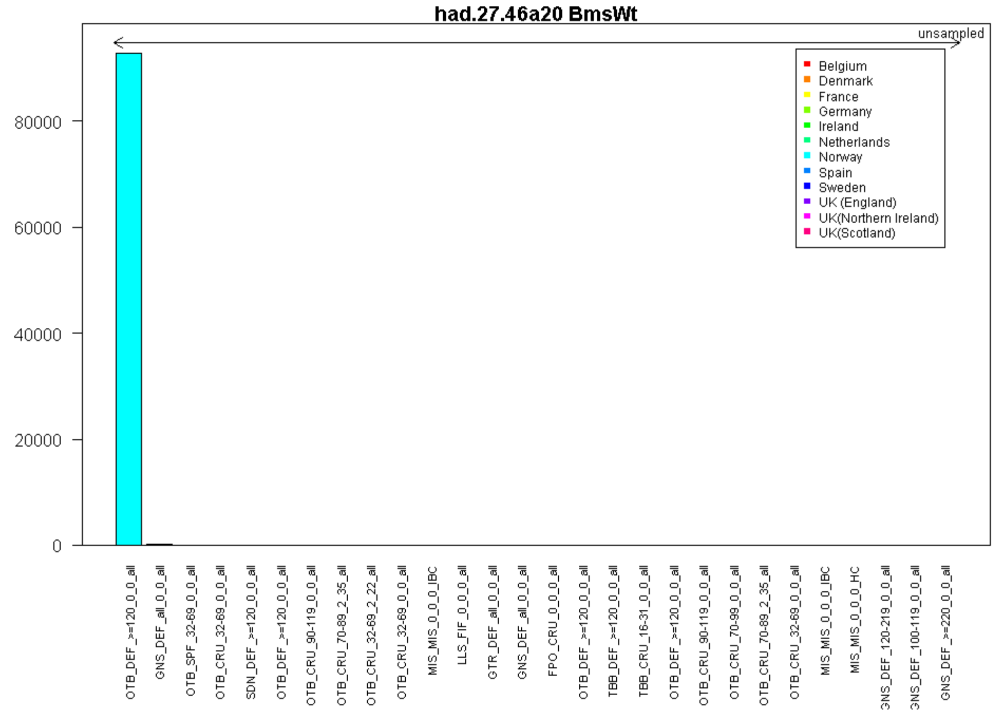


Figure 13.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported BMS landings for each sampled and unsampled fleet in the full stock area, in descending order of yield.

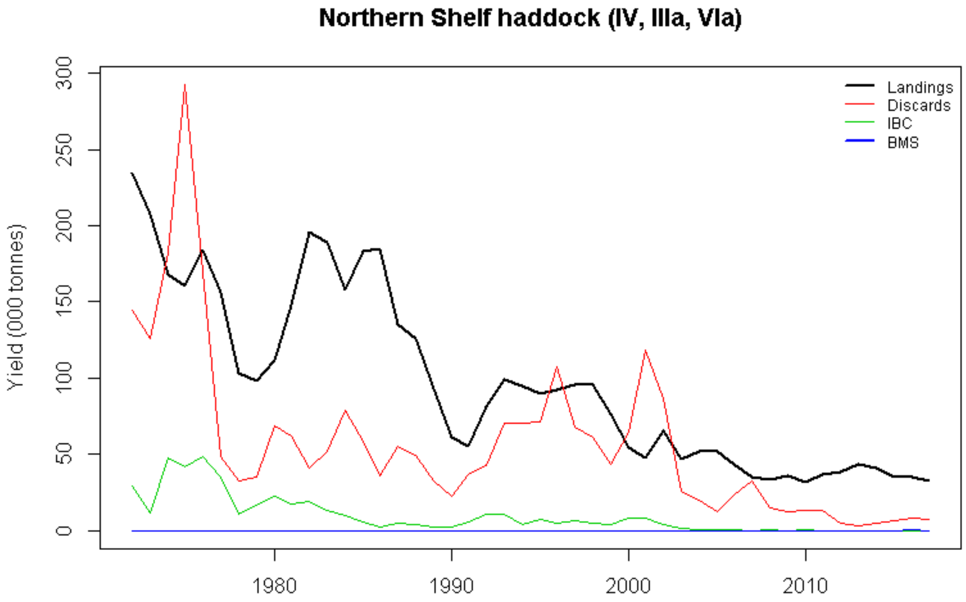


Figure 13.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Yield by catch component.

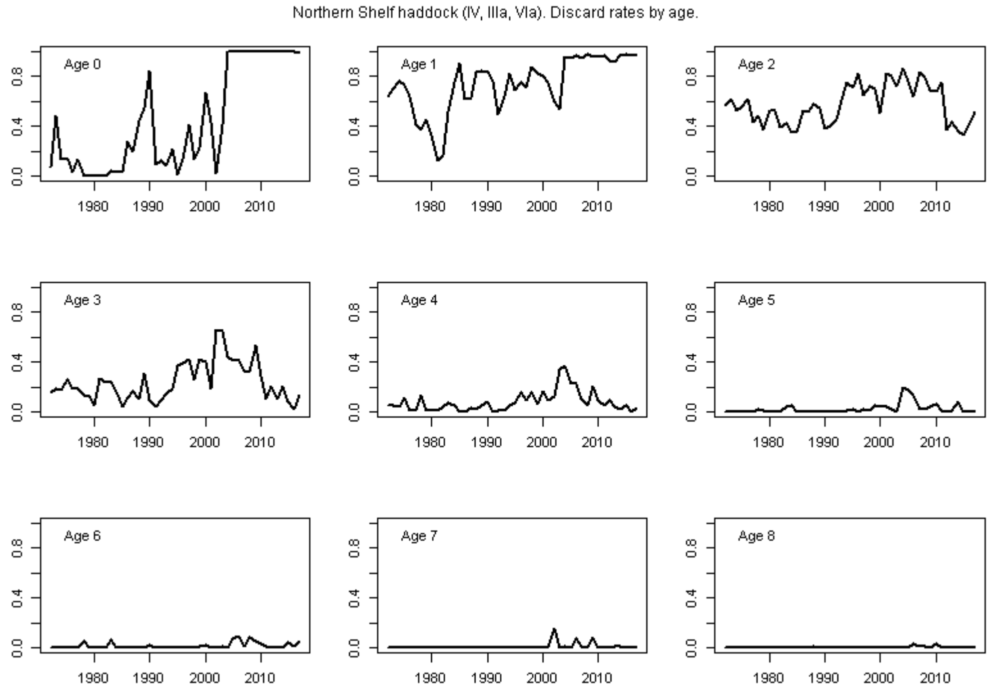


Figure 13.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of total catch discarded, by age and year.

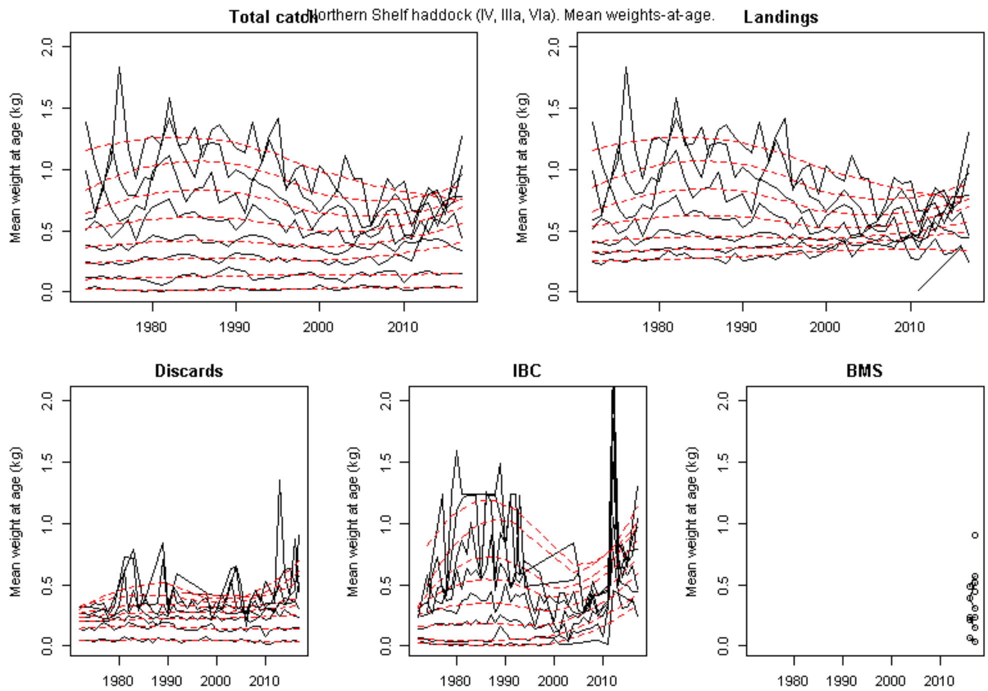


Figure 13.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

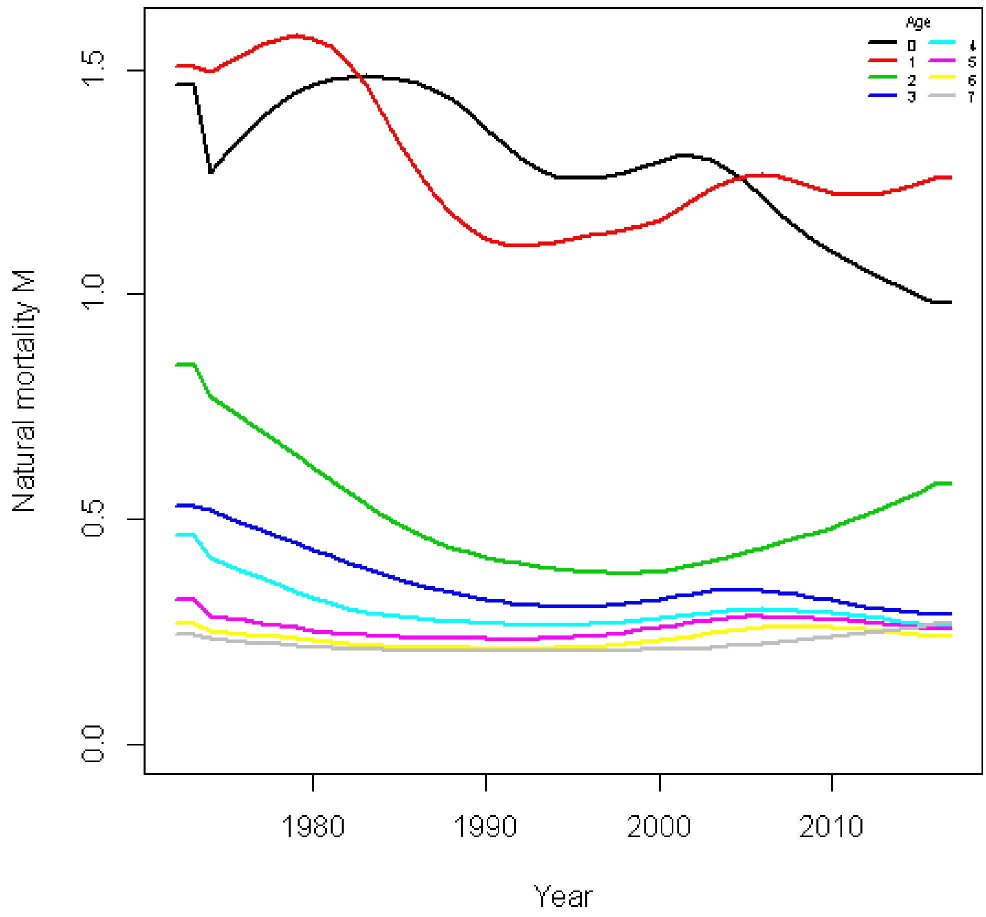


Figure 13.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time series of estimated natural mortality at age, from ICES WGSAM (2014).

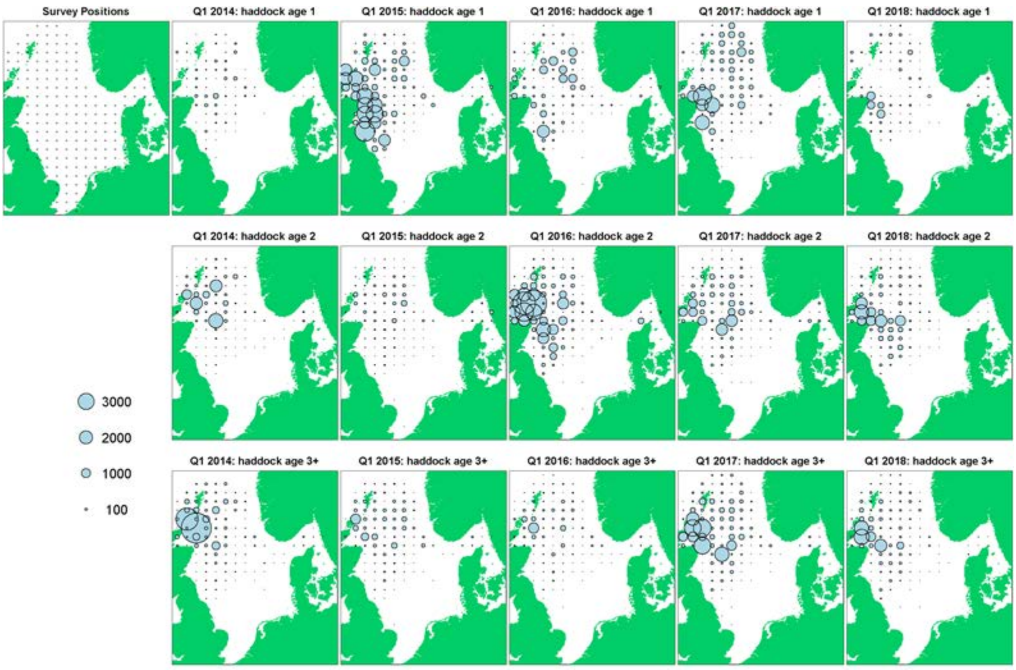


Figure 13.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q1 survey (North Sea).

Figure 13.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q3 survey (North Sea).

Figure 13.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age and quarter for the Scottish West Coast Q1 survey (West of Scotland). Rows show years 2015–2018 (from top to bottom).

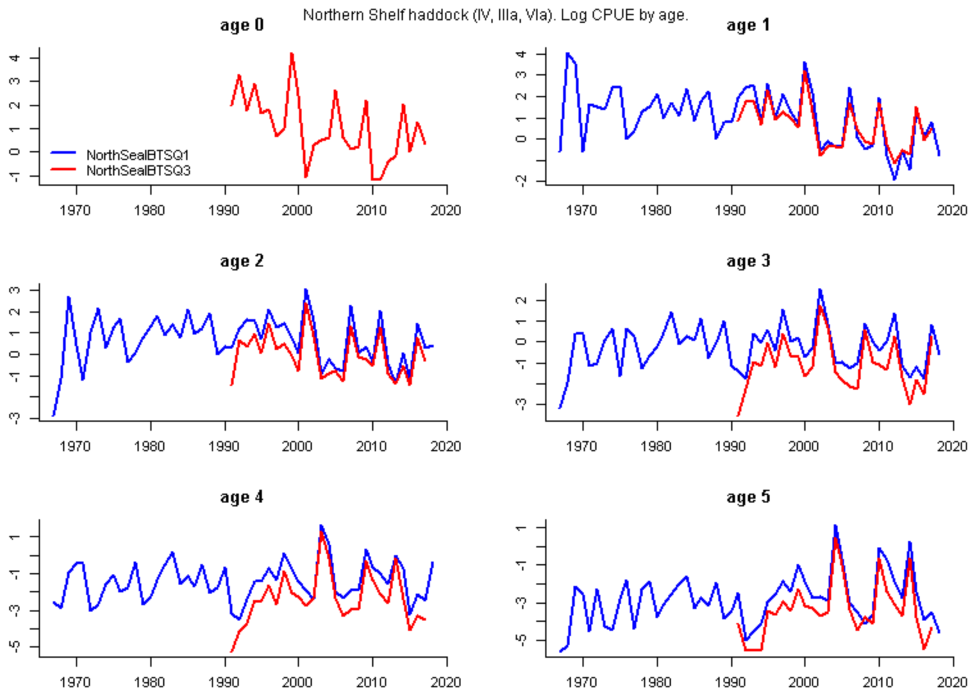


Figure 13.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey log CPUE (catch per unit effort) at age.

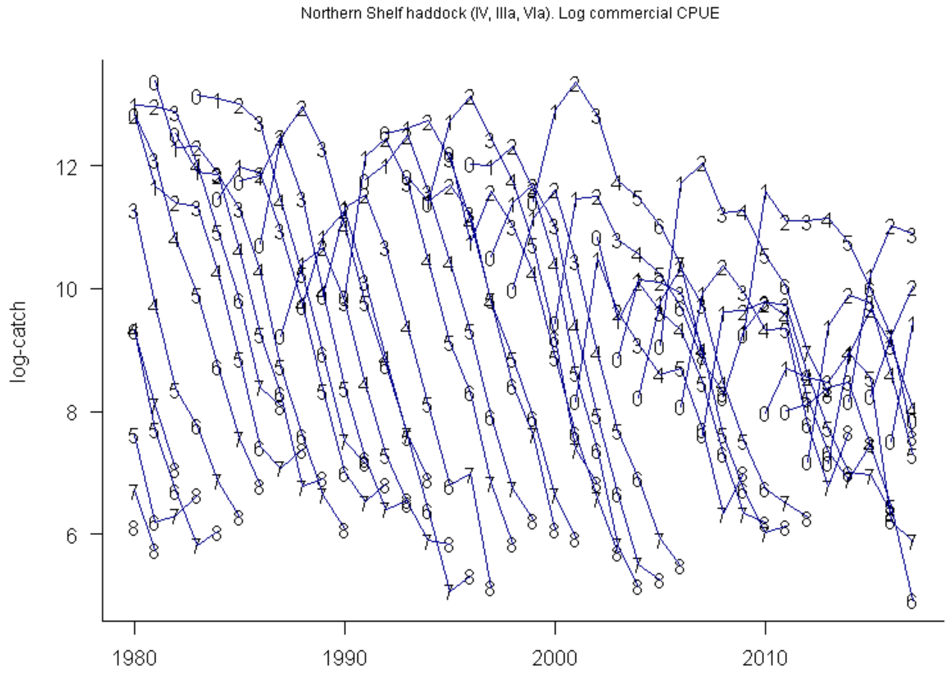


Figure 13.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log catch curves by cohort for total catches.

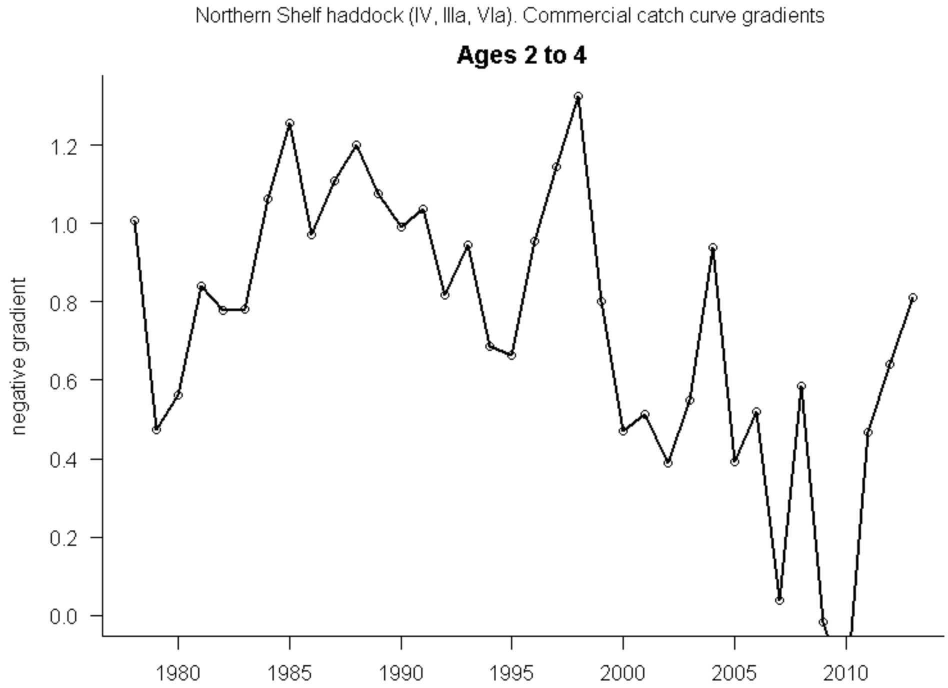


Figure 13.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Negative gradients of log catches per cohort, averaged over ages 2–4. The x-axis represents the spawning year of each cohort.

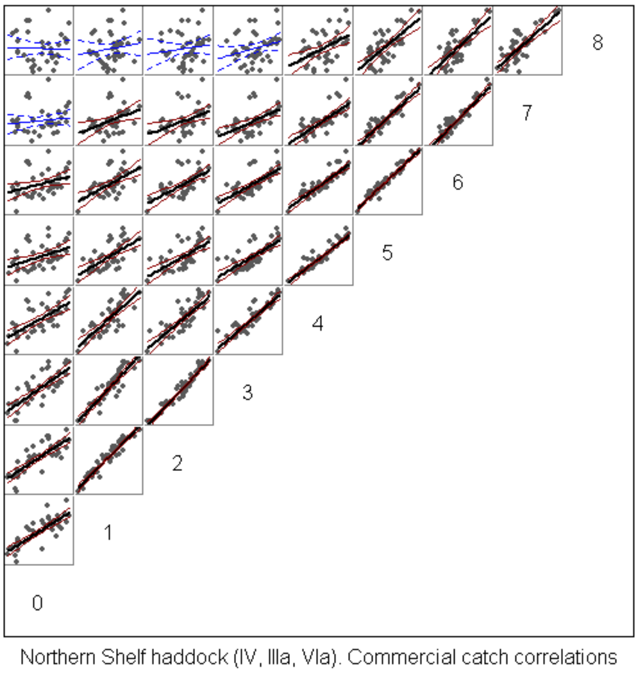


Figure 13.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and 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.

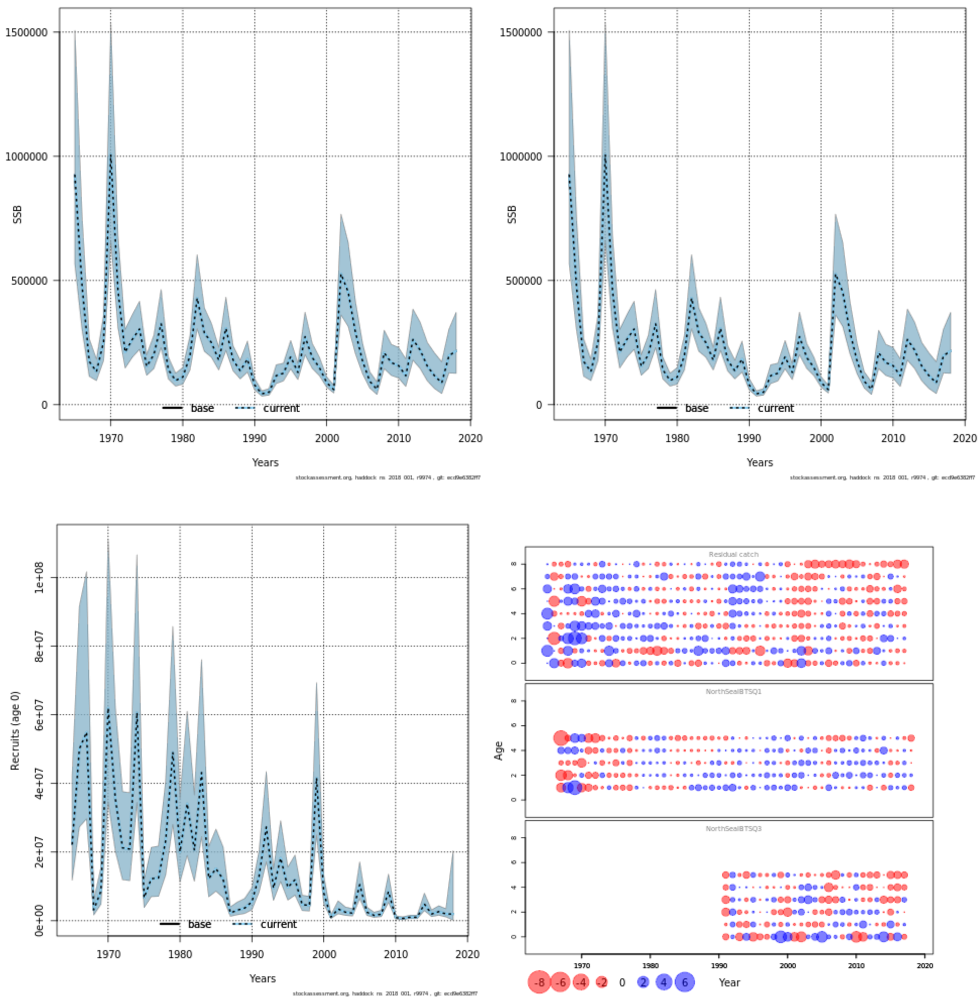


Figure 13.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SAM assessment. Time-series of estimated mean F (2–4) (top left), SSB F(2–4) (top right) and recruitment (bottom left) are shown with approximate pointwise 95% confidence intervals. Retrospective runs are included in these plots. Model residuals (bottom right) are depicted with a clear blue circle for a positive residual, and a solid red circle for a negative residual.

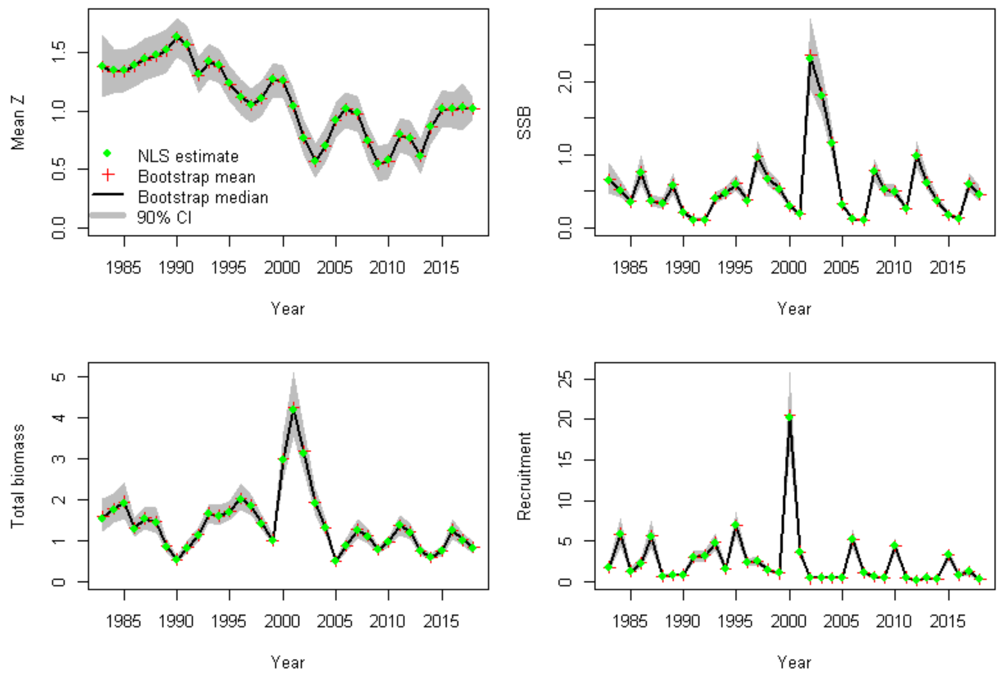


Figure 13.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded 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.

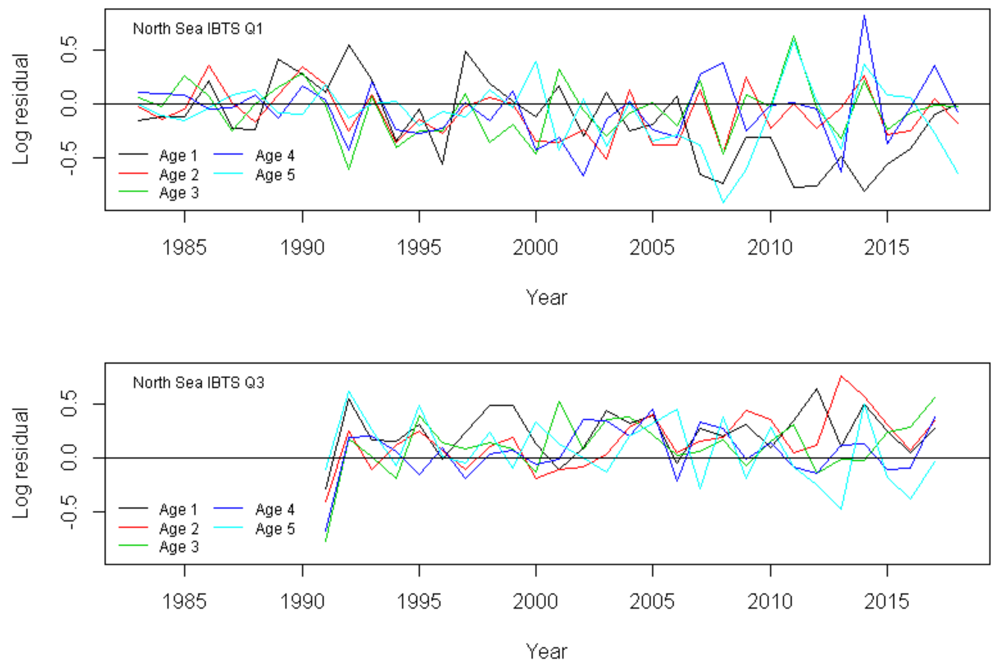


Figure 13.3.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).

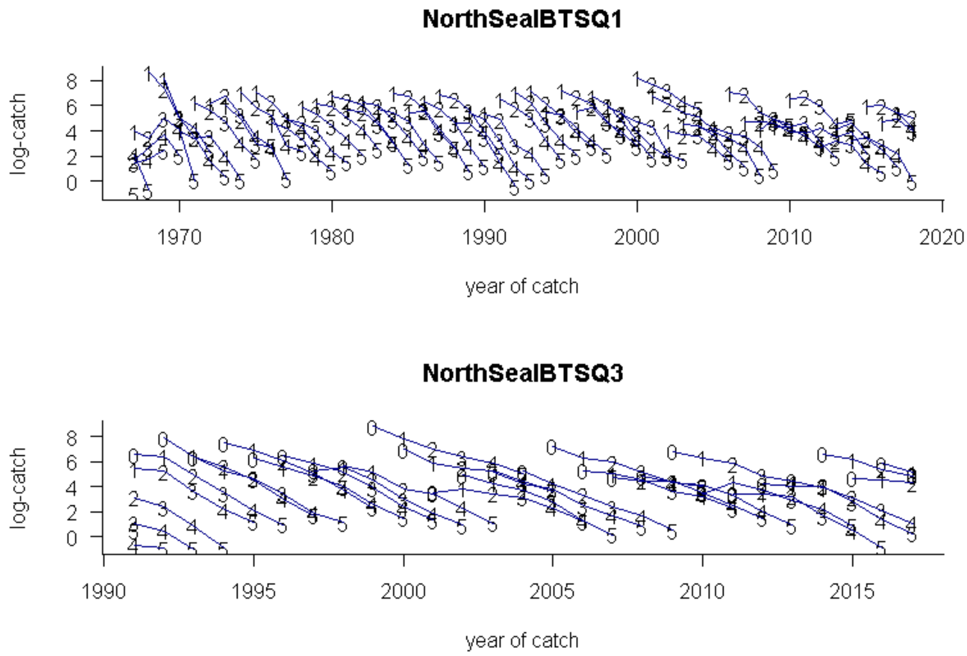


Figure 13.3.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

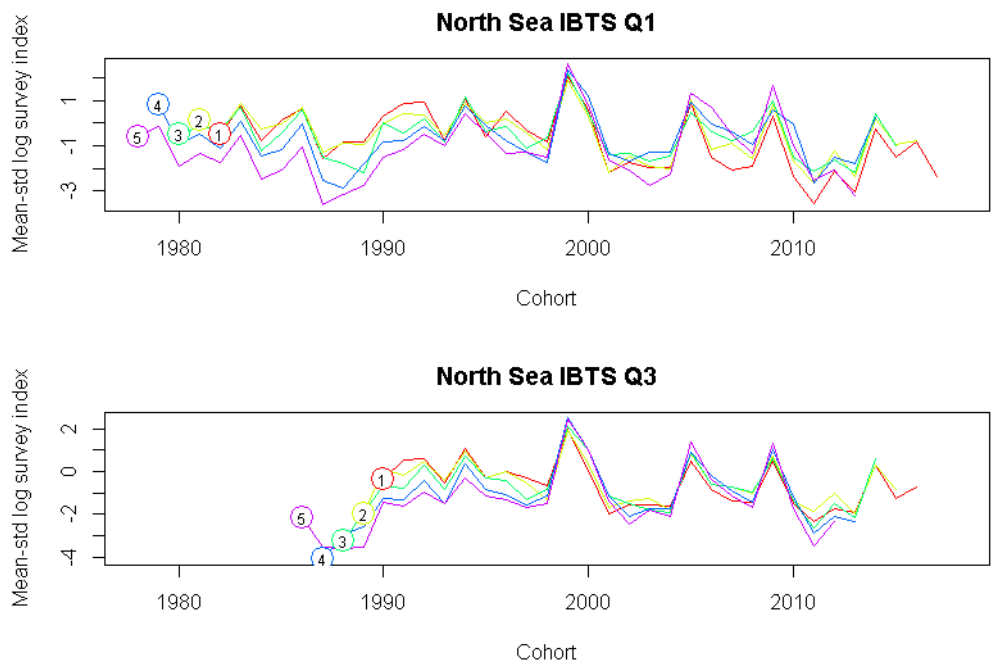
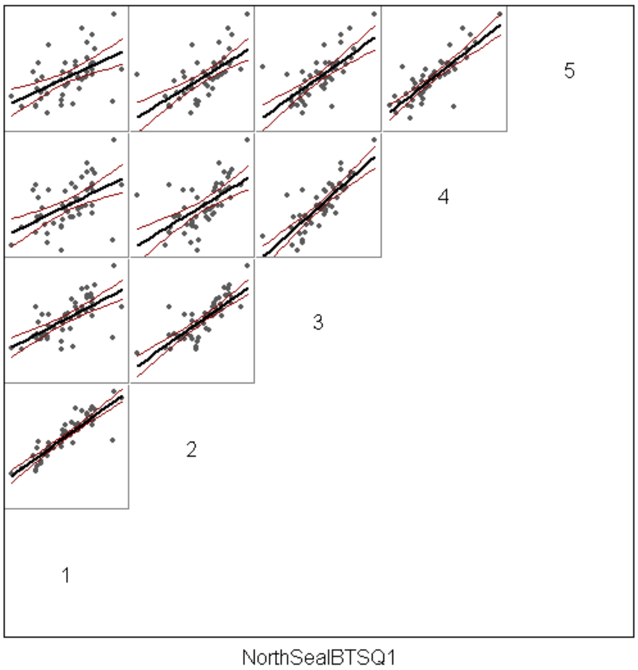


Figure 13.3.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.



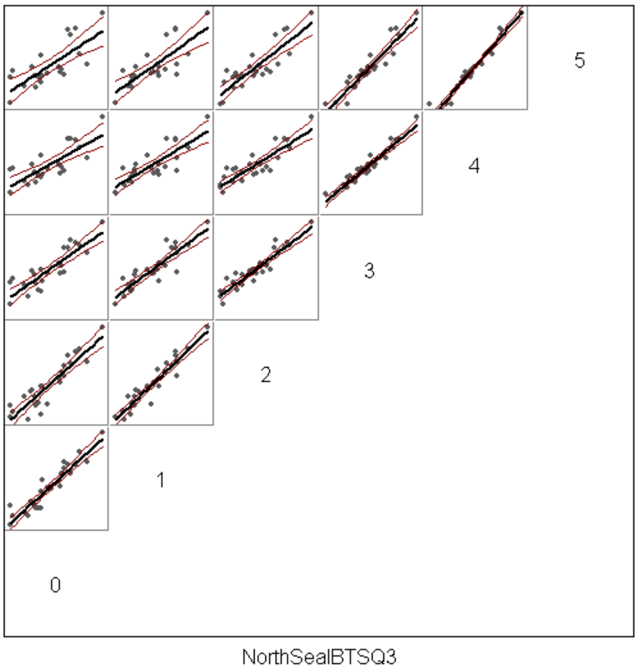


Figure 13.3.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (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.

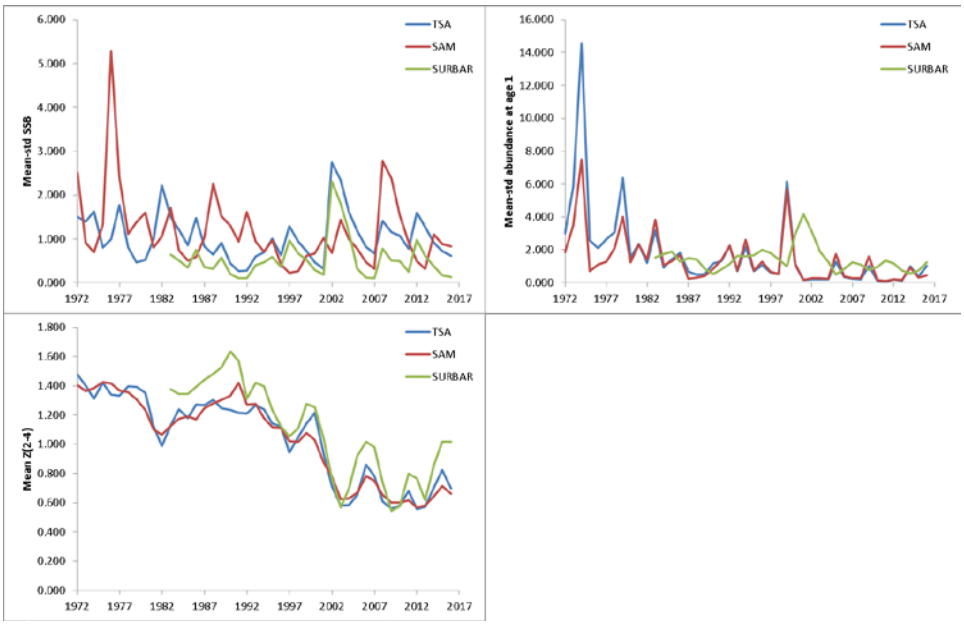


Figure 13.3.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Comparisons of stock summary estimates from TSA (blue), SAM (red) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models, and a composite Z estimate has been made for TSA, and SAM by adding natural and fishing mortality estimates.

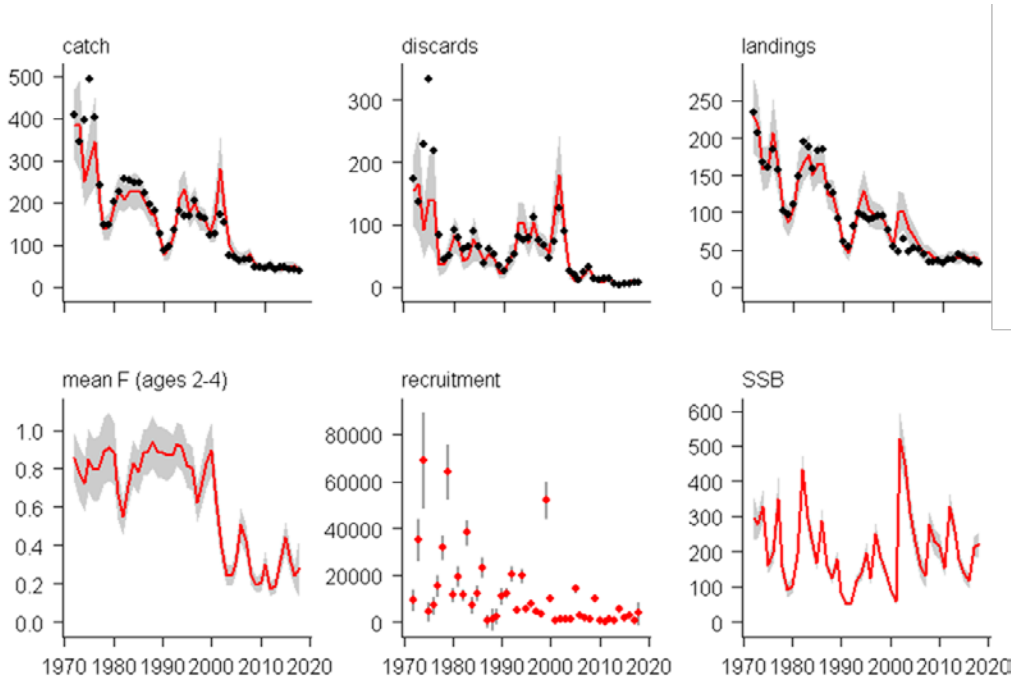


Figure 13.3.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary from final TSA assessment (including forecasts for 2017). Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for discards (discards+IBC+BMS), and landings).

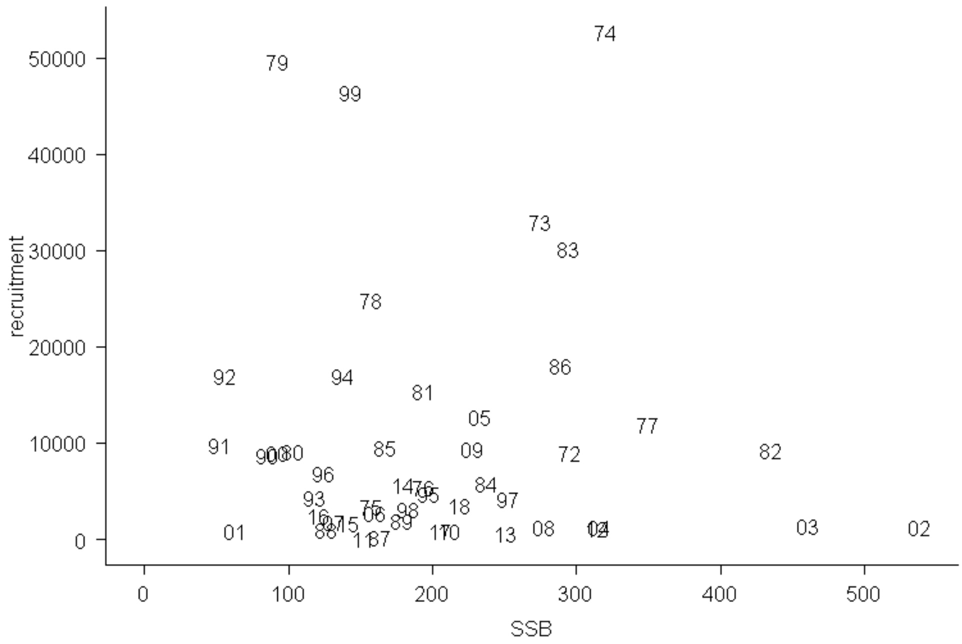


Figure 13.3.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

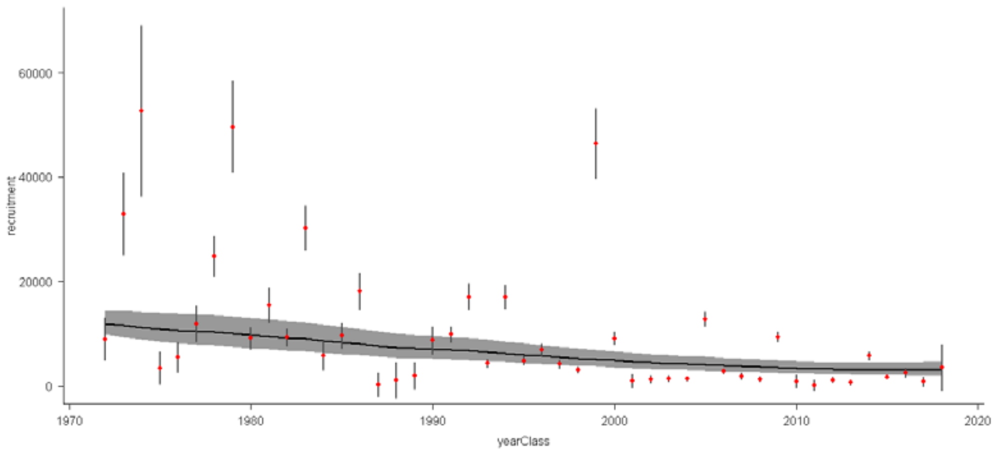


Figure 13.3.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk recruitment model estimated by TSA.

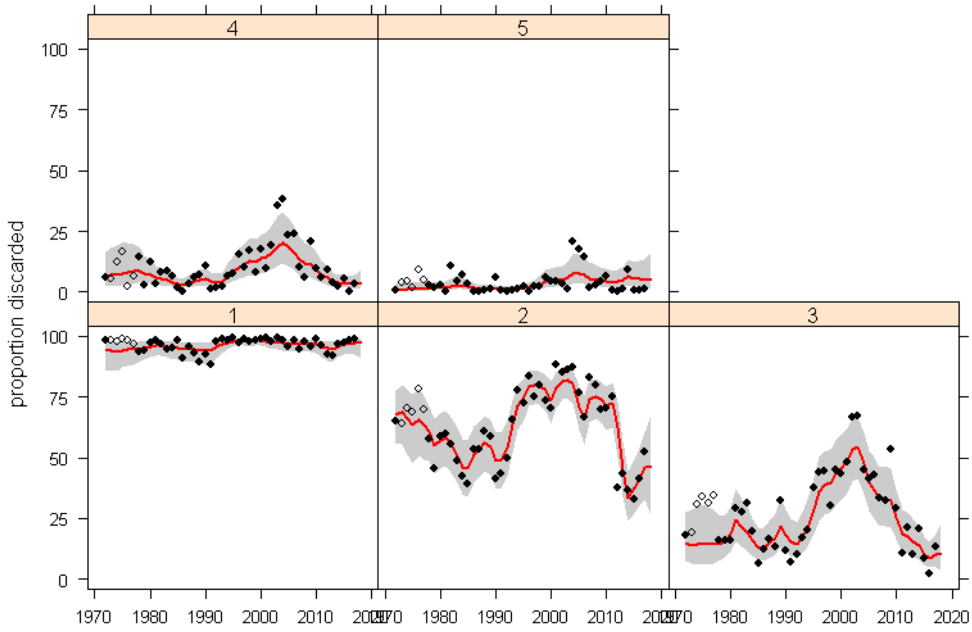


Figure 13.3.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch + BMS. The open points for the years 1973–1977 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 or BMS.

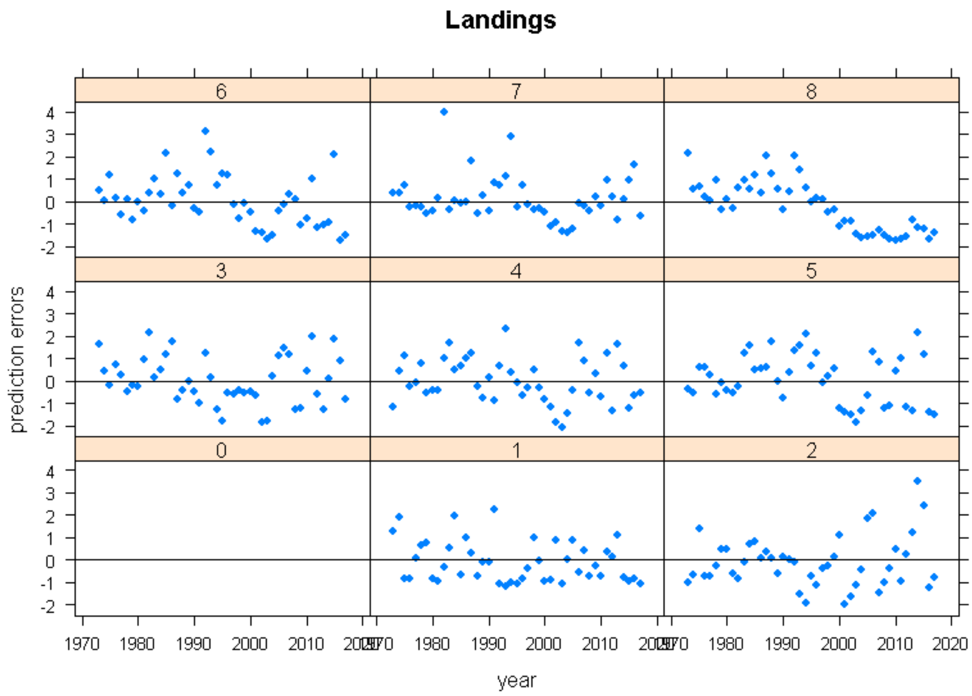


Figure 13.3.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA landings prediction errors by age.

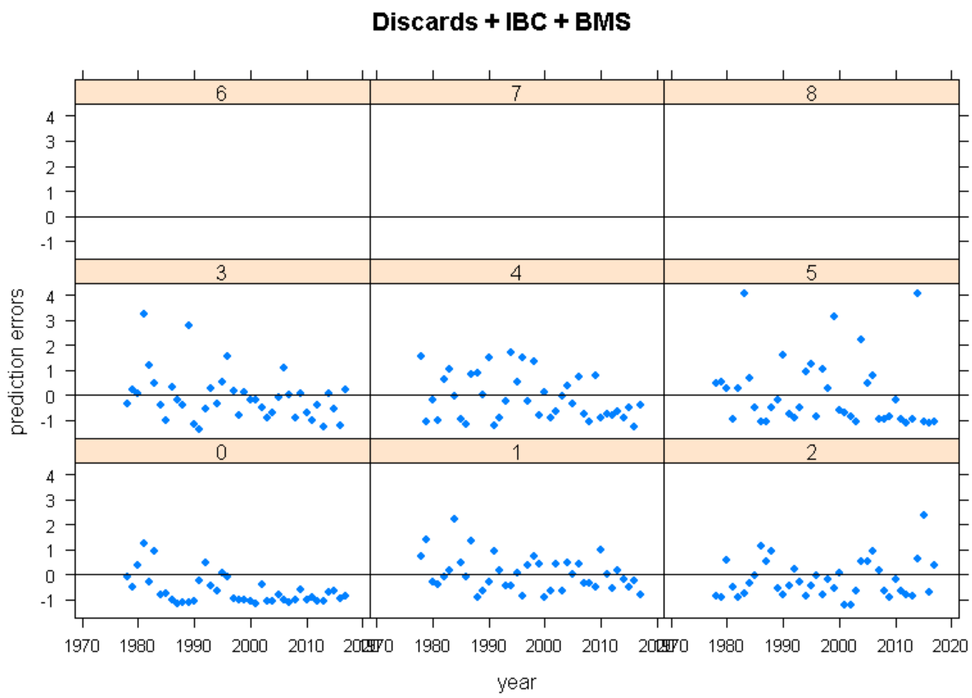


Figure 13.3.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA discards + IBC + BMS prediction errors by age.

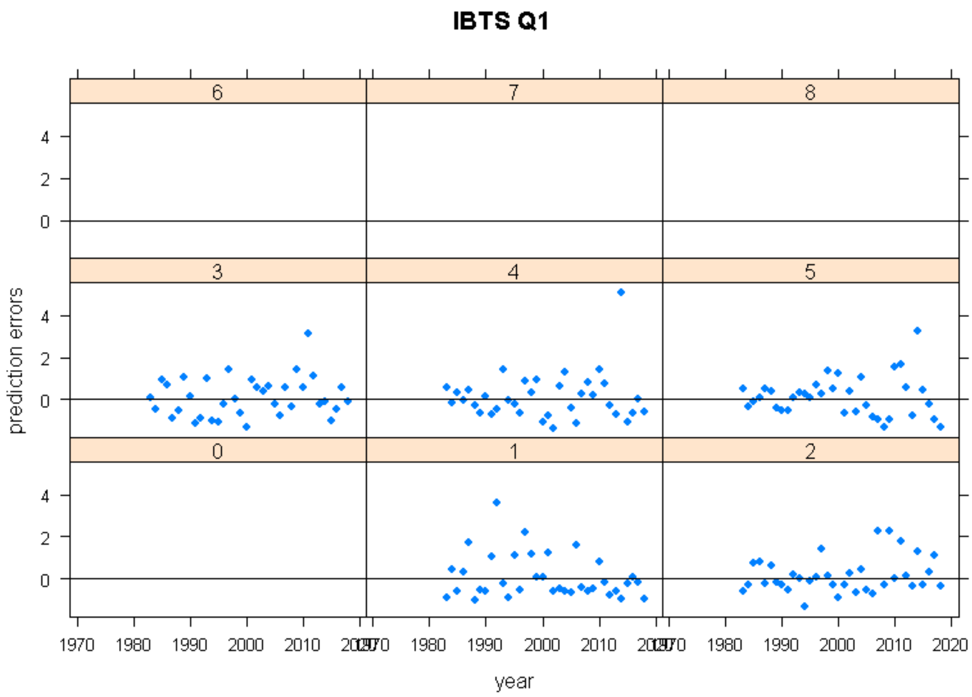


Figure 13.3.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q1 survey index.

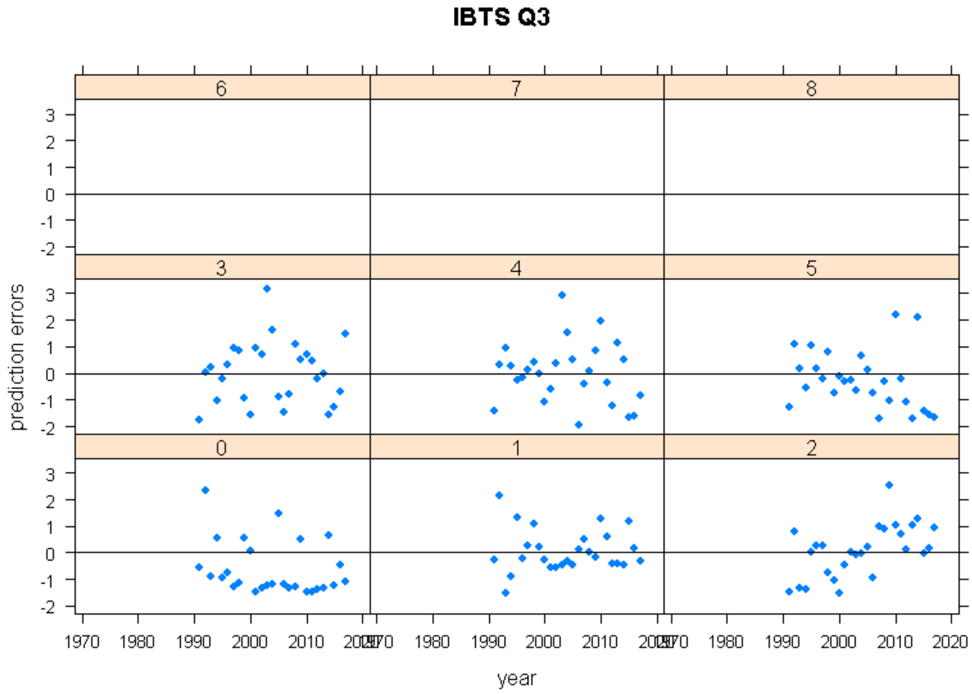


Figure 13.3.18. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q3 survey index.

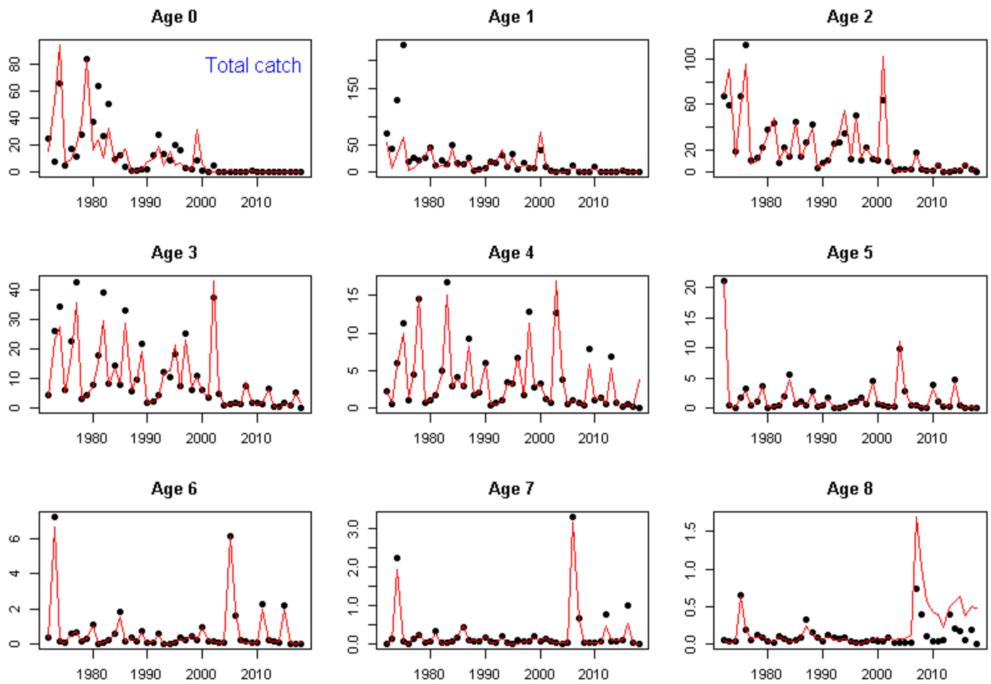


Figure 13.3.19. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time–series of observed (points) and fitted (lines) values for total catch, by age.

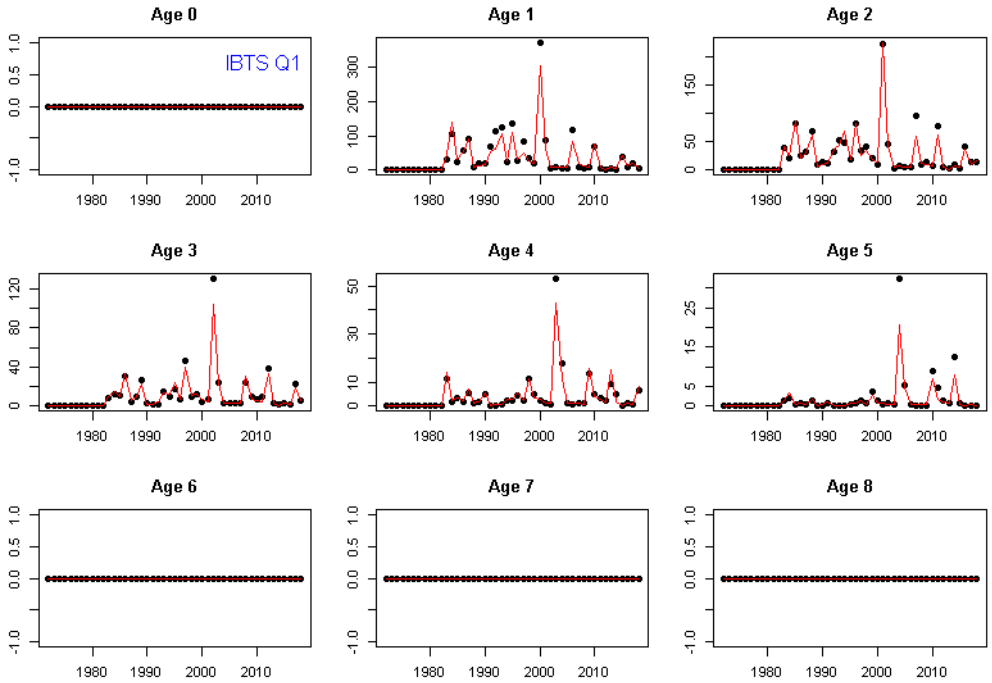


Figure 13.3.20. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

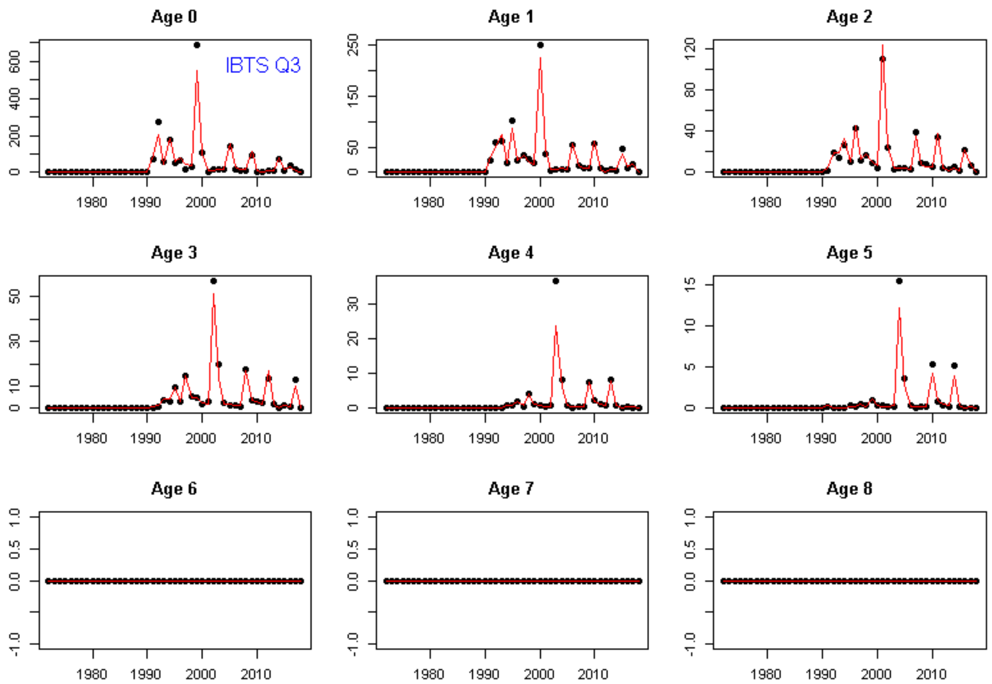


Figure 13.3.21. Haddock in Subarea 4, Division 6.a and Subdivision 20 Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.

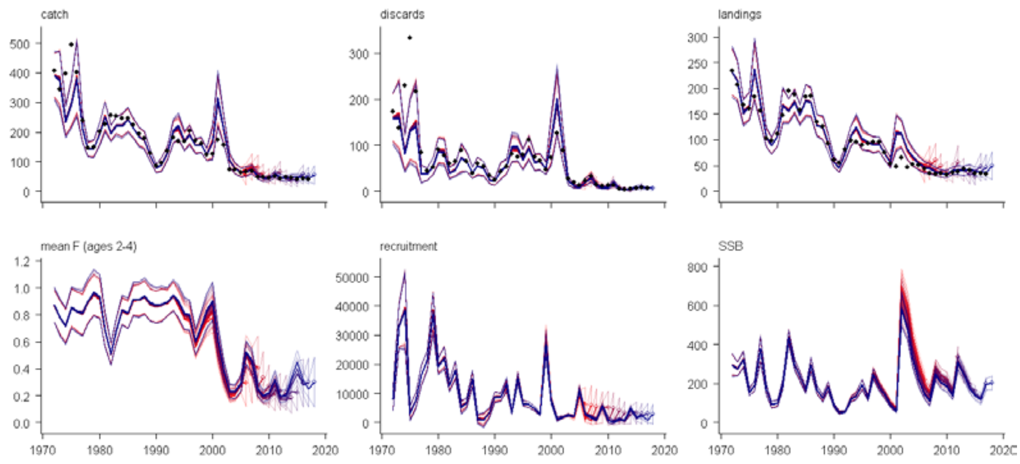


Figure 13.3.22. Haddock in Subarea 4, Division 6.a and Subdivision 20. Retrospective plots for the TSA assessment. The best estimates for each retrospective run end in an open circle, and each run is shown with the approximate pointwise 95% confidence interval. Estimates and CIs are colour-coded, with older runs becoming progressively more red.

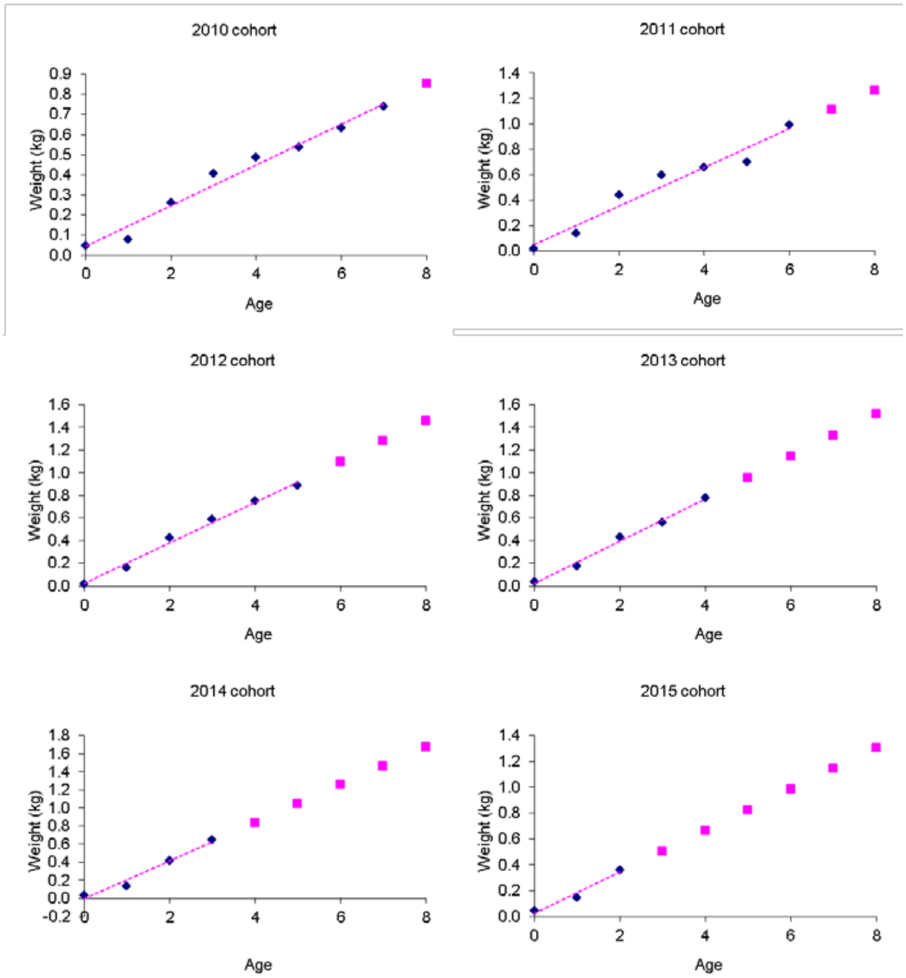


Figure 13.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski, 2011). Cohorts 2010–2015 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

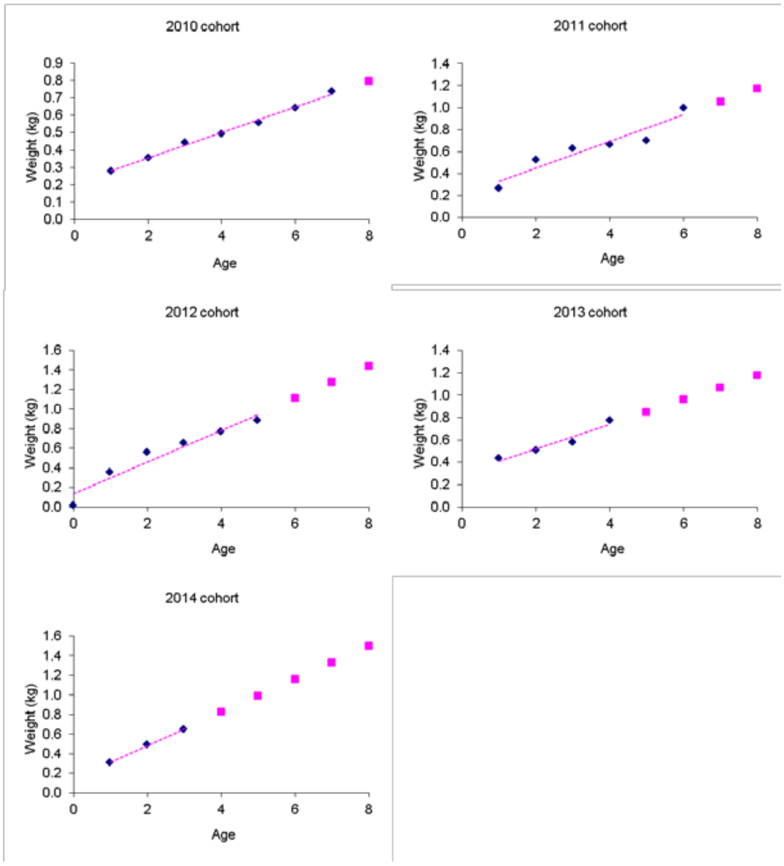


Figure 13.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for wanted catch (landings) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2010–2014 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

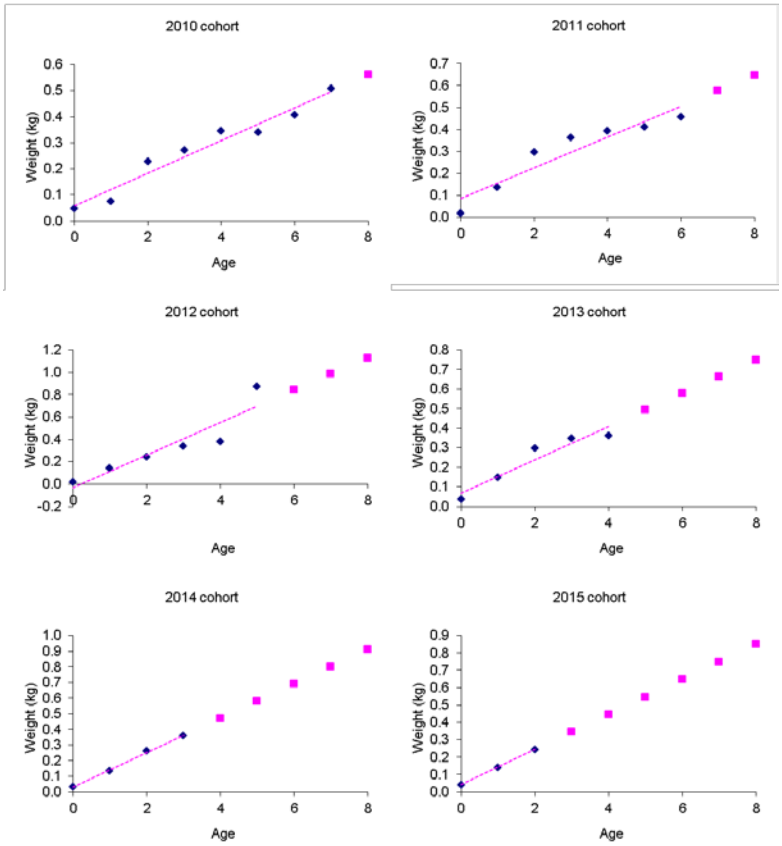
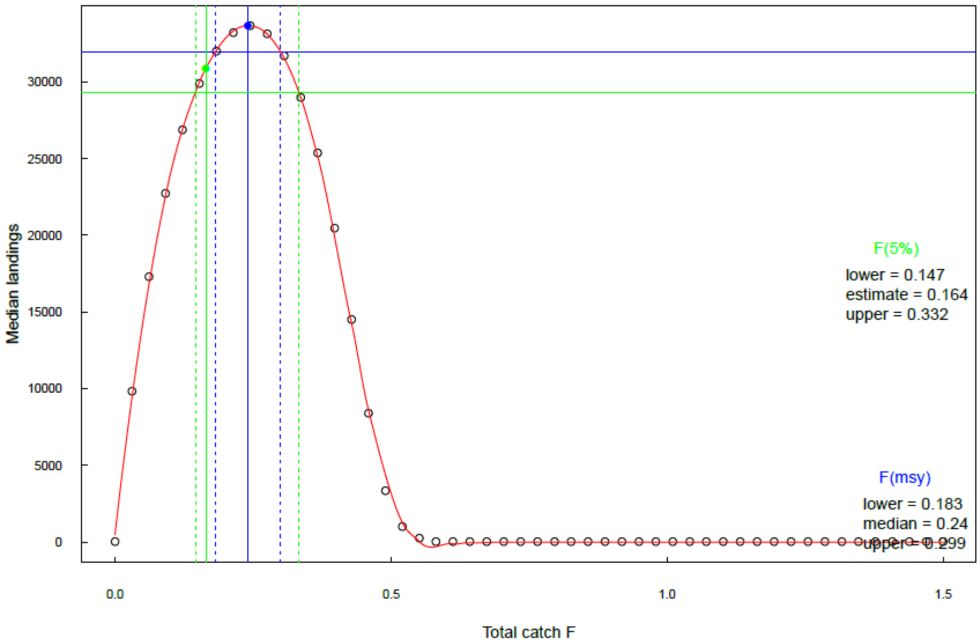


Figure 13.6.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for unwanted catch (discards + BMS) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2010–2015 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.



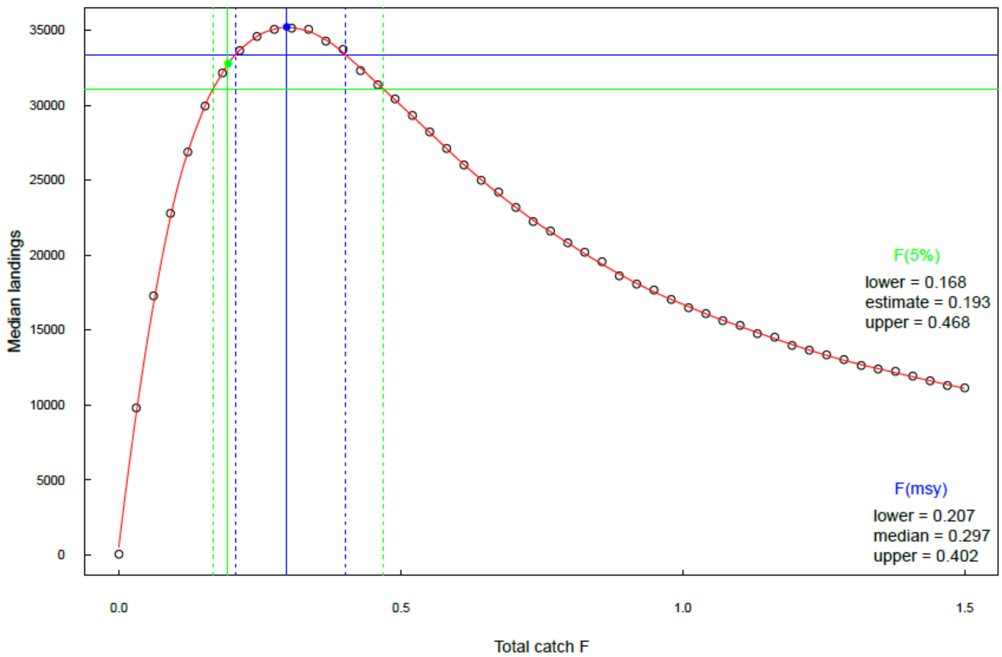


Figure 13.8.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSIM estimation of F(MSY) with the advice error but no rule (top) and of Fp05 with both advice error and rule (bottom).

9 Lemon sole in Subarea 4, divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat and Eastern English Channel)

9.1 General

The assessment of North Sea lemon sole (*Microstomus kitt*) was subject to a benchmark during the winter of 2017/18 (ICES WKNSEA, 2018). In summary, the benchmark concluded the following:

- There were insufficient age samples submitted to InterCatch to allow for a full age-structured catch-based assessment. InterCatch collation was conducted on the basis of length.
- Age-structured survey indices were developed using GAM estimation (Berg *et al.,* 2014), for Q1 (IBTS; ages 1–5, years 2007-present) and Q3 (IBTS and BTS; ages 1–9, years 2005–present).
- Maturity-at-age was fixed through time (based on IBTS Q1), while weights-at-age were based on smoothly-varying estimates from both IBTS Q1 and Q3.
- The stock assessment model used for the basis of the advice was SURBAR (Needle, 2015), including *ad hoc* adjustments for the observed low catchability of the available surveys for age 1 and 2 lemon sole.
- The advice was to be based on the 3:2 rule, applied to relative SSB estimates from SURBAR.
- Stock status in relation to F_{MSY} proxies was to be evaluated using a suite of length-based indicators (LBIs).

These stipulations have been followed almost completely in this year's WGNSSK assessment. The exception is the age range used for the Q1 survey index: the new index (updated with 2018 Q1 data) showed a significantly negative correlation between ages 1 and 2 by cohort, and WGNSSK concluded that this age could not be used for this survey. This issue is described in detail in Section 9.3.3.

This is the fifth year in which the stock status for lemon sole has been evaluated by WGNSSK. Lemon sole has been defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012), and biennial advice was given in 2017 for the years 2018 and 2019. The basis for this approach and the current stock status were evaluated during the WGNSSK 2018 meeting, at which it was concluded (see Section 9.7) that the biennial advice should **not** be reopened.

9.1.1 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. Lemon sole spawn for a considerable period in the North Sea, starting as early as April in the north and ending as late as November in the south (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.

9.1.2 Stock ID and possible assessment areas

There is no information available on lemon sole stock identity for the greater North Sea, and the assessment is assumed to cover one unit stock.

9.1.3 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). The EU has requested comments from ICES on whether several stocks (including lemon sole) should continue to be managed through TAC and quota regulations. The work regarding this special request is still ongoing. The response will be published as Annex 11 to this report in September 2018.

9.2 Fisheries data

9.2.1 Officially-reported 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. Officially-reported landings in ICES Division 7.d, Subarea 4 and Division 3.a are shown in figures 9.2.1 to 9.2.4, and in tables 9.2.1 to 9.2.4. The time-series of officially-reported landings is not fully complete, and a number of countries have gaps in data provision.

9.2.2 ICES estimates of landings and discards

Previously, catch yields, length distributions and age samples had been submitted to InterCatch only for the years 2013–2016. A more extensive data call was issued prior to the WKNSEA benchmark meeting, asking for data from 2002 onwards. Investigations into the existing data for the WKNSEA data meeting (November 2017) suggested that there would be insufficient age samples to permit an age-structured catch-based assessment, so the data call focussed on length data. Two countries (Denmark and Belgium) continued to submit age data, but these remain relatively sparse as they were not specifically requested. Many countries have not sampled lemon sole ages as a matter of routine in the past, so a historical age-based data call is unlikely to be successful (although historical collections of lemon sole otoliths may exist in national laboratories). However, age samples will be requested in the data call from 2019 onwards. The age samples submitted to InterCatch are summarised in tables 9.2.5 to 9.2.7.

The benchmark meeting (ICES WKNSEA, 2018) considered whether areas should be considered separately for raising discards and length compositions, but the prevailing view was that there was no evidence of distinct stocks between areas and that therefore all areas should be treated together for raising. Initial exploration demonstrated that the final discard raising was significantly influenced by a small number of métiers with discard ratios greater than 1.5 (in other words, those métiers for which discards/landings > 1.5). Subsequently, these métiers were discounted in calculating raising factors as they were thought to be non-representative for a high-value stock such as lemon sole. Otherwise, discards for all unsampled fleets were inferred by a discard rate generated using all sampled fleets (weighted by the landings CATON), as it was not thought likely that discard rates for an (essentially) bycatch stock would vary a great deal between different métiers (apart from the extreme and unrepresentative examples discussed above).

Length-distribution allocations were conducted in the same way (weighted by mean numbers at length), with the only distinction being made between landings and discards. Length samples are reasonably well spread across the main countries catching lemon sole, albeit with a large spike in the final year for some countries following the 2017 data call, and length-based allocations are likely to be sufficiently representative. InterCatch summary plots are given in figures 9.2.5 to 9.2.8.

The resultant estimates for landings and discards for 2002–2017 are given in Table 9.2.8 and Figure 9.2.9. We note that the official landings for 2012 did not include estimates for the UK, which is why they are considerably lower than the new InterCatch estimates. It can also be seen that the 2013 discard estimate is very high – the problem appears to originate in the discard estimates provided by the Netherlands, which unfortunately could not be corrected in time for the WGNSSK meeting. The abundances at length in the Dutch submissions are an order of magnitude higher than for any other year or country, for fish less than 210 mm. This gives rise to the high discard estimate in 2013. The issue was avoided in the F_{MSY}-proxy analysis (see Section 9.6) by applying an *ad hoc* downscaling, but this could not be done for the yield analysis during the WGNSSK meeting.

9.3 Survey data series

9.3.1 Stock distributions

Figure 9.3.1 displays the distribution of the abundance of lemon sole in the greater North Sea obtained from IBTS Q1 and BTS Q3 data, for 2016 (this is given as an example, distributions do not change noticeably from year to year). The highest concentrations of lemon sole occur in the central to northern areas of the North Sea.

9.3.2 Maturity and weights-at-age

Following the Stock Annex, maturities were assumed to be fixed through time and set to the following values by age:

AGE	PROP. MATURE
1	0.00
2	0.72
3 and older	1.00

Weights-at-age were also estimated following the Stock Annex procedure. The mean weights at each age and year were calculated from data in the SMALK dataset of the IBTS Q1 and Q3 series (ICES DATRAS, 2018). For each age, the time-series of available weights were plotted together, positioned so that Q1 weights were at y+0.25 and Q3 weights at y+0.75 (additional mean points were added at the start of each time-series to enable extrapolation). A loess smoother (span = 1) was then fitted through all points for each age, so that the final estimate was (effectively) an average of consecutive weight estimates. The fitted values are summarised in Figure 9.3.2 and Table 9.3.1.

Natural mortality (M) estimates for lemon sole are not available. For current advisory purposes, however, estimates of M are not required, as the assessment is survey-based and hence estimates total mortality Z.

9.3.3 Relative abundance indices

The GAM estimation approach (Berg *et al.*, 2014) was used by WGNSSK to generate updated Q1 (IBTS) and Q3 (IBTS and BTS) survey series for lemon sole. The new series are summarised in Figures 9.3.3 (bivariate scatterplots), 9.3.4 (catch curves), and 9.3.5 (time series by age and cohort). All three summaries indicate that the ability of the survey indices (particularly Q1) to track year-class strength is limited. In Figure 9.3.3, most of the pairwise comparisons do not show significant correlations. Of particular note is the significantly negative correlation between age 1 and age 2 for the Q1 (IBTS) index – this suggests that the Q1 (IBTS) age 1 index is likely to give an incorrect impression of subsequent year-class strength. This negative relationship was not present in the index presented at the 2018 benchmark meeting (ICES WKNSEA, 2018), and has appeared as the result of re-estimation following the inclusion of the 2018 IBTS Q1 data.

The Stock Annex for this assessment calls for the full age range (1–5) to be used from the Q1 (IBTS) series. Following the presentation of the exploratory survey analyses, particularly Figure 9.3.4, WGNSSK concluded that the age-1 data from the Q1 (IBTS) survey should not be used to indicate stock trends. Therefore the Q1 (IBTS) survey index was limited to ages 2–5 for assessment purposes. A consequence of this is that the assessment now runs to 2017 only, rather than 2018 as previously – this is because SURBAR needs at least one observation per cohort, and without the age-1 datum from Q1 (IBTS) there are no data with which to estimate the strength of the 2017 year-class.

9.4 SURBAR stock assessment

The SURBAR assessment was conducted according to the run-time settings specified in the Stock Annex, namely:

- The age- and year-effect smoother λ was set to 3.
- Mean mortality Z was calculated over ages 3–5.
- The reference age a_r for age-effect estimates was set to 3.
- GAM-estimated survey indices from both Q1 (IBTS) and Q3 (IBTS & BTS) were used.
- Catchability for ages was set as $q_1 = 0.1, q_2 = 0.5$ and q = 1.0 for all older ages.
- No downweighting of ages in the SURBAR SSQ estimation was used.

The SURBAR stock summary is given in Table 9.4.1, and the corresponding output plots are given in Figures 9.4.1 to 9.4.5. The stock summary (Figure 9.4.1) shows that mean Z_{3-5} has remained relatively constant since 2009, although values are very low and the confidence intervals overlap Z = 0 for most years. The catch curves for the surveys (Figure 9.3.4) are domed and very shallow, and remain shallow even when the catchability revision is applied, so SURBAR indicates low mortality which is probably unrealistic. Both SSB and TSB are estimated with more certainty than mean Z_{3-5}, and show steady increases since 2009. Finally, recruitment at age 1 has fluctuated without trend for much of the time series, until 2017 for which the assessment indicates the lowest estimated recruitment.

Log survey residuals (Figures 9.4.2 and 9.4.3) show that the Q3 index fits the SURBAR model better than the Q1 index, with lower residuals in general and less trends through time. Overall, the assessment is driven more directly by the Q3 index – this is to be expected given the problems with the Q1 index highlighted in Section 9.3.3 above. There are three outliers in the Q3 index (age 1 in 2013 and 2015, age 2 in 2013), but sensitivity runs reducing the SSQ estimation weighting on these points produced by the benchmark suggested that their influence on likely advice was not significant (ICES WKNSEA, 2018). The parameter estimates are summarised in Figure 9.4.4.

Finally, the retrospective analysis in Figure 9.4.5 shows little retrospective bias or noise, except for recruitment. Following the removal of age-1 data from the Q1 (IBTS) index, recruitment is initially estimated by the Q3 (IBTS & BTS) index alone. With additional years of data, recruiting year-class strength is successively updated for each cohort, and this explains the recruitment retrospective revisions. Q1 (IBTS) age-1 data was retained at the benchmark meeting, which is why such recruitment retrospective noise was not seen then (ICES WKNSEA, 2018). It is correct to remove Q1 (IBTS) age-1 data in this case (see Section 9.3.3), but the retrospective noise generated means that the low recruitment estimate in 2017 should be considered to be very uncertain.

9.5 Application of advice rule

North Sea lemon sole is currently managed according to the following advice, given in July 2017:

> *ICES advises that when the precautionary approach is applied, catches should be no more than 5484 tonnes in each of the years 2018 and 2019. If discard rates do not change from the average of the last three years (2014–2016), this implies landings of no more than 3924 t in each of the years 2018 and 2019.*

The application of the DLS 3:2 rule, based on the most recent advised catch (2017), is given in Figure 9.5.1. The change ratio of the abundance index was 14%. If this were to be used to update advice, it would suggest that catches for 2019 and 2020 should be 6268 tonnes. Applying the average discard rate from 2015–17 (24%) implies corresponding landings of 4769 tonnes. As the suggested increase in catch would be less than 20%, there would be no requirement to apply an uncertainty cap.

9.6 Length-based F_{MSY} proxy estimation

Length-based indicators (LBIs) were estimated for North Sea lemon sole, following the standard approach outlined by WKLIFE (ICES WKLIFEVI, 2017) and WKPROXY (ICES WKPROXY, 2017), and stipulated in the relevant Stock Annex by the 2018 benchmark meeting (ICES WKNSEA, 2018). Data were taken from the length samples submitted to InterCatch for 2002–2017.

The original InterCatch length distributions are given in Figure 9.6.1, from which the erroneous length submissions for fish less than 200 mm in 2013 can clearly be seen. These seem to arise from Dutch discard samples, which could not be corrected prior to the WGNSSK meeting (see also Section 9.2.2). To address this without correcting the input data, the relevant length distributions scaled downwards by dividing by 20. Figure 9.6.2 shows the result of this, along with the removal of all fish less than 100 mm (to prevent the misspecification of length at first capture). Finally, the widths of the length bins were doubled to produce smoother distributions for LBI analysis (Figure 9.6.3).

The previous LBI runs carried out at WGNSSK in 2017 (ICES WGNSSK, 2017) and WKNSEA in 2018 (ICES WKNSEA, 2018) used an assumption that $L_{50\%mat}$ was 150 mm, and L_{∞} was 670 mm. These values were taken from the FishBase dataset (Froese and Pauly, 2018), but may not be relevant to the current stock analysis as they are derived from historical records. Figure 9.6.4 shows a logit maturity ogive fitted to maturity data from the Q1 (IBTS) and Q3 (IBTS & BTS) survey records, using a binomial GLM with a logit link. This analysis indicates that a suitable estimate of $L_{50\%mat}$ would be 126 mm, which is lower than the FishBase value (150 mm).

Figure 9.6.5 shows an estimated L_∞ value of 284 mm, derived from all available survey data. This is much lower than the previous assumption of 670 mm, which was based on L_{max} from the commercial fishery. WGNSSK was concerned that the survey-derived value of 284 mm was likely to be too low, given the possibility (although uncertain) that survey catchability for older fish may be poor. Two alternative estimates of L_∞ were hence considered – the current L_{max}, and a trimmed alternative based on the 99%ile of the commercial catch length distribution (collated over all available years). The estimates are summarised in Figure 9.6.6. Given L_{max}, WGNSSK proposed that L_∞ should be derived from the following equation (García-Carreras *et al.,* 2016):

$$\log_{10} L_\infty = 0.068260 + 0.969112 \log_{10} L_\infty$$

The resultant estimates are then:

BASIS	L_{max}	L_∞
Trimmed L_{max}	385 mm	375 mm
Observed L_{max}	675 mm	642 mm
Survey data	-	284 mm

These new estimates of L_∞, along with the new estimate of $L_{50\%mat}$ were then used in three LBI estimation runs, following the protocol specified in the Stock Annex. The inferred risk of fishing above F_{MSY} increases with increasing L_∞, but even at the highest plausible L_∞ value (642 mm) fishing mortality is at or around (and often below) F_{MSY}. Figures 9.6.7 and 9.6.8 and Table 9.6.1 summarise the LBI analyses for the case where L_∞ = 642 mm (the highest plausible estimate). The key points are:

- Length at first catch (L_c) is below L_{mat} for the second half of the time-series, which indicates a significant number of immature individuals in the catches.
- The ratio of the mean length of upper 5th percentile of catches to L_∞ is close to 0.6 throughout the time series, which would suggest a lack of large (and hence old) fish in the population.
- The L_{mean}/L_{opt} ratio is less than 1.0 throughout the time series, which suggests that the exploitation does not target the most productive length classes.
- However: $L_{mean}/L_{F=M}$ is generally greater than 1.0, which would tend to show that this stock is being fished at a rate less than (or around) F_{MSY}.

At face value, the LBI results would suggest that immature fish may not be well protected, and that the catch length distribution is truncated at larger sizes: under optimal and sustainable exploitation the mean length in the catch is expected to be higher than the value observed. Specific analysis on the catch selectivity of lemon sole in the main gears used in the fishery has not yet been carried out, but it is known that selectivity of larger fish is reduced when fishing for several related species (such as plaice and sole) using similar gear. If this is also the case for lemon sole, this could be one reason why the length-based indicators given above do not lead to a more positive conclusion. However, the fact that the ratio of $L_{mean}/L_{F=M}$ is generally greater than 1.0 would suggest that F_{MSY} is **not** being exceeded for this stock.

9.7 Conclusions and further work

Biennial advice for 2018 and 2019 for North Sea lemon sole was published by ICES in July 2017, and the intention of the analyses presented in this Section was to determine whether there was sufficient evidence to indicate reopening of the advice. The 2018 benchmark for this stock (ICES WKNSEA, 2018) provided a new approach to the assessment of the stock and the provision of advice, so the aim was to determine whether the perception of the state of the stock was different to that concluded in 2017.

The SURBAR stock trends are similar to those seen in WGNSSK 2017, on the basis of which the biennial advice was determined (Section 9.4). SURBAR does indicate a very low incoming 2016 year-class at age 1, but retrospective noise problems indicated that this should be treated as being very uncertain and WGNSSK concluded that this in itself was not sufficient justification for reopening.

The estimation of status relative to F_{MSY} proxies was very dependent on the value of L_{∞} that was used. However, all plausible values indicate that fishing is occurring at or above F_{MSY}, which was also the conclusion in WGNSSK 2017.

Taking both of these key points into consideration, WGNSSK conclude that there is no strong reason to consider reopening the advice, and that the biennial advice for 2018 and 2019 should stand.

This conclusion is based on stock dynamics indicated by a survey-based assessment, and the inability (in many cases) of the available surveys to track year-class strength is a weak point of the advice. An important issue for the development of new advice in 2019 would be to reconsider the survey series used – further work may indicate an alternative method of collating the survey data that could be more appropriate for lemon sole. The erroneous length data submitted to InterCatch for 2013 also needs to be corrected.

9.8 References

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Table 9.2.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official lemon sole landings by area (tonnes).

Official landings									
Year	3.a	4	7.d	Total	Year	3.a	4	7.d	Total
1950	307	3754	208	4269	1984	595	6930	586	8111
1951	248	4710	314	5272	1985	793	6435	347	7575
1952	243	4922	298	5463	1986	639	5047	251	5937
1953	132	5440	386	5958	1987	669	5516	310	6495
1954	128	3972	534	4634	1988	642	5898	258	6798
1955	102	3836	141	4079	1989	693	5967	364	7024
1956	96	3395	103	3594	1990	872	6190	423	7485
1957	78	3419	102	3599	1991	734	6618	428	7780
1958	94	3104	82	3280	1992	952	6126	364	7442
1959	130	3647	82	3859	1993	1156	5839	422	7417
1960	153	4035	66	4254	1994	803	5262	695	6760
1961	161	4900	108	5169	1995	714	4712	877	6303
1962	93	4630	101	4824	1996	635	4737	1151	6523
1963	99	3791	66	3956	1997	768	4727	563	6058
1964	134	4121	77	4332	1998	868	6466	346	7680
1965	164	4949	105	5218	1999	844	6316	140	7300
1966	159	5415	201	5775	2000	803	5980	388	7171
1967	191	6188	331	6710	2001	584	5389	483	6456
1968	185	6270	337	6792	2002	522	3827	474	4823
1969	215	4470	315	5000	2003	543	3688	491	4722
1970	169	3434	256	3859	2004	607	3543	424	4574
1971	173	3967	357	4497	2005	674	3444	350	4468
1972	168	3672	475	4315	2006	417	3627	246	4290
1973	214	4568	451	5233	2007	432	3892	164	4488
1974	183	4227	351	4761	2008	276	3466	234	3976
1975	317	5029	33	5379	2009	262	2693	442	3397
1976	361	4830	42	5233	2010	350	2625	223	3198
1977	627	5661	37	6325	2011	251	3365	403	4019
1978	705	6108	141	6954	2012	482	2119	358	2959
1979	833	6428	260	7521	2013	289	2981	491	3761
1980	722	6424	152	7298	2014	315	3017	356	3688
1981	793	5933	290	7016	2015	269	2871	253	3393
1982	735	7168	584	8487	2016	299	3266	240	3805
1983	759	8257	491	9507	2017	343	2822	158	3323

Table 9.2.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official lemon sole landings in area 7.d by country.

Year	BEL	DNK	FRA	NED	UK	Other	Total	Year	BEL	DNK	FRA	NED	UK	Other	Total
1950	10	0	174	0	24	0	208	1984	110	0	367	0	109	0	586
1951	5	0	262	0	47	0	314	1985	117	0	164	0	66	0	347
1952	10	0	188	0	100	0	298	1986	77	0	133	0	41	0	251
1953	7	0	196	0	183	0	386	1987	81	0	185	0	44	0	310
1954	9	0	361	0	164	0	534	1988	74	0	155	0	29	0	258
1955	9	0	0	0	132	0	141	1989	68	0	252	0	44	0	364
1956	4	0	0	0	99	0	103	1990	68	0	272	0	83	0	423
1957	7	0	0	0	95	0	102	1991	83	0	272	0	73	0	428
1958	1	0	0	0	81	0	82	1992	66	0	176	0	122	0	364
1959	2	0	0	0	80	0	82	1993	36	0	311	0	75	0	422
1960	4	0	0	0	62	0	66	1994	97	0	505	0	93	0	695
1961	1	0	0	0	106	1	108	1995	138	0	584	0	155	0	877
1962	2	0	0	0	99	0	101	1996	213	0	720	0	218	0	1151
1963	3	0	0	0	63	0	66	1997	143	0	305	0	115	0	563
1964	5	0	0	0	72	0	77	1998	53	0	198	0	95	0	346
1965	16	0	0	0	89	0	105	1999	50	0	0	0	90	0	140
1966	7	0	0	0	194	0	201	2000	62	0	200	0	126	0	388
1967	6	0	0	0	325	0	331	2001	104	0	191	0	188	0	483
1968	8	0	0	0	329	0	337	2002	101	0	256	0	117	0	474
1969	12	0	0	0	303	0	315	2003	128	0	251	0	112	0	491
1970	16	0	0	0	240	0	256	2004	120	0	198	1	105	0	424
1971	22	0	0	0	335	0	357	2005	90	0	187	2	71	0	350
1972	18	0	0	0	457	0	475	2006	98	0	100	0	48	0	246
1973	25	0	0	0	426	0	451	2007	70	0	72	1	21	0	164
1974	16	0	0	1	334	0	351	2008	140	0	46	3	45	0	234
1975	19	0	0	0	14	0	33	2009	149	0	176	9	108	0	442
1976	24	0	0	0	18	0	42	2010	101	0	85	5	32	0	223
1977	21	1	0	0	15	0	37	2011	153	0	178	15	57	0	403
1978	45	2	63	0	31	0	141	2012	171	0	167	20	0	0	358
1979	60	0	165	0	35	0	260	2013	176	0	179	26	110	0	491
1980	33	0	109	0	10	0	152	2014	162	0	108	14	72	0	356
1981	66	0	212	0	12	0	290	2015	123	0	84	5	41	0	253
1982	96	0	406	1	81	0	584	2016	115	0	69	9	47	0	240
1983	108	0	298	0	85	0	491	2017	87	0	34	8	29	0	158

Table 9.2.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official lemon sole landings in ICES Subarea 4 by country.

Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total	Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total
1950	112	435	139	31	156	0	2855	26	3754	1984	1144	567	344	22	0	0	4850	3	6930
1951	115	845	90	21	167	0	3430	42	4710	1985	989	555	157	26	0	0	4703	5	6435
1952	98	391	227	26	168	0	3953	59	4922	1986	511	577	103	16	0	0	3839	1	5047
1953	73	409	189	18	132	0	4590	29	5440	1987	448	742	174	14	0	0	4137	1	5516
1954	2	272	177	24	112	0	3368	17	3972	1988	539	639	184	14	301	0	4220	1	5898
1955	49	311	0	15	78	0	3374	9	3836	1989	441	828	176	40	397	0	4083	2	5967
1956	48	222	0	19	58	0	3034	14	3395	1990	491	1007	208	49	0	0	4431	4	6190
1957	39	249	0	24	64	0	3032	11	3419	1991	544	1099	250	41	0	12	4666	6	6618
1958	30	171	0	13	43	0	2835	12	3104	1992	577	1149	177	30	0	13	4175	5	6126
1959	85	242	0	40	43	0	3226	11	3647	1993	525	966	240	37	0	9	4059	3	5839
1960	155	577	0	46	67	0	3178	12	4035	1994	436	597	436	27	0	11	3754	1	5262
1961	286	488	0	79	102	0	3934	11	4900	1995	588	585	412	70	0	9	3046	2	4712
1962	175	501	0	54	106	0	3794	0	4630	1996	592	547	534	67	0	18	2976	3	4737
1963	365	222	0	36	71	0	3097	0	3791	1997	504	499	224	76	0	29	3391	4	4727
1964	484	358	0	62	75	0	3142	0	4121	1998	815	796	197	149	838	23	3643	5	6466
1965	562	385	0	91	93	0	3818	0	4949	1999	662	1015	0	62	681	24	3866	6	6316
1966	594	548	0	98	65	0	4110	0	5415	2000	711	1277	184	72	492	17	3222	5	5980
1967	601	791	0	136	61	0	4599	0	6188	2001	694	1281	191	77	451	22	2666	7	5389
1968	422	775	0	96	34	0	4943	0	6270	2002	604	971	190	116	402	17	1521	6	3827
1969	292	639	0	80	36	0	3423	0	4470	2003	517	1008	239	136	369	16	1399	4	3688
1970	241	307	0	52	58	0	2776	0	3434	2004	667	1113	120	81	355	12	1192	3	3543
1971	348	514	0	54	122	0	2929	0	3967	2005	595	1057	102	85	402	13	1188	2	3444
1972	423	530	0	59	130	0	2530	0	3672	2006	552	968	57	183	412	13	1440	2	3627
1973	566	478	0	73	217	16	3218	0	4568	2007	542	1136	65	143	367	23	1610	6	3892
1974	486	447	0	59	269	0	2966	0	4227	2008	527	925	47	120	434	26	1383	4	3466
1975	748	521	0	83	299	0	3367	11	5029	2009	389	898	88	64	294	31	927	2	2693
1976	493	506	0	68	308	0	3443	12	4830	2010	375	821	32	102	323	35	935	2	2625
1977	618	321	0	71	262	0	4387	2	5661	2011	387	999	56	96	641	27	1157	2	3365
1978	760	517	28	54	231	0	4518	0	6108	2012	406	999	34	61	587	30	0	2	2119
1979	674	876	136	41	390	0	4308	3	6428	2013	527	649	27	67	479	16	1214	2	2981
1980	484	599	102	49	303	0	4885	2	6424	2014	648	626	27	63	425	23	1202	3	3017
1981	555	605	237	39	412	0	4084	1	5933	2015	425	794	16	82	423	12	1116	3	2871
1982	879	670	419	52	759	0	4386	3	7168	2016	448	1054	15	82	443	23	1196	5	3266
1983	1122	735	402	28	1009	0	4957	4	8257	2017	345	1032	0	42	356	14	1028	4	2822

Table 9.2.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings in area 3.a by country.

Year	BEL	DNK	GER	NED	SWE	Other	Total	Year	BEL	DNK	GER	NED	SWE	Other	Total
1950	0	100	1	0	206	0	307	1984	6	525	0	0	64	0	595
1951	0	74	1	0	173	0	248	1985	0	729	0	0	64	0	793
1952	0	64	0	0	179	0	243	1986	7	576	0	0	56	0	639
1953	0	35	0	0	97	0	132	1987	24	577	0	0	68	0	669
1954	0	33	0	0	95	0	128	1988	11	569	0	6	56	0	642
1955	0	29	0	0	73	0	102	1989	8	610	0	0	75	0	693
1956	0	33	0	0	63	0	96	1990	16	782	0	0	74	0	872
1957	0	27	0	0	51	0	78	1991	11	640	0	0	83	0	734
1958	0	38	0	0	56	0	94	1992	22	793	0	0	120	17	952
1959	0	71	0	0	59	0	130	1993	14	980	4	0	141	17	1156
1960	0	95	1	0	57	0	153	1994	10	648	2	0	127	16	803
1961	0	90	0	0	71	0	161	1995	27	576	2	0	91	18	714
1962	0	92	1	0	0	0	93	1996	0	513	1	0	97	24	635
1963	0	99	0	0	0	0	99	1997	0	628	2	0	115	23	768
1964	0	133	1	0	0	0	134	1998	0	743	3	0	100	22	868
1965	0	163	1	0	0	0	164	1999	0	731	3	0	88	22	844
1966	0	159	0	0	0	0	159	2000	0	722	1	0	65	15	803
1967	0	189	1	0	0	1	191	2001	0	511	1	0	53	19	584
1968	0	184	0	0	0	1	185	2002	0	457	4	0	41	20	522
1969	0	215	0	0	0	0	215	2003	0	451	6	30	35	21	543
1970	0	169	0	0	0	0	169	2004	0	472	5	82	29	19	607
1971	0	173	0	0	0	0	173	2005	0	468	5	147	38	16	674
1972	0	168	0	0	0	0	168	2006	0	321	8	40	32	16	417
1973	0	214	0	0	0	0	214	2007	0	374	5	16	18	19	432
1974	0	183	0	0	0	0	183	2008	0	239	7	3	15	12	276
1975	0	263	1	1	52	0	317	2009	0	233	4	1	15	9	262
1976	10	294	1	19	37	0	361	2010	0	286	3	35	19	7	350
1977	9	528	2	37	51	0	627	2011	0	223	0	0	12	16	251
1978	4	628	2	12	59	0	705	2012	0	446	3	0	15	18	482
1979	7	704	1	10	111	0	833	2013	0	259	3	5	10	12	289
1980	12	622	0	0	87	1	722	2014	0	276	7	12	14	6	315
1981	1	710	0	3	75	4	793	2015	0	250	4	0	9	6	269
1982	2	647	0	9	77	0	735	2016	0	265	5	16	7	6	299
1983	3	636	0	10	110	0	759	2017	0	314	5	11	6	7	343

Table 9.2.5. Lemon sole in areas 4, 7.d and 3.a. Number of commercial catch age samples submitted to InterCatch for area 7.d.

Area	27.7.d

	Belgium		Denmark	
	Landings	Discards	Landings	Dis-cards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	175	282	0	0
2015	126	388	0	0
2016	197	184	0	0
2017	338	0	0	0

Table 9.2.6. Lemon sole in areas 4, 7.d and 3.a. Number of commercial catch age samples submitted to InterCatch for area 4.

Area	27.4

	Belgium		Denmark	
	Landings	Discards	Landings	Discards
2002	0	0	772	0
2003	0	0	764	0
2004	0	0	868	0
2005	0	0	1	0
2006	0	0	171	0
2007	0	0	103	0
2008	0	0	225	5
2009	0	0	339	54
2010	0	0	477	1
2011	0	0	265	11
2012	0	0	423	0
2013	237	0	211	0
2014	0	0	799	0
2015	76	0	1418	0
2016	135	0	1637	0
2017	50	303	0	0

Table 9.2.7. Lemon sole in areas 4, 7.d and 3.a. Number of commercial catch age samples submitted to InterCatch for area 3.a.

Area	27.3.a

	Belgium		Denmark	
	Landings	Discards	Landings	Discards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	3
2009	0	0	0	3
2010	0	0	0	28
2011	0	0	0	15
2012	0	0	0	16
2013	365	0	0	9
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	379	10
2017	0	0	0	0

Table 9.2.8. Lemon sole in areas 4, 7.d and 3.a. ICES estimates of landings and discards for areas 3.a, 4 and 7.d.

Year	Official landings	ICES lanings	ICES dicards	ICES total catch	Discard rate
1968	6792				
1969	5000				
1970	3859				
1971	4497				
1972	4315				
1973	5233				
1974	4761				
1975	5379				
1976	5233				
1977	6325				
1978	6954				
1979	7521				
1980	7298				
1981	7016				
1982	8487				
1983	9507				
1984	8111				
1985	7575				
1986	5937				
1987	6495				
1988	6798				
1989	7024				
1990	7485				
1991	7780				
1992	7442				
1993	7417				
1994	6760				
1995	6303				
1996	6523				
1997	6058				
1998	7680				
1999	7300				
2000	7171				
2001	6456				
2002	4823	4011	511	4522	11.30%
2003	4722	4575	1036	5611	18.46%
2004	4574	4394	635	5028	12.62%
2005	4468	4429	527	4955	10.63%
2006	4290	4294	1,515	5809	26.08%
2007	4488	4468	451	4919	9.18%
2008	3976	4153	898	5051	17.77%
2009	3397	3405	996	4401	22.64%
2010	3198	3234	673	3907	17.21%
2011	4019	4030	1024	5055	20.27%
2012	2959	4099	2461	6560	37.52%
2013	3761	3725	5938	9663	61.45%
2014	3688	3645	1690	5335	31.68%
2015	3393	3480	1636	5116	31.97%
2016	3805	3834	1167	5000	23.33%
2017	3323	3315	651	3966	16.41%

Table 9.3.1. Lemon sole in areas 4, 7.d and 3.a. Estimates of mean weight-at-age.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9
2005	0.0570	0.0608	0.1056	0.2077	0.3328	0.3997	0.4456	0.2765	0.3069
2006	0.0537	0.0651	0.1129	0.2139	0.3252	0.3722	0.4109	0.2751	0.2844
2007	0.0505	0.0682	0.1186	0.2180	0.3175	0.3495	0.3835	0.2786	0.2688
2008	0.0472	0.0699	0.1226	0.2201	0.3098	0.3328	0.3637	0.2868	0.2594
2009	0.0439	0.0705	0.1250	0.2200	0.3017	0.3201	0.3489	0.2988	0.2563
2010	0.0404	0.0698	0.1261	0.2179	0.2931	0.3120	0.3390	0.3146	0.2593
2011	0.0367	0.0680	0.1250	0.2132	0.2835	0.3060	0.3409	0.3315	0.2688
2012	0.0330	0.0632	0.1194	0.2028	0.2713	0.3058	0.3419	0.3473	0.2943
2013	0.0293	0.0602	0.1148	0.1941	0.2615	0.3014	0.3320	0.3556	0.3137
2014	0.0265	0.0577	0.1099	0.1851	0.2524	0.2961	0.3305	0.3554	0.3274
2015	0.0252	0.0577	0.1081	0.1804	0.2447	0.2929	0.3368	0.3490	0.3373
2016	0.0249	0.0590	0.1075	0.1777	0.2376	0.2900	0.3475	0.3369	0.3438
2017	0.0254	0.0619	0.1082	0.1771	0.2308	0.2867	0.3623	0.3195	0.3470
2018	0.0269	0.0666	0.1109	0.1796	0.2250	0.2841	0.3830	0.2975	0.3462

Table 9.4.1. Lemon sole in areas 4, 7.d and 3.a. SURBAR stock summary. SSB, TSB and recruitment at age 1 are relative indices, while mortality is given as the mean total mortality over ages 3–5.

YEAR	RECRUITMENT AT AGE 1	SSB	TSB	MEAN Z (3–5)
2005	1.427	1.392	1.505	0.181
2006	1.521	1.462	1.566	0.185
2007	2.204	1.490	1.627	0.426
2008	1.645	1.192	1.302	0.378
2009	1.686	0.987	1.086	-0.034
2010	2.325	1.342	1.470	0.006
2011	2.422	1.677	1.810	0.139
2012	2.173	1.820	1.931	0.284
2013	1.461	1.656	1.729	0.165
2014	2.403	1.706	1.791	0.159
2015	1.528	1.754	1.828	0.056
2016	1.925	1.951	2.023	0.150
2017	0.339	1.947	1.986	0.122

Table 9.6.1. Lemon sole in areas 4, 7.d and 3.a. Output from LBI analyses. Green shows indicators that are met or exceeded, while red shows indicators that are not met.

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2002	0.7143	0.0397	0.5848	0.0000	0.6464	1.2134
2003	1.1905	0.0397	0.5822	0.0000	0.6274	0.9837
2004	1.8254	0.0397	0.5848	0.0000	0.7020	0.9023
2005	1.9841	0.0397	0.5313	0.0000	0.6579	0.8091
2006	0.8730	0.0397	0.5617	0.0000	0.6463	1.1384
2007	0.8730	0.0397	0.5695	0.0001	0.6338	1.1163
2008	1.5079	0.0397	0.5818	0.0000	0.6456	0.9119
2009	0.5556	0.0397	0.5804	0.0000	0.6215	1.2488
2010	0.7143	0.0397	0.5871	0.0000	0.6496	1.2195
2011	0.2381	0.0397	0.5600	0.0000	0.5368	1.2555
2012	0.5556	0.0397	0.5537	0.0000	0.5487	1.1026
2013	0.5556	0.0397	0.5031	0.0000	0.4097	0.8233
2014	0.5556	0.0397	0.5772	0.0000	0.5620	1.1292
2015	0.2381	0.0397	0.5812	0.0004	0.5623	1.3151
2016	0.7143	0.0397	0.5868	0.0000	0.6063	1.1381
2017	0.5556	0.0397	0.5976	0.0000	0.6078	1.2213

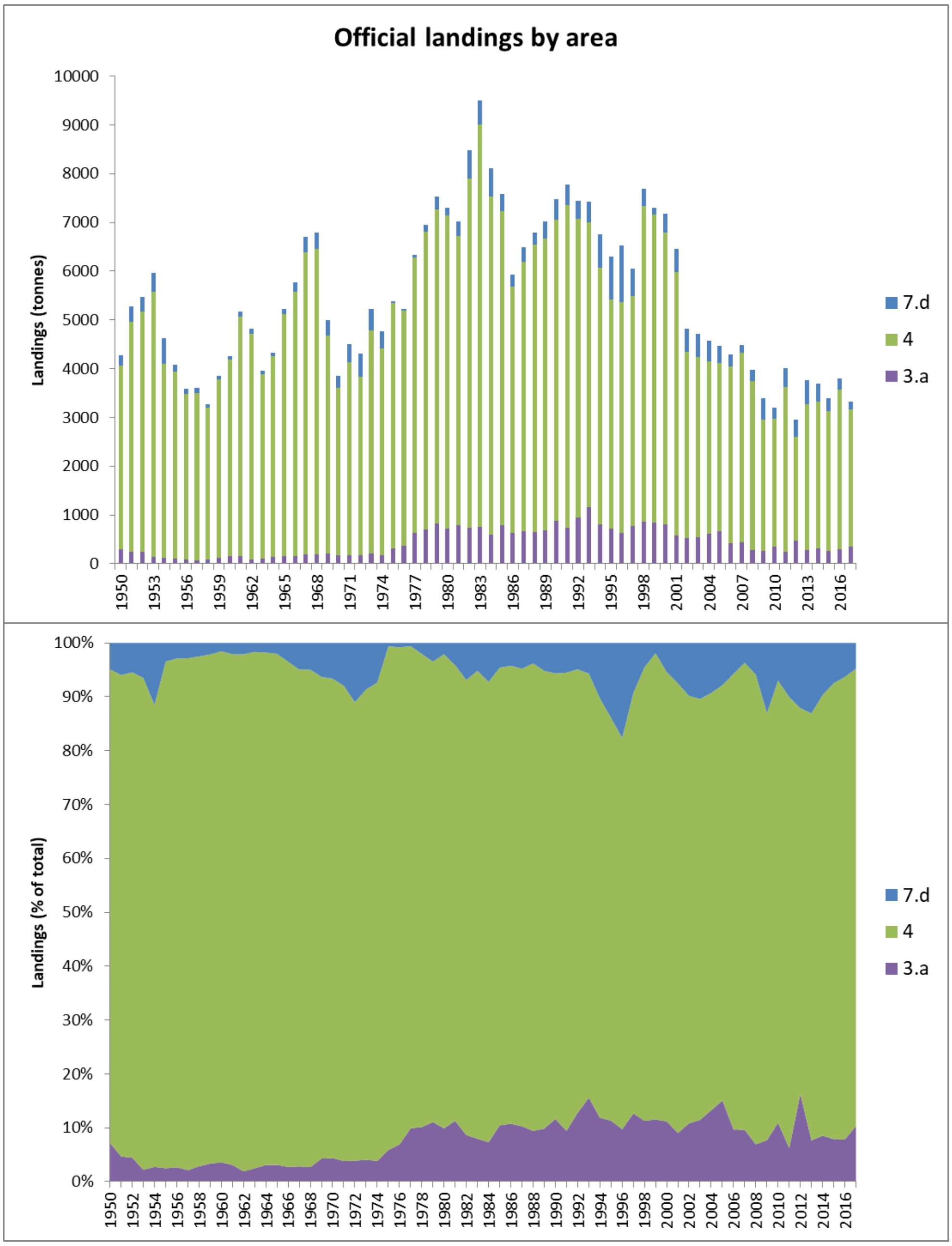


Figure 9.2.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Officially-reported landings of lemon sole by area in the greater North Sea. Upper plot: landings in tonnes. Lower plot: landings as a percentage of the full area.

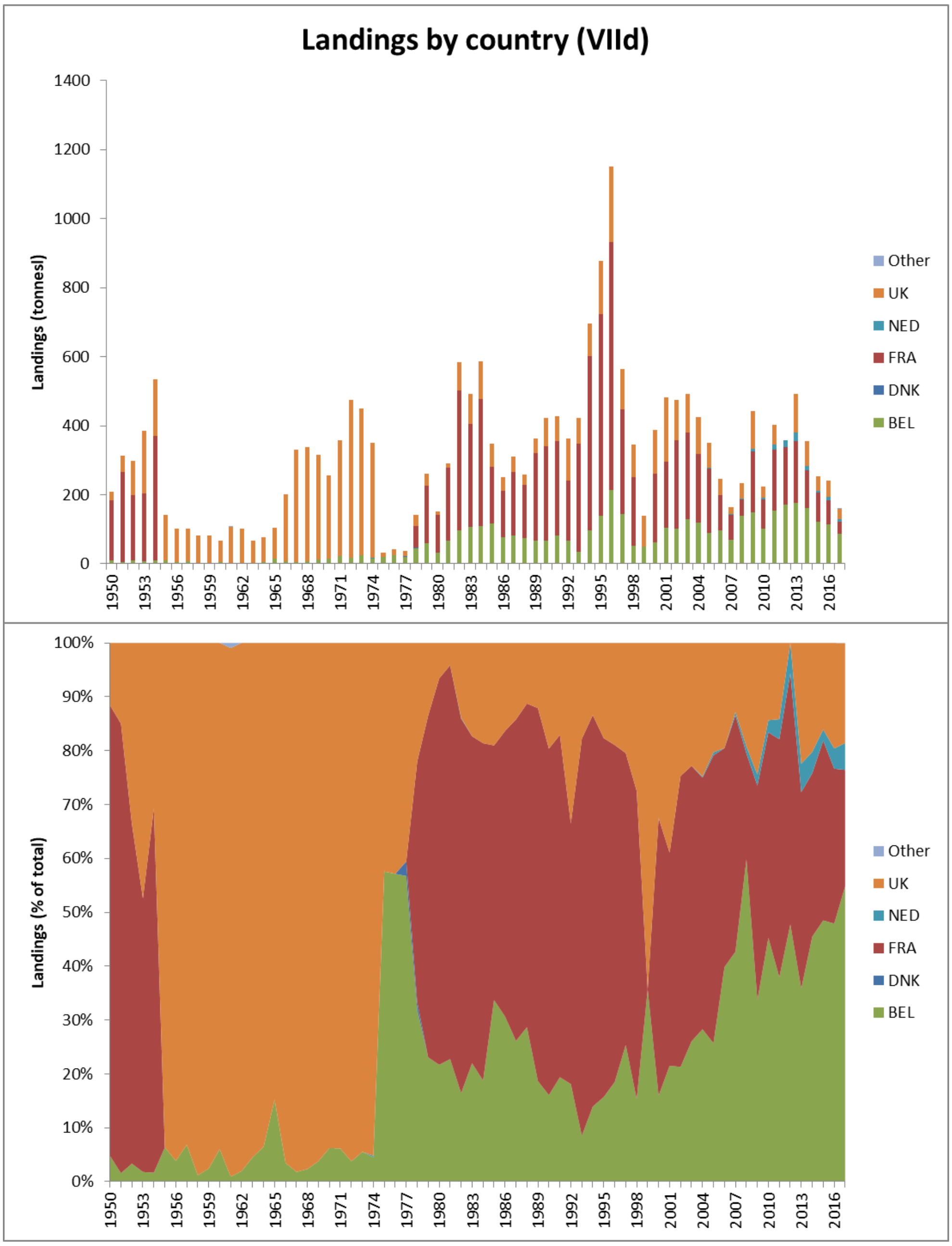


Figure 9.2.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 7.d by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 7.d landings.

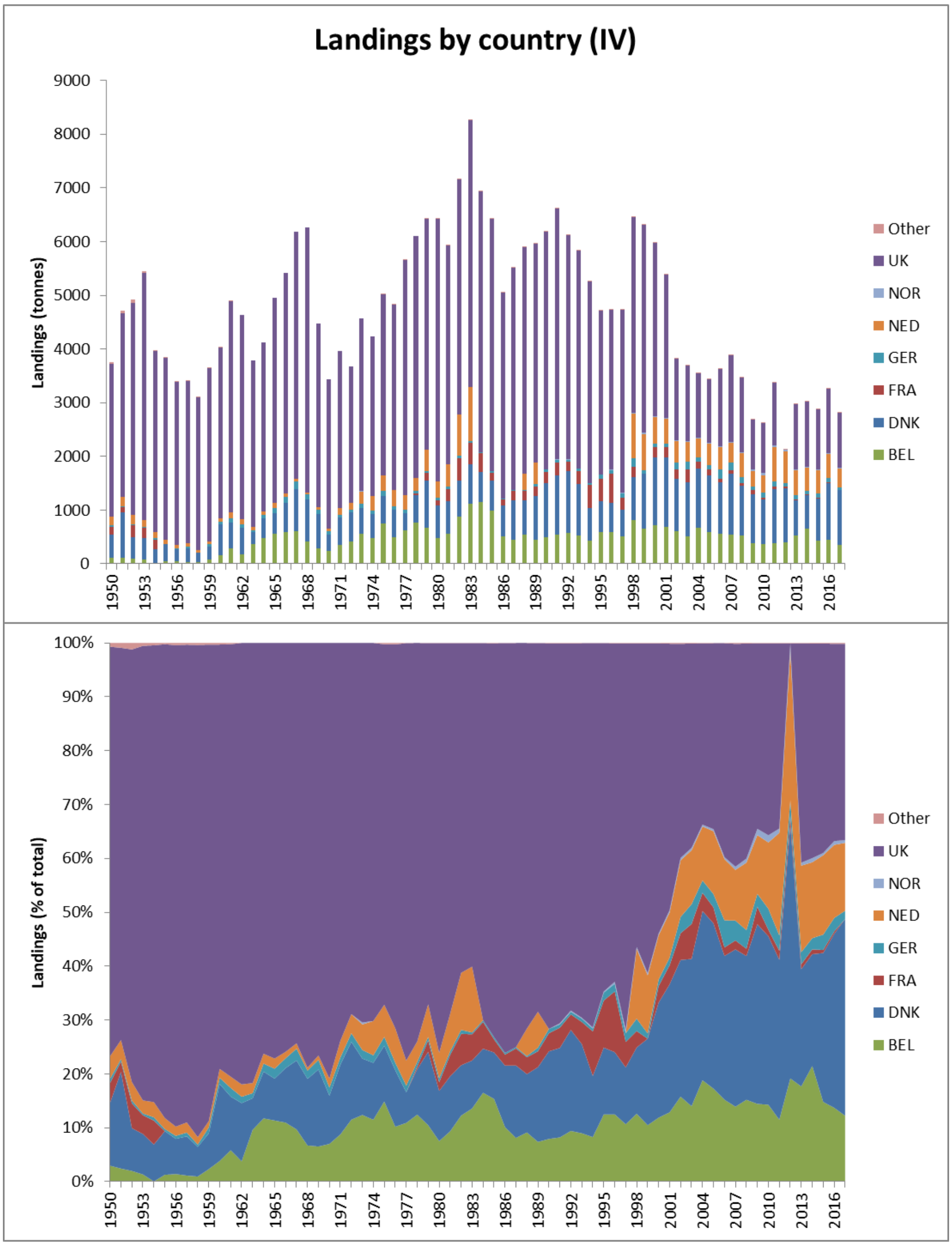


Figure 9.2.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 4 by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 4 landings.

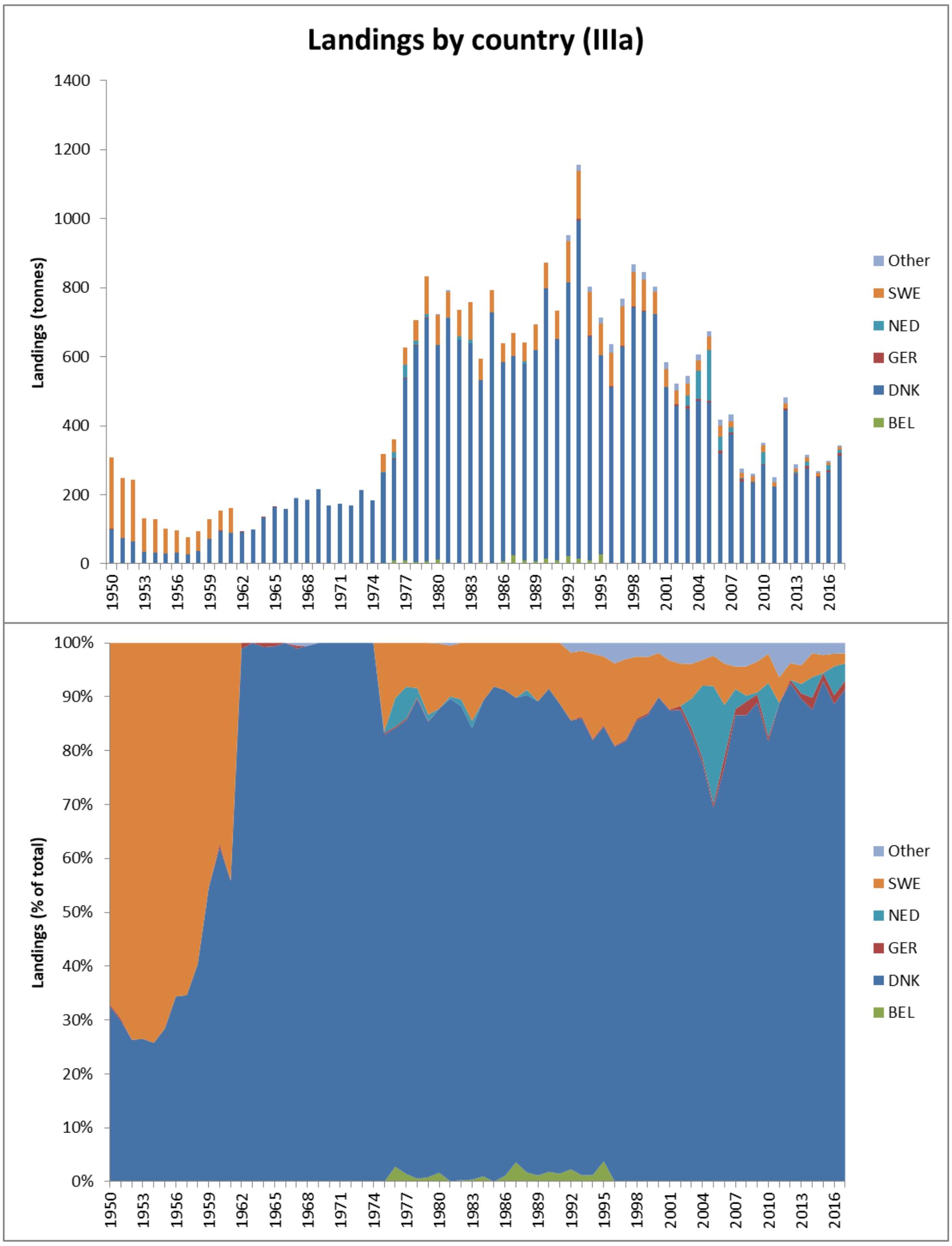


Figure 9.2.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings (tonnes) of lemon sole in area 3.a by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 3.a landings.

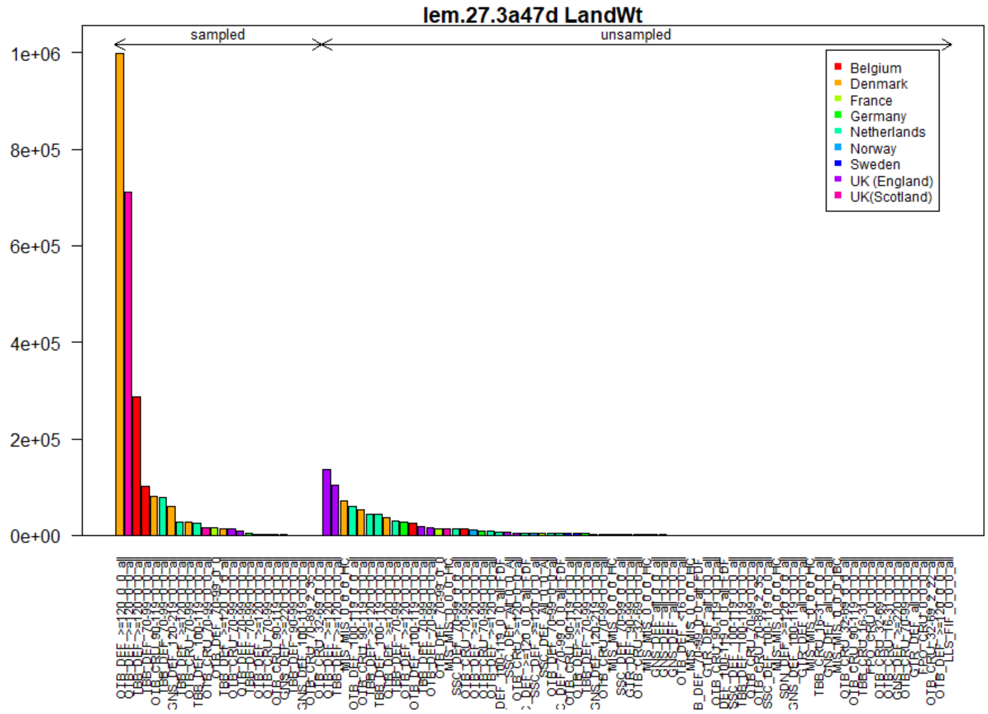


Figure 9.2.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation.

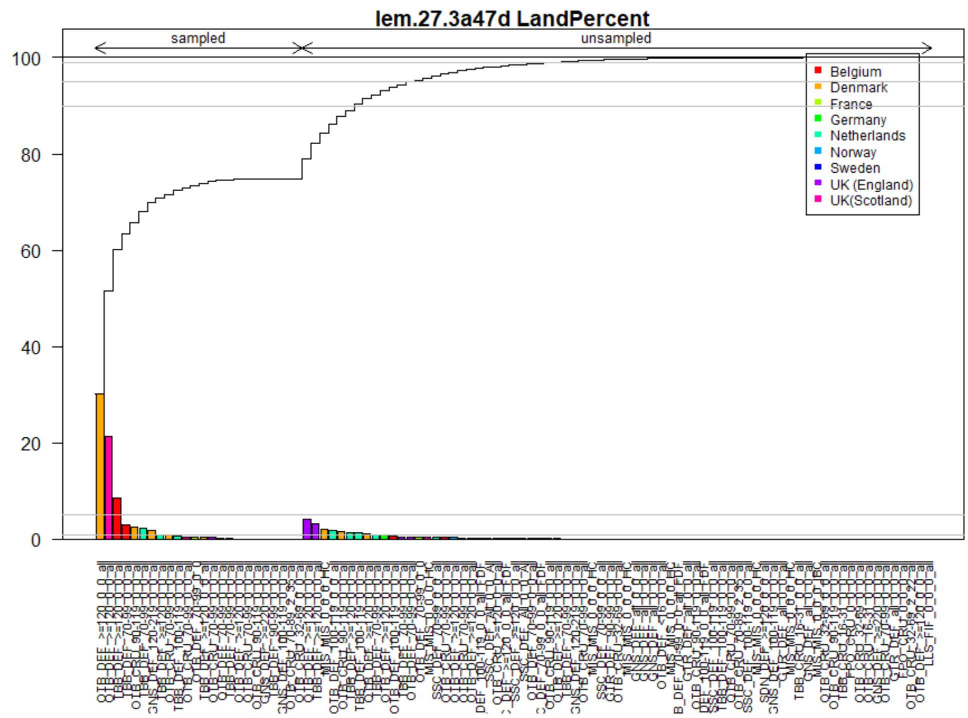


Figure 9.2.6. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (cumulative contribution).

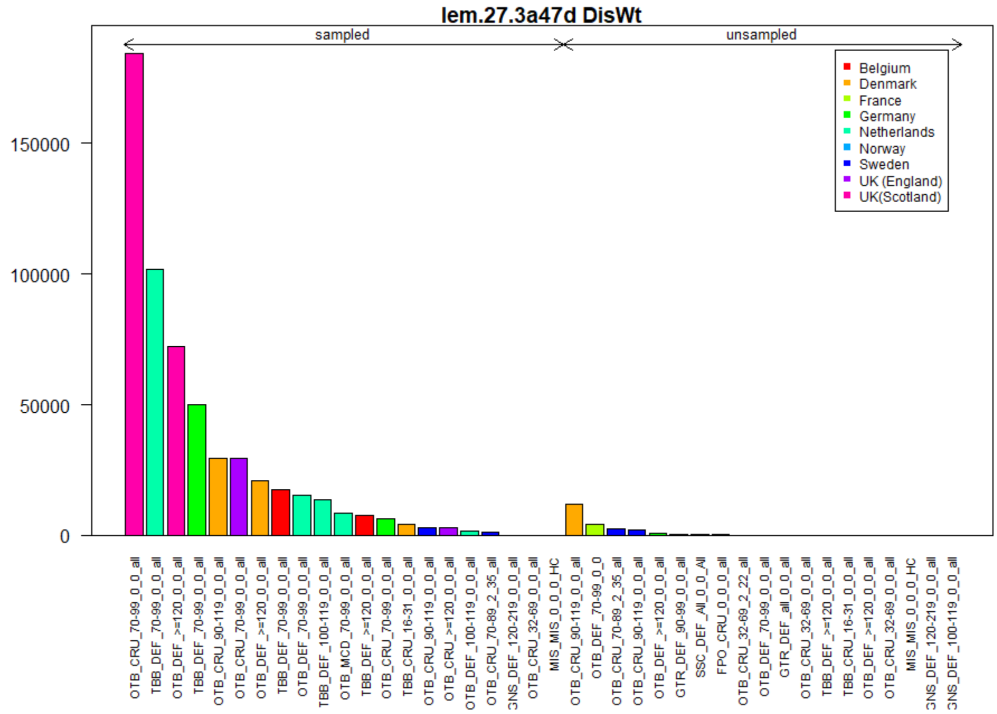


Figure 9.2.7. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for discard yield estimation.

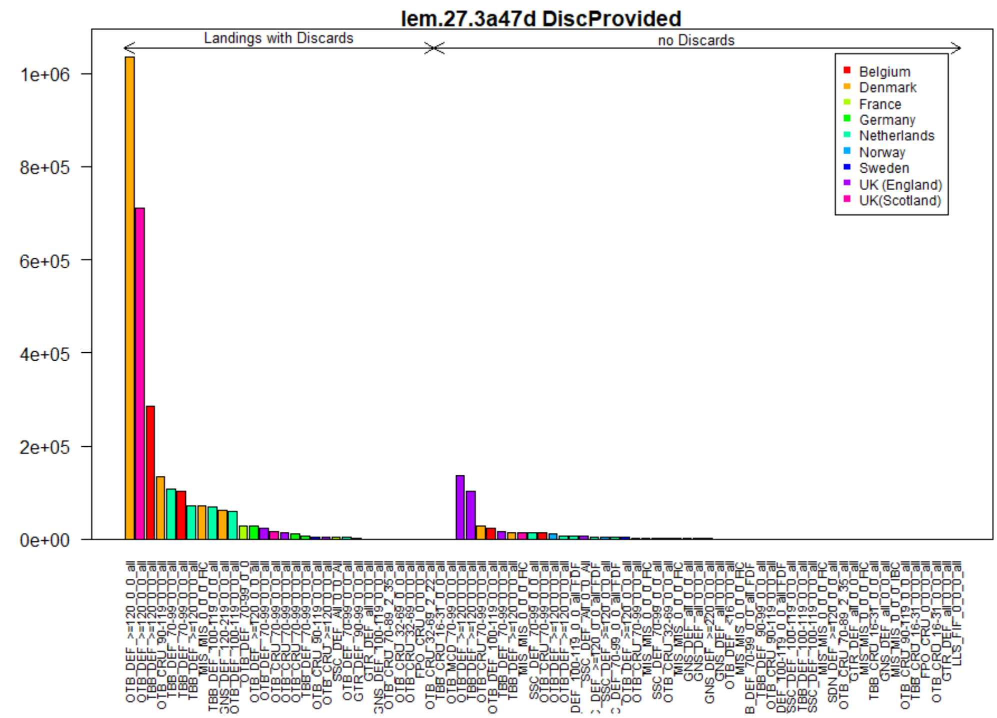


Figure 9.2.8. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Landings provided with or without discard estimates.

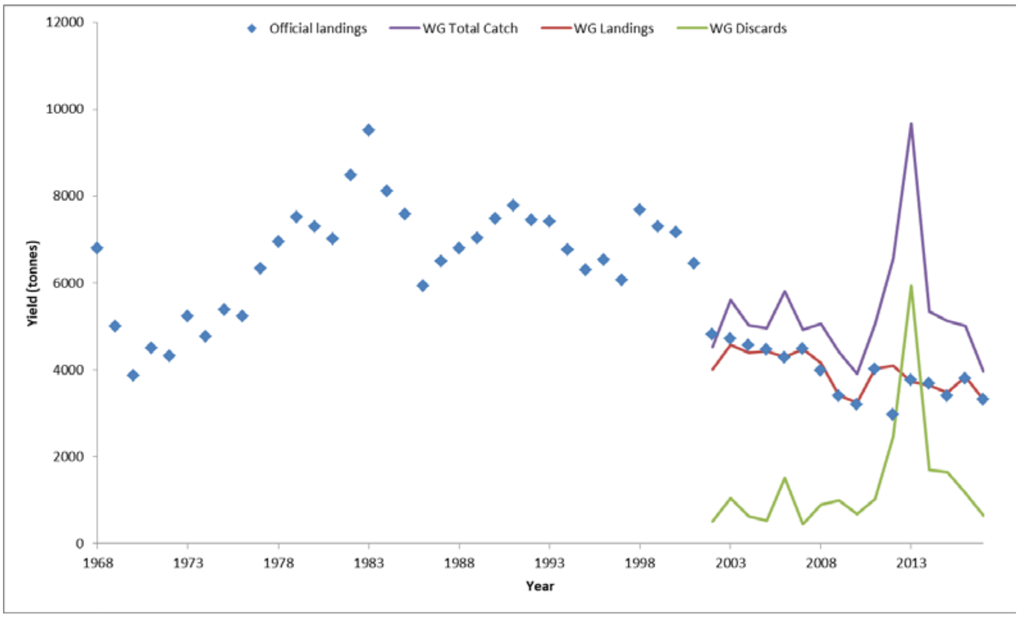


Figure 9.2.9. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Time-series of official landings (dots) along with ICES WG estimates of total catch (purple line), landings (red line) and discards (green line).

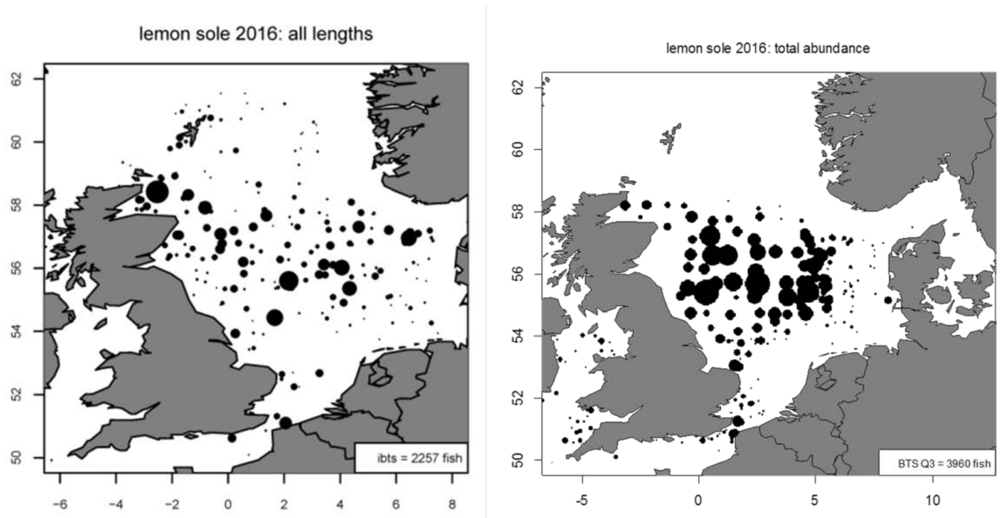


Figure 9.3.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Distribution of lemon sole in the greater North Sea derived from IBTS Q1 (left) and BTS Q3 (right), for 2016. The sizes of the circles are proportional to abundance (all lengths).

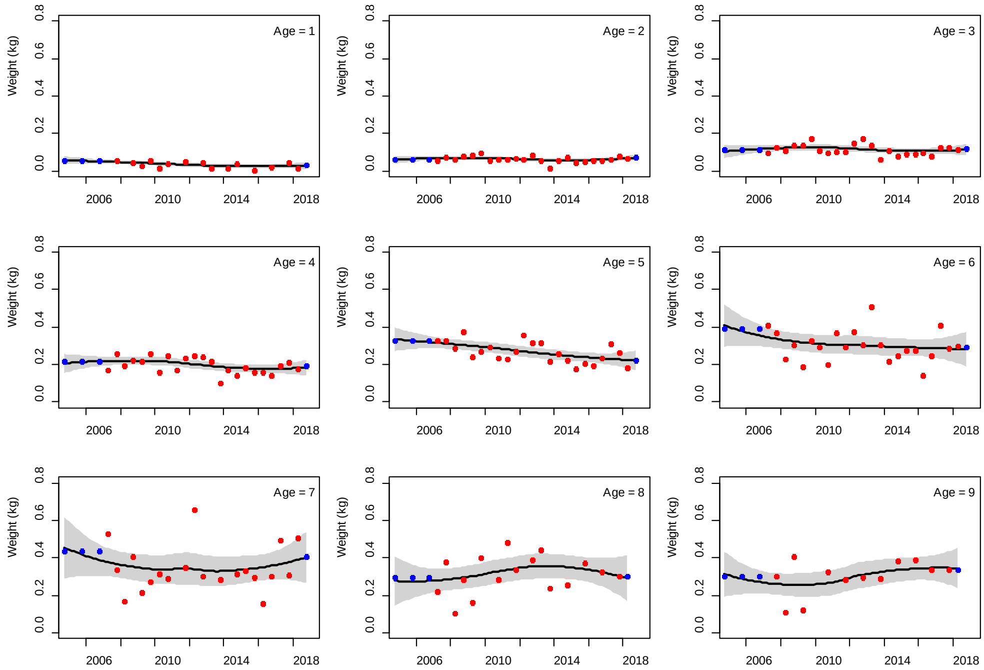


Figure 9.3.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Time-series of mean weight-at-age estimates (red dots) from IBTS Q1 and Q3 surveys, summarised by a loess smoother (span = 1) for each year (the grey band gives a 95% confidence interval about the loess smoother). The blue dots show averages (of either the first or last two estimates), included to allow extrapolation to the start and end point of the survey indices.

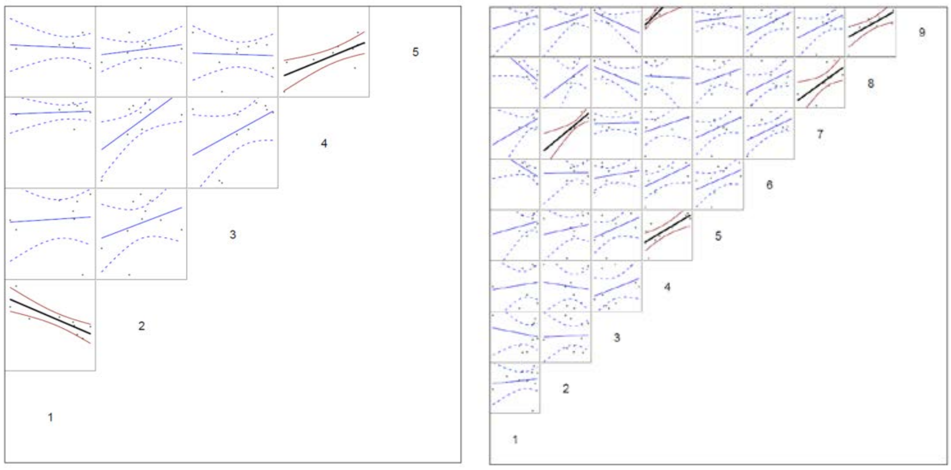


Figure 9.3.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Bivariate scatterplots showing consistency in cohort-strength estimation, for Q1 (left: IBTS) and Q3 (right: IBTS and BTS).

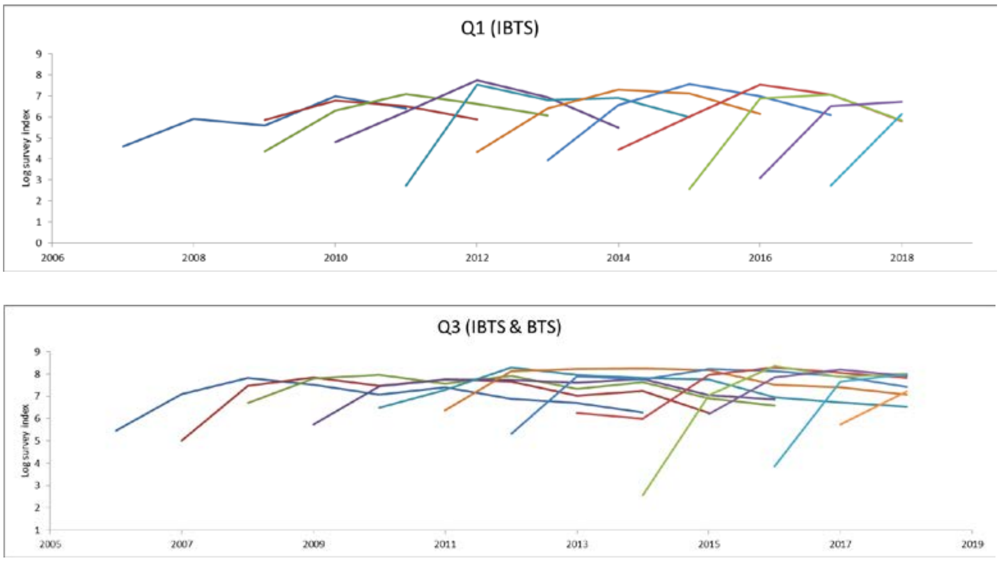


Figure 9.3.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Survey catch curves, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

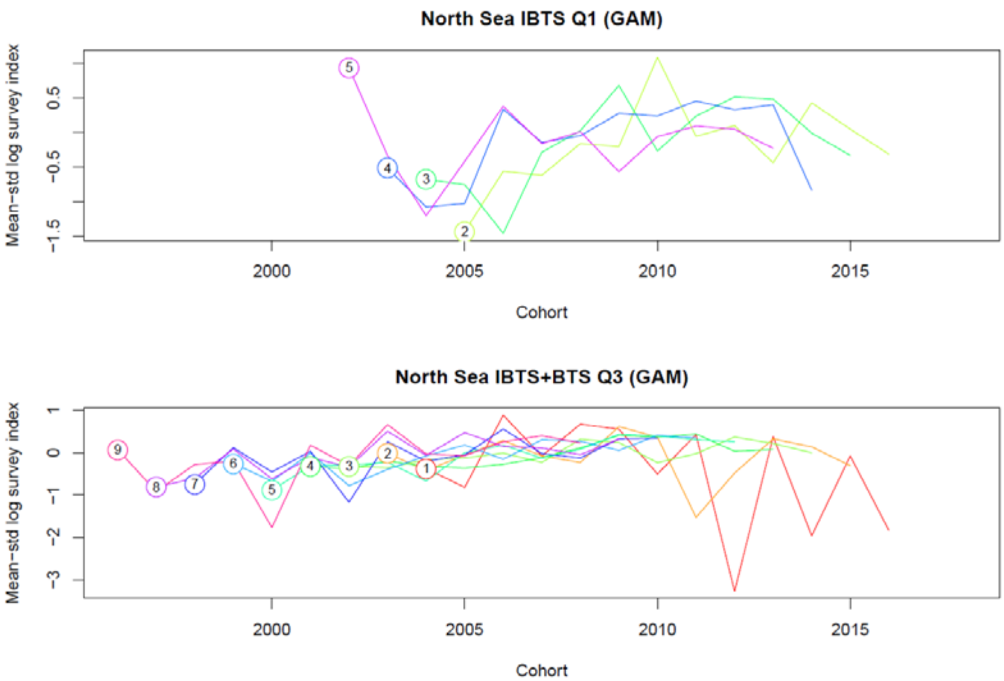


Figure 9.3.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Survey indices by age, cohort and year, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

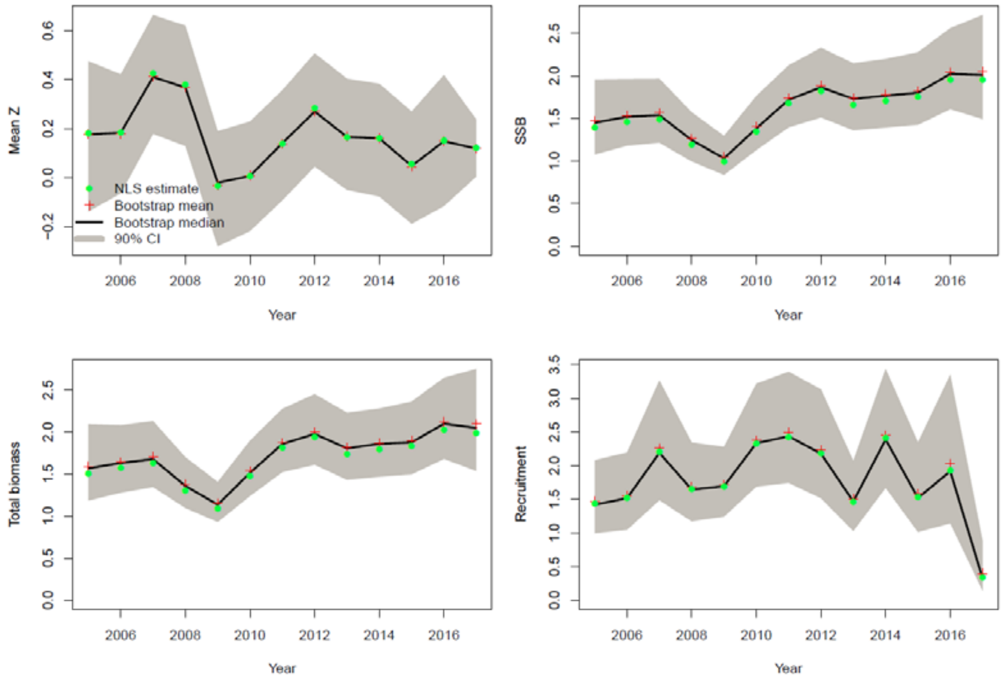


Figure 9.4.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. SURBAR stock summary (clockwise from upper left: mean Z(3–5), relative SSB, relative recruitment at age 1, relative total biomass). In each plot, the green dot gives the nonlinear least-squares estimate, the red cross gives the uncertainty-estimation bootstrap mean, the black line gives the bootstrap median, and the grey band gives a 90% confidence interval about the median.

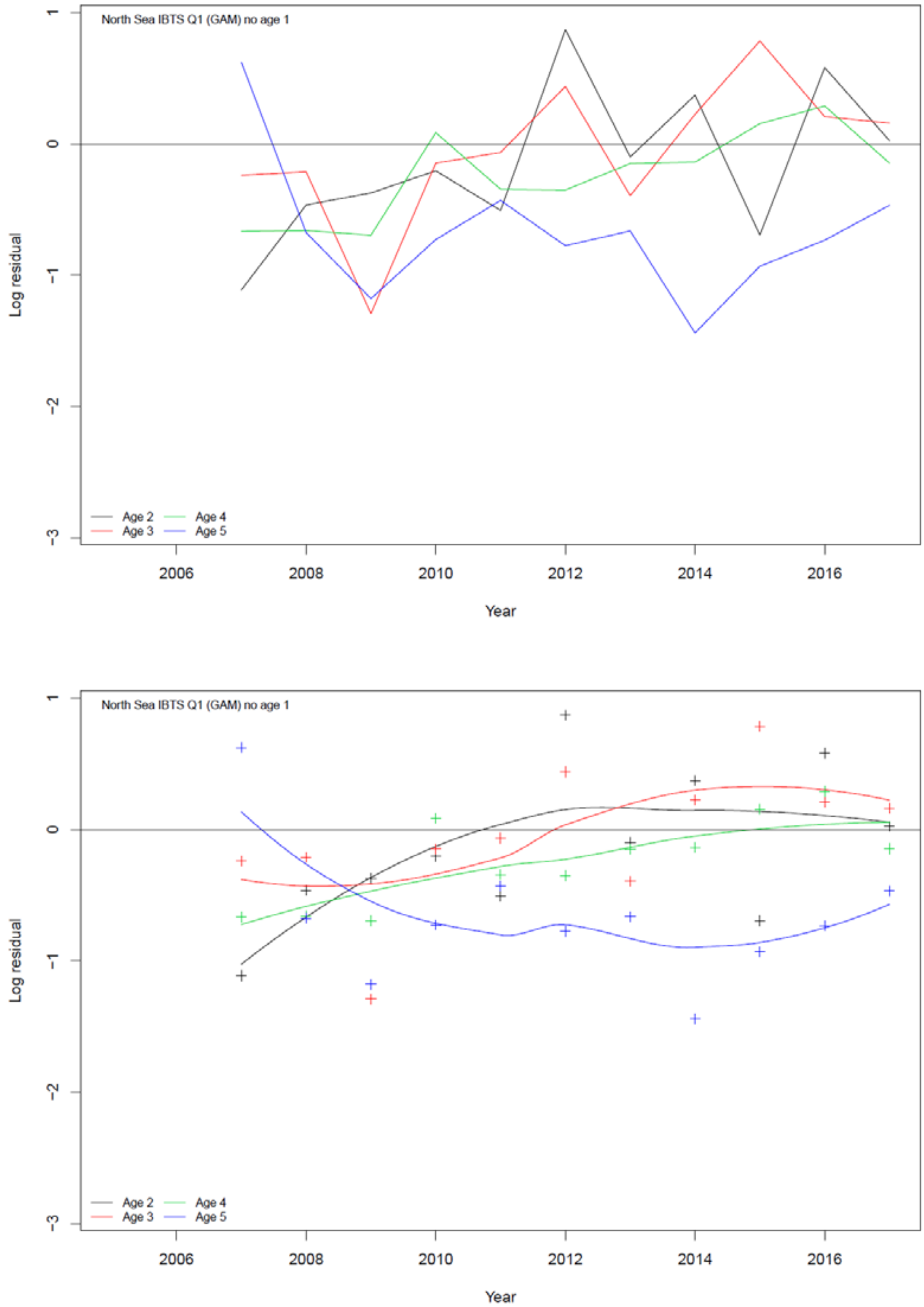
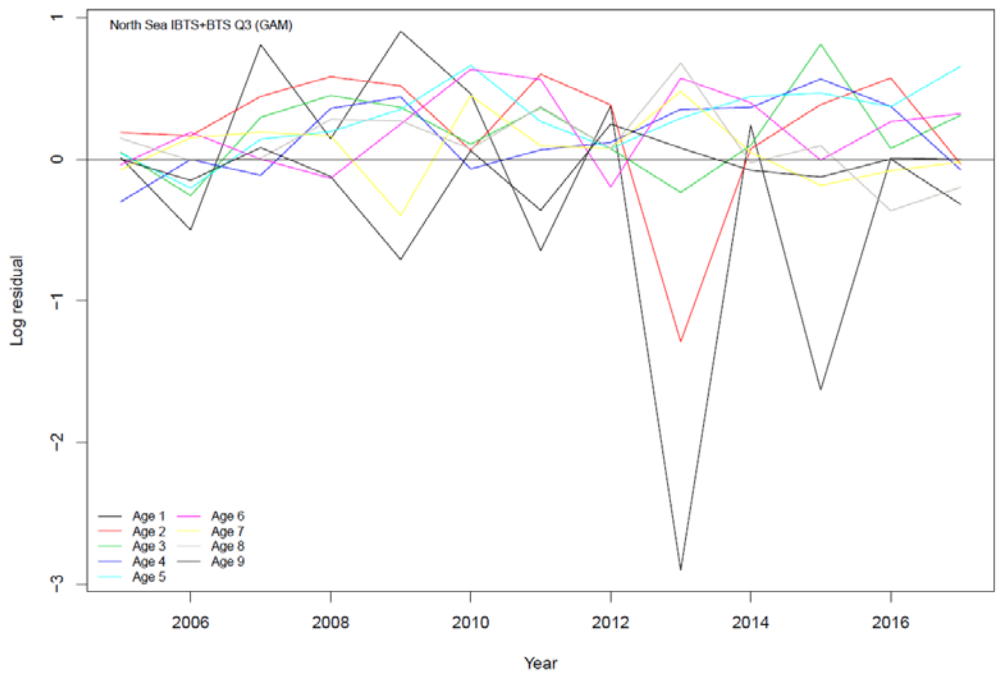


Figure 9.4.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Log SURBAR residuals for Q1 (IBTS). Upper: line per age. Lower: points per age, with loess smoothers (span = 1).



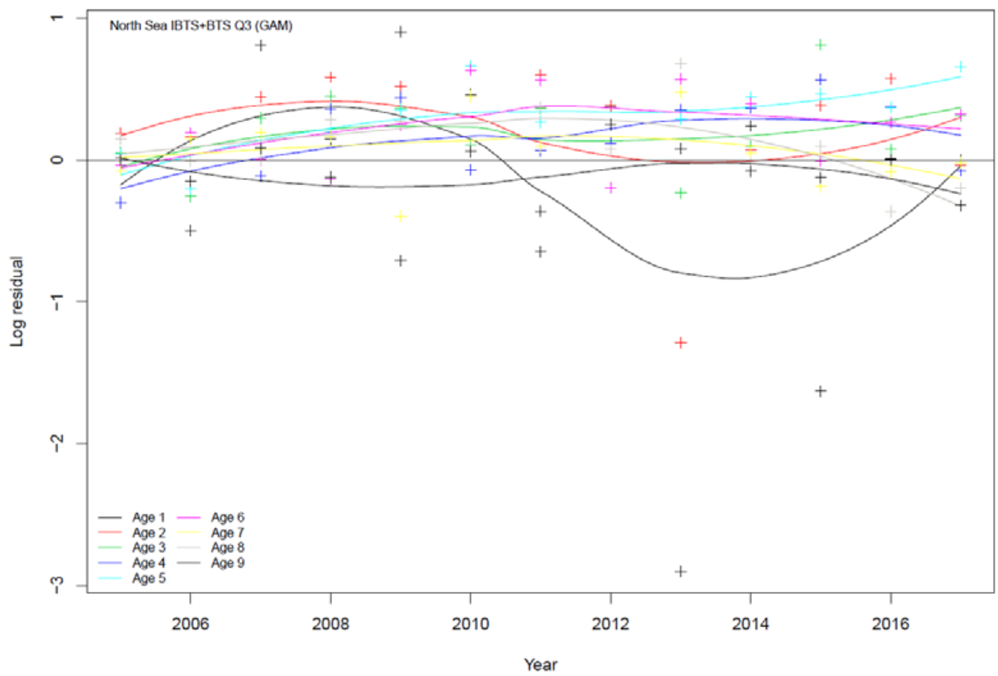


Figure 9.4.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Log SURBAR residuals for Q3 (IBTS & BTS). Upper: line per age. Lower: points per age, with loess smoothers (span = 1).

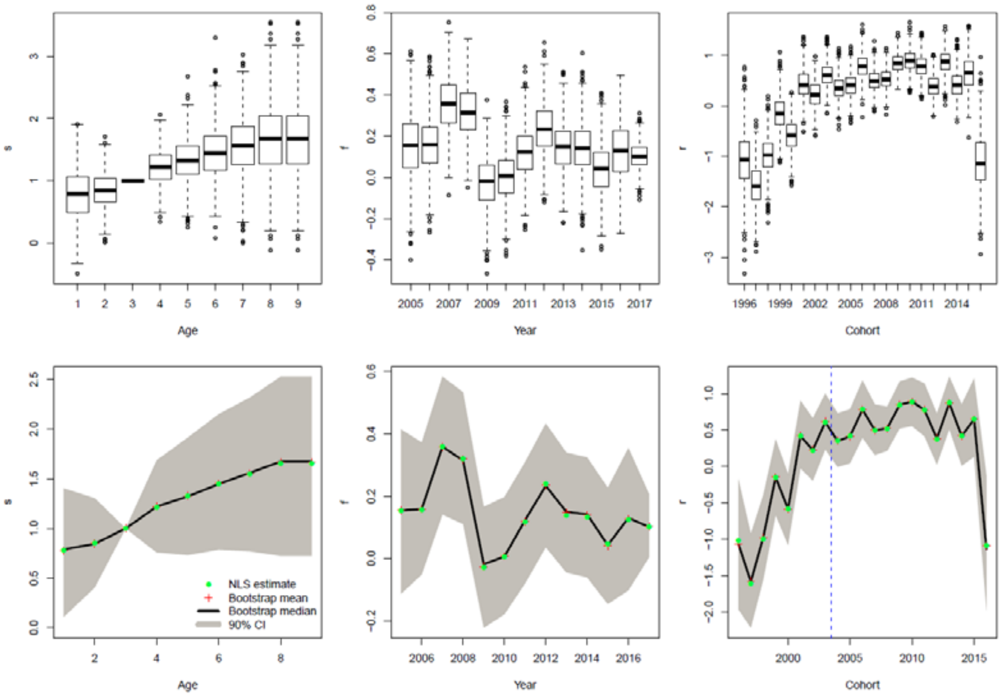


Figure 9.4.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Estimated SURBAR parameters: age effects (*s*) and year effects (*f*) of total mortality, and cohort effects (*r*). Upper: box-and-whisker plots of bootstrap distributions. Lower: the green dot gives the nonlinear least-squares estimate, the red cross gives the uncertainty-estimation bootstrap mean, the black line gives the bootstrap median, and the grey band gives a 90% confidence interval about the median.

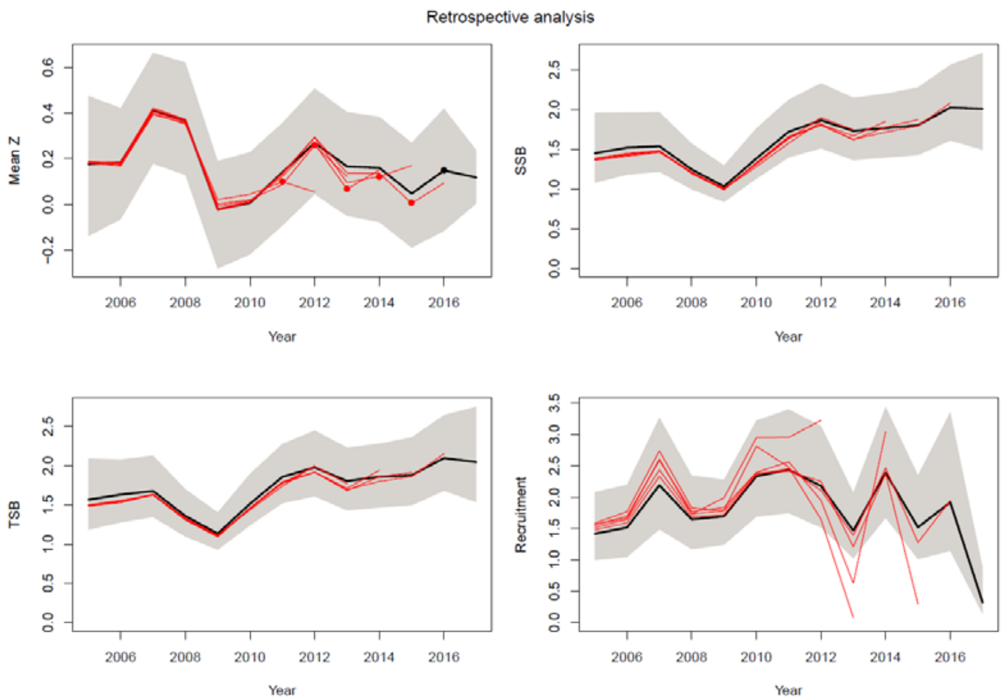


Figure 9.4.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Retrospective SURBAR analysis (clockwise from upper left: mean Z(3–5), relative SSB, relative total biomass, relative recruitment at age 1). Black lines give final-year estmates (with 90% confidence interval in grey), while red lines give the results of 5 retrospective peels.

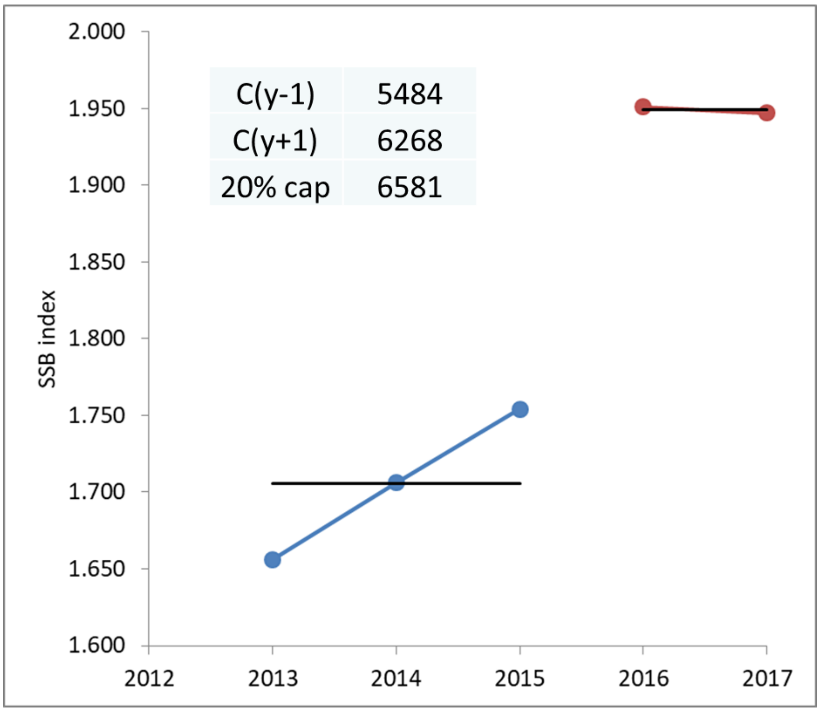


Figure 9.5.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Application of the DLS 3.2 rule, using the last five years of the relative SSB estimate given in Figure 9.4.1.

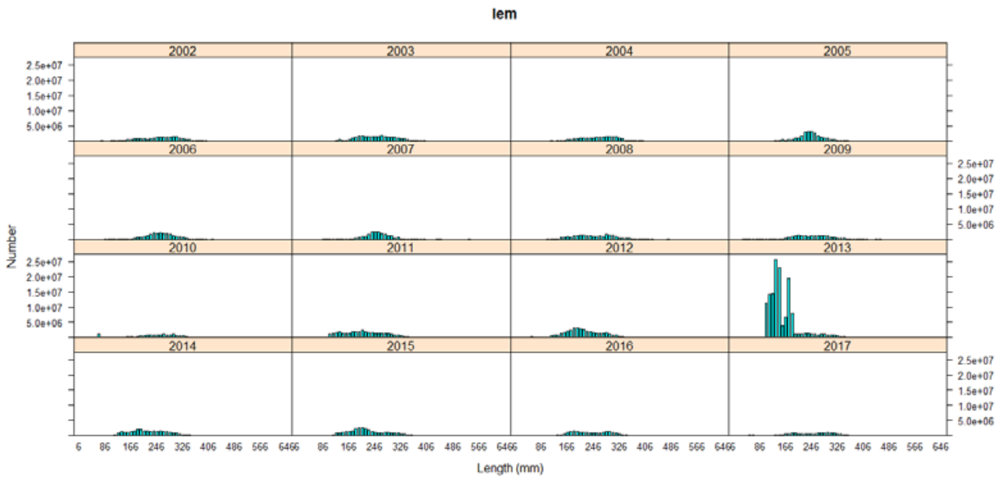


Figure 9.6.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year.

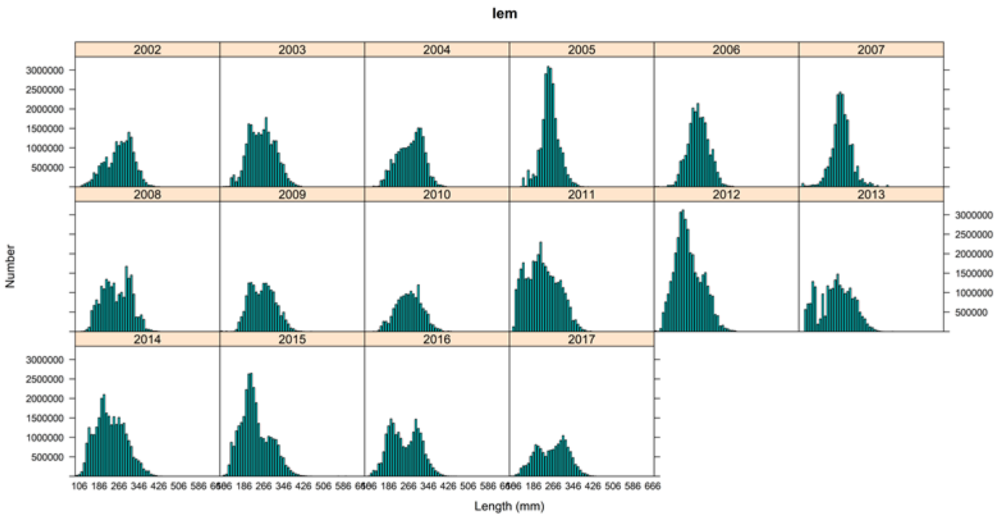


Figure 9.6.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year, with 2013 abundance for fish < 200 mm divide by 20, and all fish < 100 mm removed for all years.

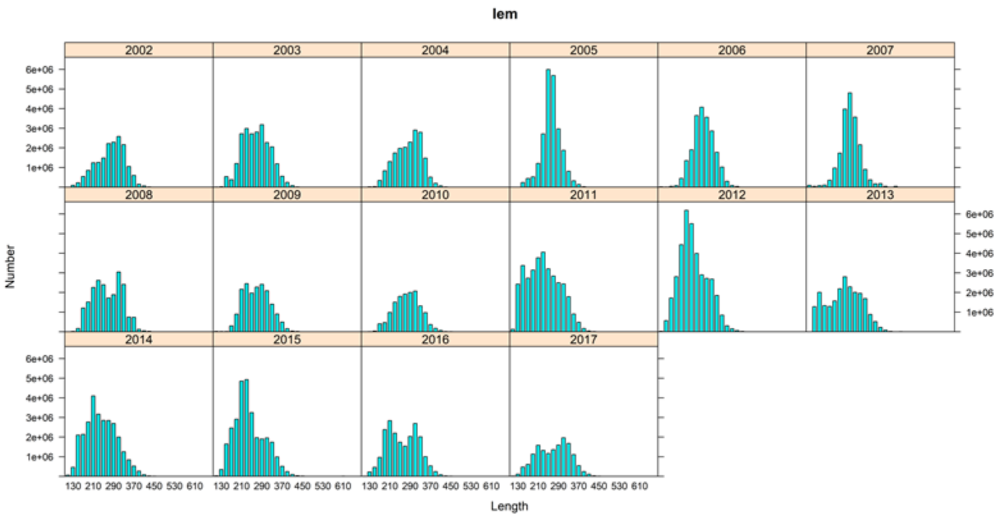


Figure 9.6.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. As for Figure 9.6.2, with bin widths doubled (to 20 mm).

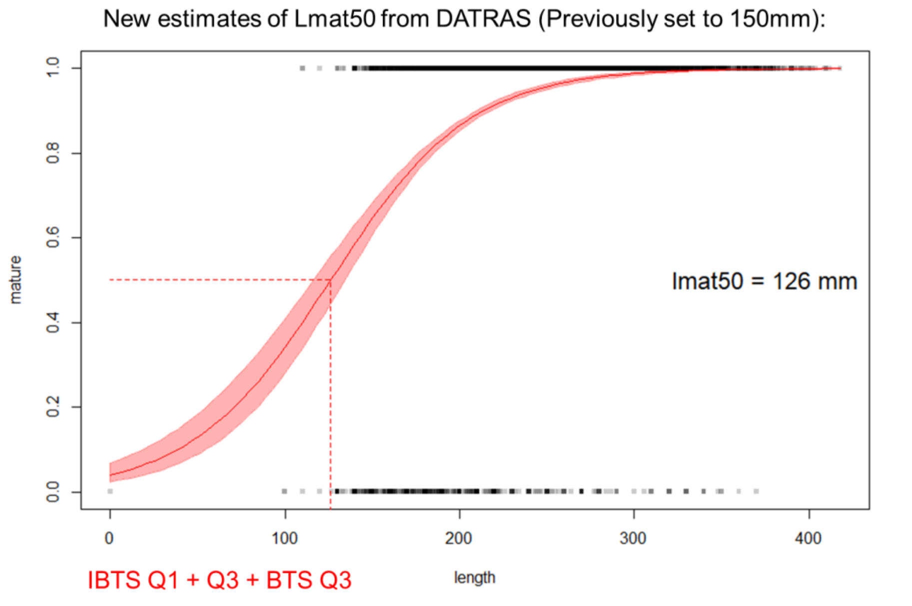


Figure 9.6.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Fitted maturity-at-age estimates from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using maturity-length observations from all available years (2007–2018). Maturity indices (0 = not mature, 1 = mature) are shown as shaded dots. The solid red line gives the fitted maturity ogive with 95% confidence interval (red band), while dotted red lines highlight the length of 50% mature ($L_{50\%mat}$ = 126 mm).

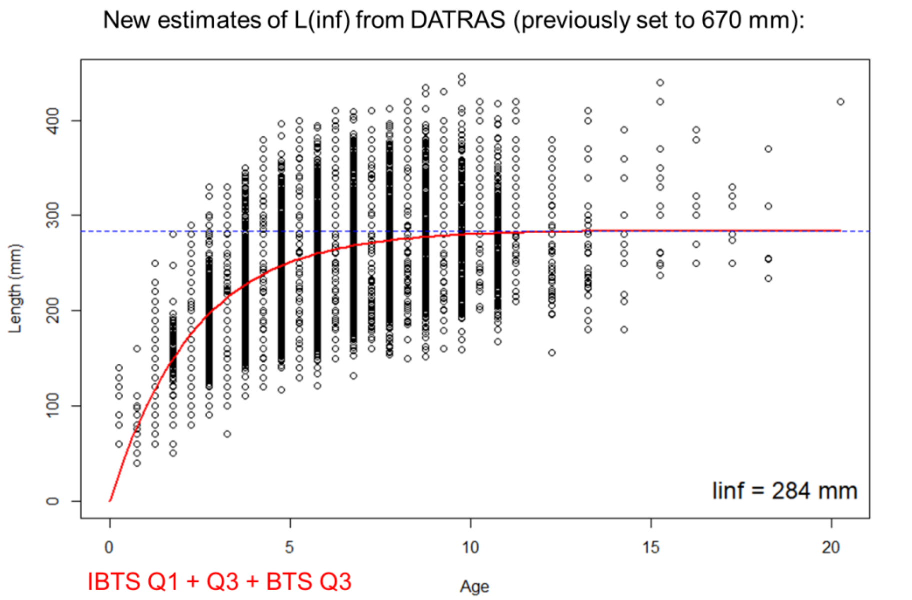


Figure 9.6.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length-at-age data from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using data from all available years (2007–2018). To account for seasons, Q1 lengths are plotted at *a* + 0.25, Q3 lengths at *a* + 0.75. The red line gives a fitted von Bertalanffy growth curve (L_∞ = 284.1066 mm, K = 0.4297, t_0 = 0).

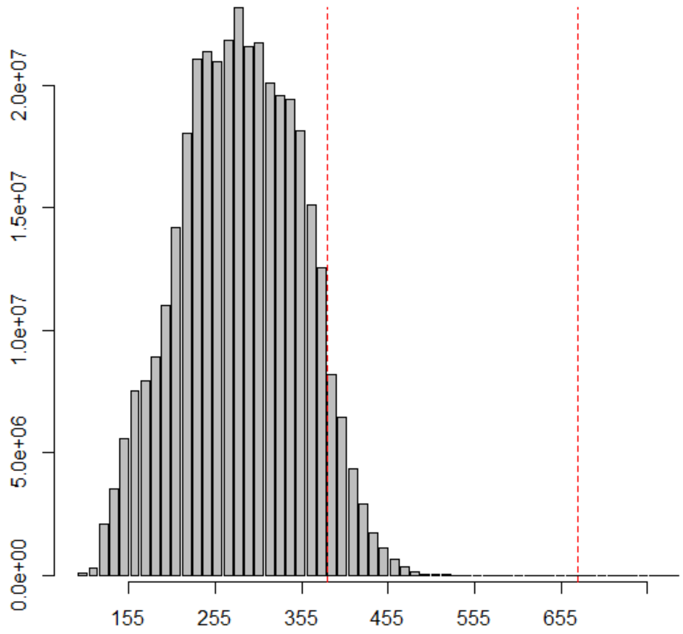


Figure 9.6.6. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distribution of the commercial catch data submitted to InterCatch, collated over all available years (2002–2017). The red lines give (from left to right) the 99%ile of the distribution (385 mm) and the longest observed fish (675 mm).

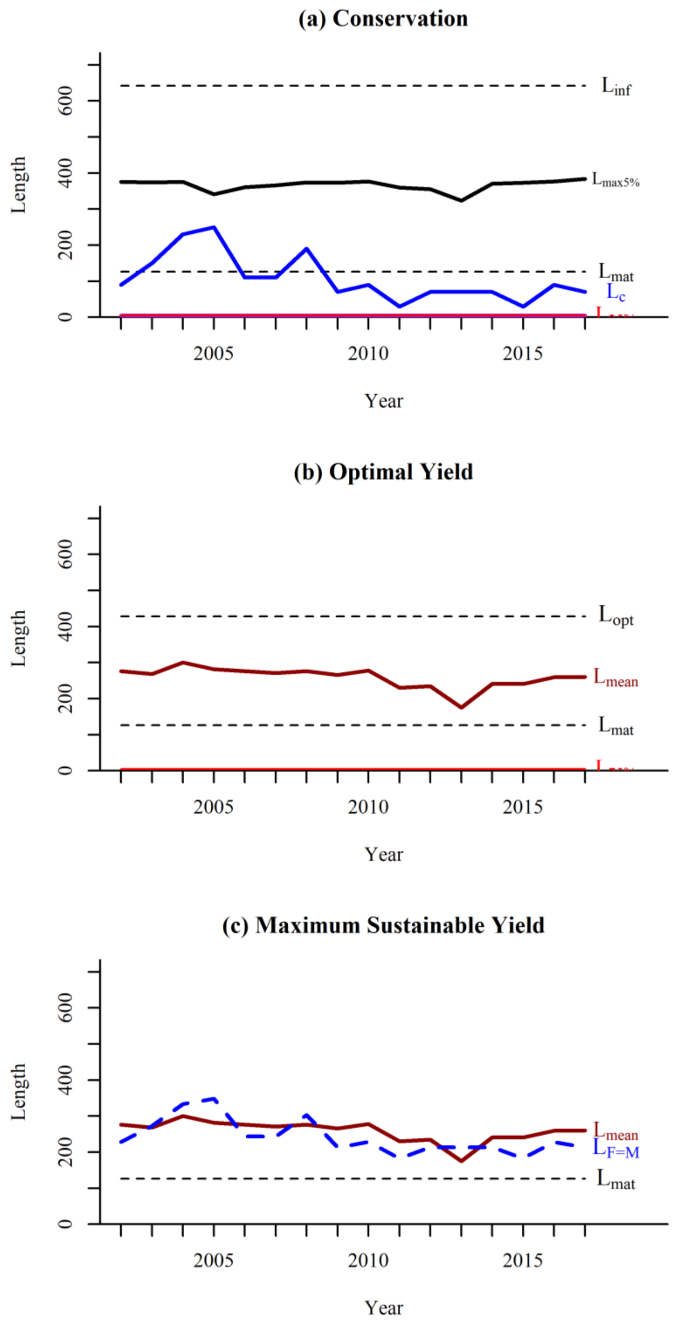


Figure 9.6.7. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Results of LBI analysis (absolute estimates).

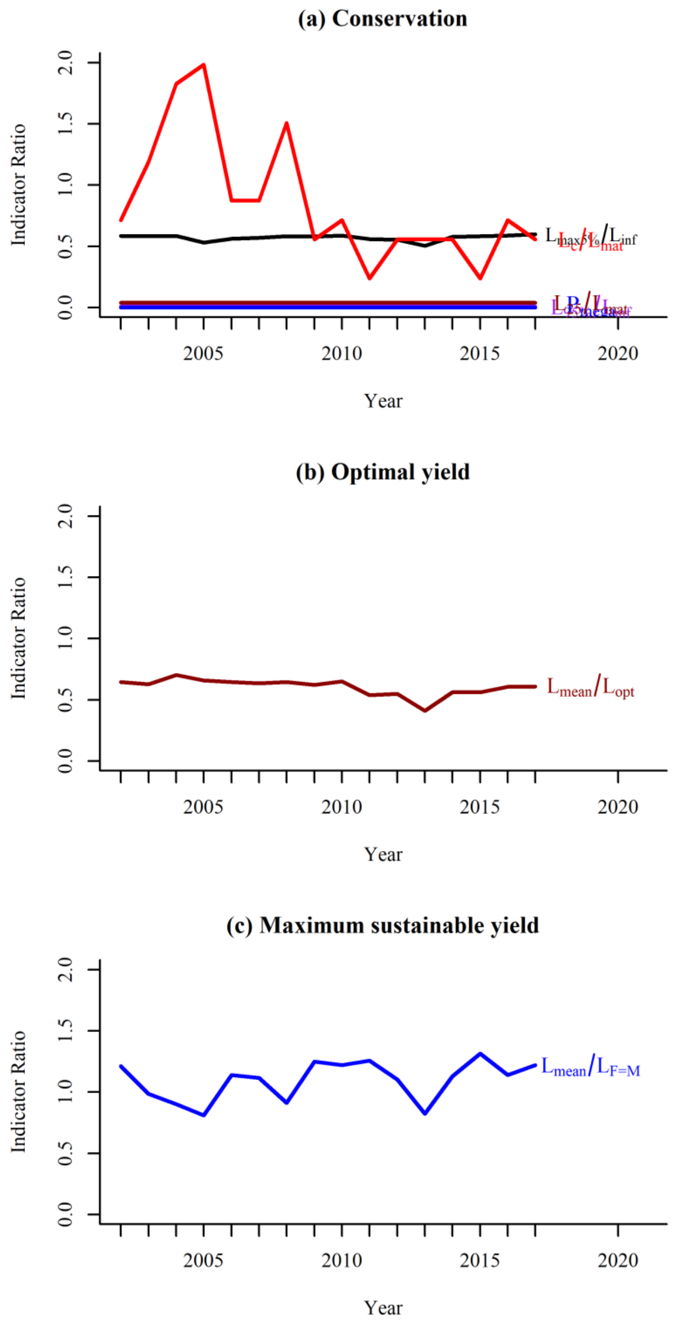


Figure 9.6.8. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Results of LBI analysis (ratio estimates).

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

10.1 *Nephrops* in Division 3.a

10.1.1 General

At present, there are two functional units in Division 3.a: Skagerrak (3.a.20) and Kattegat (3.a.21). 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 Kattegat (3.a.21) 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 3.a.20 and 3.a.21 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 2016. ICES concluded that:

´The stock size is considered to be stable. The estimated harvest rate for this stock is currently below the fishing mortality consistent with achieving Maximum Sustainable Yield (F_{MSY}).'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area 3.a was increased from 5318 tonnes in 2015 to 11 001 tonnes in 2016, 12 715 tonnes in 2017 and 11 738 tonnes in 2018. The large increase in quota 2015 to 2016 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) around 50%, and the discard proportion

2016 was decreased to 12% of the catch (in numbers) in 3.a consisted of undersized individuals. In 2017, the discard proportion increased to 32%, probably as a result of increased recruitment (Figure 10.2.1.1). The reduction in MLS has reduced 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 1 January 2015. The discard ban became applicable to *Nephrops* from 1 January 2016, however an exemption for high survivability was introduced. New technical measures have also been agreed upon and have been implemented since 1 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.

10.1.2 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 10.2.1.1 and Table 10.2.1.2.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 70 % and 28 % by weight of the landings in 2017, 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 2016 accounted for more than 30% of Swedish Skagerrak landings (Table 10.2.2.1). In the early 1980s, total *Nephrops* landings from the Skagerrak increased from around 1000 tonnes to just over 2670 tonnes. Since then they have been fluctuating around a mean of 2500 tonnes (Figure 10.2.2.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2017, Denmark accounted for about 72 % of total landings in FU4, while Sweden took 28 % (Table 10.2.2.5). 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 tonnes. However, since 2006 the landings have increased and were in 2010 the highest on record over the 50 year period (Figure 10.2.2.4). 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 1991–2017. 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 10.2.2.2 and Table 10.2.2.4. 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 1990–2017, and from Denmark for 1992–2017. 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 2017. Information on mean size is shown in Figure 10.2.2.5 and Table 10.2.2.8. Notice, that except for small mean sizes from 1993 to 1996 all categories have since been fluctuating without trend until 2016 when the minimum landing size was decreased from 40 to 32 mm carapace length.

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

Natural mortality, maturity at age and other biological parameters

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

Growth parameters are as follows:

Males:	$L\infty$ = 73 mm CL, k = 0.138.
Immature females:	$L\infty$ = 73 mm CL, k = 0.138.
Mature females:	$L\infty$ = 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 1978–2017 (Figure 10.2.2.1 and Table 10.2.2.2). 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 10.2.2.2). 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 10.2.2.1). 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 10.2.2.3 and Figure 10.2.2.1) 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 1994–1998, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2017. 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 10.2.2.3).

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 10.2.2.4 and Table 10.2.2.6). 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 10.2.2.4 and Table 10.2.2.7).

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 10.2.2.6).

10.1.3 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."

10.1.3.1 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 10.2.3.2) and in 2017 (2016 benchmark) Subarea 2 was extended east (Subarea 9). Figure 10.2.3.4 presents the distribution of stations with valid density estimates from 2011 to 2017. 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 10.2.3.3) and are described in more detail in ICES (2011). The area estimates for each Subarea are defined in Table 10.2.3.1. 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 10.2.3.2 is shown in Table 10.2.3.1 and Figure 10.2.3.4.

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

10.1.3.2 2015 Assessment

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2017. Additional used information was trends in total combined (Denmark and Sweden) lpue, and discards (numbers) as a proxy for recruitment during the period 1990–2017.

Combined relative effort declined slightly over the period 1990 to 2017 (Figure 10.2.4.1) while combined relative lpue shows an increasing trend and is at a high level in the recent 8 years (Figure 10.2.4.2). This high level may be attributed to the change in the Danish management system (Individual Transferable Quotas) in 2007 and the change in minimum landing size in 2016. 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 1993–1995 and 1999–2000 reflect strong recruitment during these years (Figure 10.2.4.3). The high levels of discards in 1993–1995 are believed to have significantly contributed to the high lpue in 1998–1999. 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 2016 is the lowest since 1991 due to the lowered MCRS. Low discard rate may also be due to a very low recruitment and/or an increase in gear size selectivity.

MSY considerations (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 it is recommended to use F_{max} as a proxy for F_{MSY} as in last years. For 2018 this corresponds to a TAC of 11 738 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 %).

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:

Landings obligation

Basis	Total catch*	Wanted catch	Unwanted catch	Harvest rate*
	L+D	L	D	for L + DD
F2017	6640	5952	688	2.6%
Fcurrent (2015-2017)	6666	5975	691	2.6%
MSY Approach	20571	18439	2132	7.9%

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	21770	21206	19513	1693	564	7.9%

Weights in tonnes.

***Total discard ratio is assumed to be 22.0% of the catches (by number, average of last three years, 2015–2017), 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 2016 is presented in Table 10.2.3.1. The estimated abundance index was 0.291 resulting in a total abundance of 2863 million individuals. Total removals (landings + dead discards) were estimated to 88 million individuals resulting in a harvest rate of 3.1%.

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 10.2.4.1 and 10.2.4.2). 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.

10.1.4 Biological reference points

No biological reference points are used for this stock.

10.1.5 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 2017 was conducted in all 8 defined subareas in 3.a. A correction factor of 1.1 was used. A total weighted mean density was estimated based on density estimates from each Subarea and weighted by the size of each Subarea. 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 10.2.4.2), which occurred in 2007 in Denmark, caused a general increase in lpue. In 3.a, fluctuations in catches of small *Nephrops* has been used as indicators of recruitment (Figure 10.2.4.3). This indicator will start a new series in 2016 depending on the lowered MCRS.

10.1.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the seventh year (2011–2017; new Subarea 7 only in 2014–2016 and new Subarea 9 in 2017) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 10.3.6.1).

The average 2015–2017 harvest rate was estimated to be relatively low (2,6 % from UWTV surveys) 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.

10.1.7 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 10.2.4.1 and 10.2.4.2). The increase in lpue in 2016 is due to the lowered MCRS in 2016 from 40 to 32 mm carapace length. Mean sizes are fluctuating without trend (figures 10.2.2.2 and 10.2.2.5). Note that the decrease in mean size for 2016 depends on the lowered MCRS. 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 bycatch 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 1 February 2013. The European Union and Norway have also agreed that a discard ban will be implemented in EU waters from 1 January 2015. The discard ban was applicable to *Nephrops* from 1 January 2016 but preliminary results indicating high discard survival has resulted in an exception of landing obligation for *Nephrops* in 3.a during 2016 to 2018.

Table 10.1.1. Definition of *Nephrops* Functional Units in 3.a and IV 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 Cut - Silver Pit	4.b,c	36–37 F1–F4; 35F2–F3
6	Farn Deeps	4.b	38–40 E8–E9; 37E9
7	Fladen Ground	4.a	44–49 E9–F1; 45–46E8
8	Firth of Forth	4.b	40–41E7; 41E6
9	Moray Firth	4.a	44–45 E6-E7; 44E8
10	Noup	4.a	47E6
32	Norwegian Deep	4.a	44–52 F2–F6; 43F5–F7
33	Off Horn Reef	4.b	39–41F5; 39–41F6
34	Devil's Hole	4.b	41–43 F0–F1

Table 10.2.1.1. Division 3.a: Total *Nephrops* landings (tonnes) by Functional Unit, 1981–2017.

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
2016	3238	1652	4890
2017	3129	2082	5211

Table 10.2.1.2. Division 3.a: Total *Nephrops* landings (tonnes) by country, 1991–2017.

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
2016	3440	87	1363	0	4889	256	5145
2017	3700	81	1430	1	5211	1024	6234

Table 10.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2017.

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
2016	2260	66	21	87	604	289	892	0	3239
2017	2118	60	20	81	672	258	930	0	3129

Table 10.2.2.2. ***Nephrops*** **Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish** ***Nephrops*** **trawlers, 1991–2017. (*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
2016*	216	188	14.9	14.4	12.6
2017*	362	232	16.9	21.4	13.7

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

Twin trawl (continued)					
Year	Catches	Landings	Effort	CPUE	LPUE
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
2016*	471	410	20.1	23.4	20.4
2017*	667	427	17.5	38.2	24.5

Table 10.2.2.3. ***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, 1991–2017.**

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
2016	2032034	8060	7673	295
2017	1940952	7391	7061	300

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2017.

Year	Catches					
	Undersized		Full sized		All	
	Males	Females	Males	Females	Males	Females
1991	30.2	30.9	41.2	42.7	30.9	29.8
1992	33.3	32.3	43.3	44.7	33.3	32.2
1993	33.0	31.5	42.0	43.6	33.0	31.5
1994	31.7	29.6	41.7	43.6	31.7	29.6
1995	30.0	28.5	41.6	41.3	32.9	29.8
1996	33.2	31.9	42.9	44.0	37.6	37.0
1997	35.8	34.5	44.6	44.1	39.8	39.1
1998	34.8	34.4	46.1	43.9	40.7	37.3
1999	34.6	33.9	44.9	43.8	39.3	36.1
2000	30.6	30.5	45.6	45.0	32.5	34.1
2001	33.6	33.6	45.5	43.6	37.3	36.4
2002	33.9	33.7	44.0	42.5	37.2	37.3
2003	33.5	32.6	43.2	43.4	38.0	36.7
2004	34.3	33.4	44.6	45.2	38.7	36.6
2005	33.5	32.4	43.7	43.0	36.4	35.3
2006	33.2	32.9	44.7	42.7	37.1	36.1
2007	32.6	31.9	44.4	42.4	34.9	33.5
2008	33.6	32.3	44.0	42.7	36.5	34.5
2009	35.0	33.8	45.3	42.8	39.8	35.9
2010	34.2	33.8	46.2	44.8	38.9	36.6
2011	33.8	33.1	44.5	43.3	38.4	36.5
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
2016	32.0	31.8	43.5	41.0	42.2	39.9
2017	32.3	31.5	42.4	41.7	39.1	39.0

Table 10.2.2.5. ***Nephrops*** **Kattegat (FU 4): Landings (tonnes) by country, 1991–2017.**

Year	Denmark	Sweden		Sub-total	Germany	Total
		Trawl	Creel			
1991	1185	119	0	119	0	1304
1992	901	111	0	111	0	1012
1993	765	159	0	159	0	924
1994	751	142	0	142	0	893
1995	850	148	0	148	0	998
1996	1072	213	0	213	0	1285
1997	1272	319	3	322	0	1594
1998	1486	306	4	310	12	1808
1999	1416	329	4	333	6	1755
2000	1448	357	4	361	7	1816
2001	1464	304	6	309	1	1774
2002	1240	219	5	224	7	1471
2003	1336	287	5	292	13	1641
2004	1360	270	11	281	12	1653
2005	1175	303	8	311	2	1488
2006	916	347	11	358	6	1280
2007	1223	491	15	505	13	1741
2008	1429	561	16	577	19	2025
2009	1360	450	16	467	15	1842
2010	1740	403	17	420	25	2185
2011	1136	308	16	324	15	1475
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
2016	1180	436	34	470	0	1650
2017	1581	468	31	500	1	2082

Table 10.2.2.6. Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2017 (*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
2016*	50	47	5.4	9.4	8.7
2017*	65	45	4.0	16.2	11.2

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

Twin trawl (continued)					
Year	Catches	Landings	Effort	cpue	lpue
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
2016*	404	378	19.4	20.9	19.5
2017*	603	418	17.5	34.4	23.8

Table 10.2.2.7. *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, 1991–2017.

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
2016	1899286	10249	7815	151
2017	1939311	10074	7703	205

Table 10.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991–2017. Since 2005 based on combined Danish and Swedish data.

Year	Catches					
	Discards		Landings		All	
	Males	Females	Males	Females	Males	Females
1991	30.7	31.1	42.4	42.5	32.5	32.9
1992	33.0	30.3	44.4	43.2	36.7	34.9
1993	30.5	29.3	42.3	43.1	31.3	30.1
1994	29.7	28.3	40.8	40.2	31.2	28.9
1995	30.8	30.5	42.4	42.0	33.7	33.2
1996	32.7	31.3	42.0	44.0	36.7	37.3
1997	33.6	33.2	45.0	44.5	37.1	35.0
1998	34.2	33.2	45.6	44.1	41.3	36.8
1999	32.9	33.8	45.3	40.9	37.8	34.9
2000	35.1	35.2	45.7	42.1	40.4	36.9
2001	32.2	33.0	44.1	41.9	35.9	36.5
2002	34.4	33.3	44.4	43.8	37.2	36.2
2003	33.0	33.2	43.5	42.2	37.1	36.0
2004	34.7	34.2	45.1	43.2	39.9	37.5
2005	33.5	33.9	45.8	43.1	38.7	38.7
2006	33.2	33.6	45.1	42.8	37.9	37.4
2007	33.9	33.2	44.8	43.5	37.2	35.5
2008	32.6	32.4	44.0	43.9	37.5	35.9
2009	33.8	33.1	44.7	44.1	36.8	35.2
2010	34.6	33.8	45.9	44.5	39.8	36.9
2011	33.7	32.9	44.7	43.3	38.1	35.5
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
2016	30.1	29.8	45.1	40.6	43.4	38.5
2017	30.1	30.6	42.6	40.6	38.6	36.7

Table 10.2.3.1. Summary output of the TV-survey in 3.a from 2017.

Subarea	Area (km²)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)
1	2575	34	0.282	0.112	724.870
2	1958	31	0.436	0.207	854.358
3	2613	35	0.350	0.099	913.786
4	962	10	0.512	0.223	492.797
5	996	12	0.471	0.403	469.511
6	1719	25	0.705	0.152	1212.268
7	1295	19	0.127	0.065	165.040
9	385	5	0.676	0.275	260.309
Total	12503	171			5092.938
			Harvest rate		0.0251
Removals 2017 (landings + dead discards**)			128*		

*** In millions**

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

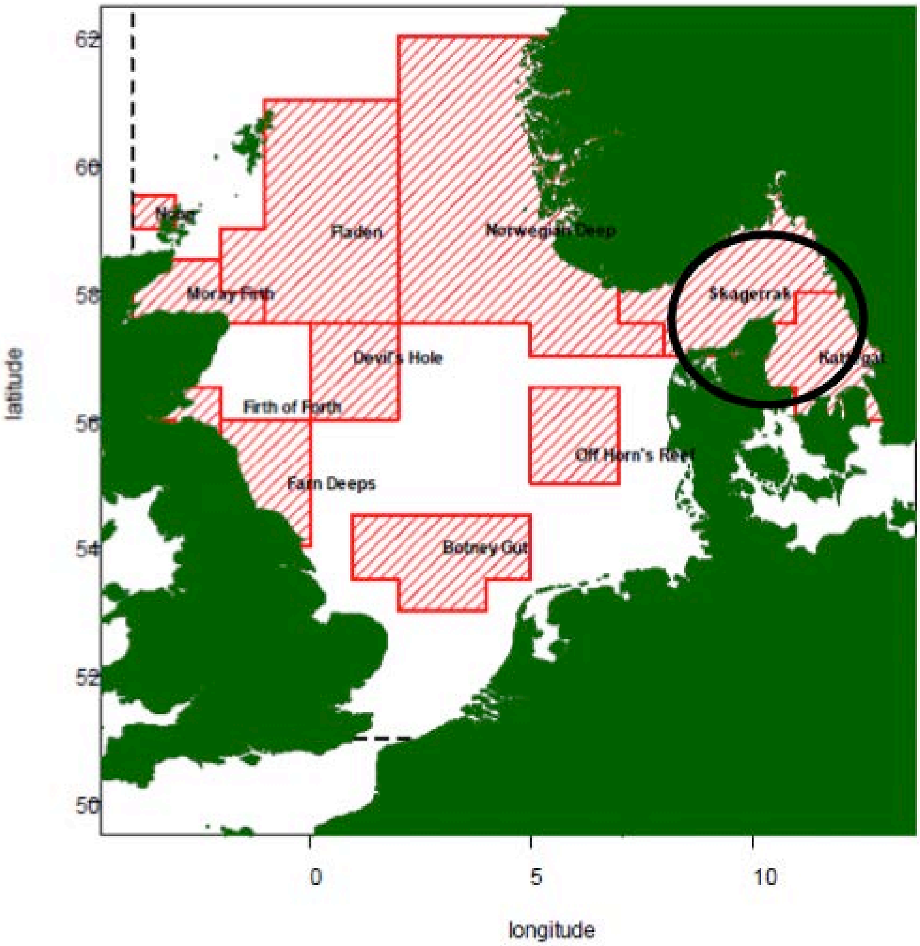


Figure 10.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

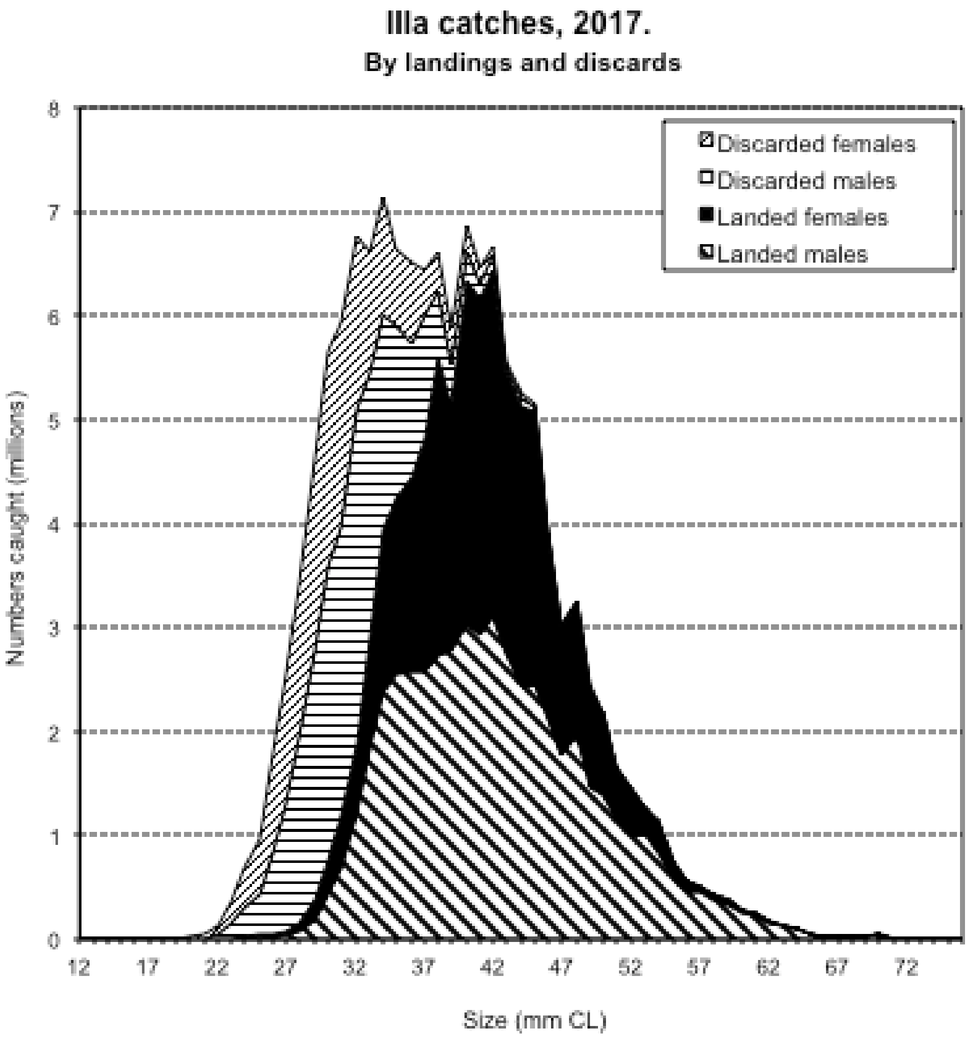


Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2017.

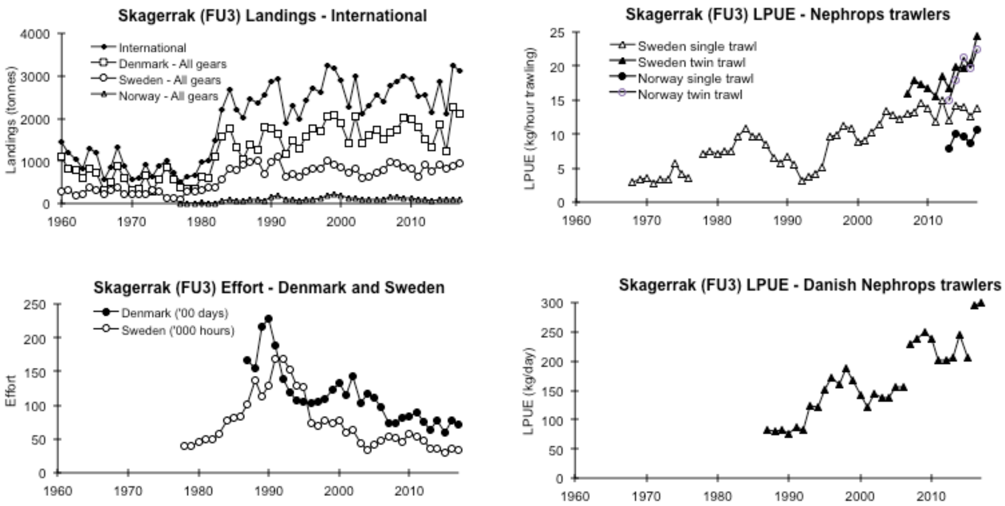


Figure 10.2.2.1. ***Nephrops*** **Skagerrak (FU 3): Long-term trends in landings, effort, and lpues.**

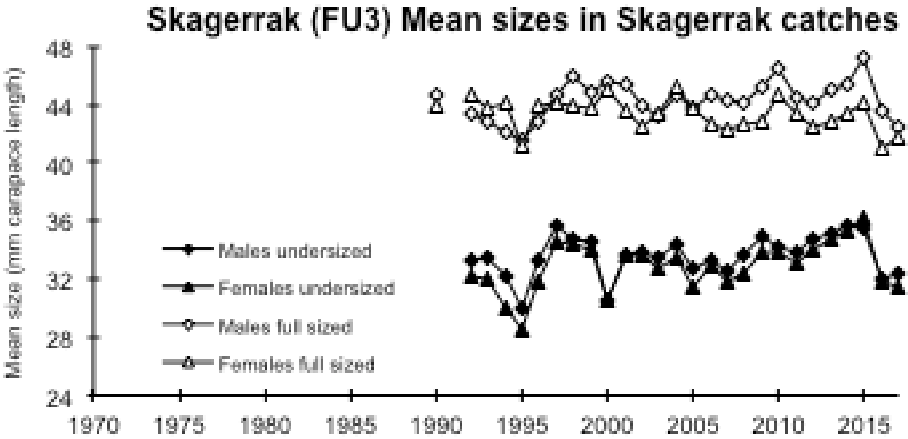


Figure 10.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

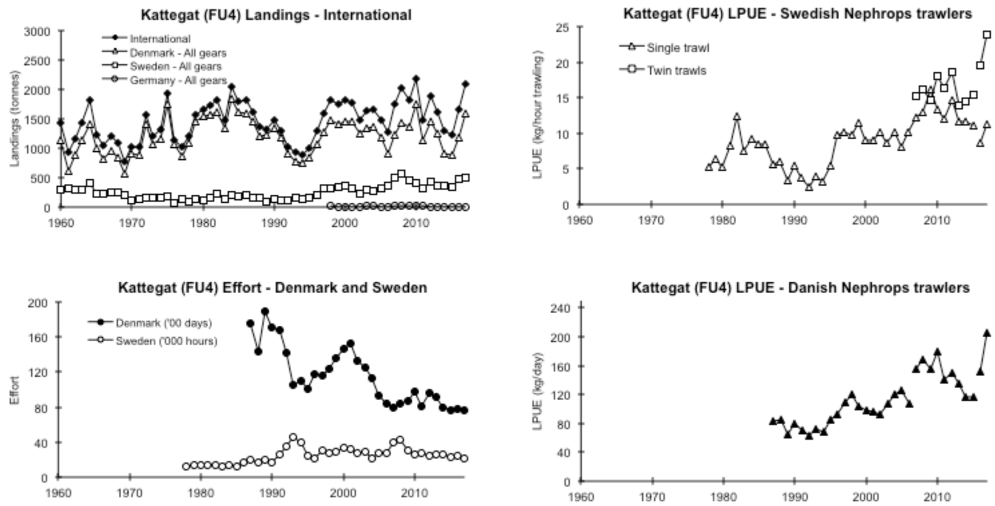


Figure 10.2.2.4. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort and lpues.**

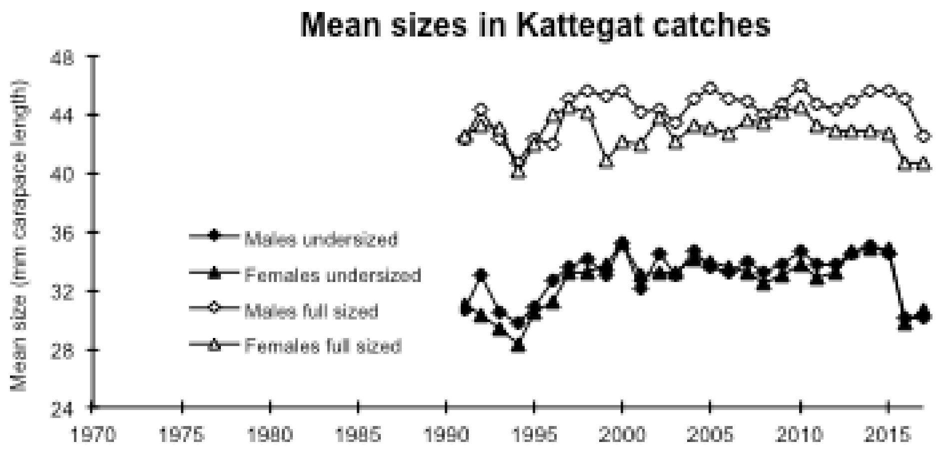


Figure 10.2.2.5. ***Nephrops*** **in FU 4: Mean sizes in the catches.**

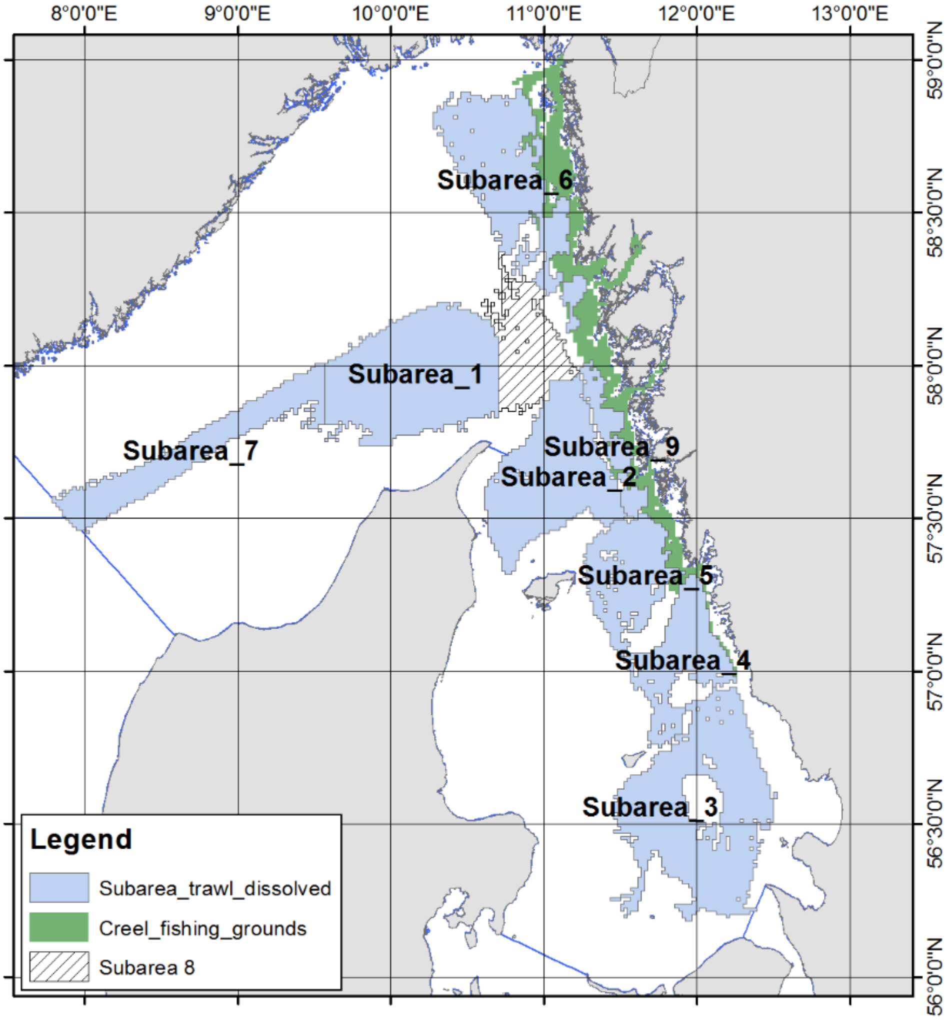


Figure 10.2.3.2. The defined sub areas of the *Nephrops* stock in 3.a.

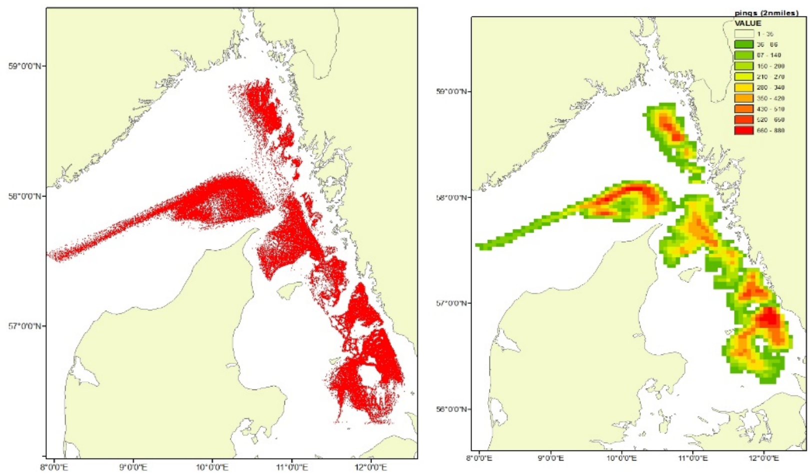


Figure 10.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

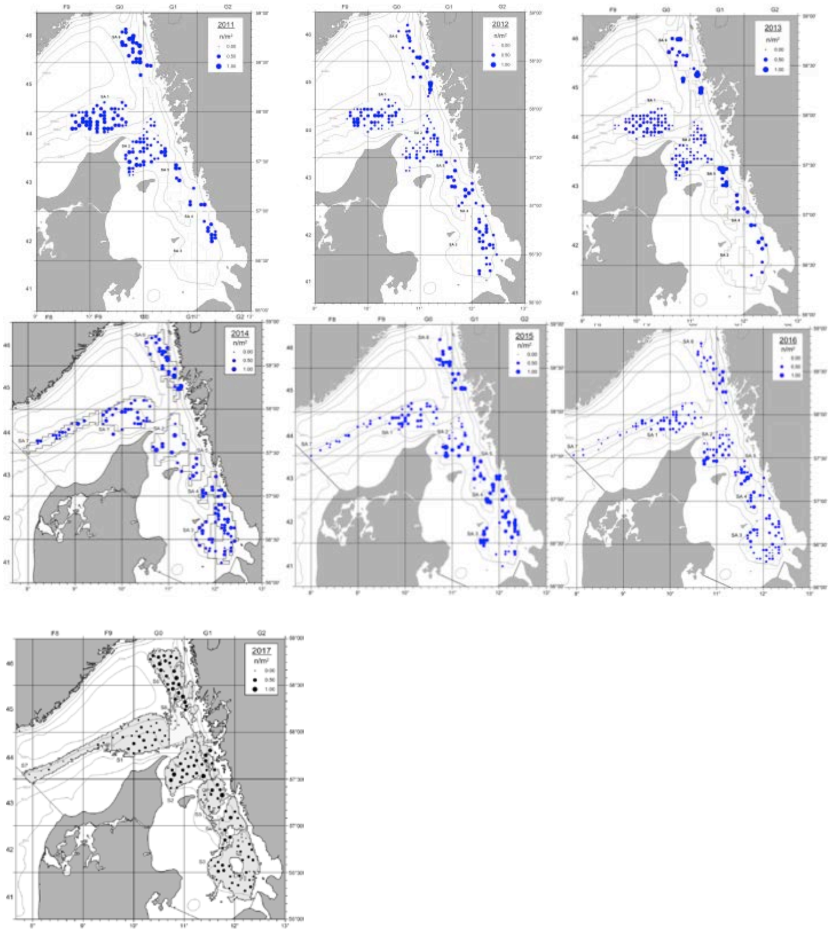


Figure 10.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations), 2016 (176 stations) and in 2017 (171 stations).

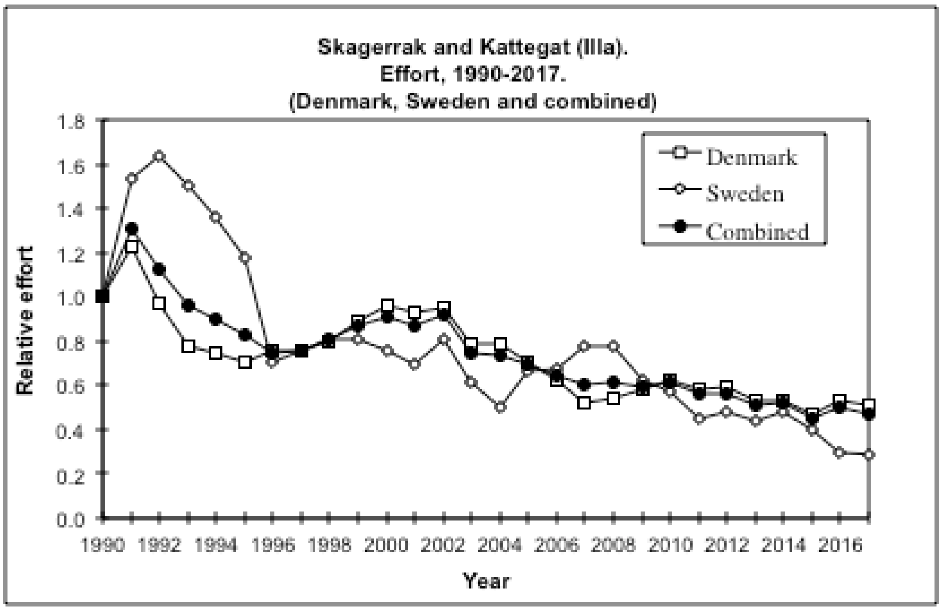


Figure 10.2.4.1 *Nephrops* in Area 3.a: Combined Effort for FU 3&4.

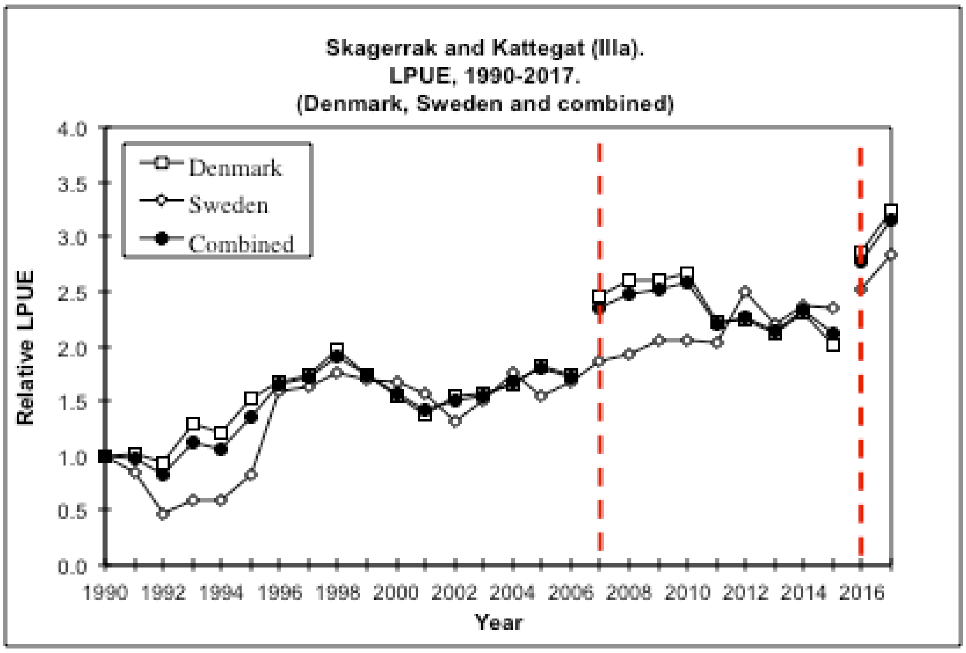


Figure 10.2.4.2 ***Nephrops*** **in Area 3.a: Combined lpue for FU 3&4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.**

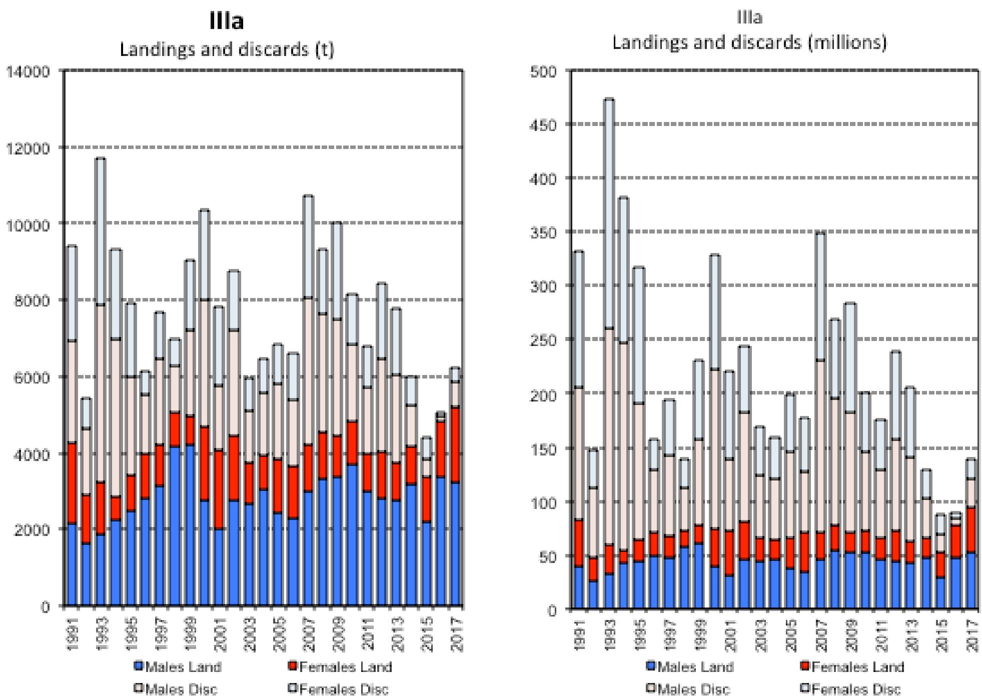


Figure 10.2.4.3. ***Nephrops*** **in 3.a: Catch by sex and size category in biomass and numbers.**

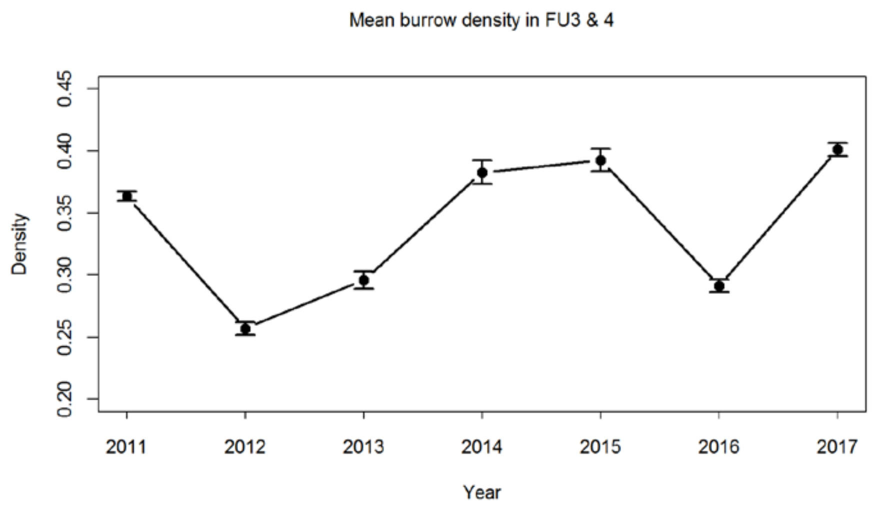


Figure 10.2.4.4. Mean burrow density in 3.a by year: Error bars indicate the 95 % confidence intervals.

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

11.1 General comments relating to all *Nephrops* stocks

See section 10.1

11.2 *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 Subarea 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).

Management at ICES Subarea Level

The 2016 EC TAC for *Nephrops* in ICES Subarea 2.a and 4 was 13 700 tonnes in EC waters (plus 1000 tonnes in Norwegian waters). For 2017, this was increased to 20 034 tonnes in EC waters and 1000 tonnes in Norwegian waters.

A major change in the management of *Nephrops* fisheries in ICES Subarea 4 since 2016 has been the introduction of the landing obligation for *Nephrops* fisheries in the 80–99 mm trawl fisheries. A *de minimis* exemption for catches below the Minimum Conservation Reference Size (MCRS) of up to 6% was permitted for the fishery in Subarea 4. The application of this exemption was not clear (i.e. whether the 6% applied at a trip level or to the total annual catch). Because there was no evidence presented to the Working Group that the introduction of the landing obligation had caused any change to discarding practices for the 2016 and 2017 fishery, the catch options have been estimated assuming discarding continues according to historic patterns. In 2016, it was calculated that 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 under the landing obligation. However those animals previously discarded above MCRS would now be expected to be landed but not for consumption. 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 1 January 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. The UK introduced emergency technical measures for UK vessels targeting *Nephrops* in the Farn Deeps in 2016 (see Section 11.4).

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

Official catch statistics for Subarea 4 are presented in Table 11.3.1. The preliminary officially reported landings in 2017 are 16 050 tonnes, the largest value since 2011 although 34% lower than the peak observed in 2009 (24 500 tonnes). Belgium, UK and Germany increased their landings in 2017 respect to 2016, causing an increase of 19% in the total landings. UK is the main producer country (reporting 74% of the total landings in 2017), followed by Netherlands (8.8%), Belgium (6.9%) and Germany (5.7%).

Table 11.2.2 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. Landings from outside the Functional Units exceeded 1000 tonnes in 2017 and overtook the landings from FU 34.

11.3 Botney Cut (FU 5)

11.3.1 The fishery in 2016 and 2017.

Landings from FU5 had been gradually increasing from a low point in 2009 to 2015, however landings for 2016 saw a 67% increase over the 2015 value and are the highest value on record at 2535 tonnes (Figure 11.3.2). This is three and a half times greater the 2009 landings. Germany and the UK saw the largest increase in landings (around double their 2015 level), with Belgium and the Netherlands increasing by 60% and 18% respectively. Danish activity has been at a low level but erratic since 2006 with minimal activity reported in 2015 and 2016. The landings decreased in 2017 to 2110 t, but they are still above the average value. All countries decreased their landings last year, except Belgium, who increased them by 78% respect to 2016.

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

ICES advice in 2016

FU5 is assessed biannually, being the last advice in 2016:

ICES advises that when the precautionary approach is applied, wanted catches in each of the years 2017 and 2018 should be no more than 895 tonnes. ICES cannot quantify the corresponding total catches.

To protect the stock in this functional unit (FU) from continued over-exploitation, management should be implemented at the functional unit level.

11.3.2 Data Available

Commercial catch

Landings by country for FU 5, including Belgium, Denmark, Netherlands, Germany and UK are available since 1991 (Table 11.3.1 & Figure 11.3.2). Landings increased from ~800 tonnes in the early 1990s to ~1200 tonnes in the early 2000s, peaking at ~1 400 tonnes in 2001. There then followed a period of general decline to a low in 2009 but landings have subsequently been over 2000 tonnes in 2016 2017. 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 increased the landings between 2010 and 2017 by a factor of 7.5. Danish landings have been sporadic since 2006 with almost no landings since 2015. 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. The sharp jump in landings in 2016 and 2017 was dominated by increases from the UK, Belgium and Germany, with lesser increases from the Netherlands.

The discard rate in 2015 was 49% by weight, but decreased to 26% and 30% in 2016 and 2017, respectively. 885 tonnes of discards were estimated for 2017. There is not information of discards before 2015.

Length composition

The length composition of landings, by sex, has been provided by Netherlands since 2004. Data were not available for 2013 as the sample rate was considered insufficient to raise the distributions. Since 2015, Netherlands has also provided the unsexed length composition of their discards. The data from 2015–2017 were pooled and used to estimate the length composition of the total catch for those years. The length composition before 2015 represents only the Dutch landings, and therefore the periods 2004–2014 and 2015–2017 should be not compared.

The mean size of the landings showed a slight increasing trend over time up to around 2010 but have been stable since then (Figure 11.3.1). The mean size of the landings for the period 2015–2017 remained constant at ~35 mm, whereas the mean size of the catch slightly increased through the period (Table 11.3.3).

Natural mortality, maturity at age and other biological parameters

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_∞ = 62 mm 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).

Commercial effort and LPUE data

Effort and LPUE data are available since 2006 for English vessels targeting Neprhops (i.e. vessels using 70–99 mm otter trawl with at least 25% by weight of *Nephrops* per record).

The fishing effort (i.e. number of fishing days) has fluctuated without trend from 2008 to 2015, with an average of 290 fishing days. In 2016, it achieved the maximum value on record, with 716 days. Althought it decreased again in 2017, it was still higher than the average (Figure 11.3.3).

Lpue has increased from 0.81 to 1.20 tonnes/day during the period 2008–2011 (Table 11.3.4). It achieved the lowest value on record in 2013, but it increased again in 2014 and it has been stable since then, with an average of 1.12 tonnes/day (Figure 11.3.3).

TV Survey in FU5 (Botney Cut / 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.

11.3.3 Intercatch

Intercatch has been used as the main data submission tool for *Nephrops* in for all nationalities from 2011 onwards, with all countries participating in the fishery submitting quarterly landings by metier as a minimum.

Annual discard data have been available since 2016 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.

There are distinct differences in the discarding rates reported by the sampled metiers between years (Table 11.3.2). Whereas the discard rate for otter trawls targeting crustaceans (OTB_CRU_70-99_0_0_all) decreased from 86% (by number) in 2015 to 45% in 2016 and 58% in 2017, the discards in otter trawls targeting fish (OTB_DEF_70-99_0_0_all) increased from 68% in 2015 to 96% in 2016 and 95% in 2017 (Table 11.3.2).

The retention at length profile is considered to be unique to the Netherlands métiers due to a Producer Organisation arrangement on landing sizes, however the overall raised length distribution for catch from Dutch sampling are considered appropriate for the fishery as a whole.

For the raising, the discards reported in 2017 for OTB_MCD_70-90_0_0_all were associated with the landings reported by Netherlands for OTB_CRU_70-90_0_0_all and MIS_MIS_70-90_0_0_HC. The landings for the miscellaneous métier (MIS_MIS_70-90_0_0_HC) came mainly from Quad-rig trawlers. The average discard rate for the metiers with data (OTB_MCD_70-90, OTB_DEF_70-90, TBB_DEF_70-90) was then used to raise the discards for the rest of the Dutch landings.

Discarding rates for all non-Dutch catches were estimated externally of intercatch by using a retention ogive borrowed from FU6 on the catch at length profile from the Dutch sampling schemes, resulting in non-Dutch discard rates of 7–11% by weight and 12–20% by number.

11.3.4 Quality of assessment

The data available to assess FU5 are limited and consequently the assessment is not robust enough to determine the status of the stock.

The assessment is based upon the assumptions length composition of catch is the same for all fleets and the discard pattern (retention at length) for non-Dutch fleet is the same as in FU6. Due to the lack of recent estimates of the stock size, the assessment also assumes the stock density has not changed since the last camera survey in 2012.

In addition, the intensity of the Dutch catch sampling programme is fairly low and as a result may not be fully representative of actual removals. Between 2005 and 2009 the average numbers measured in landings were > 10 000 individuals a year, while the sampling measurements dropped to around 2500–3000 individuals since 2010. For the period 2015–2017, the measured animals in the discards fluctuated between 5000 and 7000, and between 1500 and 5000 in the landings, and they came mainly from three metiers. Whereas the discards are measured annually, the landings measurements are quarterly, although some seasons are missed.

However, the length data were consistent between the last three years, and it is reasonable to pool the data together to estimate the length composition of the catch.

11.3.5 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 LPUE does not show any consistent temporal trend, and the size composition of the catch has been similar for the three years with data (2015–2017).

Following the procedure outlined in Section 10.1.2, an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in this functional unit and estimate the harvest rate. 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. Assuming the density has been constant since 2012, the harvest rate in 2017 was 9.7%, higher than the proxy MSY rate (7.5%).

11.3.6 Short term forecasts

Catch and landing predictions for 2019 and 2020 are given in the table below. This assumes that the absolute abundance estimate made in 2012 is relevant to the stock status for 2019 and 2020.

The advice is based upon the 10 year average (2008–2017) landings and the application of the 20% uncertainty cap in advice change on wanted catch (in accordance to the ICES data limited approach method 4.1.4), with an allowance for discarding (assuming recent patterns are continued) to derive catch advice. Applying this approach, catches in 2019 and 2020 should be no more than 1637 tones. It implies landings should be no more than 1074 tonnes.

***Nephrops* FU5. Catch options assuming discarding continues at recent average. All weights are in tonnes.**

Basis	Total Catch	Wanted Catch	Unwanted Catch	Range of potential densities (*Nephrops* m^{-2})								
				0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.5 x average landings (2008–2017)	1034	679	356	43.9%	21.9%	11.0%	7.3%	5.5%	4.4%	3.7%	3.1%	2.7%
Advice 2016	1364	895	469	57.9%	28.9%	14.5%	9.6%	7.2%	5.8%	4.8%	4.1%	3.6%
0.5 x average landings (2015–2017)	1565	1027	538	66.4%	33.2%	16.6%	11.1%	8.3%	6.6%	5.5%	4.7%	4.1%
Advice 2016 +20%	1637	1074	563	69.4%	34.7%	17.4%	11.6%	8.7%	6.9%	5.8%	5.0%	4.3%
Average landings (2008–2017)	2068	1357	711	87.7%	43.9%	21.9%	14.6%	11.0%	8.8%	7.3%	6.3%	5.5%
Average landings (2008–2017) +20%	2482	1628	853		52.6%	26.3%	17.5%	13.2%	10.5%	8.8%	7.5%	6.6%
F_{MSY}	2690	1765	925		57.1%	28.5%	19.0%	14.3%	11.4%	9.5%	8.2%	7.1%
Maximum landings	3130	2054	1076		66.4%	33.2%	22.1%	16.6%	13.3%	11.1%	9.5%	8.3%

11.3.7 Management considerations for FU 5.

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock as the landings are normally higher than the catch advice. Given the paucity of metrics available for monitoring stock development, the exploitation of this stock should monitored closely.

11.4 Farn Deeps (FU 6)

11.4.1 Fishery in 2016 & 2017

Since the beginning of the time-series, the UK fleet has accounted for virtually all landings from the Farn Deeps (Table 11.4.1). The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2017 data comprise the end of the 2016–2017 fishery and the start of the 2017–2018 fishery.

The landings in 2016 and 2017 were 1854 and 1812 tonnes, respectively. Although they were approximately 34% higher than in 2015, they are still below the last 10-year average (2008–2017) of 2043 tonnes (Figure 11.4.1). The landings in 2016 were unusually higher during the summer compared with previous years.

In 2016, the UK implemented a suite of technical measures in response to the continued poor state of the stock. The measures commenced in April 2016 for UK vessels fishing in Farn Deeps (99% of the fleet in the stock unit). These measures were as follows:

- A minimum mesh size of 90 mm using single twine of 5 mm.
- Only single-rig vessels of 350 kW (476 hp) or less are permitted to fish within 12 nm of the coast.

- Multi-rig vessels (vessels with three or more rigs) are prohibited from operating within the Farn Deeps. Twin rig vessels are permitted to operate outside 12 nm.
- No vessel can use gear with more than one cod end per rig

The discard rate in 2016 was 13% (estimated as percentage of biomass), close to the average rate for the last 10 years. In 2017, it decreased to only 7%, the joint-lowest value recorded for the fishery (also seen in 2014). This low figure might have been due to low recruitment rates for those years possibly in conjunction with the increase in minimum mesh size used in the cod end (this potential hypothesis has not been evaluated).

ICES Advice in 2017

"ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of 2014–2016, catches in 2018 should be no more than 1876 tonnes.

In order to ensure the stock in Functional Unit (FU) 6 is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to FU 6 could rapidly lead to over-exploitation."

Management of the fishery is at the ICES Subarea level as described in Section 10.1.

11.4.2 Assessment

Review of the 2017 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 11.4.3) 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 11.4.7). 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 was observed between 2009–2014, becoming more pronounced throughout that period. 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. In addition to the lack of mode in the males, the mean annual increment of the female second mode is only around 2 mm whereas, according to the growth parameters available for this stock, inter annual growth would be expected to be considerably 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 since 2015 implies a lower relative availability of females at larger sizes and may indicate a better spawning success, although there still remains a higher proportion of large females in the catches from 2015 compared to the period before 2010. The higher abundance observed in 2016 and 2017 in the TV survey, and the small animals observed in the catch in 2017 support this hypothesis (assuming that recruits enter the fishery between age 3 and 4, and they are seen in the survey from age 2).

The mean length of large animals (≥ 35 mm) in the landings have gradually increased over the period 2008–2017, especially for females (Figure 11.4.1). The mean size of small animals (< 35 mm) in the landings does not have any clear temporal pattern, and therefore, the mean size and mean weight of the landings have progressively increased over time.

Effort and LPUE

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.

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 (which land into England) has fluctuated from ~150 to ~250 since 2006 (Figure 11.4.2) but overall the pattern is declining. The majority of the dynamic in fleet size is due to changes in the above 15 m fleet, which experienced an influx of vessels from

Scotland for the periods between 2012–2014. In contrast, the size fleet for the under-10 m sector has remained fairly constant since 2006, and it has slightly declined for the 10–15 m sector. The reason for the steeper declining trend observed in 2017, most prevalent for the under-10 m sector (-15% decline from 2016) is unknown but maybe related to the introduction of the technical measures above mentioned.

Directed effort (i.e. days fishing by vessels fishing with *Nephrops* gears) from English vessels has fluctuated without trend since 2006 for all three vessel size classes (< 10 m, 10–15 and ≥ 15 m), vessels under 10 m length expend the greatest numbers of days fished. The fishing effort rose in 2016 to the highest level on record, although decreased again in 2017 (Figure 11.4.1, Table 11.4.2).

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. Therefore, the temporal trend of LPUE only can be used as an indicator of trends of abundance if the availability of *Nephrops* is assumed to be constant over the years. The LPUE was highest between 2003 and 2006, with average values ranging from 284 kg/day (for vessels 10–15 m length in 2004) and 642 kg/day (for vessels > 15 m length in 2006). It decreased in 2007 for all fleet, and it has fluctuated without trend until 2014. The LPUE decreased in 2015 but has increased in 2016 and 2017 for all fleet. The LPUE shows a positive correlation with the size of the vessels, and the LPUE in the last year was 355, 238 and 198 kg/day for vessels > 15 m, 10–15, and < 10 m, respectively (Figure 11.4.1, Table 11.4.2).

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, 2013–2014, Figure 11.4.4). The sex ratio since 2015 returned to a generally male dominated fishery and can be explained by the lack of large females in the catches during the winter months (Figure 11.4.7).

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 total effort rose in 2016 to the highest level on record, particularly for the < 10 m sector, and it declined again in 2017 to the recent average levels. The relative strength of effort within a season (i.e. the fourth quarter compared to the first quarter) fluctuates without trend. Effort in the summer of 2016 was unusually high, with a clear spike in the catch rate of females (Figure 11.4.6). 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.

A time series of indices is given in Figure 11.4.8 and Table 11.4.5. 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 500 m*500 m 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 11.4.9 shows the final maps for 2014–2017. 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 2017 were entered onto Intercatch. Landings data by fleet were provided by Scotland, England, and the Netherlands, whilst England and Scotland 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 represented 78% 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, and 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 11.4.4.

For the purposes of advising on management for the next year, the TV survey from the assessment year is assumed to be representative of the fishing opportunities for the forecast year. Whilst the main ICES assessment is undertaken in May, the TV survey for FU6 is not undertaken until June. This means that the initial assessment and advice for 2019 relies upon the TV survey from 2017, however both the assessment and advice are usually updated for the round of revised advice in the autumn. The validity of using the TV survey to determine advice for the following year was explored by looking at how the TV survey predicts metrics such as catch rate and landings in the following year. Significant relationships were found between TV survey in the previous year and LPUE, Effort and Landings (Figure 11.4.12), whereas there were no significant relationships for when using the TV survey in the same year as the fishery metrics. This suggests that for FU6, using the TV survey from the previous year is a valid predictor of fishery activity in the following year.

Final Assessment

The estimated abundance in 2017 was 902 million individuals (95% confidence interval of ±21 million), above the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2017 was 7.8% (Table 11.4.5), below the MSY proxy level of 8.1%.

The status of the stock has therefore improved since the 2017 assessment.

11.4.3 Historical stock trends.

The time series of TV surveys is 16 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 25.2% (Table 11.4.5). 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 twice in 13 years.

11.4.4 MSY considerations

Considerations for setting Harvest Ratios associated with proxies for F_{MSY} for *Nephrops* are described in ICES, WGNSSK, 2010, Section 10.1.

- 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 15.3% 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 11.4.11) is reasonable but the increasing bi-modality of the length frequency observed in the females for 2010–214 does violate model assumptions and the model under-predicts the landings of larger females.

		F_{bar} 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 have been in a period of lower productivity for a number of years and so a harvest rate which gives greater protection to the spawning potential of males would be advisable. The Working Group adopted 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 2019 are given in the table below. This assumes that the absolute abundance estimate made in June 2017 is relevant to the stock status for 2019.

In November 2016, ICES advised on fishing opportunities assuming that discarding would only occur below the MCS. Observations from the fishery in 2016 and 2017 indicate that discarding above the MCS continues and practices have not changed markedly (Figure 11.4.7). Consequently, ICES has provided advice for 2018 and 2019 assuming average discard rates observed over the last three years, which is considered to be a more realistic assumption.

The ICES MSY approach dictates that where the stock status is above the trigger point, the maximum advised fishing rate should be the MSY rate. Applying this approach, catches in 2019 should be no more than 1882 tonnes.

Norway lobster in Division 4.b, Functional Unit 6. The basis for the catch scenarios

Variable	Value	Source	Notes
Abundance in TV assessment	902 million individuals	ICES (2017a)	UWTV 2017
Mean weight in landings	29.63 g	ICES (2017a)	Average 2015–2017
Mean weight in discards	10.29 g	ICES (2017a)	Average 2015–2017
Discard rate	25.40%	ICES (2017a)	Average 2015–2017 (proportion by number)
Discard survival rate	15%	ICES (2017a)	Only applies in scenarios where discarding is allowed.
Dead discard rate	22.44%	ICES (2017a)	Average 2015–2017 (proportion by number), only applies in scenarios where discarding is allowed.

***Nephrops* FU6. Catch options assuming discarding continues at recent average. All weights are in tonnes.**

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
F_{MSY} ApproachComb	1882	1852	1683	169	30	8.12%
$F_{MSY\ Lower}$	1622	1597	1451	146	26	7.00%
F0.1Male	1648	1622	1474	148	26	7.11%
$F_{MSYUpper}$	1854	1825	1658	167	29	8.00%
F35%Male = F_{MSY}	1882	1852	1683	169	30	8.12%
F0.1Comb	2012	1980	1799	181	32	8.68%
F35%Comb	2582	2541	2309	232	41	11.14%
FmaxMale	2689	2646	2404	242	43	11.60%
Fcurrent	2533	2492	2265	228	40	10.93%
F0.1Female	3250	3198	2906	292	52	14.02%
F35%Female	3521	3465	3148	316	56	15.19%
FmaxComb	3546	3490	3171	319	56	15.30%
FmaxFemale	5007	4927	4477	450	79	21.60%

11.4.5 BRPs

Suggestions for proxies of biological reference points are shown in the catch option table and discussed in 11.4.3.

11.4.6 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 2017 survey results continues the pattern observed in other years with the spine of high density on the western edge of the ground remaining a regular feature. The main features of the survey series are peaks in abundance 2001 and 2005, with reasonably constant series since 2007.

11.4.7 Status of stock

The 2017 TV survey indicates the size of the stock has increased and it is just above of MSY $B_{trigger}$. The harvest rate, estimated as the proportion of the stock that has been fished, has decreased and it is just below the $F_{MSY\ trigger}$.

Both parameters indicate the status of the stock has improved. Nevertheless, the improvement is probably due to a year with a strong recruitment that has increased the stock abundance whereas the catch remained constant. Because recruitment is affected by many environmental factors in addition to fishing, annual recruitment is highly variable, and it could decrease again in the coming years.

11.4.8 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.

Catches generally have been well above ICES advice in Farn Deeps, highlighting the issue that current management arrangements are not sufficient to contain the fishery within the sustainable limits determined by ICES, and the management should be implemented at the functional unit level.

It is expected that, under the EU landing obligation, below minimum size individuals that would formerly have been discarded would now be reported as below minimum size (BMS) landings in logbooks. However, BMS landings reported to ICES may be lower than expected for several reasons: minimum size individuals could either not have been landed and not recorded in logbooks, or have been landed but not recorded as BMS. Furthermore, BMS landings recorded in logbooks may not have been reported to ICES. In 2016 and 2017, no Norway lobster were recorded as below MCS (BMS category) in FU 6 despite catches having been observed below the MCS.

11.5 Fladen Ground (FU 7)

11.5.1 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 10.1.1). 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. 30 000 km^2). Figure 11.5.5 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.

11.5.2 The Fishery in 2017

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (5147 tonnes in 2017), with England taking 2 tonnes and Denmark 1 tonne (Table 11.5.1). Around 90 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 2017 was generally better than in previous years. 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 time during summer in the Silver Pits (FU 5) and Devil's Hole (FU 34). The fishery in Fladen improved markedly in the second half of 2017 when most landings took place, but remained low compared with the figures obtained in the late 2000s. Most vessels fishing in FU 7 traditionally have used 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 TR1 gears with mesh size combinations of 100–109 mm/120 mm, as they can target both *Nephrops* and fish. This confirms the information on the TR1 vs TR2 split which shows that in recent years, vessels fishing in Fladen have become more dual purpose in the sense that the large majority are now 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.

11.5.3 ICES advice in 2017

The ICES conclusions in 2017 in relation to state of the stock were as follows:

"The stock size declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015. From 2016 the stock size increased and is currently above MSY Btrigger. The harvest rate has declined since 2010 and remains well below F_{MSY}."

The ICES advice in 2017 (for 2018) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of 2000–2016, catches in 2018 should be no more than 16 577 tonnes.

In order to ensure the stock in Functional Unit (FU) 7 is exploited sustainably, management should be implemented at the FU level. In recent years, the catch in FU 7 has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs."

11.5.4 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 recent year there has been a shift to using TR1 gears in Fladen allowing vessels to target *Nephrops* and fish simultaneously.

11.5.5 Assessment

Approach in 2018

The assessment of *Nephrops* in 2018 is based on examining trends in the UWTV survey data (1992–2017) 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 2018 followed the process of 2017, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

11.5.6 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 11.5.1 and Figure 11.5.1. Total international landings (as reported to the WG) in 2017 were 5147 tonnes (more than doubled in comparison with the 2016 total), consisting mostly of Scottish landings with only 3 tonnes landed by other countries. *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 7 in 2017.

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 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 2017 and only annual summaries are available.

Trends in Scottish effort of *Nephrops* trawlers and LPUE are shown in Figure 11.5.1 and Table 11.5.2. 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 2011–2012 because of poor fishing and part the fleet relocating to other areas. The spatial contraction of the fishery was further confirmed by the VMS distribution of otter trawlers fishing in Fladen (2010–2015) shown in Figure 11.5.8. In this period, a decreasing number 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 (no VMS data for 2016–2017 was analysed at the time of the WG meeting). In 2016–2017, a slight increase in effort was recorded for Scottish trawlers. Lpue has gradually increased since 2000 to a peak of over 620 kg/day in 2009. It has fallen since then until 2015 to values similar to those observed in the early 2000s (~200 kg/day). In 2017, LPUE increased again to over 300 kg/day. Danish LPUE data (1991–2017) are presented in Table 11.5.3. Effort has generally decreased over the time whilst LPUE has gradually increased to its highest value in 2009 followed by a dramatic decrease as *Nephrops* became mostly a bycatch species for the Danish fleet in recent years.

Males consistently make the largest contribution to the landings (Figure 11.5.2). 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 11.5.2. From 2012, 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 recent years landings were larger in the third and fourth quarters. Figure 11.5.7 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 2013–2016 the male proportion in quarter 2 was 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 period 2013–2015 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 from 2000 is approximately 7% by number in this FU. From 2008 to 2016 discard rates dropped below the long term average and have been close to zero. 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). In 2017, landings increased markedly in FU 7 and the discard rate rose to 4.4%.

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 2017 data (official landings and sampled data for landings and discards) were successfully uploaded into Intercatch. National data co-ordinators for other countries (England and Denmark) also uploaded landings data to Intercatch ahead of the 2018 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2017.

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 11.5.3 shows a series of annual length frequency distributions for the period 2000 to 2017. 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 until 2011 when 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. In 2017, length distributions in both sexes showed a marked decrease in the mean size in catches to similar values as those observed prior to 2011. Figure 11.5.1 and Table 11.5.4 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 fairly stable through time until 2010 when an increase is noticeable which may be associated with lower recruitments combined with the increasing use of more selective gears. In 2017, the mean size <35 mm decreased sharply and is now just under 30 mm CL. The discard rate in 2017 was estimated to have increased from zero to 4.4%, by number. Quantitative information on trends in gear changes is not currently available but a shift from TR2 to TR1 gears was observed from 2010 but no major changes were noted in 2017 suggesting the reduced mean sizes in catches may be related with a strong recruitment in recent years. 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 subareas within the ground, where size compositions may be slightly different.

Mean weights in the landings through time (1990–2017) are shown in Figure 11.5.4 and Table 11.5.5. The variability in mean size is greater in Fladen (and Devil's Hole) than in other areas. In 2017, the mean weight in landings decreased from 39.4g to 25.4g.

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 11.5.6. On average, approximately 65 stations have been considered valid each year (71 stations in 2017). Data are raised to a stock area of 28 153 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.

11.5.7 Data analyses

Exploratory analyses of survey data

Table 11.5.7 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 11.5.5 shows the distribution of stations in recent UWTV surveys (2011–2017) with the size of the symbol reflecting the *Nephrops* burrow density. The abundance in 2017 increased sharply (58% from 2016) indicating a good recruitment in the ground (which was first detected in the 2016 survey). Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground. Table 11.5.6 and Figure 11.5.6 show the time series estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. Following the low UWTV estimated densities in the period 2011–2015 and the apparent *Nephrops* fleet preference for the fishing grounds located to the south of Fladen (Figure 11.5.8), the WG looked closely at the spatial distribution of the UWTV survey in the last nine 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 recent years. To test this, the TV surveys from 2009–17 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 11.5.9). 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 even during the period of lowest abundance in FU 7 the mean densities in the south remain in average higher than those in the north. The density increase in 2016–2017 occurred across the different strata but is more evident in the three finer sediments (F, MF and MC) in the south and in the medium coarse (MC) and medium fine (MF) sediment in the north (Figure 11.5.9).

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 7 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 2017 UWTV survey data shows that the abundance has increased markedly in the last 2 years. The stock is now above the average abundance over the time series and is well above the biomass trigger. The harvest ratio in 2017 (3.1%, calculated as dead removals/TV abundance) is well below F^{MSY}. The effort by *Nephrops* trawlers and respective LPUE declined from 2010 until 2015 and this appears to be consistent with the abundance trends from the UWTV survey. The LPUE increased in 2017 and is approximately at the same level as in the period prior to 2006. The low LPUEs observed in this period may be due the under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The relatively high LPUEs calculated for the period 2009–2011, 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 remains relatively stable. The discard rate has increased from 0% in 2015–2016 to 4.4% and the mean size of individuals below 35 mm decrease markedly in 2017 which is related with the presence of smaller individuals in the catches. This suggests a period of lower recruitment between 2010 and 2015 followed by a strong recruitment event in 2016–2017.

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. The abundance has fallen subsequently and was below the $B_{trigger}$ in 2012 and 2015. In 2017, the abundance continued to increase sharply from the lowest point of the time series (2015) to 7036 million (Table 11.5.8).

Table 11.5.8 also shows the estimated harvest ratios from 1992–2017. These range from 1.4–10% over this period and are all below $F_{0.1}$. It is unlikely that prior to 2006, the estimated harvest ratios are representative of actual harvest ratios due to under-reporting of landings. In 2017, due to a large increase in the abundance and the landings remaining at a relatively low level, the harvest ratio was estimated to be 3.1%.

In addition to the discard rate, Table 11.5.8 shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards). Discards were estimated to be 4.4% by number in 2017.

11.5.8 Recruitment estimates

Recruitment estimates from surveys are not available for this FU. However, the increase in mean size of small animals <35 mm (i.e. a lower proportion of small animals in this component of the catch) observed in recent years may be indicative of lower recruitments in the period 2010–2015. The recent increase in abundance suggests a good recruitment in 2016–2017.

11.5.9 MSY considerations

F_{MSY} 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 shifted towards larger animals since 2010 (see Section 11.5.5 and Figure 11.5.3) 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, except 2017), due to a combination of low recruitments, 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 F_{MSY} proxies is given in the table below and the basis for choosing an appropriate F_{MSY} proxy remains the same and is described in WGNSSK 2010 report.

		F_{bar}(20–40 mm)		HR (%)	**SPR (%)**		
WGNSSK 2015		**M**	**F**		**M**	**F**	**T**
$F_{0.1}$	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
F_{max}	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
$F_{35\%SpR}$	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 F_{MSY} such as $F_{0.1(T)}$.

The F_{MSY} 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.

11.5.10 Short-term forecasts

A catch prediction for 2019 was made for the Fladen Ground (FU 7) 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 10.1 of this report and the harvest ratio in 2017 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 2018 considers that *Nephrops* discarding is allowed to continue as before 2016. Under this scenario the harvest rate is assumed to include landings (wanted catches) plus dead discards (dead unwanted catch). The catch options table includes surviving discards (discards survival for *Nephrops* in FU 7 is assumed to be 25%). 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 *de minimis* exemption of 2% discards by weight below MCRS is in place in the North Sea. In the past, a catch options table accounting for a continuation of this rule in the following year has been considered, although this option was not requested for 2019.

The large abundance increase in 2016–2017 is likely to be related with a strong recruitment event. The size of *Nephrops* burrows is not quantified in the TV surveys but burrow counters participating in recent surveys reported a large number of small burrows in FU 7, in particular during the 2016 survey. The mean weights for this stock have increased in the period 2010–2016. The most recent (2017) estimate is significantly lower than the 3 year average used in the forecast (Figure 11.5.4). The evidence from sampling and survey data support a reduction in mean weights in the stock but there is no methodology to take this into account in the calculation of catch options. A long-term mean weight and discard rate (from 2000–2017) was considered by the WG to be appropriate for the calculation of catch options in this situation. This approach has been recently used in FU16 (WGCSE, 2016) where a recruitment event was also recorded in recent years.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2019 at the F_{MSY} proxy harvest ratio is 16 395 tonnes. It should be noted that the F_{MSY} 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 F_{MSY} reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	7036 million	ICES (2018a)	UWTV 2017
Mean weight in wanted catch	31.71g	ICES (2018a)	Average 2000–2017
Mean weight in unwanted catch	14.89	ICES (2018a)	Average 2000–2017
Unwanted catch rate (total)	7.1%	ICES (2018a)	Average 2000–2017 (proportion by number)
Unwanted catch survival rate	25%	ICES (2018a)	Proportion by number
Dead Unwanted catch rate (total)	5.4%	ICES (2018a)	Average 2000–2017 (proportion by number)

Catch options assuming discarding to continue at recent average

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate *	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MSY approach	16 395	16 254	15 830	424	141	7.5%	-1.10%
Other scenarios							
$F_{2015–2017}$	4 808	4 767	4 643	124	41	2.2%	-71%
F_{2017}	6 776	6 718	6 543	175	58	3.1%	-59%
$F_{MSY\ lower}$	14 427	14 303	13 930	373	124	6.6%	-13.0%
$F_{MSY\ upper***}$	16 395	16 254	15 830	424	141	7.5%	-1.10%
$F_{35\%SpR}$	24 484	24 273	23 639	634	211	11.2%	48%
F_{max}	35 851	35 542	34 614	928	309	16.4%	116%

*** Calculated for dead removals.**

**** Advice value 2019 relative to advice value 2018.**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock**

Biological Reference points

Biological reference points have not been defined for this stock.

11.5.11 Quality of assessment

The low densities estimated in 2011–2015 resulted in abundance falling significantly but not to the extent that would cause such a loss of fishing opportunity as observed in that period. 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 recent lower emergences 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 11.5.6). 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 using larger mesh sizes, while reducing fuel costs.

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 60% of the landings in 2017 (90% of the discards were imported and 10% were raised discards).

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 2013–2017.

11.5.12 Status of the stock

The stock has declined in the period 2008–2015 to the lowest point in the time series, and increased in the following years to the second highest abundance recorded (2017). The abundance is now well above the MSY $B_{trigger}$ level. Landings taken from this FU in 2017 (5147 tonnes) were much lower than the 2016 advice (for 2017) of 15 693 tonnes (wanted catch). The harvest rate increased in 2017 to 3.1% and remains well below F_{MSY}. Length frequencies in the caches have evolved towards larger animals, suggesting a selectivity change and/or lower recruitment in the period 2010–2015. In 2017, length distributions in catches showed a decrease in the mean size and the discard rates (previously estimated to be zero) increased to 4.4%. The large abundance increase in 2016 and 2017 suggests a recruitment event.

11.5.13 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 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.

The increase in abundance registered in 2016 and 2017 points to a high recruitment event. Most of these small individuals only became available to the fishery in 2017 given the increase in selectivity recently observed for this FU. The selectivity of the survey is >17 mm carapace length (CL), the current MCRS is 25 mm CL. This stock is considered to be lightly exploited, and the difference between advice and catches may be transferred to other FUs in the North Sea which could result in non-precautionary exploitation of those FUs.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. Animals below the minimum conservation reference size may be discarded, up to a maximum of 2% of the total annual catches of this species by vessels using bottom trawls (OTB, OTT, TB, TBN) of mesh size 80–99 mm in ICES Subarea 4 and Union waters of ICES Division 2.a. In 2017, no *Nephrops* were recorded as below the minimum size (BMS) in FU 7. This is consistent with the discard rates estimated for the FU in recent years which have been close to zero. It remains however, uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.6 Firth of Forth (FU 8)

11.6.1 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 10.1.1.). 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 Isle of May.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 11.6.4 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.

11.6.2 The fishery in 2017

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 11.6.1). In recent years, around 40 vessels worked regularly in the Firth of Forth. Most vessels are under 12m in length with about 10 in 12–15 m category and a few above 15 m. Engine power ranges from just under 100 kw to around the 300 kw. 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 15 m) 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 2017, 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 but tend to land to harbours in the northeast of Scotland. A few English vessels also visited FU 8 with landings from the rest of UK increasing from 32 tonnes in 2016 to 61 tonnes in 2017. Catches were generally reported as good in particular around winter time, with considerable market demand and good prices for all sizes of *Nephrops* caught. Fuel prices have been reported as similar to previous years. The predominant trawl gear mesh sizes are 80 mm and 95 mm (TR2 gears with several vessels working with twin rigs). 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. Landings by creel vessels in this area were lower than in previous years (less than 1% of the total) – 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.

11.6.3 Advice in 2017

The ICES conclusions in 2017 in relation to State of the Stock were as follows:

"The stock size has been above MSY $B_{trigger}$ for most of the time-series. The harvest rate is varying and is now below F_{MSY}."

The ICES advice in 2017 (for 2018) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of 2014–2016, catches in 2018 should be no more than 2376 tonnes.

In order to ensure the stock in Functional Unit (FU) 8 is exploited sustainably, management should be implemented at the FU level. In recent years, the catch in FU 8 has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs."

11.6.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.6.5 Assessment

Approach in 2018

The assessment in 2018 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 2018 followed the process of 2017, 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 F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.6.1 and Figure 11.6.1. Most of the landings are made by trawlers with creels accounting for less than 1% of the total. Reported landings rose from 1100 to over 2650 tonnes between 2003 and 2009 and have fluctuated since then around 2000 tonnes. The value for 2009 of over 2663 tonnes was the highest in the available time series whilst the 2017 landings (2493 tonnes) are above the ten year average (2130 tonnes). *Nephrops* is one of the species in the North Sea under the landing obligation. A small amount of landings below the minimum conservation reference size (1.5 tonnes) were reported for FU 8 as BMS category in 2016 but none was recorded for 2017.

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 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 11.6.1 and Table 11.6.2. Effort data is expressed both in days fishing and kW days (there are no major differences in effort trends between these 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 11.6.2), 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 11.6.2). Figure 11.6.6 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, in particular during quarters 2 and 3. 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 16% and 55% of the catch by number (2008–2017 average 25%). In the last five years, discard rates appear to have dropped to below this value (22% on average by number) and in 2017 the discard rate was recorded at 20%. This appears to be due to increased retention of *Nephrops* rather than an absence of small *Nephrops* from the catches.

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

InterCatch

Scottish 2017 data (official landings and sampled data for landings and discards) were successfully uploaded into InterCatch. National data co-ordinators for other countries (England) also uploaded landings data to InterCatch ahead of the 2018 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions 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 11.6.3 shows a series of annual length frequency distributions for the period 2000 to 2017. 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 11.6.1 and Table 11.6.3. 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 11.6.1) 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 11.6.3), the decrease in the mean size of animals below 35 mm (Figure 11.6.1) and a slight increase in the discard rate suggest possible a better recruitment in 2015.

Mean weight in the landings is shown in Figure 11.5.4 and Table 11.5.5 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 11.6.4. On average, about 44 stations have been considered valid each year. In 2017, there were 52 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 11.6.5 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 11.6.4 shows the distribution of stations in TV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is currently higher towards the eastern parts of the ground and around the Isle of May. Table 11.6.4 and Figure 11.6.5 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 2008–2014. The stock has increased and in the last 3 years it has fluctuated around 700 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 2017 (dead removals/TV abundance) increased and is now above F_{MSY}. This is the result of a 16% decrease in stock abundance combined with a 29% increase in landings in 2017. 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.

11.6.6 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 1993–2017 are shown in Table 11.6.6. The stock is currently estimated to consist of 670 million individuals.

Table 11.6.6 also shows the estimated harvest ratios over this period. From 2003 (the period over which the survey estimates have been revised) these range from 12–29% with the upper range being the 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 2017 is 19.7% which is above the estimated value at F_{MSY} (16.3%).

In addition to the discard rate, Table 11.6.6 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).

11.6.7 Recruitment estimates

Survey recruitment estimates are not available for this stock.

11.6.8 MSY considerations

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

WGNSSK 2011		F_{bar}(20–40 mm)		HR (%)	SPR (%)		
		M	F		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 mostly been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that the sexes combined $F_{max(T)}$ is chosen as the F_{MSY} proxy.

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

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

11.6.9 Short-term forecasts

A catch prediction for 2019 was made for the Firth of Forth (FU 8) using the approach agreed at the Benchmark Workshop and outlined in Section 10.1. 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 10.1 of this report and the harvest ratio in 2017 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). The calculation of HR is based on dead removals and in FU 8 that includes landings, dead discards and the BMS component (if available).

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 2018 considers that *Nephrops* discarding is allowed to continue as before 2016. Under this scenario the harvest rate is assumed to include landings (wanted catches) plus dead discards (dead unwanted catch). The catch options table includes surviving discards (discards survival for *Nephrops* in FU 8 is assumed to be 25%). 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 *de minimis* exemption of 2% discards by weight below MCRS is in place in the North Sea. In the past, a catch options table accounting for a continuation of this rule in the following year has been considered, although this option was not requested for 2019.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2019 at the F_{MSY} proxy harvest ratio is 2334 tonnes. It should be noted that the F_{MSY} 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 F_{MSY} reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	670 million	ICES (2018a)	UWTV 2017
Mean weight in wanted catch	22.84g	ICES (2018a)	Average 2015–2017
Mean weight in unwanted catch	10.22g	ICES (2018a)	Average 2015–2017
Unwanted catch rate (total)	20.3%	ICES (2018a)	Average 2015–2017 (proportion by number)
Unwanted catch survival rate	25%	ICES (2018a)	Proportion by number
Dead Unwanted catch rate (total)	16.0%	ICES (2018a)	Average 2015–2017 (proportion by number)

Catch options assuming discarding to continue at recent average

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate *	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MSY approach	2 334	2 274	2 095	179	60	16.3%	-1.77%
Other scenarios							
$F_{0.1}$	1 345	1 311	1 208	103	34	9.4%	-43%
F_{lower}	1 518	1 479	1 363	116	39	10.6%	-36%
F_{35SpR}	1 818	1 772	1 633	139	46	12.7%	-23%
$F_{MSY\ upper}$***	2 334	2 274	2 095	179	60	16.3%	-1.77%
$F_{2015–2017}$	2 334	2 274	2 095	179	60	16.3%	-1.77%
F_{2017}	2 820	2 748	2 532	216	72	19.7%	18.7%

*** Calculated for dead removals.**

**** Advice value 2019 relative to advice value 2018.**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock**

Biological Reference points

Biological reference points have not been defined for this stock.

11.6.10 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 84% of the landings in 2016 (85% of the discards were imported and 15% 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 2013–2017.

11.6.11 Status of the stock

The stock has declined in size since 2008 when it was at the highest point in the series but is well above the average abundance and well above the MSY $B_{trigger}$ level. The value calculated for 2017 (670 million) is above the average abundance in the time series. Landings taken from this FU in 2017 (2493 tonnes) were higher than the 2016 advice (for 2017) of 2190 tonnes (wanted catch). The harvest rate increased in 2017 to 19.7% and is now above F_{MSY}. Length frequencies in the catches have been stable.

11.6.12 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 should help to improve the exploitation pattern for some species such as haddock and whiting and small cod.

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

This stock is under the landings obligation although there is a survivability exemption and a *de minimis* exemption in place for *Nephrops* in the North Sea. *Nephrops* caught with pots (all year) or in winter months (October to March) with bottom trawls (OTB, TBN) with a mesh size of at least 80 mm equipped with a netgrid selectivity device may be discarded in FU 8 without restrictions due to high survival rates. Animals below the minimum conservation reference size may be discarded, up to a maximum of 2% of the total annual catches of this species by vessels using bottom trawls (OTB, OTT, TB, TBN) of mesh size 80–99 mm in ICES Subarea 4 and Union waters of ICES Division 2.a. In 2017, no *Nephrops* were recorded as below the minimum size (BMS) in FU 8 despite this being a Functional unit that historically have shown relatively high discard rates. It remains uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.7 Moray Firth (FU 9)

11.7.1 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 10.1.1). 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 2195 km^2. In the inner parts of the Firth the sediment is patchier 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 11.7.4 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).

11.7.2 The fishery in 2017

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 11.7.1). 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 10 m and are not affected by Cod Recovery Measures. Most vessels over 10 m are using 250 mm square mesh panels and reporting better catches than when they used HSGs. Square mesh panels of 160 mm and 200 mm were introduced for under 10 m vessels in the end of 2017 but feedback on the effects of these changes have not yet been received from the local fishermen. 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. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. These larger twin riggers (typically over 15 m) fished 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 300 HP with a further small area reserved for vessels under 400 HP. Prices of *Nephrops* have been reported as slightly higher than in previous years and fuel costs were similar to 2016. Anecdotal evidence suggests some by-catch of monkfish and haddock occurred but vessels under 10 m, which make most of the fleet, are generally limited by quota restrictions. *Nephrops* creeling in the Moray Firth is not common (only 4 tonnes landed in 2017) 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 fleet participated in the squid fishery between September and October, returning to *Nephrops* fishing in November. In 2017, approximately 10 vessels from other districts joined the Moray Firth *Nephrops* fishery towards the end of the year after the squid fishery season was over. Further general information on the fishery can be found in the Stock Annex.

11.7.3 Advice in 2017

The ICES conclusions in 2017 in relation to State of the Stock were as follows:

"The stock has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate has fluctuated around F_{MSY} and is now just above."

The ICES advice in 2017 (for 2018) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of 2014–2016, catches in 2018 should be no more than 1219 tonnes.

In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the FU level. In recent years, the catch in this FU has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs."

11.7.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.7.5 Assessment

Approach in 2018

The assessment in 2018 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 2018 followed the process of 2017, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.7.1. Total landings (as reported to the WG) in 2017 for Scotland were 1119 (a 2% decrease in relation to 2016) and England landed only 1 tonne. 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 11.7.1. *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 9 in 2017.

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 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 11.7.1 and Table 11.7.2. 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 although an increase was recorded in 2017 to the same level as that estimated for the mid 2000s. 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 11.7.2), although in 2011 and 2015 the proportion of females is higher than in the recent past. In 2016–2017, males dominate again. The high contribution of females previously recorded 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 11.7.6 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 54% of the catch by number. In 2013 and 2017, the observed rate by number was at its lowest level, approximately 3% by number, suggesting poor recruitment to the fishery. Discards rates were generally higher in the past and in recent years appear to be lower but with occasional high annual levels which may be associated with sporadic high recruitments (e.g. 2002, 2004, 2010 and 2014-2016).

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 2017 data (official landings and sampled data for landings and discards) were successfully uploaded into InterCatch. National data co-ordinators for other countries (England) also uploaded landings data to InterCatch ahead of the 2017 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2017.

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 11.7.3 shows a series of annual length frequency distributions for the period 2000 to 2017. 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, 2004 and more recently, 2016). 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 11.7.1 and Table 11.7.3. 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 11.5.4 and Table 11.5.5).

The mean size in the catch in the <35 mm category (Figure 11.7.1) shows no particular trend over the time series although it has risen slightly in 2017. This is consistent with the recent decrease in the discard rate and relates to the trend found in the length frequency distributions suggesting a poor recruitment in 2017.

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 11.7.4. On average, 42 stations have been considered valid each year, 55 stations were sampled in 2017. Abundance data are raised to a stock area of 2195 km^2. General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 11.7.5 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 is higher in the muddy sand (west) strata and seems to be evenly split among the other different strata in recent years. The densities typically observed in this FU are lower than those observed in FU 8.

Figure 11.7.4 shows the distribution of stations in UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In 2017, the abundance appears to be highest at the western inshore and to the southeast of the FU, with lower densities in the central north and eastern areas. Table 11.7.4 and Figure 11.7.5 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 declined since 2007 having increased in 2013 followed by a further decrease in 2014 and increased again slightly in the last 3 years. The abundance in 2017 was 412 million, an increase of 6% compared with the previous year. The stock is currently below the average abundance over the time series but remains above the biomass trigger. The calculated harvest ratio in 2017 (dead removals/TV abundance) is now just below F_{MSY} (previously above F_{MSY}) as a result of decreasing landings and a slight increase in stock abundance in 2017. The mean size of individuals >35 mm in the catch shows no strong trend in recent years. The mean size of individuals below 35 mm has shown a slight increase in 2017 which, together with the low discard rate observed in 2017 suggests a lower recruitment in relation to the 2014–2016 period. 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.

11.7.6 Historical stock trends

The UWTV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased in 1997–2005 and has gradually fallen until 2012. In recent years abundance has remained at a relatively low level showing a slight increase in the last 3 years. The abundance estimates from 1993–2017 are shown in Table 11.7.6 and Table 11.7.6 shows the estimated harvest ratios. These range from 6–33% over this period. Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The harvest ratio has decreased in 2017 to 10.5% and is now just below the F_{MSY} proxy value of 11.8%.

In addition to the discard rate, Table 11.7.6 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).

11.7.7 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.

11.7.8 MSY considerations

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

		F_{bar}(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 F_{MSY} proxy.

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

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

11.7.9 Short-term forecasts

A catch prediction for 2019 was made for the Moray Firth (FU 9) 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 10.1 of this report and the harvest ratio in 2017 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 2018 considers that *Nephrops* discarding is allowed to continue as before 2016. Under this scenario the harvest rate is assumed to include landings (wanted catches) plus dead discards (dead unwanted catch). The catch options table includes surviving discards (discards survival for *Nephrops* in FU 9 is assumed to be 25%). 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 *de minimis* exemption of 2% discards by weight below MCRS is in place in the North Sea. In the past, a catch options table accounting for a continuation of this rule in the following year has been considered, although this option was not requested for 2019.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2019 at the F_{MSY} proxy harvest ratio is 1274 tonnes. It should be noted that the F_{MSY} 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 F_{MSY} reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	412 million	ICES (2018a)	UWTV 2017
Mean weight in wanted catch	27.42 g	ICES (2018a)	Average 2015–2017
Mean weight in unwanted catch	10.75 g	ICES (2018a)	Average 2015–2017
Unwanted catch rate (total)	11.9%	ICES (2018a)	Average 2015–2017 (proportion by number)
Unwanted catch survival rate	25%	ICES (2018a)	Proportion by number, only applies in scenarios when discarding is allowed
Dead unwanted catch rate (total)	9.2%	ICES (2018a)	Average 2015–2017 (proportion by number), only applies in scenarios where discarding is allowed.

Catch options assuming discarding to continue at recent average

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate*	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MSY approach	1 274	1 258	1 210	48	16	11.8	4.5%
Other scenarios							
$F_{0.1}$	843	832	800	32	11	7.8%	-31%
F_{lower}	982	970	933	37	12	9.1%	-19.4%
F_{2017}	1 134	1 120	1 077	43	14	10.5%	-7.0%
$F_{2015–2017}$	1 167	1 152	1 108	44	15	10.8%	-4.3%
$F_{MSY\ upper}$***	1 274	1 258	1 210	48	16	11.8	4.5%
F_{max}	1 609	1 589	1 528	61	20	14.9%	32%

*** Calculated for dead removals.**

**** Advice value 2019 relative to advice value 2018.**

***** FMSY upper = FMSY for this stock**

Biological Reference points

Biological reference points have not been defined for this stock.

11.7.10 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 43% of the landings in 2017 (59% of the discards were imported and 41% were raised discards). The lower proportion of landings covered by discard data relates to missing sampling events in quarter 2 of the main metier (*Nephrops* trawlers, TR2 gears) and the absence of sampling data for TR1 gears in quarter 1.

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 2013–2017.

11.7.11 Status of the stock

The evidence from the UWTV survey suggests that following a continuous decrease from 2007 to 2012 the abundance has fluctuated around 400 million in recent years. The abundance has increased 6% in 2017 (to 412 million) remaining approximately at the same level as in the late 2000s. The stock size is above the MSY $B_{trigger}$ level. Landings taken from this FU in 2017 (1119 tonnes) were higher than the 2016 advice (for 2017) of 1018 tonnes (wanted catch). The harvest rate decreased in 2017 to 10.5% and is now below F_{MSY} (11.8%). Length frequencies in the catches have been relatively stable.

11.7.12 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 bycatch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The estimated harvest rates have been fluctuating around F_{MSY} but the abundance (as estimated by the UWTV survey) in recent years is just above the MSY $B_{trigger}$, therefore it would be unwise to allow effort to increase in this FU.

This stock is under the landings obligation although there is a survivability exemption and a *de minimis* exemption in place for *Nephrops* in the North Sea. *Nephrops* caught with pots (all year) or in winter months (October to March) with bottom trawls (OTB, TBN) with a mesh size of at least 80 mm equipped with a netgrid selectivity device may be discarded in FU 8 without restrictions due to high survival rates. Animals below the minimum conservation reference size may be discarded, up to a maximum of 2% of the total annual catches of this species by vessels using bottom trawls (OTB, OTT, TB, TBN) of mesh size 80–99 mm in ICES Subarea 4 and Union waters of ICES Division 2.a. In 2017, no *Nephrops* were recorded as below the minimum size (BMS) in FU 9 despite this being a Functional unit that historically have shown occasional high discard rates. It remains uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.8 Noup (FU 10)

11.8.1 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.

11.8.2 The fishery in 2016 and 2017

The Noup currently supports a relatively small fishery. Few vessels target *Nephrops* regularly in this area. In Orkney there is currently only two under 10 m 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 2017 only 9 tonnes of *Nephrops* were landed (Table.11.8.1). Further general information on the fishery can be found in the Stock Annex.

11.8.3 Advice in 2016

The advice provided in 2016 was biennial and valid for 2017 and 2018.

"ICES advises that when the precautionary approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in each of the years 2017 and 2018 should not exceed 40 tonnes. This would imply wanted catch of no more than 38 tonnes.

In order to ensure the stock in this FU is exploited sustainably, 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 11.8.1 and Figure 11.8.1. Total landings (as reported to the WG) in 2017 were only 9 tonnes, a decrease of 14 tonnes from 2016. *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 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 11.8.1 and Table 11.8.2. Effort has declined over the time period and this is more marked than on other *Nephrops* grounds owing to the presence of demersal fish in the area and LPUE declined in 2017.

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 11.8.1 and Table 11.8.3. There were no sampling data available for 2015, two sampling trips in 2016 and only one trip was carried out in 2017. 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 2017 were successfully uploaded into InterCatch prior to the 2018 WG meeting according with the deadline proposed. Data for this stock in previous years has been limited to official landings (classified as “Landing only” in InterCatch with no sampling data). The 2017 data provided by Scotland was raised based on length frequencies collected in quarter 3. Careful must be taken however when interpreting this information due to the low levels of sampling.

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 11.8.3 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 11.8.4 and Table 11.8.4.

11.8.4 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, 15 tonnes in 2014–2015, 23 tonnes in 2016 and 9 tonnes in 2017.

11.8.5 Recruitment estimates

There are no recruitment estimates for this FU.

11.8.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

11.8.7 Status of the stock

The current state of the stock is unknown.

11.8.8 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 bycatch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches of cod include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. Animals below the minimum conservation reference size may be discarded, up to a maximum of 2% of the total annual catches of this species by vessels using bottom trawls (OTB, OTT, TB, TBN) of mesh size 80–99 mm in ICES Subarea 4 and Union waters of ICES Division 2.a. In 2017, no *Nephrops* were recorded as below the minimum size (BMS) in FU 10. This is consistent with the discard rates estimated for the FU in recent years which have been close to zero. It remains however, uncertain how the de minimis exemption for *Nephrops* in the North Sea is going to be enforced.

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 (ICES 2013). Following the procedure outlined (Section 10.1), 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 2016 of 40 tonnes (catch) results in a harvest ratio of 3.0%. As the stock appears to be very lightly exploited, the advice may be increased to a level corresponding to an acceptable harvest rate (HR), applying an uncertainty cap to restrict annual change to less than 20%. The same advice as given in 2016 + 20% corresponds to a potential HR of 3.5%. This is well below the range of maximum sustainable yield (MSY) harvest rates in the North Sea (between 7.5% and 16%), which is considered conservative. Additional options including a medium term (10 year) average and a recent (3 year) average wanted catches were also included in the table. Assuming the same density as estimated in 2014, 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 advice (given in 2018) for 2019 and 2020 (based on the Precautionary approach) was that catches should be no more than 48 tonnes (2016 advice + 20%) implying wanted catches of no more than 46 tonnes. 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. For data limited stocks the discard survival is assumed to be zero.

Basis for the catch scenarios.

Variable	Value	Notes
Density in TV assessment	0.13 *Nephrops* m^2	UWTV 2014
Mean weight in wanted catches	27.42 g	Average 2015–2017 (from FU 9)
Mean weight in unwanted catches	10.75 g	Average 2015–2017 (from FU 9)
Unwanted catches rate (total)	11.9%	Average 2015–2017 (from FU 9, proportion by number)
Discard survival rate	0%	Discard survival is assumed to be zero.
Surface area estimate	409 km^2	Benchmark estimate WKNEPH (2007)

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Range of potential densities (*Nephrops* m⁻²)								
				0.05	0.1	0.13	0.15	0.2	0.3	0.4	0.6	0.8
				Harvest rate in %								
Recent average (2015–2017)	17	16	1	3.2%	1.59%	1.22%	1.06%	0.79%	0.53%	0.40%	0.26%	0.20%
2016 Advice - 20%	32	30	2	6.2%	3.1%	2.4%	2.1%	1.54%	1.03%	0.77%	0.51%	0.38%
2016 Advice	40	38	2	7.7%	3.8%	3.0%	2.6%	1.92%	1.28%	0.96%	0.64%	0.48%
2016 Advice + 20%	48	46	2	9.2%	4.6%	3.5%	3.1%	2.3%	1.54%	1.15%	0.77%	0.58%
Average (2008–2017)	48	46	2	9.3%	4.6%	3.6%	3.1%	2.3%	1.54%	1.16%	0.77%	0.58%
MSY	102	97	5	19.6%	9.8%	7.5%	6.5%	4.9%	3.3%	2.5%	1.63%	1.23%
Maximum	520	494	26	100%	50%	38%	33%	25%	16.7%	12.5%	8.3%	6.2%

11.9 Norwegian Deep (FU 32)

11.9.1 Ecosystem aspects.

See stock annex (section A.3).

11.9.2 Norwegian Deep (FU 32) fisheries

See stock annex (Section A.2). Maps showing the annual spatial distribution of the Danish fishery in FU 32 were provided for the first time in 2015 (Figure 11.9.1). Maps showing the annual spatial distribution of the Norwegian trawl fishery (vessels ≥15 m) in FU 32 (since 2011) were provided for the first time in 2016 (Figure 11.9.2).

New maps of the annual spatial distribution of the Danish trawl fishery was made at the 2016 benchmark (ICES, 2016). Danish *Nephrops* fishing grounds were identified using Danish VMS and logbook data. Data from the mixed fishery (≥120 mm mesh size) were used, where daily *Nephrops* landings from logbooks were distributed evenly on the corresponding VMS signals. Spatial analysis was preformed using a geographic grid of the size of 1 x 2 minutes. The data were filtered for daily *Nephrops* ratios >0.05 in the landings. For each year, fishing ground, defined as the smallest number of grid cells containing 95% of the landings, was estimated. These maps confirm the declining temporal pattern in Figure 11.9.1, but show a further decrease in the distribution of the Danish fishery from 2012 to 2013 which is not evident from the former figure.

The benchmark decided to use the present distribution of the Danish fishery to estimate a new area for the harvest rate table for FU 32. Both the union and the intersection of the areas for each year was calculated representing the maximum and minimum estimate of the fishing grounds. By shifting the starting year to use in the calculations, the spatial contraction of the utilized fishing ground was visualized; the fishery presently uses only approximately one third of the area used in the mid–2000s.

11.9.3 Advice in 2016

Advice for *Nephrops* was updated in 2016. This advice applied for 2017 and 2018.

- 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 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 tonnes (2006–2015), while the short-term average landings are

259 tonnes (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.

11.9.4 Management

An overview of the management of *Nephrops* in FU 32 is given in the stock annex (Section A.2). The EU fisheries are managed by a separate TAC for this FU, decided by the annual Norway–EU negotiations. For 2008, the agreed TAC for EU vessels was 1300 tonnes, and for 2009–2012, 1200 tonnes. In 2013, the TAC was reduced to 1000 tonnes, following the ICES advice, and it remained at this level until 2018 when it was reduced to 800 tonnes. 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 Norwegian waters outside of Skagerrak.

11.9.5 Assessment

Data available

Landings data for all fleets in 2017 have been uploaded using InterCatch.

Catch

International landings from the Norwegian Deep increased from less than 20 tonnes in the mid–1980s to 1190 tonnes in 2001 (Table 11.9.1, Figure 11.9.3). Since then, landings have declined due to a reduction of Danish landings, and total landings in 2017 amounted to only 147 tonnes, the lowest Figure since 1990. The decreased Danish landings can be explained by increasing fuel costs, fewer vessels, and *Nephrops* catches 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 2017, Denmark landed only 36% of the total landings. Norwegian landings decreased from 2008 to 2014, but increased in 2015 and 2016, to 97 tonnes. In 2017, Norway landed 94 tonnes. In 2017, 90% of Norwegian landings were from traps; only 9 tonnes were landed from the shrimp and mixed fishery (stock annex, Section A.2).

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Table 11.9.1). In 2017, there were only three observer trips with *Nephrops* in catches in FU 32, and only a very small number of *Nephrops* were sampled (stock annex, Section B.1). On one trip, all *Nephrops* were discarded, also the big ones, as the catch was only a couple of kilos. The 2017-observer data were considered not representative and were therefore not used for updating information going into the harvest rate table used in the advice (see below).

Danish discards are low due to the legislated 120 mm mesh size. The Danish discard rate (discard as percentage of catch) varied between 10% and 35% in the years 2003 to 2013, while in 2014–2017 estimated Danish discards were only 5, 6, 1 and 1 tonnes, respectively, resulting in very low Danish discard rates of between 1% and 5%. The low discards the last four years may indicate low recruitment to the stock, but the 2017-estimate is uncertain. Discards were low also in FUs 3–4 in 2014–2016, but increased again in 2017. There are no Norwegian discard data, and Norwegian discards are assumed to be zero. As the Norwegian fishery is now basically a trap fishery, with high survival of discarded *Nephrops* (stock annex, Section A.3), this is a valid assumption at least for the last couple of years (Table 11.9.1).

Length composition

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 11.9.3). 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 has remained at this since. The average size of landed females, on the other hand, has remained at the low 2013–level. 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 *Nephrops* >40 mm could be that the Danish fishery in 2013 contracted into an area with small *Nephrops*. This contraction of the fishery has been confirmed. It is, however, unclear why it is only the large females that have shown a decreased size in recent years.

The length frequency distributions of the Danish catches from the years 2007, 2010, 2012, 2014, 2016 and 2017 had a greater proportion of large *Nephrops* compared with former years (Figure 11.9.4). 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 have not been updated since 2012 due to lack of CL data.

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 (ICES, 2013) for estimation of maturity at length. However, annual catches in the survey are too small for estimation of annual maturity values.

Catch, effort and research vessel data

Effort and LPUE Figures for the period 1989–2017 are available from Danish logbooks (Table 11.9.2, Figure 11.9.3). In 2013, the Danish effort index was changed to kW days (formerly fishing days) (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 11.9.2). In 2016 and 2017, 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 stepwise decreasing trend (Figure 11.9.3). 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 11.9.2, Figure 11.9.3). The Norwegian mesh size legislation was changed in 2004 (stock annex, Section A.2) with the introduction of a larger mesh size of 120 mm. This change in legislation occurred some years too late to explain the decrease in LPUE (catch rate) from 1999 to 2001 with a subsequent stabilizing at a lower level relative to the late 1990s. The lower LPUE may, on the other hand, reflect a stock decrease as Danish landings in 1999 increased to >1000 tonnes and remained at this level until 2006. In 2007, individual vessel quotas were introduced in the Danish fishery. This resulted in 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 has remained at this low level since.

Spatial analyses of Danish logbooks and VMS data in the 2016 benchmark (ICES, 2016) showed that the LPUE decreased over the whole Norwegian Deep from 2005 to 2015, with the largest decline in the north. Only the southernmost part of the functional unit has had reasonably good catch rates since 2013. Environmental changes resulting in lower *Nephrops* densities in the whole functional unit cannot be ruled out. The likely low recruitment to the stock in 2014–2016, and possibly also in 2017, 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 410 kW days in 2017, 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 (ICES, 2013) analysed the Norwegian LPUE Figures from bottom and shrimp trawls. The trawl data prior to 2011 are considered unsuitable for LPUE analyses (Stock Annex, Section B.4). The 2016 benchmark (ICES, 2016) analysed data from the Norwegian electronic logbooks, compulsory since 2011 for all vessels ≥15 m length. The data situation did not improve with the introduction of the electronic logbooks, basically because there are so few large Norwegian vessels landing *Nephrops* from this area. The Norwegian fishery is now basically a trap fishery (≤10% trawl landings), which is carried out by small vessels, not obliged to fill out logbooks. The 2016 benchmark concluded that an LPUE index based on the electronic logbooks is not representative of the present Norwegian *Nephrops* fishery in FU 32.

The electronic logbook data show that the Norwegian large vessel trawl fishery for *Nephrops* in FU 32 declined from 2012 to 2013 (Figure 11.9.2). In 2013–2014, the fishery was confined to the southernmost part of the FU as well as an area just west of Stavanger, while in 2015–2017 some trawling again took place along the western rim of the Norwegian Trench. The trap fishery is a coastal fishery, and landings per ICES statistical squares indicate that this fishery is concentrated in outer coastal areas from Stavanger to Bergen (Figure 11.9.5). There is no information on total effort of the trap fishery.

The annual Norwegian bottom trawl shrimp survey covers all of Skagerrak and the Norwegian Deep. Catches of *Nephrops* in the Campelen trawl are small and variable within and between years. *Nephrops* is distributed in areas deeper than 100 m in FU 32 (Figure 11.9.6). (Areas shallower than 100 m are not covered by the survey). The 2016 benchmark (ICES, 2016) analysed the *Nephrops* data from the shrimp survey with the aim of establishing a fisheries independent stock size index (see below).

Data analysis

Review of the assessment in 2016

"Technical comments

The technical comments formulated last year have been addressed in the 2016 report, and will be further investigated for the coming benchmark.

It is suggested to remove the old time series (red lines) from all figures, now that there has been three years since the change in Danish LPUE series.

Conclusions

The advice is the average catch of the last ten years. It seems OK but given the major changes in landings and discards in the recent years, a shorter average might be considered.

New data are expected to be investigated further during the incoming benchmark.

Exploratory analysis of catch data

There was no age based analysis carried out

Exploratory analysis of survey data

As part of the benchmark in 2016 (ICES, 2016) a biomass index was established using GLMs within a mixed generalized gamma-binomial model and Bayesian inference (Stock Annex, Section B.3). The biomass index showed high values in 2006 and 2007, but declined to a lower level in 2008. Thereafter it has fluctuated without trend (Figure 11.9.7). The Danish LPUE has similarly decreased since 2008–2009 (Figure 11.9.3). It should be noted that the survey index covers the whole Norwegian Deep for depths >100 m, while the Danish LPUE covers the western and southern part of the Norwegian Deep. The new survey index is based on few observations (Figure 11.9.6). However, in lack of better data, the benchmark considered that the index should be presented and updated as part of the annual assessment procedure of the FU 32 stock.

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 and data from the Norwegian bottom trawl survey.

11.9.6 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 2013–2017 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. The survey biomass index declined from 2007 to 2008 and has thereafter fluctuated without trend.

11.9.7 Recruitment estimates

There are no recruitment estimates for this stock. Fluctuations in catches of small *Nephrops* are used as a proxy for recruitment. Discards of small *Nephrops* have been very low in 2014–2016, and possibly also in 2017, indicating low recruitment these years.

11.9.8 Forecasts

There were no forecasts for this stock.

11.9.9 Biological reference points

No reference points are defined for this stock.

11.9.10 Quality of assessment

The data available for this stock remain limited.

11.9.11 Status of stock

The perceptions of this stock (FU 32) are based on Danish landings and effort data, mean sizes (CL) in landings and discards, and from 2017, a biomass index from the Norwegian bottom trawl survey. The effect of technological creep on the effective effort of the fishery is not known. The Danish LPUE index shows a stepwise declining trend from the mid–1990s until present. However, it is difficult to determine whether this decrease in LPUE is due to changes in management and fishery patterns, 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 2013–2017 might imply stock size changes in the southern part of FU 32, but could also be caused by vessels now targeting finfish rather than *Nephrops*. The survey index is presently at a low level compared with the years 2006–2007, indicating a lower stock size. 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 overexploited. However, trends in mean size of landings in 2013–2017 are difficult to interpret. The low catches of small *Nephrops* during the last four 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 318 tonnes (2008–2017), while the short-term average landings are 183 tonnes (2013–2017).

11.9.12 Management considerations

For 2006–2008 the agreed TAC for EU vessels was 1300 tonnes. This decreased to 1200 tonnes in 2009–2012, 1000 tonnes in 2013–2017, and 800 tonnes in 2018. The WG notes that there is no TAC for the Norwegian vessels fishing in FU 32.

The Danish at-sea-sampling programme did not provide a satisfactory number of observer trips in 2017. As in 2016, quarters 1 and 2 were not sampled. 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. As discard is not illegal, advice in 2017 is given for only a scenario without a discard ban. Following the procedure outlined in the stock annex (section H) a table of harvest rates (see table below) was calculated. The biomass estimates imply low harvest rates in FU 32, even in former years with high landings (1000–1200 tonnes).

Sensitivity analysis of harvest rates for a range of potential densities. All weights in tonnes.

Discarding allowed

Basis	Live discards	Dead discards	Landings	Dead removals	Range of potential densities (*Nephrops* m^{-2})								
					0.05	0.1*	0.2	0.3	0.4	0.5	0.6	0.7	0.8
					Harvest rate in %								
Average landings (2008–2017)	2	5	318	323	2.0%	1.0%	0.5%	0.3%	0.3%	0.2%	0.2%	0.1%	0.1%
0.5 × Average landings (2008–2017)	1	2	159	161	1.0%	0.5%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Maximum landings	6	18	1190	1208	7.5%	3.8%	1.9%	1.3%	0.9%	0.8%	0.6%	0.5%	0.5%

*** A density of 0.1 *Nephrops* m^{-2} is among the lowest observed densities in the North Sea in FU 7 (Fladen Ground).**

11.9.13 References

ICES. 2013. Report of the Benchmark Workshop on *Nephrops* Stocks (WKNEPH). 25 February-1 March 2013 Lysekil, Sweden. ICES CM 2013/ACOM: 45. 183 pp.

ICES. 2016. Report of the Benchmark Workshop on *Nephrops* Stocks (WKNEP), 24–28 October 2016, Cadiz, Spain. ICES CM 2016/ACOM:38. 223 pp.

11.10 Off Horns Reef (FU 33)

11.10.1 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 1097 tonnes. Denmark dominated the fishery during this period. Between 2004 and 2015, Danish landings gradually decreased, and in 2015 were 371 tonnes. In 2016 and 2017, the Danish landings increased considerably from previous years, and were 642 and 511 tonnes, respectively. 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 tonnes. Since 2007, Dutch landings show a decreasing trend and in 2015 were the lowest landings recorded over the last decade (187 tonnes). However, in 2016 and 2017 Dutch landings increased considerably from the previous year and were 320 and 336 tonnes, respectively. Belgium and German landings having increased throughout the time period and were around 423 and 197 tonnes respectively in 2017. UK landings were highest in 2009 (170 tonnes) and have since decreased dramatically. In 2016 and 2017, total landings were the highest on record (1636 and 1472 tonnes, respectively). (Table 11.10.1 and Figure 11.10.1).

Discards from FU 33 are poorly documented and scarce. Discard information from Denmark were recorded in InterCatch for 2015 and 2016. These data consist of 1 trip per year and are considered to scarce to be used for providing catch advice. No data were available from Denmark in 2017. In 2015, Dutch discards were recorded in InterCatch, however, length information was missing. In 2016 and 2017, Dutch discards included length information. Due to a National minimum landing size, a large majority of the Dutch discards were above the MCS of 25 mm set for the North Sea and not considered representative for the other countries.

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 to 2016 are shown in Figure 11.10.2. Notice, that except for 2005 and 2011 they are rather similar. No discards were observed in the Danish at-sea observer data in 2016, hence the large increase in mean length. Figure 11.10.1 shows the development of the mean size of *Nephrops* in catches. The drop in the mean CL in the catches in 2005 and 2011 reflects an increase in numbers at around 30 mm CL and could indicate a large recruitment in these years, see also Figure 11.10.1.

In the period 2001–2005, and in 2009–2016 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples do not cover all quarters. In 2017, no length distributions were available from Danish and Dutch catches.

Natural mortality, maturity at age and other biological parameters

No data available

Catch and effort data

Table 11.10.2 and Figure 11.10.1 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 2005–2016 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. In 2016 and 2017, Dutch effort returned to the same levels as observed in 2013. The Danish LPUE shows an increasing trend during the whole period, and in 2016, was the highest in the time series at around 1.7 kg/kW day. However, in 2017 the Danish LPUE decreased considerably (0.8 kg/kW day). This increase in LPUE observed from 2011–2016 could reflect an increase in gear efficiency (technological creep) or in fishers' ability to exploit the stock. Furthermore, the low number of Danish vessels exploiting this FU may explain the large variability in LPUE observed. 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

11.10.2 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 and 2014 when LPUE declined slightly. In 2017, the large decrease in the Danish LPUE corresponds with an increase in effort. In 2013, new data from the Netherlands became available for the last nine years, and shows a more stable effort. In 2017, LPUE has increased substantially for Denmark while the Dutch LPUE has slightly decreased.

In 2016, the size distribution in the catches is similar to those in 2001–2004, 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.

11.10.3 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.

11.10.4 Status of the stock

Previously, the state of this stock has been unknown, where an assumed low density (based on the lowest observed density in FU 7 (Fladen Ground) has been used to estimate harvest rates. In 2017, Denmark conducted an UWTV survey of this functional unit. The observed density (0.13 *Nephrops* m^{-2}) conforms well to those previous adopted from FU 7 (0.1 *Nephrops* m^{-2}). Harvest rates are considered low for this stock.

The mean individual weight in landings and discards in 2015 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. Based on the available landings and discards it was not possible to update these estimates and therefore the 2015 values have been used.

11.11 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 2016 using the ICES data limited approach for *Nephrops*.

11.11.1 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 11.11.1 and suggests that there is one large, and several smaller areas of muddy sand (10–50% silt and clay).

11.11.2 The Fishery in 2016 and 2017

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.

Advice in 2016

Advice provided in 2016 was biennial for 2017 and 2018.

"ICES advises that when the precautionary approach is applied, and under the assumptions that discarding would occur only below minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2008–2011), catches in each of the years 2017 and 2018 should not exceed 492 tonnes. This would imply wanted catch of no more than 459 tonnes.

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

11.11.3 Management

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

11.11.4 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.

11.11.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2017 are presented in Table 11.11.1 and Figure 11.11.2. 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 recent years landings increased again and reached 550 tonnes in 2017 (a 30% reduction in relation to 2016).

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 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 11.11.3 and Table 11.11.2. Combined effort for trawlers has declined over the time period showing generally a downwards trend and 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. From 2014, effort increased again to a similar level to that recorded in the late 2010s.

Lpue showed an increasing trend until 2009 followed by a slight drop in 2011 and has fluctuated around 400 kg/day in the last seven years.

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. In 2015–2017, occasional sampling events in observer trips targeting FU 7 reveal low levels of discarding in the fishery. No market samples were taken in 2012–2013 and in the years only a few fishing trips were sampled. Mean sizes in the catch and landings for 2006 to 2011 are shown in Table 11.11.3. Sampling has not been conducted in all quarters, so there is potential bias in these results.

InterCatch

Scottish data for 2017 were successfully uploaded into InterCatch prior the 2018 WG meeting according with the deadline proposed. Both landings and discard sampling have been very limited in recent years and Intercatch has been used mainly to record official landings data from counties who submitted data into FU 34 (Scotland and England).

Length Base Indicators (LBI)

The terms of Reference for the 2018 WGNSSK meeting requested the WG to propose appropriate MSY proxies for a number of Category 3 and 4 stocks including (*Nephrops* FU 34) by using methods provided in the ICES Technical Guidelines (ICES, 2017) along with available data and expert judgement. For FU 34, only limited length frequency information is available with few landings and discard samples collected per year. An attempt was made to run the Length Base Indicators (LBI) screening method using data from 2014 to 2017 (Figure 11.11.8). In recent years the low number of discard trips conducted within FU 34 showed discard rates to be approximately zero, therefore only landings data were used when applying the method.

Life history parameters such as L_{inf} and L_{mat} are required to run the LBI method. These parameters were taken from the stock annex for this FU although they were estimated and borrowed from other *Nephrops* stocks. The parameters used were L_{inf} = 66 mm CL and L_{mat} = 25 mm CL (for both males and females).

The results of the application of the LBI method for females and males are presented in the tables below. These show that indicators related to the conservation of immature individuals (L_c/L_{mat} and $L25\%/L_{mat}$) were generally below reference points while other indicators were mostly above reference points. The LBI method applied to FU 34 was not considered to be conclusive due to the limited data available. LBI methods applied to data limited (Category 4) *Nephrops* stocks may be explored in the future within the ICES *Nephrops* Reference Point Determination Workshop.

Females

	Conservation				Optimising yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/L(F=M)
Ref	>1	>1	>0.8	>0.3	~1(>0.9)	≥1
2014	1.32	1.48	0.69	0	0.89	0.95
2015	0.68	1.32	0.72	0.02	0.82	1.23
2016	1.08	1.16	0.67	0	0.77	0.92
2017	1.16	1.32	0.75	0.04	0.87	1

Males

	Conservation				Optimising yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/L(F=M)
Ref	>1	>1	>0.8	>0.3	~1(>0.9)	≥1
2014	1.56	1.56	0.74	0.03	0.95	0.91
2015	0.76	1.4	0.77	0.04	0.89	1.27
2016	1.24	1.32	0.74	0.03	0.87	0.97
2017	1.24	1.32	0.8	0.06	0.89	0.98

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 and 2016 but the survey has continued in 2014, 2015 and 2017. The most recent survey, conducted in the Summer of 2017 (16 TV stations completed) gives an estimate of density of 0.09 burrows/m^2, a reduction of 44% in relation to the 2015 estimate. A density distribution map of these surveys is shown in Figure 11.11.4 with the size of the symbol reflecting the *Nephrops* burrow density. Table 11.11.4 and Figure 11.11.5 show the time series of mean burrow densities and 95% confidence intervals.

11.11.6 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 recent years. Estimates of mean density in the stock show a general declining trend from 2009.

11.11.7 Recruitment estimates

There are no recruitment estimates for this FU.

11.11.8 MSY considerations

There is currently insufficient catch-at-length data to conduct a combined length cohort analysis, and therefore F_{MSY} proxy harvest rates have not been calculated for this functional unit.

11.11.9 Short-term forecasts

No short-term forecasts are presented for this FU.

11.11.10 Status of the stock

The current state of the stock is unknown.

11.11.11 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. In 2016–2017, catches increased substantially to levels well above ICES advice in 2016 and 2017, highlighting the issue that current management arrangements are not sufficient to contain the fishery within the sustainable limits determined by ICES.

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 include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. Animals below the minimum conservation reference size may be discarded, up to a maximum of 2% of the total annual catches of this species by vessels using bottom trawls (OTB, OTT, TB, TBN) of mesh size 80–99 mm in ICES Subarea 4 and Union waters of ICES Division 2.a. In 2017, no *Nephrops* were recorded as below the minimum size (BMS) in FU 34. This is consistent with the discard rates estimated for the FU in recent years which have been close to zero. It remains however, uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

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 (ICES, 2013). Following the procedure outlined (Section 10.1), 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* (0.09 *Nephrops*/m^2) from the UWTV survey (2017), was used together with the mean weight (average 2007–2010) and discard percentage (average 2008–2011). The same advice as provided in 2016 of 492 tonnes (catch) results in a harvest ratio of 10.5% which is above the range of harvest ratios observed for other North Sea functional units (7.5–16%). The 10 year average (2008–2017) results in a higher HR (13.5%). Applying a 20% precautionary buffer on the ten-year average implies a 11.6% HR. Recent average landings (2015–2017) and the same advice as given in 2016 - 20% (uncertainty cap) result respectively in 13.5% and 8.4% HR, also above the upper limit.. In order to achieve a 7.5% HR, the 2016 catch advice would have to be reduced by a percentage of 29% (which is larger than the 20% precautionary buffer). The proposed advice (given in 2018) for 2019 and 2020 was that catches should be no more than 394 tonnes (2016 advice - 20%) implying catches of no more than 394 tonnes (wanted catch of 368 tonnes). 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. For data limited stocks the discard survival is assumed to be zero.

Basis for the catch scenarios.

Variable	Value	Notes
Density in TV assessment	0.09 *Nephrops* m^2	UWTV 2017
Mean weight in wanted catches	31.76 g	Average 2007–2010 (benchmark estimate WKNEPH, 2013)
Mean weight in unwanted catches	14.89 g	Average 2000–2017 (from FU 7)
Unwanted catches rate (total)	12.9%	Average 2008–2011 (benchmark estimate WKNEPH, 2013; proportion by number)
Discard survival rate	0%	Discard survival is assumed to be zero.
Surface area estimate	1753 km^2	Benchmark estimate WKNEPH (2013)

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Range of potential densities (*Nephrops* m^{-2})							
				0.05	0.09	0.15	0.2	0.3	0.4	0.6	0.8
				Harvest rate in %							
2016 Advice - 35%	320	299	21	12.30%	6.90%	4.10%	3.10%	2.10%	1.54%	1.03%	0.77%
2016 Advice - 29%	350	327	23	13.50%	7.50%	4.50%	3.40%	2.30%	1.69%	1.13%	0.84%
2016 Advice - 25%	369	345	24	14.20%	7.90%	4.70%	3.60%	2.40%	1.78%	1.19%	0.89%
2016 Advice - 20%	394	368	26	15.20%	8.40%	5.10%	3.80%	2.50%	1.90%	1.26%	0.95%
2016 Advice	492	460	32	19.00%	10.50%	6.30%	4.70%	3.20%	2.40%	1.58%	1.19%
Recent average landings (2015–2017) – 20%	505	472	33	19.50%	10.80%	6.50%	4.90%	3.20%	2.40%	1.62%	1.22%
Average landings(2008–2017) – 20%	543	508	35	21%	11.60%	7.00%	5.20%	3.50%	2.60%	1.74%	1.31%
2016 Advice + 20%	590	552	38	23%	12.60%	7.60%	5.70%	3.80%	2.80%	1.90%	1.42%
Recent average landings (2015–2017)	631	590	41	24%	13.50%	8.10%	6.10%	4.10%	3.00%	2.00%	1.52%
Average landings(2008–2017)	679	635	44	26%	14.50%	8.70%	6.50%	4.40%	3.30%	2.20%	1.64%
Maximum	1396	1305	91	54%	30%	17.90%	13.50%	9.00%	6.70%	4.50%	3.40%

11.12. 27.4.out FU

The fishery

The *Nephrops* fishery in Subarea 4 outside of the functional units is dominated by Netherlands, Germany and Belgium, followed by Scotland, England, Denmark and Sweden (Figure 11.12.1, Table 11.12.1). *Nephrops* are landed throughout the year although the main fishing season is the summer, and the predominant gears are bottom otter trawl (OTB) and beam trawls (TBB) with 70–99 mm of mesh size. Landings by creel vessels are typically lower than 1.5%.

The *Nephrops* fishery has grown during the last years. While the landings reported in 2013 and 2014 were around 400 t, they increased to 966 t in 2016 and 1191 t in 2017 (Table 11.12.1). Except Scotland, all countries increased their landings in 2017 in comparison to 2016, specially Germany. Discards have been reported by Denmark since 2012, and by Netherlands and Scotland since 2016. The discards reported in 2017 were 142 t, 74% lower than in 2016 (Table 11.12.2).

Advice in 2017

The Subarea 4 outside the functional units is assessed every three years. The last assessment was conducted in 2017, and the outcome was *the state of Nephrops outside the functional units is unknown.*

The advice provided last year still applies for 2019:

ICES advises that when the precautionary approach is applied, wanted catch should be no more than 376 tonnes in each of the years 2018, 2019, and 2020. ICES cannot quantify the corresponding total catches.

Management

Management is at the ICES Subarea level as described in Section 10.1.

Assessment

The previous assessments of the Subarea 4 outside of the functional units has been based on the examination of the trends in landings, since they are the only information available in a consistent manner.

Table 11.2.1. Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2017, 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

Table 11.2.1 (continued). Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2017, as officially reported to ICES.

	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

Table 11.2.1 (continued). Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2017, as officially reported to ICES.

	2013	2014	2015	2016	2017
Belgium	303	494	349	880	1109
Denmark	387	624	515	755	594
Faeroe Islands	0	0	0	0	0
France	0	0	0	0	0
Germany	425	418	435	862	923
Ireland	0	1	0	0	0
Netherlands	910	1154	1113	1464	1418
Norway	63	63	81	98	94
Sweden	0		0	1	0
UK (Eng + Wales + NI)	-				
UK (Scotland)	-				
UK	8625	11211	6825	9337	11911
Total	10713	13965	9318	13397	16049

* **Landings data for 2017 are preliminary.**

Table 11.2.2. Summary of *Nephrops* landings from the ICES area, by Functional Unit, 1981–2017.

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	393	13766
2015	1516	1371	1784	1897	816	15	192	1003	440	610	9656
2016	2535	1854	2399	1937	1146	23	178	1636	780	966	13454
2017*	2110	1812	5147	2493	1119	9	147	1472	550	1191	16050

*** Provisional**

**** Includes 3.a.**

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

****** 695 t in 4 and 14 t in 3.a**

******* 4 only**

Table 11.3.1. *Nephrops* in FU 5: Nominal Landings (tonnes) of *Nephrops*, 1991–2017, 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
2016	233	0	801	442	1059	2535	3243
2017	416	0	745	374	575	2110	2995

*** provisional na = not available**

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

*****Landings plus discard estimates.**

Table 11.3.2. ***Nephrops*** **in FU 5: Landings and discards of** ***Nephrops*****, 2015–2017 estimated from the Dutch self-sampling program for three métiers.**

	Metier	Biomass (t)		% Discards (numbers)	% Discards (biomass)
		Discards	Landings		
2015	OTB_CRU_70-99_0_0_all	1268	429	85.92%	74.7%
	OTB_DEF_70-99_0_0_all	83	90	67.75%	48.0%
	TBB_DEF_70-99_0_0_all	1	31	8.42%	2.7%
2016	OTB_CRU_70-99_0_0_all	209	546	44.89%	27.7%
	OTB_DEF_70-99_0_0_all	462	37	96.27%	92.6%
	TBB_DEF_70-99_0_0_all	37	70	50.67%	34.3%
2017	OTB_CRU_70-99_0_0_all/ MIS_MIS_0-0_HC /OTB_MCD_70-90_0_0_all	423	645	58.38%	39.6%
	OTB_DEF_70-99_0_0_all	356	42	94.55%	89.4%
	TBB_DEF_70-99_0_0_all	7	46	68.89%	13.2%

Table 11.3.3. ***Nephrops*** **in FU5: Mean length (mm) in landings (2003–2017) and discards (2015–2017)**

	Landings			Discards
Year	Females	Males	Unsexed	Unsexed
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	35.6	29.8
2016	na	na	35.5	29.2
2017	na	na	35.5	30.5

*** provisional na = not available**

Table 11.3.4. ***Nephrops*** **in FU5: Landings, effort and LPUE for directed fisheries.**

	Landings tonnes	Effort Boat Days Fished	LPUE median tonnes per day
2000	20.829	10	1.85285
2001	39.2088	17	1.6
2002	99.0556	37	1.325
2003	107.8163	38	2.0868
2004	168.3099	60	1.6664
2005	100.4709	40	0.8209
2006	303.2799	335	0.8535
2007	411.0746	338	1.2402
2008	382.5	414	0.81345
2009	223.6667	225	0.9184
2010	343.8314	302	1.0658
2011	305.6628	231	1.1991
2012	420.6906	330	1.1411
2013	210.4645	238	0.7629
2014	395.3496	337	1.0333
2015	429.6048	371	1.11
2016	954.8456	716	1.2041
2017	553.0967	453	1.1206

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

Table 11.4.1. ***Nephrops*** **in FU 6: Nominal Landings (tonnes) of** ***Nephrops*****, 1981–2017, 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
2016	1726	125	1851	3	1854
2017*	1534	260	1794	18	1812

*** provisional na = not available**

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

Table 11.4.2. ***Nephrops*** **in FU 6: Landings and effort by English vessels targeting** ***Nephrops***

Year	<10 m			10–15 m			>15 m		
	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	195	1565	125	126	647	195	242	901	269
2016	486	2707	180	201	897	224	383	1287	298
2017	438	2216	198	184	774	238	364	1025	355

Table 11.4.3. ***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
2016	31.2	31.3	33.3	34.3
2017	33.3	33.1	34.9	35.2

Table 11.4.4. ***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
2016	110	Summer	0.22	697	19	Geostatistics
2017	110	Summer	0.29	902	21	Geostatistics

Table 11.4.5. ***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%
2016	697	1854	28.65%	27.97	10.23	93	13.3%
2017	902	1812	18.58%	31.53	10.75	71	7.8%

Table 11.5.1. ***Nephrops*****, Fladen (FU 7), Nominal Landings (tonnes) of** ***Nephrops*****, 1981–2017, 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	3928	206	0	4134	10	3	4147
2015	1465	307	0	1772	8	4	1784
2016	2021	374	0	2395	2	2	2399
2017*	2853	2291	0	5144	1	2	5147

*** provisional na = not available**

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

Table 11.5.2. ***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, 2000–2017.**

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	1772	10562	167.8
2016	2395	12297	194.8
2017*	5144	15205	338.3

*** Provisional**

Table 11.5.3. ***Nephrops*****, Fladen (FU 7): Logbook recorded effort (kW days) and LPUE (kg/kW day) for bottom trawlers catching** ***Nephrops*** **with cod end mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2017.**

Year	**Logbook data**	
	Effort	Lpue
1991	2522342	0.168
1992	1965624	0.183
1993	663625	0.338
1994	1044387	0.373
1995	716551	0.613
1996	538889	0.531
1997	283424	0.829
1998	210432	0.822
1999	153844	0.624
2000	266899	0.386
2001	142374	0.450
2002	217053	0.797
2003	105864	0.775
2004	212114	0.641
2005	430272	0.746
2006	363866	0.778
2007	160590	0.741
2008	121981	1.090
2009	114319	1.137
2010	129625	0.957
2011	67864	0.943
2012	129148	0.581
2013	130833	0.038
2014	168866	0.059
2015	70415	0.114
2016	117517	0.013
2017	135650	0.011

Table 11.5.4. *Nephrops*, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1993–2017.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1993	na	na	30.4	29.6	38.7	38.2
1994	na	na	30.0	28.9	39.2	37.8
1995	na	na	30.6	29.8	39.9	38.1
1996	na	na	30.4	29.1	40.6	38.8
1997	na	na	30.2	29.1	40.9	38.8
1998	na	na	30.8	29.4	40.7	38.3
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	411.5	39.2
2015	32.3	31.2	32.3	31.2	41.5	40.0
2016	32.0	31.0	32.0	31.0	41.2	40.6
2017	29.5	29.1	29.7	29.4	41.4	39.7

na = not available

Table 11.5.5. ***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
2016	39.43	23.62	26.83	33.51	35.61
2017	25.37	23.07	26.34	42.94	27.67
Mean (15–17)	31.71*	22.84	27.42	31.76**	-

*** Mean weight for Fladen based on 2000–2017 range**

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

na = not available

Table 11.5.6. ***Nephrops*****, Fladen (FU 7): Results of the 1992–2017 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
2016	78	4449	0.16	662
2017	71	7036	0.25	968

Table 11.5.7. ***Nephrops*****, Fladen Ground (FU 7): Summary of TV results for most recent 3 years (2015–2017) 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
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
2016 TV survey							
>80	3248	11	0.238	0.007	772	7067	0.065
55<80	4967	15	0.254	0.022	1261	36692	0.335
40<55	4304	14	0.197	0.009	849	11754	0.107
<40	15634	38	0.100	0.008	1566	54022	0.493
Total	28153	78			4449	109535	1
2017 TV survey							
>80	3248	10	0.479	0.026	1557	27941	0.119
55<80	4967	15	0.392	0.043	1947	71354	0.305
40<55	4304	10	0.258	0.008	1109	15396	0.066
<40	15634	36	0.155	0.018	2422	119582	0.51
Total	28153	71			7036	234273	1

Table 11.5.8. ***Nephrops*****, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2017.**

year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard rate
1992	3661	376	3.1	114	NA	NA	3363	NA	0	NA	29.61	NA	NA
1993	4450	569	3.1	138	NA	NA	3492	NA	0	NA	25.38	NA	NA
1994	6170	814	3.1	193	NA	NA	4568	NA	0	NA	23.72	NA	NA
1995	4987	896	4.7	233	NA	NA	6419	NA	0	NA	27.51	NA	NA
1996	NA	NA	NA	175	NA	NA	5210	NA	0	NA	29.82	NA	NA
1997	2767	510	7	192	NA	NA	6170	NA	0	NA	32.08	NA	NA
1998	3838	717	4.3	164	NA	NA	5136	NA	0	NA	31.37	NA	NA
1999	4146	649	5.1	213	NA	NA	6518	NA	0	NA	30.55	NA	NA
2000	3628	491	4.7	153	21	169	5570	340	255	12	36.35	16.24	9.3
2001	4981	970	5.1	221	43	253	5542	687	515	16.3	25.1	15.94	12.8
2002	6087	757	4.9	259	55	301	7245	820	615	17.4	27.93	14.97	13.7
2003	5547	1076	4.1	209	24	226	6294	349	262	10.1	30.15	14.83	7.8
2004	5725	1030	5.4	282	34	307	8730	506	379	10.6	30.98	15.06	8.2
2005	4325	662	9.3	368	46	403	10684	823	617	11.2	29.05	17.74	8.6
2006	4862	619	8.4	369	54	409	10791	798	599	12.7	29.25	14.87	9.8
2007	7017	730	7	447	55	488	11911	747	560	10.9	26.63	13.67	8.4
2008	7360	1019	6.1	434	18	448	12239	257	192	3.9	28.18	14.54	3.0
2009	5457	772	9.4	473	51	511	13327	707	530	9.7	28.20	13.85	7.5
2010	5224	711	9.9	492	34	517	12968	560	420	6.5	26.38	16.44	4.9
2011	3382	435	6.2	209	0	209	7559	0	0	0	36.17	NA	0
2012	2748	392	4.7	128	0	128	4415	0	0	0	36.91	NA	0
2013	2902	335	3.1	89	0	89	2951	0	0	0	34.90	NA	0
2014	2990	412	3.5	102	3	104	4147	37	28	2.5	43.11	13.9	1.9
2015	2569	320	2	51	0	51	1784	0	0	0	36.7	NA	0
2016	4449	662	1.4	63	0	63	2399	0	0	0	39.43	NA	0
2017	7036	968	3.1	212	10	219	5147	115	86	4.4	25.37	11.66	3.4

Table 11.6.1 *Nephrops*. Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981–2017, as reported to the WG.

Year	UK Scotland					UK	Total **
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	
1981	947	60	0	0	1007	0	1007
1982	1138	57	0	0	1195	0	1195
1983	1681	43	0	0	1724	0	1724
1984	2078	56	0	0	2134	0	2134
1985	1907	61	0	0	1968	0	1968
1986	2204	59	0	0	2263	0	2263
1987	1583	90	2	0	1675	0	1675
1988	2455	74	0	0	2529	0	2529
1989	1834	53	0	0	1887	1	1888
1990	1900	30	0	0	1930	1	1931
1991	1362	43	0	0	1405	0	1405
1992	1715	41	0	0	1756	0	1756
1993	2349	17	0	0	2366	2	2368
1994	1827	17	0	0	1844	6	1850
1995	1707	53	0	0	1760	2	1762
1996	1621	66	0	0	1687	0	1687
1997	2136	55	0	0	2191	2	2193
1998	2105	37	0	0	2142	2	2144
1999	2193	10	1	0	2204	3	2207
2000	1775	9	0	0	1784	1	1785
2001	1484	34	0	0	1518	9	1527
2002	1302	31	1	0	1334	6	1340
2003	1116	8	0	0	1124	3	1127
2004	1650	4	0	0	1654	3	1657
2005	1974	0	4	0	1978	11	1989
2006	2438	3	12	0	2453	5	2458
2007	2627	10	7	0	2644	7	2651
2008	2435	2	8	0	2445	5	2450
2009	2620	8	26	0	2654	9	2663
2010	1923	5	13	0	1941	9	1950
2011	1789	6	89	0	1884	5	1889
2012	1944	17	126	0	2087	42	2129
2013	1409	24	58	0	1491	12	1503
2014	2344	4	14	0	2362	22	2384
2015	1784	2	43	0	1829	68	1897
2016	1786	1	116	1.5	1905	32	1937
2017*	2406	16	10	0	2432	61	2493

*** provisional na = not available**

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

Table 11.6.2 ***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, 2000–2017.**

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	2348	6812	344.7
2015	1786	6024	296.5
2016	1787	5224	342.1
2017*	2422	5261	460.4

*** provisional na = not available**

Table 11.6.3 *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, 1981–2017.

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
2016	29.3	28.6	30.5	29.7	39.4	38.5
2017	29.6	28.1	30.9	29.3	38.5	38.9

na = not available

Table 11.6.4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1993–2017 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
2017	52	0.73	670	133

Table 11.6.5. ***Nephrops*****, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2015–2017) 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
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			664	4050	1
2016 TV survey							
M & SM	170	9	0.832	0.431	142	1391	0.262
MS(west)	139	7	0.495	0.183	69	506	0.095
MS(mid)	211	12	1.234	0.393	260	1451	0.273
MS(east)	395	22	0.826	0.278	326	1972	0.371
Total	915	50			797	5320	1
2017 TV survey							
M & SM	170	10	0.505	0.263	86	765	0.172
MS(west)	139	9	0.597	0.350	83	751	0.169
MS(mid)	211	11	0.921	0.366	194	1478	0.333
MS(east)	395	22	0.777	0.204	307	1445	0.325
Total	915	52			670	4439	1

Table 11.6.6. ***Nephrops*****, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2017.**

year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard rate
1993	555	142	24.1	97	49	134	2368	426	426	33.3	24.3	11.64	27.3
1994	448	78	51.3	95	180	230	1850	1188	1188	65.5	19.51	8.79	58.8
1995	NA	NA	NA	90	59	134	1762	465	465	39.5	19.55	10.54	32.9
1996	375	88	37.3	81	78	140	1687	697	697	49.2	20.81	11.85	42.1
1997	NA	NA	NA	116	56	158	2193	371	371	32.6	18.87	8.79	26.6
1998	292	81	55.7	118	60	163	2144	434	434	33.9	18.23	9.6	27.8
1999	463	78	39.6	110	97	183	2207	704	704	47	20.05	9.63	39.9
2000	443	70	33.7	82	90	150	1785	774	774	52.5	21.83	11.42	45.3
2001	419	79	25.3	72	45	106	1527	327	327	38.7	21.22	9.59	32.1
2002	508	119	21.1	68	52	107	1340	316	316	43.1	19.62	8.16	36.2
2003	767	138	12.4	51	59	95	1127	546	410	53.9	22.31	9.25	46.7
2004	630	140	16.4	74	40	103	1657	406	304	34.9	22.45	10.25	28.7
2005	710	143	19.4	89	65	138	1989	602	452	42.1	22.33	9.28	35.3
2006	827	126	26.7	115	142	221	2458	1510	1133	55.2	21.43	10.67	48.1
2007	692	132	22.9	126	43	159	2651	614	461	25.3	20.97	14.34	20.3
2008	881	297	21.1	142	58	186	2450	796	597	29.1	17.23	13.65	23.5
2009	732	142	26	137	71	190	2663	573	430	34.1	19.41	8.09	27.9
2010	682	147	19.2	99	43	131	1950	407	305	30.2	19.76	9.55	24.5
2011	533	87	22.1	100	24	118	1889	231	173	19.5	19.75	9.56	15.3
2012	522	64	24.6	100	38	129	2129	379	284	27.2	21.66	10.10	21.9
2013	668	126	15.6	81	31	104	1503	301	226	27.4	19.30	9.82	22.0
2014	428	80	29.1	102	30	124	2384	353	265	22.9	24.30	11.66	18.3
2015	664	127	16.8	90	29	112	1897	311	234	24.4	21.84	10.74	19.5
2016	797	146	12.3	85	17	98	1937	165	123	16.4	23.62	9.86	12.8
2017	670	133	19.7	111	28	132	2493	280	210	20	23.07	10.07	15.8

Table 11.7.1. ***Nephrops*****, Moray Firth (FU 9), Nominal Landings (tonnes) of** ***Nephrops*****, 1981–2017, as reported to the WG.**

Year	UK Scotland				UK *	Total **
	Nephrops trawl	Other trawl	Creel	Sub-total	England	
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	1183	56	2	1241	12	1253
2015	774	40	0	814	2	816
2016	1105	37	4	1146	<0.5	1146
2017*	931	183	4	1118	1	1119

*** provisional na = not available**

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

Table 11.7.2. ***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, 2000–2017**

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	1239	4099	302.3
2015	814	3755	216.8
2016	1142	3577	319.3
2017*	1114	5044	220.9

*** provisional na = not available**

Table 11.7.3. *Nephrops*, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1991–2017.

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
2016	29.3	28.6	30.7	29.8	40.1	38.5
2017	30.6	29.6	30.7	29.8	40.0	39.7

na = not available

Table 11.7.4. ***Nephrops*****, Moray Firth (FU 9): Results of the 1993–2016 TV surveys**

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995				no survey
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84
2016	53	0.18	388	87
2017	55	0.19	412	106

Table 11.7.5. ***Nephrops*****, Moray Firth (FU 9): Summary of TV results for most recent 3 years (2015–2017) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum	**Area** (km^2)	**Number of Stations**	**Mean burrow density** (no./m^2)	**Observed variance**	**Abundance** (millions)	**Stratum** variance	**Proportion of total variance**
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
2016 TV survey							
M & SM	169	2	0.33	0.01	55	176	0.093
MS(west)	682	18	0.14	0.04	98	913	0.479
MS(mid)	698	16	0.16	0.01	112	285	0.15
MS(east)	646	17	0.19	0.02	124	529	0.278
Total	2195	53			388	1903	1
2017 TV survey							
M & SM	169	2	0.38	0.03	64	356	0.126
MS(west)	682	19	0.19	0.06	128	1393	0.495
MS(mid)	698	17	0.16	0.01	111	364	0.129
MS(east)	646	17	0.17	0.03	109	701	0.249
Total	2195	55			412	2813	1

Table 11.7.6. ***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 2003–2017.**

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
1993	345	78	26.5	77	19	91	1809	214	161	19.8	23.42	11.26	15.6
1994	702	176	11.4	69	15	80	1537	153	115	17.8	22.25	10.21	14
1995	NA	NA	NA	62	72	116	1279	502	376	53.8	20.59	6.93	46.6
1996	465	90	21.1	68	41	98	1451	492	369	37.5	21.4	12.11	31
1997	262	55	33.3	71	22	87	1447	230	172	23.8	20.43	10.42	18.9
1998	323	95	18.1	50	11	58	1032	89	67	17.6	20.47	8.29	13.8
1999	400	87	12.8	46	6	51	1009	55	41	12	21.79	8.63	9.3
2000	386	98	20.1	61	23	78	1539	269	201	27.5	25.44	11.73	22.1
2001	345	112	19.3	58	11	66	1401	125	94	16.3	24.18	11.04	12.8
2002	521	121	11.7	41	27	61	1132	220	165	39.7	27.68	8.18	33.1
2003	730	314	7.1	46	7	52	1080	70	52	13.7	23.32	9.51	10.6
2004	626	186	10.5	48	23	66	1333	272	204	32.6	27.57	11.62	26.6
2005	869	198	8.8	67	12	76	1605	122	92	15.0	23.84	10.31	11.7
2006	445	124	20.1	81	12	90	1805	117	87	12.8	22.34	9.86	9.9
2007	531	156	16	80	7	85	1843	95	72	7.9	23.04	13.95	6.0
2008	481	151	13.7	60	8	66	1515	74	55	11.4	25.29	9.60	8.8
2009	415	140	11.6	45	4	48	1067	33	25	7.6	23.46	8.72	5.8
2010	406	115	11.5	39	10	47	1063	104	78	19.8	26.94	10.63	15.7
2011	372	161	18.9	63	10	70	1391	102	77	13.9	21.63	10.12	10.8
2012	299	90	13.7	37	6	41	866	54	41	13.2	23.16	9.72	10.3
2013	469	106	5.8	26	1	27	623	10	8	3.3	24.95	11.21	2.5
2014	331	90	14.7	43	7	49	1253	87	65	14.6	28.94	11.79	11.3
2015	347	84	9.1	28	5	32	816	56	42	15.1	29.1	11.35	11.8
2016	388	87	12.7	42	9	49	1146	95	71	18.0	26.83	10.16	14.2
2017	412	106	10.5	42	1	43	1119	12	9	2.6	26.34	10.74	2.0

Table 11.8.1. *Nephrops*, Noup (FU 10): Nominal landings (tonnes) of *Nephrops*, 1981–2017, 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	3	11	1	15	0	15
2015	1	14	0	15	0	15
2016	9	14	0	23	0	23
2017*	0	9	0	9	0	9

*** provisional**

Table 11.8.2. ***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, 2000–2017.**

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
2016	23	520	44.2
2017*	9	568	15.8

*** provisional**

Table 11.8.3. *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997–2017. No females in samples in 2010 and no sampling in 2015.

Year	Landings			
	< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females
1997	29.7	28.3	40.4	38.2
1998	30.4	29.8	38.8	38.6
1999	30.4	30.1	39.2	37.8
2000	31.8	30.1	38.2	39.1
2001	31.4	29.5	38.7	37.9
2002	30.8	29.9	39.7	38.5
2003	29.3	30.4	39.9	38.5
2004	31.4	30.0	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
2016	33.2	32.1	38.5	43.9
2017	31.0	31.6	38.0	41.5

na = not available

Table 11.8.4. ***Nephrops*****, Noup (FU 10): Results of the 1994, 1999, 2006, 2007 & 2014 TV surveys (absolute conversion factor = 1.35, from Fladen).**

Year	Stations	Mean density	Abundance	95% confidence interval
		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		
2016		no survey		
2017		no survey		

Table 11.9.1. *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993–2017, estimated Danish discards (2003–2017), and TAC (EU).

Year	Denmark	Danish discards		Norway			Sweden	UK	Netherlands	Total	TAC
		dead	live	Trawl	Creel	Sub-total					
1993	220			102	1	103		16		339	
1994	584			161	0	161		10		755	
1995	418			68	1	69		2		489	
1996	868			73	1	74		10		952	
1997	689			56	8	64		7		760	
1998	743			88	1	89		4		836	
1999	972			119	15	134		13		1119	
2000	871			143	0	143	37	34		1085	
2001	1026			72	13	85	26	53		1190	
2002	1043			42	21	63	13	52		1171	
2003	996	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
2016	80	1	0	7	90	97	0	0	1	178	1000
2017*	53	1	0	9	85	94	0	0	0	147	1000
2018											800

*** Provisional**

Table 11.9.2. ***Nephrops*** **Norwegian Deep (FU 32): Danish effort (kW days, days at sea, fishing days) and LPUE (kg/kW day) for bottom trawlers catching *Nephrops*, 1993–2017. Effort values were updated in 2016 and 2017.**

Year	kW days ('1000)	Days at sea	Fishing days	Lpue
1993	888	1974	1542	248
1994	1439	3572	2824	406
1995	1010	2464	1950	414
1996	1732	4000	3307	501
1997	1982	4189	3466	348
1998	1467	3245	2654	506
1999	2262	4658	3790	430
2000	2662	5068	4161	327
2001	3510	6426	5467	292
2002	3102	5737	4859	336
2003	3500	6294	5416	285
2004	2443	4298	3657	342
2005	2787	5078	4353	351
2006	3023	5274	4516	311
2007	1782	3052	2557	366
2008	1682	2623	2349	300
2009	1496	2334	2304	221
2010	1090	1795	1753	259
2011	1136	1840	1188	283
2012	907	1474	1265	258
2013	862	1449	1227	149
2014	752	1233	1105	190
2015	574	924	793	192
2016	462	728	644	173
2017	410	602	521	129

Table 11.10.1 *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
2016	430	642	201	320	43	1636
2017	423	511	197	336	5	1472

*** provisional na = not available**

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

Table 11.10.2. ***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 cod end mesh sizes of 70 mm or above, 1991–2015.**

Year	kW days	Days at sea	Fishing days	Lpue*
1991	596893.4	1365	1110	0.12
1992	530942.1	1373	1148	0.14
1993	626892.7	1438	1229	0.25
1994	387211.1	996	849	0.35
1995	377259.4	1070	857	0.42
1996	213421.5	636	541	0.35
1997	490283.3	1445	1157	0.56
1998	753395.8	2256	1758	0.44
1999	1169139	3400	2811	0.58
2000	1040670	3201	2535	0.52
2001	1250865	3835	3137	0.53
2002	1611737	4545	3648	0.48
2003	1598038	4722	3795	0.53
2004	1900334	5625	4415	0.58
2005	1084501	3275	2637	0.74
2006	959737.6	2703	2146	0.74
2007	773976.6	1972	1548	0.79
2008	453867.9	939	736	0.80
2009	287076.4	668	560	0.81
2010	246616.9	525	425	0.73
2011	345697.8	759	610	1.15
2012	297221.6	699	593	1.33
2013	239220.6	561	494	1.29
2014	375007.1	884	865	1.03
2015	281207.3	668	620	1.32
2016	391258.4	998	893	1.64
2017	382721.7	883	781	1.34

*** kg / kW days**

Table 11.11.1. ***Nephrops*****, Devil's Hole (FU 34): Nominal landings (tonnes) of** ***Nephrops*** **1986–2017 as reported to the WG. Scottish data only from 1986 to 2009.**

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-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	293	14	0	307	13			320
2015	383	18	0	401	39	<0.5		440
2016	738	6	0	744	36			780
2017*	400	122	0	522	28			550

*** Provisional**

Table 11.11.2. ***Nephrops*****, Devils Hole (FU 34): Landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with cod end mesh sizes of 70 mm or above, 2000–2017.**

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	401	1222	328.2
2016	744	1640	453.7
2017*	522	1088	479.8

*** Provisional**

Table 11.11.3. ***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, 2006–2017. Samples not available in 2012 and 2013.**

Year	Landings			
	< 35 mm CL		=> 35 mm CL	
	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	33.0	31.4	41.2	39.9
2016	31.7	30.6	41.0	39.1
2017	32.1	31.1	41.9	41.8

na = not available

Table 11.11.4. *Nephrops*, Devil's Hole (FU 34): Results of the 2003, 2005, 2009–12, 2014–2015 and 2017 surveys.

Year	Stations	Mean density	95% confidence interval
		burrows/m²	burrows/m²
2003	20	0.09	0.02
2004		no survey	
2005	29	0.09	0.04
2006		no survey	
2007		no survey	
2008		no survey	
2009	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
2016	no survey		
2017	16	0.09	0.04

Table 11.12.1. Summary of *Nephrops* Landings from the 4NotFU area, 2012–2017.

	Belgium	Denmark	France	Germany	Netherlands	Sweden	UK (England)	UK(Scotland)	Total
2012	57.1	27.1		131.7	128.0	0.1	43.5	202.0	532.5
2013	30.6	7.8		83.8	151.5	0.1	56.8	78.3	409.4
2014	50.6	30.9		115.1	69.2	0.1	28.4	98.2	392.5
2015	173.0	24.6		104.9	154.5	0.1	36.0	117.4	610.4
2016	217.0	22.9	-	218.6	289.7	0.1	53.3	164.0	965.6
2017	269.8	29.3		352.0	319.3	0.1	62.4	158.3	1,191.1

Table 11.12.2. Summary of *Nephrops* reported discards from the 4NotFU area, 2012–2017.

	Belgium	Denmark	France	Germany	Netherlands	Sweden	UK (England)	UK(Scotland)	Total
2012		18			-			-	-
2013		-			-			-	-
2014		0.5			-			-	0.5
2015		1.4			-			-	1.4
2016		0.1			550.6			1.8	552.5
2017		0.1			133.2			8.2	141.5

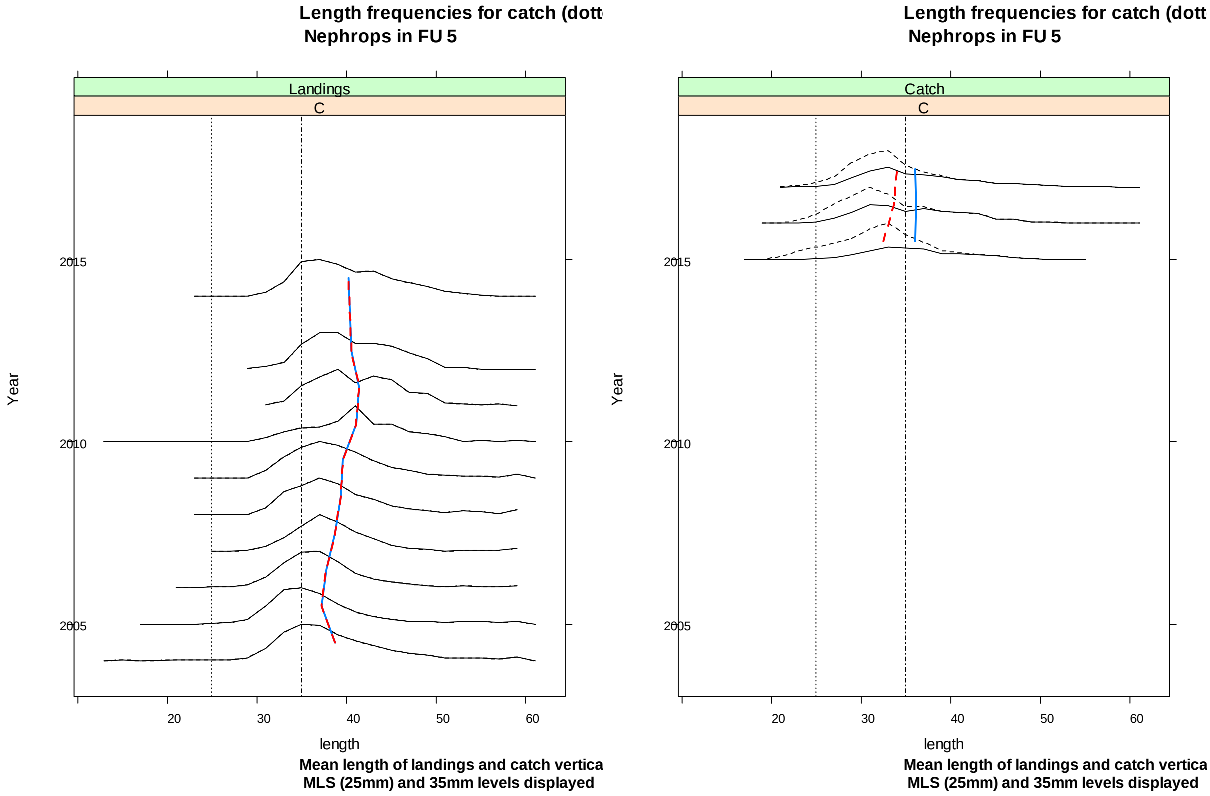


Figure 11.3.1. FU5 Botney Gut/Silver Pit: Size distribution for combined sex sampling from 2004 (bottom) to 2015 (top). Mean sizes of catch and landings (using same line types) is shown in relation to minimum landing size (MLS).

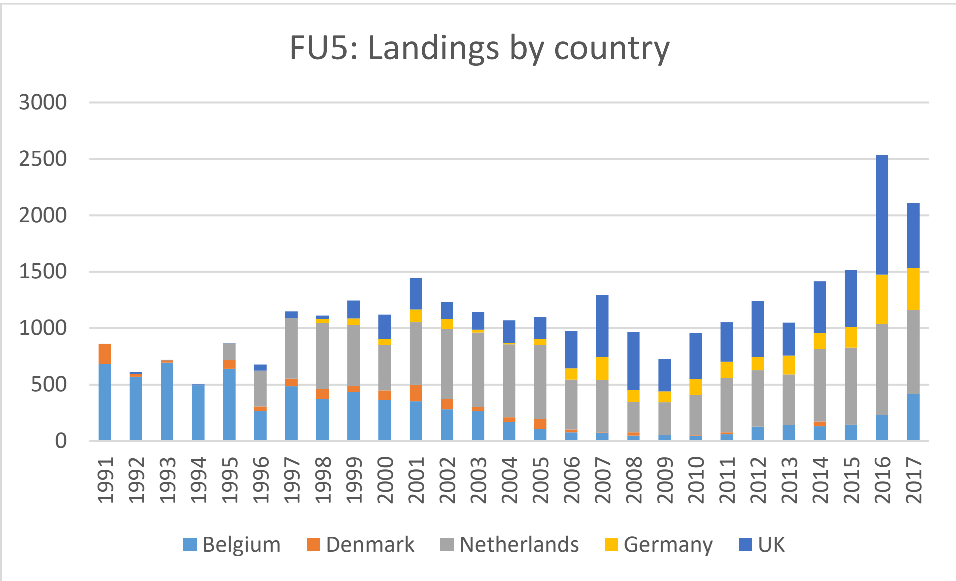


Figure 11.3.2. FU5 Botney Gut/Silver Pit: Temporal trend of landings by country

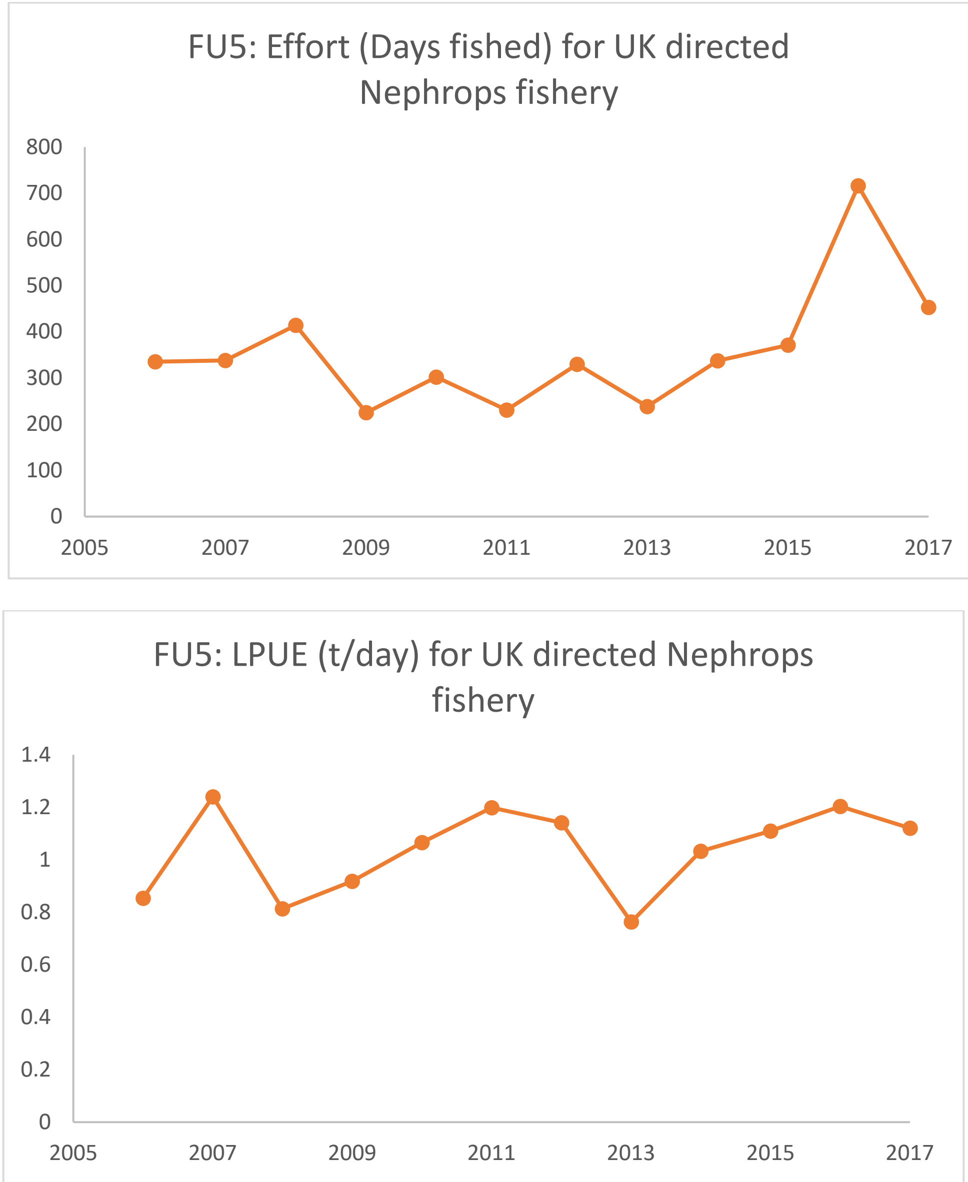


Figure 11.3.3. FU5 Botney Gut/Silver Pit: Long-term trends in fishing effort and LPUE for UK directed *Nephrops* vessels

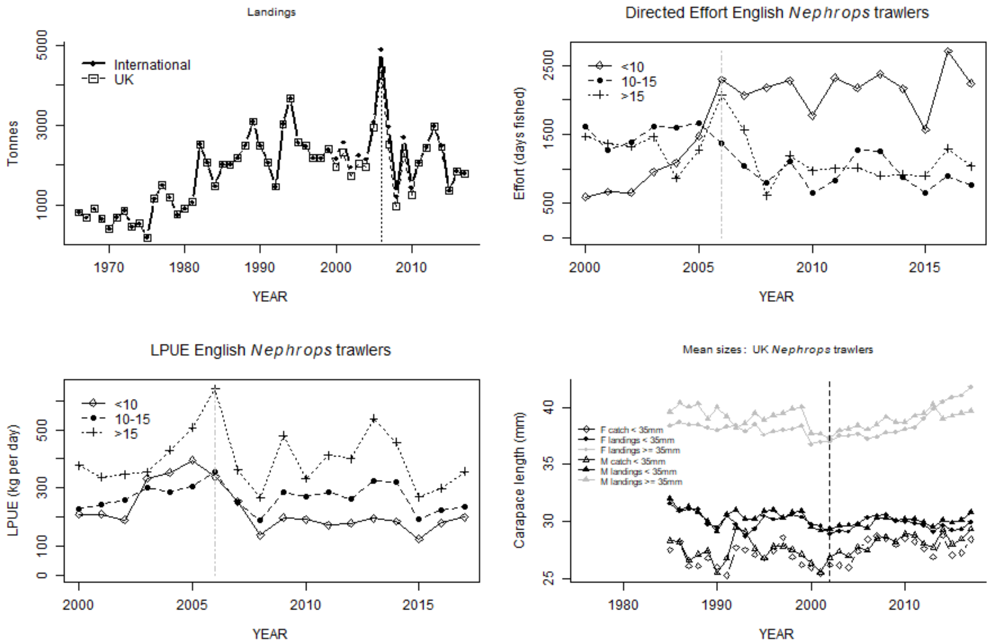


Figure 11.4.1. ***Nephrops*** **in FU6: Landings, directed effort, directed LPUE and mean sizes of different catch components.**

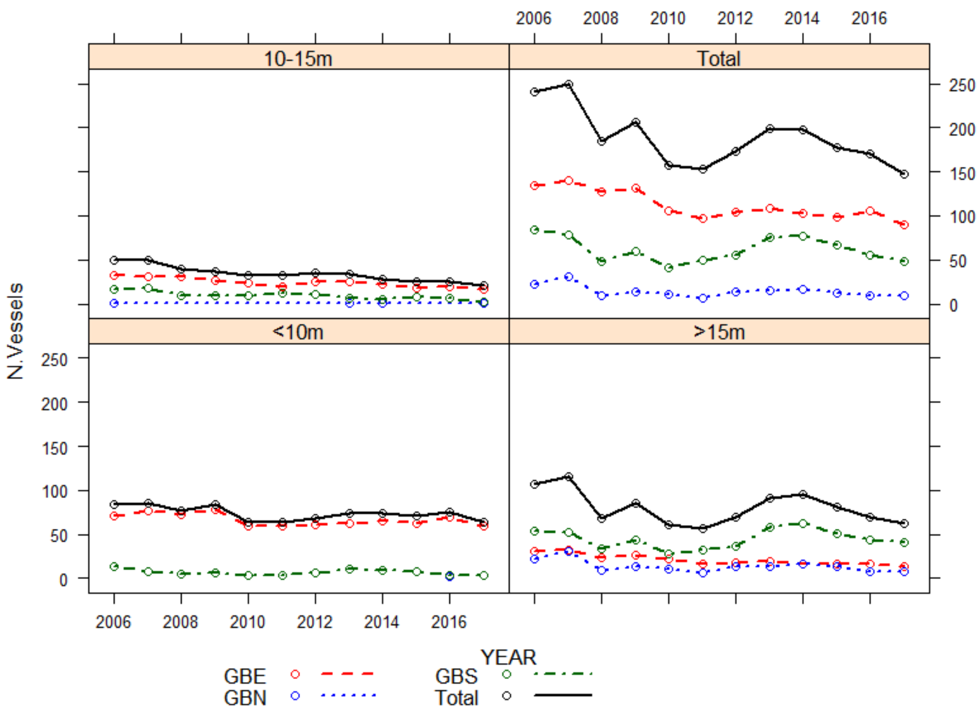


Figure 11.4.2. ***Nephrops*** **in FU6: Number of participating vessels (from UK) by vessel size category.**

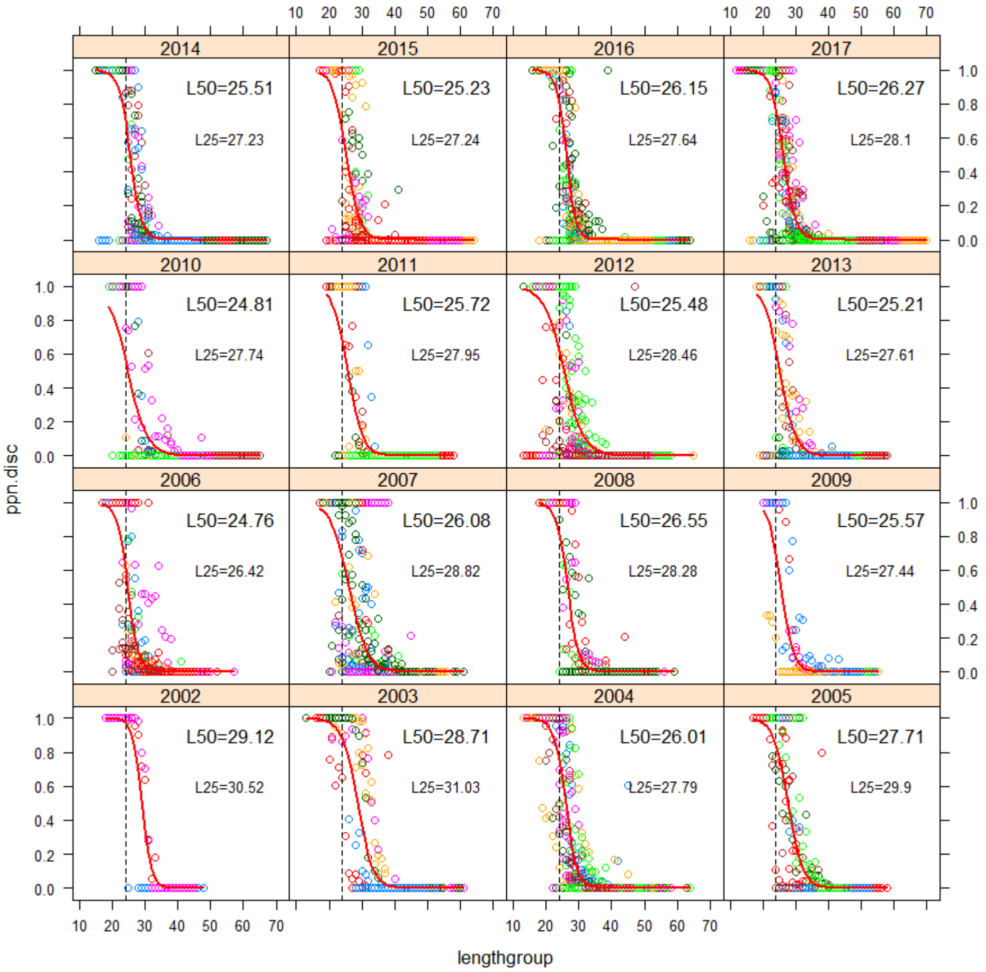


Figure 11.4.3. ***Nephrops*** **in FU6, annual discard ogives: The different point shapes represent different sampling trips within any year.**

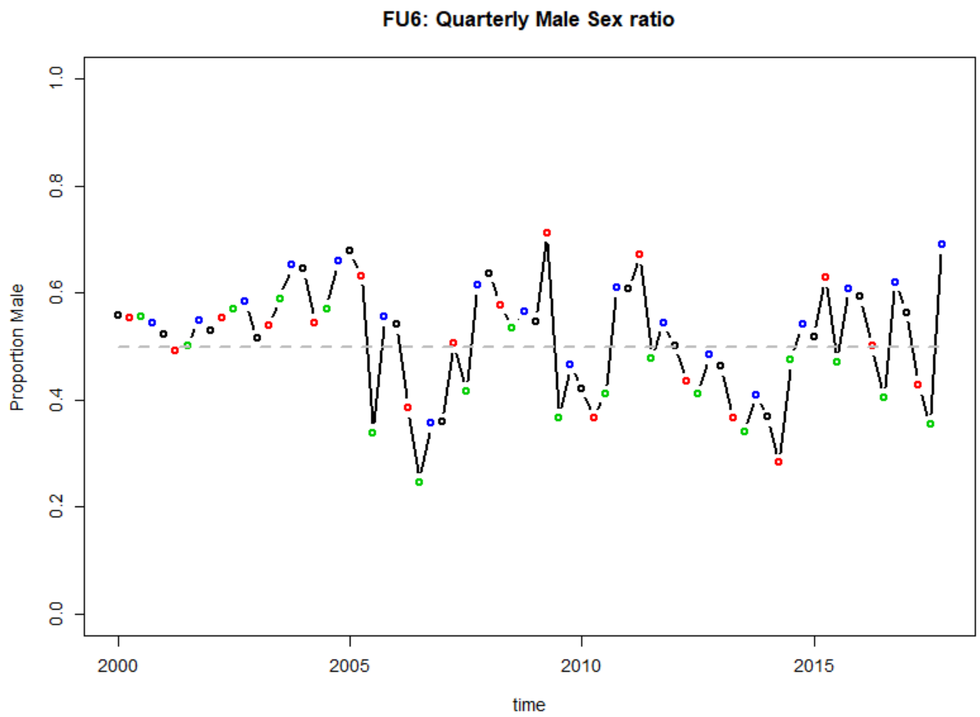


Figure 11.4.4. ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

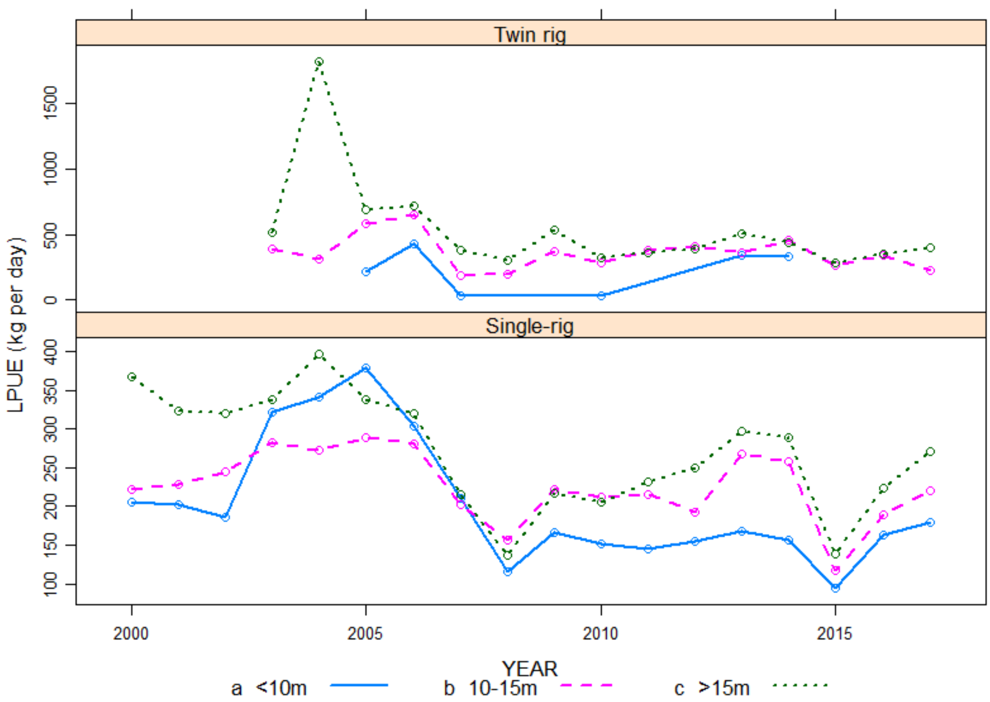


Figure 11.4.5. ***Nephrops*** **in FU6: Lpue for directed English trawlers by gear type and vessel size.**

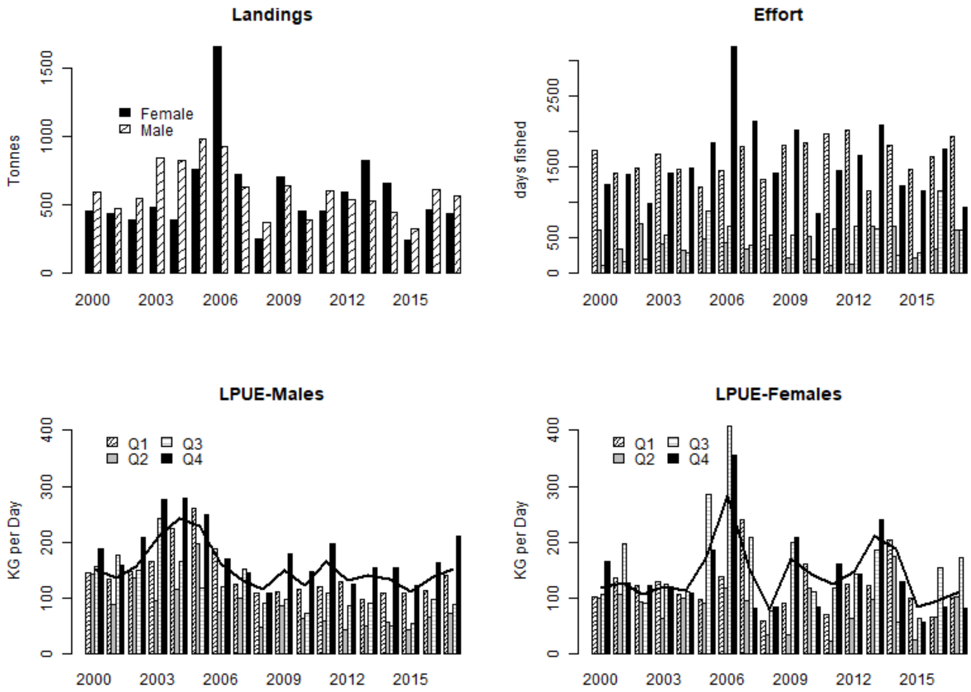


Figure 11.4.6. ***Nephrops*** **in FU6: Lpue by sex and quarter.**

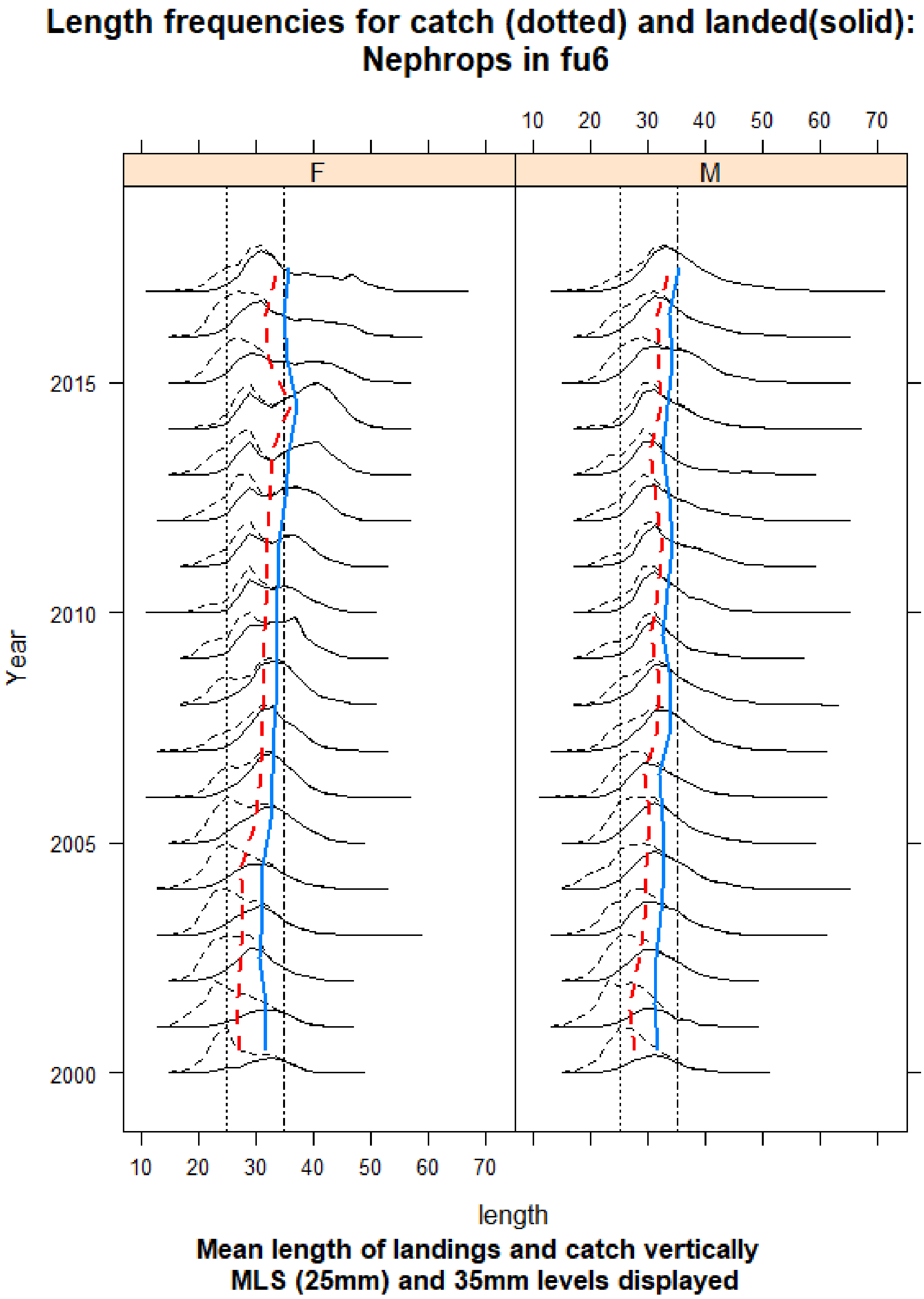


Figure 11.4.7. ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

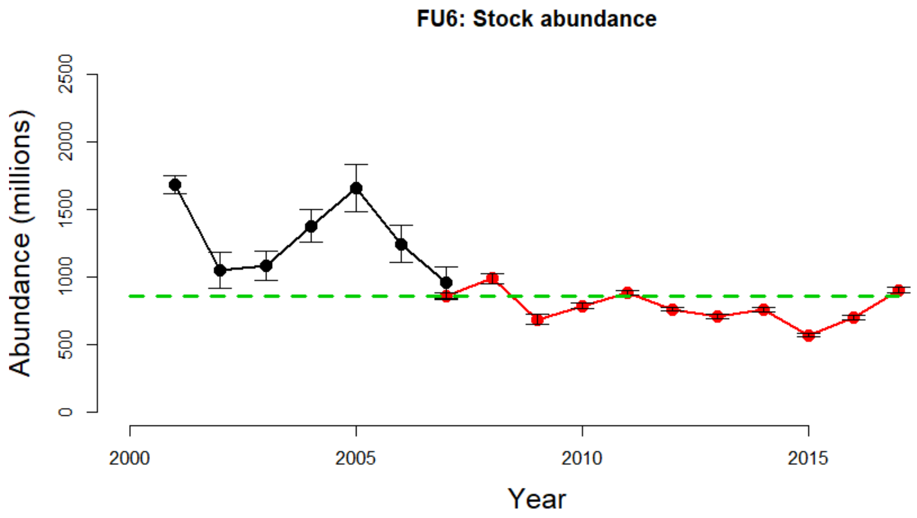


Figure 11.4.8. *Nephrops* in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the geostatistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.

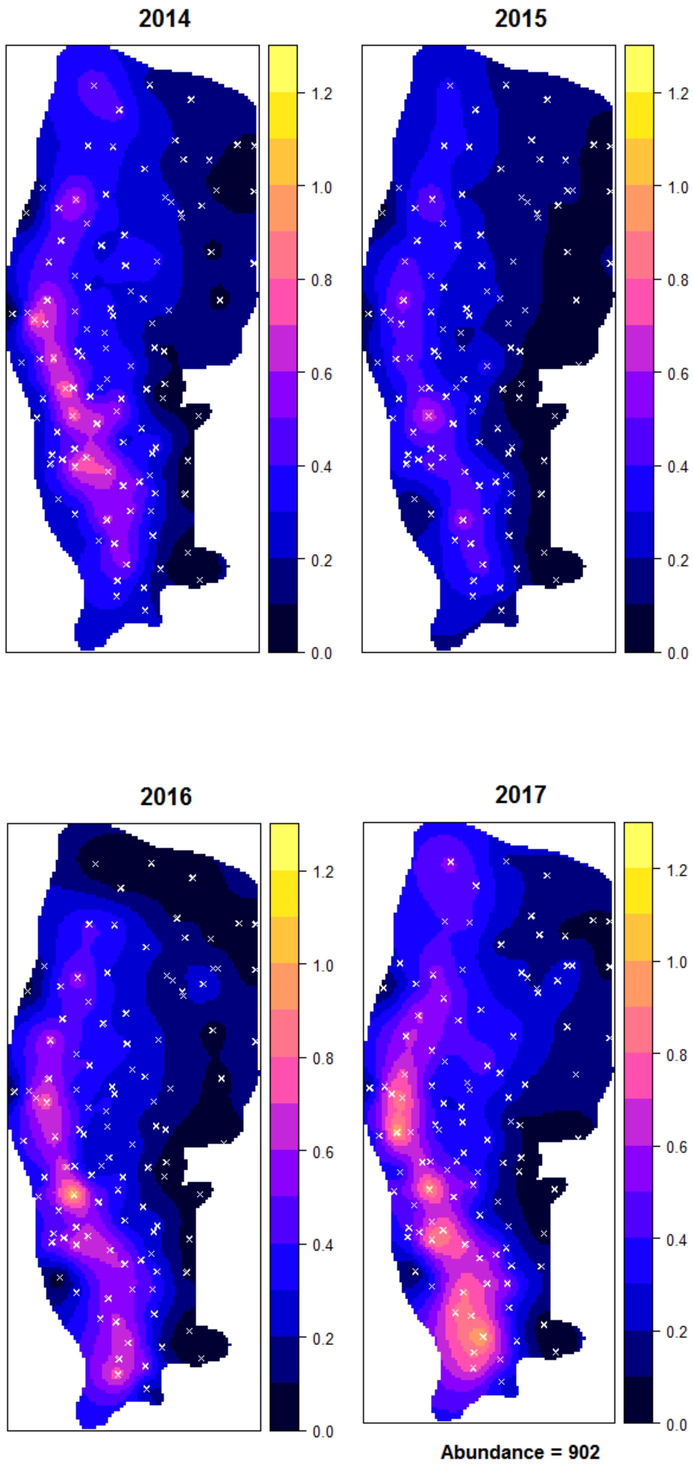


Figure 11.4.9. ***Nephrops*** **in FU6: Results of the UWTV survey.**

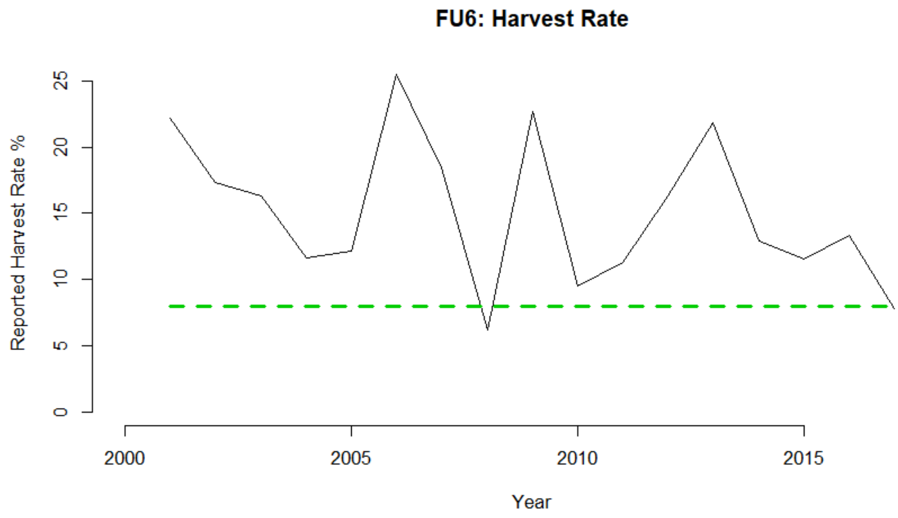


Figure 11.4.10. *Nephrops* in FU6: Observed harvest ratio (removals divided by abundance estimate).

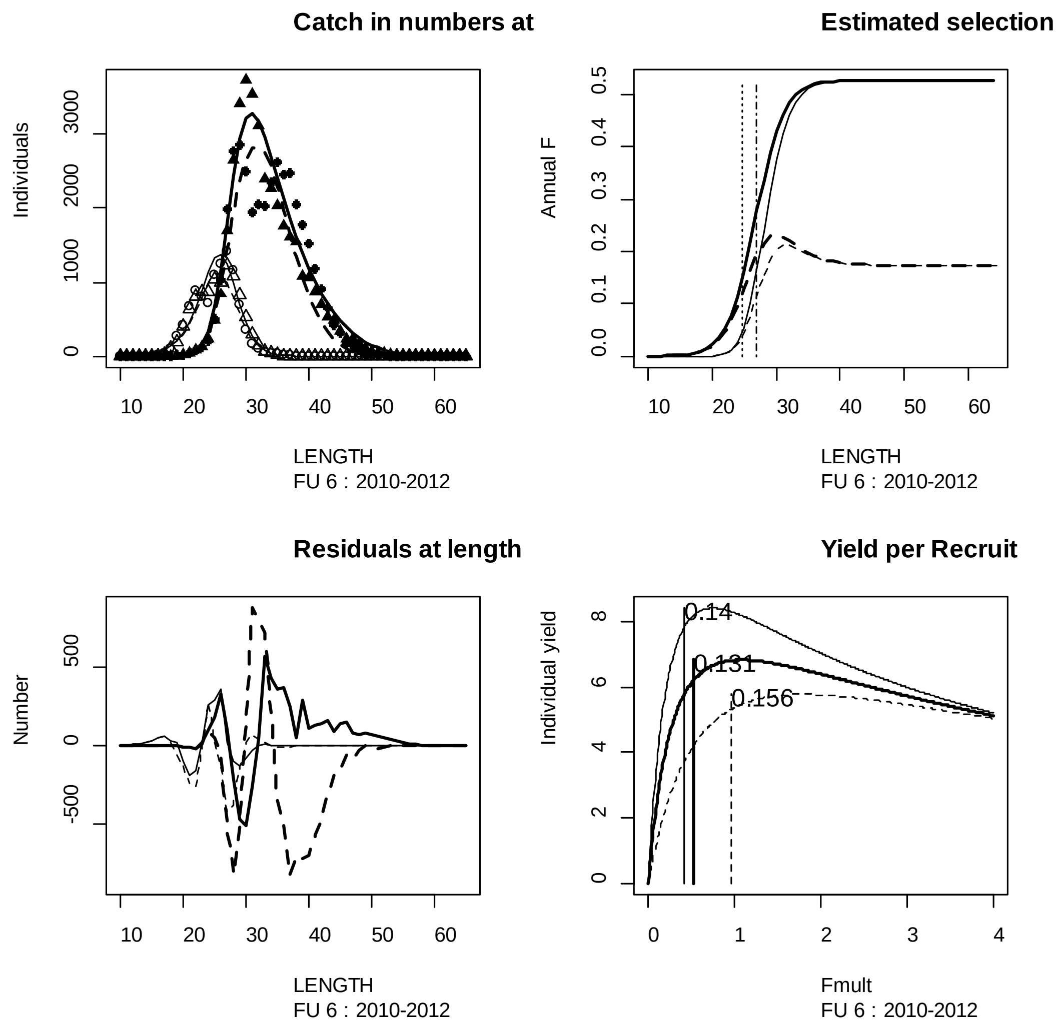


Figure 11.4.11. *Nephrops* in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed-expected) at length. The bottom right gives the Yield Per recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent $F_{0.1}$ for the three curves.

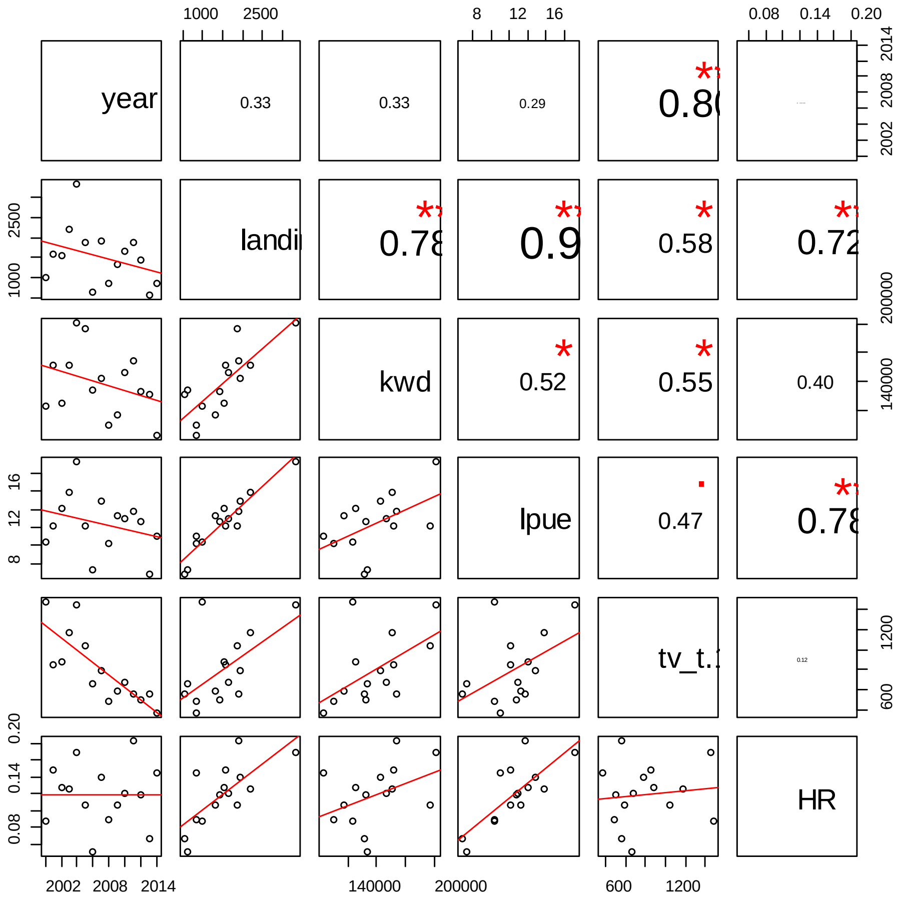


Figure 11.4.12. ***Nephrops*** **in FU6: 11.4.12 Scatterplot matrices of** ***Nephrops*** **metrics where the TV survey lagged by 1 year (i.e. TV survey in the year preceding the fishery statistics).**

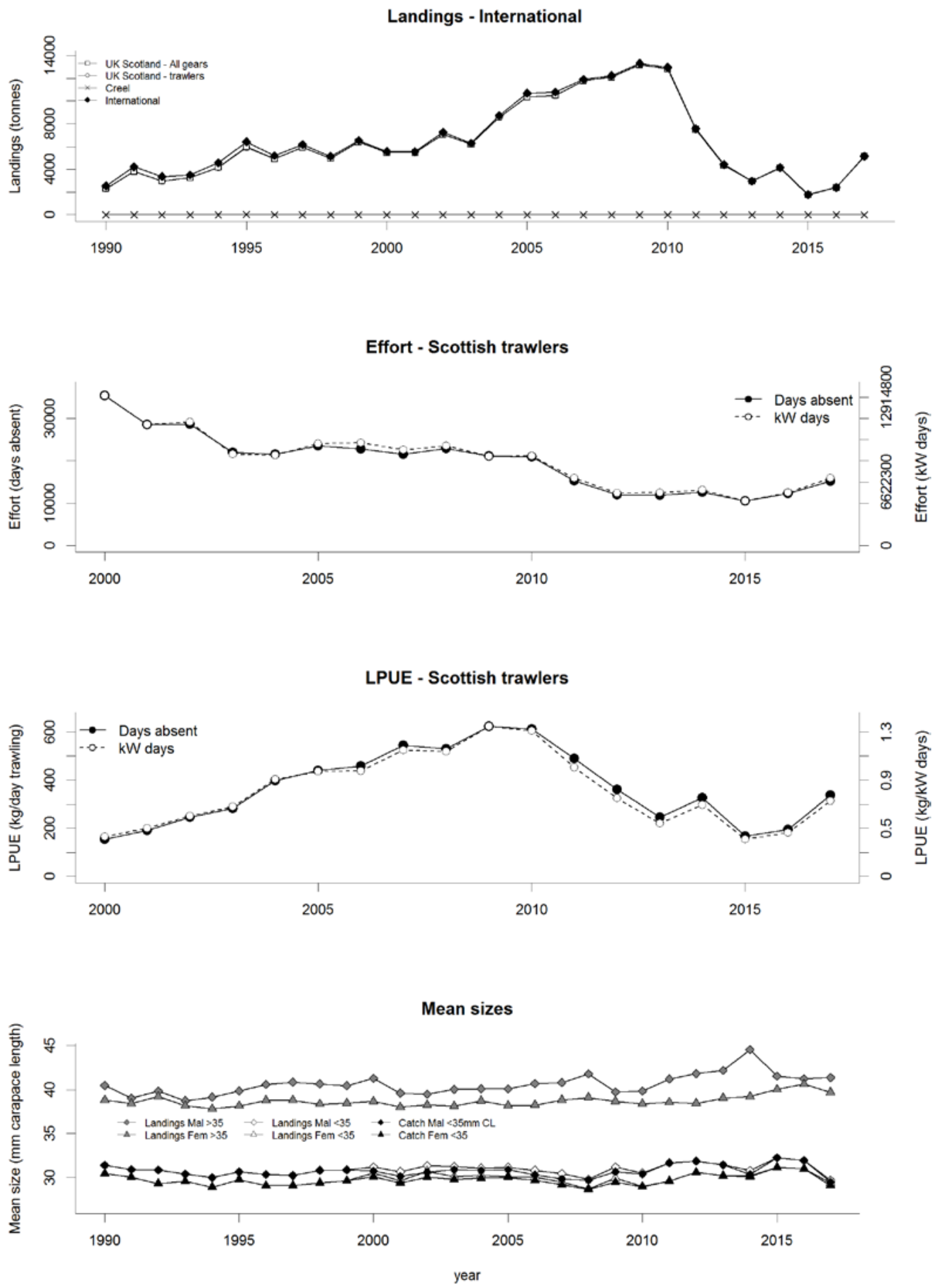
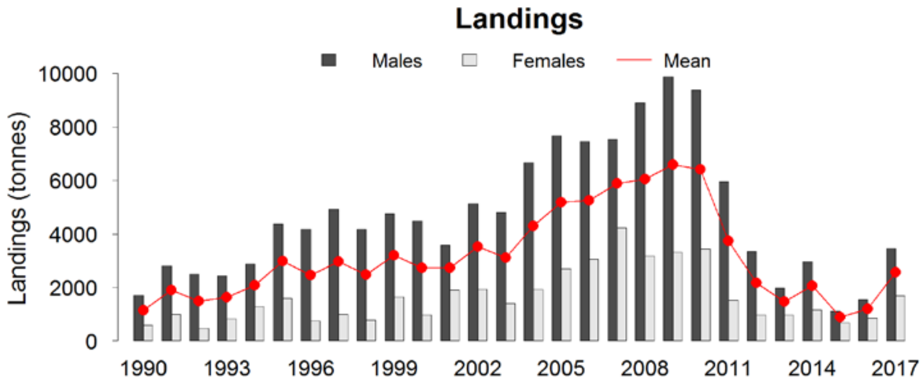


Figure 11.5.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2017.**



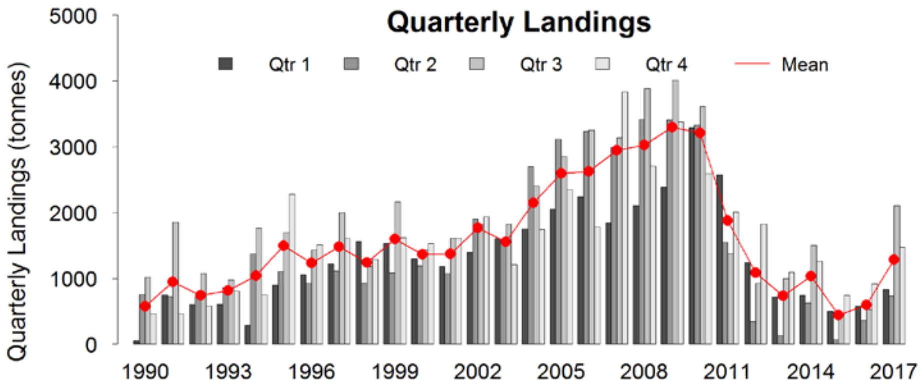


Figure 11.5.2 ***Nephrops*****, Fladen (FU 7), Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

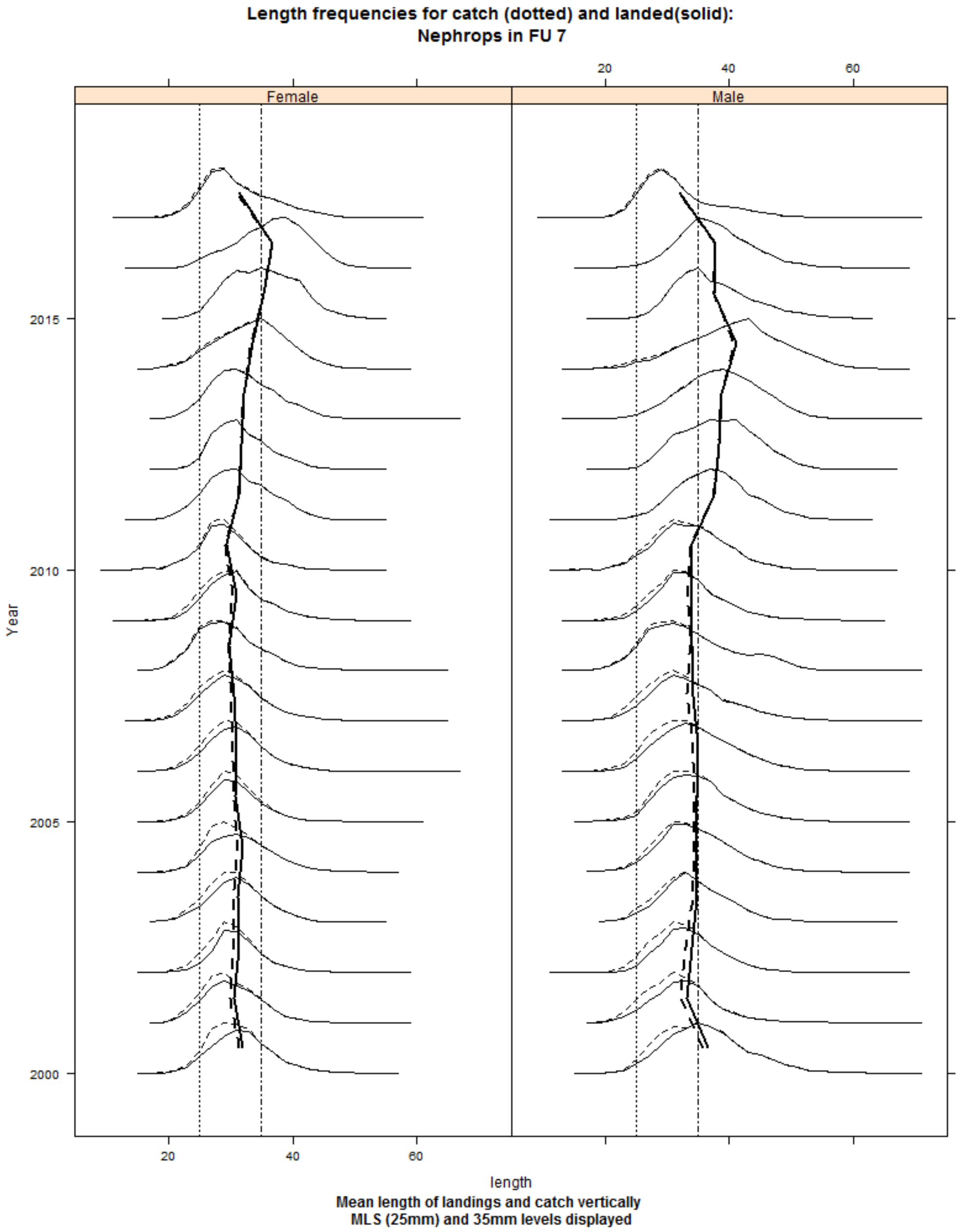
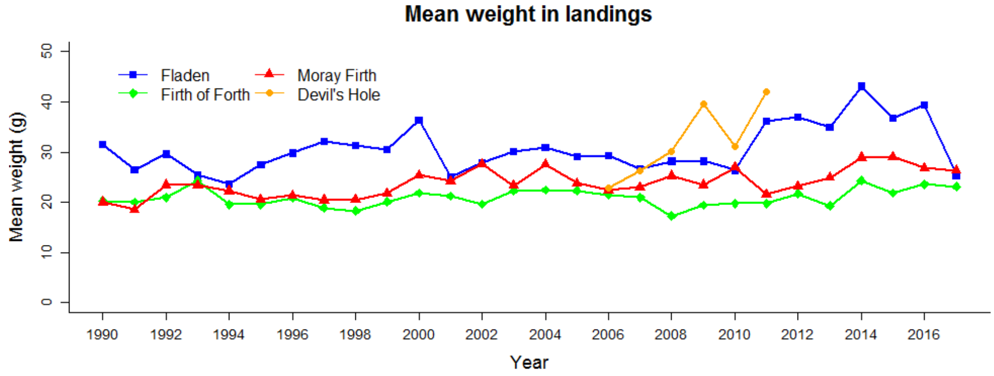


Figure11.5.3 *Nephrops* Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2017 (top). Mean sizes of catch and landings are displayed vertically.



11.5.4 *Nephrops*, (FUs 7–9 and 34, Fladen, Firth of Forth, Moray Firth and Devil's Hole). Individual mean weight (g) in the landings from 1990–2017 (Scottish market sampling data). FU 34 data only shown for 2006–2011.

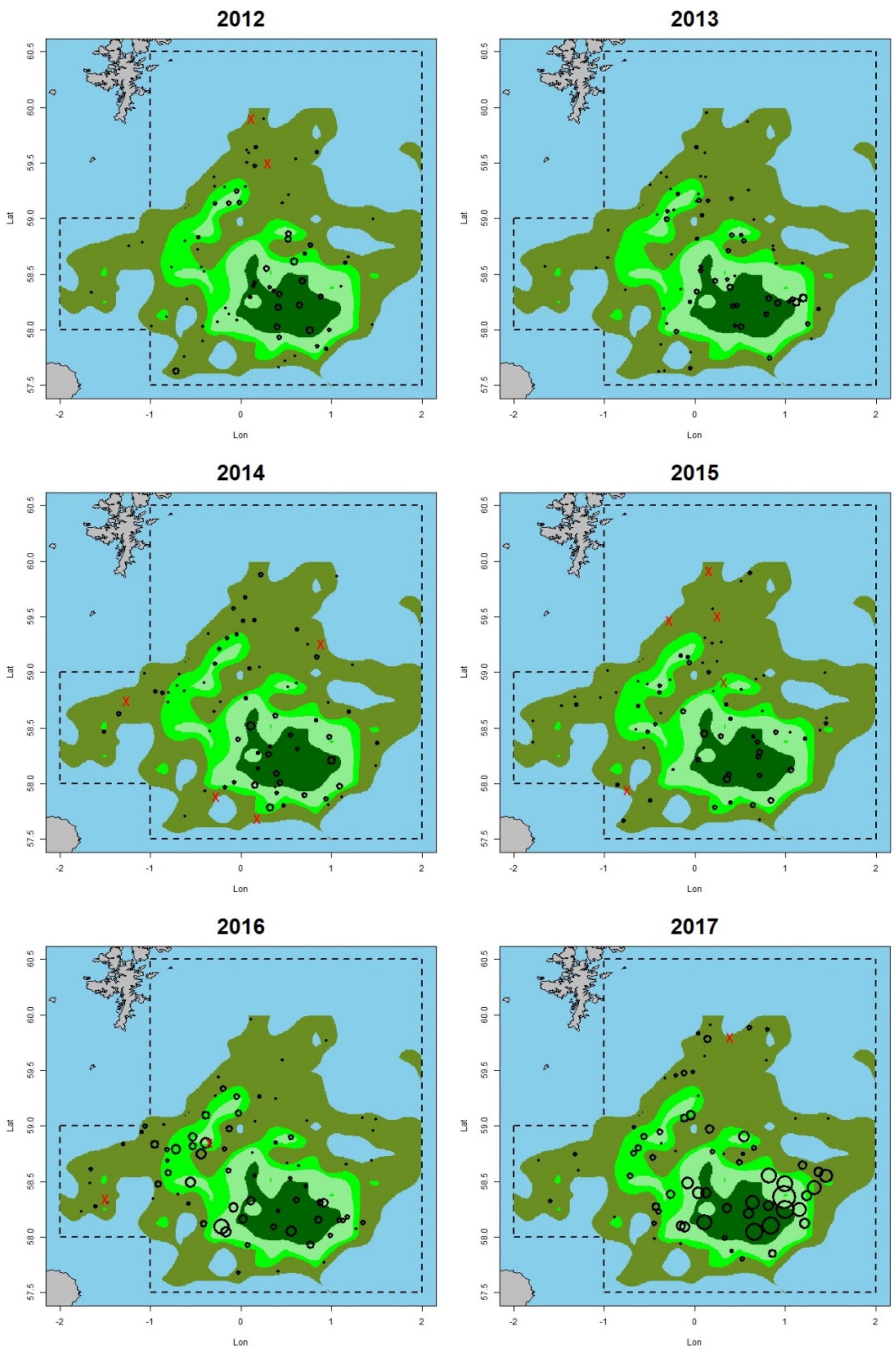


Figure 11.5.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2012–2017). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

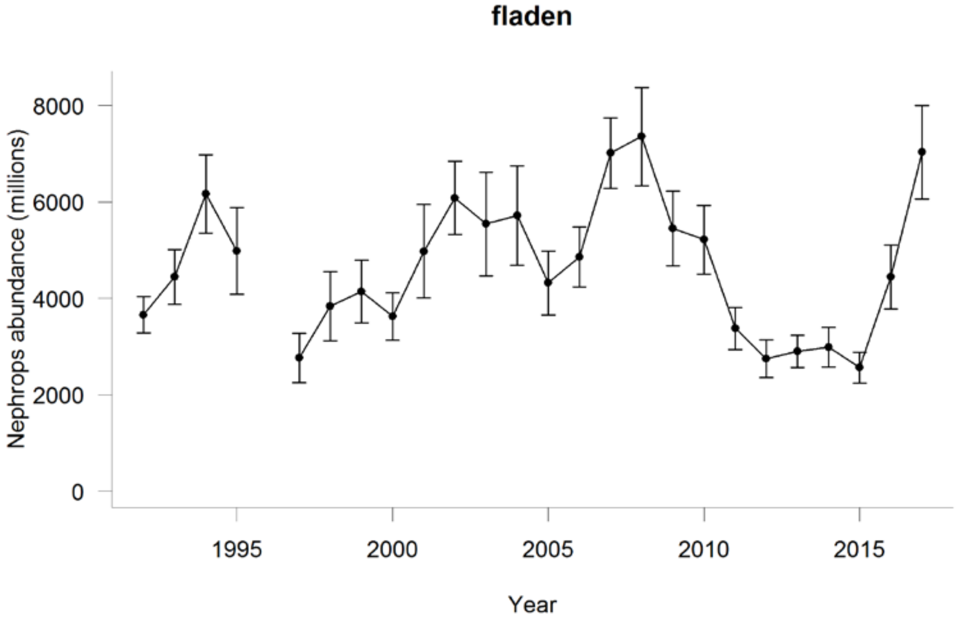


Figure 11.5.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates with 95% confidence intervals, 1992–2017.**

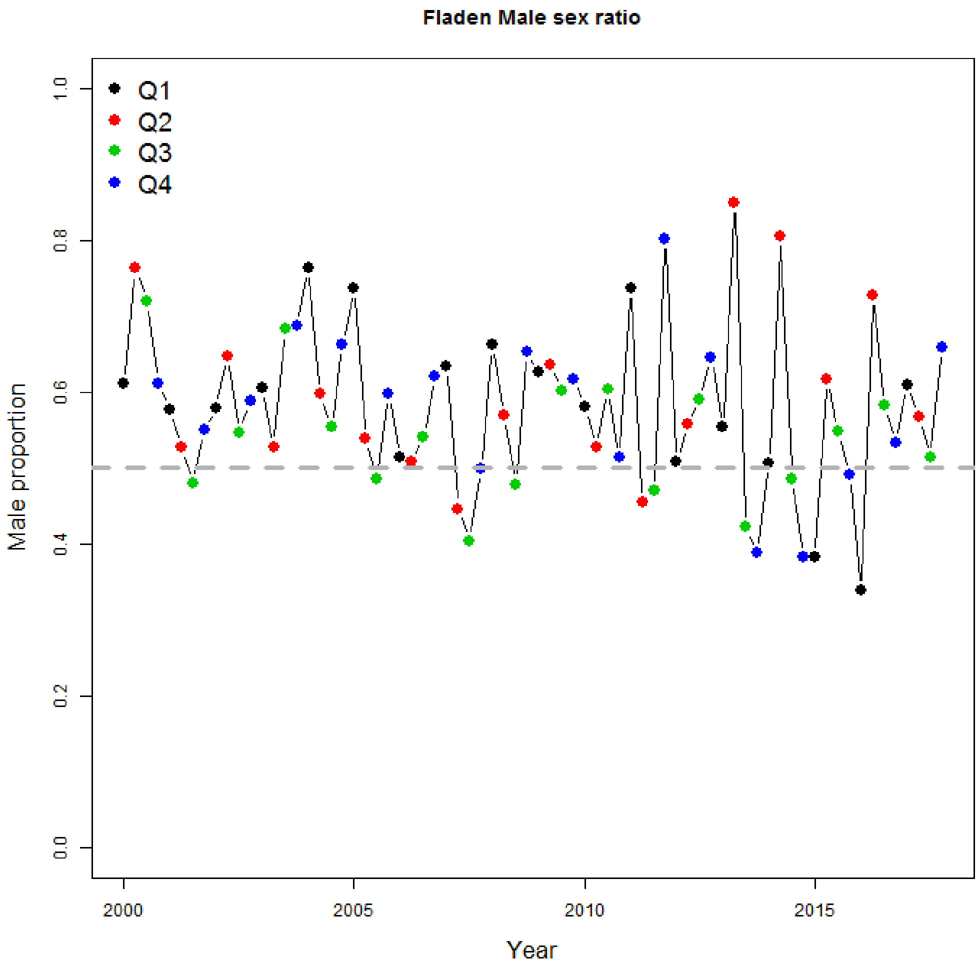


Figure 11.5.7 ***Nephrops*****, Fladen (FU 7), Quarterly sex ratio (by number) in catches.**

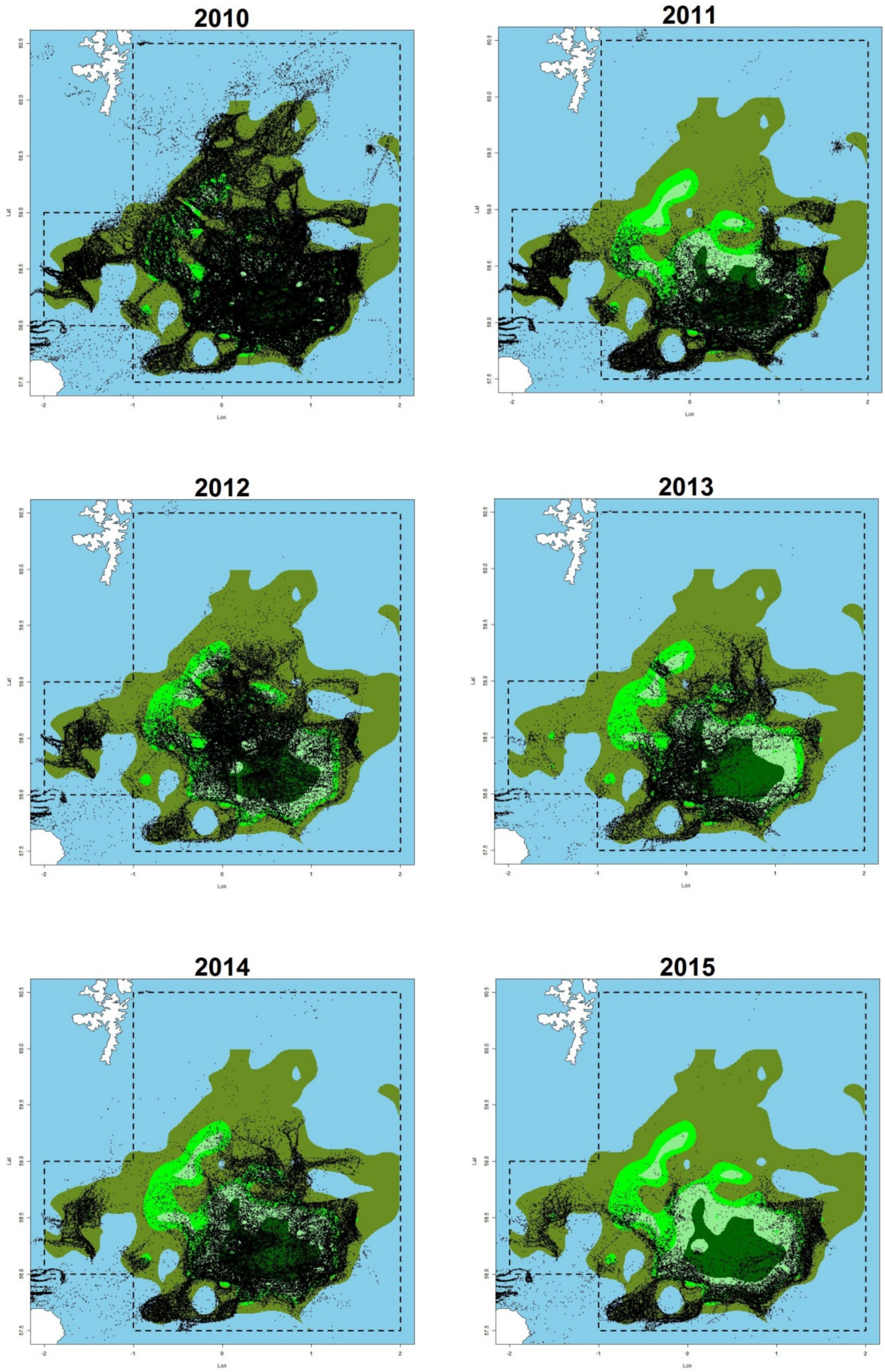


Figure 11.5.8 ***Nephrops*, Fladen (FU 7), VMS distribution of vessels in Fladen (2010–2015). Points in figure correspond to fishing pings (speed < 5 kn) associated with trips made by otter trawlers landing more than 25% of *Nephrops* by weight.**

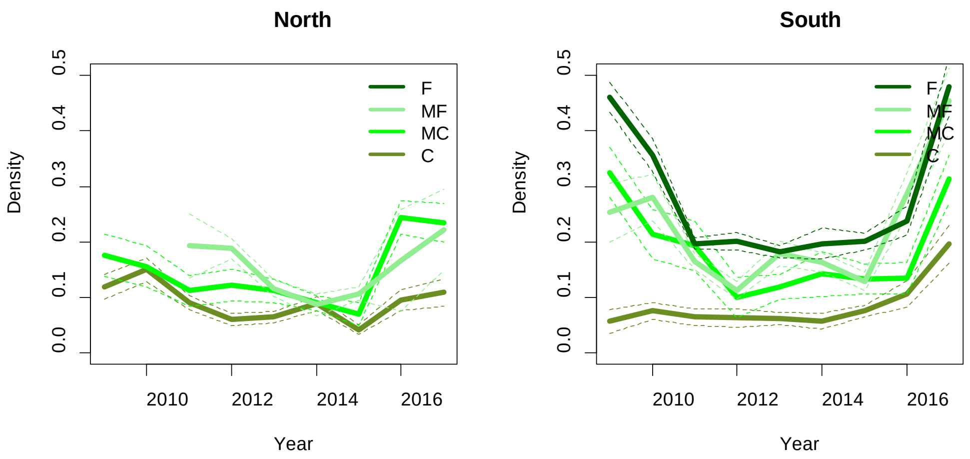


Figure 11.5.9 ***Nephrops*****, Fladen (FU 7), UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt & clay >80%); MF: medium fine sediment (55%< silt & clay< 80); MC: medium coarse sediment (40%< silt & clay< 55); C: coarse sediment (silt & clay <40%).**

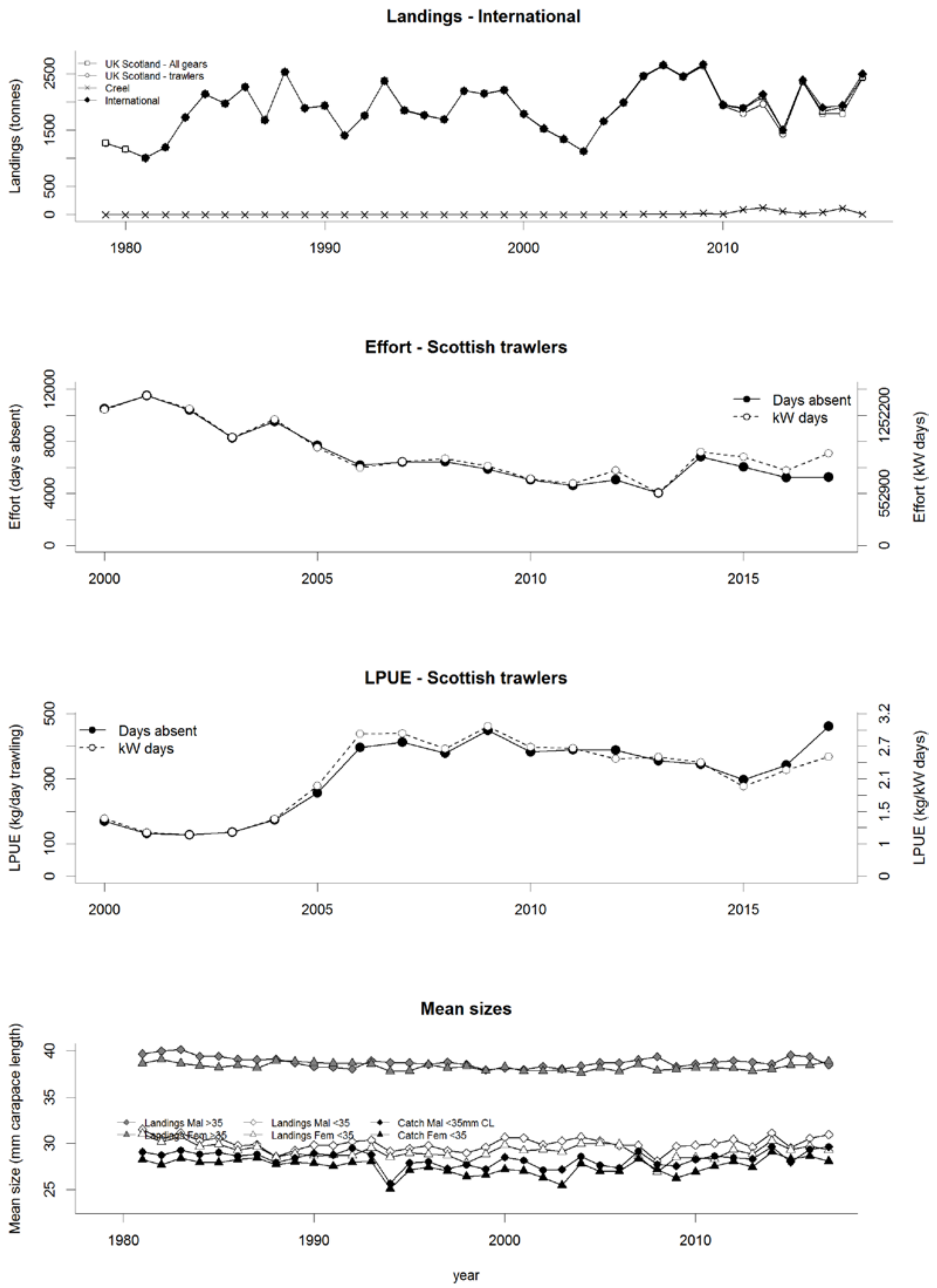
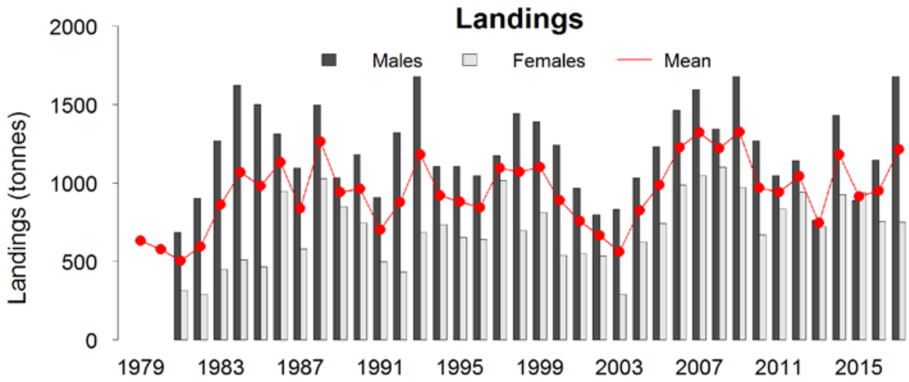


Figure 11.6.1 ***Nephrops*****, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2017.**



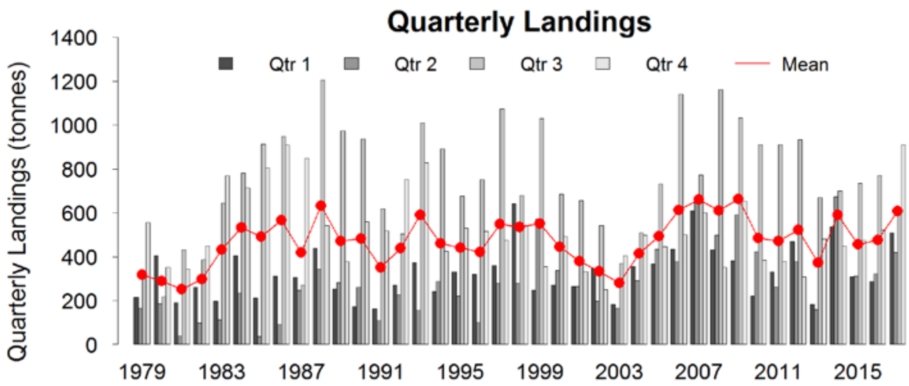


Figure 11.6.2 ***Nephrops*****, Firth of Forth (FU 8), Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

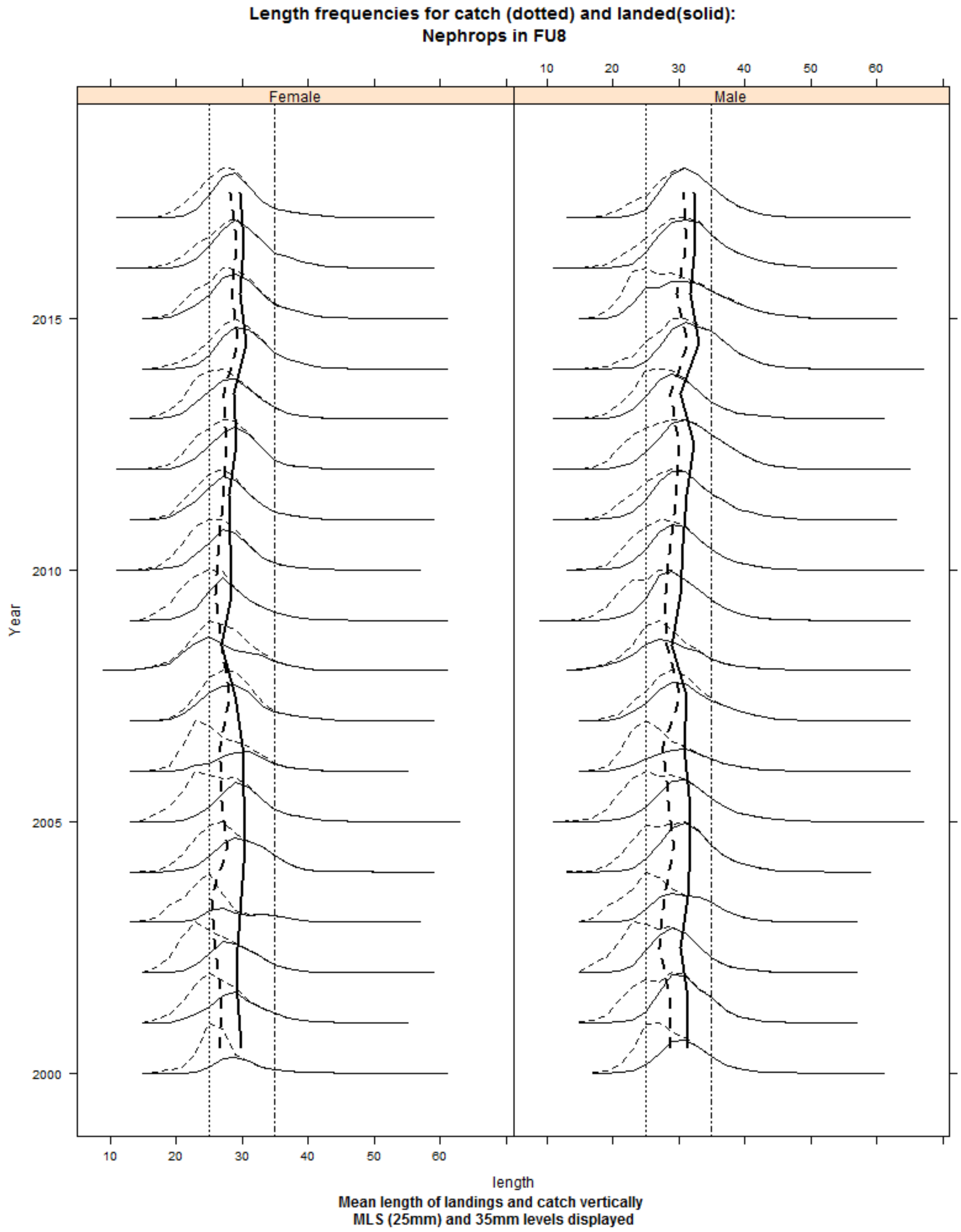


Figure 11.6.3 ***Nephrops*** **Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2017 (top). Mean sizes of catch and landings are displayed vertically.**

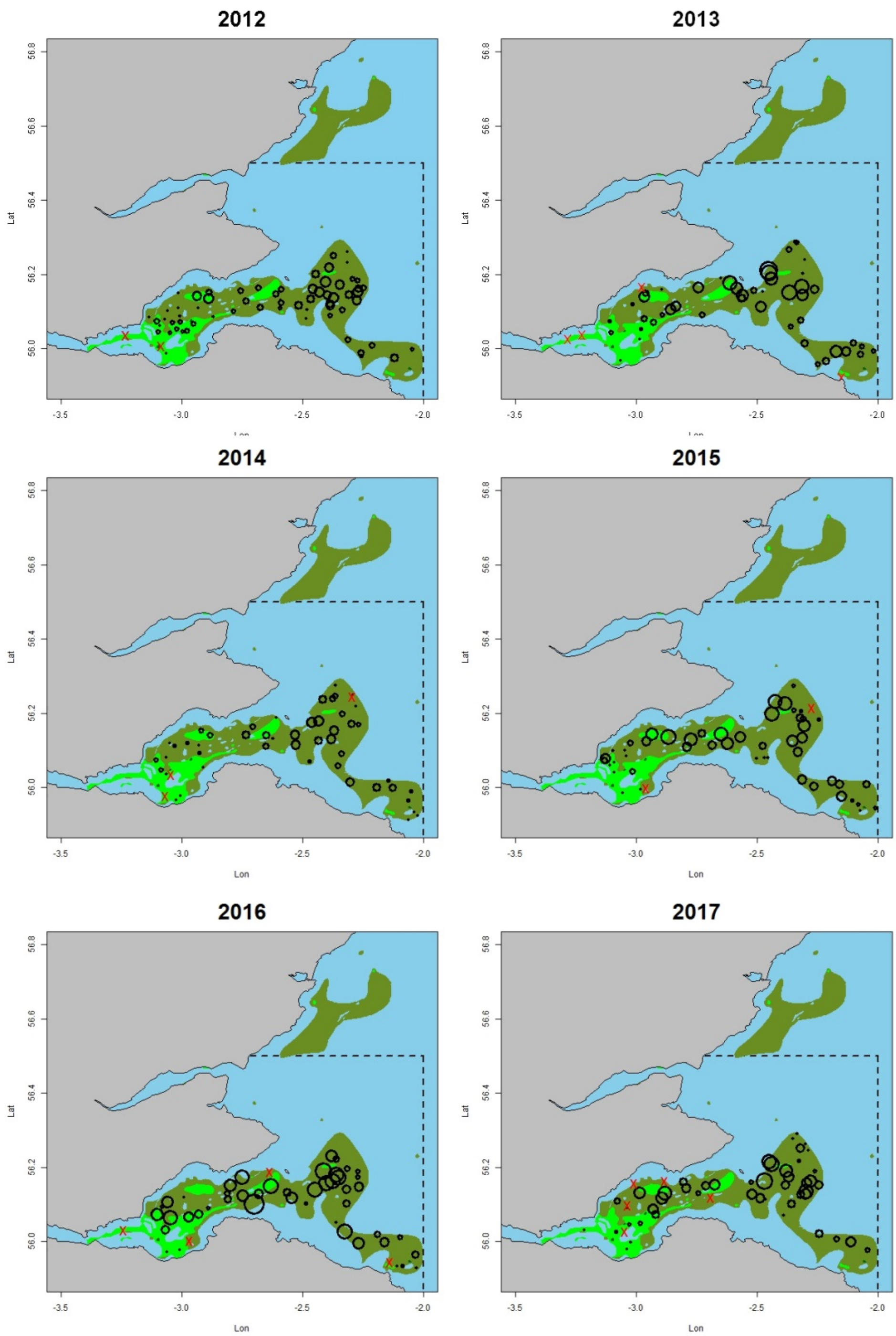


Figure 11.6.4 ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2012–2017). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

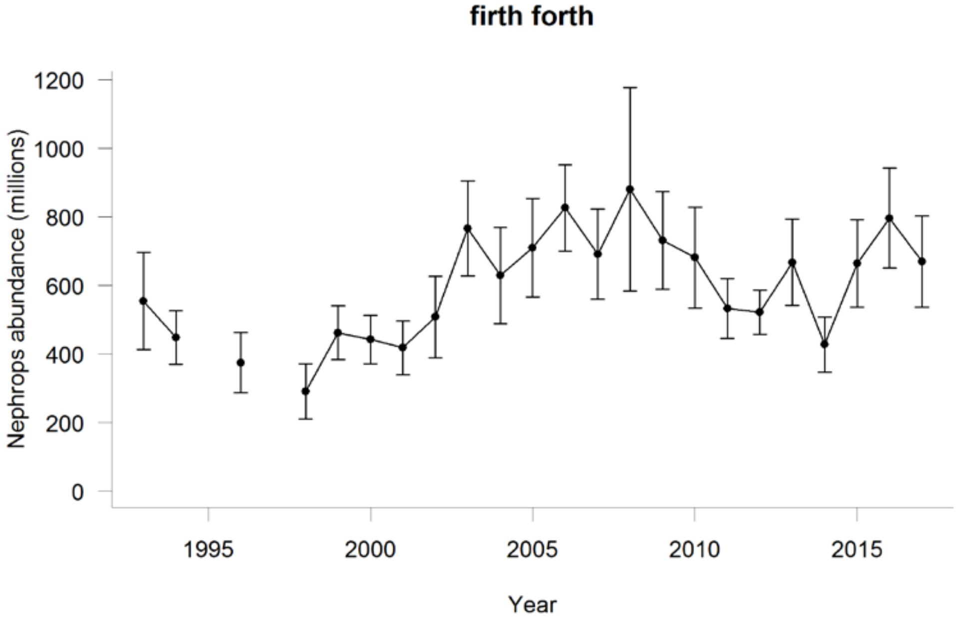


Figure 11.6.5 *Nephrops*, Firth of Forth (FU 8), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2017.

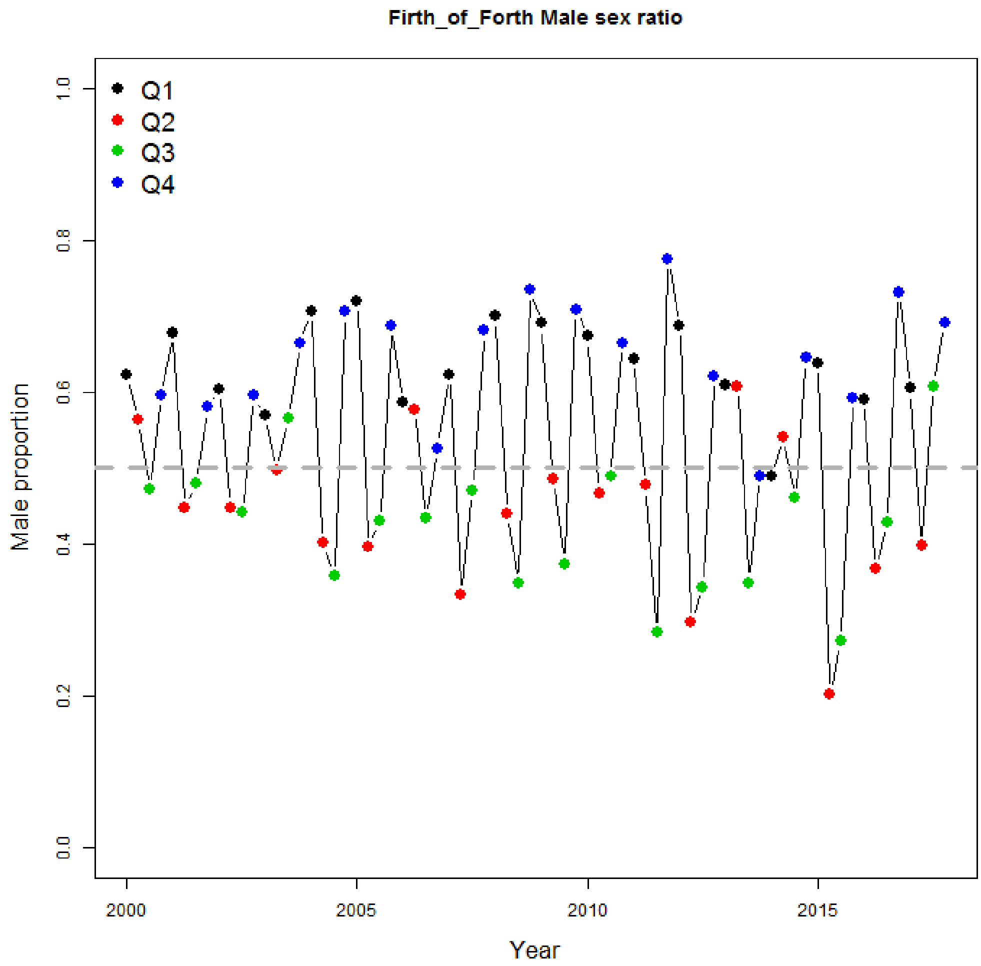


Figure 11.6.6 *Nephrops*, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.

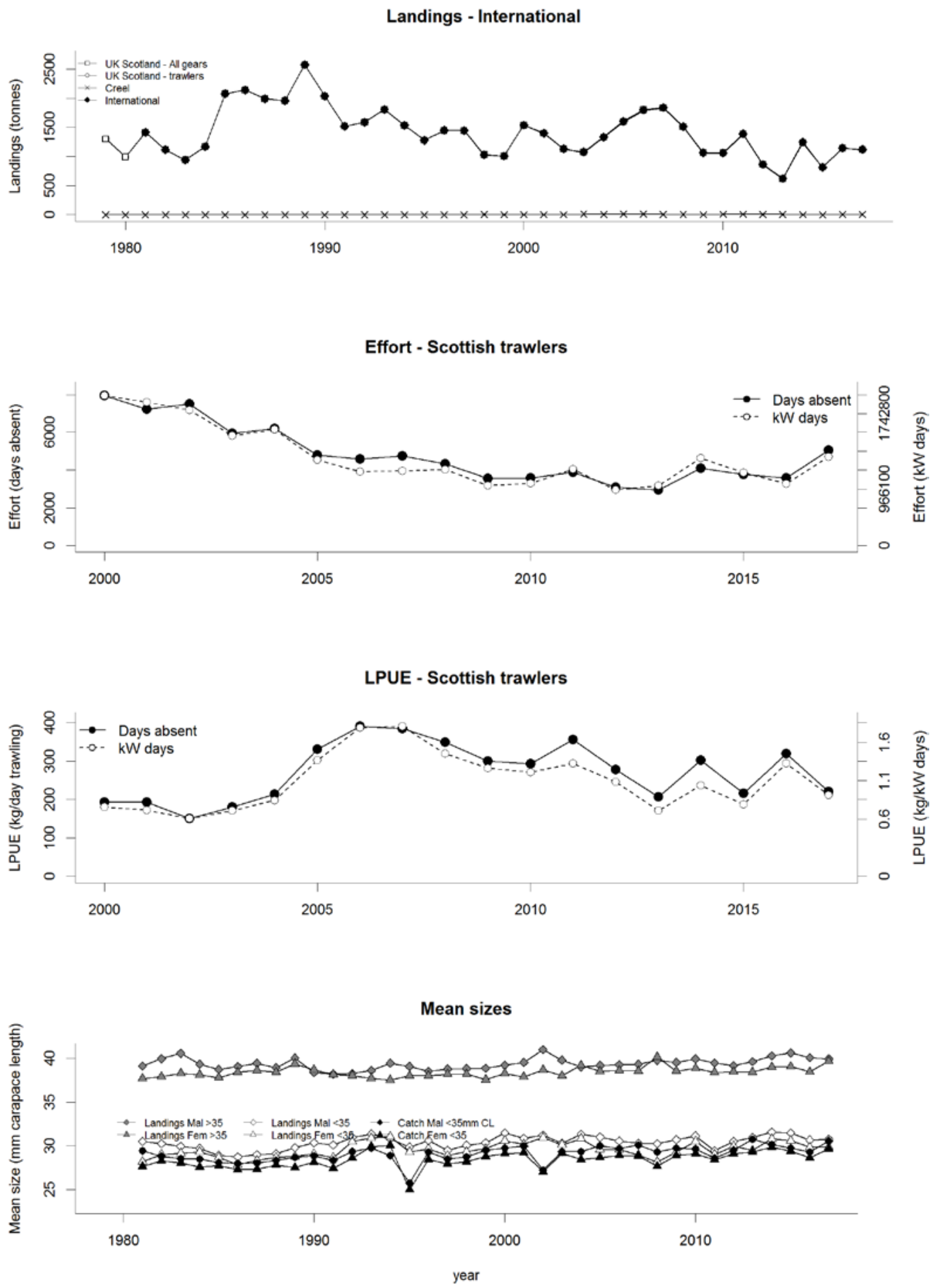
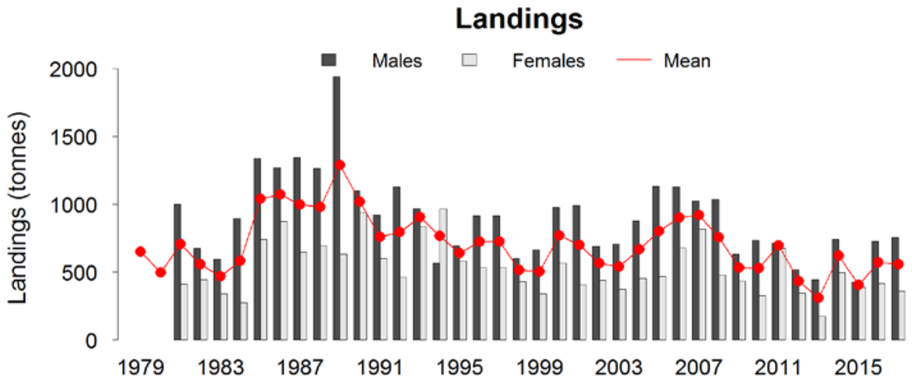


Figure 11.7.1 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2017.**



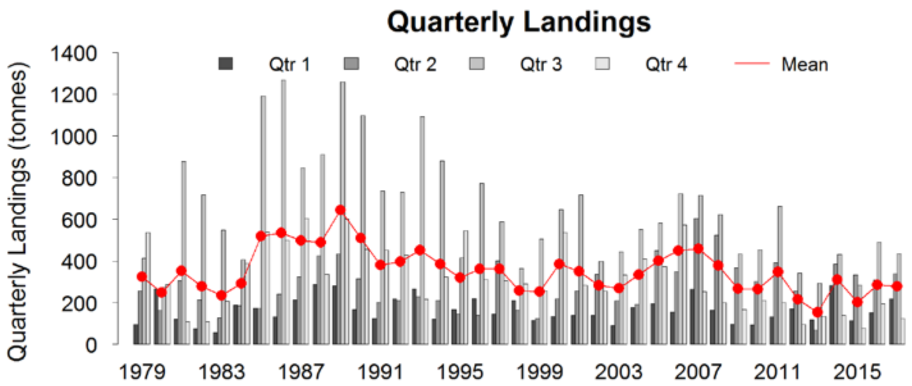


Figure 11.7.2 ***Nephrops*****, Moray Firth (FU 9), Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

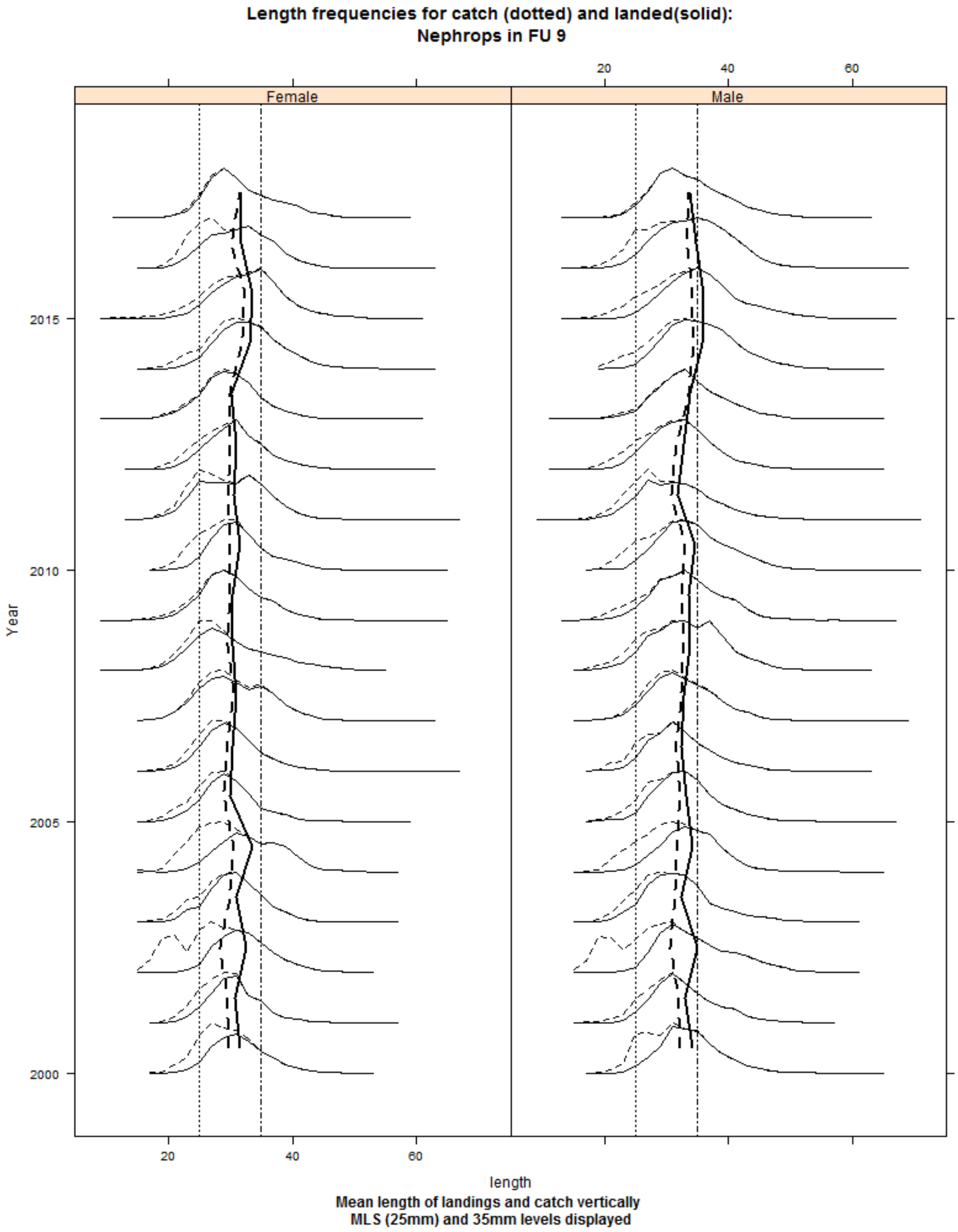


Figure 11.7.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2017 (top). Mean sizes of catch and landings are displayed vertically.**

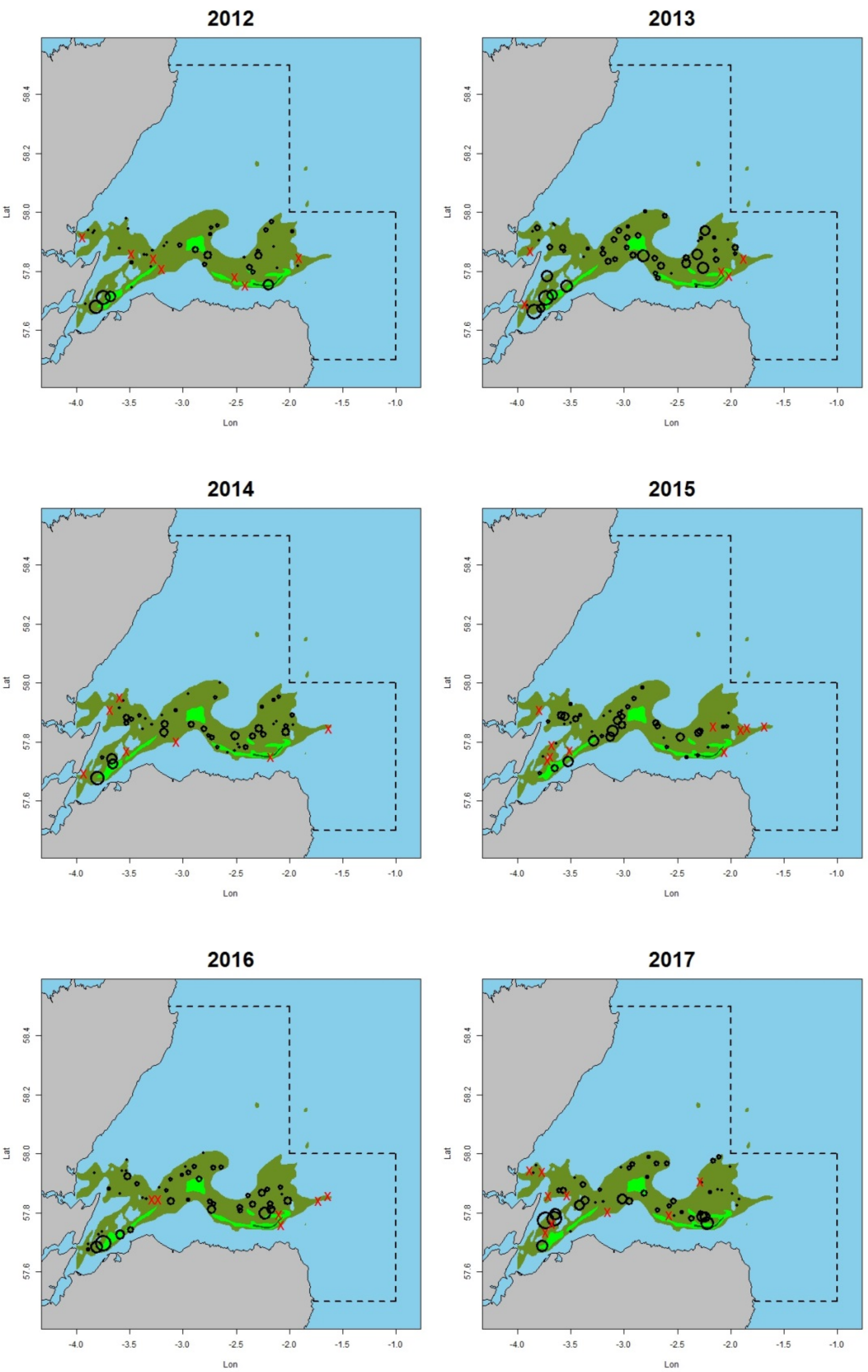


Figure11.7.4 *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2012–2017). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

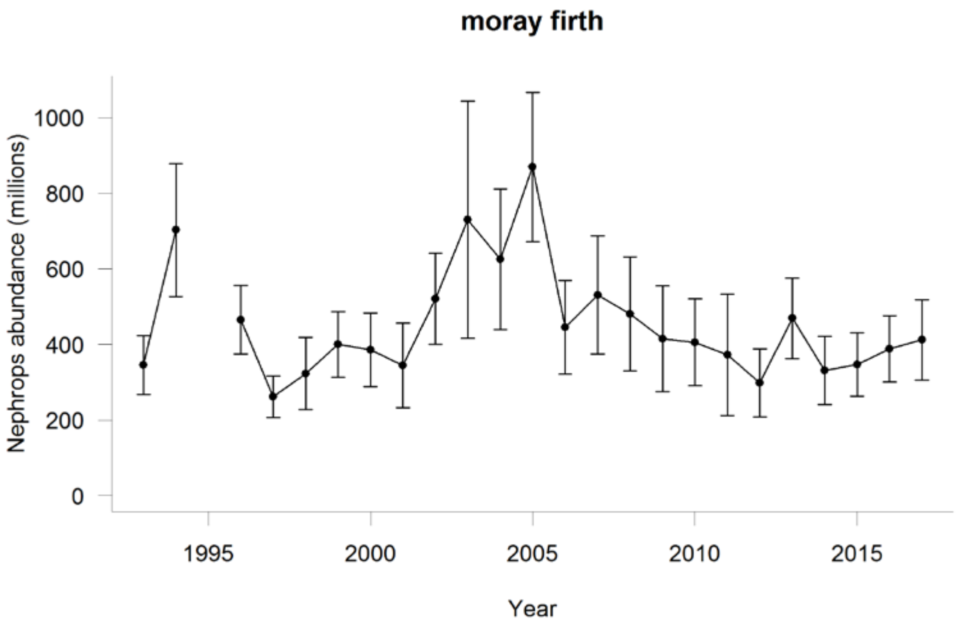


Figure 11.7.5 ***Nephrops*****, Moray Firth (FU 9), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2017.**

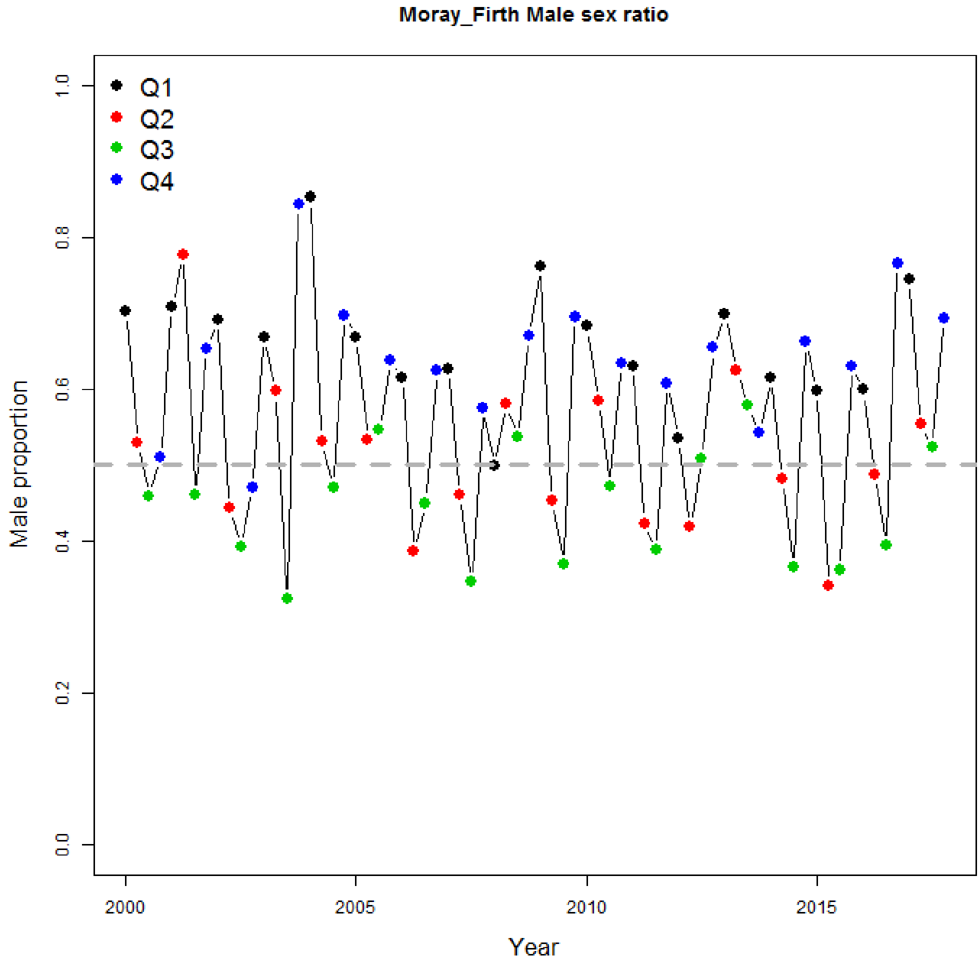


Figure 11.7.6 ***Nephrops*****, Moray Firth (FU 9), Quarterly sex ratio (by number) in catches.**

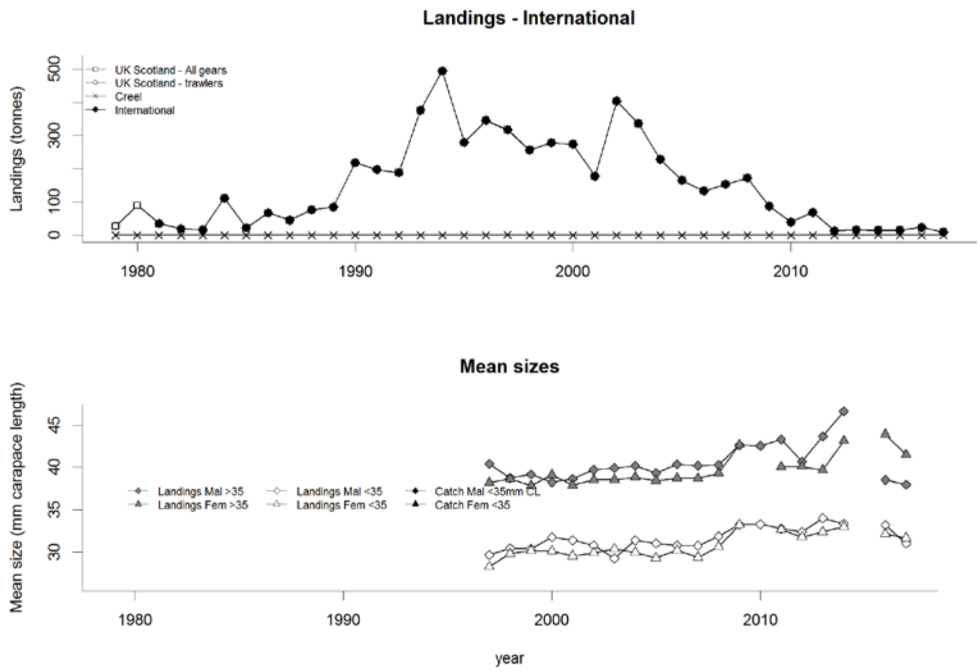


Figure 11.8.1 ***Nephrops*, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010 and no samples in 2015).**

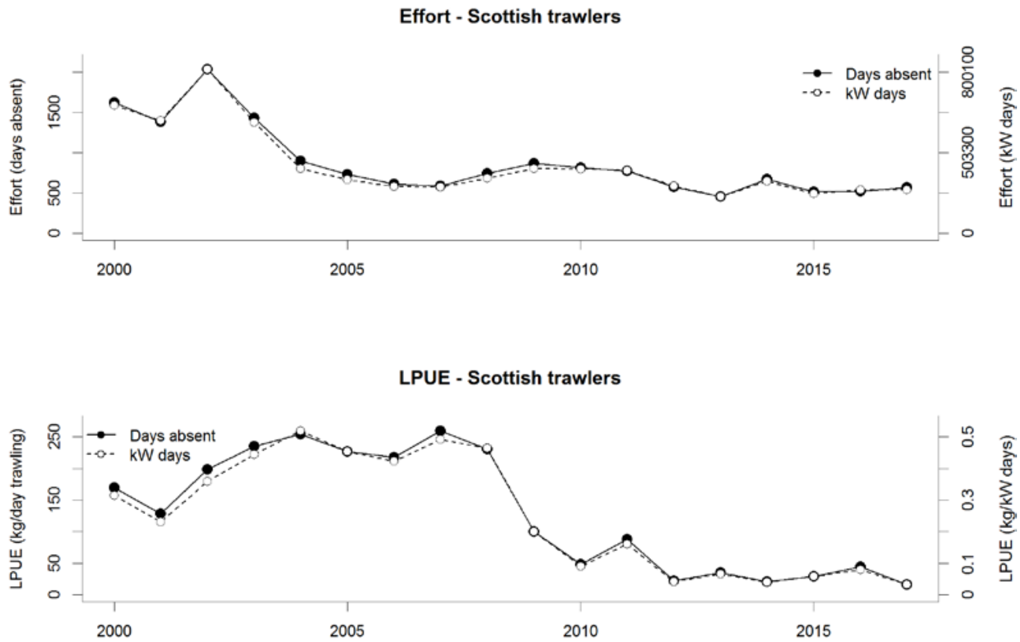


Figure 11.8.2 ***Nephrops*, Noup (FU 10), Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

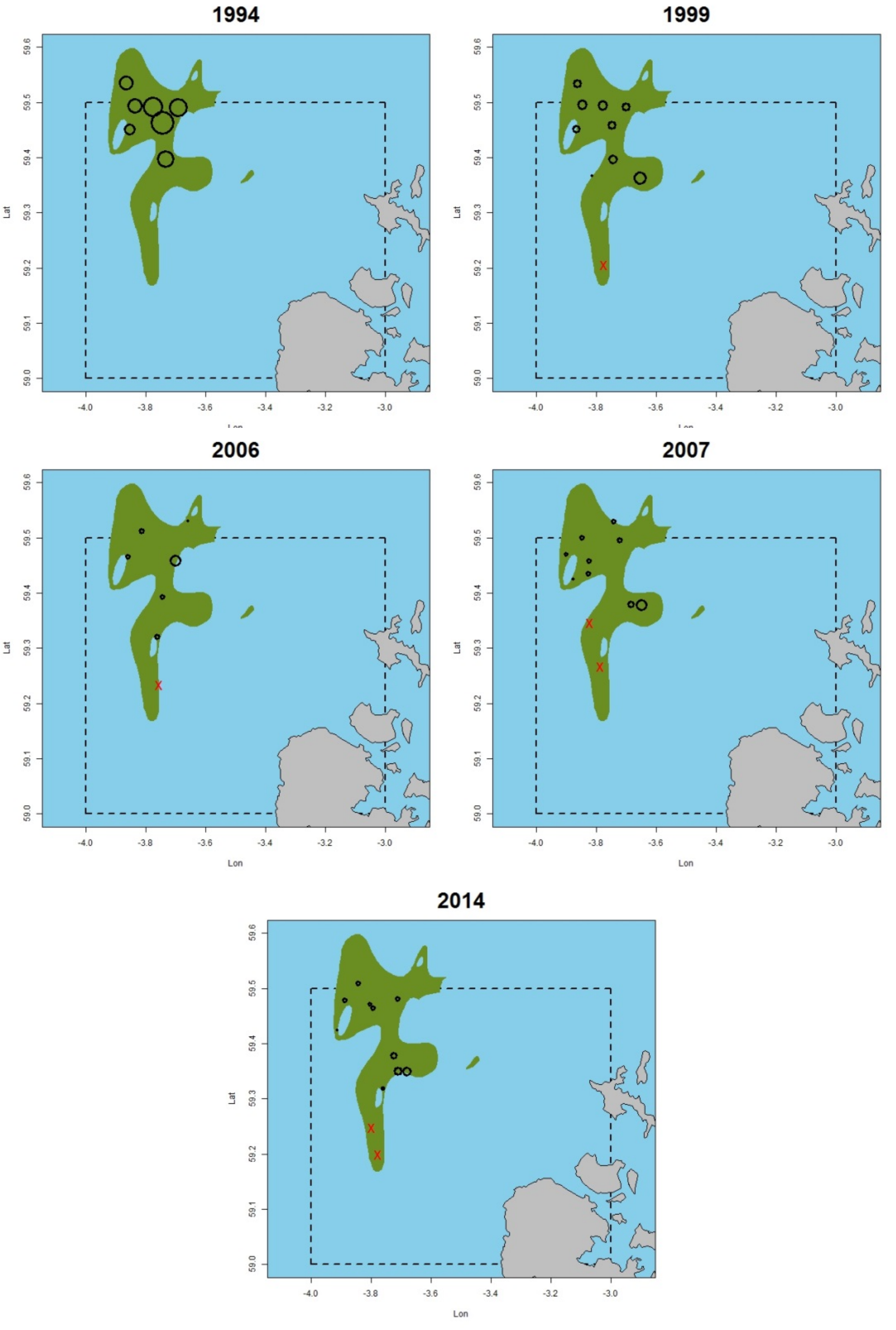


Figure 11.8.3 *Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007 & 2014). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

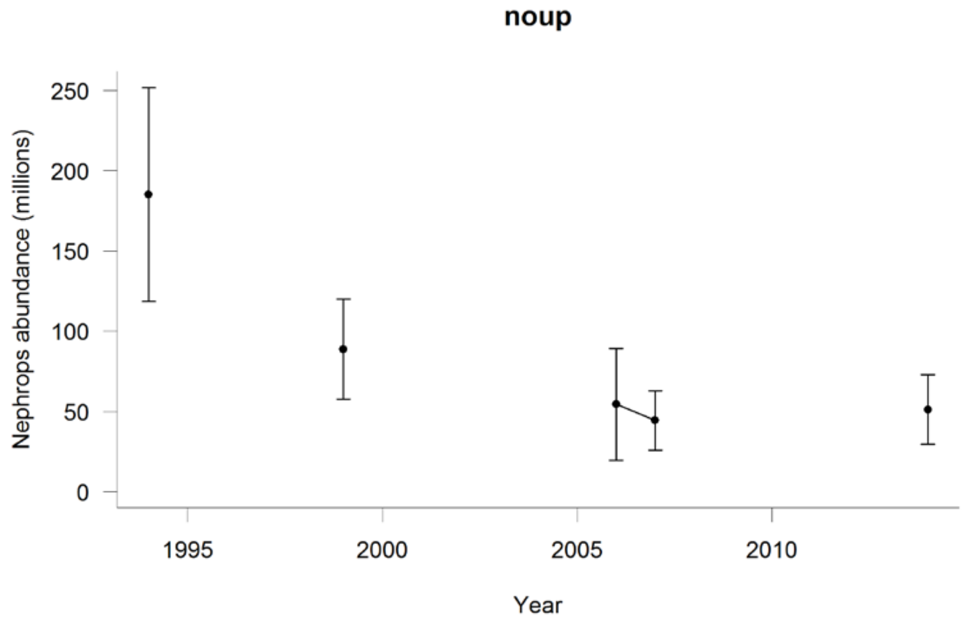
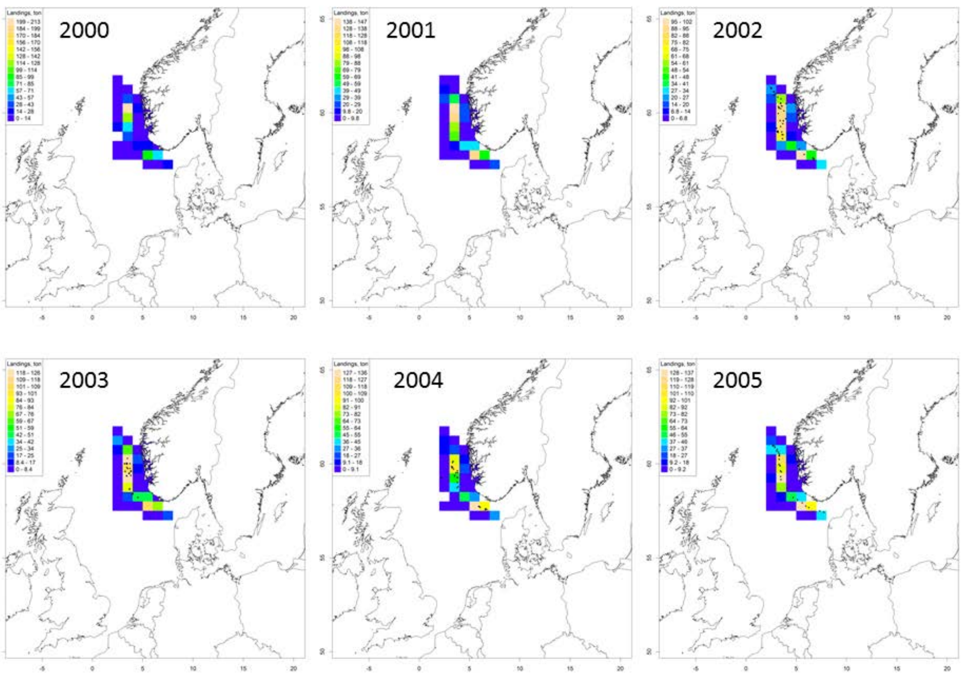
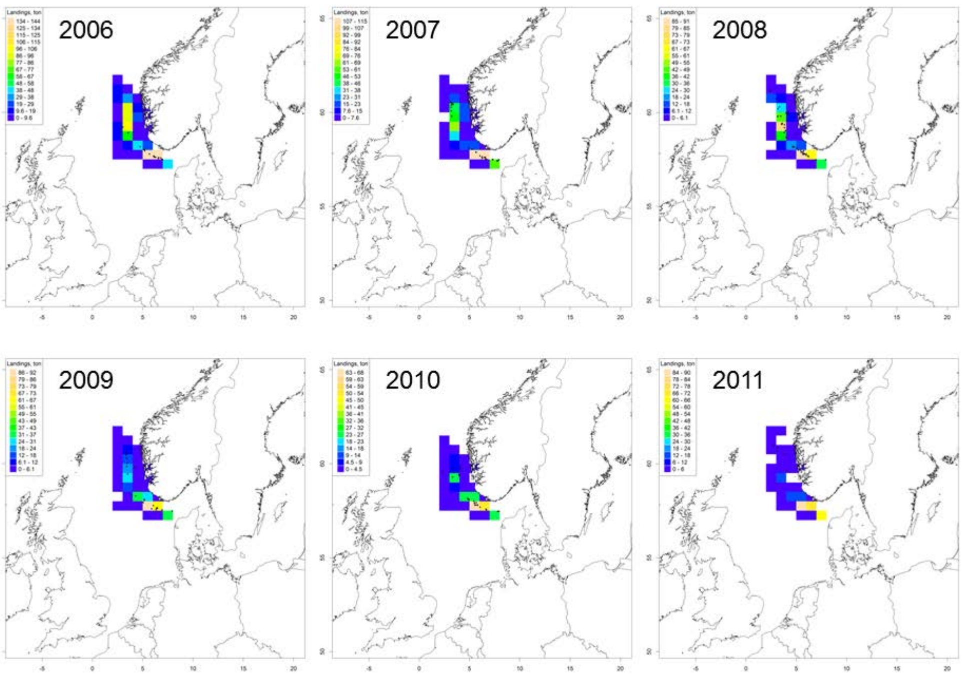


Figure 11.8.4 ***Nephrops*****, Noup (FU 10), Time series of TV survey abundance estimates (absolute conversion factor = 1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007 & 2014.**


2000
2001
2002
2003
2004
2005


2006
2007
2008
2009
2010
2011

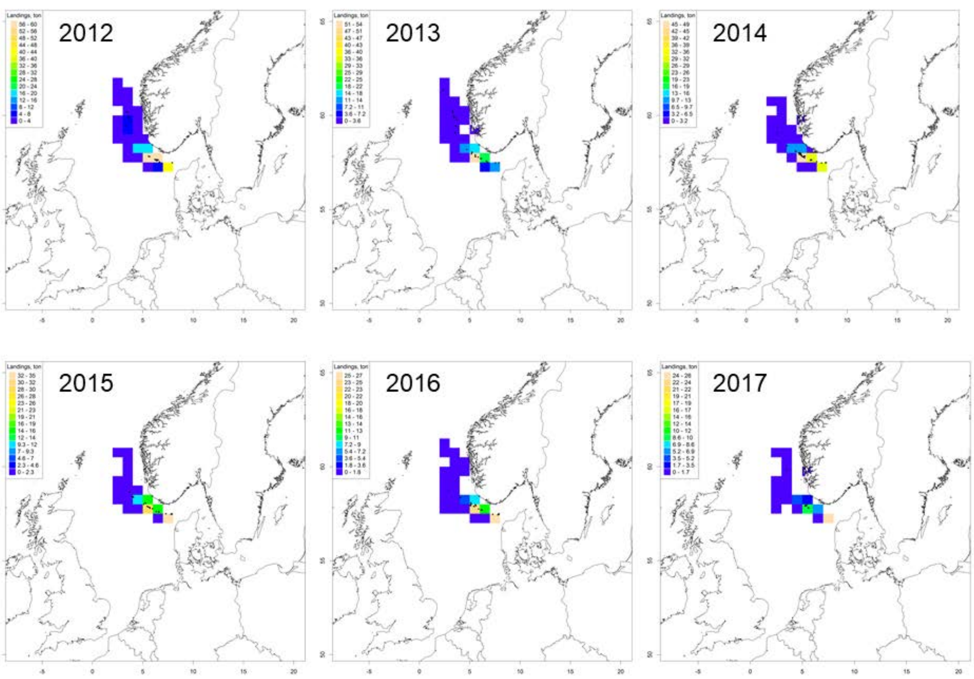


Figure 11.9.1. *Nephrops* Norwegian Deep (FU 32). Danish landings of *Nephrops* per ICES square. Dots represent hauls with *Nephrops* in at-sea-sampling program. Note, scales differ between annual plots.

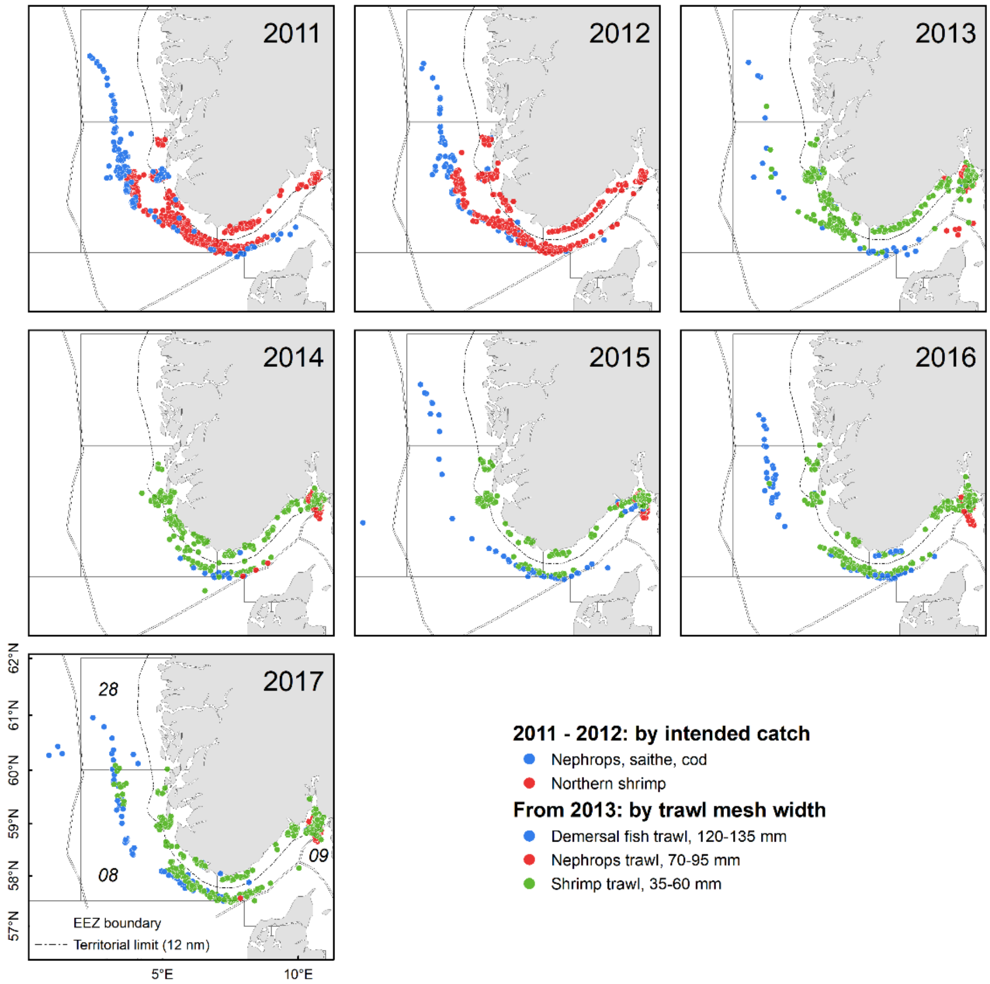


Figure 11.9.2. ***Nephrops*** **Norwegian Deep (FU 32): Positions of trawl hauls with** ***Nephrops*** **in the catch from Norwegian bottom trawlers ≥ 15 m, 2011–2017.**

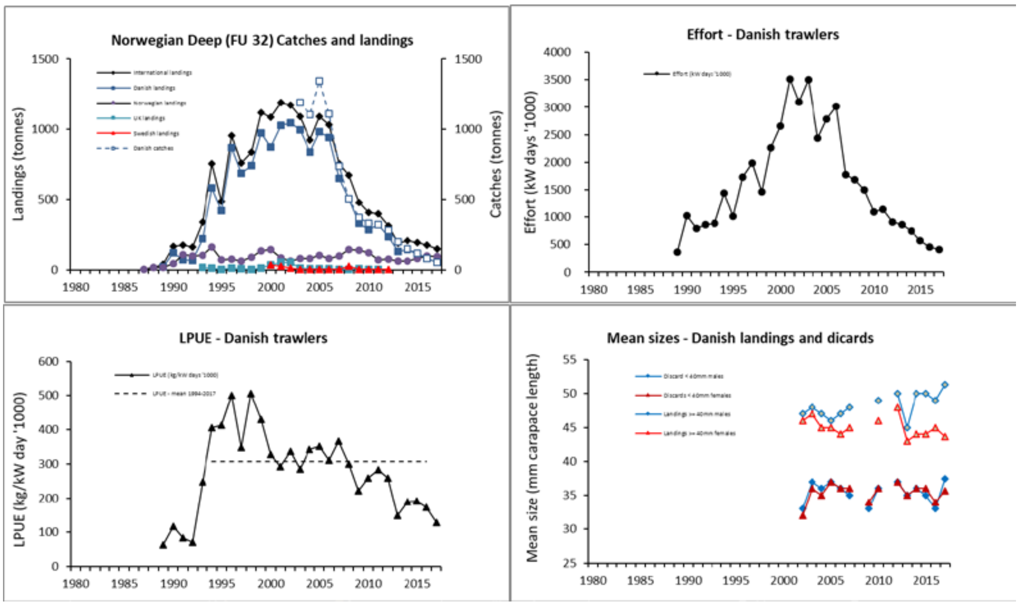


Figure 11.9.3. *Nephrops* Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards (< 40 mm) and landings (≥ 40 mm).

Figure 11.9.4. *Nephrops* Norwegian Deep (FU 32): Size distribution in Danish catches.

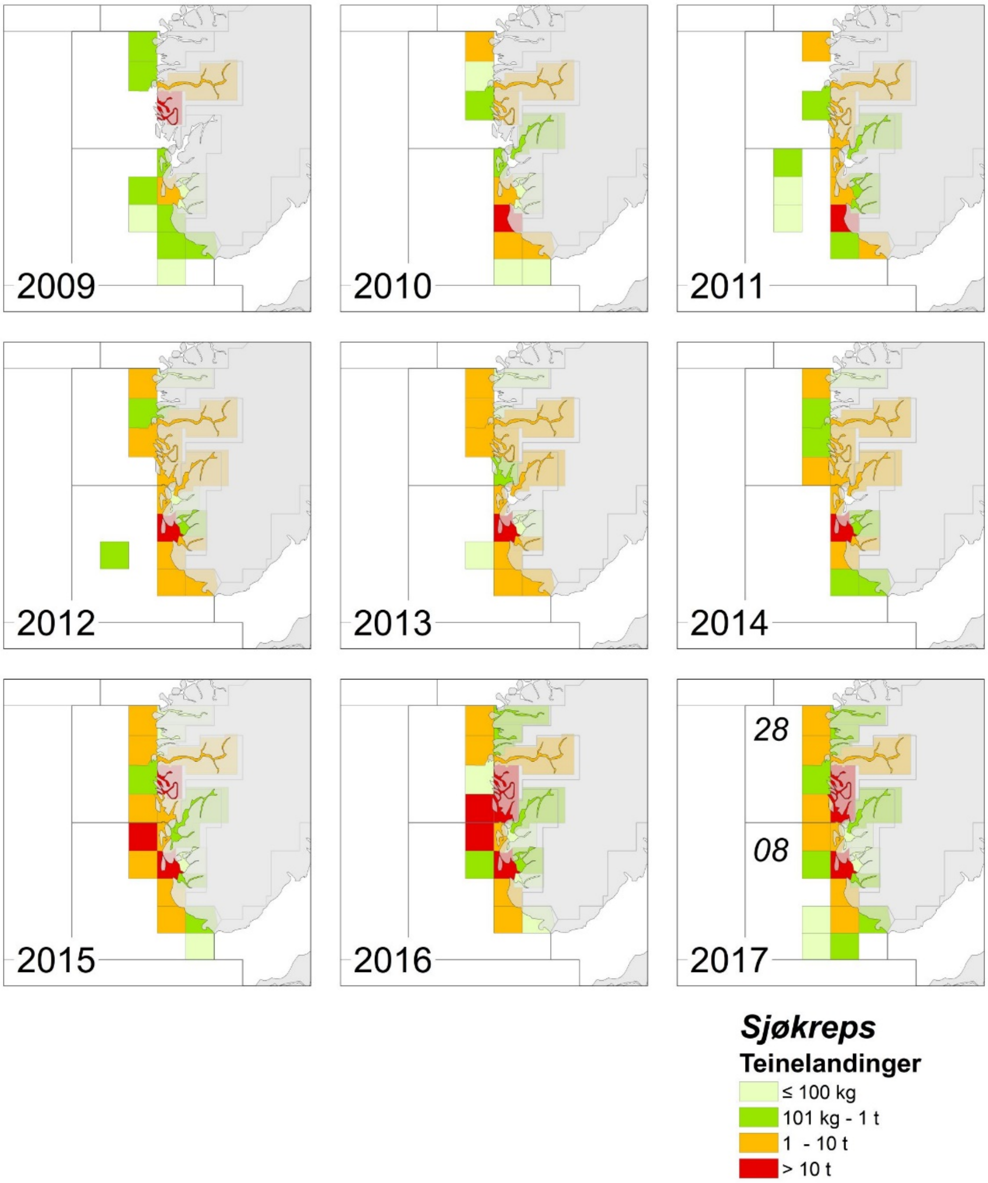


Figure 11.9.5. ***Nephrops*** **Norwegian Deep (FU 32): Norwegian creel landings by ICES statistical squares, 2009–2017.**

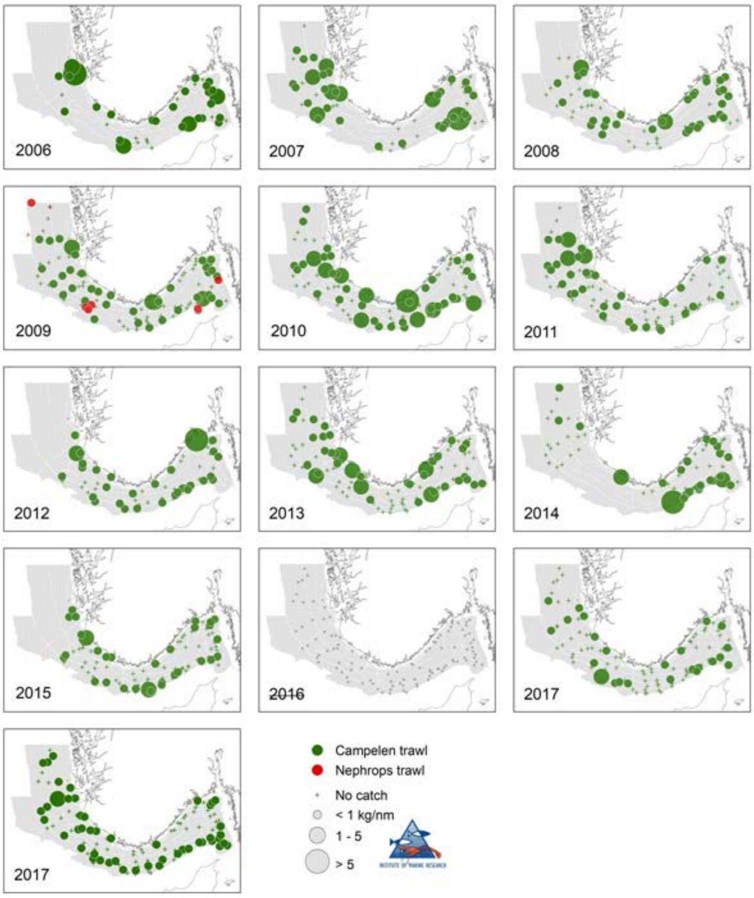


Figure 11.9.6. *Nephrops* Norwegian Deep (FU 32): Distribution of *Nephrops* in Norwegian shrimp survey, 2006–2018. The 2016-data are omitted from the time series due to technical problems with the trawl gear at this year's survey.

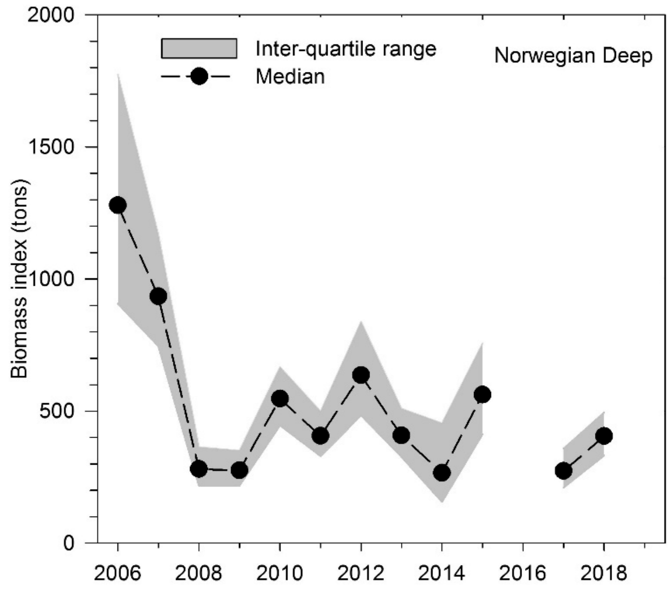


Figure 11.9.7. ***Nephrops*** **Norwegian Deep (FU 32): Biomass index (2006–2018) from the Norwegian Deep, based on trawl catches in the Norwegian shrimp survey. The 2016–data are omitted from the time series due to technical problems with the trawl gear at this year's survey.**

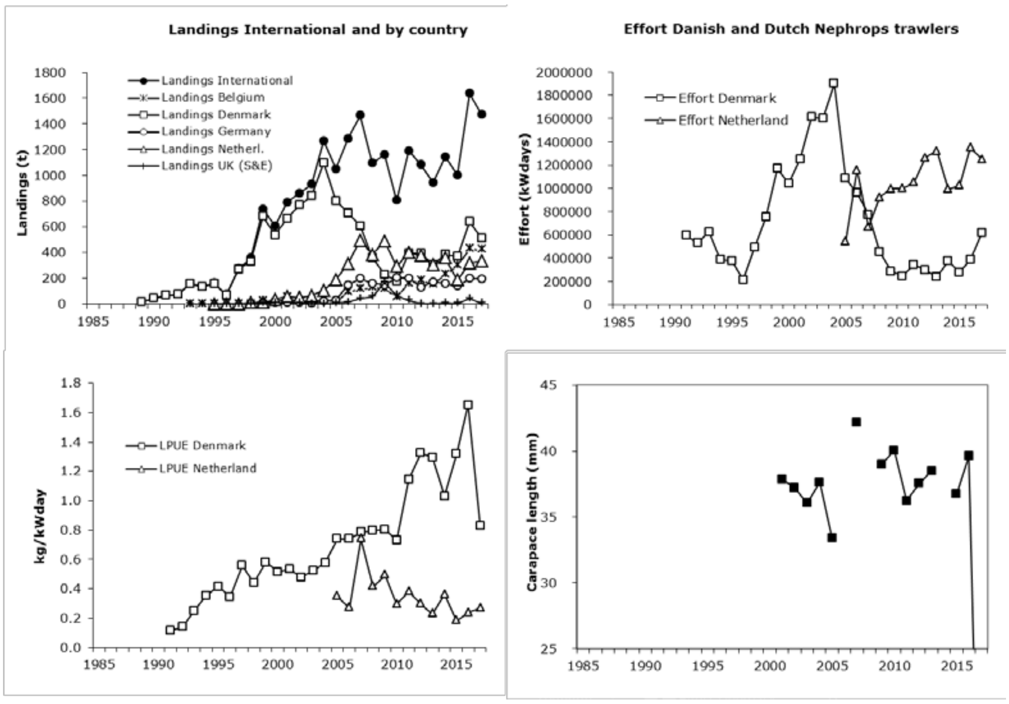


Figure 11.10.1. ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

Figure 11.10.2. ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

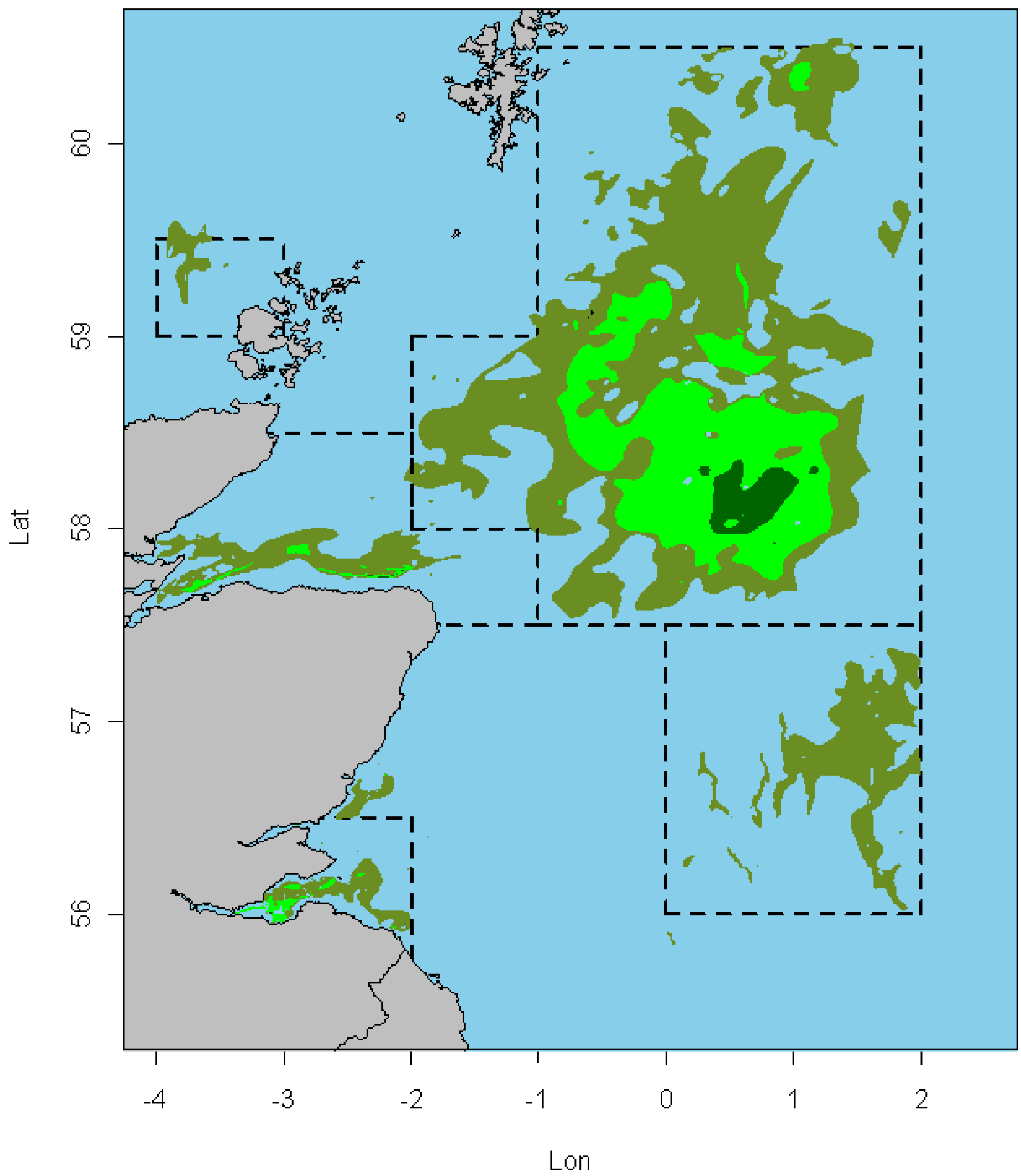


Figure 11.11.1. ***Nephrops*, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**

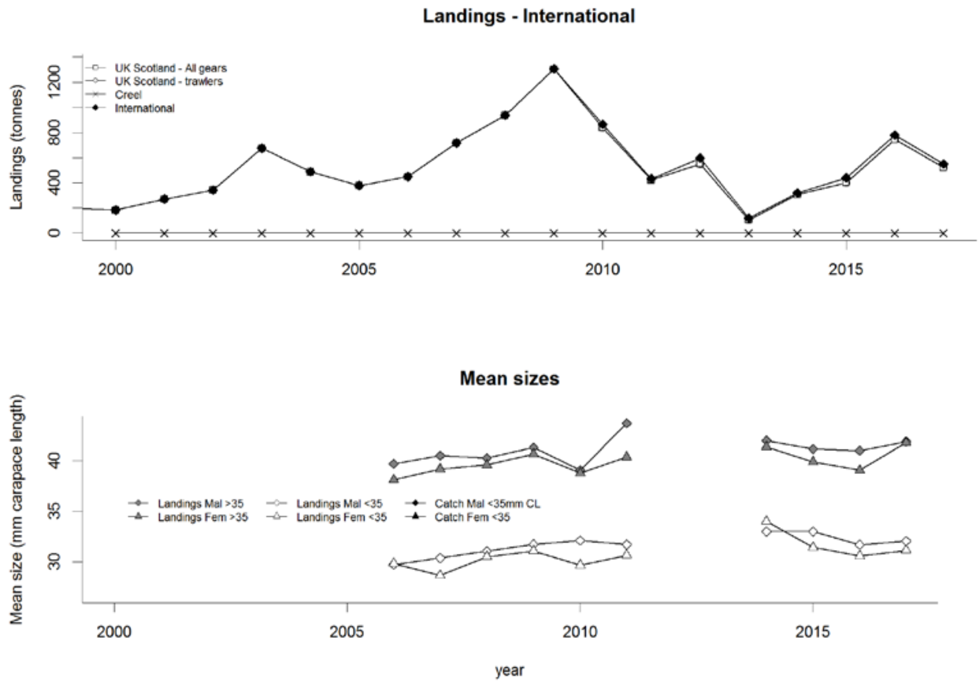


Figure 11.11.2. ***Nephrops*****, Devil's Hole (FU 34). Long term landings and mean sizes, data from year 2000.**

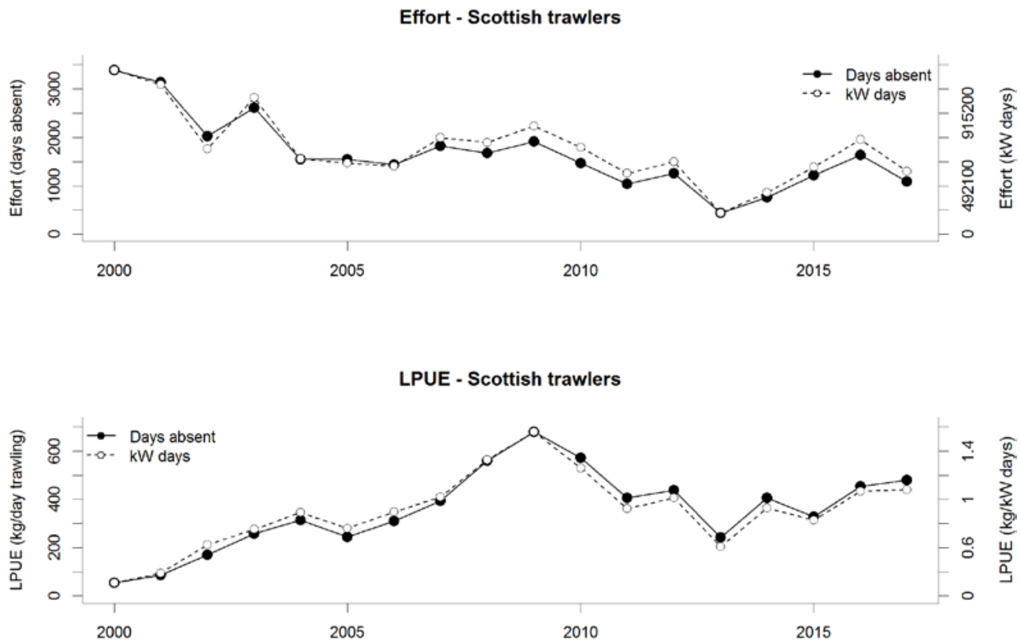


Figure 11.11.3. ***Nephrops*****, Devil's Hole (FU 34). Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

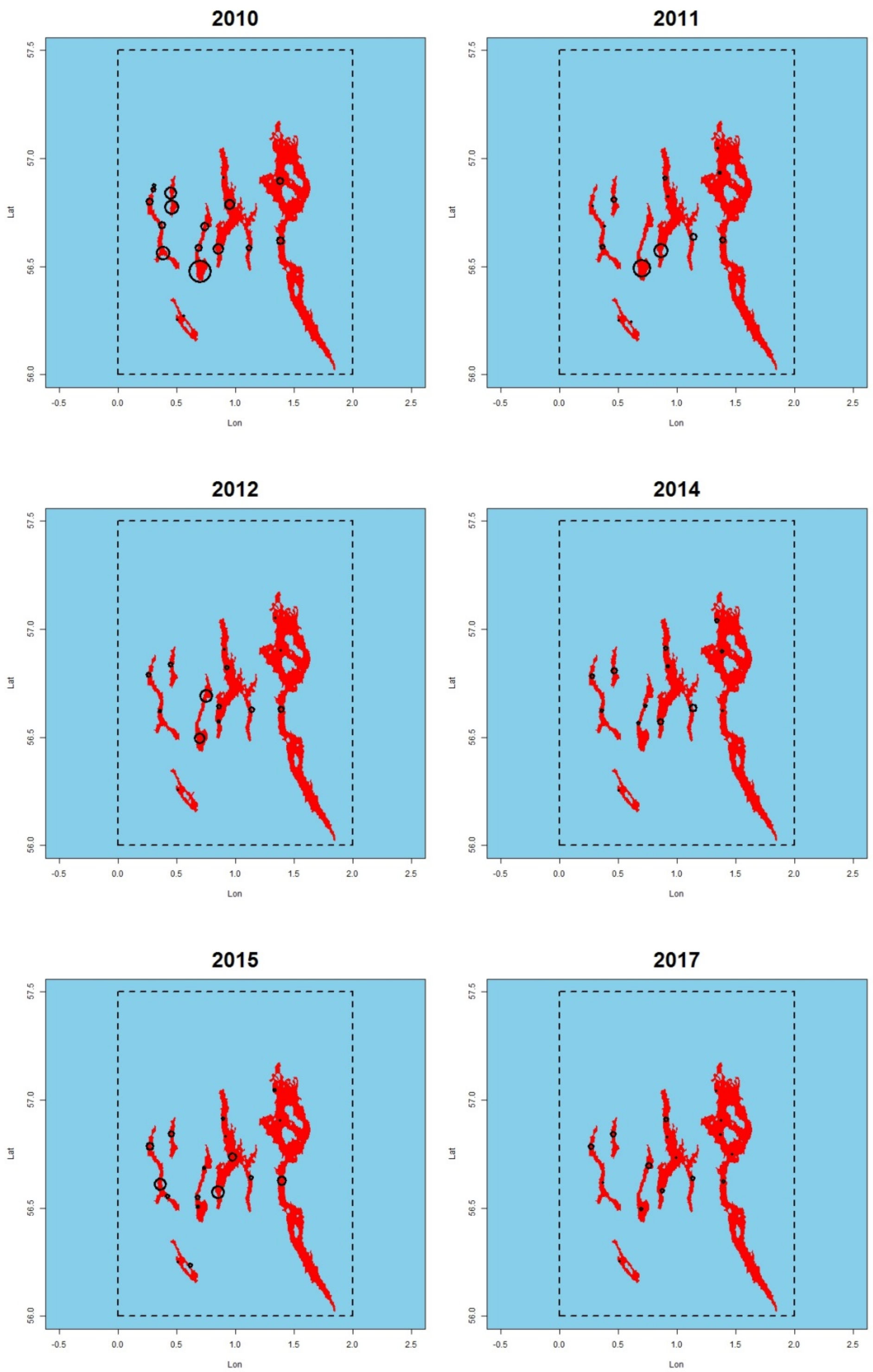


Figure 11.11.4. ***Nephrops*****, Devil's Hole (FU 34). UWTV survey distribution and relative density (2010–2017). Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

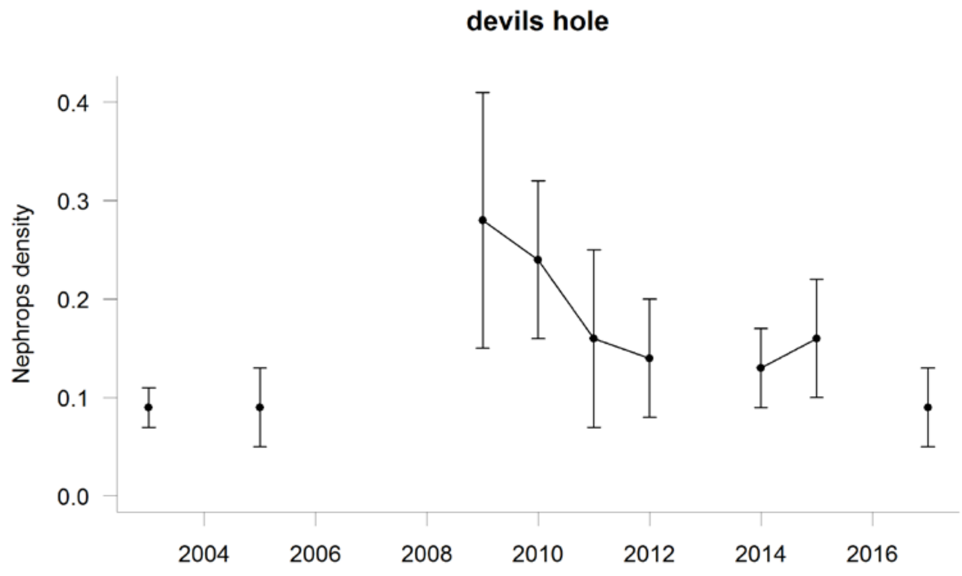


Figure 11.11.5. ***Nephrops*****, Devil's Hole (FU 34). Time series of UWTV survey density estimates with 95 % confidence intervals, 2003, 2005, 2009–2017.**

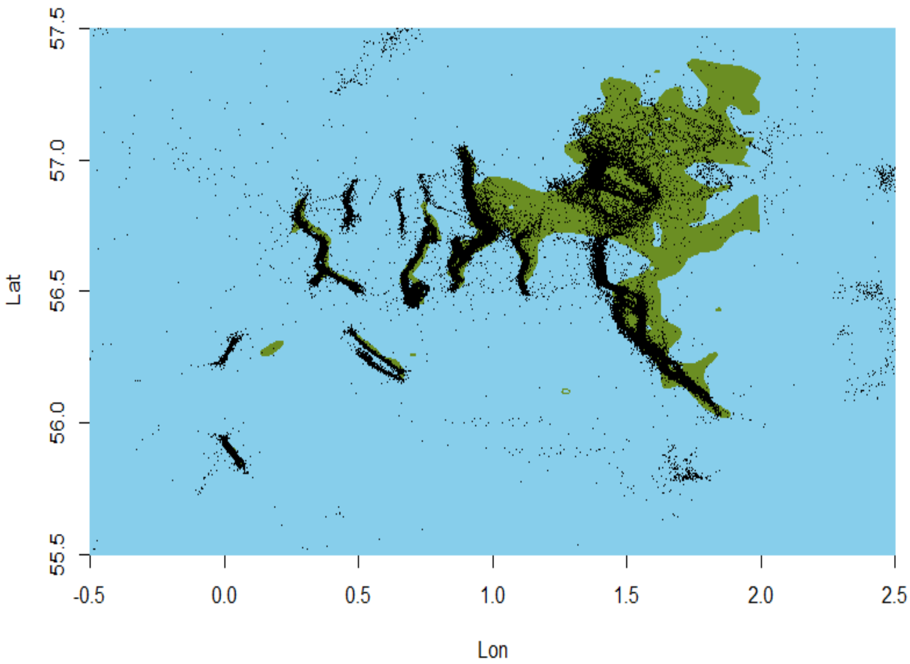


Figure 11.11.6. ***Nephrops*****, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for *****Nephrops***** landings >30% of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

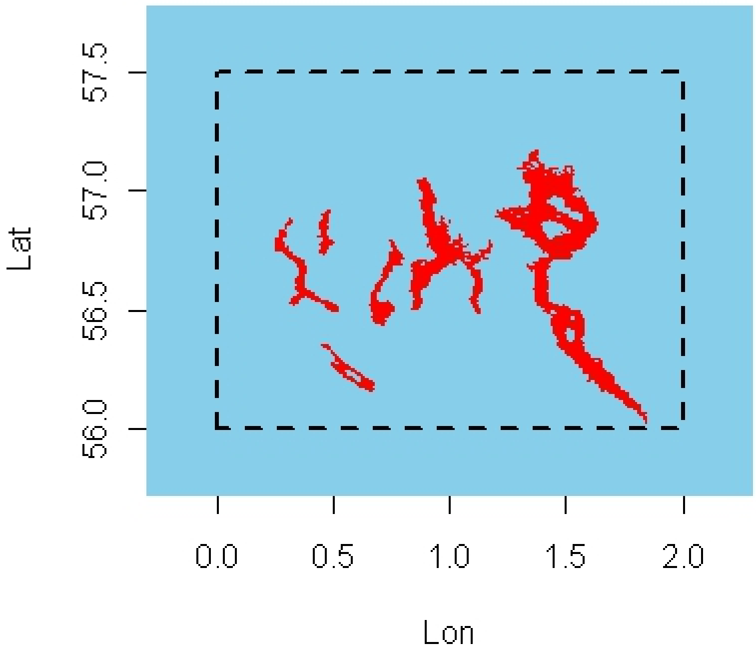


Figure 11.11.7. *Nephrops*, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for *Nephrops* landings >30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.

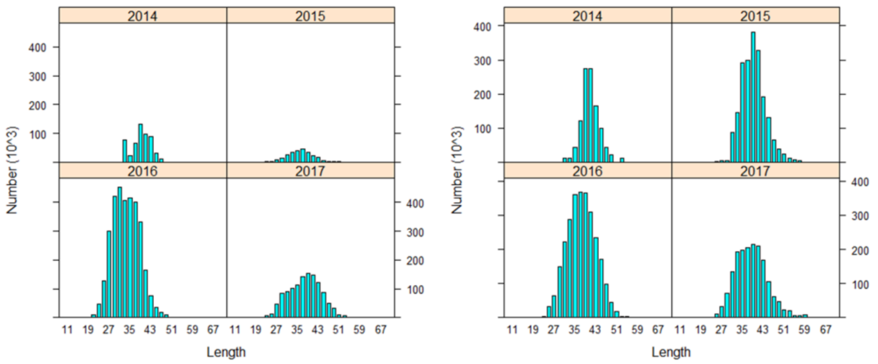


Figure 11.11.8. ***Nephrops*****, Devil's Hole (FU 34). Landings length distributions for females (left) and males (right) obtained from Intercatch and used to run the LBI screening methods (2014–2017).**

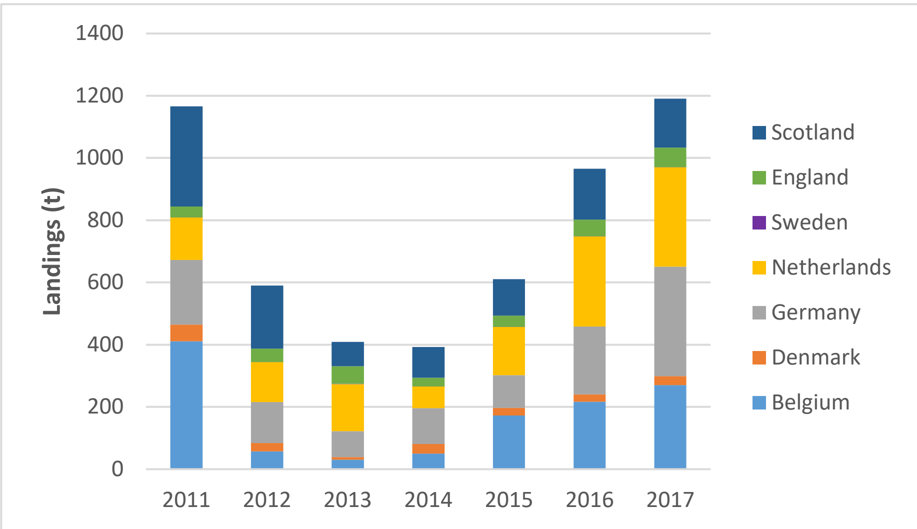


Figure 11.12.1. ***Nephrops*****, 4 out FU. Landings reported by country (2011–2017).**

12 Norway Pout in ICES Subarea 4 and Division 3.a (September 2018)

Introduction: Benchmark assessment

The September 2018 assessment of Norway pout in the North Sea and Skagerrak is an update assessment based on the August 2016 ICES WKPOUT benchmark assessment (ICES WKPOUT, ICES 2016). In the benchmark assessment, a new assessment model has been introduced (Seasonal Stochastic Assessment Model SESAM instead of the Seasonal XSA, SXSA), the assessment year has been changed (from the calendar year to 1 October to 1 October and accordingly also now including quarter 3 in the assessment year compared to quarter 2 in previous assessments), the overall assessment period has been changed (cutting off the original first assessment year 1983), the plus-group in the assessment has been changed (from 4+ to 3+), and the assessment tuning fleets have been changed (removing the quarter 1, 3, and 4 commercial tuning fleets and keeping the same survey fleets). The assessment biological parameter settings are the same according to the Inter-benchmark assessment in spring 2012 (ICES IBPNorwayPout, ICES 2012c) with respect to the population dynamic parameter settings for natural mortality, maturity at age and mean weight at age. The previous settings in the assessment were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The new settings according to the inter-benchmark (from May 2012 onwards) include constant quarterly and yearly natural mortality, but with varying M by age, 20% maturity for the 1-group, and slightly changed levels of constant mean weight at ages in the stock which have been calculated from long term averages of mean weight at age in the catch. These parameters have impact on the predictions and estimates of the SSB because the stock consists of very few year classes. The assessment is a "real time" monitoring and management run up to 1 October 2018, and includes new information from second half year 2017 and for the quarters 2, 3 and 3 in 2018. The assessment includes the new 3rd quarter 2018 survey information also covering the 0-group 2018 year class information, which is used real time in 3rd quarter. Consequently, the assessment does not backshift this survey information to 2nd quarter as done in the SXSA assessment run up to 1 July in the assessment year before the benchmark assessment in 2016.

Furthermore, a short term prognosis (Forecast) up to 1 November 2018 and 1 November 2019 is given for the stock based on the assessment. The catch projection is based on a changed forecast year from 1 November to 31 October.

12.1 General

12.1.1 Ecosystem aspects

Norway pout is a short-lived species and most likely a one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation or other natural mortality, and less by the fishery (Nielsen *et al.*, 2012). Recruitment is highly variable and influences SSB and total stock biomass (TSB) rapidly because of the short life span of the species (Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a, 2002b; see review in Nielsen 2016). Furthermore, 20% of age 1 is estimated mature and is included in the SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year influences the SSB in the following year. Also, Norway pout is to a limited extent exploited from age 0. Only limited knowledge is available on the influence of environmental factors, such as temperature, on the recruitment (Kempf *et al*. 2009; see review in Nielsen 2016, Section 7). On this basis Norway pout should be managed as a short-lived species.

Stock definition: Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen *et al.*, 2012, Lambert *et al,*, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 300 m (Raitt 1968; Sparholt *et al.*, 2002b; see review in Nielsen 2016, Sections 2&4). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al*., 2009; Nash *et al*. 2012; Huse *et al.* 2008; See review in Nielsen 2016, Section 4).

Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al* (2009) show that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), gave no evidence for a stock separation in the whole northern area, and this conclusion is supported by the results in Lambert *et al.* (2009) and in Nash *et al.* (2012). (See also review in Nielsen 2016, Section 3).

Ecological role: The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short life span of the species (Nielsen *et al.*, 2012; ICES WGSAM 2011; ICES WGSAM 2014; Sparholt *et al.* 2002a,b; Lambert *et al.,* 2009). Norway pout natural mortality is likely influenced by spawning and maturity having implications its age specific availability to predators in the ecosystem and the fishery (Nielsen *et al.*, 2012). With present fishing mortality levels in recent years the status of the stock is more determined by natural processes and less by the fishery, and in general the fishing mortality on 0-group Norway pout is low (Nielsen *et al.*, 2012; ICES WGNSSK Reports; see review in Nielsen 2016, Section 5). There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. This stock is among other important as food source for the species saithe, haddock, cod, whiting, and mackerel and predation mortality is significant (ICES-SGMSNS 2006; ICES WGSAM 2011; ICES WGSAM 2014; Cormon *et al*., 2016; see review in Nielsen 2016, Section 6). Especially the more recent high abundance of saithe predators and the more constant high stock level of northern mackerel as likely predators on smaller Norway pout are likely to significantly affect the Norway pout population dynamics. Interspecific and intraspecific density patterns in Norway pout mortality and maturity has been documented (Nielsen *et al*., 2012; Lambert *et al.* 2009; Cormon *et al.* 2016; see review in Nielsen 2016). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES WGSAM 2011; ICES WGSAM 2014), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used based on the results from Nielsen *et al*. (2012).

Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

Ecosystem impacts of fishery: In order to protect other species (cod, haddock, whiting, saithe and herring as well as mackerel, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, by-catch regulations, minimum mesh size, and minimum landing size. A review of regulations on the Norway pout stock and be found in Nielsen *et al.* (2016a).

12.1.2 Fisheries

The fishery is nearly exclusively performed by Danish and Norwegian vessels using small mesh trawls in the north-western North Sea, especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. Some catch also originates from Norwegian fishery in the 2nd quarter. The Norway pout fishery is a mixed commercial, small meshed fishery conducted nearly exclusively by Denmark and Norway directed towards Norway pout as one of the target species together with Blue Whiting in the Norwegian fishery. The international commercial Norway pout fishery has been reviewed in Nielsen *et al.* (2016a) including a detailed analysis of the Danish commercial fishery, and a detailed description of the Norwegian fishery can be found in Johnsen *et al.* (2016). These papers include among other detailed analyses of quarterly and spatial distribution of the Norway pout fishery and catches, the by-catches and discard, the quota up-take and the fishery regulations. Furthermore, the **Stock Annex** also includes the long term trends in average exploitation pattern.

Landings have been relatively low since 2001, and the 2003–2004 landings were the lowest on record (**Tables** 12.2.1–2). The directed fishery for Norway pout was closed in 2005, in the first half of 2006, and in 2007 as well as in the first half of 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery around 5 kt, as well as in a small experimental fishery in 2007 (1 kt). In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low. Catches were above 100 kt in 2010, but have in the period 2012–2018 been below 100 kt and the quota has not been taken in those years. The landings in 2016 and 2017 were 63,4 kt and 33,9 kt, respectively. The fishery has in these periods mainly been based on the 2008, 2009, 2012, 2014 and 2016 year classes being above the long term average level. The TAC was not taken in 2008–2010 and 2012–2018, while the small TAC in 2011 was taken. This was likely due to targeting of other industrial species like sprat for which fishing costs are lower, but also high fishing (fuel) costs and bycatch regulations (mainly in relation to whiting and herring bycatch) have an impact (see details in Nielsen *et al.*, 2016a). Furthermore, late opening of the fishery at the end of quarter 3 in 2012, and individual quotas for the Danish fishery as well as a general herring by-catch quota may also play a role in the uptake. Trends in yield are shown in **Table** 12.3.6 and **Figure** 12.3.5.

By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al.*, 2006, ICES CM 2007/ACFM:35, (WD 22 and Section 16.5.2.2); see also review in Nielsen *et al.*, 2016a). By-catches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from **Table** 12.2.1. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and Section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012; see also review in Nielsen *et al.*, 2016a; Johnsen *et al.*, 2016). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found in Nielsen *et al.*, (2016a) and in the **Stock Annex**.

The quality of the landings statistics in Norway and Denmark is described in the ICES WKPOUT (2016) and associated Annexes (Nielsen *et al.*, 2016a; Johnsen *et al.*, 2016). The quality seems to be relatively constant during the last 20 years and of a higher quality than in the years before. The discard level of Norway pout in the North Sea fisheries is considered to be low (Nielsen *et al.*, 2016a).

12.1.3 ICES advice

In September 2017, the advice on North Sea Norway pout was updated. Based on the estimates of SSB in September 2017, ICES classified the stock to show full reproductive capacity. Norway pout is a short-lived species. Recruitment is highly variable and strongly influences the spawning stock and total biomass. The default ICES approach to MSY-based management for short-lived species is an escapement strategy, i.e. to maintain SSB, with 95% probability, above B_{lim} after the fishery has taken place. The former F_{cap} and MSY $B_{escapement}$ reference points have not been used because the forecast is now stochastic and uncertainties in the assessment and forecast are directly taken into account to ensure the SSB stays above B_{lim} with 95% probability. For the implementation of the escapement strategy, which aims to maintain the SSB above B_{lim} after the fishery has taken place, SSB is calculated for quarter 4 as a proxy for SSB at spawning time (quarter 1). Consequently, the B_{lim} has been adjusted in the benchmark assessment in 2016. The B_{lim} estimate in the 4th quarter is lower than the previous value of B_{lim} for the 1st quarter because the 0-group and many of the 1-group fish are not yet included in the estimate of SSB. The catch forecast is for the period 1 October to 30 September. ICES considered that this forecast could be used directly for management purposes for the period 1 November 2016–31 October 2018. In recent years, the escapement strategy has been practiced in reality in management. The ICES advice in September 2017 (version April 2018) was that with catches up to 213 kt in the directed Norway pout fishery in the period 1 November 2017 to 31 October 2018 corresponding to an F around 0.74 the 5th percentile of the spawning-stock biomass in the 4th quarter 2018 will remain above a reference level of B_{lim} (39 450 t). The SSB was expected to remain high during 2017 and 2018 due to the high 2014 and 2016 recruitment, the growth and 20 % mature as 1-group, and still considering the high natural mortality as well as the short life span of the stock.

According to the escapement strategy, the fishery was closed 1 January 2012 because of the well below, nearly historical low, recruitment in 2010 and 2011. A small TAC of 6 kt was set for the second half year 2011 which was taken. Based on the high recruitment in 2012 the fishery was opened again for second half year 2012. Based on the high recruitment in 2012, 2014 and 2016, as well as a just below average recruitment in 2015 and 2017, the fishery has remained open for all of 2013–2018. The quota uptake has been less than 30% in recent years (Nielsen *et al.*, 2016a). The quota uptake has again in 2017 been very low.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long-term average F (0.42) as estimated from the assessment in September 2018.

There is bi-annual information available to perform real time monitoring and management of the stock. This can be carried out both with fishery independent and fishery dependent information as well as a combination of those. Real time advice (forecast) and management options for 2019 (up to 31 October) is provided for the stock in autumn 2018 as well.

ICES advices that there is a need to ensure that the stock remains high enough to provide food for a variety of predator species. It is advised that by-catches of other species should also be taken into account in management of the fishery. Also it is advised that existing measures to protect other species should be maintained.

12.1.4 Management up to 2017

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the MSY approach for short lived species in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing on marine ecosystems.

ICES advised in 2005 real time management of this stock. In previous years the advice was produced in relation to a precautionary TAC, which was set to 198 000 t in the EC zone and 50 000 t in the Norwegian zone. On basis of the real time management advice from ICES, EU and Norway agreed to close the directed Norway pout fishery in 2005, first part of 2006, all of 2007 and in first part of 2011 and 2012. In 2005 and 2007, the TAC was 0 in the EC zone and 5000 t in the Norwegian zone – the latter to allow for by-catches of Norway pout in the directed Norwegian blue whiting fishery. The final TAC set for 2008 was 115 kt (EU), 116 kt (EU) for 2009, 162 kt (EU) for 2010, 8 kt for 2011, 96 kt for 2012, 323 kt for 2013, 252 kt for 2014, 328 kt for 2015, 360 kt for 2016, and 346 kt for 2017, however, the TACs were not taken during this period except for the small TAC in 2011. The TAC advice for 2018 has up to now been 212 kt. Fishery was closed in first half year 2011 and 2012. By-catch regulations have sometimes been restrictive (e.g. in 2009 and 2010 mainly in relation to whiting bycatch).

In managing this fishery by-catches of other species have been taken into account. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained.

Long term management strategies have been evaluated for this stock based on joint EU-Norway requests (see Section 5.10). ICES has evaluated and commented on three management strategies in 2007, although these have not been decided on. Long term management strategies have been evaluated again in September 2012 and June 2013 based on new joint EU-Norway requests (ICES, 2012b) in spring 2012 and spring 2013 to be available for the September 2012 and September 2013 ICES advice, respectively. These MSEs have been presented in special ICES reports (Vinther and Nielsen, 2012; 2013). No long-term management strategies have been decided upon.

With the changes introduced by the August 2016 Norway pout benchmark assessment (ICES WKPOUT 2016 and Annexes) involving change of assessment model, change of assessment year, change of assessment period, removal of the commercial fishery tuning fleet in the assessment, change of the plus-group in the assessment from 4+ to 3+

and change of stock MSY reference level these previous MSEs cannot be used anymore for long term management plans of the stock (including the F_{cap} estimates made there).

Long-term management strategy evaluation according to the new assessment and the revised reference levels as established from the benchmark assessment in August 2016, have been requested in a joint EU-Norway request from November 2017. Based on this EU-Norway request, ICES on 29 May 2018 released its advice evaluating long-term management strategies for Norway pout in area 4 and 3a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) which is based on the work from the ICES WKNPOUT (ICES WKNPOUT, 2018) as presented to the ICES WGNSSK and approved by ICES ACOM in May 2018.

ICES has evaluated sustainability of a range of harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TACmin) and upper (TACmax) bounds on TAC and optional use of upper fishing mortality values (F_{cap}). Several HCRs were identified that combined TACmin in the range of 20 000–40 000 tonnes and TACmax less than or equal to 200 000 tonnes (150 000 t or 200 000 t) and F_{cap} values of 0.3 and 0.4, resulting in no more than a 5% probability of the spawning-stock biomass falling below B_{lim}.

ICES has evaluated harvest control rules (HCRs) within the escapement strategy presently used (aimed at retaining a minimum stock size in the sea every year after fishing) that are restricted by a combination of TAC lower bounds (TACmin) and upper bounds (TACmax). For some HCRs, an upper limit on F (F_{cap}) is also used for setting the TAC.

Because of uncertainties in the estimate of the incoming year class, escapement strategies for short-lived species, where catch opportunities are very dependent on the strength of the incoming year class, may lead to a TAC where a too high portion is caught. ICES evaluations were conditioned by a maximum realized level of fishing mortality the fishery can exert (assumed at 0.89; $F_{historical}$), which means that the full TAC will not be taken if the required F to catch the TAC exceeds this value.

The identified combinations of TACmin, TACmax, and F_{cap} give a less variable TAC and F from one year to the next, but also a lower long-term yield than the default escapement strategy. ICES is not in position to advise on this trade-off between higher yield and stability.

The results are sensitive to the assumption that the fishery stops catching Norway pout when F exceeds $F_{historical}$. Therefore, the HCR should be re-evaluated if future F exceeds $F_{historical}$ (0.89).

The evaluation showed that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy is only precautionary with the addition of an F_{cap} at 0.7.

In recent consultations between EU and Norway, held on 5 and 6 September 2018, the advice was presented by ICES and in the following discussions, certain limited additional elements, to be reviewed by ICES, came up. This resulted in an additional EU-Norway request from September 2018 on evaluation of additional elements concerning the ICES advice evaluating long-term management strategies for Norway pout in areas 4 and 3.a. Here, ICES is requested to assess, following MSY $B_{escapement}$:

- which scenarios of TACmin and TACmax would be precautionary, if the F_{cap} is set at 0.7 (building on request part 2 and 3, pages 3 and 4 of the advice).
- which scenarios of TACmin and TACmax would be precautionary, if an inter-annual flexibility of +/-10% (both banking and borrowing) was introduced for Norway pout (building on request part 2 and 3, pages 3 and 4 of the advice, plus including precautionary scenarios with an F_{cap} of 0.7 – following from paragraph 1 of this request).

The deadline for this request is 9 October 2018 (or else, if possible, ahead of the EU/Norway annual consultations on 26–30 November 2018). Accordingly, the evaluations and ACOM approval is ongoing, and no final advice and decision on long-term management plans are currently available for the Norway pout in area 4 and 3a.

An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the **Stock Annex.**

12.2 Data available

12.2.2 Landings / catches

Data for annual nominal landings of Norway pout as officially reported to ICES are shown in **Table** 12.2.1. The landings equal the catches of Norway pout as discard in this small meshed fishery is negligible (see also Nielsen *et al.*, 2016a). Historical data for annual landings (catches) as provided by ICES (Working Group members) are presented in **Table** 12.2.2, and data for national landings (catches) by quarter of year and by geographical area are given in **Table** 12.2.3. Total observed and predicted (by the SESAM stochastic assessment model) catches by quarter is given in **Table** 12.2.3a. Both the Danish and Norwegian landings (catches) of Norway pout were low in 2007 and 2011. The landings were moderate in 2008–09, 2012, 2014 and 2017, higher in 2013 and 2015–2016, and high in 2010. The TAC was not reached in any of those recent years. The most recent catches have been included in the assessment. Catches for 3rd quarter 2018 include Danish and Norwegian catches up to 10 September 2018. Catches in the last two-three weeks of 3rd quarter 2018 are assumed to be relatively low and no guesses on that have been included in the assessment.

12.2.3 Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 2007 and 2008). Catch at age by quarter of year is shown in **Table** 12.2.4. Only very few biological samples were taken from the low Norway pout catches in 2005 and 2011, as well as in first half year 2006, 2007, and 2012. The data are in the InterCatch database.

As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches, the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery for those years. As no age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches the catch at age numbers from Danish fishery is calculated from Danish total catch weight divided by mean weight at age from the Norwegian fishery in 2010.

12.2.4 Weight at age

Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight at age in the catch is shown in **Table** 12.2.5 and the historical levels, trends and seasonal variation in this is shown in **Figure** 12.2.1. Mean landings weight at age from Danish and Norwegian fishery from 2005–2008 as well as for 2011 are uncertain because of the few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005–2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight at age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight at age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight at age data is available from both Danish and Norwegian fishery in 2009, second half 2010, second half 2011, second half 2012, and all of 2013, 2014, 2015, 2016, 2017 as well as for quarter 1 to quarter 3, 2018.

Mean weight at age in the stock is given in **Table** 12.2.6. The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduced revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009). The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. This has resulted in slightly changed levels of constant mean weight at ages in the stock which have been calculated partly from long term averages of mean weight at age in the catch. In the **Stock Annex** and in Nielsen (2016) a summary is given of the Inter-benchmark revisions in 2012 of the population dynamic parameters in the assessment. No major revision of mean weight at age in the stock has been performed compared to the values used in previous assessments. The estimation of mean weights at age in the catches and the used mean weights in the stock in the assessment is described in Nielsen (2016) and in the **Stock Annex.** The data are in the InterCatch database.

12.2.5 Maturity and natural mortality

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM 2011; ICES WGSAM 2014). In Nielsen (2016) and in the **Stock Annex,** a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment where maturity and natural mortality used in the assessment is described. Proportion mature and natural mortality by age and quarter used in the assessment is given in **Table** 12.2.6.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a paper by Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, then variable natural mortality between ages have been introduced in the 2012 ICES IBPNorwayPout inter-benchmark assessment (ICES, 2012c) and the present assessment. The revision of the natural mortality parameter is based on results in Nielsen *et al*. (2012) and the ICES WGSAM (2011) and ICES WGSAM (2014) multi-species assessment reports. The revised values are shown in **Table** 12.2.6.

12.2.6 Summary of Inter-benchmark assessment on population dynamic parameters

A summary of the ICES Spring 2012 inter-benchmark assessment with revised weight, maturity and natural mortality parameters at age included in the assessment is given in Nielsen (2016) and in the **Stock Annex** as well as in the ICES IBPNorwayPout inter-benchmark assessment report (ICES, 2012c)

12.2.7 Catch, Effort and Research Vessel Data

Description of catch, effort and research vessel data used in the assessment is given in the ICES WKPOUT 2016 Benchmark Report and its Annexes, in Section 5.3 below, as well as in the **Stock Annex** (see also **Table** 12.3.1)**.**

12.2.7.1.1 Commercial fishery data

Catch information for 1984–2018 is included in this assessment as presented in **Tables** 12.2.1–12.2.5 and **Figure** 12.2.1. Catches in all of 2005, 1st quarter 2009, first half year 2011 and 2012, and first quarter 2013 were nearly 0 and only very limited information exists about this catch. Consequently, there has been assumed and used low catches of 0.1 million individuals per age (for age groups 1–3) per quarter in the assessment for 2005 and 2011. The fishing effort and catch efficiency (catch per unit of effort) and of the Danish and Norwegian commercial fishery according to year and quarter of year are shown in **Tables** 12.2.7 and 12.2.8, respectively, and according to year and fishing vessel engine horse power category in **Tables** 12.2.9 and 12.2.10, respectively. Furthermore, trends herein are shown in Nielsen *et al.* (2016a) and in Johnsen *et al.* (2016).

No commercial fishery tuning fleet is included in the assessment from 2006 onwards based on the decisions made in the Norway pout benchmark assessment in September 2016 (ICES WKPOUT, 2016).

12.2.7.1.2 Research vessel data

Fishery independent survey data used as tuning fleets in the present assessment is given in **Table** 12.2.11 and **Figure** 12.2.2 (see also **Table** 12.3.1).

Survey indices series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (International Bottom Trawl Survey 1st and 3rd quarter) and the EGFS (English Ground Fish Survey, 3rd quarter) and SGFS (Scottish Ground Fish Survey, 3rd quarter), **Table** 12.2.11. The new survey data from the 1st quarter 2018 IBTS and the 3rd quarter 2017 IBTS research surveys have been included in this September 2018 assessment as well as the 3rd quarter 2018 EGFS and SGFS research survey information. The survey data time series including the new information is presented in **Table** 12.2.11, as well as trends in survey indices in **Figure** 12.2.2. Surveys covering the Norway pout stock are described in detail in ICES WKPOUT (2016), Nielsen (2016) and in Johnsen and Søvik (2016) as well as in the **Stock Annex**. Survey data time series used in tuning of the Norway pout stock assessment are described below.

From 2009 and onwards, the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted subarea averages.

In 3rd quarter 2015–2016 test trials were conducted in the international third quarter IBTS with 15 min duration hauls compared to 30 min duration hauls. The new 15 min test hauls have been included in the index calculation for 3rd quarter 2015–16, and will potentially affect the Norway pout indices for the SGFS and the combined IBTS Q3 index. It has been necessary to include the 15 min hauls in the SGFS 2015–16 as extensive areas (of the total SGFS survey area) are only covered with this type of hauls. Only one 15 min test haul was included in the EGFS 2015 and none in 2016. There has been no continuation of the tow duration experiment in the Q3 surveys in 2017–2018 and, accordingly, no new 15 min hauls have been conducted and included in the Q3 2017–2018 SGFS and EGFS survey indices (and consequently in the combined Q3 IBTS survey index). Analyses of this are on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices. Preliminary analyses indicate no significant differences in catch rates of Norway pout between the 15 min hauls and the 30 min hauls in the SGFS, however, the variability is very high and there are only very few observations available. Long time series and many observations are necessary to make statistical robust evaluation of potential differences.

In September 2015, the EGFS survey indices were revised as to incorporate the relevant primes within the Norway pout area following the IBTS Manual (2015), i.e. in the selection of the prime stations to be included in the Norway pout index calculation. The revision is described in detail in an ICES working document to ICES WGNSSK 2015 (Silva, 2015 – see reference list). This has changed the EGFS indices for Norway pout for all years and ages since 1992. Especially, the indices for the 0-group have changed significantly without any obvious trends over time. However, the perception of the dynamics in the stocks (e.g. strong year classes as 0-group and also as older ages in the cohorts) seems not to have changed in relative terms for this survey. Consequently, there is consistency in this to the previous EGFS indices and in relation to the other survey indices also for Norway pout. In the EGFS Q3 2017-2018, an additional haul has been taken (prime 77 – DATRAS haul number 147) fished on behalf of the Scottish (SGFS) that falls inside ICES rectangle 40E8 and, therefore, inside the Norway pout index area according to the IBTS manual. This prime is expected to be fished from now on by the English (EGFS) so it will fall inside the English survey index instead of the Scottish survey index. In order to make the EGFS time series consistent over time it has been decided to exclude the Prime 77 haul in the 2017–2018 indices used in the assessment. By comparison, it appears that the survey trends seem similar with or without prime 77 in the EGFS for 2017–2018.

With respect to the SGFS 2017 Q3 index, around 5 survey days was lost in 2017 due to vessel issues. Hence, there were only 76 hauls in 2017 compared to 99 hauls in 2016. In 2016, there was almost a 50/50 split by ICES Subarea with 50 hauls undertaken in 4A and 49 in 4B in the SGFS. In 2017, this was slightly more unbalanced with 43 hauls taking place in 4A and 33 in 4B. Finally, it should be noted that in the 2014 IBTS Q1 survey, less hauls were conducted in the northern part of the North Sea than usual. This did not result in change in the perception of the stock dynamics.

From 3rd quarter 2018, the depth range of the IBTS survey has been extended to 250 m (previously 200 m). The tows deeper than 200 m are extra stations. These stations have not been included in the NP survey indices. Obviously, those additional hauls cannot be included into the standard indices before the effects are statistically robustly evaluated and before reasonable time series and adequate number of observations are available to analyse the potential effects of inclusion of the deeper tows in the indices.

The survey data time series including the new information are presented in **Table** 12.2.11.

12.2.7.2 Revision of assessment tuning fleets

The revision of the tuning fleets used in the benchmark 2004 assessment - as used in the 2005–2006 and 2007–2015 assessments – and the additional revisions of the tuning fleets in the benchmark 2016 assessment – as used in the September 2016 and future assessments - is summarised in **Table** 12.3.1. Details of the revision are described in the **Stock Annex** and in the ICES WKPOUT 2016 Report and its Annexes**.**

The overall assessment period has been changed by cutting off the first assessment year (1983), so the assessment period is from 1984–2018, and the assessment tuning fleets have been changed by removing the quarter 1, 3, and 4 commercial tuning fleets and keeping the same survey fleets. The assessment biological parameter settings are the same according to the Inter-benchmark assessment in spring 2012 (ICES IBPNorway-Pout, ICES 2012c) with respect to the population dynamic parameter settings in the assessment for natural mortality, maturity at age and mean weight at age in the stock (see also **Table** 12.3.1).

12.3 Catch at Age Data Analyses

12.3.2 Review of assessment

The September 2017 assessment was accepted and no overall or specific recommendations and comments were given here. Potential retrospective patterns in SSB and R were discussed at the ICES WGNSSK meeting in May 2018, but no major issues and problems were pointed at, and it was concluded that the assessment has been performed correctly and performs well. In the 2014 assessment review, it was only noted that potential area specific assessment should be considered in relation to a benchmark assessment.

12.3.3 Final Assessment

A seasonal extension to the State-space Assessment Model (SAM) was used during this September 2018 assessment (SESAM), and in the benchmark 2016 Norway pout assessments reported in ICES WKPOUT (2016). In the latter, the SESAM assessment model was evaluated and compared with the assessment model previously used (Seasonal extended survivors analysis SXSA). It was found that this new model (SESAM) estimates very similar trends in SSB and fishing mortality compared to SXSA. The SESAM model was preferred by the ICES WKPOUT (2016) benchmark assessment group due to its ability to incorporate process and observation error and estimate uncertainties in all quantities, including the forecast.

The method is described in detail in Nielsen and Berg (2016; WD6 of the ICES WKPOUT (2016)), and the source code, input data and output is available online at www.stockassessment.org under "NorPoutBench2016", and for the current September 2018 assessment under "NP_Sep18" at the same website.

In brief, the model is the same as the SAM model, except that the time step used is one quarter of a year rather than a full year. Recruitment is assumed to occur in quarter 3 only. The logarithm of the fishing mortality at age and quarter is assumed to follow a multivariate random walk with lag 4 and correlated increments, i.e. the log F-at-age in a given quarter is given by the log F-vector in the same quarter one year earlier plus a correlated noise term with mean zero.

The observation equations in SESAM are also extended to deal with zero observations (both surveys and catches), which are usually treated as missing values in SAM. This is done by introducing a detection limit for each fleet, and defining the likelihood of a zero observation to be the probability of obtaining a value less than the detection limit. The detection limit is set to 0.5 times the smallest positive observation by fleet.

A special option was included to down-weight the influence of large jumps in log F on the estimated random walk variance due to periods where the fishery was closed. This option reduced the estimated log F process variance considerably.

In the ICES WKPOUT (2016) benchmark, a number of variants of the SESAM model were investigated and compared to the previous assessment model, SXSA. These variants included the use (or not) of commercial CPUE data, omission of the earliest years of data from the assessment, alternative settings for the detection threshold used to handle zero-valued data, and omitting the years of fishery closure when estimating the random walk variance on fishing mortality.

The final SESAM model also used in this September 2018 assessment excludes commercial CPUE data, omits 1983 data from the assessment, use age 3+-group, and omits the years of fishery closure from the random walk variance calculation. In relation to evaluation of stock sustainability and forecast B_{lim} is set equal to B_{loss} based on quarter 4 SSB values to align with the new fishing season (1 November to 31 October). The short-term forecast is stochastic, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season.

Stock indices and assessment settings used in the assessment are presented in **Tables 12**.3.1-12.3.2.

Results of the SESAM analysis are presented in **Tables** 12.3.1–12.3.2 (assessment model parameters, settings, and options), **Table** 12.3.3 (population numbers at age (recruitment)), **Table** 12.3.4 (fishing mortalities by year and quarter), **Table** 12.3.5 (diagnostics), and **Table** 12.3.6 (stock summary). The summary of the results of the assessment are shown in **Table** 12.3.6 and **Figures** 12.3.1 (spawning stock biomass, SSB), 12.3.2 (total stock biomass, TSB), 12.3.3 (fishing mortality, F_{bar}), 12.3.4 (recruitment), 12.3.5 (yield, catches on yearly and quarterly basis), and 12.3.6–12.3.7 (stock-recruitment plots for quarter 1 and quarter 3, respectively). The retrospective patterns and the residuals from the SESAM September 2018 assessment are given in **Figure** 12.3.8 and **Figures** 12.3.9–12.3.11, respectively.

Fishing mortality has generally been lower than natural mortality and has decreased in the recent 20 years below the long term yearly average (0.42, **Tables** 12.3.4 and 12.3.6). Fishing mortality for the 1st and 2nd quarter has in general decreased in recent years, while fishing mortality for 3rd and especially 4th quarter, that historically constitutes the main part of the annual F, has also decreased moderately during the last 20 years. Fishing mortality in 2005, first part of 2006, 2007, 2008, 2011, and in first part of 2012 was close to zero due to the closure of the Norway pout fishery in those periods. Fishing mortality was moderate in 2009 and 2010 and on a higher level in second half 2012 and in 2013-2017, and the TACs have not been fished up in any of these recent years. In recent years the quota uptake has been below 30% (see Nielsen *et al.*, 2016a), and in 2017 the quota uptake has also been very low. The low TAC of 6 kt in 2011 was taken in second half year resulting in a very low F in 2011.

Spawning stock biomass (SSB) has since 2001 decreased continuously until 2005 but has in recent years increased again due to the strong 2008, 2009, 2012, 2014, and 2016 year classes, and the lowered fishing mortality. The stock biomass fell to a level well below $\mathbf{B_{lim}}$ in 2005 which is the lowest level ever recorded. By 1 January 2007 and 2008 the stock was at $\mathbf{B_{pa}}$ (= MSY $\mathbf{B_{escapement}}$) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1 January 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017 and 2018 has been above Bpa (i.e. the stock show full reproductive capacity).

The recruitment in 2010 was very low and at the same level as the low 2003 and 2004 year classes where these three year classes are the lowest on record since the mid-1980s. The recruitment in 2008, 2009, 2012, 2014, 2016 and 2018 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 was slightly below long term average (43 billion), but because of the strong 2012, 2014 and 2016 year classes the SSB has been well above $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{escapement}}$) by 1 January 2014, 2015, 2016, 2017 and 2018 even with a high yearly TAC in 2014–2018 considering growth, high natural mortality, and 20% maturation at age 1. Because of the nearly average recruitment in 2015 and 2017 and the strong 2016 and 2018 recruitment the stock is expected to remain above $\mathbf{B_{pa}}$ by the end of 2018.

12.3.4 Comparison with 2015–2017 assessments

The final, accepted September 2015 SXSA assessment run was compared to the Inter-benchmark May 2012 and the update September 2014 and May 2014 Scenario 2 SXSA assessments. The results of the comparative runs between the September 2015 and the September 2014 and May 2014 assessments are shown in the ICES WGNSSK 2015 Report. The resulting outputs of these assessments showed to be identical giving similar perception of stock status and dynamics.

The WKPOUT 2016 benchmarking comparison of the SESAM and SXSA May 2014 assessments are presented in the ICES WKPOUT 2016 Report. The overall conclusions were that the two assessments give the same perception of stock dynamics with respect to abundance (SSB) and recruitment over time. There was some variability in the estimates of fishing mortality especially in the middle of the assessment period, however, the SXSA estimates lies within the confidence intervals of the SESAM estimates of fishing mortality.

In **Figures** 12.3.1, 12.3.3 and 12.3.4 the SESAM September 2018 assessment estimates of spawning stock biomass, fishing mortality, and recruitment are shown, respectively, in comparison to the corresponding SXSA May 2014 assessment estimates. It also appears from this comparison that the conclusions are the same as above for the comparison of the two 2014 assessments, i.e. that the two assessments give the same perception of stock dynamics.

The retrospective analysis based on the SESAM September 2018 assessment is shown in **Figure** 12.3.8. There is a tendency towards the retrospective analyses do not fully converge even though being at the same level and showing the same perceptions of the stock dynamics. It should be noted, that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments. In the benchmark May 2014 assessment, it is estimated to 40 kt while in the present September 2018 assessment it is estimated to 30 kt.

12.4 Historical stock trends

The assessment and historical stock performance is consistent with previous years assessments, i.e. the perception of stock dynamics of the SSB and recruitment over time are consistent, while there is some variability between models in the estimates of the average fishing mortality of ages 1 and 2 over time especially in the middle of the assessment period, however, the SXSA estimates of fishing mortality is within the confidence limits of the SESAM estimates of fishing mortality. However, based on the Inter-

Benchmark in spring 2012 with revised estimates of natural mortality, maturity at age and mean weight at age for the stock in the assessment there is a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10 % in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter. This is shown in the ICES IBPNorwayPout Report (ICES, 2012c) and the **Stock Annex**.

Recruitment Estimates

The long-term average recruitment (age 0, 2nd quarter) is 43 billions (arithmetic mean) for the period 1984–2018 (**Table** 12.3.6). Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species and because 20% reach maturity as 1-group. The recruitment reached historical minima in 2003–2004 as well as in 2010. The recruitment in 2008, 2009, 2012, 2014, 2016 and 2018 was high. Recruitment in 2011 and 2013 was very low, and the recruitment in 2015 and 2017 has been slightly below long term average (43 billion).

12.5 Short-term prognoses

The short-term forecast is stochastic based on the SESAM September 2018 assessment, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season. The SESAM is, like the SXSA, a quarterly based model estimating biomass at the start of each quarter of the year.

Short-term projections are carried out as follows.

1. Assume values for M, weight-at-age in the catches and in the stock, and maturity-at-age for the projection period. Since all of those quantities except weight-at-age in the catches are assumed constant over time, only weight-at-age requires special treatment. A procedure for forecasting catch weights is described in ICES WKPOUT 2016 (WD6; Nielsen and Berg 2016), but see also below.

2. Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years.

3. Assume that log Ft = log Ft-4 + log Gt, for all future values of t where Gt is some chosen vector of multipliers of the F-process. If Gt = 1 for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year.

4. Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution.

It should be noted that the short term forecast only uses the observed 2018 recruitment (Q3 2018) in the SSB estimate by 4th quarter 2018. The recruits in 2019 do not become a part of SSB by 4th quarter (1 October) 2019 because they have not reached maturity yet by 4th quarter 2019, but will do that by 1 January 2020 (20% mature as 1-group here). However, the forecast is just run up to 4th quarter 2019, and the recruits in 2019 is accordingly not used (and shall not be that) in the forecast SSB estimate in Q4 2019.

5. Find Gt such that the fifth (or any other) percentile of the catches (total mass) in the projections equal some desired level such as B_{lim} (optional).

Forecasting weight-at-age in the catches

There is substantial variation in weight-at-age in the commercial catches from year to year, which means that usual methods of using running averages will be quite sensitive to the bandwidth of the running average. This is important, since TAC estimates calculated in step 5 above depend directly on the catch weight-at-age.

The following model is used:

$$E(\sqrt{CW_{a,q,t}}) = \mu_{a,q} + s(cohort, a) + U_t$$

where $\mu_{a,q}$ is a mean for each combination of quarter and age, s( ) is tensor product smoothing spline, and U_t are normal distributed random effects. The square root transform is used to achieve variance homogeneity in the residuals. See Figure 1 in ICES WKPOUT 2016 (WD6; Nielsen and Berg 2016).

The projected mean weight at ages in the catch used in the forecast are shown in **Table** 12.6.1.

Forecasts:

The first forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1 October as explained below in Section 12.7. The purpose of the first forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2019) equals B_{lim}, i.e. where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%. The results of the forecast are presented in **Table** 12.6.2 and **Figure** 12.6.1, and this results in a catch up to 156 kt (156 798 t) in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,843 and a SSB at 112 kt (112 160 t) by 1 October 2019.

The purpose of the second forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to zero. The results of the forecast are presented in **Table** 12.6.3 and **Figure** 12.6.2 resulting in no catch in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,00 and a SSB at 175 kt (175 250 t) by 1 October 2019.

The purpose of the third forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to F status quo for previous year up to 1 October 2018. The results of the forecast are presented in **Table** 12.6.4 and **Figure** 12.6.3 where catches up to 40 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,180 and a SSB at 157 kt (157 000 t) by 1 October 2019.

The purpose of the fourth forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled such that the median of the SSB distribution one year a head (1 October 2019) equals B_{lim}. The results of the forecast are presented in **Table** 12.6.5 and **Figure** 12.6.4 where catches up to 416 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 4,045 and a SSB of 39 kt (39 450 t) by 1 October 2019.

The purpose of the fifth forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled such that SSB one year a head (1 October 2019) equals B_{pa}. The results of the forecast are presented in **Table** 12.6.6 and **Figure** 12.6.5

where catches up to 313 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 2,308 and a SSB of 65 kt (65 000 t = B_{pa}) by 1 October 2019.

The purpose of the sixth forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to 0,3, i.e. with a F_{cap} = 0,3. The results of the forecast are presented in **Table** 12.6.7 and **Figure** 12.6.6 where catches up to 64 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,303 and a SSB of 146 kt (146 150 t) by 1 October 2019.

The purpose of the seventh forecast is to calculate the catch of Norway pout from 1st October 2018 to 31st October 2019 with F scaled to 0,4, i.e. with a F_{cap} = 0,4. The results of the forecast are presented in **Table** 12.6.8 and **Figure** 12.6.7 where catches up to 83 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,400 and a SSB of 138 kt (138 890 t) by 1 October 2019.

The purpose of the eight forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to 0,5, i.e. with a F_{cap} = 0,5. The results of the forecast are presented in **Table** 12.6.9 and **Figure** 12.6.8 where catches up to 102 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,503 and a SSB of 131 kt (131 760 t) by 1 October 2019.

The purpose of the ninth forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to 0,6, i.e. with a F_{cap} = 0,6. The results of the forecast are presented in **Table** 12.6.10 and **Figure** 12.6.9 where catches up to 119 kt can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,605 and a SSB of 125 kt (125 010 t) by 1 October 2019.

The purpose of the tenth forecast is to calculate the catch of Norway pout from 1 October 2018 to 31 October 2019 with F scaled to 0,7, i.e. with a F_{cap} = 0,7. The results of the forecast are presented in **Table** 12.6.11 and **Figure** 12.6.10 where catches up to 135 kt (135 459 t) can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,705 and a SSB of 119 kt (119 310 t) by 1 October 2019.

According to the long term management strategy evaluation based on the joint EU-Norway request from Nov. 2017 and the resulting released advice by ICES in May 2018 evaluating long-term management strategies for Norway pout in area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) it was shown that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is only precautionary with the addition of an F_{cap} at 0.7.

12.6 Medium-term projections

No medium-term projections are performed for this stock. The stock contains only a few age groups and is highly influenced by recruitment.

12.7 Biological reference points

As explained in the ICES WKPOUT 2016 Report, Section 3.8, the benchmark has recommended that the B_{lim} = B_{loss} should be the lowest SSB estimated in quarter 4, because this is closest to the beginning of the fishing season (1 November), and would be the most appropriate to use as a B_{lim} reference point, because the probability of SSB being below B_{lim} can then be evaluated immediately after the fishing season for which a TAC is being calculated. It was argued that the quarter 4 SSB (an existing output of the SESAM model) was adequate for this purpose because any attempt to calculate an SSB corresponding to 1 November would require further assumptions and would effectively only be an interpolation between the quarter 4 and subsequent quarter 1 SSBs, thus unnecessarily complicating the calculation of the SSB. The forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1 October. Accordingly, it is recommended that this TAC is used for the management year 1 November – 31 October. This is an approximation and will be sustainable unless radical changes occur in the seasonal fishing pattern used in the forecast. In the period between 1 October and 1 November in the forecast year there will be provided a new assessment.

In **Table** 12.6.12 quarterly minima of the estimated SSB time series (1984–2016) are shown from the SESAM Benchmark Assessment Baseline Run from the Norway pout benchmark assessment under ICES WKPOUT 2016. The estimates are quarterly minima estimated at the beginning of the season. The lowest observed biomasses in the assessment period are in 2005. The estimates are B_{loss} estimates which equals B_{lim} according to the ICES WKPOUT 2016 benchmark assessment which by 1 October is B_{lim} = 39 450 t.

The B_{lim} SSB estimate in Q4 is low because of the 0-group and many of the 1-group fish are not in the SSB yet at that time. However, in the forecast there is a change in maturity and a age class shift by 1 January, i.e. the 0-group becomes 1-group and 20% of those become mature, and the 1-group becomes 2-group and 100% of those become mature. This is in the forecast calculated into the SSB available for spawning in 1 quarter of the forecast year.

The fishing pattern has not changed in the most recent years. Accordingly, the use of B_{lim} by Q4 should be sustainable.

It should be noted that there is a tendency towards the retrospective analyses do not fully converge even though being at the same level. It should also be noted that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments. In the benchmark May 2014 assessment it is estimated to 40 kt (39 450 t) while in the present September 2018 assessment it is estimated to 30 kt (30 169 t).

	Type	Value	Technical basis
MSY Approach	MSY	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	B_{pa}	65 000 t, quarter 4	$= B_{lim}\ e^{0.3*1.65}$
	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

No F-based reference points are advised for this stock except for an F_{cap} (see Sections 12.1.4 and 12.10).

Norway pout is a short lived species and most likely a one time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a,b; Lambert *et al.*, 2009). Furthermore, 20 % of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short-lived species.

On this basis, advice on yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is considered sustainable. That is where F is scaled such that the fifth percentile of the SSB distribution one year a head (1 October in forecast year) equals B_{lim}. According to the long term management strategy evaluation based on the joint EU-Norway request from Nov. 2017 and the resulting released advice by ICES in May 2018 evaluating long-term management strategies for Norway pout in area 4 and 3a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) it was shown that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is only precautionary with the addition of an F_{cap} at 0.7.

B_{pa} has been calculated from

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

A SD estimate around 0.3–0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2–0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS, 1999). The relationship between the B_{lim} and B_{pa} (39 450 and 65 000 t) is 0.6.

It is obvious that the Norway pout, being a short-lived species, has no well-defined break point (inflection) in the SSB-R relationship (ICES IBPNorwayPout Report, ICES 2012c; ICES WKPOUT 2016) and therefore there is not clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high recruitment observed at B_{loss} as well as more observations above than below the inflection point).

The B_{lim} = B_{loss} = 39 450 t (quarter 4) is based on the lowest observed SSBs in 2005.

12.8 Quality of the assessment

The estimates of the SSB, recruitment and the average fishing mortality of the 1- and 2-group are consistent with the estimates of previous years assessment. The overall perception of stock dynamics with respect to abundance (SSB) and recruitment over time is the same. There is some variability in the estimates of fishing mortality especially in the middle of the assessment period, however, the previous year estimates of fishing mortality lies within the confidence intervals of the SESAM estimates of fishing mortality.

The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the assessment taking into account the seasonality in fishery, use of seasonal based fishery independent information, and using most recent information about recruitment. The assessment provides stock status and year class strengths of all year classes in the stock up to the end of third quarter of the assessment year. The assessment method gives a good indication of the stock status the 1 October the following year based on projection of existing recruitment information in 3 quarter of the assessment year.

12.9 Status of the stock

Based on the estimates of SSB in September 2018, ICES classifies the stock at full reproductive capacity.

With F scaled to 0,7, i.e. with a F_{cap} = 0,7 catches up to 135 kt (135 459 t) can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1-2)}$ of 0,705 and a SSB of 119 kt (119 310 t) by 1 October 2019. This is due to the strong 2014, 2016 and 2018 recruitment and the just slightly below long term average recruitment (43 billion) in 2015 and 2017, growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.42). Targeted fishery for Norway pout was closed in 2005, first half year 2006, in all of 2007, as well as in first half of 2011 and 2012 and fishing mortality and effort has accordingly reached historical minima in these periods (**Table** 12.3.6). The fishery was open for the second half 2006, 2011 and 2012 as well as in all of the years 2008–2010 and 2013–2018. Here, the fishing mortality was low in 2008 and 2011, moderate in 2009 and 2010, and on a higher level in 2013–2017, but still well below the long term average. The TACs have not been fished up in any of these recent years.

The recruitment reached historical minima in 2003–2004, and the 1987, 2002, 2006, and 2010 year-classes were weak. The recruitment in 2008, 2009, 2012, 2014, 2016 and 2018 was high well above the long-term average (43 billion). Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 has been slightly below the long-term average (**Table** 12.3.6).

12.10 Management considerations

There are no management objectives for this stock.

From the results of the forecast presented here with a F scaled to 0,7, i.e. with a F_{cap} = 0,7 catches up to 135 kt (135 459 t) can be taken in the directed Norway pout fishery in the period 1 October 2018 to 31 October 2019 which corresponds to a $F_{bar(1\text{-}2)}$ of 0,705 and a SSB of 119 kt (119 310 t) by 1 October 2019. This is due to the strong 2014, 2016 and 2018 recruitment and the just slightly below long term average recruitment (43 billion) in 2015 and 2017, growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Norway pout is a short lived species and most likely an one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt et al. 2002a,b; Lambert *et al.*, 2009). Furthermore, 20 % of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short lived species.

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES WGSAM, 2014; 2011; ICES-SGMSNS, 2006). Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the **Stock Annex**.

Historically, the fishery includes by-catches especially of haddock, whiting, saithe, and herring. Existing technical measures to protect these by-catch species should be maintained or improved. By-catches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from **Table** 12.2.1. Sorting grids in combination with square mesh panels have been shown to reduce by-catches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. ICES suggests, that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. The implementation of these technical measures shall be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing by-catch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the **Stock Annex.**

12.10.2 Long term management strategies

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F = 0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES does not recommend any particular one of the strategies.

The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The variable TAC escapement strategy as evaluated in 2007 has higher long term yield compared to the fixed fishing mortality strategy (and the fixed TAC strategy), but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better.

There should be no shift in management strategies between years. In recent years the escapement strategy has been practiced.

A detailed description of the long term management strategies and management plan evaluations can be found in the **Stock Annex** and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30, Section 5.3) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports as well as in Vinther and Nielsen (2012; 2013).

ICES has again in September–October 2012 and April–May 2013 (Vinther and Nielsen, 2012; 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information. In September 2012, ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100–250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the result that an initial TAC between 25–50 kt and a fixed F = 0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference between the MSE 1 and 2–3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2–3), while the minimum TAC in MSE 1 can be applied all year. As a follow up on this, ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1 November – 31 October rather than from 1 January to 31 December, and one annual advice from the September assessment, with the result that a minimum TAC up to 20 kt with maximum TAC of 100 kt (Fmax/cap = 0.8) or with maximum TAC of 200 kt (Fmax/cap = 0.6) will be long term sustainable with some level of F control according to those F_{cap} levels.

With the changes introduced by the August 2016 Norway pout benchmark assessment (ICES WKPOUT 2016 and Annexes) involving change of assessment model, change of assessment year, change of assessment period, removal of the commercial fishery tuning fleet in the assessment, change of the plus-group in the assessment from 4+ to 3+

and change of stock MSY reference level, these previous MSEs cannot be used anymore for long term management plans of the stock (including the F_{cap} estimates made there).

Long-term management strategy evaluation according to the new assessment and the revised reference levels as established from the benchmark assessment in August 2016, have been requested in a joint EU-Norway request from November 2017. Based on this EU-Norway request, ICES on 29 May 2018 released its advice evaluating long-term management strategies for Norway pout in area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) which is based on the work from the ICES WKNPOUT (2018) as presented to the ICES WGNSSK and approved by ICES ACOM in May 2018.

ICES has evaluated sustainability of a range of harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TACmin) and upper (TACmax) bounds on TAC and optional use of upper fishing mortality values (F_{cap}). Several HCRs were identified that combined TACmin in the range of 20 000–40 000 t and TACmax less than or equal to 200 000 tonnes (150 000 t or 200 000 t) and F_{cap} values of 0.3 and 0.4, resulting in no more than a 5% probability of the spawning-stock biomass falling below B_{lim}.

ICES has evaluated harvest control rules (HCRs) within the escapement strategy presently used (aimed at retaining a minimum stock size in the sea every year after fishing) that are restricted by a combination of TAC lower bounds (TACmin) and upper bounds (TACmax). For some HCRs, an upper limit on F (F_{cap}) is also used for setting the TAC.

Because of uncertainties in the estimate of the incoming year class, escapement strategies for short-lived species, where catch opportunities are very dependent on the strength of the incoming year class, may lead to a TAC where a too high portion is caught. ICES evaluations were conditioned by a maximum realized level of fishing mortality the fishery can exert (assumed at 0.89; $F_{historical}$), which means that the full TAC will not be taken if the required F to catch the TAC exceeds this value.

The identified combinations of TACmin, TACmax, and F_{cap} give a less variable TAC and F from one year to the next, but also a lower long-term yield than the default escapement strategy. ICES is not in A position to advise on this trade-off between higher yield and stability.

The results are sensitive to the assumption that the fishery stops catching Norway pout when F exceeds $F_{historical}$. Therefore, the HCR should be re-evaluated if future F exceeds $F_{historical}$ (0.89).

The evaluation showed that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy is only precautionary with the addition of an F_{cap} at 0.7.

In recent consultations between EU and Norway, held on 5 and 6 September 2018, the advice was presented by ICES and in the following discussions, certain limited additional elements, to be reviewed by ICES, came up. This resulted in an additional EU-Norway request from September 2018 on evaluation of additional elements concerning the ICES advice evaluating long-term management strategies for Norway pout in area 4 and 3.a. Here, ICES is requested to assess, following MSY $B_{escapement}$:

- which scenarios of TACmin and TACmax would be precautionary, if the F_{cap} is set at 0.7 (building on request part 2 and 3, pages 3 and 4 of the advice).
- which scenarios of TACmin and TACmax would be precautionary, if an inter-annual flexibility of +/-10% (both banking and borrowing) was introduced for

Norway pout (building on request part 2 and 3, pages 3 and 4 of the advice, plus including precautionary scenarios with an F_{cap} of 0.7 – following from paragraph 1 of this request).

The deadline for this request is by 9 October 2018 (or else, if possible, ahead of the EU/Norway annual consultations on 26–30 November 2018). Accordingly, the evaluations and ACOM approval is ongoing, and no final advice and decision on long term management plans are currently available for the Norway pout in area 4 and 3.a.

12.11 Other issues

Recommendations for future assessments:

Age reading check and otolith exchange program:

In July 2018, a preliminary report of the 2018 Norway Pout exchange was sent out by ICES WGBIOP, the first official SmartDots exchange. As decided upon by ICES WGBIOP, each of the official exchanges will now have a full report, "Norway Pout Exchange 2018 Report" and a summary report, "Norway Pout Exchange 2018 Summary Report" for the stock assessment working group, in this case WGNSSK. These will be made available on the ICES SmartDots page at a later date in 2018 (see below) along with a link to download the data.

The reports have been produced by an R-script which uses output from the SmartDots database to run a standardized analysis based on the traditional Guus Eltink sheet, so all the tables and plots should look familiar. Not all of the plots produced have been commented on in the text but have been included so that you can discuss them in your labs if this is routine for you.

Before concluding the report, WGIOP request one more thing from the national age reading co-ordinators, which is an overview of the numbers of otoliths/ages submitted for assessment purposes by each institute by reader, area and landing type for the last 3 years. This material is necessary in order to look a little further into the results in relation to the stock assessment.

The preliminary summary of the age reading check and otolith exchange program is given below. In 2015, a preliminary age reading exchange took place between the primary age readers of Norway pout from DTU Aqua (Denmark) and IMR (Norway) to identify if any age reading issues exist. The samples included in the exchange were from the commercial Norway pout fishery in the North Sea and Skagerrak-Kattegat areas (nop.27.3a4 stock) as age readings from this fishery are used directly in the Norway pout stock assessment to estimate catch, mean weight, maturity and mortality at age. Here, 227 samples were selected from quarter 4, 2014 and quarter 3, 2015 covering the fish length range of Norway pout in the North Sea. Results showed an overall percentage agreement of 72%, with 100% agreement at age 0 and a decrease in agreement with an increase in age. Results showed a tendency for the Norwegian reader to estimate the ages of the fish to be one year older in comparison to the Danish reader. As Norway pout grow very quickly in the first year, the centre of the otoliths are highly opaque and this can cause problems when identifying the first winter ring. In addition, subsequent growth zones are much narrower in comparison and the interpretation of growth zones towards the edge may also contribute to difficulties in age determination, especially for older fish. The exchange was carried out without the inclusion of otolith images and, thus, no record of which growth structures the readers identify when determining the age of the fish. These results indicated the need for a full scale exchange to be carried out based on otoliths images and including all age reading laboratories who routinely read Norway pout.

The full scale exchange was initially planned for 2016 and a timetable proposed which would allow for the results to be considered in relation to the 2017 stock assessment and potential InterBenchmark Assessment if required. Due to difficulties with sample collection and the WebGR age reading platform delays were encountered. A revised timetable was proposed in line with the launch of the BETA version of the new age reading tool – SmartDots, making the results available for the Norway pout stock assessment in Spring 2018. The exchange took place from January to March 2018 and 14 readers from seven countries participated (Scotland, UK, France, Norway, Denmark, Netherlands and Germany). Different methods are applied for age determination of this species; whole, broken and sectioned otoliths and images were provided of samples prepared using each method. Samples were collected during the 2016 Q3 IBTS and 2014 Q4 commercial fishing trips from ICES area 27.4.a. covering the length range of the fish and considered adequately representative of the stock.

Results based on sectioned otoliths were exceptional with an overall percentage agreement based on modal age of 99% and an average CV of 3%. For the whole and broken otoliths the average percentage agreement based on modal age is 82%, with an average CV of 20%. There is a slight tendency for some readers to overestimate the age at modal age 0 and 1 and underestimate in comparison to modal age 2. The bias that existed between the primary readers from Norway and Denmark in 2016 is still apparent. These results are based only on those readers who provide age data for assessment purposes.

In conclusion, there is an overall high level of agreement between readers of the Norway Pout - nop.27.3a4 stock. The agreement is higher between the countries who read sectioned otoliths (Germany and UK-England) compared to those who read whole (Denmark) and broken otoliths (Denmark, Norway and UK-Scotland). This can be partly attributed to one Norwegian and one Danish reader who occasionally overestimate in comparison to modal age 0 and 1 with the identification of the first winter ring being problematic. At modal age 2, there is a stronger tendency for readers to underestimate in comparison to modal age with the exception of the Norwegian reader who continues to overestimate. Most variability is seen in the annotations of the broken otoliths which is the preferred method. It should be noted that the image quality of the sectioned otoliths is much higher. The AEM's show that there is a difference of just one year when comparing the readers estimates to modal age.

Data needs:

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality.

The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. This also implies need for information on prey switching dynamics of North Sea fish predators which also are foraging on Norway pout. Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

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Table 12.2.1 Norway pout 4 and 3.a. Nominal landings ('000 tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas 4 and 3.a in the period 2007–2017, as officially reported to ICES, EU and FAO. By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	24	156	-	51	2	118	6.945	538	2.220	918	110 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	209	711	-	-	147	9	41	82	72 *
Sweden	-	-	-	10	-	-	1	1	1	1	2 *
Germany	-	4	-	-	-	-	-	-	-	-	2
Total	24	160	209	772	2	118	7.093	548	2.262	1.001	186

*Preliminary.

Norway pout ICES area IVa

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	59	32.158	19.226	71.032	4.038	25.431	31.375	27.894	10.760	21.125	12.312 *
Faroe Islands	-	-	-	-	-	-	-	-	5.270	3.156	- *
Netherlands	-	-	22	18	-	-	-	-	17	8	1 *
Germany	-	-	-	-	-	-	-	-	22	27	38 *
Norway	4.712	6.650	36.961	64.303	3.189	4.528	45.839	18.647	43.742	35.959	21.275 *
Sweden	-	10	-	+	1	3 *	4	1	12	-	1 *
UK(Scotland)	-	-	-	29	-	6 *	-	8	3	12	- *
Total	4.771	38.818	56.209	135.353	7.228	29.962	77.218	46.542	59.823	60.275	33.627

*Preliminary.

Norway pout ICES area IVb

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	-	244	595	229	32	9	43	16	53	1465	45 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Germany	-	-	75	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	1	-	- *
Norway	-	-	82	620	21	59 *	615	8	577	11	10 *
Sweden	-	-	-	-	-	-	0	0	714	1	3 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	6	-	18	- *
Total	0	244	752	849	53	68	658	30	1.345	1.495	58

*Preliminary.

Norway pout ICES area IVc

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	-	-	-	-	-	-	-	-	-	1	-
France	+	+	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	0	1	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	83	32.558	19.821	71.312	4.072	25.558	38.363	28.448	13.033	23.509	12.467
Faroe Islands	0	0	0	0	0	0	0	0	5.270	3.156	0
Norway	4.712	6.650	37.252	65.634	3.210	4.587	46.601	18.664	44.360	36.052	21.357
Sweden	0	10	0	10	1	3	5	2	727	2	6
Netherlands	0	0	22	18	0	0	0	0	18	8	1
Germany	0	4	75	0	0	0	0	0	22	27	40
UK	0	0	0	0	0	0	0	6	0	18	0
Total nominal landings	4.795	39.222	57.170	136.974	7.283	30.148	84.969	47.120	63.430	62.772	33.871
By-catch of other species and other	-	-3.084	-2.670	-11.019	-759	-3.075	-2.869	-2.950	-30	628	62
ICES estimate of total landings (IV+IIIaN)	-	36.138	54.500	125.955	6.524	27.073	82.100	44.170	63.400	63.400	33.933
Agreed TAC	0****	114.616 x	116.279 x	162.950 x	4.500 x	70.683 x	165.700 x	128.250 x	150.000 x	150.000 x	150.000 x

* provisional / preliminary
** provisional / preliminary
*** 781 ton from trial fishery (directed fishery); 160 ton from by-catches in other fisheries
**** A by-catch qouta of 5000 t has been set.
***** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.
\+ Landings less than 1
n/a not available
x EU TAC

Table 12.2.2 Norway pout 4 and 3.a. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, IIIaS) by country, for 1961–2017 (Data provided by ICES WGNSSK Working Group members). (Norwegian landing data include landings of by-catch of other species). Includes by-catch of Norway pout in other (small meshed) fisheries.

Year	Denmark		Faroes	Norway	Sweden	UK (Scotland)	Others	Total
	North Sea	Skagerrak						
1961	20,5	-	-	8,1	-	-	-	28,6
1962	121,8	-	-	27,9	-	-	-	149,7
1963	67,4	-	-	70,4	-	-	-	137,8
1964	10,4	-	-	51	-	-	-	61,4
1965	8,2	-	-	35	-	-	-	43,2
1966	35,2	-	-	17,8	-	-	+	53,0
1967	169,6	-	-	12,9	-	-	+	182,5
1968	410,8	-	-	40,9	-	-	+	451,7
1969	52,5	-	19,6	41,4	-	-	+	113,5
1970	142,1	-	32	63,5	-	0,2	0,2	238,0
1971	178,5	-	47,2	79,3	-	0,1	0,2	305,3
1972	259,6	-	56,8	120,5	6,8	0,9	0,2	444,8
1973	215,2	-	51,2	63	2,9	13	0,6	345,9
1974	464,5	-	85,0	154,2	2,1	26,7	3,3	735,8
1975	251,2	-	63,6	218,9	2,3	22,7	1	559,7
1976	244,9	-	64,6	108,9	+	17,3	1,7	437,4
1977	232,2	-	48,8	98,3	2,9	4,6	1	387,8
1978	163,4	-	18,5	80,8	0,7	5,5	-	268,9
1979	219,9	9	21,9	75,4	-	3	-	329,2
1980	366,2	11,6	34,1	70,2	-	0,6	-	482,7
1981	167,5	2,8	16,4	51,6	-	+	-	238,3
1982	256,3	35,6	12,3	88	-	-	-	392,2
1983	301,1	28,5	30,7	97,3	-	+	-	457,6
1984	251,9	38,1	19,11	83,8	-	0,1	-	393,01
1985	163,7	8,6	9,9	22,8	-	0,1	-	205,1
1986	146,3	4	2,5	21,5	-	-	-	174,3
1987	108,3	2,1	4,8	34,1	-	-	-	149,3
1988	79	7,9	1,3	21,1	-	-	-	109,3
1989	95,7	4,2	0,8	65,3	+	0,1	0,3	166,4
1990	61,5	23,8	0,9	77,1	+	-	-	163,3
1991	85	32	1,3	68,3	+	-	+	186,6
1992	146,9	41,7	2,6	105,5	+	-	0,1	296,8
1993	97,3	6,7	2,4	76,7	-	-	+	183,1
1994	97,9	6,3	3,6	74,2	-	-	+	182
1995	138,1	46,4	8,9	43,1	0,1	+	0,2	236,8
1996	74,3	33,8	7,6	47,8	0,2	0,1	+	163,8
1997	94,2	29,3	7,0	39,1	+	+	0,1	169,7
1998	39,8	13,2	4,7	22,1	-	-	+	57,7
1999	41	6,8	2,5	44,2	+	-	-	94,5
2000	127	9,3	-	48	0,1	-	+	184,4
2001	40,6	7,5	-	16,8	0,7	+	+	65,6
2002	50,2	2,8	3,4	23,6	-	-	-	80,0
2003	9,9	3,4	2,4	11,4	-	-	-	27,1
2004	8,1	0,3	-	5	-	-	0,1	13,5
2005	0.9*	-	-	1	-	-	-	1,9
2006	35,1	0,1	-	11,4	-	-	-	46,6
2007	2.0**	-	-	3,7	-	-	-	5,7
2008	30,4	-	-	5,7	+	-	+	36,1
2009	17,5	-	-	37,0	+	-	+	54,5
2010	64,9	0,2	-	60,9	+	+	+	126,0
2011	3,3	-	-	3,2	+	+	+	6,5
2012	22,3	0,1	-	4,6	+	+	+	27,0
2013	29,0	6,2	-	46,9	+	+	+	82,1
2014	25,0	0,5	-	18,7	+	+	+	44,2
2015	10,8	2,2	5,3	44,4	0,7	+	+	63,4
2016	23,2	0,9	3,2	36,1	+	+	+	63,4
2017	12,4	0,1	+	21,4	+	+	+	33,9

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.
** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 12.2.3 Norway pout 4 and 3.a. National landings ('000 tonnes) by quarter of year 2001–2018 and by area and country. (Data provided by Working Group members. Norwegian landing data include landings of by-catch of other species). (By-catch of Norway pout in other (small meshed) fisheries included).

Year	Quarter	Denmark									Norway		Total
	Area	IIIaN	IIIaS	Div. IIIa	IVaE	IVaW	IVb	IVc	Div. IV	Div. IV + IIIaN	IVaE	Div. IV	Div. IV + IIIaN
2001	1			302	7.341	9.734	103	72	17.250	17.250	3838	3838	21.088
	2			2.174	31	30	269	-	330	330	9268	9268	9.598
	3			2.006	15	154	191	-	360	360	2263	2263	2.623
	4			3.059	2.553	19.826	329	-	22.708	22.708	1426	1426	24.134
	Total			7.541	9.940	29.744	892	72	40.648	40.648	16.795	16795	57.443
2002	1	-	1	1	4.869	1.660	114	-	6.643	6.643	1896	1896	8.539
	2	883	161	1.045	56	9	22	-	87	970	5563	5563	6.533
	3	1.567	213	1.778	2.234	14.739	104	-	17.077	18.644	14147	14147	32.791
	4	393	100	492	1.787	24.273	335	-	26.395	26.788	2033	2033	28.821
	Total	2.843	475	3.316	8.946	40.681	575	-	50.202	53.045	23.639	23639	76.684
2003	1	-	1	1	615	581	22	-	1.218	1.218	1976,86	1976,86	3.195
	2	246	160	406	76	-	22	-	98	344	2773,5	2773,499	3.117
	3	2.984	1.005	3.989	172	1.613	89	-	1.874	4.858	5989,37	5989,366	10.847
	4	188	547	735	-	6.270	457	-	6.727	6.915	643,592	643,592	7.559
	Total	3.418	1.713	5.131	863	8.464	590	-	9.917	13.335	11.383	11383,32	24.718
2004	1	316	-	316	87	650	-	-	737	1.053	989	989	2.042
	2	-	-	-	-	-	7	-	7	7	660	660	667
	3	14	-	14	289	1.195	9	-	1.493	1.507	2484	2484	3.991
	4	13	-	13	93	5683	107	-	5.883	5.896	865	865	6.761
	Total	343	-	343	469	7.528	123	-	8.120	8.463	4.998	4.998	13.461
2005	1	-	-	-	9	0	-	-	9	9	12	12	21
	2	-	-	-	151	-	0	-	151	151	352	352	503
	3	-	-	-	781	0	0	-	781	781	387	387	1.168
	4	0	-	-	0	0	0	-	-	-	211	211	211
	Total	-	-	-	941	-	-	-	941	941	962	962	1.903
2006	1	-	-	-	75	83	-	-	158	158	2.205	2205	2.363
	2	-	-	-	-	-	15	-	15	15	2.846	2846	2.861
	3	114	-	114	-	649	20	-	669	783	5.749	5749	6.532
	4	3	-	3	-	34.262	-	-	34.262	34.265	605	605	34.870
	Total	117	-	117	75	34.994	35	-	35.104	35.221		11.405	46.626
2007	1	-	-	-	561	789	-	-	1.350	1.350	74	74	1.424
	2	-	-	-	4	-	-	-	4	4	1.097	1097	1.101
	3	1	2	3	-	-	-	-	-	1	2.429	2429	2.430
	4	-	-	-	-	682	-	-	682	682	155	155	837
	Total	1	2	3	565	1.471	-	-	2.036	2.037		3.755	5.792
2008	1	125	-	125	19	86	123	-	228	353	7	7	360
	2	-	-	-	-	-	30	-	30	30	1.803	1803	1.833
	3	-	-	-	-	6.102	-	-	6.102	6.102	3.582	3582	9.684
	4	-	-	-	-	22.686	1.239	-	23.925	23.925	336	336	24.261
	Total	125	-	125	19	28.874	1.392	-	30.285	30.410		5.728	36.138
2009	1	1	-	1	22	515	-	-	537	538	2	2	540
	2	-	-	-	-	-	-	-	-	-	4.026	4026	4.026
	3	2	-	2	-	11.567	-	-	11.567	11.569	31.251	31251	42.820
	4	-	-	-	-	5.399	4	-	5.403	5.403	1.736	1736	7.139
	Total	3	-	3	22	17.481	4	-	17.507	17.510	37.015	37.015	54.525
2010	1	-	-	-	-	194	-	-	194	194	104	104	298
	2	157	-	157	-	478	59	-	537	694	17.906	17906	18.600
	3	37	-	37	-	33.618	213	-	33.831	33.868	41.883	41883	75.751
	4	8	-	8	-	30.276	38	-	30.314	30.322	984	984	31.306
	Total	202	-	202	-	64.566	310	-	64.876	65.078	60.877	60.877	125.955
2011	1	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	-	-	-	-	188	188	188
	3	-	-	-	-	456	5	-	461	461	3.004	3004	3.465
	4	-	-	-	-	2.853	-	-	2.853	2.853	18	18	2.871
	Total	-	-	-	-	3.309	5	-	3.314	3.314	3.210	3.210	6.524
2012	1	-	-	-	-	15	-	-	15	15	12	12	27
	2	-	-	-	-	-	-	-	-	-	280	280	280
	3	2	-	2	-	62	8	-	70	72	395	395	467
	4	125	-	125	-	22.204	-	-	22.204	22.329	3.900	3.900	26.229
	Total	127	-	127	-	22.281	8	-	22.289	22.416	4.587	4.587	27.003
2013	1	-	-	-	-	59	-	-	59	59	18	18	77
	2	6	-	6	-	409	-	-	409	415	10.045	10.045	10.460
	3	4.791	-	4.791	5	3.260	43	-	3.308	8.099	16.350	16.350	24.449
	4	1.366	-	1.366	-	25.211	-	-	25.211	26.577	20.537	20.537	47.114
	Total	6.163	-	6.163	5	28.939	43	-	28.987	35.150	46.950	46.950	82.100
2014	1	-	-	-	-	1.318	-	-	1.318	1.318	6	6	1.324
	2	62	-	62	-	-	2	-	2	64	3.146	3.146	3.210
	3	492	-	492	-	5.606	20	-	5.626	6.118	7.252	7.252	13.370
	4	-	-	-	-	18.006	-	-	18.006	18.006	8.260	8.260	26.266
	Total	554	-	554	-	24.930	22	-	24.952	25.506	18.664	18.664	44.170
2015	1	-	-	-	21	305	-	-	326	326	268	268	594
	2	2	-	2	-	549	-	-	549	551	6.812	6.812	7.363
	3	2.217	1	2.218	10	3.221	19	-	3.250	5.467	21.335	21.335	26.802
	4	-	-	-	-	6.689	-	-	6.689	6.689	15.945	15.945	22.634
	Total	2.219	1	2.220	31	10.764	19	-	10.814	13.033	44.360	44.360	57.393
2016	1	-	-	-	-	514	-	-	514	514	575	575	1.089
	2	244	1	245	-	267	-	-	267	511	8.296	8.296	8.807
	3	673	1	674	5	2.222	51	-	2.278	2.951	20.897	20.897	23.848
	4	-	-	-	3	20.135	-	-	20.138	20.138	6.286	6.286	26.424
	Total	917	2	919	8	23.138	51	-	23.197	24.114	36.054	36.054	60.168
2017	1	-	-	-	-	703	-	-	703	703	30	30	733
	2	5	-	5	-	-	-	-	-	5	3.470	3.470	3.475
	3	104	-	104	6	1.969	-	-	1.975	2.079	11.546	11.546	13.625
	4	-	-	-	68	9.597	2	-	9.667	9.667	6.433	6.433	16.100
	Total	109	-	109	74	12.269	3	-	12.345	12.454	21.479	21.479	33.933
2018	1	-	-	-	-	359	-	-	359	359	9	9	368
	2	-	2	2	-	3	-	-	3	3	4.136	4.136	4.139
	3	-	67	67	-	82	-	-	82	82	8.312	8.312	8.394

Table 12.2.3a Norway pout 4 and 3.aN (Skagerrak). Observed and SESAM model predicted total catches in tonnes by quarter (millions).

	Year	observed	predicted
1	1984.00	56790	64397
2	1984.25	56532	36456
3	1984.50	152291	118258
4	1984.75	110942	99280
5	1985.00	57467	46621
6	1985.25	15509	16078
7	1985.50	62489	68805
8	1985.75	92017	64022
9	1986.00	37773	25024
10	1986.25	7657	8914
11	1986.50	45085	37694
12	1986.75	89993	40916
13	1987.00	33883	29489
14	1987.25	15435	8889
15	1987.50	38729	38621
16	1987.75	60847	73025
17	1988.00	22181	21236
18	1988.25	3559	5916
19	1988.50	21793	17374
20	1988.75	61762	32454
21	1989.00	15379	12322
22	1989.25	13234	11818
23	1989.50	55066	40364
24	1989.75	82880	49421
25	1990.00	27984	25124
26	1990.25	39713	23515
27	1990.50	26156	30490
28	1990.75	45242	46812
29	1991.00	42722	32093
30	1991.25	20786	22026
31	1991.50	62518	58600
32	1991.75	64380	60724
33	1992.00	64218	51686
34	1992.25	27973	27457
35	1992.50	114122	86177
36	1992.75	96177	83605
37	1993.00	36214	47218
38	1993.25	29291	27459
39	1993.50	62290	63609
40	1993.75	53470	54029
41	1994.00	34575	28498
42	1994.25	15373	15181
43	1994.50	53799	45303
44	1994.75	79838	42865
45	1995.00	36942	28195

	Year	observed	predicted
46	1995.25	28019	20660
47	1995.50	69763	62493
48	1995.75	97048	60249
49	1996.00	21888	26040
50	1996.25	13366	15204
51	1996.50	74631	66352
52	1996.75	46194	39419
53	1997.00	15320	16181
54	1997.25	8708	9149
55	1997.50	78809	62715
56	1997.75	54100	48773
57	1998.00	19502	18268
58	1998.25	11836	12206
59	1998.50	20866	30633
60	1998.75	22830	24701
61	1999.00	7827	7340
62	1999.25	12533	8033
63	1999.50	41445	25892
64	1999.75	30497	31131
65	2000.00	10207	11381
66	2000.25	11589	13107
67	2000.50	44173	41157
68	2000.75	119001	67130
69	2001.00	21400	16013
70	2001.25	11778	9283
71	2001.50	4630	13641
72	2001.75	26565	31629
73	2002.00	8553	7163
74	2002.25	6686	4429
75	2002.50	32922	18072
76	2002.75	28947	22569
77	2003.00	3190	3230
78	2003.25	3106	1979
79	2003.50	10833	11229
80	2003.75	7518	7369
81	2004.00	2040	1689
82	2004.25	667	623
83	2004.50	4018	5165
84	2004.75	6762	7322
85	2005.00	8	5
86	2005.25	8	5
87	2005.50	13	9
88	2005.75	13	11
89	2006.00	2205	1827
90	2006.25	2848	2400
91	2006.50	6551	7961
92	2006.75	34949	26950

	Year	observed	predicted
93	2007.00	1428	578
94	2007.25	1100	1171
95	2007.50	2430	3867
96	2007.75	838	1839
97	2008.00	361	298
98	2008.25	1840	1619
99	2008.50	8532	5859
100	2008.75	24111	4591
101	2009.00	538	202
102	2009.25	2105	2998
103	2009.50	36661	21166
104	2009.75	6509	8540
105	2010.00	198	267
106	2010.25	40322	7837
107	2010.50	57487	29425
108	2010.75	33071	18096
109	2011.00	0	0
110	2011.25	222	1167
111	2011.50	3749	6950
112	2011.75	2872	6494
113	2012.00	29	42
114	2012.25	281	558
115	2012.50	469	1533
116	2012.75	26168	14250
117	2013.00	79	115
118	2013.25	10460	3201
119	2013.50	24444	13699
120	2013.75	47126	48302
121	2014.00	1324	396
122	2014.25	3212	3910
123	2014.50	13384	16982
124	2014.75	26244	20732
125	2015.00	594	514
126	2015.25	7364	6510
127	2015.50	26804	29712
128	2015.75	22655	32087
129	2016.00	1089	651
130	2016.25	8846	6643
131	2016.50	23849	26829
132	2016.75	26457	23996
133	2017.00	735	406
134	2017.25	3475	4668
135	2017.50	13623	17523
136	2017.75	16107	24726
137	2018.00	368	156
138	2018.25	4141	4109
139	2018.50	8461	9406

Table 12.2.4 Norway pout 4 and 3.aN (Skagerrak). Catch in numbers at age by quarter (millions). SOP is given in tonnes. Data for 1990 were estimated within the SXSA program used in the 1996 assessment.

Age	Year	1984				1985				1986			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	1	2231	0	0	6	678	0	0	0	5572
1		2.759	2252	5290	3492	2.264	857	1400	2991	396	260	1186	1791
2		1.375	1165	1683	734	1.364	145	793	174	1069	87	245	39
3		143	269	8	0	192	13	19	0	72	3	6	0
4+		0	0	0	0	1	0	0	0	3	0	0	0
SOP		56790	56532	152291	110942	57464	15509	62489	92017	37889	7657	45085	89993
Age	Year	1987				1988				1989			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	8	227	0	0	741	3146	0	0	159	4854
1		2687	1075	1627	2151	249	95	183	632	1736	678	1672	1741
2		401	60	171	233	700	74	250	405	48	133	266	93
3		12	0	0	5	20	0	0	0	6	6	5	13
4+		1	0	0	0	0	0	0	0	0	0	0	0
SOP		33894	15435	38729	60847	22181	3559	21793	61762	15379	13234	55066	82880
Age	Year	1990				1991				1992			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	20	993	0	0	734	3486	0	0	879	954
1		1840	1780	971	1181	1501	636	1519	1048	3556	1522	3457	2784
2		584	572	185	116	1336	404	215	187	1086	293	389	267
3		20	19	6	4	93	19	22	18	118	20	1	2
4+		10	0	0	0	6	0	0	0	3	0	0	0
SOP		28287	39713	26156	45242	42776	20786	62518	64380	64224	27973	114122	96177
Age	Year	1993				1994				1995			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	96	1175	0	0	647	4238	0	0	700	1692
1		1942	813	1147	1050	1975	372	1029	1148	3992	1905	2545	3348
2		699	473	912	445	591	285	421	134	240	256	47	59
3		15	58	19	2	56	29	71	0	6	32	3	3
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		36206	29291	62290	53470	34575	15373	53799	79838	36942	28019	69763	97048
Age	Year	1996				1997				1998			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	724	2517	0	0	109	343	0	0	94	339
1		535	560	1043	650	672	99	3090	1922	261	210	411	531
2		772	201	1002	333	325	131	372	207	690	310	332	215
3		14	38	37	0	79	119	105	35	47	18	2	13
4+		0	0	0	0	0	0	0	0	8	24	0	0
SOP		21888	13366	74631	46194	15320	8708	78809	54100	19562	12026	20866	22830
Age	Year	1999				2000				2001			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	41	1127	0	0	73	302	0	0	32	368
1		202	318	1298	576	653	280	1368	4616	220	133	122	267
2		128	220	338	160	185	207	266	245	845	246	27	439
3		73	93	35	23	3	48	20	6	35	100	1	1
4+		1	0	0	0	0	0	0	0	0	0	0	0
SOP		7833	12535	41445	30497	10207	11589	44173	119001	21400	11778	4630	26565
Age	Year	2002				2003				2004			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	340	290	0	0	7	1	0	0	14	57
1		485	351	621	473	59	64	191	54	13	4	51	100
2		148	24	284	347	76	49	121	161	55	16	51	78
3		17	5	24	26	22	25	16	32	9	6	7	2
4+		0	0	0	0	0	0	0	1	0	0	0	0
SOP		8553	6686	32922	28947	3190	3106	10842	7549	2040	667	4018	6762
Age	Year	2005				2006				2007			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		*	*	*	*			10	368	0	0	0	0
1		*	*	*	*	30	56	130	1086	20	41	32	10
2		*	*	*	*	52	45	65	50	43	26	16	6
3		*	*	*	*	9	24	7	1	0	0	2	1
4+		*	*	*	*	0	0	0	0	0	0	0	0
SOP		8	8	13	13	2205	2848	6551	34949	1428	1100	2430	838
Age	Year	2008				2009				2010			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	1179	0	0	58	12	0	0	0	0
1		5	54	166	438	50	36	621	169	6	799	1118	716
2		10	41	115	31	1	47	613	27	1	905	738	331
3		0	0	0	0	0	5	9	1	0	17	15	0
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		361	1840	8532	24111	538	2105	36661	6509	198	40322	57487	33071
Age	Year	2011				2012				2013			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	1	0	0	1	135	0	0	8	76
1		0	1	44	23	1	5	8	404	5	631	805	1287
2		0	5	69	61	0	2	4	185	0	39	131	199
3		0	0	4	0	0	2	1	10	0	4	18	27
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		0	222	3749	2872	29	281	469	26168	79	10460	24444	47126
Age	Year	2014				2015				2016			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	141	884	0	0	14	33	0	0	13	480
1		10	33	197	522	46	365	1064	934	19	260	492	406
2		51	60	167	115	6	23	164	33	40	160	291	339
3		1	2	3	0	1	2	2	5	2	10	7	0
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		1324	3212	13384	26244	594	7364	26804	22655	1089	8846	23849	26457
Age	Year	2017				2018							
	Quarter	1	2	3	4	1	2	3					
0		0	0	7	11	0	0	0					
1		39	159	319	515	1	89	162					
2		1	25	127	87	20	106	148					
3		0	4	40	7	1	11	26					
4+		0	0	0	0	0	0	0					
SOP		735	3474	13623	16107	368	4141	8461					

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

Table 12.2.5 Norway pout 4 and 3.aN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1984–2018, from Danish and Norwegian catches combined. See footnote concerning data from 2005–2008 and 2010–2013. The mean weights at age weighted with catch number by area, quarter and country (DK, N).

Year	1984				1985				1986			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			6,54	6,54			8,37	6,23				7,20
1	6,55	8,97	17,83	20,22	7,86	12,56	23,10	26,97	6,69	14,49	28,81	26,90
2	24,04	22,66	34,28	35,07	22,7	28,81	36,52	40,90	29,74	42,92	43,39	44,00
3	39,54	37,00	34,10	46,23	45,26	43,38	58,99		44,08	55,39	47,60	
4					41,80				82,51			
Year	1987				1988				1989			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			5,80	7,40			9,42	7,91			7,48	6,69
1	8,13	12,59	20,16	23,36	9,23	11,61	26,54	30,60	7,98	13,49	26,58	26,76
2	28,26	31,51	34,53	37,32	27,31	33,26	39,82	43,31	26,74	28,70	35,44	34,70
3	52,93			46,60	38,38				39,95	44,39		46,50
4	63,09				69,48							
Year	1990				1991				1992			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			6,40	6,67			6,06	6,64		8,00	6,70	8,14
1	6,51	13,75	20,29	28,70	7,85	12,95	30,95	30,65	8,78	11,71	26,52	27,49
2	25,47	25,30	32,92	38,90	20,54	28,75	44,28	43,10	25,73	31,25	42,42	44,14
3	37,72	40,35	39,40	52,94	35,43	49,87	67,25	59,37	41,80	49,49	50,00	50,30
4	68,00				44,30				43,90			
Year	1993				1994				1995			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			4,40	8,14			5,40	8,81			5,01	7,19
1	9,32	14,76	25,03	26,24	8,56	15,22	29,26	31,23	7,70	10,99	25,37	24,6
2	24,94	30,58	35,19	36,44	25,91	29,27	38,91	49,59	24,69	22,95	33,40	39,57
3	46,50	48,73	55,40	70,80	42,09	46,88	53,95		50,78	37,69	45,56	57,00
4												
Year	1996				1997				1998			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			3,88	5,95			3,61	10,18			4,82	8,32
1	8,95	12,06	27,81	28,09	7,01	11,69	20,14	22,11	8,76	12,55	23,82	24,33
2	21,47	25,72	40,90	38,81	23,11	26,40	31,13	32,69	22,16	25,27	31,73	30,93
3	37,58	37,94	50,44	56,00	39,11	34,47	44,03	38,62	34,84	32,18	44,92	33,24
4									42,40	40,00		
Year	1999				2000				2001			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			2,84	7,56			7,21	13,86			6,34	7,90
1	8,98	12,40	22,16	25,60	10,05	15,65	23,76	22,98	8,34	16,79	27,00	30,01
2	25,84	24,15	32,66	37,74	19,21	25,14	38,90	34,48	21,50	23,57	39,54	35,51
3	36,66	35,24	43,98	51,63	32,10	41,30	39,61	50,04	39,84	37,63	54,20	55,70
4	46,57	46,57										
Year	2002				2003				2004			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			7,28	7,20			9,12	9,79			9,80	7,89
1	8,59	16,40	27,13	27,47	11,58	13,13	28,33	15,98	11,54	14,63	31,02	31,75
2	25,98	30,39	43,37	36,87	22,85	26,19	38,01	31,87	27,41	26,22	38,44	39,31
3	32,30	40,10	54,11	41,28	34,96	39,89	46,24	45,79	41,52	34,80	49,50	49,80
4							70,00	70,00				
Year	2005				2006				2007			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			9,8	7,89			8,90	8,90			8,9	8,9
1	11,97	14,65	31,02	31,75	14,80	14,70	27,42	26,92	7,8	7,8	45,00	45,00
2	27,90	26,24	38,44	39,31	27,20	26,24	39,16	47,80	29,86	29,86	57,07	57,07
3	41,36	34,80	49,50	49,80	40,60	34,80	49,80	48,50	41,52	34,80	56,22	56,22
4												
Year	2008				2009				2010			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0				9,9			6,6	8,5				
1	11,0	11,0	26,8	24,40	10,2	19,3	28,0	32,7	25,60	15,51	25,37	27,75
2	29,8	29,8	35,6	56,0	24,0	25,8	30,1	32,0	37,20	29,99	38,55	39,88
3	56,0	56,0				39,8	51,5	55,7		47,00	45,50	62,20
4												
Year	2011				2012				2013			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0				8,90			6,58	6,66			4,30	9,56
1		20,33	22,14	30,50	27,24	22,81	28,86	38,52	12,44	14,48	22,97	27,68
2		37,75	37,50	35,61	36,24	40,54	40,30	49,59	32,87	30,21	38,87	46,38
3		52,00	52,00	52,00	37,22	46,77	48,33	59,15	42,40	40,71	45,24	57,93
4												
Year	2014				2015				2016			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			5,31	6,46			8,22	5,69			15,00	12,53
1	8,69	26,06	30,12	30,00	7,53	17,82	21,14	22,61	14,90	16,54	26,91	32,26
2	23,51	36,53	39,44	42,37	29,30	32,97	25,04	34,80	19,08	26,21	34,99	34,1
3	50,63	42,77	39,30		46,20	46,61	47,97	41,68	30,76	35,91	34,05	
4												
Year	2017				2018							
Quarter of year	1	2	3	4	1	2	3					
Age 0			4,70	6,25								
1	18,17	17,11	23,69	24,11	6,23	13,34	18,21					
2	30,95	25,85	34,38	37,59	15,81	24,77	30,94					
3	23,69	27,21	41,52	49,92	28,63	30,74	35,80					
4												

Mean weights at age from Danish and Norwegian landings from 2005-2008 uncertain because of few observations and use of values from 2004 and from adjacent quarters in the same year where observations have been missing. No mean weight at age data delivered by Norway in 2007-2008.
In general, mean weights at age are uncertain for quarters and countries where only very few fish have been caught. This problem is met by always calculating and using weighted mean weights at age, i.e. weighted by the catch number by country (Denmark and Norway) and quarter of year.

Table 12.2.6 Norway pout 4 and 3.aN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment. (Inter-Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0,29
1	9	14	28	28	0,2	0,29
2	26	25	38	40	1	0,39
3	43	38	51	58	1	0,44

Table 12.2.7 Norway pout 4 and 3.aN (Skagerrak). Danish fishing effort (number of fishing days) and catch per unit of effort (CPUE in tonnes / fishing day) per year and quarter of year (1987–2017) for main Danish fishery (metiér) catching Norway pout. (Data for fishing trips where the catch has consisted of at least 70% Norway pout).

Year	Metier	Effort (no fishing days) per quarter					CPUE (ton per fishing day) per quarter				
		1	2	3	4	Yearly	1	2	3	4	Yearly
1987	OTB_DEF_16-31_0_0	84		1240	2057	3381	12		53	136	71
1988		38		164	1773	1975	27		101	132	107
1989		28		664	940	1632	99		98	54	73
1990		49		134	914	1097	33		30	84	51
1991		18		395	972	1385	5		140	103	99
1992		136		1123	1645	2904	17		130	152	112
1993		153	6	1864	1718	3741	33	2	62	107	64
1994		35		543	1645	2223	2		91	131	89
1995		26		529	1591	2146	6		139	176	127
1996		6		520	521	1047	1		73	107	73
1997				733	1363	2096			137	99	115
1998		10		116	286	412	17		30	30	28
1999				192	869	1061			40	68	56
2000				140	2377	2517			107	168	142
2001		121			527	648	142			122	132
2002				488	790	1278			78	94	89
2003				72	252	324			19	52	36
2004		44		52	196	292	23		26	111	76
2006				39	1056	1095			57	137	117
2008		6		309	292	607	5		139	162	121
2009		20		176	35	231	46		165	181	148
2010			14	749	361	1124		74	169	295	210
2011				24	73	97			54	123	88
2012	OTB_DEF_16-31_2_35				549	549				123	123
2013			21	157	805	983		41	30	99	62
2014		33		263	681	977	28		66	47	50
2015		6	27	86	130	249	19	3	58	57	38
2016		6	10	27	263	306	43	5	44	46	34
2017		20		40	165	225	43		38	67	51

Table 12.2.8 Norway pout 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2018) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	Q1	Q2	Q3	Q4	Yearly	Q1	Q2	Q3	Q4	Yearly
2011	OTB_DEF_16-31_0_0	0	1	23	0	24		1,0	24,9		23,5
2011	OTB_DEF_16-31_2_40	0	5	75	0	80		2,2	29,3		28,6
2012	OTB_DEF_16-31_0_0	0	0	3	24	27			15,7	35,4	33,2
2012	OTB_DEF_16-31_2_40	0	0	0	74	74				38,9	38,9
2013	OTB_DEF_16-31_0_0	0	101	163	99	363		31,3	29,9	47,2	35,0
2013	OTB_DEF_16-31_2_40	0	224	341	227	792		3,7	31,6	6,8	39,5
2014	OTB_DEF_16-31_0_0	0	62	64	57	183		18,2	35,7	33,9	29,0
2014	OTB_DEF_16-31_2_40	0	41	123	143	307		26,0	34,7	38,2	35,2
2015	OTB_DEF_16-31_0_0	0	130	308	71	509		38,3	37,8	38,7	38,3
2015	OTB_DEF_16-31_2_40	5	38	235	192	470	28,7	5,0	42,5	55,6	47,6
2016	OTB_DEF_16-31_0_0	0	269	269	51	589		24,8	23,0	22,7	23,4
2016	OTB_DEF_16-31_2_40	23	37	357	80	497	24,9	23,5	38,6	45,8	38,3
2017	OTB_DEF_16-31_0_0	0	125	198	15	338		28,8	22,5	25,6	25,0
2017	OTB_DEF_16-31_2_40	0	1	105	87	193		8,8	37,8	51,3	43,7
2018	OTB_DEF_16-31_0_0	0	145	99	0	244		24,5	31,1		26,9

Table 12.2.9 Norway pout 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton per fishing day) per year and vessel horse power (HP) class (1987–2017) for main Danish fishery (metiér) catching Norway pout.

Year	Metier	Effort (no fishing days) per Vessel HP Class					CPUE (ton per fishing day) per vessel hp class				
		500-1000	1000-1500	1500-2000	>=2000	Yearly	500-1000	1000-1500	1500-2000	>=2000	Yearly
1987	OTB_DEF_16-31_0_0	2625	706	32	18	3381	117	129	82	4	83
1988		913	1000	53	9	1975	128	178	279	72	164
1989		897	707	14	14	1632	111	126	5	6	62
1990		615	448	24	10	1097	105	100	27	1	58
1991		671	688	26		1385	148	172	73		131
1992		1965	845	73	21	2904	195	239	73	18	131
1993		1773	1862	93	13	3741	117	122	63	12	78
1994		1009	1114	66	34	2223	165	221	94	14	123
1995		1068	884	167	27	2146	294	259	159	58	192
1996		452	544	32	19	1047	109	122	125	15	93
1997		1229	778	47	42	2096	192	206	58	55	128
1998		163	232		17	412	61	46		10	39
1999		619	357	51	34	1061	106	89	36	80	78
2000		1449	802	138	128	2517	205	188	110	202	177
2001		322	266		60	648	185	301		71	186
2002		738	393	135	12	1278	131	144	77	30	96
2003		172	115	24	13	324	64	45	43	48	50
2004		165	109		18	292	71	116		111	100
2006		465	464	166		1095	132	183	93		136
2008		320	287			607	189	213			201
2009		111	120			231	199	324			262
2010		279	606	239		1124	349	299	206		285
2011			97			97		121			121
2012	OTB_DEF_16-31_2_35	122	314	89	24	549	123	155	119	94	123
2013		331	504	108	40	983	81	144	84	64	93
2014		425	474	78		977	55	53	53		54
2015		21	228			249	66	52			59
2016		81	139	77	9	306	45	39	37	55	44
2017		72	124	14	15	225	42	41	91	93	67

Table 12.2.10 Norway pout 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2018) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	500-1000	1000-1500	1500-2000	> 2000	Yearly	500-1000	1000-1500	1500-2000	> 2000	Yearly
2011	OTB_DEF_16-31_0_0	0	24	0	0	24		23,5			23,5
2011	OTB_DEF_16-31_2_40	0	20	0	60	80		18,3		32,1	28,6
2012	OTB_DEF_16-31_0_0	0	17	4	6	27		34,8	13,8	41,7	33,2
2012	OTB_DEF_16-31_2_40	19	28	0	27	74	21,2	26,9		63,8	38,9
2013	OTB_DEF_16-31_0_0	0	273	75	15	363		34,4	3,9	65,3	35,0
2013	OTB_DEF_16-31_2_40	0	162	130	500	792		23,2	34,1	46,2	39,5
2014	OTB_DEF_16-31_0_0	0	142	16	25	183		25,5	16,6	56,4	29,0
2014	OTB_DEF_16-31_2_40	80	58	67	102	307	42,9	14,6	36,6	39,9	35,2
2015	OTB_DEF_16-31_0_0	0	228	106	175	509		33,7	42,7	4,8	38,3
2015	OTB_DEF_16-31_2_40	0	0	103	367	470			49,7	47,2	47,6
2016	OTB_DEF_16-31_0_0	0	207	136	246	589		25,5	21,4	23,0	23,4
2016	OTB_DEF_16-31_2_40	0	18	72	407	497		28,3	42,8	37,6	38,3
2017	OTB_DEF_16-31_0_0	0	123	107	108	338		24,7	21,4	28,6	25,0
2017	OTB_DEF_16-31_2_40	0	9	86	98	193		51,9	41,6	45,2	43,7
2018	OTB_DEF_16-31_0_0	18	56	91	79	244	23,6	24,8	26,3	29,9	26,9

Table 12.2.11 Norway pout 4 and 3.aN (Skagerrak). Research vessel indices (CPUE in catch in number per trawl hour) of abundance for Norway pout.

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1971	1,556	22	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	2,578	872	3	-	-	-	-	-	-	-	-	-	-	-	-
1973	4,207	438	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	25,557	391	24	-	-	-	-	-	-	-	-	-	-	-	-
1975	4,573	1,880	4	-	-	-	-	-	-	-	-	-	-	-	-
1976	4,411	371	2	-	-	-	-	-	-	-	-	-	-	-	-
1977	6,093	274	42	-	-	-	-	-	-	-	-	-	-	-	-
1978	1,479	575	47	-	-	-	-	-	-	-	-	-	-	-	-
1979	2,738	316	75	-	-	-	-	-	-	-	-	-	-	-	-
1980	3,277	550	29	-	-	-	-	-	1,928	346	12	-	-	-	-
1981	1,092	377	15	-	-	-	-	-	185	127	9	-	-	-	-
1982	4,537	262	59	-	-	-	-	8	991	44	22	-	-	-	-
1983	2,258	592	7	-	-	-	-	13	490	91	1	-	-	-	-
1984	4,994	982	75	-	-	-	-	2	615	69	8	-	-	-	-
1985	2,342	1,429	73	-	-	-	-	5	636	173	5	-	-	-	-
1986	2,070	383	20	-	-	-	-	38	389	54	9	-	-	-	-
1987	3,171	481	61	-	-	-	-	7	338	23	1	-	-	-	-
1988	124	722	15	-	-	-	-	14	38	209	4	-	-	-	-
1989	2,019	255	172	-	-	-	-	2	382	21	14	-	-	-	-
1990	1,295	748	39	-	-	-	-	58	206	51	2	-	-	-	-
1991	2,450	712	130	-	-	-	-	10	732	42	6	7,301	1,039	189	2

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1992	5,071	885	32	2,975	6,116	1,710	303	12	1,715	221	24	2,559	4,318	633	48
1993	2,682	2,644	258	3,706	3,582	1,706	108	2	580	329	20	4,104	1,831	608	53
1994	1,839	374	66	9,487	1,148	147	25	136	387	106	6	3,196	704	102	14
1995	5,940	785	77	5,478	8,374	282	62	37	2,438	234	21	2,860	4,440	597	69
1996	923	2,631	228	8,241	1,326	378	9	127	412	321	8	4,554	763	362	12
1997	9,699	1,527	670	441	6,295	372	102	1	2,154	130	32	490	3,447	236	46
1998	1,010	5,336	265	1,391	377	340	3	2,628	938	127	5	2,931	801	748	12
1999	3,527	597	667	10,985	1,175	40	29	3,603	1,784	179	37	7,844	2,367	201	94
2000	8,095	1,535	65	2,267	9,730	264	2	2,094	6,656	207	23	1,644	7,869	281	11
2001	1,302	2,863	235	2,243	1,434	1344	31	759	727	710	26	2,088	1,274	862	27
2002	1,793	809	880	4,939	1,137	58	18	2,559	1,192	151	123	1,974	766	64	48
2003	1,239	575	94	323	572	75	5		779	126	1	1,812	1,063	146	7
2004	894	375	34	278	557	109	6	1,767	719	175	19	773	647	153	12
2005	690	133	37	3,395	414	67	15	731	343	132	18	2,679	404	97	16
2006	3,369	142	26	1,813	1,996	124	20		1,285	69	9	1,391	1,809	191	12
2007	1,286	778	23	1,610	1,181	720	43	3,073	1,023	395	8	4,151	1,201	447	11
2008	2,353	512	180	628	1,340	411	104	1,127	1,263	263	57	3,035	1,643	274	58
2009	5,480	1,633	151	4,871	3,500	306	5	5,003	1,750	202	16	5,899	2,562	254	11
2010	4,941	1,466	138	103	4,257	559	13	3,456	5,101	930	29	833	4,757	861	22
2011	541	2.252	304	290	555	1,050	40	5,835	226	935	38	1,801	474	1123	60
2012	997	336	533	3,946	505	99	59	1,449	1,070	159	216	6,416	875	179	130
2013	4,466	519	97	498	2,592	117	19	1,895	3,099	111	22	1,287	2,829	124	13
2014	812	939	52	10,157	483	268	17	10,067	524	146	0	10,238	514	224	8

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
2015	6,681	493	141	1,415	4,320	60	15	1,759	6,358	114	0	3,511	4,051	76	20
2016	2,417	915	25	7,199	1,710	314	4	24,317	1,700	288	0	8,965	1,398	278	8
2017	4,357	401	174	1,280	5,061	134	38	9,882	1,810	73	1	4,234	2,551	116	21
2018	1,161	914	69	5,096	586	144	12	14,668	660	241	3				
								7,104							
								20,202							

[1] International Bottom Trawl Survey, arithmetic mean catch in no./h in standard area. In general the quarter 1 (Q1) and quarter 3 (Q3) IBTS indices have been revised in 2012 and 2014 and 2015 (see documentation on ICES DATRAS). [2]English groundfish survey (EGFS): Arithmetic mean catch no./h. Data for 1996, 2001, 2002, and 2003 have been revised compared to the 2003 assessment. In 2007, numbers for 1997 and 1998 as well as 2002 has been adjusted based on new automatic calculation and processing process has been introduced. In September 2015, the EGFS Survey index was for all years and ages radically revised in order to incorporate the relevant primes within the Norway pout index area following the ICES IBTS manual (2015). [3]Minor GOV sweep changes in 2006 for the EGFS. [4]Scottish groundfish surveys (SGFS), arithmetic mean catch no./h. Survey design changed in 1998 and 2000The SGFS survey area changed slightly in 2009 and onwards, which is evaluated to have no main effect for the Norway pout indices as the indices are weighted by sub-area. SGFS data for the full area, i.e. indices based on all hauls, are included in the presented indices.

Table 12.3.1 Norway pout 4 and 3.aN (Skagerrak). Tuning fleets and stock indices and tuning fleets used in the final 2004 benchmark assessment, in the 2005–2015 assessments, as well as in the 2016–2018 assessments based on the 2016 benchmark assessment, compared to the 2003 assessment. (Changes from previous period marked with grey).

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-15 ASSESSMENTS	2016-18 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2018)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2018)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	3+ (SESAM) (1984-2018)
FLT01: comm Q1						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	1	1	1	1	
	Ages	1-3	1-3	1-3	1-3	
FLT01: comm Q2			NOT USED	NOT USED	NOT USED	NOT USED
	Year range	1982-2003				
	Quarter	2				
	Ages	1-3				
FLT01: comm Q3						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	3	3	3	3	
	Ages	0-3	1-3	1-3	1-3	
FLT01: comm Q4						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	4	4	4	4	
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)	
FLT02: ibtsq1						
	Year range	1982-2003	1982-2006	1982-2006	1983-2015	1984-2018
	Quarter	1	1	1	1	1
	Ages	1-3	1-3	1-3	1-3	1-3
FLT03: egfs						
	Year range	1982-2003	1992-2005	1992-2005	1992-2015	1992-2018
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT04: sgfs						
	Year range	1982-2003	1998-2006	1998-2006	1998-2015	1998-2018
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED				
	Year range		1991-2005	1991-2005	1991-2014	1991-2017
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

Table 12.3.2 Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal stochastic assessment model. Settings and tuning fleets.

SURVIVORS ANALYSIS OF: Norway pout stock in September 2018

Run: September 2018

The following parameters were used:

Year range:	1984 – 2018
Seasons per year:	4
The last season in the last year is season:	3
Youngest age:	0
Oldest age:	2
Plus age:	3
Recruitment in season:	3
Spawning in season:	1

The following tuning fleets were included:

Fleet 2:	ibtsq1	(Age 1–3)
Fleet 3:	egfsq3	(Age 0–1)
Fleet 4:	sgfsq3	(Age 0–1)
Fleet 5:	ibtsq3	(Age 2–3)

Table 12.3.3. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated stock numbers in start of quarterly and yearly season.

Time\Age	0	1	2	3
1984	0	43249	9336	410
1984.25	0	29602	5063	228
1984.5	38818	20390	2839	128
1984.75	0	11284	1085	72
1985	0	20781	5323	390
1985.25	0	13927	2488	206
1985.5	26058	9877	1432	120
1985.75	0	5636	539	67
1986	0	13677	2674	208
1986.25	0	9274	1344	114
1986.5	49357	6724	817	69
1986.75	0	4185	379	41
1987	0	27753	2253	182
1987.25	0	19662	1152	100
1987.5	9936	14485	701	61
1987.75	0	9558	349	37
1988	0	5106	4876	137
1988.25	0	3780	2834	77
1988.5	42848	2898	1882	47
1988.75	0	2082	1105	29
1989	0	23422	1268	537
1989.25	0	16805	798	325
1989.5	43959	12068	502	197
1989.75	0	7851	263	121
1990	0	23626	4547	199
1990.25	0	16922	2559	117
1990.5	55480	11867	1419	68
1990.75	0	8014	764	42
1991	0	30268	5014	407
1991.25	0	21485	2769	226
1991.5	93783	15742	1623	129
1991.75	0	10852	883	80
1992	0	51743	7152	506
1992.25	0	36559	4265	310
1992.5	49731	26316	2750	197
1992.75	0	17207	1552	121
1993	0	26900	10604	919
1993.25	0	18683	5934	557
1993.5	42942	13095	3489	344
1993.75	0	8199	1705	207
1994	0	22709	4872	907
1994.25	0	15564	2831	526
1994.5	124603	10986	1749	315
1994.75	0	7270	956	192
1995	0	69168	4720	668

Time\Age	0	1	2	3
1995.25	0	50231	2882	429
1995.5	48165	36358	1782	277
1995.75	0	24884	1048	174
1996	0	25166	16312	729
1996.25	0	18508	10067	448
1996.5	102801	13488	6464	277
1996.75	0	9326	3740	172
1997	0	57416	6493	2379
1997.25	0	41953	4135	1492
1997.5	20733	32170	2685	943
1997.75	0	22482	1523	588
1998	0	11572	15593	1255
1998.25	0	8633	9839	765
1998.5	36955	6377	6287	466
1998.75	0	4666	3764	294
1999	0	21213	3303	2461
1999.25	0	16006	2211	1562
1999.5	88721	11987	1430	978
1999.75	0	8537	816	603
2000	0	51308	5951	822
2000.25	0	38922	3954	513
2000.5	23572	30045	2598	318
2000.75	0	21465	1610	201
2001	0	12675	13886	1024
2001.25	0	9125	8651	643
2001.5	23781	6582	5489	405
2001.75	0	4753	3627	258
2002	0	13668	3206	2301
2002.25	0	10138	2019	1425
2002.5	19083	7340	1324	894
2002.75	0	4989	801	559
2003	0	9877	3162	776
2003.25	0	6923	2023	477
2003.5	7910	4840	1296	293
2003.75	0	3285	764	183
2004	0	4332	2245	534
2004.25	0	3142	1479	339
2004.5	7463	2364	982	216
2004.75	0	1667	610	137
2005	0	4171	1124	437
2005.25	0	3098	770	289
2005.5	29400	2314	526	190
2005.75	0	1755	356	124
2006	0	16467	1353	317
2006.25	0	12152	933	206
2006.5	20636	9081	624	132
2006.75	0	6728	380	83
2007	0	11531	4371	250

Time\Age	0	1	2	3
2007.25	0	8629	2899	164
2007.5	30385	6410	1914	108
2007.75	0	4771	1257	70
2008	0	17102	3643	894
2008.25	0	12963	2521	576
2008.5	47176	9802	1707	371
2008.75	0	7429	1096	234
2009	0	28852	5418	860
2009.25	0	21894	3641	542
2009.5	69738	16979	2405	339
2009.75	0	12850	1414	213
2010	0	40710	9949	1037
2010.25	0	31648	7342	665
2010.5	6339	23619	5040	421
2010.75	0	16723	3145	265
2011	0	3611	11673	2154
2011.25	0	2708	7574	1377
2011.5	10789	2090	5114	884
2011.75	0	1569	3359	563
2012	0	6157	1175	2615
2012.25	0	4654	809	1729
2012.5	53238	3571	562	1143
2012.75	0	2760	384	741
2013	0	30015	1893	697
2013.25	0	22488	1325	446
2013.5	14118	16123	896	283
2013.75	0	11045	549	179
2014	0	7696	6615	385
2014.25	0	5603	4160	243
2014.5	86227	4072	2581	152
2014.75	0	2897	1451	94
2015	0	46317	1879	835
2015.25	0	32928	1210	527
2015.5	32512	23074	764	329
2015.75	0	14950	407	201
2016	0	17329	9372	342
2016.25	0	12188	5999	218
2016.5	67050	8327	3726	137
2016.75	0	5322	2096	84
2017	0	36368	3244	1208
2017.25	0	25752	2111	769
2017.5	21801	18195	1360	485
2017.75	0	12710	815	305
2018	0	11365	8594	664
2018.25	0	8283	5726	430
2018.5	80801	5946	3735	275
2018.75	0	4341	2344	174

Table 12.3.4. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated fishing mortalities by quarter of year. (The last 2018 quarter 4 F-value is aprojection of F based on the population estimate by end of 3rd quarter).

Year\Age	0	1	2	3+
1984	0.000	0.359	1.004	0.545
1984.25	0.000	0.320	0.830	0.489
1984.5	0.012	1.179	2.311	0.500
1984.75	0.223	1.822	3.001	0.104
1985	0.001	0.472	1.321	0.717
1985.25	0.000	0.212	0.551	0.324
1985.5	0.012	1.126	2.206	0.478
1985.75	0.221	1.810	2.981	0.103
1986	0.001	0.403	1.128	0.612
1986.25	0.000	0.148	0.384	0.227
1986.5	0.008	0.739	1.447	0.313
1986.75	0.154	1.257	2.070	0.072
1987	0.000	0.357	0.998	0.542
1987.25	0.000	0.124	0.322	0.190
1987.5	0.006	0.567	1.112	0.241
1987.75	0.199	1.624	2.676	0.093
1988	0.000	0.258	0.721	0.391
1988.25	0.000	0.101	0.262	0.155
1988.5	0.004	0.389	0.761	0.165
1988.75	0.122	0.999	1.645	0.057
1989	0.000	0.191	0.534	0.290
1989.25	0.000	0.184	0.479	0.282
1989.5	0.006	0.558	1.094	0.237
1989.75	0.123	1.010	1.664	0.058
1990	0.000	0.261	0.730	0.396
1990.25	0.000	0.286	0.743	0.438
1990.5	0.005	0.450	0.882	0.191
1990.75	0.093	0.758	1.249	0.043
1991	0.000	0.297	0.830	0.450
1991.25	0.000	0.215	0.559	0.330
1991.5	0.005	0.456	0.893	0.193
1991.75	0.082	0.671	1.106	0.038
1992	0.000	0.259	0.723	0.393
1992.25	0.000	0.168	0.435	0.257
1992.5	0.005	0.459	0.899	0.195
1992.75	0.083	0.677	1.116	0.039
1993	0.000	0.227	0.635	0.345
1993.25	0.000	0.172	0.447	0.264
1993.5	0.006	0.566	1.108	0.240
1993.75	0.097	0.797	1.313	0.046
1994	0.000	0.238	0.664	0.361
1994.25	0.000	0.151	0.392	0.231
1994.5	0.005	0.484	0.948	0.205
1994.75	0.063	0.519	0.855	0.030
1995	0.000	0.150	0.420	0.228
1995.25	0.000	0.132	0.342	0.202

Year\Age	0	1	2	3+
1995.5	0.003	0.287	0.562	0.122
1995.75	0.050	0.411	0.677	0.024
1996	0.000	0.103	0.288	0.156
1996.25	0.000	0.080	0.209	0.123
1996.5	0.004	0.372	0.728	0.158
1996.75	0.043	0.349	0.575	0.020
1997	0.000	0.081	0.227	0.123
1997.25	0.000	0.051	0.133	0.078
1997.5	0.004	0.370	0.725	0.157
1997.75	0.048	0.396	0.653	0.023
1998	0.000	0.079	0.222	0.121
1998.25	0.000	0.076	0.196	0.116
1998.5	0.003	0.279	0.545	0.118
1998.75	0.045	0.370	0.610	0.021
1999	0.000	0.063	0.176	0.095
1999.25	0.000	0.092	0.239	0.141
1999.5	0.004	0.336	0.657	0.142
1999.75	0.056	0.457	0.753	0.026
2000	0.000	0.062	0.173	0.094
2000.25	0.000	0.069	0.179	0.106
2000.5	0.002	0.215	0.421	0.091
2000.75	0.066	0.541	0.892	0.031
2001	0.000	0.079	0.220	0.119
2001.25	0.000	0.063	0.163	0.096
2001.5	0.001	0.108	0.212	0.046
2001.75	0.052	0.428	0.706	0.025
2002	0.000	0.076	0.211	0.115
2002.25	0.000	0.052	0.134	0.079
2002.5	0.003	0.265	0.519	0.112
2002.75	0.069	0.566	0.934	0.032
2003	0.000	0.044	0.122	0.066
2003.25	0.000	0.037	0.096	0.056
2003.5	0.002	0.228	0.446	0.097
2003.75	0.044	0.363	0.599	0.021
2004	0.000	0.032	0.089	0.049
2004.25	0.000	0.018	0.047	0.028
2004.5	0.002	0.164	0.322	0.070
2004.75	0.045	0.369	0.608	0.021
2005	0.000	0.000	0.000	0.000
2005.25	0.000	0.000	0.001	0.000
2005.5	0.000	0.000	0.001	0.000
2005.75	0.000	0.000	0.001	0.000
2006	0.000	0.022	0.081	0.031
2006.25	0.000	0.042	0.139	0.074
2006.5	0.000	0.114	0.364	0.083
2006.75	0.035	0.611	1.060	0.032
2007	0.000	0.006	0.016	0.005
2007.25	0.000	0.019	0.049	0.022
2007.5	0.000	0.029	0.090	0.019

Year\Age	0	1	2	3+
2007.75	0.001	0.025	0.043	0.001
2008	0.000	0.003	0.007	0.002
2008.25	0.000	0.021	0.053	0.024
2008.5	0.000	0.060	0.185	0.039
2008.75	0.003	0.072	0.124	0.003
2009	0.000	0.001	0.004	0.001
2009.25	0.000	0.021	0.053	0.024
2009.5	0.000	0.143	0.440	0.094
2009.75	0.003	0.078	0.133	0.003
2010	0.000	0.001	0.002	0.000
2010.25	0.000	0.034	0.088	0.040
2010.5	0.000	0.118	0.362	0.077
2010.75	0.005	0.127	0.218	0.006
2011	0.000	0.001	0.002	0.000
2011.25	0.000	0.006	0.017	0.008
2011.5	0.000	0.051	0.157	0.034
2011.75	0.005	0.124	0.212	0.005
2012	0.000	0.001	0.001	0.000
2012.25	0.000	0.009	0.024	0.011
2012.5	0.000	0.035	0.107	0.023
2012.75	0.018	0.466	0.800	0.020
2013	0.000	0.001	0.003	0.001
2013.25	0.000	0.033	0.086	0.039
2013.5	0.000	0.134	0.412	0.088
2013.75	0.026	0.690	1.184	0.030
2014	0.000	0.004	0.010	0.003
2014.25	0.000	0.034	0.086	0.039
2014.5	0.000	0.195	0.596	0.127
2014.75	0.019	0.506	0.868	0.022
2015	0.000	0.005	0.012	0.004
2015.25	0.000	0.042	0.109	0.049
2015.5	0.001	0.256	0.785	0.168
2015.75	0.016	0.424	0.729	0.019
2016	0.000	0.004	0.011	0.003
2016.25	0.000	0.052	0.134	0.060
2016.5	0.000	0.214	0.657	0.140
2016.75	0.016	0.417	0.716	0.018
2017	0.000	0.002	0.005	0.002
2017.25	0.000	0.036	0.093	0.042
2017.5	0.000	0.143	0.437	0.093
2017.75	0.013	0.329	0.565	0.014
2018	0.000	0.002	0.004	0.001
2018.25	0.000	0.041	0.104	0.047
2018.5	0.000	0.099	0.303	0.065
2018.75	0.013	0.329	0.565	0.014

Table 12.3.5. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Estimated catchabilities by survey tuning fleet.

Index	Fleet number	Age	Catchability	Low	High
1	2	1	0.13107	0.08603	0.19969
2	2	2	0.21725	0.13108	0.36006
3	2	3	0.22117	0.09894	0.49439
4	3	0	0.07174	0.04394	0.11712
5	3	1	0.20605	0.12421	0.34181
6	4	0	0.159	0.09464	0.26715
7	4	1	0.20413	0.11955	0.34855
8	5	2	0.19592	0.10249	0.37453
9	5	3	0.08999	0.03773	0.21466

Table 12.3.5 (cont.). Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Likelihood values.

Model	Negative log likelihood	Number of parameters
Base	1158.53	19
Current	1158.53	19

Table 12.3.6 Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2018. Estimated yearly and quarterly recruitment (millions), spawning stock biomass SSB (t), total stock biomass TSB (t) and fishing mortality for ages 1–2 (F12).

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1984				327654	173190	482118	639044	370931	907158	1.353	0.857	2.135
1984.25				209046	110301	307792	493225	272500	713950			
1984.5	38818	22216	67826	223186	115501	330870	630990	332562	929418			
1984.75				104007	47894	160121	329694	161328	498061			
1985				186083	97907	274258	335705	197014	474396	1.335	0.809	2.201
1985.25				105924	53295	158554	239620	131599	347642			
1985.5	26058	14980	45330	113888	58743	169033	311440	167248	455632			
1985.75				53643	23240	84045	166371	80451	252290			
1986				99806	50189	149422	198278	110306	286250	0.947	0.564	1.592
1986.25				61557	29258	93857	150589	78780	222399			
1986.5	49357	27762	87752	70425	34929	105920	204904	106405	303404			
1986.75				38445	16738	60151	122159	58799	185519			
1987				113554	62085	165023	313374	165707	461042	0.972	0.537	1.760
1987.25				80977	41858	120097	269735	135089	404380			
1987.5	9936	5424	18203	104120	54168	154072	393832	196373	591291			
1987.75				63866	30648	97084	255034	121032	389037			
1988				136568	57711	215425	173330	84948	261711	0.642	0.382	1.078
1988.25				83774	32383	135166	120060	57360	182760			
1988.5	42848	24435	75138	92563	35635	149491	150532	74096	226969			
1988.75				56279	18362	94196	97916	44790	151043			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1989				95332	48344	142321	263973	136246	391700	0.714	0.417	1.224
1989.25				76519	37366	115672	237850	120358	355343			
1989.5	43959	25037	77183	92242	46069	138415	333609	167442	499777			
1989.75				56837	26312	87363	213870	103139	324601			
1990				164171	85800	242541	334278	185365	483191	0.670	0.393	1.142
1990.25				110460	55866	165054	272910	144463	401358			
1990.5	55480	31251	98495	120172	58978	181365	357516	181690	533342			
1990.75				73081	32985	113177	233362	113196	353528			
1991				196090	102309	289871	414022	223544	604500	0.628	0.368	1.072
1991.25				132062	65542	198581	338316	172648	503983			
1991.5	93783	53339	164895	151376	74422	228330	466222	232133	700311			
1991.75				94190	42485	145896	311244	148301	474188			
1992				292153	153365	430942	664706	355792	973619	0.592	0.347	1.009
1992.25				209879	104590	315168	560842	286303	835381			
1992.5	49731	28587	86513	253374	123930	382819	779703	391002	1168404			
1992.75				155165	68629	241701	499316	238815	759817			
1993				350281	166608	533953	543959	288312	799606	0.658	0.341	1.270
1993.25				221031	98779	343282	400383	204688	596079			
1993.5	42942	24114	76472	225678	100754	350602	487579	248658	726500			
1993.75				121194	44367	198021	285177	130509	439846			
1994				198946	85632	312261	362454	177123	547785	0.531	0.285	0.991
1994.25				134445	52419	216470	283858	130941	436774			
1994.5	124603	69033	224904	143800	57872	229729	363521	168211	558830			
1994.75				85735	28503	142967	231145	95802	366489			
1995				269198	125109	413286	767207	354523	1179891	0.373	0.196	0.708
1995.25				214037	94344	333729	696252	309075	1083429			
1995.5	48165	26376	87954	269654	117554	421753	996811	435780	1557842			
1995.75				176440	71124	281757	674123	279416	1068829			
1996				482264	196536	767992	663461	304865	1022058	0.338	0.174	0.657
1996.25				318514	122756	514271	496195	222232	770158			
1996.5	102801	56167	188155	342640	129123	556156	612399	273039	951759			
1996.75				206187	60307	352068	392720	151474	633967			
1997				360822	146869	574776	774218	346654	1201781	0.329	0.166	0.655
1997.25				278640	109425	447856	681387	298246	1064529			
1997.5	20733	11232	38270	324800	134698	514902	968195	424576	1511814			
1997.75				207399	74537	340262	657046	260066	1054026			
1998				460878	170058	751698	544196	222986	865407	0.297	0.152	0.579
1998.25				304944	106870	503019	387817	156826	618807			
1998.5	36955	20587	66339	311316	105957	516675	438868	179911	697825			
1998.75				190909	52024	329793	284243	102184	466302			
1999				219197	76937	361456	371931	158921	584940	0.347	0.174	0.691
1999.25				171786	57027	286546	325441	137162	513720			
1999.5	88721	49132	160211	175813	62512	289114	415553	179870	651235			
1999.75				110338	34284	186393	281090	110358	451822			
2000				274007	116210	431803	643423	290786	996059	0.319	0.156	0.653
2000.25				217900	90568	345233	591556	260480	922632			
2000.5	23572	12923	42994	273209	113427	432991	874122	374506	1373737			
2000.75				183414	69402	297426	612715	244765	980664			
2001				410919	146417	675420	502177	199732	804622	0.247	0.120	0.511

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2001.25				270322	90259	450386	357919	139467	576371			
2001.5	23781	13062	43295	276731	90161	463301	408374	161827	654922			
2001.75				183817	53070	314563	278876	103491	454261			
2002				196773	63907	329639	295185	115506	474864	0.345	0.156	0.762
2002.25				146053	43452	248653	243374	92314	394434			
2002.5	19083	9993	36439	143301	46482	240120	290112	116933	463291			
2002.75				89404	24794	154015	189198	69741	308655			
2003				127869	43360	212377	198984	78438	319529	0.242	0.107	0.546
2003.25				91039	29924	152155	157499	62236	252763			
2003.5	7910	4206	14875	93612	32357	154868	190425	78275	302575			
2003.75				57638	16879	98398	123353	45631	201075			
2004				85258	28720	141797	116447	44830	188064	0.206	0.086	0.495
2004.25				61486	19591	103380	91648	34590	148706			
2004.5	7463	4012	13882	64086	21072	107100	111362	43413	179311			
2004.75				40661	11527	69796	73998	26211	121784			
2005				53104	17217	88991	83138	32061	134215	0.000	0.000	0.001
2005.25				41132	12938	69326	70869	27226	114512			
2005.5	29400	15806	54684	44029	14674	73383	90305	35957	144653			
2005.75				30169	9909	50429	65266	25570	104963			
2006				76141	33868	118415	194704	84670	304738	0.304	0.116	0.797
2006.25				62790	27154	98426	179447	76361	282534			
2006.5	20636	10962	38849	78312	33211	123414	259932	108298	411565			
2006.75				53693	20990	86397	188250	73007	303493			
2007				140006	46309	233703	223027	86603	359450	0.035	0.016	0.077
2007.25				101409	33509	169309	184245	71397	297094			
2007.5	30385	16203	56981	115098	38129	192068	243312	93844	392779			
2007.75				78177	24228	132126	173608	63602	283613			
2008				157630	60938	254322	280767	117698	443835	0.066	0.030	0.142
2008.25				122966	46157	199776	247411	101005	393818			
2008.5	47176	24767	89861	139560	51944	227177	335612	133920	537304			
2008.75				94573	32495	156651	243152	89875	396429			
2009				221801	88131	355471	429539	182491	676586	0.109	0.046	0.256
2009.25				170652	67767	273537	380831	159528	602133			
2009.5	69738	37305	130369	201445	80209	322681	541019	222540	859499			
2009.75				133165	46706	219623	390173	145032	635315			
2010				363475	141123	585827	656584	276926	1036242	0.119	0.053	0.265
2010.25				292746	107418	478073	596568	239525	953611			
2010.5	6339	3334	12051	344938	122122	567753	817316	318108	1316524			
2010.75				224813	69580	380046	559274	200958	917589			
2011				384497	131364	637631	410494	146428	674560	0.071	0.031	0.162
2011.25				264709	87465	441953	290710	102181	479239			
2011.5	10789	5822	19994	268040	85461	450619	309851	108608	511093			
2011.75				174888	49233	300543	206268	66113	346423			
2012				145041	43461	246621	189368	67847	310889	0.180	0.074	0.438
2012.25				117867	32486	203247	162544	56962	268126			
2012.5	53238	28516	99393	108939	31658	186220	180367	68266	292467			
2012.75				72119	20086	124151	127318	47100	207536			
2013				129235	51775	206696	345341	141268	549414	0.318	0.124	0.818
2013.25				109407	43498	175316	325288	131245	519331			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2013.5	14118	7549	26401	133436	54901	211970	455900	189372	722428			
2013.75				87568	34484	140652	308465	126391	490538			
2014				194637	65928	323347	250050	96308	403791	0.287	0.117	0.708
2014.25				129612	45761	213463	183401	74744	292058			
2014.5	86227	43455	171096	132722	47947	217498	214173	90664	337682			
2014.75				77979	22078	133880	135920	50091	221748			
2015				163739	60474	267004	497223	183669	810778	0.295	0.114	0.762
2015.25				135622	51904	219340	451734	174280	729188			
2015.5	32512	16291	64883	165684	66850	264517	627163	252318	1002007			
2015.75				102666	36814	168517	401681	151247	652115			
2016				279161	97312	461011	403933	158605	649260	0.276	0.108	0.701
2016.25				190117	67746	312488	307119	124964	489274			
2016.5	67050	34922	128736	198871	70559	327184	365419	150991	579847			
2016.75				115319	29947	200690	221773	77839	365707			
2017				194876	68297	321455	456727	179561	733892	0.201	0.080	0.506
2017.25				153003	54044	251962	400223	158503	641944			
2017.5	21801	11184	42495	174472	64968	283976	538375	213692	863058			
2017.75				113848	37687	190009	368061	132387	603735			
2018				261847	83605	440089	343675	128233	559117			
2018.25				184525	56350	312701	264039	97845	430234			
2018.5	80801	32310	202066	195623	55366	335879	314548	113550	515546			
2018.75				125940	28360	223520	212760	67138	358381			

Table 12.3.6 (cont). Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2018. Long term arithmetic means of yearly recruitment (millions), quarterly spawning stock biomass SSB (t), quarterly total stock biomass TSB (t) and yearly fishing mortality for ages 1–2 (Fbar=F12) for the period 1984–2018. (Numbers are given for start of the season).

Avg. recruitment	43625.98
Avg SSB Q 1	223228.94
Avg SSB Q 2	159341.56
Avg SSB Q 3	176204.4
Avg SSB Q 4	109530.47
Avg TSB Q 1	396711.99
Avg TSB Q 2	326883.03
Avg TSB Q 3	430838.83
Avg TSB Q 4	283274.79
Avg. FBAR	0.42

Table 12.6.1 Norway pout 4 and 3.aN (Skagerrak). Projected mean weight at age used in the forecast by quarter of year.

Age/Quarter	1	2	3	4
0	4.484	9.259	7.032	8.327
1	8.756	12.762	23.559	26.411
2	21.076	23.768	31.461	35.81
3	30.617	30.873	36.904	42.194

Table 12.6.2 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year a head (1st October 2019) equals Blim.

Basis:

F (2018 up to Q4) = estimated from in year assessment 1st October 2018, F(age,quarter1,2,3 2018), Table 12.3.4.

SSB (2018 up to Q4) = estimated from in year assessment 1st October 2018 (start Q4) = 125 940 tonnes;

R(2018) = estimated / observed from in year assessment 1st July 2018 (age 0 in start of Q3) = 80 801million;

Biological parameters (2018–2019): Assume values for M, weight-at-age in the stock, and maturity-at-age for the projection period to be similar to the same parameter values used in the assessment. Assume projected mean weight at ages in the catches by quarter as given in Table 12.6.1.

F, R (Q4 2018– Q4 2019): (i) Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years. (ii) Assume that $\log F_t = \log F_{t-4} + \log G_t$, for all future values of t where G_t is some chosen vector of multipliers of the F-process. If $G_t = 1$ for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year. (iii) Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution. (iv) Find G_t such that the fifth (or any other) percentile of the catches (total mass) in the projections equals some desired level such as B_{lim} (optional).

	F12	SSB	SSB 5th quantile	median catch
2018.75	2.09	127.22	68.65	74688.46
2019	0.01	177.97	74.05	911.19
2019.25	0.34	152.79	61.97	21510.46
2019.5	0.93	182.81	72.34	59687.78
2019.75		112.16	39.45	
Sum				156797.9

Table 12.6.3 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	0	127.22	68.65	0
2019	0	243.95	135.46	0
2019.25	0	203.39	108.13	0
2019.5	0	245	122.64	0
2019.75		175.25	83.79	
Sum				0

Table 12.6.4 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year up to 1st October 2018.

Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2018.75	0.45	127.22	68.65	19466.42
2019	0	224.08	116.13	224.81
2019.25	0.07	188.66	95.07	5295.02
2019.5	0.2	226.55	106.32	15606.51
2019.75		157	69.56	
Sum				40592.76

Table 12.6.5 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year a head (1st October 2019) equals Blim.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	10	127.22	68.65	190015.84
2019	0.07	101.89	36.62	3267.16
2019.25	1.64	93.57	32.46	72134.9
2019.5	4.47	100.89	31.66	151079.91
2019.75		39.45	8.02	
Sum				416497.81

Table 12.6.6 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that SSB one year a head (1st October 2019) equals Bpa.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	5.7	127.22	68.65	145026.83
2019	0.04	128.53	46.53	2099.34
2019.25	0.94	113.93	41.07	48288.78
2019.5	2.55	131.35	44.4	117693.79
2019.75		65	17.17	
Sum				313108.74

Table 12.6.7 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median.catch (t) with F scaled to 0.3 (F_{cap} = 0.3) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	0.75	127.22	68.65	31209.98
2019	0.01	213.62	105.46	364.37
2019.25	0.12	181.19	86.15	8492.41
2019.5	0.33	217.01	98.2	24858.3
2019.75		146.15	61.54	
Sum				64925.06

Table 12.6.8 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.4 (F_{cap} = 0.4) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	0.99	127.22	68.65	40260.9
2019	0.01	205.86	97.59	473.03
2019.25	0.16	174.79	80.76	11090.33
2019.5	0.44	209.56	91.55	32151.97
2019.75		138.89	56.16	
Sum				83976.24

Table 12.6.9 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (F_{cap} = 0.5) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	1.24	127.22	68.65	48858.04
2019	0.01	198.67	90.67	579.43
2019.25	0.2	169.37	74.96	13604
2019.5	0.56	202.3	86.31	39034.99
2019.75		131.76	51.59	
Sum				102076.45

Table 12.6.10 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.6 (F_{cap} = 0.6) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	1.49	127.22	68.65	56893.29
2019	0.01	192.1	84.96	682.1
2019.25	0.25	163.67	70.52	16014.47
2019.5	0.67	196.18	81.5	45559.19
2019.75		125.01	47.57	
Sum				119149.05

Table 12.6.11 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.7 (F_{cap} = 0.7) for the period 1st October 2018 to 1st October 2019.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2018.75	1.74	127.22	68.65	64727.33
2019	0.01	185.78	80.31	779.08
2019.25	0.29	159	66.57	18358.96
2019.5	0.78	190.23	77.72	51593.51
2019.75		119.31	44.03	
Sum				135458.88

Table 12.6.12 Norway pout 4 and 3.aN (Skagerrak). The quarterly minima of the estimated SSB time series (1984–2016) from the SESAM Benchmark Assessment Baseline Run from the Norway pout benchmark assessment under ICES WKPOUT 2016. The estimates are quarterly minima estimated at the beginning of the season. The estimates are Bloss estimates which equals Blim according to the ICES WKPOUT 2016 benchmark assessment which by 1st October is Blim=39 450 t.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

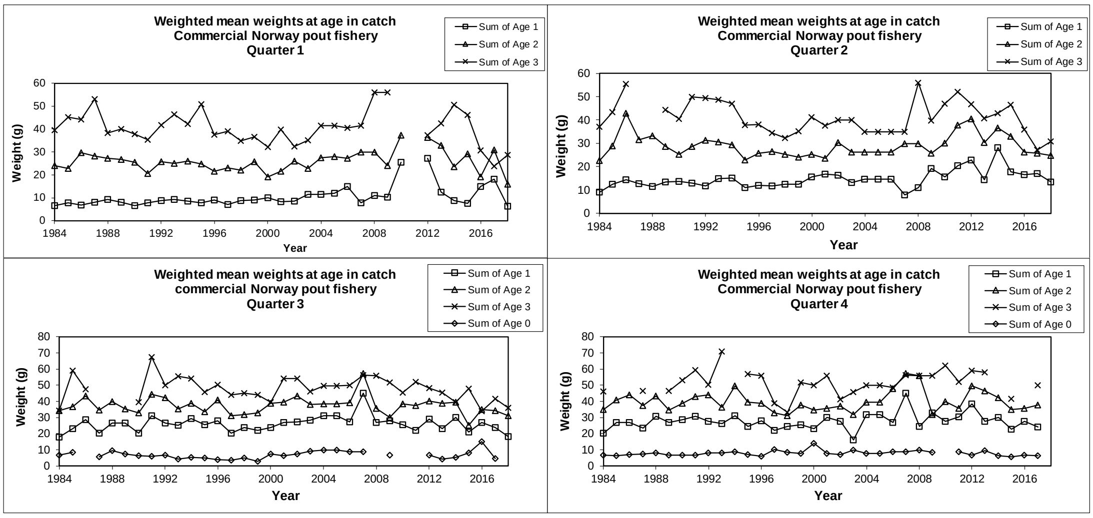


Figure 12.2.1. Norway pout 4 and 3.aN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1984–2018.

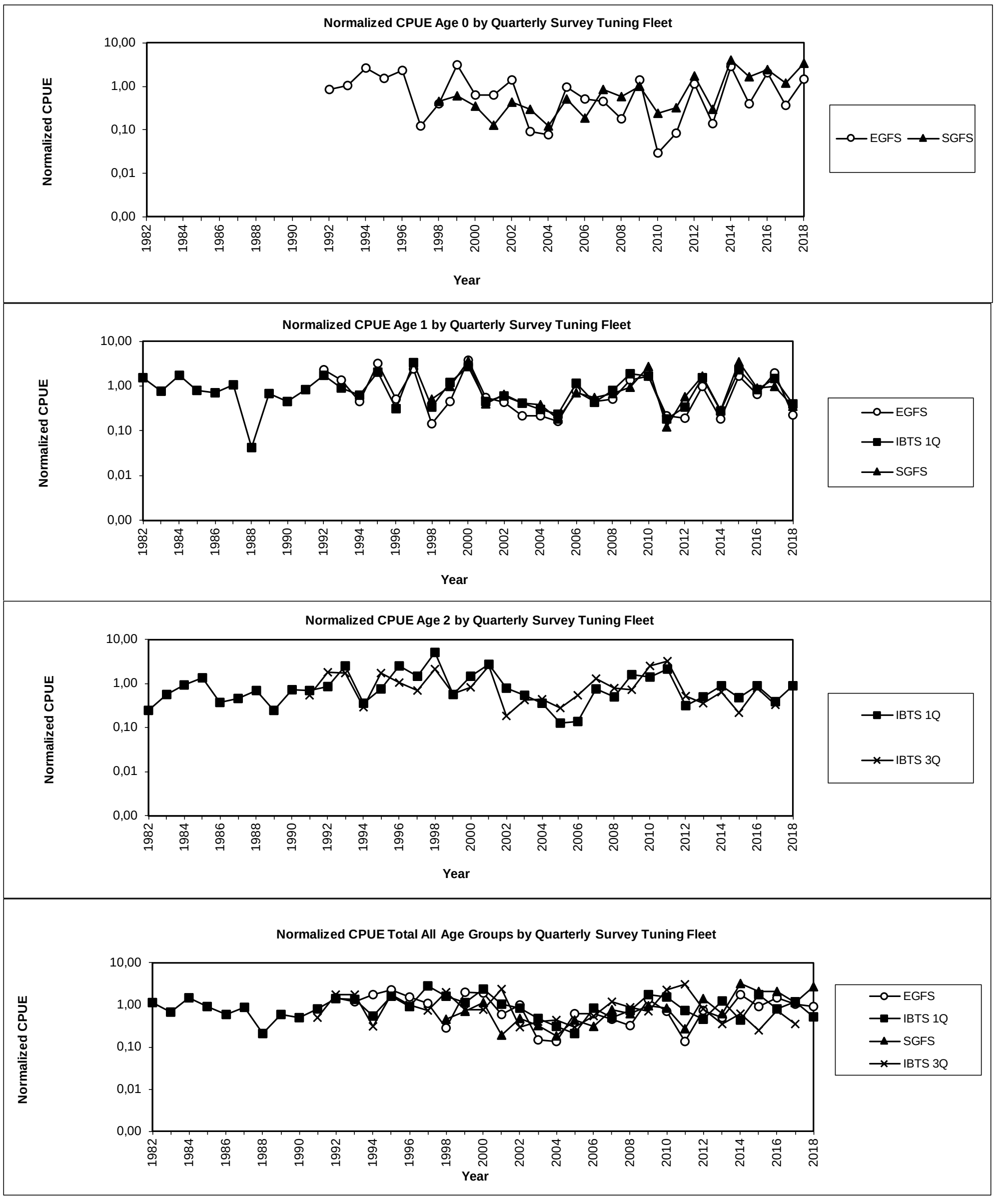


Figure 12.2.2 Norway pout 4 and 3.aN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly survey tuning fleet used in the Norway pout assessment for each age group and all age groups together.

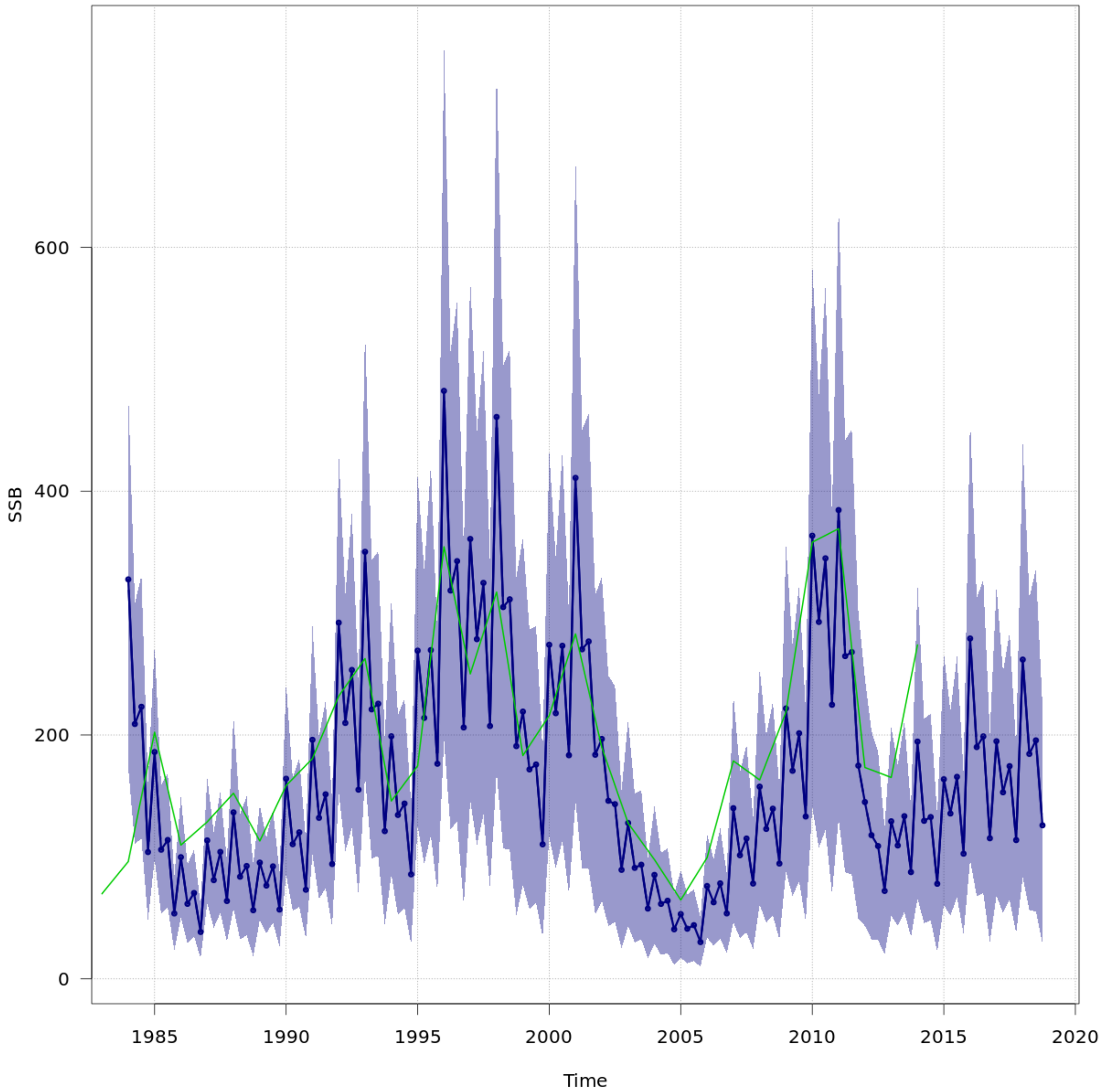


Figure 12.3.1. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: SSB (t), quarterly. SESAM baseline run September 2018. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only – connecting lines are interpolations).

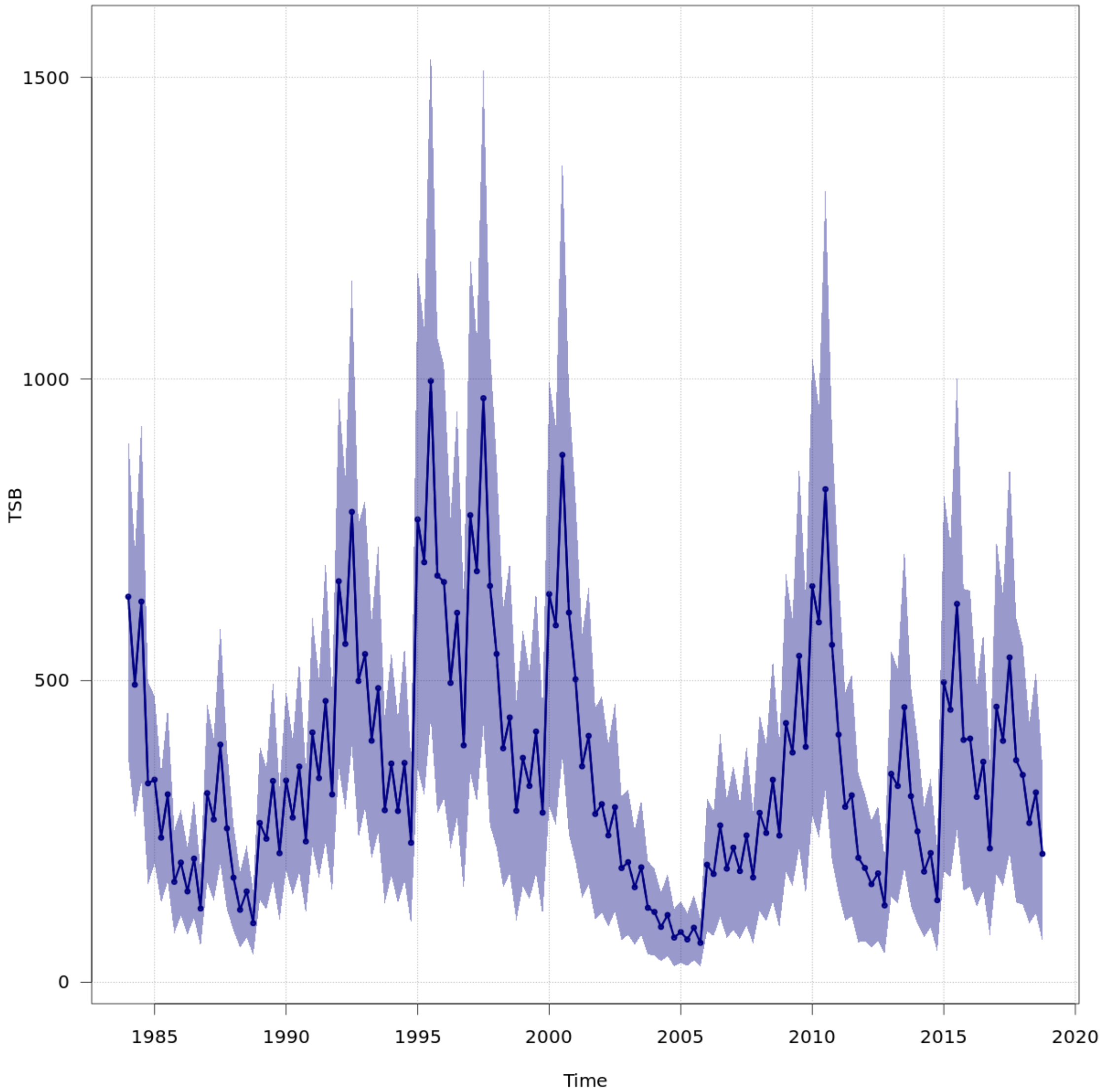


Figure 12.3.2. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: TSB (t), quarterly. SESAM baseline run September 2018.

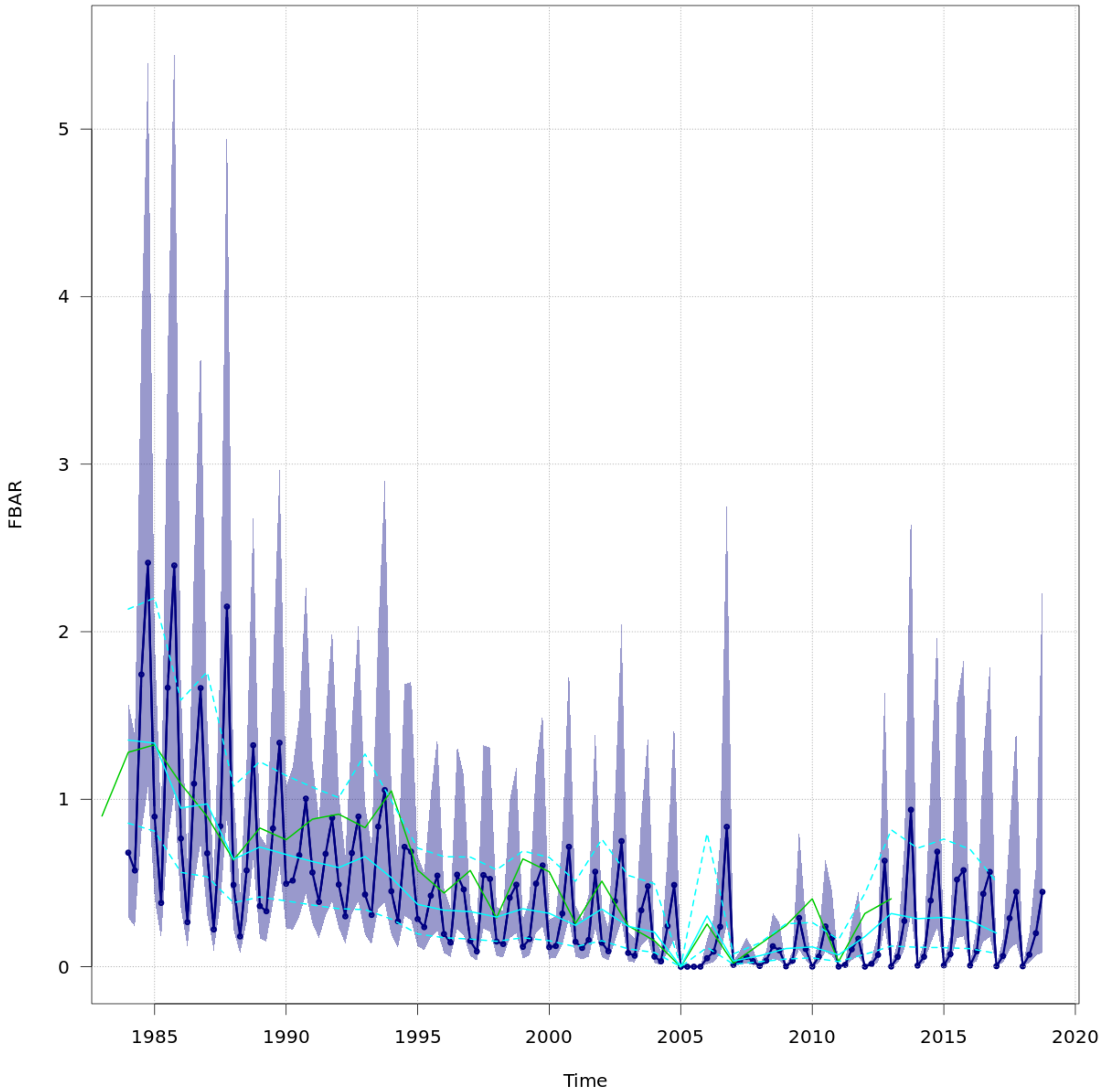


Figure 12.3.3. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: F1–2=Fbar, quarterly. SESAM baseline run September 2018. Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

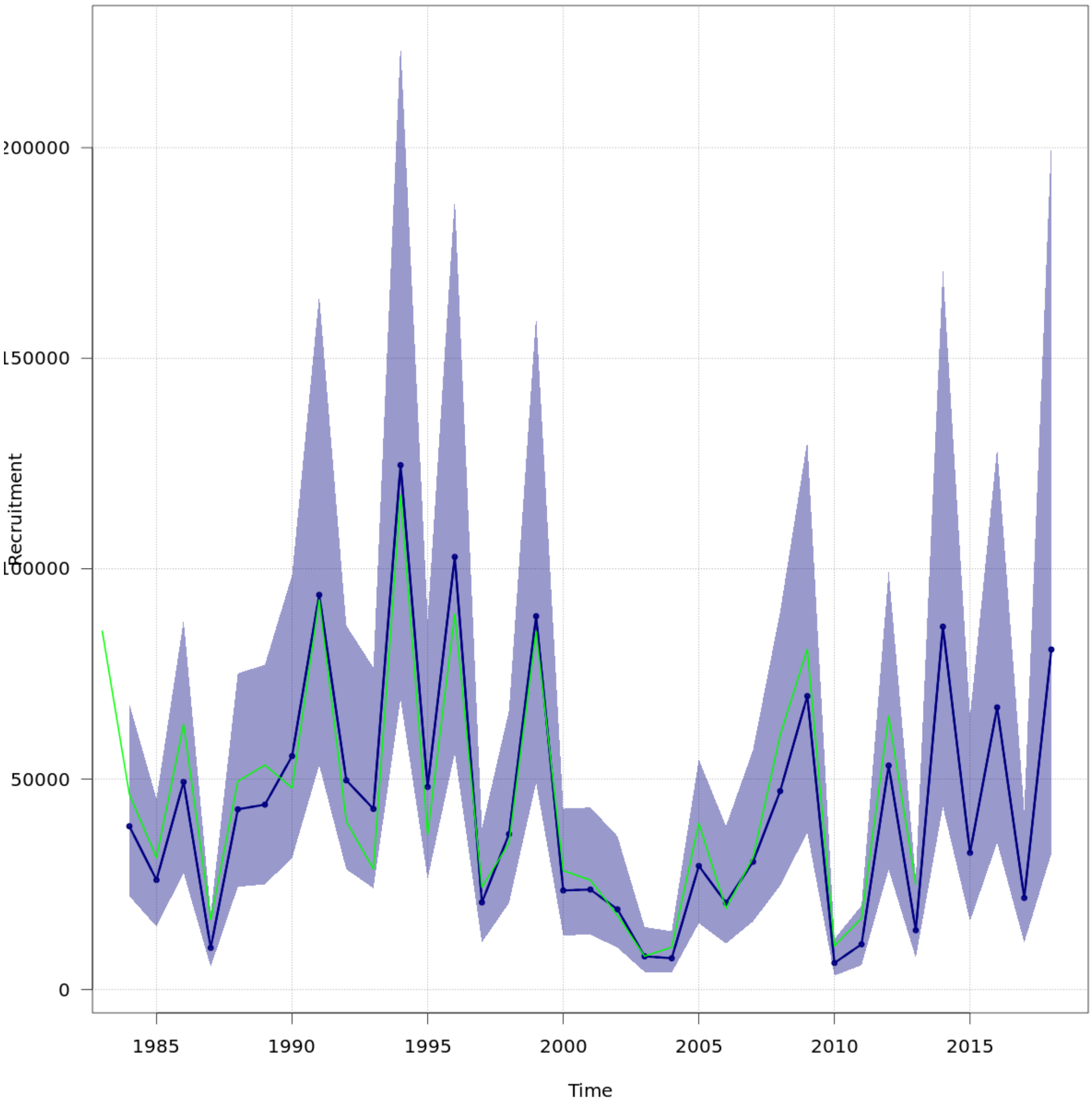
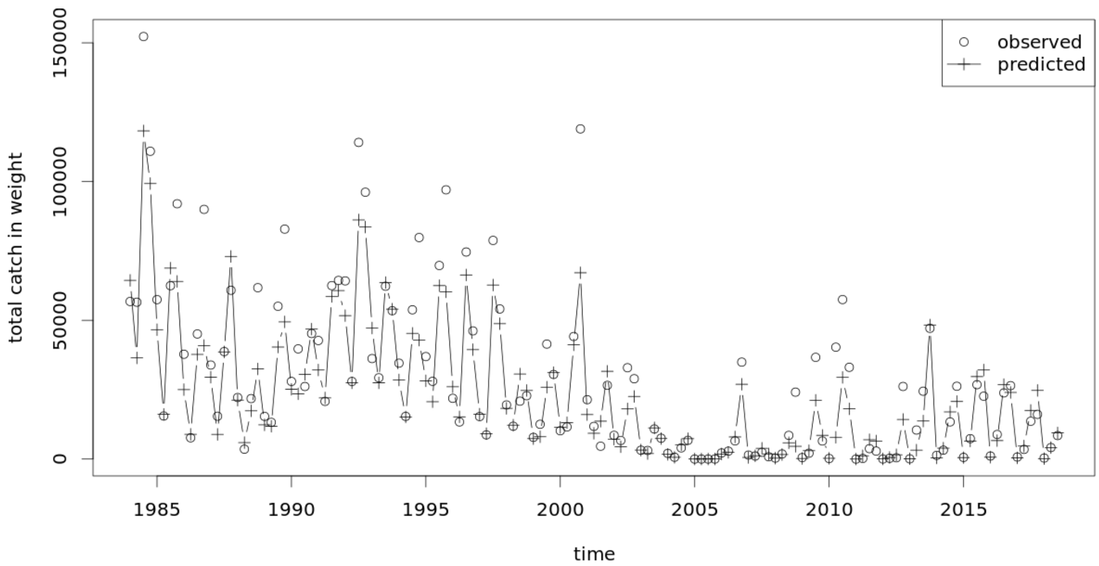


Figure 12.3.4. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Recruitment (millions), yearly. SESAM baseline run September 2018. Blue is SESAM, green is SXSA.



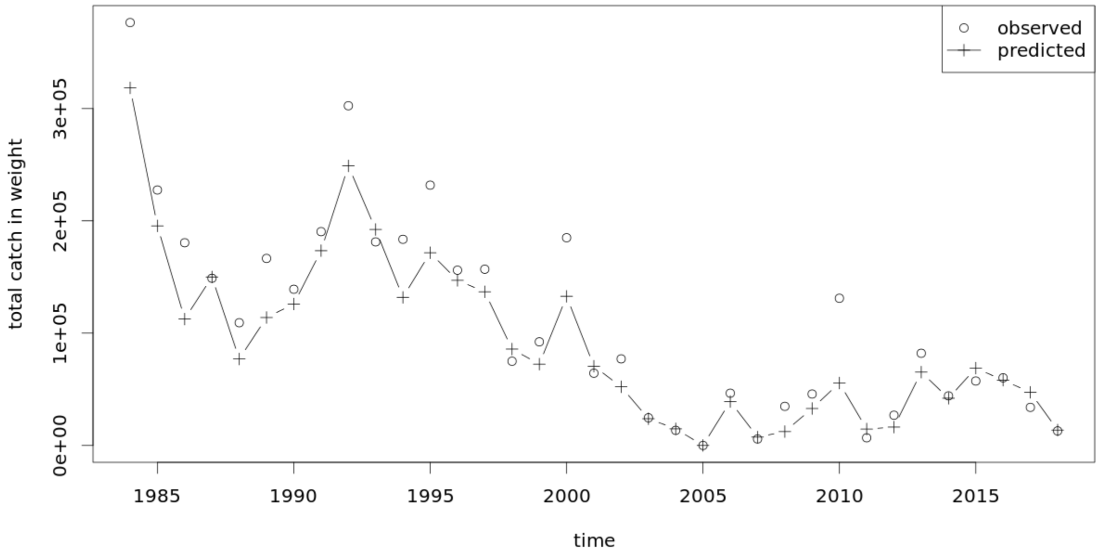


Figure 12.3.5. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Yield = Total Catch (t), quarterly and yearly. SESAM baseline run September 2018.

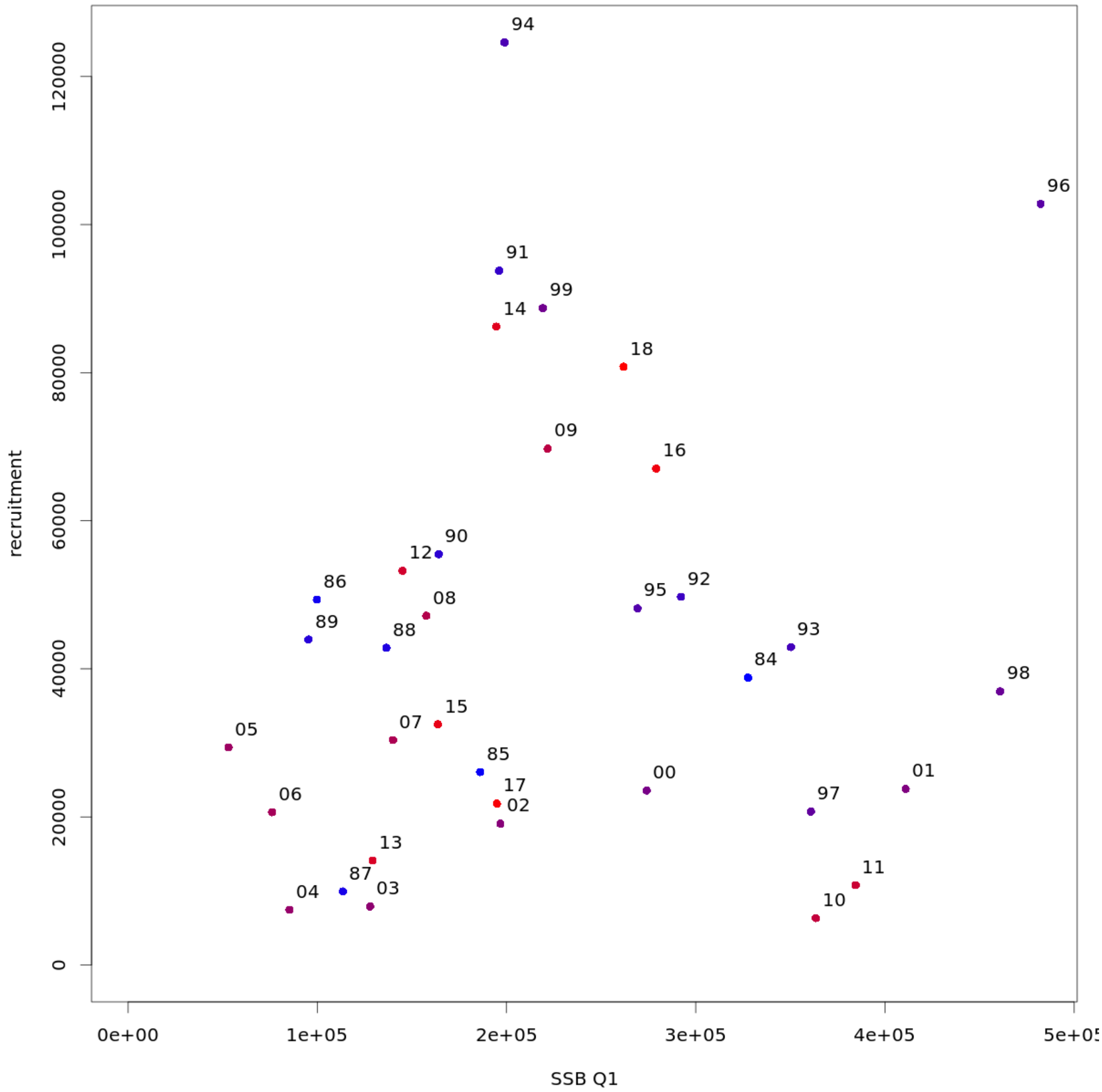


Figure 12.3.6. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 1. SESAM baseline run September 2018.

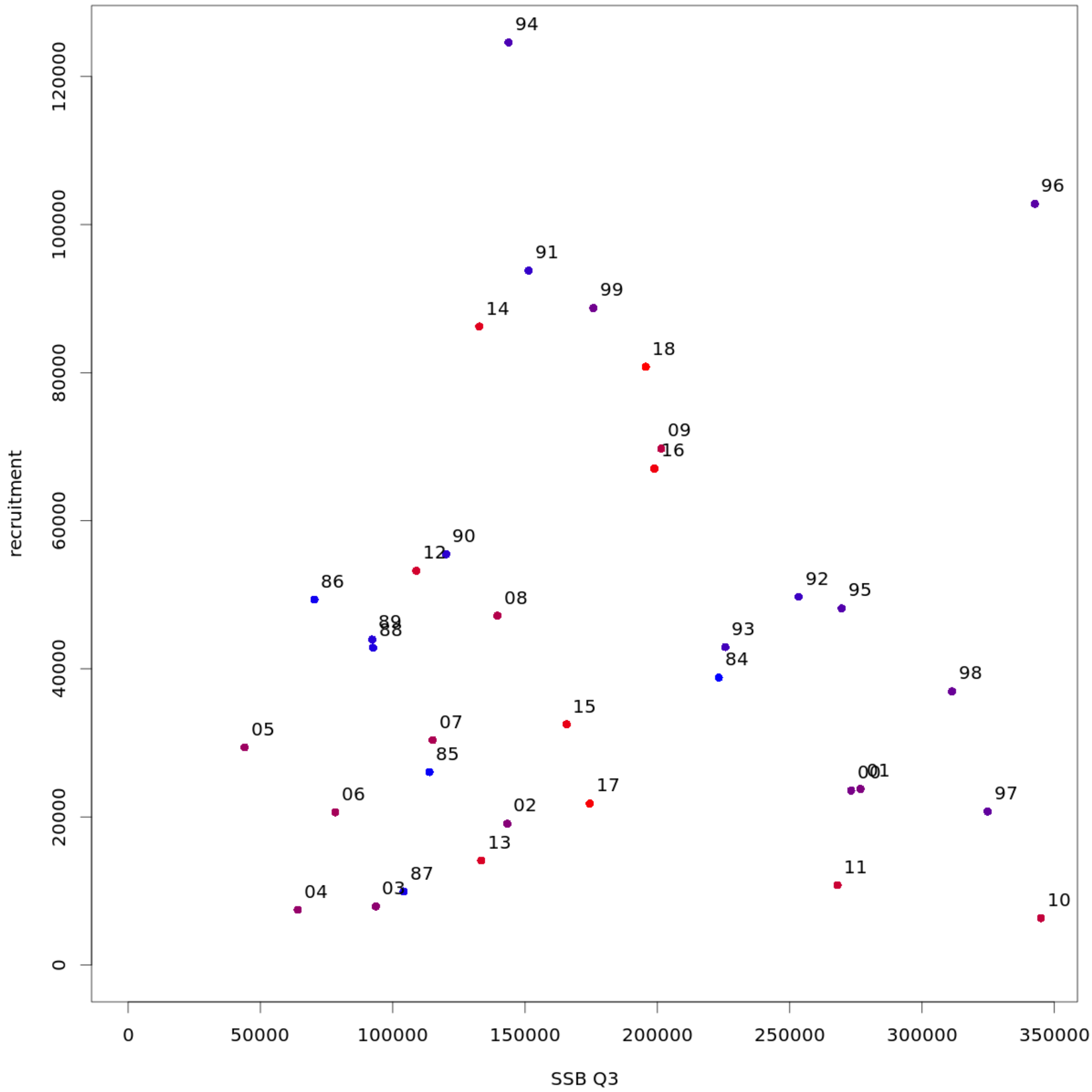


Figure 12.3.7. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 3. SESAM baseline run September 2018.

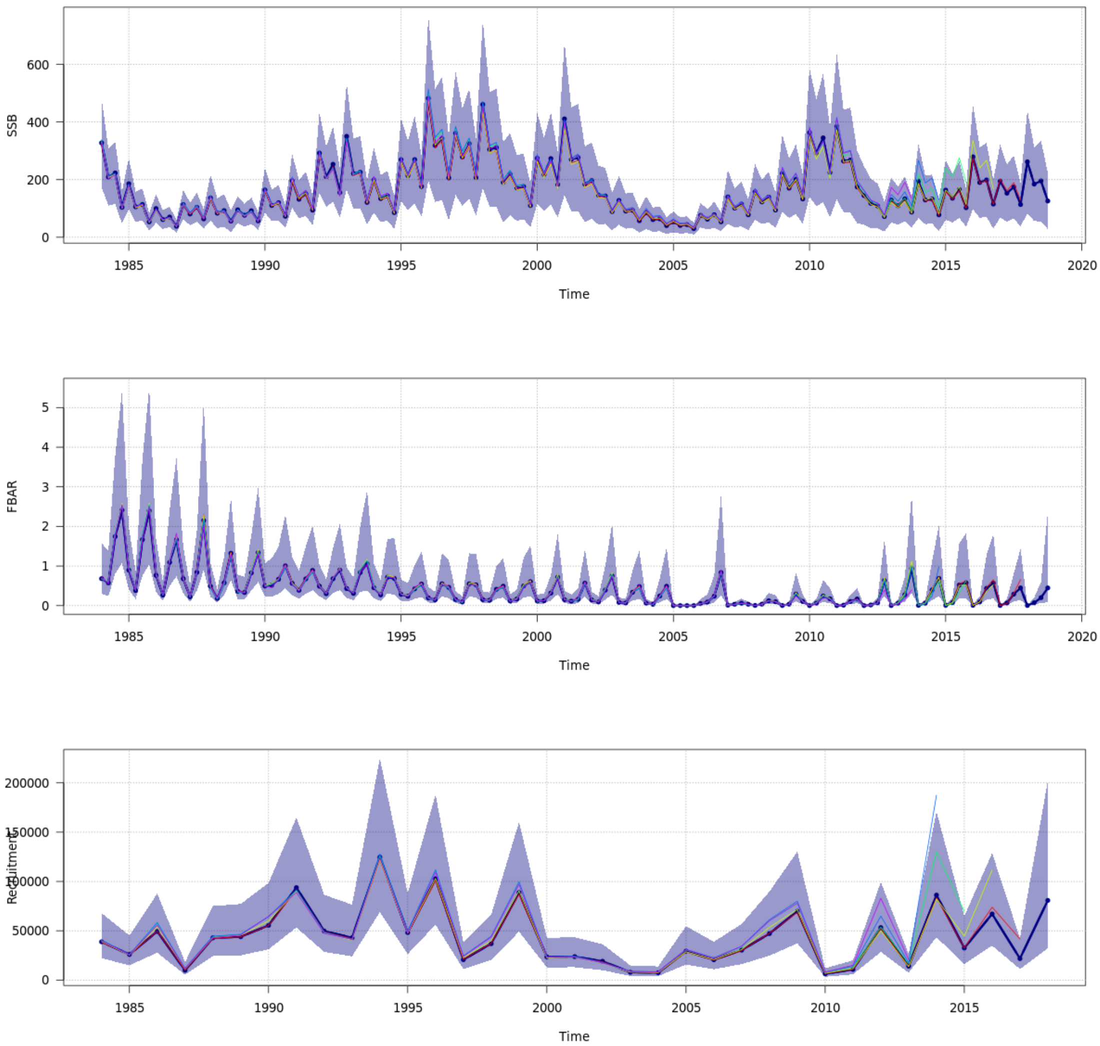


Figure 12.3.8 Norway pout IV & IIIaN (Skagerrak). Retrospective plots of baseline SESAM assessment September 2018, with terminal assessment year ranging from 2005–2018.

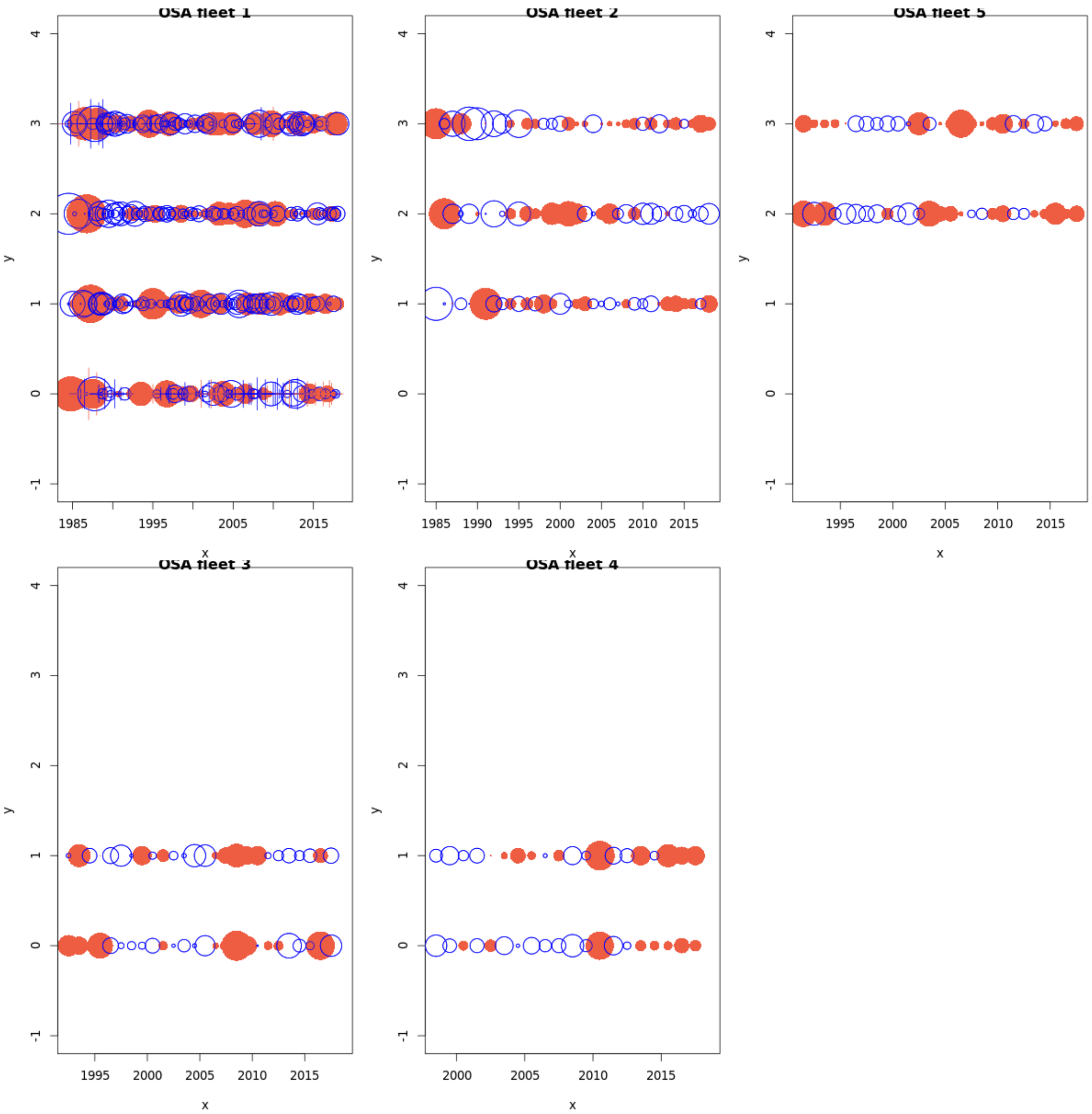


Figure 12.3.9. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet: One step ahead residuals (see Berg and Nielsen 2016). SESAM baseline run September 2018.

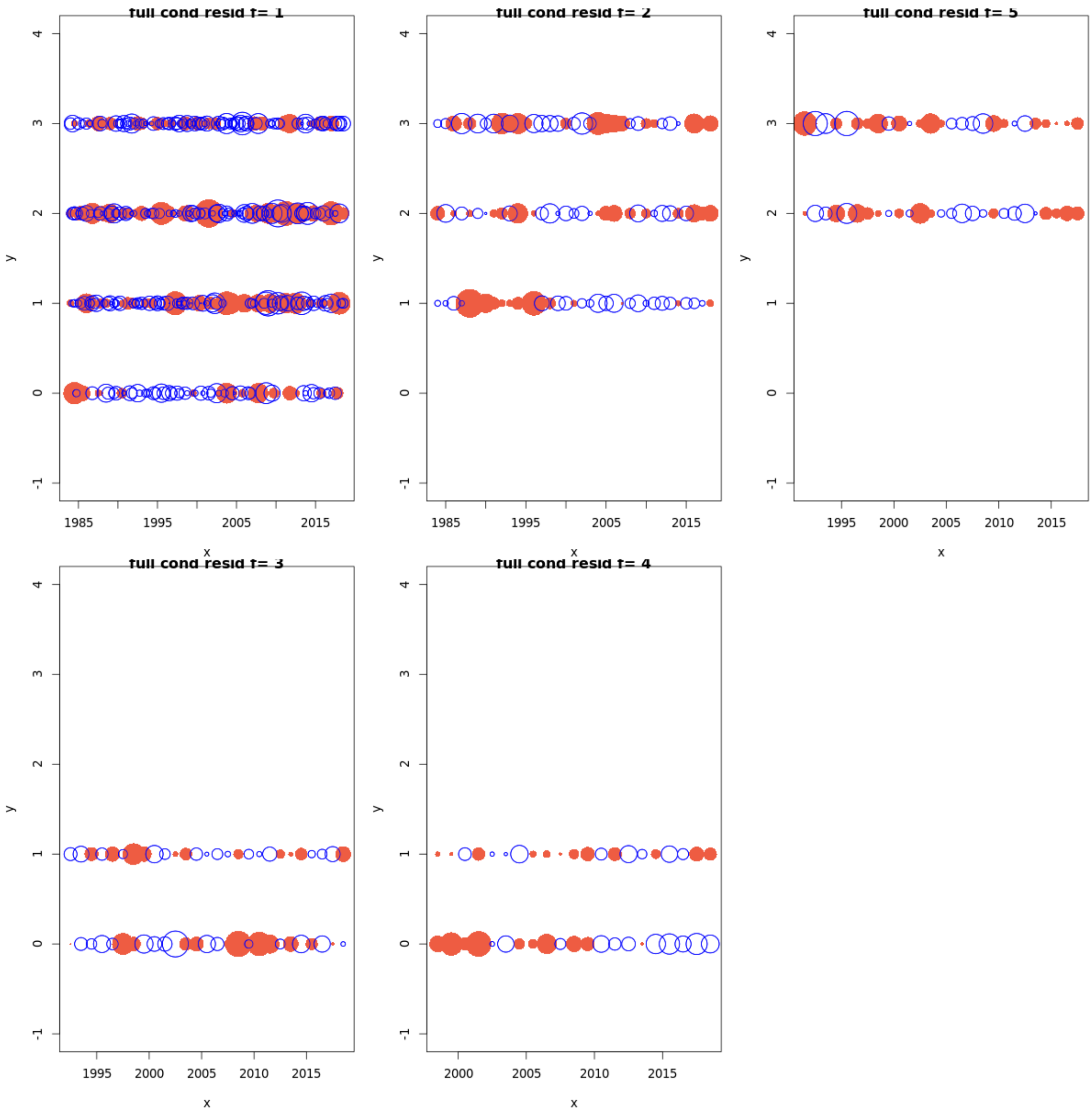


Figure 12.3.10. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots: Full conditional residuals or auxiliary residuals (see Berg and Nielsen 2016). SESAM baseline run September 2018.

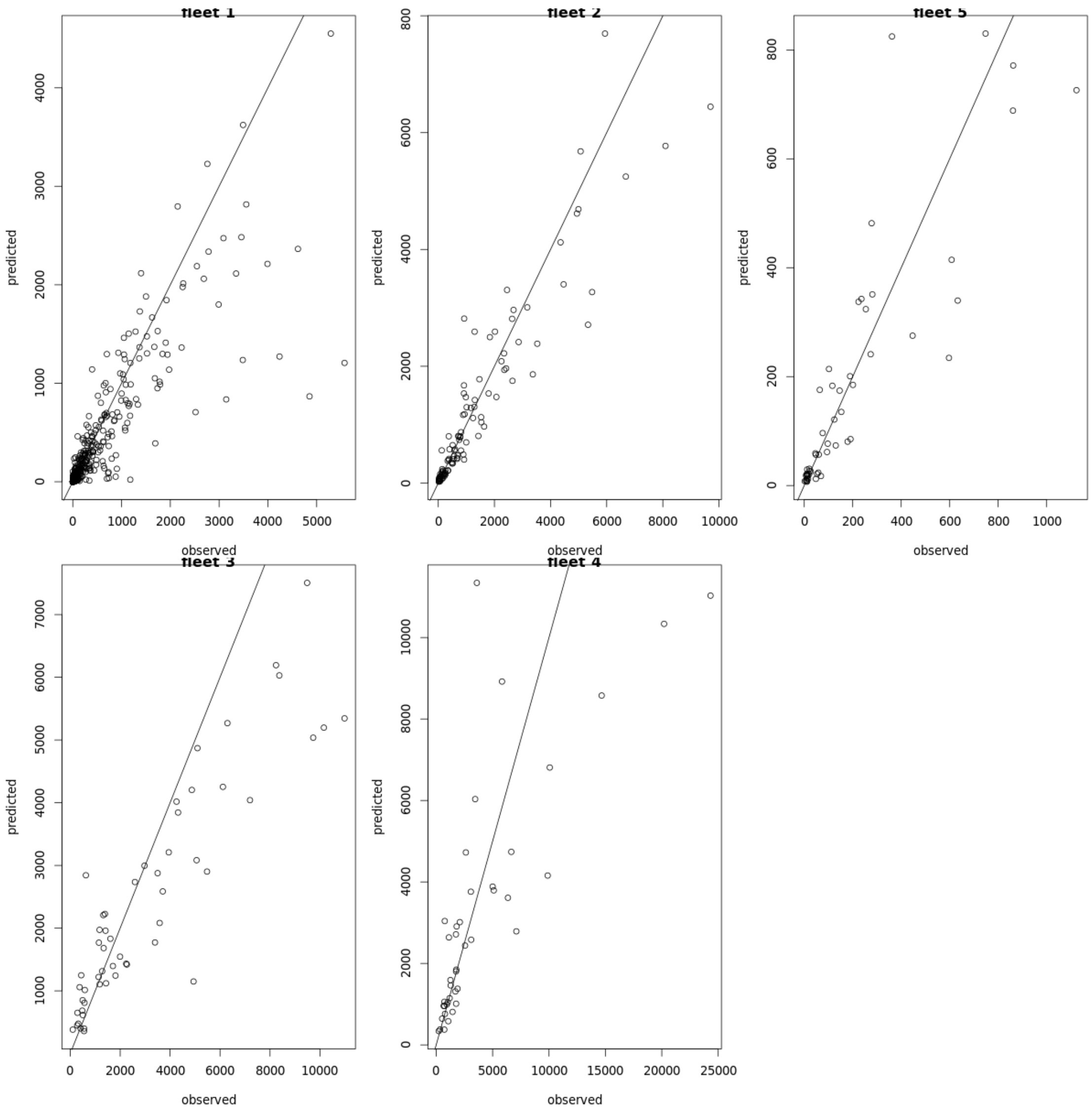


Figure 12.3.11. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet. SESAM baseline run September 2018.

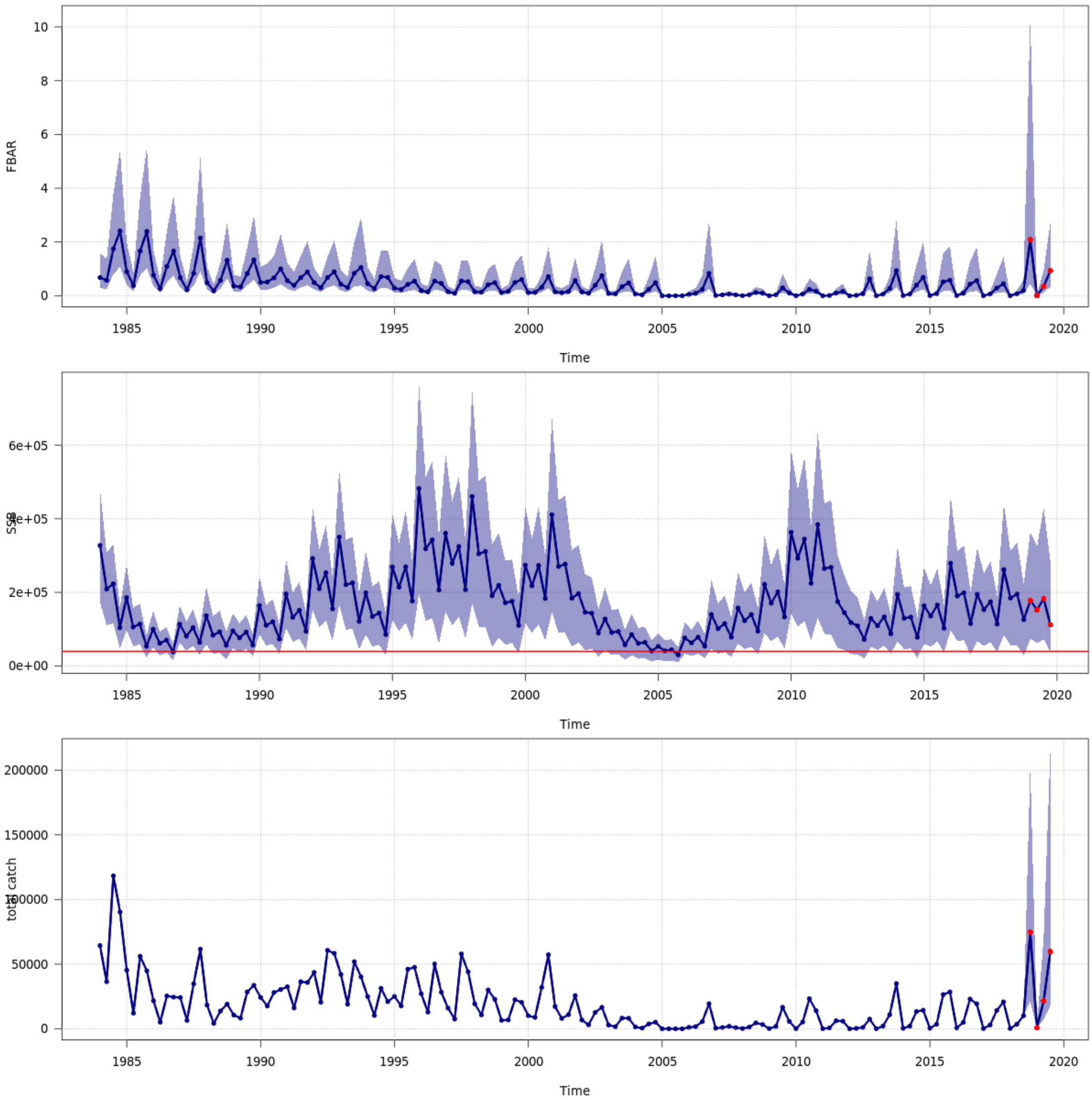


Figure 12.6.1 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year a head (1st October 2019) equals Blim.

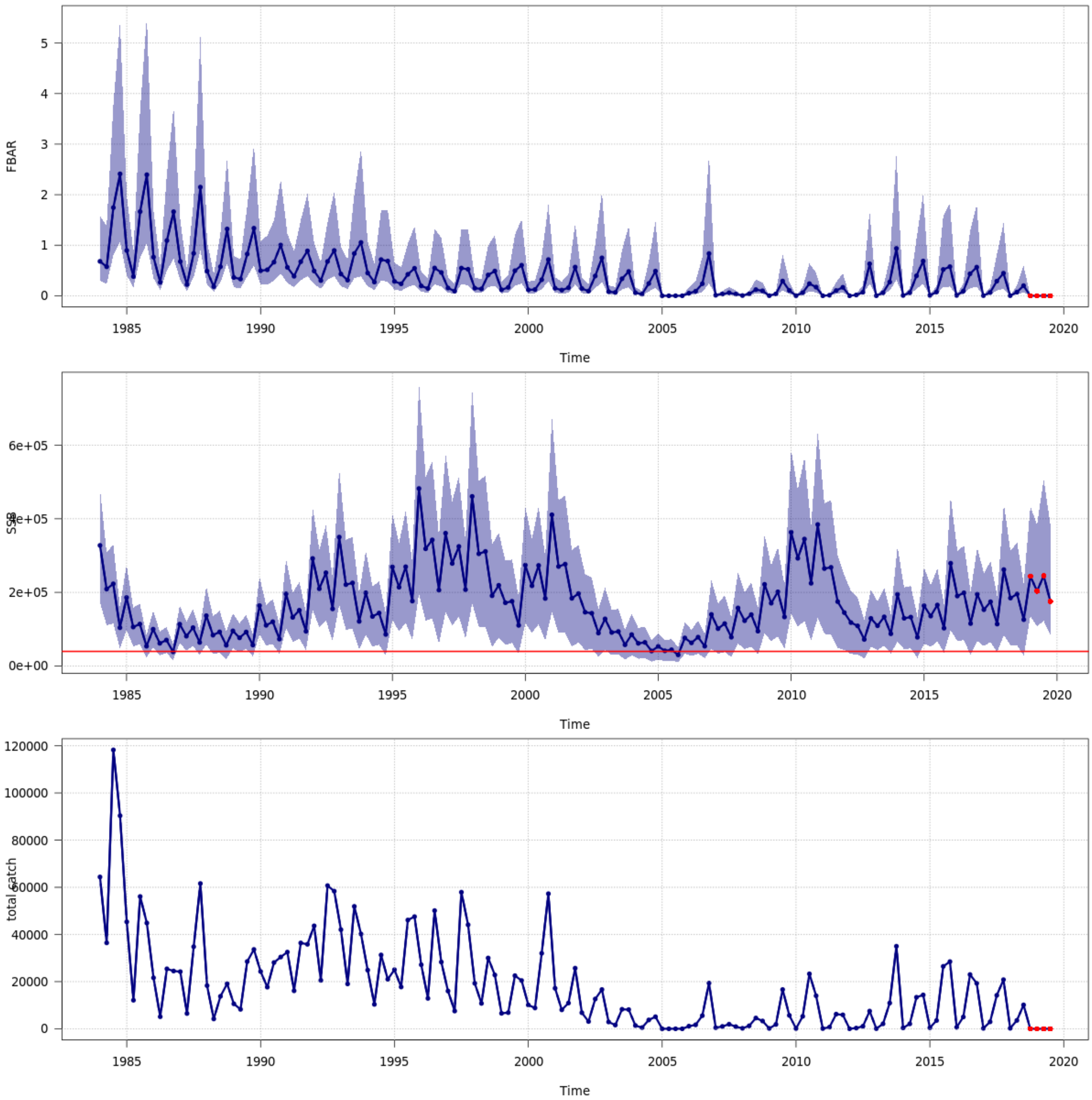


Figure 12.6.2 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2018 to 1st October 2019.

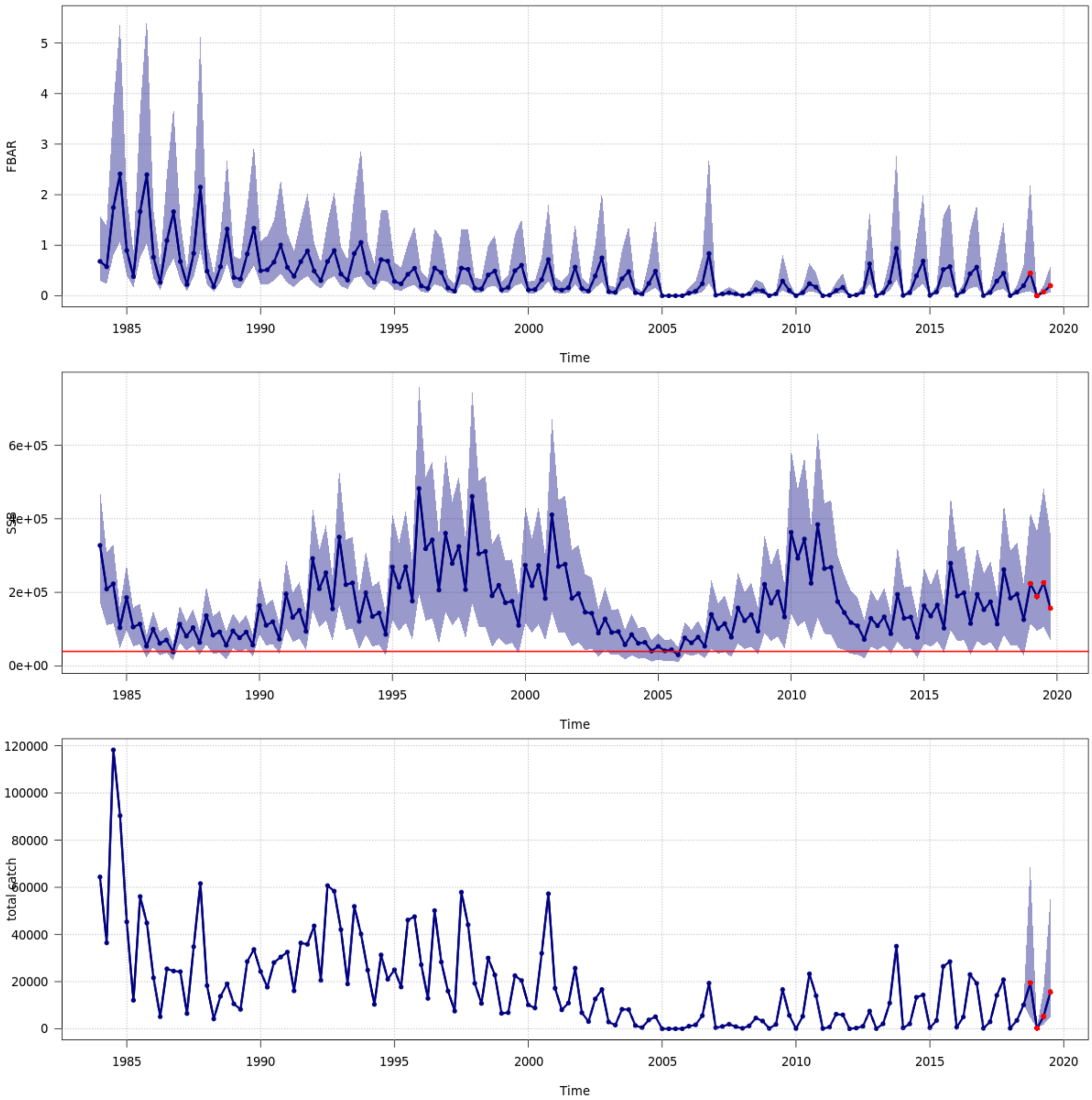


Figure 12.6.3 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year to 1st October 2018.

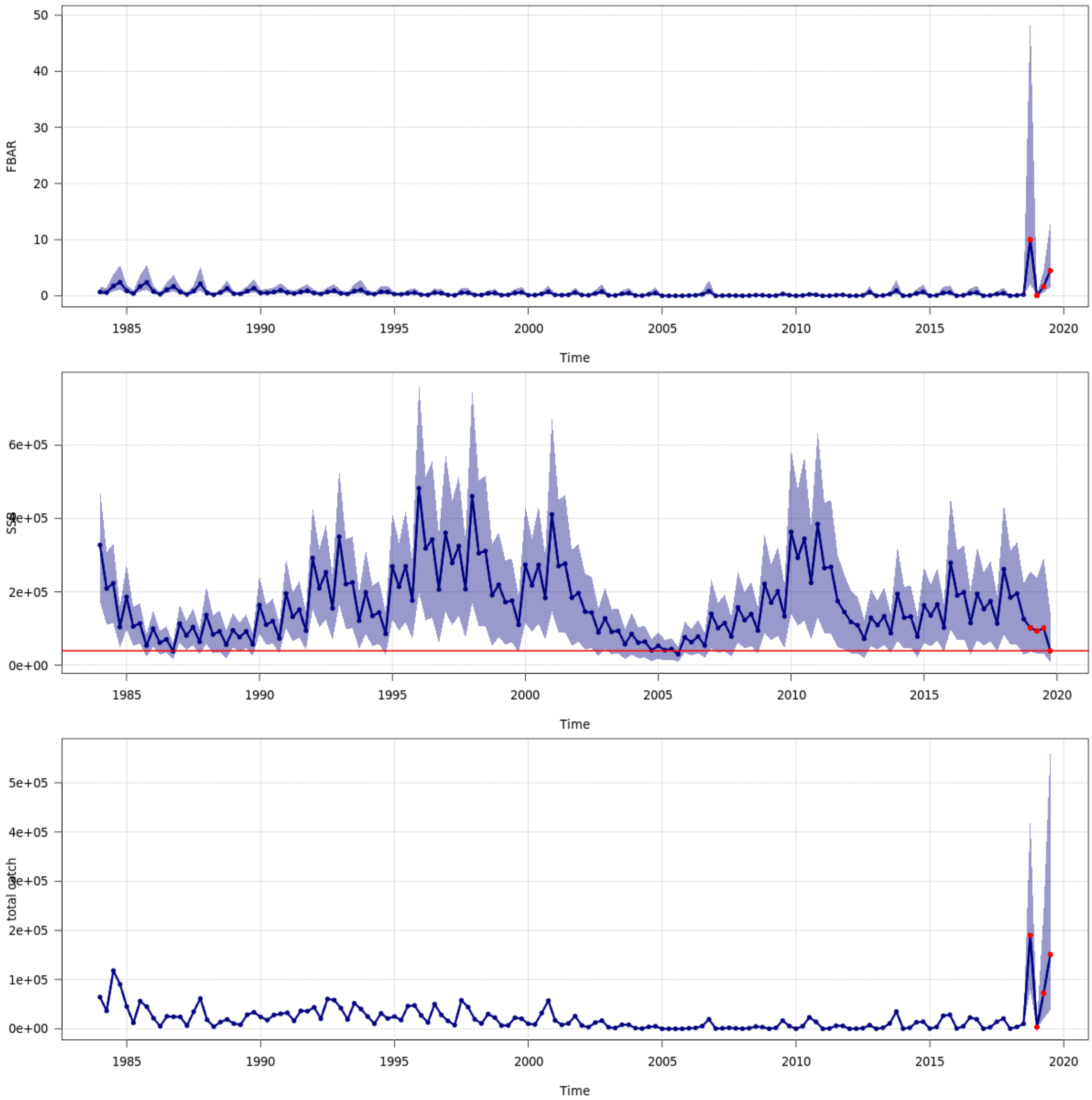


Figure 12.6.4 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year a head (1st October 2019) equals Blim.

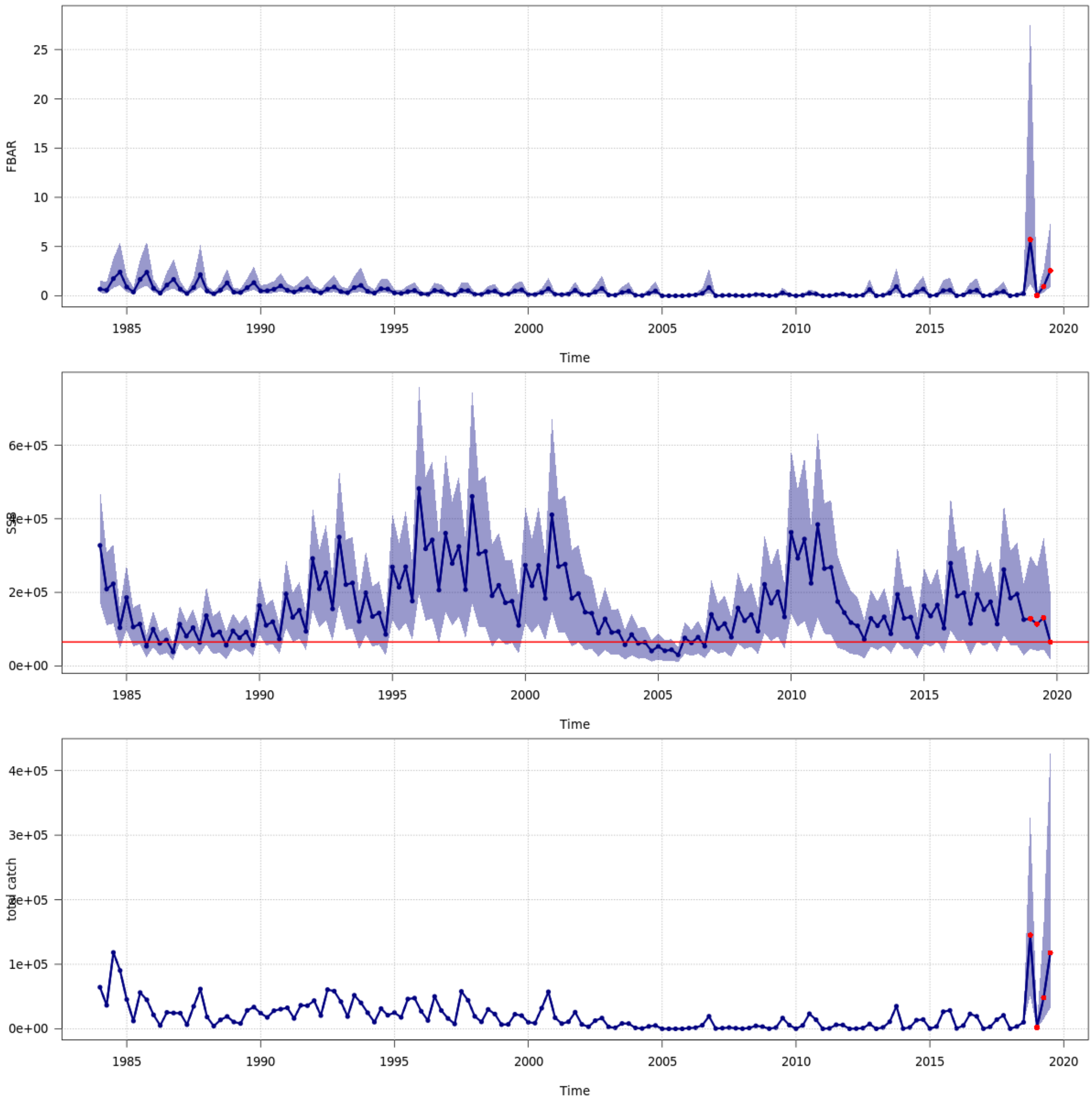


Figure 12.6.5 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the SSB distribution one year a head (1st October 2019) equals Bpa.

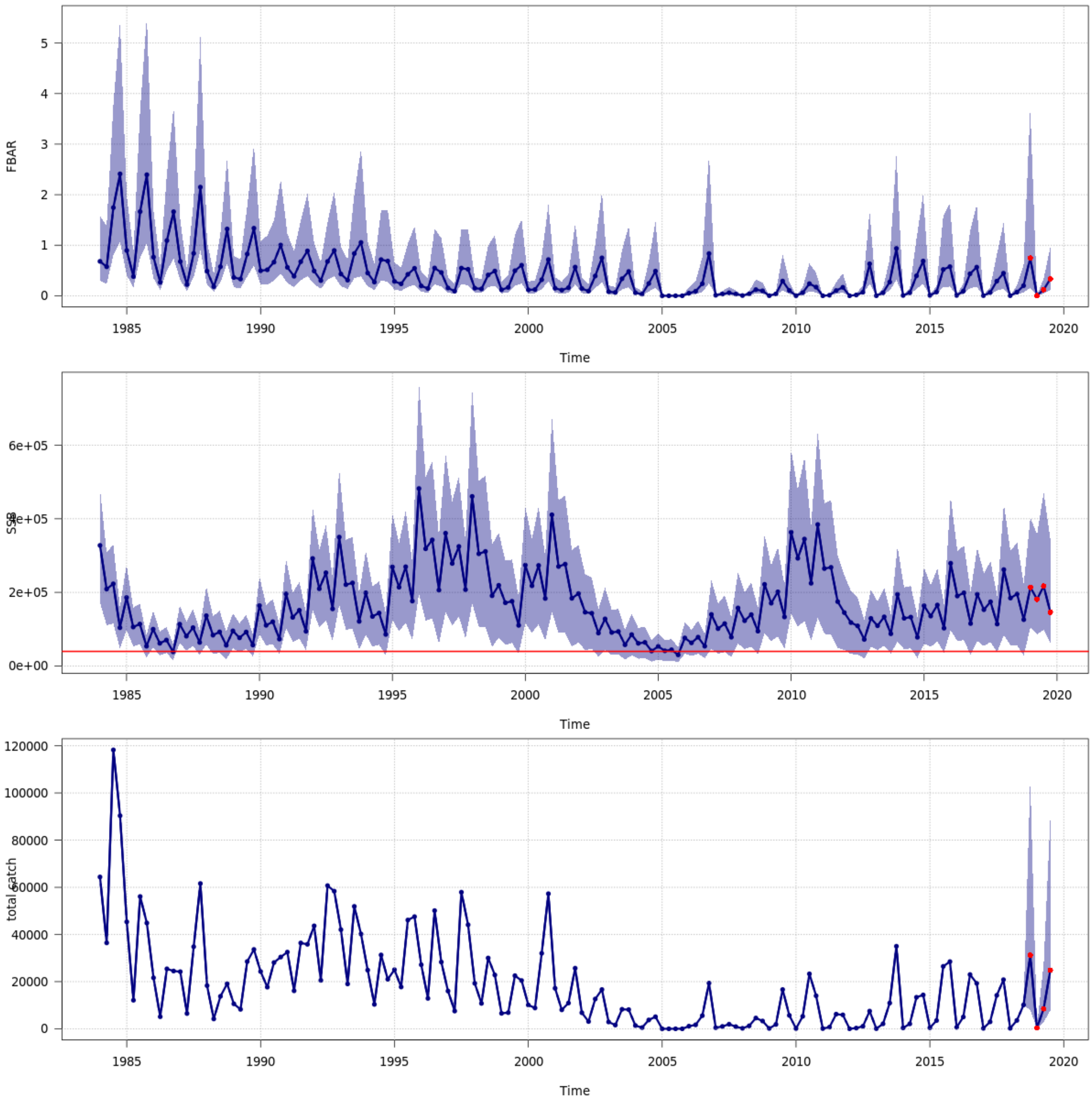


Figure 12.6.6 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.3 (F_{cap} = 0.3) for the period 1st October 2018 to 1st October 2019.

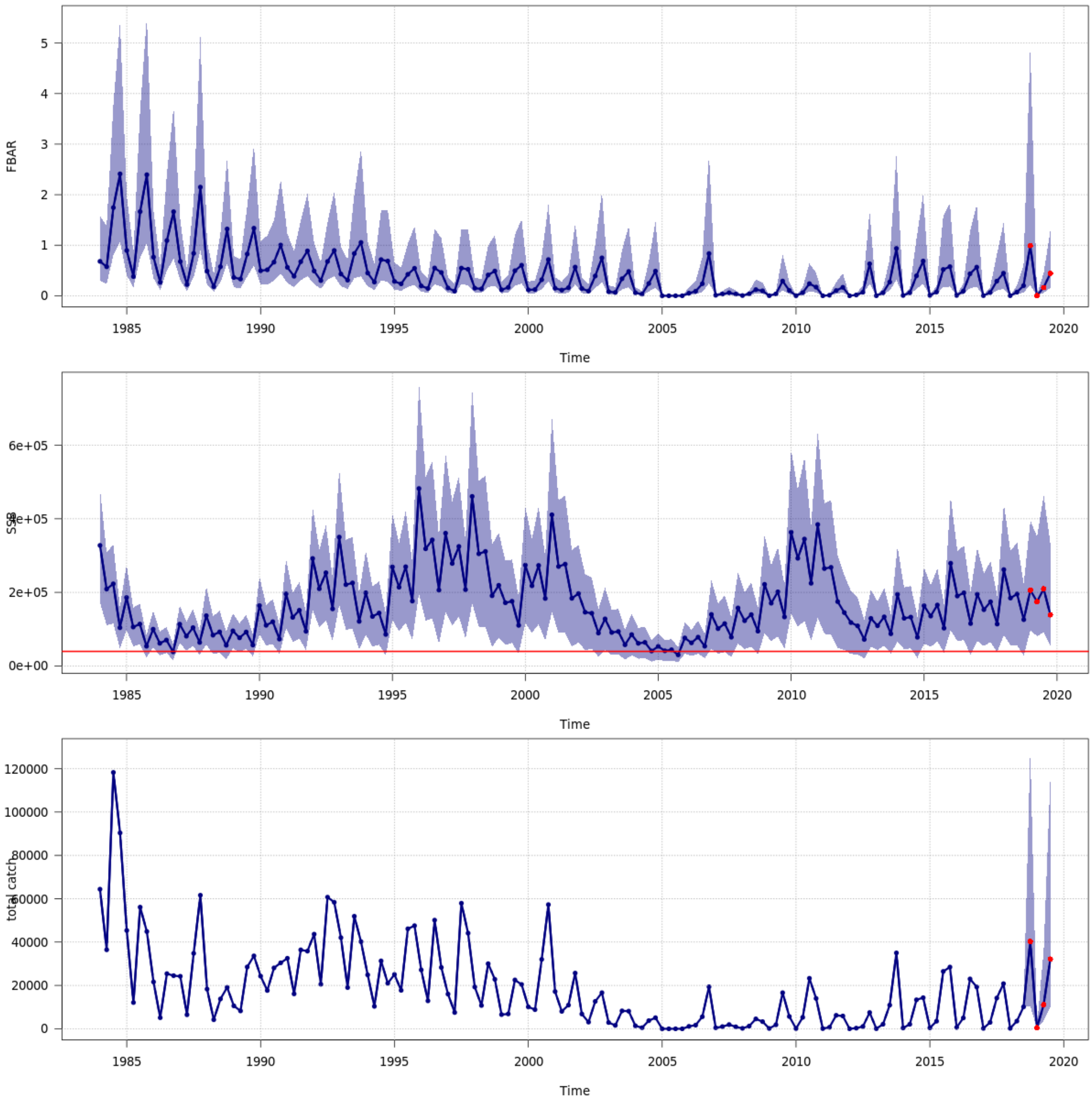


Figure 12.6.7 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.4 (F_{cap} = 0.4) for the period 1st October 2018 to 1st October 2019.

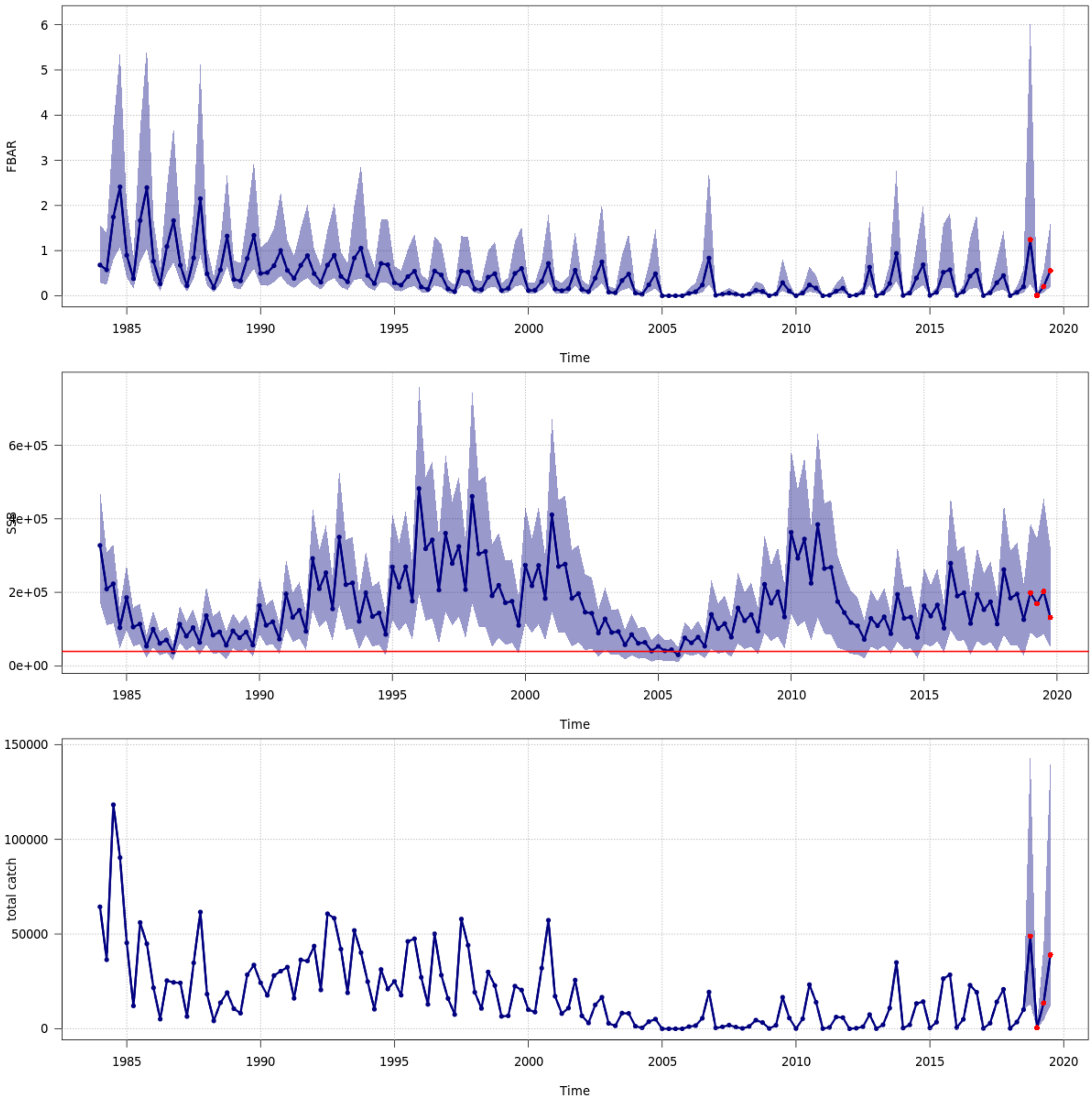


Figure 12.6.8 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (F_{cap} = 0.5) for the period 1st October 2018 to 1st October 2019.

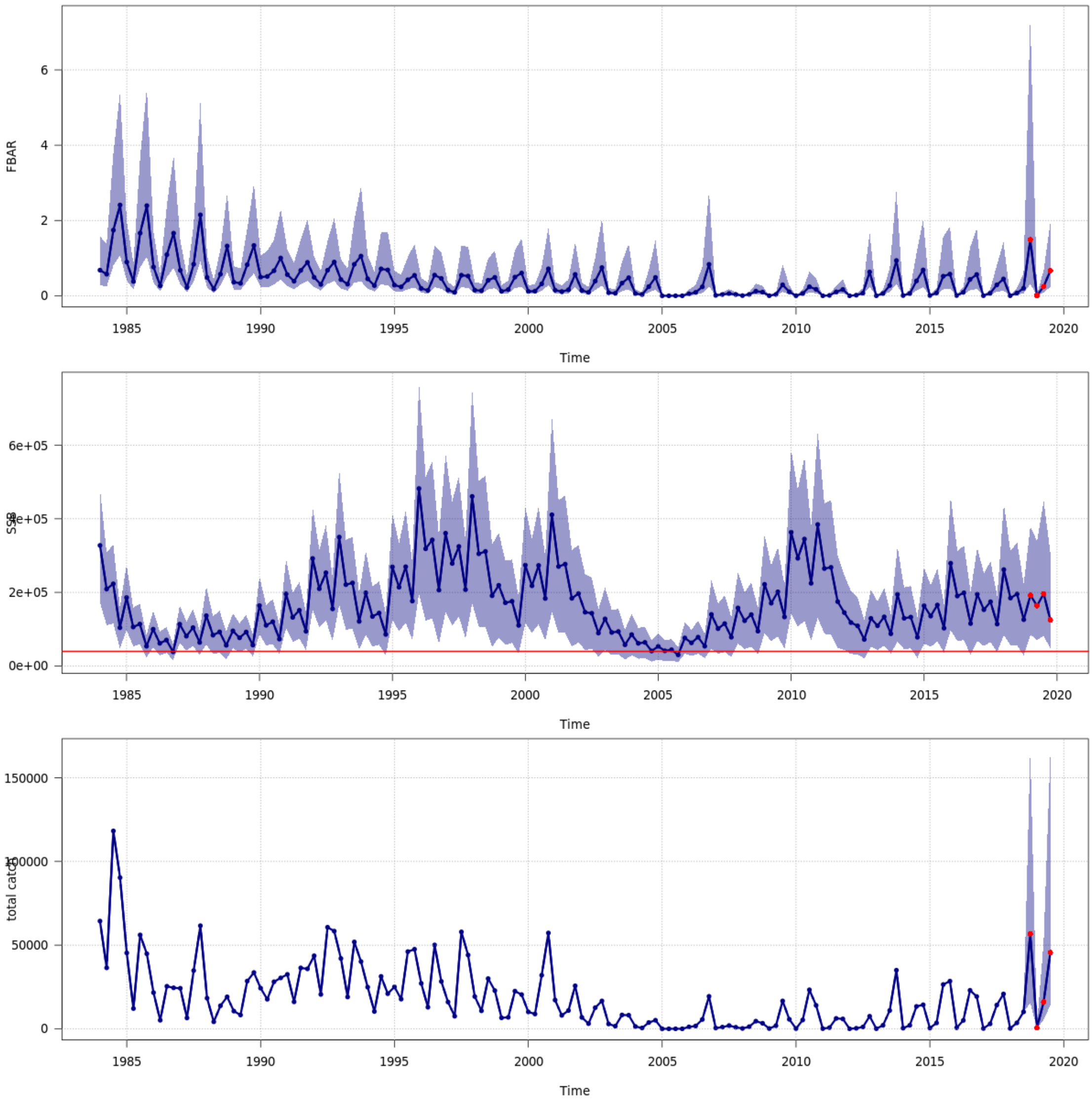


Figure 12.6.9 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.6 (F_{cap} = 0.6) for the period 1st October 2018 to 1st October 2019.

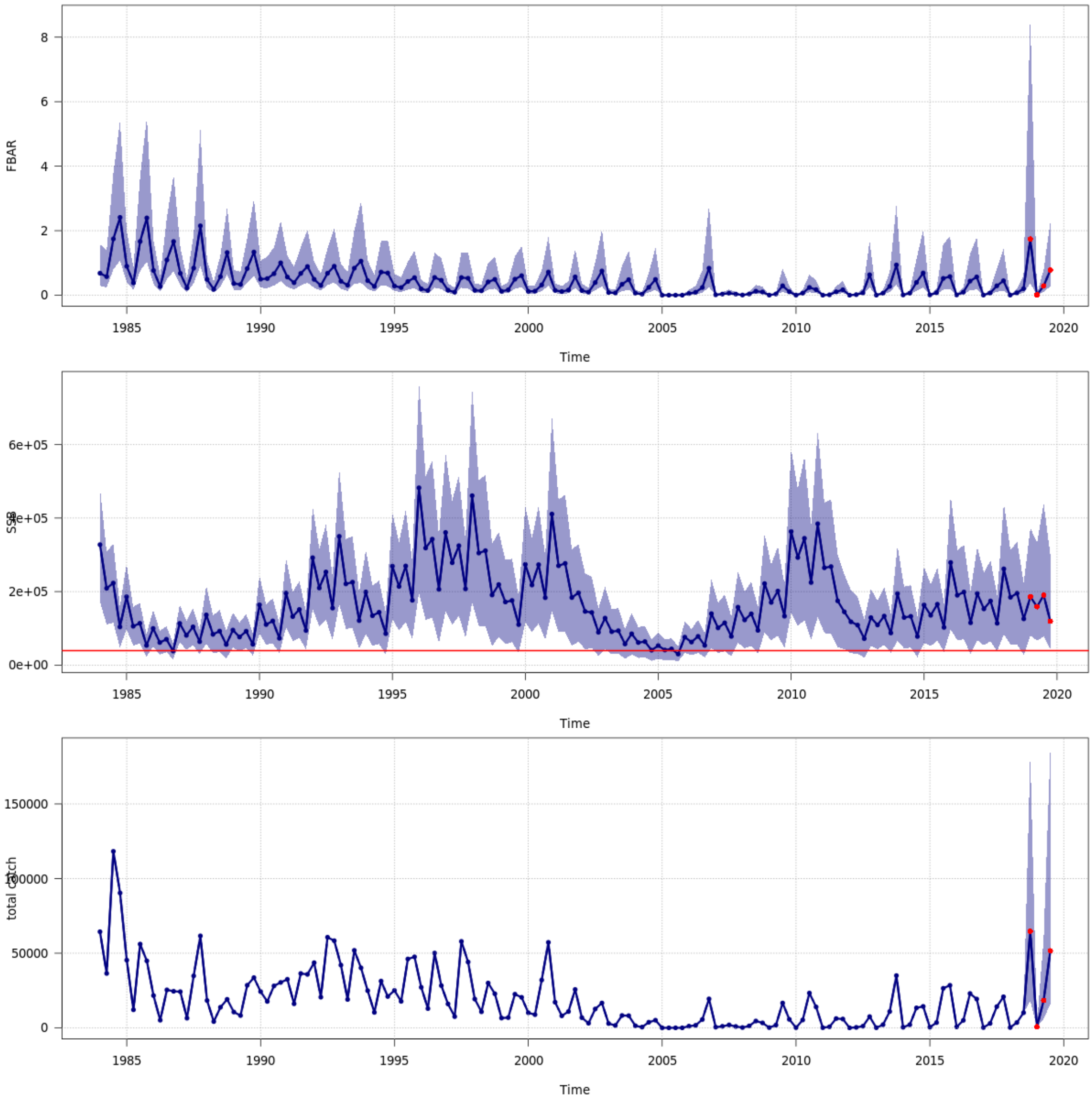


Figure 12.6.10 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.7 (F_{cap} = 0.7) for the period 1st October 2018 to 1st October 2019.

13 Plaice in Skagerrak (3aN)

Plaice in Subdivision 20 is now included with Plaice in Subarea 4 (Section 14).

14 Plaice in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)

In 2017, the Stock Annex was updated. Therefore only a comprehensive description of the stock assessment results and deviations from the stock annex are presented within this Section of the report. In 2017 the stock had a benchmark assessment. Decisions from the benchmark in 2017 are also included in the report.

14.1 General

14.1.1 Stock structure

Plaice in the Skagerrak (Subdivision 20) 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, 50% of the mature animals from 7.d in quarter 1 are included in the North Sea plaice assessment, since North Sea plaice migrates into the area in that season (ICES, 2010).

14.1.2 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 14.8 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.

14.1.3 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.

14.1.4 ICES Advice

The information in this Section is taken from the ICES advice sheet 2017:

ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 139 052 tonnes.

Since this stock is only partially under the EU landing obligation, ICES is not in a position to advice on landings corresponding to the advised catch.

14.1.5 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.

In 2016, the European Commission has informed ICES that agreement has not been reached between the EU and Norway on a method to split the joint advice between the North Sea and Skagerrak. Therefore, advice is provided based on the MSY approach.

However, using the EU multiannual plan based on plaice in the North Sea does not raise immediate concerns, given the status of the combined stock. When the new management plan for plaice is developed it should, as the current management plan, take the mixed fisheries of plaice and sole into account.

14.2 Data available

14.2.1 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 then, the assessment has been a combined assessment with Skagerrak plaice.

Since 2016, large mesh trawlers (TR1 and BT1) with low discard rates were under landing obligation in Subarea 4. A total of 6t BMS landings were reported to ICES in 2016. BMS was treated as discards in the assessment. Total ICES estimated landings (including 7.d and Subdivision 20) of North Sea plaice in 2017 was 74 928 tonnes. Of these 65 442 tonnes came from the Subarea 4, 8775 tonnes came from Subdivision 20, and 711 tonnes came from 7.d. The landings in Subarea 4 decreased 19% (of 2016) and reached 50% of the 129 917 tonnes TAC for 2017. The landings in Subdivision 20 decreased 19% (of 2016) and reached 50% of the 17 639 tonnes TAC for 2017. Total landings (in tonnes) are presented in Table 14.2.1 and landings in numbers at age in Table 14.2.2 and Figure 14.2.2.

14.2.2 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2016, 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 when it became available in InterCatch. See Section 14.2.7 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 WMR 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 14.2.3. Figure 14.2.1 presents a time series of landings, catches and discards from these different sources. Age distributions of discards are presented in Figure 14.4.2 and Table 14.2.3. The total discards weight has been gradually decreasing since our first year of observed discards 2000. The discards ratio are illustrated in Figure 14.2.15. Since 2010, the majority of discards were age 1 and 2.

14.2.3 Catch

The total catch at age as used in the assessment including all landings and all discards are presented in Table 14.2.4. These include catch of NS plaice in the 1st quarter from 7.d and catch from the Subdivision 20. Landings-at-age, discards-at-age and catch-at-age plots are presented in figures 14.2.2 and 14.2.3.

14.2.4 Weight-at-age

Stock weights at age are presented in Table 14.2.5. 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 14.2.6, 14.2.7 and 14.2.8 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 14.2.4 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.

14.2.5 Maturity and natural mortality

During the benchmark in 2017, natural mortality and maturity were re-assessed using both survey and commercial data (WKNSEA report). The mortality rates based on Hoenig's Tmax-based estimator (Hoenig, 1983) were thought to be the best for this stock, but did not deviate greatly from the previous estimate based on Beverton (1963) (0.1 $year^{-1}$ for all ages and years). Therefore, natural mortality was not changed from previous values. A new time-varying maturity ogive was estimated using Dutch commercial landings 1957–2015, but the new ogives had marginal effect on the estimated SSB. Therefore, the previously-used, time-invariant maturity ogive (Table 14.2.9) was chosen.

14.2.6 Catch, effort and survey data

During the benchmark in 2017, alternate survey indices were explored. In addition to the Beam Trawl Surveys (BTS) and sole net (SNS) surveys used in the assessment prior to the benchmark, the International Bottom Trawl Survey (IBTS) quarters 1 and 3 were included:

- Beam Trawl Survey combined for RV Tridens and ISIS (BTS-combined); (1996–2016); Age 1–9 (plus age);
- Beam Trawl Survey RV Isis (BTS–Isis) for the older part of the time series; (1985–1995); Age 1–8;
- Sole Net Survey 1 (SNS1); (1970–1999); Age 1–6
- Sole Net Survey 2 (SNS2); (2000–2016); Age 1–6
- IBTS–Q1 plaice index; 2007–2016; Age 1–7;
- IBTS–Q3 plaice index; 1997–2016; Age 1–9.

The most important surveys for demersal fish species in the greater North Sea area are the different BTS (3rd Quarter) and the IBTS (1st and 3rd Quarter). While the different BTS cover areas 4.b, 4.c and the Channel, the IBTS also covers area 4.a and the Skagerrak and Kattegat (3.a).

Since 2017, both BTS and IBTS age-structured survey indices were estimated using delta-GAM method (Berg *et al.*, 2014), rather than the in-house estimates provided by the survey group. Since the smoother for historical years will deviate with each increasing data year, the sensitivity of such indices based on such method needs to be investigated next year.

Table 14.2.10 and Figure 14.2.5 show the index values for the years that they are used in the assessment. Of the BTS-combined and IBTS–Q3 survey index, ages 1–9 are used for tuning the North Sea plaice assessment. Of the IBTS–Q1 survey index, ages 1–7 are used. Of the BTS–Isis older survey index, ages 1–8 are used. And of the Sole Net Survey (SNS1 & SNS2) ages 1–6 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 14.2.6–14.2.10). The log-catch curves of ages 1–6 for the surveys are illustrated in Figure 14.2.14. In general, SNS has a low selectivity for older ages. Compared to BTS, IBTS has a higher selectivity for older ages. Overall, all surveys show relatively consistent catch selectivity over the time series, except for IBTS–Q1 where the time series is too short to validate. A gradually increasing catch selectivity for all 1–6 ages are observed for BTS-combined and IBTS–Q3. Assuming the survey gear selectivity does not change over the time, such trend is likely due to the decreasing mortality.

An additional survey index is used for recruitment estimates in the RCT3 analysis (Table 14.5.1): Demersal Fish Survey (DFS) age–0

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.

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.

14.2.7 InterCatch

Since 2012, national research institutes submitted landings and discard estimates by métier and quarter in InterCatch. Figures 14.2.11 and 14.2.12 show the landings and discards coverage by country and by métier in Subarea 4 and Subdivision 20. Approximately 46% and 42% of the landings in weight are sampled in Subarea 4 and Subdivision 20 respectively, to obtain information on age-composition (Note that the UK vessels of the TBB_DEF_70–99_mm métier 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. 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. In 2017, 79% of the total discards are imported with landing, and 75% of the total discards in Subarea 4 were obtained from sampling. For Subdivision 20, 59% of the total discards are imported with landing, and 59% of the total discards were obtained from sampling. BMS landings, where reported, are included with discards as unwanted catch in the assessment from 2016.

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.**

14.2.8 Data analyses

The assessment of North Sea plaice by AAP was carried out using the FLR (FLCore v. 2.3 and FLXSA v.2.0), splines and mgcv packages in R version 3.2.5.

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.

14.3 Assessment

A series of assessments were conducted during the benchmark to explore the combination of surveys and model settings (ICES, 2017). In this report, we only present the assessment with the final model setting.

Final AAP assessment

The settings for the final assessment that is used for the catch option table is given below:

Stock	**PLE.27.420**
Year	2017
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 1996–2016; 1–9 SNS1 1970–1999; 1–6 SNS2 2000-2016 (excl. 2003); 1–6 IBTS-Q1 2007–2016; 1–7 IBTS-Q3 1997–2016; 1–9
Plus group	10
Last data year	2017
Suevey selectivity independent of ages for ages >=	6
Age at which the catchability for the F-at-age reaches a plateau >=	9
F tensor spline age knots	6
F tensor spline year knots	26

The estimated parameters are presented in Table 14.3.1. The estimated fishing mortality and stock numbers are shown in tables 14.3.2 and Figure 14.3.1, respectively. Model diagnostics including catch (landing and discards), survey residuals (raw residual, not standardized) and retrospective plots are illustrated in Figure 14.3.2–14.3.4. There is no strong cohort patterns in the catch residuals, however, the models lightly underestimates catches in age 2. This is likely caused by the lack of fitting from age 1 to 2 by the F-at-age smoother. The retrospective plots do not exhibit negative or positive pattern.

14.3.1 Final assessment results

Figure 14.2.1 illustrates the trends in reported catch, landing and discards. Reported landings gradually increased up to the late 1980s and then rapidly declined until 1995, in line with the decrease in TAC. The landings show a general decline from 1987 onwards, increasing slowly but steadily in recent years. Discards were particularly high in 1997 and 1998 (reconstructed), and in 2001 and 2003 (observed), resulting from strong year classes. Figure 14.3.1 and Table 14.3.4 present the model estimated mean F(2–6), SSB, and recruitment since 1957. Fishing mortality increased until the late 1990s and reached its highest observed level in 1997. Since the early 2000s, fishing mortality has been rapidly decreasing. Since 2007 it has been below the fishing mortality target established in the management plan. It is currently (2017) estimated at 0.199, lower but closer to F_{MSY}. Over the last six years SSB has been rapidly increasing and is currently (2017) estimated at 913 290 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 1960s and 1970s, then above average in the 1980s and fluctuating around the average since the 1990s.

The stock dynamics are partly affected by the occurrence of strong year-classes. However, figures 14.2.3–14.2.3 and 14.2.13–14.2.14 do not exhibit strong year-class in recent years. The increased stock size in recent years is therefore most likely the direct consequence of reduced fishing mortality.

The predominant age in the landings is currently age–4 (in 2017 as well as in the past decade, see figure 14.2.2). Notably, during the time series, this was only also observed in the 1960s. In contrast, the predominant age in the landings in the 1970s, 1980s and

1990s, was age–3. The age distribution in the landings in recent years furthermore shows more similarity with the 1960s 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 1960s, which subsequently substantially increased over the next three decades and since the early 2000s 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 1960s 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 1960s, while this is not the case in recent years. 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.

14.3.2 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.

14.4 Recruitment estimates

In the short term forecasts, assumptions are made on a number of things (see also Section 14.5). 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 AAP survivors estimate is used.

Input to the RCT3 analysis is presented in Table 14.4.1. The results for age–1 and age–2 abundance estimates are presented in Table 14.4.2, and in Table 14.4.3 respectively. For year class 2017 (age 1 in 2018), the values predicted by the SNS–0 survey and VPA through RCT3 have similar values and both have a low prediction standard error than DFS–0. The RCT3 value was used for the short-term forecasts. For year class 2016 (age 2 in 2018), the estimates from BTS–1 and SNS–0 (comparable to the VPA mean) have a relatively low standard error (compared to the other surveys). However, AAP is relatively strong in predicting age–2 survivors. Hence, the WG decided to use the AAP estimate rather than the RCT3 estimate for the 2016 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 2018	AAP survivors	RCT3	GM 1957-2014	Accepted estimate
2016	2	<u>1540180</u>	1190155	710374	AAP survivors
2017	1		<u>894683</u>	965555	RCT3
2018	0			<u>965555</u>	GM 1957–2014
2019				<u>965555</u>	GM 1957–2014

14.5 Short-term forecasts

Short-term prognoses were carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2017 (the last data year) into 2018 (the intermediate year in which the assessment is done); into 2019 (the TAC year) and finally into 2020 (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 intermediate year F is assumed to be "F–status quo" (F_{sq}), that is, the exploitation was taken to be the mean value of the last three years, scaled to have equal Fbar as Fbar_2017. The relative proportions of landings versus discards in the catch were taken to be the mean of the last three years.

A series of F options were assumed for the TAC year. The option of assuming F to correspond to the TAC being fully landed in the TAC year 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 AAP survivor estimates. Numbers at age 1 in 2018 are taken from the RCT3 output and age 1 from 2018 are taken from the long-term geometric mean (1957–2014). Input to the short term forecast is presented in Table 14.5.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	$F_{(2-6)}$ 2018	SSB2019	Recruitment 2018	Landings 2018	Discards 2018
F2018 = F2017 (Fsq)	0.199	974516 t	894683 t	84964 t	45828 t

Resulting management options for 2019 are given in Table 14.5.2.

14.6 Biological reference points

14.6.1 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 14.4.2). Therefore, ICES considered that B_{lim} can be set at B_{loss} = 160 000 tonnes and that B_{pa} can then be set at 230 000 tonnes using A multiplier of 1.44. F_{lim} was set at F_{loss} (0.74). F_{pa} was proposed to be set at 0.6 which is the 5th percentile of F_{loss} and gave a 50% probability that SSB is around B_{pa} in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 tonnes.

14.6.2 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 F_{MSY} ranges. The workshop was convened in response to a request from the European Commission for advice on potential intervals above and below F_{MSY}. This resulted in an F_{MSY} range for North Sea plaice of 0.13–0.27. The point value of F_{MSY} was set at 0.19.

This values differs from the previous value of F_{MSY} = 0.25 (range 0.2–0.3, Miller and Poos, 2010).

14.6.3 Update of F_{lim} and F_{pa} values in 2016

In 2016 (ICES 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 thou>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} = 160 000. The estimated 10 years plaice SSB are all far higher than B_{lim}. The estimated F_{lim} is 0.63 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 (Subdivision 20) data in the recent years where the original reference point was not derived from.

14.6.4 Update of reference point in 2017 benchmark

A full update of the precautionary and MSY based reference points was conducted during 2017 benchmark, using the same method as described in Section 14.6.3.

The reference points used prior to 2017 benchmark are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	230000 t	Default to value of B_{pa}	
	F_{MSY}	0.19	Combined stock	ICES (2014)
Precautionary approach	B_{lim}	160000 t	B_{loss} = 160000 t, the lowest observed biomass in 1997 as assessed in 2004	ICES (2004)
	B_{pa}	230000 t	1.44 × B_{lim}	ICES (2004)
	F_{lim}	0.63	The F that in equilibrium will maintain the stock above B_{lim} with a 50% probability	ICES (2016a)
	F_{pa}	0.45	$F_{pa} = F_{lim} \times \exp(-1.645\sigma_F)$; σ_F = 0.20	ICES (2016a)

A series of discussions have been carried out on the value of the new MSY $B_{trigger}$: F has been below (at) F_{MSY} in more than 5 years, which triggers a revision of MSY $B_{trigger}$. According to ICES guidelines the new MSY $B_{trigger}$ should in this case be the 5th percentile of the current SSB. The benchmark came up with an alternative solution: "Estimating SSB from a period with a substantially lower fishing mortality and higher SSB i.e. year 1962" (i.e. 481.5 kt). This deviation from the guidelines was questioned within the WG. The ADG that followed the WG noted that SSB has not stabilized, and could increase even more or decline as a consequence of e.g. density dependent growth or maturity. The ADG decided to follow the guidelines because they felt there was insufficient reason to deviate from the guidelines. The MSY $B_{trigger}$ value shown in the table below reflects this decision. MSY $B_{trigger}$ is therefore the maximum of the following: B_{pa}, or the 5th percentile of current SSB (SSB from the benchmark final run divided by 1.4 = 564 599 t).

The updated reference points are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	564599 t	Fifth percentile of current SSB (SSB_{2015}/1.4) as estimated at the benchmark.	WKNSEA 2017; WKMSYREF4
	F_{MSY}	0.210	Estimated by application of EqSIM evaluation	WKNSEA 2017; WKMSYREF4
	$F_{MSY\ lower}$	0.146	Estimated by application of EqSIM evaluation	WKNSEA 2017; WKMSYREF4
	F = $F_{MSY\ upper}$	0.30	Estimated by application of EqSIM evaluation	WKNSEA 2017; WKMSYREF4
Precautionary approach	B_{lim}	207288 t	Break-point of hockey stick stock-recruit relationship	WKNSEA 2017; WKMSYREF4
	B_{pa}	290203 t	$B_{pa} = B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	WKNSEA 2017; WKMSYREF4
	F_{lim}	0.516	Estimated by application of EqSIM evaluation	WKNSEA 2017; WKMSYREF4
	F_{pa}	0.369	$F_{pa} = F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	WKNSEA 2017; WKMSYREF4

And the proposed MSY reference points:

Reference point	**Value**
F_{MSY} without $B_{trigger}$	0.21
$F_{MSY\ lower}$ without $B_{trigger}$	0.146
$F_{MSY\ upper}$ without $B_{trigger}$	0.30
FP.05 (5% risk to B_{lim} without $B_{trigger}$)	0.43
F_{MSY} with $B_{trigger}$	0.21
$F_{MSY\ lower}$ with $B_{trigger}$	0.15
$F_{MSY\ upper}$ with $B_{trigger}$	0.30
FP.05 (5% risk to B_{lim} with $B_{trigger}$)	0.77
MSY	104113 t
Median SSB at F_{MSY}	1104120 t
Median SSB lower precautionary (median at $F_{MSY\ upper}$ precautionary)	690328 t
Median SSB upper (median at $F_{MSY\ lower}$)	1616173 t

14.7 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 (beam trawls, otter trawls, Scottish seines and Danish seines, gillnets and long liners); the United Kingdom (for beam trawls up to 2007); Germany (beam trawls, otter trawls, gillnets); Belgium (beam trawls, otter trawls, Scottish seines) and the Netherlands (beam trawls and otter trawls). 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.

14.8 Status of the stock

The stock is well within precautionary boundaries. SSB in 2017 is estimated around 913 290 tonnes which is well above B_{pa} (290 203 tonnes). Fishing mortality in 2017 is estimated to be at a value of 0.199 (below F_{pa} of 0.369, below the long-term management target F of 0.30 and below but close to F_{MSY} of 0.210).

14.9 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.

14.9.1 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 F_{MSY} 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 (B_{pa} = 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 F_{MSY} estimate is 0.21, 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 F_{MSY} 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 F_{MSY} point estimate of 0.21 (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.

14.9.2 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 14.2.1, 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 2014. 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 beam trawl 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.

14.9.3 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 14.1.3).

14.9.4 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.

Table 14.2.1. Plaice in Subarea 4 and Subdivision 20 (7.d Q1 not included): Official landings in thousands.

North Sea														Skagerrak	
YEAR	Belgium	Denmark	France	Ger-many	Nether-lands	Norway	Swe-den	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		
1985	9965	28236	1010	2197	90950	23	18	15912		148311	11527	159838	200000		
1986	7232	26332	751	1809	74447	21	16	17294		127902	37445	165347	180000		
1987	8554	21597	1580	1794	76612	12	7	20638		130794	22876	153670	150000	15694	
1988	11527	20259	1773	2566	77724	21	2	24497	43	138412	16063	154475	175000	12858	
1989	10939	23481	2037	5341	84173	321	12	26104		152408	17410	169818	185000	7710	
1990	13940	26474	1339	8747	78204	1756	169	25632		156261	-21	156240	180000	12078	
1991	14328	24356	508	7926	67945	560	103	27839		143565	4438	148003	175000	8685	
1992	12006	20891	537	6818	51064	836	53	31277		123482	1708	125190	175000	11823	11200
1993	10814	16452	603	6895	48552	827	7	31128		115278	1835	117113	175000	11407	11200
1994	7951	17056	407	5697	50289	524	6	27749		109679	713	110392	165000	11334	11200
1995	7093	13358	442	6329	44263	527	3	24395		96410	1946	98356	115000	10766	11200
1996	5765	11776	379	4780	35419	917	5	20992		80033	1640	81673	81000	10517	11200
1997	5223	13940	254	4159	34143	1620	10	22134		81483	1565	83048	91000	10292	11200
1998	5592	10087	489	2773	30541	965	2	19915	1	70365	1169	71534	87000	8431	11200
1999	6160	13468	624	3144	37513	643	4	17061		78617	2045	80662	102000	8719	11200
2000	7260	13408	547	4310	35030	883	3	20710		82151	-1001	81150	97000	8826	11200
2001	6369	13797	429	4739	33290	1926	3	19147		79700	2147	81847	78000	11653	9400
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000	8789	6400
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250	9110	1400
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000	9090	9500
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000	6764	7600
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441	9565	7600
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261	8747	8500
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000	8657	9300
2009	3474	NA*	NA*	2931	29142	1116	1	13143	-	NA*	-	54973	55500	6748	9300
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825	9057	9300
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400	8251	7900
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410	7611	7900
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070	6911	9142
2014	7105	12003	276	4203	29306	577	5	17370	-	69179	1668	70847	111631	9004	10056
2015	5522	14401	223	5171	32074	169	7	17240	-	74807	156	74963	128376	10171	10056
2016	6659	16398	169	4371	32227	94	9	18731	-	78659	2400	81059	131714	10883	11766
2017	5317	12518	151	2526	28775	67	5	14993	-	64352	1090	65442	129917	8467	17639
2018													112643		15343

*** Official estimates not available.**

Table 14.2.2. Plaice in Subarea 4 and Subdivision 20: Landings (SOP corrected) in numbers by age (including 1st quarter of 7.d) 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
2016	0	4179	39190	85205	60972	39883	19146	7710	5310	5125
2017	27	5289	24694	58141	57766	30891	16860	7600	3068	3213

Table 14.2.3. Plaice in Subarea 4 and Subdivision 20: Discards in numbers by age (including 1st quarter of 7.d) 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
2016	79202	144049	133284	48501	21078	7479	2068	1857
2017	129559	144559	77236	59006	16045	3812	1268	268

Table 14.2.4. Plaice in Subarea 4 and Subdivision 20: Catch in numbers by age (including 1st quarter of 7.d) 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
2016	79202	148228	172474	133706	82050	47362	21214	9567	5310	5125
2017	129586	149848	101930	117147	73811	34703	18128	7868	3068	3213

Table 14.2.5. Plaice in Subarea 4 and Subdivision 20: 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
2016	0.030	0.066	0.117	0.198	0.260	0.329	0.380	0.434	0.479	0.514
2017	0.032	0.069	0.132	0.181	0.270	0.333	0.359	0.458	0.476	0.557

Table 14.2.6. Plaice in Subarea 4 and Subdivision 20: 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
2016	NA	0.249	0.271	0.296	0.350	0.385	0.450	0.531	0.556	0.684
2017	0.212	0.247	0.276	0.299	0.357	0.410	0.455	0.543	0.642	0.735

Table 14.2.7. Plaice in Subarea 4 and Subdivision 20: 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
2016	0.048	0.079	0.124	0.150	0.151	0.179	0.166	0.192	0.251	0.500
2017	0.051	0.080	0.121	0.139	0.161	0.194	0.208	0.206	0.513	0.758

Table 14.2.8. Plaice in Subarea 4 and Subdivision 20: 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
2016	0.048	0.084	0.157	0.243	0.299	0.352	0.422	0.465	0.556	0.684
2017	0.051	0.086	0.159	0.218	0.314	0.386	0.438	0.532	0.642	0.735

Table 14.2.9 Plaice in Subarea 4 and Subdivision 20: Natural mortality at age and maturity at 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 14.2.10 Plaice in Subarea 4 and Subdivision 20: 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	314.7	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	14.27	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	25421.1	23783.0	5328.2	1825.4	1395.8	596.0	264.2	133.8	68.2
1997	86828.6	16109.8	6802.2	1655.1	581.3	451.3	161.4	205.0	31.4
1998	34532.6	82222.0	9515.3	2651.9	645.3	378.9	226.3	192.8	71.6
1999	44939.6	17802.3	29660.8	2780.6	1102.2	253.4	95.7	85.4	39.8
2000	42378.7	21451.0	9105.2	9996.3	614.6	218.2	109.4	96.0	15.7
2001	29311.1	19715.4	6791.3	3467.8	3463.8	270.0	90.6	72.1	54.8
2002	134367.0	16309.2	6894.8	3732.9	2068.3	1545.9	267.4	129.2	42.9
2003	32240.8	44967.9	6806.8	3385.7	1599.2	932.6	921.7	70.2	52.9
2004	44366.3	13238.7	17375.8	2954.9	1513.7	878.9	489.4	721.8	42.7
2005	37561.6	27225.9	4621.0	6827.4	908.4	1034.8	370.8	79.3	841.9
2006	41532.3	16493.2	9955.0	2370.2	3777.8	582.0	740.6	98.9	128.2
2007	84754.1	21429.4	10560.7	7984.1	1695.7	2521.4	283.9	616.2	71.7
2008	68596.9	45493.3	12562.7	6354.1	4409.5	941.6	1417.7	291.8	461.3
2009	64526.5	22690.9	19664.6	5073.7	3086.5	2538.6	647.0	1435.6	275.2
2010	80970.0	27581.3	13605.7	9941.4	3052.1	1698.6	1722.6	589.0	973.7
2011	126770.3	41926.9	17987.7	9149.7	6060.0	1944.2	907.2	1609.2	233.9
2012	58884.9	63231.7	38108.7	15013.8	7942.4	4960.9	1540.6	1170.6	1542.2
2013	87360.9	51484.7	37830.4	18759.5	7064.8	4167.7	3078.1	1239.2	755.3
2014	143731.6	59687.5	26609.8	20310.2	8602.0	3584.1	2191.8	1699.5	958.6
2015	51396.9	65837.6	33361.2	16222.4	12465.9	6519.7	2190.9	1600.2	1484.9
2016	82875.9	30990.8	31610.7	17224.0	9054.0	6309.6	3523.3	1625.7	1045.2
2017	140854.1	49998.5	17505.6	19195.9	10183.7	4911.5	3025.5	1891.3	651.9

	SNS1							SNS2					
	age							age					
year	1	2	3	4	5	6	year	1	2	3	4	5	6
1970	9311	9732	3273	770	170	37.5	2000	22855	2493	891	983	17	2.0
1971	13538	28164	1415	101	50	23.6	2001	11511	2898	370	176	691	105.8
1972	13207	10780	4478	89	84	0.0	2002	30809	1103	265	65	69	30.7
1973	65643	5133	1578	461	15	5.7	2003	NA	NA	NA	NA	NA	NA
1974	15366	16509	1129	160	82	7.0	2004	18202	1350	1081	51	27	29.7
1975	11628	8168	9556	65	15	0.0	2005	10118	1819	142	366	8	19.0
1976	8537	2403	868	236	0	2.3	2006	12164	1571	385	52	54	0.0
1977	18537	3424	1737	590	213	0.0	2007	14175	2134	140	52	0	7.4
1978	14012	12678	345	135	45	13.6	2008	14706	2700	464	179	34	6.7
1979	21495	9829	1575	161	17	42.2	2009	14860	2019	492	38	20	0.0
1980	59174	12882	491	180	24	7.8	2010	11947	1812	529	55	10	0.0
1981	24756	18785	834	38	32	4.7	2011	18349	1143	308	75	60	28.0
1982	69993	8642	1261	88	8	8.7	2012	5893	2929	682	82	30	15.0
1983	33974	13909	249	71	6	1.3	2013	15395	3021	1638	428	89	31.1
1984	44965	10413	2467	42	0	0.0	2014	17313	2258	514	458	58	16.4
1985	28101	13848	1598	328	17	1.5	2015	16727	5040	1882	478	200	97.5
1986	93552	7580	1152	145	30	6.6	2016	10385	2434	1086	522	223	131.7
1987	33402	32991	1227	200	30	16.7	2017	15936	1716	1212	534	144	70.6
1988	36609	14421	13153	1350	88	12.1							
1989	34276	17810	4373	7126	289	113.6							
1990	25037	7496	3160	816	422	48.8							
1991	57221	11247	1518	1077	128	74.4							
1992	46798	13842	2268	613	176	52.0							
1993	22098	9686	1006	98	60	58.8							
1994	19188	4977	856	76	23	2.7							
1995	24767	2796	381	97	38	0.0							
1996	23015	10268	1185	45	47	0.0							
1997	95901	4473	497	32	0	13.3							
1998	33666	30242	5014	50	10	0.0							
1999	32951	10272	13783	1058	17	0.0							

IBTS–Q3	1	2	3	4	5	6	7	8	9
1997	3519.8	3713.4	2530.8	756.3	336.0	265.6	165.4	160.2	42.8
1998	1005.0	5140.1	1672.8	818.4	306.9	137.9	88.8	98.6	48.1
1999	895.6	2265.9	4212.1	704.3	282.3	129.1	47.7	49.3	33.6
2000	906.1	1748.6	1906.9	2102.0	221.9	126.0	57.2	46.6	15.4
2001	1132.3	3252.9	2064.5	1101.9	1136.5	171.3	82.0	69.3	56.5
2002	6075.0	2879.2	2308.7	1242.8	659.7	432.9	104.5	101.8	48.9
2003	1307.7	4929.4	1639.9	999.1	448.3	266.7	283.2	57.1	60.3
2004	2415.6	2539.9	3931.3	906.5	594.5	298.9	191.9	241.5	48.1
2005	1883.2	4750.9	1568.6	2259.4	393.0	479.9	235.9	86.8	238.6
2006	2138.7	3087.1	3656.6	1074.2	1204.2	378.9	401.8	161.9	88.4
2007	5586.7	4705.1	3642.7	3140.0	800.4	1278.1	330.9	462.1	122.7
2008	6137.9	10748.8	4972.7	3285.6	2125.1	713.6	743.1	319.1	280.1
2009	2727.1	5023.3	7457.7	2699.3	1663.1	1159.6	454.9	740.0	199.5
2010	3111.7	4929.8	5245.4	4684.8	1571.4	1113.9	1080.4	481.3	663.0
2011	6659.7	9117.9	7139.4	4662.1	3354.3	1241.2	863.7	1092.2	274.5
2012	2697.7	11526.3	11421.5	6402.3	3591.3	2482.0	1166.2	920.3	929.0
2013	2746.0	6875.0	9535.0	6200.9	3239.6	1998.0	1548.3	731.4	483.1
2014	5388.3	9018.7	7571.9	6276.2	3176.0	1460.9	1059.8	775.1	486.9
2015	1650.5	7303.9	7973.6	5825.4	4458.1	2489.1	1285.4	950.3	786.2
2016	3170.6	4950.3	7221.8	5454.2	2997.6	2284.4	1549.1	985.8	764.4
2017	4108.0	4918.1	3451.6	4376.2	2862.3	1730.8	1162.2	898.2	526.7

IBTS–Q1	1	2	3	4	5	6	7
2007	2243.2	5373.5	5631.5	5872.7	1904.0	929.8	519.6
2008	2307.7	11453.8	7220.2	3569.1	2481.9	725.6	538.9
2009	2780.4	7690.4	12441.7	4296.3	2056.6	831.4	436.6
2010	1392.5	5803.7	9271.3	7990.5	3318.0	1308.7	840.6
2011	1118.2	6206.6	6535.6	6344.5	5076.3	1658.4	871.7
2012	1938.0	14415.1	14923.9	7184.8	4855.0	3128.5	1253.0
2013	1305.5	5496.0	9692.7	6654.3	3169.6	1707.7	877.5
2014	2542.0	7375.9	9011.6	8512.2	4682.1	1693.1	937.7
2015	805.5	10306.1	10685.6	8556.2	5908.5	2542.3	1121.3
2016	2021.3	5555.2	9063.6	7219.4	4858.7	2298.2	1233.5
2017	1902.6	7027.1	4163.9	6572.4	4471.2	2750.0	1250.2

Table 14.3.1. Plaice in Subarea 4 and Subdivision 20: Estimated parameters from AAP model in final run.

Number of parameters = 277 Objective function value = 163.551 Maximum gradient component = 0.000247082

logsigmaC:
-0.794573 -0.392090 0.0281952

logsigmaU:
-0.424490 -0.271008 0.0367691
-0.947114 -0.426955 0.0557535
-1.32637 0.430163 -0.0236184
-1.97642 0.490367 -0.00732051
-0.207272 -0.517308 0.0530134
-0.231388 -0.994577 0.137183

log_sel_coff1:
-1.02287 -0.887884 -1.04746 -1.32920 -1.65444 -0.927998 -0.461942 -0.635136 -0.228733 0.0510279 0.0630331 -0.455669 -0.194580 -0.0956079 -0.158529 -0.495790 -0.323624 -0.581699 -0.941873 -0.922803 -0.715039 -0.723141 -0.289045 -0.819224 -0.478886 -1.04179 -0.415537 0.0731429 0.00235504 0.310609 0.206569 0.0740363 0.271092 0.151923 0.431550 0.262847 0.534658 0.644086 0.544951 0.448804 0.694688 0.561337 0.602488 0.555631 0.730120 0.876157 0.359037 0.896797 0.494443 0.354100 -0.0394792 -0.374638 -0.0637311 0.0513728 0.0942050 0.153101 0.218578 0.0704801 0.112218 0.296937 0.554568 0.340432 0.502352 0.566558 0.679984 0.565823 0.738055 0.653460 0.628838 0.695664 0.750595 0.954422 0.782524 0.693068 0.310348 0.0906728 -0.235603 -0.148584 -0.472234 -0.0189444 -0.0174693 0.262519 0.156110 0.117771 0.270612 0.127035 0.445916 0.165712 0.549704 0.276772 0.363317 0.434739 0.858458 0.618762 0.993518 0.660557 0.913128 0.946156 0.903147 0.759970 0.388555 -0.275966 -0.629318 -0.781948 -0.369293 -0.330225 -0.274176 -0.0661819 -0.124892 -0.198647 0.0276498 0.0802898 0.208173 0.105403 0.176285 0.271208 0.0991160 0.156275 0.517414 0.334663 0.563460 0.793482 0.643754 0.779537 0.493770 0.758334 -0.0142601 -0.366470 -0.998814 -1.06861 -0.548595 -0.293030 -0.512162 -0.379993 -0.221903 -0.478741 -0.207533 -0.0642515 0.163129 0.00818577 -0.107379 -0.0821966 0.0746377 -0.110475 0.192099 0.107709 0.303762 0.495241 0.364812 0.489305 0.305630 0.308915 -0.551690 -1.18687 -2.20526 -2.01541

log_sel_cofU:
-8.10328 -7.75274 -8.72463 -9.93320 -10.7784 -10.6434
-2.69980 -2.91306 -3.29433 -3.47697 -3.74483 -3.74209
-3.33441 -3.39243 -4.51522 -7.02288 -8.24477 -8.63430
-4.01125 -5.04919 -6.59804 -7.54756 -8.50034 -8.59442
-5.88125 -5.09773 -4.49619 -4.43648 -4.67745 -4.27741
-6.29917 -4.99654 -3.88764 -3.99498 -3.87435 -4.37177

log_initpop:
12.5274 12.7969 12.3111 11.8731 11.0353 11.0479 10.8067 10.3794 11.1449 13.0584 13.4765 13.6968 13.5553 13.7071 13.3209 13.3401 14.7057 13.4132 13.2564 12.9486 12.9631 13.4413 13.3879 12.9741 12.8362 14.1283 13.9140 13.5703 13.4108 13.8297 13.7059 13.7365 13.8782 13.8261 14.4724 14.1348 14.0680 14.3988 15.2671 14.4937 14.3568 14.0243 13.8960 13.8137 13.6557 13.1845 13.2474 13.7613 13.7097 14.6950 13.5846 13.4640 13.7300 13.3443 14.3793 13.2263 14.0443 13.5943 13.6187 14.0977 13.8842 13.8355 13.9277 14.1278

Table 14.3.2. Plaice in Subarea 4 and Subdivision 20: Harvest (F) at age.

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.099	0.171	0.262	0.309	0.256	0.211	0.225	0.228	0.199	0.199
1958	0.114	0.212	0.310	0.329	0.292	0.250	0.226	0.223	0.233	0.233
1959	0.128	0.249	0.350	0.345	0.324	0.287	0.230	0.219	0.251	0.251
1960	0.137	0.262	0.359	0.350	0.341	0.310	0.242	0.216	0.231	0.231
1961	0.136	0.255	0.352	0.351	0.346	0.323	0.262	0.219	0.197	0.197
1962	0.119	0.254	0.369	0.360	0.353	0.342	0.287	0.232	0.189	0.189
1963	0.094	0.270	0.431	0.383	0.373	0.376	0.314	0.257	0.220	0.220
1964	0.075	0.279	0.489	0.407	0.393	0.402	0.326	0.275	0.261	0.261
1965	0.068	0.259	0.471	0.414	0.400	0.395	0.313	0.266	0.263	0.263
1966	0.075	0.233	0.411	0.402	0.393	0.371	0.292	0.246	0.235	0.235
1967	0.098	0.238	0.377	0.380	0.381	0.364	0.292	0.240	0.217	0.217
1968	0.142	0.282	0.382	0.357	0.370	0.380	0.317	0.257	0.220	0.220
1969	0.189	0.328	0.395	0.345	0.361	0.392	0.343	0.283	0.238	0.238
1970	0.204	0.330	0.392	0.353	0.360	0.381	0.349	0.304	0.267	0.267
1971	0.195	0.313	0.393	0.384	0.375	0.370	0.345	0.319	0.300	0.300
1972	0.192	0.317	0.425	0.442	0.422	0.390	0.354	0.335	0.332	0.332
1973	0.205	0.348	0.479	0.512	0.486	0.433	0.375	0.351	0.356	0.356
1974	0.237	0.379	0.508	0.545	0.517	0.453	0.387	0.361	0.369	0.369
1975	0.287	0.391	0.483	0.516	0.486	0.428	0.379	0.361	0.368	0.368
1976	0.343	0.399	0.451	0.476	0.452	0.406	0.371	0.355	0.353	0.353
1977	0.379	0.422	0.455	0.470	0.464	0.432	0.382	0.346	0.327	0.327
1978	0.371	0.453	0.499	0.498	0.507	0.486	0.407	0.343	0.303	0.303
1979	0.317	0.475	0.568	0.542	0.533	0.511	0.432	0.354	0.295	0.295
1980	0.251	0.478	0.641	0.588	0.521	0.482	0.440	0.377	0.306	0.306
1981	0.216	0.464	0.675	0.621	0.504	0.439	0.422	0.386	0.326	0.326
1982	0.230	0.444	0.639	0.628	0.507	0.414	0.383	0.365	0.343	0.343
1983	0.272	0.428	0.580	0.619	0.530	0.419	0.356	0.338	0.347	0.347
1984	0.309	0.427	0.547	0.608	0.567	0.465	0.373	0.333	0.330	0.330
1985	0.320	0.442	0.552	0.605	0.609	0.545	0.435	0.356	0.311	0.311
1986	0.306	0.463	0.586	0.616	0.643	0.622	0.512	0.406	0.327	0.327
1987	0.278	0.482	0.637	0.641	0.661	0.659	0.567	0.469	0.393	0.393
1988	0.250	0.483	0.668	0.658	0.671	0.670	0.579	0.502	0.458	0.458
1989	0.230	0.457	0.643	0.644	0.683	0.681	0.546	0.460	0.440	0.440
1990	0.222	0.427	0.596	0.615	0.692	0.697	0.514	0.409	0.390	0.390
1991	0.224	0.423	0.580	0.597	0.686	0.715	0.542	0.431	0.401	0.401
1992	0.231	0.443	0.603	0.599	0.665	0.728	0.637	0.545	0.493	0.493
1993	0.222	0.447	0.624	0.611	0.648	0.721	0.713	0.651	0.574	0.574
1994	0.190	0.411	0.615	0.626	0.647	0.691	0.680	0.616	0.531	0.531
1995	0.154	0.382	0.625	0.653	0.661	0.669	0.615	0.532	0.450	0.450
1996	0.132	0.410	0.724	0.705	0.685	0.687	0.613	0.516	0.429	0.429
1997	0.125	0.475	0.874	0.768	0.716	0.729	0.652	0.548	0.455	0.455
1998	0.132	0.476	0.869	0.791	0.749	0.737	0.621	0.519	0.458	0.458
1999	0.151	0.382	0.661	0.750	0.772	0.686	0.499	0.406	0.394	0.394
2000	0.171	0.319	0.517	0.685	0.755	0.635	0.420	0.323	0.308	0.308
2001	0.176	0.358	0.555	0.636	0.681	0.627	0.454	0.319	0.236	0.236

	age									
year	1	2	3	4	5	6	7	8	9	10
2002	0.174	0.468	0.700	0.596	0.583	0.622	0.534	0.346	0.186	0.186
2003	0.190	0.525	0.736	0.546	0.499	0.547	0.497	0.316	0.154	0.154
2004	0.223	0.459	0.591	0.481	0.434	0.419	0.343	0.227	0.130	0.130
2005	0.235	0.382	0.462	0.412	0.366	0.313	0.231	0.156	0.102	0.102
2006	0.196	0.352	0.427	0.346	0.290	0.250	0.188	0.121	0.070	0.070
2007	0.157	0.336	0.415	0.295	0.229	0.206	0.171	0.103	0.047	0.047
2008	0.155	0.294	0.355	0.264	0.193	0.166	0.149	0.089	0.036	0.036
2009	0.176	0.238	0.276	0.250	0.179	0.135	0.121	0.076	0.033	0.033
2010	0.164	0.198	0.235	0.244	0.181	0.124	0.098	0.064	0.032	0.032
2011	0.113	0.182	0.241	0.242	0.193	0.133	0.086	0.053	0.032	0.032
2012	0.084	0.182	0.262	0.242	0.204	0.146	0.081	0.048	0.032	0.032
2013	0.098	0.192	0.264	0.243	0.203	0.146	0.084	0.049	0.032	0.032
2014	0.143	0.204	0.249	0.243	0.194	0.137	0.090	0.054	0.031	0.031
2015	0.162	0.204	0.240	0.241	0.188	0.131	0.092	0.055	0.028	0.028
2016	0.118	0.189	0.244	0.236	0.189	0.136	0.089	0.050	0.025	0.025
2017	0.069	0.168	0.255	0.230	0.195	0.145	0.082	0.042	0.021	0.021

Table 14.3.3. Plaice in Subarea 4 and Subdivision 20: Stock numbers (thousands).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	477074	268185	361589	223134	147904	60609	62627	49418	31997	68585
1958	710748	391105	204551	251892	148258	103574	44412	45232	35609	74612
1959	874712	574019	286216	135739	164040	100146	73005	32054	32755	79021
1960	797702	696497	404963	182546	87018	107321	68029	52466	23309	78691
1961	870799	629331	485155	255875	116368	55977	71202	48327	38248	73222
1962	615691	688002	441333	308828	163035	74520	36670	49595	35143	82791
1963	610017	494583	482883	276136	195022	103605	47899	24892	35587	88328
1964	2449900	502620	341643	283950	170312	121552	64387	31672	17426	89950
1965	664500	2057370	343934	189574	170953	104036	73564	42048	21773	74802
1966	579075	561599	1437490	194255	113379	103728	63414	48695	29157	67159
1967	428110	486279	402660	862270	117592	69241	64736	42848	34460	68866
1968	418228	351300	346712	249951	533809	72676	43516	43754	30486	75288
1969	666902	328477	239678	214175	158259	333787	44971	28686	30610	76834
1970	671454	499525	214078	146130	137189	99805	204065	28864	19556	76615
1971	433599	495583	324931	130830	92885	86638	61698	130295	19274	66653
1972	367450	322847	328032	198448	80660	57736	54135	39537	85654	57589
1973	1391430	274502	212726	194134	115448	47858	35371	34377	25584	92987
1974	1074920	1025520	175441	119185	105314	64234	28087	21998	21900	75118
1975	787372	767410	635424	95487	62528	56842	36941	17263	13875	60678
1976	674010	534441	469588	354654	51566	34796	33525	22880	10882	46683
1977	1033740	432591	324352	270674	199395	29688	20971	20930	14513	36598
1978	879043	640577	256771	186122	153084	113431	17442	12952	13395	33352
1979	915553	548706	368443	141111	102391	83439	63121	10501	8319	31240
1980	1078660	603278	308663	188898	74240	54396	45293	37093	6669	26644
1981	999968	759629	338604	147121	94918	39883	30398	26405	23029	22198
1982	1935350	728751	431979	156042	71554	51872	23273	18034	16239	29551
1983	1375880	1391630	422976	206296	75328	38992	31033	14363	11328	29399
1984	1302060	948596	820717	214367	100486	40129	23210	19676	9270	26037
1985	1792220	864871	559870	429744	105579	51598	22812	14467	12766	22968
1986	4303680	1177750	503176	291704	212338	51971	27066	13364	9167	23691
1987	1910200	2866780	670566	253291	142492	101004	25238	14671	8060	21446
1988	1774940	1308470	1602170	320928	120680	66592	47265	12950	8304	18014
1989	1250510	1251000	730349	743636	150385	55846	30819	23965	7096	15058
1990	1083810	898824	716388	347377	353208	68750	25576	16156	13682	12910
1991	981356	785747	530410	357105	169944	159986	30985	13837	9708	16298
1992	854841	709583	465814	268732	177919	77446	70810	16301	8133	15761
1993	550376	614021	412376	230658	133599	82753	33854	33881	8552	13207
1994	566448	398693	355244	199926	113279	63227	36416	15014	15996	11094
1995	932162	423980	239117	173831	96740	53667	28660	16697	7340	14408
1996	893056	722992	261727	115825	81896	45202	24871	14022	8872	12542
1997	2431310	708162	433954	114808	51782	37346	20579	12186	7571	12624
1998	778427	1941390	398394	163844	48218	22898	16298	9697	6375	11590
1999	683151	617294	1091830	151199	67219	20632	9911	7928	5220	10286
2000	857525	531403	381345	510105	64651	28115	9398	5446	4778	9460
2001	634808	653888	349511	205661	232564	27484	13485	5587	3568	9464

	age									
year	1	2	3	4	5	6	7	8	9	10
2002	1792880	481832	413685	181506	98490	106479	13278	7752	3675	9309
2003	557844	1362670	272903	185801	90506	49763	51719	7046	4964	9758
2004	1235790	417612	729522	118238	97419	49696	26044	28479	4649	11424
2005	863893	894667	238706	365617	66113	57108	29565	16720	20534	12765
2006	875191	618023	552652	136058	219194	41505	37778	21234	12942	27199
2007	1379750	651007	393107	326369	87129	148406	29246	28311	17026	33875
2008	1135050	1067080	420759	234965	219954	62707	109232	22299	23120	43959
2009	1088820	879336	719298	266894	163268	164048	48044	85183	18461	58555
2010	1444570	826492	627121	493740	188123	123503	129629	38535	71435	67452
2011	1608190	1109460	613580	448410	349991	142101	98703	106302	32718	121698
2012	1278010	1299830	837139	436124	318435	261180	112594	81974	91210	135291
2013	1455050	1063130	980853	582663	309658	234879	204189	93938	70713	198423
2014	1640700	1193580	793858	681616	413410	228655	183635	169885	80902	235842
2015	895620	1286330	880738	559741	483694	308142	180488	151867	145583	277893
2016	1211320	689025	948914	626799	398150	362736	244483	148885	130001	372467
2017	1823000	973599	515997	672732	447979	298156	286575	202450	128177	443492

Table 14.3.4. Plaice in Subarea 4 and Subdivision 20: Stock summary table.

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1957	477074	342223.2	78360.36	70926.17	7434	0.242	0.202	0.093	0.21
1958	710748	355374.8	88785.20	74156.85	14628	0.279	0.203	0.174	0.21
1959	874712	362119.4	105186.13	78177.77	27008	0.311	0.197	0.215	0.22
1960	797702	380052.2	117974.54	88764.47	29210	0.324	0.238	0.202	0.23
1961	870799	391385.5	119540.66	85266.72	34274	0.325	0.220	0.253	0.22
1962	615691	482245.1	126290.43	90304.77	35986	0.336	0.213	0.258	0.19
1963	610017	440657.7	140814.56	103161.84	37653	0.367	0.229	0.315	0.23
1964	2449900	430475.2	147540.08	111120.63	36419	0.394	0.251	0.277	0.26
1965	664500	383583.0	151407.75	105423.90	45984	0.388	0.275	0.264	0.27
1966	579075	404515.7	162266.41	98333.56	63933	0.362	0.227	0.286	0.24
1967	428110	473938.0	154474.17	103947.16	50527	0.348	0.202	0.253	0.22
1968	418228	458977.1	149820.00	121020.34	28800	0.354	0.224	0.225	0.26
1969	666902	402864.7	146177.58	122661.08	23516	0.364	0.265	0.184	0.30
1970	671454	370472.5	136619.12	111782.98	24836	0.363	0.266	0.219	0.30
1971	433599	361610.5	141226.10	117300.57	23926	0.367	0.276	0.209	0.32
1972	367450	366129.4	149389.86	130443.04	18947	0.399	0.321	0.168	0.36
1973	1391430	302364.6	151514.91	133768.23	17747	0.452	0.400	0.119	0.44
1974	1074920	298094.1	157993.97	115180.88	42813	0.480	0.401	0.191	0.39
1975	787372	301757.1	165391.89	94458.04	70934	0.461	0.304	0.357	0.31
1976	674010	328725.6	175881.41	122165.56	53716	0.437	0.314	0.267	0.37
1977	1033740	329116.4	165843.16	108523.84	57319	0.449	0.293	0.283	0.33
1978	879043	327543.6	178165.68	128365.86	49800	0.488	0.371	0.242	0.39
1979	915553	302271.0	172652.16	119826.73	52825	0.526	0.382	0.280	0.40
1980	1078660	319089.5	184690.46	150640.39	34050	0.542	0.477	0.157	0.47
1981	999968	290780.2	184493.98	151303.92	33190	0.541	0.476	0.156	0.52
1982	1935350	284211.4	192439.19	145669.02	46770	0.526	0.449	0.186	0.51
1983	1375880	339238.2	212631.80	143690.01	68942	0.515	0.418	0.229	0.42
1984	1302060	367250.8	228265.23	162681.38	65584	0.523	0.396	0.221	0.44
1985	1792220	394665.5	247071.42	182374.13	64697	0.551	0.460	0.221	0.46
1986	4303680	407972.0	279228.49	166633.43	112595	0.586	0.451	0.270	0.41
1987	1910200	470952.4	308479.77	155005.39	153474	0.616	0.444	0.419	0.33
1988	1774940	424695.9	315244.70	168118.12	147127	0.630	0.392	0.451	0.40
1989	1250510	448230.3	292034.89	187666.11	104369	0.622	0.406	0.415	0.42
1990	1083810	396457.8	250603.98	174413.92	76190	0.606	0.428	0.375	0.44
1991	981356	356947.1	218183.76	147843.60	70340	0.600	0.414	0.364	0.41
1992	854841	311430.8	192691.33	134793.37	57898	0.607	0.426	0.342	0.43
1993	550376	279961.6	179573.06	141799.71	37773	0.610	0.483	0.267	0.51
1994	566448	233481.2	151248.50	126194.70	25054	0.598	0.507	0.218	0.54
1995	932162	222203.0	132628.57	109680.73	22948	0.598	0.521	0.182	0.49
1996	893056	203390.9	131719.27	93642.45	38077	0.642	0.516	0.286	0.46
1997	2431310	204948.4	152194.71	82874.98	69320	0.712	0.501	0.519	0.40
1998	778427	237862.6	171240.17	74217.42	97023	0.724	0.433	0.540	0.31
1999	683151	219149.1	170662.15	97339.54	73323	0.650	0.416	0.380	0.44
2000	857525	230902.1	145997.98	100317.67	45680	0.582	0.420	0.290	0.43
2001	634808	234210.5	128106.75	66595.86	61511	0.572	0.301	0.373	0.28

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1957	477074	342223.2	78360.36	70926.17	7434	0.242	0.202	0.093	0.21
2002	1792880	221902.3	143807.34	87138.35	56669	0.594	0.396	0.413	0.39
2003	557844	248311.8	154029.46	74769.93	79260	0.571	0.354	0.436	0.30
2004	1235790	233477.7	140056.39	82528.56	57528	0.477	0.300	0.368	0.35
2005	863893	253736.7	114550.68	61501.11	53050	0.387	0.206	0.321	0.24
2006	875191	284447.2	111864.14	62160.97	49703	0.333	0.198	0.289	0.22
2007	1379750	293330.5	104769.99	59712.83	45057	0.296	0.157	0.284	0.20
2008	1135050	371836.8	113396.59	64574.27	48822	0.255	0.160	0.215	0.17
2009	1088820	453026.0	115702.59	68841.73	46861	0.216	0.129	0.185	0.15
2010	1444570	554244.5	118824.22	74246.23	44578	0.196	0.116	0.154	0.13
2011	1608190	575458.9	119718.10	74436.95	45281	0.198	0.106	0.154	0.13
2012	1278010	617538.6	131871.59	82306.81	49565	0.207	0.111	0.177	0.13
2013	1455050	709947.8	141055.45	97123.20	43932	0.210	0.122	0.178	0.14
2014	1640700	823276.2	139750.13	86423.90	53326	0.205	0.095	0.192	0.10
2015	895620	774157.2	137338.37	91033.09	46305	0.201	0.098	0.191	0.12
2016	1211320	836452.8	131216.15	86381.08	44835	0.199	0.093	0.186	0.10
2017	1823000	913289.6	124921.87	84749.82	40172	0.199	0.093	0.178	0.09

Table 14.4.1. Plaice in Subarea 4 and Subdivision 20: Input table for RCT3 analysis.

Year–class	age 1 AAP	age 2 AAP	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1976	1033740	640577	NA	NA	12678.0	NA	NA	NA
1977	879043	548706	NA	NA	9828.8	NA	NA	NA
1978	915553	603278	NA	NA	12882.3	NA	NA	NA
1979	1078660	759629	NA	NA	18785.3	NA	NA	NA
1980	999968	728751	NA	NA	8642.0	NA	NA	NA
1981	1935350	1391630	NA	NA	13908.6	NA	NA	NA
1982	1375880	948596	NA	NA	10412.8	NA	NA	NA
1983	1302060	864871	NA	NA	13847.8	NA	NA	NA
1984	1792220	1177750	NA	NA	7580.4	NA	NA	NA
1985	4303680	2866780	NA	NA	32991.1	NA	NA	NA
1986	1910200	1308470	NA	NA	14421.1	NA	NA	NA
1987	1774940	1251000	NA	NA	17810.2	NA	NA	NA
1988	1250510	898824	NA	NA	7496.0	NA	NA	NA
1989	1083810	785747	NA	NA	11247.2	NA	NA	NA
1990	981356	709583	NA	NA	13841.8	NA	NA	439.60
1991	854841	614021	NA	NA	9685.6	NA	NA	332.40
1992	550376	398693	NA	NA	4976.6	NA	NA	180.30
1993	566448	423980	NA	NA	2796.4	NA	NA	217.00
1994	932162	722992	NA	NA	10268.2	NA	23782.96	283.40
1995	893056	708162	NA	NA	4472.7	25421.12	16109.78	146.10
1996	2431310	1941390	NA	NA	30242.2	86828.63	82221.96	619.60
1997	778427	617294	NA	NA	10272.1	34532.56	17802.28	229.20
1998	683151	531403	NA	NA	2493.4	44939.57	21451.02	NA
1999	857525	653888	NA	22855.0	2898.5	42378.70	19715.37	NA
2000	634808	481832	24213.5	11510.5	1102.7	29311.13	16309.18	124.90
2001	1792880	1362670	99628.0	30809.2	NA	134367.00	44967.87	313.20
2002	557844	417612	31202.0	NA	1349.7	32240.83	13238.66	122.90
2003	1235790	894667	NA	18201.6	1818.9	44366.34	27225.89	238.60
2004	863893	618023	13537.2	10118.4	1571.0	37561.60	16493.16	126.70
2005	875191	651007	27390.6	12164.2	2133.9	41532.31	21429.36	85.90
2006	1379750	1067080	51124.2	14174.5	2700.4	84754.12	45493.28	168.00
2007	1135050	879336	40580.9	14705.8	2018.7	68596.86	22690.93	98.30
2008	1088820	826492	50179.3	14860.0	1811.5	64526.50	27581.32	129.70
2009	1444570	1109460	53258.8	11946.9	1142.5	80970.01	41926.87	141.90
2010	1608190	1299830	49347.2	18348.6	2928.6	126770.26	63231.74	179.60
2011	1278010	1063130	52643.0	5893.4	3021.3	58884.94	51484.72	93.00
2012	1455050	1193580	45027.1	15394.9	2258.3	87360.92	59687.53	181.10
2013	1640700	1286330	44327.5	17312.7	5040.4	143731.62	65837.62	168.50
2014	NA	NA	11722.3	16726.5	2434.3	51396.91	30990.84	108.00
2015	NA	NA	30494.5	10384.8	1715.5	82875.92	49998.49	100.20
2016	NA	NA	44111.0	15935.9	NA	140854.07	NA	78.05
2017	NA	NA	27396.5	NA	NA	NA	NA	127.20

Table 14.4.2. Plaice in Subarea 4 and Subdivision 20. RCT3 results for age 1 in 2018 (year–class 2017).

Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 42 years : 1976 - 2017
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:2017

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
SNS0	1.0416	2.8991	0.3585	0.53456	13	10.218	13.54	0.4146	0.49582
SNS1	2.2876	-7.9432	0.8748	0.11365	14	NA	NA	NA	NA
SNS2	0.9472	5.7630	0.8137	0.22253	37	NA	NA	NA	NA
BTSC1	0.8657	4.4177	0.2492	0.72171	19	NA	NA	NA	NA
BTSC2	0.7358	6.3262	0.1648	0.84986	20	NA	NA	NA	NA
DFS0	2.6342	0.1314	1.2975	0.09238	22	4.846	12.90	1.4081	0.04298
VPA Mean	NA	NA	NA	NA	38	NA	13.95	0.4299	0.46120

	WAP	logWAP	int.se
yearclass:2017	894683	13.7	0.2919

Table 14.4.3. Plaice in Subarea 4 and Subdivision 20: RCT3 results for age 2 in 2018 (year-class 2016).

Analysis by RCT3 ver4.0

Plaice

Data for 10 surveys over 42 years : 1976 - 2017
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:2016

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
SNS0	1.0909	2.118	0.3676	0.55382	13	10.694	13.78	0.4152	0.135829
SNS1	2.8819	-13.902	1.1212	0.08260	14	9.676	13.98	1.2559	0.014843
SNS2	1.1423	3.768	1.0252	0.15144	37	NA	NA	NA	NA
BTSC1	0.9026	3.755	0.2600	0.72117	19	11.855	14.46	0.3019	0.256881
BTSC2	0.7529	5.892	0.1504	0.88051	20	NA	NA	NA	NA
DFS0	3.0918	-2.523	1.5374	0.07508	22	4.357	10.95	1.7534	0.007615
IBTSQ3_1	0.7665	7.662	0.3345	0.62117	18	8.321	14.04	0.3694	0.171557
IBTSQ3_2	0.9856	5.314	0.3497	0.58851	19	NA	NA	NA	NA
IBTSQ1_1	-0.7988	19.905	-0.2336	0.36703	8	7.551	13.87	-0.2861	0.285943
IBTSQ1_2	0.9906	4.961	0.2858	0.42116	9	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	38	NA	13.64	0.4288	0.127333

	WAP	logWAP	int.se
yearclass:2016	1190155	13.99	0.153

Table 14.5.1. Plaice in Subarea 4 and Subdivision 20: Input to the short term forecast (F values presented are for Fsq).

2019_ssb	2018_f2–6	2018_f_dis2–3	2018_f_hc2–6	2018_recruits	2018_landings	2018_discards	2018_catch	2018_TAC			
974516	0.199	0.184	0.094	894683	84964	45828	130792	128635			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2018	0.116	0.12	0	894683	0.04	0.07	0.04	0.03	0	0.1
2	2018	0.187	0.18	0	1540180	0.08	0.25	0.08	0.07	0.5	0.1
3	2018	0.246	0.19	0.06	744544	0.16	0.28	0.12	0.12	0.5	0.1
4	2018	0.235	0.1	0.14	361752	0.24	0.31	0.15	0.2	1	0.1
5	2018	0.19	0.04	0.15	483649	0.31	0.36	0.16	0.27	1	0.1
6	2018	0.137	0.02	0.12	333618	0.38	0.4	0.19	0.33	1	0.1
7	2018	0.087	0.01	0.08	233266	0.44	0.46	0.18	0.37	1	0.1
8	2018	0.049	0	0.04	238923	0.49	0.52	0.21	0.44	1	0.1
9	2018	0.025	0	0.02	175700	0.59	0.59	0.39	0.47	1	0.1
10	2018	0.025	0	0.02	506383	0.67	0.67	0	0.51	1	0.1
1	2019	0.116	0.12	0	965555	0.04	0.07	0.04	0.03	0	0.1
2	2019	0.187	0.18	0	NA	0.08	0.25	0.08	0.07	0.5	0.1
3	2019	0.246	0.19	0.06	NA	0.16	0.28	0.12	0.12	0.5	0.1
4	2019	0.235	0.1	0.14	NA	0.24	0.31	0.15	0.2	1	0.1
5	2019	0.19	0.04	0.15	NA	0.31	0.36	0.16	0.27	1	0.1
6	2019	0.137	0.02	0.12	NA	0.38	0.4	0.19	0.33	1	0.1
7	2019	0.087	0.01	0.08	NA	0.44	0.46	0.18	0.37	1	0.1
8	2019	0.049	0	0.04	NA	0.49	0.52	0.21	0.44	1	0.1
9	2019	0.025	0	0.02	NA	0.59	0.59	0.39	0.47	1	0.1
10	2019	0.025	0	0.02	NA	0.67	0.67	0	0.51	1	0.1
1	2020	0.116	0.12	0	965555	0.04	0.07	0.04	0.03	0	0.1
2	2020	0.187	0.18	0	NA	0.08	0.25	0.08	0.07	0.5	0.1
3	2020	0.246	0.19	0.06	NA	0.16	0.28	0.12	0.12	0.5	0.1

2019_ssb	2018_f2–6	2018_f_dis2–3	2018_f_hc2–6	2018_recruits	2018_landings	2018_discards	2018_catch	2018_TAC			
974516	0.199	0.184	0.094	894683	84964	45828	130792	128635			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
4	2020	0.235	0.1	0.14	NA	0.24	0.31	0.15	0.2	1	0.1
5	2020	0.19	0.04	0.15	NA	0.31	0.36	0.16	0.27	1	0.1
6	2020	0.137	0.02	0.12	NA	0.38	0.4	0.19	0.33	1	0.1
7	2020	0.087	0.01	0.08	NA	0.44	0.46	0.18	0.37	1	0.1
8	2020	0.049	0	0.04	NA	0.49	0.52	0.21	0.44	1	0.1
9	2020	0.025	0	0.02	NA	0.59	0.59	0.39	0.47	1	0.1
10	2020	0.025	0	0.02	NA	0.67	0.67	0	0.51	1	0.1

Table 14.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short term forecast assuming $F_{2017} = F_{2017}$ (rescaled).

Basis	Total catch (2019)	Wanted catch * (2019)	Unwanted catch * (2019)	F_{total} ages 2–6 (2019)	F_{wanted} ages 2–6 (2019)	$F_{unwanted}$ ages 2–3 (2019)	SSB (2020)	% SSB change **	% TAC change ***	% Advice change ^
ICES advice basis										
MSY approach: F_{MSY}	139052	92523	46529	0.21	0.100	0.19	1022768	5.0	8.6	-2.4
Other scenarios										
Management Plan (MP)	191682	128014	63668	0.3	0.143	0.28	971043	-0.4	49.8	34.5
F = 0	0	0	0	0	0	0	1161753	19.2	-100	-100
F_{pa}	229384	153628	75756	0.37	0.175	0.34	934176	-4.1	79.2	61.0
F_{lim}	302803	204015	98788	0.52	0.24	0.48	862875	-11.5	136.6	112.5
SSB (2020) = B_{lim}	1052590	801862	250728	6	2.8	5.5	207288	-78.7	722.4	638.8
SSB (2020) = B_{pa}	944014	700589	243425	4	1.91	3.7	290203	-70.2	637.6	562.6
SSB (2020) = MSY $B_{trigger}$	620438	432946	187492	1.47	0.7	1.36	564599	-42.1	384.8	335.5
Rollover TAC	191641	127986	63655	0.3	0.143	0.28	971083	-0.4	49.7	34.5
$F_{2019} = F_{2018}$	132335	88014	44321	0.199	0.095	0.185	1029390	5.6	3.4	-7.1
MAP $F_{upper} = F_{MSY\ upper}$	191682	128014	63668	0.3	0.143	0.28	971043	-0.4	49.8	34.5
MAP $F_{lower} = F_{MSY\ lower}$	101624	67456	34168	0.15	0.071	0.139	1059724	8.7	-20.6	-28.7

*** "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 average discard rate estimates for 2015–2017. Both wanted and unwanted catch refer to Subarea 4 and Subdivision 20, calculated as the projected total stock wanted catch (including Division 7.d) deducted by the catch of plaice from Subarea 4 taken in Division 7.d in 2019. The subtracted value (649 t of wanted catch and 398 t of unwanted catch) is estimated based on the plaice catch advice for Division 7.d for 2019.**

**** SSB 2020 relative to SSB 2019.**

***** Total catch in 2019 relative to the combined TAC of Subarea 4 and Subdivision 20 in 2018 (127 986 t), ignoring that large mesh trawlers (TR1 and BT1) are under landing obligation since 2016.**

^Advice value 2019 relative to advice value 2018.

Table 14.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming F = Fsq, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n
1	2018	0.116	0.12	0	894683	0.04	0.07	0.04	0.03	0	0.1	93340	3890	7	0	93333
2	2018	0.187	0.18	0	1540180	0.08	0.25	0.08	0.07	0.5	0.1	249785	20812	6379	1588	243405
3	2018	0.246	0.19	0.06	744544	0.16	0.28	0.12	0.12	0.5	0.1	154556	24616	36859	10210	117697
4	2018	0.235	0.1	0.14	361752	0.24	0.31	0.15	0.2	1	0.1	72138	17298	42482	12971	29656
5	2018	0.19	0.04	0.15	483649	0.31	0.36	0.16	0.27	1	0.1	79722	24950	62569	22233	17152
6	2018	0.137	0.02	0.12	333618	0.38	0.4	0.19	0.33	1	0.1	40694	15361	36136	14502	4558
7	2018	0.087	0.01	0.08	233266	0.44	0.46	0.18	0.37	1	0.1	18580	8183	17300	7946	1280
8	2018	0.049	0	0.04	238923	0.49	0.52	0.21	0.44	1	0.1	10833	5335	9925	5165	907
9	2018	0.025	0	0.02	175700	0.59	0.59	0.39	0.47	1	0.1	4085	2424	4085	2424	1
10	2018	0.025	0	0.02	506383	0.67	0.67	0	0.51	1	0.1	11774	7923	11773	7923	1
1	2019	0.116	0.12	0	965555	0.04	0.07	0.04	0.03	0	0.1	100734	4198	7	1	100727
2	2019	0.187	0.18	0	720877	0.08	0.25	0.08	0.07	0.5	0.1	116911	9741	2986	743	113925
3	2019	0.246	0.19	0.06	1156478	0.16	0.28	0.12	0.12	0.5	0.1	240068	38235	57252	15859	182815
4	2019	0.235	0.1	0.14	527034	0.24	0.31	0.15	0.2	1	0.1	105098	25201	61892	18898	43205
5	2019	0.19	0.04	0.15	258869	0.31	0.36	0.16	0.27	1	0.1	42670	13354	33490	11900	9181
6	2019	0.137	0.02	0.12	361942	0.38	0.4	0.19	0.33	1	0.1	44149	16665	39204	15734	4945
7	2019	0.087	0.01	0.08	263220	0.44	0.46	0.18	0.37	1	0.1	20966	9234	19522	8967	1444
8	2019	0.049	0	0.04	193414	0.49	0.52	0.21	0.44	1	0.1	8769	4319	8035	4181	734
9	2019	0.025	0	0.02	205891	0.59	0.59	0.39	0.47	1	0.1	4787	2840	4787	2840	1
10	2019	0.025	0	0.02	602097	0.67	0.67	0	0.51	1	0.1	14000	9421	13998	9421	2
1	2020	0.116	0.12	0	965555	0.04	0.07	0.04	0.03	0	0.1	100734	4198	7	1	100727
2	2020	0.187	0.18	0	777981	0.08	0.25	0.08	0.07	0.5	0.1	126172	10513	3222	802	122950

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n
3	2020	0.246	0.19	0.06	541286	0.16	0.28	0.12	0.12	0.5	0.1	112363	17896	26797	7423	85566
4	2020	0.235	0.1	0.14	818626	0.24	0.31	0.15	0.2	1	0.1	163245	39143	96135	29353	67110
5	2020	0.19	0.04	0.15	377145	0.31	0.36	0.16	0.27	1	0.1	62166	19456	48791	17337	13375
6	2020	0.137	0.02	0.12	193726	0.38	0.4	0.19	0.33	1	0.1	23630	8920	20983	8421	2647
7	2020	0.087	0.01	0.08	285568	0.44	0.46	0.18	0.37	1	0.1	22746	10018	21179	9728	1567
8	2020	0.049	0	0.04	218251	0.49	0.52	0.21	0.44	1	0.1	9895	4874	9067	4718	829
9	2020	0.025	0	0.02	166674	0.59	0.59	0.39	0.47	1	0.1	3875	2299	3875	2299	0
10	2020	0.025	0	0.02	713238	0.67	0.67	0	0.51	1	0.1	16584	11160	16582	11160	2

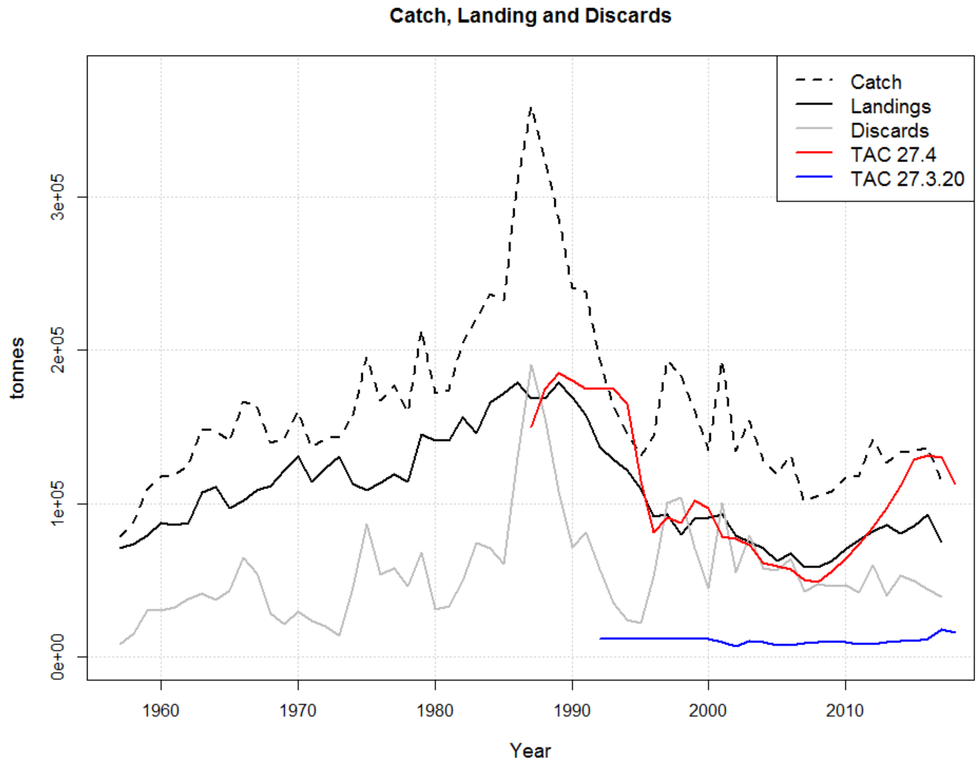


Figure 14.2.1. Plaice in Subarea 4 (including Subdivision 20 and 7.d Q1): Time series of catch (dashed line), landings (solid black line) and discards (gray line) estimates. Landings TAC for Subarea 4 (red) and Subdivision 20 (blue) are also plotted. Discards before 2000 were reconstructed using a model based method.

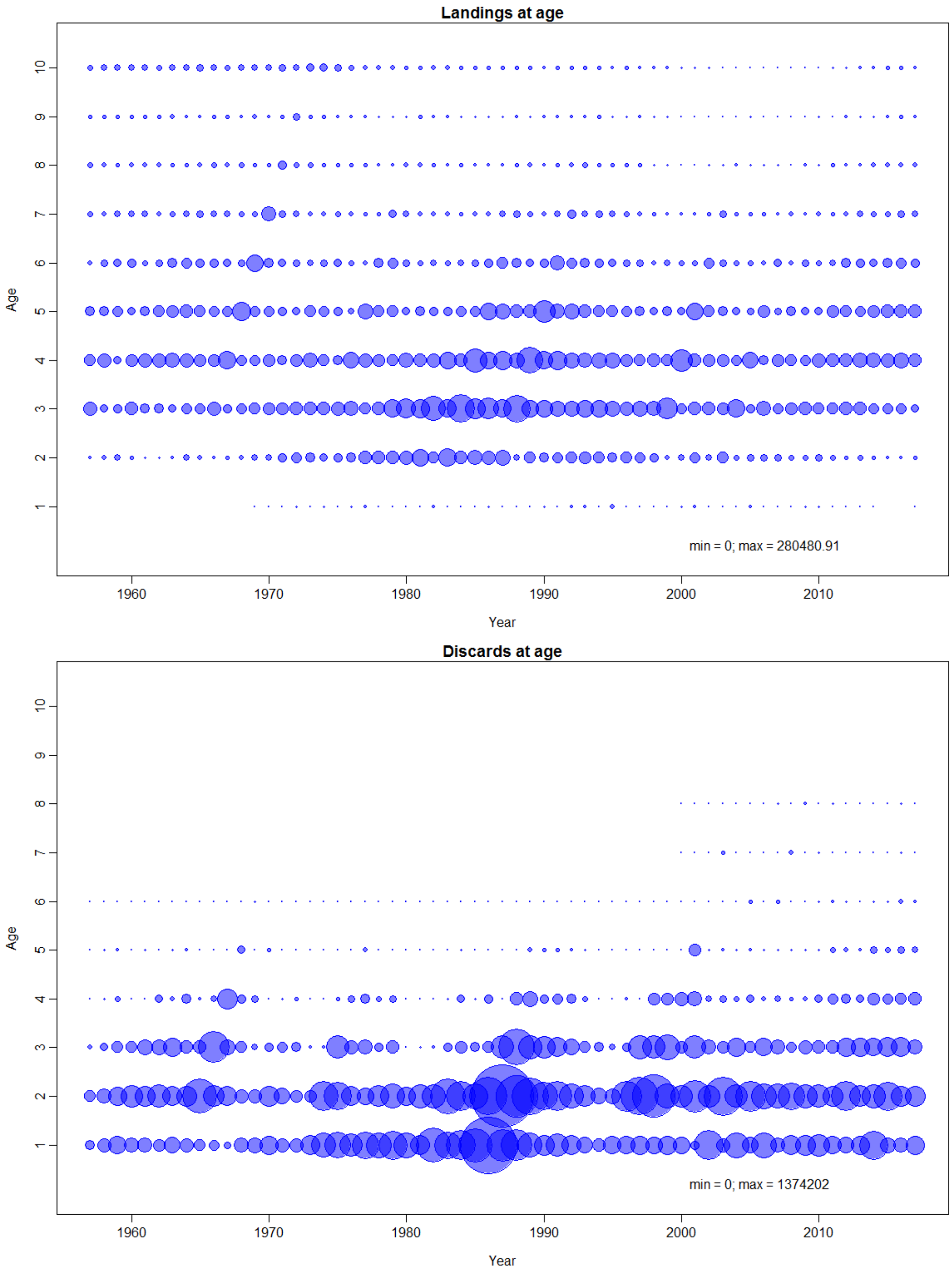


Figure 14.2.2. Plaice in Subarea 4 and Subdivision 20: Discards numbers-at-age (top) and landings numbers-at-age (down). Discards before 2000 were reconstructed using a model based method.

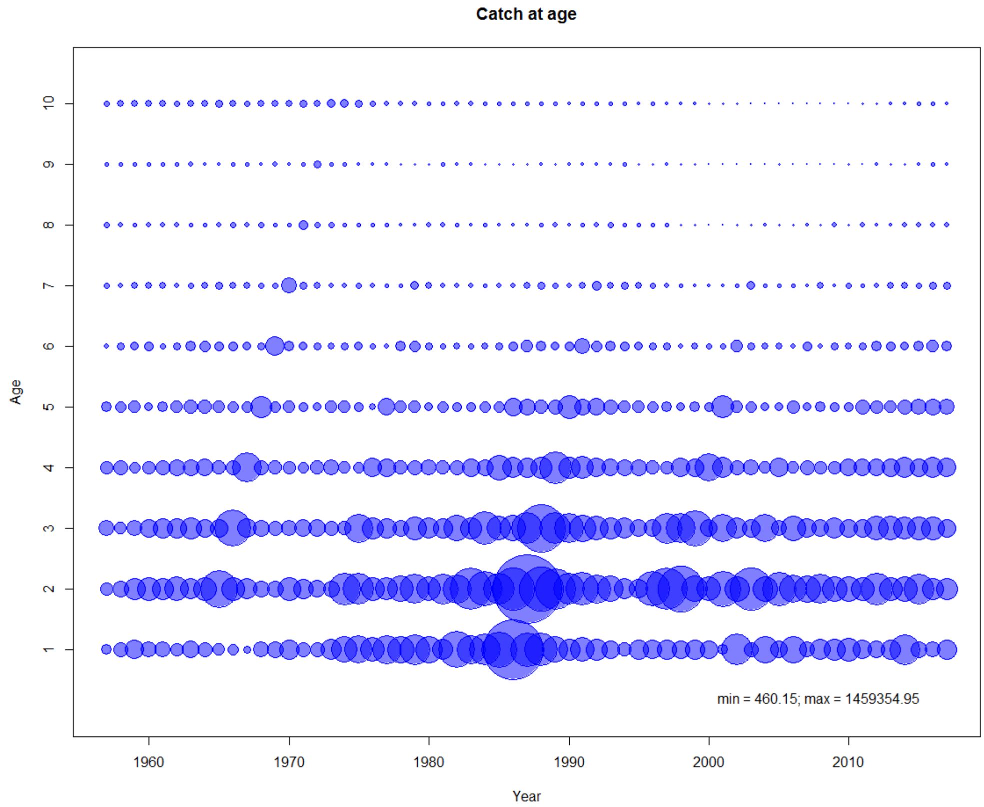


Figure 14.2.3. Plaice in Subarea 4 and Subdivision 20. Catch numbers-at-age: Discards before 2000 were reconstructed using a model based method.

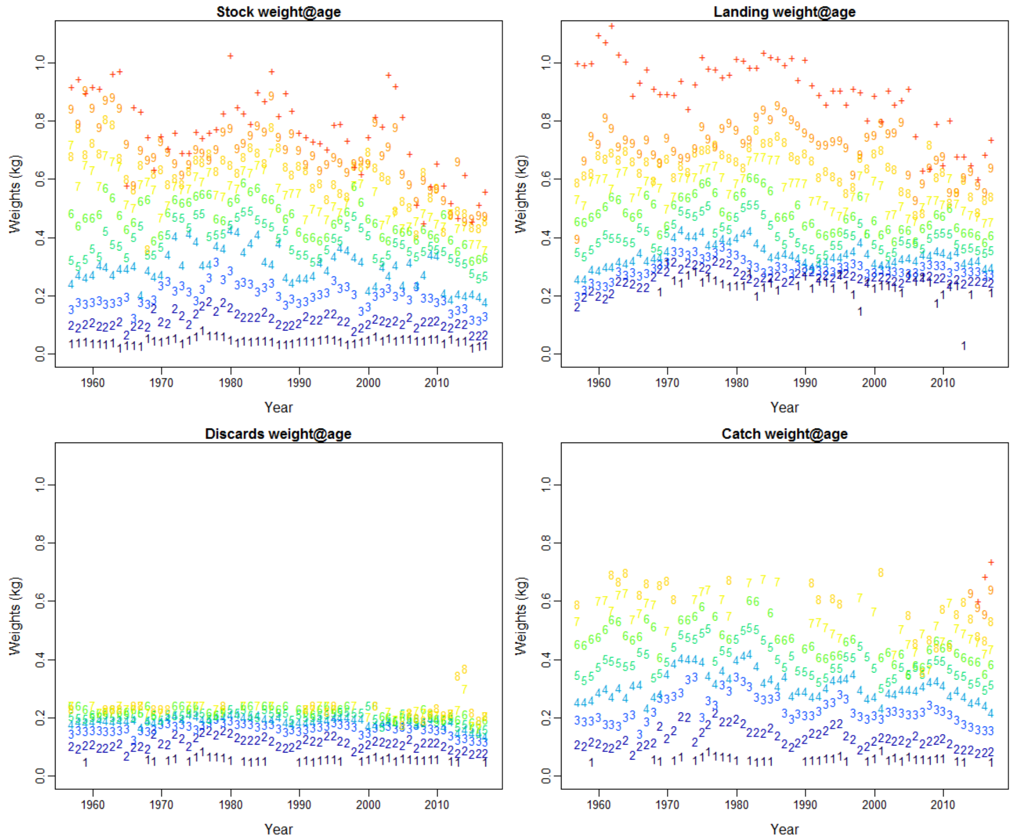


Figure 14.2.4. Plaice in Subarea 4 and Subdivision 20: Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

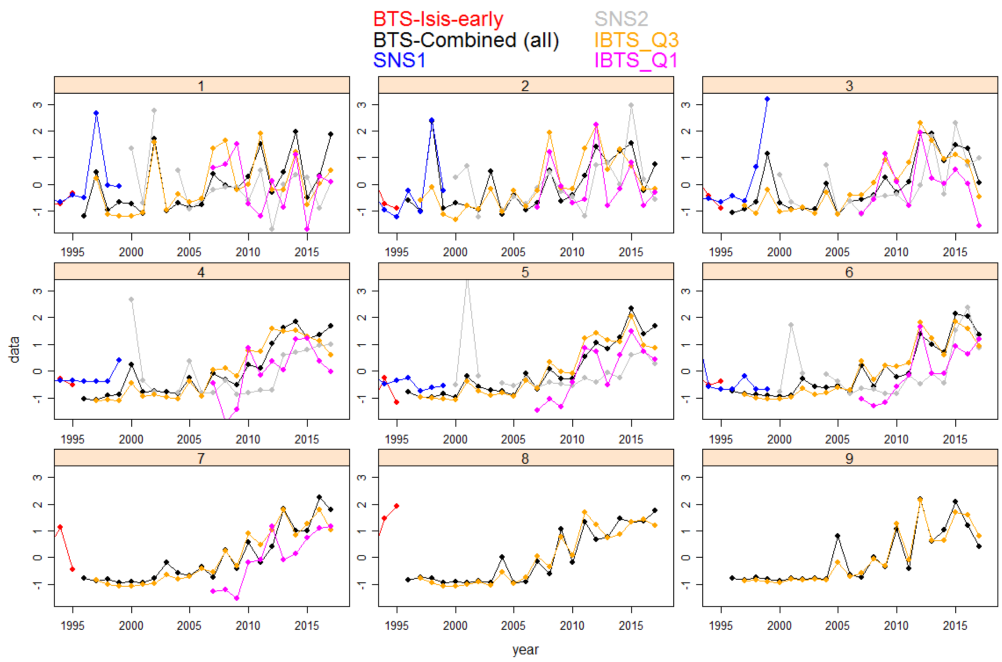


Figure 14.2.5. Plaice in Subarea 4 and Subdivision 20. Standardized survey tuning indices used for tuning stock assessment model: BTS–combined (black), BTS–Isis-early (red) SNS–1 (1984–1999, blue), SNS–2 (2000–2017, grey), IBTS–Q3 (yellow) and IBTS–Q1 (pink). Note: only ages used in the assessment are presented. The BTS–combined index combines BTS–Tridens and BTS–Isis indices.

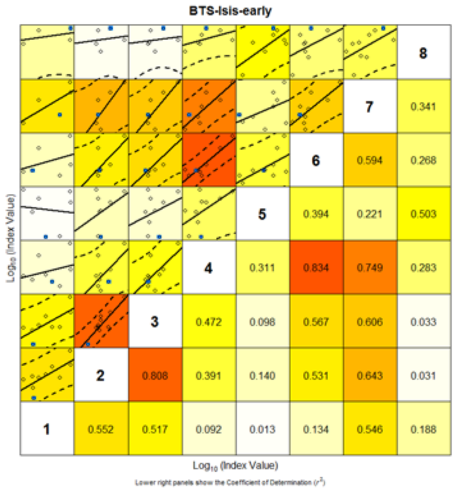


Figure 14.2.6. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the BTS-Isis-early survey index.

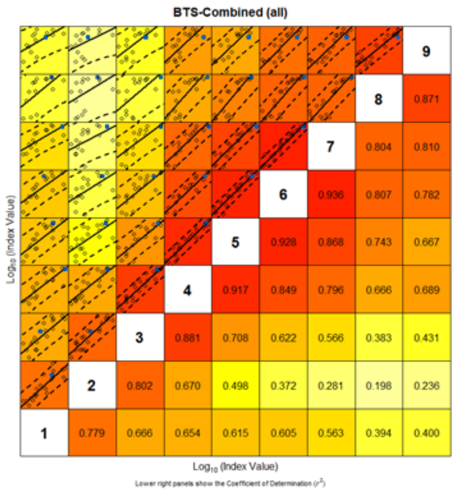


Figure 14.2.7. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the BTS–Combined survey index.

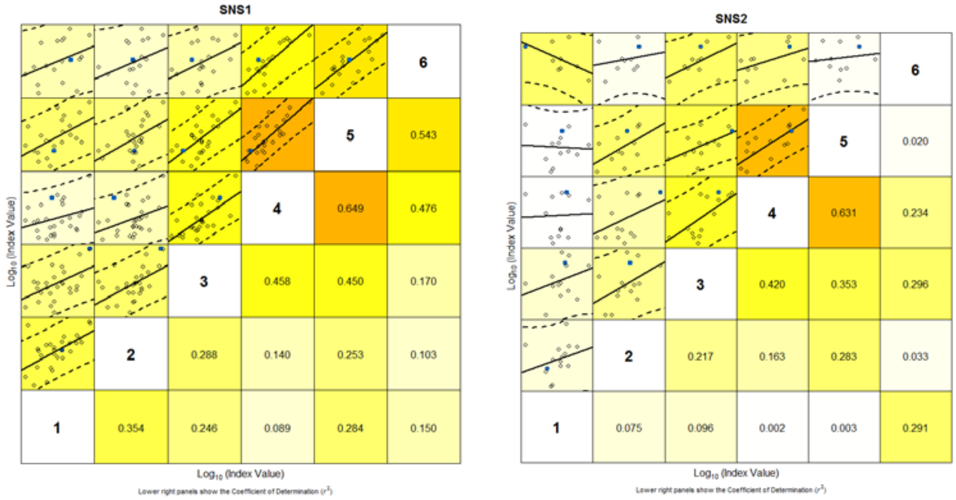


Figure 14.2.8: Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the SNS–1 (1984–1999, left) and the SNS–2 (2000–2015, right) survey indices.

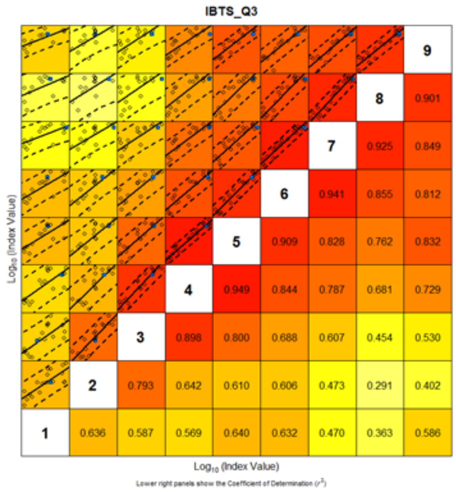


Figure 14.2.9. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the IBTS–Q3 survey indices.

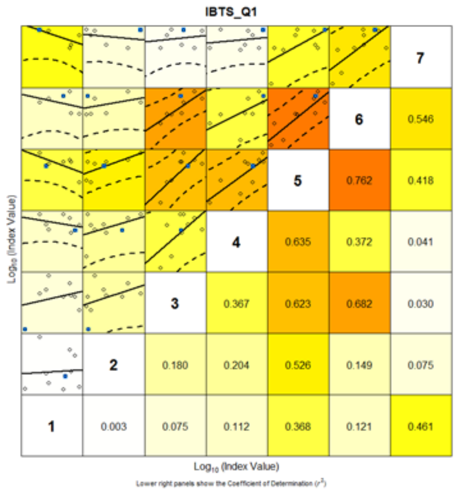
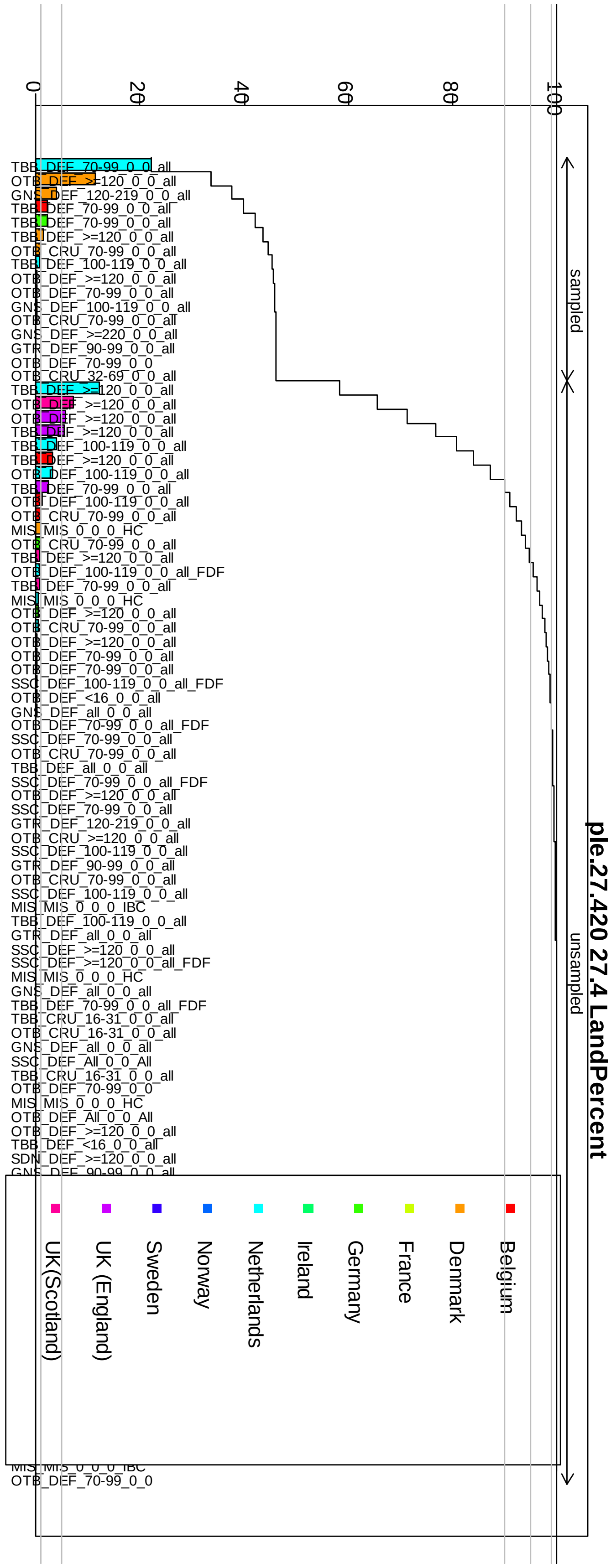
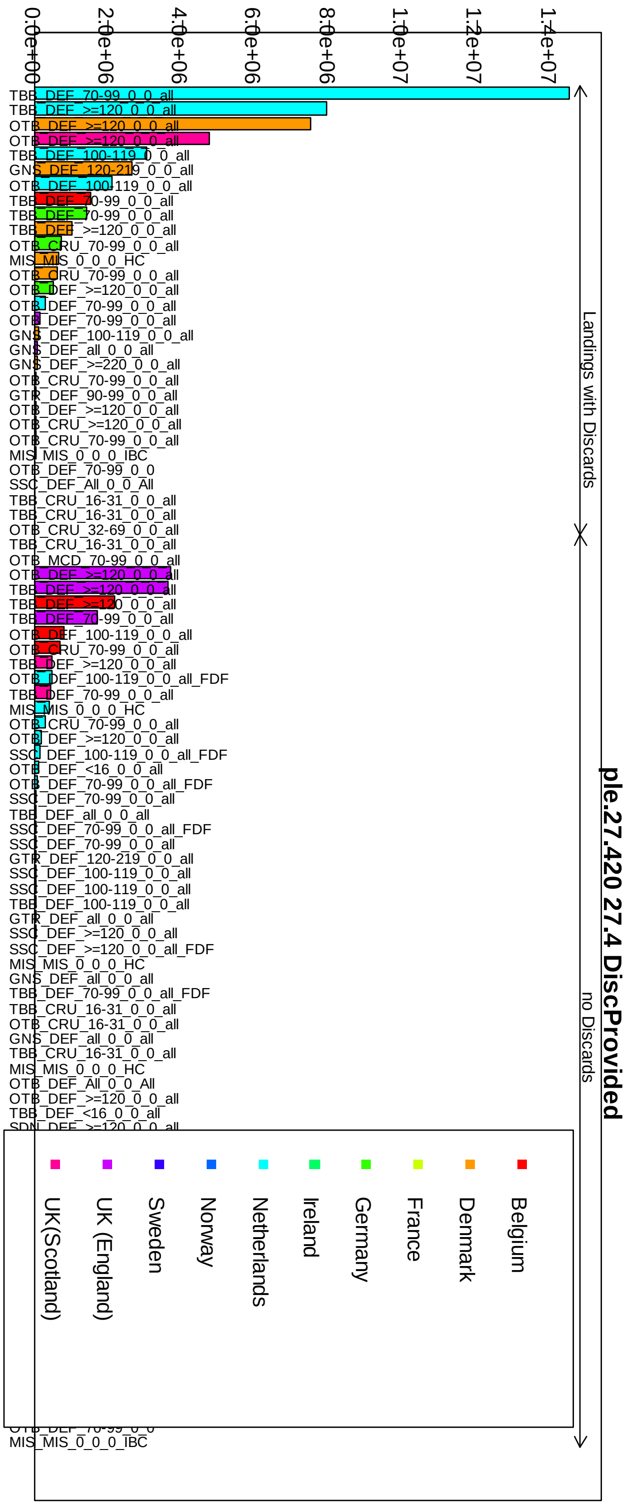


Figure 14.2.10. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the IBTS–Q1 survey indices.

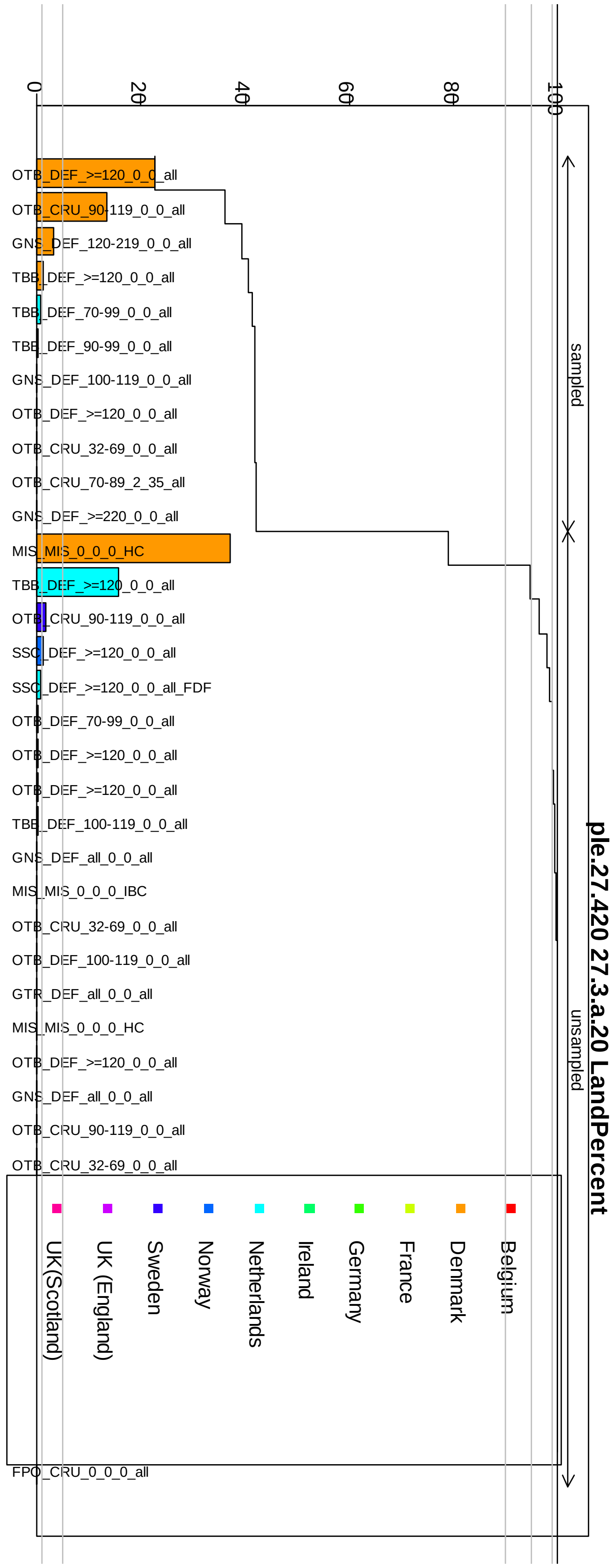

ple.27.420 27.4 LandPercent
sampled
unsampled
0
20
40
60
80
100
TBB_DEF_70-99_0_0_all
OTB_DEF_>=120_0_0_all
GNS_DEF_120-219_0_0_all
TBB_DEF_70-99_0_0_all
TBB_DEF_70-99_0_0_all
TBB_DEF_>=120_0_0_all
OTB_CRU_70-99_0_0_all
TBB_DEF_100-119_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_70-99_0_0_all
GNS_DEF_100-119_0_0_all
OTB_CRU_70-99_0_0_all
GNS_DEF_>=220_0_0_all
GTR_DEF_90-99_0_0_all
OTB_DEF_70-99_0_0
OTB_CRU_32-69_0_0_all
TBB_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
TBB_DEF_>=120_0_0_all
TBB_DEF_100-119_0_0_all
TBB_DEF_>=120_0_0_all
OTB_DEF_100-119_0_0_all
TBB_DEF_70-99_0_0_all
OTB_DEF_100-119_0_0_all
OTB_CRU_70-99_0_0_all
MIS_MIS_0_0_0_HC
OTB_CRU_70-99_0_0_all
TBB_DEF_>=120_0_0_all
OTB_DEF_100-119_0_0_all_FDF
TBB_DEF_70-99_0_0_all
MIS_MIS_0_0_0_HC
OTB_DEF_>=120_0_0_all
OTB_CRU_70-99_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_70-99_0_0_all
OTB_DEF_70-99_0_0_all
SSC_DEF_100-119_0_0_all_FDF
OTB_DEF_<16_0_0_all
GNS_DEF_all_0_0_all
OTB_DEF_70-99_0_0_all_FDF
SSC_DEF_70-99_0_0_all
OTB_CRU_70-99_0_0_all
TBB_DEF_all_0_0_all
SSC_DEF_70-99_0_0_all_FDF
OTB_DEF_>=120_0_0_all
SSC_DEF_70-99_0_0_all
GTR_DEF_120-219_0_0_all
OTB_CRU_>=120_0_0_all
SSC_DEF_100-119_0_0_all
GTR_DEF_90-99_0_0_all
OTB_CRU_70-99_0_0_all
SSC_DEF_100-119_0_0_all
MIS_MIS_0_0_0_IBC
TBB_DEF_100-119_0_0_all
GTR_DEF_all_0_0_all
SSC_DEF_>=120_0_0_all
SSC_DEF_>=120_0_0_all_FDF
MIS_MIS_0_0_0_HC
GNS_DEF_all_0_0_all
TBB_DEF_70-99_0_0_all_FDF
TBB_CRU_16-31_0_0_all
OTB_CRU_16-31_0_0_all
GNS_DEF_all_0_0_all
SSC_DEF_All_0_0_All
TBB_CRU_16-31_0_0_all
OTB_DEF_70-99_0_0
MIS_MIS_0_0_0_HC
OTB_DEF_All_0_0_All
OTB_DEF_>=120_0_0_all
TBB_DEF_<16_0_0_all
SDN_DEF_>=120_0_0_all
OTB_DEF_70-99_0_0
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(a)

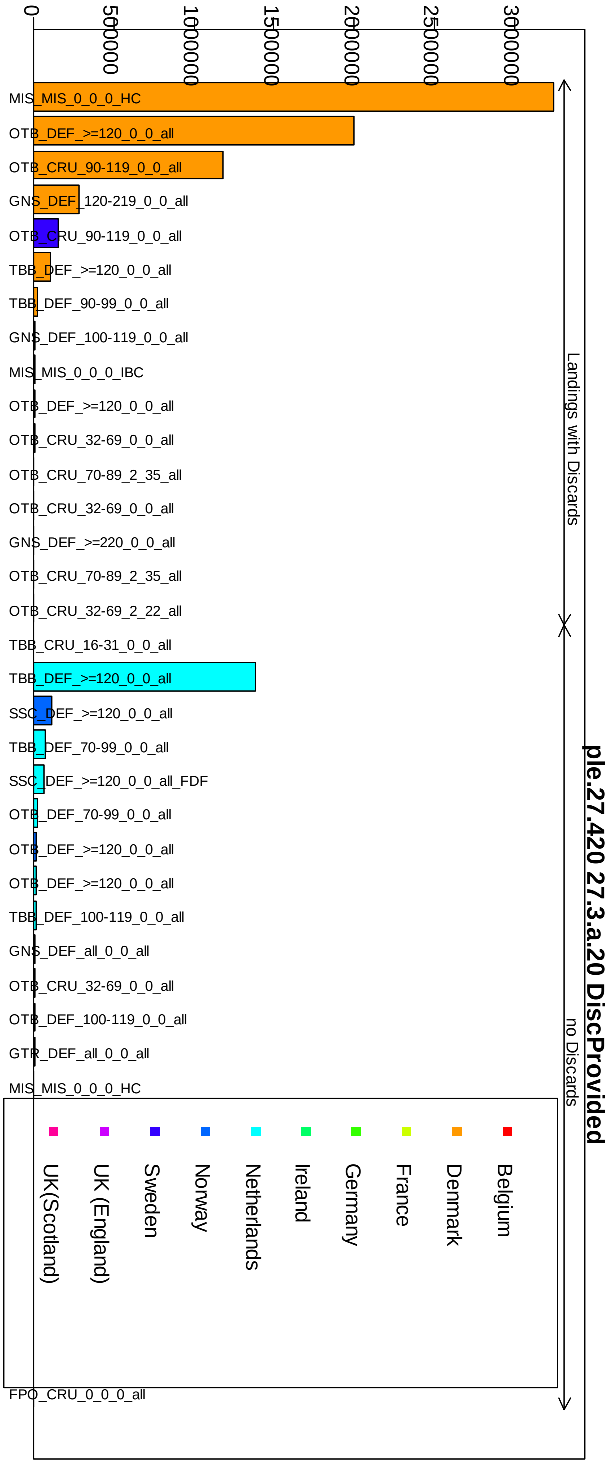


(b)

Figure 14.2.11. Summary of data upload in Intercatch for Subarea 4: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.


ple.27.420 27.3.a.20 LandPercent
0
20
40
60
80
100
sampled
unsampled
OTB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
GNS_DEF_120-219_0_0_all
TBB_DEF_>=120_0_0_all
TBB_DEF_70-99_0_0_all
TBB_DEF_90-99_0_0_all
GNS_DEF_100-119_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32-69_0_0_all
OTB_CRU_70-89_2_35_all
GNS_DEF_>=220_0_0_all
MIS_MIS_0_0_0_HC
TBB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
SSC_DEF_>=120_0_0_all
SSC_DEF_>=120_0_0_all_FDF
OTB_DEF_70-99_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
TBB_DEF_100-119_0_0_all
GNS_DEF_all_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_32-69_0_0_all
OTB_DEF_100-119_0_0_all
GTR_DEF_all_0_0_all
MIS_MIS_0_0_0_HC
OTB_DEF_>=120_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_90-119_0_0_all
OTB_CRU_32-69_0_0_all
FPO_CRU_0_0_0_all
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(a)



(b)

Figure 14.2.12. Summary of data upload in Intercatch for Subdivision 20: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

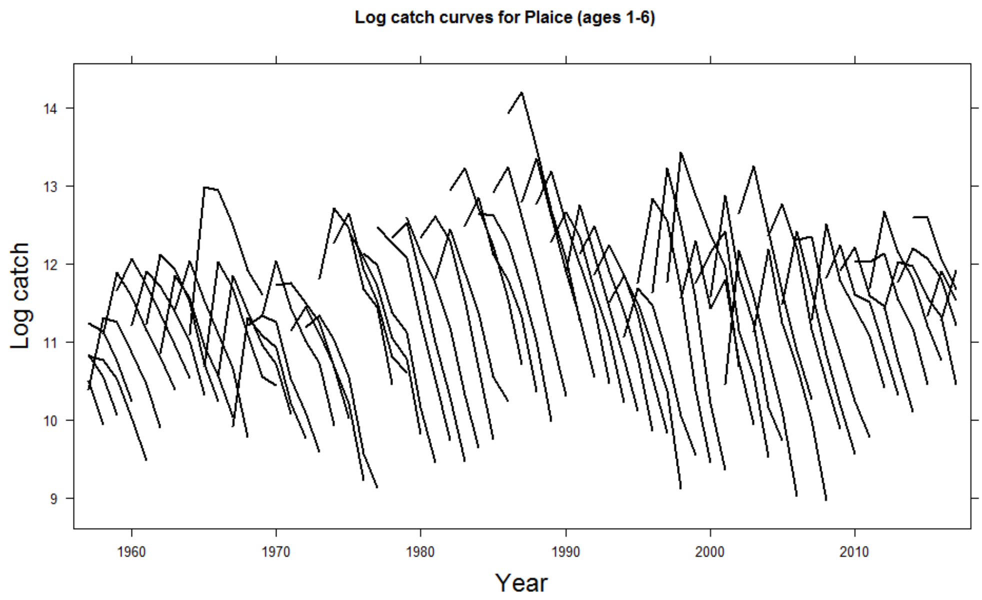


Figure 14.2.13. Catch curves for catches in age 1–6.

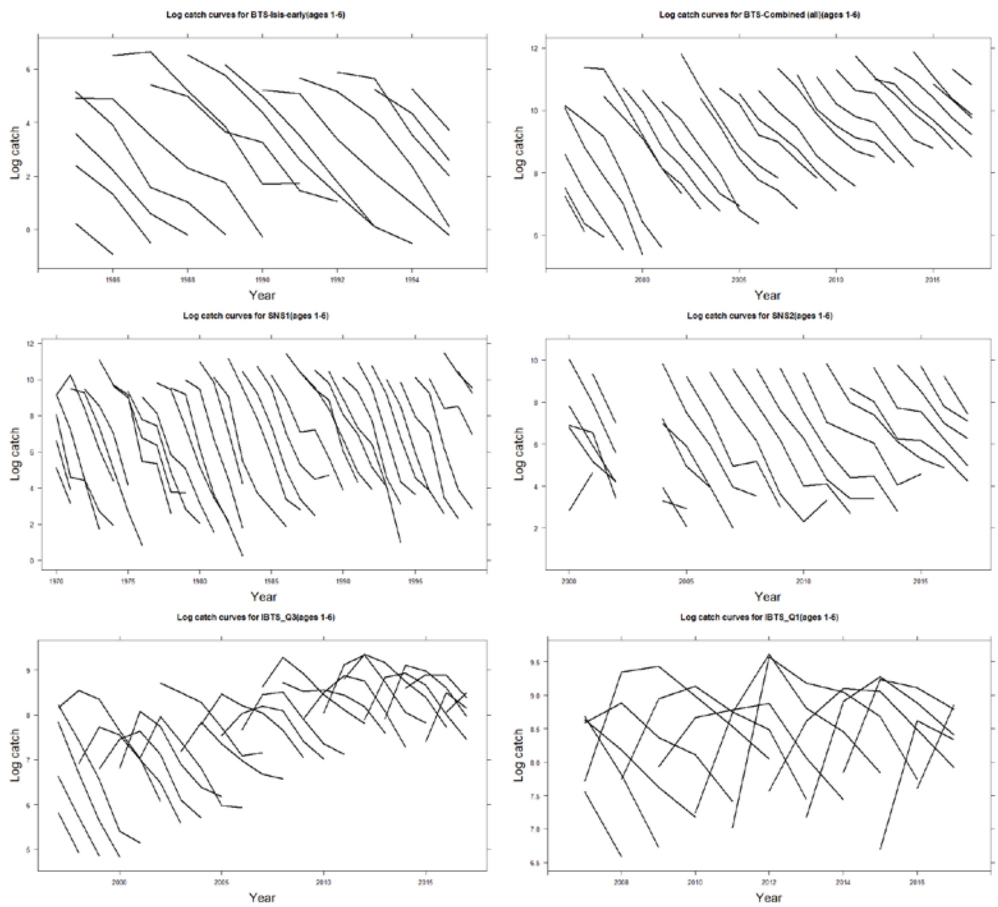


Figure 14.2.14. Catch curves for Surveys in age 1–6.

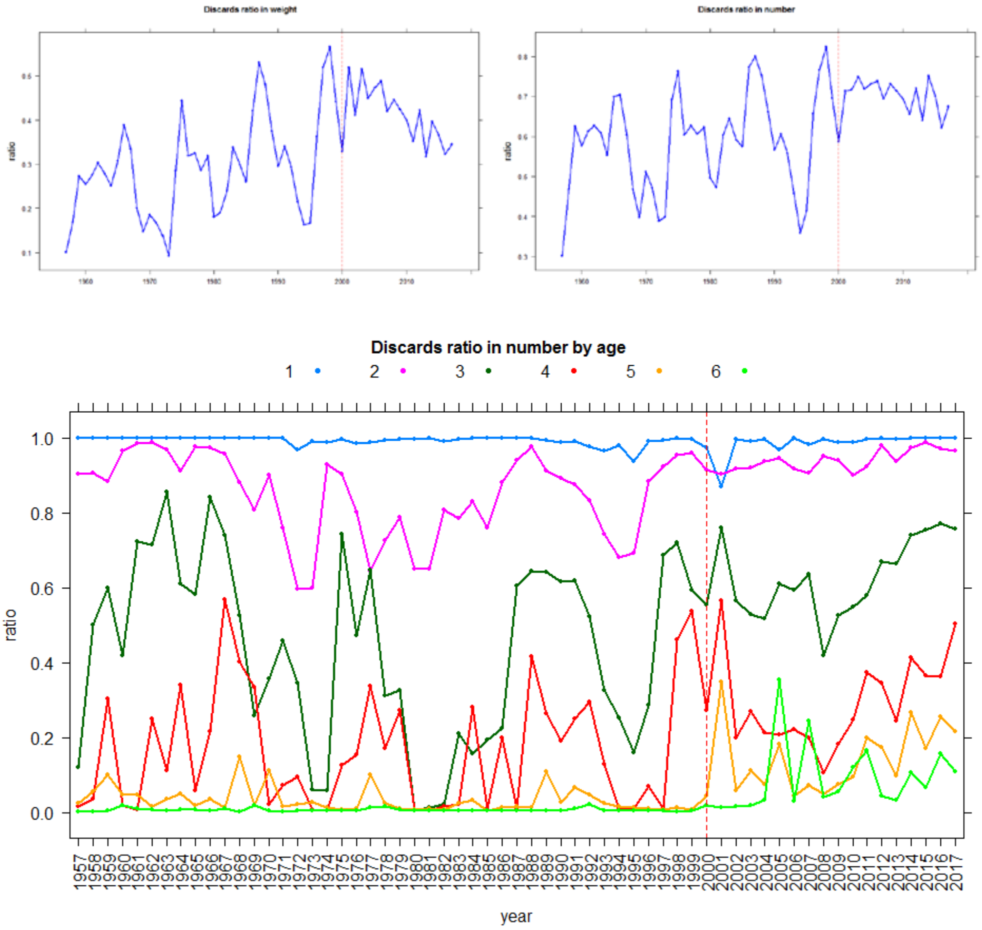
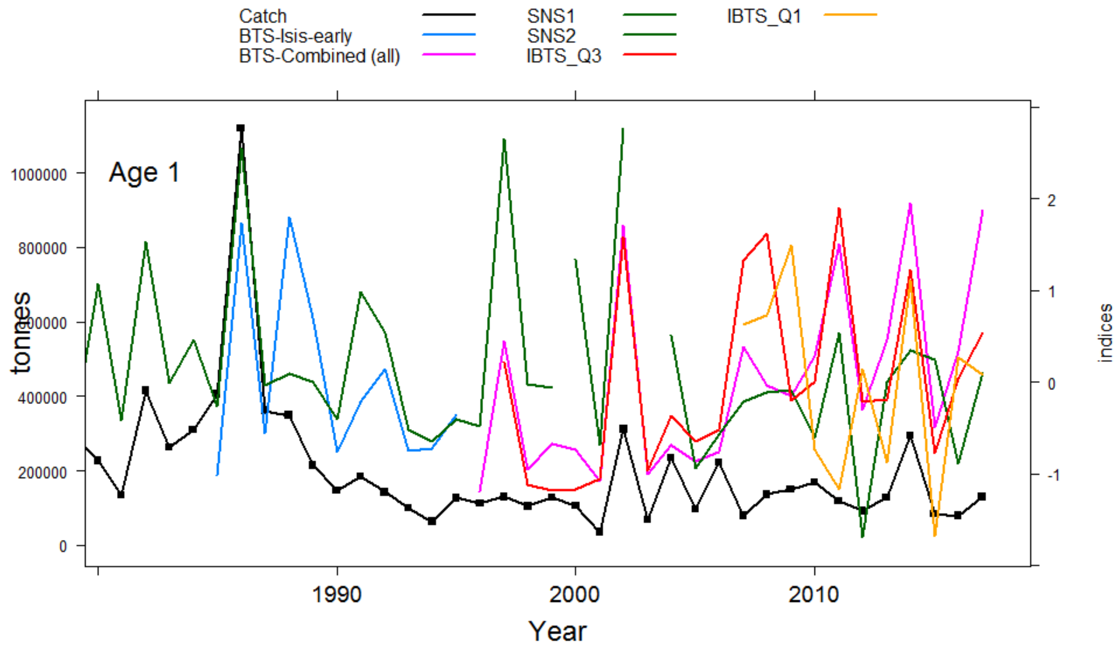
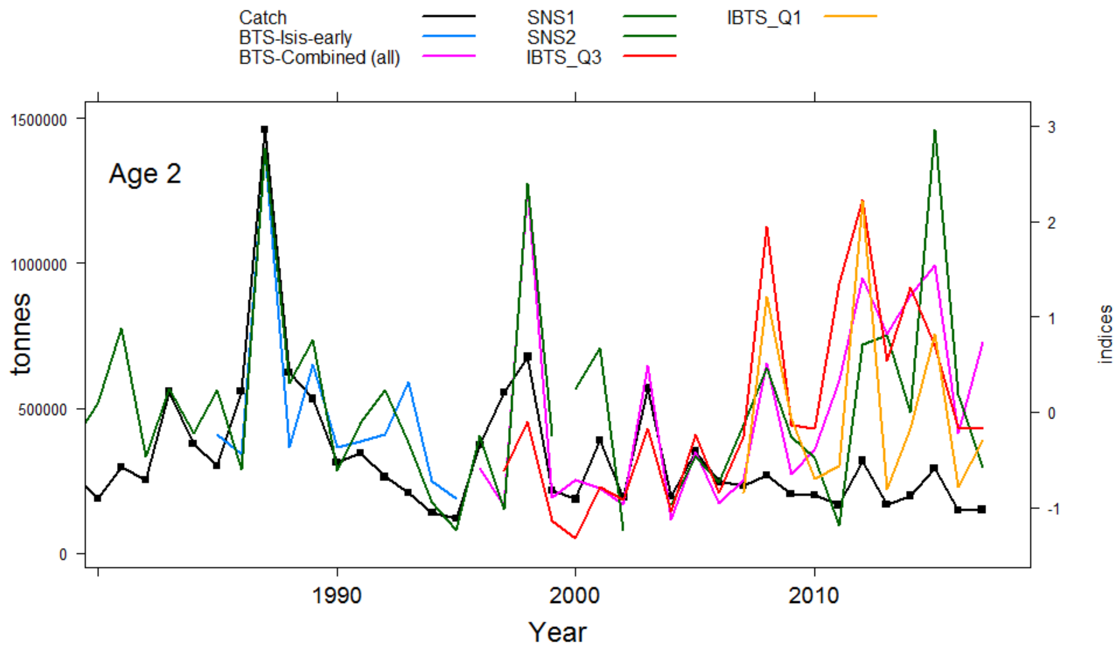


Figure 14.2.15. Discards ratio. Discards before 2000 were reconstructed using a model based method.



Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 1
tonnes
indices
Year
1990
2000
2010
0
200000
400000
600000
800000
1000000
-1
0
1
2



Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 2
tonnes
indices
Year
1990
2000
2010
0
500000
1000000
1500000
-1
0
1
2
3

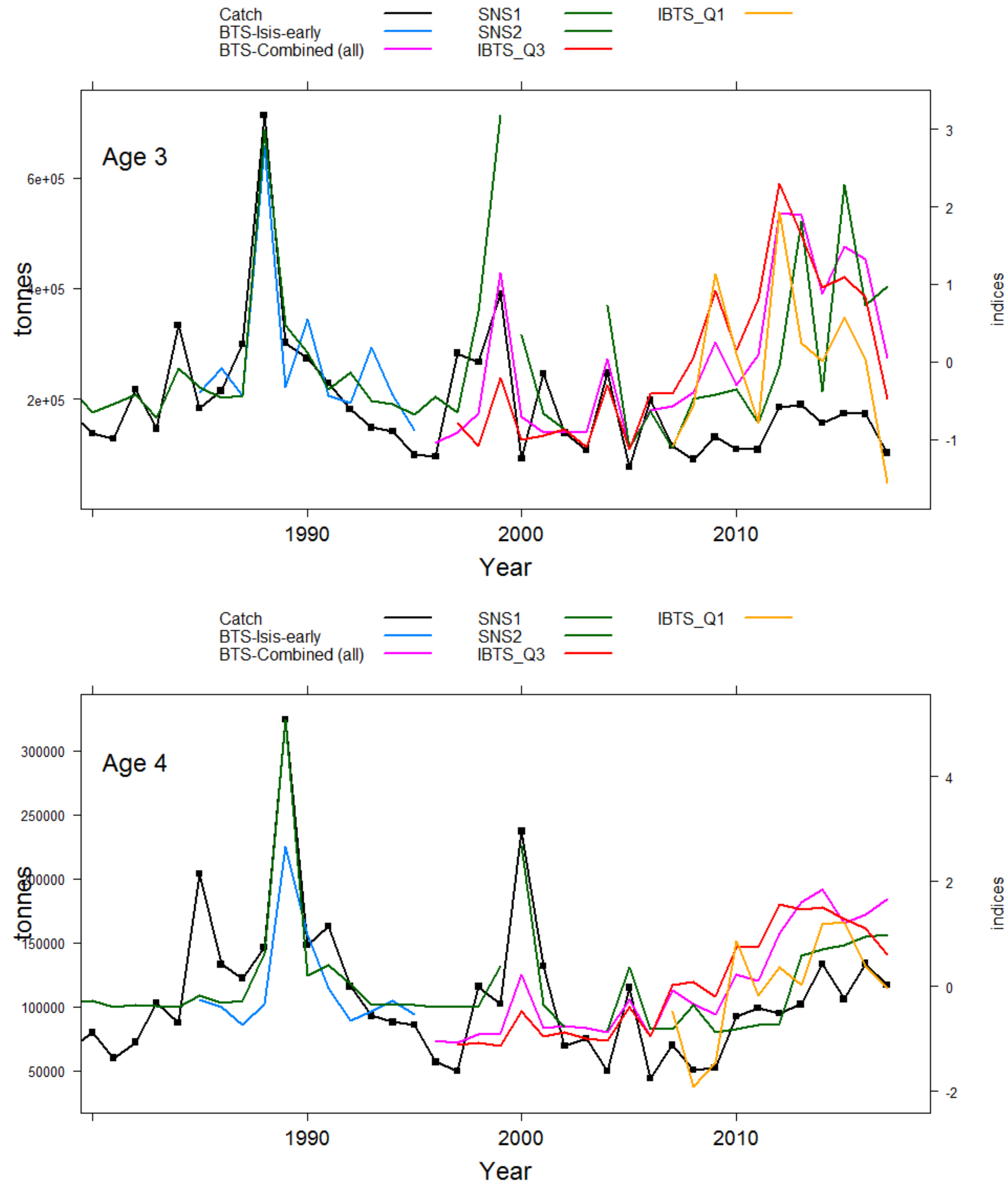


Figure 14.2.16: Catches vs. standardized survey indices by age (1–4).

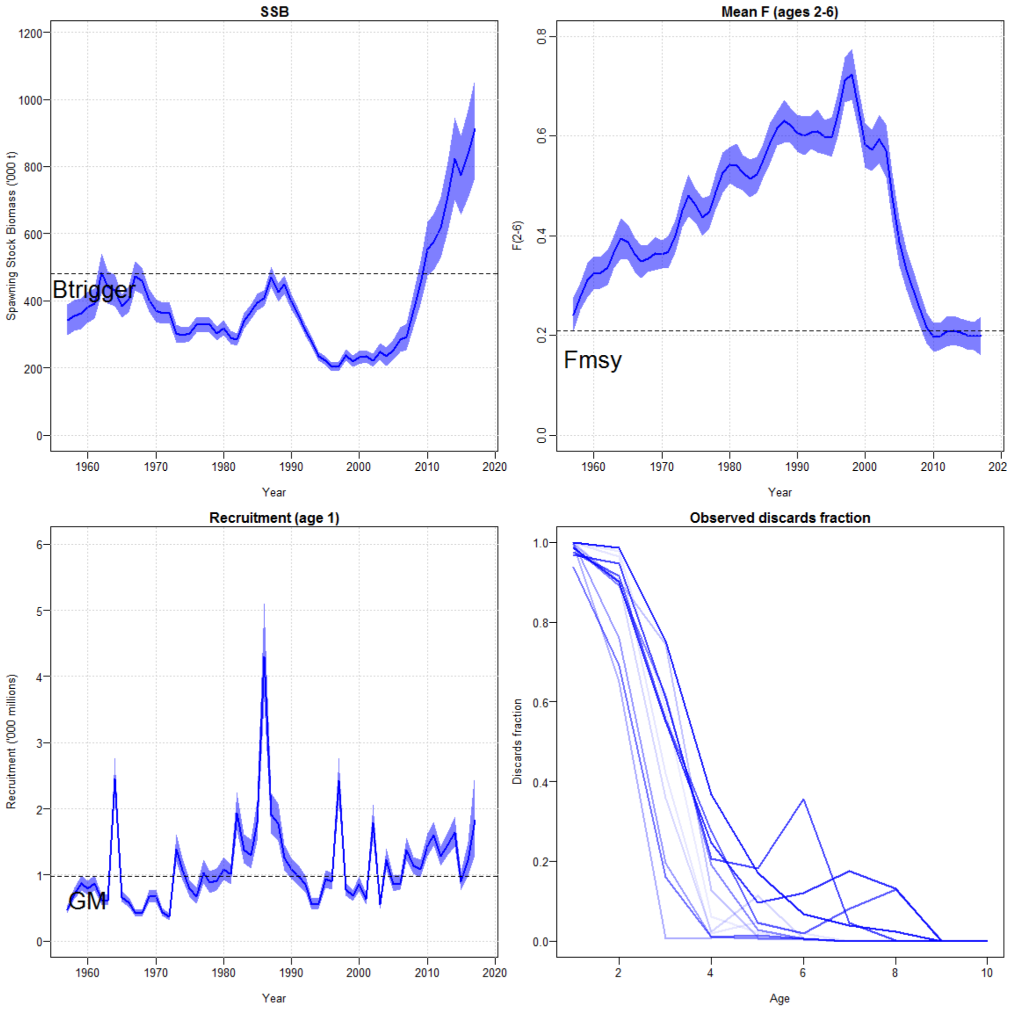


Figure 14.3.1. Stock assessment output for ple.27.420. SSB (top left), fishing mortality (top right), recruitment (bottom left) estimates of the assessment and the observed discards fraction (bottom right).

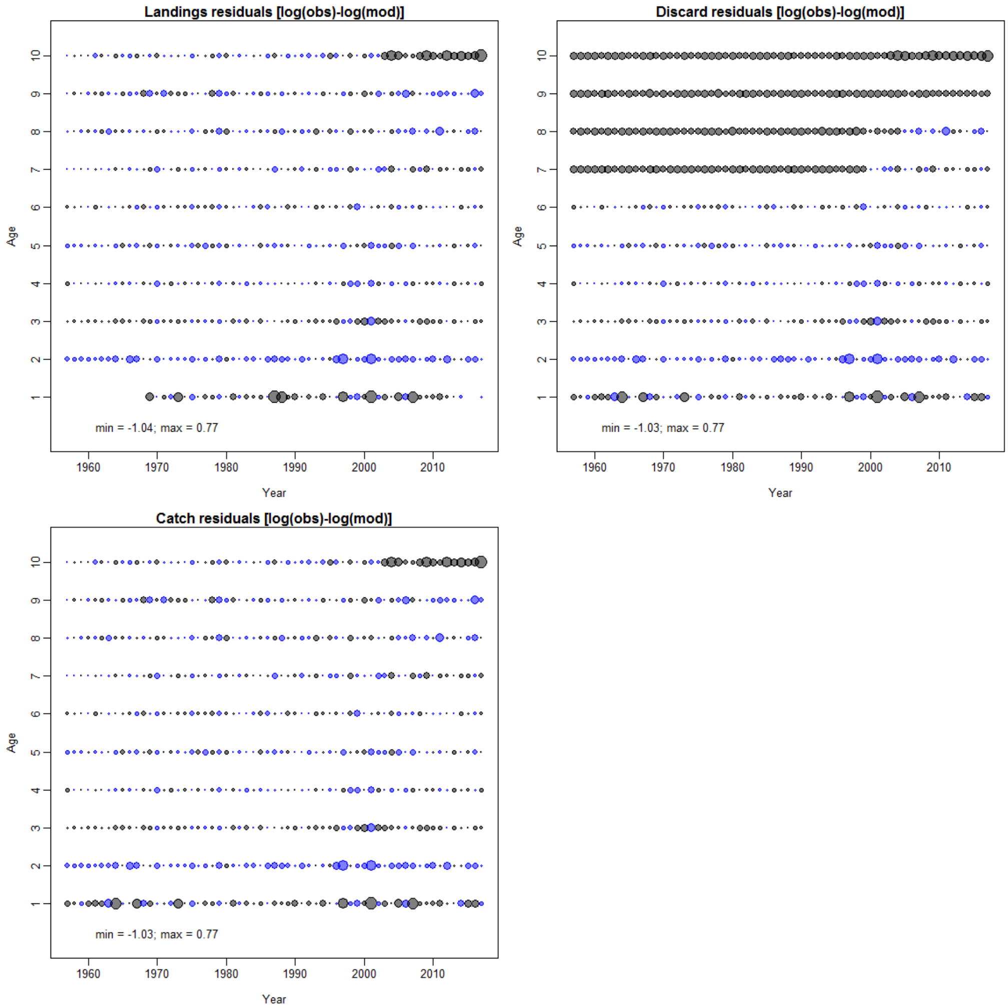


Figure 14.3.2. Landing, discard and catch residuals (not standardized): Positive values are in blue and negative values are in black.

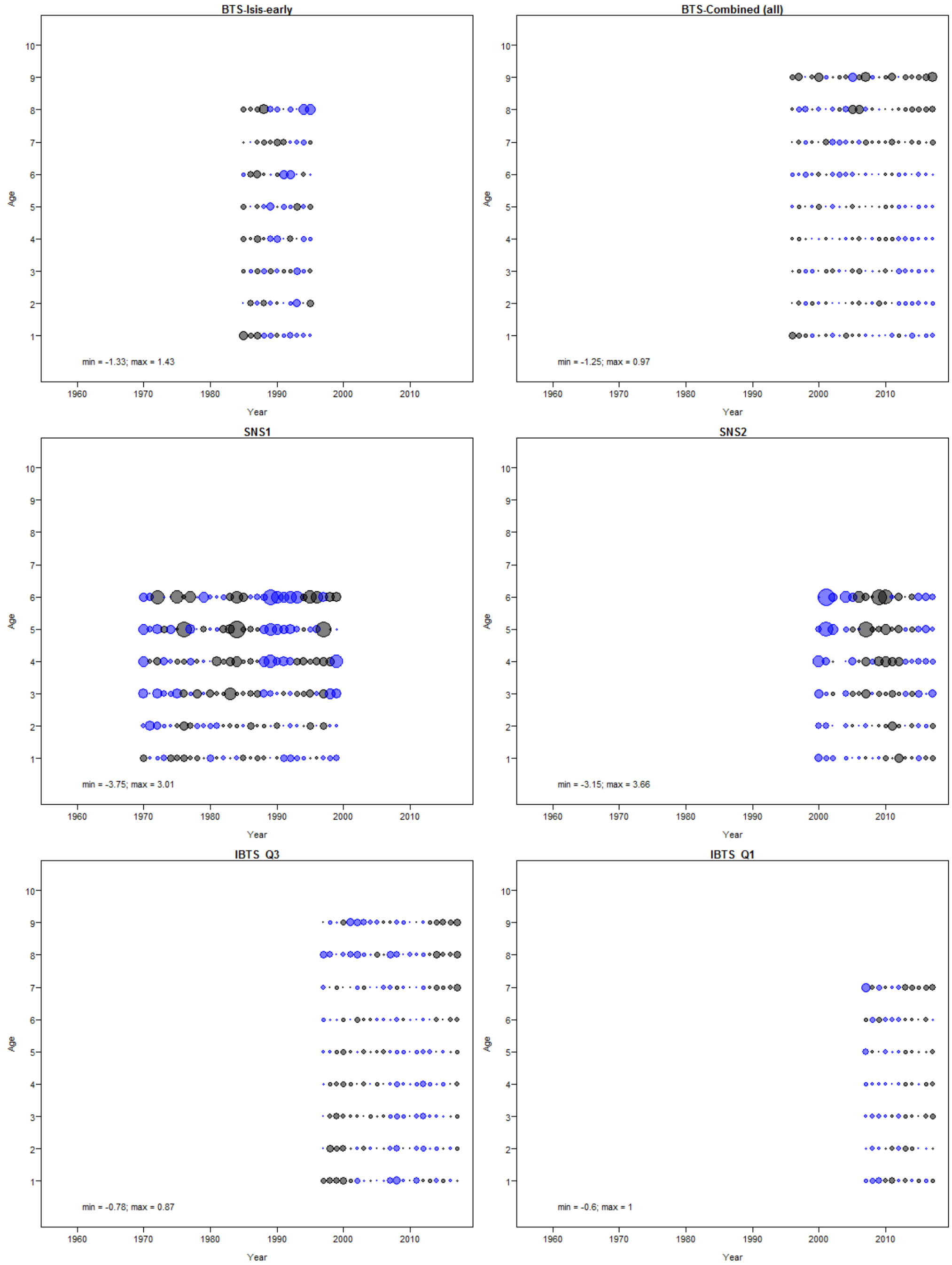


Figure 14.3.3. Survey residuals (not standardized). Positive values are in blue and negative values are in black.

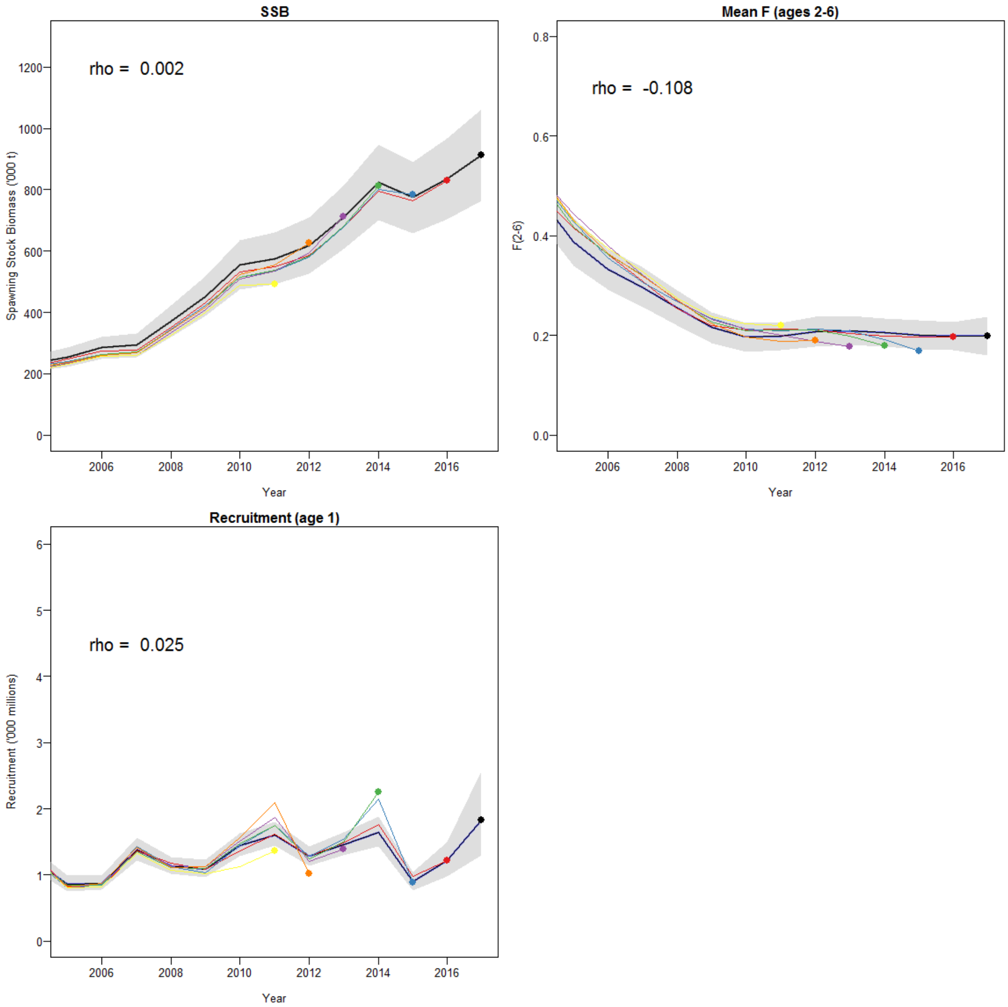


Figure 14.3.4. Retrospective pattern of the final AAP run with respect to SSB, recruitment and F.

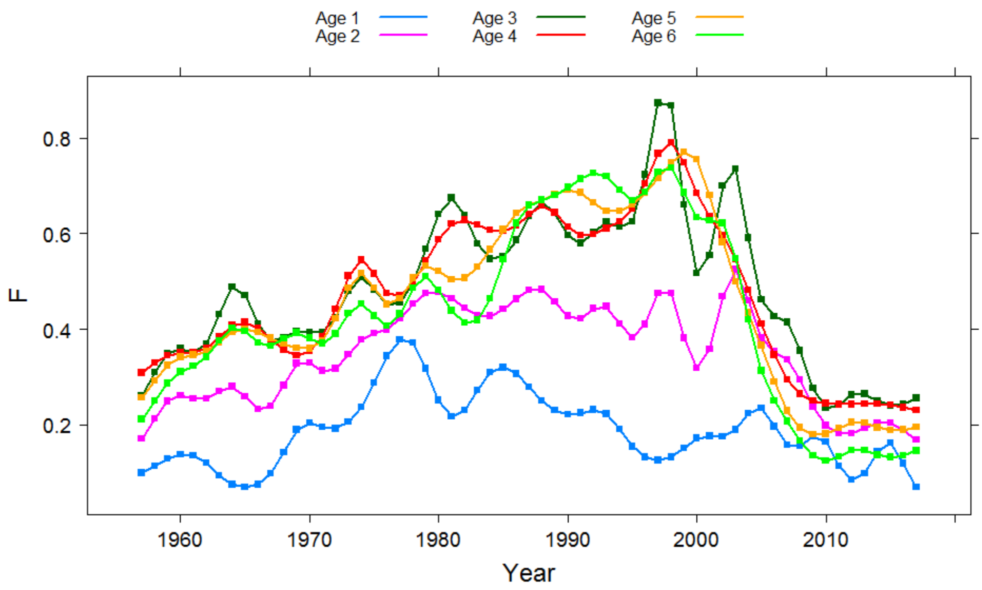


Figure 14.3.5. Estimated fishing mortality by age.

15 Plaice in Division 7.d

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). The Short Term Forecast procedure had to be modified this year, and the Stock Annex was revised accordingly.

15.1 General

15.1.1 Stock definition

A summary of available information can be found in the stock annex.

15.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2017. All available information on ecological aspects can be found in the Stock Annex.

15.1.3 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.

15.1.4 ICES advices for previous years

2016 advice: ICES advises that when the MSY approach is applied, catches of the Division 7.d plaice stock in 2017 should be no more than 12 805 tonnes. If discard rates do not change from the average of the last three years (2013–2015), this implies landings of no more than 7550 tonnes. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2015, this will correspond to catches of plaice in Division 7.d in 2017 of no more than 14 864 tonnes. If discard rates do not change from the average of the last three years (2013–2015), this implies landings of no more than 8764 tonnes.

2017 advice: ICES advises that when the MSY approach is applied, total catches from the stock in 2018 should be no more than 10 592 tonnes. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2016, this will correspond to catches of plaice in Division 7.d in 2018 of no more than 12 378 tonnes. If discard rates do not change from the average of the last three years (2014–2016), this implies landings of no more than 8335 tonnes.

15.1.5 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.

15.2 Data available

15.2.1 Catch

Landings data as reported to ICES are shown in Figure 15.2.1.1, Figure 15.2.1.2 as well as in Table 15.2.1.1 together with the total landings estimated by the Working Group. The 2017 landings of 4576 tonnes are slightly higher than the catch level of the past 10 years (between 3500 and 4400 tonnes). As last year, Belgium (48%) is the highest contributor to the total 7.d landings in 2017, with France contributing for 33% and UK for 17.7%. The landings are significantly higher for the quarter 1 (and 4 to a lesser extent), mainly due to the seasonal activity of the Belgian beam trawl fleet (figure 15.2.1.2).

Routine discard monitoring began following the introduction of the EU data collection regulations. Based on the sampling intensity (ICES 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 4 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 15.2.1.2 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.

15.2.2 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 87% of the landings (Figure 15.2.2.1). Belgium has not always been able to provide landings data per quarter: for 2004, 2005, 2006, 2011, catch data were provided per semester or year. Since 2013, they are provided per year for the TBB fleet. 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 nets quarter 4***	All nets quarter 3 and 4
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.**

***** Lack of sampled fleet in quarter 4 for netters.**

Discards data have also been provided under the ICES InterCatch format by France, Belgium, and the UK since WKPLE (ICES, 2015). In 2017, 79% 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 27% of the total discards.

Unsampled fleet*	Sampled fleet**
TBB	TBB
GNS-GTR	GNS GTR
OTB70-99	OTB70-99
OTB others	OTB
Seines (SDN and SSC)	Seines (SDN)
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 72% of the total discards (imported + raised).

15.2.3 Age compositions

Age compositions of the landings and of the discards are presented in Table 15.2.3.1 and Figure 15.2.3.1, and Table 15.2.3.2 and Figure 15.2.3.2 respectively.

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2017 in Figure 15.2.3.3.

Figure 15.2.3.4 presents the discards at age ratios (i.e. discards numbers / landings numbers) per age over the sampled period 2006–2017. From 2012, the ratio is higher for the ages 1 to 4. The ratio for age 5 also increased to more than 20% in 2015–2017.

15.2.4 Weight-at-age

Weights at age in the landings, in the discards and in the stock are presented in tables 15.2.4.1, 15.2.4.2 and 15.2.4.3 respectively and in Figure 15.2.4.1. 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 landing weights in 2013–2017 for ages 5, 6 and 7.

15.2.5 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

15.2.6 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 15.2.6.1 and Table 15.2.6.1). The International Young fish survey is also presented, although not used in the assessment. They are fully described in the stock annex.

Both time series were re-calculated in 2016 and the impact of those changes were assessed at the last WGNSSK (ICES, 2016).

The consistencies between ages are good for the UK-BTS survey, and correct for ages 2 to 6 (Figure 15.2.6.2).

15.3 Assessment

The model used is the Aart and Poos model (AAP, Aarts and Poos, 2009, for more details please refer to the Stock Annex).

Year of assessment:		**2018**
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
UK Beam Trawl Survey	Age range Year range	1–6 1988 onwards
FR Ground Fish Survey	Age range Year range	1–6 1988 onwards
Catch/Landings		
Age range:		1–7+
Landings data:		1980–2017
Discards data		2006–2017
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

15.3.1 Results

The landings and discards estimated by the model are presented in Figure 15.3.1.1 and the residuals in Tables 15.3.1.1 and 15.3.1.2. Given the observed trend in the discard at age ratio (see section 15.2.3), the average discard at age ratio over 2006–2011 is used to estimate the discards prior to 2006; while the actual discard at age ratios are used in the assessment to estimate the discards for the last 6 years (2012 to 2017).

The survey residuals are shown in Figure 15.3.1.2 and Table 15.3.1.3 for 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 most recent years for ages 1 to 3.

The final outputs are given in Table 15.3.1.4 (fishing mortalities) and Table 15.3.1.5 (stock numbers). A summary of the assessment results is given in Table 15.3.1.6 and trends in fishing mortality, recruitment, spawning stock and total catches are shown in

Figure 15.3.1.3. Retrospective patterns for the final run are shown in Figure 15.3.1.4 with their associate Mohn's Rho value.

The 1986 year class dominated the history of this stock until the late 2000s (Figure 15.3.1.5 and 15.3.1.3). 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. From 2006 onwards, a series of high recruitments occurred, reaching a maximum in 2011, which caused the biomass to increase until 2014 then stabilize and decrease in 2016–2017 (Figure 15.3.1.3). The last two years of recruitment (2016–2017) are significantly lower than the series before.

15.4 Biological reference points

F_{MSY} was estimated in 2015 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.

In 2016, F_{lim} and F_{pa} were calculated according to the recommendations from ACOM (ICES, 2016).

15.5 Short-term forecasts

Weight-at-age in the stock and in the catch were taken to be the average estimated weights 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 2015 are AAP survivors estimates.

15.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated.

For 2018 and the previsions (2019 and 2020), the recruitment was calculated as the geometric mean recruitment over the whole period 1980–2017 (red line in Figure 15.5.1.2), instead of over the period y–5 to y–2 (i.e. 2012–2015 this year, blue line) recommended in the stock annex. This decision was made during the group given the drop in the recruitment over the last three years.

15.5.2 Calculation of the 7.d resident stock

This year, F for the intermediate year is set as equal to F in 2017 (status quo). The landings in 2016 and 2017 were significantly lower than the TAC (in 2016, prorata of it in 2017, see Figure 15.2.1.1), leading to the decision that the usual fully taken TAC assumption was inappropriate.

15.5.3 Management options tested

15.5.3.1 Calculation of STF

Potential TACs for 2019 were calculated using $F_{MSY\ lower}$, $F_{MSY\ upper}$ and F_{MSY} as prescribed by the Administrative Agreement (AA) with the EU. Alternative options were also tested. Results are presented in Table 15.5.3.1.1 for the resident stock.

Following the AA would lead to catches from the stock in 2019, that correspond to the fishing mortality (F) ranges, between 5670 tonnes and 10 435 tonnes. According to the AA, catches higher than those corresponding to F_{MSY} (7864 tonnes) can only be taken under conditions specified in the AA, whilst the entire range is considered precautionary when applying the ICES advice rule.

These options are then calculated for the total 7.d stock (including the migratory components from 4 and 7.e) using the long term average of the migratory landings over the total annual landings (Figure 15.5.3.1).

Following the AA would lead to catches in 2019 for the plaice in 7.d between 6651 tonnes and 12 239 tonnes. Again, catches higher than those corresponding to F_{MSY} (9225 tonnes) can only be taken under conditions specified in the AA.

15.6 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. (The plaice 4 was benchmarked in 2017; a change in natural mortality values was explored but not adopted (ICES, 2017).

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.

Landings-at-age 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.

15.7 Status of the stock

15.8 ICES assesses that fishing pressure on the stock is below F_{MSY}; and spawning stock size is above MSY $B_{trigger}$.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}).

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.

Table 15.2.1.1. Plaice in 7.d: Nominal landings (tonnes) as officially reported to ICES, 1976–2014.

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7.d (1)	Estim.discards 7.d (2)	Tot. land. rep. in 7.e (1)	Agreed TAC (3)
1976	147	1439	376		1962	1	1963		640	
1977	149	1714	302		2165	81	2246		702	
1978	161	1810	349		2320	156	2476		784	
1979	217	2094	278		2589	28	2617		977	
1980	435	2905	304		3644	-994	2650		1178	
1981	815	3431	489		4735	34	4769		1676	
1982	738	3504	541	22	4805	60	4865		1878	
1983	1013	3119	548		4680	363	5043		1714	
1984	947	2844	640		4431	730	5161		1758	
1985	1148	3943	866		5957	65	6022		1677	
1986	1158	3288	828		5274	1560	6834		2078	
1987	1807	4768	1292		7867	499	8366		2272	8300
1988	2165	5688	1250		9103	1317	10420		2835	9960
1989	2019	3713	1383		7115	1643	8758		2742	11700
1990	2149	4739	1479		8367	680	9047		2985	10700
1991	2265	4082	1566		7913	-100	7813		2183	10700
1992	1560	3099	1572	1	6232	105	6337		1882	9600
1993	877	2792	1102		4771	560	5331		1614	8500
1994	1418	3199	1007	9	5633	488	6121		1404	9100
1995	1157	2598	814		4569	561	5130		1247	8000
1996	1112	2630	856		4598	795	5393		1266	7530
1997	1161	3077	1078		5316	991	6307		1583	7090
1998	854	3276	700		4830	932	5762		1346	5700
1999	1306	3388	743		5437	889	6326		1543	7400

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7.d (1)	Estim.discards 7.d (2)	Tot. land. rep. in 7.e (1)	Agreed TAC (3)
2000	1298	3183	754		5235	779	6014		1625	6500
2001	1346	2962	660		4968	298	5266		1310	6000
2002	1204	3450	841	1	5496	281	5777		1472	6700
2003	998	2893	756	3	4650	-564	4086		1387	5970
2004	954	2766	582	10	4312	438	4750		1337	6060
2005	832	2432	421	21	3706	285	3991		1319	5150
2006	1024	1935	550	16	3525	121	3646	749	1411	5151
2007	1355	2017	463	10	3845	156	4001	1252	1146	5050
2008	1386	1740	471	12	3609	255	3864	936	1112	5050
2009	1002	1892	612	16	3522	38	3560	1528	1024	4646
2010	1123	2190	517	62	3892	519	4411	2511	1208	4274
2011	1067	1994	472	60	3593	56	3649	2025	1417	4665
2012	1045	1962	542	63	3612	111	3723	3336	1492	5062
2013	1295	2159	641	87	4182	-55	4127	2955	1472	6400
2014	1389	2229	633	76	4327	-7	4320	3886	1490	5322
2015	1600	1702	392	54	3748	-21	3727	2821	1424	6223
2016	2244	1557	795	60	4656	-18	4638	3603	2013	12446
2017	2189	1487	814	86	4576	37	4613	5065	2128	10022

[1]As provided to ICES through InterCatch

[2]Raised with InterCatch from BE, UK and FR estimated discards data.

[3]TAC´s for Divisions 7.d,e. Since 2016, a catch advice is given rather than a landing advice.

Table 15.2.1.2. 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
2016	4638	1020	3618	3603	514	3090
2017	4613	924	3688	5065	990	4075

[1]**Takes into account the removal of 65% of the Quarter 1 landings or discards.**

Table 15.2.3.1. 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
2016	12	233	2115	2220	1431	1719	1028
2017	3	120	1370	2772	1753	987	1645

Table 15.2.3.2. 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
2016	1767	6524	7917	1801	589	227	27
2017	2045	7478	9758	4581	672	347	66

Table 15.2.4.1. Plaice in 7.d: Weights in the landings.

	1	2	3	4	5	6	7
1980	0.31439	0.31744	0.5077	0.63794	0.80073	1.15887	1.43872
1981	0.23054	0.28842	0.3598	0.44758	0.6868	0.83921	1.03182
1982	0.23742	0.26262	0.34208	0.41767	0.62021	0.77041	1.19328
1983	0.25367	0.28227	0.33282	0.40052	0.51687	0.78388	1.17753
1984	0.21111	0.26728	0.30443	0.36423	0.46027	0.62427	0.85249
1985	0.24125	0.26404	0.28589	0.40556	0.4768	0.54138	0.82009
1986	0.23065	0.31229	0.3378	0.41435	0.55723	0.49599	0.82261
1987	0.2501	0.28099	0.35871	0.47529	0.57493	0.78019	0.96679
1988	0.27934	0.25638	0.30709	0.41327	0.53573	0.62852	0.92558
1989	0.19932	0.26575	0.31831	0.3669	0.46904	0.64257	1.07336
1990	0.20864	0.26573	0.3384	0.39237	0.50137	0.63319	1.09115
1991	0.22348	0.27513	0.3089	0.38737	0.45094	0.55225	1.0089
1992	0.18102	0.2755	0.3501	0.42668	0.50625	0.58184	0.79086
1993	0.21684	0.26809	0.33117	0.42579	0.49971	0.5825	0.85251
1994	0.24814	0.27571	0.29409	0.36353	0.47585	0.58818	0.99575
1995	0.21495	0.26721	0.30862	0.38454	0.47821	0.67837	0.93169
1996	0.22815	0.3097	0.29938	0.40881	0.49037	0.6638	1.11494
1997	0.20063	0.25406	0.30044	0.33471	0.44561	0.58172	1.02408
1998	0.16748	0.25701	0.28124	0.40132	0.52877	0.80263	1.17482
1999	0.20366	0.25328	0.24295	0.31635	0.47659	0.77639	1.13307
2000	0.21654	0.25629	0.27303	0.29604	0.39228	0.60254	0.95256
2001	0.23283	0.27289	0.32812	0.40068	0.48406	0.69523	1.13258
2002	0.2461	0.24804	0.29939	0.36431	0.42438	0.54452	0.81943
2003	NA	0.28622	0.3761	0.48531	0.64257	0.65378	0.87182
2004	0.24467	0.29736	0.39867	0.49765	0.68809	0.78562	0.99318
2005	0.29038	0.31848	0.35137	0.45228	0.56756	0.66576	1.10896
2006	0.26078	0.27936	0.30636	0.36449	0.44742	0.55673	0.85001
2007	0.18198	0.31841	0.39818	0.47736	0.54608	0.61288	0.95916
2008	0.23962	0.29281	0.35094	0.43377	0.5493	0.64711	0.97517
2009	0.24041	0.29083	0.34983	0.49837	0.52618	0.65998	1.07319
2010	0.23179	0.30462	0.35903	0.45088	0.51169	0.65817	0.84652
2011	0.1591	0.26359	0.3541	0.48737	0.63683	0.82035	1.07628
2012	0.20444	0.29674	0.35771	0.45189	0.55855	0.71549	1.06209
2013	0.1454	0.26339	0.32057	0.39501	0.4977	0.73778	1.07662
2014	0.17632	0.26041	0.29535	0.37295	0.51386	0.70388	0.98627
2015	0.12573	0.22679	0.3035	0.34607	0.41311	0.53777	0.8417
2016	0.20264	0.31723	0.31916	0.35554	0.41488	0.46016	0.67328
2017	0.11464	0.1917	0.2763	0.36206	0.44454	0.52094	0.58985

Table 15.2.4.2. Plaice in 7.d. Weights in the discards.

year	1	2	3	4	5	6	7
2006	0.100	0.138	0.166	0.206	0.259	0.566	NA
2007	0.103	0.139	0.157	0.163	0.284	0.214	NA
2008	0.118	0.153	0.188	0.222	0.219	0.383	NA
2009	0.125	0.138	0.169	0.450	0.731	1.302	0.268
2010	0.104	0.135	0.167	0.180	0.237	0.381	0.369
2011	0.096	0.155	0.174	0.216	0.215	0.228	1.352
2012	0.093	0.130	0.166	0.193	0.213	0.607	NA
2013	0.083	0.128	0.155	0.188	0.249	0.464	0.421
2014	0.090	0.123	0.137	0.232	0.247	0.302	0.385
2015	0.039	0.106	0.156	0.174	0.220	0.274	0.622
2016	0.171	0.165	0.155	0.175	0.181	0.203	0.403
2017	0.131	0.147	0.162	0.191	0.227	0.218	0.221

Table 15.2.4.3. 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
2016	0.25754	0.29437	0.32643	0.36815	0.48066	0.51592	0.71946
2017	0.1089	0.18211	0.26247	0.34395	0.42229	0.49488	0.56034

Table 15.2.6.1. Plaice in 7.d: Tuning fleets.

UK BTS						
1989 2017						
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
1	12.5	101.4	102.9	37.9	21.3	23.2
1	50.1	102.1	83.2	56.0	16.6	8.4

Table 15.2.6.1. (cont.) Plaice in 7.d: Tuning fleets.

FR GFS						
1993 2017						
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
1	10.39	44.9	243.12	367.0	136.91	93.37
1	8.31	53.59	108.57	147.1	142.44	44.55

Table 15.3.1.1. Plaice in 7.d: Landings Residuals.

age	1	2	3	4	5	6	7
1980	-0.687352647	0.795871692	-0.451679186	-0.296836801	0.214964181	-0.032306778	-0.120097968
1981	-1.457144722	0.166833378	0.396113989	0.341250172	-0.1040166	-0.18594795	0.298726016
1982	0.419991155	0.164345031	-0.09365801	-0.056366082	0.062968025	0.36184556	-0.293321763
1983	-0.595540279	0.161557817	-0.270127896	0.094044451	-0.313753763	-0.221897393	-0.050520068
1984	0.793751693	-0.331932951	-0.18484181	0.145622768	0.126712772	0.135712621	0.270230476
1985	-0.230778665	0.690835504	-0.277521971	0.217015382	-0.518109328	-0.058353999	-0.00517436
1986	0.689673808	0.318098816	-0.124366649	0.160422377	0.177255244	0.555094876	-0.548115573
1987	-2.211628882	0.325243932	-0.191636631	0.042920748	0.086894251	-0.386999365	0.237301078
1988	-2.526302597	0.3694286	0.155509783	-0.026177725	-0.199029801	-0.044214798	0.083151459
1989	1.299471232	0.337443221	-0.29768154	-0.160220648	0.277508862	0.005284052	-0.027857572
1990	1.336127604	0.11789778	0.246607107	-0.081547114	-0.125283878	-0.010254064	0.20668789
1991	0.14201464	0.578710629	0.204282673	0.25138843	0.080654312	-0.022440224	-0.125741153
1992	-0.562944148	-0.003369864	0.148628471	-0.006555899	-0.02893126	0.042208062	-0.032254497
1993	-0.999301314	0.028949917	-0.245573347	-0.112574637	-0.178375313	-0.162296683	-0.208989578
1994	-0.214637647	0.155151733	0.286640105	0.370092768	0.356181451	0.333142791	0.191064859
1995	0.706049183	0.688544814	0.060120338	-0.047194942	-0.124363154	-0.284709368	-0.081822254
1996	0.558035787	0.467737276	0.184597986	-0.217030563	-0.022647799	-0.05886684	-0.12825315
1997	-0.312647765	0.250165217	0.148151314	0.5282391	0.397674754	0.305033625	0.165016306
1998	-0.269059748	-0.389863766	0.149900735	-0.079731294	-0.062701965	-0.271008403	-0.322662443
1999	-0.481768717	-0.79075942	0.05809683	0.4765222	0.100387331	0.388258521	0.172219662
2000	-0.458307058	0.591200357	-0.212432215	-0.1081269	-0.04367772	-0.021453683	0.202602898
2001	0.835116178	0.115557763	0.074563192	-0.347673819	-0.156023917	-0.279537338	-0.10445847
2002	0.292680888	0.873708913	0.102949569	0.030691172	0.519895102	-0.09592895	-0.066461165
2003	-4.986369924	-0.053933024	-0.683666166	0.049607719	-0.237940157	0.010806623	0.11761828
2004	2.090061239	0.521719344	-0.383049416	-0.423908363	-0.036636914	-0.067798612	-0.161572571
2005	-0.105464147	0.456628365	-0.432786044	-0.065361267	0.141680811	0.113433344	0.079096255
2006	0.540130162	0.616490418	-0.23802157	0.244362651	0.245804018	-0.222465494	0.039681702
2007	0.834571214	0.555369113	-0.453741823	-0.251266254	0.116219866	-0.045227474	-0.080726855
2008	-0.101799981	0.239303577	-0.355884406	-0.135220552	0.063761576	-0.116571618	-0.320651033
2009	0.140107028	-0.098108894	-0.450976361	-0.145331381	0.019017283	-0.049678982	-0.165909931
2010	0.209283482	0.124257482	-0.361855358	0.148655529	0.331861073	0.548734276	0.137768298
2011	-1.406349093	0.07500362	-0.575062421	-0.431540283	-0.164290215	-0.575574686	-0.549081184
2012	0.008572479	0.045679168	-0.014770379	0.08287352	0.124754093	0.294858721	-0.093013425
2013	-0.075247138	0.084617775	-0.034627324	0.047878143	0.189642607	0.180107723	-0.386552727
2014	-0.041960573	0.092524985	0.445691248	0.053374829	0.111768904	0.114625905	-0.471337145
2015	0.004038888	-0.138260294	-0.145768912	-0.275140568	-0.199000522	0.112618811	0.057048893
2016	-0.12174733	-0.22567486	-0.232671261	-0.102472705	0.034869049	0.061610232	-0.246528966
2017	-0.071586603	0.413953187	-0.009531792	0.069531221	0.124253058	0.154960046	-0.359401617

Table 15.3.1.2. Plaice in 7.d: Discards Residuals.

age	1	2	3	4	5	6	7
2006	-0.136554161	0.085328335	0.109192885	-0.716725796	-0.773200533	0.033724761	0.315964539
2007	-0.062514251	0.737763718	0.124755145	0.433430692	-2.68163272	-0.054503867	0.389444262
2008	0.24847103	-0.478477414	-0.865666771	0.114179446	0.826922063	1.518090033	0.805607882
2009	-0.180017187	0.114467363	-0.028642098	0.031583722	0.412559213	2.554026916	1.806616487
2010	-0.190034697	0.714135486	0.471000835	0.853661485	1.195403989	1.145551943	1.796658002
2011	0.125252836	0.334277291	-0.529375975	-0.076803817	0.275957508	3.089913943	1.386456972
2012	0.029165418	0.04608015	-0.014544743	0.083890387	0.144362698	1.426359602	3.922540767
2013	-0.039171973	0.085304069	-0.034417993	0.04854388	0.201158677	0.282044637	0.384348059
2014	-0.03681227	0.09318457	0.445994733	0.053765446	0.113998374	0.128030183	-0.370322453
2015	0.100430371	-0.137509693	-0.145318732	-0.274208858	-0.197492452	0.116638312	0.08223083
2016	-0.092100141	-0.223902723	-0.232365627	-0.101744656	0.036829268	0.066220281	-0.209552597
2017	0.012853596	0.417230668	-0.009150223	0.069884365	0.125956212	0.158219431	-0.344202545

Table 15.3.1.3. Plaice in 7.d: Survey residuals.

UK BTS						
age	1	2	3	4	5	6
1989	-1.387198137	-0.67145254	-0.057497594	0.382780043	-0.083251193	0.129118805
1990	-0.510585352	-0.673439736	-0.508518951	-0.163425936	0.196160668	-0.347220191
1991	-0.378352352	-0.123501452	0.126504858	0.033824008	0.2153196	-0.180130554
1992	-0.284916274	-0.085077438	-0.224042357	0.38882394	0.489396717	0.326095777
1993	-1.138272184	-0.266708655	-0.350952737	-0.249591333	0.205117915	-0.040379307
1994	-0.305277371	-0.422834204	-0.264342813	0.178626901	0.072828974	-0.662592352
1995	-0.403249831	-0.698388848	-0.542886512	0.043693837	-0.056972139	-0.220929628
1996	-0.169436957	-0.356140819	-1.28025974	-0.795895456	-0.121419253	0.107652986
1997	0.040170318	-0.106889819	-0.183036366	-0.53269861	0.546114437	-0.563542575
1998	0.308505267	-0.382130315	-0.396533573	0.038113029	-0.187440428	0.453872195
1999	-0.323623828	-0.857513108	-0.128950311	-0.46158781	-0.216444385	-0.065376859
2000	-0.018002336	0.501005619	0.247589757	0.323228609	0.323079099	0.134409498
2001	0.466574791	0.035689805	0.366929289	0.383739865	0.661855827	0.283514891
2002	0.296156748	0.316476633	0.245454736	0.250725025	-0.248072948	0.189518746
2003	-0.356722634	0.16562982	0.031877925	0.088697495	0.079091921	-0.450032448
2004	1.053025149	0.14952526	0.09199232	0.170442717	-0.51421478	-1.167403697
2005	-0.033693915	0.410851192	0.066720328	0.150086792	0.429460152	-0.003225945
2006	0.709825047	0.317766716	0.090488715	0.022732318	-0.076224874	0.151079429
2007	0.879167368	0.444126844	-0.061721369	-0.198882743	0.001019907	0.085681324
2008	0.418023678	0.417817125	-0.024856625	-0.37850459	-0.097464919	-0.025824286
2009	0.619462745	0.210436345	0.294822259	0.121126265	-0.100706967	-0.123540335
2010	-0.057625055	0.179252689	-0.128574307	0.166868881	0.041211016	-0.24561516
2011	0.243189316	0.201242139	0.048140578	-0.038019866	0.417154195	0.388138581
2012	-0.646316017	-0.421484431	-0.200577742	-0.12526279	-0.40783978	0.109159543
2013	-0.39813454	-0.060772379	-0.077623192	0.121768532	-0.226770323	-0.192121535
2014	0.779231955	0.869895129	0.007156306	0.096848074	0.093918073	0.071089368
2015	-0.195132572	0.692774943	0.233324493	0.018133493	-0.023399709	0.006046857
2016	-0.589660676	0.508682175	0.44751716	0.275762043	0.185050065	0.070565843
2017	0.634774395	1.244174836	0.677713075	0.435716442	-0.010411652	-0.259130043

Table 15.3.1.3. (cont.) Plaice in 7.d: Survey Residuals.

FR GFS						
age	1	2	3	4	5	6
1993	1.523787695	0.150598782	0.12763711	0.053601782	-0.507075304	-0.444826702
1994	0.736286031	-0.013856422	-0.629785142	-0.426778301	-0.036038762	0.895611828
1995	0.129517204	0.877817316	0.775485854	0.801000405	0.501502329	2.074178862
1996	-0.402154213	-0.506106611	-0.809858941	-0.3093004	0.037263658	0.958140313
1997	0.207835169	-0.380773873	0.656576758	0.221267639	0.474161503	1.846235558
1998	0.283067538	-0.514997938	-0.616601996	-0.227646035	-1.067065101	1.363798632
1999	0.786636907	-0.176651918	0.181504628	0.220398646	-0.057542923	1.655482923
2000	0.915356935	1.111489256	0.31663819	0.425912072	0.66605323	1.023207406
2001	0.208358799	-0.20205845	-0.150806429	0.286894529	-0.411900901	-0.279684317
2002	0.396760671	0.293049869	0.703689687	0.665414154	0.731343329	-0.059317934
2003	0.344334021	0.109857504	-0.089470021	-0.624553959	0.174660998	0.342793013
2004	0.39779441	0.15187838	-0.293049353	0.176886147	-0.875106898	1.21213091
2005	0.569533288	0.903321345	1.0870913	0.425765726	0.766453986	1.062207602
2006	1.184064205	0.528771708	-0.02058531	0.202651992	-0.006891057	0.722491742
2007	0.361755504	0.54249269	0.598498858	0.458436912	0.37517192	-0.582847676
2008	-0.441215425	0.671737606	0.275789798	-0.146940637	-0.820541292	0.303584392
2009	-0.692982685	-0.565444404	-0.477650532	-0.4491563	-1.13300455	-0.192949364
2010	-0.256377718	-0.374447905	-0.621715247	-0.807687814	-0.894409598	0.050843953
2011	0.432748455	0.704383522	0.615179083	0.204878298	-0.855850004	1.708761004
2012	-0.183215235	-0.054517742	0.557728879	0.303548749	0.689269191	0.33009998
2013	0.050491741	-0.383430149	0.107591984	-0.219535729	-0.089472232	-0.423299017
2014	-0.523408782	-0.577329714	-0.004313062	0.328692945	-0.060133205	-0.618817379
2015	-1.887388465	-0.510810339	0.03142838	-0.549438789	-0.390528669	-0.624942592
2016	-1.919904794	-1.150291133	-0.643083883	-0.620873452	-0.337383516	-0.954899301
2017	-1.907735762	-1.209571065	-1.085436877	-0.801351239	-0.995732021	-1.260485428

Table 15.3.1.4. Plaice in 7.d: Fishing mortality (F) at age.

	1	2	3	4	5	6	7
1980	0.0127587	0.124747	0.396105	0.314922	0.173548	0.100394	0.100394
1981	0.0170381	0.140706	0.433951	0.389099	0.234958	0.139473	0.139473
1982	0.0211899	0.159605	0.481981	0.458847	0.294764	0.182457	0.182457
1983	0.0228604	0.183089	0.550188	0.492958	0.31758	0.21166	0.21166
1984	0.0209938	0.209741	0.638416	0.475545	0.2888	0.213803	0.213803
1985	0.0183897	0.226225	0.699495	0.440472	0.252938	0.205369	0.205369
1986	0.0175675	0.215295	0.666449	0.423967	0.248829	0.208109	0.208109
1987	0.0199865	0.184932	0.552997	0.435871	0.287114	0.230983	0.230983
1988	0.0274047	0.169623	0.460105	0.451555	0.337734	0.261161	0.261161
1989	0.0454103	0.197984	0.445591	0.442001	0.347505	0.277321	0.277321
1990	0.086275	0.29321	0.50835	0.404201	0.303346	0.266765	0.266765
1991	0.167732	0.451066	0.594134	0.362102	0.249499	0.235699	0.235699
1992	0.296091	0.58976	0.620044	0.334101	0.215638	0.195371	0.195371
1993	0.405642	0.614129	0.580556	0.331986	0.209834	0.165857	0.165857
1994	0.358587	0.527616	0.544325	0.369991	0.23913	0.165369	0.165369
1995	0.180871	0.392215	0.56217	0.47382	0.325467	0.215233	0.215233
1996	0.0765452	0.287001	0.612404	0.625388	0.461623	0.311844	0.311844
1997	0.0512321	0.244711	0.629682	0.715092	0.551688	0.376879	0.376879
1998	0.0846527	0.274093	0.565545	0.625291	0.47568	0.307576	0.307576
1999	0.206519	0.354972	0.487579	0.473544	0.339064	0.203574	0.203574
2000	0.329056	0.43284	0.468038	0.380425	0.2509	0.148556	0.148556
2001	0.203779	0.428676	0.540883	0.369626	0.225495	0.146749	0.146749
2002	0.0749932	0.357361	0.650795	0.394278	0.229899	0.174214	0.174214
2003	0.0301901	0.269535	0.675069	0.400802	0.237555	0.207014	0.207014
2004	0.0195457	0.200883	0.56275	0.361538	0.23147	0.219503	0.219503
2005	0.0188793	0.166946	0.447944	0.311095	0.215015	0.212812	0.212812
2006	0.023831	0.174646	0.415168	0.278982	0.194419	0.196506	0.196506
2007	0.0329335	0.222395	0.465462	0.267876	0.172957	0.174907	0.174907
2008	0.0393025	0.270387	0.52802	0.260353	0.150911	0.146091	0.146091
2009	0.032331	0.245746	0.503334	0.241343	0.12877	0.111559	0.111559
2010	0.0200194	0.16838	0.392458	0.211434	0.109532	0.0812636	0.0812636
2011	0.0135278	0.110276	0.281273	0.181544	0.0965869	0.0626857	0.0626857
2012	0.014056	0.0866556	0.208346	0.158599	0.0915844	0.0564448	0.0564448
2013	0.0209802	0.0844945	0.170838	0.145391	0.0935093	0.0592591	0.0592591
2014	0.0328128	0.0940802	0.161301	0.143679	0.10079	0.0682755	0.0682755
2015	0.0408313	0.110714	0.180424	0.156217	0.11251	0.0816307	0.0816307
2016	0.0405516	0.13354	0.229984	0.182991	0.128359	0.0991341	0.0991341
2017	0.0359748	0.163065	0.312959	0.222498	0.148043	0.121332	0.121332

Table 15.3.1.5. Plaice in 7.d: Stock number from the assessment.

	1	2	3	4	5	6	7
1980	67189	30069	10023	2422	2004	662	1876
1981	34271	46602	18646	4738	1242	1184	1612
1982	66110	23669	28441	8487	2256	690	1709
1983	59196	45469	14175	12339	3768	1180	1404
1984	60585	40646	26598	5744	5295	1927	1469
1985	78402	41677	23151	9868	2508	2787	1926
1986	155400	54075	23351	8081	4463	1368	2696
1987	95149	107269	30630	8424	3715	2444	2319
1988	62368	65520	62634	12377	3827	1958	2656
1989	40256	42629	38847	27774	5536	1918	2497
1990	41107	27025	24568	17478	12541	2747	2350
1991	68460	26491	14160	10381	8196	6505	2743
1992	89799	40667	11854	5492	5077	4486	5132
1993	47340	46917	15840	4479	2762	2875	5558
1994	40149	22167	17835	6227	2258	1573	5019
1995	61062	19706	9188	7270	3022	1249	3925
1996	68878	35799	9352	3679	3180	1533	2931
1997	119510	44821	18875	3561	1383	1408	2296
1998	59351	79764	24652	7064	1224	560	1785
1999	50782	38310	42601	9838	2656	534	1211
2000	61350	29018	18871	18379	4304	1329	1000
2001	49805	31014	13223	8302	8826	2353	1410
2002	73854	28538	14192	5409	4030	4948	2283
2003	39033	48134	14024	5201	2562	2250	4268
2004	46751	26606	25825	5016	2447	1419	3722
2005	41120	32207	15289	10335	2455	1364	2900
2006	37584	28347	19147	6863	5319	1391	2421
2007	56278	25781	16723	8881	3647	3077	2200
2008	66844	38255	14500	7376	4773	2155	3112
2009	106675	45149	20508	6008	3994	2883	3197
2010	172257	72556	24807	8709	3315	2467	3821
2011	227263	118613	43072	11770	4952	2087	4072
2012	119187	157509	74626	22840	6896	3159	4064
2013	121909	82561	101466	42566	13692	4420	4796
2014	169922	83864	53300	60087	25856	8760	6102
2015	118585	115518	53625	31866	36562	16423	9752
2016	58276	79974	72647	31453	19149	22952	16946
2017	67929	39312	49159	40550	18401	11832	25383

Table 15.3.1.6 Plaice in 7.d: Summary table (Outputs from the model).

Year	Recruitment			SSB (tonnes)			Landings	Discards	F		
	Age 1	High	Low		High	Low	tonnes	tonnes	ages 3–6	High	Low
1980	67189	86581	52112	8212	10386	6038	2223	462	0.25	0.33	0.163
1981	34271	45074	26054	10894	13204	8584	4009	777	0.30	0.38	0.22
1982	66110	86193	50699	13300	15979	10621	4040	861	0.35	0.45	0.26
1983	59196	78020	44949	13389	16073	10705	4093	985	0.39	0.49	0.29
1984	60585	79466	46209	13377	16059	10695	4249	1209	0.40	0.50	0.31
1985	78402	100497	61213	13367	16009	10725	5000	1259	0.40	0.49	0.31
1986	155400	195998	123271	13327	15763	10891	5673	1475	0.39	0.47	0.30
1987	95149	119585	75676	15909	18487	13331	7006	2025	0.38	0.45	0.30
1988	62368	78870	49338	20705	24022	17388	8785	1892	0.38	0.45	0.30
1989	40256	51928	31206	22323	25803	18843	7093	1450	0.38	0.45	0.30
1990	41107	55134	30653	19368	22603	16133	7349	1280	0.37	0.44	0.30
1991	68460	97182	48226	15433	18337	12529	6362	1820	0.36	0.43	0.29
1992	89799	133746	60253	12702	15259	10145	5219	3302	0.34	0.41	0.27
1993	47340	73353	30545	11504	13775	9233	4479	3058	0.32	0.38	0.27
1994	40149	62174	25908	10514	12509	8519	5047	1914	0.33	0.39	0.27
1995	61062	82324	45323	9107	10791	7422	4196	1438	0.39	0.46	0.33
1996	68878	88504	53594	8030	9515	6545	4430	1235	0.50	0.58	0.42
1997	119510	150862	94644	8551	10118	6984	5180	1543	0.57	0.67	0.47
1998	59351	76720	45894	11149	13048	9250	4831	2225	0.49	0.58	0.40
1999	50782	71346	36124	14335	16799	11871	5268	2280	0.38	0.45	0.30
2000	61350	95183	39515	14903	17563	12243	4521	2434	0.31	0.38	0.24
2001	49805	69442	35731	13491	16095	10887	4380	1752	0.32	0.39	0.25
2002	73854	94980	57445	12351	14904	9798	4846	1333	0.36	0.44	0.28
2003	39033	48643	31311	12082	14609	9555	3610	1218	0.38	0.47	0.29
2004	46751	57640	37950	12585	15215	9955	4206	902	0.34	0.43	0.26
2005	41120	49736	33979	12720	15510	9930	3485	691	0.30	0.37	0.22
2006	37584	45350	31127	13186	16116	10256	3225	696	0.27	0.34	0.198
2007	56278	67621	46832	13642	16749	10535	3381	784	0.27	0.34	0.20
2008	66844	81548	54779	13777	16994	10560	3278	1251	0.27	0.34	0.200
2009	106675	128885	88373	14620	17990	11250	3124	1410	0.25	0.31	0.182
2010	172257	210421	141088	17279	21160	13398	3910	1399	0.199	0.25	0.148
2011	227263	279786	184650	24141	29316	18966	3291	1694	0.156	0.198	0.113
2012	119187	146702	96746	36956	44756	29156	3178	2978	0.129	0.163	0.095
2013	121909	152640	97359	50859	61874	39844	3604	2659	0.117	0.147	0.087
2014	169922	221966	130056	57442	70412	44472	3675	2745	0.119	0.150	0.087
2015	118585	164917	85204	56968	70161	43775	2957	2695	0.133	0.168	0.098
2016	58276	94927	35780	55303	68760	41846	3617	3731	0.160	0.20	0.116
2017	67929	154406	29872	49151	62827	35475	3689	3624	0.20	0.28	0.127

Table 15.5.3.1.1. Plaice in 7.d: Management options for 2018 and their effects on the resident stock.

VARIABLE	VALUE	SOURCE	NOTES
F ages 3–6 (2018)	0.201	AAP	Correspond to F_{2016} (status quo assumption)
SSB (2019)	47672	AAP	Short term forecast (STF), tonnes
Rage1 (2018-2019)	70057	GM 1980–2017	Thousands individuals
Catch (2018)	7114	AAP	STF, in tonnes (resident stock)
Landings (2018)	4521	AAP	STF, in tonnes; projection based on the average landing ratio (2015–2017) by age
Discards (2018)	2593	AAP	STF, in tonnes; projection based on the average landing ratio (2015–2017) by age

Table 15.5.3.1.1. (continued) Plaice in 7.d: Management options for 2018 and their effects on the resident stock.

	Total catch (2019)	Wanted catch* (2019)	Unwanted catch* (2019)	F_{total} (2019)	SSB (2020)	% SSB change	% change in wanted catch
AA**: F_{MSY}	7864	4878	2986	0.25	37200	-12.3	32
AA**: F = $F_{MSY\ lower}$	5670	3509	2162	0.175	39571	-7	-5
AA**: F = $F_{MSY\ upper}$	10435	6491	3944	0.34	34455	-18.8	76
F = 0	0	0	0	0	45814	8	-100
F_{pa}	10853	6755	4099	0.36	34012	-20	83
F_{lim}	14302	8936	5367	0.5	30399	-28	142
SSB (2020) = B_{lim}	26337	16674	9663	1.152	18447	-57	352
SSB (2020) = B_{pa}	18778	11791	6987	0.707	25826	-39	220
SSB (2020) = MSY $B_{trigger}$	18778	11791	6987	0.707	25826	-39	220
F = F_{2018}	6452	3996	2456	0.201	38723	-9	8

*** "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 rate estimates for 2015–2017.**

**** Administrative Agreement with the EU.**

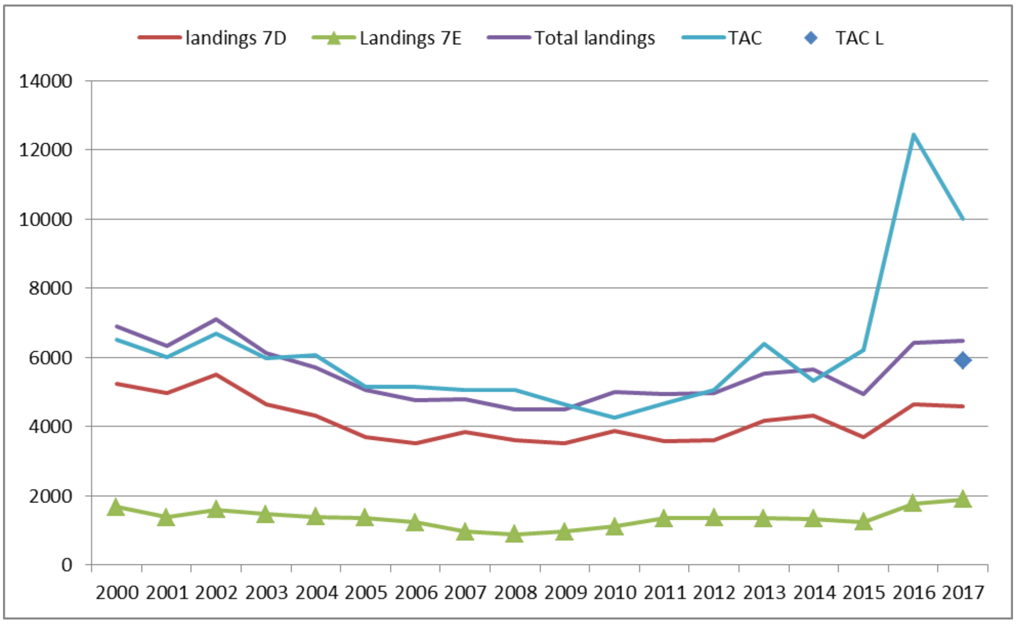


Figure 15.2.1.1. Plaice in 7.d. Official landings in 7.d and 7.e compared to the TAC: in 2017, the advice was given on catch rather than landings. The blue diamond illustrates the level of the landings associated with the catch TAC, using the discard/landings ratio between the advised catch and advised ratio (Advice sheet 2016 for 2017).

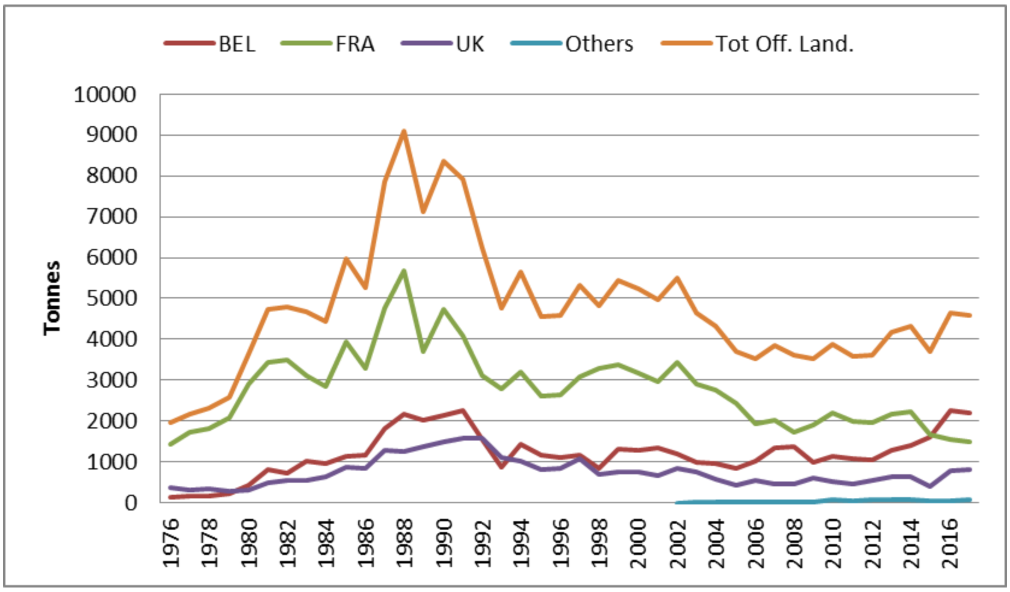


Figure 15.2.1.2. Plaice in 7.d: Official landings.

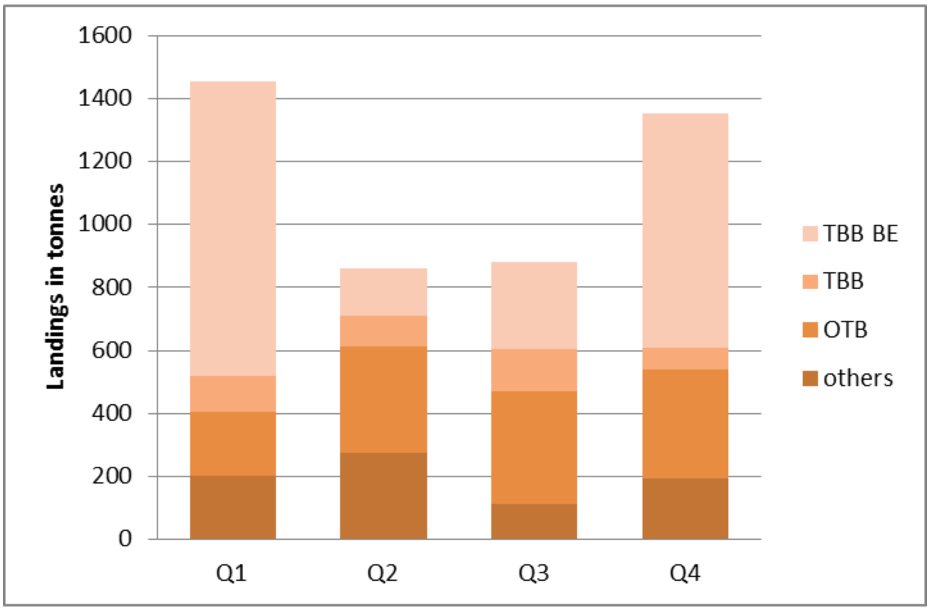


Figure 15.2.1.3. Plaice in 7.d: Landings per quarter.

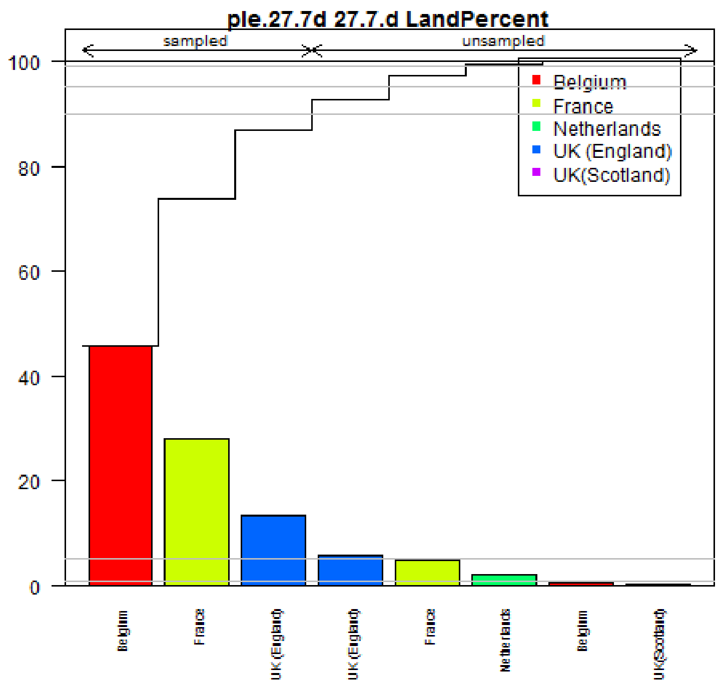


Figure 15.2.2.1. Proportions of total landings per country with and without age distribution provided.

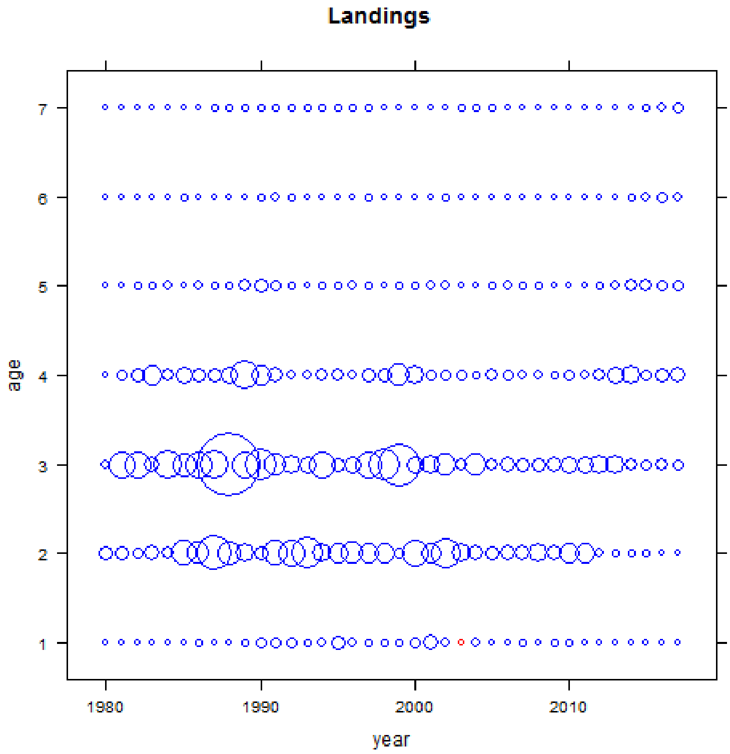


Figure 15.2.3.1. Plaice in 7.d: Age composition of the landings.

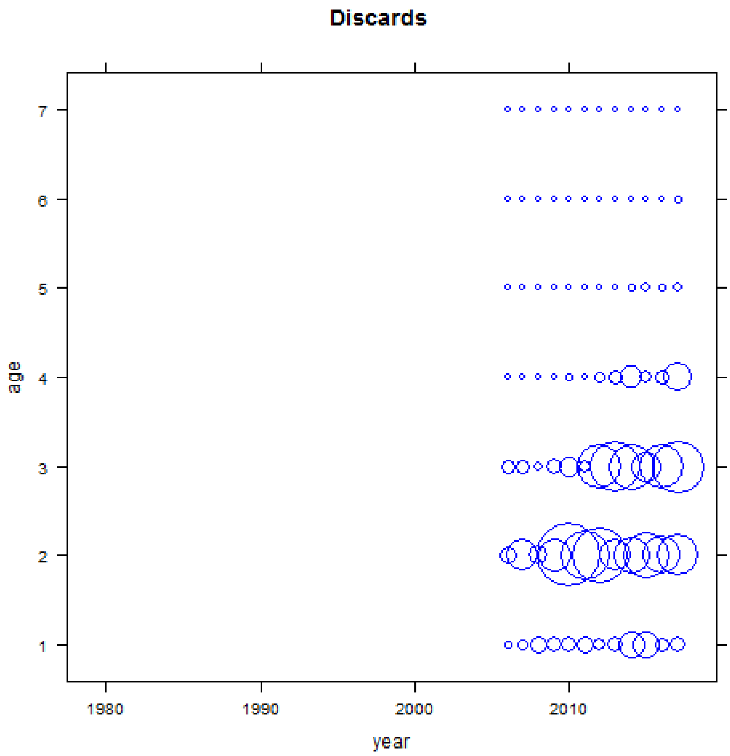
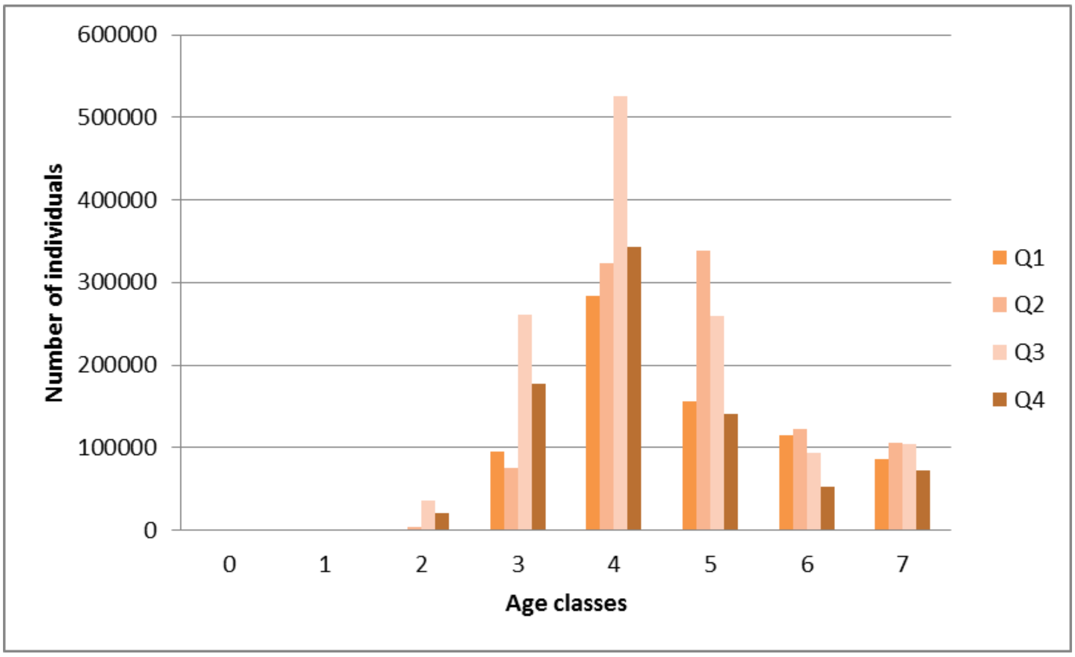


Figure 15.2.3.2. Plaice in 7.d: Age composition of the discards.

Landings



Discards

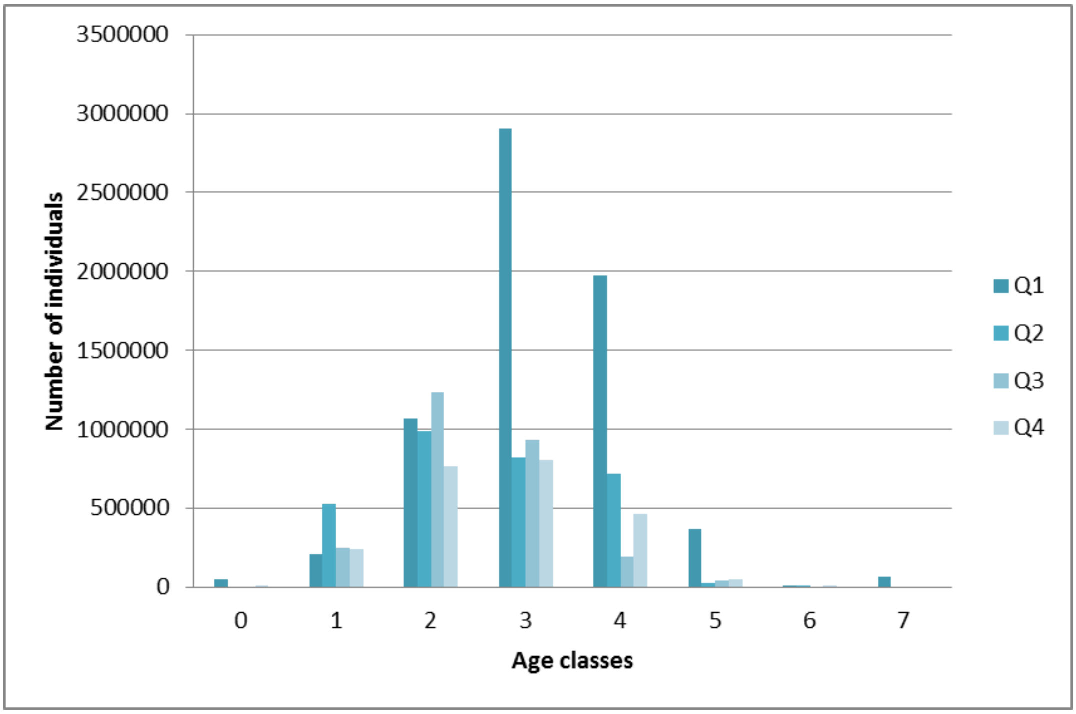
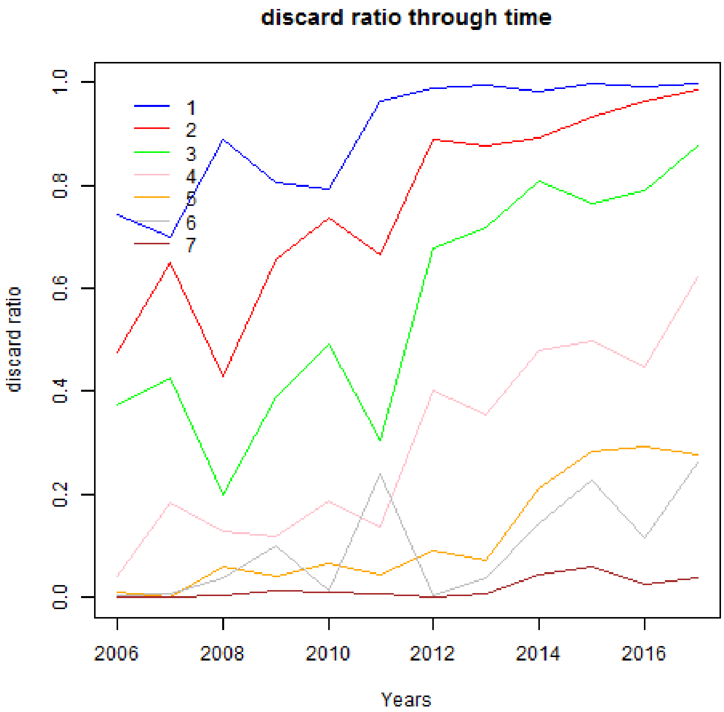


Figure 15.2.3.3. Plaice in 7.d: 2017 Age distribution in the sampled landings and discards per quarter.



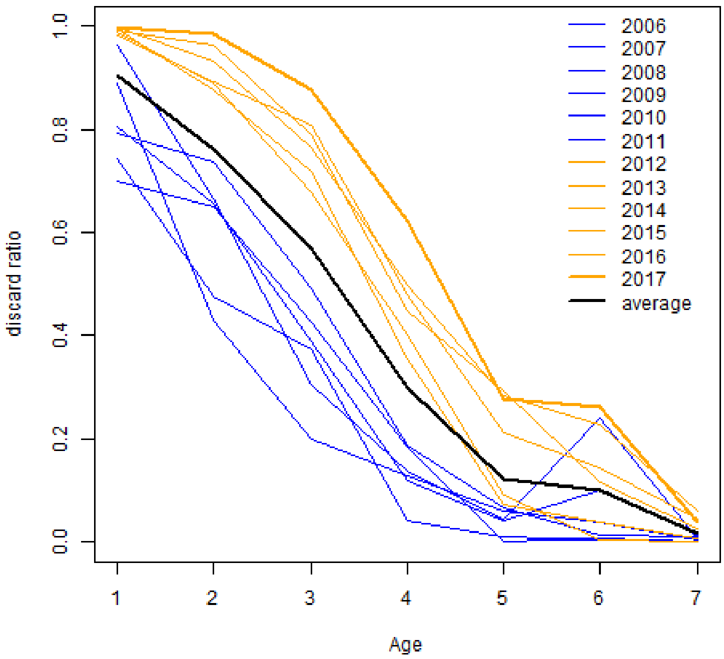


Figure 15.2.3.4. Plaice in 7.d: Discards at age ratio (discards numbers/landings numbers) per age and through time.

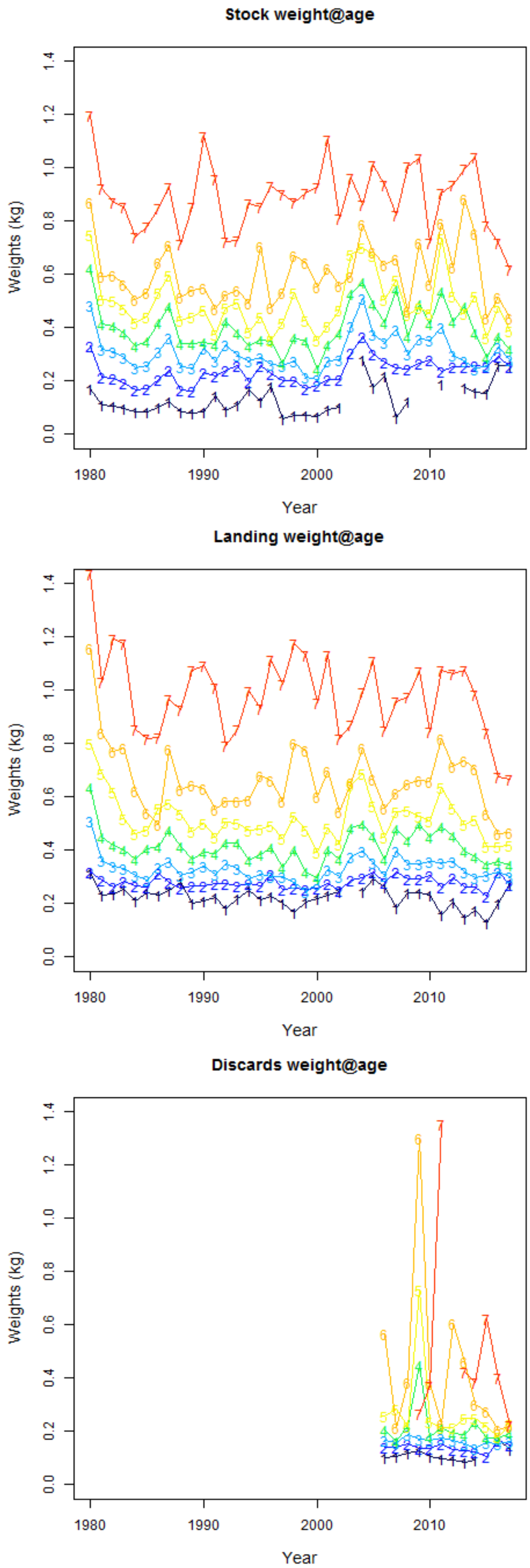


Figure 15.2.4.1. Plaice in 7.d: Stock, Catch and discard weights.

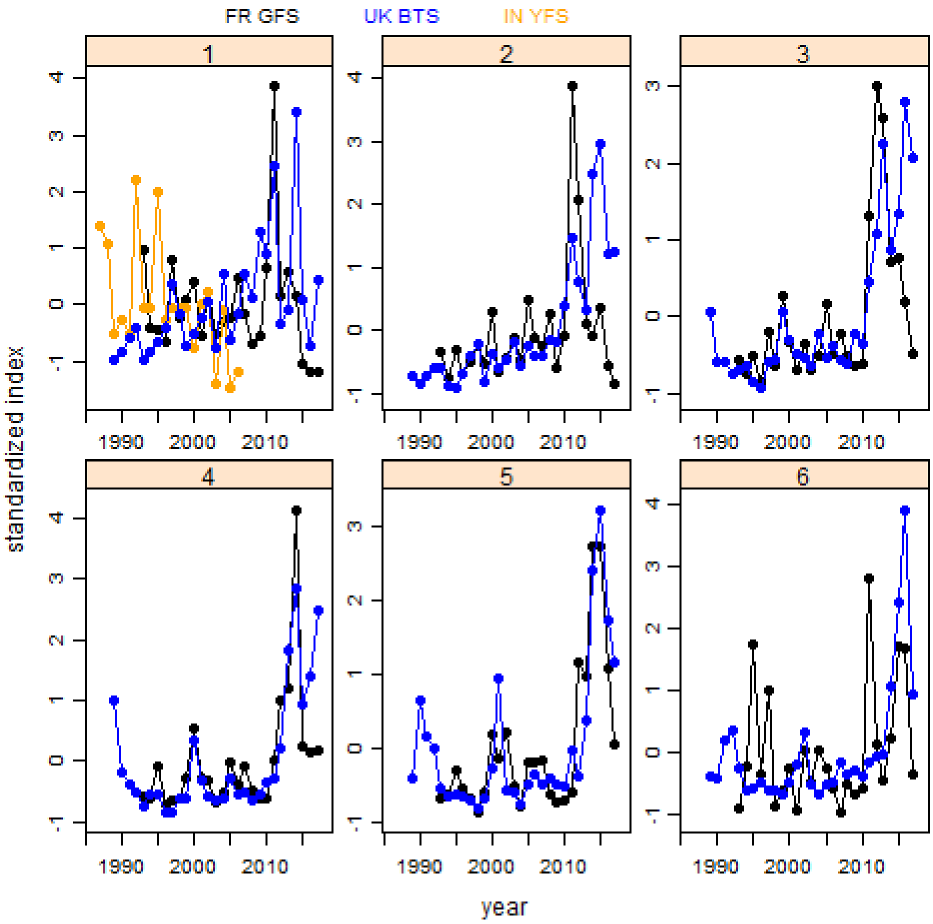


Figure 15.2.6.1. Plaice in 7.d: Survey Consistency: mean standardized indices by surveys for each age.

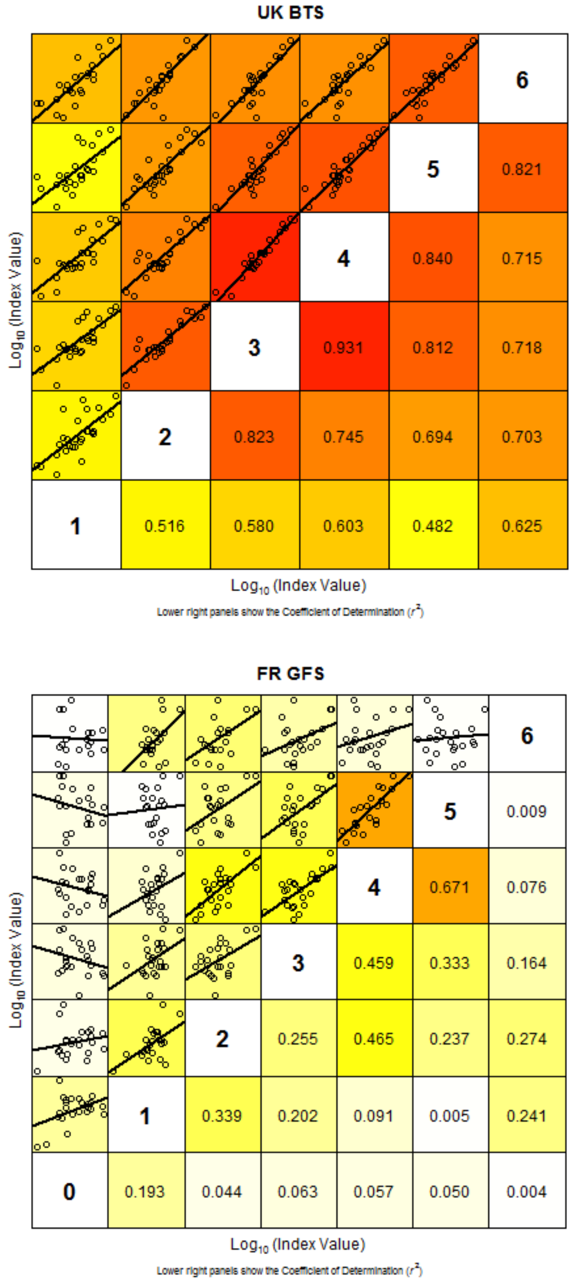


Figure 15.2.6.2. UK BTS and FR GFS indices consistencies.

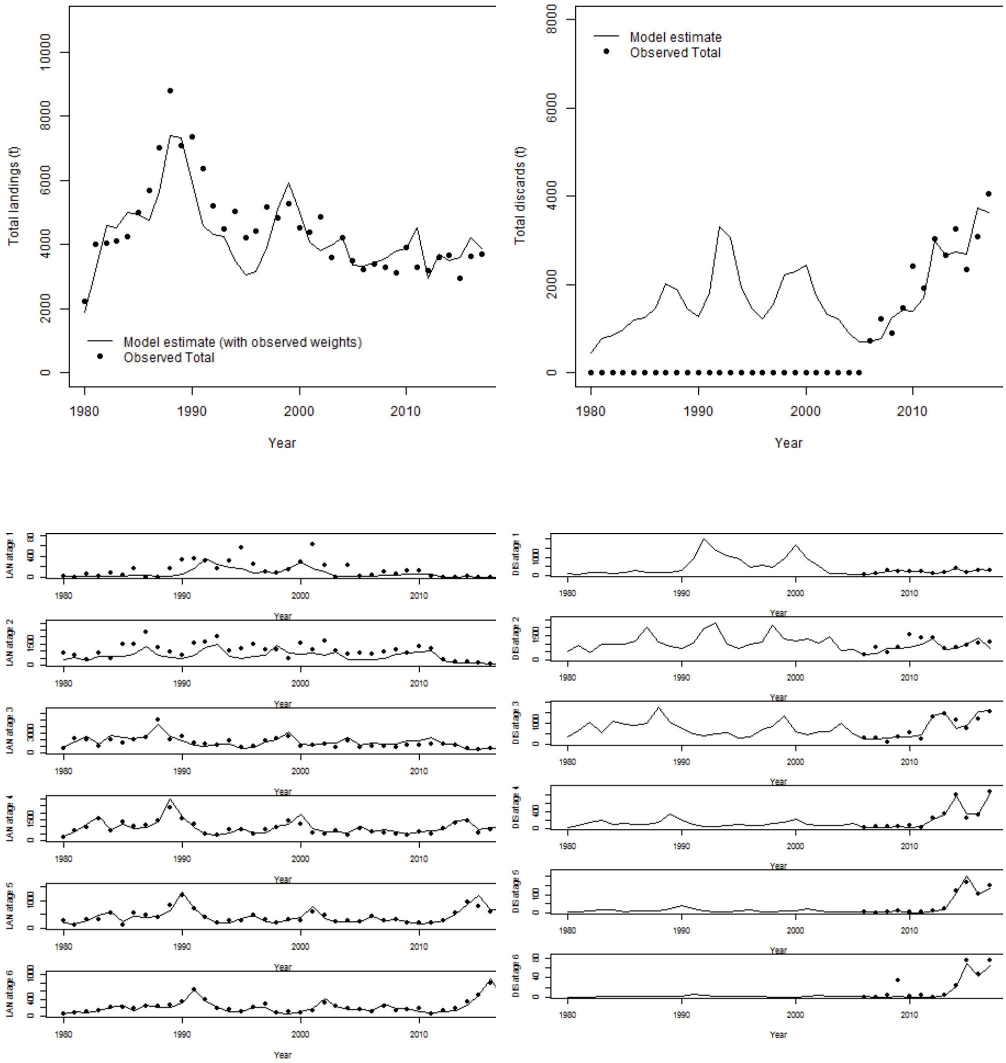
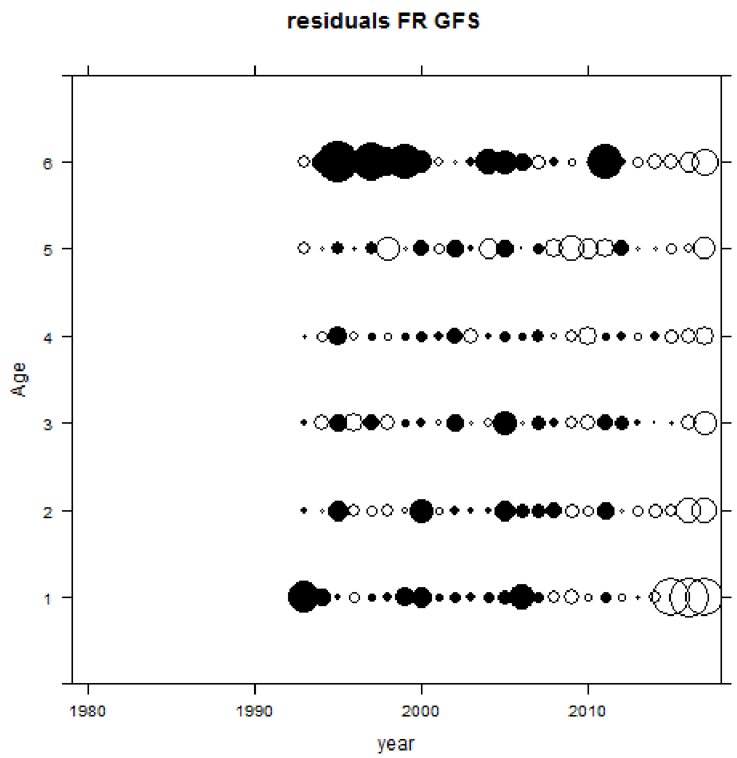


Figure 15.3.1.1. Plaice in 7.d: Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).



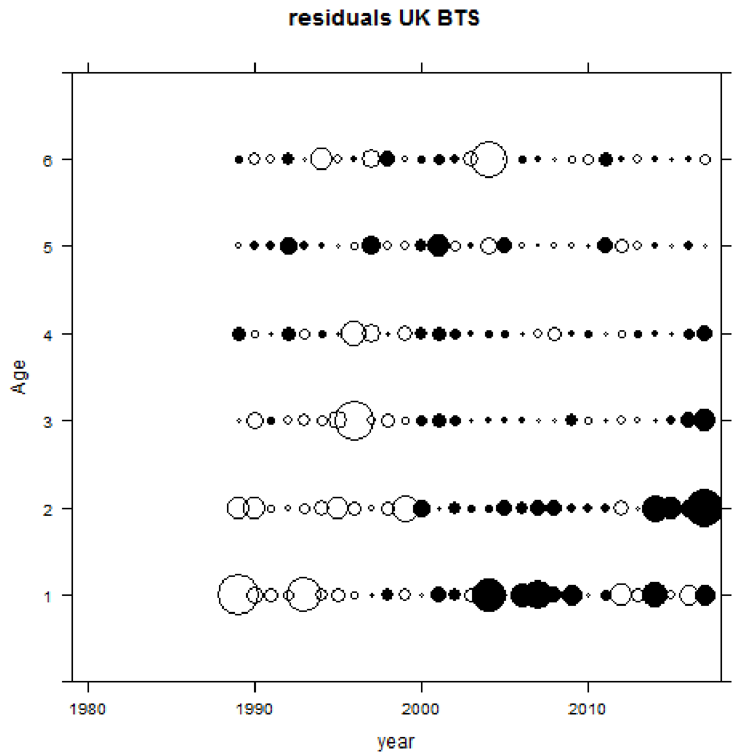


Figure 15.3.1.2. Plaice in 7.d: Survey residuals from the AAP assessment.

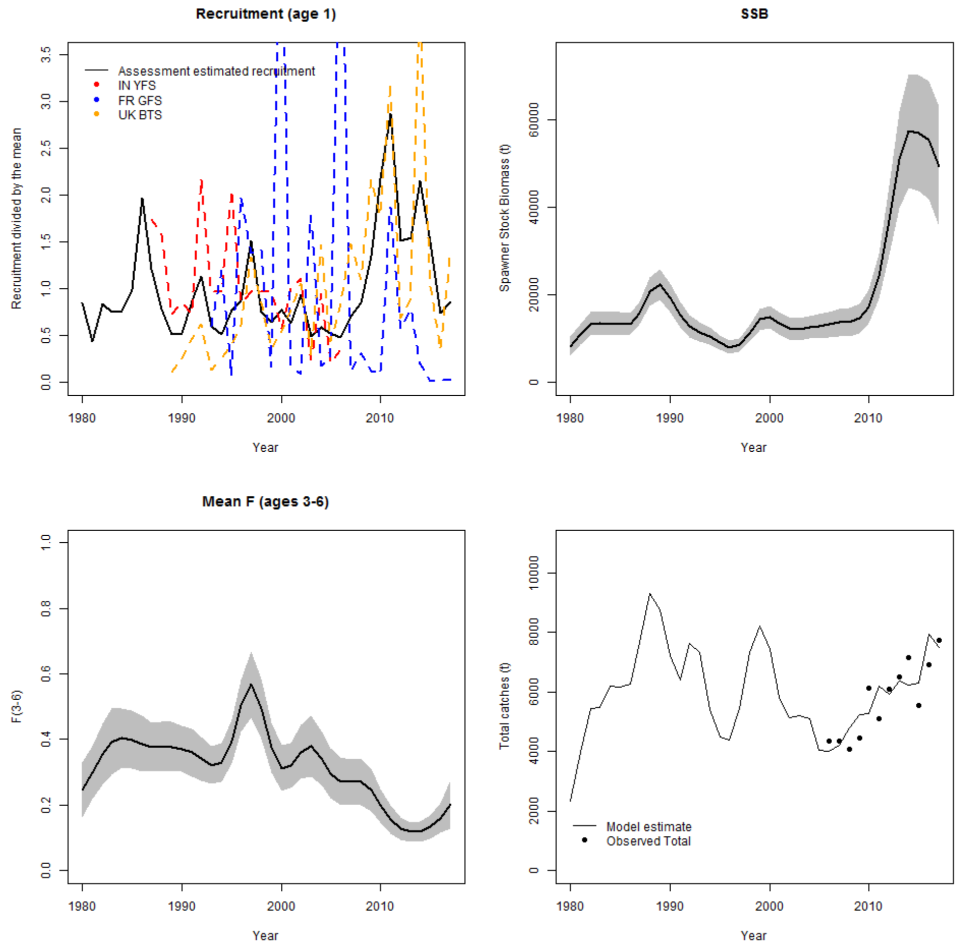


Figure 15.3.1.3. Plaice in 7.d: Summary of assessment results.

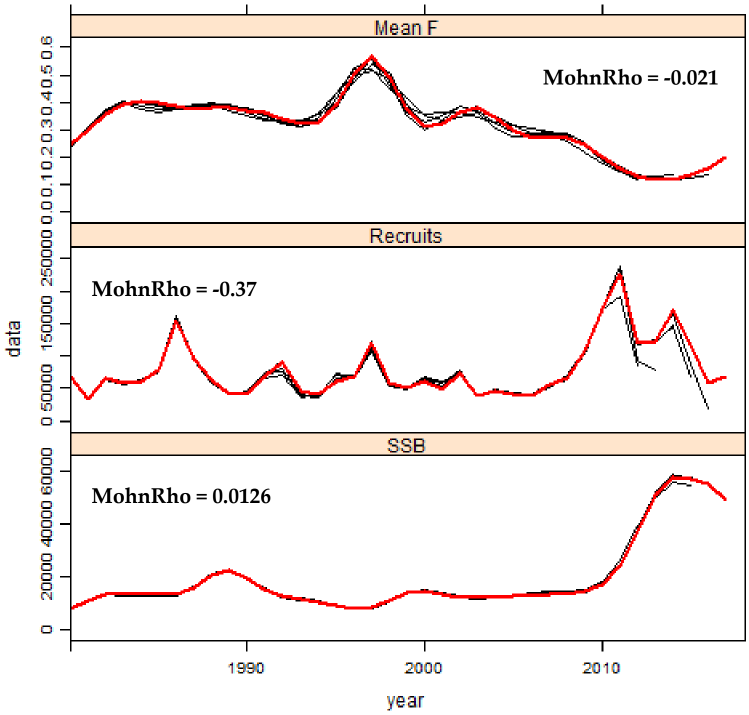


Figure 15.3.1.4: Plaice in 7.d. Retrospective patterns.

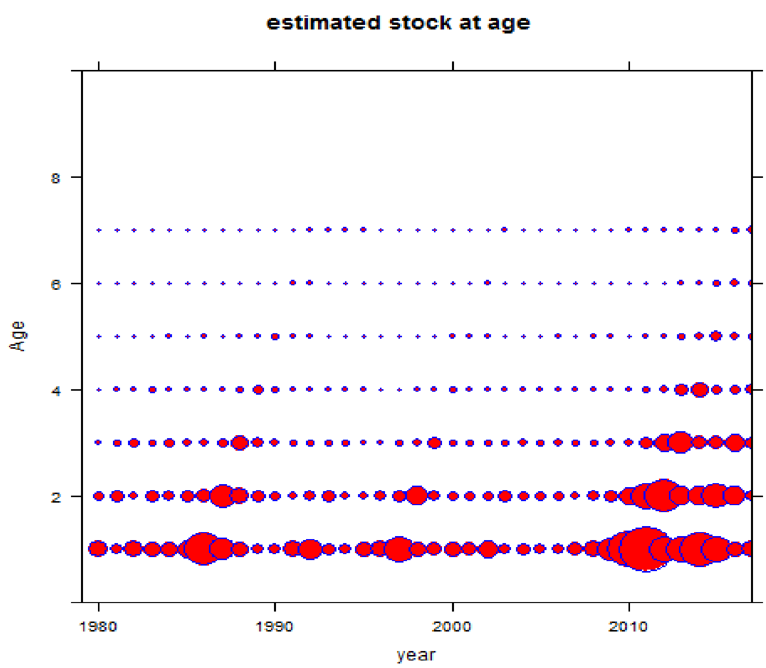


Figure 15.3.1.5: Plaice in 7.d. Estimated stock numbers.

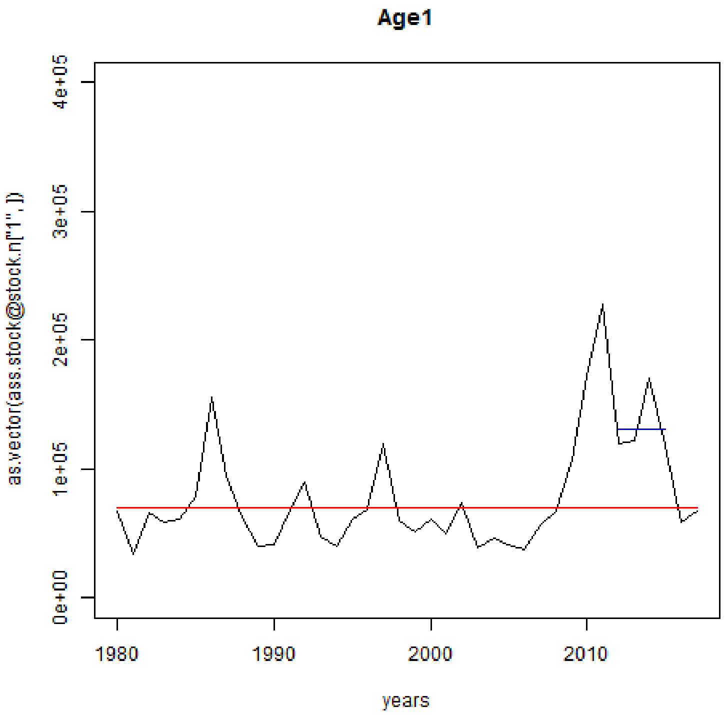


Figure 15.5.1.2. Plaice in 7.d: Number of individuals of age 1 as estimated by the assessment model (black), with the geometric mean over the whole time series (red), and the geometric mean over 2011–2014 (blue).

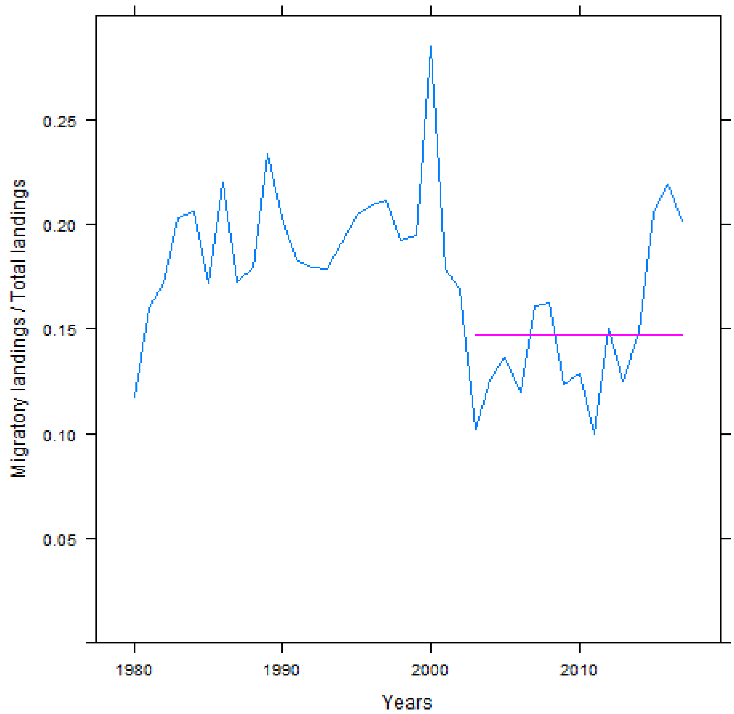


Figure 15.5.3.1. Plaice in 7.d: Time series of the proportion of the catch of fish coming from 7.e and 4 over the 7.d catch, and the average used.

16 Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea and Skagerrak)

16.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >35 cm, at 3–4 years 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.

16.2 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.

16.3 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.

16.4 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 1977–2017 in Division 3.a (Skagerrak/Kattegat) and Subarea 4 (North Sea) are shown in Table 16.1. Figure 16.1 shows total landings in Subarea 4 and Division 3.a from 1977–2017. 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 five 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 by-catch in various commercial fisheries. Norwegian catches peak in the months of March and April, and this may be associated with spawning aggregations. In 2017, 45% of the total landings were caught with gillnet and 36% with otter trawls in Division 3.a. In Subarea 4, 21% of the total landings were made with gillnets and 69% 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, although at a seemingly very small rate, and raised discards were estimated at 2.3 tonnes in total between area 3 and 4 in 2017 (see Table 16.2 for total catches and Table 16.3 for estimated discards). Discard numbers were raised for all nations. 90% of the discards were reported by bottom trawl fleets with Denmark the country reporting the largest number of discards 85% of total). In 2017, below minmum size (BMS) landings and logbook reported discards were also reported to ICES for pollack. In intercatch, the BMS and logbook reported discards were all 0. In the preliminary official landings for pollack, 5.5 kg of BMS landings were reported for Sweden in Subdivision 3.a. No other positive BMS landings were recorded in the preliminary landings.

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° north in the tourist fishery may range between 13–30 tonnes (Vølstad *et al.*, 2011).

16.5 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 16.2). The catches are small, and rather irregular, and no clear patterns emerge in 3 and 4.

16.5.1 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 16.3) compared to 50–70 cm in the Skagerrak (Figure 16.4).

16.5.2 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 16.5 and 16.6). 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).

16.5.3 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.

16.6 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

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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 16.1. Pollack in Subarea 4 and Division 3.a. Landings (tonnes) by country as officially reported to ICES 1977–2017.

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		390
2016		151	7	1	133	46		338*
2017		185	10	4	117	43		359*

*** 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	20	183		3	237	3	473		50	627	1594
2016	21	127		2	107	2	440		36	430	1166*
2017	18	187		6	231	3	510		44	512	1511*

*** Preliminary**

Table 16.2. Pollack in Subarea 4 and Division 3.a. Catches (tonnes) by country as estimated by the Working Group 2013–2017.

ICES Division 3.a					
	2013	2014	2015	2016	2017
Denmark	214	192	192	152	187
Germany	11	6	35	7	11
Netherlands	<0.5	0	0	1	5
Norway	174	156	138	135	117
Sweden	36	30	46	47	43
ICES Total	435	384	413	343	363
Official Total	420	383	389*	338*	359*
Diff Ices-Off	15	1	24	5	4

*** Preliminary**

ICES Subarea 4					
	2013	2014	2015	2016	2017
Belgium	17	24	20	21	18
Denmark	150	122	183	127	187
France	2	32	2	2	8
Germany	59	145	216	107	267
Netherland.	3	1	2	2	2
Norway	379	481	466	440	508
Sweden	29	41	50	36	44
UK	456	377	626	423	508
Ices Total	1103	1227	1567	1159	1543
Official Total	1080	1215	1591*	1166*	1511*
Diff Ices-Off	23	12	-22	-7	32

*** Preliminary**

Table 16.3. Pollack in Subarea 4 and Division 3.a. Discards (tonnes) by country estimated by the Working Group, 2013–2017.

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
2016		1.436	0.021	0.002	1.706	1.685		4.85
2017		1.152	0.047	0.001	0.892	0.237		2.32

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
2016	<0.001	0.109		0.001	0.073	<0.001	0.357		0.021	0.278	0.84
2017											0

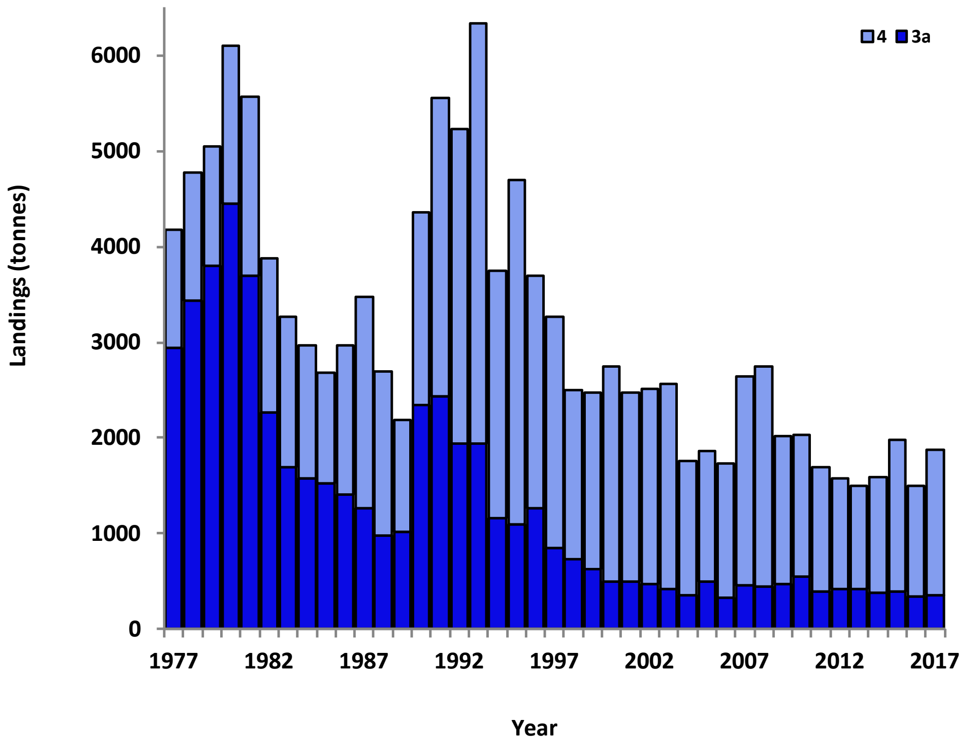
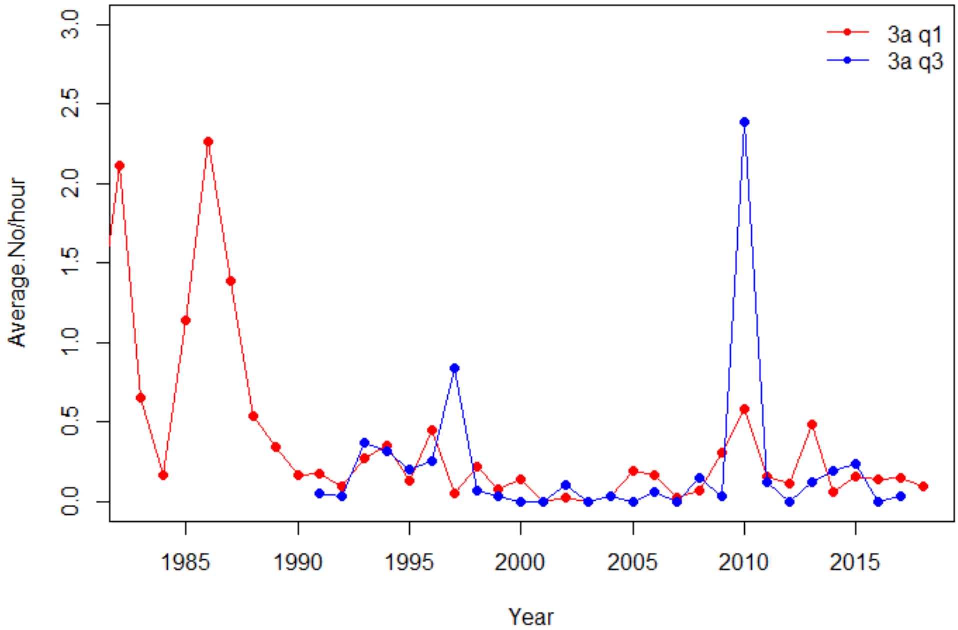


Figure 16.1. Pollack. Total landings of pollack from 2007–2017 in Division 3.a and Subarea 4 as officially reported to ICES.



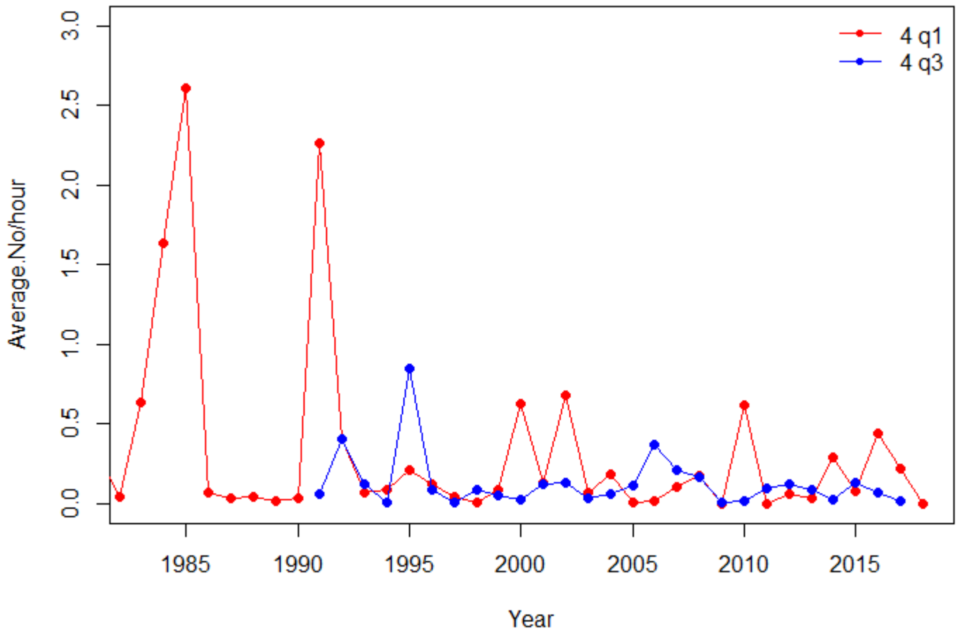


Figure 16.2. Time series of catches of pollack from 1983–2017 in ICES Division 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV-trawl. Data from Datras.

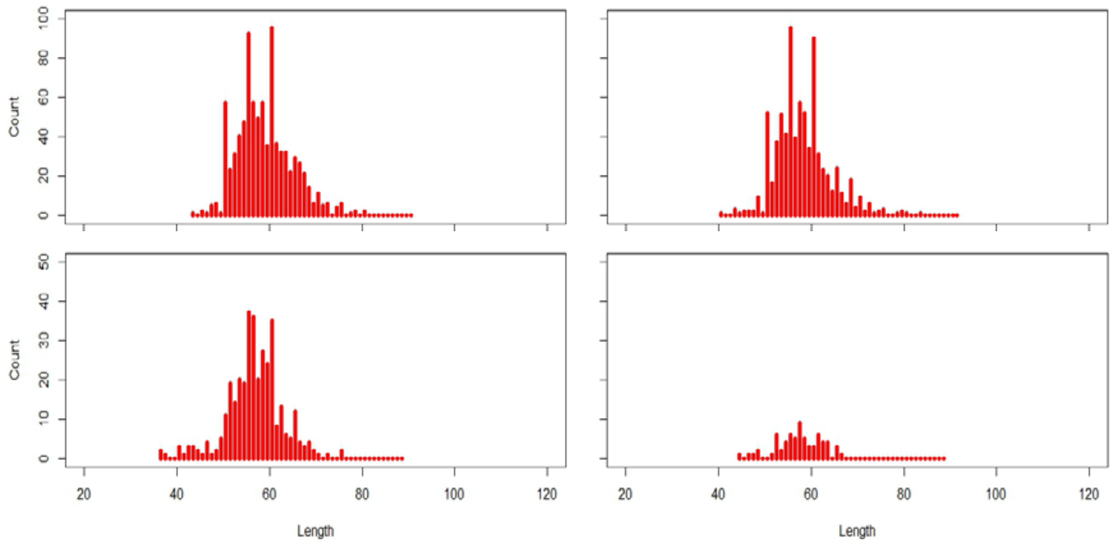


Figure 16.3 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a . The data is aggregated for gillnets with a 63 mm mesh size.

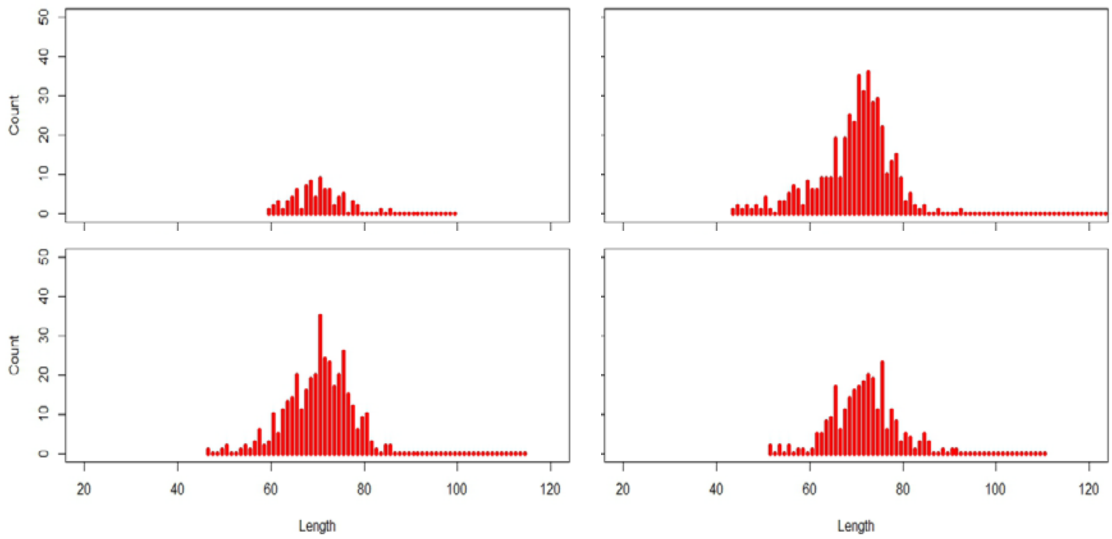


Figure 16.4 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70 mm mesh size.

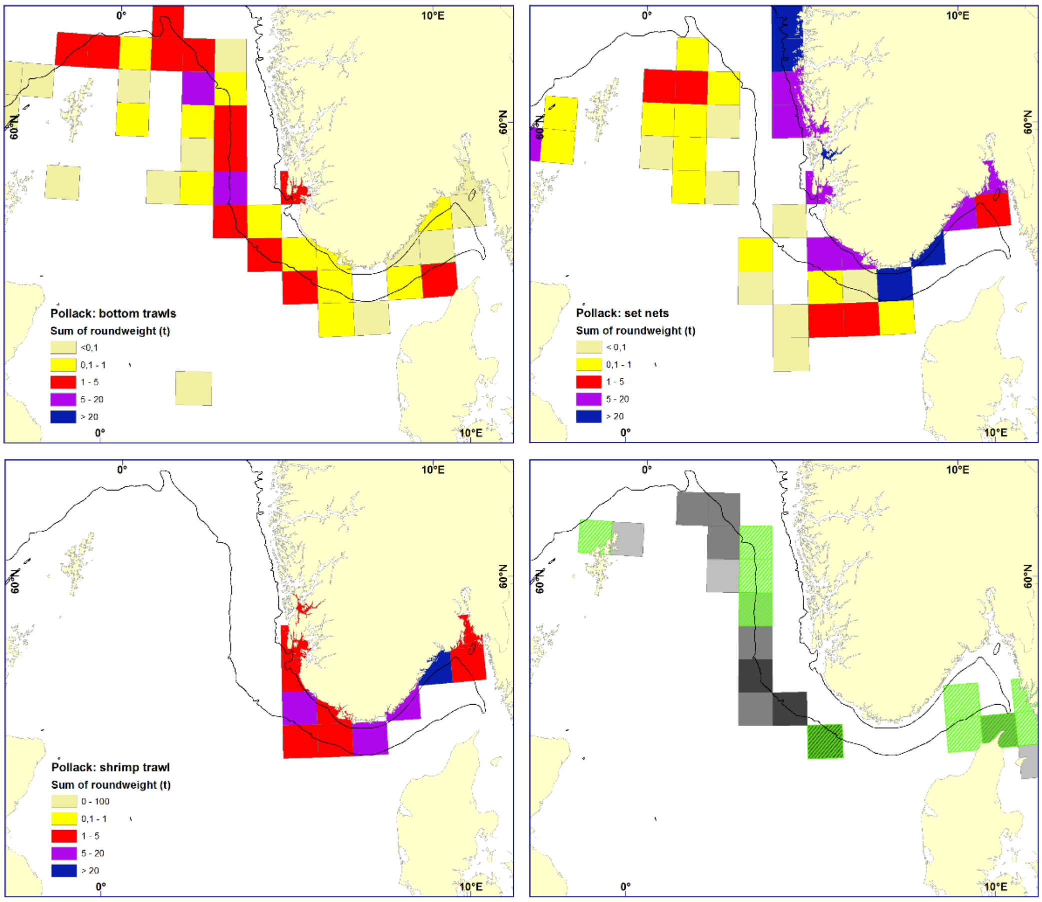


Figure 16.5 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

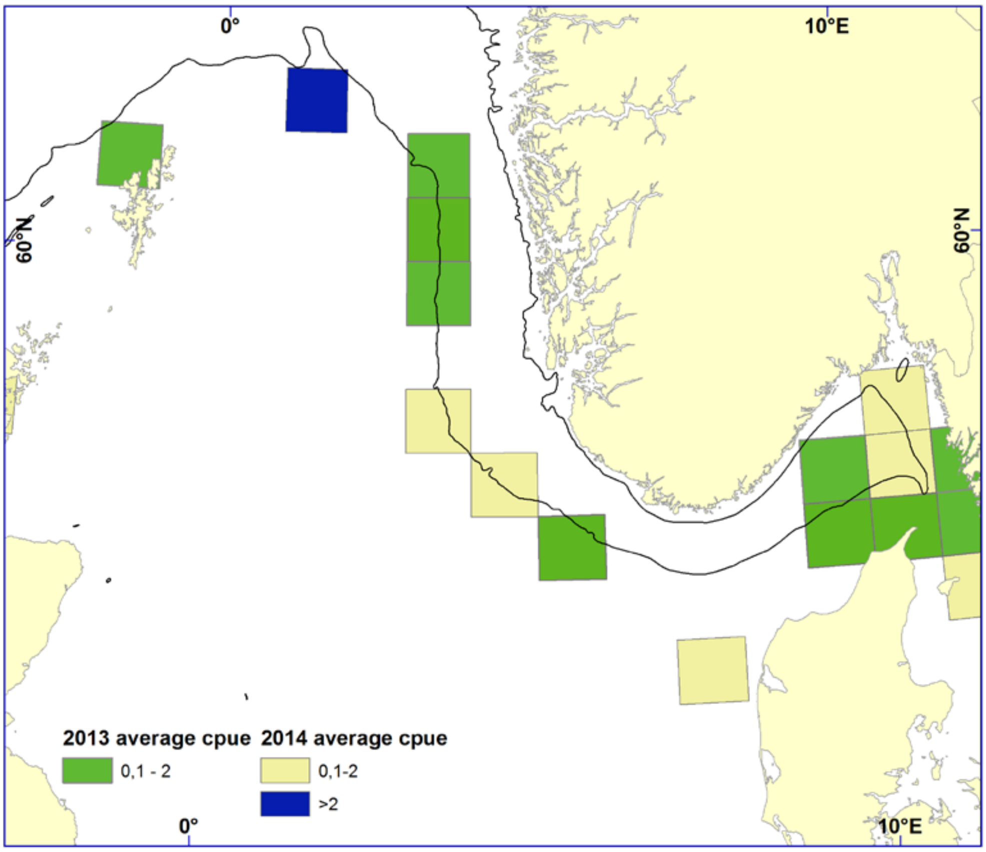


Figure 16.6 Pollack catches from IBTS surveys in 2013 (green) and 2014.

17 Saithe (*Pollachius virens*) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat)

The assessment of saithe in Division 3.a and subareas 4 and 6 is presented as an update assessment, following the protocol specified by the 2016 meeting of WKNSEA (ICES, 2016b) and a revision after the WGNSSK 2016 meeting, which was to provide a solution to the uncertainty in the assessment and forecast due to the highly uncertain and fluctuating survey indices. New information from the IBTS–Q3 survey in 2017 did not trigger the re-opening criterion.

17.1 General

17.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

17.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK in 2018. A summary of available information, prepared during WKBENCH 2011 (ICES WKBENCH, 2011), can be found in the Stock Annex. No ecosystem aspects were discussed during WKNSEA 2016 (ICES, 2016b).

17.1.3 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex.

Saithe are taken mainly in the trawler fisheries by Norway, Germany, and France. Changes in the fishing pattern of these three fleets began in 2009, but all fleets had largely reverted to their original fishing patterns by 2011 (see Stock Annex for years 2000–2015). For the German and Norwegian fleets, the original fishing pattern 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). But in 2017, there appeared to be minimal overlap between where the three nations fished (figures 17.1.1 and 17.1.2).

A restructuring of the German fleet began in recent years and, in 2016, two vessels switched from otter trawls to paired trawls. This change had an impact on the CPUE index (see Section 17.3.5). This change was only for one year; these vessels reverted to otter trawling in 2017. The French fishery is currently at capacity for processing the catch at the vessel; this fishery cannot increase their catches.

The Scottish fleets 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.

17.1.4 ICES Advice

The information in this section is taken from the Advice summary sheet 2017.

Advice for 2017

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 118 460 tonnes.

17.2 Management

Changes to the stock assessment and reference points the benchmark in 2016 imply a need to re-evaluate the management plan 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.

The agreed TAC at the EU-Norway negotiations was based on the MSY approach for wanted catch, adjusted by 4.76% in Subarea 6 and 12.57% in Subarea 4 and Division 3.a, to account for those fisheries that would be under the landing obligation in 2018. This resulted in a decrease of 2% compared to the 2017 TAC in Subarea 6 and a 5% increase in Subarea 4 and Division 3.a.

17.3 Data available

17.3.1 Catch

Official landings for each country participating in the fishery, together with the corresponding WG estimates and the agreed international quota ("total allowable catch" or TAC) are presented in Tables 17.3.1 and ICES reported discards and BMS landings are in Table 17.3.2. ICES estimates of landings are generally lower in Subarea 6 and higher in Subarea 4 than official estimates. This is likely due to discrepancies between logbooks and landings as to where a vessel fished on a given trip.

Ninety-four percent of the discards were reported and only 6% were raised within InterCatch (Table 17.3.3). Discard observations for landings from the fleets landing the majority of saithe were not available. (Figure 17.3.1). While Norway has a no landings obligation policy for all métiers and in all areas, discarding is not monitored and discard information is not collected; therefore Norwegian discards were raised for all métiers. Discards for the Norwegian, French, and German trawler fleets were raised using provided discard information from the French and German trawler fleets (i.e., the targeted fishery; quarterly stratification). Discards for other fleets (all counties), separated into passive and active gears, were raised using a stratification by quarter; area was not included due to a lack of data. Information on discarding from Scottish métiers were not included when raising discards for active gears because rates were typically high (see Section 17.1.3). The French longline metier in 46 was also not included in raising discards for other métiers because of high discard ratios.

The complete time series of catch, landings, and discards is summarized in Table 17.3.4 and illustrated in Figure 17.3.2. Catch has been relatively stable from 1990 through 2008 and then declined slightly. The WG estimates of saithe discards (as a proportion of total catch) has remained relatively constant since 2003. 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 age-specific discarding rate (see ICES, 2016b). High discards, particularly in 2016, were due to reported discarding by Scottish fisheries.

Saithe fishing in the bottom trawl fleet was covered by the EU Landing Obligation from 2016. Very few BMS landings and no logbook reported discards were reported into InterCatch, despite saithe being under the landings obligations for certain métiers in 2016 and 2017. BMS landings were 0.23% of the total catch in both 2016 and 2017. Some nations recorded only official BMS landings because of doubt that it is the total recorded amount. Instead, these nations have allowed BMS landings to be included in the landings information, making it impossible to differentiate between the two categories. This information is included in the catch for the assessment.

17.3.2 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, Ireland, and Norway, which accounted for 90% of the total landings (Table 17.3.5, Figure 17.3.3). A large number of fleets do not provide samples for the landings, but these do not contribute to a large proportion of the catch. However, the number of samples taken, especially in the targeted trawl fisheries, is an issue (Table 17.3.6, but also see ICES, 2016b). Stratification for age compositions was by quarter and area (Division 3.a or combined subareas 4/6) for the unsampled landings, as described in ICES (2016b; figures 17.3.4–17.3.6, Table 17.3.7). 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. Smaller and younger fish are generally found in Division 3.a.

Ninety-three percent of the discards were sampled for age distributions (Table 17.3.5). Two countries provided 99.9% of the age information for discards, Denmark and Scotland. While the proportion of discards sampled for age distribution was high (Table 17.3.7, figures 17.3.7–17.3.9), the number of age samples was low (Table 17.3.6). Because of this, a stratification by quarter was used when estimating the age disaggregation for discards. Catch-at-age for the BMS landings was generated from the discards age information.

Total catch-at-age data are given in Table 17.3.8, while catch-at-age data for each catch component are given in Tables 17.3.9 and 17.3.10. Age 3 fish make up a smaller portion of the landings in recent years (Figure 17.3.10). 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. A slightly stronger year class appears to be entering the discards at age 3 in 2016 and at age 4 in the landings in 2017.

17.3.3 Weight-at-age

Weight-at-age from the catch and catch components for ages 3–10+ are presented in tables 17.3.11–17.3.13 and Figure 17.3.11. Catch weights are 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 17.3.11). 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, however, there was a slight decrease in the last two years.

17.3.4 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.

17.3.5 Catch per unit effort and research vessel data

Indices used in the final assessment are included in Table 17.3.14. 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").

17.4 Data analyses

17.4.1 Exploratory survey-based analyses

Saithe are distributed over the northern North Sea shelf and along the Norwegian Trench into the Skagerrak during the IBTS–Q3 (figures 17.4.1, 17.4.2). A large amount of age 3 and age 4 fish were captured along the top of the North Sea shelf. One catch in 2016 in ICES rectangle 50F0 was particularly large at 6.8 tonnes per hour of trawling.

Numbers-at-age for saithe ages 3 to 8 (IBTS–Q3) on the log–scale, linked by cohort, showed a strong year effect in 2006, 2011, 2013, 2015, and 2016 (Figure 17.4.3), reflected in the sharp increase in age 4 when compared to earlier cohorts. The survey catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages (Figure 17.4.4). This is likely because age 3 fish are not fully represented in the survey; fish begin migrating out of the inshore nursery areas at age 3, but do not fully recruit to the ocean until after age 5.

Trends by age for the IBTS–Q3 index are shown in Figure 17.4.5. Abundance of age 3 and 4 is very low in 2014, but have increased in 2015 and again in 2016. Abundance of age 3 in 2017 is similar to the 2015 estimate. Abundance of age 3 in 2016 is the highest observed in the time series. When the single large catch of saithe is removed from the index estimation, abundance of age 3 in 2016 is still higher than in 2015, but is not the highest observed in the series (Figure 17.4.5). The single large catch of saithe was kept in the index in the 2016 assessment because it was real and observed. While it may be argued that such a dense aggregation was a rarity, it is also equally likely that, given the large amount of untrawlable area on the northern part of the shelf, equally dense aggregations are the norm and are simply not towed on (and therefore go unobserved). The uncertainty of including such observations was in the assessment output. IBTS–Q3 indices used in the final assessment are in Table 17.4.1.

17.4.2 Exploratory catch-at-age-based analyses

Catch curves for total catches show that age 3 is only partially recruited to the fishery for the latter cohorts (from around the mid–1990s), but fully recruited for many of the earlier cohorts (Figure 17.4.6). 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) also changed around this time, which would also cause a change in exploitation (targeting age 3 to targeting age 4 fish). Changes in mesh size for the trawler fleet, e.g., moving from 100 mm mesh size to 110 to 120 mm, may have also caused the change in exploitation of different age classes.

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 giving 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 ICES, 2016b for details).

The partial year effects for each of the main fleets show that CPUE declined in 2016 for all fleets, but the decline was most pronounced for the German fleet. Fleet restructuring has been occurring for several years within the German fleet and 2016 saw 2 vessels change to paired trawls (they are no longer included in the otter trawl CPUE index). In 2017, these vessels returned to otter trawling. The fit of the CPUE to the exploitable biomass shows a decline in 2016 when all fleet information is included, but the index increases again in 2017 (Figure 17.4.7).

17.4.3 Assessments

The assessment of North Sea saithe was carried out using a state-space stock assessment model (SAM; stockassessment.org). The assessment was an update assessment. Settings used in the final and exploratory assessments are given in Table 17.4.2. SOP correction of the catches has been done on all revised catches (2002–current assessment year).

17.4.4 Final assessment

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 372.81. Estimated catchabilities for the Q3 index were higher than the CPUE index (Q3 range 0.032 to 0.094; CPUE 0.0053). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.795).

Estimated fishing mortality-at-age are given in Table 17.4.3 and Figure 17.4.8. F for age 3 has declined drastically from 1990 and is now close to zero, while F for the older age classes has also decreased slightly in this period. The change in F at age 3 occurred when the catches in the purse seine fishery declined. For ages 5+, selectivity has changed from a dome-shaped to approximately flat selectivity in the last years. With the lower fishing mortality, fish have been allowed to increase in size (and age) and are likely targeted more than the younger age classes (as observed in Figure 17.4.6). This, coupled with the changes mentioned in section 17.4.2, likely explains the change in exploitation pattern. Estimated population numbers-at-age are in Table 17.4.4.

The residuals are shown in Figure 17.4.9. After accounting for the correlation between ages within years, the IBTS–Q3 residuals show less of a pattern. Even after accounting for the correlation, the series is still largely positive at the end of the series, when the increase in abundance for most ages is beginning to be apparent. The strength of the correlation between ages is strong between subsequent ages for all ages (Figure 17.4.10). For ages 5 and 6, correlations are also strong between all other age groups.

The retrospective analysis shows that SSB, F, and recruitment are fairly well estimated for the last 5 years (Figure 17.4.11). Mohn’s rho, estimated using the last 5 years, as 0.028 for SSB, -0.013 for F, and -0.069 for recruitment. Both the figures and Mohn’s rho indicate that SSB has a tendency to be slightly over-estimated, while F and recruitment tend to be underestimated slightly.

The final assessment and leave-one out results are in Figure 17.4.12. Removing the IBTS Q3 indices leads to a slightly lower SSB and recruitment, especially in the last 3 years. Conversely, using only the IBTS Q3 indices gives an extremely optimistic view of the stock; the estimated SSB is outside of the 95% confidence interval of the final assessment after 2011.

17.5 Historic stock trends

The historic stock and fishery trends from the final assessment are presented in Figure 17.5.1 and Table 17.5.1. Because of the benchmark, historic perception of the stock has changed. Recruitment has been low and highly variable since 1990. Both 2016 and 2017 show relatively stronger recruitment than in the previous decade. The decline in SSB reversed in 2010 and SSB is now around levels seen in the mid- 2000s. The final year estimate of SSB is above B_{pa} and MSY $B_{trigger}$. Fishing mortality has generally declined since the mid–1980s. Currently, fishing mortality is well below F_{MSY}.

17.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The 2003–2017 median value (111 million) used in the short-term forecast is slightly under the estimated recruitment for 2017.

17.7 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 scaled to $F_{4–7}$ in 2017. The fishing mortality in the intermediate year was F status quo. A TAC constraint had been used for the intermediate year in the past, i.e., the fishing mortality for 2017 was determined such that the landings without adjustment for the landings obligation in 2016 matched the TAC. The TAC has never been taken (except in 2015), therefore, the wrong F has been used in the intermediate year in the past. 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, resampled from the years 2003–2017. The short-term projection was run in SAM.

The input data for the short term forecast are given in Table 17.7.1. Given the options above results in an F_{2019} of 0.36 and a SSB in 2020 of 334 963 tonnes. Reference points and their technical basis are in Table 17.7.2.

The management options are given in Table 17.7.3. Because reference points were re-estimated after the benchmark, the management plan is no longer valid; therefore, the MSY approach is used as the basis for advice. Total catch in 2019 is advised to be no more than 139 978 tonnes, where wanted catch is 130 275 tonnes; this is an 18% increase when compared to the advised total catch in 2018.

The contribution of the 2010–2016 year classes to landings in 2019 are shown in Table 17.7.4. The 2015, 2014, and 2013 year classes contribute the most to the forecasts. The last 2 year classes (2016 and 2015), which are the age 3 and age 4 fish, contribute 22% to the landings in the forecast. Recruitment at age 3 does not contribute greatly to the catches in 2019, but it is the age 4–6 fish that are important; this is clearly seen in the catch-at-age (Figure 17.3.10), catch curves (Figure 17.4.6), and F at age (Figure 17.4.9).

17.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

17.9 Quality of the assessment and forecast

Many of the issues noted after the benchmark and last year's assessment still exist.

The commercial CPUE indices may introduce biases into the assessment if changes in fishing patterns occur, as seen in 2009–2011. Factors, such as vessel experience and fishing behaviour, likely contribute to the variability in CPUE for all fleets, but these factors are not captured in the CPUE model. There are conflicting signals between the survey and fishable biomass index.

The scientific survey used in the assessment does not cover the whole stock distribution; however, it is considered generally representative. The number of observations (trawl stations) where saithe is low, can be influenced by occasional large catches, and the resulting survey index is uncertain. This was apparent in 2016.

Conflicting signals between the survey and fishable biomass index contributes to the assessment uncertainty.

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. Estimates of recruitment for a given year class tend to be revised considerably with successive assessments. Less of the advised wanted catch in 2019 is based on the recruitment assumptions than in previous years.

17.10 Status of the stock

The general perception of the status of the saithe stock is slightly more optimistic than last year.

17.11 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 in most years since 2002, despite the reductions in the TAC between 2013 and 2016. After the benchmark, the perception of the stock changed and the suggested TAC (autumn update) for 2017 was a 96% increase.

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 (not including BMS landings) of saithe in all fisheries in 2016 was estimated to be approximately 14% of the official catch; this declined to 6% in 2017.

17.11.1 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.

17.12 References

ICES. 2016a. 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.

ICES. 2016b. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 14–18 March 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:37

Table 17.3.1. Saithe in subareas 4 and 6 and Division 3.a. Official nominal landings (tons) of saithe by nation, 2004–2017. ICES estimates are landings reported to ICES and the Working Group.

Subarea 4 and Division 3.a

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*	2017*
Belgium	22	28	15	18	7	27	15	2	2	3	5	6	16	15
Denmark	7991	7498	7471	5443	8068	8802	8018	6331	5171	5695	4913	4512	3109	5689
Faroe Isl.	558	463	60	15	108	841	146	2	8	3	1	0	0	16
France	13628	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7910	11574	10842	10334
Germany	9589	12401	14397	12791	14140	13410	11193	10234	8052	9690	8602	7954	6196	6629
Greenland	403	1042	924	564	888	927	0	0	0	0	0	0	0	0
Ireland	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Lithuania	0	149	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	3	40	28	5	3	16	3	24	34	168	43	75	87	190
Norway	62783	68122	61318	45396	61464	57708	52712	46809	33288	35701	37519	35631	30951	49580
Poland	0	1100	1084	1384	1407	988	654	584	0	0	0	0	0	0
Portugal			228	68										
Russia	0	35	2	5	5	13	0	0	0	0	0	0	0	0
Sweden	2249	2132	1746	1381	1639	1363	1545	1335	1306	1402	1329	1156	980	1177
UK (E/W/NI)	457	960	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	687	8888**	1707	8573**
UK (Scotland)	5924	6170									7686		6769	
Total reported	103608	111970	113354	91778	115414	103883	90755	89427	69241	71516	68695	69796	60657*	82203*
Unallocated	−862	1418	-1509	824	57	2090	6012	2101	1623	-110	677	-393	1849	-633
ICES estimate	102746	113388	111845	92602	115471	105973	96767	91528	70864	71406	69372	69403	62506 #	81570 # #
TAC	190000	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696	100287 Ħ

*** Preliminary.**

**** Scotland+E/W/NI combined.**

Ħ Includes top-up of 4.1%.

 # Since 2016, landings correspond to wanted catch, which includes Norwegian component of BMS landings.

Subarea 6

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017*
Denmark	0	0	0	0	0	0	0	0	0	0	20	0	1035	5
Faroe Islands	34	25	76	32	23	60	24	5	6	25	29	3	0	13
France	3053	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2298	3968
Germany	4	373	532	580	148	298	257	0	9	0	0	0	91	< 1
Ireland	95	168	267	322	288	407	520	359	364	313	128	105	185	124
Netherlands	0	0	3	36	1	0	0	0	0	0	0	6	12	3
Norway	16	20	28	377	78	68	121	240	5	715	442	677	968	631
Russia	6	25	7	2	50	4	2	0	0	0	9	1	0	2
Spain	2	3	6	3	4	8	18	31	13	21	9	15	60	4
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	240	0
UK (E/W/NI)	37	133	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	97	3286**	123	2641**
UK (Scotland)	1563	2922									3191		2493	
Total reported	4810	7623	9759	7103	7717	6438	6118	7492	7558	8534	6829	7577*	7505*	7391*
Unallocated	172	−1167	−1191	−501	−1005	-144	145	-575	-9	119	191	-43	-1932	-275
ICES estimate	4982	6456	8568	6602	6712	6294	6263	6917	7549	8653	7020	7534	5573 ł	7116 ł
TAC	20000	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816	10404 łł

*** Preliminary.**

**** Scotland+E/W/NI combined.**

ł does not include BMS landings.

łł Includes top-up of 4.1%.

Subarea 4, 6, and Division 3.a

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ICES estimate	107728	119844	121320	99204	122184	112267	103030	98446	78414	80059	76392	76936	68709 #	88686 #
TAC	210000	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512	110691 łł

łł Agreed upon TAC including landings top-up.

 # Since 2016, landings correspond to wanted catch, which includes Norwegian component of BMS landings.

Table 17.3.2. Saithe in subareas 4 and 6 and Division 3.a. Nominal discards and, in parenthesis, BMS landings (tons) of saithe, 2004–2017, as a combination of reported to ICES and estimated, where unreported discards were estimated following the protocol of WKNSEA 2016 (ICES WKNSEA 2016). Discard information for Norway might be more accurate if stated as BMS landings because Norway has been under a landings obligation for several decades. However, the amounts landed are poorly documented and therefore data were estimated for Norway using discarding ratios from other nations (see ICES WKNSEA 2016).

SUBAREA 4 AND DIVISION 3A

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	0.1	0.1	0.1	1	0.1	0	1	0	0.3	0.3	0.1	0	3 (0)	1
Denmark	841	441	752	622	665	84	163	358	135	198	64	220	274 (0)	424 (0)
Faroe Isl.	0	2	0.7	0.2	2	17	4	0.1	0.1	0	0	0	0	0
France	0	0	0	0	2	7	4	1	0.2	3	32	1	8	83
Germany	77	19	15	43	50	33	16	13	13	71	12	8	2 (5)	10 (6)
Greenland	12	5	21	3	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lithuania	0	0.5	0	0.2	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0.2	0	0	0	0.2	0.3	4	74	1	0.1	3 (0)	1
Norway	45	56	123	940	324	69	1090	39	1721	258	231	76	410 (174)	285 (217)
Poland	0	10	10	3	16	1	36	2	0	0	0	0	0	0
Portugal	0	0	5	3	0	0	0	0	0	0	0	0		0
Russia	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0
Sweden	112	25	291	55	184	168	496	34	83	17	96	55	62	30 (0)
UK (E/W/NI)	11	26	20	14	44	14	137	319	62	491	3	20	5	24
UK (Scotland)	6350	5974	5671	10144	6092	3382	2124	3070	4377	5279	5386	4227	9926	5481
Total reported	7464	6557	6909	11828	7378	3774	4071	3858	6395	6391	5824	4604	10693 (179*)	6339 (223*)

*** Preliminary.**

SUBAREA 6

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	0	0	0	0	0	9	0	0	0	0	1	0	0 (0)	0
Faroe Islands	0	0.1	0.8	0.3	0.4	1	0.6	0.2	0	0	1	0	0	0
France	0	0	0	0	9	2	234	0.2	1	53	16	30	1	9
Germany	0	0	0	0.4	0	0	0	0	0	0	0	0	0	1
Greenland	8	0.2	0	0.4	0	0	0	0	0	0	0	0	0	0
Ireland	21	313	2	93	5	1	6	19	5	5	2	2	1	1 (0)
Netherlands	0	0	0	2	0	0	0	0	0	0	0.1	0	1 (0)	0
Norway	0.1	0.1	0.2	2	1	0.1	14	0.1	1	0.2	1	0.4	1 (1)	3
Russia	0	0.1	0.1	0	0	0	0.1	0	0	0	0.2	0	0	0
Spain	0	0	0.1	0	0	0	0.4	1.1	0.1	0	0.2	132	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK (E/W/NI)	0.5	1.1	1	0	0.1	0	0	0	0.1	0	0.1	1	0	1
UK (Scotland)	590	1323	1670	486	966	516	157	482	2880	1339	491	240	177	125
Total reported	620	1637	1675	584	981	521	412	502	2887	1398	512	405	181 (1*)	139 (0*)

*** Preliminary.**

SUBAREAS 4 AND 6 AND DIVISION 3A

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ICES estimate discards	8085	8195	8584	12412	8359	4295	4484	4339	9282	7789	6336	5009	10874	6478
ICES esimate BMS landings													180*	223*

*** Preliminary.**

Table 17.3.3. Saithe in subareas 4 and 6 and Division 3.a. Catch data imported into InterCatch and proportion of sampling strata for discards raised within InterCatch.

Catch Category	Raised or Imported	Weight (tonnes)	Proportion
BMS landing	Imported data	217	100
Discards	Imported data	6105	94
Discards	Raised discards	373	6
Landings	Imported data	88469	100
Logbook registered discard	Imported data	0	0

Table 17.3.4. Saithe in subareas 4 and 6 and Division 3.a. Working Group estimates of catch components by weight (t). Norway was under landings obligations from 1988, but records are unclear whether saithe was fully in the landings obligation from that time.

Year	Catches	Landings	BMS 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	116503	108418		8085	7
2005	127788	119593		8195	6
2006	134264	125680		8584	6
2007	112816	100404		12412	11
2008	127026	118667		8359	7
2009	116787	112492		4295	4
2010	106424	101940		4484	4
2011	101443	97104		4339	4
2012	86954	77672		9282	11
2013	87676	79887		7789	9
2014	81755	75419		6336	8
2015	83316	78307		5009	6
2016	78956	67902	174	10874	14
2017	95169	88468	217	6478	7

Table 17.3.5. Saithe in subareas 4 and 6 and Division 3.a. Amount (weight and proportion) of sampled or estimated age distributions of catch data imported or raised in InterCatch.

Catch Category	Raised Or Imported	Sampled Or Estimated	Weight (tonnes)	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	0
Landings	Imported_Data	Sampled_Distribution	79636	90
Landings	Imported_Data	Estimated_Distribution	8832	10
Discards	Imported_Data	Sampled_Distribution	5998	93
Discards	Raised_Discards	Estimated_Distribution	373	6
Discards	Imported_Data	Estimated_Distribution	107	2
BMS landing	Imported_Data	Estimated_Distribution	217	100

Table 17.3.6. Saithe in subareas 4 and 6 and Division 3.a. Number of age sampling units and age measurements by catch category, fleet, quarter, nation, and area for 2017.

Catch Category	Fleet	Country	Season	Area	No. Age samples	No. Age measured
Discards	OTB_DEF_>=120_0_0_all	Denmark	1	4	7	3
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	1	4	18	208
Discards	GNS_DEF_120-219_0_0_all	Denmark	1	3.a.20	6	7
Discards	OTB_CRU_90-119_0_0_all	Denmark	1	3.a.20	14	16
Discards	OTB_DEF_>=120_0_0_all	Denmark	1	3.a.20	6	3
Discards	OTB_DEF_>=120_0_0_all	Denmark	2	4	3	35
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	2	4	17	164
Discards	GNS_DEF_120-219_0_0_all	Denmark	2	3.a.20	7	2
Discards	MIS_MIS_0_0_0_HC	Denmark	2	3.a.20	4	1
Discards	OTB_CRU_90-119_0_0_all	Denmark	2	3.a.20	6	1
Discards	OTB_DEF_>=120_0_0_all	Denmark	3	4	5	23
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	3	4	23	382
Discards	OTB_SPF_32-69_0_0_all	Germany	3	4	0	412
Discards	GNS_DEF_120-219_0_0_all	Denmark	3	3.a.20	3	1
Discards	MIS_MIS_0_0_0_HC	Denmark	3	3.a.20	2	2
Discards	OTB_CRU_90-119_0_0_all	Denmark	3	3.a.20	10	2
Discards	OTB_DEF_>=120_0_0_all	Denmark	3	3.a.20	9	3
Discards	GNS_DEF_120-219_0_0_all	Denmark	4	4	2	3
Discards	OTB_DEF_>=120_0_0_all	Denmark	4	4	3	28
Discards	OTB_DEF_>=120_0_0_all	Germany	4	4	0	1173
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	4	4	12	96
Discards	GNS_DEF_120-219_0_0_all	Denmark	4	3.a.20	5	2
Discards	OTB_CRU_90-119_0_0_all	Denmark	4	3.a.20	10	8
Discards	OTB_DEF_>=120_0_0_all	Denmark	4	3.a.20	5	9
Discards	OTB_CRU_70-99_0_0_all	UK(Scotland)	2017	4	45	87
Discards	OTB_CRU_70-99_0_0_all	UK(Scotland)	2017	6.a	40	29
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	2017	6.a	13	77
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	2017	6.b.2	2	2
Landings	GNS_DEF_120-219_0_0_all	Denmark	1	4	6	251
Landings	GNS_DEF_all_0_0_all	Norway	1	4	74	735
Landings	OTB_CRU_32-69_0_0_all	Denmark	1	4	6	251
Landings	OTB_CRU_70-99_0_0_all	Denmark	1	4	6	251
Landings	OTB_DEF_>=120_0_0_all	Denmark	1	4	6	251
Landings	OTB_DEF_>=120_0_0_all	France	1	4	0	0
Landings	OTB_DEF_>=120_0_0_all	Germany	1	4	0	459
Landings	OTB_DEF_>=120_0_0_all	Norway	1	4	59	140
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	1	4	16	402
Landings	GNS_DEF_120-219_0_0_all	Denmark	1	3.a.20	1	5
Landings	OTB_CRU_32-69_0_0_all	Denmark	1	3.a.20	1	5
Landings	OTB_CRU_90-119_0_0_all	Denmark	1	3.a.20	1	5
Landings	OTB_DEF_>=120_0_0_all	Denmark	1	3.a.20	1	5
Landings	OTB_DEF_>=120_0_0_all	France	1	6.a	0	0
Landings	GNS_DEF_>=220_0_0_all	Denmark	2	4	5	235
Landings	GNS_DEF_100-119_0_0_all	Denmark	2	4	5	235
Landings	GNS_DEF_120-219_0_0_all	Denmark	2	4	5	235

Catch Category	Fleet	Country	Season	Area	No. Age samples	No. Age measured
Landings	GNS_DEF_all_0_0_all	Norway	2	4	48	337
Landings	OTB_CRU_70-99_0_0_all	Denmark	2	4	5	235
Landings	OTB_DEF_>=120_0_0_all	Denmark	2	4	5	235
Landings	OTB_DEF_>=120_0_0_all	France	2	4	0	0
Landings	OTB_DEF_>=120_0_0_all	Germany	2	4	0	451
Landings	OTB_DEF_>=120_0_0_all	Norway	2	4	68	100
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	2	4	18	460
Landings	TBB_DEF_>=120_0_0_all	Denmark	2	4	5	235
Landings	GNS_DEF_>=220_0_0_all	Denmark	2	3.a.20	5	179
Landings	GNS_DEF_100-119_0_0_all	Denmark	2	3.a.20	5	179
Landings	GNS_DEF_120-219_0_0_all	Denmark	2	3.a.20	5	179
Landings	OTB_CRU_32-69_0_0_all	Denmark	2	3.a.20	5	179
Landings	OTB_CRU_90-119_0_0_all	Denmark	2	3.a.20	5	179
Landings	OTB_DEF_>=120_0_0_all	Denmark	2	3.a.20	5	179
Landings	OTB_DEF_>=120_0_0_all	France	2	6.a	0	0
Landings	GNS_DEF_>=220_0_0_all	Denmark	3	4	6	264
Landings	GNS_DEF_120-219_0_0_all	Denmark	3	4	6	264
Landings	GNS_DEF_all_0_0_all	Norway	3	4	68	366
Landings	OTB_CRU_32-69_0_0_all	Denmark	3	4	6	264
Landings	OTB_DEF_>=120_0_0_all	Denmark	3	4	6	264
Landings	OTB_DEF_>=120_0_0_all	France	3	4	0	0
Landings	OTB_DEF_>=120_0_0_all	Germany	3	4	0	412
Landings	OTB_DEF_>=120_0_0_all	Norway	3	4	59	253
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	3	4	17	374
Landings	TBB_DEF_>=120_0_0_all	Denmark	3	4	6	264
Landings	GNS_DEF_>=220_0_0_all	Denmark	3	3.a.20	7	166
Landings	GNS_DEF_120-219_0_0_all	Denmark	3	3.a.20	7	166
Landings	OTB_CRU_32-69_0_0_all	Denmark	3	3.a.20	7	166
Landings	OTB_CRU_70-89_2_35_all	Denmark	3	3.a.20	7	166
Landings	OTB_CRU_90-119_0_0_all	Denmark	3	3.a.20	7	166
Landings	OTB_DEF_>=120_0_0_all	Denmark	3	3.a.20	7	166
Landings	OTB_DEF_>=120_0_0_all	Germany	3	3.a.20	0	317
Landings	TBB_DEF_>=120_0_0_all	Denmark	3	3.a.20	7	166
Landings	OTB_DEF_>=120_0_0_all	France	3	6.a	0	0
Landings	GNS_DEF_>=220_0_0_all	Denmark	4	4	5	311
Landings	GNS_DEF_120-219_0_0_all	Denmark	4	4	5	311
Landings	GNS_DEF_all_0_0_all	Norway	4	4	57	355
Landings	OTB_CRU_32-69_0_0_all	Denmark	4	4	5	311
Landings	OTB_CRU_70-99_0_0_all	Denmark	4	4	5	311
Landings	OTB_DEF_>=120_0_0_all	Denmark	4	4	5	311
Landings	OTB_DEF_>=120_0_0_all	France	4	4	0	0
Landings	OTB_DEF_>=120_0_0_all	Germany	4	4	0	1173
Landings	OTB_DEF_>=120_0_0_all	Norway	4	4	7	40
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	4	4	16	304
Landings	TBB_DEF_>=120_0_0_all	Denmark	4	4	5	311
Landings	GNS_DEF_120-219_0_0_all	Denmark	4	3.a.20	3	130
Landings	OTB_CRU_32-69_0_0_all	Denmark	4	3.a.20	3	130
Landings	OTB_CRU_70-89_2_35_all	Denmark	4	3.a.20	3	130
Landings	OTB_CRU_90-119_0_0_all	Denmark	4	3.a.20	3	130
Landings	OTB_DEF_>=120_0_0_all	Denmark	4	3.a.20	3	130
Landings	OTB_DEF_>=120_0_0_all	France	4	6.a	0	0
Landings	OTT_DEF_100-119_0_0_all	France	4	6.a	0	0
Landings	OTB_DEF_>=120_0_0_all	Ireland	2017	6.a	0	0
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	2017	6.a	13	264
Landings	OTB_DEF_>=120_0_0_all	Ireland	2017	6.b	0	0
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	2017	6.b.2	1	3

Table 17.3.7. Saithe in subareas 4 and 6 and Division 3.a. Amount (weight and proportion) of sampled or estimated age distributions of catch data imported or raised in InterCatch by ICES area.

Catch Category	Raised or Imported	Sampled Or Estimated	Area	Weight (tons)	%
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.6	0	0
Landings	Imported_Data	Sampled_Distribution	27.6	6228	88
Landings	Imported_Data	Estimated_Distribution	27.6	888	12
Discards	Imported_Data	Sampled_Distribution	27.6	125	89
Discards	Imported_Data	Estimated_Distribution	27.6	9	6
Discards	Raised_Discards	Estimated_Distribution	27.6	6	4
BMS landing	Imported_Data	Estimated_Distribution	27.6	0	0
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4	0	0
Landings	Imported_Data	Sampled_Distribution	27.4	71920	91
Landings	Imported_Data	Estimated_Distribution	27.4	7042	9
Discards	Imported_Data	Sampled_Distribution	27.4	5861	93
Discards	Raised_Discards	Estimated_Distribution	27.4	359	6
Discards	Imported_Data	Estimated_Distribution	27.4	92	1
BMS landing	Imported_Data	Estimated_Distribution	27.4	223	100
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.3.a	0	0
Landings	Imported_Data	Sampled_Distribution	27.3.a	1489	62
Landings	Imported_Data	Estimated_Distribution	27.3.a	901	38
Discards	Imported_Data	Sampled_Distribution	27.3.a	12	46
Discards	Raised_Discards	Estimated_Distribution	27.3.a	9	32
Discards	Imported_Data	Estimated_Distribution	27.3.a	6	22
BMS landing	Imported_Data	Estimated_Distribution	27.3.a	0	0

Table 17.3.8. 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
2016	7382	14241	9661	5729	2758	1430	853	1317
2017	4977	18989	9773	6247	5364	1876	820	1113

Table 17.3.9. 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	40193	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
2016	3508	10374	8756	5156	2732	1423	852	1317
2017	3033	15139	8795	6178	5362	1876	820	1111

Table 17.3.10. Saithe in subareas 4 and 6 and Division 3.a. Discards 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
2016	3874	3867	905	573	26	7	1	0
2017	1944	3850	978	69	2	0	0	2

Table 17.3.11. 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	0.752	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
2016	0.937	1.239	1.611	2.231	2.888	3.450	4.331	6.208
2017	0.956	1.228	1.755	2.356	2.987	4.232	4.473	6.287

Table 17.3.12. 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	0.931	1.362	2.104	3.186	3.754	5.316	5.891	7.719
1968	1.278	1.652	1.989	3.009	4.040	4.428	6.136	7.406
1969	0.966	1.557	2.261	2.713	3.559	4.406	5.220	6.768
1970	0.941	1.441	2.059	2.718	3.600	4.463	5.687	6.845
1971	0.840	1.348	2.178	2.936	3.766	4.634	5.173	6.163
1972	0.808	1.196	1.961	2.369	3.794	4.228	4.630	6.326
1973	0.821	1.406	1.641	2.571	3.357	4.684	4.814	6.445
1974	0.861	1.561	2.383	2.753	3.429	4.498	5.713	7.857
1975	0.893	1.498	2.490	3.300	3.765	4.296	5.540	7.562
1976	0.702	1.309	2.260	3.071	4.035	4.383	5.112	7.147
1977	0.760	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.340	4.522	4.901	5.449	7.400
1979	1.107	1.623	2.238	3.095	4.050	5.274	6.308	7.955
1980	0.955	1.821	2.391	3.030	4.090	5.126	5.939	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.980	8.724
1982	1.086	1.575	2.529	3.220	4.207	5.125	5.905	8.823
1983	1.028	1.718	2.149	3.138	3.691	4.632	5.505	8.453
1984	0.795	1.614	2.297	2.690	3.896	4.665	6.183	8.474
1985	0.663	1.265	1.951	2.772	3.407	4.950	5.865	8.854
1986	0.694	1.035	1.794	2.432	3.572	4.209	5.651	8.218
1987	0.674	0.876	1.824	3.075	4.210	5.330	6.128	8.603
1988	0.779	0.981	1.386	2.791	4.024	5.254	6.322	8.649
1989	0.895	1.036	1.420	1.998	3.914	5.018	6.430	8.431
1990	0.844	1.196	1.583	2.247	3.242	4.858	6.315	8.416
1991	0.791	1.158	1.752	2.365	3.165	4.222	6.066	8.191
1992	0.964	1.189	1.607	2.242	3.668	4.330	5.413	7.046
1993	0.899	1.260	1.754	2.636	3.185	3.980	5.080	6.891
1994	0.944	1.119	1.601	2.434	3.618	4.787	6.548	8.326
1995	1.002	1.294	1.816	2.562	3.555	4.767	5.267	7.891
1996	0.967	1.187	1.807	2.368	2.952	4.705	6.092	8.382
1997	0.905	1.145	1.452	2.587	3.556	4.525	6.158	8.866
1998	0.892	0.966	1.393	1.744	2.949	3.883	4.996	7.227
1999	0.881	1.061	1.211	1.754	2.337	3.493	4.844	6.745
2000	1.027	1.127	1.539	1.684	2.594	3.084	4.773	7.462
2001	0.802	1.072	1.313	2.095	2.546	3.485	4.141	6.141
2002	0.923	1.035	1.478	1.769	2.947	3.426	4.407	5.674
2003	0.833	0.980	1.173	1.810	2.368	3.176	3.768	5.065
2004	0.918	1.084	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.921	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.945	1.069	1.514	1.906	2.424	3.058	4.318	5.734
2007	0.837	1.143	1.317	1.840	2.328	2.887	3.600	4.975
2008	0.944	1.193	1.565	1.720	2.226	2.795	3.206	4.565
2009	1.036	1.340	1.664	1.992	2.563	3.085	3.648	4.793
2010	1.036	1.479	2.034	2.597	3.164	3.488	3.968	5.199
2011	1.007	1.207	1.783	2.573	3.068	3.404	3.717	4.284
2012	1.015	1.321	1.408	2.201	3.223	3.536	4.177	4.482
2013	0.898	1.156	1.614	1.976	3.078	3.841	4.541	5.648
2014	1.126	1.300	1.607	2.384	2.617	4.013	5.530	6.679
2015	0.977	1.244	1.625	2.190	3.043	3.796	4.228	7.287
2016	0.998	1.292	1.628	2.283	2.892	3.453	4.333	6.208
2017	1.047	1.302	1.809	2.361	2.988	4.232	4.473	6.292

Table 17.3.13. 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
2016	0.882	1.096	1.440	1.764	2.384	2.864	2.634	4.282
2017	0.815	0.937	1.269	1.907	2.484	4.232	4.473	2.817

Table 17.4.1. Saithe in subareas 4 and 6 and Division 3.a. Data available for calibration of the final assessment. Indices include one commercial standardized CPUE index (year effects), tuned to the exploitable biomass within SAM, and indices for age 3–8 from one research survey, the third quarter NS–IBTS.

IBTS–Q3 (DATRAS standard index)							**CPUE**
Year	3	4	5	6	7	8	
1992	1.077	2.760	0.516	0.098	0.057	0.050	
1993	7.965	2.781	1.129	0.197	0.011	0.040	
1994	1.117	1.615	0.893	0.609	0.091	0.040	
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	1.580	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	0.7437
2001	21.475	6.169	3.936	0.356	0.444	0.113	0.8570
2002	10.748	18.974	1.327	1.090	0.162	0.264	0.6556
2003	19.272	23.802	13.402	0.393	0.439	0.168	0.5846
2004	4.930	6.727	3.237	0.921	0.064	0.085	0.8219
2005	8.916	7.512	4.428	1.914	1.082	0.104	0.9125
2006	10.553	29.579	2.835	1.177	0.445	0.242	0.9495
2007	34.006	5.578	11.700	1.016	0.743	0.358	0.7644
2008	3.312	5.584	0.907	1.997	0.254	0.254	0.9491
2009	1.346	1.703	0.568	0.101	0.229	0.200	0.7059
2010	1.361	0.964	0.471	0.205	0.045	0.166	0.6355
2011	4.520	8.451	1.059	1.114	0.426	0.080	0.6267
2012	11.134	2.497	2.968	0.503	0.483	0.344	0.4952
2013	14.701	16.279	1.830	1.858	0.308	0.146	0.5876
2014	1.649	3.923	2.822	0.481	0.520	0.114	0.5603
2015	11.001	5.613	4.611	1.581	0.289	0.285	0.6797
2016	37.901	17.439	3.255	2.681	0.945	0.195	0.5454
2017	11.447	13.102	3.068	1.267	0.942	0.473	0.6780

Table 17.4.2. Saithe in subareas 4 and 6 and Division 3.a. Model configuration for the 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 17.4.3. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortalities at age for the final assessment model.

Year\Age	3	4	5	6	7	8	9+
1967	0.265	0.387	0.356	0.351	0.311	0.281	0.311
1968	0.236	0.348	0.304	0.286	0.247	0.223	0.249
1969	0.254	0.372	0.325	0.312	0.277	0.253	0.275
1970	0.302	0.419	0.352	0.326	0.283	0.254	0.267
1971	0.37	0.468	0.378	0.346	0.309	0.285	0.296
1972	0.447	0.521	0.405	0.368	0.332	0.307	0.311
1973	0.525	0.572	0.43	0.381	0.346	0.32	0.318
1974	0.64	0.659	0.496	0.436	0.398	0.365	0.351
1975	0.66	0.691	0.534	0.475	0.441	0.408	0.385
1976	0.754	0.77	0.606	0.53	0.485	0.444	0.409
1977	0.634	0.708	0.594	0.538	0.507	0.471	0.429
1978	0.503	0.586	0.493	0.44	0.417	0.389	0.355
1979	0.419	0.524	0.46	0.423	0.409	0.381	0.347
1980	0.404	0.524	0.48	0.454	0.447	0.423	0.387
1981	0.363	0.501	0.474	0.46	0.465	0.452	0.416
1982	0.431	0.587	0.555	0.522	0.509	0.481	0.435
1983	0.515	0.702	0.673	0.625	0.596	0.553	0.491
1984	0.591	0.791	0.726	0.628	0.561	0.504	0.444
1985	0.632	0.866	0.771	0.625	0.541	0.483	0.436
1986	0.59	0.889	0.816	0.651	0.563	0.51	0.476
1987	0.539	0.84	0.792	0.63	0.551	0.508	0.488
1988	0.529	0.828	0.802	0.645	0.565	0.519	0.501
1989	0.518	0.809	0.782	0.627	0.537	0.482	0.462
1990	0.504	0.782	0.749	0.59	0.5	0.438	0.42
1991	0.467	0.742	0.718	0.563	0.478	0.417	0.406
1992	0.411	0.691	0.693	0.557	0.48	0.417	0.41
1993	0.391	0.677	0.707	0.599	0.554	0.496	0.493
1994	0.319	0.594	0.628	0.537	0.508	0.461	0.466
1995	0.275	0.552	0.617	0.556	0.557	0.523	0.527
1996	0.218	0.467	0.546	0.507	0.505	0.477	0.475
1997	0.184	0.407	0.479	0.447	0.437	0.417	0.413
1998	0.184	0.405	0.487	0.462	0.441	0.421	0.412
1999	0.182	0.41	0.513	0.506	0.482	0.467	0.451
2000	0.157	0.365	0.455	0.448	0.409	0.386	0.37
2001	0.151	0.349	0.427	0.417	0.369	0.345	0.332
2002	0.145	0.338	0.424	0.444	0.407	0.397	0.409
2003	0.152	0.342	0.422	0.464	0.434	0.426	0.444
2004	0.131	0.305	0.369	0.408	0.38	0.371	0.379
2005	0.136	0.318	0.383	0.419	0.383	0.363	0.355
2006	0.153	0.343	0.402	0.429	0.39	0.368	0.356
2007	0.142	0.333	0.387	0.402	0.362	0.342	0.33
2008	0.159	0.386	0.463	0.473	0.421	0.393	0.37
2009	0.15	0.379	0.467	0.481	0.431	0.408	0.386
2010	0.135	0.358	0.45	0.463	0.424	0.409	0.386
2011	0.143	0.374	0.464	0.462	0.416	0.402	0.376
2012	0.119	0.336	0.422	0.423	0.38	0.372	0.353
2013	0.095	0.292	0.374	0.38	0.345	0.342	0.326
2014	0.079	0.255	0.336	0.346	0.317	0.319	0.312
2015	0.074	0.245	0.326	0.332	0.3	0.303	0.299
2016	0.062	0.219	0.295	0.303	0.28	0.293	0.301
2017	0.057	0.207	0.285	0.298	0.279	0.292	0.306

Table 17.4.4. Saithe in subareas 4 and 6 and Division 3.a: Estimated population numbers-at-age for the final assessment model.

Year\Age	3	4	5	6	7	8	9	10+
1967	141195	81247	57243	7161	4917	1156	757	693
1968	161380	91949	50217	31760	3722	2530	662	788
1969	283452	90597	54266	30949	20460	2833	1960	828
1970	293348	215844	49090	35307	18617	11672	1797	1634
1971	352835	191298	118843	24573	19378	11895	7804	2514
1972	224485	208629	102660	67140	14462	11334	7278	6488
1973	201431	111320	104949	63042	35612	8646	6308	8583
1974	199862	90578	48316	62500	41834	20439	5374	8501
1975	235293	76570	35487	24190	36061	25038	11924	8461
1976	401577	102742	29721	17405	12861	19052	13211	11532
1977	150029	147514	35775	12457	8675	7190	10722	13930
1978	120435	72428	58046	14266	5118	4008	3387	13102
1979	87591	53805	34777	29247	7806	2810	2205	9509
1980	85859	47008	25642	18707	16073	4037	1666	7673
1981	161831	41850	24819	12250	9622	8284	2142	5902
1982	141029	108086	22927	15018	6261	4817	3766	4080
1983	148822	69520	54780	11319	8264	3131	2527	3821
1984	255252	76214	29995	23846	4727	3478	1331	2788
1985	354958	108122	29530	12778	9456	2221	1590	2301
1986	288406	141650	32301	11804	6368	4476	1193	2265
1987	149399	163761	36434	10221	5151	3294	2292	1807
1988	137799	71442	61706	11438	4557	2600	1749	1940
1989	102877	69250	27755	21864	4709	2094	1247	1658
1990	150902	48044	25732	11156	8391	2310	1027	1413
1991	174246	71417	17431	10284	5269	3797	1238	1397
1992	104120	88996	26094	6818	5208	2862	2061	1487
1993	176380	58928	34156	9248	2921	3159	1814	2273
1994	118559	97648	28627	13560	3493	1428	1485	2179
1995	211662	66685	42407	13024	6414	1658	937	1956
1996	118226	147305	29958	19855	7016	2519	727	1372
1997	148154	78603	89450	13307	9352	3434	1133	1001
1998	88916	119679	44936	48701	7294	4660	1887	1072
1999	111591	56008	73449	22641	26540	4278	2415	1651
2000	97514	94109	29300	36590	11077	12613	2047	1778
2001	200380	67838	64877	14109	17473	6380	6930	1653
2002	159826	140890	34911	34352	8174	9532	3884	5034
2003	167103	120978	83924	16618	17431	5212	5239	5012
2004	117329	110325	75320	48592	7999	8305	3264	4690
2005	141541	76365	67986	50065	27676	4952	4541	4359
2006	100917	123190	42504	37048	27022	13889	3062	4892
2007	152393	54993	78004	24470	19628	14963	7068	4376
2008	73407	97638	31212	48941	15493	11156	10073	8155
2009	58954	51531	43259	14470	24957	9763	5874	10360
2010	89610	38616	28111	20147	7073	13336	5658	9651
2011	82156	79078	22993	14360	10147	3655	6646	10136
2012	139716	47797	47684	12131	7478	5086	1998	9463
2013	101788	106043	24000	26857	6989	4069	2716	6615
2014	65267	76830	58086	13847	14865	4187	2131	5507
2015	111094	49698	53112	31426	8328	7726	2714	4593
2016	143944	76290	34070	30700	16029	5349	4182	4666
2017	114414	109881	44988	22181	20379	9450	3304	5058

Table 17.5.1. 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 ($F_{4\text{–}7}$), 1967–2016. 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	141195	100361	198644	412609	337941	503775	152662	120694	193098	0.351	0.274	0.45
1968	161380	116634	223292	579443	477735	702806	210375	168878	262069	0.296	0.232	0.377
1969	283452	204774	392361	710111	589037	856072	276532	224872	340060	0.321	0.258	0.4
1970	293348	213132	403754	909122	761645	1085155	345552	285601	418086	0.345	0.281	0.425
1971	352835	258877	480896	1053054	891667	1243650	460416	381603	555507	0.375	0.308	0.458
1972	224485	165849	303853	957112	818537	1119147	488655	407623	585796	0.407	0.336	0.492
1973	201431	148905	272487	892543	769273	1035567	520346	434189	623599	0.432	0.359	0.52
1974	199862	147526	270765	924317	801456	1066013	575211	482417	685854	0.497	0.417	0.593
1975	235293	174653	316988	856492	742777	987617	515979	431689	616727	0.535	0.45	0.636
1976	401577	292259	551786	810011	693802	945684	398544	331488	479165	0.598	0.502	0.711
1977	150029	110486	203726	612151	525942	712490	325066	269785	391675	0.587	0.488	0.706
1978	120435	89013	162950	520204	446461	606127	297294	245733	359673	0.484	0.403	0.581
1979	87591	64484	118978	483317	416734	560538	278537	232809	333246	0.454	0.378	0.545
1980	85859	63198	116645	439727	381002	507504	260927	219687	309908	0.476	0.399	0.568
1981	161831	118278	221423	491440	423695	570017	249637	211206	295060	0.475	0.398	0.567
1982	141029	104284	190720	530350	456099	616688	220035	188767	256483	0.543	0.461	0.64
1983	148822	109927	201480	508848	439680	588898	219750	188039	256809	0.649	0.552	0.764
1984	255252	188018	346529	515836	442222	601704	188522	162019	219361	0.676	0.578	0.792
1985	354958	258421	487558	527261	444331	625668	165818	143220	191981	0.701	0.6	0.819
1986	288406	212799	390877	490705	417453	576811	156678	135544	181106	0.73	0.62	0.86
1987	149399	110244	202462	404573	348659	469455	165756	143404	191591	0.704	0.601	0.824
1988	137799	102130	185926	349282	302590	403178	155174	132797	181323	0.71	0.606	0.831
1989	102877	76115	139050	293236	253915	338646	126649	108781	147452	0.689	0.587	0.808
1990	150902	111451	204318	301775	258396	352436	114668	98286	133779	0.655	0.558	0.769
1991	174246	128998	235367	320697	272713	377122	107583	92702	124852	0.625	0.532	0.735
1992	104120	77437	139998	311025	266302	363260	113306	98097	130873	0.605	0.513	0.714
1993	176380	131142	237223	356842	303610	419409	120307	103421	139950	0.634	0.536	0.751
1994	118559	88168	159425	341296	291727	399288	125779	108204	146208	0.567	0.479	0.67
1995	211662	155514	288081	450570	379124	535478	145177	124345	169498	0.57	0.48	0.678
1996	118226	87095	160484	431551	365377	509710	156727	134531	182585	0.506	0.424	0.604
1997	148154	108295	202685	446115	379555	524346	194255	164099	229953	0.442	0.368	0.532
1998	88916	64537	122506	394070	338046	459378	190626	161407	225136	0.449	0.375	0.537
1999	111591	81236	153288	381258	328522	442460	200498	169264	237495	0.478	0.397	0.575
2000	97514	71398	133183	398020	341927	463314	191547	162707	225499	0.419	0.346	0.507
2001	200380	146084	274856	446486	379851	524810	198434	168001	234382	0.39	0.32	0.476
2002	159826	116937	218445	487553	414670	573245	220462	186446	260683	0.403	0.334	0.486
2003	167103	122490	227966	444771	380050	520515	212160	179631	250579	0.416	0.344	0.502
2004	117329	86199	159700	503936	432622	587005	269436	227753	318746	0.365	0.3	0.445
2005	141541	103358	193830	480467	413756	557933	261661	221929	308507	0.376	0.31	0.455
2006	100917	72511	140452	499039	430868	577996	272663	231362	321336	0.391	0.324	0.473
2007	152393	107371	216294	460282	394983	536377	249992	211281	295795	0.371	0.307	0.449
2008	73407	53871	100027	435417	374300	506515	254449	215126	300961	0.436	0.361	0.527
2009	58954	43265	80332	395975	340488	460504	248284	208535	295610	0.439	0.364	0.531
2010	89610	65757	122116	401059	343346	468473	233554	194651	280232	0.424	0.35	0.513
2011	82156	58750	114886	362587	307283	427845	187445	155933	225325	0.429	0.352	0.524
2012	139716	100539	194159	374058	311301	449466	169671	140385	205067	0.39	0.316	0.482
2013	101788	72138	143626	386868	318156	470420	179077	147012	218136	0.348	0.276	0.439
2014	65267	44593	95525	395922	320306	489390	208726	169091	257650	0.314	0.241	0.408
2015	111094	71155	173449	422095	326690	545361	224739	177789	284088	0.301	0.221	0.41
2016	143944	82345	251624	464641	330994	652250	222544	168143	294545	0.274	0.187	0.401
2017	114414	56728	230760	523059	342608	798552	267853	187267	383119	0.267	0.168	0.424
2018	111094*						305137					

*** Preliminary**

Table 17.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2018)	0.267	Average exploitation pattern (2015-2017) scaled to F_{4-7} in 2017
SSB (2019)	339997 t	SSB at the beginning of the TAC year, tonnes
$R_{age\ 3}$ (2018–2019)	111 million	Median recruitment re-sampled from the years 2003–2017
Total catch (2018)	101522 t	Assuming 2017 landings fraction by age, tonnes
Wanted catch (2018)	93689 t	Wanted catch fishing at F_{2018}
Unwanted catch (2018)	7834 t	Assuming 2017 discard fraction by age, tonnes

Table 17.7.2. Saithe in subareas 4 and 6 and Division 3.a. Reference points and their technical basis.

Framework	Reference Point	Value	Technical Basis	Source
MSY approach	MSY $B_{trigger}$	150000 t	B_{pa}	ICES (2016a)
	F_{MSY}	0.358	Stochastic simulation using hockey-stick stock–recruitment; estimated by application of EqSim	ICES (2016a)
Precautionary approach	B_{lim}	107000 t	B_{loss}	ICES (2016a)
	B_{pa}	150000 t	$B_{pa} = B_{lim} \times \exp(1.645\ \sigma_B) = = B_{lim} \times 1.4$; $\sigma_B = 0.20$	ICES (2016a)
	F_{lim}	0.564	F_{lim} gives the 50% probability of falling below B_{lim} in the stochastic EqSim simulations	ICES (2016a)
	F_{pa}	0.403	$F_{pa} = F_{lim} \times \exp(−1.645\ \sigma_F) = ;\ \sigma_F = 0.20$	ICES (2016a)

Table 17.7.3. Saithe in subareas 4 and 6 and Division 3.a. All weights in tonnes.

Basis	Total catch (2019)	Wanted catch* (2019)	Unwanted catch* (2019)	Wanted catch* 3a4	Wanted catch* 6	F_{total} (2019)	F_{wanted} (2019)	$F_{unwanted}$ (2019)	SSB (2020)	% SSB change **	% TAC change ***	% advice change ^
ICES advice basis												
MSY approach: F_{MSY}	139978	130275	9704	118029	12246	0.36	0.33	0.025	334963	-1.48	21	18
Other scenarios												
F = 0	0	0	0	0	0	0	0	0	475333	40	-100	-100
F_{pa}	154490	143719	10771	130210	13510	0.40	0.38	0.028	320712	-5.7	33	30
F_{lim}	201664	187381	14282	169768	17614	0.56	0.52	0.040	274466	-19	74	70
SSB2020 = B_{lim}	383055	352742	30313	319584	33158	1.58	1.47	0.111	107000	-69	230	223
SSB2020 = B_{pa}	334056	308568	25488	279563	29005	1.21	1.12	0.085	150000	-56	188	182
SSB2020 = $B_{Trigger}$	334056	308568	25488	279563	29005	1.21	1.12	0.085	150000	-56	188	182
F = F_{2018}	108758	101271	7487	91752	9519	0.27	0.25	0.019	365832	7.6	-6.3	-8.2
TAC_{2018}	116008	108019	7989	97865	10154	0.29	0.27	0.020	358570	5.5	0	-2.07
F = $F_{MSY\ lower\ without\ Btrigger}$	88908	82832	6076	75046	7786	0.213	0.198	0.015	385352	13	-23	-25
	91537	85272	6265	77257	8016	0.22	0.21	0.015	382700	13	-21	-23
	95264	88738	6526	80397	8341	0.23	0.21	0.016	379054	12	-18	-20
	98957	92169	6788	83505	8664	0.24	0.22	0.017	375468	10	-15	-17
	102617	95566	7051	86583	8983	0.25	0.23	0.018	371827	9	-12	-13
	106241	98933	7308	89634	9300	0.26	0.24	0.018	368286	8	-8	-10
	109831	102268	7563	92655	9613	0.27	0.25	0.019	364777	7	-5	-7
	113380	105572	7808	95648	9924	0.28	0.26	0.020	361247	6	-2	-4
	116892	108844	8048	98612	10231	0.29	0.27	0.020	357684	5	0.8	-1
	120370	112091	8279	101554	10537	0.30	0.28	0.021	354265	4	3	1
	123820	115305	8515	104466	10839	0.31	0.29	0.022	350884	3	7	5
	127253	118484	8769	107347	11137	0.32	0.30	0.023	347503	2	10	7

Basis	Total catch (2019)	Wanted catch* (2019)	Unwanted catch* (2019)	Wanted catch* 3a4	Wanted catch* 6	F_{total} (2019)	F_{wanted} (2019)	$F_{unwanted}$ (2019)	SSB (2020)	% SSB change **	% TAC change ***	% advice change ^
	130650	121629	9020	110196	11433	0.33	0.31	0.023	344170	1	13	10
	134012	124745	9267	113019	11726	0.34	0.32	0.024	340848	0.25	16	13
	137337	127824	9513	115809	12015	0.35	0.33	0.025	337558	-0.72	18	16
	140636	130885	9752	118581	12303	0.36	0.34	0.025	334326	-2	21	19
	143908	133916	9992	121328	12588	0.37	0.34	0.026	331132	-3	24	22
	147147	136919	10227	124049	12870	0.38	0.35	0.027	327971	-4	27	24
	150355	139894	10461	126744	13150	0.39	0.36	0.027	324834	-5	30	27
	153538	142841	10697	129414	13427	0.40	0.37	0.028	321650	-5	32	30
	156702	145759	10943	132058	13701	0.41	0.38	0.029	318534	-6	35	32
	159835	148649	11186	134676	13973	0.42	0.39	0.030	315429	-7	38	35
	162928	151506	11422	137265	14242	0.43	0.40	0.030	312358	-8	40	38
	165986	154343	11643	139835	14508	0.44	0.41	0.031	309341	-9	43	40
	169009	157155	11855	142382	14773	0.45	0.42	0.032	306362	-10	46	43
	172004	159934	12070	144901	15034	0.46	0.43	0.032	303393	-11	48	45
	174988	162686	12302	147393	15292	0.47	0.44	0.033	300489	-12	51	48
	177943	165415	12528	149866	15549	0.48	0.45	0.034	297611	-13	53	50
$F = F_{MSY\ upper}$	181445	168651	12794	152798	15853	0.49	0.46	0.035	294229	-13	56	53

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation.**

**** SSB 2020 relative to SSB 2019.**

***** Total catch in 2019 relative to TAC, including top-up for fleets under landing obligation in 2018 (116 008 t).**

^ Total catch 2019 relative to advice total catch 2018.

Table 17.7.4. Saithe in subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2019.

Year class	Contribution to landings (%)
2016	5
2015	17
2014	21
2013	23
2012	10
2011	7
2010	7

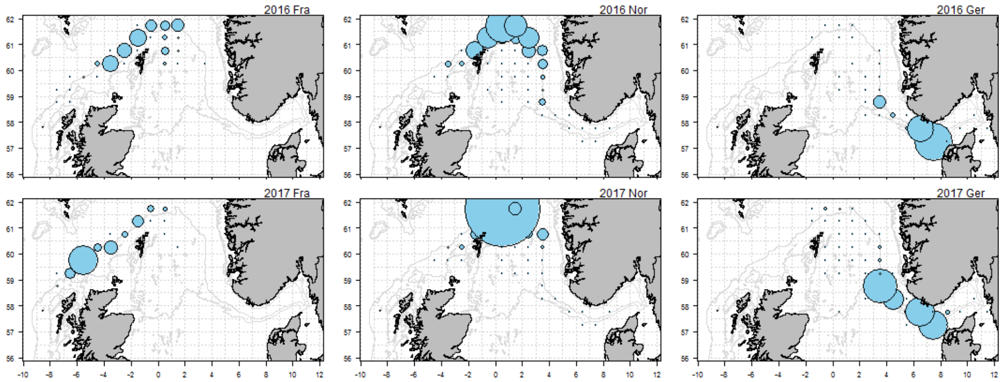


Figure 17.1.1. Saithe in subareas 4 and 6 and Subdivision 3.a.20. Spatial distribution of landings for French (Fra), Norwegian (Nor), and German (Ger) trawler fleets, 2016–2017. Landings for each nation in each year has been scaled by dividing by mean landings for that nation in that year. Bubble size across years and between nations is not comparable. Plots for years 2000–2015 are in the Stock Annex.

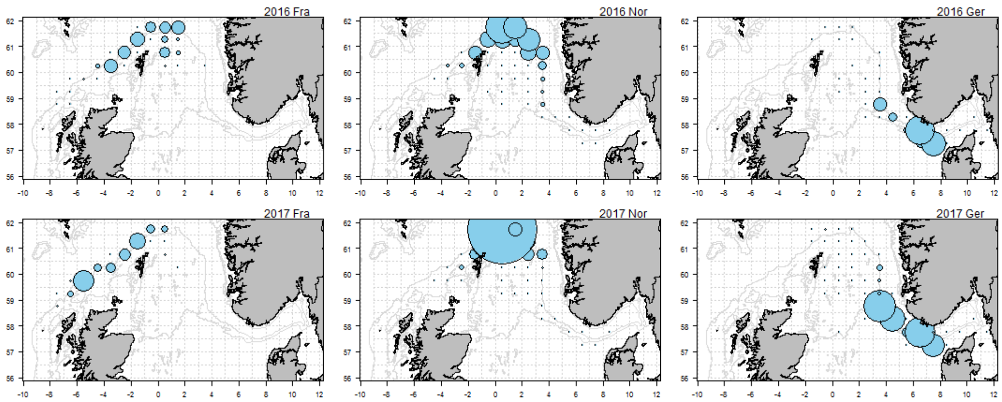


Figure 17.1.2. Saithe in subareas 4 and 6 and Subdivision 3.a.20. Spatial distribution of effort for French (Fra), Norwegian (Nor), and German (Ger) trawler fleets, 2016–2017. Effort for each nation in each year has been scaled by dividing by mean effort for that nation in that year. Bubble size across years and between nations is not comparable. Plots for years 2000–2015 are in the Stock Annex.

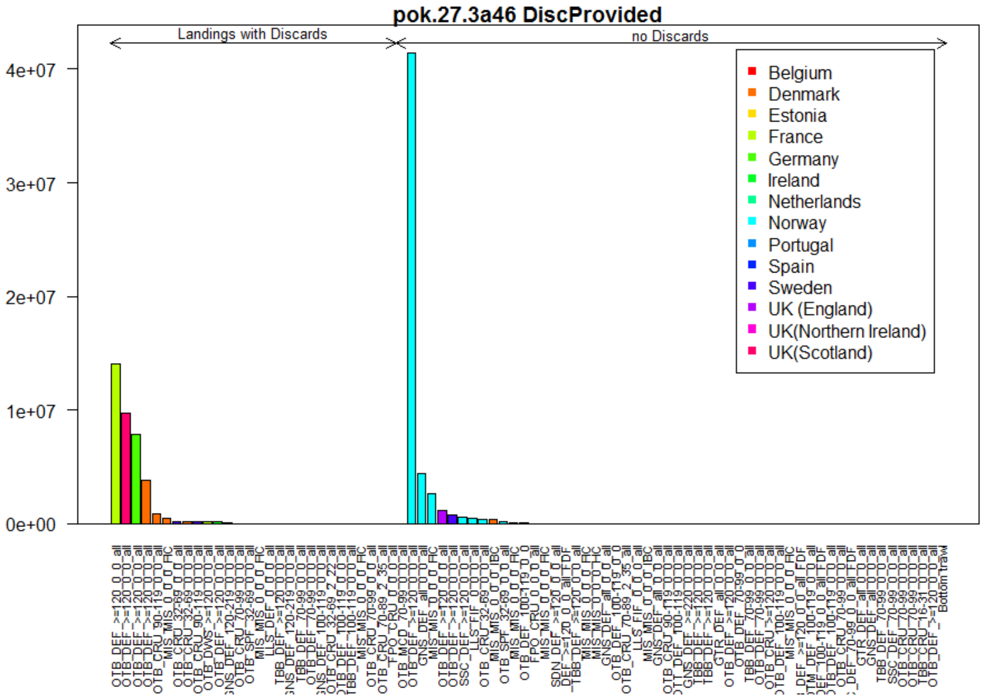


Figure 17.3.1. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier.

Figure 17.3.2. Saithe in subareas 4 and 6 and Division 3.a: Yield by catch component.

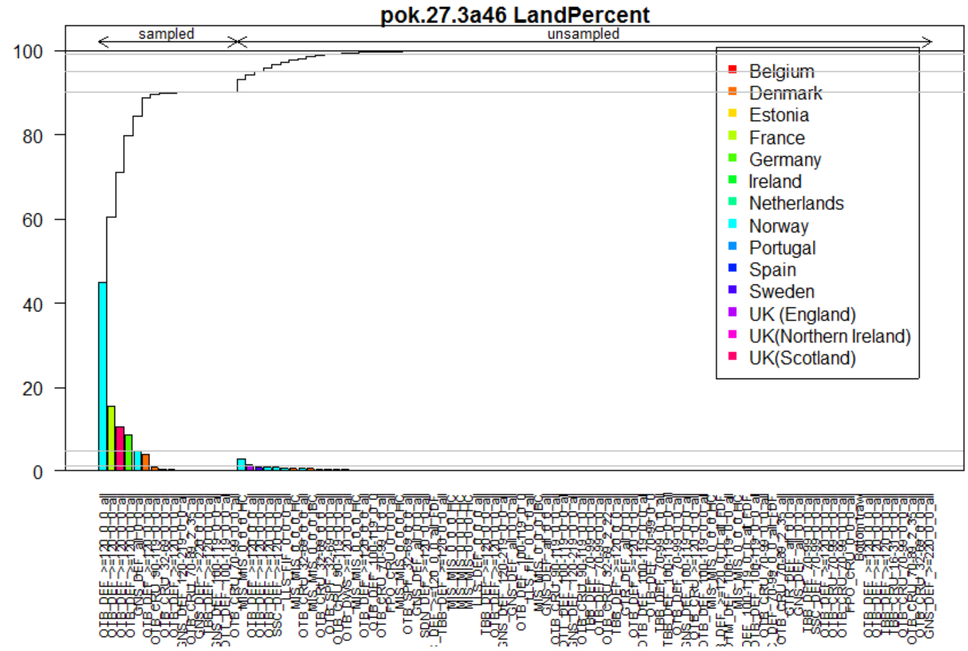


Figure 17.3.3. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier.

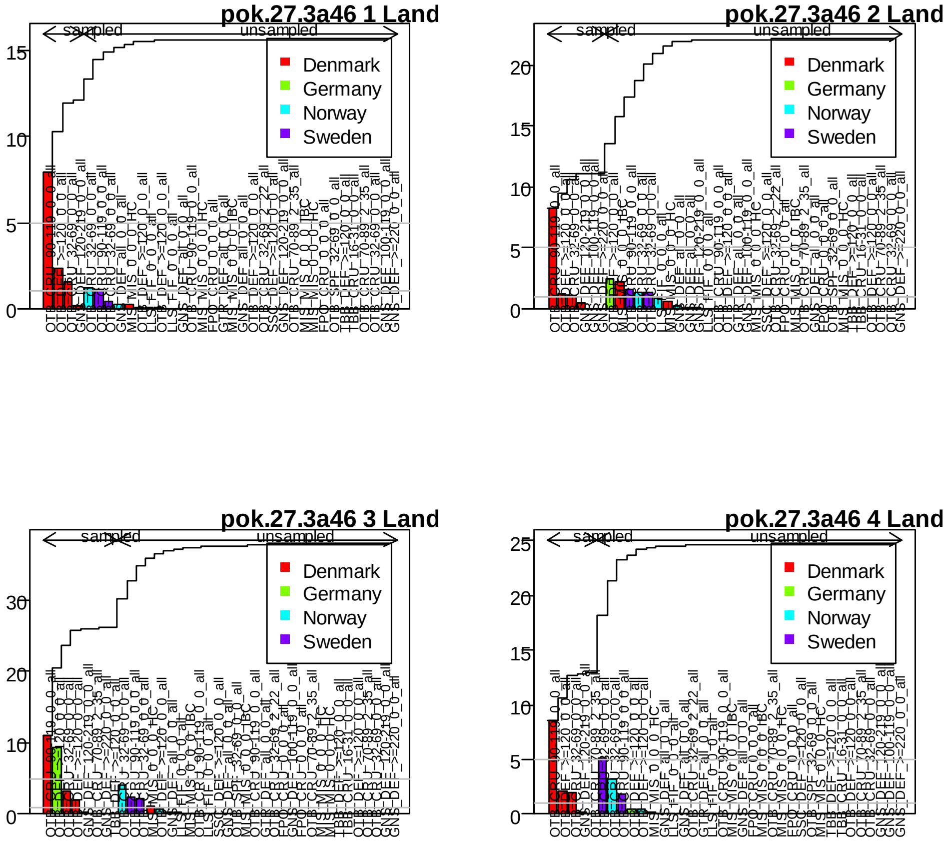


Figure 17.3.4. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country, métier, and quarter for saithe catches in Division 3.a.

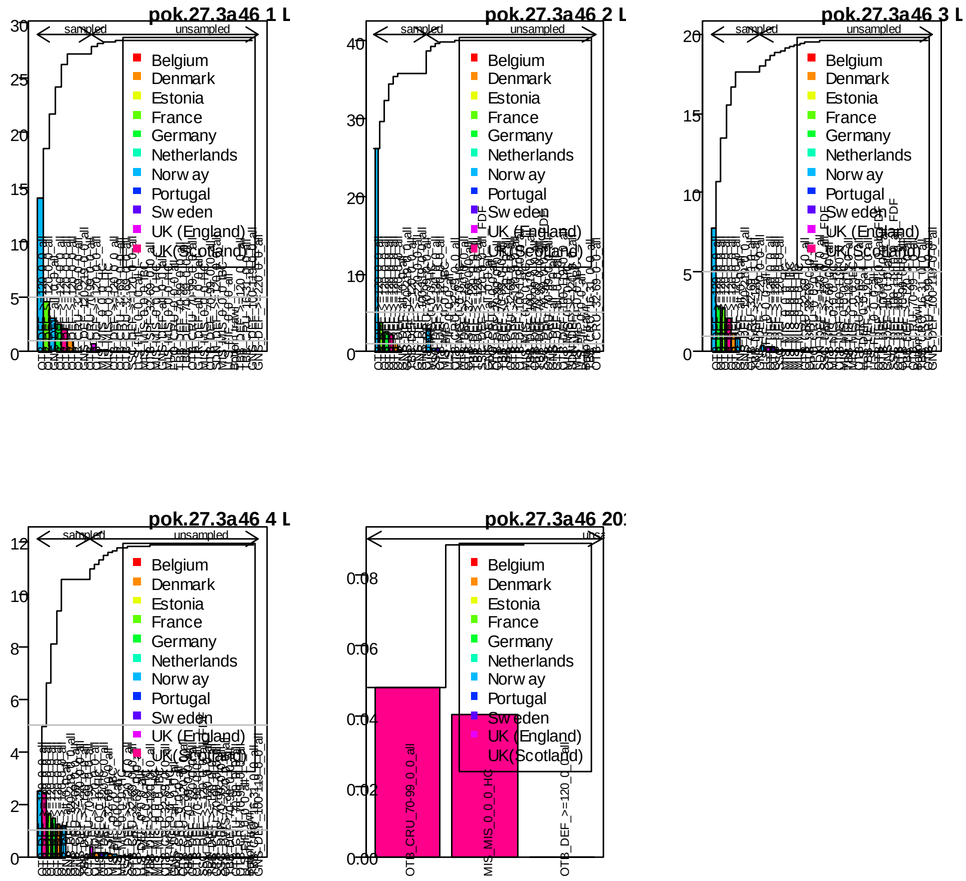


Figure 17.3.5. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 4. Scotland reported by year, not quarter.

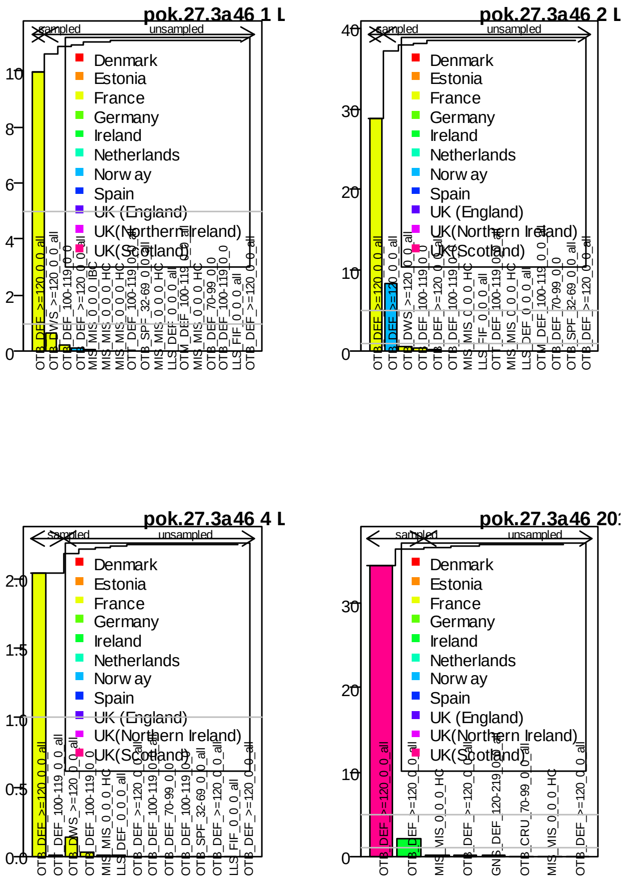


Figure 17.3.6. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 6. Scotland reported by year, not quarter.

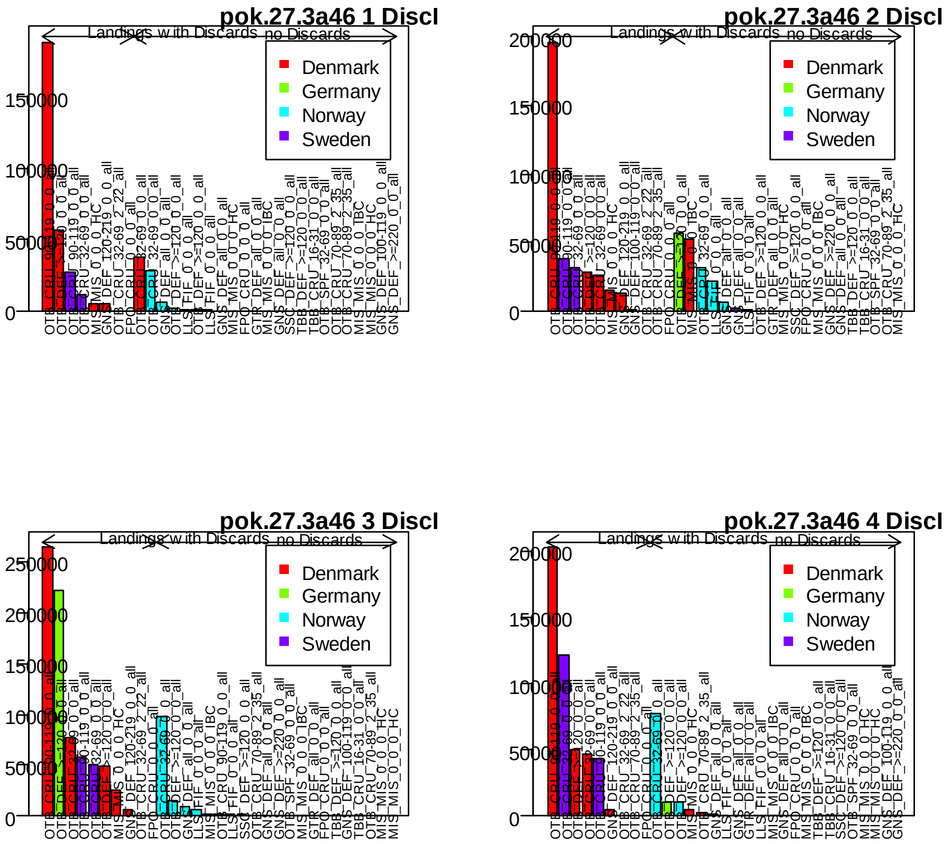


Figure 17.3.7. Saithe in subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Division 3.a.

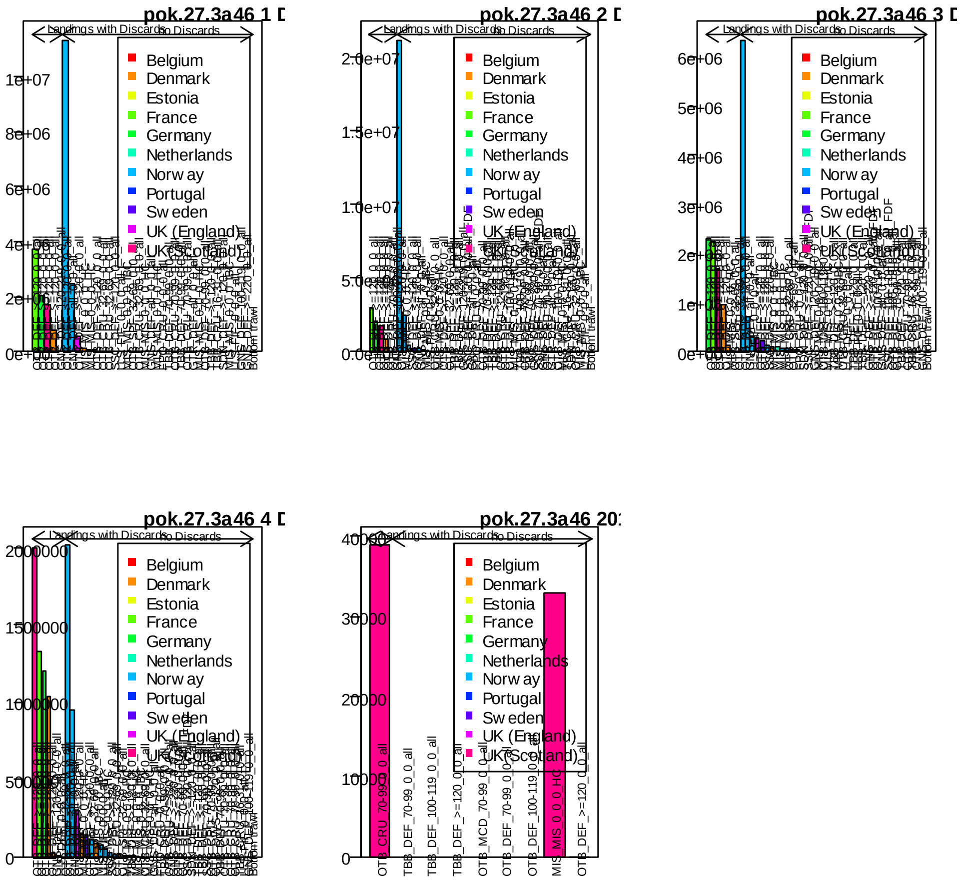


Figure 17.3.8. Saithe in subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Subarea 4. Scotland submitted sample information by quarter and annual samples.

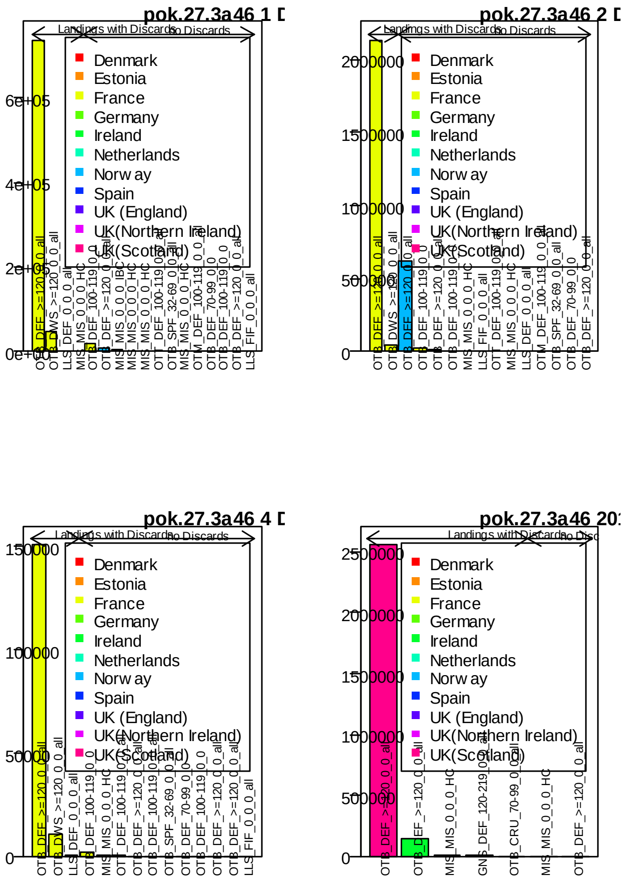


Figure 17.3.9. Saithe in subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Subarea 6. Scotland submitted sample information by quarter and annual samples.

Figure 17.3.10. Saithe in subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2017; smallest bubble corresponds to 210 thousand individuals and largest to 46 thousand individuals. (Right) Discard weights at age for saithe ages 3–10+, 2000–2017 (min: 0, max: 15 thousand individuals).

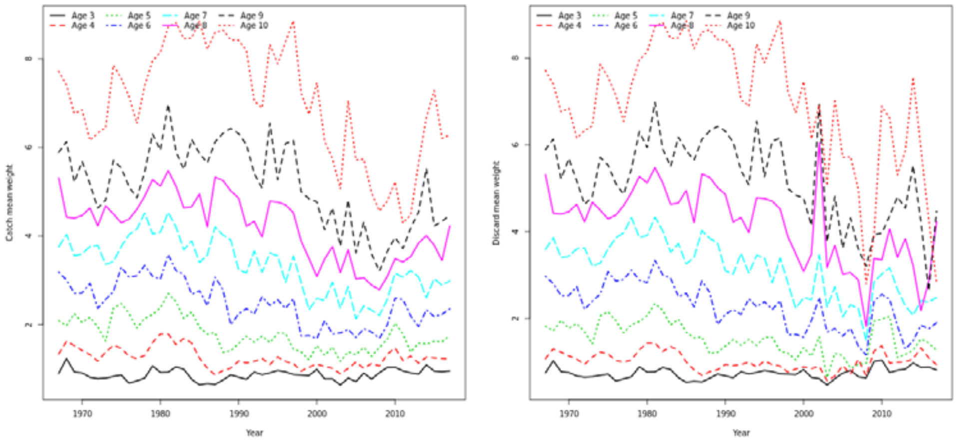


Figure 17.3.11. Saithe in subareas 4 and 6 and Division 3.a. (left) Catch weight-at-age (kg) for saithe ages 3–10+, 1967–2017. Catch weight-at-age are also stock weight-at-age in the assessment. (Right) Discard weights-at-age (kg) for saithe ages 3–10+, 1967–2017.

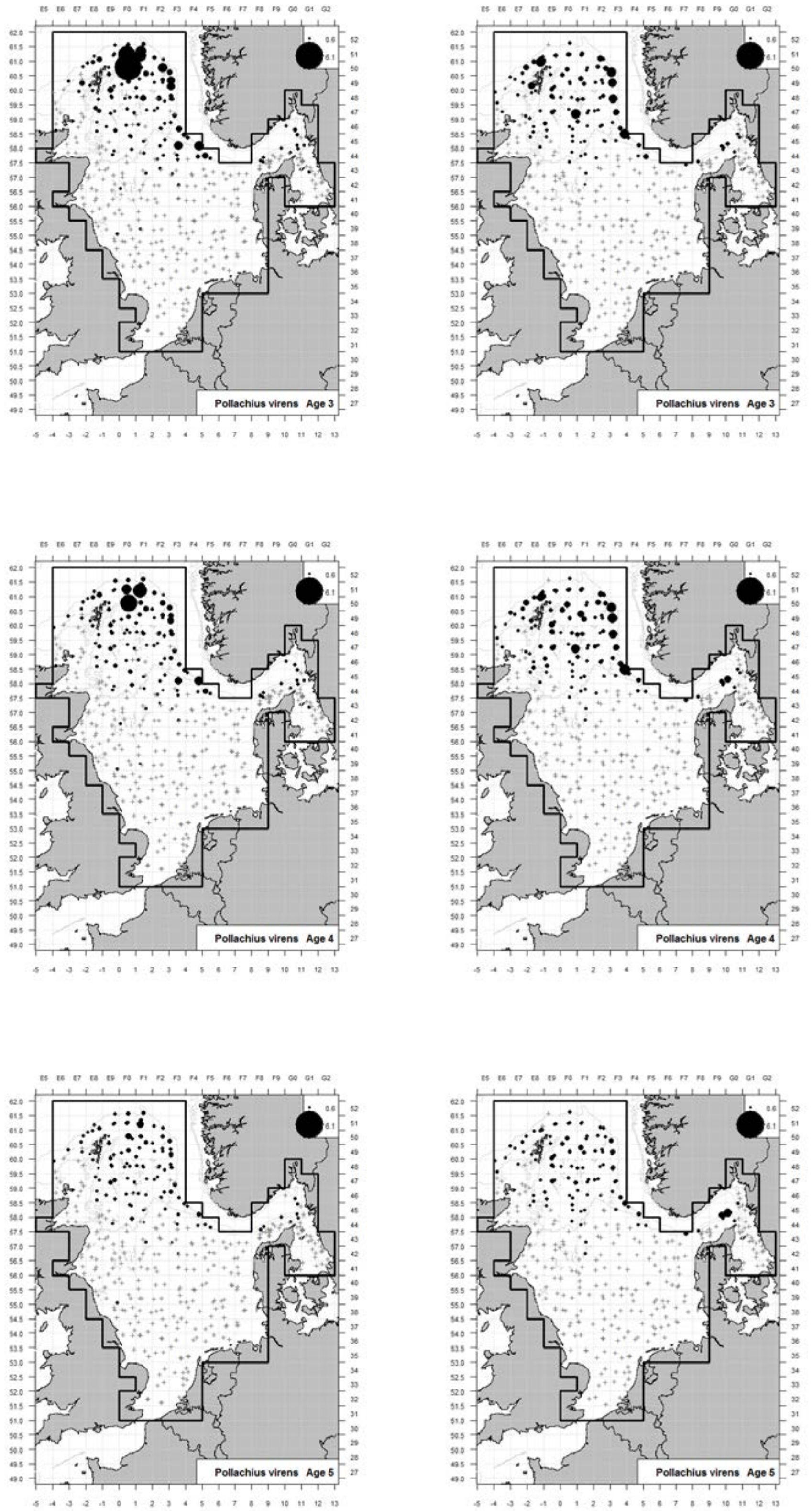


Figure 17.4.1. Saithe in subareas 4 and 6 and Division 3.a. Distribution of saithe in the IBTS–Q3 survey in 2016 (left) and 2017 (right) for ages 3 to 5. The single large catch of saithe in 2016 is visible in ICES rectangle 50F0 in ages 3 and 4. Catches are scaled to the same scale for all ages and years.

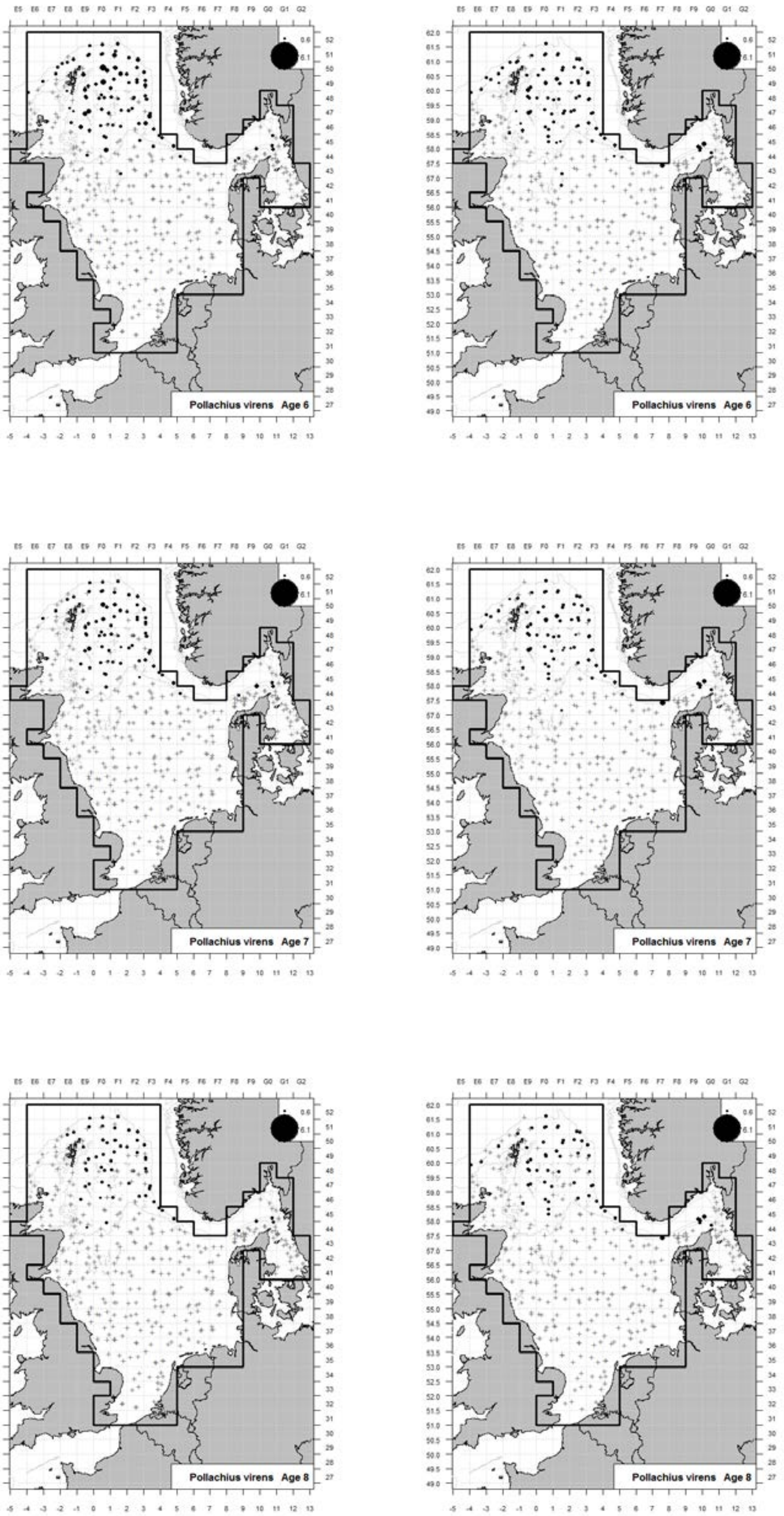


Figure 17.4.2. Saithe in subareas 4 and 6 and Division 3.a. Distribution of saithe in the IBTS–Q3 survey in 2016 (left) and 2017 (right) for ages 6 to 8. Catches are scaled to the same scale for all ages and years.

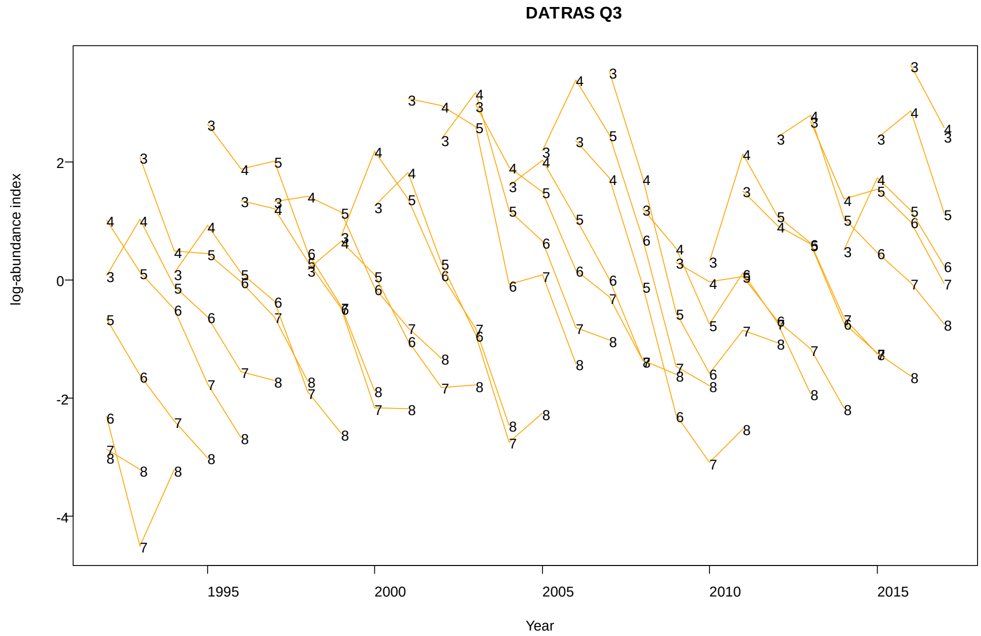


Figure 17.4.3. Saithe in subareas 4 and 6 and Division 3.a: Log-catch curves by cohort from the research survey index, IBTS–Q3, for ages 3 to 8, 1992–2017.

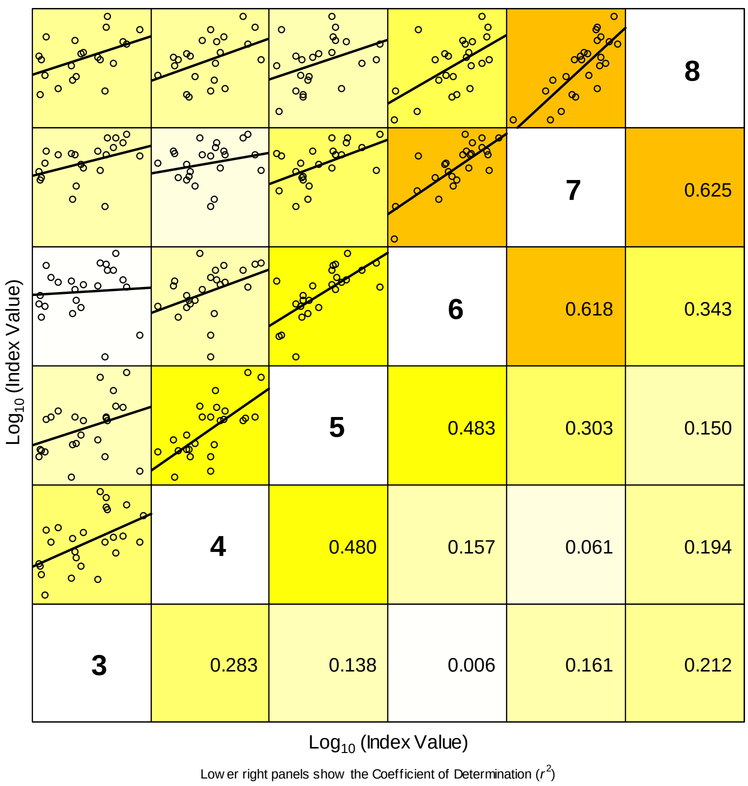


Figure 17.4.4. Saithe in subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2017, ages 3 to 8.

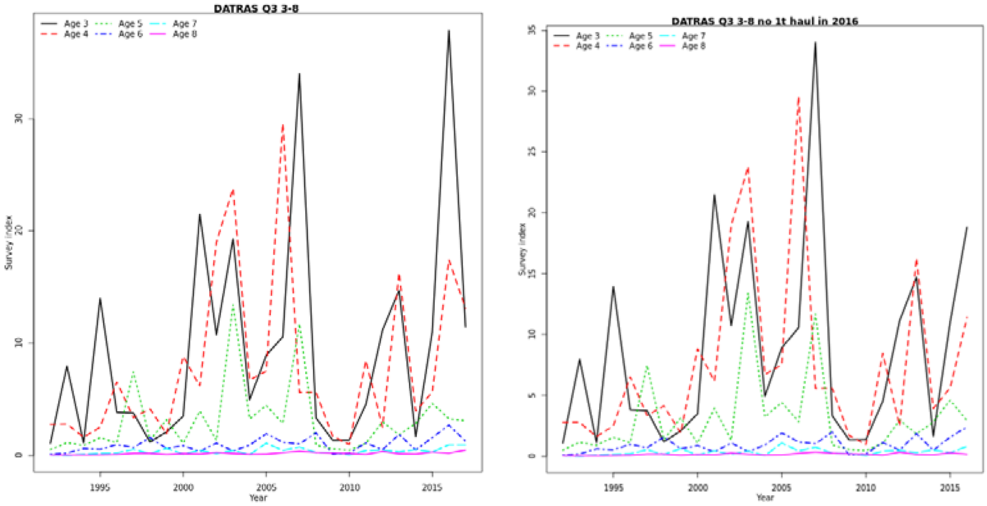


Figure 17.4.5. Saithe in subareas 4 and 6 and Division 3.a. Right: Standardised IBTS-Q3 research tuning series index, 1992–2017, ages 3 to 8. Left: Standardised IBTS Q3 research tuning series index with the single large catch of saithe removed before the indices estimation, 1992–2016, ages 3 to 8.

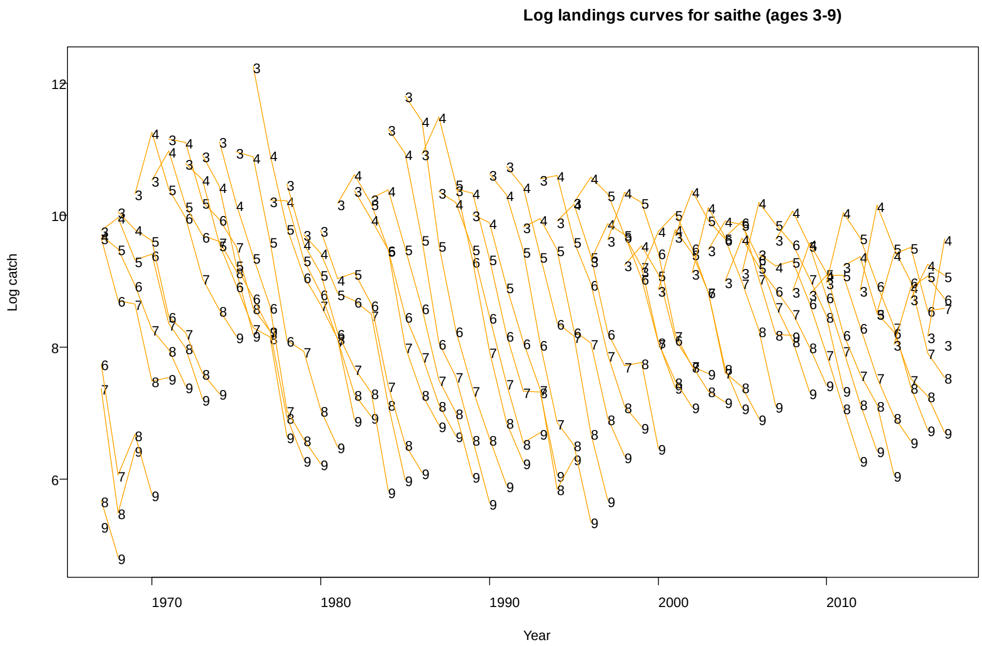


Figure 17.4.6. Saithe in subareas 4 and 6 and Division 3.a. Log-catch curves by cohort for landings, ages 3 to 9, 1967–2017.

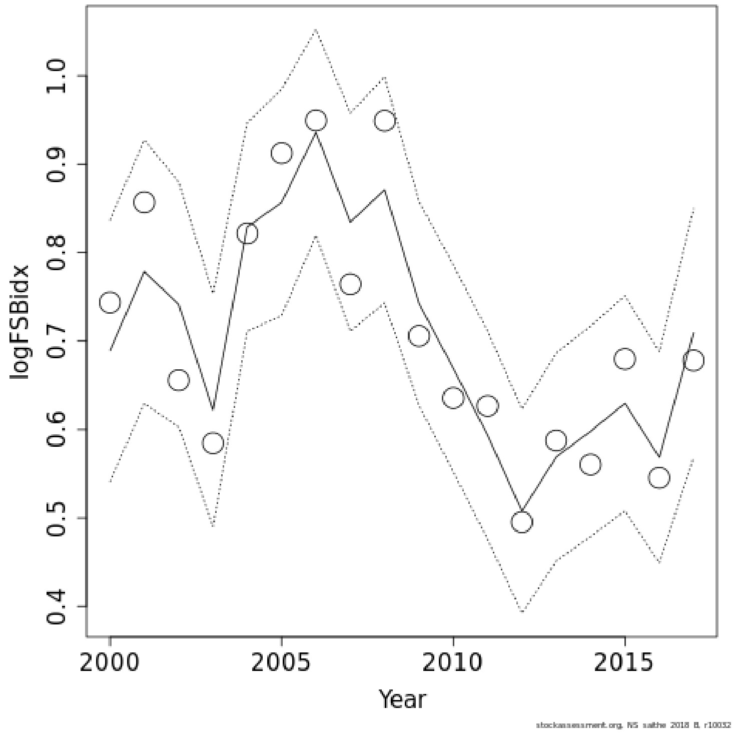


Figure 17.4.7. Saithe in subareas 4 and 6 and Division 3.a. Standardized combined CPUE index (year effects, open circles) and fit of model after tuning to the exploitable biomass, 2000–2017.

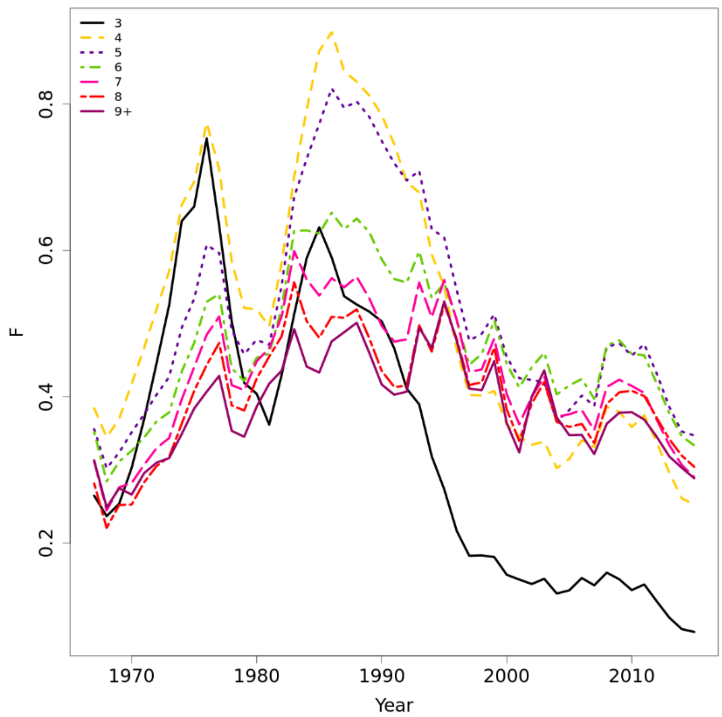


Figure 17.4.8. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortality at age for the final assessment model.

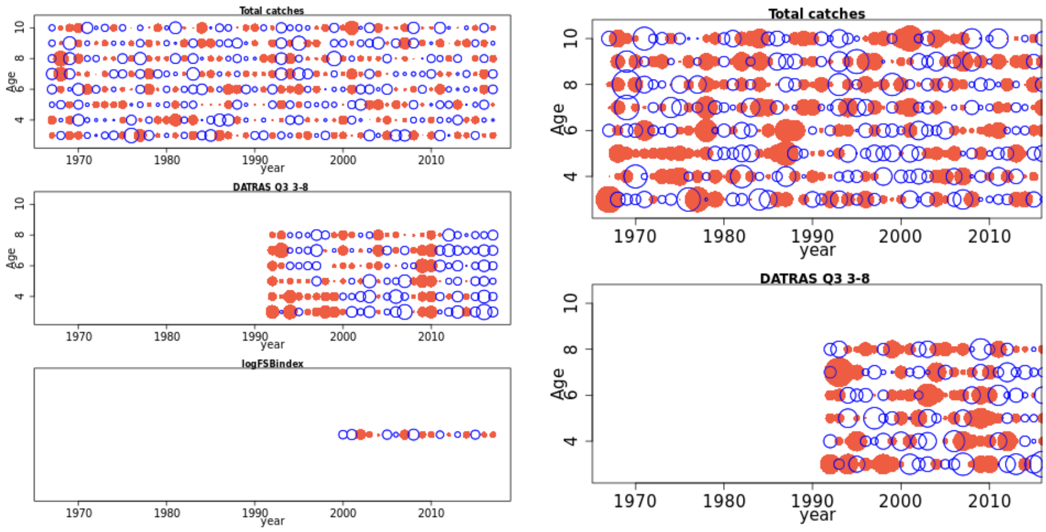


Figure 17.4.9. Saithe in subareas 4 and 6 and Division 3.a. Residual patterns for the final SAM model. Left: Before correlation taken into account between ages, within years in the Q3 index. Right: After accounting for the correlation between ages within years in the Q3 index. Open circles (blue) indicate positive residuals and filled red circles indicate negative residuals.

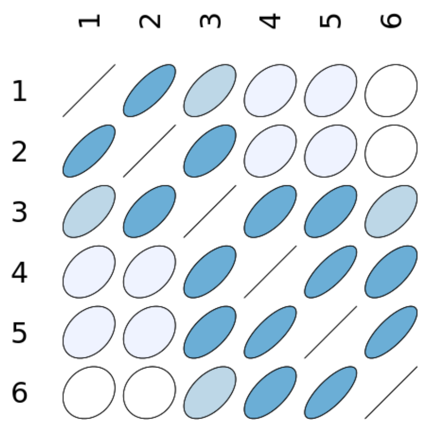


Figure 17.4.10. Saithe in subareas 4 and 6 and Division 3.a. Correlation between age classes within years for IBTS Q3 (ages 3-8). The darker the blue color, the stronger the correlation.

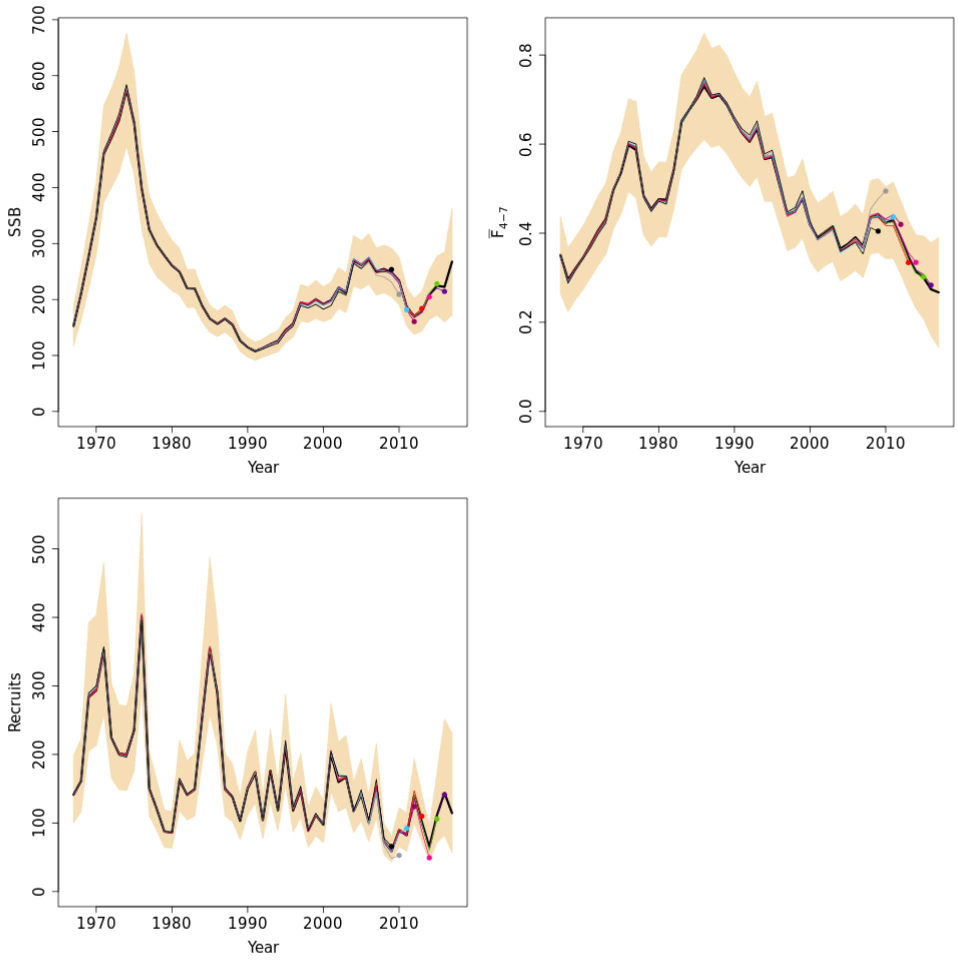


Figure 17.4.11. Saithe in subareas 4 and 6 and Division 3.a. Eight year retrospective pattern in SSB, F_{4-7}, and recruitment for the final assessment.

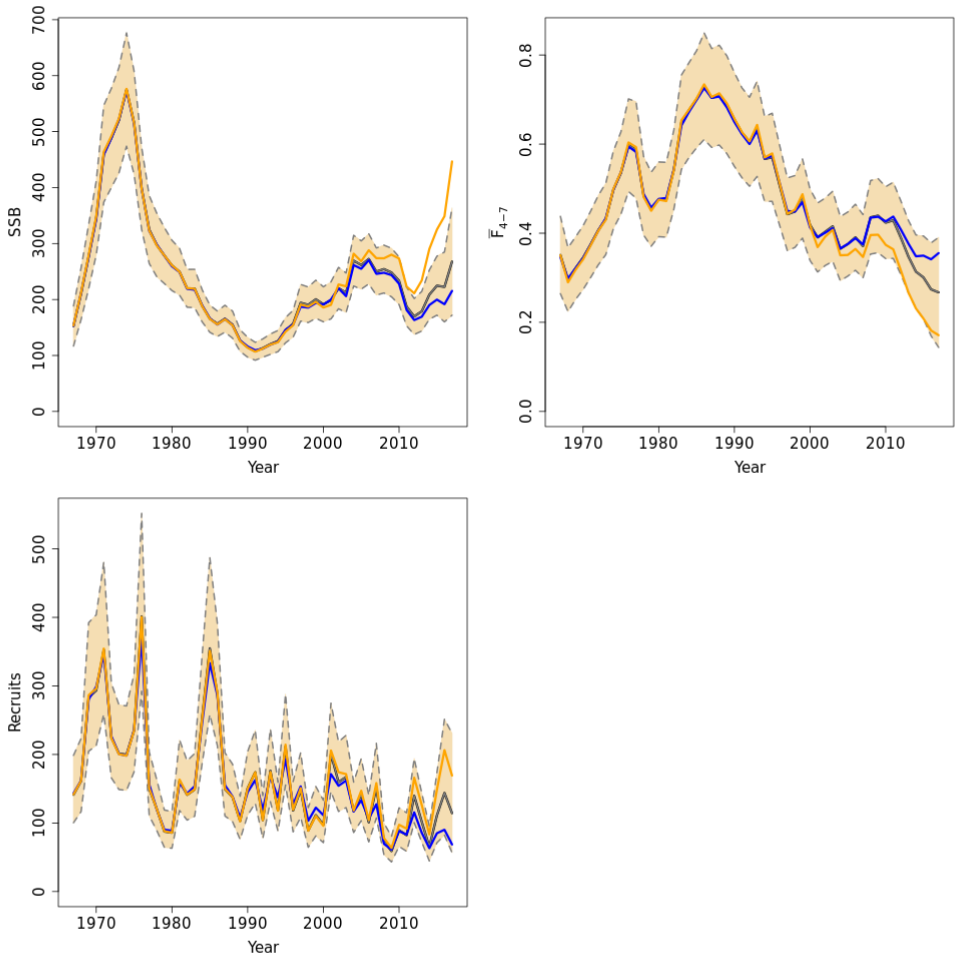


Figure 17.4.12. Saithe in subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, and recruitment for the final assessment model. Black lines and tan-shaded confidence interval indicates the final assessment model, including the IBTS Q3 indices for ages 3–8 and the CPUE index. The orange line is the assessment with only the IBTS Q3 tuning series, while the blue line is the assessment with only the CPUE index.

Figure 17.5.1. Saithe in subareas 4 and 6 and Division 3.a. Summary of stock assessment in relation to reference points for SSB and F. Predicted recruitment values are not shaded. Shaded areas (F, SSB) and error bars (R) indicate point-wise 95% confidence intervals.

18 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 concise description of the methods are presented within this Section of the report. In 2018, there were no deviations from the Stock Annex.

18.1 General

18.1.1 Stock definition

See Stock Annex.

18.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK (2018). All available information on ecological aspects can be found in the Stock Annex.

18.1.3 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. These developments include electric pulse fishing, hydrodynamic fuel-saving wings, etc. The catch composition of these "advanced" gears are found to be different from the traditional beam trawl (van Marlen *et al.*, 2014). As of 2018, the operational use of these new gears can be distinguished using logbook and VMS data.

In recent years stakeholders from different member states have found difficulties finding North sea sole on their fishing grounds. Especially in the southern North Sea competitive interactions exist between traditional gears (beam trawl and gillnet fisheries) and innovative gears (Dutch pulse trawl fleet) (Sys *et al*. 2016). WGNSSK (2018) compared spatial and temporal changes in LPUEs for the Dutch pulse, French gillnet and Belgian beam trawl fleet (Figures 18.8.8 to 18.8.14). Outcomes are consistent with Sys *et al*. 2016, arguing competition in efficiency of the different fishing fleets targeting sole may provide a potential explanation. Figures 18.8.11 to 18.8.14 show this transition into the southern North Sea and the LPUEs associated with the main sole-targeting fishing fleets.

18.1.4 ICES Advice

The information in this section is taken from the update advice from section 6.3.49 in the Advice summary sheet 2017.

ICES stock advice

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2018 should be no more than 15 726 tonnes.

Issues relevant for the advice

Based on the survey information (BTS Q3) that has become available in summer 2017, the advice has been updated from that released in June 2017 (ICES, 2017b).

Between 2014 and 2017, the use of pulse trawls in the Dutch fishery operating in the North Sea has increased to 76 vessels (of which 65 > 221 kW); only a handful of vessels operating with traditional beam trawls are now left.

The EU long-term management plan for North Sea plaice and sole was evaluated by ICES to be in accordance with the precautionary approach (ICES, 2010). ICES continues to use the management plan as the basis of advice for North Sea sole.

It is expected that under the EU landing obligation, below minimum size fish that would formerly have been discarded would now be reported as below minimum size (BMS) landings in logbooks. However, BMS landings reported to ICES may be lower than expected for several reasons: fish caught below minimum size could either not have been landed and not recorded in logbooks, or landed but not recorded as BMS; additionally, BMS landings recorded in logbooks may not have been reported to ICES.

In the case of sole, there is no indication that fish that would formerly have been discarded are being reported as BMS, based on the observation that BMS landings reported to ICES are currently much lower than the estimates of discards from observer programmes, which estimate discards at 9.2% of the total catch.

Results from a North Sea mixed-fisheries analysis are presented in ICES (2017c); this analysis has not been updated. The analysis for 2018, assuming a strictly implemented discard ban (corresponding to the "Minimum" scenario), indicated that whiting would be the most limiting stock, being estimated to constrain 24 out of 42 fleet segments. Haddock is the second most limiting stock, constraining eight fleet segments. Additionally, if Norway lobster was managed by separate TACs for the individual functional units (FUs), Norway lobster in FU 6 would be considered the most limiting stock for ten fleet segments. Conversely, in the "Maximum" scenario, saithe and eastern English Channel plaice would be least limiting for 20 and 11 fleet segments, respectively. Finally, if Norway lobster was managed by separate TACs, Norway lobster in FUs 7, 5, 33, and outside the FUs in Subarea 4 would be the least limiting for nine, two, one, and two fleet segments, respectively. For those demersal fish stocks for which the F_{MSY} range is available, a "Range" scenario is presented that minimizes the potential for TAC mismatches in 2018 within the F_{MSY} range. This scenario returns a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2018, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. This "Range" scenario suggests that the potential for mixed-fisheries mismatch would be lowered with a 2018 TAC in the lower part of the F_{MSY} range for eastern English Channel plaice and saithe, and in the upper part of the range for cod and North Sea plaice.

18.1.5 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 had officially moved to the stage two (EU, 2014).

In 2018, the EU was still negotiating the multiannual plan

Mixed fishery advice

The information in this section is taken from the North Sea Advice overview Section 6.3 in the ICES Advisory report 2008.

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. 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.

18.2 Data available

18.2.1 Landings

Annual landings by country and TACs are presented next to the landings submitted to InterCatch in Table 18.2.1. The TAC in 2017 was 16 123 tonnes (this includes a top-up for fleets under the landing obligation). Officially reported to FAO landings and BMS (below minimum size) landings amounted to 11 781 tonnes and 30 tonnes. Landings reported to ICES were 12 370 tonnes in 2017. Landings in numbers by age that are input for the assessment model are presented in Table 18.2.2. A time series of total landings is shown on Figure 18.2.1.

18.2.2 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 18.2.3. A time series of total discards is shown on Figure 18.2.2. Discards reported to ICES were 1250 tonnes in 2017.

18.2.3 BMS landings

In 2016, 3 tonnes of BMS landings were reported to InterCatch as official amount, not as caton. They are therefore considered to be under the total estimate of discards. They are thus not separately raised.

18.2.4 Logbook registered discards

In 2016, no Logbook registered discards were reported to InterCatch.

18.2.5 InterCatch

Since 2012, InterCatch is used for raising the catch. Age distributions were provided for 89% of the landings in 2017 (Figure 18.2.3).

Discards estimates for 2017 were available for 88% of the landings (in weight) (Figure 18.2.3). This implies that 88% of the discards were imported and 12% was raised. Age distributions were given for 95% of the discards (in weight).

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 passive gears apart from active 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 99 mm 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.

18.2.6 Age compositions

The age composition of the landings and discards is presented in numbers in Tables 18.2.2–3., and Figure 18.2.4.

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 0.99 and was 0.99 for discards.

18.2.7 Weight-at-age

Weights at age in the landings for both sexes combined (Table 18.2.4) are measured weights from the various national market sampling programmes. Discard weights at age (Table 18.2.5) are derived from the various national discard programmes (observer and self-sampling).

Mean stock weights at age (Table 18.2.6.) are the average weights from the 2nd Quarter landings and discards and are derived from the InterCatch (Catch and Sample Data Table file as output from InterCatch).

Landing, discard, and mean stock weights at age are presented on Figure 18.2.5.

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.

18.2.8 Maturity and natural mortality

A knife-edged maturity-ogive with full maturation at age 3 is assumed for North Sea sole (Table 18.2.7.). No new data was presented at in 2018.

Natural mortality at age (Table 18.2.7.) is 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).

18.2.9 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 are not available.

A standardised comparison of the two surveys that are used as tuning indices over the available time series is given in Figure 18.2.7.1. The internal consistency of the year class cohorts in these two surveys is presented in Figure 18.2.7.2.

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 18.2.8.

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 the working group are observed.

18.3 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:		2018
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		
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 18.3.1 and in Figure 18.3.1. The retrospective performance of the assessment is shown in Figure 18.3.2.

18.4 Recruitment estimates

Recruitment estimation was carried out using RCT3. Input to the RCT3 model is presented in Table 18.4.1. Results are presented in Table 18.4.2 for age 1 and Table 18.4.3. for age 2. Average recruitment of 1–year old fish in the period 1957–2014 was around 112 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 2018	AAP thousands	RCT3 thousands	GM(1957–2014) thousands
2016	2	72802.3	87651	98966.6
2017	1		108555	113075.7
2018	Recruit (0)			113075.7

Additional recruitment information will be available from the 3rd quarter surveys (BTS–ISIS). ICES will only issue an updated advice if these surveys provide a very different perspective on the short-term developments that were used during the working group.

18.5 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. There was a debate over this assumption due to the perceived doming in the fishing mortality over ages (Figure 18.8.7). But since most model uncertainty is in the final year the group chose to stay with the three year average assumption. 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. Recruitment of the 2016 year class and later year-classes are taken from the long-term geometric mean (1957–2014). Input to and results from the short term forecast are presented in Table 18.5.1–4 for F = Fsq.

For the intermediate year 2018, it was assumed that catches equal the mean of the fishing mortality in 2015–2017. No obvious trend in fishing mortality is present during the last 3 years. Therefore, a similar fishing mortality is assumed in the intermediate year. Additionally, the TAC in 2017 was not constraining in 2017 (TAC 2017 = 16 123 t; ICES catch estimates = 13 620 tonnes (16% undershoot)).

Figure 18.5.1 shows the relative contribution of this assumption under this scenario.

18.6 Medium-term forecasts

No medium term projections were done this year.

18.7 Biological reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	37 000 t	Default to value of B_{pa}	ICES (2015a)
	F_{MSY}	0.202	EQsim analysis, assuming a hockey-stick stock–recruit relationship based on the recruitment period 1958–2010	ICES (2015a)
Precautionary approach	B_{lim}	26 300 t	Break-point of hockey-stick stock–recruit relationship, based on the recruitment period 1958–2010	ICES (2015a)
	B_{pa}	37 000 t	B_{lim} × exp(1.645 × 0.2) ≈ 1.4 × B_{lim}	ICES (2015a)
	F_{lim}	0.63	EQsim analysis, based on the recruitment period 1958–2010	ICES (2016a)
	F_{pa}	0.44	F_{lim} × exp(−1.645 × 0.2) ≈ F_{lim} / 1.4	ICES (2016a)
Management plan*	MAP MSY $B_{trigger}$	37 000 t	MSY $B_{trigger}$	Annex II column A in EU (2016)
	MAP B_{lim}	26 300 t	B_{lim}	Annex II column B in EU (2016)
	MAP F_{MSY}	0.202	F_{MSY}	Annex I columns A and B in EU (2016)
	MAP target range F_{lower}	0.113-0.202	Consistent with ranges provided by ICES (2015a), resulting in no more than 5% reduction in long-term yield compared with MSY.	ICES (2015a), and Annex I column A in EU (2016)
	MAP target range F_{upper}	0.202-0.367	Consistent with ranges provided by ICES (2015a), resulting in no more than 5% reduction in long-term yield compared with MSY.	ICES (2015a), and Annex I column B in EU (2016)

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 0.113–0.367. The point value of F_{MSY} was set at 0.202.

In 2016, F_{pa} and F_{lim} were defined according to ICES reference points guidelines (ACOM), respectively 0.44 and 0.63. 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.

North Sea sole is included in the Multi-Annual management Plan (MAP), but this management plan has not yet been agreed upon.

18.8 Quality of the assessment

The assessment was benchmarked in 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 16 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years. However, the impact of the landing obligation cannot be distinguished at present.

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 (Verkempynck *et al*. (in prep.)).

At the working group the newest data year (2017) was added to the assessment. The assessment performed well and modelled landings, discards, and catch fitted well to observed landings, and discards (Figure 18.8.1–3.).

Residual plots of landings and discards are shown in Figure 18.8.4.–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 18.8.6.

Both surveys included in the assessment of North Sea sole (BTS-ISIS and SNS) are not covering the main fishing grounds of the main sole-targeting fishing fleets. Most sole-targeting fishing fleets have concentrated their fishing effort in the most southern rectangles of the North Sea in recent years. Addition of survey information covering these grounds could potentially improve our perception of the stock.

18.9 Status of the stock

Fishing mortality was estimated at 0.22 in 2017 which is well within biological limits but still above the point value of F_{MSY} The SSB in 2017 was estimated at about 58 895 tonnes which is well above both B_{lim} and B_{pa}.

18.10 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 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 on the basis of maximum sustainable yield. An overall objective of the CFP is to exploit all fish stocks within F_{MSY} ranges.

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.

In recent years the mixed reports have been reported from the main sole-targeting fleets in the southern North Sea. The LPUEs in the most southern rectangles in the North Sea of the Dutch beam trawl fleet (mainly operating the pulse fishing gear) have increased and stayed stable (Figure 18.8.8). Whereas the LPUEs in the most southern rectangles in the North Sea of the French gillnetters and the Belgian traditional beam trawl fleets have decreased (Figures 18.8.9. and 18.8.10), especially where fishing grounds overlap and the most efficient gears outcompete the less efficient. This competition has increased with a transition in the last years of the Dutch pulse trawl fleet (in BT2) into fishing grounds more southern in the North Sea.

18.11 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 the working group in 2017 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 18.2.1. North Sea sole: total reported landings per country, total landings and total bms landings as reported to the FAO*, ICES total landings, and TAC (rounded to the nearest t)

Year	BE*	DK*	FR*	DE*	NL*	UK*	Other*	Total*	Total BMS*	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
2016	767	355	362	861	9600	705	0	12651		14127	13262
2017	557	432	393	731	9155	513	0	11781	30	12370	16123

Table 18.2.2. North Sea sole: Landings in numbers by age 1–10 (in thousands)

	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
1999	284	15601	71730	8103	6049	1200	657	1964	328	804
2000	2329	14929	32425	42394	3257	2453	796	431	922	708

	1	2	3	4	5	6	7	8	9	10
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
2016	119	6151	24249	11489	4475	8994	4495	774	278	140
2017	416	4928	17641	16818	5909	2118	3745	2005	443	204

Table 18.2.3. North Sea sole: Discards (including BMS) in numbers by age 1–10 (in thousands)

	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
2016	5145	5338	5048	1393	291	536	226	4	1	0
2017	6083	4171	3633	2712	469	89	342	138	0	0

Table 18.2.4. North Sea sole: Landings weights (kg) at age 1–10

	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
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

	1	2	3	4	5	6	7	8	9	10
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
2016	0.143	0.175	0.200	0.236	0.265	0.275	0.273	0.294	0.325	0.397
2017	0.10909	0.16783	0.18953	0.22612	0.27582	0.27408	0.31272	0.30942	0.28009	0.31066

Table 18.2.5. North Sea sole: Discard weights (kg) at age 1–10

	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
2016	0.024	0.073	0.087	0.095	0.114	0.108	0.124	0.221	0.214	0.197
2017	0.0474	0.07279	0.08622	0.08657	0.09671	0.12379	0.11101	0.11255	0.28666	0.22258

Table 18.2.6. North Sea sole: Stock weights (kg) at age 1–10 (kg): Mean weights of sampled catches in quarter 2 are exported from InterCatch

	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
1999	0.05	0.131	0.187	0.216	0.259	0.296	0.34	0.322	0.369	0.46388

	1	2	3	4	5	6	7	8	9	10
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
2016	0.010	0.067	0.151	0.186	0.248	0.236	0.261	0.221	0.359	0.227
2017	0.021	0.074	0.131	0.174	0.231	0.242	0.249	0.217	0.233	0.338

Table 18.2.7. 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 18.2.8. 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
2016	6.454	11.832	8.417	2.912	0.415	1.498	0.471	0.042	0.000
2017	16.279	7.098	5.989	6.301	1.363	0.198	0.453	0.222	0.009

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
2016	733.8	623.3	494.6	109.8	16.7	42.9
2017	956.7	204.3	209.6	209.7	41.6	5.2

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
2016	0.88	1.11	0.00460	12.28
2017	1.36	2.41	0.12	20.97

Table 18.3.1. North Sea sole: Assessment summary- values in intermediate year are assumed

Year	Recruitment Age 1	High 2 * Standard Error (approx. 95% confidence interval)	Low 2 * Standard Error (approx. 95% confidence interval)	SSB	High 2 * Standard Error (approx. 95% confidence interval)	Low 2 * Standard Error (approx. 95% confidence interval)	Landings	F Ages 2–6	High 2 * Standard Error (approx. 95% confidence interval)	Low 2 * Standard Error (approx. 95% confidence interval)
	Thousands			Tonnes				Per year		
1957	133586	157780	113215	62970	70918	55022	12991	0.21	0.25	0.168
1958	118413	141127	99368	65698	73524	57872	13409	0.22	0.25	0.192
1959	442829	525378	373296	68439	75878	61000	15836	0.24	0.27	0.21
1960	41904	50109	35033	68968	76176	61760	17526	0.26	0.3	0.23
1961	69102	82692	57706	102554	113288	91812	27303	0.3	0.33	0.27
1962	11006	13107	9242	86468	95311	77627	27212	0.34	0.38	0.3
1963	12735	15343	10570	70850	78098	63602	22757	0.34	0.38	0.29
1964	602766	739981	490716	52098	58468	45728	15396	0.3	0.34	0.27
1965	147946	184193	118926	41059	47244	34874	10675	0.28	0.32	0.24
1966	54857	70962	42366	108191	124445	91935	32113	0.3	0.35	0.26
1967	87350	116541	65513	103223	114496	91944	30470	0.38	0.42	0.33
1968	126355	168771	94627	90639	99873	81405	33374	0.48	0.54	0.42
1969	90175	122013	66711	70546	77938	63154	24711	0.55	0.62	0.48
1970	202188	273397	149540	64468	71802	57134	22195	0.55	0.61	0.49
1971	55491	72436	42512	55752	62245	49259	21783	0.52	0.59	0.45
1972	110079	143120	84674	63768	71655	55881	24200	0.52	0.58	0.46
1973	150542	192918	117475	47238	52624	41852	19723	0.54	0.59	0.48
1974	126237	158797	100370	46738	52195	41281	20483	0.55	0.61	0.49
1975	59910	76267	47099	48240	53640	42840	20484	0.52	0.58	0.47
1976	135636	172781	106534	46192	50928	41456	17800	0.48	0.53	0.43

Year	Recruitment Age 1	High: 2 * Standard Error (approx. 95% confidence interval)	Low: 2 * Standard Error (approx. 95% confidence interval)	SSB	High: 2 * Standard Error (approx. 95% confidence interval)	Low: 2 * Standard Error (approx. 95% confidence interval)	Landings	F Ages 2–6	High: 2 * Standard Error (approx. 95% confidence interval)	Low: 2 * Standard Error (approx. 95% confidence interval)
	Thousands			Tonnes				Per year		
1977	165074	209107	130275	36520	39757	33283	15322	0.46	0.51	0.4
1978	62074	79665	48360	42090	46347	37833	17703	0.46	0.51	0.41
1979	18378	23319	14483	51612	57554	45670	21217	0.5	0.55	0.45
1980	192025	246077	149732	40029	43793	36265	16946	0.53	0.59	0.48
1981	227767	303143	171106	26438	28554	24322	13707	0.56	0.61	0.51
1982	203001	271088	152025	39534	45281	33787	22328	0.58	0.64	0.52
1983	194315	254562	148257	49678	56755	42601	26551	0.6	0.67	0.53
1984	92609	119680	71641	50063	55946	44180	25739	0.62	0.68	0.56
1985	114664	143186	91867	47072	52710	41434	23656	0.62	0.68	0.56
1986	171169	214649	136385	38707	42227	35187	18439	0.6	0.66	0.54
1987	84358	104816	67917	35217	38657	31777	16605	0.55	0.6	0.51
1988	662255	807989	542366	42986	48293	37679	18454	0.51	0.56	0.45
1989	130468	159730	106592	38033	41443	34623	20855	0.48	0.53	0.43
1990	250123	305429	204951	120762	138934	102586	45027	0.47	0.52	0.43
1991	91004	111032	74640	90560	101035	80087	37161	0.49	0.54	0.44
1992	450654	560374	362087	90815	98986	82644	35277	0.52	0.56	0.47
1993	88517	111469	70298	60068	64997	55139	30788	0.55	0.59	0.5
1994	64306	80660	51226	85544	96531	74557	36153	0.58	0.64	0.52
1995	110938	139687	88154	62538	68852	56224	28654	0.61	0.66	0.56
1996	73770	92865	58636	38419	41643	35195	19861	0.64	0.68	0.59
1997	323391	408938	255935	32185	35349	29021	15665	0.66	0.71	0.6

Year	Recruitment Age 1	High	Low	SSB	High	Low	Landings	F Ages 2–6	High	Low
		2 * Standard Error (approx. 95% confidence interval)	2 * Standard Error (approx. 95% confidence interval)		2 * Standard Error (approx. 95% confidence interval)	2 * Standard Error (approx. 95% confidence interval)			2 * Standard Error (approx. 95% confidence interval)	2 * Standard Error (approx. 95% confidence interval)
	Thousands			Tonnes				Per year		
1998	154837	198916	120495	24500	26795	22205	16985	0.66	0.71	0.61
1999	120138	151206	95378	50473	58883	42063	26507	0.66	0.71	0.6
2000	138983	170734	113113	41738	46976	36500	22036	0.64	0.71	0.58
2001	69884	85393	57238	33990	37205	30775	18437	0.62	0.66	0.57
2002	211702	256362	174845	34007	37577	30437	15595	0.59	0.64	0.54
2003	97264	117909	80204	26853	29201	24505	15278	0.57	0.63	0.52
2004	54509	66205	44869	39733	44238	35228	16900	0.56	0.61	0.52
2005	51612	61457	43386	32306	35663	28949	13913	0.55	0.6	0.5
2006	183551	217751	154646	25407	27366	23448	11099	0.51	0.56	0.46
2007	66759	79223	56274	18029	19422	16636	9586	0.46	0.5	0.42
2008	74905	88903	63114	34538	38581	30495	11884	0.43	0.47	0.39
2009	99144	119446	82238	31239	34245	28233	11660	0.42	0.47	0.38
2010	228454	275533	189385	30900	33733	28067	12036	0.44	0.49	0.39
2011	229017	276039	190176	29984	33249	26719	13141	0.44	0.5	0.37
2012	58348	71408	47660	37528	42642	32414	15830	0.39	0.45	0.32
2013	111226	139986	88318	45170	52129	38211	14871	0.32	0.38	0.25
2014	219372	287938	167293	42460	50247	34673	13160	0.26	0.32	0.2
2015	152536	208939	111324	43907	52808	35006	12509	0.23	0.28	0.176
2016	65144	96452	43967	57983	69725	46241	13462	0.22	0.27	0.164
2017	89941	166122	48704	58895	71933	45857	13101	0.22	0.29	0.144
2018	108555			58012						

Table 18.4.1. North Sea sole: Input table for RCT3 analysis

YEARCLASS	N_AGE_1	N_AGE_2	DFS0	SNS0	SNS1	BTS1
1976	168197	149389	NA	464.6	3742.9	NA
1977	63044.3	56504.9	NA	1585	1547.7	NA
1978	18291.3	16465.7	NA	10370.5	93.8	NA
1979	187369	168599	NA	3922.7	4312.9	NA
1980	221990	198541	NA	5145.8	3737.2	NA
1981	200654	177122	NA	3240.7	5856.5	NA
1982	197456	173556	NA	2147	2621.1	NA
1983	94911.2	84288.8	NA	769.1	2493.1	NA
1984	115068	103152	NA	3334	3619.4	7.031
1985	167104	150464	NA	2713.4	3705.1	7.168
1986	82857.6	74742.7	NA	742	1947.9	6.973
1987	667131	602167	NA	13610.1	11226.7	83.111
1988	133529	120510	NA	522.7	2830.7	9.015
1989	253242	228340	NA	1743.4	2856.2	37.839
1990	91031.4	81887.4	6.38	50.8	1253.6	4.035
1991	448133	401062	167.56	3639.7	11114	81.625
1992	87271.7	77465.2	9.27	302.9	1290.8	6.35
1993	63189.1	55705.8	15.32	231.3	651.8	7.66
1994	110762	97551.7	22.06	4692.7	1362.1	28.125
1995	75317.6	66452.6	7.06	1374.9	218.4	3.975
1996	336195	296696	40.27	2322.3	10279.3	169.343
1997	156889	138214	26.94	803	4094.6	17.108
1998	118445	104134	NA	327.9	1648.9	11.96
1999	138196	121424	NA	2187.9	1639.2	14.594
2000	71605	62879	9.5	70	970.3	7.998
2001	220969	193382	51.42	8340	7547.5	20.989
2002	99002.7	85892.4	58.58	1127.7	NA	10.507
2003	53342.1	45847.2	10.61	NA	1369.5	4.192
2004	49858.3	42906.9	31.25	162	568.1	5.534
2005	181664	158395	40.99	305	2726.4	17.089
2006	68706.6	60556.6	12.57	16	848.6	7.498
2007	78724.3	69598.2	13.73	466.9	1259.1	15.247
2008	103983	91599.9	11.77	754.7	1931.6	15.95
2009	221683	194161	27.33	2291	2636.9	54.811
2010	219556	192086	42.86	333.9	1248	26.166
2011	56462.5	49541.1	12.13	136.3	226.6	5.149
2012	127683	111999	11.23	144.7	967.4	6.844
2013	219372	187779	44.82	237.3	2849	18.926
2014	NA	NA	23.62	126	3192	21.099
2015	NA	NA	7.45	109.7	733.8	6.454
2016	NA	NA	12.28	373.2	956.7	16.279
2017	NA	NA	20.97	205.9	NA	NA

Table 18.4.2. North Sea sole. RCT3 results for age 1

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years : 1976 - 2017

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:2017

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0182	8.563	0.5810	0.5464	22	3.043	11.66	0.623	0.5066
SNS0	1.1188	4.196	1.6280	0.1495	37	5.327	10.16	1.716	0.0668
SNS1	0.7621	5.993	0.4146	0.7386	37	NA	NA	NA	NA
BTS1	0.7749	9.740	0.3958	0.7287	30	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	38	NA	11.74	0.679	0.4266

	WAP	logWAP	int.se
yearclass:2017	108555	11.6	0.4435

Table 18.4.3. North Sea sole. RCT3 results for age 2

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years : 1976 - 2017

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:2016

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0300	8.397	0.5936	0.5373	22	2.508	10.98	0.6428	0.15322
SNS0	1.1012	4.192	1.5975	0.1548	37	5.922	10.71	1.6712	0.02267
SNS1	0.7629	5.865	0.4130	0.7412	37	6.863	11.10	0.4328	0.33801
BTS1	0.7834	9.593	0.4042	0.7232	30	2.790	11.78	0.4256	0.34959
VPA Mean	NA	NA	NA	NA	38	NA	11.62	0.6810	0.13651

	WAP	logWAP	int.se
yearclass:2016	87651	11.38	0.2516

Table 18.5.1. North Sea sole. Input and assumptions for the intermediate year to the short–term forecast (F values presented are assuming F = Fsq mean 2015–2017)

2018_SSB	2018_F2-6	2018_F_DIS1-3	2018_F_HC2-6	2018_RECRUITS	2018_LANDINGS	2018_DISCARDS	2018_CATCH	2018_TAC			
58012	0.22	0.068	0.183	108555	13568	1037	14605	15694			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2018	0.092	0.062	0.030	108555	0.066	0.132	0.034	0.034	0	0.1
2	2018	0.165	0.076	0.089	72802	0.126	0.171	0.074	0.072	0	0.1
3	2018	0.23	0.060	0.170	39244	0.170	0.198	0.089	0.141	1	0.1
4	2018	0.25	0.032	0.220	69434	0.22	0.23	0.090	0.169	1	0.1
5	2018	0.24	0.0135	0.222	78424	0.26	0.27	0.105	0.23	1	0.1
6	2018	0.22	0.0054	0.214	29384	0.27	0.27	0.116	0.24	1	0.1
7	2018	0.198	0.0020	0.196	10667	0.29	0.30	0.122	0.25	1	0.1
8	2018	0.164	0.00071	0.163	25802	0.30	0.30	0.153	0.26	1	0.1
9	2018	0.164	0.00029	0.164	14099	0.31	0.31	0.22	0.27	1	0.1
10	2018	0.164	0.000122	0.164	7929	0.31	0.31	0.136	0.30	1	0.1
1	2019	0.092	0.062	0.030	113076	0.066	0.132	0.034	0.034	0	0.1
2	2019	0.165	0.076	0.089	NA	0.126	0.171	0.074	0.072	0	0.1
3	2019	0.23	0.060	0.170	NA	0.170	0.198	0.089	0.141	1	0.1
4	2019	0.25	0.032	0.220	NA	0.22	0.23	0.090	0.169	1	0.1
5	2019	0.24	0.0135	0.222	NA	0.26	0.27	0.105	0.23	1	0.1
6	2019	0.22	0.0054	0.214	NA	0.27	0.27	0.116	0.24	1	0.1
7	2019	0.20	0.0020	0.196	NA	0.29	0.30	0.122	0.25	1	0.1
8	2019	0.164	0.00071	0.163	NA	0.30	0.30	0.153	0.26	1	0.1
9	2019	0.164	0.00029	0.164	NA	0.31	0.31	0.22	0.27	1	0.1
10	2019	0.164	0.000122	0.164	NA	0.31	0.31	0.136	0.30	1	0.1
1	2020	0.092	0.062	0.030	113076	0.066	0.132	0.034	0.034	0	0.1
2	2020	0.165	0.076	0.089	NA	0.126	0.171	0.074	0.072	0	0.1
3	2020	0.23	0.060	0.170	NA	0.170	0.198	0.089	0.141	1	0.1

2018_SSB	**2018_F2-6**	**2018_F_DIS1-3**	**2018_F_HC2-6**	**2018_RECRUITS**	**2018_LANDINGS**	**2018_DISCARDS**	**2018_CATCH**	**2018_TAC**			
4	2020	0.25	0.032	0.220	NA	0.22	0.23	0.090	0.169	1	0.1
5	2020	0.24	0.0135	0.222	NA	0.26	0.27	0.105	0.23	1	0.1
6	2020	0.22	0.0054	0.214	NA	0.27	0.27	0.116	0.24	1	0.1
7	2020	0.198	0.0020	0.196	NA	0.29	0.30	0.122	0.25	1	0.1
8	2020	0.162	0.000697762229802555	0.161137653367676	NA	0.298175929174854	0.298806666666667	0.152516666666667	0.255333333333333	1	0.1
9	2020	0.162	0.000289806275523117	0.161545609321955	NA	0.311532258176217	0.311696666666667	0.219886666666667	0.274666666666667	1	0.1
10	2020	0.162	0.000120189105476383	0.161715226492002	NA	0.311165155788707	0.31129534108244	0.136	0.297753733107019	1	0.1

Table 18.5.2. North Sea sole. Detailed STF table by age, assuming F = Fsq mean 2015-2017

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	2018	0.092	0.062	0.030	108555.000	0.066	0.132	0.034	0.034	0	0.1	9110	605	2970	393	6140	212	0	3655
2	2018	0.165	0.076	0.089	72802.285	0.126	0.171	0.074	0.072	0	0.1	10561	1331	5689	971	4872	360	0	5242
3	2018	0.230	0.060	0.170	39244.120	0.170	0.198	0.089	0.141	1	0.1	7693	1306	5679	1125	2015	180	5547	5547
4	2018	0.252	0.032	0.220	69433.656	0.216	0.234	0.090	0.169	1	0.1	14745	3178	12855	3009	1890	169	11757	11757
5	2018	0.236	0.014	0.222	78424.092	0.259	0.268	0.105	0.230	1	0.1	15699	4060	14798	3965	901	95	18038	18038
6	2018	0.219	0.005	0.214	29384.046	0.270	0.274	0.116	0.245	1	0.1	5518	1492	5382	1477	136	16	7189	7189
7	2018	0.198	0.002	0.196	10667.198	0.295	0.297	0.122	0.249	1	0.1	1827	538	1808	536	19	2	2660	2660
8	2018	0.164	0.001	0.163	25802.352	0.298	0.299	0.153	0.255	1	0.1	3716	1108	3700	1106	16	2	6588	6588
9	2018	0.164	0.000	0.164	14099.355	0.312	0.312	0.220	0.275	1	0.1	2031	633	2027	632	4	1	3873	3873
10	2018	0.164	0.000	0.164	7929.443	0.311	0.311	0.136	0.298	1	0.1	1142	355	1141	355	1	0	2361	2361
1	2019	0.092	0.062	0.030	113075.690	0.066	0.132	0.034	0.034	0	0.1	9489	630	3094	409	6396	220	0	3807
2	2019	0.165	0.076	0.089	89569.258	0.126	0.171	0.074	0.072	0	0.1	12993	1637	6999	1194	5994	443	0	6449
3	2019	0.230	0.060	0.170	55846.397	0.170	0.198	0.089	0.141	1	0.1	10948	1858	8081	1601	2867	256	7893	7893
4	2019	0.252	0.032	0.220	28208.395	0.216	0.234	0.090	0.169	1	0.1	5990	1291	5222	1222	768	69	4777	4777
5	2019	0.236	0.014	0.222	48835.949	0.259	0.268	0.105	0.230	1	0.1	9776	2528	9215	2469	561	59	11232	11232
6	2019	0.219	0.005	0.214	56063.156	0.270	0.274	0.116	0.245	1	0.1	10527	2847	10268	2817	259	30	13717	13717
7	2019	0.198	0.002	0.196	21350.935	0.295	0.297	0.122	0.249	1	0.1	3656	1078	3618	1073	38	5	5323	5323
8	2019	0.164	0.001	0.163	7918.191	0.298	0.299	0.153	0.255	1	0.1	1141	340	1136	339	5	1	2022	2022
9	2019	0.164	0.000	0.164	19818.014	0.312	0.312	0.220	0.275	1	0.1	2855	889	2849	888	5	1	5443	5443
10	2019	0.164	0.000	0.164	16919.660	0.311	0.311	0.136	0.298	1	0.1	2437	758	2435	758	2	0	5038	5038

Table 18.5.3. North Sea sole. Assumptions made for the interim year and in the forecast

Variable	Value	Notes
$F_{ages\ 2–6}$ (2018)	0.22	Average exploitation pattern (2015-2017) scaled to average $F_{ages\ 2–6}$ (2015-2017)
SSB (2019)	55445	Short-term forecast (STF), in tonnes
R_{age1} (2018)	108555	RCT3; thousands
R_{age1} (2019)	113058	Geometric mean (1957–2014); thousands
Total catch (2018)	14605	STF, in tonnes
Wanted catch (2018)	13568	STF, average landings rate by age 2015–2017; tonnes
Unwanted catch (2018)	1037	STF, average discard rate by age 2015–2017; tonnes

Table 18.5.4. North Sea sole. Annual catch scenarios. Weights in tonnes

Basis	Total catch * (2019)	Wanted catch ** (2019)	Unwanted catch (2019)	F_{total} (ages 2–6) (2019)	F_{wanted} (ages 2–6) (2019)	$F_{unwanted}$ (ages 1–3) (2019)	SSB (2020)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis										
EU AA^^^: F_{MSY}	12801	11800	1001	0.202	0.168	0.063	54818	-1.13	-18.4	-18.6
F = AA $F_{MSY\ lower}$	7451	6871	579	0.113	0.094	0.035	59539	7.4	-53	-53
F = AA $F_{MSY\ upper}$	21644	19935	1709	0.367	0.30	0.114	47056	-15.1	38	38
Other scenarios										
MSY approach: F_{MSY}	12801	11800	1001	0.202	0.168	0.063	54818	-1.13	-18.4	-18.6
F_{mp} (former management plan)	12685	11694	992	0.2	0.166	0.062	54920	-0.95	-19.2	-19.3
F = 0	0	0	0	0	0	0	66140	19.3	-100	-100
F_{pa}	25155	23160	1994	0.44	0.37	0.136	43990	-21	60	60
F_{lim}	33281	30614	2667	0.63	0.52	0.195	36935	-33	112	112
SSB (2020) = B_{lim}	45702	41967	3735	1.00	0.83	0.31	26300	-53	191	191
SSB (2020) = B_{pa}	33206	30546	2661	0.63	0.52	0.194	37000	-33	112	111
SSB (2020) = MSY $B_{trigger}$	33206	30546	2661	0.63	0.52	0.194	37000	-33	112	111
F = F_{2018}	13857	12772	1085	0.22	0.183	0.068	53889	-2.8	-11.7	-11.9

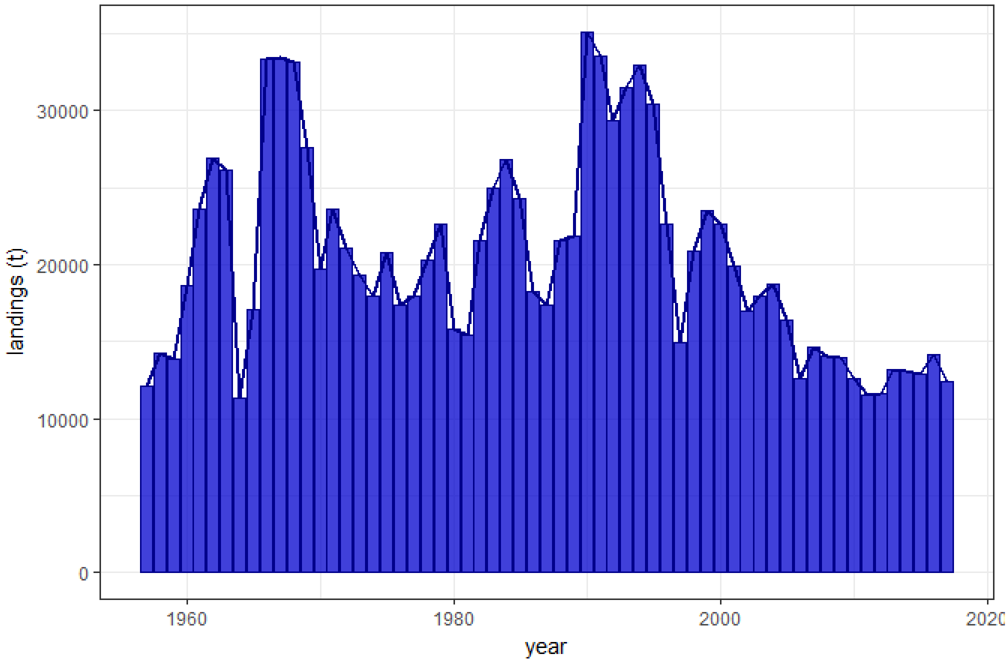


Figure 18.2.1. North Sea sole: Time series of landings (reported to ICES) (1957–present), from market and observer programmes.

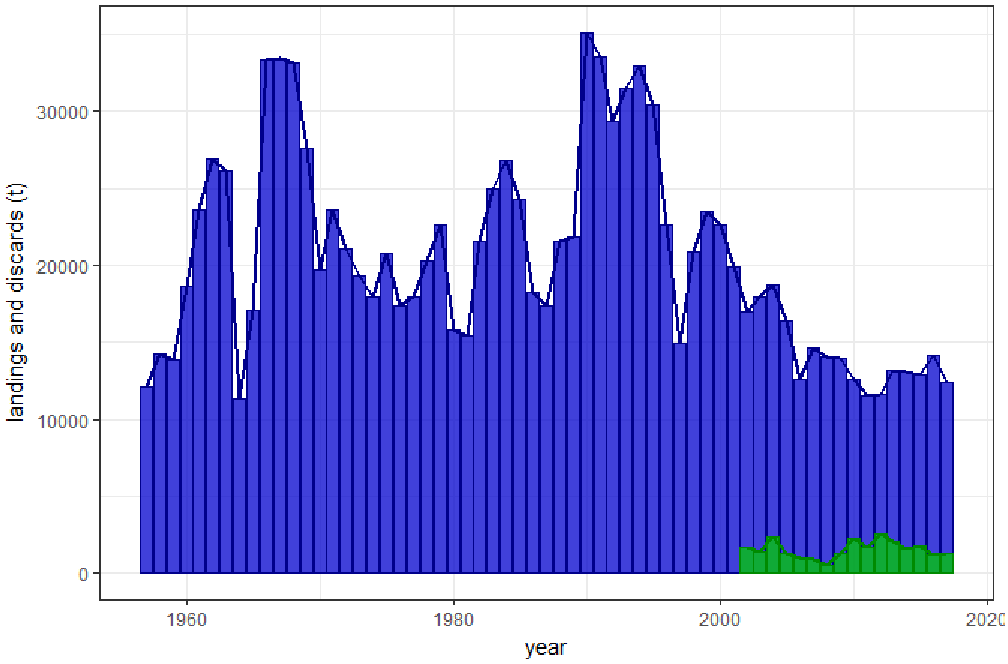


Figure 18.2.2. North Sea sole: Time series of landings (blue) and discards (green) (reported to ICES) (2002–present) from market and observer programmes

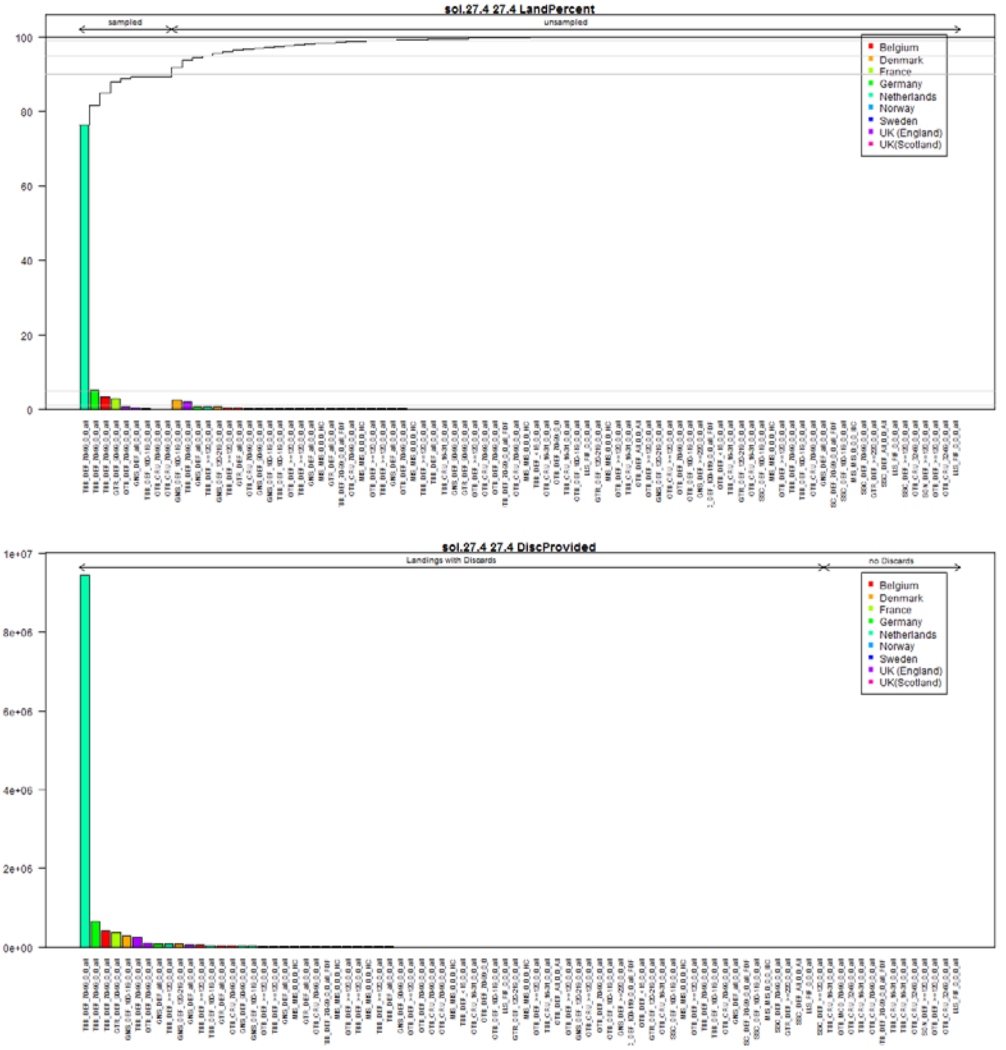


Figure 18.2.3. North Sea sole. Data upload in InterCatch: landings% by country by métier (top); discards% by country by métier (bottom). Sampled and unsampled refers to availability of age-composition information.

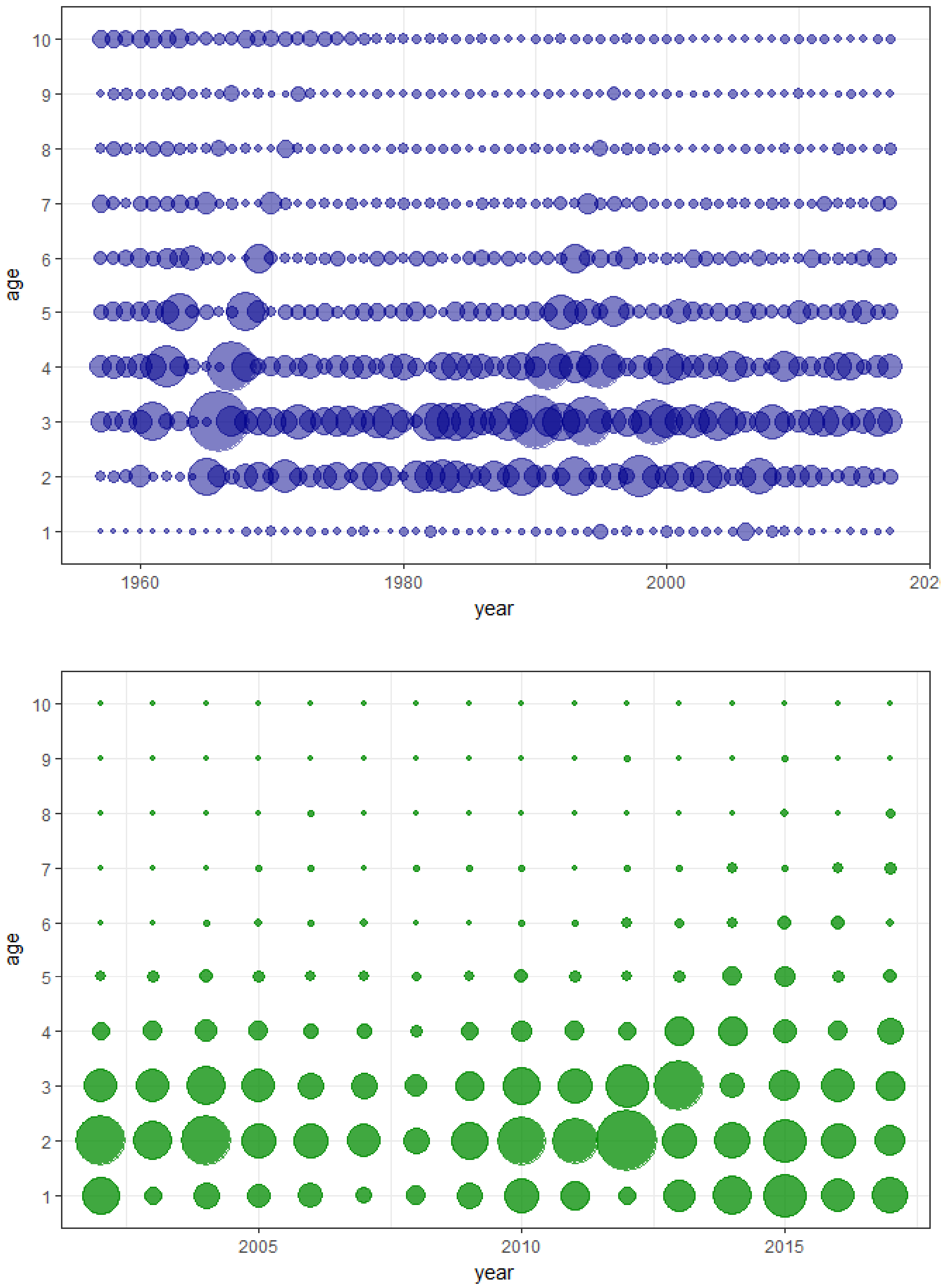
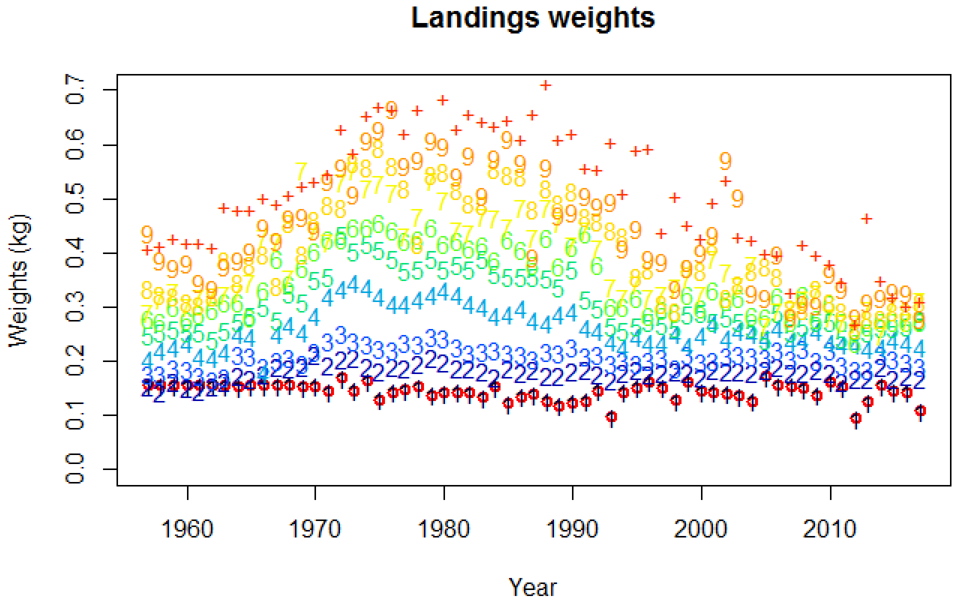
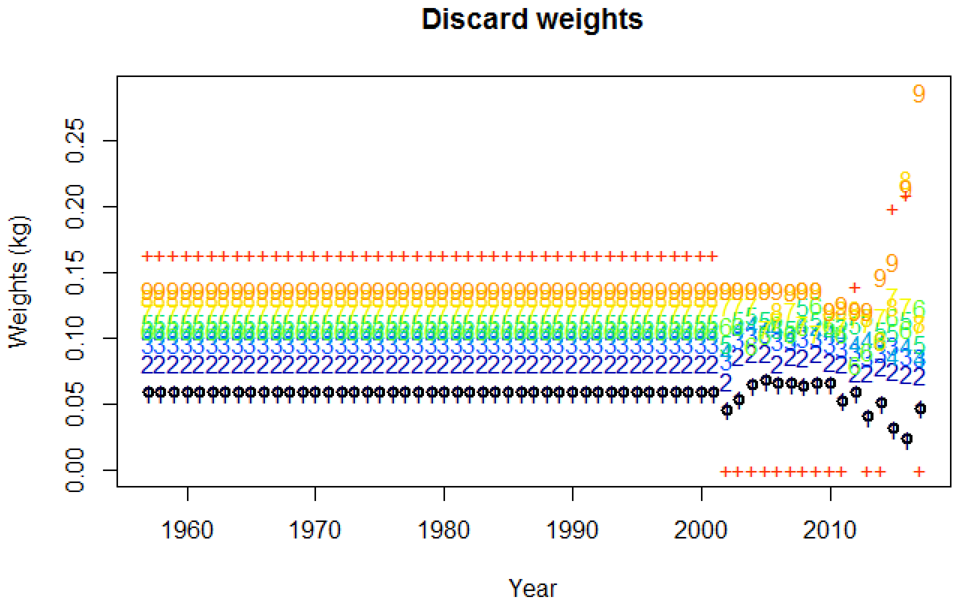
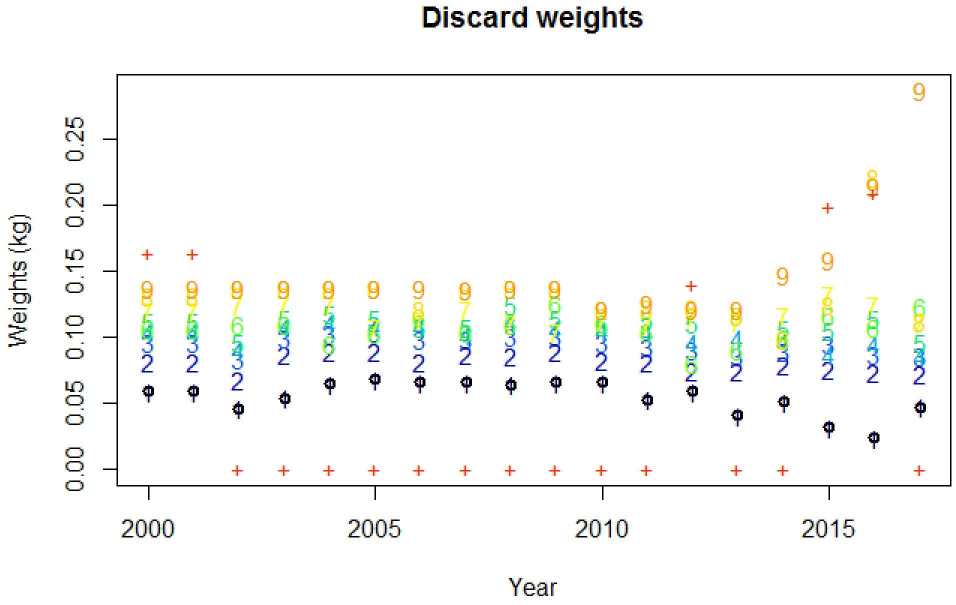
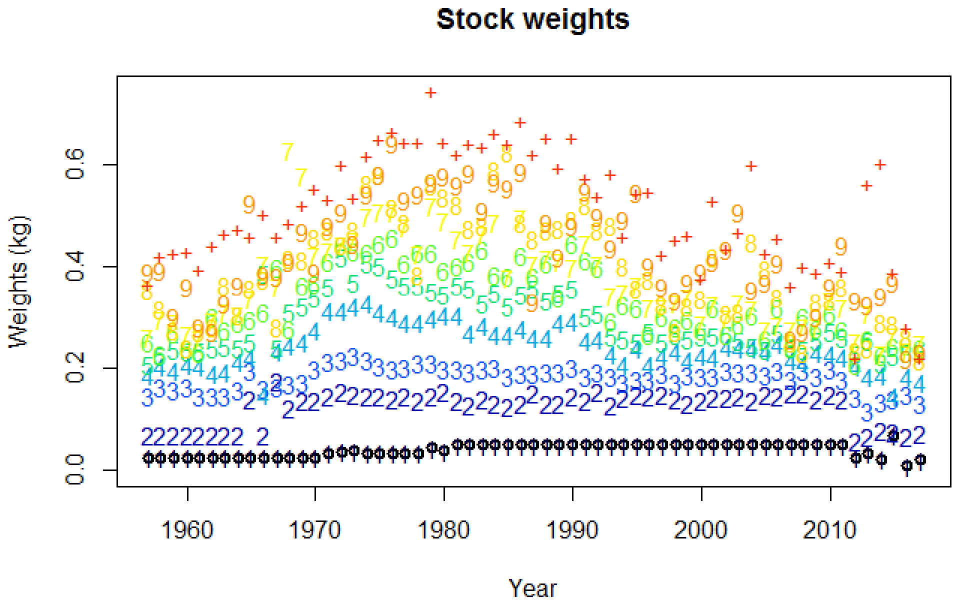


Figure 18.2.4. North Sea sole: Landings and discards numbers-at-age.


Landings weights
Weights (kg)
Year


Discard weights
Weights (kg)
Year


Discard weights
Weights (kg)
0.00
0.05
0.10
0.15
0.20
0.25
2000
2005
2010
2015
Year


Stock weights
Weights (kg)
0.0
0.2
0.4
0.6
1960
1970
1980
1990
2000
2010
Year

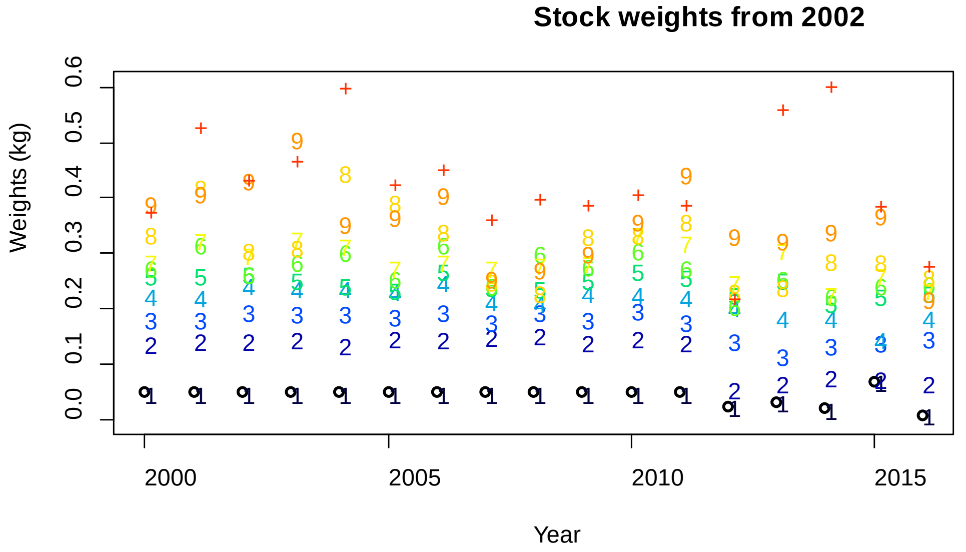


Figure 18.2.5. North Sea sole: Landing, discard, and mean stock weights at age for the whole time series, and for the most recent years (only discard and mean stock weights, 2000–present – actual discard data available from 2002 onwards).

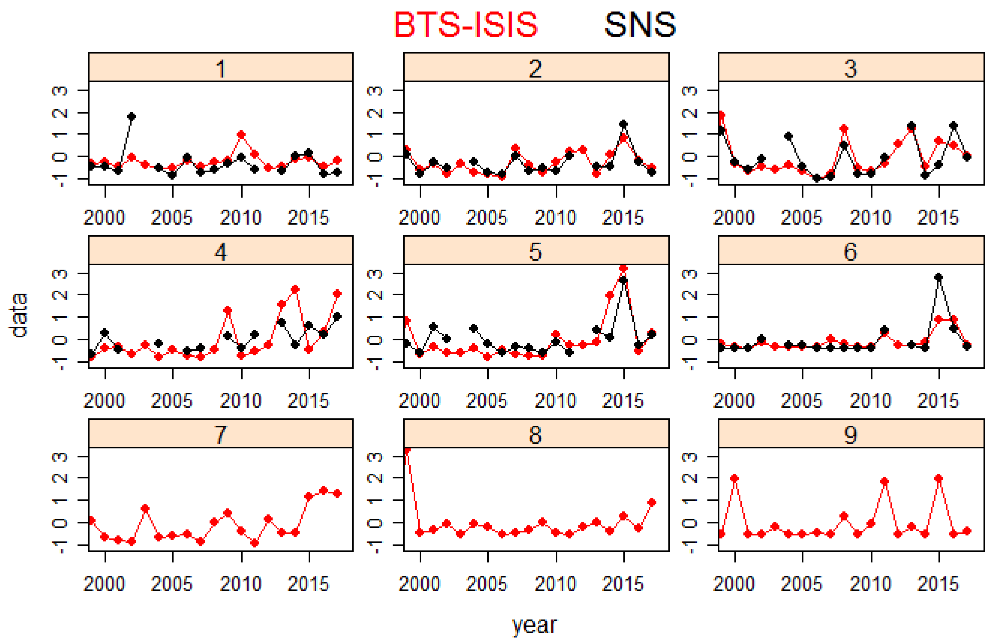


Figure 18.2.7.1. North Sea sole: Standardized survey tuning indices. BTS–Isis (red), SNS (black)

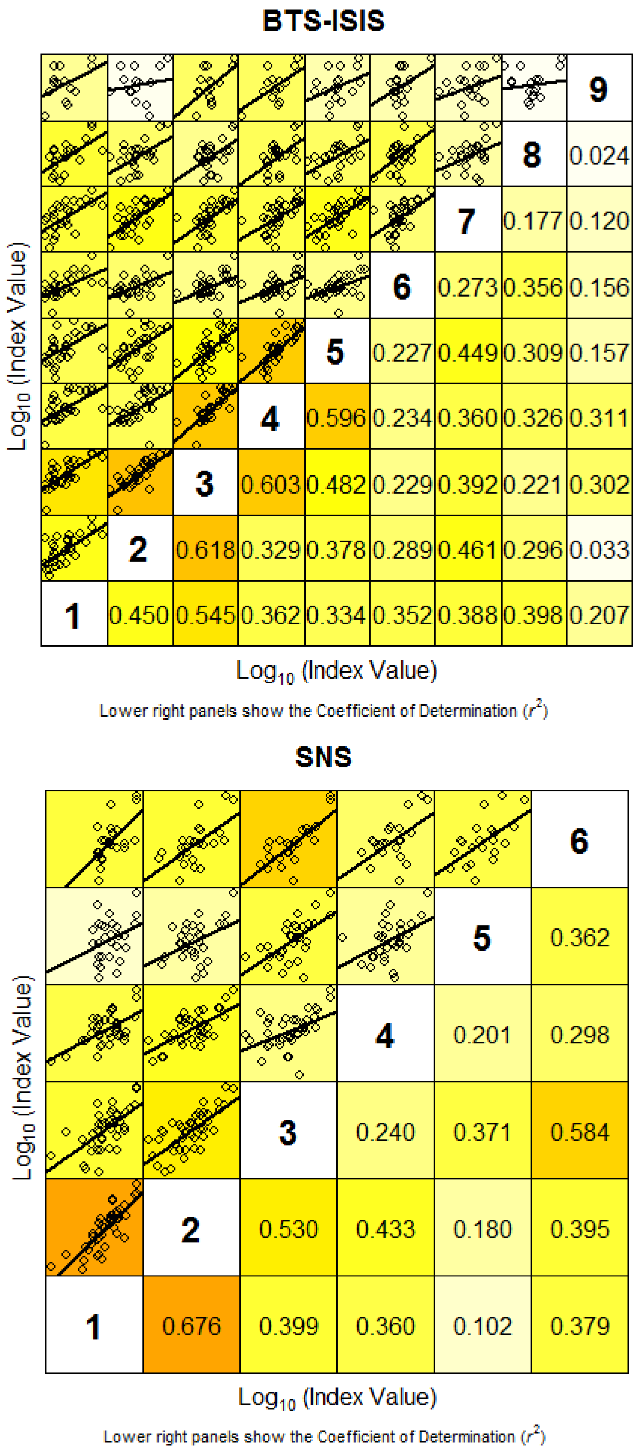


Figure 18.2.7.2 North Sea sole: Correlation plots for both tuning indices

Figure 18.3.1. North Sea sole: Assessment summary, SSB (top), Fishing mortality (middle), Recruitment (bottom).

Figure 18.3.2. North Sea sole: Retrospective performance of assessment summary, Y axis: Mean F, no units, Recruits: thousands, SSB: thousand tonnes.

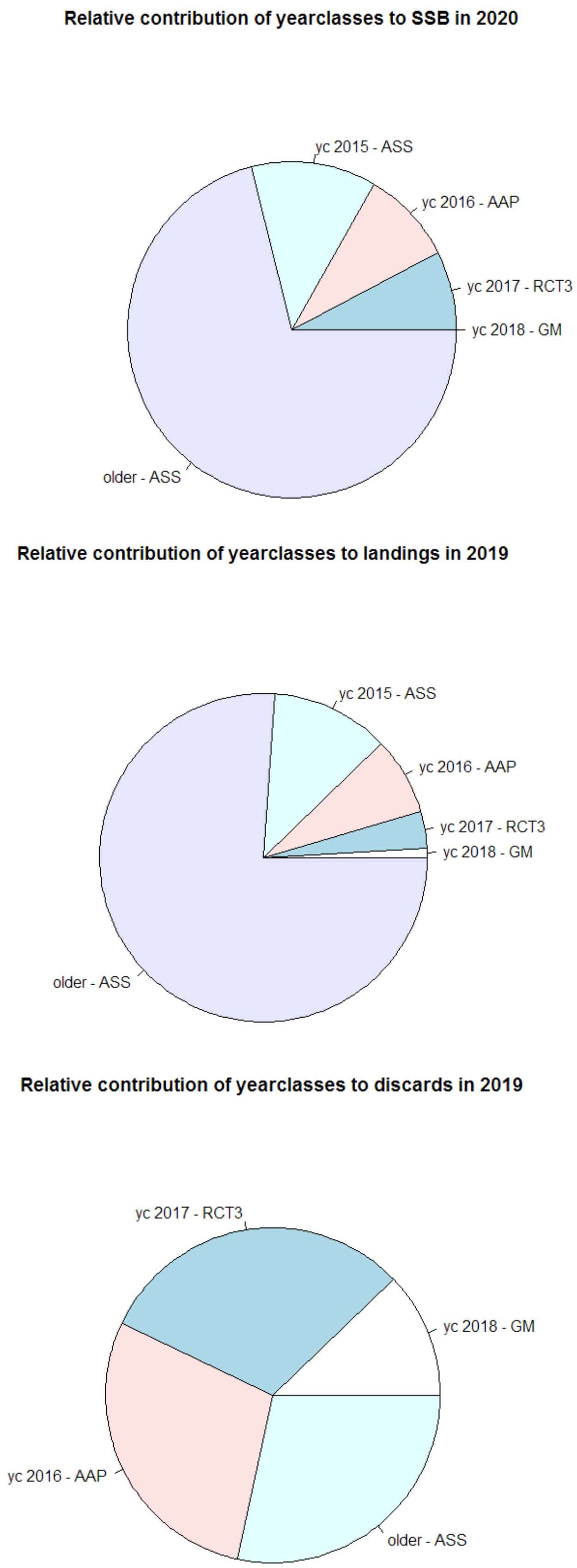


Figure 18.5.1. North Sea sole: Pieplots showing relative contribution of intermediate year assumptions for both F = Fsq mean 2015–2017 scenario.

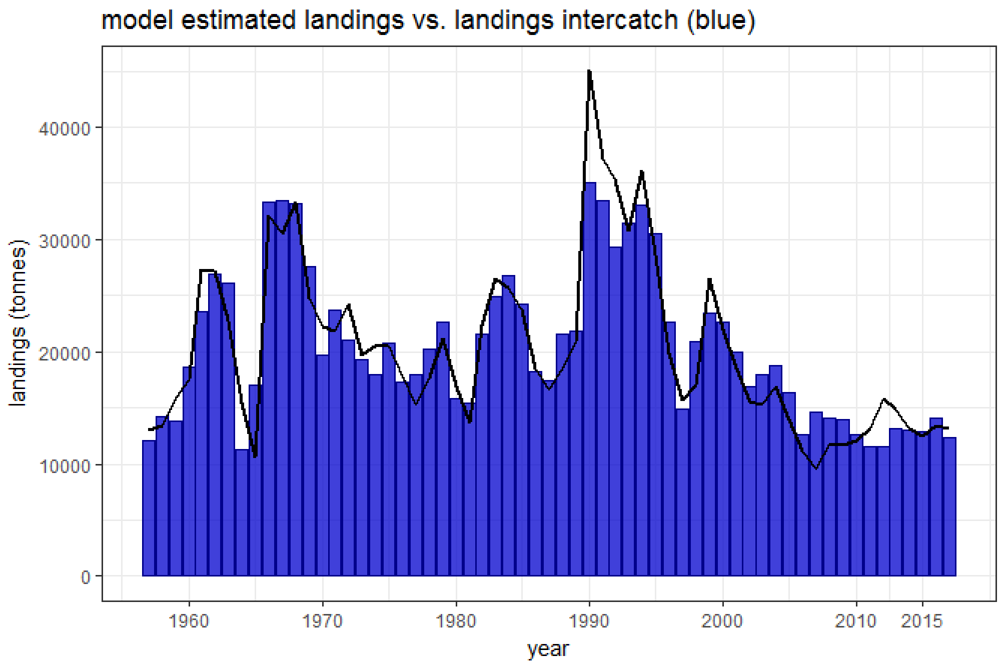


Figure 18.8.1. North Sea sole: Modelled landings (black line) versus observed landings (blue area).

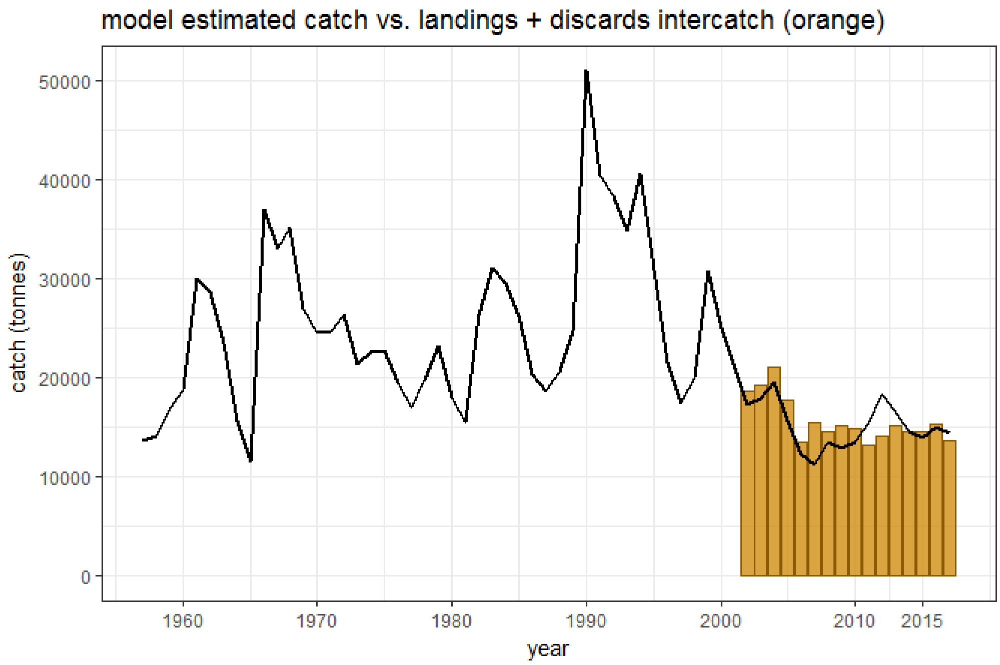


Figure 18.8.2. North Sea sole: Modelled catch (black line) versus observed catches (orange area).

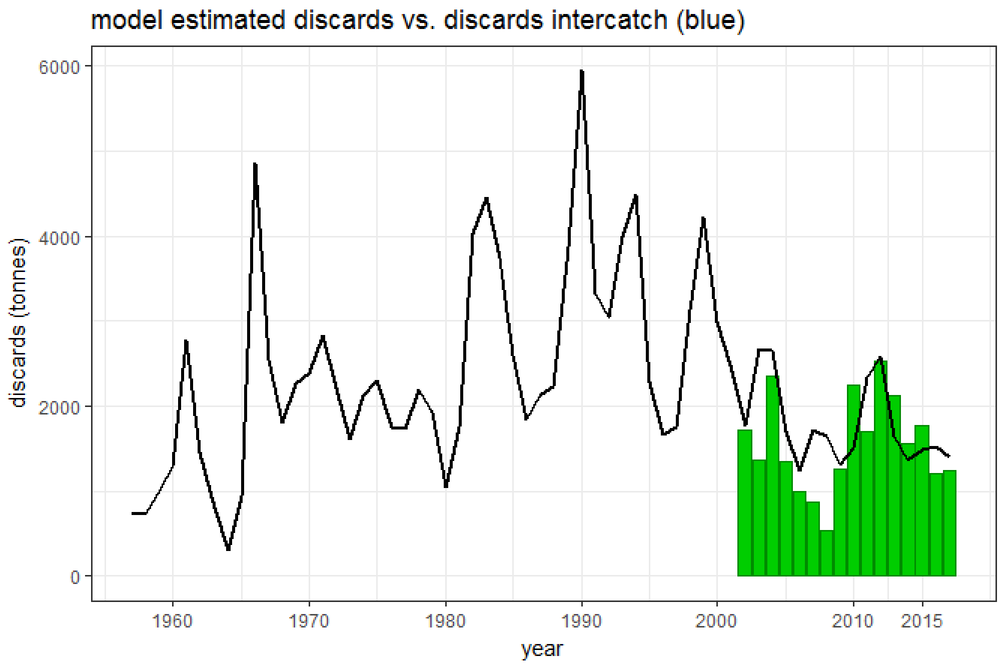


Figure 18.8.3. North Sea sole: Modelled discards (black line) versus observed discards (green area).

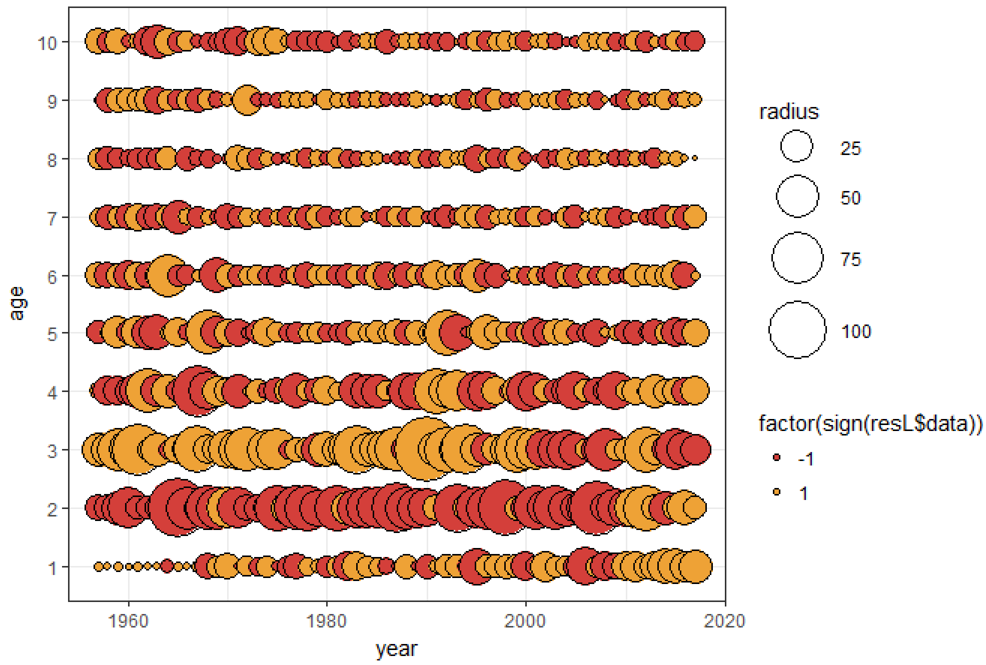


Figure 18.8.4. North Sea sole: Landings residuals.

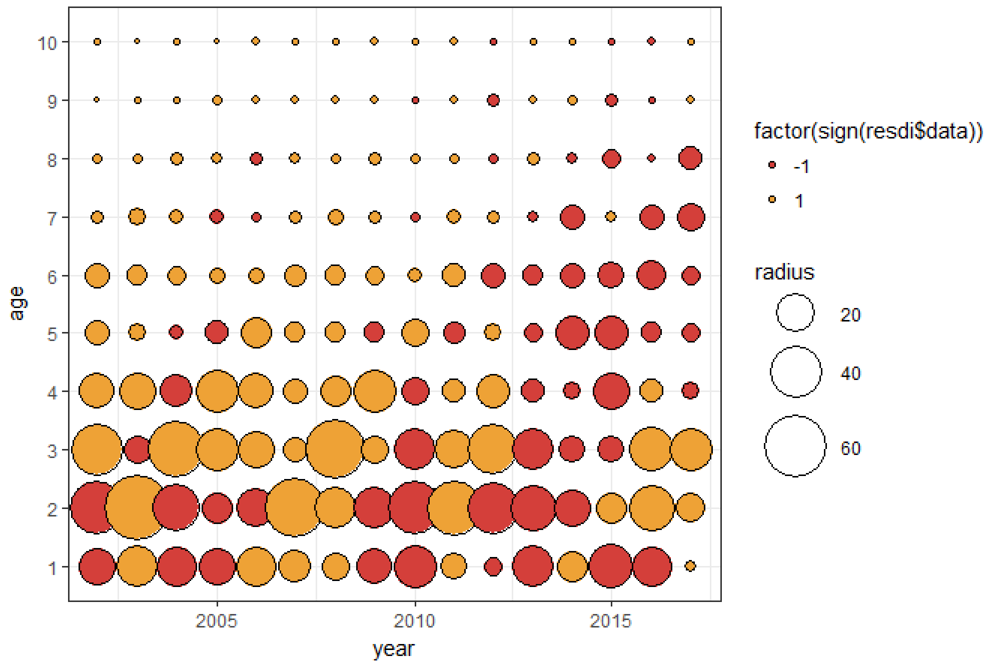


Figure 18.8.5. North Sea sole: Discard residuals.

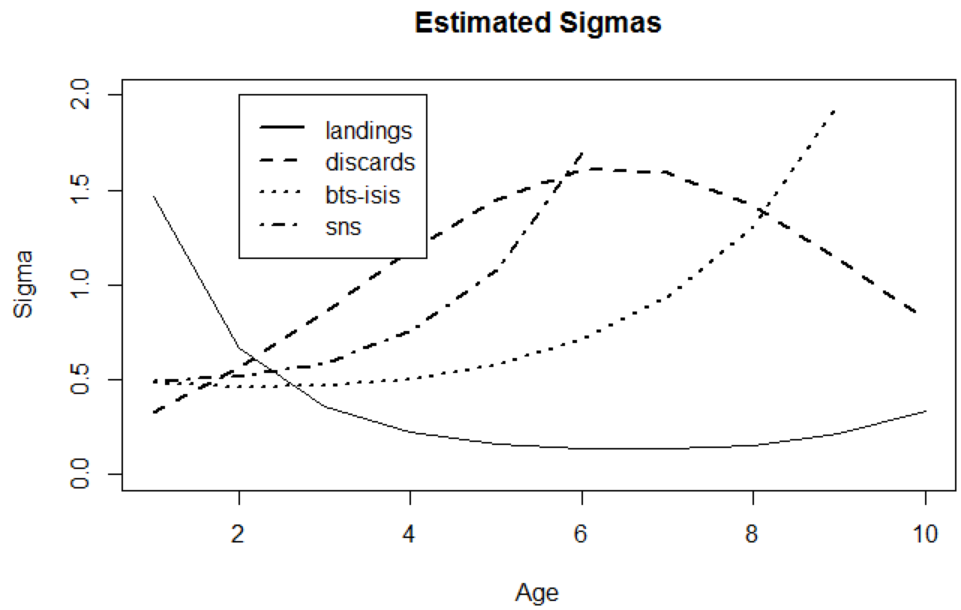


Figure 18.8.6. North Sea sole: Sigmas of different input time series.

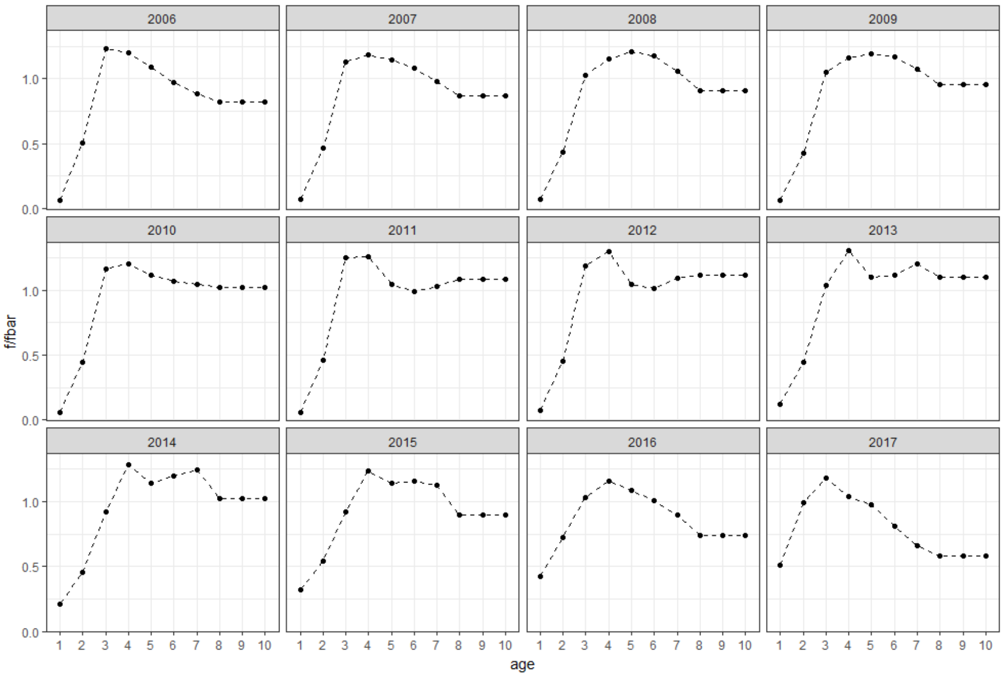


Figure 18.8.7. North Sea sole: Fishing mortality over ages from 2006–2017

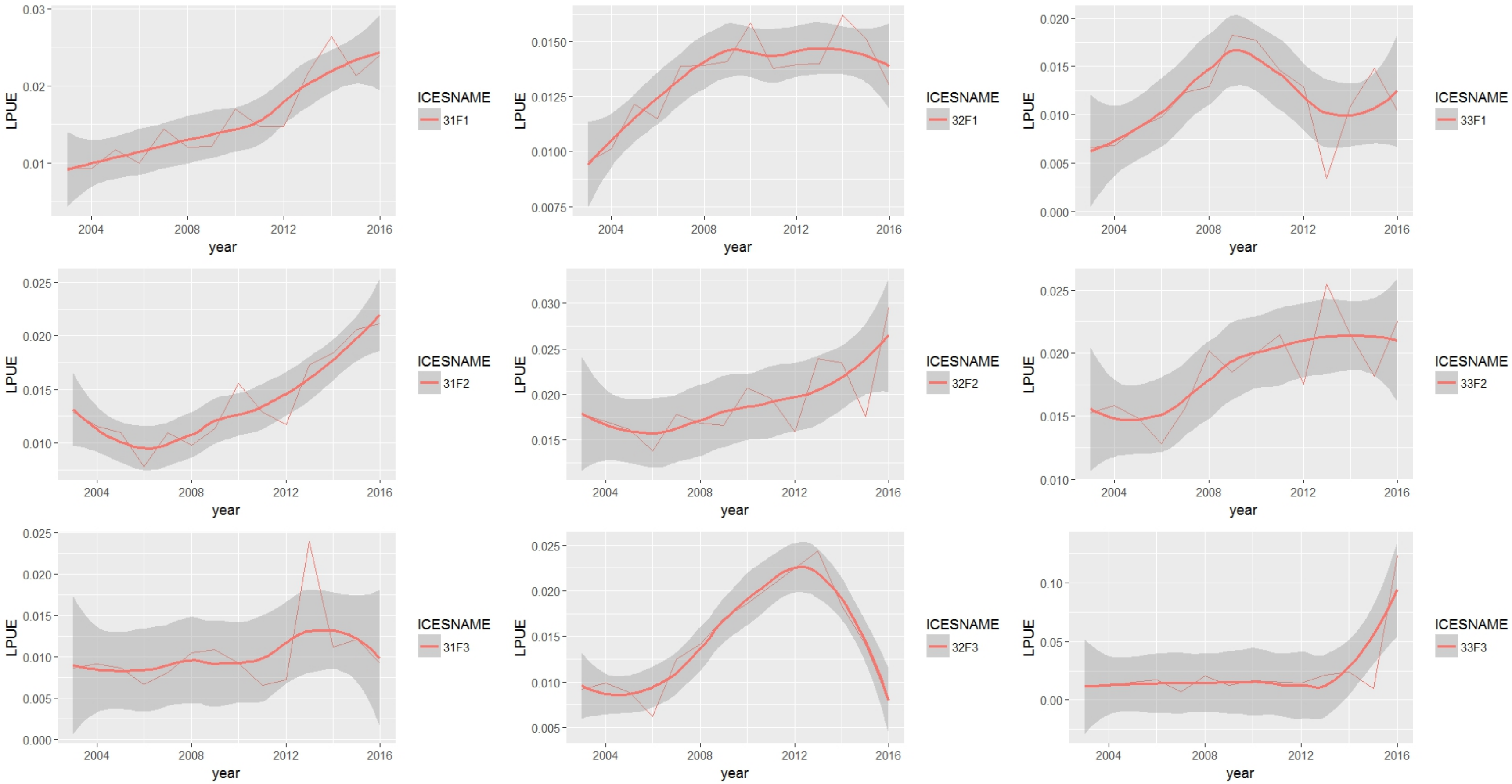


Figure 18.8.8. North Sea sole: LPUE per rectangle per year of BE BT2

Figure 18.8.9. North Sea sole: LPUE per rectangle per year of FR GT2

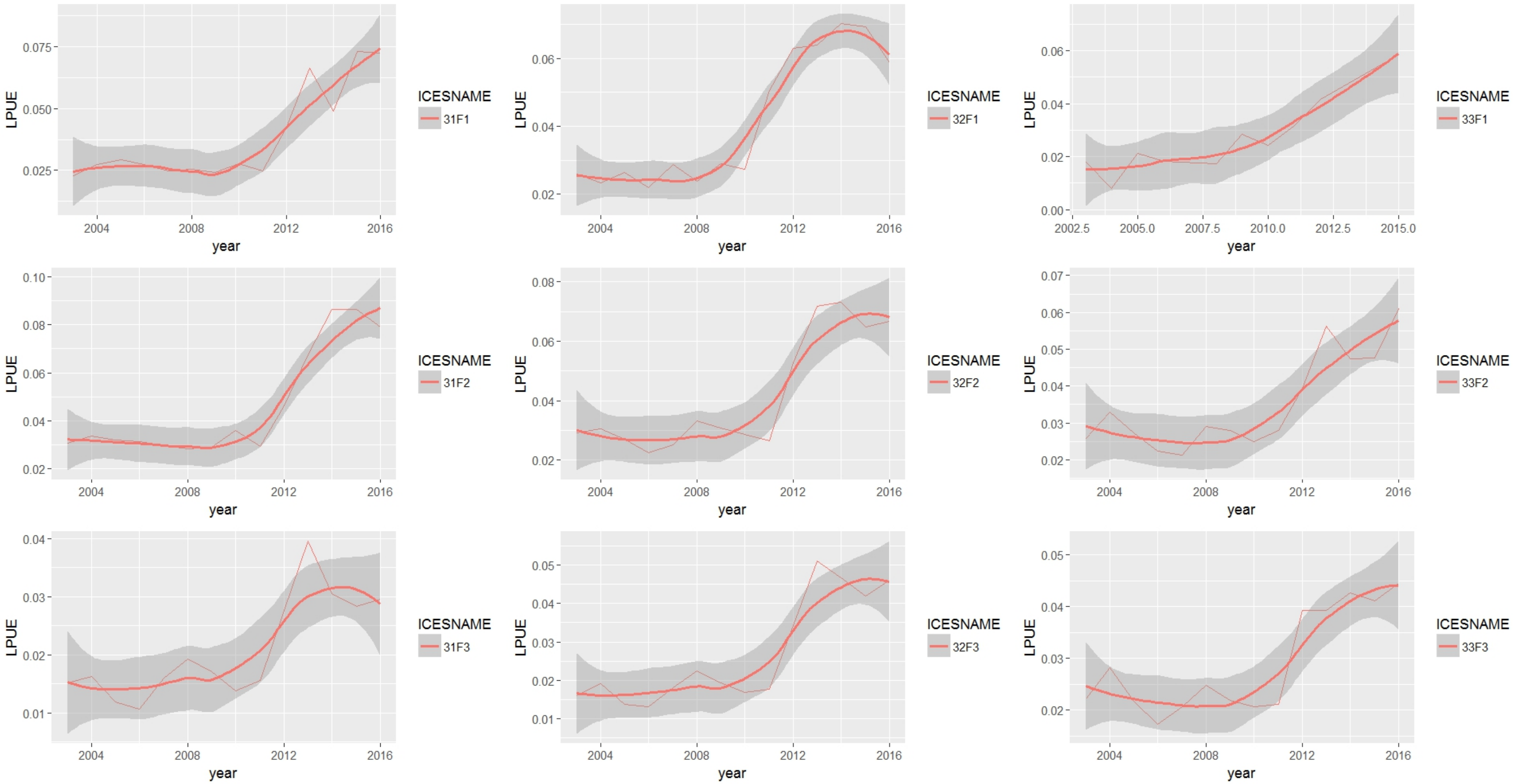


Figure 18.8.10. North Sea sole: LPUE per rectangle per year of NL BT2

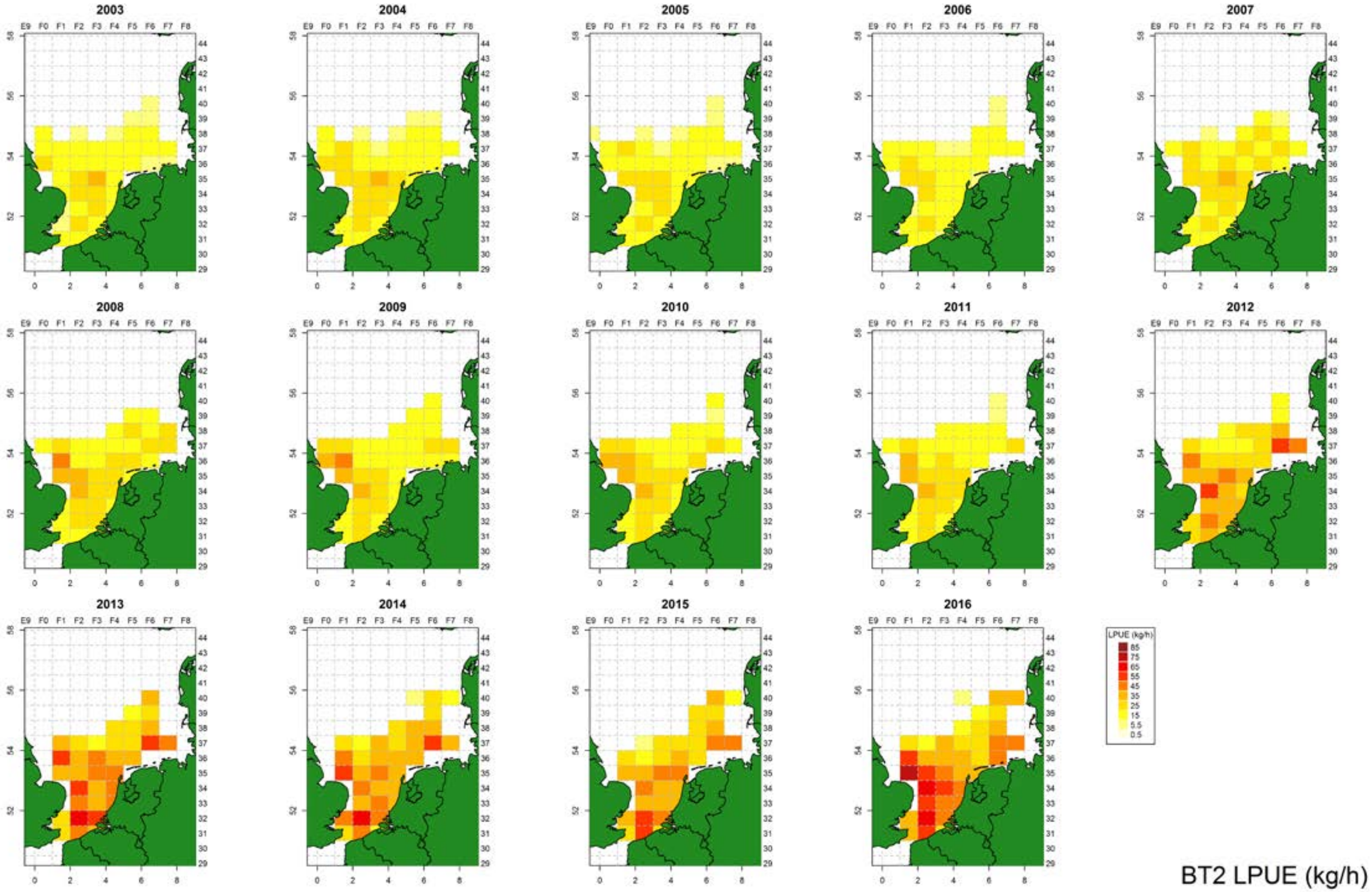


Figure 18.8.11. North Sea sole: Sole LPUE of BT2

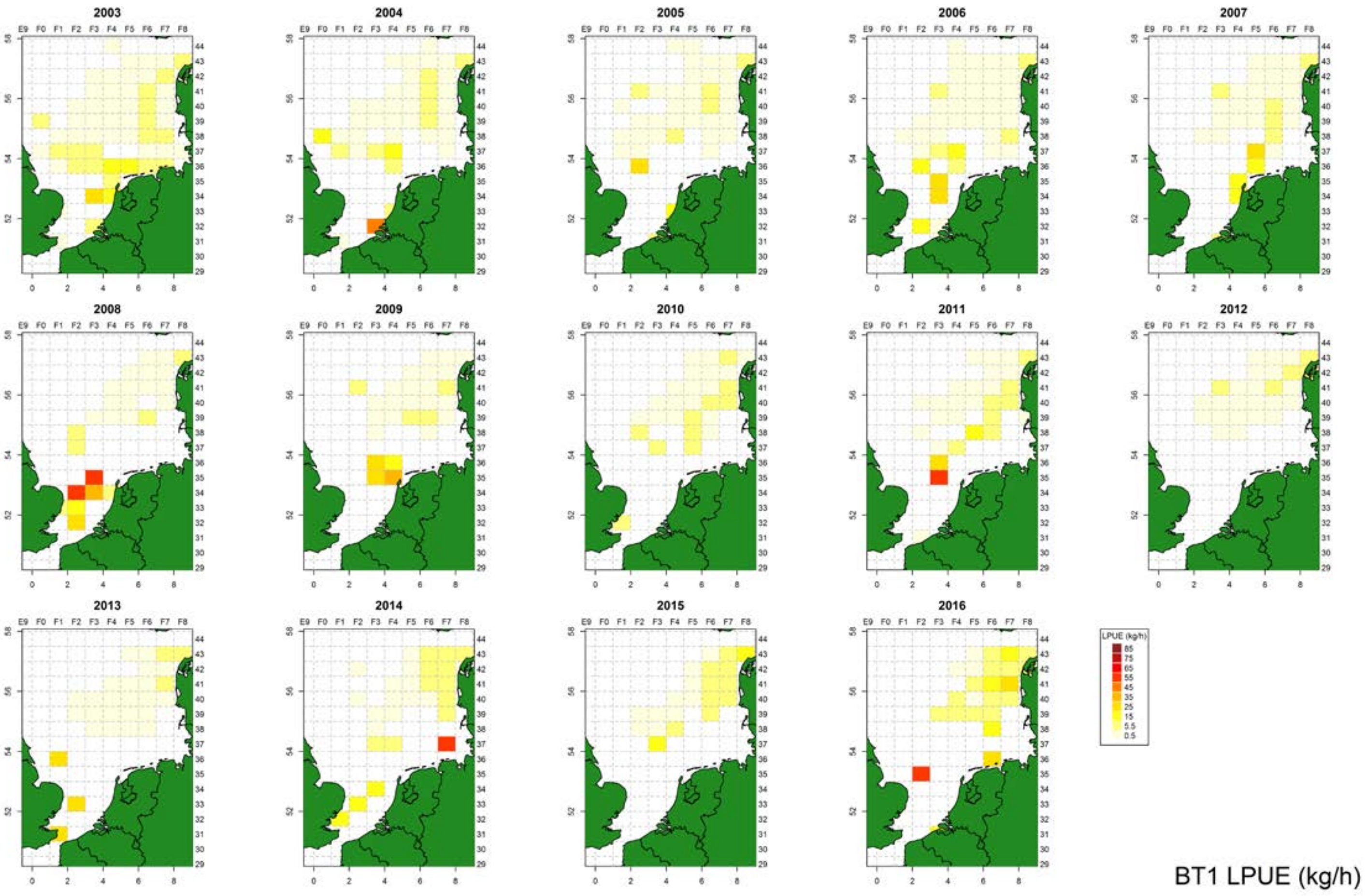


Figure 18.8.12. North Sea sole: Sole LPUE of BT1

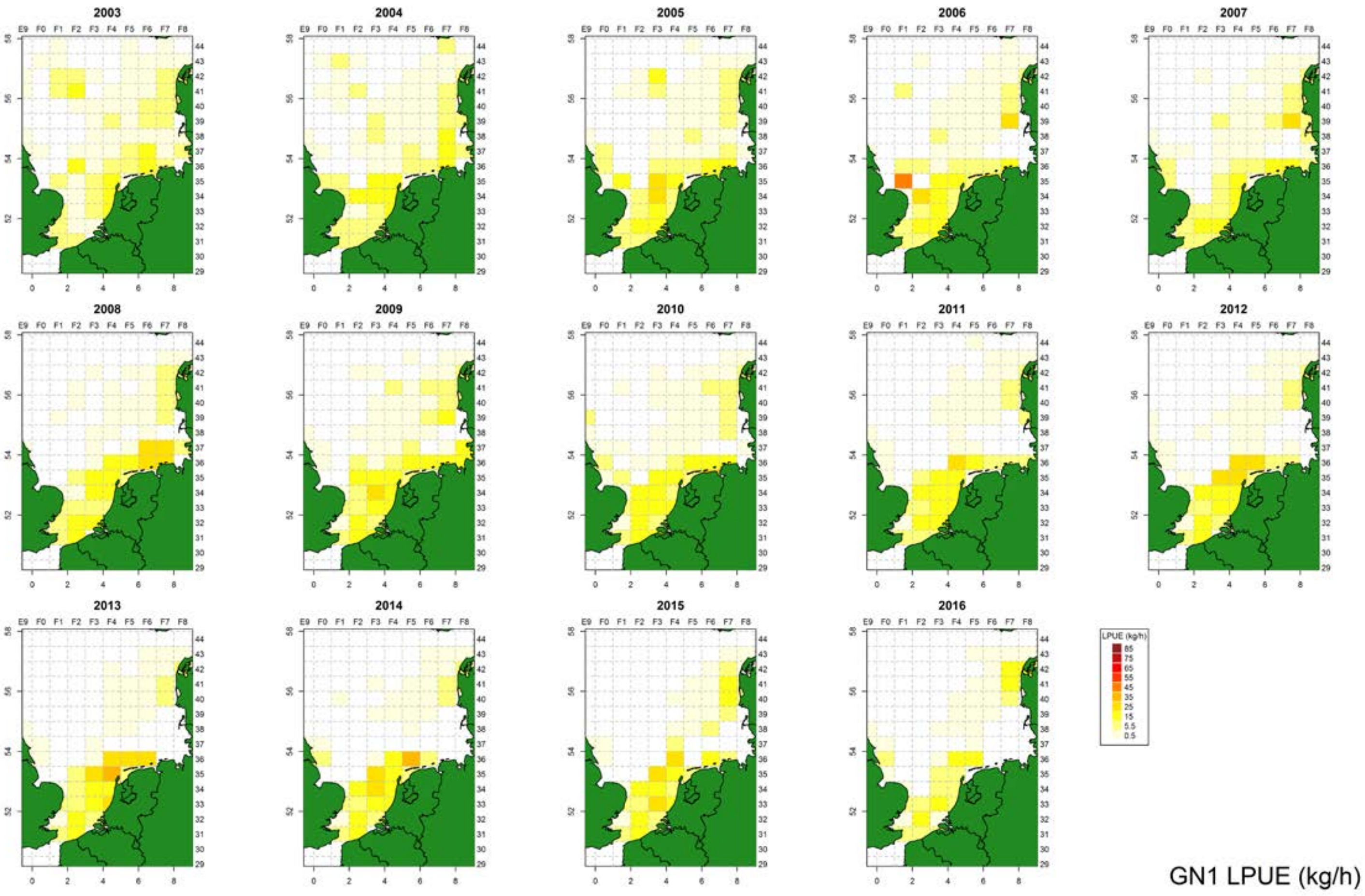


Figure 18.8.13. North Sea sole: Sole LPUE of GN1

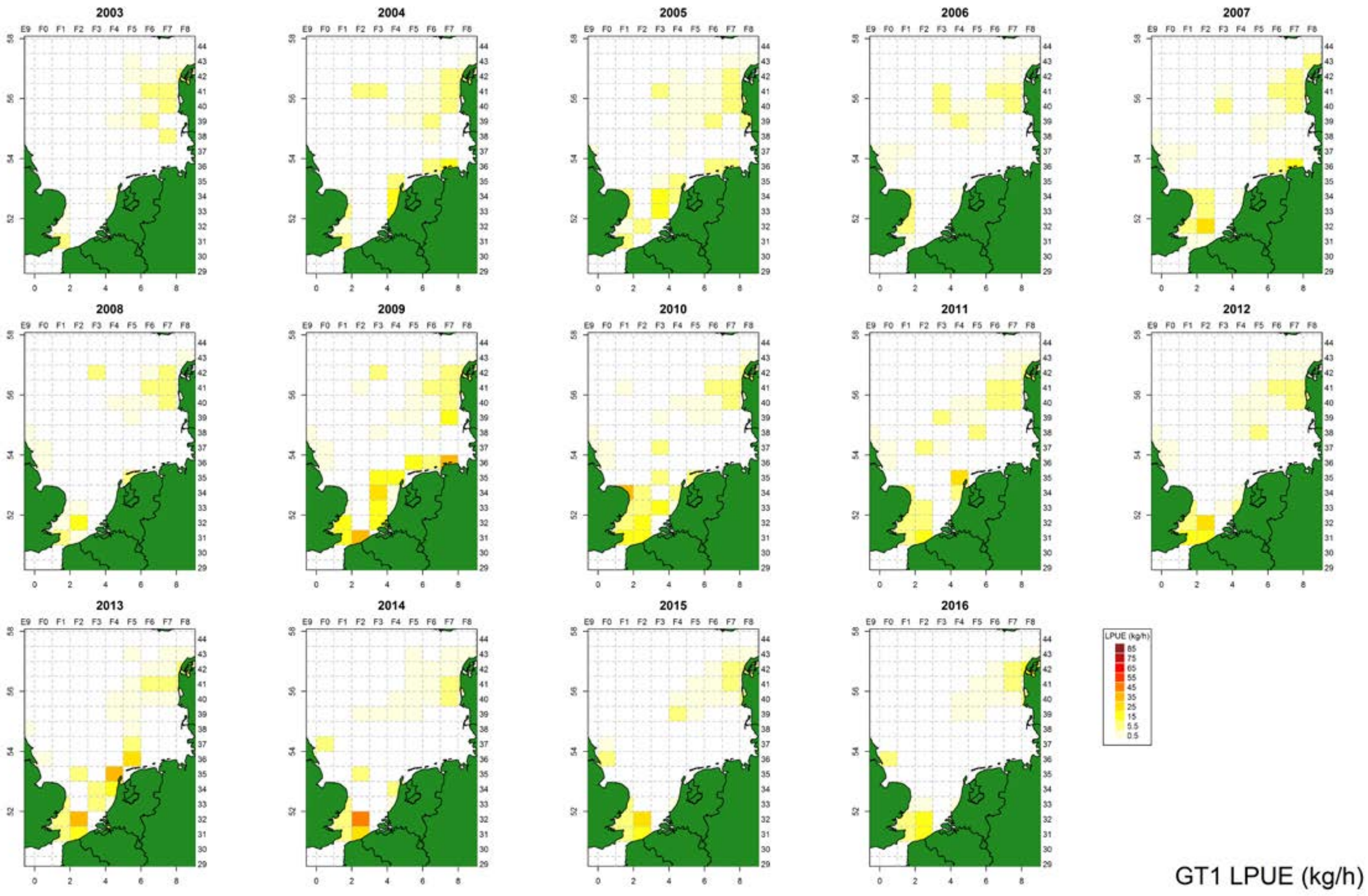


Figure 18.8.14. North Sea sole: Sole LPUE of GT1

19 Sole (*Solea solea*) in Division 27.7.d (Eastern English Channel)

The assessment of sole in Division 27.7.d (category 1) presented at WGNSKK 2018 is the second assessment after the stock was benchmarked (ICES 2017) in February 2017 (ICES WKNSEA 2017). This section of the report provides a comprehensive description of the methods and data used for the 2018 assessment. Additional background information can be found in the Stock Annex which was updated to this year's assessment.

19.1 General

19.1.1 Stock definition

During the WKNSEA 2017 benchmark, the available information on stock identity was investigated, including genetic, tagging and otolith information. Sole in the eastern English Channel (7.d) is still considered to be a stock separated from the larger North Sea stock (27.4) to the east and the smaller geographically-separated stock to the west in 27.7.e (western English Channel). Considering the sub-stock structure, three regions with low connectivity were identified within Division 7.d for both larvae and juveniles, and adults. More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES WKNSEA 2017).

19.1.2 Ecosystem aspects

A general description of the available information on ecological aspects can be found in the Stock Annex.

19.1.3 Fisheries

A general description of the fishery is presented in the Stock Annex.

19.1.3.1 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 otter trawlers. Fixed nets for the sole fisheries are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

A historical overview of the TAC for sole 7.d since 2000 is presented in the table below.

Historical overview of the TACs for sole in Division 27.7.d (2000–2018); Note: TAC represents catch from 2016 onwards (landing obligation)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TAC	4100	4600	5200	5400	5900	5700	5720	6220	6590	5274
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016***	**2017***	**2018***	
TAC	4219	4852	5580	5900	4838	3483	3258	2724	3405	

*** Catch TAC**

Except for 2009 and 2010, the TAC has not been restrictive since 2003. In 2014, it became restrictive for Belgium, and in 2015 this was the case for Belgium and France (see 19.2.1 Landings).

In response to the drop in SSB and the poor recruitment in 2012, the two main countries participating in the fishery (France and Belgium) have also implemented additional conservation measures. For Belgian beam trawlers in 7.d (and 27.7.fg, 27.7.a) it is mandatory since 1 April 2015 to incorporate a 3 m long section (tunnel) with a 120 mm mesh size before the cod-end, in order to reduce the catches of small sole (reduction of undersized sole with 40% and marketable sole with 16%). 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. From 11 March until 31 December 2017, the minimum conservation reference size for Belgian vessels has also increased to 25 cm. Finally, UK beam trawlers usually fish using mesh sizes greater than statutory in order to avoid discarding and to avoid wasting quota.

19.1.3.2 Additional information provided by the fishing industry

For the occasion of the benchmark, the UK fishing industry provided data showing that more small sole (both in size and weight) are caught over the last three years. The industry suggests this might indicate good recruitment. However, a thorough analysis of the complete sole 7.d dataset showed that sole seems to have decreased in size and weight at age over the past 10 years, and thus not necessarily reflecting recruitment. More information on this is provided in the benchmark report (ICES WKNSEA 2017), the associated working document on biological parameters and below in the section 19.2.2 Discards.

For the occasion of the WGNSSK 2018, the French fishing industry and more specifically the gillnet fleet (GTR) reported that although their effort is not decreasing, catches of sole are recently going down in Division 7.d. Additional analyses were executed to evaluate this information. The available catch data from 2004 until 2017 were investigated per country and gear at age. Catch numbers at age showed that the Belgian TBB and French GTR and OTB fleet were most important for sole fisheries in Division 7.d over this time period (Figure 19.1). When looking at the age structure by country, year and gear, all important fleets showed a higher proportion of the older age classes in the catch in recent years (2016–2017) compared to previous years (Figure 19.2). The standardised catch proportions by year and age showed that a strong yearclass failed to come in since 2009–2010 (Figure 19.3).

19.1.4 ICES advice

19.1.4.1 ICES advice for 2017

The ICES advice for 2017 was:

ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2487 tonnes.

In 2016 the stock status was presented as follows:

		Fishing pressure					Stock size			
		2013	2014	2015			2014	2015	2016	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✗	Below trigger
Precautionary approach	F_{pa}, F_{lim}	O	O	O	Increased risk	B_{pa}, B_{lim}	✓	✓	O	Increased risk
Management plan	F_{MGT}	-	-	-	Not applicable	SSB_{MGT}	-	-		Not applicable

19.1.4.2 ICES advice for 2018

The ICES advice for 2018 was:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 3866 tonnes.

In 2017 the stock status was presented as follows:

		Fishing pressure					Stock size			
		2014	2015	2016			2015	2016	2017	
Maximum sustainable yield	F_{MSY}	✗	✗	✓	Below	MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	O	O	✓	Harvested sustainably	B_{pa},B_{lim}	O	O	O	Increased risk
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

19.2 Data

As a result of the data call for the 2017 WKNSEA benchmark, new landings and discard data were uploaded in InterCatch from 2003–2015.

19.2.1 Landings

Table 19.1 and Figure 19.4 summarise the official sole landings by country for Division 7.d. The landings have steadily increased over the 1970s and 1990s, fluctuated around an average of 4839 t in 2000–2014 (range: 3832 t–6247 t), and dropped to 3411 tonnes in 2015 and even further to 2218 tonnes in 2017. 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 (~30% Belgium, ~20% UK, and ~50% France) (Figure 19.5).

Since 2010, full uptake of the sole 27.7.d TAC has not been realized. However, in 2014, the national Belgian quotum was overshot by 15%. In 2015, Belgium overshot its national quotum again by 12% and France faced a 1% overshoot. The total uptake in this year (2015) was 98% (official landings; for comparison: 72% in 2012, 75% in 2013, 96% in 2014). From 2016 onwards, official landings should no longer be compared to the TAC, as the latter represents catch data instead of only landings. When comparing ICES catch estimates (InterCatch) with the TAC (catch), a total uptake of 88% was realized in 2016 and 89% in 2017 (Figure 19.6). Figure 19.7 presents a historic overview of TAC levels compared to official landings and ICES estimates (both landings and discards).

ICES estimates were uploaded to InterCatch from 2003 onwards as a result of the benchmark data call. Figure 19.8 summarises the proportion of landings for which samples (age) have been provided in InterCatch by country (93%; see also Table 19.2). Figure 19.9

provides this overview by fleet and country. For some fleets, landings had not been sampled. However, the overall contribution of these fleets to total landings is small (7%). Age compositions for the remaining landings were allocated using the 'mean weight weighted by numbers at age' weighting factor and according to the following scenarios.

- By **métier** for métiers representing 75% of the total landings
- By **gear group** when the proportion of landings covered by age was ≥75%. The following gear groups were distinguished: TBB, OTB/SSC/SDN and GTR/GNS. GNS/GTR, TBB and OTB/SSC/SDN contribute respectively 43%, 39% and 17% to the landings of sole in 27.7.d (Table 19.3).
- **Overall**: When the proportion of landings covered by age was < 75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

19.2.2 Discards

For the benchmark (WKNSEA 2017), a data call for all countries involved in this fishery was launched to acquire discard data from 2003 onwards. From the 2017 assessment onwards, discards are included.

Figure 19.10 shows that for the major part of the landings, discard weights are available (85%; shown by fleet and country). When discards were not available, these were raised in InterCatch. Discards on a country-quarter-métier basis were automatically matched by InterCatch to the corresponding landings. The matched discards-landings provided a landing-discard ratio estimate, which was then used for further raising (creating discard amounts) of the unmatched discards (discard ratios larger than 0.5 were excluded as they were not assumed to be representative for the available strata). The weighting factor for raising the discards was 'Landings CATON'. Discard raising was performed on a gear level regardless of season or country.

- The following groups were distinguished based on the gear:
  - TBB
  - OTB, SSC and SDN
  - GTR and GNS
- The remaining gears were combined in a REST group (including for example MIS, FPO, LLS and DRB)
- Raising within a gear group was performed when the proportion of landings for which discard weights are available, was equal or larger than 75% compared to the total landings of that group.

More information on how discard raising was performed is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

The proportion of discards that was sampled for age was 67% (Table 19.2). For some fleets, discards had not been sampled. Age compositions for the remaining discards were allocated using the 'mean weight weighted by numbers at age' weighting factor and according to the following scenarios.

- By **gear group** when the proportion of discards covered by age was ≥75%. The following gear groups were distinguished: TBB, OTB/SSC/SDN and GTR/GNS.
- **Overall**: When the proportion of landings covered by age was < 75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

19.2.3 Weigth-at-age

Weights-at-age for discards and landings are shown in Figure 19.11 and 19.12 respectively and weights-at-age in the catch are given in Table 19.4.

During the benchmark, the landings mean weight- and number-at-age data for the years 2003–2010 and discard mean weight- and number-at-age data for the years 2003–2015 were processed through InterCatch for the first time. Because in 2003 the percentage of landings with associated discards is only 4%, it was decided to exclude the estimated discard mean weight- and number-at-age for that year. To estimate discards mean weights- and numbers-at-age prior to 2004, a constant ratio of discards to landings by age was applied using data from 2004–2008 (Figure 19.13). Only data from 2004–2008 were used as a notably larger proportion of age 2 and age 3 sole are discarded in more recent years (2009–2016). Analysing data from 2004–2015 indicated that weights and lengths-at-age seem to be decreasing (Figure 19.14). More information is available in the WKNSEA 2017 report (ICES WKNSEA 2017).

Stock weights-at-age were calculated from the quarter 2 mean catch weights (Figure 19.15; Table 19.5). Note that in the current assessment, the Belgian yearly data for the TBB_DEF_70-99 métier were not taken into account for the calculation of the quarter 2 catch weights in InterCatch (similar to last year 2016). Belgium stated that it was not possible to provide a high quality age distribution for TBB_DEF_70-99 for all quarters, because sampling in Division 27.7.d is limited in some quarters. For the years 2006–2007 and 2012–2015, weights from this Belgian stratum were available and included.

19.2.4 Maturity and natural mortality

During the benchmark, the knife-edged maturity ogive with full maturation from age 3 onwards was investigated. Using data from the French IBTS survey and commercial data from Belgium, France and the UK (15 191 records), a new maturity ogive was constructed (see table below). More information on how this was achieved is provided in the WKNSEA 2017 report and the associated working document (ICES WKNSEA 2017).

Age	0	1	2	3	4	5	6	7	8	9	10	11(+)
Maturity	0.00	0.00	0.53	0.92	0.96	0.97	1.00	1.00	1.00	1.00	1.00	1.00

Natural mortality is assumed to be a fixed value (0.1) for all ages across all years. This biological parameter was not further investigated during the benchmark.

19.2.5 Tuning series

During the benchmark, the tuning series used for the calibration of the assessment of sole in Division 27.7.d were modified. More specifically, the Belgian commercial beam trawl tuning series was shortened (starting in 2004, instead of 1986) and focused only on the large fleetsegment (horsepower of > 221 kW). A French commercial otter trawl series was added (from 2002 onwards) and the UK commercial beam trawl series (from 1986 onwards) remained in the assessment as prior to the benchmark. However, all commercial tuning series were trimmed to age 3–8. The three survey data series (FRA YFS from 1987 funded by EDF (Noursom), UK YFS from 1987–2006 and the UK BTS from 1989) remained in the assessment as prior to the benchmark. The full series are presented in Tables 19.6–19.11.

19.3 Analyses of stock trends/Assessment

19.3.1 Review of last year's assessment

Last year, the TAC used in the report and advice sheet was 2769 tonnes. However, this was the preliminary value, which was later changed by the Commission to 2724 tonnes. This mistake was justified in the advice sheet. Besides the large differences in SSB en F as a result of the benchmark, no major issues arose during the review of the assessment.

19.3.2 Exploratory catch at age analysis

Catch numbers-at-age are shown in Figure 19.16. Catch proportions at age and standardized catch proportions at age are shown in Figures 19.17 and 19.18 respectively. Proportionally, more older fish are present in the catch in more recent years than before. This trend was observed last year as well. Moreover, no strong year classes are entering the population since 2009–2010 according to the catch information.

The time series of the standardized indices for ages 1 to 8 from the six tuning fleets (BE-CBT, UK(E&W)-CBT, FRA-COT, UK(E&W)-BTS, UK(E&W)-YFS and the FRA-YFS) are plotted in Figure 19.19. All tuning fleets appear to track the year classes reasonably well. It should be mentioned that the UK BTS gives a more optimistic estimate compared to the other tuning fleets for each age, e.g. age 1 compared to the very stable FRA YFS, age 3–6 compared to the commercial tuning fleets. Internal consistency plots for the 3 commercial fleets and the UK beam trawl survey are presented in Figures 19.20–19.23. The internal consistency of these three fleets is reasonable for the entire age-range. Although the UK BTS should provide valuable information to the assessment concerning the younger ages compared to commercial tuning fleets, it gives rather poor consistency for these ages (age 1–3). The catchability residuals for the proposed final XSA (see below) are shown in Figure 19.24. Some concern rises considering the UK(E&W)-BTS-Q3, that shows an age effect for Age 1 (which is more effectively estimated by the UK(E&W)-YFS

and the FRA-YFS) and a year effect in the most recent years. The latter was also observed in the UK(E&W)-CBT series.

19.3.3 Survivors estimates

In this year's assessment, the estimates for the year class 2016 (recruits (age 1) in 2017) were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of 41.1% and 47.1% respectively in the final year survivor estimates (Table 19.12). Shrinkage takes 11.7% of the weighting. However, 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. Nevertheless, this estimate was used in the forecast (age 2 in 2018).

The 2015 year class is also estimated by the UK beam trawl survey and the French component of the Young Fish Survey, with a weighting of 79.6% and 16.1% respectively (Table 19.12). Shrinkage takes 4.3% of the weighting.

The 2014 year class is estimated by 5 tuning fleets and the F shrinkage (Table 19.12). The latter getting lower weights from this year class onwards. Significant rescaling of the recruits happened in the current assessment, compared to last year (Figure 19.25). This was due to a lower estimate of this 2014 year class by the French YFS survey (8216 instead of 11 406 thousand survivors at age 1 in 2015) and by the UK BTS survey (30 726 instead of 47 964 thousand survivors). Additionally, three commercial tuning fleets help tuning this 2014 year class (age 3 in 2017) which all give a lower survivor estimate and get more weight, e.g. UK CBT 5494 thousand survivors with a 23.4% weighting.

19.3.4 Final assessment

The final settings used in this year's assessment (using the XSA model) are specified in the Stock Annex and detailed below:

	2018 ASSESSMENT		
Fleets	Years	Ages	α-β
BE_CBT_2004–2017 commercial	04–17	3–8	0–1
FR_COT commercial	02–17	3–8	0–1
UK(E&W)_CBT commercial	86–17	3–8	0–1
UK(E&W)_BTS survey	89–17	1–6	0.5–0.75
UK_YFS survey	87–06	1–1	0.5–0.75
FR_YFS survey	87–17	1–1	0.5–0.75
-First data year	1982		
-Last data year	2017		
-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 19.12. A summary of the XSA results is given in Table 19.13 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 19.25.

Retrospective patterns for the final run are shown in Figure 19.26. There appears to be no apparent retrospective bias. Recruitment estimates are uncertain.

19.3.5 Historical stock trends

Trends in catch, SSB, Fbar and recruitment are presented in Table 19.13 and Figure 19.25.

Catches have remained stable around 4000 tonnes up to 2003. Higher catches from 2003 onwards are a result of the benchmark data call (ICES WKNSEA 2017) and fluctuate around 5000 tonnes. In more recent years, catches have decreased to approximately 2500 tonnes (2428 tonnes in 2017).

For most of the time series, the *spawning-stock biomass* (SSB) has been fluctuating between B_{lim} (13 751 tonnes) and MSY $B_{trigger}$ (19 251 tonnes; = B_{pa}). From 2012–2014, SSB exceeded MSY $B_{trigger}$, probably as a result of the decreased F. The incoming weak year classes of 2012–2014 have reversed the increasing trend in SSB. Consequently, since 2015, SSB is below MSY $B_{trigger}$. In 2017, SSB decreased until below B_{lim}, but is estimated just above B_{lim} in 2018.

Fishing mortality (F) has been fluctuating between 0.25 and 0.5 over the entire time series, generally staying above F_{MSY} (0.256; = F_{pa}) and occasionally exceeding F_{lim} (0.359). In

1993, F dropped to F_{MSY}, but steadily increased in 1997 to the highest level in the time series (0.50), being far above F_{lim}. After 1997, F fluctuated around F_{lim} until 2009. In 2011, F dropped well below F_{lim}, almost reaching F_{MSY}. During the last 6 years, F fluctuated around F_{MSY}, with the highest value (0.31) reached in 2014 and the lowest value (0.24) in 2017.

Recruitment has been fluctuating around 20 million recruits with occasional strong year classes. However, in 2013 the lowest recruitment of the time series was reached. No strong recruitment has occurred since 2011.

Comparing the current stock trends with those prior to the benchmark show that the inclusion of the new commercial tuning series (BE_CBT_2004-2015 and FRA_COT) resulted in a significant increase of the SSB for the whole time series and a substantial decrease of the Fbar, especially in the most recent years. Additionally, the number of recruits are estimated to be higher over the whole time series. Those trends were further enhanced by trimming the age range of the commercial tuning series and excluding the BE_CBT_1986–2003 series (more information is provided in the WKNSEA report and associated working document; ICES WKNSEA 2017). When comparing the current assessment with the 2017 assessment, the 2015 recruitment was overestimated and is in the current assessment revised down because it has not been observed in the commercial catches in 2017.

19.4 Recruitment estimates and short-term forecast

19.4.1 Recruitment estimates

To estimate the number of recruits in 2018 (age 1; *i.e.* yearclass 2017), two methods were explored, as is defined in the Stock Annex.

The <u>first</u> method uses the long-term geometric mean excluding the last 3 data years, *i.e.* 1982–2014. This resulted in 28 806 thousand recruits in 2018.

The <u>second</u> method is an RCT3-analysis. This analysis compares the information on the younger yearclasses between the assessment and the available surveys using a regression. For this comparison, data from the French YFS age 0 and 1 and the UK BTS age 1 were used (Table 19.14 and 19.15 present the input for ages 1 and 2 respectively). This resulted in 24 875 thousand recruits in 2018. The RCT3 diagnostics (Table 19.16) showed that the VPA mean contributed most to this number (WAP weight = 92%).

The working group decided to move forward with the RCT3 assumption for recruits in 2018 (age 1). The main reason is that recruitment during the last 7 years is lower compared to the geometric mean (minus the last data years 2015–2017) of the time series according to the assessment output. The RCT3-analysis gives a more conservative estimation of the recruits.

To estimate age 2 numbers in 2018, the assessment estimate was used, being 22 048 thousand recruits by applying F as in 2017 and M (natural mortality) (XSA; this has been the chosen option since 2004).

The table below summarizes the recruitment estimates from the XSA (blue), RCT3-analysis (orange) and the long-term geometric mean (GM 1982–2013; green).

Predict age 1 in 2018			
Age	2018 (estimate using F2017 and M)	2018 GM (1982–2014)	2018 RCT3
0			
1		28806	24875
2	**22048**	25381	26762

An overview of the accepted estimates as input for the short-term forecast is provided in the table below.

Year class	Age in 2018	XSA survivors	GM 1982–2014	RCT3	Accepted estimate
2016	2	**22048**	25381	26762	XSA
2017	1	-	28806	**24875**	RCT3
2018	0	-	28806	-	GM 1982–2014
2019	0	-	28806	-	GM 1982–2014

19.4.2 Short-term forecast

For the short-term forecast, two different Fbar's for the intermediate year (2017) were tested: 1) F_{sq} scaled to the last data year (*i.e.* 2017) and 2) F_{sq} being the mean of the 3 last data years (2015–2017). The results of testing these scenarios are listed below:

1) F_{sq} scaled to the last data year:
   The Fbar of 0.241 resulted in a catch of 2788 tonnes in 2018.

SSB 2018	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
14294	0.241	0.052	0.22	24875

landings	discards	catch	TAC
2452	336	2788	3405

The output of the forecast, giving several options, is shown in the table below. The F_{MSY} was rescaled to F_{tar} (0.202), because the SSB in 2019 would be below MSY $B_{trigger}$.

basis	catch	discards	landings	f3–7	f_hc3–7	f_dis1–3	ssb2019	ssb2020	ssb_change	tac_change
Fmsy	3181	381	2800	0.256	0.23	0.07	15224	15988	5	-7
Ftar	**2571**	**305**	**2266**	**0.202**	**0.19**	**0.06**	**15224**	**16615**	**9**	**-24**
Fmsy_low	2484	295	2189	0.195	0.18	0.05	15224	16704	10	-27
Fmsy_low_ rescaled	**1998**	**236**	**1762**	**0.154**	**0.141**	**0.043**	**15224**	**17205**	**+13**	**-41**
Fmsy_high	4166	504	3662	0.348	0.32	0.1	15224	14975	-2	22
Fmsy_high_wo_ Btrig	3510	421	3089	0.286	0.26	0.08	15224	15649	3	3
Fpa	3181	381	2800	0.256	0.23	0.07	15224	15988	5	-7
Flim	4279	518	3761	0.359	0.33	0.1	15224	14860	-2	26
SSB>Bpa	16	2	14	0.001	0	0	15224	19251	26	-100
SSB>Blim	5360	656	4704	0.47	0.43	0.13	15224	13751	-10	57
TACsq	3405	408	2997	0.276	0.25	0.08	15224	15757	4	0

2) F_{sq} mean 2015–2017 (not scaled):

The Fbar of 0.258 resulted in a catch of 2972 tonnes in 2018.

SSB 2018	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
14294	0.258	0.056	0.237	24875

landings	discards	catch	TAC	%fished of TAC
2614	358	2972	3405	0.872834

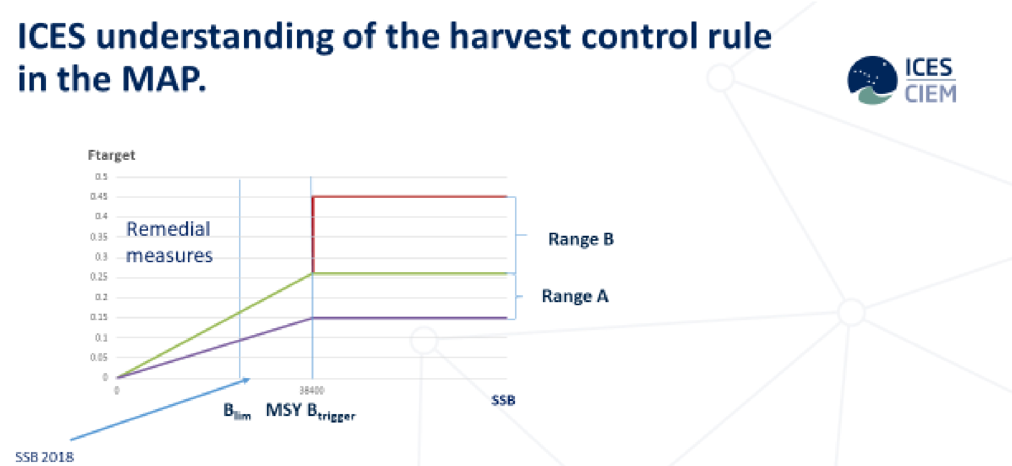
The output of the forecast, giving several options, is shown in the table below. The F_{MSY} was rescaled to F_{tar} (0.2), because the SSB in 2019 would be below MSY $B_{trigger}$.

basis	catch	discards	landings	f3–7	f_hc3–7	f_dis1–3	ssb2019	ssb2020	ssb_change	tac_change
Fmsy	3141	379	2762	0.256	0.23	0.07	15034	15827	5	-8
Ftar	2510	301	2209	0.2	0.18	0.06	15034	16476	10	-26
Fmsy_low	2453	294	2159	0.195	0.18	0.05	15034	16534	10	-28
Fmsy_high	4113	500	3613	0.348	0.32	0.1	15034	14827	-1	21
Fmsy_high_wo_ Btrig	3466	419	3047	0.286	0.26	0.08	15034	15492	3	2
Fpa	3141	379	2762	0.256	0.23	0.07	15034	15827	5	-8
Flim	4225	515	3710	0.359	0.33	0.1	15034	14712	-2	24
SSB>Blim	5162	635	4527	0.456	0.42	0.13	15034	13751	-9	52
TACsq	3405	411	2994	0.28	0.26	0.08	15034	15555	3	0

The working group decided to go forward with the first option (using the scaled F_{sq} scaled to the last data year) because the last three years (2015–2017), a downward trend in F is observed.

The TAC constraint scenario was not explored because the TAC was not restrictive in 2017 (11% undershoot when comparing the ICES catch estimates with the TAC) and because the French fishing industry (having the major part of the TAC) indicated they have trouble finding sole (see §19.1.3.2).

For target stocks involved in the administrative agreement (AA) with the EU, advice should be given according to F_{MSY} ranges being the $F_{MSY\ upper}$ and $F_{MSY\ lower}$. For sole in Division 7.d, F_{MSY} has been rescaled to F_{tar} (0.202) as the SSB in 2019 is below MSY $B_{trigger}$ (F_{MSY} x SSB(2019)/MSY $B_{trigger}$). Giving advice on $F_{MSY\ upper}$ would not be sustainable. Therefore, $F_{MSY\ upper}$ was set to the MSY approach (= F_{tar}; green line in figure below). In addition, the $F_{MSY\ lower}$ (0.195) was rescaled to the MSY approach using the same methodology: $F_{MSY\ lower}$ x SSB(2019)/MSY $B_{trigger}$ (purple line in figure below).



The results for different management options under this scenario are presented in Table 19.17 and 19.18 and the accompanying relative contributions of yearclasses to the catch in 2019 and to the SSB in 2020 are shown in Figures 19.27 and 19.28 respectively.

The ICES advice for 2019 will officially be formulated by the ADG North Sea group. The suggested advice at the end of the WGNSSK, assuming an Fsq scaled to the last data year, is the following: ICES advises that when the Administrative Agreement with the EU (AA) is applied, catches in 2019 that correspond to the F ranges are between 1998 and 2571 tonnes.

19.5 Biological reference points

The table below summarizes all known reference points for sole in Division 27.7.d and their technical basis. Reference points have been redefined as a result of the benchmark (more information is provided in the WKNSEA 2017 report; ICES WKNSEA 2017).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	19251 t	B_{pa}	ICES (2016, 2017)
	F_{MSY}	0.256	EQsim analysis based on the recruitment period 1983–2012.	ICES (2016, 2017)
Precautionary approach	B_{lim}	13751 t	Break-point of hockey stick stock–recruit relationship, based on the recruitment period 1983–2012.	ICES (2016, 2017)
	B_{pa}	19251 t	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2016, 2017)
	F_{lim}	0.359	EQsim analysis, based on the recruitment period 1983–2012.	ICES (2016, 2017)
	F_{pa}	0.256	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	ICES (2016, 2017)
Management plan	AA* MSY $B_{trigger}$	19251 t	MSY $B_{trigger}$	ICES (2017)
	AA* B_{lim}	13751 t	B_{lim}	ICES (2017)
	AA* F_{MSY}	0.256	F_{MSY}	ICES (2017)
	AA* target range F_{lower}	0.195	F_{lower}	ICES (2017)
	AA* F = $F_{MSY\ upper}$ (set to the MSY approach)	0.256	F_{MSY}	ICES (2017)

19.6 Quality of the assessment

This stock was benchmarked in 2017 (ICES WKNSEA 2017), which resulted in an upward revision in SSB and downward revision in F, especially in more recent years. Recruitment estimates are uncertain.

19.7 Management considerations

- Since 1 January 2016, sole fisheries in 27.7.d fall under the landing obligation (EU regulation nr. 2015/2438 (12/10/2015)). However, some fleets where the total landings were less than 5% of sole were excempted from the landing obligation (STECF-15-10). However, from 2018 onwards, all fleets active in Division 7.d fall under the sole landing obligation (STECF-17-13).
- The observed decreasing trend in weight- and length-at-age from 2004 onwards evokes concern. Although the advice for this stock (post-benchmark) appears to be positive, this decreasing trend does not fully support the healthy status of the stock. This year's assessment confirms that new strong year classes are not entering the population and that the older fraction of the population is being fished (Figure 19.18).
- SSB is close to B_{lim} entailing a risk of stock collapse. In the forecast, a reduction of F was needed below F_{MSY} in the application of the MSY approach as the SSB was smaller than MSY $B_{trigger}$ in 2019.
- The sole stock in Division 27.7.d is harvested in a mixed fishery with plaice in 27.7.d. Due to the minimum mesh size in the mixed beam and otter trawl fisheries (80 mm), 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.

19.8 References

Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligation - Part 5 (demersal species for NWW, SWW and North Sea) (STECF-15-10) 2015. Publications Office of the European Union, Luxembourg, EUR 27407 EN, JRC 96949, 62 pp.

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES. 2017. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 6–10 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:34. 673 pp.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Data and information requested by the Commission to support the preparation of proposals for fishing opportunities in 2018 (STECF-17-13). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67485-3, doi: 10.2760/628725, JRC108053

Table 19.1: Sole 27.7.d - Official landings (tonnes) by country over the period 1974–2017; ICES estimates (as reported in InterCatch) for both landings and discards (tonnes) used by the working group. TAC (tonnes) represents landings until 2015. From 2016 onwards TAC represents catch.

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
1974	159	383	309	3	854	884		
1975	132	464	244	1	841	882		
1976	203	599	404		1206	1305		
1977	225	737	315		1277	1335		
1978	241	782	366		1389	1589		
1979	311	1129	402		1842	2215		
1980	302	1075	159		1536	1923		
1981	464	1513	160		2137	2477		
1982	525	1828	317	4	2674	3190	183	
1983	502	1120	419		2041	3458	100	
1984	592	1309	505		2406	3575	131	
1985	568	2545	520		3633	3837	219	
1986	858	1528	551		2937	3932	139	
1987	1100	2086	655		3841	4791	179	3850
1988	667	2057	578		3302	3853	188	3850
1989	646	1610	689		2945	3805	171	3850
1990	996	1255	785		3036	3647	300	3850
1991	904	2054	826		3784	4351	317	3850
1992	891	2187	706	10	3794	4072	251	3500
1993	917	2322	610	13	3862	4299	247	3200
1994	940	2382	701	15	4038	4383	123	3800
1995	817	2248	669	9	3743	4420	249	3800
1996	899	2322	877		4098	4797	166	3500
1997	1306	1702	933		3941	4764	143	5230
1998	541	1703	803		3047	3363	120	5230
1999	880	2251	769		3900	4135	227	4700
2000	1021	2190	621		3832	3476	180	4100
2001	1313	2482	822		4617	4025	280	4600
2002	1643	2780	976		5399	4733	390	5200
2003	1657	3475	1114	1	6247	6977.23	473	5400
2004	1485	3070	1112		5667	6283	308	5900
2005	1221	2832	567		4620	5056	319	5700
2006	1547	2627	678	0.000	4852	5040	229	5720
2007	1530	2981	801	1.000	5313	5588	379	6220
2008	1368	2880	724	0.000	4972	5256	256	6593
2009	1475	3047	760	0.000	5282	5251	360	5274
2010	1294	2476	679	0.000	4449	4269	438	4219
2011	1222	2281	700	0.000	4203	4225	477	4852
2012	941	2475	627	0.250	4043	4131	533	5580
2013	952	2884	605	0.000	4441	4372	466	5900
2014	1496	2507	648	0.100	4651	4655	528	4838
2015	1048	1895	468	0.000	3411	3443	294	3483
2016	799	1337	391	0.044	2527	2538	344	3258*
2017	696	1178	344	0.154	2218	2228	200	2724*
2018								3405*

Table 19.2: Sole 27.7.d - Summary of the InterCatch data in 2017 (imported vs. raised data; sampled vs. estimated data)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	2064	93
Landings	Imported_Data	Estimated_Distribution	163.1	7
Discards	Imported_Data	Sampled_Distribution	133.7	67
Discards	Imported_Data	Estimated_Distribution	31.7	16
Discards	Raised_Discards	Estimated_Distribution	34.67	17

Table 19.3: Sole 27.7.d - Landings percentages by gear type for 2015–2017 (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB/SSC/SDN = otter trawls and seines)

Landings by gear	2015	2016	2017
GNS/GTR	46%	43%	43%
TBB	34%	40%	39%
OTB/SSC/SDN	15%	16%	17%
Other	5%	1%	1%

Table 19.4: Sole 27.7.d - Catch weights at age

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.078	NA	0.076	0.069	0.103	0.072	0.078	0.081	0.091	0.087	0.078	0.065	0.075
2	0.155	0.157	0.162	0.166	0.164	0.159	0.139	0.140	0.162	0.147	0.139	0.134	0.137
3	0.213	0.218	0.222	0.218	0.201	0.224	0.215	0.182	0.226	0.198	0.193	0.187	0.177
4	0.309	0.299	0.311	0.278	0.303	0.292	0.275	0.268	0.286	0.263	0.264	0.244	0.233
5	0.385	0.403	0.379	0.367	0.362	0.352	0.359	0.292	0.348	0.353	0.289	0.334	0.287
6	0.426	0.434	0.434	0.392	0.385	0.405	0.407	0.357	0.338	0.392	0.401	0.382	0.353
7	0.439	0.434	0.417	0.516	0.436	0.411	0.459	0.388	0.470	0.420	0.391	0.537	0.381
8	0.509	0.523	0.537	0.543	0.520	0.482	0.514	0.472	0.464	0.430	0.462	0.553	0.505
9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459	0.515	0.484
10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463	0.766	0.496
11	0.673	0.628	0.714	0.800	0.602	0.618	0.665	0.701	0.562	0.566	0.566	0.667	0.616

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.098	0.108	0.106	0.101	0.099	0.111	0.082	0.091	0.102	0.131	0.120	0.157	0.079
2	0.160	0.150	0.139	0.145	0.138	0.129	0.139	0.148	0.149	0.178	0.156	0.158	0.154
3	0.170	0.169	0.179	0.163	0.179	0.167	0.200	0.194	0.217	0.194	0.202	0.198	0.188
4	0.228	0.227	0.231	0.233	0.213	0.221	0.280	0.250	0.286	0.262	0.268	0.260	0.215
5	0.254	0.268	0.291	0.285	0.259	0.331	0.287	0.315	0.365	0.306	0.330	0.299	0.272
6	0.332	0.323	0.342	0.342	0.279	0.375	0.333	0.373	0.406	0.341	0.384	0.344	0.291
7	0.357	0.361	0.390	0.383	0.290	0.423	0.366	0.375	0.165	0.380	0.448	0.386	0.389
8	0.385	0.404	0.404	0.417	0.341	0.427	0.374	0.393	0.474	0.434	0.462	0.416	0.400
9	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.424	0.483	0.554	0.503	0.466
10	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.504	0.442	0.544	0.530	0.406
11	0.654	0.585	0.651	0.616	0.535	0.680	0.544	0.531	0.565	0.635	0.557	0.560	0.550

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.115	0.149	0.081	0.081	0.039	0.039	0.048	0.067	0.110	0.096
2	0.151	0.130	0.142	0.120	0.097	0.105	0.128	0.122	0.135	0.130
3	0.207	0.206	0.192	0.199	0.179	0.180	0.174	0.174	0.184	0.173
4	0.243	0.257	0.235	0.245	0.231	0.237	0.224	0.227	0.238	0.210
5	0.159	0.301	0.275	0.295	0.259	0.295	0.262	0.268	0.262	0.253
6	0.299	0.313	0.316	0.329	0.299	0.305	0.322	0.282	0.276	0.306
7	0.377	0.354	0.337	0.334	0.342	0.378	0.335	0.321	0.324	0.305
8	0.392	0.388	0.354	0.382	0.322	0.432	0.393	0.340	0.376	0.342
9	0.420	0.385	0.417	0.378	0.381	0.392	0.408	0.405	0.351	0.422
10	0.449	0.384	0.462	0.430	0.443	0.462	0.475	0.355	0.407	0.415
11	0.492	0.376	0.433	0.470	0.373	0.481	0.450	0.461	0.546	0.573

Table 19.5: Sole 27.7.d - Stock weights at age

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.059	0.070	0.067	0.065	0.070	0.072	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.114	0.135	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138	0.144	0.130	0.116	0.126	0.155
3	0.167	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225	0.199	0.189	0.161	0.129	0.176
4	0.217	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279	0.277	0.246	0.215	0.220	0.258
5	0.263	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.400	0.380	0.305	0.366	0.273	0.234	0.286
6	0.306	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384	0.454	0.377	0.316	0.333	0.308
7	0.347	0.406	0.403	0.436	0.403	0.417	0.477	0.480	0.476	0.410	0.405	0.545	0.368	0.357	0.366
8	0.384	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449	0.459	0.560	0.530	0.330	0.391
9	0.418	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474	0.430	0.559	0.461	0.614	0.438
10	0.450	0.522	0.529	0.611	0.512	0.536	0.636	0.536	0.507	0.451	0.528	0.813	0.470	0.382	0.466
11	0.530	0.601	0.627	0.780	0.576	0.616	0.750	0.714	0.577	0.620	0.527	0.566	0.612	0.629	0.630

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.050	0.050	0.050	0.050	0.050	0.050	0.118	0.092	0.102	0.101	0.071	0.107	0.130	0.081	0.081
2	0.139	0.140	0.128	0.122	0.127	0.136	0.155	0.110	0.132	0.128	0.119	0.146	0.111	0.124	0.081
3	0.165	0.158	0.180	0.148	0.157	0.179	0.212	0.171	0.186	0.169	0.157	0.190	0.180	0.175	0.186
4	0.220	0.233	0.205	0.208	0.216	0.209	0.280	0.241	0.249	0.268	0.181	0.239	0.244	0.212	0.232
5	0.264	0.299	0.253	0.402	0.226	0.258	0.345	0.271	0.292	0.297	0.240	0.266	0.290	0.251	0.267
6	0.317	0.374	0.277	0.440	0.223	0.254	0.432	0.318	0.318	0.363	0.251	0.329	0.321	0.263	0.309
7	0.376	0.363	0.298	0.395	0.231	0.301	0.298	0.303	0.487	0.393	0.302	0.370	0.416	0.292	0.339
8	0.404	0.357	0.324	0.554	0.253	0.234	0.531	0.371	0.498	0.444	0.341	0.406	0.412	0.312	0.329
9	0.563	0.450	0.336	0.443	0.256	0.326	0.332	0.475	0.584	0.507	0.388	0.445	0.372	0.289	0.458
10	0.494	0.372	0.323	0.420	0.301	0.404	0.529	0.312	0.586	0.585	0.377	0.516	0.439	0.405	0.505
11	0.654	0.577	0.512	0.682	0.420	0.417	0.507	0.602	0.525	0.609	0.535	0.530	0.447	0.362	0.441

age	2012	2013	2014	2015	2016	2017
1	0.044	0.044	0.052	0.068	0.127	0.094
2	0.057	0.082	0.117	0.070	0.120	0.122
3	0.151	0.160	0.160	0.164	0.156	0.169
4	0.223	0.239	0.210	0.213	0.222	0.208
5	0.240	0.301	0.259	0.254	0.259	0.236
6	0.275	0.315	0.310	0.279	0.259	0.287
7	0.381	0.393	0.288	0.301	0.303	0.288
8	0.342	0.472	0.360	0.341	0.348	0.335
9	0.381	0.433	0.336	0.460	0.295	0.381
10	0.519	0.456	0.425	0.384	0.384	0.416
11	0.345	0.526	0.487	0.472	0.502	0.566

Table 19.6: Sole 27.7.d - Tuning series 1: Belgian commercial beam trawl (2004–2017)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2004	35.06	1021.34	435.15	646.20	230.74	51.87	49.96
2005	30.34	575.70	591.07	157.21	114.76	85.07	44.09
2006	48.98	611.06	558.75	520.60	219.64	211.17	107.21
2007	57.07	918.74	477.17	195.70	379.63	151.44	187.80
2008	43.34	1116.78	1093.80	255.84	174.78	150.35	82.45
2009	32.63	714.84	771.79	522.56	130.14	75.39	79.50
2010	26.15	768.87	254.80	425.27	226.87	79.22	42.80
2011	26.46	1186.39	368.05	215.91	159.56	112.53	34.85
2012	21.24	1115.28	810.60	230.51	71.10	85.07	83.46
2013	25.90	193.67	724.32	676.31	197.93	96.57	114.82
2014	36.91	501.54	831.85	1059.80	630.70	165.61	80.06
2015	35.62	231.05	368.09	335.41	546.88	441.19	157.85
2016	35.05	257.28	167.10	272.41	219.97	259.49	245.13
2017	33.27	258.11	231.67	106.89	168.19	117.01	205.30

Table 19.7: Sole 27.7.d - Tuning series 2: UK (E&W) commercial beam trawl (1986–2017)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
1986	2.79	144.8	100.5	28	28.8	39.4	1.2
1987	5.64	106	143.5	99.2	18.6	14.6	37.6
1988	5.09	281.3	56.4	62.9	39.6	9	11.5
1989	5.65	78.1	144.2	18.2	31.7	23.1	5.1
1990	7.27	327.4	47.7	66.1	14.1	15.1	15.1
1991	7.67	139.2	195.2	8.4	30.7	5.1	7.4
1992	8.78	516.6	81.3	167.5	11.1	20.3	6.4
1993	6.4	222.5	218.9	34.6	52.7	5.2	10.7
1994	5.43	260.9	144.1	113.3	27.5	45.5	4.4
1995	6.89	106.9	220.4	107.6	94.6	18.3	37.5
1996	10.31	251.3	79.5	169	84.6	67.4	17.5
1997	10.25	331.1	158.5	42.4	125.2	50.8	48.7
1998	7.31	169.4	97.5	65.2	22.1	51.7	28.8
1999	5.86	300	105.6	43.6	31.8	12.3	26.3
2000	5.65	178.8	171.4	54.7	25.8	18.2	6.9
2001	7.64	268	101	111.9	44	19	19.6
2002	7.9	449	222.2	71.7	54.9	22.9	18.6
2003	6.69	220.8	149.5	64.8	27.2	32	15
2004	4.87	440.41	103.2	62.24	32.62	9.61	18.18
2005	6	178.27	376.44	69.41	72.25	35.36	17.41
2006	5.94	350.51	113.46	188.96	31.71	28.12	13.55
2007	5	303.67	114.86	34.62	102.76	23.99	23.55
2008	6.21	612.94	184.74	40.66	24.66	34.21	12.57
2009	6.21	113.51	272.97	98.85	15.33	12.47	26.55
2010	4.35	151.85	50.86	101.02	33.93	11.9	7.8
2011	3	121.43	59.61	16.54	37.19	10.8	2.5
2012	3.31	323.85	59.64	34.35	5.88	15.99	8.54
2013	2.88	109.6	200.66	36.49	21.35	6.73	9.04
2014	3.02	72.96	164.94	95.63	14.27	8.56	1.03
2015	4.19	54.11	28.85	55.41	41.61	5.8	3.73
2016	7.04	110.1	65.69	22.75	44.63	31.66	9.25
2017	1.55	22.40	10.60	6.66	2.83	6.69	5.93

Table 19.8: Sole 27.7.d - Tuning series 3: French commercial otter trawl (2002–2017)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2002	1	2.42	1.09	0.47	0.38	0.14	0.04
2003	1	2.04	0.73	0.59	0.18	0.23	0.08
2004	1	3.42	1	0.69	0.42	0.24	0.17
2005	1	1.13	1.24	0.54	0.41	0.16	0.15
2006	1	0.92	0.96	1.18	0.39	0.27	0.18
2007	1	3.15	1.28	0.67	0.86	0.23	0.11
2008	1	3.44	2.01	0.49	0.47	0.61	0.32
2009	1	2.23	2.54	0.58	0.3	0.18	0.22
2010	1	1.57	2.13	1.71	0.61	0.16	0.32
2011	1	3.98	1.18	0.94	1	0.44	0.1
2012	1	7.82	5.6	1.36	1.3	0.77	0.29
2013	1	5.03	4.04	1.69	0.76	0.73	0.73
2014	1	2.42	4.86	2.81	1.37	0.51	0.36
2015	1	1.02	1.54	2.03	1.41	0.74	0.33
2016	1	1.96	1.09	1.2	1.18	0.76	0.49
2017	1	1.73	1.23	0.76	0.85	0.74	0.65

Table 19.9: Sole 27.7.d - Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2017)

	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	4.3	0.28
1995	1	5.89	16.09	2.22	3.51	1.67	2.12
1996	1	5.3	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	8.6	5.11	0.45	1.04
2003	1	11.03	45.65	5.87	3.2	2.05	0.42
2004	1	12.67	11.81	10.97	2.08	2.02	1.34
2005	1	43.27	6.91	3.5	5.18	1.9	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	0.4	0.68
2009	1	51.25	19.16	7.1	5.81	5.02	0.44
2010	1	16.59	30.76	5.14	1.66	2.7	2.73
2011	1	13.66	28.6	14.7	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
2016	1	10.17	33.14	11.17	3.16	3.17	3.02
2017	1	27.85	15.18	16.26	2.67	2.13	1.52

Table 19.10: Sole 27.7.d - Tuning series 5: UK (E&W) young fish survey (1987–2006)

	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 19.11: Sole 27.7.d - Tuning series 6: French young fish survey (1987–2017) funded by EDF (noursom)

	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	0.052
2014	1	0.04
2015	1	0.09
2016	1	0.04
2017	1	0.05

Table 19.12: Sole 27.7.d - XSA diagnostics of the 2018 assessment

FLR XSA Diagnostics 2018-04-19 16:22:59
CPUE data from indices
Catch data for 36 years. 1982 to 2017. Ages 1 to 11.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE-CBT-new	3	8	2004	2017	0	1
2	UK(E&W)-CBT	3	8	1986	2017	0	1
3	FR-COTB	3	8	2002	2017	0	1
4	UK(E&W)-BTS-Q3	1	6	1989	2017	0.5	0.75
5	UK(E&W)-YFS	1	1	1987	2006	0.5	0.75
6	FR-YFS	1	1	1987	2017	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

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.046	0.059	0.020	0.005	0.015	0.022	0.060	0.021	0.033	0.026
2	0.181	0.255	0.220	0.200	0.144	0.194	0.179	0.209	0.106	0.064
3	0.372	0.421	0.328	0.298	0.292	0.271	0.367	0.294	0.264	0.171
4	0.470	0.452	0.396	0.310	0.326	0.319	0.478	0.306	0.280	0.270
5	0.409	0.210	0.311	0.322	0.241	0.220	0.303	0.365	0.271	0.310
6	0.394	0.358	0.286	0.233	0.337	0.179	0.219	0.267	0.259	0.268
7	0.226	0.383	0.206	0.131	0.129	0.271	0.192	0.204	0.163	0.185
8	0.319	0.188	0.242	0.161	0.136	0.120	0.283	0.180	0.150	0.154
9	0.116	0.365	0.156	0.154	0.122	0.082	0.109	0.113	0.233	0.112
10	0.176	0.162	0.131	0.062	0.065	0.089	0.063	0.088	0.134	0.180
11	0.176	0.162	0.131	0.062	0.065	0.089	0.063	0.088	0.134	0.180

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10	11
2008	29040	22134	32823	16881	4787	3794	4340	1708	1573	1046	1925
2009	48946	25083	16707	20468	9548	2877	2315	3131	1124	1267	2858
2010	58911	41763	17587	9918	11781	7005	1820	1428	2348	706	2927
2011	43207	52228	30340	11465	6042	7807	4760	1340	1014	1818	3088
2012	22355	38899	38704	20371	7611	3963	5598	3779	1032	787	4623
2013	13760	19925	30490	26162	13300	5409	2559	4454	2984	827	2236
2014	17932	12178	14856	21039	17214	9654	4093	1766	3574	2488	4990
2015	21097	15288	9208	9315	11808	11505	7014	3058	1205	2900	3217
2016	20580	18690	11224	6208	6206	7420	7972	5175	2310	973	1899
2017	25008	18018	15210	7798	4245	4282	5184	6127	4029	1655	976

Estimated population abundance at 1st Jan 2018

year \ age	1	2	3	4	5	6	7	8	9	10	11
2018	3259	22048	15293	11600	5388	2818	2964	3898	4754	3259	1251

Fleet: BE-CBT-new

Log catchability residuals.

year

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
3	0.110	0.339	0.096	-0.351	-0.061	0.475	0.674	0.537	0.449	-1.272	0.089	-0.205	-0.294	-0.587
4	0.025	-0.089	0.060	-0.088	0.340	0.075	-0.113	0.058	0.500	-0.065	0.010	-0.033	-0.413	-0.267
5	0.484	-0.422	-0.259	-0.708	0.091	0.306	0.159	0.142	0.159	0.469	0.344	-0.365	0.043	-0.443
6	0.244	-0.430	-0.054	-0.152	0.015	0.264	0.119	-0.379	-0.241	0.199	0.444	0.184	-0.276	0.062
7	-0.277	-0.120	0.187	-0.005	-0.235	0.060	0.489	-0.169	-0.393	0.386	0.064	0.547	-0.115	-0.419
8	-0.175	0.165	-0.044	0.333	0.140	-0.280	0.133	-0.059	-0.015	-0.067	0.221	0.338	0.254	-0.039

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-6.8620	-6.5745	-6.5458	-6.6254	-6.7378	-6.7378
S.E_Logq	0.3233	0.3233	0.3233	0.3233	0.3233	0.3233

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
3	0.630	0.113	0.464	0.131	0.051	-0.114	-0.081	-0.380	-0.015	-0.457	-0.448	0.227	-0.172	0.145	0.334
4	0.438	0.544	0.209	0.367	0.087	-0.049	-0.203	-0.164	-0.146	0.045	-0.541	-0.221	0.017	0.231	0.202
5	0.458	0.363	0.566	-0.164	0.133	-0.958	0.305	-0.057	-0.027	0.063	0.076	-0.215	0.045	0.201	0.362
6	0.501	-0.045	0.047	0.344	0.073	-0.086	-0.224	-0.098	0.431	0.076	0.035	0.386	0.325	0.119	0.281
7	0.289	-0.292	0.017	-0.122	-0.068	-0.403	-0.053	-0.105	0.334	0.356	-0.131	0.152	0.378	0.688	0.117
8	-0.302	-0.243	-0.061	-0.316	-0.579	-0.534	0.073	-0.122	0.203	0.096	0.259	-0.158	0.245	0.205	0.590

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
3	-0.068	0.131	-0.117	0.460	0.004	0.867	0.194	0.499	-0.489	0.063	-0.348	0.288	-0.427	-0.118
4	0.015	0.247	-0.333	0.089	0.610	0.105	0.451	0.034	0.224	-0.402	-0.057	-0.721	0.377	0.425
5	0.198	0.297	-0.109	-0.091	0.173	0.629	-0.214	-0.014	0.091	0.307	-0.459	-0.095	-0.463	0.234
6	0.386	-0.026	0.077	0.133	0.599	-0.009	0.847	-0.129	-0.344	-0.117	0.213	-1.003	0.040	-0.970
7	0.183	0.235	0.320	-0.020	0.591	0.249	0.556	0.196	-0.112	0.355	-0.368	-0.237	-0.113	-0.427
8	0.092	0.364	0.237	0.757	0.825	-0.035	0.661	0.170	0.250	0.192	-0.549	-0.467	-0.443	-1.661

year

age	2015	2016	2017
3	-0.300	-0.320	-0.747
4	-0.910	-0.213	-0.756
5	-0.234	-1.043	-0.361
6	-0.381	-0.395	-1.085
7	-1.676	-0.645	-0.245
8	-1.299	-1.450	-0.548

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-6.0791	-6.1034	-6.3372	-6.4964	-6.7063	-6.7063
S.E_Logq	0.4336	0.4336	0.4336	0.4336	0.4336	0.4336

Fleet: FR-COTB

Log catchability residuals.

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
3	-0.248	-0.124	-0.038	-0.488	-0.517	0.012	-0.080	0.184	-0.261	0.110	0.539	0.326	0.358	-0.061	0.380
4	-0.364	-1.116	-0.325	-0.675	-0.247	0.203	-0.022	0.012	0.534	-0.241	0.749	0.169	0.644	0.231	0.279
5	-0.159	-0.403	-0.506	-0.387	-0.161	-0.045	-0.102	-0.716	0.203	0.277	0.378	0.027	0.316	0.396	0.470
6	-0.554	-0.662	-0.259	-0.403	-0.247	0.051	0.115	-0.074	-0.287	0.073	1.063	0.140	0.170	0.045	0.302
7	-0.454	-0.374	0.214	-0.674	-0.274	-0.141	0.336	-0.183	-0.143	-0.128	0.268	1.065	0.199	0.039	-0.082
8	-1.370	-0.755	0.008	0.204	-0.233	-0.755	0.667	-0.375	0.810	-0.328	-0.312	0.439	0.734	0.050	-0.095

year

age	2017
3	-0.093

4 0.167
5 0.412
6 0.528
7 0.332
8 0.020
Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
3 4 5 6 7 8
Mean_Logq -8.8563 -8.7427 -8.8416 -8.8744 -9.0474 -9.0474
S.E_Logq 0.4287 0.4287 0.4287 0.4287 0.4287 0.4287

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
1 -0.662 0.075 -0.006 -2.215 -1.920 -0.162 -0.167 -0.243 0.879 -0.699 1.320 0.129 -0.162 1.132
2 0.159 -0.596 0.074 -0.376 0.055 -0.945 -0.123 -0.159 -0.173 0.179 -0.327 0.458 0.189 -0.216
3 0.632 -0.505 -0.284 -0.015 0.042 0.053 -0.844 -0.286 -0.178 -0.445 0.200 0.161 0.373 -0.212
4 0.013 0.388 -0.296 -0.404 0.549 0.079 -0.212 -0.534 -0.303 -0.216 -0.215 0.330 -0.113 0.501
5 0.065 -0.145 0.143 -0.260 0.303 0.305 -0.249 -0.174 -0.994 -0.409 -0.193 0.395 0.285 -0.781
6 -0.592 0.131 -0.031 0.295 0.017 -0.633 0.033 -0.086 -0.479 -0.586 0.279 0.201 0.181 -0.114
year
age 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
1 0.316 0.628 1.151 -0.331 -1.079 -0.832 1.263 -0.074 0.032 -1.357 -1.756 1.566 1.373 0.496 1.304
2 0.498 -0.183 -0.496 0.596 0.067 -0.623 0.256 0.198 -0.111 -0.931 -0.317 0.773 0.831 1.006 0.235
3 -0.251 -0.103 -0.575 -0.169 0.372 -0.337 0.116 -0.317 0.170 -0.749 0.175 0.755 0.471 0.869 0.882
4 -0.334 -0.280 0.074 0.093 -0.322 0.374 0.169 -0.395 -0.594 -0.403 0.354 0.875 -0.066 0.645 0.242
5 0.261 0.043 0.290 0.040 -0.184 -0.878 0.838 0.071 -0.865 -0.613 0.072 0.320 0.614 0.847 0.853
6 -0.363 0.366 0.080 -0.445 0.131 -0.043 -0.224 0.667 0.483 -0.678 -0.033 0.304 -0.114 0.693 0.562
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 -8.0259 -7.2119 -7.5542 -7.9911 -8.1949 -8.2755
S.E_Logq 0.5786 0.5786 0.5786 0.5786 0.5786 0.5786

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
1 0.703 0.03 -0.507 -0.437 0.538 -0.359 0.299 0.439 0.863 -0.738 -0.482 -0.036 -0.143 0.062 -1.716 0.309
year
age 2003 2004 2005 2006
1 0.015 0.824 0.522 -0.186
Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
1
Mean_Logq -9.7608
S.E_Logq 0.6163

Fleet: FR-YFS

Log catchability residuals.
year
age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
1 -0.095 -0.185 0.188 0.489 0.449 -0.095 -1.309 1.28 0.705 0.11 -1.918 -0.268 0.605 0.17 1.626 -1.138
year
age 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
1 0.695 0.11 1.103 1.018 -0.63 -1.054 2.267 -1.267 0.197 0.952 -0.465 -0.969 -0.345 -1.124 -1.1
Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
1
Mean_Logq -11.9443
S.E_Logq 0.9689

Survivors
Age = 1 . Catchability constand w.r.t. time and dependant on age
Year class = 2016
Fleet = FR-YFS
1
Survivors 7341.000
Raw weights 1.005
Fleet = fshk
1
Survivors 18914.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
1
Survivors 81260.000
Raw weights 0.877

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"FR-YFS"	"7341"	"0.984"	"Inf"	"Inf"	"1"	"0.471"	"0.076"
[2,]	"fshk"	"18914"	"1.974"	"Inf"	"Inf"	"1"	"0.117"	"0.03"
[3,]	"UK(E&W)-BTS-Q3"	"81260"	"1.054"	"Inf"	"Inf"	"1"	"0.411"	"0.007"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"22048"	""	""	""	"0.026"

Age = 2 . Catchability constand w.r.t. time and dependant on age
Year class = 2015
Fleet = FR-YFS
1
Survivors 4972.000
Raw weights 0.937
Fleet = fshk
2
Survivors 5573.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
2 1
Survivors 19347.000 25120.000
Raw weights 3.825 0.817

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"FR-YFS"	"4972"	"0.984"	"Inf"	"Inf"	"1"	"0.161"	"0.185"
[2,]	"fshk"	"5573"	"1.937"	"Inf"	"Inf"	"1"	"0.043"	"0.167"
[3,]	"UK(E&W)-BTS-Q3"	"20257"	"0.448"	"0.099"	"0.221"	"2"	"0.796"	"0.049"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"15293"	""	""	""	"0.064"

Age = 3 . Catchability constand w.r.t. time and dependant on age
Year class = 2014
Fleet = BE-CBT-new
3
Survivors 6452.000
Raw weights 2.897
Fleet = FR-COTB
3
Survivors 10571.000
Raw weights 8.586
Fleet = FR-YFS
1
Survivors 8216.000
Raw weights 0.766

Fleet = fshk
3
Survivors 6221.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
3 2 1
Survivors 28032.000 31706.000 45789.000
Raw weights 3.961 3.091 0.668
Fleet = UK(E&W)-CBT
3
Survivors 5494.00
Raw weights 6.16

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"6452"	"0.539"	"Inf"	"Inf"	"1"	"0.11"	"0.289"
[2,]	"FR-COTB"	"10571"	"0.313"	"Inf"	"Inf"	"1"	"0.326"	"0.186"
[3,]	"FR-YFS"	"8216"	"0.984"	"Inf"	"Inf"	"1"	"0.029"	"0.234"
[4,]	"fshk"	"6221"	"1.836"	"Inf"	"Inf"	"1"	"0.009"	"0.298"
[5,]	"UK(E&W)-BTS-Q3"	"30726"	"0.322"	"0.096"	"0.298"	"3"	"0.293"	"0.068"
[6,]	"UK(E&W)-CBT"	"5494"	"0.37"	"Inf"	"Inf"	"1"	"0.234"	"0.332"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"11600"	""	""	""	"0.171"

Age = 4 . Catchability constand w.r.t. time and dependant on age
Year class = 2013
Fleet = BE-CBT-new
4 3
Survivors 4124.000 4016.000
Raw weights 8.484 2.015
Fleet = FR-COTB
4 3
Survivors 6368.000 7879.000
Raw weights 3.037 5.973
Fleet = FR-YFS
1
Survivors 2044.000
Raw weights 0.463
Fleet = fshk
4
Survivors 4082.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
4 3 2 1
Survivors 6865.000 12846.000 12374.00 25782.000
Raw weights 5.024 2.755 1.94 0.403
Fleet = UK(E&W)-CBT
4 3
Survivors 2529.00 3911.000
Raw weights 5.13 4.285

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"4103"	"0.264"	"0.01"	"0.038"	"2"	"0.264"	"0.341"
[2,]	"FR-COTB"	"7333"	"0.268"	"0.101"	"0.377"	"2"	"0.227"	"0.205"
[3,]	"FR-YFS"	"2044"	"0.984"	"Inf"	"Inf"	"1"	"0.012"	"0.597"
[4,]	"fshk"	"4082"	"1.748"	"Inf"	"Inf"	"1"	"0.006"	"0.343"
[5,]	"UK(E&W)-BTS-Q3"	"9608"	"0.253"	"0.208"	"0.822"	"4"	"0.255"	"0.16"
[6,]	"UK(E&W)-CBT"	"3084"	"0.269"	"0.217"	"0.807"	"2"	"0.237"	"0.432"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"5388"	""	""	""	"0.27"

Age = 5 . Catchability constand w.r.t. time and dependant on age
Year class = 2012
Fleet = BE-CBT-new
5 4 3
Survivors 1810.000 1864.000 2295.00
Raw weights 4.887 6.161 1.42
Fleet = FR-COTB
5 4 3
Survivors 4253.000 3726.000 2651.000
Raw weights 5.046 2.206 4.209
Fleet = FR-YFS
1
Survivors 1769.000
Raw weights 0.348
Fleet = fshk
5
Survivors 3155.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
5 4 3 2 1
Survivors 6615.000 5373.000 4513.000 6106.000 487.000
Raw weights 2.778 3.648 1.941 1.408 0.304
Fleet = UK(E&W)-CBT
5 4 3
Survivors 1965.000 2278.000 2088.000
Raw weights 4.974 3.725 3.019

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"1887"	"0.221"	"0.051"	"0.231"	"3"	"0.269"	"0.433"
[2,]	"FR-COTB"	"3486"	"0.225"	"0.151"	"0.671"	"3"	"0.247"	"0.257"
[3,]	"FR-YFS"	"1769"	"0.984"	"Inf"	"Inf"	"1"	"0.008"	"0.456"
[4,]	"fshk"	"3155"	"1.713"	"Inf"	"Inf"	"1"	"0.005"	"0.281"
[5,]	"UK(E&W)-BTS-Q3"	"5210"	"0.232"	"0.22"	"0.948"	"5"	"0.218"	"0.179"
[6,]	"UK(E&W)-CBT"	"2092"	"0.225"	"0.045"	"0.2"	"3"	"0.253"	"0.398"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"2818"	""	""	""	"0.31"

Age = 6 . Catchability constand w.r.t. time and dependant on age
Year class = 2011
Fleet = BE-CBT-new
6 5 4 3
Survivors 3153.000 3093.000 2866.000 3240.000
Raw weights 8.498 3.884 4.772 1.023
Fleet = FR-COTB
6 5 4 3
Survivors 5025.000 4744.000 3734.000 4240.000
Raw weights 4.007 4.011 1.708 3.032
Fleet = FR-YFS
1
Survivors 7674.000
Raw weights 0.249
Fleet = fshk
6
Survivors 3168.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 5197.000 6912.000 2773.000 6307.000 2157 763.000
Raw weights 4.952 2.208 2.825 1.398 1 0.217

Fleet = UK(E&W)-CBT
6 5 4 3
Survivors 1001.000 1044.000 1192.000 2633.000
Raw weights 3.925 3.954 2.885 2.175

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"3067"	"0.183"	"0.024"	"0.131"	"4"	"0.319"	"0.26"
[2,]	"FR-COTB"	"4555"	"0.208"	"0.058"	"0.279"	"4"	"0.224"	"0.182"
[3,]	"FR-YFS"	"7674"	"0.984"	"Inf"	"Inf"	"1"	"0.004"	"0.112"
[4,]	"fshk"	"3168"	"1.749"	"Inf"	"Inf"	"1"	"0.004"	"0.253"
[5,]	"UK(E&W)-BTS-Q3"	"4375"	"0.21"	"0.201"	"0.957"	"6"	"0.221"	"0.189"
[6,]	"UK(E&W)-CBT"	"1240"	"0.207"	"0.199"	"0.961"	"4"	"0.227"	"0.551"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"2964"	""	""	""	"0.268"

Age = 7 . Catchability constand w.r.t. time and dependant on age

Year class = 2010

Fleet = BE-CBT-new
7 6 5 4 3
Survivors 2564.00 2958.000 2706.000 3938.000 1093.000
Raw weights 8.08 7.128 2.967 3.071 0.724

Fleet = FR-COTB
7 6 5 4 3
Survivors 5433.000 5271.000 5794.000 7425.000 5402.000
Raw weights 4.712 3.361 3.064 1.099 2.147

Fleet = FR-YFS
1
Survivors 4745.000
Raw weights 0.187

Fleet = fshk
7
Survivors 3746.00
Raw weights 0.25

Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 7791.000 7205.000 9353.000 4641.00 1537.000 4025.000
Raw weights 4.154 1.687 1.818 0.99 0.744 0.164

Fleet = UK(E&W)-CBT
7 6 5 4 3
Survivors 3049.00 2626.000 3085.00 5959.000 2543.00
Raw weights 4.14 3.292 3.02 1.857 1.54

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"2793"	"0.168"	"0.111"	"0.661"	"5"	"0.365"	"0.25"
[2,]	"FR-COTB"	"5597"	"0.199"	"0.044"	"0.221"	"5"	"0.239"	"0.133"
[3,]	"FR-YFS"	"4745"	"0.984"	"Inf"	"Inf"	"1"	"0.003"	"0.155"
[4,]	"fshk"	"3746"	"1.823"	"Inf"	"Inf"	"1"	"0.004"	"0.192"
[5,]	"UK(E&W)-BTS-Q3"	"6570"	"0.217"	"0.209"	"0.963"	"6"	"0.159"	"0.114"
[6,]	"UK(E&W)-CBT"	"3163"	"0.201"	"0.13"	"0.647"	"5"	"0.23"	"0.224"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"3898"	""	""	""	"0.185"

Age = 8 . Catchability constand w.r.t. time and dependant on age

Year class = 2009

Fleet = BE-CBT-new
8 7 6 5 4 3
Survivors 4574.000 4237.000 5714.000 6708.000 4456.000 7446.000
Raw weights 9.528 7.083 6.197 2.744 3.329 0.769

Fleet = FR-COTB
8 7 6 5 4 3
Survivors 4852.000 4380.000 4974.000 6521.000 5628.000 8147.00

Raw weights 2.282 4.131 2.922 2.833 1.192 2.28
Fleet = FR-YFS
1
Survivors 1339.000
Raw weights 0.185
Fleet = fshk
8
Survivors 4149.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 4243.000 6548.00 6776.000 2248.000 4254.000 4415.000
Raw weights 3.611 1.56 1.971 1.052 0.747 0.162
Fleet = UK(E&W)-CBT
8 7 6 5 4 3
Survivors 2748.000 2494.000 3249.000 6005.000 6932.000 6342.000
Raw weights 2.329 3.629 2.862 2.793 2.013 1.636
Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BE-CBT-new" "4922" "0.147" "0.072" "0.49" "6" "0.423" "0.149"
[2,] "FR-COTB" "5460" "0.188" "0.096" "0.511" "6" "0.223" "0.135"
[3,] "FR-YFS" "1339" "0.984" "Inf" "Inf" "1" "0.003" "0.464"
[4,] "fshk" "4149" "1.852" "Inf" "Inf" "1" "0.004" "0.174"
[5,] "UK(E&W)-BTS-Q3" "4704" "0.21" "0.152" "0.724" "6" "0.13" "0.155"
[6,] "UK(E&W)-CBT" "3951" "0.189" "0.187" "0.989" "6" "0.218" "0.182"
Weighted prediction:
Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "4754" "" "" "" "0.154"
Age = 9 . Catchability constand w.r.t. time and dependant on age
Year class = 2008
Fleet = BE-CBT-new
8 7 6 5 4 3
Survivors 4200.000 5631.000 5081.000 5207.000 5374.000 5578.000
Raw weights 8.546 6.099 5.596 2.691 3.239 0.743
Fleet = FR-COTB
8 7 6 5 4 3
Survivors 2964.000 3388.000 3861.000 3347.000 6893.00 3638.000
Raw weights 2.047 3.557 2.638 2.778 1.16 2.204
Fleet = FR-YFS
1
Survivors 31461.000
Raw weights 0.169
Fleet = fshk
9
Survivors 2737.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 4417.000 3502.000 2177.000 3864.000 3972.000 11526.000
Raw weights 3.261 1.529 1.918 1.016 0.708 0.147
Fleet = UK(E&W)-CBT
8 7 6 5 4 3
Survivors 765.000 610.000 1235.000 2051.000 1584.000 2302.000
Raw weights 2.089 3.125 2.584 2.738 1.958 1.581
Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BE-CBT-new" "4954" "0.146" "0.053" "0.363" "6" "0.418" "0.075"
[2,] "FR-COTB" "3636" "0.185" "0.092" "0.497" "6" "0.223" "0.101"
[3,] "FR-YFS" "31461" "0.984" "Inf" "Inf" "1" "0.003" "0.012"
[4,] "fshk" "2737" "1.891" "Inf" "Inf" "1" "0.004" "0.132"
[5,] "UK(E&W)-BTS-Q3" "3589" "0.208" "0.139" "0.668" "6" "0.133" "0.102"
[6,] "UK(E&W)-CBT" "1205" "0.186" "0.222" "1.194" "6" "0.219" "0.278"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"3259"	""	""	""	"0.112"

Age = 10 . Catchability constand w.r.t. time and dependant on age

Year class = 2007

Fleet = BE-CBT-new

	8	7	6	5	4	3
Survivors	1754.000	1334.000	1527.000	1466.000	1325.000	2455.000
Raw weights	6.134	4.433	4.235	1.994	2.441	0.544

Fleet = FR-COTB

	8	7	6	5	4	3
Survivors	1315.000	1526.000	1439.000	1824.000	983.000	963.000
Raw weights	1.469	2.585	1.997	2.059	0.874	1.612

Fleet = FR-YFS

	1
Survivors	436.000
Raw weights	0.121

Fleet = fshk

	10
Survivors	1079.00
Raw weights	0.25

Fleet = UK(E&W)-BTS-Q3

	6	5	4	3	2	1
Survivors	1210.000	678.000	691.000	911.000	1616.0	544.000
Raw weights	2.468	1.133	1.445	0.744	0.5	0.105

Fleet = UK(E&W)-CBT

	8	7	6	5	4	3
Survivors	341.0	816.000	1302.000	1138.00	1182.000	1332.000
Raw weights	1.5	2.271	1.956	2.03	1.476	1.157

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"1533"	"0.145"	"0.061"	"0.421"	"6"	"0.416"	"0.149"
[2,]	"FR-COTB"	"1376"	"0.184"	"0.097"	"0.527"	"6"	"0.223"	"0.165"
[3,]	"FR-YFS"	"436"	"0.984"	"Inf"	"Inf"	"1"	"0.003"	"0.449"
[4,]	"fshk"	"1079"	"1.828"	"Inf"	"Inf"	"1"	"0.005"	"0.206"
[5,]	"UK(E&W)-BTS-Q3"	"940"	"0.209"	"0.136"	"0.651"	"6"	"0.135"	"0.233"
[6,]	"UK(E&W)-CBT"	"933"	"0.186"	"0.2"	"1.075"	"6"	"0.219"	"0.235"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"1251"	""	""	""	"0.18"

Table 19.13: Sole 27.7.d - XSA summary

Year	Recruitment	SSB	Landings	Discards	F
	Age 1				Ages 3–7
	thousands	tonnes	tonnes	tonnes	Year–1
1982	14896	10604	3190	183	0.29
1983	27632	13203	3458	100	0.31
1984	25182	13917	3575	131	0.37
1985	14325	16007	3837	219	0.25
1986	29846	16171	3932	139	0.28
1987	12629	16415	4791	179	0.45
1988	33646	16711	3853	188	0.34
1989	19256	19350	3805	171	0.48
1990	56154	17037	3647	300	0.32
1991	40338	16518	4351	317	0.39
1992	39816	19929	4072	251	0.29
1993	18336	19768	4299	247	0.25
1994	31952	16891	4383	123	0.29
1995	23940	17231	4420	249	0.33
1996	22027	17762	4797	166	0.40
1997	33502	18419	4764	143	0.50
1998	21471	13814	3363	120	0.38
1999	31570	15742	4135	227	0.42
2000	43070	14525	3476	180	0.32
2001	39262	14065	4025	280	0.31
2002	57284	14338	4733	390	0.29
2003	26212	21942	6977	473	0.46
2004	22607	16715	6283	308	0.43
2005	44980	17396	5056	319	0.34
2006	49523	16344	5040	229	0.32
2007	24849	14967	5588	379	0.43
2008	29040	18365	5256	256	0.37
2009	48946	17152	5251	360	0.36
2010	58911	15307	4269	438	0.31
2011	43207	18762	4225	477	0.26
2012	22355	19597	4131	533	0.27
2013	13760	22898	4372	466	0.25
2014	17932	21004	4655	528	0.31
2015	21097	16320	3443	294	0.29
2016	20580	13828	2538	344	0.25
2017	25008	13609	2228	200	0.24
2018	24875	14294			

Table 19.14: Sole 27.7.d - RCT3-input for Age 1

Sole	7.d	Age1		
3	36	2		
1981	14824	3.33	0.07	-11
1982	27535	1.04	0.02	-11
1983	25152	0.79	-11	-11
1984	14322	-11	-11	-11
1985	29797	-11	-11	-11
1986	12621	-11	0.07	-11
1987	33481	0.75	0.17	8.2
1988	19215	0.04	0.14	3.01
1989	56111	17.43	0.54	17.96
1990	40224	0.57	0.38	12.14
1991	39749	1.04	0.22	1.33
1992	18284	0.48	0.03	0.82
1993	31910	0.27	0.7	8.33
1994	24008	4.04	0.28	5.89
1995	22115	3.5	0.15	5.3
1996	33458	0.28	0.03	24.75
1997	21407	0.07	0.1	3.27
1998	31564	10.52	0.35	35.99
1999	43058	2.84	0.31	14.98
2000	39174	2.41	1.21	10.19
2001	57268	4.32	0.11	53.56
2002	26138	0.94	0.32	11.03
2003	22550	0.21	0.15	12.67
2004	44955	7.29	0.82	43.27
2005	49428	0.05	0.83	10.84
2006	24696	1.04	0.08	2.57
2007	28972	0.03	0.06	3.77
2008	48721	6.58	2.78	51.25
2009	59315	2.47	0.1	16.59
2010	44252	0.2	0.32	13.66
2011	21980	2.78	0.35	1.75
2012	13660	0.44	0.052	0.72
2013	17932	0.72	0.04	25.39
2014	-11	1.08	0.09	25.24
2015	-11	0.26	0.04	10.17
2016	-11	0.34	0.05	27.85
2017	-11	0.09	-11	-11
FRYF0				
FRYF1				
BTS1				

Table 19.15: Sole 27.7.d - RCT3-input for Age 2

Sole	7.d	Age2			
4	36	2			
1981	13081	3.33	0.07	-11	-11
1982	24914	1.04	0.02	-11	-11
1983	22706	0.79	-11	-11	-11
1984	12852	-11	-11	-11	-11
1985	26855	-11	-11	-11	-11
1986	11400	-11	0.07	-11	14.2
1987	30088	0.75	0.17	8.2	22.09
1988	17032	0.04	0.14	3.01	5.55
1989	48063	17.43	0.54	17.96	31.17
1990	35563	0.57	0.38	12.14	15.29
1991	35738	1.04	0.22	1.33	22.96
1992	16359	0.48	0.03	0.82	4.26
1993	28806	0.27	0.7	8.33	16.09
1994	19901	4.04	0.28	5.89	10.79
1995	19990	3.5	0.15	5.3	10.85
1996	30222	0.28	0.03	24.75	24.11
1997	19299	0.07	0.1	3.27	8.22
1998	28196	10.52	0.35	35.99	27.45
1999	38660	2.84	0.31	14.98	27.88
2000	35080	2.41	1.21	10.19	16.11
2001	50280	4.32	0.11	53.56	45.65
2002	23603	0.94	0.32	11.03	11.81
2003	19553	0.21	0.15	12.67	6.91
2004	40107	7.29	0.82	43.27	42.62
2005	44169	0.05	0.83	10.84	28.97
2006	21996	1.04	0.08	2.57	7.35
2007	25022	0.03	0.06	3.77	19.16
2008	41559	6.58	2.78	51.25	30.76
2009	52593	2.47	0.1	16.59	28.6
2010	39844	0.2	0.32	13.66	9.72
2011	19586	2.78	0.35	1.75	8.91
2012	12087	0.44	0.052	0.72	16.35
2013	15288	0.72	0.04	25.39	21.36
2014	-11	1.08	0.09	25.24	33.14
2015	-11	0.26	0.04	10.17	15.18
2016	-11	0.34	0.05	27.85	-11
2017	-11	0.09	-11	-11	-11
FRYF0					
FRYF1					
BTS1					
BTS2					

Table 19.16: Sole 27.7.d - Diagnostics of the RCT3 analysis for Age 1

RCT3 - age 1

yearclass:	2017								
index	**slope**	**intercept**	**se**	**rsquare**	**n**	**indices**	**prediction**	**se.pred**	**WAP.weights**
FRYF0	0.8569	10.4	1.3942	0.08064	30	-2.408	8.335	1.5134	**0.07587**
FRYF1	0.6597	11.43	0.6668	0.30598	30	NA	NA	NA	NA
BTS1	0.5195	9.25	0.4883	0.41294	27	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	33	NA	10.268	0.4336	**0.92413**
		WAP	logWAP	int.se					
yearclass:	2017	**24875**	10.12	0.4168					

Table 19.17: Sole 27.7.d - Output of the short-term forecast showing different management options under the scenario of scaling F for the intermediate year (2018) to the last data year (2017)

basis	**catch**	**land-ings**	**dis-cards**	**f3-7**	**f_hc3-7**	**f_dis1-3**	**ssb2019**	**ssb2020**	**ssb_change**	**tac_change**	**%ad-vice change**
Fmsy	3181	2800	381	0.256	0.23445	0.07057	15224	15988	5.018	-6.579	-17.719
Ftar	2571	2266	305	0.20244	0.1854	0.05581	15224	16615	9.137	-24.493	-33.497
Fmsy_low	2484	2189	295	0.195	0.17859	0.05375	15224	16704	9.721	-27.048	-35.748
Fmsy_low_re-scaled	1998	1762	236	0.15421	0.14123	0.04251	15224	17205	13.012	-41.322	-48.319
Fmsy_high	4166	3662	504	0.348	0.31871	0.09593	15224	14975	-1.636	22.349	7.760
Fmsy_high_wo_Btrig	3510	3089	421	0.286	0.26193	0.07884	15224	15649	2.792	3.084	-9.208
Fpa	3181	2800	381	0.256	0.23445	0.07057	15224	15988	5.018	-6.579	-17.719
Flim	4279	3761	518	0.359	0.32878	0.09896	15224	14860	-2.391	25.668	10.683
SSB>Bpa	16	14	2	0.00114	0.00104	0.00031	15224	19251	26.452	-99.530	-99.586
SSB>Blim	5360	4704	656	0.46987	0.43032	0.12953	15224	13751	-9.676	57.416	38.645
TACsq	3405	2997	408	0.27633	0.25307	0.07617	15224	15757	3.501	0.000	-11.924
15%_TAC_inc	3916	3444	472	0.32397	0.2967	0.08931	15224	15232	0.053	15.007	1.293
15%_TAC_dec	2894	2549	345	0.23052	0.21111	0.06355	15224	16282	6.950	-15.007	-25.142
Fsq*0	0	0	0	0	NA	NA	15224	19267	26.557	-100.000	-100.000
Fsq*0.25	809	714	95	0.06	0.05495	0.01654	15224	18432	21.072	-76.241	-79.074
Fsq*0.5	1578	1392	186	0.12	0.1099	0.03308	15224	17639	15.863	-53.656	-59.183
Fsq*0.9	2740	2413	327	0.217	0.19873	0.05982	15224	16441	7.994	-19.530	-29.126
Fsq*1	3013	2653	360	0.241	0.22071	0.06644	15224	16160	6.148	-11.512	-22.064
Fsq*1.1	3281	2888	393	0.265	0.24269	0.07305	15224	15885	4.342	-3.642	-15.132
Fsq*1.25	3672	3231	441	0.301	0.27566	0.08297	15224	15482	1.695	7.841	-5.018
Fsq*1.5	4299	3779	520	0.361	0.33061	0.09951	15224	14839	-2.529	26.256	11.200
Fsq*1.75	4895	4299	596	0.421	0.38556	0.11605	15224	14227	-6.549	43.759	26.617
Fsq*2	5463	4794	669	0.481	0.44051	0.13259	15224	13645	-10.372	60.441	41.309

Table 19.18: Sole 27.7.d - Output of the short-term forecast providing a list of F changing in 0.01 intervals, using a scaled F for the intermediate year (2018)

basis	catch	landings	discards	f3-7	f_hc3-7	f_dis1-3	ssb2019	ssb2020	ssb_change	tac_change%	advice change
F=0	0	0	0	0	NA	NA	15224	19267	26.55675	-100	-100.000
F=0.01	138	122	16	0.01	0.00916	0.00276	15224	19125	25.62401	-95.9471	-96.430
F=0.02	274	242	32	0.02	0.01832	0.00551	15224	18984	24.69785	-91.953	-92.913
F=0.03	410	362	48	0.03	0.02747	0.00827	15224	18844	23.77824	-87.9589	-89.395
F=0.04	544	480	64	0.04	0.03663	0.01103	15224	18705	22.86521	-84.0235	-85.929
F=0.05	677	598	79	0.05	0.04579	0.01378	15224	18568	21.96532	-80.1175	-82.488
F=0.06	809	714	95	0.06	0.05495	0.01654	15224	18432	21.07199	-76.2408	-79.074
F=0.07	940	830	110	0.07	0.06411	0.0193	15224	18297	20.18523	-72.3935	-75.685
F=0.08	1070	944	126	0.08	0.07327	0.02205	15224	18163	19.30504	-68.5756	-72.323
F=0.09	1198	1057	141	0.09	0.08242	0.02481	15224	18030	18.43142	-64.8164	-69.012
F=0.1	1326	1170	156	0.1	0.09158	0.02757	15224	17898	17.56437	-61.0573	-65.701
F=0.11	1452	1281	171	0.11	0.10074	0.03032	15224	17768	16.71046	-57.3568	-62.442
F=0.12	1578	1392	186	0.12	0.1099	0.03308	15224	17639	15.86311	-53.6564	-59.183
F=0.13	1702	1501	201	0.13	0.11906	0.03584	15224	17511	15.02233	-50.0147	-55.975
F=0.14	1825	1609	216	0.14	0.12822	0.03859	15224	17384	14.18812	-46.4023	-52.794
F=0.15	1947	1717	230	0.15	0.13737	0.04135	15224	17258	13.36048	-42.8194	-49.638
F=0.16	2068	1824	244	0.16	0.14653	0.04411	15224	17133	12.53941	-39.2658	-46.508
F=0.17	2189	1929	260	0.17	0.15569	0.04686	15224	17009	11.72491	-35.7122	-43.378
F=0.18	2308	2034	274	0.18	0.16485	0.04962	15224	16886	10.91697	-32.2173	-40.300
F=0.19	2426	2138	288	0.19	0.17401	0.05238	15224	16765	10.12218	-28.7518	-37.248
F=0.2	2543	2240	303	0.2	0.18317	0.05513	15224	16644	9.327378	-25.3157	-34.221
F=0.21	2659	2342	317	0.21	0.19232	0.05789	15224	16524	8.539149	-21.909	-31.221
F=0.22	2774	2444	330	0.22	0.20148	0.06065	15224	16406	7.764057	-18.5316	-28.246
F=0.23	2888	2544	344	0.23	0.21064	0.0634	15224	16288	6.988965	-15.1836	-25.297
F=0.24	3002	2643	359	0.24	0.2198	0.06616	15224	16172	6.22701	-11.8355	-22.349
F=0.25	3114	2742	372	0.25	0.22896	0.06892	15224	16056	5.465055	-8.54626	-19.452
F=0.26	3225	2839	386	0.26	0.23811	0.07167	15224	15942	4.716238	-5.28634	-16.580
F=0.27	3336	2936	400	0.27	0.24727	0.07443	15224	15828	3.96742	-2.02643	-13.709
F=0.28	3445	3032	413	0.28	0.25643	0.07719	15224	15716	3.231739	1.174743	-10.890
F=0.29	3554	3127	427	0.29	0.26559	0.07994	15224	15604	2.496059	4.375918	-8.070
F=0.3	3661	3221	440	0.3	0.27475	0.0827	15224	15493	1.766947	7.518355	-5.303
F=0.31	3768	3315	453	0.31	0.28391	0.08546	15224	15384	1.050972	10.66079	-2.535
F=0.32	3874	3407	467	0.32	0.29306	0.08821	15224	15275	0.334997	13.77386	0.207
F=0.33	3979	3499	480	0.33	0.30222	0.09097	15224	15167	-0.37441	16.85756	2.923
F=0.34	4083	3590	493	0.34	0.31138	0.09373	15224	15060	-1.07725	19.91189	5.613
F=0.35	4186	3680	506	0.35	0.32054	0.09648	15224	14954	-1.77352	22.93686	8.277
F=0.36	4289	3770	519	0.36	0.3297	0.09924	15224	14849	-2.46322	25.96182	10.942
F=0.37	4390	3859	531	0.37	0.33886	0.102	15224	14745	-3.14635	28.92805	13.554
F=0.38	4491	3947	544	0.38	0.34801	0.10475	15224	14641	-3.82948	31.89427	16.167
F=0.39	4591	4034	557	0.39	0.35717	0.10751	15224	14539	-4.49947	34.83113	18.753
F=0.4	4690	4120	570	0.4	0.36633	0.11027	15224	14437	-5.16947	37.73862	21.314
F=0.41	4788	4206	582	0.41	0.37549	0.11302	15224	14337	-5.82633	40.61674	23.849
F=0.42	4886	4291	595	0.42	0.38465	0.11578	15224	14237	-6.48318	43.49486	26.384
F=0.43	4982	4375	607	0.43	0.39381	0.11854	15224	14138	-7.13347	46.31424	28.867
F=0.44	5078	4459	619	0.44	0.40296	0.12129	15224	14039	-7.78376	49.13363	31.350
F=0.45	5173	4541	632	0.45	0.41212	0.12405	15224	13942	-8.42091	51.92364	33.808
F=0.46	5267	4623	644	0.46	0.42128	0.12681	15224	13846	-9.0515	54.68429	36.239
F=0.47	5361	4705	656	0.47	0.43044	0.12956	15224	13750	-9.68208	57.44493	38.670
F=0.48	5454	4786	668	0.48	0.4396	0.13232	15224	13655	-10.3061	60.17621	41.076
F=0.49	5546	4866	680	0.49	0.44875	0.13508	15224	13561	-10.9235	62.87812	43.456
F=0.5	5637	4945	692	0.5	0.45791	0.13783	15224	13467	-11.541	65.55066	45.810
F=0.51	5727	5023	704	0.51	0.46707	0.14059	15224	13375	-12.1453	68.19383	48.138
F=0.52	5817	5101	716	0.52	0.47623	0.14335	15224	13283	-12.7496	70.837	50.466
F=0.53	5906	5179	727	0.53	0.48539	0.1461	15224	13192	-13.3473	73.45081	52.768
F=0.54	5994	5255	739	0.54	0.49455	0.14886	15224	13102	-13.9385	76.03524	55.044

basis	catch	landings	discards	f3-7	f_hc3-7	f_dis1-3	ssb2019	ssb2020	ssb_change	tac_change	%advice change
F=0.55	6082	5331	751	0.55	0.5037	0.15162	15224	13012	-14.5297	78.61968	57.320
F=0.56	6169	5407	762	0.56	0.51286	0.15437	15224	12923	-15.1143	81.17474	59.571
F=0.57	6255	5482	773	0.57	0.52202	0.15713	15224	12835	-15.6923	83.70044	61.795
F=0.58	6340	5556	784	0.58	0.53118	0.15989	15224	12748	-16.2638	86.19677	63.994
F=0.59	6425	5629	796	0.59	0.54034	0.16264	15224	12661	-16.8353	88.6931	66.192
F=0.6	6509	5702	807	0.6	0.5495	0.1654	15224	12575	-17.4002	91.16006	68.365
F=0.61	6593	5774	819	0.61	0.55865	0.16816	15224	12490	-17.9585	93.62702	70.538
F=0.62	6675	5846	829	0.62	0.56781	0.17091	15224	12406	-18.5102	96.03524	72.659
F=0.63	6757	5917	840	0.63	0.57697	0.17367	15224	12322	-19.062	98.44347	74.780
F=0.64	6839	5987	852	0.64	0.58613	0.17642	15224	12239	-19.6072	100.8517	76.901
F=0.65	6920	6057	863	0.65	0.59529	0.17918	15224	12156	-20.1524	103.2305	78.996
F=0.66	7000	6126	874	0.66	0.60445	0.18194	15224	12075	-20.6844	105.58	81.066
F=0.67	7079	6195	884	0.67	0.6136	0.18469	15224	11994	-21.2165	107.9001	83.109
F=0.68	7158	6263	895	0.68	0.62276	0.18745	15224	11913	-21.7486	110.2203	85.153
F=0.69	7236	6331	905	0.69	0.63192	0.19021	15224	11834	-22.2675	112.511	87.170
F=0.7	7314	6398	916	0.7	0.64108	0.19296	15224	11755	-22.7864	114.8018	89.188
F=0.71	7391	6464	927	0.71	0.65024	0.19572	15224	11676	-23.3053	117.0631	91.180
F=0.72	7467	6530	937	0.72	0.65939	0.19848	15224	11598	-23.8177	119.2952	93.145
F=0.73	7543	6595	948	0.73	0.66855	0.20123	15224	11521	-24.3234	121.5272	95.111
F=0.74	7618	6660	958	0.74	0.67771	0.20399	15224	11445	-24.8226	123.7298	97.051
F=0.75	7693	6724	969	0.75	0.68687	0.20675	15224	11369	-25.3219	125.9325	98.991
F=0.76	7767	6788	979	0.76	0.69603	0.2095	15224	11294	-25.8145	128.1057	100.905
F=0.77	7840	6851	989	0.77	0.70519	0.21226	15224	11219	-26.3071	130.2496	102.794
F=0.78	7913	6914	999	0.78	0.71434	0.21502	15224	11145	-26.7932	132.3935	104.682
F=0.79	7985	6976	1009	0.79	0.7235	0.21777	15224	11072	-27.2727	134.5081	106.544
F=0.8	8057	7037	1020	0.8	0.73266	0.22053	15224	10999	-27.7522	136.6226	108.407
F=0.81	8128	7099	1029	0.81	0.74182	0.22329	15224	10927	-28.2252	138.7078	110.243
F=0.82	8198	7159	1039	0.82	0.75098	0.22604	15224	10855	-28.6981	140.7636	112.054
F=0.83	8268	7219	1049	0.83	0.76014	0.2288	15224	10784	-29.1645	142.8194	113.864
F=0.84	8337	7279	1058	0.84	0.76929	0.23156	15224	10713	-29.6308	144.8458	115.649
F=0.85	8406	7338	1068	0.85	0.77845	0.23431	15224	10643	-30.0906	146.8722	117.434
F=0.86	8475	7397	1078	0.86	0.78761	0.23707	15224	10574	-30.5439	148.8987	119.219
F=0.87	8543	7455	1088	0.87	0.79677	0.23983	15224	10505	-30.9971	150.8957	120.978
F=0.88	8610	7512	1098	0.88	0.80593	0.24258	15224	10437	-31.4438	152.8634	122.711
F=0.89	8677	7570	1107	0.89	0.81509	0.24534	15224	10369	-31.8904	154.8311	124.444
F=0.9	8743	7626	1117	0.9	0.82424	0.2481	15224	10302	-32.3305	156.7695	126.151
F=0.91	8808	7683	1125	0.91	0.8334	0.25085	15224	10236	-32.7641	158.6784	127.832
F=0.92	8874	7738	1136	0.92	0.84256	0.25361	15224	10170	-33.1976	160.6167	129.540
F=0.93	8938	7794	1144	0.93	0.85172	0.25637	15224	10104	-33.6311	162.4963	131.195
F=0.94	9003	7849	1154	0.94	0.86088	0.25912	15224	10039	-34.0581	164.4053	132.876
F=0.95	9066	7903	1163	0.95	0.87003	0.26188	15224	9975	-34.4785	166.2555	134.506
F=0.96	9129	7957	1172	0.96	0.87919	0.26464	15224	9911	-34.8988	168.1057	136.136
F=0.97	9192	8011	1181	0.97	0.88835	0.26739	15224	9847	-35.3192	169.9559	137.765
F=0.98	9254	8064	1190	0.98	0.89751	0.27015	15224	9784	-35.7331	171.7768	139.369
F=0.99	9316	8116	1200	0.99	0.90667	0.27291	15224	9722	-36.1403	173.5977	140.973
F=1	9377	8169	1208	1	0.91583	0.27566	15224	9660	-36.5476	175.3891	142.550

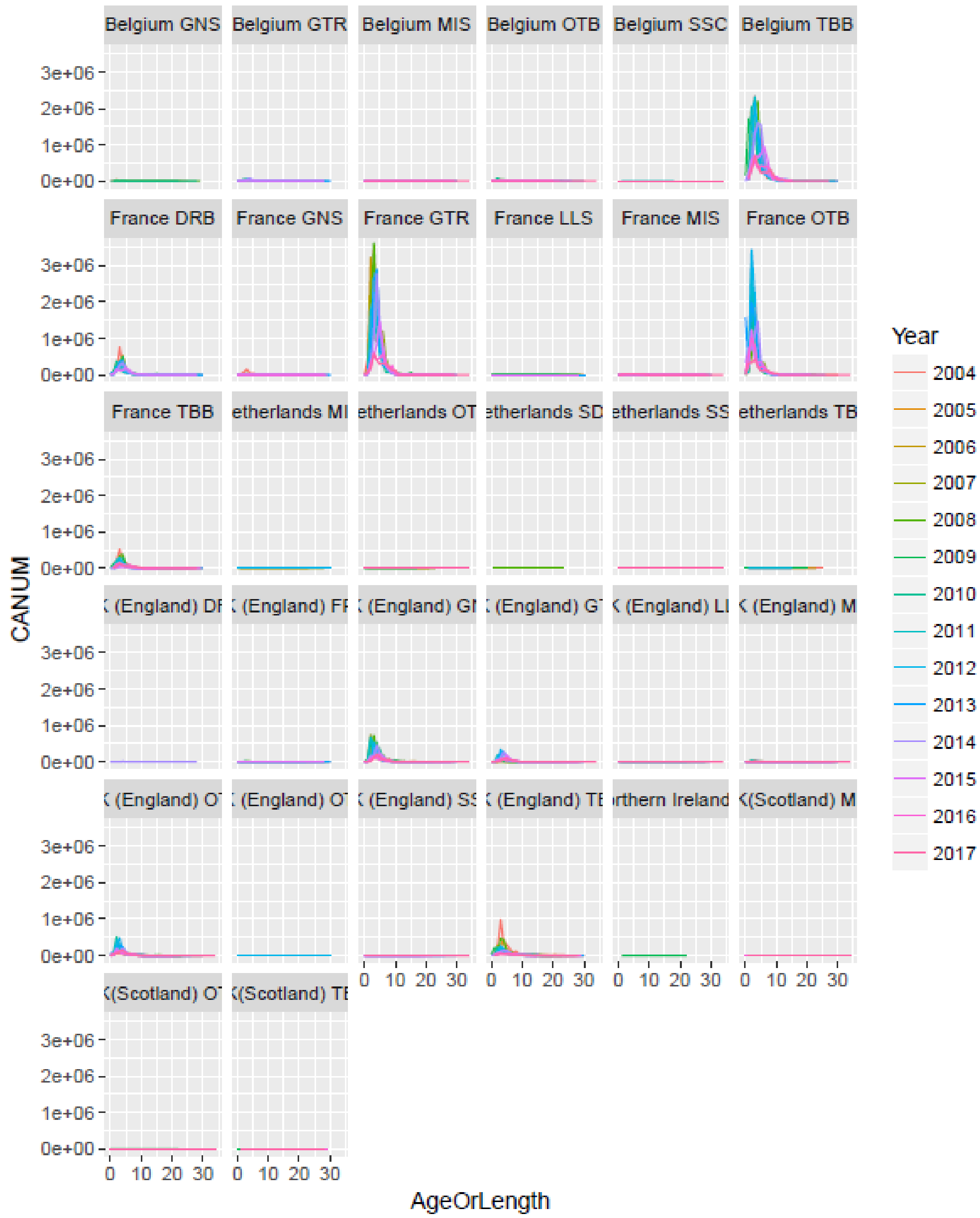


Figure 19.1: Sole 27.7.d - Catch numbers at age per gear and country from 2004–2017

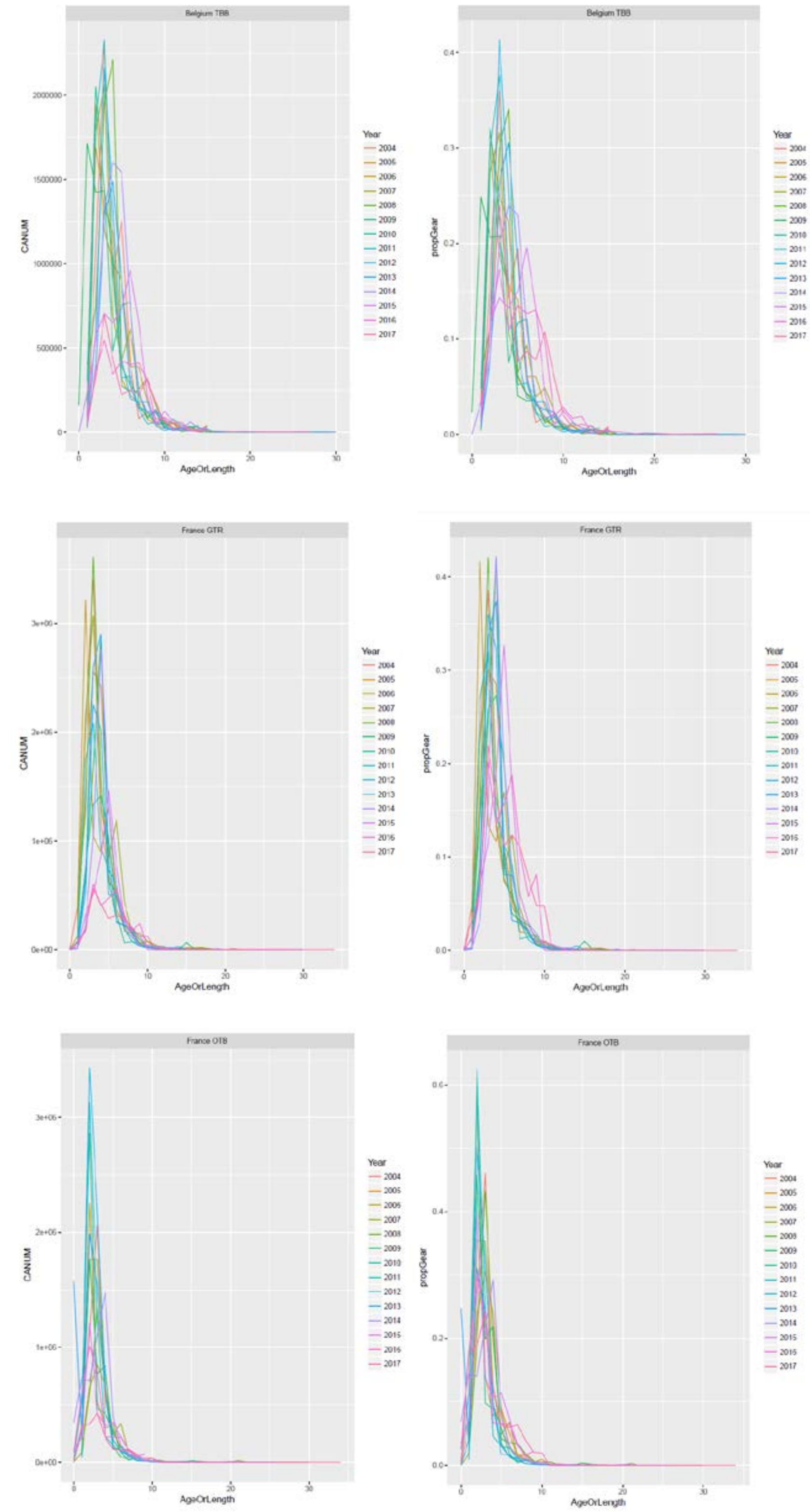


Figure 19.2: Sole 27.7.d - Zooming in on the important fleets (Belgian TBB, French GTR and OTB) showing catch numbers at age and proportionally by country, year and gear.

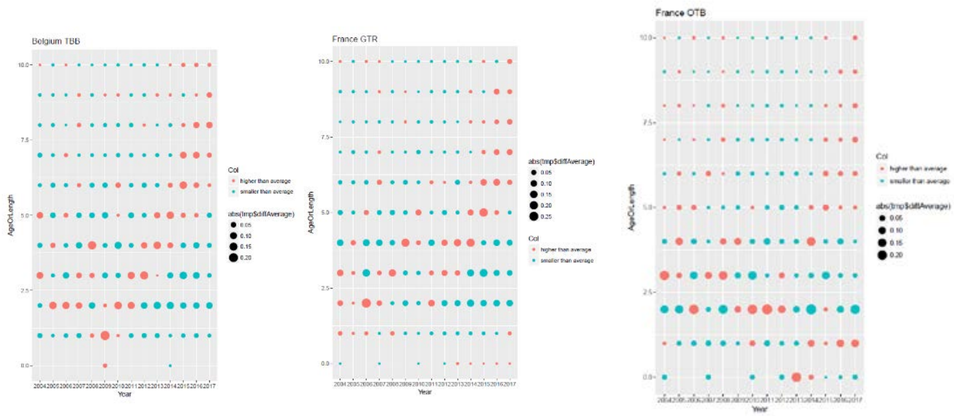


Figure 19.3: Sole 27.7.d - Showing the standardized catch by country and gear per year and age. Red dots represent more sole of that age present in the catch than the average over all years within that age. Blue dots represent the opposite: less than average. The size of the dots represents how much deviation there is from the average.

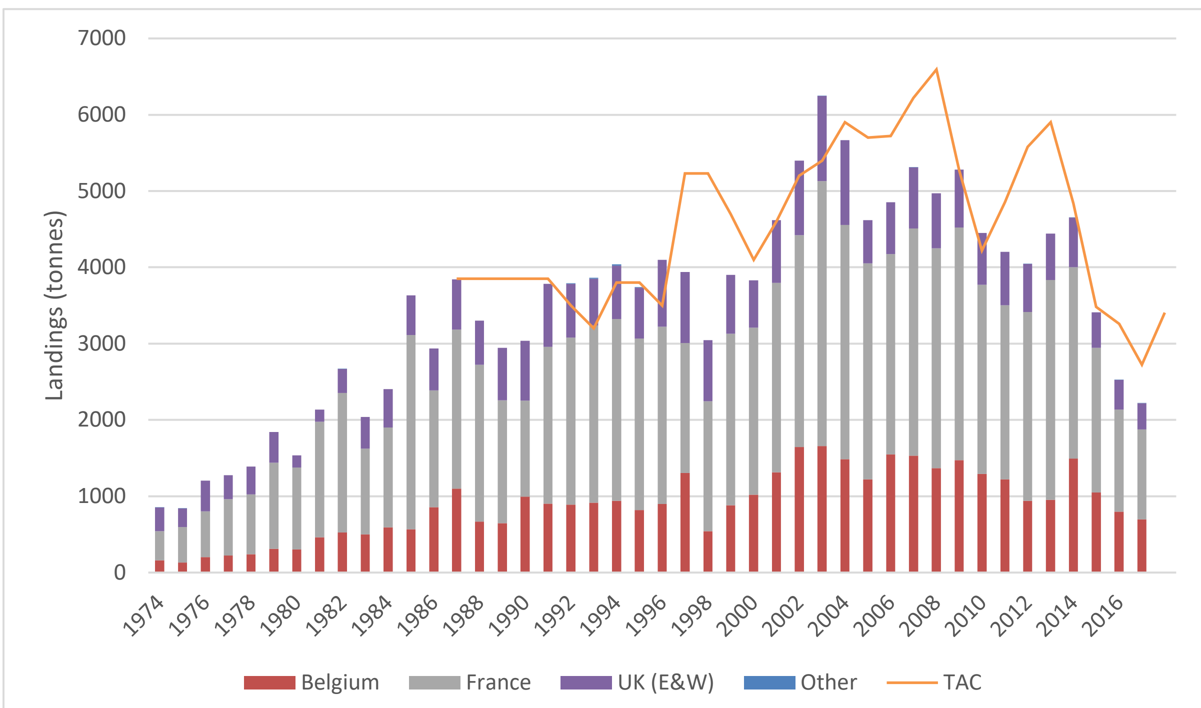


Figure 19.4: Sole 27.7.d - Official landings (tonnes) for sole in Division 27.7.d by country over the period 1974–2017, as officially reported (Rec 12) (stacked barplot; other represents landings from UK Scotland or The Netherlands); green line represents the official TAC (landings; Note that from 2016 onwards the TAC represents catch).

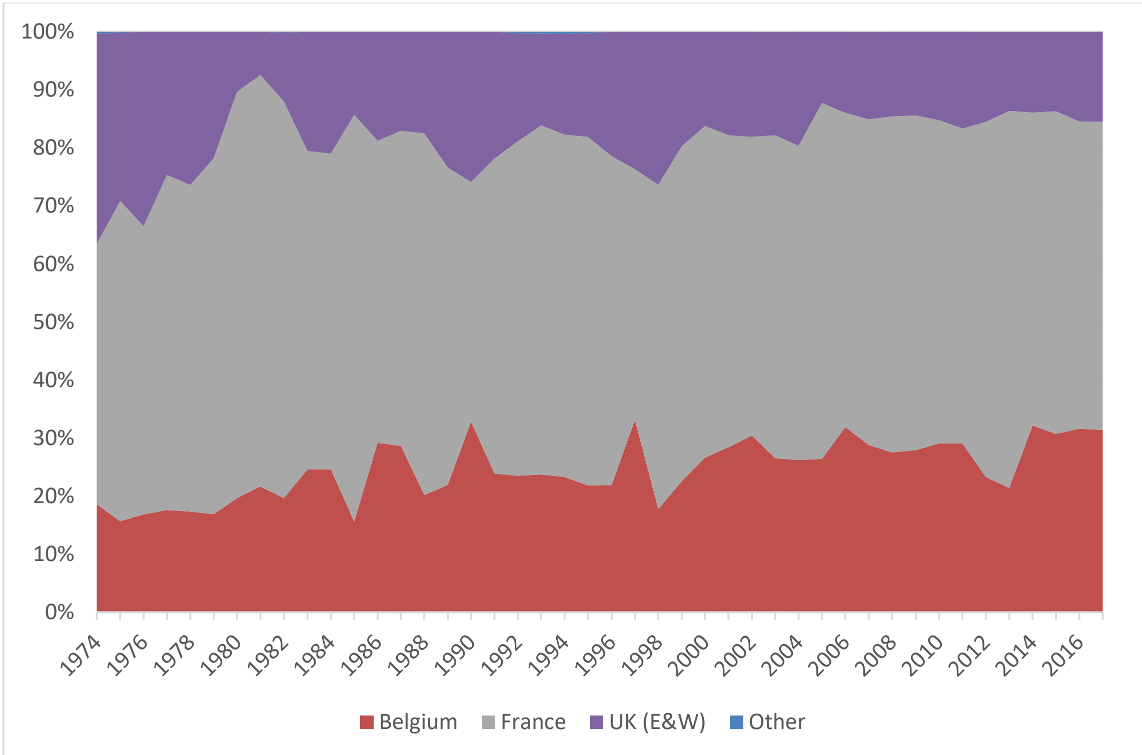


Figure 19.5: Sole 27.7.d - Relative contribution to the official landings of sole in Division 27.7.d for the main countries involved over the period 1974–2017.

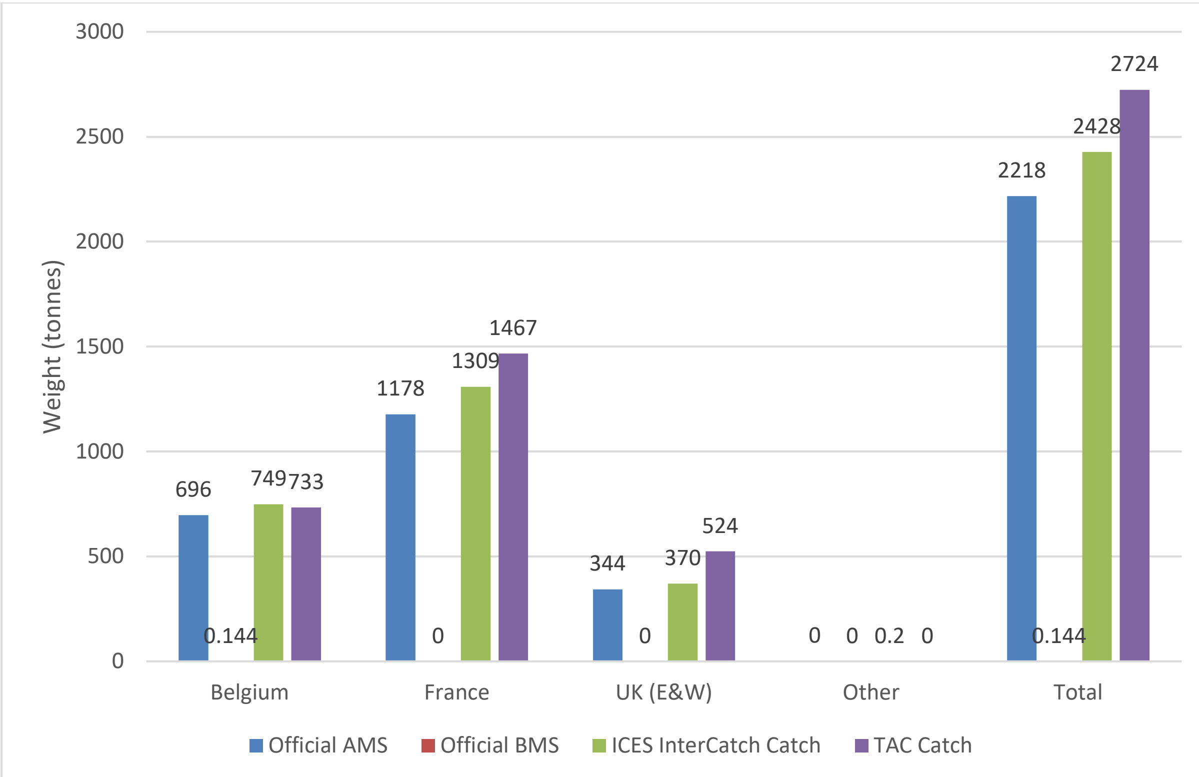


Figure 19.6: Sole 27.7.d - Uptake of the national quota and the total TAC of sole in 27.7.d in 2017; note that TAC represents catch; official AMS and BMS represent landings above and below minimum landings size respectively.

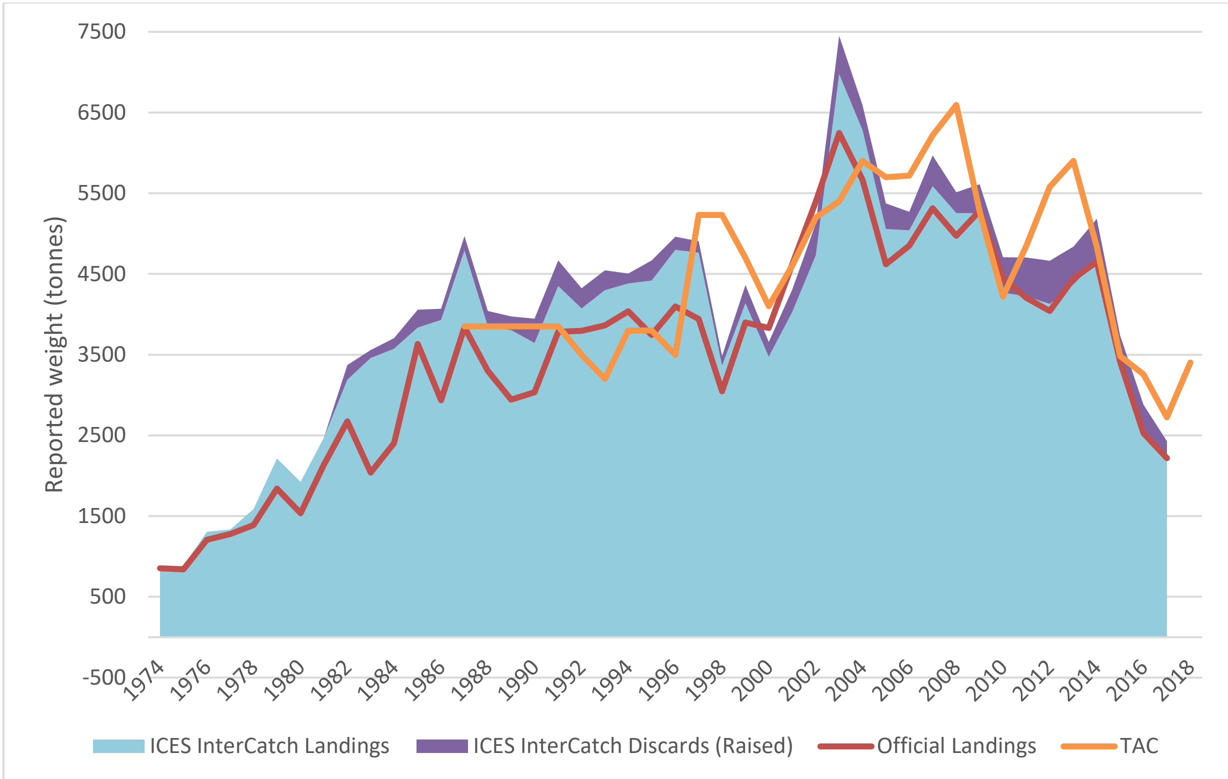


Figure 19.7: Sole 27.7.d - Historic overview (1974–2017) of the official landings, TAC and ICES estimates (InterCatch; including actual discards from 2004 onwards and extrapolated to years prior to 2004); Note that the TAC value represents catch from 2016 onwards.

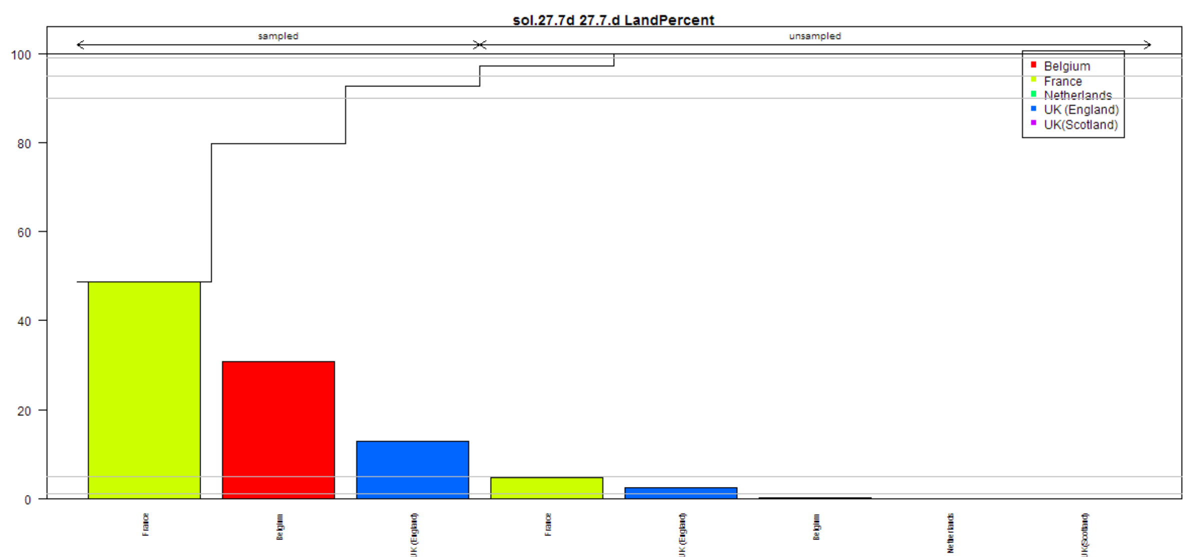


Figure 19.8: Sole 27.7.d - Overview of the proportion of 2017 landings of sole in Division 27.7.d for which samples (age) have been provided in InterCatch by country.

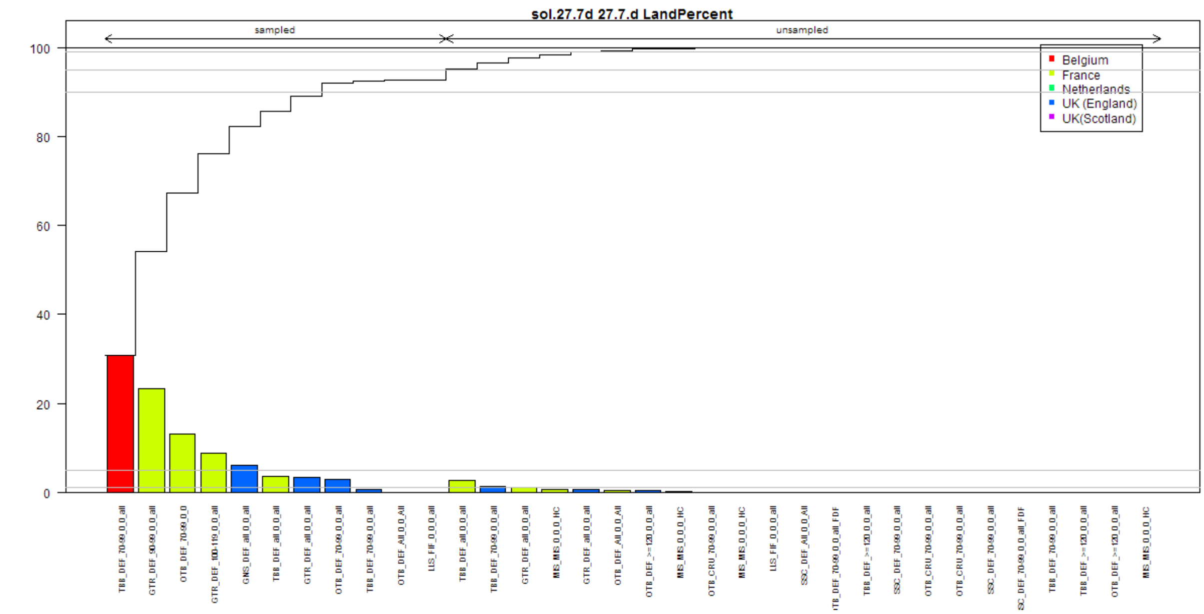


Figure 19.9: Sole 27.7.d - Overview of the proportion of 2017 landings of sole in Division 27.7.d for which samples have been provided in InterCatch by fleet and country.

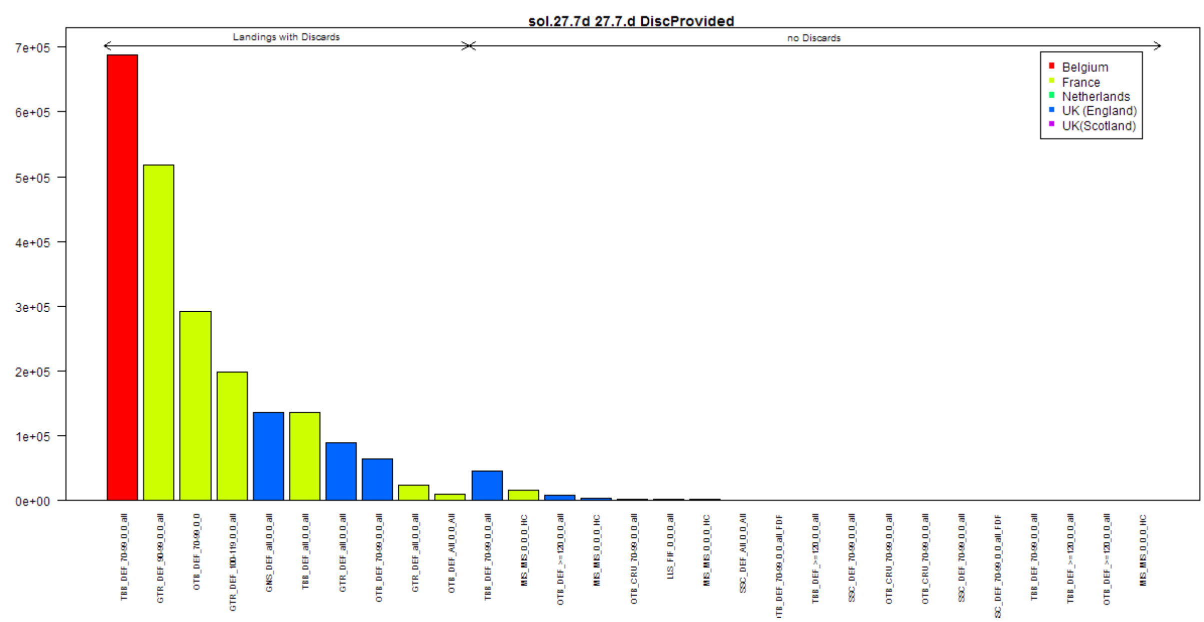


Figure 19.10: Sole 27.7.d - Overview of the 2017 landings with and without discards by fleet and country.

Figure 19.11: Sole 27.7.d - Discard weights-at-age (ages 1–5 are shown).

Figure 19.12: Sole 27.7.d - Landings weights-at-age (ages 1–8 are shown).

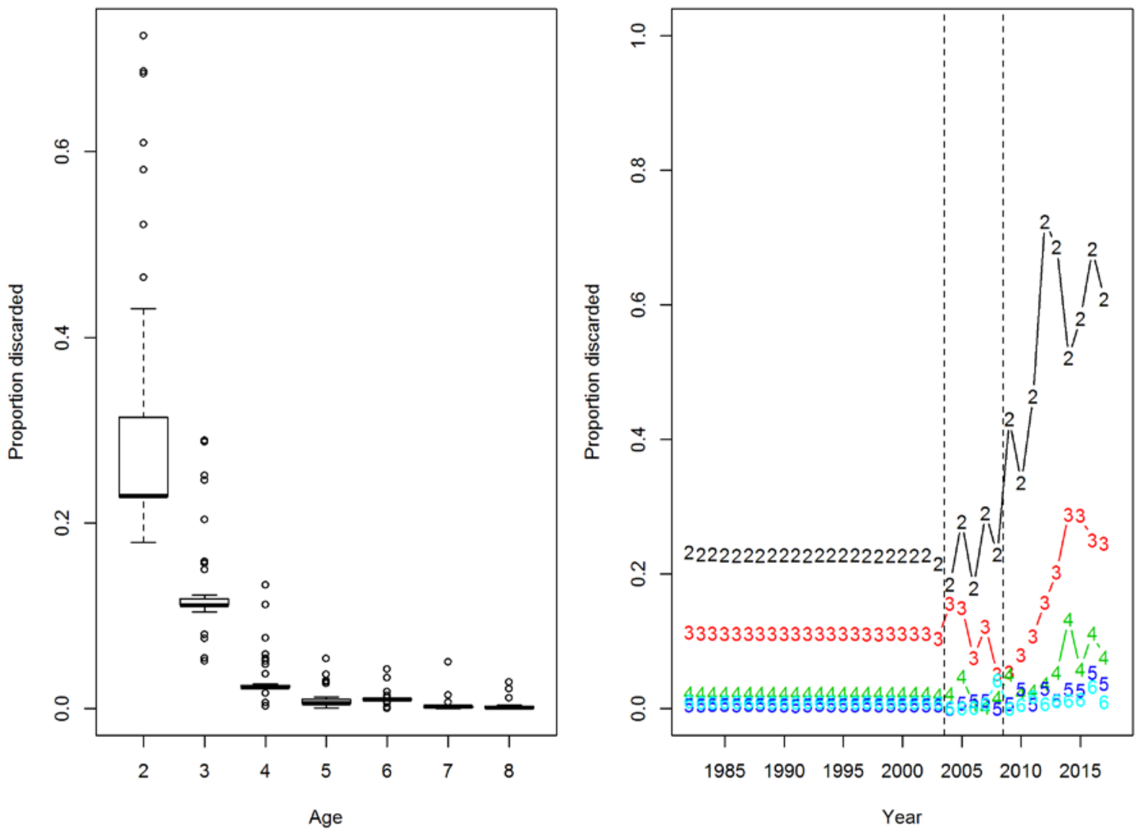


Figure 19.13: Sole 27.7.d - Proportion discarded (discard numbers/catch numbers) (data before 2004 are estimated based on an average ratio from 2004-2008 (indicated by dotted lines)) at age.

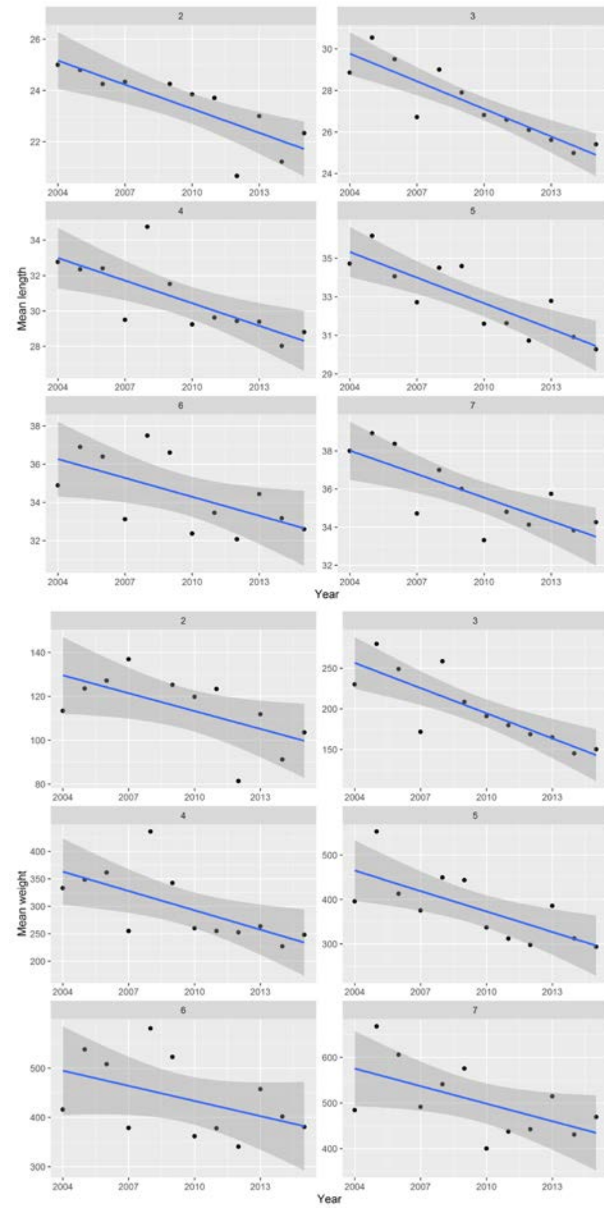


Figure 19.14: Sole 27.7.d - Left: Mean length-at-age from 2004–2015 for ages 2–7; Right: Mean weight-at-age from 2004–2015 for ages 2–7.

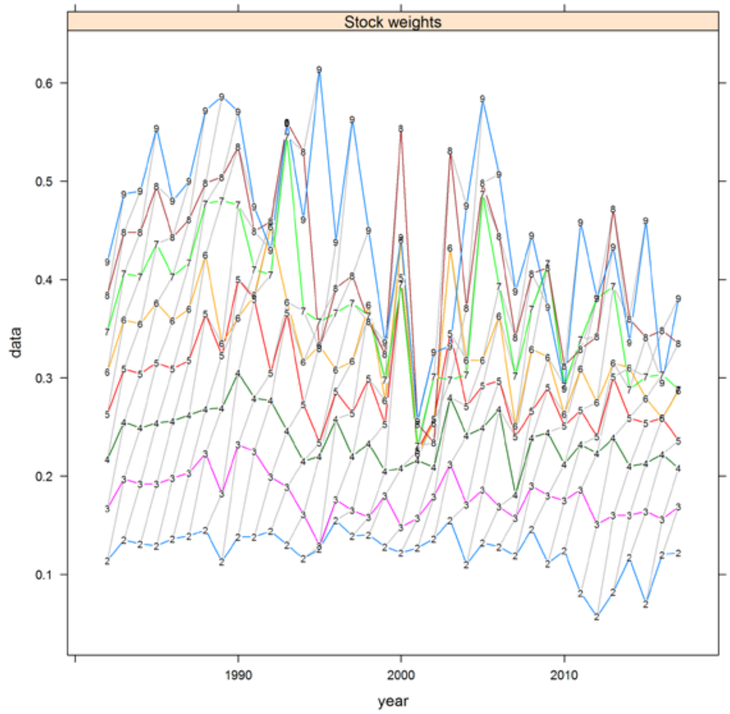


Figure 19.15: Sole 27.7.d - Stock weights (kg) at age (Q2) with indication of year classes (grey lines).

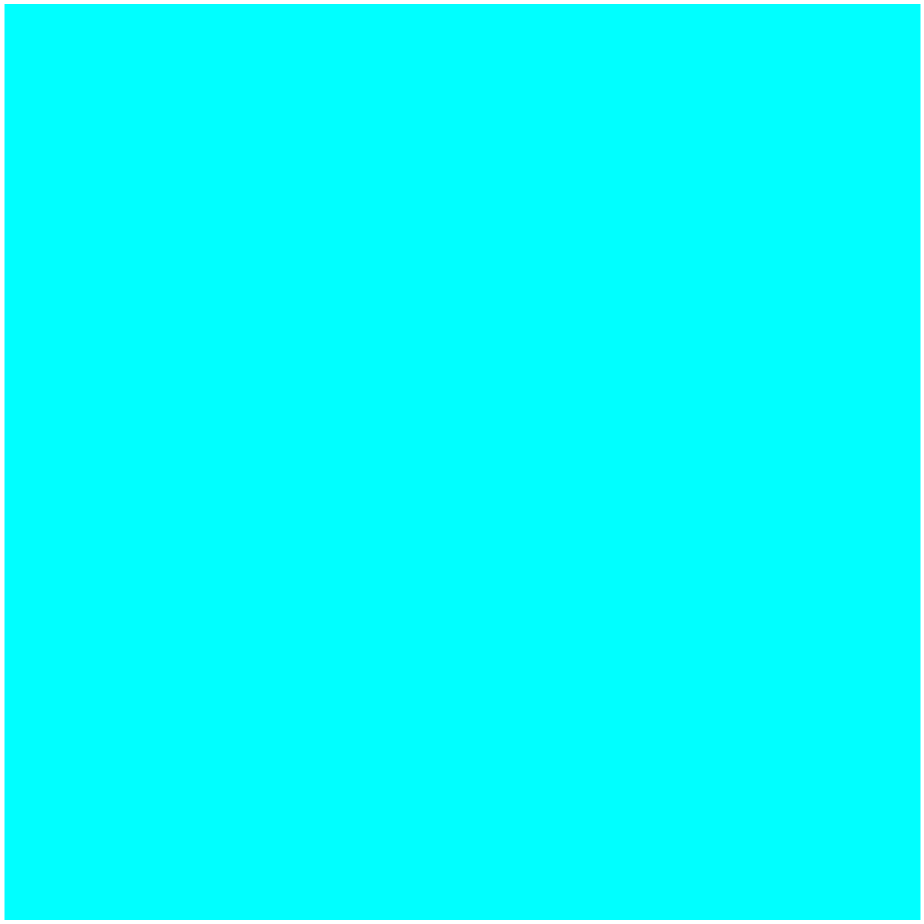


Figure 19.16: Sole 27.7.d - Catch numbers at age.

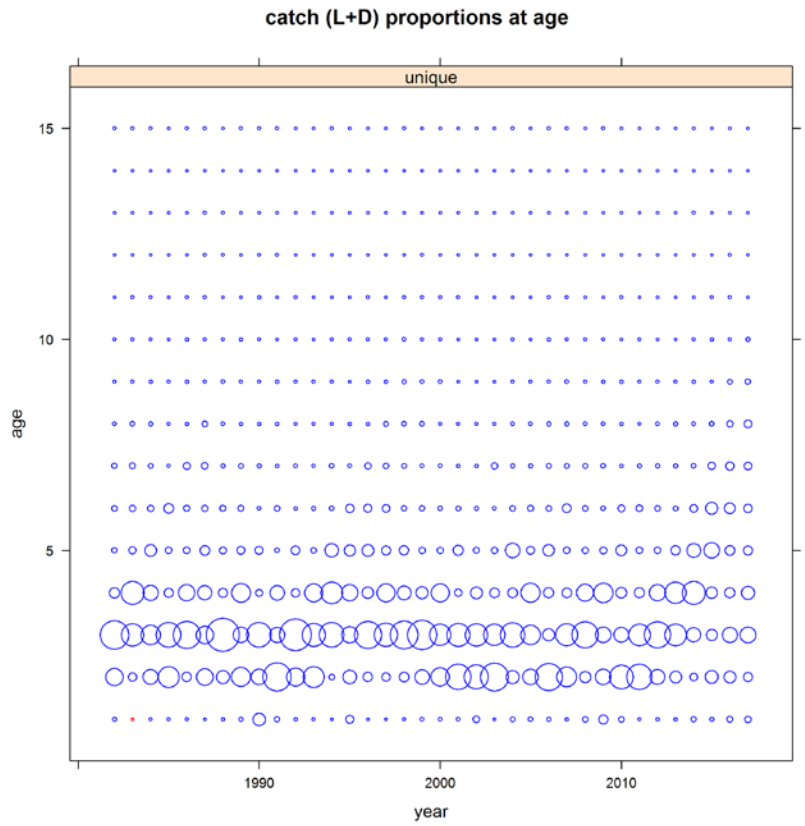


Figure 19.17: Sole 27.7.d - Catch proportion at age.

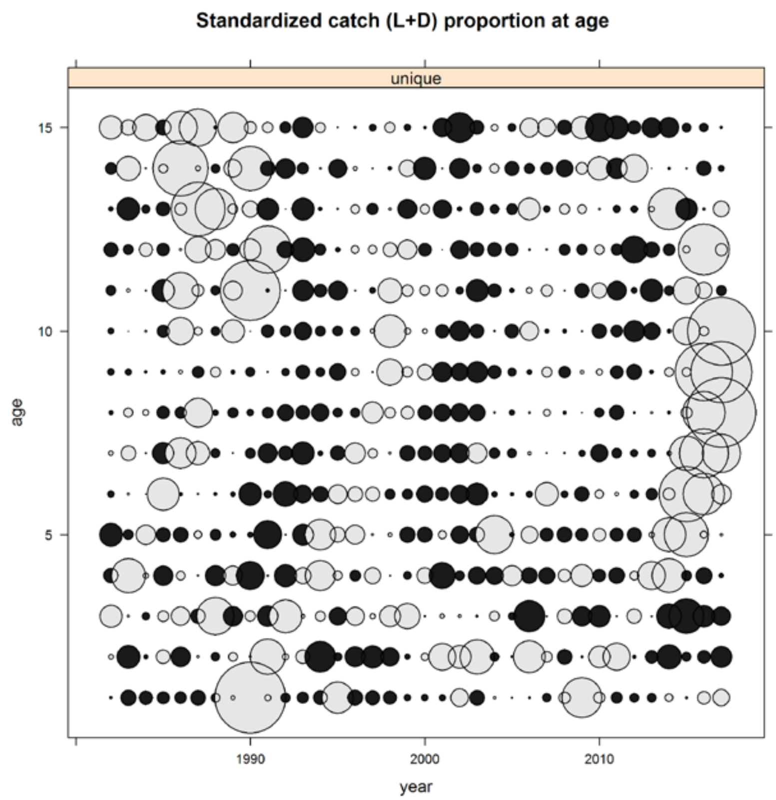


Figure 19.18: Sole 27.7.d - Standardised catch proportion at age.

Figure 19.19: Sole 27.7.d - Standardized tuning indices at age.

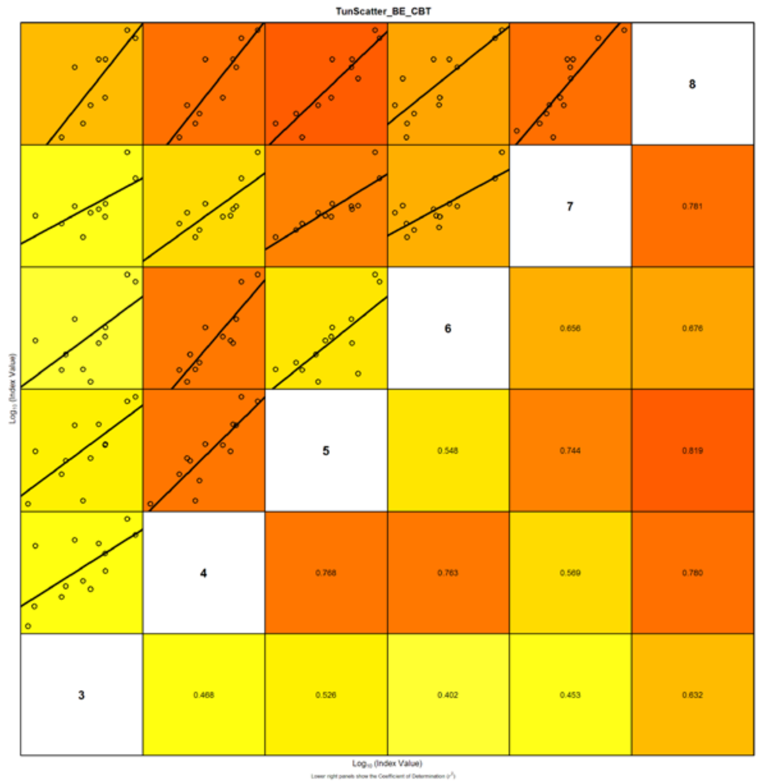


Figure 19.20: Sole 27.7.d - Internal consistency plot of the BEL-CBT tuning series.

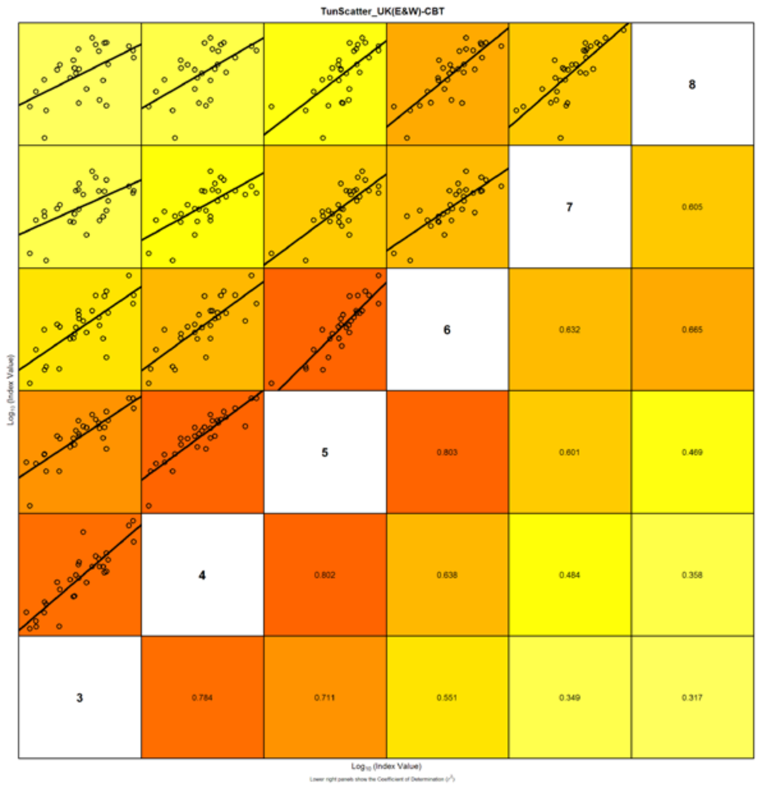


Figure 19.21: Sole 27.7.d - Internal consistency plot of the UK-CBT tuning series.

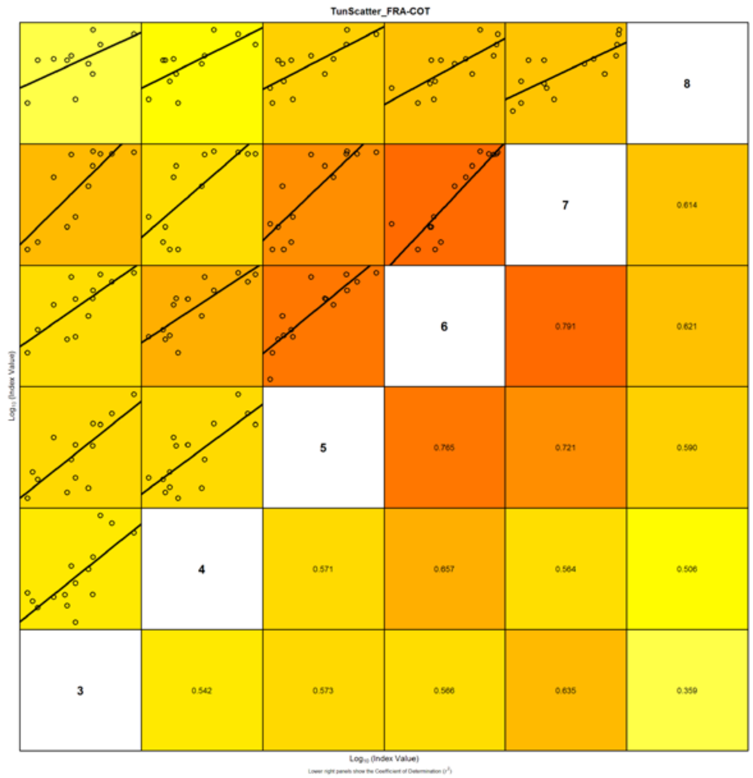


Figure 19.22: Sole 27.7.d - Internal consistency plot of the FRA-COT tuning series.

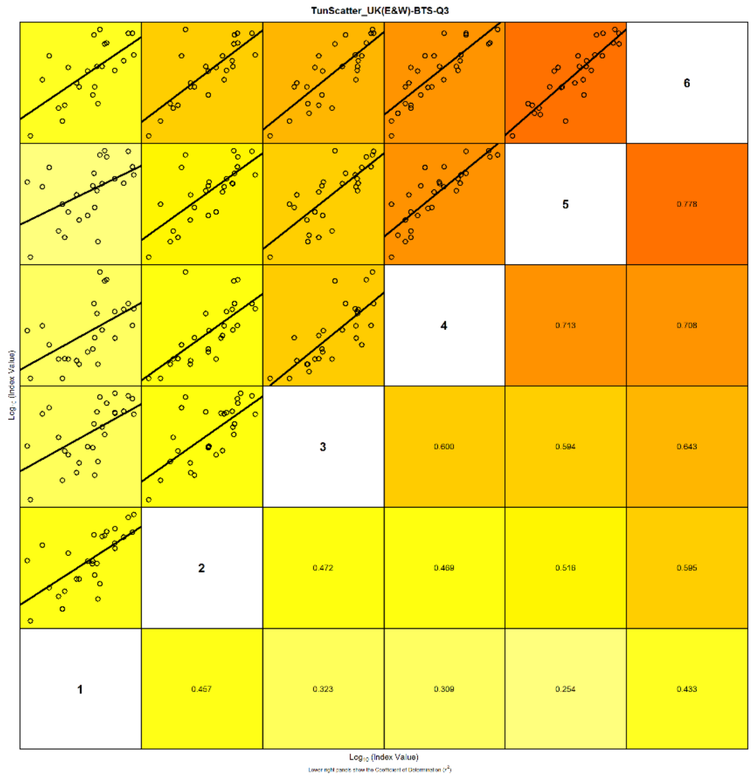


Figure 19.23: Sole 27.7.d - Internal consistency plot of the UK-BTS tuning series.

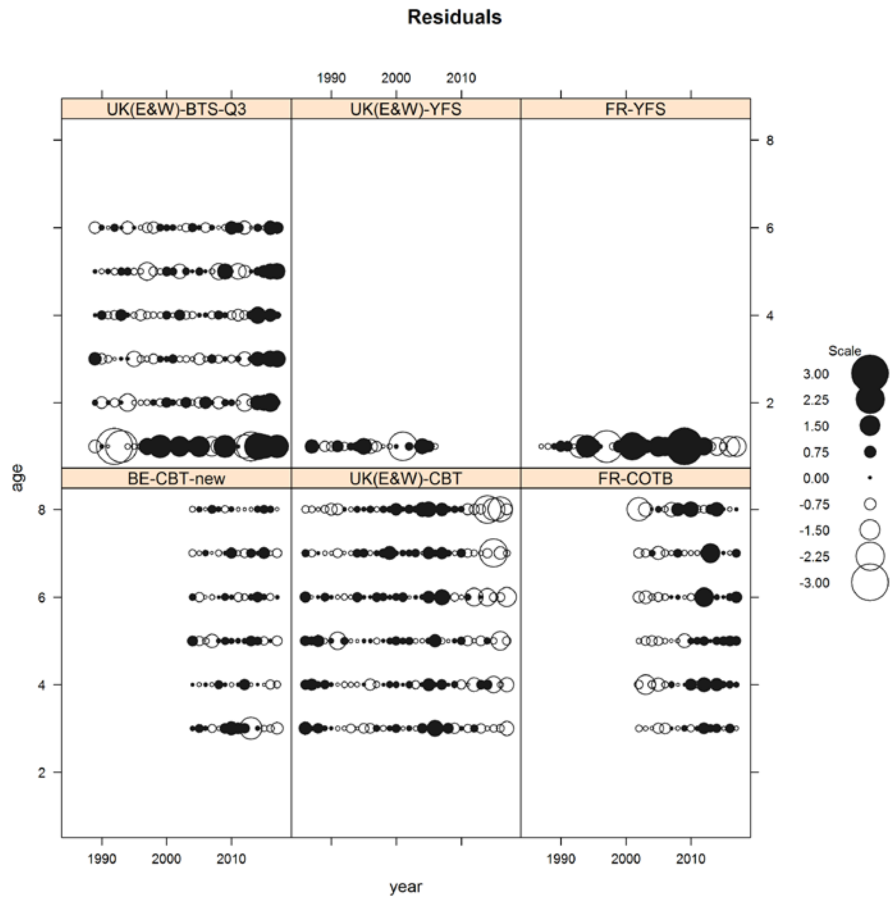


Figure 19.24: Sole 27.7.d - Catchability residuals for all tuning fleets used in the 2018 assessment.

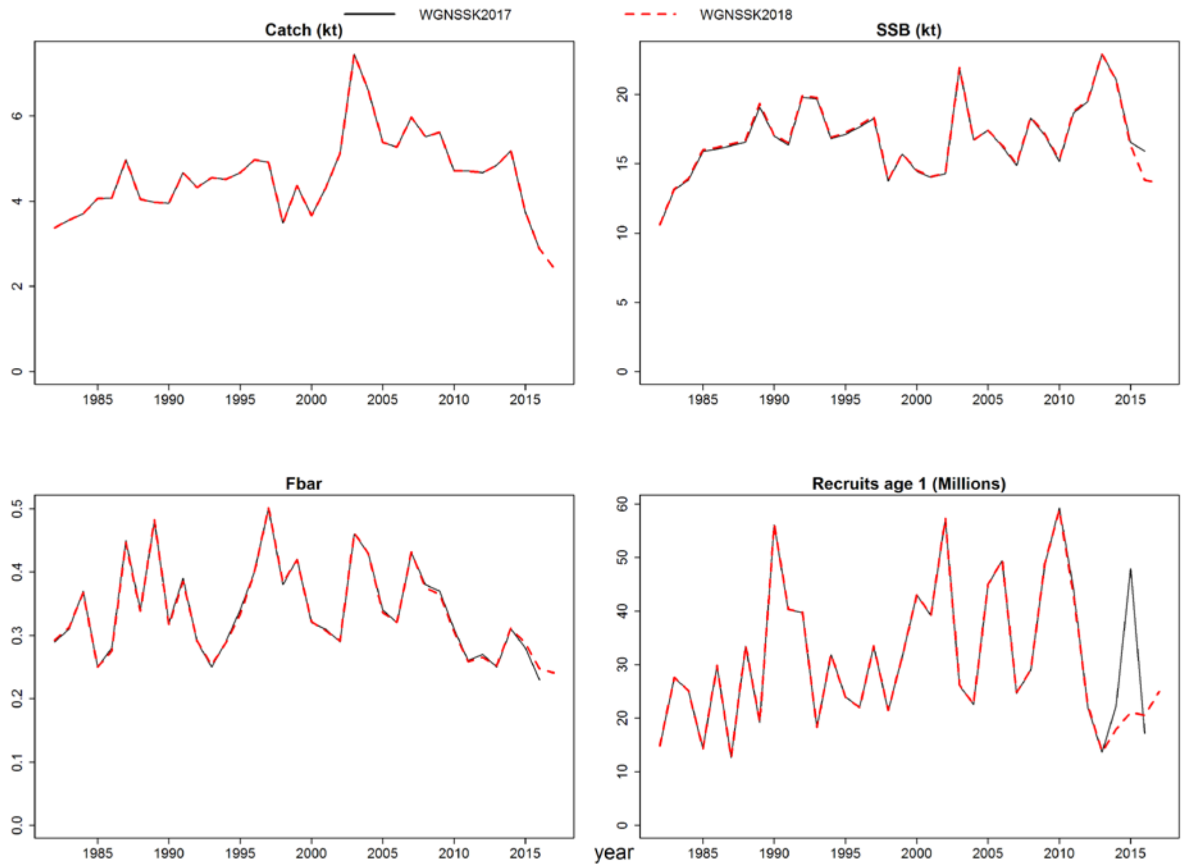


Figure 19.25: Sole 27.7.d - XSA summary: trends in catch, spawning stock biomass (SSB), Fbar and recruitment with indication of 2017 assessment (black line) and 2018 assessment (dashed red line).

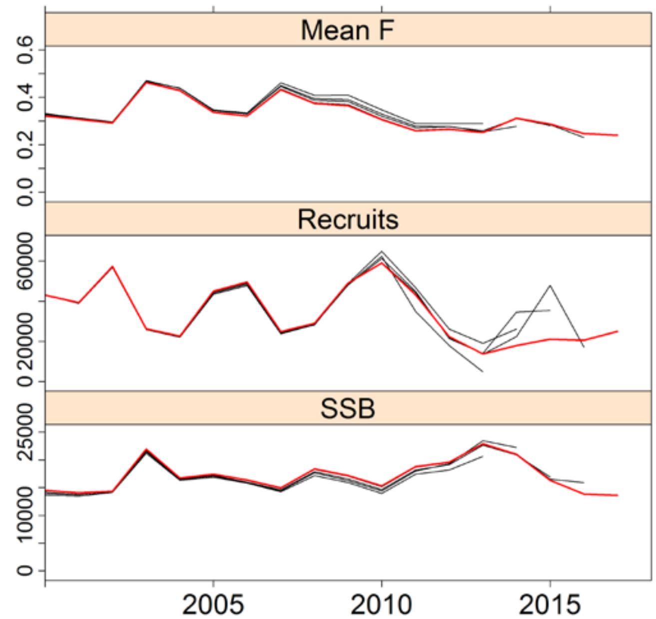


Figure 19.26: Sole 27.7.d - Retrospective pattern in F, recruitment and SSB.

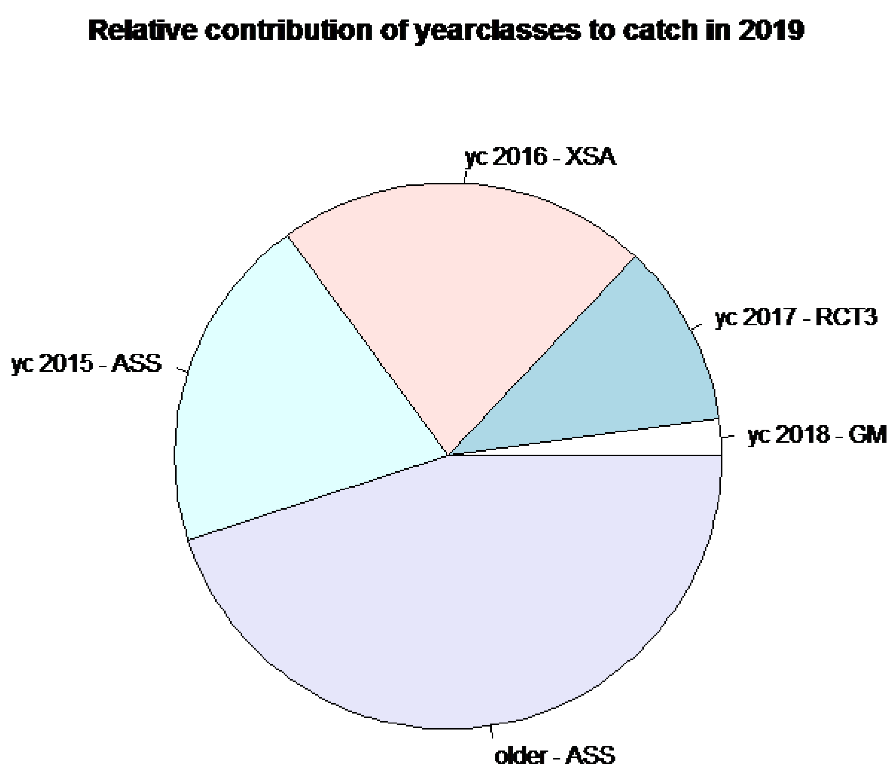


Figure 19.27: Sole 27.7.d - Relative contribution of year classes to catch in 2019.

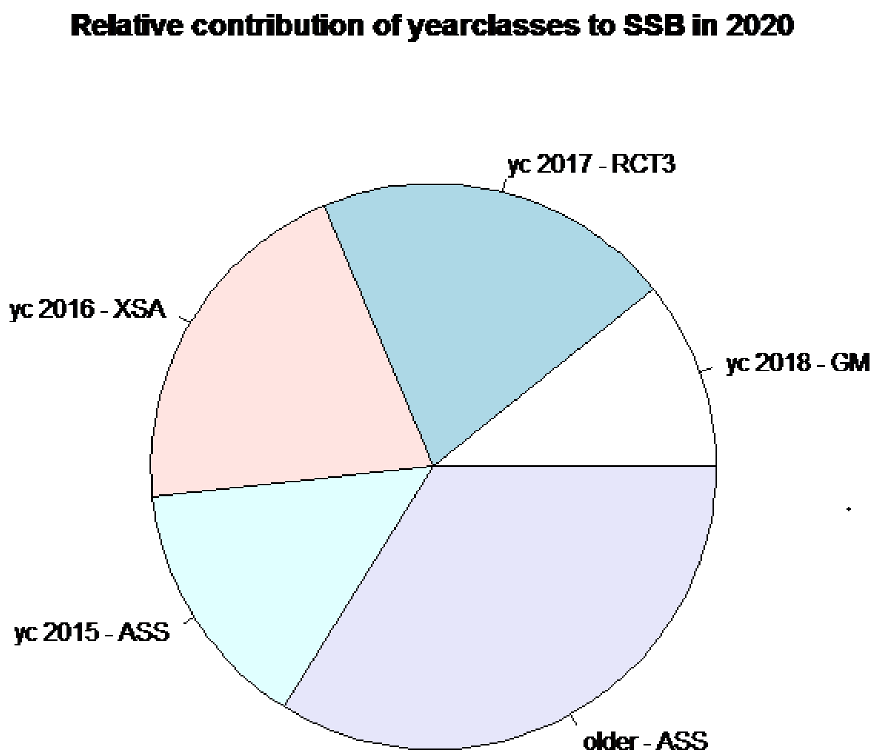


Figure 19.28: Sole 27.7.d - Relative contribution of year classes to SSB in 2020.

20 Striped red mullet in Subarea 4 (North Sea), divisions 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

This stock is under a biennial advice. No TAC is set for this stock. No advice was scheduled for this stock in 2018. The last advice issued in 2017 was based on the 4:1 rule applied to the SSB estimated by the age based model.

The general perception is that the landings in 2017 have decreased compared to 2016, following the perception of the recruitment and biomass estimated last year by the group. These landings are however far from the ICES advice (2205 tonnes compared to an advice of 465 tonnes). The aged based model was run indicating an increase in fishing mortality and a decrease in Spawning Stock Biomass but also a better recruitment observed in 2017 compared to 2014 and 2015.

20.1 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, the first sexual maturity was identified on fish of 16.2 cm for the male and 16.7 cm for the female (Mahé *et al*., 2005).Juveniles are found in waters of low salinity, while adults are found at high salinity. Striped red mullet prefers sandy sediments (Carpentier *et al*., 2009).

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud.

20.2 Fisheries

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (>90% of landings in the beginning of the 2000s). 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 fly shooters, and a UK fisheries have also developed. Landings are shared by these three fleets in the latter years. The Netherlands landed about or more than half of the total landings since the 2010s.

20.3 ICES advice

Advice for 2018 and 2019.

ICES advices that the fishery for striped red mullet should be managed through technical measures that would reduce the catches of small fish and would contribute to more stable yields.

Fishing mortality is above proxies of the MSY reference points (as indicated by a length-based analysis). The stock size relative to reference points is unknown. For these reasons, the precautionary buffer, which was last applied in 2013, was applied again in this assessment.

ICES advises that when the precautionary approach is applied, catches should be no more than 465 tonnes in each of the years 2018 and 2019. All catches are assumed to be landed.

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.

20.4 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.

20.5 Data available

20.5.1 Catch

Official landings data are shown by country in Table 20.5.1.1 and by area in Table 20.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 20.5.1.3 presents total official landings and ICES estimates over the period 2006–2017 as well as the predicted catch corresponding to advice. In 2017, 71% of the catches were made using demersal seines and 26% 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 to 2017 landings were provided under the ICES InterCatch format. Figure 20.5.1.1 shows that only landings from France in the Eastern Channel (representing around 30% of the total landings) were provided in 2014 to 2017 with an age structure. Figure 20.5.1.2 shows that IC data and official landings are consistent over years and countries.

Prior to 2009, no landings of age 0 were observed (Figure 20.5.1.3). Most of the landings are made on age 1. There is no age reading problem reported. This change in the landings might reflect a change in the reporting or a change in the fishing behaviour.

Only France provides age structures for and only for the area 27.7.d, all landings are then raised using French structures for that area.

20.5.2 Weight-at-age

Mean weight at age were computed as described in the Stock Annex and are presented in Figures 20.5.2.1 and 20.5.2.2 and Table 20.5.2.1.

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.

20.5.3 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 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

20.5.4 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 inter-calibration in 2014 and some analysis of the catch data (ICES, 2017, section "CGFS : Change of vessel from 2015 onwards and consequences on survey design and stock indices"). 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 (Figure 20.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 20.5.4.2. The age composition is still truncated with catches hardly only composed by age 0 and 1 individual. The Abundance index shows an increase of the age 0 compared to 2015 and 2016.

20.6 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 Figure 20.6.1. Log residuals of the model are presented in Figure 20.6.2 and observed and predicted catches in Figure 20.6.3 and indices in Figure 20.6.4.

As observed during WKNSEA, there is still a relatively high uncertainty in this assessment. SSB is at a low level and the recruitment seems poorly estimated. Trends show a lot of variation in spawning stock biomass and a very high fishing mortality. Most of the catches rely only on the recruitment (age 0) and age 1 fishes.

20.7 Length-based indicators screening

These analyses were not done in 2017; Results presented are from 2016 WG

The ICES LBI were computed for three years of data (2014–2016), using the length distributions from InterCatch (Tables 20.7.1–2).

Most of the indicators appeared outside the established references:

- Length at first catch Lc and Length of 25% of catches are above Lmaturity (16 cm) in 2015 and 2016. These indicators are below Lmat in 2014. This is directly linked with the good recruitment observed in 2014. The good recruitment observed in 2014 decreased Lc and L25, but the two next years no good recruitment was observed and Lc and L25 increased to be above Lmat.
- ratio of the 5% largest catches to Linf (40 cm) around 0.6/0.7 clearly show the lack of big/old fish in the population
- Lmean/Lopt around 0.8 give the same picture as Lmax5
- Lmean/$L_{F=M}$ below 1 tend to show that this stock is not exploited optimally

This indicates that the stock may be considered not to be exploited sustainably. The main concerns are for the big/old fish that are missing from the population. Length-based indicators based on samples from commercial catches (2014–2016) show that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized it's growth potential (Table 20.7.2).

20.8 Mean length Z

These analyses were not done in 2017; Results presented are from 2016 WG

The Mean length Z was computed for three years of data (2014–2016), using the length distributions from InterCatch (Table 20.8.1).

Based on the Mean length Z method using the length distributions from InterCatch, Z is estimated around **0.9**. Considering natural mortality around 0.4 and given that YPR methods on the same data estimate F0.1 at 0.41. Mean length based methods tend to assess this stock as fished beyond the reference limits.

20.9 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. Since, no good recruitment was observed in 2015 or 2016. There is no TAC on that species so the advice was not followed and the catches overshot the advice for 2015, 2016 and 2017 (4487, 2579 and 2195 tonnes against 460 and 552 and 552 tonnes respectively in the advice). In 2017, the recruitment as seen by CGFS seems to be higher than 2016's recruitment but still far from the observed recruitment in 2009 and 2014.

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016) showed in 2017 that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized its growth potential. The SSB is dependent on recruitment

Assessment year		2017	2018
Index A (last year)		1.34	0.86
Index B (four previous years)		1.27	1.28
Index ratio (A/B)		1.05	0.67
Uncertainty cap	Applied	1.2	
Advised catch for 2016–2017		552 tonnes	
Discard rate	Negligible		
Precautionary buffer	Applied	0.8	
Catch advice		**530** tonnes	

The index ratio decreased compared to last year however, no TAC is set for that stock and the stock perception did not drastically changed from last year.

20.10 References

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Table 20.5.1.1. Striped red mullet in Subarea 4 and divisions 7.d and 3.a: Official 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
1999[1)]	0	4	NA	0	103	107
2000	0	4	3201	464	133	3802
2001	0	10	1789	915	183	2897
2002	0	24	1658	560	141	2383
2003	28	0	3256	626	177	4087
2004	31	0	4137	1148	129	5445
2005	29	0	1918	914	136	2997
2006	16	0	1145	466	97	1724
2007	16	0	3982	1147	183	5328
2008	19	0	3723	1270	353	5365
2009	17	0	827	889	293	2026
2010	80	0	947	802	337	2166
2011	97	0	705	771	244	1817
2012	52	0	170	525	146	893
2013	40	0	121	260	40	461
2014	79		765	912	246	2002
2015	250		1741	2657	679	5328
2016	147	0	556	1421	485	2609
2017	93	0	784	973	310	2160

[1)] No data reported by France in 1999.

[2)] ICES estimates.

Table 20.5.1.2. 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
1999[1)]	70	0	37	107
2000	1764	0	2038	3802
2001	1600	0	1297	2897
2002	1234	0	1149	2383
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	641	0	1083	1724
2007	1546	0	3782	5328
2008	1824	0	3536	5365
2009	910	0	1113	2026
2010	698	0	1468	2166
2011	611	0	1206	1817
2012	388	0	505	893
2013	195	0	266	461
2014	526	0	1476	2002
2015	1601		3727	5328
2016	824		1785	2609
2017	647		1513	2160

[1)] No data reported by France in 1999.

Table 20.5.1.3. 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		-	1724	1475
2007		-	5328	4604
2008		-	5365	2063
2009		-	2026	1513
2010		-	2166	1920
2011		-	1817	1512
2012	No increase in catch	-	893	725
2013	No increase in catches (average 2009–2010)	< 1700	461	408
2014	Reduce catches by 36% compared to 2012	< 460	2002	1718
2015	No new advice, same as for 2014	< 460	5327	4487
2016	Precautionary approach	<552	2609	2579
2017	Precautionary approach	<552	2160	2195
2018	Precautionary approach	<465		
2019	Precautionary approach	<465		

Weights in tonnes.

Table 20.5.1.4. Striped red mullet landing numbers at age (thousands).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	55	14734	0	6	1384	10124	1832	45
1	43375	16606	3912	37013	1323	16259	15203	9317	1335	2771	10790	37485	4113
2	1839	2455	2332	1124	10518	1319	674	1454	1244	467	1329	6310	11381
3	947	263	1679	553	1255	662	142	639	1477	289	14	19	2503
4	187	256	188	127	537	102	102	80	183	0	29	36	234

Table 20.5.2.1. Striped red mullet stock weights (kg).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0.046	0.042	0	0.02	0.02	0.029	0.038	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	0.1135
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	0.1379
3	0.27	0.3	0.24	0.422	0.226	0.177	0.24	0	0.25	0.12	0.259	0.37	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	0.2

Table 20.7.1. Striped red mullet 27.3a47d length based indicators.

Data Type	Value/Year	Source
Length at maturit	162 162 162	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
von Bertalanffy growth parameter	400 400 400	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
Catch at length by year	2014 2016	Length data from IC
Length-weight relationship parameters for landings and discards	2014 2016	Mean weight at length from IC

Table 20.7.2. Striped red mullet in Subarea 4 and divisions 7.d and 3.a.: Traffic light table for length-based indicators. Conservation criteria for small fish: L_c (length at first catch) and 25% percentile relative to L_{mat} (length at 50% maturity); and for large fish: mean length of the largest 5% in the catch ($L_{max5\%}$) relative to asymptotic length L_{inf} and the proportion of mega spawners (P_{mega}). Optimising yield criterion: the mean length L_{mean} is compared to the theoretical length of optimal biomass (L_{opt}). MSY criterion: L_{mean} is compared to $L_{F=M}$, the MSY proxy. "Ref" indicates the reference criterion: green colour for meeting the criterion, and red flagging issues (e.g. dome-shaped vs. overexploitation). "Ref" indicates the criterion required for a green light. Each year is evaluated separately.

	Conservation				Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2014	0.87	0.93	0.66	0.01	0.72	0.96
2015	1.2	1.17	0.64	0	0.82	0.89
2016	1.2	1.23	0.68	0.01	0.84	0.91

Table 20.8.1. Striped red mullet 27.3a47d Mean Length based input.

Data Type	Value/Year	Source
Linf	360	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
K	0.218	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
max age	11	
Data (year range)	2014 2016	Mean length from IC

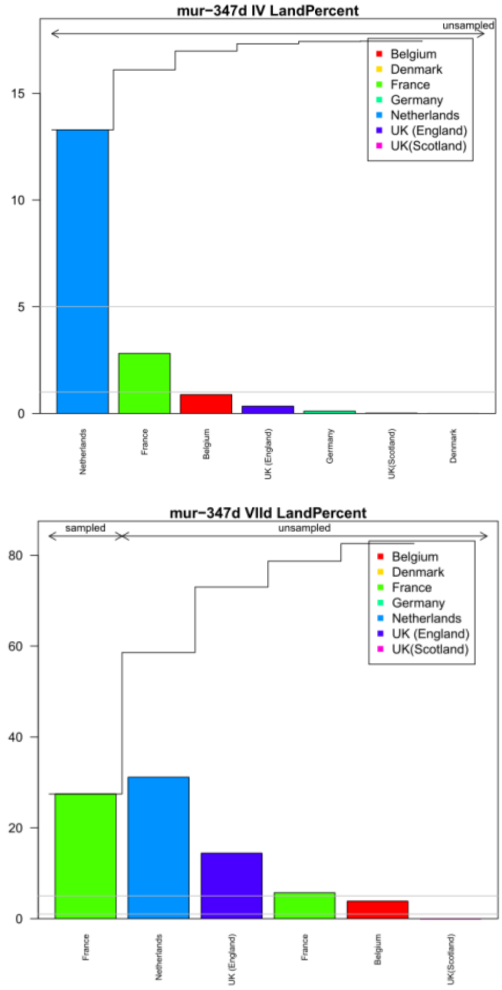

Figure 20.5.1.1. Striped red mullet in Subarea 4 and Division 7.d ICES landings by country (percentage over the total area).

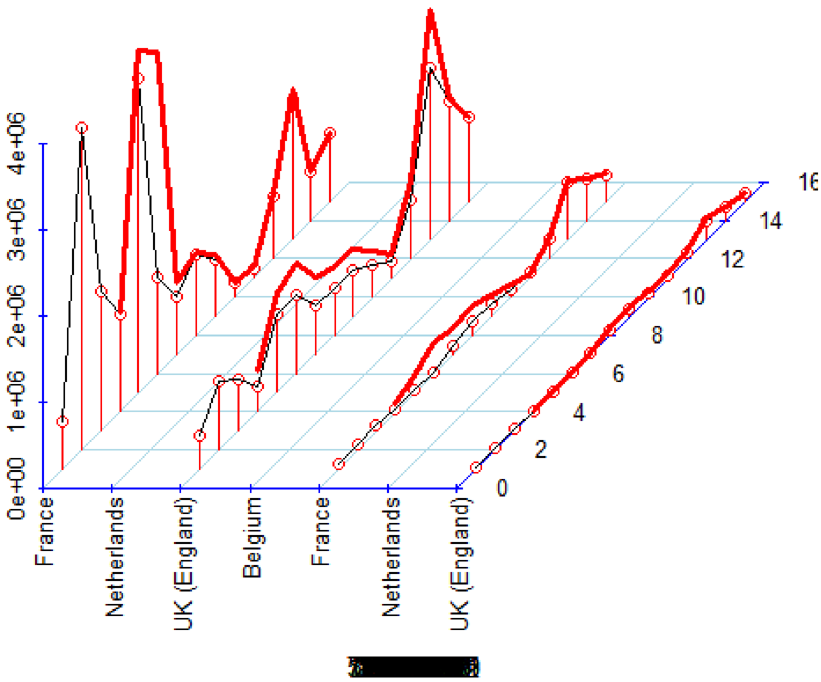

Figure 20.5.1.2. Striped red mullet in Subarea 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

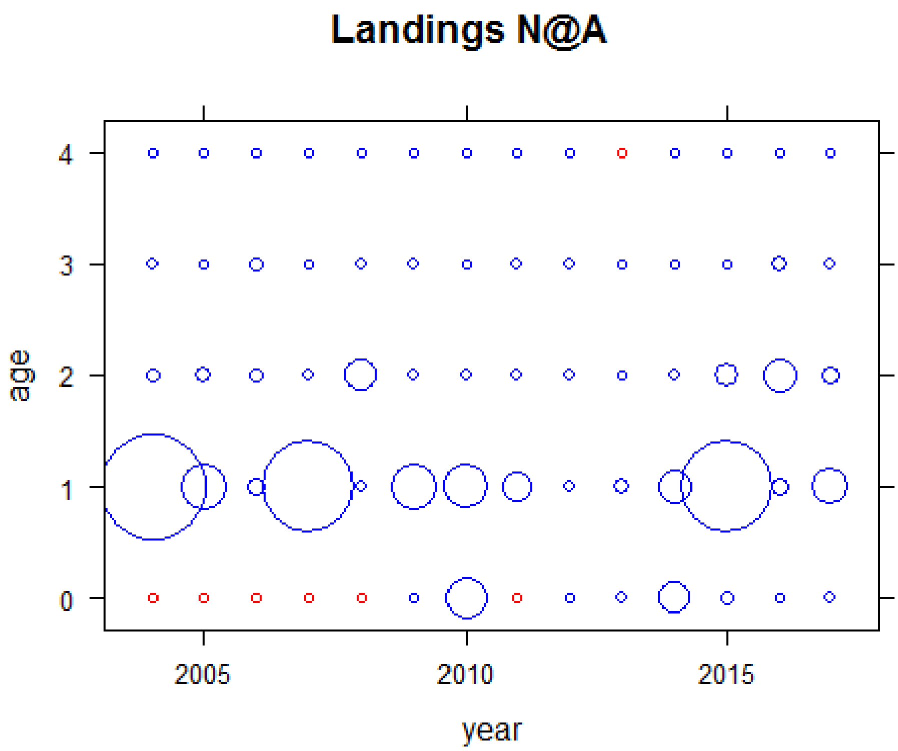

Figure 20.5.1.3. Striped red mullet age structure (in numbers) as provided in the landings.

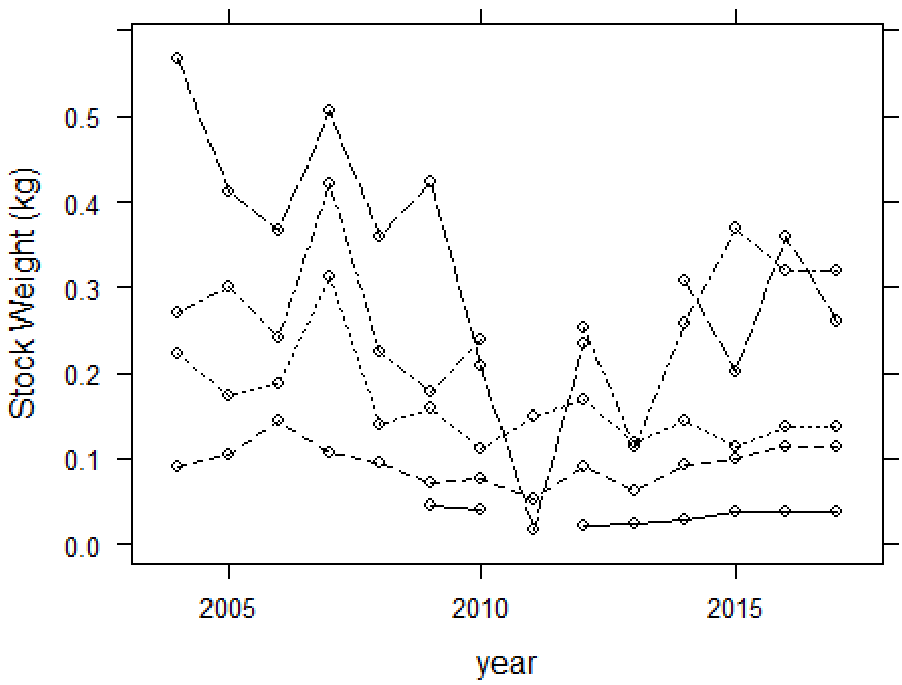

Figure 20.5.2.1. Weight at age in the stock.

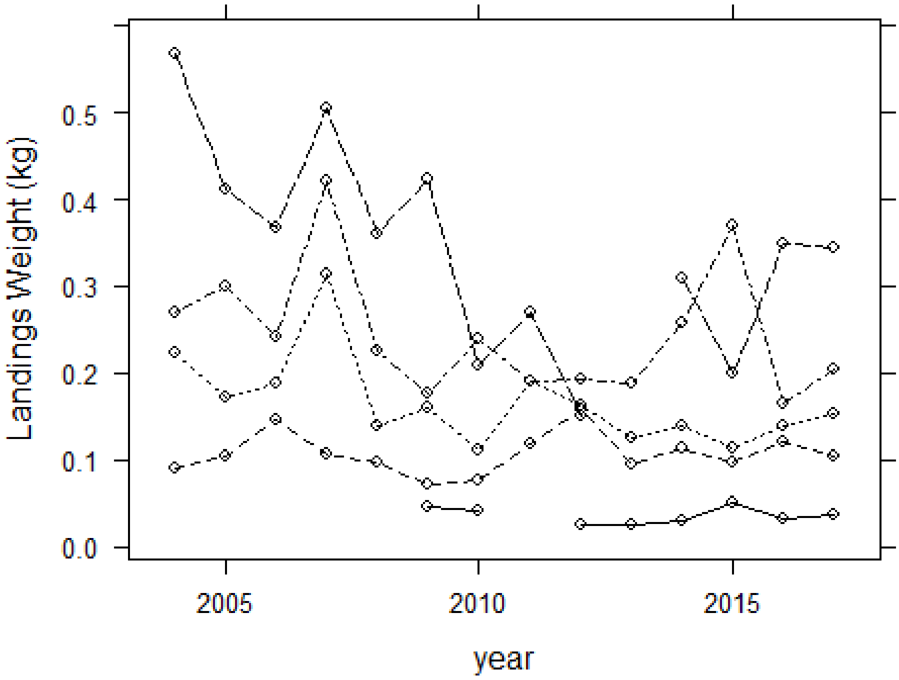

Figure 20.5.2.2. Weight at age in the landings.

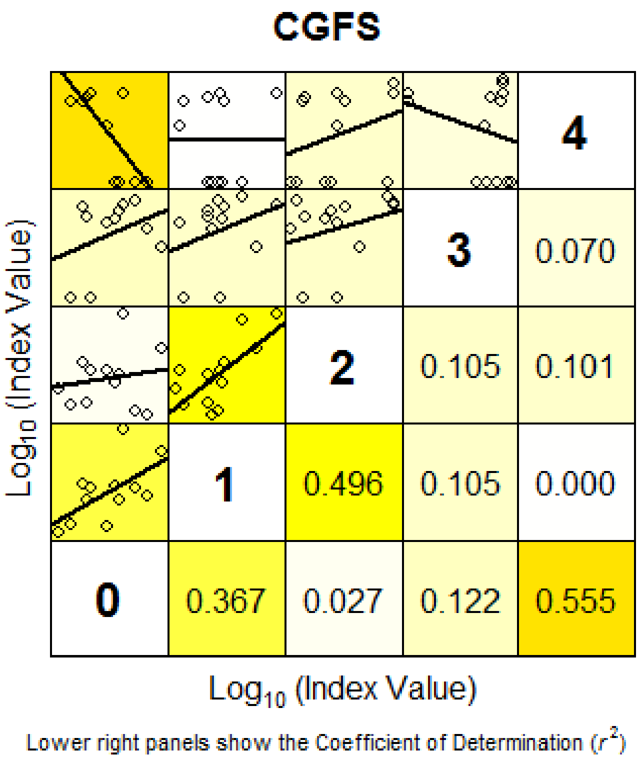

Figure 20.5.4.1. CGFS internal consistencies.

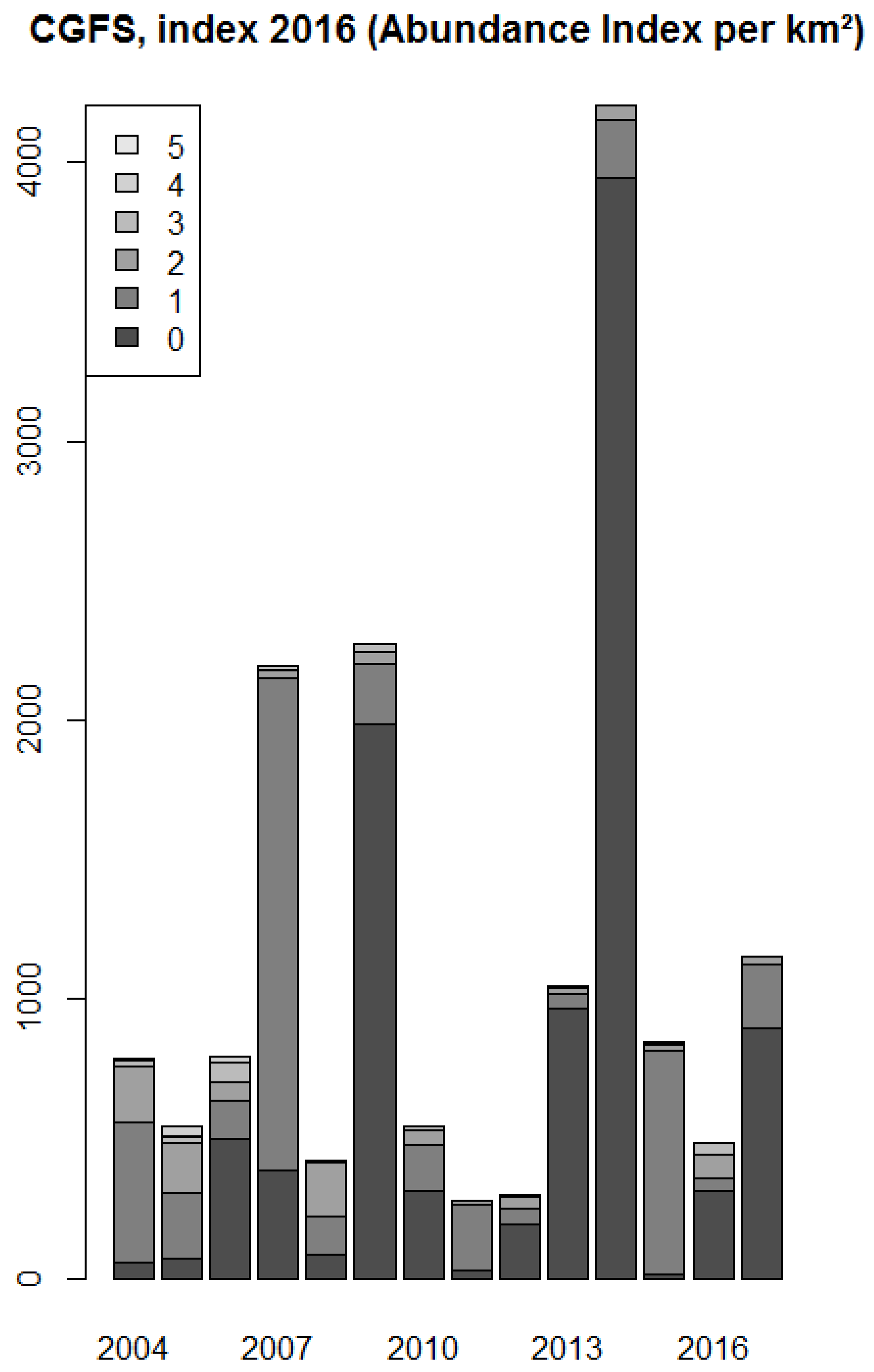

Figure 20.5.4.2. CGFS catch age composition.

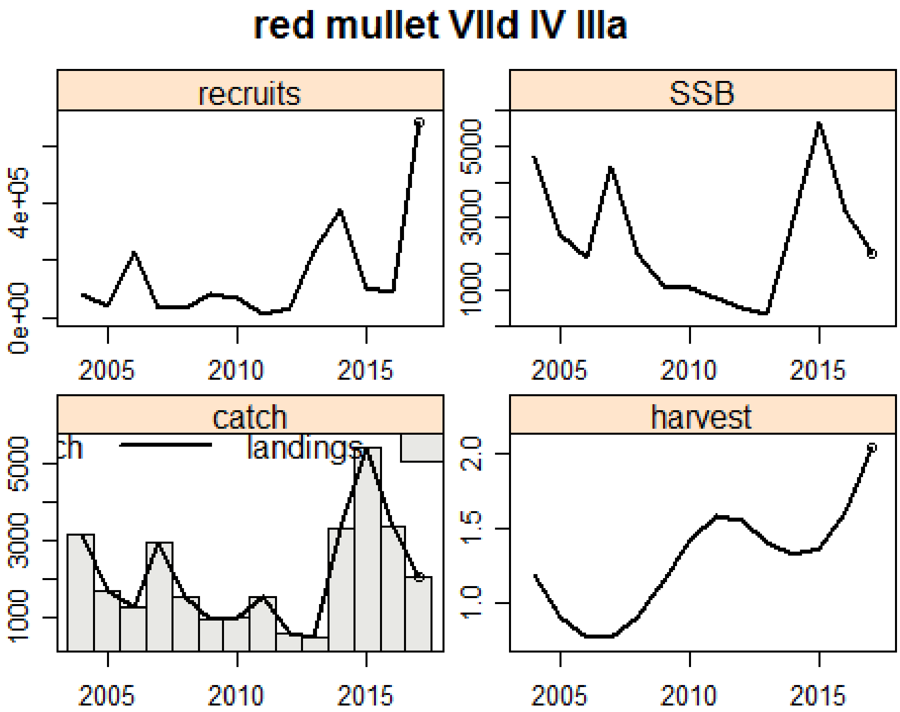

Figure 20.6.1. CGFS internal consistencies

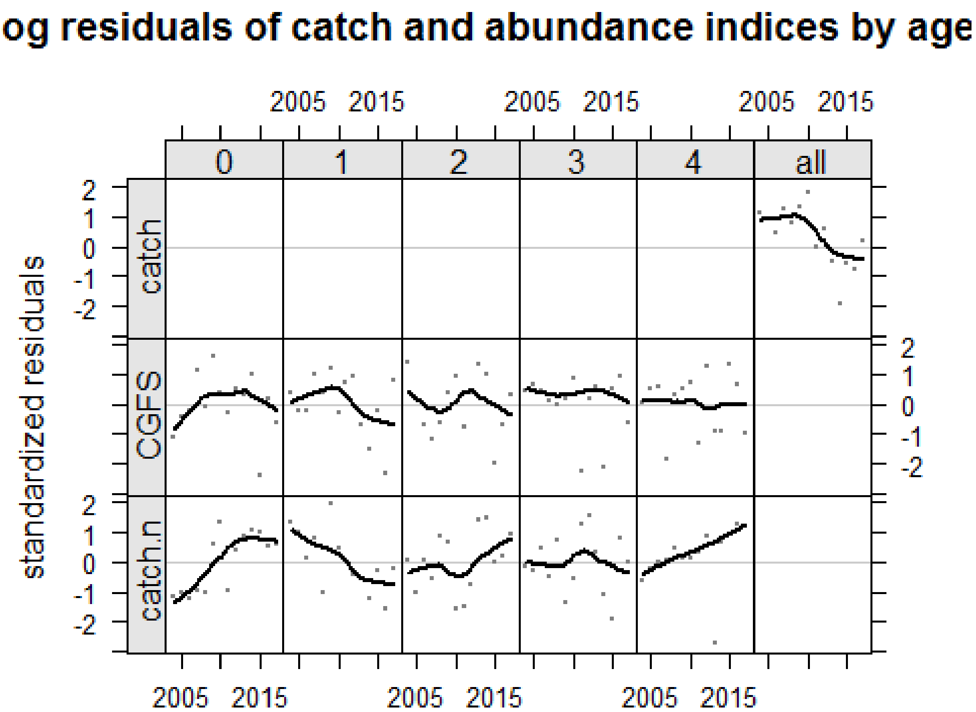

Figure 20.6.2. Log residuals of the assessment.

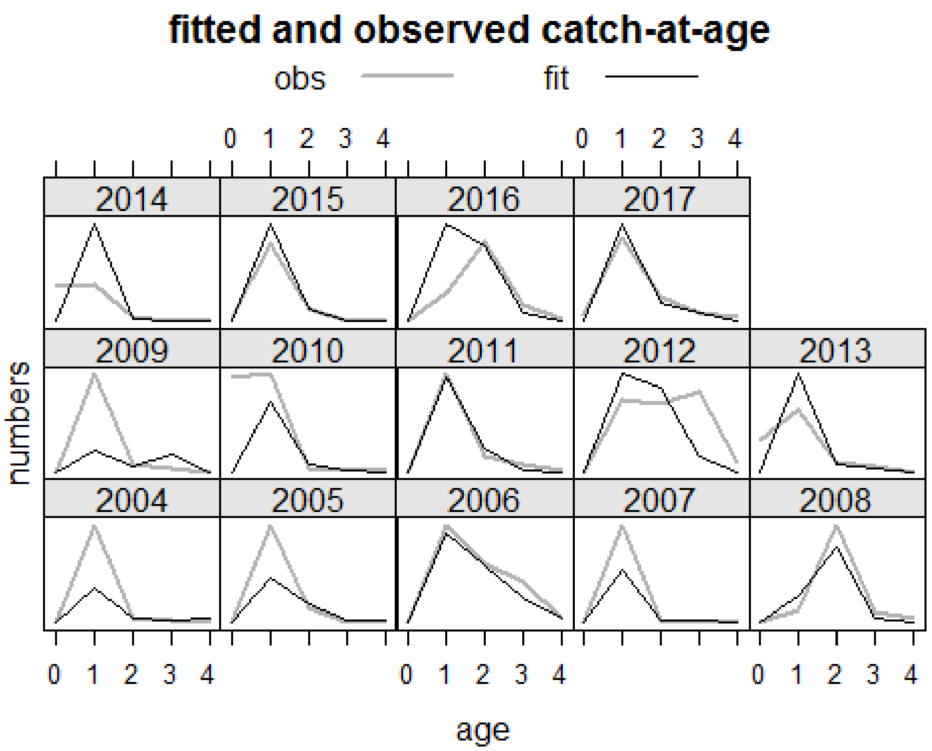

Figure 20.6.3. Observed (pink) and estimated (blue) catch number-at-age.

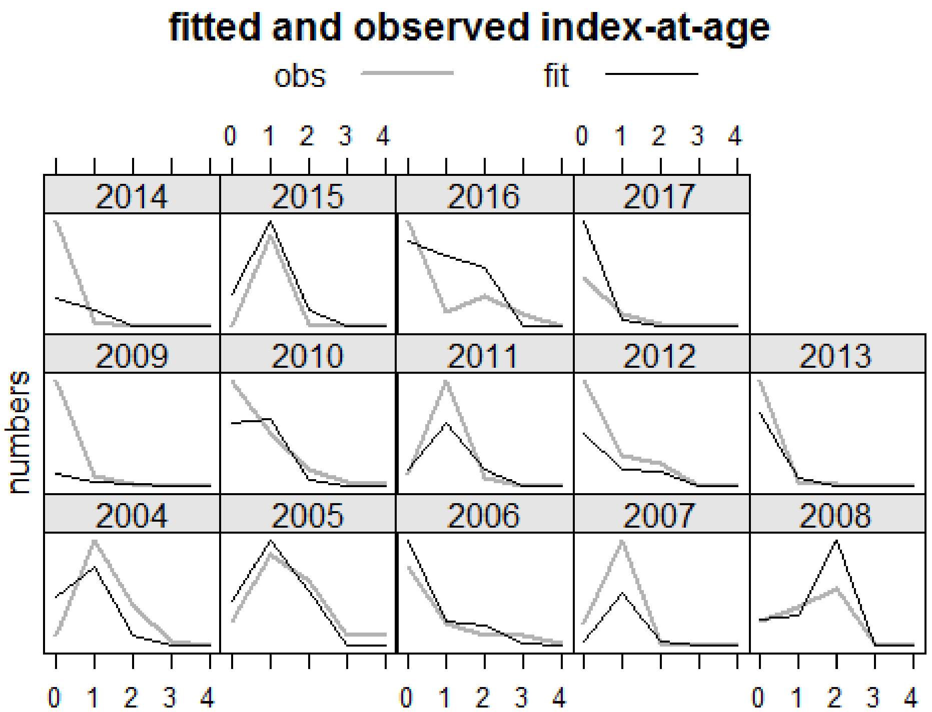

Figure 20.6.4. Observed (pink) and estimated (blue) indices at age.

21 Turbot in 3.a (Kattegat, Skagerrak)

This stock is under a biennial advice, so no advice was scheduled for this stock in 2018. The last advice issued in 2017 was based on the 3:2 rule applied to the IBTS Q1 and Q3 biomass indices, after some changes in the procedures compared to previous years.

The general perception is that landings have fluctuated without trends over a long period. The survey indices are of poor quality, with low catch rates and large annual fluctuations, and they are showing no trends. In 2017, length-based indicators and exploratory SPiCT runs had been run, pointing out that the stock may be exploited sustainably.

21.1 Management regulations

There are no TACs in place for turbot in area 3.a.

There is no official EC minimum landing size, but Denmark has a minimum size at 30 cm. In the Netherlands, quotas restrictions for North Sea turbot led Dutch POs to increase their own MLS during the course of 2016 (see Section 14), which would also affect the Dutch discarding of turbot caught in Skagerrak.

21.2 Fisheries data

Turbot is now only caught as by-catch in the trawl and gillnet fisheries. Table 21.1 and Figure 21.1 summarize turbot landings in ICES area 3.a. Over the period 1950–2016, total landings (3.a) ranged from 64 t to 736 t per year, with the lowest landings during the end of 1960s and the beginning of the 1970s, and the highest peaks in 1977 and in the early nineties. The peak is linked to exceptionally high records from the Netherlands for four years, the reasons of which being unclear. The Danish catches which are present throughout the time series have fluctuated without trends around 100–200 t per year.

Over the last fifteen years, the total landings of turbot in 3.a had declined to around 100 t per year, but have increased again since 2015 around (190 tonnes in 2017), at the level observed in the 50s–60s.

2017 catch data for turbot.27.3a 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, but no age information. The difference between official and ICES landing estimates observed in 2015 and 2016 did not occur in 2017.

Discard ratios were provided for strata summing up to 75% of the reported landings (Figure 21.2a). For those strata where information exist, discards ratios were estimated at 18% in the Kattegat and 12% in the Skagerrak. This is an increase compared to last year.

The raising of discards was performed by groups of métiers: all passive gears together (discards ratio close to zero), all trawled gears together (medium discards ratio), without distinction of area or mesh size. After raising, the discard ratio for the entire stock area was estimated at 13.7%, (Table 21.2), but can be substantially higher in some trawl fisheries.

Length distributions were also estimated for 2017 (Figure 21.3). However the stock was poorly sampled for length distributions in 2017, owing to changes in the Danish sampling program following Commission implementing decision (EU) 2016/1251, considering that the total annual landings are less than 200 tonnes. Only 9% of the landings had length distribution sampled, against 65% in 2016. For discards, 51% of the discards had sampled length distribution, which is the same level as 2016. (Table 21.3). The high SOP discrepancies observed in 2014 and 2015 data have not been further investigated yet.

Turbot is fully discarded until 30 cm (Figure 21.3). In 2017, the increased discard rate may be linked to smaller fish entering the fishery compared to 2016, which might be indicative of a larger year class coming in.

21.3 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). Since the initial investigations of ICES WGNEW (2013), and until 2016, only the Havfisken trawl survey (BITS) had been used to derive an index of abundance of turbot in 3.a.

In 2017, this basis was reconsidered, and the advice was finally given using a biomass index for both IBTS Q1 and Q3, computed from the file "CPUE_per length_per haul" from the ICES DATRAS database. CPUE per length were translated to weight using a fixed length-weight relationship from www.fishbase.org (a = 0.00802, b = 3.260), then summed over length classes within a haul and finally averaged across all hauls.

Indices are noisy (Table 21.4 and Figure 21.4). In IBTS Q1 and Q3, the ratio of the average of the last two years over the average of the last three preceding years (2:3 rule) was between 0.8 and 0.9.

21.4 Summary

No assessment was performed in 2017 other than updating the catches and survey data time series. The indicators do not show strong deviation from the previous year. It is thus not suggested to re-open the advice in 2018.

A benchmark is not scheduled before 2020.

Table 21.1. Turbot in 27.3a: Official landings by country from 1950 to 2016.

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
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
2016	0	0	137	0	25	6	10	179
2017	0	0	153	0	16	7	12	188

Table 21.2. Turbot in 27.3a: Landings and discards (in kg) after raising in InterCatch (using CATON estimate).

	Discards	Landings	Grand Total	Discard Ratio
2013	**7365**	**112960**	**120326**	**6.1%**
3.aN	1905	78830	80735	2.4%
3.aS	5461	34130	39591	13.8%
2014	**10508**	**120240**	**130748**	**8.0%**
3.aN	2712	80969	83681	3.2%
3.aS	7796	39272	47068	16.6%
2015	**18274**	**183502**	**201776**	**9.1%**
3.aN	4639	145084	149723	3.1%
3.aS	13635	38417	52052	26.2%
2016	**16349**	**188027**	**204376**	**8%**
3.aN	12543	145240	157783	8%
3.aS	3806	42787	46593	8.2%
2017	**30059**	**189801**	**219860**	**13.7%**
3.aN	19985	139744	159729	12.5%
3.aS	10074	50057	60131	16.8%

Table 21.3: Turbot in 27.3a. Summary of the imported/Raised data for 2017 (based on SOP CANUM*WECA; small differences arise with the previous table)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	172240	91
Landings	Imported_Data	Sampled_Distribution	17561	9
Discards	Imported_Data	Sampled_Distribution	15369	51
Discards	Raised_Discards	Estimated_Distribution	7757	26
Discards	Imported_Data	Estimated_Distribution	6933	23

Table 21.4. Turbot in 27.3a: Average CPUE (kg/hr) estimated from IBTS and BITS surveys, and DLS calculations using 2:3 rule

Year	IBTS Q1	IBTS Q3	BITS Q1	BITS Q4
1991	1.061	0.218		
1992	0.378	0.225		
1993	0.595	0.066		
1994	0.437	0.427		
1995	0.540	0.087		
1996	0.591	0.225	0.280	
1997	0.426	0.095	0.523	
1998	0.381	0.029		
1999	0.109	0.109	0.590	0.579
2000	0.232	0.000	0.194	0.161
2001	0.397	0.121	0.094	0.411
2002	0.155	0.337	0.207	0.271
2003	0.297	0.117	0.130	0.187
2004	0.350	0.095	0.366	2.076
2005	0.304	0.133	0.340	0.434
2006	0.700	0.316	0.598	0.104
2007	0.461	0.253	0.424	0.407
2008	0.099	0.599	0.507	0.315
2009	0.316	0.418	0.467	0.110
2010	0.294	0.312	0.138	0.510
2011	0.271	0.201	0.540	0.611
2012	0.466	0.386	0.471	0.348
2013	0.418	0.167	1.002	0.239
2014	0.088	0.382	0.067	0.303
2015	0.922	0.379	0.364	0.919
2016	0.661	0.355	1.550	0.800
2017	0.529	0.167	0.467	0.615
2018	0.454		0.388	
last 2	0.492	0.261	0.428	0.707
previous 3	0.557	0.309	0.698	0.487
2:3 rule	0.883	0.843	0.613	1.452

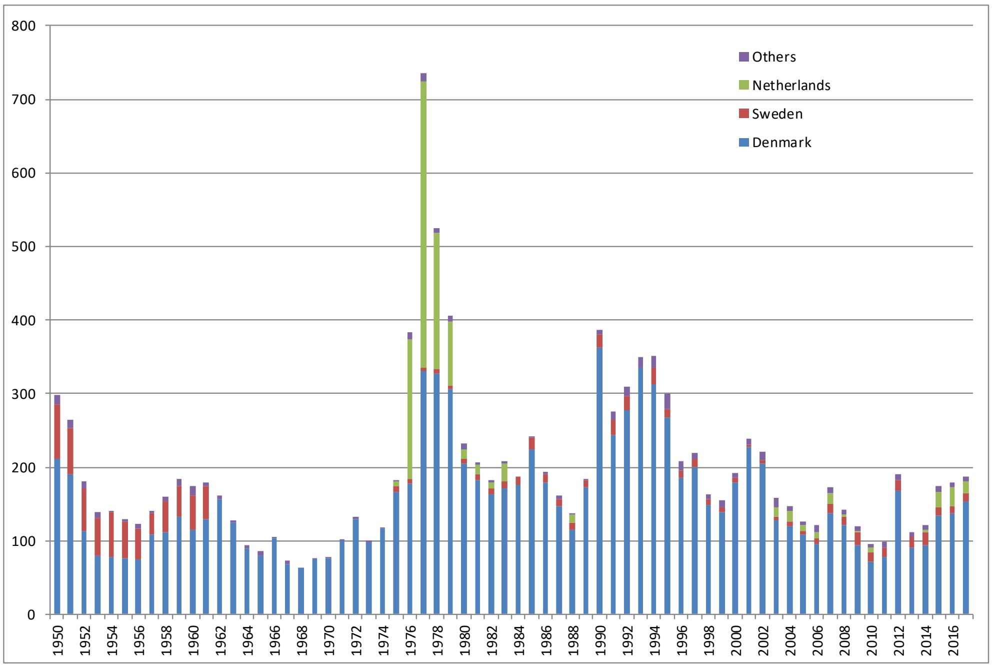

Figure 21.1. Turbot in 27.3a: official landings by country from 1950 to 2017

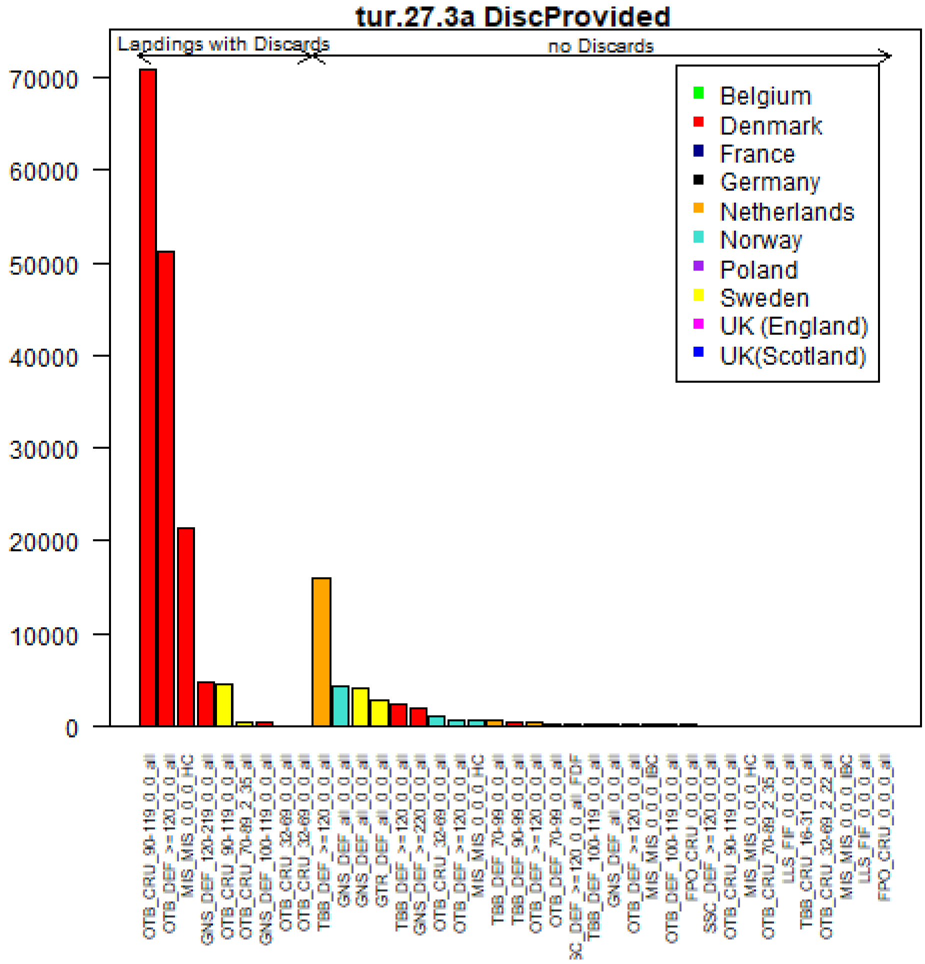

Figure 21.2a. Turbot in 27.3a. Summary of the information provided to InterCatch for 2017. Landings by metier and country, distinguishing between strata with and without discard information provided.

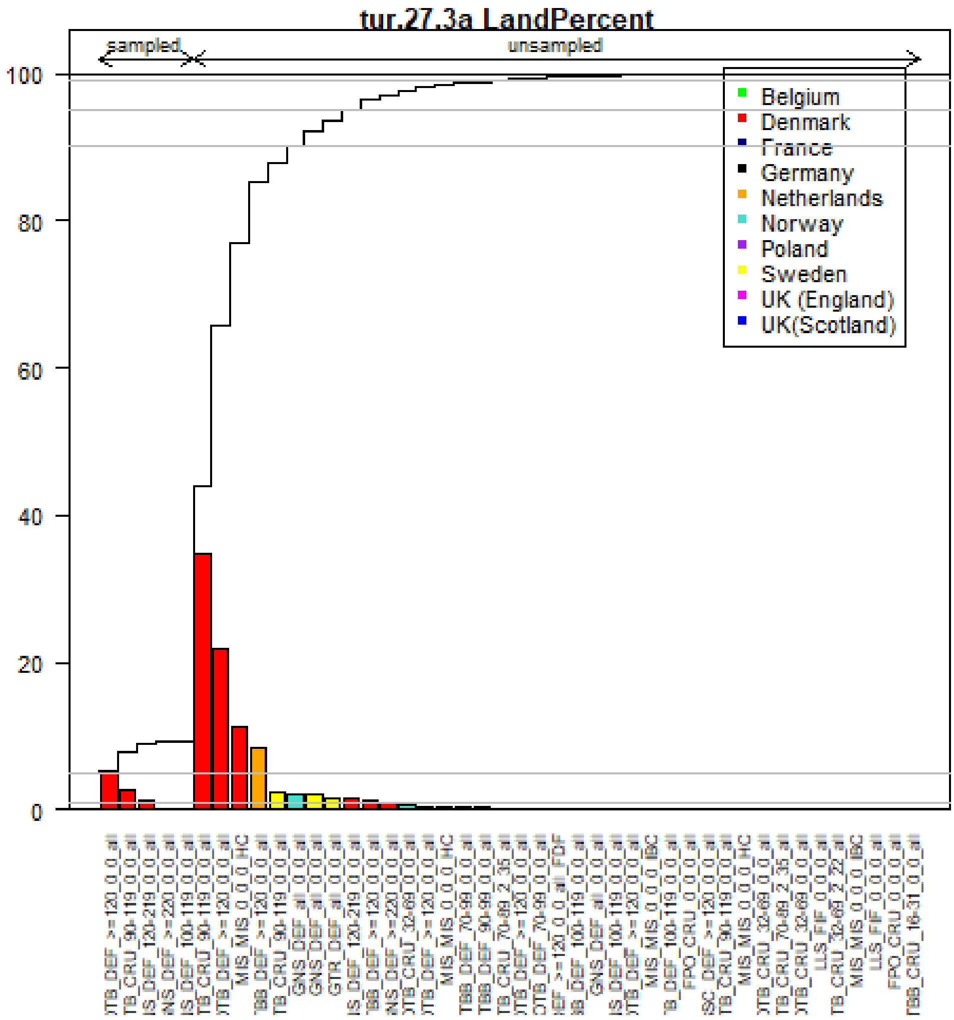

Figure 21.2b. Turbot in 27.3a. Summary of the information provided to InterCatch for 2017. Total landings by métier, sorted by sampled/unsampled for numbers at age in InterCatch.

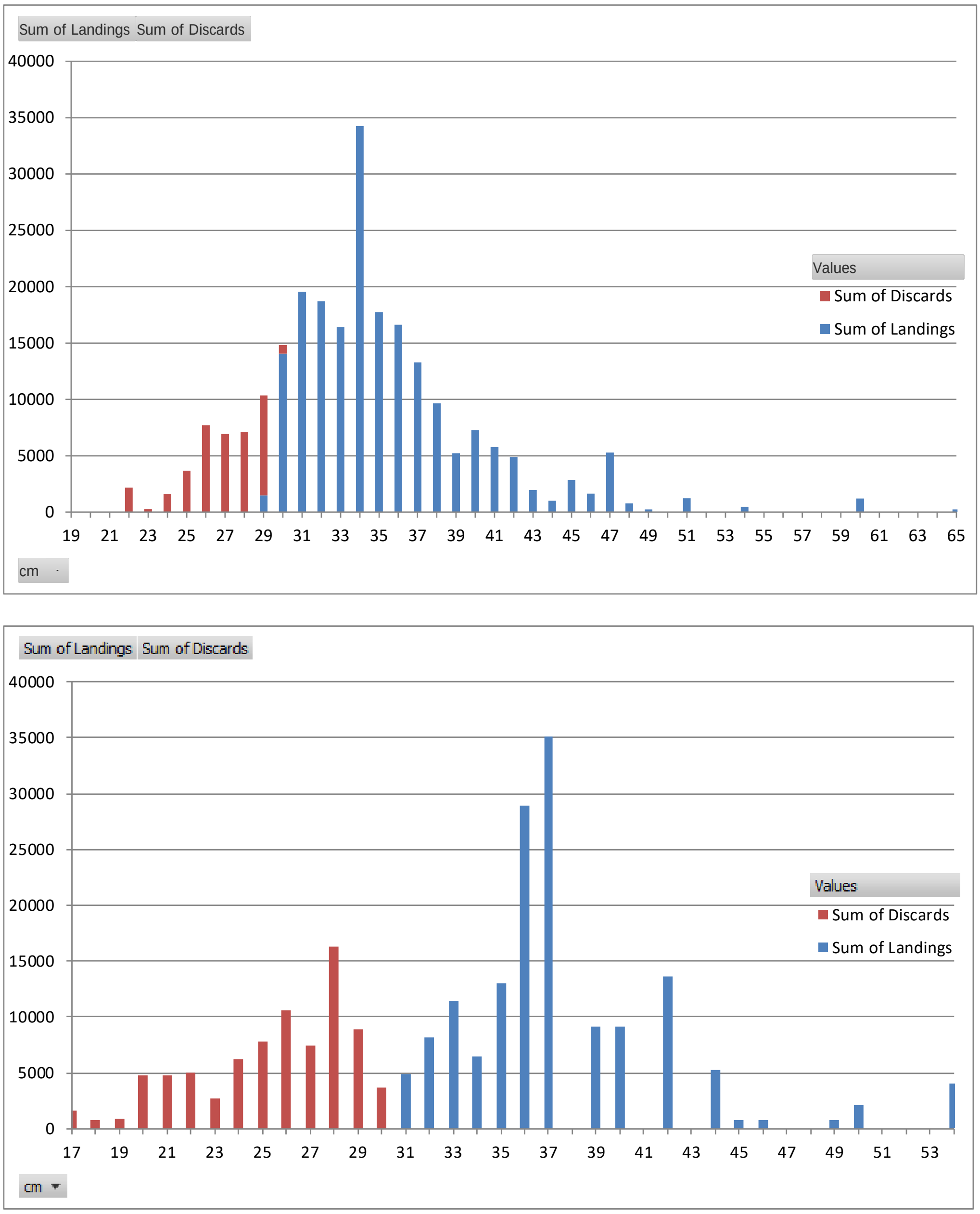

Figure 21.3. Turbot in 27.3a: Length distribution in landings and discards in 2016 (top) and 2017 (bottom), after raising in InterCatch

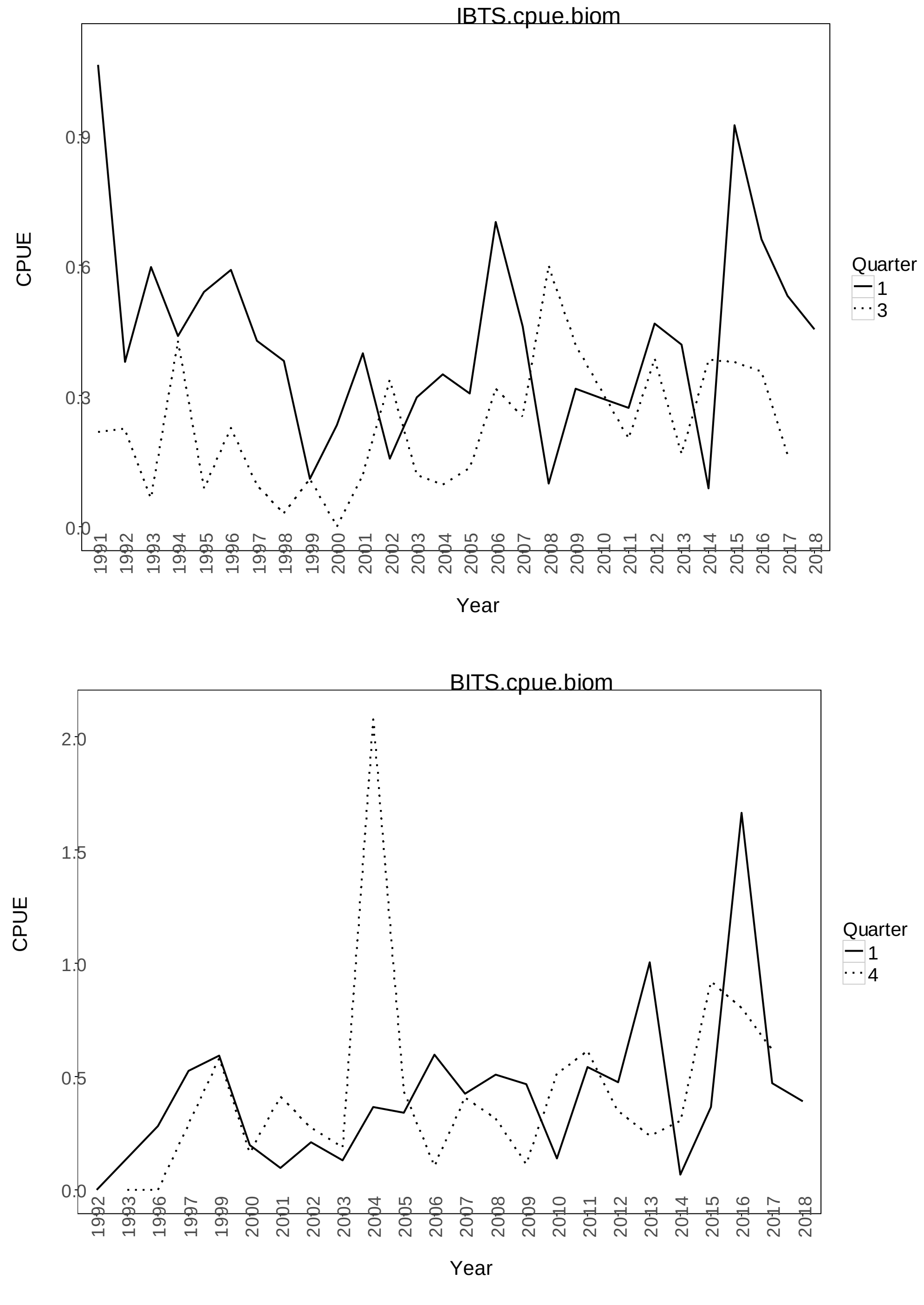

Figure 21.4. Turbot in 27.3a. IBTS and BITS biomass survey indices by quarter

22 Turbot in Subarea 4

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2018. Following an inter-benchmark procedure for this stock in 2015 and another one in 2017, 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 and inter-benchmark report (ICES, 2017). Following the inter-benchmark, the assessment output (SSB) was used as the basis for deriving advice under category 3 of the ICES DLS approach in 2017. In this context, WGNSSK 2018 did not provide new advice for turbot as it was provided for the years 2017, 2018 and 2019.

WGNSSK 2018 noted an issue with the results of the Turbot inter-benchmark of 2017. A mistake was found which related to how one of the surveys was being treated. The mistake was fixed and the group decided not to reopen the advice but proposed to revise the advice of 2017. More information is provided in the report when discussing the stock assessment model.

22.1 General

22.1.1 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).

22.1.2 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 for more details.

22.1.3 Management

A combined EU TAC for turbot and brill is set for EU waters in areas 2.a and 4. This TAC only applies to the EU fisheries. This management area (particularly the inclusion of Area 2.a) 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.

As a primarily bycatch species, regulations relating to effort restrictions for the primary métiers 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 2013. In 2016, this size was increased to 30 cm first, and then to 32 cm. In the summer of 2016, the POs decided to prohibit landing the smallest market category and in October and November the weekly landings were capped to respectively 375 kg and 600 kg wk^{-1}. These measures were taken in order to try and keep the landings within the national quota. In 2018, these measures were continued implementing a minimum landing size of 30 cm and a limiting the landings to 2000 kg wk^{-1}.

Measures taken by the Dutch Producer Organisations from 2016 up to present.

Dutch PO-measures			
Year	**Date**	**Max kg per week/trip**	**MLS**
2016	January	-	27 cm
2016	April	-	30 cm
2016	May	-	32 cm
2016	October	375 kg	32 cm
2016	November	600 kg	32 cm
2017	January	-	32 cm
2017	March	800 kg	32 cm
2017	November	2000 kg	30 cm
2018	January	2000 kg	30 cm

22.2 Data used

Following the inter-benchmark conducted in the summer of 2017, the assessment of North Sea turbot 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 for more details on the data used in the assessment, sources and historical values.

22.2.1 Catch data

Figure 22.2.1 shows the trend in total landings over time.Landing of turbot decreased during the 1990s and for the last ten years have been stable in the region of 3000 tonnes. Over this time effort by the Dutch beam trawl fleet, which contributes most to the landings (ca. 45%), has decreased notably. Since turbot is primarily a bycatch species, this indicates that abundance of turbot has likely increased over this period. The last two years landings have exceeded 3400 tonnes. In 2017, landings in Subarea 4 decreased slightly (1.5%) and reached 70% of the 4937 tonnes of the combined TAC for turbot and brill.

Landings in numbers at age are presented in Table 22.2.1 and Figure 22.2.2, with weights-at-age in the catch presented in Table 22.2.2. 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, a high proportion of immature fish are 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, these are now in the same order of magnitude as the estimates in the 1980s. This could reflect the recent reduction in F leading to an increasing proportion of older fish in the landings. However, since the catch data up to 2016 are 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. In 2017, there is a decrease in landings of age 2. This decrease may suggest a weak 2015 year class or reflect the constraints set by the PO-measures to landing smaller/younger individuals.

22.2.2 Discards

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 1 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.

The discard rate (discards: 495 634 / (discards + landings: 3 936 353) was 13% in 2017. This is a minor decrease compared to 2016 but a substantial increase compared to the most recent period (2013–2015), when discard ratios were approximately 5%. No useable age structure information was submitted for the discard estimates.

22.2.3 BMS landings

In 2017, no BMS landings were reported to InterCatch. They are not raised.

22.2.4 Logbook registered discards

In 2017, logbook registered discards were reported to InterCatch. They are not raised.

22.2.5 InterCatch

InterCatch was used for the first time for the North Sea turbot stock at WGNSSK 2014, and has been used since.

For the landings Dutch (for data from 2004–present) and Danish (from 2014–present) samples (landings and discards) accounting for auctions, quarters and market categories are provided. In addition, Belgium submitted samples by year (only 2017) for the TBB 79–99 and TBB >=120 fleet. All data (2551 samples) are used for estimating the age structure of the landings. Prior to 2004, the landings-at-age information is from an old Dutch monitoring scheme from the 1980s. Figure 22.2.3 shows the métiers with numbers at age samples for the landings in 2017. Approximately 65% of the landings in weight are sampled in Subarea 4. Allocations to calculate the age structure were done separately for discards and landings and were done per quarter using the groups below.

Unsampled fleet*	**Sampled fleet****
OTB and SSC	OTB and TBB
OTB and TBB CRU	OTB
TBB 70–99	TBB 70–99
TBB 100–119, >= 120	TBB 100–119 & >=120
Passive gears	GNS
Others	All métiers

*** Unsampled fleet are those fleets for which no dicards or age structure is known.**

**** Sampled fleet are those fleets for which age structure is known.**

In 2018, most countries provided estimates of discards to InterCatch. However, there is very limited age sampling of the discards. Only 6% of the discards in weight are sampled. Few fish were sampled in the discards of some of the Danish métiers (<10 per métier) and the Belgian TBB 70–99 fleet (138 samples in 2017). Discards were raised by grouping metiers with small meshes apart from metiers with larger mesh sizes, and by grouping passive gears apart from active 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 99 mm 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.

Out of the 496 tonnes of estimated discards, 267 (54%) was reported data and 229 tonnes is raised in InterCatch. The proportion of landings with discards associated (same strata) is 20 percent.

22.2.6 Survey data and commercial LPUE

Two survey abundance indices, the Sole Net Survey (SNS) and the Beam Trawl Survey (BTS ISIS), and one standardised commercial LPUE abundance index based on the Dutch 80 mm beam trawl fleet (BT2), are used to tune the assessment (Table 22.3.1–3 and Figure 22.2.4).

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. After a decrease in some of the older ages and no clear indications of strong year classes since 2010, year class 2015 (ages 2 in 2016 and 3 in 2017) appear strong. Also, in 2017 an increase in recruitment (age 1) is observerd. The Dutch BT2 lpue index shows a continuous gradual increase since 2000. In 2017, the lpue remained stable compared to 2016.

There is fairly close agreement between the two survey 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 22.2.5). The SNS survey is particularly poor at picking up cohort signals, with low R^2 values on the correlations between numbers at consecutive ages. Though all correlations 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 from this index may be appropriate.

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. The Dutch BT2 lpue time-series is now standardised by building a statistical model that includes interactions in space, time and gear. Raw lpues are calculated per trip and per ICES rectangle. The fishing effort per rectangle is then taken as a weighting factor in the analysis. Only those rectangles where fishing occurred in eleven or more years are then used. This dataset amounted to 99% of all turbot catches since 1995. There is a possibility of excluding ages 1–2 from the Dutch lpue data. However, currently, this would mean to shorten the time-series of the lpue-index considerably since dissaggregated data to distinguish market categories/ages are not available before 2002. Work on providing such data further back in time could be beneficial for the assessment.

22.2.7 Biological data

All biological data used in the assessment are presented in Table 22.2.3–5.

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 22.2.6). 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.

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.

22.3 Stock assessment model

WGNSSK 2018 noted a mistake was made at the turbot inter-benchmark relating to how one of the surveys was being treated. At the benchmark it was concluded to use the Dutch BT2 lpue index as an indicator for exploitable biomass. However, the parameter configuration of the SAM assessment that was used for presenting the results and making final decisions were based on an lpue index as indicator of SSB. However, the information and codes stored on the github website (https://github.com/ices-eg/wg_IBPTur.27.4) were configured the way the interbenchmark group had agreed.

During WGNSSK 2018, the mistake was fixed. As a result the retrospective bias in the estimate of F, which was the main argument for considereing the assessment as a category 3, is much improved. With this improvement the stock has a quantitative assessment that could potentially qualify as category 1.

WGNSSK 2018 proposed to update the advice of December 2017 using the parameter configurations agreed at the inter-benchmark. However, the inter-benchmark went through a number of steps to derive the final assessment. Each new step depends on the result from the previous step / choice. These steps need to be revisited using the corrected survey treatment, and the final assessment from that procedure can be used for advisory purposes. It was proposed to organise an new inter-benchmark in 2018 in which the parameter configuration, stock category including the a short term forecast and refence point (when category 1) will be determined.

After the inter-benchmark protocol of 2017, a new assessment model (SAM) is used. More details on the data used, assumptions made and the assessment model settings can be found in the Stock Annex and in the inter-benchmark protocol report.

The 2018 assessment is still run with the agreed configurations of the 2017 inter-benchmark. As such, the assessment output (SSB) is used as the basis for advice under category 3 of the ICES DLS approach (2 over 3 rule). Note that in 2018, no new advice was requested for turbot.

22.3.1 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 and 2017 Interbenchmark report (see also tables 22.3.3–5).

Assessment settings used in the final assessment

Year	2018
Model	SAM
First tuning year	1981
Last data year	2017
Ages	1–8+
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	1981–1990, 1998, 2000–present
Discards	Not used (assumed 0)
Abundance indices	BTS-Isis 1991–2017 SNS 2004–2017
	Standardized NL-BT2 LPUE age-aggregated catchable biomass 1995–2017
Catchability in catch at age matrix independent of age for ages >=	7
Coupling of fishing mortality STATES (Row represent Catch, columns represent ages)	1 2 3 4 5 6 7 7
Use correlated random walks for the fishing mortalities (0 = independent, 1= correlation estimated)	2
Coupling of catchability PARAMETERS (Surveys)) Row represent fleets (SNS and BTS-only, lpue age-aggregated), Columns represent ages)	1 1 2 3 3 3 0 0 4 4 5 5 6 6 6 0 7 0 0 0 0 0 0 0
Coupling of fishing mortality RW VARIANCES	1 1 2 2 3 3 3 3
Coupling of log N RW VARIANCES	1 2 2 2 2 2 2 2
Coupling of OBSERVATION VARIANCES (Row represent fleets (Catch, SNS, BTS, lpue age-aggregated), Columns represent ages)	1 1 2 2 2 3 3 3 4 4 5 5 5 5 0 0 6 6 6 7 8 8 8 0 9 0 0 0 0 0 0 0
LPUE time-series indicator (0=SSB, 1 = catch, 2 = exploitable biomass)	2
Stock-recruitment model code (0=RW, 1=Ricker, 2=BH)	0
Fbar ranges	2–6

22.4 Assessment model results

The stock summary is given in Table 22.4.1, while fishing mortality at age and abundance at age estimated by the assessment model are presented in tables 22.4.2 and 22.4.3, respectively. Other key model outputs are given in tables 22.4.4–9 and plotted in Figure 22.4.1–12.

22.4.1 Status of the stock

Fishing mortality was estimated at 0.32 in 2017, an decrease from 2016 (0.36). This is well below the long term geometric mean (0.52). The SSB in 2017 was estimated to be 10 368 tonnes, a small (9%) increase from 2016 which was estimated at 9478 tonnes. Both years are higher than the long term geometric mean (5969 tonnes). The estimated recruitment (age 1) for 2017 (5084) is above the geometric mean of the time series (4589). However, this estimate is based on very little data and is unlikely to be a reliable estimate.

22.4.2 Historic stock trends

SSB was at its highest in the early 1980s (possibly higher before that time for which no reliable data is available). From the mid–1980s up until the early 2000s SSB declined gradually and F increased gradually (Figure 22.4.6). The lowest observed SSB was in 1999, SSB subsequently increased and has continued to increase since. Recruitment has been variable over the time-series without a clear trend. Recent recruitment (2014 and 2015) have been well above long term mean and do now contribute to the increase in SSB.

Mean F peaked in 1994 at 0.86, but then declined to ~0.61 in 1999, before rapidly increasing again to 0.81 in 2002. After 2002, there is a steep decline in F to 0.36 in 2007. After 2007, F remains relatively stable around 0.35. These trends correspond well with the trends in fishing effort of the beam trawl fleet.

There are no clear patterns in recruitment, though values are estimated at a slightly higher level, but with more uncertainty, during the years of missing landings at age data (1990s). Recent recruitment has been at or above average.

22.4.3 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 figures 22.4.9–11. The retrospective plots in SSB, F and recruitment do not exhibit a strong negative or positive pattern.

22.5 Model diagnostics

Model diagnostics are provided in tables 22.4.4–9 and figures 22.4.1–2, 22.4.4, and 22.4.7–11. Please refer to the Turbot Inter-benchmark 2017 report for more detailed specifications.

22.6 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.

22.6.1 Effort regulations

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.

22.6.2 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.

22.6.3 Combined TAC

At present the EU provides a combined TAC for turbot and brill in the North Sea. This TAC seems largely ineffective in reducing F: increases in the stock at similar TACs lead to increased discarding. In addition, 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 is on that is not used.

22.7 References

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ICES. 2017. Report of the Inter-Benchmark Protocol for Turbot in 27.4 (IBP Turbot), June-September 2017, By correspondence. ICES CM 2017/ACOM:50. 116 pp.

Table 22.2.1. Turbot in Area 4. Catch in numbers (units: thousands).

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0	285.331	720.486	507.68	437.063	167	63.937	102.109
1982	0	151.099	935.203	238.718	149.311	261.07	87.619	138.582
1983	0	360.736	603.919	429.832	98.709	101.401	161.524	182.163
1984	0	1198.994	1131.458	287.722	145.249	55.509	52.734	180.404
1985	0	622.971	1892.42	512.482	140.266	85.414	20.374	125.378
1986	0	321.716	1274.725	604.41	158.69	58.1	25.148	107.528
1987	12.614	628.781	529.806	655.951	153.314	50.458	18.436	67.924
1988	32.12	967.155	800.312	158.813	157.029	80.299	24.982	68.7
1989	0	663.134	1157.694	351.662	155.178	81.496	31.259	68.1
1990	43.95	978.144	1054.802	311.739	163.535	74.613	100.165	112.43
1991 – 1997	NO DATA							
1998	0	398.732	855.059	351.475	71.624	29.019	8.344	14.037
1999 – 2002	NO DATA							
2003	212.204	1930.499	465.736	300.423	71.529	33.301	20.902	20.744
2004	442.127	2012.453	805.342	140.529	83.777	9.819	7.657	6.171
2005	350.492	2020.356	735.66	234.785	25.285	22.274	2.649	19.565
2006	907.696	1687.54	828.335	122.192	36.015	8.103	16.592	18.599
2007	81.09	2871.144	636.341	294.32	41.611	30.041	8.525	16.431
2008	183.135	1393.611	847.681	227.306	201.498	48.637	13.301	10.551
2009	123.723	1138.797	1063.654	459.329	97.369	27.412	12.065	20.278
2010	282.922	1425.362	391.885	314.225	174.437	89.488	31.064	19.857
2011	215.655	1985.288	616.158	113.192	140.752	78.742	32.973	24.125
2012	0	1921.386	781.969	268.443	42.728	64.314	73.481	24.878
2013	171.972	1574.794	1077.62	324.223	90.645	25.889	41.855	25.794
2014	63.778	362.687	602.217	633.041	127.337	112.876	35.203	97.305
2015	37.673	1164.122	445.213	312.619	303.01	105.12	41.36	76.375
2016	0	971.662	928.824	311.644	334.783	175.081	42.177	65.977
2017	6.292	300.58	1513.412	546.421	126.431	57.071	89.373	55.296

Table 22.2.2. Turbot in Area 4. Weights at age in the catch (units: kg).

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.346	0.742	1.282	1.939	2.682	3.481	4.308	5.932
1982	0.358	0.769	1.329	2.009	2.779	3.606	4.464	6.255
1983	0.371	0.796	1.375	2.08	2.876	3.732	4.62	6.34
1984	0.383	0.823	1.421	2.149	2.972	3.857	4.774	6.579
1985	0.395	0.849	1.466	2.217	3.066	3.978	4.924	7.014
1986	0.407	0.873	1.509	2.281	3.155	4.095	5.068	7.57
1987	0.418	0.897	1.549	2.342	3.239	4.204	5.203	7.955
1988	0.428	0.918	1.586	2.398	3.316	4.304	5.326	7.138
1989	0.436	0.937	1.618	2.447	3.384	4.391	5.435	7.627
1990	0.444	0.952	1.645	2.488	3.441	4.465	5.527	7.456
1991	0.449	0.965	1.667	2.52	3.485	4.523	5.598	7.738
1992	0.453	0.973	1.681	2.542	3.516	4.562	5.647	7.805
1993	0.455	0.977	1.688	2.552	3.53	4.581	5.67	7.837
1994	0.455	0.976	1.686	2.55	3.527	4.577	5.665	7.831
1995	0.452	0.97	1.676	2.535	3.506	4.55	5.631	7.783
1996	0.447	0.959	1.657	2.506	3.465	4.497	5.566	7.694
1997	0.439	0.943	1.629	2.463	3.406	4.42	5.471	7.562
1998	0.429	0.922	1.592	2.408	3.33	4.322	5.349	7.278
1999	0.418	0.897	1.55	2.344	3.241	4.206	5.206	7.196
2000	0.405	0.87	1.503	2.272	3.143	4.079	5.048	6.978
2001	0.392	0.841	1.453	2.197	3.038	3.943	4.88	6.745
2002	0.378	0.811	1.401	2.118	2.93	3.802	4.706	6.505
2003	0.364	0.781	1.349	2.04	2.821	3.661	4.531	6.276
2004	0.35	0.751	1.297	1.962	2.713	3.521	4.358	5.738
2005	0.336	0.722	1.247	1.886	2.609	3.385	4.19	5.382
2006	0.324	0.695	1.2	1.814	2.509	3.257	4.031	5.963
2007	0.312	0.669	1.155	1.747	2.417	3.136	3.882	5.219
2008	0.301	0.645	1.115	1.686	2.331	3.026	3.745	5.273
2009	0.291	0.624	1.078	1.631	2.255	2.927	3.622	5.072
2010	0.282	0.606	1.046	1.582	2.188	2.84	3.515	4.863
2011	0.275	0.59	1.019	1.541	2.132	2.767	3.424	4.43
2012	0.269	0.578	0.998	1.509	2.086	2.708	3.351	4.409
2013	0.265	0.568	0.982	1.484	2.053	2.664	3.298	4.239
2014	0.262	0.563	0.972	1.469	2.032	2.638	3.264	4.382
2015	0.261	0.561	0.968	1.465	2.026	2.629	3.254	4.527
2016	0.262	0.563	0.972	1.471	2.034	2.639	3.267	4.602
2017	0.265	0.57	0.984	1.489	2.059	2.672	3.307	4.635

Table 22.2.3. Turbot in Area 4. Weights at age in the stock (units: kg)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.334	0.716	1.238	1.871	2.588	3.359	4.158	5.725
1982	0.346	0.742	1.282	1.939	2.682	3.48	4.308	6.037
1983	0.358	0.768	1.327	2.007	2.776	3.602	4.458	6.118
1984	0.37	0.794	1.371	2.074	2.868	3.722	4.607	6.349
1985	0.381	0.819	1.415	2.139	2.959	3.839	4.752	6.768
1986	0.393	0.843	1.456	2.202	3.045	3.952	4.891	7.305
1987	0.403	0.865	1.495	2.26	3.126	4.057	5.021	7.677
1988	0.413	0.886	1.530	2.314	3.200	4.153	5.140	6.889
1989	0.421	0.904	1.561	2.361	3.266	4.238	5.245	7.361
1990	0.428	0.919	1.588	2.401	3.321	4.309	5.334	7.196
1991	0.434	0.931	1.608	2.432	3.364	4.365	5.403	7.468
1992	0.437	0.939	1.622	2.453	3.393	4.403	5.450	7.532
1993	0.439	0.943	1.629	2.463	3.407	4.421	5.472	7.563
1994	0.439	0.942	1.628	2.461	3.404	4.417	5.467	7.557
1995	0.436	0.937	1.618	2.446	3.383	4.391	5.435	7.511
1996	0.431	0.926	1.599	2.418	3.344	4.34	5.372	7.425
1997	0.424	0.910	1.572	2.377	3.287	4.266	5.280	7.297
1998	0.414	0.890	1.537	2.324	3.214	4.171	5.162	7.023
1999	0.403	0.866	1.496	2.262	3.128	4.059	5.024	6.945
2000	0.391	0.840	1.450	2.193	3.033	3.936	4.872	6.734
2001	0.378	0.812	1.402	2.120	2.932	3.805	4.710	6.510
2002	0.365	0.783	1.352	2.044	2.828	3.67	4.542	6.278
2003	0.351	0.754	1.302	1.968	2.722	3.533	4.373	6.057
2004	0.338	0.725	1.252	1.893	2.618	3.398	4.205	5.537
2005	0.325	0.697	1.204	1.820	2.518	3.267	4.044	5.194
2006	0.312	0.670	1.158	1.751	2.422	3.143	3.89	5.755
2007	0.301	0.646	1.115	1.686	2.332	3.027	3.746	5.037
2008	0.29	0.623	1.076	1.627	2.250	2.920	3.614	5.089
2009	0.281	0.602	1.041	1.574	2.176	2.824	3.496	4.894
2010	0.272	0.585	1.01	1.527	2.112	2.741	3.392	4.693
2011	0.265	0.569	0.984	1.488	2.057	2.670	3.305	4.275
2012	0.260	0.557	0.963	1.456	2.014	2.613	3.234	4.255
2013	0.255	0.548	0.947	1.433	1.981	2.571	3.182	4.091
2014	0.253	0.543	0.938	1.418	1.961	2.545	3.150	4.229
2015	0.252	0.541	0.935	1.413	1.955	2.537	3.140	4.369
2016	0.253	0.543	0.938	1.419	1.963	2.547	3.153	4.441
2017	0.256	0.550	0.950	1.437	1.987	2.579	3.192	4.473

Table 22.2.4. Turbot in Area 4. Natural mortality at age and maturity at age.

Age	1	2	3	4	5	6	7	8
natural mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
maturity	0	0.04	0.47	0.95	1	1	1	1

Table 22.2.5. Turbot in Area 4. Fraction of harvest before spawning and fraction of natural mortality before spawning.

Age	1	2	3	4	5	6	7	8
Harvest	0	0	0	0	0	0	0	0
Natural mortality	0	0	0	0	0	0	0	0

Table 22.3.1. Turbot in Area 4. SNS survey index

	Age					
Year	1	2	3	4	5	6
2004	186.515	27.029	18.756	4.090	2.998	3.422
2005	75.391	155.548	23.663	0.000	0.000	0.000
2006	196.154	97.472	14.868	3.614	1.089	0.000
2007	89.742	55.605	33.782	11.845	1.324	0.000
2008	52.090	99.743	40.828	11.867	10.922	1.200
2009	26.267	20.311	5.646	14.467	5.090	0.000
2010	96.019	35.812	9.257	5.367	3.700	6.756
2011	116.690	36.889	0.000	0.000	0.000	1.690
2012	39.858	33.511	9.464	1.232	0.000	0.000
2013	110.160	16.116	15.640	0.440	0.000	0.000
2014	102.714	18.306	9.447	6.165	4.741	1.200
2015	273.794	45.873	2.000	2.000	0.000	0.000
2016	52.833	115.686	26.710	2.000	1.310	0.500
2017	275.408	51.376	56.126	0.500	0.000	0.500

Table 22.3.2. Turbot in Area 4. BTS survey index

	Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	1.227	1.665	0.217	0.024	0.014	0.000	0.012
1992	1.361	1.178	0.320	0.034	0.015	0.011	0.003
1993	1.680	1.406	0.185	0.052	0.045	0.002	0.001
1994	1.830	1.580	0.102	0.031	0.006	0.003	0.003
1995	1.833	0.607	0.101	0.012	0.009	0.003	0.000
1996	0.615	1.901	0.113	0.075	0.040	0.000	0.009
1997	0.669	1.308	0.378	0.026	0.038	0.013	0.012
1998	1.915	0.916	0.233	0.152	0.005	0.000	0.001
1999	1.243	1.181	0.195	0.095	0.017	0.003	0.001
2000	4.214	0.847	0.386	0.164	0.054	0.055	0.000
2001	1.044	1.410	0.129	0.152	0.000	0.000	0.040
2002	2.814	0.493	0.146	0.046	0.032	0.022	0.001
2003	1.543	0.875	0.101	0.054	0.000	0.012	0.011
2004	2.166	0.640	0.359	0.000	0.069	0.017	0.000
2005	1.143	1.538	0.526	0.116	0.036	0.006	0.012
2006	1.705	0.799	0.273	0.114	0.005	0.000	0.000
2007	1.342	0.902	0.563	0.280	0.090	0.060	0.000
2008	1.196	1.125	0.431	0.143	0.076	0.017	0.080
2009	0.972	0.420	0.346	0.281	0.152	0.050	0.005
2010	1.691	0.348	0.099	0.070	0.089	0.015	0.015
2011	1.840	0.892	0.163	0.063	0.065	0.017	0.000
2012	0.977	0.930	0.240	0.236	0.021	0.045	0.084
2013	0.668	0.585	0.456	0.158	0.018	0.037	0.041
2014	2.270	0.176	0.225	0.321	0.120	0.050	0.014
2015	4.279	1.163	0.192	0.088	0.099	0.000	0.012
2016	0.774	1.909	0.451	0.056	0.035	0.037	0.024
2017	2.654	0.460	0.843	0.058	0.013	0.014	0.039

Table 22.3.3. Turbot in Area 4. Dutch_BT2_LPUE survey index (biomass)

Year	
1995	0.0422
1996	0.0369
1997	0.0372
1998	0.0345
1999	0.0344
2000	0.044
2001	0.0456
2002	0.0453
2003	0.0468
2004	0.0476
2005	0.0471
2006	0.0484
2007	0.0642
2008	0.0666
2009	0.0659
2010	0.0583
2011	0.0592
2012	0.0733
2013	0.0751
2014	0.0745
2015	0.0871
2016	0.0968
2017	0.0927

Table 22.3.4. Turbot in Area 4. Stock object and SAM configuration settings

Configuration settings	2018 assessment
Model	SAM
First tuning year	1981
Last data year	2017
Ages	1–8+
Plus group	Yes
fbar	2–6
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	1981–1990, 1998, 2000–present
Discards	Not used (assumed 0)
Abundance indices	BTS-Isis 1991–2017 SNS 2004–2017
	Standardized NL-BT2 lpue age-aggregated catchable biomass 1995–2017

Table 22.3.5. Turbot in Area 4. SAM configuration settings

FLSAM.version	2.1.0
FLCore.version	2.6.7
R version	3.4.3 (2017-11-30)
Platform	i386-w64-mingw32/i386 (32-bit)
run.date	2018-05-02 11:48:55

Min Age
1
Max Age
8
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

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	1	2	3	3	3	0	0
4	4	5	5	6	6	6	0
7	0	0	0	0	0	0	0

Coupling of power law model EXPONENTS
(not used)
Coupling of fishing mortality RW VARIANCES

1	2	2	3	3	3	3	3

Coupling of log N RW VARIANCES

1	2	2	2	2	2	2	2

Coupling of OBSERVATION VARIANCES
Row represent fleets (Catch, SNS, BTS, lpue age-aggregated), Columns represent ages.

1	1	2	2	2	3	3	3
4	4	5	5	5	5	0	0
6	6	6	7	8	8	8	0
9	0	0	0	0	0	0	0

Coupling of SURVEY CORRELATION CORRECTION BY AGE
Row represent fleets (Catch, SNS, BTS, lpue age-aggregated), Columns represent correlated ages.

NA	NA	NA	NA	NA	NA	NA	NA
0	0	0	0	0	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA

Stock–recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
0
Indicator for LPUE time series (biomass treatment) (0 = SSB, 1 = catch, 2 = exploitable biomass)
2
Years in which catch data are to be scaled by an estimated parameter
(Catch not scaled)
Define F_{BAR} range
2–6

Table 22.4.1a. Recruitement (Age 1) of turbot in Area 4. (Thousands)

YEAR	VALUE	LOW	HIGH
1981	2847.279	1960.633	4134.887
1982	4242.082	3035.467	5928.334
1983	5853.494	4110.812	8334.944
1984	4956.406	3457.38	7105.37
1985	2852.39	1984.409	4100.027
1986	3390.042	2424.243	4740.606
1987	3684.571	2634.695	5152.803
1988	3853.046	2687.169	5524.761
1989	4547.594	2887.47	7162.192
1990	5569.703	3440.16	9017.486
1991	5053.675	3182.052	8026.151
1992	4683.355	2908.669	7540.841
1993	5061.899	3188.127	8036.952
1994	4155.288	2642.948	6533.016
1995	4861.686	3287.452	7189.759
1996	3370.165	2361.883	4808.88
1997	3073.113	2150.816	4390.904
1998	4033.922	2783.892	5845.244
1999	3651.458	2443.796	5455.916
2000	5518.498	3735.861	8151.752
2001	4247.708	2717.103	6640.537
2002	6318.404	4454.749	8961.725
2003	5199.998	3786.625	7140.918
2004	6130.993	4569.148	8226.712
2005	4758.03	3553.234	6371.335
2006	6531.284	4877.63	8745.574
2007	5142.526	3798.724	6961.7
2008	3480.294	2495.365	4853.979
2009	3979.648	2929.345	5406.533
2010	5457.441	4102.394	7260.068
2011	6637.519	4814.067	9151.651
2012	4235.549	3082.891	5819.174
2013	3570.585	2563.237	4973.819
2014	6447.111	4692.522	8857.762
2015	8735.722	6057.542	12597.99
2016	3659.999	2360.008	5676.078
2017	5084.035	2885.047	8959.094

Table 22.4.1b. Total and Spawning stock Biomass of turbot in Area 4.

Year	TSB	Low	High	SSB	Low	High
1981	19681	15800	24515	15414	11797	20141
1982	18591	14803	23348	13917	10432	18568
1983	18495	14833	23060	12594	9354	16958
1984	19161	15601	23532	11573	8636	15509
1985	18656	15369	22647	11503	8809	15020
1986	16429	13477	20028	10940	8391	14262
1987	14716	11974	18085	9712	7302	12919
1988	14124	11593	17207	8366	6248	11201
1989	14719	12038	17998	8449	6354	11235
1990	14536	11494	18384	7367	5416	10021
1991	14315	10624	19290	6117	4218	8871
1992	13734	10135	18610	5635	3926	8087
1993	12641	9391	17015	5076	3607	7144
1994	11346	8598	14971	4238	3030	5928
1995	10323	8222	12959	3770	2810	5057
1996	9510	7726	11707	3301	2498	4363
1997	9314	7700	11267	3697	2987	4577
1998	9192	7707	10963	3973	3320	4755
1999	9386	7539	11685	3906	3027	5039
2000	10397	8344	12954	4321	3354	5565
2001	10265	8249	12773	4122	3216	5285
2002	10082	8190	12411	3899	3141	4840
2003	9352	7935	11022	3188	2633	3860
2004	8828	7570	10295	2927	2372	3613
2005	8470	7204	9959	2948	2343	3710
2006	8960	7600	10564	3350	2633	4261
2007	10214	8810	11842	4322	3457	5403
2008	10646	9116	12432	5398	4330	6730
2009	10444	8767	12442	6368	5055	8023
2010	10246	8469	12396	6264	4816	8148
2011	10889	8916	13299	5927	4446	7903
2012	11710	9603	14279	6420	4835	8523
2013	11967	9794	14622	7452	5721	9707
2014	12943	10571	15848	8865	6858	11458
2015	14890	12045	18406	9077	6813	12094
2016	16083	13061	19804	9478	7056	12731
2017	15812	12750	19610	10368	7948	13524

Table 22.4.1c. Fbar (Ages 2–6) and landings (tonnes) of turbot in Area 4.

Year	Fbar	Low	High	Land	Land
1981	0.3763	0.2987	0.4741	4755	1
1982	0.3696	0.2956	0.462	4453	1
1983	0.4089	0.3279	0.5098	4575	1
1984	0.4504	0.3612	0.5617	5297	1
1985	0.5061	0.4049	0.6325	6188	1
1986	0.4871	0.3867	0.6137	5263	1
1987	0.4532	0.359	0.5722	4271	1
1988	0.4476	0.3525	0.5682	4041	1
1989	0.5892	0.4714	0.7366	4927	1
1990	0.7286	0.565	0.9396	5750	1
1991	0.7823	0.5978	1.0239	6340	-0.0067
1992	0.822	0.626	1.0793	5933	-0.0072
1993	0.8589	0.6548	1.1266	5546	-0.0077
1994	0.8619	0.6649	1.1174	5244	-0.0082
1995	0.8387	0.6478	1.0858	4671	-0.0091
1996	0.7332	0.5864	0.9167	3644	-0.0116
1997	0.6866	0.5374	0.8771	3382	-0.0123
1998	0.6581	0.5238	0.8269	3086	1
1999	0.6128	0.476	0.7891	3187	-0.0124
2000	0.6373	0.4935	0.8229	4025	-0.0095
2001	0.6985	0.5521	0.8839	4100	-0.009
2002	0.8096	0.6262	1.0467	3749	-0.0095
2003	0.75	0.6051	0.9296	3374	1
2004	0.6469	0.5135	0.8149	3317	1
2005	0.514	0.4056	0.6513	3195	1
2006	0.3952	0.308	0.5071	2976	1
2007	0.3598	0.2795	0.4631	3509	1
2008	0.3797	0.296	0.4871	3005	1
2009	0.3997	0.3096	0.516	3089	1
2010	0.3924	0.3062	0.5029	2692	1
2011	0.3532	0.2756	0.4527	2771	1
2012	0.3184	0.2483	0.4083	2914	1
2013	0.3139	0.2451	0.4022	2982	1
2014	0.3065	0.2403	0.391	2834	1
2015	0.3108	0.2403	0.4018	2922	1
2016	0.3598	0.2735	0.4733	3493	1
2017	0.3226	0.2423	0.4295	3441	1

Table 22.4.2. Turbot in Area 4. Estimated fishing mortality (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.004	0.114	0.615	0.535	0.321	0.296	0.227	0.227
1982	0.003	0.107	0.585	0.520	0.326	0.309	0.243	0.243
1983	0.004	0.129	0.610	0.562	0.385	0.358	0.277	0.277
1984	0.005	0.174	0.667	0.597	0.429	0.384	0.282	0.282
1985	0.005	0.207	0.733	0.668	0.506	0.417	0.284	0.284
1986	0.005	0.212	0.701	0.644	0.484	0.395	0.273	0.273
1987	0.006	0.219	0.688	0.590	0.423	0.346	0.254	0.254
1988	0.007	0.250	0.705	0.538	0.405	0.340	0.266	0.266
1989	0.009	0.338	0.890	0.688	0.593	0.438	0.337	0.337
1990	0.010	0.391	1.020	0.818	0.800	0.614	0.491	0.491
1991	0.012	0.415	1.069	0.874	0.878	0.674	0.538	0.538
1992	0.014	0.470	1.116	0.904	0.909	0.710	0.578	0.578
1993	0.017	0.566	1.177	0.929	0.909	0.715	0.600	0.600
1994	0.020	0.608	1.204	0.925	0.880	0.692	0.597	0.597
1995	0.022	0.625	1.174	0.901	0.834	0.660	0.593	0.593
1996	0.018	0.401	1.005	0.821	0.790	0.649	0.609	0.609
1997	0.016	0.296	0.870	0.769	0.800	0.697	0.672	0.672
1998	0.016	0.263	0.802	0.724	0.786	0.715	0.723	0.723
1999	0.018	0.268	0.752	0.684	0.704	0.656	0.696	0.696
2000	0.027	0.422	0.821	0.709	0.675	0.560	0.576	0.576
2001	0.037	0.596	0.904	0.768	0.695	0.530	0.511	0.511
2002	0.058	0.998	1.004	0.835	0.722	0.489	0.444	0.444
2003	0.062	0.933	0.939	0.791	0.657	0.429	0.379	0.379
2004	0.072	0.894	0.866	0.701	0.476	0.297	0.243	0.243
2005	0.065	0.630	0.738	0.585	0.358	0.259	0.228	0.228
2006	0.056	0.482	0.569	0.433	0.262	0.230	0.233	0.233
2007	0.040	0.432	0.504	0.383	0.253	0.227	0.216	0.216
2008	0.041	0.441	0.497	0.393	0.313	0.256	0.209	0.209
2009	0.046	0.605	0.537	0.387	0.262	0.209	0.178	0.178
2010	0.043	0.573	0.523	0.381	0.265	0.221	0.182	0.182
2011	0.034	0.490	0.480	0.359	0.238	0.199	0.167	0.167
2012	0.026	0.410	0.442	0.347	0.212	0.181	0.152	0.152
2013	0.023	0.412	0.418	0.346	0.216	0.179	0.142	0.142
2014	0.012	0.303	0.390	0.355	0.259	0.225	0.180	0.180
2015	0.007	0.258	0.382	0.368	0.309	0.236	0.177	0.177
2016	0.005	0.237	0.411	0.444	0.434	0.274	0.185	0.185
2017	0.003	0.164	0.378	0.427	0.399	0.246	0.170	0.170

Table 22.4.3. Turbot in Area 4. Estimated population abundance (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	2847.28	3114.48	1604.19	1304.89	1781.81	737.45	365.26	605.09
1982	4242.08	2227.29	2284.50	686.32	617.12	1069.26	450.79	644.66
1983	5853.49	3489.50	1602.43	1041.38	333.67	368.60	648.74	711.97
1984	4956.41	5026.25	2541.22	735.74	473.64	184.29	213.27	834.59
1985	2852.39	4206.57	3524.40	1081.97	351.48	250.84	101.44	640.90
1986	3390.04	2151.86	2942.73	1328.90	446.37	175.15	132.98	461.61
1987	3684.57	2786.61	1333.59	1298.56	535.09	219.72	96.23	370.37
1988	3853.05	3088.63	1821.96	551.43	573.32	282.11	126.56	301.44
1989	4547.59	3037.03	1970.60	754.18	305.97	321.39	160.05	271.74
1990	5569.70	3675.90	1739.85	635.79	313.78	143.82	179.71	258.92
1991	5053.68	4705.61	2041.38	496.36	225.67	114.89	64.47	220.02
1992	4683.36	4180.01	2571.96	569.39	168.54	75.68	47.68	136.10
1993	5061.90	3754.61	2152.97	679.33	191.05	55.12	29.77	84.51
1994	4155.29	4184.73	1659.29	547.39	218.67	62.58	22.27	51.44
1995	4861.69	3131.65	1828.04	397.85	182.77	75.16	25.68	33.29
1996	3370.17	4060.62	1287.21	464.81	134.47	67.30	32.55	26.78
1997	3073.11	2761.71	2230.64	369.93	167.20	49.77	29.83	26.64
1998	4033.92	2464.23	1660.59	777.00	138.50	60.76	19.88	24.18
1999	3651.46	3276.32	1535.02	592.61	316.94	50.95	24.00	17.45
2000	5518.50	2775.30	2097.66	623.18	244.43	136.75	21.67	16.93
2001	4247.71	4399.79	1385.18	745.13	257.44	100.32	66.59	17.80
2002	6318.40	3198.47	1996.05	443.40	279.18	108.81	47.77	42.07
2003	5200.00	5042.14	915.02	609.98	151.81	108.67	55.79	48.62
2004	6130.99	3931.37	1610.62	284.37	230.62	59.67	56.68	55.86
2005	4758.03	4615.90	1319.79	521.55	106.04	114.75	33.38	75.84
2006	6531.28	3574.26	2005.81	455.55	213.86	59.10	72.92	72.48
2007	5142.53	5105.61	1853.11	1020.97	233.11	141.87	39.06	92.15
2008	3480.29	4379.20	2714.45	882.15	601.09	150.06	93.56	83.38
2009	3979.65	2561.45	2469.63	1475.01	503.40	319.08	91.35	118.00
2010	5457.44	3283.39	1051.55	1176.44	820.78	331.08	202.96	139.14
2011	6637.52	4233.50	1632.87	471.78	684.79	512.44	212.09	217.83
2012	4235.55	5625.89	2184.95	899.38	271.09	451.35	356.95	277.80
2013	3570.59	3405.50	3440.52	1147.60	531.70	191.31	318.58	421.51
2014	6447.11	2485.85	2017.54	2109.82	677.10	375.07	140.50	556.56
2015	8735.72	5314.27	1539.22	1234.96	1302.80	446.61	247.89	496.68
2016	3660.00	7661.06	3258.24	868.31	783.34	796.33	285.02	504.24
2017	5084.04	2747.65	5110.54	1639.10	436.44	388.10	504.10	516.72

Table 22.4.4a. Turbot in Area 4. Predicted catch numbers at age (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	9.128	305.691	674.598	494.451	446.033	172.047	67.605	111.993
1982	12.987	205.545	925.584	254.479	156.592	259.165	88.614	126.723
1983	20.413	384.573	670.279	409.393	97.271	101.075	142.757	156.670
1984	21.286	731.035	1133.582	302.892	150.896	53.613	47.652	186.477
1985	13.822	715.314	1679.297	483.093	127.533	78.045	22.804	144.075
1986	16.671	373.334	1360.226	577.752	156.581	52.089	28.967	100.551
1987	18.569	499.337	607.829	529.567	168.610	58.562	19.624	75.528
1988	24.239	621.474	844.792	209.861	174.250	74.152	26.866	63.989
1989	36.521	793.280	1067.880	343.791	125.252	104.100	41.758	70.900
1990	51.270	1085.206	1025.239	326.297	158.642	60.421	63.680	91.746
1991	53.004	1459.211	1236.306	266.022	121.291	51.655	24.534	83.732
1992	58.540	1432.590	1596.277	311.740	92.546	35.295	19.158	54.682
1993	78.491	1483.719	1375.813	378.179	104.919	25.813	12.296	34.900
1994	74.150	1745.432	1073.272	304.011	117.704	28.658	9.165	21.170
1995	96.279	1332.166	1166.710	217.326	94.978	33.268	10.510	13.625
1996	53.806	1223.947	751.698	239.067	67.435	29.448	13.596	11.184
1997	43.536	644.848	1191.510	182.198	84.574	22.913	13.376	11.946
1998	57.601	519.617	840.948	367.195	69.209	28.474	9.385	11.417
1999	57.815	700.941	744.318	269.154	146.944	22.457	11.035	8.022
2000	130.896	872.073	1079.149	290.253	109.899	53.614	8.683	6.783
2001	140.803	1808.347	758.006	366.591	118.260	37.725	24.348	6.508
2002	324.985	1860.681	1164.887	230.602	131.668	38.467	15.640	13.774
2003	282.431	2814.676	512.971	306.068	67.015	34.635	16.042	13.981
2004	386.325	2136.157	858.080	131.413	79.764	13.983	11.132	10.972
2005	271.193	1976.455	632.060	211.305	29.079	23.826	6.184	14.049
2006	324.621	1248.540	796.645	146.188	44.801	11.050	13.770	13.687
2007	183.018	1635.188	670.101	296.478	47.382	26.229	6.889	16.251
2008	128.015	1424.495	970.922	261.579	146.996	30.835	16.074	14.325
2009	162.025	1063.816	938.028	431.673	105.521	54.642	13.561	17.518
2010	209.656	1310.785	391.622	339.721	173.660	59.600	30.691	21.039
2011	202.139	1499.286	568.716	129.603	132.079	84.037	29.581	30.382
2012	99.920	1726.687	713.166	240.133	47.195	67.775	45.794	35.640
2013	73.772	1048.455	1072.052	305.726	94.030	28.448	38.394	50.800
2014	69.736	592.754	594.811	574.922	140.605	68.704	21.003	83.200
2015	56.312	1101.883	445.684	346.794	315.331	85.568	36.596	73.325
2016	16.954	1468.621	1003.008	284.027	251.594	173.644	43.698	77.307
2017	13.911	377.099	1466.039	519.697	131.116	76.940	71.536	73.327

Table 22.4.4b. Turbot in Area 4. Catch at age residuals (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.000	0.184	1.278	1.514	1.499	1.141	0.033	1.349
1982	0.000	0.025	3.700	-0.058	-0.031	-0.718	-1.825	0.022
1983	0.000	1.044	-0.062	0.720	0.442	-0.049	0.117	-0.037
1984	0.000	1.835	0.530	0.274	-0.148	-0.173	-0.172	-0.886
1985	0.000	-0.146	0.652	0.434	1.000	-0.222	-0.849	-0.943
1986	0.000	-0.899	-0.317	-0.536	-0.290	-0.054	-0.644	-0.202
1987	0.337	0.493	-1.786	1.095	-1.180	-0.804	-0.175	-0.603
1988	1.101	0.722	-0.277	-1.456	0.062	0.205	0.036	-0.032
1989	0.000	-0.409	0.698	0.591	2.813	-0.429	-0.371	-0.243
1990	0.631	0.013	-0.243	-0.915	0.352	1.050	1.998	0.224
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.000	0.155	-0.495	0.310	0.453	0.050	-0.251	0.519
1999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	1.451	0.022	-1.945	0.026	-0.693	-1.017	-0.036	0.781
2004	1.134	-0.289	-0.602	-0.368	-0.398	-1.922	-2.152	-2.023
2005	0.069	-0.498	0.464	-0.475	-1.773	-0.055	-2.445	1.513
2006	1.687	0.208	-0.873	-2.390	-1.585	-0.322	1.034	0.889
2007	-2.280	1.234	-0.633	0.694	0.009	1.082	0.414	-0.634
2008	0.076	0.348	-0.486	-0.589	2.591	0.992	-0.923	-1.272
2009	-0.338	0.408	1.011	0.803	-0.569	-2.491	-0.478	0.308
2010	0.926	0.708	-0.993	-0.378	0.174	1.505	-0.314	-0.399
2011	-0.177	0.475	0.898	-1.123	0.284	-0.265	0.079	-1.042
2012	0.000	0.054	0.218	1.256	-0.911	-0.020	1.264	-1.668
2013	-0.017	0.359	0.676	0.363	-0.034	0.161	0.215	-2.205
2014	-1.178	-1.485	0.454	1.494	0.342	1.917	1.832	0.348
2015	-1.296	0.756	0.286	0.472	1.041	0.323	-0.113	-0.114
2016	0.000	-0.656	-0.124	1.153	2.672	-0.320	-0.496	-0.621
2017	-2.093	-0.443	0.895	-0.118	-0.624	-1.301	0.674	-0.861

Table 22.4.5a. Turbot in Area 4. Predicted index at age SNS (units: na).

	Age					
Year	1	2	3	4	5	6
2004	103.085	37.039	9.784	0.891	0.847	0.248
2005	80.401	52.359	8.776	1.773	0.423	0.491
2006	111.032	45.015	15.023	1.724	0.913	0.258
2007	88.434	66.597	14.538	4.001	1.002	0.621
2008	59.792	56.784	21.400	3.433	2.476	0.643
2009	68.153	29.586	18.927	5.766	2.149	1.414
2010	93.635	38.771	8.137	4.619	3.497	1.455
2011	114.617	52.999	13.025	1.881	2.973	2.287
2012	73.543	74.535	17.897	3.617	1.198	2.041
2013	62.142	45.069	28.677	4.618	2.344	0.866
2014	113.081	35.502	17.143	8.434	2.897	1.644
2015	153.750	78.343	13.157	4.892	5.381	1.941
2016	64.508	114.697	27.276	3.261	2.963	3.371
2017	89.739	43.305	43.816	6.230	1.691	1.676

Table 22.4.5b. Turbot in Area 4. Index at age residuals SNS

	Age					
Year	1	2	3	4	5	6
2004	0.504	-1.010	0.982	1.142	0.636	1.960
2005	-0.665	1.888	0.271	0.000	0.000	0.000
2006	0.790	0.931	-0.341	0.844	-0.301	0.000
2007	0.388	-0.250	1.300	0.978	-0.316	0.000
2008	-0.447	1.653	0.217	0.931	0.728	-0.134
2009	-1.200	-0.493	-0.737	1.760	0.559	0.000
2010	0.612	0.145	-0.108	0.182	-0.032	1.539
2011	0.477	-0.493	0.000	0.000	0.000	-0.264
2012	-1.134	-0.012	-0.151	-0.725	0.000	0.000
2013	0.526	-1.647	0.392	-2.238	0.000	0.000
2014	0.989	-1.531	0.123	0.063	0.666	-0.599
2015	2.037	-1.217	-1.663	0.183	0.000	0.000
2016	-1.215	1.009	-0.237	-0.652	-0.651	-1.484
2017	2.283	-1.132	0.185	-3.005	0.000	-0.671

Table 22.4.6a. Turbot in Area 4. Predicted index at age BTS-ISIS

	Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	1.6421	1.1504	0.1910	0.0533	0.0174	0.0102	0.0063
1992	1.5194	0.9830	0.2328	0.0598	0.0127	0.0066	0.0045
1993	1.6383	0.8256	0.1867	0.0702	0.0144	0.0048	0.0028
1994	1.3424	0.8930	0.1412	0.0567	0.0168	0.0055	0.0021
1995	1.5681	0.6605	0.1588	0.0419	0.0145	0.0068	0.0024
1996	1.0904	1.0027	0.1260	0.0518	0.0110	0.0061	0.0030
1997	0.9957	0.7343	0.2402	0.0428	0.0136	0.0044	0.0027
1998	1.3069	0.6704	0.1876	0.0927	0.0114	0.0053	0.0017
1999	1.1815	0.8886	0.1796	0.0727	0.0276	0.0046	0.0021
2000	1.7745	0.6752	0.2338	0.0751	0.0217	0.0132	0.0021
2001	1.3555	0.9469	0.1456	0.0862	0.0226	0.0099	0.0066
2002	1.9865	0.5184	0.1956	0.0489	0.0240	0.0110	0.0050
2003	1.6310	0.8557	0.0938	0.0694	0.0137	0.0115	0.0061
2004	1.9092	0.6860	0.1738	0.0345	0.0236	0.0069	0.0068
2005	1.4891	0.9697	0.1559	0.0687	0.0118	0.0137	0.0041
2006	2.0564	0.8337	0.2669	0.0667	0.0255	0.0072	0.0089
2007	1.6379	1.2334	0.2583	0.1549	0.0279	0.0173	0.0048
2008	1.1074	1.0517	0.3802	0.1329	0.0690	0.0179	0.0116
2009	1.2622	0.5480	0.3363	0.2232	0.0599	0.0394	0.0115
2010	1.7342	0.7181	0.1446	0.1788	0.0975	0.0406	0.0256
2011	2.1228	0.9816	0.2314	0.0728	0.0829	0.0638	0.0270
2012	1.3621	1.3805	0.3180	0.1400	0.0334	0.0569	0.0459
2013	1.1509	0.8347	0.5095	0.1788	0.0654	0.0241	0.0413
2014	2.0944	0.6575	0.3046	0.3265	0.0808	0.0458	0.0177
2015	2.8476	1.4510	0.2338	0.1894	0.1500	0.0541	0.0313
2016	1.1947	2.1243	0.4846	0.1263	0.0826	0.0940	0.0358
2017	1.6620	0.8020	0.7785	0.2412	0.0471	0.0467	0.0640

Table 22.4.6b. Turbot in Area 4. Index at age residuals BTS-ISIS

	Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	-0.6189	0.7388	-0.8888	-2.3111	-0.8217	0.0000	0.0860
1992	-0.1173	0.4900	0.2376	-1.2816	-0.2319	-0.1098	-0.8832
1993	0.2349	0.7343	-0.5348	-0.8152	0.9924	-1.4101	-1.5796
1994	0.1813	0.7261	-1.6004	-0.7975	-0.8015	-0.1941	0.7285
1995	0.0293	-1.0455	-0.9635	-1.2951	0.3600	-0.0332	0.0000
1996	-1.5801	1.8062	-0.2591	1.1734	1.8422	0.0000	1.3573
1997	-0.6043	1.5199	1.2442	-0.6097	1.2355	1.1383	1.5387
1998	1.3241	0.5548	0.6436	0.9725	-1.0067	0.0000	-0.4867
1999	-0.1265	0.4305	0.0049	0.5437	-0.2353	-0.4236	-0.6513
2000	1.8278	-0.6705	0.7313	1.1587	1.0689	1.8923	0.0000
2001	-1.2518	-0.0454	-1.6390	0.3100	0.0000	0.0000	2.1470
2002	1.0809	-1.6687	-1.6109	-0.8058	-0.0466	0.6699	-1.6465
2003	-0.5093	0.1184	0.0161	-0.5137	0.0000	-0.0803	0.8147
2004	-0.2467	-0.0934	1.4663	0.0000	0.9679	0.5643	0.0000
2005	-1.0072	0.4841	2.2774	0.4560	1.0079	-1.0478	0.9264
2006	-0.5924	-0.1876	0.5920	0.9544	-1.8360	0.0000	0.0000
2007	0.0700	-0.2120	2.3867	1.2969	1.2984	1.2993	0.0000
2008	-0.0300	0.4608	0.5032	0.0570	-0.1426	-0.1706	2.0911
2009	0.0013	-0.9961	0.2823	0.5542	1.1474	0.1263	-1.0396
2010	0.5333	-0.8934	-0.8111	-1.2370	-0.0324	-1.1596	-0.7572
2011	0.1783	0.2141	-0.2704	-0.1276	-0.1700	-1.4062	0.0000
2012	-0.6138	0.2441	-0.0933	1.0866	-0.2845	-0.1495	0.5702
2013	-1.5112	0.3017	0.7089	0.0990	-1.2282	0.6543	-0.0173
2014	1.2981	-2.5644	0.1398	0.3440	0.5028	0.1142	-0.1825
2015	1.6570	0.0104	0.0183	-0.7579	-0.3700	0.0000	-0.9295
2016	-1.5422	0.4203	-0.2096	-1.3875	-0.9881	-0.8653	-0.3775
2017	1.0858	-1.6124	0.0431	-2.3360	-1.4763	-1.3324	-0.5533

Table 22.4.7. Turbot in Area 4. Predicted index at age and index at age residuals of the Dutch LPUE

Year	Index	Resid
1995	0.0419	0.3995
1996	0.0372	-0.7979
1997	0.0381	-1.6327
1998	0.0347	-0.3619
1999	0.0360	-0.3593
2000	0.0441	-0.0447
2001	0.0468	-0.2130
2002	0.0449	0.1461
2003	0.0454	0.9412
2004	0.0468	-0.7710
2005	0.0495	-2.5076
2006	0.0517	-1.1507
2007	0.0634	0.6343
2008	0.0676	-0.0022
2009	0.0643	0.1739
2010	0.0564	1.5838
2011	0.0606	0.4514
2012	0.0733	1.6122
2013	0.0763	1.7469
2014	0.0738	1.9943
2015	0.0792	2.5943
2016	0.0892	1.4666
2017	0.0936	-0.2087

Table 22.4.8. Turbot in Area 4. Fit parameters

NAME	VALUE	STD.DEV
logFpar	-3.89382	0.164534
logFpar	-4.35182	0.287846
logFpar	-5.13075	0.278005
logFpar	-7.88268	0.090129
logFpar	-8.3822	0.102178
logFpar	-8.7106	0.189212
logFpar	-9.84312	0.108586
logSdLogFsta	-0.93991	0.202549
logSdLogFsta	-1.8749	0.217032
logSdLogFsta	-1.48466	0.212035
logSdLogN	-0.9774	0.219721
logSdLogN	-2.10222	0.344117
logSdLogObs	-0.73445	0.215957
logSdLogObs	-1.7743	0.235146
logSdLogObs	-1.06235	0.141245
logSdLogObs	-0.42437	0.169095
logSdLogObs	0.068209	0.121605
logSdLogObs	-0.85482	0.100816
logSdLogObs	-0.42723	0.162268
logSdLogObs	-0.07618	0.093188
logSdLogObs	-2.79846	0.621386
transfIRARdist	0.033788	0.364464
itrans_rho	0.862209	0.197536

Table 22.4.9. Turbot in Area 4. Negative Log-Likelihood

390.265

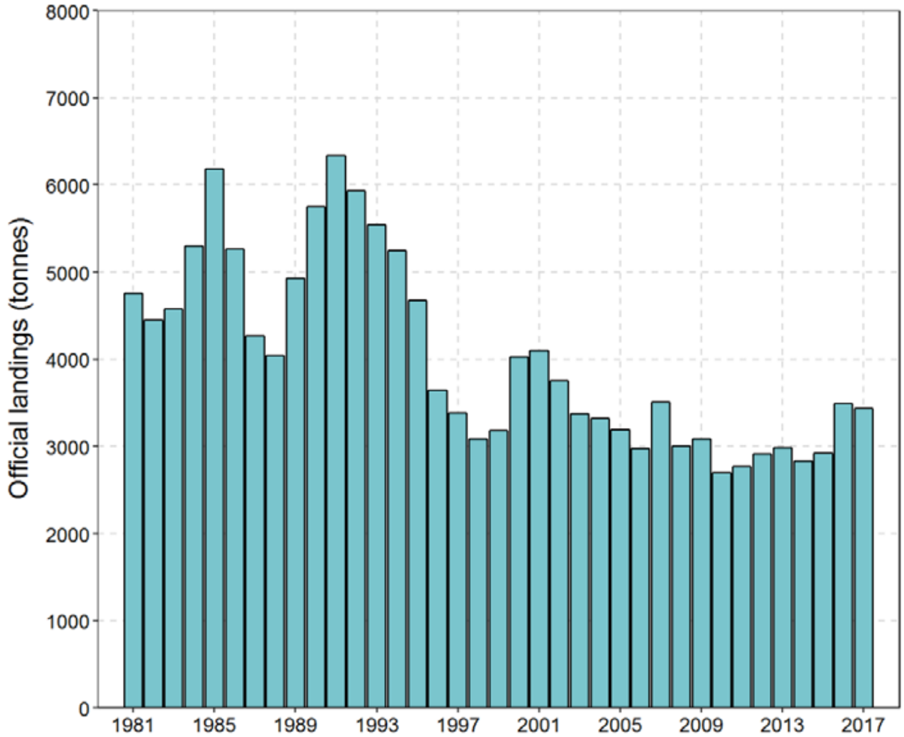


Figure 22.2.1. Turbot in 27.4.20. Total landings 1981–2017 (from the ICES database of official landings).

Figure 22.2.2. Turbot in 27.4.20. Landings at age for the years with available data between 1975–2017.

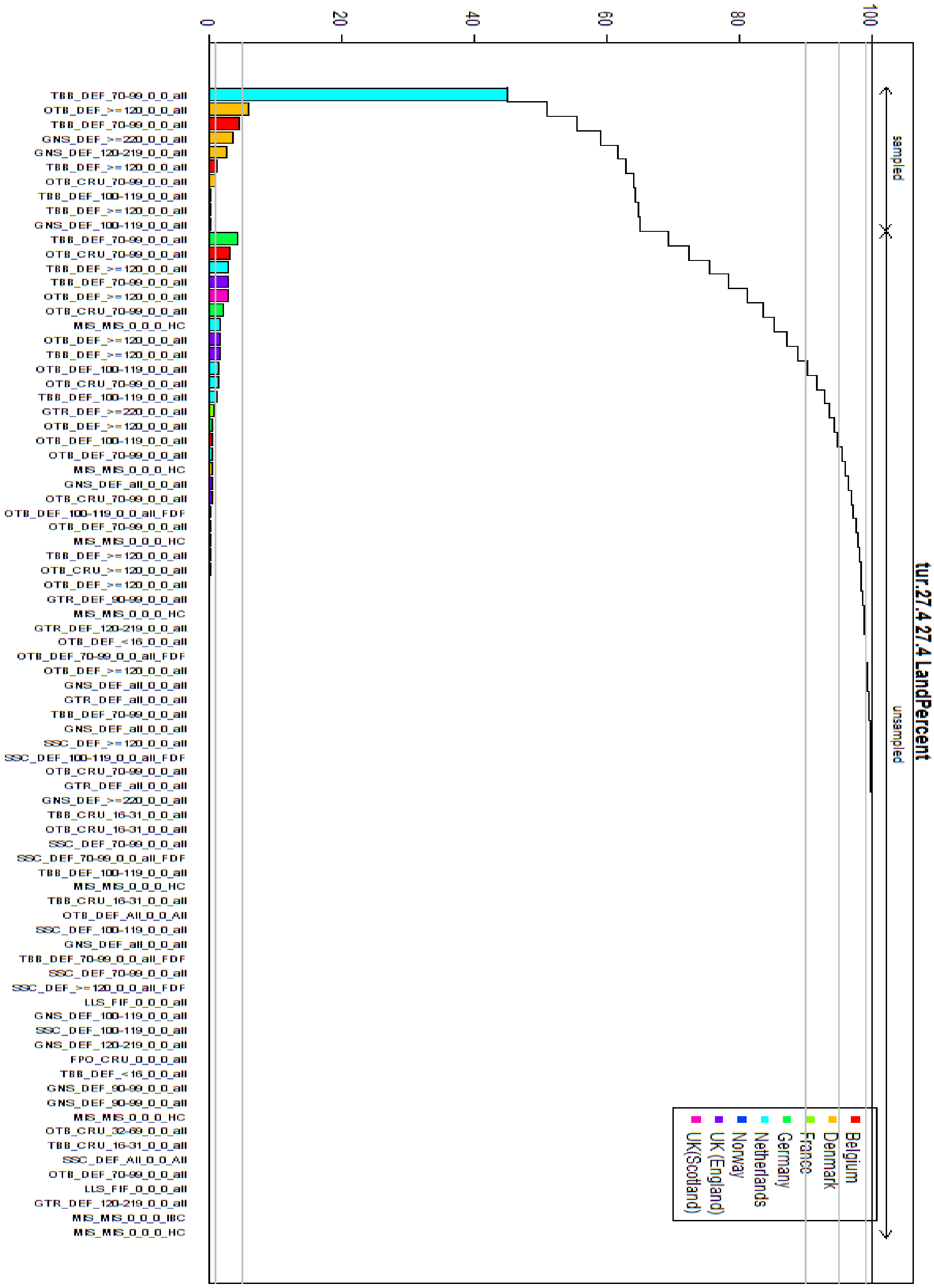


Figure 22.2.3. Turbot in 27.4.20: Total landings by métier in 2017 sorted by sampled/unsampled for numbers at age in InterCatch.

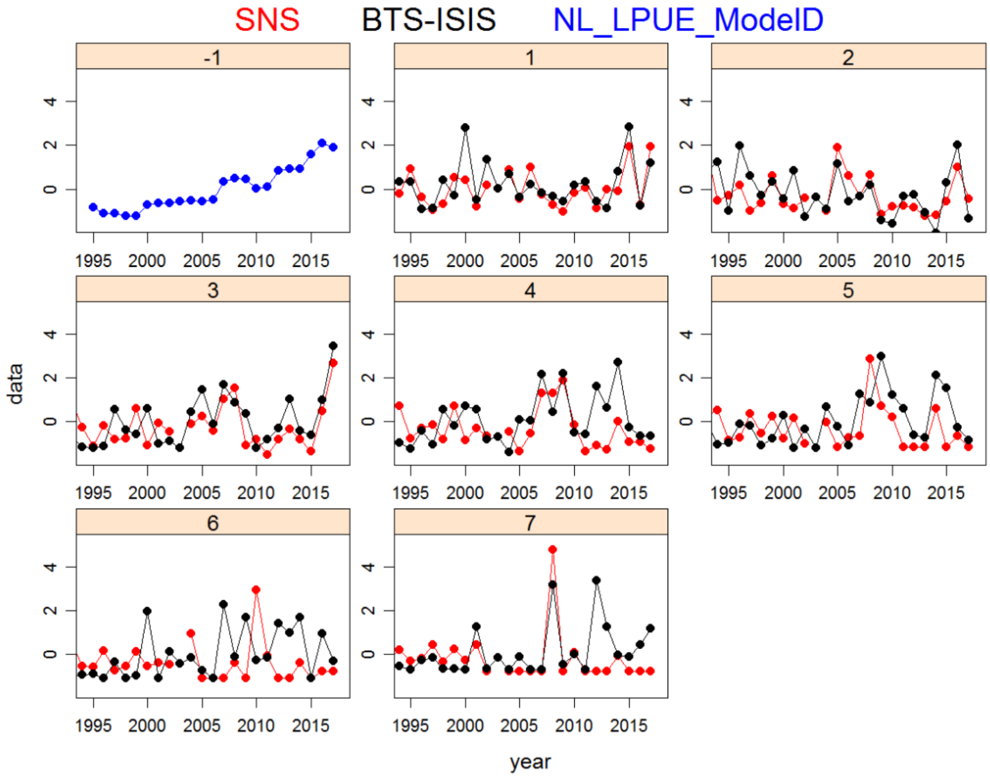
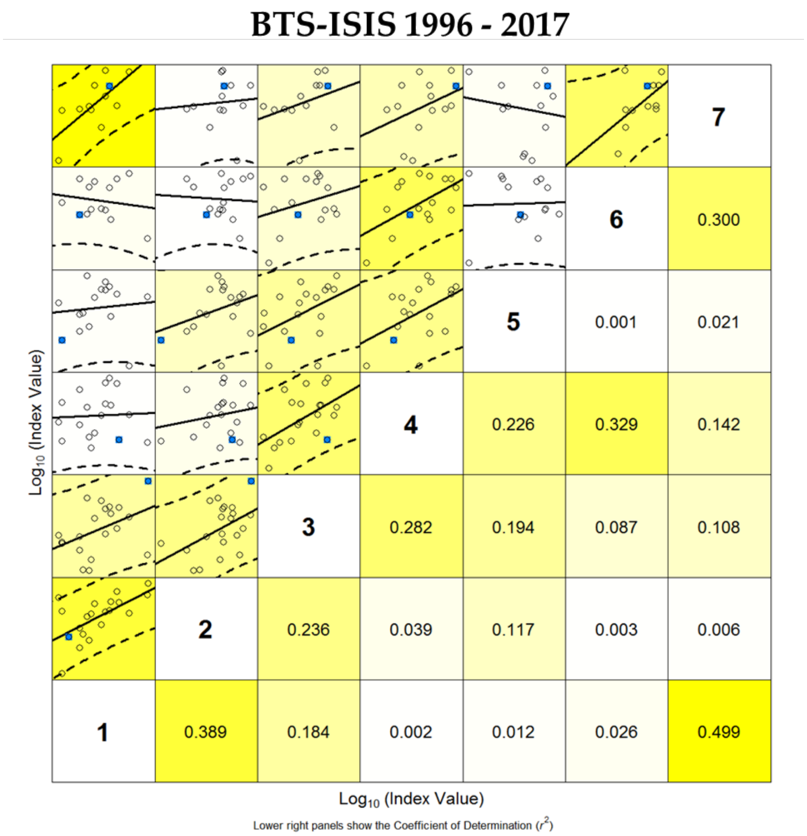


Figure 22.2.4. Turbot in 27.4.20. Time series of the standardized indices for ages 1 to 7 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE.



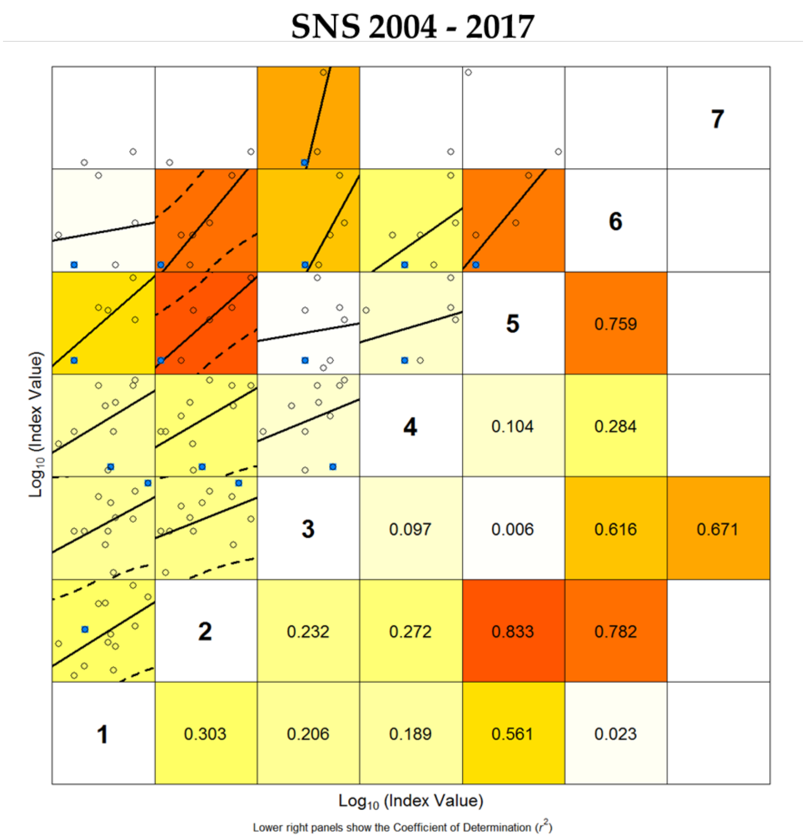


Figure 22.2.5. Turbot in 27.4.20. Internal consistency of the two tuning indices available for the assessment : BTS-ISIS (top), and SNS (bottom)

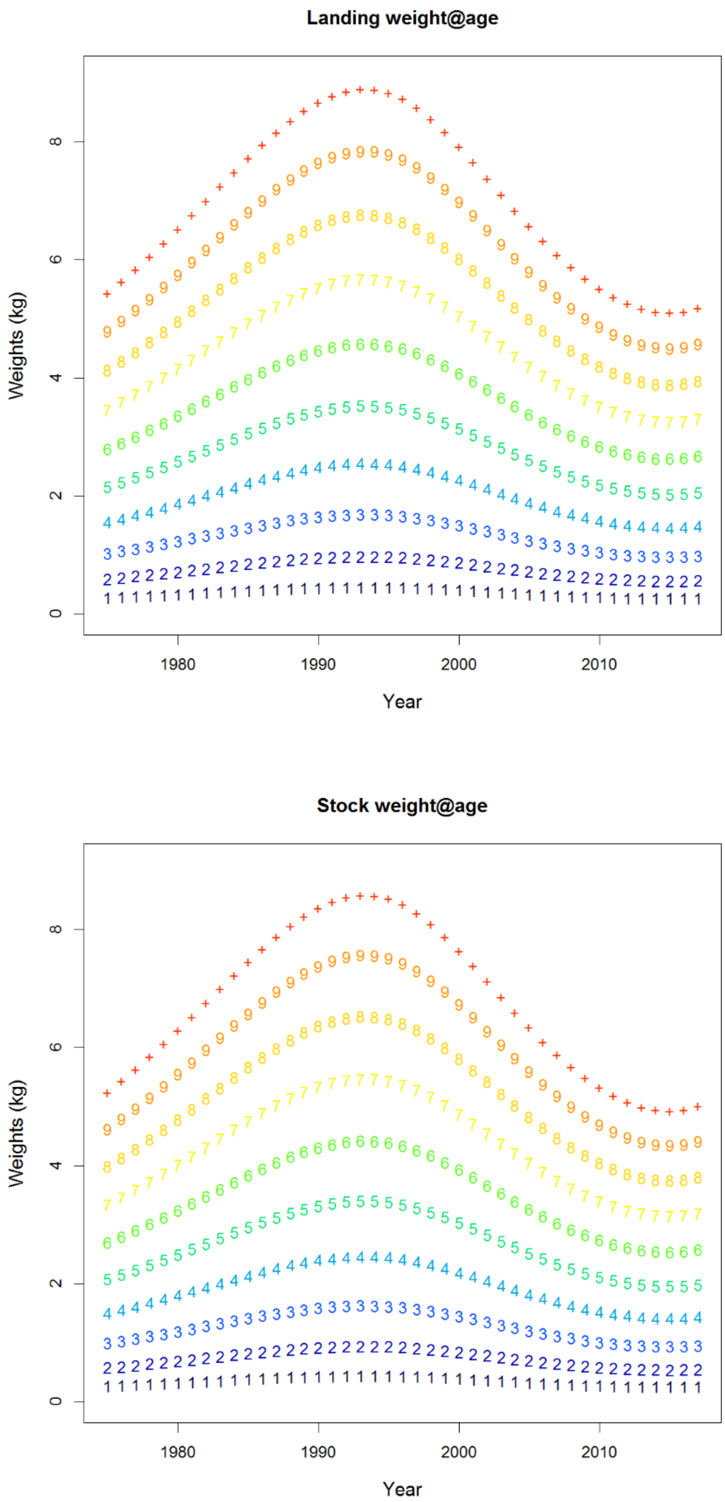


Figure 22.2.6. Landings (top) and stock (bottom) weight at age from modelled values (points).

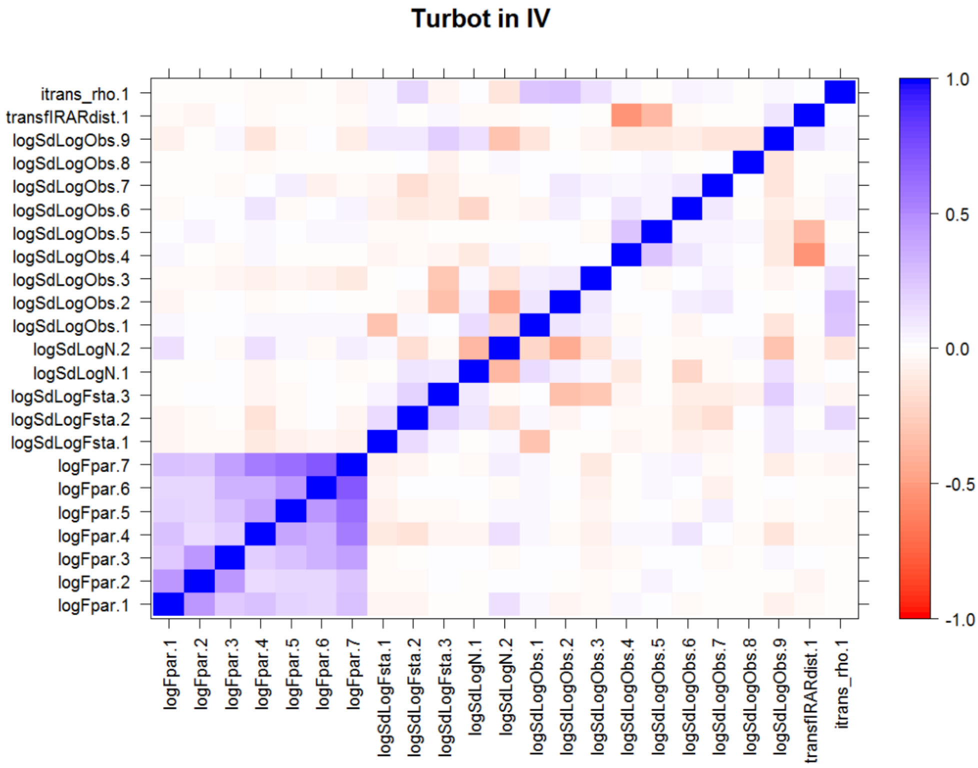


Figure 22.4.1. Parameter-correlation plot. It shows the correlation among all parameters that are estimated in the model. Fpar parameters refer to catchabilities, Fstates to the random walk in F, logN to the random walk in N, logObs to the observation variances, fRARdist to the auto-correlation in the surveys and trans_rho to the correlation in the F-random walks.

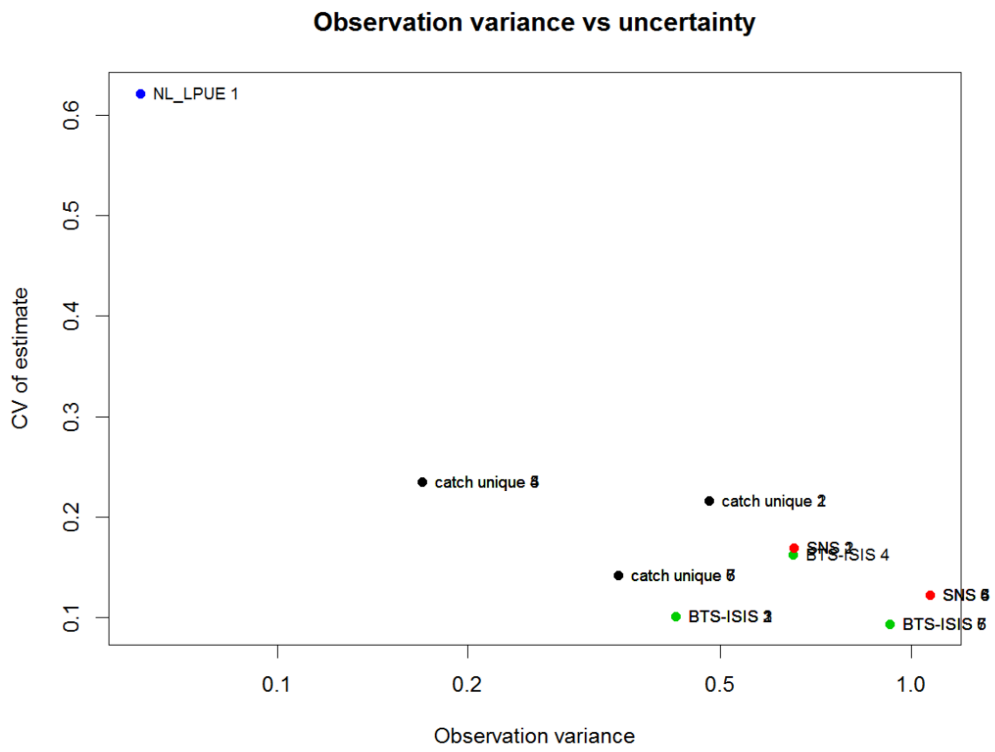


Figure 22.4.2. Plot showing the observation variance vs the CV of that estimate.

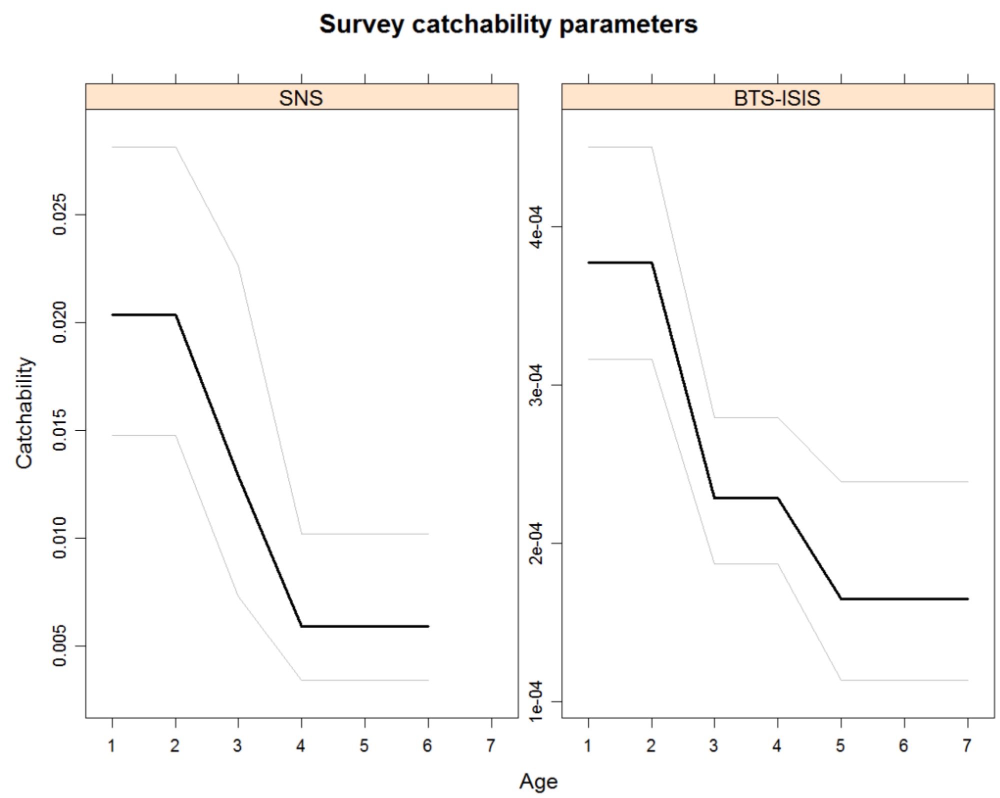


Figure 22.4.3. Catchabilities of the surveys for all surveys with more than 1 age-group.

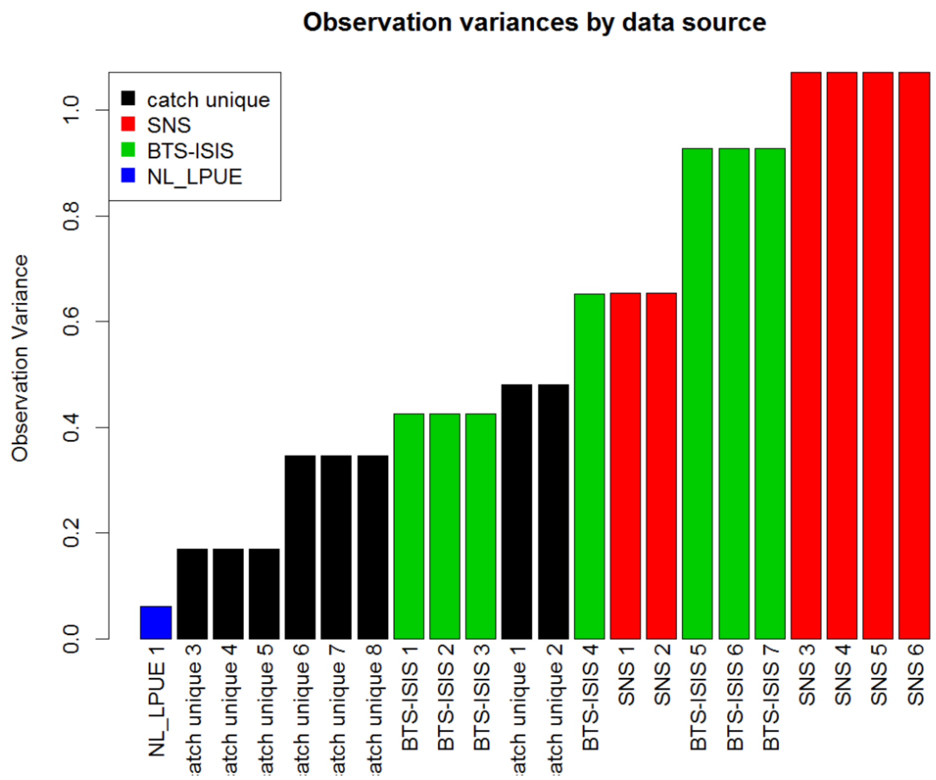


Figure 22.4.4. Estimated observation variances (scaling factor for each of the surveys), ordered from the best to the worst survey fit and has colour coding to show which bars belong to one dataset.

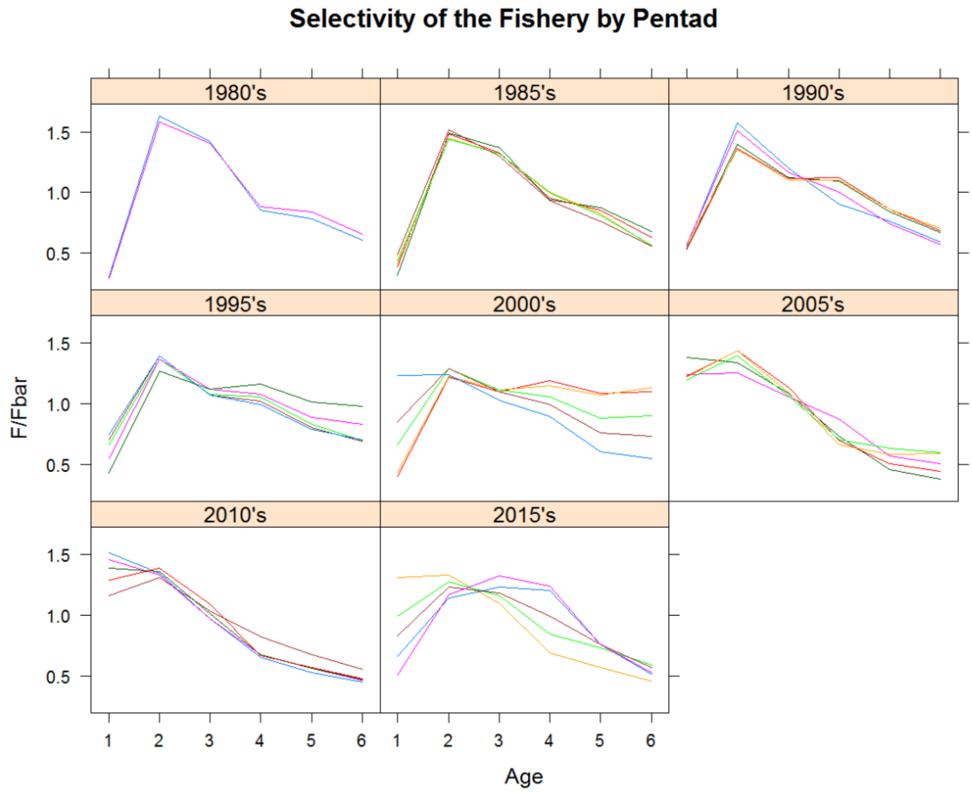


Figure 22.4.5. Estimated selectivity, grouped by a 5-year period. Values represent actual F-at-age.

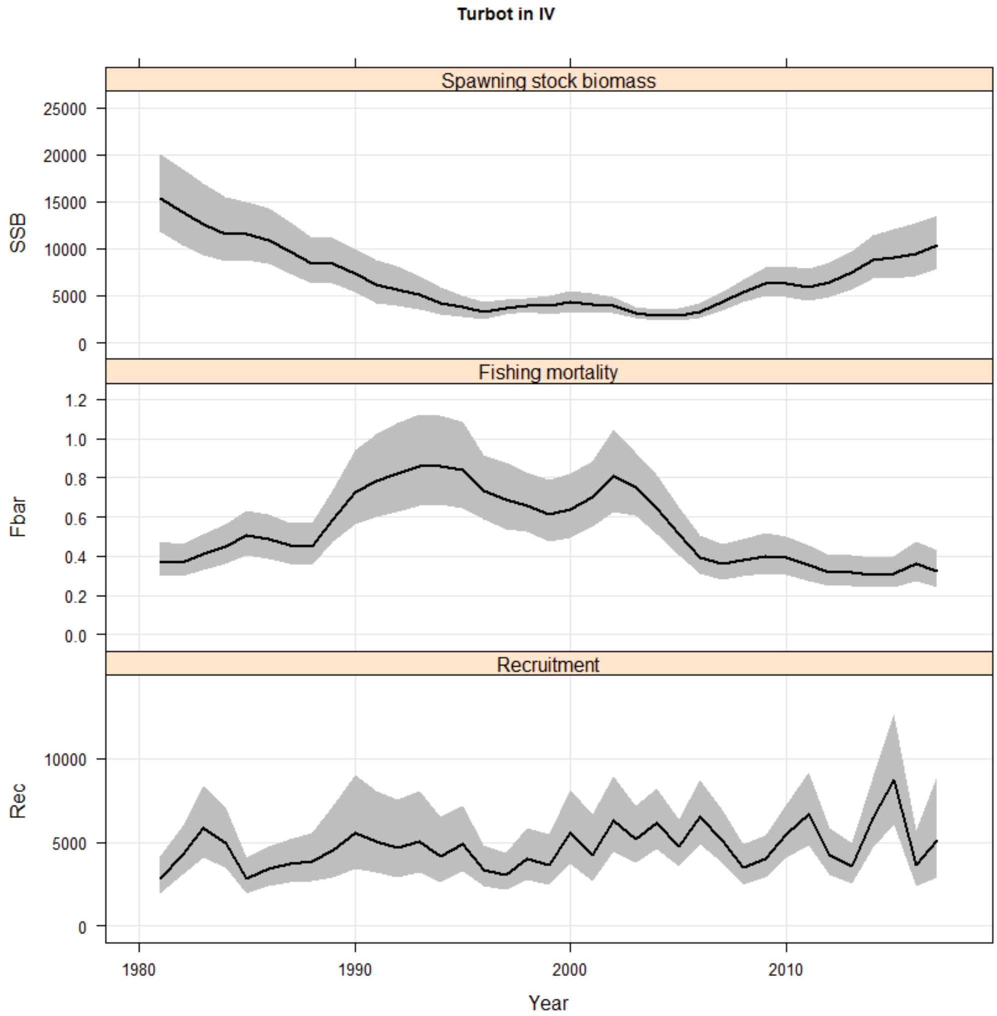


Figure 22.4.6. Summary plot of SSB, F and Recruitment, including the uncertainty bounds.

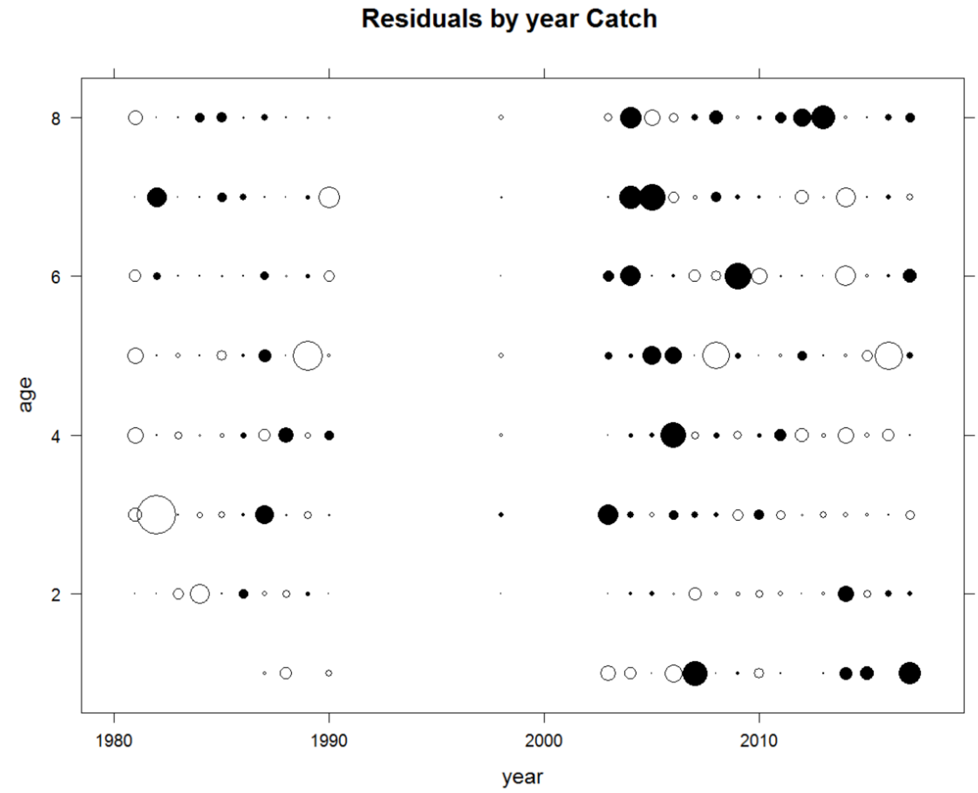


Figure 22.4.7. Residual bubble plot of catches

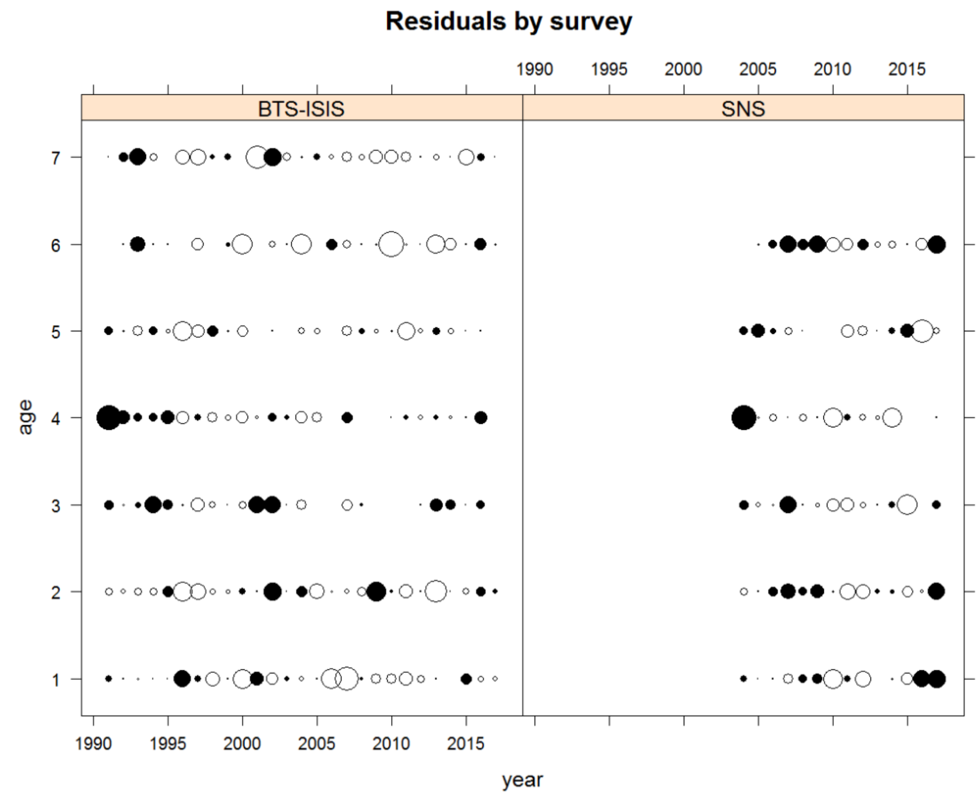


Figure 22.4.8. Residual bubble plot of SNS and BTS-ISIS survey.

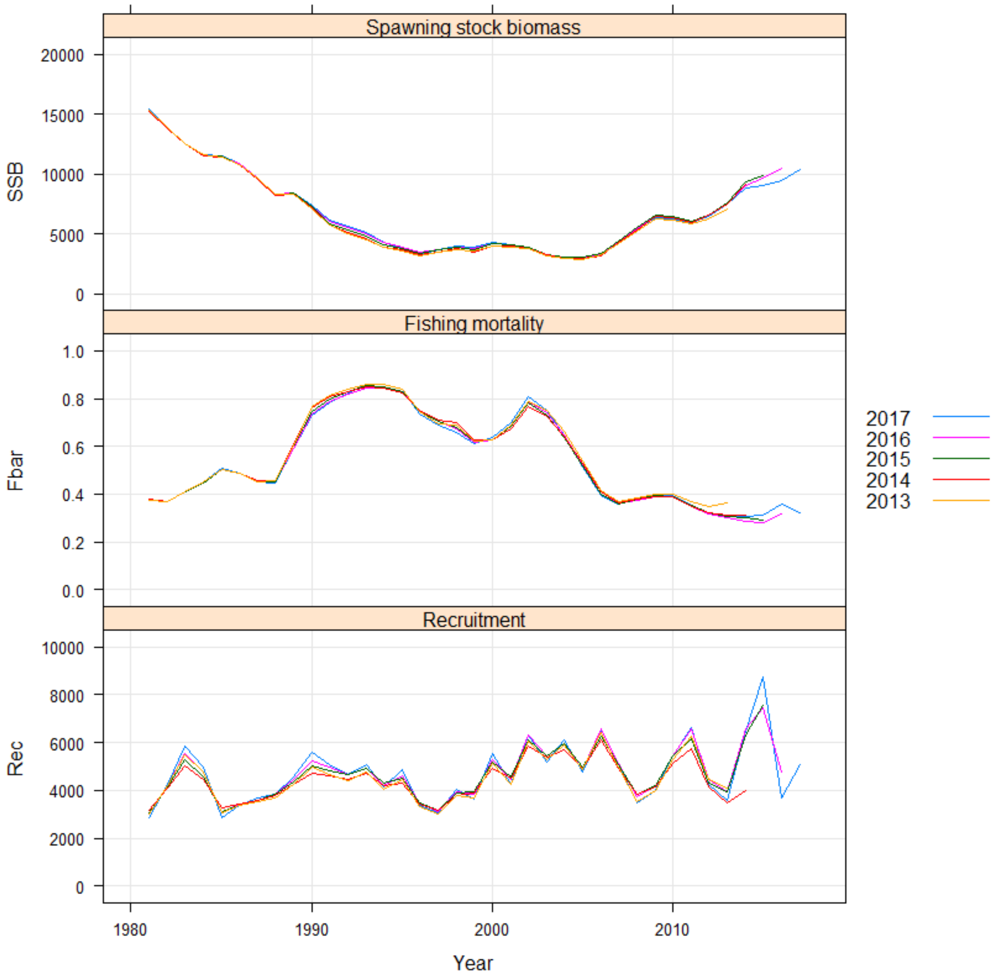


Figure 22.4.9. Retrospective analysis plot on SSB, F and R.

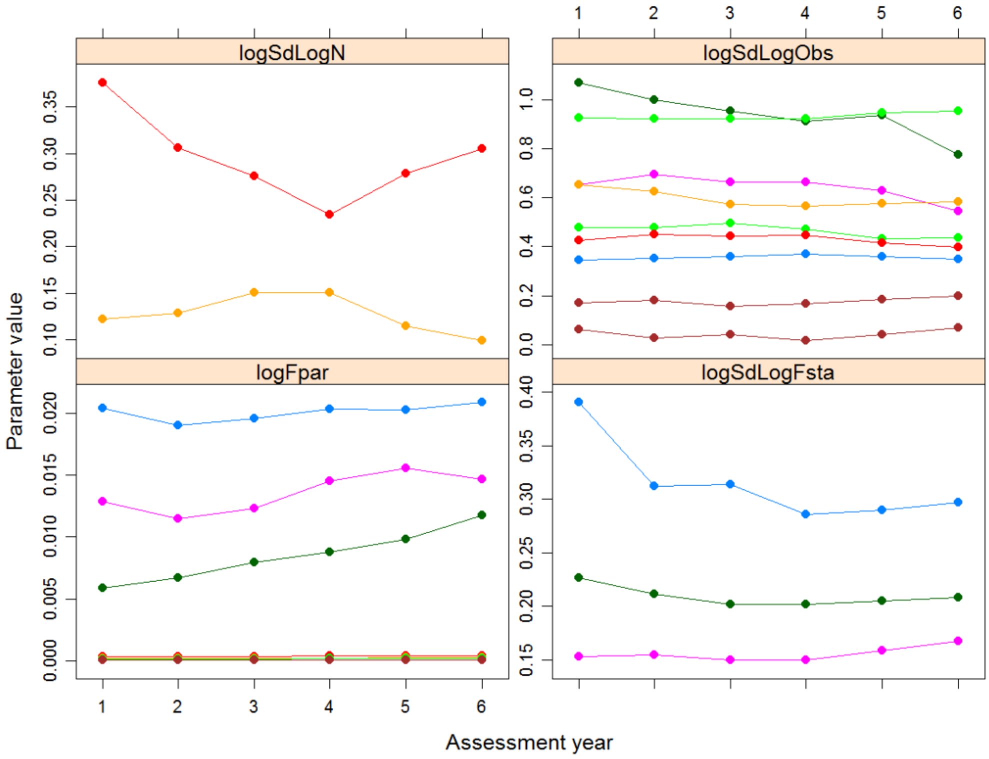


Figure 22.4.10. Retrospective analysis plot on the value of the estimated parameters, ideally, all show a flat line indicating that with reducing the model with a year's worth of data does not affect the parameters to be estimated: logSdLogN = the random walk in N, logSdLogObs is the observation variance in the surveys and catch, logFpar are the catchability parameters and logSdLogFsta are the sd's of the random walks in F.

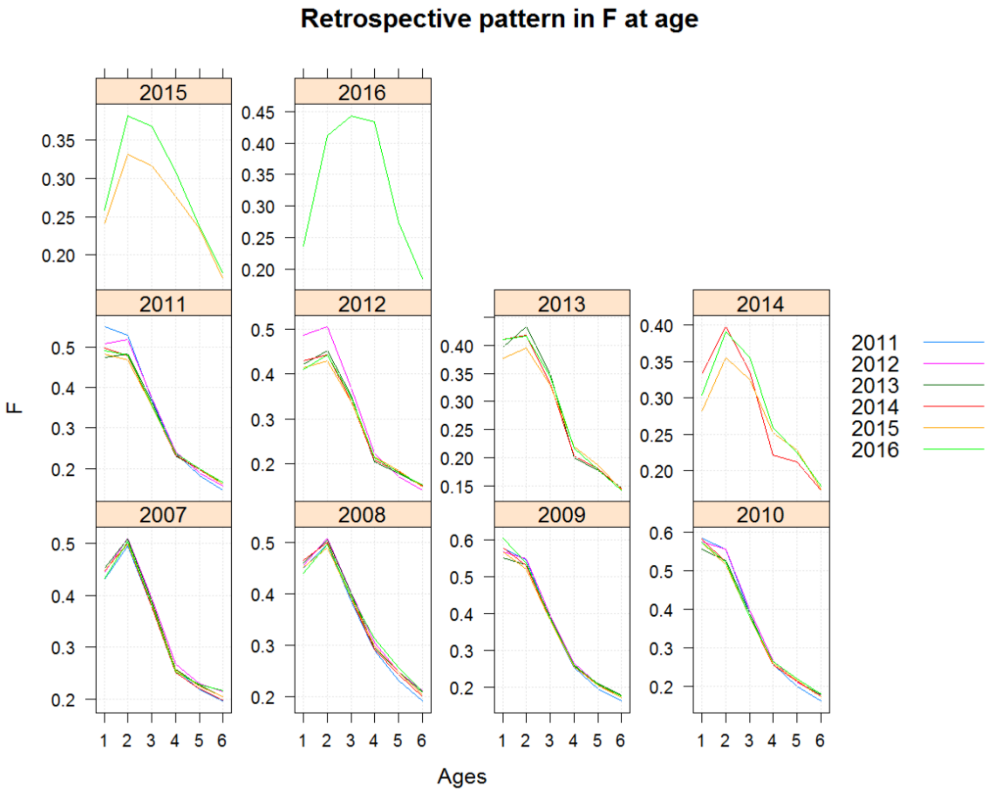


Figure 22.4.11. Retrospective analysis plot of selectivity pattern.

23 Whiting (*Merlangius merlangus*) in Subarea 4 (North Sea), Division 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

23.1 Whiting in Subarea 4 and Division 7.d

This Section contains the assessment and forecast 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 2018 (ICES 2018a). The benchmark concluded with a SAM assessment with new input data and updated reference points.

Available information on whiting in Division 3.a (Skagerrak and Kattegat) is presented in Section 23.2.

23.1.1 General

23.1.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex and in the WKNSEA 2018 benchmark report working documents (ICES, 2018a). A complex population structure for whiting in the North Sea has been proposed, based on studies about whiting movements, life-history traits, genetic data, identification of spawning aggregation, as well as on population temporal asynchrony observed in SSB, recruitment and egg abundance between areas. Exploratory SURBAR assessments were run for individual components and the combined stock. The benchmark concluded that literature and provided data did not suffice to revise management units for this stock. As before, the new assessment was run for the North Sea and Eastern Channel (27.4 and 27.7d).

23.1.1.2 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).

23.1.2 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES WKNSEA (2018a).

23.1.3 ICES advice

ICES advice for 2017

In November 2016, ICES concluded as follows:

ICES advised that when the MSY approach is applied, total catches in 2017 should be no more than 23 527 tonnes. If discard and industrial bycatch rates do not change from the average (2013–2015), this implies human consumption landings of no more than 12 679 tonnes.

ICES advice for 2018

In November 2017, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 26 804 tonnes. If unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2014–2016), this implies wanted catch of no more than 13 445 tonnes.

ICES advice for 2019

In May 2018, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 25 302 tonnes. If unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2015–2017), this implies wanted catch of no more than 13 298 tonnes and human consumption catch of no more than 22 113 tonnes.

23.1.4 Management

Management of whiting is implemtend 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 TAC for 2016 was set as a Roll-over TAC at 13 678 tonnes, for 2017 the TAC was increased to 16 003 tonnes of wanted catch for human consumption. In 2018, with introduction of the landing obligation the TAC accounts for total human consumption catch, including discards and landings below minimum landings size (BMS) but excluding industrial bycatch (IBC). The TAC in 2018 is 22 057 tonnes. There is no separate TAC for Division 7.d; landings from this Division are counted against the TAC for Divisions 7b–k combined (22 778 tonnes in 2016, 27 500 tonnes in 2017, and 22 213 tonnes in 2018). 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.

Since 2006, the landings data have been collated separately for each area. In previous years, the human consumption landings in Subarea 4 and Division 7.d were calculated as about 80% and 20% of the combined area totals, respectively. In 2017, 78% of the total landings 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 bycatch 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. Industrial bycatch occurred mainly in Subarea 4 by Danish industrial fisheries.

Conservation credit scheme

Since 2008, real time closures (RTCs) have been implemented under the Scottish Conservation Credits Scheme (CCS). 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. 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), 97 (2015) and 114 (2016). Although the scheme is intended to reduce mortality on cod, it undoubtedly has an effect on the mortality of associated species such as whiting. However, the scheme was suspended 20 November 2016 and there are no plans for its reintroduction.

In 2016, 14 Scottish demersal whitefish vessels participated in a trial Fully Documented Fishery (FDF) scheme, following similar schemes during 2010–2015. The uptake of the scheme declined due to concerns about monitoring of discards under the EU Landing Obligation. The cod-specific FDF scheme terminated at the end of 2016, due to the suspension of most aspects of the EU Cod Recovery plan which removed the opportunity for countries to provide additional quota for participants. However, a new Scottish FDF scheme has commenced, which is being run along similar lines and which is intended to monitor discarding of saithe and monkfish. There were three demersal vessels participating in the FDF scheme in 2017. Currently, there are no vessels participating in 2018.

23.1.5 Data available

23.1.5.1 Catch

Since 2009, international data on landings and discards have been collated through the InterCatch system. As additional categories logbook registered discards and BMS landings can be uploaded. In 2017, no logbook registered discards are submitted. Minor whiting landings (originating from a Norwegian OTB fisheries) are imported as BMS landing into InterCatch.

In 2017 data, 65% of the landings (here total landings include industrial bycatch) had associated discard data imported to InterCatch. The landings of métiers for which discard data was provided in 2017 are illustrated in Figure 23.1.1. Discards were raised from discard ratios from Subarea 4 and Division 7.d combined. The data were stratified by gear type (TR1 and TR2) and quarter to raise discards. The raised discards amounted to 24% of total discards (Table 21.1.3b). Industrial bycatch landings were excluded from the discard raising, as no discards occur in that fleet. Throughout this report minor BMS landings were grouped together with discards as "unwanted catch", for age allocations as well as estimation of mean weights-at-age.

Figure 23.1.2a shows métier specific landings in percent of the total landings in 2017 for whiting in Subarea 4 and Division 7.d, for fleets sampled for age compositions in landings and unsampled fleets. The Figure also shows the cumulative landings when sampled and unsampled fleets are ordered by landings yield. Sampled fleets comprise around 63% of the overall landings, from 11 métiers.

However, although the unsampled fleets provide considerable landings overall (37%), most métiers provide each less than 5% of the overall landings each. A métier summarized as miscellaneous landings of industrial bycatch (MIS_MIS_0_0_0_IBC) provides about 15% of the total landings, occurred in the Danish fishery and were not sampled.

For raising discard rates from sampled to unsampled fleets all samples were used with splitting of fleets on the basis of quarter or gear type. Discard rates for unsampled whiting fleet components were obtained from discards reported by France, UK (England, Scotland), Netherlands, Denmark, Belgium and Germany.

Of the total discards, 76% were imported into InterCatch. 50% of the imported discards were sampled for age distributions. The 17 métiers providing discard samples and unsampled métiers are listed in Figure 23.1.2b.

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 23.1.1 for the North Sea (Subarea 4) and in Table 23.1.2 for the Eastern Channel (Division 7.d).

ICES estimates of numbers and weights at age for the defined catch components (total catch, landings, unwanted catch and industrial bycatch) are given in tables 23.1.4–23.1.11. Unwanted catch represented 39% of the total catches. Figure 23.1.3 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 an increase in discards and bycatch in recent years. There continued to be high discard of whiting up to age 2 (Figure 23.1.4).

23.1.5.2 Age compositions

Age compositions in the landings and unwanted catch were based on samples provided by France, UK (England, Scotland) and Denmark. Age compositions were applied to landings with splitting of fleets on the basis of quarter (1,2 vs 3,4) and gear type (TR1 and TR2). Unwanted catch age compositions were allocated using all discard samples with splitting of fleets on the basis of gear type (TR1) and quarter (1,2 vs 3,4).

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. In recent years age compositions for industrial bycatch are estimated from all samples (wanted and unwanted catch) without splitting of fleets. Minor BMS landings (below minimum landing size) were not sampled. BMS was treated the same as discards, and age compositions are inferred from discard samples only. BMS and discards were combined as unwanted catch.

Total international catch numbers at age (Subarea 4 and Division 7.d combined) as estimated by ICES are presented in Table 23.1.4. Numbers for human consumption landings, unwanted, and industrial bycatch are given in Tables 23.1.5 to 23.1.7.

23.1.5.3 Weight at age

Mean weights at age (Subarea 4 and Division 7.d combined) in the catch are presented in Table 23.1.8. Mean weights at age (both areas combined) in human consumption landings are presented in Table 23.1.9, and for the unwanted catch and industrial bycatch in the North Sea in tables 23.1.10 and 23.1.11, respectively. Weights-at-age are depicted graphically in Figure 23.1.5, which indicates an increasing trend (with annual fluctuations) in mean weight-at-age in the landings, unwanted catch and total catch for ages >2 since the early 2000s. In recent years, mean weights at age have stabilized on the higher level. Mean weights at age in landings have decreased for ages 0 and 1 since the late 2000s.

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). From 2009 onwards, the weights at ages of total catches were used for weights at ages of industrial bycatch.

Stock mean weights at age are estimated from commercial catch weights at age scaled to the level of weights at age estimated in IBTS Q1 (Figure 23.1.6).

Unsmoothed values of weights at age are used in the assessment.

23.1.5.4 Maturity and natural mortality

Values for maturity are updated using IBTS Q1, in Table 23.1.14 and Figure 23.1.8. The estimation procedure is discussed in the Stock Annex. Values prior 1991 are assumed constant using values of 1991, due to data quality issues and high variability in results in the earlier time period.

Estimates of natural mortality (M) are taken from the 2017 update key run from of the SMS multispecies model (ICES–WGSAM 2018) (Table 23.1.15 and Figure 23.1.7). At the benchmark WKNSEA 2018, the most recent estimates of natural mortality values were smoothed. The new natural mortality values are assumed to be constant for ages 6+ (Figure 23.1.7).

23.1.5.5 Research vessel data

Survey tuning indices are presented in Table 23.1.16. The indices used in the assessment are ages 1–5 from the IBTS–Q1 and ages 0–5 from IBTS–Q3 surveys, from 1983–2018 and 1991–2017, 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 WKNSEA (2018).

In Figure 23.1.9, survey distribution maps based on the IBTS–Q1 survey in the North Sea, for ages 1–3+ of the first quarter (Q1) 2014–2018, are presented. Figure 23.1.10, the third quarter is represented (Q3) for ages 0–3+ for the years 2014–2017. For ages 2–3+ CPUE is higher along the UK east coast. Whiting at age 0 and 1 are found in the Northern North Sea and Scottish east coast as well as in the German Bight. CPUE at age 0 in Q3 is lower in 2017 than in previous years. This is confirmed by the relatively low numbers at age 1 in Q1 in 2018.

23.1.6 Benchmark

The ICES Benchmark Workshop on North Sea Stocks 2018 (WKNSEA) whiting in Subarea 4 and Division 7.d was benchmarked. The benchmark meeting was held at ICES in Copenhagen in early 2018. Analyses focused on a number of key issues: these are listed below, details can be found in WKNSEA report (ICES 2018a) and stock annex.

As before, Area 27.4 represents the management unit with TAC advice to be given. No changes were made to the use of survey indices. The maturity ogive, stock weights-at-age, and natural mortality estimates were updated with new information. Catch data was updated in Intercatch following a data call for 2009–2016 and a new stratification design to allocate discard ratios and age distributions. The assessment model was changed from XSA to SAM and new reference points were estimated.

Intercatch raising

Discard rates and sampled age distributions were investigated during the benchmark. Stratification designs to raise unsampled discards and allocate age distribution to catch components were developed. Data since 2009 was updated following a data call and reraised in Intercatch. Details of the allocation scheme can be found in the stock annex.

Length of assessment time-series

In the benchmark 2018, it was concluded that there is no reason to exclude catch data from 1978 onwards. Due to improved survey quality due to standardization survey data is included only for years since 1983.

Biological parameters

The constant maturity estimates were updated with annually varying values estimated from NS IBTS Q1 data. Area-specific maturity data were weighted by area-specific catch rates. Stock weights at age were updated instead of using commercial catch weights at age from the entire year directly, values were scaled using available weights at age from IBTS Q1. Natural mortality estimates were updated using estimates provided by WGSAM (ICES, 2018b).

Stock identity

The issue of how to define stock units for whiting that are biologically relevant remains a difficult one to address. WKNSEA evaluated the available evidence and concluded assessment should remain combined for Area 4 and Division 7.d. Area-specific SURBAR analyses were produced to determine whether estimated time-series of biomass and mortality were correlated between different areas (northern and southern component according to Holmes *et al*. 2014, see Stock Annex). Although dynamics appeared to be linked for the northern and southern component, the assessment results for the combined North Sea better reflected the status of the northern component. SSB as well as total mortality were more variable in the South with larger confidence intervals. This can be related to higher variability in maturity estimates and survey indices with lower within survey correlations between age groups of a cohort for the southern component. However in recent years, the southern component showed an upwards trend in SSB and recruitment. Therefore currently, management decisions appropriate for the combined stock are not expected to negatively impact the southern component.

WGNSSK and WKNSEA recommended, that the stock identity issue should be reviewed in the future when firm evidences become available. Until then it is recommended to monitor area-specific stock development based on survey data when it is available (recommendation in stock annex for area-specific survey indices). The feasibility of combining Subdivision 3.a with Area 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks.

Assessment models

WKNSEA concluded that the update assessment model should be updated to SAM, with supporting exploratory runs using SURBAR.

23.1.7 Data analyses

23.1.7.1 Exploratory survey-based analyses

In Figure 23.1.11, time-series of survey log CPUE at age (ages 1–8+) are presented, which suggest 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 Figure 23.1.12. These show consistent tracking of year classes (since catch curves are mostly smooth) and consistent selection with some exceptions in recent years. 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, 2012 and 2013 year class at age 1. However, numbers at age 2 in the 2007 year class may well be an overestimate.

The consistency within surveys is assessed using correlation plots in figures 23.1.13 and 23.1.14. These indicate that the IBTS–Q1 and Q3 surveys both show good internal consistency across ages. The log cpue plots by survey (Figure 23.1.15) support the conclusion of good internal consistency. Only in recent years, age 1 differs somewhat from overall pattern.

Figures 23.1.16–23.1.18 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.

23.1.7.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 23.1.19 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 are given in Figure 23.1.20. The gradients (since the 2002 year class) appear to be have been decreasing since 1990 and are fluctuating around a mean level that is lower than the mean level for more recent cohorts. This suggests that recent fishing mortality is likely to be lower than in the past. For the 2000 cohort the negative gradient of commercial catch data was lowest in the series (similar to 2010 cohort). Slopes for the catch curves were less steep for this cohort, indicating relatively higher cpue at higher ages.

Within cohort correlations between ages are presented in Figure 23.1.21. In general, catch numbers correlate well between cohorts with the relationship breaking down as cohorts are compared across increasing age gaps. Correlation were negative comparing age groups upto age 4 to ages 8+. This is due to the increased catches of older fish over the years and decreasing trends for younger age groups (Figure 23.1.19).

23.1.7.3 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 (Figure 23.1.12–14, 23.1.19–21). However, beginning with the 2006 year class, the IBTS Q1 appears to be underestimating the abundance of age 1 whiting in some years (Figure 23.1.12). In previous assessments, this had implications for the estimation of recruitment and can result in a considerable retrospective bias in recruitment.

23.1.7.4 Final assessment

The final assessment used SAM fitted to the combined landings, unwanted catch and industrial bycatch data for the period and two survey tuning indices. The used time range for input data for SAM is updated from the XSA assessment used last year, agreed at WKNSEA (ICES, 2018a). The assessment model, including input data, results and diagnostics can be found on stockassessment.org as "NSwhiting_2018".

The settings are provided below (further details can be found in the Stock Annex).

Catch-at-age data	1978–2017	ages 0–8+
Survey: IBTS Q1	1983–2018	ages 1–5
Survey: IBTS Q3	1991–2017	ages 0–5

The results of the final assessment run are illustrated in Figure 23.1.22. Estimated correlations are illustrated in Figure 23.1.23. The correlations reflect SAM settings of autocorrelations and parameter coupling, assuming independence in the catch fleet and autocorrelation in both survey fleets coupled for ages 3+.

Standardized one-observation–ahead residuals are presented in Figure 23.1.24. These show that the IBTS–Q3 survey fits more closely to the model than the IBTS–Q1 survey, which demonstrate some year effects in the 2000s and 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 Figures 23.1.27 and 28 which show the comparison of predicted and observed points for each survey fleet. The single fleet SAM runs were conducted to compare trends in the catch data with using only survey data for quarter 1 or 3 separately. The leave-one-out runs show that both surveys used were in agreement. Summary plots of these runs together with the final run are presented in Figure 23.1.29. The population trends from each survey are consistent. The mean F estimates are consistent across the time series with only some difference in most recent year's estimates. Estimates of SSB and recruitment are in some years lower when using only IBTS Q1 data in the model. The run using only quarter 3 matches more closely the final SAM run with both surveys included, because only IBTS Q3 survey delivers indices for age 0.

The joint–sample residuals for the unobserved processes show no apparent cohort effects across ages (Figure 23.1.25).

A retrospective analysis is shown in Figure 23.1.30. The retrospective patterns show that results were robust to removing up to 5 years of recent data. There is very low retrospective bias in SSB, catches, and fishing mortality. Some retrospective bias in recruitment is estimated for the most recent years. Mohn's rho measures the retrospective bias, values are given in Table 23.1.21 and confirm the relatively higher retrospective bias in recruitment. There is tendency to overestimate recruitment in the final year.

The spawning stock recruitment relationship shows no apparent pattern, confirming that the assumed random walk in recruitment in the model is appropriate (Figure 23.1.31).

Finally, Figure 23.1.32 compares the SURBAR results with the final SAM assessment. Dynamics in SAM and SURBAR are similar with higher variability in the SSB estimates from SURBAR. The comparison of recruitment shows a lag due to the difference in age (recruitment age 0 in SAM, age 1 in SURBAR. The mean Z (total mortality) estimates from SURBAR show year-to-year variation and some increase in mortality in recent years, but the trends are similar. The relative constant fishing mortality in recent years follows the relatively constant catches included in the SAM assessment.

Fishing mortality estimates at age from final SAM run are presented in Table 23.1.17. Estimated stock numbers at age are given in Table 23.1.18. The assessment summaries are presented in Table 23.1.19 for recruitment, SSB, mean F, and TSB including upper and lower ranges. Catch biomass with lower and upper range as estimated in SAM are given in Table 23.1.20.

Final SAM run model parameters are given in Table 23.1.22.

23.1.8 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 23.1.22. These show that mean F has been declining since 1990 and reached the minimum of time-series in 2005 of 0.166, but is slightly increasing in the recent years to levels above 0.2. The SSB was at extremely high levels before 1983. The medium level of 1990 has not been reached since. Some recent increase in SSB indicate that SSB to be at a similar level as in the early 2000s. Recruitment is fluctuating around a recent low average. The levels of high recruitment occurred between 1998 and 2001 have not been reached since. In the most recent year, landings, unwanted catch and industrial bycatch have also all remained at or around a recent average. The stock–recruitment plot in Figure 23.1.31 does not show a clear relationship between SSB and subsequent recruitment.

23.1.9 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. 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 in early 2016 (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.

In the WKNSEA 2018 benchmark, Eqsim was run to determine new reference points (ICES, 2018a).

This stock does not exhibit an apparent spawning stock recruitment relationship or impairment of recruitment at low levels of SSB, it is therefore the lowest observed SSB (SSB in 2007, 119 970 tonnes in the 2018 benchmark assessment) can be used as a B_{lim} reference point. In the Eqsim, the parameters sigmaF and sigmaSSB were set to default values (0.2), the average of the last 10 years of biological parameters and most recent 3 years for fisheries selectivity were used. The time series since 1983 and autocorrelation in recruitment was included. $F_{p.05}$ was calculated by running Eqsim with assessment/advice error and with advice rule to ensure that the long term risk of SSB<B_{lim} of any F used does not exceed 5% when applying the advice rule. Accordingly, F_{MSY} had to be reduced to $F_{p.05}$ = 0.172. It was found that F = 0.15 would not be precautionary without advice rule (EU–Norway Management Plan). Instead, MSY approach with F = 0.172 (with advice rule) will be applied. As a result new reference points are listed in Table 23.1.23.

23.1.10 Short-term forecasts

A short-term forecast was carried out based on the final SAM assessment. SAM survivors from 2017 were used as input population numbers for ages 1 and older in 2018. Recruitment assumptions are detailed in Table 23.1.24. In the intermediate and following two years the geometric mean of recruitment from 2002–2017 is used.

The exploitation pattern is chosen as the mean exploitation pattern over the most recent three years 2015–2017. The mean exploitation pattern was scaled to the mean F_{2-6} in 2017 for forecasts (Figure 23.1.33). 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 2015–2017. The F at age used in the forecast is compared with the F at age estimates for 2015–2017 in Figure 23.1.33.

Mean weights at age are generally consistent over the recent period but there is variability at several ages (Figure 23.1.5 and 6). To avoid introducing bias, therefore, the average of estimates of 2015–2017 are used for the purposes of forecasting. The strong trend as observed between 2000 and 2010 is not apparent in the recent three years.

The inputs to the short-term forecast are given in Table 23.1.25, and results are presented in Table 23.1.26. As in previous years, the MFDP program was used to carry out the forecasts, accounting for separate fleet for industrial bycatch. The generic forecast function within SAM will be updated for this special case in the near future.

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_{2018} to equal mean F_{2017}, results in human consumption catches in the intermediate year 2018 of 29 451 tonnes from a total catch of 32 556 tonnes, giving an SSB in 2019 of 172 124 tonnes (Table 23.1.26).

Carrying the same fishing mortality forward into 2019 (the status quo F option, F_{sq}) would result in human consumption catches of 28 481 tonnes out of total catches of 31 614 tonnes, and would result in an SSB of 167 297 tonnes in 2020 (a 2.8% decrease in SSB relative to 2019).

Applying the F_{MSY} of 0.172 in 2019 would generate human consumption catches of 22 113 tonnes out of total catches of 25 302 tonnes, and result in an SSB of 171 663 tonnes in 2020 (a 0.27% decrease in SSB relative to 2019). In 2020, SSB would be above B_{lim}. F of 0.172 would cause the TAC (relative to the TAC in 2018) to be changed by -18.3%.

23.1.11 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting.

23.1.12 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. WKNSEA (ICES, 2018a) considered the question of time series length again and concluded that the divergence between survey-based and catch-based analysis are not sufficient to exclude pre-1990 data. Survey data was included since 1983 with standardization of survey design.

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. It is recommended to run area specific SURBAR (as recommended in the Stock Annex) when area-specific indices are routinely available.

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.

In 2017, French samples for quarter 1 and 2 particularly in Subdivision 7.d are sparse due a disruption in the onshore sampling scheme. Therefore, a percentage of data was simulated randomly from previous year's data. This affected about 8% of total catch weight (landings more than discards, in particular TR2 fleet in 7.d).

There have been issues with regard to the age readings of North Sea whiting as compared to other gadoids in the past (Norway as compared to Netherlands and UK (Scotland)). This applies in particular to the age readings used for the IBTS indices. An otholith workshop took place in late 2016, to improve consistency in preparation techniques and readings (ICES WKARWHG2, 2016). This exercise showed an improvement in age reading compared to the same read in the 2015 exchange.

The historical performance of the assessment is summarized in Figure 23.1.34. The difference in SSB and recruitment is due to new benchmark model and input data. In this year's assessment recruitment is estimated at age 0 instead of age 1. SSB is estimated using new, scaled stock weights at age and maturity estimates. As the assessment model operates on numbers at age rather than biomass the new stock weights at age and maturities did not directly affect estimates of fishing mortality. Catch data and natural mortalities are updated. Estimates of fishing mortality remained at a similar level as before.

23.1.13 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 above B_{lim} since 2008 (Figure 23.1.22, 23.1.34). The stock, at the level of the entire North Sea and Eastern Channel, was at an historical low level in the late 2000s (relative to the period since 1978), and the recent increase in SSB is in large part due to relatively improved perception of recruitment in 2007–2010 and 2014–2016. All indications are that fishing mortality has been declining over most of the time-series, currently fluctuating around a low level with some increase in recent years. Since 2006, fishing mortality remained above $F_{MSY} = 0.172$, but has been below F_{pa} and F_{lim}. While landings have been relatively stable and even decreased in recent years, unwanted catch and industrial bycatch increased in recent years slightly. Recruitment is varying around a recent mean, but that mean is low relative to recruitment in the late 1990s. Recruitment in 2014–2016 was above the average of recent years. The development of whiting biomass depends on the size of recruitment. If the low recruitment estimated for 2017 continues in 2018, stock biomass is likely to decrease again in the future.

23.1.14 Management considerations

In 1996, 2006 and 2017, the whiting stock produced the lowest recruitments in the series. In recent years and increased proportion of whiting mature already at age 1 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 tonnes in 1979 to 29 344 tonnes in 2017, 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 industrial 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 industrial bycatch of whiting in the sprat, 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.

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.

The stock dynamics of North Sea whiting are largely driven by recruitment and natural mortality. To maximize the benefit for the fishery of this stock, the most significant measure would be to improve selectivity and reduce under-sized catches in those fisheries with high rates of discarding.

BMS landings reported to ICES in 2015–2017 were low. In 2017, whiting was not fully under Landings Obligation. In 2018, whiting catches in all fleets (including TR2, BT2) of Subarea 4 and Division 7.d will enter the landing obligation, with a *de minimis* exemption for whiting caught with bottom trawls in ICES Division 4.c. The amount of reported BMS is expected to increase in the next years.

ICES has developed a generic approach to evaluate whether new survey information that becomes available in autumn forms a basis to update the advice. ICES will publish new advice in November 2018 if this is the case for this year.

Table 23.1.1. Whiting in Subarea 4 and Division 7.d: Whiting in Subarea 4. Nominal landings (in tonnes) as officially reported to ICES, ICES estimates of catch components, and TACs. *In 2017, the official landings from Denmark are likely to include Industrial bycatch.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
belgium.4	1040	913	1030	944	1042	880	843	391	268	529	536
denmark.4	1206	1528	1377	1418	549	368	189	103	46	58	105
france.4	4951	5188	5115	5502	4735	5963	4704	3526	1908	NA	2527
germany.4	692	865	511	441	239	124	187	196	103	176	424
netherlands.4	3273	4028	5390	4799	3864	3640	3388	2539	1941	1795	1884
norway.4	55	103	232	130	79	115	66	75	65	68	33
sweden.4	16	48	22	18	10	1	1	1	0	9	4
england.wales.4	2338	2676	2528	2774	2722	2477	2329	2638	2909	2268	1782
scotland.4	23486	31257	30821	31268	28974	27811	23409	22098	16696	17206	17158
uk.4	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
unallocated.landings.4	-1123	396	1816	685	344	829	-434	627	246	NA	173
ices.landings.4	42180	46210	45210	46610	41870	40550	35550	30940	23690	25700	24280
ices.unwanted.catch.4	52270	30840	28470	41400	31840	28940	27130	16660	12480	22110	21931
ices.ibc.4	51337	39755	25045	20723	17473	27379	5116	6213	3494	5038	9160
ices.catch.4	145787	116805	98725	108733	91183	96869	67796	53813	39664	52848	55371
tac.4.2a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30000

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.4	454	270	248	144	105	93	45	115	162	147	74
denmark.4	105	96	89	62	57	251	78	42	79	156	135
france.4	3455	3314	2675	1721	1261	2711	3336	3076	2305	2644	2794
germany.4	402	354	334	296	149	252	76	76	124	156	111
netherlands.4	2478	2425	1442	977	805	702	618	656	718	614	514
norway.4	44	47	39	23	16	17	11	92	73	118	28
sweden.4	6	7	10	2	0	2	1	2	4	8	6
england.wales.4	1301	1322	680	1209	2560	NA	NA	NA	NA	NA	NA
scotland.4	10589	7756	5734	5057	3441	NA	NA	NA	NA	NA	NA
uk.4	NA	NA	NA	NA	NA	11632	12110	10391	8853	7845	8892
total.landings.4	18834	15591	11251	9491	8394	15660	16275	14451	12318	11690	12554
unallocated.landings.4	-426	721	801	541	-2286	563	609	972	-126	-1111	-706
ices.landings.4	19260	14870	10450	8950	10680	15097	15666	13479	12444	12801	13260
ices.unwanted.catch.4	16130	17144	26135	18142	10300	14018	5206	8356	6597	8451	7989
ices.ibc.4	940	7270	2730	1210	890	2190	1240	0	1344	1907	1035
ices.catch.4	36330	39284	39315	28302	21870	31305	22112	21835	20385	23159	22283
tac.4.2.a	29700	41000	16000	16000	28500	23800	23800	17850	15173	12897	14832

Year	2012	2013	2014	2015	2016	2017	2018
belgium.4	45	33	46	69	65	71	NA
denmark.4	131	124	160	215	208	2803	NA
france.4	1925	942	1884	1130	1232	952	NA
germany.4	25	44	31	73	0	81	NA
netherlands.4	471	495	464	548	644	687	NA
norway.4	94	560	914	1088	1148	993	NA
sweden.4	4	1	2	5	6	11	NA
england.wales.4	NA	NA	NA	NA	NA	NA	NA
scotland.4	NA	NA	NA	NA	NA	NA	NA
uk.4	9893	11162	10290	9970	9406	9120	NA
total.landings.4	12588	13361	13791	13098	12709	14718	NA
unallocated.landings.4	-356	-456	-56	-134	467	2890	NA
ices.landings.4	12944	13817	13847	13232	12242	11828	NA
ices.unwanted.catch.4	9307	4608	7016	12265	10413	9799	NA
ices.ibc.4	1117	1654	1623	2097	4551	2635	NA
ices.catch.4	23368	20079	22486	27593	27206	24262	NA
tac.4.2.a	17056	18932	16092	13678	13678	16003	22057

Table 23.1.2. Whiting in Subarea 4 and Division 7.d: Whiting in Division 7.d. Nominal landings (in tonnes) as officially reported to ICES, ICES estimates of catch components, and TACs.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
belgium.7.d	83	83	66	74	61	68	84	98	53	48	65
france.7.d	NA	NA	5414	5032	6734	5202	4771	4532	4495	NA	5875
netherlands.7.d	0	0	0	0	0	0	1	1	32	6	14
england.wales.7.d	239	292	419	321	293	280	199	147	185	135	118
scotland.7.d	0	0	24	2	0	1	1	1	0	0	0
uk.7.d	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
unallocat.landings.7.d	NA	NA	183	219	468	161	106	159	165	NA	1772
ices.landings.7.d	3480	5720	5740	5210	6620	5390	4950	4620	4600	4430	4300
ices.unwanted.catch.7.d	3330	4220	4090	2970	3850	3240	3370	3000	3210	3570	4129
ices.catch.7.d	6810	9940	9830	8180	10470	8630	8320	7620	7810	8000	8429
tac.7b.k	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22000

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.7.d	75	58	67	46	45	73	75	69	71	88	78
france.7.d	6338	5172	6654	5006	4638	3487	3135	2875	6248	5512	4833
netherlands.7.d	67	19	175	132	128	117	118	162	112	275	282
england.wales.7.d	134	112	109	99	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	0	0	0	0	NA	NA	NA	NA	NA	NA	NA
uk.7.d	NA	NA	NA	NA	90	72	63	87	138	258	271
total.landings.7.d	6614	5361	7005	5283	4901	3749	3391	3193	6569	6133	5464
unalloc.landings.7.d	814	-439	1295	933	111	306	137	-1278	649	-967	315
ices.landings.7.d	5800	5800	5710	4350	4790	3443	3254	4471	5920	7100	5149
ices.unwanted.catch.7.d	3109	1356	604	907	2219	2291	1763	1943	2086	4532	3183
ices.catch.7.d	8909	7156	6314	5257	7009	5734	5017	6414	8006	11632	8332
tac.7b.k	21000	31700	31700	27000	21600	19940	19940	19940	16949	14407	16568

Year	2012	2013	2014	2015	2016	2017	2018
belgium.7.d	66	95	89	121	144	128	NA
france.7.d	3093	3076	2115	3065	2771	2378	NA
netherlands.7.d	437	650	663	558	557	583	NA
england.wales.7.d	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	NA	NA	NA	NA	NA	NA	NA
uk.7.d	261	472	345	365	259	354	NA
total.landings.7.d	3857	4293	3212	4109	3730	3443	NA
unalloc.landings.7.d	-556	-15	87	132	30	89	NA
ices.landings.7.d	4413	4308	3125	3977	3700	3354	NA
ices.unwanted.catch.7.d	2389	2186	2709	4627	2313	1550	NA
ices.catch.7.d	6802	6494	5834	8604	6013	4904	NA
tac.7b.k	19053	24500	20668	17742	22778	27500	22213

Table 23.1.3.a. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of catch and sample data.Tables.txt. SOP.

CATCH CATEGORY	SOP
Discards	1.049
Landings (incl.IBC)	1.050
BMS landing	1.008

Table 23.1.3.b. 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.

CATCH CATEGORY	RAISED OR IMPORTED	CATON TONNES	PERCENT
Discards	Imported	7880	76
Discards	Raised	2537	24
Landings (incl.IBC)	Imported	17636	100
BMS landing	Imported	412	100
Logbook Registered Discards	Imported	0	NA

Table 23.1.3.c. 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/sampled or estimated data.

CATCH CATEGORY	RAISED OR IMPORTED	SAMPLED OR ESTIMATED DISTRIBUTION	CATON TONNES	PERCENT
Landings (incl.IBC)	Imported	Sampled	11151	63
Landings (incl.IBC)	Imported	Estimated	6486	37
Discards	Imported	Sampled	5200	50
Discards	Imported	Estimated	2680	26
Discards	Raised	Estimated	2537	24
BMS landing	Imported	Estimated	412	100

Table 23.1.3d. 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/sampled or estimated data by area.

Catch Category	Raised Imported	Sampled or Estimated distribution	Area	CATON tonnes	percent
Landings	Imported	Sampled	27.7.d	0	NA
Landings	Imported	Estimated	27.7.d	2193	64
Discards	Raised	Estimated	27.7.d	1239	36
Discards	Imported	Sampled	27.7.d	712.5	48
Discards	Imported	Estimated	27.7.d	576.7	39
BMS landing	Imported	Estimated	27.7.d	185.3	13
Landings	Imported	Estimated	27.7.d	0	NA
Discards	Raised	Estimated	27.4.c	28.83	100
Discards	Imported	Estimated	27.4.c	28.16	59
Landings	Imported	Estimated	27.4.c	19.39	41
Discards	Imported	Estimated	27.4.b	0	NA
Discards	Raised	Estimated	27.4.b	50.12	100
BMS landing	Imported	Estimated	27.4.b	65.68	74
Landings	Imported	Estimated	27.4.b	23.6	26
Discards	Raised	Estimated	27.4.b	0	NA
BMS landing	Imported	Estimated	27.4.a	0	NA
Landings	Imported	Sampled	27.4.a	1.993	100
Landings	Imported	Estimated	27.4.a	0.7418	100
Discards	Imported	Sampled	27.4.a	0	NA
Discards	Imported	Estimated	27.4	0	NA
Discards	Raised	Estimated	27.4	8958	63
BMS landing	Imported	Estimated	27.4	5166	37

Table 23.1.4. Whiting in Subarea 4 and Division 7.d: Total catch numbers at age (thousands). Age 8 is a plus-group. Estimated by ICES, input data for SAM. Ages 0–8+ 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	418909	313391	242369	90047	7564	7564	1851	253	11	9	4	0	0	0	0	277
1979	476383	615525	467538	218283	100976	29267	3111	1657	264	35	1	4	0	0	0	0	304
1980	332209	265359	416009	286077	90719	52969	10752	1153	689	58	14	5	1	0	0	0	767
1981	516869	162899	346343	266518	102295	27776	12297	3540	244	45	37	1	0	0	0	0	327
1982	101057	192641	114443	245247	88137	26796	6909	2082	400	53	26	4	1	0	0	0	484
1983	668604	205647	184747	118411	131507	37231	8688	1780	793	101	35	0	0	0	0	0	929
1984	157819	323408	175965	124886	49504	59817	13860	2964	410	182	21	0	0	0	0	0	613
1985	186723	203321	141716	82037	37847	14420	17446	3329	805	89	9	1	0	0	0	0	904
1986	225202	576732	167078	169578	46516	13368	3487	3975	497	71	0	1	0	0	0	0	569
1987	84863	267051	368230	122748	85240	11391	4555	928	930	98	7	0	0	0	0	0	1035
1988	416924	430344	307429	179503	39635	17902	2174	544	59	72	37	0	0	0	0	0	168
1989	87325	331672	173676	191942	78464	14367	5051	517	291	37	6	1	0	0	0	0	335
1990	289174	258102	501373	127967	84147	31102	1933	719	93	16	0	0	0	0	0	0	109
1991	1057999	135797	194921	184960	36290	25554	5339	526	249	17	1	0	0	0	0	0	267
1992	259390	230302	167479	87820	91081	11654	6634	2546	104	7	1	0	0	0	0	0	112
1993	628301	223424	172049	125599	46181	45300	3898	1501	682	56	15	0	0	0	0	0	753
1994	218287	191544	158369	97559	51041	18683	17905	1258	441	73	0	0	0	0	0	0	514
1995	1597900	148169	144023	112416	35649	15061	5117	4472	314	101	54	0	0	0	0	0	469
1996	96515	86318	118910	99644	48304	14087	4638	1282	897	166	24	6	2	0	0	0	1095
1997	19001	60946	80471	84336	41975	18303	3333	1012	305	135	16	0	0	0	0	0	456
1998	72289	92556	50362	43424	36295	17628	6343	1417	306	66	34	0	0	0	0	0	406
1999	76975	189162	95415	45920	33921	18271	7443	2021	565	95	12	0	0	0	0	0	672
2000	1970	82546	129582	63706	23913	16199	8758	4309	969	244	47	3	0	0	0	0	1263
2001	18012	52567	83085	52076	20800	9256	4826	2233	896	246	124	2	0	0	0	0	1268
2002	135848	51338	62462	84600	34659	8099	2048	1461	621	102	13	9	9	0	0	0	754
2003	60744	83680	111144	55866	41841	14217	2359	473	329	50	16	1	0	0	0	0	396
2004	34210	47966	23009	32557	30400	21755	8342	1352	198	93	12	1	4	0	0	0	308
2005	17622	47805	34626	12204	18146	14931	8979	3041	540	83	29	1	0	0	0	0	653
2006	15673	73908	42199	21651	8642	15077	11822	4618	1300	142	14	0	0	0	0	0	1456
2007	2490	39041	34001	24900	9906	4008	7657	5268	2560	476	82	0	0	0	0	0	3118
2008	5631	62163	28301	22741	13571	4305	1847	3954	2134	631	143	43	0	0	0	0	2951
2009	12139	57412	31004	15181	12782	7432	3380	2153	2601	1801	1967	20	1	0	0	0	6390
2010	3930	33756	33320	25516	9932	7776	6263	2136	4347	1491	1053	30	1	0	3	0	6925
2011	3563	31377	42201	28903	12537	3813	3178	2090	877	472	1293	31	1	0	0	0	2674
2012	3548	53445	32509	18882	14862	6952	2773	1558	1213	624	482	15	37	0	0	0	2371
2013	4341	20378	15548	25362	15593	10812	3343	1048	643	660	292	0	0	0	0	0	1595
2014	6225	29785	14623	17450	19683	11351	4710	2038	1018	641	431	0	0	0	0	0	2090
2015	7705	48349	53345	15714	10220	14163	5068	2086	1210	607	401	4	0	0	0	0	2222
2016	17208	27639	36165	36788	9129	7813	6046	2548	691	694	376	0	0	0	0	0	1761
2017	28724	27355	27315	24442	18432	4176	2421	2683	1349	1165	26	5	0	0	0	0	2545

Table 23.1.5. Whiting in Subarea 4 and Division 7.d: Landings numbers at age (thousands), as estimated by ICES. Age 8 is a plus-group. Data used to calculate the landing fraction in the model estimates of catches.

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	327
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	920
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	165
1989	52	8636	28406	77009	44307	9249	3888	420	208	35	6	1	0	0	0	0	250
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	267
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	1156
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	638
2003	20	403	11613	13990	18974	9513	1861	443	329	50	16	0	0	0	0	0	395
2004	0	3973	2812	9629	13302	11846	4409	747	174	84	12	1	4	0	0	0	275
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	1191
2007	140	10378	14740	16491	7666	3310	6681	4227	2179	383	77	0	0	0	0	0	2639
2008	0	13234	12334	14120	9106	3564	1519	2505	1481	568	143	43	0	0	0	0	2235
2009	79	3056	17397	11259	10762	6411	3072	1994	2408	1679	1846	19	1	0	0	0	5953
2010	2	1368	8848	15426	6939	6296	3922	1922	1331	1378	979	24	1	0	0	0	3713
2011	32	4524	17621	14180	10021	2811	2303	1741	820	441	1215	30	1	0	0	0	2507
2012	0	2540	10148	11200	11692	6127	2020	1331	902	557	401	14	35	0	0	0	1909
2013	0	1724	7008	15154	11656	9344	2774	937	556	405	232	0	0	0	0	0	1193
2014	1	3211	7422	9439	12082	8031	3221	1673	806	566	329	0	0	0	0	0	1701
2015	136	3022	15736	7802	6584	9232	3800	1617	887	523	358	4	0	0	0	0	1772
2016	0	1405	9098	16279	5922	4187	4104	1747	550	573	312	0	0	0	0	0	1435
2017	0	731	6509	10287	12841	2666	1711	1640	1092	962	23	5	0	0	0	0	2082

Table 23.1.6. Whiting in Subarea 4 and Division 7.d: Unwanted catch numbers at age (thousands), as estimated by ICES. Age 8 is a plus–group. Data used to calculate the unwanted catch fraction from the model estimate of catches.

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	107
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	264
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	11540	51883	12179	3192	1382	653	139	52	64	32	24	0	0	0	0	0	120
2010	3701	30464	22610	8713	2444	1038	1988	99	2775	34	18	4	0	0	3	0	2834
2011	3430	25925	23211	13753	2053	862	760	272	24	13	29	0	0	0	0	0	66
2012	3471	49677	21362	6943	2497	493	633	154	259	37	59	0	0	0	0	0	355
2013	4149	17715	7711	8710	2899	693	343	40	44	217	43	0	0	0	0	0	304
2014	5943	25159	6425	7025	6438	2597	1193	239	155	38	79	0	0	0	0	0	272
2015	7249	43271	34943	6950	2940	3947	888	313	238	39	13	0	0	0	0	0	290
2016	14941	22682	22342	15500	1889	2536	1075	432	42	23	11	0	0	0	0	0	76
2017	26493	24515	18650	11973	3735	1111	476	804	129	100	0	0	0	0	0	0	229

Table 23.1.7. Whiting in Subarea 4 and Division 7.d: Industrial bycatch numbers at age (thousands), as estimated by ICES. Data used to calculate the IBC fraction in the model estimates of catches.

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	133207	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	104767	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	178225	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	73
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	520	2473	1428	730	638	368	169	107	129	90	97	1	0	0	0	0	317
2010	227	1924	1862	1377	549	442	353	115	241	79	56	2	0	0	0	0	378
2011	101	928	1369	970	463	140	115	77	33	18	49	1	0	0	0	0	101
2012	77	1228	999	739	673	332	120	73	52	30	22	1	2	0	0	0	107
2013	192	939	829	1498	1038	775	226	71	43	38	17	0	0	0	0	0	98
2014	281	1415	776	986	1163	723	296	126	57	37	23	0	0	0	0	0	117
2015	320	2056	2666	962	696	984	380	156	85	45	30	0	0	0	0	0	160
2016	2267	3552	4725	5009	1318	1090	867	369	99	98	53	0	0	0	0	0	250
2017	2231	2109	2156	2182	1856	399	234	239	128	103	3	0	0	0	0	0	234

Table 23.1.8. Whiting in Subarea 4 and Division 7.d: Total catch mean weights at age (kg), as estimated by ICES. Age 8 is a plus-group. Ages 0–8+ and years 1978–2017 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	0.321	0.428	0.428	0.466	0.615	0.702	1.539	0.589	0.000	0.000	0.000	0.000	0.648
1979	0.009	0.098	0.167	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	0.457	0.459	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	0.322	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	0.735
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	0.189	0.271	0.337	0.381	0.390	0.462	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	0.401	0.435	0.494	0.426	0.507	0.852	0.976	0.000	0.000	0.000	0.000	0.439
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	0.380	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	0.424	0.506	0.856	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	0.370	0.515	0.857	0.609	0.000	0.000	0.000	0.000	0.395
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	0.400
1992	0.013	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.481	0.763	1.728	0.000	0.000	0.000	0.000	0.000	0.510
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	0.386	0.394	0.479	0.458	0.000	0.000	0.000	0.000	0.000	0.421
1998	0.018	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.335	0.494	0.434	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	0.315	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	0.411	0.289	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	0.346	0.351	0.352	1.463	0.337	0.000	0.000	0.000	0.351
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	0.000	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	0.091	0.213	0.286	0.370	0.374	0.373	0.344	0.351	0.335	0.330	0.350	0.419	0.000	0.000	0.000	0.340
2010	0.049	0.111	0.234	0.373	0.406	0.456	0.355	0.459	0.272	0.475	0.471	0.399	0.259	0.000	0.368	0.000	0.346
2011	0.048	0.114	0.214	0.298	0.374	0.415	0.424	0.364	0.341	0.372	0.320	0.550	0.894	0.000	0.000	0.000	0.339
2012	0.038	0.105	0.195	0.311	0.445	0.411	0.430	0.428	0.366	0.418	0.406	0.552	0.733	0.000	0.000	0.000	0.395
2013	0.028	0.110	0.222	0.273	0.390	0.468	0.496	0.465	0.424	0.340	0.406	0.000	0.000	0.000	0.000	0.000	0.386
2014	0.055	0.137	0.227	0.294	0.331	0.442	0.465	0.469	0.403	0.403	0.359	1.754	0.000	0.000	0.000	0.000	0.394
2015	0.044	0.125	0.218	0.307	0.368	0.386	0.469	0.464	0.374	0.372	0.400	0.778	0.000	0.000	0.000	0.000	0.379
2016	0.030	0.120	0.210	0.291	0.399	0.389	0.415	0.488	0.452	0.460	0.472	1.293	0.000	0.000	0.000	0.000	0.459
2017	0.026	0.078	0.212	0.320	0.409	0.436	0.487	0.444	0.457	0.419	0.528	0.489	0.000	0.000	0.000	0.000	0.440

Table 23.1.9. Whiting in Subarea 4 and Division 7.d: Landings mean weights at age (kg), as estimated by ICES. Age 8 is a plus-group.

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	0.648
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	0.735
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	0.539
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	0.439
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	0.633
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	0.406
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	0.400
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	0.504
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	0.368
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	0.364
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	0.114	0.184	0.239	0.299	0.375	0.376	0.373	0.346	0.349	0.336	0.327	0.350	0.419	0.000	0.000	0.000	0.339
2010	0.069	0.312	0.303	0.424	0.433	0.468	0.413	0.468	0.459	0.478	0.470	0.409	0.259	0.000	0.368	0.000	0.469
2011	0.046	0.194	0.263	0.363	0.397	0.455	0.459	0.367	0.342	0.374	0.322	0.550	0.894	0.000	0.000	0.000	0.341
2012	0.046	0.203	0.236	0.362	0.478	0.420	0.483	0.431	0.376	0.387	0.356	0.552	0.733	0.000	0.000	0.000	0.383
2013	0.038	0.203	0.247	0.295	0.417	0.477	0.515	0.460	0.419	0.413	0.391	0.000	0.000	0.000	0.000	0.000	0.412
2014	0.064	0.194	0.259	0.330	0.363	0.490	0.508	0.457	0.375	0.393	0.358	1.754	0.000	0.000	0.000	0.000	0.378
2015	0.103	0.197	0.253	0.355	0.401	0.428	0.495	0.466	0.406	0.380	0.400	0.778	0.000	0.000	0.000	0.000	0.398
2016	0.050	0.169	0.265	0.339	0.434	0.463	0.448	0.537	0.463	0.466	0.477	1.293	0.000	0.000	0.000	0.000	0.467
2017	0.035	0.146	0.249	0.394	0.434	0.493	0.552	0.498	0.465	0.432	0.528	0.489	0.000	0.000	0.000	0.000	0.451

Table 23.1.10. Whiting in Subarea 4 and Division 7.d: Unwanted catch mean weights at age (kg), as estimated by ICES. Age 8 is a plus-group.

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	0.347
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	0.351
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	0.000
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	0.244
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	0.086	0.177	0.240	0.333	0.360	0.375	0.265	0.426	0.273	0.594	0.000	0.000	0.000	0.000	0.000	0.419
2010	0.049	0.102	0.207	0.283	0.331	0.381	0.242	0.277	0.182	0.362	0.521	0.337	0.000	0.000	0.368	0.000	0.187
2011	0.048	0.100	0.176	0.231	0.264	0.285	0.316	0.346	0.291	0.305	0.251	0.000	0.000	0.000	0.000	0.000	0.276
2012	0.038	0.100	0.175	0.229	0.290	0.296	0.261	0.405	0.333	0.877	0.746	0.000	0.000	0.000	0.000	0.000	0.458
2013	0.028	0.101	0.199	0.236	0.283	0.353	0.346	0.578	0.484	0.205	0.484	0.000	0.000	0.000	0.000	0.000	0.285
2014	0.055	0.130	0.189	0.245	0.270	0.294	0.348	0.556	0.547	0.550	0.361	0.000	0.000	0.000	0.000	0.000	0.493
2015	0.043	0.120	0.202	0.254	0.293	0.289	0.358	0.454	0.253	0.271	0.393	0.000	0.000	0.000	0.000	0.000	0.262
2016	0.030	0.117	0.188	0.241	0.291	0.267	0.287	0.290	0.309	0.305	0.315	0.000	0.000	0.000	0.000	0.000	0.309
2017	0.026	0.076	0.199	0.257	0.322	0.298	0.255	0.335	0.392	0.291	0.362	0.459	0.000	0.000	0.000	0.000	0.348

Table 23.1.11. Whiting in Subarea 4 and Division 7.d: Industrial bycatch mean weights at age (kg), as estimated by ICES. Age 8 is a plus-group.

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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.046	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	0.000
2009	0.042	0.092	0.213	0.286	0.370	0.374	0.373	0.343	0.351	0.335	0.331	0.350	0.419	0.000	0.000	0.000	0.340
2010	0.049	0.111	0.234	0.373	0.407	0.455	0.355	0.458	0.272	0.475	0.471	0.398	0.259	0.000	0.368	0.000	0.345
2011	0.048	0.114	0.214	0.298	0.374	0.415	0.424	0.364	0.340	0.372	0.320	0.550	0.894	0.000	0.000	0.000	0.338
2012	0.038	0.105	0.194	0.311	0.445	0.411	0.430	0.428	0.366	0.418	0.407	0.552	0.733	0.000	0.000	0.000	0.398
2013	0.028	0.110	0.222	0.273	0.391	0.468	0.496	0.464	0.424	0.341	0.406	0.000	0.000	0.000	0.000	0.000	0.389
2014	0.055	0.137	0.227	0.294	0.331	0.442	0.465	0.469	0.403	0.402	0.359	1.754	0.000	0.000	0.000	0.000	0.394
2015	0.044	0.125	0.218	0.308	0.368	0.386	0.469	0.464	0.374	0.372	0.400	0.778	0.000	0.000	0.000	0.000	0.378
2016	0.030	0.120	0.210	0.291	0.399	0.389	0.415	0.488	0.452	0.460	0.472	1.293	0.000	0.000	0.000	0.000	0.459
2017	0.026	0.078	0.212	0.320	0.409	0.436	0.487	0.444	0.457	0.419	0.526	0.488	0.000	0.000	0.000	0.000	0.441

Table 23.1.12. Whiting in Subarea 4 and Division 7.d: Catch component as estimated by ICES in tonnes. Unwanted catch includes discards and BMS.

Year	Catch	Wanted Catch	Unwanted Catch	IBC
1978	188222	97553	35382	55287
1979	243570	107231	77391	58948
1980	223361	100775	77003	45584
1981	192119	89583	35894	66641
1982	140250	80576	26620	33055
1983	161316	88002	49562	23753
1984	145636	86275	40483	18878
1985	100330	56059	28961	15310
1986	161494	64019	79523	17953
1987	138737	68317	53901	16519
1988	133215	56100	28146	48969
1989	123533	45103	35787	42643
1990	152602	45662	55603	51337
1991	126742	51929	35058	39755
1992	108555	50946	32564	25045
1993	116911	51818	44370	20723
1994	101650	48486	35692	17473
1995	105494	45938	32176	27379
1996	76123	40503	30505	5116
1997	61435	35563	19660	6213
1998	47475	28288	15693	3494
1999	60845	30130	25677	5038
2000	63806	28583	26063	9160
2001	45242	25061	19237	944
2002	46450	20675	18501	7275
2003	45640	16161	26745	2734
2004	33557	13295	19048	1214
2005	28883	15471	12525	888
2006	36769	18535	16310	1924
2007	26974	18915	6971	1088
2008	28247	17951	10296	0
2009	28430	18403	8684	1344
2010	34436	19846	12683	1907
2011	30668	18461	11173	1035
2012	30221	17407	11697	1117
2013	26573	18211	6795	1654
2014	28375	17027	9725	1623
2015	36287	17299	16891	2097
2016	33396	16118	12726	4551
2017	29344	15361	11348	2635

Table 23.1.13. Whiting in Subarea 4 and Division 7.d: Stock weights at age (kg), as estimated from scaled (using IBTS Q1) commercial catch weights at age. Age 8 is a plus-group.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.003	0.025	0.091	0.155	0.248	0.385	0.412	0.475	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741
1979	0.003	0.032	0.083	0.172	0.233	0.370	0.437	0.502	0.665	0.665	0.665	0.665	0.665	0.665	0.665	0.665	0.665
1980	0.004	0.025	0.088	0.167	0.253	0.303	0.440	0.468	0.654	0.654	0.654	0.654	0.654	0.654	0.654	0.654	0.654
1981	0.004	0.027	0.083	0.161	0.248	0.341	0.395	0.453	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823
1982	0.010	0.020	0.092	0.168	0.242	0.338	0.460	0.514	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840
1983	0.005	0.035	0.095	0.181	0.251	0.346	0.410	0.461	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
1984	0.007	0.029	0.094	0.180	0.260	0.343	0.375	0.471	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
1985	0.005	0.031	0.096	0.189	0.256	0.361	0.419	0.504	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502
1986	0.005	0.035	0.091	0.169	0.246	0.340	0.457	0.477	0.715	0.715	0.715	0.715	0.715	0.715	0.715	0.715	0.715
1987	0.004	0.025	0.074	0.164	0.229	0.337	0.365	0.553	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667
1988	0.004	0.018	0.073	0.148	0.232	0.311	0.408	0.516	0.793	0.793	0.793	0.793	0.793	0.793	0.793	0.793	0.793
1989	0.008	0.023	0.078	0.149	0.206	0.286	0.376	0.440	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452
1990	0.005	0.028	0.068	0.139	0.194	0.251	0.395	0.508	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680
1991	0.006	0.034	0.084	0.144	0.223	0.275	0.326	0.372	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1992	0.004	0.028	0.092	0.170	0.214	0.298	0.333	0.320	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583
1993	0.004	0.024	0.087	0.166	0.244	0.295	0.333	0.408	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433
1994	0.004	0.028	0.083	0.169	0.253	0.344	0.362	0.427	0.493	0.493	0.493	0.493	0.493	0.493	0.493	0.493	0.493
1995	0.003	0.029	0.090	0.171	0.263	0.346	0.413	0.443	0.479	0.479	0.479	0.479	0.479	0.479	0.479	0.479	0.479
1996	0.006	0.031	0.083	0.156	0.233	0.349	0.392	0.440	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494
1997	0.009	0.032	0.089	0.160	0.228	0.300	0.369	0.394	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482
1998	0.006	0.030	0.089	0.156	0.217	0.283	0.327	0.339	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422
1999	0.007	0.026	0.087	0.154	0.198	0.260	0.293	0.317	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
2000	0.011	0.039	0.090	0.157	0.221	0.258	0.265	0.281	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306
2001	0.008	0.033	0.096	0.162	0.218	0.241	0.287	0.290	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334
2002	0.003	0.023	0.077	0.145	0.211	0.272	0.337	0.350	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384
2003	0.004	0.019	0.059	0.128	0.200	0.269	0.340	0.392	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420
2004	0.010	0.037	0.075	0.141	0.195	0.258	0.275	0.292	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402
2005	0.011	0.041	0.099	0.159	0.193	0.254	0.293	0.304	0.327	0.327	0.327	0.327	0.327	0.327	0.327	0.327	0.327
2006	0.031	0.043	0.090	0.153	0.212	0.259	0.346	0.352	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361
2007	0.019	0.032	0.103	0.171	0.251	0.310	0.298	0.315	0.365	0.365	0.365	0.365	0.365	0.365	0.365	0.365	0.365
2008	0.009	0.034	0.108	0.187	0.243	0.362	0.391	0.323	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405
2009	0.014	0.030	0.106	0.190	0.286	0.337	0.359	0.351	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389
2010	0.016	0.037	0.117	0.247	0.314	0.410	0.342	0.468	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
2011	0.016	0.038	0.106	0.198	0.289	0.374	0.407	0.371	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387
2012	0.013	0.035	0.097	0.206	0.343	0.370	0.414	0.437	0.451	0.451	0.451	0.451	0.451	0.451	0.451	0.451	0.451
2013	0.009	0.036	0.110	0.181	0.301	0.422	0.478	0.474	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441
2014	0.018	0.045	0.113	0.195	0.255	0.398	0.447	0.479	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450
2015	0.015	0.041	0.108	0.204	0.284	0.348	0.451	0.473	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433
2016	0.010	0.040	0.105	0.193	0.308	0.350	0.399	0.498	0.525	0.525	0.525	0.525	0.525	0.525	0.525	0.525	0.525
2017	0.009	0.026	0.106	0.212	0.316	0.392	0.469	0.453	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503

Table 23.1.14. Whiting in Subarea 4 and Division 7.d: Estimated proportion mature at age as used in the assessment.

Age	0	1	2	3	4	5	6	7	8+
1978	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1980	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1981	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1982	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1983	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1984	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1985	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1986	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1991	0.000	0.190	0.830	0.991	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.189	0.825	0.989	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.188	0.818	0.986	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.189	0.810	0.982	0.999	1.000	1.000	1.000	1.000
1995	0.000	0.192	0.801	0.977	0.997	0.999	1.000	1.000	1.000
1996	0.000	0.196	0.790	0.971	0.995	0.999	1.000	1.000	1.000
1997	0.000	0.203	0.779	0.963	0.992	0.998	1.000	1.000	1.000
1998	0.000	0.213	0.765	0.953	0.988	0.997	1.000	1.000	1.000
1999	0.000	0.227	0.750	0.943	0.985	0.996	1.000	1.000	1.000
2000	0.000	0.244	0.735	0.934	0.982	0.996	1.000	1.000	1.000
2001	0.000	0.262	0.725	0.928	0.981	0.996	1.000	1.000	1.000
2002	0.000	0.280	0.722	0.927	0.981	0.996	1.000	1.000	1.000
2003	0.000	0.296	0.726	0.929	0.983	0.997	1.000	1.000	1.000
2004	0.000	0.310	0.734	0.934	0.985	0.998	1.000	1.000	1.000
2005	0.000	0.322	0.747	0.941	0.988	0.998	1.000	1.000	1.000
2006	0.000	0.332	0.761	0.948	0.991	0.999	1.000	1.000	1.000
2007	0.000	0.339	0.777	0.955	0.993	0.999	1.000	1.000	1.000
2008	0.000	0.345	0.791	0.961	0.995	1.000	1.000	1.000	1.000
2009	0.000	0.350	0.804	0.966	0.996	1.000	1.000	1.000	1.000
2010	0.000	0.355	0.815	0.970	0.997	1.000	1.000	1.000	1.000
2011	0.000	0.359	0.823	0.972	0.998	1.000	1.000	1.000	1.000
2012	0.000	0.362	0.828	0.974	0.998	1.000	1.000	1.000	1.000
2013	0.000	0.365	0.832	0.975	0.998	1.000	1.000	1.000	1.000
2014	0.000	0.368	0.837	0.976	0.998	1.000	1.000	1.000	1.000
2015	0.000	0.374	0.843	0.977	0.998	1.000	1.000	1.000	1.000
2016	0.000	0.381	0.852	0.979	0.999	1.000	1.000	1.000	1.000
2017	0.000	0.389	0.861	0.980	0.999	1.000	1.000	1.000	1.000

Table 23.1.15. Whiting in Subarea 4 and Division 7.d: Natural mortality at age estimates based on ICES WGSAM (2018b).

AGE	0	1	2	3	4	5	6	7	8+
1978	1.297	1.285	0.660	0.518	0.484	0.416	0.337	0.337	0.337
1979	1.315	1.300	0.648	0.520	0.487	0.433	0.346	0.346	0.346
1980	1.332	1.309	0.637	0.522	0.489	0.446	0.354	0.354	0.354
1981	1.347	1.311	0.626	0.522	0.491	0.457	0.361	0.361	0.361
1982	1.356	1.303	0.615	0.521	0.491	0.464	0.366	0.366	0.366
1983	1.361	1.287	0.604	0.518	0.489	0.468	0.369	0.369	0.369
1984	1.365	1.266	0.592	0.514	0.487	0.469	0.372	0.372	0.372
1985	1.368	1.244	0.580	0.510	0.484	0.470	0.374	0.374	0.374
1986	1.373	1.224	0.569	0.506	0.482	0.470	0.377	0.377	0.377
1987	1.381	1.208	0.559	0.502	0.479	0.469	0.381	0.381	0.381
1988	1.392	1.196	0.551	0.499	0.478	0.469	0.387	0.387	0.387
1989	1.406	1.187	0.544	0.496	0.477	0.470	0.396	0.396	0.396
1990	1.425	1.181	0.539	0.494	0.477	0.470	0.406	0.406	0.406
1991	1.449	1.177	0.536	0.493	0.477	0.471	0.416	0.416	0.416
1992	1.479	1.176	0.535	0.492	0.477	0.471	0.427	0.427	0.427
1993	1.517	1.176	0.535	0.491	0.477	0.471	0.437	0.437	0.437
1994	1.564	1.179	0.536	0.492	0.478	0.472	0.446	0.446	0.446
1995	1.621	1.185	0.538	0.493	0.479	0.472	0.454	0.454	0.454
1996	1.688	1.193	0.541	0.496	0.481	0.474	0.461	0.461	0.461
1997	1.762	1.202	0.543	0.498	0.483	0.476	0.468	0.468	0.468
1998	1.840	1.213	0.546	0.502	0.486	0.479	0.474	0.474	0.474
1999	1.919	1.225	0.550	0.506	0.488	0.482	0.480	0.480	0.480
2000	1.997	1.238	0.556	0.511	0.492	0.487	0.486	0.486	0.486
2001	2.070	1.252	0.563	0.517	0.497	0.492	0.492	0.492	0.492
2002	2.135	1.266	0.572	0.525	0.503	0.499	0.499	0.499	0.499
2003	2.186	1.276	0.583	0.533	0.510	0.506	0.505	0.505	0.505
2004	2.224	1.280	0.596	0.540	0.516	0.512	0.510	0.510	0.510
2005	2.247	1.276	0.609	0.547	0.522	0.517	0.512	0.512	0.512
2006	2.259	1.266	0.621	0.552	0.526	0.520	0.510	0.510	0.510
2007	2.261	1.251	0.633	0.555	0.529	0.520	0.504	0.504	0.504
2008	2.255	1.234	0.644	0.557	0.531	0.518	0.494	0.494	0.494
2009	2.246	1.217	0.653	0.559	0.531	0.515	0.480	0.480	0.480
2010	2.236	1.203	0.661	0.560	0.532	0.510	0.462	0.462	0.462
2011	2.222	1.193	0.668	0.561	0.533	0.505	0.443	0.443	0.443
2012	2.202	1.187	0.676	0.564	0.535	0.501	0.423	0.423	0.423
2013	2.174	1.183	0.684	0.567	0.538	0.498	0.404	0.404	0.404
2014	2.142	1.180	0.692	0.572	0.541	0.497	0.385	0.385	0.385
2015	2.106	1.179	0.701	0.576	0.544	0.498	0.369	0.369	0.369
2016	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355
2017	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355

Table 23.1.16a. Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series used in the assessment and forecast.

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	0.658	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	7.679	5.449	1.836	0.536	0.202
2001	6.142	5.924	2.995	0.983	0.258
2002	5.585	3.428	2.629	0.632	0.208
2003	1.316	2.984	2.367	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	5.885	1.148	0.466	0.325
2013	0.545	1.630	2.413	0.883	0.269
2014	2.653	1.846	0.992	0.659	0.228
2015	3.151	2.127	0.598	0.288	0.241
2016	3.022	3.236	0.912	0.204	0.117
2017	6.126	2.486	1.090	0.284	0.081
2018	1.147	2.372	0.761	0.342	0.103

Table 23.1.16b. Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series used in the assessment and forecast.

IBTS-Q3						
Age	**0**	**1**	**2**	**3**	**4**	**5**
1991	5.370	7.034	1.586	0.790	0.146	0.052
1992	13.795	6.009	2.961	0.725	0.575	0.103
1993	9.192	6.387	1.774	0.661	0.147	0.159
1994	6.107	6.776	2.195	0.747	0.195	0.047
1995	7.292	6.198	2.912	1.072	0.215	0.060
1996	3.165	5.457	2.782	1.294	0.340	0.069
1997	20.627	3.330	1.807	1.090	0.280	0.107
1998	26.317	3.306	1.502	0.528	0.310	0.112
1999	24.986	12.035	1.906	0.539	0.245	0.095
2000	19.615	9.408	3.265	0.644	0.136	0.065
2001	35.488	6.689	2.831	0.940	0.191	0.043
2002	2.693	8.119	2.571	1.315	0.350	0.054
2003	3.565	2.576	2.928	1.287	0.679	0.173
2004	7.143	1.506	0.590	0.663	0.457	0.271
2005	1.693	1.714	0.683	0.314	0.456	0.340
2006	1.989	1.746	0.863	0.326	0.135	0.233
2007	8.229	0.955	0.636	0.376	0.115	0.084
2008	7.648	3.623	0.689	0.309	0.138	0.041
2009	5.938	5.855	3.848	0.410	0.123	0.080
2010	5.101	2.243	1.457	0.546	0.128	0.060
2011	2.471	4.468	1.444	0.472	0.162	0.069
2012	3.068	2.567	1.935	0.570	0.201	0.106
2013	3.343	0.675	0.601	0.658	0.175	0.071
2014	14.010	2.234	0.980	0.656	0.333	0.103
2015	20.916	3.125	2.226	0.431	0.240	0.184
2016	9.718	2.973	2.438	0.778	0.123	0.081
2017	1.766	9.510	2.008	0.777	0.254	0.070

Table 23.1.17. Whiting in Subarea 4 and Division 7.d: Final fishing mortality estimates from SAM.

AGE	0	1	2	3	4	5	6	7	8+
1978	0.025	0.103	0.307	0.547	0.671	0.773	1.009	1.260	1.260
1979	0.027	0.111	0.328	0.581	0.676	0.769	0.899	1.039	1.039
1980	0.024	0.100	0.309	0.617	0.793	0.969	1.110	1.304	1.304
1981	0.024	0.102	0.292	0.584	0.777	0.983	1.173	1.338	1.338
1982	0.024	0.105	0.261	0.487	0.617	0.771	0.925	1.009	1.009
1983	0.029	0.136	0.333	0.582	0.697	0.823	0.969	1.099	1.099
1984	0.030	0.151	0.370	0.667	0.838	0.956	1.119	1.229	1.229
1985	0.026	0.127	0.293	0.555	0.791	0.971	1.167	1.378	1.378
1986	0.029	0.152	0.358	0.635	0.907	1.023	1.171	1.307	1.307
1987	0.027	0.143	0.376	0.685	1.001	1.218	1.363	1.496	1.496
1988	0.028	0.153	0.371	0.601	0.835	1.037	1.073	1.045	1.045
1989	0.024	0.130	0.352	0.584	0.831	1.193	1.262	1.323	1.323
1990	0.025	0.141	0.406	0.617	0.785	1.006	1.006	1.072	1.072
1991	0.021	0.113	0.332	0.501	0.633	0.841	0.866	1.066	1.066
1992	0.021	0.119	0.321	0.487	0.584	0.728	0.822	0.936	0.936
1993	0.020	0.122	0.335	0.533	0.667	0.768	0.857	0.976	0.976
1994	0.018	0.112	0.306	0.516	0.703	0.842	0.916	0.983	0.983
1995	0.015	0.098	0.271	0.461	0.628	0.798	0.898	0.986	0.986
1996	0.012	0.084	0.241	0.410	0.565	0.728	0.819	0.914	0.914
1997	0.010	0.075	0.215	0.350	0.470	0.574	0.610	0.688	0.688
1998	0.008	0.068	0.194	0.309	0.416	0.514	0.554	0.615	0.615
1999	0.008	0.074	0.222	0.357	0.475	0.578	0.591	0.645	0.645
2000	0.006	0.055	0.187	0.337	0.502	0.684	0.751	0.830	0.830
2001	0.004	0.041	0.128	0.224	0.354	0.541	0.625	0.714	0.714
2002	0.004	0.047	0.124	0.190	0.266	0.373	0.438	0.504	0.504
2003	0.006	0.079	0.168	0.188	0.215	0.256	0.275	0.294	0.294
2004	0.005	0.071	0.140	0.152	0.174	0.213	0.245	0.253	0.253
2005	0.005	0.073	0.143	0.150	0.156	0.176	0.206	0.218	0.218
2006	0.005	0.088	0.173	0.199	0.199	0.201	0.221	0.220	0.220
2007	0.004	0.074	0.152	0.196	0.207	0.195	0.208	0.216	0.216
2008	0.003	0.065	0.136	0.192	0.211	0.196	0.197	0.203	0.203
2009	0.003	0.055	0.116	0.184	0.236	0.252	0.287	0.308	0.308
2010	0.003	0.047	0.111	0.185	0.249	0.302	0.370	0.407	0.407
2011	0.002	0.046	0.107	0.172	0.217	0.249	0.298	0.325	0.325
2012	0.003	0.052	0.103	0.160	0.218	0.266	0.295	0.308	0.308
2013	0.002	0.042	0.089	0.148	0.212	0.282	0.276	0.271	0.271
2014	0.002	0.039	0.097	0.169	0.237	0.327	0.321	0.318	0.318
2015	0.002	0.042	0.121	0.209	0.269	0.353	0.331	0.327	0.327
2016	0.002	0.032	0.103	0.205	0.281	0.353	0.319	0.311	0.311
2017	0.002	0.025	0.083	0.168	0.253	0.305	0.283	0.294	0.294

Table 23.1.18. Whiting in Subarea 4 and Division 7.d: Final abundance estimates from SAM.

Age	0	1	2	3	4	5	6	7	8+
1978	32173603	7943855	1587786	758235	217318	18351	13199	2698	434
1979	23508077	8825760	2023282	603172	266802	67423	5790	3390	610
1980	13435164	6286144	2083780	748443	198183	86971	20196	1698	1051
1981	12486394	3273886	1723785	783746	232068	53813	20677	4820	519
1982	11129465	3152752	782999	757003	254940	63186	12533	4380	955
1983	14992109	2690814	742706	343071	297543	85311	18097	3311	1413
1984	12788531	3880785	646694	292398	110374	101483	23023	4872	1068
1985	20747524	2972907	965760	241923	87278	28168	26521	5020	1240
1986	18224476	5505577	722607	441628	85746	24990	6347	5936	1033
1987	15682572	4504439	1417357	276898	151069	20034	6129	1327	1327
1988	20484987	3706328	1295022	545084	82697	34211	3677	1106	381
1989	13482017	5304974	855078	542286	184618	21914	7705	831	395
1990	12519715	3130546	1543694	340137	187668	52593	3872	1456	213
1991	12985402	2889515	796099	597395	108432	50974	12911	906	399
1992	14844061	3020743	823298	297418	253182	33064	12968	4104	273
1993	14124277	3307270	769525	355337	108800	100989	9326	3397	1194
1994	12674306	3032169	858246	313392	124544	34577	31380	2527	1080
1995	10440111	2675277	806456	376001	110158	34672	9616	8188	874
1996	8466452	1980591	725045	367824	140220	35540	9607	2496	2150
1997	14203355	1479657	527887	341505	140835	49952	10397	2590	1153
1998	23676831	2310287	396153	232417	142759	54491	17316	3655	1156
1999	23972919	3761060	589736	185336	109779	54144	21425	6001	1659
2000	21103066	3410788	922682	255370	75905	40348	18908	7922	2562
2001	21402326	2784835	965982	388881	100028	25672	12561	5377	2856
2002	11013379	2690644	789378	537830	182039	38085	7902	4092	2388
2003	10488591	1254817	762926	434340	273935	84559	15074	2777	2199
2004	11793614	1166348	270542	350907	237472	132757	41099	7066	2081
2005	11019676	1262837	295211	126272	184898	125065	62904	18849	4224
2006	9396302	1250982	348531	137192	63982	100707	66324	30368	10582
2007	15274161	957116	322358	172884	61894	31869	51867	32198	19742
2008	14931925	1674079	282483	147586	84819	29498	15803	27021	24667
2009	14006950	1570043	485199	128238	67401	41677	15434	8666	28849
2010	13779469	1485239	414737	209171	64221	32055	21018	7400	19404
2011	10076610	1546151	454052	192741	92586	27912	14608	9287	11579
2012	7359536	1145274	534694	192253	89616	43208	12884	7054	10094
2013	11852610	758395	297302	267303	100481	43214	18875	6115	8435
2014	15969752	1416440	228564	147212	125697	47575	19508	9444	7908
2015	14888780	1878053	469487	106439	67913	58077	21465	9304	8733
2016	16125587	1670092	550410	207989	48540	30376	24998	10998	8742
2017	8423682	2163703	487679	232956	90153	21852	12549	12642	10578

Table 23.1.19. Whiting in Subarea 4 and Division 7.d: Final SAM summary table. Units are individuals and tonnes.

Year	R (age 0)	Low	High	SSB	Low	High	F (2–6)	Low	High	TSB	Low	High
1978	32173603	23454181	44134592	340871	299297	388221	0.662	0.576	0.76	631554	554641	719132
1979	23508077	17355918	31840994	387713	342985	438274	0.651	0.572	0.74	715406	624663	819330
1980	13435164	10013986	18025154	392462	346294	444784	0.759	0.671	0.86	608900	538744	688192
1981	12486394	9356597	16663113	348041	307212	394296	0.762	0.672	0.863	491838	437674	552705
1982	11129465	8382863	14775978	289448	255950	327331	0.612	0.536	0.699	461053	410312	518069
1983	14992109	11303314	19884729	252147	225948	281385	0.681	0.6	0.772	413489	370617	461321
1984	12788531	9617356	17005353	199334	179477	221388	0.79	0.699	0.892	387405	344277	435935
1985	20747524	15618277	27561283	186196	165653	209286	0.755	0.668	0.854	375494	331346	425523
1986	18224476	13761827	24134262	200945	179029	225544	0.819	0.726	0.922	455211	399156	519137
1987	15682572	11812128	20821232	198580	176298	223677	0.929	0.828	1.042	374038	331726	421747
1988	20484987	15370958	27300491	203003	179436	229665	0.783	0.693	0.885	361029	320280	406961
1989	13482017	10210990	17800898	206810	184149	232261	0.845	0.75	0.952	420149	371875	474690
1990	12519715	9528105	16450622	202625	180357	227641	0.764	0.675	0.864	355781	316982	399330
1991	12985402	9975390	16903667	202410	180504	226974	0.635	0.558	0.723	372575	332215	417838
1992	14844061	11418464	19297354	198249	177798	221052	0.588	0.515	0.672	343666	308122	383312
1993	14124277	10864515	18362089	188901	169953	209962	0.632	0.555	0.719	323000	290102	359630
1994	12674306	9737444	16496942	182103	163847	202394	0.657	0.577	0.747	319715	286543	356728
1995	10440111	7972841	13670900	184580	165318	206086	0.611	0.534	0.699	296653	265601	331336
1996	8466452	6359491	11271470	166215	148719	185770	0.552	0.48	0.636	280638	250040	314980
1997	14203355	10691318	18869077	150875	134748	168932	0.444	0.382	0.515	331569	286780	383353
1998	23676831	17787569	31515961	129787	116179	144989	0.397	0.341	0.463	334954	286673	391367
1999	23972919	17990241	31945144	131422	116567	148171	0.445	0.381	0.518	399132	336933	472813
2000	21103066	15783584	28215353	165850	144543	190298	0.492	0.415	0.585	525231	438614	628953
2001	21402326	15927860	28758386	183566	156721	215010	0.374	0.303	0.462	449806	377065	536580
2002	11013379	8269763	14667232	186201	158075	219331	0.278	0.219	0.353	290827	249776	338625
2003	10488591	7941524	13852574	174785	148387	205879	0.22	0.176	0.276	251129	216761	290945
2004	11793614	8886768	15651285	168255	143026	197935	0.185	0.148	0.231	328341	280046	384966
2005	11019676	8277653	14670011	149868	128066	175382	0.166	0.134	0.206	310710	264129	365505
2006	9396302	7057805	12509624	138601	119496	160761	0.199	0.163	0.242	471987	387186	575360
2007	15274161	11496718	20292747	122457	106021	141442	0.192	0.158	0.232	446770	363792	548675
2008	14931925	11265731	19791204	126656	110429	145267	0.186	0.154	0.225	304962	258624	359602
2009	14006950	10547058	18601837	134569	117200	154513	0.215	0.178	0.26	372690	310661	447104
2010	13779469	10196426	18621600	160466	138752	185578	0.244	0.199	0.297	428978	354505	519097
2011	10076610	7559073	13432609	148654	127589	173196	0.209	0.169	0.258	355148	297289	424268
2012	7359536	5445879	9945644	155561	132698	182362	0.208	0.167	0.26	283176	239709	334525
2013	11852610	8772261	16014612	148700	125893	175640	0.201	0.16	0.253	282497	236346	337662
2014	15969752	11622758	21942553	140928	118740	167262	0.23	0.181	0.293	476282	378033	600066
2015	14888780	10564794	20982500	150416	124519	181700	0.256	0.199	0.331	424136	333963	538655
2016	16125587	10962978	23719337	159234	127829	198355	0.252	0.189	0.337	369212	285824	476930
2017	8423682	4973682	14266776	168397	130157	217871	0.218	0.156	0.305	282884	216308	369951

Table 23.1.20. Whiting in Subarea 4 and Division 7.d: Final SAM summary catch table. Units: tonnes.

Year	Catch	Low	High
1978	189292	160686	222991
1979	227205	196033	263334
1980	220975	190518	256302
1981	189301	163088	219729
1982	143946	123940	167181
1983	147895	129023	169527
1984	136115	118738	156035
1985	110774	96110	127675
1986	147823	127308	171643
1987	139015	120160	160828
1988	130171	111836	151512
1989	134635	116392	155736
1990	135279	116020	157735
1991	114219	98634	132266
1992	108388	94221	124686
1993	108586	94671	124546
1994	102774	89654	117813
1995	93997	81636	108229
1996	76748	66777	88207
1997	62025	53988	71259
1998	50186	43939	57321
1999	57512	50156	65947
2000	65116	56526	75012
2001	51068	43682	59704
2002	45446	39327	52518
2003	42028	36456	48453
2004	33790	29669	38484
2005	29664	26167	33629
2006	34141	29919	38958
2007	27797	24436	31620
2008	27399	24090	31162
2009	29104	25614	33070
2010	35017	30765	39857
2011	29571	25952	33695
2012	30224	26550	34406
2013	27017	23704	30794
2014	29087	25698	32922
2015	33548	29534	38108
2016	31907	28022	36332
2017	29255	25396	33700

Table 23.1.21. Whiting in Subarea 4 and Division 7.d: SAM model parameters.

	PAR	SD(PAR)	EXP(PAR)	LOW	HIGH
logFpar_0	-6.2814	0.0807	0.0019	0.0016	0.0022
logFpar_1	-5.1972	0.0781	0.0055	0.0047	0.0065
logFpar_2	-5.1572	0.0769	0.0058	0.0049	0.0067
logFpar_3	-5.3247	0.0764	0.0049	0.0042	0.0057
logFpar_4	-6.307	0.0992	0.0018	0.0015	0.0022
logFpar_5	-5.4038	0.0964	0.0045	0.0037	0.0055
logFpar_6	-5.252	0.0943	0.0052	0.0043	0.0063
logFpar_7	-5.433	0.0941	0.0044	0.0036	0.0053
logFpar_8	-5.6486	0.0955	0.0035	0.0029	0.0043
logSdLogFsta_0	-1.5339	0.1292	0.2157	0.1666	0.2793
logSdLogN_0	-1.0752	0.1669	0.3412	0.2444	0.4764
logSdLogN_1	-2.2114	0.1537	0.1096	0.0806	0.149
logSdLogObs_0	0.1921	0.1304	1.2118	0.9336	1.5727
logSdLogObs_1	-1.7423	0.112	0.1751	0.14	0.2191
logSdLogObs_2	-0.8585	0.0889	0.4238	0.3548	0.5063
logSdLogObs_3	-0.8302	0.0918	0.4359	0.3628	0.5238
transfIRARdist_0	-0.2467	0.3675	0.7814	0.3747	1.6298
transfIRARdist_1	-1.1122	0.2622	0.3288	0.1946	0.5556
transfIRARdist_2	1.1479	0.6044	3.1516	0.9409	10.5564
transfIRARdist_3	-1.7569	0.3025	0.1726	0.0942	0.3161
itrans_rho_0	1.0841	0.1436	2.9569	2.2187	3.9408

Table 23.1.22. Whiting in Subarea 4 and Division 7.d: Mohn's rho.

	MOHN'S RHO
R(age 0)	0.138
SSB	-0.047
Fbar(2-6)	0.025

Table 23.1.23. Whiting in Subarea 4 and Division 7.d: Reference points as determined in the Benchmark 2018 (ICES, 2018a).

REFERENCE POINT	VALUE
B_{lim}	119 970 t (B_{loss})
F_{lim}	0.458
B_{pa}	166 708 t ($MSYB_{trigger}$)
F_{pa}	0.330
$F_{p.05}$ (with $B_{trigger}$)	0.172 (final F_{MSY})

Table 23.1.24. Whiting in Subarea 4 and Division 7.d: Recruitment estimates as used in the short-term forecast.

YEAR	GEOMETRIC MEAN OF RECRUITMENT TIME SERIES 2002–2017
2018	11964
2019	11964
2020	11964

Table 23.1.25. Whiting in Subarea 4 and Division 7.d: Short-term forecast inputs.

MFDP version 1a						
MFDP version 1a						
Run: run						
Time and date: 16:01 28/04/2018						
Fbar age range (Total) : 2-6						
Fbar age range Fleet 1 : 2-6						
2018						
Age	N	M	Mat	PF	PM	SWt
0	11964329	2.066	0	0	0	0.011
1	1064775	1.178	0.38	0	0	0.036
2	649436	0.71	0.85	0	0	0.106
3	220715	0.582	0.98	0	0	0.203
4	110066	0.548	1	0	0	0.303
5	40464	0.5	1	0	0	0.363
6	9772	0.355	1	0	0	0.44
7	6631	0.355	1	0	0	0.475
8	12135	0.355	1	0	0	0.487
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00001	0.063	0.00165	0.033		
1	0.00138	0.171	0.02567	0.104		
2	0.024	0.256	0.05979	0.196		
3	0.07909	0.363	0.07871	0.251		
4	0.16034	0.423	0.05619	0.302		
5	0.18488	0.461	0.08801	0.285		
6	0.19953	0.498	0.05136	0.3		
7	0.19377	0.5	0.05791	0.36		
8	0.22728	0.439	0.02466	0.306		
IBC						
Age	Sel	CWt				
0	0.00015	0.033				
1	0.00244	0.108				
2	0.00794	0.213				
3	0.01667	0.306				
4	0.02524	0.392				
5	0.03083	0.404				
6	0.02944	0.457				

7	0.02887	0.465				
8	0.02861	0.426				
2019						
Age	N	M	Mat	PF	PM	SWt
0	11964329	2.066	0	0	0	0.011
1	.	1.178	0.38	0	0	0.036
2	.	0.71	0.85	0	0	0.106
3	.	0.582	0.98	0	0	0.203
4	.	0.548	1	0	0	0.303
5	.	0.5	1	0	0	0.363
6	.	0.355	1	0	0	0.44
7	.	0.355	1	0	0	0.475
8	.	0.355	1	0	0	0.487
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00001	0.063	0.00165	0.033		
1	0.00138	0.171	0.02567	0.104		
2	0.024	0.256	0.05979	0.196		
3	0.07909	0.363	0.07871	0.251		
4	0.16034	0.423	0.05619	0.302		
5	0.18488	0.461	0.08801	0.285		
6	0.19953	0.498	0.05136	0.3		
7	0.19377	0.5	0.05791	0.36		
8	0.22728	0.439	0.02466	0.306		
IBC						
Age	Sel	CWt				
0	0.00015	0.033				
1	0.00244	0.108				
2	0.00794	0.213				
3	0.01667	0.306				
4	0.02524	0.392				
5	0.03083	0.404				
6	0.02944	0.457				
7	0.02887	0.465				
8	0.02861	0.426				
2020						
Age	N	M	Mat	PF	PM	SWt
0	11964329	2.066	0	0	0	0.011
1	.	1.178	0.38	0	0	0.036
2	.	0.71	0.85	0	0	0.106
3	.	0.582	0.98	0	0	0.203
4	.	0.548	1	0	0	0.303
5	.	0.5	1	0	0	0.363
6	.	0.355	1	0	0	0.44
7	.	0.355	1	0	0	0.475
8	.	0.355	1	0	0	0.487
Catch						
Age	Sel	CWt	DSel	DCWt		

0	0.00001	0.063	0.00165	0.033
1	0.00138	0.171	0.02567	0.104
2	0.024	0.256	0.05979	0.196
3	0.07909	0.363	0.07871	0.251
4	0.16034	0.423	0.05619	0.302
5	0.18488	0.461	0.08801	0.285
6	0.19953	0.498	0.05136	0.3
7	0.19377	0.5	0.05791	0.36
8	0.22728	0.439	0.02466	0.306
IBC				
Age	Sel	CWt		
0	0.00015	0.033		
1	0.00244	0.108		
2	0.00794	0.213		
3	0.01667	0.306		
4	0.02524	0.392		
5	0.03083	0.404		
6	0.02944	0.457		
Input units are thousands and kg - output in tonnes				

Table 23.1.26. Whiting in Subarea 4 and Division 7.d: MFDP output table for short-term forecasts.

MFDP version 1a; Run: run. Time and date: 16:01 28/04/2018; Basis: F(2018) = average exploitation (2015-2017), scaled to F(2017) = 0.218; Fbar age range: 2–6; Recruitment (2018–2020) = 11 964 million (geometric mean 2002–2017); TAC 27.4 (2018) = 22 057.

Output units in tonnes

2018

	Catch				Landings					Discards		IBC			0.75*Fbar	1.25*Fbar
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**	**27.4+27.7d HC catch**	**27.4 HC catch**	**27.7d HC catch**	**FBar**	**Yield**	**FMult**	**FBar**	**Yield**	**0.164**	**0.273**
344982	178387	1	0.2184	32556	0.1296	16961	29451	24008	5443	0.0668	12490	1	0.022	3105		

2019 | **2020** | **2018 TAC 27.4** | **22057**

	Catch				Landings					Discards		IBC							
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**	**27.4+27.7d HC catch**	**27.4 HC catch**	**27.7d HC catch**	**FBar**	**Yield**	**FMult**	**FBar**	**Yield**	**Biomass**	**SSB**	**27.4 TAC change**	**SSB change**	
343746	172124	0	0.022	3385	0	0	0	0	0	0	0	1	0.022	3385	360450	186996	-100%	8.60%	
.	172124	0.1	0.042	6494	0.013	1911	3137	2557	580	0.007	1226	1	0.022	3357	358213	184790	-88.40%	7.40%	.
.	172124	0.2	0.061	9557	0.026	3788	6226	5075	1151	0.013	2438	1	0.022	3331	356017	182625	-77.00%	6.10%	.
.	172124	0.3	0.081	12570	0.039	5631	9266	7554	1712	0.02	3635	1	0.022	3304	353860	180498	-65.80%	4.90%	.
.	172124	0.4	0.101	15538	0.052	7441	12260	9994	2266	0.027	4819	1	0.022	3278	351742	178411	-54.70%	3.70%	.
.	172124	0.5	0.12	18460	0.065	9219	15208	12398	2810	0.033	5989	1	0.022	3252	349662	176361	-43.80%	2.50%	.
.	172124	0.6	0.14	21336	0.078	10965	18110	14763	3347	0.04	7145	1	0.022	3226	347618	174348	-33.10%	1.30%	.
.	172124	0.7	0.16	24170	0.091	12680	20969	17094	3875	0.047	8289	1	0.022	3201	345611	172371	-22.50%	0.10%	.
.	172124	0.8	0.179	26959	0.104	14364	23783	19388	4395	0.053	9419	1	0.022	3176	343639	170429	-12.10%	-1.00%	.
.	172124	0.9	0.199	29707	0.117	16019	26556	21648	4908	0.06	10537	1	0.022	3151	341702	168522	-1.90%	-2.10%	.
.	172124	1	0.218	32413	0.13	17644	29286	23874	5412	0.067	11642	1	0.022	3127	339800	166650	8.20%	-3.20%	.
.	172124	1.1	0.238	35079	0.143	19241	31976	26067	5909	0.074	12735	1	0.022	3103	337930	164810	18.20%	-4.20%	.
.	172124	1.2	0.258	37705	0.156	20810	34626	28227	6399	0.08	13816	1	0.022	3079	336094	163003	28%	-5.30%	.

.	172124	1.3	0.277	40291	0.168	22351	37235	30354	6881	0.087	14884	1	0.022	3056	334289	161228	37.60%	-6.30%		.
.	172124	1.4	0.297	42839	0.181	23865	39806	32450	7356	0.094	15941	1	0.022	3033	332516	159484	47.10%	-7.30%		.
.	172124	1.5	0.317	45350	0.194	25353	42340	34516	7824	0.1	16987	1	0.022	3010	330773	157771	56.50%	-8.30%		.
.	172124	1.6	0.336	47824	0.207	26815	44836	36550	8286	0.107	18021	1	0.022	2988	329060	156088	65.70%	-9.30%		.
.	172124	1.7	0.356	50261	0.22	28252	47296	38556	8740	0.114	19044	1	0.022	2965	327378	154435	74.80%	-10.30%		.
.	172124	1.8	0.376	52663	0.233	29664	49720	40532	9188	0.12	20056	1	0.022	2943	325724	152810	83.80%	-11.20%		.
.	172124	1.9	0.395	55030	0.246	31051	52108	42478	9630	0.127	21057	1	0.022	2922	324098	151213	92.60%	-12.10%		.
.	172124	2	0.415	57362	0.259	32415	54462	44397	10065	0.134	22047	1	0.022	2900	322500	149644	101%	-13.10%		.
.	172124	**0.75**	0.169	24930	0.097	13075	21737	17720	4017	0.05	8663	1	0.022	3193	345147	171920	-19.70%	-0.10%	0.75 * Fsq	
.	172124	0.76	**0.172**	25302	0.099	13298	22113	18026	4086	0.051	8815	1	0.022	3190	344885	171663	-18.30%	-0.30%	Fmsy	
.	172124	**1.25**	0.267	38402	0.162	21162	35330	28801	6529	0.084	14169	1	0.022	3072	335679	162602	30.60%	-5.50%	1.25 * Fsq	
.	172124	0.8	0.178	26181	0.103	13824	23008	18748	4250	0.053	9175	1	0.022	3182	344269	171057	**-15.00%**	-0.60%	15% TAC decrease (27.4)	
.	172124	1.09	0.237	34225	0.142	18655	31111	25366	5750	0.073	12461	1	0.022	3110	338614	165491	**15.00%**	-3.90%	15% TAC increase (27.4)	
.	172124	0.95	0.208	30203	0.123	16239	27060	22057	5000	0.063	10818	1	0.022	3146	341442	168274	**0.00%**	-2.20%	Rollover TAC	
.	172124	1	**0.218**	31614	0.129	17087	28481	23218	5263	0.067	11394	1	0.022	3133	340450	167297	5.30%	-2.80%	Fsq	
.	172124	1.57	**0.33**	46981	0.203	26311	43986	35858	8129	0.105	17675	1	0.022	2995	329650	156668	62.60%	-9.00%	Fpa	
.	172124	2.22	**0.458**	64544	0.288	36854	61707	50303	11403	0.148	24853	1	0.022	2837	317308	144521	128%	-16.00%	Flim	
.	172124	1.03	0.224	32464	0.133	17597	29339	23917	5422	0.069	11742	1	0.022	3126	339852	**166708**	8.40%	-3.10%	Bpa, MSY Btrigger	
.	172124	3.53	0.716	99878	0.458	58065	97359	79367	17992	0.236	39294	1	0.022	2520	292476	**119970**	260%	-30.20%	Blim	

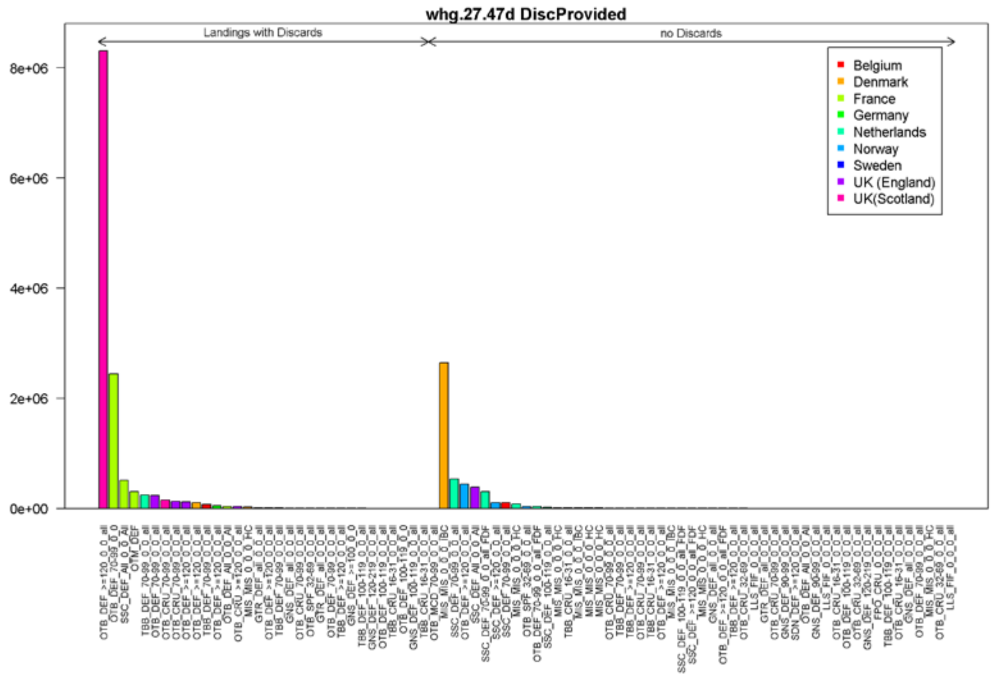


Figure 23.1.1. Whiting in Subarea 4 and Division 7.d: Landings with provided discards. Métier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

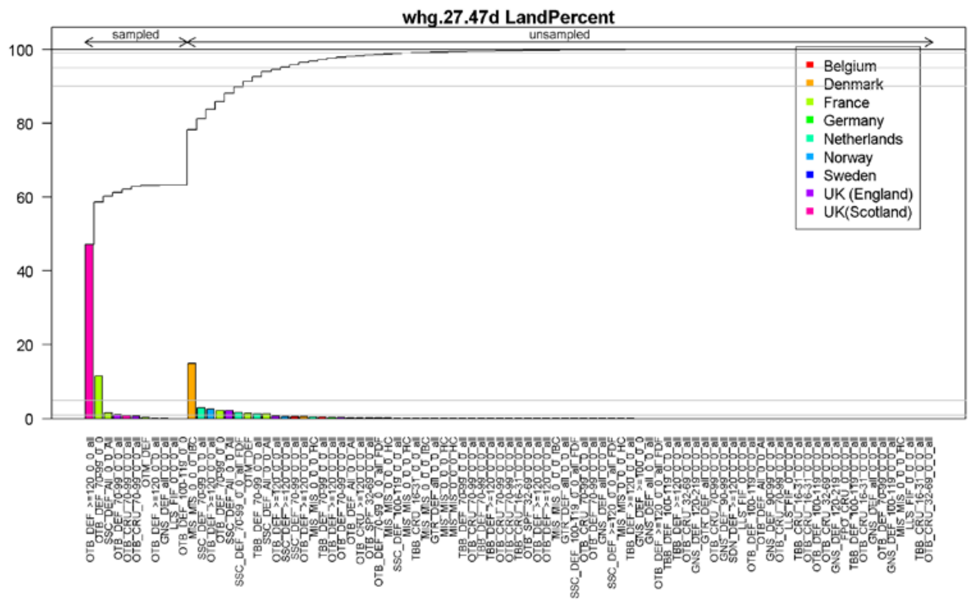


Figure 23.1.2a. Whiting in Subarea 4 and Division 7.d: Reported landings (in percent, colored bars) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

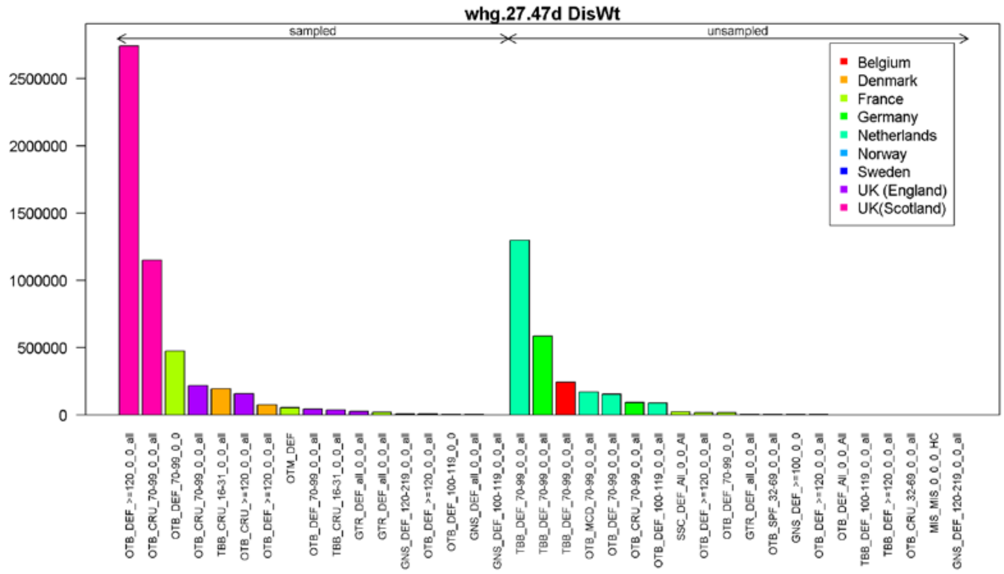


Figure 23.1.2b. Whiting in Subarea 4 and Division 7.d: Reported discards (in tonnes, colored bars) for each sampled and unsampled fleet, in descending order of yield.

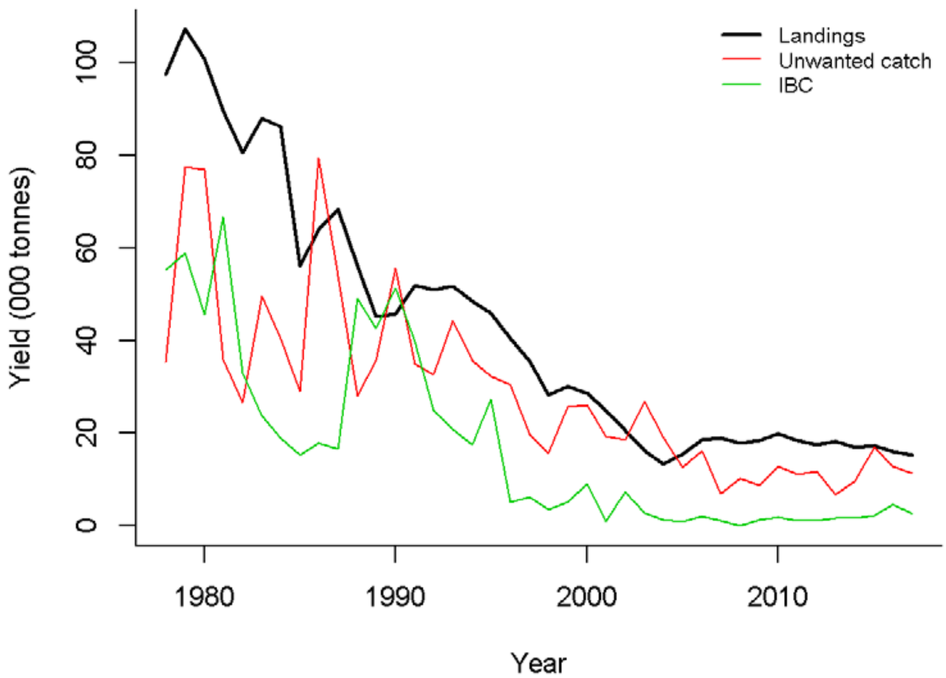


Figure 23.1.3. Whiting in Subarea 4 and Division 7.d: Yield by catch component. Unwanted catch includes discards and BMS landings as estimated by ICES.

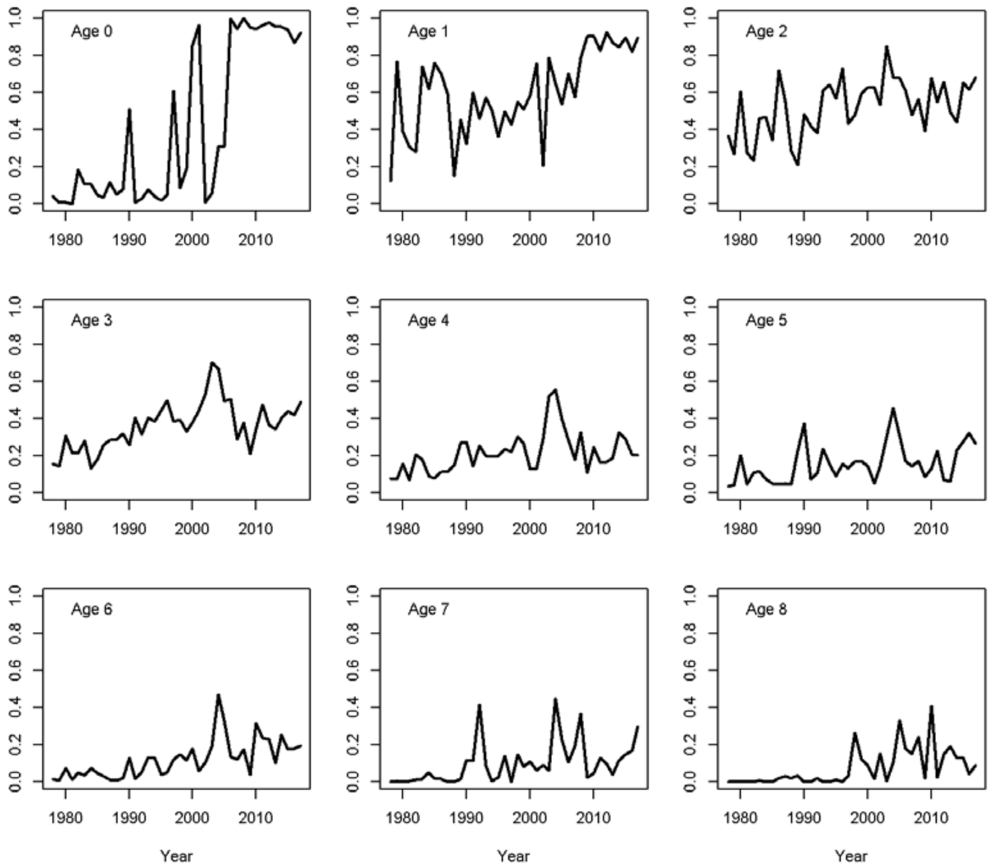


Figure 23.1.4. Whiting in Subarea 4 and Division 7.d: Proportion of unwanted catch in total catch, by age and year.

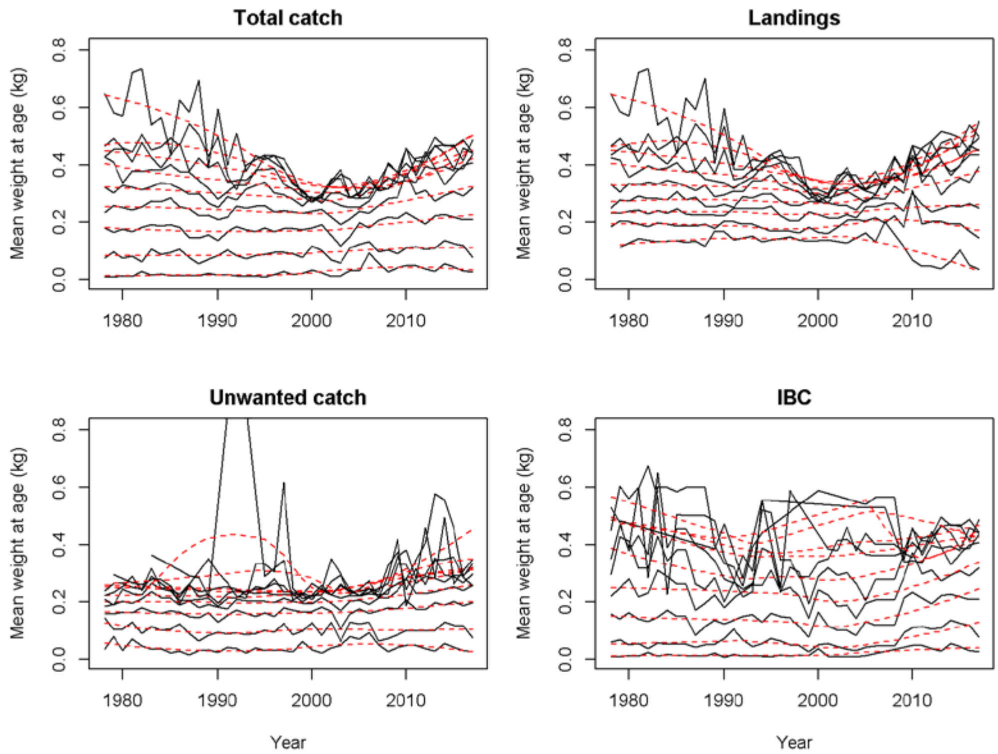


Figure 23.1.5. Whiting in Subarea 4 and Division 7.d: Mean weights-at-age (kg) by catch component (black lines, age 0-8+) and LOESS smoothers through each time-series of mean weights-at-age (red dashed lines).

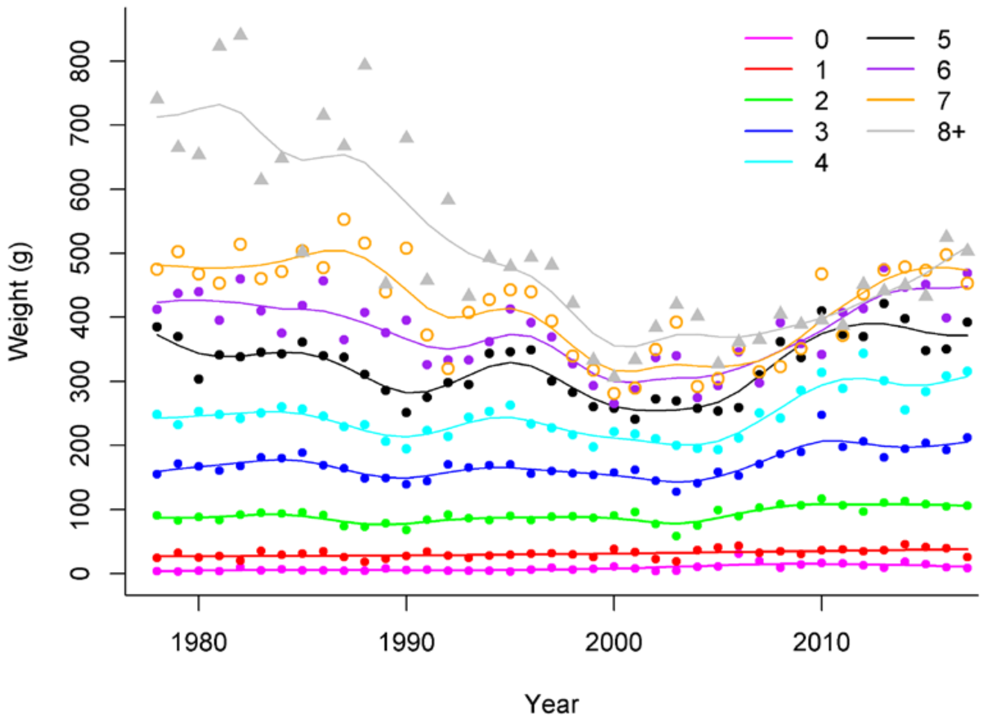


Figure 23.1.6. Whiting in Subarea 4 and Division 7.d: Stock mean weights-at-age (kg) by catch component (dots, age 0-8+) and smoothers through each time-series of mean weights-at-age (lines).

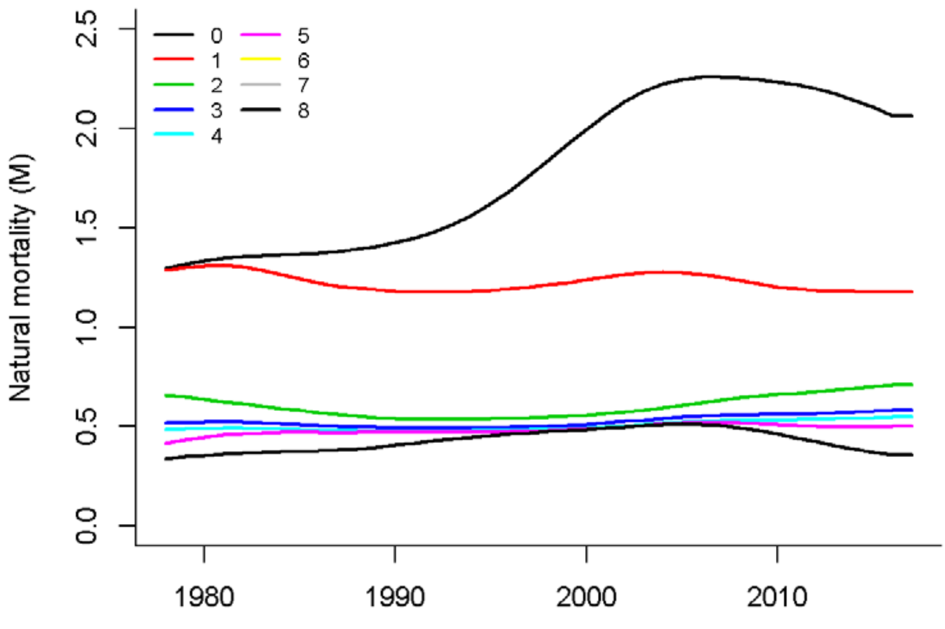


Figure 23.1.7. Whiting in Subarea 4 and Division 7.d: Natural mortality estimates from the 2017 update of SMS key run (WGSAM 2018b) used in assessment. Ages 6–8+ have the same natural mortality.

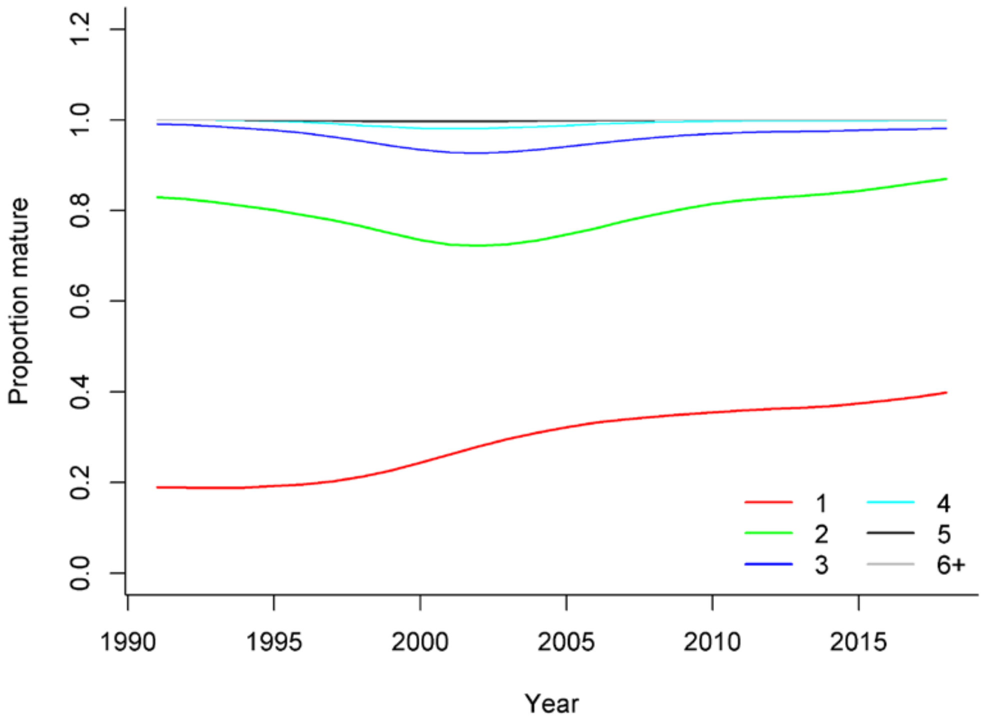


Figure 23.1.8. Whiting in Subarea 4 and Division 7.d: Maturity estimates from NS IBTS Q1 data. Ages 6-8+ have the same maturity values. Estimates prior 1991 are assumed constant using values of 1991.

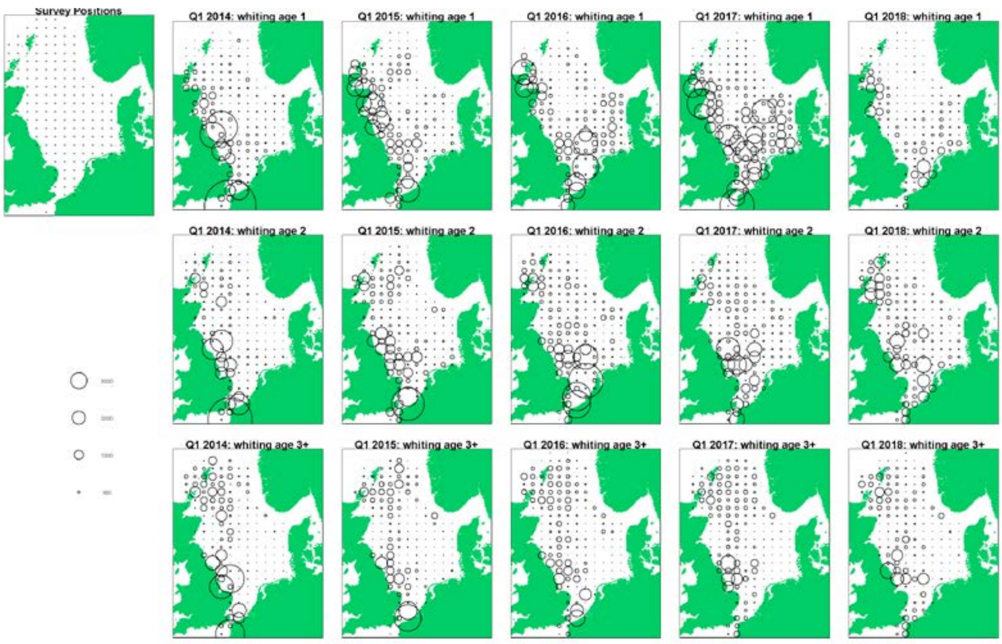


Figure 23.1.9. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for Ages 1–3+ Q1 2014–2018. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q1 survey in the North Sea.

Figure 23.1.10. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for ages 0–3+ Q3 2014–2017. Size of the bubbles indicates 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.

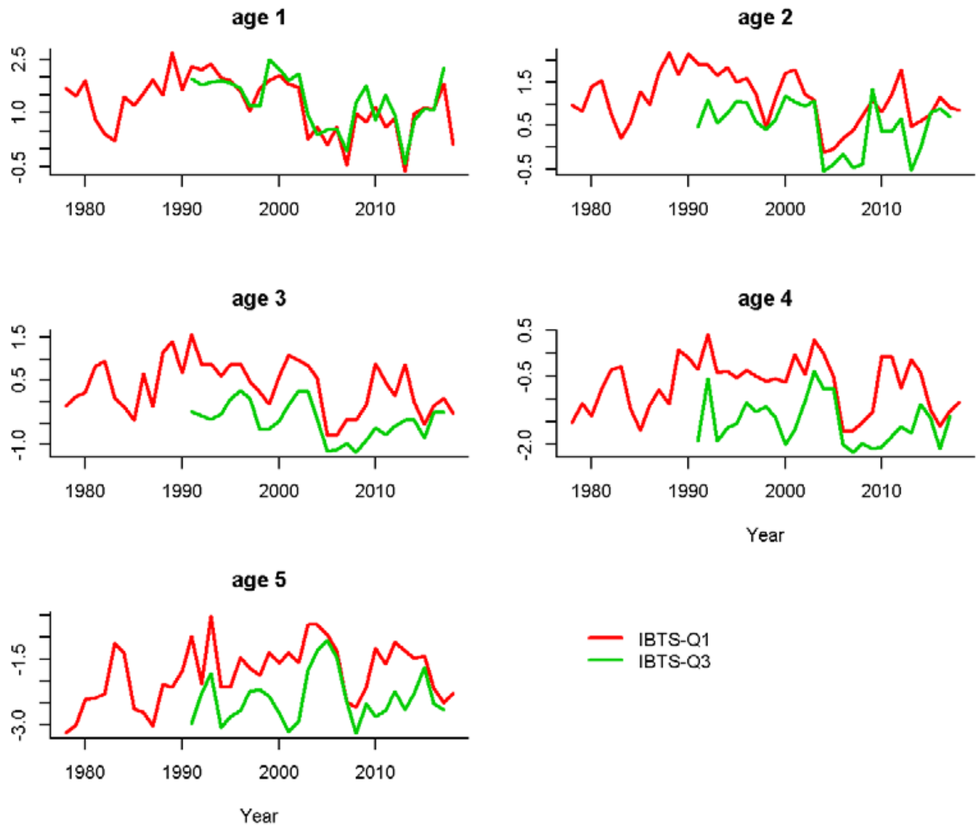


Figure 23.1.11. Whiting in Subarea 4 and Division 7.d: Survey log cpue (catch per unit effort) at age.

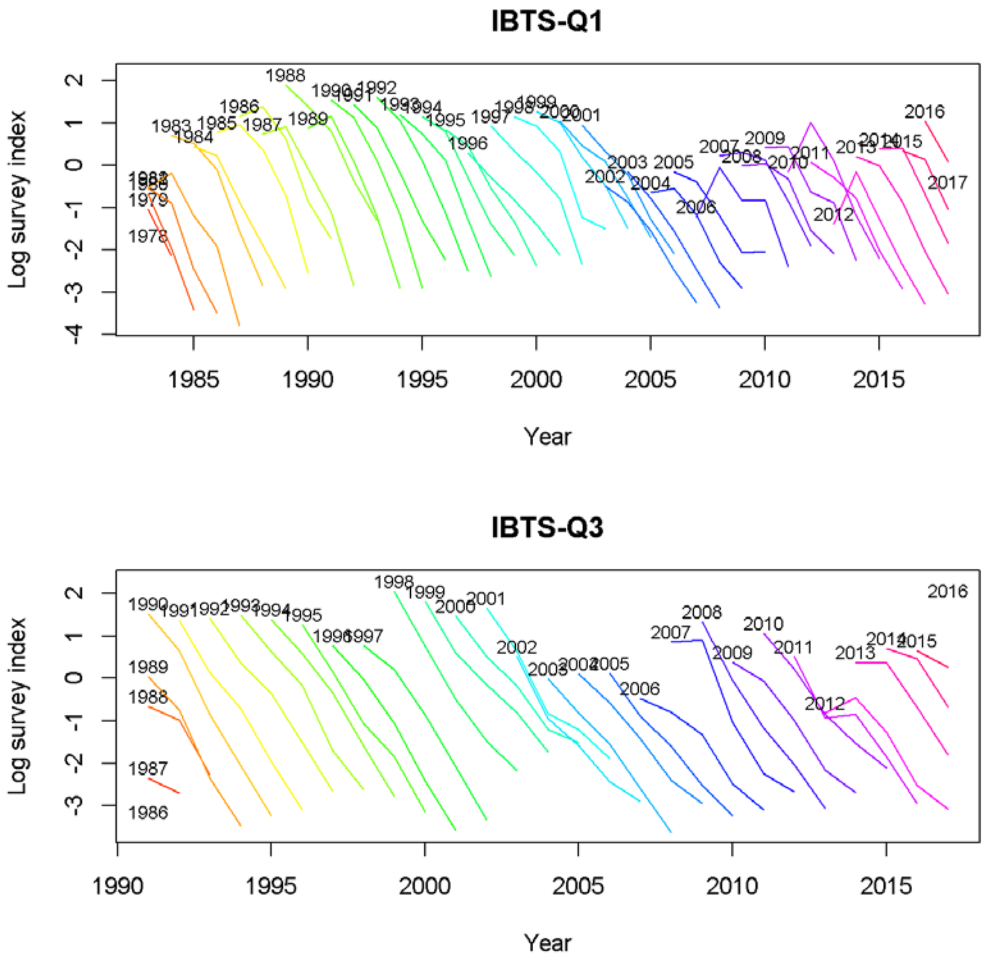


Figure 23.1.12. Whiting in Subarea 4 and Division 7.d: Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

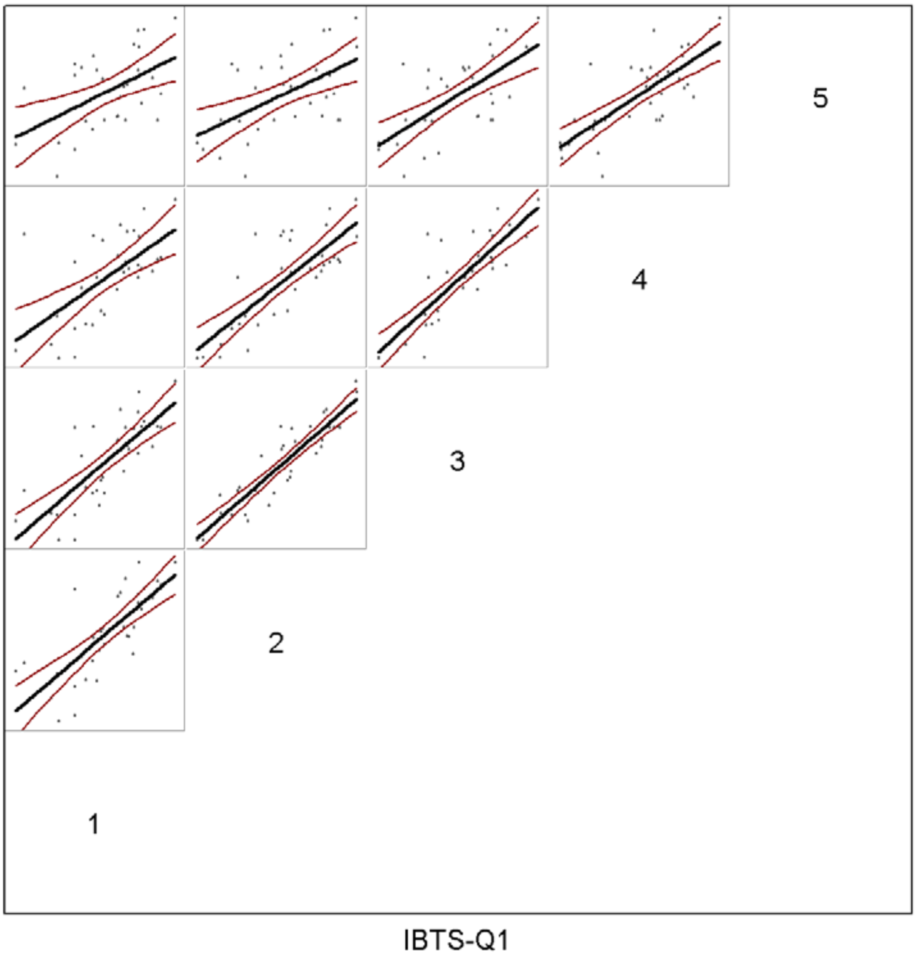


Figure 23.1.13. Within-survey correlations for the IBTS–Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximatee 95% confidence intervals for each fit are also shown.

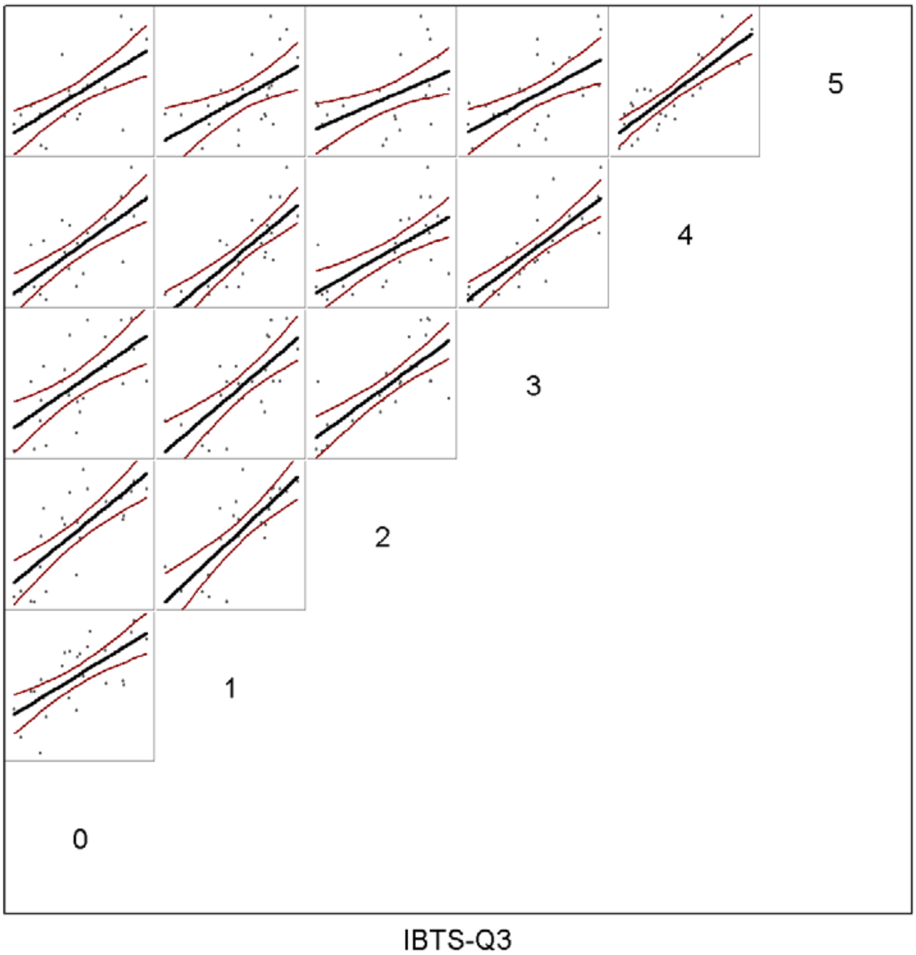


Figure 23.1.14. Within-survey correlations for the IBTS–Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

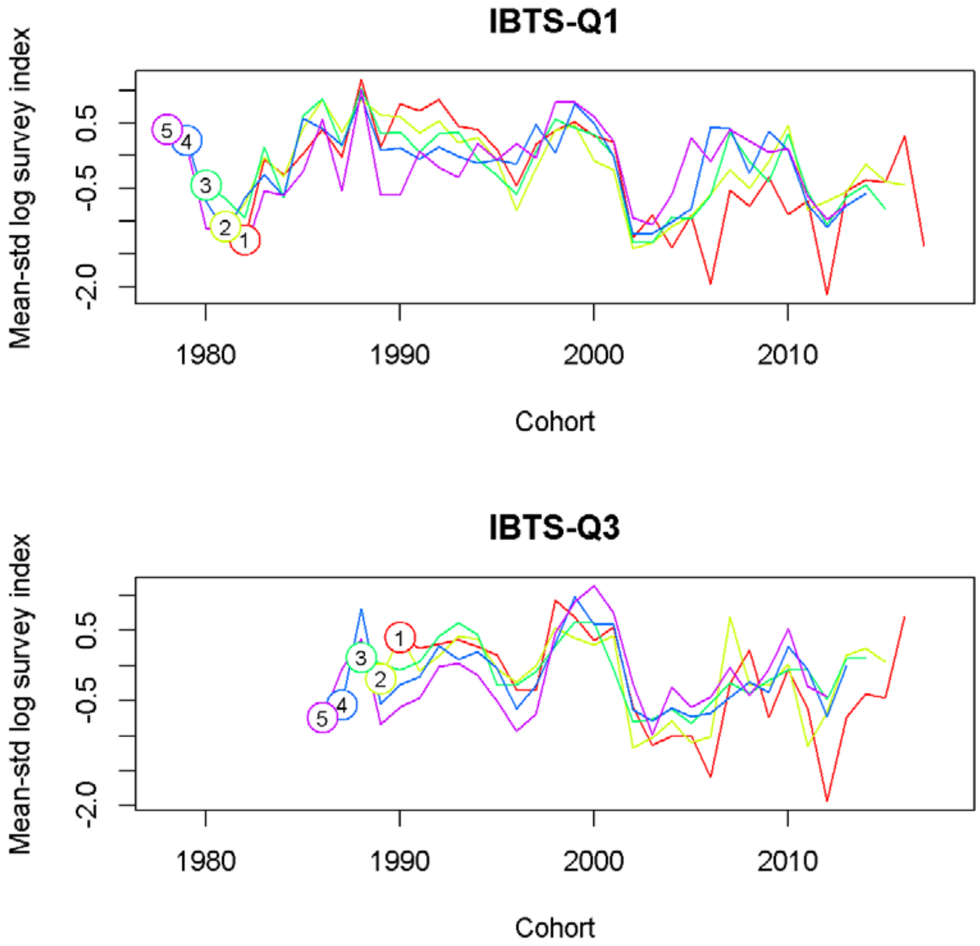


Figure 23.1.15. Whiting in Subarea 4 and Division 7.d: Survey log cpue (catch per unit effort) for the IBTS–Q1 and Q3 surveys, by cohort. Each line shows the log cpue for the age indicated at the start of the line.

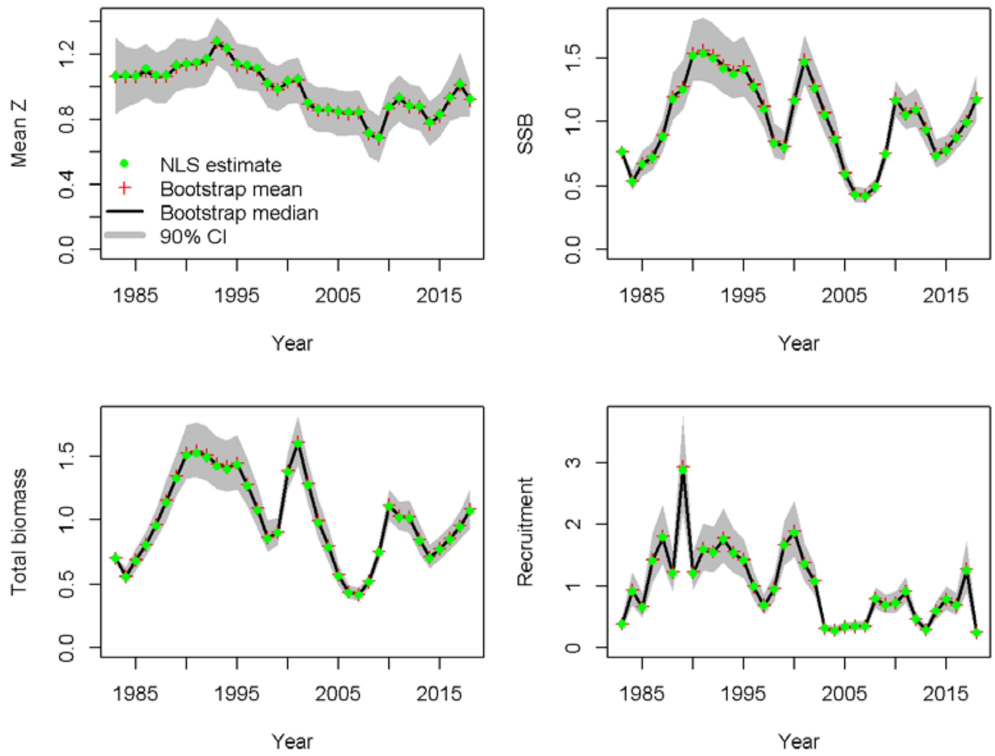
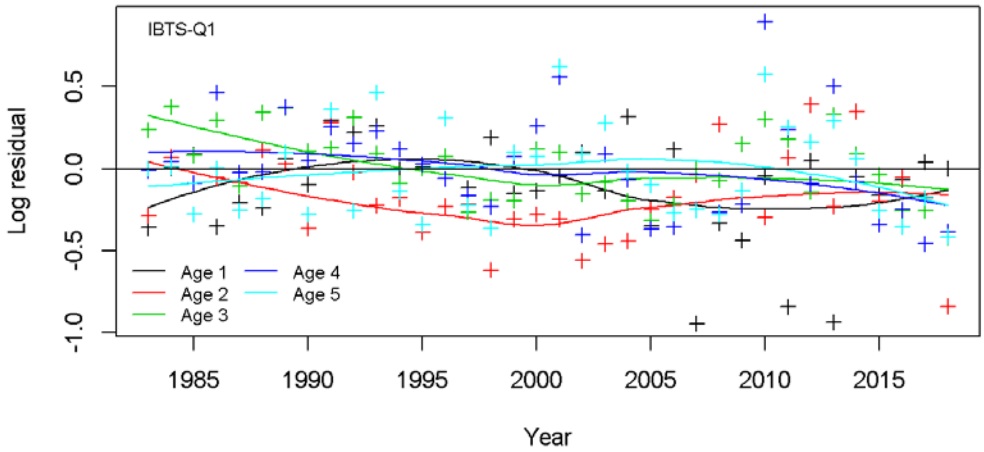


Figure 23.1.16. Whiting in Subarea 4 and Division 7.d: Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment (age 1). Shaded grey 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.



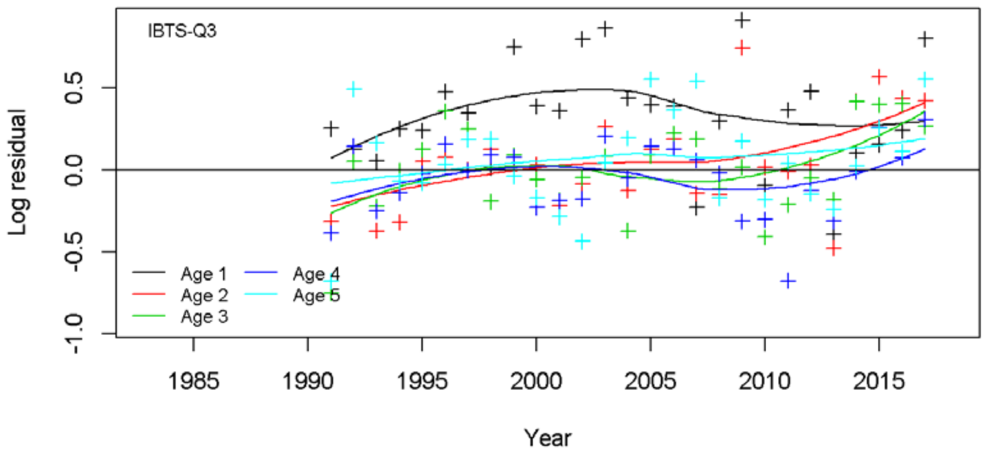


Figure 23.1.17. Whiting in Subarea 4 and Division 7.d: Log survey residuals from the SURBAR analysis. Ages are color-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

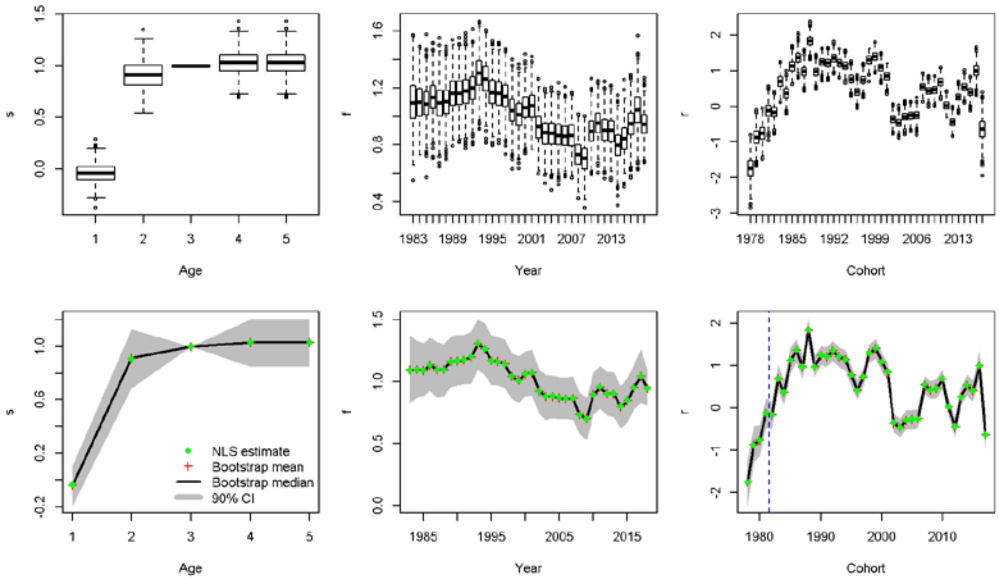


Figure 23.1.18. Whiting in Subarea 4 and Division 7.d: Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

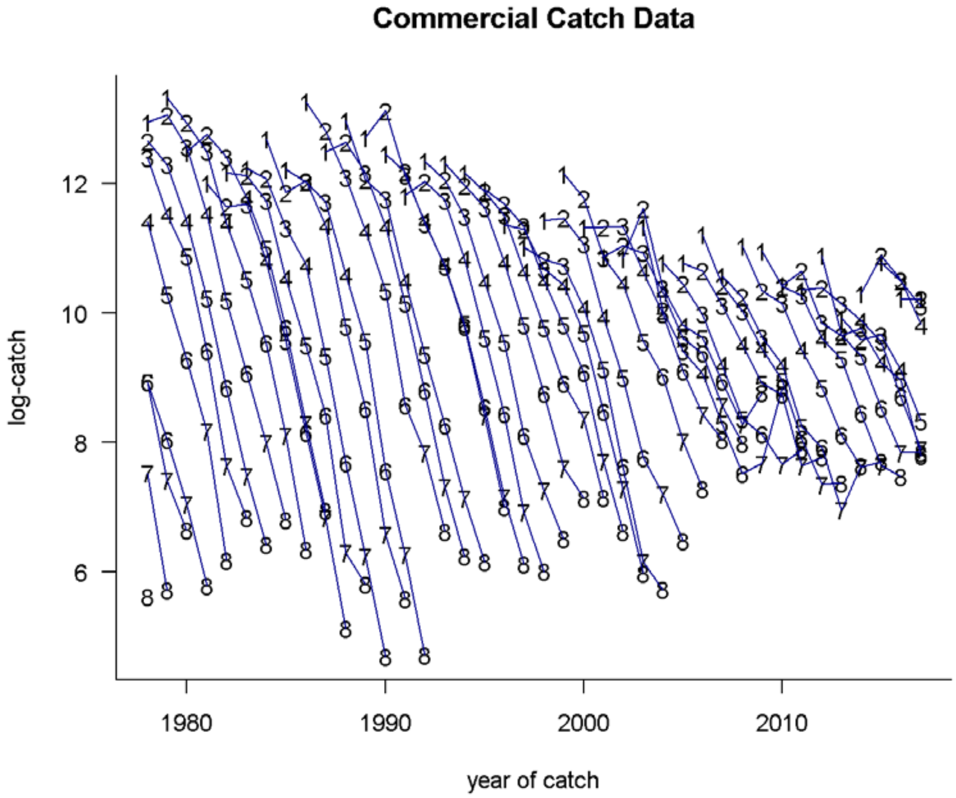


Figure 23.1.19. Whiting in Subarea 4 and Division 7.d: Log-catch curves by cohort for total catches (ages 1–8+).

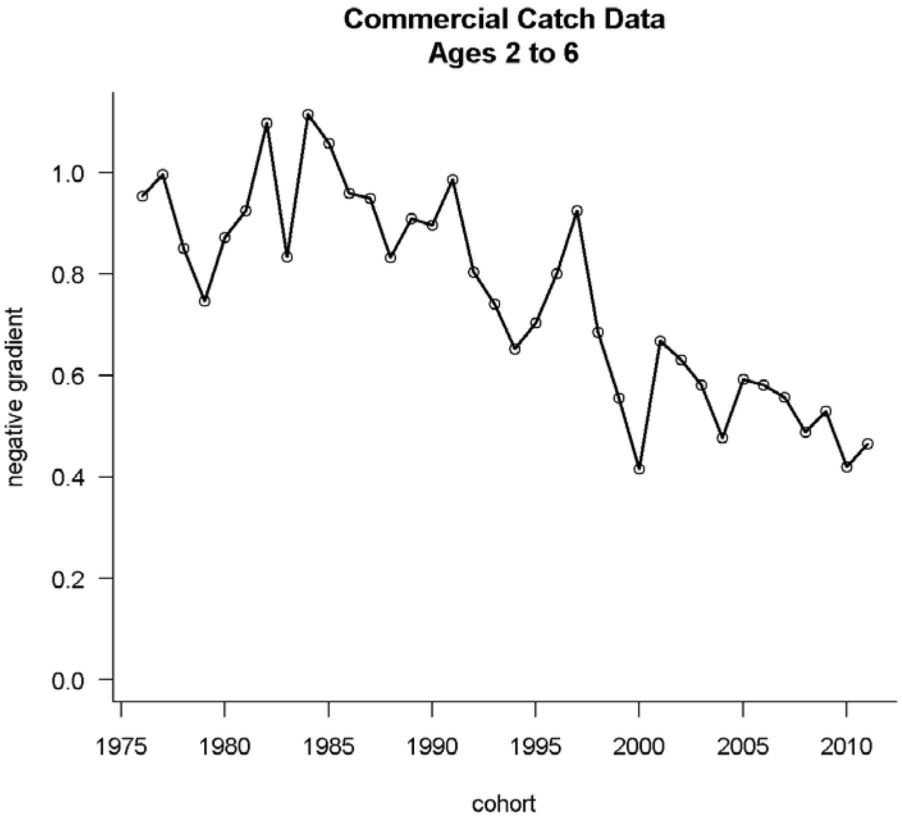


Figure 23.1.20. Whiting in Subarea 4 and Division 7.d: Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

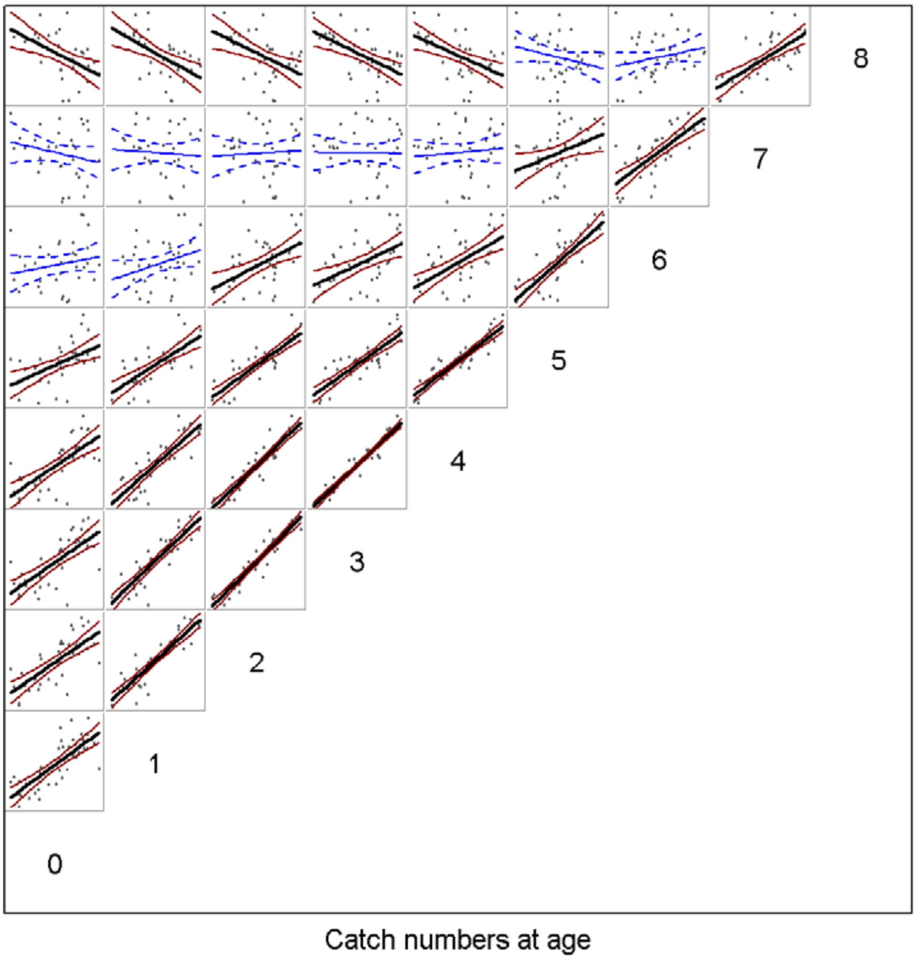


Figure 23.1.21. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black 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.

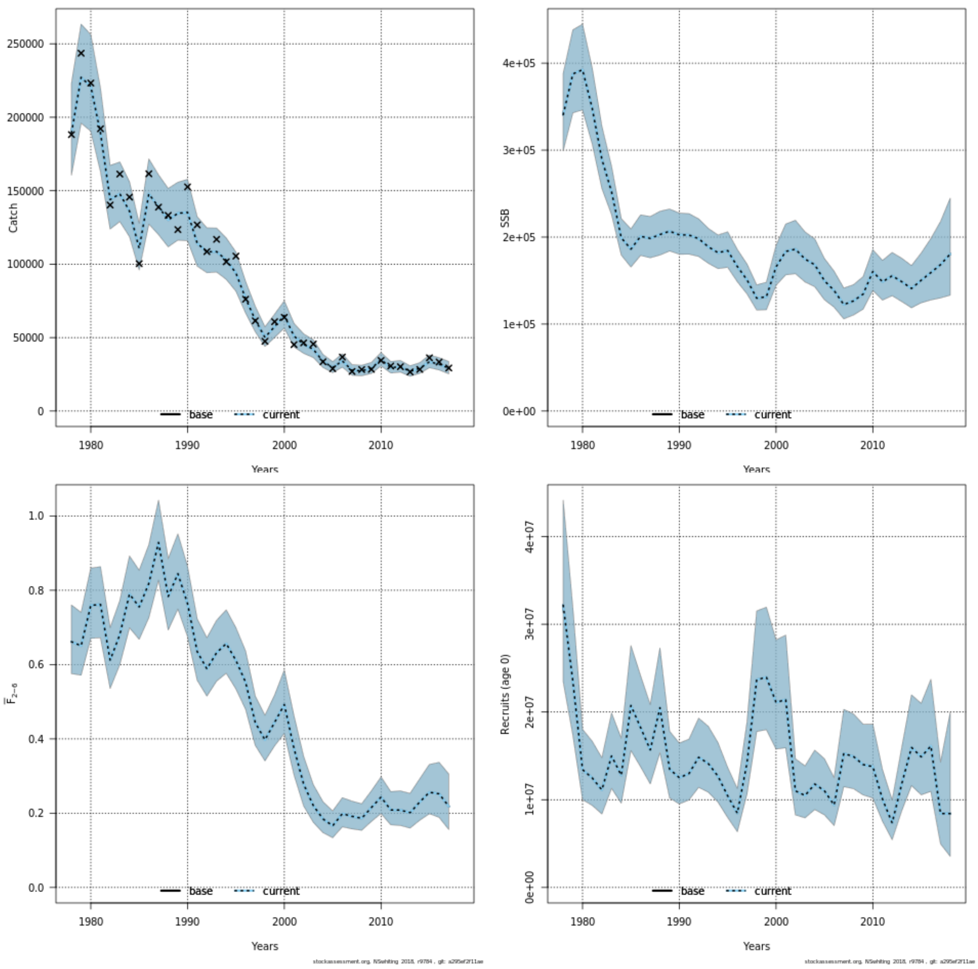


Figure 23.1.22. Whiting in Subarea 4 and Division 7.d: SAM assessment results using catch data series (1978–2017) with IBTS survey data starting in 1983 (Q1) and 1991 (Q3). Estimates with 95% Confidence intervals for total catch weight, SSB, mean fishing mortality and recruitment (at age 0).

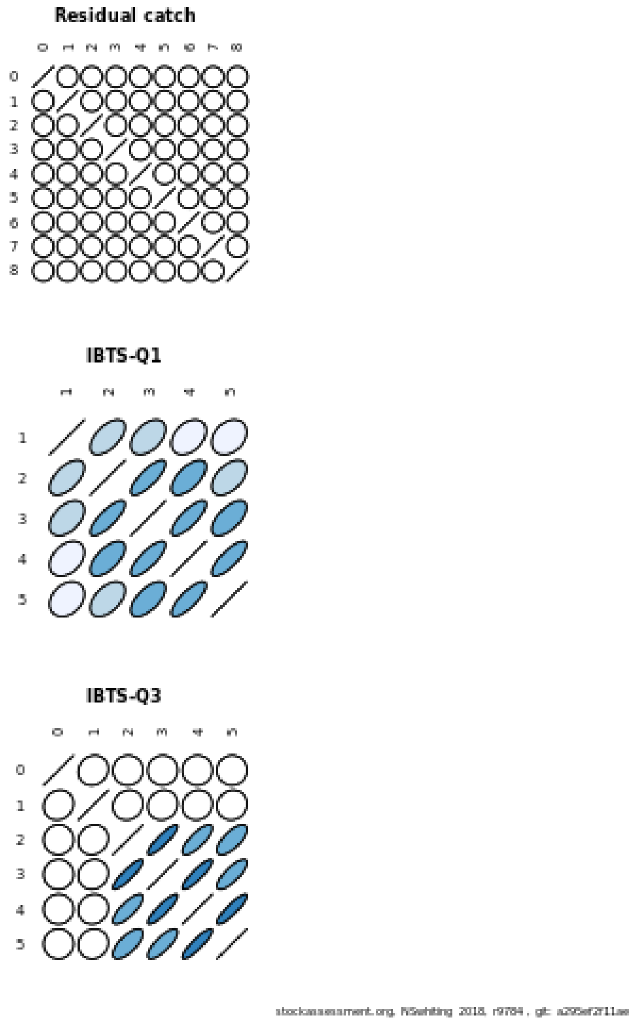


Figure 23.1.23. Whiting in Subarea 4 and Division 7.d: SAM estimated correlations between age groups for each fleet.

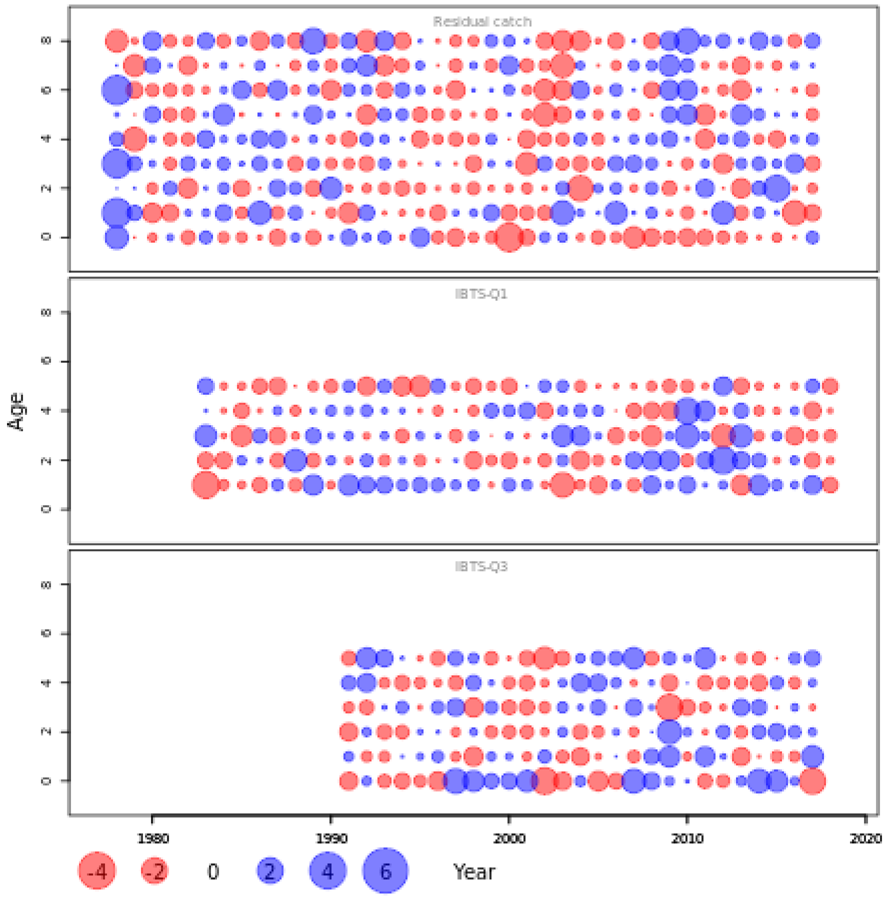


Figure 23.1.24. Whiting in Subarea 4 and Division 7.d: SAM standardized one-observation-ahead residuals.

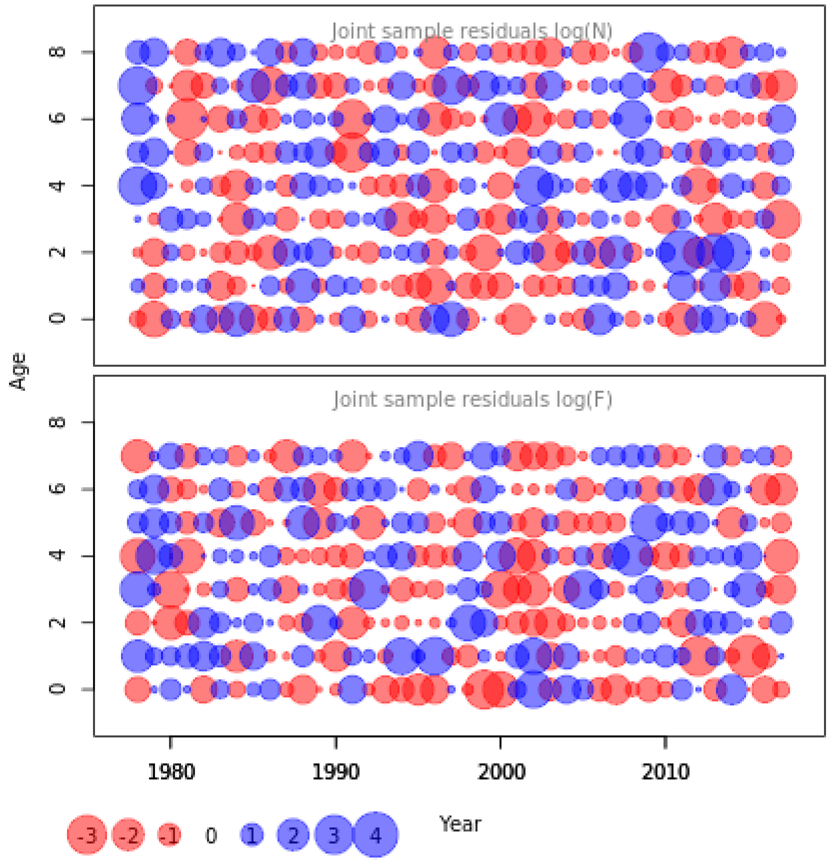


Figure 23.1.25. Whiting in Subarea 4 and Division 7.d: SAM standardized -joint-sample residuals of process increments (for stock size N and fishing mortality F processes).

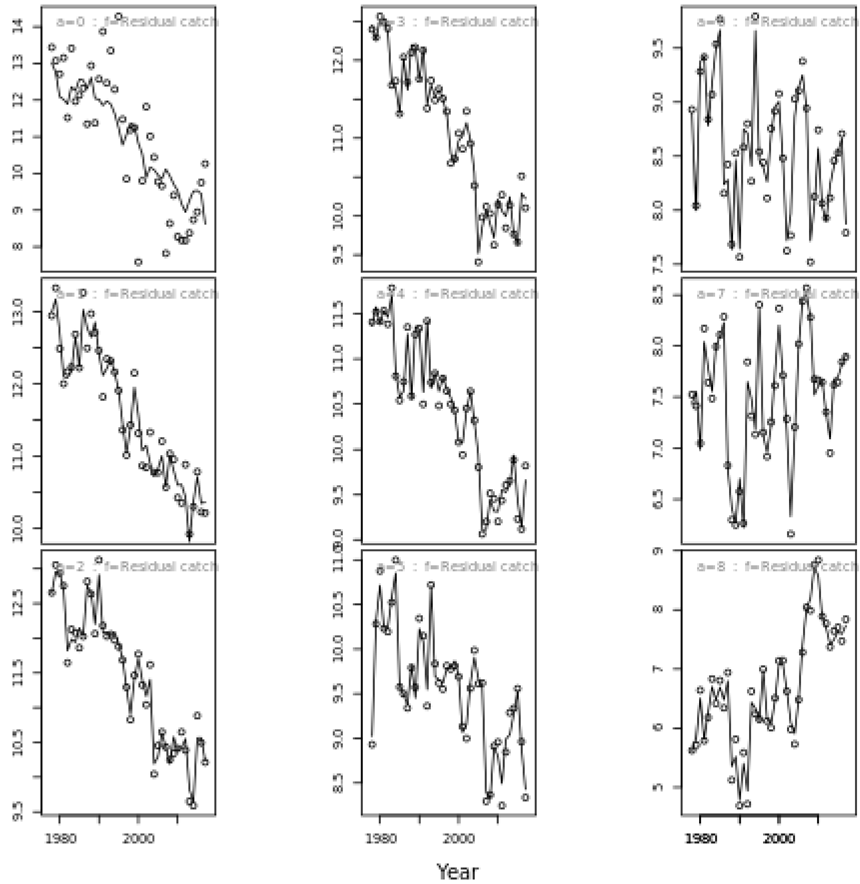


Figure 23.1.26. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale) for the catch fleet.

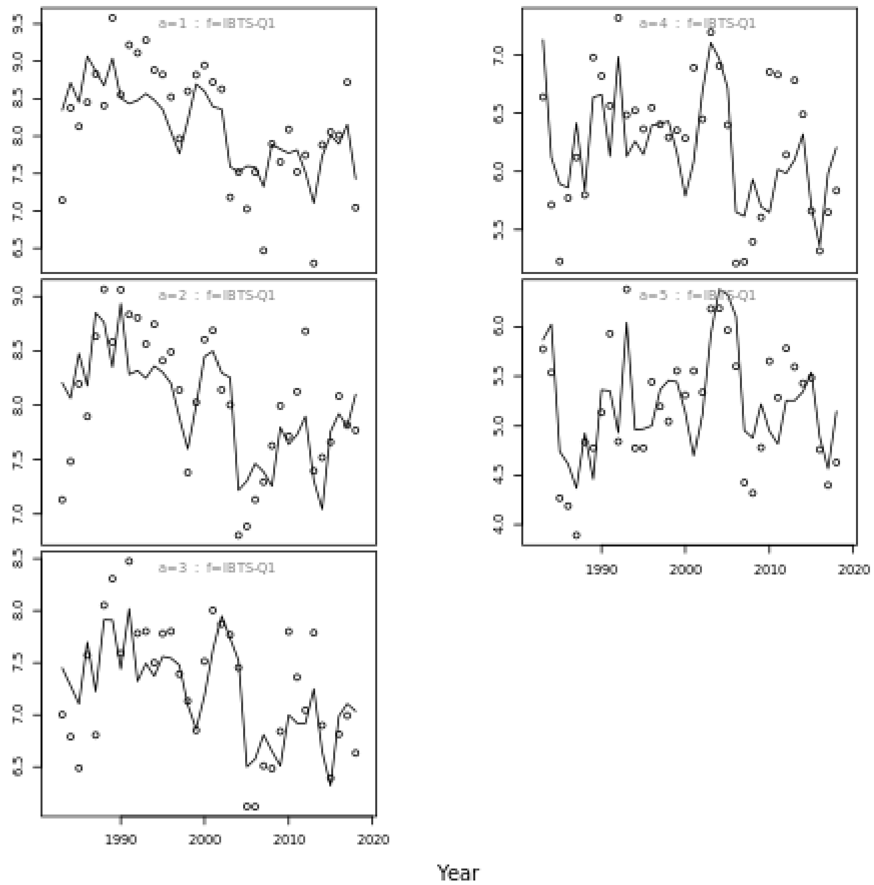


Figure 23.1.27. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q1.

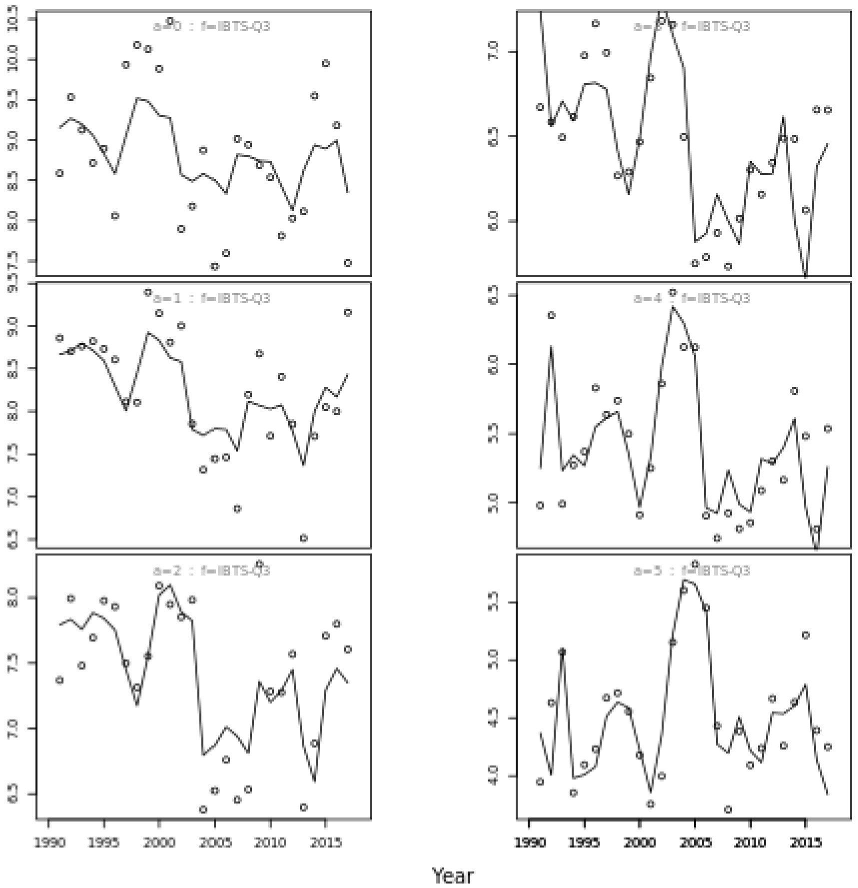


Figure 23.1.28. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q3.

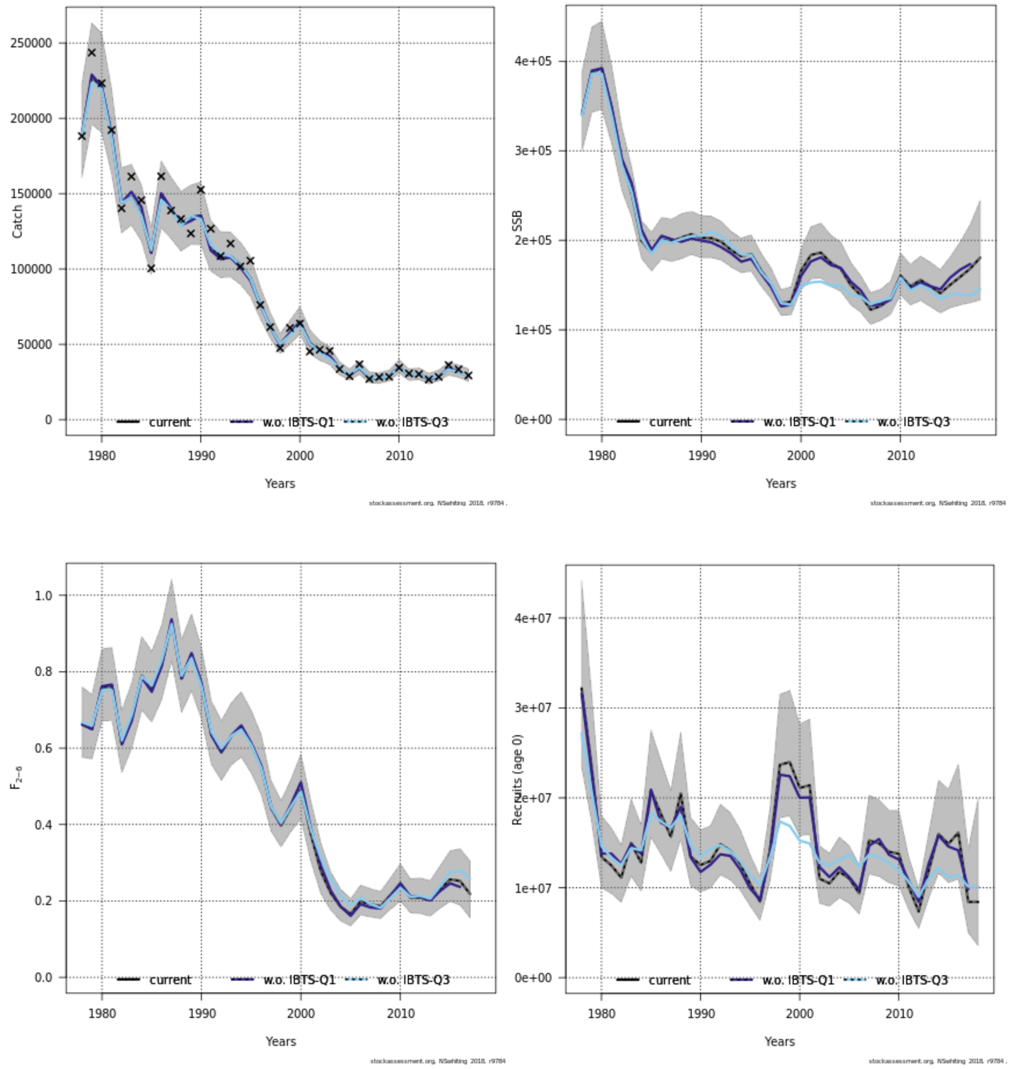


Figure 23.1.29. Whiting in Subarea 4 and Division 7.d: SAM leave-one-out diagnostics. Final run (black), run without IBTS Q1 (dark blue), run without IBTS Q3 (light blue).

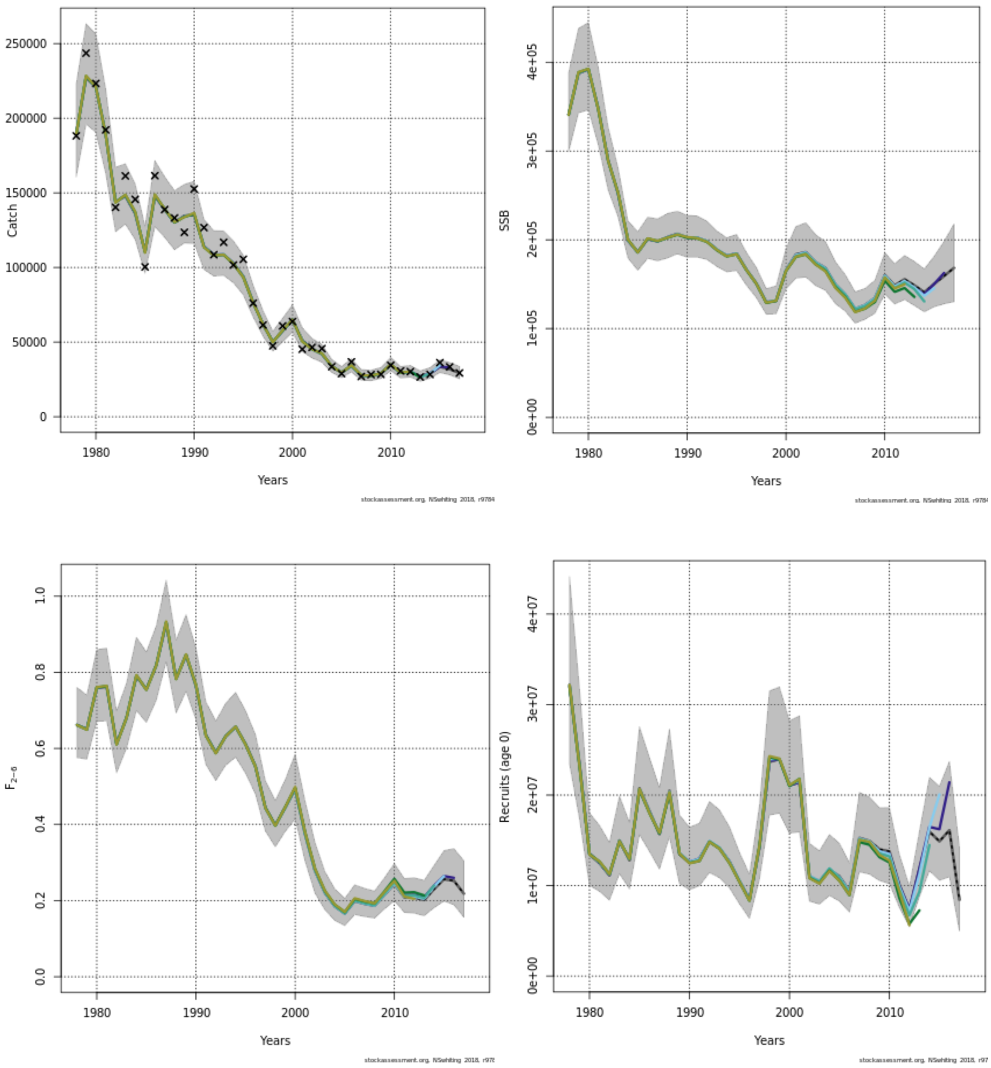


Figure 23.1.30. Whiting in Subarea 4 and Division 7.d: SAM Retrospective pattern in catch estimates, SSB, fishing mortality and recruitment.

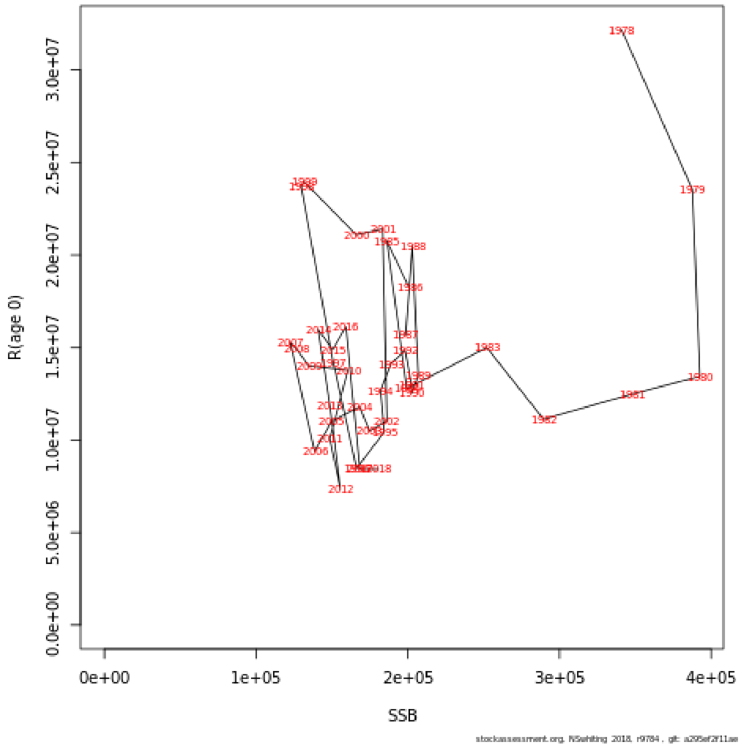


Figure 23.1.31. Whiting in Subarea 4 and Division 7.d: Stock-recruitment relationship.

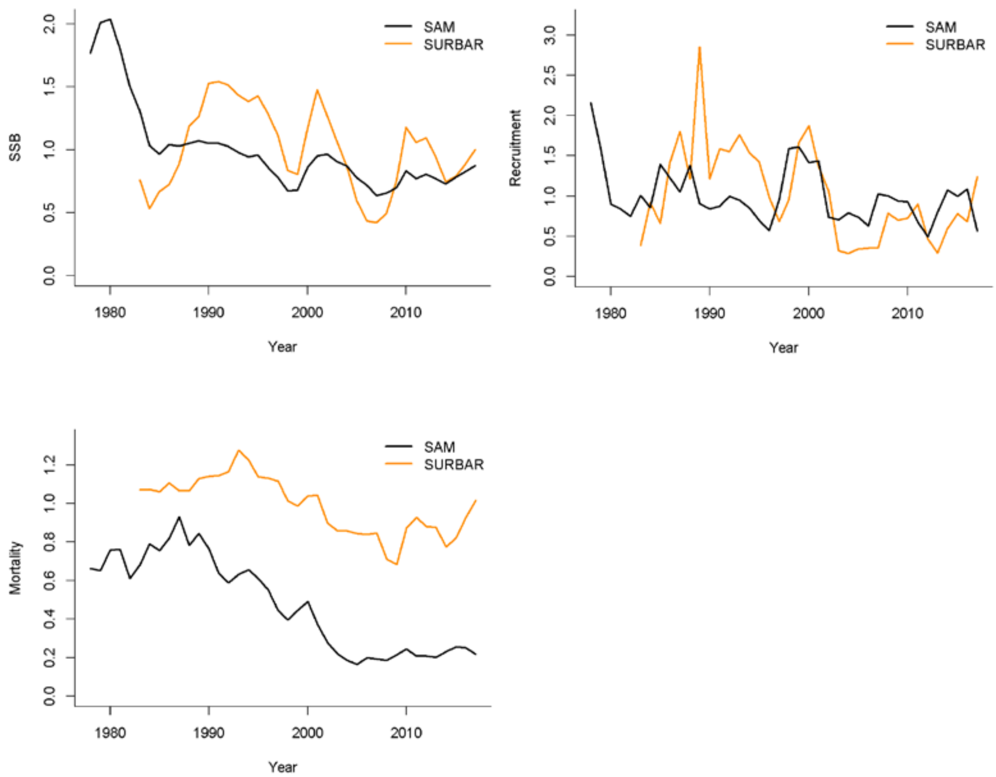


Figure 23.1.32. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final SAM (black) and SURBAR (orange) models. To facilitate comparison, recruitment and SSB values have been mean-standardised using the year range for which estimates are available from all three models. Mortality is presented as F(2-6) for SAM and Z(2-6) for SURBAR.

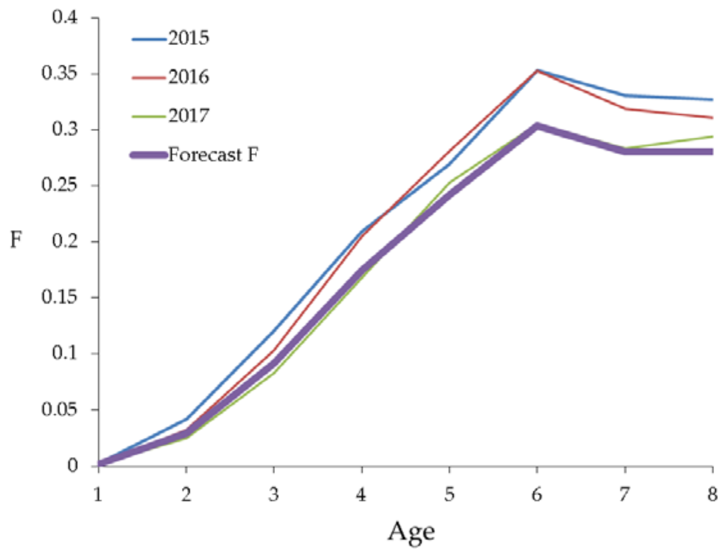


Figure 23.1.33. Whiting in Subarea 4 and Division 7.d: SAM F at age estimates for 2015–2017, along with scaled mean exploitation used for the forecast.

Figure 23.1.34. Whiting in Subarea 4 and Division 7.d: Standard graphs. Historical assessment comparison plot.

23.2 Whiting in Division 3.a

This section was last updated in 2017, as WGNSSK was not requested to provide updated advice on this stock in 2018.

23.2.1 General

23.2.1.1 Stock definition

There is a paucity of information on the population structure of whiting in Division 3.a (the Skagerrak-Kattegat area). No genetic or otolith-based surveys have been conducted. Tagging of whiting has previously been undertaken, but these data need to be re-examined. Results from previously modelled survey data (SURBAR) were inconclusive regarding independent population dynamics in Division 3.a in comparison with the North Sea (ICES 2016), presumably due to the need of age readings in 3.a (age information used in SURBAR was borrowed from Subarea 4). 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. There are also findings of locally spawned whiting eggs in Kattegat 3.aS (Börjesson *et al.*, 2013).

23.2.1.2 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).

23.2.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the landings and discard information from InterCatch. 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.

23.2.1.4 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 23.2.1.

The WGNSSK in 2017 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. ALK was borrowed from Subarea 4 and no ALK exists for Division 3a, however in 2018 years and individuals will be sufficient to generate an ALK for Division 3a. Plots of the IBTS–Q1 and IBTS–Q3 per area are shown in Figure 23.2.1 and BITS–Q1 and Q4 in Figure 23.2.2. IBTS–Q3 indicate high inter-annual variability in recruitment. IBTS–Q1 in Kattegat shows a marked increase in cpue in 2015 which has since come down. The 2015 index was assigned to one single haul dominating the data series. Survey abundance indices are plotted in log-mean standardized form by year and cohort in Figure 23.2.3 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 23.2.4. Year effects occur (top left) and the importance of cohorts fluctuate through the time-series (top right) indicating migratory behavior. No clear pattern of total mortality (bottom right).

23.2.2 Data analyses

23.2.2.1 Exploratory survey-based analysis

Previously exploratory SURBAR analysis has been performed and showed that internal consistency was virtually absent, impeding cohort analysis for the stock (ICES 2016).

23.2.2.2 Conclusions drawn from exploratory analysis

The lack of internal consistency in the available survey indices (Figure 12.1.6 in ICES 2016) 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 2017 to change the perception of the stock.

23.2.2.3 Advice

DLS-category 5.2, which is based on catch information only. Multi-annual advice was given (2015). There are no new data that change the perception of the stock status.

Table 23.2.1. Whiting in Division 3.a (Skagerrak and Kattegat): Nominal landings (t) 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	970	1,031	27	126	+	1,184	
2002	101	975	1,076	23	127	1	1,227	
2003	93	654	747	20	71.9	2	840.9	429
2004	93	1,120	1,213	17	74	1	1,305	909
2005	49	907	956	13	73	0	1,042	299
2006	591	290	349	n/a	85.92	n/a	434.9	331
2007	532	278	331	14	82	1	428	561
2008	522	288	340	14	52	n/a	406	241
2009	712	173	244	10.3	33.82	-	288.1	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
2016	129	335	464	13	62	6	545	1115

[1] Values from 1992 updated by WGNSSK (2007).

[2] Values updated by WGNSSK (2011).

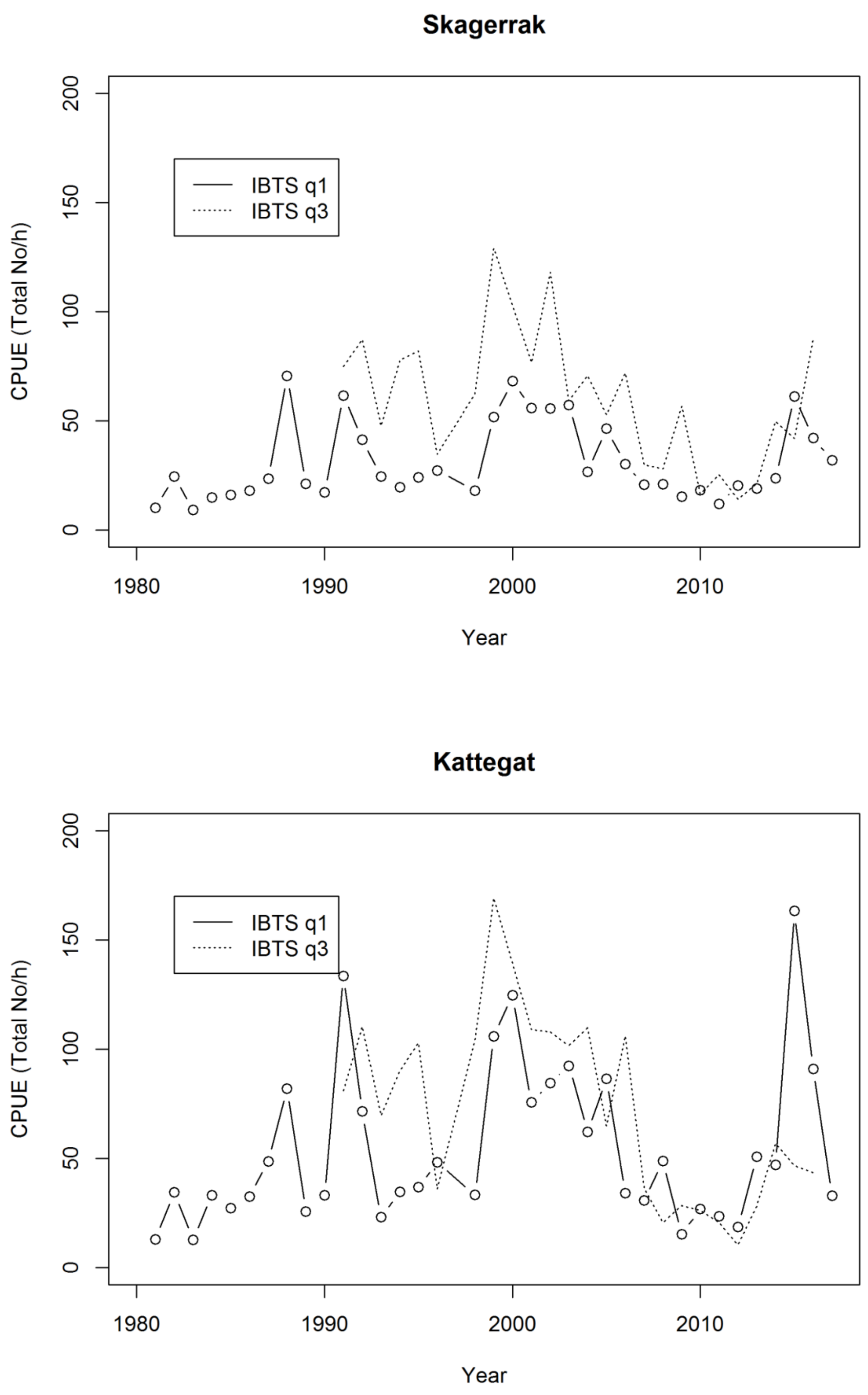


Figure 23.2.1. Whiting in Division 3.a (Skagerrak and Kattegat): IBTS cpue for fish >21 cm per area Q1 covering the years 1981–2017 and Q3 covering the years 1991–2016.

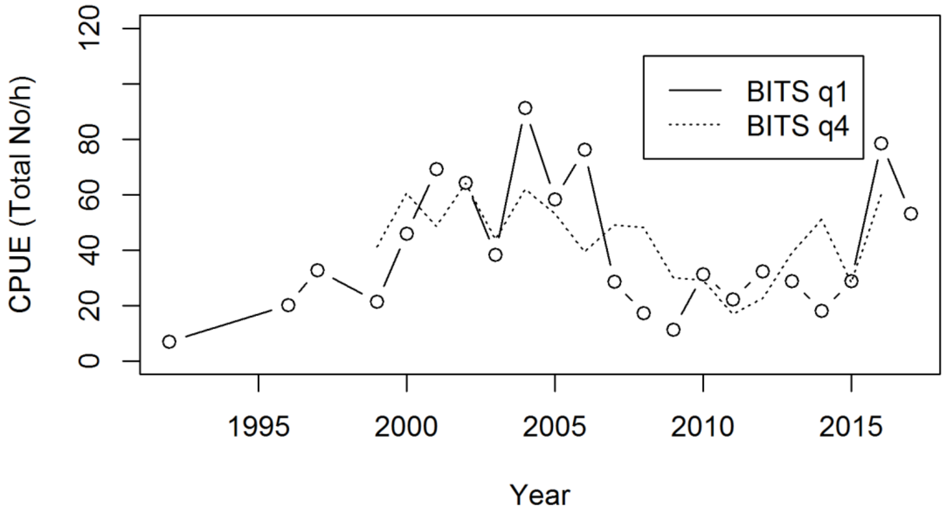


Figure 23.2.2. Whiting in Division 3.a S (Kattegat): BITS cpue for fish >21 cm per Q1 and Q4 covering the years 1992–2017 and 1999–2016, respectively.

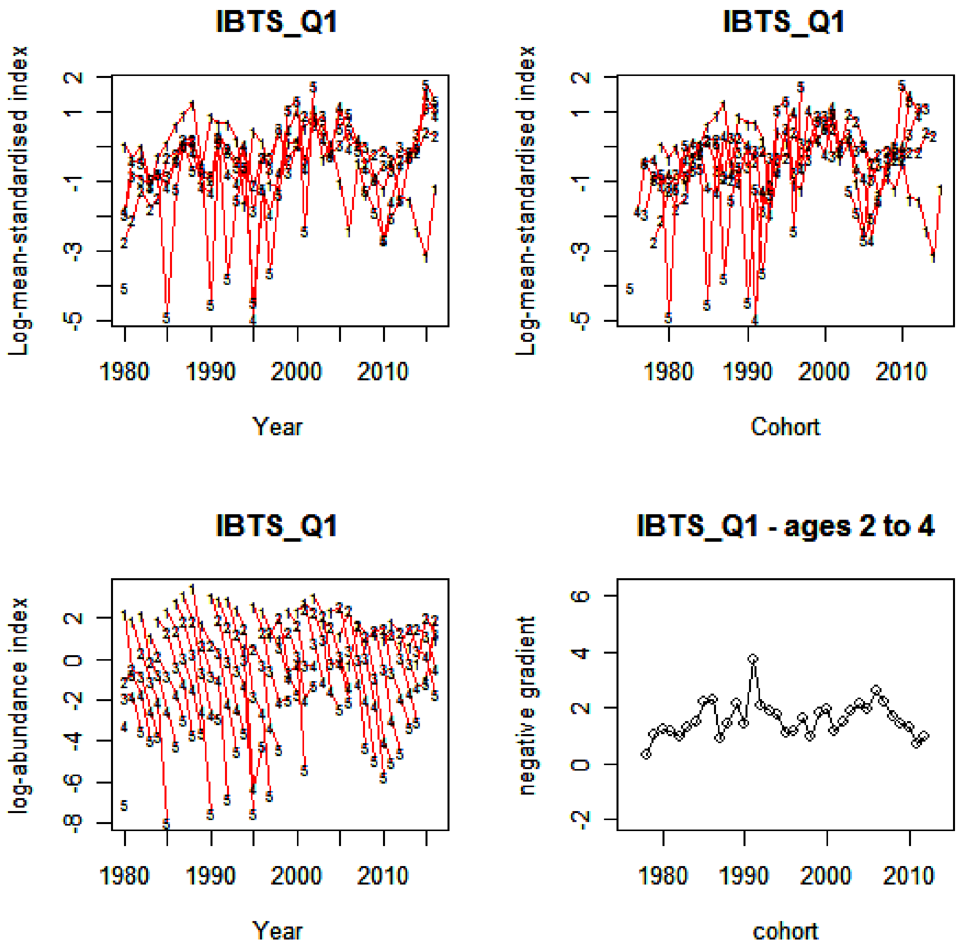


Figure 23.2.3. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta-GAM index).

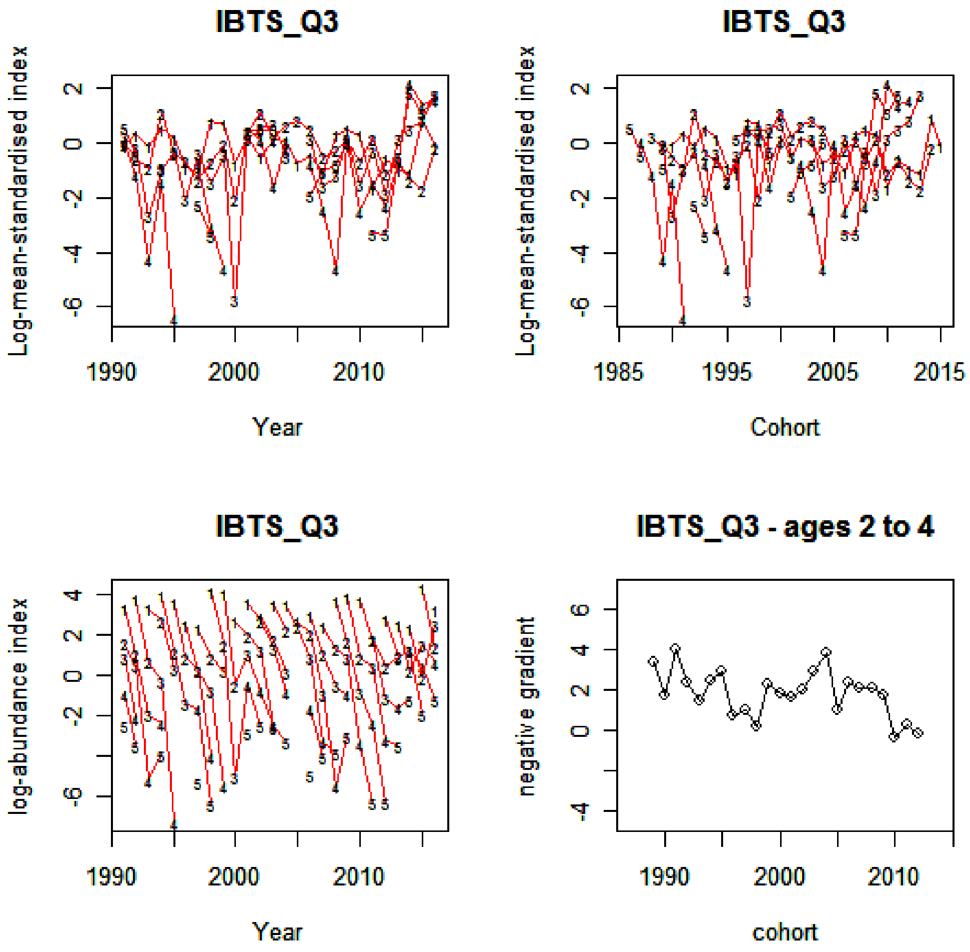


Figure 23.2.4. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

24 Witch in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat) and 7.d (Eastern Channel)

24.1 General

Witch flounder (*Glyptocephalus cynoglossus*) was assessed, between 2010 and 2013, by the Working Group on Assessment of New MoU Species (WGNEW, ICES 2013a). 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 (DATRAS standardized cpue in number per 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 was 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 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. The same was done in 2017, with landing and discard data updated up to 2016. The new data-call in 2017 for the Benchmark Workshop (WKNSEA, 2018) included landing and discards data, by age and length, for the years 2002–2016. Also, data were updated up to 2017 during WGNSSK 2018.

24.1.1 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.

Up to 2016, age determination has been conducted by Sweden also for Scotland and Denmark (only landings). Age readings techniques are now well established but an inter-calibration among readers will soon be planned as from 2017 also Scotland has started to read otoliths for age estimation. The macroscopic evaluation of maturity status is still uncertain and gonadal histological analysis is under development. A fixed maturity ogive was employed in the assessment model. Data exploration and reason for the final decision are elucidated in WKNSEA 2018, WD3.

24.1.2 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 tons 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.

24.2 Fisheries data

24.2.1 Historical landings

North Sea witch flounder's landings have declined from a peak in 2000 up to 2010, but from 2011 a general increasing trend is observed. This species is nowadays mainly landed by Denmark, Norway and Sweden in both areas (3.a and 4) and UK (Scotland and England) mainly in Subarea 4. A small fraction of the total landings are reported by The Netherlands and Belgium in Subarea 4 and Germany in both areas as this species it is mostly discarded (Figure 24.2.1.1). The landings of witch in in Division 7.d reported by France, UK-England and Belgium are negligible. 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.

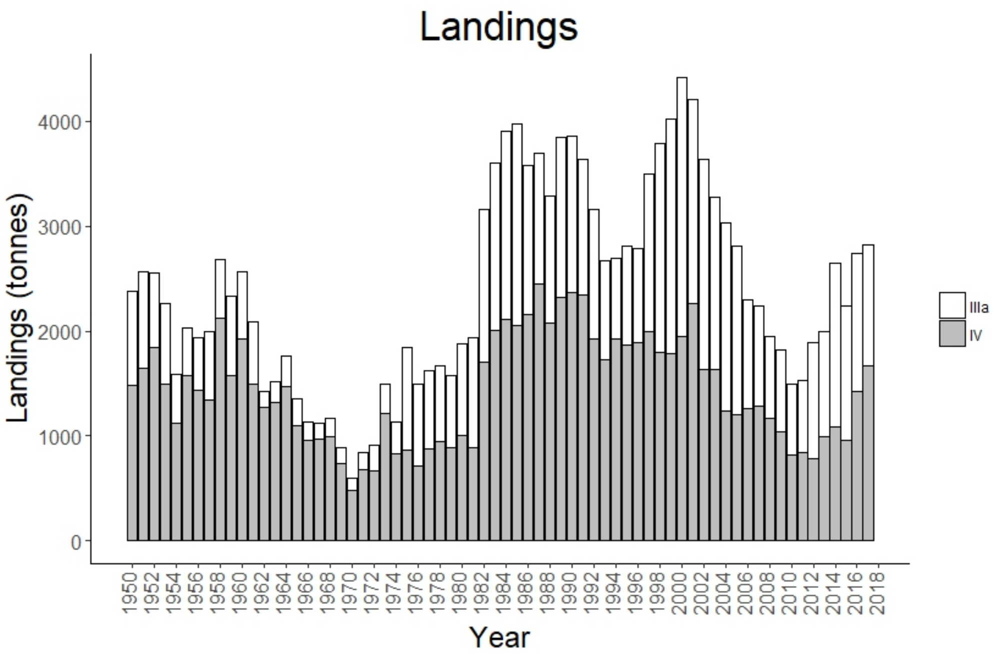


Figure 24.2.1.1. Witch flounder in Subarea 4 and Division 3.a: Total official landings (in tons).

24.2.2 InterCatch

InterCatch was used for estimation of both landings and discards numbers, length composition (2002–2017) and age compositions (2009–2017). In 2014, witch flounder was included for the first time into the data call for WGNSSK 2014. In 2015, the data call was extended to obtain landing and discard data for the years 2012–2016 and InterCatch was used to estimate the discard rate for 2012–2016. In preparation for WKNSEA 2018 and WGNSSK 2018 the data-call was furtherly extended and catch data for the years 2002–2017 have now been processed through InterCatch for the first time.

Allocations of discard ratios (2002–2017) and age (2009–2017) compositions for unsampled strata were then performed to obtain the data required for the assessment. The length (2002–2017) composition was also calculated but not used in assessment.

Discards could thus be raised for the period 2002–2017 and catches estimated. In general, the discard rate is moderately low except for the first year of investigation (2002) when it was 34%. As problems were encountered when raising this year data, further investigation is needed. For the following period, the discard rate has been increasing from almost 10% in 2003 to 27% in 2010 and then decreasing again to 8% in 2017. However, it should be noted that not all métiers 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 combined for all fleets is given in table 24.4.1. Landings showed a decline from 2002 to 2010, decreasing from 3800 to 1531 tonnes followed by an increase to 2387 tonnes in 2017.

For 2017, the largest amount of landings and discards was reported by Scotland in Subarea 4 using the métiers OTB_DEF_>=120_0_0_all and the OTB_CRU_70-99_0_0_all and Denmark in Division 3.a using the OTB_CRU_90-119_0_0_all métier (figures 24.2.2.1–3). The total catch estimated with InterCatch in 2016 was 3086 tonnes, of which only 236 tonnes were discards (8% of the total catch).

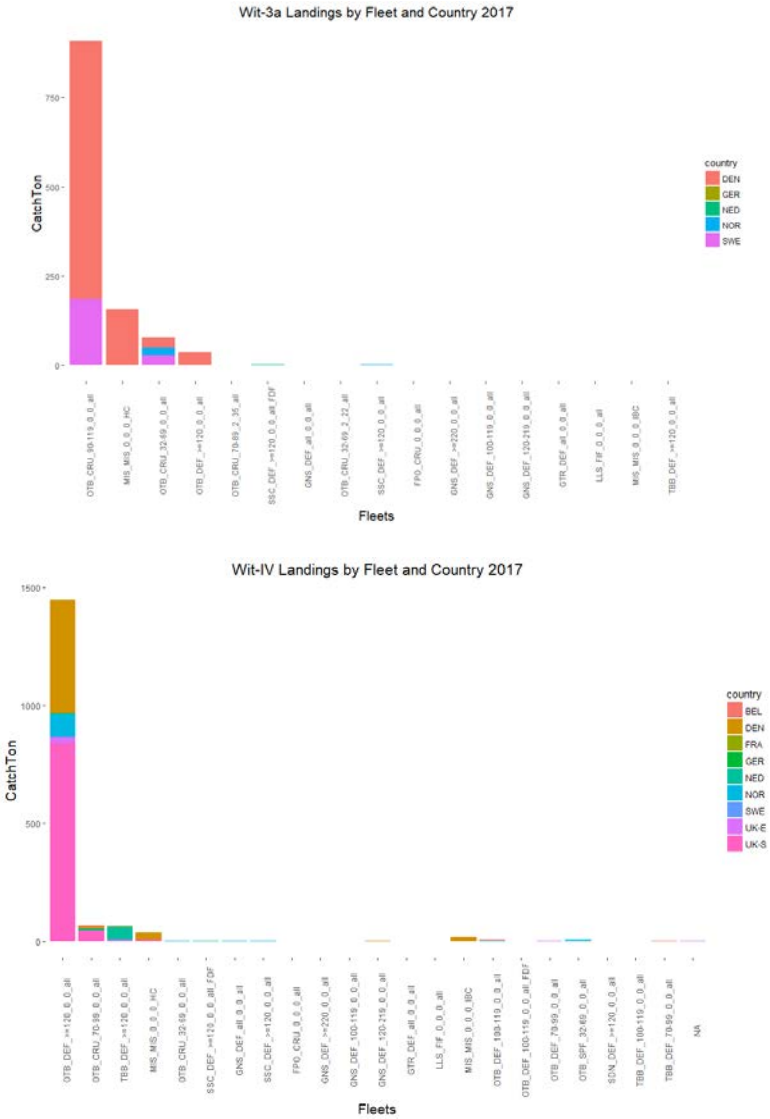


Figure 24.2.2.1. Witch flounder Division 3.a (upper plot) and in Subarea 4 (lower plot): Landings by métier and country in 2017.

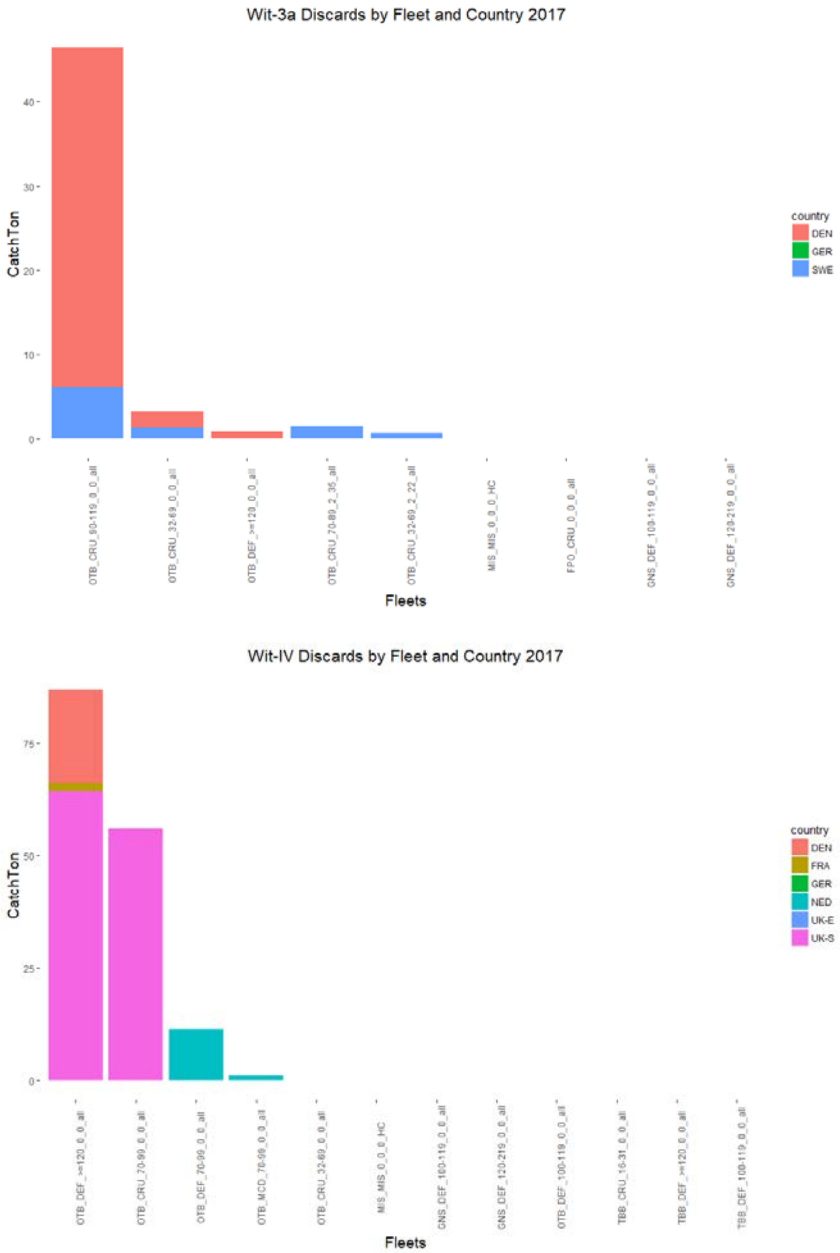


Figure 24.2.2.2. Witch flounder in Division 3.a (upper plot) and Subarea 4 (lower plot): Discards by métier and country in 2017.

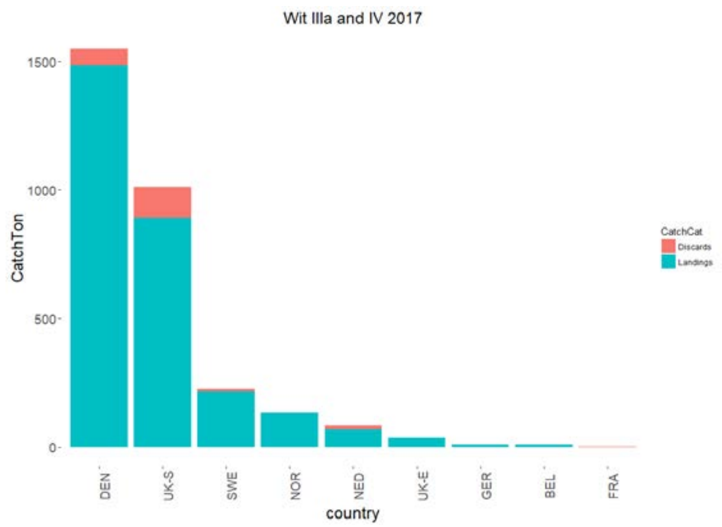


Figure 24.2.2.3. Witch flounder in Subarea 4 and Division 3.a: Estimated landings and discards by countries in 2017.

24.3 Survey data/recruit series

Two survey time-series exist which are potentially useful for the witch 3a47d stock assessment model to be used as tuning indices. Those surveys for demersal fish species in the greater North Sea area are the International Bottom Trawl Survey (IBTS, 1st and 3rd Quarter) and the Beam Trawl Surveys (BTS, 3rd Quarter). While the BTS cover areas 4.b, 4.c and the English Channel (Division 7.d), the IBTS covers area 4.a, the Skagerrak (Division 3.aS) and Kattegat (Division 3.aS).

Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. This species in fact inhabits deep water and the distribution (Figure 24.2.3.1) is not entirely covered by those surveys. The deeper Norwegian Trench is a known habitat for the species and not sampled by the IBTS. The use of the IMR deep-water shrimp survey (held in national database) was mentioned as a potential future data source, but was not explored for the benchmark.

Data exploration and results are included in WKNSEA 2018 Report, Working Document 2. The delta-GAM approach was used to generate survey indices by age from IBTS Q1 (ages 1–7) and IBTS Q3 (ages 1–6) for 2009–2016; no age data exist prior to 2009. No age data for witch existed in the BTS data. Total biomass indices were also generated for IBTS Q1 and combined BTS-IBTS Q3 using the same approach The length distributions (total number caught by length group over all years divided by total number caught) in the commercial samples and in the survey (Q1 IBTS) are similar so the survey may be regarded as representative of exploitable stock biomass (Figure 24.2.3.3).

DATRAS-generated IBTS Q1 and Q3 indices by age were also provided by the ICES DataCentre for comparison. Given the better internal and external consistencies, the DATRAS-generated indices were chosen for inclusion in the SAM run.

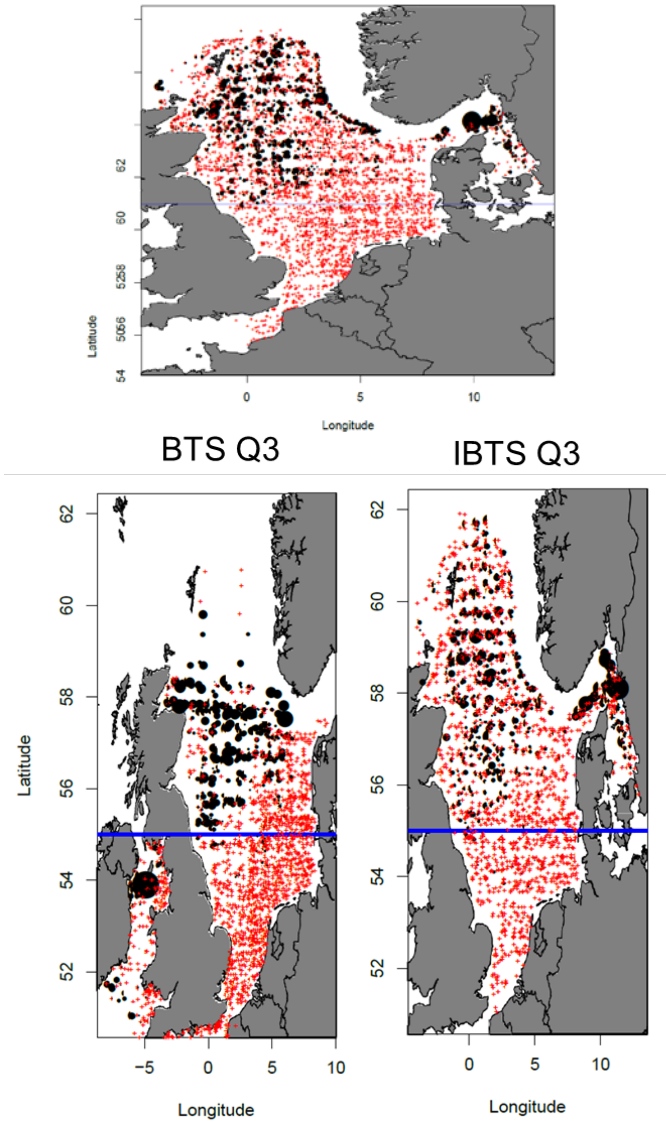


Figure 24.3.1. Witch flounder in Subarea 4 and Division 3.a: Aggregated distribution over the entire time series in the North Sea derived from IBTS–Q1 (upper) and Q3 (lower) using data collected between 1968 and 2017. The sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls. The area above the blue line was used to calculate the survey index.

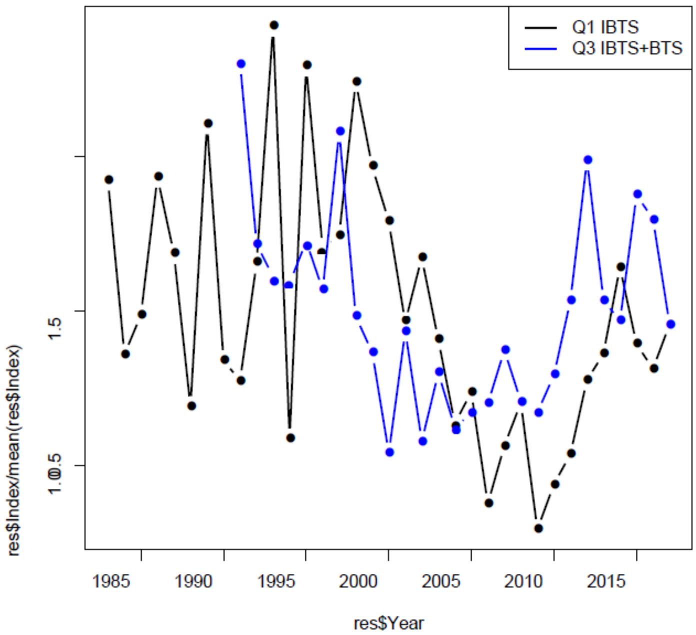


Figure 24.3.2. Witch flounder in Subarea 4 and Division 3.a: Q1 and Q3 indices of biomass (rescaled to mean 1).

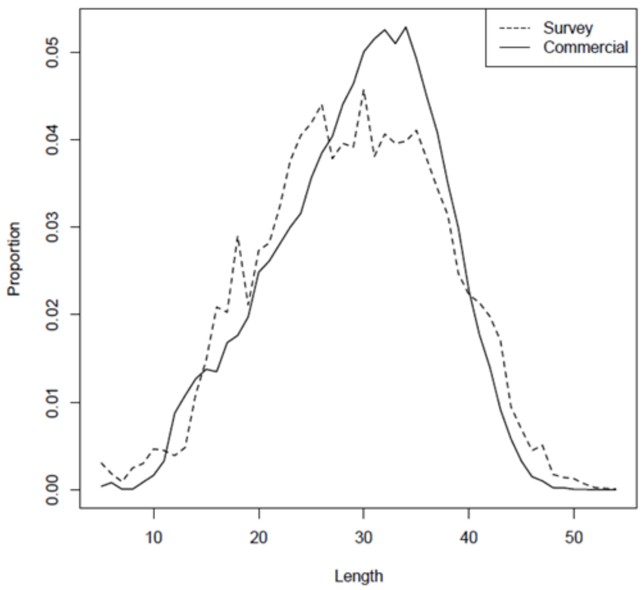


Figure 24.3.3. Witch flounder in Subarea 4 and Division 3.a: Comparison of length distributions in surveys and commercial catches.

24.4 Analysis of stock trends/assessment

In 2014, 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. However, since 2015 the ICES DLS guidelines two versus three years average was used to provide advice for this stock.

During WGNSSK 2017, 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) index was compared to the mean of the three previous years (2012–2014) indices. The combined mature biomass index (i.e. average of IBTS–Q1 and IBTS–Q3) corresponds to an increase of 8% between 2012–2014 and 2015–2016 and therefore the uncertainty cap was not applied in estimating the catch advice. The precautionary buffer was not applied because current F is estimated to be below F_{MSY} (i.e. based on the results of the latest SPiCT assessment; ICES 2017).

Based on this information, WGNSSK 2017 considered that a biannual advice was issued by ICES in 2017 and valid for 2018 and 2019. According to this advice, total catches in 2018 should be no more than 3165 tonnes.

The accepted assessment model during WKNSEA 2018 was a SAM (State–space Assessment Model) (WKNSEA 2018, WD 4). A SPiCT (stochastic surplus production model in continuous time) was run in parallel and considered as exploratory (WKNSEA 2018, WD 5). The SAM was furtherly updated during WGNSSK 2018 including data from 2017. The results are shown in figures 2.5.1–2.5.4

Table 24.4.1. Witch flounder in Subarea 4 and Division 3.a. Landings, discards and catches are in tons. The IBTS indices indicate total 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	3813	5800	1988	0.16	0.09	0.343
2003	3281	3308	3657	349	0.12	0.05	0.095
2004	3029	3059	3428	369	0.12	0.08	0.108
2005	2813	2960	3379	419	0.14	0.05	0.124
2006	2303	2335	2631	296	0.06	0.08	0.112
2007	2236	2271	2470	199	0.08	0.12	0.081
2008	1953	1999	2317	318	0.11	0.06	0,137

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS–Q1 index	IBTS–Q3 index	Discard rate
2009	1818	1863	2319	455	0.06	0.05	0.196
2010	1490	1531	2090	559	0.04	0.06	0.268
2011	1530	1567	2114	547	0.05	0.09	0.259
2012	1895	1952	2509	557	0.09	0.13	0.222
2013	1993	2013	2267	254	0.08	0.13	0.112
2014	2646	2685	2992	307	0.29	0.08	0.103
2015	2359	2240	2690	449	0.19	0.12	0.167
2016	2658	2744	3135	390	0.13	0.13	0.125
2017	2827	2850	3086	236	0.23	XXX	0.076

24.5 MSY proxy reference points

During WKNSEA 2018 EQSIM simulations were conducted using data from the accepted SAM assessment for the witch stock in the Greater North Sea. These followed the ICES advice technical guidelines as published 20 January 2017 (ICES, 2017) for the estimation of the reference points.

Recruitment at-age 1 from the assessment was used. Though strong autocorrelation in recruitment values was evident, no historic trends were observed in the stock–recruitment relation and therefore the entire time-series from 1940 was utilized in the estimation of reference points.

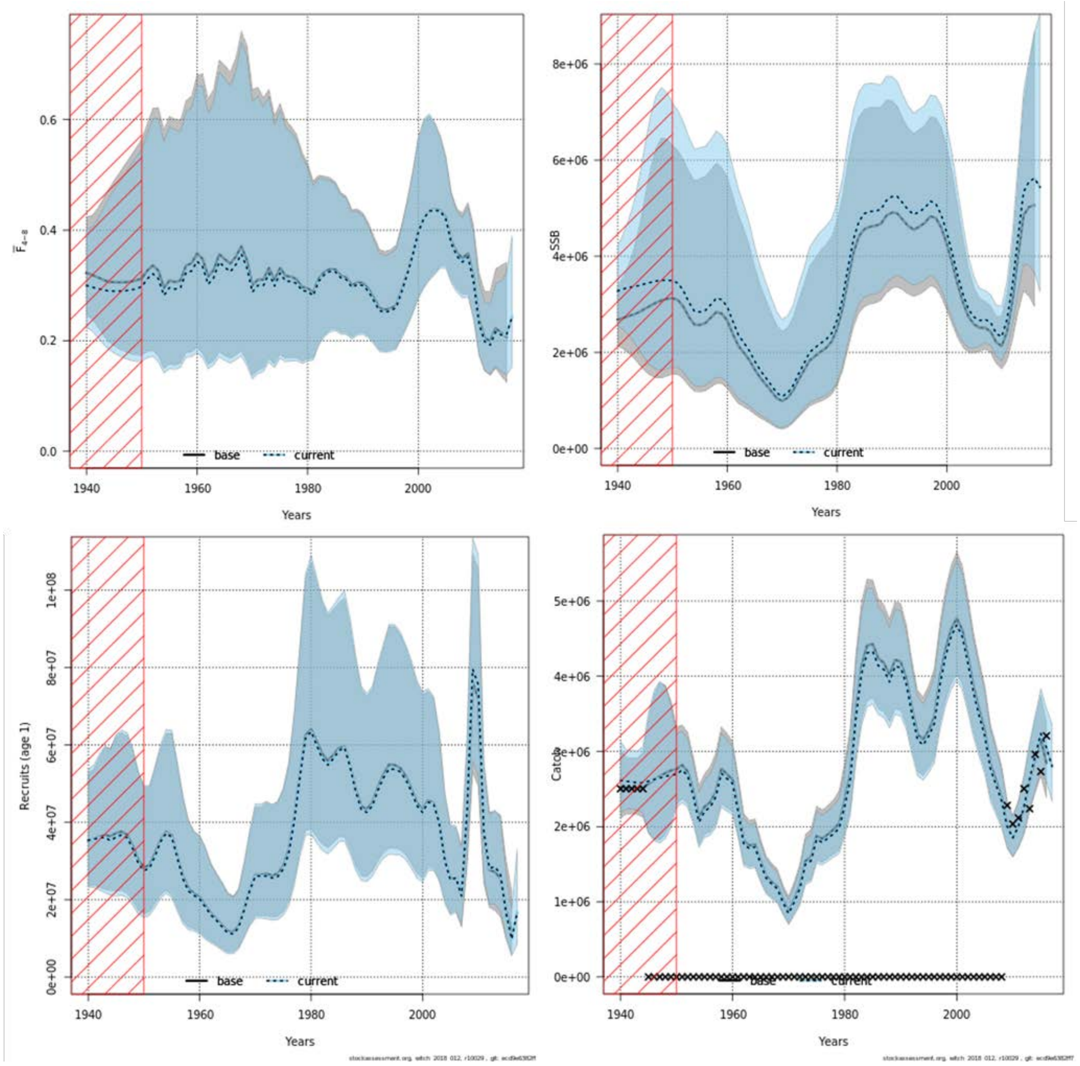


Figure 24.5.1. Witch flounder in Subarea 4 and Division 3.a: Results of the SAM model. Estimates and point wise 95% confidence intervals. The area shaded with red lines is the period prior to the observations, used for initialization. The shaded light blue area and the dotted line is the results from the model using the two new indices of exploitable biomass.

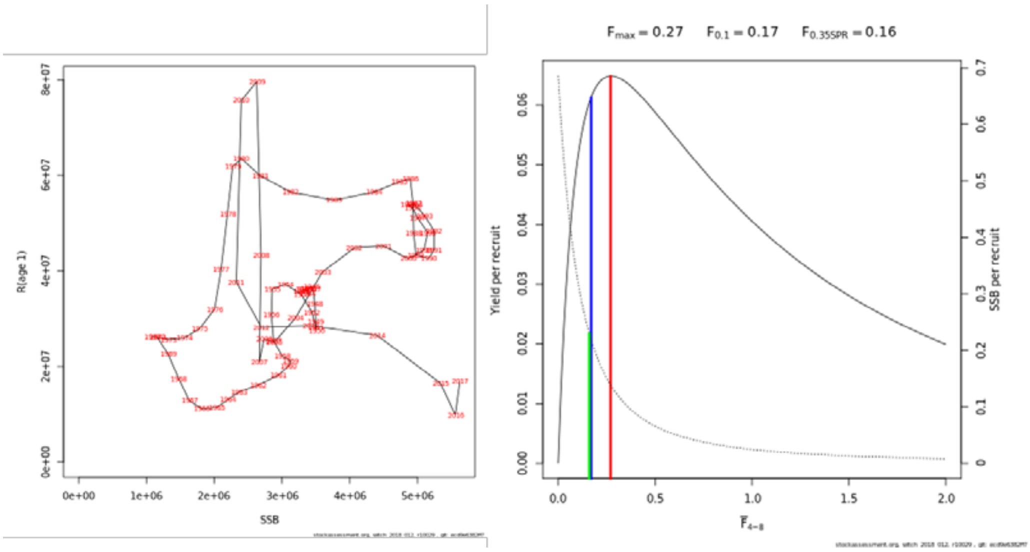


Figure 24.5.2. Witch flounder in Subarea 4 and Division 3.a: Results of the SAM model. Diagnostic, spawner-recruit (left plot) and Yield per recruit (right plot)

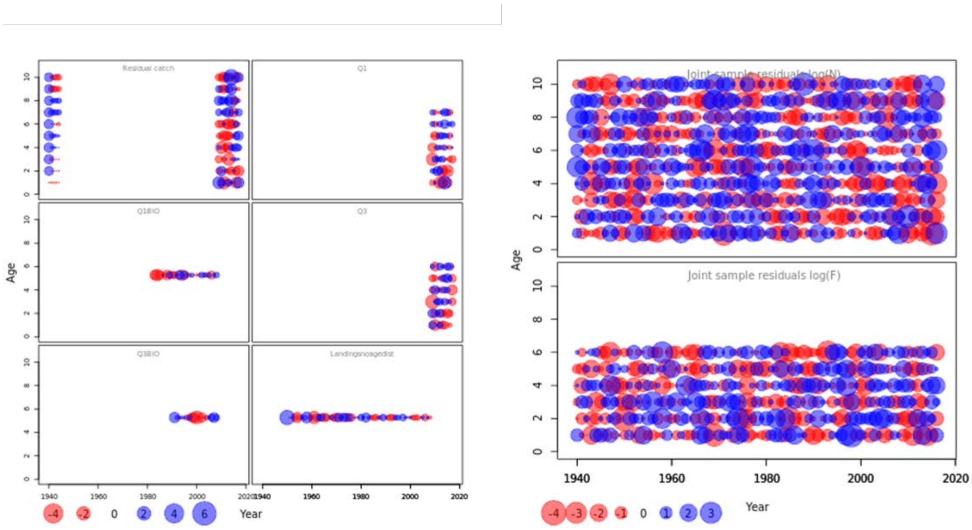


Figure 24.5.3. Witch flounder in Subarea 4 and Division 3.a: Results of the SAM model. Residuals plots, standardized one-observation-ahead residuals (left plot) and standardized single-joint-sample residuals of process increments (right plot).

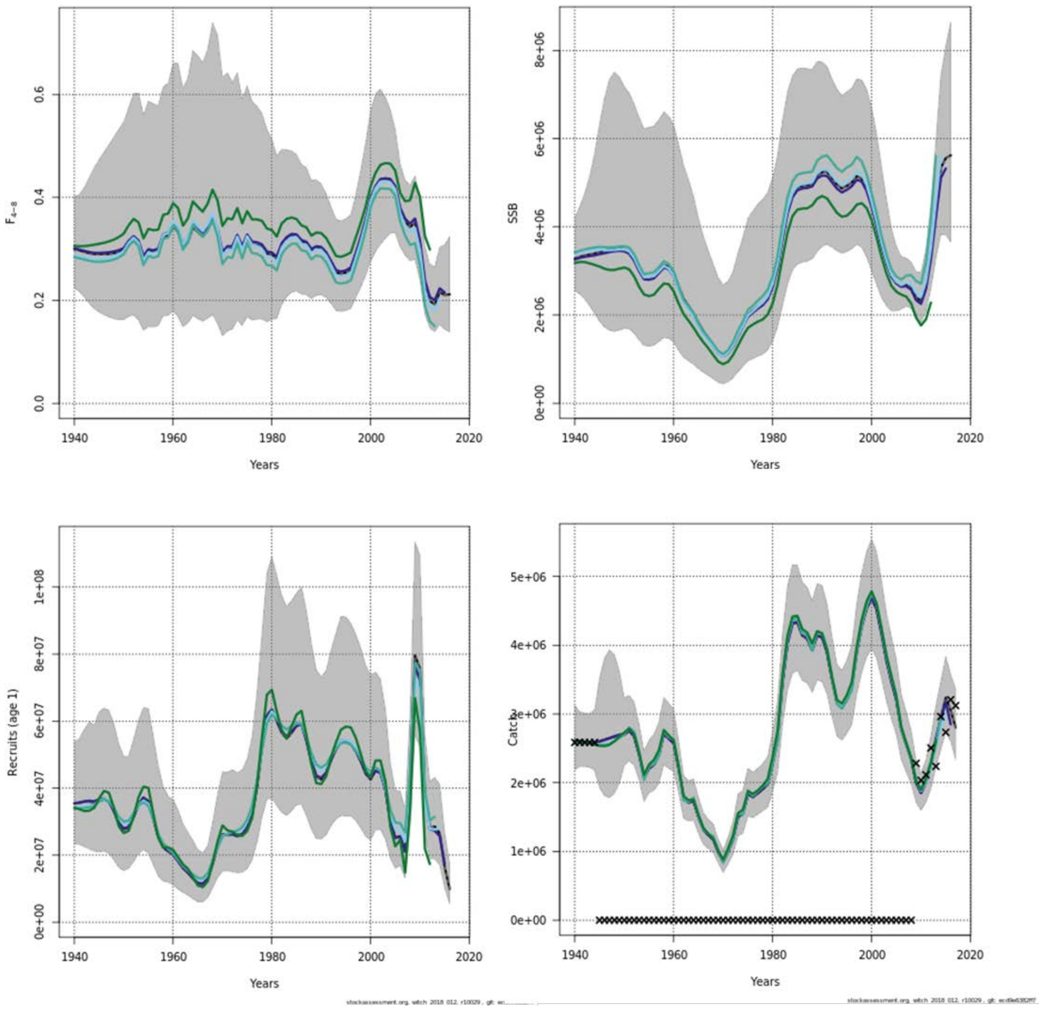


Figure 24.5.4. Witch flounder in Subarea 4 and Division 3.a: Results of the SAM model. Retrospective analysis.

Table 24.6.1. Witch flounder in Subarea 4 and Division 3.a: Official ICES landings by Subarea 4 and Division 3.a. Landings in 2017 are preliminary.

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
2016	1317	1421	2739
2017	1162	1665	2827

Annex 1: List of Participants

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Other participation:	Anders Nielsen provided support for SAM, and Casper Berg listened in to the presentation given by Natoya Jourdain. There was also a WebEx presentation made by Mollie Brooks on the MSE work for Norway Pout, which included a WebEx review discussion on the WKNPOUT report with remote participation by other WKNPOUT participants Andres Uriarte, Morten Vinther and the review panel comprising Manuela (Manica) Azevedo and Martin Dorn; WGNSSK listened in to this discussion, but were unable to participate in a meaningful way, given that the group was not part of the WKNPOUT process (i.e. did not have the opportunity to study working documents, etc.). The ICES secretariat was represented by Sarah Millar (Professional Secretary) and Arni Magnusson (TAF support).		

Annex 2: Recommendations

The following table summarises the main recommendations arising from the WGNSSK and identifies suggested responsibilities for action.

RECOMMENDATION	FOR FOLLOW UP BY:
Production of survey indices on a regular basis by ICES according to the stock annexes for cod.27.47d20 (extended index), whg.27.47d (area-specific index), wit.27.3a47d (regular index).	DATRAS
Information collected in ICES (RCGs, WGCATCH, DCF Annual Report), reflecting the impact of the Landing Obligation on data quality, should be summarised and reported in advice sheets or Fisheries Overviews.	ACOM
Workshop to consider using additional information for reopening (better informing assumptions for the intermediate year in catch forecasts, in particular using information from the fisheries such as quota uptake, fishing effort, etc.), and to revisit reopening protocols.	ACOM
Advice guidelines are difficult to follow, and sometimes contradictory. Specific examples prepared by the secretariat as individual documents (instead of everything in one document) would be helpful. Furthermore, this would also help with standardisation across Expert Groups.	ACOM

Annex 3: ToRs for next meeting

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

2018/2/ACOM22 The **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak** (WGNSSK), chaired by José De Oliveira, UK, and Jennifer Devine*, Norway, will meet in Bergen, Norway, 24 April – 3 May 2019 and by correspondence in September 2019 to:

a) Address generic ToRs for Regional and Species Working Groups.
b) Assess Norway pout assessments by correspondence.

The assessments will be carried out on the basis of the stock annex. 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 on the dates specified in the 2019 ICES data call.

WGNSSK will report by 17 May 2019, and by 24 September 2019 (Norway pout) for the attention of ACOM.

Annex 5: Audit Reports

Audits for stocks for which advice sheets were produced were conducted during and immediately following the WGNSSK 2018 meeting. The audits were made available to the stock assessors, who had the opportunity to adjust their reports and advice sheets if any problems were detected in the audit. The audits were also made available to the relevant advice-drafting group.

cod.27.47d20

General

The assessment is identical to last year's "final assessment" with one additional year of data added. Revisions of input data made some changes to the assessment (maturation data and delta GAM indices). The retrospective performance of the assessment may in addition to revisions of maturity and delta GAM indices be influenced by the dome shaped selectivity.

For single stock summary sheet advice:

1) **Assessment type:** Modified update of last year's assessment
2) **Assessment**: Analytical
3) **Forecast**: Same approach as decided in 2017.
4) **Assessment model**: SAM model using a random walk for F at age, but with additional correlation AR(1) imposed between agegroups. Variance of age 1 estimates of F separated from the other ages and the plus group is "decoupled" from the agegroup below allowing for $F_5 \neq F_{6+}$. This year's assessment used the TMB implementation of SAM instead of the ADMB implementation used last year. This audit has not compared the two implementations, but it is known that convergence is different with TMB and miniscule differences should be expected.
5) **Data issues:** Maturity at age smoother was used on a revised input dataset. This had minor impact on the perception of maturity. Revision to historic Datras data had an impact on delta GAM indices as well (minor)
6) **Consistency**: Consistent with last year's assessment except for minor changes to historic values used as input. All settings and assumptions identical to 2017 assessment
7) **Stock status:** F is above F_{MSY} and between F_{pa} and F_{lim}; and spawning stock size is below MSY $B_{trigger}$ and between B_{pa} and $B_{lim.}$
8) **Man. Plan.**: Agreed management plan in its long term phase uses B_{lim} and B_{pa}, but with a paragraph stating what values those translates into. Advice should be given according to ICES F_{MSY} approach.

General comments

The assessment is very well described and visualized. This includes the estimation of prediction error in the forecast which has very interesting implications. The prediction error in the forecast now take into account the uncertainty related to the recruitment estimate.

Technical comments

This assessment (as last year) estimates a domed shaped selectivity at age with very low fishing mortality for older fish. This fishing mortality level is far below any "mentally comfortable level" as it introduces a large fraction of the SSB not being available to fishing. This is likely to have negligible effect on TAC advice, but may represent a bias in the perception of stock status.

2018: The delta-GAM approach has now produced tuning indices for four consecutive years and the change introduced by adding one year of data can be evaluated (kind of a retrospective performance of the approach) The impact of revisions to maturity data relative to last year (2017) maturity ogives is shown in Table 1.1.1. The intense coloring at age 1 happens since maturity at age 1 is typically around 2 percent and small changes in input data can give a large relative change at this age.

Other changes (age and/or cpue) to the IBTS data used as input to the delta GAM produced the effects shown in Table 1.1.2 and Table 1.1.3.

Assumed stock weights for the intermediate year (last year's advice) deviates some from this year's estimate of stock weights in 2017 (see Table 1.1.4)

Table 1.1.1 Relative change (in percent) from last years smoothed maturity ogives.

1973	-28	2	0	0	0	0	0
1974	-25	-1	0	0	0	0	0
1975	-23	-2	1	1	0	0	0
1976	-19	-4	1	1	0	0	0
1977	-15	-5	2	1	0	0	0
1978	-12	-5	2	1	0	0	0
1979	-7	-4	2	1	0	0	0
1980	-5	-2	1	1	0	0	0
1981	-2	1	1	1	-1	0	0
1982	3	4	1	1	-1	0	0
1983	6	5	1	1	-1	0	0
1984	11	5	1	1	-1	0	0
1985	14	2	0	0	-1	0	0
1986	17	-2	0	0	-1	0	0
1987	21	-6	0	0	0	0	0
1988	23	-9	0	0	0	0	0
1989	27	-11	-1	0	0	0	0
1990	31	-10	0	0	0	0	0
1991	34	-8	0	0	0	0	0
1992	39	-3	0	0	0	0	0
1993	41	5	0	0	0	0	0
1994	41	14	1	1	0	0	0
1995	42	22	1	1	0	0	0
1996	39	27	1	1	0	0	0
1997	38	27	2	1	0	0	0
1998	34	23	1	1	0	0	0
1999	29	17	1	1	0	0	0
2000	25	11	1	0	0	0	0
2001	21	5	1	0	0	0	0
2002	16	1	0	0	0	0	0
2003	13	-1	0	0	0	0	0
2004	8	-3	0	0	0	0	0
2005	5	-3	0	0	0	0	0
2006	2	-3	0	0	0	0	0
2007	-1	-3	0	0	0	0	0
2008	-4	-2	0	0	0	0	0
2009	-6	-2	0	0	0	0	0
2010	-8	-2	0	0	0	0	0
2011	-10	-2	0	0	0	0	0
2012	-12	-2	0	0	0	0	0
2013	-13	-1	0	0	0	0	0
2014	-15	-1	1	0	1	0	0
2015	-16	0	1	0	1	0	0
2016	-17	0	2	-1	2	0	0
2017	-18	1	3	-1	2	0	0

Table 1.1.2. Differences in tuning indices modelled last year relative to this year's indices modelled with one additional year of data (IBTS Q1).

	1	2	3	4	5	6
1983	4.5	6.7	1.7	5.1	-3.8	0.2
1984	5.9	5.0	4.1	1.0	1.3	-1.4
1985	7.1	8.6	-1.1	0.3	2.0	0.3
1986	4.2	3.8	4.5	-2.1	5.1	-0.1
1987	2.7	3.6	-0.5	2.6	2.4	-0.4
1988	11.0	4.2	3.3	3.4	3.2	-4.6
1989	-0.8	5.0	1.8	7.9	-5.8	2.8
1990	3.3	4.5	2.6	1.2	4.5	-3.6
1991	3.3	4.1	3.0	2.3	1.5	0.4
1992	5.3	-0.5	3.3	2.8	0.6	-0.7
1993	3.2	4.2	2.0	3.3	-0.5	0.3
1994	5.7	2.0	3.4	4.1	-0.5	-0.3
1995	1.8	3.8	4.4	3.7	0.9	-0.1
1996	4.9	0.2	3.9	7.4	1.7	-1.0
1997	2.7	5.9	6.1	2.7	2.3	1.0
1998	1.1	0.3	2.1	3.6	1.4	-0.2
1999	0.3	-8.5	6.0	2.2	2.5	-1.6
2000	-0.5	4.1	1.9	3.7	1.6	0.1
2001	4.6	2.2	3.7	3.4	0.6	-1.4
2002	4.1	-1.1	1.2	2.3	0.8	-0.7
2003	1.6	1.6	3.9	3.3	0.8	-2.2
2004	-0.7	3.7	4.0	3.0	0.5	0.0
2005	1.5	1.5	3.8	3.8	0.7	-0.9
2006	1.7	1.4	2.8	5.0	1.0	-0.6
2007	0.1	1.1	2.6	2.6	1.1	0.4
2008	1.8	2.0	1.8	3.2	1.8	0.1
2009	0.3	0.2	1.4	1.9	2.4	1.7
2010	2.5	1.1	3.0	3.7	2.7	2.0
2011	2.1	0.2	0.6	0.8	-1.4	-2.8
2012	0.2	0.9	0.5	-0.1	0.9	0.0
2013	1.0	1.0	2.2	-0.1	0.9	0.0
2014	0.7	0.0	0.7	0.6	1.0	-3.8
2015	0.5	0.1	0.0	-1.0	-0.5	-8.6
2016	-5.0	-1.6	0.8	-0.6	2.8	0.1
2017	0.3	-0.3	-3.9	-7.8	-3.5	-3.1

Table 1.1.3. Relative differences in tuning indices modelled last year relative to this year's indices modelled with one additional year of data (IBTS Q3).

	1	2	3	4	5	6
1992	-1.6	1.4	2.4	0.4	2.1	-3.0
1993	-0.2	2.0	1.5	3.0	2.6	-1.6
1994	-0.3	2.8	0.9	2.2	3.7	-1.1
1995	-1.2	1.3	1.1	2.6	2.8	2.8
1996	-2.9	1.8	0.5	3.1	3.6	2.9
1997	-1.1	3.5	1.2	2.7	2.9	-0.1
1998	-4.6	3.7	1.5	2.6	3.7	0.9
1999	-1.4	3.6	1.8	2.2	3.1	-1.6
2000	-3.2	3.0	1.5	3.1	2.6	-0.7
2001	-2.4	2.5	2.7	3.2	4.6	-1.8
2002	-6.0	4.4	1.5	2.0	1.7	-1.3
2003	-5.4	3.1	1.6	3.2	1.9	6.1
2004	-4.0	0.9	1.7	3.7	0.6	8.5
2005	-5.2	1.1	1.0	2.4	3.3	7.0
2006	-2.4	1.3	1.3	2.2	2.5	12.2
2007	-4.0	-1.4	0.0	2.5	2.3	3.3
2008	-9.9	-1.0	1.9	2.9	3.3	2.5
2009	-6.0	-0.5	0.8	2.4	2.4	-0.5
2010	-3.7	-3.1	0.1	1.8	2.2	0.5
2011	-2.4	-0.3	1.6	2.9	1.6	1.6
2012	-3.3	1.0	0.0	1.4	2.5	1.5
2013	-6.4	-1.2	-2.9	-0.1	0.1	1.9
2014	-6.2	-1.9	-2.2	0.9	1.9	1.1
2015	-6.3	-6.2	-2.8	0.2	2.4	2.4
2016	-6.7	-4.2	-2.5	-0.4	0.7	-0.2

Table 1.1.4. Percentage change to stock weights at age (assumed for last year's prediction versus observed in 2017).

	1	2	3	4	5	6	7	8	9	10	11
2017	-35.2	-5.0	3.7	-4.5	-7.2	-4.3	3.2	-5.3	-5.7	24.9	0.8

Conclusions

The assessment has been performed correctly.

gug.27.3a47d

General

All information is present on the sharepoint. No catch advice was requested for this stock.

For single stock summary sheet advice:

1) **Assessment type: update/SALY**
2) **Assessment**: trends
3) **Forecast**: not presented
4) **Assessment model**: trend-based assessment
5) **Data issues:** Species misidentification continues to be a problem for grey gurnard. Additionally, catches consist predominantly of discards, but discard information is only provided for 15 % of the landings.
6) **Consistency**: not applicable.
7) **Stock status**: Stock status cannot be assessed based on current data availability, exploitation status is currently below the F_{MSY} proxy.
8) **Management Plan**: no management plan exists

General comments

Well done assessment.

Technical comments

- In Table 4 in the advice draft a citation to ICES (2017b) is given. This reference does not appear in the reference list.
- In the heading of Table 7 in the advice draft it is stated that "estimated ICES landings are presented in Table 6.3.15.8." Should presumably be Table 9?

Conclusions

The assessment has been performed correctly

had.27.46a20

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical assessment (TSA; ICES, 2018a) that uses catches in the model and in the forecast + 2 survey indices
5) **Data issues:** No issues reported
6) **Consistency**: Update assessment, consistent between years.

7) **Stock status**: F has been fluctuating above F_{MSY} for most of the time-series and is above F_{MSY} and Fpa < F < Flim in 2017. SSB is above MSY $B_{trigger}$ and above B_{pa} and B_{lim}. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing.
8) **Management Plan**: There is currently no agreed management plan for haddock for the full stock area.

General comments

There was no deviation from the standard procedure. Data, assessment and forecast are done as specified in the stock annex. Advice sheet and report section are consistent.

Technical comments

- Some minor edits on advice sheet: stock and exploitation table, the 3 years for fishing pressure should be 2015, 2016, 2017 (instead of 2016, 2017, 2018)
- The % change in Table 3 (last 3 columns) needs to be 1 digit
- Footnote in Table 3: TAC of 6a in 2018 is 4654t
- No reference ICES2017a in Table 5
- Correct Table 8 caption
- The wanted catch in Table 8 is not equal to the number reported in Table 9 (ICES landings). I think you reported the model estimated wanted catch in Table 8.
- The total catch in Table 8 is not equal to wanted + unwanted + bycatch, should be 40010?
- In Table 9: is the ICES total catch = ICES landing + ICES discards + ICES BMS + ICES IBC?

Conclusions

The assessment has been performed correctly.

nep.fu.10

General

The assessment has been performed as described in the stock annex.

For single stock summary sheet advice:

1) **Assessment type:** Biennial
2) **Assessment**: Data-limited approach for *Nephrops*
3) **Forecast**: no forecast
4) **Assessment model**: Data limited approach calculates harvest rate (HR) based on catch numbers (i.e. individuals) as a proportion of population estimates. Population numbers are calculated from density estimates from the most recent UWTV survey (0.13 ind m^-2) multiplied by the functional functional unit (FU) suitable habitat area (409 km^2). Due to insufficient information from FU 10, the mean weight in landings and discards, and discard rate (discards/landings in numbers) is assumed to be the same as the Moray Firth (FU 9) as this is the closest functional unit. These values allow for the conversion of total landings weight into landings and discards in terms of numbers. Harvest Rate (HR) is calculated as the ratio of catch numbers to population numbers. The *Nephrops* data limited approach compares HR to a range of maximum sustainable yield (MSY) harvest rates for other North Sea Functional Units (between 7.5 % and 16 %).
5) **Data issues:** No issues.

6) **Consistency:** No issues.
7) **Stock status**: ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined, but low catches and estimated harvest rate is low.
8) **Management Plan**: No management plan.

General comments

The assessment was well-documented, with an Excel worksheet supplied to the auditor for examination.

Technical comments

A more conservative discard survival rate of 0 % has been used, which differed from the value of 25 % listed in the stock annex, but is consistent with the last advice given in 2016. The stock annex has now been updated with this new information by the assessment leader.

Conclusions

The advice of 2016 +20 % is well founded given the results of the assessment, which results in an HR of 3.5 %. This HR is below the most conservative lower bound for MSY in other FUs.

nep.fu.32

General

The assessment has been performed as described in the stock annex.

For single stock summary sheet advice:

1) **Assessment type:** Biennial
2) **Assessment**: Data-limited approach for *Nephrops*
3) **Forecast**: no forecast
4) **Assessment model**: Data limited approach calculates harvest rate (HR) based on ratio of dead removals to population numbers (i.e. individuals). Population numbers are calculated from density estimates from the neighbouring functional unit (FU) Fladen Ground (FU 7) (0.1 ind m^-2) multiplied by FU 32 habitat area (3613 km^2). Mean weight in landings and discards, and discard rate (discards/landings in numbers) are local estimates taken from length-frequency data sampled from Danish catches in 2016. These values allow for the conversion of total landings weight into landings and discards in terms of numbers, as well as total dead removals given a discard survival rate. HR is calculated as the ratio of dead removals to population numbers. The *Nephrops* data limited approach compares HR to a range of maximum sustainable yield (MSY) HRs for other North Sea FUs (between 7.5 % and 16 %).
5) **Data issues:** No issues.
6) **Consistency:** No issues.
7) **Stock status**: ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined, but low catches and estimated harvest rate is low.
8) **Management Plan**: No management plan.

General comments

The assessment was well-documented and consistent with the stock annex.

Technical comments

It was discussed whether the recent length-frequency data (LFD) from 2017 could be used to update the mean individual weights of landings and discards, and discard rate. The sample size (n=173) was deemed insufficient to justify a change, and thus the previous values calculated from 2016 data (n=4548) were used.

Conclusions

The advice is based on the average catches of the last 10 year period (2008-2017), which follows the precautionary approach for the stock and is well founded given the results of the assessment. The advice translates to an estimated harvest rate of 1.0 %, which is below the most conservative lower bound for MSY in other FUs (7.5 %).

nep.fu.33

General

The stock annex does not currently describe the process for calculating catch advice.

For single stock summary sheet advice:

1) **Assessment type:** Biennial
2) **Assessment**: Data-limited approach for *Nephrops*
3) **Forecast**: no forecast
4) **Assessment model**: Data limited approach for *Nephrops* calculates harvest rate (HR) based on ratio of dead removals to population numbers (i.e. individuals). Population numbers are calculated from an observed density estimate for this functional unit (FU) derived from an UWTV survey conducted in 2017 (0.13 ind m^{-2}), multiplied by FU 33 habitat area (5737 km^2). Previously, density estimates from the neighbouring FU Fladen Ground (FU 7) (0.1 ind m^{-2}) were used. Mean weight in landings is an estimate from this FU from 2015. It was not possible to update mean weight estimates for landings because current sampling levels are too. Due to the lack of discard data from this functional unit the advice is based on landings only. A second scenario is presented in the advice sheet where an assumed discard rate of 25% by number is applied, allowing for the conversion of total landings weight into landings and discards in terms of numbers. HR is calculated as the ratio of dead removals to population numbers. The *Nephrops* data limited approach compares HR to a range of maximum sustainable yield (MSY) HRs for other North Sea FUs (between 7.5 % and 16 %).
5) **Data issues:** Scarce sampling of catches. In 2017, no length distributions were available from Danish and Dutch catches.
6) **Consistency:** No issues.
7) **Stock status**: ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined. Perceptions of the stock are based on Danish and Dutch lpue data and trends in size composition in Danish catches. The available data do not provide any clear signals on stock development. Previously, the state of this stock has been unknown, where an assumed low density (based on the lowest observed density in FU 7 (Fladen Ground) has been used to estimate harvest rates. In 2017, Denmark conducted an UWTV survey of this functional unit. The observed density (0.13 *Nephrops* m^{-2}) conforms well to those previously adopted from FU 7 (0.1 *Nephrops* m^{-2}). Harvest rates are considered low for this stock.

8) **Management Plan**: No management plan.

General comments
The assessment was well-documented. There is no available stock annex.

Technical comments
The advice is given for landings only. However, the harvest rates in Table 3 (The catch scenarios) come from table 10, where a 25% discard rate is assumed. Since discards data are lacking for this stock, it seems more correct to base the advice on the harvest rates in Table 9.

In Table 2 in the advice, discard survival is stated to be 0, however, in the report it is said that a discard survival of 25% is assumed (section 11.10.4, second paragraph). Which is correct?

In Table 3 in the advice, the % change in advice relative to the advice given in 2016, should be relative to the advice of 1119 tonnes, not relative to the values of the different catch scenarios two years back. This needs to be changed. Foot note in Table 3: The change in advice (%) is due to the change in the average of the landings of the ten last years, the advice will necessarily change every time an assessment is conducted. In addition, there is a change in the density as stated in the advice sheet.

In Table 6 in the advice, ICES landings in tonnes should correspond to numbers in Table 8.

Conclusions
The advice is based on the average catches of the last 10 year period (2008-2017), which follows the precautionary approach for the stock and is well founded given the results of the assessment. It is not clear whether the advice is/should be based on Table 9 or 10. In both cases, the harvest rate is below the most conservative lower bound for MSY in other FUs (7.5 %).

nep.fu.34

General

The assessment has been performed as described in the stock annex.

For single stock summary sheet advice:

1) **Assessment type:** Biennial
2) **Assessment**: Data-limited approach for *Nephrops*
3) **Forecast**: no forecast
4) **Assessment model**: Data limited approach calculates harvest rate (HR) based on catch numbers (i.e. individuals) as a proportion of population estimates. Population numbers are calculated from density estimates from the most recent UWTV survey (0.09 ind m^-2) multiplied by the functional functional unit (FU) suitable habitat area (1753 km^2). Due to insufficient information from FU 34, the mean weight of discards is assumed to be the same as the Fladen (FU 7) as this is the closest functional unit. Together with local estimates of mean weight of landings and discards rate (discards/landings in numbers), total landings weight is converted into landings and discards in terms of numbers. HR is calculated as the ratio of catch numbers to population numbers.

The *Nephrops* data limited approach compares HR to a range of maximum sustainable yield (MSY) harvest rates for other North Sea Functional Units (between 7.5 % and 16 %).

5) **Data issues:** No issues.
6) **Consistency:** No issues.
7) **Stock status**: ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined. Catches are currently above recommended levels.
8) **Management Plan**: No management plan.

General comments

The assessment was well-documented, with an Excel worksheet supplied to the auditor for examination.

Technical comments

None.

Conclusions

The advice of 2016 -29 % is well founded given the results of the assessment, and results in an HR of 7.5 %, which is consistent with the precautionary approach for *Nephrops*, based on the most conservative lower bound for MSY calculated for other FUs. The advice also emphasizes that catches have increased substantially, and were well above the sustainable limits given by the ICES advice for the previous years of 2016 and 2017.

nep.fu.3-4

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment:** UWTV survey
3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 3-4 may be updated once the results from the 2018 TV survey become available (subject to the advice reopening rules). This is <u>unlikely</u> to happen before ICES releases the summer advice (June/July 2018).
4) **Assessment model:** UWTV survey
5) **Data issues:** A few minor things in the advice sheet, which have been corrected. Only advice sheet available for review
6) **Consistency:** This stock has been benchmarked by ICES in 2016 (WKNEPH, 2016).
7) **Stock status**:

- Landings in 2017 saw a 7% increase over 2016 levels and discarding increased by 300%, giving an overall catch difference of +21%.
- The reason for the change in discarding from 2016 to 2017 may be due to increased recruitment.
- The UWTV survey abundance increased in 2017, to above the historical range, but the survey area was extended following the 2016 benchmark. During the wg meeting, it was noted that the survey area was extended also in 2014, and it was recommended that the UWTV index figure should

reflect these area extensions by incorporating breaks in the line connecting annual values between 2013 and 2014, and between 2016 and 2017.

- No MSY Btrigger value has been defined for this stock due to the brevity of the time series of surveys.
- The observed harvest rate was well below the Fmsy value and has been for the last four years.

8) **Management Plan**: There is no formal management plan for this stock.

General comments

- The assessment report was not available at the time of writing this audit. The available advice sheet was used instead and the advice values were checked against spreadsheets for this stock uploaded to the sharepoint.
- Advice: It is not totally clear whether this stock is under the EU landing obligation or not. Under "Issues relevant for the advice", the landing obligation is mentioned, and reasons for lack of reporting of BMS *Nephrops* are listed. Then it is stated that there is an exemption for this stock from the landing obligation due to high discard survival. I suggest to move paragraphs in this section to make this clearer (my sentence in red below):

  In this area, there was a mismatch between the minimum conservation size (MCS, previously MLS) and mesh size in Nephrops trawl fisheries. Since 1 January 2016 the MCS was lowered from 40 to 32 mm carapace length for EU countries fishing in this area. This considerably reduced the proportion of the catch that was discarded. A discard ban implemented in the Norwegian zone of the Skagerrak on 1st of January 2015 retains a minimum landing size of 40 mm carapace length. The nep.fu.3-4 stock is, however, not under the EU Landing Obligation.

  For this stock, recent Swedish discard survival experiments indicate that the trawl discard survival may be higher (around 50%; Valentinsson and Nilsson, 2015). As a result, an exemption from the landing obligation based on high survivability has been granted by the European Commission. ICES continues to use the survival rate of 25% (ICES, 2016a) because the higher survival rates have not been evaluated by ICES, and the impact on realised harvest rates is expected to be small due to the low discard rates.

- Advice, Table 3: last two lines (Fcurrent and F2017) need to be corrected according to spread sheet.

Technical comments

- Advice, Table 2: It seems the note in the last line of Table 2 should be changed/deleted: "*Only apply in scenarios where discarding allowed.*" According to the Advice sheet, there is for this stock "*an exemption from the landing obligation based on high survivability*". So, discarding is allowed. Scenarios where discarding is not allowed are not presented this year.
- Advice, Table 3: there is a "^" inserted after MAP in the third line. Does this refer to a footnote that is not there?
- Advice, Table 3: footnote for *** is missing below table 3.
- Advice, Table 5: in line 3, "*Harvest ratio*" should be "*Harvest rate*" since "*rate*" is used throughout the rest of the advice sheet.

- Advice, Table 8: The sum of Landings (5211) and Discards (1024) does not add up to Catch (6234), due to rounding. 5211+1024=6235. Same goes for Table 9 for 2017. As for several other years in Table 9: discards and landings do not add exactly to the given value of catch.

Conclusions

The assessment has been performed correctly.

nep.fu.5

General

This stock is considered a data limited stock. UWTV survey information for 2010 and 2012

For single stock summary sheet advice:

1) **Assessment type:** Biennal
2) **Assessment**: no analytical assessment
3) **Forecast**: no forecast
4) **Assessment model**:
   The advice is based on a calculation of potential landing options and harvest rates (HR), given the known surface area of Norway lobster habitat, assumed densities of the functional unit (UWTV survey information for 2010 and 2012) and mean weights for discard and landed components.
5) **Data issues:**
   Discard data available from 2015 onwards, but only from the Dutch fleet. Discard data available from Dutch self sampling. Discard patterns are considered unique to the Dutch fleet due to Producer Organisation guidelines. Discard rates for all non-Dutch catches were therefore estimated by using a retention ogive borrowed from FU6 on the catch at length profile from the Dutch sampling schemes.
6) **Consistency**: This advice differs from last advice due to the inclusion of discard discard data to derive catch advice.
7) **Stock status**: unknown
8) **Management Plan**: no management plan

General comments

This advice is based on *Nephrops* densities observed in the 2012 UWTV survey

Technical comments

No comments

Conclusions

The assessment has been performed correctly

nep.fu.6

For single stock summary sheet advice:

1) **Assessment type:** update

2) **Assessment**: UWTV survey
3) **Forecast**: A short-term forecast for 2019 was presented. The advice for FU 6 will be updated once the results from the 2018 TV survey become available. This is likely to happen before ICES releases the summer advice (June/July 2018).
4) **Assessment model**: Underwater television (UWTV).
5) **Data issues:** Not found
6) **Consistency**: This stock has been benchmarked by ICES in 2013 (WKNEPH, 2013) and the stock annex was updated.
7) **Stock status**:
   - In 2017, 1812 t were landed in FU6 area, which is an decrease of 2% from 2016.
   - The 2017 burrow abundance estimate (902 million) increased by about 29% in relation to 2016 (697 million) and is now above Btrigger.
   - F_{2017} for FU6 is 7.8% and is estimated to be below the F_{msy} (8.1%) proposed by ICES for this FU.
   - The short-term forecast based on MSY proxies suggests catches for 2019 of 1882 t in FU6 (assuming discarding to continue at recent average). This value will however be updated in June after the latest results from the 2018 UWTV survey become available.
   - The advice is based on a HR of 8.1%, corresponding to the HR FMSY.
8) **Man. Plan.** There is no specific management plan for FU 6. The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale (FU level) than the ICES subarea level.

General comments

Some comments and edits were added directly to the advice sheet where necessary using track changes.

Technical comments

None

Conclusions

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.

nep.fu.7

For single stock summary sheet advice:

1) **Assessment type:** Update

2) **Assessment:** Analytical and temporal trends

3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 7 will be updated if needed once the results from the 2018 TV survey become available. This is likely to happen before the end of 2018

4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data

5) **Data issues:** Not found

6) **Consistency:** All input data used are identical with one more year added

7) **Stock status**:

- UWTV surveys show the stock size has greatly increased since 2016 and it is above MSY Btrigger
- The harvest rate has increased in 2017, but it still well below the proxy of MSY rate.
- Discard rates have been close to zero since 2011, altought they increased in 2017. In addition, mean size of landings and catch has decreased in 2017, probably due to a strong recruitment event.

8) **Management Plan**: There is no specific management plan for FU 7. The WG, ACOM and STECF have repeatedly advised that management should be implemented at the FU level.

General comments

The assessment report was not available at the time of writing this audit. The available spreadsheets and advice sheets were used instead.

Technical comments

None

Conclusions

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.

nep.fu.8

For single stock summary sheet advice:

1) **Assessment type:** Update

2) **Assessment:** Analytical and temporal trends

3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 8 will be updated if needed once the results from the 2018 TV survey become available. This is likely to happen before the end of 2018

4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data

5) **Data issues:** Not found

6) **Consistency:** All input data used are identical with one more year added

7) **Stock status**:
   - The stock size is above MSY Btrigger
   - The harvest rate decreased abruptly in the late 1990s and since then it has been close to FMSY. In 2017 the harvest rate is above the proxy of FMSY.

8) **Management Plan**: There is no specific management plan for FU 8. The WG, ACOM and STECF have repeatedly advised that management should be implemented at the FU level.

General comments

The assessment report was not available at the time of writing this audit. The available spreadsheets and advice sheets were used instead.

Technical comments

None

Conclusions

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.

nep.fu.9

For single stock summary sheet advice:

1) **Assessment type:** Update

2) **Assessment:** Analytical and temporal trends

3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 9 will be updated if needed once the results from the 2018 TV survey become available. This is likely to happen before the end of 2018

4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data

5) **Data issues:** Not found

6) **Consistency:** All input data used are identical with one more year added

7) **Stock status**: - The stock size has been above MSY Btrigger for the entire time-series

   - The harvest rate has fluctuaded around FMSY. In 2017 it is just below FMSY

8) **Management Plan**: There is no specific management plan for FU 9. The WG, ACOM and STECF have repeatedly advised that management should be implemented at the FU level.

General comments

The assessment report was not available at the time of writing this audit. The available spreadsheets and advice sheets were used instead.

Technical comments

None

Conclusions

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.

ple.27.420

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: age structured stock assessment, based on Aarts and Poos (2009) + Six survey indices
5) **Data issues:** No issues reported
6) **Consistency**: Update assessment, consistent between years.
7) **Stock status**: B>Blim, Bpa,Btrigger, F<Flim,Fpa, below Fmsy (close to it), R in 2017 above long-term average, estimated for 2018 around average
8) **Management Plan**: The EU management plan (EU, 2007) for North Sea plaice and sole does not cover the current stock area for this stock. Advice is currently based on the MSY approach and the management plan is included as a catch option.

General comments

There was no deviation from the standard procedure. Data, assessment and forecast are done as specified in the stock annex. Advice sheet and report section are consistent.

Technical comments

The stock annex allows some flexibility for age 1 estimates in the intermediate year 2018 (model estimate survivors or RCT3 estimate). This year the RCT3 estimate is used for age 1 in 2018. Recruitment in the forecast at age 1 for 2019 is defined as the longterm geometric mean (1957-2014). For age 2+ AAP surviovors are used.
However, the stock annex mentions here that XSA survivors are used, while the report uses the term AAP survivors. A consistent terminology could be used in report and stock annex if the same is meant.

In a few instances in the report, the SSB units “thousand tonnes” or “kt” was used while giving numbers in tonnes. A few tables containing SSB and recruitment numbers from forecast lack units in the caption or as footnote.

Advice sheet is generally fine (a small typo in Table 9). The change in TAC (Table 3) is mainly due to the fact that total catches are compared to a landings TAC, this could be made clearer in the footnote. In Table 3 not all percentages are given according to the rounding rules in the technical guidelines.

Conclusions

The assessment and forecast has been performed correctly, as specified in the stock annex. The report and advice sheet were easy to follow and matched each other and the details given in the stock annex (minor edits and comments are added to the report and advice sheet, see technical details).

ple.27.7d

General

The input data, assessment and forecast settings and outputs were checked and appear to be correct. Deviations from the stock annex are well described and consistent with the approach taken last year.

For single stock summary sheet advice:

The stock is assessed with the Aarts and Poos statistical catch at age model. Two survey indices are used to tune the assessment. Discards time series are included from 2006 and are estimated by the model prior to that. 65% of mature Q1 catches are removed to correct for spawning migrations. Constant Peterson and Wroblewski M-at-age is assumed.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Aarts and Poos assessment model; 2 survey indices (UK BTS and FR GFS)
5) **Data issues:** Spawning migrations of plaice from neighbouring areas are taken into account by a 65% removal of mature fish from the catch in quarter 1, following the stock annex. This removal amount is based on the results of tagging studies, but could be subject to major interannual variability.
6) **Consistency**: Consistent with last years assessment and forecasts, both of which deviate slightly from the stock annex.

7) **Stock status**: SSB > $B_{trigger}$; F < F_{MSY}; recruitment is around the average of the time series.
8) **Management Plan**: No management plan for this stock. TACs are set for ICES Divisions 7.d and 7.e together. Advice based on Administrative Agreement with the EU.

General comments

The assessment and forecasts are well described and presented.

Technical comments

Input data:

- Identical to last year with one additional year of data added.
- The starting years of the tuning indices are 1989 and 1993 for the UK BTS and FR GFS surveys respectively, and not 1988 as stated in the stock annex and report.

Assessment:

- The assessment uses the actual discard ratio to estimate discards for 2012–2017 and the average logistic curve described in the stock annex for earlier years, due to higher observed discard at age ratios from 2012. This is a slight deviation from the stock annex but is documented in the report and consistent with the approach taken since 2015.

Forecasts:

- Consistent with the approach taken last year, which deviated from the stock annex because (1) recruitment in the intermediate year was taken as the geometric mean over the whole recruitment time series rather than from y-5 to y-2 to reflect recent decreased recruitment and (2) a status quo F was assumed in the intermediate year rather than full utilization of the TAC as landings in 2017 were significantly lower than the TAC. These changes were discussed and agreed at the WG.
- The ratio of landings taken in 7.d as a proportion of total landings in 7.de was calculated from 2002 rather than 2003. This will have no effect on the advice as status quo F was assumed rather than full utilization of the TAC, but may result in minor differences to the '%change in the 7.d portion of the TAC' column of the catch scenarios.
- The rounding of $F_{MSY\ lower}$ and $F_{MSY\ upper}$ is different between stock annex and advice sheet. The values given in the advice sheet were used to conduct the forecasts for these catch scenarios.

Conclusions

The assessment and forecasts have been performed correctly.

pok.27.3a46

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM assessment with 1 commercial exploitable biomass index and 1 scientific survey (IBTS q3)
5) **Data issues:** Data were available as specified in the stock annex.

6) **Consistency**: Update assessment; Intermediate year assumption in the forecast changed from TAC constraint to Fsq.
7) **Stock status**: Above $MSYB_{trigger}$ and F below F_{MSY}
8) **Management Plan**: No management plan

General comments

This was a well-documented and well-ordered section. It includes many tables on Intercatch output that help to audit the input data. It is a bit unclear what happened to the BMS exactly. Most of it comes from Norway. I wonder whether this fish below MCS has been really landed or would be better treated as discards. As far as I understand BMS has been added to the landings. This is in contrast to the other stocks, where BMS is together with discards part of the unwanted catch.

There are several inconsistencies between tables that most likely have their origin in tabulating in some cases the SOP and in other cases the imported landings/discards by weight. This makes it very difficult and will in its current version lead to many questions in the advice drafting group. An SOP correction may be considered next time to avoid such discrepancies. For now, the tables have to be made consistent in some way. Would be good to discuss also with Jose what is the best solution for now.

Technical comments

Advice Sheet:

- BMS needs to be removed from table 8 according to the decision in the group. Just leave wanted and unwanted catch as heading.
- In table 8 the wanted and unwanted catch does not sum up to the total catch
- Table 8, 9 and 10 are still inconsistent. Wanted catch/landings are 90,155 tonnes (Intercatch caton = 90,792.777 – ages 0-2?) in table 8, 88,469 tonnes in table 9 (what is in line with what I get from Intercatch SOP, however with ages 0-2 included) and 88,687 in table 10 (unclear how this is derived, maybe + BMS?)). Needs to be made more consistent and/or maybe more footnotes are needed to explain the differences.
- BMS in table 7 is different to BMS in table 8 (although it needs to be deleted). I am unsure whether Norwegian values are real BMS like in the EU. BMS is reported in logbooks in the EU and it is landed.

- SSB in 2019 in table 2 is wrong. It are 339997 according to forecast tables. SSB in 2018 has been tabulated by accident.

Report (vs advice sheet):

The total catch in table 17.3.4 is 95170t, however 97485t in table 8 of the advice sheet. Has to be made consistent between all tables. In addition, discard is 6474 in the tables in the advice sheet, but 6478 in the tables in the report.

Table 17.3.5 suggests that 93% of the discards had a sampled age distribution. In table 6 of the advice sheet it is stated that only 7% of the "reported" discards had a sampled age distribution. I think 98% is the correct value if you want to focus on the imported discards only (to my opinion imported is the right word, not reported like written in table 6. Reported is for me reported in logbooks).

Figure caption 17.4.1: I think 2016 is on the left side and 2017 on the right side

Figure 17.4.7 has not been updated. It stops in 2016.

Figure 17.4.9 is different to what I see on stockassessment.org for the assessment 2018_B.

Several places in the text: It is called Otter trawling and not autotrawling.

The detailed forecast tables from the SAM output could be added to the report to provide more information.

Assessment and forecast Configuration:
Use correlated random walks for the fishing mortalities
(0 = independent, 1 = correlation estimated)
2 ➔ According to the comment only 0 and 1 is allowed in the SAM version used. Please check whether 2 is correct and enables the AR1 option.

The intermediate year assumption changed from TAC constraint to Fsq. This needs to be changed in the stock annex.

The F in the Fmsy upper option seems to be the wrong one. The FMSY upper with advice rule has been used but only the FMSY upper without advice rule counts according to Jose. Please, ask Jose what to finally use. FMSY upper without advice rule is 0.419 to my knowledge.

Conclusions
The assessment has been performed correctly. However, several inconsistencies in the tables and in the advice sheet need to be resolved.

pol.27.3a4

General

All information is present on the sharepoint. Assessment is straightforward and according to ICES cat. 5 guidelines. No advice was requested for this stock.

For single stock summary sheet advice:

1) **Assessment type: update/SALY**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: none existent
5) **Data issues:** there are no adequate surveys for tracking stock trends
6) **Consistency:** not applicable
7) **Stock status**: cannot be assessed based on current data availability
8) **Management Plan**: no management plan

General comments
Very fine assessment!

Technical comments
None

Conclusions
The assessment has been performed correctly

sol.27.4

General

The necessary data was available and the assessment was carried out as described in the stock annex using the AAP model. For the forecast, no TAC constraint assumption was used cfr. last year's forecast (2017). This year the EG decided to use the Fsq option set as the mean of 2015-2017. Besides some minor comments, the advice sheet and report are consistent.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: AAP statistical catch at age model - tuning by 2 surveys (BTS-ISIS 1985-2017, ages 1-9 and SNS 1970-2017, ages 1-6)
5) **Data issues:** The data are available as described in the stock annex.
6) **Consistency:** Update assessment, consistent between years.
7) **Stock status**: B>Blim, Bpa, MSYBtrigger, F<Flim, Fpa, F>FMSY, R fluctuating without trend
8) **Management Plan**: Former management plan agreed in 2007: EU Management Plan, reduce fishing mortality to Fmp = 0.2, SSBmp = 35000 t. The MSY approach is in accordance with the plan (Fmsy=0.202, MSYBtrigger = 37000t). The plan is evaluated by ICES as precautionary. A new proposed EU multiannual plan (MAP) for the North Sea is drafted. This year advice is given according to the ranges defined in this multi-annual plan (Flower = 0.113 – Fmsy = 0.202 – Fupper = 0.367).

General comments
The report was well-documented and allowed the reader to follow and interpret the assessment and forecast. During the WGNSSK 2018, several issues were further investigated, such as the doming effect in F and the Belgian BTS index. All these issues were appropriately explained in the report. Numbering of the figures and tables is a bit confusing.

Technical comments
Two survey indices are included in the assessment. However, these no longer cover the main fishing area of the sole fleet. The Belgian BTS index overlaps with the current main fishing area. Trends of this index were investigated and possibilities of including this index in the assessment were explored.

Most of the technical comments to the advice sheet and the report were directly communicated to the chair and the stock coordinator and modified accordingly.

A remaining issue in the advice sheet is whether the * in table 9 for 2016 should be deleted or not.

In the report, a paragraph on the management plan is missing (old and new) and numbering of the tables and figures is a bit confusing.

Conclusions

The assessment has been performed correctly. As agreed upon during the WGNSSK 2018, the stock coordinator will try to include the Belgian BTS index in the assessment and explore the effects. If major discrepancies with the current assessment are identified, this stock should be brought to benchmark.

sol.27.7d

General

The input data, assessment and forecast settings and outputs were checked and appear to be correct. Deviations from the stock annex are well described and consistent with the approach taken last year.

For single stock summary sheet advice:

The stock is assessed with XSA. Three survey indices and three commercial indices are used to tune the assessment. Discards time series are included from 2004 (and reconstructed 1982-2003).

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA; 3 survey indices: UK(E&W)-BTS ,UK(E&W)-YFS, and FR-YFS; 3 commercial indices: BE-CBT, FR-COT and UK(E&W)-CBT
5) **Data issues:** Data available as described in the Stock Annex.
6) **Consistency**: main change in the stock perception is due to a re-evaluation of 2015 recruitment (UK-BTS seemed highly positives and young fishes seen during the survey were not confirmed by the catches the following year).
7) **Stock status**: SSB > $B_{trigger}$; F < F_{MSY}; SSB is close to Blim
8) **Management Plan**: No management plan for this stock. Advice based on Administrative Agreement with the EU.

General comments

The assessment and forecasts are well described and presented.

Technical comments

No major comments, the few edits were directly provided to the stock coordinator and taken into account before the ADG

Conclusions

The assessment and forecasts have been performed correctly.

whg.27.47d

For single stock summary sheet advice:

1) **Assessment type:** update assessment
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM assessment with 2 survey indices (IBTS Q1 and Q3)
5) **Data issues:** Data available were as specified in the stock annex

6) **Consistency**: Update assessment, follows recommendations from 2018 benchmark
7) **Stock status**: Above MSYBtrigger and F below FMSY. No TAC constraint in intermediate year;
8) **Management Plan**: No management plan

General comments

This was a well-documented and well-ordered section. The presentation of the data inputs and model results were easy to follow and interpret.

There is a discrepancy between the advice tables and the report tables in wanted catch and unwanted catch; the numbers do not match for the ICES reported data, even if excluded BMS and IBC or if the SOP correction is taking into account.

Technical comments

Advice sheet

- Discrepancy between Advice Table 7 and Report Tables 23.1.1 and 23.1.2 needs explained or resolved.
- Discrepancy between Advice Table 9 and Report Tables 23.1.1 and 23.1.2 in unallocated landings and ICES landings.

Report

- Figure 23.1.2b – legend incorrectly states 'along with cumulative discards (black line)' – the figure does not sho cumulative discards.
- Figure 23.1.6 legend on page without figure.
- Figure 23.1.10 legend breaks across 2 pages

Conclusions

The assessment has been performed correctly

nop.27.3a4

General

Assessment and forecast completed in good time and according the the specifications of the Stock Annex following the 2016 benchmark.

For single stock summary sheet advice:

1) **Assessment type:** update assessment
2) **Assessment**: analytical
3) **Forecast**: Stochastic forecast
4) **Assessment model**: Quarterly SESAM model
5) **Data issues:** Q3 English and Scottish survey data available in time for assessment schedule (despite some delays in the former). No issues.
6) **Consistency**: Update assessment, following specifications in the Stock Annex.
7) **Stock status**: Above B_{lim} and B_{pa}, no F reference points except for F_{cap} (F_{bar}(1–2));
8) **Management Plan**: No management plan, but ICES currently evaluating long-term management strategies for Norway Pout following an EU-Norway request

General comments

This was a well-documented and well-ordered assessment and advice. The stock assessor is to be commended for a rapid turn-around from provision of data to completion of report and advice (just a few days).

There are some discrepancies between tables in the advice sheet and the report (see technical comments below). The report could do with some judicious pruning, with legacy material either referenced or moved to the stock annex.

Technical comments

- Table 2 in the advice sheet had incorrect inputs for F and Catch (the last quarter was left off calculations), but these were corrected.
- As a result of correction to Table 2, the %catch change in Table 3 was corrected.
- Table 3 in the advice sheet truncated the catch values to the nearest tonne, instead of doing proper rounding. This was corrected.
- There are discrepancies between Table 9 in the advice sheet and Table 12.2.1 in the report. For example:
  - Div. 3.a – 2007
  - Div. 4.a – 2007, 2012–14
  - Div. 4.b – 2012
  - All areas combined – 2007

  This needs to be investigated.
- Table 10 of the advice sheet could do with less rounding for years before 2017, if it is possible to do.

Conclusions

The assessment has been performed correctly

Annex 6: Benchmarks and Data Problems by Stock

A.1 Benchmarks

A.1.1 Summaries of recent benchmarks and inter-benchmarks

A.1.1.1 Turbot in 4 (IBP Turbot 2017)

After screening all available input data and work conducted during the inter-benchmark, the turbot 27.4 assessment still has to be based on poor input data to some extent:

- Only an incomplete catch-at-age matrix is available that needs to be reconstructed by modelling for the years 1991 to 1997 and 1999 to 2001. Age in-formation for recent years is mainly available only from the Dutch fishing fleets representing more than 50% of total landings. Data from Denmark were available for the three most recent years. Danish data showed a shift towards older fish compared to the Dutch data. This may also be true for other countries but no information is available. Although the inclusion of Danish data impacted the overall catch-at-age matrix only to a minor extent, this highlights the need to get catch-at-age data not only from the Netherlands but also from other countries. Also, data back in time would be highly beneficial if available.
- The available scientific surveys have a low internal consistency especially for older ages leading to a low ability to track cohorts over time. Because of this, the assessment is strongly influenced by a Dutch LPUE index. This index has been standardized for changes in fishing areas and gears used (i.e. traditional beam trawls vs. pulse trawls). It is also used as exploitable biomass index without age information to avoid that the catch-at-age matrix is used twice. However, a scientific survey with higher catch rates for turbot and a better internal consistency would be preferable

The inter-benchmark critically reviewed SAM model settings and carried out sensitivity runs with various combinations of input data, plus group settings, highest age used in survey indices and different length of the assessment time-series. Finally, a number of changes compared to previous assessments were agreed relating to the start of the assessment (1981 instead of 1975), the use of catch-at-age data (German and UK data omitted because they were potentially biased, but recent Danish data added), the use of survey data (only those years with reliable ALKs were included), the inclusion of a standardised and age-aggregated Dutch LPUE time series, and the reduction of the plus-group to 8+. The model configuration was adjusted from scratch (through a series of sensitivity runs) using AIC and Mohn's rho as tools to find the optimal number of free parameters; the final configuration included a survey correlation correction by age.

The final agreed SAM assessment showed acceptable diagnostics and was of sufficient quality apart from a retrospective pattern in the fishing mortality that could not be resolved. Because of this and issues with some of the input data, it was concluded that the assessment is currently better used as basis for category 3 advice (i.e. the SSB trends over time). However, it may be possible to move the assessment to a Category 1 assessment in the next years after a further benchmark. Reference point proxies were calculated based on SPICT in accordance with other category 3 stocks. Also, an EqSim analysis was carried out under the assumption that the SAM assessment can be treated as category 1 assessment.

During WGNSSK 2018, it was discovered that the Dutch LPUE series was actually being treated as an SSB index, instead of an exploitable biomass index, and this was the source of the retrospective patter in F. A subsequent inter-benchmark was held following WGNSSK 2018 (during the summer of 2018; see below), and results from the inter-benchmark will be reported next year.

A.1.1.2 Whiting in 4 and 7.d (WKNSEA 2018)

A complex population structure for whiting in the North Sea has been proposed, based on studies about movements, life-history traits, genetic data, identification of spawning aggregation, population temporal asynchrony observed in SSB, recruitment and egg abundance between areas. Exploratory SURBAR assessments were run for individual components and the combined stock. Literature and provided data did not suffice to revise management unit for this stock. The feasibility of combining Division 3a with Subarea 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks. The new assessment was run for the North Sea and Eastern Channel (27.4 and 27.7d). As before, Subarea 27.4 represents the management unit with TAC advice to be given. No changes were made to the use of survey indices. The maturity ogive, stock weights-at-age, and natural mortality were updated with new information. Catch data were updated in Intercatch with new data submissions for 2009–2016 and a new stratification design to allocate discard ratios and age distributions. The assessment model was changed from XSA to SAM and new reference points were estimated.

A.1.1.3 Lemon sole (WKNSEA 2018)

Alternate survey indices were explored. The agreed-upon method was the GAM estimation for Q1 and Q3, where the Q3 incorporates both IBTS and BTS survey data. The length coverage of the surveys was concluded to be sufficiently representative of the stock as a whole, and therefore that advice could appropriately be based on survey data alone. SMALK data were used to determine the proportion mature-at-age, mean weight-at-age in the stock, and an annual length–weight relationship. Natural mortality estimates for lemon sole are not available; total mortality is an output of the survey-based assessment. Age data were sparse; therefore, an age-based assessment was not possible. The stochastic production model SPiCT was assessed but was deemed unsuitable for use as an assessment model for lemon sole at this time. The age- and survey-based assessment model SURBAR was agreed upon. No new reference points could be proposed by WKNSEA. It is proposed that the status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis through the LBI analyses.

A.1.1.4 Flounder in 3.a and 4 (WKNSEA 2018)

Age data were sparse in the surveys and catch data. Survey indices were based on the catch weight per haul applying a general length–weight relationship with the length distribution data by haul. Indices were generated using the delta-GAM method for Q1 from IBTS data and Q3 by combining information from three beam trawl surveys and the IBTS. Length-based data show that most flounder reach maturity above 20 cm in length. Lack of data prevented analyses of interannual trends in weight-at-age or growth. Natural mortality estimates were not available for flounder. A SPiCT model was agreed upon, which obtained robust results in terms of relative fishing mortality and relative biomass. The status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis by updating the SPiCT model, where the relative values of biomass and fishing mortality gives an indication for the stock status in relation to F_{MSY} and B_{MSY}.

A.1.1.5 Witch flounder in 3.a 4 and 7.d (WKNSEA 2018)

The delta-GAM approach was used to generate survey indices for IBTS Q1 and Q3 for years with age data, 2009–present. Total biomass indices were also estimated for use in the SPiCT model. Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. Stock weights-at-age and a new constant maturity ogive were estimated from survey data; natural mortality was left at 0.2. A SAM assessment model was used. The catch time-series was extended back in time by using landings from 1950 to 2008. Two new surveys of fishable stock biomass for Q1 (1983 to 2008) and Q3 (1991 to 2008) were included. Age-specific information for surveys and catches were available from 2009. The stock was upgraded to a Category 1 assessment and new reference points estimated.

A.1.2 Benchmarks and inter-benchmarks for 2018 and beyond

A.1.2.1 Turbot in 4 (IBP turbot 2018)

The 2015 inter-benchmark for turbot in 27.4 ended with several issues left in the final SAM assessment. Among other things, the low quality of input data and a strong retro-pattern in F was highlighted. Finally, the assessment was accepted as a Category 3 assessment, using the relative trends in SSB only (ICES 2:3 rule) to provide advice. During WGNSSK 2017 questionable model settings used since the 2015 inter-benchmark were detected. This led to the decision that a further inter-benchmark was needed before biennial advice on turbot in 27.4 could be provided for 2018 and 2019.

During the 2017 inter-benchmark, all available input data were screened again, including a new LPUE index from UK, a Delta-GAM survey index combining several BTS surveys and, for the first time, age-based catch data from Denmark for most recent years. Also, different models to standardise the Dutch LPUE time-series were tested. The SAM model settings were reviewed, and sensitivity runs were conducted with various combinations of input data, plus-group settings, highest age used in survey indices and different length of the assessment time-series. Decisions were made on final input data and model settings. In addition, reference point proxies were estimated. The 2017 inter-benchmark met by correspondence between July 2017 and September 2017 (see above).

At WGNSSK 2018 a mistake was found in the IBP assessment configuration which led to questions on the persistence of the retrospective pattern on F and assessment category used to provide advice. For this reason, an inter-benchmark has been organised for the summer of 2018 to:

1) Correct the mistake in the IBP 2017 settings (using the NL LPUE series as an indicator of exploitable biomass rather than as an indicator of SSB)
2) Check the plus-group of the catch and maximum age in the survey data
3) Re-evaluate parameter bindings in the assessment configuration
4) Decide on the categorisation of the stock based on the new assessment.
5) Estimate reference points for either Category 1 (using EqSim) or Category 3 (using SPiCT)
6) Provide a short-term forecast

A.1.2.2 Possible inter-benchmark for sole in 4

A mismatch between the area covered by surveys and the area were some fisheries are focussed currently exists for sole in 4, and a new Belgian BTS survey could provide the necessary area coverage to deal with this problem. A working document on the new survey is currently being prepared by Belgian scientists, and once this is received by ICES, it would initiate an inter-benchmark for sole in 4 to analyse the new survey time series to see if it can be included in the assessment, and then to incorporate this new survey in the assessment.

A.1.3 Future benchmarks

There remain a few Category 3+ stocks that have not yet been benchmarked, namely bll.27.3a47de (brill), whg.27.3a (whiting), tur.27.3a (turbot), pol.27.3a4 (pollack) and gug.27.3a47d (grey gurnard). Of these, the only realistic prospect of a benchmark in 2020 (related to available resources) is for brill, turbot in 3a, and whiting in 3a (the latter for a possible upgrade to a Category 3 stock).

ICES has proposed a new approach for conducting benchmarks, which includes a scoping workshop (to take broader issues into account and include wider participation) and a mechanism to initiate a benchmark only when sufficient progress has been made on relevant issues. The WG discussed this and generally supported the approach. This may mean that there is a scoping process sometime during 2019 prior to the actual benchmarks in 2020.

Issues lists for brill, turbot in 3.a and whiting in 3.a were previously drawn up and are given below as a potential starting point for this process.

A.1.3.1 Brill in 3.a, 4 and 7.d-e

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	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	Check whether BITS and BTS ISI still give an adequate estimation of the stock trends (cfr earlier analysis by WGNEW in 2012). Check whether there is survey information available in the 7.d,e part of the stock area.	Analyse DATRAS data; Investigate whether a survey should be designed focussing mainly on fast flatfish species such as brill and turbot.	Data available in DATRAS. Consult with survey experts concerning the suitability of existing surveys in catching brill.	Survey 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
Discards	Discards are not included in the 'assessment' (lpue biomass index)	Considering that discarding of larger length classes occurs when the TAC is restrictive, it should be verified whether the NL lpue could be revised to a cpue index.	Discard data from the Netherlands	Dutch experts to revise the lpue index
Biological Parameters	When using length based indicators, correct information on length at maturity (Lmat), and length von Bertalanfy growth curve (L inifinity) are needed. Determine the sex ratio in the stock area.	van der Hammen et al (2013) suggested values for Linf and Lmat based on Dutch market samples; check whether these are representative for the entire fleet fishing on brill	Data from surveys and commercial sampling on maturity (at age/length per sex) and on individual weights (at age/length per sex)	
Assessment method	Currently a biomass index is calculated Check whether the index series can be elongated Investigate how this series should be corrected for technological creep (Dutch fleet has an increasing amount of pulse trawlers compared to the beginning of the series) Check whether age 0 and 1 should be included in the index Should the index be age structured or not? Explore whether other assessment methods can be used.	Verify whether aim 1–4 are feasible. Investigate all available data and use them in SPiCT, SAM or length based indicator analyses	A longer time-series of age and/or length data is needed from all countries involved in the fisheries.	Experts on length based indicators, SPiCT and SAM; experts on the Dutch biomass index currently used
Biological Reference Points	Determine MSY (proxy) reference points	Depending on the assessment method and available data	See issue 'assessment method'	Experts in computation of reference points

A.1.3.2 Whiting in 3.a

Data available/needed

Survey data for 3.a (the Skagerrak-Kattegat area): IBTS-Q1 index available since 1980; IBTS-Q3 since 1991; Depending on whether whiting in the Kattegat and Skagerrak is subdivided, BITS Q1 index is available since 1992 and BITS Q4 index is available since 1999.

Catch data are available back to 2003. For landings statistics alone in 3.a, data are available since 1940s, as such data were recently updated in a project financed by the Nordic council.

Swedish historical survey trawling data are available from about 1902.

Age readings are available since 2012, although some age readings might exist from earlier years.

Any tagging information should if possible be made available.

Current assessment issues

1. Descriptions of whiting population structure, possible recruitment sources, and migratory patterns in 3.a.
2. The development of historical whiting biomass in 3.a
3. The development of the population age structure over time in 3.a, or in 3.aN and 3.aS, separately.
4. Growth development over time
5. Modelling of natural mortality
6. Choice of assessment model

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	ICES/External expertise needed at benchmark type of expertise / EG's, names
(New) data to be considered and/or quantified	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	Inconsistencies in survey indices	Age reading improvements, stock identification	Age reading intercalibrations. Genetic and/ or otolith chemistry studies	SIMWG/ geneticists / otolith chemistry researchers
Discards				
Biological Parameters	Maturity ogive	Maturity studies	Sampling during the IBTS-Q1, BITS-Q1	Within ICES

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	ICES/External expertise needed at benchmark type of expertise / EG's, names
Assessment method				
Biological Reference Points				

A.1.3.3 Turbot in 3.a

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			
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			
	Stock ID. Is Turbot 3a a real stock? What is the li	Review of available knowledge and data - update since 2013.	No new data sources will likely be available	experts in flatfish/turbot ecology/genetics (DTU Aqua, SLU, IMARES)
Tuning series	Stock perception different from the work by Cardinale *et al.*, 2009	To check and validate further. Consider extensions and linkages with the time series by Cardinale *et al.*, 2009	Historical survey data	SLU
Discards	Short time series	Length data to be provided back in time	Standard intercatch data	DTU Aqua, SLU, IMARES
Biological Parameters				
Assessment method	Validate SPiCT assessment	Additional runs and analyses of outcomes		DTU Aqua

Issue	**Problem/Aim**	**Work needed/ possible direction of solution**	**Data needed to be able to do this: are these available/ where should these come from?**	**External expertise needed at benchmark type of expertise/ proposed names**
Biological Reference Points				

A.2 Stock Data Problems Relevant to Data Collection

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.
Plaice in Subarea 4 and Division 3.a Sole in Subarea 4	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.	ACOM (Netherlands)
Sole in Subarea 4	Survey area coverage	A mismatch between the area covered by surveys and the area were some fisheries are focussed currently exists for sole in 4, and a new Belgian BTS survey could provide the necessary area coverage to deal with this problem. The time series needs to be made available to WGNSSK to evaluate it and potentially include it in the assessment.	ACOM (Belgium)
Saithe in Subarea 4, 6 and Division 3.a	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, Germany, France, Denmark, UK-Scotland)
Saithe in Subarea 4, 6 and Division 3.a	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 4, 6 and Division 3.a	Age sampling from commercial fleets	Possible cluster sampling due to few vessels in the reference fleet (Norway), needs review/redesign	ACOM (Norway); PGDATA
Turbot in 3.a	Small turbot stocks cannot be easily	Most knowledge about stocks connectivity is based on old and limited tagging experiments. New tagging studies would be	SIMWG; ACOM (Denmark, Sweden)

Stock	Data Problem	How to be addressed in	By who
	assessed because of potentially large migrations in and out the large areas IV and the Baltic.	necessary to improve the understanding of migratory patterns	
Turbot in 3.a	Landings are fluctuating slightly below the DCF thresholds for sampling, implying that length data are not available in recent years	Not yet known how this is to be addressed.	Not yet known.
Nep 32 and 3.a	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. Logbooks should be introduced for vessels <15m. A growing part of the Norwegian Nephrops landings come from the trap fishery, a fishery we know little about. A reference fleet of trap fishers would provide information on this fishery, as well as provide biological information about the coastal part of the stocks.	ACOM (Norway)
Pollack in Subarea 4 and Division 3.a	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 4 and Division 3.a, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity WGNEW recommended that otoliths and maturity information should be collected during these surveys for a few years. WGNSSK also recommends that biological data from commercial catches should be processed.	IBTSWG; RCM-NS&EA
Whiting in Division 4 and 3.a	General lack of stock identity and area specific age readings	Studies on whiting stock identity and connectivity in western Baltic, Division IIIa and Division 4 should be encouraged. In the routine surveys, IBTS quarter 1 and quarter 3 in Division 3.a, apart from reporting catches at length, no biological data are collected for this species; in order to understand better their growth and maturity in this area, it is recommendable that otoliths and maturity information should be collected during surveys.	National research services and IBTSWG

Stock	Data Problem	How to be addressed in	By who
Cod in subdivision 3.aW, subarea 4, and Division 7.d	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 4	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, and for recent years from Denmark and Belgium. 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. Sampling should include age information for discards from all countries.	ACOM (Denmark, Belgium, UK, Germany)
Turbot in 4	Improved surveys for large flatfish	Currently, scientific surveys show relatively poor performance (due to low catch rates) in assessments of large flatfish. A new standardised survey with higher catch rates for large flatfish should be developed to improve assessments for these species. Such a survey could be developed through and Science-Industry partnerships, which is being planned.	ACOM (Netherlands and others); Industry involvement through Science-Industry partnership
Nep 5	Incomplete catch sampling	Only Dutch catches are sampled. 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)
Nep 5	The current population size is unknown	The catch advice is based on the population size estimated in 2013. A new estimate is needed to provide a better advice	ACOM (UK, Netherlands, Germany, Belgium)

Annex 7: Update Forecasts and Assessments

7.1 Summary

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chair: José De Oliveira, UK) communicated by correspondence at the beginning of October 2018 to evaluate new information from the fisheries independent surveys carried out during 2018 subsequent to the meeting of the group in April/May.

The WGNSSK followed the protocol defined by the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES CM 2008/ACOM: 60) in its evaluation of the survey information - fitting the RCT3 regression model to data that included the 2018 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 in the past, 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 UWTV 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.

Following the re-opening protocol, the following stocks could be considered for re-opening:

- Haddock in Subarea 4 and Division 6.a and Subdivision 20 [potential decrease from 35 761 t to 33 956 t, i.e. -5%]
- Saithe in Subareas 4 and 6 and Division 3.a [potential decrease from 139 978 t to 135 035 t, i.e -4%].
- Whiting in Subarea 4 and Division 7.d [potential decrease from 25 302 t to 24 499 t, i.e. -3%]
- Plaice in Subarea 4 and Subdivision 20 [potential increase from 139 052 t to 142 216 t, i.e. +2%]
- *Nephrops* in FU 6 (Farn Deeps) [potential increase, based on F_{MSY}, from 1882 t to 1982 t, i.e. +5%]
- *Nephrops* in FU 7 (Fladen) [potential decrease, based on F_{MSY}, from 16 394 t to 13 178 t, i.e. -20%]
- *Nephrops* in FU 8 (Firth of Forth) [potential increase, based on F_{MSY}, from 2333 t to 3569 t, i.e. +53%]
- *Nephrops* in FU 34 (Devil's Hole) [potential increase, based on F_{MSY}, from 315 t to 590 t, i.e. +87%]

Details are provided in the sub-sections below.

7.2 Cod in Subarea 4, Division 7.d and Subdivision 20

7.2.1 New survey information

New survey information, in the form of the IBTS Q3 2018 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 7.2.1.

7.2.2 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 (2017) year-class at age 1. The RCT3 input and output files are given in Tables 7.2.2 and 7.2.3, respectively

7.2.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2017 year-class at age 1	
Log WAP from RCT3 (R)	11.61
Log of recruitment assumed in spring (A)	11.51
Int SE of log WAP (S)	0.139
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.741**

7.2.4 Conclusions from Protocol

As the distance -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea cod should not be reopened**. The autumn indices suggest that the size of the incoming year-class is not significantly different to what had been assumed in the forecast produced by WGNSSK in May 2018.

7.2.5 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

Table 7.2.1. Cod in Subarea 4, Division 7.d and Subdivision 20. 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 4, Table 4.6 of this report).

North Sea Cod Survey Index Q3 (DG) calculated 2018-10-04 14:48:50

1992	2018						
1	1	0.627568	0.627568				
1	6						
1	**17556.61**	**1763.745**	**396.1511**	**360.732**	123.7432	44.6216	1992
1	**4591.094**	**4654.701**	**590.9934**	**134.0599**	97.053	8.2113	1993
1	**18072.77**	**2407.25**	**949.7324**	**170.7799**	46.7327	37.6656	1994
1	**9684.248**	**7139.599**	**712.9039**	**322.2757**	36.3817	20.8277	1995
1	**5114.379**	**2995.001**	**1086.736**	**189.5926**	152.5326	15.3824	1996
1	**30261.38**	**2100.964**	**740.5883**	**284.1008**	54.8113	39.5648	1997
1	**884.136**	**9356.07**	**708.7534**	**202.2059**	123.7468	42.4399	1998
1	**3442.43**	**500.2281**	**2499.605**	**161.8814**	43.5849	18.6885	1999
1	**6477.703**	**996.0927**	**119.7616**	**359.9847**	38.9875	34.867	2000
1	**1419.241**	**2228.673**	**378.9596**	**80.4066**	61.3055	38.7761	2001
1	**3952.103**	**902.1226**	**763.0241**	**202.5874**	54.3655	25.0065	2002
1	**937.4516**	**1320.708**	**250.8282**	**187.5515**	90.3684	63.3472	2003
1	**3132.846**	**784.8095**	**489.3505**	**97.9821**	74.0205	26.903	2004
1	**1066.693**	**751.8071**	**290.8283**	**124.7851**	27.9288	50.7168	2005
1	**5409.423**	**730.3679**	**614.6114**	**123.8977**	30.992	20.5145	2006
1	**1815.75**	**2318.248**	**439.3316**	**180.7953**	104.4061	48.6994	2007
1	**2401.812**	**1204.99**	**1129.395**	**236.2027**	128.8015	33.4716	2008
1	**1863.051**	**981.9015**	**294.0915**	**243.1227**	54.9985	27.1006	2009
1	**4523.937**	**1647.264**	**540.9878**	**185.6751**	114.7124	23.0721	2010
1	**1199.535**	**2849.019**	**895.8274**	**382.289**	109.0146	105.84	2011
1	**2116.117**	**1009.287**	**1262.679**	**380.0358**	106.0695	19.4876	2012
1	**3072.9**	**1061.607**	**479.7688**	**485.957**	136.5489	64.4415	2013
1	**3312.729**	**1463.343**	**608.4539**	**303.749**	199.9792	98.7353	2014
1	**1839.984**	**2937.795**	**1044.77**	**462.3545**	140.5948	137.7236	2015
1	**1358.249**	**1114.441**	**1646.127**	**832.2182**	201.9766	134.4899	2016
1	**7030.777**	**592.7648**	**468.417**	**420.959**	220.4285	49.0028	2017
1	**1080.876**	**2070.859**	**375.4909**	**210.2993**	144.771	102.7436	2018

Table 7.2.2. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Inputs.

"yearclass"	"recruitment"	"DeltaGAMq11"	"DeltaGAMq31"
1982	800367	4412.257	NA
1983	1481585	13407.8178	NA
1984	358913	628.7467	NA
1985	1625467	12980.7956	NA
1986	617457	5256.8651	NA
1987	426224	2960.8084	NA
1988	745534	9834.4856	NA
1989	295322	2070.3091	NA
1990	339399	1744.3912	NA
1991	792194	9891.2111	17556.6108
1992	394504	3359.6208	4591.0938
1993	955384	7373.8301	18072.7715
1994	547278	7224.1537	9684.248
1995	351284	1910.0675	5114.3792
1996	1089999	15792.8522	30261.3794
1997	111936	660.1816	884.136
1998	229672	1413.8093	3442.4296
1999	422524	3502.6596	6477.7028
2000	154024	886.8431	1419.2408
2001	233307	2974.6322	3952.1026
2002	115009	363.4471	937.4516
2003	196468	2762.9691	3132.8455
2004	154259	1107.6286	1066.6925
2005	359929	3946.0994	5409.423
2006	168870	1441.507	1815.7502
2007	190204	2313.6417	2401.8119
2008	183318	1071.3236	1863.0511
2009	274919	2925.4016	4523.9368
2010	132904	779.5383	1199.5346
2011	179434	1548.4736	2116.1174
2012	226194	1639.6422	3072.8996
2013	317568	2681.5517	3312.7289
2014	155316	1680.2366	1839.9842
2015	109912	898.2148	1358.2494
2016	385593	8451.9666	7030.7773
2017	NA	469.4061	1080.8758

Table 7.2.3. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Outputs.

```
Analysis by RCT3 ver4.0

Cod

Data for 2 surveys over 36 years : 1982 - 2017
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:2017
       index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
 DeltaGAMq11 0.8695     5.849 0.3960  0.7826 35   6.151      11.20  0.4320      0.1078
 DeltaGAMq31 0.7041     6.738 0.1377  0.9581 26   6.986      11.66  0.1502      0.8922
    VPA Mean     NA        NA     NA      NA 35      NA      12.69  0.7403      0.0000

                  WAP logWAP int.se
yearclass:2017 109900  11.61 0.1393
```

7.3 Haddock in Subarea 4 and Division 6.a and Subdivision 20

7.3.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 7.3.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2018), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

7.3.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2018) year-class at age 0. The RCT3 input and output files are given in Tables 7.3.2 and 7.3.3.

7.3.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2018 year-class at age 0	
Log WAP from RCT3 (R)	7.115
Log of recruitment assumed in spring (A)	8.169
Int SE of log WAP (S)	0.5526
Distance D $\left(D = \frac{R-A}{S}\right)$	**-1.907**

7.3.4 Conclusions from protocol

As the distance D <-1.0, the protocol concludes that **the advisory process for Northern Shelf haddock should be reopened.** The autumn indices suggest that the size of the incoming year-class is significantly lower than had been assumed in the forecast produced by WGNSSK in May 2018.

7.3.2 Updated forecast

The forecast from May 2018 was re-run with the same parameters and settings, apart from the assumed recruitment at age 0 in 2018 which was reduced from 3529 million to 1231 million, following the new RCT3 analysis reported above. Recruitment in 2019 and 2020 was assumed to be 3529 million, as before. A TAC constraint was needed for the 2018 intermediate year as a combined-area TAC overshoot of 11675 tonnes would have occurred if a similar level of effort to 2017 was assumed for the intermediate year. The updated catch-option table is given in Table 7.3.4, while the original catch-option table from May 2018 in given in Table 7.3.5. The new wanted catch forecast at F(msy) in 2018 is **31 120 tonnes** (a decrease of 31% over the 2018 TAC), compared to the original wanted catch forecast of **31 247 tonnes** (a decrease of **27%** over the 2018 TAC). The difference of **127 tonnes** is caused by the updated recruitment assumption for 2018: the forecast settings are otherwise unchanged.

7.3.5 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2017). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2017/ACOM:21.

Table 7.3.1. Haddock in Subarea 4 and Divisions 3.a and 6.a. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2018 are highlighted.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5
1991	718.479	233.55	22.921	2.842	0.507	1.561
1992	2741.14	595.235	189.015	10.529	1.583	0.396
1993	577.382	605.99	140.146	37.604	2.36	0.372
1994	1781.191	195.331	262.643	32.423	8.383	0.381
1995	520.855	1019.607	106.642	97.383	8.06	3.131
1996	627.502	247.469	428.471	30.426	20.215	2.649
1997	195.255	347.567	123.793	149.048	6.672	5.282
1998	276.401	257.14	164.853	53.69	42.66	3.093
1999	6904.537	176.457	94.108	47.947	13.268	9.904
2000	1092.754	2504.185	44.3	19.502	10.287	4.264
2001	34.751	360.427	1099.298	30.289	6.371	3.648
2002	137.707	45.969	237.729	573.752	9.826	2.485
2003	163.931	69.348	31.171	199.259	368.665	2.942
2004	183.977	69.539	40.556	23.119	82.685	154.82
2005	1412.973	67.605	45.54	16.254	9.845	37.095
2006	191.608	547.284	27.543	11.709	3.612	3.352
2007	111.475	149.743	385.791	10.354	5.35	1.126
2008	126.428	86.627	89.934	174.968	5.206	2.253
2009	909.334	77.703	79.994	38.131	73.972	1.643
2010	30.294	557.39	59.017	34.214	25.186	53.33
2011	30.64	77.035	344.508	27.159	12.209	9.196
2012	68.068	31.515	40.248	132.237	7.344	4.397
2013	86.249	58.345	25.17	18.291	82.779	2.515
2014	747.522	48.207	58.51	5.216	9.093	51.625
2015	104.274	463.428	22.807	15.993	1.662	2.307
2016	351.819	94.564	220.165	8.057	3.669	0.4
2017	146.171	167.605	72.398	130.786	2.896	1.290
2018	123.141	74.11	94.752	22.692	32.776	0.724

Table 7.3.2. Haddock in Subarea 4 and Divisions 3.a and 6.a. RCT3 input file. Data from surveys in autumn 2018 are highlighted.

YEAR	TSA	IBTS Q1 AGE 1	IBTS Q1 AGE 2	IBTS Q3 AGE 0	IBTS Q3 AGE 1	IBTS Q3 AGE 2
1981	15398.99	-11	403.079	-11	-11	-11
1982	9254.48	302.278	221.275	-11	-11	-11
1983	30169.94	1072.285	833.257	-11	-11	-11
1984	5827.69	230.968	266.912	-11	-11	-11
1985	9593.36	573.023	328.062	-11	-11	-11
1986	18110.55	912.559	677.641	-11	-11	-11
1987	265.07	101.691	97.372	-11	-11	-11
1988	1044.19	219.060	139.114	-11	-11	-11
1989	1978.73	217.448	134.076	-11	-11	22.921
1990	8710.82	680.231	331.044	-11	233.55	189.015
1991	9817.75	1141.396	519.521	718.479	595.235	140.146
1992	17033.39	1242.121	491.051	2741.14	605.99	262.643
1993	4304.56	227.919	201.069	577.382	195.331	106.642
1994	17004.12	1355.485	813.268	1781.191	1019.607	428.471
1995	4796.3	267.411	354.766	520.855	247.469	123.793
1996	6890.1	848.966	420.926	627.502	347.567	164.853
1997	4149.97	357.597	222.907	195.255	257.14	94.108
1998	3126.27	211.139	107.125	276.401	176.457	44.3
1999	46386.98	3734.200	2220.593	6904.537	2504.185	1099.298
2000	9058.77	893.460	473.461	1092.754	360.427	237.729
2001	914.49	57.304	39.261	34.751	45.969	31.171
2002	1222.95	89.981	79.256	137.707	69.348	40.556
2003	1362.61	71.745	51.885	163.931	69.539	45.54
2004	1337.62	70.189	46.081	183.977	67.605	27.543
2005	12763.56	1158.194	963.393	1412.973	547.284	385.791
2006	2727.54	109.440	107.390	191.608	149.743	89.934
2007	1813.23	61.357	141.444	111.475	86.627	79.994
2008	1269.31	75.068	71.132	126.428	77.703	59.017
2009	9336.94	674.962	781.507	909.334	557.39	344.508
2010	857.28	46.068	66.523	30.294	77.035	40.248
2011	64.9	14.103	24.585	30.64	31.515	25.17
2012	1136.96	58.249	104.034	68.068	58.345	58.51
2013	607.3	24.067	32.612	86.249	48.207	22.807
2014	5711.61	388.241	413.503	747.522	463.428	220.165
2015	1663.01	111.384	138.465	104.274	94.564	72.398
2016	-11	218.515	155.745	351.819	167.605	94.752
2017	-11	47.057	-11	146.171	74.110	-11
2018	-11	-11	-11	123.141	-11	-11

Table 7.3.3. Haddock in Subarea 4 and Divisions 3.a and 6.a. RCT3 output file.

ANALYSIS BY RCT3 VER4.0

Haddock

Data for 5 surveys over 38 years : 1981 - 2018
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:2018

index	slope	inter-cept	se	rsquare	n	indi-ces	predic-tion	se.pred	WAP.weights
ibtsq11	1.146	1.8478	0.5923	0.8527	34	NA	NA	NA	NA
ibtsq12	1.419	0.6325	0.6488	0.8287	35	NA	NA	NA	NA
ibtsq30	1.035	2.1319	0.5611	0.8632	25	4.813	7.115	0.601	1
ibtsq31	1.315	1.1987	0.5037	0.8848	26	NA	NA	NA	NA
ibtsq32	1.48	1.2939	0.7111	0.7879	27	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	35	NA	8.184	1.406	0

	WAP	log-WAP	int.se
year-class:2018	1231	7.115	0.5526

Table 7.3.4. Haddock in Subarea 4 and Divisions 3.a and 6.a. Updated catch option table following RCT3 analysis.

Basis: F(2018) = F based on TAC constraint of 48990 tonnes = 0.2266; SSB (2019) =228.145; TAC 4 (2018) = 41767; TAC 3.a (2018) = 2.569; TAC 6.a (2018) = 4654; HC landings (2018) = 44.049; Discards+BMS (2018) = 4.941, IBC (2018) = 0.041; Recruitment (2018) = RCT3 = 1231 millions. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 2020 relative to SSB 2019. 2) Wanted catch 2019 relative to TAC 2018.

Rationale	Total catch 2019	Wanted catch 2019	Unwanted catch 2019	IBC 2019	HC catch 2019	Total F 2019	F(land) 2019	F(disc) 2019	F(IBC) 2019	SSB 2020	% SSB	% TAC change (2)
MSY approach: FMSY	33956	31120	2799	38	33918	0.194	0.165	0.029	0.00020	202799	-11.1%	-31%
F = MAP FMSY lower	29532	27069	2425	38	29494	0.167	0.142	0.025	0.00020	207715	-9.0%	-40%
F = MAP FMSY upper	33956	31120	2799	38	33918	0.194	0.165	0.029	0.00020	202799	-11.1%	-31%
F = 0	41	0	0	41	0	0	0	0	0.00020	240935	5.6%	-100%
Fpa	46493	42579	3877	36	46456	0.274	0.23	0.041	0.00020	188923	-17.2%	-5.223%
Flim	62334	57013	5286	35	62299	0.384	0.33	0.058	0.00020	171531	-25%	27%
SSB (2020) = Blim	122118	110341	11751	26	122091	1.02	0.86	0.153	0.00020	94000	-59%	151%
SSB (2020) = Bpa = MSY Btrigger	97084	88381	8672	30	97054	0.68	0.58	0.103	0.00020	132000	-42%	98%
F_{2018}	39199	35916	3246	37	39162	0.23	0.19	0.034	0.00020	196985	-13.7%	-20.1%
Rollover TAC	49026	44891	4099	36	48990	0.29	0.25	0.044	0.00020	186130	-18.4%	0%

Table 7.3.5. Haddock in Subarea 4 and Divisions 3.a and 6.a. Previous catch-option table from ICES advice released on 29 June 2018.

Basis: F(2018) = F based on TAC constraint of 48990 tonnes = 0.226; SSB (2019) =228.314; TAC 4 (2018) =41.767; TAC 3.a (2018) = 2.569; TAC 6.a (2018) = 4.654; HC landings (2018) = 43.891; Discards+BMS (2018) = 5.057, IBC (2018) = 0.042; Recruitment (2018) = TSA projection = 3529 millions. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 20209 relative to SSB 2019. 2) Wanted catch 2019 relative to TAC 2018

Rationale	Total catch 2019	Wanted catch 2019	Unwanted catch 2019	IBC 2019	HC catch (2019)	Total F 2019	F(land) 2019	F(disc) 2019	F(IBC) 2019	SSB 2019	% SSB	% TAC change (2)
MSY approach: FMSY	**35761**	**31247**	**4477**	**38**	**35723**	**0.194**	**0.165**	**0.029**	**0.00020**	**202935**	**-11.1%**	**-27%**
F = MAP FMSY lower	31088	27179	3871	38	31049	0.167	0.142	0.025	0.00020	207855	-9.0%	-37%
F = MAP FMSY upper	35761	31247	4477	38	35723	0.194	0.165	0.029	0.00020	202935	-11.1%	-27%
F = 0	41	0	0	41	0	0	0	0	0.00020	241100	5.6%	-100%
Fpa	49031	42757	6238	36	48995	0.274	0.23	0.041	0.00020	189049	-17.2%	-0.041%
Flim	65872	57259	8578	35	65837	0.384	0.33	0.058	0.00020	171644	-25%	34%
SSB (2020) = Blim	131208	110964	20217	26	131182	1.02	0.86	0.153	0.00020	94000	-59%	169%
SSB (2020) = Bpa = MSY Btrigger	103336	88861	14444	30	103305	0.68	0.58	0.103	0.00020	132000	-42%	111%
Rollover TAC	49026	42752	6238	36	48990	0.27	0.23	0.041	0.00020	189054	-17.2%	0%

7.4 Saithe in Subarea 4, 6 and Division 3a

7.4.1 New survey information

New survey data are available from the 2018 international third quarter North Sea 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 2018), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008). DATRAS survey indices, generated by ICES, are used in the analysis.

7.4.2 RCT3 analysis

An RCT3 analysis was run, following the protocol outlined by AGCREFA (ICES-AGCREFA 2008), to provide an estimate of the abundance of the incoming 2015 age 3 and 2014 age 4 year-classes. The RCT3 input and output files are given in tables 7.4.1 to 7.4.3.

7.4.3 Update protocol calculation

The outcome of following the protocol was:

Calculation of 2014 year-class at:	Age 3	Age 4
Log WAP from RCT3 (*R*)	11.276	11.407
Log of recruitment assumed in spring (*A*)	11.618	11.382
	0.17	0.25
Distance D $\left(D = \frac{R-A}{S}\right)$	-2.05	-0.68

7.4.4 Conclusions from protocol

The autumn indices suggest that the size of the incoming age 3 year-class is smaller than the median value assumed in the forecast produced by WGNSSK in May 2018. Although age 3 is not yet fully recruited to the North Sea, the most recent benchmark concluded the IBTS Q3 survey was thought to be representative; strong cohorts appeared in the older ages when expected and cohorts persisted for several years (ICES 2017). Although the internal consistencies of the Q3 survey between age 3 and age 4 are not high (correlation = 0.29; Figure 7.4.1), the benchmark found no evidence in the internal consistencies that this age or these data should be removed. The age 3 index value is uncertain, but still provides information.

Age 4 can be seen as the first fully recruited year class although the assessment starts with age 3. Therefore, an RCT3 analysis for age 4 was also explored; D = -0.68, indicating that age 4 is marginally smaller than expected.

The overall conclusion is that **the advisory process for North Sea saithe should be reopened.**

7.4.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea saithe. The assessment and forecast were rerun with the new Q3 time-series of survey data; all other settings were unchanged from those used by WGNSSK in May 2018. The table of the assumptions made for the interim year and the forecast are in Table 7.4.4.

Outputs from the assessment rerun with the new Q3 data included are in Figure 7.4.2,the updated catch options are in Table 7.4.5, and the assessment summary is in Table 7.4.6.

Following the ICES MSY approach, the new short-term forecasts lead to a **decrease in advised catch from 139 978 tonnes to 135 035 tonnes** (a decrease of 4943 tonnes).

7.4.6 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2017. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 14-18 March 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:37. 698 pp.

ICES-WGNSSK (2018). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2018/ACOM:22.

Table 7.4.1. Saithe in subareas 4 and 6 and Division 3a. RCT3 data input file for the age 3 and age 4 year-classes.

Year class	Age 3		Age 4	
	Recruitment	IBTS Q3	Recruitment	IBTS Q3
1987	–	–	71417	0.402
1988	174246	1.946	88996	2.76
1989	104120	1.077	58928	2.781
1990	176380	7.965	97648	1.615
1991	118559	1.117	66685	2.501
1992	211662	13.959	147305	6.533
1993	118226	3.825	78603	3.351
1994	148154	3.756	119679	4.134
1995	88916	1.181	56008	1.907
1996	111591	2.086	94109	8.836
1997	97514	3.479	67838	6.169
1998	200380	21.475	140890	18.974
1999	159826	10.748	120978	23.802
2000	167103	19.272	110325	6.727
2001	117329	4.93	76365	7.512
2002	141541	8.916	123190	29.579
2003	100917	10.553	54993	5.578
2004	152393	34.006	97638	5.584
2005	73407	3.312	51531	1.703
2006	58954	1.346	38616	0.964
2007	89610	1.361	79078	8.451
2008	82156	4.52	47797	2.497
2009	139716	11.134	106043	16.279
2010	101788	14.701	76830	3.923
2011	65267	1.649	49698	5.613
2012	111094	11.001	76290	17.439
2013	143944	37.901	109881	13.102
2014	114414	11.447	NA	6.885
2015	NA	1.877		

Table 7.4.2. 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 2018.txt
RCT3 input for D calculations for sai3a46 age 3
Data for 1 surveys over 28 years :  1988 - 2015

Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

Year class = 2015

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series          cept   Error           Pts  Value   Value    Error   Weights

 IBTS      0.41  10.66   0.21  0.718     27   1.06   11.09    0.255    0.435

                                Assessment Mean =   11.42    0.224    0.565

 Year     Weighted      Log     Int      Ext     Var
 Class     Average      WAP     Std      Std    Ratio
          Prediction           Error   Error
 2015       78906      11.28    0.17    0.16     0.92
```

Table 7.4.3. 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 2018.txt
RCT3 input for D calculations for sai3a46 age 4
Data for 1 surveys over 28 years :  1987 - 2014

Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

Year class = 2014

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series          cept   Error           Pts  Value   Value    Error   Weights

 IBTS    0.58  10.01   0.27  0.678     27   2.06   11.21    0.312    0.664

                                Assessment Mean =   11.20    0.439    0.336

 Year     Weighted      Log     Int      Ext     Var
 Class     Average      WAP     Std      Std    Ratio
          Prediction           Error   Error
 2014       73640      11.21    0.25    0.01     0.00
```

Table 7.4.4. Saithe in subareas 4 and 6, and in Division 3a. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2018)	0.258	Average exploitation pattern (2015-2017) scaled to $F_{4–7}$ in 2017
SSB (2019)	344 673 tonnes	SSB at the beginning of the TAC year
$R_{age\ 3}$ (2018)	61 461 thousands	Median recruitment estimate in 2018
$R_{age\ 3}$ (2019)	105 825 thousands	Median recruitment re-sampled from the years 2003–2018
Total catch (2018)	100 640 tonnes	Short-term forecast
Wanted catch (2018)	93 947 tonnes	Assuming 2017 wanted catch fraction by age
Unwanted catch (2018)	6 693 tonnes	Assuming 2017 wanted catch fraction by age

Table 7.4.5. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2019)	Wanted catch* (2019)	Un-wanted catch* (2019)	Wanted catch*# 3a4	Wanted catch*# 6	F_{Total} (2019)	F_{Wanted} (2019)	$F_{Un-wanted}$ (2019)	SSB (2020)	% SSB change **	% TAC change ***	% advice change ^
ICES advice basis												
MSY approach: F_{MSY}	135035	127619	7416	115623	11996	0.36	0.33	0.025	319880	-7.19	16.4	14.0
Other scenarios												
F = MAP^^ $F_{MSY\ lower}$	85912	81291	4621	73649	7641	0.21	0.198	0.015	370401	7.464	-25.943	-27.476
F = MAP $F_{MSY\ upper}$	174789	164980	9809	149472	15508	0.49	0.46	0.034	280051	-18.749	50.67	47.551
F = 0	0	0	0	0	0	0	0	0	459630	33	-100	-100
F_{pa}	148973	140725	8248	127497	13228	0.40	0.38	0.028	305711	-11.3	28	26
F_{lim}	194139	183090	11049	165880	17210	0.56	0.53	0.039	260516	-24	67	64
SSB2020 = B_{lim} = B_{lim}	355855	332849	23006	301562	31288	1.49	1.39	0.103	107000	-69	207	200
SSB2020 = B_{pa}= B_{pa}	308299	289180	19119	261997	27183	1.13	1.05	0.078	150000	-56	166	160
SSB2020 = $B_{Trigger}$=	319476	299432	20044	271285	28147	1.21	1.12	0.083	139672	-59	175	170
F = F_{2018}	101902	96386	5516	87326	9060	0.26	0.24	0.018	353949	2.7	-12.2	-14.0
TAC_{2018}	116008	109673	6334	99364	10309	0.30	0.28	0.021	339375	-1.54	0	-2.1

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation.**

**** SSB 2020 relative to SSB 2019.**

***** Total catch in 2019 relative to TAC in 2018 (116 008 t).**

 # 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.

^ Total catch 2019 relative to advice value 2018 (118 460 t).

^^ Proposed EU multiannual plan (MAP) for the North Sea (EU, 2016)

Table 7.4.6. Saithe in subareas 4 and 6, and in Division 3a. Assessment summary. 'High' and 'Low' indicate 95% confidence intervals.

Year	Recruit-ment	High	Low	SSB	High	Low	Wante d catch	Un-wanted	Fish-ing pres sure	Hig h	Low
	thousands			tonnes			tonnes				
196	141056	19831	10032	15280	19320	12084	113751	12992	0.35	0.45	0.27
196	160983	22277	11632	21069	26239	16917	88326	20818	0.29	0.38	0.23
196	284268	39342	20539	27705	34059	22536	130588	19713	0.32	0.40	0.26
197	293109	40328	21303	34618	41872	28620	234962	35817	0.35	0.42	0.28
197	354289	48289	25993	46113	55618	38233	265381	43821	0.38	0.46	0.31
197	224044	30334	16547	48940	58641	40844	261877	34567	0.41	0.49	0.34
197	201260	27229	14875	52109	62412	43507	242499	32651	0.43	0.52	0.36
197	199605	27040	14734	57592	68644	48320	298351	38674	0.50	0.59	0.42
197	234934	31660	17432	51632	61696	43210	271584	33035	0.54	0.64	0.45
197	405658	55615	29588	39857	47906	33160	343967	79449	0.60	0.71	0.50
197	149400	20279	11006	32511	39156	26994	216395	23520	0.59	0.71	0.49
197	120498	16309	89028	29725	35951	24578	155141	21727	0.48	0.58	0.40
197	87392	11870	64340	27873	33338	23304	128360	14295	0.45	0.54	0.38
198	85515	11617	62947	26114	31004	21995	131908	13392	0.48	0.57	0.40
198	162621	22245	11888	24973	29509	21134	132278	15971	0.47	0.57	0.40
198	140888	19057	10415	22022	25662	18899	174351	27775	0.54	0.64	0.46
198	148360	20083	10959	21998	25696	18832	180044	22978	0.65	0.77	0.55
198	255854	34721	18853	18852	21928	16208	200834	39723	0.68	0.79	0.58
198	356814	48926	26021	16592	19204	14335	220869	52802	0.70	0.82	0.60
198	289441	39232	21353	15689	18130	13577	198596	34190	0.73	0.86	0.62
198	148943	20178	10993	16589	19174	14353	167514	24877	0.70	0.82	0.60
198	138223	18658	10239	15536	18153	13296	135172	19076	0.71	0.83	0.61
198	102529	13860	75843	12697	14786	10903	108877	15707	0.69	0.81	0.59
199	151018	20452	11150	11521	13446	98722	103800	20619	0.65	0.77	0.56
199	175187	23642	12981	10829	12570	93297	108048	22902	0.62	0.73	0.53
199	104011	13954	77527	11420	13177	98979	99742	15792	0.60	0.71	0.51
199	175886	23656	13077	12159	14138	10457	111491	21119	0.63	0.75	0.53
199	118300	15872	88168	12630	14681	10866	109622	17138	0.56	0.67	0.48
199	214714	29212	15781	14561	16992	12477	121810	19395	0.57	0.68	0.48
199	119314	16197	87890	15744	18326	13526	114997	13928	0.50	0.60	0.42
199	146935	20056	10764	19792	23450	16705	107327	12755	0.44	0.53	0.36
199	85299	11603	62704	19442	22896	16509	106123	11096	0.45	0.54	0.37
199	112741	15427	82390	20054	23623	17023	110716	8936	0.48	0.58	0.40
200	98327	13403	72133	18976	22255	16179	91322	8014	0.42	0.51	0.35
200	208241	28424	15256	19627	23119	16661	95042	11118	0.39	0.47	0.32
200	158272	21572	11612	22082	25924	18810	122036	21544	0.40	0.48	0.33
200	161993	22163	11840	21382	25161	18171	112383	11438	0.42	0.50	0.34
200	117916	16029	86740	26774	31618	22672	107728	8085	0.37	0.45	0.30
200	145060	19833	10609	25787	30358	21904	119844	8195	0.38	0.46	0.31
200	100263	13933	72148	26925	31646	22907	121320	8585	0.40	0.48	0.33
200	155660	21616	11209	24626	29027	20892	99204	12413	0.38	0.45	0.31
200	72421	98476	53260	25078	29530	21297	122184	8359	0.44	0.54	0.37
200	57477	78085	42309	24435	28956	20620	112267	4295	0.45	0.54	0.37
201	91916	12531	67417	22831	27251	19128	103030	4483	0.43	0.52	0.36
201	83881	11576	60780	18359	21934	15367	98446	4339	0.43	0.53	0.36
201	139812	19239	10160	16905	20223	14130	78414	9282	0.39	0.48	0.32
201	102359	14214	73710	17926	21522	14930	80059	7789	0.35	0.43	0.28
201	67226	95782	47184	20929	25302	17311	76392	6336	0.31	0.39	0.25
201	115408	17027	78222	22674	27824	18477	76936	5009	0.29	0.38	0.23
201	150155	23688	95179	22532	28481	17826	67902 #	10874#	0.27	0.36	0.19
201	105825	18798	59575	27545	36491	20792	88468 #	6478 ##	0.26	0.37	0.17
201	62179##	14793	26135	32594	47884	22186					

 # Since 2016, landings correspond to wanted catch, which includes Norwegian component of BMS landings.

Since 2016, discards correspond to unwanted catch, including all BMS landings except the Norwegian component.

Recruitment in 2018 is the assessment estimate. The value given in Table 7.4.4 is the median from a normal distribution of the assessment estimate required for stochastic projections.

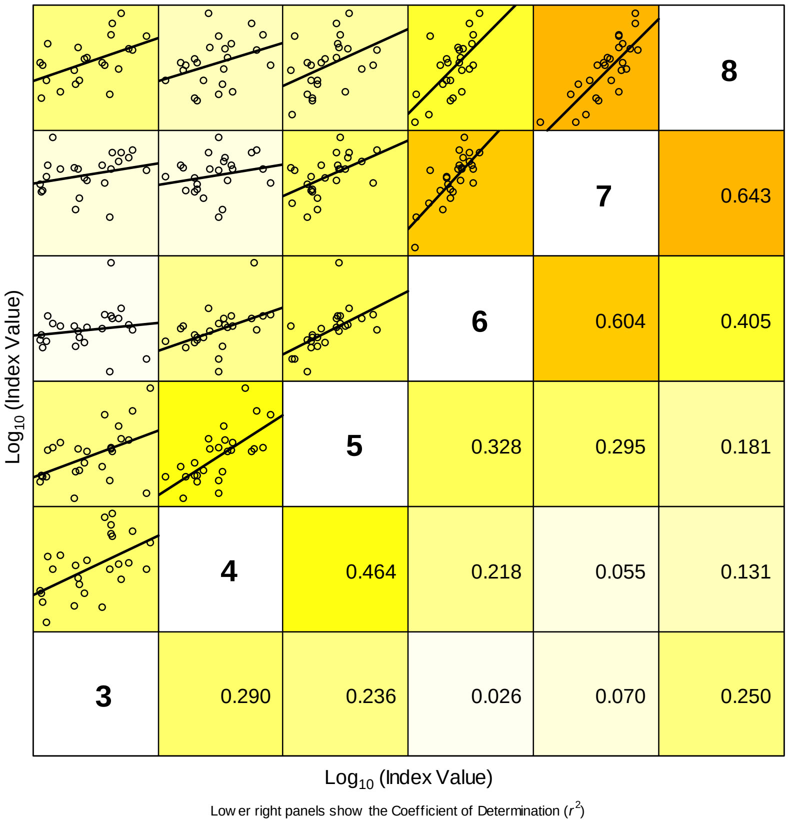

Figure 7.4.1. Saithe in subareas 4 and 6 and Division 3a. Internal consistencies between subsequent ages in the IBTS Q3 survey.

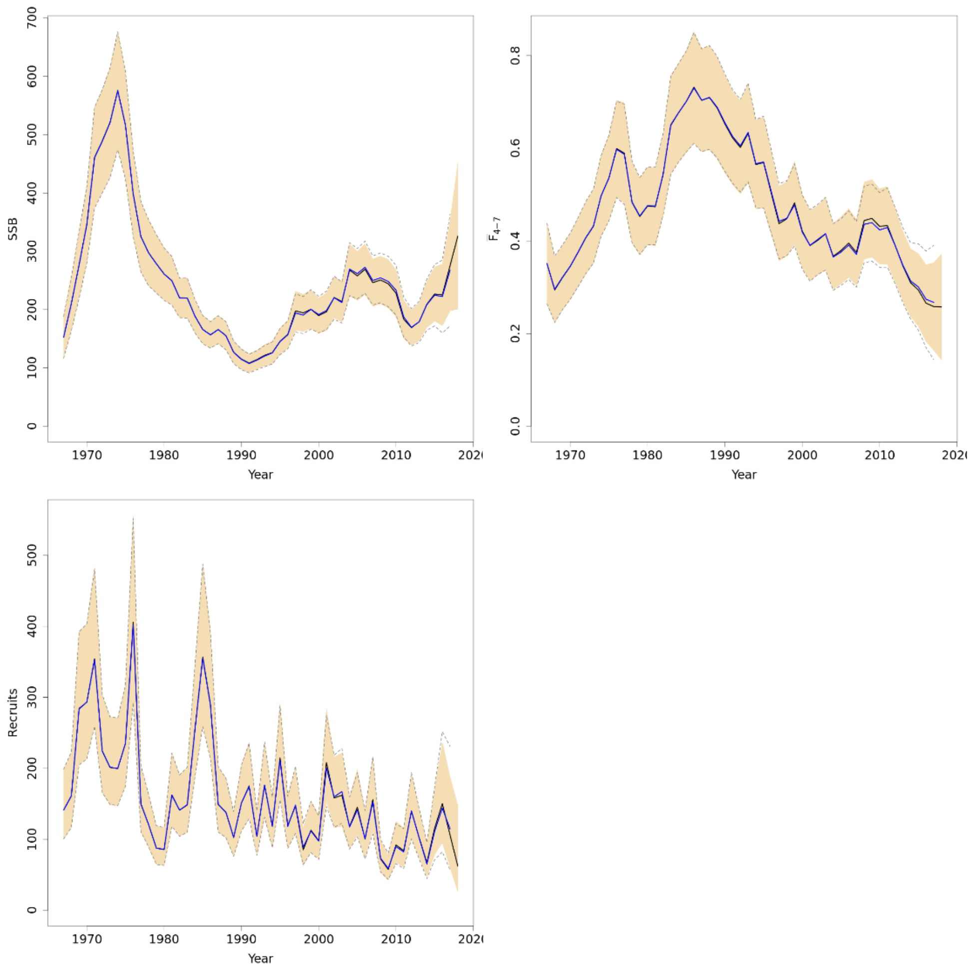

Figure 7.4.2. Saithe in subareas 4 and 6 and Division 3a. Summary of stock assessment with point-wise 95% confidence intervals. The SAM assessment produced by WGNSSK in May 2018 is plotted in blue for comparison.

7.5 Whiting in Subarea 4 and Division 7.d

7.5.1 New survey information

The new data available for a potential autumn forecast update are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 7.5.1. Note that the following analysis compares the effect of the new survey data with the forecast estimates provided by the relevant assessment Working Group (ICES-WGNSSK 2018), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

7.5.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2018) year-class. The RCT3 input and output files are given in Tables 7.5.2 and 7.5.3.

7.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2018 year-class at age 0	
Log WAP from RCT3 (R)	15.84
Log of recruitment assumed in spring (A)	16.297
Int SE of log WAP (S)	0.1647
Distance D $\left(D = \frac{R-A}{S}\right)$	**-2.775**

7.5.4 Conclusions from protocol

The 2018 year class: in the spring advice, a geometric mean value was used for this year class. As the distance is D< -1.0 for this year-class, the protocol concludes that the original geometric mean overestimates the true size of the 2018 year class by a significant amount.

The overall conclusion is that **the advisory process for North Sea whiting should be reopened based on the RCT3 analysis.**

7.5.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea whiting using the new estimate of recruitment in 2018 (7 550 millions for the 2018 year-class at age 0). The settings and assumptions for the forecast were otherwise unchanged from those presented in

ICES-WGNSSK (2018). The survey predicts relatively low recruitment (below the geometrical mean of the time series) for the 2018 year class.

Table 7.5.4 shows the updated advice option table from the new October 2018 run. The previous advice option table from spring 2018 is given in table 7.5.5.

The baseline advice uses the MSY approach with a target F of 0.172. On this basis, predicted total catch in 2019 decreases from 25 302 t (spring results) to **24 499 t** (October results), while the corresponding TAC change (2019 human consumption catches in subarea 4 relative to TAC subarea 4 in 2018) changes slightly from -18.3% (spring results) to **-20.9%** (October results). The forecast for SSB in 2020 decreases from 171 663 t (spring results) to 156 528 t (October results). The corresponding change in SSB in 2020 from 2019 is predicted to be -4.84% (instead of -0.27%, spring results).

7.5.6 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2018). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2018/ACOM:22.

Table 7.5.1. Whiting in Subarea 4 and Division 7d. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2017 are highlighted.

	Age					
Year	**0**	**1**	**2**	**3**	**4**	**5**
1991	536.99	703.368	158.594	79.024	14.568	5.183
1992	1379.459	600.867	296.1	72.451	57.498	10.273
1993	919.193	638.722	177.377	66.118	14.711	15.904
1994	610.743	677.645	219.541	74.71	19.506	4.722
1995	729.246	619.786	291.18	107.195	21.512	6.013
1996	316.501	545.708	278.218	129.356	34.003	6.893
1997	2062.67	332.968	180.681	108.985	28.006	10.711
1998	2631.69	330.6	150.205	52.766	31.01	11.179
1999	2498.56	1203.502	190.644	53.932	24.452	9.529
2000	1961.467	940.784	326.515	64.396	13.597	6.534
2001	3548.817	668.905	283.082	93.978	19.076	4.279
2002	269.275	811.9	257.15	131.466	35.034	5.45
2003	356.523	257.637	292.805	128.67	67.944	17.313
2004	714.27	150.623	59.032	66.326	45.724	27.103
2005	169.321	171.386	68.259	31.433	45.616	33.96
2006	198.949	174.625	86.336	32.619	13.511	23.287
2007	822.902	95.495	63.592	37.636	11.482	8.405
2008	764.759	362.299	68.886	30.907	13.774	4.081
2009	593.801	585.529	384.777	40.984	12.295	8.037
2010	510.123	224.321	145.671	54.635	12.844	5.996
2011	247.085	446.812	144.439	47.243	16.217	6.929
2012	306.812	256.718	193.523	57.001	20.081	10.644
2013	334.257	67.451	60.102	65.787	17.504	7.08
2014	1401.008	223.4	97.962	65.552	33.278	10.311
2015	2091.636	312.453	222.551	43.072	24.038	18.433
2016	971.786	297.257	243.828	77.833	12.278	8.091
2017	176.649	950.96	200.82	77.706	25.397	7.021
2018	168.11	245.533	301.452	90.84	31.43	13.68

Table 7.5.2 Whiting in Subarea 4 and Division 7d. RCT3 input file. Data from surveys in autumn 2018 are highlighted.

Year class	SAM Recruits at age 0	IBTS Q3 Age 0
1991	12985402	536.99
1992	14844061	1379.459
1993	14124277	919.193
1994	12674306	610.743
1995	10440111	729.246
1996	8466452	316.501
1997	14203355	2062.67
1998	23676831	2631.69
1999	23972919	2498.56
2000	21103066	1961.467
2001	21402326	3548.817
2002	11013379	269.275
2003	10488591	356.523
2004	11793614	714.27
2005	11019676	169.321
2006	9396302	198.949
2007	15274161	822.902
2008	14931925	764.759
2009	14006950	593.801
2010	13779469	510.123
2011	10076610	247.085
2012	7359536	306.812
2013	11852610	334.257
2014	15969752	1401.008
2015	14888780	2091.636
2016	16125587	971.786
2017	8423682	176.649
2018	-11	168.11

Table 7.5.3. Whiting in Subarea 4 and Division 7d. RCT3 output file.

Analysis by RCT3 ver4.0

Whiting

Data for 5 surveys over 29 years : 1989 - 2018

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: 2018

index	slope	intercept	se	rsquare	n	indices	predic-tion	se.pred	WAP.weights
IBTSq11	0.5691	13.1	0.3574	0.4142	29	NA	NA	NA	NA
IBTSq12	0.9297	11.14	0.4718	0.278	28	NA	NA	NA	NA
IBTSq30	0.3965	13.81	0.1793	0.7518	27	5.125	15.84	0.1985	1
IBTSq31	0.5616	13.08	0.272	0.559	28	NA	NA	NA	NA
IBTSq32	0.7319	12.66	0.3147	0.4639	28	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	29	NA	16.4	0.2951	0

	WAP	logWAP	int.se
Year class:2018	**7550007**	**15.84**	**0.1647**

Table 7.5.4. Whiting in Subarea 4 and Division 7d. Updated catch option table following RCT3 analysis, October 2018.

Basis: F(2018) = average exploitation (2015-2017), scaled to 2017 Fsq = 0.218; SSB (2019) = 164 487; Recruitment (2018)=RCT3 Forecast=7 550 million, Recruitment (2019)= geometric mean (2002-2017) = 11 964 million; TAC 27.4 (2018) = 22 057; Catch (2018) = 32 443; Landings (2018) = 16 959; Discards (2018) = 12 388; IBC (2018) = 3 096.

Rationale	Total catch 2019	Wanted catch 2019	Unwanted catch 2019	Total IBC 2019	HC catch 27.4+7d 2019	HC catch 27.4[1] 2019	HC catch 27.7d[1] 2019	Total F 2019	F(wanted) 2019	F(unwanted) 2019	F(IBC) 2019	SSB 2020	% SSB change [2]	% TAC change [3]	% Advice change [4]	Basis
MSY target	24499	13240	8155	3104	21395	17441	3954	0.172	0.099	0.051	0.022	156528	-4.84%	-20.9%	-6.5%	Fmsy, Fmsyupper
IBC only	3298	0	0	3298	0	0	0	0.022	0.000	0.000	0.022	171547	4.3%	-100%	-87%	No HC fishery
Other options	30592	17011	10534	3048	27545	22454	5090	0.22	0.129	0.067	0.022	152258	-7.4%	1.8%	17%	Fsq
	30109	16712	10345	3052	27058	22057	5000	0.21	0.127	0.065	0.022	152597	-7.2%	0%	15.0%	Rollover TAC
	26088	14223	8776	3089	23007	18748	4250	0.184	0.107	0.055	0.022	155416	-5.51%	-15.0%	-0.393%	15% TAC decrease (27.4)
	34131	19201	11915	3015	31110	25366	5750	0.25	0.147	0.076	0.022	149778	-8.9%	15.0%	30%	15% TAC increase (27.4)
	24139	13017	8015	3108	21032	17145	3887	0.169	0.097	0.050	0.022	156780	-4.685%	-22%	-7.8%	0.75 * Fsq
	37146	21067	13093	2987	34159	27847	6313	0.27	0.162	0.084	0.022	147665	-10.2%	26%	42%	1.25 * Fsq
	45429	26192	16326	2910	42519	34661	7857	0.33	0.20	0.105	0.022	141861	-13.8%	57%	73%	Fpa
	62386	36686	22946	2753	59632	48612	11020	0.46	0.29	0.148	0.022	129978	-21.0%	120%	138%	Flim
	10023	4281	2503	3238	6784	5531	1254	0.06	0.027	0.014	0.022	166708	1.3%	-74.9%	-62%	Bpa, MSY Btrigger
	76556	45455	28478	2622	73934	60271	13663	0.57	0.36	0.185	0.022	119970	-27%	173%	192%	Blim
	21584	11436	7017	3131	18453	15043	3410	0.150	0.084	0.044	0.022	158571	-3.60%	-32%	-17.6%	Fmanagement
	22644	12092	7431	3121	19523	15915	3608	0.158	0.090	0.046	0.022	157828	-4.05%	-28%	-13.5%	Fmsylower

Units: tonnes.

Under the assumption that effort is linearly related to fishing mortality

[1] Total human consumption catches are assumed to be split 81.5% (Subarea 27.4), 18.5% (Division 27.7d).

[2] SSB 2020 relative to SSB 2019.

[3] HC catches in 27.4 in 2019 relative to TAC 27.4 in 2018

[4] Advice total catches in 2019 relative to Advice total catches in 2018

Table 7.5.5. Whiting in Subarea 4 and Division 7d. Catch option table following assessment in Spring 2018.

Basis: F(2018) = average exploitation (2015-2017), scaled to 2017 Fsq = 0.218; SSB (2018) = 178 387; Recruitment (2018, 2019)=geometric mean(2002-2017) = 11 964 million; TAC 27.4 (2018) = 22 057; Landings (2017) = 15 229; Discards (2017) = 11 409; IBC (2016) = 2 617.

Rationale	Total catch 2019	Wanted catch 2019	Un-wanted catch 2019	Total IBC 2019	HC catch 27.4+7d 2019	HC catch 27.4[1] 2019	HC catch 27.7d[1] 2019	Total F 2019	F(wanted) 2019	F(un-wanted) 2019	F(IBC) 2019	SSB 2020	% SSB change [2]	% TAC change [3]	% Advice change [4]	Basis
MSY target	25302	13298	8815	3190	22113	18026	4086	0.172	0.099	0.051	0.022	171663	-0.27%	-18.3%	-3.4%	Fmsy, Fmsyupper
IBC only	3385	0	0	3385	0	0	0	0.022	0.000	0.000	0.022	186996	8.6%	-100%	-87%	No HC fishery
Other options	31614	17087	11394	3133	28481	23218	5263	0.22	0.129	0.067	0.022	167297	-2.8%	5.3%	21%	Fsq
	30203	16239	10818	3146	27060	22057	5000	0.21	0.123	0.063	0.022	168274	-2.2%	0%	15.3%	Rollover TAC
	26181	13824	9175	3182	23008	18748	4250	0.178	0.103	0.053	0.022	171057	-0.62%	-15.0%	-0.040%	15% TAC de-crease (27.4)
	34225	18655	12461	3110	31111	25366	5750	0.24	0.142	0.073	0.022	165491	-3.9%	15.0%	31%	15% TAC increase (27.4)
	24930	13075	8663	3193	21737	17720	4017	0.169	0.097	0.050	0.022	171920	-0.118%	-20%	-4.8%	0.75 * Fsq
	38402	21162	14169	3072	35330	28801	6529	0.27	0.162	0.084	0.022	162602	-5.5%	31%	47%	1.25 * Fsq
	46981	26311	17675	2995	43986	35858	8129	0.33	0.20	0.105	0.022	156668	-9.0%	63%	79%	Fpa
	64544	36854	24853	2837	61707	50303	11403	0.46	0.29	0.148	0.022	144521	-16.0%	128%	146%	Flim
	32464	17597	11742	3126	29339	23917	5422	0.22	0.133	0.069	0.022	166708	-3.1%	8.4%	24%	Bpa, MSY Btrigger
	99878	58065	39294	2520	97359	79367	17992	0.72	0.46	0.236	0.022	119970	-30%	260%	281%	Blim
	22284	11486	7581	3217	19067	15543	3524	0.150	0.084	0.044	0.022	173751	0.95%	-30%	-14.9%	Fmanagement
	23382	12145	8030	3207	20174	16446	3728	0.158	0.090	0.046	0.022	172992	0.50%	-25%	-10.7%	Fmsylower

Units: tonnes.

Under the assumption that effort is linearly related to fishing mortality

[1] Total human consumption catches are assumed to be split 81.5% (Subarea 27.4), 18.5% (Division 27.7d).

[2] SSB 2020 relative to SSB 2019.

[3] HC catches in 27.4 in 2019 relative to TAC 27.4 in 2018

[4] Advice total catches in 2019 relative to Advice total catches in 2018

7.6 Plaice in Subarea 4 and Subdivision 20

7.6.1 Short term forecast and June advice

At WGNSSK 2018 (ICES, 2018), the following short term forecast settings were used:

Year class	Age in 2018	AAP survivors	RCT3	GM 1957-2014	Accepted estimate
2016	2	1540180	1190155	710374	AAP survivors
2017	1		894683	965555	RCT3
2018	0			965555	GM 1957–2014

7.6.2 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 IBP-plaice (ICES 2013), the assessment uses the combined BTS-Isis and BTS-Tridens index. This index has a shorter time series due to the BTS-Tridens only starting in 1996.

Since the plaice benchmark in 2017, the survey indices were calculated though a delta-GAM model (Berg et al., 2014). This means the generated indices will differ after every update of the survey data input.

The 2018 BTS-Q3 survey included in the autumn re-opening analysis is incomplete: The 2018 UK BTS-Q3 has not been imported into DATRAS.

7.6.3 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 7.6.1. In 2018, the new data comprises age 1 of year class 2017 and age 2 of year class 2016. The last 4 years from the assessment estimates were re-moved from the time series.

Table 7.6.1 plaice 27.420 RCT3 input data

yearclass	N@Age1	N@Age2	SNS0	SNS1	SNS2	BTSC1	BTSC2	DFS0
1976	1033740	640577	NA	NA	12678	NA	NA	NA
1977	879043	548706	NA	NA	9828.8	NA	NA	NA
1978	915553	603278	NA	NA	12882.3	NA	NA	NA
1979	1078660	759629	NA	NA	18785.3	NA	NA	NA
1980	999968	728751	NA	NA	8642	NA	NA	NA
1981	1935350	1391630	NA	NA	13908.6	NA	NA	NA
1982	1375880	948596	NA	NA	10412.8	NA	NA	NA
1983	1302060	864871	NA	NA	13847.8	NA	NA	NA
1984	1792220	1177750	NA	NA	7580.4	NA	NA	NA
1985	4303680	2866780	NA	NA	32991.1	NA	NA	NA
1986	1910200	1308470	NA	NA	14421.1	NA	NA	NA
1987	1774940	1251000	NA	NA	17810.2	NA	NA	NA
1988	1250510	898824	NA	NA	7496	NA	NA	NA
1989	1083810	785747	NA	NA	11247.2	NA	NA	NA
1990	981356	709583	NA	NA	13841.8	NA	NA	439.6
1991	854841	614021	NA	NA	9685.6	NA	NA	332.4
1992	550376	398693	NA	NA	4976.6	NA	NA	180.3
1993	566448	423980	NA	NA	2796.4	NA	NA	217
1994	932162	722992	NA	NA	10268.2	NA	24676.85	283.4
1995	893056	708162	NA	NA	4472.7	24909.96	16546.29	146.1
1996	2431310	1941390	NA	NA	30242.2	86687.33	84058.38	619.6
1997	778427	617294	NA	NA	10272.1	34371.34	18293.38	229.2
1998	683151	531403	NA	NA	2493.4	44484.73	22099.33	NA
1999	857525	653888	NA	22855	2898.5	42348.34	20249.66	NA
2000	634808	481832	24213.5	11510.5	1102.7	29123.44	16638.68	124.9
2001	1792880	1362670	99628	30809.2	NA	135143.4	45810.39	313.2
2002	557844	417612	31202	NA	1349.7	32373.99	13551.04	122.9
2003	1235790	894667	NA	18201.6	1818.9	44493.1	27992.33	238.6
2004	863893	618023	13537.2	10118.4	1571	37666.75	16987.14	126.7
2005	875191	651007	27390.6	12164.2	2133.9	42056.5	21917.05	85.9
2006	1379750	1067080	51124.2	14174.5	2700.4	85025.42	46239.95	168
2007	1135050	879336	40580.9	14705.8	2018.7	69007.87	23123.71	98.3
2008	1088820	826492	50179.3	14860	1811.5	64809.93	28299.15	129.7
2009	1444570	1109460	53258.8	11946.9	1142.5	81159.45	42776.96	141.9
2010	1608190	1299830	49347.2	18348.6	2928.6	126973.9	65004.29	179.6
2011	1278010	1063130	52643	5893.4	3021.3	59452.41	52239.27	93
2012	1455050	1193580	45027.1	15394.9	2258.3	86187.79	61041.31	181.1
2013	1640700	1286330	44327.5	17312.7	5040.4	144505.4	66448.39	168.5
2014	NA	NA	11722.3	16726.5	2434.3	51144.85	30962.28	108
2015	NA	NA	30494.5	10384.8	1715.5	81348.73	50616.42	100.2
2016	NA	NA	44111	15935.9	NA	139545.6	70102.79	78.05
2017	NA	NA	27396.5	NA	NA	82020.69	NA	127.2

7.6.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in Table 7.6.2.

For age 1, the D value = 2.21, a substantial positive signal (i.e. >1). Thus, BTS-Q3 2018 survey yields a substantial higher signal for age 1 than our assumption in spring WGNSSK (which was based on SNS, DFS and VPA mean). Therefore, age 1 assumption needs to be updated in the short term forecast.

For age 2 the D value=0.19 (D<<1), thus, the new information of age 2 from BTS-Q3 2018 is not statistically different than the assumption we used in spring WGNSSK (which was based on AAP model survivals). Therefore, no changes will be made for age 2 assumption.

Table 7.6.2 plaice 27.420 RCT3 output for age 1 and 2 and D calculation

D calculation North Sea plaice age 1

```
Data for 1 surveys over 42 years : 1976 - 2017
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:2017
    index  slope intercept     se rsquare  n indices prediction se.pred
WAP.weights
    BTSC1 0.8625     4.453 0.2505  0.7195 19   11.31      14.21  0.2747
1
 VPA Mean     NA        NA     NA      NA 38      NA      13.95  0.4299
0

                  WAP logWAP int.se
yearclass:2017 1486072  14.21 0.2314

Spring assumption for age 1: 894683; log(894683) = 13.70
```

Calculations for 2017 year-class at age 1	
Log WAP from RCT3 (R)	14.21
Log of recruitment assumed in spring (A)	13.70
Int SE of log WAP (S)	0.231
Distance D $\left(D=\frac{R-A}{S}\right)$	**2.21**

D calculation North Sea plaice age 2

```
Data for 1 surveys over 42 years : 1976 - 2017
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:2016
    index  slope intercept   se rsquare  n indices prediction se.pred
WAP.weights
    BTSC2 0.7567     5.836 0.15  0.8811 20   11.16      14.28  0.1707
1
 VPA Mean     NA        NA   NA      NA 38      NA      13.64  0.4288
0

                   WAP logWAP int.se
yearclass:2016 1588470  14.28 0.1586

Spring assumption for age 2: 1540180; log(1540180) = 14.25
```

Calculations for 2016 year-class at age 2	
Log WAP from RCT3 (R)	14.28
Log of recruitment assumed in spring (A)	14.25
Int SE of log WAP (S)	0.159
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.19**

7.6.5 Revised forecast

7.6.5.1 Full RCT3 analyses

Since the new survey indices indicates a substantial difference in perceived recruitment (compared to the spring assumptions), a new STF was done. To this end, we first re-calculated the rct3 recruitment estimates (for age 1 and age 2) using the full set of surveys that is now available. The settings are the same as during the working group in spring. Clearly, the added surveys (BTSC1 and BTSC2) have a substantial part of the weight in the predictions, and these rct3 estimates are higher than those in spring. The results are in Table 7.6.3.

Table 7.6.3 plaice 27.420 RCT3 output for age 1, using full RCT with all available survey information

Age 1

```
Data for 6 surveys over 42 years : 1976 - 2017
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:2017
    index   slope  intercept        se  rsquare   n  indices  prediction  se.pred
WAP.weights
     SNS0 1.0416    2.8991 0.3585 0.53456 13  10.218     13.54  0.4146    0.23281
     SNS1 2.2876   -7.9432 0.8748 0.11365 14      NA        NA      NA         NA
     SNS2 0.9472    5.7630 0.8137 0.22253 37      NA        NA      NA         NA
    BTSC1 0.8625    4.4529 0.2505 0.71951 19  11.315     14.21  0.2747    0.53046
    BTSC2 0.7394    6.2711 0.1644 0.85040 20      NA        NA      NA         NA
     DFS0 2.6342    0.1314 1.2975 0.09238 22   4.846     12.90  1.4081    0.02018
 VPA Mean     NA        NA     NA      NA 38      NA     13.95  0.4299    0.21655

                   WAP logWAP int.se
yearclass:2017 1171029  13.97    0.2
```

D value: (13.97-13.70)/0.231=1.17

Age 2 (note this one is not used, since we do not need to update age 2 assumption)

```
Data for 6 surveys over 42 years : 1976 - 2017
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:2016
    index   slope  intercept        se  rsquare   n  indices  prediction  se.pred
WAP.weights
     SNS0 1.0909     2.118 0.3676 0.55382 13  10.694     13.78  0.4152   0.101127
     SNS1 2.8819   -13.902 1.1212 0.08260 14   9.676     13.98  1.2559   0.011051
     SNS2 1.1423     3.768 1.0252 0.15144 37      NA        NA      NA         NA
    BTSC1 0.8998     3.785 0.2621 0.71798 19  11.846     14.44  0.3037   0.189018
    BTSC2 0.7567     5.836 0.1500 0.88106 20  11.158     14.28  0.1707   0.598333
     DFS0 3.0918    -2.523 1.5374 0.07508 22   4.357     10.95  1.7534   0.005669
 VPA Mean     NA        NA     NA      NA 38      NA     13.64  0.4288   0.094802

                   WAP logWAP int.se
yearclass:2016 1436236  14.18  0.132
```

D value: (14.18-14.25)/0.159=-0.44

The updated recruitment choices table is in Table 7.6.4. In this table, column RCT3 have been updated with the RCT3 analysis using all available surveys as shown in Table 7.6.3. It is also obvious that the new age 2 RCT3 number is not very much different than AAP survivors; while the new age 1 RCT3 is substantially larger than the spring estimate (894683).

Table 7.6.4 Updated recruitment choice table (without indication of used assumptions in forecasts.

Year class	Age in 2018	AAP survivors	RCT3	GM 1957-2014	Accepted estimate
2016	2	1540180	1436236	710374	AAP survivors
2017	1		1171029	965555	RCT3
2018	0			965555	GM 1957–2014

7.6.5.2 Updated forecasts

If we only update the RCT3 analysis for age 1, then we get the following recruitment estimates table (including the underlining for the estimate used in the forecast)(Table 7.6.5)

Table 7.6.5 Updated recruitment assumption table (with indication of used assumptions in in this forecast; using RCT3 for age1, assessment survivors for age 2).

Year class	Age in 2018	AAP survivors	RCT3	GM 1957-2014	Accepted estimate
2016	2	<u>1540180</u>	1436236	710374	AAP survivors
2017	1		<u>1171029</u>	965555	RCT3
2018	0			965555	GM 1957–2014

The updated forecast tables are in Table 7.6.6 and 7.6.7. To compare with the STF in spring, we also listed the spring forecast in Table 7.6.9. As a result, the estimated catches in 2019 (142216 tonnes) under Fmsy is higher than spring forecast (139052 tonnes), due to the increased age 1 in 2018.

Table 7.6.6 Plaice in Subarea 4 and Subdivision 20. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2–6}$ (2018)	0.199	Average exploitation pattern in 2015–2017, scaled to $F_{ages\ 2\text{-}6}$ in 2017
SSB (2019)	981938	Short-term forecast (STF), in tonnes
R_{age1} (2018)	1171029	RCT3, in thousands
R_{age1} (2019)	965555	Geometric mean (GM, 1957–2014), in thousands
Total catch (2018)	131993	Short-term forecast (STF), in tonnes
Wanted catch (2018)	84964	Short-term forecast (STF), average landings rate by age 2015–2017, in tonnes
Unwanted catch (2018)	47029	Short-term forecast (STF), average discard rate by age 2015–2017, in tonnes

Table 7.6.7 Updated forecast (using RCT3 for age1, assessment survivors for age 2).

Basis	Total catch (2019)	Wanted catch * (2019)	Unwanted catch * (2019)	F_{total} ages 2–6 (2019)	F_{wanted} ages 2–6 (2019)	$F_{unwanted}$ ages 2–3 (2019)	SSB (2020)	% SSB change **	% TAC change ***	% Advice change ^
ICES advice basis										
MSY approach: F_{MSY}	142217	92764	49453	0.21	0.100	0.195	1032942	5.1	11.1	-0.185
Other scenarios										
Management Plan (MP)	196026	128345	67681	0.30	0.143	0.28	980393	0	53	38
F = 0	0	0	0	0.00	0.00	0.00	1174144	19.4	-100	-100
F_{pa}	234569	154023	80546	0.37	0.175	0.34	942939	-4.1	83	65
F_{lim}	309609	204534	105075	0.52	0.25	0.48	870509	-11.2	142	117
SSB (2020) = B_{lim}	1070822	803306	267516	6.0	2.8	5.5	207288	-79	740	650
SSB (2020) = B_{pa}	962080	702268	259812	4.0	1.91	3.7	290203	-70	650	580
SSB (2020) = MSY $B_{trigger}$	637266	436555	200711	1.48	0.71	1.38	564599	-43	400	350
Rollover TAC (total catch)	127986	83139	44847	0.187	0.089	0.173	1047281	7.1	0	-10.2
$F_{2019} = F_{2018}$	135349	88244	47105	0.199	0.095	0.185	1039670	6.1	5.8	-5.0
F = $F_{MSY\ upper}$	196026	128345	67681	0.30	0.143	0.28	980393	0	53	38
F = $F_{MSY\ lower}$	101322	65915	35407	0.146	0.069	0.135	1073066	9.2	-21	-29

"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 average discard rate estimates for 2015–2017. Both wanted and unwanted catch refer to Subarea 4 and Subdivision 20, calculated as the projected total stock wanted catch (including Division 7.d) deducted by the catch of plaice from Subarea 4 taken in Division 7.d in 2019. The subtracted value (649 t of wanted catch and 398 t of unwanted catch) is estimated based on the plaice catch advice for Division 7.d for 2019.

** SSB 2020 relative to SSB 2019.

*** Total catch in 2019 relative to the combined TAC of Subarea 4 and Subdivision 20 in 2018 (127 986 t).

^ Total catch in 2019 relative to advice value 2018 (142 481 t).

The age structured detailed input data for this short term forecast are in Table 7.6.8.

Table 7.6.8 Updated forecast (using RCT3 for age1, assessment survivors for age 2). Detailed age structured forecast for F=Fsq forecast. Recruitment assumptions in bold

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	2018	0.116	0.12	0	**1171029**	0.04	0.07	0.04	0.03	122171	5092	9	1	122162	5090	0	33569
2	2018	0.187	0.18	0	**1540180**	0.08	0.25	0.08	0.07	249785	20812	6379	1588	243405	19229	51339	102679
3	2018	0.246	0.19	0.06	744544	0.16	0.28	0.12	0.12	154556	24616	36859	10210	117697	14398	45789	91579
4	2018	0.235	0.1	0.14	361752	0.24	0.31	0.15	0.2	72138	17298	42482	12971	29656	4330	70662	70662
5	2018	0.19	0.04	0.15	483649	0.31	0.36	0.16	0.27	79722	24950	62569	22233	17152	2721	130424	130424
6	2018	0.137	0.02	0.12	333618	0.38	0.4	0.19	0.33	40694	15361	36136	14502	4558	848	109538	109538
7	2018	0.087	0.01	0.08	233266	0.44	0.46	0.18	0.37	18580	8183	17300	7946	1280	233	86930	86930
8	2018	0.049	0	0.04	238923	0.49	0.52	0.21	0.44	10833	5335	9925	5165	907	186	105684	105684
9	2018	0.025	0	0.02	175700	0.59	0.59	0.39	0.47	4085	2424	4085	2424	1	0	83165	83165
10	2018	0.025	0	0.02	506383	0.67	0.67	0	0.51	11774	7923	11773	7923	1	0	257917	257917
1	2019	0.116	0.12	0	**965555**	0.04	0.07	0.04	0.03	100734	4198	7	1	100727	4197	0	27679
2	2019	0.187	0.18	0	943539	0.08	0.25	0.08	0.07	153022	12750	3908	973	149114	11780	31451	62903
3	2019	0.246	0.19	0.06	1156478	0.16	0.28	0.12	0.12	240068	38235	57252	15859	182815	22364	71123	142247
4	2019	0.235	0.1	0.14	527034	0.24	0.31	0.15	0.2	105098	25201	61892	18898	43205	6308	102947	102947
5	2019	0.19	0.04	0.15	258869	0.31	0.36	0.16	0.27	42670	13354	33490	11900	9181	1457	69808	69808
6	2019	0.137	0.02	0.12	361942	0.38	0.4	0.19	0.33	44149	16665	39204	15734	4945	920	118838	118838
7	2019	0.087	0.01	0.08	263220	0.44	0.46	0.18	0.37	20966	9234	19522	8967	1444	263	98093	98093
8	2019	0.049	0	0.04	193414	0.49	0.52	0.21	0.44	8769	4319	8035	4181	734	151	85554	85554
9	2019	0.025	0	0.02	205891	0.59	0.59	0.39	0.47	4787	2840	4787	2840	1	0	97455	97455
10	2019	0.025	0	0.02	602097	0.67	0.67	0	0.51	14000	9421	13998	9421	2	0	306668	306668
1	2020	0.116	0.12	0	**965555**	0.04	0.07	0.04	0.03	100734	4198	7	1	100727	4197	0	27679
2	2020	0.187	0.18	0	777981	0.08	0.25	0.08	0.07	126172	10513	3222	802	122950	9713	25933	51865
3	2020	0.246	0.19	0.06	708476	0.16	0.28	0.12	0.12	147069	23423	35074	9715	111995	13701	43571	87143
4	2020	0.235	0.1	0.14	818626	0.24	0.31	0.15	0.2	163245	39143	96135	29353	67110	9798	159905	159905
5	2020	0.19	0.04	0.15	377145	0.31	0.36	0.16	0.27	62166	19456	48791	17337	13375	2122	101703	101703
6	2020	0.137	0.02	0.12	193726	0.38	0.4	0.19	0.33	23630	8920	20983	8421	2647	492	63607	63607
7	2020	0.087	0.01	0.08	285568	0.44	0.46	0.18	0.37	22746	10018	21179	9728	1567	286	106422	106422
8	2020	0.049	0	0.04	218251	0.49	0.52	0.21	0.44	9895	4874	9067	4718	829	170	96540	96540
9	2020	0.025	0	0.02	166674	0.59	0.59	0.39	0.47	3875	2299	3875	2299	0	0	78892	78892
10	2020	0.025	0	0.02	713238	0.67	0.67	0	0.51	16584	11160	16582	11160	2	0	363276	363276

Table 7.6.9. STF result in spring WGNSSK2018.

Basis	Total catch (2019)	Wanted catch * (2019)	Unwanted catch * (2019)	F_{total} ages 2–6 (2019)	F_{wanted} ages 2–6 (2019)	$F_{unwanted}$ ages 2–3 (2019)	SSB (2020)	% SSB change **	% TAC change ***	% Advice change ^
ICES advice basis										
MSY approach: F_{MSY}	139052	92523	46529	0.21	0.100	0.190	1022768	5.0	8.6	-2.4
Other scenarios										
Management Plan (MP)	191682	128014	63668	0.30	0.143	0.28	971043	-0.36	50	35
F = 0	0	0	0	0	0	0	1161753	19.2	-100	-100
F_{pa}	229384	153628	75756	0.37	0.175	0.34	934176	-4.1	79	61
F_{lim}	302803	204015	98788	0.52	0.24	0.48	862875	-11.5	137	113
SSB (2020) = B_{lim}	1052590	801862	250728	6.0	2.8	5.5	207288	-79	720	640
SSB (2020) = B_{pa}	944014	700589	243425	4.0	1.91	3.7	290203	-70	640	560
SSB (2020) = MSY $B_{trigger}$	620438	432946	187492	1.47	0.70	1.36	564599	-42	380	340
Rollover TAC (total catch)	127986	84827	43159	0.191	0.091	0.178	1034077	6.1	0	-10.2
$F_{2019} = F_{2018}$	132335	88014	44321	0.199	0.095	0.185	1029390	5.6	3.4	-7.1
F = $F_{MSY\ upper}$	191682	128014	63668	0.30	0.143	0.28	971043	-0.36	50	35
F = $F_{MSY\ lower}$	99057	65742	33315	0.146	0.069	0.136	1062262	9	-23	-30

7.6.7 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 4 (IBP Plaice), April 2013, By correspondence. ICES CM 2013/ACOM:63. 78 pp.

ICES. 2018. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:22.

7.7 Sole in Subarea 4

7.7.1 Short term forecast and June advice

At WGNSSK 2018 (ICES, 2018), the following short term forecast settings were used:

Table 7.7.1 spring assumption recruitment table

Year Class	Age in 2018	AAP thousands	RCT3 thousands	GM (1957-2014) thousands
2016	2	72802.3	87651	98966.6
2017	1		108555	113075.7
2018	Recruit (0)			113075.7

Population numbers in the intermediate year for age 2 are taken from the AAP survivor estimates. Numbers at age 1 in 2018 are taken from the RCT3 output and age 1 in 2019 are taken from the long-term geometric mean. Both age 1 and age 2 assumptions are checked with the new survey information.

7.7.2 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.

Just as last year, the survey was not conducted on the RV Isis but on the RV Tridens this year. The RV Tridens was equipped with the original gears of the RV Isis BTS survey.

7.7.3 RCT3 Analysis

The RCT3 analysis on the BTS ISIS survey indices for age 1 and age 2 was conducted as specified in chapter 12.4.8 on Reopening of the advice from the ICES Technical Guidelines. 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 are presented in Table 7.7.1. In autumn 2018, the new data derived from the recently conducted "BTS-ISIS" survey comprises age 1 of year class 2017 and age 2 of year class 2018.

Table 7.7.1. North Sea sole RCT3 input data for age 1 and age 2

yearclass	N_Age_1	N_Age_2	DFS0	SNS0	SNS1	BTS1	BTS2
1976	168197	149389	NA	464.6	3742.9	NA	NA
1977	63044.3	56504.9	NA	1585	1547.7	NA	NA
1978	18291.3	16465.7	NA	10370.5	93.8	NA	NA
1979	187369	168599	NA	3922.7	4312.9	NA	NA
1980	221990	198541	NA	5145.8	3737.2	NA	NA
1981	200654	177122	NA	3240.7	5856.5	NA	NA
1982	197456	173556	NA	2147	2621.1	NA	NA
1983	94911.2	84288.8	NA	769.1	2493.1	NA	7.121
1984	115068	103152	NA	3334	3619.4	7.031	5.183
1985	167104	150464	NA	2713.4	3705.1	7.168	12.548
1986	82857.6	74742.7	NA	742	1947.9	6.973	12.512
1987	667131	602167	NA	13610.1	11226.7	83.111	68.084
1988	133529	120510	NA	522.7	2830.7	9.015	24.487
1989	253242	228340	NA	1743.4	2856.2	37.839	28.841
1990	91031.4	81887.4	6.38	50.8	1253.6	4.035	22.284
1991	448133	401062	167.56	3639.7	11114	81.625	42.345
1992	87271.7	77465.2	9.27	302.9	1290.8	6.35	7.121
1993	63189.1	55705.8	15.32	231.3	651.8	7.66	8.458
1994	110762	97551.7	22.06	4692.7	1362.1	28.125	7.634
1995	75317.6	66452.6	7.06	1374.9	218.4	3.975	4.919
1996	336195	296696	40.27	2322.3	10279.3	169.343	27.422
1997	156889	138214	26.94	803	4094.6	17.108	18.363
1998	118445	104134	NA	327.9	1648.9	11.96	6.144
1999	138196	121424	NA	2187.9	1639.2	14.594	9.963
2000	71605	62879	9.5	70	970.3	7.998	4.182
2001	220969	193382	51.42	8340	7547.5	20.989	9.947
2002	99002.7	85892.4	58.58	1127.7	NA	10.507	4.354
2003	53342.1	45847.2	10.61	NA	1369.5	4.192	3.395
2004	49858.3	42906.9	31.25	162	568.1	5.534	2.332
2005	181664	158395	40.99	305	2726.4	17.089	19.504
2006	68706.6	60556.6	12.57	16	848.6	7.498	9.062
2007	78724.3	69598.2	13.73	466.9	1259.1	15.247	4.999
2008	103983	91599.9	11.77	754.7	1931.6	15.95	10.707
2009	221683	194161	27.33	2291	2636.9	54.811	17.387
2010	219556	192086	42.86	333.9	1248	26.166	18.212
2011	56462.5	49541.1	12.13	136.3	226.6	5.149	3.558
2012	127683	111999	11.23	144.7	967.4	6.844	15.576
2013	219372	187779	44.82	237.3	2849	18.926	25.601
2014	NA	NA	23.62	126	3192	21.099	11.832
2015	NA	NA	7.45	109.7	733.8	6.454	7.098
2016	NA	NA	12.28	373.2	956.7	16.279	14.347
2017	NA	NA	20.97	205.9	NA	16.037	NA

7.7.4 Update protocol calculations

The autumn update protocol checks the spring assumptions of age 1 and age 2 with the new information.

The D value for age 1 is **+0. 8316773**, not significantly different from the spring assumption (|D| < 1). The D-value for age 2 is **+0.1459053**, not significantly different from the spring assumption (|D| < 1).

Hence, **the short term forecast should not be re-run**.

The RCT3 outcomes for the D-calculation for the ages 1 and 2 are presented in Table 7.7.2.

Table 7.7.2 North Sea sole RCT3 output for age 1 and age 2 - D calculation

Age 1

```
Analysis by RCT3 ver4.0

Sole

Data for 1 surveys over 42 years : 1976 - 2017
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:2017
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS1 0.7749      9.74 0.3958  0.7287 30   2.775      11.89  0.4167           1
 VPA Mean     NA        NA     NA      NA 38      NA      11.74  0.6790           0

                  WAP logWAP int.se
yearclass:2017 145851  11.89 0.3551
```

Spring assumption for age 1: 108555; log(108555) = 11.59501

D – calculation for age 1	
Log WAP from RCT3 (R)	11.89034
Log of recruitment assumed in spring (A)	11.59501
Int SE of log WAP (S)	0.3551
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.8316773**

Age 2

```
Analysis by RCT3 ver4.0

Sole

Data for 1 surveys over 42 years : 1976 - 2017
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:2016
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS2 0.9121     9.459 0.3846  0.7373 31   2.664      11.89  0.4048           1
 VPA Mean     NA        NA     NA      NA 38      NA      11.62  0.6810           0

                  WAP logWAP int.se
yearclass:2016 145540  11.89  0.348
```

Spring assumption for age 2: 76601; log(76601) = 11.24637

D – calculation for age 2	
Log WAP from RCT3 (R)	11.89
Log of recruitment assumed in spring (A)	11.24637
Int SE of log WAP (S)	0.348
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.1459053**

7.7.5 Conclusion from the protocol.

As the distance for both ages is -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea sole should not be reopened**. The autumn indices suggest that the size of the incoming year-class is not significantly different to what had been assumed in the forecast produced by WGNSSK in May 2018.

7.7.6 References

ICES. 2018. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 2018, Ostend, Copenhagen, Denmark. ICES CM 2018/ACOM:22.

7.8 North Sea *Nephrops*

7.8.1 *Nephrops* FU6 (Farn Deeps)

The annual underwater TV survey of the Farn Deeps area was undertaken 19–26 June 2018.

The survey was completed without any technical issues and the visibility was again excellent. 109 stations were completed with valid counts generated using the standard protocols for counting and quality assurance.

Total abundance in 2018 is estimated to be 950 million with a 95% CI of 23 million. The advice in June 2018 was based upon the 2017 survey which showed 902 million with a 95% CI of 21 million. The increase in abundance from 2017 to 2018 was 48 million, beyond the 95% confidence envelope of the 2018 survey.

<u>It is therefore recommended that the advice be reopened.</u>

Catch and landing predictions for 2018 are given in the text table below. This assumes that the absolute abundance estimate made in June 2018 is relevant to the stock status for 2019.

Headline advice for total catch (assuming the current discarding arrangements continue) is between 1709 and 1982 t (compared to the range 1622–1882 t in the June 2018 advice).

The updated catch scenarios are shown below.

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate*	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
EU MAP^: F_{MSY}	1982	1951	1773	178	31	8.12%	5.66
F = MAP $F_{MSY\ lower}$	1709	1682	1528	154	27	7.00%	-8.91
F = MAP $F_{MSY\ upper}$***	1982	1951	1773	178	31	8.12%	5.66
Other options							
MSY approach	1982	1951	1773	178	31	8.12%	5.66
F_{2017}	1909	1879	1707	172	30	7.82%	1.76

^ Proposed EU multiannual plan (MAP) for the North Sea (EU, 2016)

*** Calculated for dead removals.**

**** Total catch 2019 relative to advice value 2018 (1876 t)**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock**

Table 7.8.1.1. Results of the UWTV surveys for FU6 Nephrops

Year	Stations	Season	Mean density (burrows·m^{-2})	Absolute Abundance (millions)	95% confidence interval (millions)	Method
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	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
2017	110	Summer	0.29	902	21	Geostatistics
2018	109	Summer	0.31	950	23	Geostatistics

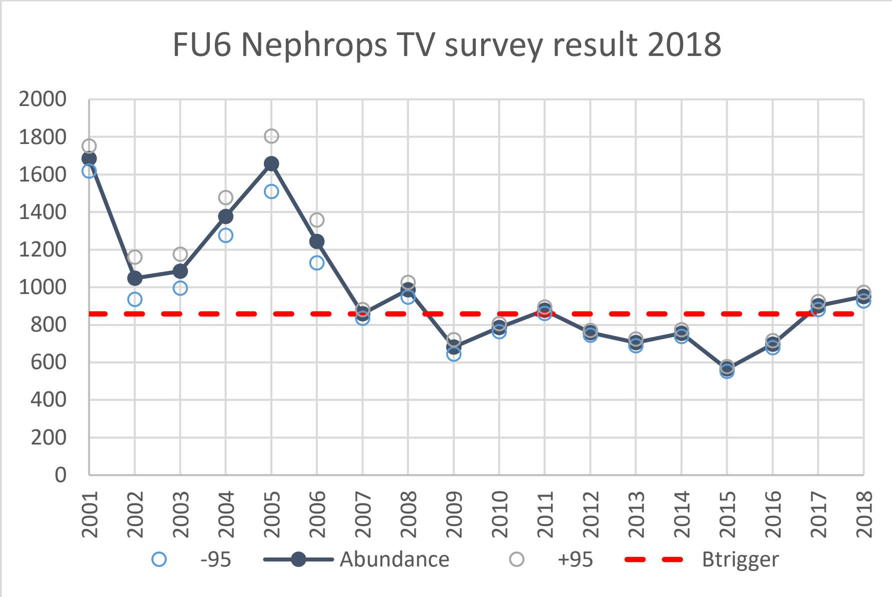

Figure 7.8.1.1. FU6 UWTV survey history

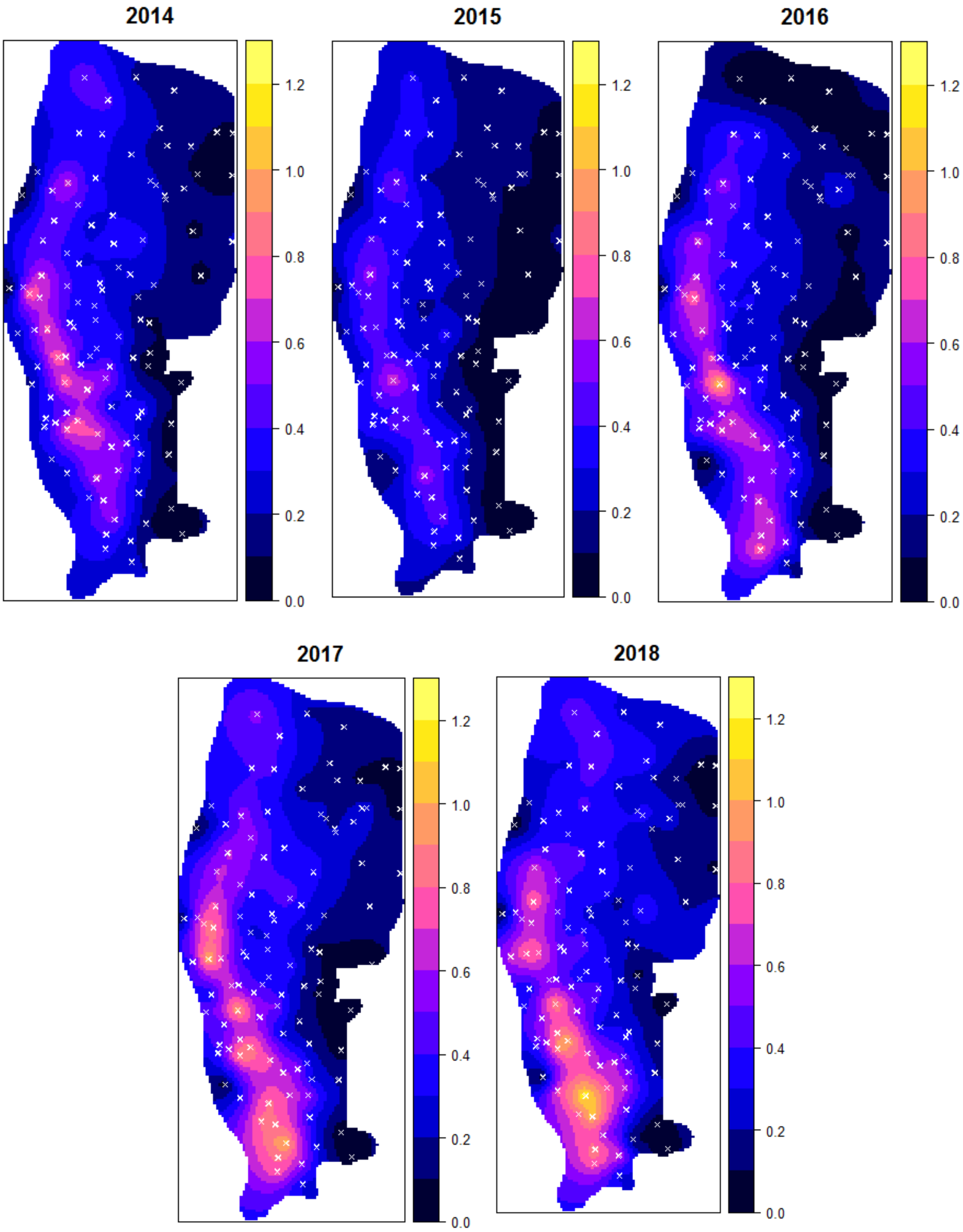

Figure 7.8.1.2. FU6 UWTV density maps (burrows·m^{-2}) 2014–2018

7.8.2 *Nephrops* FU7 (Fladen)

The most recent UWTV survey for this stock was carried out in June 2018. 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 2018 advice and based on the 2017 survey was 7036 million with a 95 % CI of 968 million (Table 7.8.2.1; Figure 7.8.1 and 7.8.2.2). The estimate from the 2018 summer survey is 5656 million (20% decrease on the 2017 value). The 2018 value is significantly different from that of 2017 (ACOM specifies 1 SD, this is over 2 SD) and therefore **the advice for FU7 may be reopened**.

The large abundance increase in 2016-2017 is likely to be related with a strong recruitment event. In 2017, increased amounts of small *Nephrops* were anecdotally reported in the Fladen fishery. Analysis of 2017 sampling catch data showed a large decrease in the mean weight in landings and an increase in the discard rate by number to 4.4%. Discard rates in 2011–2016 were close to zero. Given the recent fluctuations in the mean weights and discard rates, the long-term average (2000–2017) was considered to be most appropriate in the calculation of the catch scenarios for 2019.

The advice for 2019 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2019 under the landing obligation and assuming discard rates and fishery selection patterns do not change from the long term average of 2000–2017 (Table 7.8.2.2 and 7.8.2.3) following the MSY approach is 13178 tonnes (the June advice was 16394 tonnes). Mean weights and discard rates have not been revised in October 2018 (as this update has only new 2018 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%.

Table 7.8.2.1. *Nephrops*, Fladen (FU 7): Results of the 1992–2017 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	0.16	662
2017	71	7036	0.25	968
2018	71	5656	0.20	689

Table 7.8.2.2. FU7 basis for the catch options

Variable	Value	Notes
Stock abundance	5656 million individuals	UWTV 2018
Mean weight in wanted catch	32 g	Average 2000–2017
Mean weight in unwanted catch	14.9 g	Average 2000–2017
Unwanted catch rate (total)	7.1%	Average 2000–2017 (proportion by number)
Unwanted catch survival rate	25%	Proportion by number
Dead unwanted catch discard rate (total)	5.4%	Average 2000–2017 (proportion by number)

Table 7.8.2.3. Revised Advice table assuming discarding continues at recent average

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate *	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MAP^: F_{MSY}	13178	13064	12722	342	114	7.5	-21%
F= MAP $F_{MSY\ lower}$	11596	11496	11195	301	100	6.6	-30%
F = MAP $F_{MSY\ upper}$***	13178	13064	12722	342	114	7.5	-21%
Other scenarios							
MSY approach	13178	13064	12722	342	114	7.5	-21%
$F_{2015–2017}$	3865	3832	3732	100	33	2.2	-77%
F_{2017}	5447	5400	5258	142	47	3.1	-67%
$F_{35\%SpR}$	19679	19509	18998	511	170	11.2	18.7%
F_{max}	28818	28568	27819	749	250	16.4	74%

^ Proposed EU multiannual plan (MAP) for the North Sea (EU, 2016)

*** Calculated for dead removals.**

**** Total catch 2019 relative to advice value 2018 (16 577 t).**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock**

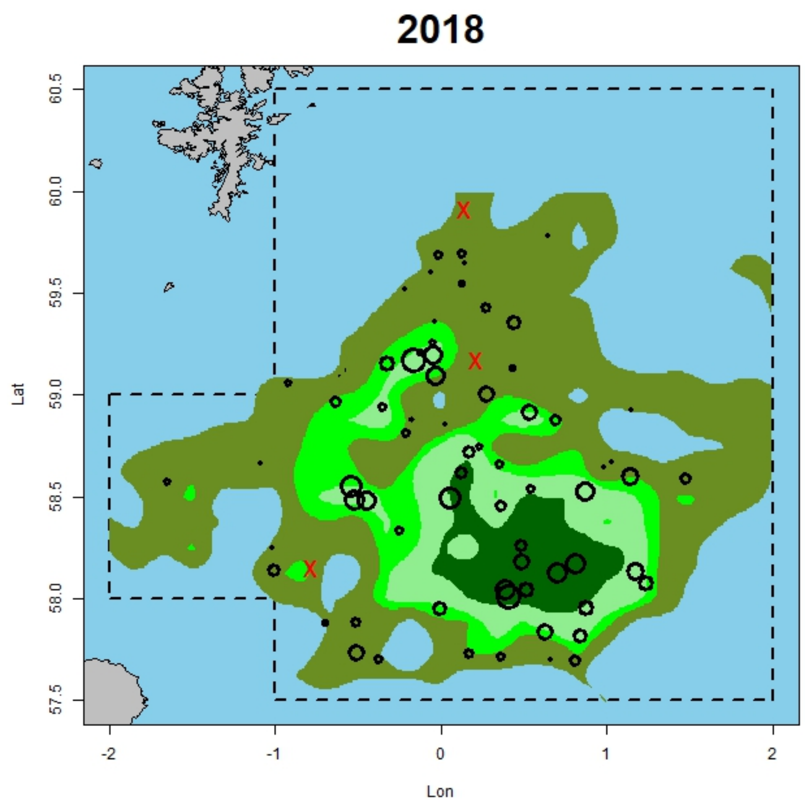

Figure 7.8.2.1. ***Nephrops*, Fladen (FU 7). TV survey distribution and relative density in 2018. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

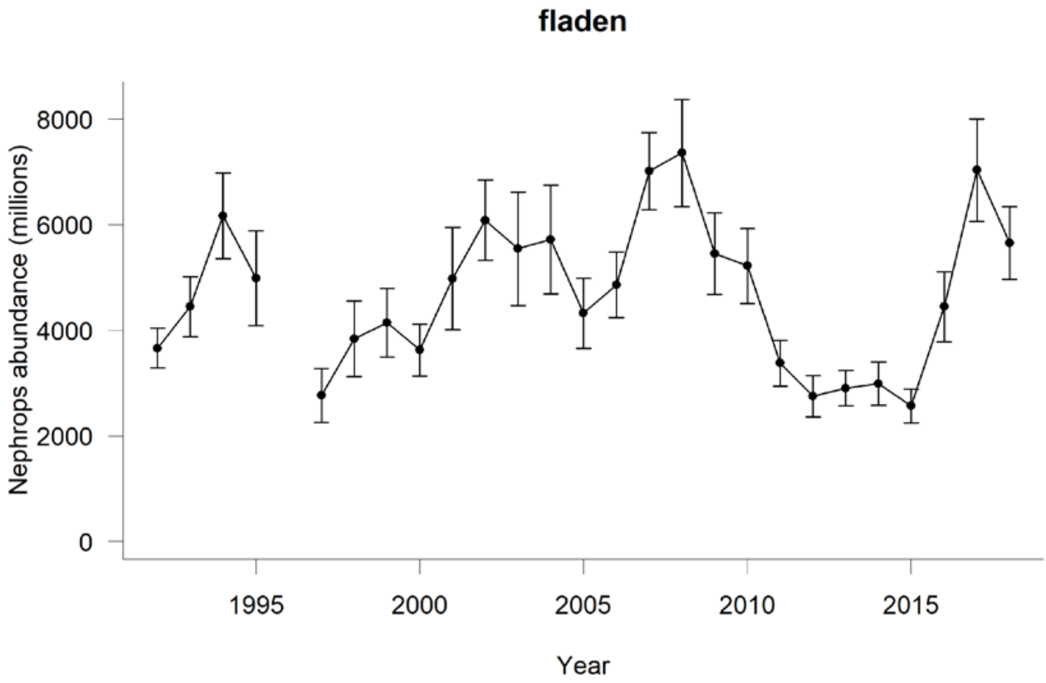

Figure 7.8.2.2. ***Nephrops*****, Fladen (FU 7): Results of the 1992–2018 TV surveys.**

7.8.3 *Nephrops* FU8 (Firth of Forth)

The most recent UWTV survey for this stock was carried out in September 2018. 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 2018 advice and based on the 2017 survey was 670 million with a 95 % CI of 133 million (Table 7.8.3.1; Figure 7.8.3.1 and 7.8.3.2). The estimate from the 2018 summer survey is 1025 million (53% increase on the 2017 value). The 2018 value is significantly different from that of 2017 (ACOM specifies 1 SD, this is well over the specified threshold) and therefore **the advice for FU8 may be reopened**. The advice for 2019 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2019 under the landing obligation and assuming discard rates and fishery selection patterns do not change from the average of 2015–2017 (Table 7.8.3.2 and 7.8.3.3) following the MSY approach is 3569 tonnes (the June advice was 2333 tonnes). Mean weights and discard rates have not been revised in October 2018 (as this update has only new 2018 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%.

Table 7.8.3.1. *Nephrops*, Firth of Forth (FU 8): Results of the 1993–2017 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
2016	50	0.87	797	146
2017	52	0.73	670	133
2018	50	1.12	1025	190

Table 7.8.3.2. FU8 basis for the catch options

Variable	Value	Notes
Stock abundance	1025 million individuals	UWTV 2018
Mean weight in wanted catch	23 g	Average 2015–2017
Mean weight in unwanted catch	10.2 g	Average 2015–2017
Unwanted catch rate (total)	20%	Average 2015–2017 (proportion by number)
Unwanted catch survival rate	25%	Proportion by number
Dead unwanted catch discard rate (total)	16.0%	Average 2015–2017 (proportion by number)

Table 7.8.3.3. Revised Advice table assuming discarding continues at recent average

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate *	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
EU MAP^: F_{MSY}	3569	3478	3204	274	91	16.3	50%
F= MAP $F_{MSY\ lower}$	2321	2262	2084	178	59	10.6	-2.30%
F = MAP $F_{MSY\ upper}$***	3569	3478	3204	274	91	16.3	50%
Other scenarios							
MSY approach	3569	3478	3204	274	91	16.3	50%
$F_{0.1}$	2059	2006	1848	158	53	9.4	-13.3%
F_{35SpR}	2780	2709	2496	213	71	12.7	17.0%
$F_{2015–2017}$	3569	3478	3204	274	91	16.3	50%
F_{2017}	4313	4203	3872	331	110	19.7	82%

^ Proposed EU multiannual plan (MAP) for the North Sea (EU, 2016)

*** Calculated for dead removals.**

**** Total catch 2019 relative to advice value 2018 (2376 t).**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock**

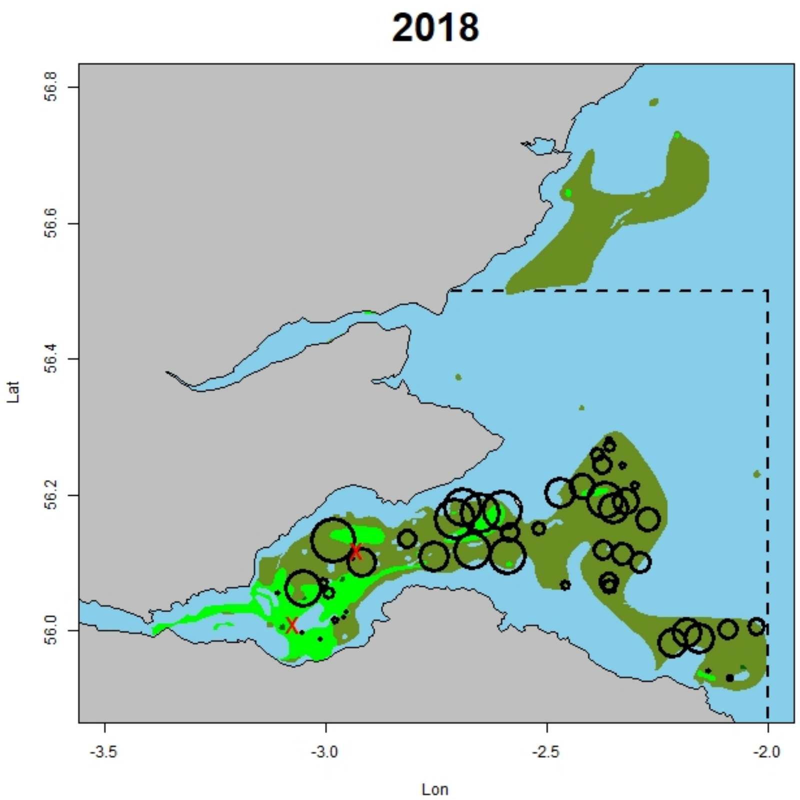

Figure 7.8.3.1. ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density in 2018. Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

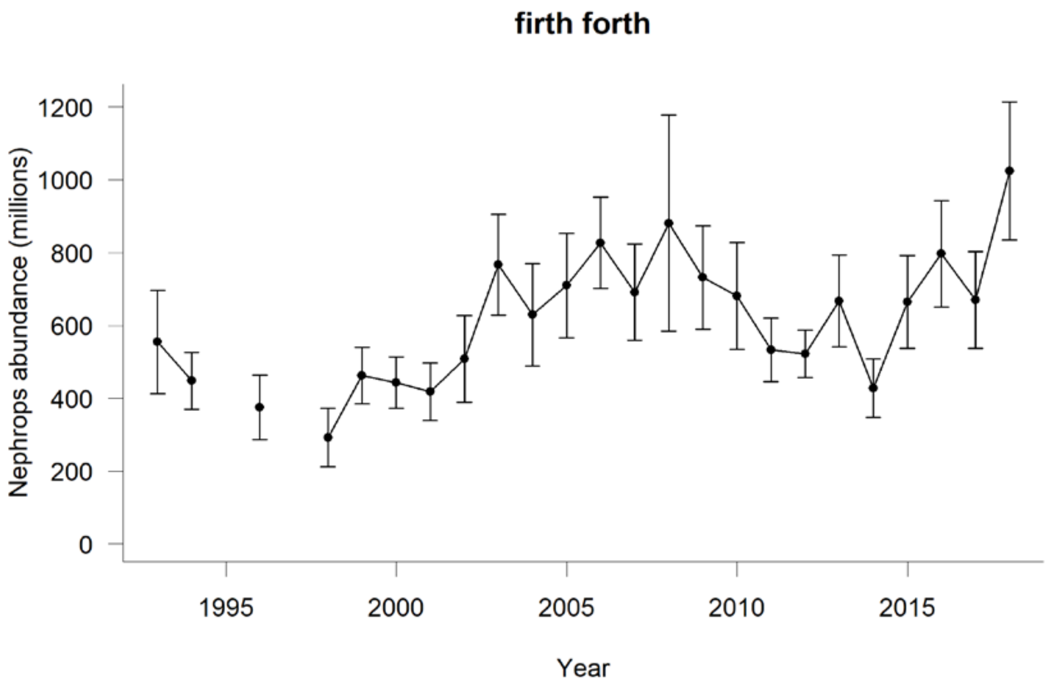

Figure 7.8.3.2. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1992-2018 TV surveys.**

7.8.4 *Nephrops* FU9 (Moray Firth)

The most recent UWTV survey for this stock was carried out in August 2018. 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 2018 advice and based on the 2017 survey was 412 million with a 95 % CI of 106 million (Table 7.8.4.1; Figure 7.8.4.1 and 7.8.4.2). The estimate from the 2018 summer survey is 417 million (1% increase on the 2017 value). The 2018 value is within 1 SD of the 2017 abundance estimate and therefore **the advice for FU9 should not be reopened**.

Table 7.8.4.1. *Nephrops*, Moray Firth (FU 9): Results of the 1993–2018 TV surveys.

Year	Stations	Mean	Abundance	95%
		Density burrows/m²	millions	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
2017	55	0.19	412	106
2018	55	0.19	417	126

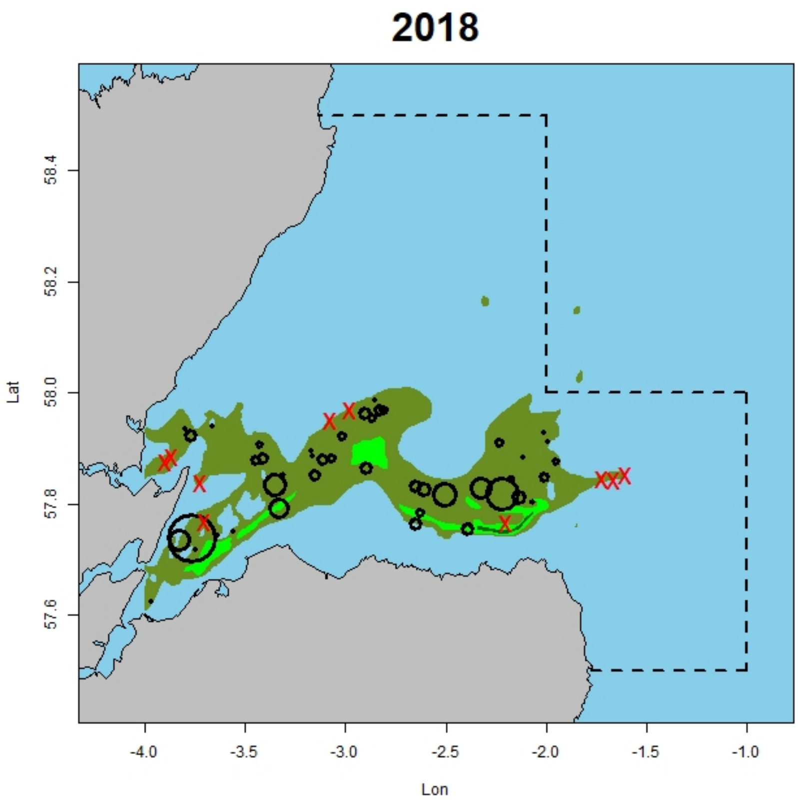

Figure 7.8.4.1. ***Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density in 2018. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

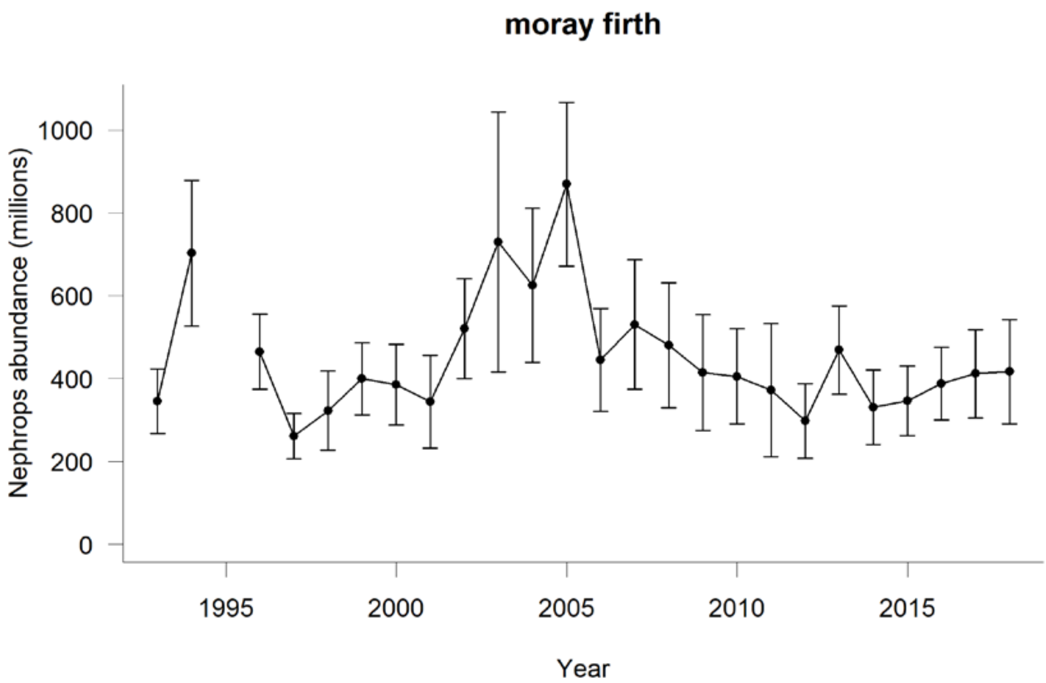

Figure 7.8.4.2. ***Nephrops*, Moray Firth (FU 9): Results of the 1992–2018 TV surveys.**

7.8.5 *Nephrops* FU34 (Devil's Hole)

The most recent UWTV survey for this stock was carried out in June 2018. 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 density used in the June 2018 advice and based on the 2017 survey was 0.09 burrows/m^2 with a 95 % CI of 0.04 burrows/m^2 (Table 7.8.5.1; Figure 7.8.5.1 and 7.8.5.2). The estimate from the 2018 summer survey is 0.21 burrows/m^2 (more than double of the 2017 value). The 2018 value is therefore significantly different from that of 2017 (ACOM specifies 1 SD, this is well over the specified threshold) and **the advice for FU34 may be reopened**.

The advice for for category 4 *Nephrops* stocks is biennial and the catch options are based on a calculation of potential landing options and harvest rates, given the known surface area of *Nephrops* habitat and observed densities of the functional unit. For data limited stocks the discard survival is also assumed to be zero. A catch prediction for 2019 and 2020 is shown below in Table 7.8.5.3 (assumptions described in Table 7.8.5.2). Using the density estimated in the latest survey, the same advice as provided in 2016 of 492 tonnes (catch) results in a harvest ratio of 4.5%., while advice based on the 10-year average (679 tonnes) results in a harvest ratio of 6.2% but is 38% above the 2016 advice. Applying the uncertainty cap, the same advice as given in 2016 + 20% (590 tonnes) corresponds to a potential HR of 5.4%; this is below the range of maximum sustainable yield (MSY) harvest rates in the North Sea (between 7.5% and 16%). The revised advice should therefore be the 2016 advice + 20%, resulting in a total catch of 590 tonnes.

In the June advice (using a density of 0.09 burrows/m^2) any of the options above resulted in harvest ratios higher than 7.5%. As such, both an uncertainty cap (20%) and the precautionary approach buffer (20%) were applied resulting in a catch advice of 315 tonnes (advice 2016 – 36%).

The mean density of this stock has been fluctuating considerably in recent years. Effort in the ground has generally increased since 2013 and, from 2015, landings have been higher than the ICES advice. This highlights that the current management is not sufficient to contain catches within the limits determined by ICES.

Table 7.8.5.1. *Nephrops*, Devil's Hole (FU 34): Results of the UWTV 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
2016		no survey	
2017	16	0.09	0.04
2018	15	0.21	0.09

Table 7.8.5.2. FU34 basis for the catch options

Variable	Value	Notes
Stock Density	0.21 *Nephrops* m²	UWTV 2018
Mean weight in wanted catches	32 g	Average 2007–2010 (benchmark estimate WKNEPH, 2013)
Mean weight in unwanted catches	14.9 g	Average 2000–2017 (from FU 7)
Unwanted catches rate (total)	12.9%	Average 2008–2011 (benchmark estimate WKNEPH, 2013; proportion by number)
Discard survival rate	0%	Discard survival is assumed to be zero.
Surface area estimate	1753 km²	Benchmark estimate WKNEPH (2013)

Table 7.8.5.3. Revised Advice for 2019 and 2020 table assuming discarding continues at recent average.

Basis	Total Catch	Wanted Catch	Unwanted Catch	Density (Nephrops per m2) 0.05	0.09	0.15	0.21	0.3	0.4	0.6	0.8	% advice change
2016 Advice - 36%	315	294	20	12.14%	6.75%	4.05%	2.89%	2.02%	1.52%	1.01%	0.76%	-36.0%
2016 Advice - 29%	350	328	23	13.51%	7.50%	4.50%	3.22%	2.25%	1.69%	1.13%	0.84%	-28.8%
2016 Advice - 25%	369	345	24	14.23%	7.91%	4.74%	3.39%	2.37%	1.78%	1.19%	0.89%	-25.0%
2016 Advice - 20%	394	368	26	15.18%	8.43%	5.06%	3.61%	2.53%	1.90%	1.26%	0.95%	-20.0%
2016 Advice	492	460	32	18.97%	10.54%	6.32%	4.52%	3.16%	2.37%	1.58%	1.19%	0.0%
2016 Advice + 20%	590	552	38	22.77%	12.65%	7.59%	5.42%	3.79%	2.85%	1.90%	1.42%	20.0%
Average (2015-2017)	631	590	41	24.33%	13.52%	8.11%	5.79%	4.06%	3.04%	2.03%	1.52%	28.2%
Average (2008-2017)	679	635	44	26.17%	14.54%	8.72%	6.23%	4.36%	3.27%	2.18%	1.64%	37.9%
2016 Advice + 66% (MSY)	817	764	53	31.51%	17.50%	10.50%	7.50%	5.25%	3.94%	2.63%	1.97%	66.1%
Maximum	1396	1305	91	53.82%	29.90%	17.94%	12.81%	8.97%	6.73%	4.49%	3.36%	183.7%

% advice change in total catch for 2019 and 2020 relative to advice value for 2017 & 2018 (492 t)

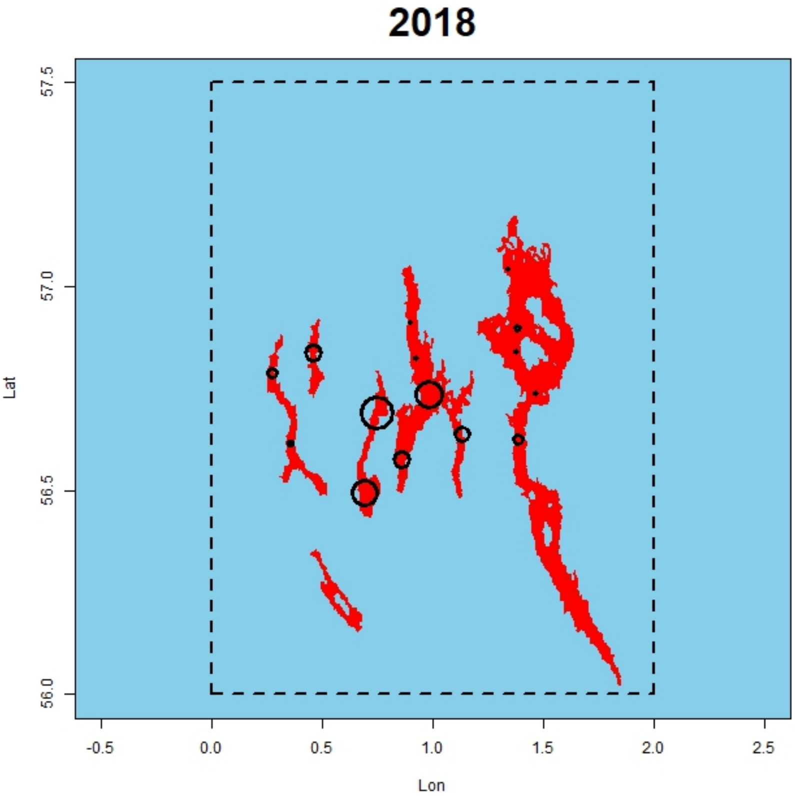

Figure 7.8.5.1. ***Nephrops*****, Devil's Hole (FU 34). UWTV survey distribution and relative density in 2018. Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

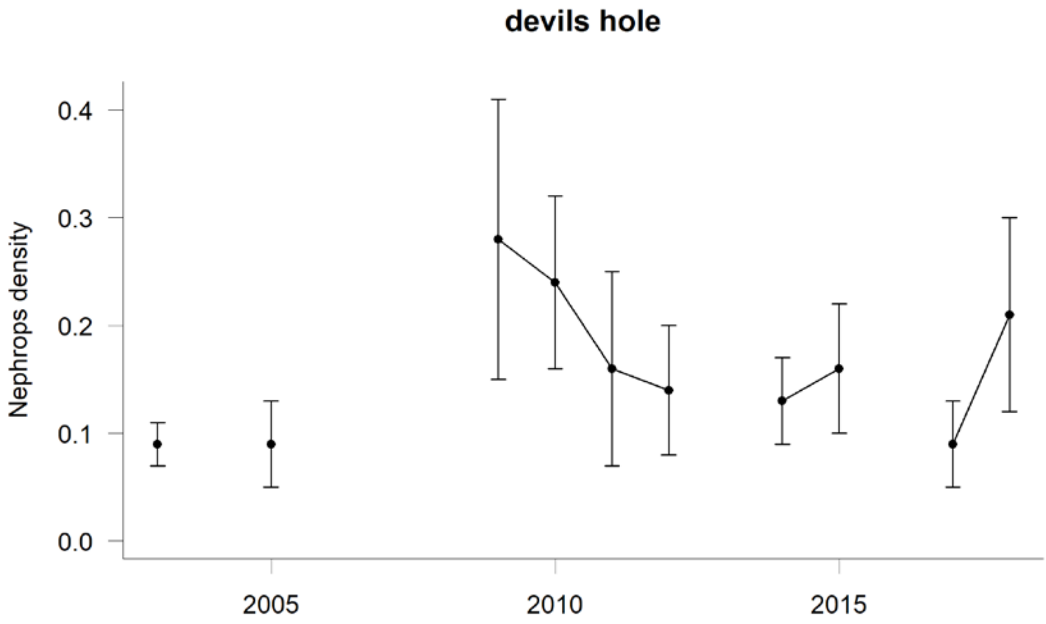

Figure 7.8.5.2. Devil's Hole (FU 34). Time series of UWTV survey density estimates, 2003, 2005, 2009–2018.

7.9 Audits for re-opened stocks

7.9.1 Haddock in Subarea 4 and Division 6.a and Subdivision 20

No problems encountered with numbers and plots in the haddock re-opened advice.

7.9.2 Saithe in Subarea 4, 6 and Division 3a

For single stock summary sheet advice:

1) **Assessment type: update (reopening)**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM assessment with 1 commercial exploitable biomass index and 1 scientific survey (IBTS q3)
5) **Data issues:** Data were available as specified in the stock annex.
6) **Consistency**: Update assessment; Intermediate year assumption in the forecast changed from TAC constraint to Fsq. 2018 q3 IBTS indices were included in the assessment compared to the May 2018 assessment
7) **Stock status**: Above $MSYB_{trigger}$ and F below F_{MSY}
8) **Management Plan**: No management plan

General comments

This was a well-documented and well-ordered section. Apart from minor issues no major inconsistencies were found between the report (Annex 7) and the advice sheets. The assessment has been carried out in the same way as in May 2018, only the 2018 q3 IBTS indices were added as input to provide for a better estimation of recruitment strength for the intermediate year.

Technical comments

Advice Sheet:

Just to be sure, is Figure 1 updated?

Catch options table in advice sheet:

Ftotal in the MSY approach scenario is 0.358 (=FMSY) and not 0.39. Advice change 13.9% (table 7.45 in report)) or 14.0% (in advice sheet)? According to the model output summary tables (13.992 %), "14.0" should be correct.

SSB change missing in Fpa scenario (-11.3)

Ftotal in Btrigger scenario =1.20 or 1.21?

Report:

Something is wrong in table 7.46 (assessment summary) in the saithe reopening file under annex 7. The columns seem to be not wide enough and numbers are cut off. But seems to be already corrected in the final document containing all stocks.

Conclusions

The assessment has been performed correctly. However, minor inconsistencies in the tables and in the advice sheet need to be resolved.

7.9.3 Whiting in Subarea 4 and Division 7.d

For single stock summary sheet advice:

1) **Assessment type:** October update
2) **Assessment**: Analytical
3) **Forecast**: An updated short-term forecast for 2019 was presented.
4) **Assessment model**: SAM assessment with 2 survey indices (IBTS Q1 and Q3, including 2018 Q3 estimates)
5) **Data issues:** Data available were as specified in the stock annex
6) **Consistency**: Update assessment, follows recommendations from 2018 benchmark
7) **Stock status**: Above MSY $B_{trigger}$ and F above F_{MSY}, but below F_{pa} and F_{lim}. No TAC constraint in intermediate year
8) **Management Plan:** No specific management plan

General comments

Technical comments

- The stock summary table should include 2018 estimates for high/low for recruitment
- The F in the whiting assumption table has not changed. Was the updated F from SAM used in the forecast, but not updated in Table 2 in the advice sheet?
- SSB 2019 value in Table 2 (assumptions) should also change because of the different values for recruitment now being used.
- Table 3, the rounding rules haven't been consistently applied for the percentages.

Conclusions

The forecast has been performed with no deviations from the standard procedure for this stock.

7.9.4 Plaice in Subarea 4 and Subdivision 20

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: age structured stock assessment, based on Aarts and Poos (2009) + Six survey indices
5) **Data issues:** No issues reported
6) **Consistency**: Update assessment, consistent between years.
7) **Stock status**: B>Blim, Bpa,Btrigger, F<Flim,Fpa, below Fmsy (close to it), R in 2017 above long-term average, estimated for 2018 around average
8) **Management Plan**: The EU management plan (EU, 2007) for North Sea plaice and sole does not cover the current stock area for this stock. Advice is currently based on the MSY approach and the management plan is included as a catch option.

Technical comments

- In the advice sheet, table 3 does not match with the forecast table on the sharepoint nor the Advice reopening document. (For example, the scenario with F=0 does not have a zero mortality).
- Table 12 needs update of Recruitment/SSB.
- Check for rounding of values in Table 3, last 3 columns.

General conclusion

There was no deviation from the standard procedure, although detailed calculations of forecasts were not available at the time of the audit.
Some details in the advice sheet need updating.

7.9.5 *Nephrops* FU6 (Farn Deeps)

For single stock summary sheet advice:

1) **Assessment type:** October update
2) **Assessment**: UWTV survey
3) **Forecast**: An updated short-term forecast for 2019 was presented.
4) **Assessment model**: Underwater television (UWTV).
5) **Data issues:** No data issues
6) **Consistency**: This stock has been benchmarked by ICES in 2013 (WKNEPH, 2013) and the stock annex was updated.
7) **Stock status**:
   - The 2018 burrow abundance estimate increased 5% in relation to 2017 and remains just above the Btrigger.
   - In the previous years the FMY HR was derived (according with the MSY approach) by multiplying the HR by the ratio of the current year abundance and the MSY Btrigger. As the 2018 abundance is above Btrigger the advice is based on the FMSY proxy ($F_{35\%SPR}$ males) of 8.12%.
8) **Man. Plan.** There is no specific management plan for FU 6. The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale (FU level) than the ICES subarea level.

Conclusions

The forecast has been performed correctly with no deviations from the standard procedure for this stock.

7.9.6 *Nephrops* FU7 (Fladen)

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment:** Analytical and temporal trends
3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 7 was updated to include the latest information from the 2018 TV survey
4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data
5) **Data issues:** Not found
6) **Consistency:** All input data used are identical with one more year added

7) **Stock status**:
- The last UWTV survey shows the stock size has decreased in 2018, but it is still above MSY Btrigger
- The harvest rate has increased in 2017, but it still well below the proxy of MSY rate and the F range proposed for the EU management plan.
- Discard rates have been close to zero since 2011, altought they increased in 2017. In addition, mean size of landings and catch has decreased in 2017, probably due to a strong recruitment event.

8) **Management Plan:** The EU MAP for the North Sea is not yet adopted, although the F range proposed for the MAP is used in the advice. The WG, ACOM and STECF have repeatedly advised that management should be implemented at the FU level.

General comments

The available spreadsheets and advice sheet were used for this audit.

Conclusions

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.

7.9.7 *Nephrops* FU8 (Firth of Forth)

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment:** Analytical and temporal trends
3) **Forecast:** A short-term forecast for 2019 was presented. The advice for FU 8 was updated to include the latest information from the 2018 TV survey
4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data
5) **Data issues:** Not found
6) **Consistency:** All input data used are identical with one more year added
7) **Stock status**:
- The stock size is above MSY Btrigger
- The harvest rate decreased abruptly in the late 1990s and since then it has been close to FMSY. In 2017 the harvest rate is above the proxy of FMSY and the F range proposed for the management plan.

8) **Management Plan**: The EU MAP for the North Sea is not yet adopted, although the F range proposed for the MAP is used in the advice. The WG, ACOM and STECF have repeatedly advised that management should be implemented at the FU level.

General comments

The assessment report was not available at the time of writing this audit. The available spreadsheets and advice sheets were used instead.

Conclusions

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.

7.9.8 *Nephrops* FU34 (Devil's Hole)

For single stock summary sheet advice:

1) **Assessment type:** update of biennial advice (reopening)
2) **Assessment**: Data-limited approach for Nephrops
3) **Forecast**: no forecast
4) **Assessment model**: Data limited approach calculates harvest rate (HR) based on catch numbers (i.e. individuals) as a proportion of population estimates. Population numbers are calculated from density estimates from the most recent UWTV survey. The updated advice revises the previous density estimate (0.09 ind m^-2) from 2017 to the recent June 2018 UWTV survey. This density is multiplied by the functional functional unit (FU) suitable habitat area (1753 km^2) to arrive at overall population size. Due to insufficient information from FU 34, the mean weight of discards is assumed to be the same as the Fladen (FU 7) as this is the closest functional unit. Together with local estimates of mean weight of landings and discards rate (discards/landings in numbers), total landings weight is converted into landings and discards in terms of numbers. HR is calculated as the ratio of catch numbers to population numbers. The Nephrops data limited approach compares HR to a range of maximum sustainable yield (MSY) harvest rates for other North Sea Functional Units (between 7.5 % and 16 %).
5) **Data issues:** No issues.
6) **Consistency**: Update assessment using most recent density estimates from the June 2018 UWTV survey.
7) **Stock status**: ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined.
8) **Management Plan**: No management plan

General comments

The updates to the advice and accompanying report are well documented. The change to advice is primarily an updating of the density value, with some adjustments to the alternate scenarios presented. The higher density estimates also result in a removal of the precautionary buffer, although the application of an uncertainty cap (+20%) remains.

Technical comments

<u>Advice Sheet:</u>

- Table 3. - Advice Basis "2016 advice for 2017 & 2018 + 20%" is listed twice – Once as "Precautionary approach" and once as "Other scenarios". Change is not desired.
- Table 9. – Some small inconsistencies in % values due to rounding in Excel rather than according to ICES rounding method. e.g. % change (To Advice) for the max. basis, should be 184%, consistent with Table 3. A few other values were also slightly off.

Conclusions

The assessment has been performed correctly with only a few small inconsistencies in Table 9 due to rounding issues, which need to be resolved.

Annex 8: Data call: Data submission for ICES fisheries advisory work

Data call: Data submission for ICES fisheries advisory work

1 Scope of the Data call

ICES Member Countries are requested to provide, for selected ICES fish and shellfish stocks:

- landings, discards, biological and effort data from 2017 and other supporting information;
- for stocks identified in Annex 1 with "**DLS 1**" or "**DLS 3**" under column "DLS proxy RP"; supporting information on life history parameters[1] and estimates of length compositions for landings and discards from:
  - o The latest year (i.e. 2017) for stocks identified with "**DLS 1**",
  - o The three most recent consecutive years (i.e. 2017, 2016, 2015) for stocks identified with "**DLS 3**".

For some species, countries should also submit landings below minimum size (BMS) and logbook registered discard. Those species are under NWWG, WGBFAS, WGBIE, WGNSSK, WGCSE and WGWIDE and relevant details are specified further under section 6.1.4.

A list of stocks included in the data call are provided in Annex 1. **All countries having catch or landings data on these stocks should submit data, even if not listed on the data request spreadsheets.** The countries listed on the data request spreadsheets were identified based on previous year catches and therefore new fisheries (in 2017) are not detected but should also be reported.

2 Rationale

The requested data will be used by ICES advisory groups involved in the provision of ICES advice.

3 Legal framework

The legal framework for the data call is as follows:

- Council Regulation (EC) No 2017/1004 concerning the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.
- Council Regulation (EU) No 1380/2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009.

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[1] "Supporting information on life history parameters" includes information on specific life history traits, if available, noting that some candidate reference points require input on length at first maturity (L_{mat}), growth parameters (e.g., L_{inf}, K) and M (natural mortality). See Annex 2 for more details

4 Deadlines

ICES requests the data to be delivered by a Working Group specific date to provide enough time for additional quality assurance prior to the meeting. Data submission deadlines for each of the Working Groups are given in table 1. **Missing the reporting deadline will compromise the indispensable data quality checking (on a stock basis) before the use of that data to update assessments.**

The deadline does not apply to the survey data. It is expected that survey data will be submitted to DATRAS (Database of Trawl Surveys) by the agreed timetable (see http://www.ices.dk/marine-data/data-portals/Pages/DATRAS-deadlines.aspx), to ICES acoustic database, or sent to accessions@ices.dk as early as possible prior to the Working Group meeting.

Table 1. Data submission deadline for ICES expert groups and respective chair contact.

EXPERT GROUP (EG)	CHAIR OF THE EG	EMAIL ADDRESS	DATA SUBMISSION DEADLINE
AFWG	Daniel Howell	daniel.howell@imr.no	**28.03.2018**
NIPAG	Guldborg Søvik & Karen Dwyer	guldborg.soevik@imr.no dwyerk@dfo-mpo.gc.ca	**28.09.2018**
NWWG	Kristjan Kristinsson	kristjan.kristinsson@hafogvatn.is	**05.04.2018**
WGBFAS	Tomas Groehsler	tomas.groehsler@thuenen.de	**22.03.2018**
WGBIE	Lisa Readdy	lisa.readdy@cefas.co.uk	**05.04.2018**
WGCSE	Timothy Earl & Helen Dobby	timothy.earl@cefas.co.uk h.dobby@marlab.ac.uk	**11.04.2018**
WGDEEP	Pascal Lorance & Gudmundur Thordarson	pascal.lorance@ifremer.fr gudthor@hafro.is	**22.03.2018**
WGHANSA	Alexandra Silva	asilva@ipma.pt	**28.05.2018**
WGMIXFISH-ADVICE	Youen Vermard	youen.vermard@ifremer.fr	**30.04.2018**
WGNSSK	José de Oliveira	jose.deoliveira@cefas.co.uk	**27.03.2018**
WGWIDE	Gudmundur Oskarsson	gjos@hafro.is	**31.07.2018**

5 Data to report

ICES Member Countries are requested to supply data as specified on the Working Groups' data request spreadsheets (Annex 1) to InterCatch, to ICES Secretariat via email (accessions@ices.dk) or both. Data include:

- landings, discards, biological data and effort data from 2017 and other supporting information;

- for stocks identified in Annex 1 with "**DLS 1**" or "**DLS 3**" under column "DLS proxy RP"; supporting information on life history parameters[2] and estimates of length compositions for landings and discards from:

[2] "Supporting information on life history parameters" includes information on specific life history traits, if available, noting that some candidate reference points require input on length at first maturity (L_{mat}), growth parameters (e.g., L_{inf}, K) and M (natural mortality). See Annex 2 for more details

- The latest year (i.e. 2017) for stocks identified with "**DLS 1**",
- The three most recent consecutive years (i.e. 2017, 2016, 2015) for stocks identified with "**DLS 3**".

- supporting information on life history parameters (see Annex 2) should be submitted directly to accessions@ices.dk.

The list of species and stocks, for which data should be submitted, are given in Annex 1. ICES aims at maintain stable definitions over the years of species – stock – metier combinations to facilitate raising data at the institute level.

Data should be reported by the lowest subdivision possible. Aggregations should not be beyond the assessment area of individual stocks. If the format for submission of accession data (Annex 1) is not specified further through the provided templates (Annex 1-3), the format should be the same as used in previous data calls and previous years (if anything is unclear, please contact accessions@ices.dk).

If corrections for earlier years need to be made, please inform the Expert Group chair (see e-mail contact details in Table 1) and Advice@ices.dk. A full corrected set of data may need to be uploaded.

6 Data submission

6.1 Reporting to InterCatch

The InterCatch formatted national data should be uploaded into InterCatch, which is available at this link: https://InterCatch.ices.dk/Login.aspx.

Please see the 'InterCatch Exchange Manuals' on the ICES website for information on the required exchange format and used codes at http://www.ices.dk/marine-data/data-portals/Pages/InterCatch.aspx. An overview of the data fields used in the InterCatch exchange format are detailed in appendix 2. The codes for metiers/fleets, countries and areas are in appendix 1, 3 and 4.

For stocks where discard data have been submitted in previous years to InterCatch, it should also be submitted to InterCatch for 2017 (Annex 1).

Area-disaggregated catch data should be submitted to InterCatch in a consistent manner between Data Calls. If area aggregations must be made it should be clearly stated in the InfoStockCoordinator information text field (number 23 in the import file to InterCatch).

6.1.1 Data conversion to InterCatch format

A description of the InterCatch Exchange format is found in the InterCatch User Manual[3]. An overview of the fields in the InterCatch commercial catch format is found in the InterCatch Format overview[4] , where valid codes are also listed.

[3]http://www.ices.dk/marine-data/Documents/Intercatch/InterCatch%20User%20Manual%20Doc1-11.pdf

[4] http://dome.ices.dk/datsu/selRep.aspx?Dataset=76

To ease the process of converting the national data into the InterCatch format, Andrew Campbell from Ireland has made the conversion tool "InterCatchFileMaker", which converts data manually entered in the 'Exchange format spreadsheet' into a file in the InterCatch format. **Be aware that the tool does not currently support the new catch categories BMS Landings and Logbook Registered Discards** (see section 6.1.4.). The conversion tool "InterCatchFileMaker" can be downloaded from the ICES webpage under 'Format conversion tools' (link). The download includes a spreadsheet in which the landings and sampling data can be placed; the program then converts the data into the InterCatch format.

If the "InterCatchFilemaker" conversion program and the exchange format spreadsheet have been used to convert your data to InterCatch format, then the values in the data field "NumSamplesAge" in the InterCatch format file must be entered manually.

If in some areas and quarters there are only length samples available (age samples are missing), then it is possible to use ALKs from neighboring areas or quarters to calculate CANUM and WECA for "Species Data" (SD)records, before importing data to InterCatch. In this case "-9" must be entered in the data fields of "NumSamplesAge" and "NumAgeMeas".

6.1.2 New and simple age and length data in parallel in InterCatch

A small change in the way InterCatch can work with age and length data in parallel has been implemented. Before it was important that length was imported latest although currently the order of importing catches with sample data (age/length) does not matter. In the current version it is important that for a given stratum a catch without samples is not imported after a catch with samples has been imported. So e.g. never import a catch with age samples followed by the same catch without samples, because this will erase the age samples already imported. This is the way to remove wrongly imported age or length data which do not belong to the strata. A simple procedure to follow would be to first import catches for all strata and in this first import the existing age samples. Then in a second import only the strata where there are catches with length samples should be imported.

6.1.3 Sample information on age and length data

When age or length data are imported it is requested to fill in the following age and length sampling information fields for both landing and discard samples:

- Number samples of length, field: NumSamplesLngt
- Number length measured, field: NumLngtMeas
- Number samples of age, field: NumSamplesAge
- Number age measured, field: NumAgeMeas

Data submitters are encouraged to use the fields related to data quality within InterCatch (NumSamplesLngt, NumLngtMeas, NumSamplesAge, NumAgeMeas). This will help stock assessors to make allocations in InterCatch and to identify sampling levels changes from one year to another.

The units of the samples in the record types "NumSamplesLngt" and "NumSamplesAge" of the species data record should be the number of primary sample units (vessel, trip, harbour day, etc.). The units should be given in the InterCatch species information field named "InfoFleet".

If there is any question regarding InterCatch submissions, please contact the working group chair (see Table 1) and ICES Secretariat at InterCatchsupport@ices.dk.

6.1.4 Catch categories in InterCatch

Landing, 'L'

The 'Landing' catch category in InterCatch will cover the scientific estimates of landing as it has been done previously.

Discard, 'D'

The 'Discard' catch category in InterCatch will cover the discard fraction as it has been done previously. This category is the part of the catch, which is thrown overboard into the sea. This catch category is based on fishery observer estimations.

This component should be in the CATON field and in the OffLandings field a 0 (zero) should be inserted.

Data for this fraction should be reported even when discard values are low. Also, discard estimations for pelagic species based on demersal observer programs should be reported. This is especially important for some small pelagic stocks.

BMS Landing, 'B'

Relevant for stocks under landing obligation. The BMS landings consist of fish and crustaceans Below Minimum Size as registered in the logbook.

If the discard estimation includes the BMS a 0 (zero) should be inserted into the CATON field. If the BMS **is not** included in the discard, your best estimate should be inserted into the CATON field. Either way, the value of BMS as reported in the logbook should always be inserted in the OffLandings field.

Logbook Registered Discard, 'R'

Relevant for stocks under landing obligation. This component are discards, which are registered in the logbook and are under the landing obligation exemption rules (e.g. *de minimis*).

This component should be inserted in the OffLandings field as reported in the logbook. A 0 (zero) has to be inserted in the CATON field as this component is already accounted for in the discard estimates (see Tables 2 and 3).

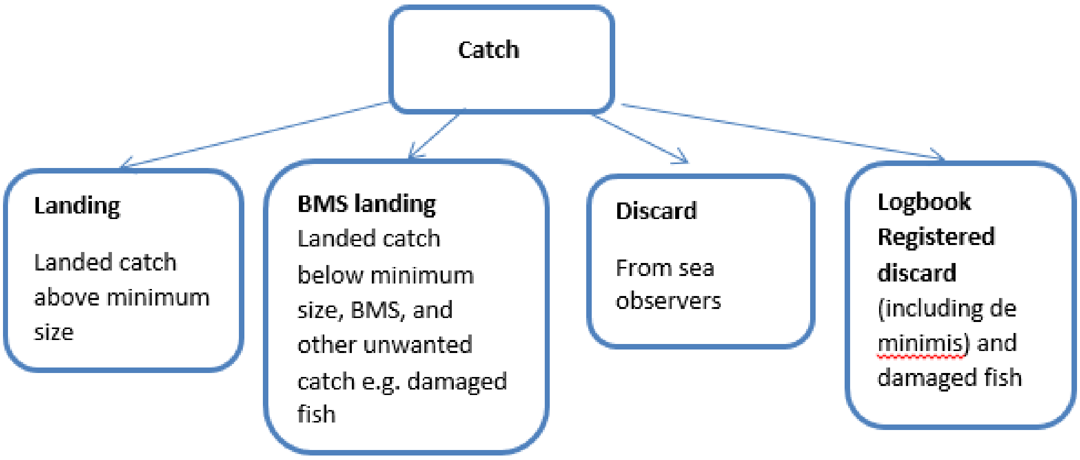


Figure 1. Description of the four current catch categories.

The following species under the relevant Working Groups should also submit data for BMS landings and logbook registered discards:

- **NWWG**: Capelin.
- **WGBFAS**: Cod, herring, plaice and sprat.
- **WGBIE**: Sole, hake, Norway lobster, plaice, anglerfish.
- **WGCSE**: Cod, haddock, whiting, Norway lobster, sole, plaice, pollack.
- **WGNSSK**: Saithe, sole, cod, haddock, whiting, hake, plaice, Norway lobster and northern prawn.
- **WGWIDE**: Blue whiting, boarfish, herring, horse mackerel, mackerel.

In InterCatch only CATON is used to derive the total catch used in stock assessment. The values for the different categories in the OffLandings fields (OfficialLanding) are only informative and will not be used in the catch estimate.

Use only the Reporting Category R (for all catch categories) in case of black landings. For Non-reported, please use Reporting Category N.

Table 2. The species information (SI) record in InterCatch – landing obligation example. In this example the observer sampling on board has access only to landings and discards with no differentiation being made between the discards and BMS fractions.

							Comments
Record number	10	11	12	13	19	20	
Field code	Species	Stock	Catch Category	Reporting Category	CATON	OffLandings	
	COD	NA	D	R	1300	0	Observer discard estimate (discards and BMS treated as one).
	COD	NA	B	R	0	0.1	The BMS registered in the logbook (if any), should be inserted in the OffLandings field. CATON should be zero as the Catch category D already accounts for the BMS
	COD	NA	R	R	0	0.2	The Discards registered in the logbook (if any), should be inserted in the OffLandings field. The CATON field will be zero as the Catch category D already accounts for all Discards (registered and not registered)

Table 3. The species information (SI) record in InterCatch – landing obligation example. In this example the observer sampling on board has access to landings, discards and BMS fractions. The observer is able to estimate all fractions independently.

							Comments
Record number	10	11	12	13	19	20	
Field code	Species	Stock	Catch Category	Reporting Category	CATON	OffLandings	
	COD	NA	D	R	1300	0	The discard fraction is an estimate of the discard only.
	COD	NA	B	R	0.1	0.1	The BMS fraction estimated by the observer is added to the CATON field. The BMS registered in the logbooks is entered in OffLandings field.
	COD	NA	R	R	0	0.2	The Discards registered in the logbook (if any), should be inserted in the OffLandings field. The CATON field will be zero as the discards and BMS are already estimated.

6.1.5 Effort data in InterCatch

Effort is recorded in position 11 of the InterCatch header information. Effort is required in kWdays for all species and areas, with the exception of WGBFAS that requires effort in days-at-sea (WGBFAS specifications are detailed in section 7.3). The effort in InterCatch supports WGMIXFISH which needs effort by metier and not by species. This means, that the effort value should be the same for all species, for a given strata. If landing data and discard data are imported in separated files then effort should only be imported once in the landings data. Effort for the discard data should be indicated with a '-9' (indicating no effort).

6.2 Reporting to other destinations

Files for accessions@ices.dk should be submitted in as few e-mails as possible. The file name must include working group, stock, country and data type references as specified below. The email subject must include working group, stock and country references.

"2018 DC [expert group] [stock code/stock codes] [country] [type of data]"

(example: 2018 DC WGBFAS her.27.28 LV landings)

The files will be forwarded to the respective stock coordinators and the Expert Group chairs.

6.3 Metiers

In response to ICES Data Calls, landings and effort data by métier should be submitted to InterCatch in a consistent manner. The following text will focus on the codes used for the field "Fleet", which in general is referred to as "*metier*". The *metiers* for each Working Group are listed in Annex 1 (sheet "IC Metier tags"). If a *metier* needed is not available in InterCatch, please contact the Working Group chair (see email address in Table 1).

The *metier* tag entries closely follow the naming convention used for the EU Data Collection Framework (DCF). Below is an explanation of the *metier* tag elements; an underscore separates each of the elements (Figure 2).

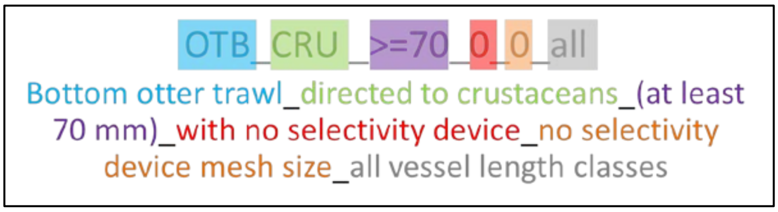


Figure 2. Explanation of the *metier* tag elements; an underscore separates each of the elements.

<u>*Metier* tag elements</u>

1. GEAR TYPE (gear types available under the DCF are shown in 2010/93/EU Appendix IV). Note that WGCSE, WGNSSK, WGBIE and WGMIXFISH allow only specific *metiers* in specific areas (see Appendix 1–5).

2. TARGET ASSEMBLAGE CODE (code conforming to target assemblage under the DCF are shown in 2010/93/EU Appendix IV). Data can be aggregated over more than one category but in this case the most significant *metier* code is entered.
3. MESH SIZE RANGE (mesh size ranges available under the DCF). If necessary data can be aggregated over more than one category but in this case the most significant mesh size range is entered. Exception to this general rules are cases where, for that gear type, data have been aggregated over all ranges used by a nation. In this case an additional entry "**0**" can be used (The metier should look like e.g. LHM_DEF_**0**_0_0. The use of "_all_" in this tag element should be avoided).
4. SELECTIVITY DEVICE (types of selectivity device available: 0: No selectivity device, 1: Exit window or panel, 2: Grid, 3: Square meshes (T90) under the DCF). See 2010/93/EU Appendix IV.
5. SELECTIVITY DEVICE MESH SIZE (if the actual mesh size of any selectivity device is entered, this level is referred to as level 6). Data aggregation over several DCF level 6 categories is possible although should be avoided. In these cases the *metier* tag corresponding to the most significant category is chosen e.g., a mobile gear with mesh sizes covering 70–119 mm (combining 70–99 and 100–119) but for which 70–99 mm is most significant, the code 70–99 will apply. Exceptions to this general rule are cases where data have been aggregated over all mesh size ranges within the national fleet. In these instances the mesh size is omitted and only a *metier* with level 5 (Gear code Target assemblage) is used.
6. VESSEL LENGTH CLASS (Member states have been indicated by national sampling scheme designs to not take account of vessel lengths. Therefore the standard entry of "all" or omitted is currently provided for in InterCatch). The option has been left open for length category specific *metier* tags to be added in future years if nations begin to sample and raise data independently for different vessel length categories.

Unspecified data accounting all together for less than 10 % of catches and effort, can be coded into a miscellaneous group named either MIS_MIS_0_0_0_HC (Miscellaneous Human Consumption) or MIS_MIS_0_0_0_IBC (Miscellaneous Industrial By-Catch) However, this métier aggregation label hinders the ability to effectively model the fishery interactions and its use **should be minimised.**

If multiple metiers are aggregated or merged into dominant metiers, these should be clearly stated In the InfoStockCoordinator information text (field number 23 in the import file to InterCatch).

6.4 Data reporting units

Landings, discards, and biological sampling data: as specified in InterCatch Exchange Format.

Landings, discards: by number and in tonnes at 1 cm length intervals for fish and 1 mm intervals for Norway lobster.

Effort (WGNSSK, WGCSE, WGBIE, WGDEEP, WGHANSA): kW days (in InterCatch).

Effort (WGBFAS): in days-at-sea, see further WGBFAS specifications in Section 7.3).

Year must be entered as four digits, e.g. "2017".

6.5 Zero catch

Countries with no landings for stocks for which they usually report catches should enter a value of zero for landing to InterCatch. This will reassure the stock assessor that no data are missing. A single import of an annual zero landing stratum is acceptable.

For stocks where fishing only occurs in specific quarters, data for quarters with no catches should also be entered (by metier/fleet) to ensure that no data submission was missed. (e.g. for stocks where there are catches in quarter 1, 2 and 4, a catch of zero should be added for quarter 3).

6.6 NEAFC Areas and ICES subdivisions

For stocks with catches in areas shared between ICES and NEAFC regulatory area; the areas should be reported with the correct NEAFC area code (e.g. specifying 7.k.1, 7.k.2 vs. 7.k only, or 6.b.1, 6.b.2, vs. 6.b only). This is particularly relevant for stocks under WGDEEP and WGWIDE.

6.7 Recreational fisheries data

Recreational fisheries catch data should not be included as commercial landings, even if this has been the case in previous years. The recreational fisheries data should be submitted separately via email to accessions@ices.dk with a note about the previous practices of data reporting. The respective Working Group chair (see email addresses in Table 1) and ICES Secretariat should be informed accordingly.

7 Expert group specific uploading information

7.1 WGDEEP specification

Black scabbardfish (*Aphanopus carbo*) is believed to constitute a unique stock with three migratory components located in the West of the British Islands, Portugal mainland and Canary/Madeira areas. The southernmost component lies under the Fishery Committee for the Eastern Central Atlantic (CECAF) competence and it is believed to be an important spawning area for the species. In order to strengthen the ICES advisory process and a more comprehensive stock assessment of black scabbardfish, access to the southernmost component data (FAO Fishing Area 34, Division 1.2) is requested in this Data Call from all ICES country members with data available from this area.

The data requested if available should be provided as follows:

Landings and discards per month in tonnes.

Fishing effort per month (KW days).

Length frequency distribution per month or per quarter.

Weight length relationship.

Proportion of mature individuals (by sex) in the last quarter of the year.

7.2 WGMIXFISH-ADVICE specification (WGNSSK, WGCSE, WGBIE, WGBFAS)

WGMIXFISH undertakes fleet-based mixed fisheries forecasts, and intends to develop advice for the North Sea, Celtic Sea and Iberian waters in 2018. ICES is requesting for member countries to submit 2017 data. WGMIXFISH operates both at the level of the

DCF *metier*, as explained above, AND at the level of the fleet segment, consistently with the approach for the collection of economic data. In addition WGMIXFISH needs specific information by vessel length categories and disaggregated area. Therefore we kindly request estimates of landings weight totals and effort in a format similar to previous WGMIXFISH Data Calls, with the aforementioned parameters specified. Area should be at ICES division level, except for Norway lobster where the InterCatch code for the relevant Functional Unit should be used (see Annex 1, worksheet "ICES area codes").

WGMIXFISH doesn't ask for discard data as these data are available for all *metiers* from the raising procedure done for the single stock advice in InterCatch. Data submitters should aggregate discard InterCatch submissions to the level considered most appropriate for national sampling programs. However, consistency is requested in the aggregation level submitted year by year, to allow mapping to WGMIXFISH *metier* level 6 and vessel length data aggregations. It must be accepted that the InterCatch discard submission level will be proportioned out across all underlying metiers and vessel length for use with *metier* level 6 WGMIXFISH landings data (i.e. the assumption of the same discarding and age-distribution in catch will be made by WGMIXFISH). Additional information on discard rates is not needed if estimated discard rates are the same for all vessel length categories within a metier, as this information can be taken from InterCatch. However, if specific discard rates exist for each vessel length category, data submitters should provide differentiated discard estimates in an extra column labelled "discards" (see Annex 1, sheet WGMIXFISH-catch and Figures 3 and 4).

7.2.1 WGNSSK: All stocks (2017 data requested)

Provide data by filling the spreadsheets described in section 7.2.5 and in Annex 1.

7.2.2 WGCSE: All stocks (2017 data requested)

Provide data by filling the spreadsheets described in section 7.2.5 and in Annex 1.

Species catch data should be submitted according to the following:

ANF (aggregated ANF, MON, MNZ),

LEZ (aggregated LEZ, MEG),

RJA (aggregated RJC, SKA, RAJ, RJA, RJB, RJC, RJE, RJF, RJH, RJI, RJM, RJN, RJO, RJR, SKA, SKX, SRX),

SDV (aggregated DGS, DGH, DGX, DGZ, SDV),

COD, HAD, HKE, LIN, NEP, PLE, POK, POL, SOL, WHG.

All remaining catch to be aggregated into an '**OTH**' class.

7.2.3 WGBIE: (2017 data requested)

Provide data by filling the spreadsheets described in section 7.2.5 and in Annex 1.

Relevant stocks: southern hake (hke.27.8c9a), northern hake (hke.27.3a46-8abd), black anglerfish (ank.27.78ab), white anglerfish (mon.27.78ab), black anglerfish (mon.27.8c9a), white anglerfish (ank.27.8c9a), megrim (meg.27.8c9a), four-spotted megrim (ldb.27.8c9a), megrim (meg.27.7b-k8abd) and four-spotted megrim (ldb.27.7b-k8abd).

7.2.4 WGBFAS: (2017 data requested)

Provide data by filling the spreadsheets described in section 7.2.5 and in Annex 1.

7.2.5 WGMIXFISH-ADVICE Data format

Information on vessel length and *metier* used is kept separately in two columns in the .csv files (Annex 1, sheet WGMIXFISH-effort, sheet WGMIXFISH-catch). **To specify the *metier*, use exactly the same tags as used for InterCatch** (Annex 1, sheet IC Metier tags)**.**

A field is included to specifically flag FDF (Fully Documented Fisheries) Vessels. As some vessels are involved in FDF *metiers* in one area (e.g. North Sea), while being involved in non-FDF *metiers* in another (e.g. West of Scotland), it is important to flag these vessels at the fleet level, and not only at the *metier* level. Please leave the field blank for the non FDF fleet, and write "FDF" for the FDF flagged vessels.

Two comma separated (.csv) files should be provided:

1) A single .csv file reporting *metier* and vessel length disaggregated effort;

2) A single .csv file reporting *metier* and vessel length disaggregated catch.

Both files should be sent electronically as .csv files to accessions@ices.dk, clearly indicating in the subject of the file name "2018 WGMIXFISH-ADVICE" [country] [*metier*_catch/*metier*_effort]" (example: 2018 WGMIXFISH-ADVICE UK metier catch).

1.) The CSV 'effort' file (see Annex 1, sheet WGMIXFISH-effort) should be supplied containing the following entries:

ID (Unique identifier), Country, Year, Quarter, InterCatch *Metier* Tag, Vessel Length Category, FDF vessel flag, Area, kW_Days, Days at Sea, No Vessels

ID	Country	Year	Quarter	Intercatch Metier Tag	Vessel Length Ca	FDF vessel	Area	KW_Days	Days At Sea	No Vessel
dnk1	DK	2015	1	OTB_DEF>=120_0_0_all	<10m		27.4	1000	100	10
dnk2	DK	2015	1	OTB_DEF>=120_0_0_all_FDF	10<24m	FDF	27.4	1000	100	10
dnk3	DK	2015	1	OTB_DEF>=120_0_0_all	10<24	FDF	27.6.a	1000	100	10

Figure 3. Example of WGMIXFISH-ADVICE CSV 'effort' file.

2.) The CSV 'catch' file (see Annex 1, sheet WGMIXFISH-Catch) should be supplied containing the following entries:

ID (Unique identifier), Country, Year, Quarter, InterCatch *Metier* Tag, Vessel Length Category, FDF vessel flag, Area, Species, Landings (tonnes), Value (average price*landings at first sale, expressed in Euros), Discards (only if discard rate differs from the one submitted to InterCatch).

ID	Country	Year	Quarter	Intercatch Metier Tag	Vessel Length Ca	FDF vessel	Area	Species	Landings	Value	Discards
dnk1	DK	2015	1	OTB_DEF>=120_0_0_all	<10m		27.4	COD	100	1000	
dnk2	DK	2015	1	OTB_DEF>=120_0_0_all_FDF	10<24m	FDF	27.4.b	NEP	100	1000	
dnk3	DK	2015	1	OTB_DEF>=120_0_0_all	10<24	FDF	FU.33	NEP	100	1000	

Figure 4. Example of WGMIXFISH-ADVICE CSV 'catch' file.

Note that:

- Vessel length splits are only required for metier tags starting with OTB or TBB.
- Vessel length categories are: <10m, 10<24m, 24<40m, >=40m (Please use exactly these codes)

- Sums of effort and landings across metier tags disaggregated by vessel length should equal the corresponding totals submitted to InterCatch.

7.3 WGBFAS specifications

1.7.1 Units for data submission

For landings and discards; numbers (in `000) and mean weight (in grams) by age or length (depending on the stock and according to Annex 1 specifications) per fleet/segment, quarter, year, Subdivision, country.

1.7.2 Data specification

- Discard survival rates **should not** be accounted for by the countries, when uploading the data
- **Landing obligation -** The EU Landing obligation is mandatory for all fish species in the Baltic Sea subject to catch limits since 1 January 2017. A new fraction of the catch, the BMS (below minimum reference size) catch, has been introduced. It is important that Member Countries are aware of this new fraction in the catch when data are uploaded.
- for **sprat,** fleet segments to be considered are; "Pelagic trawlers" for all trawl gears and "Passive " for all passive gears.

Besides landings and discards InterCatch includes the catch categories: i) BMS landings and ii) logbook registered discard (see Section 6.1.4.). It is important when Member Countries are uploading data to InterCatch that the four categories in CATON are summing up to the total catch. BMS landings can either be calculated as an estimate from the observer trips or from official registrations such as sale slips, logbooks or landing declarations. Both the landed BMS catch and the discard estimate will be needed for the WGBFAS.

1.7.3 Specifics of data requirements for eastern and western Baltic cod

Specifics of length/age distribution data in IC:

- For cod in SD 22–23, age distribution data should be uploaded to IC.
- For cod in SD 24, length distribution data should be provided through accessions@ices.dk (can be in the form of IC file or an *Excel* spreadsheet). No biological information (no age/length distribution data) should be uploaded to IC.

For Recreational catch from Germany of western Baltic cod (cod.27.22–24):

- Catch in weight, separately for SD 22 and 24
- Catch at age in numbers, separately for SD 22 and 24 (age readings originating from SD 22 should only be used. i.e. not age readings from SD 24)
- Mean weight at age in the catch

The data should be provided as Excel spreadsheets and submitted to accessions@ices.dk.

The unit for commercial effort is **days-at-sea** and should be aggregated at the same level as the sampling data (i.e. effort per subdivision, year, quarter and fleet).

8 Contact information

For support concerning any data call issues about the data call please contact the Advisory Department (Advice@ices.dk).

For support concerning InterCatch submissions please contact: InterCatchSupport@ices.dk.

For support concerning other data-submission issues, please contact: accessions@ices.dk.

Appendix 1

Gear coding (as defined under the EU Data Collection Framework), allowed for WGNSSK and WGMIXFISH-ADVICE. Based on information from countries fishing in areas 27.3.a.20, 27.4 and 27.7.d and significant fishing gears. Note that the vessel length category (currently '_all') must appear at the end of every *metier* tag except the MIS_MIS *metier* tags.

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
27.3.a.20 (Skagerrak) and 27.3.a.21 (Kattegat) Area Type = SubDiv	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_90-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_CRU_32-69_2_22_all
		OTB_CRU_70-89_2_35_all
		OTB_CRU_90-119_0_0_all OTB_CRU_90-119_0_0_all_FDF
		OTB_DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all SSC_DEF_>=120_0_0_all_FDF
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all GNS_DEF_120-219_0_0_all_FDF
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all LLS_FIF_0_0_0_all_FDF
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
27.4 – (North Sea) Area type = SubArea & 27.7.d (Eastern Channel) Area Type = Div & 27.6.a (for saithe and haddock only) Area Type = Div	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_70-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_SPF_32-69_0_0_all
		OTB_CRU_70-99_0_0_all OTB_CRU_70-99_0_0_all_FDF
		OTB_ DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF OTB_DEF_70-99_0_0_all
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all SSC_DEF_>=120_0_0_all_FDF

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all GNS_DEF_120-219_0_0_all_FDF
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all LLS_FIF_0_0_0_all_FDF
	Pots and Traps	FPO_CRU_0_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC

*** The use of metiers under the MIS_MIS category should be minimized.**

Appendix 2

Gear coding (as defined under the DCF), allowed for WGCSE and WGMIXFISH-ADVICE in specific areas. Note that the vessel length category (currently '_all') must appear at the end of every *metier* tag except the MIS_MIS *metier* tags.

AREA	GEAR TYPE	AVAILABLE METIER TAGS
West of Scotland (27.6.a) and Rockall (27.6.b)	Pots and traps	FPO_CRU_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
	Longline	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_>=120_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DWS_>=120_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_>=120_0_0_all
		OTB_MOL_100-119_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Irish Sea (27.7.a)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_120-219_0_0_all
		GNS_DEF_90-99_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_MOL_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)	MIS_MIS_0_0_0_IBC
West of Ireland (27.7.b-c) and Celtic Sea slope (27.7.k–j)	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_DWS_100-119_0_0_all
	Otter trawl	OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_100-119_0_0_all
		OTB_CRU_100-119_0_0_all
	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all
		OTM_DEF_100-119_0_0_all
		OTM_LPF_70-99_0_0_all

		OTM_LPF_100-119_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Celtic Sea Shelf (27.7.f–h)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_SPF_10-30_0_0_all
		GTR_DEF_>=220_0_0_all
	Lines	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MCD_70-99_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_100-119_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Western Channel (27.7.e)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_CRU_0_0_0_all
		GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GTR_CRU_0_0_0_all
		GTR_DEF_>=220_0_0_all
		GTR_DEF_120-219_0_0_all
	Lines	LLS_DEF_0_0_0_all
		LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_70-99_0_0_all
	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all

		OTM_DEF_70-99_0_0_all
		OTM_DEF_100-119_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC

*** The use of metiers under the MIS_MIS category should be minimized.**

Appendix 3

Gear coding (as defined under the DCF), allowed for WGBIE and WGMIXFISH-ADVICE in specific areas.

Métier Level 6	Description
DRB_MOL_0_0_0_all	Boat dredge, molluscs, no selectivity devise, all vessels
FPO_CRU_0_0_0_all	Pots and Traps, Crustaceans, no selectivity device, all vessels
GN_DEF_100-109_0_0_all	Gill nets, demersal fish, mesh size 100-109mm, no selectivity device, all vessels
GNS_DEF_>=100_0_0	Set gillnet, Demersal fish, mesh size more than 100mm, no selectivity device
GNS_DEF_>=220_0_0_all	Set gillnet, Demersal fish, mesh size more than 220mm, no selectivity device, all vessels
GNS_DEF_>=220_0_0_all_FDF	Set gillnet, Demersal fish, mesh size >=220mm, no selectivity device, all vessels, Fully Documented Fisheries
GNS_DEF_100-119_0_0_all	Set gillnet, Demersal fish, mesh size 100-119mm, no selectivity device, all vessels
GNS_DEF_100-219_0_0	Set gillnet directed to demersal fish (100-219 mm)
GNS_DEF_10-30_0_0_all	Set gillnet, Demersal fish, mesh size 10-30mm, no selectivity device, all vessels
GNS_DEF_120-219_0_0_all	Set gillnet, Demersal fish, mesh size 120-219mm, no selectivity device, all vessels
GNS_DEF_120-219_0_0_all_FDF	Set Gillnet, Demersal Fish, Mesh size 120-219, All Vessels, No grid selectivity, Fully Documented Fisheries
GNS_DEF_45-59_0_0	Set gillnet directed to demersal fish (45-59 mm)
GNS_DEF_60-79_0_0	Set gillnet, Demersal fish, mesh size 60-79 mm, no selectivity device
GNS_DEF_80-99_0_0	Set gillnet directed to demersal fish (80-99 mm)
GNS_DEF_all_0_0_all	Set gillnet, Demersal fish, all mesh sizes, no selectivity device, all vessels
GTR_DEF_60-79_0_0	Trammel nets, Demersal fish, mesh size 60-79mm, no selectivity device
GTR_DEF_all_0_0_all	Trammel nets, Demersal fish, all mesh sizes, no selectivity device, all vessels
LHM_DEF_0_0_0 LLS_DEF_0_0_0	Hand lines directed to demersal fish Set longline directed to demersal fish
LLS_DEF_0_0_0_all	Set longlines, Demersal fish, mesh size not specified, no selectivity device, all vessels.
LLS_FIF_0_0_0_all	Set longlines, Finfish, no selectivity device, all vessels
MIS_DEF_all_0_0_all*	Demersal fisheries, Demersal fish, mesh size any, no selectivity device, all vessels
MIS_MIS_0_0_0_IBC*	Demersal fisheries - Miscellaneous Industrial bycatch
MIS_MIS_All_0_0_All*	Demersal fisheries - Miscellaneous
OTB_CRU _>=70_0_0	Bottom otter trawl directed to crustaceans (at least 70 mm)
OTB_CRU_100-119_0_0_all	Otter trawl, Crustaceans, mesh size 100-119, no selectivity device, all vessels
OTB_CRU_32-69_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 32-69, no selectivity device, all vessels
OTB_CRU_32-69_2_22_all	Otter trawl, Crustaceans, mesh size 32-69, selectivity device - grid 22mm, all vessels
OTB_CRU_70-89_2_35_all	Otter trawl, Crustaceans, mesh size 70-89, selectivity device - grid 35mm, all vessels
OTB_CRU_70-99_0_0	Bottom otter trawl directed to crustaceans (70-99 mm)

MÉTIER LEVEL 6	DESCRIPTION
OTB_CRU_70-99_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 70-99, no selectivity device, all vessels
OTB_CRU_90-119_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 90-119, no selectivity device, all vessels
OTB_CRU_90-119_0_0_all_FDF	Bottom otter trawl, Crustaceans, mesh Size 90-119, Selectivity Device - none, All vessel types, Fully Documented Fisheries
OTB_CRU_All_0_0_All	Bottom otter trawl, Crustaceans, all mesh sizes, no selectivity devise, all vessel types
OTB_DEF _100-119_0_0	Bottom otter trawl directed to demersal fish (100-119 mm)
OTB_DEF_>=120_0_0_all	Otter trawl, Demersal fish and Crustaceans, mesh size more than 120mm, no selectivity device, all vessels
OTB_DEF_>=120_0_0_all_FDF	Bottom otter trawl, Demersal fish, Mesh Size 120 or greater, Selectivity Device - none, All vessel types, Fully Documented Fisheries
OTB_DEF_>=55_0_0	Bottom otter trawl directed to demersal fish (at least 55 mm)
OTB_DEF_>=70_0_0	Bottom otter trawler targeting demersal fish with a mesh size > 70 mm
OTB_DEF_100-119_0_0_all	Bottom otter trawler targeting demersal fish with a mesh size 100-119 mm
OTB_DEF_70-99_0_0	Bottom otter trawl directed to demersal fish (70-99 mm)
OTB_DEF_All_0_0_All	Bottom otter trawl directed to demersal fish, all mesh sizes, no selectivity devise
OTB_MCD_>=55_0_0	Otter trawl, Mixed crustaceans and demersal fish, mesh size more than 55mm, no selectivity device.
OTB_MCF_>=70_0_0	Otter trawler targeting cephalopods and fish
OTB_MOL_70-99_0_0_all	Otter trawl, Molluscs, mesh size 70-99mm, no selectivity device, all vessels
OTB_MPD _>=70_0_0	Bottom otter trawl directed to mixed pelagic and demersal fish (at least 70 mm)
OTB_MPD_>=55_0_0	Bottom otter trawl directed to pelagic and demersal fish (at least 55 mm)
OTB_SPF_32-69_0_0_all	Otter Bottom trawl, Small pelagic fish, 32-69 mm, no selectivity devise, all vessels
OTM_DEF_100-119_0_0_all	Midwater otter trawl, Demersal species, mesh size 100-119mm, no selectivity device, all vessels
OTM_DEF_32-54_0_0_all	Midwater otter trawl, Demersal species, mesh size 32-54mm, no selectivity device, all vessels
OTM_DEF_55-69_0_0_all	Midwater otter trawl, Demersal species, mesh size 55-69mm, no selectivity device, all vessels
OTM_DEF_70-99_0_0_all	Midwater otter trawl, Demersal species, mesh size 70-99mm, no selectivity device, all vessels
OTM_DEF_80-89_0_0_all	Midwater otter trawl, Demersal species, mesh size 80-89mm, no selectivity device, all vessels
OTT_CRU _>=70_0_0	Multi-rig otter trawl directed to crustaceans (at least 70 mm)
OTT_DEF _>=70_0_0	Multi-rig otter trawl directed to demersal fish (at least 70 mm)
OTT_DEF_>=120_0_0_all	Multi-rig otter trawl, demersal fish, mesh size more than 120mm, no selectivity device, all vessels
OTT_DEF_100-119_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 100-119mm, no selectivity device, all vessels
OTT_DEF_16-31_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 16-31mm, no selectivity device, all vessels
OTT_DEF_80-89_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 80-89mm, no selectivity device, all vessels

Métier Level 6	Description
OTT_DEF_90-99_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 90-99mm, no selectivity device, all vessels
PS_SPF_0_0_0	Purse seine, Small pelagic fish, no selectivity device.
PTB_DEF _>=70_0_0	Bottom pair trawl directed to demersal fish (at least 70 mm)
PTB_DEF_>=120_0_0_all	Pair bottom trawl, demersal fish, mesh size more than 120mm, no selectivity device, all vessels
PTB_DEF_>=70_0_0	Pair bottom trawler targeting demersal fish
PTB_DEF_80-89_0_0_all	Pair bottom trawl, demersal fish, mesh size 80-89mm, no selectivity device, all vessels
PTB_MPD_>=55_0_0	Bottom pair trawl directed to mixed pelagic and demersal fish (at least 55 mm)
PTM_DEF_90-104_0_0	Midwater pair trawl, demersal fish, mesh size 90-104 mm, no selectivity device
SDN_DEF_>=120_0_0_all	Anchored seine, Demersal fish, mesh size more than 120mm, no selectivity device, all vessels
SDN_DEF_>=120_0_0_all_FDF	Anchored Seine, Demersal Fish, Mesh Size 120 or above, Selectivity Device - none, All vessels, Fully Documented Fisheries
SSC_DEF_>=120_0_0_all	Fly shooting seine, Demersal fish, mesh size more than 120mm, no selectivity device, all vessels
SSC_DEF_>=120_0_0_all_FDF	Fly shooting seine, Demersal Fish, Mesh Size 120 or greater, Selectivity Device - none, All vessels, Fully Documented Fisheries
SSC_DEF_100-119_0_0_all	Fly shooting seine, Demersal fish, mesh size 100-119mm, no selectivity device, all vessels.
SSC_DEF_80-89_0_0_all	Fly shooting seine, Demersal fish, mesh size 80-89mm, no selectivity device, all vessels.
SSC_DEF_All_0_0_All	Fly shooting seine, , Demersal fish, all mesh sizes, no selectivity, all vessels
TBB_CRU_16-31_0_0_all	Beam trawl, Crustaceans, mesh size 16-31mm, no selectivity device, all vessels
TBB_DEF_<16_0_0_all	Beam trawl, Demersal fish, mesh size 16mm or less, no selectivity device, all vessels
TBB_DEF_>=120_0_0_all	Beam trawl, Demersal fish, mesh size more than 120, no selectivity device, all vessels
TBB_DEF_100-119_0_0_all	Beam Trawl, mesh size 100-119mm
TBB_DEF_70-99_0_0_all	Beam trawl, Demersal fish, mesh size 70-99, no selectivity device, all vessels
TBB_DEF_90-99_0_0_all	Beam trawl, Demersal fish, mesh size 90-99, no selectivity device, all vessels
TBB_DEF_all_0_0_all	Beam trawl, Demersal fish, all mesh sizes, no selectivity, all vessels

*** The use of metiers under the MIS_MIS category should be minimized.**

Appendix 4

The information requested in this appendix is only required for stocks identified in Annex 1 with "DLS 1" or "DLS 3" under column "DLS proxy RP".

Supporting life history information in the 2018 ICES data call in Annex 2.

"Supporting life history information" would include information on life history traits, if available, noting that some candidate reference points may require input on L_{mat} (length at first maturity), growth parameters (e.g., L_{inf}, K), and M (natural mortality). ICES recognizes that for countries which are also EU members, this type of information is not under the Regulation (EC) No 2017/1004.That said, this type of information is important to the delivery of advice associated with this data call. ICES asks Member countries to report this information if they are aware of it, but it is not obligatory.

^ If information is provided on traits not listed in the template, include them in these rows with the parameter name in the comments column.						
	Value	Reference	Country code	Stock code	Species code	Comments
Lmat						
Linf						
K						
M						
Unspecified parameter^						
Unspecified parameter^						

Figure 7. Supporting life history information.

Annex 9: Working Documents

No working documents were presented.

Annex 10: Review of the estimation of MSY proxy reference points for gug.27.3a47d

A review of the estimation of MSY proxy reference points for gug.27.3a47d for various methods was carried out, and is given below.

GENERAL COMMENTS

1) Assessment method(s): Length Based Indicators (LBI), Mean Length Z (MLZ) and Length-Based Spawner per Recruit (LB-SPR)

2) Evaluating Uncertainties

- The nature mortality is not known for this species and assumed at 0.2.
- The only one reference available is for the theoretical asymptotic length (Linf) and the growth parameter K from the von Bertalanffy growth equation for grey gurnard; they differ largely from values obtained from more recent survey data.
- The age reading for grey gurnard is unreliable, which might result in bias in growth parameter estimation. Ageing was only done in two years and ageing for this species is known to be difficult.
- Catch data time series is short (2012–2017) and these data are highly uncertain. Catch can be highly variable and discards were not estimated to species for some areas.
- The length data for 2015 and 2016 length samples from landings were not complete (only provided by Sweden and UK England).
- While the distribution of 2016 shows comparable high numbers, the distribution of 2017 contains more large individuals.
- The result of MLZ is not consistent with the LBI and LB-SPR.

3) Consistency:

- This stock has not been assessed previously.
- The result of the LBI and LB-SPR are quite consistent. However, the result of MLZ is not consistent with the LBI and LB-SPR, but the MLZ method may not be appropriate for the stock.

4) Proxy reference points & stock status:

- Method tried: Length Based Indicator (LBI) and Mean Length Z (MLZ) and Length-Based Spawner per Recruit (LB-SPR).

- Proxy reference points:
  LBI: L_c/L_{mat}; $L_{25\%}/L_{mat}$; $L_{max5\%}/L_{inf}$; P_{mega}; L_{mean}/L_{opt}; $L_{mean}/L_{F=M}$
  LB-SPR: $L_{F=M}$

- **EG's conclusions: Overfished/Overfishing occurring?**
  The LBI method indicates the stock is not overfished. The LBI and the LB-SPR methods both indicate that the overfishing is not occurring in the most recent year (2017). EG accepts the proxy points and concludes that the stock is not overfished and overfishing is not occurring.

- **RG's conclusions: methods and stock status**
  The RG agrees with the EG that the stock is not overfished and the overfishing is not occurring. Based on the results from EG and results of Table 1, the RG concludes that the stock is not overfished and the overfishing is not occurring.

- **Recruitment**: no information related to recruitment.

5) Comments & Suggestions:

- The RG believes the EG did a thoughtful assessment to consider all four models. The RG also agrees with the EG that SPiCT is not applicable due to the data availability and limitations.

- The RG agrees with the EG that the MLZ may not be an appropriate method to use due to the data limitations and uncertain natural mortality (M) estimate.

- M for this stock is unknown and was set to 0.2. The EG also uses the default M/K=1.5 setting. Because all of the three methods are sensitive to M, the RG suggests that the EG should conduct sensitivity analysis on different M values. Equation A.3 from Jardim *et al.*2015 allows for any M/K ratio to be used.

- The only one reference available for Linf and the growth parameter K from the von Bertalanffy growth equation for grey gurnard differs largely from values obtained from more recent survey data. Based on the length frequency data, the RG agrees with the EG that the Linf derived from Lmax is more reasonable to use in this case. However, the RG encourages the EG to carry out sensitivity analysis on different values of Linfs for each length-based method. The RG calculates the traffic light indictor for LBI method using Linf = 46 cm (Table 1). The results are consistent with the previous results.

- For both LBI and LB-SPR, the exploitation rate is above F_{MSY} for the years 2015 and 2016 and is below F_{MSY} for year 2017. The EG suggests it is due to the incomplete data collection. The RG agrees with the EG that the stock assessment should use the most completed data. However, one year of length data are not enough to observe the population dynamics of the stock. Therefore, the RG encourages the EG to advocate for further data collection and preform the length-based methods on multiple years of length frequency data.

- LBI and LB-SPR both assume constant recruitment. The EG does not provide any information on recruitment.

PROXY REFERENCE POINTS: CONCLUSIONS

Proxy Reference Points:

LBI: L_c/L_{mat}; $L_{25\%}/L_{mat}$; $L_{max5\%}/L_{inf}$; P_{mega}; L_{mean}/L_{opt} ; $L_{mean}/L_{F=M}$
LB-SPR: $L_{F=M}$

1. **EG Conclusions:**
   The stock is not overfished and the overfishing is not occurring.
2. **RG Conclusions:**
   The stock is not overfished and the overfishing is not occurring.

Table 1. Traffic light indicators

	L_c/L_{mat} (>1)	$L_{25\%}/L_{mat}$ (>1)	$L_{max5\%}/L_{inf}$ (>0.8)	L_{mean}/L_{opt} ~1(>0.9)	$L_{mean}/L_{F=M}$ >=1
2015	1.042944785	1.073619632	0.646913043	0.705978261	0.892783505
2016	1.042944785	1.073619632	0.631478261	0.688695652	0.870927835
2017	1.042944785	1.196319018	0.800217391	0.807391304	1.021030928

Annex 11: Special Request - Revision of the contribution of TACs to fisheries management and stock conservation

A. TAC Management for witch flounder and lemon sole

Introduction

A Special Request was submitted to ICES by the European Commission to investigate the contribution of TACs to fisheries management and stock conservation. The request in full is as follows:

ICES is requested to analyse for witch (Glyptocephalus cynoglossus) and lemon sole (Microstomus kitt)] the role of the Total Allowable Catch instrument. It is asked to assess the risks of removing TAC for each case in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of other conservation tools in absence of TACs to the requirement that the stock concerned remains within safe biological limits.

In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs.

It was agreed with ICES that the main request would be handled by answering a series of six questions originally developed when responding to a similar request for dab and flounder in 2017. The six questions were as follows:

Was the TAC restrictive in the past?

Is there a targeted fishery for the stock or are the species mainly discarded?

Is the stock of large economic importance or are the species of high value?

How are the most important fisheries for the stock managed?

What are the fishing effort and stock trends over time?

What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

This document gives qualitative answers for witch flounder (denoted as witch below) and lemon sole and provides a conclusion to the request at the end.

Important remark

The available information is insufficient to do a full quantitative management-strategy evaluation of the probabilistic risk of having no catch limits for witch and lemon sole. The following analysis is therefore based on a more qualitative evaluation.

Answers to the questions for witch and lemon sole

1. Was the TAC restrictive in the past?

In order to answer this question, the percentage of the TAC that was utilised each year is calculated: first, using the landings inside the TAC area,[1] and then using the total stock area.

The combined TAC for witch and lemon sole does not appear to have been restrictive in the past when only the TAC area is considered, and the comparison is made only with landings (Table 1.1). Taking into account the landings from the whole stock area, i.e. including areas 3.a and 7.d, the TAC has been exceeded in 2006, 2007 and 2016 (Table 1.2). Furthermore, looking at the total catch (i.e. including the discards), and considering the whole stock area, the TAC was exceeded in most of the years since 2002 (Table 1.3). Figure 1.1 shows the TAC utilisation percentage for all the years considering only landings in the TAC area, landings in the stock area, and total catches (landings and discards) in the stock area.

Table 1.1. Overview of the TAC and official landings (tonnes) of witch (WIT) and lemon sole (LEM) in Subarea 4 (North Sea).

Year	WIT	LEM	WIT + LEM	TAC	TAC utilisation (%)
2006	1260	3627	4887	6175	79
2007	1287	3892	5179	6175	84
2008	1170	3466	4636	6793	68
2009	1045	2693	3738	6793	55
2010	815	2625	3440	6521	53
2011	837	3365	4202	6391	66
2012	788	2119	2907	6391	45
2013	993	2981	3974	6391	62
2014	1085	3017	4102	6391	64
2015	956	2871	3827	6391	60
2016	1421	3266	4687	6391	73
2017	1665	2822	4487	6391	70

[1] Landings in area 2.a for both stocks and landings in area 7.d for witch are considered negligible and are not included here.

Table 1.2 Overview of TAC and official landings (tonnes) of witch (WIT) and lemon sole (LEM) in the stock area that includes Skagerrak and Kattegat (3.a), North Sea (4) and eastern English Channel (7.d).

	WIT			LEM						
Year	3.a	4	Total	3.a	4	7.d	Total	Combined	TAC	TAC uptake (%)
2006	1043	1260	2303	417	3627	246	4290	6593	6175	107
2007	949	1287	2236	432	3892	164	4488	6724	6175	109
2008	783	1170	1953	276	3466	234	3976	5929	6793	87
2009	773	1045	1818	262	2693	442	3397	5215	6793	77
2010	675	815	1490	350	2625	223	3198	4688	6521	72
2011	693	837	1530	251	3365	403	4019	5549	6391	87
2012	1107	788	1895	482	2119	358	2959	4854	6391	76
2013	1000	993	1993	289	2981	491	3761	5754	6391	90
2014	1562	1085	2646	315	3017	356	3688	6334	6391	99
2015	1282	956	2238	269	2871	253	3393	5631	6391	88
2016	1317	1421	2739	299	3266	240	3805	6544	6391	102
2017	1162	1665	2827	343	2822	158	3323	6150	6391	96

Table 1.3 Overview of TAC and ICES estimated total catches (landings and discards; tonnes) of witch (WIT) and lemon sole (LEM) in the stock area that includes Skagerrak and Kattegat (3.a), North Sea (4) and eastern English Channel (7.d).

Year	WIT	LEM	Total	TAC	TAC uptake (%)
2006	2631	5809	8440	6175	137
2007	2470	4919	7389	6175	120
2008	2317	5051	7368	6793	108
2009	2319	4401	6720	6793	99
2010	2090	3907	5997	6521	92
2011	2114	5055	7169	6391	112
2012	2509	6560	9069	6391	142
2013	2267	9663	11930	6391	187
2014	2992	5335	8327	6391	130
2015	2690	5116	7806	6391	122
2016	3135	5000	8135	6391	127
2017	3086	3966	7052	6391	110

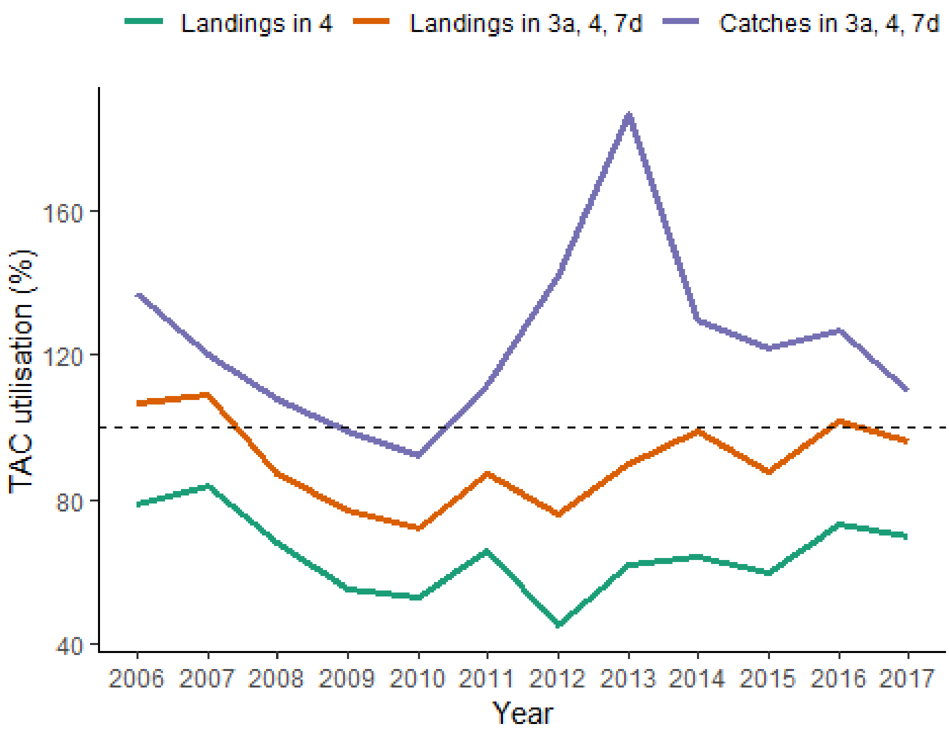


Figure 1.1. TAC utilisation for landings in 4 (green line), landings in 3.a, 4 and 7.d (orange line), and total catches in 3.a, 4 and 7.d (purple line). The horizontal dashed line shows the full uptake (100%) of the TAC.

In conclusion, a comparison of landings from the TAC area (4) with the combined witch-lemon sole TAC for area 4 suggests that the TAC has not been restrictive for these stocks. However, this ignores the contribution of landings from areas 3.a and 7.d, which are outwith the TAC area but which may comprise the same biological stock, and discards. If the total catch from the stock area (landings and discards from areas 4, 3.a and 7.d) are compared with the TAC, it is clear that the TAC has in effect been exceeded in 10 of the 12 years for which data are available. This would indicate that the TAC has indeed been restrictive on fishing practices, and remains so.

Generally speaking, management of witch and lemon sole under a combined TAC prevents effective control of the single-species exploitation rates and could potentially lead to the overexploitation of either species. Furthermore, the stock areas do not match the area for which the advice is issued. This TAC area covers only areas 4 (North Sea) and 2.a (Norwegian Sea), whereas the stock areas for both witch and lemon sole include the areas 3.a (Kattegat and Skagerrak), 4 (North Sea) and 7.d (eastern English Channel).

2. Is there a targeted fishery for the stock or are the species mainly discarded?

There is no targeted fishery for the lemon sole in any of the areas covered here. A directed fishery for witch has been identified in Division 3.a (Feekings, 2011), which encompasses all the fleets catching more than 30% of this species. Furthermore, the targeting behaviour analysis shown in Section D shows moderate interactions for witch (diagonal element, Figure D.1) that suggests some targeting in Subarea 4. Discards for lemon sole and witch have been fluctuating around 20% in most years, although lemon sole discards were lower in the early 2000s. Lemon sole discards were above 30% between 2012 and 2015 reaching a peak of 61% in 2013 (Table 2.1, Figure 2.1), although WGNSSK noted that there were problems with data submissions in that year which may have artificially inflated the discard estimate.

Both witch and lemon sole are high value species (particularly lemon sole), so a high discard rate would be unlikely to arise through fishermen choosing to discard. The discard rate could be due to a combination of the often-restrictive quota (see Section 1 of this Annex 11), or a lack of local markets or processing options. Witch are predominantly caught in the beam-trawl fishery. Lemon sole are usually caught in mixed-species demersal trawls which would not directly target the species, but will land them opportunistically.

Table 2.1. ICES estimates of landings and discards (tonnes) for witch (WIT) and lemon sole (LEM) in areas 3.a, 4 and 7.d.

	WIT			LEM		
Year	Landings	Discards	Discard rate	Landings	Discards	Discard rate
2002	3813	1988	34.3	4011	511	11.3
2003	3308	349	9.5	4575	1036	18.5
2004	3059	369	10.8	4394	635	12.6
2005	2960	419	12.4	4429	527	10.6
2006	2335	296	11.3	4294	1515	26.1
2007	2271	199	8.1	4468	451	9.2
2008	1999	318	13.7	4153	898	17.8
2009	1863	455	19.6	3405	996	22.6
2010	1531	559	26.7	3234	673	17.2
2011	1567	547	25.9	4030	1024	20.3
2012	1952	557	22.2	4099	2461	37.5
2013	2013	254	11.2	3725	5938	61.5
2014	2685	307	10.3	3645	1690	31.7
2015	2240	449	16.7	3480	1636	32.0
2016	2744	390	12.4	3834	1167	23.3
2017	2850	236	7.6	3315	651	16.4

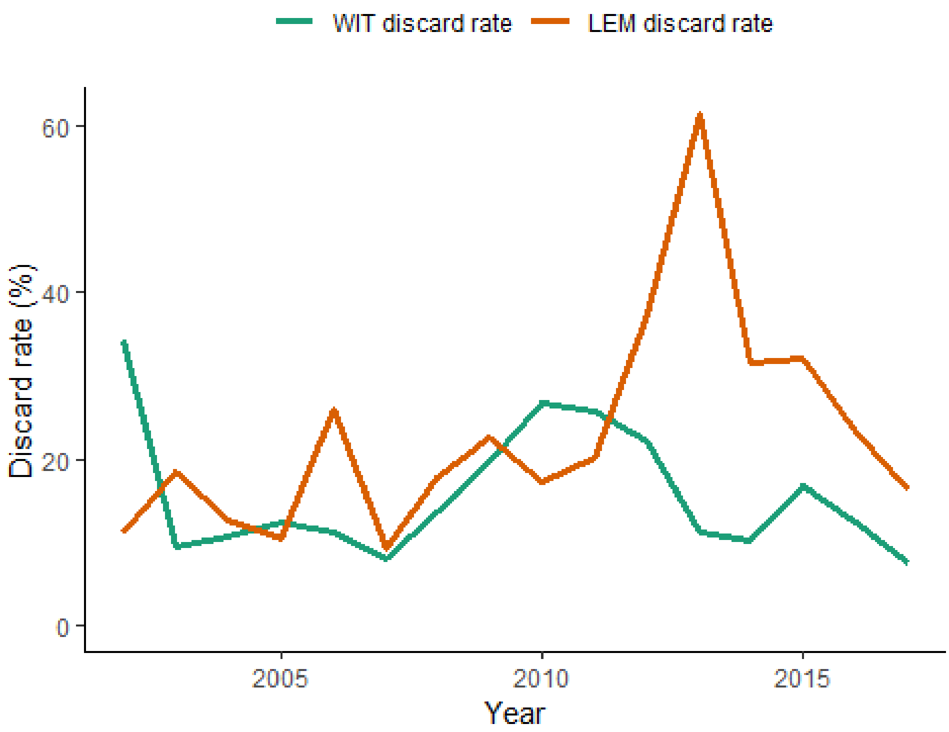


Figure 2.1. Discard rate of witch and lemon sole based on ICES estimates of landings and discards.

Witch

In Subarea 4, lower than 2% of the landings (by volume) of witch are from strata where witch makes up 5% or more of the landings of all species (Figure 2.2). By value the percentage of the landings is slightly higher and for most years less than 3% of the landings value comes from strata where witch makes up 5% or more of the total value of all landings (Figure 2.3). That suggests low or no targeting in Subarea 4. The above contradicts the indication of targeting from the targeting behaviour analysis in Section D, where the diagonal element for witch shows medium interactions (orange cell, Figure D.1). The main fisheries that land witch in Subarea 4 are mainly targeting plaice, cod, haddock and saithe (red boxes in the witch row in Figure D.1).

In area 3.a.N (Skagerrak), there are indications of targeting, as around 10% of the landings of witch (by volume) are from strata that make up 25% or more of witch (Figure 2.2). By value, the effect is stronger around 20% of witch landings come from strata that make up 25% or more witch in all years except 2017 (Figure 2.3).

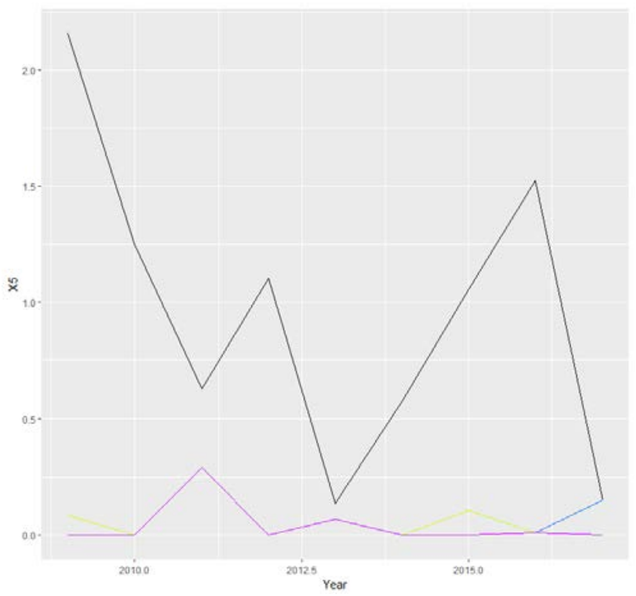
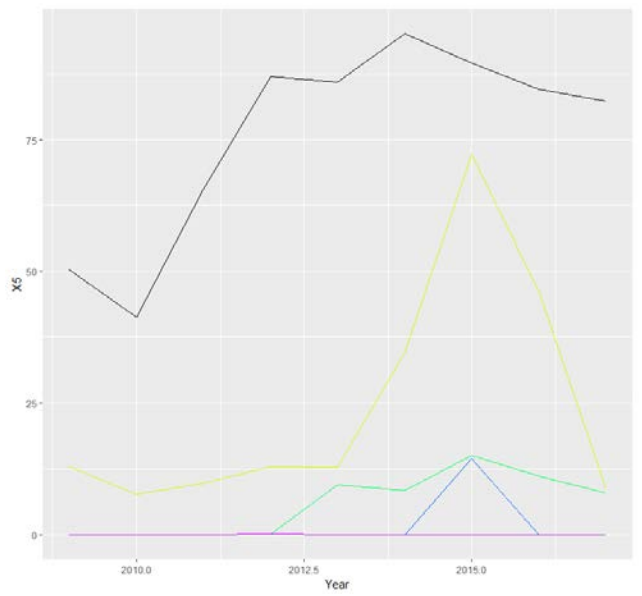
4	3.A
	

Figure 2.2. Percentage of total witch landings (by volume) for those strata for which witch makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by volume), for the period 2009–2017. [Note that 3.A is actually just Subdivision 20 (Skagerrak)]

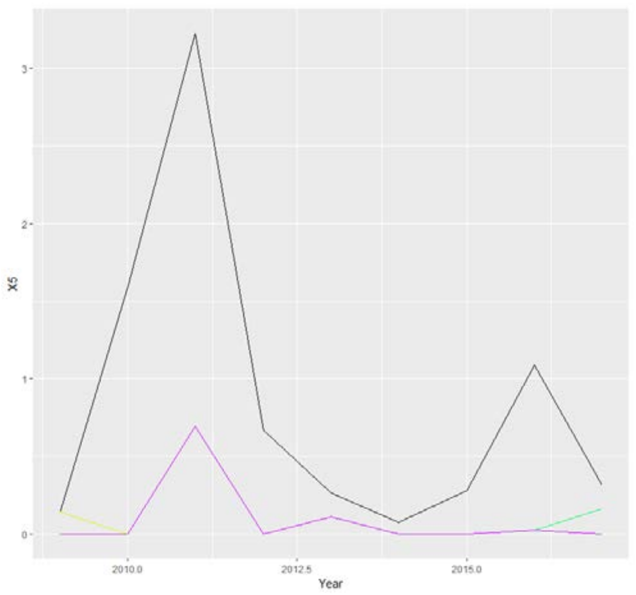
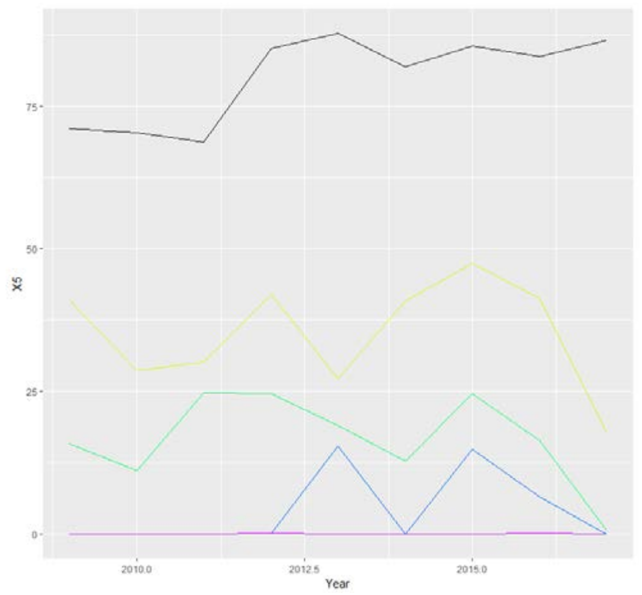
4	3.A
	

Figure 2.3. Percentage of total witch landings (by value) for those strata for which witch makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by value), for the period 2009-2017. [Note that 3.A is actually just Subdivision 20 (Skagerrak)]

Lemon sole

In area 4, and on average during 2009–2017, 30% of lemon sole landings (by volume) came from fishery strata for which lemon sole made up a threshold of 5% or more of all species landings, while the average was less than 5% for all other thresholds considered (15%, 25%, 35%, 45%; Figure 2.4). Around 70% of lemon sole landings came from strata for which lemon sole made up less than 5% of all species landings. By value, around 55% of landings came from strata for which lemon sole made up 5% or more of all species landings, while around 15% came from strata for which lemon sole made up 15% or more of landings (Figure 2.5). That is: in terms of volume in area 4, most lemon sole is landed by fleets for which lemon sole is not a large component of the catch. However, in terms of value, there are parts of the fleet which make a reasonable return on lemon sole landings. This is consistent with the observation that lemon sole is not landed in great numbers, but that there is a high unit value.

The picture is similar in area 3.a (Figure 2.4 and 2.5). In area 7.d, the percentage of lemon sole landings (by volume and value) coming from strata for which lemon sole make up 5% or more of all landings is less than in areas 4 and 3.a, while the higher thresholds are roughly similar – this suggests that in 7.d, the bulk of lemon sole landings come from strata for which lemon sole make up less than 5% of total landings.

In conclusion, lemon sole are a very small part of the landings (by volume) of fleets operating in areas 4 and 3.a, and form an even smaller part of the landings for fleets in area 7.d. The species is of more importance when considered in terms of value, but the income generated is still rather small on average. The Figure in Section D (for area 4) shows that lemon sole landings are most frequently associated with plaice landings. The low association between lemon sole in both rows and columns of this Figure indicates that it is seldom targeted. We also note that less than 10% of lemon sole landings come from the beam trawl fleet (WGNSSK report, ICES, 2018b), which land most of the plaice in area 4, so it would be appropriate to suggest that lemon sole is generally a bycatch species.

We note there is currently no evidence of targeting for lemon sole, either now or in the past. Mortality on lemon sole therefore seems to be driven more by effort towards other species in the key demersal fisheries (bottom trawl with some beam trawl). In this regard, the removal of the lemon sole TAC may not necessarily lead to overexploitation. Until very recently, effort in the demersal fleet has been declining over a number of years. However, this trend has reversed with the implementation of the EU Landing Obligation and associated relaxation in effort restrictions: the landings "top up" has been taken in full with no obvious reduction in discards, so overall effort has tended to increase. Although there is little targeting yet, the effort increase (along with a TAC removal) could have implication for lemon sole mortality.

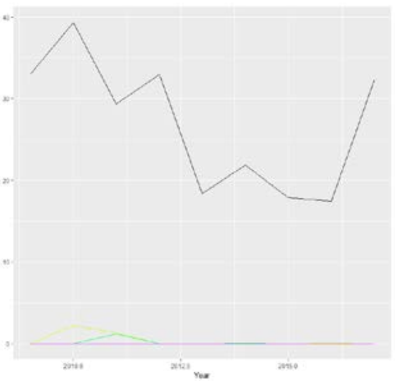
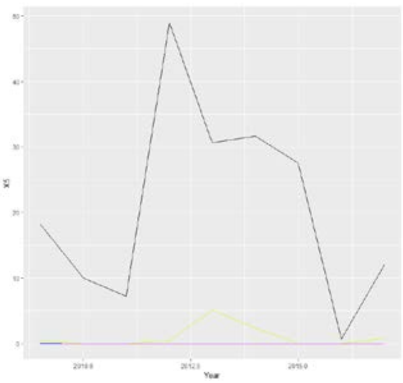
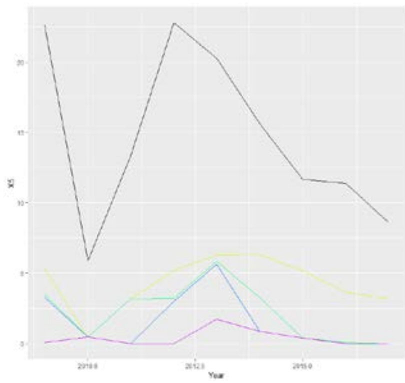
4	3.A	7.D
		

Figure 2.4. Percentage of total lemon sole landings (by volume) for those strata for which lemon sole makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by volume), for the period 2009–2017.

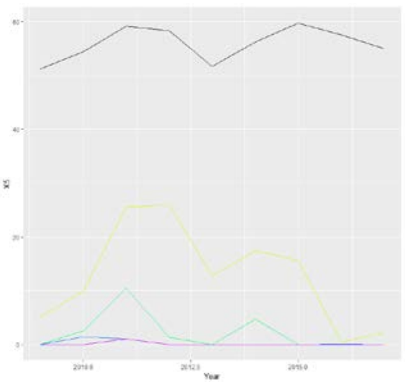
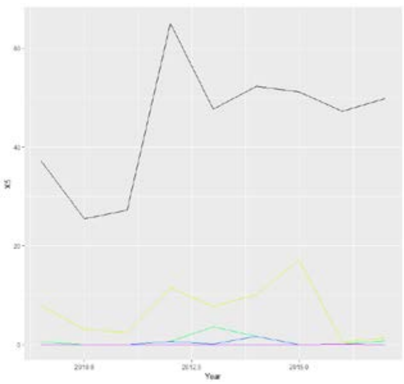
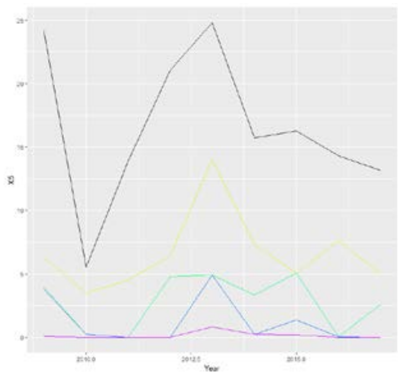
4	3.A	7.D
		

Figure 2.5. Percentage of total lemon sole landings (by value) for those strata for which lemon sole makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by value), for the period 2009-2017.

3. Is the stock of large economic importance or are the species of high value?

Figures 3.1 and 3.2 show respectively the landed value and weight per year for four key flatfish species (witch, lemon sole, sole and plaice) and the three main demersal species (cod, haddock and whiting) for the three areas under consideration (3.a, 4 and 7.d). The data are also summarized in Table 3.1, and for all areas in Figure 3.3. In terms of landed value, sole is the most valuable stock in areas 4 and 7.d, while plaice and cod are the most valuable in area 3.a. In area 4, the landed value of lemon sole is around 1/10th that of sole, while the landed value of witch is around 1/100th that of sole. In area 3.a, the landed value of witch is greater than that of lemon sole, but both are lower than sole, plaice and cod. In area 7.d, sole is by far the most economically valuable stock, with the other species all some way behind.

The landed yields of lemon sole and witch are both very low in comparison with plaice, sole, cod, haddock and whiting. The unit price is relatively consistent across the three areas: sole is the most expensive fish, followed by lemon sole at roughly half the value, cod at around a third, witch flounder at around a fifth, and then plaice, haddock and whiting at roughly 1/10th or less (Table 3.1).

In conclusion, the landed values and yields of lemon sole and witch are generally much less than those of the comparative stocks. Lemon sole commands a high price per unit, but overall the landed quantities are too low for the stock to be of real economic importance across the sea basin. The fishery for witch in area 3.a does provide landed value almost equivalent to sole and haddock in that area, but this is still much less than plaice and cod. For both lemon sole and witch, economic importance is likely to be limited to smaller discrete areas (such as 3.a).

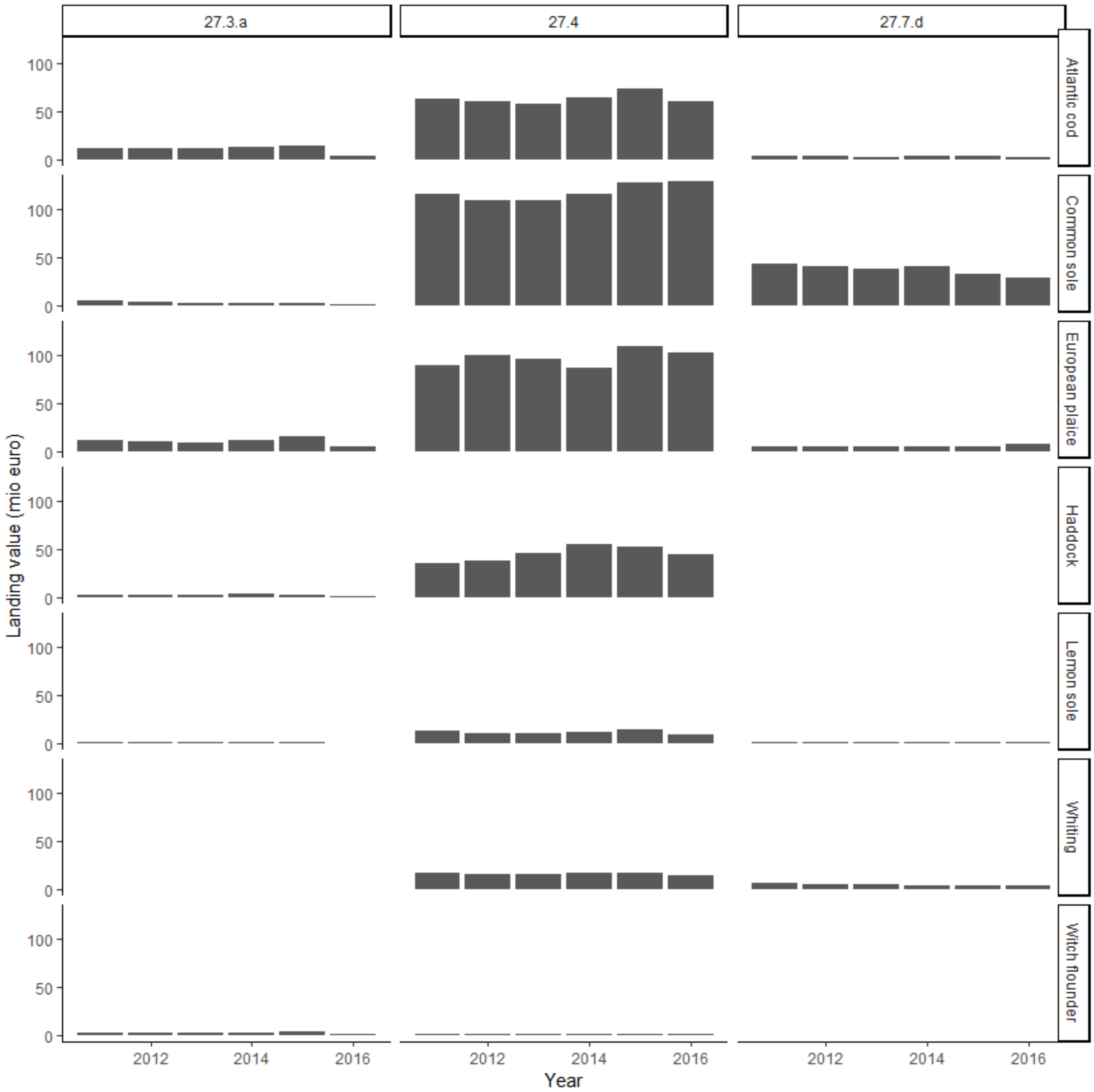


Figure 3.1. Landing value per area for witch, lemon sole, sole, plaice, cod, haddock and whiting.

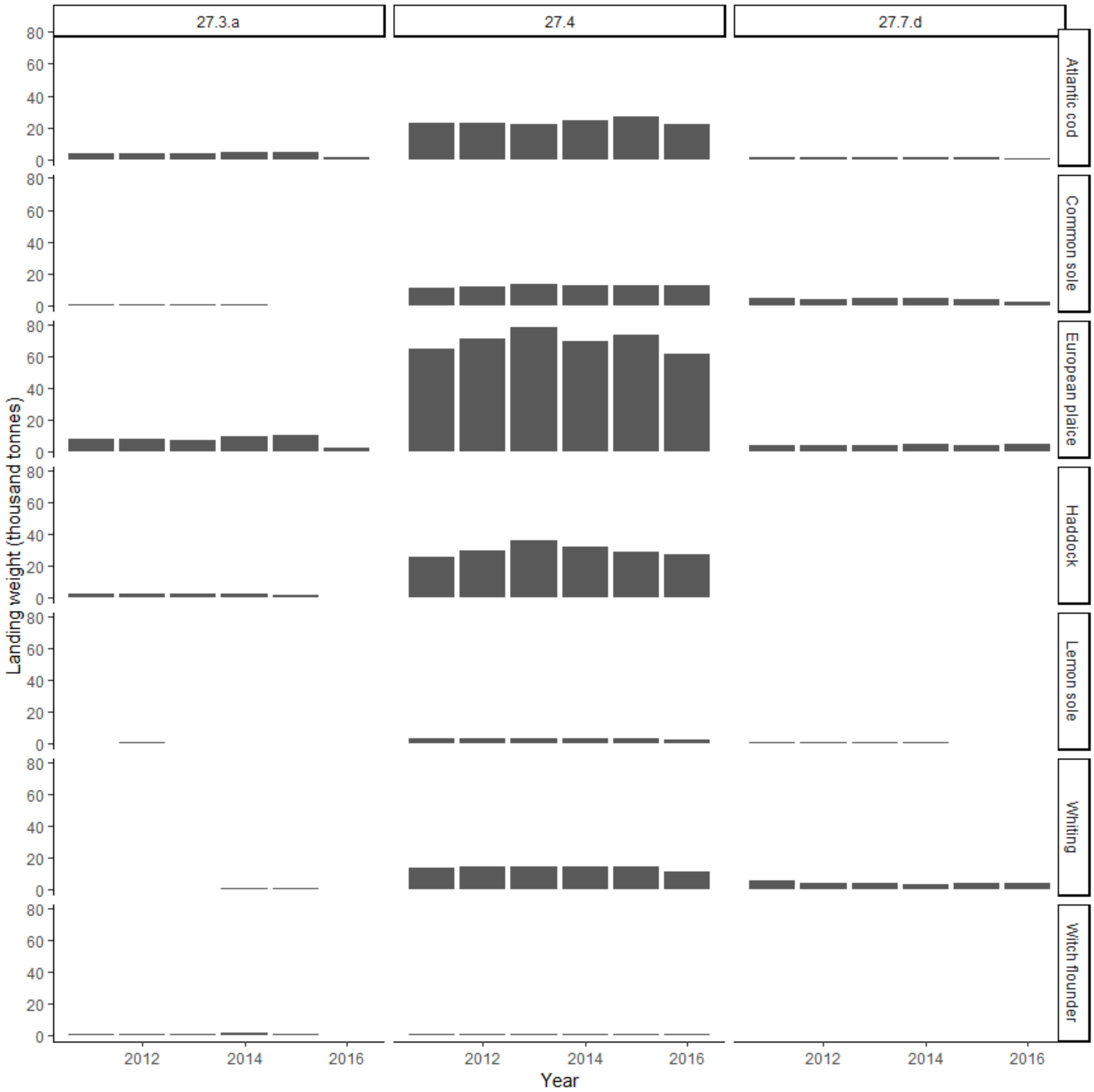


Figure 3.2. Landing weight per area for witch, lemon sole, sole, plaice, cod, haddock and whiting.

Table 3.1. Total value (million euros) and price in euro / kg of witch, lemon sole, sole and plaice in areas 3.a, 4 and 7.d.

Species	Area	Total value	Price
Atlantic cod		65.0	3.08
Common sole		16.3	10.43
European plaice		61.6	1.42
Haddock	27.3.a	15.0	1.63
Lemon sole		7.3	4.50
Whiting		0.9	0.75
Witch flounder		14.9	2.89
Atlantic cod		376.6	2.67
Common sole		706.1	9.64
European plaice		584.8	1.41
Haddock	27.4	270.8	1.52
Lemon sole		70.0	4.00
Whiting		97.1	1.18
Witch flounder		8.3	1.66
Atlantic cod		19.1	2.94
Common sole		222.6	9.63
European plaice		32.3	1.34
Haddock	27.7.d	0.1	1.52
Lemon sole		8.7	4.07
Whiting		29.2	1.21
Witch flounder		0.0	1.97
Atlantic cod		460.7	2.90
Common sole		945.0	9.90
European plaice		678.7	1.39
Haddock	All areas	285.9	1.56
Lemon sole		86.0	4.19
Whiting		127.2	1.05
Witch flounder		23.2	2.17

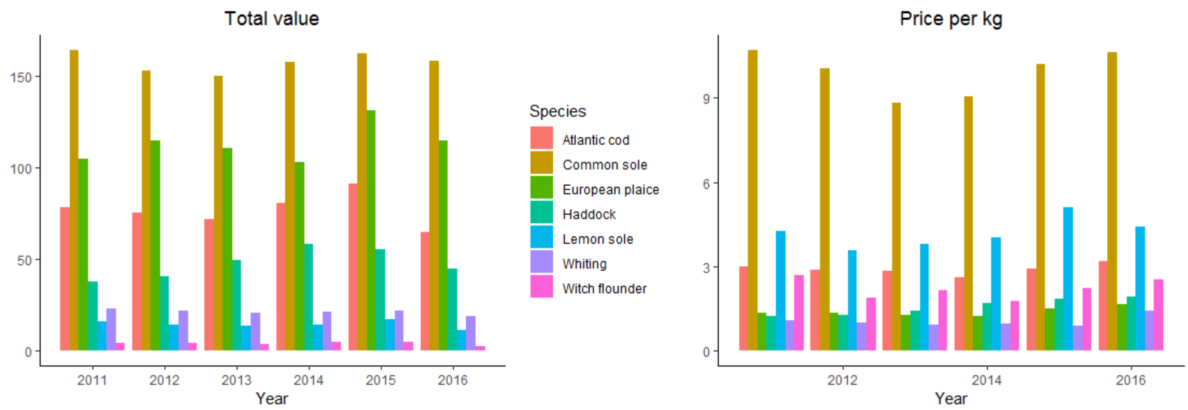


Figure 3.3. Comparison of total value (million euros) and average price (euro per kg) for witch, lemon sole, sole, plaice, cod, haddock and whiting

4. How are the most important fisheries for the stock managed?

Witch and lemon sole are managed under a combined TAC. The TAC area does not coincide with the stock area, which increases the risk of overexploitation of the stocks in the areas outside the TAC area. Witch is since 2018 a Category 1 stock assessed using an age based analytical assessment (SAM). Lemon sole is a Category 3 stock and is assessed with an age-based survey analysis (SURBAR). These new assessments for the two stocks were evaluated and accepted by a benchmark workshop in 2018 (WKNSEA report, ICES, 2018c). Nevertheless, the TAC that is in use for 2018 and 2019 is the one that was set with previous assessments, and ICES advice has not been updated because the perception of the stocks did not change considerably.

Lemon sole are mostly caught by the mixed-species international demersal trawl fishery, with smaller amounts being landed by the corresponding beam trawl fishery. These are currently managed under the EU CFP and related EU-Norway agreements. Management instruments include quota, effort and gear regulations.

5. What are the fishing effort and stock trends over time?

Effort trends

As there is not a specific lemon sole fishery, lemon-sole directed effort cannot be readily identified. Nevertheless, we describe the effort trends for the dominant gears targeting lemon sole and witch.

Since the early 2000s, there has been a large reduction in the effort of the dominant gears in the stock areas for witch and lemon sole (Figures 5.1, STECF 2017b). Since 2003, a large reduction in effort (-51%) of the dominant BT2 gear was observed in subarea 4 (BT2 includes beam trawls with mesh sizes ≥ 80 mm and < 120 mm; Figure 5.1). This reduction corresponds to a substantial reduction in fishing mortality for the main target species of plaice and sole. There have also been reductions in the TR2 and TR1 effort in subarea 4 (albeit smaller for the latter, with a steady increase since 2013). In parallel, since 2003, there was a large reduction in effort of the dominant gear in ICES Division 3.a (TR2, -52%) and in ICES Division 7.d (TR2, -49%) (Figure 5.1).

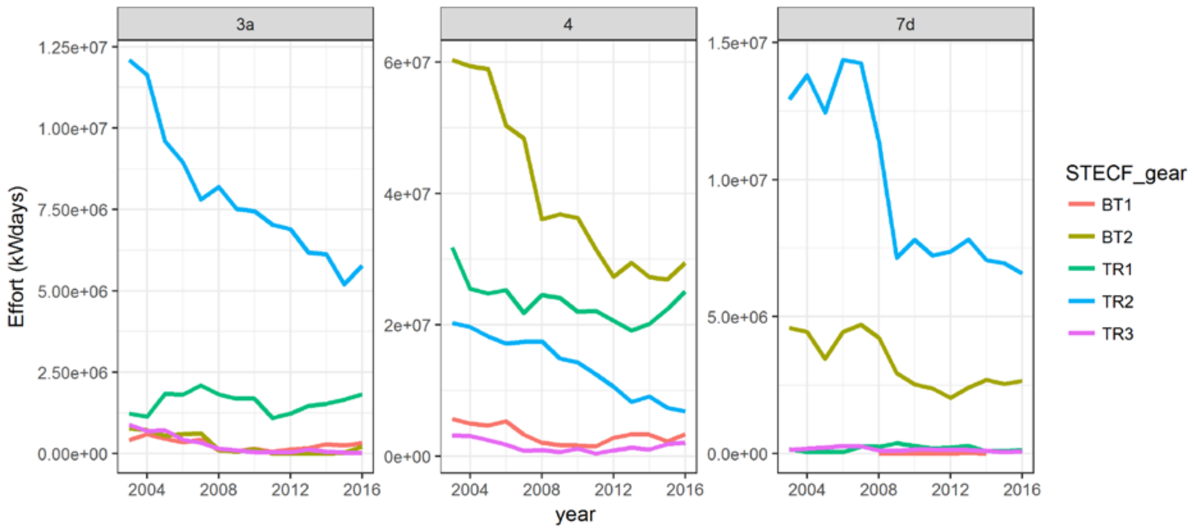


Figure 5.1. Trends in fishing effort for different STECF fishing gear groups in ICES Division 3.a, ICES Subarea 4 and ICES Division 7.d for the period 2003–2016 (STECF, 2017b). Regulated gears: BT1 are beam trawls with mesh sizes ≥ 120 mm. BT2 are beam trawls with mesh sizes ≥ 80 mm and < 120 mm. TR1 are bottom trawl and seines with mesh sizes ≥ 100 mm. TR2 are bottom trawl and seines with mesh sizes ≥ 70 mm and < 100 mm. TR3 are bottom trawl and seines with mesh sizes ≥ 16 mm and < 32 mm.

Stock trends

Witch

The assessment of witch was benchmarked in 2018 (WKNSEA report, ICES, 2018c) where a new assessment using SAM (State-space Assessment Model, Nielsen and Berg 2014) was accepted. The assessment (Figure 5.2) is based on total catch and exploitable biomass index (non-age disaggregated) from the beginning of the time series until 2008, as age specific information is available only from 2009 onwards. An extra burn-in period was added in the beginning of the time series to allow convergence of the parameter estimation; sensitivity analysis of the choice of values for the burn-in period showed no effect on the results.

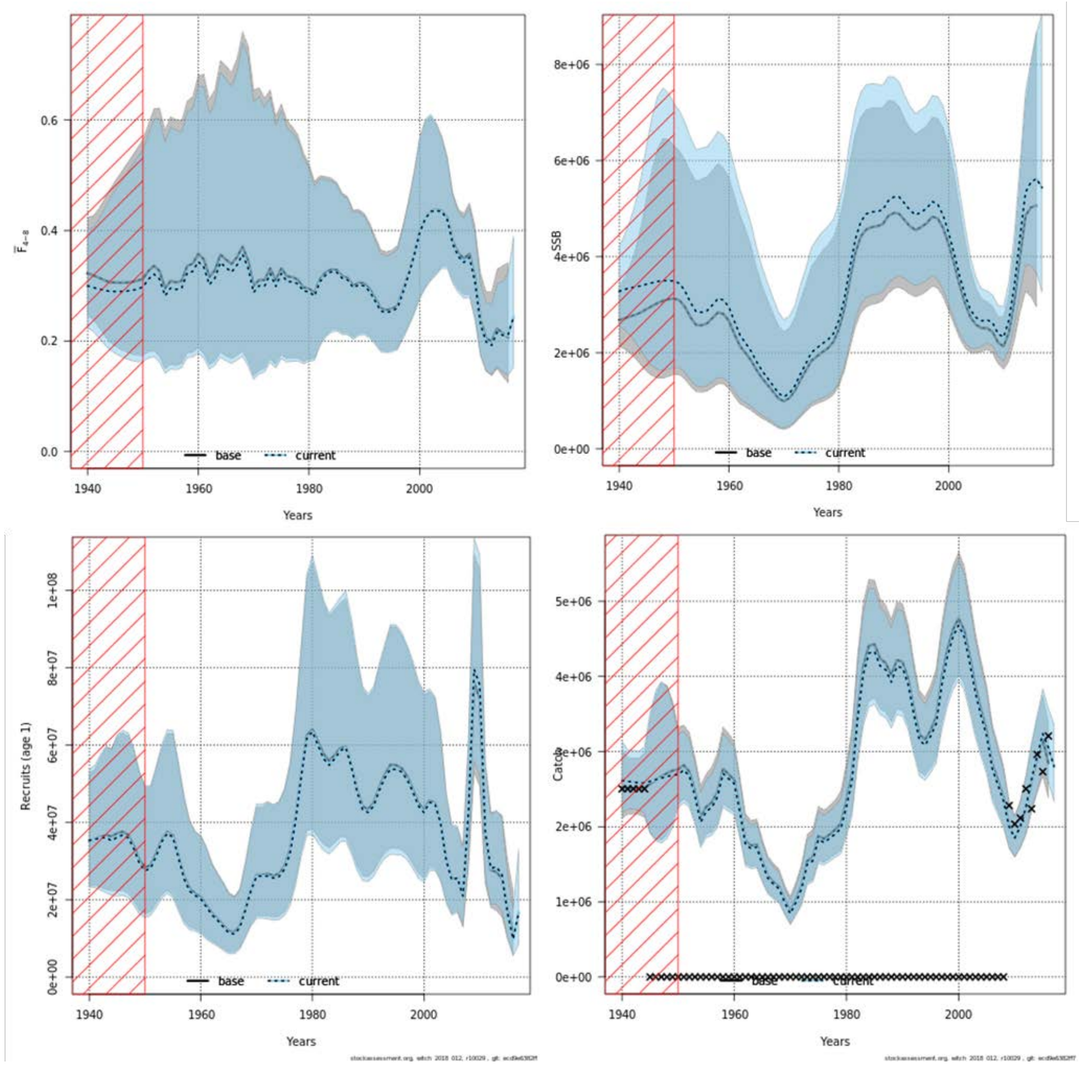


Figure 5.2. Stock summary for witch flounder in Subarea 4 and Division 3.a: Results of the SAM model. Estimates and point wise 95% confidence intervals. The area shaded with red lines is the period prior to the observations, used for initialization. The shaded light blue area and the dotted line is the results from the model using the two new indices of exploitable biomass.

Lemon sole

The lemon sole assessment was benchmarked in 2018 (WKNSEA report, ICES 2018c), and advice is now provided on the basis of a survey-based assessment model SURBAR (Needle 2015). The most recent relative stock trends (WGNSSK report, ICES 2018b) are given in the SURBAR assessment summary in Figure 5.3. Total mortality (mean Z) is uncertain, and firm conclusions about trends in mortality cannot be inferred from this analysis. SSB and total biomass have both increased steadily (albeit slowly) since 2009. However, the estimate of recruitment in 2017 is the lowest in the short time-series, so it is likely that stock abundance will decline over the next few years.

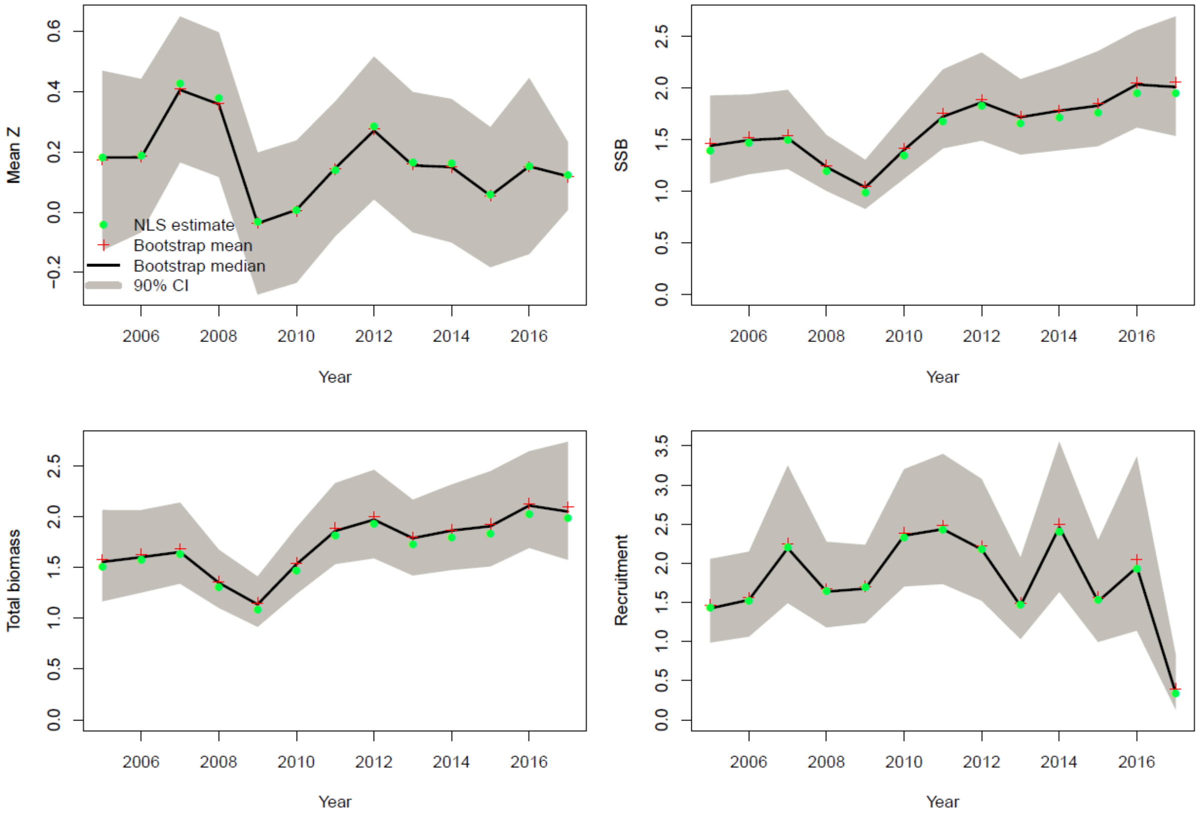


Figure 5.3. SURBAR stock summary for North Sea lemon sole.

6. What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

Although TACs can be considered to have been restrictive (Section 1 of this Annex 11), there is no evidence of significant targeting behaviour in any of the fleets that land witch or lemon sole inside the TAC area, and both stocks can be considered to be by-catch species in the main prosecuting fisheries. The fishing mortalities exerted by these fisheries are therefore almost entirely driven by targeting activity towards other species: for the beam trawl fleet (important for witch), these will be sole and plaice, while for the demersal fleet (important for lemon sole) these will be mixed whitefish species such as cod, haddock and whiting (and in some areas *Nephrops*). In both cases, F_{MSY} for the target stocks has been determined on a single-stock basis, so it is difficult to be certain a) what the resultant multi-fleet effort would be to achieve F_{MSY} across all target stocks, and b) what that would imply for fishing mortality for witch and lemon sole.

The main landing fleet in area 4 for witch is the mixed demersal fleet (WGNSSK report, ICES, 2018b) and it is mostly caught by fleets targeting plaice, cod, haddock and saithe (Figure D.1, Section D). Effort of the plaice fishery fleet has declined in recent years resulting in lower fishing mortality rates. Currently plaice is exploited at around F_{MSY}. Current effort levels do not seem to have a negative effect on witch biomass, as in recent years the biomass of the stock has increased.

For lemon sole, the main landing fleet is the mixed whitefish demersal fleet. The stock assessment for lemon sole extends back to 2007. During the period 2007-2017, estimated fishing mortality rates for the key demersal species (cod, haddock and whiting) have been much lower than historically, and are generally now just above F_{MSY}. We can say therefore that the lemon sole stock has coexisted (and indeed seen an SSB increase) with a demersal fisheries regime that has seen fishing mortality rates a little above F_{MSY}. This indicates that were fisheries managers to be successful in achieving F_{MSY} across the key demersal stocks, then the implied mortality on lemon sole would be lower than that experienced recently (during a time when biomass has increased). It is therefore unlikely that achievement of multi-stock F_{MSY} fishing would adversely affect the lemon sole stock.

Conclusion for witch and lemon sole

Our first conclusion is that continuance of a joint witch – lemon sole TAC is unlikely to contribute to the long term sustainability of either stock. In Section 1 (of this Annex 11) we showed that the combined TAC has been restrictive for most of the available time-series, but it is impossible to determine which (if either) of the two stocks is contributing most to this issue. If TACs are to remain, then they should be implemented for witch and lemon sole separately.

We recommend that single-species TACs for witch and lemon sole be implemented, using (if possible) the same area as currently used for the stock assessments (areas 3.a, 4 and 7.d). The main reasons for this are as follows:

1) The combined TAC has generally been restrictive in the past. While Table 1.1 would suggest that it is lemon sole that is contributing most to this issue, it seems likely that the removal of a TAC for either could lead to an increase in exploitation and therefore mortality.

2) Lemon sole is a high-value species, intermediate in unit price between common sole and plaice. This could also lead to an increase in targeting and overexploitation were the TAC to be removed.

3) In Division 3.a, which is at the moment outside the TAC area, there are indications that witch is to some extent targeted. Removing the TAC could lead to targeting of witch in area 4 and to overexploitation of the stock.

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B. TAC Management for or brill and turbot

Introduction

A Special Request was submitted to ICES by the European Commission to investigate the contribution of TACs to fisheries management and stock conservation. The request in full is as follows:

> *ICES is requested to analyse for a list of stocks (as specified below) the role of the Total Allowable Catch instrument. It is asked to assess the risks of removing TAC for each case analysed in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of other conservation tools in absence of TACs to the requirement that the stock concerned remains within safe biological limits. In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs.*

The stocks from WGNSSK were brill (3a47de), turbot (4), lemon sole (3a47d), witch (3a47d) and whiting (3a). Due to several reasons (data paucity, lack of stock assessor), WGNSSK was unable to undertake the evaluation for whiting. It was agreed with ICES that the main request would be handled by answering a series of six questions originally developed when responding to a similar request for dab and flounder in 2017. The six questions were as follows:

Was the TAC restrictive in the past?

Is there a targeted fishery for the stock or are the species mainly discarded?

Is the stock of large economic importance or are the species of high value?

How are the most important fisheries for the stock managed?

What are the fishing effort and stock trends over time?

What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

This document describes the analysis for brill and turbot, first covering each of the above questions, then providing a concluding section.

Answering the questions for brill and turbot

1. Was the TAC restrictive in the past?

The combined TAC for brill (BLL) and turbot (TUR) has been restrictive in 2007, 2015 and 2016 (average overshoot 220 ± 200 tonnes) (see Table 1.1 and Figure 1.1).

Table 1.1. Overview of TAC and official landings of brill and turbot in the TAC area (2.a and 4)

Year	TAC	SUM landings TUR and BLL	usage of TAC (%)	BLL landings			TUR landings		
	2.a, 4	2.a, 4		2.a	4	Total TAC area (2.a, 4)	2.a	4	Total TAC area (2.a, 4)
2000	9000	5540	62	0	1508	1508	7	4025	4032
2001	9000	5680	63	0	1573	1573	7	4100	4107
2002	6750	5055	75	0	1302	1302	4	3749	3753
2003	5738	4725	82	0	1346	1346	5	3374	3379
2004	4877	4571	94	0	1249	1249	5	3317	3322
2005	4550	4362	96	0	1160	1160	7	3195	3202
2006	4323	4158	96	0	1175	1175	6	2977	2983
2007	4323	4756	110	0	1240	1240	7	3509	3516
2008	5263	4015	76	0	1004	1004	6	3005	3011
2009	5263	4258	81	0	1162	1162	6	3090	3096
2010	5263	4201	80	0	1500	1500	7	2694	2701
2011	4642	4313	93	0	1497	1497	5	2811	2816
2012	4642	4529	98	0	1532	1532	6	2991	2997
2013	4642	4479	96	0	1390	1390	5	3084	3089
2014	4642	4132	89	0.04	1256	1256.04	5	2871	2876
2015	4642	4677	101	0.12	1695	1695.12	4	2978	2982
2016	4488	4679	104	0.041	1526	1526.041	6	3147	3153
2017	5924	4547	77	0.055	1366	1366.055	6	3175	3181
2018	7102								

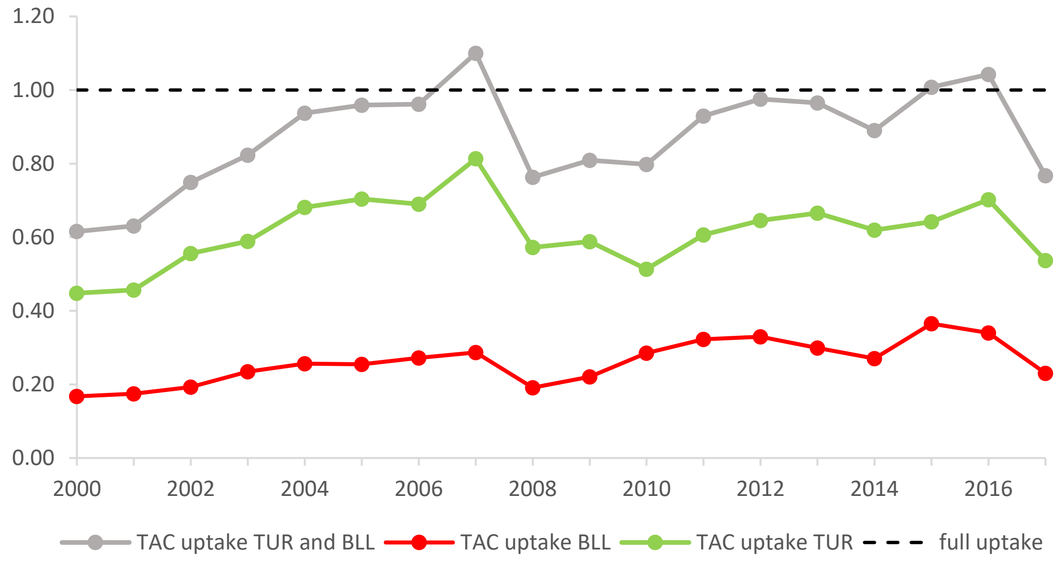


Figure 1.1. TAC uptake for brill and turbot over the period 2000–2017

In 2016, an increase in the catches of turbot and brill was observed and fishers expected an early exhaustion of the quota. In reaction, Dutch producer organisations (POs) decided to increase the Minimum Conservation Reference Size (MCRS) from 27 cm to 30 cm and prohibited landings of the smallest marketable size classes. These measures were updated throughout the year with a further increase to 32 cm and capping the maximum weekly landings to as low as 375 kg per week in October (Table 1.2). In addition, in 2016 several member states asked for an advance of their 2017 quota.

Table 1.2. Measures taken (from 2016 onwards) by the Dutch Producer Organizations to limit the landings of turbot and brill.

Dutch PO-measures			
Year	**Date**	**Max kg per week/trip**	**MLS**
2016	January	-	27 cm
2016	April	-	30 cm
2016	May	-	32 cm
2016	October	375 kg	32 cm
2016	November	600 kg	32 cm
2017	January	-	32 cm
2017	March	800 kg	32 cm
2017	November	2000 kg	30 cm
2018	January	2000 kg	30 cm

Similar to 2016, Member States feared an overshoot of their 2017 quota for turbot and brill, and requested an advance of their quota for 2018. Given the concerns of multiple Member States, an inter-benchmark for turbot was held in 2017 to reconsider input data and improve the assessment, and if warranted, to revise the advice. The inter-benchmark resulted in a new turbot advice for 2018 and 2019 (including an upward revision of the previous 2017 advice), providing a difference of +148% compared to the previous advice (for 2016 and 2017). At the end of 2017, the request of Member States for an advance on their quota for 2018 was nullified and the TAC of 2017 was increased from 4937 tonnes to 5924 tonnes. If there would not have been an upward revision of the 2017 advice, 92% of the TAC would have been fished in 2017. Currently, Dutch POs continue to implement measures (*i.e.* an MCRS of 30 cm and limiting the landings to 2000 kg.wk^{-1}) in order to try and keep the landings within the national quota.

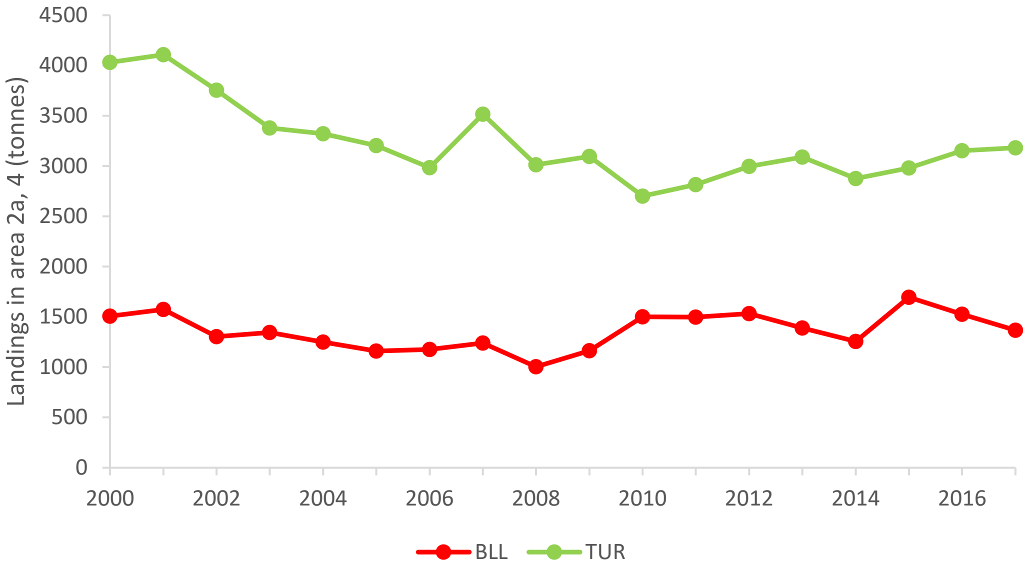


Figure 1.2. The official landings of brill and turbot in the TAC area (2.a, 4).

Management of brill and turbot under a combined species TAC prevents effective control of the single-species exploitation rates. Furthermore, the areas for which the TAC applies are different to those for which the advice is issued. For brill, the stock area includes Subarea 4 and divisions 3.a, 7.d and 7.e. For turbot, the stock area covers only Subarea 4. In addition, the advice for brill concerning catches in the entire stock area is applied to the TAC area (2.a, 4) only without reducing the advice to take into account this difference in area. This could lead to overexploitation of the brill stock, when turbot catches are lower. Table 1.3 shows the official landings in these areas separately. When comparing the landings in the respective stock areas for turbot and brill and the TAC set for the period 2000–2017, the TAC is overshot in 10 out of 19 years.

Table 1.3. Official landings of brill and turbot in their respective stock areas.

Year	TAC	BLL landings					TUR landings	SUM landings TUR and BLL	usage of TAC (%)
	2.a, 4	3a	4	7d	7e	**Total stock area (3.a, 4, 7.d-e)**	4 (= stock area)	for their respective stock area	
2000	9000	142	1508	363	315	2328	4025	6353	71
2001	9000	98	1573	405	333	2409	4100	6509	72
2002	6750	89	1302	358	358	2107	3749	5856	87
2003	5738	129	1346	353	406	2234	3374	5608	98
2004	4877	156	1249	277	389	2071	3317	5388	110
2005	4550	133	1160	242	369	1904	3195	5099	112
2006	4323	139	1175	294	353	1961	2977	4938	114
2007	4323	160	1240	336	407	2143	3509	5652	131
2008	5263	182	1004	250	343	1779	3005	4784	91
2009	5263	146	1162	244	347	1899	3090	4989	95
2010	5263	122	1500	290	409	2321	2694	5015	95
2011	4642	131	1497	271	395	2294	2811	5105	110
2012	4642	120	1532	254	371	2277	2991	5268	113
2013	4642	92	1390	258	347	2087	3084	5171	111
2014	4642	78	1256	284	360	1978	2871	4849	104
2015	4642	145	1695	270	428	2538	2978	5516	119
2016	4488	165	1526	254	466	2411	3147	5558	124
2017	5924	169	1366	215	447	2197	3175	5372	91
2018	7102								

Figure 1.3 shows the landings of brill and turbot in their respective stock areas for which ICES advice is issued. When comparing Figures 1.2 and 1.3, the same trend is observed over this 18-year period as most landings originate from area 4. However, brill landings are higher because a substantial portion of the catch comes from the English Channel area (Table 1.3).

Figure 1.3. Landings of turbot in area 4 and brill in area 3.a, 4, 7.d and 7.e.

2. Is there a targeted fishery for the stock or are the species mainly discarded?

According to ICES estimates, brill and turbot are not heavily discarded, with discard rates below 10% (the exceptions being 16.0% and 16.9% for turbot in 2016 and 2017 respectively; this was the period during which a series of PO measures were instituted to help control catches of turbot – see response to Question 1 above).

Table 2.1. ICES estimates of landings and discards.

Year	Brill in 3a47de			Turbot in 4		
	Landings	Discards	Discard rate	Landings	Discards	Discard rate
2013	1873	103	5.2%	2982	97	3.2%
2014	1920	203	9.6%	2834	158	5.3%
2015	2470	199	7.5%	2922	112	3.7%
2016	2444	204	7.7%	3493	666	16.0%
2017	2207	208	8.6%	3441	698	16.9%

WGMIXFISH data were explored in order to analyse the targeting behaviour of fleets catching brill and turbot; Section D describes the method used.

Brill

When considering Subarea 4, only a very small percentage (< 2%) of total brill landings (by volume) is taken in strata that make up 5% or more of brill (by volume) in their landings (Figure 2.1). However, this percentage increases dramatically in the other areas (Subdivision 20 [indicated as 3.A) and Division 7.d), even for the higher threshold of 45% (colour cyan). The effect is even stronger when considering the analysis by value instead of volume (Figure 2.2). This seems to indicate that targeting of brill does indeed occur in some areas (here, Subdivision 20 and Division 7.d), and that less targeting occurs in the areas where catches are constrained by a TAC (here, Subarea 4). It would therefore be reasonable to assume that if the TAC were to be removed for brill, that targeting behaviour would emerge in Subarea 4.

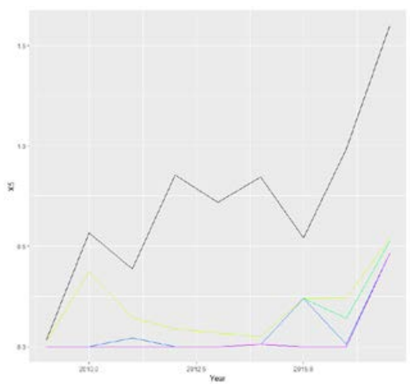
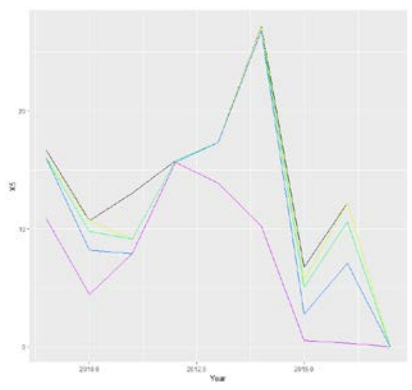
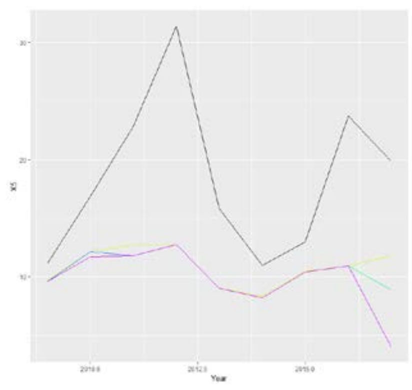
4	3.A	7.D
		

Figure 2.1. Percentage of total brill landings (by volume) for those strata for which brill makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by volume), for the period 2009–2017. [Note that 3.A is actually just Subdivision 20 (i.e. the north-western part of Division 3.a).]

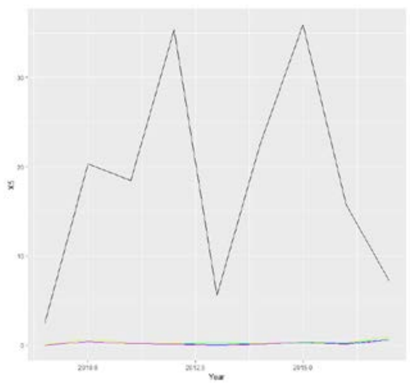
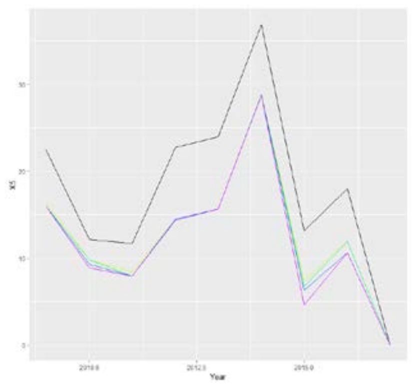
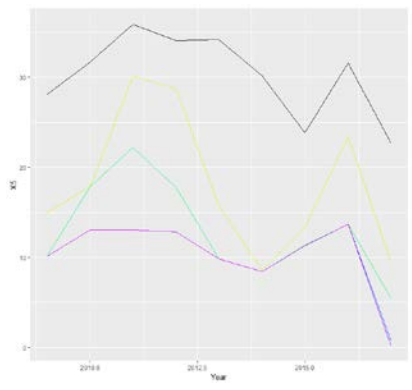
4	3.A	7.D
		

Figure 2.2. Percentage of total brill landings (by value) for those strata for which brill makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by value), for the period 2009–2017. [Note that 3.A is actually just Subdivision 20 (i.e. the north-western part of Division 3.a).]

Turbot

Around 5–10% of total turbot landings (by volume) in subarea 4 occur in strata were turbot comprises up to 45% of landings (by volume) (Figure 2.3), which offers some weak-to-moderate evidence that targeting behaviour is occurring in subarea 4. If considered by value (Figure 2.4), a similar (but slightly stronger) picture emerges. There was already an indication of targeting behaviour from Figure D.1 in Section D (where the diagonal turbot cell was orange).

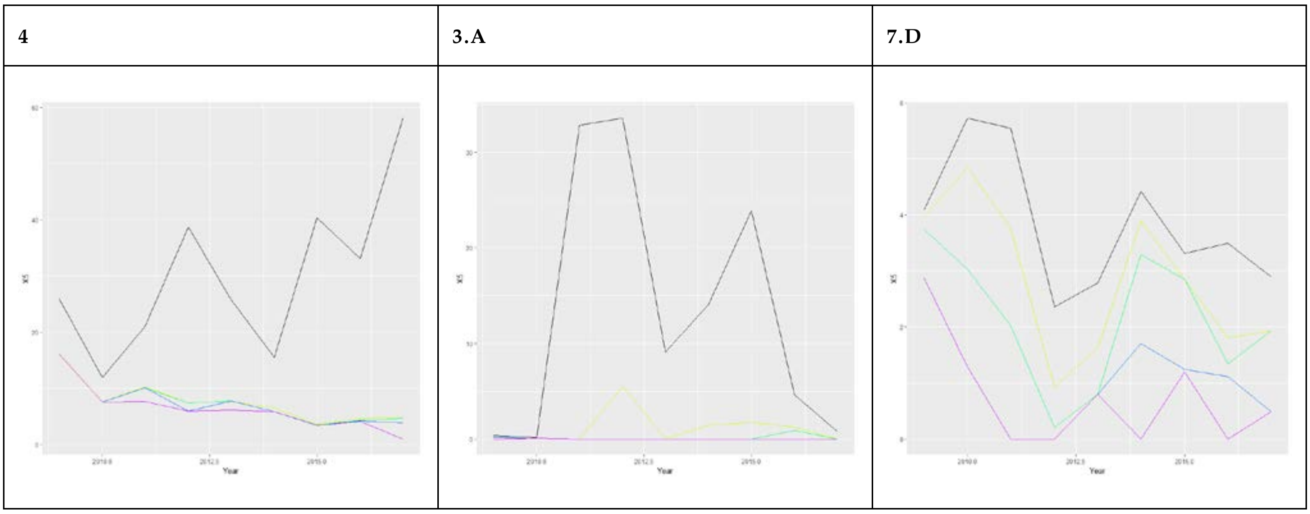


Figure 2.3. Percentage of total turbot landings (by volume) for those strata for which turbot makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by volume), for the period 2009–2017. [Note that 3.A is actually just Subdivision 20 (i.e. the north-western part of Division 3.a).]

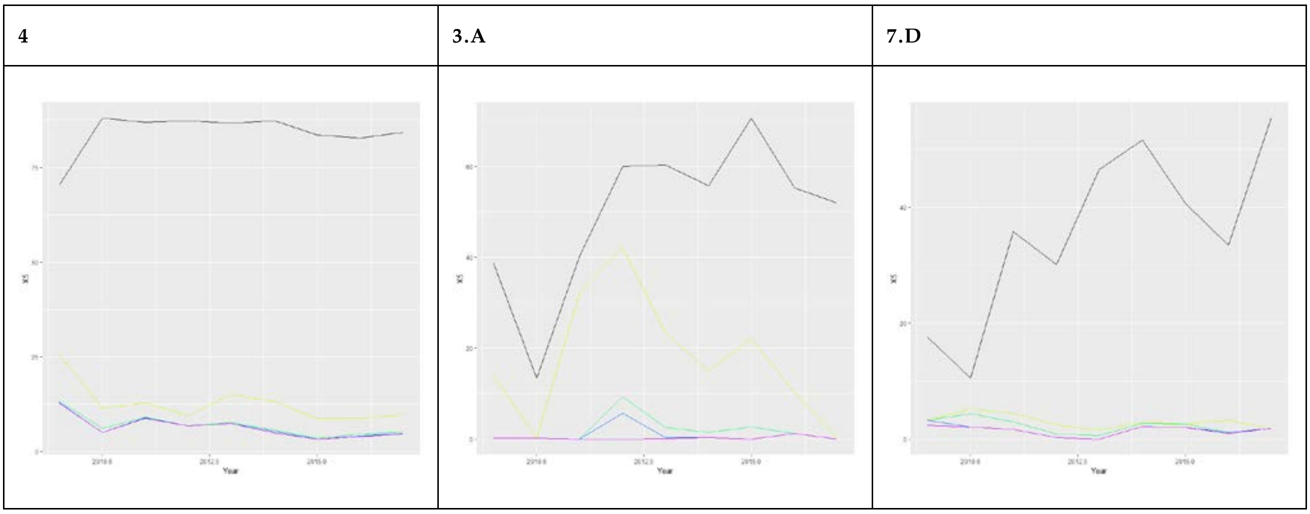


Figure 2.4. Percentage of total turbot landings (by value) for those strata for which brill makes up 5% (black), 15% (yellow), 25% (green), 35% (blue) or 45% (cyan) of the landings of all species (by value), for the period 2009–2017. [Note that 3.A is actually just Subdivision 20 (i.e. the north-western part of Division 3.a).]

3. Is this stock of large economic importance or are the species of high value?

Demersal fishing activities of the Members States bordering the North Sea (i.e. Belgium, Denmark, Germany, France, Netherlands, United Kingdom and Sweden) generate a total landing value of more than €850 million (2012) (EPRS 2018); according to STECF data over €1 billion each year since 2014, not including Norway. The main demersal species contributing to this value are several roundfish species including cod, haddock, saithe and whiting, but also Norwegian lobster, anglerfish and several flatfish species such as sole, plaice, lemon sole and turbot.

There is a clear difference between turbot and brill in the North Sea in terms of total annual landing value (Figure 3.1). In Subarea 4 the total annual landing value of brill has been stable since 2010, generating close to an average of €9 million each year in the period 2008–2016. For turbot the annual landing values appear to vary by year but are in general over or close to €25 million. In the North Sea, turbot is mainly caught by the Dutch, UK and Danish demersal fishing fleet, which contribute almost 85% to the total annual landing value. For brill, the Netherlands followed by Belgium and the UK account for most landings, generating most (~87%) of the total annual landing value. For brill, it is important to note that divisions 7de are also important areas in terms of total annual landing value. In the period 2008 to 2016 the average annual landing value in divisions 7.d and 7.e was €4.9 million.

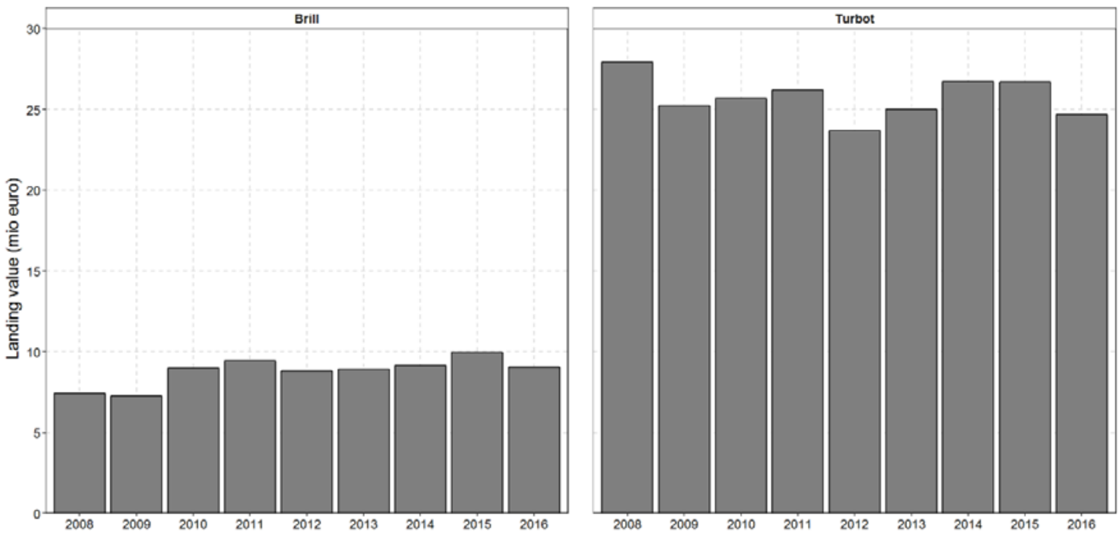


Figure 3.1. Total annual landing value for turbot and brill in the period 2008–2016 for the North Sea (area 4). Data are obtained from STECF - EU Fleet economic performance (STECF, 2017a). Note that Danish data are missing in 2016.

The contribution of turbot and brill to the overall economic value of the demersal fleet in the North Sea is much lower compared to the main target species (sole and plaice). The average annual landing value of sole is approximately €120 million, plaice contributes approximately €90 million (Table 3.1). This is a difference of > 70% and > 90% in economic value for turbot and brill, respectively. The economic importance of plaice is mainly due to the large volume of plaice being caught and landed in the demersal fishery. However, the average price per kg in Subarea 4 for plaice is low (1.42€ kg-1) compared to brill (6.43€ kg-1), turbot (8.86€ kg-1) and sole (9.71€ kg-1) (Table 3.1). In Subarea 4, the average price per kg sole and turbot are quite similar (Figure 3.2). An analysis of sale slips has shown that the average price of the largest market class of turbot can fetch a higher price than the largest market class of sole (Rijnsdorp *et al.*, 2012). This can be related to the higher prices allocated to larger fish and the different periods within a year (Rijnsdorp *et al.*, 2012; Zimmermann and Heino, 2013). In this context, turbot can certainly be regarded as a highly valuable species.

Table 3.1. The average total annual landing value and average price per kg for plaice, sole, turbot and brill in areas 3.a, 4 and 7.d and 7.e.

Species	Sub region	Total value (€)	Price (€ kg-1)
Plaice	3.a	10 738 463	1.43
Brill	3.a	536 129	5.02
Sole	3.a	3 441 382	10.34
Plaice	4	89 475 053	1.42
Brill	4	8 783 682	6.43
Turbot	4	25 763 584	8.86
Sole	4	119 990 782	9.71
Plaice	7.d-e	6 797 860	1.46
Brill	7.d-e	4 377 351	7.51
Sole	7.d-e	43 177 937	10.01

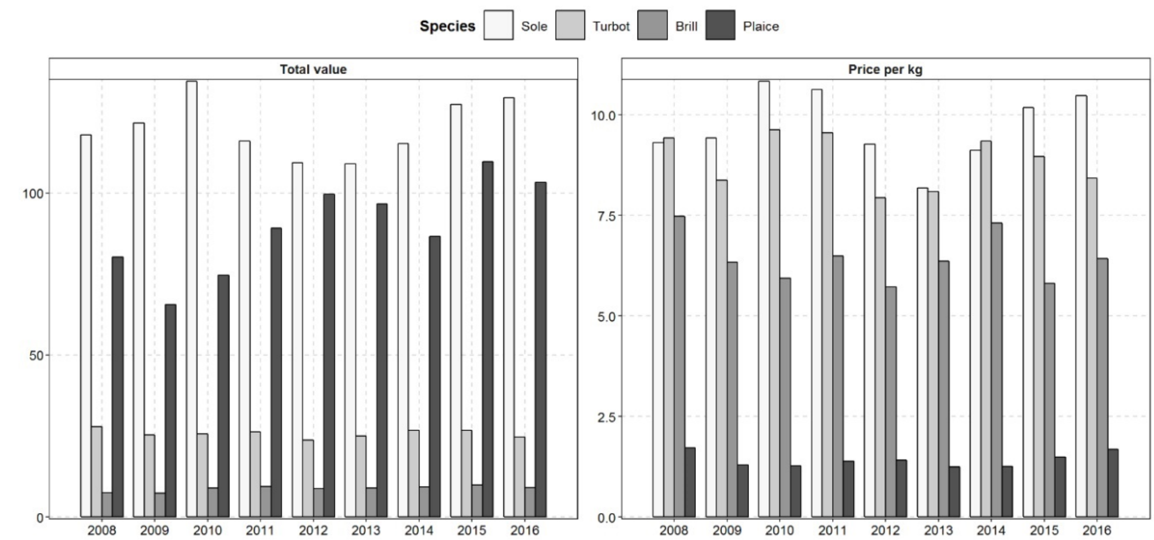


Figure 3.2. Comparison of the total annual landing value and value per kg landed sole, plaice, turbot and brill in the period 2008–2016 for the North Sea. Data are obtained from STECF - EU Fleet economic performance (STECF, 2017a). Note that Danish data are missing in 2016.

4. How are the most important fisheries for the stock managed?

The most important fleet catching flatfish in the North Sea mixed demersal fisheries is the beam-trawl fleet using small mesh (80–99mm, BT2). The main target species of this fleet is plaice (landing 53% of the wanted catch from the North Sea and Skagerrak in 2017) and sole (landing 89% of the wanted catch in the North Sea in 2017). While turbot and brill are mainly by-catch species in this fleet, the BT2 gear is responsible for 70% of turbot in the North Sea, and 65% of brill landings in the North Sea, Skagerrak and Kattegat and the English Channel. The most important gear types that are used to fish turbot and brill are beam trawls (TBB), otter trawls (OTB) and passive gears including trammel-nets and gillnets (GTR/GNS), yielding approximately 65%, 20% and 11% of the landings, respectively. There are no specific regulations concerning these gear types when fishing these stocks.

Plaice and sole are both managed under the Common Fisheries Policy (CFP) using an MSY approach whereby a total annual catch (TAC) is used to regulate the exploitation rate for each species individually. The EU has proposed a multiannual plan (MAP) for the North Sea covering demersal fish stocks. The MAP should act as a roadmap to ensure the sustainable exploitation of stocks in a mixed fisheries context (EU, 2016). For sole, the EU MAP is being finalized, but not yet adopted. Nevertheless, ICES catch advice for sole is based on F_{MSY} ranges, as specified in the EU MAP. Plaice is a shared stock with Norway, and because the EU MAP has not been agreed for shared stocks, it is not used as a basis for the advice. Within the ICES framework, both stocks are categorized as Category 1, i.e. ICES provides annual advice using an analytical assessment. Also, for both target species, there is a European restriction on landing size (27 cm for plaice and 24 cm for sole).

In contrast to the single species TACs for the main target species, turbot and brill are managed under a combined TAC. Within the ICES advisory framework, turbot is a Category 1 stock (upgraded during IBP turbot 2018 meeting; ICES, 2018a) and brill is a Category 3 stock, i.e. "*stock for which survey-based assessments indicate trends*" (ICES, 2016). For turbot, an age-based is used because more commercial and survey data are available. For brill, only commercial data are available and used to perform a commercial trends-based assessment. Although, there is no European restriction in landing size for turbot and brill, some authorities and producer organisations have introduced a minimum conservation reference size (MCRS) in order to regulate quota uptake and market prices. The most frequently applied MCRS for brill and turbot is 30 cm (e.g. in the Netherlands, Table 1.2) and 32 cm (e.g. in Belgium).

5. What are the fishing effort and stock trends over time?

Effort trends

Since the early 2000s, there has been a large reduction in the effort of the dominant gears in the stock areas for brill and turbot (figures 5.1 and 5.2, STECF, 2017b). The North Sea (ICES Subarea 4) accounts for the major part of the brill landings (on average 63% of the landings from 2000–2017). Since 2003, a large reduction in effort (-51%) of the dominant BT2 gear was observed in Subarea 4 (BT2 includes beam trawls with mesh sizes ≥ 80 mm and < 120 mm; Figure 5.1). This reduction corresponds to a substantial reduction in fishing mortality for the main target species of plaice and sole (see Table 6.1). In parallel, since 2003, there was a large reduction in effort of the dominant gear in ICES Division 3.a (TR2, -52%) and in ICES Division 7.d (TR2, -49%) (Figure 5.1).

In ICES Division 7.e, there was a 31% decrease in effort the dominant gear OTTER (Figure 5.2). These bottom trawls and seines with mesh sizes ≥ 70 mm and < 100 mm (TR2), or for OTTER in Division 7.e, otter trawls with all mesh sizes, are the dominant gear in these areas and are important gears catching brill and turbot (approximately 20% of the landings; see Question 4).

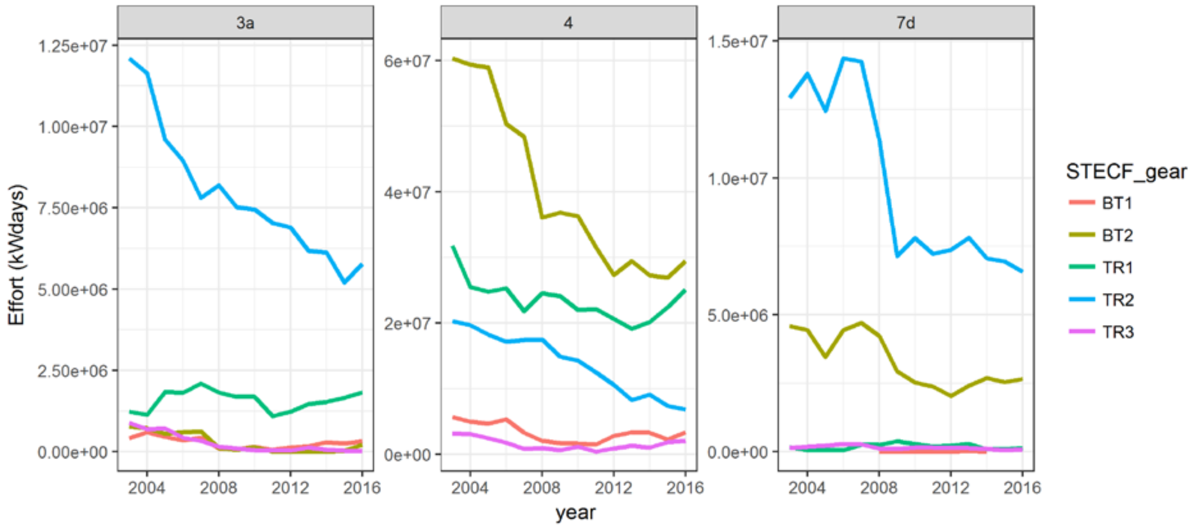


Figure 5.1. Trends in fishing effort for different STECF fishing gear groups in ICES Division 3.a, ICES Subarea 4 and ICES Division 7d for the period 2003–2016 (STECF, 2017b). Regulated gears: BT1 are beam trawls with mesh sizes ≥ 120 mm. BT2 are beam trawls with mesh sizes ≥ 80 mm and < 120 mm. TR1 are bottom trawl and seines with mesh sizes ≥ 100 mm. TR2 are bottom trawl and seines with mesh sizes ≥ 70 mm and < 100 mm. TR3 are bottom trawl and seines with mesh sizes ≥ 16 mm and < 32 mm.

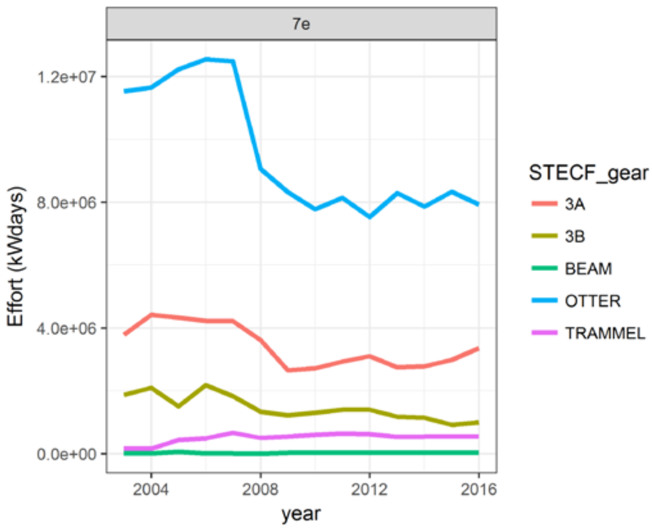


Figure 5.2. Trends in fishing effort for different STECF fishing gear groups for ICES Division 7.e for the period 2003–2016 (STECF, 2017b). Regulated gears: 3.A are beam trawls with mesh sizes ≥ 80 mm. 3.B are gill nets, entangling nets or trammel nets ≤ 220 mm. BEAM are beam trawls with mesh sizes < 80 mm or missing mesh size. OTTER are otter trawls all mesh sizes. TRAMMEL are trammel nets with mesh sizes > 220 mm or missing mesh size.

In line with these observations of decreasing effort, a decreasing trend in fishing mortality and an increasing trend in biomass for brill and turbot was observed during this time frame (Figures 5.4 and 5.5), as shown below.

Stock trends

Brill follows the framework for category 3 stocks, which includes stocks for which survey indices are available that provide reliable indications of trends in stock metrics such as mortality, recruitment and biomass (ICES, 2012). Turbot has been upgraded to a Category 1 stock following the 2018 inter-benchmark for turbot (ICES, 2018a).

For brill, the standardized lpue from the Dutch beam-trawl fleet (vessels > 221 kW) is available as a reliable biomass index (kg d^{-1}) (Figure 5.3). The advice is based on a comparison of the two most recent index values with the three preceding values and then multiplied by the recent advised catch. In June 2017, stock trends were perceived to be increasing (ICES advice for brill, published in 2017).

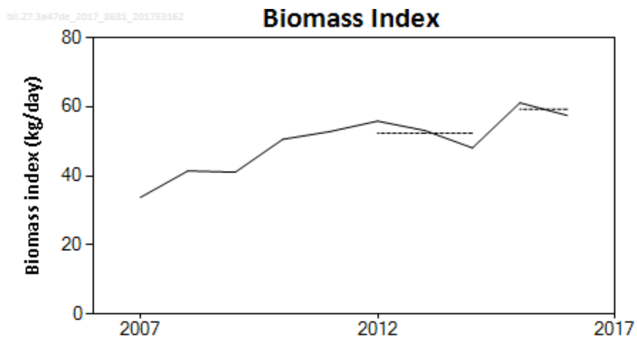


Figure 5.3. Standardized lpue index from the Dutch beam trawl fleet (vessels > 221 kW) as used in the advice issued in June 2017.

During WGNSSK 2017, a Surplus Production Model in Continuous Time model (SPiCT, Pedersen and Berg, 2017) was used to estimate MSY proxy reference points. A fishery independent survey time series (BTS_ISI_Q3), a standardized lpue index from the Dutch beam-trawl fleet (with vessels > 221 kW), and a catch time series (1987–2016) were used as input for the model. The results (Figure 5.4) suggest that the relative fishing mortality is below the reference $F/F_{MSY} = 1$ proxy and the relative biomass is well above the reference $B/B_{MSY} = 0.5$ proxy.

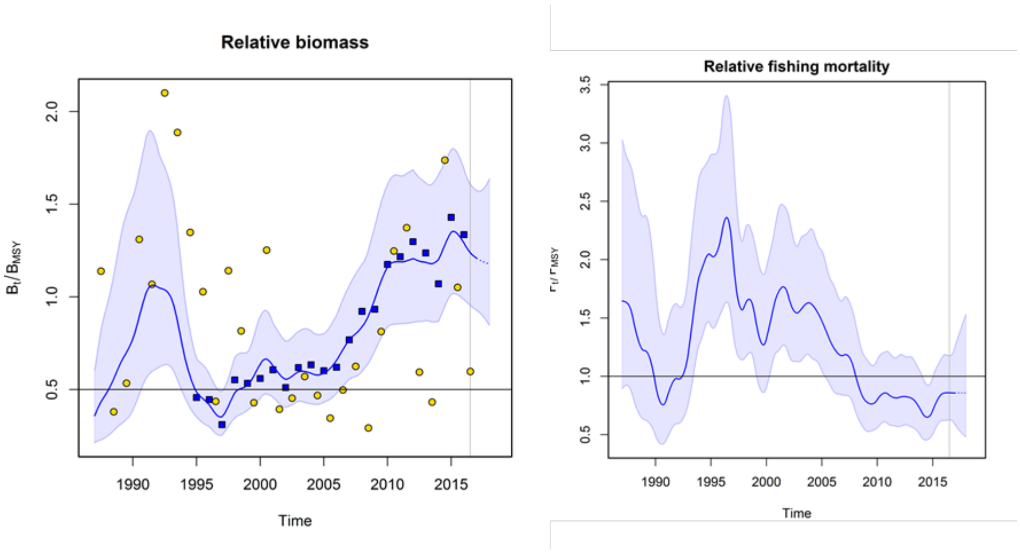
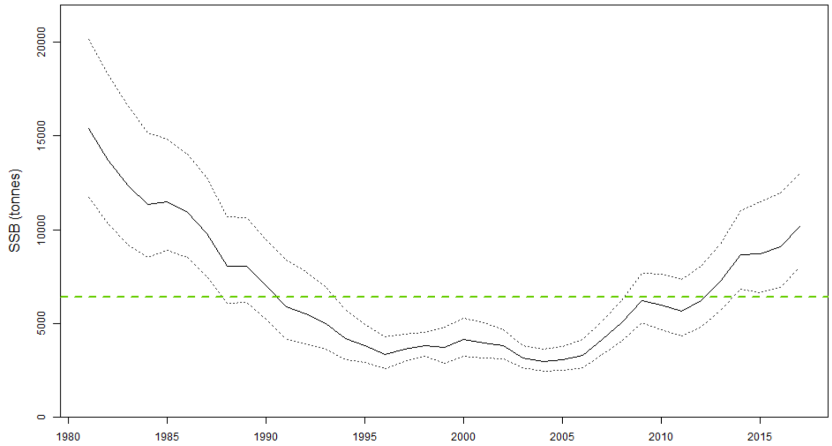


Figure 5.4. Estimation of relative biomass and relative fishing mortality from the SPiCT analysis over time (WGNSSK 2017 report, ICES, 2017a). The symbols in the relative biomass plot indicate observed biomass indices (blue squares = standardized lpue from the Dutch beam trawl fleet with vessels > 221 Kw, yellow dots = BTS_ISI_Q3). The shaded areas in both plots indicate 95% confidence intervals. The horizontal lines indicate levels relative to the MSY $B_{trigger}$ and F_{MSY} proxies.

Turbot in Subarea 4 was inter-benchmarked in 2017 (ICES, 2017b), and again in 2018 (ICES, 2018a). Age information is mainly derived from the age composition of Dutch (1981–1990, 1998, 2003–present) and Danish (2014–2017) commercial landings. In addition, two fisheries-independent indices, i.e. SNS and BTS-Isis surveys, as well as one standardized commercial biomass index (Dutch_BT2 fleet) are included. The long-term trend in this age-aggregated fisheries-dependent biomass index has the most weight in estimating the final biomass trend in the assessment. Similar to brill, the advice for turbot given in 2017 (for 2018 and 2019) was based on the 2 over 3 rule, but applied to the age-based assessment (from the 2017 inter-benchmark meeting) and multiplied by the recent catch. During the 2018 inter-benchmark meeting, a new assessment configuration was defined for turbot and the stock was upgraded to Category 1, with a new set of reference points estimated. This new assessment shows that fishing mortality has decreased since the early 2000s and has been stable at just below F_{MSY} since 2012 (Figure 5.5). An increasing trend in SSB has been estimated for turbot since the mid-2000s, and the stock has been above MSY $B_{trigger}$ since 2013 (Figure 5.5).



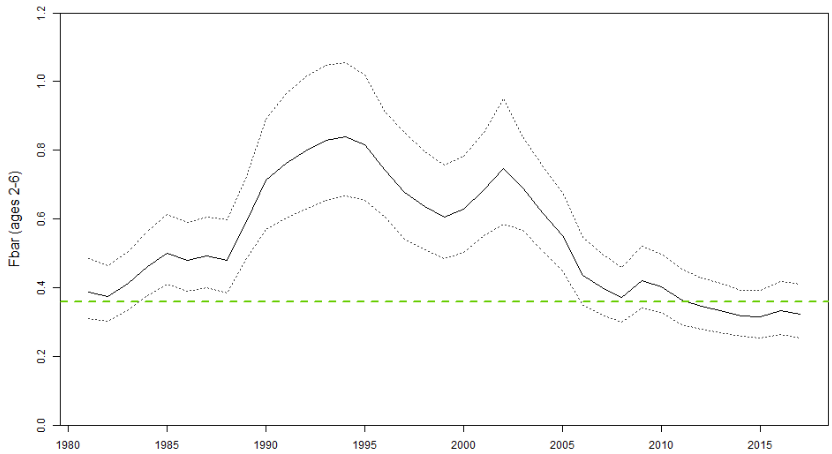


Figure 5.5. Fishing mortality (left panel) and Spawning Stock Biomass (SSB) (right panel) for turbot (IBP turbot 2018 meeting; ICES, 2018a), with 95% point-wise confidence bounds. The hashed lines indicate MSY $B_{trigger}$ (6387 t) and F_{MSY} (0.36).

6. What maximum effort of the main fleets can be expected under management based on F_{MSY} ranges for the target stocks, and has the stock experience similar levels of fishing effort before?

There is evidence that targeting occurs for turbot and brill (see Question 2), and furthermore that although turbot and brill are mainly by-catch species in the fleet targeting flatfish (plaice and sole) in the North Sea mixed demersal fisheries using the BT2 gear, this gear is only responsible for 70% of turbot and 65% of brill landings (Question 4), and other gears are also important (otter trawls and passive gears). It is also clear for brill that targeting occurs to a greater extent in areas not constrained by a TAC, which implies that were the TAC to be removed for Subarea 4 and Division 2.a, targeting behaviour would emerge or strengthen for turbot and brill. There are therefore serious reservations about whether managing the target stocks, plaice and sole, within their respective F_{MSY} ranges, would be sufficient to control fishing mortality on turbot and brill in the absence of TACs for the latter. Nevertheless, we have made an attempt to answer this question.

The analysis included most recent official landings, ICES catch estimates and assessment results of plaice, sole, turbot and brill (ICES WGNSSK report, ICES, 2018b). Effort information was extracted from the Fisheries Dependent Information (FDI) database of STECF (STECF, 2017b). We chose to use only the effort information from the main fleet targeting turbot and brill, being the beam trawl fleet using smaller mesh sizes (BT2) targeting plaice and sole. Note that effort information was available from 2003 to 2016 (Table 6.1).

The turbot assessment allows the estimation of the average F at age ($F_{bar2–6}$). For brill, however, such information is lacking. For both stocks, the relative stock trends are related to possible changes in effort of the fleets targeting plaice and sole, which may occur, for example, when fishing is increased to the upper bound of the F_{MSY} range (ICES WGNSSK report, ICES, 2018b; Table 6.2). Given that F_{bar} can be estimated for turbot, a linear regression was applied between estimated fishing mortalities for plaice, sole and turbot and the effort of the main fleet catching turbot (BT2). This analysis allows one to investigate the potential increase in effort and potential impact on the stock when fishing at the upper bound of the F_{MSY} range. Note, however, that a linear relationship between F and effort was assumed; this assumption may not hold true if fishing patterns or selectivity changes.

Table 6.1: Estimated catch (tonnes; ICES WGNSSK report, ICES, 2018b), effort (kW days × 10^5; BT2 – main fleet; STECF, 2017b), catch per unit effort (CPUE) based on total catch and BT2 effort data for brill, turbot, sole and plaice, and assessment estimates of F for plaice, sole and turbot.

	Catch				Effort	CPUE				$F_{bar(2–6)}$		
Year	Brill	Turbot	Sole	Plaice	(STECF area 3b2)	Brill	Turbot	Sole	Plaice	plaice	sole	turbot
2003			19284	144327	603			31.95	239.15	0.57	0.57	0.69
2004			21110	116041	594			35.55	195.44	0.48	0.56	0.62
2005			17696	109869	590			30.01	186.34	0.39	0.55	0.55
2006			13588	119860	504			26.98	238.00	0.33	0.51	0.44
2007			15506	89255	484			32.05	184.50	0.30	0.46	0.40
2008			14616	94825	361			40.53	262.92	0.25	0.43	0.37
2009			15213	100265	368			41.32	272.33	0.22	0.42	0.42
2010			14849	106402	362			40.96	293.53	0.20	0.44	0.40
2011			13188	107939	315			41.81	342.17	0.20	0.44	0.37
2012			14130	132898	273	8.88		51.69	486.14	0.21	0.39	0.35
2013	1976	3079	15256	117769	295	7.37	10.45	51.79	399.79	0.21	0.32	0.33
2014	2123	2992	14628	122762	273	7.65	10.97	53.64	450.17	0.21	0.26	0.32
2015	2669	3034	14630	124395	269	9.82	11.26	54.31	461.79	0.20	0.23	0.32
2016	2648	4159	15347	123122	294	8.90	14.12	52.12	418.10	0.20	0.22	0.33

Table 6.2. Fishing mortalities for plaice and sole at different scenarios for F_{MSY} and mixed fisheries options.

	F_{2017}	Current F_{MSY}**	Upper bound F_{MSY} **	Lower bound F_{MSY} **	Highest observed $F_{(2-6)}$**
Plaice	0.199	0.21	0.30	0.146	0.72 (1998)
Sole	0.22	0.202	0.367	0.113	0.66 (1997–1999)

****WGNSSK report (ICES, 2018b).**

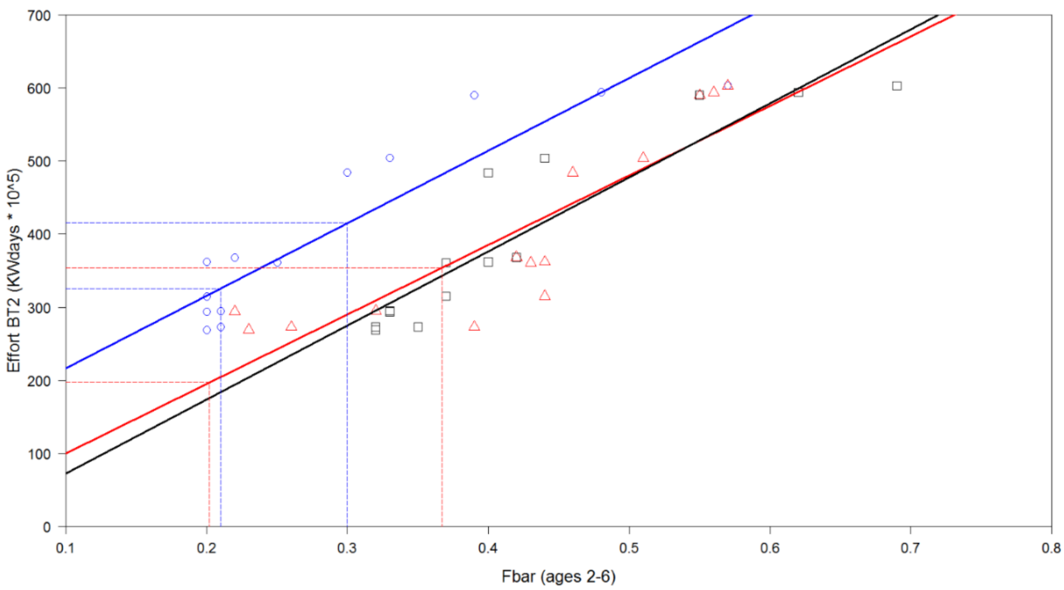


Figure 6.1. Relation between plaice (blue), sole (red) and turbot (black) fishing mortality (F) and effort (KW-days x 10^5; BT2). Solid lines represent linear regressions, dashed lines display F_{MSY} and $F_{MSY\ upper}$ values for plaice and sole. Plaice: effort x 10^5 = 117.2 + 993.5 x F (R^2 = 0.83); Sole: effort x 10^5 = 4.996 + 950.873 x F (R^2= 0.74) and Turbot: effort x 10^5 = -28.81 + 1013.25 x F (R^2 = 0.83).

From 2003 to 2005, turbot experienced high fishing mortalities (range: 0.55 to 0.69; but high values occurred before this – see Figure 5.5), correlating with high values of fishing effort observed in the BT2 fleet (R^2 = 0.83, Figure 6.1). The impact of these high Fs are reflected in the strong declines Spawning Stock Biomass (SSB) in the first part of the time series (Figure 5.5). The SSB remained low and continued to decrease during the 1990s and 2000s, reaching the lowest value (2974 tonnes) in 2004. From 2003 onwards, the effort of the BT2 fleet gradually decreases resulting in lower mortalities for plaice, sole as well as turbot (Table 6.1). However, as our analysis of Question 2 showed, there may be some targeting on turbot and brill, which means our analysis is likely missing effort associated with the fishing mortality for both species.

Under the assumption of a linear relationship between F and effort, the effort at F_{MSY} (0.21) for plaice would be 326 KW days x 10^5 and would be 415 KW days x10^5 at the upper range of F_{MSY} (0.3); for sole this would be 197 KW days x 10^5 and 351 KW days x 10^5, respectively (Figure 6.1). Fishing at the upper bound of the F_{MSY} range would correspond to an increase in effort of 41% for plaice and 19% for sole compared to the effort in 2016. Before 2010, fishing effort was higher than 351 x 10^5 KW days corresponding to the effort at the upper level of the F_{MSY} range of sole; this effort would be below the levels observed when the SSB of turbot and biomass index of brill started to increase (Figure 6.2 and 6.3). For plaice up to 2007, fishing effort was higher than 415 x 10^5 KW days corresponding to the effort at the upper level of the F_{MSY} range; 2007 was also the year when the SSB for plaice and sole were at or around their lowest in the time series, just before starting to increase (Figure 6.4). Around this time, the SSB for turbot as well as the biomass index for brill are still low and just starting to recover. This indicates that returning to levels of effort associated with the upper bound of the F_{MSY} range for plaice may result in a biomass reduction for both stocks. Furthermore, managing the mortality for the main target species does not directly imply the mortality for the by-catch species is regulated in a similar manner, especially when knowing some targeting may occur.

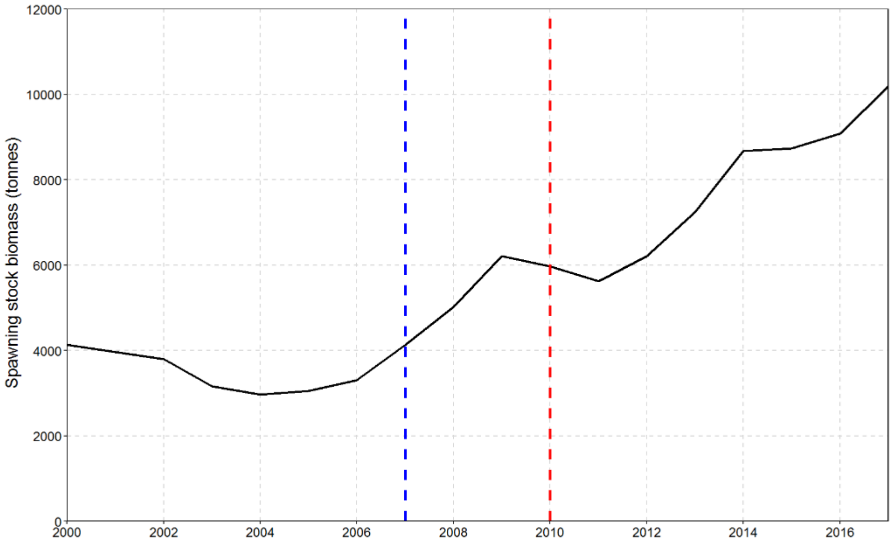


Figure 6.2. The estimated Spawning Stock Biomass (SSB) for turbot in the period 2000–2017 (black line). The vertical lines denote the first year at which the effort of the BT2 fleet was below the fishing effort corresponding to the upper level of the F_{MSY} range for plaice (blue) and sole (red).

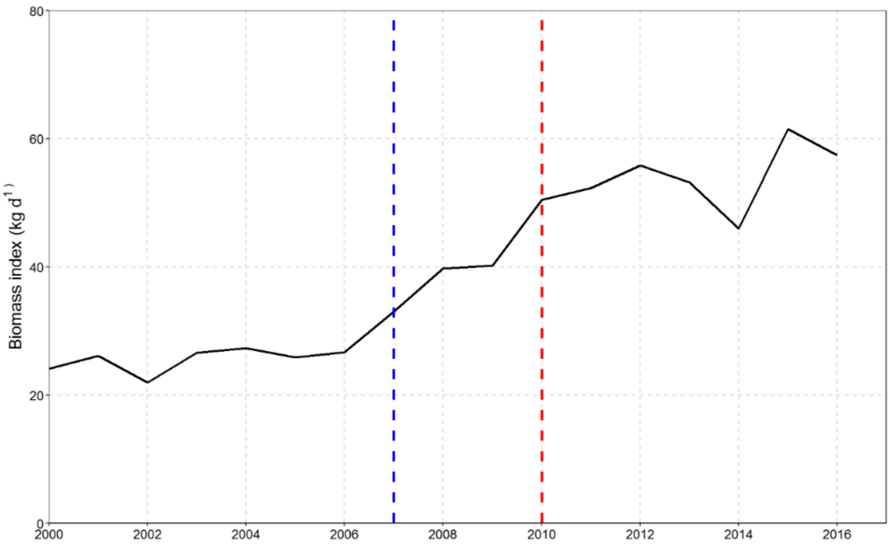


Figure 6.3. The estimated Biomass index (kg d-1) for brill in the period 2000–2017 (black line). The vertical lines denote the first year at which the effort of the BT2 fleet was below the fishing effort corresponding to the upper level of the F_{MSY} range for plaice (blue) and sole (red).

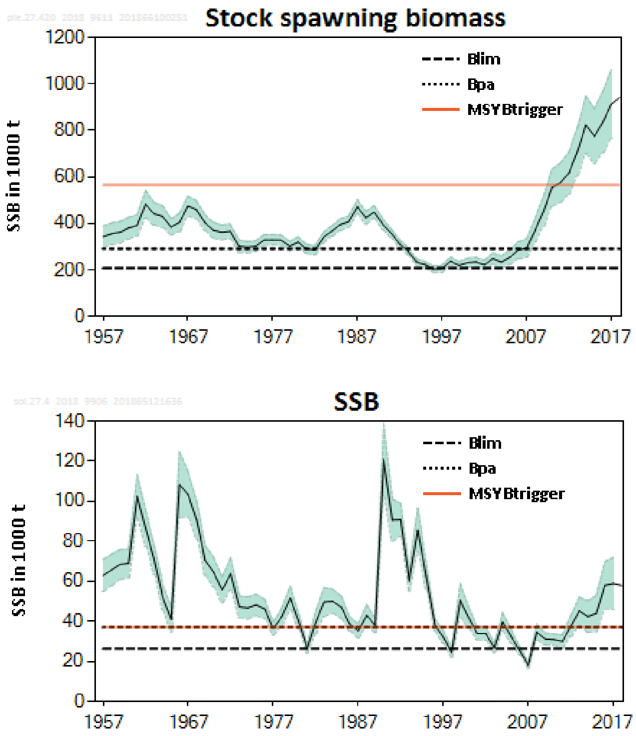


Figure 6.4. SSB trends for plaice in Subarea 4 and Subdivision 20 (left) and sole in Subarea 4 (right) (from ICES advice for each stock, published in June 2018).

Conclusion for brill and turbot

The general conclusion is that we cannot recommend the removal of the TAC for brill and turbot. In fact, we strongly recommend that a separate TAC be set for brill and turbot, and that the TAC set for brill should match the stock area better (i.e. in addition to subarea 4, include divisions 3a, 7d and 7e; note that catches in Division 2a are negligible for both stocks, so inclusion of this area does not seem problematic, even though it is not part of the stock area for either stock). This is because management of brill and turbot under a combined TAC prevents effective control of the single-species exploitation rates and could potentially lead to the overexploitation of either species.

This general conclusion relies on several factors:

(a) The joint TAC for brill and turbot is sometimes restrictive when considering only Subarea 4 and Division 2.a, but even more so when considering the other areas for brill that are not currently covered by a TAC. Furthermore, PO measures are needed (limiting minimum landings size and weekly landing capacity per trip) in order to control fishing pressure on brill and turbot (e.g. during 2016 and 2017) so as to keep within the TAC.

(b) Both brill and turbot are high-value species when considering their value per kg, and their substantial contribution to the total value of the demersal mixed-fishery sector.

(c) There is evidence of targeting for both species, with targeting behaviour differences for brill in the different areas indicating that were the TAC in Subarea 4 to be lifted, then targeting is highly likely to increase substantially in Subarea 4, particularly given the value of these species.

(d) The potential for a change in targeting behaviour for brill and turbot with the removal of a TAC indicates that a reliance on managing the main target species (plaice and sole) to within their F_{MSY} ranges would not be an effective tool for controlling fishing pressure on brill and turbot.

For these reasons, removing the TAC for brill and turbot may severely compromise the ability of managers to keep both stocks within safe biological limits in the short- and medium-term.

With regard to what other conservation tools could be used in the absence of TACs to keep the stocks within safe biological limits, there are many possibilities (minimum landing size, gear restrictions, effort restrictions, etc.), but without targeted research to investigate how effective these measures would be, we cannot make any recommendations in this regard.

With regard to possible approaches to contribute to inter-annual stability of TACs, we already have such measures within the ICES advisory system, whereby TACs are set biennially and are not allowed to vary by more than 20% for Category 3–6 stocks (unless the application of an additional -20% precautionary buffer is warranted). TAC constraints are currently not considered for Category 1 stocks unless they have been evaluated as part of a management strategy/plan – such constraints could be considered for turbot (now a Category 1 stock).

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C. TAC Management for whiting in 3.a

Introduction

A Special Request was submitted to ICES by the European Commission to investigate the contribution of TACs to fisheries management and stock conservation. The request in full is as follows:

ICES is requested to analyse for [whiting (Merlangius merlangus) in Division 27.3.a (Skagerrak and Kattegat)] the role of the Total Allowable Catch instrument. It is asked to assess the risks of removing TAC for each case in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of other conservation tools in absence of TACs to the requirement that the stock concerned remains within safe biological limits.

In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs.

It was agreed with ICES that the main request would be handled by answering a series of six questions originally developed when responding to a similar request for dab and flounder in 2017. The six questions were as follows:

1. Was the TAC restrictive in the past?
2. Is there a targeted fishery for the stock or are the species mainly discarded?
3. Is the stock of large economic importance or are the species of high value?
4. How are the most important fisheries for the stock managed?
5. What are the fishing effort and stock trends over time?
6. What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

This document gives qualitative answers for some of the above questions and does not answer some of them due to lack of available information. The information here is collated from the whiting 3.a stock annex and the WGNSSK 2017 report.

General information about the stock

There is a paucity of information on the population structure of whiting in Division 3.a (the Skagerrak-Kattegat area). No genetic or otolith-based surveys have been conducted. Tagging of whiting has previously been undertaken, but these data need to be re-examined. Results from previously modelled survey data (SURBAR) were inconclusive regarding independent population dynamics in Division 3.a in comparison with the North Sea (ICES, 2016), presumably due to the need of age readings in 3.a (age information used in SURBAR was borrowed from Subarea 4). 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. There are also findings of locally spawned whiting eggs in Kattegat 3.aS. Furthermore, there are differences in growth and consumption dynamics between whiting in the Western Baltic area and the North Sea which may indicate stock separation (Ross *et al.*, 2018, Ross *et al.*, 2016).

Whiting in Skagerrak and Kattegat is mainly caught by Denmark, with significantly lower catches by Sweden and Norway. Around 60% of the catch comes from the Danish small-mesh industrial fisheries and the rest comes from the international demersal trawl fleet.

The landings of whiting have declined from over 10 000 tonnes in the 1980s and early 1990s to few hundred tonnes in recent years, with a minimum of 63 tonnes in 2012. The cause of the decrease is not clear. Since mid-1970 until now several changes in management of the fisheries in Division 3.a such as changes in permitted mesh-sizes, in by-catch regulations, in the fishing fleet and in the fishery. In the 1970s and 1980s the demersal human consumption mainly targeted fish where the fishery the latest 25 years especially in the Kattegat is targeting *Nephrops* where fish species are caught as by-catch. The small meshed fishery was in the 1970s and 1980s at an annual level on 200–250 000 tonnes. The annual level for the last 15 years has been around 20 000 tonnes. Introduction of by-catch restrictions have also taken place. A decline of the stock biomass cannot be ruled out.

Since 2003, there is discard information available. The discard rate seems to have increased during that period and was on average 57% of the catch in the period 2014–2016, but with large interannual fluctuations. There may have been variable and significant un-registered discard over time in different fisheries and areas. This is also partly due to not all fisheries have been equally well covered by discard sampling – and discard sampling intensity has varied over the years. This aspect should be explored further, especially considering the introduction of landing obligation which is expected to affect catch patterns of whiting in the area.

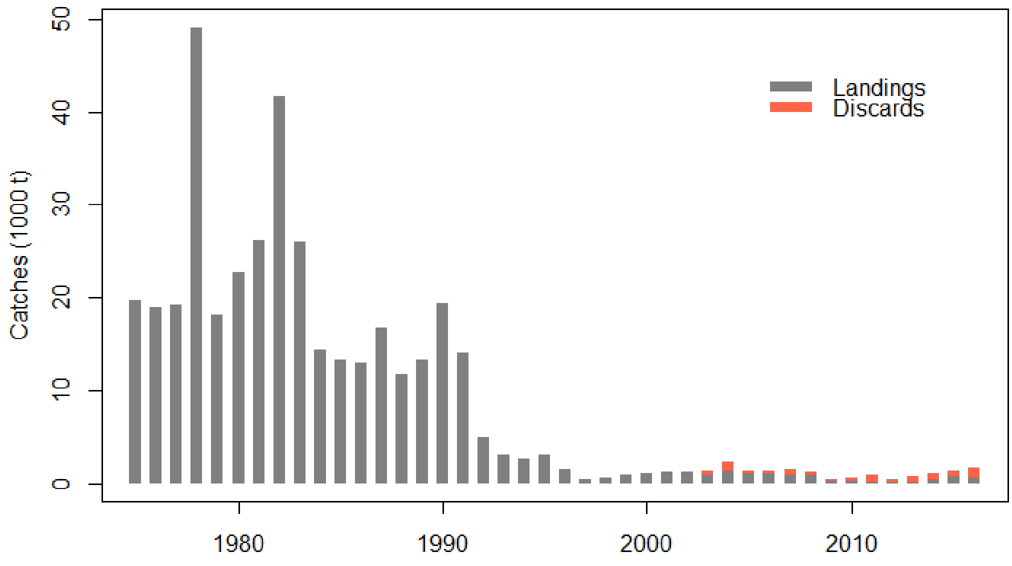

Figure 1. Landings (grey) and discards (red) of whiting in Skagerrak and Kattegat.

Whiting in Division 3.a is a category 5 stock (ICES, 2012) and has no analytical assessment and no reference points. Advice is given based on the precautionary approach. The latest TAC advice is 400 tonnes was given in 2017 and is effective for 2018 and 2019. The agreed TAC has been 1050 t since 2008.

There are several survey time series for this stock, but ICES concluded in 2017 that the lack of internal consistency in the available survey indices (by age) prevents analytical assessment (ICES, 2017). This internal inconsistency could be related to a) age reading problems, and/or b) a mixture of several stock components leading to unaccounted migrations.

Answers to the questions for whiting in Division 27.3.a

Was the TAC restrictive in the past?

Landings in the period since 2003 have been lower than the (landings) TAC; however catches (landing + discards) exceed the TAC in 2015 and 2016.

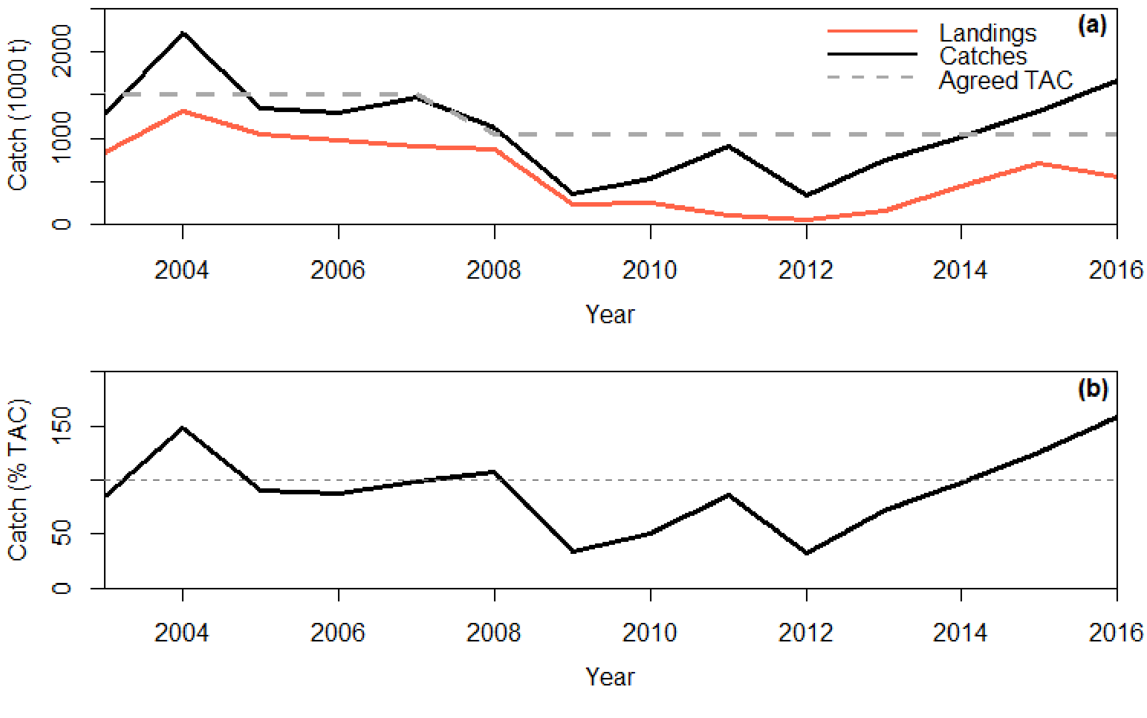

Figure 2. (a) Landings (red solid line) and catches (black solid line) and agreed TAC (grey dashed line) of whiting in Skagerrak and Kattegat. (b) The catch is shown as percentage of the agreed TAC.

2. Is there a targeted fishery for the stock or are the species mainly discarded?

There seems to be no targeted fishery for the stock.

3. Is the stock of large economic importance or are the species of high value?

The stock is of low economic value. The total value of the human consumption landings in the period 2011–2016 were from 100,000 to 300,000 € (STECF, 2017) and the average price in the same period was under 1€/kg.

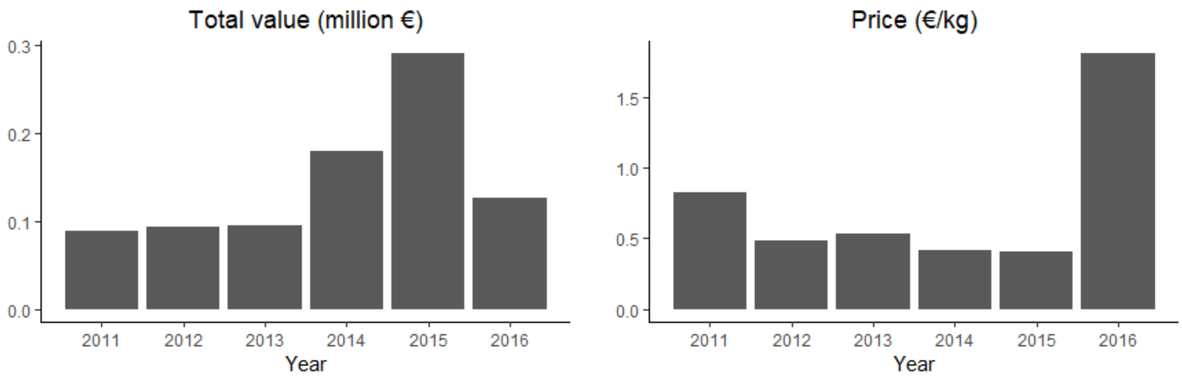

Figure 3. Total value (million €) and price (€/kg) of whiting in Skagerrak and Kattegat.

4. How are the most important fisheries for the stock managed?

Whiting has for the last 25 years been caught as by-catch in the demersal human consumption trawl fishery and the small meshed fishery for sprat, sandeel and Norway pout. Since 1983, the EU fisheries has been managed in accordance with the EU CFP and in accordance with the EU – Norway agreement on the management of shared stocks. There has since until now been implemented several changes in management of the fisheries in Division 3.a such as changes in permitted mesh-sizes, in by-catch regulations, in the fishing fleet and in the fishery.

In the 1970s and 1980s, the demersal human consumption mainly targeted fish where the fishery for the latest 25 years especially in the Kattegat is targeting *nephrops* where fish species are caught as by-catch. These fisheries have been managed by using technical measures where several changes in legal mesh-sizes have been implemented.

The small meshed fishery has been managed TAC and by-catch limit restrictions. Minimum target species percentages in combination with maximum by-catch percentages for species such as for herring, cod, haddock, saithe and whiting have been set.

5. What are the fishing effort and stock trends over time?

Stock trend

There is no analytical assessment for this stock. Available survey indices (figures 4 and 5) show a highly variable CPUE between years but show no long-term trend.

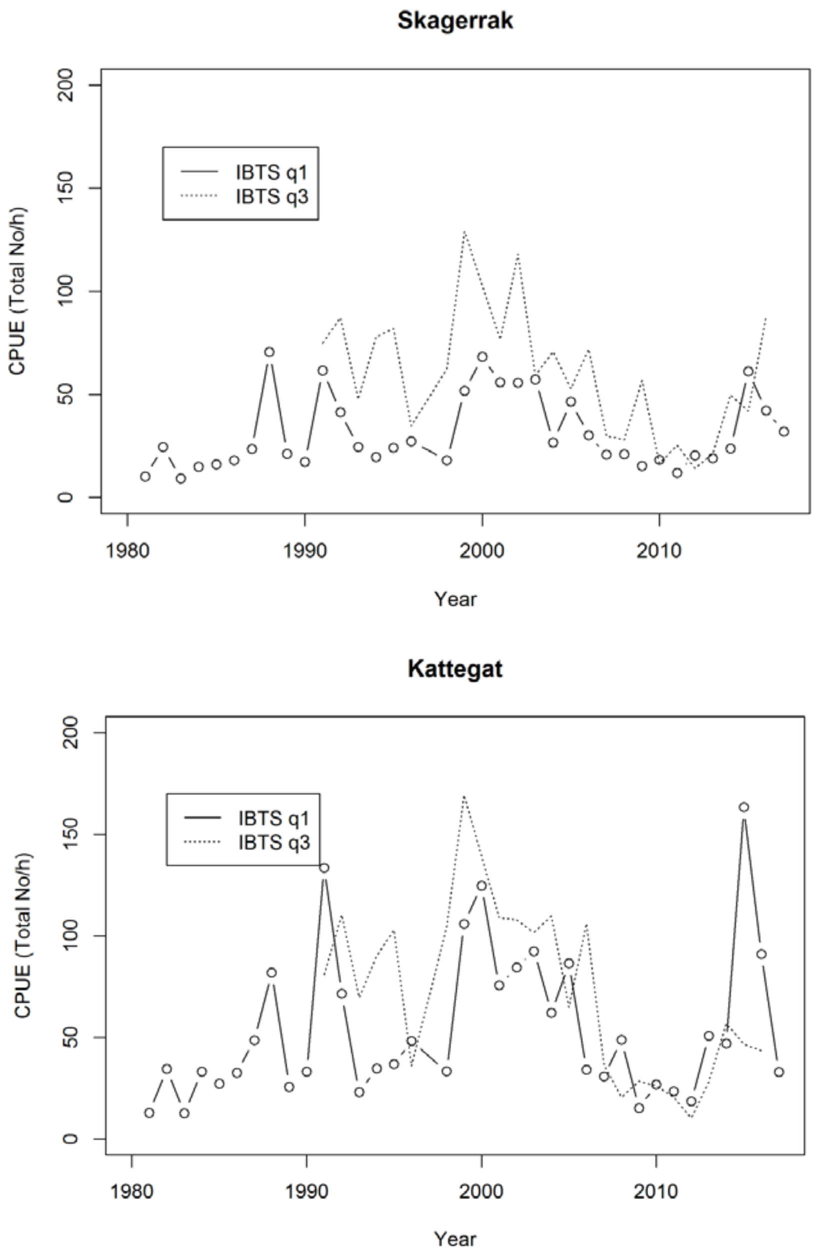

Figure 4. Whiting in Division 3.a (Skagerrak and Kattegat): IBTS CPUE for fish > 21 cm per area Q1 covering the years 1981–2017 and Q3 covering the years 1991–2016 (source: WGNSSK, 2017).

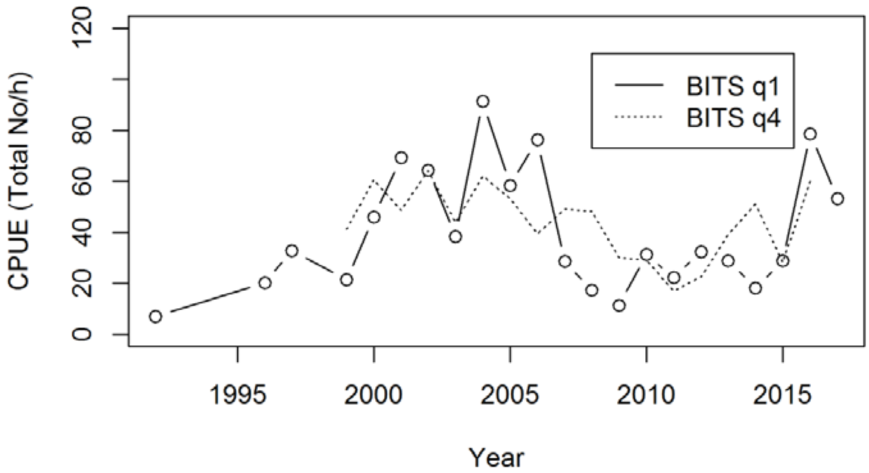

Figure 5. Whiting in Division 3.aS (Kattegat): BITS CPUE for fish > 21 cm per Q1 and Q4 covering the years 1992–2017 and 1999–2016, respectively (source: WGNSSK, 2017).

6. What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

There is not enough information to answer this question.

Conclusion

Whiting catches in 3.a have greatly declined in recent decades, something that could indicate a decline in the stock biomass, but survey indices do not indicate a long-term trend in stock size. ICES advises that the stock status and exploitation level for whiting in 3.a. are unknown and therefore it is not possible to judge whether a removal of the TAC is likely to lead to unsustainable exploitation. It is therefore recommended, based on precautionary considerations, that the TAC be maintained.

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D. Method for analysing targeting behaviour

Targeting can be seen as a proportion of a given species in the landings. If a species is targeted, it should contribute to a high proportion of the landings. However, a "high" proportion of a species in the landings is hard to define. This proportion can be impacted by lots of different factors, the main ones being the gear, its selectivity and the diversity of species in the fishing grounds in term of number of species and abundance. This proportion can be expressed in either volume or value.

Method:

Fix a threshold of a given species in the landings by stratum to define the targeting behaviour. The percentage of landings with a proportion of that given species over the total landings of that species (in volume and in value) higher than the threshold is then computed. The threshold is varied from 5 to 45% representing the "targeting" behaviour. Figure A1.1 only provides an analysis for the 5% threshold averaged over the years 2014–2015; this method applied in the main document explores each cell in the diagonal of Figure D.1 for temporal trends and several thresholds.

Limitations:

The proportion is computed over strata that are here defined by métier/quarter/area as submitted for the WGMIXFISH data call. This level of aggregation does not allow for fine exploration of the fishing behaviour. Some targeting might exist/happen at the trip scale and may not be reflected in the stratum used, which averages the trips over the same quarter/area. Other factors will impact the landings profiles (TACs, fish abundances, market).

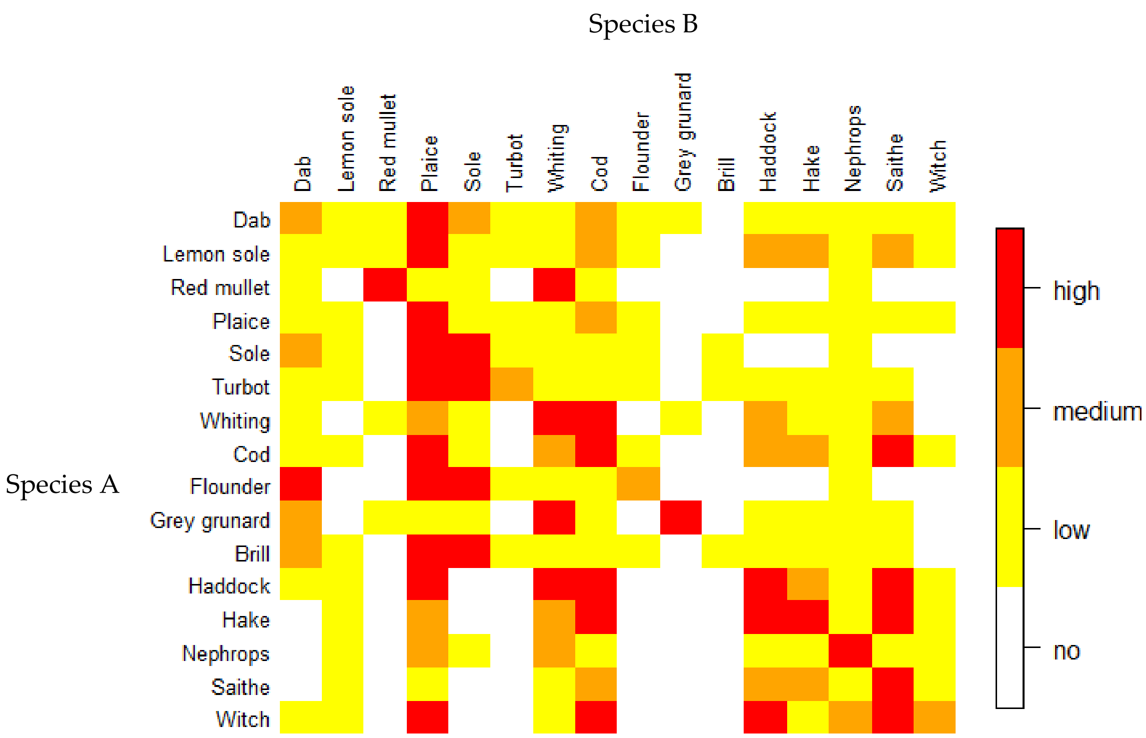

Figure D.1. Technical interactions (Subarea 4 only) amongst Greater North Sea demersal stocks. The rows of the figure illustrate the fisheries where the species A was caught. Red cells indicate the species B with which species A are frequently caught. Orange cells indicate medium interactions and yellow cells indicate weak interactions. The column shows the degree of mixing in fisheries where species B account for at least 5% of the total landings.

E. Reviewer's comments

Review 1 (Sections A and B)

Review report of provision of advice on a revision of the contribution of TACS to fisheries management and stock conservation:

<u>Executive Summary</u>

ICES requested that a list of species be analysed in terms of the risk (whether it is biologically safe in the short and medium term) of removing TACs for each case and to assess the potential use of other conservation tools in the place of TACs. Specific questions to be addressed were:

- A general impression of the evaluation method (questions asked, data looked at)
- Stock by stock impression of whether the summary of the questions and data provide a solid background to say y/n to lifting TAC
- Any thoughts on additional comments from experts (valid concerns, etc.)
- The EC have set which species are target/bycatch; is this definition critical to the outcome of the evaluation?

The review report follows the above structure and addressed each question below.

A general impression of the evaluation method (questions asked, data looked at)

The following questions were addressed for each stock:

4) Was the TAC restrictive in the past?

5) Is there a targeted fishery for the stock or are the species mainly discarded?

6) Is the stock of large economic importance or are the species of high value?

7) How are the most important fisheries for the stock managed?

8) What are the fishing effort and stock trends over time?

9) What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

Although these questions are very informative, how these questions link to the key issue at hand (removing the TAC) is important. Therefore, for this review, a few high-level queries to synthesise the conclusions were added to provide a consistent process and summary approach:

1. Has the species/stock/group (hereafter just called stock) got characteristics that places it at high relative risk?
    - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem importance
    - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

2. Is the present TAC/management influenced by past unsustainable practices?
   - If yes, are those fisheries still active?
   - Was the stock targeted?
3. Can these or new unsustainable practices return if the TAC is removed?
   - Can they be targeted with the present fleet?
   - Are they heavily discarded?
   - Is the stock valuable?
4. Are there alternatives to a TAC to manage this stock?
   - Can they be managed as companion species through target TACs (if applicable)?
   - Can they be spatially managed?
   - Any other mechanism? E.g. Multi-Year TACs (MYTAC).
5. Comment on the conclusions

As can be seen from these points, most of the questions posed within the report inform the high-level queries well, except for the companion species component. To help the reviewer, the information from the 6 question was added to the 5 questions above to see whether the information provided could address the issues therein.

The report addressed the removal of TACs on a single species case-by-case basis. In reality, the issue of removing a TAC can be much more complex. For example, there is a distinction between a low or zero TAC being removed to reduce administrative overheads compared to its removal to avoid choke TACs. It was not clear to this reviewer why this particular list was chosen on a species by species basis. There may be value in sequencing the questions a bit differently. This may reflect a non-ICES reviewer needing more background information than may be the case for a reviewer more familiar with ICES history.

Similarly, adding a web link to the latest ICES advice (if available) would be useful. Many of the reports added more information, including figures and tables that comprehensively addressed this question. This approach did not assume a certain level of knowledge from the reader.

On the other hand, few reports provided biological information and the overall relative riskiness of the species and their interactions with the fisheries. This would have helped place the riskiness of making a potentially incorrect decision to keep a TAC or not in context.

The authors struggled with question 6. This question did get placed in the form of reference points which would be difficult for several to address. Several of the species provided an analysis comparing fishing effort on the key target species with the catch on the stock of concern. This was very useful, but there would be several caveats to this work (also presented in many of the reports). The key one being that the relationship between target effort and associated stock landings were linear (in most cases) and would remain the same if the TAC is lifted. Without a full assessment and fleet dynamics models it would be difficult to suggest more sophisticated approaches. On the other hand, looking at alternative management approaches and their pros and cons (as was done for skates and rays, for example) would be useful here, so perhaps the question was more complicated than it needed to be.

Finally, there is a policy issue highlighted by some small inconsistencies in the final recommendations that should be discussed. As an example, two overfished and overfishing stocks had opposite recommendations (keep the TAC, and no risk to removing TAC). The difference was that the landings for the one species was being restricted by the TAC whereas for the other, landings were well below the TAC. In both cases, discarding was large and not prohibited. Superficially one would agree that the one TAC is restrictive but not the other. However, in terms of total catch neither are restrictive and therefore nor is fishing mortality (F). Is the difference not therefore about the relative value of the stock concerned rather than the effectiveness of the TAC? i.e. the one stock is worth keeping at least until the TAC is met and then it is discarded, whereas the other is not worth keeping at all. In the case where the TAC was recommended not to be kept, alternative input control measures were not successful, yet F did need to be reduced on the species to ensure recovery. In this case, therefore, one would want to discuss adding effective management measures either by making the TAC work through restricting discarding (and allowing the stock to become a potential choke species) or clearly articulating workable alternatives.

On a related point, most of the MSY reference points provided were based on single species assessments. It is now becoming clear that not all stocks in an ecosystem can reach their single species MSY together and at the same time, so another question not addressed one species at a time is the ecosystem interactions between these species and whether all species in the present system can be sustainably managed at single species MSY levels. Although it was pleasing to see the inclusion of more companion species work and analyses attempting to address how useful the management of one bycatch stock is through the management of the target stock, this work needs much further research.

Species: stock by stock impression of whether the summary of the questions and data provide a solid background to say y/n to lifting tac.

Brill and turbot

1. Has the species/stock/group (hereafter referred to as stock) got characteristics that places it at high relative risk?
    - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem important
    - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

Little information is provided on the general biology of the stock. It would be beneficial if this was added. Much discussion and information are provided on targeting and how these species/stocks link to other species. Stock status shows evidence that this stock complex can be overfished.

2. Is the present TAC/management influenced by past unsustainable practices?
    - If yes, are those fisheries still active?
    - Was the stock targeted?

The TAC has been a high proportion of the landings or been restrictive both in the past as well as in the present. The proportion of certain gear types used have changed and have been influential on the landings.

The stock status of brill is described using a category 3 assessment which uses relative biomass index, in this case using LPUE from the Dutch beam trawl fleet. These do not provide a clear reference point, but rather whether the resource is increasing or declining. Much (but not all) of the series shows an increasing trend. In addition, a SPiCT model was also recently undertaken which shows that the resource in the past decade has a relative biomass above Bmsy and F/Fmsy is less than 1. The resource in the late 1990s is likely have fallen below 0.5Bmsy and been below Bmsy for the 2000s.

The stock of turbot has recently been assessed using a Category 1 approach. Analyses also show that past high effort values may result in declines of both stocks.

3. Can these or new unsustainable practices return if the TAC is removed?
    - Can they be targeted with present fleet?
    - Are they heavily discarded?
    - Is the stock valuable?

The TAC has been restrictive and an increase in the 2017 TAC also resulted in higher catches. Discard information is provided and shows that it is low, except for recent years, despite additional management measures. A mixture of area based plots show that some targeting does occur in some areas (especially when value is also considered).

The relative value of these stocks is well set out and informative, and would be very helpful in other stocks being reviewed. These are relatively valuable stocks especially turbot. It shows the resource was below Bmsy for some period, but been above the Bmsy since about 2013.

4. Are there alternatives to a TAC to manage this stock?
    - Can they be managed as companion species through target TACs (if applicable)?
    - Can they be spatially managed?
    - Any other mechanism? E.g. Multi-Year TACs (MYTAC).

When the catches of turbot and brill in 2016 were close to being reaching TAC early in the season, the Minimum Conservation Reference Size was increased, and later weekly landings limits were applied by Dutch producer organisations. These were effective although the economics of these actions were not discussed. Gear type plots show that these are influential on the volume of the landings. Evidence is also provided that targeting occurs in areas not constrained by a TAC. Analyses also show that managing the mortality of the main target species (given their assumption of linearity) does not necessarily lead to controlling the mortality for the by-catch species.

5. Conclusion

The report is well set out answering all the requested questions. It is a good example of what could be provided and undertaken (if information was available) for other stocks. The relative value and management is well described and places these stocks into the larger context of the fisheries. The consequence of the difference in " the areas for which the TAC applies are different *to those for which the advice is issued" is clearly set out. The analyses taking this issue to account show that the official landings of brill and turbot in their stock areas mostly overshoot the TAC. This report also attempts toclearly address and interpret alternative effort measures and the question of maximum effort based on Fmsy ranges.*

The conclusions are well set out, comprehensive and supported by evidence.

Witch flounder and lemon sole

1. Has the species/stock/group (hereafter referred to as stock) got characteristics that places it at high relative risk?
   - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem important
   - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

The points above are not comprehensively discussed in terms of biology, but do provide information on targeting and technical interactions. This former was not asked of the authors. As stated in the section evaluating the methods, this addition would be useful. Lemon sole in some areas (e.g. Subarea 4) are mostly caught as a byproduct or bycatch species of plaice targeting. Witch flounder in Subarea 4 are caught mainly from targeting plaice, cod, haddock and saithe (based on technical interaction data).

2. Is the present TAC/management influenced by past unsustainable practices?
   - If yes, are those fisheries still active?
   - Was the stock targeted?

There was no directed fishery for lemon sole or witch flounder (except for witch Division 3a). There are mixed signals from the value and technical interactions for witch flounder in Subarea 4.

Stock status is from a Category 1 and 3 assessment for witch flounder and lemon sole respectively. The TAC area does not coincide with the stock boundaries and the TAC is for both species combined. The assessment for witch flounder shows there were periods of low SSB in the past, but SSB is presently high and F is lower. The lemon sole assessment shows total mortality being uncertain with firm a conclusion about F trends not being possible. SSB has steadily increased but, recent recruitment values are low.

3. Can these or new unsustainable practices return if the TAC is removed?
   - Can they be targeted with present fleet?
   - Are they heavily discarded?
   - Is the stock valuable?

The TAC has not been restrictive in the area for which the TAC is set, because the landings are generally below 80% of the TAC. However, when considering both stock and discards, the TAC *uptake is mostly well over 100%. It is unclear why the argument is therefore mounted that the TAC has been restrictive on fishing practices if the TAC advice area landings are below the TAC. Is it because it has shifted effort into other areas despite the TAC utilisation not been reached? Further articulation is provided. Furthermore, a plot of the TAC advice area should also include the discards, which would be useful.*

Lemon sole is not landed in large numbers, but have a high value per number. In combination, this still points to sole not being of high relative value overall.

Since the early 2000s, there has been a large reduction of dominant gears that catch witch flounder and lemon sole (BT2, TR2 and TR1), resulting in effort reduction on the main target species plaice and sole. It is unclear whether this is directly as a result of active management on plaice and sole. Clarity on this point would be beneficial.

Discarding is variable but averages about 16% and 23% for witch flounder and lemon sole respectively for the period since 2002 from estimates provided.

Relative to targeted species such as plaice, cod and haddock, lemon sole and witch flounder is not valuable in terms of landed value except for small discrete areas.

4. Are there alternatives to a TAC to manage this stock?
   - Can they be managed as companion species through target TACs (if applicable)?
   - Can they be spatially managed?
   - Any other mechanism? E.g. Multi-Year TACs (MYTAC).

Generally, evidence suggests no significant targeting of both species and they can generally be considered byproduct or bycatch species. Management of sole and plaice in the beam trawl fleet (witch flounder) and the demersal fleet of species such as cod, haddock and whiting (lemon sole) is likely to be very important indicators of future effort on these species. Currently plaice exploitation approximates Fmsy and these levels do not seem to have a negative impact on witch flounder biomass. It is argued that estimated F values for the key demersal species have been lower historically (during the period 2007- 2017), which has allowed the lemon sole stock to increase. The argument that multi-stock Fmsy fishing for the key demersal stock is unlikely to negatively impact the lemon sole stock appears sound. The recent very low recruitment should be considered though, as this value is at the lowest of the series, admittedly for high effort levels in the demersal fishery.

5. Conclusion

This section is well laid out with reasonably clear recommendations. A good case is mounted for the TAC advice area to better correspond to the stock. Similarly, keeping the TACs separate for lemon sole and witch flounder. There are also indications that lemon sole may be managed through the TAC of key demersal species, but with caveats that recent overall effort has tended to increase and recruitment for this stock is low.

Review 2 (Sections A and B)

The key question here is whether total allowable catches (TACs) can be removed for any of the stocks in question, or should be retained for all stocks. The disparate documents would be improved by an overall grammar check, and efforts to ensure that the data provided are in similar formats to allow decisions to be made fairly across stocks. I first make some overall points, and then summarize my thoughts on individual stocks.

1. Overall, I am sceptical that removing TACs for any stock is a good idea. Any stock with no TAC can be targeted with unlimited catches, and the EU has a large amount of latent fishing effort combined with ready markets. In such circumstances, a new market, technology, or stock can lead to rapid deployment of latent effort, leading to stock collapses in a short period of time. If the current TACs are too precautionary, TACs should be increased rather than abolished. For pilot fisheries, TACs could be set at levels that are economically viable but low enough to avoid substantial and rapid depletion.
2. TACs should be set separately for each species. TACs set on species complexes (such as "skates") risk targeting on the most valuable species within the complex, resulting in overfishing of that species even as TACs are not exceeded.
3. TACs should be set for management areas that correspond to stock boundaries. In a few instances, the TACs are set for areas that include portions of two stocks, rather than separate TACs being set for each stock. It is, of course, reasonable to set TACs for subareas of a single stock to ensure that catches are not concentrated in a single part of the stock range.
4. A major weakness in the current approach is that TACs are applied only to landings, not to total catch (landings + discards). In a multispecies fishery managed by TACs on individual species, some species will become choke species that constrain landings of other species. When discards are not accounted for in TAC advice, and are not measured, this provides incentives to discard catches that are over the TAC (or over individual quotas), and this is especially true for those stocks at lowest levels that currently have a "zero" TAC. A key part of management should be measuring and holding fishers accountable for discards, and then setting TACs for total catches instead of just for landings.
5. In a few cases, the bulk of catches, biomass, and habitat is outside EU waters, but TACs are still set at very low levels inside EU waters. These nominal TACs could be increased for stocks that are not targeted, have little EU commercial value, and are currently managed by TACs that are so low as to have a negligible impact on stock status. Increasing TACs would ensure that bycatch does not constrain catches of more valuable target species.
6. In cases where choke species are healthy, and current catches do not constitute overfishing, but catches are close to TACs, the TACs could be increased so that fewer fishers are constrained by catches of these choke species.

A stock-by-stock review follows.

Brill (3a47de) and turbot (4)

As for plaice above, it is odd that the TAC is set on the basis of stock boundaries, but management advice is based on entirely different boundaries. Furthermore, a combined TAC for both brill and turbot is a bad idea because catches for one species could exceed sustainable levels for that species, while remaining within the combined TAC. Each TAC should be for one species, and the area for each TAC should correspond to stock boundaries for that stock.

The combined TAC is clearly constraining, even though brill and turbot are largely bycatch species. As such, they are likely constraining catches of other target species in the multispecies fishery. Removing the TAC would lead to catches of these species exceeding sustainable levels, and is not advised.

Witch Flounder and Lemon Sole

These two species raise questions about which quantities should be compared when estimating TAC utilization: landings are less than the TAC in the area where the TAC is applied, but catches outside the TAC region, plus discards, result in total catch exceeding the TACs. Obviously, it should be made clear whether the TACs apply to landings or catches, and to what area the TACs should be applied. Neither species is of high overall economic value, so that it is less likely that a targeted fishery would develop.

Nevertheless, it makes little sense to have a combined TAC for two separate species, since this could lead to overfishing of one of the two species even when combined landings do not exceed the combined TAC. Furthermore, the TACs should apply to the full range of the stocks, to avoid the nefarious scenario of unrestricted catches outside the TAC boundaries.

I therefore concur with the recommendation that single-species TACs for witch flounder and lemon sole be implemented, and these should be applied to the same area used in the assessments (areas 3a, 4, 7d).

Review 3 (Section C)

[Note this reviewer is the same as Reviewer 1, but the review was conducted at a later time]

1. Has the species/stock/group (hereafter referred to as stock) got characteristics that places it at high relative risk?
    - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem important
    - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

There is some indication that there is a localised stock structure based on locally spawned eggs and landings patterns, and different population dynamics. Whiting is presently not targeted and mainly caught in the Nephrops fishery as a by-catch.

2. Is the present TAC/management influenced by past unsustainable practices?
    - If yes, are those fisheries still active?
    - Was the stock targeted?

Catches have declined substantially from over 10,000 tonnes in the early 1980's and 1990's to a few hundred tons recently. Several changes in management have occurred during this period, such as mesh size restrictions. The fleet structure has also changed from fish targeting fleets to targeting mainly Nephrops. There is no analytical assessment for the stock and available biomass indices are highly variable between years and show no trend. Despite these management changes, evidence was not provided that excluded possible stock biomass declines.

3. Can these or new unsustainable practices return if the TAC is removed?
    - Can they be targeted with present fleet?
    - Are they heavily discarded?
    - Is the stock valuable?

Total catches in two years have exceeded the TAC even though landings have not. The value of the resource is low relative to other product caught. The present fleet would not be targeting whiting. Management measures include maximum by-catch percentages and a TAC (noting the total catches have recently exceeded the TAC).

4. Are there alternatives to a TAC to manage this stock?
    - Can they be managed as companion species through target TACs (if applicable)?
    - Can they be spatially managed?
    - Any other mechanism? E.g. Multi-Year TACs (MYTAC).

Direct management of the stock would be difficult as it is a bycatch of a small mesh directed fishery. Bycatch mitigation measures in this fishery may be an option, but are not mentioned in the report.

5. Conclusion

The report provides a conclusion and information that can be used for decision making. These include that there is no analytical assessment, survey indices are highly variable and show no trend, yet the landings have declined substantially compared to the 1980s and early 1990s. Given it is a by-catch species it is likely to be vulnerable to management changes in the Nephrops fishery management. The report therefore recommends that the TAC be maintained for precautionary reasons.