WORKING GROUP ON THE ASSESSMENT OF DEMERSAL STOCKS IN THE NORTH SEA AND SKAGERRAK (WGNSSK)

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i Executive summary

The main terms of reference for the The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) 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.. 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).

Benchmarks and Inter-benchmarks in 2018/2019

No full benchmarks were conducted during 2019 for WGNSSK stocks. However, there were several inter-benchmark protocol (IBP) meetings during 2018/2019. These were on North Sea turbot and saithe, and on sole in 7.d.

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 reference points (Category 1 stocks) are above B_{lim}, apart from cod in 4, 7.d and 20, and only the SSBs of cod in 4, 7.d and 20 and whiting in 4 and 7.d are below MSY $B_{trigger}$ at the beginning of 2019. Several North Sea stocks are exploited at or below F_{MSY} levels (saithe in 3.a, 4 and 6, plaice in 4 and 20, plaice in 7.d, sole in 7.d, and turbot in 4); however, just as many are being fished above F_{MSY} (cod in 4, 7.d and 20, haddock in 4, 6.a and 20, whiting in 4 and 7.d, sole in 4, and witch in 3.a, 4 and 7.d). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids, although there are signs of a strong recruitment for haddock in 2019 (the strongest since the 1999 year-class; to be confirmed with future data).

All *Nephrops* stocks with agreed biomass reference points (Category 1 stocks, excluding nep.fu.3-4) are currently above MSY $B_{trigger}$, and all *Nephrops* stocks with defined F_{MSY} (Category 1 stocks, including nep.fu.3-4) are being fished at or below F_{MSY} in 2018, apart from *Nephrops* in FU 6 (nep.fu.6).

WGNSSK is also responsible for the assessment of several data-limited species (Category 3+ stocks) that are mainly by catch in demersal fisheries (brill in 3.a, 4 and 7.d-e, lemon sole in 3.a, 4 and 7.d, dab in 3.a and 4, flounder in 3.a and 4, turbot in 3.a, whiting in 3a), along with striped red mullet in 3.a, 4 and 7.d. Biennial precautionary approach (PA) advice was provided in 2015 for the first time, and again in 2017; for 2019, biennial advice was either PA, where catch advice was still needed, or simply reporting stock status where no catch advice was needed. Reopening of advice was triggered for several Category 1 stocks in the autumn, following the availability of Q3 survey results in 2019, namely cod in 4, 7.d and 20, haddock in 4, 6.a and 20, plaice in 4 and 20, sole in 4, and *Nephrops* in FU 6, 7 and 8 (Annex 7).

The summary of stock status is as follows:

1) *Nephrops*:

Category 1:

a) FU 3-4 (nep.fu.3-4): The stock size is considered to be stable. The estimated harvest rate for this stock is currently below F_{MSY}. No reference points for stock size have been defined for this stock.

b) FU 6 (nep.fu.6): The stock abundance has increased since 2015, and currently it is above MSY $B_{trigger}$. The harvest rate has shown a decreasing trend since 2013, and is just above F_{MSY} in 2018.

c) FU 7 (nep.fu.7): The stock size has been above MSY $B_{trigger}$ for most of the time-series. The harvest rate has declined since 2010 and remains well below F_{MSY}.

d) FU 8 (nep.fu.8): The stock size has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate is varying and is now below F_{MSY}.

e) FU 9 (nep.fu.9): The stock has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate has fluctuated around F_{MSY} in recent years and is now just below F_{MSY}.

Category 4:

f) FU 33 (nep.fu.33): The state of this stock is unknown. Landings have been relatively stable since 2004, fluctuating without trend at around 1000 tonnes. The mean density of Norway lobster decreased by 43% from 2017 to 2018. Advice was provided for this stock in 2019 (although it was not scheduled) because of the availability of data from a UWTV survey conducted in 2018.

No new advice was provided in 2019 for *Nephrops* outside the functional units (nep.27.4outFU; Category 5), and for the remaining Category 4 *Nephrops* stocks (nep.fu.5, nep.fu.10, nep.fu.32, nep.fu.34).

A workshop on Methodologies for *Nephrops* Reference Points (WKNephrops) is being held 25–29 November 2019 to evaluate reference point estimation for stocks with UWTV surveys. This workshop will also consider a consistent methodology to determine stock status and provide catch advice for data-limited *Nephrops* stocks, taking into account available data and knowledge from other areas.

2) Cod (cod.27.47d20): Fishing mortality has increased since 2016, and is above F_{lim} in 2018. Spawning-stock biomass has decreased since 2015 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, F_{pa}, and F_{lim}; the spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}.

3) Haddock (had.27.46a20): Fishing mortality has declined since the beginning of the 2000s, but it has been above F_{MSY} for the entire time-series. Spawning-stock biomass has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019 year-class is estimated to be the largest since 2000. Currently, fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just below it in 2019. Fishing mortality has been above F_{MSY} through-out the time-series, apart from 2005. Recruitment (R) has been fluctuating without trend, but the last two year-classes are below average. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and B_{pa}, but above B_{lim}.

5) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality has decreased and stabilized at or below F_{MSY} since 2014. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. Currently, fishing pressure on the stock is at F_{MSY} and below F_{pa} and F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

6) Plaice (ple.27.420): The spawning-stock biomass is well above MSY $B_{trigger}$ and has mark-edly increased since 2008, following a substantial reduction in fishing mortality since 1999. Recruitment in 2019 is estimated to be the second highest in the time-series. Since 2009, fishing mortality has been estimated below F_{MSY}. Currently, fishing pressure on the

stock is below F_{MSY}, F_{pa}, and F_{lim}, and that spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

7) Sole (sol.27.4): The spawning-stock biomass has increased since 2007, and has been estimated above MSY $B_{trigger}$ since 2012. Fishing mortality has declined since 1999 and is close to F_{MSY} in 2018. Recruitment in 2019 is estimated to be the highest since 1988. Currently, fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}, and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

8) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing mortality has declined since the early 2000s, with an increase in the recent years to slightly below F_{MSY}. Recruitment is currently around the average of the last 10 years of the time series. Currently, fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

9) Sole (sol.27.7d): The spawning-stock biomass (SSB) has been fluctuating without trend and has been above MSY $B_{trigger}$ since 2017. Fishing mortality has been decreasing trend since 2009 and has been below F_{MSY} since 2017. Recruitment has been fluctuating without trend. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$, F_{pa}, and F_{lim}; spawning-stock size is above MSY $B_{trigger\ proxy}$ and above B_{pa} and B_{lim}. This stock underwent an inter-benchmark during 2019 to incorporate revised tuning indices and re-estimate reference points, but was subsequently down-graded to a Category 3 assessment due to unreliable plus-group data and plus-group estimation that led to a large increase in advice. The assessment is currently indicative of trends only. A full benchmark is planned for early 2020.

10) Turbot (tur.27.4): Recruitment is variable without a trend. Fishing mortality has decreased since the mid-1990s, and has been just below F_{MSY} since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY $B_{trigger}$ since 2013. This stock was upgraded to Category 1 from Category 3 following an inter-benchmark during 2018. Currently, fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}; spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

11) Witch (wit.27.3a47d): Fishing mortality has been above F_{MSY} since the beginning of the time-series. Spawning-stock biomass that was below B_{lim} around 2010, has increased since then and is now above MSY $B_{trigger}$. Recruitment has declined since 2010 and is currently at a low level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY} and between F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

12) Norway pout (nop.27.3a4): The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass is estimated to have been fluctuating above B_{pa} for most of the time-series. Fishing mortality declined between 1985 and 1995 and has been fluctuating at a lower level since 1995. Recruitment in 2018 and 2019 was above the long-term average. Currently, spawning stock size is above B_{pa} and B_{lim}; no reference points for fishing pressure or for MSY $B_{trigger}$ have been defined for this stock.

13) Category 3–6 finfish stocks: In 2019, new advice has been produced for bll.27.3a47de, dab.27.3a4, fle.27.3a4, lem.27.3a47d, mur.27.3a47d, tur.27.3a (all Category 3 stocks) and whg.27.3a (Category 5). Although not requested, advice was provided for dab.27.3a4 to deal with an advice gap left by the Commission changing the advice cycle for dab from 2 to 3 years. Advice was not provided for gug.27.3a47d (Category 3) and pol.27.3a4 (Category 5).

a) Brill (bll.27.3a47de): The biomass index has been gradually increasing over the time-series until 2015, and has then decreased. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger\ proxy}$.

b) Dab (dab.27.3a4): The biomass has been increasing since the start of the time-series, but has declined since its peak in 2016. Total mortality is fluctuating without trend. Recruitment showed an increasing trend until 2014, but has declined since then. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$, and the spawning stock size is above MSY $B_{trigger\ proxy}$.

c) Flounder (fle.27.3a4): The available survey information indicates no clear trend in stock biomass. Currently, fishing pressure on the stock is below F_{MSY}; no reference points for stock size have been defined for this stock.

d) Lemon sole (lem.27.3a47d): Total mortality has fluctuated without trend. Spawning-stock biomass increased from 2007 to 2012, and has remained stable since, albeit with a small decline in 2018. Recruitment has shown a mostly downwards trend since a peak in 2011. Currently, fishing pressure on the stock is below F_{MSY}. No reference points for stock size have been defined for this stock.

e) Striped red mullet (mur.27.3a47d): Spawning-stock biomass has decreased since 2015 as a consequence of poor recruitment and an increase in F. Recruitment in 2018 is estimated to be large. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

f) Turbot (tur.27.3a): The IBTS Q1 biomass index is variable and has been fluctuating without trend over time. The IBTS Q3 biomass index is also variable but has shown an increased level after 2005. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

g) Whiting (whg.27.3a): Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid-1990s. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

ii Expert group information

Expert group name	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	José De Oliveira, UK
Meeting venue and dates	24 April – 3 May 2019, Bergen, Norway (30 participants)

1 General

1.1 Terms of Reference

2018/2/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 2019 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 Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2018.

   iv. Estimate MSY proxy reference points for the category 3 and 4 stocks

   v. 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;

   vi. The state of the stocks against relevant reference points;

   vii. Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

   viii. Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) 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. Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

d) Review progress on benchmark processes of relevance to the Expert Group;

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

f) Identify research needs of relevance for the work of the Expert Group.

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 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.

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 Base and Estimation System (RDBES) is 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 2019, 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 3 April 2019, three weeks prior to the start of the WGNSSK meeting in Bergen. 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. Age and length data in parallel in InterCatch

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. Technical improvements in the InterCatch interface

- Allocation Group Setup: define a group of unsampled catch/strata for which each distribution will be calculated according to the (for the group) allocated sampled catches/strata;
- Automatic allocation 'same' strata: automatically find and allocate identically sampled strata from other countries to unsampled catches/strata (with the identical stratum);
- Discard Group setup: Define a group of raised discards for which each discard weight will be calculated according to the (for the group) selected landing-discard ratios;
- CATON and age/length data overviews: it is possible to 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. Summary outputs and inspection of data before raising

The new features included in InterCatch allowed improved inspection and visualization of the data submitted by national data providers and a comparison with data from previous years. A generic R script has been developed in 2016 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. Raising procedures

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

- 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. However, there is limited scope for improvements in InterCatch, given the focus on getting RDBES (its successor) operational and fully functional in the near future.

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	2018	Extracted	Exported	Data Used For Assessment
cod.27.47d20	2018	Extracted	Exported	Data Used For Assessment
dab.27.3a4	2018	Extracted	Exported	Data Used For Assessment
fle.27.3a4	2018	Extracted	Exported	Data Used For Assessment
gug.27.3a47d	2018	Extracted	Exported	Data Used For Assessment
had.27.46a20	2018	Extracted	Exported	Data Used For Assessment
lem.27.3a47d	2018	Extracted	Exported	Not filled
mur.27.3a47d	2018	Extracted	Exported	Data Used For Assessment
nep.27.4outFU	2018	Extracted	Exported	Data Used For Assessment
nep.fu.10	2018	Extracted	Exported	Data Used For Assessment
nep.fu.32	2018	Extracted	Exported	Data Used For Assessment
nep.fu.33	2018	No	No	Notfilled
nep.fu.34	2018	Extracted	Exported	Data Used For Assessment
nep.fu.3-4	2018	Extracted	Exported	Data NOT used For Assessment
nep.fu.5	2018	Extracted	Exported	Data Used For Assessment
nep.fu.6	2018	Extracted	Exported	Data Used For Assessment
nep.fu.7	2018	Extracted	Exported	Data Used For Assessment
nep.fu.8	2018	Extracted	Exported	Data Used For Assessment
nep.fu.9	2018	Extracted	Exported	Data Used For Assessment
nop.27.3a4	2018	No	No	Notfilled
ple.27.420	2018	Extracted	Exported	Data Used For Assessment
ple.27.7d	2018	Extracted	Exported	Data Used For Assessment
pok.27.3a46	2018	Extracted	Exported	Data Used For Assessment
pol.27.3a4	2018	Extracted	Exported	Data Used For Assessment
sol.27.4	2018	Extracted	Exported	Data Used For Assessment
sol.27.7d	2018	Extracted	Exported	Data Used For Assessment
tur.27.3a	2018	Extracted	Exported	Notfilled
tur.27.4	2018	Extracted	Exported	Notfilled
whg.27.3a	2018	Extracted	Exported	Data Used For Assessment
whg.27.47d	2018	Extracted	Exported	Data Used For Assessment
wit.27.3a47d	2018	Extracted	Exported	Data Used For 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 2018 and 2019

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

1.5 Internal auditing

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. It is hoped that the move to TAF will both make auditing easier and more transparent, and improve the quality of auditing procedures.

All WGNSSK stocks with advice in 2019 could be covered by the internal audit (Table 1.5.1). The audits are given in Annex 5 of the report.

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

Stock	Internal Audit Spring	Internal Audit Autumn
bll.27.3a47de	✓	
cod.27.47d20	✓	✓
dab.27.3a4	delayed	✓
fle.27.3a4	✓	
gug.27.3a47d	no new advice in 2019	
had.27.46a20	✓	✓
lem.27.3a47d	✓	
mur.27.3a47d	✓	
nep.27.4outFU	no new advice in 2019	
nep.fu.10	no new advice in 2019	
nep.fu.32	no new advice in 2019	
nep.fu.33	✓	
nep.fu.34	no new advice in 2019	
nep.fu.3-4	✓	
nep.fu.5	no new advice in 2019	
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	no new advice in 2019	
sol.27.4	✓	✓
sol.27.7d	delayed	✓
tur.27.3a	✓	
tur.27.4	✓	
whg.27.3a	✓	
whg.27.47d	✓	
wit.27.3a47d	✓	

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 pre-processed. 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 have been scripted in standard TAF scripts. See http://taf.ices.dk for more information. Progress continues to be made, and there are now 14 out of 30 WGNSSK stocks in varying states of completeness in TAF

During the WGNSSK 2019 meeting, a presentation on TAF was made, and stock assessors were encouraged to take part in workshops offered by ICES to get their assessments into TAF.

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 June 2019 (WGMIXFISH-METH), and also in late October 2019 (WGMIXFISH-ADVICE) in order to produce mixed-fisheries advice for the North Sea (integrated into the Fisheries Overview for the North Sea). We therefore refer to the ICES WGMIXFISH 2019 report and Fisheries Overview 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 EU MAPs, which are mixed-fishery multiannual plans for demersal stocks in the North Sea (Regulation (EU) 2018/973) and stocks in Western Waters (Regulation (EU) 2019/472). These plans allow 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 key-run 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 Special requests

There were no special requests for WGNSSK to handle during the meeting, apart from initially drafting advice with catch scenarios that included management strategies that were evaluated for cod, haddock, whiting and saithe by ICES WKNSMSE (2019). These additional catch scenarios can be found in individual chapters, but were subsequently removed from advice sheets.

1.10 Presentations

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

Annual industry survey targeting turbot and brill

Wouter van Broekhoven presented the new annual industry survey targeting turbot and brill, which took place for the first time in Q4 of 2018.

Current surveys show poor internal consistency performance for these species. The aim here is to deliver a long-term annual survey using commercial fishing vessels fishing at predefined locations, providing a data stream allowing the detection of trends and direct application in stock assessments. The programme is a science-industry collaboration between the Dutch demersal fishing industry and WMR.

The first iteration of the survey took place in Q4 of 2018. Three Dutch vessels were recruited to take part in the programme. Each vessel was assigned a zone in the southern North Sea/south-central North Sea/German Bight area spanning 5.5 ICES rectangles based on the vessel's usual fishing grounds, and on known turbot and brill occurrence based on LPUE information and the skippers' expert judgment. Within each rectangle, 2 hauls using randomly predetermined starting coordinates were executed, plus 2 "free" hauls where the skipper was asked to choose the haul such that turbot & brill catches would be expected, for a total of 22 hauls per zone. In each rectangle, 2 otoliths per cm length class were collected.

The survey generally went well, but one of the vessels was unable to participate during this first iteration of the survey due to repeated occurrence of adverse weather conditions. It has been decided to plan the survey a little earlier as of 2019, aiming to start in September/October rather than November as had been attempted in 2018. Another issue was the distance that needed to be covered in the available time, which meant that the free hauls were not always really free in terms of starting coordinates within a rectangle, and in a few cases predetermined haul coordinates had to be moved closer together. Based on this experience the original plan was considered overly ambitious. On the 2018 survey, 373 otoliths were collected (by two out of the three vessels so 50% more would be expected from the 2019 survey onwards), compared to 747 on the 2018 market sampling, 58 on the BTS, and 26 on the SNS (sole net survey).

Specific issues relating to the design of the survey were put to the WGNSSK group for discussion. Useful feedback was provided by the group, which will feed into the design of the survey from 2019 onwards. One issue which was discussed was the gear used, because one of the vessels in 2018 used a pulse gear, which has become clear, since the survey took place, will be banned as of 2021. The group advised to switch this vessel to an alternative gear immediately as of 2019, rather than continue using it and risk causing an irreparable break in the data series in 2021. Comparative fishing between the pulse gear and the alternative (e.g. classic beam trawl with tickler chains) in order to establish a conversion factor was considered very uncertain in terms of expected success. The issue with the distance needing to be covered in the current survey design was also discussed, in conjunction with perceived difficulties relating to the statistical treatment due to the design choice of the combination of predetermined and free hauls. An arrangement used in a joint Danish/Swedish survey using a relatively fine-scale permanent grid from which cells are randomly assigned each year within which skippers are free to execute the hauls as they see fit, was offered as a potential alternative setup. In general, it was advised not to maintain the ICES rectangles as the basis for the definition of the survey zones if this leads to overly large distances to be covered. The gear and spatial survey design issues together led the group to advise to redesign the survey from 2019 and consider 2018 a pilot year. It will be attempted in future to use the valuable 2018 data in trends analysis as much as possible, but a redesign which will be kept stable starting from 2019 was considered the most robust approach to building a data series which is likely to be used in the stock assessments of turbot and brill in future.

New Dutch catch monitoring programme from 2019

Wouter van Broekhoven presented the new Dutch *Nephrops norvegicus* catch monitoring programme which will start operation in 2019.

The Dutch *Nephrops* fleet target FU5 (Botney Cut), FU33 (Off Horn's Reef), and also fish out-FU, and these areas are data-poor. Landings are well quantified using standard procedures, but they are not assigned to specific FUs. Discards are estimated from the Dutch discards self-sampling programme, but the coverage and resolution are not sufficient to assign catches of discards to FUs. The aim here is to commence long-term full catch monitoring on a reference fleet targeting *Nephrops* in order to quantify catches and discards per FU, and allow for the detection of trends over time. The programme is a science-industry collaboration between the Dutch demersal fishing industry and WMR.

Three vessels were recruited to participate in the first stage of the programme. Each will sample 5 trips per quarter (20 per year). On these trips, 2 hauls will be sampled, measuring carapace length of 50 males and 50 females, and filling 80 kg bags at point of discarding for analysis in the lab. Landings of 9 species will also be recorded per haul. Catches will be raised to trip level based on automated haul-by-haul measurements of total catch weight using electronic spring balances mounted on the booms. The assumption is that total catch weight correlates with catches of *Nephrops*. Alternative methods of raising to trip level will be explored. Some delay in commencing the monitoring has been incurred due to development and installation of the spring balances which have to compensate for wave action. In the first stage of the programme, validation of recordings will be made by 10 observer trips distributed over the participating vessels.

The design with three vessels, 5 trips per quarter, and 2 hauls per trip was based on a power analysis which was shown in the presentation, where each of these numbers was varied to arrive at the optimum configuration. The group agreed that the analysis showed that adding vessels was likely to be the most potent way of expanding the power of the programme further. The point was raised that the 40% Coefficient of Variance target which was used for discards in the power analysis should be reduced if trends are to be detected over time. The corresponding CV for landings was 20%, which was deemed a more appropriate number. The combined CV for total catch was unknown at the time of the presentation. The first stage of the programme should be expanded in order to achieve the stated aims because the CV's mentioned relate to the full area and not to the individual FUs. In order for trends to be detected at FU level, more vessels would need to be added to the programme. It was agreed that the first data set produced by the programme once data collection commences should be used to refine the analysis in order to determine the required scale of expansion of the programme. It was noted that representativeness of the reference fleet's expected catch composition for the entire *Nephrops*-targeting fleet should be given consideration when recruiting additional vessels.

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 below 500 000 tonnes (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/GreaterNorthSeaEcoregion_FisheriesOverview.pdf).

For some stocks, the North Sea assessment area may also cover other regions adjacent to ICES Subarea 4. Thus, combined category 1 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, witch including Divisions 3.a and 7.d, 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 current 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. 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 2019), which meets straight after the WGNSSK. Both WGs share a joint data call issued by ICES for fulfilling the data needs of both groups (Annex 8).

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 former 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 advice. 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 former 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 (Figure 2.1.1), and effort in gill and trammelnet fisheries (not shown in Figure 2.1.1) has increased. An update of Figure 2.1.1 is not yet available, but there are indications of a general increase in TR1 effort since 2016.

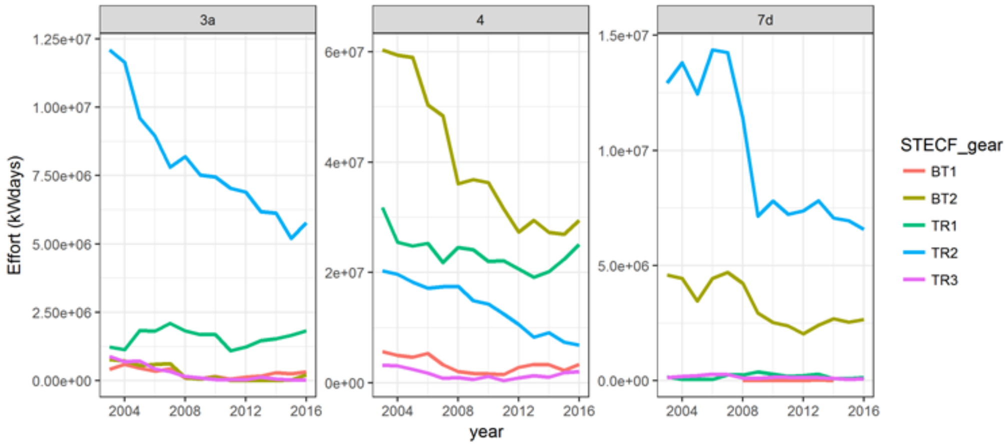

Figure 2.1.1. Trends in fishing effort for different STECF fishing gear groups in ICES Division 3.a, ICES Subarea 4 and ICES Division 7.d for the period 2003–2016 (STECF, 2017b). Regulated gears: BT1 are beam trawls with mesh sizes ≥ 120 mm. BT2 are beam trawls with mesh sizes ≥ 80 mm and < 120 mm. TR1 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.

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 2.1.2). 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.

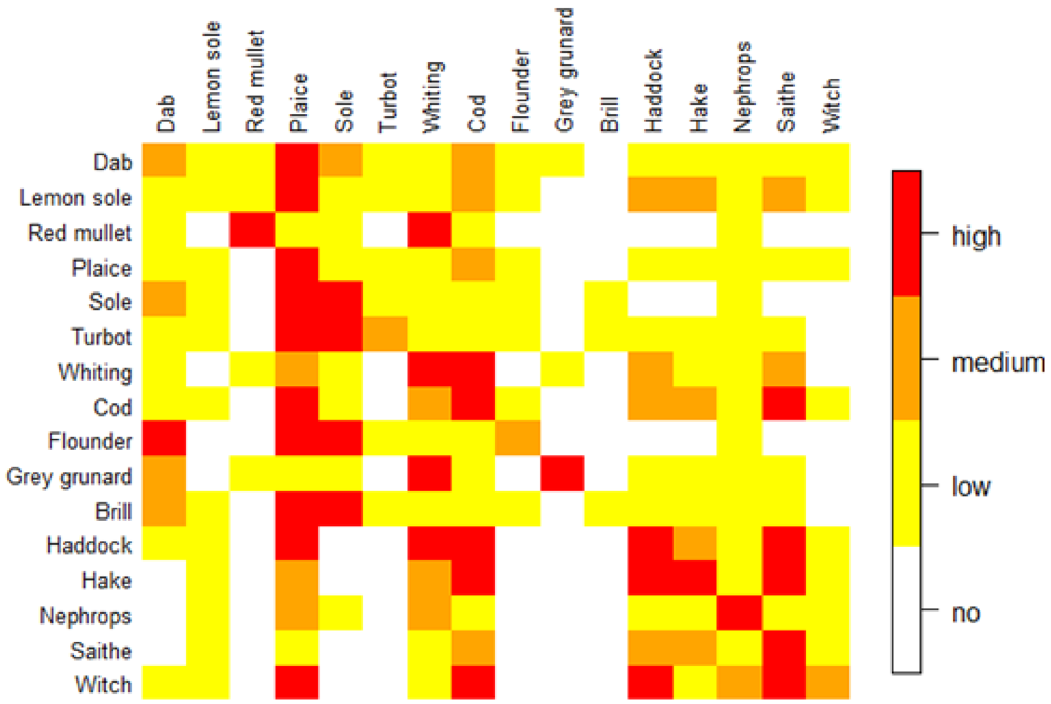

Figure 2.1.2. Technical interactions amongst North Sea demersal stocks (averaged over the years 2014–2015). Horizontal lines of the figure represent the target species of the fishery (species A) for which the interaction with species in each column (species B) was assessed. Red cells indicate that the 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 developed and are now available for North Sea demersal stocks (Regulation (EU) 2018/973) and for stocks fished in western waters (Regulation (EU) 2019/472).

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 was 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; Regulation (EU) 2018/45) and in Union and international waters of Subarea 6 and Division 5.b (Table 2.2.1.2; Regulation (EU) 2018/46), and in Division 7.d (Table 2.2.1.3; ; Regulation (EU) 2018/46), defining for which species, gear and mesh size combinations the landing obligation applies. These have been updated for 2019–2021 (Regulation (EU) 2018/2035 and Regulation (EU)

2018/34) to reflect that all demersal quota stocks are now subject to landings obligations, but also to detail survivability and *de minimis* exemptions and specific technical measures.

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.

The data provided to ICES does not include information that would allow ICES to evaluate the impact or take account of the complex survivability and *de minimis* exemptions. For example, no information was provided on the use of netgrid selectivity devices, which were part of survivability exemptions for *Nephrops* in 2018, and *de minimis* information is not reported to ICES. Furthermore, 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* and other fisheries 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. The effort management regime for plaice and sole continued to apply in 2018 while the second stage of the management plan (Council Regulation (EC) 676/2007) was still 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 effort management regime for plaice and sole has now also been revoked (from 2019 onwards) with the implementation of the EU MAP for sole (Regulation (EU) 2018/973).

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 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. EU multiannual management plans (EU MAPs) are now available for demersal stocks in the North Sea (Regulation (EU) 2018/973), and demersal and deep-sea stocks in Western Waters (Regulation (EU) 2019/472), which cover stocks within WGNSSK. These have been used as the basis for advice for North Sea sole, and Eastern English Channel plaice and sole for 2019; they have not been used for shared stocks in the North Sea (cod, haddock, whiting, saithe and plaice) because Norway has not agreed to the EU MAP. Instead, the EU and Norway have jointly proposed alternative, single-species plans for these shared stocks, which ICES have evaluated (ICES-WKNSMSE 2019). 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)

2.2.5 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.

2.2.5.1 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

General observations

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. In general, links are missing between trends in observations and the impact on particular stocks. Such links need to be added either in the ecosystem overviews or as additional information in the single stock advice sheets. 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 changes are 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. This is most important to make the overviews useful for managers.

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 in the analysis. 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.

Reports from STECF on the monitoring of the CFP provide useful information on general trends in fishing pressure and biomass of stocks in the greater North Sea. Also, an indicator of developments in recruitment levels is provided. The report provides the full code used for the analyses. The work is based on ICES assessments and uses the assessment graph database. Therefore, it could be easily used for regular updates of ecosystem overviews.

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 any 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 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.

Ideas for the next version of ecosystem overviews

WGNSS together with the Pandora project discussed what useful information could be included in the next version of ecosystem overviews. In general, WGNSSK suggests to ask stakeholders about their main interests to make the ecosystem overviews fit for purpose. WGNSSK itself has the following ideas:

1. Trends in the condition and productivity (e.g., mean weight, recruitment) common for certain stocks (e.g., flatfish, pelagics, gadoids) could add important information for scientists and managers. For example, the current low productivity of many gadoids in the North Sea is not discussed in the document. Overview figures showing trends in condition and productivity (similar to figures for F/F_{MSY} and B/MSY $B_{trigger}$) may provide valuable information.
2. So far, no information is available on the distribution of stocks and changes over time. This information could be useful from a scientific but also a management perspective.
3. Density dependent and competition effects may become more important when stocks are recovering. This could have an impact on the appropriateness of current reference points and is therefore relevant for fisheries management.
4. Closed areas, including windfarms, play an increasing role in the greater North Sea. Information on the impact of such closed areas on different species (communities) would be interesting for the assessments (also how much biomass can be expected in areas not

covered by surveys?) but also to make conclusions on the effectiveness of spatial management as alternative or addition to TACs. Groups like WGSAM could provide more detailed information on changes in the North Sea food web over time, on descriptions of who eats whom.

5. Information on spawning areas, spawning times, nursery areas and shifts over time could be highly informative for conservation management.
6. 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.

2.4 Fisheries Overviews

ICES has published a Fisheries Overview for the Greater North Sea Ecoregion (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/Greater-NorthSeaEcoregion_FisheriesOverview.pdf). 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 that require it.

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 occurs in most human-consumption fisheries. 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 (from 2006 onwards) 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 only some 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 of the ten category 1 assessments, only saithe and sole in 7.d include 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 reference points (Category 1 stocks) are above B_{lim}, apart from cod in 4, 7.d and 20, and only the SSBs of cod in 4, 7.d and 20 and whiting in 4 and 7.d are below MSY $B_{trigger}$ at the beginning of 2019. Several North Sea stocks are exploited at or below F_{MSY} levels (saithe in 3a, 4 and 6, plaice in 4 and 20, plaice in 7.d, sole in 7.d, and turbot in 4); however, just as many are being fished above F_{MSY} (cod in 4, 7.d and 20, haddock in 4, 6.a and 20, whiting in 4 and 7.d, sole in 4, and witch in 3.a, 4 and 7.d). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids, although there are signs of a strong recruitment for haddock in 2019 (the strongest since the 1999 year-class; to be confirmed with future data).

All *Nephrops* stocks with agreed biomass reference points (Category 1 stocks, excluding nep.fu.3-4) are currently above MSY $B_{trigger}$, and all *Nephrops* stocks with defined F_{MSY} (Category 1 stocks, including nep.fu.3-4) are being fished at or below F_{MSY} in 2018, apart from *Nephrops* in FU 6 (nep.fu.6).

WGNSSK is also responsible for the assessment of several data-limited species (Category 3+ stocks) that are mainly by catch in demersal fisheries (brill in 3.a, 4 and 7.d-e, lemon sole in 3.a, 4 and 7.d, dab in 3.a and 4, flounder in 3.a and 4, turbot in 3a, whiting in 3a), along with striped red mullet in 3.a, 4 and 7.d. Biennial precautionary approach (PA) advice was provided in 2015 for the first time, and again in 2017; for 2019, biennial advice was either PA, where catch advice was still needed, or simply reporting stock status where no catch advice was needed. Biennial advice is required on a different cycle for pollack in 3.a and 4 and grey gurnard in 3.a, 4 and 7d, and was not provided in 2019; instead, it was only necessary to determine whether the perception of the stocks has changed compared to 2018; because these perceptions have not changed, no reopening was needed for either of these stocks. Triennial advice in now required for dab (provided from 2019 onwards).

Biennial PA advice was provided for data-limited *Nephrops* stocks (Category 4: FU 5, 10, 32, 33, 34) for the first time in 2016, and subsequently in 2018, with the next advice due in 2020. However, this advice is updated whenever the results from a new UWTV survey becomes available and the re-opening protocol is triggered (e.g. FU 34 in 2018 and FU 33 in 2019). For *Nephrops* in 4 outside functional units biennial PA advice was produced for the first time in 2015; however, it did not make sense to have biennial advice for this unit (Category 5) misaligned with biennial advice for other data-limited *Nephrops* stocks (Category 4), so in order to achieve alignment, triennial PA advice was provided in 2017, with biennial PA advice expected in 2020 (aligned with other data-limited *Nephrops* stocks).

Reopening of advice was triggered for several Category 1 stocks in the autumn, following the availability of Q3 survey results in 2019, namely cod in 4, 7.d and 20, haddock in 4, 6.a and 20, plaice in 4 and 20, sole in 4, and *Nephrops* in FU 6, 7 and 8 (Annex 7). Advice for sole in 7.d and dab in 3.a and 4 were delayed until the autumn because of the inter-benchmark for the former, and because of the change to triennial advice for the latter.

The summary of stock status is as follows:

1) *Nephrops*:

Category 1:

a) FU 3-4 (nep.fu.3-4): The stock size is considered to be stable. The estimated harvest rate for this stock is currently below F_{MSY}. No reference points for stock size have been defined for this stock.

b) FU 6 (nep.fu.6): The stock abundance has increased since 2015, and currently it is above MSY $B_{trigger}$. The harvest rate has shown a decreasing trend since 2013, and is just above F_{MSY} in 2018.

c) FU 7 (nep.fu.7): The stock size has been above MSY $B_{trigger}$ for most of the time-series. The harvest rate has declined since 2010 and remains well below F_{MSY}.

d) FU 8 (nep.fu.8): The stock size has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate is varying and is now below F_{MSY}.

e) FU 9 (nep.fu.9): The stock has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate has fluctuated around F_{MSY} in recent years and is now just below F_{MSY}.

Category 4:

f) FU 33 (nep.fu.33): The state of this stock is unknown. Landings have been relatively stable since 2004, fluctuating without trend at around 1000 tonnes. The mean density of Norway lobster decreased by 43% from 2017 to 2018. Advice was provided for this stock in 2019 (although it was not scheduled) because of the availability of data from a UWTV survey conducted in 2018.

No new advice was provided in 2019 for *Nephrops* outside the functional units (nep.27.4outFU; Category 5), and for the remaining Category 4 *Nephrops* stocks (nep.fu.5, nep.fu.10, nep.fu.32, nep.fu.34).

A workshop on Methodologies for *Nephrops* Reference Points (WKNephrops) is being held 25-29 November 2019 to evaluate reference point estimation for stocks with UWTV surveys. This workshop will also consider a consistent methodology to determine stock status and provide catch advice for data-limited *Nephrops* stocks, taking into account available data and knowledge from other areas.

2) Cod (cod.27.47d20): Fishing mortality has increased since 2016, and is above F_{lim} in 2018. Spawning-stock biomass has decreased since 2015 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, F_{pa}, and F_{lim}; the spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}.

3) Haddock (had.27.46a20): Fishing mortality has declined since the beginning of the 2000s, but it has been above F_{MSY} for the entire time-series. Spawning-stock biomass has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019 year-class is estimated to be the largest since 2000. Currently, fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, $B_{pa,}$ and B_{lim}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just below it in 2019. Fishing mortality has been above F_{MSY} throughout the time-series, apart from 2005. Recruitment (R) has been fluctuating without trend, but the last two year-classes are below average. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and B_{pa}, but above B_{lim}.

5) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality has decreased and stabilized at or below F_{MSY} since 2014. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. Currently, fishing pressure on the stock is at F_{MSY} and below F_{pa} and F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

6) Plaice (ple.27.420): 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 in 2019 is estimated to be the second highest in the time-series. Since 2009, fishing mortality has been estimated below F_{MSY}. Currently, fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}, and that spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

7) Sole (sol.27.4): The spawning-stock biomass has increased since 2007, and has been estimated above MSY $B_{trigger}$ since 2012. Fishing mortality has declined since 1999 and is close to F_{MSY} in 2018. Recruitment in 2019 is estimated to be the highest since 1988. Currently, fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}, and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

8) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing mortality has declined since the early 2000s, with an increase in the recent years to slightly below F_{MSY}. Recruitment is currently around the average of the last 10 years of the time series. Currently, fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

9) Sole (sol.27.7d): The spawning-stock biomass (SSB) has been fluctuating without trend and has been above MSY $B_{trigger}$ since 2017. Fishing mortality has been decreasing trend since 2009 and has been below F_{MSY} since 2017. Recruitment has been fluctuating without

trend. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$, F_{pa}, and F_{lim}; spawning-stock size is above MSY $B_{trigger\ proxy}$ and above B_{pa} and B_{lim}. This stock underwent an inter-benchmark during 2019 to incorporate revised tuning indices and re-estimate reference points, but was subsequently down-graded to a Category 3 assessment due to unreliable plus-group data and plus-group estimation that led to a large increase in advice. The assessment is currently indicative of trends only. A full benchmark is planned for early 2020.

10) Turbot (tur.27.4): Recruitment is variable without a trend. Fishing mortality has decreased since the mid-1990s, and has been just below F_{MSY} since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY $B_{trigger}$ since 2013. This stock was upgraded to Category 1 from Category 3 following an inter-benchmark during 2018. Currently, fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}; spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

11) Witch (wit.27.3a47d): Fishing mortality has been above F_{MSY} since the beginning of the time-series. Spawning-stock biomass that was below B_{lim} around 2010, has increased since then and is now above MSY $B_{trigger}$. Recruitment has declined since 2010 and is currently at a low level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY} and between F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

12) Category 3–6 finfish stocks: In 2019, new advice has been produced for bll.27.3a47de, dab.27.3a4, fle.27.3a4, lem.27.3a47d, mur.27.3a47d, tur.27.3a (all Category 3 stocks) and whg.27.3a (Category 5). Although not requested, advice was provided for dab.27.3a4 to deal with an advice gap left by the Commission changing the advice cycle for dab from 2 to 3 years. Advice was not provided for gug.27.3a47d (Category 3) and pol.27.3a4 (Category 5).

a) Brill (bll.27.3a47de): The biomass index has been gradually increasing over the time-series until 2015, and has then decreased. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger\ proxy}$.

b) Dab (dab.27.3a4): The biomass has been increasing since the start of the time-series, but has declined since its peak in 2016. Total mortality is fluctuating without trend. Recruitment showed an increasing trend until 2014, but has declined since then. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$, and the spawning stock size is above MSY $B_{trigger\ proxy}$.

c) Flounder (fle.27.3a4): The available survey information indicates no clear trend in stock biomass. Currently, fishing pressure on the stock is below F_{MSY}; no reference points for stock size have been defined for this stock.

d) Lemon sole (lem.27.3a47d): Total mortality has fluctuated without trend. Spawning-stock biomass increased from 2007 to 2012, and has remained stable since, albeit with a small decline in 2018. Recruitment has shown a mostly downwards trend since a peak in 2011. Currently, fishing pressure on the stock is below F_{MSY}. No reference points for stock size have been defined for this stock.

e) Striped red mullet (mur.27.3a47d): Spawning-stock biomass has decreased since 2015 as a consequence of poor recruitment and an increase in F. Recruitment in 2018 is estimated to be large. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

f) Turbot (tur.27.3a): The IBTS Q1 biomass index is variable and has been fluctuating without trend over time. The IBTS Q3 biomass index is also variable but has shown an increased level after 2005. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

g) Whiting (whg.27.3a): Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid-1990s. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

Industrial fisheries

The Norway Pout (nop.27.3a4) 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 2019.

The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass is estimated to have been fluctuating above B_{pa} for most of the time-series. Fishing mortality declined between 1985 and 1995 and has been fluctuating at a lower level since 1995. Recruitment in 2018 and 2019 was above the long-term average. Currently, spawning stock size is above B_{pa} and B_{lim}; no reference points for fishing pressure or for MSY $B_{trigger}$ have been defined for this stock.

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, 2018a). 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 2019), new advice for 2020 and 2021 is given.

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, 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, 4, 7.d, 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	2019
TAC	5263	4642	4642	4642	4642	4642	4488	5924*	7102	8122

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

Although turbot (27.4) and brill (27.3.a47de) cover different stock areas, and have quantitative single species advice, there is a combined TAC. This impedes sustainable management of one or both stocks. A TAC combining two high-value species (turbot and brill) under a low TAC can, in some instances, lead to highgrading of the lesser-valued species (brill). 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; Figure 3.1). In 2016, some of the Member States with a share in the TAC, such as Belgium, Germany and The Netherlands asked for 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

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

year (2018), c) observations and catches of fishermen did not seem to confirm the assessment (delay with data).

Although no new advice was given in 2018 (no re-opening), the TAC for 2019 was increased to 8122 tonnes. The reason for this remains unclear. The combined TAC for brill and turbot was not restrictive in 2017 and 2018, and was undershot by 23% and 39% respectively (Figure 3.1).

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). It should be considered that Dutch producer organizations increase the MLS when the TAC is limiting (e.g. from 27 cm to 30 cm in 2016 and later even to 32 cm). Nevertheless, in 2019, brill is entirely under the landing obligations, which implies landing of all sizes. An additional management regulation is imposed by Dutch producer organizations, who cap the weekly landings of turbot and brill to stay within the TAC (especially when the TAC is limiting). Following increased advice in 2018–2019, PO measures were relaxed.

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 and 2019, similarly both age and length data were requested.

3.2.1 Landings

Tables 3.1–3 summarize the official brill landings by country for Division 3.a, Subarea 27.4, and divisions 27.7.d-e respectively (Source: ICES Fishstat). The total official landings can be consulted in Table 3.4 and Figure 3.2. Over the period 1950–1970, total landings stayed quite constant under 1000 tonnes (range from 582 to 947 tonnes), followed by a gradual increase to 2121 tonnes in 1977. During 1978–2014, total landings varied between 1517 tonnes (in 1980) and 3141 tonnes (in 1993). From 2000–2014, annual total landings fluctuated around an average of 2112 tonnes (range: 1781 tonnes–2409 tonnes). In 2015, landings increased to the third highest value in the time series (2537 tonnes) and also in 2016, landings stayed in the same range (2415 tonnes). In 2017, landings decreased a little further to 2293 tonnes, but are still amongst the highest of the time series. In 2018, a further decrease was observed to 1947 tonnes.

Subarea 27.4 accounts for the major part of these landings (Figure 3.3), on average generating 68% of the total landings over the time series (range: 50–86%). The English Channel and the Skagerrak-Kattegat area are responsible for average contributions to the international brill landings of 20% and 13% respectively. Skagerrak-Kattegat 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. In 2018, the relative proportion of landings in Subarea 27.4 consisted of 60% of the total landings, for Division 27.3a 6% and for Division 27.7.d, e 34% (Table 3.5).

Figure 3.4 shows the ICES catch estimates (both discards and landings provided through InterCatch) and the official catch statistics by country for 2018. The Netherlands fishes the majority of the catches and fish predominantly in Subarea 4, followed by the UK (including the Channel Islands) and France. France is responsible for the majority of the landings in Division 27.7e. Belgium and Denmark have the highest landings in Division 27.7d and 27.3a respectively (Table 3.6). No BMS landings were reported to InterCatch, whilst the official catch statistics reported 681 kg.

The most important gear types are TBB (especially in Subarea 27.4) and OTB (mainly in Subarea 27.4 and 27.7e) (Table 3.7).

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 and 2019 WGNSSK data call also asked for both age and length. For assessment purposes age/length allocations in InterCatch did not need to be performed.

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. From 2019 onwards, the stock is completely under the landing obligation.

Discard data from 2014–2018 are available in InterCatch. The proportion of landings for which discard weights are available in 2018 was 65%. Discards raising was performed on a gear level, regardless of season or country.

- The following groups were distinguished based on the gear:
    - TBB
    - OTB, OTT, SSC and SDN
    - GTR and GNS
- The remaining gears were combined in a REST group

All discard rates were retained during the raising (none were excluded for example due to being higher than average). Raised discards by country for 2018 are shown in Figure 3.4.

An overview of the overall discard rates from 2014–2018 is shown in Table 3.8 and for 2017 and 2018 broken down by country and Subarea/Division in Table 3.9 and 3.10 respectively. There is no obvious trend over the period 2014–2018. However, discard rates are overall higher in 2018 compared to the previous years. Discard rates well-above the average are found for e.g. Denmark (30% in 2018) and Sweden (30% in 2018), corresponding to the higher discard rates in the North of the stock area (up to 41% in 27.3.a in 2018; Table 3.10). These higher numbers in the North are largely the result of gillnet and bottom trawl fisheries.

For assessment purposes age/length allocations in InterCatch did not need to be performed.

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, 2012) 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, 2012), 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 2019.

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 and for several years in Figure 3.5 and over time in Figure 3.6 and Table 3.11. These seem to illustrate a recovery of the species in the south-eastern part of 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 towards 2017. In 2018, the index shows again a slight increase. However, it should be noted that the recorded numbers per hour are low, especially in the most recent years (Figure 3.7), and that inter-annual variation over the years is large. Therefore, no general trend can be identified for this time series. The corresponding age–length key is illustrated in Figure 3.8. The main part of the catches in this survey represent brill of ages 1–2 and lengths of 20–30 cm. No obvious shifts in length distributions are apparent over the time series (1987–2018), but a decrease in the numbers caught since the 1990s is unmistakable.

Kattegat (Division 27.3.a21)

The abundance indices (numbers per hour) for brill in the BITS_HAF quarter 1 (Q1) and quarter 4 (Q4) are spatially plotted per rectangle and for several years in Figure 3.9 and 3.12 respectively. The index plotted over time for quarter 1 is shown in Figure 3.10 and Table 3.12 and for quarter 4 in Figure 3.13 and Table 3.13. Note that the quarter 1 survey includes the 2019 data point.

The quarter 1 index shows a gradual increase from the late 1990s to 2006. Up until 2015, the series fluctuates around 3 fish per hour. In 2017, the index reaches the highest point of the time series (approximately 8 fish per hour) to decrease again in 2018 (around 1 fish per hour). The 2019 value increases to approximately 4 fish per hour. The quarter 4 index shows a gradual increase from the late 1990s to 2007. The period 2007–2013 fluctuates around 4 fish per hour. In 2014–2015, the index increases up to 6 fish per hour to decrease again in 2017 to < 4 fish per hour. The highest point in the time series is observed in 2018 where almost 11 fish per hour are found. Although both indices have been showing more or less the same trend over the time series, the quarter 1 index has showed a further increase up to 2017, while the quarter 4 index has decreased again. Also the 2018 value of the indices is contradictive (Figure 3.14). The quarter 4 index is more in line with the BTS-ISI_Q3 index in the most recent years.

The corresponding length distributions for the BITS_HAF in quarter 1 and 4 in 27.3.a21 are shown in Figure 3.11 and 3.15. 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 (1996–2019). In some years, cohorts are visible, e.g. 2011 in Q1 and 2016–2018 in Q4.

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; 2012; 2013).

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, 2013 for interpretation), and has been used as the basis for the advice since. This LPUE was standardized 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 LPUE's, the standardization of engine power, the correction for targeting behaviour and the results can be found in van der Hammen *et al*. (2011).

The Dutch LPUE series used during the WGNSSK 2019 is shown in Figure 3.16 and Table 3.14. The series shows a gradual increase in the LPUE (kg/day) up to 2012, dropping slightly over the period 2013–2014, but increasing again in 2015. In the period 2016–2018, a stronger decrease is observed (from 55.72 to 39.093 kg/day).

3.3.3 New industry-based survey initiated

Available fisheries independent surveys showed to have a low catchability for large flatfish, which did not benefit the turbot and brill assessments. In 2018, the Dutch producer organization VisNed and Wageningen Marine Research initiated an industry-based survey to monitor large flatfish such as turbot and brill in the North Sea. The survey took place in quarter 4 and 3 vessels were selected to monitor 3 different zones covering 5.5 ICES rectangles each (Figure 3.17). These zones were defined based on LPUE data and information from fishers. Per ICES statistical rectangle, 2 haul positions were set by scientists and 2 haul positions could be chosen by the fisher (22 hauls per zone in total; haul positions are shown in Figure 3.17). Two otoliths per cm class per rectangle were sampled.

Due to bad weather conditions one of the zones could not be monitored (purple zone in Figure 3.17). The numbers of brill caught during this survey were approximately 5 times higher than caught during the BTS-ISI survey. Clear cohorts could be delineated, which added new information to the existing data from the commercial sampling and the fisheries independent surveys (Figure 3.18).

Once a period of 5 years is covered, the index of this new survey is a potential candidate to include in the brill assessment. However, there are some practical drawbacks, which need to be sorted out to verify if this rather costly survey could be continued.

3.4 Analyses of stock trends and potential status indicators

During the WGNSSK 2019, advice was given based on the Dutch commercial LPUE series and the outcome of the Surplus Production in Continuous Time (SPiCT) model.

During the WGNSSK 2017, this stock showed to be a potential candidate to upgrade to a higher category (*i.e.* category 1). However, for an age or length-based assessment more data as well as resources are needed.

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. In 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.

In 2019, new advice was needed and applying the 2:3 rule led to a 19.3% decrease in advice for 2020 and 2021. The index is estimated to have decrease by less than 20% and thus the uncertainty cap was not applied. In order to decide whether the precautionary buffer should be applied, the Surplus Production in Continuous Time (SPiCT) model was run (see §3.4.2).

3.4.2 SPiCT MSY proxy reference points

A Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was applied during the WGNSSK 2019 to estimate the status of the stock against MSY proxy reference points. The procedure and settings of the SPiCT analysis were identical to the agreed method of the WGNSSK 2017 (ICES, 2017).

One fishery independent survey time series (BTS_ISI_Q3), a standardized LPUE from the Dutch beam-trawl fleet (with vessels > 221 kW), and a catch time series (1950–2018) were used as input for the model.

The SPiCT run used the following settings:

- Landings data from 1987 onwards (landings data were trimmed to have a full coverage of the landings time series by the tuning series);
- Including BTS Q3 survey (1987–2018) and standardized LPUE from the Dutch beam-trawl fleet (vessels > 221 kW) (1995–2018);
- 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.

A summary of the SPiCT assessment is given in Figure 3.19 and in Table 3.15. 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 relatively stable pattern, from which was concluded that the model performed quite well. The trends are similar and the estimated status with respect to reference points is consistent.

3.5 Biological reference points

The table below summarises all known reference points for brill in area 3a47de and their technical basis. No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the proxy MSY reference points.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger_{proxy}}$	$\frac{B}{B_{MSY}} = 0.5$	Relative value from SPiCT model. B_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2017)
	$F_{MSY_{proxy}}$	$\frac{F}{F_{MSY}} = 1$	Relative value from SPiCT model. F_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2017)
Precautionary approach	B_{lim}	Not defined		
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

3.6 Quality of the assessment

- The advice is based on a commercial biomass index (Dutch beam-trawl fleet, vessels > 221 kW) used as an indicator of stock size. Between 2014 and 2018 the use of pulse trawls in the Dutch fishery operating in the North Sea has increased to 76 vessels (65 of which are > 221 kW) and a handful of vessels operating with traditional beam trawls are now left. The increased use of pulse trawls and other adaptations, like fuel-saving wings, may affect catchability and selectivity of North Sea brill. The effect of these changes on the LPUE as an index has not yet been quantified.
- When the TAC is limiting, Dutch producer organizations increase the minimum market landing size and cap the weekly landings to stay within the TAC, which has likely biased the commercial biomass index downwards for 2016. These measures were relaxed in 2018 and 2019 following an upward revision in the TAC at the end of 2017. The combined TAC for brill and turbot was no longer restrictive in 2017 and 2018, and was undershot by 23% and 39% respectively.
- The current surveys in this area are not designed for catching brill, especially large brill. A fisheries-independent survey, both with adequate catchability of large flatfish and covering the entire distribution area of the stock, would improve the assessment.

3.7 Management considerations

Brill is mainly a bycatch species in fisheries for plaice and sole. ICES was requested to evaluate the role of the TAC in the management of turbot and brill in the North Sea (ICES, 2018b). ICES concluded that turbot and brill should be managed using single-species TACs covering an area appropriate to the relevant stock distribution (for brill: ICES Division 3.a, Subarea 4, and divisions 7.d and 7.e). A TAC combining two high-value species (turbot and brill) under a low TAC can, in some instances, lead to highgrading of the lesser-valued species (brill).

The assessment uses a commercial biomass index based only on landings; as a result the index and the advice may be affected by the discard pattern.

3.8 Benchmark issue list

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		
New data	Currently a limited amount of brill data is available in InterCatch. Ask all countries involved in the fisheries to provide all available brill data on landings, discards, @age, @length including historical data.	Process data in Inter Catch, use model to bridge gaps in time series (cfr. Turbot assessment)	Data from all countries involved in brill fisheries.	Dutch expert in modelling (cfr. Turbot assessment)
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 7d, e part of the stock area.	Analyse DATRAS data	Data available in DATRAS.	Survey experts
	Check whether any commercial tuning series could be used in the assessment (besides the Dutch LPUE series currently used)	Analyse data and construct index	Catch and effort information from all countries involved in the brill fisheries	Experts from each Member State providing the data
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 all countries involved in the brill fisheries	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)	

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	Currently a biomass index is calculated 1) Check whether the index series can be extended. 2) 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) 3) Check whether age 0 and 1 should be included in the index 4) Should the index be age structured or not? (cfr. Turbot assessment) 5) Explore whether other assessment methods can be used (SPiCT/SAM).	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

3.9 References

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Table 3.1: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivision 27.3a (Skagerrak/Kattegat) by country, over the period 1950–2018 (Source: ICES Fishstat); *including BMS landings.

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

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
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
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	125	7	8	28	168
2017	0	0	131	4	8	27*	170
2018	0	0	90	8	9	17*	125

Table 3.2: BLL 27.3a47de – Official landings (tonnes) of brill in Subarea 27.4 by country, over the period 1950–2018 (Source: ICES Fishstat); * including BMS landings.

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

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1989	112	0	43	9	58	1080	0	0	1302
1990	168	0	139	24	82	480	0	0	893
1991	205	38	145	28	147	1111	8	0	1682
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	76	121	7	116	1000*	2	0	1460
2018	99	79	96	6	99	782*	2	0	1163

Table 3.3: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivisions 27.7.d, e (English Channel) by country, over the period 1950–2018 (Source: ICES Fishstat).

Year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
1950	11	0	0	48	0	0	0	59
1951	8	0	0	70	0	0	0	78
1952	6	0	0	66	0	0	0	72
1953	2	0	0	60	0	0	0	62
1954	1	0	0	59	0	0	0	60
1955	4	0	0	57	0	0	0	61
1956	2	0	0	58	0	0	0	60
1957	4	0	0	66	0	0	0	70
1958	2	0	0	65	0	0	0	67
1959	1	0	0	58	0	0	0	59
1960	6	0	0	46	0	0	0	52
1961	1	0	0	46	0	0	0	47
1962	3	0	0	52	0	0	0	55
1963	1	0	0	50	0	0	0	51
1964	0	0	0	60	0	0	0	60
1965	2	0	0	46	0	0	0	48
1966	0	0	0	53	0	0	0	53
1967	1	0	0	66	0	0	0	67
1968	3	0	0	54	0	0	0	57
1969	2	0	121	67	0	0	0	190
1970	10	0	0	49	0	0	0	59
1971	18	0	0	48	0	0	0	66
1972	20	0	0	52	0	3	0	75
1973	20	0	0	70	0	0	0	90
1974	25	0	0	56	0	0	0	81
1975	24	0	55	56	0	0	2	137
1976	41	0	170	72	0	0	2	285
1977	45	0	197	77	0	0	4	323
1978	58	3	227	120	0	0	3	411
1979	55	0	262	140	0	0	2	459
1980	64	2	213	118	3	0	2	402
1981	83	0	271	130	0	0	6	490
1982	105	0	225	149	0	1	7	487
1983	107	0	234	181	0	1	3	526
1984	114	0	226	186	0	0	5	531
1985	94	0	213	177	0	0	10	494
1986	115	0	183	147	0	0	11	456
1987	126	0	216	141	0	0	10	493
1988	112	0	202	133	0	0	5	452

Year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
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	6	721
2017	135	0	276	246	0	2	3	663
2018	128	0	280	247	1	2	1	659

Table 3.4: BLL 27.3a47de – Total official landings (tonnes) of brill in the 27.3a47de (Greater North Sea) over the period 1950–2018, subdivided into Subarea 27.4 and Divisions 27.3.a and 27.7.d, e (Source: ICES Fishstat).

Year	3.a	4	7.de	TOTAL
1950	319	384	59	762
1951	337	511	78	926
1952	236	565	72	873
1953	246	589	62	897
1954	234	529	60	823
1955	212	571	61	844
1956	213	516	60	789
1957	148	468	70	686
1958	203	480	67	750
1959	233	424	59	716
1960	318	486	52	856
1961	305	581	47	933
1962	207	591	55	853
1963	120	620	51	791
1964	106	565	60	731
1965	155	535	48	738
1966	187	546	53	786
1967	106	409	67	582
1968	100	579	57	736
1969	99	658	190	947
1970	97	618	59	774
1971	104	1073	66	1243
1972	120	994	75	1189
1973	131	989	90	1210
1974	200	1152	81	1433
1975	187	1222	137	1546
1976	224	1208	285	1717
1977	388	1410	323	2121
1978	216	1375	411	2002
1979	184	1363	459	2006
1980	82	1033	402	1517
1981	59	1218	490	1767
1982	74	1294	487	1855
1983	83	1448	526	2057
1984	97	1522	531	2150
1985	110	1709	494	2313
1986	107	1207	456	1770
1987	105	970	493	1568
1988	101	1085	452	1638

Year	3.a	4	7.de	TOTAL
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	168	1526	721	2415
2017	170	1460	663	2293
2018	125	1163	659	1947

Table 3.5: BLL 27.3a47de – Overview of absolute landings per area over the last 9 years with an indication of the relative proportion by area.

	Absolute landings (tonnes)				Relative proportion		
Year	3a	4	7de	TOTAL	3a	4	7de
2010	122	1500	695	**2317**	0.05	0.65	0.30
2011	131	1497	622	**2250**	0.06	0.67	0.28
2012	120	1512	617	**2249**	0.05	0.67	0.27
2013	92	1389	601	**2082**	0.04	0.67	0.29
2014	79	1212	651	**1942**	0.04	0.62	0.34
2015	143	1655	691	**2489**	0.06	0.66	0.28
2016	164	1526	719	**2409**	0.07	0.63	0.30
2017	169	1366	662	**2197**	0.08	0.62	0.30
2018	125	1163	658	**1946**	0.06	0.60	0.34

Table 3.6: BLL 27.3a47de – Overview of 2018 catches reported to InterCatch (ICES) by country and area.

Country	3a		4		7d		7e		Total		
	Dis	Lan	Dis	Lan	Dis	Lan	Dis	Lan	Dis	Lan	All
Belgium	0	0	19	64	4	162	0	0	22	226	248
Denmark	77	90	4	96	0	0	0	0	81	186	267
France	0	0	1	6	51	56	11	223	63	286	349
Germany	0	0	16	79	0	0	0	0	16	79	95
Ireland	0	0	0	0	0	0	0	0	0	0	0
Netherlands	1	9	91	769	1	2	0	0	94	781	874
Norway	2	8	1	2	0	0	0	0	2	10	13
Sweden	7	17	0	0	0	0	0	0	7	17	25
UK (England)	0	0	10	71	2	24	34	221	46	316	362
UK(Northern Ireland)	0	0	0	0	0	0	0	0	0	0	0
UK(Scotland)	0	0	11	28	1	2	0	0	12	31	43
Total	87	125	152	1116	60	247	45	445	344	1933	**2277**

Table 3.7: BLL 27.3a47de – Overview of 2018 landings for the most important gear types per area.

Gear type	3a	4	7d	7e	Total
DRB	0	0	12	2	15
FPO	0	0	0	0	0
GNS	17	51	7	7	82
GTR	3	6	17	129	155
LLS	0	0	0	0	0
MIS	0	13	5	22	40
OTB	95	178	25	117	415
OTT	0	0	0	1	1
SDN	1	1	0	0	2
SSC	0	2	4	0	6
TBB	9	865	175	167	1217
Total	**125**	**1116**	**247**	**445**	**1933**

Table 3.8: BLL 27.3a47de – Overall discard rates (all countries and métiers) for brill over the period 2014–2018 (Source: InterCatch).

Year	Discard rate
2014	0.11
2015	0.09
2016	0.10
2017	0.09
2018	0.15

Table 3.9: BLL 27.3a47de – Discard rates for brill by country for 2017 and 2018 (source: InterCatch).

Country	Discard rate 2017	Discard rate 2018
Belgium	0.04	0.09
Denmark	0.15	0.30
France	0.09	0.18
Germany	0.13	0.17
Ireland		
Netherlands	0.09	0.11
Norway	0.10	0.19
Sweden	0.17	0.30
UK (England)	0.05	0.13
UK (Northern Ireland)	0.14	0.34
UK(Scotland)	0.03	0.28
Overall	0.09	0.15

Table 3.10: BLL 27.3a47de – Discard rates for brill by area for 2017 and 2018 (Source: InterCatch).

Subarea/ Division	Discard rate 2017	Discard rate 2018
27.3.a	0.22	0.41
27.4	0.08	0.12
27.7.d	0.09	0.19
27.7.e	0.02	0.09
Overall	0.09	0.15

Table 3.11: BLL 27.3a47de – Survey index (N°/h) for brill in the BTS_ISI_Q3, Subarea 27.4.

Year	N/hr	Year	N/hr
1987	2.104167	2003	1.084337
1988	0.685714	2004	0.938272
1989	1.036585	2005	0.695652
1990	2.361702	2006	0.962963
1991	1.730612	2007	1.243902
1992	2.818557	2008	0.588235
1993	2.325769	2009	1.555556
1994	1.719281	2010	2.434842
1995	1.294353	2011	2.676993
1996	0.585366	2012	1.177282
1997	1.421687	2013	0.833333
1998	1.665552	2014	2.949902
1999	0.893617	2015	1.929677
2000	2.554228	2016	1.069767
2001	0.885714	2017	0.870027
2002	0.881016	2018	1.448486

Table 3.12: BLL 27.3a47de – Survey index (N°/h) for brill in the BITS_HAF_Q1, Division 27.3a21 (Kattegat).

Year	N/hr
1996	1.777778
1997	0.272727
1998	0.500000
1999	0.714286
2000	1.071429
2001	0.642857
2002	1.928571
2003	1.379310
2004	2.000000
2005	1.714286
2006	3.866667
2007	3.214286
2008	2.733333
2009	2.038462
2010	2.896552
2011	3.285714
2012	2.533333
2013	1.571429
2014	2.857143
2015	3.555556
2016	4.857143
2017	7.923077
2018	1.076923
2019	4.086957

Table 3.13: BLL 27.3a47de – Survey index (N°/h) for brill in the BITS_HAF_Q4, Division 27.3a21 (Kattegat).

Year	N/hr
1999	2.857143
2000	0.315789
2001	1.800000
2002	2.071429
2003	1.928571
2004	3.310345
2005	2.896552
2006	4.758621
2007	5.117241
2008	4.400000
2009	3.750000
2010	4.838710
2011	5.034483
2012	3.000000
2013	3.830889
2014	6.090370
2015	6.636364
2016	4.666667
2017	3.636364
2018	10.869565

Table 3.14: BLL 27.3a47de – Commercial LPUE (kg/day) for brill by the Dutch beam trawl fleet > 221 kW, Subarea 27.4.

Year	LPUE (kg/day)
1995	19.670
1996	19.187
1997	13.387
1998	23.752
1999	22.973
2000	24.077
2001	26.099
2002	22.147
2003	26.821
2004	27.058
2005	25.903
2006	26.676
2007	32.883
2008	39.854
2009	40.096
2010	50.430
2011	52.139
2012	55.820
2013	53.009
2014	46.116
2015	61.505
2016	55.723
2017	48.814
2018	39.093

Table 3.15: BLL 27.3a47de – SPiCT summary output from the analyses performed during the WGNSSK 2019.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 8.0077875
Euler time step (years):  1/16 or 0.0625
Nobs C: 32,  Nobs I1: 32,  Nobs I2: 24

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    3.7465327    1.1538943 1.216447e+01  1.3208308
 alpha2    0.5453000    0.0406185 7.320604e+00 -0.6064192
 beta      0.1454133    0.0257686 8.205728e-01 -1.9281753
 r         0.7927136    0.2306433 2.724531e+00 -0.2322933
 rc        2.1720368    1.3458594 3.505376e+00  0.7756653
 rold      2.9351773    0.0493148 1.746993e+02  1.0767679
 m      2231.8717684 2075.0133100 2.400588e+03  7.7105959
 K      6592.7687456 3030.2697456 1.434348e+04  8.7937287
 q1        0.0007320    0.0004530 1.183000e-03 -7.2196681
 q2        0.0187595    0.0117252 3.001400e-02 -3.9760531
 n         0.7299265    0.2478702 2.149482e+00 -0.3148114
 sdb       0.1258437    0.0410350 3.859299e-01 -2.0727143
 sdf       0.2134239    0.1469128 3.100461e-01 -1.5444751
 sdi1      0.4714777    0.3621679 6.137795e-01 -0.7518835
 sdi2      0.0686226    0.0144052 3.268992e-01 -2.6791335
 sdc       0.0310347    0.0058223 1.654256e-01 -3.4726505

Deterministic reference points (Drp)
          estimate        cilow       ciupp   log.est
 Bmsyd 2055.095759 1258.4293860 3356.102952 7.6280777
 Fmsyd    1.086018    0.6729297    1.752688 0.0825181
 MSYd  2231.871768 2075.0133100 2400.587778 7.7105959
Stochastic reference points (Srp)
          estimate        cilow       ciupp   log.est rel.diff.Drp
 Bmsys 2043.962592 1245.2434401 3354.993041 7.6226456 -0.005446855
 Fmsys    1.085578    0.6747298    1.746595 0.0821125 -0.000405665
 MSYs  2218.875851 2063.5822389 2385.855988 7.7047560 -0.005856983

States w 95% CI (inp$msytype: s)
                    estimate        cilow       ciupp    log.est
 B_2018.50      2236.6487603 1250.5546949 4000.302983  7.7127339
 F_2018.50         0.8663746    0.4793530    1.565871 -0.1434379
 B_2018.50/Bmsy    1.0942709    0.7899617    1.515806  0.0900883
 F_2018.50/Fmsy    0.7980768    0.5536413    1.150432 -0.2255504

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow       ciupp    log.est
 B_2019.00      2346.0838414 1300.4459662 4232.478345  7.7605028
 F_2019.00         0.8470008    0.4491669    1.597202 -0.1660536
 B_2019.00/Bmsy    1.1478115    0.8113522    1.623797  0.1378571
 F_2019.00/Fmsy    0.7802303    0.5100821    1.193454 -0.2481661
 Catch_2019.00  2051.2807353 1565.7876496 2687.307347  7.6262196
 E(B_inf)       2563.0758709           NA          NA  7.8489633
```

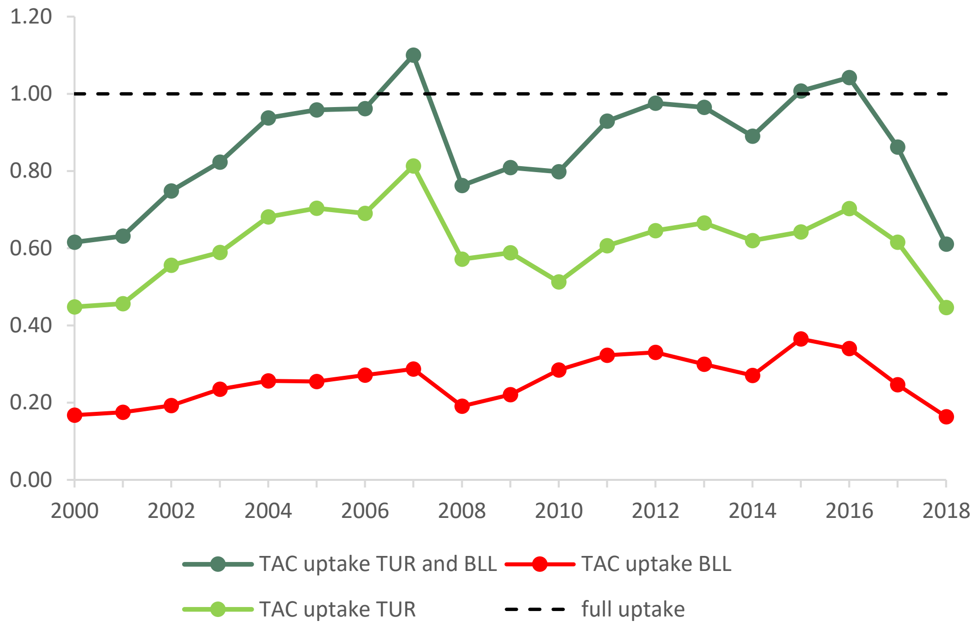

Figure 3.1: BLL 27.3a47de – TAC uptake for both brill and turbot in area 2.a and 4.

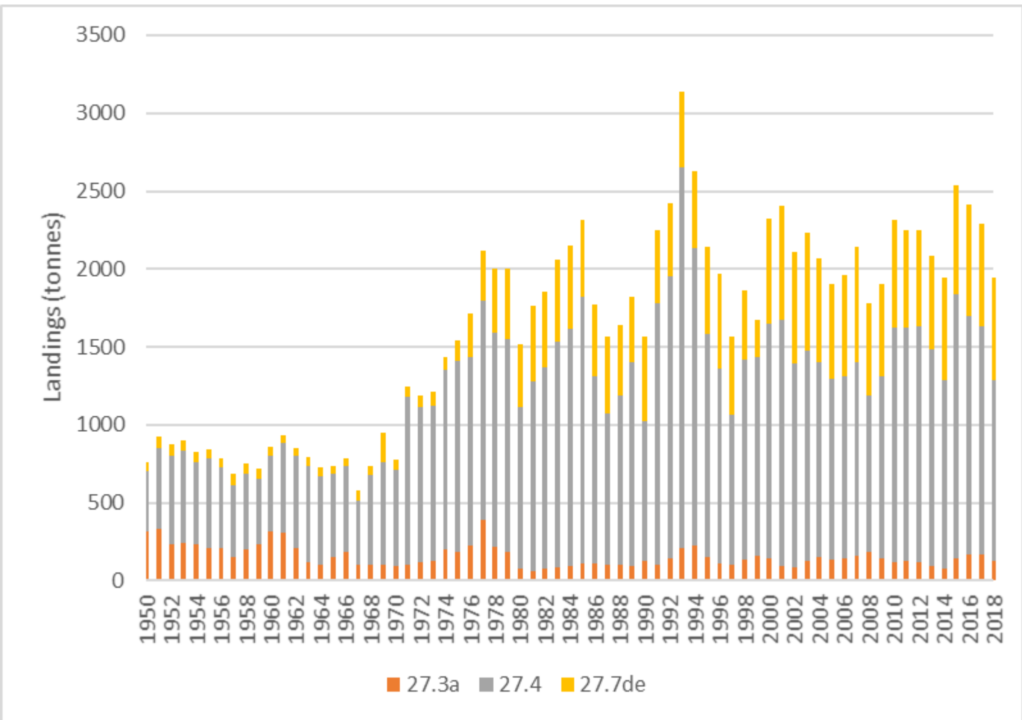

Figure 3.2: BLL 27.3a47de – Official landings (tonnes) over the period 1950–2018, as officially reported (Rec 12; ICES Fishstat).

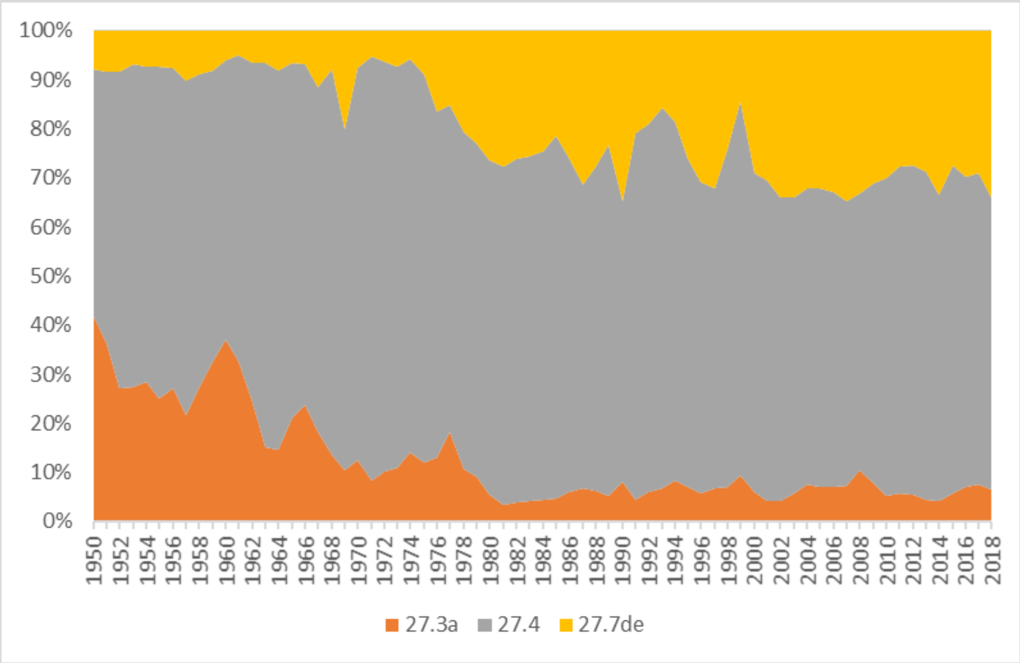

Figure 3.3: BLL 27.3a47de – Relative contribution to the official landings of brill from Subarea 27.4, Division 27.3.a and 27.7.d,e to the total international landings (tonnes) in the Greater North Sea over the period 1950–2018 (Source: ICES Fishstat).

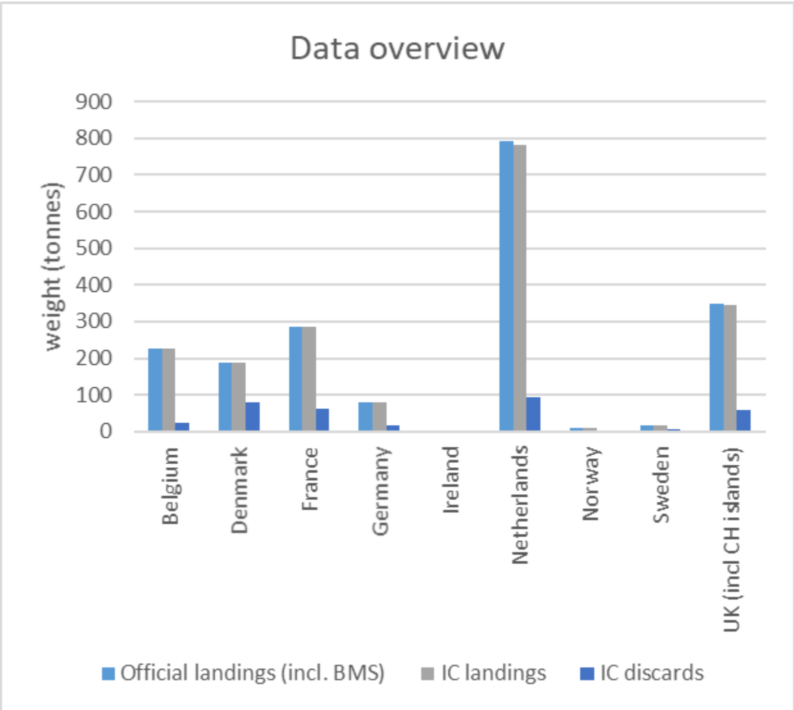

Figure 3.4: BLL 27.3a47de – Comparing ICES catch estimates (InterCatch, IC) to the official catch statistics by country for 2018.

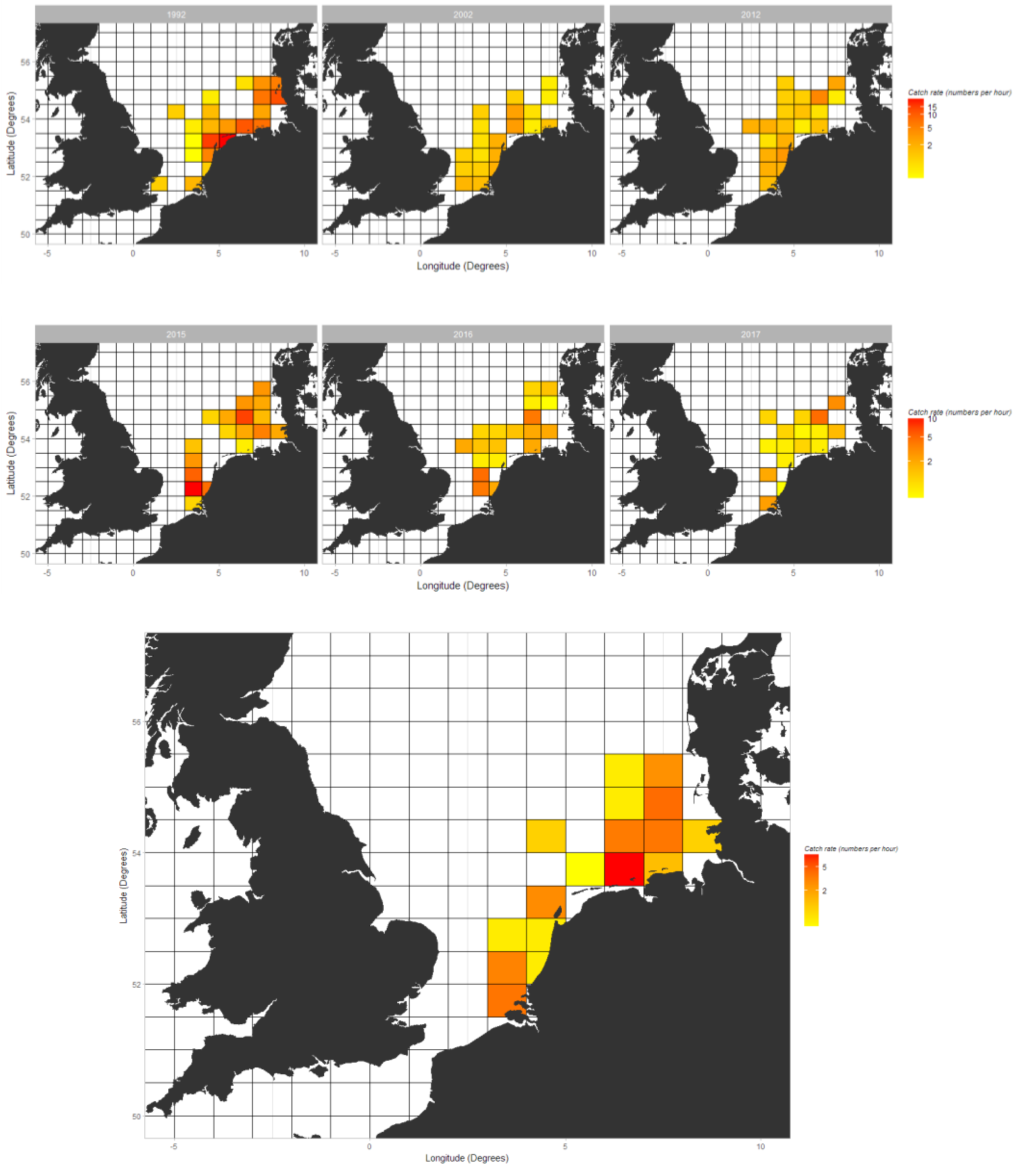

Figure 3.5: BLL 27.3a47de – Average numbers of brill caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (27.4) for 1992, 2002, 2012, 2015, 2016, 2017 and 2018; note the slightly different scales for the different graphs.

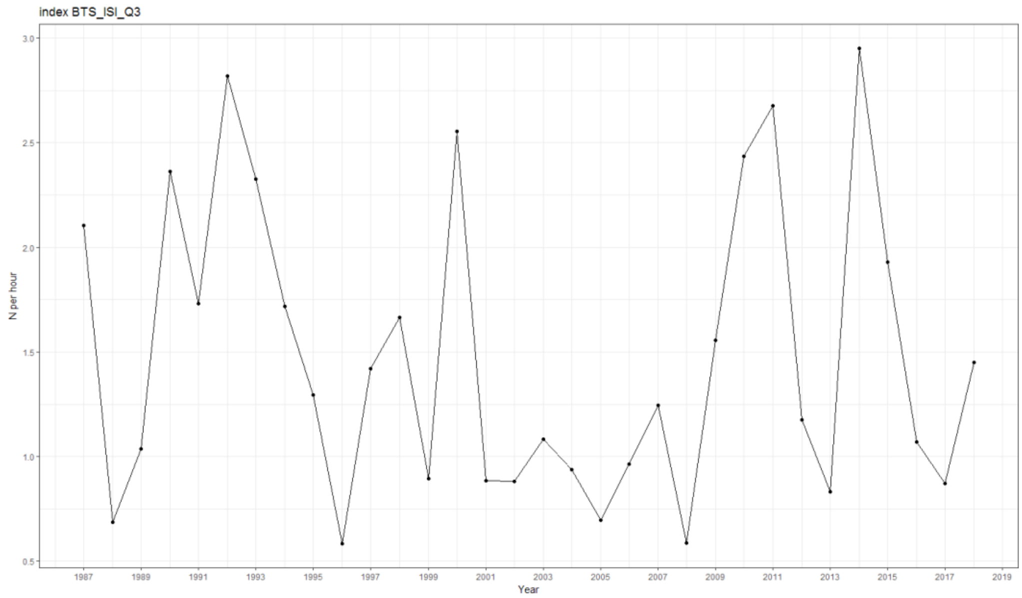

Figure 3.6: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2018.

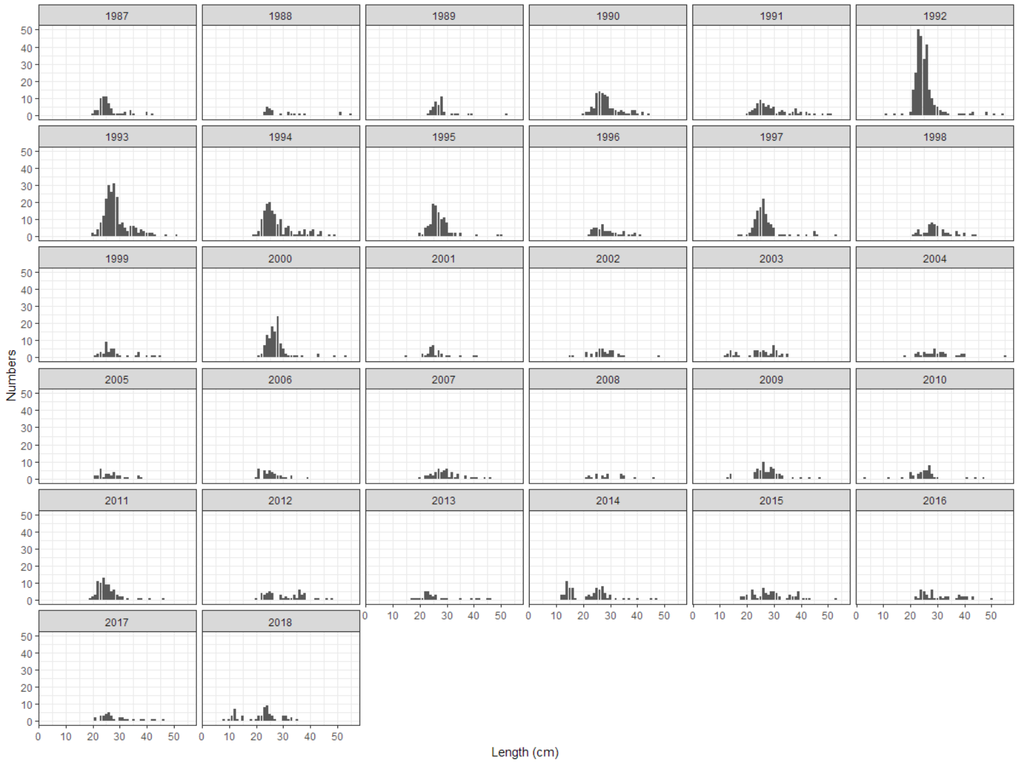

Figure 3.7: BLL 27.3a47de – Length distributions of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1987–2018)

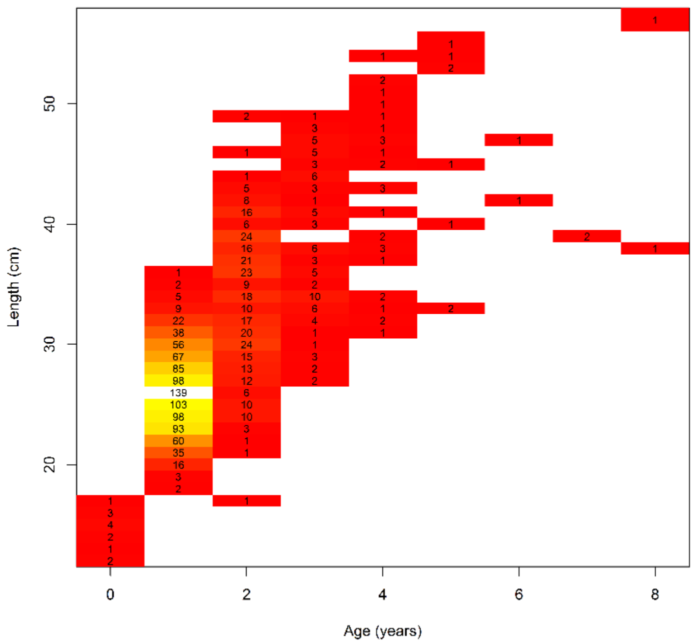

Figure 3.8: BLL 27.3a47de – Age-length key of brill in the North Sea (27.4) as documented by the BTS_ISI_Q3 (1992–2018).

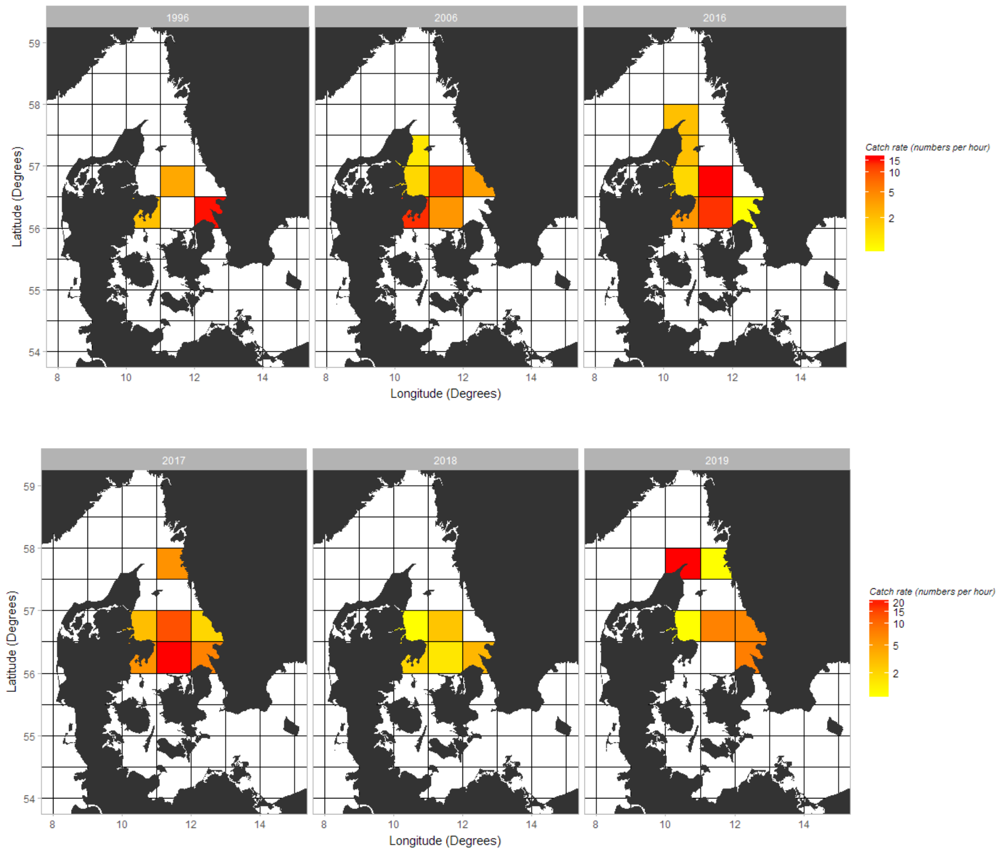

Figure 3.9: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q1 in the Kattegat (27.3.a21) in 1996, 2006, 2016, 2017, 2018 and 2019; note the slightly different scales for the different graphs.

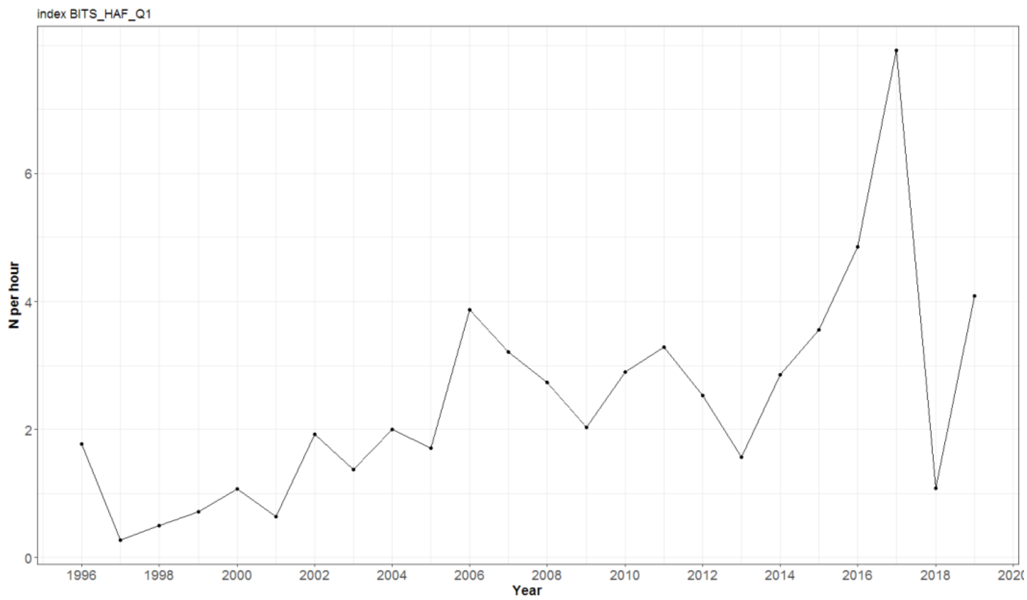

Figure 3.10: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q1) over the period 1996–2019.

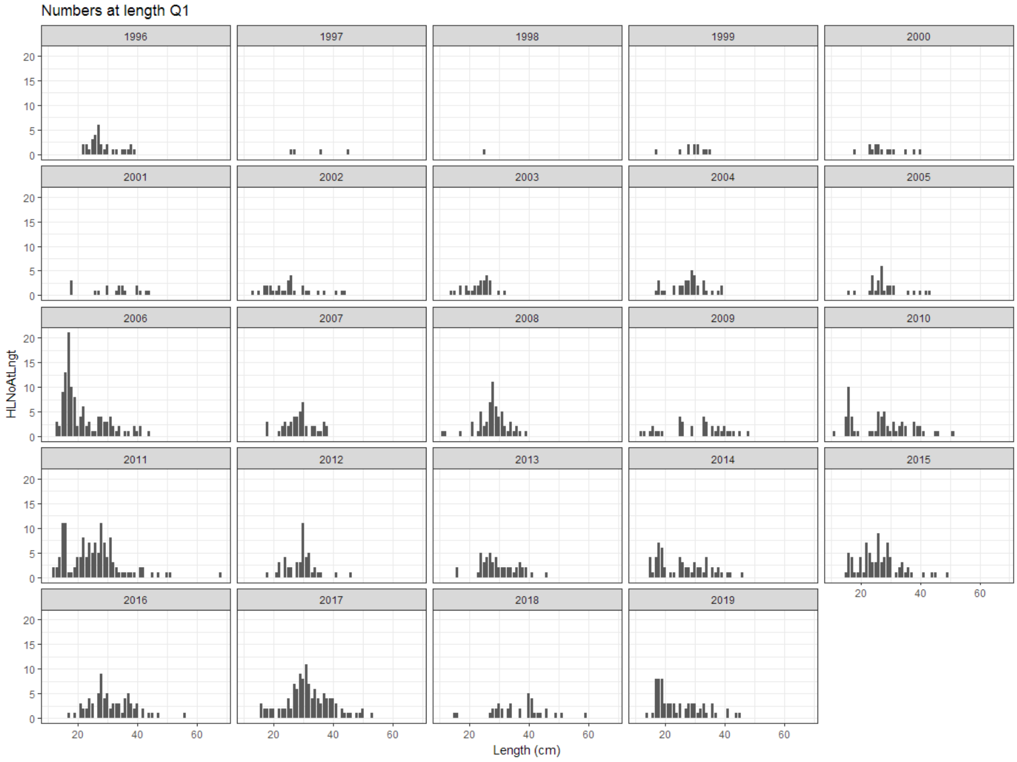

Figure 3.11: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q1 (1996–2019).

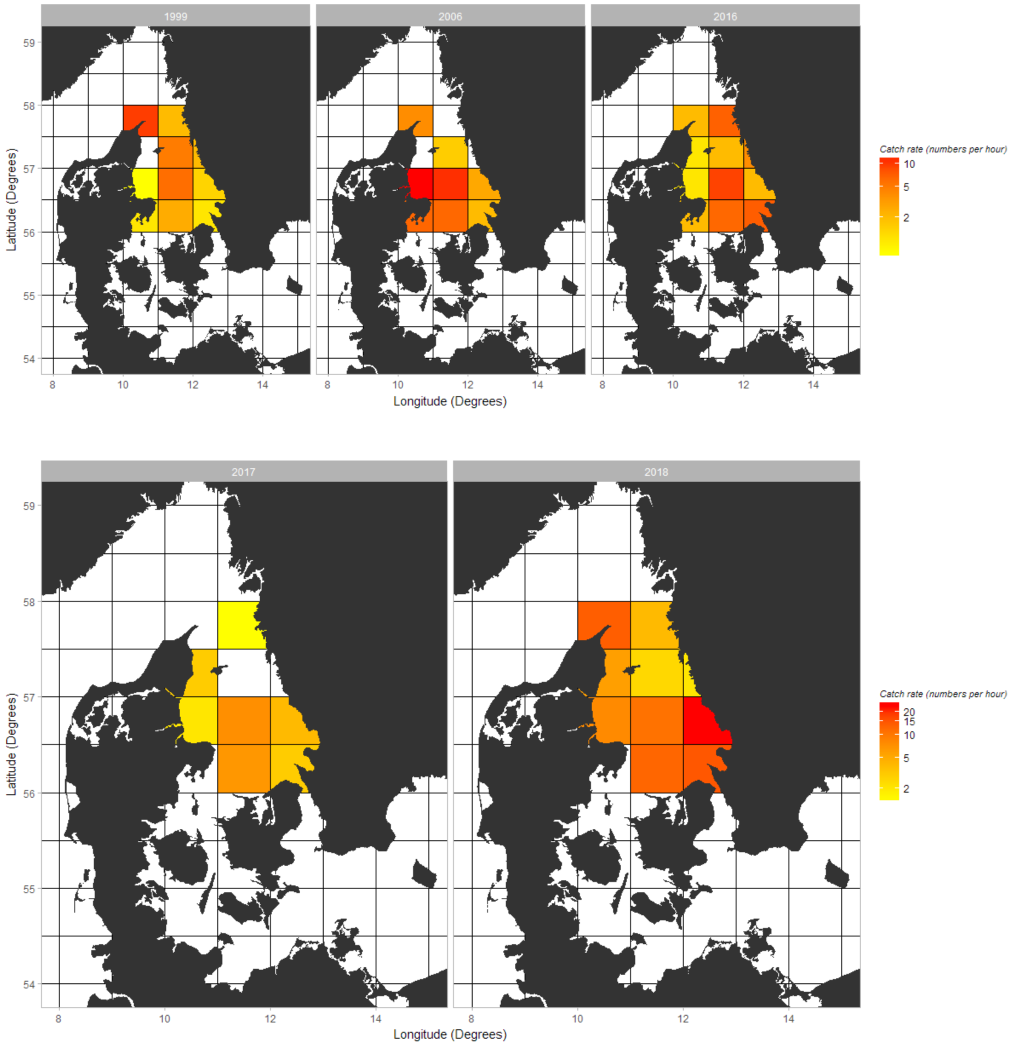

Figure 3.12: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q4 in the Kattegat (27.3.a21) in 1999, 2006, 2016, 2017 and 2018; note the slightly different scales for the different graphs.

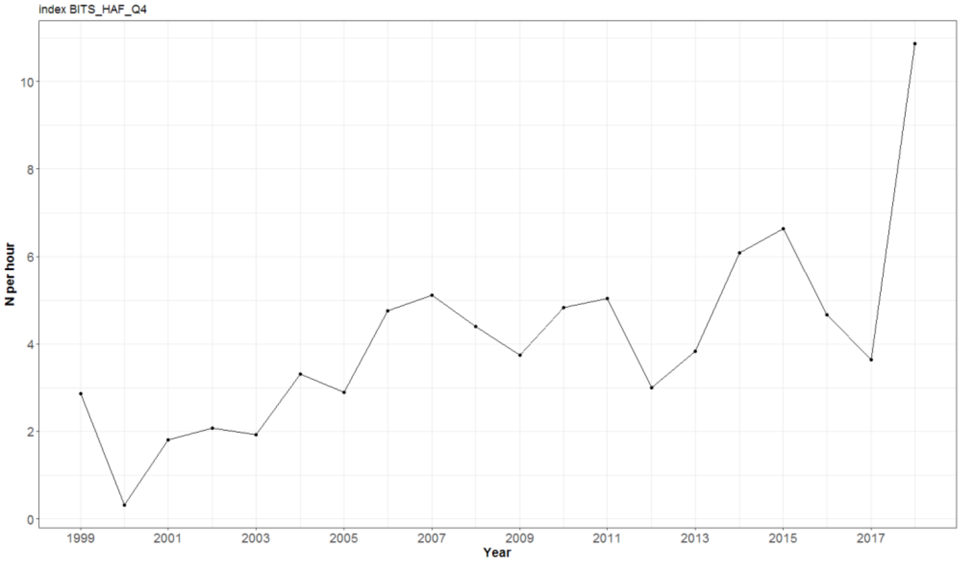

Figure 3.13: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q4) over the period 1996–2018.

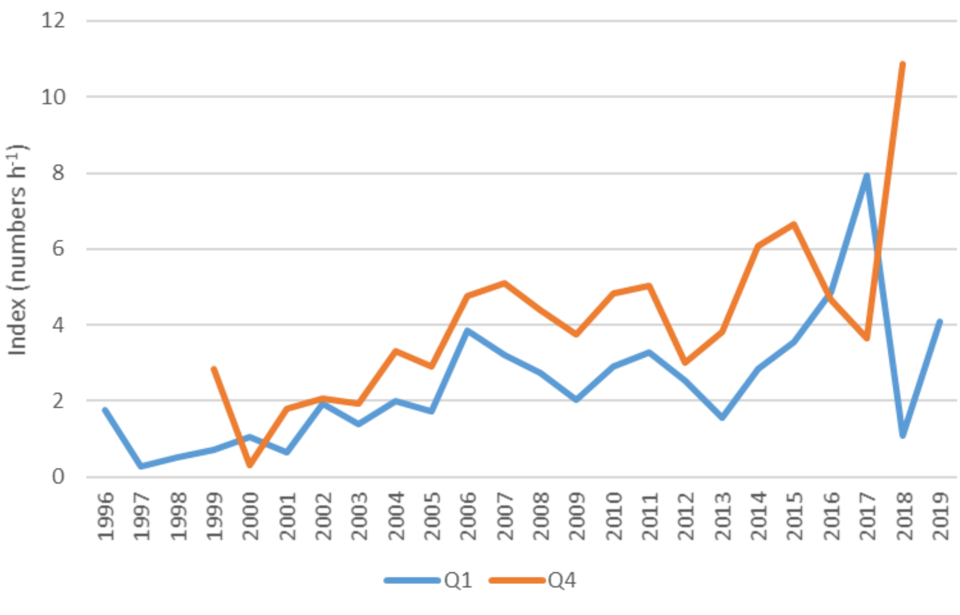

Figure 3.14: BLL 27.3a47de – Abundance indices (numbers caught per hour) of brill for both quarters (Q1 and Q4) of the BITS_HAF in the Kattegat over the period 1996–2019.

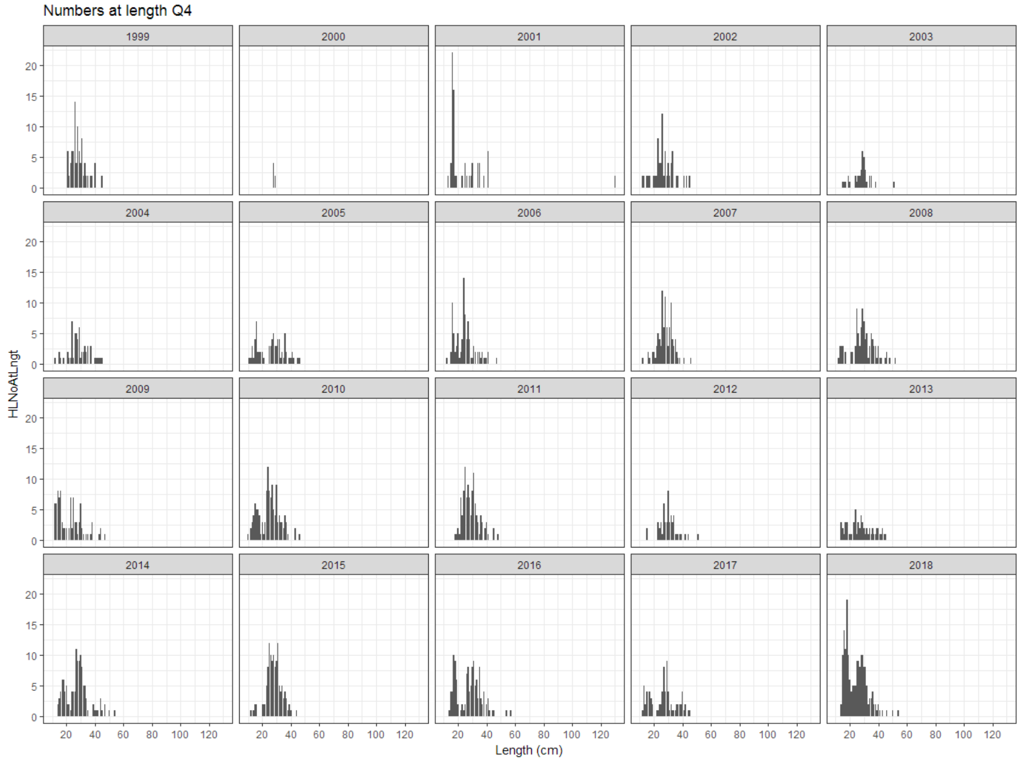

Figure 3.15: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q4 (1996–2018).

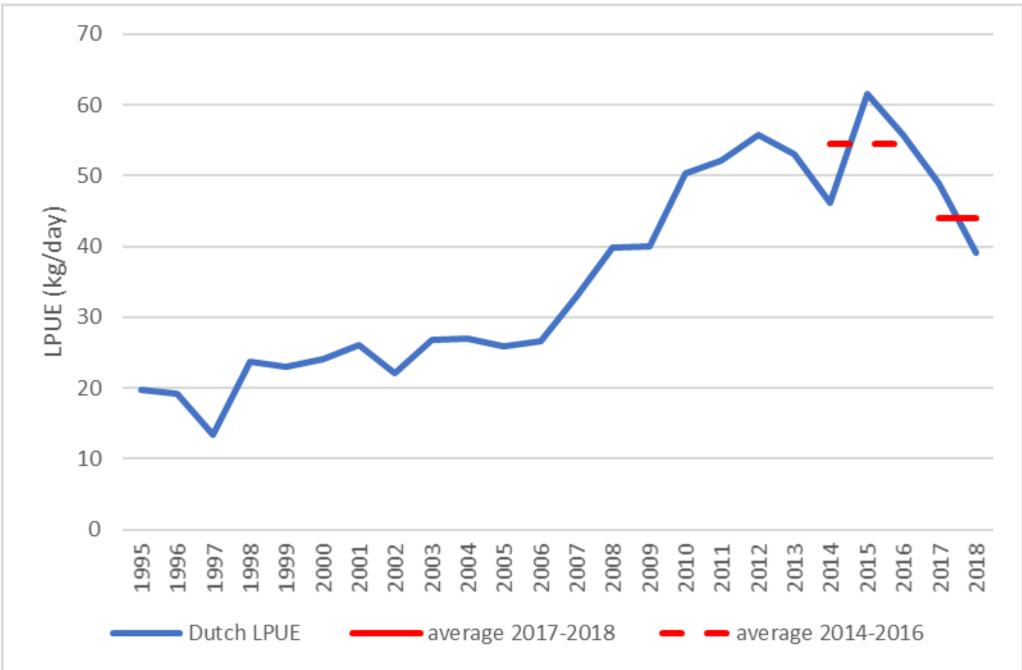

Figure 3.16: BLL 27.3a47de – Commercial LPUE (kg/day) of brill by the Dutch beam trawl fleet > 221 kW (standardized for engine power and corrected for targeting behavior). The red lines are the averages of the last two (2017–2018) and the previous three (2014–2016) years.

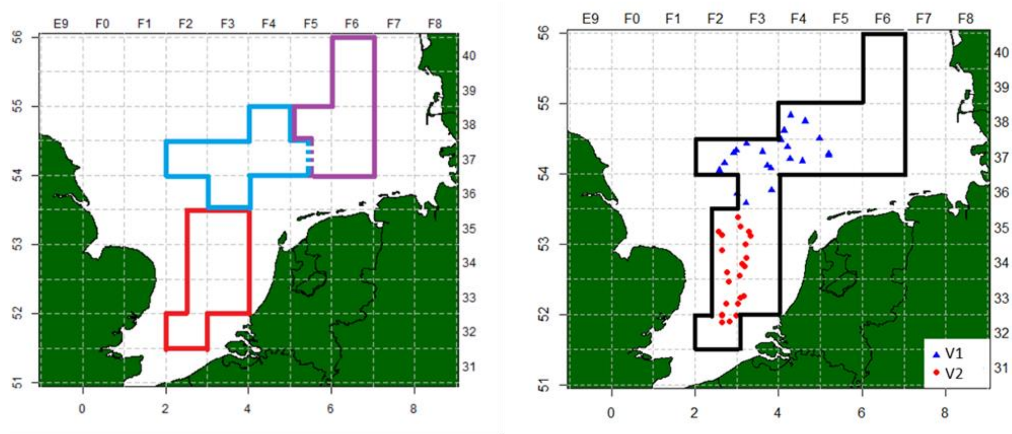

Figure 3.17: BLL 27.3a47de – Left: map showing the 3 zones to be monitored during the new Dutch industry-based survey. Right: map showing the monitored stations per zone during the 2018 survey.

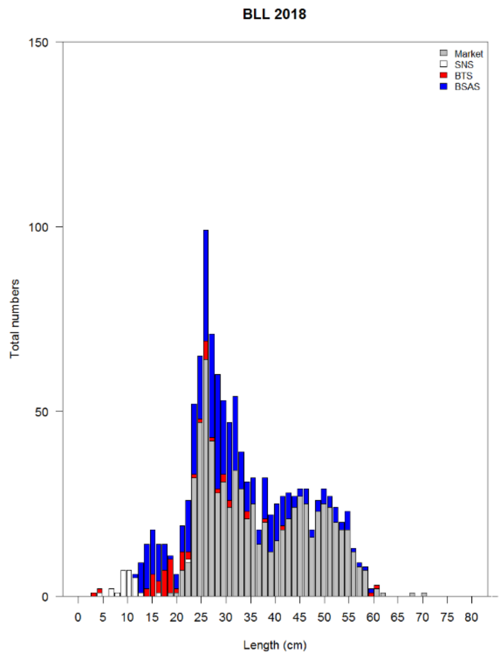

Figure 3.18: BLL 27.3a47de – Length distribution plot showing all brill samples collected in 2018 by The Netherlands. Commercial market samples are indicated in grey, fisheries independent survey data are shown in red (BTS) and white (SNS) and the industry-based survey samples are indicated in blue.

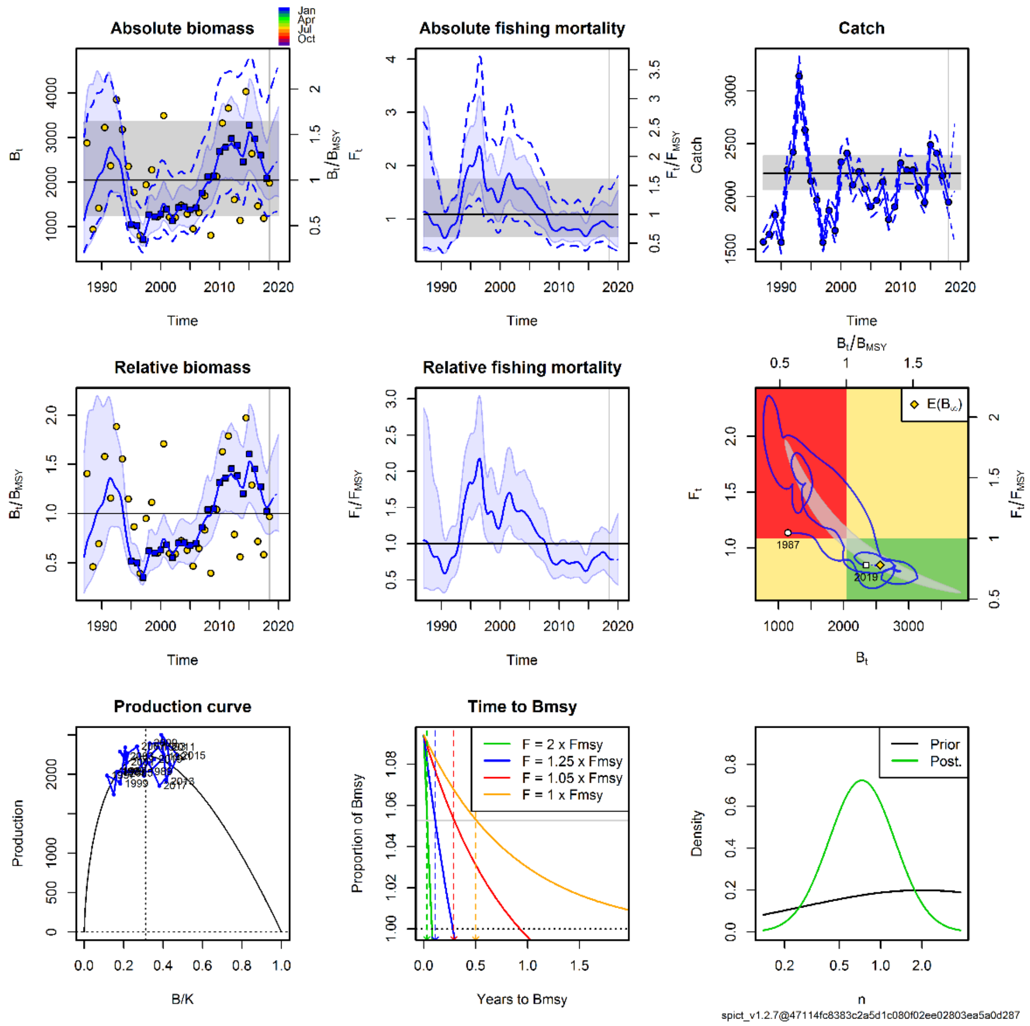

Figure 3.19: BLL 27.3a47de – SPiCT model results from WGNSSK 2019. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. 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).

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 avoidance 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 20 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 Subarea 4, Division 7.d and Subdivision 20 (Skagerrak) over the last ten years were as follows:

TAC(000t)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
20(Skagerrak)	4.8	3.8	3.8	3.8	4.0	4.2	4.8	5.7	8.0	4.2
2.a + 4	33.6	26.8	26.5	26.5	27.8	29.2	33.7	39.2	43.2	29.4
7.d	2.0	1.6	1.5	1.5	1.6	1.7	2.0	2.1	1.7	1.7

Council Regulation (EC) N°43/2009 allocated 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 2017–2019 are given in Council Regulations (EC) N°2017/127, N°2018/120 and N°2019/124 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.

In July 2018, the European Union agreed a multiannual management plan (MAP). However, the plan was not adopted by Norway and is therefore not used as the basis of advice for this shared stock. Details of the plan are given in EC 2018/973. Since 2015, advice has been given according to the ICES MSY approach.

EU-Norway have requested an evaluation of multiple management strategies (ICES WKNSMSE, 2019), which are currently under consideration.

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 2018 is 48 620 tonnes, split as follows for the separate areas (tonnes):

	TAC	Landings	Discards	BMS landings
20–Skagerrak	7995	5484	951	4
4	43156	35064	7036	34
7.d	1733	84	<1	0
Total	52884	40633	7988	38

*** 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 2002–2018 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 76% of the landings in 2018, 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 2018 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 2002–2018 (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 tonnes 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 2018, 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 2018 are reported in Table 4.2e.

Landings in numbers at age for age groups 1–11+ and 1963–2018 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 67% of the international landings in number were accounted for by juvenile cod aged 1–3; this average rises to 82% when considering landings and discards combined. In 2018, age 1 cod comprised 11% of the total catch by number, age 2, 55% and age 3, 16%.

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% from 2015, except for 2017 when the total numbers discarded increased to 56% 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. At ages 2 to 4 discard proportions increased to a maximum around 2006–10 but have subsequently declined to give 60% for age 2, 17% for age 3 and 7% for 4-year-old cod in 2018. 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 2018. 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 2018. 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 eighth 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 2018 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	26	100
Discards	Raised	1730	22
Discards	Imported	6231	78
Landings	Imported	40633	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 2018 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	36936	91
Landings	Imported	Estimated	3697	9
Discards	Imported	Sampled	6153	77
Discards	Raised	Estimated	1730	22
Discards	Imported	Estimated	78	1
BMS landing	Imported	Estimated	25	97
BMS landing	Imported	Sampled	1	3

InterCatch is discussed in Section 1.2, and all results are available on the WGNSSK SharePoint. Further work is ongoing, analysing the InterCatch data (cf. ICES WGMIXFISH meeting during 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 2018. 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 (ICES, 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 1976–2019. 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 1991–2018. 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.

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 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 over the past two years. The 2017- and 2018-year classes appear 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 2019.

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 that there may be year-effects in recent years, particularly for the IBTS-Q1 which shows a peak for most ages in 2017 followed by a subsequent decline (top-left plots). The log-mean standardised curves track cohort signals well (top right), although there is some loss of signal between the 2012 and 2013 cohorts associated with the apparent positive year effect in 2017 and rapid disappearance of the strong 2013-year class from survey catches. 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 two most recent data points for the NS-IBTS Q1 consistently fall below the linear regression line, indicating lower than expected catch rates in 2018–2019. The third most recent data points in both surveys mostly fall above the regression line and often close to the upper confidence bound suggesting a positive year effect going from the NS-IBTS-Q3 in 2016 to the NS-IBTS-Q1 in 2017.

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 14.6a.

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. SSB is currently declining, with poorer survival to older ages now evident. This trend 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, followed by a rapid increase peaking in 2017.

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 since then.

Residuals from the SURBAR analysis indicate year-effects over the last three years with positive residuals for all ages in the NS-IBTS-Q1 in 2017 and negative residuals for ages 2+ in the NS-IBTS-Q3 in 2017–2018 (Figure 14.6b).

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- and 2013-year classes feature 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 three 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 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 indicates stronger cohorts than observed in the catch that year.

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 last two years of IBTS-Q1 and IBTS-Q3 data (bar age 1) 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 0.157, -0.154 and 0.44 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 is provided in Figure 4.14a. Differences between the assessments are due to the addition of one year of catch and NS–IBTS Q1 and Q3 survey data, as well as slight revisions to maturity and delta-GAM indices. Addition of the new data results in a downscaling of SSB and an upscaling of F, primarily caused by reduced cohort consistency and lower catch rates of older fish in the IBTS surveys (Figure 4.14b).

4.4 Historic Stock Trends

The historic stock and fishery trends are presented in figures 4.12–13 and tables 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 and declined to its lowest level in 2013. This decline in F appears to have reversed and F is now above both the precautionary reference points, F_{lim} and F_{pa}, and 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 to its lowest level in 2006. SSB subsequently increased with a decline in fishing mortality, reaching a peak in 2015, but has since declined and is now below B_{lim}. TSB estimates follow a similar trend but with a less pronounced peak as SSB in recent years because of continued low recruitment.

Figure 4.15 indicates that the age structure in the population gradually improved (number of fish aged 5 and older in the population increased) with the decrease in fishing mortality, but this trend appears to have reversed, with poorer survival to the older ages now evident.

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, peaking in 2016–2017, in all areas thereafter, apart from the southern area where cod has further declined. 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 (2019) was taken as the median from a normal distribution about the assessment estimate. Estimates of recruitment for subsequent years were resampled from the 1997–2017 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).

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.

The usual intermediate year assumption is a status quo F relative to the final year of the assessment. Given the 33% reduction in TAC for 2019, this would result in an assumed catch that exceeds the TAC by over 8500 tonnes in the intermediate year. Given that ICES estimated catches have been in line with the TAC for the last two years, the WG assumed full TAC utilisation in the intermediate year.

Forecasts are presented for both intermediate year assumptions in tables 4.12a–b (TAC utilisation) and 4.12c–d (status quo F). Forecast assumptions are as follows (note that the values that appear in the catch scenarios in tables 4.12a–d 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	Median total catch in the intermediate year set equal to the TAC in the intermediate year.
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 approach: SSB (2021) = B_{lim}: F corresponding to SSB (2021) = B_{lim}
2. MSY framework: F_{bar} (2020) = F_{MSY}×min{1; $SSB_{2020}/B_{trigger}$}
3. EU-MAP: F_{bar} (2020) = $F_{MSY\ lower}$×min{1; $SSB_{2020}/B_{trigger}$}
4. Zero catch: F_{bar} (2020) = 0
5. F_{pa}: F_{bar} (2020) = F_{pa} = F_{lim}/1.4 = 0.39
6. F_{lim}: F_{bar} (2020) = F_{lim} = 0.54
7. SSB (2021) = B_{pa}: F corresponding to SSB (2021) = B_{pa}
8. SSB (2021) = $B_{trigger}$: F corresponding to SSB (2021) = $B_{trigger}$
9. Lower TAC constraint: F_{bar} (2020) such that TAC (2020) = 0.8×TAC (2019)
10. Rollover TAC 15%: F_{bar} (2020) such that TAC (2020) = 0.85×TAC (2019)
11. Rollover TAC 10%: F_{bar} (2020) such that TAC (2020) = 0.9×TAC (2019)
12. Rollover TAC 5%: F_{bar} (2020) such that TAC (2020) = 0.95×TAC (2019)
13. Rollover TAC: F_{bar} (2020) such that TAC (2020) = TAC (2019)
14. Rollover TAC + 5%: F_{bar} (2020) such that TAC (2020) = 1.05×TAC (2019)
15. Rollover TAC + 10%: F_{bar} (2020) such that TAC (2020) = 1.1×TAC (2019)
16. Rollover TAC + 15%: F_{bar} (2020) such that TAC (2020) = 1.15×TAC (2019)
17. Upper TAC constraint: F_{bar} (2020) such that TAC (2020) = 1.2×TAC (2019)
18. Status quo – constant F: F_{bar} (2020) = F_{bar} (2019)
19. $F_{MSY\ lower}$: F_{bar} (2020) = $F_{FMY\ lower}$ = 0.198
20. F_{MSY}: F_{bar} (2020) = F_{FMY} = 0.31

These scenarios do not include $F_{MSY\ upper}$ because SSB(2020) < MSY $B_{trigger}$.

EU-Norway have requested an evaluation of multiple management strategies comprising harvest control rules (HCRs) and stability mechanisms (ICES WKNSMSE, 2019), which are currently under consideration:

1. A: F_{target}=0.38, $B_{trigger}$=170 000 t, no constraints on TAC variation
2. B: F_{target}=0.38, $B_{trigger}$=160 000 t, no constraints on TAC variation
3. C: F_{target}=0.38, $B_{trigger}$=170 000 t, no constraints on TAC variation
4. A+D: F_{target}=0.40, $B_{trigger}$=190 000 t, constraints on TAC variation of +25% and -20%, where SSB at the start of the TAC year is above MSY $B_{trigger}$
5. B+E: F_{target}=0.36, $B_{trigger}$=130 000 t, constraints on TAC variation of +25% and -20%, where SSB at the start of the TAC year is above MSY $B_{trigger}$
6. C+E: F_{target}=0.36, $B_{trigger}$=140 000 t, constraints on TAC variation of +25% and -20%, where SSB at the start of the TAC year is above MSY $B_{trigger}$
7. A*+D: F_{target}=F_{MSY}=0.31, $B_{trigger}$=MSY $B_{trigger}$=150 000 t, constraints on TAC variation of +25% and -20%, where SSB at the start of the TAC year is above MSY $B_{trigger}$

Harvest control rules A, B and C differ by the extent of reduction below B_{lim} while the stability elements D and E differ by the combination of constraints on interannual TAC variations and banking and borrowing scenarios.

Forecasts for the SAM final run and associated scenarios assuming full TAC utilisation are given in Tables 4.12a and b. For completeness, tables 4.12c and d provide the corresponding forecasts assuming status quo fishing mortality in the intermediate year.

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. 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	

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 2015 due to reduced cohort consistency and lower catch rates of older fish in the NS-IBTS Q1 and Q3 survey data; the stock is below B_{lim}; fishing mortality has increased over the last two years, and is above both the precautionary reference points, F_{lim} and F_{pa}, and 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: 58%, 48%, 37% and 79%, 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.

Conflicts between the information from catches and surveys are becoming more apparent. The high correlation (0.88) estimated for the increments of log[F(y,a)] across ages suggests that the model might react slowly to changes in selectivity that may be associated with e.g. increased targeting of older cod. This discrepancy between catch and survey data appears to have introduced retrospective biases to the assessment.

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 41% of the SSB (by weight) in 2019 (increasing from 32% in 2018), and if the SSB increases, 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 a recent decrease in SSB and corresponding increase in fishing mortality (total mortality for SURBAR), and stronger 2005, 2009, 2013 and 2016 year classes in recent years. 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 1978–2019, 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 a sharp decline in the status of the stock in the last few years. SSB has decreased and is now B_{lim}.

Fishing mortality appears to have increased is now above both the precautionary reference points, F_{lim} and F_{pa}, and the level that achieves the long-term objective of maximum yield, F_{MSY}.

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 but the 2017–2018 year classes appear to be weak.

4.12 Management considerations

The EU landing obligation was implemented from 1 January 2017 for several gears, including TR1, BT1, and fixed gears. From 2018, cod is fully under the EU landing obligation in Subarea 4 and Subdivision 20. The EU landing obligation did not apply to cod in Division 7.d in 2018. BMS landings of cod reported to ICES are currently negligible and much lower than the estimates of catches below MCRS (Minimum Conservation Reference Size) estimated by observer programmes. ICES understands this to be not in accordance with the current EU regulations.

The decrease in fishing mortality from 2000 in combination with the stronger 2005-, 2009- and 2013-year classes lead to an increase in SSB and allowed the recent series of poor recruitments to make an improved contribution to the stock. This trend appears to have reversed, with poorer survival to the older ages now evident (6% survival to age 3, 2% age 2 and 1% age 5).

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. Although unwanted catches currently contribute less than a fifth of the total catch by weight, incidence of discarding remain high, with the proportion of unwanted fish by number in 2018 being 94% of 1 year old (compared to 97% in 2017), 60% of 2 year old (56% in 2017), 17% of 3 year old (28% in 2017) and 7% of 4 year old cod (12% in 2017).

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 younger fish currently survive to maturity. At the same time, the unbalanced age structure of the stock reduces its reproductive capacity even if a sufficient SSB were reached, as first-time spawners reproduce less successfully than older fish. Both factors are believed to have contributed to the reduction in recruitment of cod.

The recruitment of the relatively more abundant year classes to the fishery may have no beneficial effect on the stock if they are caught and heavily discarded. 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.

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.

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 2018 were 40 633 tonnes and the estimated discards (including BMS landings) in 2018 were 7988 tonnes, giving a total of 48 620 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.

There are both retrospective biases and model / data adjustments, which together have combined to lead to a perception of considerable annual overestimation of SSB and underestimation of F over the last 4 years, which may have led to over-optimistic forecasts in recent years. There are several possible ecological and anthropogenic drivers for this, including a positive survey year-effect in 2017, and discrepancies between catch and survey data under which all models would struggle. If the recent observed retrospective pattern continues, then the current forecast may also be too optimistic.

The catch scenarios assuming that the TAC is taken in 2019 imply that management measures in place are sufficient to ensure that catches remain at or below the TAC. This TAC may become restrictive in some areas because it is a 33% reduction of the TAC in 2018. This assumption is more optimistic than assuming constant F for the intermediate year.

The forecast procedure uses the assessment estimate of recruitment in 2019. This remains to be confirmed by the IBTS-Q3 survey and a reopening of the advice may be triggered in October.

The change in advice (-63%) is due to a combination of: (a) a change in the perception of the stock size with the addition of extra year of data, (b) a number of poor recruitments and (c) a reduction in the advised fishing mortality in order to recover the stock to B_{lim} by 2021.

4.13 Issues for future benchmarks

The stock was last benchmarked in 2015. Below is a list of issues which were either left unresolved from the last benchmark or have arisen during subsequent WGNSSK meetings. A scoring system has been developed to aid working groups in prioritising stocks to be put forward for benchmark (see Annex 6 for further details). The current scoring for this stock is:

1. Assessment quality	2. Opportunity to improve	3. Management importance	4. Perceived stock status	5. Time since last benchmark	Total Score
3	3	5	5	2	3.3

4.13.1 Data

Stock identity

The last benchmark identified stock ID as an issue for North Sea cod and recommended focusing on the possibility of conducting assessments that allow for multiple stocks. This would require the ability to allocate catch and survey data to stock and account for uncertainty where these data come from areas of overlap or substantial mixing. Trends in substock biomass have been monitored in the meantime.

Maturity

The last benchmark raised concerns that accounting for the increase in maturity may give the impression that the spawning stock is in better condition than it is given the possibility of lower fecundity of younger age groups and the potential for a maternal age effect on survival, and recommended exploration of the significance of spawner age on reproductive potential. Further attention to consider the base approach for weighting subarea differences in maturity-at-age and the importance of sampling intensity to the interannual variation in maturity estimates was also recommended.

Survey

Appropriate standardisation of IBTS–Q1 and Q3 surveys was carried out during the last benchmark. Inconsistencies were found between Q1 and Q3 in the Skagerrak area. However, so far only one vessel is fishing in the Skagerrak (DANS), which was introduced in 2011 along with a change in survey design, making it impossible to differentiate vessel, gear and crew effects from real changes in abundance. It was recommended that the stated NS-IBTS design of vessel overlap be fully implemented in the Skagerrak and that model specifications of the Delta-GAM be re-evaluated once more samples have been collected from DANS. It was further recommended that swept area, rather than haul duration, be used for standardisation to remove possible bias from different riggings or gear specifications.

Catchability issues and year effects are becoming apparent in the IBTS surveys, with reduced cohort consistency and lower than expected catch rates of older fish in recent years. There are also discrepancies between catch and survey data, with cohorts disappearing faster than expected in the scientific surveys compared to the catches.

Recreational catches

Recreational catches are estimated to account for 10% of the total removals of this stock (Radford *et al.*, 2018). The amount and quality of data on recreational catches of North Sea cod should therefore be evaluated and considered for inclusion in the assessment.

4.13.2 Assessment

Year effects

Year effects are becoming apparent in the surveys and should be considered for inclusion in the assessment. MSE analyses show that more precautionary advice is needed when year effects in the survey are present but ignored in the assessment (ICES WKNSMSE, 2019).

Diagnostics

Residuals for the last two years of IBTS-Q1 and Q3 data (bar age 1) are all negative. Retrospective analyses indicate a tendency to overestimate SSB and recruitment and underestimate fishing mortality.

Plus group

The proportion of spawning fish in the plus group has increased since the plus group age was reduced from 7+ to 6+ in 2015, resulting in an increasing loss of cohort information with 41% of spawning stock biomass now estimated to be aggregated within the plus group.

4.13.3 Forecast

Assumptions

The last benchmark explored the perception that short-term forecasts in a given year tend to be more optimistic than realised values in subsequent years and recommended that this be explored further to gain a better idea of potential biases.

From 2017, recruitment in the intermediate year has been taken as the SAM estimate of numbers at age 1. This estimate is uncertain and retrospective analyses indicate a strong tendency for the assessment to overestimate recruitment ($\rho_{n=5}$ = 0.44) which may lead to biased catch forecasts and TAC.

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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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Belgium	3,882	3,304	2,470	2,616	1,482	1,627	1,722	1,309	1,008	894
Denmark	19,697	14,000	8,358	9,022	4,676	5,889	6,291	5,105	3,430	3,831
Faroe Islands	96	-	9	34	36	37	34	3	-	16
France	.	1,222	717	1,777	620	294	664	354	659	573
Germany	3,386	1,740	1,810	2,018	2,048	2,213	2,648	2,537	1,899	1,736
Greenland	.	.	.	.	.	.	35	23	17	17
Netherlands	9,068	5,995	3,574	4,707	2,305	1,726	1,660	1,585	1,523	1,896
Norway	7,432	6,410	4,369	5,217	4,417	3,223	2,900	2,749	3,057	4,128
Poland	19	18	18	39	35	-	-	-	1	2
Sweden	625	640	661	463	252	240	319	309	386	439
UK (E/W/NI)	10,344	6,543	4,087	3,112	2,213	1,890	1,270	1,491	1,587	1,546
UK (Scotland)	23,017	21,009	15,640	15,416	7,852	6,650	4,936	6,857	6,511	7,185
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	786	0	0
Danish industrial by-catch *	.	.	.	105	22	17	21	11	23	1
Norwegian industrial by-catch *	.	.	.	.	.	.	.	48	101	22
Total Nominal Catch	77,566	60,881	41,713	44,526	25,958	23,806	22,500	23,119	20,102	22,262
Unallocated landings	826	-1,114	-740	-2,333	-1,875	-1,277	356	-2,041	-1,046	-605
WG estimate of total landings	**78,392**	**59,767**	**40,973**	**42,193**	**24,083**	**22,529**	**22,855**	**21,078**	**19,056**	**21,657**
Agreed TAC	**132,400**	**81,000**	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**

Division VIId

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Belgium	172	110	93	51	54	47	51	80	84	154
Denmark	-	-	-	-	-	-	-	-	-	-
France	.	3,084	1,677	1,361	1,730	810	986	1,124	1,743	1,326
Netherlands	3	4	17	6	36	14	9	9	59	30
UK (E/W/NI)	454	385	249	145	121	103	184	267	174	144
UK (Scotland)	-	-	-	-	-	-	-	1	12	7
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	629	3,583	2,036	1,563	1,941	974	1,230	1,480	2,073	1,662
Unallocated landings	6,229	-1,258	-463	1,576	190	40	29	-2	74	-33
WG estimate of total landings	**6,858**	**2,325**	**1,573**	**3,139**	**2,131**	**1,014**	**1,259**	**1,479**	**2,147**	**1,629**

Division IIIa (Skagerrak)**

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Denmark	8,681	7,684	5,900	5,525	3,067	3,038	3,019	2,513	2,246	2,553
Germany	54	54	32	83	49	99	86	84	67	52
Norway	1,146	926	762	645	825	856	759	628	681	779
Sweden	1,909	1,293	1,035	897	510	495	488	372	370	365
Others	-	-	-	-	27	24	21	373	385	13
Danish industrial by-catch *	62	99	687	20	5	4	2	3	2	7
Total Nominal Catch	11,790	9,957	7,729	7,170	4,483	4,516	4,375	3,972	3,751	3,769
Unallocated landings	-816	-680	-643	-316	-504	-602	-376	-715	-731	-376
WG estimate of total landings	**10,974**	**9,277**	**7,086**	**6,854**	**3,979**	**3,914**	**3,998**	**3,258**	**3,020**	**3,393**
Agreed TAC	**19,000**	**11,600**	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**

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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Nominal Catch	89,985	74,421	51,478	53,260	32,382	29,296	28,104	28,572	25,926	27,693
Unallocated landings	6,240	-3,052	-1,846	-1,074	-2,189	-1,839	9	-2,757	-1,703	-1,014
WG estimate of total landings	**96,225**	**71,369**	**49,632**	**52,186**	**30,193**	**27,457**	**28,113**	**25,815**	**24,223**	**26,679**

** 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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Danish industrial by-catch *	62	99	687	-	-	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	.	.	48	101	22
Total	**62**	**99**	**687**	**0**	**0**	**0**	**0**	**48**	**101**	**22**

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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium	946	666	653	862	1,075	1,258	1,223	1,103	696	818
Denmark	4,402	5,686	4,863	4,803	4,536	5,457	6,026	6,713	6,119	5,489
Faroe Islands	45	32	-	-	-	-	-	-	.	.
France	950	782	619	369	287	637	517	391	401	583
Germany	2,374	2,844	2,211	2,385	1,921	2,257	2,133	2,083	1,987	1,506
Greenland	11	-	-	-	-	-	-	2	1	.
Netherlands	2,649	2,657	1,928	1,955	1,344	1,242	1,403	1,365	645	513
Norway	4,234	4,495	4,898	4,601	4,080	4,600	5,404	5,627	5,521	5,553
Poland	3	-	2	-	-	-	-	-	.	.
Sweden	378	362	316	471	332	401	415	373	387	274
UK (E/W/NI)	2,383	2,553	2,169	1,629	2,129	2,962	.	.	.	.
UK (Scotland)	9,052	11,567	10,141	10,565	10,619	10,517	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	13,479	14,889	16,603	18,293	21,054
Others	0	0	0	0	0	0	0	0	0	0
Danish industrial by-catch	72	12	0	0	2	24	0	5	147	0
Norwegian indust by-catch *	4	201	1	.	.	.	.	.	.	.
Total Nominal Catch	27,497	31,657	27,800	27,640	26,324	29,355	32,011	34,265	34,198	35,789
Unallocated landings	136	-677	-1,125	-1,013	-1,009	-805	-767	-1,230	-1,089	-725
BMS landings	-	-	-	-	-	-	-	-	1	8
WG estimate of total landings	**27,634**	**30,980**	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**	**33,109**	**35,064**
Agreed TAC	**28,798**	**33,552**	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**33,651**	**39,220**	**43,156**
Division VIId										
Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium	73	57	56	40	53	72	78	39	17	8
Denmark	-	-	-	-	-	-	-	-	.	.
France	1,779	1,606	1,078	885	768	1,270	1,142	279	92	35
Netherlands	35	45	51	40	38	50	52	40	22	10
UK (E/W/NI)	133	127	125	99	100	156	.	.	.	.
UK (Scotland)	3	1	1	-	-	-	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	156	162	102	48	39
Total Nominal Catch	2,023	1,836	1,311	1,064	959	1,548	1,434	459	179	92
Unallocated landings	-135	-128	8	56	-43	-112	-36	-38	-9	-8
WG estimate of total landings	**1,887**	**1,708**	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**	**170**	**84**
Agreed TAC	**1,678**	**1,955**	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**1,961**	**2,059**	**1,733**
Division IIIa (Skagerrak)**										
Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	3,024	3,286	3,118	3,178	3,033	3,430	3,344	3,696	3,663	4,220
Germany	55	56	60	78	69	84	87	94	63	86
Norway	440	375	421	615	575	533	500	551	486	288
Sweden	459	458	518	520	529	570	571	641	559	668
Others	2	26	0	0	33	28	26	25	37	58
Danish industrial by-catch	2	10	0	1	1	5	5	0	40	7
Total Nominal Catch	3,982	4,211	4,117	4,391	4,240	4,650	4,533	5,006	4,848	5,327
Unallocated landings	-188	-154	-161	-64	-86	37	31	-232	-133	157
BMS landings	-	-	-	-	-	-	-	-	1	4
WG estimate of total landings	**3,794**	**4,057**	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**	**4,715**	**5,484**
Agreed TAC	**4,114**	**4,793**	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**4,807**	**5,744**	**7,995**
Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Nominal Catch	33,502	37,704	33,228	33,095	31,523	35,554	37,978	39,730	39,225	41,208
Unallocated landings	-187	-958	-1,277	-1,022	-1,137	-880	-773	-1,500	-1,231	-576
BMS landings	.	.	.	.	.	.	.	.	2	12
WG estimate of total landings	**33,315**	**36,746**	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**	**37,994**	**40,632**

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

** Skaggerak/Kattegat split derived from national statistics prior to 2016

* 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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Norwegian indust by-catch *	4	201	1	.	.	.	.	.	.	.
Total	**4**	**201**	**1**	**0**	**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	1974
1	3198	5004	15734	18133	10749	5800	2932	54219	44599	3813	25836	15484
2	42377	22373	51628	62202	70539	83416	22561	33747	154565	186744	31596	58624
3	6995	20003	17557	29695	32529	42373	31419	18395	17132	47885	54655	11347
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002	15745
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195	4601
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103	956
7	81	596	655	475	884	866	585	956	888	1671	1055	436
8	489	117	297	368	353	307	420	208	455	609	487	393
9	13	93	51	125	137	150	147	185	227	388	79	330
10	6	11	75	56	40	111	46	97	77	112	57	80
+gp	0	4	8	83	17	24	77	40	93	17	161	188
TOTALNUM	60659	56203	98460	121923	131671	152829	79251	129139	234508	252789	131226	108183
TONSLAND	115893	125393	180120	220197	251687	286948	199746	224993	326492	352161	237874	213215
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	33210	5695	75130	29593	34627	62394	20131	66220	25488	64358	8795	99841
2	46907	99779	50926	174912	91143	104356	187626	64755	128396	66026	117383	32308
3	18849	18481	25525	17178	44384	34938	34567	59907	21456	31087	18888	33973
4	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238	7779	5791
5	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415	1369	2981
6	2057	3056	833	1103	708	1269	779	2048	1246	1013	1257	602
7	447	920	1140	408	396	494	599	425	589	434	371	554
8	195	130	370	403	139	197	133	234	179	243	172	170
9	228	67	262	152	157	73	64	77	89	59	78	69
10	95	63	26	36	42	55	36	27	28	44	16	44
+gp	63	43	96	44	17	25	21	16	23	19	31	23
TOTALNUM	114215	136672	161191	236214	178997	218034	256998	206643	192083	170937	156139	176355
TONSLAND	204249	233007	208318	294640	266019	293753	333616	302365	257634	227070	214354	201279
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	24816	21362	22072	11629	13288	27162	4688	15366	15486	4871	23443	1243
2	127774	55025	36084	53783	23145	31472	54171	24969	62650	36303	28793	80948
3	9761	43712	18056	11795	16554	8523	11134	20885	12753	23046	18390	16794
4	8689	3117	9791	4299	3267	4916	3126	3045	5223	3125	6409	5909
5	1528	2543	994	2445	1372	1041	1546	859	790	1834	1221	2379
6	1071	652	1028	307	1039	482	426	513	282	393	690	504
7	234	293	249	307	222	323	200	140	148	159	151	233
8	215	66	139	54	137	51	106	57	41	87	47	41
9	55	63	27	60	27	39	17	32	14	42	14	16
10	48	23	31	12	4	17	10	7	13	4	15	4
+gp	12	18	10	9	9	9	13	16	5	8	10	12
TOTALNUM	174203	126873	88481	84698	59065	74034	75437	65889	97405	69872	79183	108083
TONSLAND	216041	183202	139578	124835	101442	112740	119947	109915	136397	124721	122434	144637
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	5831	8087	2164	4425	438	1470	1009	1286	776	338	519	1120
2	9549	22457	20309	8029	8893	3511	8175	4401	6334	3268	4833	5037
3	31624	6310	6044	13831	3552	5453	3036	4410	2264	4130	2839	4578
4	3959	6529	1114	2787	3072	1527	1714	969	1562	1146	2888	1582
5	1419	996	1053	395	397	939	479	520	398	706	596	1315
6	614	375	140	384	68	155	339	187	137	213	237	198
7	219	135	82	58	61	29	52	120	40	70	44	65
8	89	39	27	38	15	19	13	23	39	26	19	16
9	14	18	13	18	5	6	9	4	6	13	17	6
10	10	5	6	4	2	2	1	1	1	1	8	4
+gp	2	1	1	1	0	0	1	0	1	1	3	2
TOTALNUM	53329	44952	30953	29971	16505	13111	14830	11921	11558	9911	12003	13923
TONSLAND	94108	69567	48440	53152	30426	27748	28165	25665	24215	26814	33177	36762
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018
1	1099	665	683	2240	686	167	351	171
2	4540	2230	2688	4207	6384	2035	2240	6048
3	4046	5367	3063	4376	4903	5644	3233	3615
4	1408	1963	2592	1605	1933	3150	3495	2062
5	610	633	865	1286	745	1012	1660	1781
6	451	248	190	332	584	277	385	789
7	48	139	84	64	144	188	94	286
8	27	15	38	38	22	44	78	67
9	5	4	5	6	6	9	24	45
10	2	4	1	2	1	5	9	15
+gp	2	1	1	0	2	2	2	9
TOTALNUM	12237	11269	10208	14156	15411	12534	11571	14889
TONSLAND	31979	32124	30474	34651	37373	38104	37668	40658
SOPCOF %	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	1974
1	16150	8049	97921	108375	50214	31115	2502	52958	258920	38250	85915	124151
2	19902	6168	6599	22125	24736	22957	10279	8656	37224	59342	17387	15878
3	33	115	89	71	160	197	113	152	47	177	246	71
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	36085	14332	104609	130570	75110	54268	12894	61766	296192	97768	103548	140100
TONSDISC	12198.57	4655.611	28972.64	37861.71	23284.92	17468.34	4756.776	17662.66	84006.59	33602.62	29965.76	39532.68
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	136651	226781	472599	28908	581071	1185689	155732	181946	54949	537521	63301	563506
2	16214	83210	48009	78114	5270	17692	34307	8377	11130	12518	36573	5761
3	0	192	464	0	0	0	79	98	25	5	115	303
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	152866	310182	521072	107022	586341	1203381	190118	190421	66103	550043	99989	569571
TONSDISC	36840.85	72396.83	139026.6	32433.69	162278.1	294208.1	57075.62	54007.83	21430.4	151003.9	31297.6	138603.8
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	24634	15376	176920	33875	47473	102410	33433	320725	44756	14254	86109	15458
2	61948	17084	8685	48244	8383	9881	28538	16804	43434	23058	13701	90259
3	0	216	489	78	448	2	11	160	30	764	40	1500
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	86583	32676	186094	82197	56304	112293	61983	337689	88220	38075	99851	107216
TONSDISC	27706.11	10504.47	61655.63	26747.11	18198.97	36192.59	21411.61	98208.27	31706.81	14030	33183.67	40102.32
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	30962	37031	5460	26267	5696	20336	10213	26890	16171	10847	9608	9867
2	5630	5509	33094	13236	6082	8941	8303	35342	23047	9331	9055	9151
3	8280	0	753	3181	775	2007	1795	1965	2657	7591	2655	1254
4	0	0	0	17	55	122	149	51	481	223	650	65
5	0	0	0	0	0	6	66	4	52	14	50	30
6	0	0	0	0	0	0	12	1	24	11	17	0
7	0	0	0	0	0	0	0	1	0	0	9	0
8	0	0	0	0	0	0	0	0	2	0	0	0
9	0	0	0	0	0	0	2	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	2	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	44872	42540	39307	42702	12608	31413	20540	64253	42433	28017	22047	20366
TONSDISC	13641.52	13359.94	13519.42	11900.56	4007.44	8721.211	9931.799	11923	30422	24984	20846	12341
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018
1	3936	11149	6188	7756	3980	3067	9767	2788
2	7851	5190	6055	6504	8935	4942	2814	9139
3	925	1422	856	1434	1965	3110	1271	744
4	81	115	397	163	180	257	493	149
5	6	5	83	58	55	31	96	8
6	4	1	40	5	64	1	9	0
7	1	1	16	0	15	0	1	0
8	1	0	0	0	5	0	1	0
9	0	0	0	0	3	0	0	2
10	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0
TOTALNUM	12804	17884	13635	15921	15201	11409	14453	12830
TONSDISC	8711	8638	10289	10538	12537	12203	8702	7873
SOPCOF %	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	1974
1	19347	13052	113655	126508	60962	36915	5434	107177	303519	42062	111751	139635
2	62280	28541	58227	84327	95275	106373	32840	42403	191789	246086	48983	74502
3	7028	20118	17646	29766	32689	42569	31532	18547	17179	48062	54901	11418
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002	15745
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195	4601
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103	956
7	81	596	655	475	884	866	585	956	888	1671	1055	436
8	489	117	297	368	353	307	420	208	455	609	487	393
9	13	93	51	125	137	150	147	185	227	388	79	330
10	6	11	75	56	40	111	46	97	77	112	57	80
+gp	0	4	8	83	17	24	77	40	93	17	161	188
TOTALNUM	96744	70535	203069	252494	206780	207098	92145	190905	530700	350558	234774	248283
TONSLAND	128092	130049	209092	258059	274972	304417	204503	242656	410498	385764	267840	252748
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	169862	232476	547729	58501	615698	1248084	175863	248166	80437	601879	72096	663347
2	63121	182989	98935	253025	96413	122048	221933	73132	139526	78543	153957	38069
3	18849	18672	25989	17178	44384	34938	34646	60005	21480	31092	19003	34277
4	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238	7779	5791
5	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415	1369	2981
6	2057	3056	833	1103	708	1269	779	2048	1246	1013	1257	602
7	447	920	1140	408	396	494	599	425	589	434	371	554
8	195	130	370	403	139	197	133	234	179	243	172	170
9	228	67	262	152	157	73	64	77	89	59	78	69
10	95	63	26	36	42	55	36	27	28	44	16	44
+gp	63	43	96	44	17	25	21	16	23	19	31	23
TOTALNUM	267081	446854	682263	343235	765338	1421415	447116	397064	258186	720980	256129	745925
TONSLAND	241089	305404	347345	327074	428297	587962	390691	356372	279065	378074	245651	339883
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	49451	36738	198992	45504	60761	129572	38121	336092	60242	19124	109552	16701
2	189722	72109	44768	102027	31528	41353	82709	41773	106084	59360	42494	171206
3	9761	43929	18544	11873	17002	8525	11145	21045	12783	23809	18430	18293
4	8689	3117	9791	4299	3267	4916	3126	3045	5223	3125	6409	5909
5	1528	2543	994	2445	1372	1041	1546	859	790	1834	1221	2379
6	1071	652	1028	307	1039	482	426	513	282	393	690	504
7	234	293	249	307	222	323	200	140	148	159	151	233
8	215	66	139	54	137	51	106	57	41	87	47	41
9	55	63	27	60	27	39	17	32	14	42	14	16
10	48	23	31	12	4	17	10	7	13	4	15	4
+gp	12	18	10	9	9	9	13	16	5	8	10	12
TOTALNUM	260786	159550	274574	166895	115368	186327	137419	403578	185625	107947	179034	215299
TONSLAND	243747	193706	201233	151582	119641	148932	141358	208123	168104	138751	155618	184740
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	36793	45118	7624	30692	6135	21807	11222	28177	16947	11185	10127	10987
2	15180	27965	53403	21265	14975	12452	16478	39743	29381	12599	13887	14188
3	39904	6310	6797	17012	4328	7460	4831	6375	4921	11721	5494	5831
4	3959	6529	1114	2805	3127	1650	1863	1020	2043	1369	3539	1646
5	1419	996	1053	395	397	944	546	524	451	720	646	1344
6	614	375	140	384	68	155	351	187	161	224	254	199
7	219	135	82	58	61	29	52	121	40	70	53	65
8	89	39	27	38	15	19	13	23	41	26	19	16
9	14	18	13	18	5	6	11	4	6	13	17	6
10	10	5	6	4	2	2	1	1	1	1	10	4
+gp	2	1	1	1	0	0	1	0	1	1	3	2
TOTALNUM	98201	87491	70260	72673	29113	44524	35370	76174	53992	37928	34050	34288
TONSLAND	107749	82927	61960	65053	34433	36469	38097	37589	54637	51798	54023	49103
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018
1	5035	11815	6871	9995	4666	3234	10118	2959
2	12391	7420	8743	10711	15319	6977	5054	15187
3	4970	6789	3919	5810	6869	8754	4504	4359
4	1489	2077	2989	1768	2113	3408	3987	2210
5	616	638	949	1345	800	1044	1756	1789
6	455	249	229	337	648	279	395	789
7	49	139	100	64	159	188	95	286
8	28	15	38	38	27	44	79	67
9	5	4	5	6	9	9	24	48
10	2	4	2	2	1	5	9	15
+gp	2	1	1	0	2	2	2	9
TOTALNUM	25041	29153	23844	30076	30612	23942	26024	27719
TONSLAND	40689	40762	40763	45190	49910	50307	46371	48531
SOPCOF %	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 2018.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	10	16	6	96	43	171
2	643	922	1512	2666	305	6048
3	753	892	889	950	131	3615
4	463	606	387	433	173	2062
5	573	382	446	215	166	1782
6	169	212	175	103	128	787
7	58	95	65	25	43	286
8	11	6	12	21	18	68
9	22	12	2	2	7	45
10	0	3	6	6	1	16
+gp	0	0	2	0	7	9
TOTALNUM	2702	3146	3502	4517	1022	14889

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	272	143	696	1149	527	2787
2	1764	1951	2099	840	2484	9138
3	290	171	124	37	122	744
4	65	19	29	7	29	149
5	0	2	4	1	2	9
6	0	0	0	0	2	2
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	2391	2286	2952	2034	3166	12829

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	282	159	702	1245	571	2959
2	2408	2874	3611	3506	2789	15188
3	1043	1063	1013	988	252	4359
4	529	625	416	439	202	2211
5	573	384	450	215	168	1790
6	169	212	175	103	128	787
7	58	95	65	25	43	286
8	11	6	12	21	18	68
9	22	12	2	2	9	47
10	0	3	6	6	1	16
+gp	0	0	2	0	7	9
TOTALNUM	5095	5433	6454	6550	4188	27720

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 2018, 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	90%	81%	80%	86%	7%
27.3.a.20	91%	91%	83%	63%	-
27.7.d	39%	62%	76%	67%	-

Landings age composition coverage					
Area/Season	**Q1**	**Q2**	**Q3**	**Q4**	**annual**
27.4	94%	86%	82%	90%	96%
27.3.a.20	95%	94%	93%	91%	100%
27.7.d	52%	66%	31%	46%	-

Discards age composition coverage					
Area/Season	**Q1**	**Q2**	**Q3**	**Q4**	**annual**
27.4	71%	99%	94%	72%	100%
27.3.a.20	90%	100%	100%	100%	-
27.7.d	-	-	-	-	-

Contribution to total (before raising)		
Area/Type	**Landings**	**Discards**
27.4	86%	69%
27.3.a.20	13%	31%
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	1974
1	0.538	0.496	0.581	0.579	0.590	0.640	0.544	0.626	0.579	0.616	0.559	0.594
2	1.004	0.863	0.965	0.994	1.035	0.973	0.921	0.961	0.941	0.836	0.869	1.039
3	2.657	2.377	2.304	2.442	2.404	2.223	2.133	2.041	2.193	2.086	1.919	2.217
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776	4.156
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488	6.174
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453	8.333
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019	9.889
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810	10.791
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077	12.175
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359	12.425
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886	13.731

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.619	0.568	0.541	0.573	0.550	0.550	0.723	0.589	0.632	0.594	0.590	0.583
2	0.899	1.029	0.948	0.937	0.936	1.003	0.837	0.962	0.919	1.007	0.932	0.856
3	2.348	2.470	2.160	2.001	2.411	1.948	2.190	1.858	1.835	2.156	2.141	1.834
4	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972	4.164	3.504
5	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190	6.324	6.230
6	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362	8.430	8.140
7	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317	10.362	9.896
8	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352	12.074	11.940
9	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505	13.072	12.951
10	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408	14.443	13.859
+gp	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472	16.588	14.707

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.635	0.585	0.673	0.737	0.670	0.699	0.699	0.677	0.721	0.699	0.656	0.542
2	0.976	0.881	1.052	0.976	1.078	1.146	1.065	1.075	1.021	1.117	0.960	0.922
3	1.955	1.982	1.846	2.176	2.038	2.546	2.479	2.201	2.210	2.147	2.120	1.724
4	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293	4.034	3.821	3.495
5	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220	6.637	6.228	5.387
6	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980	8.494	8.394	7.563
7	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282	9.729	9.979	9.628
8	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743	11.080	11.424	10.643
9	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107	12.264	12.300	11.499
10	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052	12.756	12.761	13.085
+gp	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954	11.304	13.416	14.921

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.640	0.611	0.725	0.626	0.573	0.726	0.747	0.793	0.830	1.06679	0.78826	0.71481
2	0.935	1.021	1.004	0.996	1.079	1.072	1.160	1.200	1.182	1.38884	1.41193	1.29224
3	1.663	1.747	2.303	1.844	1.895	2.089	1.952	2.239	2.365	2.45605	2.67433	2.67091
4	3.305	3.216	3.663	3.735	3.347	3.252	3.647	3.894	4.050	4.06299	4.14457	4.22308
5	5.726	4.903	5.871	5.537	5.757	5.184	5.244	5.676	6.053	6.22405	6.11913	6.04897
6	7.403	7.488	7.333	8.006	6.694	7.438	7.225	7.234	8.250	7.39317	7.48963	8.29925
7	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.243	9.262	9.65076	8.96797	9.47215
8	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477	10.015	11.48868	11.44744	11.63072
9	11.600	10.894	12.062	11.888	11.518	11.857	12.015	12.325	12.282	11.38721	11.29135	12.82728
10	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862	14.559	12.72507	11.71648	12.08332
+gp	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887	17.522	15.38134	18.764	10.05238

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018
1	0.862	0.938	0.883	0.699	0.596	0.800	0.753	0.608
2	1.328	1.369	1.240	1.213	1.206	1.315	1.119	1.068
3	2.525	2.354	2.461	2.390	2.291	2.342	2.379	1.958
4	4.596	4.175	4.164	4.180	4.112	3.862	3.906	3.869
5	6.481	6.391	6.187	5.678	5.935	5.744	5.393	5.650
6	7.843	8.115	8.347	7.435	6.920	7.342	6.897	6.874
7	9.681	9.092	9.817	9.191	8.775	7.928	8.906	7.746
8	9.629	11.799	9.486	9.180	9.622	8.717	8.664	8.893
9	10.845	12.548	11.364	11.469	10.654	10.367	9.586	8.490
10	14.436	11.436	10.935	16.456	13.838	11.926	17.579	8.980
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.565

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	1974
1	0.270	0.270	0.269	0.269	0.269	0.269	0.268	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	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	0.508
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	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	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	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	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	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	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	0.000

AGE/YEAI	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.227	0.189	0.255	0.287	0.276	0.242	0.279	0.274	0.297	0.270	0.276	0.242
2	0.359	0.354	0.382	0.309	0.361	0.411	0.396	0.489	0.458	0.469	0.376	0.365
3	0.000	0.412	0.376	0.000	0.000	0.000	0.517	0.593	0.534	0.509	0.652	0.437
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	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	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	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	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	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	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	0.000

AGE/YEAI	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.237	0.300	0.326	0.260	0.315	0.314	0.274	0.287	0.316	0.342	0.313	0.358
2	0.353	0.339	0.431	0.371	0.366	0.408	0.429	0.362	0.404	0.380	0.453	0.375
3	0.000	0.463	0.484	0.526	0.395	2.309	0.705	0.483	0.553	0.515	0.616	0.481
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	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	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	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	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	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	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	0.000

AGE/YEAI	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.257	0.298	0.232	0.243	0.262	0.236	0.302	0.224	0.288	0.404	0.385	0.292
2	0.389	0.422	0.361	0.314	0.345	0.270	0.565	0.116	0.814	0.735	0.984	0.785
3	0.422	0.000	0.406	0.413	0.498	0.686	0.814	0.827	1.690	1.699	2.013	1.533
4	0.000	0.000	0.000	2.205	0.528	0.864	2.223	2.557	3.949	3.002	3.485	3.137
5	0.000	0.000	0.000	0.000	0.000	3.852	4.255	4.208	6.609	5.311	6.565	5.323
6	0.000	0.000	0.000	0.000	0.000	11.300	6.509	5.437	10.198	9.341	8.521	8.369
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.048	5.900	5.128	13.464	6.728
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.906	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	8.100	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	12.014	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	0.000

AGE/YEAI	2011	2012	2013	2014	2015	2016	2017	2018
1	0.277	0.234	0.334	0.311	0.326	0.364	0.231	0.280
2	0.677	0.556	0.796	0.742	0.759	0.939	0.771	0.611
3	2.057	1.867	1.493	1.772	1.617	1.767	1.881	1.414
4	4.099	3.803	3.375	3.128	3.158	3.092	3.002	2.699
5	5.576	6.456	4.048	3.826	3.983	4.687	3.629	3.564
6	6.071	8.579	8.419	4.642	5.303	5.439	5.172	0.000
7	8.264	9.733	7.086	4.423	6.940	0.000	5.313	0.000
8	6.213	0.000	0.000	0.000	8.390	0.000	4.577	0.000
9	11.617	0.000	0.000	0.000	4.087	0.000	0.000	9.790
10	0.000	16.370	16.370	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

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	1974
1	0.314	0.357	0.312	0.313	0.326	0.327	0.417	0.449	0.314	0.300	0.335	0.304
2	0.809	0.761	0.900	0.836	0.868	0.848	0.755	0.845	0.834	0.729	0.700	0.901
3	2.647	2.366	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.913	2.206
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776	4.156
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488	6.174
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453	8.333
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019	9.889
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810	10.791
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077	12.175
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359	12.425
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886	13.731

AGE/YEAI	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.304	0.198	0.294	0.432	0.291	0.257	0.330	0.358	0.403	0.305	0.314	0.293
2	0.760	0.722	0.673	0.743	0.905	0.917	0.769	0.908	0.882	0.921	0.800	0.782
3	2.348	2.449	2.128	2.001	2.411	1.948	2.186	1.856	1.834	2.156	2.132	1.822
4	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972	4.164	3.504
5	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190	6.324	6.230
6	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362	8.430	8.140
7	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317	10.362	9.896
8	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352	12.074	11.940
9	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505	13.072	12.951
10	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408	14.443	13.859
+gp	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472	16.588	14.707

AGE/YEAI	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.437	0.466	0.364	0.382	0.393	0.395	0.326	0.305	0.420	0.433	0.386	0.372
2	0.773	0.753	0.932	0.690	0.889	0.970	0.846	0.788	0.768	0.831	0.797	0.634
3	1.955	1.975	1.810	2.165	1.995	2.546	2.477	2.188	2.206	2.095	2.117	1.622
4	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293	4.034	3.821	3.495
5	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220	6.637	6.228	5.387
6	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980	8.494	8.394	7.563
7	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282	9.729	9.979	9.628
8	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743	11.080	11.424	10.643
9	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107	12.264	12.300	11.499
10	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052	12.756	12.761	13.085
+gp	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954	11.304	13.416	14.921

AGE/YEAI	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010.000
1	0.318	0.354	0.372	0.298	0.285	0.269	0.342	0.250	0.313	0.424	0.406	0.335
2	0.732	0.903	0.606	0.572	0.781	0.496	0.860	0.236	0.893	0.904	1.133	0.965
3	1.405	1.747	2.093	1.576	1.645	1.712	1.529	1.804	2.001	1.966	2.355	2.426
4	3.305	3.216	3.663	3.726	3.298	3.075	3.533	3.828	4.026	3.890	4.023	4.180
5	5.726	4.903	5.871	5.537	5.757	5.175	5.124	5.665	6.117	6.207	6.154	6.033
6	7.403	7.488	7.333	8.006	6.694	7.449	7.201	7.229	8.543	7.491	7.560	8.299
7	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.262	9.255	9.644	9.733	9.472
8	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477	10.293	11.489	11.447	11.631
9	11.600	10.894	12.062	11.888	11.518	11.857	11.384	12.325	12.282	11.387	11.291	12.827
10	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862	14.559	12.725	11.786	12.083
+gp	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887	17.522	15.381	18.764	10.052

AGE/YEAI	2011	2012	2013	2014	2015	2016	2017	2018
1	0.405	0.274	0.388	0.398	0.366	0.387	0.249	0.299
2	0.915	0.800	0.932	0.927	0.945	1.049	0.925	0.793
3	2.438	2.252	2.249	2.237	2.098	2.138	2.238	1.865
4	4.569	4.154	4.060	4.083	4.031	3.803	3.794	3.791
5	6.472	6.392	5.999	5.598	5.802	5.712	5.296	5.641
6	7.829	8.117	8.360	7.392	6.761	7.332	6.857	6.874
7	9.656	9.095	9.385	9.190	8.602	7.928	8.850	7.746
8	9.461	11.799	9.486	9.180	9.410	8.717	8.618	8.893
9	10.853	12.548	11.364	11.469	8.663	10.367	9.586	8.554
10	14.436	11.754	11.680	16.456	13.838	11.926	17.579	8.980
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.565

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 2018 (note, any differences in the +gp values between Tables 4.3a–c and Table 4.3d is due to rounding error alone).

Landing weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.654	0.727	0.566	0.628	0.513	0.607
2	0.819	0.95	1.03	1.168	1.255	1.067
3	1.833	1.718	1.988	2.2	2.293	1.956
4	3.455	3.536	4.302	4.441	3.726	3.867
5	5.159	5.61	6.446	5.867	5.062	5.654
6	5.893	6.638	7.705	8.138	6.489	6.888
7	7.77	6.952	8.205	8.944	8.214	7.765
8	9.591	8.51	8.476	7.879	10.18	8.922
9	7.686	8.373	8.927	9.901	10.768	8.502
10	15.057	9.297	8.08	9.097	13.325	8.991
+gp	32.651	24.112	5.627	20.624	28.135	23.805

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.114	0.221	0.258	0.347	0.259	0.279
2	0.491	0.552	0.752	0.622	0.617	0.61
3	1.284	0.906	2.017	1.127	1.872	1.408
4	2.229	2.628	3.254	3.058	3.175	2.701
5	3.593	2.976	3.497	3.738	4.17	3.571
6	9.79	9.79	9.79	9.79	9.79	9.79
7	0	0	0	0	0	0
8	0	0	0	0	0	0
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	0.132	0.272	0.261	0.369	0.278	0.298
2	0.578	0.68	0.868	1.037	0.687	0.792
3	1.68	1.588	1.991	2.159	2.09	1.862
4	3.304	3.508	4.228	4.42	3.648	3.789
5	5.159	5.598	6.422	5.86	5.053	5.645
6	5.893	6.638	7.705	8.138	6.489	6.888
7	7.77	6.952	8.205	8.944	8.214	7.765
8	9.591	8.51	8.476	7.879	10.18	8.922
9	7.69	8.383	8.981	9.896	10.555	8.566
10	15.057	9.297	8.08	9.097	13.325	8.991
+gp	32.651	24.112	5.627	20.624	28.135	23.805

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
2018	40658	7873	48531

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	0.011	0.051	0.236	0.640	0.883	1.000
1974	0.010	0.053	0.229	0.616	0.850	1.000
1975	0.010	0.054	0.223	0.591	0.817	1.000
1976	0.009	0.055	0.218	0.568	0.786	1.000
1977	0.008	0.056	0.213	0.546	0.756	1.000
1978	0.006	0.057	0.210	0.526	0.730	1.000
1979	0.005	0.057	0.207	0.509	0.708	1.000
1980	0.004	0.058	0.206	0.496	0.691	1.000
1981	0.003	0.058	0.206	0.487	0.681	1.000
1982	0.004	0.060	0.208	0.483	0.678	1.000
1983	0.005	0.062	0.212	0.485	0.682	1.000
1984	0.007	0.065	0.221	0.492	0.693	1.000
1985	0.009	0.069	0.235	0.505	0.709	1.000
1986	0.012	0.074	0.255	0.524	0.730	1.000
1987	0.014	0.080	0.282	0.547	0.754	1.000
1988	0.016	0.086	0.314	0.574	0.779	1.000
1989	0.016	0.092	0.349	0.603	0.805	1.000
1990	0.016	0.097	0.385	0.633	0.829	1.000
1991	0.014	0.103	0.419	0.661	0.851	1.000
1992	0.012	0.109	0.447	0.688	0.870	1.000
1993	0.009	0.115	0.468	0.711	0.887	1.000
1994	0.007	0.122	0.482	0.730	0.902	1.000
1995	0.005	0.131	0.488	0.745	0.914	1.000
1996	0.003	0.142	0.490	0.757	0.924	1.000
1997	0.003	0.156	0.491	0.767	0.932	1.000
1998	0.002	0.173	0.495	0.775	0.938	1.000
1999	0.003	0.192	0.505	0.782	0.943	1.000
2000	0.004	0.213	0.524	0.791	0.946	1.000
2001	0.006	0.235	0.552	0.799	0.949	1.000
2002	0.008	0.258	0.588	0.809	0.950	1.000
2003	0.011	0.279	0.629	0.820	0.951	1.000
2004	0.016	0.298	0.671	0.831	0.951	1.000
2005	0.021	0.315	0.710	0.841	0.952	1.000
2006	0.027	0.329	0.741	0.851	0.953	1.000
2007	0.034	0.339	0.761	0.859	0.953	1.000
2008	0.041	0.348	0.768	0.866	0.953	1.000
2009	0.048	0.353	0.763	0.872	0.953	1.000
2010	0.055	0.357	0.748	0.875	0.953	1.000
2011	0.059	0.359	0.724	0.876	0.952	1.000
2012	0.062	0.360	0.696	0.876	0.951	1.000
2013	0.063	0.359	0.668	0.873	0.949	1.000
2014	0.061	0.357	0.643	0.868	0.948	1.000
2015	0.056	0.354	0.622	0.862	0.947	1.000
2016	0.050	0.350	0.605	0.854	0.947	1.000
2017	0.042	0.344	0.594	0.846	0.947	1.000
2018	0.033	0.339	0.585	0.836	0.947	1.000
2019	0.023	0.333	0.578	0.826	0.947	1.000

Smoothed to 2019

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
2018*	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 2017–2018 M–values are 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	2019						
1	1	0	0.25				
1	5						
1	**4270.79**	**14177.05**	**1632.85**	**977.12**	**376.71**	393.66	1983
1	**12958.20**	**5446.28**	**2290.84**	**461.97**	**437.13**	183.34	1984
1	**617.51**	**14498.27**	**1964.46**	**794.76**	**234.96**	284.30	1985
1	**12785.20**	**2216.68**	**3303.59**	**945.84**	**436.59**	242.27	1986
1	**5266.88**	**14195.25**	**667.18**	**797.59**	**225.02**	201.88	1987
1	**2876.33**	**3414.70**	**3352.99**	**198.29**	**362.83**	210.23	1988
1	**9900.20**	**3347.84**	**2530.74**	**1187.15**	**172.37**	243.36	1989
1	**2077.00**	**7137.48**	**1112.00**	**433.05**	**490.43**	81.82	1990
1	**1743.49**	**2242.41**	**1902.23**	**512.69**	**274.26**	264.85	1991
1	**9554.83**	**3167.56**	**725.55**	**513.67**	**161.64**	68.41	1992
1	**3321.58**	**7794.98**	**942.67**	**349.37**	**255.43**	74.65	1993
1	**7254.40**	**2107.48**	**1546.90**	**487.90**	**230.52**	125.98	1994
1	**7072.81**	**9235.94**	**1801.62**	**525.57**	**194.35**	71.29	1995
1	**1857.58**	**4057.64**	**2403.72**	**421.56**	**263.72**	69.23	1996
1	**16261.07**	**3021.40**	**1194.67**	**551.40**	**163.69**	109.72	1997
1	**649.55**	**9722.90**	**1177.30**	**492.50**	**299.86**	101.59	1998
1	**1419.12**	**474.17**	**4142.96**	**618.08**	**294.80**	102.40	1999
1	**3592.07**	**2079.43**	**505.00**	**962.79**	**174.36**	108.23	2000
1	**877.05**	**3720.28**	**861.70**	**160.70**	**151.28**	56.46	2001
1	**2950.59**	**1505.09**	**1571.35**	**249.21**	**57.39**	61.55	2002
1	**359.99**	**1916.81**	**706.06**	**479.50**	**159.15**	31.83	2003
1	**2747.85**	**1213.47**	**1134.11**	**190.72**	**187.71**	73.84	2004
1	**1099.83**	**1445.68**	**484.03**	**403.79**	**69.84**	111.93	2005
1	**3868.14**	**845.99**	**757.75**	**157.15**	**87.17**	58.81	2006
1	**1448.49**	**2550.87**	**693.84**	**231.92**	**88.32**	68.50	2007
1	**2305.78**	**1043.63**	**1163.35**	**294.29**	**201.02**	52.11	2008
1	**1064.81**	**1707.84**	**814.68**	**393.71**	**127.30**	75.62	2009
1	**2842.22**	**1591.55**	**1147.24**	**328.62**	**207.42**	85.47	2010
1	**768.23**	**2818.41**	**591.99**	**336.14**	**212.66**	135.62	2011
1	**1585.27**	**1507.40**	**1848.97**	**412.23**	**226.58**	82.30	2012
1	**1631.50**	**1431.03**	**764.53**	**558.10**	**372.80**	101.62	2013
1	**2713.58**	**1692.78**	**740.84**	**288.65**	**348.85**	114.41	2014
1	**1688.14**	**3530.23**	**1213.69**	**451.92**	**198.99**	154.93	2015
1	**956.06**	**1072.38**	**1889.81**	**623.55**	**361.07**	138.51	2016
1	**8238.45**	**889.46**	**1202.85**	**1054.48**	**571.87**	138.84	2017
1	**473.31**	**2568.35**	**512.33**	**303.69**	**262.06**	225.58	2018
1	**1314.17**	**503.71**	**908.28**	**96.33**	**91.71**	81.64	2019
IBTS_Q3_gam							
1992	2018						
1	1	0.50	0.75				
1	4						
1	**18440.65**	**1766.92**	**397.75**	**370.71**	118.78	45.65	1992
1	**4843.44**	**4667.84**	**625.14**	**135.99**	92.44	7.17	1993
1	**18884.51**	**2374.81**	**973.43**	**173.30**	43.28	32.59	1994
1	**10084.22**	**7229.23**	**747.14**	**325.72**	34.48	18.15	1995
1	**5367.84**	**2976.70**	**1107.61**	**187.73**	138.64	12.90	1996
1	**30717.83**	**2060.37**	**749.14**	**287.40**	51.06	34.23	1997
1	**901.94**	**9257.79**	**699.11**	**197.90**	121.30	39.54	1998
1	**3552.64**	**493.84**	**2481.06**	**163.82**	42.93	17.37	1999
1	**6608.23**	**984.16**	**118.69**	**358.96**	40.47	30.98	2000
1	**1459.52**	**2217.00**	**385.12**	**82.84**	64.45	38.27	2001
1	**4128.16**	**899.40**	**763.45**	**203.23**	53.10	23.37	2002
1	**968.20**	**1289.68**	**249.39**	**189.52**	104.82	76.07	2003
1	**3208.34**	**777.34**	**489.92**	**99.15**	74.28	26.19	2004
1	**1097.37**	**750.82**	**292.82**	**123.85**	27.53	48.15	2005
1	**5554.17**	**730.03**	**610.27**	**124.34**	30.81	19.45	2006
1	**1913.53**	**2326.43**	**439.79**	**185.02**	104.35	48.20	2007
1	**2542.35**	**1227.06**	**1128.47**	**237.30**	127.82	33.97	2008
1	**1962.00**	**986.69**	**293.18**	**245.38**	55.10	26.63	2009
1	**4648.68**	**1638.59**	**539.17**	**188.85**	112.94	22.24	2010
1	**1236.59**	**2875.09**	**916.91**	**399.52**	115.60	108.33	2011
1	**2192.86**	**1029.22**	**1271.61**	**389.38**	106.53	20.06	2012
1	**3209.46**	**1094.35**	**482.97**	**508.31**	141.55	66.10	2013
1	**3448.28**	**1477.29**	**625.74**	**315.42**	201.59	97.54	2014
1	**1919.27**	**2962.57**	**1044.74**	**473.21**	137.08	132.43	2015
1	**1438.61**	**1130.01**	**1639.67**	**857.23**	208.57	133.13	2016
1	**7301.90**	**599.97**	**458.97**	**425.55**	219.37	47.57	2017
1	**1137.33**	**2086.10**	**373.15**	**216.45**	146.03	99.25	2018

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
-181.17	34	430.3397

	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.Log	logSd.Log	logSd.Log	logSd.Log	logSd.Log	logSd.Log	logSd.Log	logSd.log	logSd.Lod	logSd.Log	LogSd.Log	itrans_rho	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult	log.Cmult
logq Q1_1	-4.66	0.09	1																																	
logq Q1_2	-3.32	0.05	0.23	1																																
logq Q1_3	-2.68	0.05	0.17	0.3	1																															
logq Q1_4	-2.56	0.06	0.19	0.32	0.4	1																														
logq Q1_5	-2.27	0.08	0.2	0.35	0.44	0.58	1																													
logq Q3_1	-3.49	0.08	0.22	0.28	0.23	0.24	0.26	1																												
logq Q3_2	-2.9	0.07	0.21	0.36	0.33	0.36	0.39	0.27	1																											
logq Q3_3	-2.59	0.07	0.19	0.33	0.41	0.46	0.5	0.25	0.37	1																										
logq Q3_4	-2.49	0.09	0.2	0.35	0.43	0.56	0.65	0.26	0.39	0.5	1																									
logSd LogF1	-1.86	0.22	-0.04	-0.02	-0.05	-0.06	-0.09	-0.04	-0.04	-0.05	-0.08	1																								
logSd LogF2+	-2.37	0.14	-0.09	-0.16	-0.19	-0.24	-0.31	-0.11	-0.18	-0.22	-0.29	0.39	1																							
logSd LogN1	-0.24	0.11	-0.02	-0.01	-0.03	-0.03	-0.03	-0.02	-0.02	-0.03	-0.04	0	0.01	1																						
logSd LogN2+	-2.13	0.14	-0.01	-0.01	-0.02	-0.02	0	-0.02	-0.01	-0.04	-0.04	-0.04	-0.04	0.25	1																					
logSd LogC1	-0.54	0.11	0.01	0.01	0.02	0.02	0.02	0	0.02	0.02	0.02	-0.08	-0.01	-0.09	-0.08	1																				
logSd LogC2	-1.47	0.14	0.01	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0	-0.02	-0.03	-0.07	0.06	1																			
logSd Log3+	-2.85	0.31	-0.01	-0.02	-0.02	-0.05	-0.09	-0.01	-0.02	-0.03	-0.06	-0.04	-0.1	-0.11	-0.55	0.06	0.01	1																		
logSd logQ1_1	-0.73	0.13	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.01	-0.01	-0.17	-0.15	0.03	0	0.07	1																	
logSd LodQ1_2+	-1.35	0.07	0.06	0.11	0.13	0.17	0.21	0.07	0.12	0.17	0.22	-0.04	-0.18	-0.09	-0.16	0.02	0	0	0.05	1																
logSd LogQ3_1	-1.01	0.16	0.03	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05	0.01	-0.01	-0.18	-0.19	0.04	-0.05	0.08	0.17	0.08	1															
LogSd LogQ3_2+	-1.32	0.09	0.03	0.05	0.08	0.12	0.16	0.04	0.06	0.1	0.15	-0.03	-0.14	-0.06	-0.09	0	-0.01	-0.06	0.04	0.11	0.07	1														
itrans_rho	1.37	0.24	0	0.02	0.02	0.01	0.02	0	0.02	0	0	0.04	0.19	0.05	0.22	0.09	0.08	0.11	-0.03	-0.09	-0.04	-0.08	1													
log Cmult1993	-0.08	0.09	-0.12	-0.2	-0.23	-0.25	-0.27	-0.14	-0.2	-0.23	-0.26	0.02	0.08	0.02	0.03	-0.02	-0.04	0.04	-0.02	-0.08	-0.06	-0.01	0.02	1												
log Cmult1994	0.01	0.1	-0.14	-0.24	-0.27	-0.3	-0.31	-0.18	-0.25	-0.28	-0.31	0.04	0.1	0.03	0.04	0	-0.03	0.01	-0.03	-0.11	-0.07	0	0.01	0.43	1											
log Cmult1995	0.14	0.1	-0.16	-0.27	-0.31	-0.35	-0.37	-0.21	-0.29	-0.33	-0.36	0.03	0.16	0.03	0.03	0	0	0.02	-0.04	-0.13	-0.08	-0.03	0.04	0.23	0.46	1										
log Cmult1996	0.02	0.1	-0.16	-0.27	-0.31	-0.35	-0.37	-0.21	-0.29	-0.33	-0.36	0.01	0.16	0.04	0.05	-0.03	-0.02	0.01	-0.04	-0.11	-0.09	-0.05	0.04	0.15	0.25	0.48	1									
log Cmult1997	-0.15	0.1	-0.14	-0.23	-0.27	-0.29	-0.3	-0.18	-0.26	-0.28	-0.3	0.01	0.07	0.01	-0.03	-0.02	-0.04	0.03	-0.03	-0.03	-0.07	0.01	-0.06	0.11	0.15	0.23	0.44	1								
log Cmult1998	-0.32	0.1	-0.15	-0.25	-0.29	-0.32	-0.34	-0.2	-0.28	-0.31	-0.34	0.05	0.15	0.02	0	-0.02	-0.02	0.01	-0.03	-0.1	-0.07	-0.02	-0.01	0.13	0.15	0.18	0.25	0.45	1							
log Cmult1999	-0.16	0.11	-0.15	-0.25	-0.29	-0.32	-0.33	-0.2	-0.28	-0.31	-0.34	0.1	0.28	0.04	0.09	-0.02	-0.03	-0.05	-0.03	-0.21	-0.06	-0.07	0.04	0.14	0.16	0.18	0.19	0.22	0.45	1						
log Cmult2000	-0.12	0.1	-0.15	-0.25	-0.28	-0.31	-0.32	-0.19	-0.27	-0.31	-0.33	0.06	0.21	0	0	-0.01	-0.02	0.01	0	-0.19	-0.01	0.01	0	0.14	0.17	0.18	0.17	0.15	0.24	0.46	1					
log Cmult2001	0.18	0.1	-0.14	-0.24	-0.27	-0.29	-0.29	-0.18	-0.25	-0.28	-0.3	0	0.06	0.01	-0.01	-0.02	0.03	0.01	0	-0.12	-0.01	0.05	-0.06	0.13	0.16	0.18	0.17	0.14	0.15	0.21	0.44	1				
log Cmult2002	-0.2	0.1	-0.13	-0.21	-0.24	-0.24	-0.23	-0.17	-0.23	-0.25	-0.24	0.01	0.05	0.02	0.05	-0.02	-0.02	-0.04	-0.01	-0.11	-0.01	0.03	-0.04	0.11	0.15	0.15	0.15	0.13	0.13	0.14	0.21	0.44	1			
log Cmult2003	0.34	0.1	-0.15	-0.25	-0.29	-0.32	-0.33	-0.2	-0.27	-0.31	-0.33	0.04	0.14	0.01	-0.01	-0.01	-0.04	0.05	0	-0.17	0	0.02	-0.02	0.15	0.18	0.2	0.2	0.16	0.17	0.17	0.18	0.25	0.45	1		
log Cmult2004	0.04	0.1	-0.14	-0.23	-0.25	-0.27	-0.28	-0.18	-0.24	-0.27	-0.28	0.04	0.11	0.01	0.01	-0.01	-0.02	0.02	0	-0.15	0	0.03	0	0.13	0.16	0.18	0.17	0.15	0.16	0.16	0.15	0.16	0.22	0.46	1	
log Cmult2005	-0.09	0.09	-0.09	-0.15	-0.16	-0.16	-0.14	-0.12	-0.16	-0.16	-0.15	0.01	0.05	0.01	0.04	-0.01	-0.06	0	0	-0.09	0.01	0.05	0.01	0.08	0.1	0.11	0.11	0.1	0.1	0.11	0.1	0.09	0.11	0.19	0.41	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	0.090	0.467	0.514	0.473	0.474	0.527	0.485
1964	0.100	0.501	0.564	0.514	0.511	0.564	0.526
1965	0.119	0.556	0.630	0.558	0.543	0.589	0.581
1966	0.124	0.569	0.638	0.551	0.538	0.589	0.586
1967	0.135	0.603	0.676	0.586	0.581	0.633	0.621
1968	0.148	0.640	0.715	0.621	0.614	0.657	0.659
1969	0.138	0.610	0.671	0.585	0.586	0.629	0.622
1970	0.162	0.668	0.714	0.605	0.595	0.625	0.662
1971	0.209	0.774	0.803	0.672	0.650	0.671	0.750
1972	0.248	0.851	0.860	0.718	0.694	0.714	0.809
1973	0.259	0.857	0.837	0.695	0.666	0.678	0.797
1974	0.256	0.834	0.789	0.655	0.637	0.653	0.759
1975	0.293	0.902	0.847	0.699	0.681	0.685	0.816
1976	0.338	0.980	0.907	0.727	0.705	0.702	0.871
1977	0.319	0.935	0.861	0.681	0.680	0.685	0.826
1978	0.355	1.006	0.965	0.767	0.767	0.757	0.913
1979	0.327	0.936	0.914	0.713	0.697	0.685	0.855
1980	0.362	1.000	1.003	0.786	0.745	0.727	0.930
1981	0.358	1.002	1.026	0.806	0.745	0.729	0.944
1982	0.396	1.087	1.152	0.919	0.838	0.813	1.053
1983	0.384	1.074	1.145	0.925	0.834	0.804	1.048
1984	0.348	1.006	1.064	0.879	0.794	0.770	0.983
1985	0.323	0.964	1.017	0.859	0.773	0.749	0.947
1986	0.334	0.995	1.073	0.935	0.834	0.804	1.001
1987	0.311	0.964	1.049	0.927	0.823	0.795	0.980
1988	0.314	0.979	1.081	0.953	0.836	0.800	1.004
1989	0.320	0.993	1.096	0.976	0.858	0.819	1.021
1990	0.290	0.935	1.019	0.903	0.788	0.749	0.952
1991	0.274	0.906	1.003	0.910	0.807	0.762	0.940
1992	0.262	0.886	0.998	0.914	0.805	0.745	0.932
1993	0.254	0.878	1.015	0.928	0.812	0.738	0.940
1994	0.250	0.875	1.044	0.941	0.820	0.733	0.953
1995	0.253	0.899	1.104	0.977	0.848	0.742	0.994
1996	0.233	0.867	1.113	1.004	0.904	0.786	0.995
1997	0.211	0.819	1.095	1.010	0.923	0.786	0.975
1998	0.210	0.819	1.133	1.061	0.967	0.803	1.005
1999	0.212	0.829	1.199	1.145	1.052	0.854	1.058
2000	0.203	0.810	1.189	1.157	1.061	0.835	1.052
2001	0.181	0.750	1.097	1.086	0.991	0.762	0.977
2002	0.166	0.704	1.036	1.033	0.940	0.710	0.924
2003	0.163	0.690	1.027	1.007	0.900	0.663	0.908
2004	0.155	0.664	0.987	0.932	0.839	0.608	0.861
2005	0.143	0.625	0.923	0.851	0.790	0.568	0.800
2006	0.132	0.588	0.854	0.769	0.737	0.525	0.737
2007	0.119	0.543	0.805	0.723	0.694	0.481	0.690
2008	0.109	0.511	0.776	0.696	0.687	0.474	0.661
2009	0.105	0.497	0.774	0.704	0.695	0.465	0.658
2010	0.087	0.436	0.685	0.626	0.617	0.405	0.582
2011	0.066	0.358	0.563	0.524	0.523	0.344	0.482
2012	0.059	0.330	0.523	0.491	0.482	0.309	0.448
2013	0.057	0.322	0.520	0.488	0.468	0.291	0.443
2014	0.057	0.322	0.532	0.496	0.466	0.284	0.450
2015	0.054	0.314	0.524	0.497	0.473	0.287	0.445
2016	0.054	0.312	0.528	0.498	0.460	0.270	0.446
2017	0.062	0.345	0.598	0.564	0.502	0.288	0.502
2018	0.083	0.423	0.758	0.715	0.623	0.350	0.632

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	397633	168500	20027	10207	8073	4802	609241
1964	650569	120027	51684	11452	5174	6562	845468
1965	871808	205880	40329	22796	6141	5135	1152090
1966	1059734	251542	67632	16262	9263	5758	1410191
1967	891641	307703	72743	28356	7945	7692	1316080
1968	448190	263919	89984	28620	14170	6600	851484
1969	391338	127254	72243	33908	11252	9461	645456
1970	1319269	118351	38922	32160	15245	7893	1531840
1971	1740206	383565	33619	14922	15986	10047	2198346
1972	431806	480379	90846	12112	5943	12284	1033369
1973	635677	109265	105932	29924	4942	6737	892476
1974	632510	163420	23682	36392	10907	5308	872217
1975	1092931	157950	36877	9703	16364	6813	1320638
1976	755228	273636	34058	13706	3792	9427	1089847
1977	1842843	165591	51137	10796	5105	5850	2081323
1978	1122754	431552	30856	18832	5645	4376	1614016
1979	1399884	257472	81062	8908	7322	3323	1757970
1980	2254006	301026	59388	24600	3977	4456	2647455
1981	877285	479905	59298	17631	8758	3437	1446315
1982	1414554	182564	93801	17003	6577	5372	1719872
1983	784294	303281	33560	21226	5393	4267	1152020
1984	1436937	169812	52359	7972	6738	3647	1677464
1985	350975	319790	33201	14729	2769	3999	725464
1986	1597931	82321	58294	10148	5610	2832	1757137
1987	609972	378414	16635	15428	2993	3199	1026640
1988	421805	148872	71614	5287	4924	2227	654728
1989	733346	104715	30675	17280	1832	2809	890657
1990	294268	177470	20497	7863	5070	1575	506744
1991	341888	74326	30801	5996	2678	2832	458521
1992	780266	90491	15127	8808	2023	1938	898653
1993	395474	197952	18177	4990	2813	1490	620897
1994	951238	106664	36679	5450	1700	1616	1103348
1995	544657	249635	23908	10295	1788	1237	831520
1996	350372	140455	41050	5647	3338	1346	542208
1997	1072352	99580	26812	9541	1850	1595	1211730
1998	112966	300503	21867	6992	3024	1169	446521
1999	227641	33139	55151	5441	2024	1481	324877
2000	416935	65680	8562	9627	1454	988	503246
2001	152852	124645	14148	2137	2200	679	296661
2002	229713	47721	25583	3785	579	881	308262
2003	113961	66135	10897	7067	1052	489	199600
2004	193972	36817	14277	2996	1953	535	250549
2005	154826	54133	8338	3335	984	987	222603
2006	354524	48027	13039	2195	1089	875	419750
2007	168447	102833	10473	4162	967	753	287634
2008	190527	47731	24650	3157	1601	926	268592
2009	183333	54029	11654	7539	1369	1055	258980
2010	270365	54469	13336	3868	3132	987	346157
2011	131827	77152	13625	4180	1666	1986	230437
2012	179746	39548	20171	5803	1854	1723	248845
2013	223389	50546	11239	8425	2789	1664	298052
2014	310228	62944	15496	4872	4013	2078	399631
2015	150660	89029	19763	6137	2294	3528	271410
2016	114185	39649	25180	9525	3077	2560	194175
2017	320063	29346	11740	10117	4923	2766	378954
2018	77677	78025	8984	4608	4236	4432	177961
2019	133583	19220	19728	2670	1654	4416	181271

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	20980	47561	7315	3513	2783	1799
1964	37860	35808	20264	4206	1893	2589
1965	59839	66684	17157	8918	2353	2093
1966	75815	82998	29040	6302	3524	2345
1967	68997	106028	32572	11502	3206	3303
1968	37832	95225	41934	12131	5956	2913
1969	30960	44265	32198	13750	4569	4046
1970	121771	44047	18111	13369	6258	3358
1971	202814	158776	16948	6693	6999	4501
1972	58741	212285	47899	5688	2726	5751
1973	89910	48505	54897	13750	2203	3040
1974	88698	71222	11804	16023	4708	2331
1975	171997	72680	19232	4476	7405	3098
1976	134141	133047	18540	6498	1759	4360
1977	308823	78213	26912	4886	2310	2659
1978	205810	213785	17428	9261	2776	2132
1979	238084	121809	44214	4167	3369	1511
1980	417388	148460	34260	12291	1917	2112
1981	160649	236546	34647	8961	4220	1632
1982	282368	94494	58519	9406	3429	2745
1983	152895	155616	20842	11787	2803	2166
1984	258715	83563	31174	4287	3391	1797
1985	59532	153016	19238	7806	1368	1934
1986	280403	40149	34818	5672	2916	1437
1987	101227	180578	9799	8581	1543	1611
1988	70957	71563	42897	2992	2562	1126
1989	126117	50662	18510	9916	970	1443
1990	46692	82413	11842	4302	2538	762
1991	51709	33699	17617	3296	1362	1387
1992	113574	40309	8618	4854	1028	934
1993	56175	87425	10452	2776	1436	713
1994	133363	46866	21406	3058	874	770
1995	77278	111288	14377	5914	939	595
1996	46190	60856	24715	3296	1827	672
1997	129485	41305	15928	5591	1026	797
1998	13570	123996	13191	4218	1725	593
1999	27607	13699	34162	3425	1215	782
2000	48672	26547	5252	6095	877	514
2001	15999	47309	8248	1306	1274	332
2002	22131	17148	14355	2247	324	411
2003	10691	23228	6056	4132	574	217
2004	17324	12453	7722	1671	1019	223
2005	12697	17358	4321	1756	494	391
2006	26798	14610	6426	1081	521	327
2007	11434	29273	4971	1965	444	263
2008	11845	12921	11451	1452	729	319
2009	10939	14300	5423	3495	629	358
2010	13419	12964	5716	1648	1320	300
2011	4968	15587	5067	1558	620	527
2012	6043	7464	7105	2059	647	417
2013	7154	9340	3949	2973	952	383
2014	9854	11673	5546	1742	1366	467
2015	4565	16182	6998	2195	789	801
2016	3391	7187	8967	3416	1035	551
2017	10912	5793	4594	3988	1775	630
2018	3534	18320	4169	2159	1798	1194

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	397633	289452	546246	464040	400658	537450	145016	114233	184094	117527	104415	132286	0.485	0.420	0.560
1964	650569	474239	892462	591847	507989	689548	156610	125894	194820	143937	130981	158174	0.526	0.462	0.599
1965	871808	637817	1191641	753551	652485	870270	191632	158680	231427	198302	177406	221658	0.581	0.511	0.660
1966	1059734	776140	1446950	902833	782622	1041508	212893	177118	255894	240635	215825	268296	0.586	0.518	0.663
1967	891641	652622	1218200	958527	839712	1094154	241337	201148	289556	286289	256401	319661	0.621	0.551	0.700
1968	448190	327485	613387	820370	734914	915764	254072	217826	296349	293004	266733	321864	0.659	0.584	0.744
1969	391338	284048	539153	680353	605813	764064	250569	212605	295312	224897	208535	242543	0.622	0.553	0.701
1970	1319269	963442	1806514	1065433	887950	1278391	261239	222613	306567	251116	221001	285336	0.662	0.591	0.742
1971	1740206	1265171	2393604	1205173	1021990	1421191	264919	226254	310193	351007	301510	408628	0.750	0.672	0.836
1972	431806	313383	594980	865561	768163	975308	235866	201568	276000	363903	318887	415272	0.809	0.725	0.904
1973	635677	461558	875483	692120	616246	777336	210206	185143	238663	260138	237319	285150	0.797	0.714	0.889
1974	632510	458498	872562	664050	588917	748768	225745	198174	257152	236425	211318	264515	0.759	0.681	0.847
1975	1092931	784945	1521759	749778	639961	878440	204016	177746	234169	248621	216227	285869	0.816	0.734	0.907
1976	755228	538030	1060107	604932	531872	688027	172409	148352	200367	249457	216267	287741	0.871	0.782	0.971
1977	1842843	1322444	2568027	905569	738565	1110335	146131	126087	169360	265761	217357	324945	0.826	0.742	0.919
1978	1122754	802406	1570995	1025074	857679	1225139	144837	128523	163222	359955	296496	436996	0.913	0.822	1.013
1979	1399884	1003940	1951983	956920	817673	1119879	143438	128208	160476	341959	292395	399925	0.855	0.770	0.948
1980	2254006	1607701	3160129	1147283	953899	1379873	156049	140130	173776	396662	327695	480143	0.930	0.841	1.028
1981	877285	627775	1225964	965339	837997	1112032	164850	149267	182060	397923	339324	466641	0.944	0.857	1.041
1982	1414554	1022443	1957042	1012802	852881	1202710	163662	147630	181435	384026	326016	452359	1.053	0.956	1.159
1983	784294	576545	1066903	802555	692379	930264	134944	121409	149988	321366	273873	377095	1.048	0.953	1.152
1984	1436937	1057232	1953013	815841	686234	969927	117444	105418	130843	278310	235683	328647	0.983	0.894	1.081
1985	350975	255833	481500	553634	489787	625804	116664	104638	130072	241644	209091	279266	0.947	0.860	1.043
1986	1597931	1178693	2166285	736905	605699	896531	109218	99003	120487	229053	190916	274807	1.001	0.911	1.099
1987	609972	451901	823335	696410	599225	809358	111058	100317	122949	258940	218085	307448	0.980	0.892	1.077
1988	421805	312043	570175	517269	454068	589267	110518	101316	120555	207086	183737	233403	1.004	0.914	1.103
1989	733346	540067	995795	516439	437057	610239	102521	93470	112448	180014	154619	209580	1.021	0.929	1.123
1990	294268	218401	396489	354513	312008	402809	89916	81462	99247	139147	121446	159429	0.952	0.862	1.052
1991	341888	254386	459490	326647	284112	375551	88679	79620	98769	118871	105435	134019	0.940	0.848	1.041
1992	780266	580038	1049612	502696	413526	611094	85356	76286	95505	141675	119081	168554	0.932	0.834	1.043
1993	395474	295868	528613	396110	333909	469897	87538	74114	103394	146695	119526	180039	0.940	0.831	1.064
1994	951238	700253	1292182	505640	410394	622991	94324	79183	112360	151362	121129	189142	0.953	0.841	1.081
1995	544657	404465	733440	542491	447502	657642	108795	91139	129872	187661	149229	235991	0.994	0.876	1.127
1996	350372	261637	469202	411994	345997	490579	109556	91857	130666	154087	125089	189807	0.995	0.877	1.128
1997	1072352	785294	1464342	612371	485724	772039	94290	79441	111916	151543	119623	191981	0.975	0.861	1.103
1998	112966	83595	152657	318707	265796	382151	94704	79340	113043	134147	107673	167130	1.005	0.889	1.135
1999	227641	170628	303702	215669	181865	255756	80941	67247	97423	91396	74712	111804	1.058	0.935	1.196
2000	416935	312638	556026	268215	220427	326362	60530	50558	72469	78576	63335	97485	1.052	0.930	1.190
2001	152852	114297	204413	188549	159153	223374	58733	49404	69825	66984	54661	82084	0.977	0.864	1.106
2002	229713	172403	306073	160870	135118	191530	53225	44761	63289	52691	43309	64105	0.924	0.813	1.051
2003	113961	85151	152518	135520	115157	159483	55002	46209	65469	49906	40801	61042	0.908	0.798	1.033
2004	193972	147609	254899	118502	100514	139709	44228	37218	52558	36264	29791	44144	0.861	0.755	0.982
2005	154826	116268	206172	136714	117412	159190	47151	40551	54825	37637	31205	45395	0.800	0.697	0.917
2006	354524	271669	462648	145296	122225	172722	43808	38428	49943	31533	28024	35481	0.737	0.656	0.827
2007	168447	129247	219536	195025	171578	221675	75783	67081	85614	52678	46114	60176	0.690	0.612	0.778
2008	190527	146093	248477	202428	177161	231300	83490	74002	94195	52082	47484	57125	0.661	0.581	0.752
2009	183333	140260	239634	210805	184284	241143	89598	78440	102343	54383	49311	59976	0.658	0.575	0.754
2010	270365	206170	354548	219341	188004	255902	88837	75725	104219	48398	44113	53098	0.582	0.499	0.679
2011	131827	100694	172587	203266	174103	237313	95767	78893	116250	44050	39960	48560	0.482	0.406	0.572
2012	179746	137773	234505	177250	150884	208223	93437	75738	115272	39944	37102	43003	0.448	0.375	0.536
2013	223389	171141	291588	224712	190720	264764	99704	80722	123150	41532	38327	45004	0.443	0.373	0.527
2014	310228	237456	405302	275297	232795	325558	105637	85875	129946	45608	41741	49834	0.450	0.383	0.529
2015	150660	115523	196482	244444	208493	286593	118237	94999	147159	50896	46443	55776	0.445	0.379	0.523
2016	114185	87473	149055	213365	182636	249265	116859	94287	144835	51225	47739	54966	0.446	0.379	0.525
2017	320063	234487	436870	218919	183196	261608	106745	84593	134697	47746	44547	51175	0.502	0.431	0.585
2018	77677	53035	113770	176060	144495	214522	101582	77818	132603	50537	45608	56000	0.632	0.529	0.755
2019	133583	57128	312360				81224	57451	114834						

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	106802	10719	117527		117527
1964	134541	9404	143937		143937
1965	181440	16875	198302		198302
1966	214641	26042	240635		240635
1967	260099	26159	286289		286289
1968	276249	16732	293004		293004
1969	215608	9310	224897		224897
1970	231405	19725	251116		251116
1971	292551	58471	351007		351007
1972	329398	34472	363903		363903
1973	234730	25399	260138		260138
1974	209328	27122	236425		236425
1975	210468	38112	248621		248621
1976	203274	46227	249457		249457
1977	183236	82627	265761		265761
1978	310333	49582	359955		359955
1979	277586	64419	341959		341959
1980	292052	104803	396662		396662
1981	343649	54211	397923		397923
1982	321947	62074	384026		384026
1983	284695	36719	321366		321366
1984	209600	68632	278310		278310
1985	213480	28170	241644		241644
1986	169122	59997	229053		229053
1987	226071	32765	258940		258940
1988	192261	14755	207086		207086
1989	139028	41026	180014		180014
1990	115602	23536	139147		139147
1991	102648	16189	118871		118871
1992	109507	32121	141675		141675
1993	130320	28669	159013	0.92	146695
1994	106797	42976	149788	1.01	151362
1995	130907	31673	162535	1.15	187661
1996	130737	20821	151587	1.02	154087
1997	132011	44032	176011	0.86	151543
1998	144621	40842	185532	0.72	134147
1999	94599	12859	107440	0.85	91396
2000	72758	15925	88678	0.89	78576
2001	44357	11319	55697	1.2	66984
2002	53200	11095	64293	0.82	52691
2003	31016	4592	35617	1.4	49906
2004	27264	7458	34723	1.04	36264
2005	29804	11361	41159	0.91	37637
2006	22489	9043	31533		31533
2007	23857	28827	52678		52678
2008	26928	25159	52082		52082
2009	33077	21300	54383		54383
2010	36076	12325	48398		48398
2011	33937	10120	44050		44050
2012	32442	7503	39944		39944
2013	30819	10721	41532		41532
2014	34791	10818	45608		45608
2015	37958	12941	50896		50896
2016	38690	12532	51225		51225
2017	38500	9252	47746		47746
2018	41418	9118	50537		50537

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	1.11
1994	1.01	0.83	1.24
1995	1.15	0.94	1.42
1996	1.02	0.82	1.25
1997	0.86	0.7	1.05
1998	0.72	0.59	0.89
1999	0.85	0.69	1.05
2000	0.89	0.72	1.09
2001	1.2	0.98	1.47
2002	0.82	0.67	1
2003	1.4	1.14	1.73
2004	1.04	0.85	1.28
2005	0.91	0.76	1.1

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

Forecast assumptions

Fbar(2019)	0.487
SSB(2020)	81755
R(2019)	136231
R(2020)	183333
Catch(2019)	35358
Landings(2019)	30271
Discards(2019)	5087

Catch scenarios

Basis	Total catch (2020)	Wanted catch (2020)	Unwanted catch (2020)	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	%SSB change	%TAC change	%advice change
SSB(2021)=B_{lim}	10457	8613	1844	0.131	0.101	0.030	107000	31	-70	-63
MSY HCR	13289	10933	2356	0.169	0.130	0.039	104036	27	-62	-53
MAP	8699	7178	1521	0.108	0.083	0.025	108827	33	-75	-69
F=0	0	0	0	0.00	0.00	0.00	118230	45	-100	-100
F_{pa}	28056	22944	5112	0.39	0.30	0.090	88516	8.3	-21	-0.52
F_{lim}	36634	29848	6786	0.54	0.42	0.124	79709	-2.5	3.6	30
SSB(2021)=B_{pa}	0	0	0	0.00	0.00	0.00	118230	45	-100	-100
SSB(2021)=$B_{trigger}$	0	0	0	0.00	0.00	0.00	118230	45	-100	-100
TAC(2019)-20%	28286	23131	5155	0.39	0.30	0.091	88253	7.9	-20.0	0.29
TAC(2019)-15%	30053	24574	5479	0.42	0.33	0.098	86409	5.7	-15.0	6.6
TAC(2019)-10%	31821	25985	5836	0.45	0.35	0.104	84513	3.4	-10.0	12.8
TAC(2019)-5%	33589	27374	6215	0.48	0.37	0.112	82710	1.17	-5.0	19.1
Constant TAC	35357	28803	6554	0.52	0.40	0.119	80950	-0.98	0.00	25
TAC(2019)+5%	37125	30254	6871	0.55	0.42	0.126	79208	-3.1	5.0	32
TAC(2019)+10%	38893	31690	7203	0.58	0.45	0.135	77422	-5.3	10.0	38
TAC(2019)+15%	40661	33107	7554	0.62	0.48	0.142	75386	-7.8	15.0	44
TAC(2019)+20%	42428	34494	7934	0.65	0.50	0.150	73575	-10.0	20.0	50
F=F(2019)	33714	27472	6242	0.49	0.38	0.112	82598	1.03	-4.6	19.5
$F_{MSY\ lower}$	15374	12646	2728	0.198	0.152	0.046	101873	25	-57	-45
F_{MSY}	23024	18870	4154	0.31	0.24	0.071	93892	14.8	-35	-18.4

Table 4.12b. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios related to management strategies evaluated following an EU request (ICES WKNSMSE, 2019) based on the SAM assessment and assuming full TAC utilisation in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2019)	0.487
SSB(2020)	81755
R(2019)	136231
R(2020)	183333
Catch(2019)	35358
Landings(2019)	30271
Discards(2019)	5087

Catch scenarios

Basis	Total catch (2020)	Wanted catch (2020)	Unwanted catch (2020)	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	%SSB change	%TAC change	%advice change
A	14284	11749	2535	0.183	0.141	0.042	102980	26	-60	-49
B	7695	6356	1339	0.095	0.073	0.022	109921	34	-78	-73
C	14284	11749	2535	0.183	0.141	0.042	102980	26	-60	-49
A+D	13518	11121	2397	0.172	0.133	0.039	103798	27	-62	-52
B+E	7304	6032	1272	0.090	0.069	0.021	110340	35	-79	-74
C+E	16254	13356	2898	0.21	0.162	0.048	101046	24	-54	-42
A*	13289	10933	2356	0.169	0.130	0.039	104036	27	-62	-53
A*+D	13289	10933	2356	0.169	0.130	0.039	104036	27	-62	-53

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

Forecast assumptions

Fbar(2019)	0.645
SSB(2020)	72219
R(2019)	136231
R(2020)	183333
Catch(2019)	43889
Landings(2019)	37407
Discards(2019)	6482

Catch scenarios

Basis	Total catch (2020)	Wanted catch (2020)	Unwanted catch (2020)	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	%SSB change	%TAC change	%advice change
SSB(2021)=B_{lim}	0	0	0	0.00	0.00	0.00	106920	48	-100	-100
MSY HCR	10496	8515	1981	0.149	0.115	0.034	95788	33	-70	-63
MAP	6859	5565	1294	0.095	0.073	0.022	99563	38	-81	-76
F=0	0	0	0	0.00	0.00	0.00	106920	48	-100	-100
F_{pa}	24960	20114	4846	0.39	0.30	0.090	80691	11.7	-29	-11.5
F_{lim}	32642	26208	6434	0.54	0.42	0.124	72907	0.95	-7.7	15.7
SSB(2021)=B_{pa}	0	0	0	0.00	0.00	0.00	106920	48	-100	-100
SSB(2021)=$B_{trigger}$	0	0	0	0.00	0.00	0.00	106920	48	-100	-100
TAC(2019)-20%	28286	22760	5526	0.45	0.35	0.104	77230	6.9	-20.0	0.29
TAC(2019)-15%	30053	24174	5879	0.49	0.38	0.112	75484	4.5	-15.0	6.6
TAC(2019)-10%	31821	25566	6255	0.52	0.40	0.120	73658	1.99	-10.0	12.8
TAC(2019)-5%	33589	26944	6645	0.56	0.43	0.129	71996	-0.31	-5.0	19.1
Constant TAC	35358	28331	7027	0.60	0.46	0.137	70109	-2.9	0.0028	25
TAC(2019)+5%	37124	29763	7361	0.64	0.49	0.146	68229	-5.5	5.0	32
TAC(2019)+10%	38893	31151	7742	0.68	0.52	0.156	66491	-7.9	10.0	38
TAC(2019)+15%	40660	32512	8148	0.72	0.55	0.165	64829	-10.2	15.0	44
TAC(2019)+20%	42428	33846	8582	0.76	0.58	0.175	63082	-12.7	20.0	50
F=F(2019)	37470	30031	7439	0.64	0.50	0.149	67896	-6.0	6.0	33
$F_{MSY\ lower}$	13645	11064	2581	0.198	0.152	0.046	92331	28	-61	-52
F_{MSY}	20454	16530	3924	0.31	0.24	0.071	85464	18.3	-42	-27

Table 4.12d. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios related to management strategies evaluated following an EU request (ICES WKNSMSE, 2019) based on the SAM assessment and assuming status quo fishing mortality in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2019)	0.645
SSB(2020)	72219
R(2019)	136231
R(2020)	183333
Catch(2019)	43889
Landings(2019)	37407
Discards(2019)	6482

Catch scenarios

Basis	Total catch (2020)	Wanted catch (2020)	Unwanted catch (2020)	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	%SSB change	%TAC change	%advice change
A	11292	9159	2133	0.161	0.124	0.037	94967	31	-68	-60
B	6836	5547	1289	0.095	0.073	0.022	99588	38	-81	-76
C	11292	9159	2133	0.161	0.124	0.037	94967	31	-68	-60
A+D	10678	8664	2014	0.152	0.117	0.035	95604	32	-70	-62
B+E	6489	5266	1223	0.090	0.069	0.021	99982	38	-82	-77
C+E	12862	10423	2439	0.186	0.143	0.043	93183	29	-64	-54
A*	10496	8515	1981	0.149	0.115	0.034	95788	33	-70	-63
A*+D	10496	8515	1981	0.149	0.115	0.034	95788	33	-70	-63

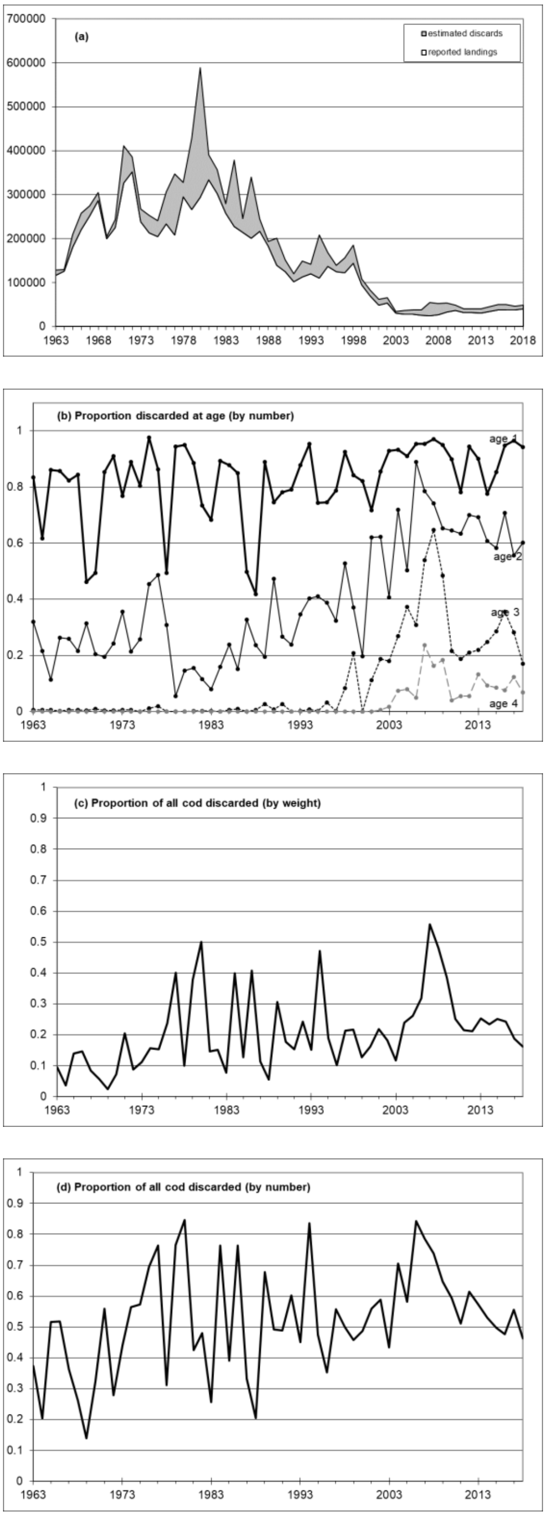


Figure 4.1. Cod in Subarea 4, Division 7.d and Subdivision 20: (a) stacked area plot of reported landings and estimated discards (including BMS landings; in tonnes); (b) proportion of total numbers caught at age that are discarded; (c) proportion of total weight caught that is discarded; (d) and proportion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

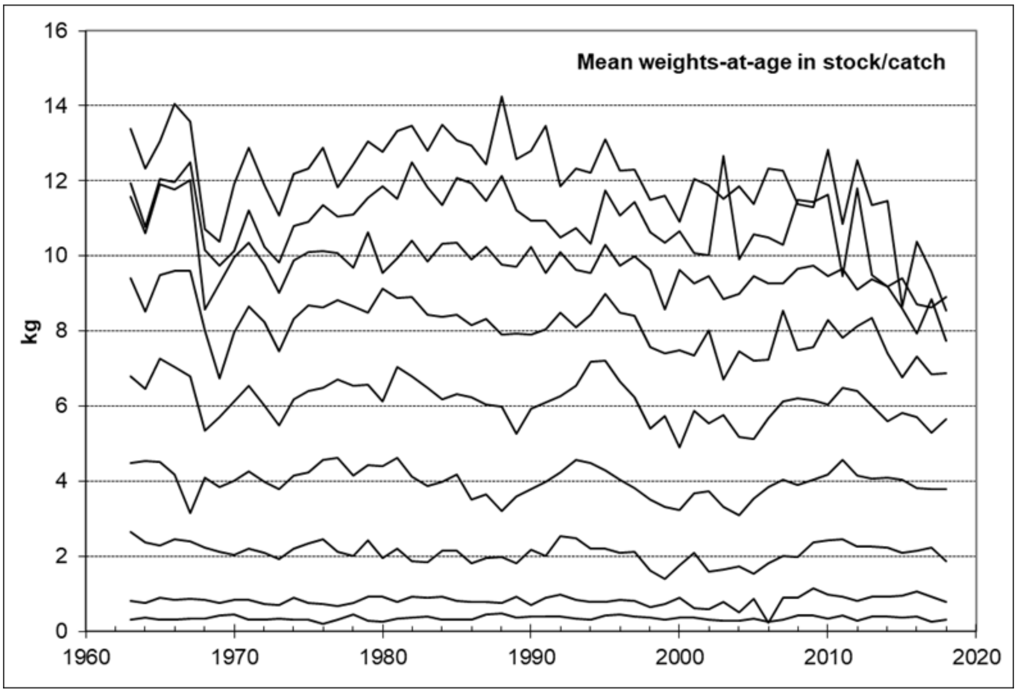


Figure 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weight at age in the catch for ages 1–9.

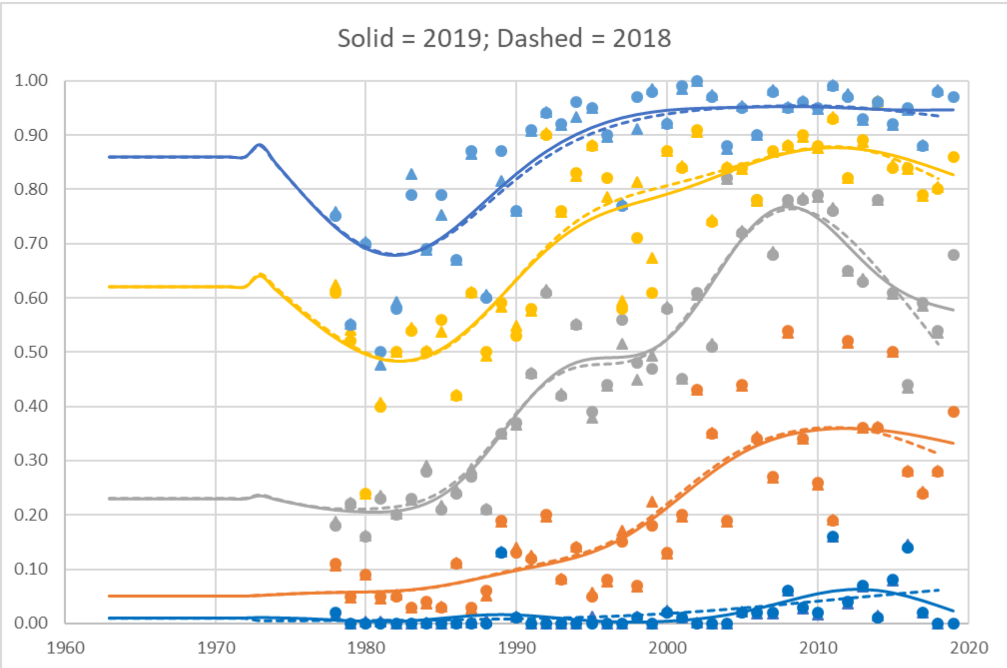


Figure 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Annually varying maturity-at-age used in the assessment compared to that used in 2018. Values for 1963–1972 are the former constant maturity values used for cod.

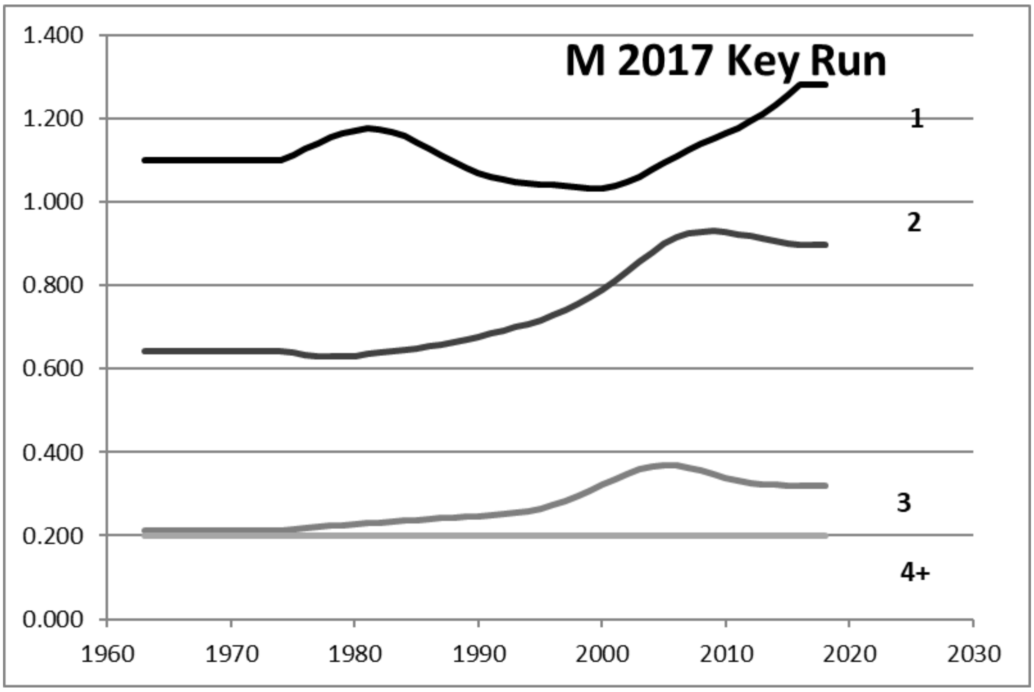


Figure 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2017 key run (ICES WGSAM, 2017). Values for 1963–1972 are set equal to the 1973 value, while values for 2017–2018 are set equal to 2016.

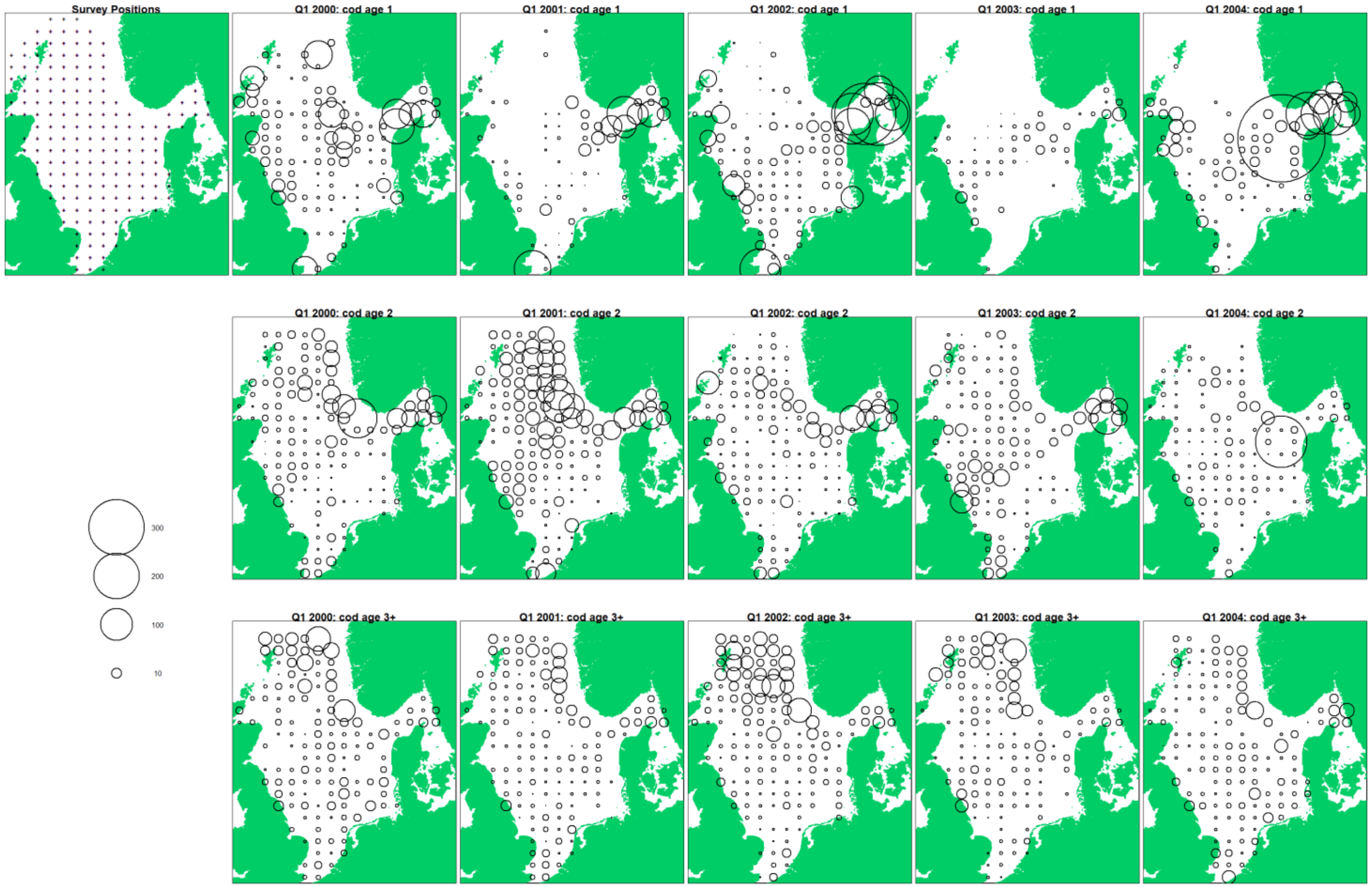


Figure 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2000–2019 in the North Sea.

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 2000–2019 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 2000–2019 in the North Sea.

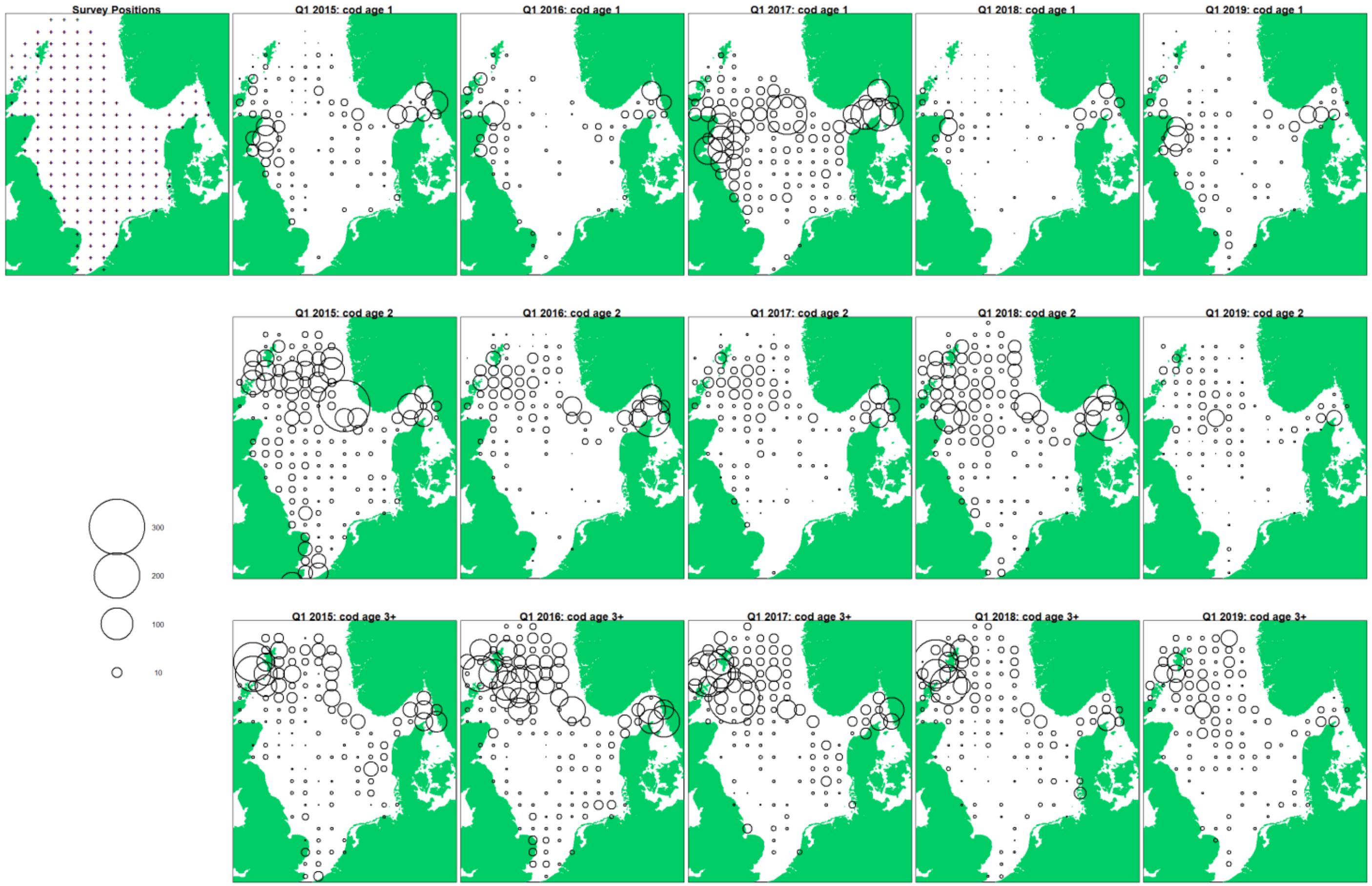


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2000–2019 in the North Sea.

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 2000–2018 in the North Sea.

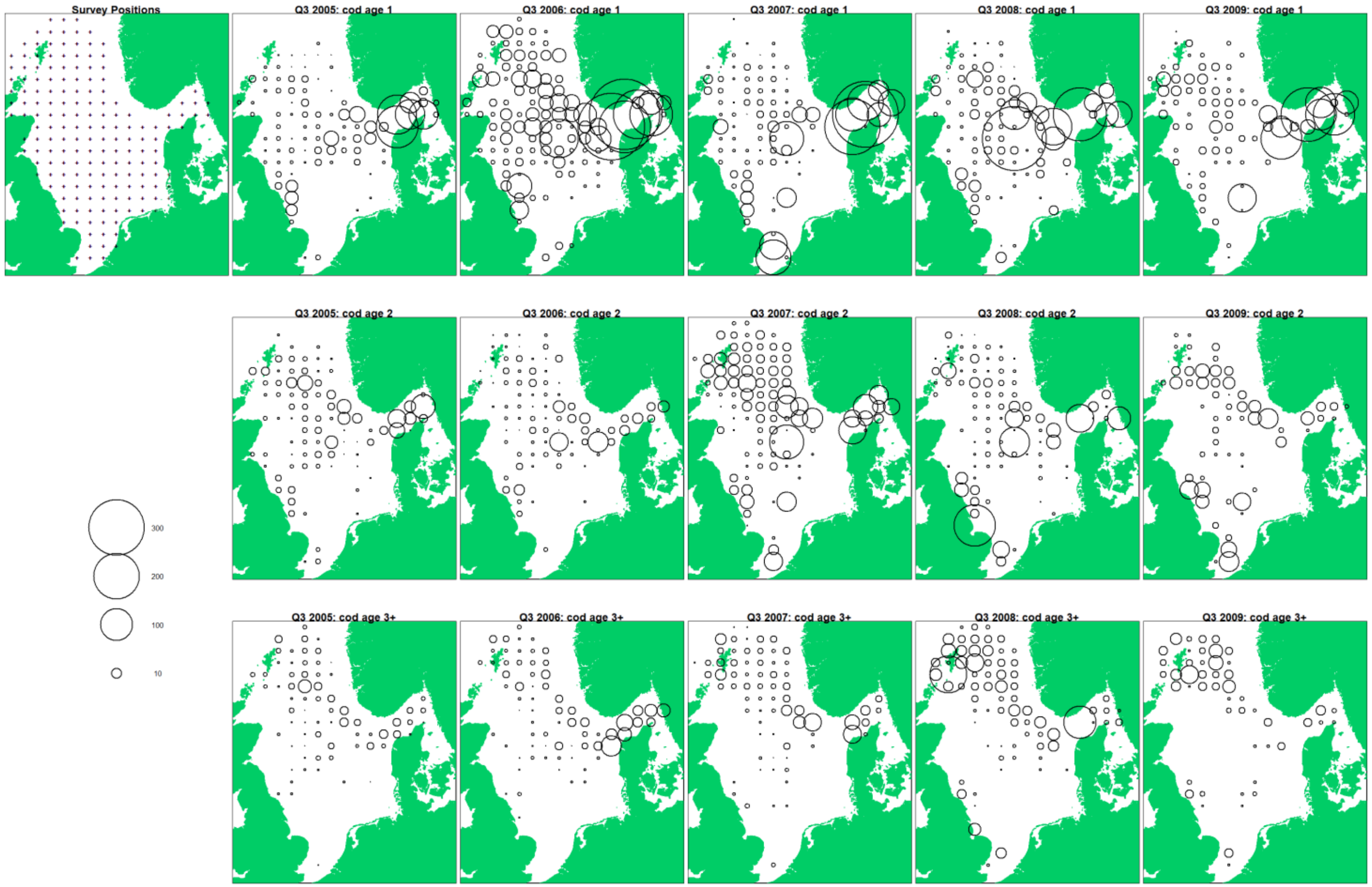


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2000–2018 in the North Sea.

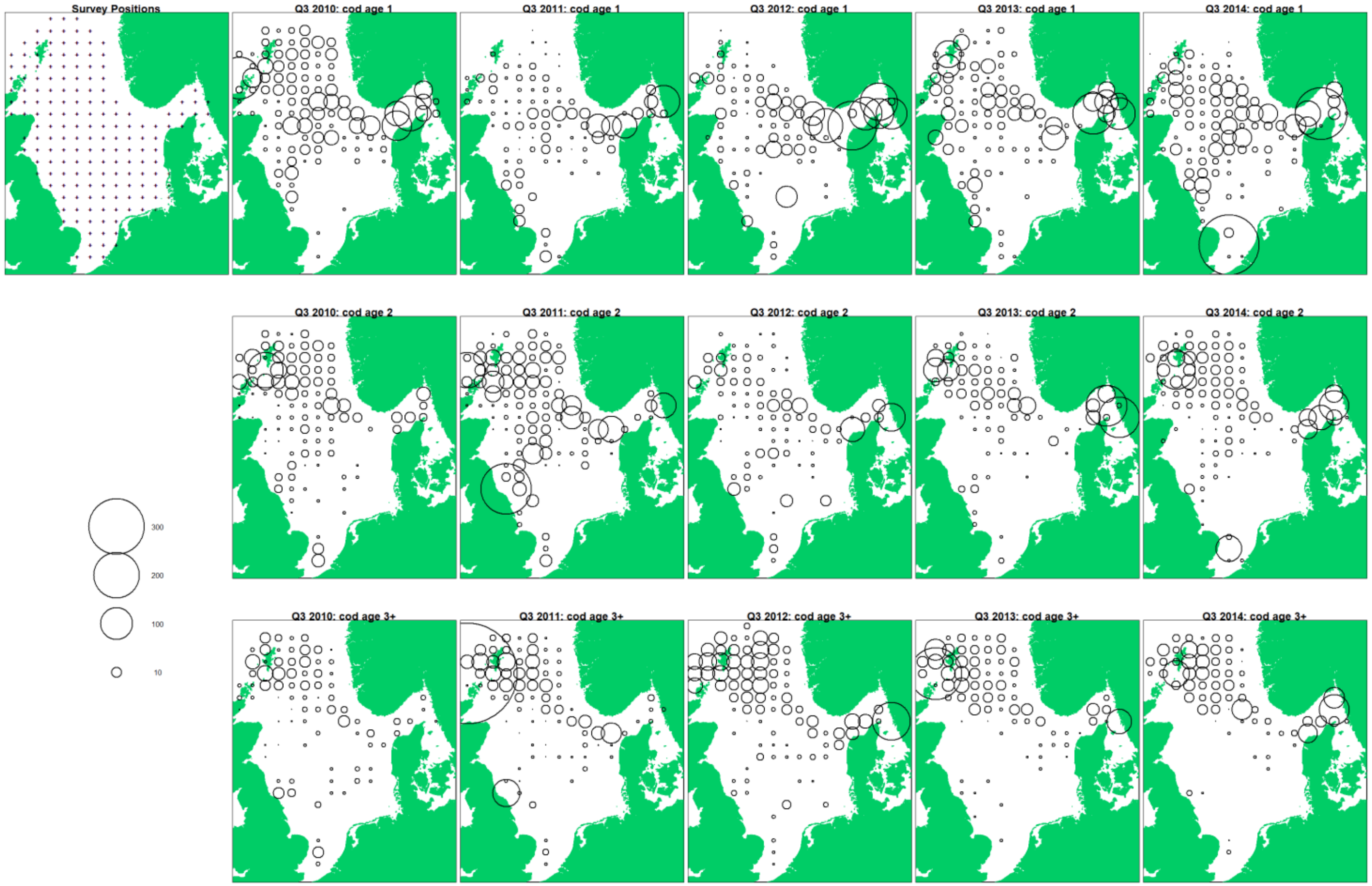


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2000–2018 in the North Sea.

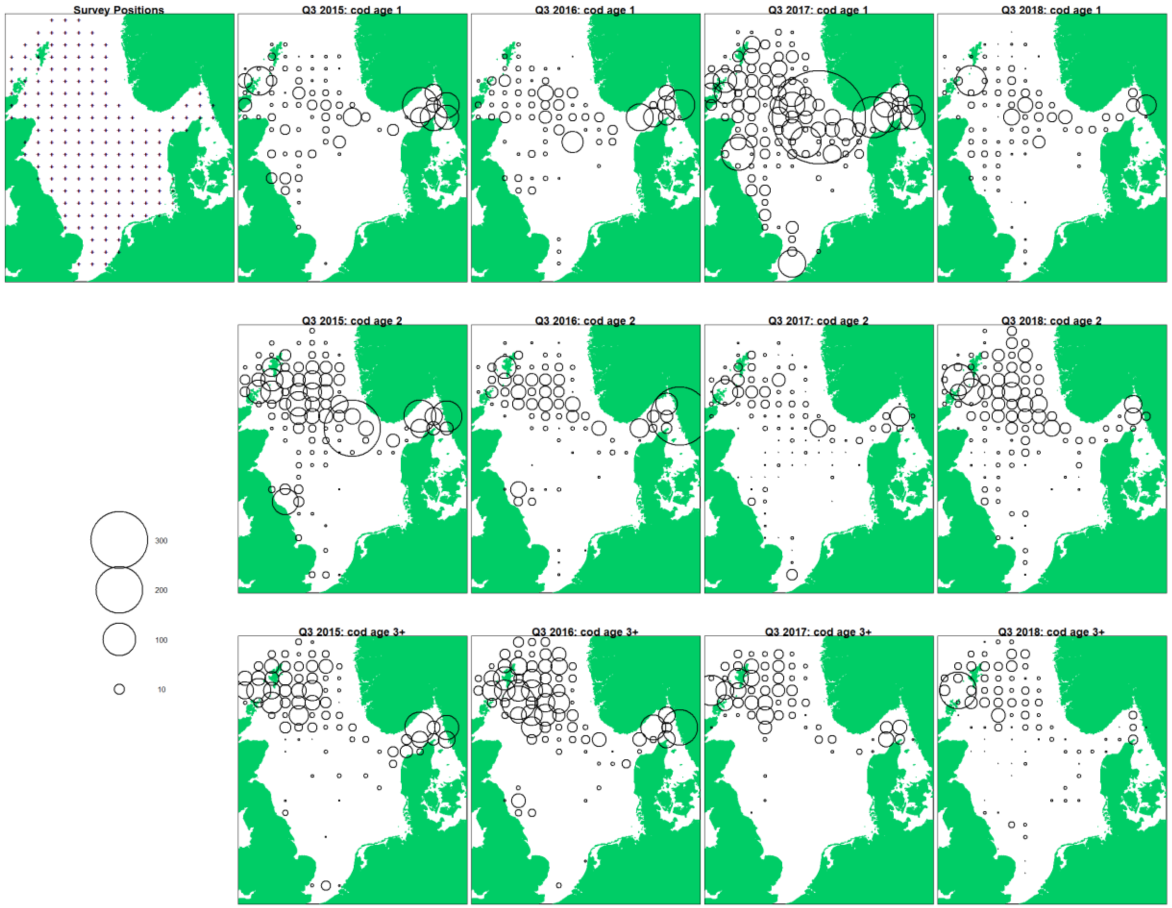


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2000–2018 in the North Sea.

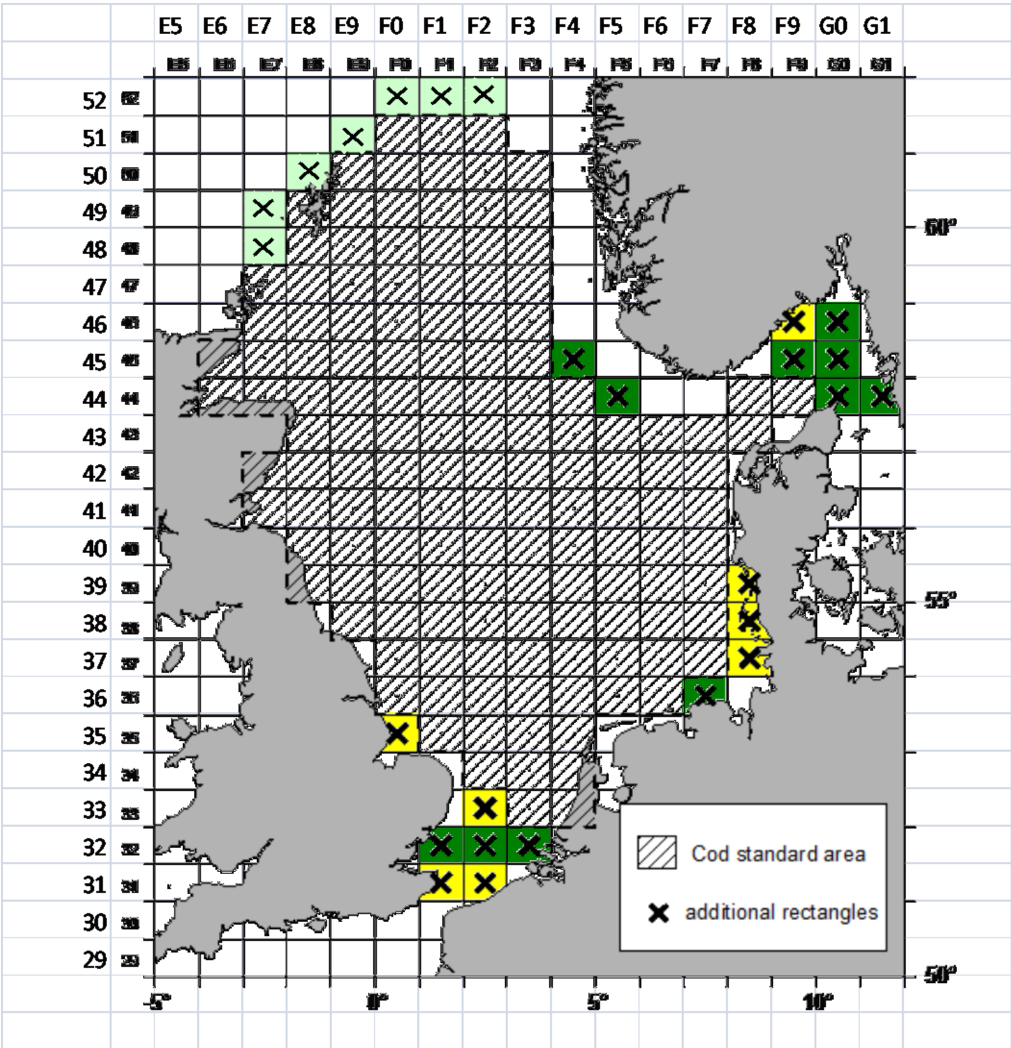


Figure 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND, 2009; ICES WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is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

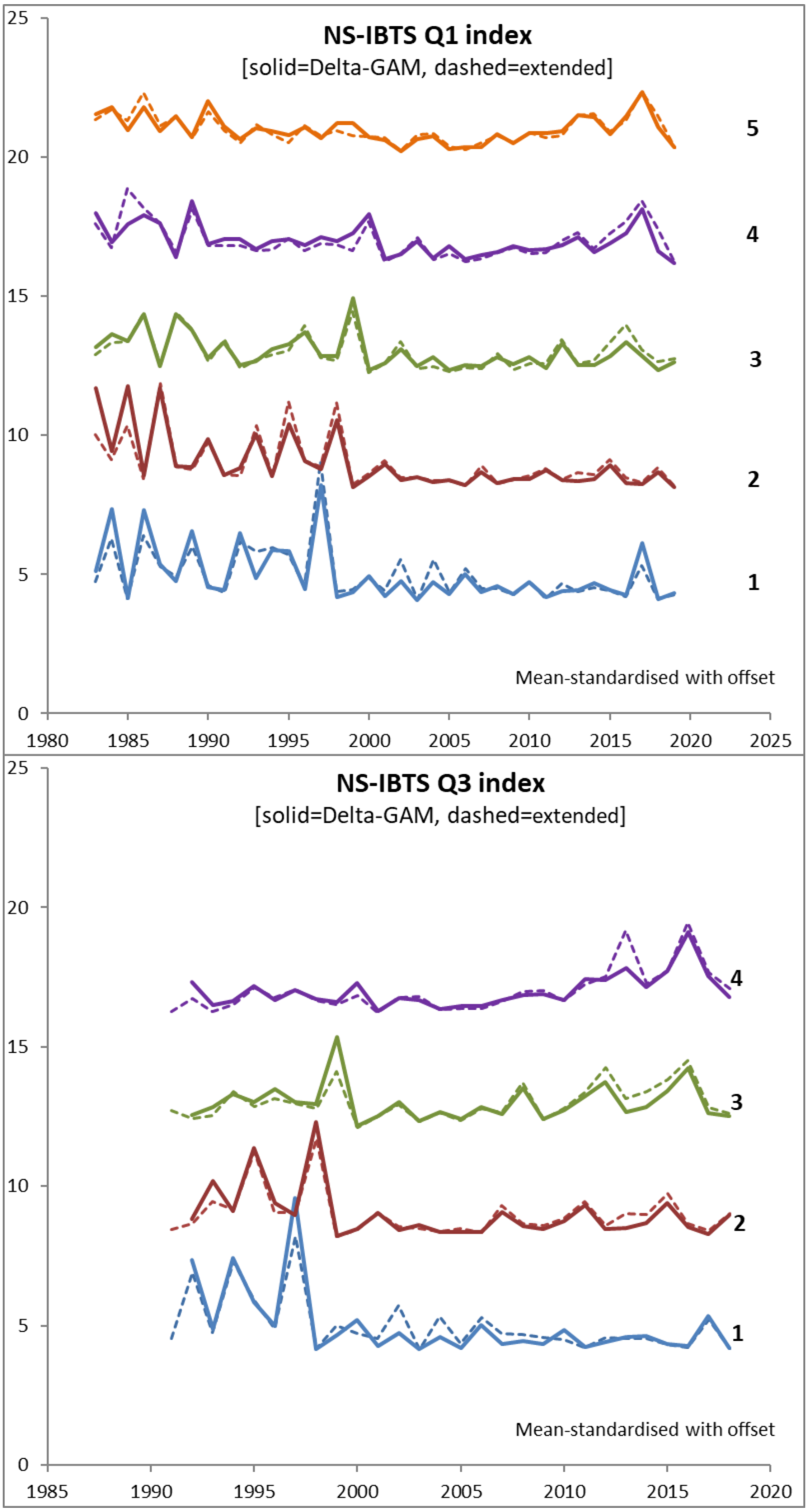


Figure 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS extended indices to the corresponding NS–IBTS Delta–GAM indices used in the assessment. The indices are mean-standardised with an offset for ease of presentation.

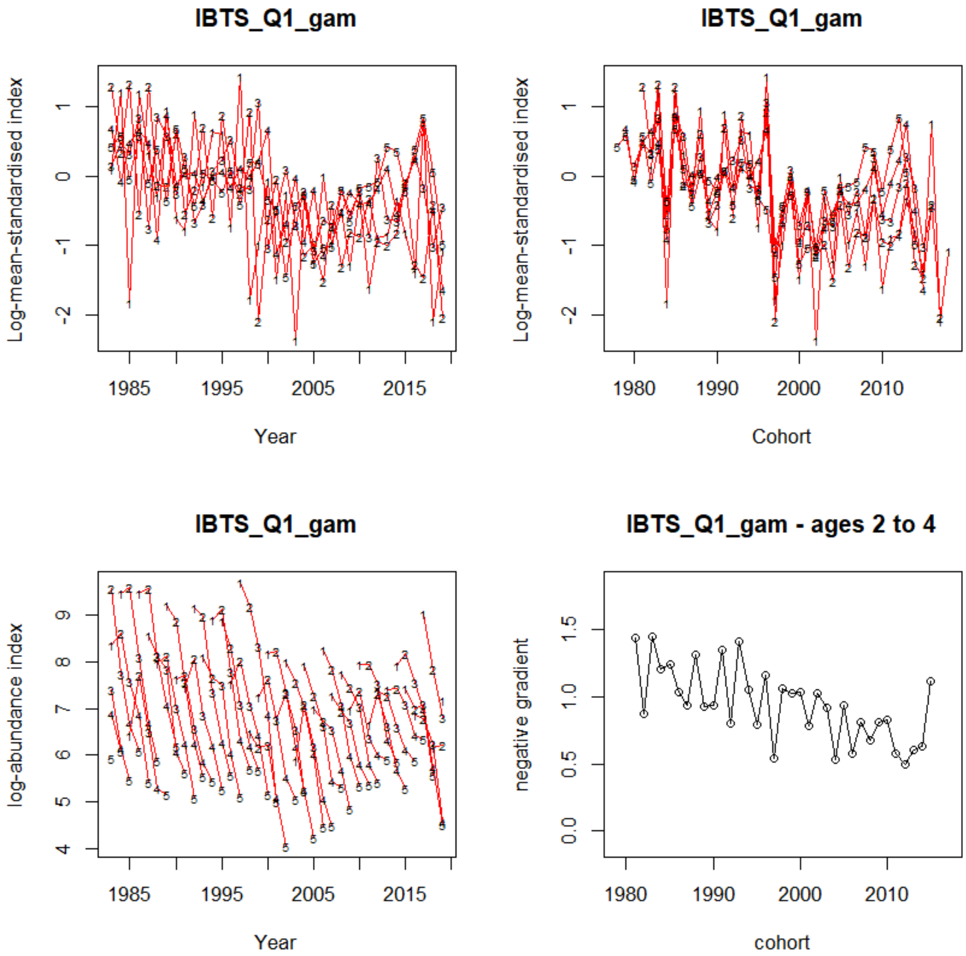


Figure 4.4a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

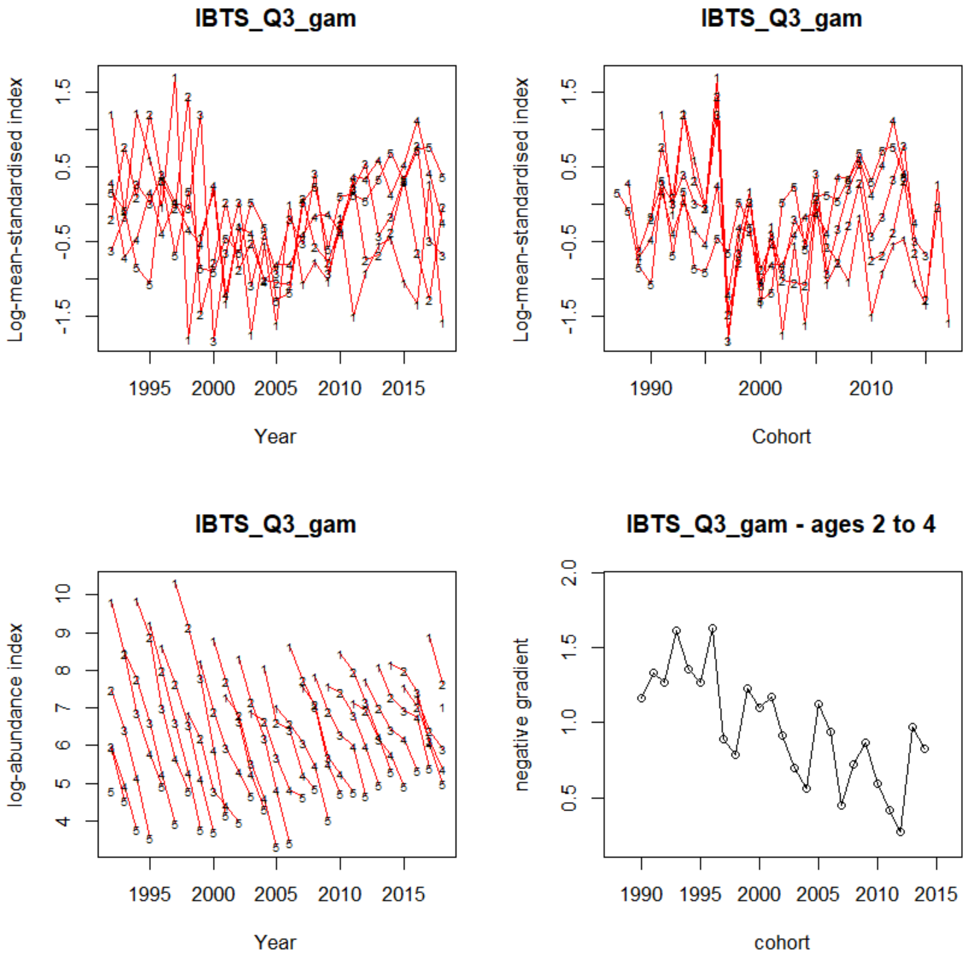


Figure 4.4b. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

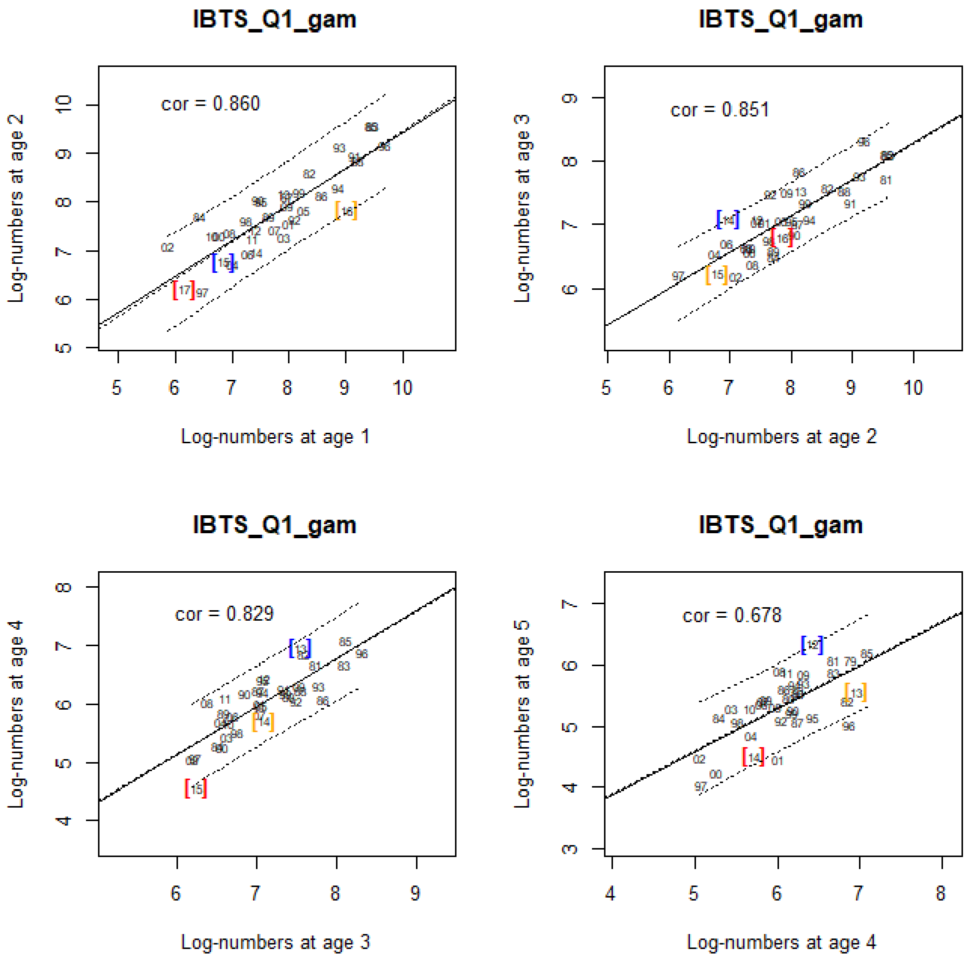


Figure 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2019. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The three most recent data points appear in square brackets (blue = 2017; orange = 2018; red = 2019).

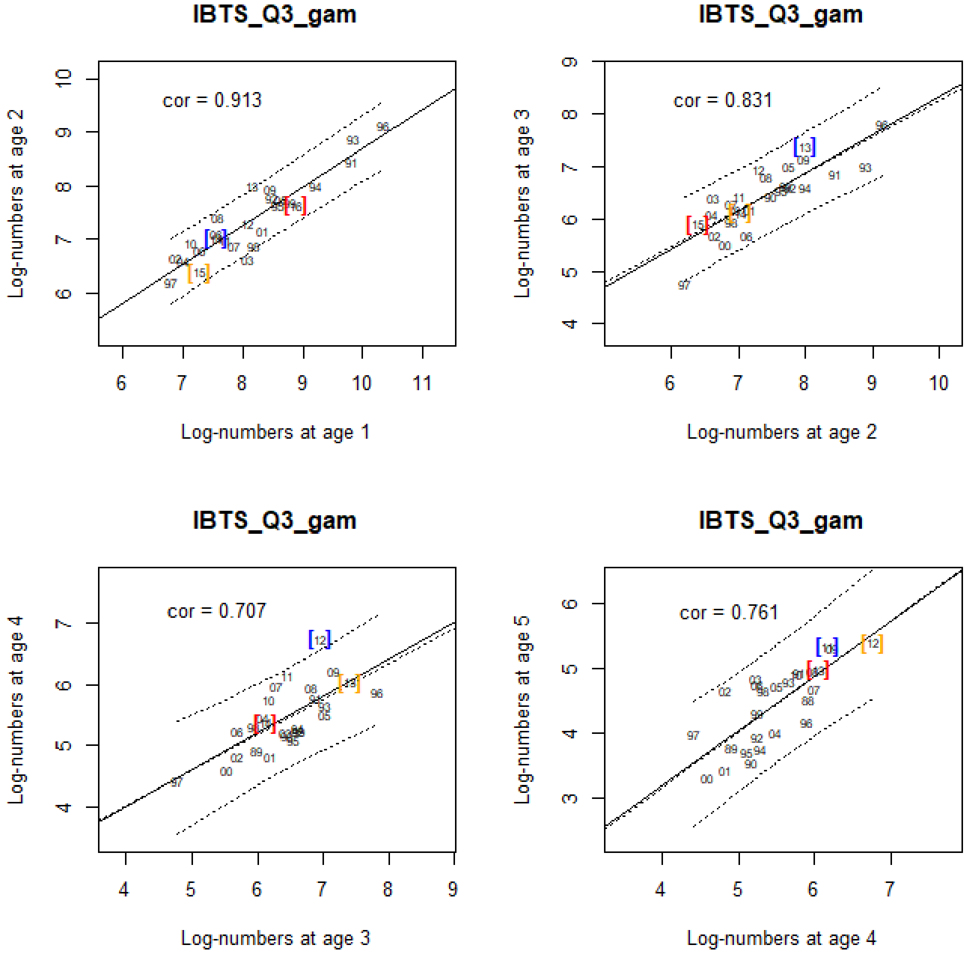


Figure 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2018. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The three most recent data points appear in square brackets (blue = 2016; orange = 2017; red = 2018).

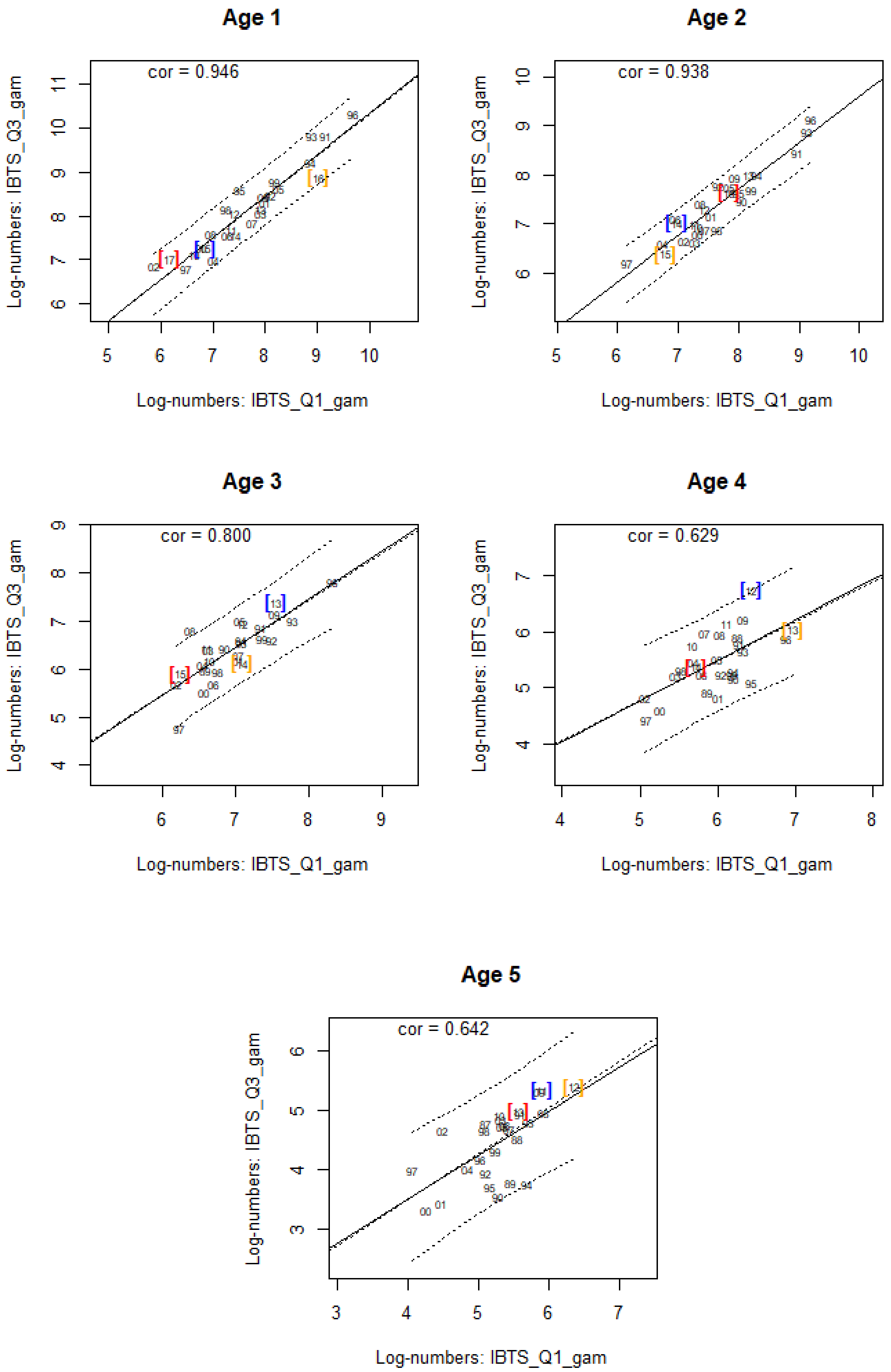


Figure 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2018. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The three most recent data points appear in square brackets (blue = 2016; orange = 2017; red = 2018).

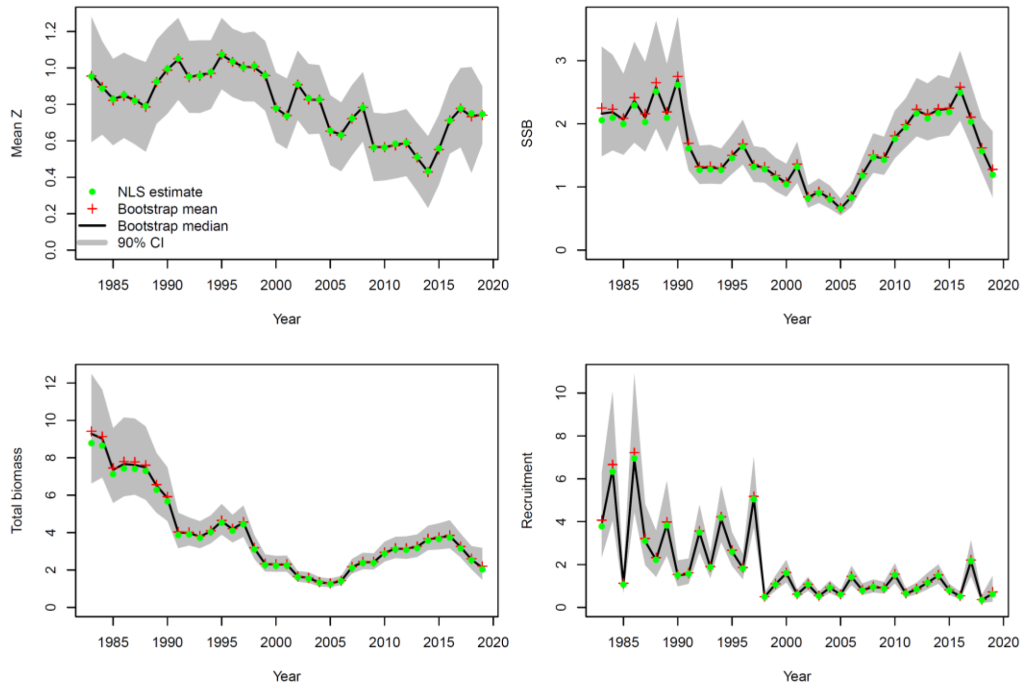


Figure 4.6a. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (IBTS–Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set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

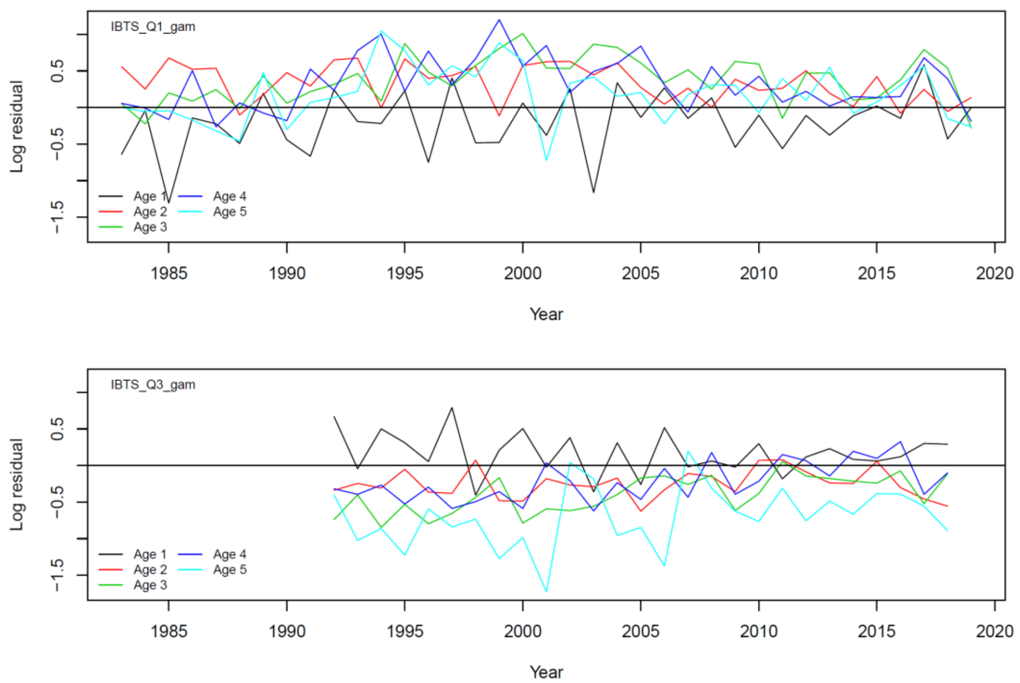


Figure 4.6b. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR residual plots for a combined SURBAR run with both surveys (IBTS–Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3.

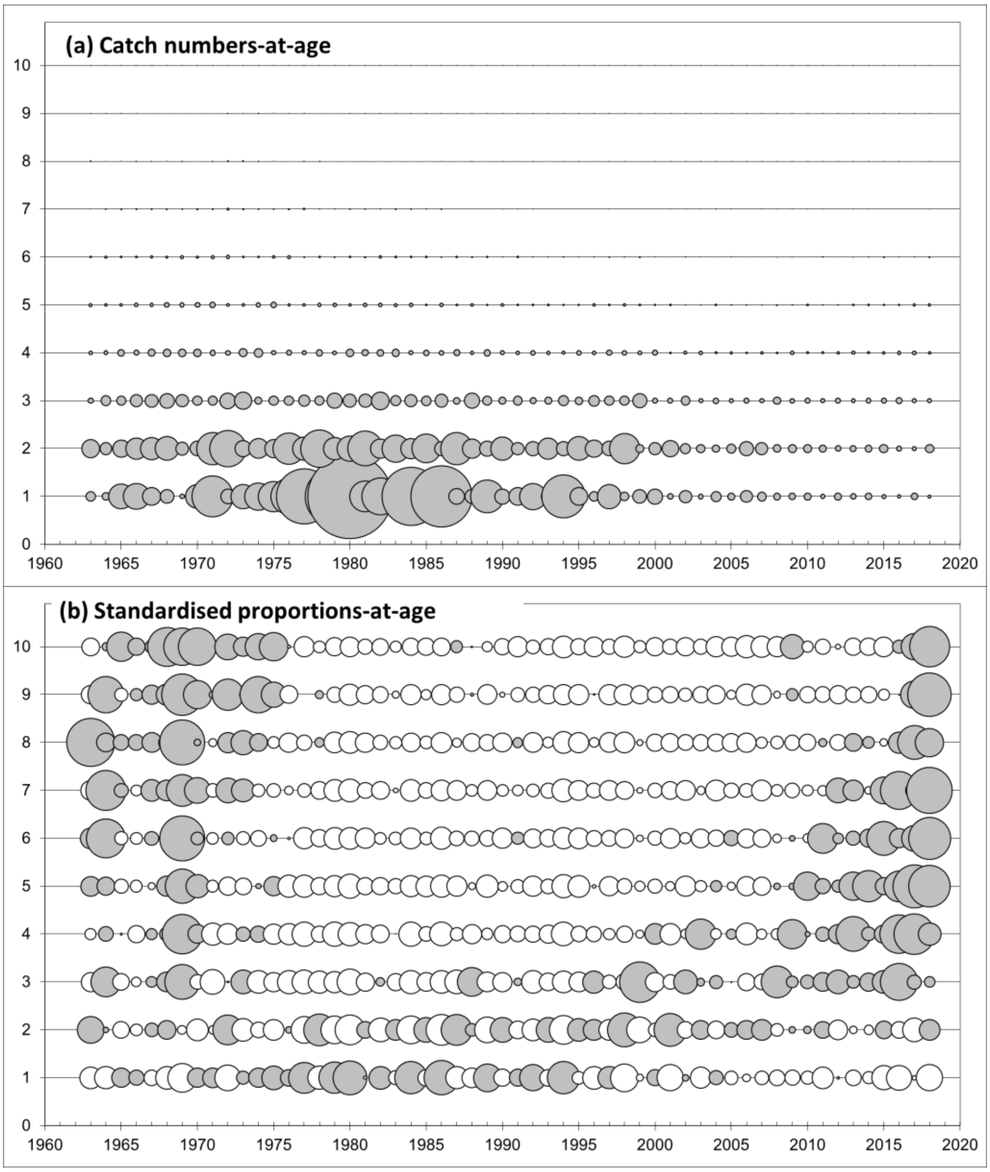
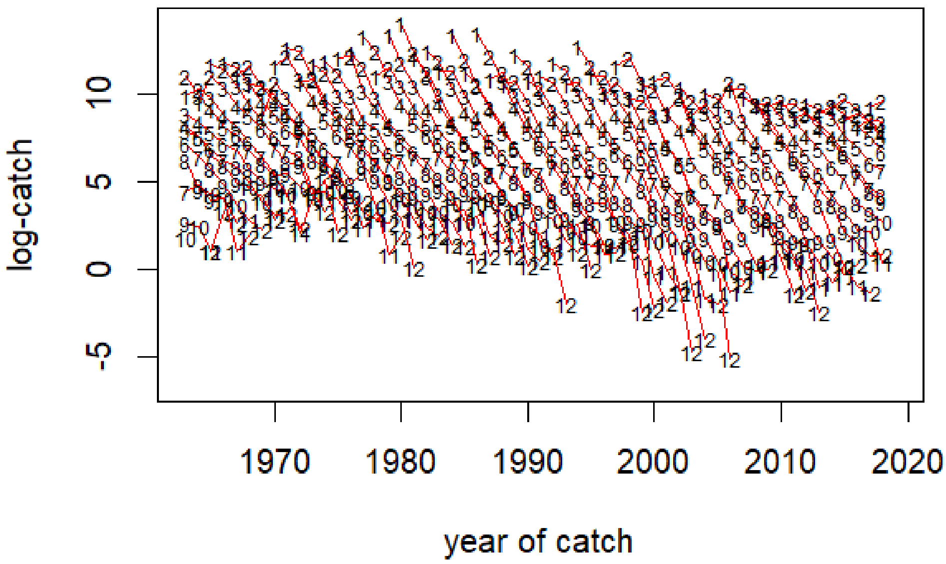


Figure 4.7. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the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



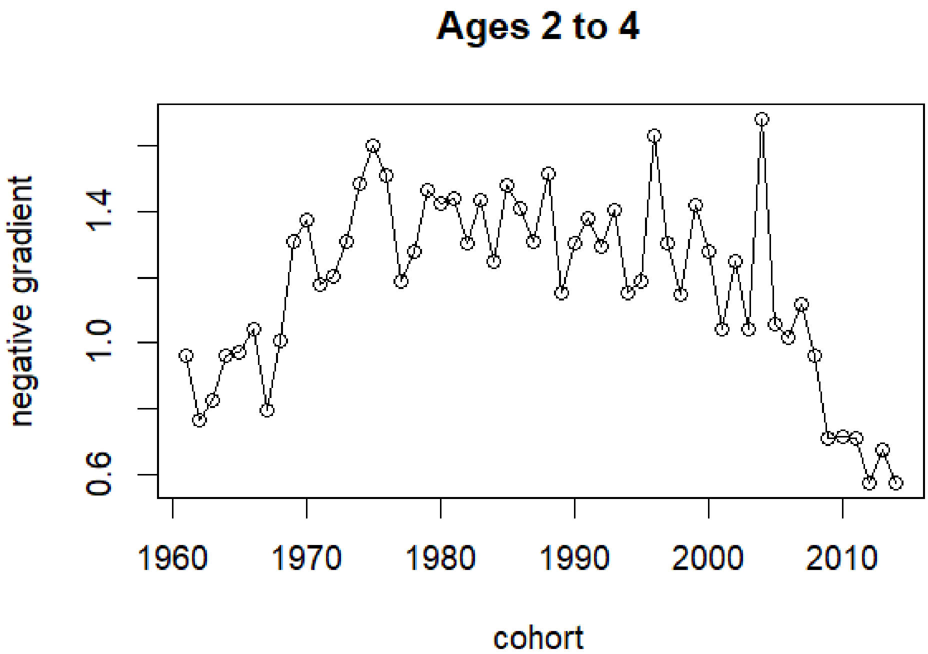


Figure 4.8a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

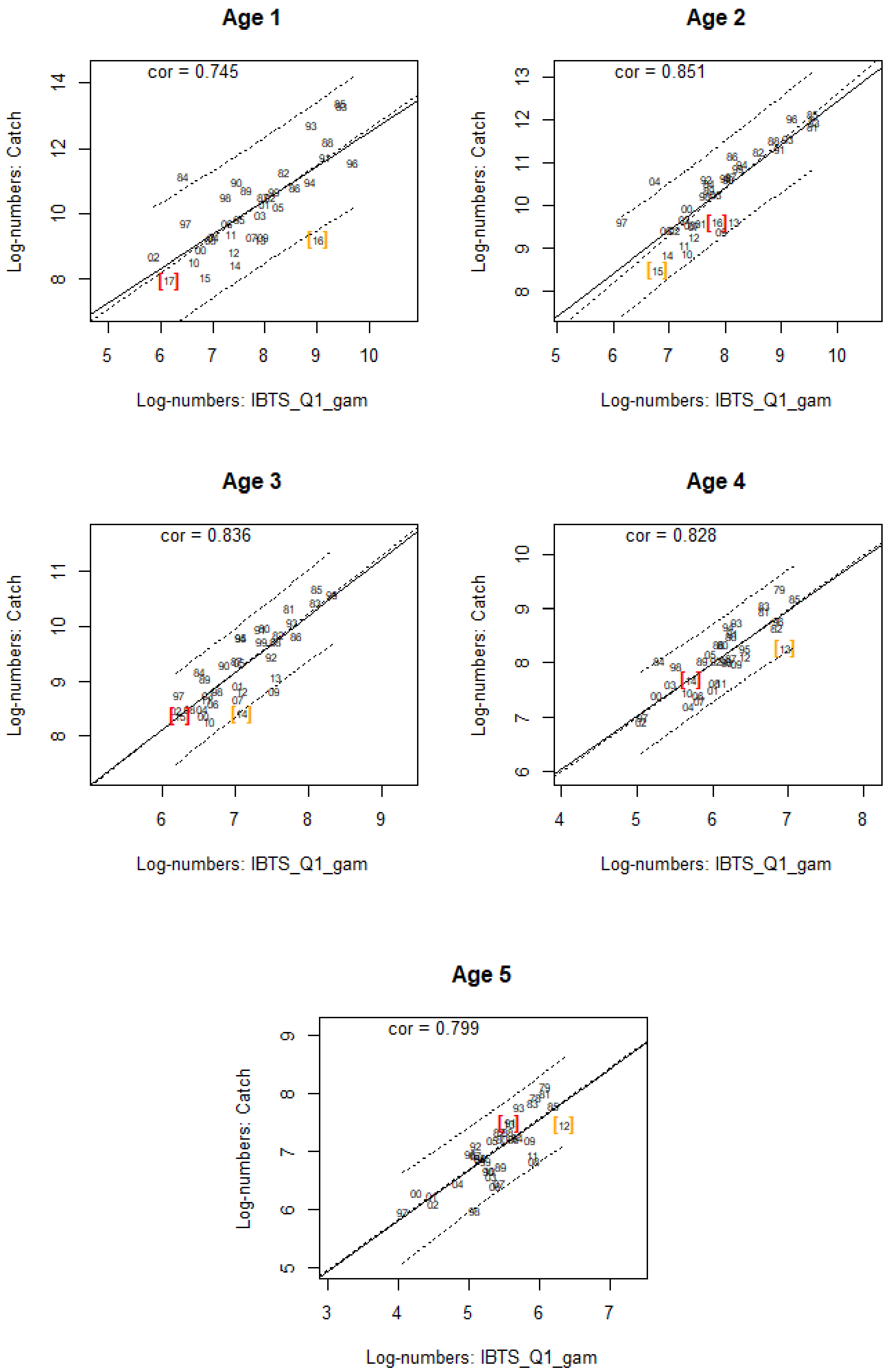


Figure 4.8b. Cod in Subarea 4, Division 7.d and Subdivision 20: Correlations between the IBTS–Q1 survey (NS–IBTS Delta–GAM index) and catch-at-age data for the period 1987–2018. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The two most recent data points appear in square brackets (orange = 2017; red = 2018).

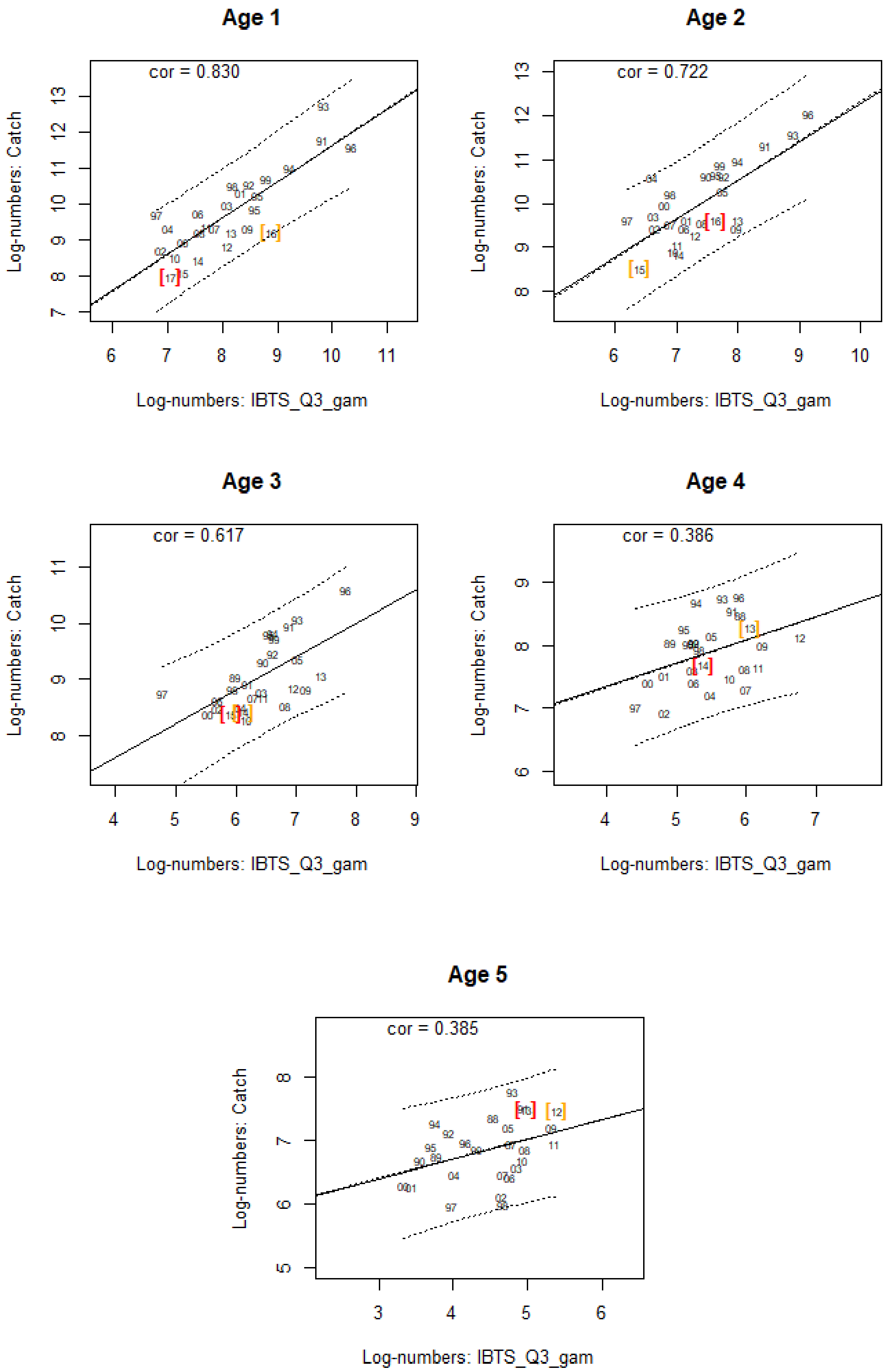


Figure 4.8c. Cod in Subarea 4, Division 7.d and Subdivision 20: Correlations between the IBTS–Q3 survey (NS–IBTS Delta–GAM index) and catch-at-age data for the period 1992–2018. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The two most recent data points appear in square brackets (orange = 2017; red = 2018).

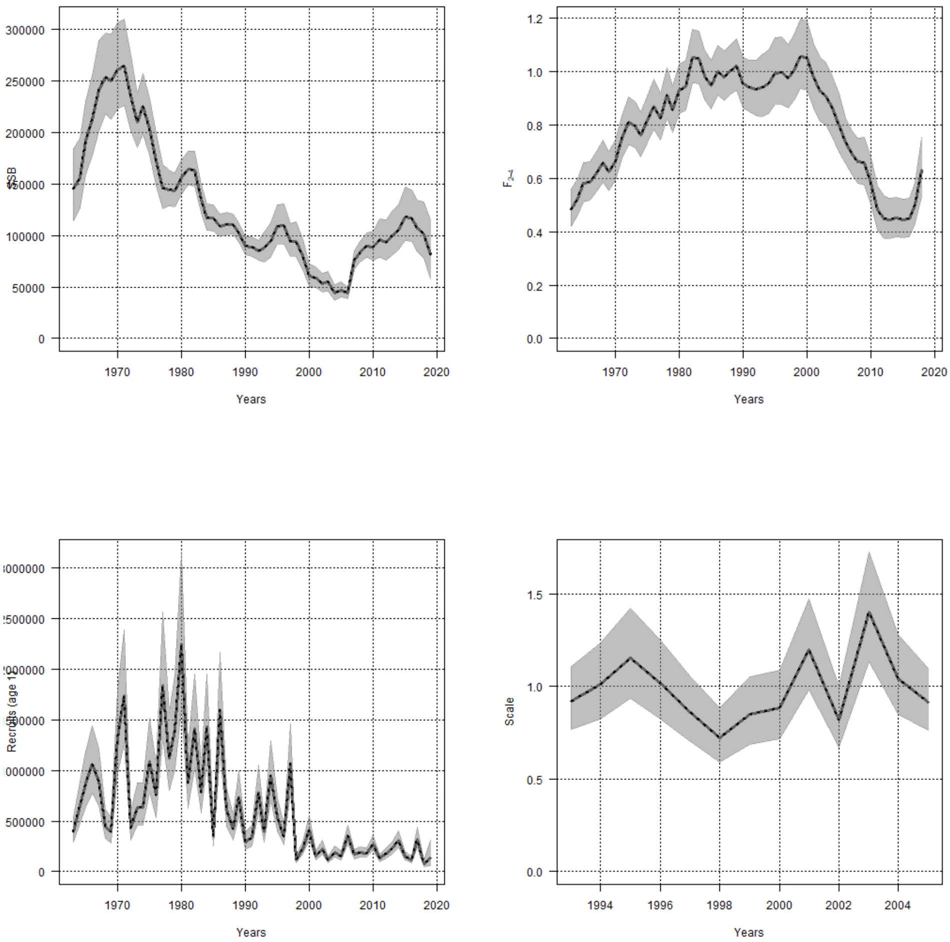


Figure 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and the catch multiplier from the SAM assessment (black lines = estimate and shaded area = corresponding point-wise 95% confidence intervals).

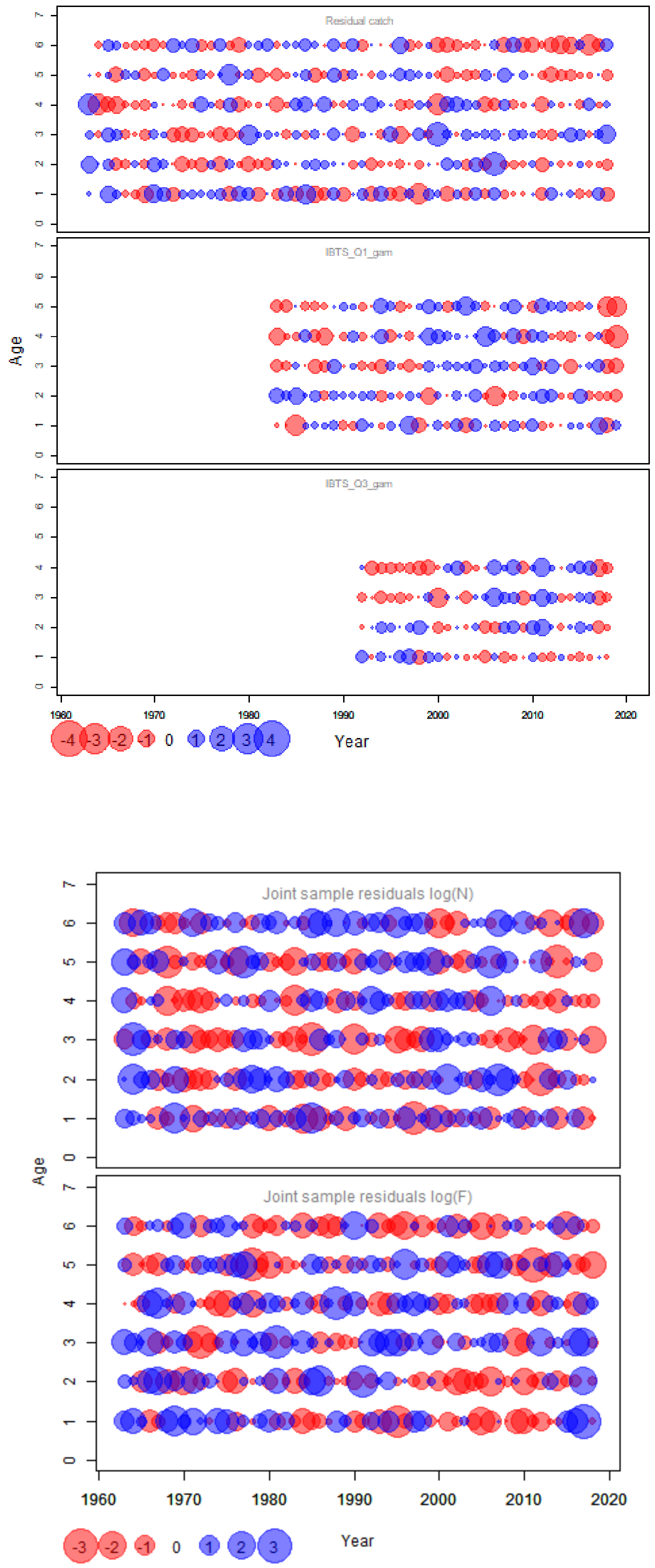


Figure 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: Normalized residuals for the SAM assessment, for total catch, IBTS–Q1, IBTS–Q3, and the recruitment and survival process error. Blue circles indicate a positive residual and red circles a negative residual.

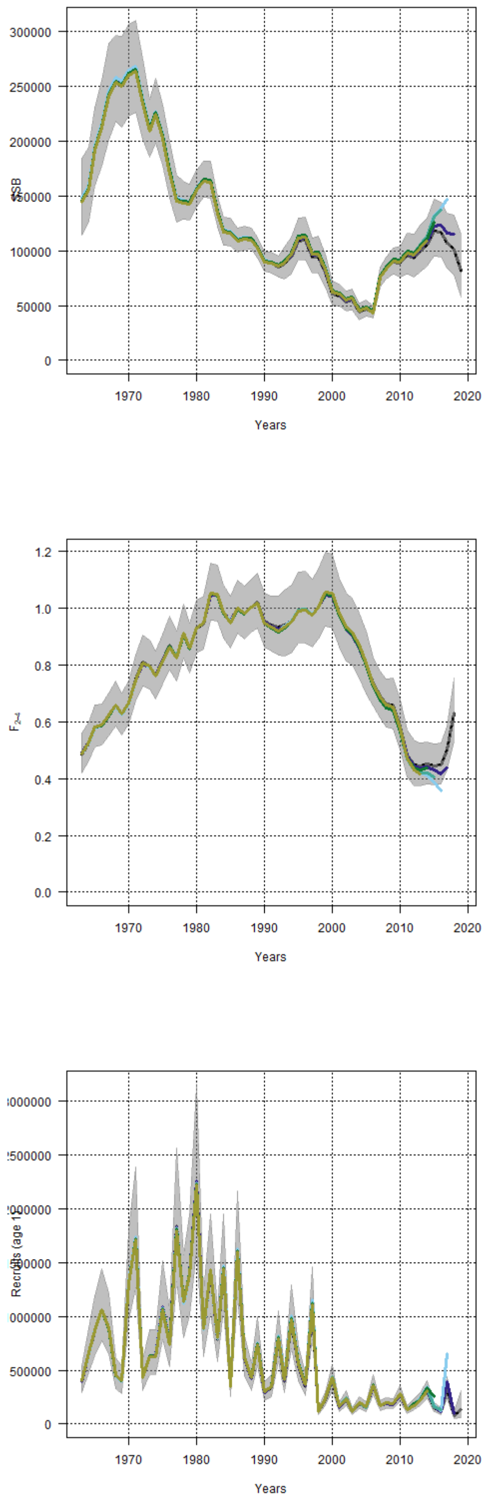


Figure 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: Retrospective estimates (5 years) from the SAM assessment. Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals.

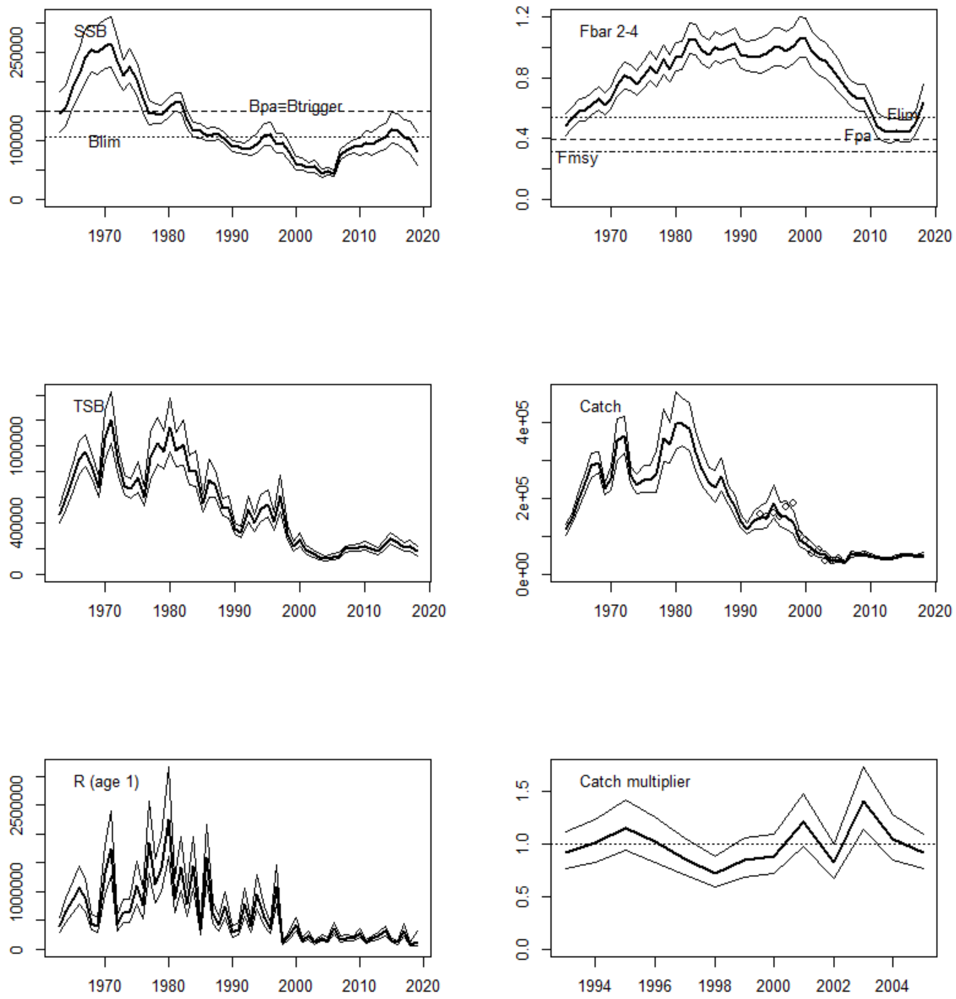
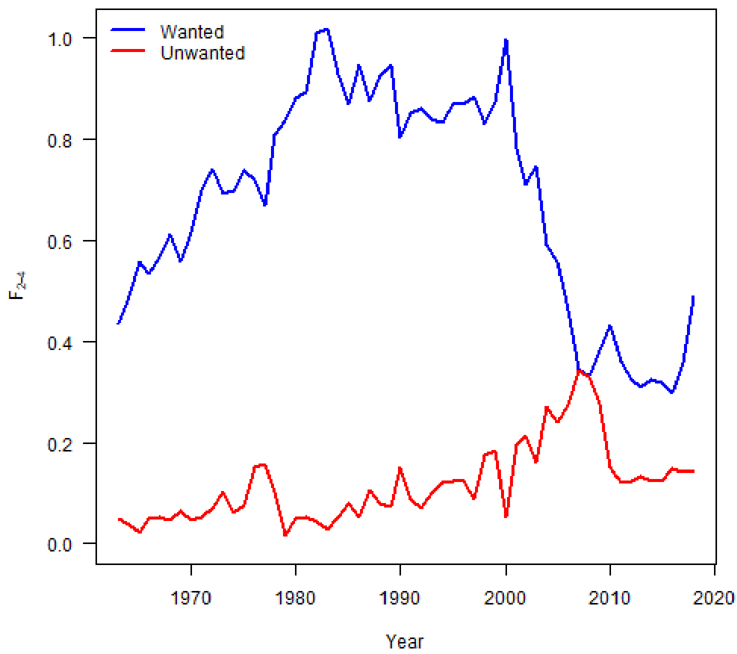


Figure 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Anticlockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2–4 (F(2–4)), 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.



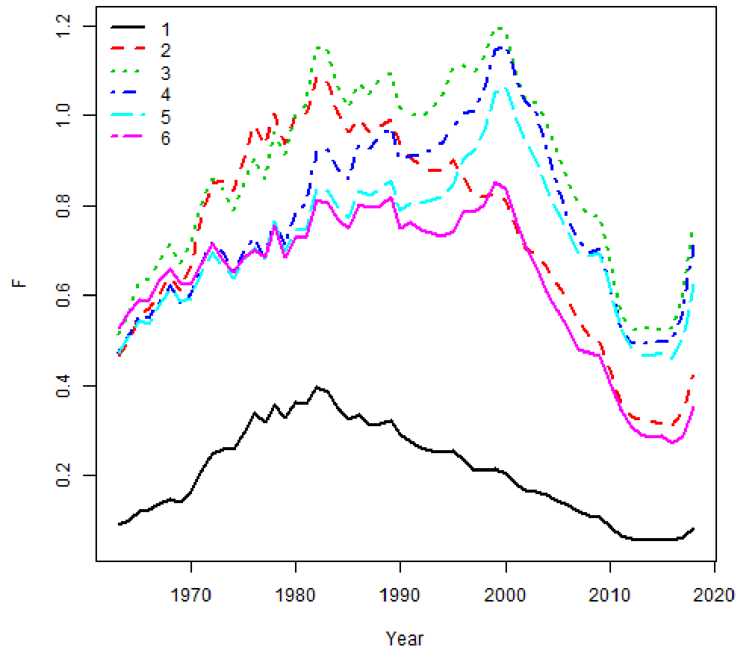


Figure 4.13. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age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

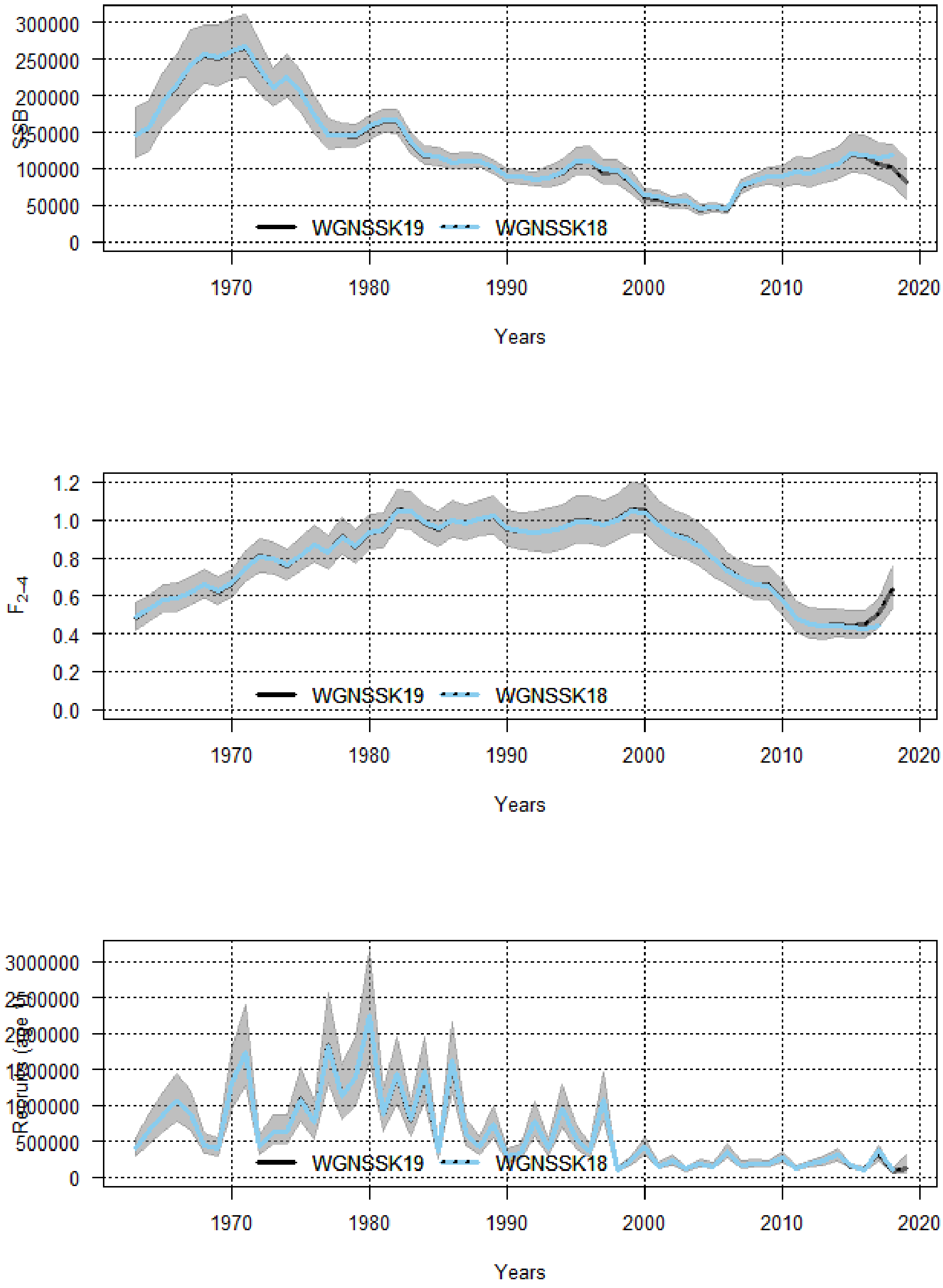
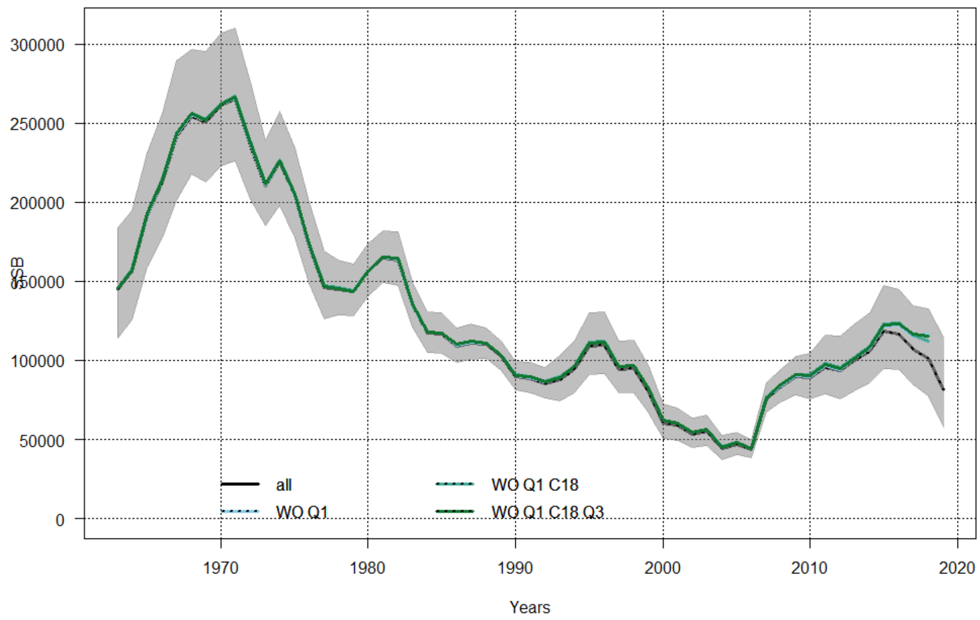


Figure 4.14a. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of final SAM assessment for 2019 with the final SAM assessment for 2018. Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals.



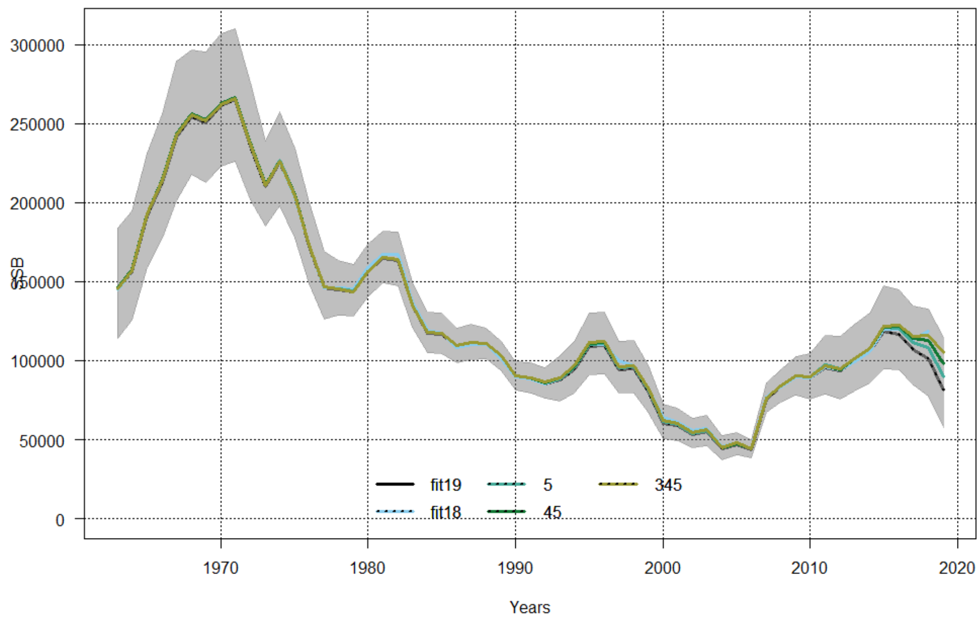


Figure 4.14b. Cod in Subarea 4, Division 7.d and Subdivision 20: Contribution of new data to the downscaling of SSB in the final SAM assessment for 2019. Top: Assessment runs without NS-IBTS Q1 data for 2019 (Q1), 2018 catch data (C18) and NS-IBTS Q3 data for 2018 (Q3). Bottom: Assessment runs excluding older ages from the NS-IBTS Q1 survey indices in 2019.

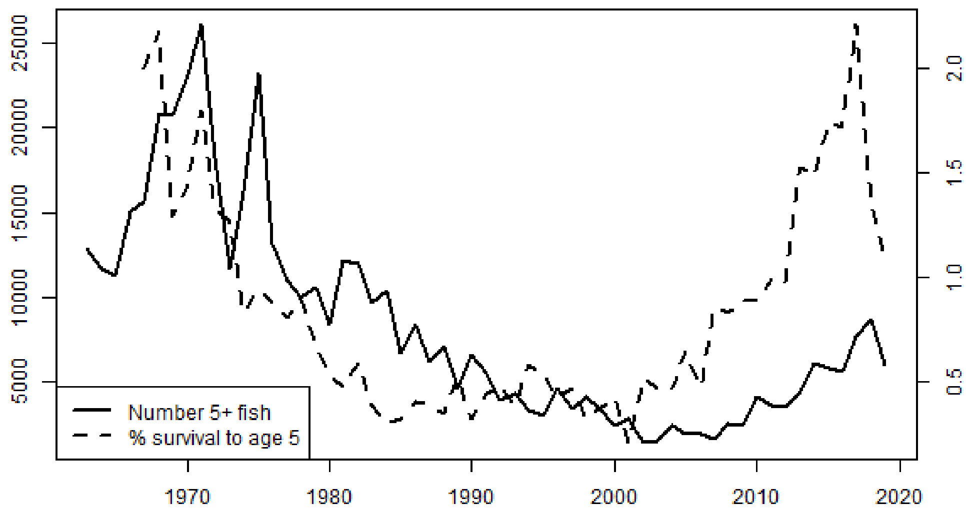


Figure 4.15. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimates of the number of 5-year-old and older cod in the population (solid line; thousands) and the percentage of 1 year olds by number that have survived to age 5 in the given year (hashed line).

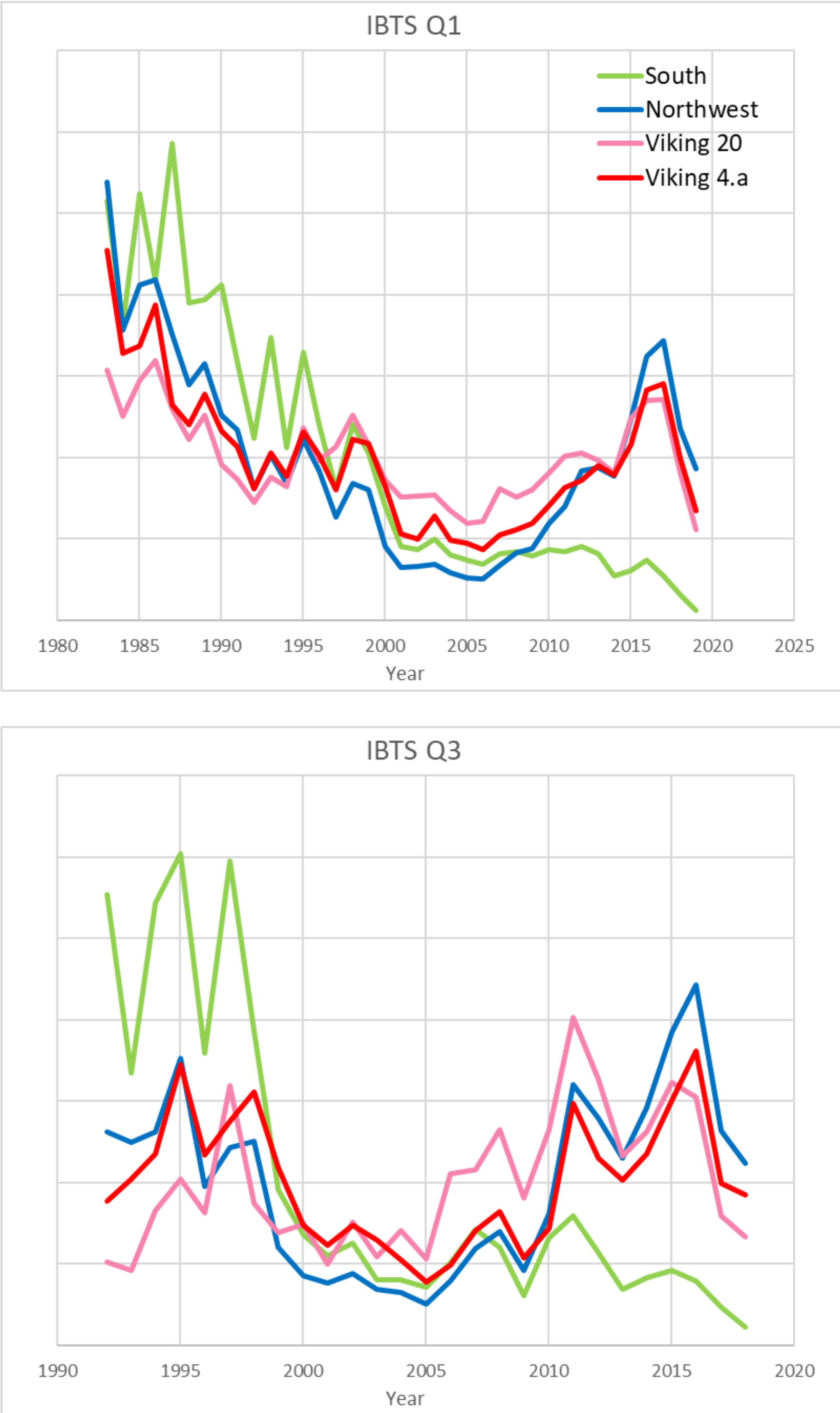
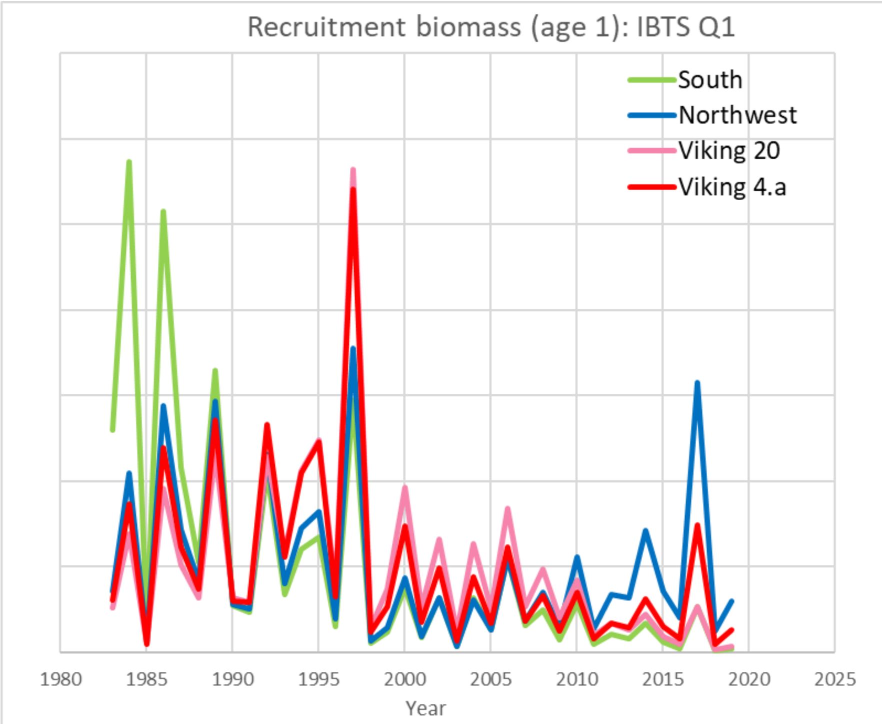


Figure 4.16a. Cod in Subarea 4, Division 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model (including ship effects) to numbers-at-age for the entire dataset and integrating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



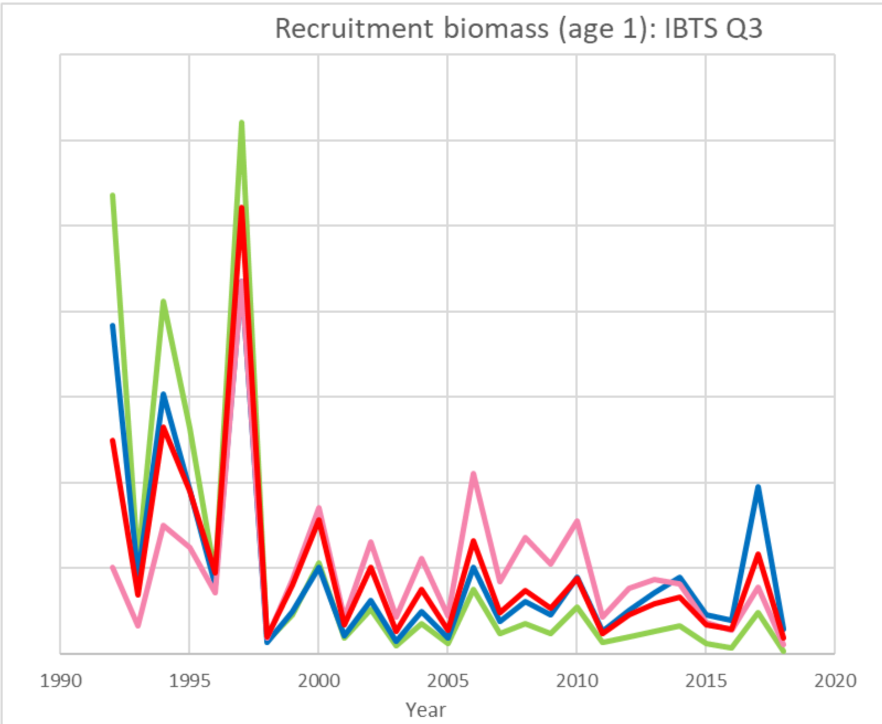


Figure 4.16b. Cod in Subarea 4, Division 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data.

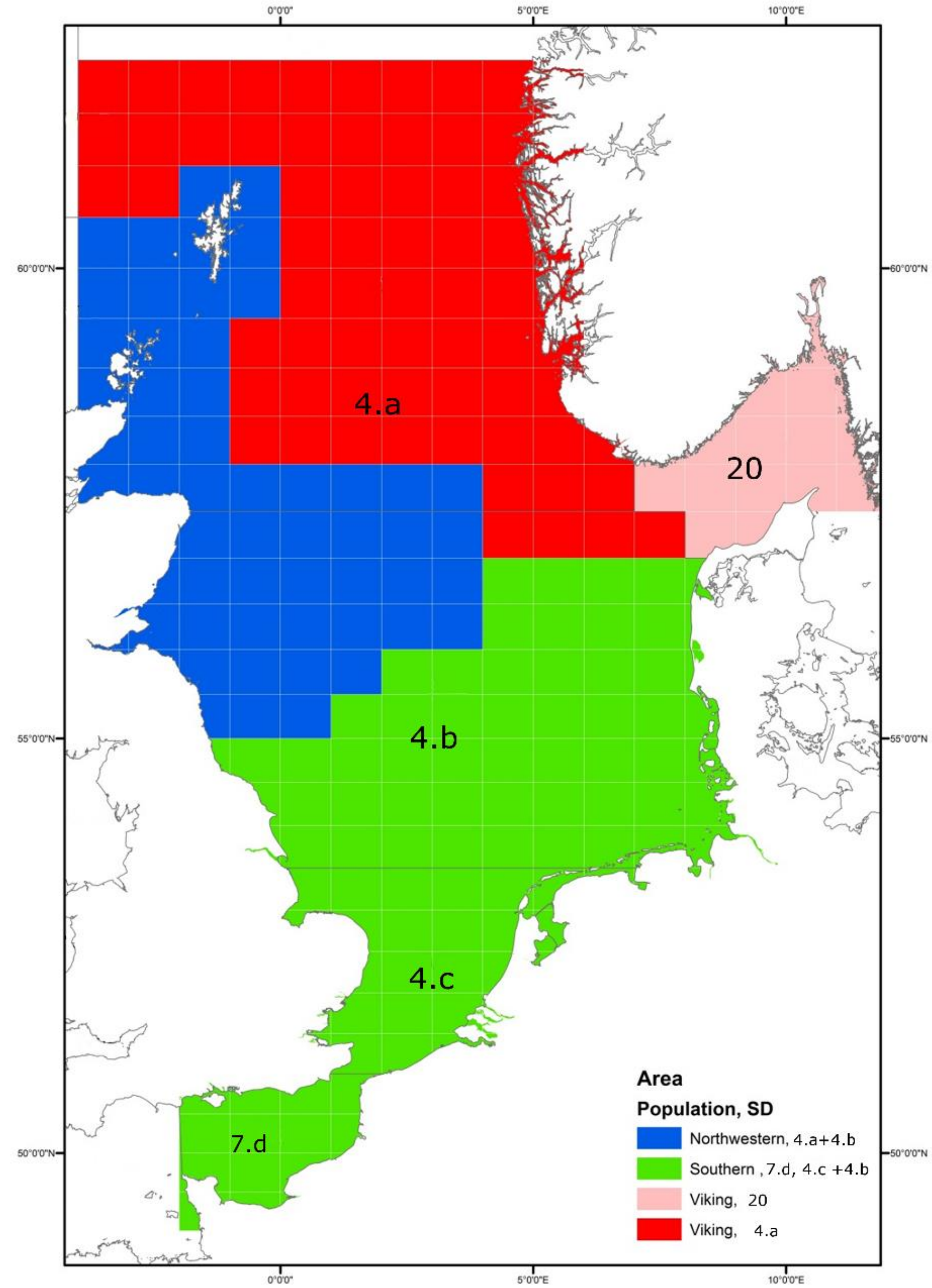


Figure 4.16c. Cod in Subarea 4, Division 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

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 since then. However, catch data, indices and the SURBAR assessment were updated and also an updated SPiCT assessment was performed. Total catches in 2017 were the lowest observed since the start of the catch time series in 2002. In 2018 catches increased again to 44 792 tonnes (compared to 35 113 tonnes in 2017). The SSB showed a decrease for the second year in a row now, but is still on a comparable high level. Recruitment showed a decreasing trend since 2015 and decreased sharply in 2018. The updated 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 was the lowest record of official landings for the whole time series (1950–2018). In 2018 the official landings increased again to 4377 tonnes.

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 Denmark and the UK (Figure 5.2, Table 5.14). In Division 3.a, Denmark lands by far 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).

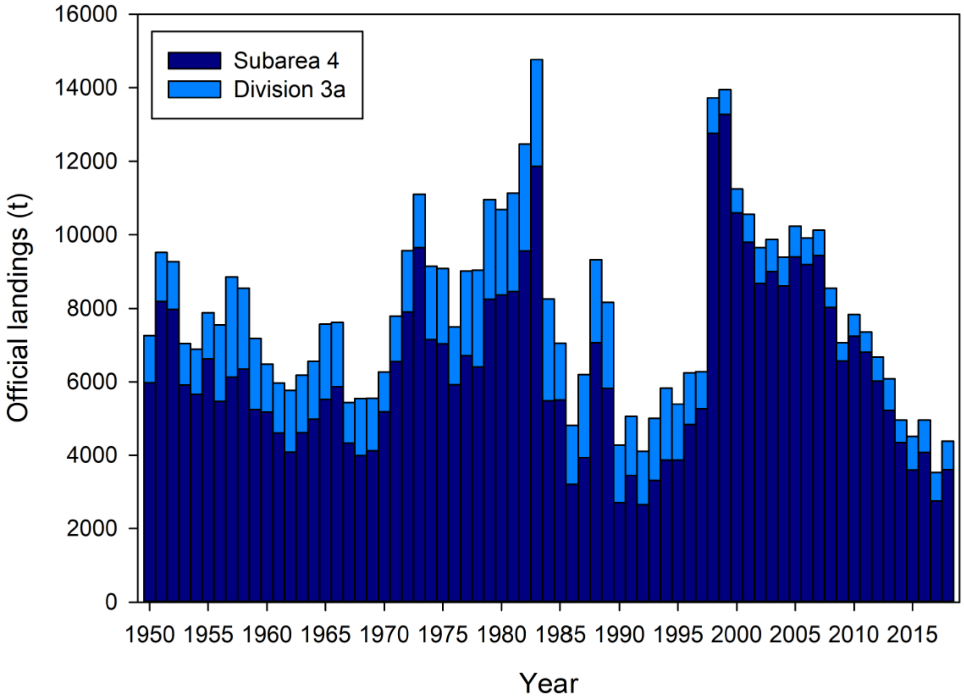


Figure 5.1. Dab in Subarea 4 and Division 3.a: Total official landings of dab in Subarea 4 and Division 3.a in 1950–2018.

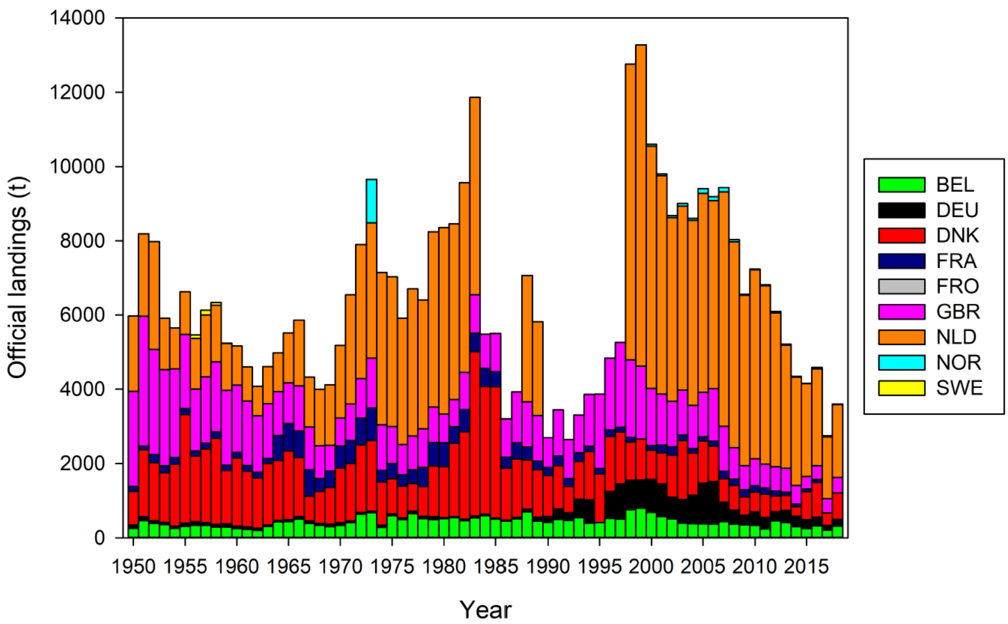


Figure 5.2. Dab in Subarea 4 and Division 3.a: Official landings of dab in Subarea 4 by country 1950 to 2018.

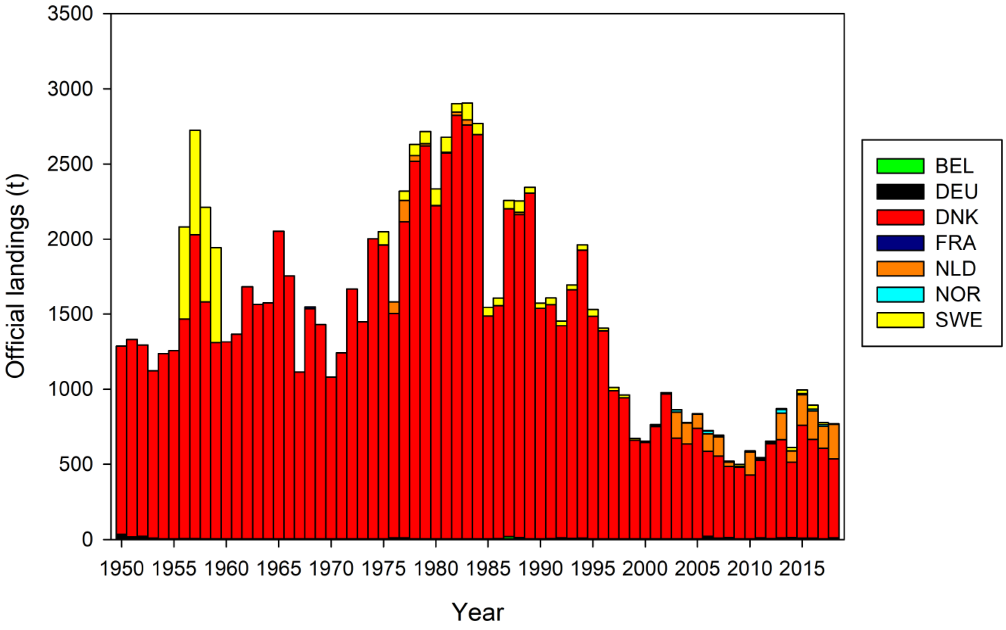


Figure 5.3. Dab in Subarea 4 and Division 3.a: Official landings of dab in Division 3.a by country 1950–2018.

5.2.2 InterCatch

For the current assessment year dab landing and discard data from 2002–2018 were available in the InterCatch system. Discard information for 2018 was provided for 76% of total landings in relation to weight (Figure 5.4).

In 2018, the largest amount of landings and discards was again reported by The Netherlands for the TBB_DEF_70-99_0_0_all métier (Figure 5.5 and Figure 5.6). Consequently, by far the largest catch in 2018 was taken by The Netherlands (25 501 tonnes in total) followed by Germany with 7934 tonnes. All other countries did not catch more than 4000 tonnes (Figure 5.7). The total dab catch estimated with InterCatch for 2018 was 44 792 tonnes (+9679 tonnes compared to 2017) from which 4233 tonnes were landings and 40 545 tonnes discards (91% of total catch). It should be noted that not all métiers 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 métiers for which zero landings were 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 métier is by far the most important one in terms of landings and information on discard weights was provided for every quarter for this important métier.

In general it was attempted to use the same groupings for discard raising as for the previous data years. However, this was not possible for all cases and compared to the previous year slight changes had to be made. The grouping is generally based on gear type and mesh size and where possible also by area. For the sample allocation scheme landings and discards were grouped by season. The following groupings were used for the 2018 data discard raising:

Group 1: MIS_MIS_HC all area 3.a and area 4 -> raised with all other métiers because no specific MIS_MIS_HC all data were available in 2018 data.

Group 2: passive gears area 3.a raised -> raised with all available passive gears in 3.a

Group 3: passive gears area 4 -> raised with all available passive gears in area in 4

Group 4: OTB_CRU_70-99__0_0_all -> raised with all OTB_CRU_70-99_0_0_all métiers available.

Group 5: OTB_CRU_90-119_0_0_all -> raised with all available OTB_CRU_90-119_0_0_all métiers.

Group 6: OTB_DEF_>120__0_0_all area 4 (including OTB_CRU_>=120_0_0_all) -> raised with all available OTB_DEF_>120__0_0_all métiers in area 4.

Group 7: OTB_DEF_>120__0_0_all area 3.a -> raised with all available OTB_DEF_>120__0_0_all métiers in area 3.a.

Group 8: SSC_SDN_DEF_>=120__0_0_all -> raised with all OTB_DEF_>=120__0_0_all métiers, all areas combined.

Group 9: TBB_DEF_70-99 _0_0_all -> raised with all TBB_DEF_70-99 _0_0_all métiers.

Group 10: TBB_DEF_100-119__0_0_all and TBB_DEF_>=120 _0_0_all -> raised with all fleets of the same métiers.

Group 11: OTB_DEF_100-119_0_0_all -> raised with all available OTB_DEF_100-119_0_0_all métiers.

Group 12: SSC_DEF_100-119_0_0_all (including SSC_DEF_all_all ENG) -> raised with all available OTB_DEF_100-119_0_0_all métiers.

Group 13: OTB_SSC_SDN_DEF_70-99_0_0_all -> raised with Dutch OTB_DEF_70-99_0_0_all and France OTB_DEF_70-99__0_0_all métiers.

Group 15: OTB_SPF_70-99_0_0_all -> raised with all available OTB_SPF_70-99_0_0_all métiers (FRA only)

The following métiers were not raised because they were negligible or no suitable data were available:

- TBB_OTB_CRU_16-31
- OTB_CRU_70-89_2_35_all
- MIS_MIS_all_IBC
- OTB_SPF_32-69_0_0_all

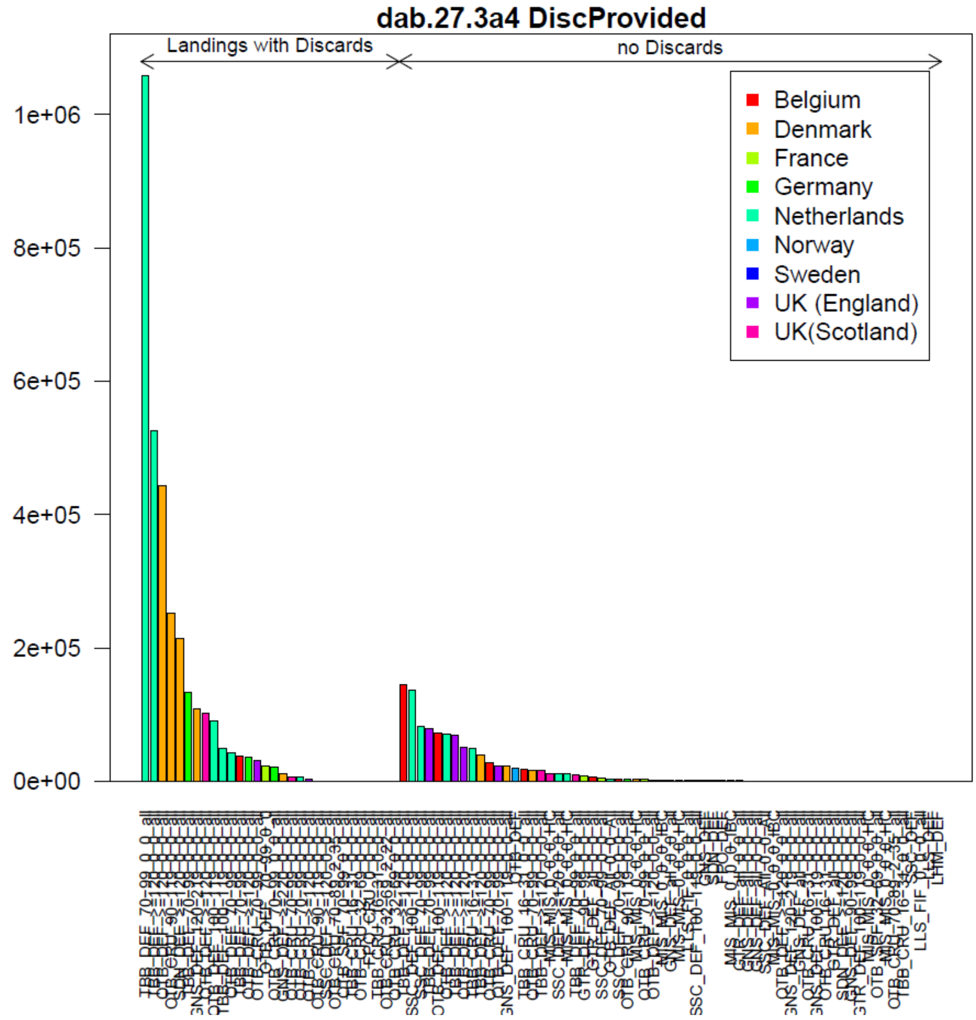


Figure 5.4. Dab in Subarea 4 and Division 3.a: Dab landings and discards (kg) provision for Subarea 4 and Division 3.a by métier and country in 2018 as uploaded into InterCatch.

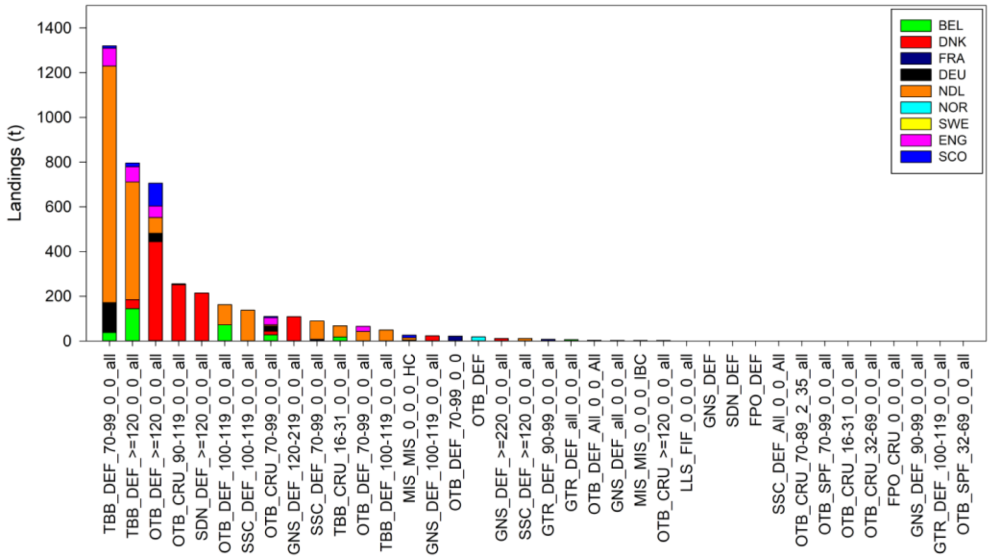


Figure 5.5. Dab in Subarea 4 and Division 3.a: Dab landings (tonnes) for Subarea 4 and Division 3.a by métier and country in 2018 as uploaded to InterCatch.

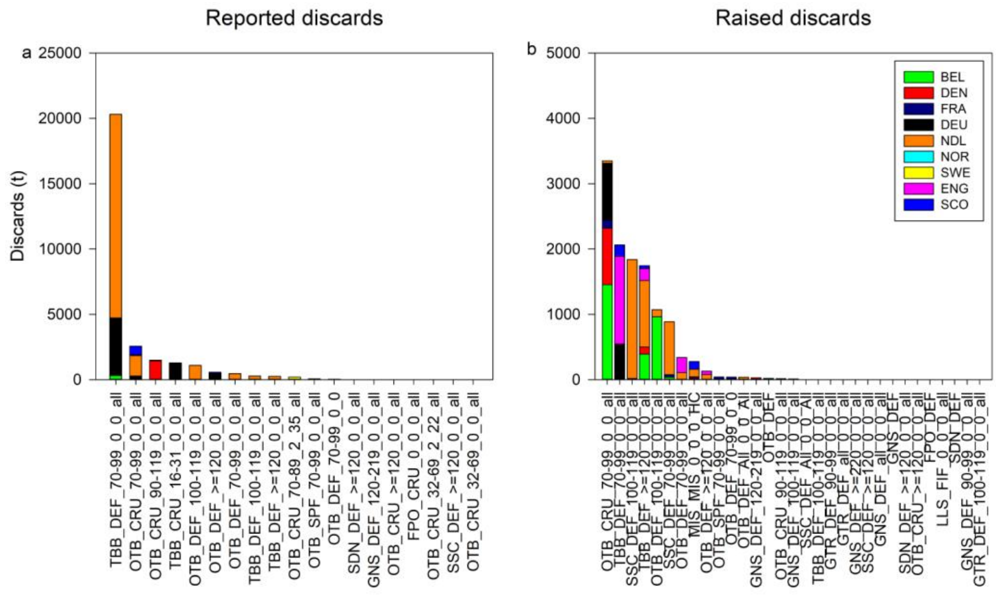


Figure 5.6. Dab in Subarea 4 and Division 3.a: Dab discards for Subarea 4 and Division 3.a by métier and country in 2018. Reported discards (a), raised discards (b).

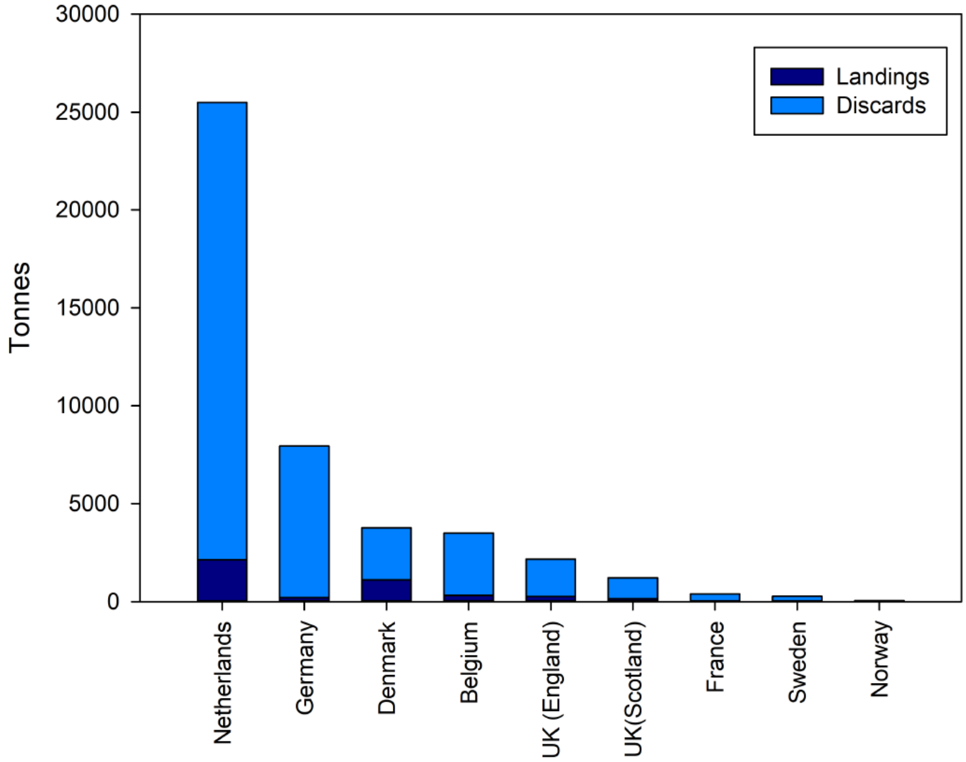


Figure 5.7. Dab in Subarea 4 and Division 3.a: Dab landings and estimated discards for Subarea 4 and Division 3.a by countries in 2018.

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). In 2019 this index increased again. 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 was confirmed for recent years.

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 for the most recent years. 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 an increase in 2016 for the age groups 1–5 (Figure 5.15). Overall the weight at age over the age groups showed a rather stable trend over the recent years.

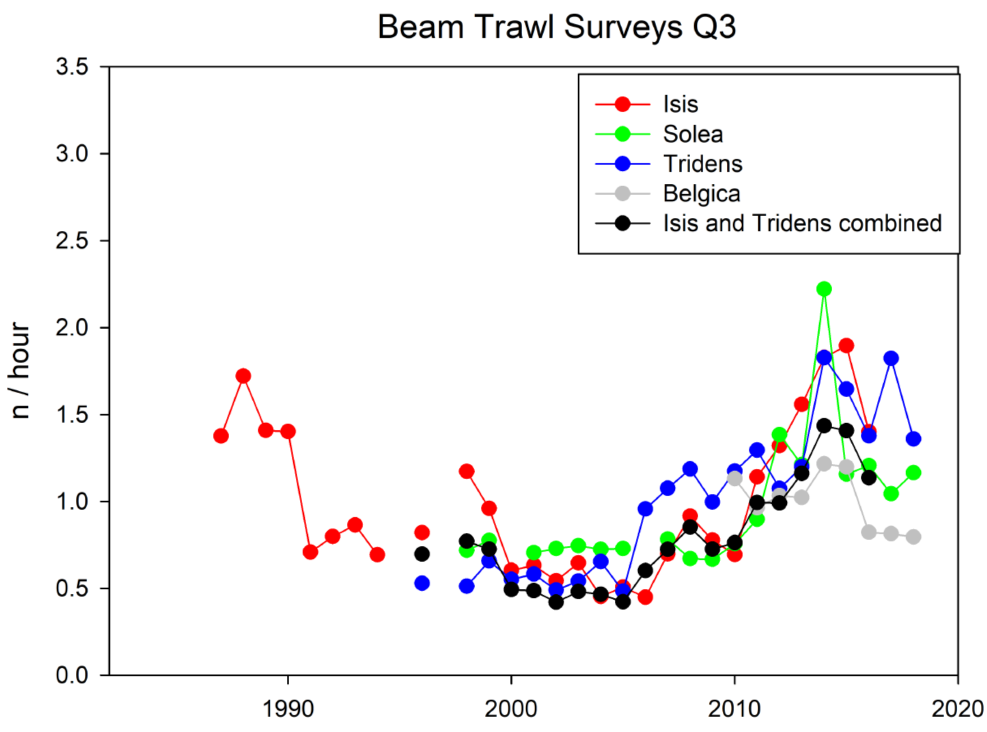


Figure 5.8. Dab in Subarea 4 and Division 3.a: Standardized dab beam trawl survey indices (n/hour) in Subarea 4.

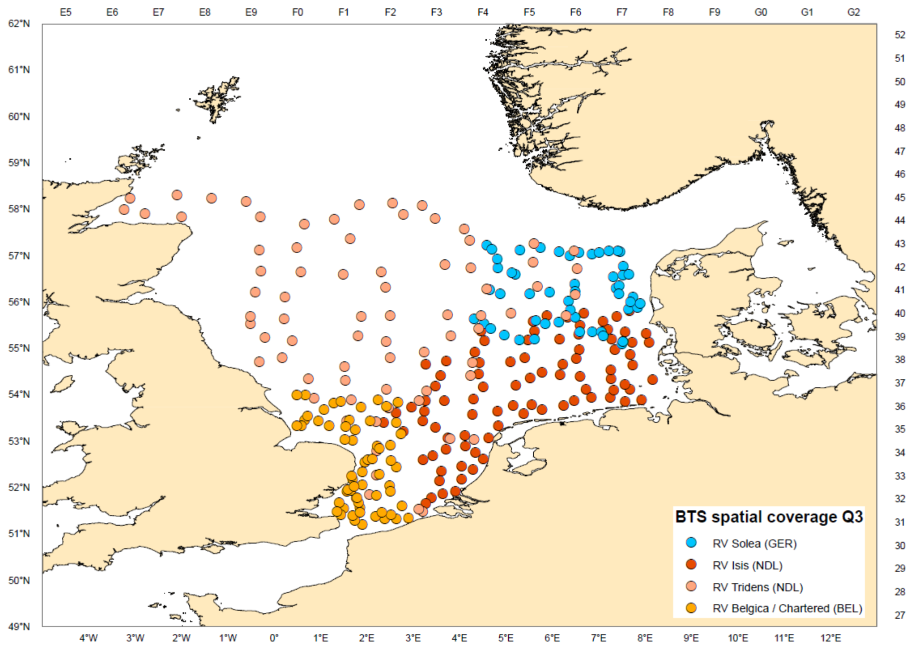


Figure 5.9. Dab in Subarea 4 and Division 3.a: Spatial coverage of the different beam trawl surveys in the North Sea (1987–2018). Since 2017, the survey area from RV Isis is also covered by RV Tridens.

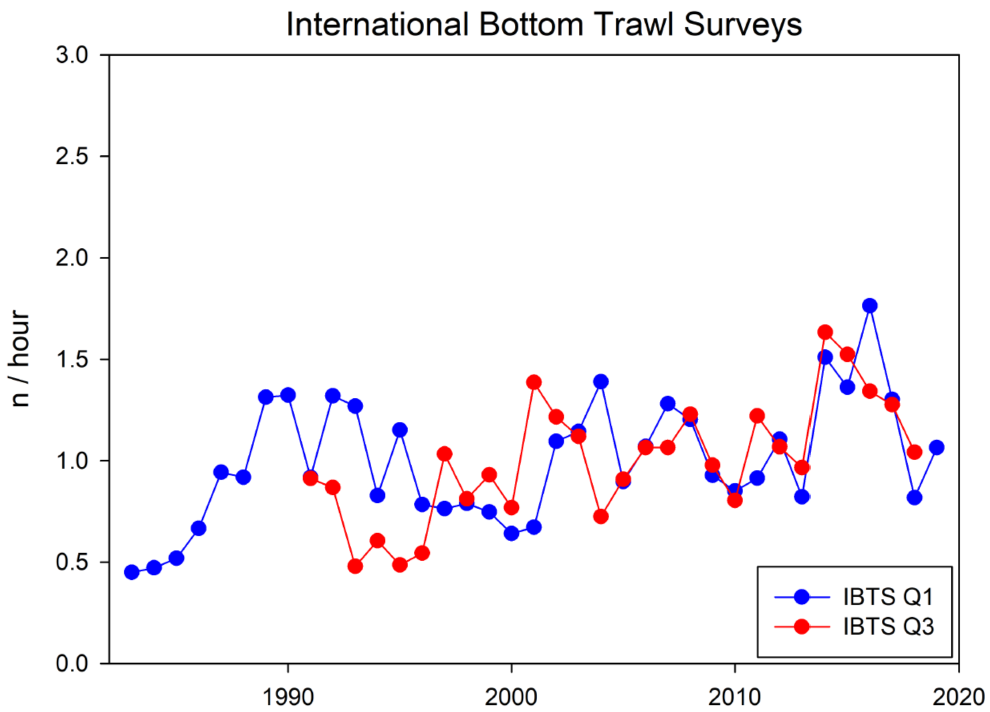


Figure 5.10. Dab in Subarea 4 and Division 3.a: Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

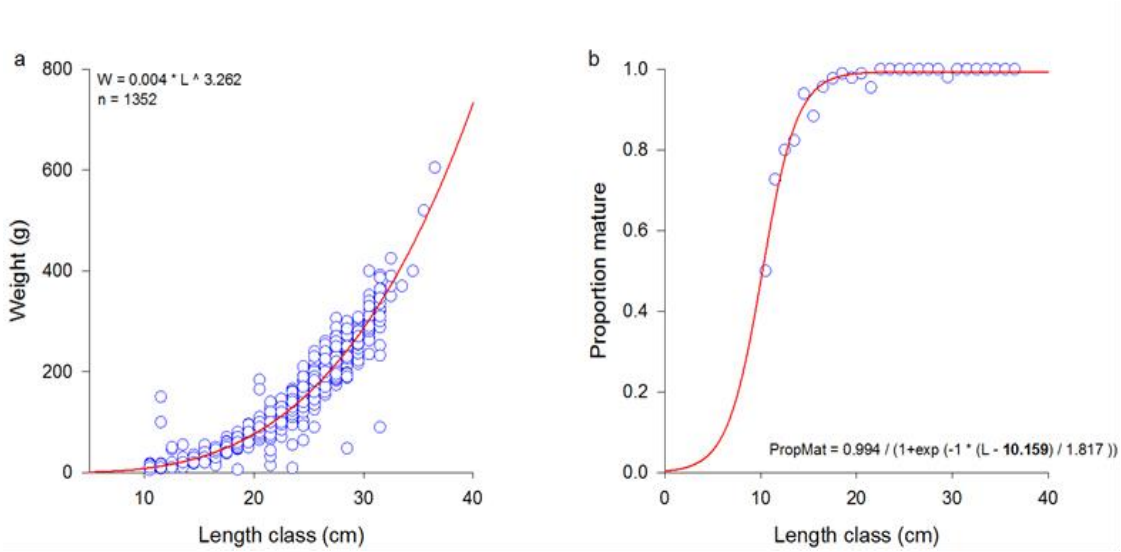


Figure 5.11. Dab in Subarea 4 and Division 3.a: Length weight relation (a) and length based maturity ogive (b) obtained from survey data (IBTS–Q1).

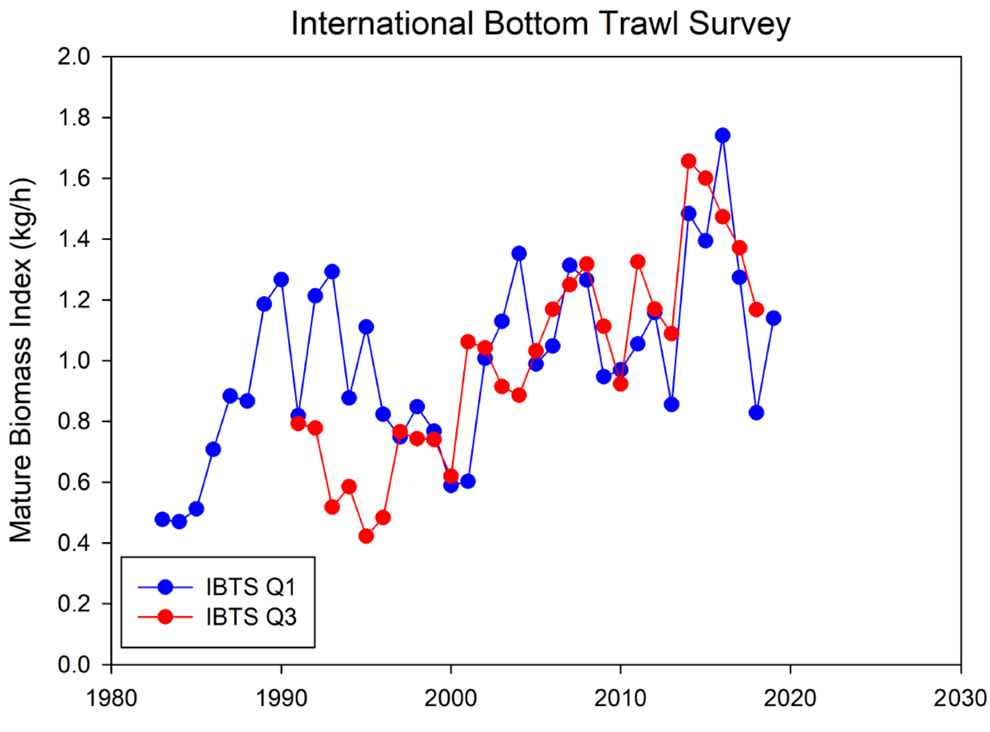


Figure 5.12. Dab in Subarea 4 and Division 3.a: Mature biomass index IBTSQ1 and IBTSQ3.

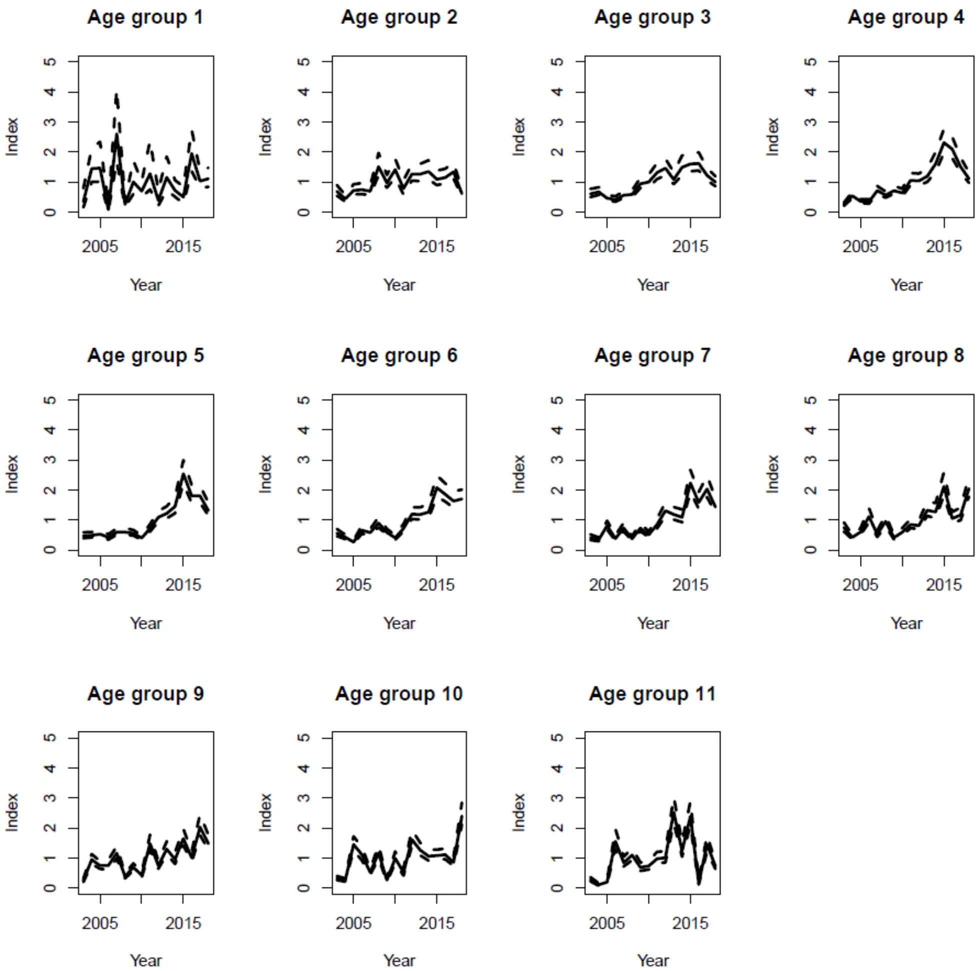


Figure 5.13. Dab in Subarea 4 and Division 3.a: Combined beam trawl index by age groups (2003–2018). Age group = age group -1.

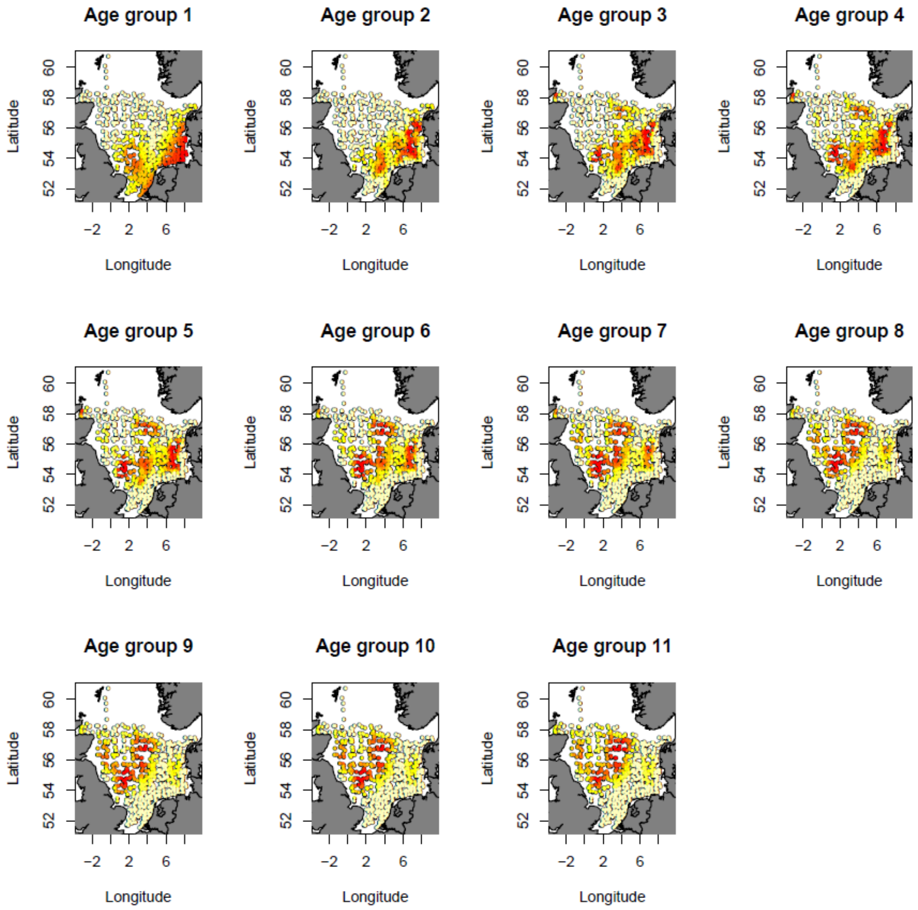


Figure 5.14. Dab in Subarea 4 and Division 3.a: Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys (age group = age group –1).

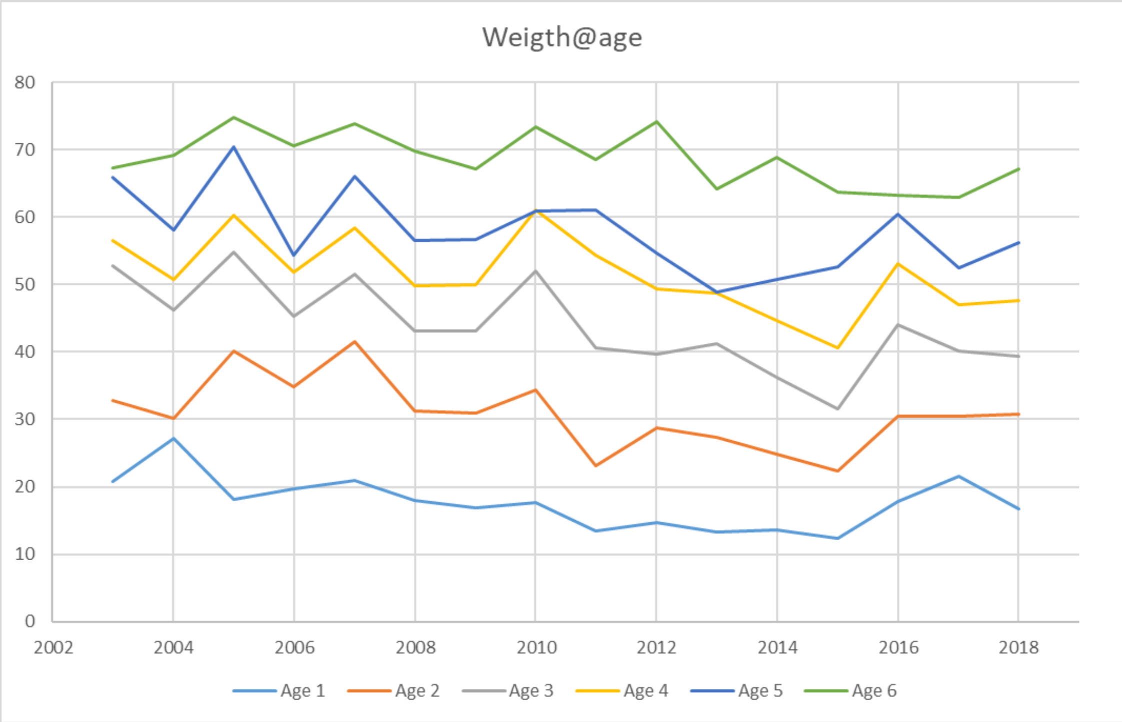


Figure. 5.15 Dab in Subarea 4 and Division 3.a: Weight at age derived from beam trawl survey data 2003–2018).

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 2015–2017, but dropped again slightly in 2018. The spawning stock biomass also decreases since 2017, but is still on a comparable high level. The recruitment increased by a factor of 2.6 from 2003 to 2014 but decreased since 2015 (Figure 5.16, lower right panel). In 2018 a sharp decrease of recruitment was observed. However, there was quite a strong retrospective pattern in recruitment with an underestimation of recruitment for some 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)

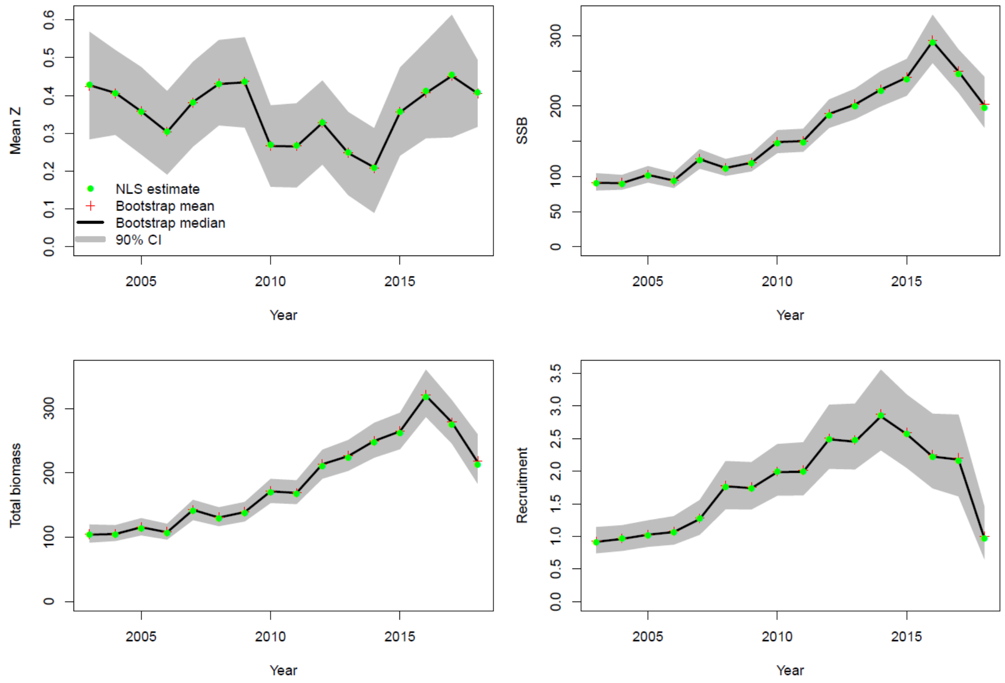


Figure 5.16. Dab in Subarea 4 and Division 3.a: SURBAR model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

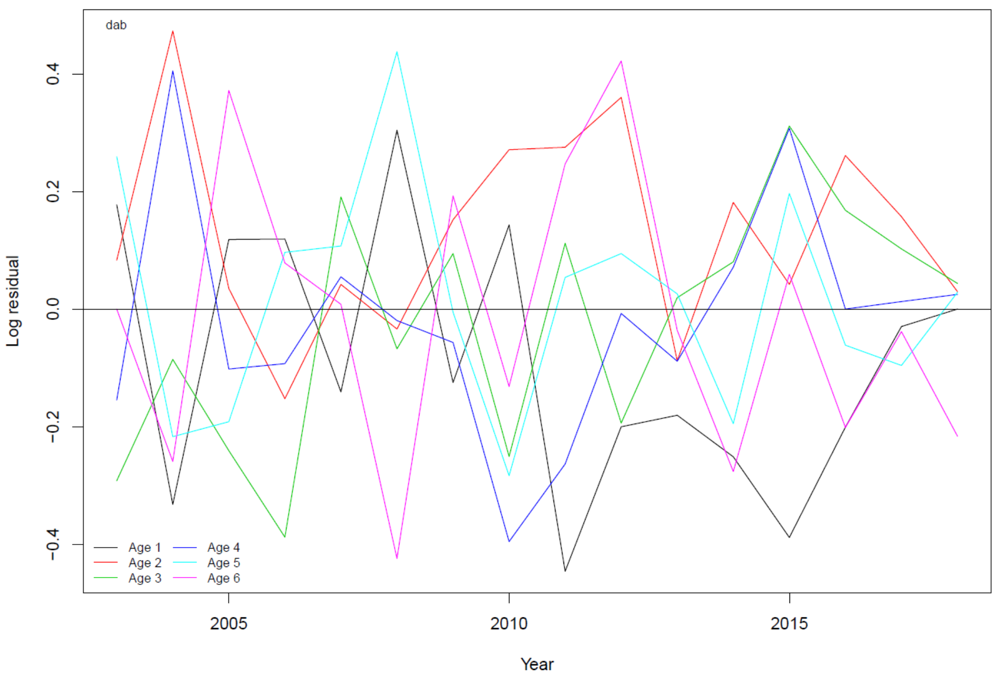


Figure 5.17. Dab in Subarea 4 and Division 3.a: SURBAR model results of log residuals.

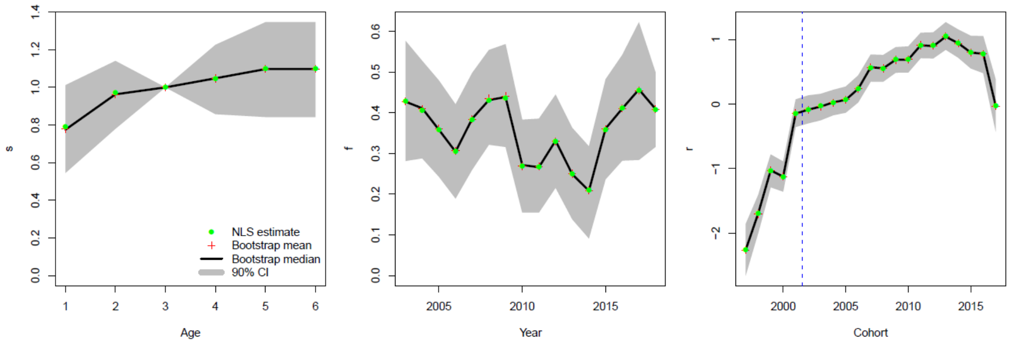


Figure 5.18. Dab in Subarea 4 and Division 3.a: SURBAR model results displaying the age, year and cohort effects.

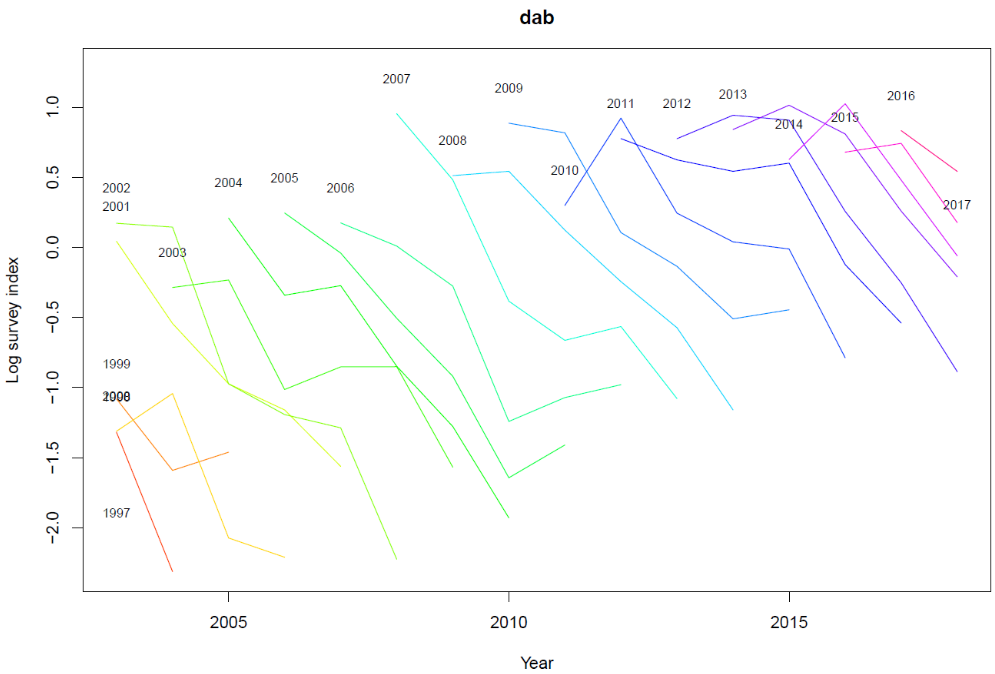


Figure 5.19. Dab in Subarea 4 and Division 3.a: SURBAR model results: catch curves.

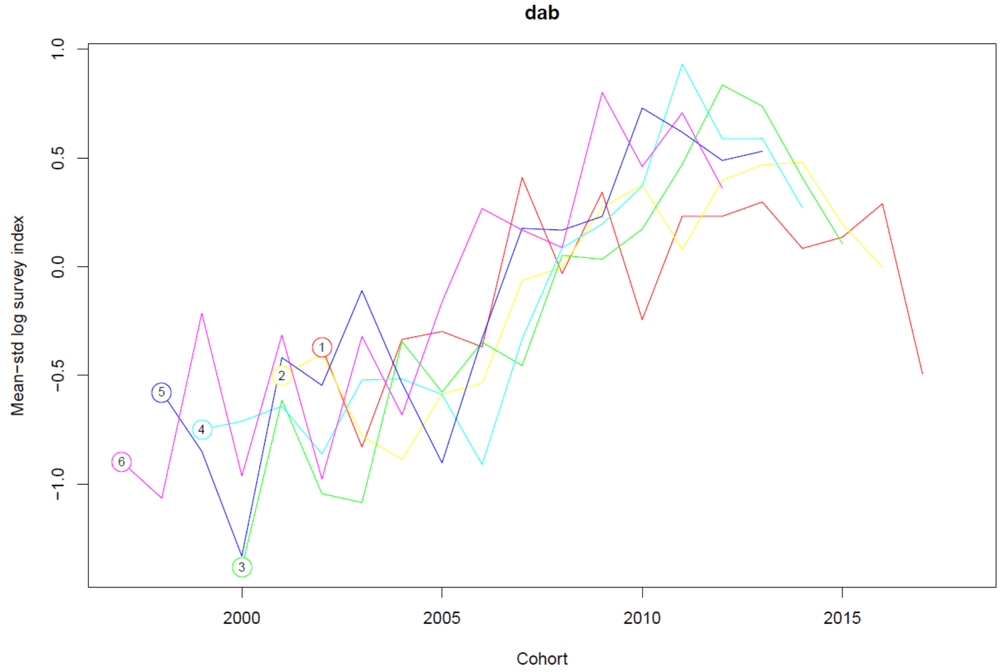


Figure 5.20. Dab in Subarea 4 and Division 3.a: SURBAR mean-standardized log survey index.

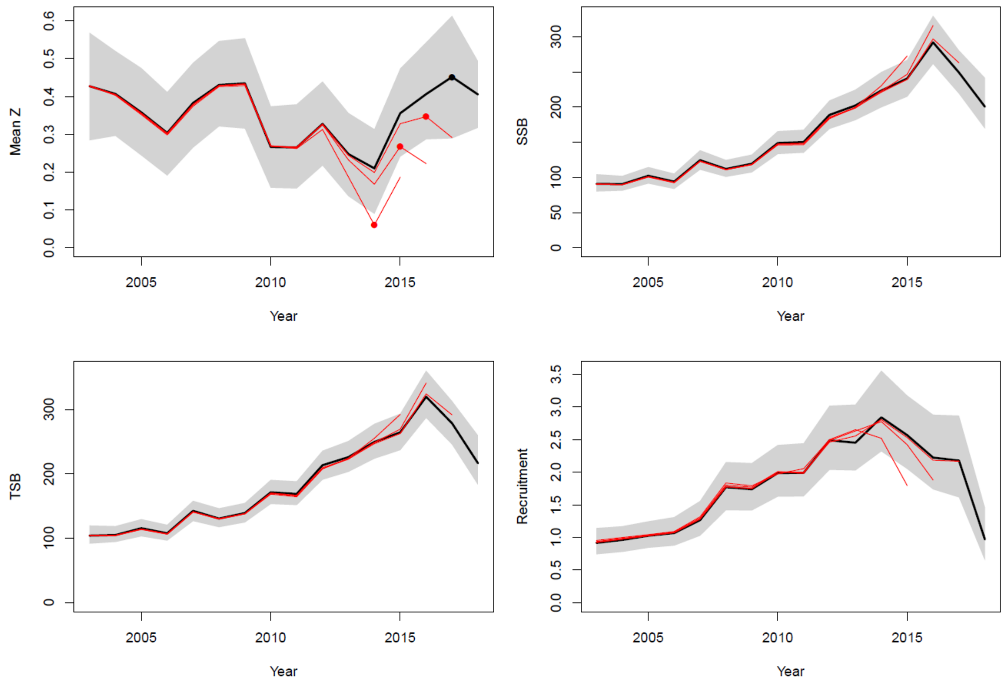


Figure 5.21. Dab in Subarea 4 and Division 3.a: SURBAR Retrospective runs.

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 (2002–2018) 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 2002–2018
BTS Isis	1987–2002, >12 cm
BTS Tridens	1996–2002, >12 cm
Combined BTS (Isis, Tridens, Solea)	2003–2018, Age > 1 yr
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 B_{MSY}* 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.

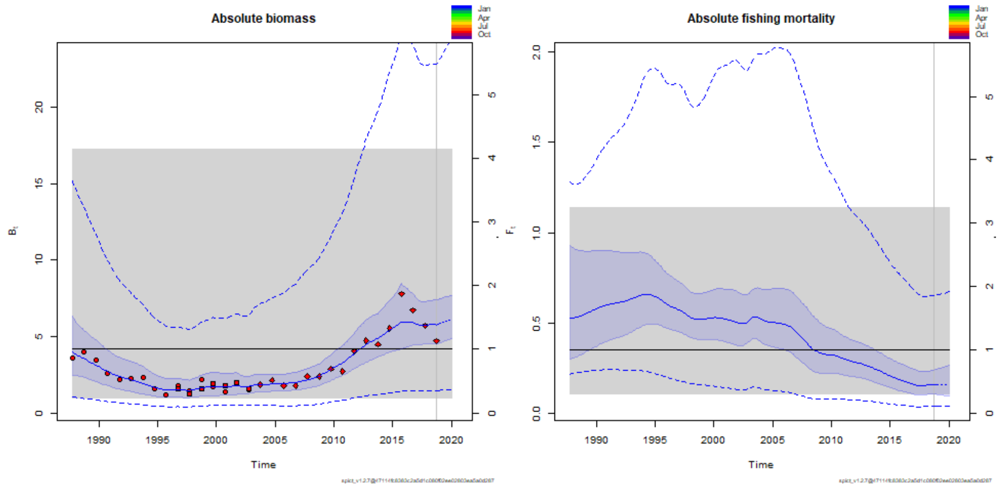


Figure 5.22. Dab in Subarea 4 and Division 3.a: SPiCT results. Absolute biomass (left panel) and absolute fishing mortality (right panel).

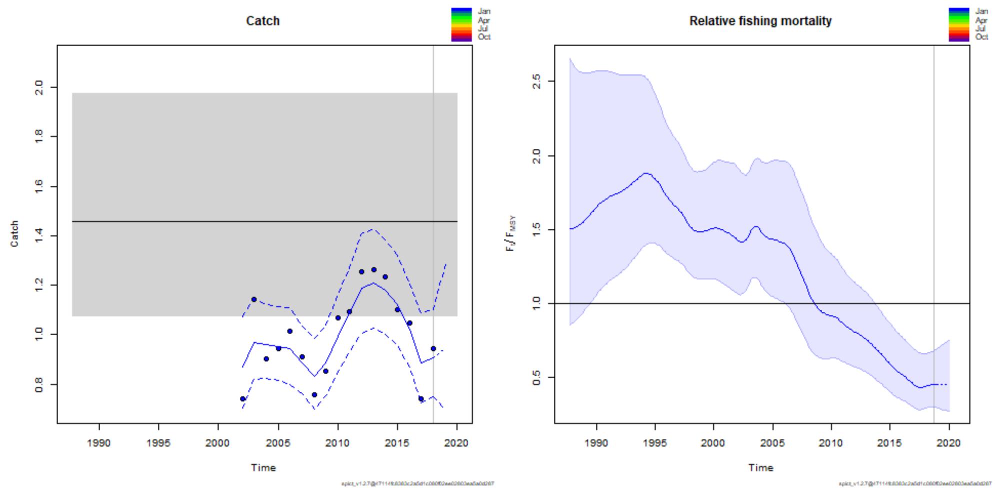


Figure 5.23. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch time series (left panel) and relative fishing mortality (right panel).

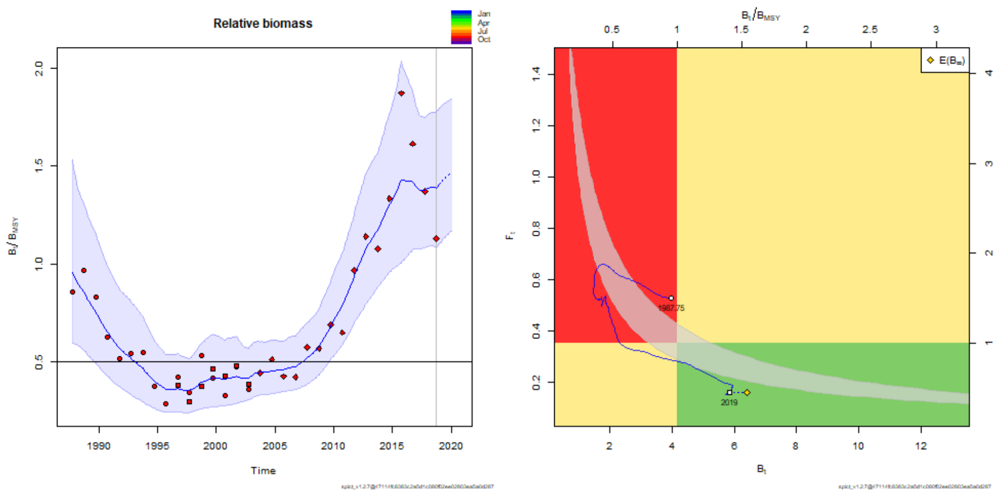


Figure 5.24. Dab in Subarea 4 and Division 3.a: SPiCT results. Relative biomass (left panel) and Kobe plot of relative fishing mortality over biomass estimate (right panel).

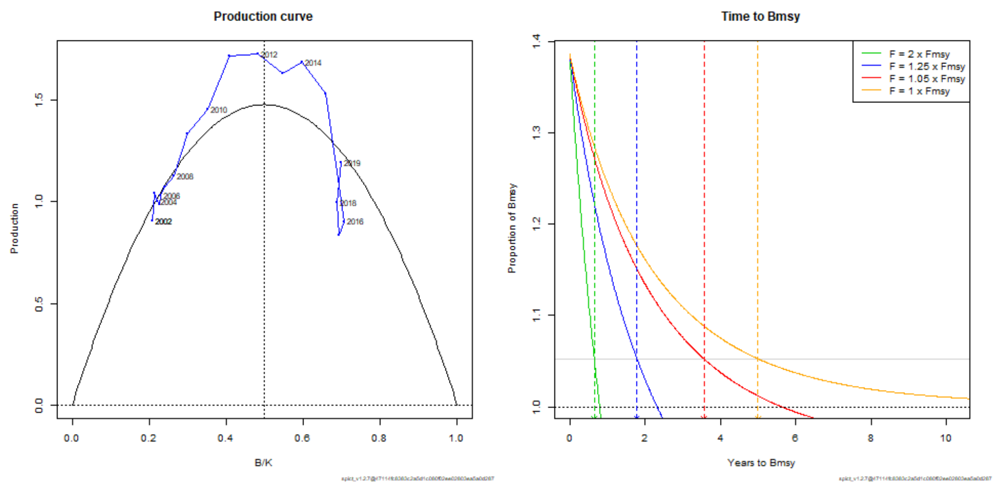


Figure 5.25. Dab in Subarea 4 and Division 3.a: SPiCT results. Production curve (left panel) and estimated time to B_{MSY} (right panel).

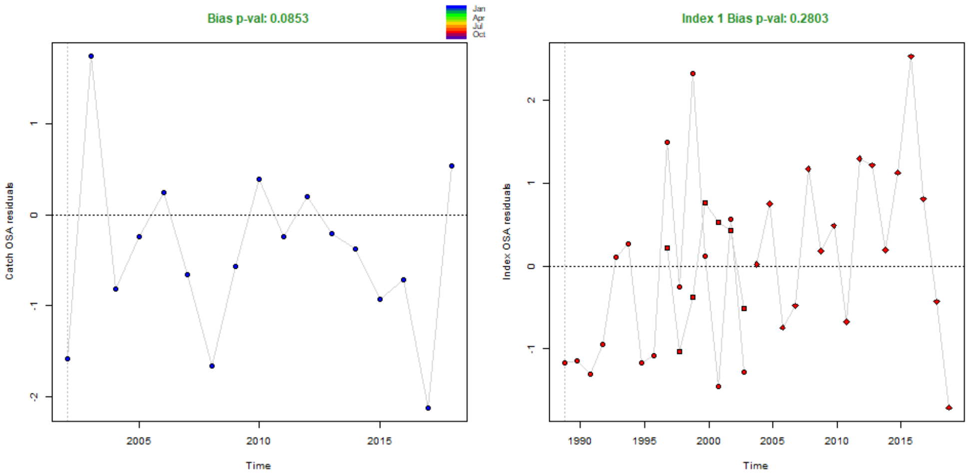


Figure 5.26. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch residuals (left panel) and survey residuals (right panel).

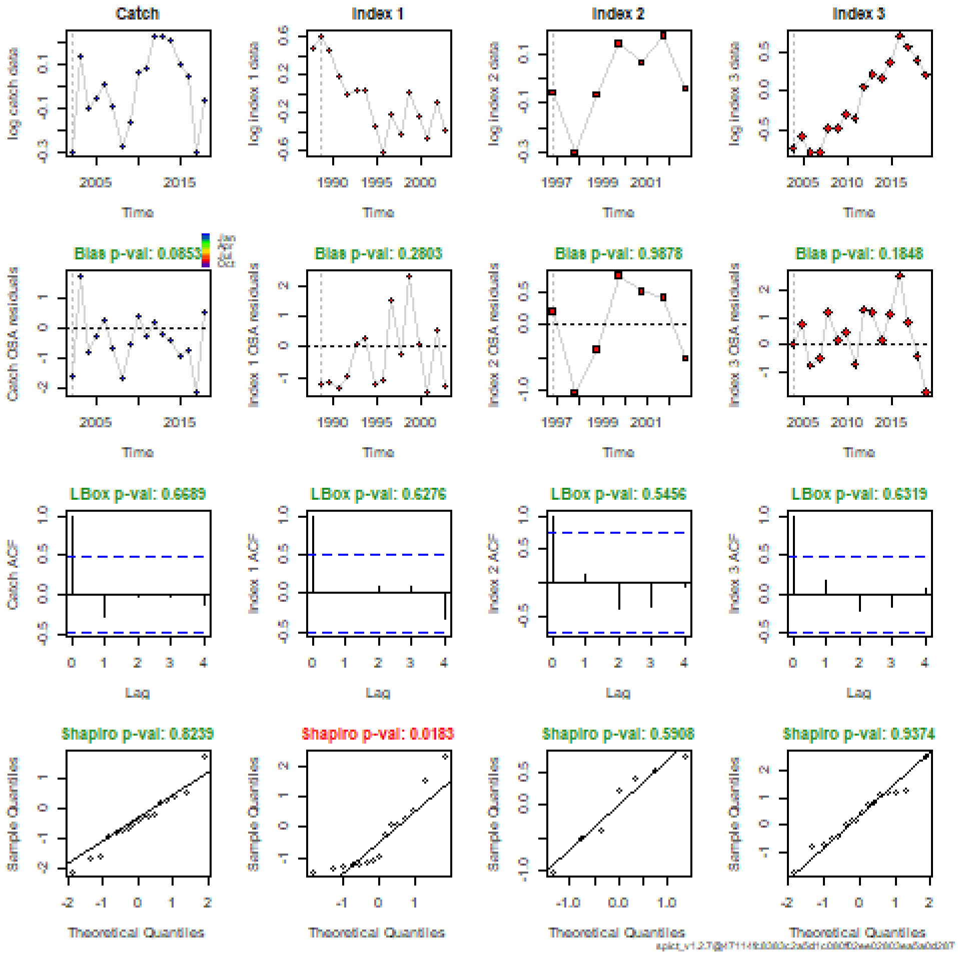


Figure 5.27. Dab in Subarea 4 and Division 3.a: SPiCT diagnostics.

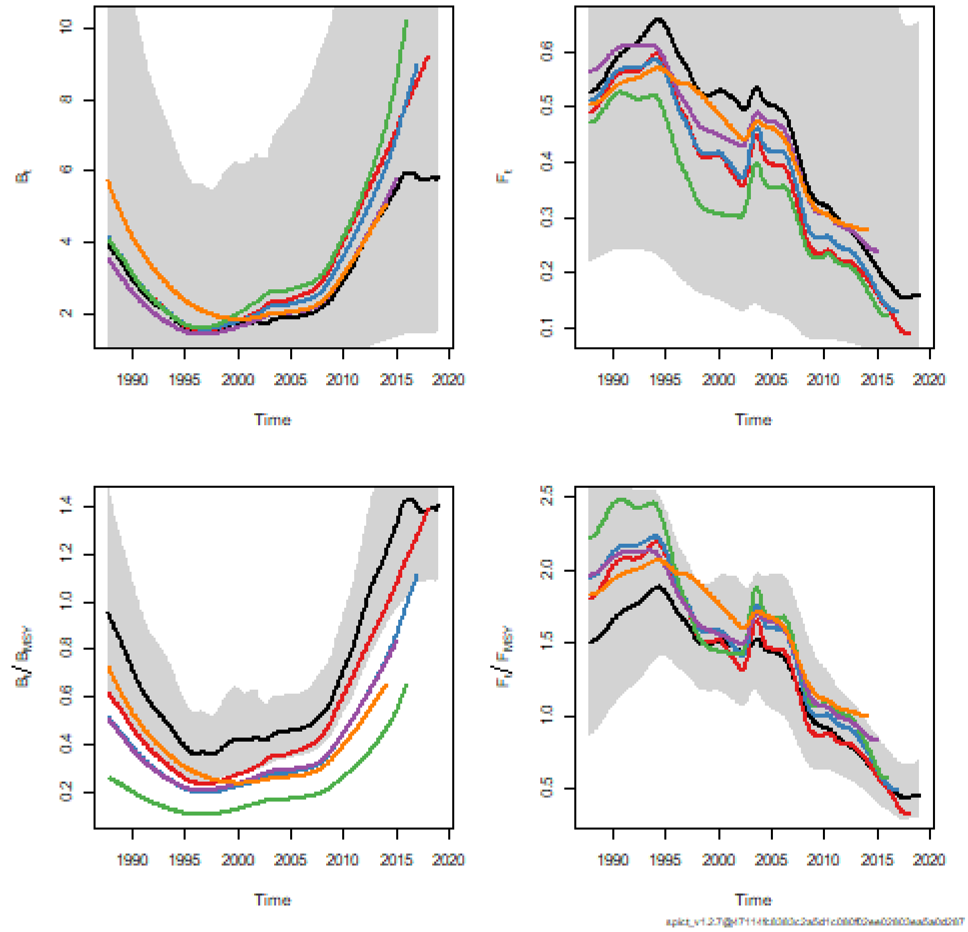


Figure 5.28. Dab in Subarea 4 and Division 3.a: SPiCT retrospective plots.

5.6 Issues list

- Métiers with zero landings but no discards reported. No raising possible for these cases. What is the possible impact on catch estimation? Are there other ways to estimate relaistic discards for these métiers?
- No suitable data available for the shrimper fleets operating in coastal waters. No raising possible for these fleets. What is the possible impact on catch estimation? Is there another way to estimate the discards of these fleets?
- Investigate extending the delta-GAM index with Belgian and German BTS data (prior to 2002).
- Investigate the use of DYFS, DFS inshore surveys to estimate a recruitment index.
- Investigate which effort data are available and if these could be used as further input for the SPiCT model.

5.7 References

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5.8 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

Year	Subarea 4	Division 3.a	Total
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
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
2018*	3607	770	4377

*** 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

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Subarea 4
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
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	406	333	404	84	0	647	3314	26	0	5214
2014	304	282	253	72	0	506	2907	23	0	4347
2015	247	244	747	75	0	339	2500	10	0	4162
2016	321	244	932	75	0	372	2611	35	0	4590
2017*	210	125	340	n.a.	0	379	1662	35	0	2751
2018*	315	184	709	n.a.	0	417	1960	22	0	3607

*** 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

Year	Bel	Deu	Dnk	Fra	Nld	Nor	Swe	Division 3.a
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
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	752	0	203	8	24	995
2016	0	9	657	0	189	14	26	895
2017*	0	5	601	0	146	14	12	778
2018*	0	10	528	n.a.	229	2	1	770

*** preliminary catch statistics**

Table 5.6. Dab in Subarea 4 and Division 3.a.: InterCatch landings, discards and total catch (2002–2018).

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%
2018	4233	28630	11915	40545	44792	91%

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, 2018a). Catch advice for flounder 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 flounder since then, but a new advice sheet presenting the stock and exploitation status of flounder was prepared. Catch data, survey indices and the SPiCT assessment were updated and presented. Updating the SPiCT assessment model with 2017 and 2018 data increased the uncertainties to unacceptable levels. Therefore, the LBI method was used instead, as it was done for the previous advice (ICES, 2017b).

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 6.5). Landings in ICES Subarea 4 and Division 3.a by country are shown in Figures 6.2 and 6.3 and in Tables 6.3 and 6.4. 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 2018, total official landings were reported with 1582 tonnes, compared to 1262 tonnes in 2017. This is a slight increase but still the second 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 2018 (192 tonnes), but they are still on low levels compared with earlier years (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.

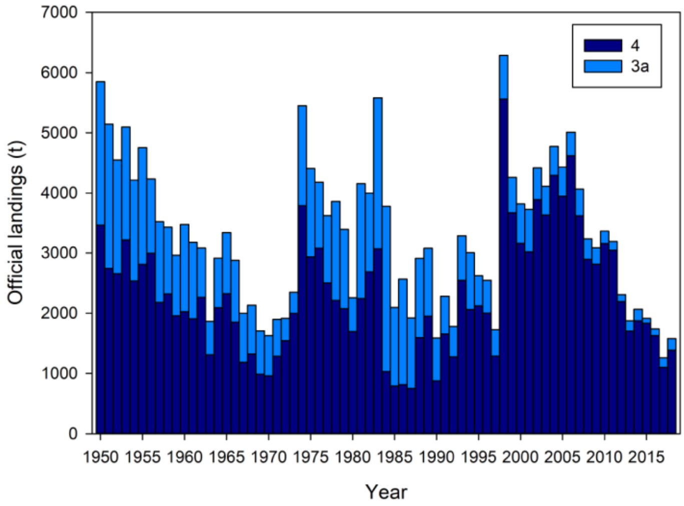

Figure. 6.1. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder by area 1950–2018.

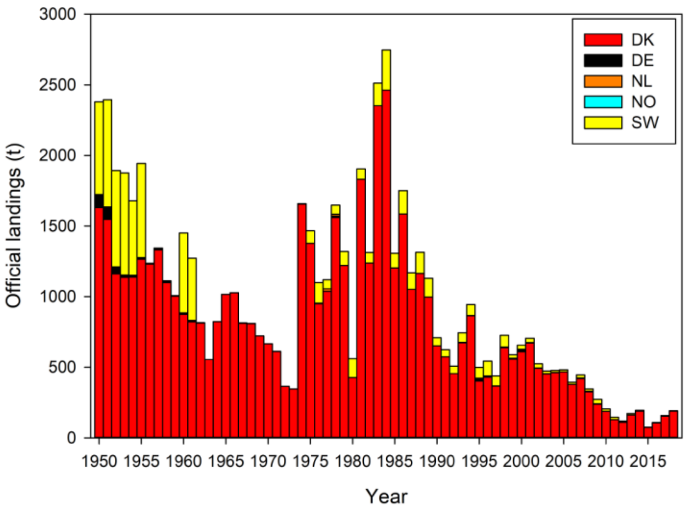

Figure 6.2. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder in ICES Division 3.a by country 1950–2018.

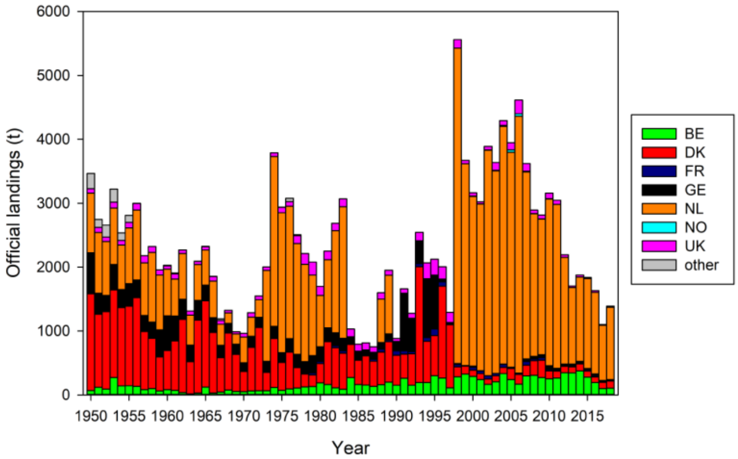

Figure 6.3. Flounder in Subarea 4 and Division 3.a: Official landings of flounder in ICES Subarea 4 by country 1950–2018.

6.2.2 InterCatch

Flounder landings and discards data from 2002–2018 were available in the InterCatch system for the current assessment year.

In general it was tried only to raise equivalent or similar métiers with each other in InterCatch. Discard information was provided for 86% of all métiers in 2018 (Figure 6.4). However, for a number of métiers zero landings were reported. For these métiers no raising with InterCatch was possible. A further problem in the estimation of total flounder discards maybe the TBB_CRU_16-32_0_0_all métier targeting brown shrimp in coastal areas of the Southeastern North Sea. 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.

In 2018, by far the largest proportion of landings (1036 tonnes, ~65% of total landings) was reported by Dutch beam trawlers (TBB_DEF_70_99_0_0_all), followed by the Danish OTB_CRU_90-119_0_0_all metier (130 tonnes) and the Danish GNS_DEF_120_219_0_0_all (100 tonnes). Other métiers landing flounder in considerable amounts did in general not land more than 60 tonnes each (Figure 6.5). The highest amount of discards in 2018 was reported for the Danish OTB_CRU_90-119_0_0_all (262 tonnes) and Belgian and Dutch TBB_DEF_70_99_0_0_all métiers with 121 and 105 tonnes respectively (Figure 6.6).

The largest total catch estimated in 2018 was taken by the Netherlands (1194 tonnes), followed by Denmark (577 tonnes), Belgium (240 tonnes) and Germany (112 tonnes). All other countries catch less than 40 tonnes (Figure 6.7). The total catch estimated with InterCatch was 2244 tonnes from which 1587 tonnes were landings (compared to 1582 tonnes reported official landings) and 657 tonnes discards (29% 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.

In general it was attempted to use the same groupings for discard raising as for the previous data years. However, this was not possible for all cases and compared to the previous year slight changes had to be made. The grouping is based on gear type and mesh size over areas and season. For the sample allocation scheme only one landing and one discard group was set up, because data availability did not allow for a higher resolution. Danish sample data were not used for the allocation scheme because only dummy values were uploaded for mean weights. The following groupings were used for the 2018 data discard raising:

Group 1: TBB_DEF_70-99_0_0_all -> raised with all available TBB_DEF_70-99_0_0_all

Group 2: MIS_MIS_0_0_0_HC -> raised with all other métiers because no specific MIS_MIS_0_0_0_HC data were available.

Group 3: OTB_DEF_70-99_0_0_all -> raised with all available OTB_DEF_70-99_0_0_all métiers.

Group 4: SSC_DEF_70-99-119__0_0_all -> raised with all available OTB_DEF_70-99_0_0_all métiers.

Group 5: OTB_CRU_70-99_0_0_all -> raised with all available OTB_CRU_90-119_0_0_all, no specific discard ratios available for OTB_CRU_70-99_0_0_all.

Group 6: All passive gear métiers -> raised with all available passive gear métiers.

Group 7: OTB_DEF>=120_0_0_all (including OTB_DEF all_all NOR métiers) -> raised with all available OTB_DEF_>=120_0_0_all métiers.

Group 8: SDN_DEF_>=120_0_0_all and SSC_DEF_>=_0_0_all métiers -> raised with all available SDN_DEF_>120_0_0_all and SSC_DEF_>=120_0_0_all métiers.

Group 9: OTB_DEF_100-119_0_0_all métiers -> raised with all available OTB_DEF métiers (specific OTB_DEF_100-119_0_0_all not available)

Group 10: TBB_DEF_>=120_0_0_0_all -> raised with all available TBB_DEF_70-99_0_0_all métiers. No specific data for TBB_DEF_>=120_0_0_all were available.

The following métiers were not raised because they were negligible or no suitable data were available:

- MIS_MIS_0_0_0_IBC (negligible, no data available)
- TBB_CRU_16-32_0_0_0_all (no suitable data available)
- OTB_CRU_16-31_0_0_all (no suitable data available)
- OTB_DEF_<16 (no suitable data available)
- OTB_SPF_32-69_0_0_all (no suitable data available)
- OTB_CRU_70-89_2_35_all (no suitable data available)

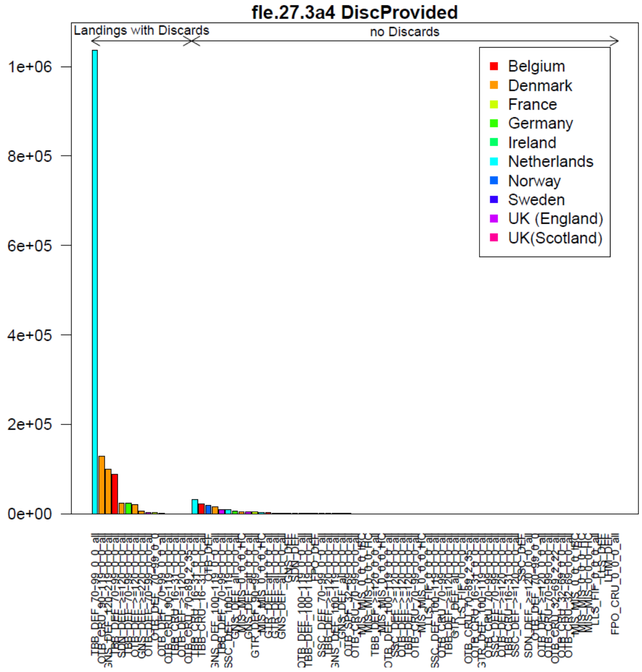

Figure 6.4. Flounder in Subarea 4 and Division 3.a: Provision of discards information by country and fleets imported to InterCatch for 2018 data.

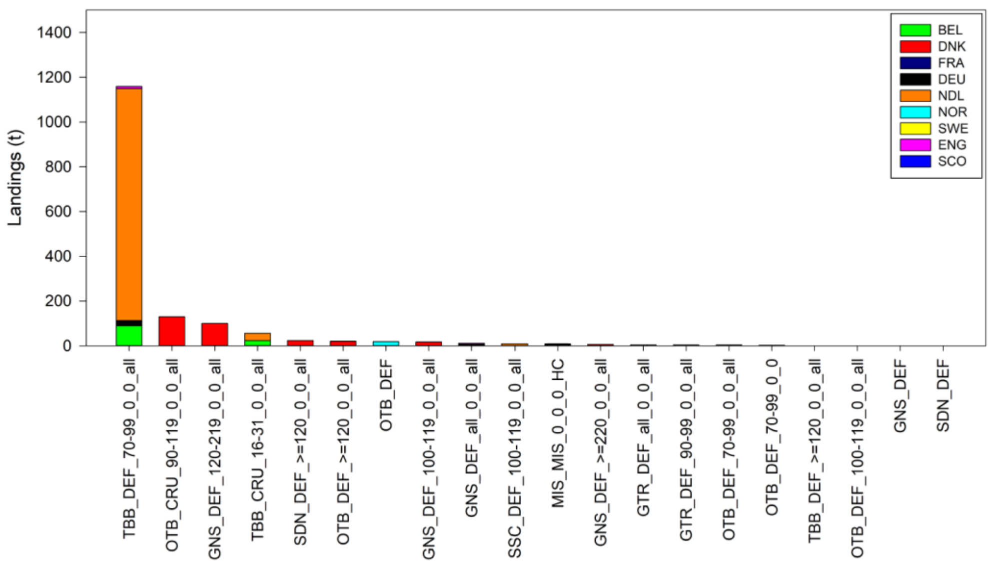

Figure 6.5. Flounder in Subarea 4 and Division 3.a: Flounder landings by métier and country in 2018 as uploaded to Inter-Catch.

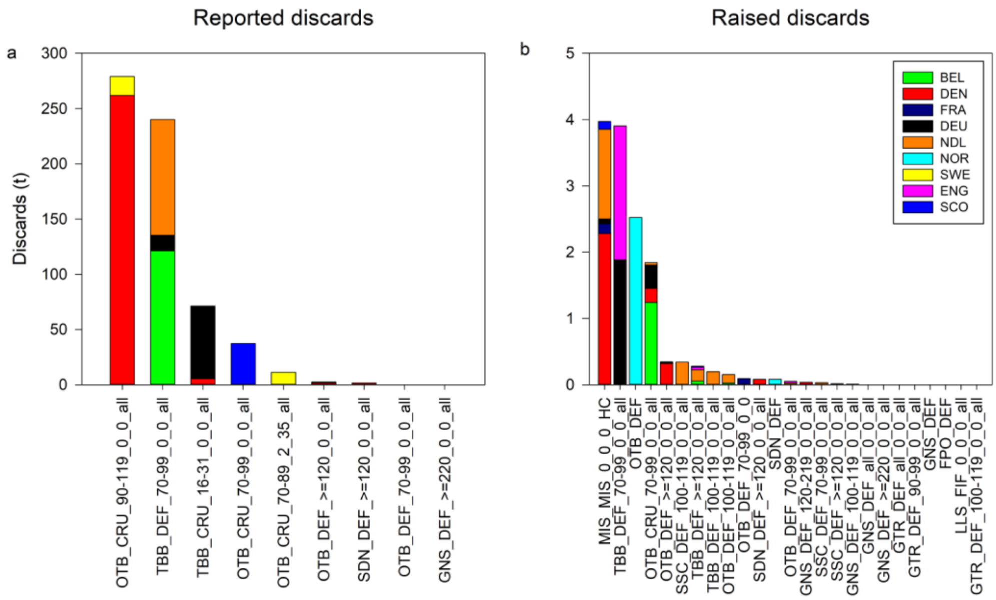

Figure 6.6. Flounder in Subarea 4 and Division 3.a: Flounder discards by métier and country in 2018. Reported discards panel (a), raised discards panel (b).

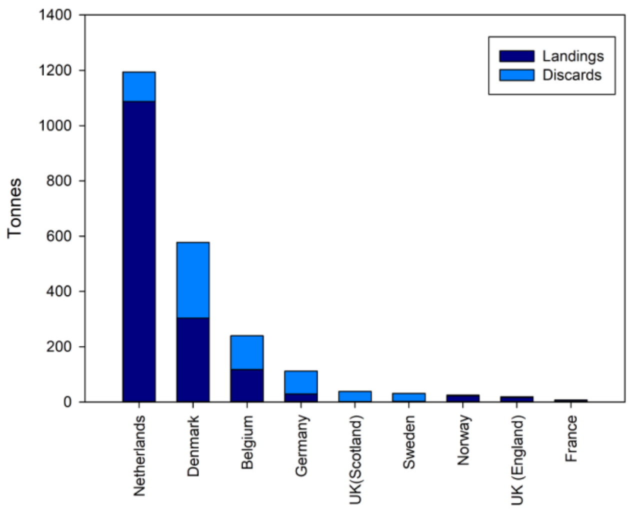

Figure 6.7. Flounder in Subarea 4 and Division 3.a: Flounder landings and discards by country in 2018 estimated with InterCatch.

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 even a higher catchability compared to the beam trawl surveys conducted in quarter 3. However, the IBTSQ1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. Further, 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 beam trawl surveys (BTS) use a beam trawl and are designed for catching flatfish. However, they are carried out in quarter 3, in a time of year in which flounder still maybe distributed in more coastal, shallow and brackish waters.

The mature biomass index (kg/hour) was based on the IBTSQ1 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 available IBTSQ1 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.

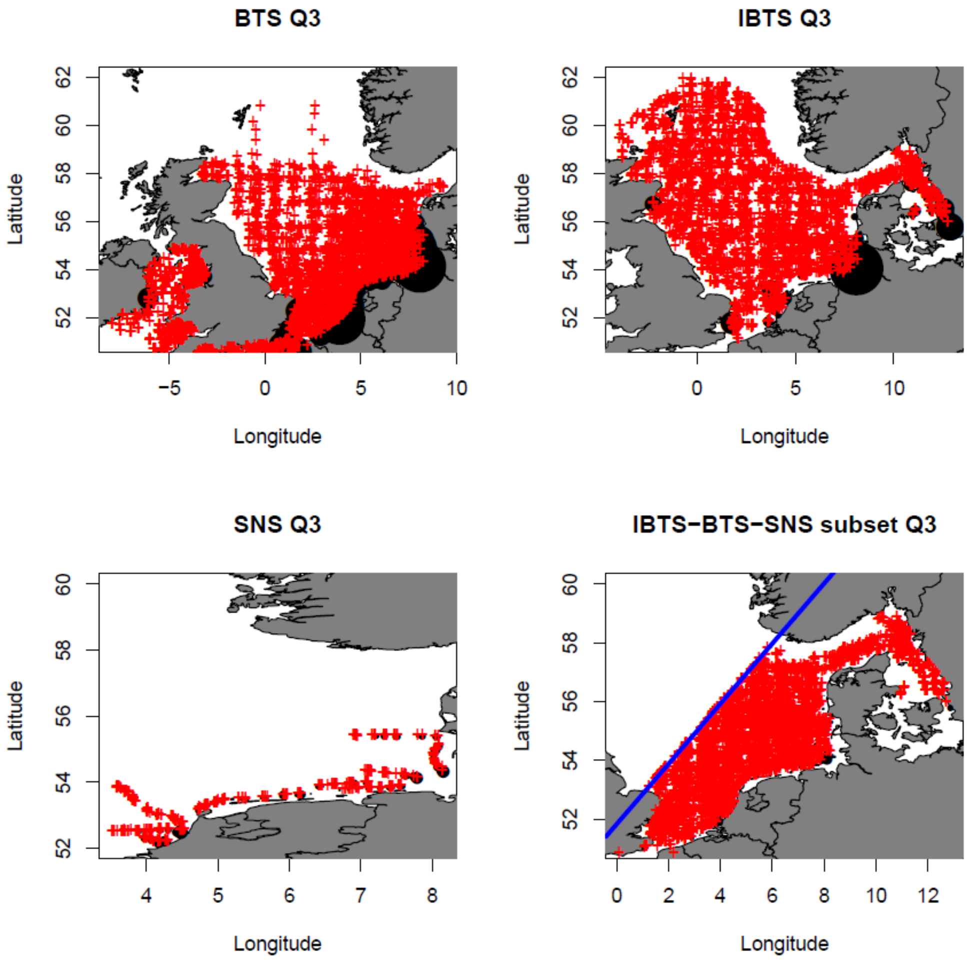

Figure 6.8. Flounder in Subarea 4 and Division 3.a: Distribution of flounder derived from different bottom trawl surveys in Subarea 4 and Division 3.a and the defined index area (lower right panel).

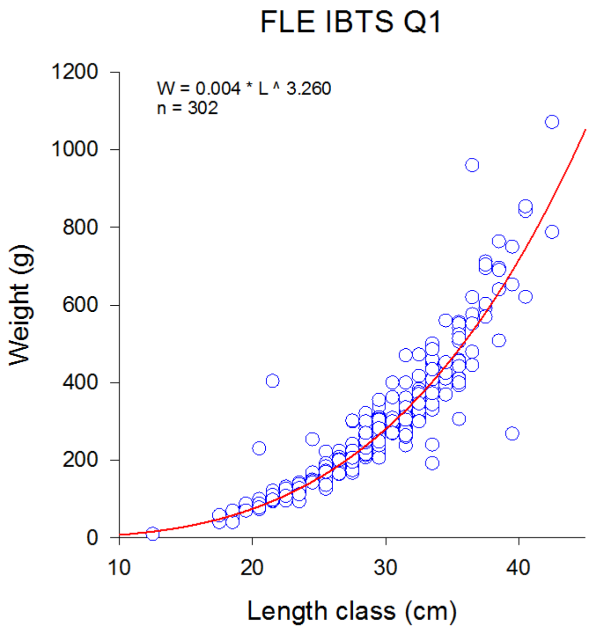

Figure 6.9. Flounder in Subarea 4 and Division 3.a: Length weight relationship of flounder derived from IBTS–Q1 data.

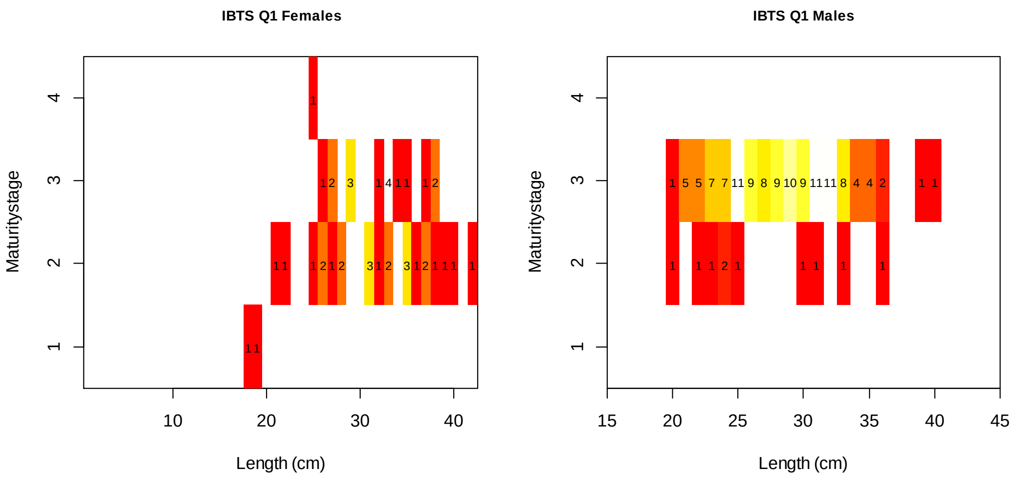

Figure 6.10. Flounder in Subarea 4 and Division 3.a: Maturity at length of female and male flounder derived from IBTS–Q1 data.

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. In 2019 the index only slightly increase and stayed on the same level as in the previous year.

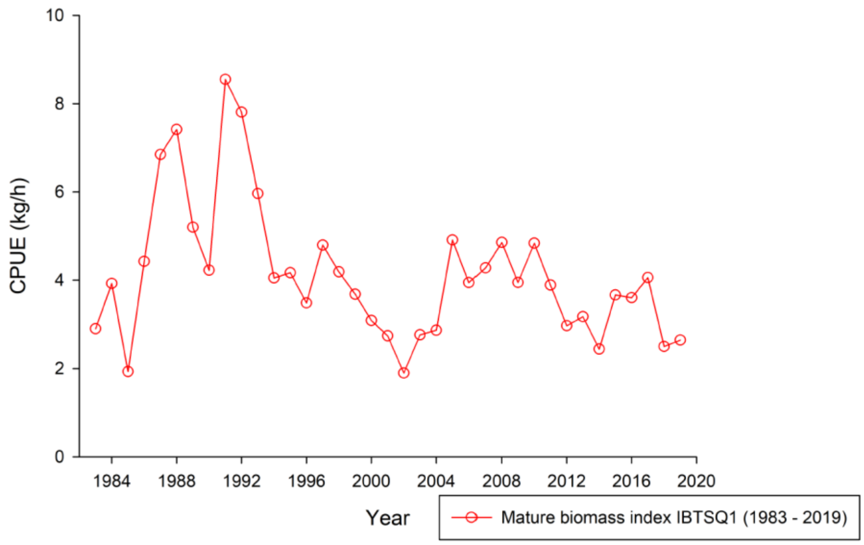

Figure 6.11. Flounder in Subarea 4 and Division 3.a: Mature biomass index of flounder in Subarea 4 and Division 3.a derived from IBTS–Q1 data 1983–2019.

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 compared to 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 left panel). 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.

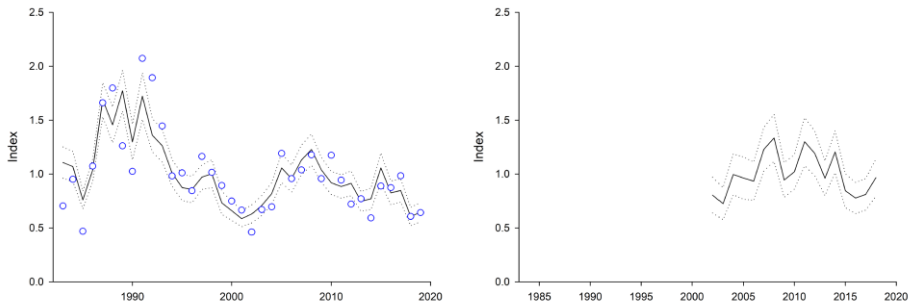

Figure 6.12. Flounder in Subarea 4 and Division 3.a: IBTS Quarter 1 biomass index (left panel; black line = deltaGAM index, blue dots = old mature biomass index) and combined quarter 3 biomass index (right panel).

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 2019 with the most recent catch and survey data. The results are summarized below. Details on the settings of the model can be found in the benchmark report (ICES, 2018a). However, updating the SPiCT assessment model with 2017 and 2018 data increased the uncertainties to unacceptable levels and the assessment was rejected.

Input data

Based on the InterCatch raising procedure a catch time series for the years 2002–2018 was available and used (Figure 6.13). 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 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 (ICES, 2018a).

A biomass index from the IBTS quarter 1 (1983–2019) and a biomass index combining the quarter 3 surveys IBTS, BTS and SNS (2002–2018) were used (Figure 6.13). These indices were calculated by applying the deltaGAM method (Berg *et al.*, 2014).

The results 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. However, updating the SPiCT assessment model with 2017 and 2018 data increased the uncertainties to unacceptable levels (Figure 6.14) and the SPiCT model was thus not accepted. It was therefore decided to use the Length Based Indicator method to check the exploitation status of flounder in relation to F_{MSY} proxies (see Section 6.4.2).

The SPiCT model uses the following input data and settings:

- catch time series 1983–2018
- InterCatch data 2002–2018
- reconstructed Dutch landings for time period 1984–1997 by applying average Dutch landings proportion 1974–1983 (0.64)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002–2016)

- deltaGAM Index Q1 (1983–2019), deltaGAM combined index Q3 (2002–2018)
- Different uncertainties were applied for different time periods:
    - + (4) 1983–1997
    - + (3) 1998–2001
    - + (2) 2002–2010
    - + (1) 2011–2018
- priors on sd log(n) set to 1

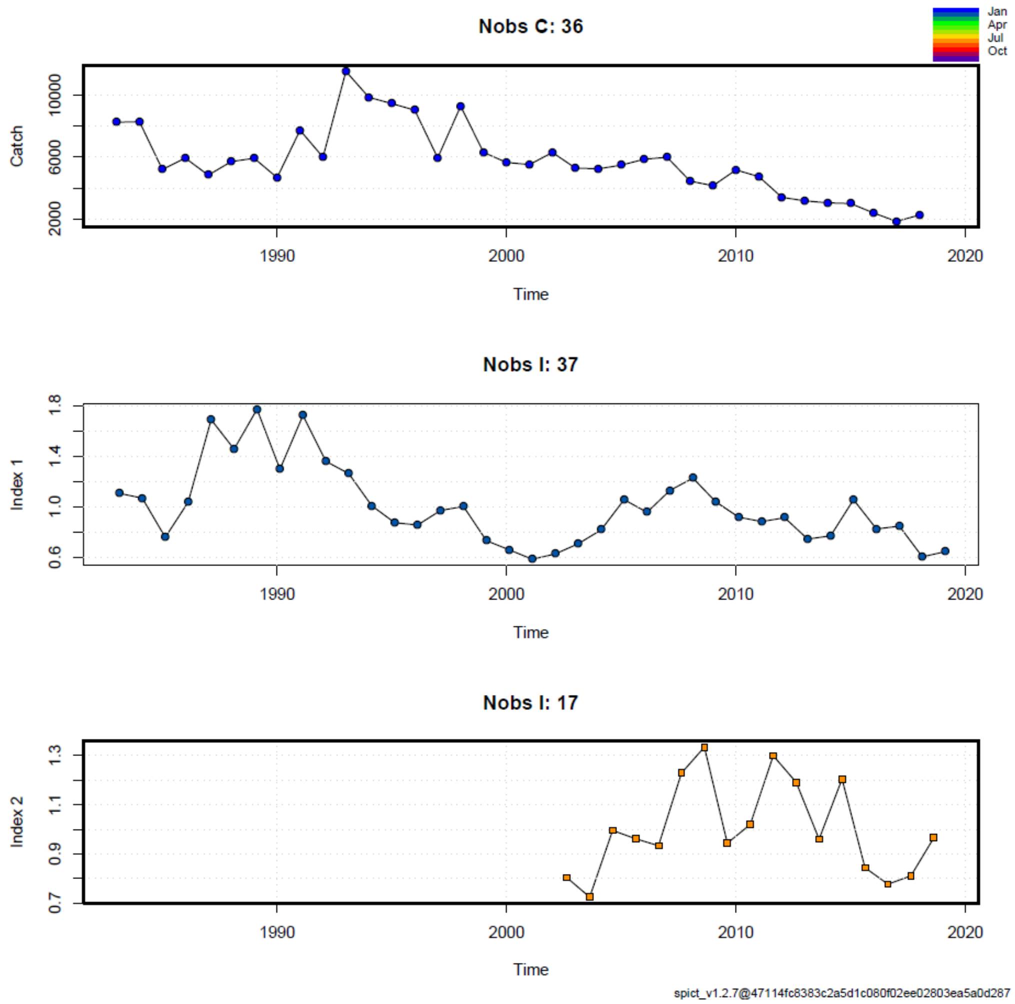

Figure 6.13. Flounder in Subarea 4 and Division 3.a: Input data for the SPiCT model: catch time series (upper panel), IBTS Q1 index (middle panel), and combined quarter 3 index (lower panel).

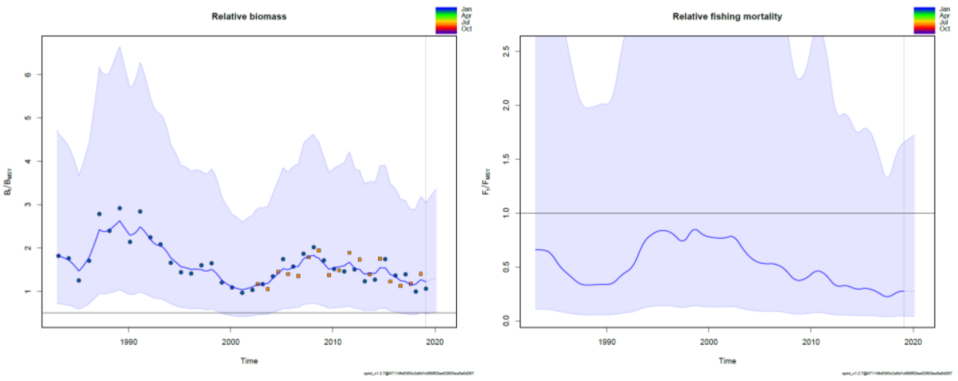

Figure 6.14. Flounder in Subarea 4 and Division 3.a: Relative biomass (left panel) and relative fishing mortality obtained from the SPiCT assessment.

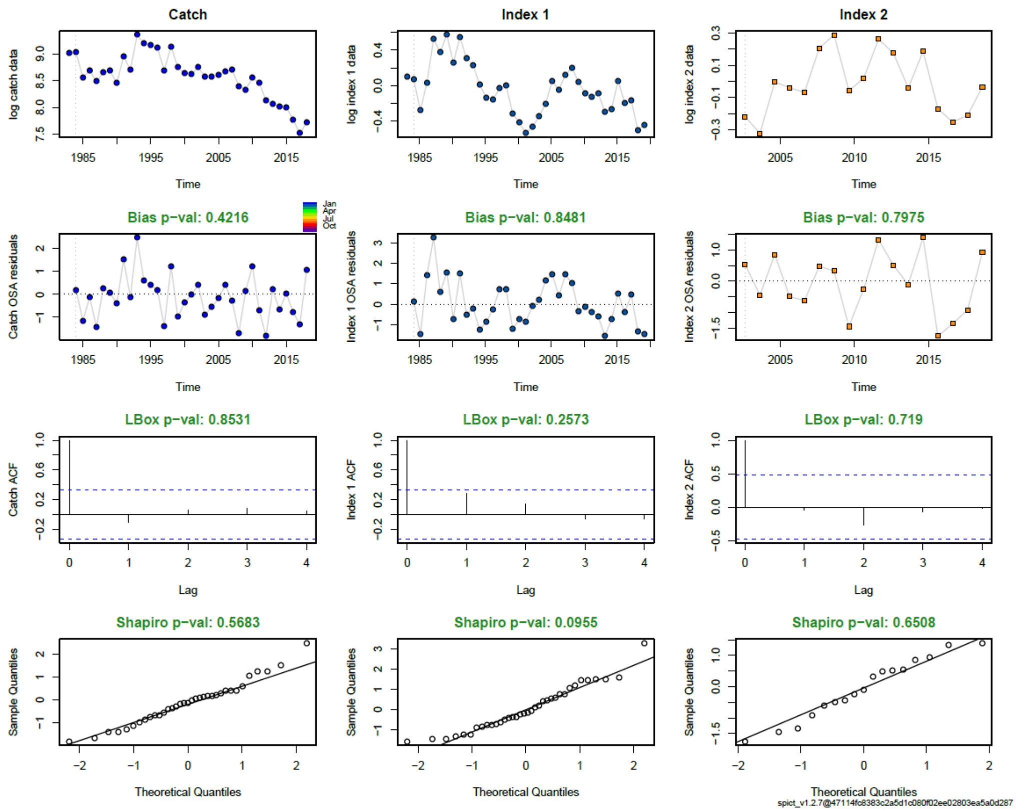

Figure 6.15. Flounder in Subarea 4 and Division 3.a: Model diagnostics of the SPiCT assessment.

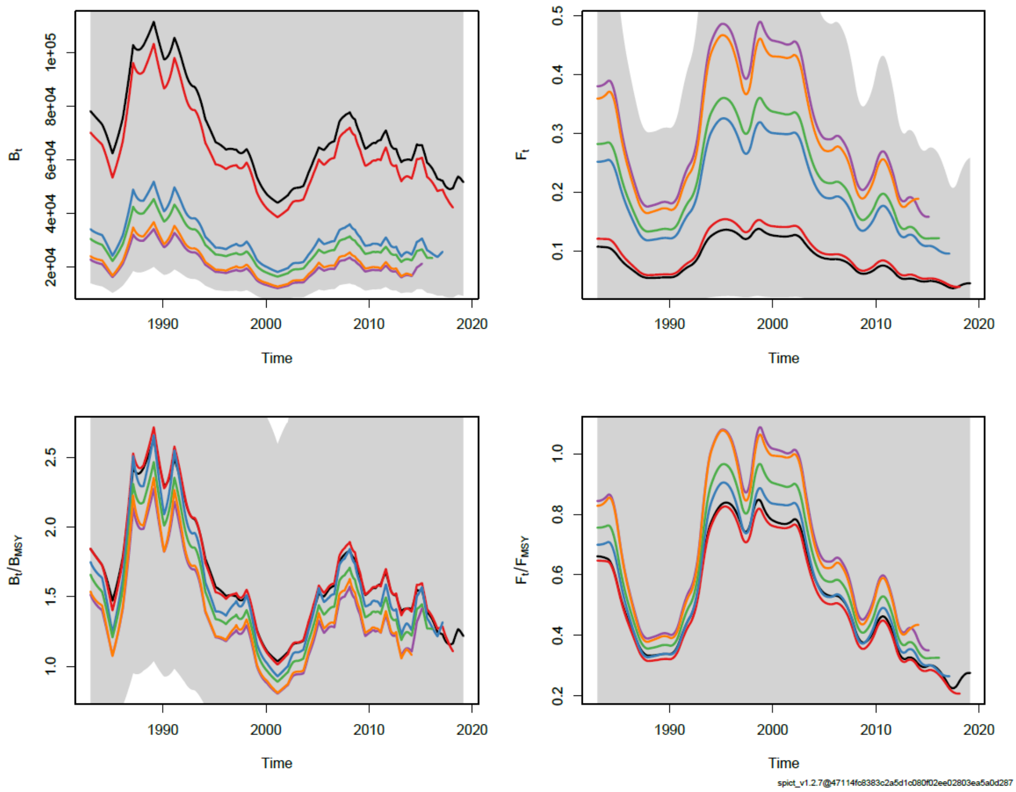

Figure 6.16. Flounder in Subarea 4 and Division 3.a: Retrospective diagnostics for the SPiCT model.

6.4.2 Length based indicators

Flounder length samples (sex combined) from commercial catches were provided in InterCatch format for the years 2014–2018. These data were used for the analyses of MSY proxies applying the Length Based Indicator method (LBI; ICES 2017). The commercial length data show incoming recruitment peaks for some of the years (Figure 6.17). Since the LBI method assumes constant recruitment, the data sets were reduced by length classes below 16 cm (corresponding to ages below 2 years) for the analyses. Further, the length distributions were binned to 30 mm length classes. The method also requires growth parameters, which were taken from literature (Froese and Sampang, 2013; Table 6.1).

The results of the LBI method showed that most of the indicators are above the reference points (Table 6.2). Only the P_{mega} indicator decreased since 2014 and dropped below the 30% reference point in 2018. The L_C / L_{mat} ratio fluctuated around 1 but was above in 2018. In terms of the F_{MSY} proxy $L_{mean}/L_{F=M}$ the indicator ratio is above 1 for all the years (Table 6.2; Figure 6.20). From these results it was concluded that flounder is currently exploited below F_{MSY}.

Table 6.1. Flounder in Subarea 4 and Division 3.a. Parameters used as input for the LBI method.

Parameter	Sex combined
von Bertalanffy L∞ (cm)	41
von Bertalanffy k (yr^{-1})	0.36
Length-weight a	0.00867
Length weight b	3.06
Natural mortality M (yr^{-1})	0.2
Length-at-maturity (mm)	21
Natural mortality M	0.2

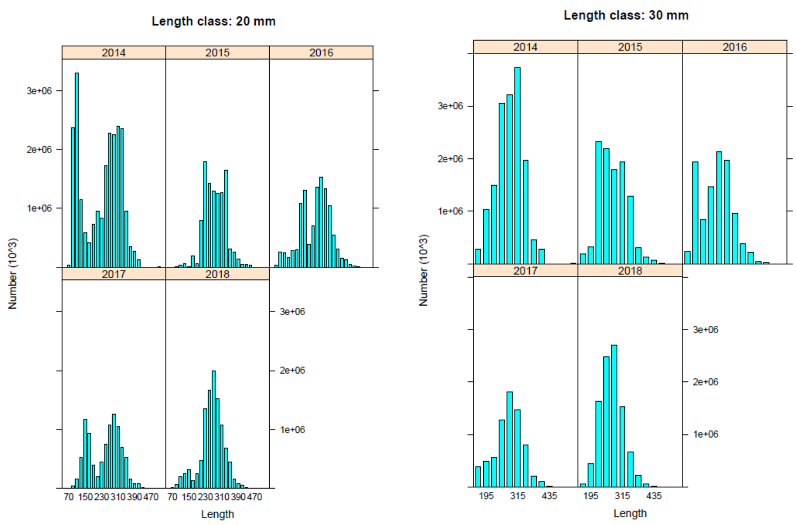

Figure 6.17. Flounder in Subarea 4 and Division 3.a. Left panel: Length distribution (20 mm length classes) from InterCatch 2014–2018. Right panel: Binned to 30 mm and reduced by incoming recruits (>150 mm, right panel) as used in the analyses.

Table 6.2. Flounder in Subarea 4 and Division 3.a. Length Based Indicator table displaying the reference points and indicators based in InterCatch length sample data 2014–2018.

	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	0.90	1.21	0.94	0.42	1.06	1.18
2015	1.10	1.12	0.95	0.36	1.06	1.06
2016	0.90	1.02	0.97	0.35	1.02	1.14
2017	0.81	1.17	0.94	0.37	1.03	1.22
2018	1.10	1.17	0.91	0.26	1.04	1.04

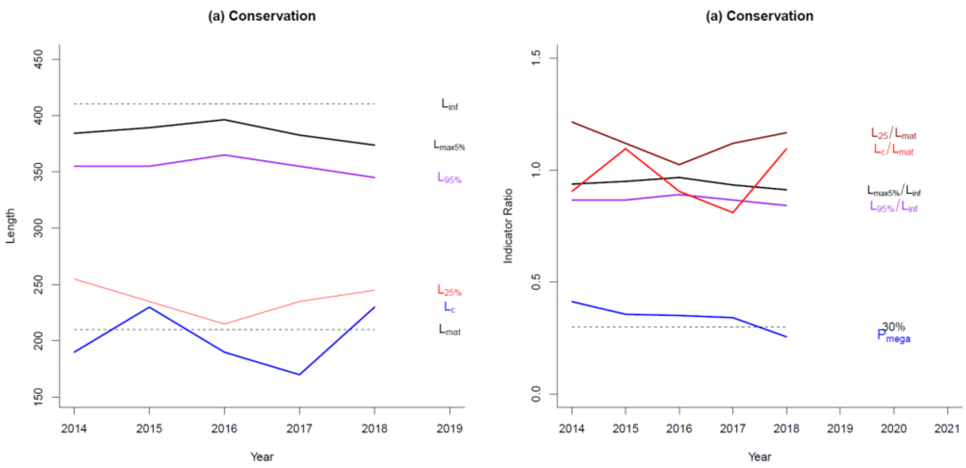

Figure 6.18. Flounder in Subarea 4 and Division 3.a. Conservation indicators (left panel) and indicator ratios (right panel).

Figure 6.19. Flounder in Subarea 4 and Division 3.a. Optimum yield indicators (left panel) and indicator ratios (right panel).

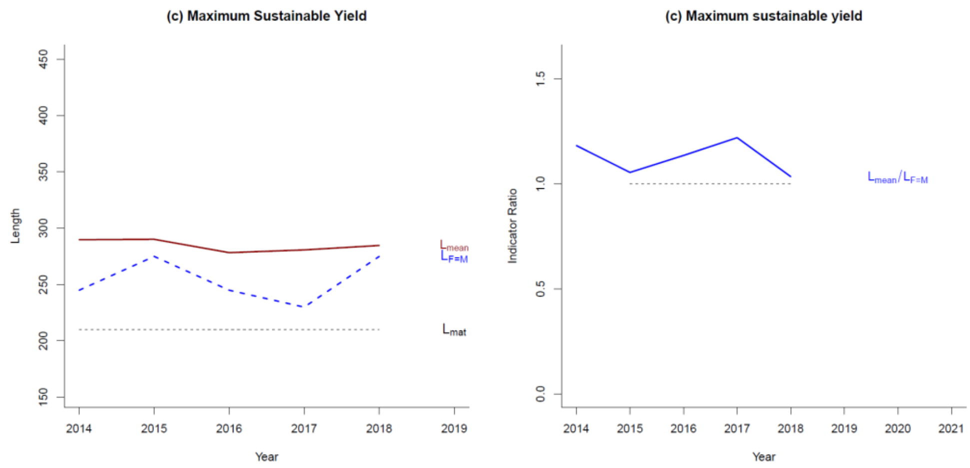

Figure 6.20. Flounder in Subarea 4 and Division 3.a. Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

6.5 Issues List

- Métiers with zero landings but no discards reported. No raising possible for these cases. What is the possible impact on catch estimation? Are there other ways to estimate discards for these métiers?
- No suitable data available for the shrimper fleets operating in coastal waters. No raising possible for these fleets. What is the possible impact on catch estimation? Is there another way to estimate the discards of these fleets?
- SPiCT model not acceptable any longer. Investigate what could be done/changed to improve the model (e.g. include effort data).
- Investigate the use of alternative stock indices (DYFS, DFS, others?) which are able to better reflect the stock status.
- Investigate again length based methods for the estimation of MSY proxies with the new data available (e.g. MLZ, LBI, LBSPR). The LBI was first used for the advice prepared in 2017 and reviewed (ICES, 2017a). However, the LBI never went through a benchmark workshop.

6.6 References

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6.7 Tables

Table 6.3. 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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
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
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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
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	0	28	944	1	14	0	1185
2018*	104	114	n.a.	23	1130	1	18	0	1390

***Preliminary catch statistics**

Table 6.4. 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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
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
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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
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	106	0	0	0	3	109
2017*	153	0	0	1	5	159
2018*	189	0	0	0	3	192

*** preliminary catch statistics**

Table 6.5. 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

Year	Division 3.a	Subarea 4	Total
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
2005	482	3946	4428
2006	393	4616	5009
2007	445	3620	4065

Year	Division 3.a	Subarea 4	Total
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	1873	2067
2015	77	1836	1913
2016	109	1630	1739
2017*	159	1103	1262
2018*	192	1390	1582

*** preliminary catch statistics**

Table 6.6. 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	6301	33.07%
2003	4110	3922	1370	5292	25.89%
2004	4772	4601	637	5238	12.16%
2005	4428	4214	1265	5479	23.09%
2006	5009	4837	1026	5863	17.50%
2007	4065	3908	2082	5990	34.76%
2008	3240	3067	1376	4443	30.97%
2009	3088	2804	1342	4146	32.38%
2010	3365	3166	3087	6253	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	3034	37.15%
2015	1883	1762	1228	2990	41.07%
2016	1738	1750	628	2378	26.41%
2017	1262	1244	588	1832	32.10%
2018	1582	1587	657	2244	29.28%

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 (2012–2018) were available. Official landings data are incomplete or were not reported specifically for grey gurnard in the past. During the WGNSSK 2019 new available discard and landings data and IBTS mature biomass indices were updated. 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 three 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. 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.

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 grey 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 7.4–7.6). 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 7.5) because of Danish landings for reduction purposes. After this peak, the Danish landings dropped again to low levels. Compared to 2017 the official landings in 2018 decreased from 3203 tonnes to 1600 tonnes. However, the comparatively high value from 2017 is probably due to the fact that in this year Danish grey gurnard industrial bycatch was included in the official landings data. The average official landings for the last ten years (2009–2018) was 1147 tonnes. Official landings data from 1950 to 2005 were taken from the "ICES catch statistics 1950 to 2010" (http://www.ices.dk/marine-data/Documents/CatchStats/HistoricalLandings1950-2010.zip). Data from 2006 to 2016 were taken from the "ICES catch statistics 2006 to 2016" (http://www.ices.dk/marine-data/Documents/CatchStats/OfficialNominalCatches.zip). Data for 2017 and 2018 were taken from the preliminary catch statistics provided by ICES (http://data.ices.dk/rec12/login.aspx).

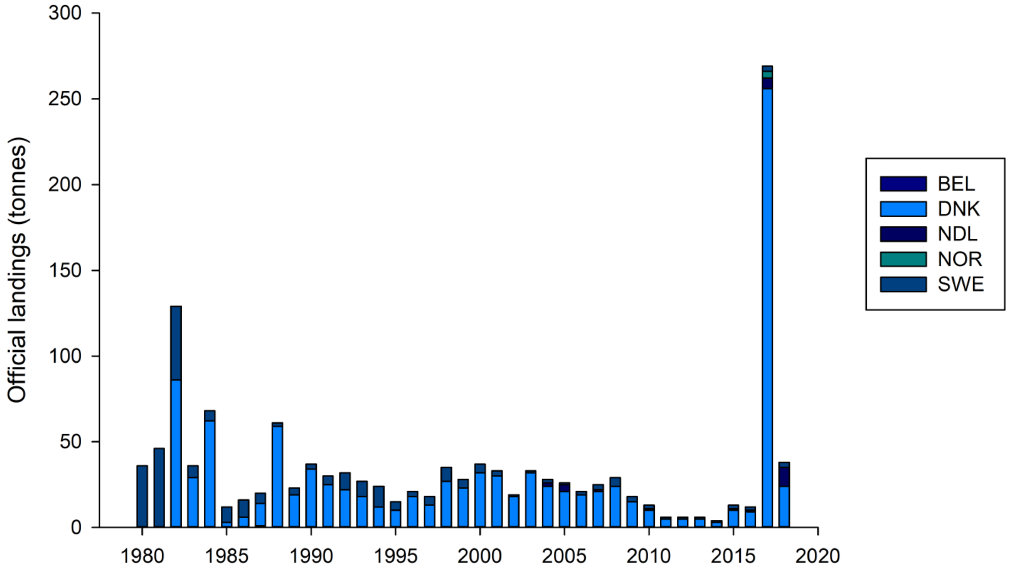

Figure 7.1. Grey gurnard in Subarea 4, Division 3.a and Division 7.d: Official landings of grey gurnard in Division 3.a 1980–2018.

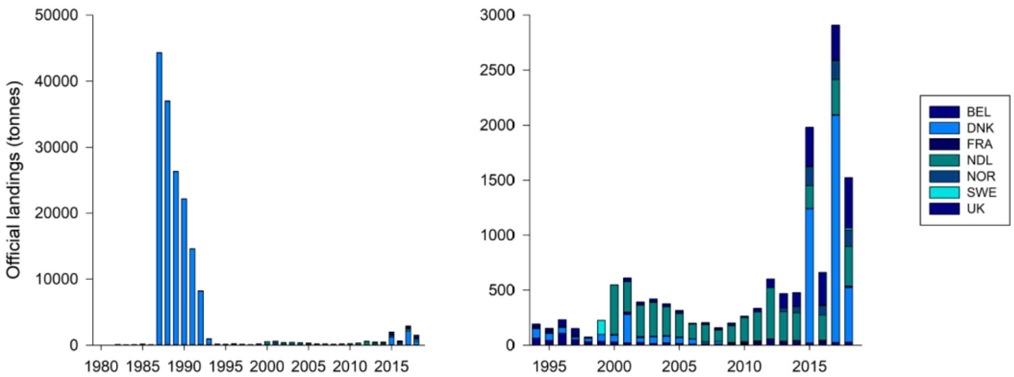

Figure 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Subarea 4 by country for the years 1980–2018 (a), and official landings of grey gurnard by country in Subarea 4 since 1993 only (b).

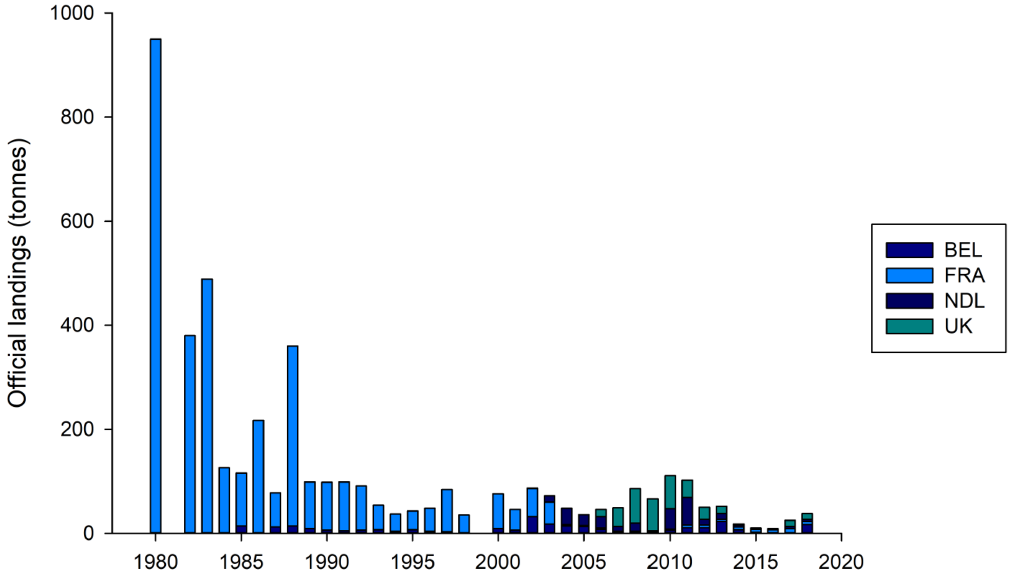

Figure 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings by country of grey gurnard in Division 7.d for the years 1980–2018.

7.2.2 InterCatch data

InterCatch contains now data for the years 2012–2018. The largest amount of landings in 2018 was reported by Scotland for the OTB_DEF_>=120_0_0_all metier (331 tonnes). Considerable amounts of landings were also reported by The Netherlands (132 tonnes, TBB_DEF_70-99_0_0_all), Germany (93 tonnes, TBB_DEF_70-99_0_0_all), Norway (126 tonnes, MIS_MIS_0_0_0_HC), and England (112 tonnes, OTB_DEF_70-99_0_0_all). For all other metiers the landings were below 80 tonnes (Figure 7.4). For all countries the amount of discards exceeded by far the amount of landings (Figure 7.5). The largest amounts of discards were reported for the German (1520 tonnes) and Dutch (933) TBB_DEF_70-99_0_0_all metiers, and the Scottish OTB_DEF_>=120_0_0_all metier (1303 tonnes).

The largest amount of discards was estimated for the UK England OTB_DEF_70-99_0_0_all metier (682 tonnes raised discards). The total catch estimated with InterCatch for the year 2018 was 11 419 tonnes from which 1282 tonnes were landings (11%) and 10 136 tonnes estimated discards (89% of total catch). In total The Netherlands took the largest proportion of the total catch in 2018 with a high amount of discards, followed by Germany, UK Scotland, and UK England.

In general it was attempted to use the same groupings for discard raising as for the previous data years. However, this was not possible for all cases and compared to the previous year slight changes had to be made. The grouping is based on gear type and mesh size over areas and season. For the sample allocation scheme only one landing and one discard group was set up, because data availability did not allow for a higher resolution. The following groupings were used for the 2018 data discard raising:

Group 1: all passive gears -> only one passive gear métier with discard ratio zero available. Therefore these métiers were raised with all other métiers.

Group 2: MIS_MIS_HC -> There were no discard data available for this metier. Therefore, it was raised with all other métiers.

Group 3: TBB_DEF_70-99_0_0_all -> rasied with all other TBB_DEF_70-99_0_0_all métiers available. Also one Dutch TBB_DEF_100-119_0_0_all metier without discard data was included in this group.

Group 4: TBB_DEF_>=120_0_0_all -> Raised with TBB_DEF_>=120_0_0_all (only one Dutch métier available).

Group 5: OTB_CRU_70-99_0_0_all -> Raised with all OTB_CRU_70-99_0_0_all métiers available.

Group 6: OTB_DEF_120_0_0_all –> Raised with all OTB_DEF_120_0_0_all métiers available.

Group 7: OTB_DEF_100-119_0_0_all –> Raised with all OTB_DEF_100-119_0_0_all métiers available.

Group 8: OTB_DEF_70-99_0_0_all -> Raised with all OTB_DEF_70-99_0_0_all métiers available.

Group 9: SSC_SDN_DEF_>=120_0_0_all -> Raised with all SDN_DEF_>=120_0_0_all métiers available.

Group 10: SSC_DEF_100-119_0_0_all -> No SSC_DEF_100-119_0_0_all métiers available. Therefore raised with all OTB_DEF_100-119_0_0_all (only Dutch fleet available).

Group 11: SSC_DEF_70-99_0_0_all and SSC_DEF_ALL_0_0_ALL -> No discard data available for these métiers. Therefore raised with OTB_DEF_70_99_all métiers.

Group 12: OTB_CRU_>=120_0_0_all -> raised with OTB_DEF_>=120_0_0_all métiers.

Some métiers were not raised because no suitable data were available or they were negligible:

- MIS_MIS_0_0_0_IBC
- OTB_DEF_<16_0_0_all
- OTB_SPF_32-69_0_0_all
- OTB_CRU_16-31_0_0_all
- PS_SPF_0_0_0
- TBB_CRU_16-31_0_0_all

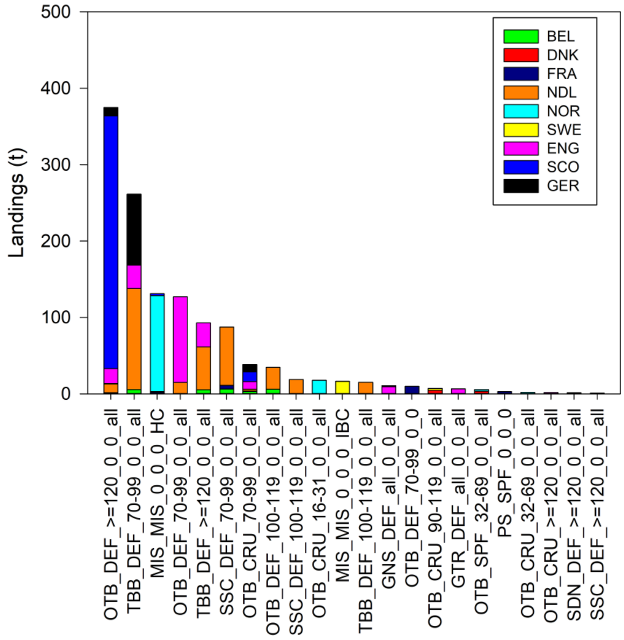

Figure 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard landings in 2018 by metier and country as uploaded into InterCatch.

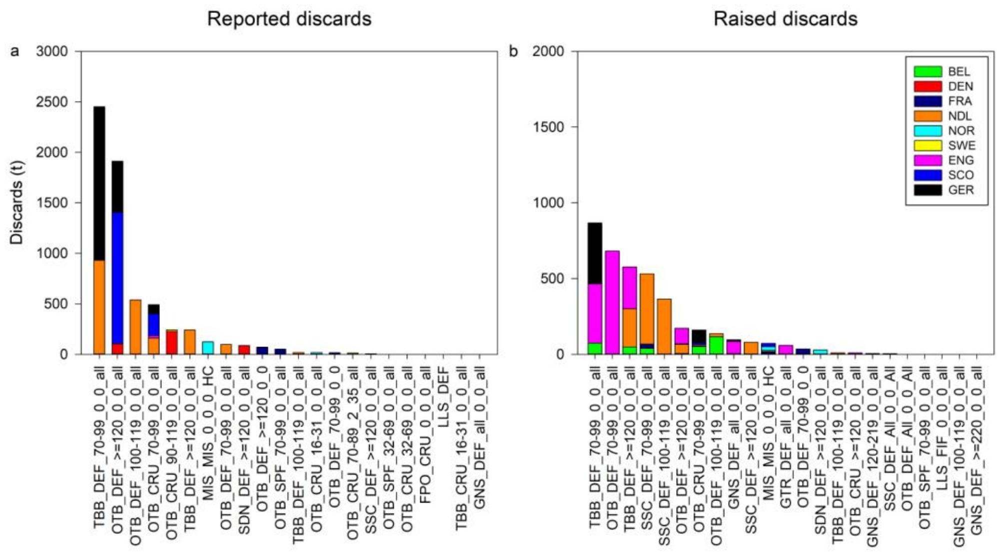

Figure 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard discards in 2018 by metier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

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 metiers, with highest values observed for the SSC_DEF metiers. 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).

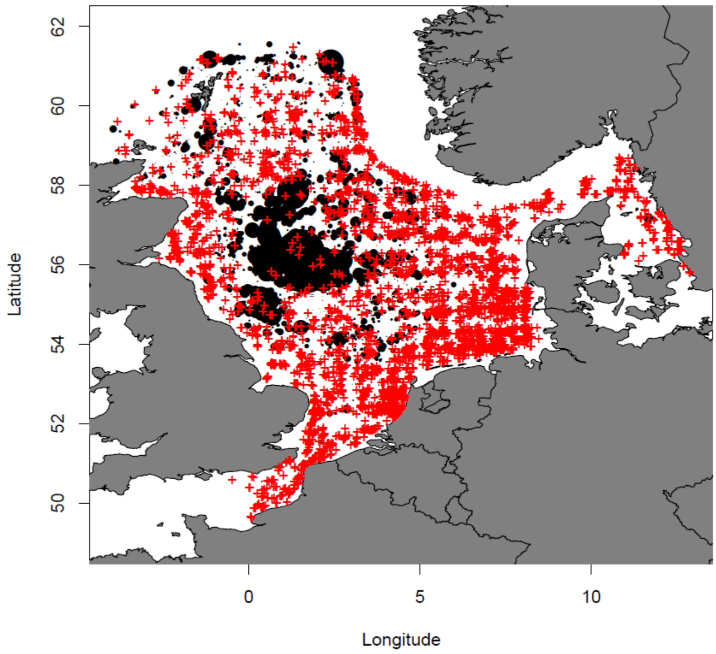

Figure 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Spatial distribution of grey gurnard from IBTS–Q1 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

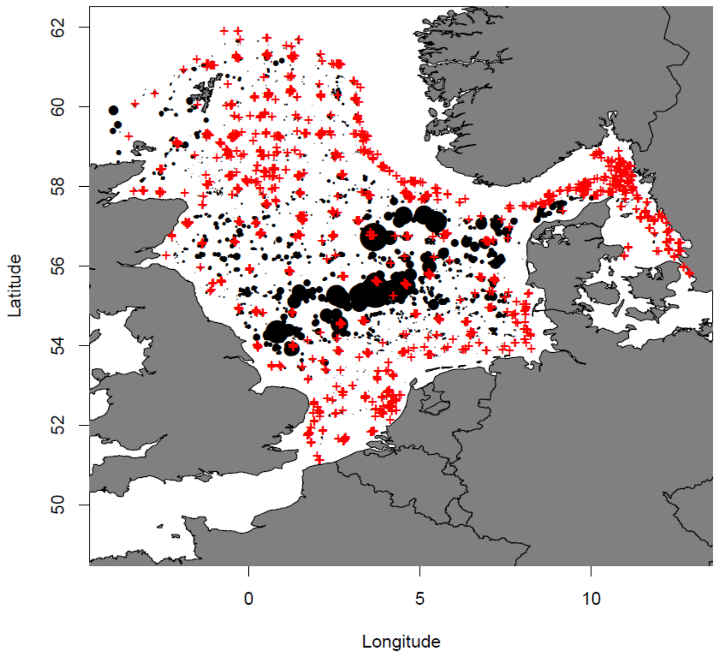

Figure 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q3 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

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.

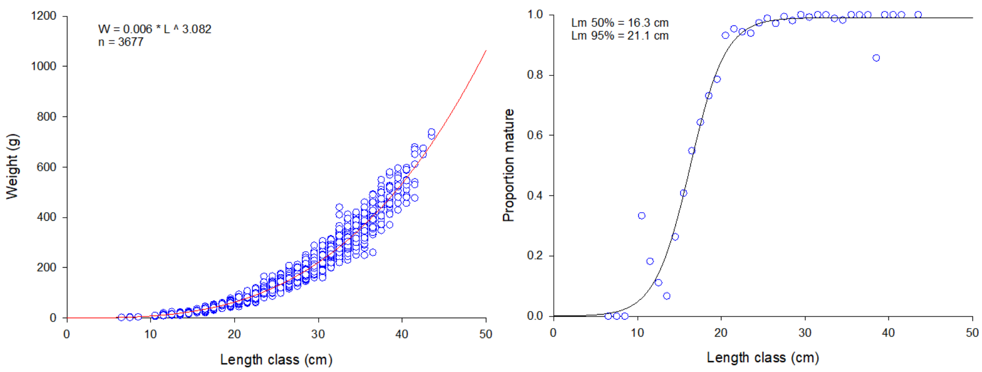

Figure 7.8 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length-weight relationship from IBTS CA data (left panel); maturity ogive obtained from IBTS CA data (right panel).

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 7.7).

Since then it was fluctuating on a high level until 2017. A strong decline of the index was observed for the year 2018. In 2019 the index value was only slightly higher compared to the 2018 value. The mature biomass index for the IBTS–Q3 does not show the same pronounced increasing trend compared to the quarter 1 index but the 2014 value was the highest observed in the time series ever. Since then the IBTS–Q3 index decreased 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 distribution area.

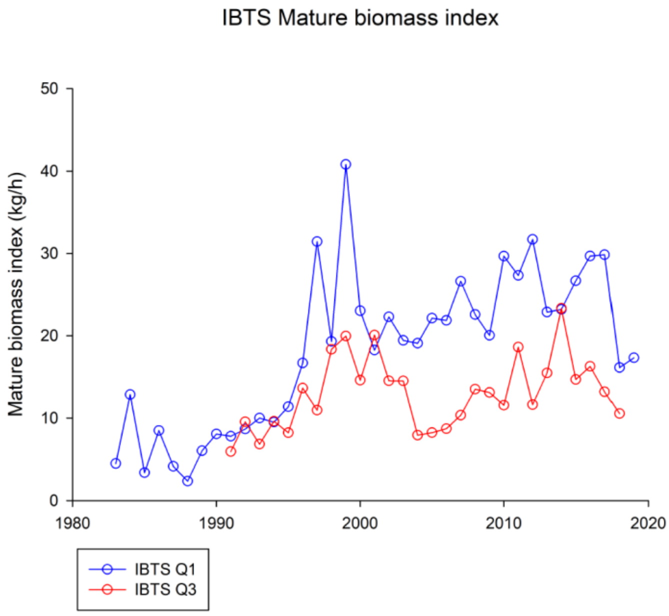

Figure 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: IBTS–Q1 and IBTS–Q3 grey gurnard mature biomass index.

7.6 MSY Proxies

7.6.1 Length Based Indicators (LBI) - update

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 in detail in the previous year WGNSSK report (ICES, 2018). The length frequency distributions were binned into 20 mm size classes and all show a unimodal distribution (Figure 7.10). 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 four years (Figure 7.11 and Table 7.2 and Table 7.3). For the $L_{max5\%}$ / L_{inf} reference point the indicator is only above the reference point for the last two years. The P_{mega} was for the years 2015–2017 below the reference of 30%, but is now above it for the last data year. With respect to optimum yield and MSY the indicators are above the reference points for the last two data years (Figure 7.12 and Figure 7.13). It was concluded that the exploitation for this stock was below F_{MSY} in the year 2018 and that there is no need to reopen the previous advice.

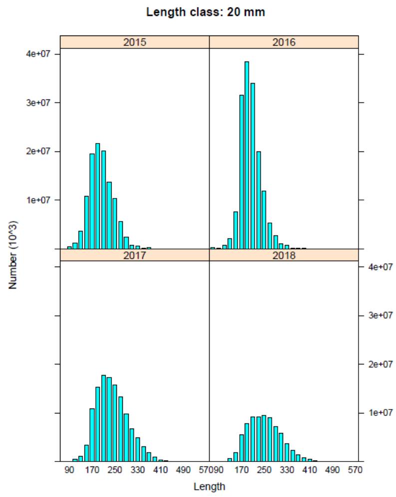

Figure 7.10 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Obtained length frequency distributions binned into 20 mm size classes.

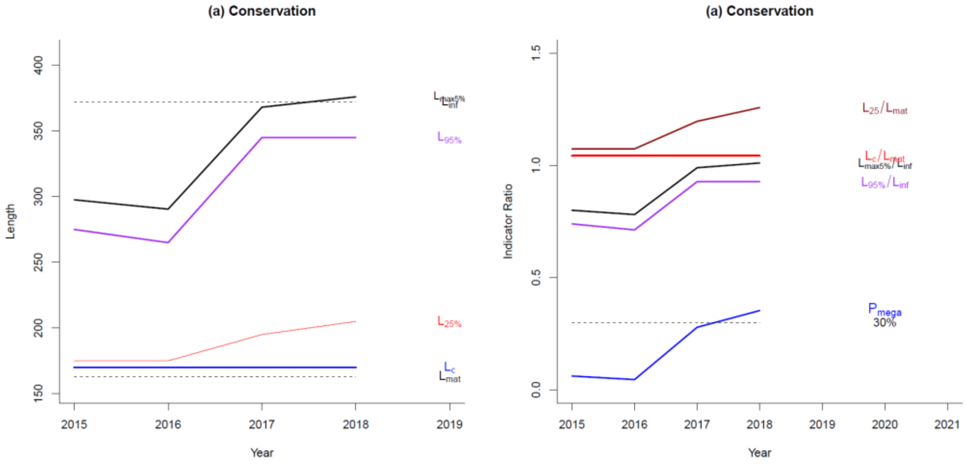

Figure 7.11 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Conservation indicators (left panel) and indicator ratios (right panel).

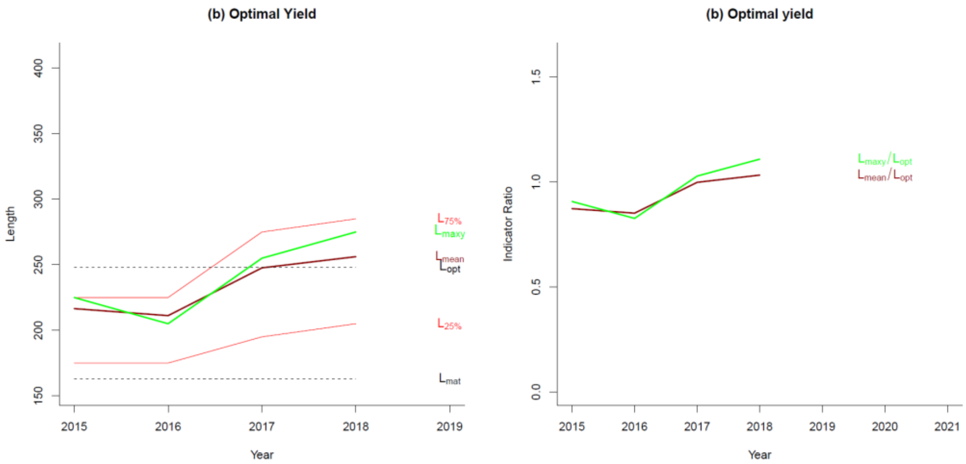

Figure 7.12 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Optimum yield indicators (left panel) and indicator ratios (right panel).

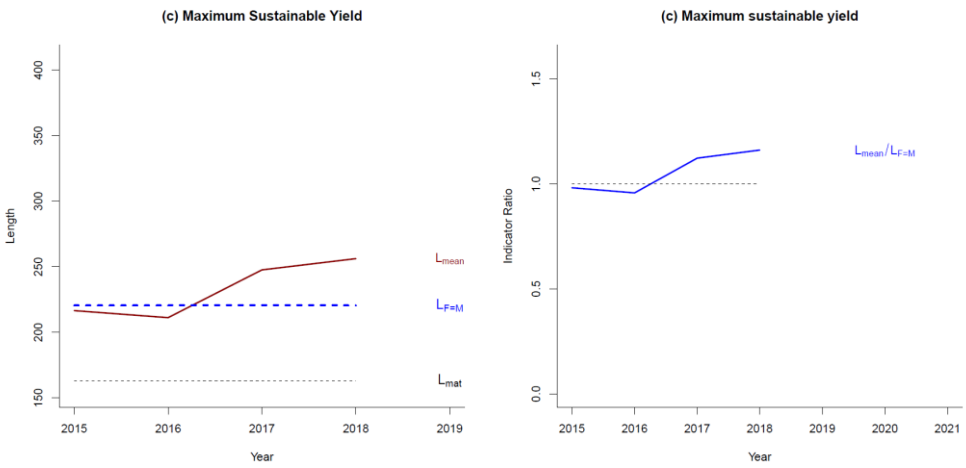

Figure 7.13 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

Table 7.2 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	216.53	170	220.5	225	163	248	372	297.77
2016	225	175	195	245	265	211.17	170	220.5	205	163	248	372	290.57
2017	275	195	235	315	345	247.62	170	220.5	255	163	248	372	368.15
2018	285	205	245	325	345	256.17	170	220.5	275	163	248	372	376.01

Table 7.3 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
	LC/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**
2018	**1.04**	**1.26**	**1.01**	**0.35**	**1.03**	**1.16**

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 (2012–2018).

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 Issues list

At the moment there seem not to be any major issues which could be improved in the near future. The available data (landings, discards, length samples) are uploaded into InterCatch and are used for the assessment. The used survey indices are well suitable for this stock as the IBTS covers most of the stock distribution area and shows a good catchability for this species.

There are some issues with the reporting of grey gurnard for some nations, e.g. Germany does not officially report grey gurnard but only a generic gurnard group in which also other gurnard species are included. This is usually not corrected for when uploading data to InterCatch. This is similar to the UK data for which a ratio from survey data was used to correct for the proportion of other gurnard species. However, also this method will introduce a bias in the final estimates because the survey abundance does not necessarily reflect what is landed or discarded in the fishery.

For some fleets zero landings are reported, but at the same time no discards are reported. For these cases it is not possible to raise any discards in InterCatch, although high discards may occur in these fleets. It is not known how this affects the estimation of the total catch within InterCatch.

Biological data are not collected on a routine basis for grey gurnard on the IBTS. However, from time to time new data are available via DATRAS and the availability of these data should be checked yearly.

7.9 References

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7.10 Catch and index tables

Table 7.4. 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

Year	BE	DK	NL	NO	SE	Total
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	10	0	1	2	14
2016	0	13	1	0	2	16
2017	0	256	6	4	3	269
2018	0	24	11	0	3	38

Table 7.5. 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

Year	BE	DK	FR	NL	NO	SE	UK	Total
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	1151	6	232	83	6	297	1806
2017	24	2067	4	320	172	8	314	2909
2018	27	497	14	360	149	16	461	1524

Table 7.6. 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

Year	BE	FR	NL	UK	Total
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
2018	17	6	4	11	38

Table 7.7. 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	4.48	
1984	12.85	
1985	3.38	
1986	8.49	
1987	4.15	
1988	2.35	
1989	6.03	
1990	8.07	
1991	7.80	5.93
1992	8.67	9.55
1993	10.01	6.84
1994	9.51	9.62
1995	11.38	8.22
1996	16.68	13.63
1997	31.44	10.96
1998	19.31	18.35

Year	IBTS–Q1	IBTS–Q3
1999	40.80	19.96
2000	23.04	14.59
2001	18.26	20.08
2002	22.29	14.53
2003	19.44	14.52
2004	19.08	7.93
2005	22.13	8.23
2006	21.87	8.71
2007	26.62	10.35
2008	22.58	13.52
2009	20.04	13.10
2010	29.67	11.56
2011	27.33	18.63
2012	31.70	11.64
2013	22.88	15.47
2014	23.20	23.33
2015	26.68	14.68
2016	29.69	16.28
2017	29.84	13.19
2018	16.14	10.54
2019	17.32	

Table 7.8. 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
1983	589				
1984	265				
1985	301				
1986	326				
1987	44422				
1988	37445				
1989	26470				
1990	22303				
1991	14741				
1992	8365				
1993	1060				
1994	254				
1995	211				
1996	301				
1997	253				
1998	145				
1999	254				
2000	661				
2001	690				
2002	499				
2003	525				
2004	452				
2005	378				
2006	267				
2007	279				
2008	273				
2009	285				
2010	390				

Year	Official landings	ICES Landings	ICES catches	ICES discards	Discard rate
2011	442				
2012	658	689	8345	7656	0.92
2013	528	1180	10230	9050	0.88
2014	500	1892	8596	6704	0.78
2015	2028	2141	8451	6310	0.75
2016	682	2156	12129	9973	0.82
2017	3203	3451	17121	13670	0.80
2018	1600	1282	10136	11419	0.89

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, 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 2014 year-class form the bulk of haddock catches in 2018, and the growth of this year class beyond the minimum conservation reference size (MCRS) has led to a decline in the discarding rate for 2018. Previous changes in discarding rates may also have been due to other measures related to the Scottish Conservation Credits scheme (CCS; see Section 8.1.4).

Specific information on changes in the Scottish fleet during 2011–2018 was not provided to WGNSSK in 2019. 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: 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 2018

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

8.1.3.2 ICES advice for 2019

Subarea 4, Division 6.a and Subdivision 20

The advice for 2019 was updated in November 2018:

ICES advises that when the MSY approach is applied, total catches in 2019 should be no more than 33 956 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 did not occurred as the basis for management of shared EU-Norway stocks was not agreed. More recently, in 2018, EU-Norway requested an evaluation of multiple management strategies (ICES, 2019a), which are currently under consideration. 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.

The EU landings obligation was initially implemented from 1 January 2016 for directed haddock fisheries and was fully implemented in the North Sea and North Western Waters from 1 January 2019. A small number of exemptions exist for catches of haddock in ICES division 3.a. These include *de minimis* exemptions for catches of haddock from creels and some bottom trawls targeting *Nephrops* or Northern prawn. A survivability exemption exists for haddock caught using pots and fyke nets.

Annual management of the fishery operates through TACs for three discrete areas. The first is Subarea 4 (and EU Waters of 2.a). The 2018 and 2019 TACs for haddock in this area were 41 767 tonnes and 28 950 tonnes respectively. The second is Division 3.a (EU waters), for which the TACs for 2018 and 2019 were 2569 t and 1780 t respectively. The third is Division 6.a, for which the TACs in 2018 and 2019 were 4654 tonnes and 3226 tonnes respectively.

8.2 Data available

8.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 8.2.1, 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 8.2.1 and Tables 8.2.2 to 8.2.4 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 94% 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 8.2.2), so discard rates for the remaining fleets have also been inferred using simple averaging weighted by landing weight.

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. In 2018, BMS landings were only partially sampled in Scotland (2 out of 4 quarters) resulting in just 28% of the total BMS landings being sampled (see Figure 8.2.3). 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 have not been submitted by any country for haddock since 2016.

The full time series of landings, discards, BMS landings and industrial by-catch (IBC) is presented in Table 8.2.5. These data are illustrated further in Figure 8.2.4. The total landed yield of the international fishery has been relatively stable since 2007. The WG estimates (Table 8.2.5) 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 year on year to 18% in 2016; dropping slightly to 17% in 2017. In 2018, the discard rate has dropped again to 13%. Total catches in 2018 are similar to 2017 suggesting that the drop in discarding is due to more fish being retain; possibly a result of the 2014 year class growing past the MCRS. The recent changes in discarding are not consistent across ages (Figure 8.2.5).

It would be expected that under the EU Landing Obligation fish caught under the 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 2018 are 0.39% of the total catch which is significantly lower than the discard estimate of 12.38% 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, the Netherlands, 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. Division 6.a discard estimates are provided by UK (Scotland) and Ireland. 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 8.1.2). 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 8.2.6, while catch-at-age data for each catch component are given in Tables 8.2.7 to 8.2.10. The fishery in 2018 (landings for human consumption) was strongly reliant on the 2014 year-class. 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.

8.2.3 Weight at age

Weight-at-age for the total catch in the North Sea is given in Table 8.2.11. 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 8.2.12 to 8.2.15 and are illustrated in Figure 8.2.6: 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 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 8.6).

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 8.2.7 and Table 8.2.16. 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, 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 8.2.17. Survey-based abundance distributions by age and year are given in Figures 8.2.8 (North Sea IBTS Q1), 8.2.9 (North Sea IBTS Q3) and 8.2.10 (Scottish West Coast IBTS Q1 and 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 2014 year-class is evident in all three surveys. Abundance trends in survey indices are shown in Figure 8.2.11. These indicate reasonably good consistency in stock signals from the two North Sea surveys, and support the perception of a relatively 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 8.3.1), 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 8.3.2 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 8.3.3. 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 8.3.4. The SAM assessment follows similar trends to the final TSA assessment, although the F estimates are less variable (see also Figure 8.3.10). 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, 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 8.3.5, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The SURBAR residual plot in Figure 8.3.6 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 8.3.7). The plots of mean-standardised log survey indices by age and cohort (Figure 8.3.8) and the pairwise within-survey correlations (Figure 8.3.9) show that both surveys track year-class strength well through the population overall. The results are discussed further in Section 8.3.4 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 8.3.10. 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 mean Z time-series from SAM and SURBAR are consistent with that from TSA though while the SURBAR mean Z estimates tend to be smoother, but the overall trajectory are not different. 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 8.3.1 gives the final TSA assessment settings, while Table 8.3.2 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 8.3.11, with the stock-recruit plot in Figure 8.3.12 and the recruitment time-series in Figure 8.3.13. 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 8.3.14 summarizes 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.

Standardized prediction errors are given in Figures 8.3.15 (landings), 8.3.16 (discard+bycatch+BMS), 8.3.17 (the IBTS Q1 survey) and 8.3.18 (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 down weighted to improve the model fit, but as TSA also includes a backwards smoothing step they cannot be considered to be residuals in the usual sense.

Following the inspection of the standardized prediction errors, this year's assessment includes a new ad-hoc adjustment to the model settings. An outlier was identified in the standardised prediction errors of IBTS Q1 survey data (age 4, 2014) in the base model run. This outlier corresponds to a seemingly erroneous data point in the IBTS Q1 survey index for the 2010 year class: the index value increases as the cohort age from age 3 to age 4 implying that the cohort size is increasing over time. However, it is likely that this is an artefact arising from the 2010 year class's proximity to the significantly large 2009 year class. Down weighting this survey point resulted in a lower model deviance (639.73 to 613.67) and was therefore adopted as the final model run.

The time-series of observed and fitted values for total catch (Figure 8.3.19), the IBTS Q1 survey (Figure 8.3.20) and the IBTS Q3 survey (Figure 8.3.21) 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 the larger 1999 year-classes, whereas survey indices tend to be slightly underestimated for this year class: the TSA model fit is a compromise between the two.

Figure 8.3.22 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.

Mohn's rho values (average relative bias of retrospective estimates) were calculated for SSB, F and recruitment estimates from TSA and were 0.0673, -0.0689 and 1.0653 respectively. The Mohn's rho value for recruitment is significantly high. This results from the tendency of TSA to overestimate the recruitment forecast for the terminal year (last year of data + 1). The TSA forecast of recruitment is used in the Mohn's rho calculation since this value is used in the short term forecast. The tendency of TSA to overestimate the forecasted recruitment has implications for the validity of short term forecasts.

Fishing mortality estimates for the final TSA assessment are presented in Table 8.3.3, the stock numbers in Table 8.3.4, and the assessment summary in Table 8.3.5.

8.4 Historical Stock Trends

The historical stock and fishery trends are presented in Figure 8.3.11.

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 8.2.3).

Estimated fishing mortality for 2008 to 2018 appears to fluctuate between 0.2 and 0.4 and remains above the F_{MSY} value of 0.194 in 2018 (see Section 8.7). 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 = 2019) and in the quota year (IY + 1 = 2020) 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 2018	TSA estimate (millions)	TSA forecast (millions)
2017	2	134	
2018	1	563	
2019	0		3287
2020	Age 0 in 2020		3287
2021	Age 0 in 2021		3287

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 8.6.1 and 8.6.2 respectively. The weights-at-age for discards and BMS were combined into an unwanted catch category using the relative contribution of each component (in 2018) to the total catch. These combined weights were used in the extrapolation to calculate the forecast weights and are shown in Figure 8.6.3. There is insufficient data to allow for cohort-based modelling of weights-at-age in the industrial bycatch component, so simple three-year (2016–2018) 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. A TAC constraint was needed for the intermediate year to avoid a TAC overshoot of 7620 t. The combined-area TAC for 2019 was 33 596 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 2016–2018) 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 8.6.2 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 8.6.1. Results for the short-term forecasts are presented in Table 8.6.2. Assuming an F of 0.194 in 2019, SSB is expected to be 223 911 tonnes in 2019, before decreasing in 2020 to 203 239 tonnes. In this case, wanted catch (human consumption yield) in 2020 would be 30 508 tonnes with associated unwanted catch (discards + BMS) of 3448 t.

Several alternative options for 2020 have been highlighted in Table 8.6.2. These are based on various reference points including F_{MSY}, F_{pa}, F_{lim}, B_{pa}, B_{lim}, $B_{trigger}$ as well as F_{2019}, $F_{MSY\text{-}upper}$, $F_{MSY\text{-}lower}$.

Under the assumption of F_{MSY}, the 2020 total catch is forecast to be 30 228 tonnes, which corresponds (if 2019 discard+BMS rates remain unchanged) to a wanted-catch yield of 25 537 tonnes and unwanted catch of 4662 tonnes. This exploitation is forecast to lead in turn to a SSB in 2021 of 196 243 tonnes, a decrease of 11% on the 2019 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 8.1.4 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 8.8.1 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 8.3.11) 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 8.8.1, top plot). However, an EqSim run with advice error and rule showed that $F_{p05} = 0.19 < F_{MSY}$ (Figure 8.8.1, 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, 2016).

8.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2018 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 currently well above B_{pa} (132 kt) and is predicted to increase during 2019 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 have been ongoing between the EU and Norway which may establish a new management strategy on the basis of the Northern Shelf stock. In 2018 EU-Norway requested an evaluation of multiple management strategies (ICES, 2019a), which are currently under consideration. However, 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 2019 as the 2014 year-class continues to mature. 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 8.1.4). 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 -0.0689, 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 "Living issues" benchmark list

Below is a list of issues which were either left unresolved from the last benchmark or have arisen during subsequent WGNSSK meetings. A scoring system has been developed to aid Working Groups in prioritising stocks to be put forward for benchmark (see Annex 6 for further details). The current scoring for this stock is:

1. Assessment quality	2. Opportunity to improve	3. Management importance	4. Perceived stock status	5. Time since last benchmark	Total Score
3	4	5	2	3	3.4

8.13.1 Data and stock ID

- Explore combining survey indices (North Sea and West Coast of Scotland)
- Derive time-varying maturity estimates
- Derive estimates of mean weight at age in the stock
- Investigate indices of reproductive potential and methods to use them in management advice
- Stock ID and substructure
  - Otolith micro-chemistry study to track fish from nursery to first and subsequent spawnings
  - Tagging data to determine migration rates
  - Assess spatial range of genetic structure
- Evaluate density dependence effects

8.13.2 Assessment

- The model fit to catch data for the plus group (age 8+) is poor relative to other age classes. The impact of this on the perception of the stock biomass needs assessing since the contribution of the plus group to the SSB seems to be increasing over time
- Assessment model (TSA) is not compatible with analyses involving large numbers of simulation runs (i.e. management strategy evaluations).
- Technical support for the assessment model (TSA) will likely be unavailable after 2021 following the retirement of model developer.

8.13.3 Forecast

- Weights at age – linear extrapolation of mean weights at age for individual cohorts are not always consistent across catch components
- Determine extent of growth rate dependent on cohort size (not clear from last benchmark).
- Investigate alternative intermediate year recruitment assumptions

8.14 References

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Table 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Nominal landings (000 t) during 2008–2018, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2018 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota before 2018. Quota uptake from 2018 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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	105	65	102	120	90	114	103	125	0	31
DK	1263	1139	1661	1916	1456	1763	1057	973	852	542
NL	0	1	0	0	5	6	4	2	20	4
NO	121	81	125	239	223	81	63	70	65	0
PT	0	0	0	0	0	0	0	0	0	0
SE	166	126	198	210	217	219	202	129	103	140
UK	0	0	0	0	3	0	0	0	0	0
Subarea 4										
Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BE	108	78	106	78	78	98	45	53	30	29
DE	657	634	575	548	677	677	599	554	534	347
DK	552	725	697	947	1283	1079	1426	1213	1185	1117
ES	0	0	0	0	0	0	0	0	0	0
FO	32	5	0	0	0	0	0	0	0	0
FR	135	276	320	175	177	209	101	121	140	201
GL	4	0	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	24	41	71	191	172	99	43	146	75	89
NO	1278	1126	1195	1069	1661	2705	2004	1484	2164	1431
PL	0	0	0	0	0	0	0	0	0	0
PT	0	0	0	0	0	0	0	0	0	0
SE	141	90	128	103	113	154	135	117	179	99
UK	28393	24983	23343	0	32993	29758	25852	26374	25376	25880
Division 6.a										
Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	0	1	0	0	0	0	0	0	0	0
DK	0	0	0	0	0	0	0	2	2	1
ES	21	28	36	15	0	19	9	33	28	28
FO	0	0	0	0	0	0	0	0	0	0
FR	136	89	73	32	51	67	41	62	68	66
IE	297	396	290	845	746	653	768	1033	641	758
NL	0	0	0	0	0	0	0	28	31	15
NO	18	9	4	0	6	15	7	5	1	7
UK	2380	2415	1364	0	3878	3230	3051	3090	2492	3295

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Official landings	35831	32308	30288	6488	43830	40945	35520	35238	32290	34083
ICES landings	35590	31940	36570	38162	43734	41143	35295	35058	32827	34343
ICES discards	12326	13071	13067	5032	3305	5090	6255	7749	6936	4895
ICES IBC	52	431	24	1	54	65	21	37	19	5
ICES BMS								201	93	155
ICES total catch	47968	45442	49661	43195	47092	46295	41571	43133	40801	39398
TAC 4	42110	35794	34057	39000	45041	38284	40711	61933	33643	41767
TAC 3.a	2590	2201	2100	2095	2770	2355	2504	3926	2069	2569
TAC 6.a	3520	2670	2005	6015	4211	3988	4536	6462	3697	4654
Total TAC	48220	40665	38162	47110	52022	44627	47751	72321	39409	48990
ICES quota uptake	74%	79%	96%	81%	84%	92%	74%	49%	82%	70%

Table 8.2.2. 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	158	100
Discards	Imported	4536	93
Discards	Raised	357	7
Landings	Imported	34349	100

Table 8.2.3. 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	32346	94
Landings	Imported	Estimated	2003	6
Discards	Imported	Sampled	4477	91
Discards	Raised	Estimated	357	7
Discards	Imported	Estimated	59	1
BMS landings	Imported	Estimated	114	72
BMS landings	Imported	Sampled	44	28

Table 8.2.4. 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	4026	94
Landings	Imported	Estimated	27.6.a	249	6
Discards	Imported	Sampled	27.6.a	1175	97
Discards	Imported	Estimated	27.6.a	3	0
Discards	Raised	Estimated	27.6.a	30	2
BMS landings	Imported	Sampled	27.6.a	14	97
BMS landings	Imported	Estimated	27.6.a	>1	3
Landings	Imported	Sampled	27.4	27714	95
Landings	Imported	Estimated	27.4	1568	5
Discards	Imported	Sampled	27.4	3267	90
Discards	Raised	Estimated	27.4	313	9
Discards	Imported	Estimated	27.4	38	1
BMS landings	Imported	Estimated	27.4	113	79
BMS landings	Imported	Sampled	27.4	30	21
Landings	Imported	Sampled	27.3.a.20	605	77
Landings	Imported	Estimated	27.3.a.20	186	23
Discards	Raised	Estimated	27.3.a.20	15	22
Discards	Imported	Sampled	27.3.a.20	35	51
Discards	Imported	Estimated	27.3.a.20	18	27
BMS landings	Imported	Estimated	27.3.a.20	>1	100

Table 8.2.5. 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
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

	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
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
2018	29.3	3.6	0.1	0.0	33.0	0.1	0.0	0.0	0.1	4.3	1.2	0.0	5.5	34.3	4.9	0.2	0.0	39.4

Table 8.2.6. 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 1972–2018 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1990	19286	82571	78881	17811	60888	4373	1104	1839	254	100	54	13	12	1	4	2	439
1991	128703	188087	101425	24822	4706	17618	1388	684	1024	171	65	11	11	1	2	2	1287
1992	277933	166550	255051	43257	7162	1486	6376	611	337	401	149	22	6	2	0	0	918
1993	136841	302610	269220	123469	11822	1986	669	2050	215	210	188	84	4	4	0	0	706
1994	89104	91674	339428	106673	35056	3381	601	366	746	132	48	36	26	5	0	0	992
1995	200151	336460	119210	182969	33802	9237	898	161	155	151	21	8	6	2	1	0	345
1996	167032	46797	505401	73987	66245	11159	4058	1080	75	72	37	9	8	3	1	0	205
1997	36954	162449	107657	251339	18037	18288	2762	937	121	16	18	5	4	4	2	0	170
1998	21919	88387	224037	60861	128348	7110	4590	850	263	60	7	8	3	2	1	1	345
1999	90634	69455	119094	110046	28510	45221	2700	2047	438	53	8	3	3	2	0	0	507
2000	12630	397390	110381	61263	33137	7254	9935	765	367	53	13	2	1	1	0	0	438
2001	3518	95086	633162	34548	12078	5573	2094	1611	257	89	28	3	4	0	0	0	382
2002	50927	36063	99685	372036	7812	2801	1615	729	603	283	25	8	5	0	0	0	923
2003	7082	13136	15234	48729	127241	2166	786	339	144	100	48	5	1	0	0	0	299
2004	3758	25698	24627	8958	38784	97827	1010	248	82	42	37	12	1	0	0	0	174
2005	8779	17695	24596	15085	5446	27745	61457	371	132	38	11	8	4	1	0	0	193
2006	3229	122537	30995	20657	11284	6078	16415	32978	156	56	20	7	4	1	0	0	243
2007	2046	20565	171600	16796	8187	4782	2237	6876	7254	75	8	14	3	1	0	0	7355
2008	3780	15005	31864	75341	4757	2050	1516	566	1432	2570	5	8	1	1	0	0	4017
2009	10483	11042	15303	20764	78513	1860	845	567	239	276	569	6	2	0	0	0	1092
2010	2930	108139	17377	17834	11301	38134	853	416	160	83	85	148	9	0	0	3	488
2011	3003	6082	66355	17091	14138	11495	23124	677	282	95	17	5	60	0	0	0	459
2012	1319	3389	5260	66109	5388	3670	2416	7900	157	178	68	44	57	24	4	0	532
2013	1285	11998	4394	4838	68899	2269	1539	879	3896	37	7	8	2	2	2	0	3954
2014	3537	7504	19838	4818	7799	46760	1104	980	390	1706	14	6	1	1	0	2	2121
2015	3820	27637	15799	17624	1730	5166	22109	1059	433	437	782	107	0	0	0	0	1759

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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
2018	3645	5557	24110	16970	34925	958	526	206	103	985	25	1	3	3	1	1	1122

Table 8.2.7. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706
1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381
2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284
2008	0	299	6472	50965	4461	1986	1378	563	1402	2566	5	8	1	1	0	0	3983
2009	0	486	4605	9666	61972	1775	793	521	239	276	566	6	2	0	0	0	1088

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2010	0	1089	5150	12597	10176	35718	828	416	146	83	85	147	9	0	0	3	473
2011	0	224	16505	15260	13321	11383	22889	677	282	95	16	5	60	0	0	0	458
2012	0	261	3286	52091	4884	3660	2408	7885	157	178	68	44	57	24	4	0	532
2013	0	983	2493	4338	66123	2240	1526	867	3868	37	6	8	2	2	2	0	3924
2014	0	232	12630	3832	7626	42509	1100	965	382	1703	14	6	1	1	0	2	2110
2015	0	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
2018	0	108	12017	15115	33215	956	526	202	103	981	25	1	3	3	1	1	1119

Table 8.2.8. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1978	1193	83683	63997	4214	19568	248	80	0	0	0	0	0	0	0	0	0	0
1979	4795	119245	82074	5734	142	365	0	0	0	0	0	0	0	0	0	0	0
1980	258	146751	197725	4726	96	0	0	0	0	0	0	0	0	0	0	0	0
1981	442	15023	225773	47838	157	1	0	0	0	0	0	0	0	0	0	0	0
1982	505	36063	35089	94315	2293	0	0	0	0	0	0	0	0	0	0	0	0
1983	24327	76672	94323	20914	12092	905	164	0	0	0	0	0	0	0	0	0	0
1984	3275	361946	48893	23714	1623	3317	0	0	0	0	0	0	0	0	0	0	0
1985	4924	146668	156400	3624	115	1	16	0	0	0	0	0	0	0	0	0	0
1986	13007	84333	75071	39219	23	1	0	0	0	0	0	0	0	0	0	0	0
1987	1996	159860	134988	9142	2795	2	0	0	0	0	0	0	0	0	0	0	0
1988	7399	27412	244105	10535	427	10	0	0	24	0	0	0	0	0	0	0	24
1989	10673	43756	23611	67102	1048	23	35	0	2	0	2	0	0	0	0	0	4
1990	16290	69073	30530	1772	4932	28	25	0	0	0	0	0	0	0	0	0	0
1991	11794	143967	40697	1163	17	107	0	0	0	0	0	0	0	0	0	0	0
1992	36231	82605	115933	4063	97	0	6	0	0	0	0	0	0	0	0	0	0
1993	12346	191714	163172	17474	170	1	0	3	0	0	0	0	0	0	0	0	0
1994	19197	75840	254112	20271	2069	30	0	0	0	0	0	0	0	0	0	0	0
1995	2118	231490	84163	67644	2539	199	0	0	0	0	0	0	0	0	0	0	0
1996	22563	35010	413599	28996	10344	36	0	0	0	0	0	0	0	0	0	0	0
1997	15260	114893	69948	106789	1700	425	0	0	0	0	0	0	0	0	0	0	0
1998	2936	77065	162251	15801	20732	88	11	0	0	0	0	0	0	0	0	0	0
1999	20814	57336	83205	46764	1905	2561	49	0	0	0	0	0	0	0	0	0	0
2000	8472	320463	55818	24661	5703	321	201	0	0	0	0	0	0	0	0	0	0
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2004	3758	24613	21221	3967	14548	19811	5	4	0	0	0	0	0	0	0	0	0
2005	8779	16730	18722	6181	1258	4826	4496	1	1	0	0	0	0	0	0	0	1
2006	3229	118636	19862	8636	2634	823	1596	2520	6	1	1	0	0	0	0	0	8
2007	2045	19393	142509	5585	826	97	38	103	71	0	0	0	0	0	0	0	71
2008	3768	14623	25111	24195	243	46	134	2	30	4	0	0	0	0	0	0	34
2009	10468	10521	10601	11050	16522	79	50	46	0	1	4	0	0	0	0	0	5
2010	2930	102881	11872	5201	1125	2415	25	0	14	0	0	1	0	0	0	0	15
2011	3002	5858	49830	1817	806	105	224	0	0	0	1	1	0	0	0	0	2
2012	1319	3128	1973	14017	503	11	7	15	0	0	0	0	0	0	0	0	0
2013	1285	11014	1898	494	2695	26	11	12	24	0	1	0	0	0	0	0	25
2014	3537	7272	7187	980	161	4185	2	14	7	1	0	0	0	0	0	0	8
2015	3820	26920	5225	1545	94	31	989	0	0	0	2	0	0	0	0	0	2
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
2018	3645	5441	11544	1840	1631	3	0	4	0	3	0	0	0	0	0	0	3

Table 8.2.9. 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
2018	0	8	547	13	74	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.2.10. 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
1989	8914	2541	1751	2789	460	37	86	10	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+
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0
1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198033	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0
2004	0	590	265	84	258	753	8	4	0	0	0	0	0	0	0	0	0
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	0	1
2007	1	27	218	6	1	0	0	0	0	0	0	0	0	0	0	0	0
2008	12	82	280	180	52	18	4	1	0	0	0	0	0	0	0	0	0
2009	15	36	97	48	19	6	2	0	0	0	0	0	0	0	0	0	0
2010	0	4169	355	36	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	19	14	11	7	12	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	1	3	5	82	3	2	1	5	0	0	0	0	0	0	0	5
2014	0	0	20	6	12	67	2	2	1	3	0	0	0	0	0	0	3
2015	0	6	9	1	3	12	1	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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
2018	0	0	2	2	5	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.2.11. 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
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1984	0.010	0.142	0.303	0.461	0.645	0.736	1.077	1.205	1.821	2.030	1.732	1.950	2.422	2.822	4.995	0.000
1985	0.010	0.148	0.296	0.466	0.649	0.835	0.934	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.023	0.123	0.261	0.406	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.010	0.125	0.264	0.405	0.594	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.042	0.163	0.232	0.411	0.581	0.731	1.203	1.363	1.281	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.036	0.200	0.282	0.367	0.590	0.770	0.935	1.259	1.586	1.507	1.034	1.534	2.431	2.559	2.307	0.980
1990	0.040	0.187	0.313	0.422	0.506	0.795	0.995	1.179	1.495	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.030	0.175	0.308	0.454	0.574	0.644	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.019	0.102	0.306	0.466	0.717	0.923	0.903	1.382	1.514	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.010	0.110	0.282	0.454	0.660	0.877	1.053	1.062	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.018	0.121	0.247	0.435	0.599	0.846	1.240	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.012	0.107	0.290	0.369	0.581	0.774	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.022	0.126	0.241	0.382	0.484	0.746	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.029	0.138	0.280	0.360	0.585	0.634	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.027	0.153	0.255	0.396	0.444	0.665	0.777	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.025	0.166	0.250	0.356	0.477	0.510	0.735	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.052	0.121	0.256	0.355	0.480	0.605	0.656	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.029	0.111	0.219	0.321	0.466	0.658	0.735	0.945	1.690	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.017	0.109	0.255	0.311	0.527	0.703	0.829	0.818	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.024	0.082	0.221	0.327	0.400	0.681	0.758	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.039	0.139	0.238	0.378	0.395	0.440	0.686	0.926	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.054	0.160	0.271	0.364	0.495	0.479	0.522	0.925	1.054	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.042	0.126	0.283	0.352	0.442	0.507	0.538	0.550	1.048	1.395	2.031	2.525	1.834	3.532	5.274	2.580
2007	0.042	0.159	0.227	0.407	0.478	0.538	0.657	0.700	0.745	0.902	2.272	0.971	1.712	2.348	4.244	0.000
2008	0.030	0.170	0.256	0.366	0.593	0.662	0.714	0.928	0.924	0.878	1.689	1.970	0.988	0.224	3.792	3.024
2009	0.048	0.175	0.305	0.323	0.388	0.677	0.799	0.839	1.308	1.318	1.025	1.045	1.150	3.091	2.115	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2018	0.043	0.139	0.356	0.504	0.533	1.024	1.031	1.135	1.437	0.895	1.255	2.921	2.408	3.356	2.198	4.662

Table 8.2.12. 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
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.000	0.257	0.333	0.427	0.456	0.717	0.812	0.922	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.000	0.262	0.348	0.447	0.620	0.675	0.932	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.000	0.274	0.347	0.501	0.706	0.992	0.907	1.261	1.511	1.499	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.000	0.334	0.364	0.503	0.734	1.056	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.000	0.299	0.349	0.478	0.788	1.153	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.000	0.320	0.375	0.464	0.624	0.914	1.242	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.000	0.280	0.350	0.493	0.666	0.764	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000
1985	0.000	0.279	0.348	0.478	0.651	0.844	0.935	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.000	0.277	0.348	0.428	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.000	0.265	0.335	0.440	0.603	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.000	0.236	0.322	0.437	0.594	0.732	1.203	1.363	1.370	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.000	0.319	0.356	0.413	0.602	0.769	0.934	1.256	1.579	1.507	1.025	1.534	2.431	2.559	2.307	0.980
1990	0.000	0.260	0.372	0.439	0.525	0.796	1.015	1.196	1.504	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.000	0.269	0.363	0.462	0.576	0.645	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.000	0.287	0.367	0.486	0.723	0.924	0.904	1.382	1.515	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.000	0.293	0.372	0.484	0.666	0.878	1.053	1.067	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.000	0.269	0.378	0.473	0.617	0.851	1.241	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.000	0.316	0.400	0.424	0.600	0.782	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.000	0.326	0.364	0.471	0.519	0.747	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.000	0.344	0.410	0.418	0.615	0.641	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.000	0.271	0.370	0.441	0.470	0.670	0.778	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.000	0.297	0.349	0.422	0.490	0.523	0.746	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.000	0.334	0.368	0.421	0.515	0.617	0.663	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.000	0.379	0.352	0.448	0.483	0.675	0.735	0.946	1.695	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.000	0.427	0.446	0.397	0.569	0.713	0.829	0.901	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.000	0.283	0.377	0.464	0.441	0.684	0.759	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2018	0.000	0.417	0.470	0.524	0.542	1.025	1.031	1.145	1.437	0.895	1.255	2.921	2.408	3.356	2.198	4.661

Table 8.2.13. 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
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1990	0.047	0.189	0.229	0.248	0.264	0.290	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.059	0.179	0.238	0.341	0.464	0.480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.136	0.246	0.282	0.345	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.028	0.139	0.237	0.287	0.355	0.369	0.000	0.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.042	0.130	0.212	0.273	0.310	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.044	0.132	0.250	0.276	0.356	0.384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.047	0.133	0.218	0.279	0.297	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.060	0.159	0.250	0.286	0.322	0.374	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.075	0.159	0.232	0.293	0.317	0.391	0.428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.047	0.182	0.217	0.273	0.308	0.304	0.227	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.049	0.129	0.245	0.278	0.316	0.355	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.049	0.115	0.206	0.300	0.301	0.300	0.000	0.411	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.044	0.125	0.223	0.267	0.334	0.382	0.000	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.042	0.124	0.223	0.261	0.327	0.536	0.630	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.039	0.135	0.218	0.263	0.299	0.330	0.639	0.650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.054	0.150	0.232	0.273	0.318	0.301	0.342	0.499	0.493	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.042	0.121	0.231	0.265	0.279	0.274	0.217	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.042	0.146	0.195	0.291	0.314	0.358	0.375	0.356	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.030	0.166	0.217	0.262	0.365	0.456	0.317	0.454	0.427	0.596	0.321	0.000	0.000	0.000	0.000	0.000
2009	0.048	0.162	0.250	0.248	0.282	0.394	0.315	0.357	0.366	0.409	0.452	0.000	0.000	0.000	0.000	0.000
2010	0.016	0.076	0.209	0.303	0.307	0.315	0.350	0.523	0.284	0.000	0.000	1.445	0.000	0.000	0.000	0.000
2011	0.017	0.135	0.227	0.297	0.310	0.352	0.351	0.000	0.000	0.000	2.027	2.215	0.000	0.000	0.000	0.000
2012	0.035	0.143	0.295	0.271	0.286	0.406	0.353	0.392	0.633	0.488	0.316	0.000	0.000	0.000	0.000	0.000
2013	0.034	0.148	0.243	0.362	0.345	0.498	1.355	0.533	0.842	0.000	2.113	0.000	0.000	0.000	0.000	0.000
2014	0.042	0.133	0.298	0.336	0.394	0.340	0.572	0.617	0.475	0.885	0.000	0.000	0.000	0.000	0.000	0.000
2015	0.031	0.141	0.261	0.347	0.377	0.411	0.407	0.634	0.634	0.000	1.082	0.000	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2018	0.043	0.133	0.243	0.342	0.352	0.478	0.000	0.561	0.000	0.905	0.000	0.000	0.000	0.000	0.000	0.000

Table 8.2.14. 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
2018	0.000	0.286	0.233	0.299	0.291	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8.2.15. 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0.013	0.042	0.184	0.307	0.490	0.352	0.442	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.011	0.040	0.174	0.286	0.372	0.473	0.411	0.456	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1979	0.009	0.039	0.177	0.285	0.384	0.461	0.735	1.234	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1980	0.012	0.039	0.176	0.268	0.623	0.722	1.102	1.591	0.000	1.796	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.009	0.040	0.176	0.371	0.467	0.858	1.200	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1982	0.010	0.040	0.206	0.379	0.636	0.751	1.225	1.233	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.008	0.047	0.173	0.428	0.584	1.006	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.009	0.045	0.211	0.414	0.626	0.751	1.225	1.234	1.315	1.319	1.400	1.400	0.000	0.000	0.000	0.000
1985	0.009	0.043	0.186	0.371	0.550	0.563	0.565	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1986	0.010	0.040	0.186	0.375	0.626	1.259	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1987	0.006	0.038	0.258	0.442	0.908	1.171	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.018	0.077	0.196	0.274	0.455	0.549	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1989	0.015	0.165	0.251	0.347	0.670	0.923	1.065	1.492	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1990	0.005	0.104	0.229	0.506	0.609	0.842	0.829	0.796	0.956	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.027	0.058	0.206	0.357	0.472	0.477	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.015	0.059	0.217	0.422	0.552	0.615	0.548	1.234	0.621	0.820	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.008	0.053	0.206	0.399	0.521	0.578	1.225	0.582	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.011	0.055	0.155	0.435	0.595	0.698	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.012	0.045	0.193	0.285	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.018	0.077	0.136	0.162	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.007	0.076	0.149	0.309	0.419	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.020	0.075	0.166	0.291	0.351	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.018	0.064	0.177	0.304	0.416	0.309	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.058	0.070	0.113	0.176	0.370	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.014	0.086	0.133	0.110	0.353	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.016	0.064	0.178	0.283	0.374	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2003	0.012	0.031	0.056	0.231	0.326	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.116	0.183	0.255	0.276	0.446	0.539	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.107	0.187	0.239	0.268	0.287	0.598	0.619	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.127	0.232	0.273	0.273	0.280	0.283	0.286	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.035	0.141	0.192	0.290	0.315	0.370	0.427	0.342	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.042	0.146	0.291	0.388	0.454	0.526	0.414	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.047	0.180	0.252	0.247	0.279	0.410	0.417	0.413	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.080	0.244	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000
2012	0.451	0.762	1.045	1.498	1.854	2.098	2.188	2.317	2.541	2.173	2.324	2.121	2.452	2.368	0.000	0.000
2013	0.000	0.437	0.564	0.626	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.830
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000
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
2018	0.000	0.417	0.470	0.524	0.542	1.025	1.031	1.145	1.437	0.895	1.255	2.921	2.408	3.356	2.198	0.000

Table 8.2.16. 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
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

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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2018	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 8.2.17. 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	2019				
1	1	0.00	0.25		
1	5				
100	302.278	403.079	89.463	116.447	13.182
100	1072.285	221.275	127.770	20.410	20.900
100	230.968	833.257	107.598	32.317	3.575
100	573.023	266.912	303.546	17.888	6.490
100	912.559	328.062	45.201	58.262	4.345
100	101.691	677.641	97.149	12.684	13.965
100	219.060	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	4.260	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	3734.200	107.125	48.605	24.504	15.594
100	893.460	2220.593	76.321	14.493	6.385
100	57.309	473.459	1309.380	9.180	6.886
100	89.981	39.261	241.523	532.045	5.355
100	71.745	79.256	36.962	176.352	324.910
100	70.189	51.885	38.458	14.057	54.576
100	1158.194	46.081	28.477	9.896	4.837
100	109.440	963.393	35.962	14.956	3.019
100	61.357	107.390	241.221	14.886	1.592
100	75.068	141.444	102.986	135.595	2.528
100	674.962	71.132	68.015	51.480	90.942
100	46.068	781.507	101.666	35.942	47.870
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	3.070
100	47.048	155.733	54.928	67.800	1.016
100	153.070	126.234	150.811	22.464	77.331

Table 8.2.17. (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	2018					
1	1	0.50	0.75			
0	5					
100	718.479	233.550	22.921	2.842	0.507	1.561
100	2741.140	595.235	189.015	10.529	1.583	0.396
100	577.382	605.990	140.146	37.604	2.360	0.372
100	1781.191	195.331	262.643	32.423	8.383	0.381
100	520.855	1019.607	106.642	97.383	8.060	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	257.140	164.853	53.690	42.660	3.093
100	6904.539	176.457	94.108	47.947	13.268	9.904
100	1092.754	2504.185	44.300	19.502	10.287	4.264
100	34.743	360.422	1099.293	30.290	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	154.820
100	1412.973	67.605	45.540	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	5.350	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	557.390	59.017	34.214	25.186	53.330
100	30.640	77.035	344.508	27.159	12.209	9.196
100	68.068	31.515	40.248	132.237	7.344	4.397
100	86.267	58.356	25.177	18.293	82.781	2.515
100	747.545	48.207	58.510	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	0.410
100	146.171	167.605	72.398	130.786	2.896	1.290
100	123.141	74.110	94.752	22.692	32.776	0.724

Table 8.3.1. 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	1972–2018
Discards	Ages	0–8+
	Years	1972, 1978–2018
Industrial bycatch	Ages	0–8+
	Years	1972, 1978–2018
BMS landings	Ages	0–8+
	Years	2016–2018
Survey: NS IBTS Q1	Ages	1–5
	Years	1983–2019
Survey: NS IBTS Q3	Ages	0–5
	Years	1991–2018
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 (ω = 3)
Downweighted discards+bycatch+bms outliers		1982, age 5; 2002, age 0; 2012, age 2 (ω = 3 for all)
Downweighted survey outliers		NS IBST Q1: 2011, age 5; 2014, age 4 (ω = 3 for all)

Table 8.3.2. 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	0.0401	0.005	0.1	TRUE	FALSE
F age 1	0.0873	0.05	0.15	TRUE	FALSE
F age 2	0.845	0.6	1	TRUE	FALSE
F age 7	1.2746	1	1.4	TRUE	FALSE
sd F	0.1655	0.01	0.2	TRUE	FALSE
sd U	0.0713	0.01	0.15	TRUE	FALSE
sd V	0.1492	0.01	0.2	TRUE	FALSE
sd Y	0.1522	0.01	0.25	TRUE	FALSE
cv landings	0.1489	0.1	0.3	TRUE	FALSE
cv discards+bycatch+bms	0.2807	0.2	0.4	TRUE	FALSE
log mean recruitment at start	7.1352	7	9	TRUE	FALSE
sd of random walk	0.0732	0	0.25	TRUE	FALSE
recruitment cv	0.5217	0.3	0.6	TRUE	FALSE
discards sd transitory	0.0053	0	0.35	TRUE	FALSE
discards sd persistent	0.3337	0.25	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2801	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.7154	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.7521	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5376	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4798	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.328	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.1501	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.0986	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2495	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3927	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5881	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.495	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3852	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.337	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.2534	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.0963	0	0.3	TRUE	FALSE
NSQ3 omega	0.0819	0	0.3	TRUE	FALSE
NSQ3 beta	0	0	0.1	FALSE	TRUE

Table 8.3.3. 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 2019 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
1972	0.039	0.084	0.615	1.011	0.960	0.922	1.014	1.053	0.996	0.862
1973	0.034	0.092	0.598	0.902	0.862	0.901	0.999	1.037	1.102	0.787
1974	0.032	0.088	0.631	0.727	0.865	0.777	0.904	0.969	0.972	0.741
1975	0.036	0.092	0.718	0.905	0.993	0.951	1.108	1.091	1.080	0.872
1976	0.033	0.093	0.578	0.980	0.875	1.059	0.979	1.002	1.007	0.811
1977	0.032	0.100	0.623	0.756	1.079	0.978	0.975	0.943	0.970	0.819
1978	0.028	0.120	0.667	0.947	1.095	1.082	1.068	1.071	1.108	0.903
1979	0.032	0.103	0.711	1.045	0.998	1.018	1.026	1.036	1.043	0.918
1980	0.036	0.086	0.519	1.047	1.115	0.808	0.921	0.962	0.964	0.894
1981	0.031	0.077	0.341	0.799	0.910	0.752	0.482	0.739	0.708	0.683
1982	0.022	0.077	0.397	0.589	0.717	0.602	0.612	0.713	0.634	0.568
1983	0.021	0.088	0.467	0.843	0.869	0.905	0.757	0.751	0.766	0.726
1984	0.024	0.121	0.508	0.940	1.095	0.817	0.834	0.802	0.803	0.848
1985	0.024	0.122	0.465	0.914	1.028	0.872	0.825	0.769	0.776	0.802
1986	0.018	0.126	0.666	0.929	1.117	0.825	0.680	0.682	0.728	0.904
1987	0.025	0.103	0.759	1.009	0.968	0.884	0.889	0.822	0.795	0.912
1988	0.024	0.122	0.608	1.160	1.109	0.947	0.860	0.784	0.824	0.959
1989	0.021	0.124	0.657	0.949	1.121	0.879	0.852	0.785	0.790	0.909
1990	0.017	0.121	0.741	0.975	0.995	0.866	0.733	0.688	0.707	0.904
1991	0.019	0.167	0.713	1.020	0.936	0.790	0.783	0.742	0.706	0.890
1992	0.021	0.126	0.653	0.980	0.995	0.665	0.858	0.703	0.728	0.876
1993	0.023	0.170	0.815	0.997	1.020	0.974	0.847	0.829	0.849	0.944
1994	0.016	0.128	0.746	1.024	0.992	1.034	0.981	0.915	0.836	0.921
1995	0.021	0.102	0.595	0.917	0.949	0.827	0.917	0.719	0.715	0.820
1996	0.019	0.100	0.526	0.866	1.018	0.974	0.969	0.712	0.708	0.803
1997	0.014	0.117	0.487	0.625	0.747	0.894	0.788	0.609	0.596	0.620
1998	0.014	0.144	0.627	0.679	0.873	0.823	0.803	0.619	0.606	0.726
1999	0.012	0.126	0.677	0.909	0.854	1.082	0.881	0.678	0.649	0.813
2000	0.011	0.101	0.734	0.948	0.966	0.826	0.866	0.614	0.591	0.883
2001	0.010	0.082	0.411	0.679	0.703	0.665	0.600	0.433	0.421	0.598
2002	0.006	0.103	0.274	0.358	0.482	0.466	0.423	0.291	0.290	0.371
2003	0.005	0.047	0.212	0.219	0.266	0.329	0.279	0.185	0.182	0.232
2004	0.004	0.051	0.209	0.238	0.250	0.309	0.246	0.159	0.156	0.232
2005	0.003	0.057	0.273	0.343	0.275	0.330	0.309	0.171	0.167	0.297
2006	0.005	0.053	0.419	0.524	0.553	0.533	0.398	0.271	0.228	0.499
2007	0.005	0.056	0.236	0.508	0.520	0.494	0.389	0.229	0.223	0.421
2008	0.004	0.037	0.180	0.225	0.335	0.310	0.259	0.147	0.146	0.247
2009	0.002	0.032	0.129	0.193	0.267	0.245	0.183	0.115	0.108	0.196

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
2010	0.003	0.033	0.167	0.243	0.234	0.269	0.180	0.113	0.107	0.215
2011	0.004	0.040	0.135	0.408	0.403	0.376	0.270	0.150	0.130	0.315
2012	0.002	0.035	0.138	0.179	0.257	0.232	0.158	0.102	0.090	0.191
2013	0.002	0.041	0.178	0.183	0.260	0.223	0.148	0.092	0.094	0.207
2014	0.002	0.037	0.313	0.345	0.349	0.361	0.173	0.122	0.116	0.336
2015	0.004	0.038	0.441	0.560	0.388	0.487	0.292	0.172	0.154	0.463
2016	0.003	0.033	0.186	0.438	0.370	0.303	0.167	0.134	0.112	0.331
2017	0.002	0.026	0.177	0.254	0.309	0.245	0.127	0.094	0.090	0.247
2018	0.002	0.023	0.140	0.270	0.262	0.215	0.119	0.093	0.081	0.224
2019*	0.002	0.028	0.169	0.281	0.283	0.243	0.136	0.094	0.094	0.244

Table 8.3.4. 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	8897050	13395380	2101520	79100	45100	396720	7160	440	1160
1973	32877660	1979430	2740520	482900	17320	11240	118110	2070	460
1974	53042170	7314520	400760	650340	117920	4820	3450	34570	720
1975	3460810	14496550	1497030	107260	186660	33530	1680	1110	10740
1976	5458580	933210	2938100	348400	27620	48180	10220	460	3420
1977	11845430	1512770	212600	826400	83360	8290	13400	3230	1240
1978	24774410	2896730	280240	64620	255910	21040	2630	4500	1540
1979	49783830	5797250	534330	76970	16310	62870	5380	750	1760
1980	9098300	11439500	1084810	140310	17970	4690	18840	1680	800
1981	15397810	2033870	2200820	345310	33640	4650	1650	6300	830
1982	9257260	3446460	403010	800540	101430	10690	1780	650	2630
1983	29956740	2072390	699000	162070	296910	37350	4690	790	1410
1984	5814890	6620170	439820	260660	48450	92770	12130	1810	840
1985	9559590	1456330	1436180	159500	71490	12510	30200	4280	910
1986	18058150	2204250	339370	548760	45330	19830	4200	10710	1930
1987	331750	3907520	542700	110600	150790	11510	6740	1620	4740
1988	1050170	330700	1038500	161380	29360	43110	3820	2300	2330
1989	1979350	525640	102160	366050	35920	7560	13320	1330	1730
1990	8687180	728080	145710	34920	104130	9140	2560	4730	1180
1991	9895040	2218600	208590	41940	9640	30380	3170	1020	2480
1992	17124700	2553670	612630	68480	11340	2730	9750	1160	1340
1993	4295180	4562980	737050	214020	17890	3170	1060	3370	1020
1994	16997410	1170990	1252320	217970	58560	4960	970	370	1630
1995	4791000	4730850	337380	397510	58340	16660	1410	300	740
1996	6849310	1338720	1386820	126680	117910	17400	5800	470	430
1997	4112150	1915030	390900	557300	39460	32910	5230	1830	370

	0	1	2	3	4	5	6	7	8+
1998	3101240	1143930	544510	164390	219330	14360	10560	1950	1000
1999	46518860	860850	314230	196160	61230	70230	4930	3790	1340
2000	9077860	12728580	239590	106790	55660	19710	18300	1640	2190
2001	899610	2456480	3583550	78790	29360	15620	6600	6080	1770
2002	1220440	336760	692800	1613280	28220	10870	6130	2880	4240
2003	1371760	384680	90940	354260	808080	12940	5200	3180	4410
2004	1345300	408560	107130	49080	202710	461990	7030	3070	5180
2005	12761200	411200	110920	57260	27430	117070	253870	4240	5740
2006	2712350	3641720	109910	55130	28820	15470	63240	142210	6810
2007	1806880	800950	974500	46870	23310	12350	6880	32810	90290
2008	1271670	566870	214570	491950	20210	10320	5710	3620	79440
2009	9243720	449540	156060	113370	280480	10770	5730	3410	58320
2010	793470	3015330	126360	85880	67510	159980	6380	3690	45110
2011	82160	310210	855230	66130	48980	39970	92820	4130	35510
2012	1117750	113610	87950	454980	31730	24520	20870	54970	28080
2013	566280	411070	32400	46000	279390	18380	14820	13860	59580
2014	5906610	255650	115830	15700	28350	162840	11230	9950	53550
2015	1646560	2131390	71810	48980	7950	15210	87340	7390	45180
2016	2631180	604840	590710	26460	20430	4080	7220	51310	35900
2017	1294730	983790	166430	275440	12770	10750	2350	4820	60090
2018	1503940	484280	272520	78440	160410	7200	6540	1630	47250
2019*	3287400	562630	134430	133000	45010	95040	4510	4580	35950

Table 8.3.5. 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	408043	390275	41705	234140	230865	24999	173903	159410	29344	0.862	0.064	294702	29518	2592956	247388	8897047	1989956
1973	344581	379014	50299	207383	215768	20645	137198	163246	39580	0.787	0.071	274524	19055	2576821	225641	32877662	3894203
1974	397158	248491	28628	167655	157681	13725	229503	90811	22148	0.741	0.072	321618	22456	2681818	267075	53042168	8206252
1975	494390	303896	41573	160380	164672	14007	334009	139224	35923	0.872	0.082	157849	10985	2118873	255718	3460809	1515425
1976	401969	346462	53857	184244	212845	24503	217725	133617	40216	0.811	0.082	193714	15461	1051590	124952	5458582	1435939
1977	240259	200401	22334	156534	163580	18508	83726	36821	9128	0.819	0.086	350331	30159	805756	66265	11845426	1711605
1978	146700	137966	13551	102940	102365	10141	43760	35601	7081	0.903	0.087	157408	13653	802366	54642	24774409	1959785
1979	149260	142493	16064	97884	85805	9328	51376	56688	10293	0.918	0.089	92555	10907	1233108	68772	49783830	4420220
1980	202640	191838	19649	111375	107004	10585	91265	84834	14396	0.893	0.082	102738	10846	1437926	86556	9098298	1032751
1981	226585	229270	21700	147920	154487	15350	78665	74782	12228	0.683	0.065	193876	13253	1035505	56019	15397809	1611887
1982	256302	213027	15915	195572	170316	13629	60730	42711	6919	0.568	0.047	435007	20702	897878	37694	9257265	829582
1983	253185	228407	16870	188735	180028	13082	64451	48379	7620	0.726	0.054	294138	15248	1109015	45245	29956735	2126533
1984	247238	227105	22580	158181	149564	11101	89057	77541	16904	0.848	0.060	236480	14666	1367957	71990	5814892	1375479
1985	247430	226788	18320	183055	165913	13843	64375	60875	9779	0.802	0.057	166810	8294	903053	39042	9559588	1203563
1986	223854	206897	15090	185119	164511	12543	38735	42386	6743	0.904	0.060	286791	16317	1061825	52797	18058148	1719992
1987	195046	179879	14908	135000	125650	9540	60046	54229	9388	0.912	0.063	162245	8771	797275	40167	331750	1075736
1988	179911	169492	14132	126181	122621	10968	53729	46871	7433	0.959	0.068	125316	8490	464260	79348	1050173	1707115
1989	127679	118856	10075	92801	94066	8724	34878	24790	4370	0.909	0.068	177765	11361	382957	50561	1979345	1262127
1990	86743	78445	7505	61584	57192	5172	25159	21253	4076	0.904	0.067	84914	5760	614161	55023	8687179	1266887
1991	97205	92295	12631	55211	45367	4545	41993	46928	10275	0.890	0.067	51865	3897	801217	40877	9895037	774066
1992	134993	126907	12064	81572	71730	7242	53421	55176	8371	0.876	0.053	55300	2758	828609	36477	17124698	1246022

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
1993	180206	215317	21804	98697	111205	10685	81509	104112	16866	0.944	0.058	118132	7383	870860	43351	4295180	389526
1994	169472	235398	22349	95175	131601	13658	74297	103797	15047	0.921	0.061	138111	9670	895077	38713	16997410	1151436
1995	168893	174687	17165	89858	103777	10794	79035	70910	11478	0.820	0.059	196413	14183	857947	40657	4790999	388190
1996	204687	199266	18447	92632	98234	8863	112055	101031	14279	0.804	0.056	124446	7189	778033	33650	6849311	578197
1997	170051	161683	14471	95448	93687	8676	74603	67996	10102	0.620	0.049	251804	14643	744783	33496	4112149	390519
1998	161971	158224	13515	95513	92231	7608	66457	65993	9297	0.726	0.056	183476	9613	581082	25101	3101245	276305
1999	123421	126828	10871	75974	73431	6081	47446	53397	7385	0.813	0.063	142730	8773	1527160	88144	46518857	3338419
2000	126870	168159	30113	54476	55607	5080	72395	112552	27742	0.883	0.067	92626	6378	2166169	120901	9077862	612061
2001	173526	276058	38059	47549	100103	14716	125978	175955	30540	0.598	0.053	62639	4402	1146195	65131	899610	660672
2002	155145	185803	21712	65399	99234	12141	89745	86568	15572	0.371	0.037	538076	36437	772195	40403	1220443	322608
2003	74415	98313	11272	47266	76104	9391	27149	22209	4249	0.232	0.025	462130	27576	546694	28902	1371758	249382
2004	72511	76822	9287	51925	65745	8440	20586	11077	1938	0.232	0.025	317376	21792	452130	24155	1345295	175499
2005	64116	64263	7537	51542	55065	6906	12573	9199	1429	0.297	0.030	234188	19038	1019146	43259	12761202	671959
2006	66955	65626	7902	43333	45521	5397	23622	20105	4271	0.499	0.043	160913	15333	764794	31985	2712346	201424
2007	67430	74872	7877	34680	45128	5120	32751	29744	4563	0.421	0.038	132007	15144	556457	26548	1806883	325385
2008	47733	54787	5645	33037	40464	4306	14697	14323	2464	0.247	0.026	277624	18229	467073	22068	1271674	248081
2009	47943	43846	4380	35569	35943	3742	12374	7903	1216	0.196	0.021	227942	17285	797908	30985	9243723	468111
2010	45412	43435	4514	31937	34881	3577	13474	8555	1640	0.215	0.023	211325	16725	495608	24190	793470	612817
2011	49658	56476	5354	36572	40029	3644	13086	16447	2808	0.316	0.032	151577	11078	418763	19216	82155	474922
2012	43196	45227	4539	38164	39984	4020	5032	5242	1067	0.191	0.021	311353	17226	407263	19836	1117754	222436
2013	47066	42750	4449	43712	39545	4146	3354	3205	644	0.207	0.021	246434	13306	350160	16173	566276	188896
2014	46317	48952	4858	41165	44240	4483	5152	4711	834	0.336	0.032	176827	11257	510595	20009	5906614	352507
2015	41594	48018	4808	35306	38777	3645	6287	9241	2167	0.463	0.041	139537	10129	529577	22865	1646562	155319

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
2016	43053	48324	5112	35060	38140	4201	7994	10184	1821	0.332	0.033	117461	10150	550740	24672	2631177	279563
2017	39898	42939	4296	32843	36670	3771	7055	6269	1131	0.247	0.027	207480	12632	460811	24426	1294733	207295
2018	39398	41343	3986	34343	36140	3554	5055	5203	961	0.224	0.027	186846	11914	415906	28178	1503943	388260
2019*		49028	12009		43964	10854		5064	1608	0.244	0.069	236941	16809	509663	89823	3287400	1938969

Table 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

MFDP version 1a							
Run: runTAC							
Time and date: 10:03 27/04/2019							
Fbar age range (Total) : 2-4							
Fbar age range Fleet 1 : 2-4							
Fbar age range Fleet 2 : 2-4							
2019							
Age		N	M	Mat	PF	PM	SWt
	0	3287400	0.981	0	0	0	0.043
	1	562630	1.258	0	0	0	0.147
	2	134430	0.577	0	0	0	0.352
	3	133000	0.288	1	0	0	0.492
	4	45010	0.263	1	0	0	0.658
	5	95040	0.255	1	0	0	0.691
	6	4510	0.24	1	0	0	1.213
	7	4580	0.267	1	0	0	1.267
	8	35950	0.376	1	0	0	1.444
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0.356	0.002	0.043		
	1	0	0.35	0.028	0.143		
	2	0.087	0.454	0.081	0.236		
	3	0.254	0.472	0.025	0.326		
	4	0.272	0.593	0.008	0.44		
	5	0.239	0.616	0.001	0.438		
	6	0.131	1.168	0.003	0.64		
	7	0.092	1.169	0.001	0.616		
	8	0.093	1.407	0	0.886		
IBC							
Age		Sel	CWt				
	0	0	0.356				
	1	0	0.35				
	2	0.0001	0.454				
	3	0.0002	0.547				
	4	0.0002	0.701				
	5	0.0001	0.958				
	6	0.0001	1.108				
	7	0.0001	0.972				
	8	0.0001	0.969				

Table 8.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

2020						
Age	N	M	Mat	PF	PM	SWt
0	3287400	0.981	0	0	0	0.043
1	.	1.258	0	0	0	0.147
2	.	0.577	0	0	0	0.352
3	.	0.288	1	0	0	0.531
4	.	0.263	1	0	0	0.646
5	.	0.255	1	0	0	0.818
6	.	0.24	1	0	0	0.82
7	.	0.267	1	0	0	1.415
8	.	0.376	1	0	0	1.519
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.356	0.002	0.043		
1	0	0.35	0.028	0.143		
2	0.087	0.454	0.081	0.236		
3	0.254	0.547	0.025	0.333		
4	0.272	0.529	0.008	0.417		
5	0.239	0.664	0.001	0.54		
6	0.131	0.685	0.003	0.513		
7	0.092	1.339	0.001	0.739		
8	0.093	1.432	0	0.776		
IBC						
Age	Sel	CWt				
0	0	0.356				
1	0	0.3497				
2	0.0001	0.4544				
3	0.0002	0.5473				
4	0.0002	0.7009				
5	0.0001	0.9581				
6	0.0001	1.108				
7	0.0001	0.9723				

Table 8.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast input.

2021							
Age		N	M	Mat	PF	PM	SWt
	0	3287400	0.981	0	0	0	0.043
	1	.	1.258	0	0	0	0.147
	2	.	0.577	0	0	0	0.352
	3	.	0.288	1	0	0	0.531
	4	.	0.263	1	0	0	0.694
	5	.	0.255	1	0	0	0.8
	6	.	0.24	1	0	0	0.979
	7	.	0.267	1	0	0	0.948
	8	.	0.376	1	0	0	1.625
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0.356	0.002	0.043		
	1	0	0.35	0.028	0.143		
	2	0.087	0.454	0.081	0.236		
	3	0.254	0.547	0.025	0.333		
	4	0.272	0.701	0.008	0.403		
	5	0.239	0.586	0.001	0.509		
	6	0.131	0.735	0.003	0.641		
	7	0.092	0.754	0.001	0.588		
	8	0.093	1.484	0	0.826		
IBC							
Age		Sel	CWt				
	0	0	0.356				
	1	0	0.3497				
	2	0.0001	0.4544				
	3	0.0002	0.5473				
	4	0.0002	0.7009				
	5	0.0001	0.9581				
	6	0.0001	1.108				
	7	0.0001	0.9723				

Input units are thousands and kg - output in tonnes

Table 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Short-term forecast output. A number of management options are highlighted.

Basis	Total catch (2020)	Wanted catch * (2020)	Unwanted catch * (2020)	IBC ** (2020)	HC ** catch (2020)	F_{total} (ages 2-4) (2020)	F_{wanted} (ages 2-4) (2020)	$F_{unwanted}$ (ages 2-4) (2020)	F_{IBC} (ages 2-4) (2020)	SSB (2021)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis													
MSY approach: F_{MSY}	30228	25537	4662	30	30199	0.194	0.163	0.030	0.00020	196243	-3.4%	-11%	-11%
Other scenarios													
F = MAP^^^ $F_{MSY\ lower}$	26269	22207	4032	30	26239	0.167	0.141	0.026	0.00020	200542	-1.33%	-23%	-23%
F = MAP $F_{MSY\ upper}$[#]	30228	25537	4 662	30	30199	0.194	0.163	0.030	0.00020	196243	-3.4%	-11%	-11%
F = 0[##]	32	0	0	32	0	0	0	0	0.00020	229410	12.9%	-100%	-100%
F_{pa}	41488	34971	6 489	29	41460	0.27	0.23	0.043	0.00020	184091	-9.4%	22%	22%
F_{lim}	55822	46886	8 908	28	55794	0.38	0.32	0.060	0.00020	168805	-16.9%	64%	64%
SSB (2021) = B_{lim}	114594	93181	21 392	21	114573	1.06	0.89	0.166	0.00020	94000	-54%	237%	237%
SSB (2021) = B_{pa} = MSY $B_{trigger}$	88573	73499	15 049	24	88549	0.69	0.58	0.108	0.00020	132000	-35%	161%	161%
F_{2019}	30257	25561	4666	30	30228	0.194	0.164	0.030	0.00020	196212	-3.5%	-11%	-11%
Rollover TAC	33985	28691	5 265	29	33956	0.22	0.19	0.034	0.00020	192176	-5.4%	0%	0%

*** "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 2016–2018. Unwanted catch includes discards and below minimum size (BMS) landings.**

**** IBC = Industrial bycatch, HC = Human Consumption.**

***** SSB 2021 relative to SSB 2020.**

^ Human Consumption catch in 2020 relative to TAC in 2019: Subdivision 20 (1780 t) + Subarea 4 (28 950 t) + Division 6.a (3226 t) = 33 956 t.

^^ Total catch 2020 relative to advice value 2019 (33 956 t).

^^^ Proposed EU multiannual plan (MAP) for the North Sea (EU, 2016).

[#] For this stock, $F_{MSY\ upper}$ = F_{MSY}.

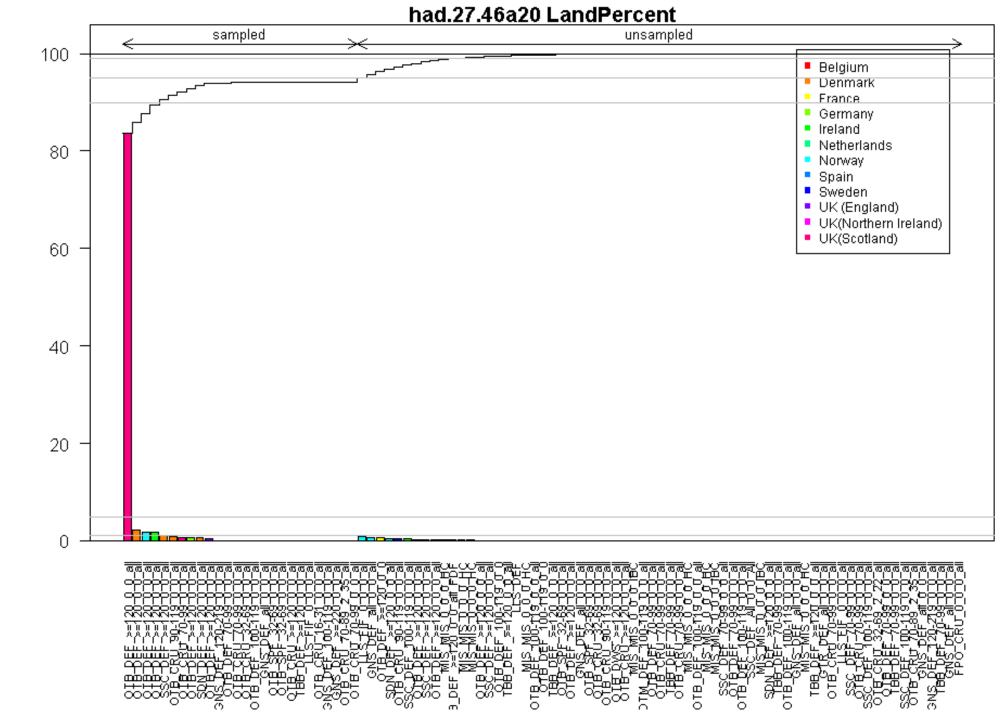


Figure 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

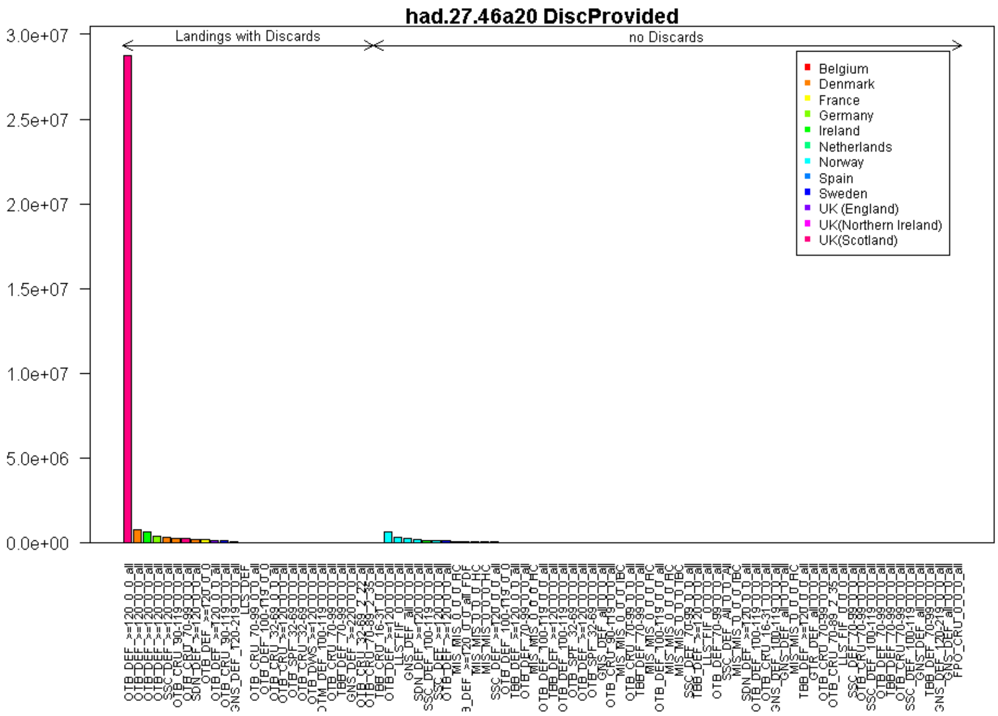


Figure 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary of landings for fleets with and without discard estimates.

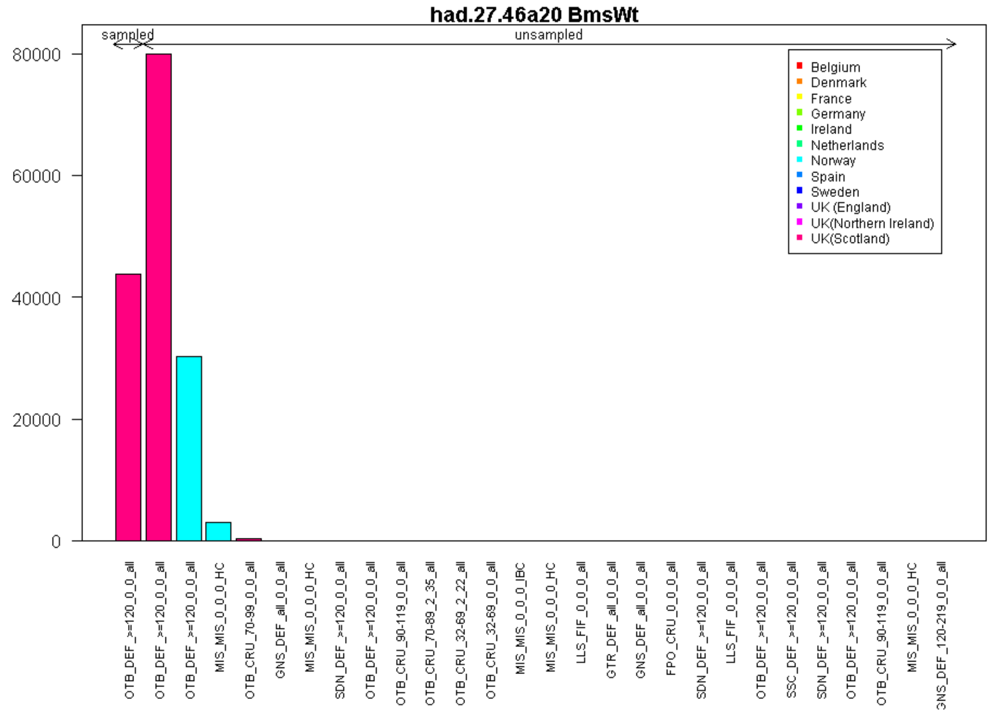


Figure 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported BMS landings for each sampled and unsampled fleet in the full stock area, in descending order of yield.

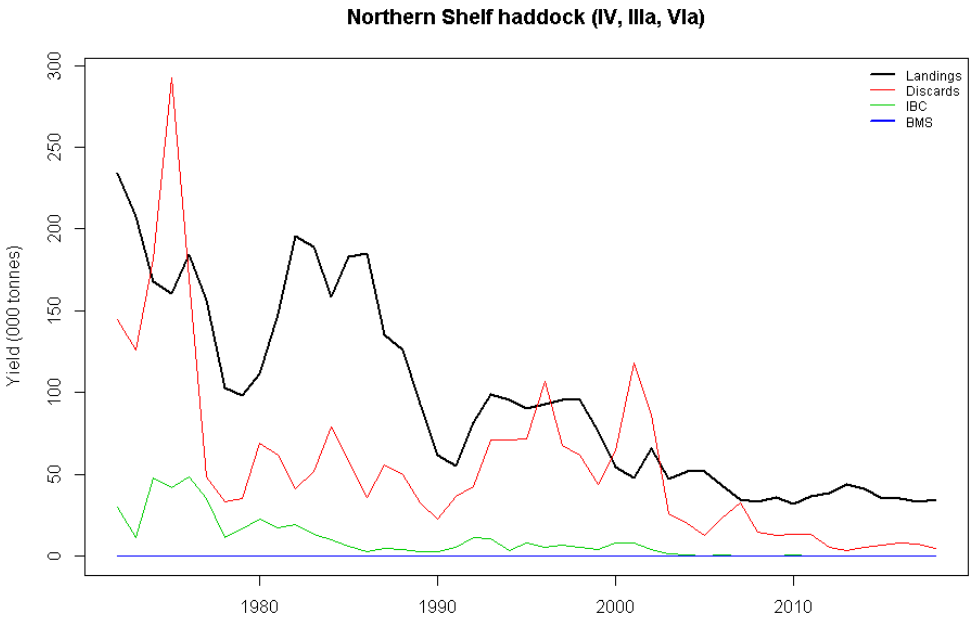


Figure 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Yield by catch component.

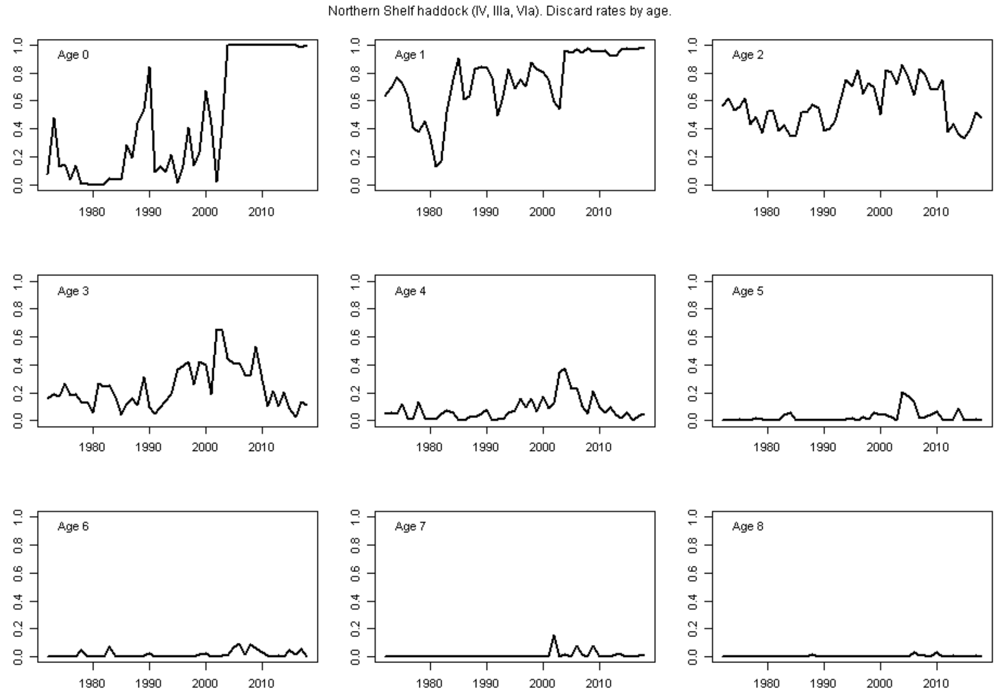


Figure 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of total catch discarded, by age and year.

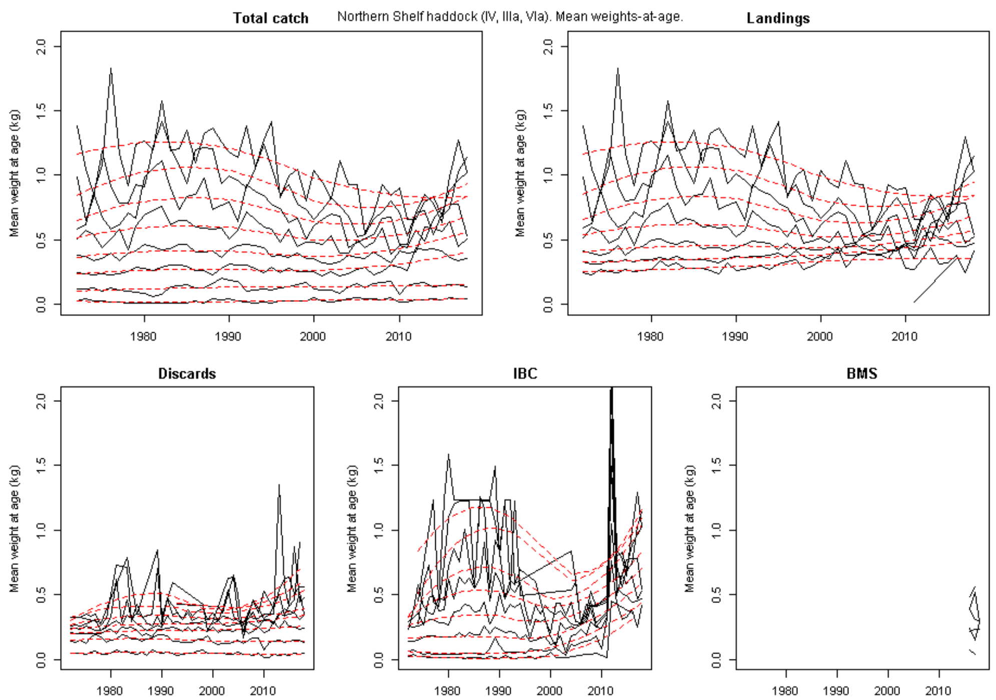


Figure 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

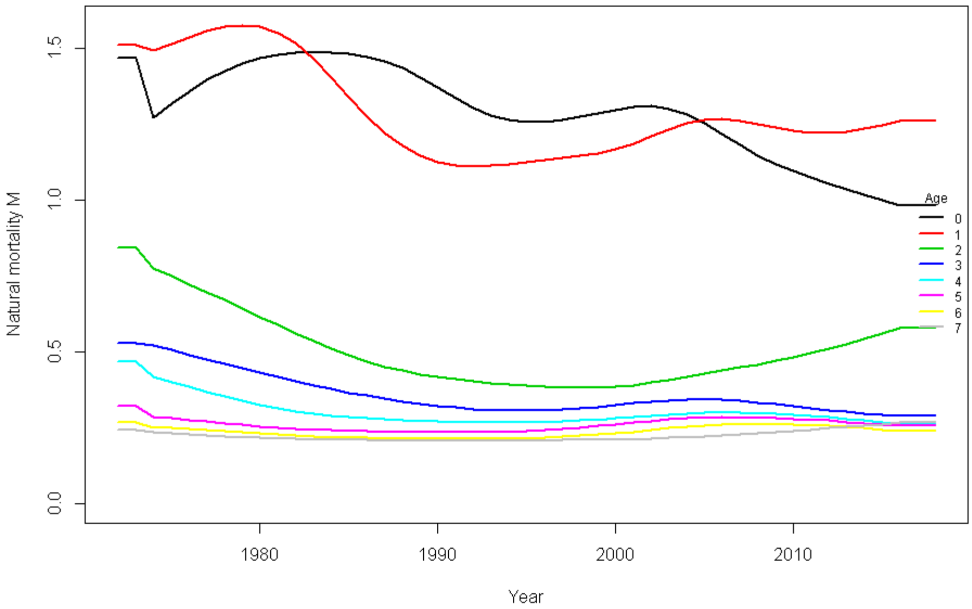


Figure 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time series of estimated natural mortality at age, from ICES WGSAM (2014).

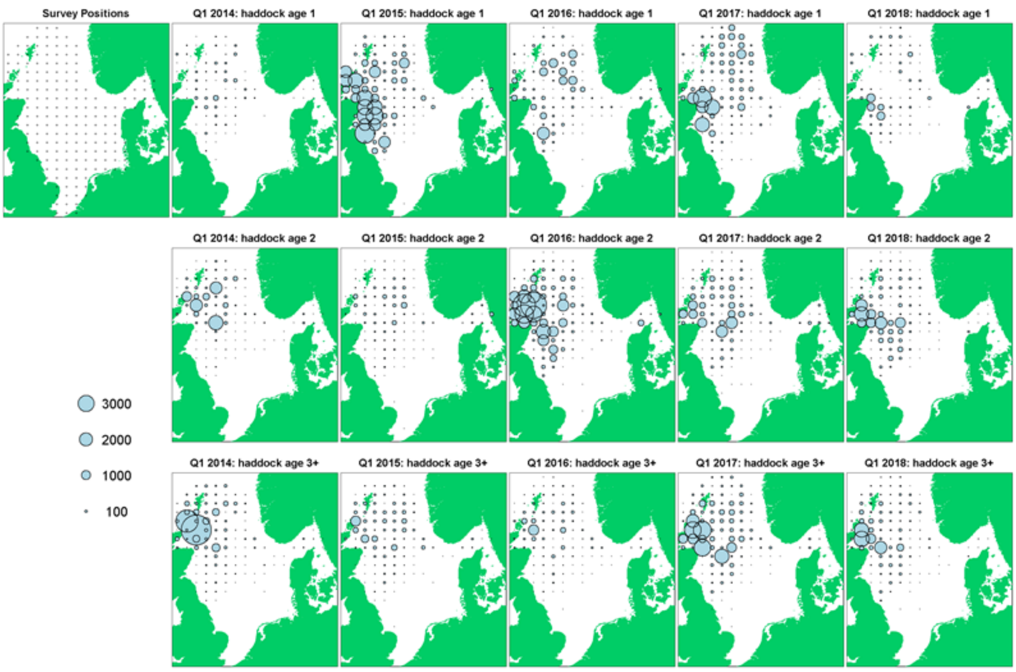


Figure 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q1 survey (North Sea).

Figure 8.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q3 survey (North Sea).

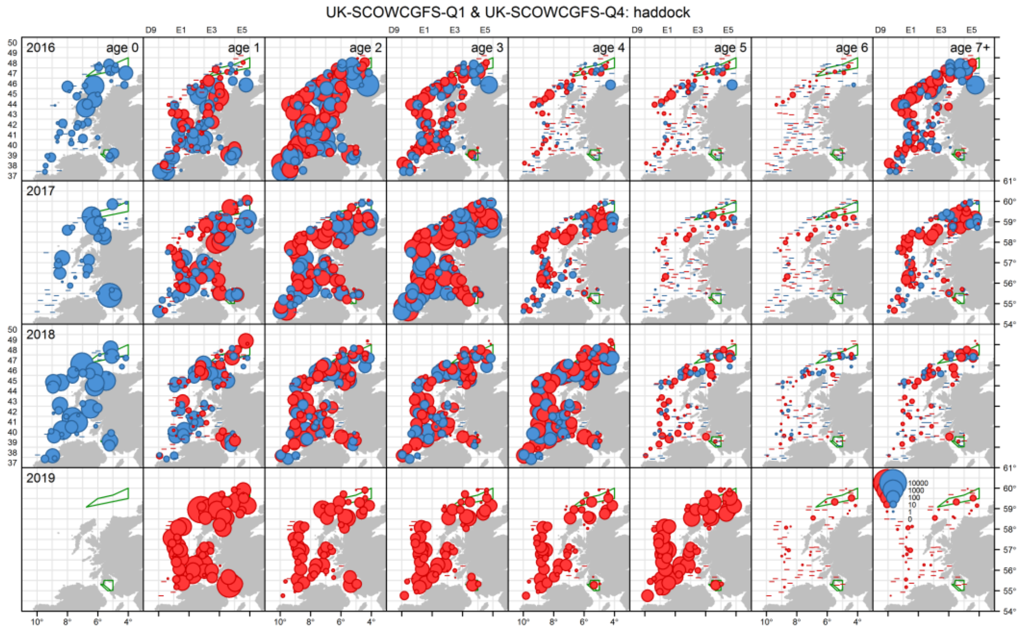


Figure 8.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age and quarter for the Scottish West Coast Q1 survey (West of Scotland). Rows show years 2016–2019 (from top to bottom).

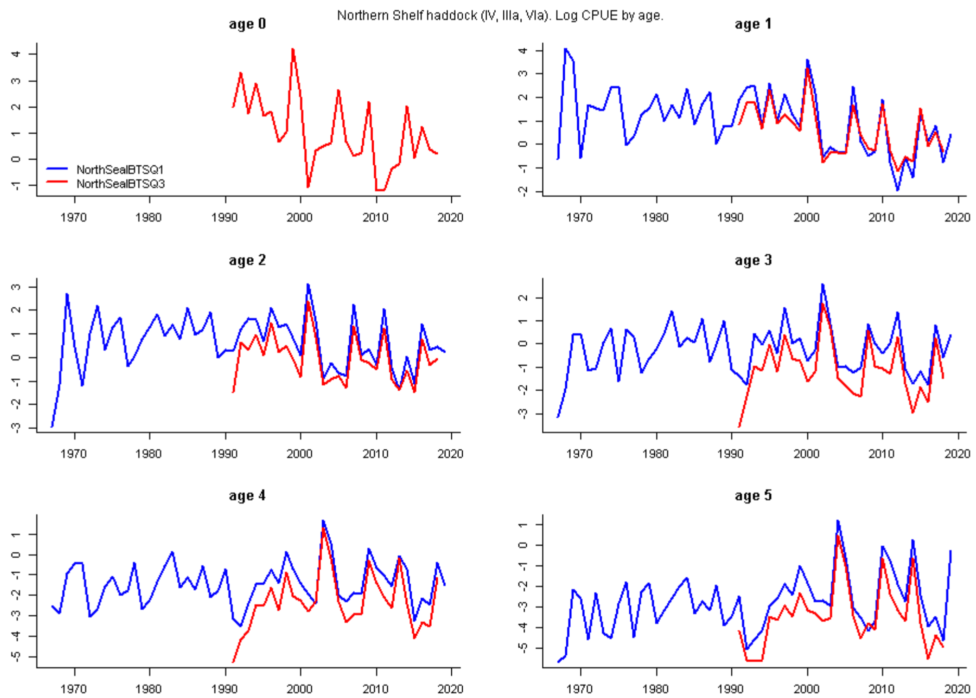


Figure 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey log CPUE (catch per unit effort) at age.

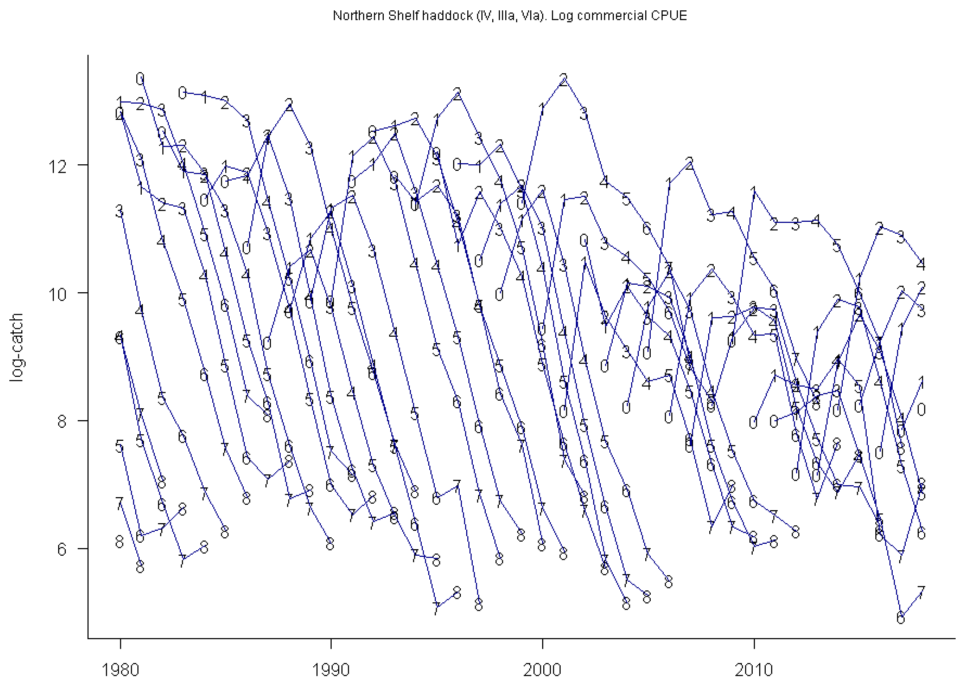


Figure 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log catch curves by cohort for total catches.

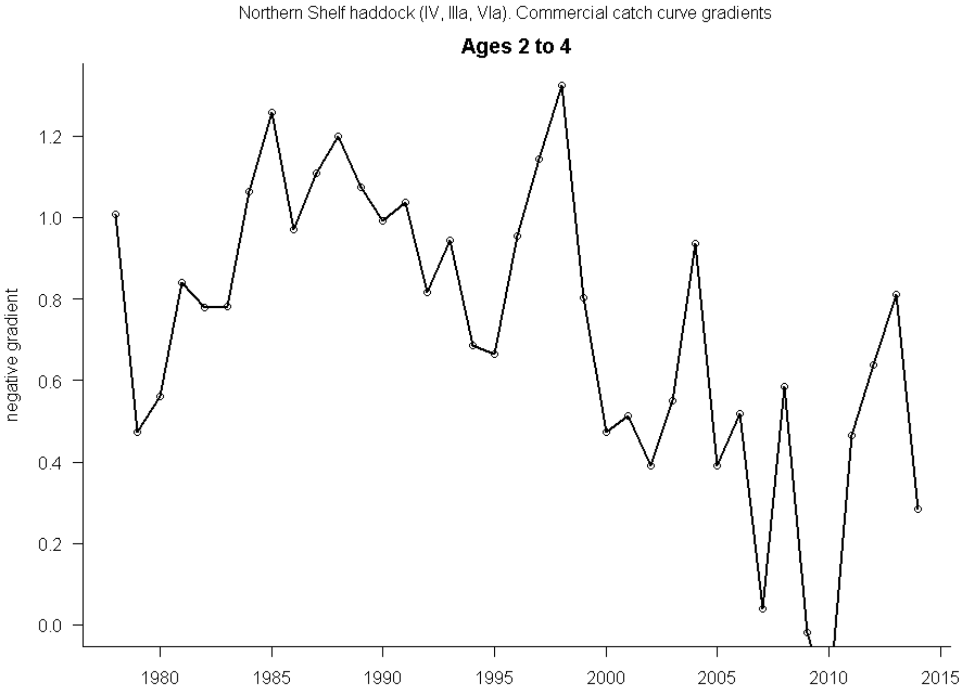


Figure 8.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Negative gradients of log catches per cohort, averaged over ages 2–4. The x-axis represents the spawning year of each cohort.

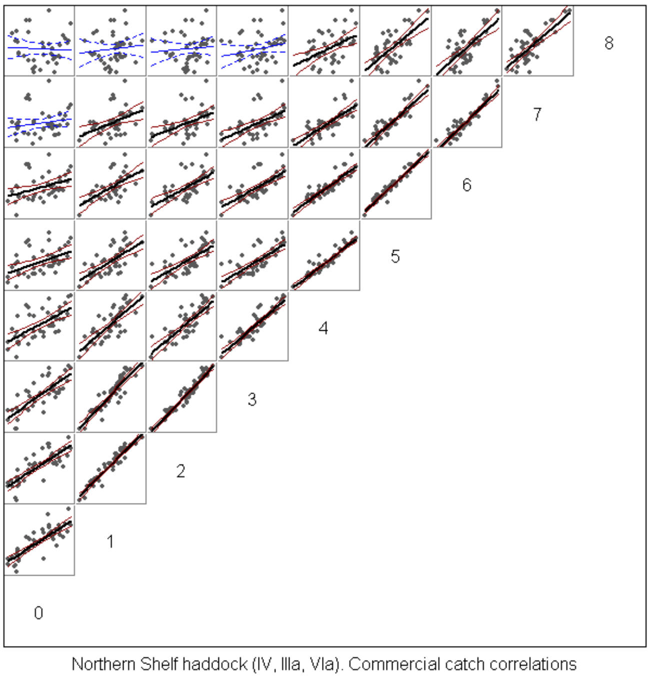


Figure 8.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and 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 8.3.4. 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.

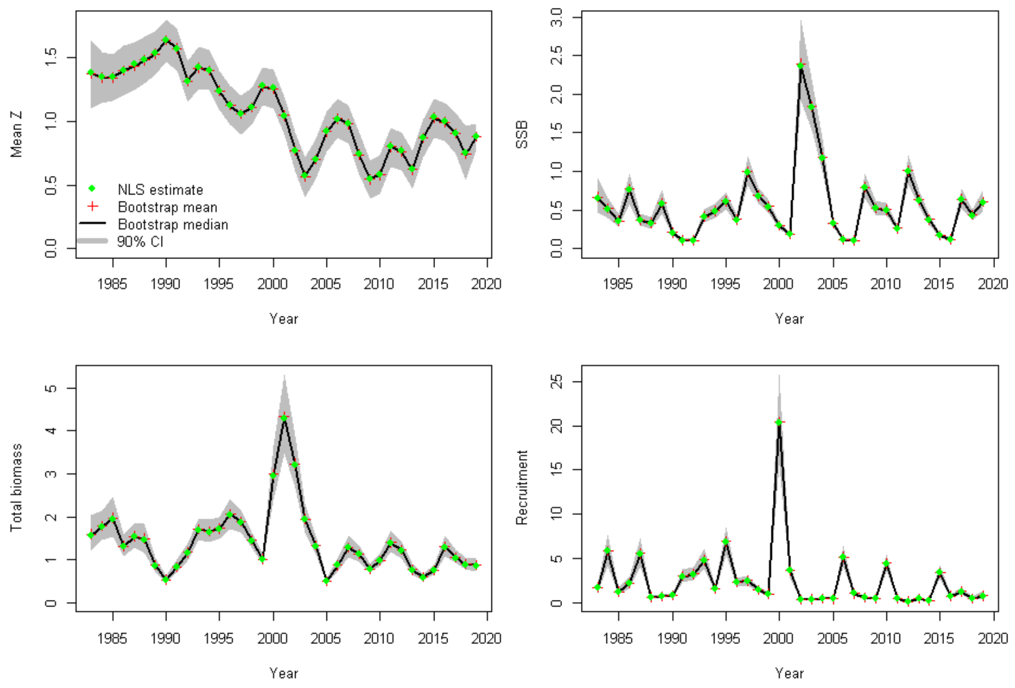


Figure 8.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded 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.

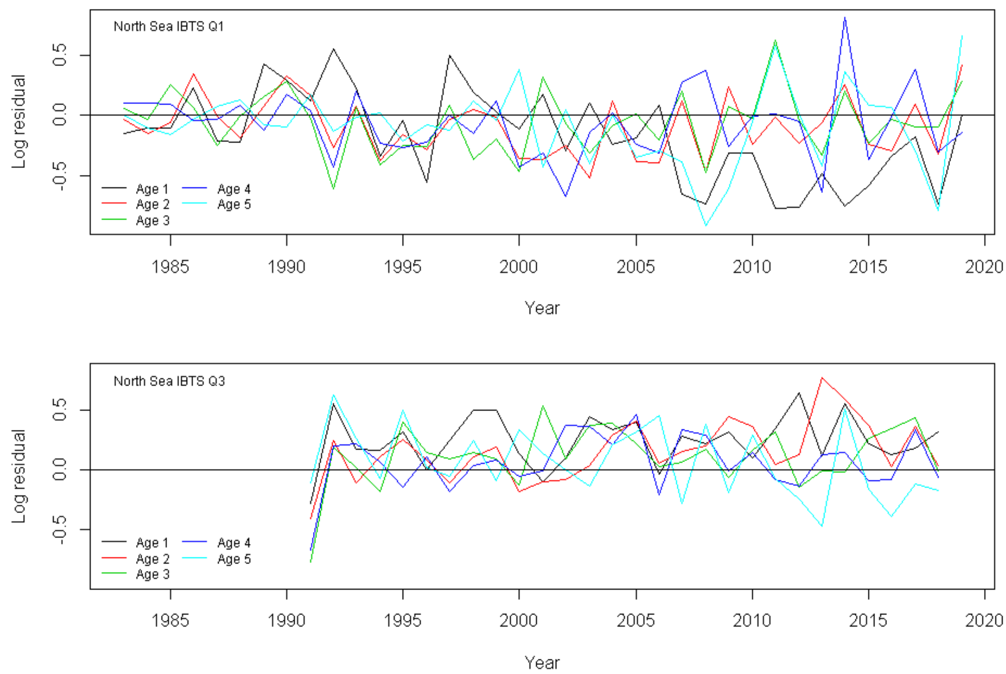


Figure 8.3.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).

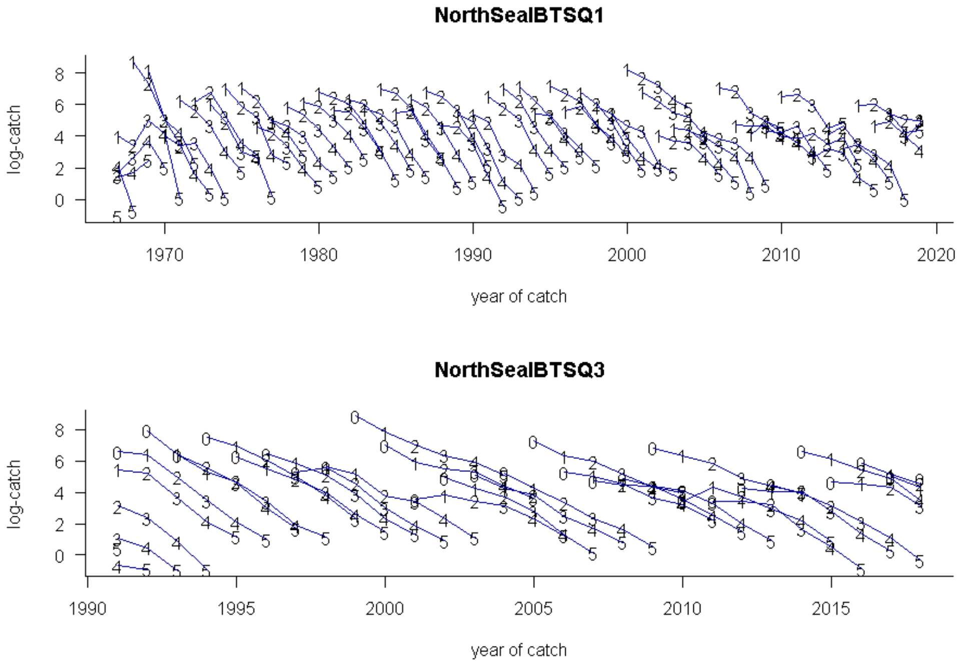


Figure 8.3.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

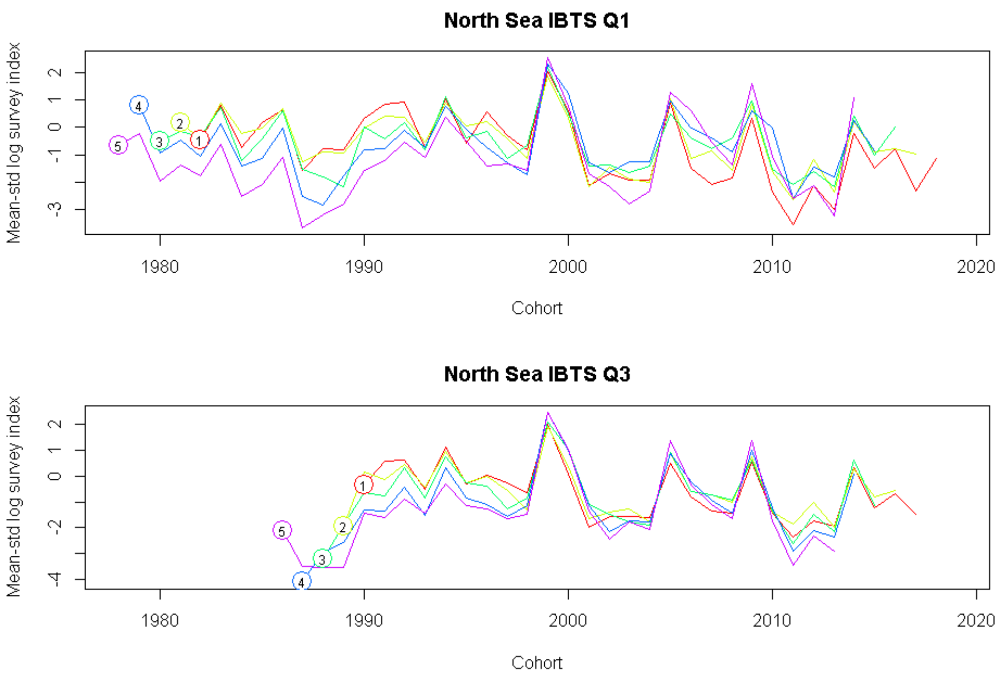
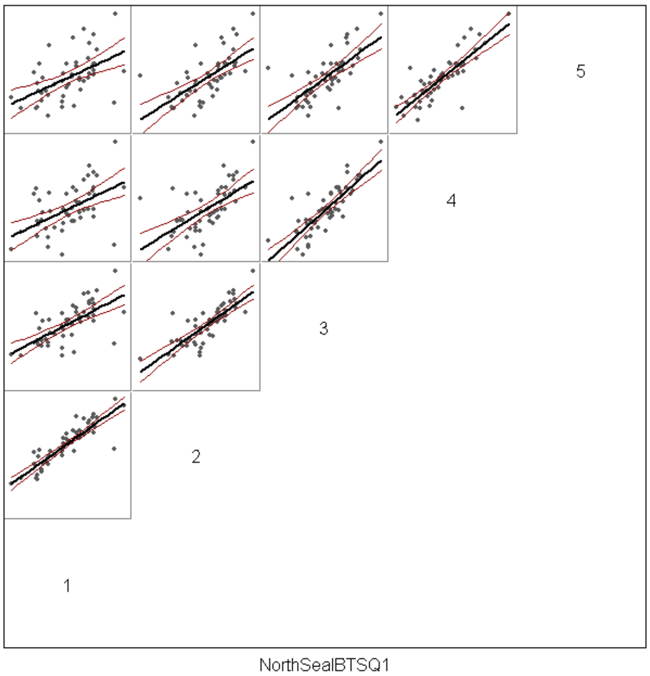


Figure 8.3.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.



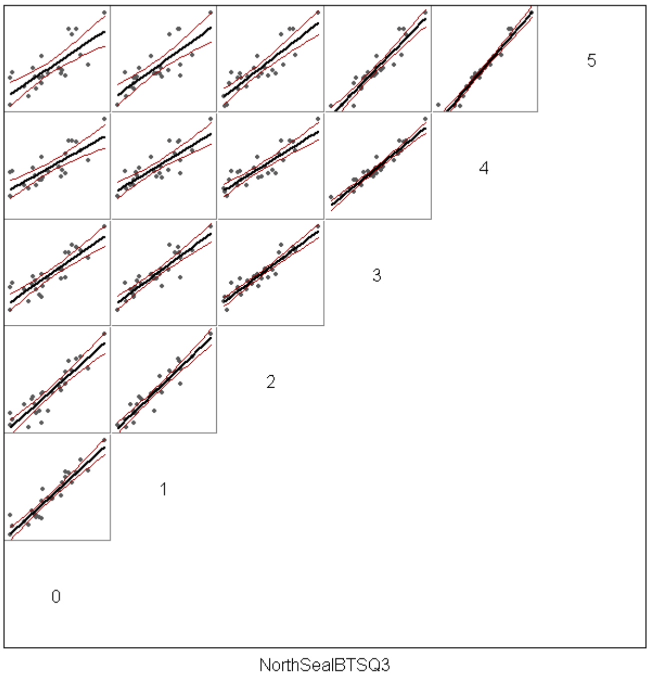


Figure 8.3.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (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.

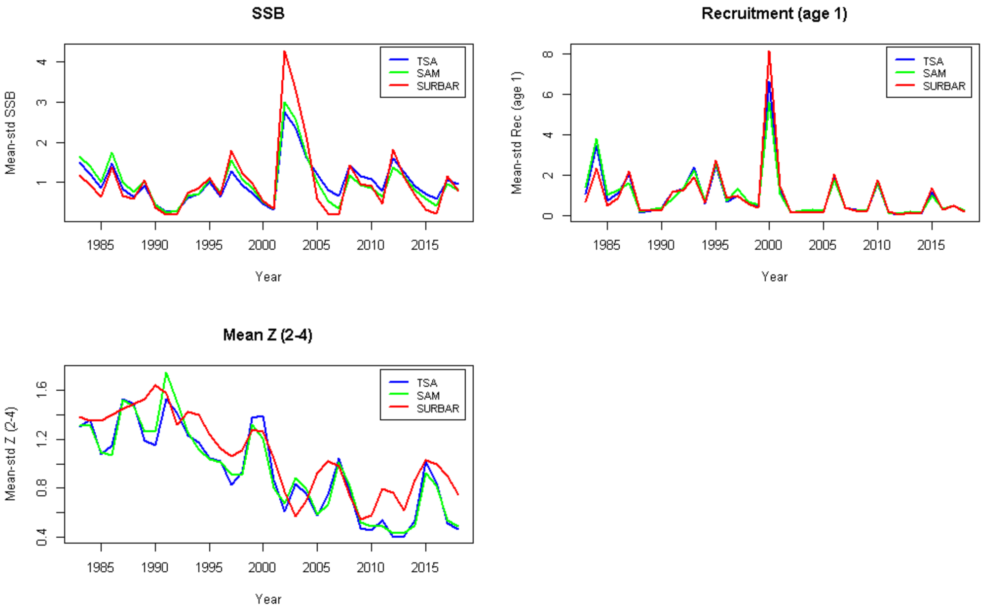


Figure 8.3.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Comparisons of stock summary estimates from TSA (blue), SAM (red) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models, and a composite Z estimate has been made for TSA, and SAM by adding natural and fishing mortality estimates.

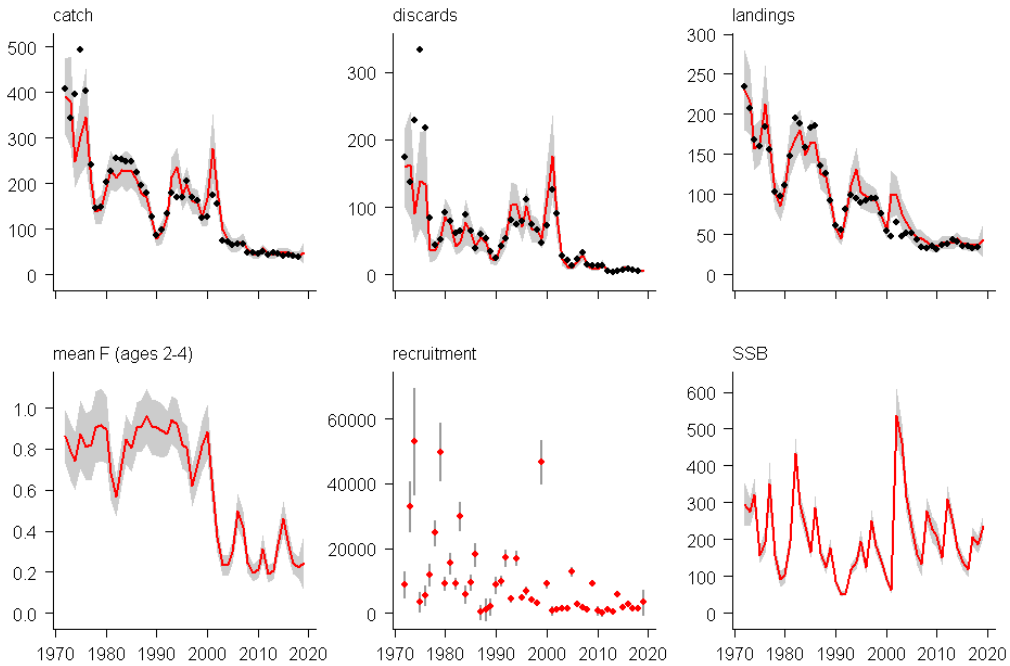


Figure 8.3.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary from final TSA assessment (including forecasts for 2017). Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for discards (discards+IBC+BMS), and landings).

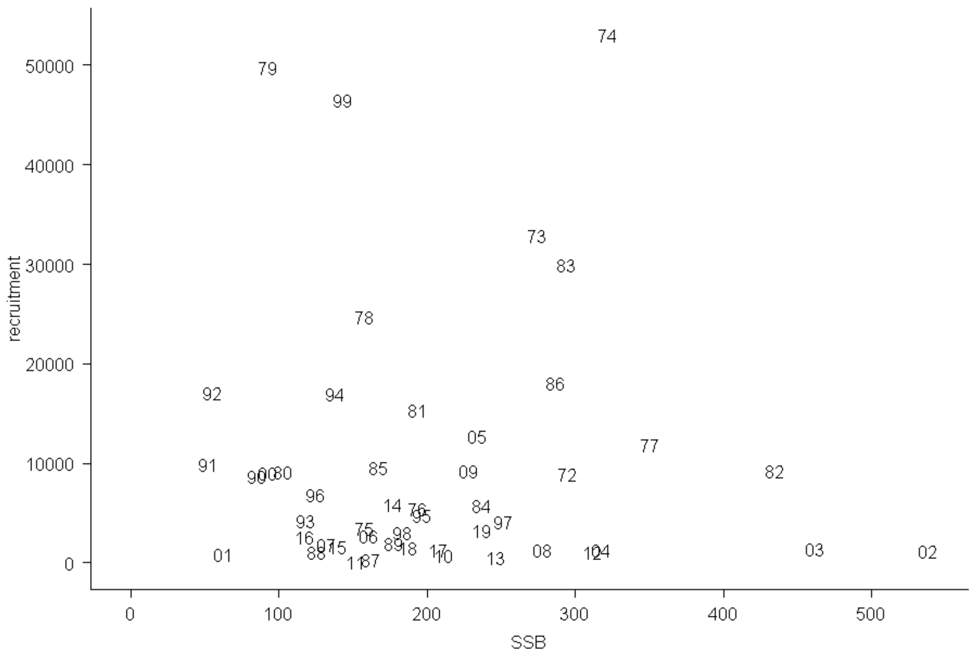


Figure 8.3.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

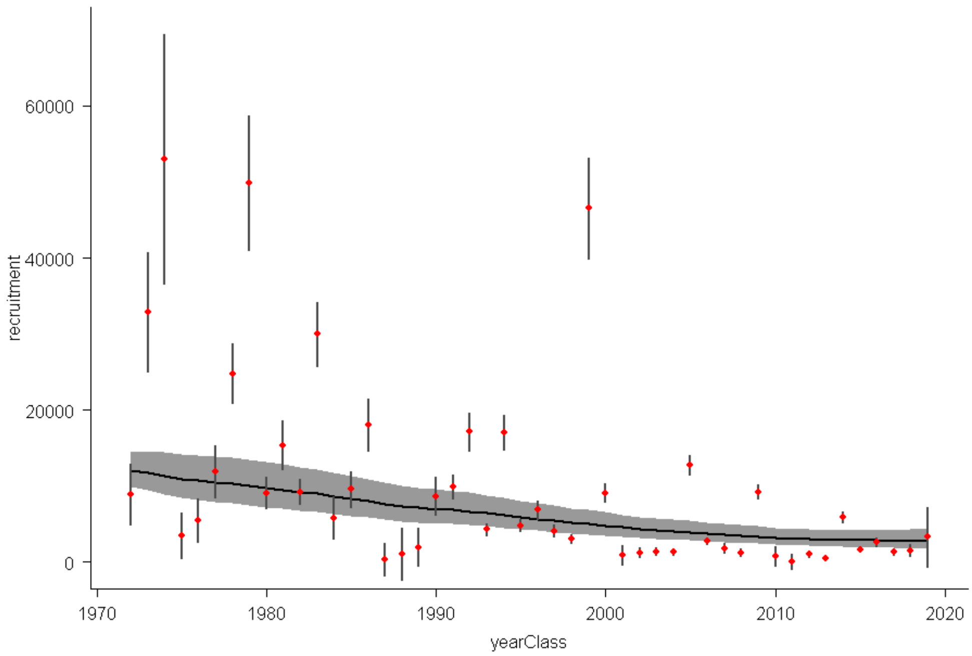


Figure 8.3.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk recruitment model estimated by TSA.

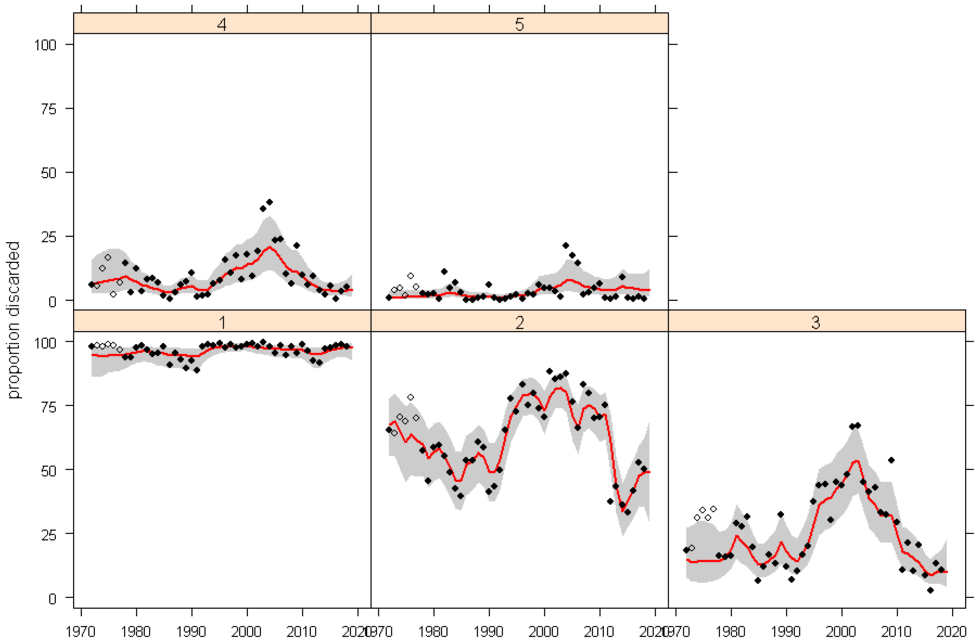


Figure 8.3.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch + BMS. The open points for the years 1973–1977 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.

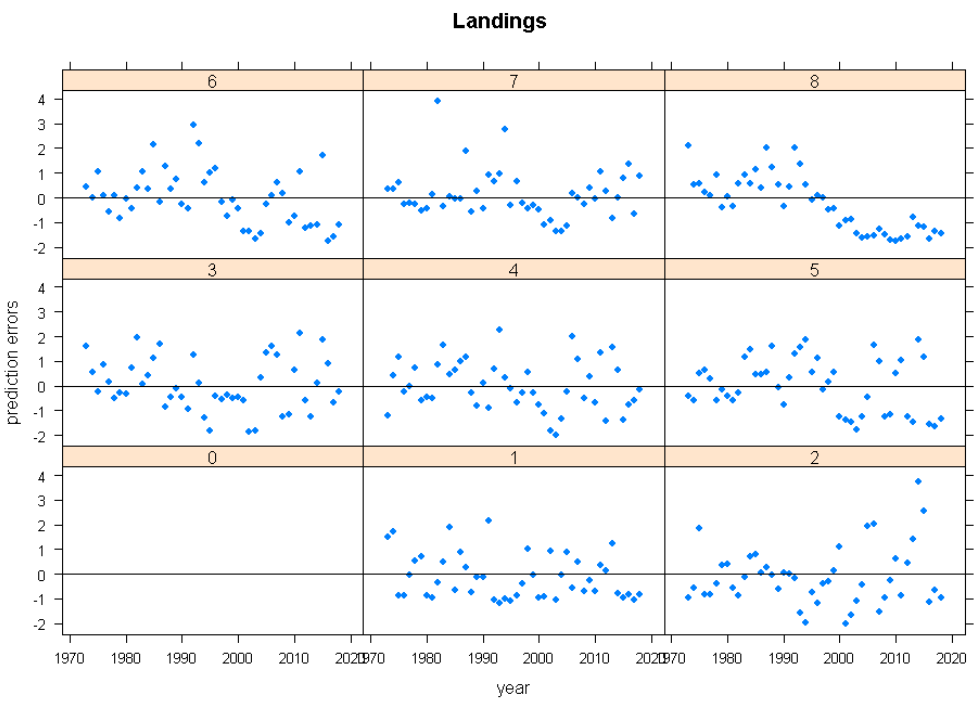


Figure 8.3.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA landings prediction errors by age.

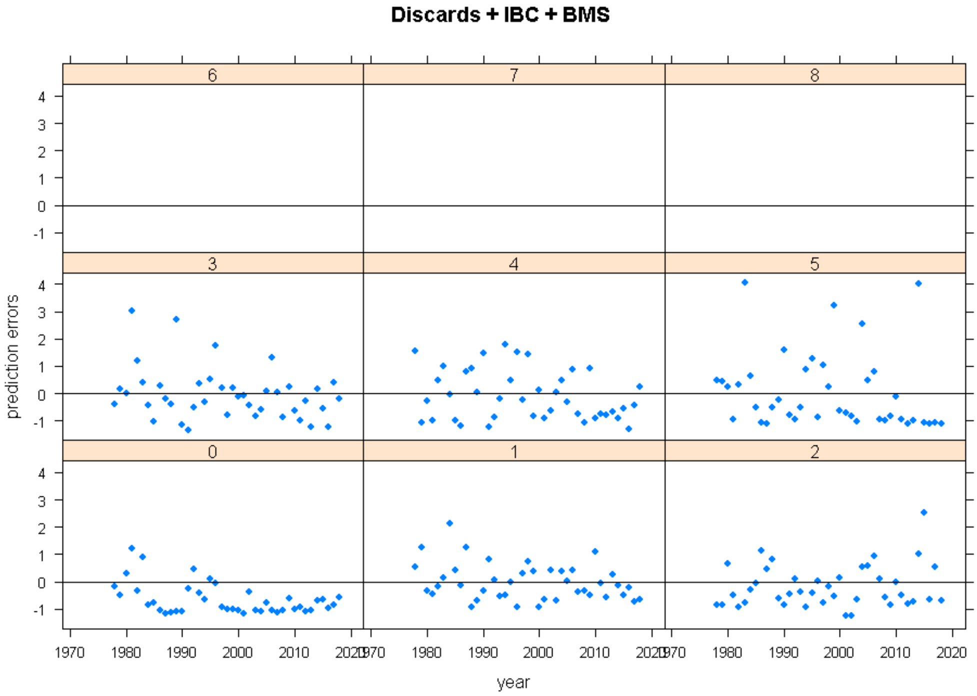


Figure 8.3.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA discards + IBC + BMS prediction errors by age.

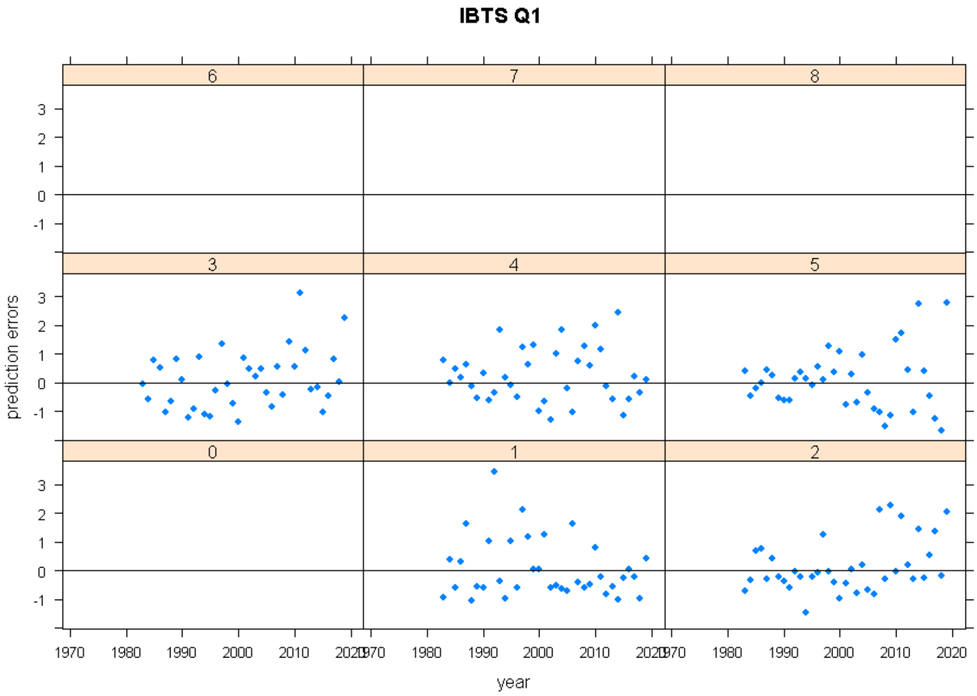


Figure 8.3.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q1 survey index.

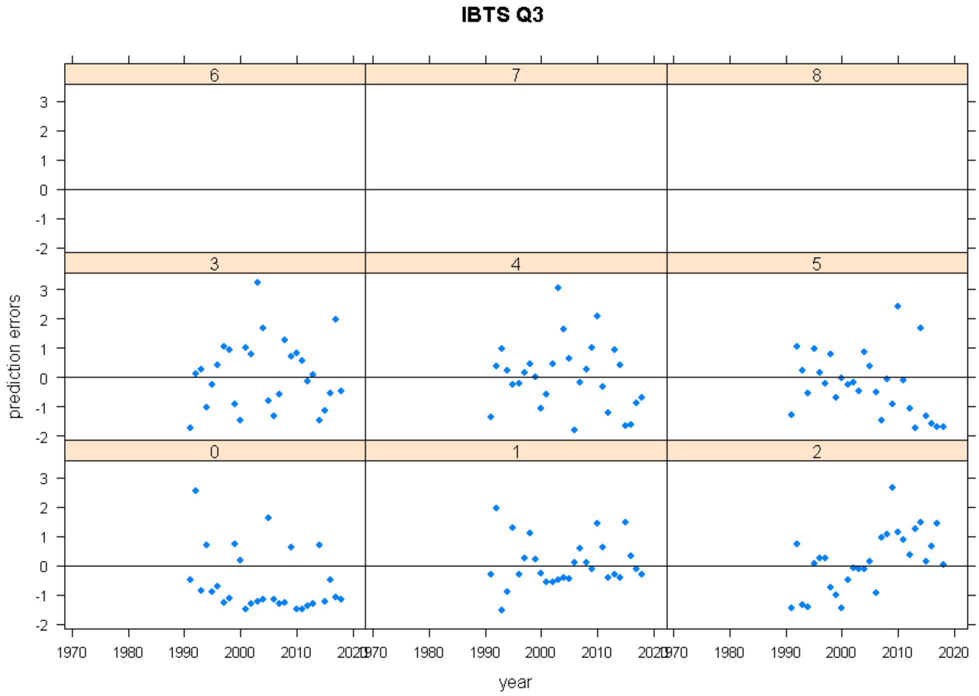


Figure 8.3.18. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q3 survey index.

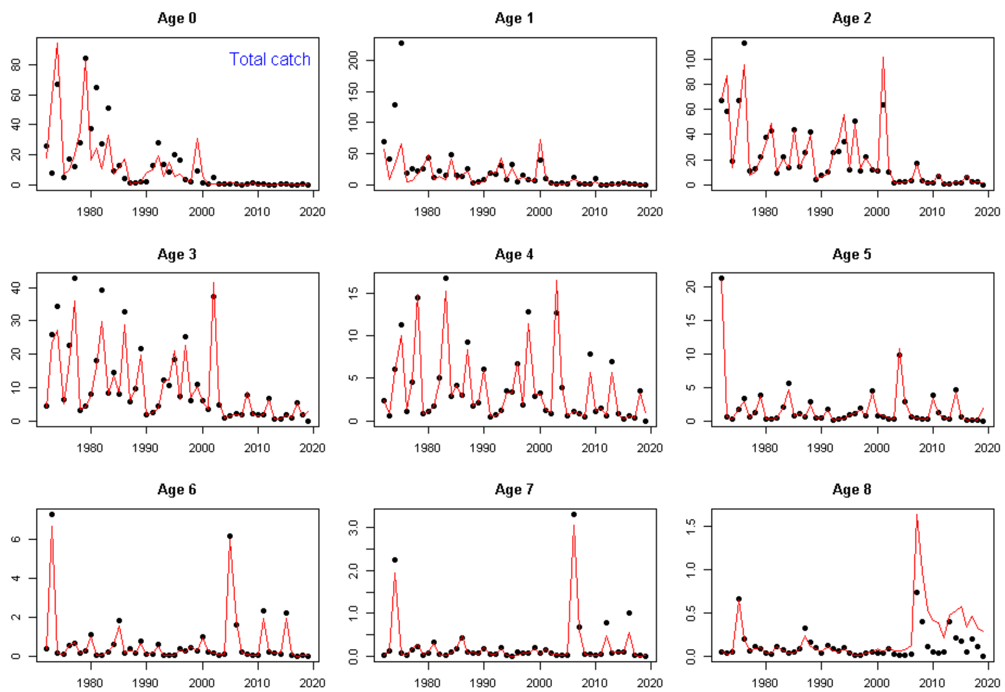


Figure 8.3.19. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for total catch, by age.

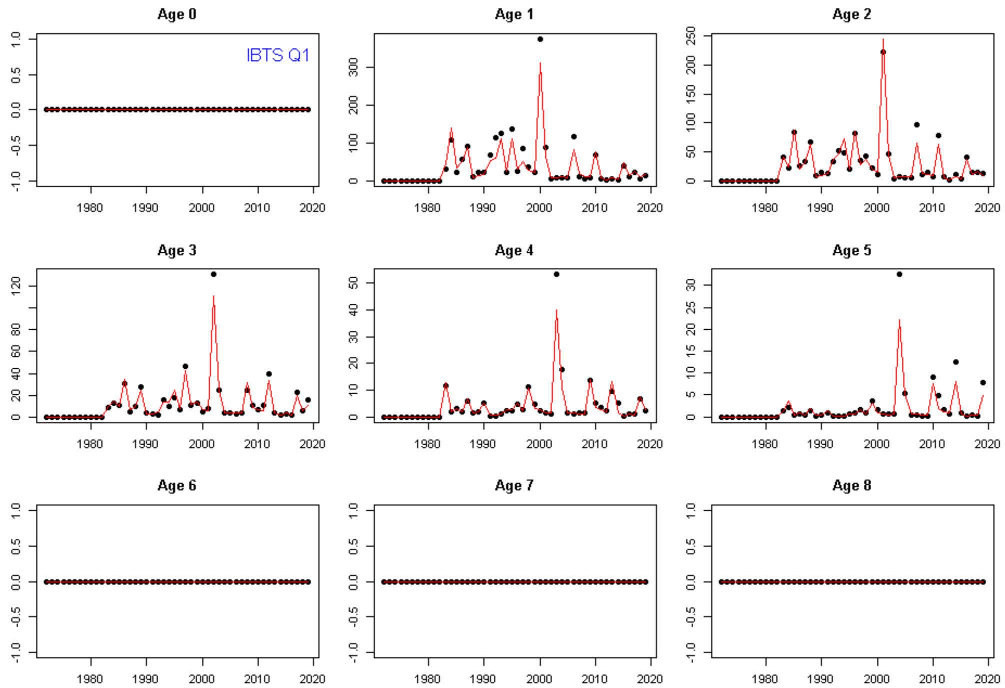


Figure 8.3.20. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

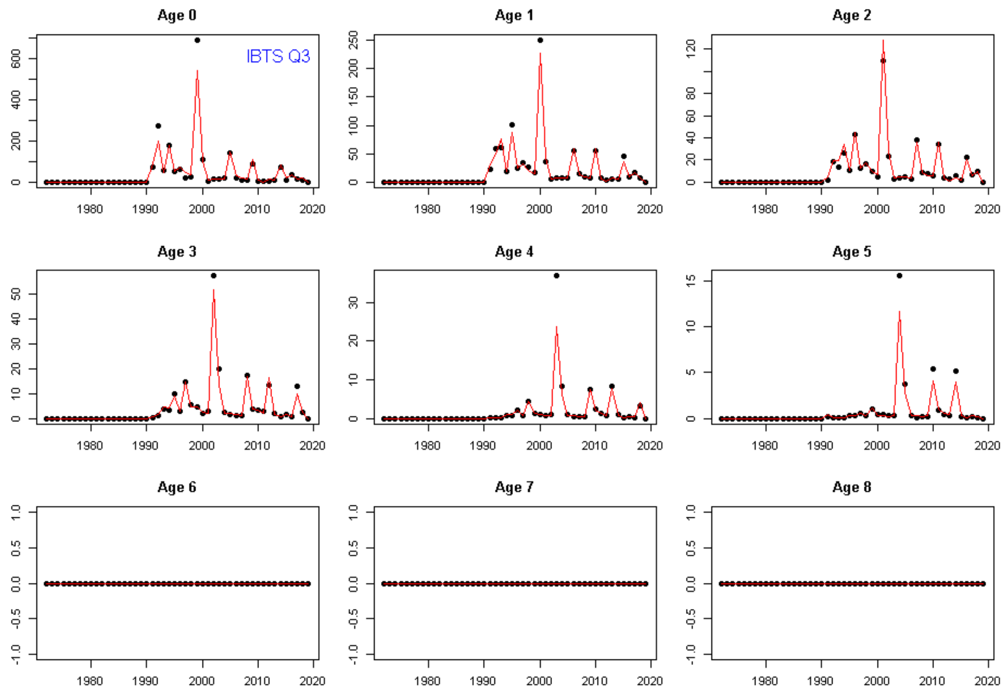


Figure 8.3.21. Haddock in Subarea 4, Division 6.a and Subdivision 20 Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.

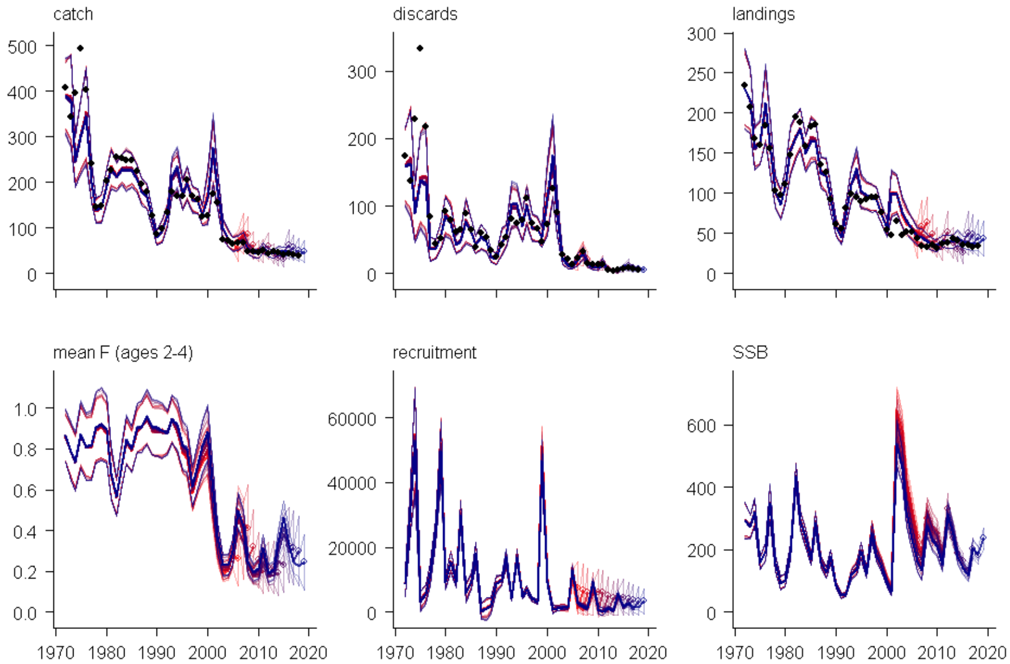


Figure 8.3.22. Haddock in Subarea 4, Division 6.a and Subdivision 20. Retrospective plots for the TSA assessment. The best estimates for each retrospective run end in an open circle, and each run is shown with the approximate pointwise 95% confidence interval. Estimates and CIs are colour-coded, with older runs becoming progressively more red.

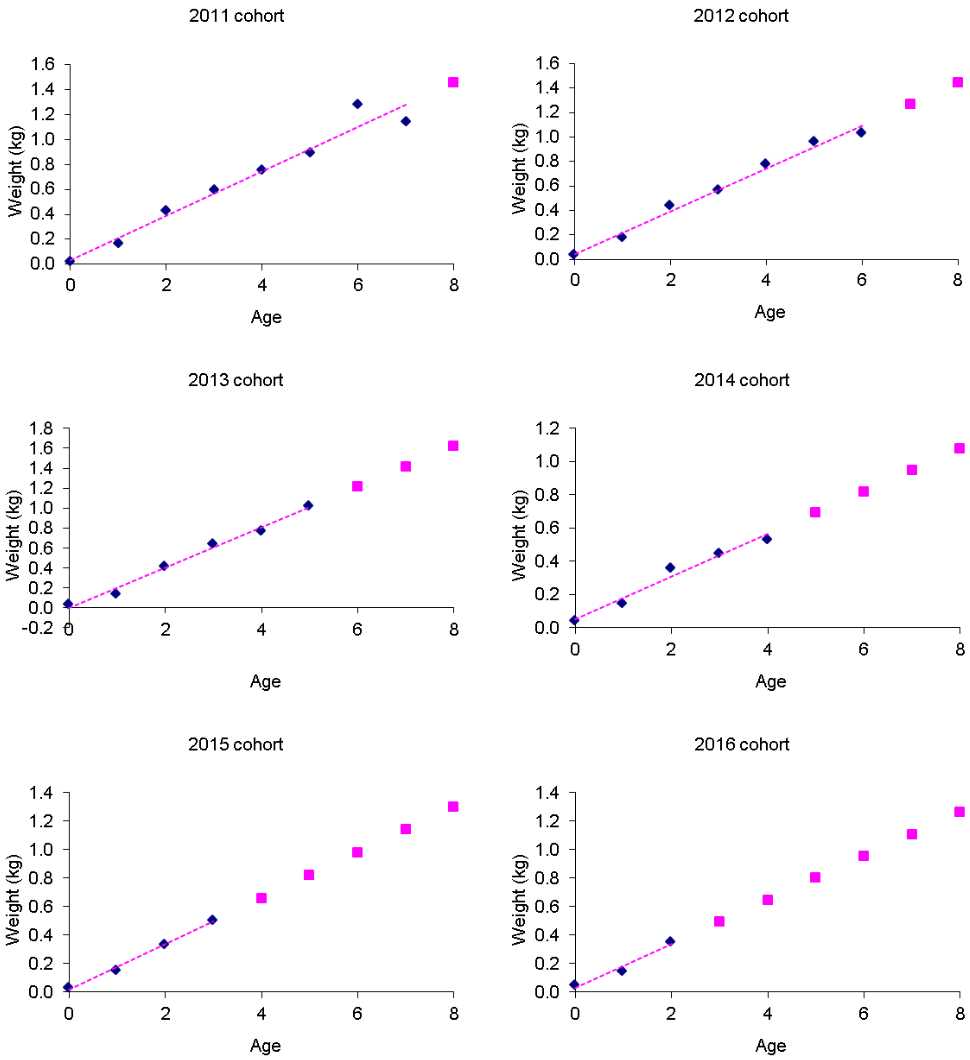


Figure 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski, 2011). Cohorts 2011–2016 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

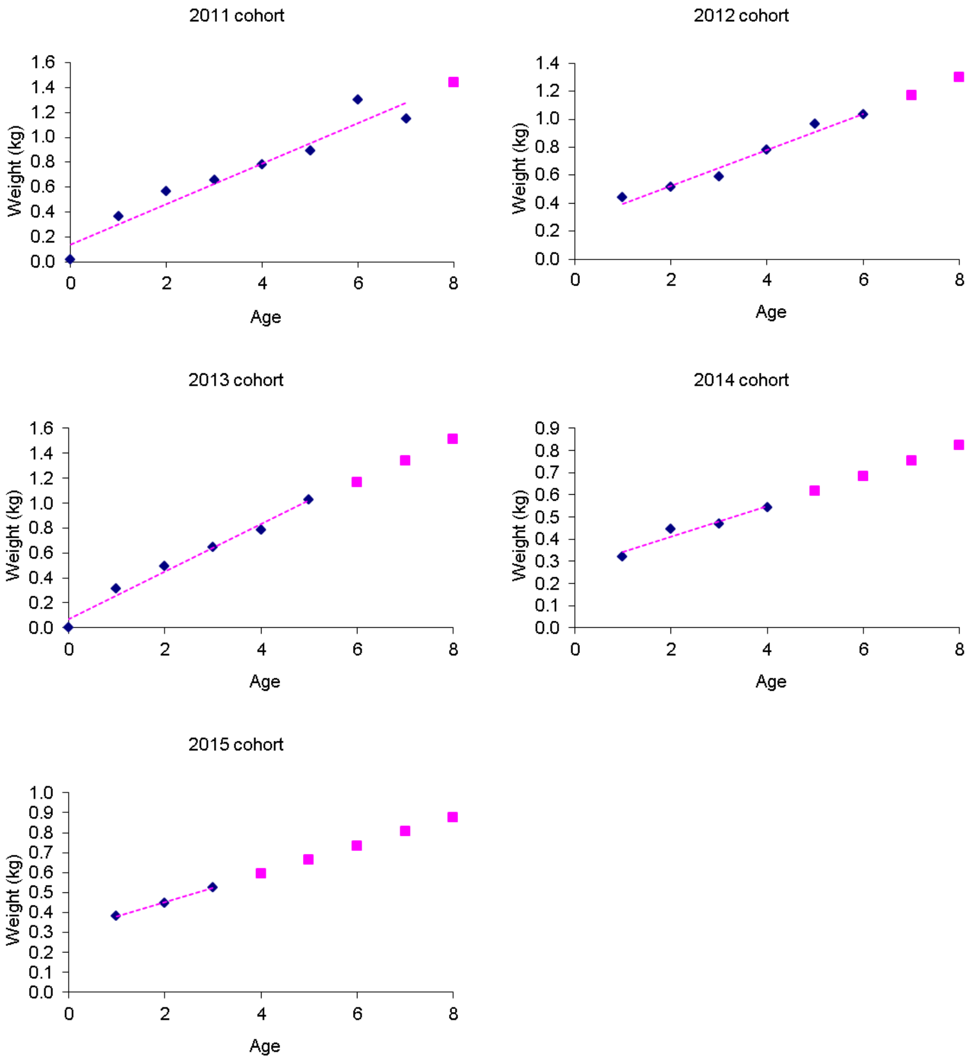


Figure 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for wanted catch (landings) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2011–2015 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

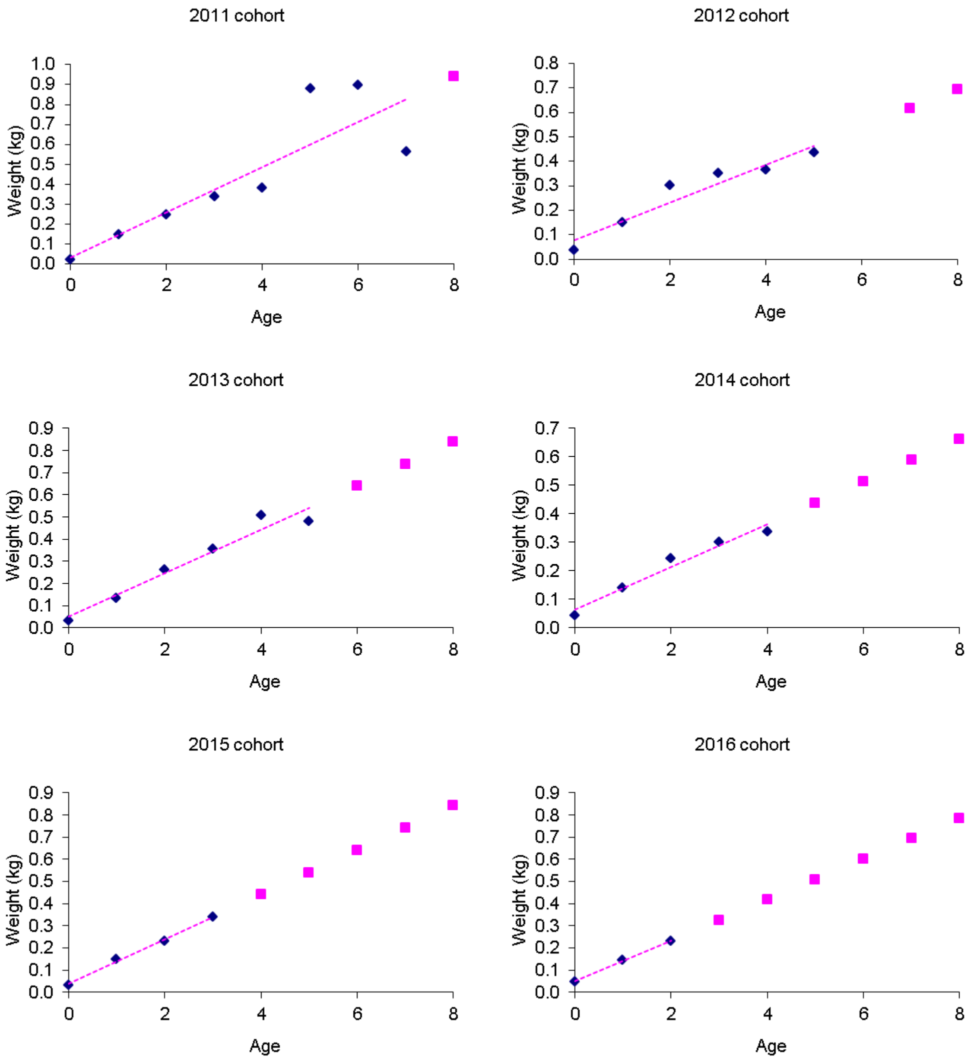


Figure 8.6.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for unwanted catch (discards + BMS) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2011–2016 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

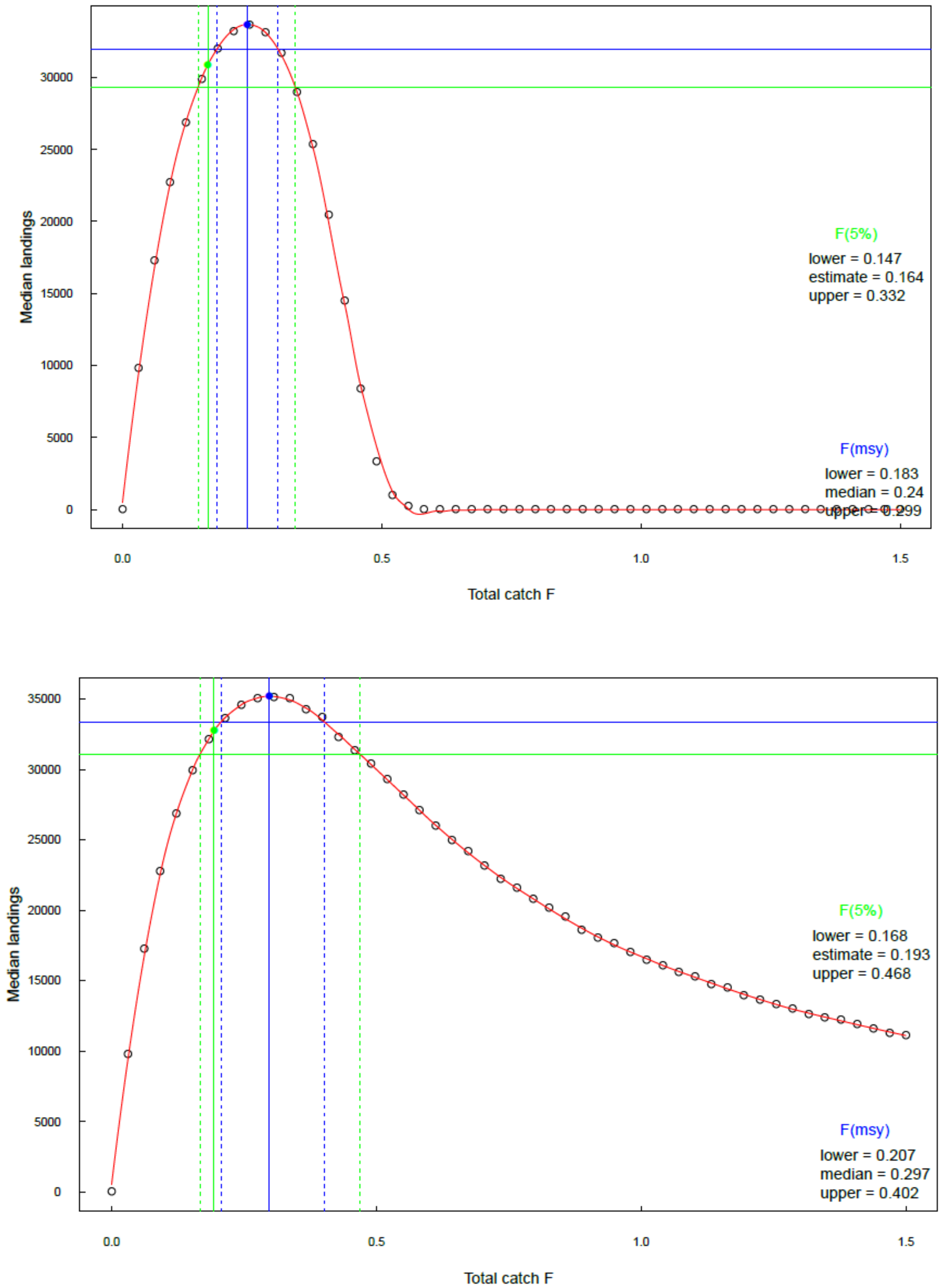


Figure 8.8.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSIM estimation of F($_{MSY}$) with the advice error but no rule (top) and of Fp05 with both advice error and rule (bottom).

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 therefore 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). Only ages 2–5 for the Q1 survey were used in the assessment, due to very low sample sizes for age-1 lemon sole in the Q1 IBTS survey.
- Maturity-at-age was fixed through time (based on IBTS Q1 samples), while weights-at-age were based on smoothly-varying observations 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 based on the DLS 3.2 rule, applied to relative SSB estimates provided by SURBAR.
- Stock status in relation to F_{MSY} proxies was evaluated using a suite of length-based indicators (LBIs).

These stipulations have been followed completely in this year's WGNSSK update assessment.

This is the sixth year in which the stock status for lemon sole has been evaluated by WGNSSK. Lemon sole has been defined as a category 3 stock 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 assessment given in this Section is intended to provide the basis for advice for 2020 and 2021.

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 lengthy 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 feed 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, which is a joint TAC together with witch flounder (ICES, 2013). ICES provided advice to the EU in 2018 whether several stocks (including lemon sole) should continue to be managed through TAC and quota regulations (see Annex 11 of ICES WGNSSK, 2018). This concluded that the TAC for lemon sole could be removed, or if maintained that a single-species lemon sole TAC would be more appropriate. However, the joint TAC with witch flounder continues to be the basis for management.

9.2 Fisheries data

9.2.1 Officially-reported landings

In the North Sea and in the Skagerrak and Kattegat, lemon sole is mainly a by-catch species in the fisheries for mixed demersal stocks and for plaice. 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

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 subsequent data calls and collations have focussed on length data.

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, and length-based allocations are likely to be sufficiently representative.

New categories were available for lemon sole data submissions in 2019, for BMS (Below Minimum Size) landings and logbook-recorded discards. Both were included with discards for length-allocation purposes as the length distributions are likely to be similar. In the event, there were no submissions for logbook-recorded discards (0 tonnes), and very few submissions for BMS landings as shown below (in tonnes):

Area	Belgium	Netherlands	Sweden	Total
4	0.000	0.051		0.051
3A		0.042	0.002	0.044
7D	0.000			0.000
Total	0.000	0.093	0.002	0.095

InterCatch summary plots are given in figures 9.2.5 to 9.2.7. The resultant estimates for landings and discards for 2002–2018 are given in Table 9.2.5 and Figure 9.2.8. 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 has not yet been corrected. 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 has not yet been addressed for the yield analysis .

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 (2019) and IBTS Q3 data (the year 2018 is given as an example, as 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, 2019). 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) a smoothed 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.

Not shown here is a 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, which is likely to be due to very small samples sizes at that age. 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 at the 2018 meeting, 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.

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 down weighting 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 9.4.4. 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 very low. Both SSB and TSB are estimated with more certainty than mean $Z_{3–5}$, and show steady increases since 2009 until a decline in 2018. Finally, recruitment at age 1 has fluctuated without trend for much of the time series, until starting to decline in 2016 for which the assessment indicates the lowest estimated recruitment. The 2018 estimate is the lowest in the available time series.

Log survey residuals (figures 9.4.2) show that the Q3 index fits the SURBAR model better than the Q1 index, with lower residuals in general and less trends through time. Consequently, 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 suggested that their influence on likely advice was not significant (ICES WKNSEA, 2018). The parameter estimates are summarised in Figure 9.4.3.

Finally, the retrospective analysis in Figure 9.4.4 shows little retrospective bias or noise, except for retrospective noise in 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 helps to explain the recruitment retrospective revisions. 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 2018 should be considered to be uncertain.

9.5 Application of advice rule

North Sea lemon sole are 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 (for 2018 and 2019), is given in Figure 9.5.1. The change ratio of the abundance index was -2%, which implies that catches for 2019 and 2020 should be **5348 tonnes**. As lemon sole are under the EU Landing Obligation, there is no corresponding advice for landings.

As the suggested change in catch is less than ±20%, there is no requirement to apply an uncertainty cap. Section 9.7 discusses whether a precautionary buffer should be applied for this stock.

9.6 Length–based F_{MSY} proxy estimation

Length-based indicators (LBIs) for F_{MSY} proxies 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 2002–2018.

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 were 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).

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 128 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):

$$\log_{10} L_\infty = 0.068260 + 0.969112 \log_{10} L_{max}$$

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

WGNSSK conclude that L_∞ should be set to 375 mm, as the estimate of 642 mm does not seem to be representative of the bulk of the stock, and the survey-based estimate may be biased low by reduced catchability for older lemon sole in the surveys.

This new estimate of L_∞, along with the new estimate of $L_{50\%mat}$ were then used in an LBI estimation run which is summarised in Figures 9.6.7 and 9.6.8, and Table 9.6.1. The key points are:

- Length at first catch (L_c) is above L_{mat} for the full time-series, which indicates few immature individuals in the catches.
- The ratio of the mean length of the upper 5th percentile of catches to L_∞ is around 1.0 throughout the time series, which would suggest a reasonable number of large (and hence old) fish in the population.
- The L_{mean}/L_{opt} ratio is greater than 1.0 for most of the time series, which suggests that the exploitation is targeting the most productive length classes.
- $L_{mean}/L_{F=M}$ is greater than 1.0 for nearly all years in the time-series, which would tend to show that this stock is being fished at a rate less than (or around) F_{MSY}.

The LBI results suggest that immature fish are well protected, and that the catch length distribution is not truncated at larger sizes: under optimal and sustainable exploitation the mean length in the catch is expected to be higher than the value observed, and this is the case here. 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 The precautionary buffer

The ICES "Guideline for preparing single-stock advice 2019" provides the following checklist for DLS 3.2 stocks:

1. If the PA buffer has not been applied in 2017 or later, then the following guidelines for applying the PA buffer (-20%) should be used:

		Stock size proxy/qualitative evaluation		
		✗	✓	?
Fishing pressure proxy/qualitative evaluation	✗	Apply PA buffer	Apply PA buffer	Apply PA buffer
	✓	Apply PA buffer	Do not apply PA buffer	Consider applying PA buffer
	?	Apply PA buffer	Consider applying PA buffer	Consider applying PA buffer

2. If the table above indicates "Apply PA buffer", the PA buffer should be applied.

3. If the table above indicates "Consider applying PA buffer, the PA buffer should be applied unless there is additional information indicating that it is not necessary to apply it. The basis for the exceptions is:
   a) Where there is evidence that the stock is increasing significantly; some examples could be: (1) if the stock has been continuously increasing for a period of several years (as a general rule > 5 years, but this may depend on the stock's biology); (2) if application of the "2 versus 3" advice rule gives an indicator ratio > 1.5.
   b) Where there is evidence that fishing pressure on the stock is low or has been reduced significantly during the last decade (for example, if there are data showing a significant decrease in fishing effort in the main fishery where the stock is taken as a bycatch species).
4. When not applying the PA buffer, sufficient justification and evidence should be provided in the EG report and in the advice sheet.

For North Sea lemon sole, the PA buffer has not been previously applied. The LBI analysis (Section 9.6) indicates that fishing pressure is at an acceptable level, suggesting a green tick is the table above against "Fishing pressure proxy/qualitative evaluation". However, there are no equivalent biomass proxy reference points, so only a question mark could be placed against "Stock size proxy/qualitative evaluation". The table then indicates that we should "consider applying the PA buffer".

Advice from ICES indicates that the two bases for exceptions (points 3.a) and 3.b) above) are to be considered as "either/or". While there is no evidence that the stock is increasing continuously (point 3.a)), there are indications that fishing pressure on the stock has been reduced significantly in the last decade. Figure 9.7.1 summarises recorded effort for the main metiers in the North Sea. Most lemon sole are caught by demersal (TR1, TR2) or beam (BT1, BT2) trawl, and the effort of both of these metiers in area 4 (North Sea) has indeed declined significantly. This suggests that there is no requirement to apply the PA buffer.

9.8 Quality of the assessment

The lemon sole assessment is based on a SURBAR analysis of two GAM-derived survey indices. SURBAR is an accepted method that is used either as the basis of advice, or as exploratory analyses, for many ICES stocks. However, the survey indices themselves are noisy, variable from year to year (and within year), and do not track lemon sole cohort strength very well. The indices were deemed to be appropriate in the recent benchmark, but they are not as reliable as those for some other stocks.

This issue is not thought to affect estimates of relative SSB. However, in one year the SURBAR estimates of mean Z are negative. This arises when the survey observation of cohort strength increases as the cohort ages, rather than decreasing as expected. If this happens for enough ages within a year, the estimated mean Z can be negative. Although this is not physically realistic, it is an expected consequence of the use of noisy survey series, and does not affect the advice which is based primarily on the last 5 years of the relative SSB estimate.

9.9 Conclusions and further work

While the SURBAR stock trends indicate a very low incoming 2017 year-class at age 1, and retrospective noise problems indicated that this should be treated as being very uncertain, there is increasing evidence for a reduction in SSB over the most recent two years. This is not yet reflected in the catch advice, due to the DLS 3.2 rule, but WGNSSK suggests that the assessment be considered carefully next year as the biennial advice may become inappropriate.

The estimation of status relative to F_{MSY} proxies indicates that fishing is occurring at or above F_{MSY}, which was also the conclusion in WGNSSK 2017 and 2018.

These conclusions are 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 2020 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.

9.10 Issues for future benchmarks

9.10.1 Data and stock ID

The erroneous length data submitted to InterCatch for 2013 needs to be corrected.

Further work may indicate an alternative method of collating the survey data that could be more appropriate for lemon sole

9.10.2 Assessment

The generation of negative *Z* estimates in the SURBAR model is a concern. Work is ongoing to develop a new method of estimating age-based survey catchability coefficients which may help to address this problem.

9.10.3 Forecast and reference points

Reference points are currently based on length-based indicators, and further work could help derive more robust estimates.

9.11 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	1985	793	6435	347	7575
1951	248	4710	314	5272	1986	639	5047	251	5937
1952	243	4922	298	5463	1987	669	5516	310	6495
1953	132	5440	386	5958	1988	642	5898	258	6798
1954	128	3972	534	4634	1989	693	5967	364	7024
1955	102	3836	141	4079	1990	872	6190	423	7485
1956	96	3395	103	3594	1991	734	6618	428	7780
1957	78	3419	102	3599	1992	952	6126	364	7442
1958	94	3104	82	3280	1993	1156	5839	422	7417
1959	130	3647	82	3859	1994	803	5262	695	6760
1960	153	4035	66	4254	1995	714	4712	877	6303
1961	161	4900	108	5169	1996	635	4737	1151	6523
1962	93	4630	101	4824	1997	768	4727	563	6058
1963	99	3791	66	3956	1998	868	6466	346	7680
1964	134	4121	77	4332	1999	844	6316	140	7300
1965	164	4949	105	5218	2000	803	5980	388	7171
1966	159	5415	201	5775	2001	584	5389	483	6456
1967	191	6188	331	6710	2002	522	3827	474	4823
1968	185	6270	337	6792	2003	543	3688	491	4722
1969	215	4470	315	5000	2004	607	3543	424	4574
1970	169	3434	256	3859	2005	674	3444	350	4468
1971	173	3967	357	4497	2006	417	3627	246	4290
1972	168	3672	475	4315	2007	432	3892	164	4488
1973	214	4568	451	5233	2008	276	3466	234	3976
1974	183	4227	351	4761	2009	262	2693	442	3397
1975	317	5029	33	5379	2010	350	2625	223	3198
1976	361	4830	42	5233	2011	251	3365	403	4019
1977	627	5661	37	6325	2012	482	2119	358	2959
1978	705	6108	141	6954	2013	289	2981	491	3761
1979	833	6428	260	7521	2014	315	3017	356	3688
1980	722	6424	152	7298	2015	269	2871	253	3393
1981	793	5933	290	7016	2016	299	3266	240	3805
1982	735	7168	584	8487	2017	343	2822	158	3323
1983	759	8257	491	9507	2018	280	2635	99	3014
1984	595	6930	586	8111					

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	1985	117	0	164	0	66	0	347
1951	5	0	262	0	47	0	314	1986	77	0	133	0	41	0	251
1952	10	0	188	0	100	0	298	1987	81	0	185	0	44	0	310
1953	7	0	196	0	183	0	386	1988	74	0	155	0	29	0	258
1954	9	0	361	0	164	0	534	1989	68	0	252	0	44	0	364
1955	9	0	0	0	132	0	141	1990	68	0	272	0	83	0	423
1956	4	0	0	0	99	0	103	1991	83	0	272	0	73	0	428
1957	7	0	0	0	95	0	102	1992	66	0	176	0	122	0	364
1958	1	0	0	0	81	0	82	1993	36	0	311	0	75	0	422
1959	2	0	0	0	80	0	82	1994	97	0	505	0	93	0	695
1960	4	0	0	0	62	0	66	1995	138	0	584	0	155	0	877
1961	1	0	0	0	106	1	108	1996	213	0	720	0	218	0	1151
1962	2	0	0	0	99	0	101	1997	143	0	305	0	115	0	563
1963	3	0	0	0	63	0	66	1998	53	0	198	0	95	0	346
1964	5	0	0	0	72	0	77	1999	50	0	0	0	90	0	140
1965	16	0	0	0	89	0	105	2000	62	0	200	0	126	0	388
1966	7	0	0	0	194	0	201	2001	104	0	191	0	188	0	483
1967	6	0	0	0	325	0	331	2002	101	0	256	0	117	0	474
1968	8	0	0	0	329	0	337	2003	128	0	251	0	112	0	491
1969	12	0	0	0	303	0	315	2004	120	0	198	1	105	0	424
1970	16	0	0	0	240	0	256	2005	90	0	187	2	71	0	350
1971	22	0	0	0	335	0	357	2006	98	0	100	0	48	0	246
1972	18	0	0	0	457	0	475	2007	70	0	72	1	21	0	164
1973	25	0	0	0	426	0	451	2008	140	0	46	3	45	0	234
1974	16	0	0	1	334	0	351	2009	149	0	176	9	108	0	442
1975	19	0	0	0	14	0	33	2010	101	0	85	5	32	0	223
1976	24	0	0	0	18	0	42	2011	153	0	178	15	57	0	403
1977	21	1	0	0	15	0	37	2012	171	0	167	20	0	0	358
1978	45	2	63	0	31	0	141	2013	176	0	179	26	110	0	491
1979	60	0	165	0	35	0	260	2014	162	0	108	14	72	0	356
1980	33	0	109	0	10	0	152	2015	123	0	84	5	41	0	253
1981	66	0	212	0	12	0	290	2016	115	0	69	9	47	0	240
1982	96	0	406	1	81	0	584	2017	87	0	34	8	29	0	158
1983	108	0	298	0	85	0	491	2018	57	0	21	5	15	0	99
1984	110	0	367	0	109	0	586								

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	1985	989	555	157	26	0	0	4703	5	6435
1951	115	845	90	21	167	0	3430	42	4710	1986	511	577	103	16	0	0	3839	1	5047
1952	98	391	227	26	168	0	3953	59	4922	1987	448	742	174	14	0	0	4137	1	5516
1953	73	409	189	18	132	0	4590	29	5440	1988	539	639	184	14	301	0	4220	1	5898
1954	2	272	177	24	112	0	3368	17	3972	1989	441	828	176	40	397	0	4083	2	5967
1955	49	311	0	15	78	0	3374	9	3836	1990	491	1007	208	49	0	0	4431	4	6190
1956	48	222	0	19	58	0	3034	14	3395	1991	544	1099	250	41	0	12	4666	6	6618
1957	39	249	0	24	64	0	3032	11	3419	1992	577	1149	177	30	0	13	4175	5	6126
1958	30	171	0	13	43	0	2835	12	3104	1993	525	966	240	37	0	9	4059	3	5839
1959	85	242	0	40	43	0	3226	11	3647	1994	436	597	436	27	0	11	3754	1	5262
1960	155	577	0	46	67	0	3178	12	4035	1995	588	585	412	70	0	9	3046	2	4712
1961	286	488	0	79	102	0	3934	11	4900	1996	592	547	534	67	0	18	2976	3	4737
1962	175	501	0	54	106	0	3794	0	4630	1997	504	499	224	76	0	29	3391	4	4727
1963	365	222	0	36	71	0	3097	0	3791	1998	815	796	197	149	838	23	3643	5	6466
1964	484	358	0	62	75	0	3142	0	4121	1999	662	1015	0	62	681	24	3866	6	6316
1965	562	385	0	91	93	0	3818	0	4949	2000	711	1277	184	72	492	17	3222	5	5980
1966	594	548	0	98	65	0	4110	0	5415	2001	694	1281	191	77	451	22	2666	7	5389
1967	601	791	0	136	61	0	4599	0	6188	2002	604	971	190	116	402	17	1521	6	3827
1968	422	775	0	96	34	0	4943	0	6270	2003	517	1008	239	136	369	16	1399	4	3688
1969	292	639	0	80	36	0	3423	0	4470	2004	667	1113	120	81	355	12	1192	3	3543
1970	241	307	0	52	58	0	2776	0	3434	2005	595	1057	102	85	402	13	1188	2	3444
1971	348	514	0	54	122	0	2929	0	3967	2006	552	968	57	183	412	13	1440	2	3627
1972	423	530	0	59	130	0	2530	0	3672	2007	542	1136	65	143	367	23	1610	6	3892
1973	566	478	0	73	217	16	3218	0	4568	2008	527	925	47	120	434	26	1383	4	3466
1974	486	447	0	59	269	0	2966	0	4227	2009	389	898	88	64	294	31	927	2	2693
1975	748	521	0	83	299	0	3367	11	5029	2010	375	821	32	102	323	35	935	2	2625
1976	493	506	0	68	308	0	3443	12	4830	2011	387	999	56	96	641	27	1157	2	3365
1977	618	321	0	71	262	0	4387	2	5661	2012	406	999	34	61	587	30	0	2	2119
1978	760	517	28	54	231	0	4518	0	6108	2013	527	649	27	67	479	16	1214	2	2981
1979	674	876	136	41	390	0	4308	3	6428	2014	648	626	27	63	425	23	1202	3	3017
1980	484	599	102	49	303	0	4885	2	6424	2015	425	794	16	82	423	12	1116	3	2871
1981	555	605	237	39	412	0	4084	1	5933	2016	448	1054	15	82	443	23	1196	5	3266
1982	879	670	419	52	759	0	4386	3	7168	2017	345	1032	0	42	356	14	1028	4	2822
1983	1122	735	402	28	1009	0	4957	4	8257	2018	370	815	9	52	347	14	1025	3	2635
1984	1144	567	344	22	0	0	4850	3	6930										

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	1985	0	729	0	0	64	0	793
1951	0	74	1	0	173	0	248	1986	7	576	0	0	56	0	639
1952	0	64	0	0	179	0	243	1987	24	577	0	0	68	0	669
1953	0	35	0	0	97	0	132	1988	11	569	0	6	56	0	642
1954	0	33	0	0	95	0	128	1989	8	610	0	0	75	0	693
1955	0	29	0	0	73	0	102	1990	16	782	0	0	74	0	872
1956	0	33	0	0	63	0	96	1991	11	640	0	0	83	0	734
1957	0	27	0	0	51	0	78	1992	22	793	0	0	120	17	952
1958	0	38	0	0	56	0	94	1993	14	980	4	0	141	17	1156
1959	0	71	0	0	59	0	130	1994	10	648	2	0	127	16	803
1960	0	95	1	0	57	0	153	1995	27	576	2	0	91	18	714
1961	0	90	0	0	71	0	161	1996	0	513	1	0	97	24	635
1962	0	92	1	0	0	0	93	1997	0	628	2	0	115	23	768
1963	0	99	0	0	0	0	99	1998	0	743	3	0	100	22	868
1964	0	133	1	0	0	0	134	1999	0	731	3	0	88	22	844
1965	0	163	1	0	0	0	164	2000	0	722	1	0	65	15	803
1966	0	159	0	0	0	0	159	2001	0	511	1	0	53	19	584
1967	0	189	1	0	0	1	191	2002	0	457	4	0	41	20	522
1968	0	184	0	0	0	1	185	2003	0	451	6	30	35	21	543
1969	0	215	0	0	0	0	215	2004	0	472	5	82	29	19	607
1970	0	169	0	0	0	0	169	2005	0	468	5	147	38	16	674
1971	0	173	0	0	0	0	173	2006	0	321	8	40	32	16	417
1972	0	168	0	0	0	0	168	2007	0	374	5	16	18	19	432
1973	0	214	0	0	0	0	214	2008	0	239	7	3	15	12	276
1974	0	183	0	0	0	0	183	2009	0	233	4	1	15	9	262
1975	0	263	1	1	52	0	317	2010	0	286	3	35	19	7	350
1976	10	294	1	19	37	0	361	2011	0	223	0	0	12	16	251
1977	9	528	2	37	51	0	627	2012	0	446	3	0	15	18	482
1978	4	628	2	12	59	0	705	2013	0	259	3	5	10	12	289
1979	7	704	1	10	111	0	833	2014	0	276	7	12	14	6	315
1980	12	622	0	0	87	1	722	2015	0	250	4	0	9	6	269
1981	1	710	0	3	75	4	793	2016	0	265	5	16	7	6	299
1982	2	647	0	9	77	0	735	2017	0	314	5	11	6	7	343
1983	3	636	0	10	110	0	759	2018	0	252	5	14	6	2	280
1984	6	525	0	0	64	0	595								

Table 9.2.5. 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 Landings	ICES Discards	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%

Year	Official landings	ICES Landings	ICES Discards	ICES Total Catch	Discard rate
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%
2018	3014	3046	332	3377	9.82%

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	0.0558	0.0637	0.1092	0.2178	0.3448	0.3870	0.4379	0.2699	0.2988
2006	0.0534	0.0676	0.1161	0.2213	0.3393	0.3684	0.4131	0.2691	0.2828
2007	0.0507	0.0704	0.1213	0.2233	0.3331	0.3529	0.3924	0.2739	0.2724
2008	0.0479	0.0717	0.1246	0.2239	0.3264	0.3414	0.3770	0.2840	0.2675
2009	0.0448	0.0720	0.1264	0.2230	0.3188	0.3323	0.3648	0.2984	0.2675
2010	0.0415	0.0711	0.1265	0.2206	0.3099	0.3258	0.3553	0.3165	0.2732
2011	0.0377	0.0693	0.1250	0.2167	0.3000	0.3205	0.3514	0.3396	0.2859
2012	0.0339	0.0654	0.1207	0.2091	0.2871	0.3163	0.3540	0.3585	0.3008
2013	0.0303	0.0616	0.1155	0.1985	0.2739	0.3137	0.3512	0.3782	0.3253
2014	0.0270	0.0577	0.1095	0.1897	0.2608	0.3048	0.3467	0.3923	0.3427
2015	0.0242	0.0546	0.1055	0.1803	0.2500	0.3082	0.3492	0.4028	0.3534
2016	0.0217	0.0518	0.1020	0.1725	0.2450	0.3223	0.3622	0.4140	0.3602
2017	0.0195	0.0497	0.0992	0.1652	0.2430	0.3460	0.3808	0.4301	0.3635
2018	0.0176	0.0479	0.0969	0.1586	0.2444	0.3776	0.4055	0.4486	0.3631
2019	0.0162	0.0468	0.0956	0.1531	0.2499	0.4196	0.4385	0.4700	0.3584

Table 9.4.1. Lemon sole in areas 4, 7.d and 3.a. SURBAR stock summary. Mortality Z is given as the mean total mortality over ages 3–5, while SSB and recruitment at age 1 are relative indices. Each estimate is given with lower and upper bounds of a 90% confidence interval.

Year	Z.low	z	Z.high	ssb.low	ssb	ssb.high	rec.low	rec	rec.high
2005	-0.143	0.177	0.451	1.099	1.411	1.924	0.984	1.378	1.929
2006	-0.065	0.194	0.443	1.212	1.508	2.049	1.030	1.456	2.049
2007	0.150	0.422	0.647	1.246	1.524	2.007	1.376	2.011	3.013
2008	0.132	0.383	0.631	1.043	1.240	1.650	1.173	1.568	2.173
2009	-0.275	-0.037	0.178	0.872	1.029	1.375	1.302	1.747	2.320

Year	Z.low	z	Z.high	ssb.low	ssb	ssb.high	rec.low	rec	rec.high
2010	-0.216	0.006	0.242	1.181	1.416	1.890	1.731	2.311	3.072
2011	-0.100	0.148	0.376	1.456	1.776	2.287	1.775	2.401	3.372
2012	0.001	0.267	0.478	1.580	1.912	2.480	1.538	2.168	3.041
2013	-0.015	0.220	0.458	1.486	1.786	2.327	1.135	1.593	2.235
2014	-0.082	0.148	0.377	1.447	1.750	2.295	1.591	2.212	3.089
2015	-0.143	0.082	0.306	1.510	1.833	2.418	1.009	1.473	2.144
2016	-0.060	0.200	0.421	1.655	2.024	2.646	1.219	1.873	2.914
2017	0.008	0.296	0.572	1.587	1.969	2.628	0.627	1.084	1.913
2018	0.069	0.193	0.308	1.314	1.676	2.417	0.358	0.913	2.215

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	0.703125	1.835938	1.001124	0.588403	1.106591	1.715645
2003	1.171875	1.757813	0.996787	0.481383	1.074147	1.301996
2004	1.796875	1.914063	1.0012	0.609388	1.2018	1.128451
2005	1.953125	1.914063	0.90966	0.383082	1.126301	1.001156
2006	0.859375	1.914063	0.961637	0.555418	1.106481	1.569477
2007	0.859375	1.914063	0.974924	0.500742	1.084997	1.539003
2008	1.484375	1.757813	0.995991	0.476914	1.105271	1.169599
2009	0.546875	1.757813	0.993689	0.479194	1.064006	1.818814
2010	0.703125	1.835938	1.00503	0.517791	1.112151	1.724265
2011	0.546875	1.367188	0.958791	0.285228	0.918999	1.570938
2012	0.546875	1.523438	0.94789	0.267429	0.93938	1.605778
2013	0.546875	1.132813	0.86139	0.059692	0.701476	1.199104
2014	0.546875	1.523438	0.98821	0.324987	0.962061	1.644548
2015	1.484375	1.601563	0.995098	0.283552	1.035911	1.096202
2016	0.703125	1.601563	1.004552	0.448823	1.037958	1.609236
2017	0.546875	1.601563	1.023164	0.49904	1.040552	1.778722
2018	2.109375	1.992188	1.076182	0.698065	1.291407	1.089795

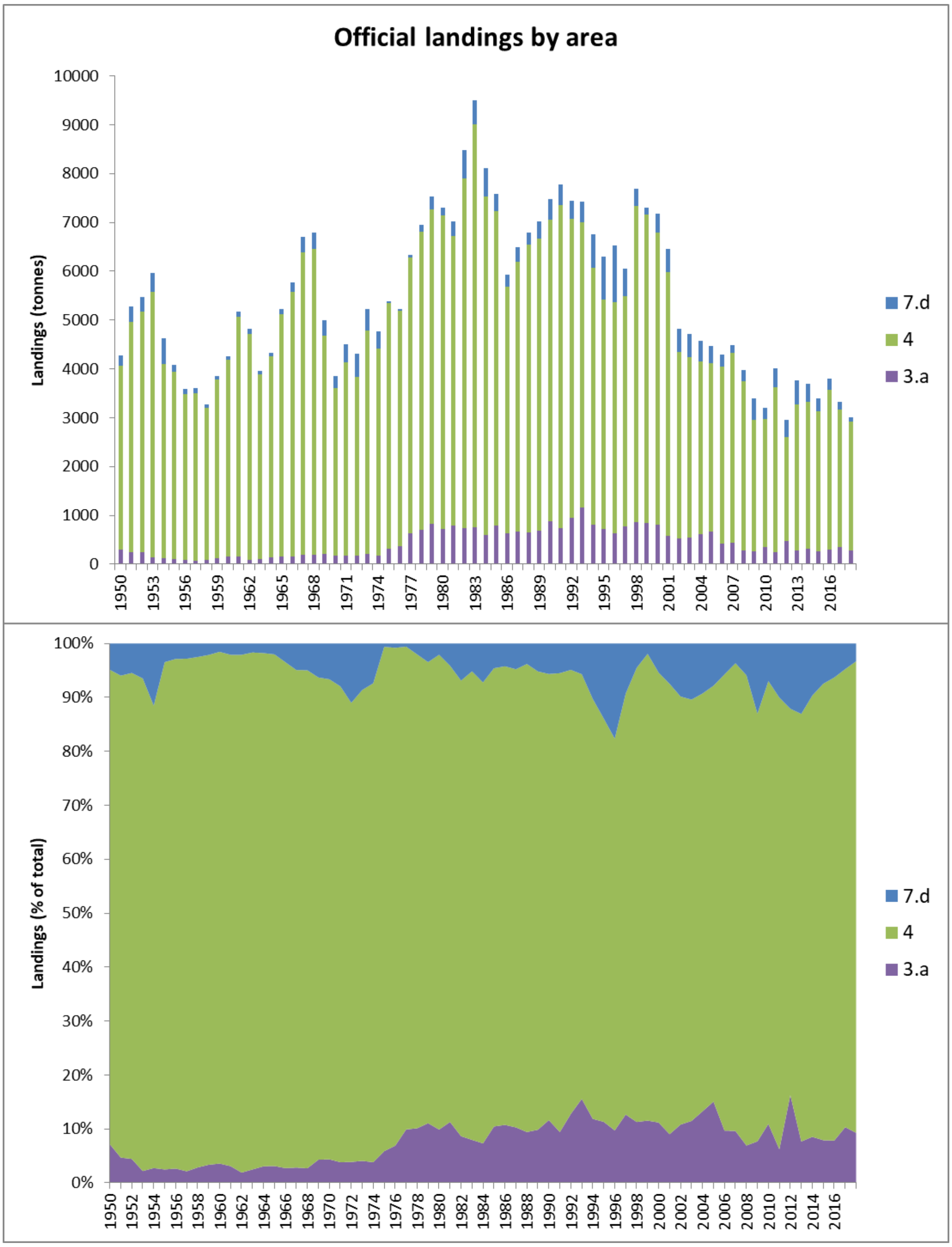


Figure 9.2.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Officially-reported landings of lemon sole by area in the greater North Sea. Upper plot: landings in tonnes. Lower plot: landings by area as a percentage of the full area.

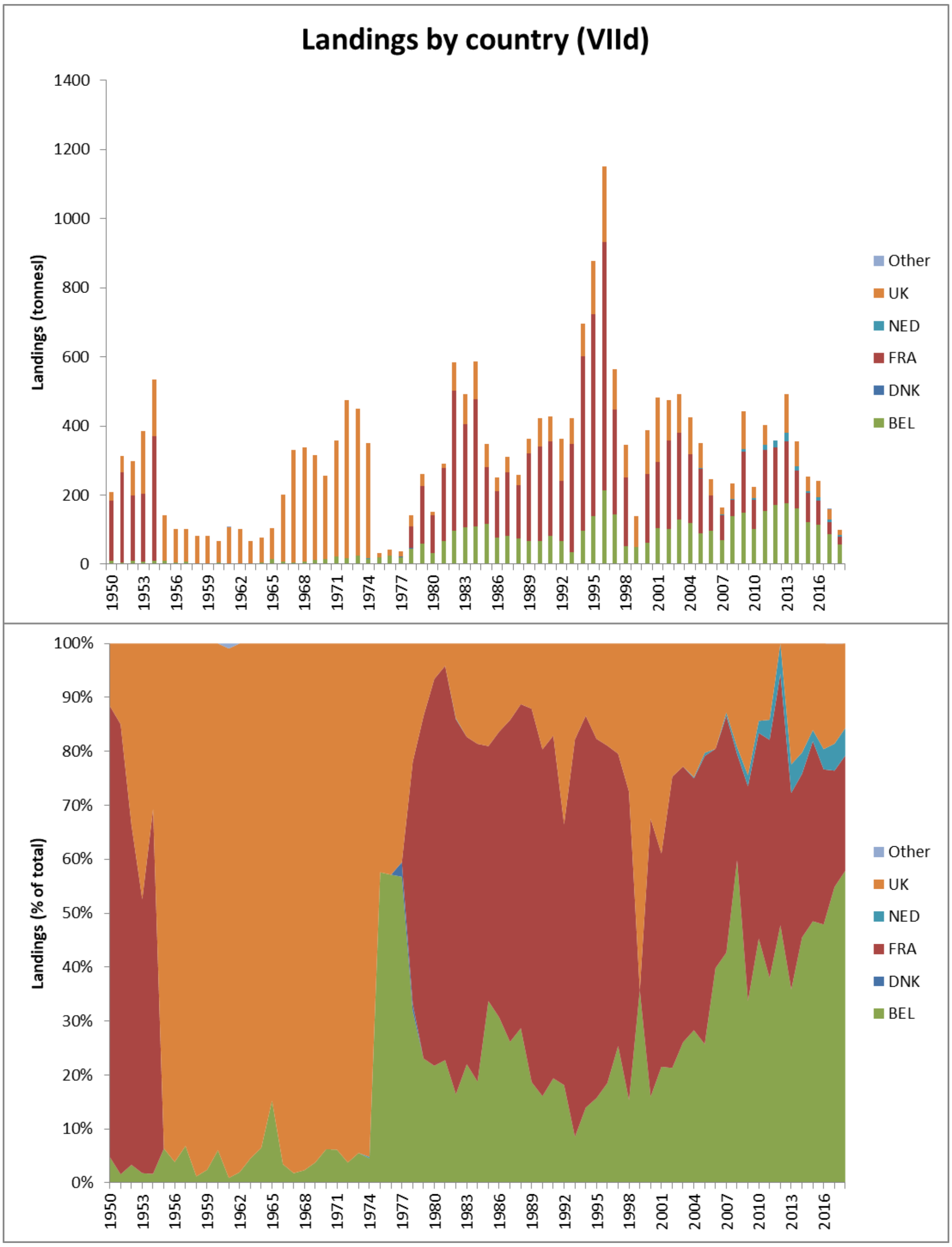


Figure 9.2.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings of lemon sole in area 7.d by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 7.d landings.

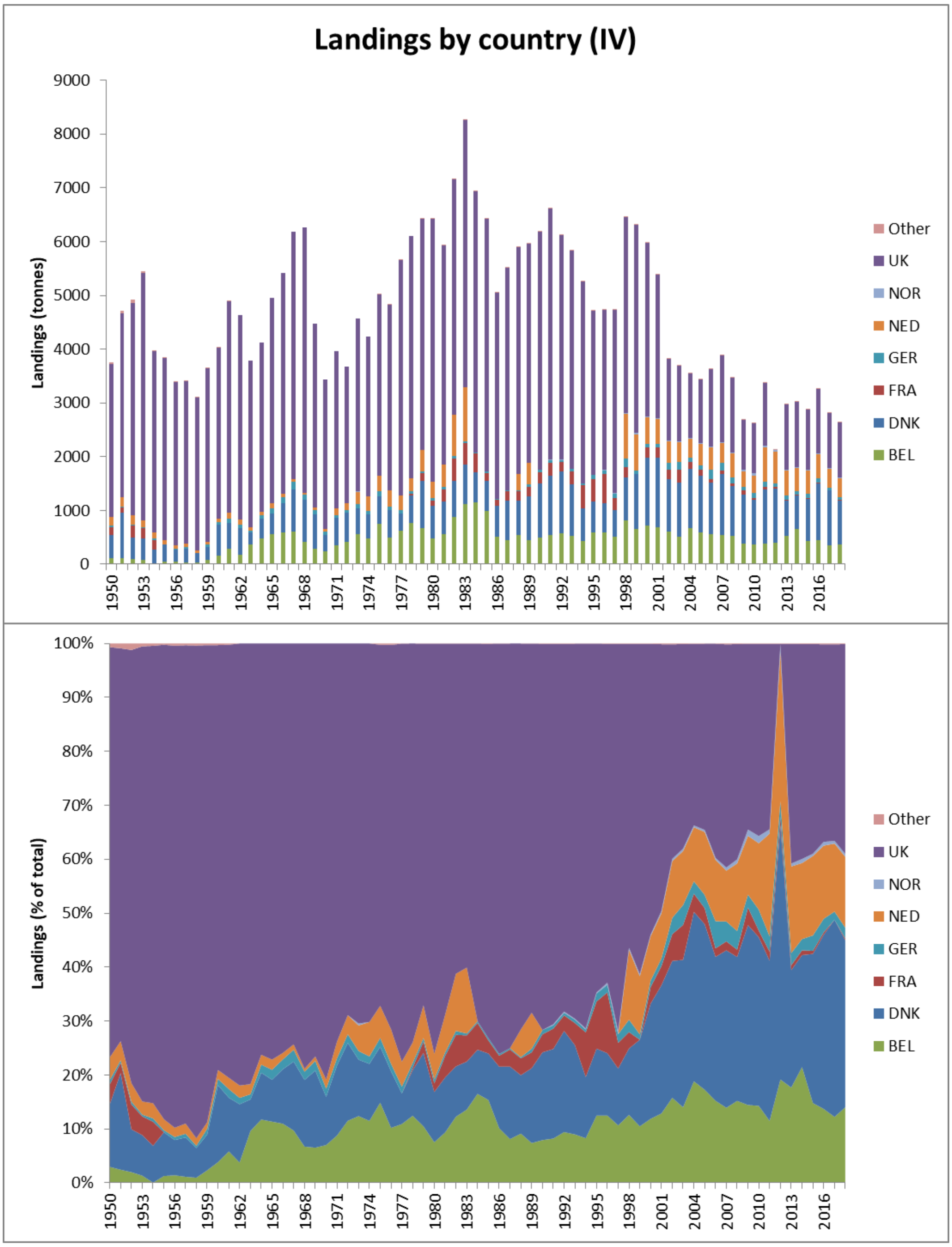


Figure 9.2.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings of lemon sole in area 4 by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 4 landings.

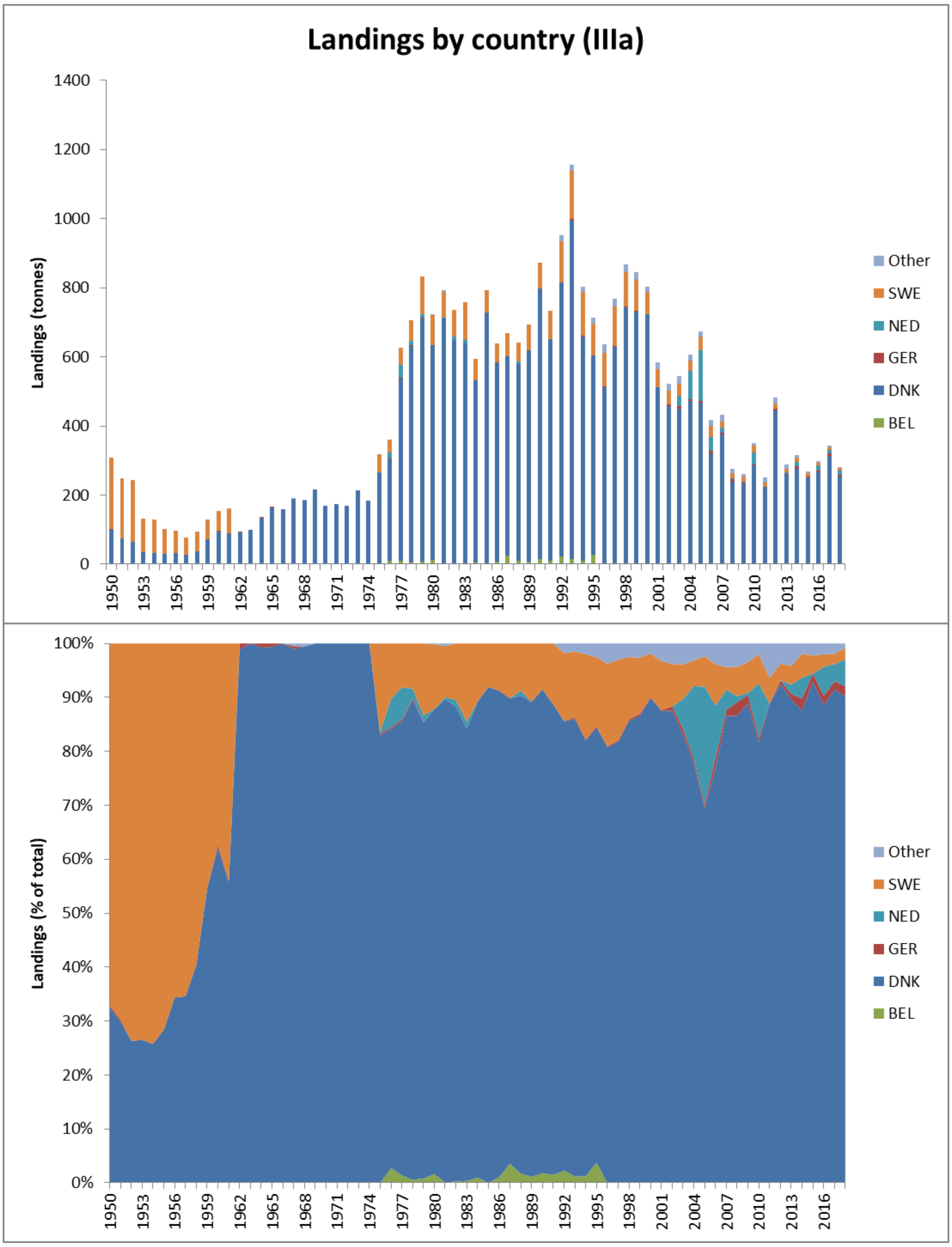


Figure 9.2.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Official landings of lemon sole in area 3.a by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 3.a landings.

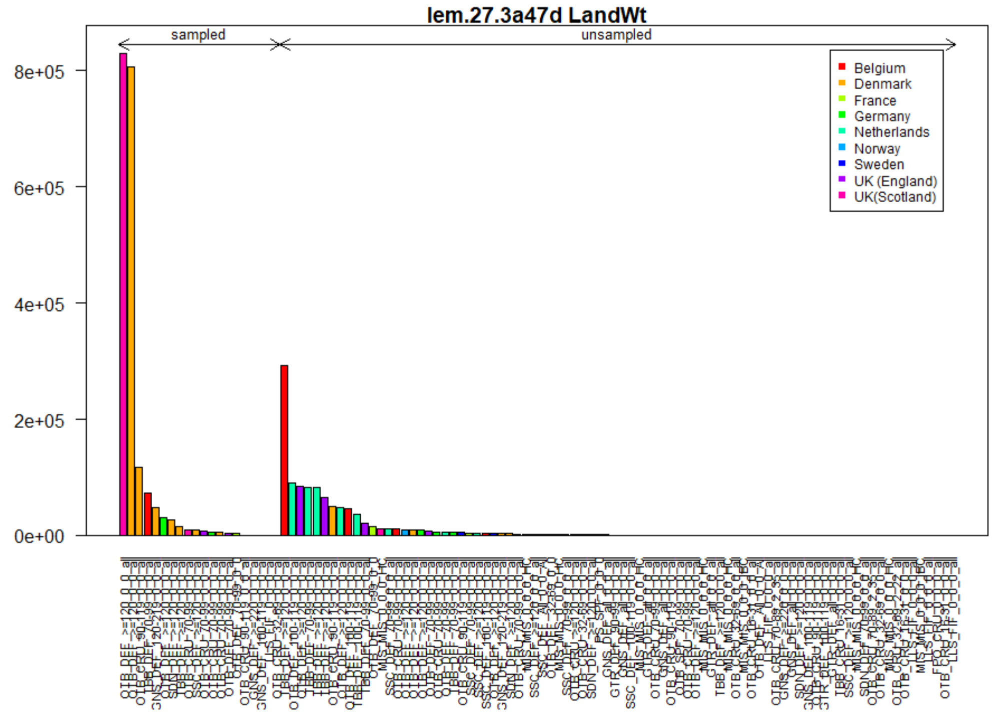


Figure 9.2.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (tonnes).

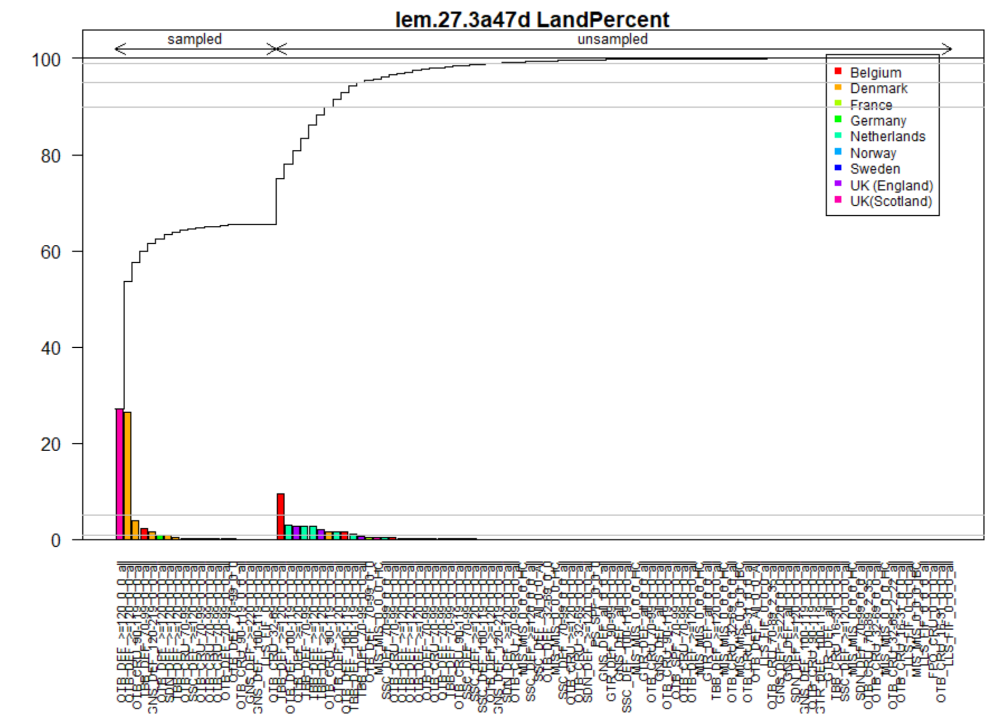


Figure 9.2.6. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (cumulative contribution).

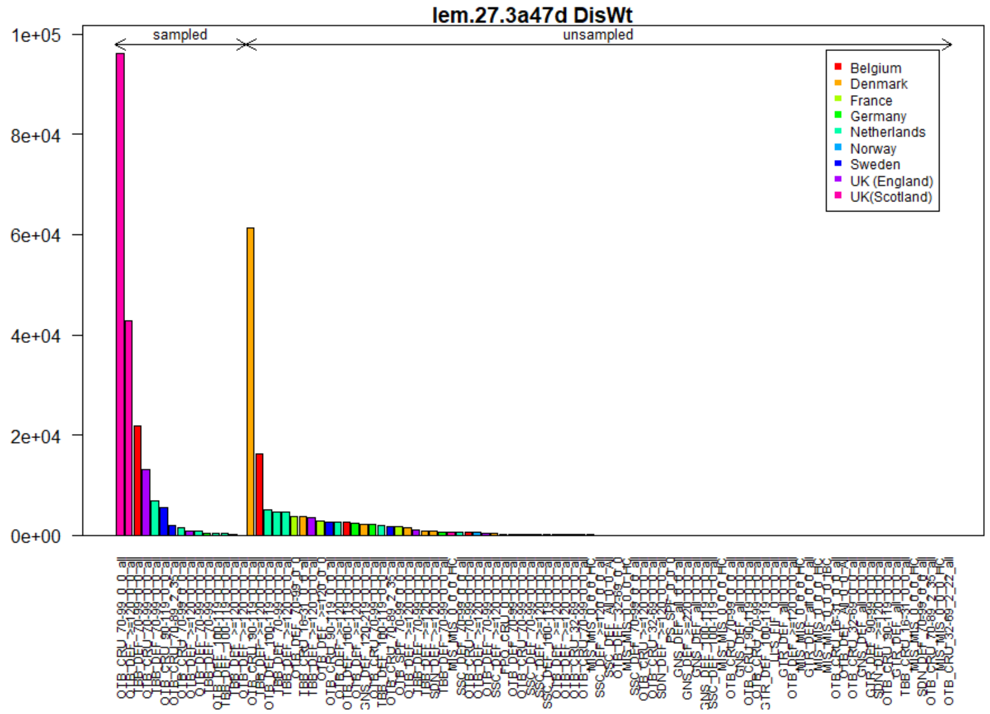


Figure 9.2.7. Lemon sole in Subarea 4, and divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for discard yield estimation.

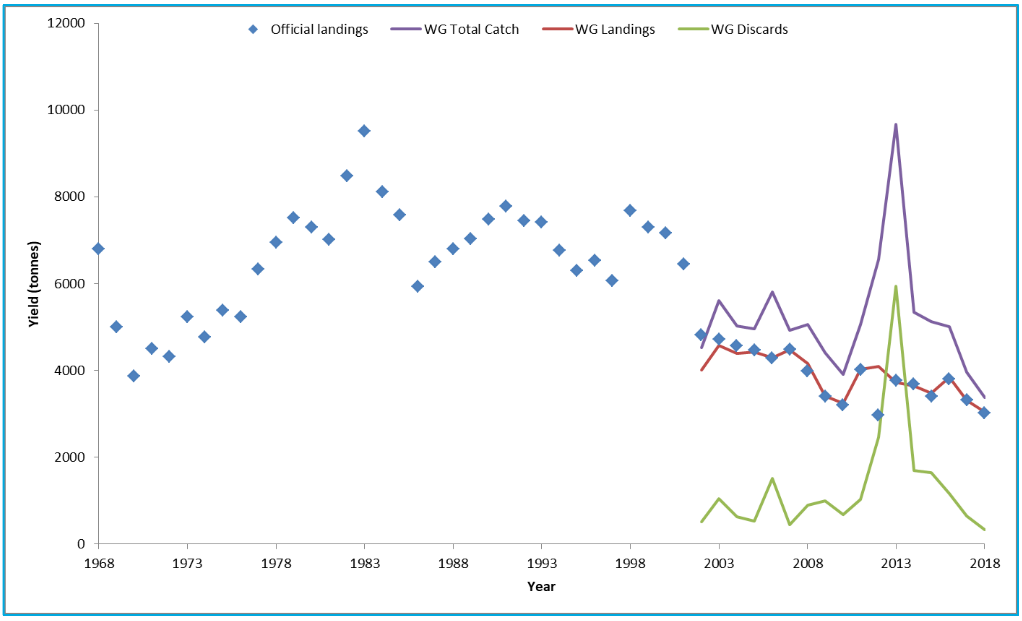


Figure 9.2.8. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Time-series of official landings (dots) along with ICES WG estimates of total catch (purple line), landings (red line) and discards (green line).

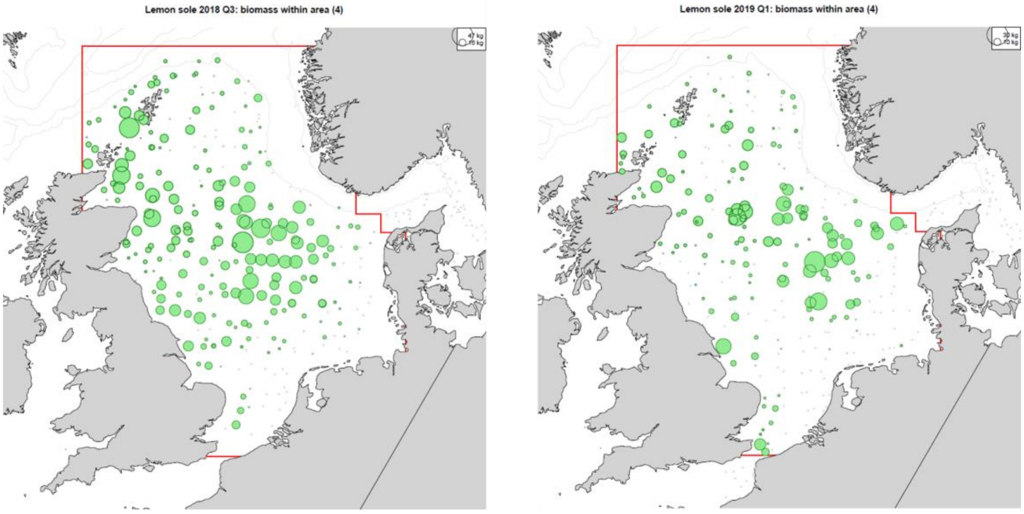


Figure 9.3.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Distribution of lemon sole in the North Sea derived from IBTS Q3 2018 (left) and IBTS Q1 2019 (right). The sizes of the circles are proportional to the square root of the estimated weight of lemon sole caught in each haul.

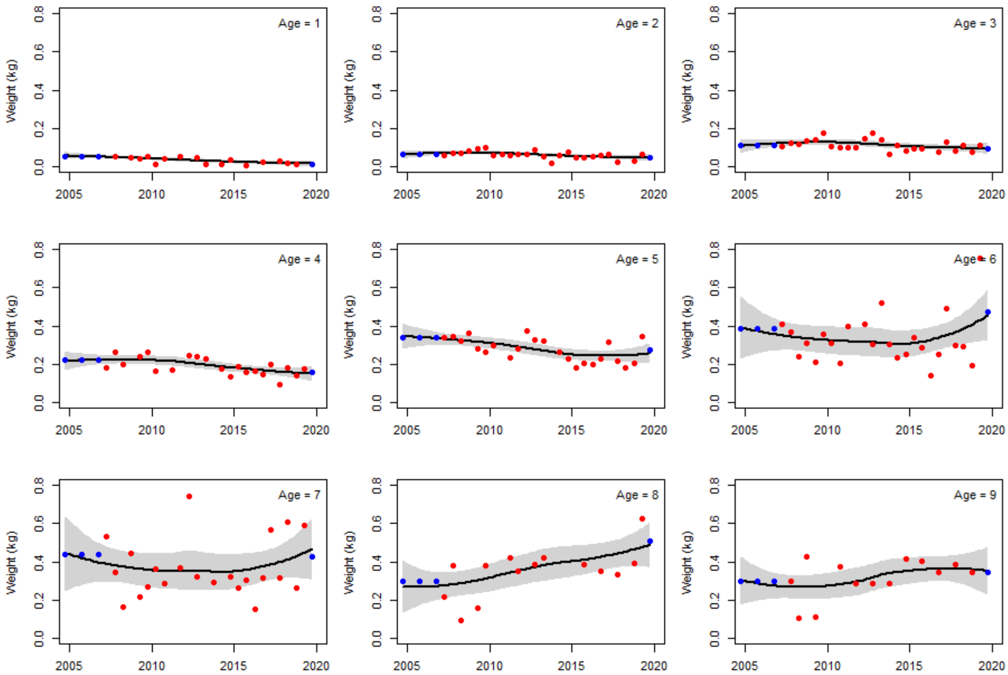


Figure 9.3.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Time-series of mean weight-at-age estimates (red dots) from IBTS Q1 and Q3 surveys, summarised by a loess smoother (span = 1) for each year (the grey band gives a 95% confidence interval about the loess smoother). The blue dots show averages (of either the first or last two estimates), included to allow extrapolation to the start and end point of the survey indices.

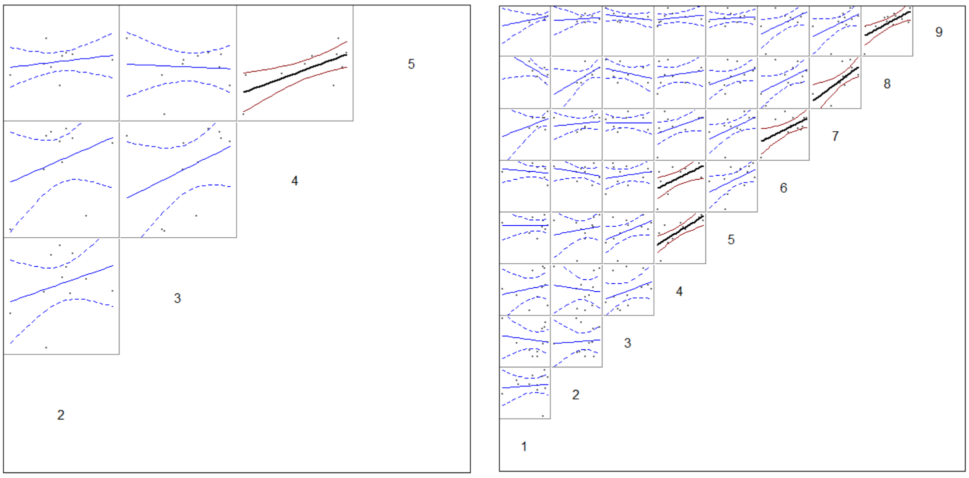


Figure 9.3.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Bivariate scatterplots showing consistency in cohort-strength estimation, for Q1 (left: IBTS) and Q3 (right: IBTS and BTS).

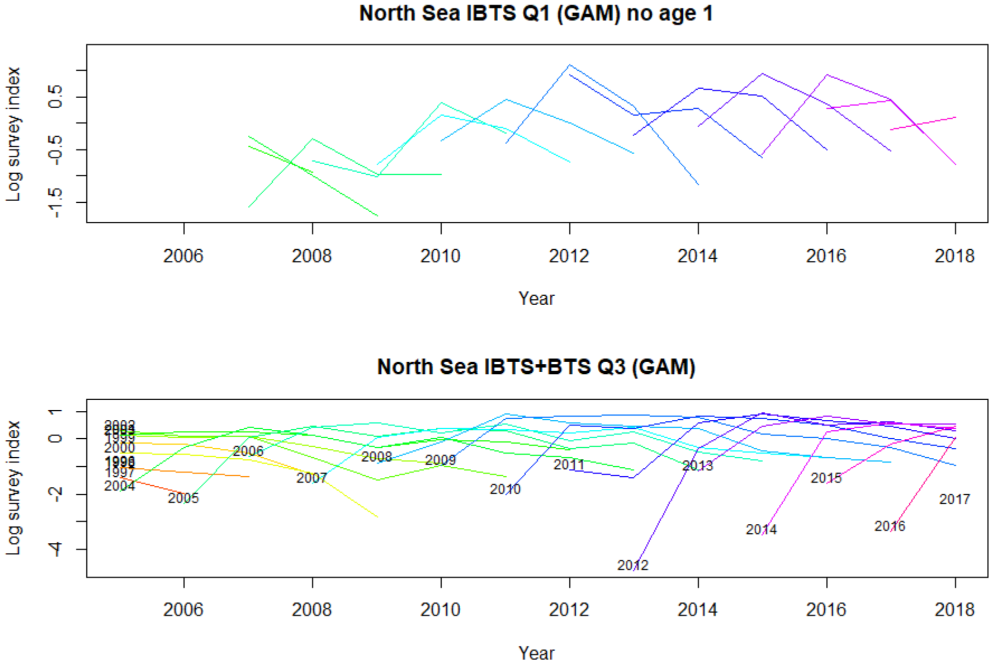


Figure 9.3.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Survey catch curves, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

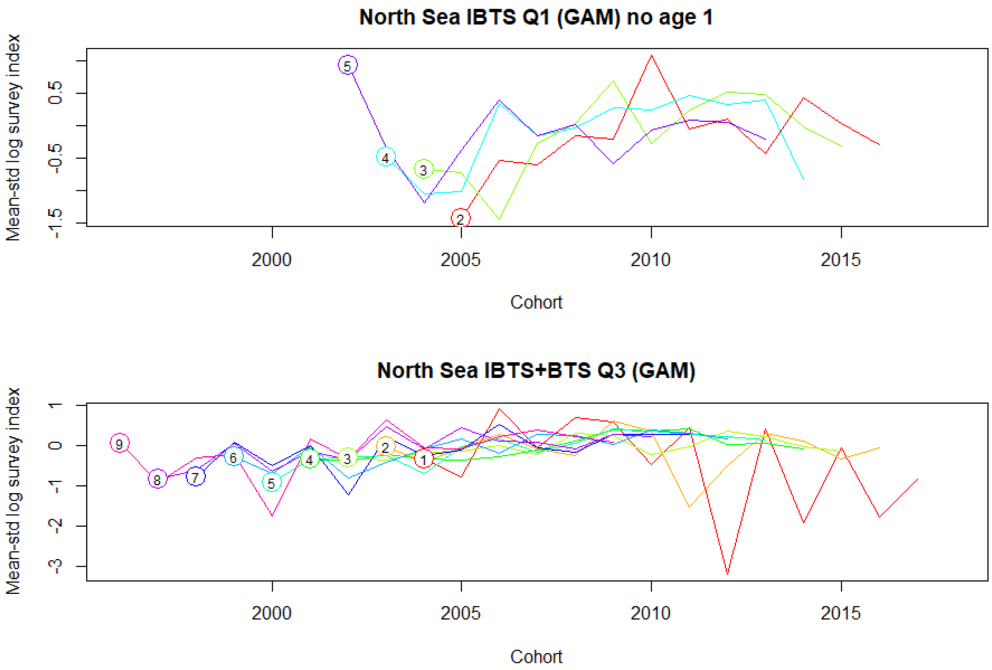


Figure 9.3.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Survey indices by age, cohort and year, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

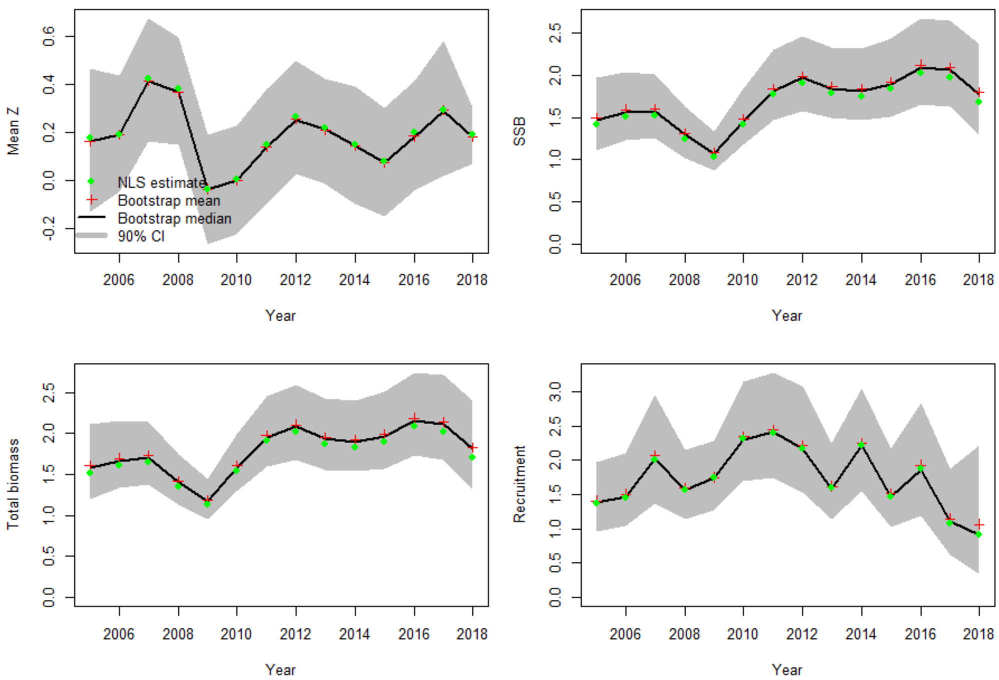
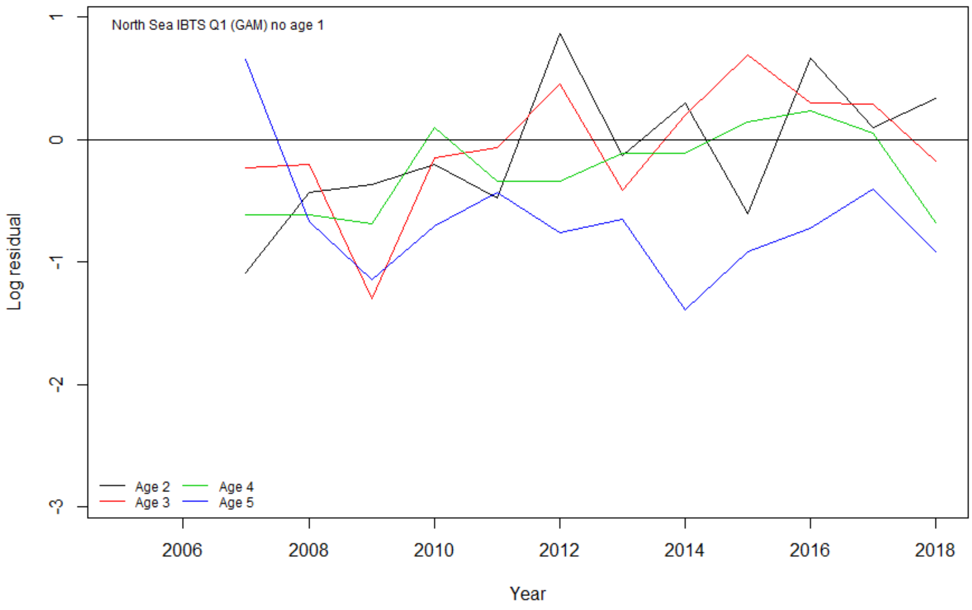


Figure 9.4.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. SURBAR stock summary (clockwise from upper left: mean Z(3-5), relative SSB, relative recruitment at age 1, relative total biomass). In each plot, the green dots give the nonlinear least-squares estimates, the red crosses give the uncertainty-estimation bootstrap mean, the black line gives the bootstrap median, and the grey band gives a 90% confidence interval about the median.



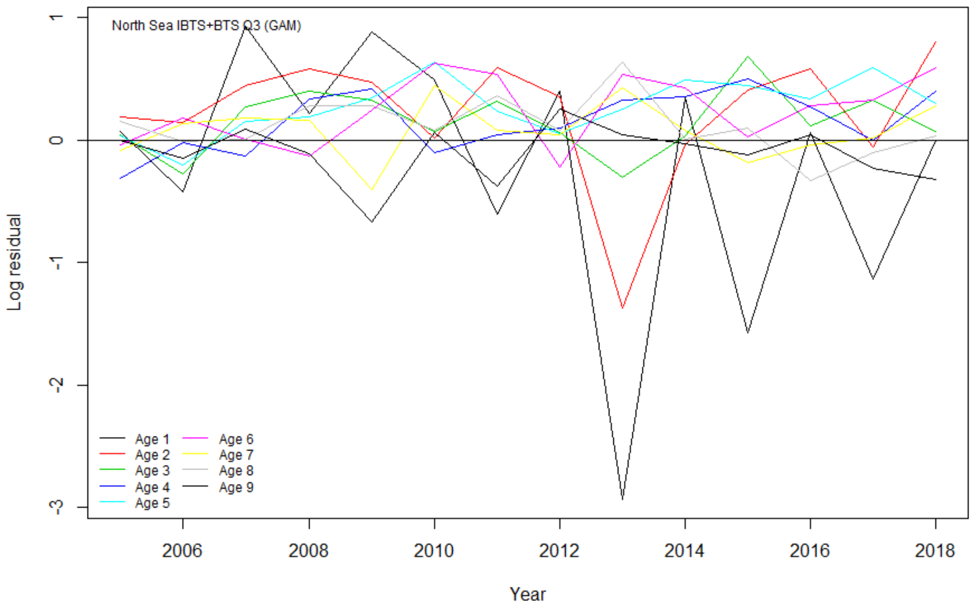


Figure 9.4.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Upper: Log SURBAR residuals for Q1 (IBTS). Lower: Log SURBAR residuals for Q3 (IBTS+BTS).

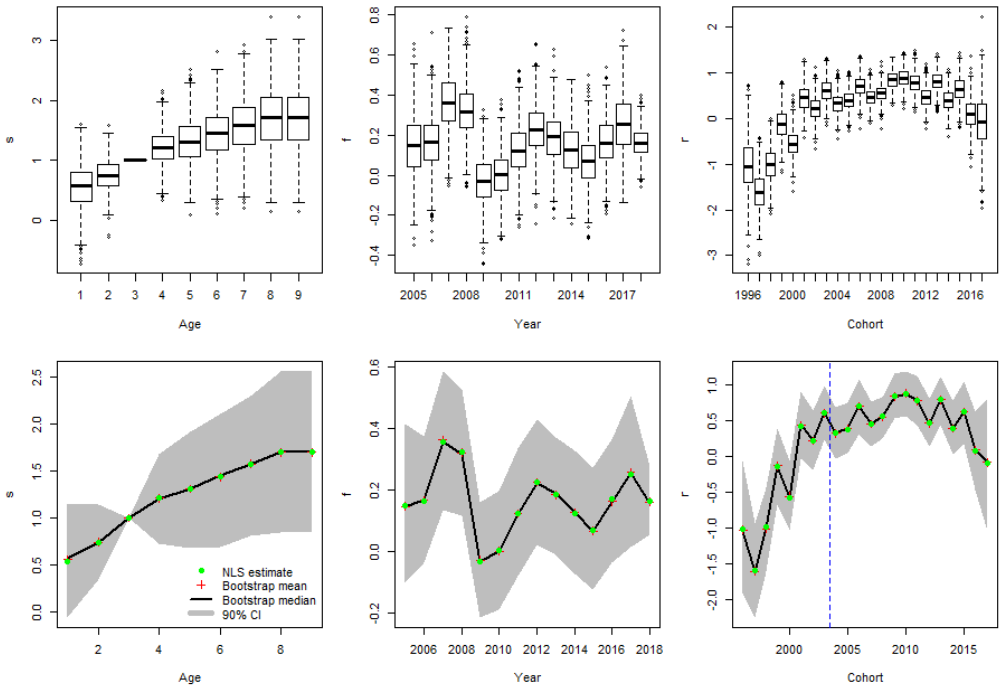


Figure 9.4.3. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Estimated SURBAR parameters: age effects (*s*) and year effects (*f*) of total mortality, and cohort effects (*r*). Upper: box-and-whisker plots of bootstrap distributions. Lower: the green dots give the nonlinear least-squares estimates, the red crosses give the uncertainty-estimation bootstrap means, the black line gives the bootstrap median, and the grey band gives a 90% confidence interval about the median.

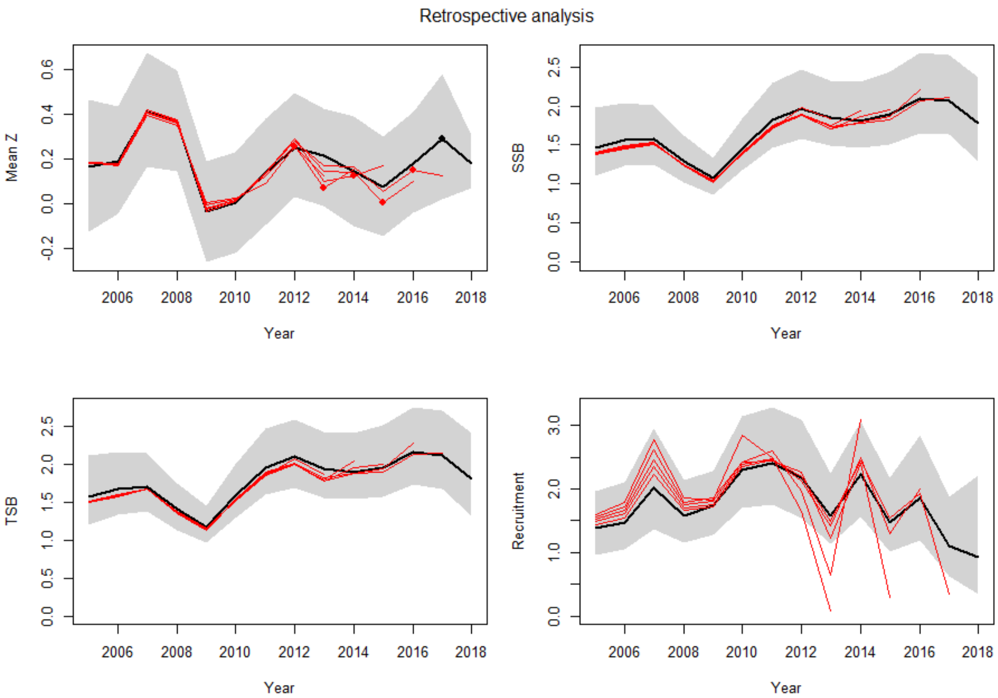


Figure 9.4.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Retrospective SURBAR analysis (clockwise from upper left: mean Z(3-5), relative SSB, relative total biomass, relative recruitment at age 1). Black lines give final-year estimates (with 90% confidence interval in grey), while red lines give the results of 5 retrospective peels.

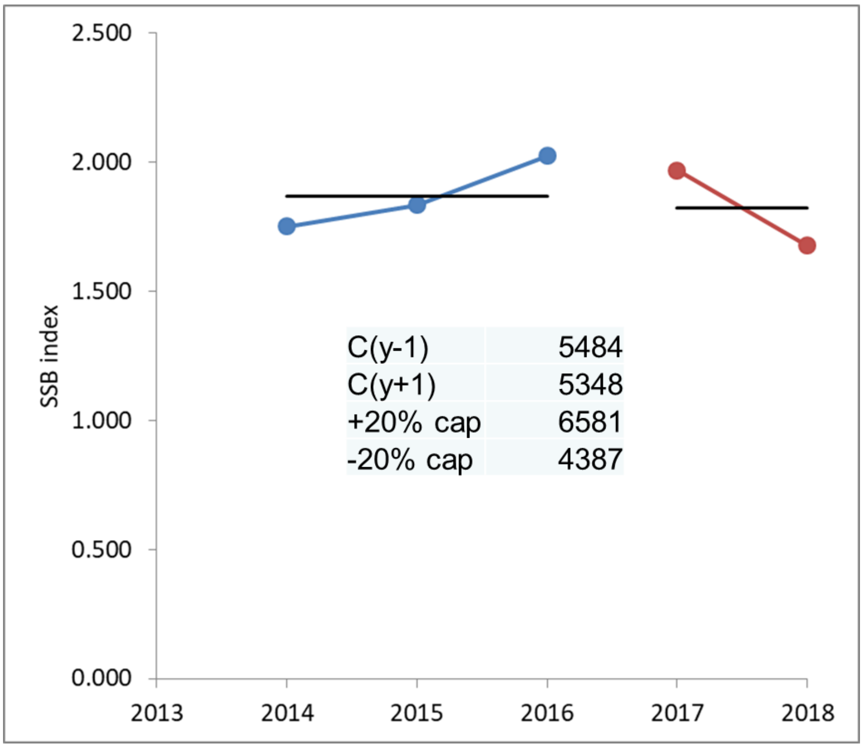


Figure 9.5.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Application of the DLS 3.2 rule, using the last five years of the relative SSB estimate given in Figure 9.4.1.

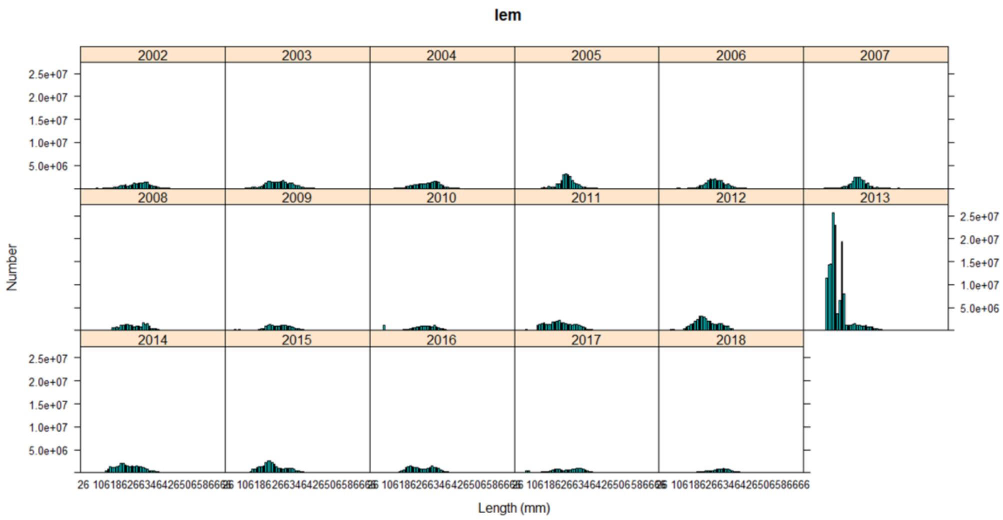


Figure 9.6.1. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year.

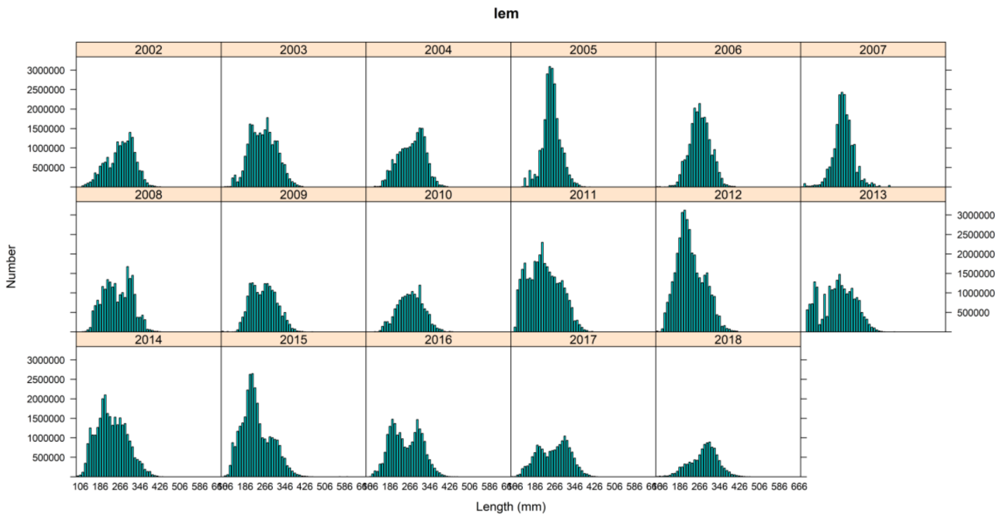


Figure 9.6.2. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year, with 2013 abundance for fish < 200 mm divided by 20, and all fish < 100 mm removed for all years.

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).

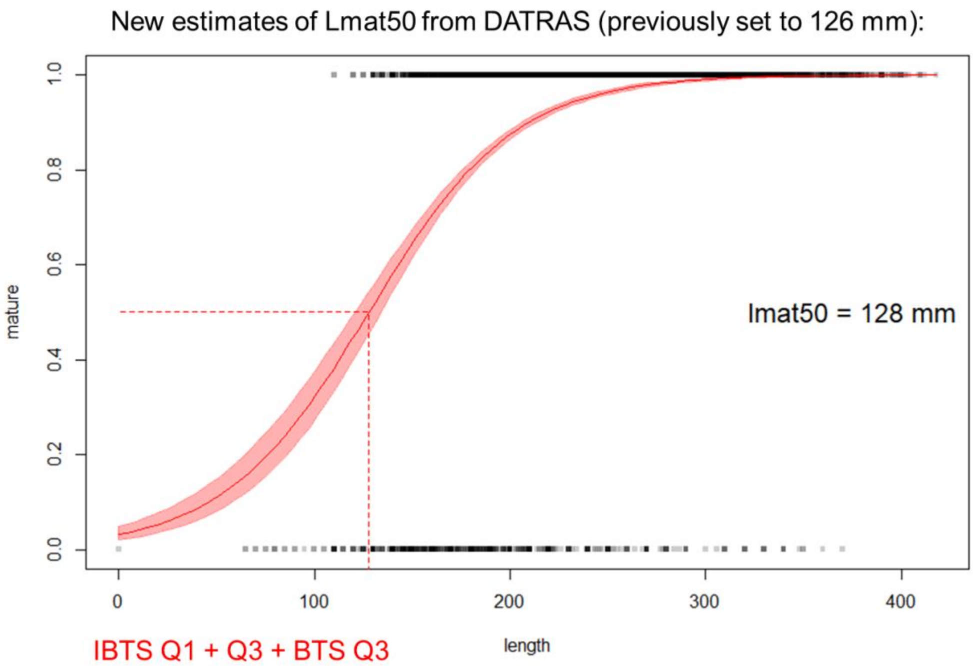


Figure 9.6.4. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Fitted maturity-at-age estimates from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using maturity-length observations from all available years (2007–2019). Maturity indices (0 = not mature, 1 = mature) are shown as shaded dots. The solid red line gives the fitted maturity ogive with 95% confidence interval (red band), while dotted red lines highlight the length of 50% mature ($L_{50\%mat}$ = 128 mm).

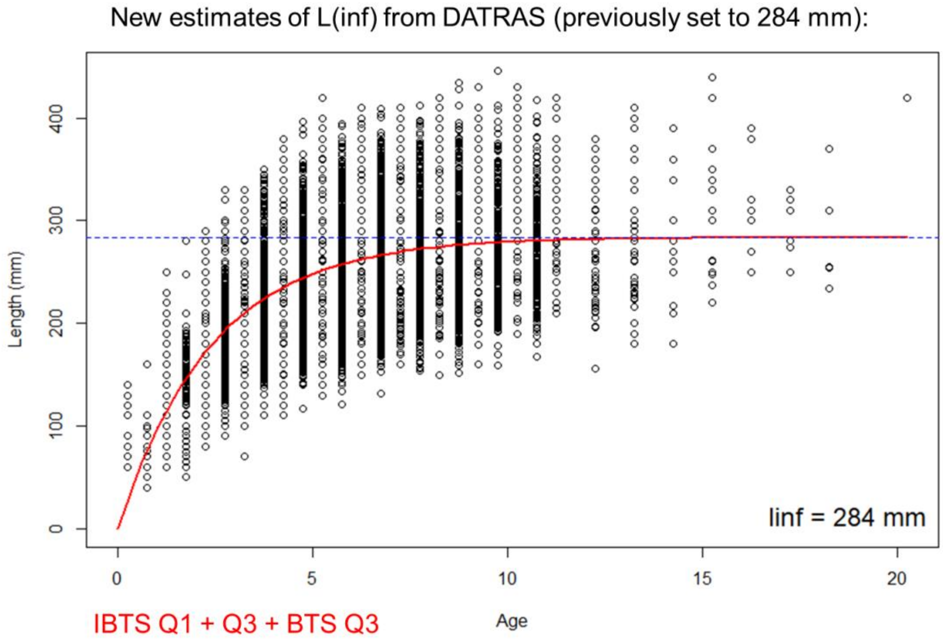


Figure 9.6.5. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length-at-age data from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using data from all available years (2007–2019). To account for seasons, Q1 lengths are plotted at *a* + 0.25, Q3 lengths at *a* + 0.75. The red line gives a fitted von Bertalanffy growth curve (L_∞ = 283.6735 mm, K = 0.4166, t_0 = 0).

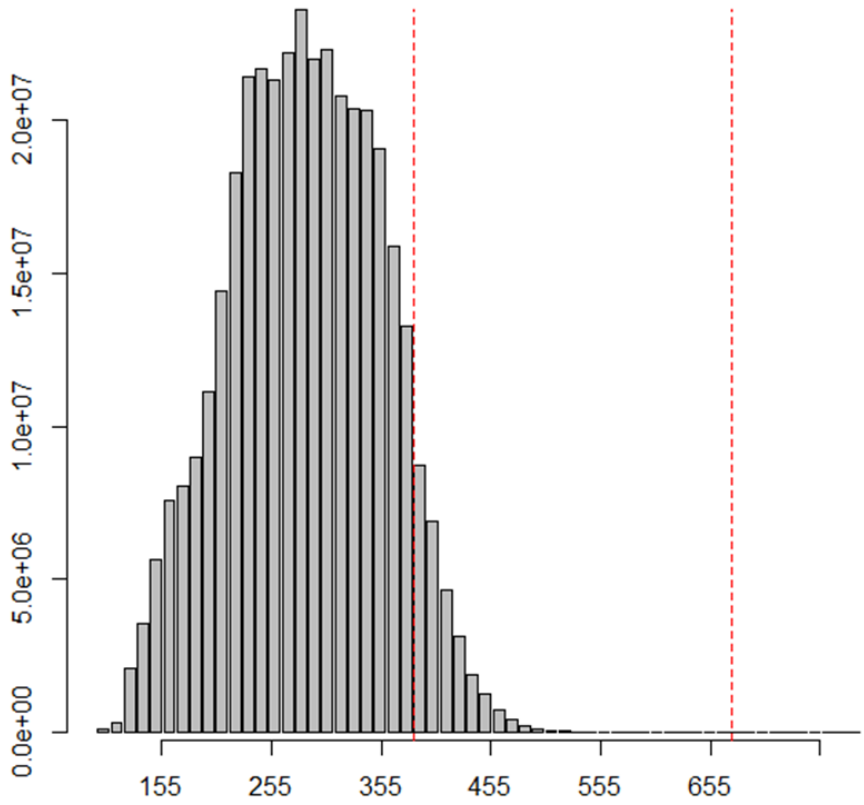


Figure 9.6.6. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Length distribution of the commercial catch data submitted to InterCatch, collated over all available years (2002–2018). The red lines give (from left to right) the 99%ile of the distribution (385 mm) and the longest observed fish (675 mm).

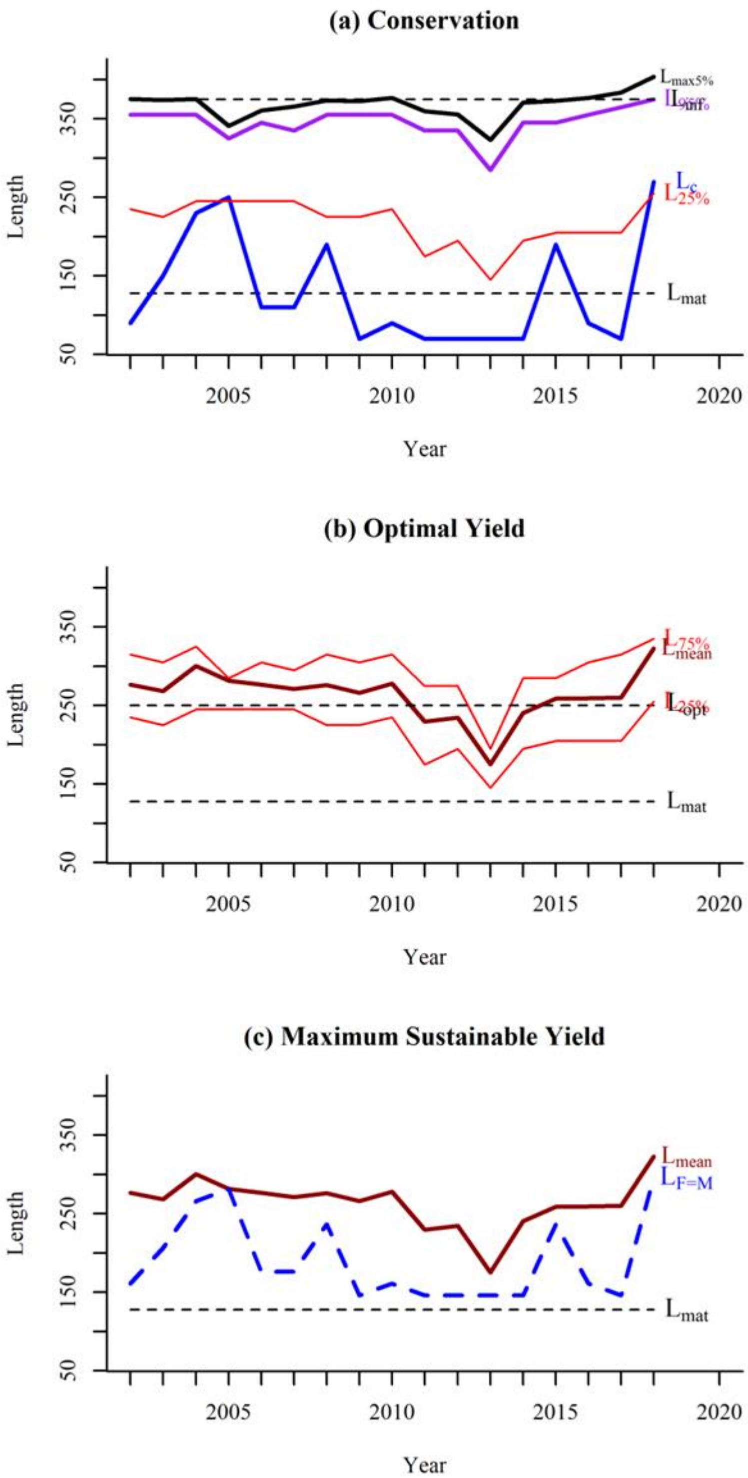


Figure 9.6.7. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Results of LBI analysis (absolute estimates).

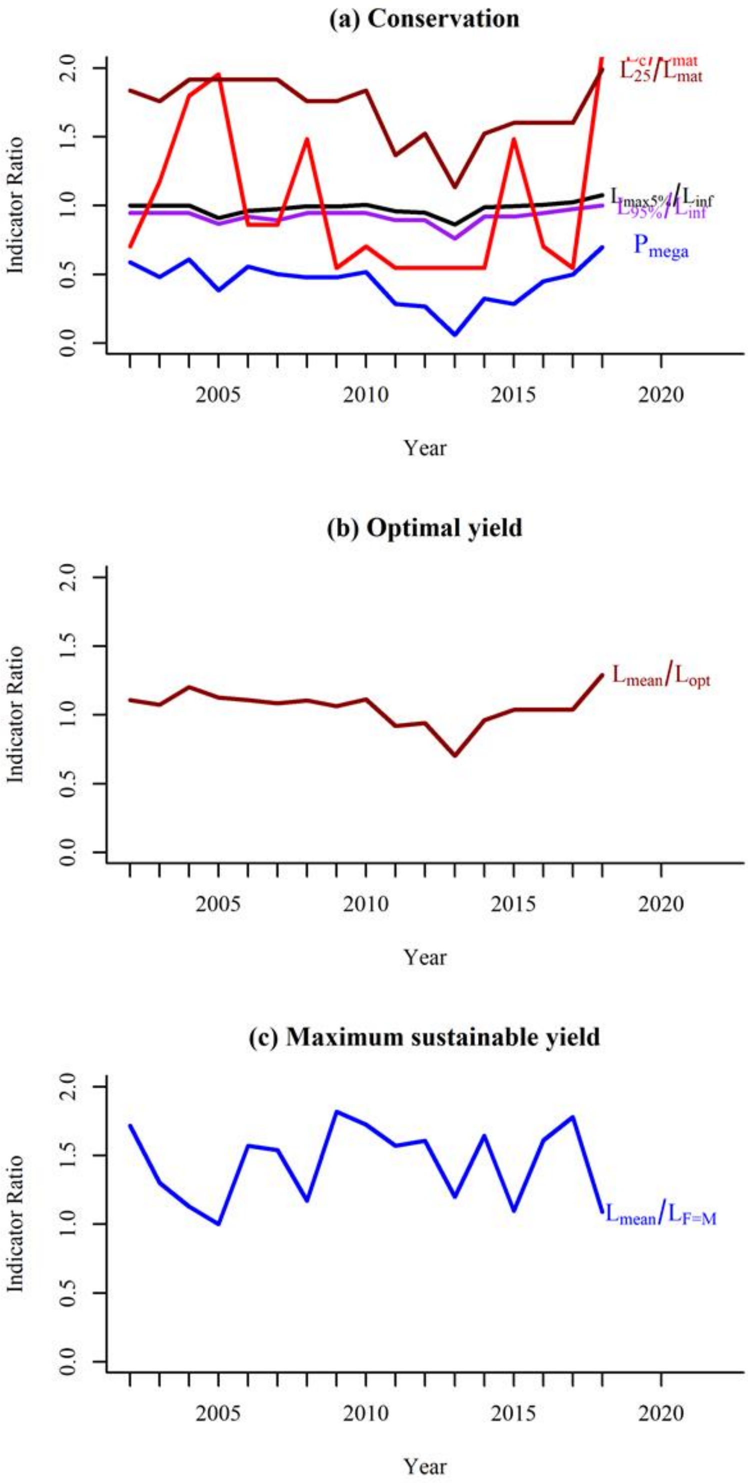


Figure 9.6.8. Lemon sole in Subarea 4, and divisions 3.a and 7.d. Results of LBI analysis (ratio estimates).

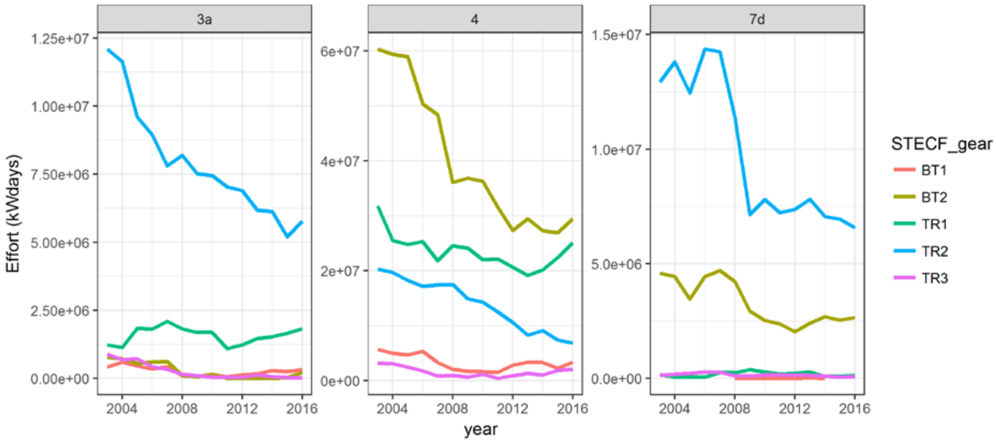


Figure 9.7.1. Recorded effort for the principal North Sea fishing metiers. Source: TACMAN report (see Annex 11, ICES WGNSSK, 2018).

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 2018. ICES concluded that:

'The stock size is considered to be stable. The estimated harvest rate for this stock is currently below 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, 11 738 tonnes in 2018 and 13 733 tonnes in 2019. 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 and 2018, the discard proportion increased to 32 and 46%, respectively, 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 (FU 3) and Kattegat (FU 4)

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 FU 4, 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 10.2.2.3). 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 1991–2018. 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 1990–2018, and from Denmark for 1992–2018. 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 2018. Information on mean size is shown in Figure 10.2.2.4 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 and Charuau, 1975; Redant and Polet, 1994; and Wileman *et al*. 1999).

Growth parameters are as follows:

Males: L_∞ = 73 mm CL, k = 0.138.

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

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

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

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

Catch and effort data–FU 3

Effort data for the Swedish fleet are available from logbooks for 1978–2018 (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–FU 4

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 (Figure 10.2.2.3 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 10.2.2.3 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.

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 2018. 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 sub-areas 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	1.3	0.75	1.05	1	1.1

10.1.3.2 Assessment

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2018. Additional used information was trends in total combined (Denmark and Sweden) LPUE, and discards (numbers) as a proxy for recruitment during the period 1990–2018.

Combined relative effort declined slightly over the period 1990 to 2018 (Figure 10.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level in 2018 (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 2019 this corresponds to a TAC of 13 733 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 abundance) 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 scenarios (weight in tonnes):

Discarding assumed 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							
EU MAP^: F_{MSY}	19 904	19 313	17 540	1773	591	7.9	-8.02%
F= MAP $F_{MSY\ lower}$	14 109	13 690	12 433	1257	419	5.6	-34.80%
F = MAP $F_{MSY\ upper}$***	19 904	19 313	17 540	1773	591	7.9	-8.02%
Other scenarios							
F_{2018}	9019	8751	7948	803	268	3.6	-58.32%

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP^: F_{MSY}	18 643	16 429	2214	7.9	-13.85%
F= MAP $F_{MSY\ lower}$	13 215	11 646	1569	5.6	-38.93%
F = MAP $F_{MSY\ upper}$***	18 643	16 429	2214	7.9	-13.85%
Other scenarios					
F_{2018}	8 448	7 445	1003	3.58	-60.96%

^ EU multiannual plan (MAP) for the North Sea (EU, 2016)

* Calculated in numbers for dead removals.

** Total catch 2020 relative to advice value 2019 (21 639 t).

*** $F_{MSY\ upper}$ = F_{MSY} for this stock

A summary of the results from the TV survey 2018 is presented in Table 10.2.3.1. The estimated abundance index was 0.391 resulting in a total abundance of 4887 million individuals. Total removals (landings + dead discards) were estimated to 175 million individuals resulting in a harvest rate of 3.6%.

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 2018 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 an exemption of landing obligation (high discard survival) in 3.a. 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.

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 consists of vessels <12 m, the logbook data will continue to be limited. Logbooks should be introduced for vessels <12m.

10.1.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the eighth year (2011–2018; new Subarea 7 only in 2014–2018 and new Subarea 9 in 2017 and 2018) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 10.3.6.1).

The average 2016–2018 harvest rate was estimated to be relatively low (3,1% 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

10.2.2.4). 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 4 in terms of ICES statistical rectangles.

FU no.	Name	ICES area	Statistical rectangles
3	Skagerrak	3.aN	47G0; 46F9–G1; 45F8–G1; 44F7–G0; 43F8–F9
4	Kattegat	3.aS	44G1; 42-43 G0–G2; 41G1–G2
5	Botney 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, 1981–2018.

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

Year	FU 3	FU 4	Total
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
2018	4222	2878	7100

Table 10.2.1.2. Division 3.a: Total *Nephrops* landings (tonnes) by country, 1991–2018.

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
2018	5133	97	1870	0	7100	1336	8435

Table 10.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2018.

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
2018	2938	71	25	97	897	290	1187	0	4222

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, 1991–2018. (*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
2018*	369	265	13,5	27,3	19,6

Twin trawl					
Year	**Catches**	**Landings**	**Effort**	**CPUE**	**LPUE**
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1
2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3
2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6
2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8
2014*	484	316	16.0	30.3	19.8
2015*	328	234	11.3	28.9	20.6
2016*	471	410	20.1	23.4	20.4
2017*	667	427	17.5	38.2	24.5
2018*	851	610	21,1	40,4	29,0

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, 1991–2018.

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
2018	2366657	8345	7936	370

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2018.

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
2018	31,1	30,7	41,6	41,1	38,7	37,6

Table 10.2.2.5. *Nephrops* Kattegat (FU 4): Landings (tonnes) by country, 1991–2018.

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
2018	2195	649	33	683	0	2878

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, 1991–2018 (*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
2018*	84	63	4,1	20,4	15,4

Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	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
2018*	774	586	18,7	41,4	31,3

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, 1991–2018.

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
2018				243

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
2018	32,1	31,5	42,7	40,5	39,8	36,9

Table 10.2.3.1. Summary output of the TV-survey in 3.a from 2018.

Subarea	Area (km²)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)
1	2575	31	0,271	0,136	696,696
2	1958	32	0,519	0,305	1016,489
3	2613	35	0,374	0,125	978,078
4	962	10	0,359	0,241	345,555
5	996	18	0,330	0,218	328,776
6	1719	32	0,628	0,131	1079,028
7	1295	17	0,143	0,103	185,625
9	385	2	0,666	0,356	256,334
Total	12503	177	0.391		4886,580
				Harvest rate	0.0358
Removals 2018 (landings + dead discards**)				175*	

*** In millions**

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

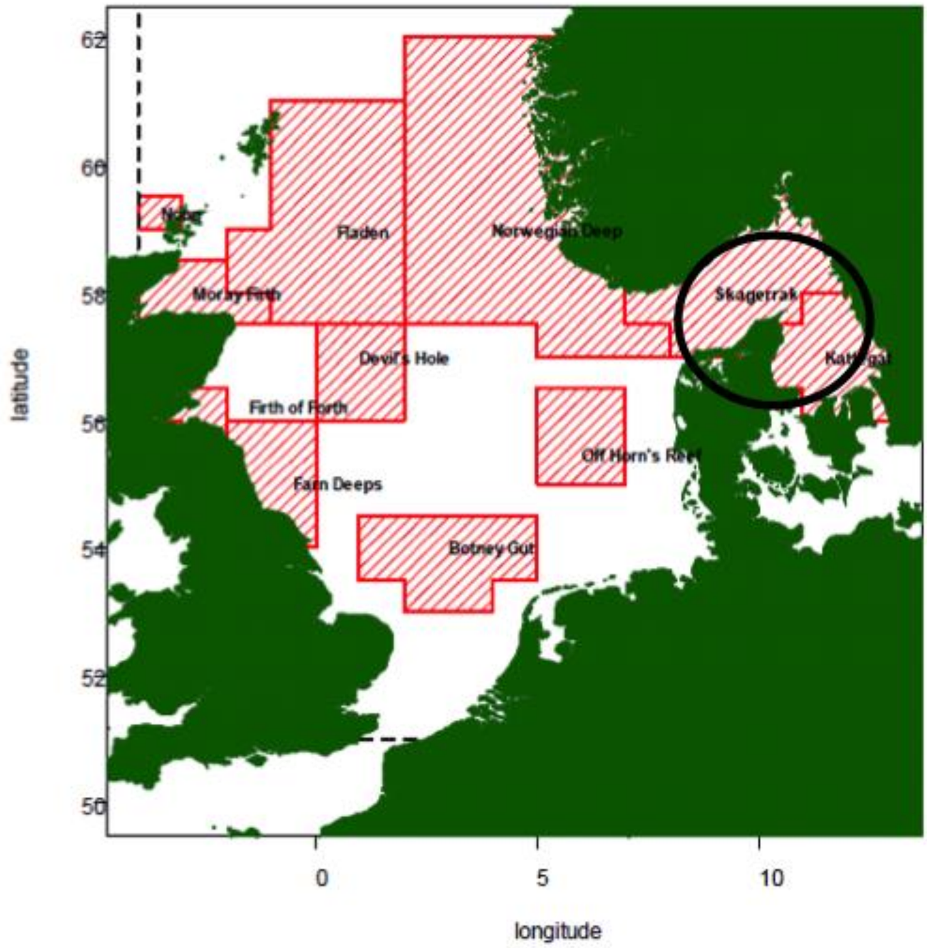


Figure 10.1.1. *Nephrops* Functional Units in the North Sea and Skagerrak/Kattegat region.

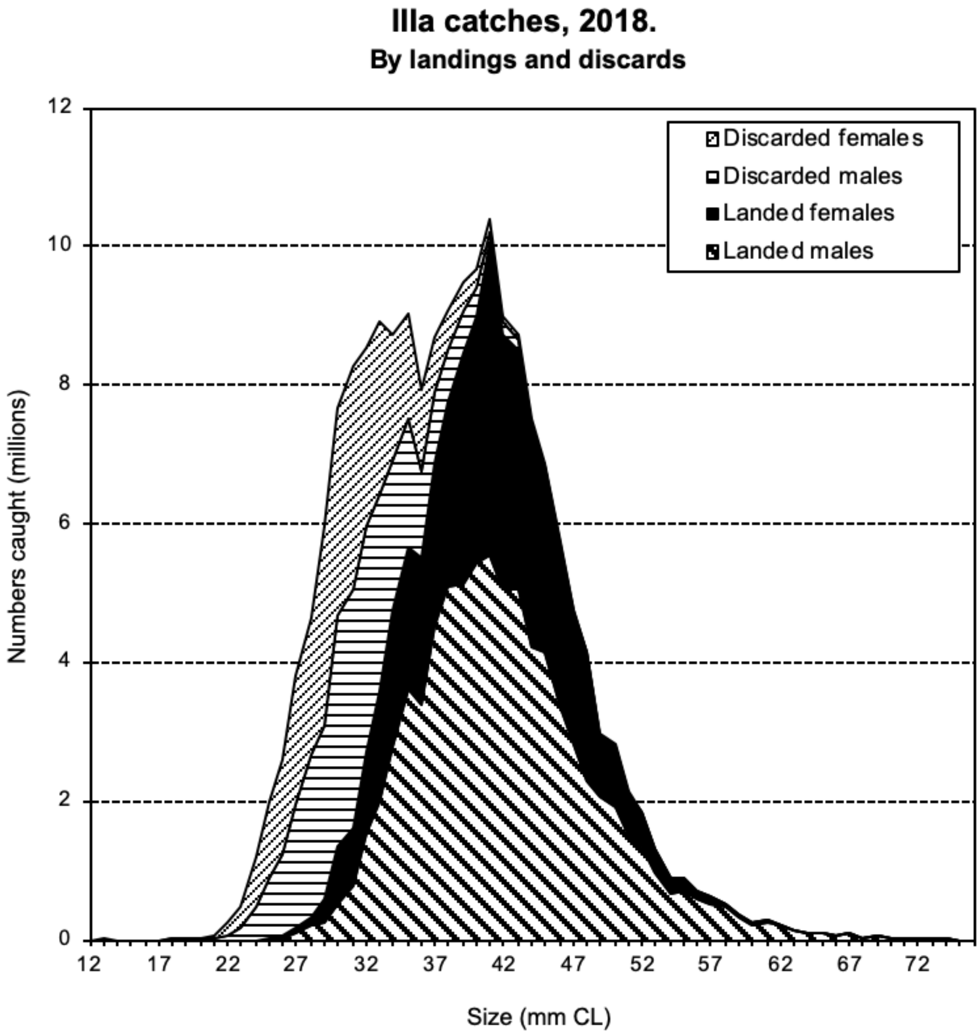


Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU 4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2018.

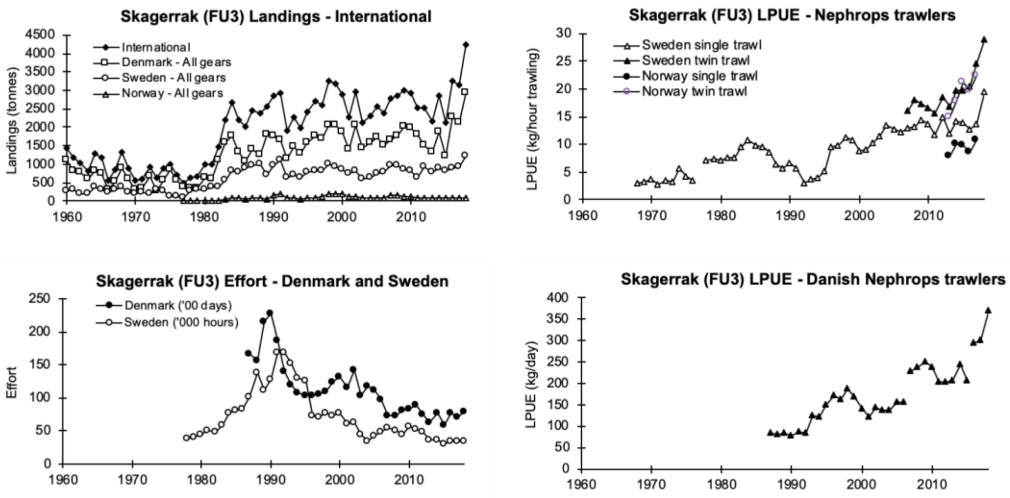


Figure 10.2.2.1. ***Nephrops*** **Skagerrak (FU 3): Long-term trends in landings, effort, and LPUEs.**

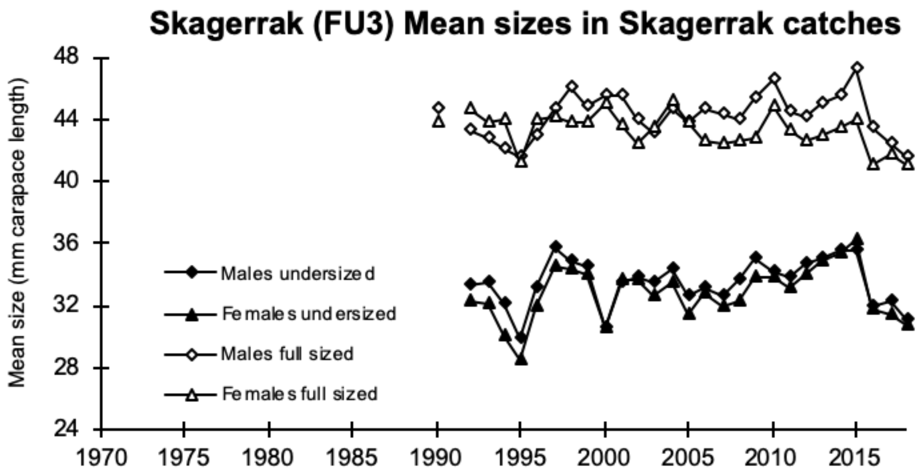


Figure 10.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

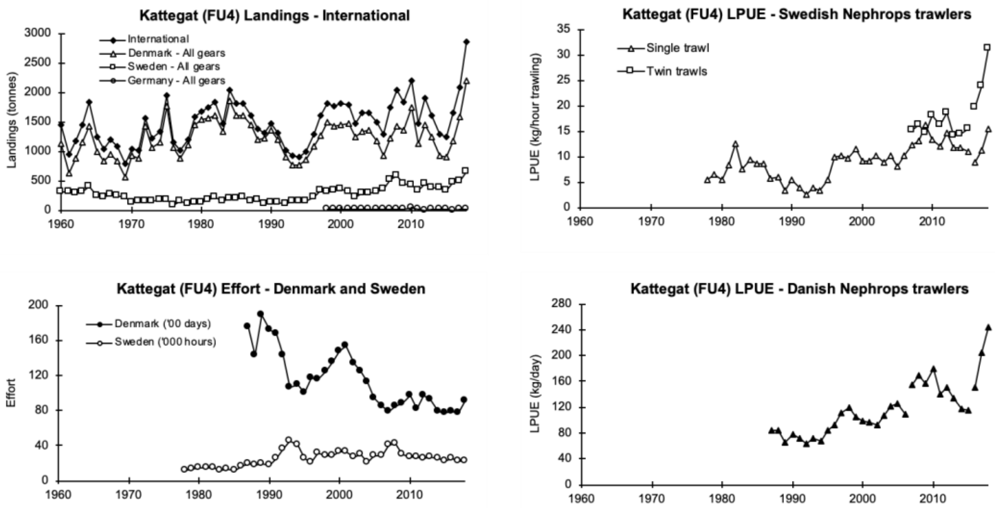


Figure 10.2.2.3. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort and LPUEs.**

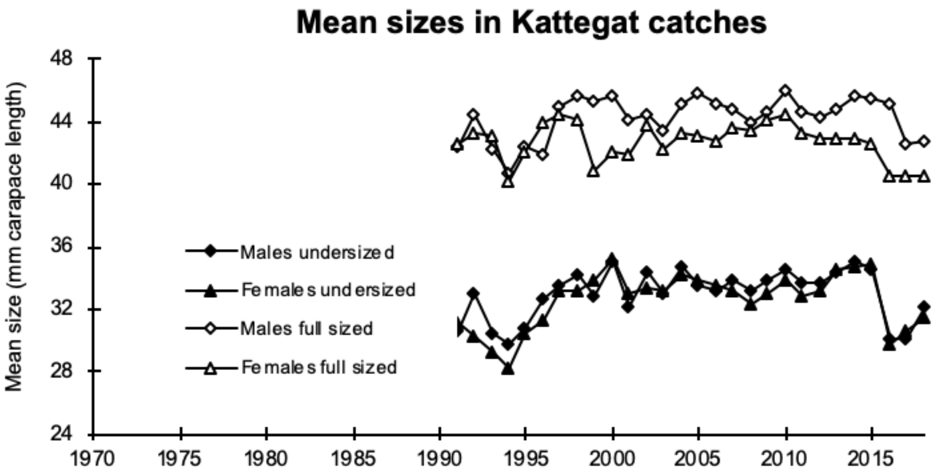


Figure 10.2.2.4. ***Nephrops*** **in FU 4: Mean sizes in the catches.**

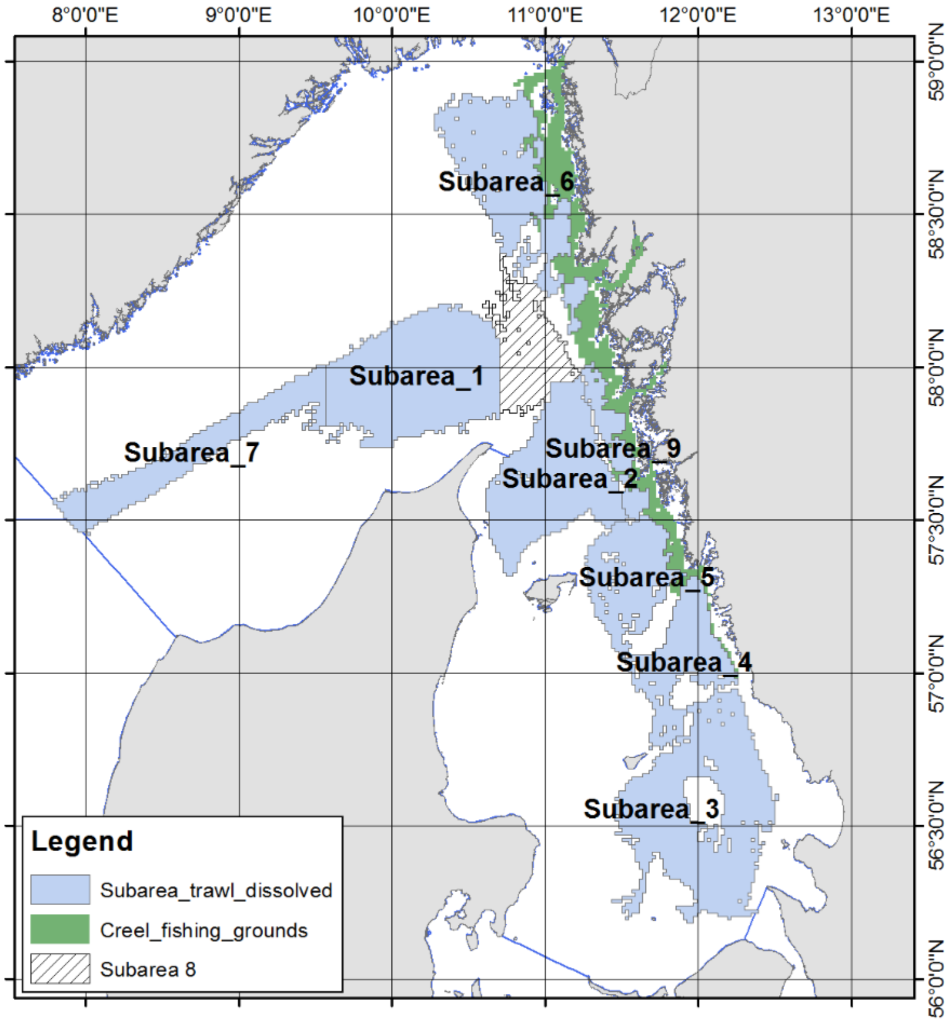


Figure 10.2.3.2. The defined sub areas of the *Nephrops* stock in 3.a.

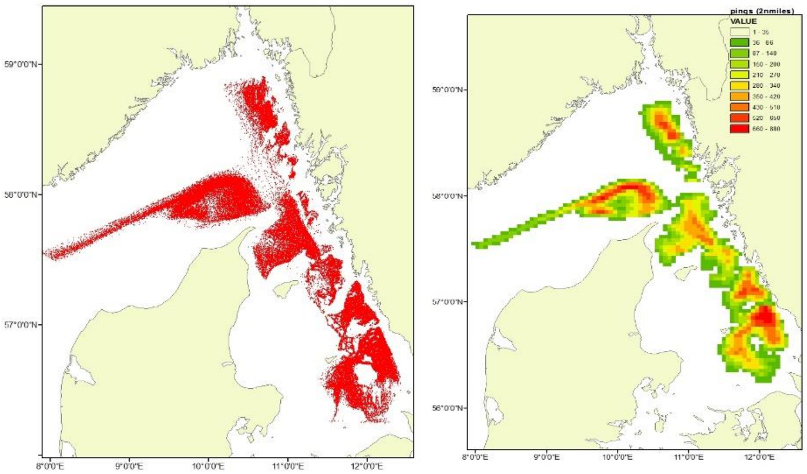


Figure 10.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

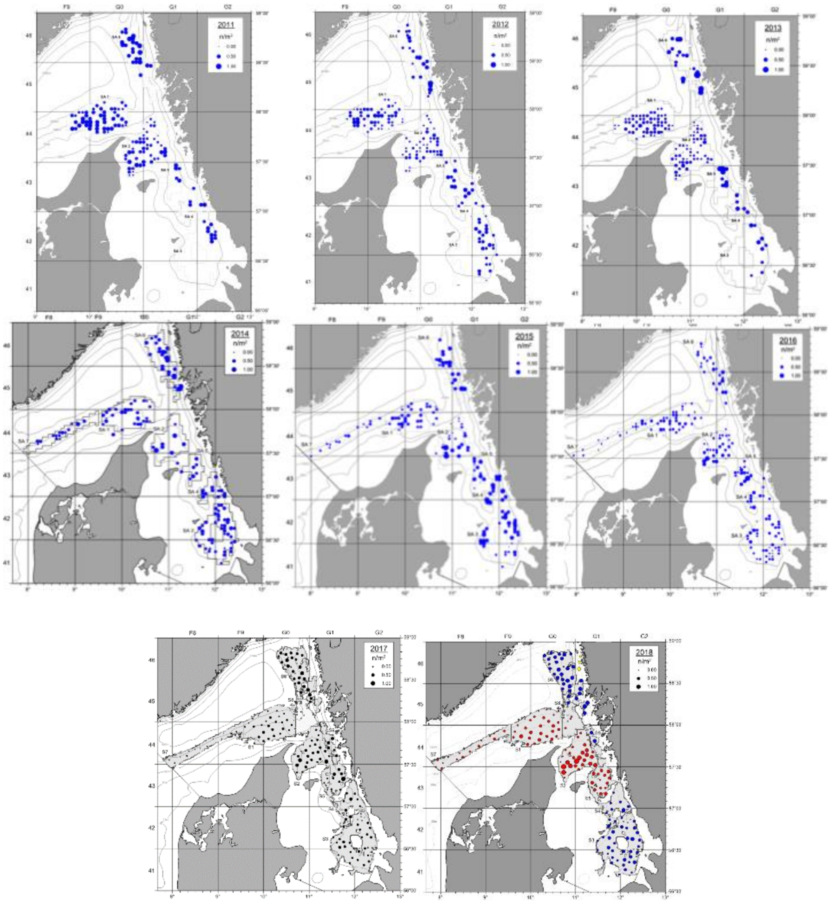


Figure 10.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations), 2016 (176 stations), in 2017 (171 stations) and 2018 (177 stations).

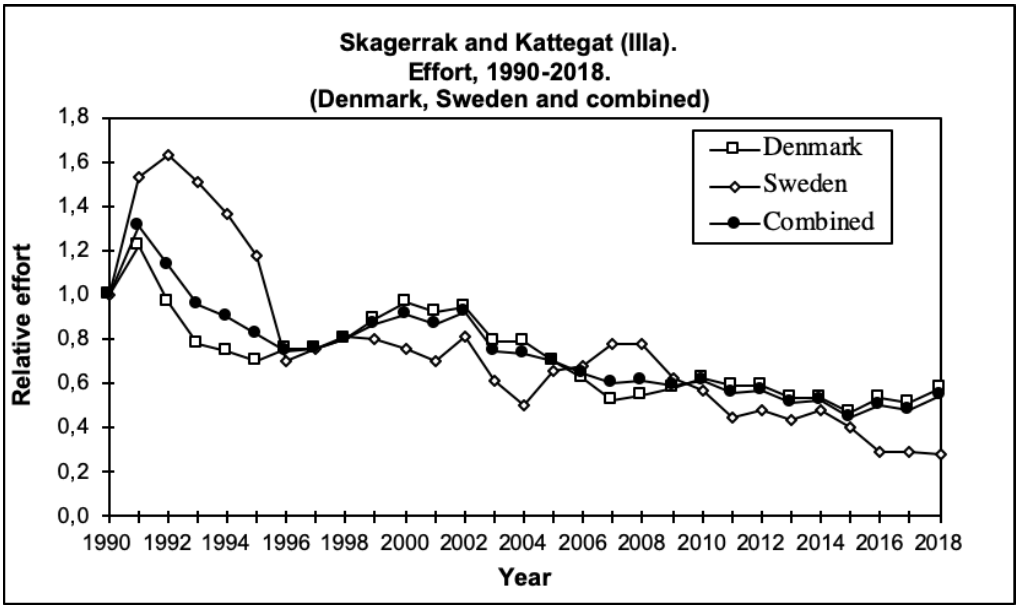


Figure 10.2.4.1 ***Nephrops*** **in Area 3.a: Combined Effort for FU 3&4.**

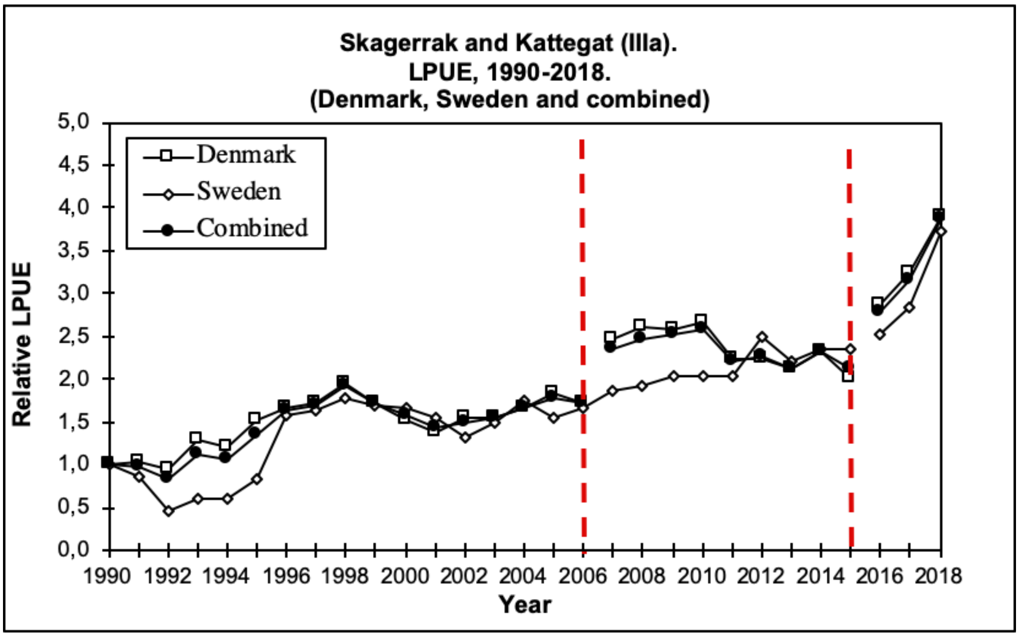


Figure 10.2.4.2 ***Nephrops*** **in Area 3.a: Combined LPUE for FU 3&4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.**

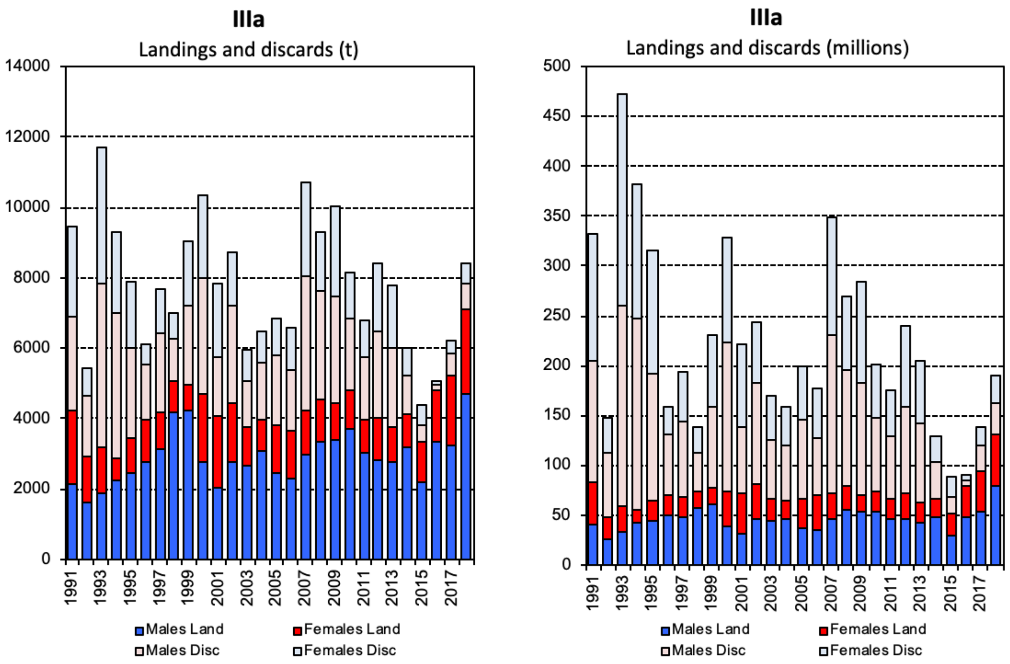


Figure 10.2.4.3. *Nephrops* in 3.a: Catch by sex and size category in biomass and numbers.

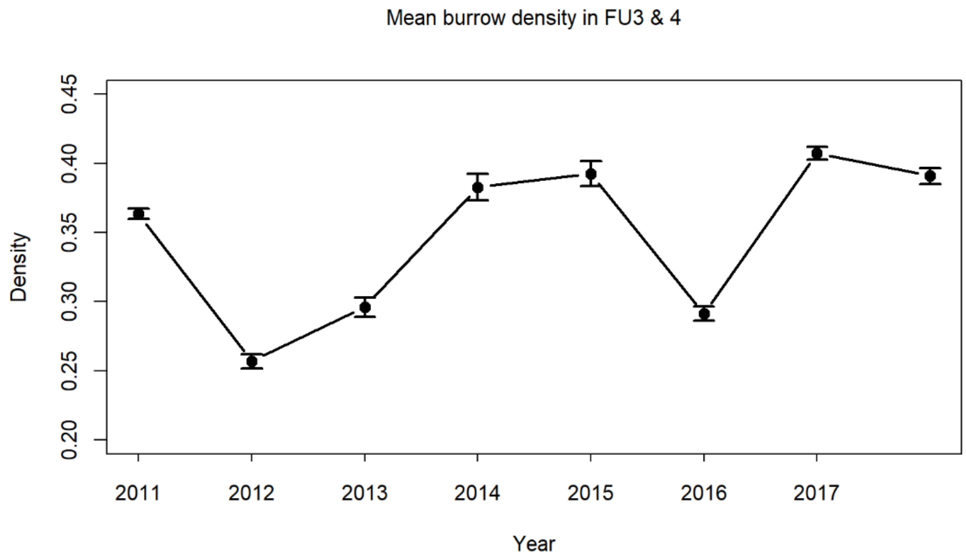


Figure 10.2.4.4. Mean burrow density in 3.a by year: Error bars indicate the 95% confidence intervals.

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. FU 34 (The Devil's Hole) is a relatively new functional unit having been designated in 2010 (SGNepS, 2010).

Management at ICES Subarea Level

The 2018 EC TAC for *Nephrops* in ICES Subarea 2.a and 4 was 24 518 tonnes in EC waters (plus 800 tonnes in Norwegian waters). For 2019, this was decreased to 22 103 tonnes in EC waters and 600 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 2017 and 2018 fishery, the catch options have been estimated assuming discarding continues according to historic patterns.

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 11.2.1. The preliminary officially reported landings in 2018 are 13 164 tonnes, 18% lower than in 2017 (16 049 tonnes), and 54% lower than the peak observed in 2009 (24 597 tonnes). All countries except Norway decreased their landings in 2018 compared to 2017. UK is the main producer country (reporting 83.3% of the total landings in 2018), followed by Netherlands (6.1%), Belgium (4.8%) and Germany (4.2%).

Table 11.2.2 shows landings by FU as reported to the WG. The most productive functional units are 7 (34% of the total landings), followed by 8 (20%), 6 (14%) and 9 (11%). 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 decreased to 612 tonnes in 2018. However, they still overtook the landings from FU 34.

11.3 Botney Cut (FU 5)

11.3.1 The fishery in 2017 and 2018.

FU 5 is an offshore stock that encompasses 1850 km^2 in the south of the North Sea. There is no creeling in the area, and Nephrops are caught by trawling by 5 countries: Netherlands is the main producer, often followed by the UK, Belgium and Germany. Danish landings have been negligible since 2015. Although Nephrops are caught throughout all year, the main activity takes places during the summer.

The highest landings from FU 5 were reached in 2016, with a value on record at 2535 tonnes (Figure 11.3.1). The landings in 2017 were also high (2110 tonnes) but decreased in 2018 to average values (1004 tonnes). In 2018 all countries reduced their landings, especially in the UK, where decreased by 76% compared to 2017.

ICES advice in 2018

FU 5 is assessed every two years, being the last advice in 2018:

ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should be no more than 1637 tonnes.

To protect the stock in this functional unit (FU) from continued overexploitation, 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 and Figure 11.3.1). Landings increased from ~800 tonnes in the early 1990s to ~1200 tonnes in the early 2000s, peaking at ~1400 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 and 2017. In 2018 the landings decreased to average values with 1004 tonnes.

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 was dominated by increases from the UK, Belgium and Germany, with lesser increases from the Netherlands. In 2017 and 2018, the UK reduced their participation in the fishery, catching only 14% of the total landings in 2018.

The discard rate in 2015 was 61% (proportion by number), and decreased to 38% in 2016. It slightly increased again in the last two years up to a value of 45% in 2018. 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 2015–2018 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 2015–2018 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 11.3.2, Table 11.3.2). The mean size of the landings for the period 2015–2017 remained constant at 35 mm but decreased to 33 mm in 2018. This decrease was caused by a significant reduction of individuals larger than 40 mm in the catch (Figure 11.3.3). The decrease of the landings and the fishing effort by the UK vessels observed in 2018 could have been also caused by the scarce abundance of large animals in FU 5 and the consequent decrease of the fishing yield. The mean size of the discards has slightly increased through the period 2015–2018, and it could mean the fleet is more selective or there were years with low recruitment. Nevertheless, these results need to be interpreted with caution because the length samples were very limited in 2018 and may not be representative of the catch. More data are needed to support these conclusions.

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 and Charuau, 1975; and Redant and Polet, 1994).

Growth parameters are as follows:

Males: $L\infty = 62$ mm CL, k = 0.165.

Immature females: $L\infty = 62$ mm CL, k = 0.165.

Mature females: $L\infty = 60$ 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 Nephrops (i.e. vessels using 70–99 mm otter trawl with at least 25% by weight of *Nephrops* per record).

FU 5 is an offshore stock and most of the vessels are greater than 15 m, being the under 10 m fleet totally absent in this fishing ground (Figure 11.3.4). On average, around 10 English vessels fished

Nephrops in FU 5 between 2006 and 2015. The number of vessels increased up to 26 in 2016, but it decreased to the minimum value on record in 2018 (only 4 vessels).

The number of fishing days and LPUE were estimated only for vessels greater than 15 m. The number of fishing days has fluctuated without trend from 2006 to 2015, with an average of 312 fishing days (Figure 11.3.5). Following the same time pattern as the number of vessels, the fishing days achieved the maximum value on record in 2016, with 716 days, and the minimum in 2018, with 120 fishing days.

LPUE has fluctuated between 0.76 and 1.24 tonnes/day throughout the time series (Table 11.3.3), achieving the lowest values in 2008 and 2013. The LPUE has decreased since the last peak in 2016, and the LPUE in 2018 was 0.98 tonnes/day (Figure 11.3.6).

TV Survey in FU 5 (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. In addition, Netherlands has provided length distributions for landings and discards by métier where available.

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. The procedure to raise the data in 2018 was as follow:

1. The annual discards provided by Netherlands were associated with the quarter landings for the same métier and fleet.
2. Discard ratios for all unsampled Dutch fleets were raised on the combined annual data from Netherlands. 107 tonnes of discards were raised in this step (Figure 11.3.7).
3. The length distributions imported by Netherlands represented 2% of the landings and 83% of the discards from Netherlands. The length frequencies for the remaining metiers from Netherlands were generated from the pooled data (i.e. irrespective of metier or quarter) for both landing and discard components.
4. Externally of intercatch, the pooled length distribution of the Dutch catch was used to generate the length distribution of the other fleets, irrespective of metier, quarter or country. Then, the retention ogive borrowed from FU 6 was applied on the catch at length profile from the non-Dutch fleet to estimate discard ratios.

11.3.4 Quality of assessment

The data available to assess FU 5 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 FU 6. 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 2015–2018, the measured animals in the discards fluctuated between 4000 and 7000, and between 1300 and 5000 in the landings. The sampled distribution of landings was especially low in 2018, when only 0.94% of the total landings was sampled (Figure 11.3.8).

11.3.5 Status of stock

The status of this stock is uncertain although there are signs that the fishing yield of this stock has decreased over the years. The number of UK vessels fishing in FU 5 has decreased over time and only two vessels fished in this functional unit in 2018. Although the number of fishing vessels from other nationalities is not available, all countries decreased their landings in 2018, and therefore either their LPUE or their fishing effort decreased as well. In addition, *Nephrops* larger than 40 mm were very scarce in the catch in 2018, and this could explain the drop in the number of vessels fishing in FU 5. However, this result is not conclusive as the number of length samples was very poor and might not be representative of the actual length profile of the catch.

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

The short term forecasts and the quota advice for this stock is updated every two years. Catch and landing predictions for 2019 and 2020 were estimated in WGNSSK (2018) and 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* FU 5. 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 2017 and 2018

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 2018 data comprise the end of the 2017–2018 fishery and the start of the 2018–2019 fishery.

The landings in 2017 and 2018 were 1963 and 1807 tonnes, respectively. Although they were approximately 31% higher than in 2015, they are still below the last 10-year average (2009–2018) of 2117 tonnes (Figure 11.4.1). The discard rate in 2017 and 2018 was 9.2% and 9.5% (estimated as percentage of biomass), lower than the average rate for the last 10 years (11.4%).

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

ICES Advice in 2018

"ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catches in 2019 that correspond to the F ranges in the MAP are between 1709 tonnes and 1982 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

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 overexploitation".

Management of the fishery is at the ICES Subarea level as described in Section 10.1.

11.4.2 Assessment

Review of the 2018 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 11.4.2) 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 11.4.3). 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 (Figure 11.4.4).

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 (Table 11.4.3). 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. The higher abundance observed in 2017 and 2018 in the TV survey, and the small animals observed in the catch for those years 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 2008–2018, 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 ~100 to ~250 since 2006 (Figure 11.4.5) 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.

Directed effort (i.e. days fishing by vessels fishing with *Nephrops* gears) from English vessels has fluctuated without trend since 2006 for vessels above 10 m, with an average of 1147 fishing days (±337 standard deviation) per year (Figure 11.4.1, Table 11.4.2). Vessels under 10 m length expend the greatest numbers of days fished since 2006, reaching the highest values in the last three years (2216 days in 2018). 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).

The use of LPUE (landings per unit effort) 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 catchability 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 and increased in 2016 and 2017 for all fleet. Vessels above 15 m increased again the LPUE in 2018, whereas smaller vessels kept similar values to 2017. The LPUE shows a positive correlation with the size of the vessels, and the LPUE in the last year was 397, 232 and 193 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 11.4.7). 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 11.4.3).

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 (Figure 11.4.6).

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 11.4.4 and Table 11.4.4. The procedure used to work up the TV survey has been changed in 2007. 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, re-fitting the semi-variogram and re-estimating the surface. Uncertainty estimates are typically 2%, much lower than the previous estimates which ignored spatial structure to a large degree. Since 2013, the survey takes place during the summer instead of the autumn, in order to avoid the fishing vessels working in the area and disturbing the sediment.

The total abundance at the beginning of the time series was higher than 1000 million of individuals, reaching 1685 million in 2001. Since 2007 the abundance fluctuated between 565 and 987 million of individuals, obtaining the lowest value in 2015. 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. In 2017 and 2018 the mean density and total abundance increased again, with values of 0.31 ind m^{-2} and 950 (95% confidence interval = 23) million of individuals in 2018. Figure 11.4.8 shows the final maps for 2014–2018. 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

2018 landings data by fleet were provided by Scotland, England, Belgium, and the Netherlands via Intercatch. England also provided an update of their landings for 2017, which resulted in an increase of 151 tonnes compared with the values submitted in 2017 (see Section 11.4.6: quality of the assessment).

In addition, England provided length distributions for landings and discards by fleet and quarter where available. Scotland provided for 2018 some length distributions for landings by fleet and quarter.

Discard ratios for all unsampled fleets were raised on the combined annual data from England. 50.6 tonnes of discards (27% of the total) were raised using this procedure (Figure 11.4.9).

The length distributions imported by England and Scotland represented 80% of the landings and 73% of the discards (Table 11.4.6, Figure 11.4.10). 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. The cumulative bias-correction factor estimated for FU 6 was 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 and 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 FU 6 is not undertaken until June. This means that the initial assessment and advice for 2020 relies upon the TV survey from 2018, although 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 FU 6, 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 2018 was 950 million individuals (95% confidence interval of ±23 million), above the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2018 was 8.3% (Table 11.4.5), above the MSY proxy level of 8.1%.

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 overestimation 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, Figure 11.4.13). The harvest ratio jumped from around 12% in 2004–2005 to 25.5% in 2006 when the new reporting legislation came in. The harvest rate has only been below the MSY level once (in 2008) in the last 12 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 13.5% 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 2020 are given in the table below. This assumes that the absolute abundance estimate made in June 2018 is relevant to the stock status for 2020.

In November 2016, ICES advised on fishing opportunities assuming that discarding would only occur below the MCS. Observations from the fishery in 2016, 2017 and 2018 indicate that discarding above the MCS continues, and practices have not changed markedly (Figure 11.4.3). Consequently, ICES has provided advice for 2018–2020 assuming average discard rates observed over the last three years, which is considered to be a more realistic assumption. A table with the catch and landing predictions assuming zero discards is also presented for comparison.

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 2020 that correspond to the F ranges in the EU multiannual plan for the North Sea are between 1679 tonnes and 1947 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

Norway lobster in Division 4.b, Functional Unit 6. The basis for the catch scenarios

Variable	Value	Notes
Stock abundance	950 million individuals	UWTV 2018
Mean weight in wanted catch	28.71 g	Average 2016–2018
Mean weight in unwanted catch	10.55 g	Average 2016–2018
Unwanted catch proportion	24%	Average 2016–2018 (proportion by number)
Unwanted catch survival rate	15%	Only applies in scenarios where discarding is allowed.
Dead unwanted catch proportion	21%	Average 2016–2018 (proportion by number), only applies in scenarios where discarding is allowed

Nephrops FU 6. Catch options assuming discarding continues at recent average. All weights are in tonnes.

Catch options assuming recent discard rates

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	1947	1917	1744	173	30	8.12%
$F_{MSY\ Upper}$	1947	1917	1744	173	30	8.12%
$F_{MSY\ Lower}$	1679	1653	1504	149	26	7.00%
F0.1Male	1705	1679	1527	151	27	7.11%
F35%Male = F_{MSY}	1947	1917	1744	173	30	8.12%
F0.1Comb	2082	2049	1865	185	33	8.68%
F35%Comb	2672	2630	2393	237	42	11.14%
FmaxMale	2782	2739	2492	247	44	11.60%
Fcurrent	2500	2461	2239	222	39	10.42%
F0.1Female	3363	3310	3012	298	53	14.02%
F35%Female	3643	3586	3263	323	57	15.19%
FmaxComb	3670	3612	3287	326	57	15.30%
FmaxFemale	5181	5099	4640	460	81	21.60%

Catch options assuming zero discard rates

Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
F_{MSY} ApproachComb	1877	1681	196	8.12%
$F_{MSY\ Lower}$	1618	1449	169	7.00%
F0.1Male	1644	1472	172	7.11%
$F_{MSY\ Upper}$	1849	1656	193	8.00%
F35%Male = F_{MSY}	1877	1681	196	8.12%
F0.1Comb	2007	1797	209	8.68%
F35%Comb	2575	2307	269	11.14%
FmaxMale	2682	2402	280	11.60%
Fcurrent	2410	2158	251	10.42%
F0.1Female	3241	2903	338	14.02%
F35%Female	3512	3145	367	15.19%
FmaxComb	3537	3168	369	15.30%
FmaxFemale	4993	4472	521	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 the 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.

There was an issue with the UK official database in 2017 and 2018 and some fishing trips were missed. These trips were made by non-Scottish vessels that sold their catch to Scottish buyers. In order to associate the missing landings with a functional unit, it was assumed the vessels (all of them under 10 m length) fished near the landing port. Consequently, vessels landing Nephrops in North Shields, Amber, Hartlepool, Blyth, North Sunderland and Boulmer (England) were assumed to fish in Farn Deeps during those missing trips.

The addition of these missing landings for 2017 resulted in an increase of 151 t compared with the value submitted in 2017. It also caused an increase of the estimated discard and harvest rate, and a decrease of the mean weight and size of the catch for that year. The fishing effort and LPUE for English vessels were also updated.

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 2018 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.

11.4.7 Status of stock

The 2018 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 but it is still above the $F_{MSY\ trigger}$.

The temporal trend of both parameters indicates the status of the stock has slightly improved compared to 2017, but the harvest rate is still higher than the value at MSY. This improvement is probably due to a year with a strong recruitment that has increased the stock abundance, and to a slight decrease of the catch. 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 2016–2018, 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 2018

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (4418 tonnes in 2018), 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 2018 was generally poorer than in 2017. 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 in the second half of 2018 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 2018

The ICES conclusions in 2018 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. The stock size increased in 2016 and 2017, but decreased again in 2018. However, it is still above MSY $B_{trigger}$. The harvest rate has declined since 2010 and remains well below F_{MSY}."

The ICES advice in 2018 (for 2019) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catches in 2019 that correspond to the F ranges in the MAP are between 11 596 tonnes and 13 178 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

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 2019

The assessment of *Nephrops* in 2019 is based on examining trends in the UWTV survey data (1992–2018) 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 2019 followed the process of 2018, 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 2018 were 4418 tonnes (14% decrease in comparison with the 2017 total), consisting mostly of Scottish landings with only 5 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 2018.

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 2018 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 2016–2018 was analysed at the time of the WG meeting). In 2017–2018, 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 and is currently above 300 kg/day. Danish LPUE data (1991–2018) 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 the last two years, landings increased in FU 7 and the discard rate in 2018 was estimated to be 2.9%.

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 2018 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 2019 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 2018.

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 2018. 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. In 2018 length distributions were relatively similar to the previous year with a small decrease in the male mean size. For females, a second peak (mode) in the length distribution was detected, implying possibly a large cohort moving through the population (alternatively, it could be a sampling artifact – further sampling data collected in 2019 may help in clarifying this). 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 over-exploitation 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 in catches <35 mm decreased sharply followed by a small increase in 2018 and is now around 30 mm CL for females and 31 mm CL for males. The discard rate in 2018 was estimated to have decreased slightly from the previous year 4.4% to 2.9%, 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 2018 suggesting the recent reduced mean sizes in catches may be related with a strong recruitment in 2016–2017. 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 (1990–2018) are shown in Figure 11.5.4 and Table 11.5.5. The variability in mean size is greater in FU 7 (and FU 34) than in other areas. In 2018, the mean weight in landings increased from 25.4g to 30.6g and is similar to the values observed in 2010 before the stock declined markedly.

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 2018). 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 (2013–2018) with the size of the symbol reflecting the *Nephrops* burrow density. The abundance in 2018 decreased 20% from 2017. 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 2009–2018 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 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 latest UWTV survey data shows that the abundance has decreased 20% in 2018. The stock is above the average abundance over the time series and is well above the biomass trigger. The harvest ratio in 2018 (2.8%, 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 followed by a slight decrease in 2018 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 in catches has increased and the mean size of individuals below 35 mm decrease markedly in 2017. This suggests a period of lower recruitment between 2010 and 2015 followed by a strong recruitment event in 2016–2017. In 2018 the observed recruitment pulse seems to be moving up in the length distributions as suggested by a slight decrease in the discard rate and an increase in the mean sizes of catches below 35 mm CL.

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 2016–2017 the abundance continued to increase sharply from the lowest point in the time series. In 2018, the abundance remains at a relatively high level estimated to be 5656 million (Table 11.5.8).

Table 11.5.8 also shows the estimated harvest ratios from 1992–2018. These range from 1.4–10% over this period and are all below F_{MSY}. It is unlikely that prior to 2006, the estimated harvest ratios are representative of actual harvest ratios due to under-reporting of landings. In 2018, due to the recent increase in the abundance and the landings remaining at a relatively low level, the harvest ratio is still estimated to be low at 2.8%.

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 2.9% by number in 2018.

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 shown generally a declining trend over the last 10 years 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.

WGNSSK 2015		F_{bar}(20–40 mm)		HR (%)	SPR (%)		
		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 2020 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 2018 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 2019 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 was in place in the North Sea in 2018 with a survivability exemption for certain TR2 gears. 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 2019–2020. Instead, an extra catch options table assuming a discard ban for 2020 was requested. The main difference in this scenario is that there is no survival assumed for the unwanted catches.

The large abundance increase in 2016–2017 is likely to be related with a strong recruitment event. The mean weights for this stock have increased in the period 2010–2016 but the most recent estimates in 2017–2018 are considerably lower (Figure 11.5.4). The evidence from sampling and survey data shows highly variable discard rates and consequently large fluctuations in the mean weights. This implies that the use of long term averages for these inputs should be considered as these are less sensitive to recent fluctuations and more representative over the time period for which sampling is available. Therefore, a long-term discard rate and mean weight averages (landings and discards) from year 2000, were 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 2020 at the F_{MSY} proxy harvest ratio is 13 162 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). 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	Notes
Stock abundance	5656 million individuals	UWTV 2018
Mean weight in wanted catch	31.65 g	Average 2000–2018
Mean weight in unwanted catch	14.86 g	Average 2000–2018
Unwanted catch rate (total)	6.9%	Average 2000–2018 (proportion by number)
Unwanted catch survival rate	25%	Proportion by number
Dead unwanted catch discard rate (total)	5.3%	Average 2000–2018 (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							
EU MAP^: F_{MSY}	13 162	13 051	12 719	332	111	7.5	-0.121%
F= MAP $F_{MSY\ lower}$	11 582	11 485	11 193	292	97	6.6	-12.1%
F = MAP $F_{MSY\ upper}$***	13 162	13 051	12 719	332	111	7.5	-0.121%
Other scenarios							
MSY approach	13 162	13 051	12 719	332	111	7.5	-0.121%
$F_{2016–2018}$	4211	4176	4070	106	35	2.4	-68%
F_{2018}	4913	4872	4748	124	41	2.8	-63%
$F_{35\%SpR}$	19 655	19 490	18 994	496	165	11.2	49%
F_{max}	28 780	28 538	27 812	726	242	16.4	118%

Catch options assuming zero discards

Basis	Total catch WC+UC	Wanted catch WC	Unwanted catch UC	Harvest rate * for WC+UC	% advice change **
EU MAP^: F_{MSY}	12 935	12 500	435	7.5	-1.84%
F= MAP $F_{MSY\ lower}$	11 383	11 000	383	6.6	-13.6%
F = MAP $F_{MSY\ upper}$***	12 935	12 500	435	7.5	-1.84%
Other scenarios					
MSY approach	12 935	12 500	435	7.5	-1.84%
$F_{2016–2018}$	4139	4000	139	2.4	-69%
F_{2018}	4828	4666	162	2.8	-63%
$F_{35\%SpR}$	19 316	18 666	650	11.2	47%
F_{max}	28 283	27 332	951	16.4	115%

^ EU multiannual plan (MAP) for the North Sea (EU, 2016).

*** Calculated for dead removals.**

**** Total catch 2020 relative to advice value 2019 (3569 t).**

***** FMSY upper = FMSY for this stock.**

Biological Reference points

Biological reference points have not been defined for this stock.

11.5.11 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately. The proportion of landings with discards associated (same strata) is 92% in 2018 (91% of the discards were imported and 9% 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 2013–2018.

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 and remains close to the highest abundance recorded in 2017. The abundance is well above the MSY $B_{trigger}$ level. Landings taken from this FU in 2018 (4418 tonnes) were much lower than the 2017 advice (for 2018) of 15 981 tonnes (wanted catch). The harvest rate decreased slightly in 2018 to 2.8% 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. From 2017, length distributions in catches showed a decrease in the mean size and the discard rates (previously estimated to be zero) increased. 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. The Scottish industry is implementing improved selectivity measures in gears which target *Nephrops* with a view to reducing unwanted by-catch of cod and other species.

The increase in abundance registered in recent years 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 was a *de minimis* exemption in place for *Nephrops* in the North Sea in 2018. Animals below the minimum conservation reference size could 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 2018, 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 low.

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 2018

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 recent years 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 estimated at 41 tonnes in 2018. Catches were generally reported as good in particular towards the end of summer 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 2018

The ICES conclusions in 2018 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 above F_{MSY}."

The ICES advice in 2018 (for 2019) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catches in 2019 that correspond to the F ranges in the MAP are between 2321 tonnes and 3569 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

In order to ensure the stock in Functional Unit (FU) 8 is exploited sustainably, management should be implemented at the FU level."

11.6.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.6.5 Assessment

Approach in 2019

The assessment in 2019 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 2019 followed the process of 2018, 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 2019 of 2690 tonnes was the highest in the available time series and is above the ten year average (2150 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 (estimated at less than 0.1 tonnes) was reported for FU 8 as BMS category.

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 (only small differences in recent years are noticeable 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, stabilised at a relatively high level from 2006 to 2016 and in the last two years increased to reach the highest level in the time series.

Males consistently make the largest contribution to the landings by weight (Figure 11.6.2), although the sex ratio does vary. In 2011-2013 more females recorded in the catches moved the ratio closer to 1:1. This may be due to the changes in seasonal effort distribution in the late 2000's with greatest effort in the 3rd quarter when females are likely to be more available to the fishery (compared with a more evenly distributed seasonal effort pattern in 2003–2005 and 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 up to 2015, 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 (2009–2018 average 24%). In the last five years, discard rates appear to have dropped to below this value (20% on average by number) and in 2018 the discard rate was recorded at 17.4%. 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 2018 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 2019 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 2018. 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. 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 45 stations have been considered valid each year. In 2018, there were 50 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 in the last 4 years and in 2018 it reached the highest point in the time series. The stock is currently above the average abundance over the time series and remains well above the biomass trigger. The calculated harvest ratio in 2018 (dead removals/TV abundance) decreased and is now below F_{MSY} (previously above F_{MSY}). This is mostly the result of a 52% decrease in stock abundance combined with a small (8%) increase in landings in 2018. 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 2008. Abundance is estimated to have fluctuated in the years since then. The abundance estimates from 1993–2018 are shown in Table 11.6.6. The stock is currently estimated to consist of 1025 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 2018 is 12.9% which is below 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
	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	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 2020 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 2018 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 2019 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 was in place in the North Sea in 2018 with a survivability exemption for certain TR2 gears in winter months. 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 2019–2020. Instead, an extra catch options table assuming a discard ban for 2020 was requested. The main difference in this scenario is that there is no survival assumed for the unwanted catches.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2020 at the F_{MSY} proxy harvest ratio is 3724 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	Notes
Stock abundance	1025 million individuals	UWTV 2018
Mean weight in wanted catch	23.66 g	Average 2016–2018
Mean weight in unwanted catch	10.45 g	Average 2016–2018
Unwanted catch rate (total)	17.9%	Average 2016–2018 (proportion by number)
Unwanted catch survival rate	25%	Proportion by number
Dead unwanted catch discard rate (total)	14.1%	Average 2016–2018 (proportion by number)

Catch options assuming discarding to continue at recent average

Basis	Total catch WC+DUC+SUC	Dead removals WC+DUC	Wanted catch WC	Dead unwanted catch DUC	Surviving unwanted catch SUC	Harvest rate * for WC+DUC	% advice change **
ICES advice basis							
EU MAP^: F_{MSY}	3724	3642	3397	245	82	16.3%	4.3%
F= MAP $F_{MSY\ lower}$	2422	2369	2209	160	53	10.6%	-32%
F = MAP $F_{MSY\ upper}$***	3724	3642	3397	245	82	16.3%	4.3%
Other scenarios							
MSY approach	3724	3642	3397	245	82	16.3%	4.3%
$F_{0.1}$	2148	2101	1959	142	47	9.4%	-40%
F_{35SpR}	2902	2838	2647	191	64	12.7%	-18.7%
F_{2018}	2948	2883	2689	194	65	12.9%	-17.4%
$F_{2016-2018}$	3427	3352	3126	226	75	15.0%	-4.0%

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP^: F_{MSY}	3558	3245	313	16.3	-0.31%
F= MAP $F_{MSY\ lower}$	2314	2111	203	10.6	-35%
F = MAP $F_{MSY\ upper}$***	3558	3245	313	16.3	-0.31%
Other scenarios					
MSY approach	3558	3245	313	16.3	-0.31%
$F_{0.1}$	2052	1872	180	9.4	-43%
F_{35SpR}	2772	2529	243	12.7	-22%
F_{2018}	2815	2568	247	12.9	-21%
$F_{2016\text{-}2018}$	3275	2987	288	15	-8.2%

^ EU multiannual plan (MAP) for the North Sea (EU, 2016).

*** Calculated for dead removals.**

**** Total catch 2020 relative to advice value 2019 (3569 t).**

***** FMSY upper = FMSY 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. The proportion of landings with discards associated (same strata) is 96% in 2018 (97% of the discards were imported and 3% 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 2013–2018.

11.6.11 Status of the stock

The stock has shown an increasing trend in the last 4 years and is above the average abundance and well above the MSY $B_{trigger}$ level. The value calculated for 2018 (1 025 million) is the highest in the time series. Landings taken from this FU in 2018 (2690 tonnes) were higher than the 2017 total catch advice (for 2018) of 2376 tonnes. Despite this, the harvest rate decreased in 2018 to 12.9% (due to the current high abundance) and is now below F_{MSY}. Length frequencies in the catches have been stable.

11.6.12 Management considerations

Catches in 2018 increased to levels above ICES advice in 2018, highlighting the issue that current management arrangements are not sufficient to contain the fishery within the sustainable limits determined by ICES. 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 in place for *Nephrops* in the North Sea. *Nephrops* below MCRS caught with pots (all year) or in winter months (October to March) with certain TR2 gears could be discarded in FU 8 without restrictions due to high survival rates. In 2018, no *Nephrops* were recorded as below the minimum size (BMS) in FU 8 despite catches having been observed below the MCRS and this being a Functional unit that historically have shown relatively high discard rates.

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 2018

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 20–25 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. 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. 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 2017. 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 9 tonnes landed in 2018) 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 2018, a number of 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 2018

The ICES conclusions in 2018 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 below."

The ICES advice in 2018 (for 2019) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catches in 2019 that correspond to the F ranges in the MAP are between 982 tonnes and 1274 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

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

11.7.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.7.5 Assessment

Approach in 2019

The assessment in 2019 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 2019 followed the process of 2018, 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 2018 for Scotland were 1399 (a 25% decrease in relation to 2017) and England landed only 2 tonnes. Landings in recent years (post 2006) are more reliable due to the introduction of 'buyers and sellers' legislation. The long term landings trends are shown in Figure 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 2018.

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 2016–2018, 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 1% to 54% of the catch by number. In 2018 the observed rate by number was at its lowest level, approximately 1% 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 2018 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 2019 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 2018.

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 2018. 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 in 2017–2018. 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 the last two years.

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, 43 stations have been considered valid each year, 55 stations were sampled in 2018. 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 2018, 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, as found in previous years. 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 4 years. The abundance in 2018 was 417 million, an increase of 1% 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 2018 (dead removals/TV abundance) is just below F_{MSY}. 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 an increase in 2017–2018 which, together with the low discard rate observed in the last 2 years 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 4 years. The abundance estimates from 1993–2018 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 increased in 2018 to 11.7% 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 2020 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 2018 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 2019 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 was in place in the North Sea in 2018 with a survivability exemption for certain TR2 gears in winter months. 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 2019–2020. Instead, an extra catch options table assuming a discard ban for 2020 was requested. The main difference in this scenario is that there is no survival assumed for the unwanted catches.

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 1307 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	Notes
Stock abundance	417 million individuals	UWTV 2018
Mean weight in wanted catch	27.34 g	Average 2016–2018
Mean weight in unwanted catch	10.16 g	Average 2016–2018
Unwanted catch rate (total)	7.2%	Average 2016–2018 (proportion by number)
Unwanted catchsurvival rate	25%	Proportion by number
Dead unwanted catch rate*	5.5%	Average 2016–2018 (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							
MAP^: F_{MSY}	1307	1298	1271	27	9	11.8%	2.6%
F = MAP^ $F_{MSY\ lower}$	1008	1001	980	21	7	9.1%	-21%
F = MAP^ $F_{MSY\ upper}$***	1307	1298	1271	27	9	11.8%	2.6%
Other scenarios							
MSY approach	1307	1298	1271	27	9	11.8%	2.6%
$F_{0.1}$	864	858	840	18	6	7.8%	-32%
$F_{2016–2018}$	1286	1277	1250	27	9	11.6%	0.94%
F_{2018}	1297	1288	1261	27	9	11.7%	1.81%
F_{max}	1652	1640	1605	35	12	14.9%	30%

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP^: F_{MSY}	1284	1248	36	11.8	0.78%
F= MAP $F_{MSY\ lower}$	991	963	28	9.1	-22%
F = MAP $F_{MSY\ upper}$***	1284	1248	36	11.8	0.78%
Other scenarios					
MSY approach	1284	1248	36	11.8	0.78%
$F_{0.1}$	849	825	24	7.8	-33%
$F_{2016–2018}$	1262	1227	35	11.6	-0.94%
F_{2018}	1274	1238	36	11.7	0.00%
F_{max}	1621	1576	45	14.9	27%

^ EU multiannual plan (MAP) for the North Sea (EU, 2016).

*** Calculated for dead removals.**

**** Total catch 2020 relative to advice value 2019 (3569 t).**

***** 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 relatively 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. The proportion of landings with discards associated (same strata) is 52% in 2018 (49% of the discards were imported and 51% were raised discards). The lower proportion of landings covered by discard data relates to missing sampling events in quarter 1 of the main metiers (TR2 and TR1 gears).

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

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

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. Area 3 covers the Moray Firth, Firth of Forth and areas of the Devil's Hole and there appears to be some inconsistencies between the report in 2011 and 2012. In 2011 the report documented a perceived increase in the *Nephrops* abundance in this area since 2008; however the 2012 report appears to show a perceived decrease since 2008. There are no Fishers' North Sea survey data available for 2013–2018.

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 1% in 2018 (to 417 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 2018 (1399 tonnes) were higher than the 2017 total catch advice (for 2018) of 1219 tonnes (wanted catch). The harvest rate increased in 2018 to 11.7% and is just below F_{MSY} (11.8%). Length frequencies in the catches have been relatively stable.

11.7.12 Management considerations

Catches in 2018 increased to levels above ICES advice in 2018, highlighting the issue that current management arrangements are not sufficient to contain the fishery within the sustainable limits determined by ICES. 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.

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 in place for *Nephrops* in the North Sea. *Nephrops* below MCRS caught with pots (all year) or in winter months (October to March) with certain TR2 gears could be discarded in FU 8 without restrictions due to high survival rates. In 2018, no *Nephrops* were recorded as below the minimum size (BMS) in FU 9 despite catches having been observed below the MCRS and this being a Functional unit that historically have shown occasional high discard rates.

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 2017 and 2018

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 2018 only 4 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 2018

The advice provided in 2018 was biennial and valid for 2019 and 2020.

"*ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should not exceed 48 tonnes.*

To ensure the stock in Functional Unit (FU) 10 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 2018 were only 4 tonnes, a decrease of 5 tonnes from 2017. *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. In the last five years effort has been relatively stable but the LPUE has declined slightly in 2018.

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 and 2018, 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 2018 were successfully uploaded into InterCatch prior to the 2019 WG meeting according with the deadline proposed. The 2018 data for this stock was limited to official landings (classified as “Landing only” in InterCatch with no sampling data).

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, 23 tonnes in 2016, 9 tonnes in 2017 and 4 tonnes in 2018.

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 Quality of the assessment

The time-series of UWTV survey data is incomplete, and the last survey was conducted in 2014. There are no reliable effort data for this FU and therefore no resulting landings per unit of effort (LPUE).

There is no recent discard information for this fishery. Discard percentages and mean weights have been taken from the closest inshore functional unit (FU 9). The catch options are based on a calculation of potential landing options and harvest rates, given the known surface area of Norway lobster habitat and observed densities of the functional unit.

11.8.8 Status of the stock

The current state of the stock is unknown.

11.8.9 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.

This stock is under the landings obligation although there is a survivability exemption in place for *Nephrops* in in the Union waters of the North Sea (ICES divisions 2.a, 3.a and Subarea 4) with certain gears (Regulation (EU) 2018/2035) for the period 2019–2021 (Regulation (EU) 2018/2035).

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). The annual spatial distribution of the Danish and Norwegian fisheries in FU 32 are shown in Figures 11.9.1 and 11.9.2.

New maps of the annual spatial distribution of the Danish trawl fishery made at the 2016 benchmark (ICES, 2016) 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 Figure 11.9.1.

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.

11.9.3 Advice in 2018

Advice for *Nephrops* was updated in 2018. This advice applies for 2019 and 2020.

- 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 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 over-exploited.
- 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). The biomass estimates imply low harvest rates in FU 32, even in former years with high landings (1000–1200 tonnes).

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 TAC was further reduced to 600 tonnes in 2019. 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 2018 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 2018 amounted to only 137 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 2018, Denmark landed only 25% of the total landings. Norwegian landings decreased from 2008 to 2014, but have increased since, to 103 tonnes in 2018. In 2017–2018, 90% of Norwegian landings were from traps; only 9 and 10 tonnes were landed from the shrimp and mixed trawl fisheries (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 2018 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 2003–2013, while in 2014–2018 estimated Danish discards were only 5, 6, 1, 1, and 0 tonnes, respectively, resulting in very low Danish discard rates of between 0% and 5%. The low discards the last five 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 in 2017 and 2018. 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 thereafter increased further. The average size of landed females, on the other hand, has remained at the low 2013-levels. 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 landed females (not the males) that have shown a decreased size in recent years.

Mean size of the Danish catches from the years 2007, 2010, 2012, 2014, 2016, 2017, and especially 2018, were larger compared with former years (Figure 11.9.4). The high 2018 mean size is due to the high mean size of the males. 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 1989–2018 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). 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 decreasing Danish *Nephrops* 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 2014–2018 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 313 kW days in 2018, the lowest observed effort in the time series. 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 functional unit 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 fishery independent stock size index (see below).

Data analysis

Audit of the assessment in 2018

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%).

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 around this lower level (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 shrimp 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 2018 in males could reflect the lower exploitation pressure in recent years. 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* were very low in 2014–2018, 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.

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.

The advice is based on a calculation of potential catch options and harvest rate, given the estimated surface area of Norway lobster habitat and assumed densities of the functional unit. The area of the Norway lobster grounds in FU 32 is based on the distribution of the current Danish trawl fishery; this estimate does not include the Norway lobster habitat along the Norwegian coast where a growing creel fishery takes place.

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 a biomass index from the Norwegian shrimp 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 2013–2018 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 over-exploited. However, trends in mean size of female landings in 2013–2018 are difficult to interpret. The low catches of small *Nephrops* during the last five 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 264 tonnes (2009–2018), while the short-term average landings are 172 tonnes (2014–2018).

11.9.12 Management considerations

For 2006–2008, the agreed TAC for EU vessels was 1300 tonnes. Since 2009, the TAC has steadily decreased, to 600 tonnes in 2019. The WG notes that there is no TAC for the Norwegian vessels fishing in FU 32.

Sampling of trawl catches by the Norwegian coast guard should be improved. 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 2018 was only given for 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)

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, however, in 2018 they were at the lowest level since the beginning of the 1990s. 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. In 2018, the Dutch landings decreased to 236 tonnes. Belgium and German landings having increased throughout the time period and were around 280 and 210 tonnes respectively in 2018. 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). However, in 2018 total landings decreased substantially, primarily due to the large reduction in Danish landings (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 length data were available from Denmark in 2017 and 2018. In 2015, Dutch discards were recorded in InterCatch, however, length information was missing. Between 2016 and 2018, 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 2005–2018 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. Between 2016 and 2018, 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 and again in 2018 the Danish LPUE decreased considerably, to 0.8 kg/kW day and 0.2 kg/kW day respectively). 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

11.10.1 Historic stock trends

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

Danish effort began decreasing after 2004. Since then, the LPUE has steadily increased, except for 2010 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 2018, the Danish LPUE decreased substantially while the Dutch LPUE has slightly increased.

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.

11.10.2 Quality of the assessment

Catch sampling needs to be improved. Discard data exist but are not considered representative and are not used to formulate advice. It is currently not possible to update mean weight estimates for landings because current sampling levels are too low. Samples are needed from the main fleets fishing in this FU.

The advice is based on a calculation of potential landing options and harvest rates, given the known surface area of Norway lobster habitat and observed densities of the functional unit.

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 began conducting an UWTV survey of this functional unit. The observed density in 2017 (0.13 *Nephrops* m^{-2}) conformed well to those previous adopted from FU 7 (0.1 *Nephrops* m^{-2}). In 2018, the observed density was lower than what was observed in 2017 at 0.07 *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 Dutch fishery. These data are not believed to be representative for the entire fishery as considerable highgrading is known to take place. Therefore, these data have not 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 2018 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 2017 and 2018

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 2018 was biennial for 2019 and 2020.

"ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should not exceed 590 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.

Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2018 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 have fluctuated around 500 tonnes and in 2018 a value of 318 tonnes was recorded (a 42% reduction in relation to 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.

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. Effort increased in the period 2013–2016 to a similar level to that recorded in the late 2010s but declined again in 2017–2018.

LPUE showed an increasing trend until 2009 followed by a slight drop in 2011 and has fluctuated around 400 kg/day in the last ten 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 2015–2018, 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 2018 were successfully uploaded into InterCatch prior the 2019 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 2017–2018. The most recent survey, conducted in the Summer of 2018 (15 TV stations completed) gives an estimate of density of 0.09 burrows/m^2, a significant increase in relation to the 2017 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.

11.11.5 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.

11.11.6 Recruitment estimates

There are no recruitment estimates for this FU.

11.11.7 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.

11.11.8 Short-term forecasts

No short-term forecasts are presented for this FU.

11.11.9 Quality of the assessment

The time-series of underwater TV (UWTV) survey data is incomplete. Surveys were conducted in 2003 and 2005 and during the periods 2009–2012, 2014–2015, and 2017–2018.

The catch options are based on a calculation of potential landing options and harvest rates, given the known surface area of Norway lobster habitat and observed densities of the functional unit. The surface area is based on an estimate of area derived from Scottish vessel monitoring system (VMS) data from Scottish Norway lobster vessels from 2006 to 2009. The area of ground shown in geological charts is significantly larger than this and landings have been made from these areas. Therefore, the area should be regarded as a minimum estimate and the harvest rate could well be lower than implied by the analysis.

In recent years, only limited sampling data of catches have been available for this stock. Therefore, mean weights in discards are borrowed from the adjacent FU 7 and are used in addition to historical data.

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.

This stock is under the landings obligation although there is a survivability exemption in place for *Nephrops* in in the Union waters of the North Sea (ICES divisions 2.a, 3.a and Subarea 4) with certain gears (Regulation (EU) 2018/2035) for the period 2019-2021 (Regulation (EU) 2018/2035).

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). The results from the 2018 UWTV survey were used to update the advice given in June (based on the 2017 survey). UWTV survey information on the mean density of *Nephrops* (0.21 *Nephrops*/m^2) (2018 UWTV survey), was used together with the mean weight (average 2007–2010) and discard percentage (average 2008–2011). A catch based on the advice given in 2016 +20% (uncertainty cap) corresponds to a potential harvest rate of 5.4% which is below the range of MSY harvest rates in the North Sea (between 7.5% and 16%). Assuming that discard rates do not change from the rate of 12.9% (by number) and that the discard mortality rate is 100%, this implies catches of no more than 590 tonnes. For data limited stocks the discard survival is assumed to be zero.

Basis for the catch scenarios.

Variable	Value	Notes
Density in TV assessment	0.21 *Nephrops* m^2	UWTV 2018
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	Density (*Nephrops* m⁻²)								% advice change
				0.05	0.09	0.15	0.21*	0.3	0.4	0.6	0.8	
2016 Advice −36%	315	294	20	12.1	6.8	4	2.9	2	1.52%	1.01%	0.76%	−36%
2016 Advice −29%	350	328	23	13.5	7.5	4.5	3.2	2.2	1.69%	1.13%	0.84%	−29%
2016 Advice −25%	369	345	24	14.2	7.9	4.7	3.4	2.4	1.78%	1.19%	0.89%	−25%
2016 Advice −20%	394	368	26	15.2	8.4	5.1	3.6	2.5	1.90%	1.26%	0.95%	−20%
2016 Advice	492	460	32	19	10.5	6.3	4.5	3.2	2.4	1.58%	1.19%	0%
2016 Advice + 20%	590	552	38	23	12.6	7.6	5.4	3.8	2.8	1.90%	1.42%	20%
Average (2015–2017)	631	590	41	24	13.5	8.1	5.8	4.1	3	2	1.52%	28%
Average (2008–2017)	679	635	44	26	14.5	8.7	6.2	4.4	3.3	2.2	1.64%	38%
2016 Advice + 66% (MSY)	817	764	53	32	17.5	10.5	7.5	5.2	3.9	2.6	1.97%	66%
Maximum	1396	1305	91	54	30	17.9	12.8	9	6.7	4.5	3.4	184%

11.12 *Nephrops* in Subarea 4, outside the functional units (27.4outFU)

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 outside of the functional units has fluctuated over time. Landings exceeded 1000 tonnes in 2011, the first year with data. Then they dropped during the period 2012–2015, reaching a minimum of 393 tonnes in 2014. In 2016 and 2017 landings increased up to the original values, but they were reduced by half in 2018 (Table 11.12.1). Except Scotland and Sweden, all countries decreased their landings in 2018 by 50% or 60% in comparison to 2017.

Discards have been reported by Denmark since 2012, and by Netherlands since 2016. Scotland also reported discards in 2016 and 2017. The discards reported in 2018 were 176 t, 25% higher than in 2017 but 68% 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 2020:

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	2018
Belgium	303	494	349	880	1109	635
Denmark	387	624	515	755	594	100
Faeroe Islands	0	0	0	0	0	0
France	0	0	0	0	0	0
Germany	425	418	435	862	923	557
Ireland	0	1	0	0	0	0
Netherlands	910	1154	1113	1464	1418	803
Norway	63	63	81	98	94	103
Sweden	0		0	1	0	0
UK (Eng + Wales + NI)	-					
UK (Scotland)	-					
UK	8625	11211	6825	9337	11911	10966
Total	10713	13965	9318	13397	16049	13164

* **Landings data for 2018 are preliminary.**

Table 11.2.2. Summary of *Nephrops* landings from the ICES area, by Functional Unit, 1981–2018.

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

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
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	1963	5147	2493	1119	9	147	1472	550	1191	16050
2018*	1004	1807	4418	2690	1399	4	137	776	318	612	13165

*** 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*, 1991–2018, 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
2018*	234	1	429	204	136	1004	1709

*** 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: Mean length (mm) in landings (2003–2018) and discards (2015–2018)**

	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
2018*	na	na	32.8	31.0

*** provisional**

na = not available

Table 11.3.3. ***Nephrops*** **in FU 5: Landings, effort and LPUE for directed fisheries.**

	Landings	Effort	LPUE
	tonnes	Boat Days Fished	median tonnes per day
2006	303.28	335	0.85
2007	411.07	338	1.24
2008	382.50	414	0.81
2009	223.67	225	0.92
2010	343.83	302	1.07
2011	305.66	231	1.20
2012	420.69	330	1.14
2013	210.46	238	0.76
2014	395.35	337	1.03
2015	429.60	371	1.11
2016	954.85	716	1.20
2017	572.91	479	1.10
2018*	124.09	120	0.98

*** Provisional**

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*, 1981–2018, 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

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
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	1685	260	1945	18	1963
2018*	1557	229	1786	21	1807

*** 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	723	2953	245	189	786	240	371	1038	358
2018*	543	2811	193	179	771	232	377	949	397

*Provisional

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	32.5	31.8	34.2	34.3
2018	32.5	32.3	34.0	34.6

Table 11.4.4. *Nephrops* in FU 6: Results of the UWTV survey.

Year	Stations	Season	Mean density burrows/m²	Absolute Abundance millions	95% confidence interval millions	Method
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn		No survey		Box
2000	-	Autumn		No survey		Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	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

Table 11.4.5. *Nephrops* in FU 6: Historical harvest rate determination.

Year	TV abun-dance 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	1963	22.25%	29.18	10.29	87	9.6%
2018	950	1807	21.34%	28.97	11.22	79	8.3%

Table 11.4.6. Nephrops in FU 6: Summary of the imported and sampled data submitted in Intercatch

Catch category	Raised Or Imported	Sampled Or Estimated	Tonnes	percent
Landings	Imported_Data	Sampled_Distribution	1439	80
Landings	Imported_Data	Estimated_Distribution	368.1	20
Discards	Imported_Data	Sampled_Distribution	139.3	73
Discards	Raised_Discards	Estimated_Distribution	50.56	27

Table 11.5.1. *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981–2018, as reported to the WG

Year	UK Scotland				Denmark	Other countries **	Total
	Nephrops trawl	Other trawl	Creel	Sub-total			
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
2018*	2283	2130	0	4413	1	4	4418

*** 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, 2000–2018.

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
2018*	4413	14431	305.8

* 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, 1991–2018.

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
2018	121761	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, 1993–2018.

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
2018	31.3	29.7	31.3	29.7	39.7	40.0

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
2018	30.58	24.29	28.86	40.91	Na
Mean (16–18)	31.65*	23.66	27.34	31.76**	-

*** Mean weight for Fladen based on 2000–2018 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 1992–2018 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
2018	71	5656	0.20	689

Table 11.5.7. *Nephrops*, Fladen Ground (FU 7): Summary of TV results for most recent 3 years (2016–2018) 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
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
2018 TV survey							
>80	3248	9	0.364	0.007	1182	8658	0.073
55<80	4967	16	0.290	0.012	1437	18334	0.154
40<55	4304	11	0.245	0.013	1055	21311	0.179
<40	15634	35	0.127	0.010	1982	70523	0.593
Total	28153	71			5656	118826	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 2003–2018.

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
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

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
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
2018	5656	689	2.8	155	5	159	4418	68	51	2.9	30.58	14.42	2.2

Table 11.6.1 ***Nephrops*. Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981–2018, 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

Year	UK Scotland					UK	Total **
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	
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
2018*	2638	7	4	0	2649	41	2690

* 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, 2000–2018.

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

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
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
2018*	2645	4886	541.3

*** 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, 1981–2018.

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

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
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
2018	29.2	28.6	30.1	29.5	39.1	39.1

na = not available

Table 11.6.4. *Nephrops*, Firth of Forth (FU 8): Results of the 1993–2018 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
2018	50	1.12	1025	190

Table 11.6.5. ***Nephrops*****, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2016–2018) 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
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
2018 TV survey							
M & SM	170	9	0.694	0.855	118	2760	0.306
MS(west)	139	8	0.790	0.954	110	2302	0.255
MS(mid)	211	11	1.714	0.432	361	1744	0.193
MS(east)	395	22	1.103	0.313	436	2220	0.246
Total	915	50			1025	9026	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 2003–2018.

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	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

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
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
2018	1025	190	12.9	114	24	132	2690	275	206	17.4	24.29	11.42	13.6

Table 11.7.1. *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981–2018, 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
2018*	1204	184	9	1397	2	1399

*** 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, 2000–2018

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
2018*	1388	4579	303.1

*** 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, 1991–2018.

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
2018	31.5	30.7	31.6	30.8	39.7	38.8

na = not available

Table 11.7.4. *Nephrops*, Moray Firth (FU 9): Results of the 1993–2018 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
2018	55	0.19	417	126

Table 11.7.5. *Nephrops*, Moray Firth (FU 9): Summary of TV results for most recent 3 years (2016–2018) 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
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
2018 TV survey							
M & SM	169	3	0.30	0.02	51	199	0.05
MS(west)	682	18	0.19	0.08	127	2135	0.539
MS(mid)	698	18	0.20	0.02	141	492	0.124
MS(east)	646	16	0.15	0.04	98	1134	0.286
Total	2195	55			417	3960	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 2003–2018.

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

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
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
2018	417	126	11.7	48	0	49	1399	4	3	0.9	28.86	9.58	0.7

Table 11.8.1. *Nephrops*, Noup (FU 10): Nominal landings (tonnes) of *Nephrops*, 1981–2018, 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
2018*	0	4	0	4	0	4

*** 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, 2000–2018.

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
2018*	4	744	5.4

* 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 and 2018.

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
2018	na	na	na	na

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		
2018		no survey		

Table 11.9.1. *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993–2018, estimated Danish discards (2003–2018), 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*	34	0	0	10	93#	103	0	0		137	800
2019											600

*** Provisional**

 # Contains some landings from gillnets

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*****, 1993–2018.**

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
2018	313	441	387	109

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
2018	280	48	210	236	2	776

*** 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
2018	90562.9	195	159	0.53

*** kg / kW days**

Table 11.11.1. ***Nephrops*****, Devil's Hole (FU 34): Nominal landings (tonnes) of** ***Nephrops*** **1986–2018 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

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-total				
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
2018*	218	86	0	304	14			318

* 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, 2000–2018.

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
2018*	304	620	490.3

* 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, 2006–2018. 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
2018	32.3	31.1	43.8	40.7

na = not available

Table 11.11.4. *Nephrops*, Devil's Hole (FU 34): Results of the 2003, 2005, 2009–12, 2014–2015 and 2017–2018 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
2018	15	0.21	0.09

Table 11.12.1. Summary of *Nephrops* Landings from the 4NotFU area, 2012–2018.

Year	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
2018	121.2	16.3		143.4	117.8	0.1	32.9	180.7	612.4

Table 11.12.2. Summary of *Nephrops* reported discards from the 4NotFU area, 2012–2018.

Year	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		0.01			133.2			8.2	141.5
2018		0.01			176			-	176

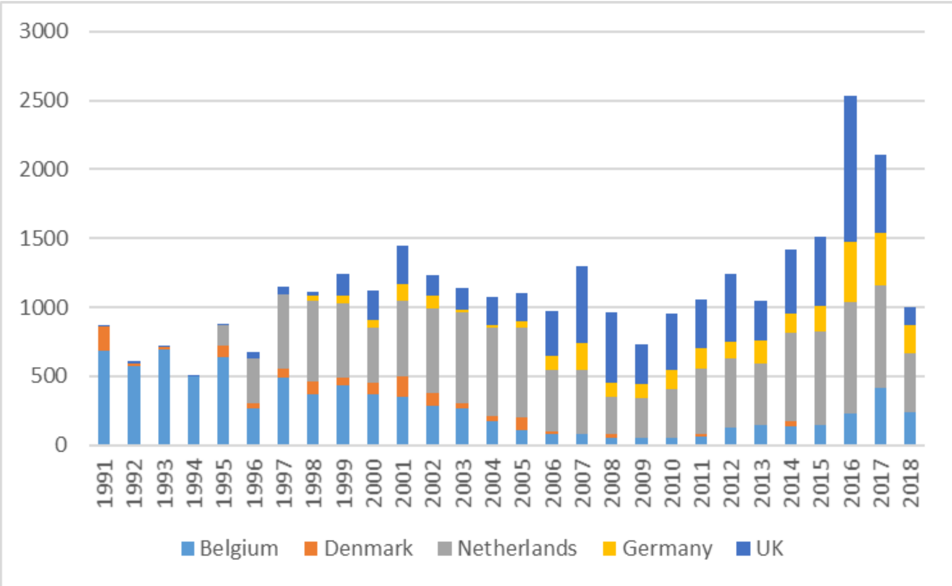


Figure 11.3.1. FU 5 Botney Cut/Silver Pit: Temporal trend of landings by country

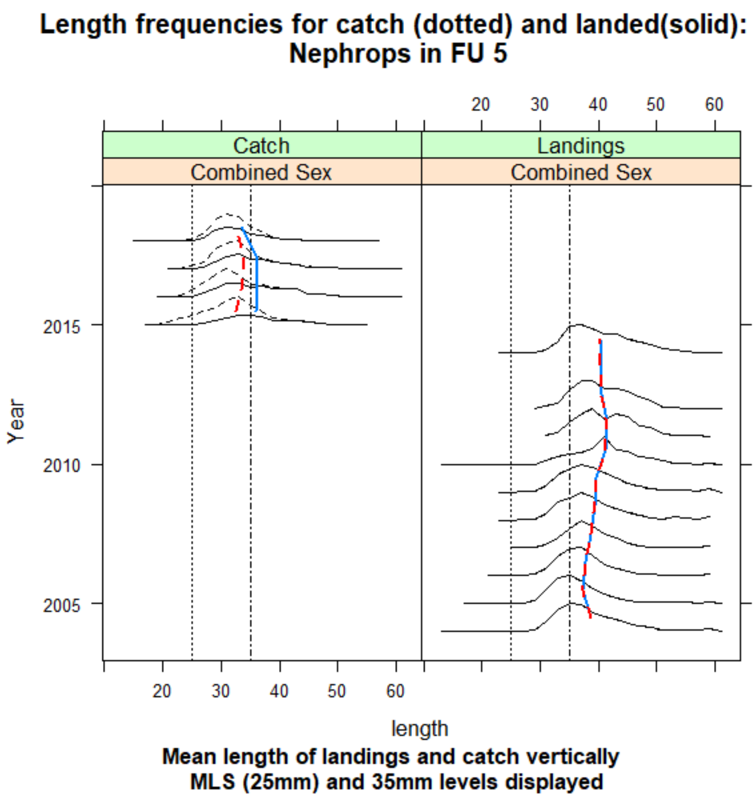


Figure 11.3.2. FU 5 Botney Cut/Silver Pit: Size distribution for combined sex sampling from 2004 (bottom) to 2018 (top). Mean sizes of catch (red line) and landings (blue line) are shown in relation to minimum landing size (MLS).

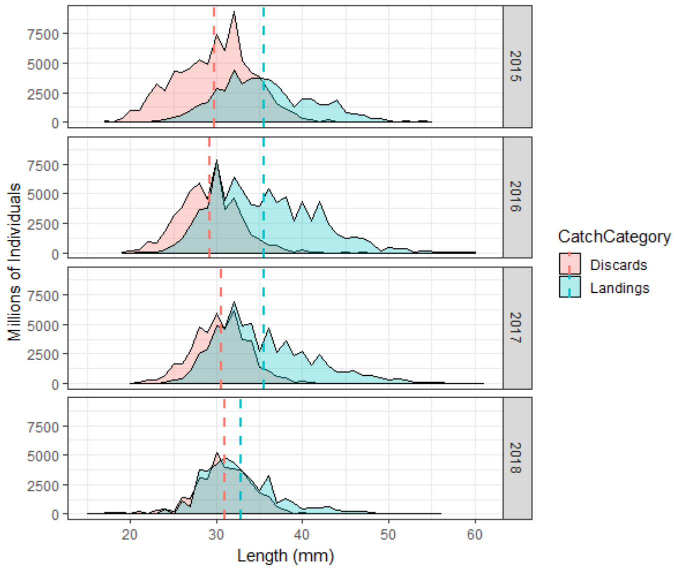


Figure 11.3.3. FU 5 Botney Cut/Silver Pit: Size distribution for combined sex sampling from 2015 to 2018. Mean sizes of discards (red line) and landings (blue line) are shown.

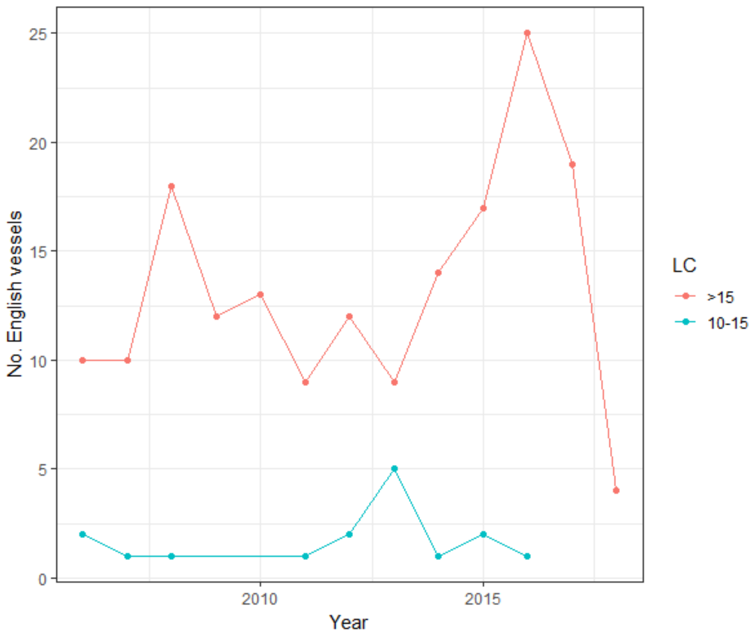


Figure 11.3.4. FU 5 Botney Cut/Silver Pit: Temporal trends in number of English directed Nephrops vessels. The colour of the line represents the fleet segment (i.e. vessels between 10 and 15 m, and vessels greater than 15 m).

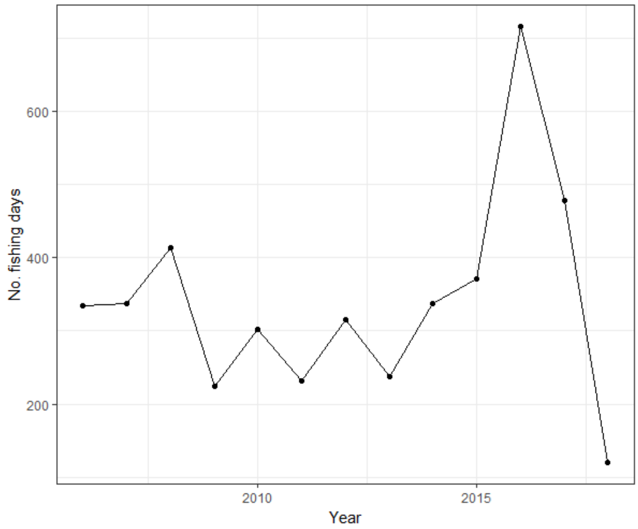


Figure 11.3.5. FU 5 Botney Cut/Silver Pit: Temporal trends in fishing effort for UK directed *Nephrops* vessels greater than 15 m

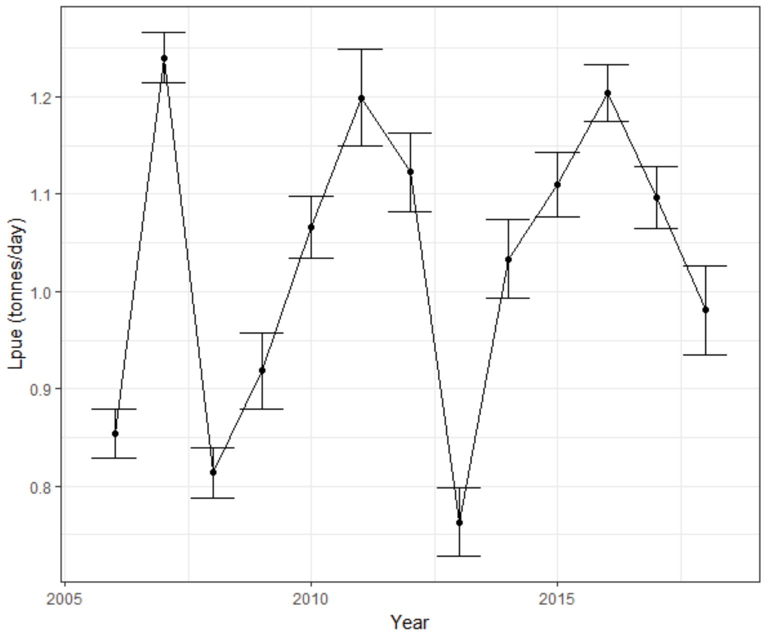


Figure 11.3.6. FU 5 Botney Cut/Silver Pit: Temporal trends in LPUE for UK directed *Nephrops* vessels greater than 15 m. The median and the standard error are shown.

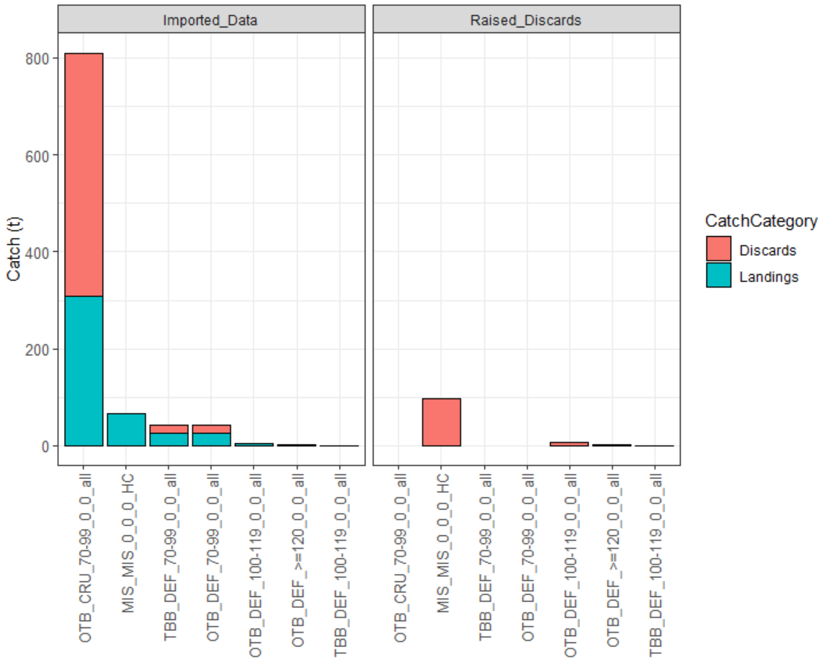


Figure 11.3.7. FU 5 Botney Cut/Silver Pit: Data imported by Netherlands and discards raised in Intercatch for this country in 2018.

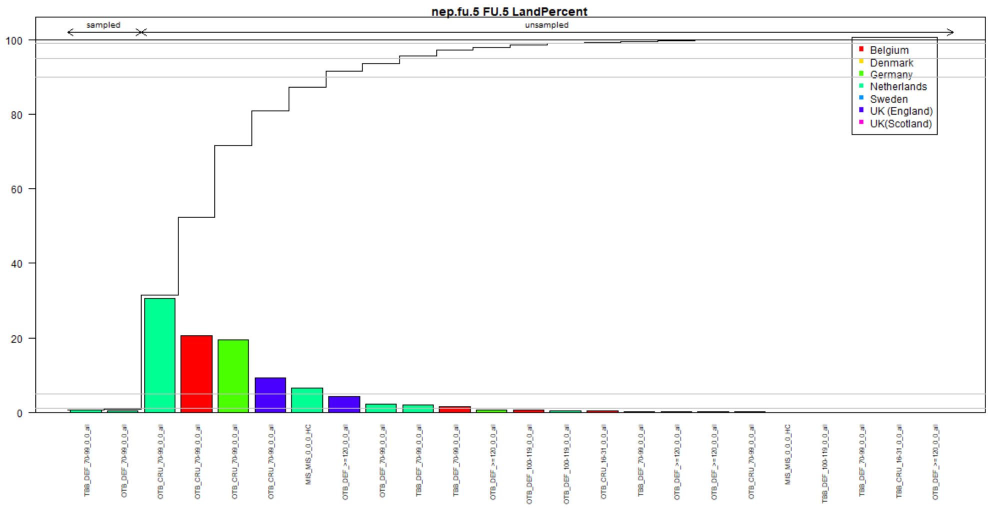


Figure 11.3.8. FU 5 Botney Cut/Silver Pit: Percentage of landings in 2018 with and without length samples.

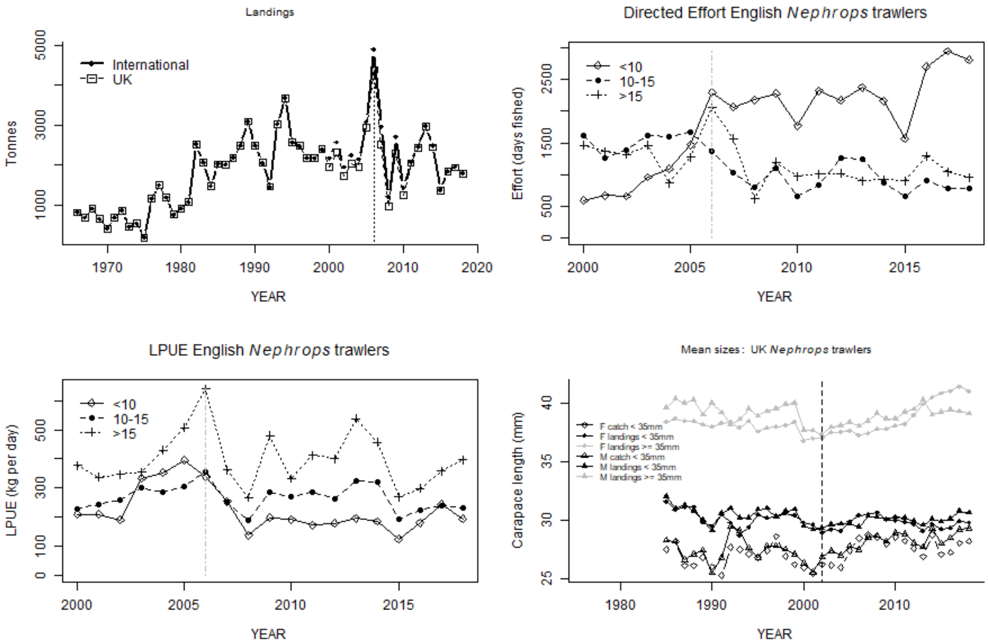


Figure 11.4.1. ***Nephrops*** **in FU 6: Landings, directed effort, directed LPUE and mean sizes of different catch components.**

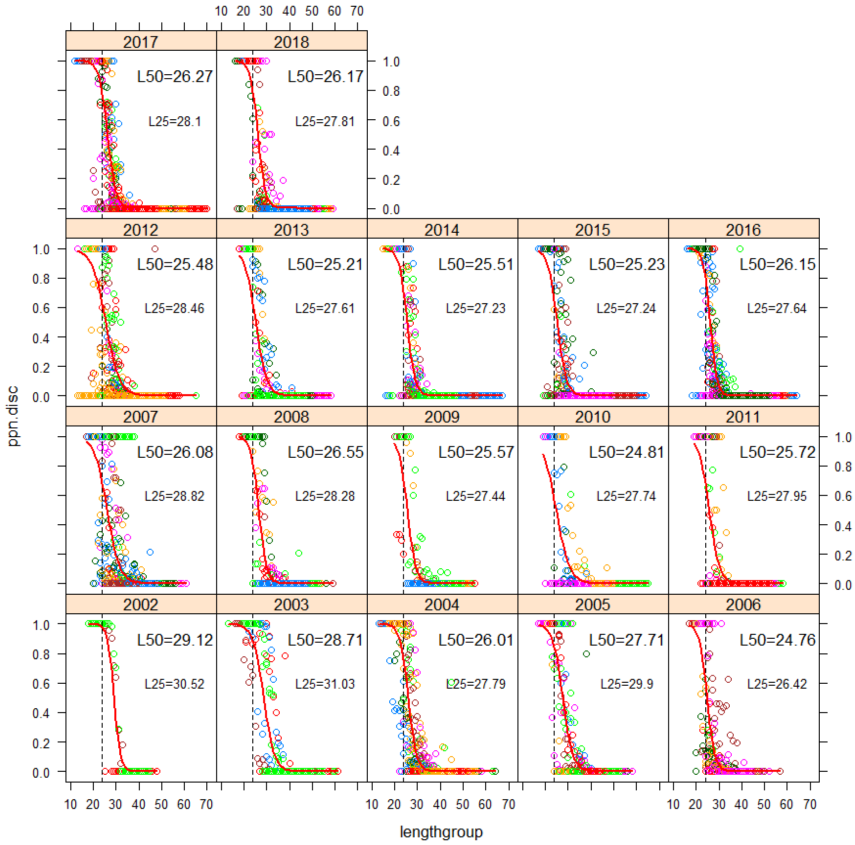


Figure 11.4.2. ***Nephrops*** **in FU 6, annual discard ogives: The different point shapes represent different sampling trips within any year.**

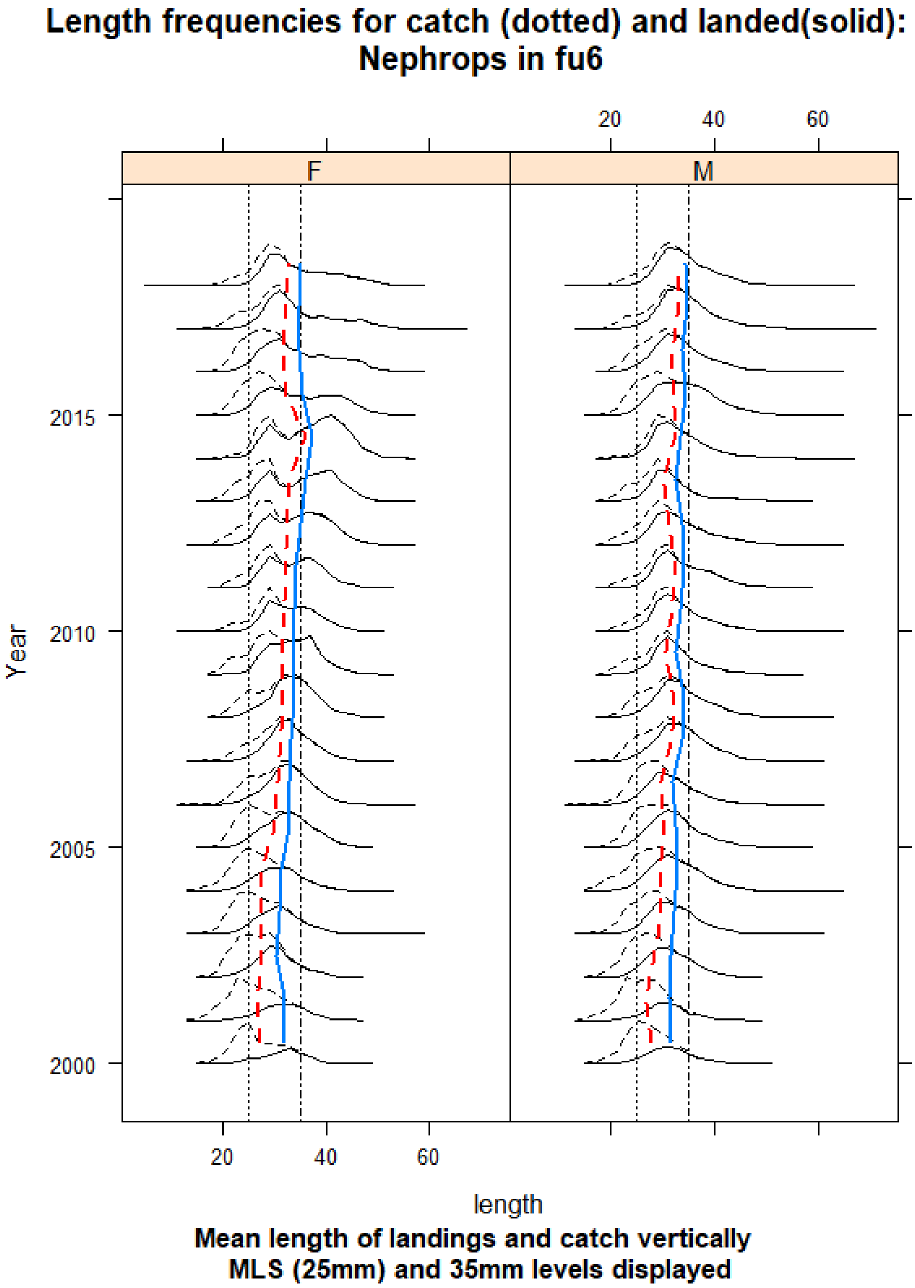


Figure 11.4.3. ***Nephrops*** **in FU 6: Annual length frequencies for landings and catch by sex. Mean size of the landings (blue line) and catch (red line) are shown.**

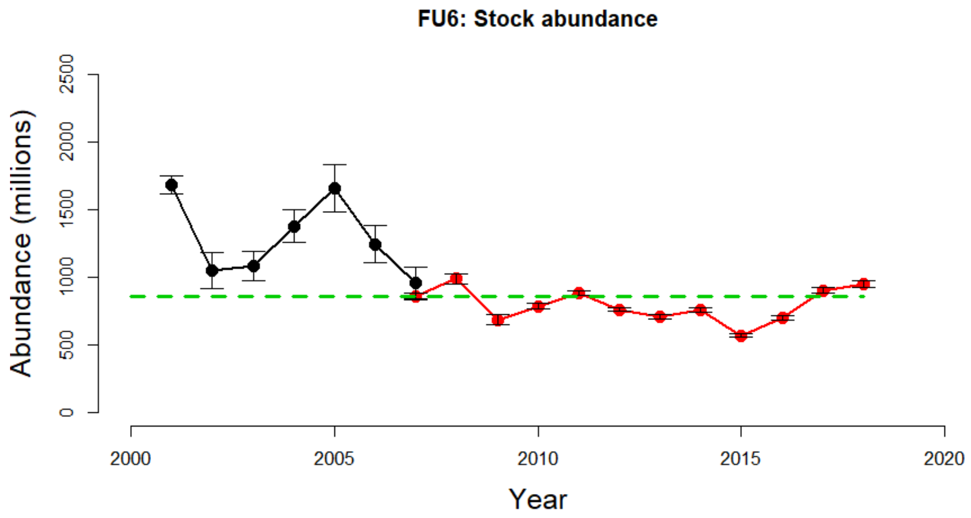


Figure 11.4.4. ***Nephrops*** **in FU 6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the geostatistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.**

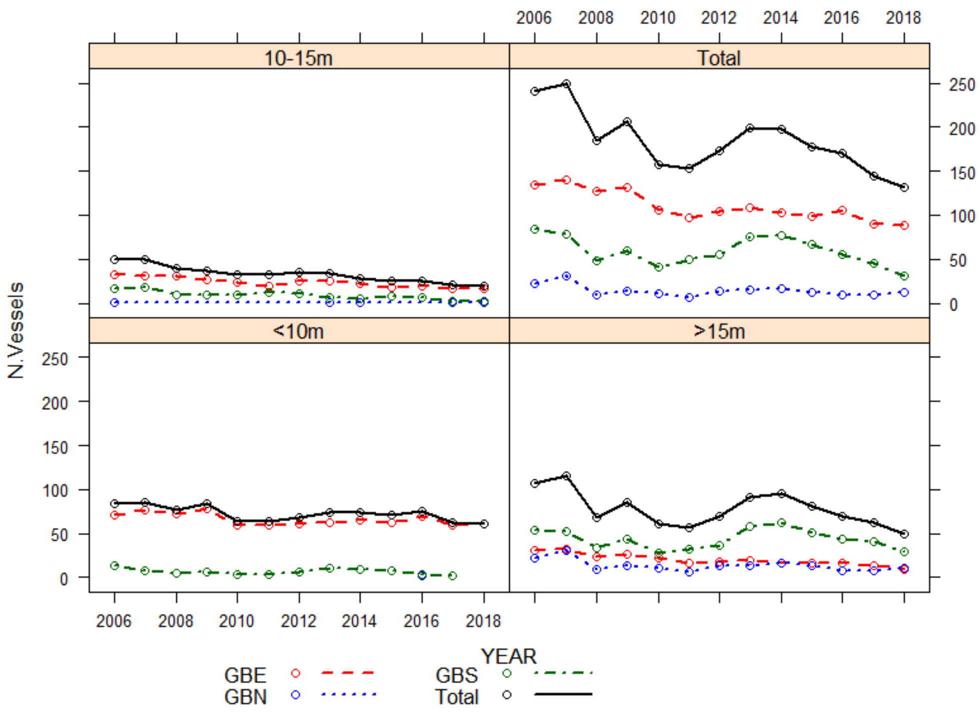


Figure 11.4.5. ***Nephrops*** **in FU 6: Number of participating vessels (from UK) by vessel size category.**

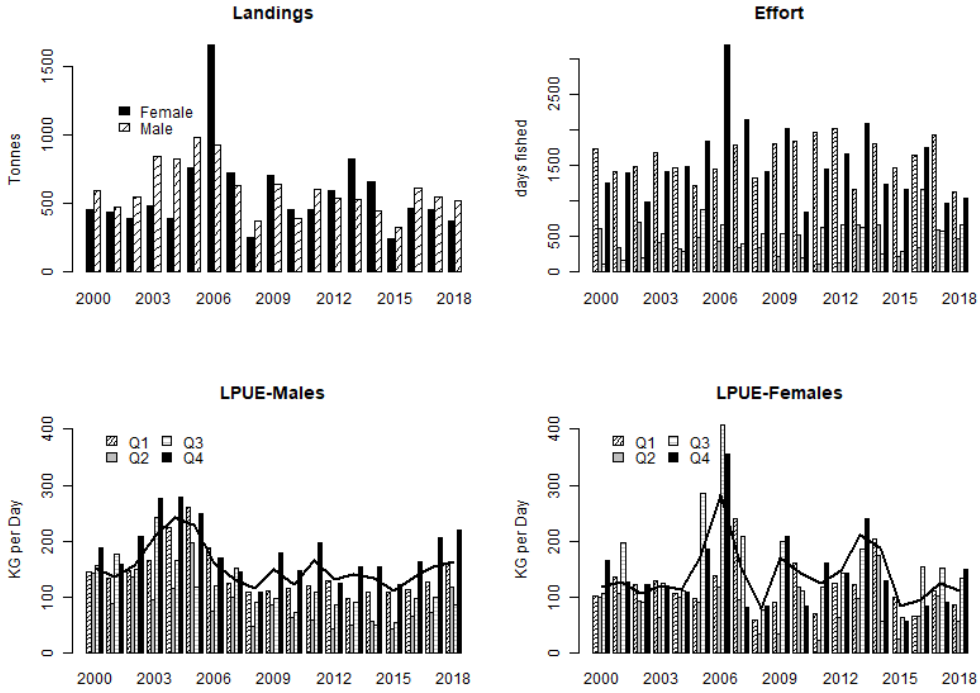


Figure 11.4.6. ***Nephrops*** **in FU 6: LPUE by sex and quarter.**

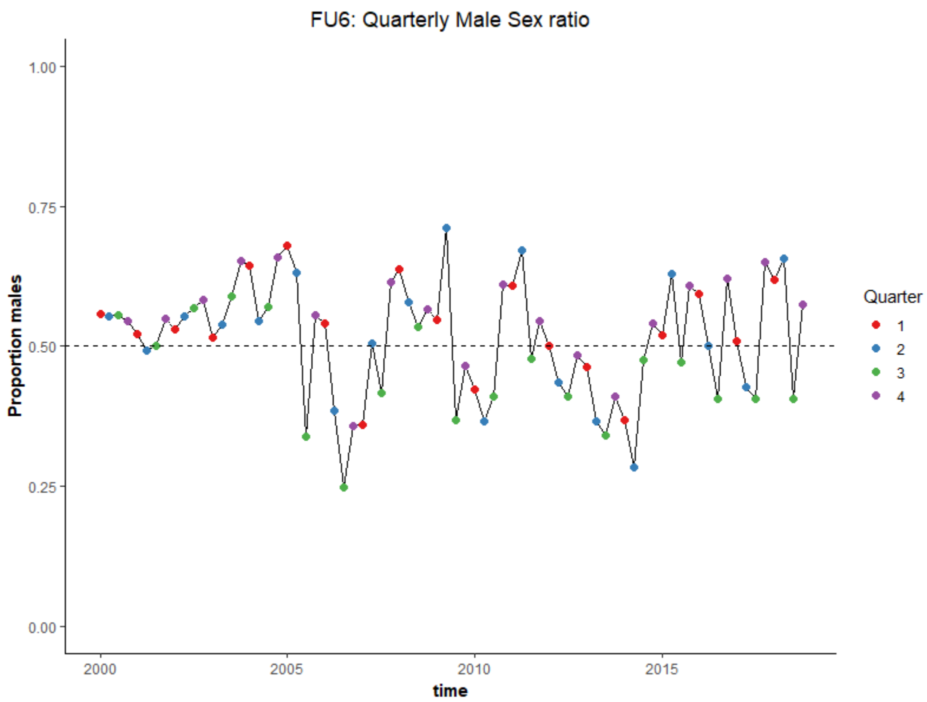


Figure 11.4.7. ***Nephrops*** **in FU 6: Quarterly sex ratio in the catches.**

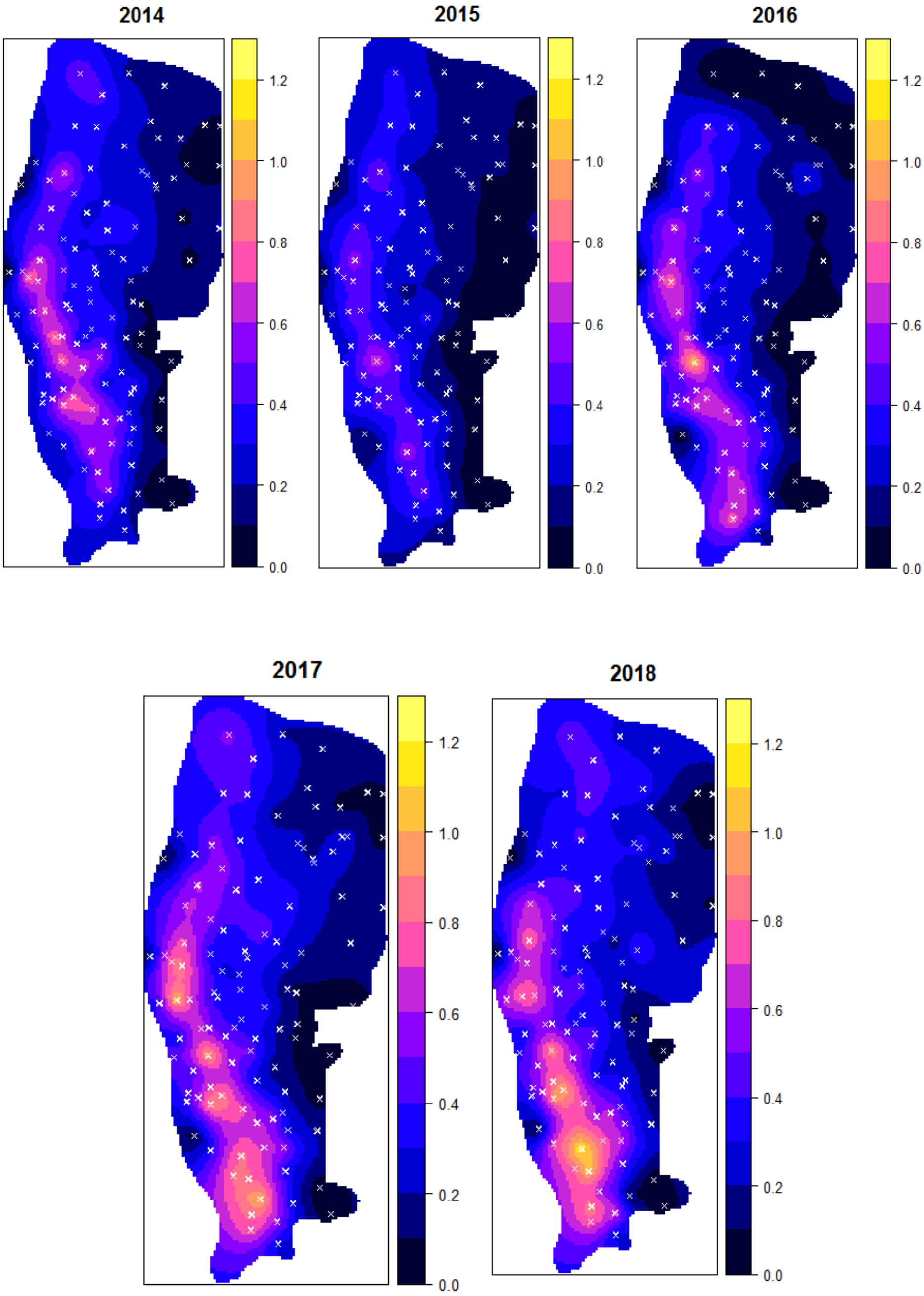


Figure 11.4.8. *Nephrops* in FU 6: Results of the UWTV survey.

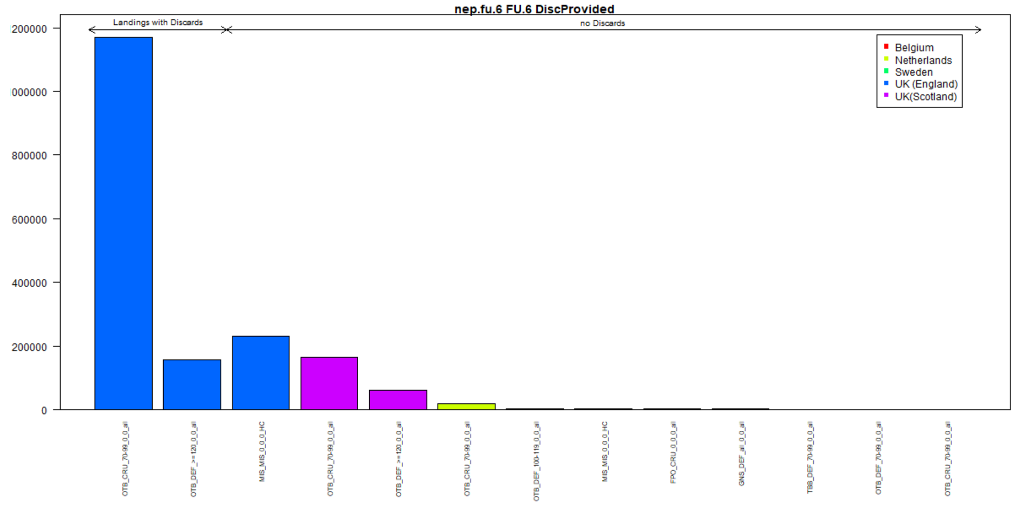


Figure 11.4.9. Nephrops in FU 6: Landings by country and fleet associated with discards in Intercatch.

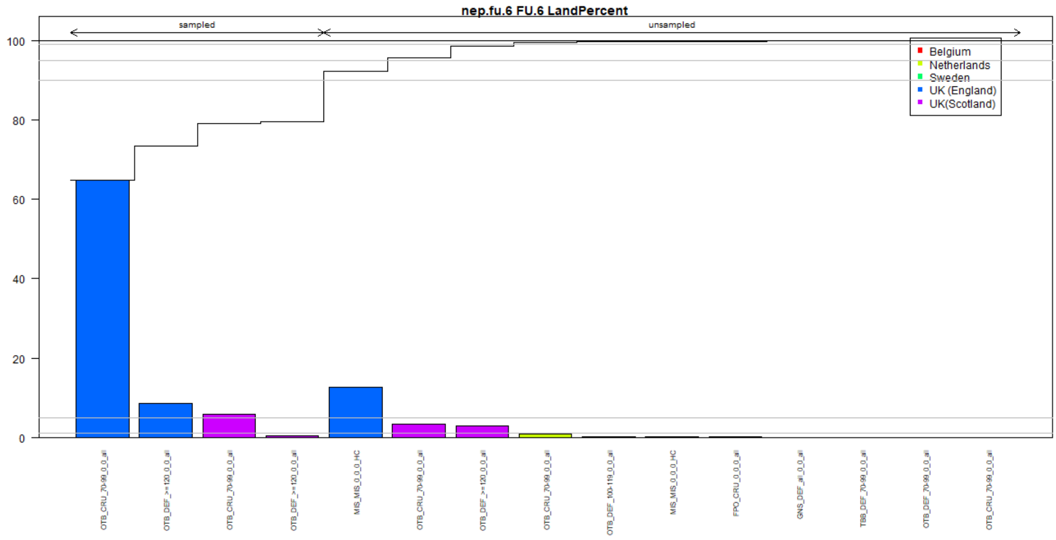


Figure 11.4.10. Nephrops in FU 6: Proportion of landings by country and fleet with length samples

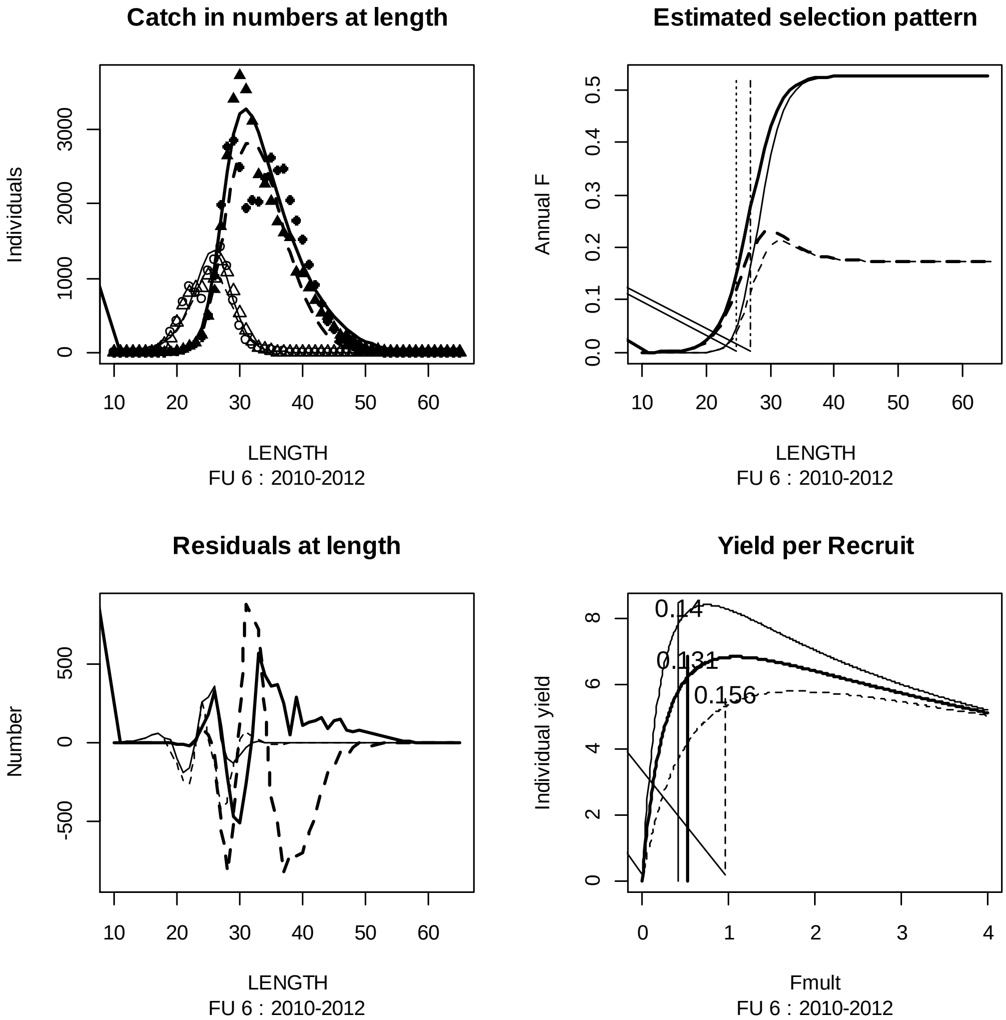


Figure 11.4.11. *Nephrops* in FU 6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards 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.

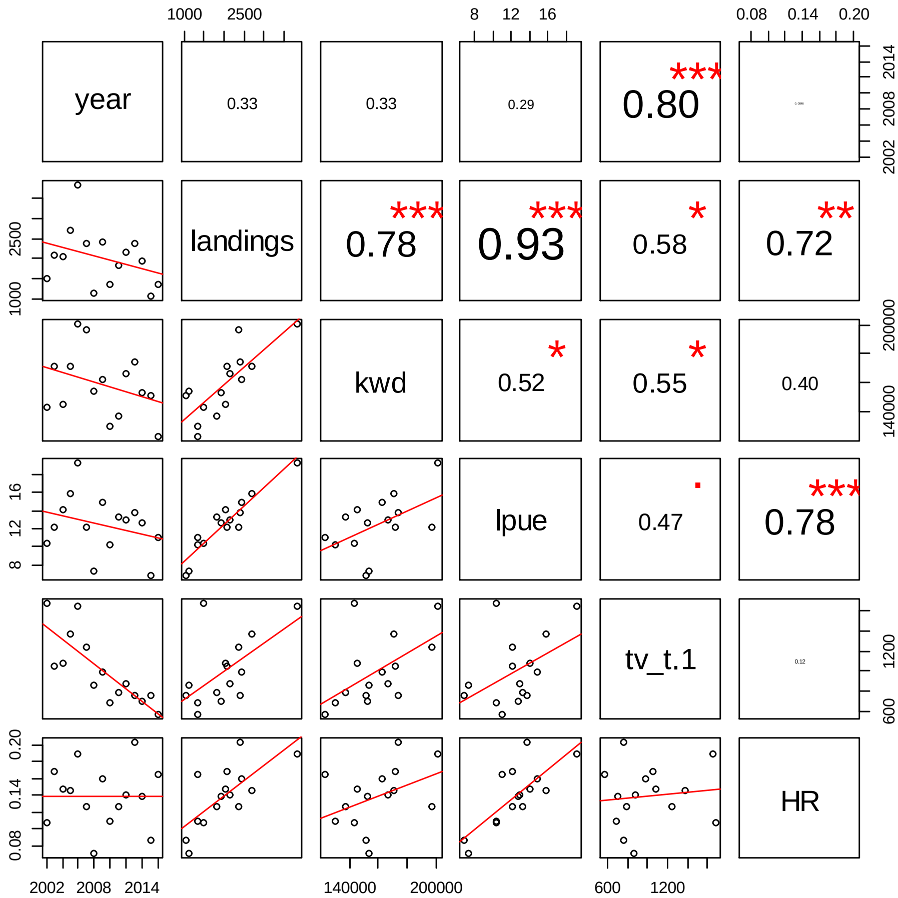


Figure 11.4.12. *Nephrops* in FU 6: 11.4.12 Scatterplot matrices of *Nephrops* metrics where the TV survey lagged by 1 year (i.e. TV survey in the year preceding the fishery statistics).

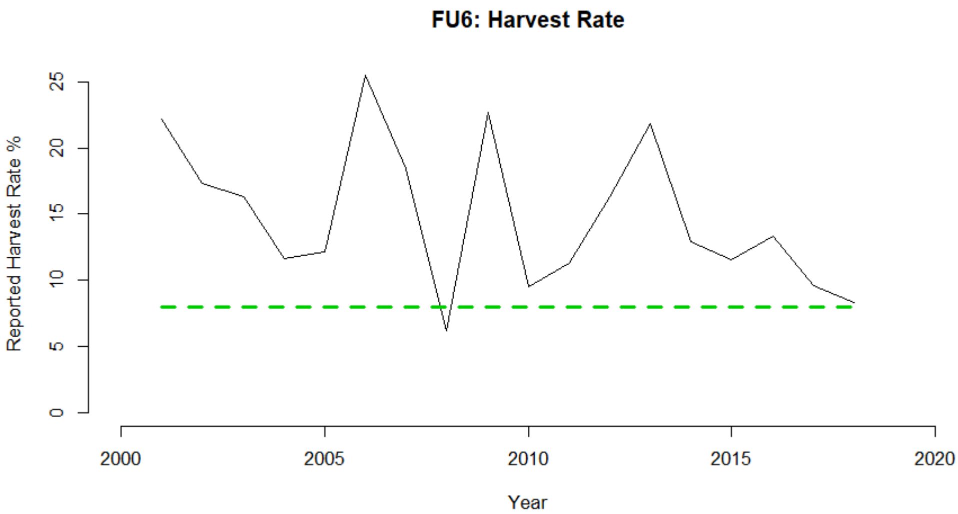


Figure 11.4.13. *Nephrops* in FU 6: Observed harvest ratio (removals divided by abundance estimate).

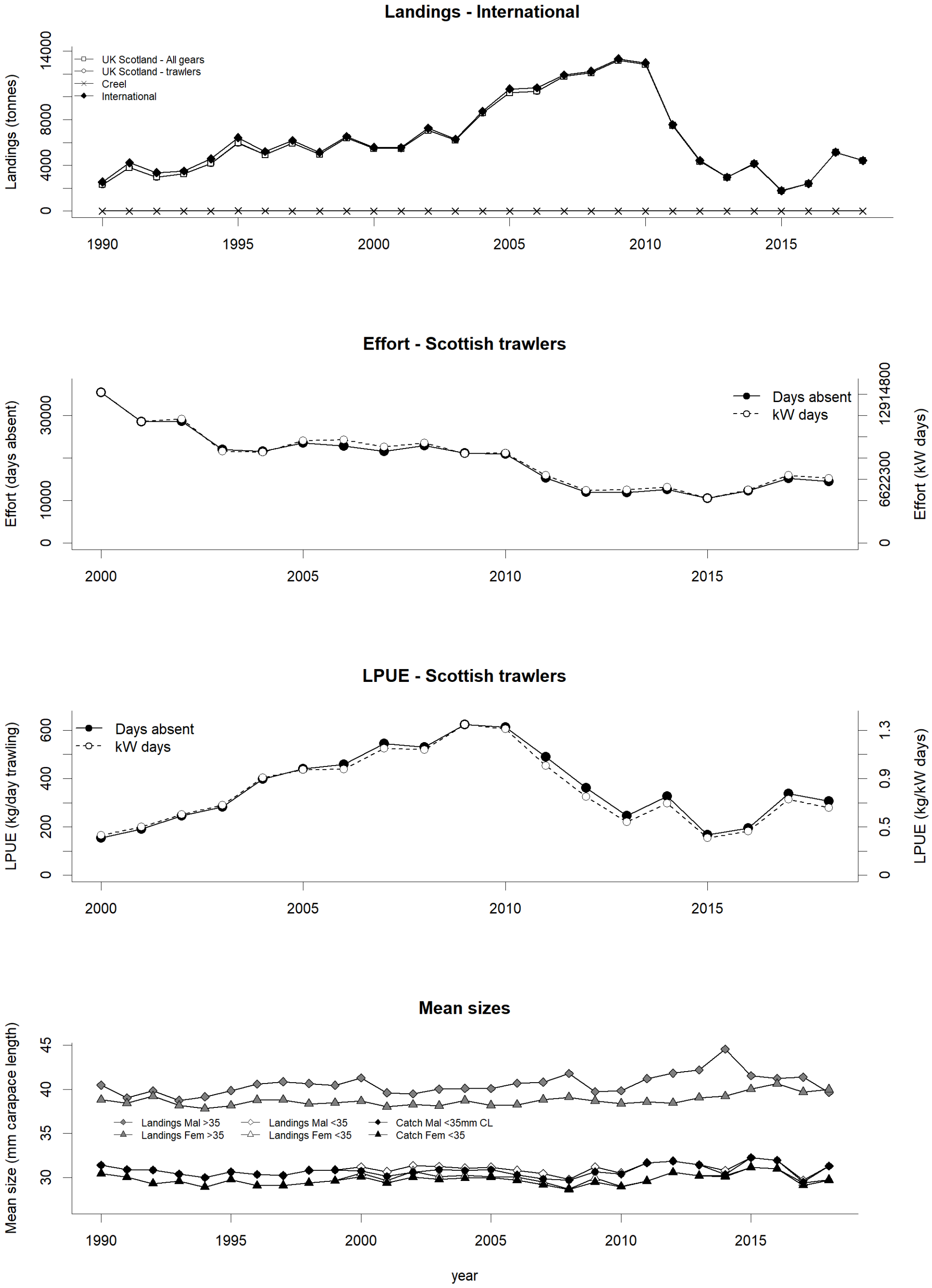


Figure 11.5.1 *Nephrops*, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2018.

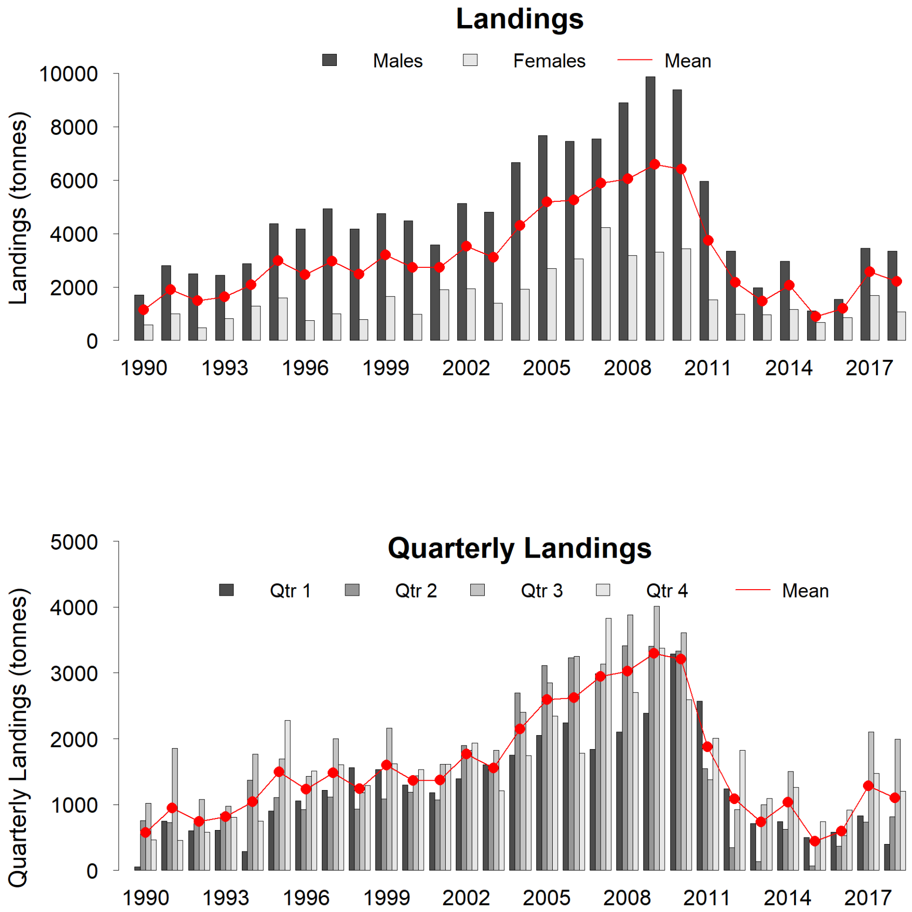


Figure 11.5.2 *Nephrops*, Fladen (FU 7), Landings by quarter and sex from Scottish *Nephrops* trawlers.

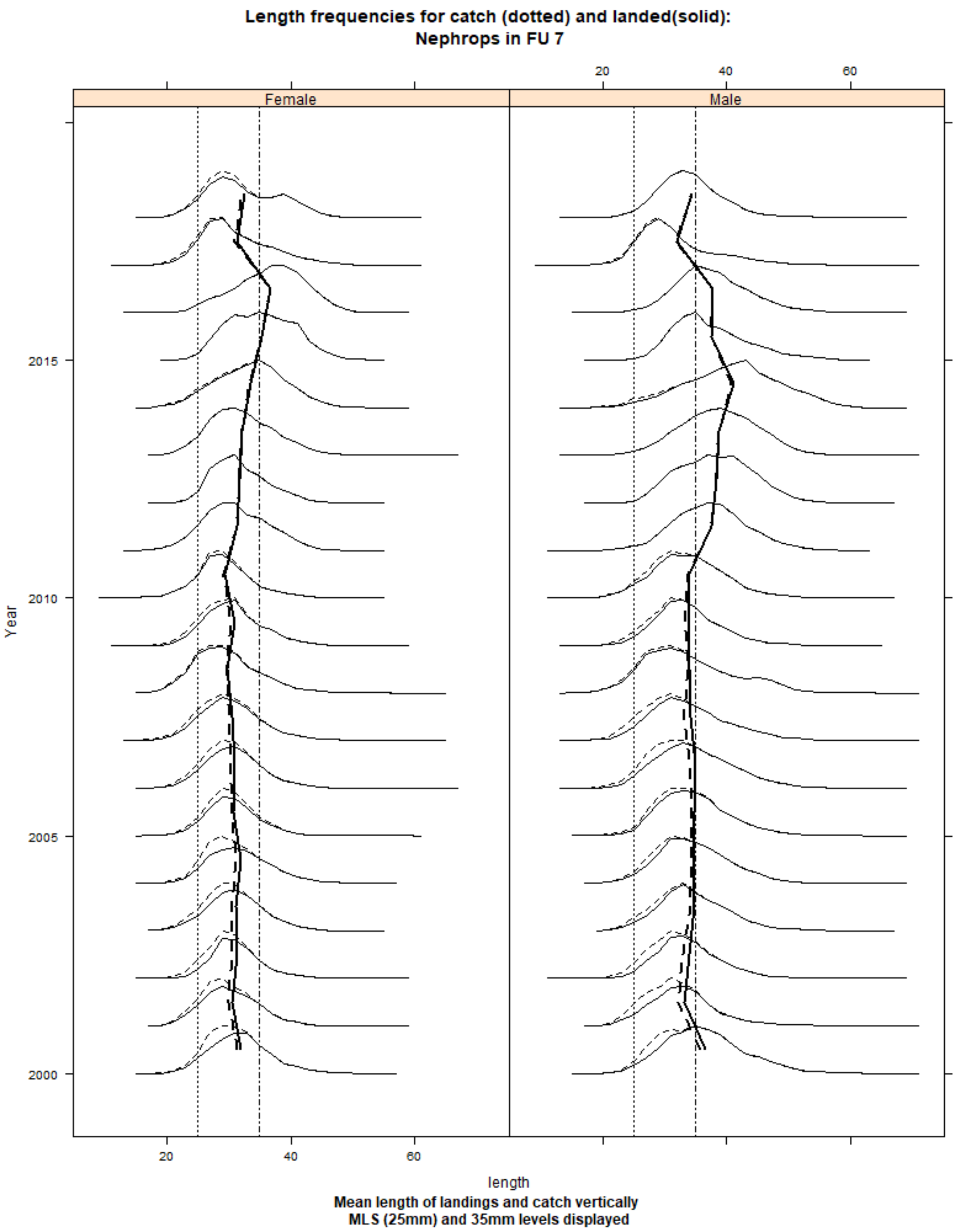
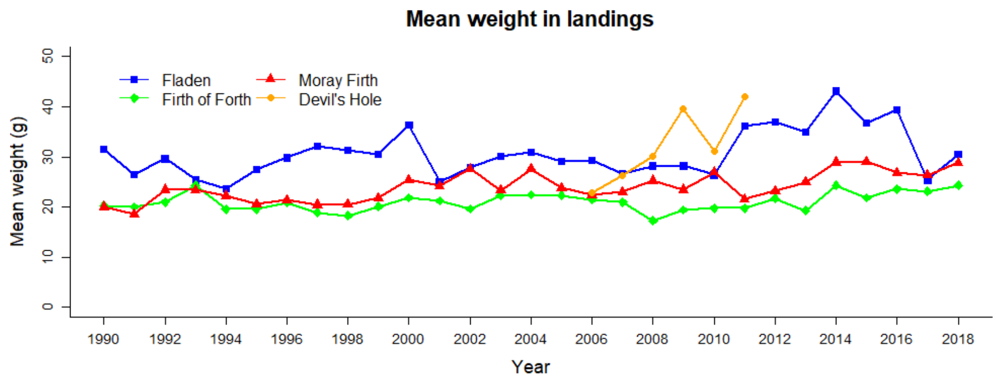


Figure11.5.3 ***Nephrops*** **Fladen Ground (FU 7) Length composition of catch of males (right) and females left from 2000 (bottom) to 2018 (top). Mean sizes of catch and landings are displayed vertically.**



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 1990–2018 (Scottish market sampling data). FU 34 data only shown for 2006–2011.

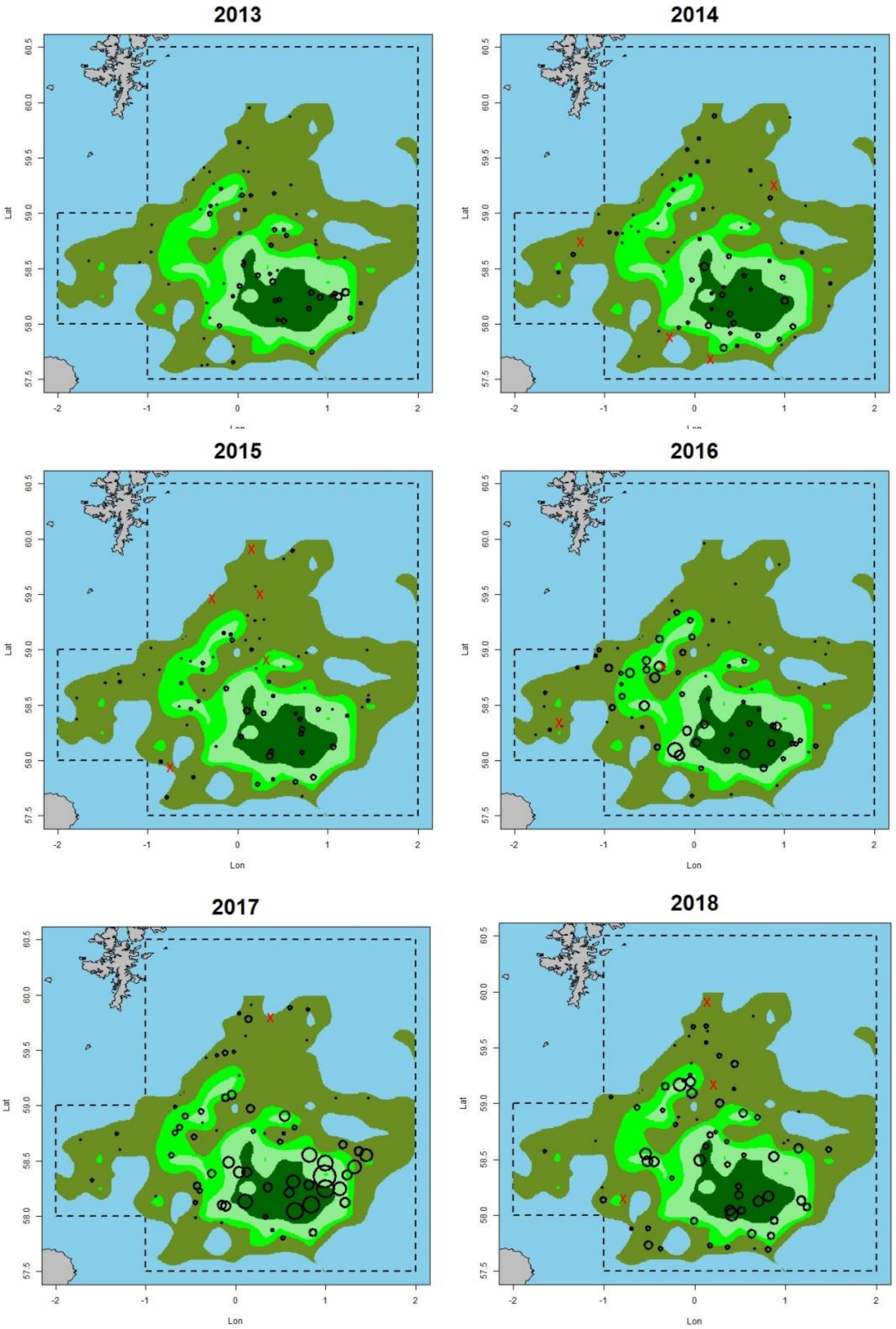


Figure 11.5.5 *Nephrops*, Fladen (FU 7). TV survey distribution and relative density (2013–2018). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

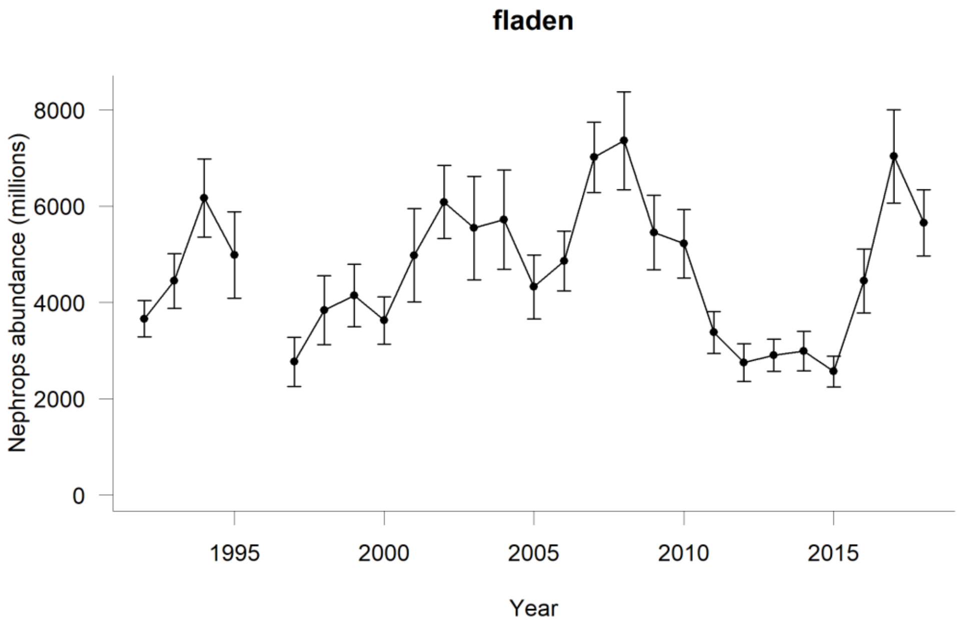


Figure 11.5.6 *Nephrops*, Fladen (FU 7), Time series of TV survey abundance estimates with 95% confidence intervals, 1992–2018.

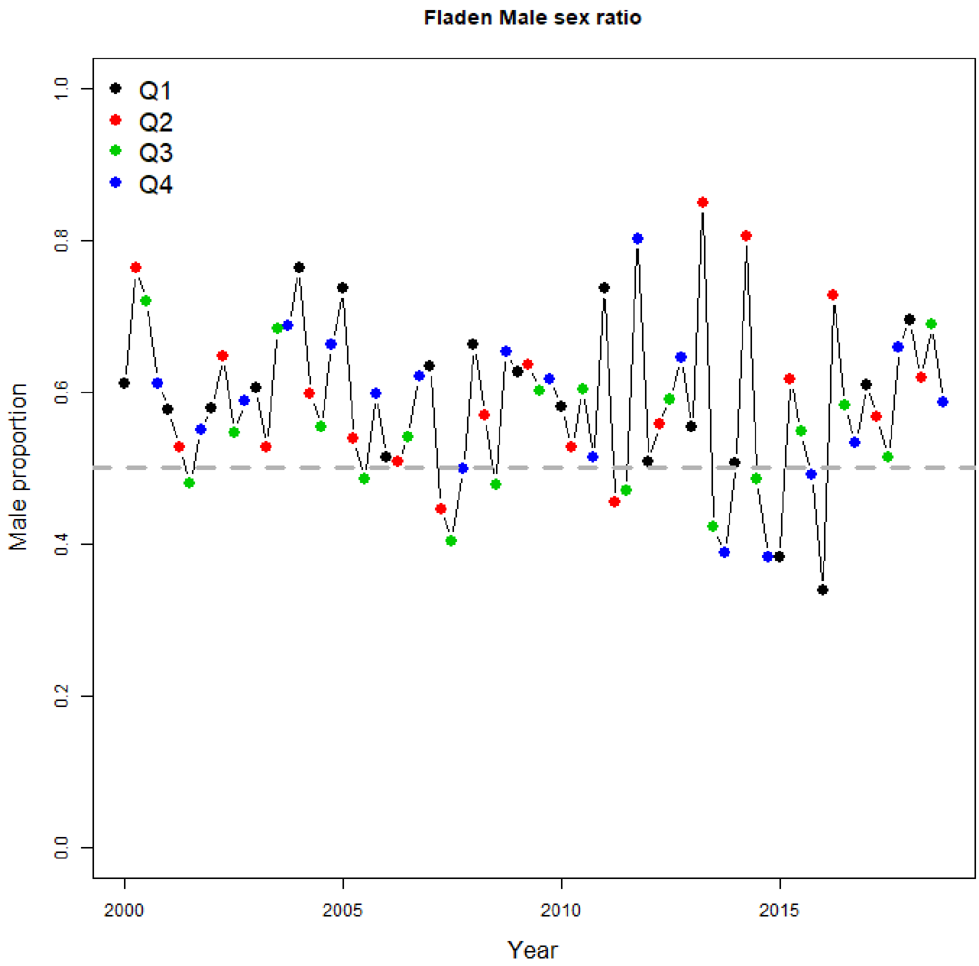


Figure 11.5.7 ***Nephrops*****, Fladen (FU 7), Quarterly sex ratio (by number) in catches.**

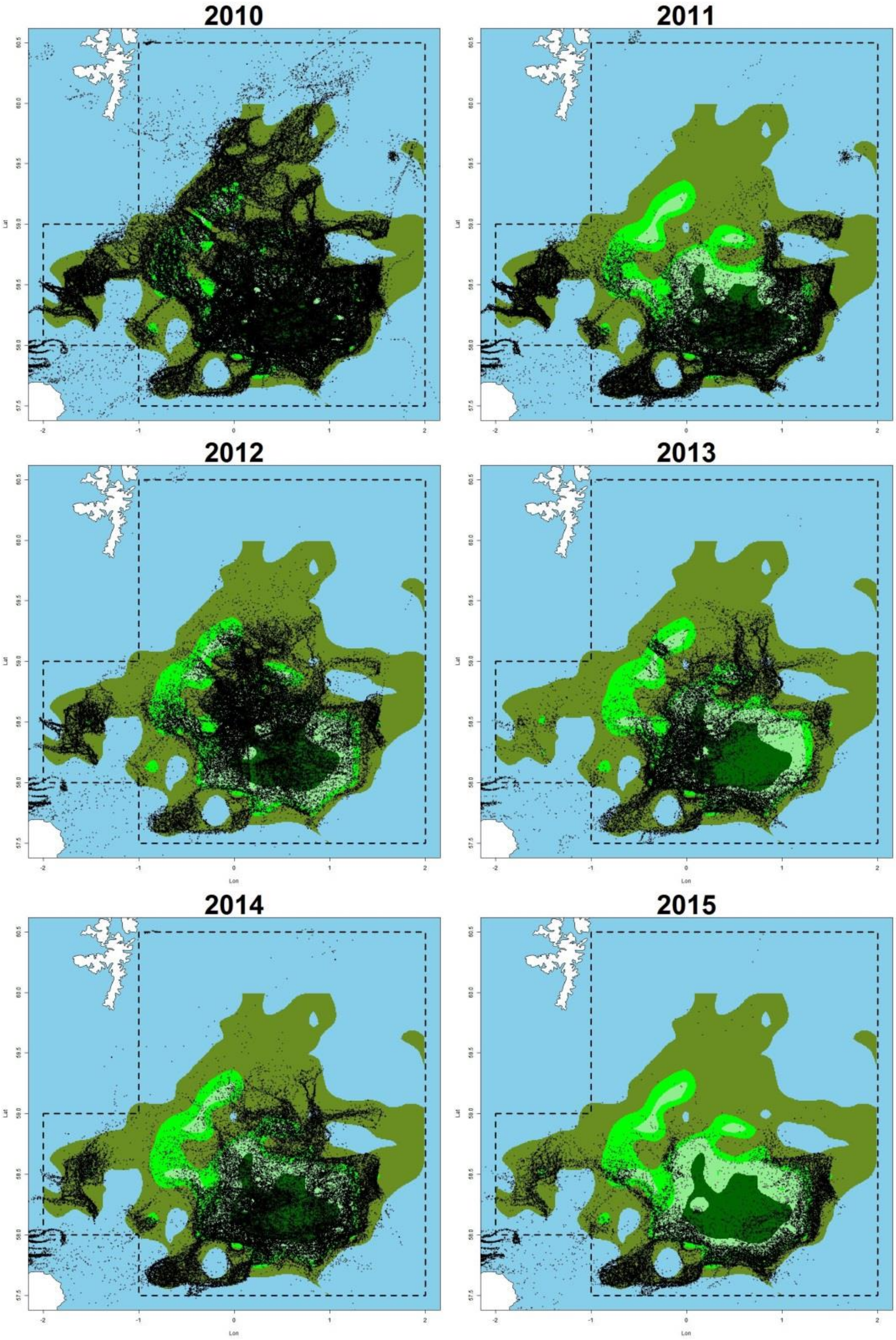


Figure 11.5.8 ***Nephrops*****, Fladen (FU 7), VMS distribution of vessels in Fladen (2010–2015). Points in figure correspond to fishing pings (speed < 5 kn) associated with trips made by otter trawlers landing more than 25% of *Nephrops* by weight.**

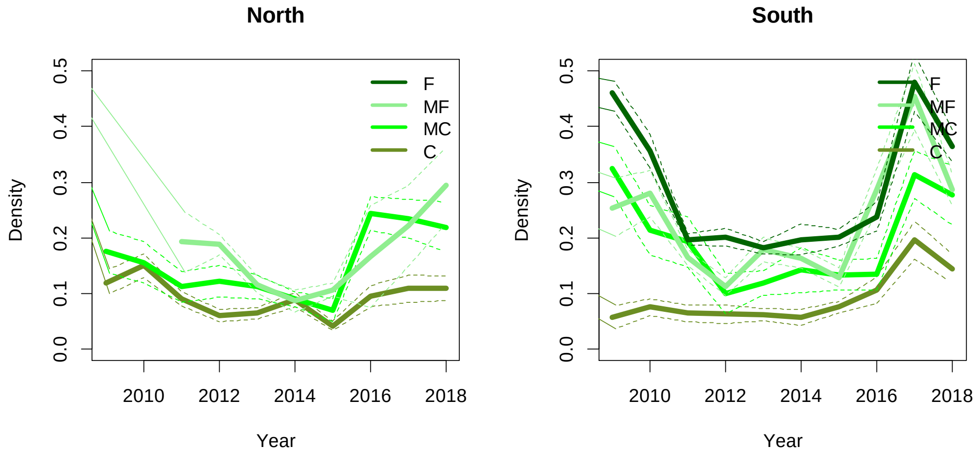


Figure 11.5.9 ***Nephrops*****, Fladen (FU 7), UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt & clay > 80%); MF: medium fine sediment (55% < silt and clay < 80); MC: medium coarse sediment (40% < silt and clay < 55); C: coarse sediment (silt and clay < 40%).**

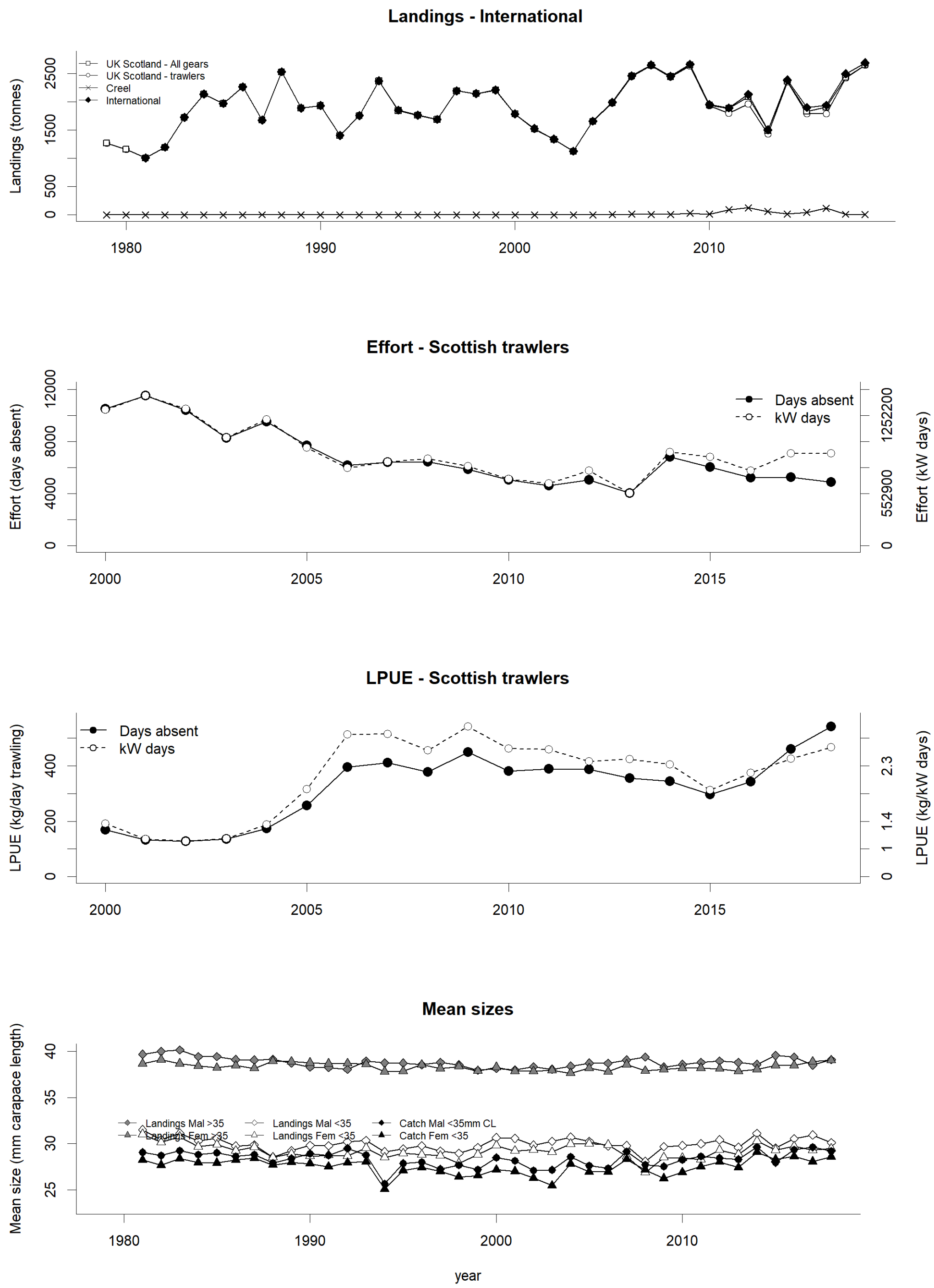
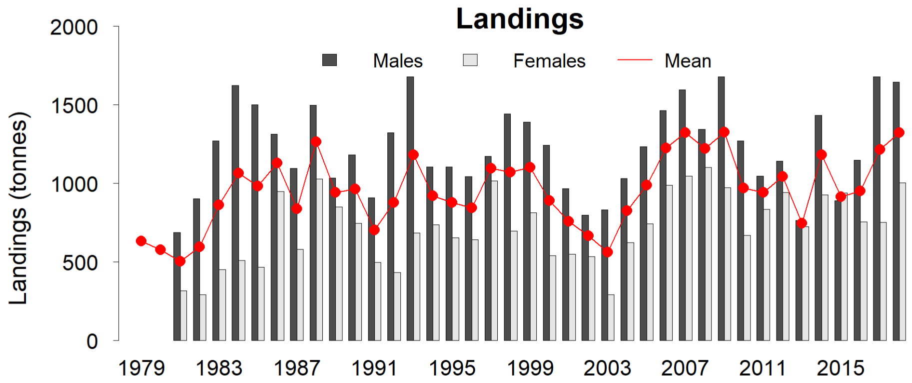


Figure 11.6.1 *Nephrops*, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2018.



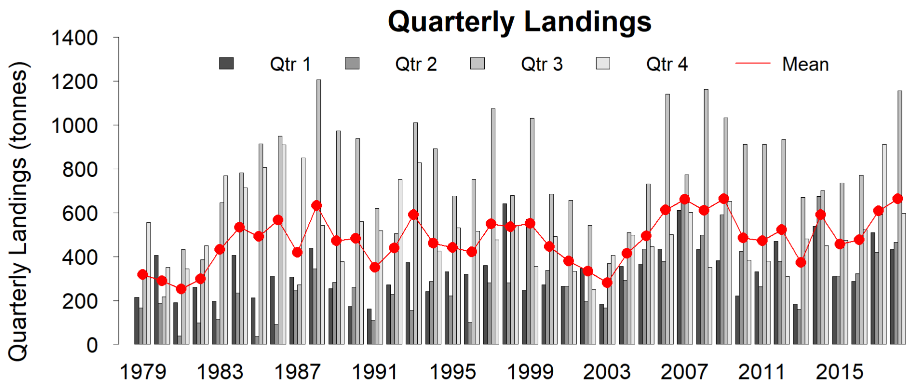


Figure 11.6.2 *Nephrops*, Firth of Forth (FU 8), Landings by quarter and sex from Scottish *Nephrops* trawlers.

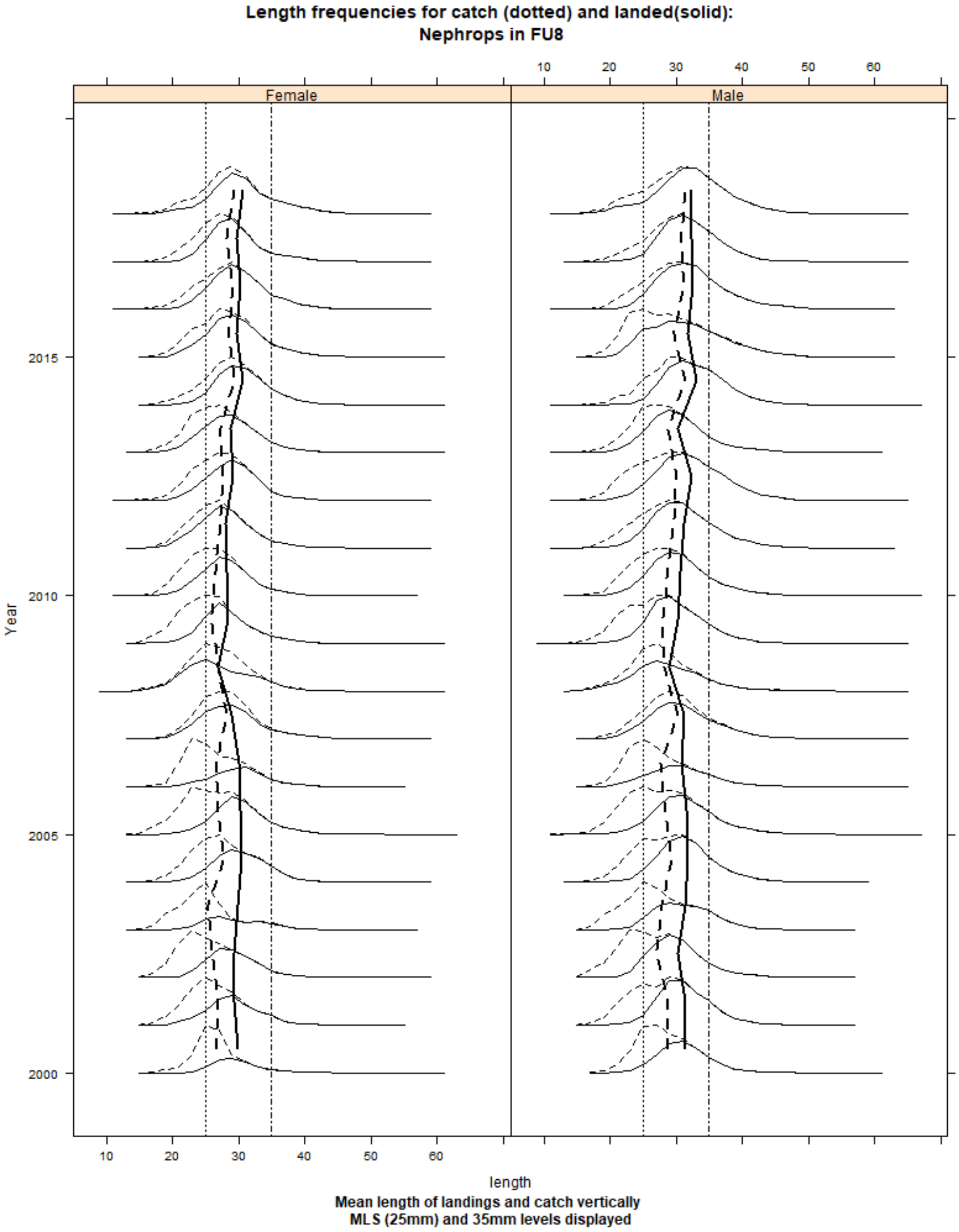


Figure 11.6.3 ***Nephrops*** **Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2018 (top). Mean sizes of catch and landings are displayed vertically.**

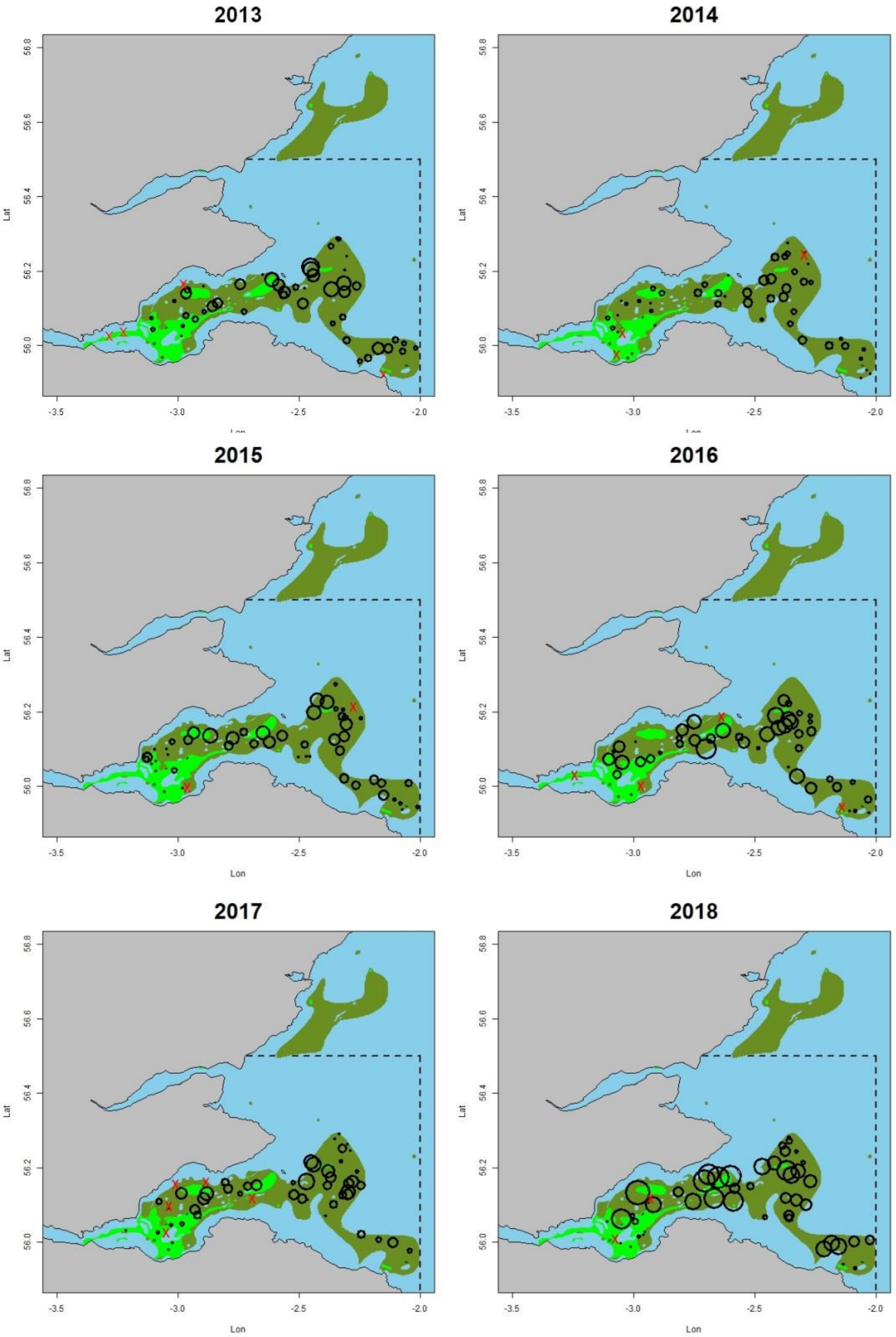


Figure 11.6.4 *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density (2013–2018). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

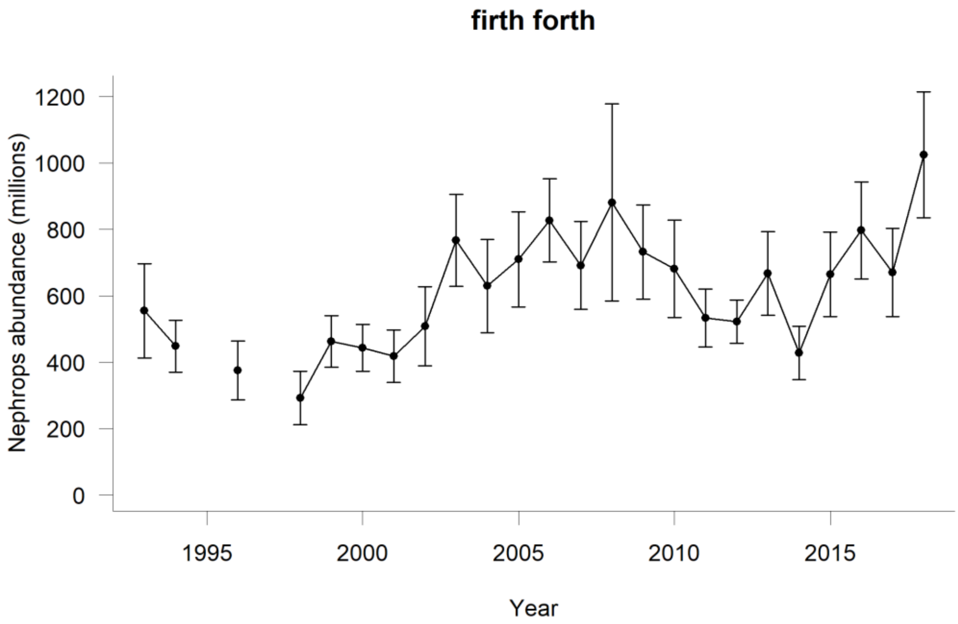


Figure 11.6.5 *Nephrops*, Firth of Forth (FU 8), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2018.

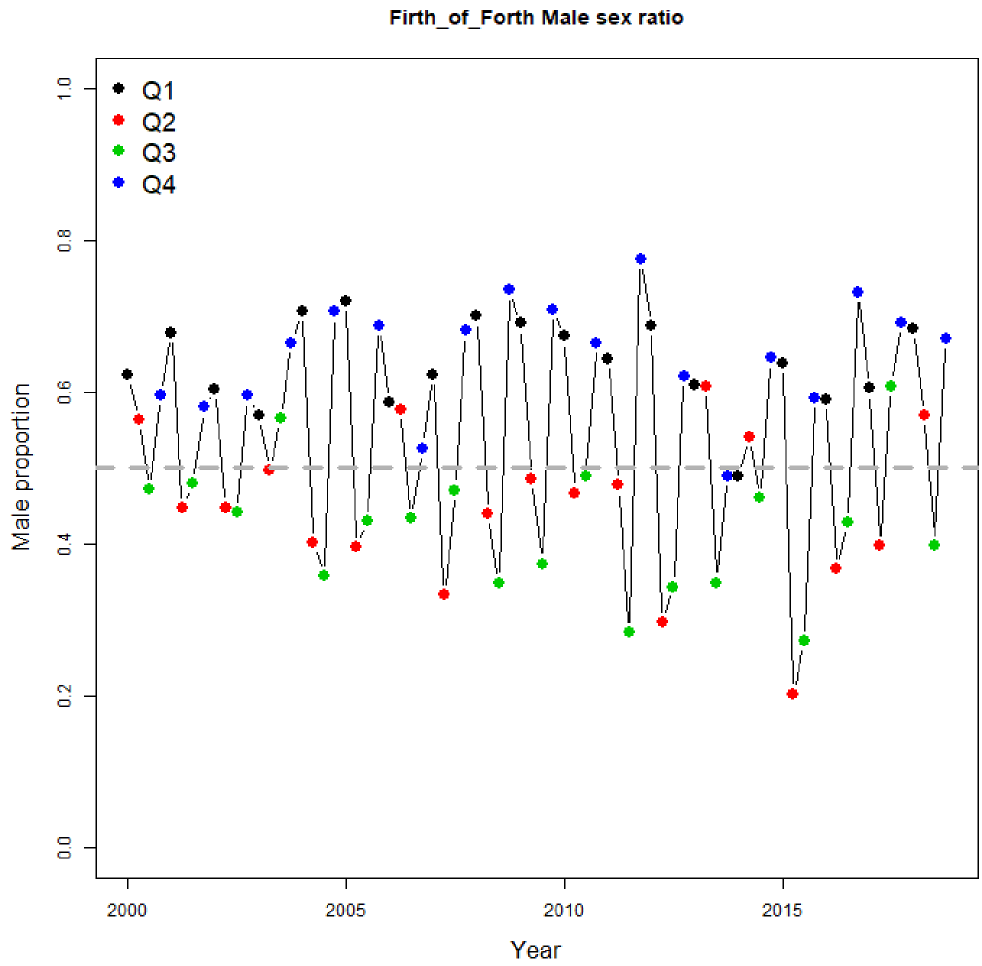


Figure 11.6.6 *Nephrops*, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.

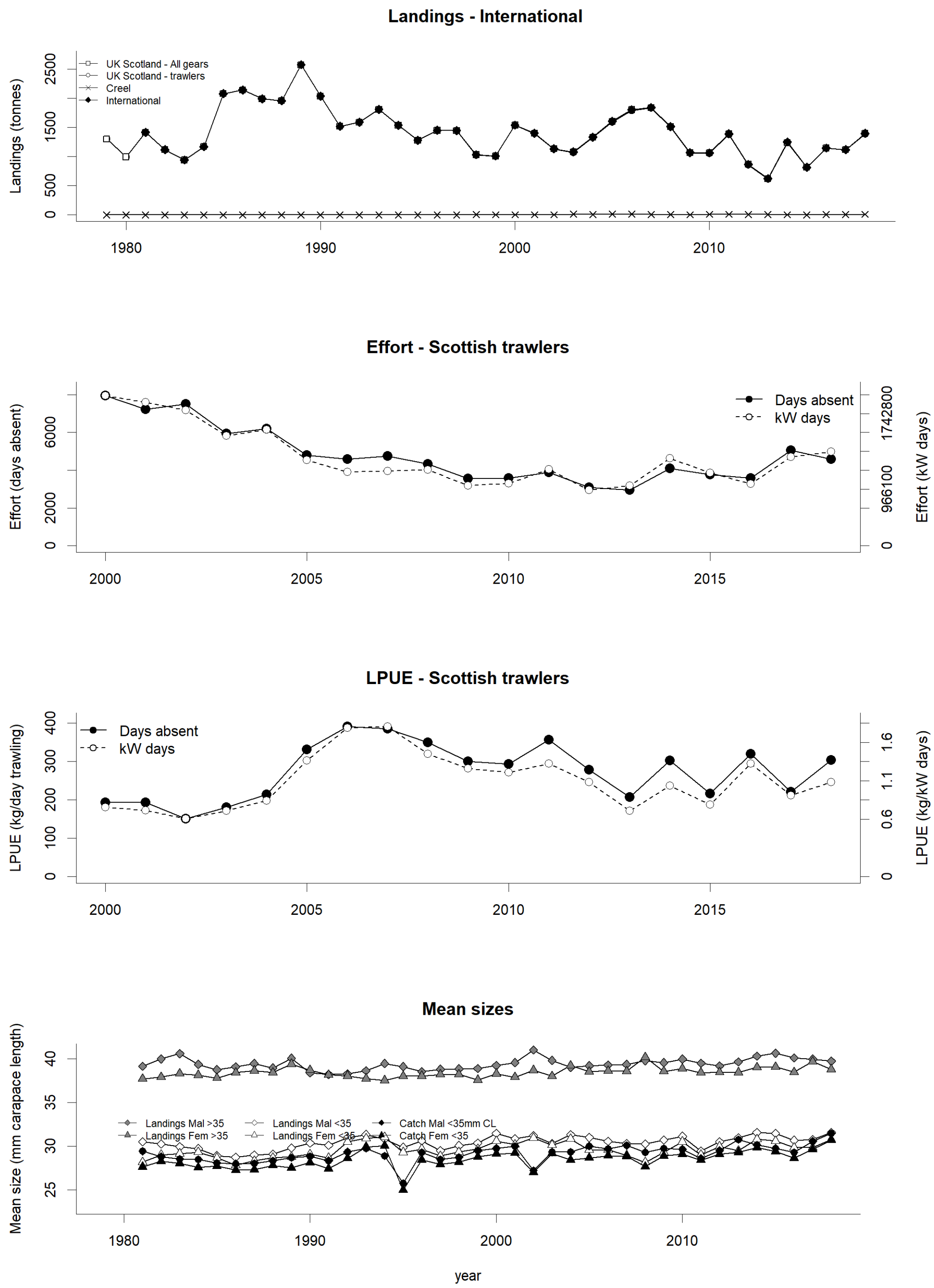
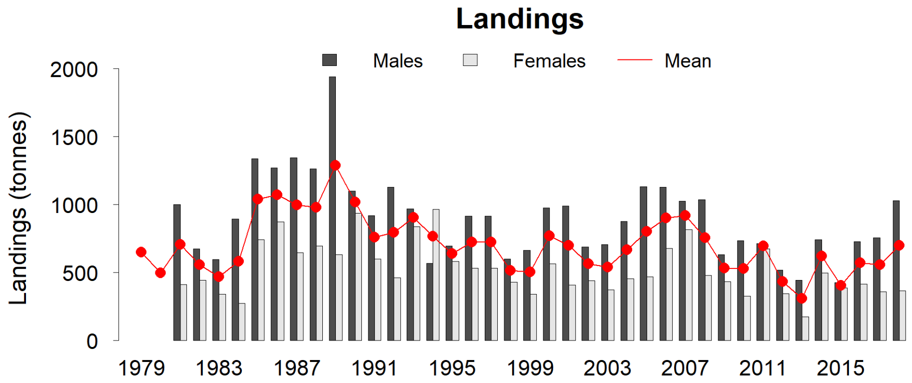


Figure 11.7.1 *Nephrops*, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2018.



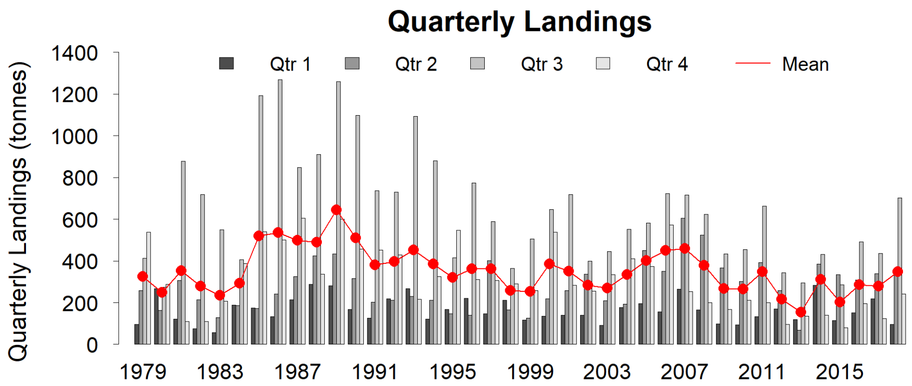


Figure 11.7.2 *Nephrops*, Moray Firth (FU 9), Landings by quarter and sex from Scottish *Nephrops* trawlers.

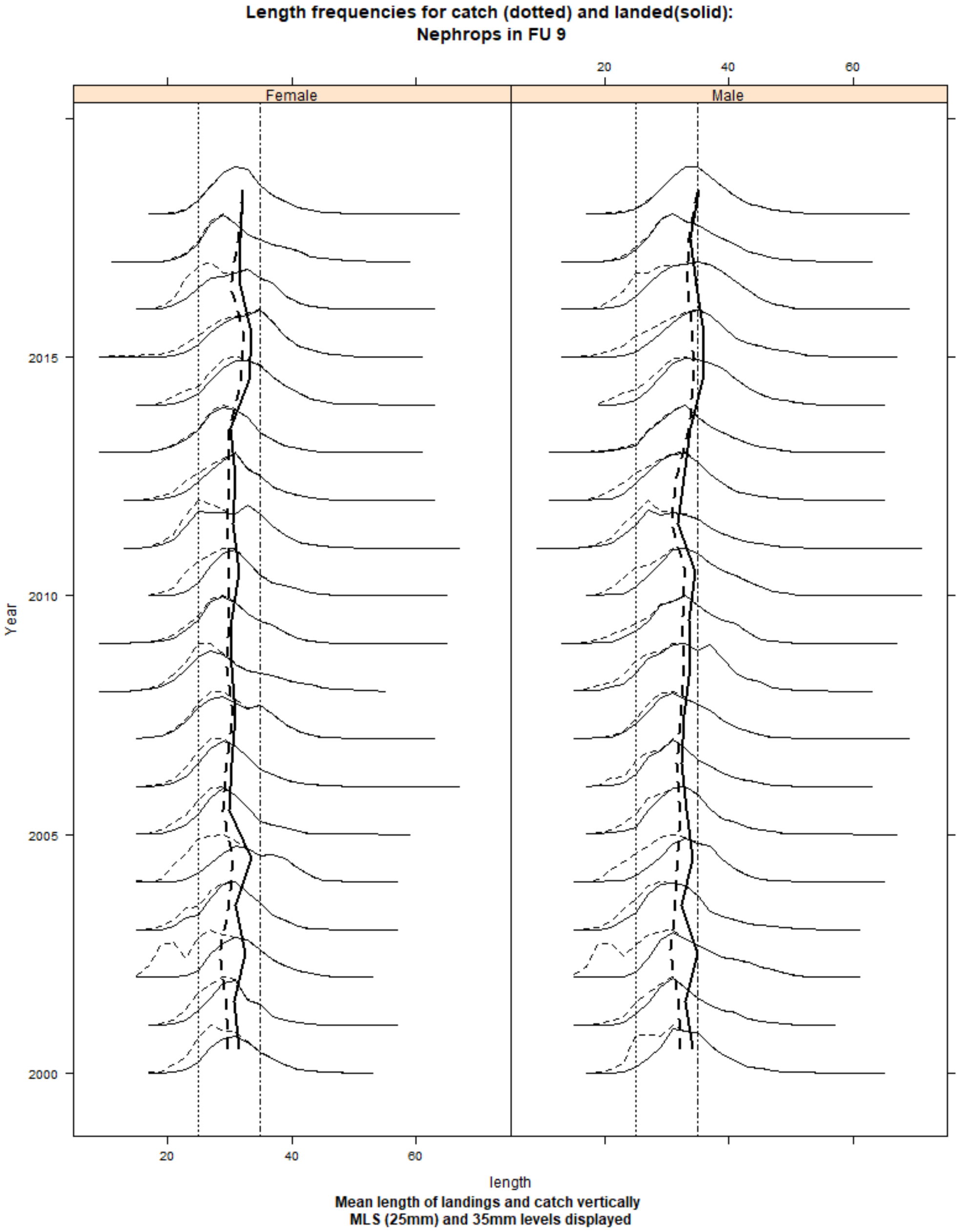
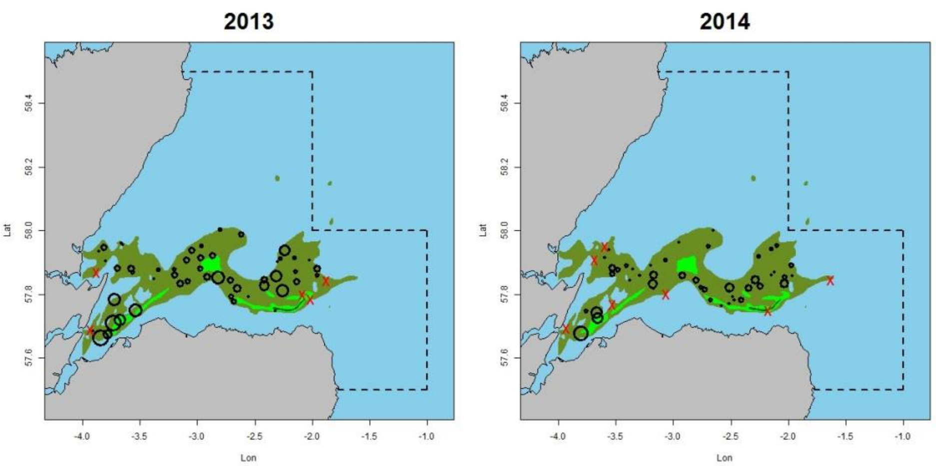


Figure 11.7.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2018 (top). Mean sizes of catch and landings are displayed vertically.**



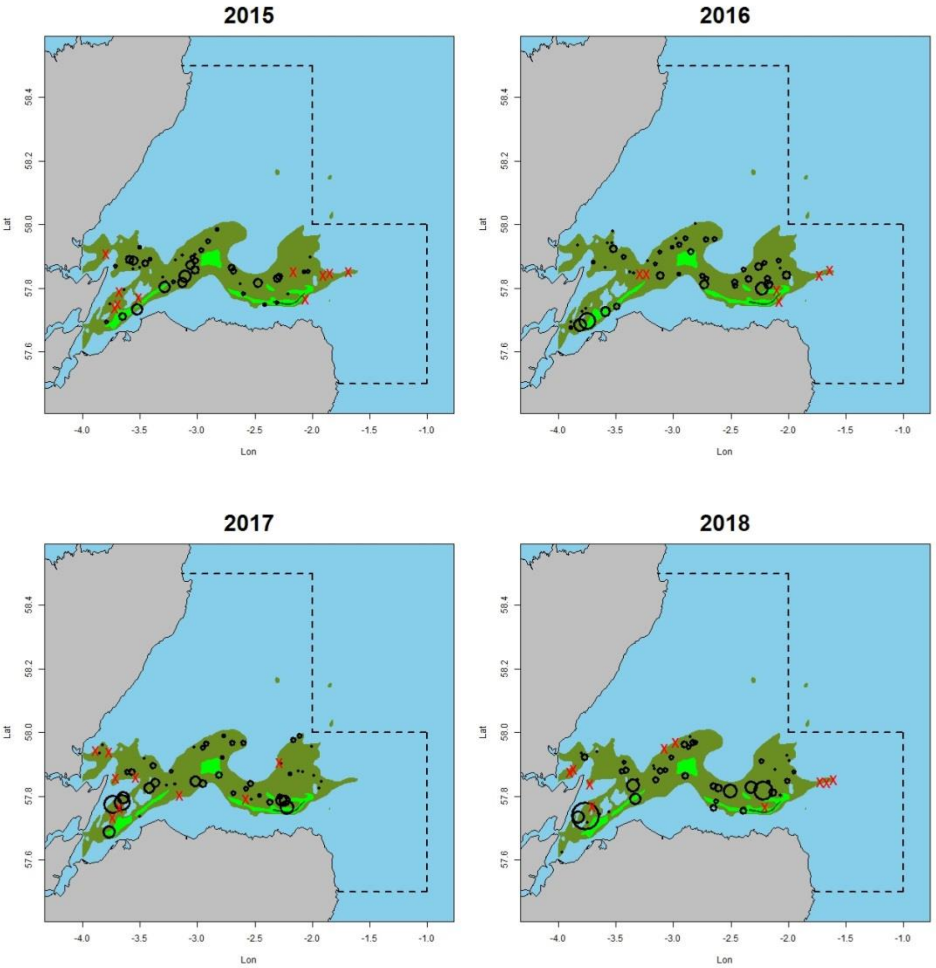


Figure11.7.4 ***Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2013–2018). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

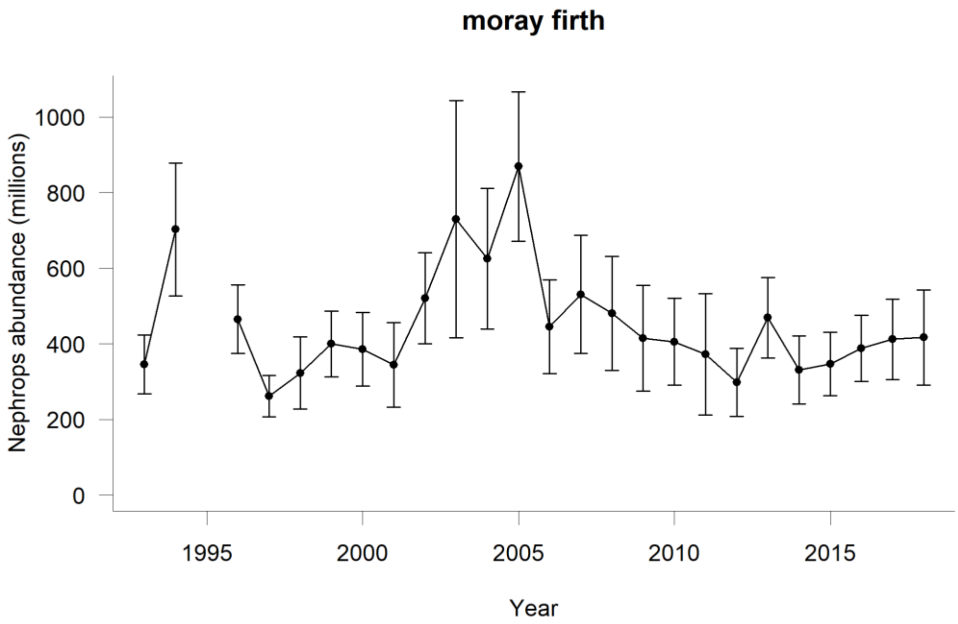


Figure 11.7.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2018.

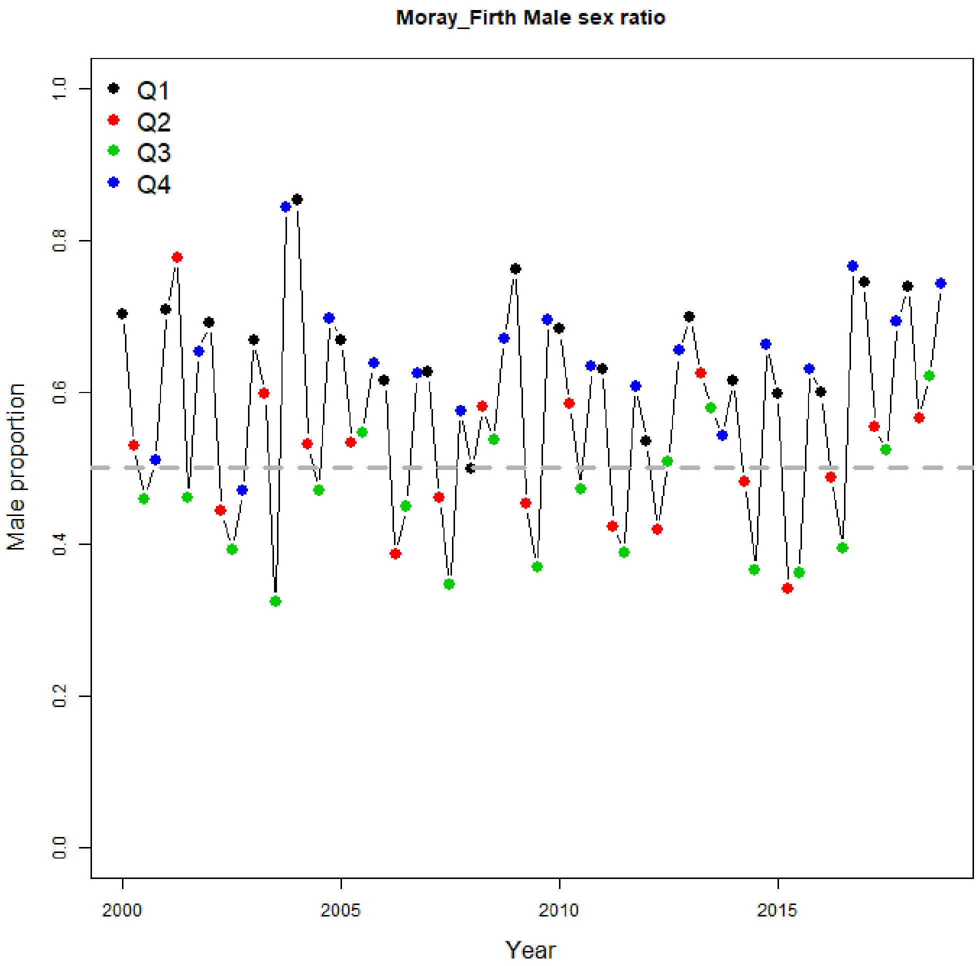


Figure 11.7.6 *Nephrops*, Moray Firth (FU 9), Quarterly sex ratio (by number) in catches.

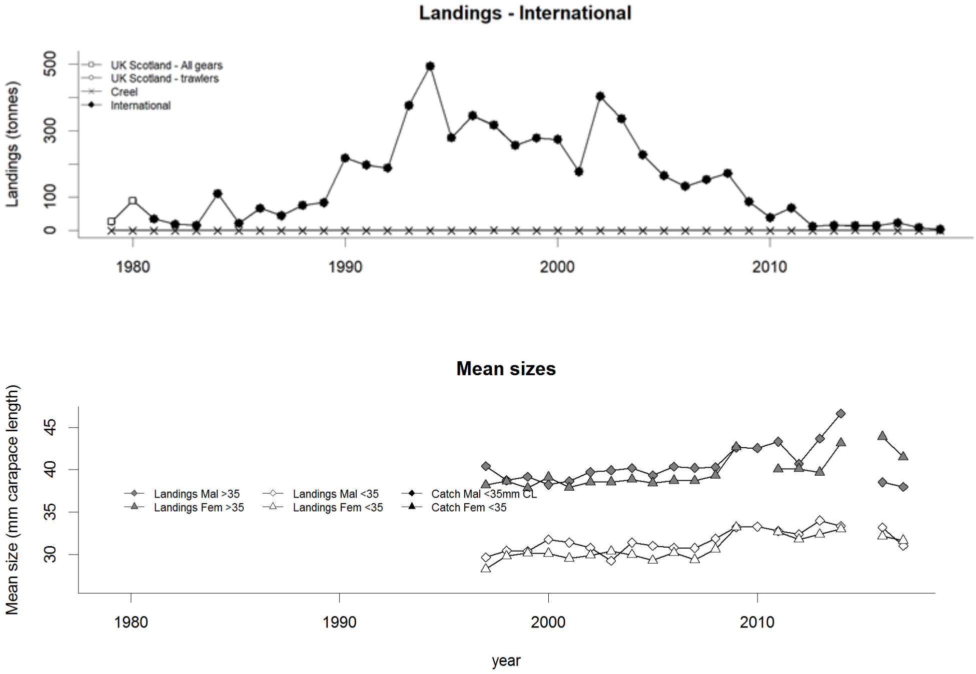


Figure 11.8.1 ***Nephrops*****, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010 and no samples in 2015).**

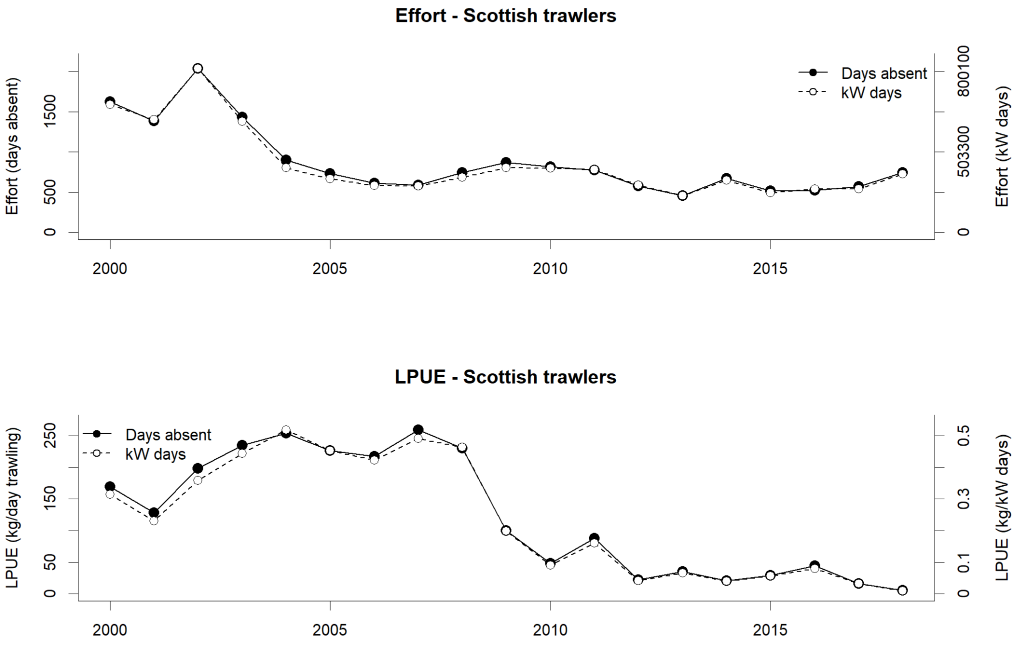


Figure 11.8.2 ***Nephrops*****, Noup (FU 10), Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

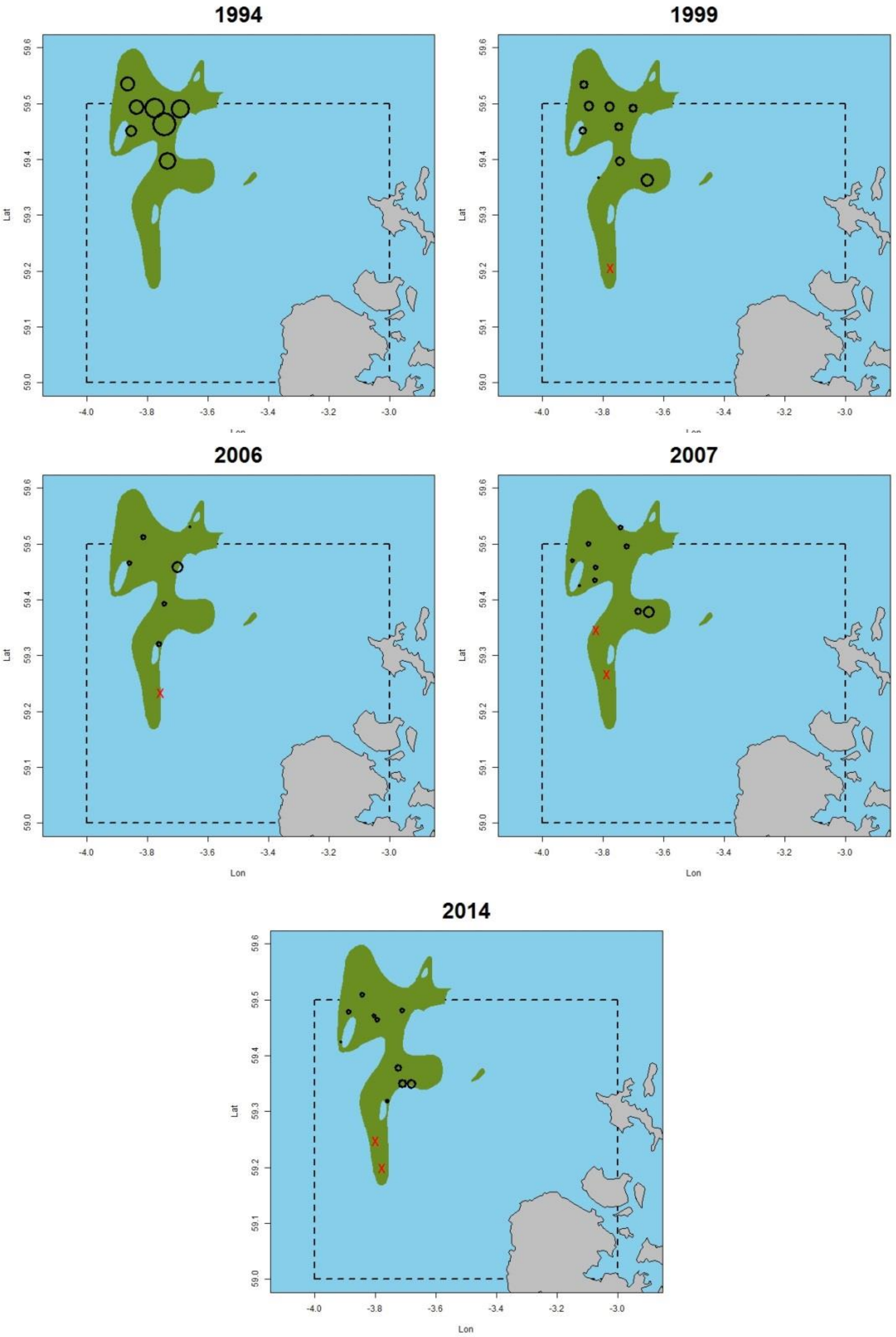


Figure 11.8.3 ***Nephrops*****, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007 & 2014). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

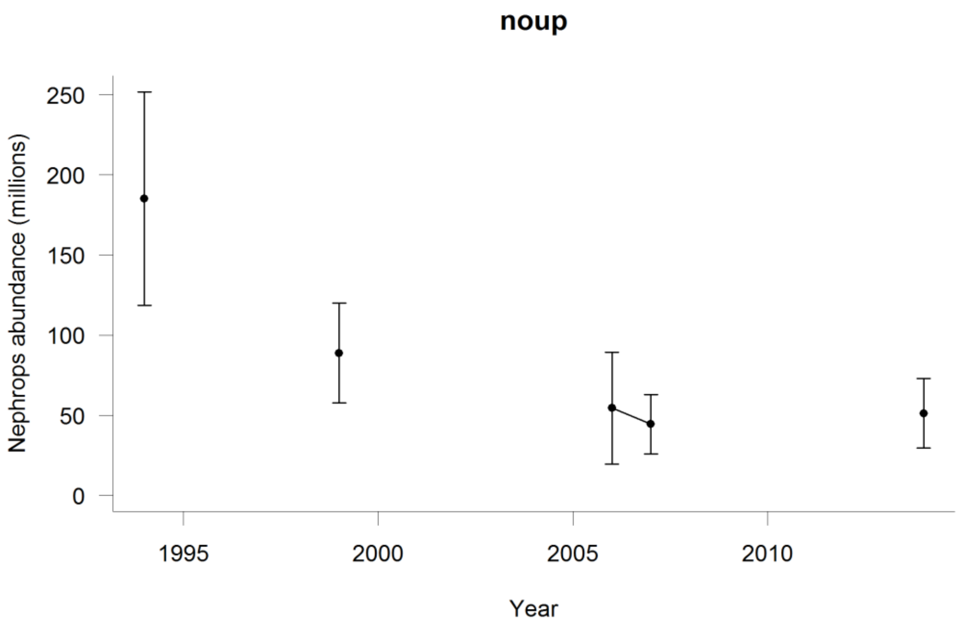
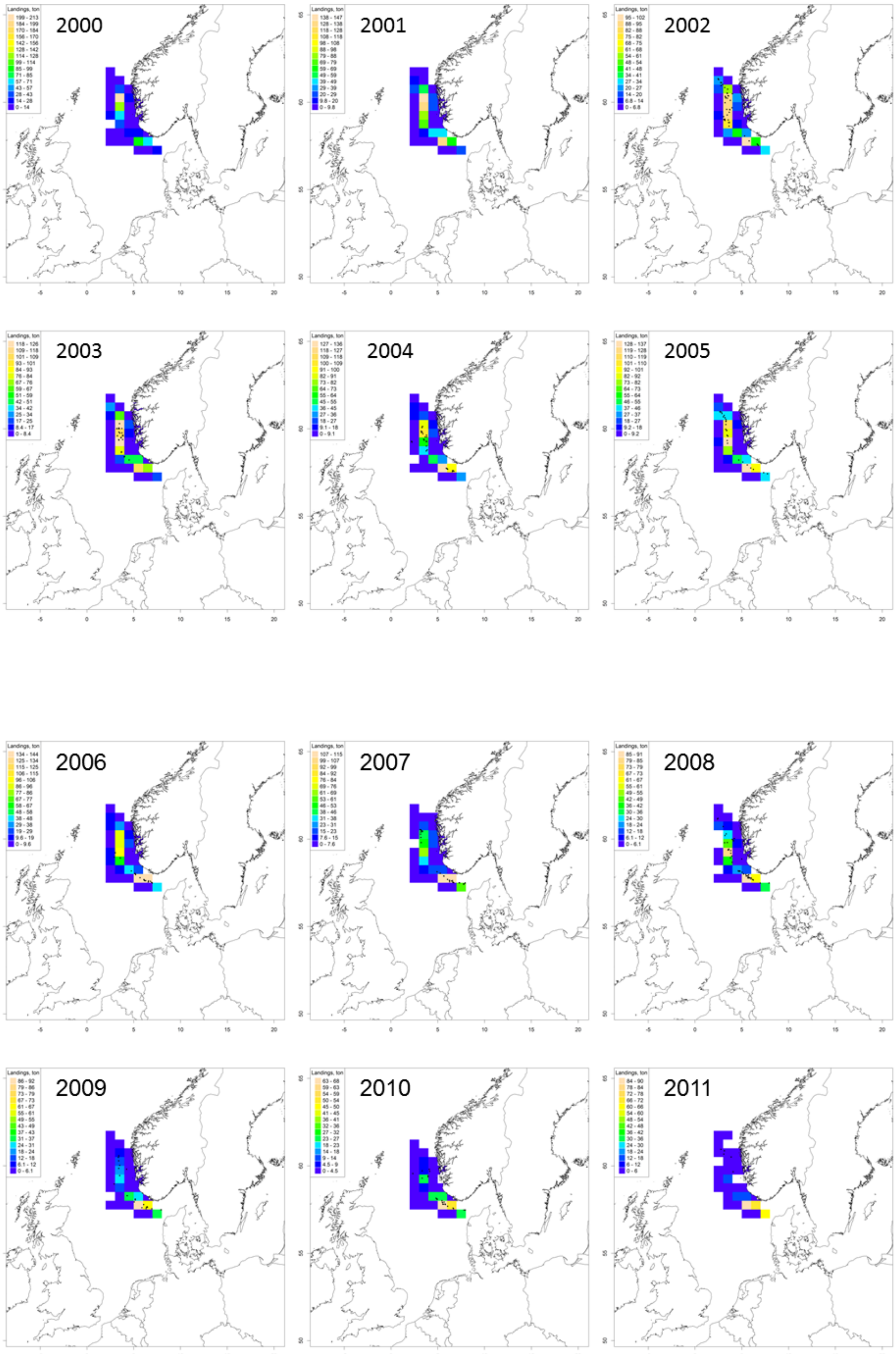


Figure 11.8.4 ***Nephrops*****, Noup (FU 10), Time series of TV survey abundance estimates (absolute conversion factor = 1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007 and 2014.**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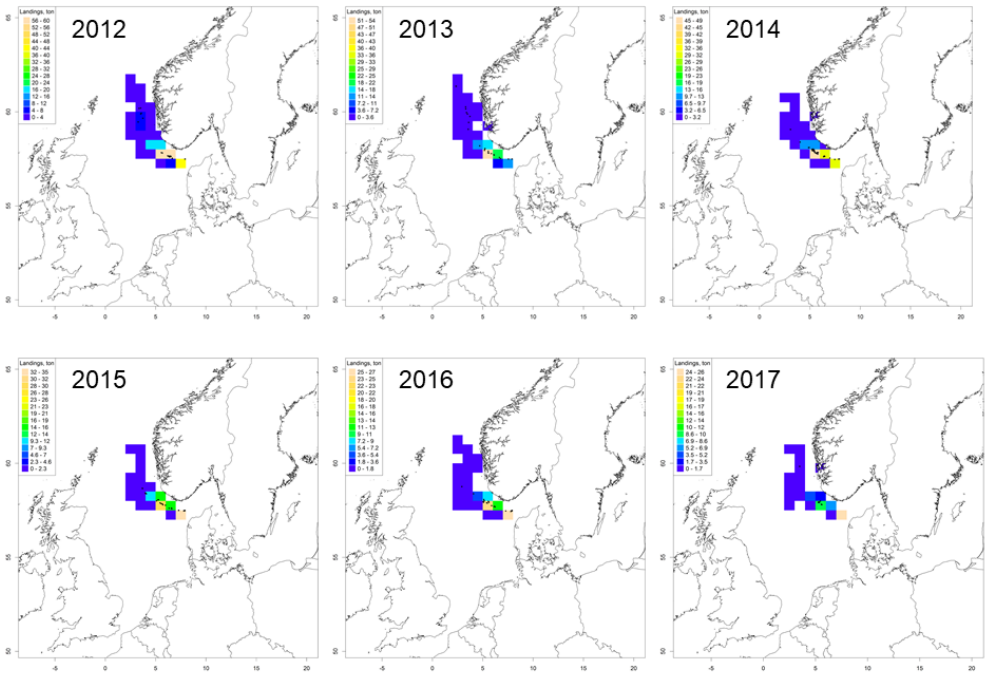

Figure 11.9.1. ***Nephrops*** **Norwegian Deep (FU 32). Danish landings of** ***Nephrops*** **per ICES square, 2000–2017. Dots represent hauls with** ***Nephrops*** **in at-sea-sampling program. Note, scales differ between annual plots.**

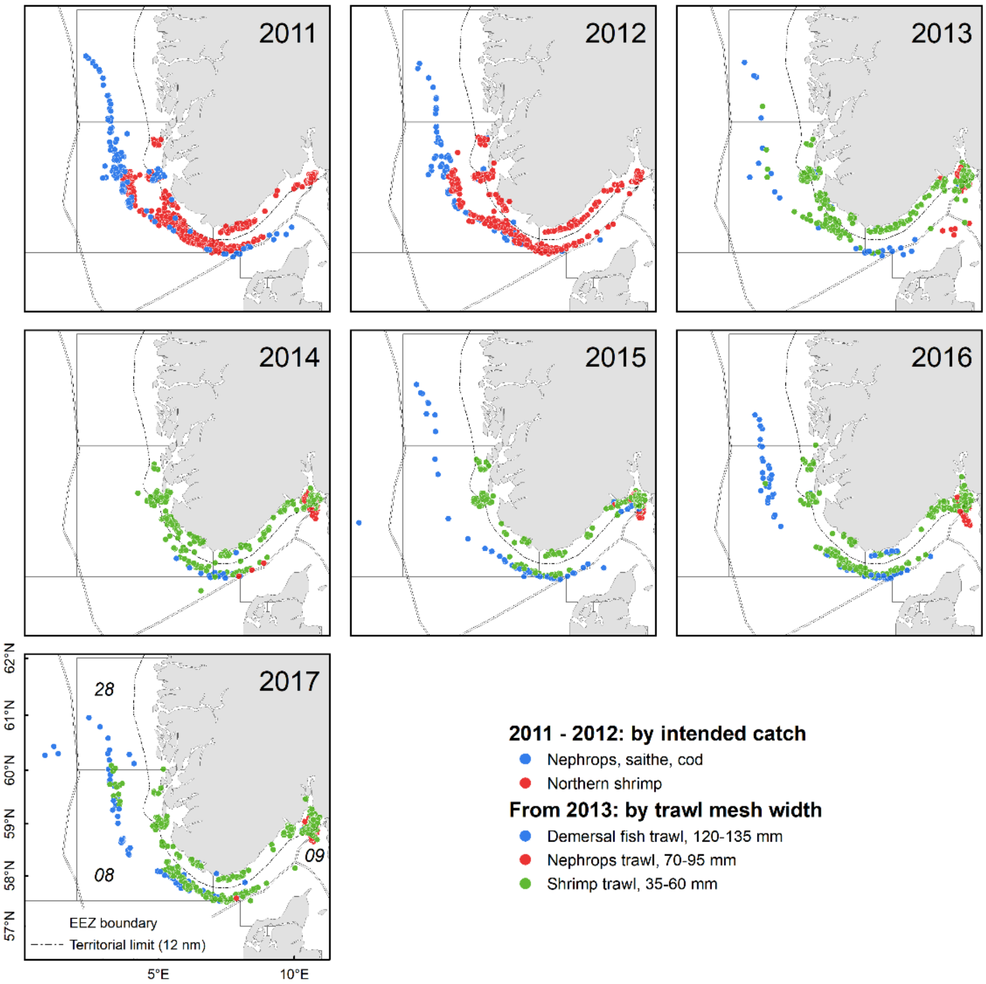

Figure 11.9.2. *Nephrops* Norwegian Deep (FU 32): Positions of trawl hauls with *Nephrops* in the catch from Norwegian bottom trawlers ≥ 15 m, 2011–2017.

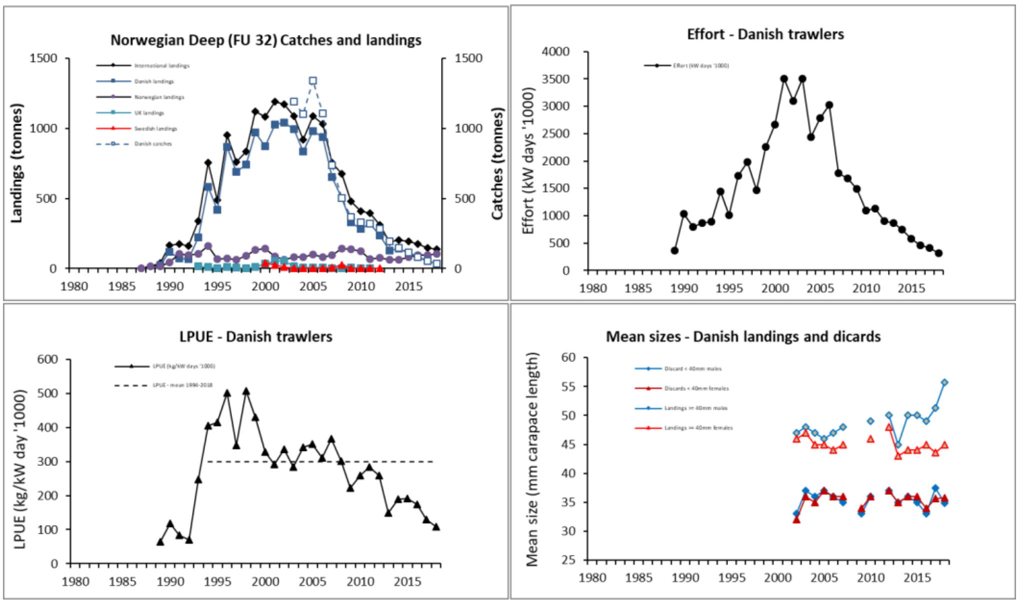

Figure 11.9.3. ***Nephrops*** **Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards (< 40 mm) and landings (≥ 40 mm).**

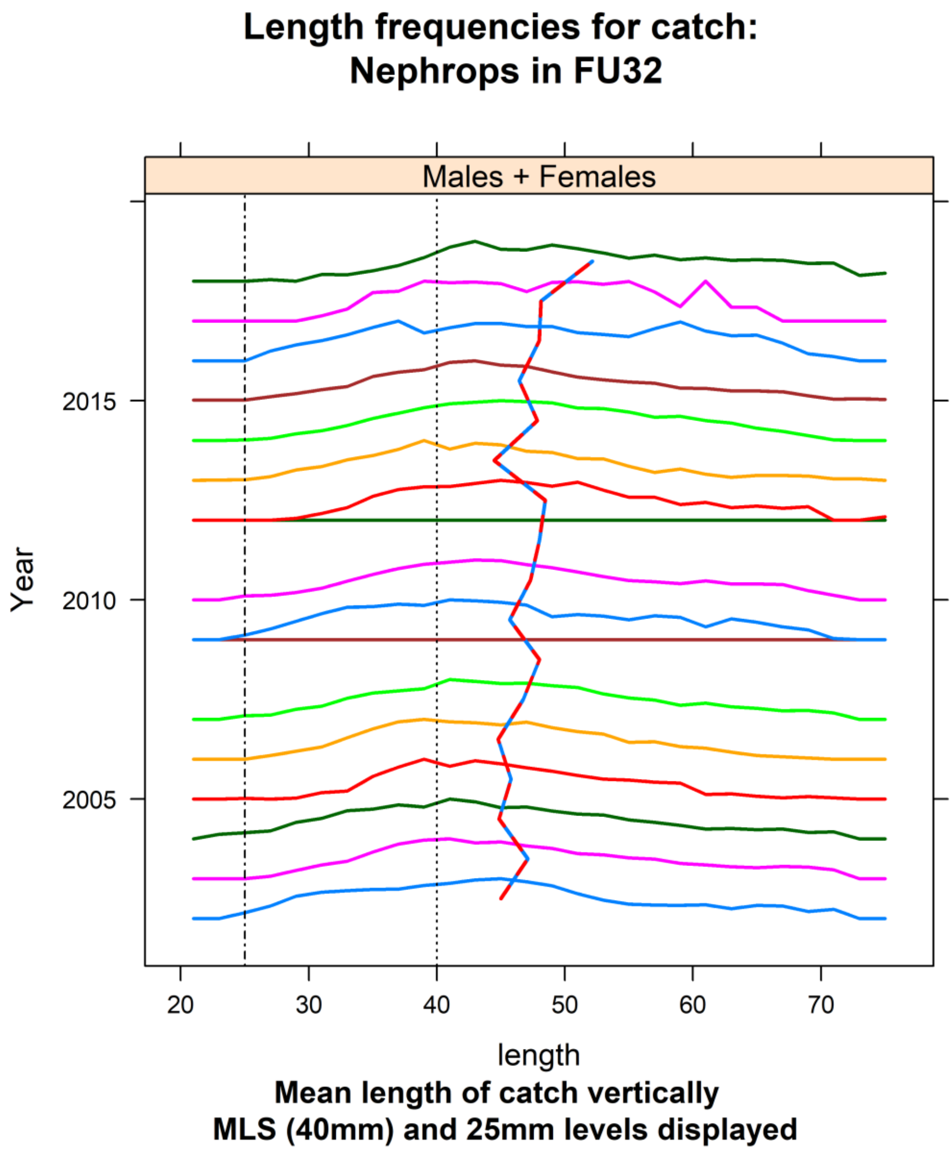

Figure 11.9.4. ***Nephrops*** **Norwegian Deep (FU 32): Size distribution in Danish catches.**

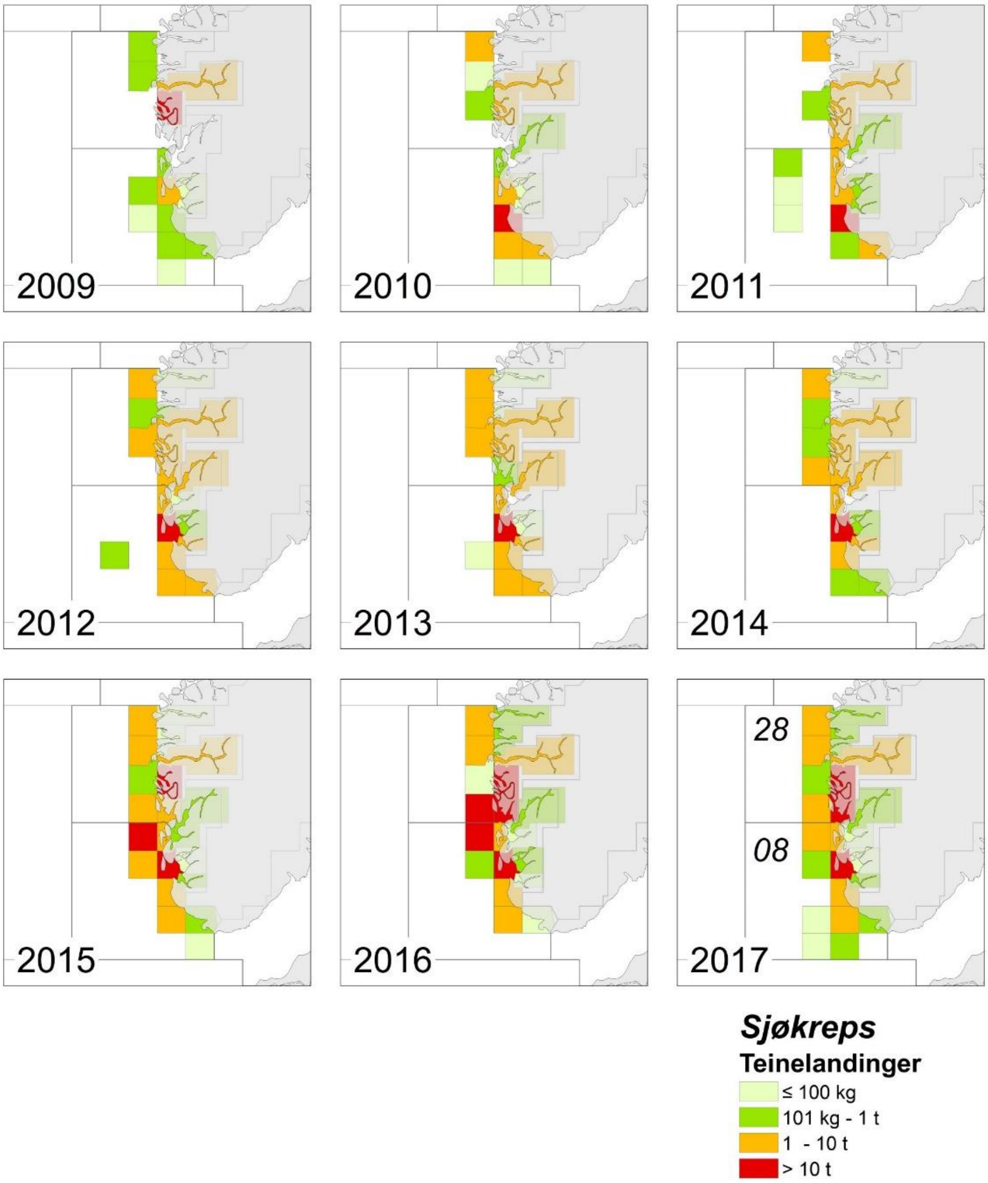

Figure 11.9.5. ***Nephrops*** **Norwegian Deep (FU 32): Norwegian creel landings by ICES statistical squares, 2009–2017.**

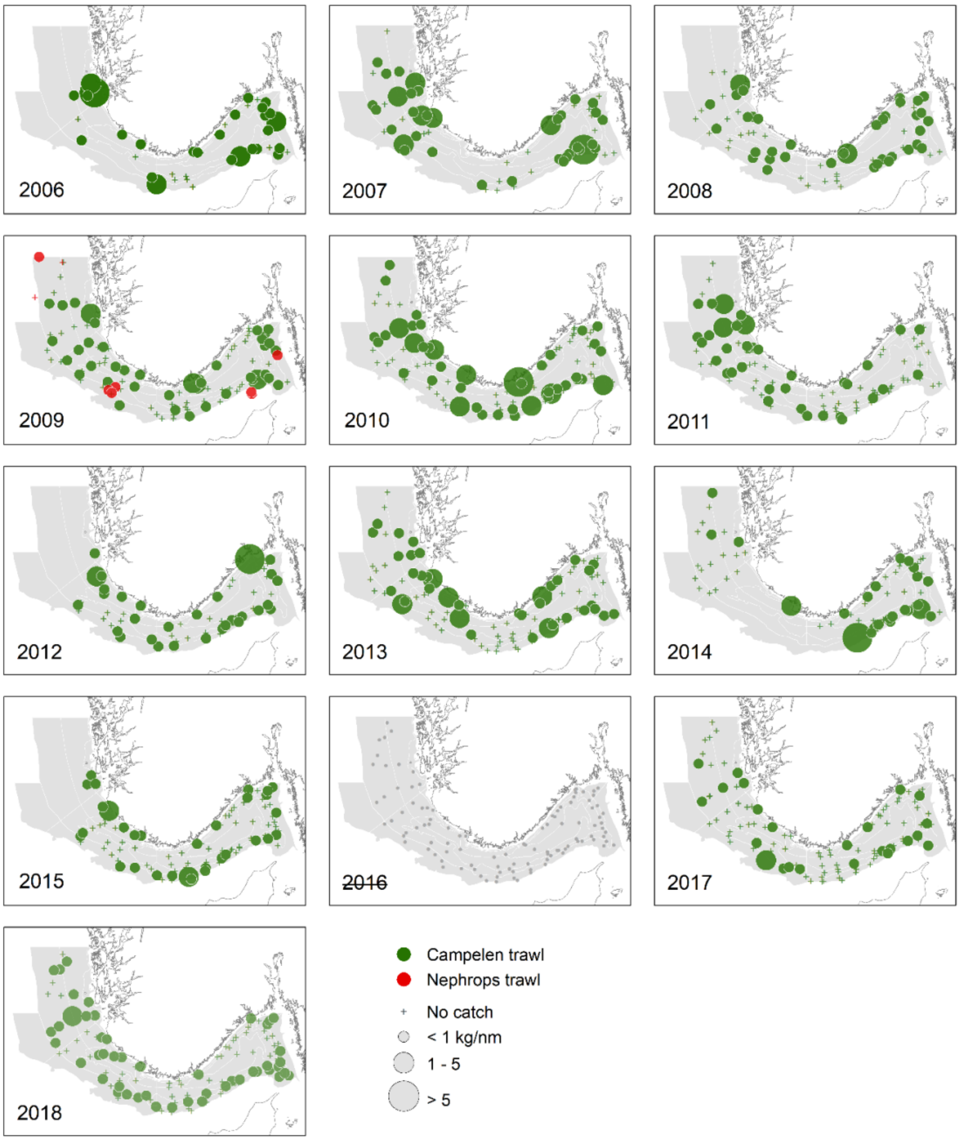

Figure 11.9.6. *Nephrops* Norwegian Deep (FU 32): Distribution of *Nephrops* in Norwegian shrimp survey, 2006–2018. The 2016-data are omitted from the time series due to technical problems with the trawl gear at this year's survey.

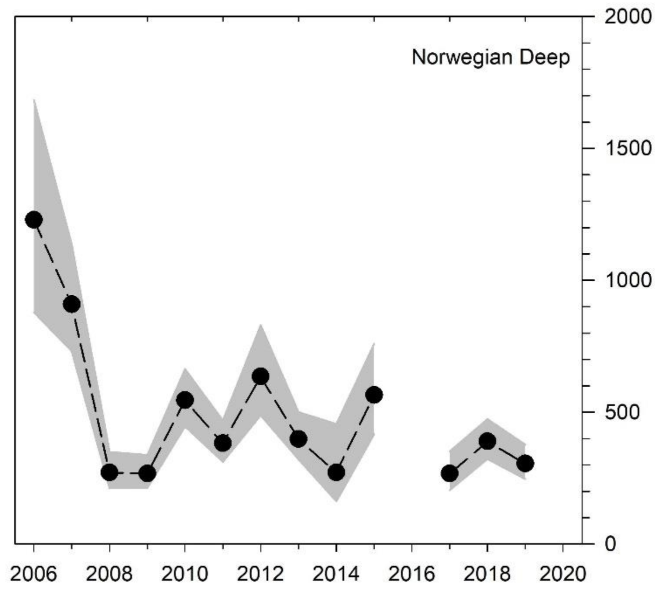

Figure 11.9.7. ***Nephrops*** **Norwegian Deep (FU 32): Biomass index (tonnes) (2006–2019) from the Norwegian Deep, based on trawl catches in the Norwegian shrimp survey. The 2016–data are omitted from the time series due to technical problems with the trawl gear at this year's survey.**

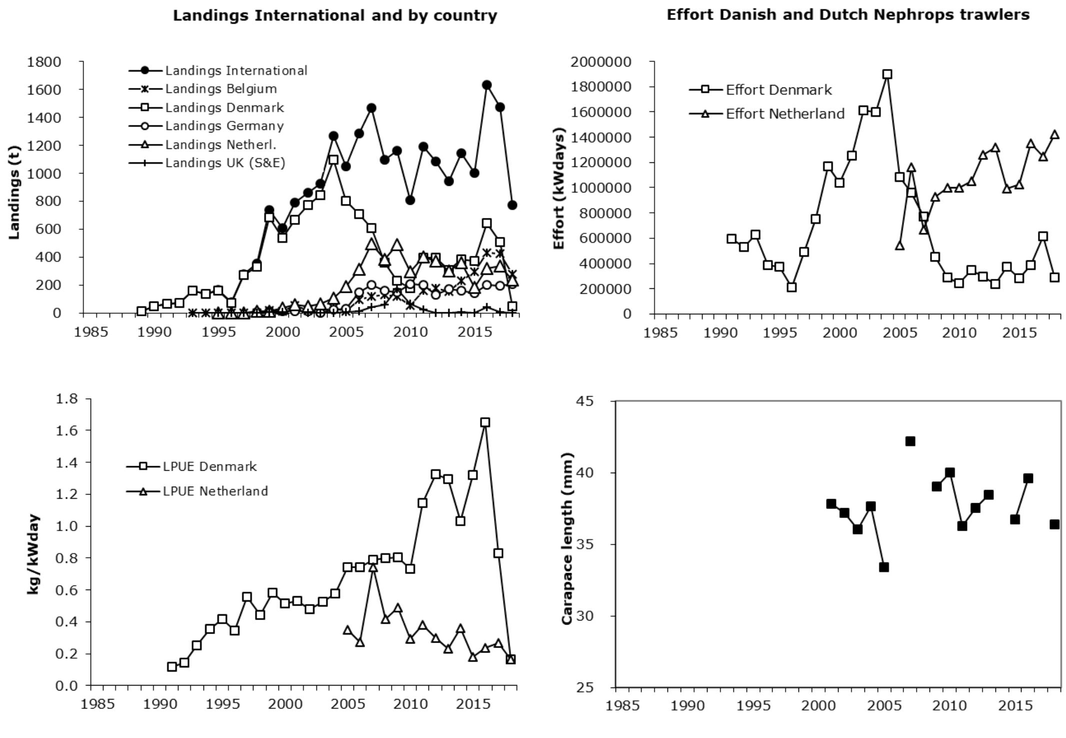

Figure 11.10.1. ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

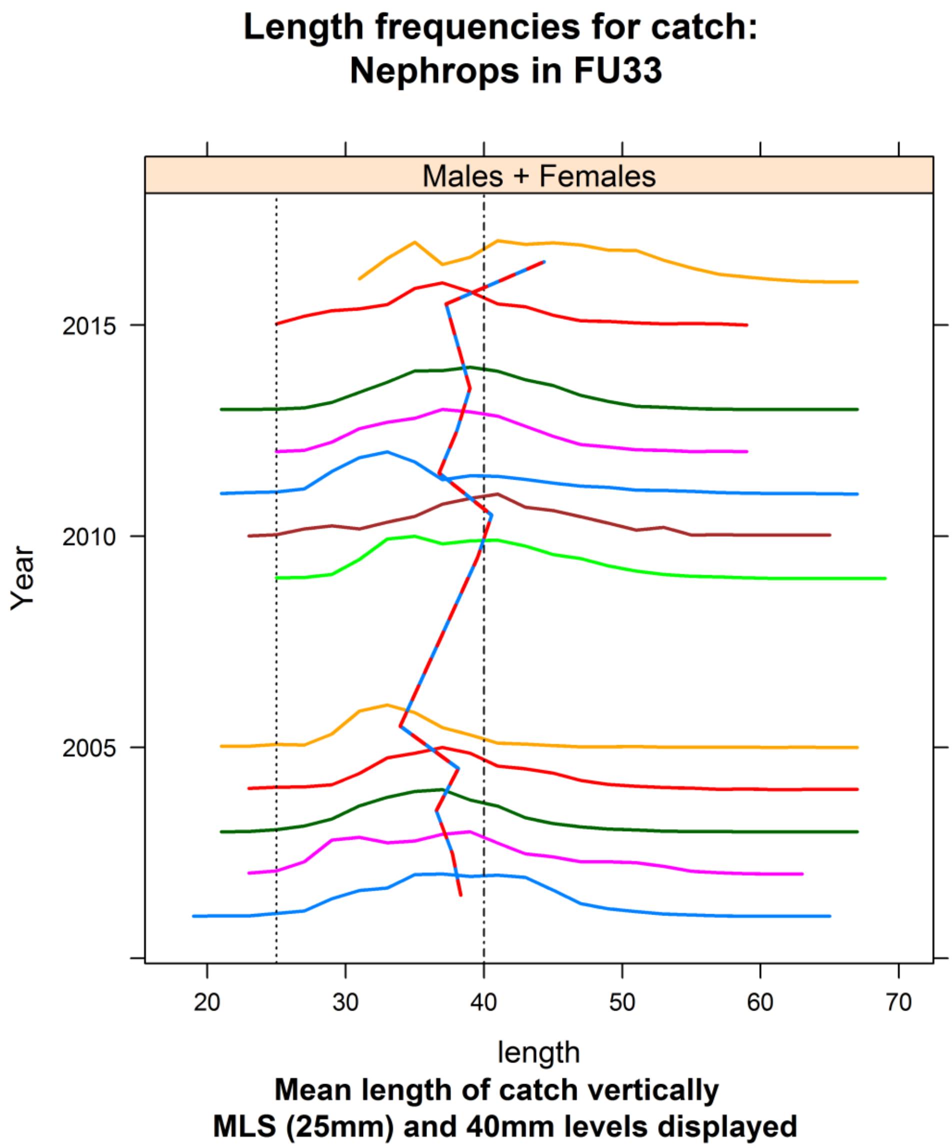

Figure 11.10.2. ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

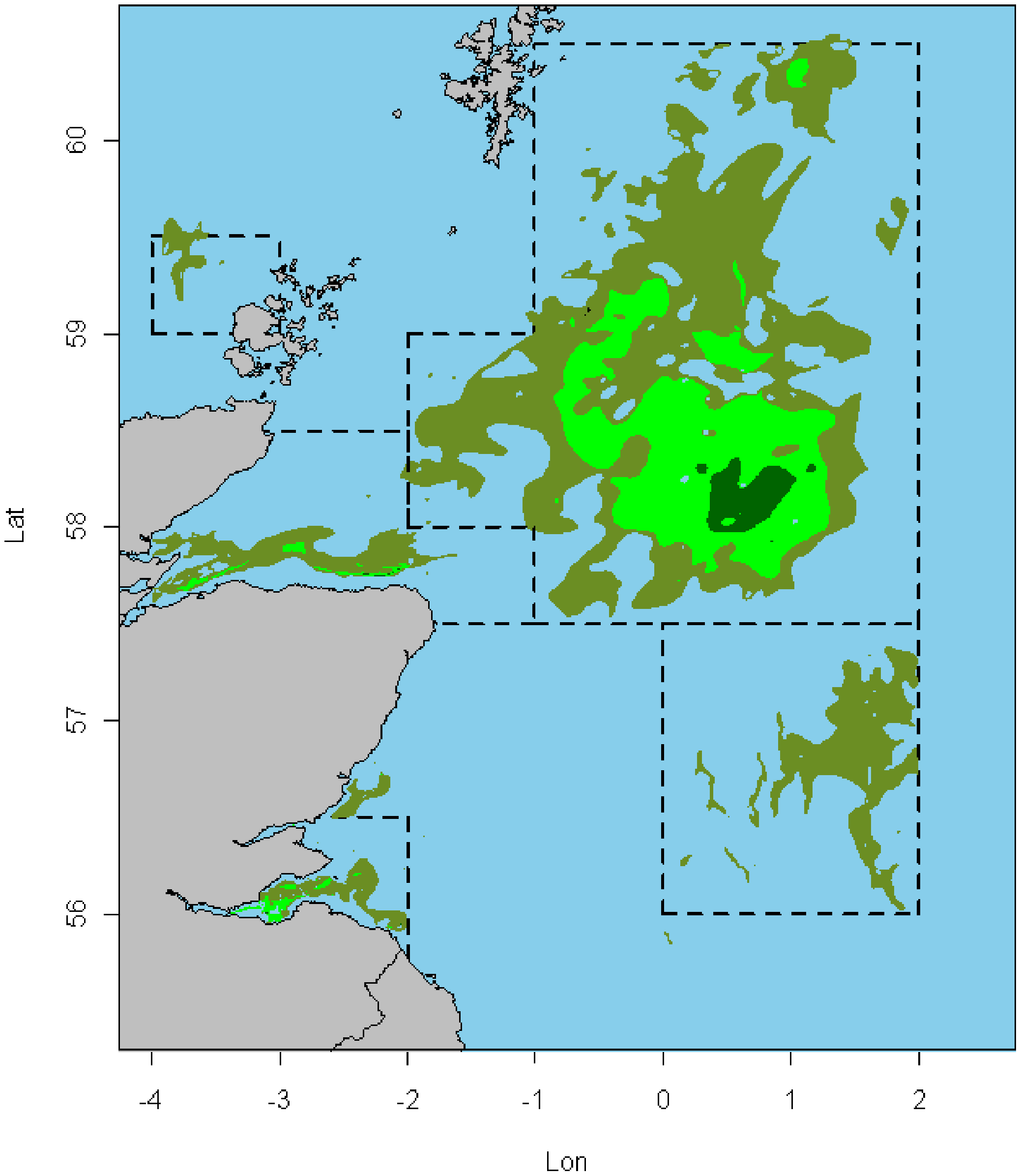

Figure 11.11.1. *Nephrops*, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.

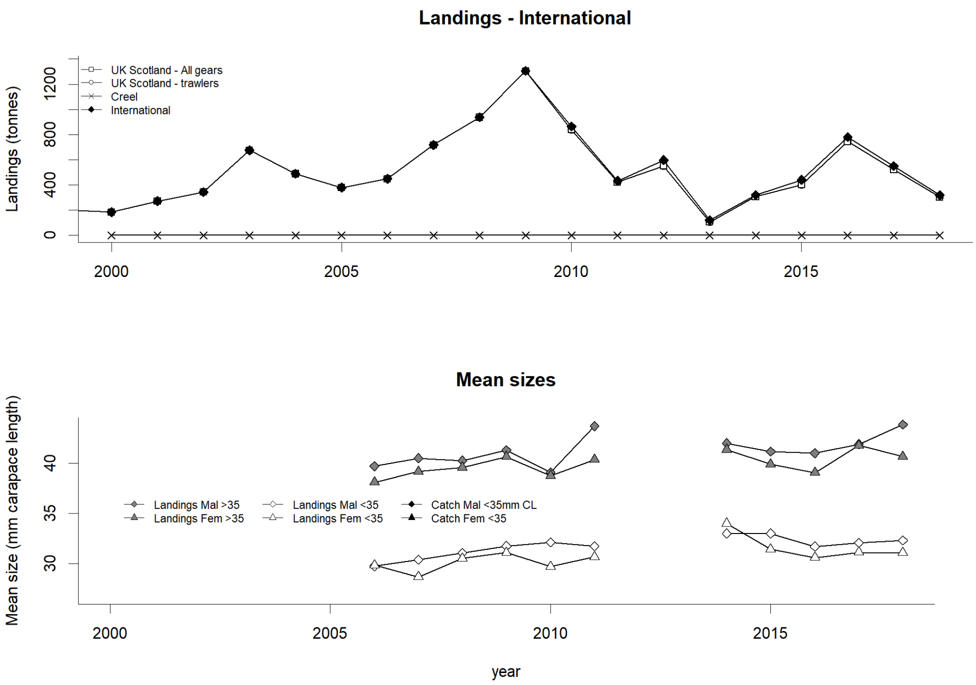

Figure 11.11.2. ***Nephrops*****, Devil's Hole (FU 34). Long term landings and mean sizes, data from year 2000.**

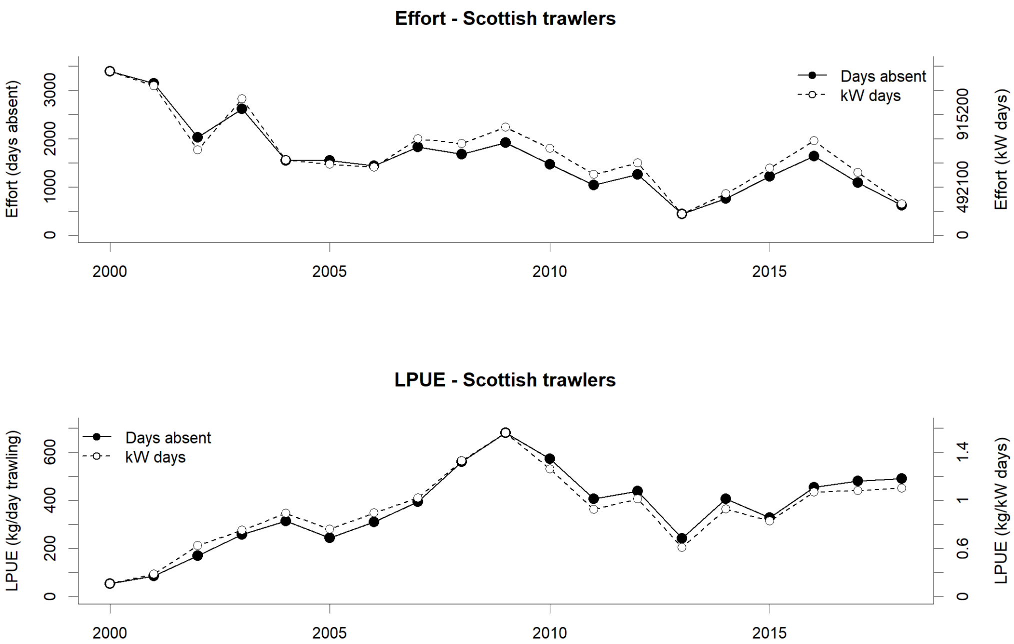

Figure 11.11.3. ***Nephrops*****, Devil's Hole (FU 34). Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

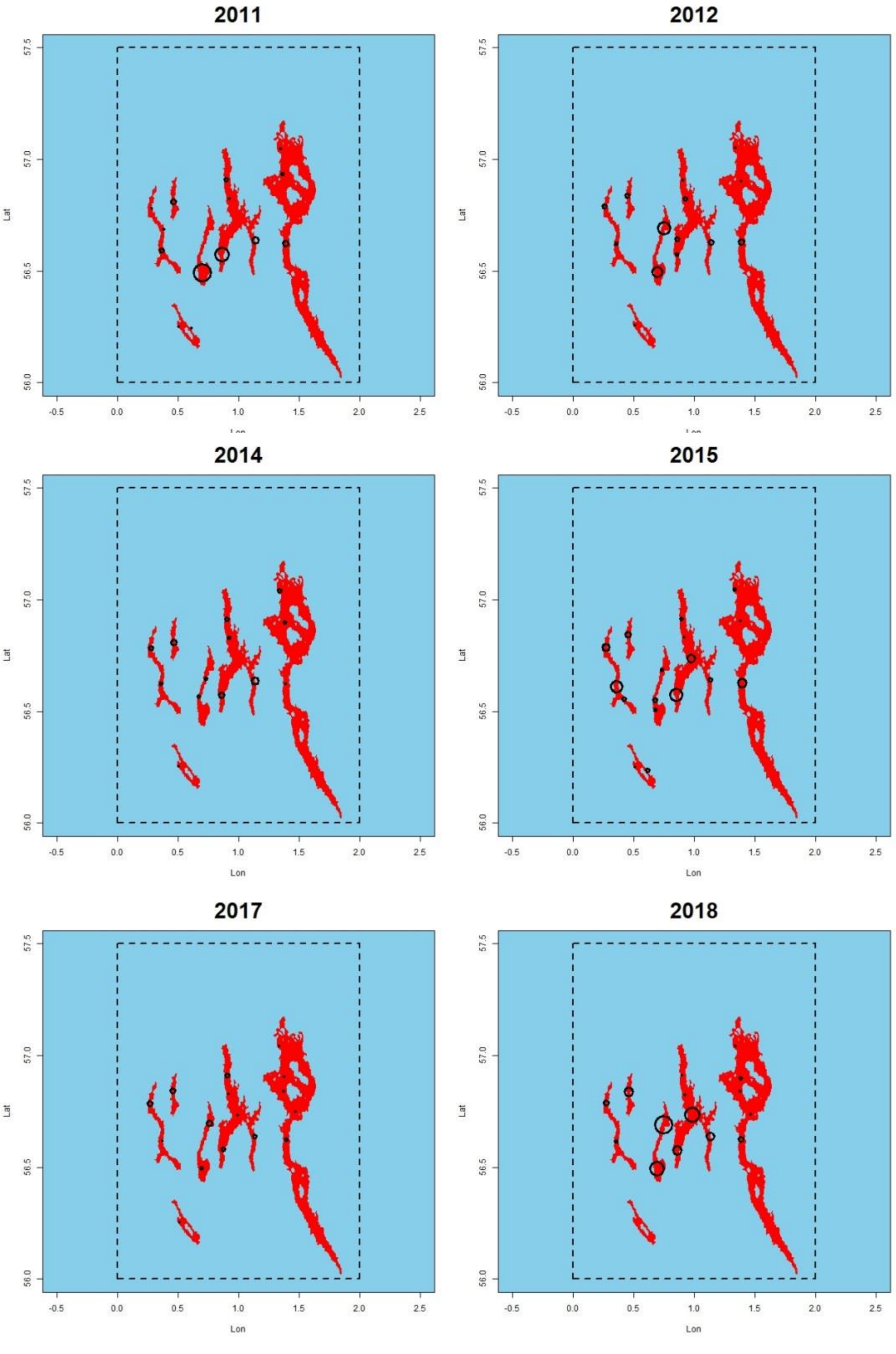

Figure 11.11.4. ***Nephrops*, Devil's Hole (FU 34). UWTV survey distribution and relative density (2011–2018). Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

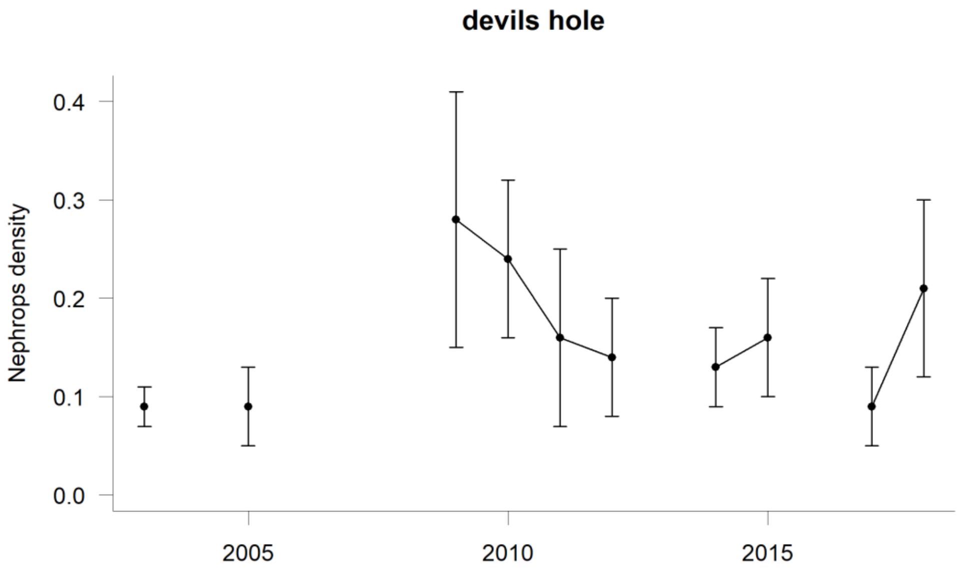

Figure 11.11.5. ***Nephrops*****, Devil's Hole (FU 34). Time series of UWTV survey density estimates with 95 % confidence intervals, 2003, 2005, 2009–2018.**

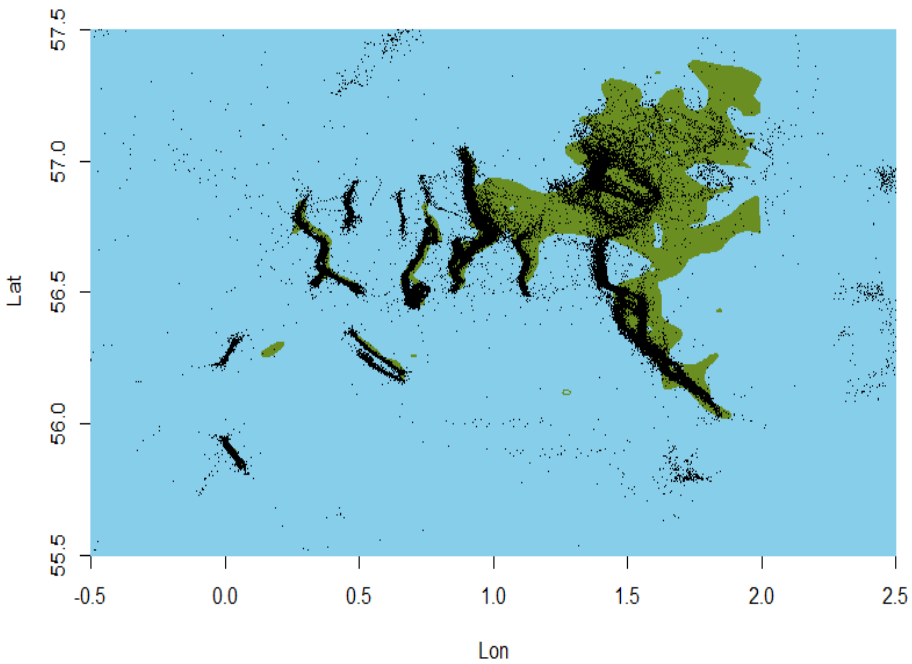

Figure 11.11.6. ***Nephrops*****, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for** ***Nephrops*** **landings > 30% of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

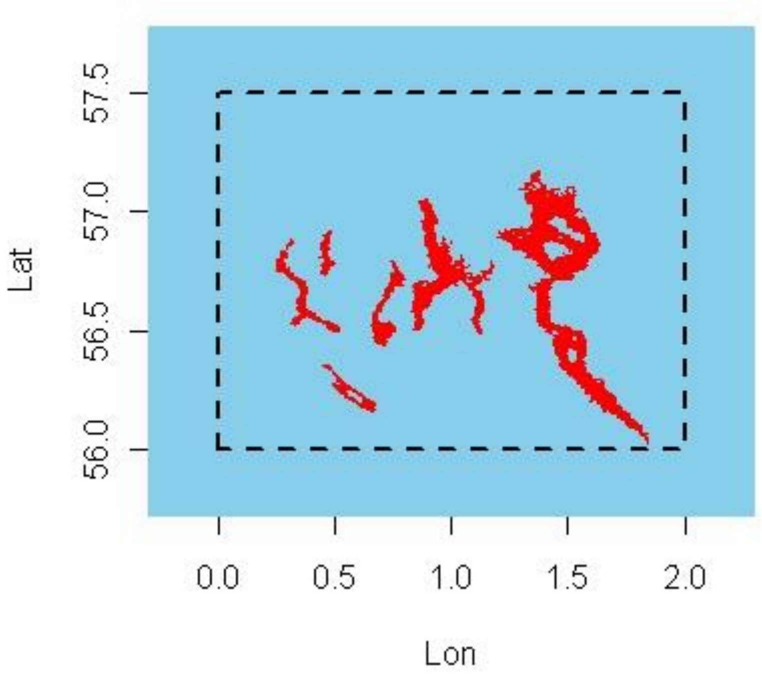

Figure 11.11.7. ***Nephrops*, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for *Nephrops* landings > 30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

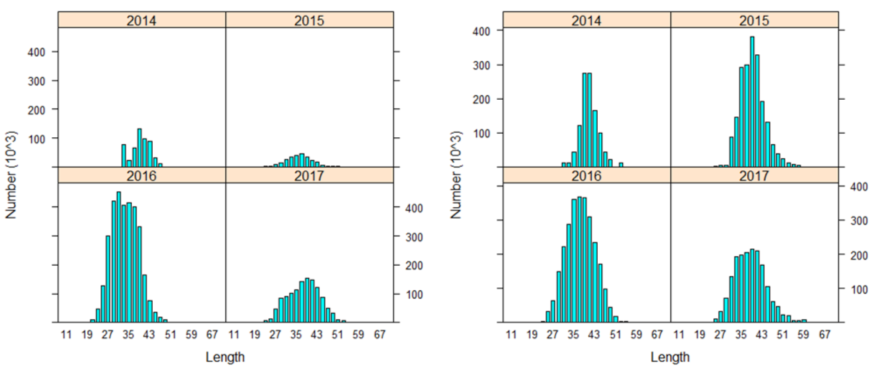

Figure 11.11.8. ***Nephrops*, Devil's Hole (FU 34). Landings length distributions for females (left) and males (right) obtained from Intercatch and used to run the LBI screening methods (2014–2017).**

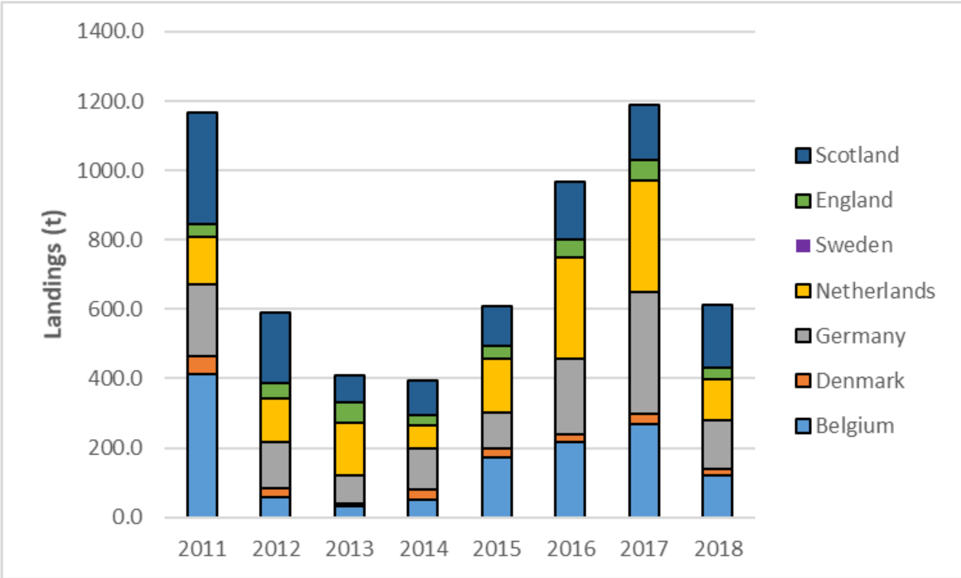

Figure 11.12.1. *Nephrops*, 4 out FU. Landings reported by country (2011–2018).

12 Norway Pout in ICES Subarea 4 and Division 3.a

The Section was added to the report in October 2019.

Introduction: Benchmark assessment

The September 2019 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 2012d) 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 2019, and includes new information from 2nd half year 2018 and for the quarters 2, 3 and 4 in 2019. The assessment includes the new 3rd quarter 2019 survey information also covering the 0-group 2019 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 2019 and 1 November 2020 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 and4). 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 before 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 2012–2019 been below 100 kt and the quota has not been taken in those years. The landings in 2017 and 2018 were 33,9 kt and 36,2 kt, respectively. The fishery has in these periods mainly been based on the 2008, 2009, 2012, 2014, 2016 and 2018 year classes being above the long term average level. The TAC was not taken in 2008–2010 and 2012–2019, 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 2018, the advice on North Sea Norway pout was updated. Based on the estimates of SSB in September 2018, 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 2019. In recent years, the escapement strategy has been practiced in reality in management. The ICES advice in September 2018 was that with catches up to 135 kt in the directed Norway pout fishery in the period 1 November 2018 to 31 October 2019 corresponding to a F around 0.70 taking into account an F_{cap} of 0.70 and that the 5th percentile of the spawning-stock biomass in the 4th quarter 2019 will remain above a reference level of B_{lim} (39 450 t). The SSB was expected to remain high during 2018 and 2019 due to the high 2016 and 2018 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, 2016 and 2018, as well as a just below average recruitment in 2015 and 2017, the fishery has remained open for all of 2013–2019. The quota uptake has been less than 30% in recent years (Nielsen *et al*. 2016a). The quota uptake in 2018 has again 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 (0.43) as estimated from the assessment in September 2019.

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 2020 (up to 31 October) is provided for the stock in autumn 2019 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. Furthermore, it is advised that existing measures to protect other species should be maintained.

12.1.4 Management up to 2018

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.

In 2005, ICES advised 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 t 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, 251 kt for 2014, 328 kt for 2015, 360 kt for 2016, 346 kt for 2017 and 146 kt for 2018. However, the TACs were not taken during this period except for the small TAC in 2011. Up to now, the TAC advice for 2019 has been 135 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 12.10). ICES has evaluated and commented on three management strategies in 2007, although these have not been decided upon. Long-term management strategies have been evaluated again in September 2012 and June 2013 based on new joint EU-Norway requests (ICES, 2012c) 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 the 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 released its advice evaluating long-term management strategies for Norway pout in Subarea 4 and Division 3.a on 29 May 2018 (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 (Report of the Workshop for Management Strategy Evaluation for Norway Pout, ICES, Copenhagen 26–28 February 2018, ICES CM2018/ACOM:38 Ref WGNSSK, 96 pp) 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 practiced (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 of the stock 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 consultations between EU and Norway, held on 5–6 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 Subarea 4 and Division 3.a. ICES was requested to assess, following MSY $B_{escapement}$:

→ *Which scenarios of TACmin and TACmax would be precautionary, if the Fcap 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 Fcap of 0.7 – following from paragraph 1 of this request).*

On this basis, ICES has evaluated additional harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TACmin) and upper (TACmax) bounds on TAC and use of an upper fishing mortality (F_{cap}) at 0.7. As for the scenario made for ICES May 2018 advice (ICES, 2018), 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.

This is presented in the ICES advice:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu.2018.19.pdf.

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, resulting in no more than a 5% probability of the spawning-stock biomass falling below B_{lim}. Increasing the F_{cap} from 0.4 (which was previously evaluated) to 0.7 results in a higher median and mean TAC, but also in a higher long-term probability of SSB falling below B_{lim}. It also results in a higher probability of being constrained by the TACmax.

The evaluations and ACOM approval of this led to identification of an expanded set of sustainable scenarios with an F_{cap} of 0.7. Tables 1 and 2 in http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu.2018.19.pdf summarize the long-term (2023–2037) performance metrics for the (precautionary) combinations that result in no more than 5% probability of SSB falling below B_{lim} in the period 2023–2037. More detailed statistics for both precautionary and non-precautionary HCRs are shown in the Table 3 of this advice.

Given that Norway pout is a short-lived species and that the HCR scenarios are based on the escapement strategy, the application of an additional interannual quota flexibility of ±10% is not considered precautionary.

No decision on long-term management plans are currently available for the Norway pout in Subarea 4 and Division 3.a based on the identified sustainable scenarios.

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

12.2.1 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 2017–2018, 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 2019 include Danish and Norwegian catches up to 10 September 2019. Catches in the last two-three weeks of 3rd quarter 2019 are assumed to be relatively low and no guesses on that have been included in the assessment.

12.2.2 Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 2007 and 2008). Catch at age by quarter of year is shown in Table 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.

12.2.3 Weight at age

Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight at age in the catch is shown in Table 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, 2018 as well as for quarter 1 to quarter 3 2019. Relative low mean weights at age have been observed for age groups 1–2 in quarter 1–2 in 2019. Danish data and age readings have been checked according to this. Very small fish have been observed in this period in the Danish catches, so this is not an artefact.

Mean weight at age in the stock is given in Table 12.2.6. The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012d) 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, 2012d) 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.

12.2.4 Maturity and natural mortality

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012d) 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, 2012d) 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, 2012d) 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.

12.2.5 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, 2012d)

12.2.6 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)**.**

12.2.6.1 Commercial fishery data

Catch information for 1984–2019 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).

12.2.6.2 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 2019 IBTS and the 3rd quarter 2018 IBTS research surveys have been included in this September 2019 assessment as well as the 3rd quarter 2019 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 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 2017–2019 and, accordingly, no new 15 min hauls have been conducted and included in the Q3 2017–2019 SGFS and EGFS survey indices (and consequently in the combined Q3 IBTS survey index). Analyses of this are still 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-–019, 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 2017–2019 indices used in the assessment. By comparison it appears that the survey trends seem similar with or without prime 77 in the EGFS for 2017–2019.

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. In 2019, there has been a slight revision of the SGFS indices from 2013–2018 because of additional data check and removal of invalid hauls. This have resulted in very slight changes. As expected, the divergence is very small and typically around 1–3% increase and obviously is dependent on how many invalid hauls were recorded during each survey year. This does not at all change the perception of the trends in this survey index and does not have significant effect on the assessment results. Also, a few invalid hauls during the 2019 survey was encountered with the result that in order to ensure that there would be no loss to the overall survey Norway covered 6 of the stations normally completed by Scotland within the most North-Easterly 2 legs of the SGFS survey. These were stations 50F0, 50F1, 50F2, 48F1, 48F2 and 48F3. In 2018, these stations accounted for around 2% of the overall Norway Pout abundance for the survey so it is expected that although not an ideal situation from the perspective of providing consistent coverage the impact of this change will be minimal. 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.

12.2.6.3 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 2012d) 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

12.3.1 Review of assessment

The September 2018 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.

12.3.2 Final Assessment

A seasonal extension to the State-space Assessment Model (SAM) was used during this September 2019 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 2019 assessment under "NP_Sep19_b" 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 2019 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 2019 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 (0.43, 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 2013–2018, 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 2018 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, 2016 and 2018-year classes, and the lowered fishing mortality. The stock biomass fell to a level well below B_{lim} in 2005 which is the lowest level ever recorded. By 1 January 2007 and 2008 the stock was at B_{pa} (= MSY $B_{escapement}$) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1 January 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018 and 2019 has been above B_{pa} (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-1980'ies. The recruitment in 2008, 2009, 2012, 2014, 2016, 2018 and 2019 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 was slightly below long-term average (42 billion), but because of the strong 2012, 2014, 2016 and 2018 year classes, the SSB has been well above B_{pa} (= MSY $B_{escapement}$) by 1 January 2014, 2015, 2016, 2017, 2018 and 2019 even with a high yearly TAC in 2014–2019 considering growth, high natural mortality, and 20% maturation at age 1. Because of the strong 2016, 2018 and 2019 recruitment the stock is expected to remain above B_{pa} by the end of 2019.

12.3.3 Comparison with 2015–2018 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 2019 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 2019 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 2019 assessment, it is estimated to 28 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 2012d) and the **Stock Annex**.

Recruitment Estimates

The long-term average recruitment (age 0, 2nd quarter) is 42 billion (arithmetic mean) for the period 1984–2019 (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, 2018 and 2019 was high. Recruitment in 2011 and 2013 was very low, and the recruitment in 2015 and 2017 has been below long-term average (42 billion).

12.5 Short-term prognoses

The short-term forecast is stochastic based on the SESAM September 2019 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 2019 recruitment (Q3 2019) in the SSB estimate by 4th quarter 2019. The recruits in 2020 do not become a part of SSB by 4th quarter (1 October) 2020 because they have not reached maturity yet by 4th quarter 2020, but will do that by 1 January 2021 (20% mature as 1-group here). However, the forecast is just run up to 4th quarter 2020, and the recruits in 2020 is accordingly not used (and shall not be that) in the forecast SSB estimate in Q4 2020.

5. Find Gt so 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 μa,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 2019 to 31 October 2020 with F scaled so that the fifth percentile of the SSB distribution one year a head (1 October 2020) 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. This results in a catch up to 185 kt (185 404 t) in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1–2)}$ of 0,808 and an SSB at 131 kt (131 130 t) by 1 October 2019.

The purpose of the second forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 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 1st October 2019 to 31st October 2020 which corresponds to an $F_{bar(1–2)}$ of 0,00 and an SSB at 228 kt (228 020 t) by 1 October 2019.

The purpose of the third forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to F status quo for previous year up to 1 October 2019. The results of the forecast are presented in Table 12.6.4 and Figure 12.6.3 where catches up to 91 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1–2)}$ of 0,348 and an SSB at 176 kt (176 070 t) by 1 October 2020.

The purpose of the fourth forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled so that the median of the SSB distribution one year ahead (1 October 2020) equals B_{lim}. The results of the forecast are presented in Table 12.6.5 and Figure 12.6.4 where catches up to 458 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1–2)}$ of 3,580 and an SSB of 39 kt (39 450 t) by 1 October 2020.

The purpose of the fifth forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled so that SSB one year ahead (1 October 2020) equals B_{pa}. The results of the forecast are presented in Table 12.6.6 and Figure 12.6.5 where catches up to 367 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 2,268 and an SSB of 65 kt (65 000 t = B_{pa}) by 1 October 2020.

The purpose of the sixth forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to 0,3. I.e. with an 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 81 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1–2)}$ of 0,303 and an SSB of 181 kt (181 770 t) by 1 October 2020.

The purpose of the seventh forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to 0,4, i.e. with an 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 104 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 0,405 and an SSB of 168 kt (168 840 t) by 1 October 2020.

The purpose of the eight forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to 0,5. I.e. with an 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 126 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 0,503 and an SSB of 158 kt (158 050 t) by 1 October 2019.

The purpose of the ninth forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to 0,6. I.e. with an 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 148 kt can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 0,608 and an SSB of 148 kt (148 350 t) by 1 October 2020.

The purpose of the tenth forecast is to calculate the catch of Norway pout from 1 October 2019 to 31 October 2020 with F scaled to 0,7. I.e. with an 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 167 kt (167 105 t) can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 0,708 and an SSB of 139 kt (139 130 t) by 1 October 2020.

According to the long term management strategy evaluation based on the joint EU-Norway request from November 2017 and the resulting released advice by ICES in May 2018 evaluating long-term management strategies for Norway pout in Subarea 4 and Division 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 Section 3.8 of the ICES WKPOUT 2016 Report, 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, a new assessment will be provided.

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 1st 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 not fully converging 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 2019 assessment it is estimated to 28 kt (28 279 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, 12.5 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 a 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 so 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 November 2017 and the resulting released advice by ICES in May 2018 evaluating long-term management strategies for Norway pout in Subarea 4 and Division 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.

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 2012d; ICES WKPOUT 2016) and therefore there is no 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 estimates of Mohn's Rho in the retrospective analyses are of the baseline SESAM assessment September 2019, with terminal assessment year ranging from 2005–2019, is 50% for SSB, -33% for F_{bar}, and 103% for R shown in Figure 12.3.8. Despite these tendencies of overestimating spawning stock biomass, underestimating fishing mortality, and overestimating recruitment, then the terminal year estimates lie within the confidence limits of the model estimates which appear from Figure 12.3.8.

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 3rd quarter of the assessment year.

12.9 Status of the stock

Based on the estimates of SSB in September 2019, ICES classifies the stock at full reproductive capacity.

With F scaled to 0,7, i.e. with an F_{cap} = 0,7 catches up to 167 kt (167 105 t) can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1–2)}$ of 0,708 and an SSB of 139 kt (139 130 t) by 1 October 2020. This is due to the strong 2016, 2018 and 2019 recruitment being above the long-term average recruitment (42 billion), 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 (0.43). 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 2013–2018, 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, 2018 and 2019 was high well above the long-term average (42 billion). Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 has been 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 an F scaled to 0,7, i.e. with an F_{cap} = 0,7 catches up to 167 kt (167 105 t) can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to an $F_{bar(1-2)}$ of 0,708 and an SSB of 139 kt (139 130 t) by 1 October 2020. This is due to the strong 2016, 2018 and 2019 recruitment being above the long term average recruitment (42 billion) 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 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. In addition, Norway pout is to a limited extent exploited already from age 0. Overall, 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 these) 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.**

12.10.1 Long term management strategies

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F = 0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above 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 these 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 updated 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 update 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, in April 2013, ICES evaluated 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 ($F_{max/cap}$ = 0.8) or with maximum TAC of 200 kt ($F_{max/cap}$ = 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, the above 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 Subarea 4 and Division 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 (Report of the Workshop for Management Strategy Evaluation for Norway Pout, ICES, Copenhagen 26-28 February 2018, ICES CM2018/ACOM:38 Ref WGNSSK, 96 pp) 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 consultations between EU and Norway, held on 5–6 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 Subarea 4 and Division 3.a. Here ICES is requested to assess, following MSY $B_{escapement}$:

→ *- Which scenarios of TACmin and TACmax would be precautionary, if the Fcap 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 Fcap of 0.7 – following from paragraph 1 of this request).*

On this basis, ICES has evaluated additional harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TACmin) and upper (TACmax) bounds on TAC and use of an upper fishing mortality (F_{cap}) at 0.7. As for the scenario made for ICES May 2018 advice (ICES, 2018), 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.

This is presented in the ICES advice:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu.2018.19.pdf.

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, resulting in no more than a 5% probability of the spawning-stock biomass falling below B_{lim}. Increasing the F_{cap} from 0.4 (which was previously evaluated) to 0.7 results in a higher median and mean TAC, but also in a higher long-term probability of SSB falling below B_{lim}. It also results in a higher probability of being constrained by the TACmax.

The evaluations and ACOM approval of this led to identification of an expanded set of sustainable scenarios with a F_{cap} of 0.7. Tables 1 and 2 in http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu.2018.19.pdf summarize the long-term (2023–2037) performance metrics for the (precautionary) combinations that result in no more than 5% probability of SSB falling below B_{lim} in the period 2023–2037. More detailed statistics for both precautionary and non-precautionary HCRs are shown in the Table 3 of this advice.

Given that Norway pout is short-lived and that the HCR scenarios are based on the escapement strategy, the application of an additional interannual quota flexibility of ±10% is not considered precautionary.

No decision on long-term management plans are currently available for the Norway pout in Subarea 4 and Division 3.a based on the identified sustainable scenarios.

12.11 Other issues

Recommendations for future assessments:

Age reading check and otolith exchange program:

In July 2018 a report of the 2018 Norway Pout exchange was sent out by ICES WGIOP, 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. This has been made available on the ICES SmartDots page late 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 upon in the text but have been included so they can be discussed in the relevant labs according to the routines there.

The 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 Inter-Benchmark 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 were 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.

It will be relevant to investigate retrospective patterns in the assessment among other in relation to the Mohn´s Rho values for recruitment, SSB and F.

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Table 12.2.1. Norway pout in 4 and 3.a. Nominal landings (tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas 4 and 3.a in the period 2008-2018, 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	156	-	51	2	118	6.945	538	2.220	918	110	159 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	209	711	-	-	147	9	41	82	72	6 *
Sweden	-	-	10	-	-	1	1	1	1	4	1 *
Germany	-	-	-	-	-	-	-	-	-	-	-
Total	156	209	772	2	118	7.093	548	2.262	1.001	186	166

*Preliminary.

Norway pout ICES area IVa

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	32.158	19.226	71.032	4.038	25.431	31.375	27.894	10.760	21.125	12.312	10.367 *
Faroe Islands	-	-	-	-	-	-	-	5.270	3.156	-	- *
Netherlands	-	22	18	-	-	-	-	17	8	1	2 *
Germany	-	-	-	-	-	-	-	22	27	1	- *
Norway	6.650	36.961	64.303	3.189	4.528	45.839	18.647	43.742	35.959	21.275	25.498 *
Sweden	10	-	+	1	3	4	1	12	-	-	4 *
UK(Scotland)	-	-	29	-	-	-	8	3	12	-	- *
Total	38.818	56.209	135.353	7.228	29.962	77.218	46.542	59.823	60.275	33.589	35.871

*Preliminary.

Norway pout ICES area IVb

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	244	595	229	32	9	43	16	53	1463	45	20 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Germany	-	75	-	-	-	-	-	-	-	13	3 *
Netherlands	-	-	-	-	-	-	-	1	-	-	- *
Norway	-	82	620	21	59	615	8	577	11	10	- *
Sweden	-	-	-	-	-	0	0	714	1	2	- *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	6	-	18	-	- *
Total	244	752	849	53	68	658	30	1.345	1.493	70	23

*Preliminary.

Norway pout ICES area IVc

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	-	-	-	-	-	-	-	-	1	-	-
France	+	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	1	0	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	32.558	19.821	71.312	4.072	25.558	38.363	28.448	13.033	23.507	12.467	10.546
Faroe Islands	0	0	0	0	0	0	0	5.270	3.156	0	0
Norway	6.650	37.252	65.634	3.210	4.587	46.601	18.664	44.360	36.052	21.357	25.504
Sweden	10	0	10	1	3	5	2	727	2	6	5
Netherlands	0	22	18	0	0	0	0	18	8	1	2
Germany	0	75	0	0	0	0	0	22	27	14	3
UK	0	0	0	0	0	0	6	0	18	0	0
Total nominal landings	39.218	57.170	136.974	7.283	30.148	84.969	47.120	63.430	62.770	33.845	36.060
By-catch of other species and other	-3.080	-2.670	-11.019	-759	-3.075	-2.869	-2.950	-30	630	88	87
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	36.147
Agreed TAC	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	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 in 4 and 3.a. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, 3.aS) by country, for 1961–2018 (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
2018	10,5	0,2	+	25,5	+	+	+	36,2

* 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 in 4 and 3.a. National landings (tonnes) by quarter of year 2002–2019 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
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	-	-	-	-	371	-	-	371	371	9	9	380
	2	2	-	2	-	3	-	-	3	5	4.138	4.138	4.143
	3	157	-	157	-	190	1	-	191	348	8.969	8.969	9.317
	4	-	-	-	-	9.921	-	-	9.921	9.921	12.386	12.386	22.307
	Total	159	-	159	-	10.485	1	-	10.486	10.645	25.502	25.502	36.147
2019	1	-	-	-	-	483	-	-	483	483	13	13	496
	2	178	-	178	-	2.166	-	-	2.166	2.344	8.832	8.832	11.176
	3	890	-	890	-	938	480	-	1.418	2.308	37.852	37.852	40.160

Table 12.2.3a. Norway pout in 4 and 3.aN (Skagerrak). Observed and SESAM model predicted total catches in tonnes by quarter (millions).

	Year	Observed	Predicted
1	1984.00	56790	66189
2	1984.25	56532	32363
3	1984.50	152291	109296
4	1984.75	110942	96446
5	1985.00	57467	45032
6	1985.25	15509	16068
7	1985.50	62489	62634
8	1985.75	92017	61836
9	1986.00	37773	25281
10	1986.25	7657	9459
11	1986.50	45085	36714
12	1986.75	89993	41492
13	1987.00	33883	28035
14	1987.25	15435	9023
15	1987.50	38729	37300
16	1987.75	60847	65295
17	1988.00	22181	22231
18	1988.25	3559	6681
19	1988.50	21793	18498
20	1988.75	61762	31367
21	1989.00	15379	13268
22	1989.25	13234	11057
23	1989.50	55066	37163
24	1989.75	82880	47057
25	1990.00	27984	24616
26	1990.25	39713	19935
27	1990.50	26156	30911
28	1990.75	45242	47681
29	1991.00	42722	29845
30	1991.25	20786	20872
31	1991.50	62518	59226
32	1991.75	64380	62750
33	1992.00	64218	49958
34	1992.25	27973	27916
35	1992.50	114122	87104
36	1992.75	96177	84366
37	1993.00	36214	46530
38	1993.25	29291	26496
39	1993.50	62290	59088

	Year	Observed	Predicted
40	1993.75	53470	49259
41	1994.00	34575	25791
42	1994.25	15373	14711
43	1994.50	53799	43821
44	1994.75	79838	42263
45	1995.00	36942	27598
46	1995.25	28019	19430
47	1995.50	69763	69488
48	1995.75	97048	61590
49	1996.00	21888	26743
50	1996.25	13366	15734
51	1996.50	74631	64059
52	1996.75	46194	40836
53	1997.00	15320	16893
54	1997.25	8708	10848
55	1997.50	78809	61063
56	1997.75	54100	50135
57	1998.00	19502	18974
58	1998.25	11836	12557
59	1998.50	20866	32059
60	1998.75	22830	25821
61	1999.00	7827	7609
62	1999.25	12533	7313
63	1999.50	41445	23484
64	1999.75	30497	30392
65	2000.00	10207	11692
66	2000.25	11589	13123
67	2000.50	44173	42648
68	2000.75	119001	64130
69	2001.00	21400	15309
70	2001.25	11778	9227
71	2001.50	4630	17768
72	2001.75	26565	32572
73	2002.00	8553	6443
74	2002.25	6686	4243
75	2002.50	32922	16489
76	2002.75	28947	20788
77	2003.00	3190	3415
78	2003.25	3106	1971
79	2003.50	10833	10892

	Year	Observed	Predicted
80	2003.75	7518	7831
81	2004.00	2040	1865
82	2004.25	667	749
83	2004.50	4018	5579
84	2004.75	6762	7609
85	2005.00	8	5
86	2005.25	8	5
87	2005.50	13	9
88	2005.75	13	11
89	2006.00	2205	1840
90	2006.25	2848	2466
91	2006.50	6551	8148
92	2006.75	34949	26975
93	2007.00	1428	482
94	2007.25	1100	1198
95	2007.50	2430	4507
96	2007.75	838	2315
97	2008.00	361	291
98	2008.25	1840	1590
99	2008.50	8532	5561
100	2008.75	24111	4282
101	2009.00	538	211
102	2009.25	2105	2911
103	2009.50	36661	16031
104	2009.75	6509	8531
105	2010.00	198	327
106	2010.25	40322	6138
107	2010.50	57487	24803
108	2010.75	33071	17207
109	2011.00	0	0
110	2011.25	222	1702
111	2011.50	3749	7665
112	2011.75	2872	7590
113	2012.00	29	56
114	2012.25	281	706
115	2012.50	469	2021
116	2012.75	26168	11747
117	2013.00	79	129
118	2013.25	10460	2747
119	2013.50	24444	12519

	Year	Observed	Predicted
120	2013.75	47126	39134
121	2014.00	1324	359
122	2014.25	3212	3953
123	2014.50	13384	15759
124	2014.75	26244	21054
125	2015.00	594	422
126	2015.25	7364	6514
127	2015.50	26804	27745
128	2015.75	22655	34595
129	2016.00	1089	580
130	2016.25	8846	6730
131	2016.50	23849	27638
132	2016.75	26457	26382
133	2017.00	735	374
134	2017.25	3475	5486
135	2017.50	13623	20312
136	2017.75	16107	26653
137	2018.00	379	136
138	2018.25	4143	5404
139	2018.50	9316	15834
140	2018.75	22292	16954
141	2019.00	284	79
142	2019.25	11181	7101
143	2019.50	40148	22236

Table 12.2.4. Norway pout in 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				2019			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	
0		0	0	7	11	0	0	24	638	0	0	1	
1		39	159	319	515	1	114	111	261	1	222	1628	
2		1	25	127	87	21	84	140	385	10	145	162	
3		0	4	40	7	1	8	17	0	4	11	11	
4+		0	0	0	0	0	0	0	0	0	0	0	
SOP		735	3474	13623	16107	379	4143	9316	22291	495	11179	40149	

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 in 4 and 3.aN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1984–2019, 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				2019			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	
Age 0			4,70	6,25			4,82					
1	18,17	17,11	23,69	24,11	6,05	15,56	25,62		4,57	9,82	6,00	
2	30,95	25,85	34,38	37,59	15,78	25,21	39,50		13,58	18,59	20,98	
3	23,69	27,21	41,52	49,92	28,59	30,13	48,75		33,25	29,36	33,83	
4											44,21	

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 in 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 in 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 (1987–2019) 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
2018		11	1	6	136	154	34		28	45	45
2019		20	18	5		43	17	24	36		51

Table 12.2.8. Norway pout in 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2019) 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		10,0	24,1		23,5
2011	OTB_DEF_16-31_2_40	0	5	75	0	80		20,2	29,2		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		30,7	31,1	60,8	39,5
2014	OTB_DEF_16-31_0_0	0	62	64	57	183		18,2	35,1	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	38,0
2015	OTB_DEF_16-31_2_40	5	38	235	192	470	28,7	41,0	42,5	55,6	47,6
2016	OTB_DEF_16-31_0_0	0	269	269	51	589		24,1	23,0	22,6	23,4
2016	OTB_DEF_16-31_2_40	23	37	357	80	497	24,9	23,5	38,6	45,8	38,0
2017	OTB_DEF_16-31_0_0	0	125	198	15	338		28,7	22,5	25,6	24,9
2017	OTB_DEF_16-31_2_40	0	1	105	87	193		8,8	37,8	51,2	43,7
2018	OTB_DEF_16-31_0_0	0	128	163	43	334		23,5	22,4		22,4
2018	OTB_DEF_16-31_2_40	0	17	112	233	362		27,8	35,3		41,2
2019	OTB_DEF_16-31_0_0	0	243	292	0	535		31,6	41,7		37,1
2019	OTB_DEF_16-31_2_40	0	44	135	0	179		36,1	44,0		42,1

Table 12.2.9. Norway pout 4 and 3.aN (Skagerak). 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 (1987–2019) 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
2018		35	86	12	21	154	38	40	30	81	45
2019		7	22	14		43	23	16	30		24

Table 12.2.10. Norway pout in 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2019) 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	30,9	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	39,8	35,2
2015	OTB_DEF_16-31_0_0	0	228	106	175	509		33,7	42,7	40,8	38,0
2015	OTB_DEF_16-31_2_40	0	0	103	367	470			49,7	47,0	47,6
2016	OTB_DEF_16-31_0_0	0	207	136	246	589		25,5	21,0	23,0	23,4
2016	OTB_DEF_16-31_2_40	0	18	72	407	497		28,3	42,8	37,6	38,0
2017	OTB_DEF_16-31_0_0	0	123	107	108	338		24,7	21,4	28,6	24,9
2017	OTB_DEF_16-31_2_40	0	9	86	98	193		51,9	41,1	45,2	43,7
2018	OTB_DEF_16-31_0_0	40	121	107	66	334	20,9	20,2	22,1	27,8	22,4
2018	OTB_DEF_16-31_2_40	14	26	63	259	362	36,2	46,6	34,4	42,5	41,2
2019	OTB_DEF_16-31_0_0	90	147	110	188	535	26,9	29,2	32,7	50,8	37,1
2019	OTB_DEF_16-31_2_40	0	0	55	124	179			48,2	39,3	42,1

Table 12.2.11. Norway pout in 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
1992	5,071	885	32	2,975	6,116	1,710	303	12	1,715	221	24	2,559	4,318	633	48

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
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	1,240	575	94	323	572	75	5	1,767	779	126	1	1,812	1,063	146	7
2004	894	375	34	278	557	109	6	731	719	175	19	773	647	153	12
2005	690	133	37	3,395	414	67	15	3,073	343	132	18	2,679	404	97	16
2006	3,369	142	26	1,813	1,996	124	20	1,127	1,285	69	9	1,391	1,809	191	12
2007	1,286	778	23	1,610	1,181	720	43	5,003	1,023	395	8	4,151	1,201	447	11
2008	2,353	512	180	628	1,340	411	104	3,456	1,263	263	57	3,035	1,643	274	58
2009	5,480	1,633	151	4,871	3,500	306	5	5,835	1,750	202	16	5,899	2,562	254	11
2010	4,941	1,466	138	103	4,257	559	13	1,449	5,101	930	29	833	4,757	861	22
2011	541	2.252	304	290	555	1,050	40	1,895	226	935	38	1,801	474	1123	60
2012	997	336	533	3,946	505	99	59	10,067	1,070	159	216	6,416	875	179	130
2013	4,466	519	97	498	2,592	117	19	1,754	2,888	107	22	1,315	2,831	124	13
2014	812	939	52	10,157	483	268	17	24,896	537	149	0	10,238	514	224	8
2015	6,704	494	141	1,415	4,320	60	15	10,208	6,568	118	0	3,511	4,051	76	20
2016	2,417	915	25	7,199	1,710	314	4	14,830	1,696	290	0	8,965	1,394	277	8
								7,478							

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
2017	4,357	401	174	1,280	5,061	134	38	20,632	1,906	77	2	4,234	2,551	116	21
2018	1,158	914	69	5,096	586	144	12	17,856	674	246	3	6,115	595	186	6
2019	3901	295	54	4,286	1,308	68	8		3,888	86	3				

[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 2000. The 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. In September 2019, the indices from 2013 onwards for all age groups were corrected with removal of a few invalid hauls (including also the Q3 2019 survey) resulting in very minor changes of the indices for all age groups not affecting the assessment.

Table 12.3.1. Norway pout in 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 2016–2019 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	2016-19 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2019)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2019)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	3+ (SESAM) (1984-2019)
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	1984-2019
	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	1992-2019
	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	1998-2019
	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	1991-2018
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

Table 12.3.2. Norway pout in 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 2019

Run: September 2019

The following parameters were used:

Year range:		1984 - 2019
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 in 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	42472	8828	404
1984.25	0	28992	4729	223
1984.5	37068	20090	2703	126
1984.75	0	11293	1066	71
1985	0	20048	5360	386
1985.25	0	13534	2485	204
1985.5	25786	9599	1410	118
1985.75	0	5598	543	67
1986	0	13589	2683	208
1986.25	0	9193	1340	114
1986.5	44841	6647	811	68
1986.75	0	4144	378	40
1987	0	25689	2180	177
1987.25	0	18412	1097	97
1987.5	9106	13651	657	59
1987.75	0	9045	320	35
1988	0	4626	4757	128
1988.25	0	3467	2747	71
1988.5	40400	2696	1835	42
1988.75	0	1954	1074	26
1989	0	22201	1203	522
1989.25	0	15986	754	315
1989.5	41711	11578	481	193
1989.75	0	7612	257	120
1990	0	22367	4430	197
1990.25	0	16181	2493	117
1990.5	53309	11480	1410	69
1990.75	0	7740	751	43
1991	0	29061	4800	393
1991.25	0	20827	2671	216
1991.5	90984	15381	1570	122
1991.75	0	10630	847	76
1992	0	50371	6985	476
1992.25	0	35859	4236	300
1992.5	48587	25937	2772	194
1992.75	0	16915	1575	120
1993	0	26197	10367	937
1993.25	0	18168	5744	574
1993.5	42684	12692	3351	358

Time\Age	0	1	2	3
1993.75	0	7889	1625	216
1994	0	22406	4663	865
1994.25	0	15365	2740	504
1994.5	118210	10813	1691	301
1994.75	0	7198	935	183
1995	0	65903	4670	654
1995.25	0	48189	2868	430
1995.5	45998	35044	1788	284
1995.75	0	23720	1031	179
1996	0	23462	15408	721
1996.25	0	17285	9452	441
1996.5	99101	12598	6066	271
1996.75	0	8752	3541	168
1997	0	55734	6087	2263
1997.25	0	40732	3850	1423
1997.5	19121	31575	2488	899
1997.75	0	22290	1416	563
1998	0	10676	15556	1179
1998.25	0	7973	9773	712
1998.5	34286	5880	6235	429
1998.75	0	4340	3722	271
1999	0	19980	3084	2423
1999.25	0	15160	2076	1543
1999.5	82929	11410	1351	973
1999.75	0	8244	774	600
2000	0	48992	5789	786
2000.25	0	37628	3850	489
2000.5	22710	29505	2534	302
2000.75	0	21118	1572	192
2001	0	12167	13723	1008
2001.25	0	8728	8534	636
2001.5	22130	6258	5398	400
2001.75	0	4500	3549	254
2002	0	12916	3034	2260
2002.25	0	9634	1902	1400
2002.5	18835	6965	1242	877
2002.75	0	4726	758	550
2003	0	9606	2988	749
2003.25	0	6637	1893	455
2003.5	7600	4575	1202	276

Time\Age	0	1	2	3
2003.75	0	3075	700	173
2004	0	4160	2073	477
2004.25	0	2993	1361	304
2004.5	6993	2259	905	195
2004.75	0	1573	557	123
2005	0	3923	1045	394
2005.25	0	2899	720	265
2005.5	28125	2160	494	177
2005.75	0	1641	334	116
2006	0	15860	1273	297
2006.25	0	11663	890	195
2006.5	19601	8715	602	127
2006.75	0	6468	366	80
2007	0	11005	4194	235
2007.25	0	8183	2769	156
2007.5	28739	6026	1820	104
2007.75	0	4456	1184	68
2008	0	16337	3412	848
2008.25	0	12406	2381	548
2008.5	42128	9384	1622	355
2008.75	0	7164	1042	223
2009	0	26631	5224	817
2009.25	0	20320	3494	511
2009.5	64106	15874	2298	317
2009.75	0	12123	1364	200
2010	0	38198	9398	985
2010.25	0	30283	7076	632
2010.5	5740	22772	4903	401
2010.75	0	16100	3083	253
2011	0	3287	11143	2087
2011.25	0	2453	7141	1329
2011.5	9867	1907	4840	852
2011.75	0	1432	3173	542
2012	0	5680	1074	2486
2012.25	0	4300	742	1664
2012.5	50298	3329	521	1114
2012.75	0	2598	356	725
2013	0	28690	1825	678
2013.25	0	21635	1288	434
2013.5	13933	15460	875	275

Time\Age	0	1	2	3
2013.75	0	10552	539	174
2014	0	7589	6442	382
2014.25	0	5482	4005	239
2014.5	86685	3952	2456	149
2014.75	0	2819	1382	91
2015	0	46426	1827	783
2015.25	0	32598	1161	493
2015.5	31761	22531	722	307
2015.75	0	14285	382	187
2016	0	16721	8652	308
2016.25	0	11485	5472	196
2016.5	58187	7633	3348	123
2016.75	0	4661	1831	75
2017	0	30891	2680	997
2017.25	0	21045	1692	631
2017.5	20599	14329	1054	394
2017.75	0	9338	583	243
2018	0	10507	5788	448
2018.25	0	7532	3585	276
2018.5	57745	5307	2152	166
2018.75	0	3867	1214	102
2019	0	30008	2649	678
2019.25	0	22406	1854	438
2019.5	80528	16320	1170	273
2019.75	0	11537	664	170

Table 12.3.4. Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated fishing mortalities by quarter of year. (The last 2019 quarter 4 F-value is a projection of F based on the population estimate by end of 3rd quarter).

Year\Age	0	1	2	3+
1984	0.001	0.382	1.093	0.571
1984.25	0.000	0.294	0.771	0.438
1984.5	0.011	1.104	2.185	0.462
1984.75	0.202	1.783	2.965	0.089
1985	0.001	0.453	1.295	0.676
1985.25	0.000	0.214	0.562	0.319
1985.5	0.010	1.035	2.050	0.434
1985.75	0.199	1.755	2.918	0.087
1986	0.001	0.402	1.151	0.600
1986.25	0.000	0.158	0.413	0.235
1986.5	0.007	0.724	1.433	0.303
1986.75	0.152	1.337	2.224	0.067
1987	0.001	0.357	1.020	0.533
1987.25	0.000	0.134	0.350	0.199
1987.5	0.006	0.582	1.153	0.244
1987.75	0.173	1.525	2.536	0.076
1988	0.000	0.276	0.788	0.411
1988.25	0.000	0.118	0.310	0.176
1988.5	0.004	0.433	0.857	0.181
1988.75	0.117	1.028	1.709	0.051
1989	0.000	0.217	0.619	0.323
1989.25	0.000	0.181	0.475	0.270
1989.5	0.005	0.534	1.057	0.224
1989.75	0.113	1.001	1.665	0.050
1990	0.000	0.262	0.748	0.390
1990.25	0.000	0.249	0.654	0.371
1990.5	0.005	0.469	0.928	0.196
1990.75	0.092	0.808	1.344	0.040
1991	0.000	0.284	0.812	0.424
1991.25	0.000	0.210	0.551	0.313
1991.5	0.005	0.473	0.936	0.198
1991.75	0.082	0.721	1.200	0.036
1992	0.000	0.254	0.726	0.379
1992.25	0.000	0.173	0.452	0.257
1992.5	0.005	0.468	0.926	0.196
1992.75	0.079	0.696	1.157	0.035
1993	0.000	0.226	0.645	0.336
1993.25	0.000	0.170	0.446	0.253

Year\Age	0	1	2	3+
1993.5	0.005	0.539	1.068	0.226
1993.75	0.086	0.755	1.255	0.038
1994	0.000	0.219	0.627	0.327
1994.25	0.000	0.149	0.392	0.223
1994.5	0.005	0.477	0.944	0.200
1994.75	0.060	0.533	0.887	0.027
1995	0.000	0.151	0.432	0.225
1995.25	0.000	0.128	0.335	0.190
1995.5	0.003	0.331	0.655	0.139
1995.75	0.050	0.442	0.736	0.022
1996	0.000	0.111	0.316	0.165
1996.25	0.000	0.088	0.232	0.132
1996.5	0.004	0.382	0.755	0.160
1996.75	0.044	0.386	0.642	0.019
1997	0.000	0.088	0.253	0.132
1997.25	0.000	0.063	0.166	0.094
1997.5	0.004	0.371	0.734	0.155
1997.75	0.047	0.417	0.693	0.021
1998	0.000	0.082	0.235	0.123
1998.25	0.000	0.079	0.207	0.117
1998.5	0.003	0.300	0.593	0.125
1998.75	0.046	0.404	0.673	0.020
1999	0.000	0.068	0.196	0.102
1999.25	0.000	0.088	0.231	0.131
1999.5	0.003	0.318	0.630	0.133
1999.75	0.054	0.473	0.787	0.024
2000	0.000	0.066	0.188	0.098
2000.25	0.000	0.071	0.187	0.106
2000.5	0.002	0.227	0.449	0.095
2000.75	0.060	0.527	0.877	0.026
2001	0.000	0.075	0.214	0.112
2001.25	0.000	0.063	0.166	0.094
2001.5	0.001	0.145	0.286	0.061
2001.75	0.052	0.460	0.765	0.023
2002	0.000	0.071	0.202	0.105
2002.25	0.000	0.052	0.136	0.077
2002.5	0.003	0.254	0.503	0.106
2002.75	0.062	0.550	0.916	0.027
2003	0.000	0.048	0.136	0.071
2003.25	0.000	0.039	0.102	0.058

Year\Age	0	1	2	3+
2003.5	0.002	0.235	0.465	0.098
2003.75	0.047	0.419	0.697	0.021
2004	0.000	0.038	0.108	0.056
2004.25	0.000	0.023	0.062	0.035
2004.5	0.002	0.189	0.375	0.079
2004.75	0.047	0.414	0.690	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	0.001	0.001	0.000
2006	0.000	0.022	0.087	0.037
2006.25	0.000	0.046	0.143	0.074
2006.5	0.001	0.123	0.367	0.081
2006.75	0.041	0.630	1.163	0.028
2007	0.000	0.004	0.015	0.005
2007.25	0.000	0.019	0.053	0.025
2007.5	0.000	0.036	0.112	0.023
2007.75	0.002	0.032	0.061	0.001
2008	0.000	0.002	0.008	0.003
2008.25	0.000	0.020	0.057	0.026
2008.5	0.000	0.060	0.186	0.039
2008.75	0.003	0.067	0.128	0.003
2009	0.000	0.001	0.005	0.002
2009.25	0.000	0.021	0.057	0.026
2009.5	0.000	0.114	0.355	0.075
2009.75	0.004	0.080	0.152	0.003
2010	0.000	0.001	0.002	0.001
2010.25	0.000	0.027	0.074	0.034
2010.5	0.000	0.102	0.317	0.067
2010.75	0.006	0.121	0.229	0.005
2011	0.000	0.001	0.002	0.001
2011.25	0.000	0.009	0.026	0.012
2011.5	0.000	0.059	0.184	0.039
2011.75	0.007	0.143	0.270	0.005
2012	0.000	0.001	0.002	0.001
2012.25	0.000	0.012	0.033	0.015
2012.5	0.000	0.049	0.152	0.032
2012.75	0.019	0.390	0.740	0.015
2013	0.000	0.001	0.004	0.001
2013.25	0.000	0.029	0.081	0.037

Year\Age	0	1	2	3+
2013.5	0.000	0.127	0.395	0.083
2013.75	0.028	0.566	1.073	0.021
2014	0.000	0.003	0.010	0.004
2014.25	0.000	0.033	0.092	0.043
2014.5	0.001	0.186	0.578	0.122
2014.75	0.024	0.497	0.941	0.019
2015	0.000	0.003	0.012	0.004
2015.25	0.000	0.043	0.118	0.054
2015.5	0.001	0.245	0.762	0.160
2015.75	0.023	0.477	0.905	0.018
2016	0.000	0.003	0.012	0.004
2016.25	0.000	0.055	0.151	0.070
2016.5	0.001	0.243	0.756	0.159
2016.75	0.025	0.504	0.955	0.019
2017	0.000	0.002	0.007	0.003
2017.25	0.000	0.051	0.142	0.066
2017.5	0.001	0.212	0.660	0.139
2017.75	0.024	0.484	0.918	0.018
2018	0.000	0.002	0.006	0.002
2018.25	0.000	0.069	0.192	0.089
2018.5	0.001	0.195	0.607	0.128
2018.75	0.024	0.491	0.930	0.018
2019	0.000	0.001	0.005	0.002
2019.25	0.000	0.102	0.282	0.131
2019.5	0.001	0.227	0.707	0.149
2019.75	0.024	0.491	0.930	0.018

Table 12.3.5. Norway pout in 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	0.13859	0.08769	0.21902
2	2	2	0.22721	0.13045	0.39577
3	2	3	0.22803	0.09241	0.56267
4	3	0	0.07618	0.04512	0.12860
5	3	1	0.21265	0.12346	0.36627
6	4	0	0.17593	0.10141	0.30521
7	4	1	0.22244	0.12552	0.39420
8	5	2	0.20429	0.10078	0.41411
9	5	3	0.09207	0.03481	0.24354

Table 12.3.5 (cont.). Norway pout in 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	1198.50	19
Current	1198.50	19

Table 12.3.6. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2019. 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				313315	152056	474573	619116	330431	907802	1.322	0.804	2.174
1984.25				198963	95262	302664	477287	239145	715430			
1984.5	37068	20039	68569	216131	102126	330137	617930	296195	939665			
1984.75				103230	42408	164051	329094	144957	513230			
1985				185506	87759	283253	329852	177753	481950	1.285	0.758	2.18
1985.25				104824	47189	162459	234752	117931	351573			
1985.5	25786	14006	47473	111514	52145	170882	303506	149447	457565			
1985.75				53578	20873	86283	165546	73065	258027			
1986				99859	45869	153850	197696	101062	294331	0.98	0.576	1.668
1986.25				61273	26234	96312	149530	71070	227991			
1986.5	44841	23994	83800	69781	31291	108272	202722	95330	310114			
1986.75				38189	14861	61517	121080	52495	189665			
1987				107822	53659	161985	292784	142083	443484	0.957	0.532	1.722
1987.25				76438	35810	117065	253189	114882	391496			
1987.5	9106	4734	17516	98055	46381	149729	371083	167388	574777			
1987.75				60076	26062	94089	240978	103234	378722			
1988				132364	51087	213641	165672	75373	255972	0.69	0.407	1.169
1988.25				80535	27526	133544	113818	49827	177809			
1988.5	40400	21731	75108	89390	29577	149203	143314	63978	222649			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1988.75				54211	13979	94444	93300	37446	149153			
1989				90922	40940	140905	250766	116577	384956	0.719	0.419	1.233
1989.25				72974	30929	115018	226437	101865	351010			
1989.5	41711	22409	77638	88716	38895	138536	320289	142847	497730			
1989.75				55293	22274	88312	207545	88763	326328			
1990				158911	75173	242649	319955	162639	477271	0.683	0.396	1.179
1990.25				106994	48508	165479	262328	125899	398756			
1990.5	53309	28577	99444	117957	52636	183278	347553	160735	534371			
1990.75				71218	28715	113720	226014	98946	353082			
1991				188025	89609	286441	397266	198449	596082	0.649	0.374	1.125
1991.25				127567	57868	197267	327510	153950	501070			
1991.5	90984	48688	170021	147033	66415	227651	454656	207501	701812			
1991.75				91417	37255	145579	304032	131600	476464			
1992				284350	135865	432835	647020	314167	979873	0.607	0.346	1.063
1992.25				206965	92312	321619	551216	252348	850085			
1992.5	48587	26369	89528	252248	109322	395173	771002	344879	1197124			
1992.75				154545	58597	250492	492844	206684	779004			
1993				343816	141931	545702	532435	251055	813815	0.638	0.327	1.245
1993.25				215904	82086	349723	390316	176139	604492			
1993.5	42684	22763	80037	218995	83711	354279	472848	214169	731528			
1993.75				116964	35733	198196	274744	111165	438322			
1994				191516	74830	308203	352836	157713	547960	0.529	0.278	1.004
1994.25				130568	45907	215230	278077	117119	439034			
1994.5	118210	62431	223826	139790	50946	228634	356045	150660	561429			
1994.75				83995	24457	143533	227956	85086	370826			
1995				261517	110844	412190	736017	310271	1161762	0.401	0.207	0.778
1995.25				208831	82680	334981	671449	268551	1074347			
1995.5	45998	23976	88246	263803	103403	424203	964685	380076	1549293			
1995.75				170206	59684	280727	644605	235565	1053646			
1996				456270	163855	748685	625195	260254	990137	0.364	0.184	0.718
1996.25				299826	99934	499717	465761	187606	743916			
1996.5	99101	51692	189988	321881	103849	539913	573836	229802	917869			
1996.75				195122	44605	345639	370166	123663	616668			
1997				343014	121228	564799	744295	299220	1189371	0.348	0.173	0.699
1997.25				265145	88999	441292	656175	256300	1056051			
1997.5	19121	9880	37004	311312	111684	510939	942814	367130	1518498			
1997.75				200764	60384	341143	646578	222395	1070761			
1998				455253	142855	767652	532119	189241	874998	0.322	0.161	0.644
1998.25				299036	87477	510594	375581	131186	619975			
1998.5	34286	18309	64205	304553	85815	523290	422163	150369	693956			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1998.75				186295	37334	335256	273097	80496	465699			
1999				209987	58085	361889	353842	129642	578041	0.349	0.171	0.711
1999.25				165424	41592	289256	310957	111251	510662			
1999.5	82929	43913	156610	169439	47671	291207	397638	149376	645899			
1999.75				106986	25501	188472	271870	91015	452725			
2000				264359	98168	430550	617099	250363	983836	0.324	0.155	0.676
2000.25				211005	76083	345926	572233	223684	920781			
2000.5	22710	11889	43379	266995	96447	437542	857091	324297	1389885			
2000.75				179598	57113	302082	601956	207000	996912			
2001				405289	122301	688276	492889	170633	815145	0.272	0.127	0.581
2001.25				266077	73740	458415	349862	118093	581632			
2001.5	22130	11566	42342	271196	72886	469507	396357	137019	655694			
2001.75				179223	38123	320323	269227	82192	456263			
2002				189498	46504	332493	282497	91242	473751	0.335	0.149	0.755
2002.25				140679	30369	250990	233170	72600	393741			
2002.5	18835	9472	37453	137143	34031	240255	276444	94540	458347			
2002.75				85865	17091	154639	180385	55326	305445			
2003				121947	34804	209091	191110	66562	315657	0.268	0.114	0.629
2003.25				85997	23388	148605	149712	52149	247275			
2003.5	7600	3873	14913	87509	25719	149298	179019	66186	291852			
2003.75				53407	12688	94126	114921	37582	192259			
2004				78377	22435	134320	108333	36797	179868	0.237	0.095	0.595
2004.25				56420	14765	98076	85153	27986	142320			
2004.5	6993	3598	13589	59204	16058	102350	104390	35572	173208			
2004.75				37301	7997	66606	68771	20401	117141			
2005				48967	12668	85266	77214	25488	128939	0.001	0	0.001
2005.25				38200	9210	67191	66031	21466	110596			
2005.5	28125	14491	54584	41194	10699	71689	84394	28866	139923			
2005.75				28279	7117	49441	61096	20323	101868			
2006				72270	28565	115974	186460	72898	300023	0.323	0.112	0.93
2006.25				60003	22689	97318	171966	65275	278657			
2006.5	19601	9976	38515	75262	27847	122678	249561	92470	406652			
2006.75				51610	17110	86111	180975	60518	301432			
2007				134057	36169	231945	213293	71686	354900	0.042	0.017	0.102
2007.25				96689	25641	167737	175247	58404	292090			
2007.5	28739	14669	56304	109181	28802	189561	229700	76119	383280			
2007.75				73577	17128	130026	162710	49485	275934			
2008				148613	48065	249162	266242	97499	434984	0.066	0.029	0.151
2008.25				116717	35575	197859	235812	82527	389097			
2008.5	42128	21368	83059	133090	39867	226313	320768	108937	532598			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2008.75				90443	23852	157035	233728	70470	396986			
2009				211205	69854	352557	402951	148849	657054	0.098	0.041	0.234
2009.25				161683	52965	270401	356752	129301	584204			
2009.5	64106	32840	125140	190314	62573	318055	507797	179594	836001			
2009.75				126809	36103	217514	369276	115377	623175			
2010				343116	112789	573443	618142	229069	1007216	0.109	0.047	0.251
2010.25				281188	84043	478334	571906	196051	947762			
2010.5	5740	2892	11394	334036	95356	572717	789487	260940	1318034			
2010.75				218498	52153	384844	540508	161262	919753			
2011				367961	102466	633456	391625	115270	667979	0.087	0.035	0.213
2011.25				250856	65837	435876	274408	78287	470529			
2011.5	9867	5076	19180	254269	62626	445913	292409	82134	502683			
2011.75				165517	32503	298531	194157	46529	341785			
2012				136514	27685	245342	177413	48463	306363	0.172	0.069	0.434
2012.25				112054	19138	204970	153339	39952	266726			
2012.5	50298	25752	98240	104308	19248	189369	170885	50195	291575			
2012.75				69243	11453	127033	121211	33876	208546			
2013				124393	41706	207081	330958	118186	543730	0.284	0.106	0.765
2013.25				105801	34924	176677	313499	109012	517986			
2013.5	13933	7133	27214	128786	44896	212676	437993	158063	717923			
2013.75				84413	27489	141336	295465	103212	487718			
2014				189993	56280	323706	244632	84462	404802	0.292	0.11	0.776
2014.25				125245	38543	211948	177874	65057	290692			
2014.5	86685	42468	176941	126914	40248	213580	205967	78726	333208			
2014.75				74686	17504	131868	131075	42395	219755			
2015				160571	52379	268763	494836	165397	824275	0.321	0.114	0.9
2015.25				131889	44905	218872	444831	155348	734315			
2015.5	31761	15237	66206	159966	58528	261403	610581	224969	996193			
2015.75				97555	31768	163342	383265	133004	633525			
2016				258722	81289	436155	379110	135737	622482	0.335	0.118	0.948
2016.25				174191	56803	291580	284443	106604	462281			
2016.5	58187	28401	119212	179438	59347	299529	332107	128377	535838			
2016.75				100870	21883	179857	194090	61841	326340			
2017				162466	47984	276949	384879	129919	639839	0.31	0.11	0.873
2017.25				124330	37969	210691	326363	115596	537130			
2017.5	20599	10336	41054	137414	46291	228537	424000	157294	690706			
2017.75				84099	23624	144574	270872	91122	450621			
2018				181528	52321	310735	257178	89891	424465	0.311	0.111	0.87
2018.25				121501	35973	207029	193808	70579	317036			
2018.5	57745	28564	116737	122598	35854	209341	228732	83569	373895			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2018.75				73774	15089	132459	151110	45404	256817			
2019				147363	44276	250451	363418	125911	600925			
2019.25				122012	36264	207760	337108	111767	562449			
2019.5	80528	32061	202264	144812	41631	247992	471211	142708	799714			
2019.75				94420	19176	169664	325157	71421	578894			

Table 12.3.6 (cont). Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2019. 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 (F_{bar} = F12) for the period 1984–2019. (Numbers are given for start of the season).

	value
Avg. recruitment	41956.37
Avg SSB Q 1	210268.26
Avg SSB Q 2	150105.70
Avg SSB Q 3	166228.52
Avg SSB Q 4	103091.02
Avg TSB Q 1	377142.92
Avg TSB Q 2	311608.39
Avg TSB Q 3	411971.52
Avg TSB Q 4	270538.99
Avg. FBAR	0.43

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	2.887	6.865	5.025	6.632
1	7.328	11.157	21.530	24.360
2	19.846	22.567	30.520	34.203
3	30.787	30.893	37.560	41.511

Table 12.6.2. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that the fifth percentile of the SSB distribution one year a head (1st October 2020) equals B_{lim}.
Basis:
F (2019 up to Q4) = estimated from in year assessment 1st October 2019, F(age,quarter1,2,3 2019), Table 12.3.4.
SSB (2019 up to Q4) = estimated from in year assessment 1st October 2019 (start Q4) = 94 420 tonnes;
R(2019) = estimated / observed from in year assessment 1st July 2019 (age 0 in start of Q3) = 80 528 million;
Biological parameters (2019-2020): 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 2019- Q4 2020): (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 so 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
2019.75	1.67	96.81	50.59	74610.67
2020	0.01	261.23	106.60	511.26
2020.25	0.46	207.62	82.36	32473.00
2020.5	1.09	237.04	85.92	77809.50
2020.75		131.13	39.45	
Sum				185404.42

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 2019 to 1st October 2020.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	0.00	96.81	50.59	0.00
2020	0.00	334.02	165.68	0.00
2020.25	0.00	261.34	121.30	0.00
2020.5	0.00	322.07	143.22	0.00
2020.75		228.02	97.58	
Sum				0.00

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 2019.
Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2019.75	0.72	96.81	50.59	34944.41
2020	0.00	298.52	136.81	246.21
2020.25	0.20	235.01	101.84	15832.54
2020.5	0.47	277.82	114.60	40233.71
2020.75		176.07	63.73	
Sum				91256.86

Table 12.6.5. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that the median of the SSB distribution one year a head (1st October 2020) equals B_{lim}.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	7.40	96.81	50.59	215140.72
2020	0.03	148.44	45.51	1413.64
2020.25	2.04	126.51	39.39	87266.33
2020.5	4.85	117.07	29.90	154394.73
2020.75		39.45	6.37	
Sum				458215.42

Table 12.6.6. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that SSB one year a head (1st October 2020) equals B_{pa}.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	4.69	96.81	50.59	163998.21
2020	0.02	187.64	60.68	1077.90
2020.25	1.29	154.91	51.04	67273.46
2020.5	3.07	155.41	44.89	135091.24
2020.75		65.00	13.47	
Sum				367440.81

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 2019 to 1st October 2020.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	0.63	96.81	50.59	30864.31
2020	0.00	302.35	140.67	217.86
2020.25	0.17	238.31	103.82	13971.87
2020.5	0.41	282.57	117.76	35915.43
2020.75		181.77	67.00	
Sum				80969.47

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 2019 to 1st October 2020.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	0.84	96.81	50.59	40285.52
2020	0.00	293.80	131.93	282.93
2020.25	0.23	231.46	99.24	18153.46
2020.5	0.55	271.39	110.78	45643.74
2020.75		168.84	59.83	
Sum				104365.64

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 2019 to 1st October 2020.
Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	1.04	96.81	50.59	49362.15
2020	0.00	285.88	124.99	344.16
2020.25	0.29	225.26	94.69	22025.82
2020.5	0.68	262.13	103.33	54764.83
2020.75		158.05	53.33	
Sum				126496.96

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 2019 to 1st October 2020. Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	1.25	96.81	50.59	58141.86
2020	0.01	277.21	118.03	403.32
2020.25	0.35	218.70	90.27	25763.26
2020.5	0.82	253.07	97.19	63284.22
2020.75		148.35	48.22	
Sum				147592.66

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 2019 to 1st October 2020. Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2019.75	1.46	96.81	50.59	66567.79
2020	0.01	268.89	112.40	458.39
2020.25	0.40	213.05	86.65	29266.67
2020.5	0.96	245.34	90.98	70812.91
2020.75		139.13	43.61	
Sum				167105.76

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 B_{loss} estimates which equals B_{lim} according to the ICES WKPOUT 2016 benchmark assessment which by 1st October is B_{lim} = 39 450 t.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

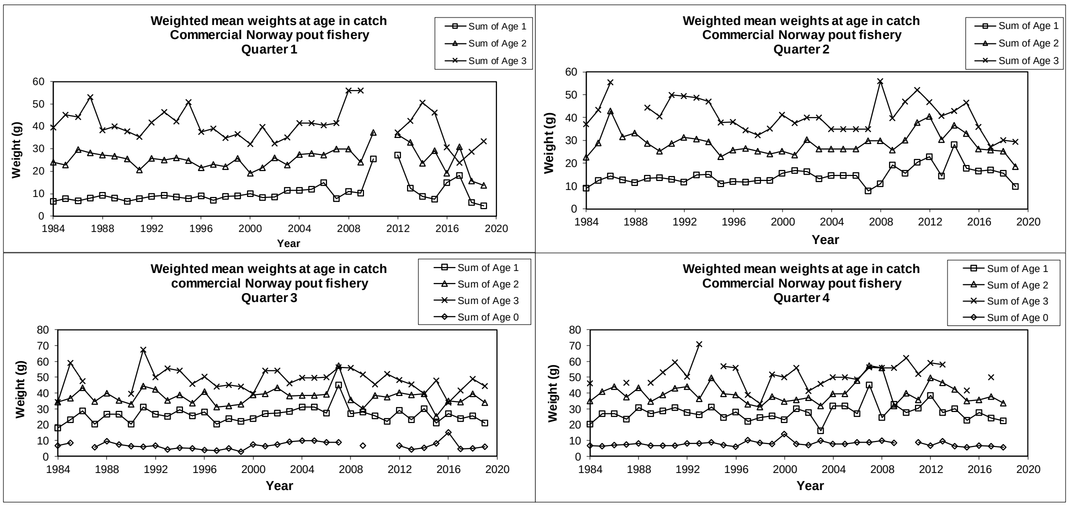

Figure 12.2.1. Norway pout in 4 and 3.aN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1984–2019.

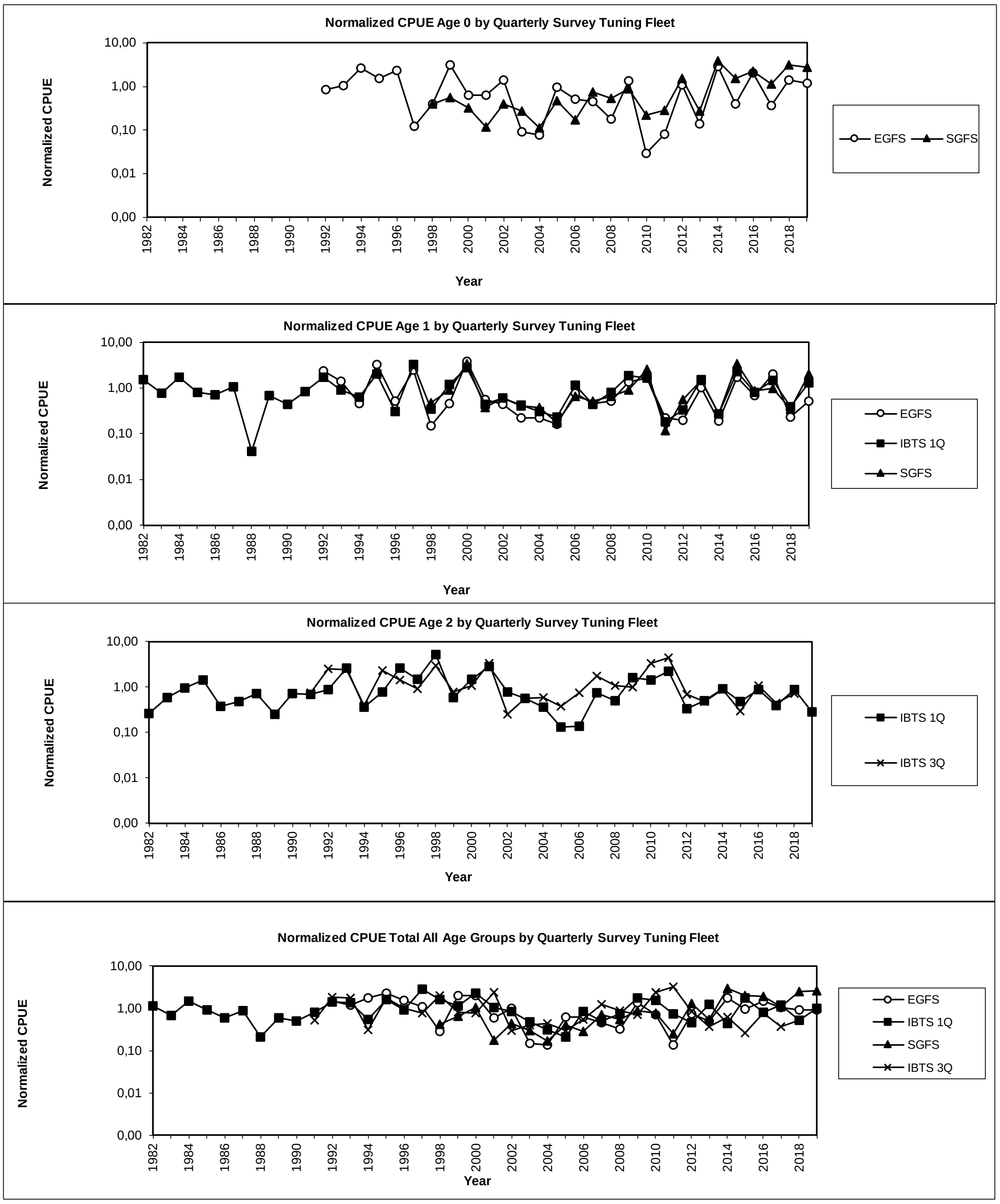

Figure 12.2.2 Norway pout in 4 and 3.aN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly survey tuning fleet used in the Norway pout assessment for each age group and all age groups together.

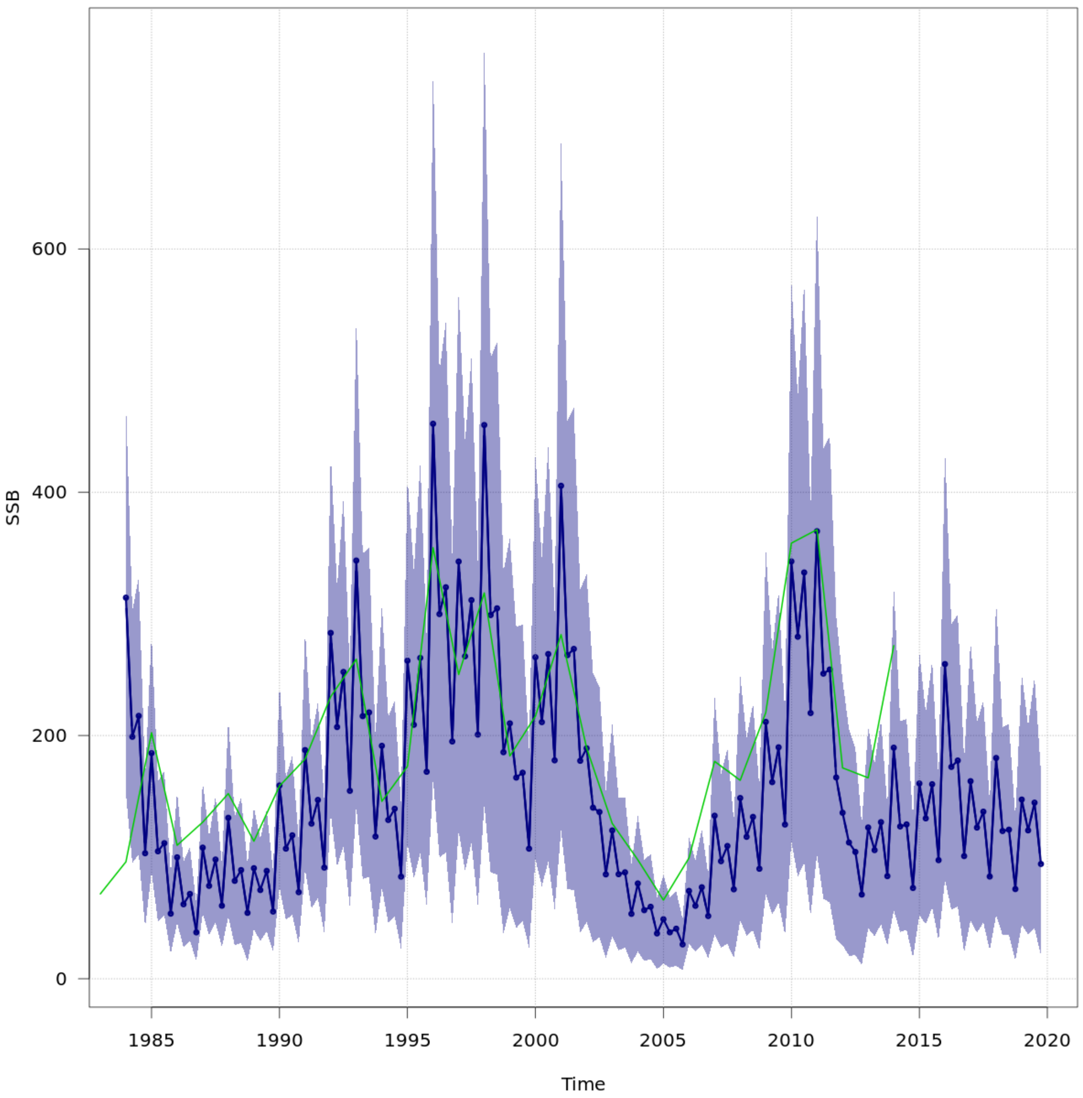

Figure 12.3.1. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: SSB (t), quarterly. SESAM baseline run September 2019. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only – connecting lines are interpolations).

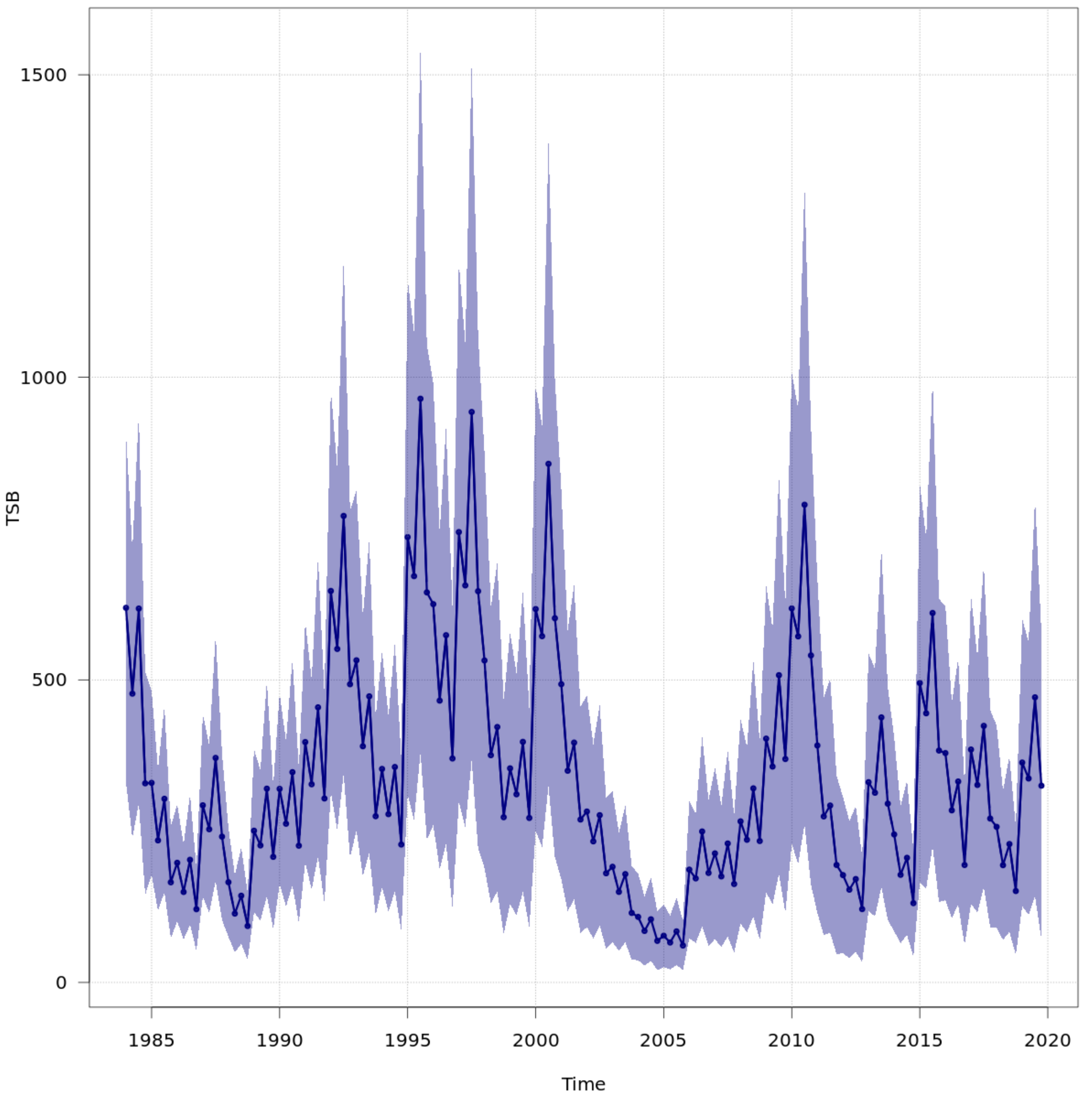

Figure 12.3.2. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: TSB (t), quarterly. SESAM baseline run September 2019.

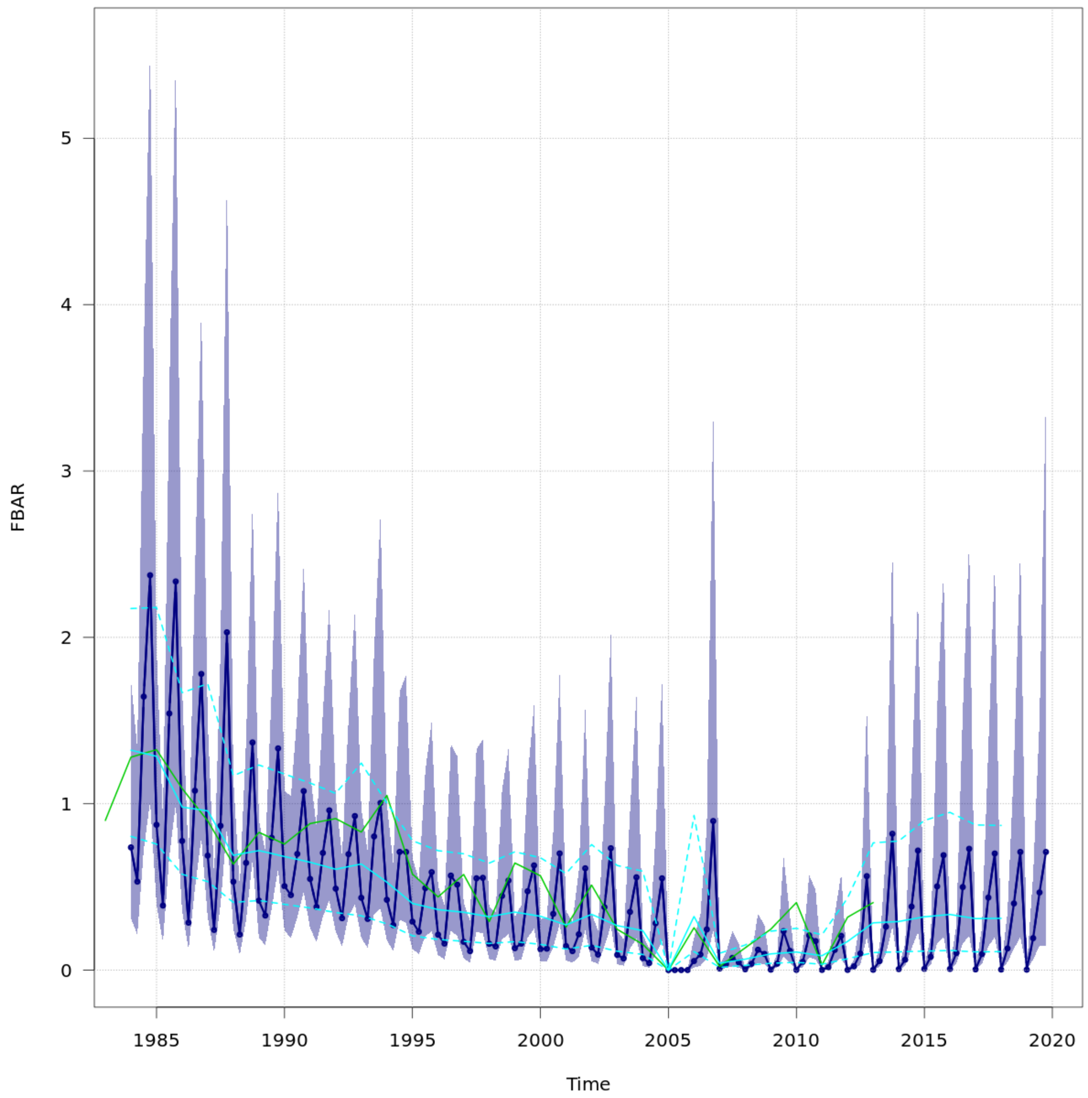

Figure 12.3.3. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: $F_{1-2} = F_{bar}$, quarterly. SESAM baseline run September 2018. Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

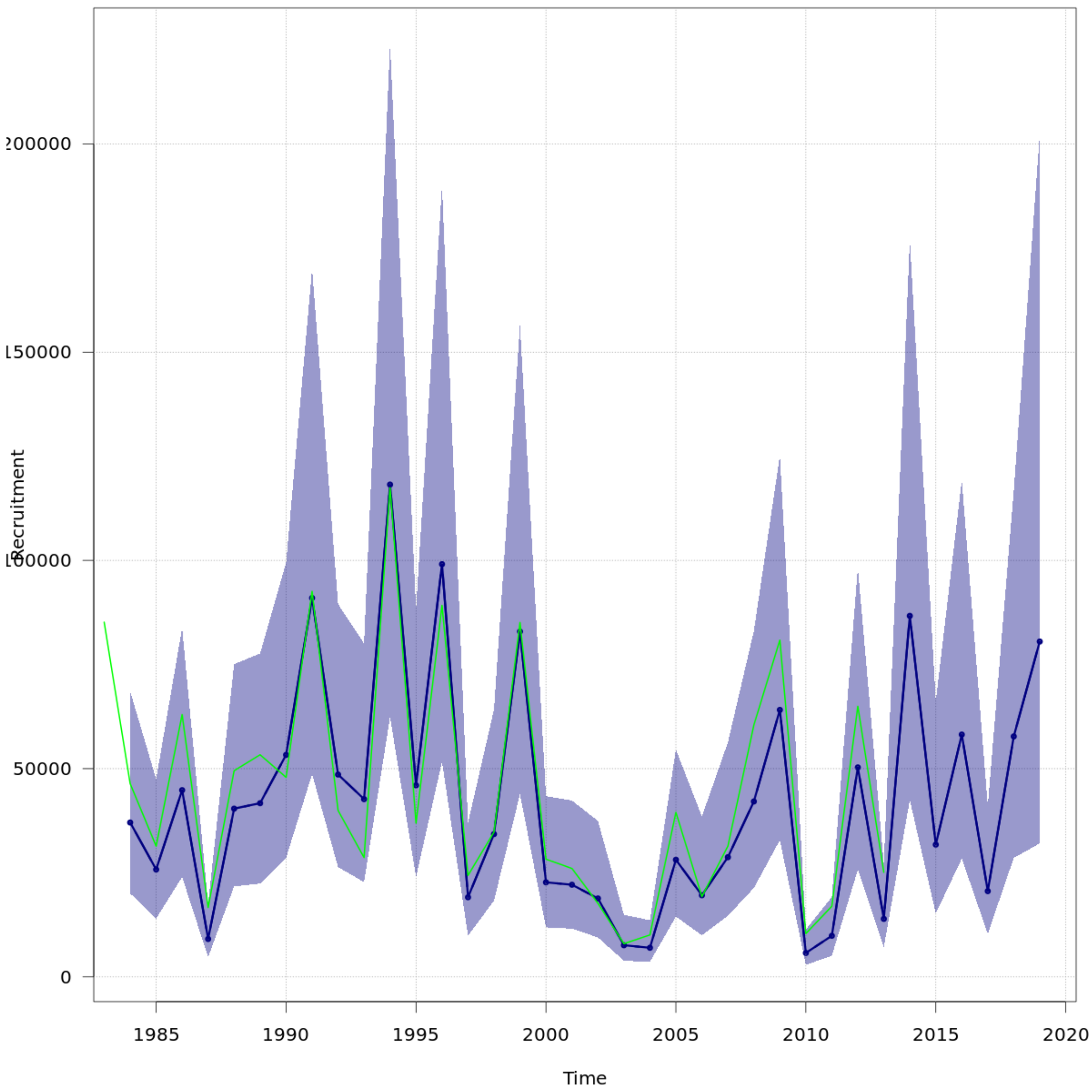

Figure 12.3.4. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Recruitment (millions), yearly. SESAM baseline run September 2018. Blue is SESAM, green is SXSA.

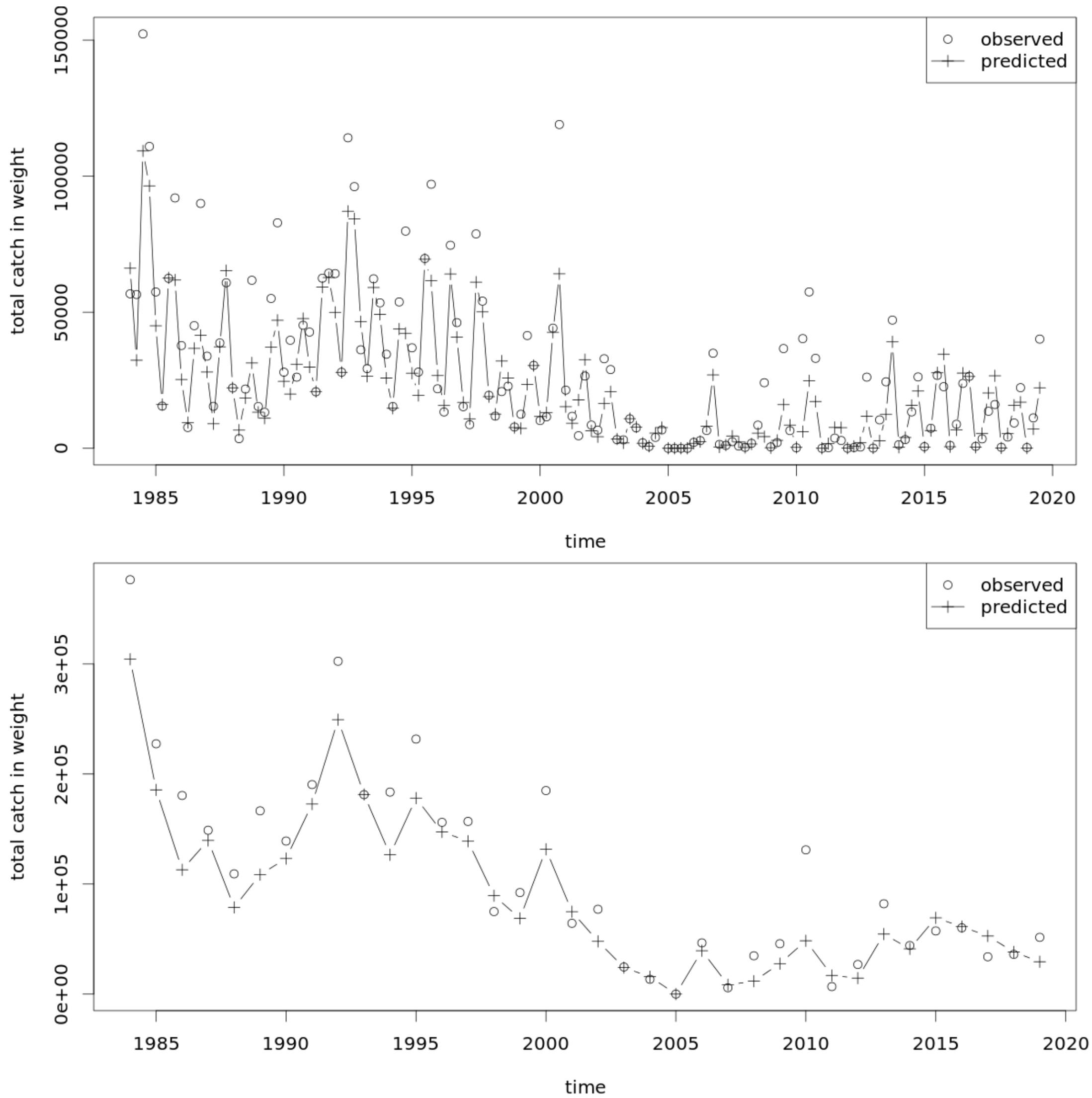

Figure 12.3.5. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Yield = Total Catch (t), quarterly and yearly. SESAM baseline run September 2019.

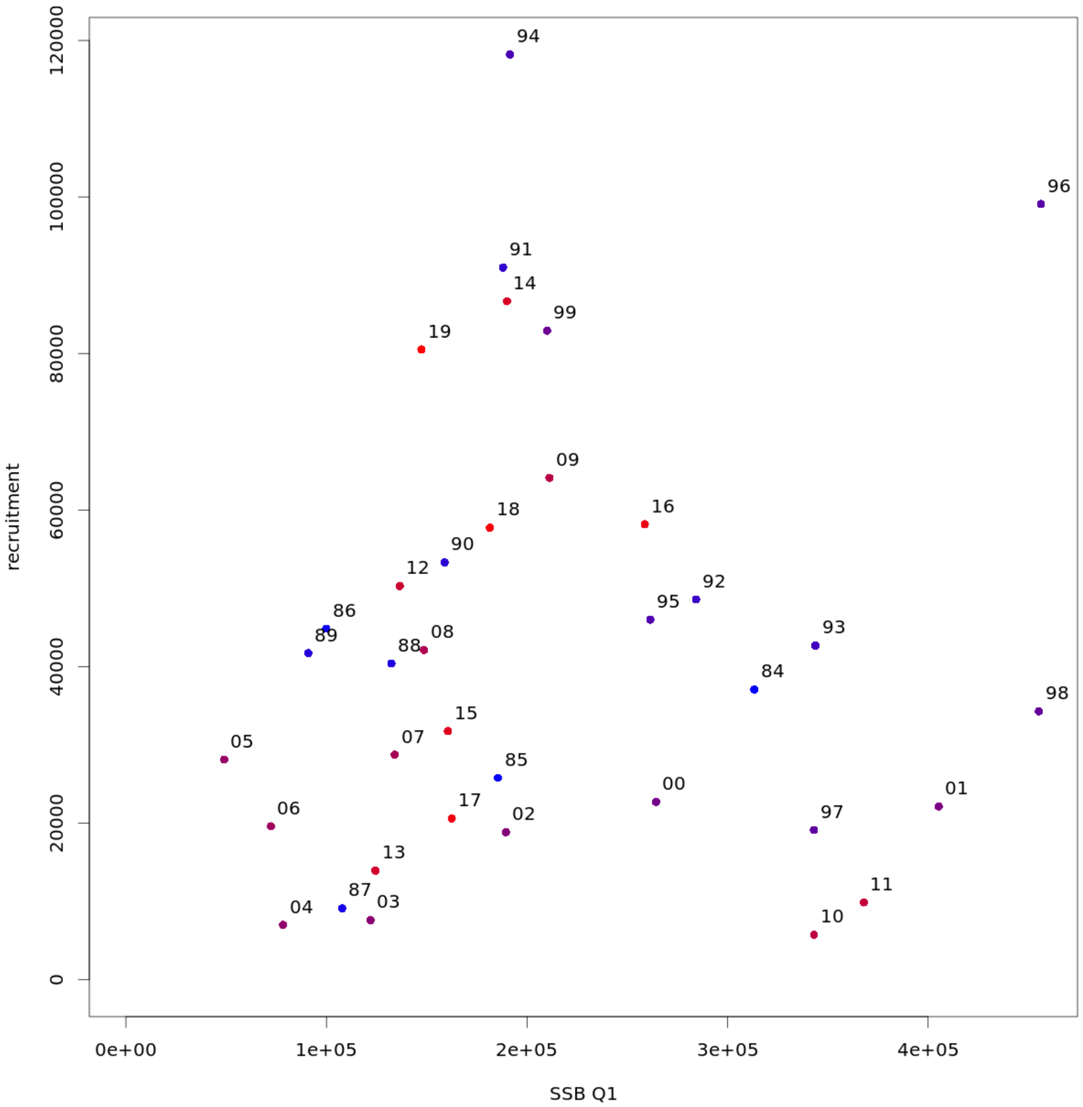

Figure 12.3.6. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 1. SESAM baseline run September 2019.

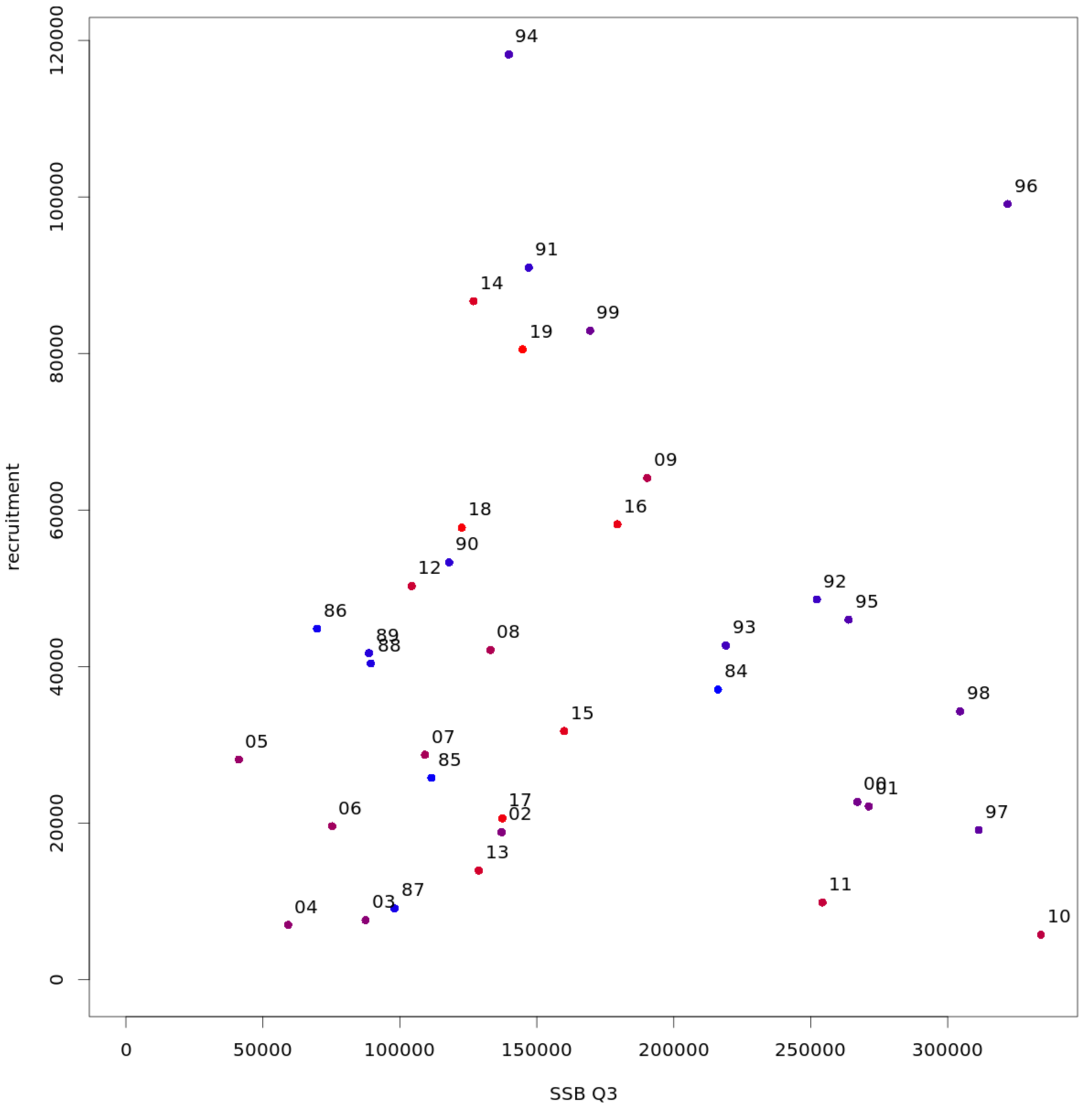

Figure 12.3.7. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 3. SESAM baseline run September 2019.

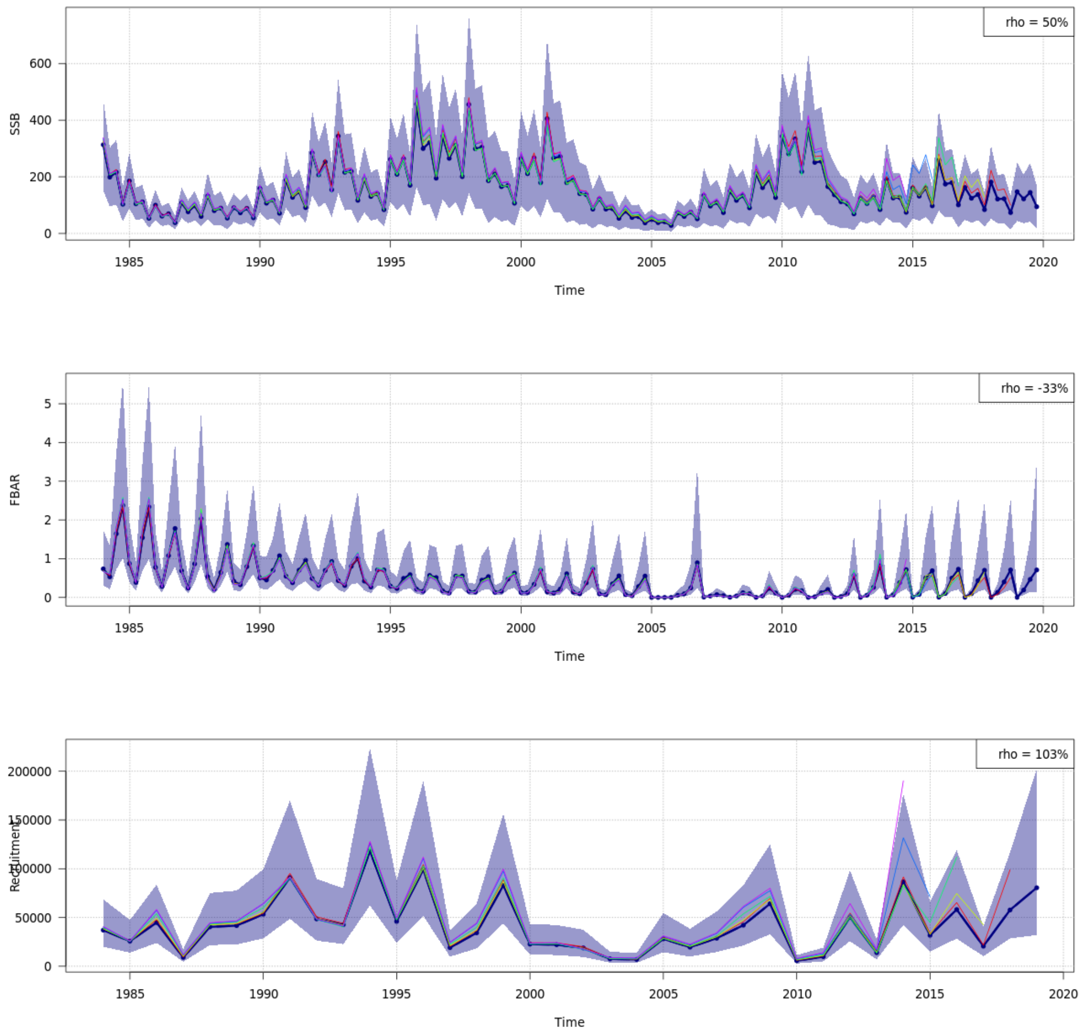

Figure 12.3.8 Norway pout in 4 and 3.aN (Skagerrak). Retrospective plots of baseline SESAM assessment September 2019, with terminal assessment year ranging from 2005–2019.

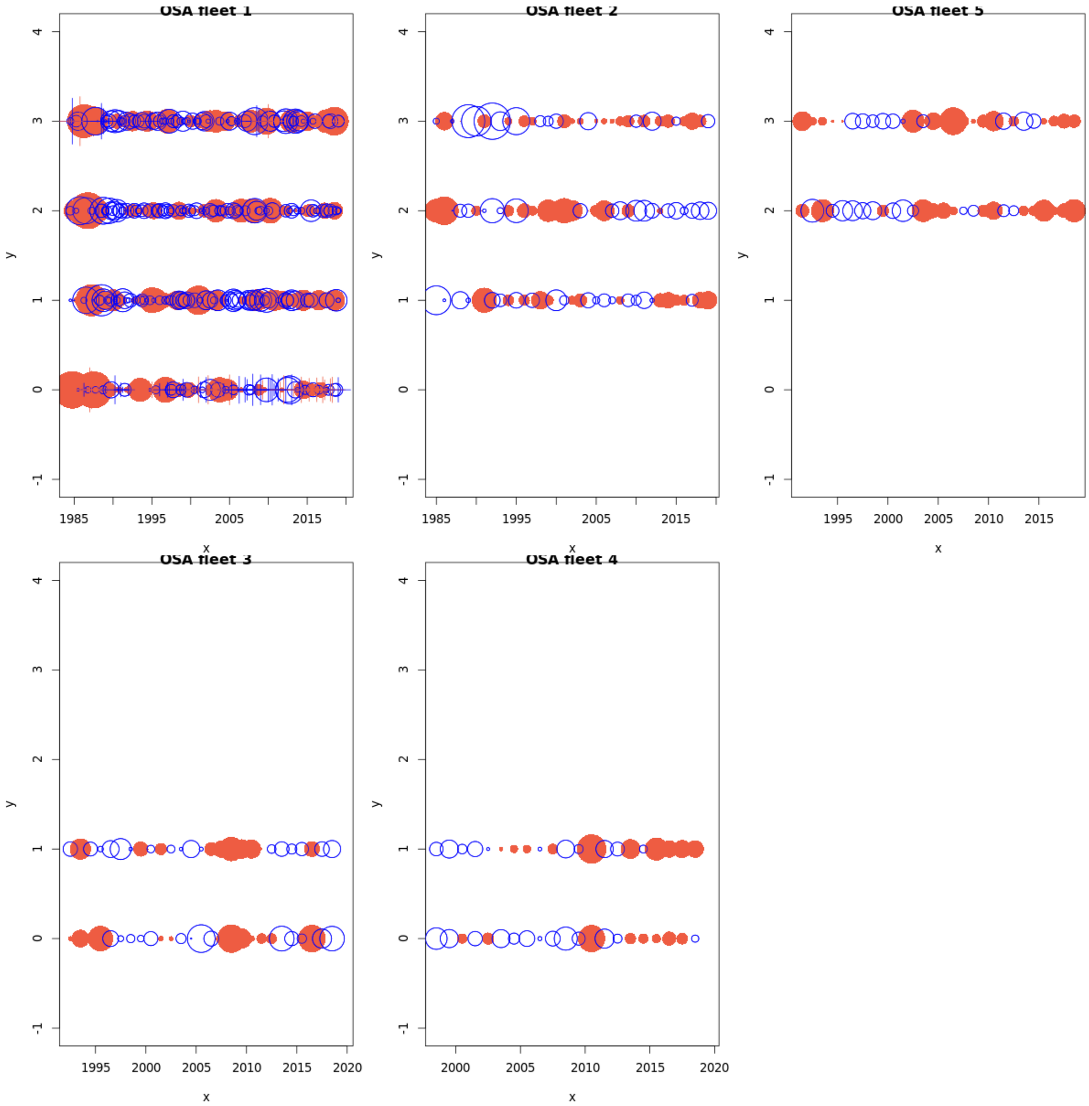

Figure 12.3.9. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet: One step ahead residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2019.

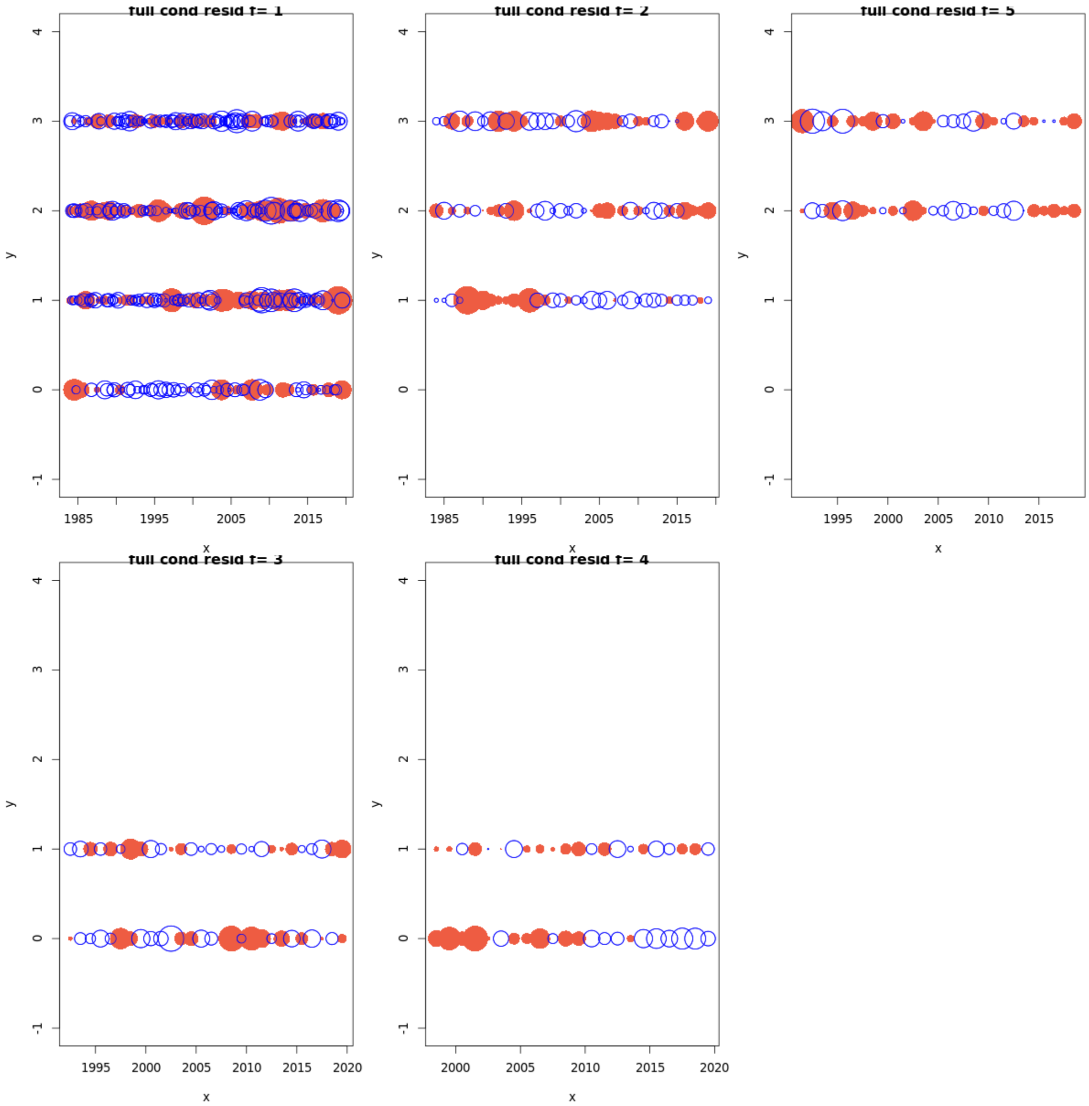

Figure 12.3.10. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots: Full conditional residuals or auxiliary residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2019.

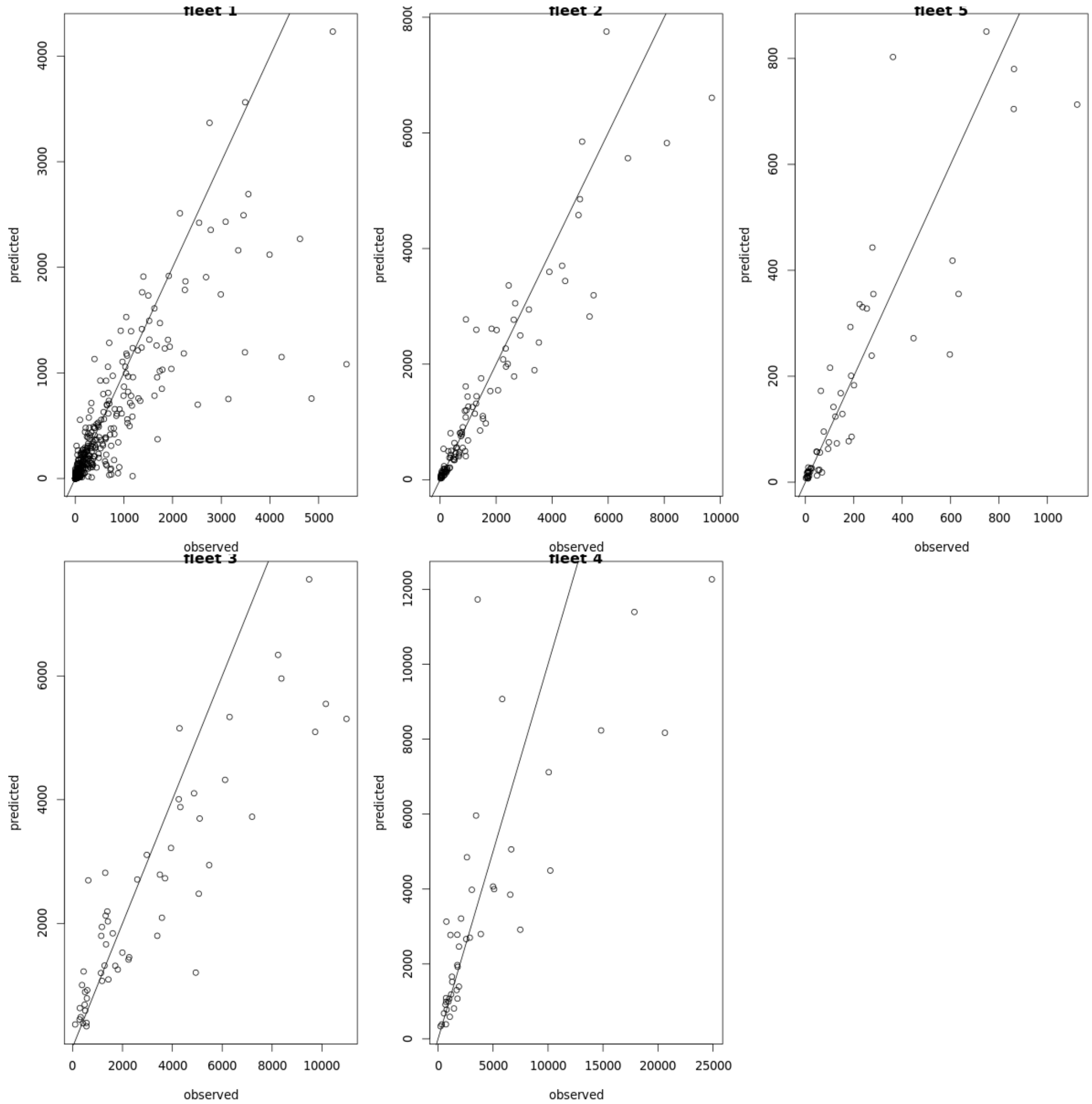

Figure 12.3.11. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet. SESAM baseline run September 2019.

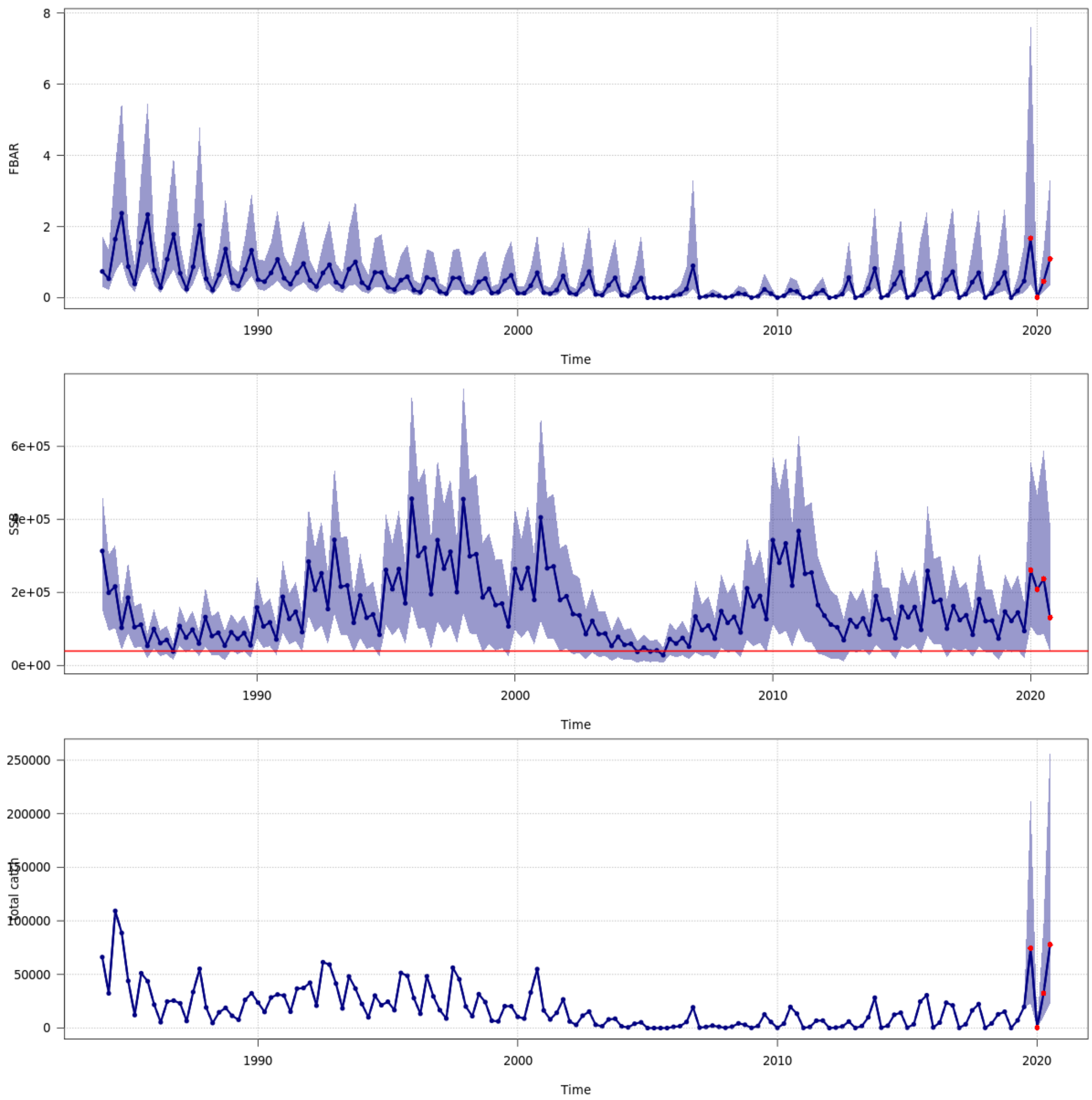

Figure 12.6.1 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that the fifth percentile of the SSB distribution one year a head (1st October 2020) equals B_{lim}.

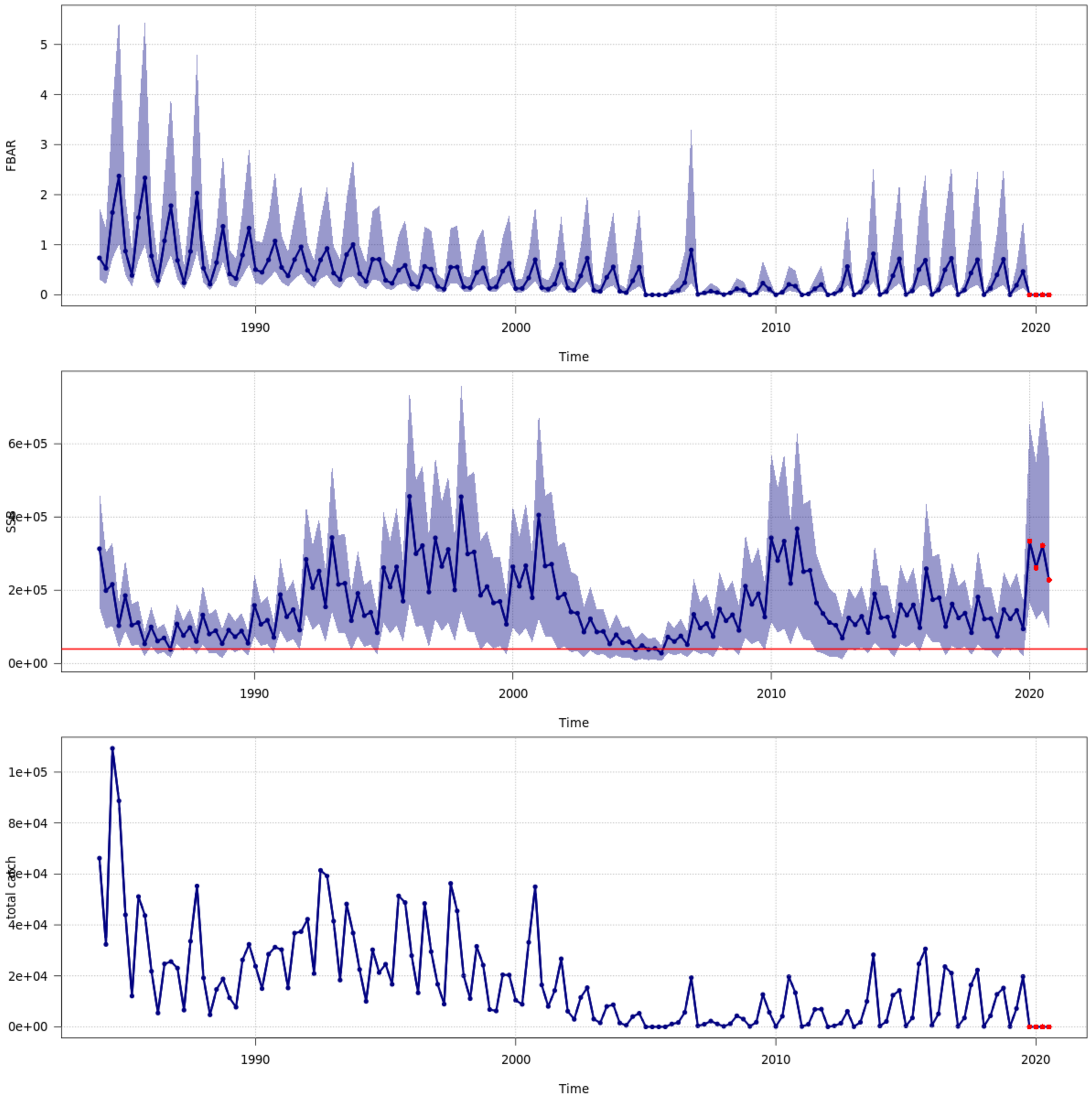

Figure 12.6.2 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2019 to 1st October 2020.

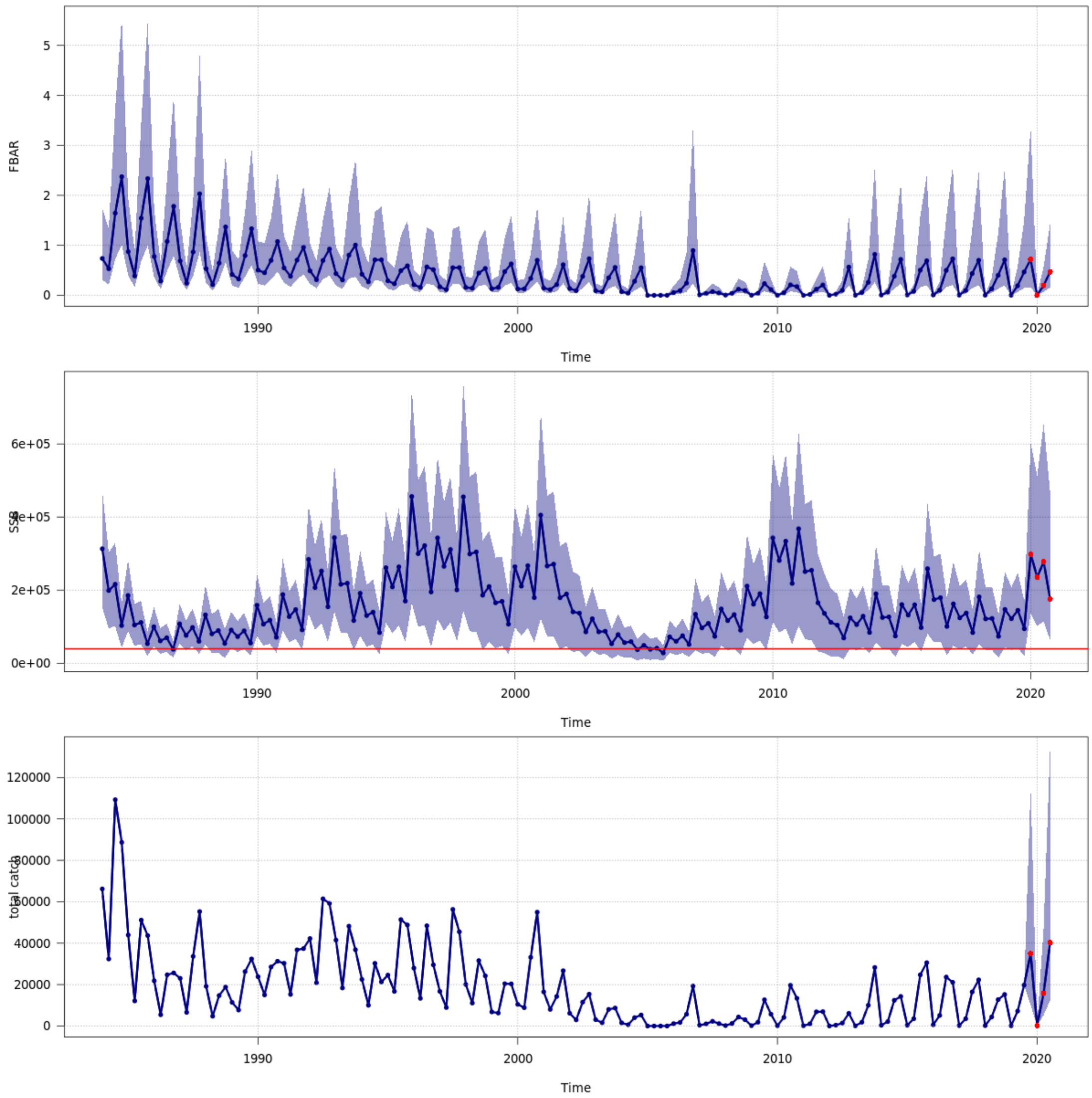

Figure 12.6.3 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year to 1st October 2019.

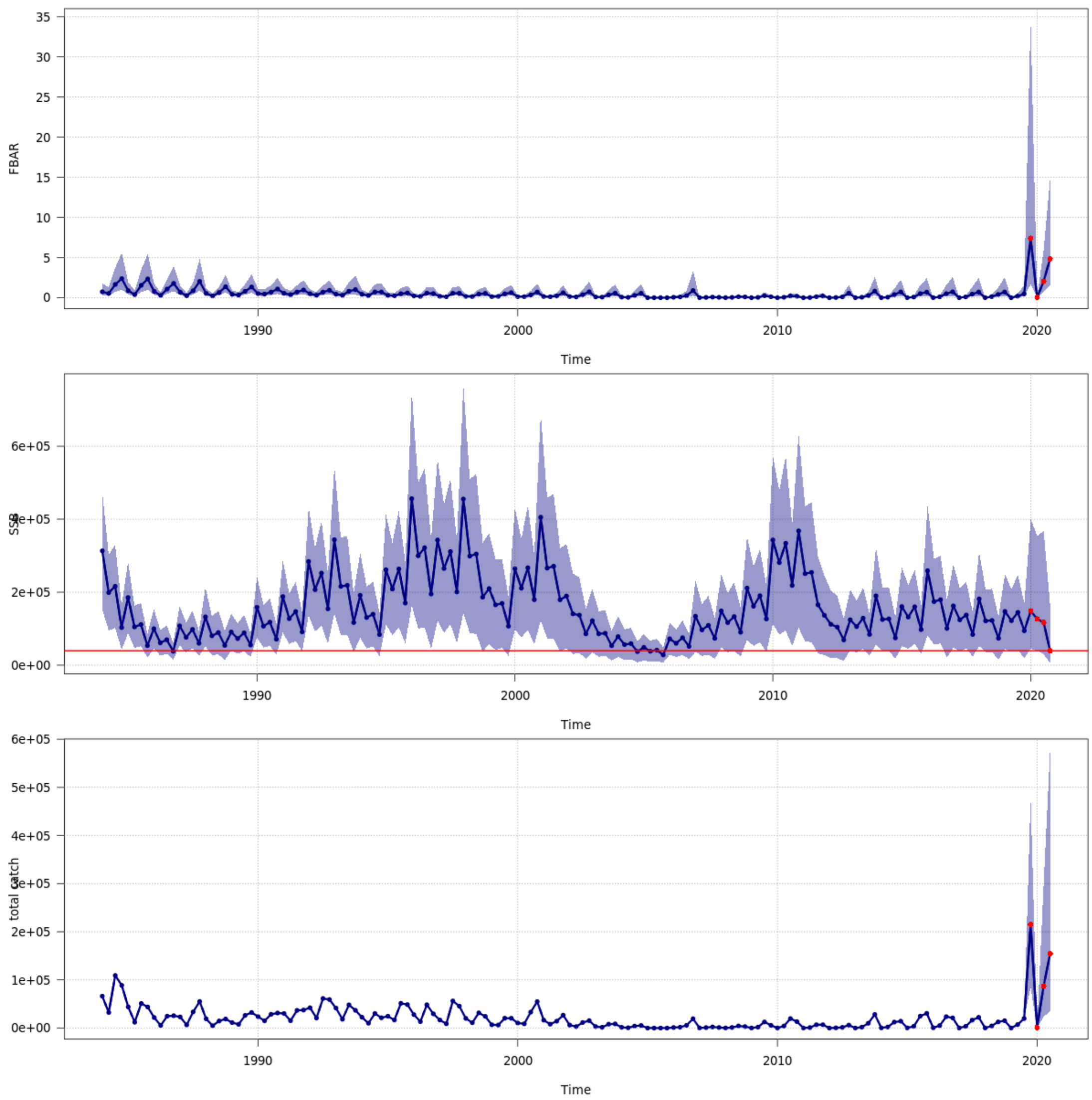

Figure 12.6.4 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that the median of the SSB distribution one year a head (1st October 2020) equals Blim.

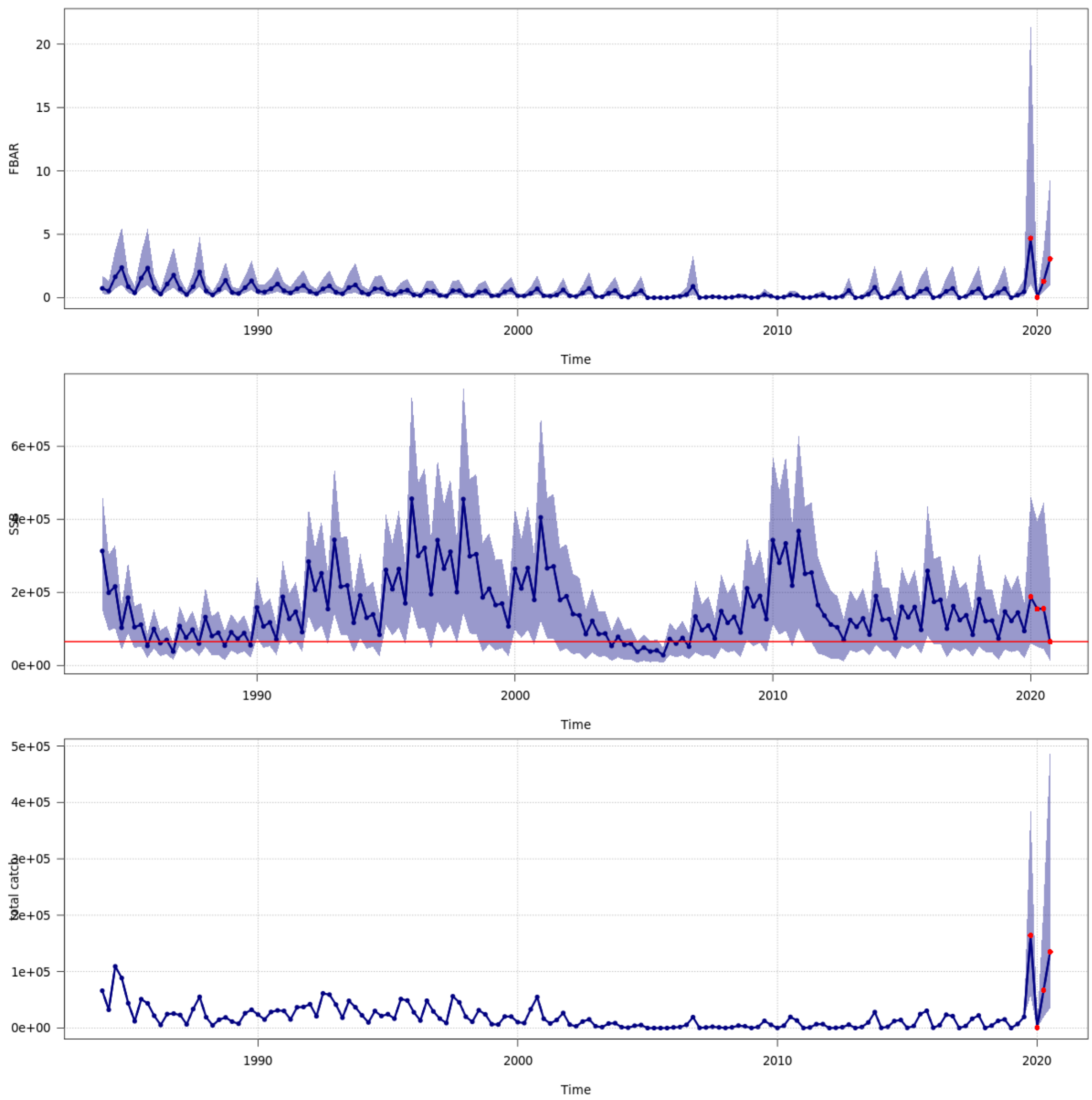

Figure 12.6.5 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled so that the SSB distribution one year a head (1st October 2020) equals Bpa.

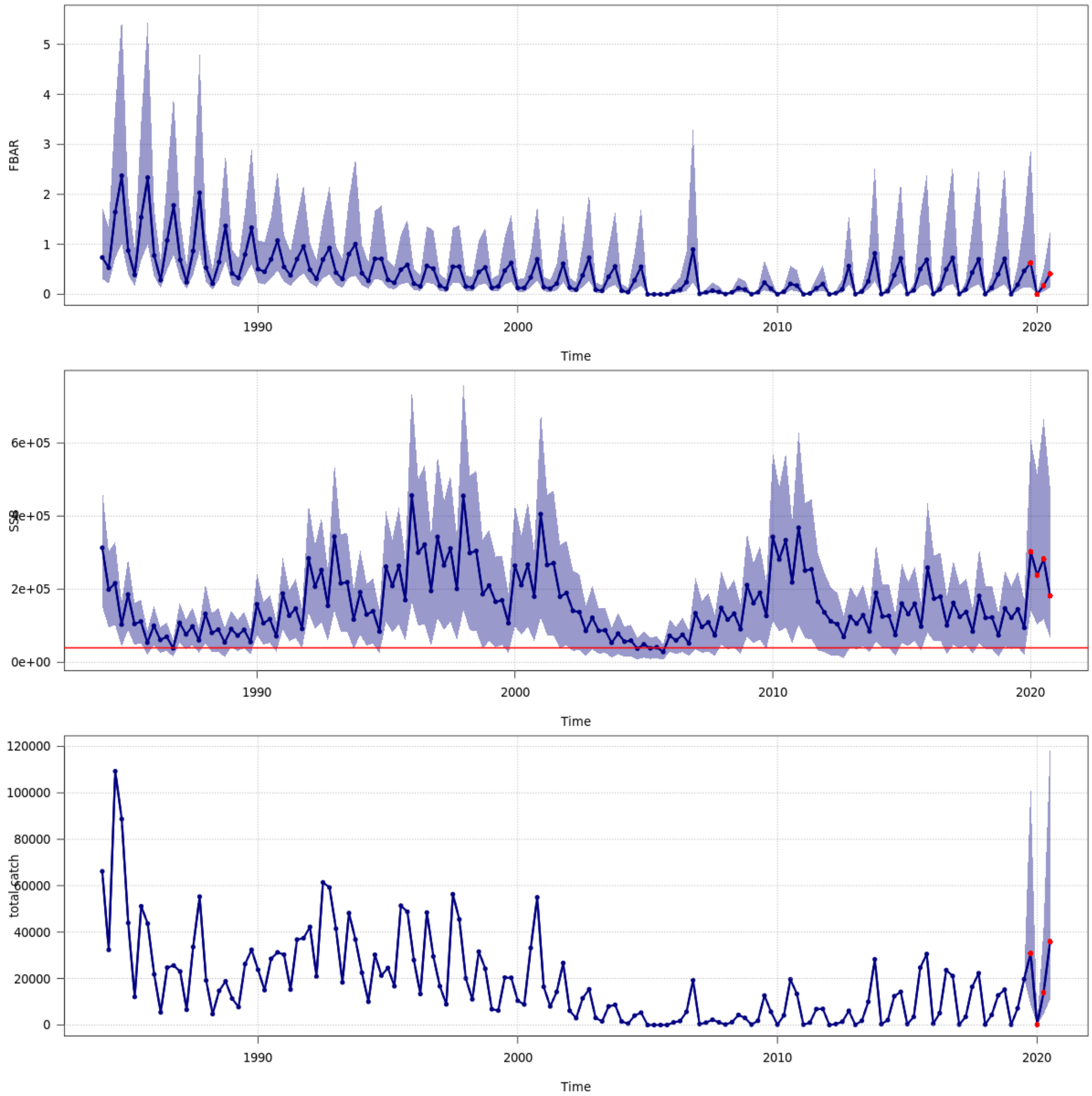

Figure 12.6.6 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.3 (F_{cap} = 0.3) for the period 1st October 2019 to 1st October 2020.

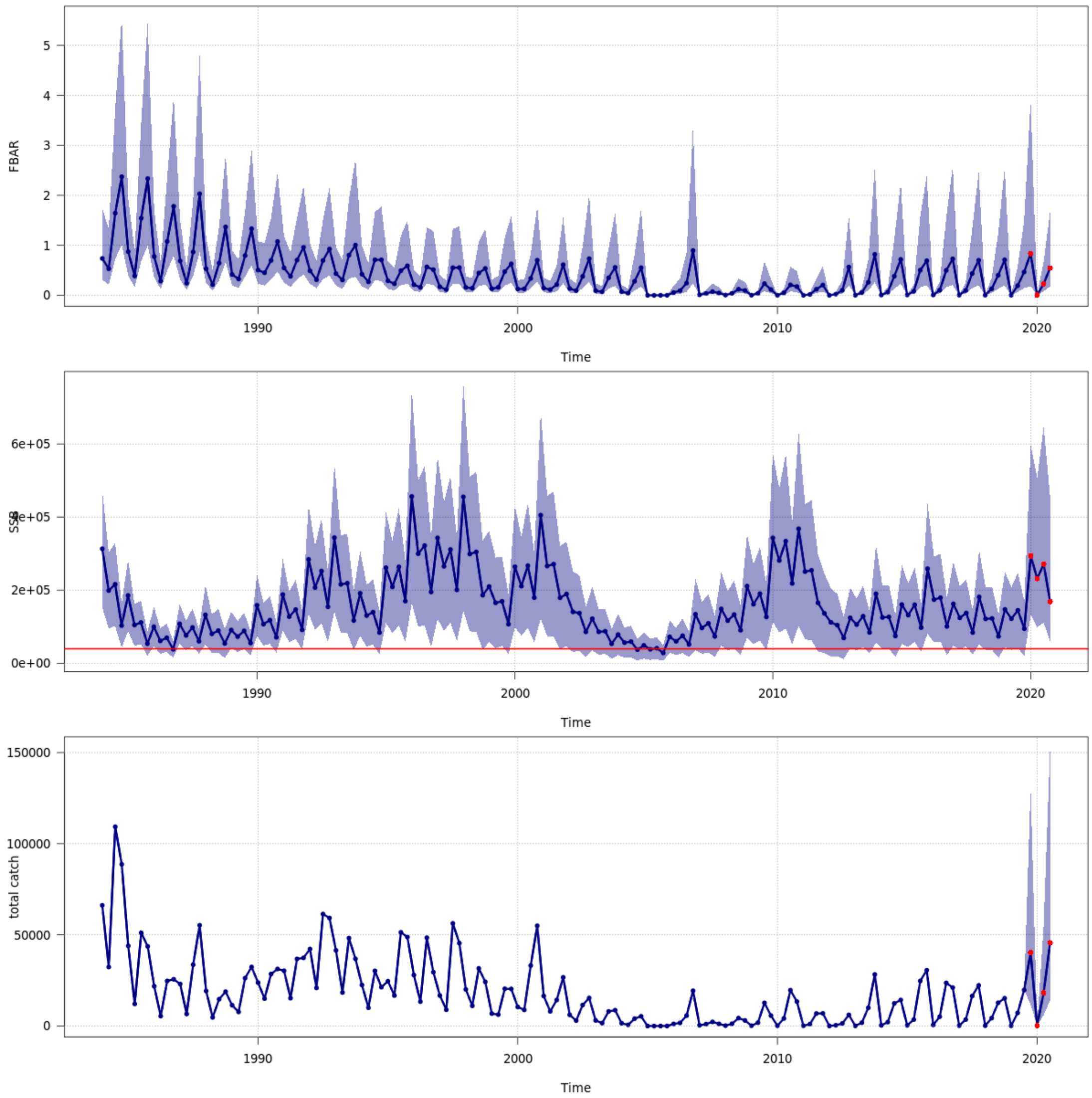

Figure 12.6.7 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.4 (F_{cap} = 0.4) for the period 1st October 2019 to 1st October 2020.

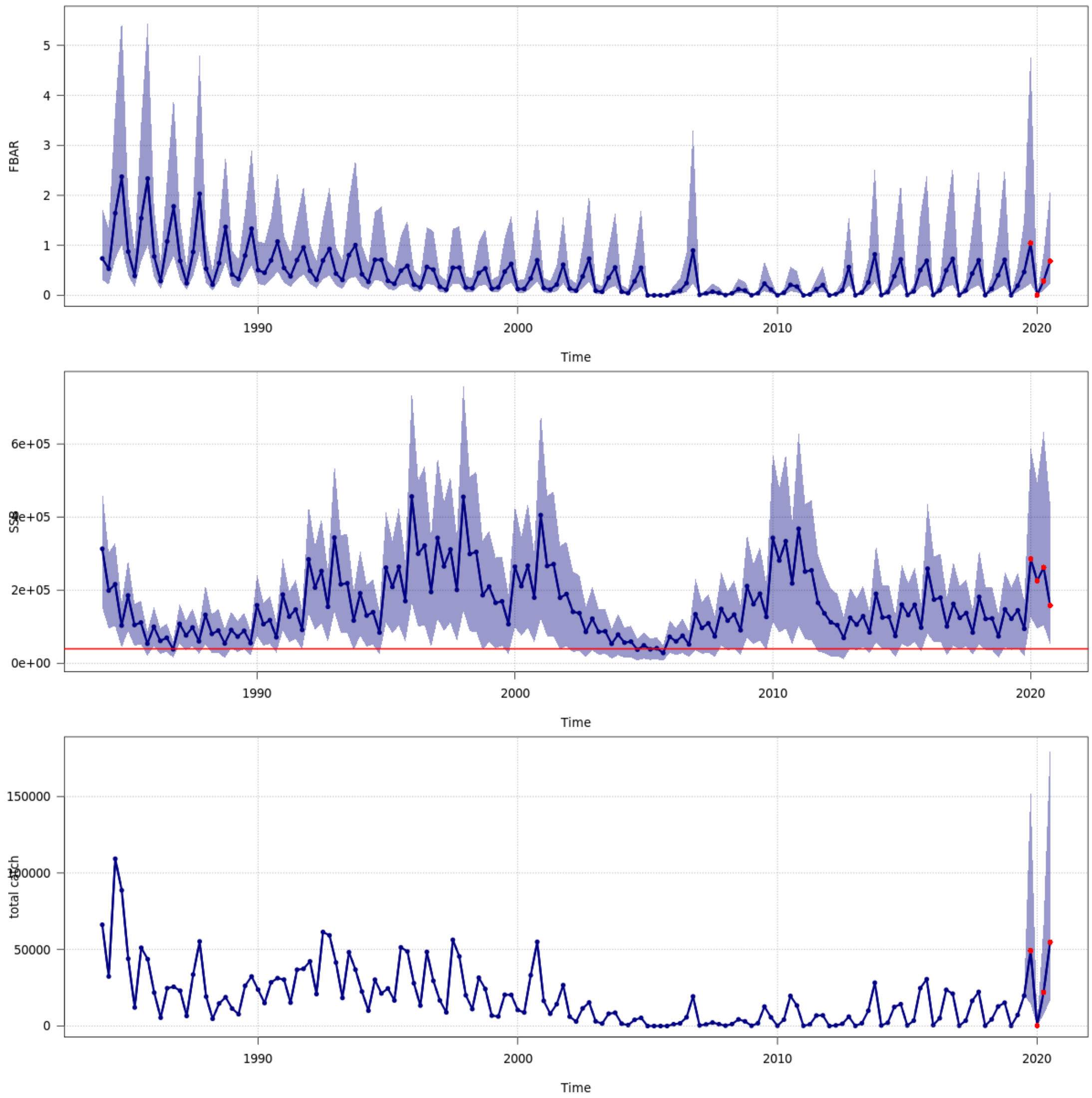

Figure 12.6.8 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (F_{cap} = 0.5) for the period 1st October 2019 to 1st October 2020.

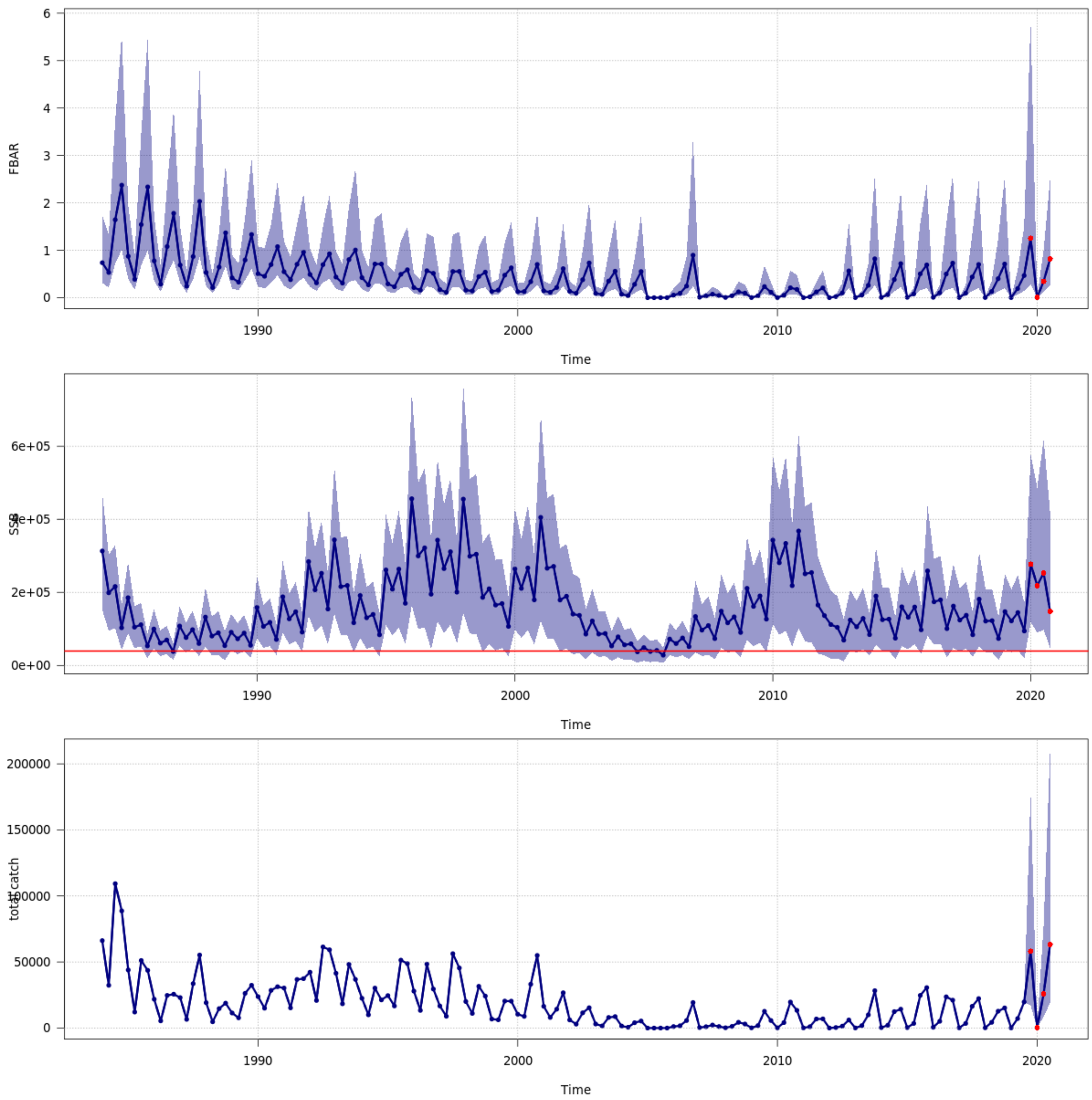

Figure 12.6.9 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.6 (F_{cap} = 0.6) for the period 1st October 2019 to 1st October 2020.

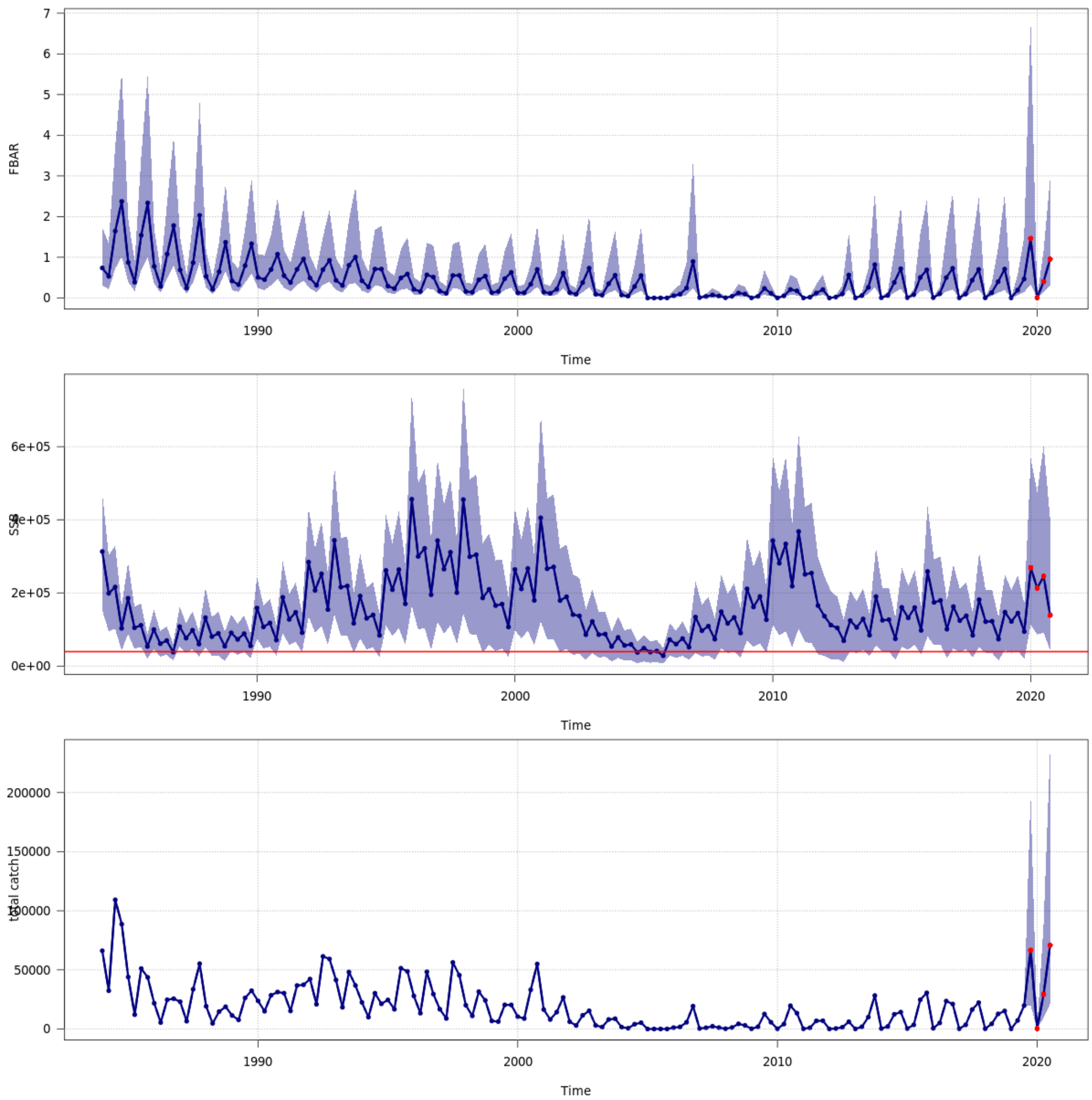

Figure 12.6.10 Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.7 (F_{cap} = 0.7) for the period 1st October 2019 to 1st October 2020.

13 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.

13.1 General

13.1.1 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).

13.1.2 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 13.8 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.

More in-depth analysis in WGECO 2018 using the recent years' data showed that the co-occurrence of reduced size at age and increasing stock abundance has led to a negative relationship in period 2006–2016. This correlative indication of density-dependent growth reduction, is further strengthened by a coinciding reduction in physical condition across a range of sizes, hinting that food scarcity may indeed be the mechanism behind the patterns (ICES, 2018b).

13.1.3 Fisheries

A basic description of the fisheries is available in the Stock Annex. In recent years, pulse trawling, aiming at reduction of fuel consumption and reduction of bottom disturbance, has been adopted in fisheries. 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. In 2016 and 2018, ICES published advices on ecological and environmental effects of pulse trawling, compared to traditional beam trawls (ICES, 2016; ICES, 2018a). It was concluded that pulse trawling has fewer environmental and ecological effects than beam trawls. Pulse trawls have been increasingly used in the North Sea flatfish fisheries since 2009. Over this period, the fishing mortality has reduced and stock biomass has increased, mostly due to an overall decrease in effort. The shift in fishing method has resulted in a change in distribution of the fishery. Pulse trawling has increased in areas such as off the Thames estuary and the Belgian coast but decreased in others. This change is related to lighter gear, which can be used on softer grounds than the beam trawls (ICES, 2018a).

In 2019 the European Parliament decided to ban pulse fisheries in European waters. This ban on pulse fishing implies that ultimately only 5% of the fleet of each member state can continue its fishing activities with the pulse trawl until the first of July 2021, after which a total ban will apply. In this context, research into the effects of the pulse trawl on commercial stocks and wider ecosystem effects will continue.

13.1.4 ICES Advice

The information in this Section is taken from the ICES advice sheet 2019:

ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 131 439 tonnes.

13.1.5 Management

An EU multiannual management plan (MAP) has been agreed by the EU for this stock (EU, 2018). This plan is not adopted by Norway, thus, not used as the basis of the advice for this shared stock. ICES was requested by the EC to provide advice based on the MSY approach and to include the MAP as a catch option.

13.2 Data available

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 both landings and 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.

13.2.1 InterCatch processing

Since 2012, national research institutes submitted landings and discard estimates by métier and quarter in InterCatch. Figures 13.2.1 and 13.2.2 show the landings and discards coverage by country and by métier in Subarea 4 and Subdivision 20. Approximately 52% and 93% of the landings in weight were 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 and to raise the landings and discards for which no age distribution was known, the same grouping strategy was used (see table below). The TBB and OTB fleets that covered most of the catches each had their own group (TBB<100, TBB >=100, OTB/OTM<100, and OTB/OTM>=100). Other major groups include Seines, shrimper, gillnets. All discards raising and age allocations were done per quarter. If discards/age structures were present for data for the whole year only, these were added to all quarters. If there were no discards/age structures in a specific quarter, all other quarters were used. Allocations to calculate the age compositions were done separately for discards and landings.

For Subarea 4, 78% of the total discards in 2018 were imported with landing, and 75% of the total discards in Subarea 4 were obtained from sampling. For Subdivision 20, 64% of the total discards are imported with landing, and 59% of the total discards were obtained from sampling. BMS landings, where reported, were included with discards as unwanted catch in the assessment since 2016.

Grouping strategies to raise discards and allocate age structures.

Group for raising discards and age allocation	Description
TBB<100	Beam trawl, smaller mesh size
TBB>=100	Beam trawl, larger mesh size
OTB/OTM-CRU/DEF/SPF<100	Otter trawl, smaller mesh size
OTB/OTM-CRU/DEF/SPF>=100	Otter trawl, larger mesh size
SSC/SDN<100	Seines, smaller mesh size
SSC/SDN>=100	Seines, larger mesh size
TBB-CRU-16-31	Shrimper
GNS/GTS/GTR>=100	Gillnet, larger mesh size
Others	All other metiers

13.2.2 Landings

Since 2016, large mesh trawlers (TR1 and BT1) with low discard rates were required to report BMS under landing obligation in Subarea 4. According to ICES data, in 2018, BMS landings were only 15.7 tonnes because Norway was the only country to report to ICES. Meanwhile the official reported BMS landings were 109.5 tonnes from all countries. For the assessment in this report, BMS was treated as discards.

Total ICES estimated landings (including 7.d and Subdivision 20) of North Sea plaice in 2018 was 57 800 tonnes. Of these 50 783 tonnes came from the Subarea 4, 6229 tonnes came from Subdivision 20, and 788 tonnes came from 7.d. The landings in Subarea 4 decreased 23% (of 2017) and reached 45% of the 112 643 tonnes landing TAC for 2018. The landings in Subdivision 20 decreased 29% (of 2017) and reached 41% of the 15 343 tonnes landing TAC for 2018. Total landings (in tonnes) are presented in Table 13.2.1 and landings in numbers at age in Table 13.2.2 and Figure 13.2.4. Since 2010, the majority of landings were age 3–5.

13.2.3 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2018, as 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 13.2.7 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 13.2.3. Figure 13.2.3 presents a time series of landings, catches and discards from these different sources. Age distributions of discards are presented in Figure 13.2.4 and Table 13.2.3. The total discards weight has been gradually decreasing since our first year of observed discards 2000. The discards ratio are illustrated in Figure 13.2.6. Since 2010, the majority of discards were age 1–3.

13.2.4 Catch

The total catch at age as used in the assessment including all landings and all discards are presented in Table 13.2.4. 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 13.2.4 and 13.2.5.

13.2.5 Weight-at-age

Stock weights at age are presented in Table 13.2.5. 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 13.2.6, 13.2.7 and 13.2.8 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 13.2.7 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.

13.2.6 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 13.2.9) was chosen.

13.2.7 Catch, effort and survey data

The following six survey indices are used in the plaice assessment:

- Beam Trawl Survey combined for RV Tridens and ISIS (BTS-combined); (1996–2018); 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); (2000–2018); Age 1–6
- IBTS–Q1 plaice index; 2007–2018; Age 1–7;
- IBTS–Q3 plaice index; 1997–2018; Age 1–9.

The most important surveys for demersal fish species in the greater North Sea area are the BTS (3rd Quarter) and the IBTS (1st and 3rd Quarter). The BTS covers areas 4.b, 4.c and the Channel, while the IBTS also covers area 4.a and the Skagerrak and Kattegat (3.a). The spatial distributions of plaice biomass per haul for these 3 surveys in 2018 are illustrated in Figure 13.2.8.

Since 2017, both BTS and IBTS age-structured survey indices were estimated using smoother based delta-GAM method (Berg *et al.*, 2014). Since the smoother for historical years will deviate with each increasing data year, the sensitivity to adding new year data needs to be checked before adopting the updated indices for assessment. The recent 2 year updates show that the delta-GAM method is robust to adding new year data (deviation of historical year indices was small).

A time-invariant spatial abundance distribution could be estimated per age from the delta-GAM model for each of these three surveys (Figure 13.2.9). Both Q3 (BTS and IBTS) surveys indicates similar age distributions: Younger plaices are nursed in the Belgium-Netherlands-Germany-Denmark coastal area. As they get older, they move north-west towards the center of North Sea and Scotland coastal area. On the other hand, the IBTS-Q1 survey does not show strong difference in age distributions. This is likely due to the spawning and nursery season in Q1.

Table 13.2.10 and Figure 13.2.10 show the survey index values. Overall, BTS-Q3 and IBTS-Q3 give consistent indices. Two moderately strong year class 2013 and 2016 were spotted. Additionally, all surveys show an increasing trend for older fishes (age >= 5) since 2005.

The internal consistency of the survey indices (Figure 13.2.11) appears relatively high for BTS-Q3, but low for the SNS surveys. The log-catch curves of ages 1–6 for the surveys are illustrated in Figure 13.2.14. 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 pattern over the time series (which is the assumption for the stock assessment), except for IBTS–Q1 where the time series is too short to validate. A gradually increasing catch since 2000 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.

Besides stock assessment, additional survey indices are used for recruitment estimates in the RCT3 analysis (Table 13.4.1):

- Demersal Fish Survey (DFS) ; (1990–2018); age–0;
- Sole Net Survey (SNS); (2000–2018); age-0

Information on these survey indices are described in Section 13.6.

13.3 Data analysis

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 3.5.1.

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.

13.4 Assessment

13.4.1 Model parameters and diagnostics

The table below gives an overview of data and parameters used in the AAP assessment model:

Stock	PLE.27.420
Assessment year	2019
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 1996–2018; 1–9 SNS1 1970–1999; 1–6 SNS2 2000-2018 (excl. 2003); 1–6 IBTS-Q1 2007–2018; 1–7 IBTS-Q3 1997–2019; 1–9
Plus group	10
Last data year	2018
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

Model diagnostics including standardized catch and survey residuals and retrospective plots are illustrated in figures 13.3.2–13.3.4. There is no strong cohort patterns in the catch residuals, however, the model slightly underestimates age 2 and overestimates age 1 and 3. This is likely caused by the lack of fitting from F-at-age-at-time smoother. The survey residuals show some year patterns. The retrospective plots do not exhibit negative or positive pattern.

13.4.2 Assessment results

Figure 13.2.1 illustrates the trends in observed 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 13.3.1 and Table 13.3.4 present the model estimated F(2–6), SSB, and recruitment. The estimated SSB in 2018 is 967 508 tonnes and it is well above MSY $B_{trigger}$. SSB has markedly increased since 2008, following a substantial reduction in fishing mortality (F) since 1999. The estimated F in 2018 is 0.187 year^{-1}, and it has been around F_{MSY} since 2009. Recruitment has been fluctuating around the long-term average since the mid-1990s.

The estimated model parameters are presented in Table 13.3.1. The estimated fishing mortality and stock numbers are shown in Tables 13.3.2 and Figure 13.3.5, respectively.

The stock dynamics are partly affected by the occurrence of strong year-classes. However, catch and survey indices do not exhibit strong year-class in recent years. The increased stock size in recent years is therefore partly the direct consequence of reduced fishing mortality. Additionally, The age composition in SSB (Figure 13.3.6) implies that older aged plaices (age >= 5) have been increasing since 2010. In 2018, they contribute to as high as 85% of SSB. Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies that older fishes are likely migrating to the north western part of the North Sea (ICES 2019a), where the targeted fishing effort is low (Figure 13.2.12).

The predominant age in the landings is currently age–4 (in 2017 as well as in the past decade, see Figure 13.2.4). 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.

13.5 Recruitment estimates for short-term forecast

In the short term forecasts, assumptions are made on a number of things (see also Section 13.5). 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 13.4.1. The results for age–1 and age–2 abundance estimates are presented in Table 13.4.2, and in Table 13.4.3 respectively. An extremely strong 2018 year class (approximately 5 times of the average magnitude over the time period) was observed in SNS survey as well as BTS-Q3 survey (Figure 13.3.7), although BTS-Q3 was not used in RCT3 analysis. In the meantime, the DFS survey was also showing an upward signal. Because of the high weights for SNS-age0 in RCT3 analysis, this consequently gives extremely optimistic estimate for age 1 in 2019 (2 084 830 thousand). In the end, the geometric mean of 2006–2015 was chosen for age 1 in 2019. For age 2 in 2019, the estimates from BTS–1 and SNS–0 have a relatively low standard error (compared to the other surveys). However, AAP is relatively strong in predicting age–2 survivors. Hence, AAP estimate was selected. 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 2019	AAP survivors	RCT3	GM 2006–2015	Accepted estimate
2017	2	<u>827716</u>	903568	1287315	AAP survivors
2018	1		2084830	<u>1287315</u>	GM 2006–2015*
2019	0			<u>1287315</u>	GM 2006–2015

*** GM of recent 10 years data, excluding the last 3 data years due to large uncertainty**

13.6 Short-term forecasts

Short-term prognoses were carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2018 (the last data year) into 2019 (the intermediate year in which the assessment is done); into 2020 (the TAC year) and finally into 2021 (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 were taken to be the average over the last 3 years.

The intermediate year F was assumed to be "F–status quo" (F_{sq}), that is, the exploitation was taken to be the mean value of the last three years. Since there was no strong increasing or decreasing trend of Fbar in the last few years, F_{sq} was not further scaled (to have equal Fbar as Fbar_2018). The relative proportions of landings versus discards in the catch were taken to be the mean of the last three years. The option of assuming F to correspond to the TAC being fully caught in the intermediate year was abandoned as an option to pursue, due to the fact that the TAC has not been fully utilised in previous years (Note that the TAC prior to 2019 was not based on ICES catch advice). 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 both 2019 and 2020 were taken from the geometric mean

(2006–2015). Input to the short term forecast is presented in Table 13.5.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	$F_{(2-6)}$ 2019	SSB 2020	Recruitment 2019	Landings 2019	Discards 2019
F2019 = Fsq	0.193	1112164 t	1287315	76314 t	47769 t

A series of F options were assumed for the TAC year. Resulting management options for 2020 are given in Table 13.5.2.

13.7 Biological reference points

13.7.1 Precautionary approach reference points

The current precautionary approach reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks (Figure 13.4.2). 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.

13.7.2 F_{MSY} reference points

In 2010, ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 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).

13.7.3 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 $F_{pa} = F_{lim} / \exp(1.645*\sigma)$, 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.

13.7.4 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 13.6.3.

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	$F_{pa} = F_{lim} \times \exp(-1.645\sigma_F)$; $\sigma_F = 0.20$	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 5^{th} 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 (SSB2015/1.4) 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 $B_{trigger}$	0.3
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 $B_{trigger}$	0.3
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

13.8 Quality of the assessment

The assessment does not provide robust estimates for ages 1–3 because of conflicting information between different data sources. Information from BTS, SNS and DFS surveys suggest that in recent years the nursery area of plaice (or age 0–1) are shifting from coastal area (covered by DFS and SNS) towards off-shore (covered by BTS and IBTS) (ICES, 2019a). Older ages also show a northward expansion in distribution that may affect estimates for these ages.

The deterioration of recruitment signal of age 0 in SNS and DFS has led to less consistent recruitment estimate for the intermediate year in Spring (using RCT3), as compared to the Autumn estimation where BTS-age1 data are added. However, there are indications that the 2018 year class may be stronger than the recruitment assumed in the forecast. If this is confirmed by the summer surveys in 2019 to be significantly different to the current recruitment assumption in the forecast, the forecast will be updated in the autumn.

Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies that older fishes are likely migrating to the north western part of the North Sea (ICES, 2019a), where the targeted fishing effort is low. This partly resulted in a reduced fishing mortality at older ages and an upward trend of SSB in recent years (for example, in 2018 plaice aged five and older contribute to 85% of the SSB).

Since 2016, large mesh trawlers (TR1 and BT1) are under landing obligation in Subarea 4. In 2019 the fleets (BT2 and TR2) that contribute most to the total discards will fall under landing obligation in Subarea 4, with *de minimis* exemptions in certain fisheries.

Despite the introduction of the landing obligation 52% and 19% of the total catch in 2018 was discarded in Subarea 4 and Subdivision 20, respectively. The reported BMS landings for fleets that are under the landing obligation in Subarea 4 are currently much lower than the estimates of unwanted catch from catch monitoring programmes. ICES understands that this is not in accordance with the current EU regulation.

13.9 Status of the stock

SSB in 2018 is estimated around 967 508 tonnes which is well above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Fishing mortality in 2018 is estimated to be at a value of 0.187 (below F_{pa} of 0.369, below the long-term management target F of 0.30 and below F_{MSY} of 0.210).

13.10 Management considerations

Plaice is mainly taken by beam trawlers in a mixed fishery with sole in the southern and central part of the North Sea. There are a number of EC regulations that affect the fisheries on plaice and sole in the North Sea, e.g. as a basis for setting the TAC, limiting effort, minimum landing size and minimum mesh size.

13.10.1 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.

13.10.2 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 Figure 13.2.1, 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.

13.10.3 Technical measures

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea where sole has become relatively more abundant, affect both sole and plaice. The minimum mesh size of 80 mm selects sole at the minimum landing size. However, this mesh size generates high discards of plaice with a larger minimum landing size than sole. For the overall fleet the discards ratio has been slightly decreasing since 2003 and at present is approximately 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 13.1.3).

13.10.4 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.

13.11 Issues for future benchmarks

13.11.1 Data

Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies that older fishes are likely migrating to the north western part of the North Sea (ICES, 2019a). As a result, the current multiple survey indices are no longer suitable for stock assessment. It is suggested to explore the possibility of combining all surveys into one index using delta-GAM method.

13.11.2 Assessment

The parameter settings in the current assessment model result in residual patterns in catches as well as surveys. This is likely caused by the lack of fitting from F-at-age-at-time smoother. It is suggested to explore parameters settings to improve model fitting.

13.11.3 Short-term forecast

The methodology and principles of RCT3 analysis was developed many years ago and might be no longer valid for the current stock situation. Therefore, the RCT3 analysis needs to be validated.

13.12 Added reference

EU. 2018. Regulation (EU) 2018/973 of the European Parliament and of the council of 4 July 2018 establishing a multiannual plan for demersal stocks in the North Sea and the fisheries exploiting those stocks, specifying details of the implementation of the landing obligation in the North Sea and repealing Council Regulations (EC) No 676/2007 and (EC) No 1342/2008. Official Journal of the European Union, L 179: 1–13. http://data.europa.eu/eli/reg/2018/973/oj

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ICES 2018b. Report of the Working Group on the Ecosystem Effects of Fishing Activities (WGECO). 12–19 April 2018, San Pedro del Pinatar, Spain. ICES CM 2018/ACOM:27. 65 pp.

Table 13.2.1. Plaice in Subarea 4 and Subdivision 20 (7.d Q1 not included): Official landings in thousands.

North Sea														Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
1982	6755	24532	1046	3626	41208	17	6	20740		97930	56616	154546	140000		
1983	9716	18749	1185	2397	51328	15	22	17400		100812	43218	144030	164000		
1984	11393	22154	604	2485	61478	16	13	16853		114996	41153	156149	182000		
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

					North Sea									Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
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

	North Sea													Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
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	0	64352	1090	65442	129917	8467	17639
2018	4894	9666	112	2580	22586	69	3	9603	0	49513	1270	50783	112643	5958	15343
2019													125435		16782

*** Official estimates not available.**

Table 13.2.2. 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

	age									
year	1	2	3	4	5	6	7	8	9	10
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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2018	17	7829	24768	34001	43504	31018	15991	8987	5394	4159

Table 13.2.3. Plaice in Subarea 4 and Subdivision 20: Discards in numbers by age (including 1st quarter of 7.d) in thousands.

year	age							
	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

year	age							
	1	2	3	4	5	6	7	8
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
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

year	age							
	1	2	3	4	5	6	7	8
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
2018	64618	266462	101461	39258	21422	4803	1480	243

Table 13.2.4. Plaice in Subarea 4 and Subdivision 20: Catch in numbers by age (including 1st quarter of 7.d) in thousands.

year	age									
	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

year	age									
	1	2	3	4	5	6	7	8	9	10
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2018	64635	274291	126229	73259	64926	35821	17471	9230	5394	4159

Table 13.2.5. Plaice in Subarea 4 and Subdivision 20: Stock weight at age (kg).

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	0.038	0.102	0.157	0.242	0.325	0.485	0.719	0.682	0.844	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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2018	0.036	0.064	0.116	0.165	0.215	0.276	0.327	0.366	0.412	0.595

Table 13.2.6. Plaice in Subarea 4 and Subdivision 20: Landings weight at age (kg).

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	0.000	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	0.000	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.750	1.000
1960	0.000	0.200	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.094
1961	0.000	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.071
1962	0.000	0.211	0.248	0.300	0.400	0.541	0.570	0.692	0.777	1.127
1963	0.000	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.028
1964	0.000	0.250	0.273	0.312	0.388	0.487	0.628	0.700	0.737	1.005
1965	0.000	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.887
1966	0.000	0.232	0.270	0.348	0.436	0.484	0.559	0.624	0.690	0.933
1967	0.000	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.978
1968	0.000	0.267	0.298	0.331	0.366	0.517	0.590	0.596	0.686	0.911
1969	0.217	0.294	0.310	0.333	0.359	0.412	0.573	0.655	0.658	0.893
1970	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.892
1971	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.891
1972	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.939
1973	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.842
1974	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.926

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2018	0.167	0.243	0.259	0.287	0.306	0.356	0.400	0.447	0.439	0.589

Table 13.2.7. Plaice in Subarea 4 and Subdivision 20: Discards weight at age (kg).

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.104	0.146	0.181	0.206	0.244	0.244	0.231	0.000	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

year	age									
	1	2	3	4	5	6	7	8	9	10
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2018	0.058	0.084	0.121	0.137	0.149	0.152	0.159	0.179	0.196	NA

Table 13.2.8. Plaice in Subarea 4 and Subdivision 20: Catch weight at age (kg).

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.110	0.194	0.257	0.349	0.455	0.533	0.589	0.396	0.998
1958	0.047	0.106	0.189	0.256	0.329	0.452	0.513	0.615	0.665	0.992
1959	0.051	0.120	0.192	0.260	0.345	0.472	0.592	0.623	0.750	1.000
1960	0.045	0.115	0.204	0.287	0.377	0.480	0.601	0.683	0.724	1.094
1961	0.044	0.101	0.180	0.301	0.402	0.506	0.604	0.671	0.812	1.071
1962	0.042	0.099	0.181	0.273	0.397	0.538	0.570	0.692	0.777	1.127
1963	0.048	0.110	0.175	0.304	0.392	0.531	0.624	0.667	0.715	1.028
1964	0.032	0.126	0.204	0.271	0.379	0.485	0.628	0.700	0.737	1.005
1965	0.038	0.076	0.214	0.313	0.381	0.469	0.539	0.663	0.726	0.887
1966	0.038	0.104	0.148	0.315	0.428	0.483	0.559	0.624	0.690	0.933
1967	0.036	0.111	0.190	0.235	0.422	0.543	0.597	0.662	0.738	0.978
1968	0.060	0.116	0.223	0.275	0.340	0.516	0.590	0.596	0.686	0.911
1969	0.052	0.174	0.272	0.284	0.356	0.408	0.573	0.655	0.658	0.893
1970	0.049	0.131	0.268	0.352	0.394	0.441	0.499	0.672	0.744	0.892
1971	0.057	0.160	0.277	0.388	0.444	0.512	0.542	0.607	0.699	0.891
1972	0.067	0.207	0.290	0.407	0.486	0.540	0.608	0.646	0.674	0.939
1973	0.045	0.205	0.334	0.403	0.478	0.538	0.605	0.627	0.677	0.842
1974	0.056	0.121	0.343	0.404	0.472	0.552	0.609	0.693	0.707	0.926
1975	0.069	0.152	0.205	0.393	0.492	0.585	0.636	0.703	0.783	1.019
1976	0.088	0.181	0.262	0.347	0.509	0.592	0.641	0.705	0.741	0.980
1977	0.071	0.218	0.245	0.318	0.396	0.551	0.647	0.721	0.715	0.978
1978	0.070	0.190	0.315	0.364	0.432	0.486	0.609	0.687	0.776	0.950
1979	0.067	0.190	0.295	0.338	0.426	0.472	0.550	0.675	0.796	0.960
1980	0.056	0.197	0.343	0.399	0.471	0.542	0.588	0.662	0.772	1.013
1981	0.048	0.183	0.327	0.415	0.502	0.556	0.604	0.642	0.725	1.007
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2018	0.058	0.089	0.148	0.207	0.254	0.329	0.380	0.440	0.439	0.622

Table 13.2.9 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 13.2.10 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	24785.0	24776.7	5304.4	1816.9	1419.7	606.5	264.0	140.1	77.3
1997	86903.1	16651.9	6669.4	1628.3	573.9	442.5	160.9	200.5	30.1
1998	34341.2	84447.6	9453.4	2634.9	639.4	375.9	225.5	187.7	72.7
1999	44468.2	18241.3	29128.3	2741.6	1101.3	246.1	93.4	84.2	41.6
2000	42041.0	22061.4	8847.1	9705.5	596.5	206.5	101.9	90.2	15.5
2001	29321.9	20220.6	6756.4	3406.8	3479.3	265.2	88.4	72.3	54.6
2002	135695.7	16603.6	6973.7	3824.1	2160.8	1587.9	286.0	138.5	47.5
2003	32578.4	46599.5	6855.5	3429.1	1640.3	947.4	939.3	72.6	52.9
2004	44914.6	13625.6	17504.7	3008.1	1561.3	897.6	506.7	736.0	49.5
2005	38150.7	28361.9	4684.0	6931.8	951.1	1062.9	386.9	90.8	877.4
2006	42317.3	17135.6	10058.2	2393.6	3844.9	600.0	761.0	109.6	136.9
2007	85808.7	22096.1	10724.1	8078.0	1742.4	2561.6	297.7	623.5	77.7
2008	69588.1	46747.2	12681.8	6465.0	4519.4	955.1	1441.5	295.8	463.0
2009	65528.7	23409.5	19957.4	5191.1	3169.5	2582.5	659.9	1451.9	279.9
2010	79188.2	28444.0	13655.0	10000.2	3105.0	1715.3	1760.0	601.4	994.2
2011	127483.9	42235.4	17951.8	9052.8	6081.9	1955.0	900.0	1556.2	232.3
2012	58335.1	62344.5	37503.3	13541.5	6789.7	4411.1	1404.8	1085.4	1526.6
2013	86614.3	52651.6	38433.3	19127.5	7249.8	4280.5	3167.2	1258.8	785.4
2014	144680.4	61554.8	26722.6	20356.4	8721.4	3697.4	2238.7	1720.0	983.3
2015	51652.0	66989.5	34227.7	16739.8	12847.5	6668.5	2272.8	1634.7	1540.1
2016	81863.3	31292.0	32213.7	17806.9	9371.1	6453.7	3636.8	1660.4	1090.3
2017	140332.7	51049.5	17728.9	19481.7	10370.9	5022.3	3127.6	1917.5	669.7
2018	85346.9	71780.7	21772.2	11263.6	11189.6	5395.4	3349.2	1884.0	1587.8

	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	2018	9465	5250	993	533	489	88
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							

	SNS1						SNS2						
	age						age						
year	1	2	3	4	5	6	year	1	2	3	4	5	6
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	3413.1	3297.7	1928.0	545.2	221.9	167.5	95.4	90.1	28.9
1998	1006.0	5099.4	1668.2	821.3	312.9	140.1	89.4	99.3	48.5
1999	905.2	2276.3	4232.0	712.7	288.4	134.7	49.0	50.3	34.9
2000	907.8	1754.2	1908.0	2114.0	224.2	129.0	57.9	46.1	15.4
2001	1129.2	3242.0	2067.3	1110.9	1148.4	176.3	83.0	69.8	57.1
2002	6026.3	2849.4	2305.6	1250.6	665.6	439.0	106.2	101.1	48.8
2003	1317.9	4920.6	1642.8	1008.4	455.2	273.6	286.4	57.1	61.0
2004	2411.8	2538.1	3954.3	918.0	604.8	309.1	195.2	243.4	48.2
2005	1900.8	4752.7	1562.3	2267.5	398.7	496.7	241.7	86.2	244.7
2006	2137.3	3078.5	3693.0	1083.1	1215.0	393.2	411.4	163.4	90.3
2007	5582.0	4695.2	3619.4	3154.6	811.3	1307.7	338.6	468.1	124.9
2008	6073.3	10768.0	4951.2	3317.6	2147.9	730.8	754.3	322.6	287.4
2009	2700.0	5011.6	7466.8	2724.0	1687.8	1192.6	466.5	754.7	203.1
2010	3108.2	4958.5	5239.8	4772.8	1602.9	1149.7	1107.3	492.8	684.4
2011	6503.9	9080.9	7165.8	4722.3	3381.8	1270.4	871.0	1084.6	281.1
2012	2401.6	11087.8	11181.7	6220.5	3534.8	2454.2	1135.1	917.3	954.1
2013	2701.2	6890.3	9443.1	6290.4	3335.2	2065.2	1587.6	747.1	499.8
2014	5225.9	8998.1	7565.0	6328.0	3218.1	1503.3	1083.8	785.3	500.8
2015	1660.1	7366.8	8093.2	5934.1	4565.8	2574.1	1325.3	975.3	819.0
2016	3124.1	4937.9	7215.9	5486.7	3054.8	2356.6	1587.7	1004.6	791.1
2017	4012.2	4896.8	3463.7	4390.5	2900.2	1774.2	1188.8	907.4	539.8
2018	2179.2	6154.3	3886.5	2463.6	2438.5	1617.6	1269.5	783.0	666.4

IBTS–Q1	1	2	3	4	5	6	7
2007	2285.3	5572.9	5761.6	6198.3	2095.4	1030.6	549.0
2008	2327.2	11504.4	7716.2	3634.7	2626.1	727.9	627.8
2009	2814.2	7607.3	13113.9	4474.2	2181.3	893.5	465.8
2010	1383.3	6015.2	9450.6	8307.8	3521.8	1366.7	926.2
2011	1140.6	6210.4	6726.6	6673.0	5229.6	1725.6	915.3
2012	1919.4	14293.1	15738.5	7351.7	5079.4	3272.0	1346.0
2013	1366.6	5365.2	10339.7	6833.0	3301.6	1821.1	937.1
2014	2655.8	7530.4	9103.8	8942.8	5017.7	1782.9	1025.8
2015	833.8	10308.7	11169.5	8961.9	6265.0	2752.4	1177.8
2016	2062.5	5413.0	9673.0	7587.8	5267.0	2420.4	1363.8
2017	1949.3	6928.2	4335.0	7026.7	4741.4	2884.6	1401.8
2018	687.1	5950.7	6254.0	2323.0	3123.1	1889.6	1257.1

Table 13.3.1. Plaice in Subarea 4 and Subdivision 20: Estimated parameters from AAP model in final run.

Number of parameters = 284 Objective function value = 302.090 Maximum gradient component = 0.00126749

logsigmaC:
-0.421343 -0.614001 0.0545137

logsigmaU:
-0.447038 -0.260497 0.0344467
-1.05591 -0.317966 0.0426641
-1.32486 0.421891 -0.0220785
-1.16340 0.141508 0.0235450
-0.633890 -0.377463 0.0397268
-0.785561 -0.330303 0.0449593

log_sel_coff1:
-1.22227 -0.723999 -0.796551 -1.35083 -1.09827 -0.339766 -0.379238 -0.112322 0.270304 0.155891 -0.230315 0.0887658 0.123754 -0.211441 -0.121784 -0.341292 -0.708883 -0.638360 -0.496414 -0.278812 -0.364960 -0.488387 -0.865587 -0.940153 -0.681823 -1.38104 -0.204473 0.222595 0.223447 0.509492 0.223759 0.392077 0.334995 0.573248 0.458205 0.728622 0.823993 0.616423 0.764069 0.780961 0.750317 0.664749 0.973346 0.797832 0.640726 0.845125 0.412761 0.132224 -0.250236 -0.158576 -0.127414 -0.131491 0.0865608 0.255723 0.263222 0.394109 0.343608 0.237760 0.424796 0.703081 0.547934 0.682302 0.815479 0.793862 0.863100 0.867309 0.795684 0.849067 0.891350 1.04994 0.827291 0.526605 0.164005 -0.243374 -0.206912 -0.245490 -0.158649 -0.314211 -0.265367 0.147005 0.251323 0.409506 0.334349 0.370613 0.344169 0.557247 0.439296 0.666432 0.485537 0.539056 0.930553 0.864619 1.07590 0.848388 0.996047 0.865268 0.835663 0.495764 -0.141200 -0.688167 -0.760841 -0.706313 -0.650632 -0.790601 -0.179311 -0.197074 -0.0238754 0.0994992 -0.0249794 0.205657 0.214417 0.342372 0.272146 0.426382 0.397734 0.250996 0.620700 0.639533 0.606256 0.945307 0.704727 0.567394 0.137306 0.220664 -0.693520 -0.975713 -1.40705 -1.56980 -1.36307 -1.62904 -0.345110 -0.102644 -0.393299 -0.0127610 -0.257366 -0.103704 0.133379 0.323359 0.175462 0.0906134 0.201123 0.182704 0.252735 0.473758 0.455938 0.596782 0.510501 0.190367 -0.243175 -1.16840 -1.35217 -2.49784 -2.19090 -2.44344 -2.41683 -2.81149

log_sel_cofU:
-8.10530 -7.75411 -8.72856 -9.94805 -10.7816 -10.6430
-2.67215 -2.80009 -3.27918 -3.53416 -3.88842 -4.15388
-3.33302 -3.38447 -4.51877 -7.03805 -8.26577 -8.66423
-4.24766 -5.25437 -6.49461 -7.53550 -8.60418 -8.79122
-5.95816 -5.11485 -4.56583 -4.55470 -4.88691 -4.80376
-6.52210 -5.17877 -4.13206 -4.33069 -4.26014 -4.74261

log_initpop:
12.4948 12.7989 12.3173 11.9099 11.0113 11.0468 10.8085 10.3679 11.1341 13.0764 13.4741 13.6820 13.5958 13.6732 13.3297 13.3181 14.7155 13.4051 13.2672 12.9698 12.9469 13.4132 13.4164 12.9713 12.8127 14.1621 13.8923 13.5696 13.4085 13.8449 13.6861 13.7343 13.8993 13.8138 14.4669 14.1278 14.0888 14.4134 15.2757 14.4394 14.3827 14.0609 13.9225 13.7851 13.6212 13.2344 13.3161 13.7440 13.6224 14.6780 13.6280 13.4939 13.6369 13.3150 14.4319 13.3242 14.0559 13.6344 13.6898 14.2176 14.0196 13.9141 14.1745 14.3059 14.1263 14.2305 14.2902 13.7123 13.9343 14.3713 13.7975

Table 13.3.2. Plaice in Subarea 4 and Subdivision 20: Harvest (F) at age.

year	age								
	1	2	3	4	5	6	7	8	9	10
1957	0.101	0.172	0.262	0.308	0.256	0.211	0.225	0.228	0.200	0.200
1958	0.114	0.211	0.309	0.329	0.292	0.248	0.224	0.222	0.233	0.233
1959	0.128	0.247	0.348	0.346	0.325	0.284	0.228	0.217	0.250	0.250
1960	0.137	0.261	0.359	0.351	0.342	0.310	0.241	0.215	0.231	0.231
1961	0.137	0.257	0.352	0.350	0.347	0.326	0.263	0.219	0.197	0.197
1962	0.122	0.256	0.367	0.358	0.354	0.344	0.290	0.232	0.188	0.188
1963	0.095	0.268	0.427	0.383	0.372	0.373	0.313	0.257	0.219	0.219
1964	0.075	0.277	0.486	0.410	0.392	0.396	0.323	0.275	0.264	0.264
1965	0.069	0.260	0.474	0.417	0.400	0.393	0.311	0.266	0.267	0.267
1966	0.076	0.235	0.411	0.401	0.395	0.375	0.291	0.243	0.233	0.233
1967	0.099	0.237	0.371	0.377	0.383	0.367	0.291	0.237	0.211	0.211
1968	0.142	0.279	0.377	0.357	0.370	0.379	0.318	0.258	0.218	0.218
1969	0.189	0.329	0.397	0.348	0.361	0.391	0.349	0.290	0.243	0.243
1970	0.205	0.335	0.398	0.356	0.361	0.384	0.354	0.309	0.270	0.270
1971	0.194	0.312	0.393	0.385	0.377	0.371	0.343	0.316	0.296	0.296
1972	0.189	0.310	0.416	0.437	0.418	0.383	0.346	0.328	0.327	0.327
1973	0.207	0.345	0.472	0.505	0.478	0.425	0.372	0.352	0.361	0.361
1974	0.243	0.386	0.515	0.547	0.518	0.457	0.392	0.369	0.380	0.380
1975	0.292	0.399	0.492	0.525	0.499	0.440	0.383	0.362	0.370	0.370
1976	0.342	0.396	0.449	0.480	0.461	0.411	0.365	0.345	0.343	0.343
1977	0.371	0.410	0.445	0.465	0.457	0.422	0.373	0.338	0.317	0.317
1978	0.362	0.448	0.495	0.492	0.494	0.475	0.409	0.348	0.303	0.303
1979	0.320	0.482	0.574	0.542	0.533	0.518	0.444	0.366	0.302	0.302
1980	0.262	0.486	0.644	0.594	0.535	0.497	0.447	0.382	0.315	0.315
1981	0.224	0.467	0.674	0.629	0.516	0.446	0.421	0.385	0.332	0.332
1982	0.225	0.440	0.639	0.631	0.506	0.411	0.382	0.365	0.339	0.339
1983	0.262	0.420	0.575	0.612	0.517	0.409	0.356	0.337	0.336	0.336
1984	0.308	0.422	0.539	0.598	0.553	0.454	0.369	0.333	0.330	0.330

year	age									
	1	2	3	4	5	6	7	8	9	10
1985	0.331	0.450	0.556	0.607	0.614	0.552	0.438	0.366	0.332	0.332
1986	0.321	0.478	0.599	0.629	0.669	0.655	0.530	0.420	0.347	0.347
1987	0.281	0.477	0.631	0.648	0.677	0.676	0.574	0.465	0.381	0.381
1988	0.240	0.455	0.640	0.654	0.655	0.638	0.560	0.482	0.422	0.422
1989	0.221	0.444	0.635	0.640	0.652	0.638	0.535	0.467	0.446	0.446
1990	0.230	0.454	0.621	0.611	0.686	0.707	0.530	0.437	0.440	0.440
1991	0.243	0.456	0.600	0.590	0.712	0.771	0.553	0.436	0.434	0.434
1992	0.238	0.428	0.575	0.596	0.686	0.739	0.610	0.502	0.452	0.452
1993	0.215	0.395	0.568	0.619	0.638	0.664	0.673	0.603	0.485	0.485
1994	0.183	0.393	0.606	0.638	0.620	0.640	0.688	0.637	0.506	0.506
1995	0.153	0.427	0.692	0.649	0.644	0.682	0.645	0.572	0.497	0.497
1996	0.136	0.458	0.774	0.674	0.683	0.722	0.594	0.496	0.461	0.461
1997	0.134	0.447	0.788	0.727	0.707	0.698	0.568	0.465	0.408	0.408
1998	0.141	0.409	0.738	0.775	0.716	0.642	0.539	0.439	0.355	0.355
1999	0.150	0.372	0.659	0.760	0.719	0.606	0.473	0.378	0.314	0.314
2000	0.157	0.355	0.591	0.686	0.706	0.597	0.399	0.300	0.273	0.273
2001	0.169	0.371	0.569	0.606	0.652	0.585	0.369	0.252	0.210	0.210
2002	0.188	0.426	0.605	0.548	0.556	0.549	0.398	0.242	0.138	0.138
2003	0.205	0.477	0.636	0.499	0.458	0.479	0.412	0.232	0.093	0.093
2004	0.209	0.458	0.586	0.445	0.383	0.380	0.327	0.191	0.081	0.081
2005	0.200	0.387	0.481	0.383	0.323	0.282	0.213	0.138	0.081	0.081
2006	0.190	0.329	0.395	0.322	0.261	0.210	0.148	0.100	0.066	0.066
2007	0.184	0.302	0.346	0.268	0.203	0.164	0.128	0.079	0.039	0.039
2008	0.173	0.277	0.310	0.233	0.166	0.137	0.120	0.067	0.024	0.024
2009	0.152	0.234	0.271	0.221	0.157	0.123	0.105	0.060	0.022	0.022
2010	0.129	0.191	0.237	0.224	0.166	0.117	0.087	0.054	0.027	0.027
2011	0.111	0.170	0.223	0.226	0.176	0.116	0.074	0.048	0.031	0.031
2012	0.104	0.172	0.228	0.223	0.177	0.118	0.069	0.043	0.028	0.028

year	age									
	1	2	3	4	5	6	7	8	9	10
2013	0.107	0.185	0.240	0.220	0.176	0.121	0.070	0.040	0.024	0.024
2014	0.122	0.196	0.245	0.225	0.180	0.126	0.075	0.042	0.024	0.024
2015	0.138	0.201	0.245	0.234	0.185	0.129	0.082	0.046	0.024	0.024
2016	0.132	0.198	0.247	0.236	0.184	0.128	0.083	0.047	0.024	0.024
2017	0.102	0.188	0.252	0.228	0.175	0.123	0.078	0.042	0.021	0.021
2018	0.071	0.176	0.260	0.216	0.164	0.117	0.070	0.036	0.017	0.017

Table 13.3.3. Plaice in Subarea 4 and Subdivision 20: Stock numbers (thousands).

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	477525	266936	361804	223524	148734	60555	62741	49437	31821	68464
1958	710787	390726	203308	252031	148671	104205	44369	45311	35602	74278
1959	875057	573640	286183	135122	164076	100453	73572	32075	32842	78759
1960	802714	696875	405622	182927	86515	107319	68397	52998	23362	78613
1961	867365	633111	485663	256431	116510	55590	71203	48645	38679	73216
1962	615217	684054	443055	308948	163507	74507	36302	49528	35374	83136
1963	608124	492873	479379	277634	195461	103883	47778	24587	35523	88898
1964	2459690	500269	340983	283134	171281	121972	64754	31606	17207	90394
1965	663359	2064800	343102	189702	170010	104746	74285	42416	21716	74745
1966	577954	560380	1440960	193320	113161	103069	63952	49266	29410	66847
1967	429273	484631	400994	864320	117114	68952	64114	43240	34953	69001
1968	419523	351717	346123	250278	536178	72253	43241	43380	30883	76194
1969	668786	329388	240794	214771	158458	335274	44761	28477	30325	77896
1970	670920	500683	214426	146463	137251	99977	205099	28571	19275	76810
1971	429894	494355	324044	130268	92827	86543	61628	130263	18980	66386
1972	366857	320301	327349	197846	80224	57588	54017	39567	85952	57450
1973	1414310	274670	212513	195410	115609	47794	35511	34563	25781	93569
1974	1079830	1040760	176037	119891	106735	64869	28276	22157	21995	75286

year	age									
	1	2	3	4	5	6	7	8	9	10
1975	782016	766491	639881	95195	62780	57545	37183	17285	13866	60169
1976	665645	528372	465415	353847	50933	34486	33538	22942	10892	46252
1977	1029840	427806	321790	268816	198102	29066	20686	21056	14709	36693
1978	878573	643229	256883	186558	152824	113468	17250	12890	13588	33863
1979	921985	553375	372005	141629	103217	84337	63828	10366	8237	31718
1980	1087410	605875	309230	189641	74519	54825	45476	37038	6507	26730
1981	998312	756982	337062	146952	94776	39504	30182	26322	22874	21943
1982	1918150	722164	429315	155485	70912	51165	22876	17931	16209	29086
1983	1366570	1385660	420851	204936	74831	38684	30703	14126	11268	29186
1984	1314260	951873	823587	214321	100597	40394	23249	19468	9123	26171
1985	1818360	874272	564673	434820	106621	52347	23221	14546	12631	22951
1986	4306660	1181680	504473	293023	214313	52184	27283	13554	9129	23090
1987	1866210	2827550	662622	250806	141355	99299	24535	14533	8060	20597
1988	1763250	1274770	1587840	319091	118715	64985	45718	12511	8263	17718
1989	1278120	1255600	731707	757382	150139	55806	31054	23632	6993	15411
1990	1112890	926940	728507	350867	361443	70753	26685	16460	13411	12982
1991	970053	800409	532839	354242	172375	164721	31556	14214	9624	15374
1992	823400	688318	459096	264669	177652	76556	68911	16421	8317	14657
1993	559267	586968	406107	233761	131932	80980	33080	33879	8994	13231
1994	606864	408199	357903	208262	113864	63073	37712	15273	16779	12386
1995	931026	457421	249264	176629	99526	55425	30089	17148	7307	15914
1996	824369	722667	270062	112891	83489	47285	25364	14288	8761	12782
1997	2369150	651071	413712	112681	52076	38170	20787	12670	7869	12293
1998	829033	1874820	376804	170267	49272	23236	17192	10653	7205	12136
1999	724979	651341	1126980	163053	70986	21778	11066	9071	6213	12277
2000	836436	564782	406081	527795	68971	31286	10746	6237	5627	12219
2001	606235	646646	358162	203555	240485	30808	15587	6527	4180	12284
2002	1852180	463267	403684	183439	100474	113371	15523	9752	4589	12075

year	age									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2003	611844	1389210	273805	199547	95911	52130	59233	9432	6931	13140
2004	1271770	450941	780060	131159	109577	54910	29222	35490	6769	16543
2005	834323	933906	258043	392800	76086	67622	33986	19061	26528	19449
2006	881839	618243	573710	144288	242267	49860	46139	24852	15028	38362
2007	1494920	660013	402435	349785	94660	168776	36570	35988	20356	45208
2008	1226400	1125810	441388	257679	242195	69922	129562	29105	30091	57039
2009	1103570	933240	772059	292942	184779	185620	55151	103937	24620	76956
2010	1431820	857361	668312	532839	212461	142844	148494	44908	88579	89882
2011	1632940	1139010	640784	476949	385363	162812	114945	123146	38502	157115
2012	1364450	1321860	869476	464006	344096	292513	131156	96546	106211	171564
2013	1514410	1113120	1006910	626285	336089	260894	235246	110728	83722	244348
2014	1607560	1231720	837095	716713	454852	255032	209084	198468	96248	289734
2015	901948	1287570	915891	592608	517795	343871	203501	175454	172133	341127
2016	1126150	711007	952856	648379	424551	389510	273542	169696	151562	453218
2017	1743340	893329	527814	673678	463550	319625	310060	227774	146504	534388
2018	982127	1424400	669571	371153	485237	351959	255645	259531	197550	603486

Table 13.3.4. 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	477525	342348.6	78538.05	71054.66	7483	0.242	0.202	0.094	0.21
1958	710787	355402.6	88626.61	74047.02	14580	0.278	0.203	0.173	0.21
1959	875057	362316.2	104803.33	77941.58	26862	0.310	0.197	0.213	0.22
1960	802714	380645.3	118056.98	88827.26	29230	0.325	0.238	0.201	0.23
1961	867365	392198.6	120016.08	85483.56	34533	0.326	0.220	0.254	0.22
1962	615217	482790.0	126310.36	90284.30	36026	0.336	0.213	0.258	0.19
1963	608124	441157.1	140314.92	103049.35	37266	0.364	0.228	0.312	0.23
1964	2459690	431041.9	147464.28	111198.52	36266	0.392	0.250	0.275	0.26
1965	663359	384301.1	152091.82	105836.62	46255	0.389	0.275	0.265	0.28
1966	577954	404479.1	162344.98	98223.29	64122	0.363	0.228	0.287	0.24
1967	429273	474108.6	153417.80	103241.45	50176	0.347	0.202	0.250	0.22
1968	419523	460272.3	149694.38	121014.50	28680	0.352	0.223	0.222	0.26
1969	668786	404080.1	147361.78	123692.95	23669	0.365	0.265	0.185	0.31
1970	670920	371001.8	138189.09	113039.78	25149	0.367	0.268	0.222	0.30
1971	429894	360721.2	140496.15	116675.36	23821	0.368	0.277	0.209	0.32
1972	366857	365362.3	146988.08	128416.14	18572	0.393	0.317	0.165	0.35
1973	1414310	303496.2	151340.01	133399.57	17940	0.445	0.394	0.118	0.44
1974	1079830	300591.9	161358.22	117259.92	44098	0.484	0.404	0.195	0.39
1975	782016	302267.4	167957.13	95869.66	72087	0.471	0.311	0.363	0.32
1976	665645	326752.4	174113.50	121174.29	52939	0.439	0.317	0.265	0.37
1977	1029840	327003.4	161998.26	106086.32	55912	0.440	0.288	0.276	0.32
1978	878573	328221.4	176524.28	127275.28	49249	0.481	0.364	0.240	0.39
1979	921985	304718.1	175624.76	121921.65	53703	0.530	0.384	0.284	0.40
1980	1087410	320083.3	187812.29	152748.16	35064	0.551	0.485	0.160	0.48
1981	998312	289567.3	185065.88	151593.06	33473	0.546	0.481	0.157	0.52
1982	1918150	281802.0	190222.31	144412.49	45810	0.525	0.448	0.185	0.51
1983	1366570	337075.6	208486.13	141124.15	67362	0.506	0.410	0.225	0.42
1984	1314260	367840.9	226502.69	161178.79	65324	0.513	0.388	0.218	0.44
1985	1818360	398599.0	252567.71	185822.79	66745	0.556	0.463	0.225	0.47

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1986	4306660	409451.9	287567.93	171203.20	116365	0.606	0.467	0.278	0.42
1987	1866210	464638.4	303893.78	153476.29	150417	0.622	0.451	0.415	0.33
1988	1763250	418332.4	301927.47	161639.99	140287	0.609	0.380	0.428	0.39
1989	1278120	452022.0	290245.16	186904.40	103341	0.602	0.391	0.406	0.41
1990	1112890	404299.3	260700.43	180009.86	80691	0.616	0.430	0.394	0.45
1991	970053	359877.0	227329.37	153333.71	73996	0.626	0.431	0.385	0.43
1992	823400	306374.0	186382.52	130905.98	55477	0.605	0.428	0.329	0.43
1993	559267	277350.7	168319.42	133988.85	34331	0.577	0.461	0.239	0.48
1994	606864	239157.0	152431.57	127356.28	25075	0.580	0.491	0.211	0.53
1995	931026	230861.9	143299.79	117741.11	25559	0.619	0.534	0.203	0.51
1996	824369	205334.6	137525.87	96951.06	40575	0.662	0.525	0.314	0.47
1997	2369150	199394.1	140348.67	77209.82	63139	0.673	0.479	0.476	0.39
1998	829033	237800.6	154451.09	69044.23	85407	0.656	0.398	0.461	0.29
1999	724979	232669.6	176522.16	100370.04	76152	0.623	0.390	0.375	0.43
2000	836436	245863.9	157029.41	107172.89	49857	0.587	0.410	0.327	0.44
2001	606235	242846.5	128758.55	66900.99	61858	0.557	0.287	0.384	0.28
2002	1852180	228745.6	135370.87	81638.55	53732	0.537	0.360	0.366	0.36
2003	611844	265938.7	147897.27	71735.10	76162	0.510	0.316	0.388	0.27
2004	1271770	262747.4	146637.71	86492.34	60145	0.450	0.276	0.367	0.33
2005	834323	284876.9	118121.83	63990.33	54132	0.371	0.192	0.330	0.22
2006	881839	315171.2	110022.47	62099.57	47923	0.303	0.178	0.269	0.20
2007	1494920	325053.3	101482.46	56860.17	44622	0.257	0.136	0.247	0.17
2008	1226400	418569.1	111708.06	61773.36	49935	0.225	0.138	0.197	0.15
2009	1103570	514648.4	117562.86	70179.51	47383	0.201	0.117	0.181	0.14
2010	1431820	626083.3	119825.38	76863.93	42961	0.187	0.110	0.151	0.12
2011	1632940	645834.3	119716.22	75253.37	44463	0.182	0.097	0.143	0.12
2012	1364450	688862.4	127648.40	78790.41	48858	0.183	0.096	0.161	0.11
2013	1514410	793217.3	136871.29	93112.62	43759	0.188	0.107	0.166	0.12
2014	1607560	923896.6	139240.13	86218.84	53021	0.194	0.089	0.186	0.09

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
2015	901948	864390.7	142260.28	95282.60	46978	0.199	0.097	0.192	0.11
2016	1126150	929262.7	136417.07	90116.65	46300	0.198	0.091	0.192	0.10
2017	1743340	1002207.0	127114.00	84537.67	42576	0.193	0.086	0.186	0.08
2018	982127	967507.6	106361.18	61045.38	45316	0.187	0.073	0.190	0.06

Table 13.4.1. 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
1977	878573	553375	NA	NA	9828.8	NA	NA	NA
1978	921985	605875	NA	NA	12882.3	NA	NA	NA
1979	1087410	756982	NA	NA	18785.3	NA	NA	NA
1980	998312	722164	NA	NA	8642.0	NA	NA	NA
1981	1918150	1385660	NA	NA	13908.6	NA	NA	NA
1982	1366570	951873	NA	NA	10412.8	NA	NA	NA
1983	1314260	874272	NA	NA	13847.8	NA	NA	NA
1984	1818360	1181680	NA	NA	7580.4	NA	NA	NA
1985	4306660	2827550	NA	NA	32991.1	NA	NA	NA
1986	1866210	1274770	NA	NA	14421.1	NA	NA	NA
1987	1763250	1255600	NA	NA	17810.2	NA	NA	NA
1988	1278120	926940	NA	NA	7496.0	NA	NA	NA
1989	1112890	800409	NA	NA	11247.2	NA	NA	NA
1990	970053	688318	NA	NA	13841.8	NA	NA	439.60
1991	823400	586968	NA	NA	9685.6	NA	NA	332.40
1992	559267	408199	NA	NA	4976.6	NA	NA	180.30
1993	606864	457421	NA	NA	2796.4	NA	NA	217.00
1994	931026	722667	NA	NA	10268.2	NA	24776.67	283.40
1995	824369	651071	NA	NA	4472.7	24784.96	16651.90	146.10
1996	2369150	1874820	NA	NA	30242.2	86903.05	84447.65	619.60
1997	829033	651341	NA	NA	10272.1	34341.21	18241.26	229.20
1998	724979	564782	NA	NA	2493.4	44468.19	22061.36	NA
1999	836436	646646	NA	22855.000	2898.5	42041.05	20220.58	NA
2000	606235	463267	24213.50	11510.524	1102.7	29321.92	16603.60	124.90
2001	1852180	1389210	99628.05	30809.227	NA	135695.66	46599.54	313.20
2002	611844	450941	31202.02	NA	1349.7	32578.42	13625.57	122.90
2003	1271770	933906	NA	18201.602	1818.9	44914.63	28361.91	238.60
2004	834323	618243	13537.18	10118.405	1571.0	38150.65	17135.61	126.70
2005	881839	660013	27390.56	12164.222	2133.9	42317.29	22096.13	85.90

Year–class	age 1 AAP	age 2 AAP	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
2006	1494920	1125810	51124.24	14174.543	2700.4	85808.72	46747.25	168.00
2007	1226400	933240	40580.90	14705.767	2018.7	69588.10	23409.50	98.30
2008	1103570	857361	50179.33	14860.033	1811.5	65528.67	28444.02	129.70
2009	1431820	1139010	53258.82	11946.907	1142.5	79188.24	42235.42	141.90
2010	1632940	1321860	49347.24	18348.596	2928.6	127483.87	62344.47	179.60
2011	1364450	1113120	52643.00	5893.440	3021.3	58335.07	52651.62	93.00
2012	1514410	1231720	45027.08	15394.879	2258.3	86614.32	61554.79	181.10
2013	1607560	1287570	44327.52	17312.697	5040.4	144680.38	66989.49	168.50
2014	901948	711007	11722.34	16726.486	2434.3	51652.00	31291.96	108.00
2015	NA	NA	30494.46	10384.821	1715.5	81863.34	51049.46	100.20
2016	NA	NA	44110.99	15935.908	5250.0	140332.68	71780.73	78.05
2017	NA	NA	27396.53	9464.911	NA	85346.88	NA	127.20
2018	NA	NA	190207.50	NA	NA	NA	NA	219.34

Table 13.4.2. Plaice in Subarea 4 and Subdivision 20. RCT3 results for age 1 in 2019 (year class 2018).

```
Analysis by RCT3 ver4.0

Data for 6 surveys over 42 years : 1977 - 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 prediction se.pred WAP.weights
     SNS0 0.8799    4.6976 0.3587 0.52844 14  12.156      15.39  0.5056     0.39561
     DFS0 2.6935   -0.1081 1.3329 0.08436 23   5.391      14.41  1.4298     0.04948
 VPA Mean     NA        NA     NA      NA 38      NA      13.96  0.4269     0.55491

                  WAP logWAP int.se
yearclass:2018 2084830  14.55  0.318
```

Table 13.4.3. Plaice in Subarea 4 and Subdivision 20: RCT3 results for age 2 in 2019 (year class 2017).

```
Analysis by RCT3 ver4.0

Data for 10 surveys over 42 years : 1977 - 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:2017
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     SNS0 0.9494     3.711 0.3963 0.50557 14  10.218      13.41  0.4476    0.140386
     SNS1 3.7007   -21.782 1.4088 0.05691 15   9.155      12.10  1.6325    0.010554
    BTSC1 0.8779     4.039 0.2330 0.75260 20  11.354      14.01  0.2551    0.432248
     DFS0 3.2898    -3.469 1.6470 0.06279 23   4.846      12.47  1.7785    0.008892
 IBTSQ3_1 0.7543     7.797 0.3136 0.63333 19   7.687      13.60  0.3404    0.242691
 IBTSQ1_1 3.0375    -8.768 1.3446 0.02624  9   6.533      11.07  1.9964    0.007057
VPA Mean     NA         NA     NA      NA  38      NA      13.66  0.4217    0.158172

                 WAP logWAP int.se
yearclass:2017 903568  13.71 0.1677
```

Table 13.5.1. Plaice in Subarea 4 and Subdivision 20: Input to the short term forecast (F values presented are for Fsq).

2019_ssb	2019_f2–6	2019_f_dis2–3	2019_f_hc2–6	2019_recruits	2019_landings	2019_discards	2019_catch	2019_TAC			
1052266	0.193	0.189	0.083	1287315	76314	47769	124083	142217			
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
1	2019	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1
2	2019	0.187	0.182	0.006	827716	0.086	0.246	0.081	0.066	0.5	0.1
3	2019	0.253	0.197	0.056	1080785	0.155	0.269	0.122	0.122	0.5	0.1
4	2019	0.227	0.106	0.121	467174	0.223	0.294	0.142	0.181	1	0.1
5	2019	0.174	0.047	0.128	270531	0.289	0.338	0.154	0.248	1	0.1
6	2019	0.123	0.016	0.106	372793	0.356	0.384	0.175	0.313	1	0.1
7	2019	0.077	0.006	0.071	283361	0.413	0.435	0.178	0.355	1	0.1
8	2019	0.042	0.004	0.038	215690	0.479	0.507	0.192	0.419	1	0.1
9	2019	0.020	0.000	0.020	226534	0.546	0.546	0.320	0.456	1	0.1
10	2019	0.020	0.000	0.020	712593	0.680	0.680	0.000	0.556	1	0.1
1	2020	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1
2	2020	0.187	0.182	0.006	NA	0.086	0.246	0.081	0.066	0.5	0.1
3	2020	0.253	0.197	0.056	NA	0.155	0.269	0.122	0.122	0.5	0.1
4	2020	0.227	0.106	0.121	NA	0.223	0.294	0.142	0.181	1	0.1
5	2020	0.174	0.047	0.128	NA	0.289	0.338	0.154	0.248	1	0.1

2019_ssb	2019_f2–6	2019_f_dis2–3	2019_f_hc2–6	2019_recruits	2019_landings	2019_discards	2019_catch	2019_TAC			
1052266	0.193	0.189	0.083	1287315	76314	47769	124083	142217			
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
6	2020	0.123	0.016	0.106	NA	0.356	0.384	0.175	0.313	1	0.1
7	2020	0.077	0.006	0.071	NA	0.413	0.435	0.178	0.355	1	0.1
8	2020	0.042	0.004	0.038	NA	0.479	0.507	0.192	0.419	1	0.1
9	2020	0.020	0.000	0.020	NA	0.546	0.546	0.320	0.456	1	0.1
10	2020	0.020	0.000	0.020	NA	0.680	0.680	0.000	0.556	1	0.1
1	2021	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1
2	2021	0.187	0.182	0.006	NA	0.086	0.246	0.081	0.066	0.5	0.1
3	2021	0.253	0.197	0.056	NA	0.155	0.269	0.122	0.122	0.5	0.1
4	2021	0.227	0.106	0.121	NA	0.223	0.294	0.142	0.181	1	0.1
5	2021	0.174	0.047	0.128	NA	0.289	0.338	0.154	0.248	1	0.1
6	2021	0.123	0.016	0.106	NA	0.356	0.384	0.175	0.313	1	0.1
7	2021	0.077	0.006	0.071	NA	0.413	0.435	0.178	0.355	1	0.1
8	2021	0.042	0.004	0.038	NA	0.479	0.507	0.192	0.419	1	0.1
9	2021	0.020	0.000	0.020	NA	0.546	0.546	0.320	0.456	1	0.1
10	2021	0.020	0.000	0.020	NA	0.680	0.680	0.000	0.556	1	0.1

Table 13.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short term forecast assuming F_{2019} = $F_{-status\ quo}$ (not rescaled).

Basis	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	^^ F_{total} ages 2–6 (2020)	F_{wanted} ages 2–6 (2020)	$F_{unwanted}$ ages 2–3 (2020)	SSB (2021)	% SSB change **	% TAC change ***	% Advice change ^
ICES advice basis										
EU MAP: F_{MSY}	131439	83536	47903	0.21	0.091	0.21	1128558	1.47	-7.6	-7.6
F = MAP $F_{MSY\ upper}$	181628	115827	65801	0.30	0.130	0.29	1081370	-2.8	28	28
F = MAP $F_{MSY\ lower}$	93382	59231	34151	0.146	0.063	0.143	1164489	4.7	-34	-34
Other scenarios										
F = 0	0	0	0	0.00	0.00	0.00	1254686	12.8	-100	-100
F_{pa}	217665	139194	78471	0.37	0.159	0.36	1047633	-5.8	53	53
F_{lim}	288072	185339	102733	0.52	0.22	0.51	982104	-11.7	103	103
SSB (2021) = B_{lim}	1154707	875141	279566	8.0	3.5	7.9	242443	-78	710	710
SSB (2021) = B_{pa}	1093919	816779	277140	6.6	2.8	6.4	290203	-74	670	670
SSB (2021) = MSY $B_{trigger}$	756458	520017	236441	2.3	1.00	2.3	564599	-49	430	430
Rollover TAC	142217	90441	51776	0.23	0.099	0.22	1118414	0.56	0	0
F_{2020} = F_{2019}	121529	77193	44336	0.193	0.083	0.189	1137903	2.3	-14.5	-14.5

*** "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 2016–2018. 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 2020. The subtracted value (836 t of wanted catch and 779 t of unwanted catch) is estimated based on the plaice catch advice for Division 7.d for 2020.**

**** SSB 2021 relative to SSB 2020.**

***** Total catch in 2020 relative to the combined TAC of Subarea 4 and Subdivision 20 in 2019 (142 217 t).**

^ Total catch in 2020 relative to advice value 2019 (142 217 t).

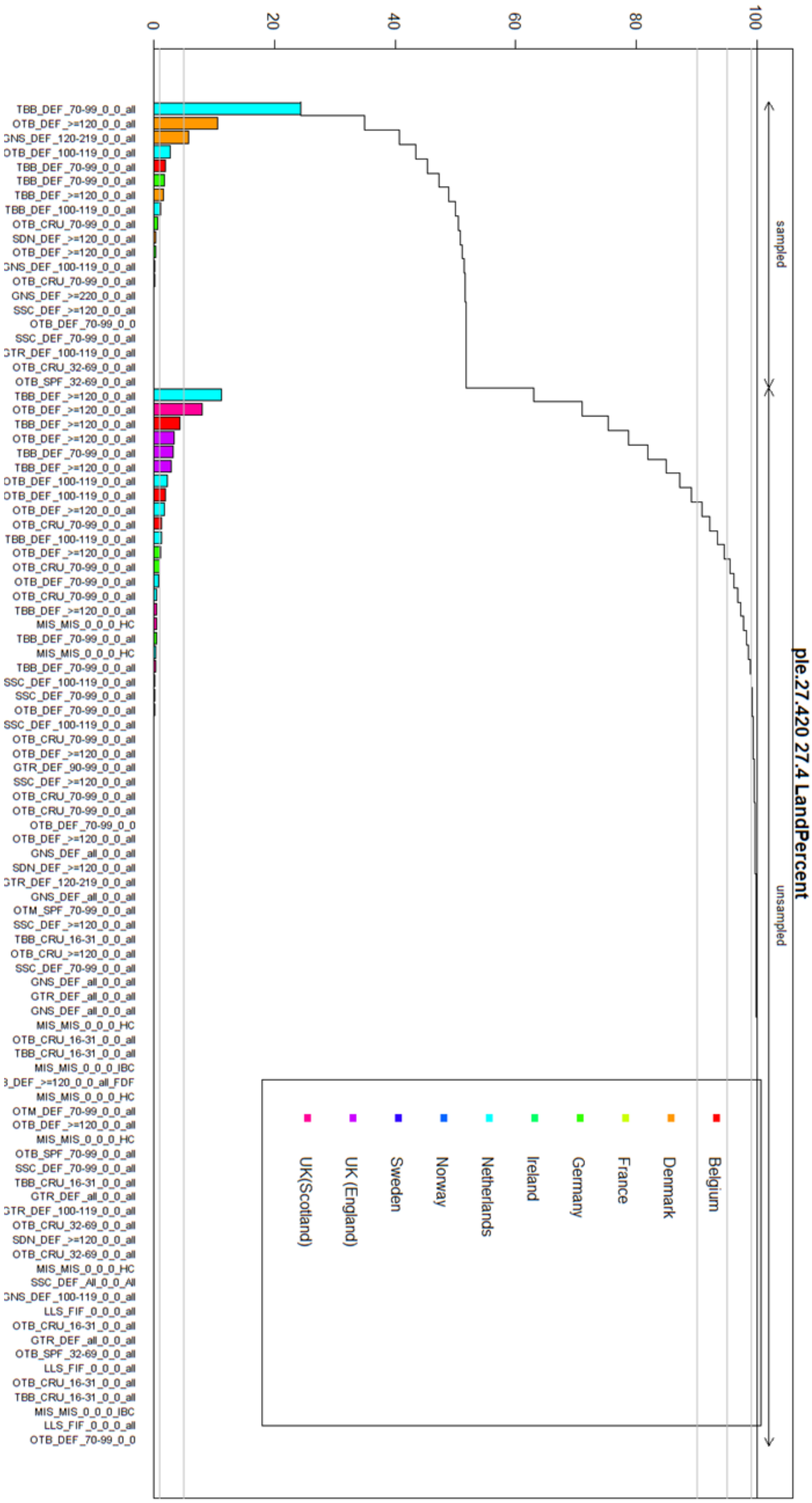
^^ F_{wanted} and $F_{unwanted}$ do not sum up to the F_{total} as they are calculated using different ages.

Table 13.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming $F_{2019} = F_{\text{-status quo}}$, not 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	2019	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1	118420	6200	19	2	118400
2	2019	0.187	0.182	0.006	827716	0.086	0.246	0.081	0.066	0.5	0.1	134840	11606	4137	1019	130704
3	2019	0.253	0.197	0.056	1080785	0.155	0.269	0.122	0.122	0.5	0.1	230328	35627	51111	13732	179217
4	2019	0.227	0.106	0.121	467174	0.223	0.294	0.142	0.181	1	0.1	90325	20114	48103	14142	42221
5	2019	0.174	0.047	0.128	270531	0.289	0.338	0.154	0.248	1	0.1	41239	11924	30184	10192	11055
6	2019	0.123	0.016	0.106	372793	0.356	0.384	0.175	0.313	1	0.1	41025	14596	35529	13631	5496
7	2019	0.077	0.006	0.071	283361	0.413	0.435	0.178	0.355	1	0.1	19992	8261	18311	7965	1681
8	2019	0.042	0.004	0.038	215690	0.479	0.507	0.192	0.419	1	0.1	8399	4022	7686	3897	713
9	2019	0.020	0.000	0.020	226534	0.546	0.546	0.320	0.456	1	0.1	4369	2384	4369	2384	1
10	2019	0.020	0.000	0.020	712593	0.680	0.680	0.000	0.556	1	0.1	13745	9348	13743	9348	2
1	2020	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1	118420	6200	19	2	118400
2	2020	0.187	0.182	0.006	1052308	0.086	0.246	0.081	0.066	0.5	0.1	171428	14756	5259	1296	166169
3	2020	0.253	0.197	0.056	620937	0.155	0.269	0.122	0.122	0.5	0.1	132329	20468	29364	7889	102965
4	2020	0.227	0.106	0.121	759391	0.223	0.294	0.142	0.181	1	0.1	146823	32696	78192	22988	68631
5	2020	0.174	0.047	0.128	336994	0.289	0.338	0.154	0.248	1	0.1	51370	14854	37599	12696	13771
6	2020	0.123	0.016	0.106	205632	0.356	0.384	0.175	0.313	1	0.1	22629	8051	19598	7519	3031

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
7	2020	0.077	0.006	0.071	298349	0.413	0.435	0.178	0.355	1	0.1	21050	8698	19280	8387	1770
8	2020	0.042	0.004	0.038	237399	0.479	0.507	0.192	0.419	1	0.1	9245	4427	8460	4289	785
9	2020	0.020	0.000	0.020	187181	0.546	0.546	0.320	0.456	1	0.1	3610	1970	3610	1970	0
10	2020	0.020	0.000	0.020	832536	0.680	0.680	0.000	0.556	1	0.1	16058	10922	16056	10922	2
1	2021	0.102	0.102	0.000	1287315	0.052	0.126	0.052	0.033	0	0.1	118420	6200	19	2	118400
2	2021	0.187	0.182	0.006	1052309	0.086	0.246	0.081	0.066	0.5	0.1	171428	14756	5259	1296	166169
3	2021	0.253	0.197	0.056	789423	0.155	0.269	0.122	0.122	0.5	0.1	168235	26022	37332	10030	130903
4	2021	0.227	0.106	0.121	436289	0.223	0.294	0.142	0.181	1	0.1	84353	18785	44923	13207	39430
5	2021	0.174	0.047	0.128	547785	0.289	0.338	0.154	0.248	1	0.1	83503	24145	61118	20637	22385
6	2021	0.123	0.016	0.106	256151	0.356	0.384	0.175	0.313	1	0.1	28189	10029	24413	9366	3776
7	2021	0.077	0.006	0.071	164569	0.413	0.435	0.178	0.355	1	0.1	11611	4798	10635	4626	976
8	2021	0.042	0.004	0.038	249956	0.479	0.507	0.192	0.419	1	0.1	9734	4661	8907	4516	826
9	2021	0.020	0.000	0.020	206020	0.546	0.546	0.320	0.456	1	0.1	3974	2168	3973	2168	0
10	2021	0.020	0.000	0.020	903980	0.680	0.680	0.000	0.556	1	0.1	17436	11859	17434	11859	2

(a)


ple.27.420 27.4 LandPercent
0
20
40
60
80
100
sampled
unsampled
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(b)

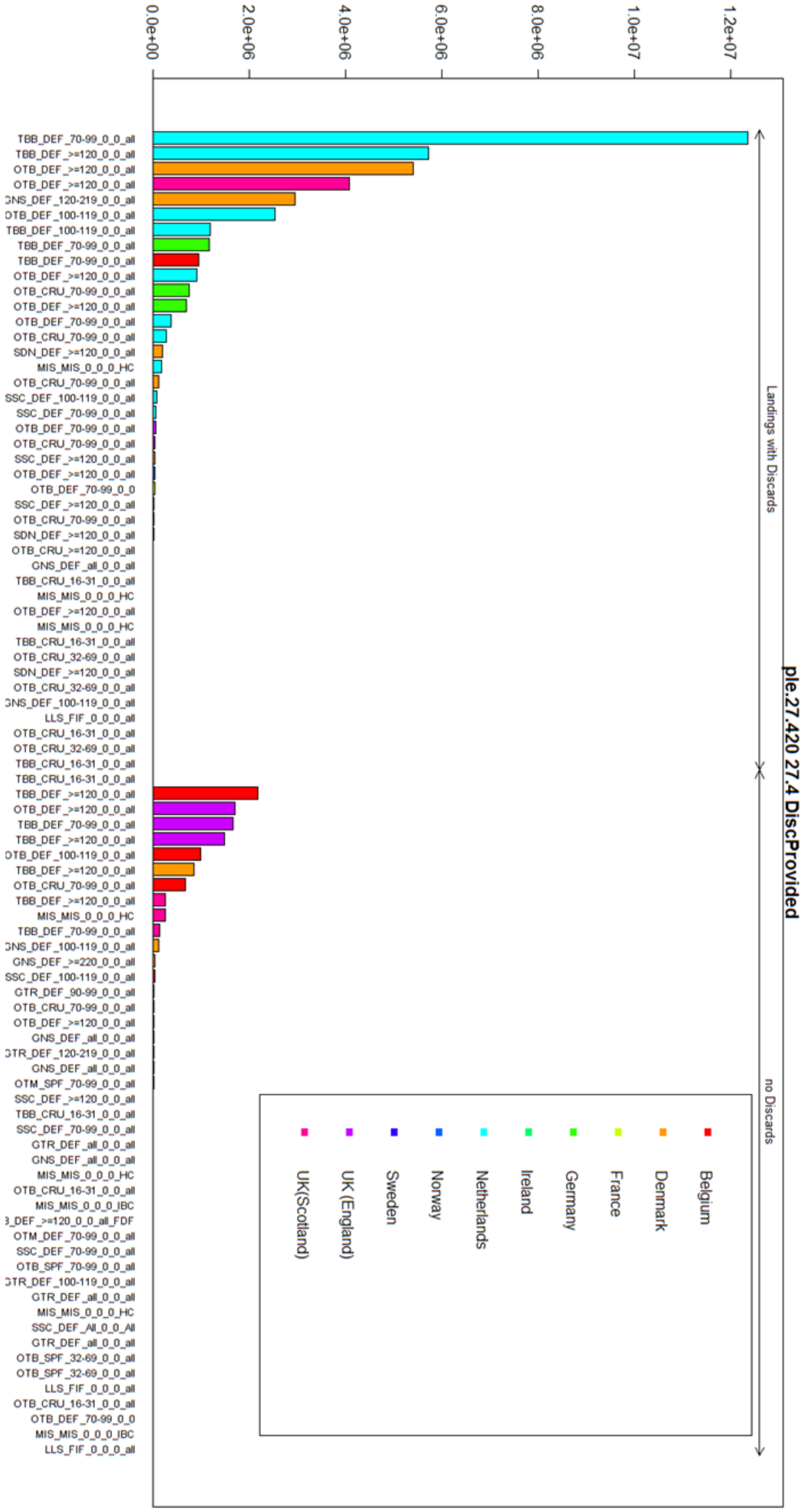
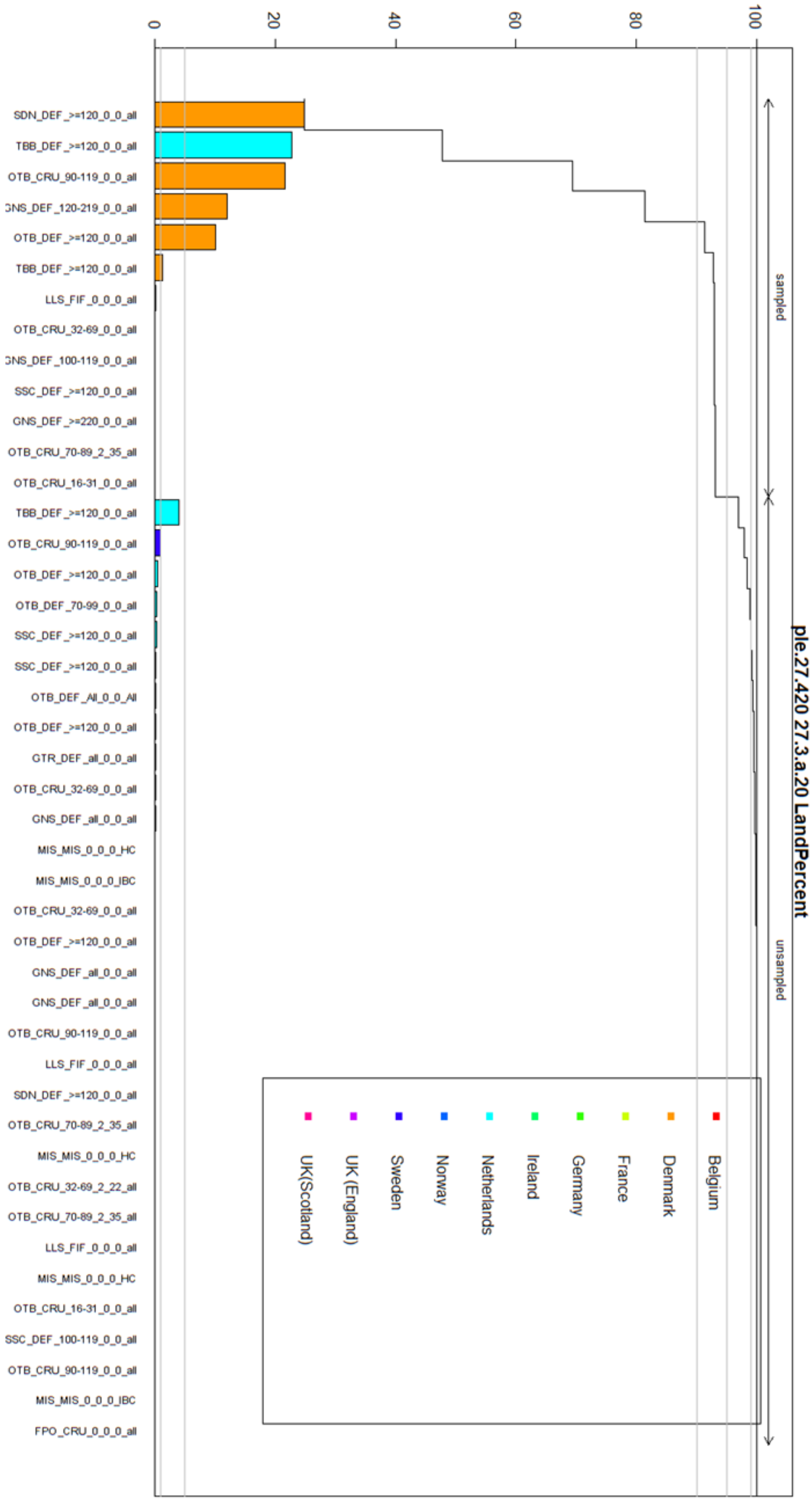


Figure 13.2.1. Summary of data upload in Intercatch for Subarea 4: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

(a)


ple.27.420 27.3.a.20 LandPercent
0
20
40
60
80
100
sampled
unsampled
SDN_DEF_>=120_0_0_all
TBB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
GNS_DEF_120-219_0_0_all
OTB_DEF_>=120_0_0_all
TBB_DEF_>=120_0_0_all
LLS_FIF_0_0_0_all
OTB_CRU_32-69_0_0_all
GNS_DEF_100-119_0_0_all
SSC_DEF_>=120_0_0_all
GNS_DEF_>=220_0_0_all
OTB_CRU_70-89_2_35_all
OTB_CRU_16-31_0_0_all
TBB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_70-99_0_0_all
SSC_DEF_>=120_0_0_all
SSC_DEF_>=120_0_0_all
OTB_DEF_All_0_0_All
OTB_DEF_>=120_0_0_all
GTR_DEF_all_0_0_all
OTB_CRU_32-69_0_0_all
GNS_DEF_all_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_IBC
OTB_CRU_32-69_0_0_all
OTB_DEF_>=120_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_90-119_0_0_all
LLS_FIF_0_0_0_all
SDN_DEF_>=120_0_0_all
OTB_CRU_70-89_2_35_all
MIS_MIS_0_0_0_HC
OTB_CRU_32-69_2_22_all
OTB_CRU_70-89_2_35_all
LLS_FIF_0_0_0_all
MIS_MIS_0_0_0_HC
OTB_CRU_16-31_0_0_all
SSC_DEF_100-119_0_0_all
OTB_CRU_90-119_0_0_all
MIS_MIS_0_0_0_IBC
FPO_CRU_0_0_0_all
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(b)

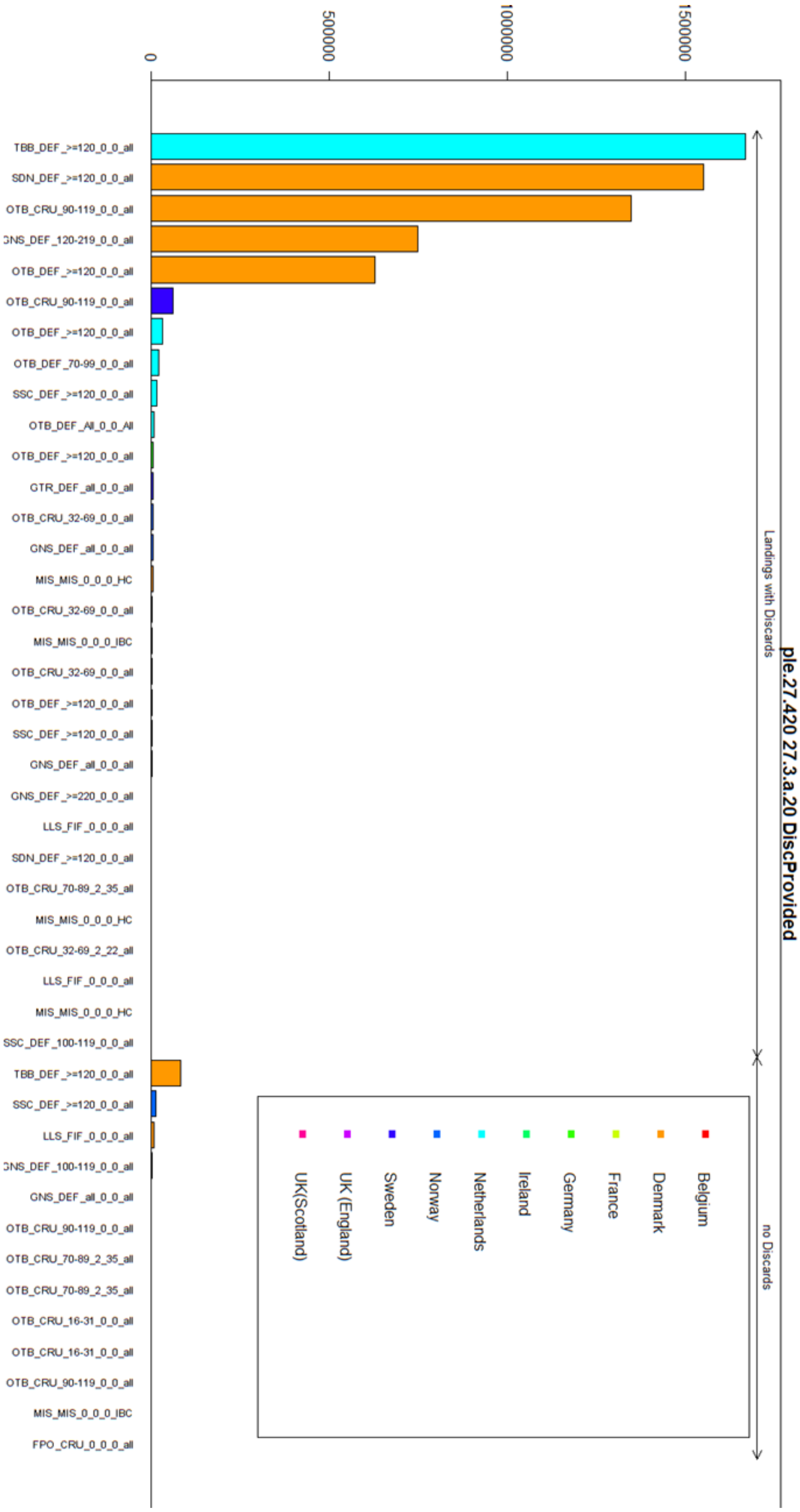


Figure 13.2.2. Summary of data upload in Intercatch for Subdivision 20: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

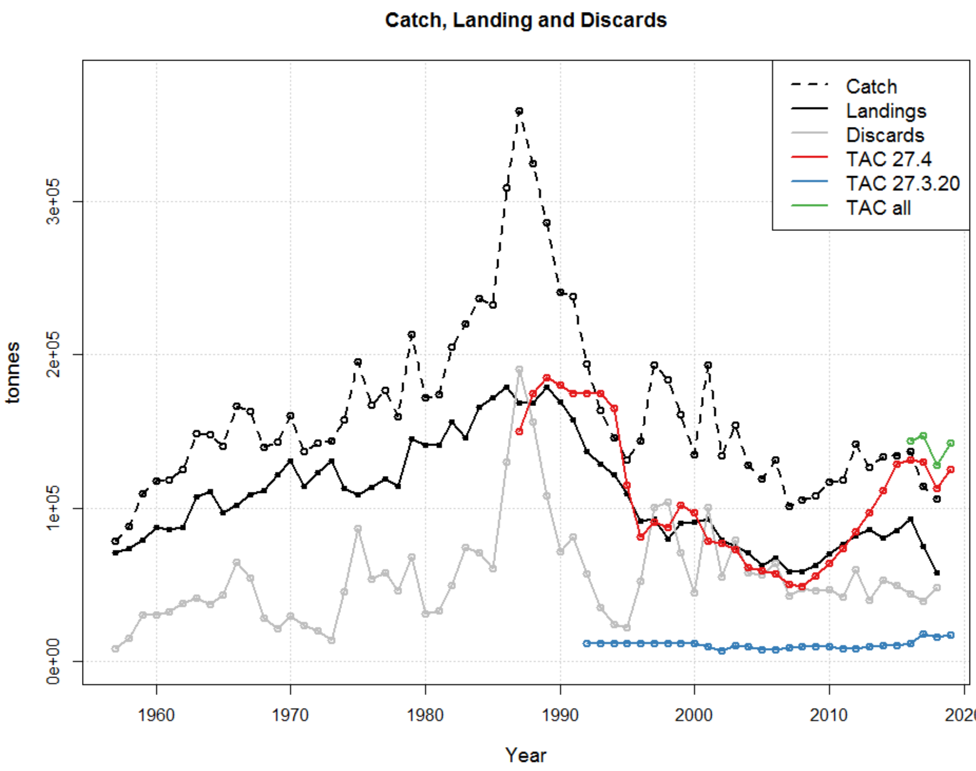


Figure 13.2.3. Plaice in Subarea 4 (including Subdivision 20 and 7.d Q1): Time series of catch (dashed line), landings (solid black line) and discards (gray line) estimates. Landings TAC for Subarea 4 (red) and Subdivision 20 (blue) are also plotted. Discards before 2000 were reconstructed using a model based method.

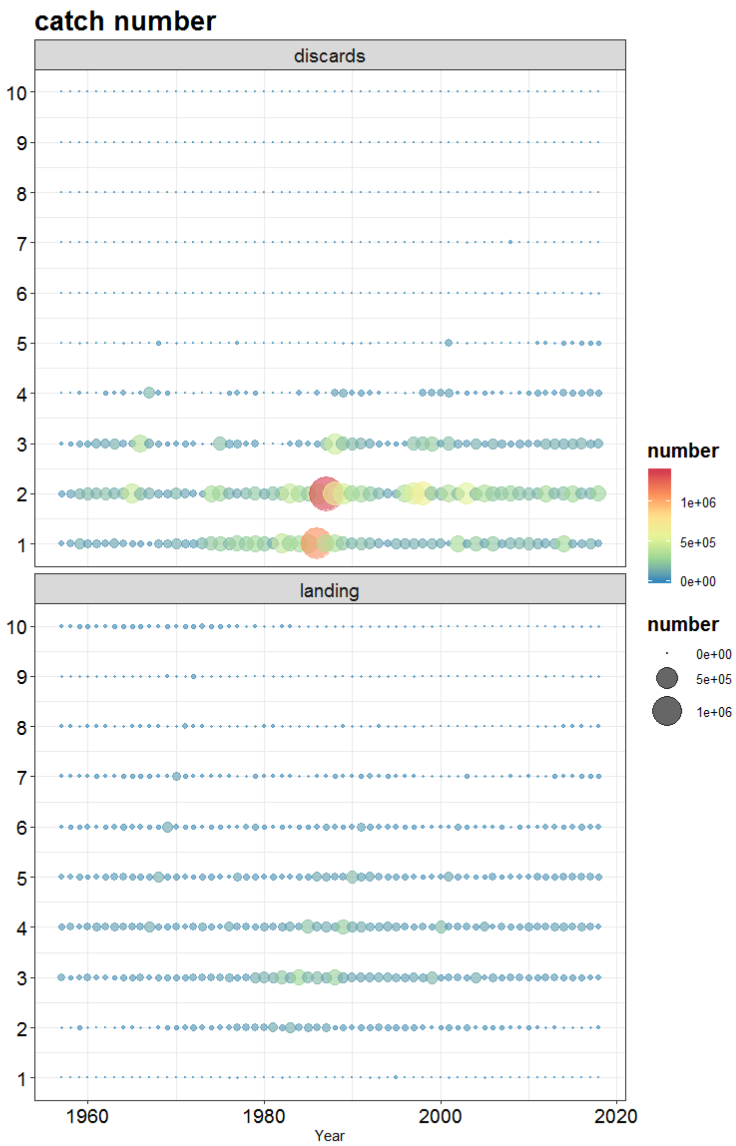


Figure 13.2.4. Plaice in Subarea 4 and Subdivision 20: Discards numbers-at-age (top) and landings numbers-at-age (down). Discards before 2000 were reconstructed using a model based method.

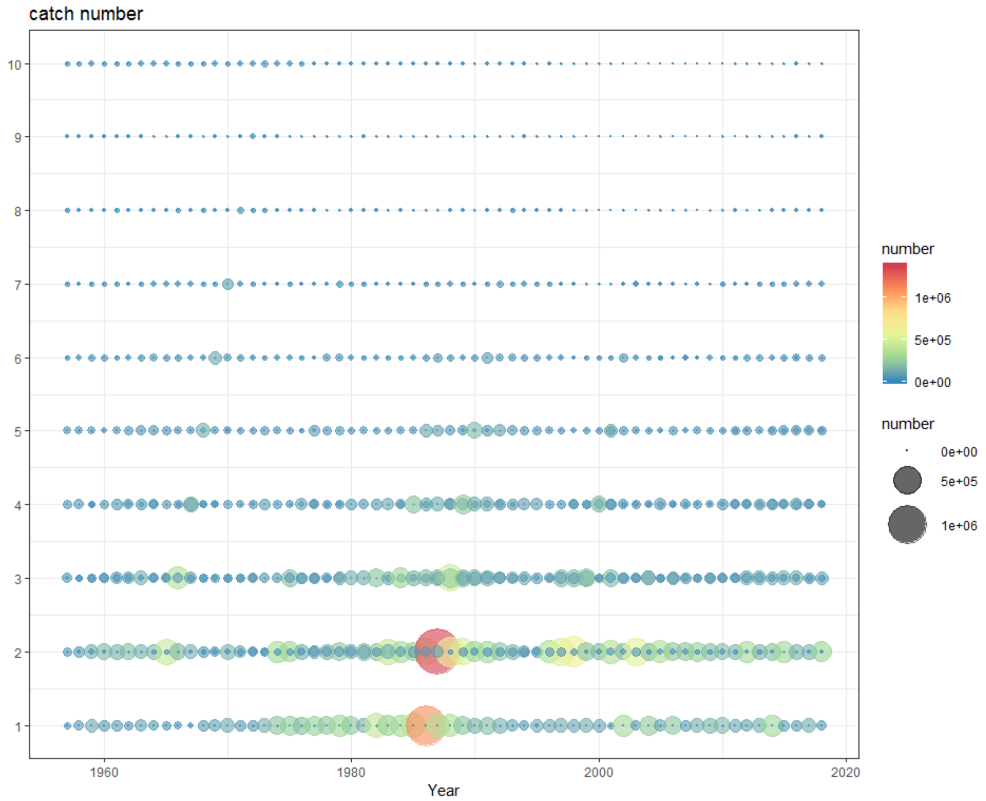


Figure 13.2.5. Plaice in Subarea 4 and Subdivision 20. Catch numbers-at-age: Discards before 2000 were reconstructed using a model based method.

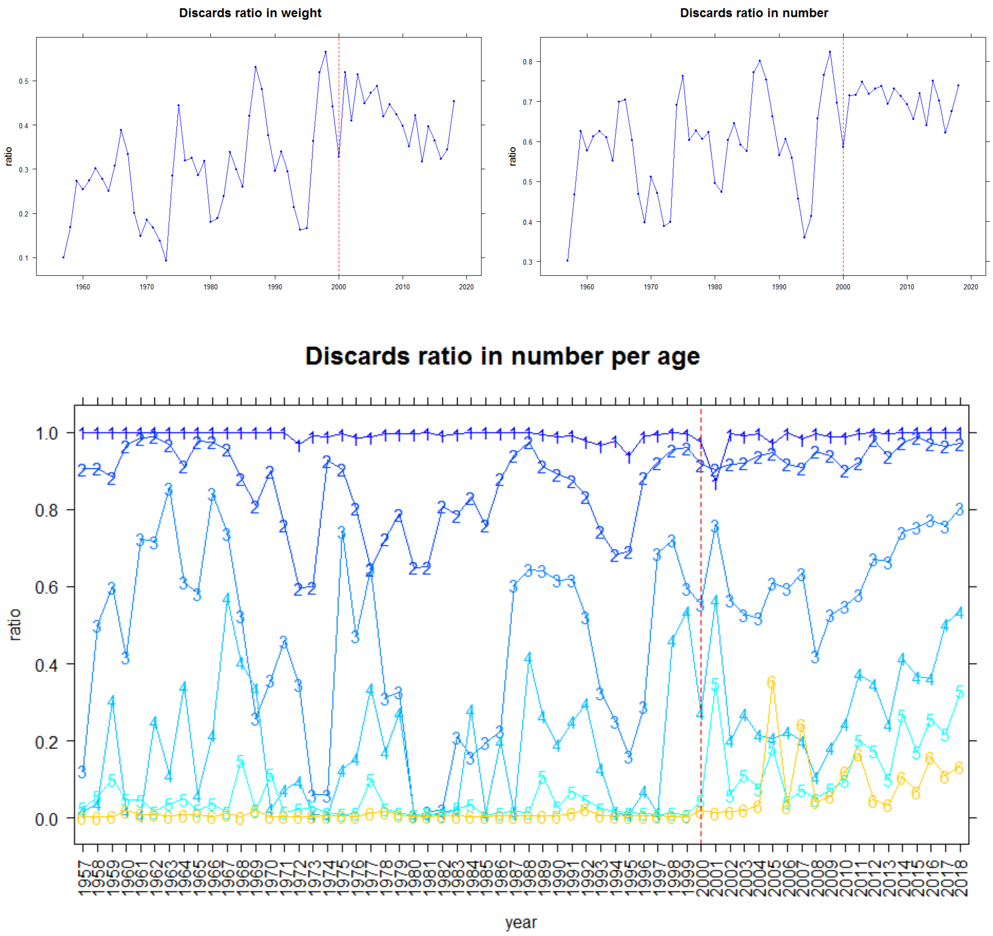


Figure 13.2.6. Discards ratio. Discards before 2000 were reconstructed using a model based method.

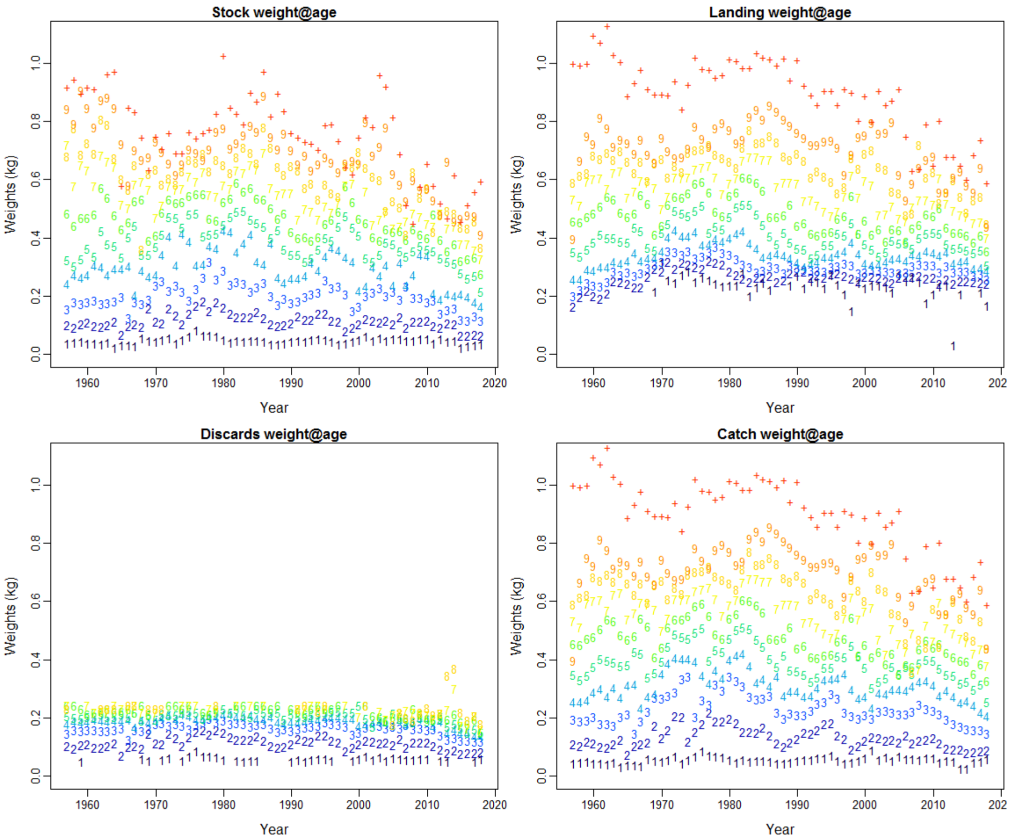


Figure 13.2.7. Plaice in Subarea 4 and Subdivision 20: Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

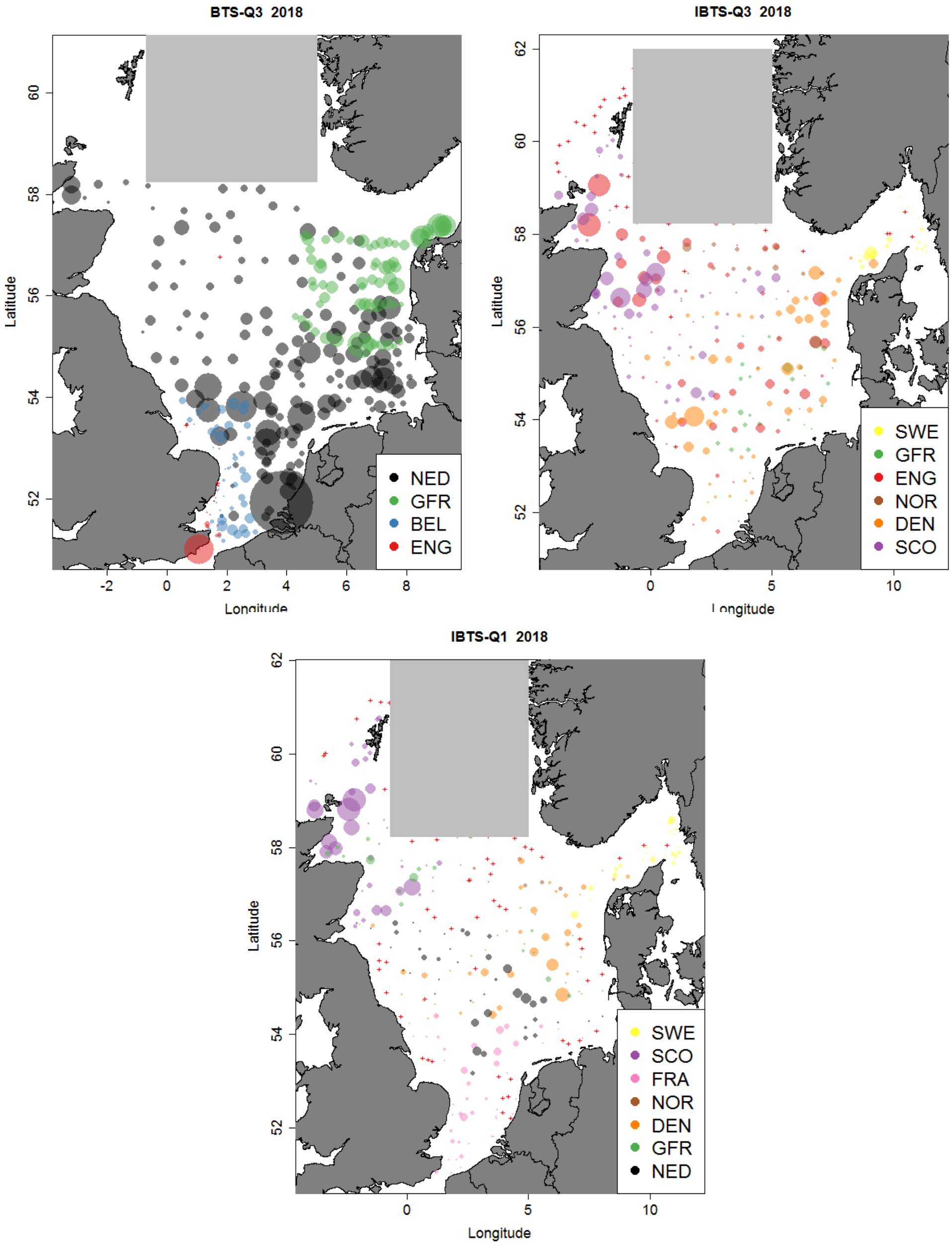
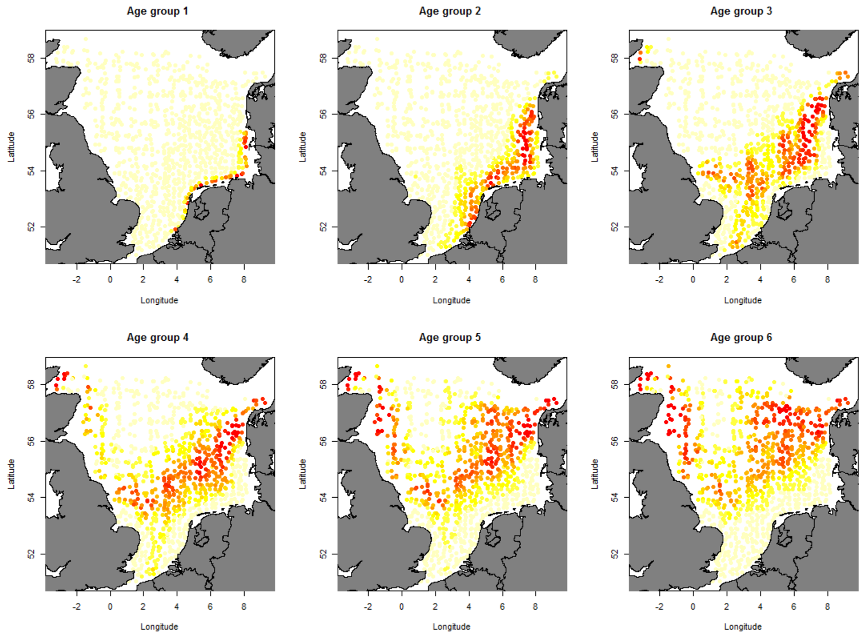
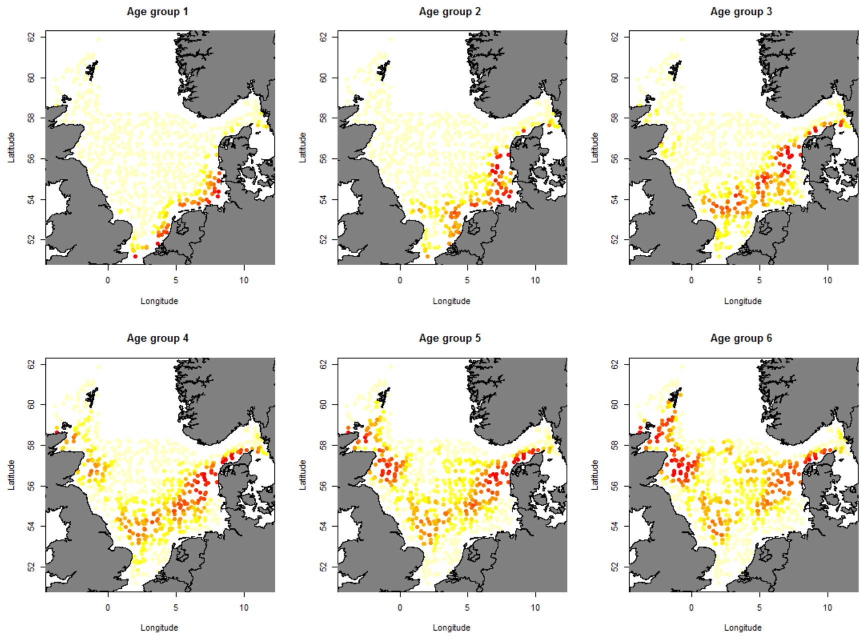


Figure 13.2.8. Spatial distribution of biomass per haul for BTS-Q3, IBTS-Q3 and IBTS-Q1 surveys in 2018. Indices for these 3 surveys were extracted using the delta-GAM method. Samples in gray area were excluded due to low coverage.

(a) BTS-Q3



(b) IBTS-Q3



(c) IBTS-Q1

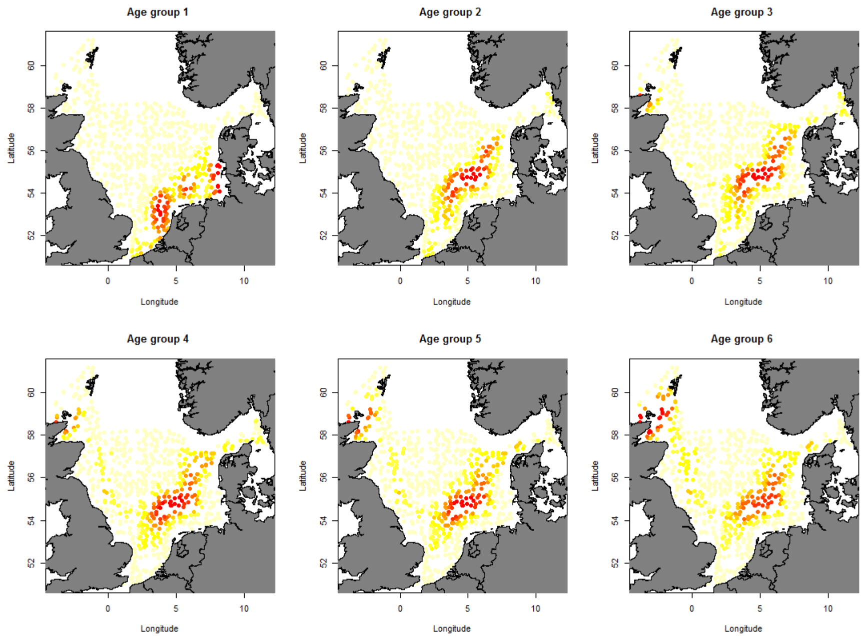


Figure 13.2.9. The estimated spatial abundance distribution per age for (a) BTS-Q3, (b) IBTS-Q3 and (c) IBTS-Q1, estimated using delta-GAM method. Age group 1–6 refers to age 0–5. Abundance decreasing from red to white color.

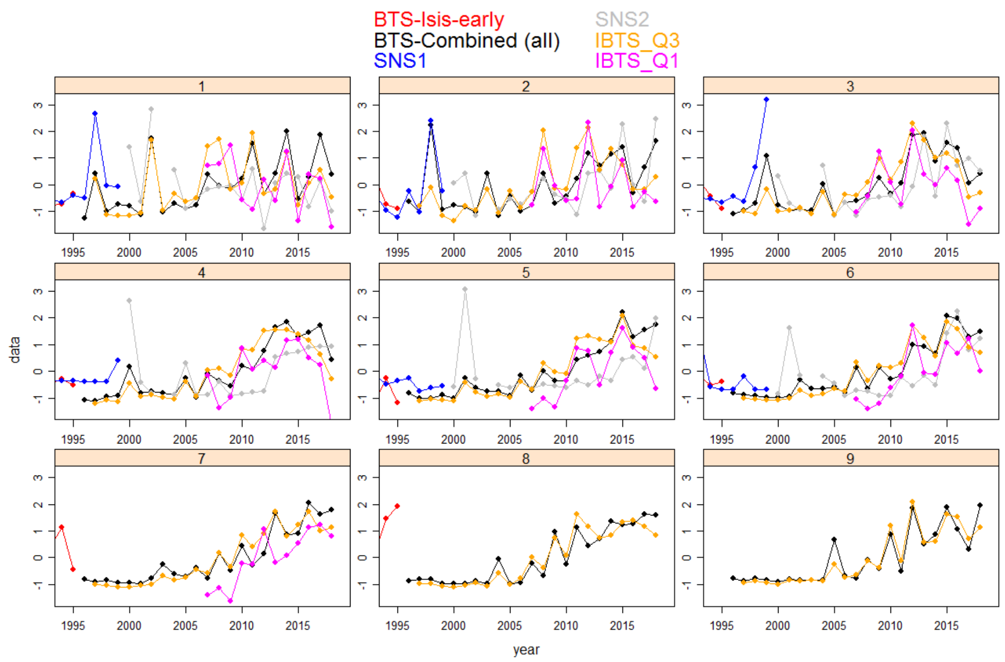


Figure 13.2.10. Plaice in Subarea 4 and Subdivision 20. Standardized survey tuning indices used for tuning stock assessment model: BTS–combined (1996–2018, black), BTS–Isis-early (1985–1995, red) SNS–1 (1970–1999, blue), SNS–2 (2000–2018, grey), IBTS–Q3 (1997–2018, yellow) and IBTS–Q1 (2007-2018, pink). Note: only ages used in the assessment are presented. The BTS–combined index combines BTS–Tridens and BTS–Isis indices.

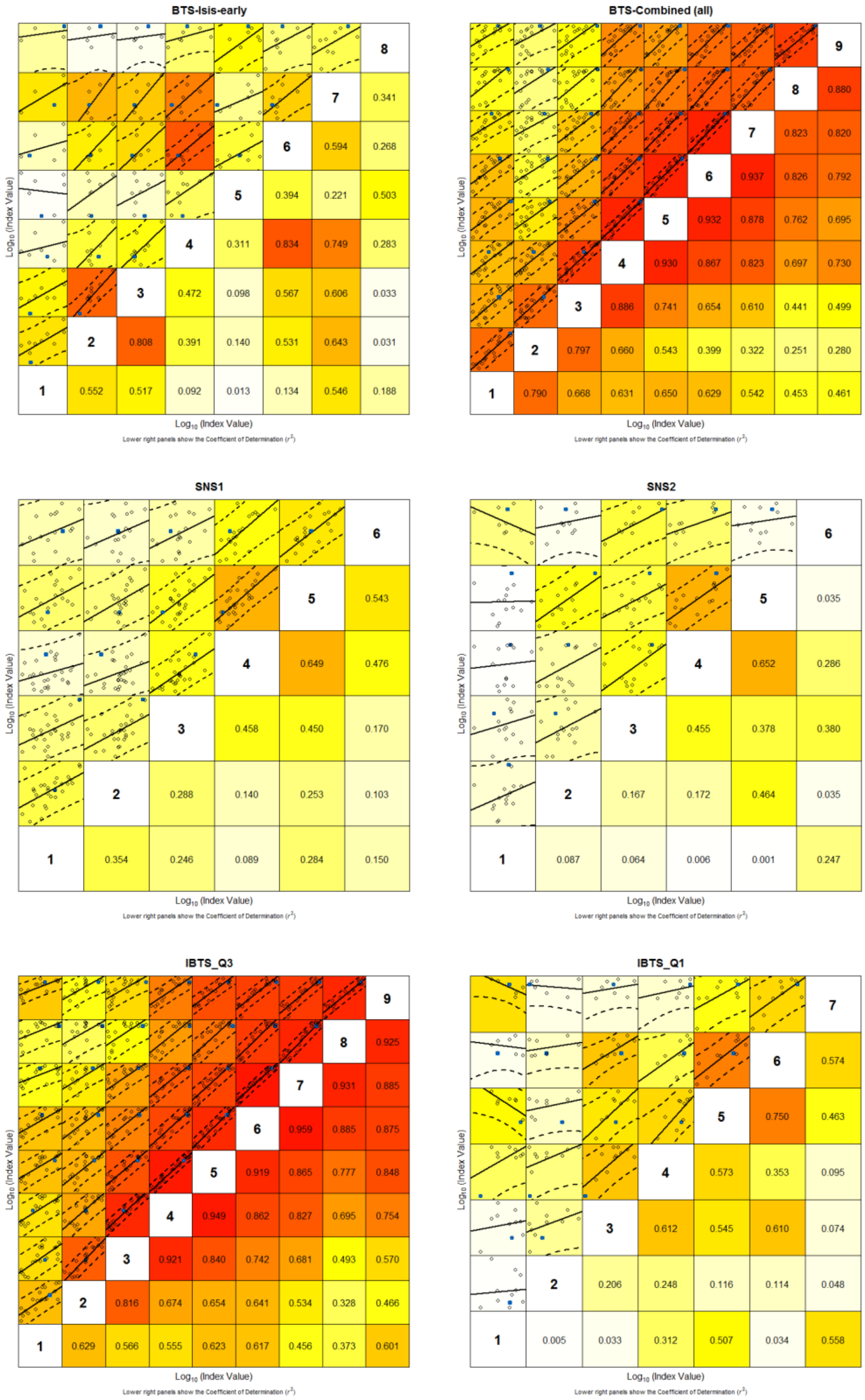


Figure 13.2.11. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for surveys.

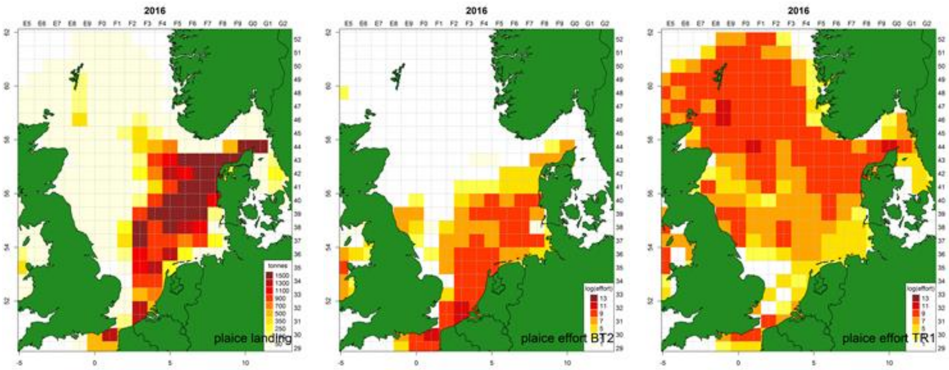


Figure 13.2.12. (a) Spatial distribution (by ICES rectangle) of landed plaice in 2016; (b) Spatial distribution of log-transformed TB2 fishing effort in 2016; (c) Spatial distribution of log-transformed TR1 fishing effort in 2016. Data were extracted from STECF FDI dataset. TB2 and TR1 are the two major gears in catching plaice in North Sea.

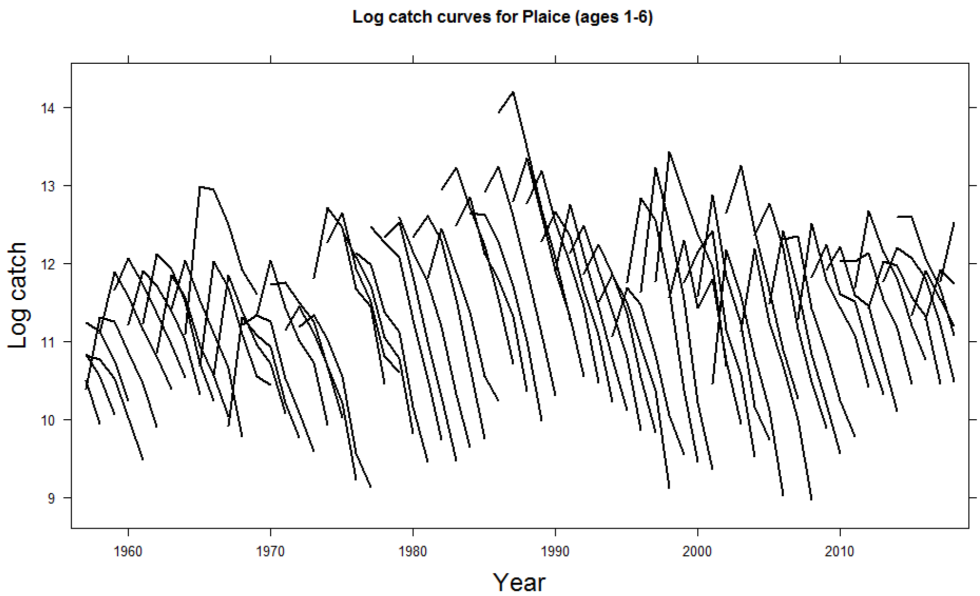


Figure 13.2.13. Catch curves for catches in age 1–6.

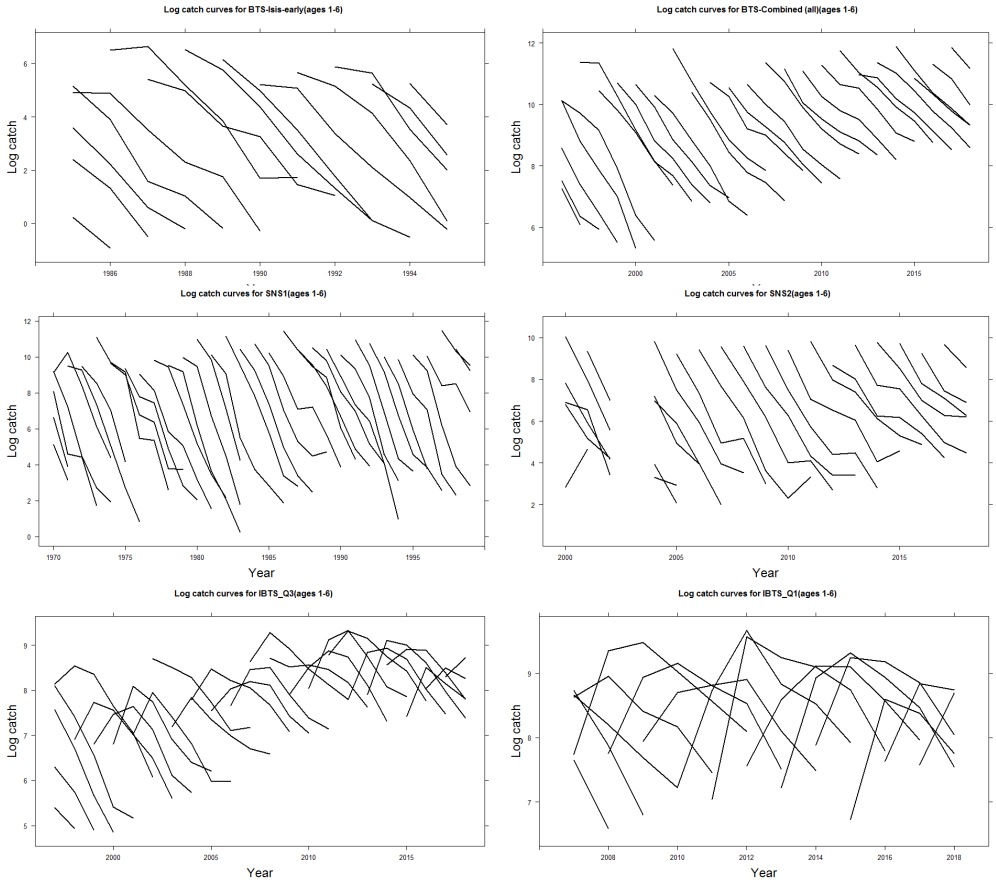
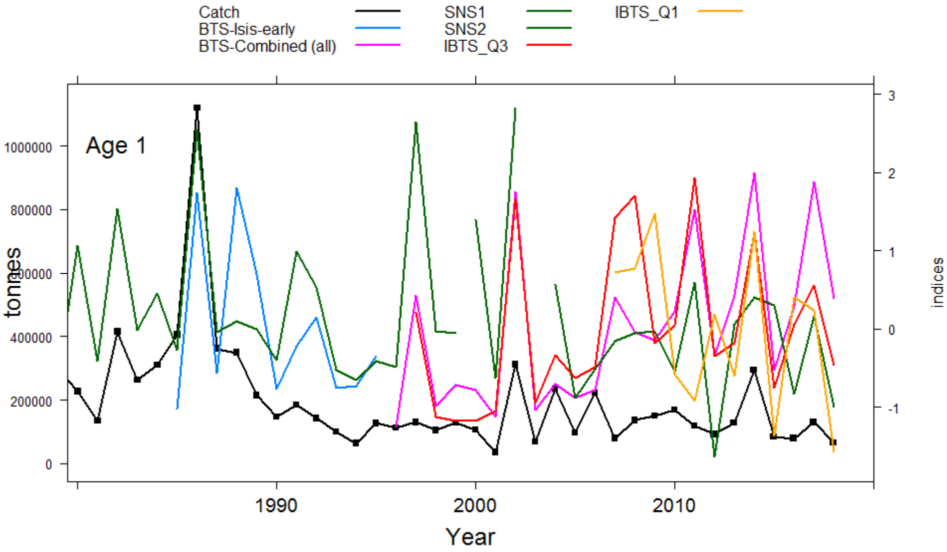
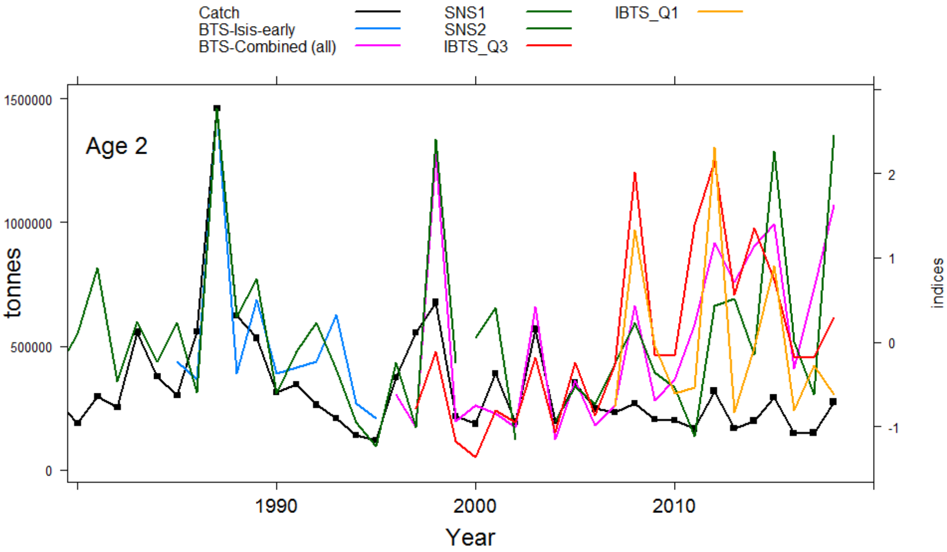
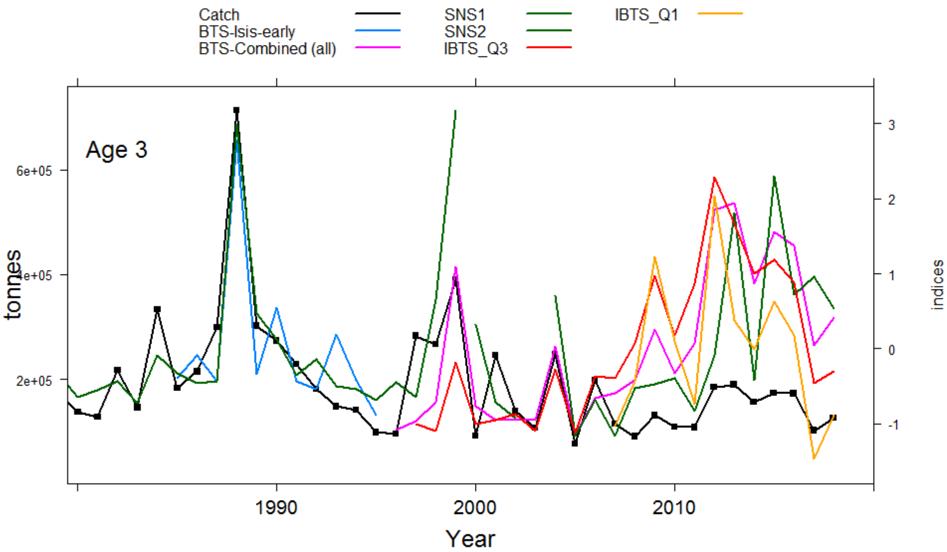


Figure 13.2.14. Catch curves for Surveys in age 1–6.


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 1
tonnes
indices
Year
1990
2000
2010


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 2
tonnes
indices
Year
1990
2000
2010


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 3
tonnes
indices
Year
1990
2000
2010

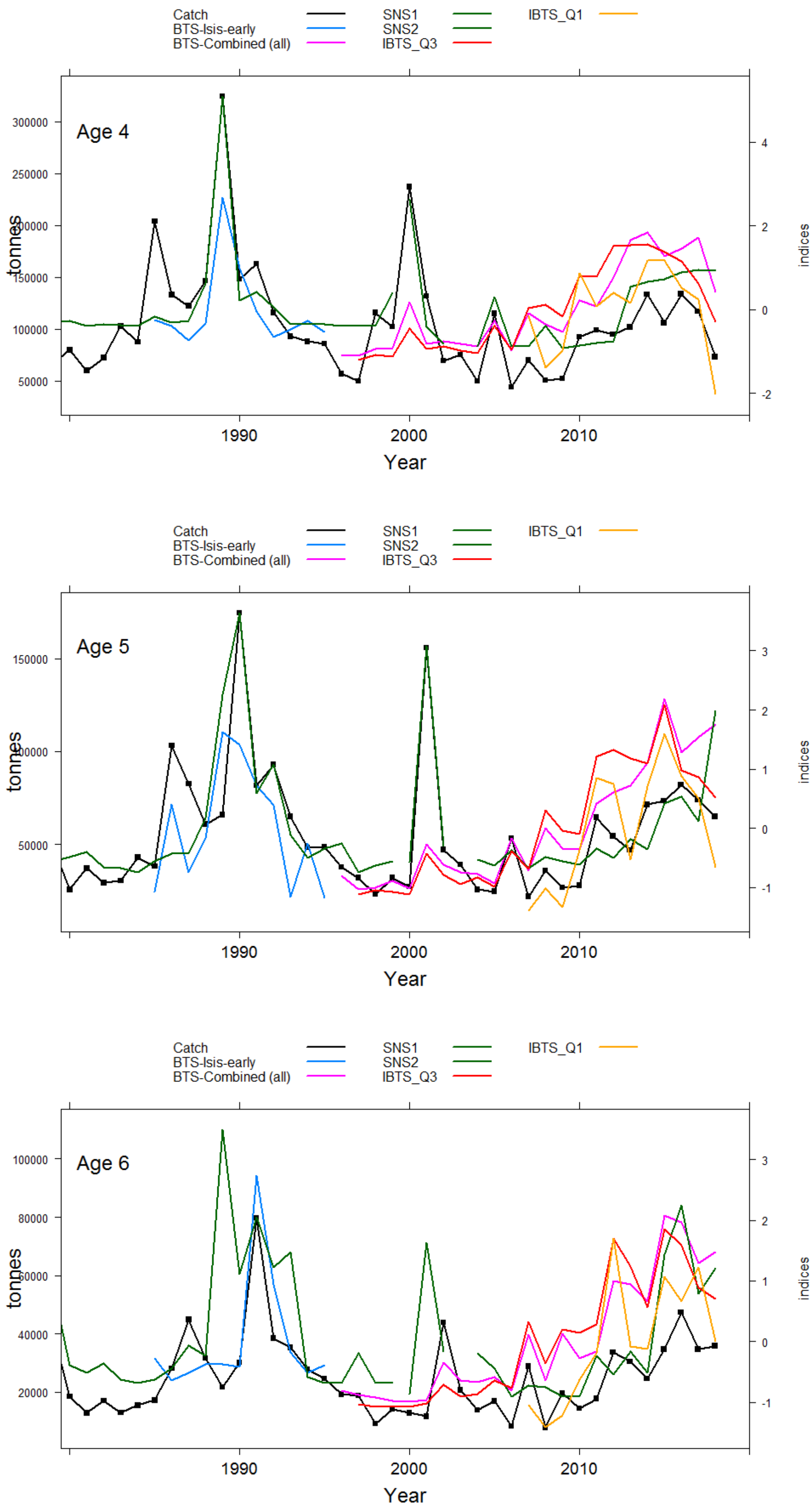


Figure 13.2.15: Catches vs. standardized survey indices by age (1–6).

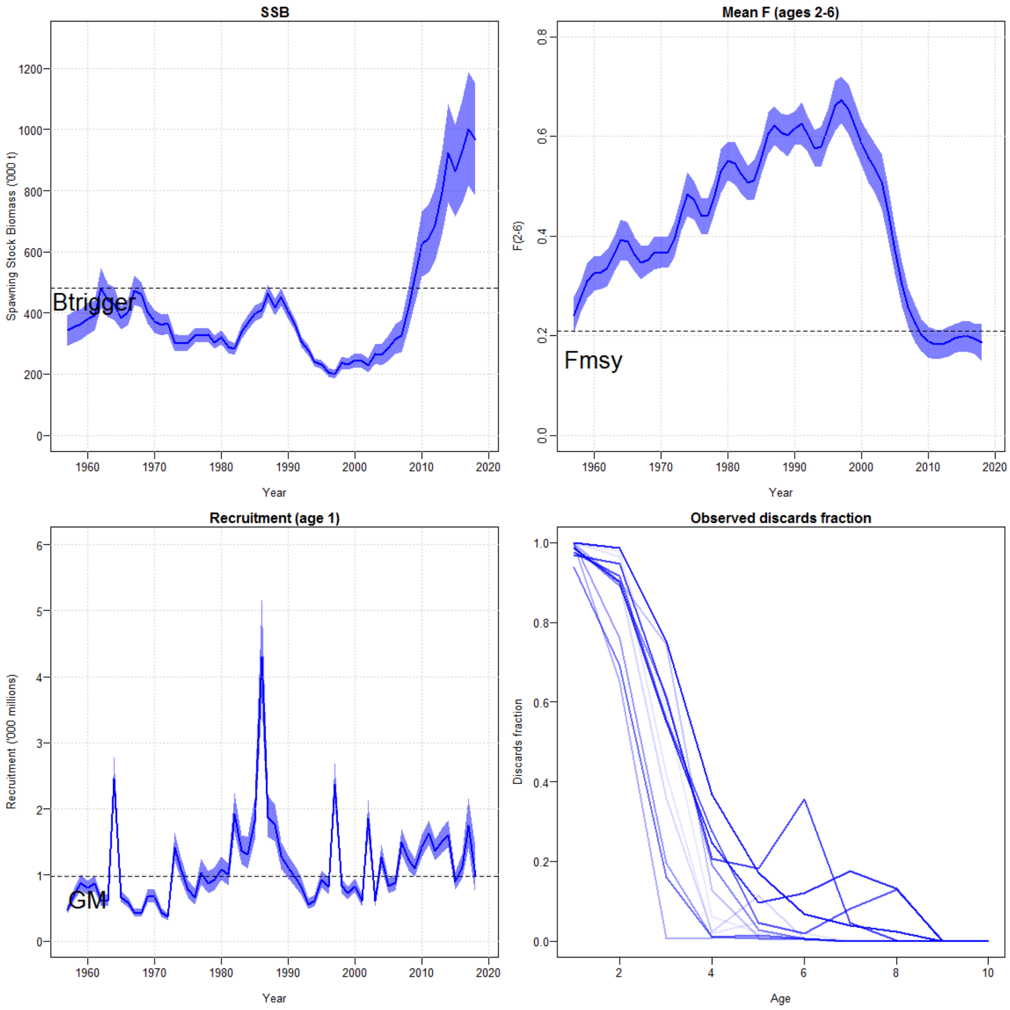


Figure 13.3.1. Stock assessment output for ple.27.420. SSB (top left), fishing mortality (top right), recruitment (bottom left) estimates of the assessment and the observed discards fraction (bottom right).

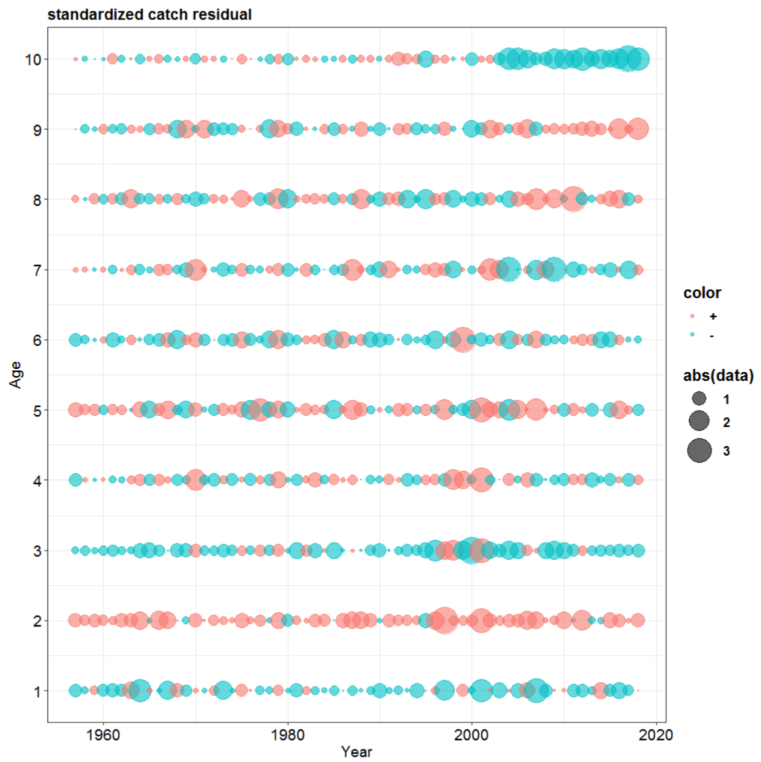


Figure 13.3.2. Log-catch residuals (observed minus estimated), standardized by the standard error of catch. Positive values are in red and negative values are in blue.

Figure 13.3.3. Log-survey indices residuals (observed minus estimated), standardized by the standard error of indices. Positive values are in red and negative values are in blue.

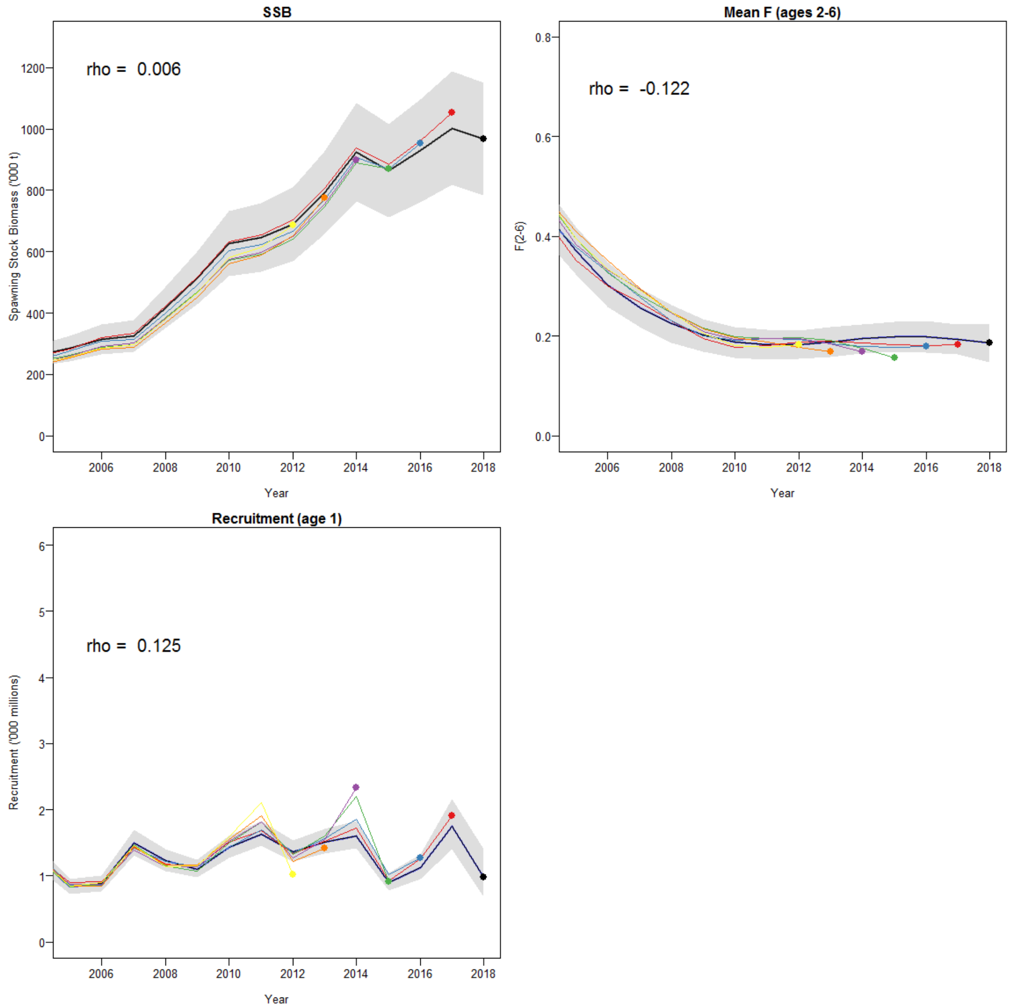


Figure 13.3.4. Retrospective pattern of the final AAP run with respect to SSB, recruitment and F.

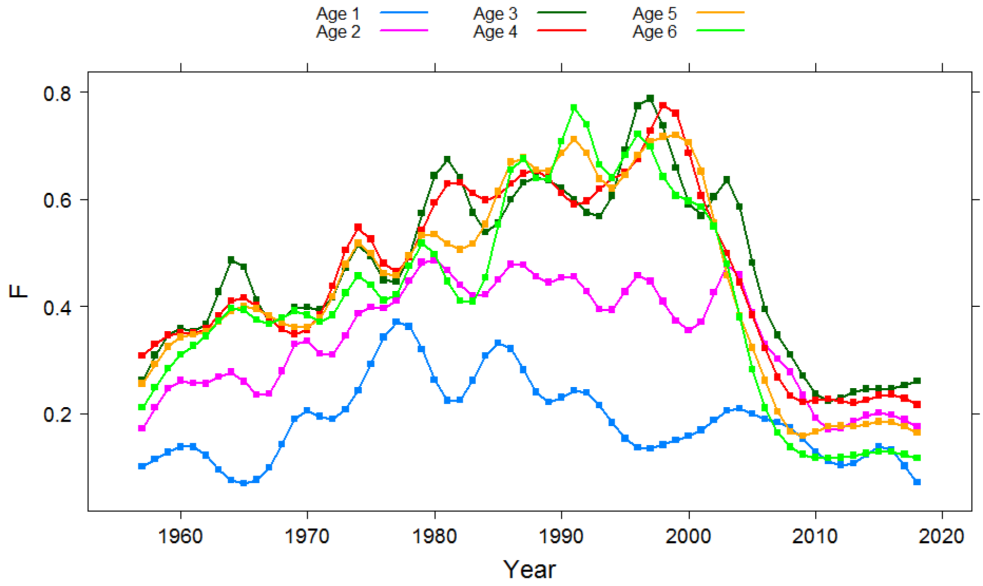


Figure 13.3.5. Estimated fishing mortality by age.

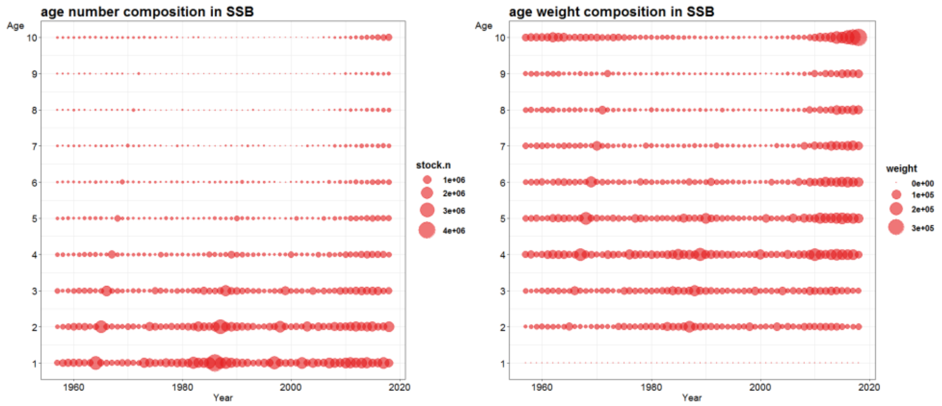


Figure 13.3.6. Age compositions in the estimated SSB.

Figure 13.3.7. Indices of age 0 in SNS, DFS and BTS-Q3 surveys.

14 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).

14.1 General

14.1.1 Stock definition

A summary of available information can be found in the stock annex.

14.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2019. All available information on ecological aspects can be found in the Stock Annex.

14.1.3 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.

14.1.4 ICES advices for previous years

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.

2018 advice: ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 7864 tonnes. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2017, this will correspond to catches of plaice in Division 7.d in 2019 of no more than 9225 tonnes.

14.1.5 Management

There are no explicit management objectives for this stock.

The TACs have been set to for **the combined ICES divisions 7.d and 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.

14.2 Data available

14.2.1 Catch

Landings data as reported to ICES are shown in Figure 14.2.1.1, Figure 14.2.1.2 as well as in Table 14.2.1.1 together with the total landings estimated by the Working Group. The 2018 landings of 4977 tonnes are slightly higher than the catch level of the past 10 years (between 3500 and 4700 tonnes). France, as before 2015 (44%), is the highest contributor to the total 7.d landings in 2018, with Belgium contributing for 38% and UK for 16.7%.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 14.2.1.2).

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 14.2.1.2 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.

14.2.2 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 83% of the landings (Figure 14.2.2.1). 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 were provided per year for the TBB fleet with at least quarter 1 landings data on a separate excel spreadsheet. Since 2018, Belgium landings data are provided per quarter even for TBB. 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, OTT, DRB, TBB and Seines	All OTB, OTT and TBB
Others (MIS, OTM 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 2018, 77% 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-DRB	TBB
GNS-GTR	GNS GTR
OTB-OTT	OTB-OTT
Seines (SDN, SSC and PS)	Seines (SSC)
Others (MIS, OTM and LLS)	All métiers

*** Unsampled fleet are those fleets for which no discards data have been provided.**

**** Sampled fleet are those fleets for which the discards volumes are known.**

Age distributions were provided by France, Belgium and England, accounting for 79% of the total discards (imported + raised).

14.2.3 Age compositions

Age compositions of the landings and of the discards are presented in Table 14.2.3.1 and Figure 14.2.3.1, and Table 14.2.3.2 and Figure 14.2.3.2 respectively.

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2017 in Figure 14.2.3.3.

Figure 14.2.3.4 presents the discards at age ratios (i.e. discards numbers / landings numbers) per age over the sampled period 2006–2018. From 2012, the ratio is higher for the ages 1 to 4. The ratio for age 5 also increased to more than 20% in 2015–2018.

14.2.4 Weight-at-age

Weights at age in the landings, in the discards and in the stock are presented in tables 14.2.4.1, 14.2.4.2 and 14.2.4.3 respectively and in Figure 14.2.4.1. 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 2013–2018 for ages 5, 6 and 7.

14.2.5 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

14.2.6 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 14.2.6.1 and Table 14.2.6.1). 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 14.2.6.2).

14.3 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:		**2019**
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
UK Beam Trawl Survey	Age range	1–6
	Year range	1988 onwards
FR Ground Fish Survey	Age range	1–6
	Year range	1988 onwards
Catch/Landings		
Age range:		1–7+
Landings data:		1980–2018
Discards data		2006–2018
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

14.3.1 Results

The landings and discards estimated by the model are presented in Figure 14.3.1.1 and the residuals in tables 14.3.1.1 and 14.3.1.2. Given the observed trend in the discard at age ratio (see Section 14.2.3), 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 7 years (2012 to 2018).

The survey residuals are shown in Figure 14.3.1.2 and Table 14.3.1.3 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. Since 2014, the model overestimates the French GFS survey for all ages, the vessel used during this survey has changed in 2015, moving from the R/V Gwen Drez to the R/V Thalassa. Even if the inter-calibration between the two vessels realised in 2015 showed no significant effect on plaice catches (Auber *et al.*, 2015) and no correction coefficients were applied to calculate plaice survey indices (Travers-Trolet et al., 2016), further investigation is needed.

The final outputs are given in Table 14.3.1.4 (fishing mortalities) and Table 14.3.1.5 (stock numbers). A summary of the assessment results is given in Table 14.3.1.6 and trends in fishing mortality, recruitment, spawning stock and total catches are shown in Figure 14.3.1.3. Retrospective patterns for the final run are shown in Figure 14.3.1.4 with their associate Mohn's Rho value.

The 1986 year class dominated the history of this stock until the late 2000s (Figure 14.3.1.5 and 14.3.1.3). 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 2016–2018 (Figure 14.3.1.3). After the decline in recruitment in 2016-2017, the recruitment in 2018 is increasing.

14.4 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).

14.5 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.

14.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated.

For 2019 and the previsions (2020 and 2021), the recruitment was calculated as the geometric mean recruitment over the period y–5 to y–2 (i.e. 2013–2016 this year, blue line in Figure 14.5.1.2) as recommended in the stock annex. Last year the geometric mean over the entire time series (i.e. 1980–2018 red line in Figure 14.5.1.2) was used given the drop in the recruitment in 2016-

2017. With the increase of recruitment in 2018, the group decided to follow the stock annex method.

14.5.2 Calculation of the 7.d resident stock

This year, F for the intermediate year is set as equal to F in 2018 (status quo). Plaice in 7.d are under landing obligation since the 1 January 2019. To assess if the TAC in 2019 will be fully taken, we compared ICES catches of resident plaice in 7.d in 2018 to the proportion of the 2019 TAC corresponding to resident plaice in 7.d (6674 tonnes, dark green dot in Figure 14.5.2.1). Using first the average official landing proportion between 7.e and 7.d, e over the period 2003–2018 (Figure 14.5.2.2) we obtain the TAC in 7.d. Then we applied the Q1 removal ratio over the same period to account for migration of mature plaice from the 7.e and 4.c during Q1 (Figure 14.5.2.3). If we compare ICES catches to 2019 TAC corresponding to resident plaice in 7.d (dark green line and dot, Figure 14.5.2.1), TAC will be fully used in 2019. However if we account for survivability exemption applied to otter trawl and trammel netters (green dot, Figure 14.5.2.1) (EU, 2018), landings under landing obligation are significantly lower than the TAC (dark green dot, Figure 14.5.2.1), leading to the decision that the usual fully taken TAC assumption was inappropriate[1].

14.5.3 Management options tested

14.5.3.1 Calculation of STF

Potential TACs for 2020 were calculated using $F_{MSY\ lower}$, $F_{MSY\ upper}$ and F_{MSY} as prescribed by the EU multiannual plan (MAP) for the Western Waters (EU, 2019). Alternative options were also tested. Results are presented in Table 14.5.3.1.1 for the resident stock.

Following the MAP would lead to catches from the stock in 2020 that correspond to the fishing mortality (F) ranges, between 6545 tonnes and 12 029 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (9073 tonnes) can only be taken under conditions specified in the MAP, 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 14.5.2.3).

Following the MAP would lead to catches in 2020 for the plaice in 7.d between 7710 tonnes and 14 170 tonnes. Again, catches higher than those corresponding to F_{MSY} (10 687 tonnes) can only be taken under conditions specified in the MAP.

14.6 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).

[1] Note: Didn't account for TBB, because it is not possible to estimates with InterCatch data (regulation based on kW, vessel length and fishing area).

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.

The use of FR GFS survey during the assessment needs to be further investigated. In the recent years, this index has always been overestimated by the model.

14.7 Status of the stock

ICES assesses that fishing pressure on the stock is below F_{MSY}; and spawning stock size is above MSY $B_{trigger}$ (Figure 14.3.1.3).

	Fishing pressure					Stock size				
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Appropriate	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within range	B_{MGT}	✓	✓	✓	Above trigger

14.8 Management considerations

The stock identity of plaice in the Channel is unclear and may raise some issues.

The TAC is combined for divisions 7.d and 7.e. Plaice in 7.e is considered at risk of being harvested unsustainably (F above F_{MSY}).

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.

14.9 Issue for future benchmarks

14.9.1 Data

The vessel used for FR GFS survey was changed in 2014, moving from the R/V Gwen Drez to the R/V Thalassa. Even if the inter-calibration between the two vessels realised in 2015 showed no significant effect on plaice catches (Auber *et al.*, 2015) and no correction coefficients were applied to calculate plaice survey indices (Travers-Trolet *et al.*, 2016), further investigation is needed to evaluate if a vessel effect is significant in the data.

Ifremer has started a new young fish surveys (YFS) in the Channel since 2016 (Bay of Canche-Authie, and Bay of Seine) in addition to the YFS in the Bay of Somme used in sole.27.7d assessment. Further investigation is needed to evaluate if recruitment indices could be produced from those surveys.

Data is available from FR GFS to calculate new maturity ogive and test them. The one currently used is based on ICES WKFLAT 2010.

Migration data is required to update the Q1 migration proportion.

14.9.2 Assessment

Residual patterns are noticeable in the FR GFS residuals and the landings residual at age 2–3. The use of a new survey index for FR GFS might correct this issue. In addition, parameters settings might improve the fitting of the model.

14.9.3 Short-term forecast

If FR YFS indices are available, the use of RCT3 to estimate recruitment could be investigated. New information for age 0 could be introduced from YFS.

14.10 Additional References

Auber Arnaud, Ernande Bruno, Travers-Trolet Morgane, Coppin Franck, Marchal Paul (2015). Intercalibration of research survey vessels: “GWEN DREZ” and “THALASSA”. .27p.

EU. 2018. COMMISSION DELEGATED REGULATION (EU) 2018/2034 of 18 October 2018 establishing a discard plan for certain demersal fisheries in North-Western waters for the period 2019-2021. 9pp.

EU. 2019. REGULATION (EU) 2019/472 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008. 17pp. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0472

Travers-Trolet Morgane, Girardin Raphael, Coppin Franck (2016). Calcul des indices d’abondance issus de CGFS. 28p.

Table 14.2.1.1. Plaice in 7.d: Nominal landings (tonnes) as officially reported to ICES, 1976–2018.

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

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)
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
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

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)
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	2247	1557	795	60	4659	-21	4638	3603	2013	12446
2017	2189	1487	814	86	4576	37	4613	5065	2128	10022
2018	1876	2171	832	98	4977	27	5004	3425	1644	10360

(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 14.2.1.2. 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	5219			
1993	5331	852	4479			
1994	6121	1074	5047			
1995	5130	934	4196			
1996	5393	963	4430			
1997	6307	1127	5180			
1998	5762	931	4831			
1999	6326	1058	5268			
2000	6015	1494	4521			
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	3178	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	3617	3603	514	3090
2017	4613	924	3689	5065	990	4075
2018	5004	1024	3680	3425	579	2846

(1) Takes into account the removal of 65% of the Quarter 1 landings or discards.

Table 14.2.3.1. 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

year	age						
	1	2	3	4	5	6	7+
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
2018	15	210	1016	2573	2422	1295	2203

Table 14.2.3.2. 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
2018	2455	5910	6136	4357	1589	531	290

Table 14.2.4.1. 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

	1	2	3	4	5	6	7
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	0.27619	0.27207	0.30150	0.34393	0.41733	0.46755	0.66655
2018	0.23932	0.25972	0.29308	0.30318	0.34992	0.42252	0.65770

Table 14.2.4.2. 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
2018	0.122	0.121	0.127	0.139	0.156	0.187	0.169

Table 14.2.4.3. 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

year	1	2	3	4	5	6	7
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	0.25638	0.25255	0.27987	0.31926	0.38739	0.43401	0.61873
2018	0.22997	0.24957	0.28162	0.29133	0.33624	0.406	0.63199

Table 14.2.6.1. Plaice in 7.d: Tuning fleets.

UK BTS						
1989 2018						
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
1	25.6	97	112.2	52.4	30.3	9.3

Table 14.2.6.1. (cont.) Plaice in 7.d: Tuning fleets.

FR GFS						
1993 2018						
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
1	42.64	83.82	241.83	119.56	170.23	52.43

Table 14.3.1.1. Plaice in 7.d: Landings Residuals.

age	1	2	3	4	5	6	7
1980	-0.587960518	0.834411722	-0.452242683	-0.312589349	0.215341629	-0.033549768	-0.120283329
1981	-1.481204728	0.155078308	0.38833988	0.344756045	-0.100172594	-0.177567221	0.297592156
1982	0.337161948	0.11490521	-0.09735632	-0.045689831	0.072523906	0.355731245	-0.290706448
1983	-0.662920736	0.137709791	-0.272683191	0.107181727	-0.315798172	-0.232508534	-0.050043152
1984	0.826011315	-0.298740198	-0.165706249	0.139625865	0.119639815	0.125866078	0.271786949
1985	-0.093585871	0.758751934	-0.260659697	0.208735384	-0.530131691	-0.048534739	-0.001650349
1986	0.834714133	0.356762158	-0.140664601	0.151443312	0.190062086	0.569910998	-0.539180547
1987	-2.205955582	0.283011	-0.236455645	0.040503013	0.103606511	-0.379387277	0.22759415
1988	-2.666676584	0.270858517	0.115974539	-0.019335032	-0.194229264	-0.064705702	0.059494822
1989	1.145498583	0.290229531	-0.292738757	-0.151407423	0.267563549	-0.019353892	-0.046138867
1990	1.300803429	0.176459563	0.303368533	-0.077754393	-0.126975094	0.008281892	0.227008402
1991	0.265717255	0.668063401	0.269559756	0.259755112	0.086922448	0.027454845	-0.078551631
1992	-0.369889763	0.030301197	0.125778898	-0.000765075	-0.017290408	0.056125427	-0.013228903
1993	-0.910883426	-0.020421548	-0.336256957	-0.143012389	-0.180853981	-0.203455389	-0.249917598
1994	-0.347382506	0.060567034	0.21697777	0.336114943	0.332419858	0.290715028	0.144387492
1995	0.427093389	0.61820639	0.091009148	-0.025739045	-0.1162745	-0.265342198	-0.039678291
1996	0.400120488	0.501857272	0.28427797	-0.160207784	0.013446795	0.004734006	-0.023135321
1997	-0.128313401	0.364469254	0.22798436	0.544845032	0.40307971	0.332996197	0.230254297
1998	0.159797778	-0.260036976	0.099330621	-0.145319165	-0.127096226	-0.340035435	-0.366913089
1999	-0.301491272	-0.821544918	-0.075267654	0.376279822	0.049480889	0.311185315	0.117745656
2000	-0.820371696	0.396180521	-0.318019505	-0.13557247	-0.048420024	-0.015845918	0.226283326
2001	0.321946125	-0.049330114	0.133810253	-0.274033506	-0.091897356	-0.213078838	0.002222413
2002	0.24642748	0.979046592	0.252727499	0.139735337	0.567417762	-0.056236742	-0.00851674
2003	-4.429145164	0.218472346	-0.584060474	0.066725893	-0.232361204	-0.031933021	0.078813598
2004	2.804149237	0.728999794	-0.455975914	-0.493810154	-0.086222535	-0.132520228	-0.235922421
2005	0.220258337	0.43327083	-0.591628517	-0.144539707	0.115916142	0.070244192	0.072519006
2006	0.426328309	0.484668661	-0.34707455	0.236787123	0.266786096	-0.199111295	0.114002858
2007	0.665548612	0.514583055	-0.425265591	-0.207861718	0.173738305	0.009184321	0.017455008
2008	-0.134451236	0.31898921	-0.267015044	-0.078877399	0.098036539	-0.077840405	-0.274948648

age	1	2	3	4	5	6	7
2009	0.160547715	-0.114528364	-0.421730795	-0.125386731	0.020311422	-0.090308112	-0.188916854
2010	0.120267643	-0.017796689	-0.463164683	0.146813041	0.308233361	0.473120848	0.078630387
2011	-1.612706792	-0.068040049	-0.688478994	-0.492161343	-0.173715818	-0.619838053	-0.573162739
2012	-0.059683185	0.04230512	-0.031969265	0.024103318	0.090050469	0.34436589	-0.036437705
2013	-0.010067902	0.138390367	-0.000433256	0.048492796	0.171190144	0.217065045	-0.295775631
2014	0.08188121	0.120308005	0.462517404	0.10489231	0.151662307	0.121213052	-0.440403942
2015	0.004886	-0.150525441	-0.150471129	-0.222497526	-0.132129845	0.115798729	0.005762099
2016	-0.220689473	-0.259168963	-0.224713336	-0.108142438	0.046334495	0.061059914	-0.308339074
2017	-0.114337699	0.430145614	-0.008179361	-0.019699064	0.008688405	0.093073436	-0.401533044
2018	0.034539777	0.023001763	0.024680876	0.08151176	0.016813016	0.154916347	-0.128799504

Table 14.3.1.2. Plaice in 7.d: Discards Residuals.

age	1	2	3	4	5	6	7
2006	-0.162389877	0.012841701	0.03085481	-0.72221326	-0.778753464	0.001915736	0.306498926
2007	-0.143572953	0.756318415	0.183945493	0.478918139	-2.650646673	-0.055252631	0.40384198
2008	0.303782719	-0.339451567	-0.74608897	0.172612329	0.834659998	1.501657116	0.767524818
2009	-0.071609896	0.157384632	0.031316783	0.053615816	0.38731674	2.458235491	1.699822718
2010	-0.191088179	0.63141926	0.400402902	0.853912197	1.145239756	1.014775308	1.65373267
2011	0.006858806	0.250571365	-0.612077761	-0.13533729	0.239997333	2.990495421	1.278593282
2012	-0.039093747	0.042702449	-0.031743558	0.025118527	0.109660482	1.475867541	3.979120729
2013	0.026008465	0.139077656	-0.000222144	0.049155896	0.182706946	0.319001386	0.475127398
2014	0.08702987	0.120968358	0.462825542	0.10528586	0.153890941	0.134619021	-0.339390856
2015	0.101278581	-0.149774023	-0.150019155	-0.221562486	-0.130622783	0.119819334	0.030944527
2016	-0.191042929	-0.257399283	-0.224408509	-0.107418608	0.048295768	0.06566787	-0.271367526
2017	-0.029897233	0.433423126	-0.007799847	-0.019341745	0.01039053	0.096334806	-0.386332329
2018	0.058031912	0.024963758	0.025216509	0.081888543	0.017593887	0.157091056	-0.125191267

Table 14.3.1.3. Plaice in 7.d: Survey residuals.

UK BTS						
age	**1**	**2**	**3**	**4**	**5**	**6**
1989	-1.293340502	-0.66591842	-0.090161843	0.36331991	-0.096454801	0.113883869
1990	-0.43217883	-0.649595982	-0.527681461	-0.185733483	0.191580201	-0.352591148
1991	-0.323182238	-0.13738366	0.117100767	0.018629931	0.204594474	-0.181656622
1992	-0.240347354	-0.132843168	-0.263643955	0.385327616	0.48553083	0.320381597
1993	-1.0896297	-0.311991372	-0.408340388	-0.267123244	0.218507005	-0.032503782
1994	-0.257915136	-0.435582225	-0.30596604	0.153493997	0.077853211	-0.632457015
1995	-0.345828756	-0.68980315	-0.562364012	0.020771572	-0.064738024	-0.2043576
1996	-0.132099576	-0.353911011	-1.307574865	-0.825842029	-0.143226406	0.097198975
1997	0.083817285	-0.15564731	-0.232368012	-0.577851425	0.514432919	-0.590586115
1998	0.349682966	-0.436968867	-0.472071829	0.003707034	-0.206519519	0.442164484
1999	-0.289818833	-0.897202843	-0.184285268	-0.497565353	-0.208188845	-0.052259257
2000	-0.011719184	0.504997923	0.222239899	0.306941366	0.31709906	0.161329314
2001	0.534288798	0.059770136	0.384164189	0.376657232	0.654369184	0.27876924
2002	0.374088631	0.34583599	0.242808138	0.261113438	-0.256562388	0.178834257
2003	-0.306183525	0.135000935	0.001497673	0.07083446	0.095000575	-0.448359295
2004	1.085207469	0.100877677	0.036010235	0.146421855	-0.511920464	-1.125835102
2005	0.019902778	0.370975757	0.02712604	0.130998553	0.431964986	0.0222792
2006	0.788813366	0.317520183	0.061754018	0.024146216	-0.075491506	0.162985153
2007	0.967851075	0.466017066	-0.070766867	-0.204571288	0.012571706	0.086833377
2008	0.428996043	0.431620394	-0.032726008	-0.384401001	-0.097848698	-0.013031454
2009	0.613694995	0.147238769	0.284045444	0.11090714	-0.099850274	-0.117105898
2010	0.004615909	0.113658658	-0.197134607	0.167721326	0.041893945	-0.235922594
2011	0.361995073	0.208428029	-0.015492634	-0.084229546	0.430704186	0.395412423
2012	-0.548164311	-0.362222865	-0.196292845	-0.168214093	-0.442688735	0.125420064
2013	-0.380284226	-0.027327115	-0.026658269	0.14268293	-0.259566342	-0.226608027
2014	0.715407936	0.818394438	0.027737966	0.162494454	0.125449636	0.039402514
2015	-0.354032668	0.554336823	0.15951158	0.049282701	0.054080004	0.042773242
2016	-0.801793419	0.267869434	0.269085774	0.203402709	0.228486264	0.158749616
2017	0.462559085	0.938814089	0.367212211	0.244321144	-0.070015482	-0.198912494
2018	-0.530398969	0.7760585	1.371400925	0.530997072	0.21078357	-0.117474339

Table 14.3.1.3. (cont.) Plaice in 7.d: Survey Residuals.

FR GFS						
age	1	2	3	4	5	6
1993	1.61233513	0.184852101	0.147680628	0.084301473	-0.455551064	-0.398010684
1994	0.842883523	0.062500386	-0.595220321	-0.403546402	0.008307363	0.965713472
1995	0.251084089	0.972965949	0.822302882	0.821763558	0.530907148	2.127933275
1996	-0.310125287	-0.42683212	-0.781020551	-0.301288672	0.048933914	0.980466613
1997	0.301647012	-0.359179283	0.662839818	0.217209011	0.47825799	1.853167672
1998	0.36901225	-0.501721008	-0.622617187	-0.207519389	-1.041129919	1.394767195
1999	0.862125414	-0.137939471	0.207552807	0.240449427	-0.005706142	1.710620875
2000	0.997309868	1.216151178	0.372430269	0.458330677	0.697698955	1.087592447
2001	0.358195326	-0.078652056	-0.066226571	0.320353756	-0.385849174	-0.250358761
2002	0.527963582	0.395399845	0.753208147	0.714576953	0.757209093	-0.035253037
2003	0.444385705	0.141444409	-0.065090975	-0.597878987	0.228753135	0.384061494
2004	0.480278584	0.171456136	-0.274053513	0.204474797	-0.832231006	1.297212988
2005	0.674604591	0.942050966	1.132636314	0.458370414	0.807849738	1.128802692
2006	1.316542877	0.61370746	0.030417799	0.25130915	0.029993643	0.770972647
2007	0.504728932	0.647059327	0.657269108	0.496045193	0.421671354	-0.547064881
2008	-0.377879351	0.760618972	0.32887033	-0.110347783	-0.785537516	0.352060197
2009	-0.646794316	-0.552119859	-0.420857261	-0.414961825	-1.095700912	-0.148866605
2010	-0.14094911	-0.35754012	-0.615881797	-0.76080614	-0.856774374	0.098354889
2011	0.605342996	0.79523798	0.625277374	0.204890675	-0.805596683	1.752652461
2012	-0.0316001	0.086267609	0.633099038	0.30654866	0.690472971	0.381576127
2013	0.120901904	-0.270340363	0.228779073	-0.152701899	-0.086528488	-0.423119299
2014	-0.535887498	-0.550498615	0.085787175	0.440003432	0.00733269	-0.61535065
2015	-1.995107682	-0.572292812	0.024140255	-0.473853645	-0.276470391	-0.551544344
2016	-2.080448282	-1.316968431	-0.761238019	-0.650649805	-0.25645405	-0.828227379
2017	-2.028330237	-1.445569004	-1.345843191	-0.952179342	-1.016548987	-1.15989027
2018	-1.920646462	-0.764617041	-0.829205252	-0.412726513	-1.170440629	-1.123455364

Table 14.3.1.4. Plaice in 7.d: Fishing mortality (F) at age.

	1	2	3	4	5	6	7
1980	0.0108218	0.116404	0.393657	0.319279	0.175768	0.10087	0.10087
1981	0.0162068	0.138349	0.433534	0.387744	0.234323	0.140308	0.140308
1982	0.0217162	0.161972	0.482219	0.45266	0.291634	0.18377	0.18377
1983	0.0232947	0.184	0.547138	0.488323	0.316346	0.213407	0.213407
1984	0.0192816	0.200074	0.629007	0.478479	0.291849	0.214488	0.214488
1985	0.0150409	0.206359	0.690205	0.449215	0.25722	0.204233	0.204233
1986	0.0141501	0.200266	0.673928	0.432272	0.250102	0.206274	0.206274
1987	0.0185487	0.186525	0.574884	0.441509	0.286923	0.233752	0.233752
1988	0.0301844	0.182549	0.479775	0.45636	0.341667	0.272091	0.272091
1989	0.0521788	0.207735	0.44757	0.449428	0.36056	0.291284	0.291284
1990	0.086779	0.282875	0.493068	0.411876	0.314956	0.271463	0.271463
1991	0.141239	0.408862	0.577241	0.369917	0.255677	0.233619	0.233619
1992	0.231758	0.546709	0.634303	0.345967	0.221327	0.199682	0.199682
1993	0.353388	0.614721	0.62108	0.351032	0.221989	0.181229	0.181229
1994	0.383683	0.566492	0.579913	0.38957	0.256049	0.184869	0.184869
1995	0.225584	0.420883	0.558166	0.474677	0.333763	0.223562	0.223562
1996	0.0834465	0.277621	0.567839	0.603333	0.455146	0.30257	0.30257
1997	0.04003	0.208569	0.582889	0.705582	0.554401	0.372392	0.372392
1998	0.0518474	0.228994	0.574469	0.669539	0.515357	0.337899	0.337899
1999	0.161379	0.351024	0.543932	0.523776	0.373023	0.231283	0.231283
2000	0.419871	0.517973	0.523431	0.401373	0.261014	0.158045	0.158045
2001	0.320404	0.508417	0.541079	0.357908	0.219267	0.14265	0.14265
2002	0.0762154	0.331769	0.590273	0.375495	0.226937	0.172835	0.172835
2003	0.0163654	0.200857	0.624929	0.405061	0.24991	0.225043	0.225043
2004	0.00888788	0.156232	0.59348	0.394086	0.253415	0.253155	0.253155
2005	0.0129235	0.163806	0.519307	0.343978	0.230186	0.236786	0.236786
2006	0.0259358	0.197828	0.464952	0.294067	0.198655	0.202437	0.202437
2007	0.0382271	0.235533	0.467556	0.267177	0.17238	0.173037	0.173037
2008	0.036873	0.253154	0.502607	0.256427	0.152074	0.148428	0.148428
2009	0.0282934	0.23428	0.504432	0.24512	0.134185	0.121771	0.121771
2010	0.0209053	0.180834	0.420846	0.22167	0.116961	0.0921523	0.0921523
2011	0.0168034	0.127409	0.307024	0.192556	0.103018	0.0687783	0.0687783
2012	0.0160487	0.0951815	0.223511	0.168527	0.0954136	0.0569211	0.0569211
2013	0.0193556	0.085522	0.182527	0.155191	0.0960659	0.0575396	0.0575396
2014	0.0263286	0.0898492	0.17019	0.152447	0.104153	0.068509	0.068509
2015	0.0336936	0.100983	0.177346	0.160079	0.11844	0.0879229	0.0879229
2016	0.0350485	0.112519	0.201914	0.179453	0.137956	0.112699	0.112699
2017	0.0305904	0.122958	0.244155	0.210886	0.162832	0.142434	0.142434
2018	0.0244566	0.133064	0.304259	0.253737	0.193471	0.178749	0.178749

Table 14.3.1.5. Plaice in 7.d: Stock number from the assessment.

	1	2	3	4	5	6	7
1980	66523	29807	9990	2431	1982	660	1868
1981	34250	46230	18639	4734	1241	1168	1606
1982	65076	23674	28281	8488	2257	690	1693
1983	57703	44734	14144	12266	3792	1184	1393
1984	59250	39603	26144	5749	5288	1941	1463
1985	77463	40828	22777	9792	2503	2775	1930
1986	154684	53606	23334	8024	4390	1360	2694
1987	94580	107140	30824	8355	3659	2401	2317
1988	60571	65222	62459	12186	3775	1929	2624
1989	38059	41286	38174	27157	5424	1884	2437
1990	39315	25378	23563	17141	12172	2657	2268
1991	65893	25324	13435	10110	7976	6240	2637
1992	85312	40193	11820	5299	4906	4339	4937
1993	45131	47534	16345	4403	2634	2762	5337
1994	40223	22266	18059	6170	2178	1482	4747
1995	61309	19253	8877	7104	2936	1184	3637
1996	68911	34372	8879	3569	3104	1477	2709
1997	117480	44535	18293	3535	1371	1383	2173
1998	57702	79292	25396	7175	1226	553	1722
1999	49355	38488	44303	10045	2580	515	1140
2000	66726	29505	19034	18066	4179	1248	922
2001	51769	30803	12348	7922	8496	2262	1302
2002	70699	26398	13015	5050	3891	4793	2171
2003	38044	46022	13309	5067	2437	2179	4116
2004	46503	26292	26448	5005	2374	1333	3531
2005	40153	32379	15799	10263	2371	1294	2653
2006	35960	27846	19310	6603	5112	1323	2188
2007	53434	24616	16051	8521	3457	2944	2015
2008	68264	36130	13664	7065	4583	2044	2930
2009	110669	46220	19705	5807	3840	2765	3012
2010	167472	75577	25688	8359	3193	2359	3593
2011	209111	115216	44310	11847	4705	1995	3814
2012	111866	144454	71258	22899	6865	2982	3809
2013	123708	77336	92267	40032	13592	4384	4507
2014	186536	85240	49876	54004	24080	8674	5896
2015	143106	127638	54736	29555	32574	15243	9558
2016	74247	97202	81054	32203	17691	20327	15957
2017	83165	50362	61018	46530	18907	10827	22773
2018	114548	56664	31287	33580	26473	11286	20470

Table 14.3.1.6 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	66523	85502	51725	8173	10274	6072	2223		0.25	0.33	0.165
1981	34250	44970	26062	10864	13108	8620	4009		0.3	0.38	0.22
1982	65076	84691	49973	13263	15870	10656	4040		0.35	0.44	0.26
1983	57703	75691	43984	13333	15930	10736	4093		0.39	0.49	0.29
1984	59250	77545	45314	13265	15845	10685	4249		0.4	0.49	0.32
1985	77463	99064	60626	13236	15770	10702	5000		0.4	0.48	0.32
1986	154684	194530	122966	13245	15583	10907	5673		0.39	0.47	0.31
1987	94580	118900	75204	15871	18334	13408	7006		0.38	0.46	0.31
1988	60571	76582	47948	20561	23744	17378	8785		0.39	0.46	0.31
1989	38059	48916	29618	21861	25124	18598	7093		0.39	0.46	0.31
1990	39315	52108	29641	18774	21709	15839	7349		0.37	0.44	0.31
1991	65893	91243	47606	14872	17467	12277	6362		0.36	0.43	0.29
1992	85312	123197	59069	12324	14597	10051	5219		0.35	0.42	0.28
1993	45131	67547	30134	11309	13334	9284	4479		0.34	0.4	0.29
1994	40223	62540	25860	10271	12059	8483	5047		0.35	0.41	0.29
1995	61309	84445	44540	8724	10212	7237	4196		0.4	0.46	0.33
1996	68911	88015	54000	7663	8956	6371	4430		0.48	0.56	0.41
1997	117480	146946	93918	8347	9759	6936	5180		0.55	0.65	0.46
1998	57702	73665	45194	11267	13058	9476	4831		0.52	0.62	0.43
1999	49355	68058	35806	14613	16963	12263	5268		0.42	0.49	0.34
2000	66726	110521	40257	14650	17107	12193	4521		0.34	0.4	0.27
2001	51769	76992	34841	12861	15168	10554	4380		0.32	0.38	0.25
2002	70699	89804	55638	11650	13876	9424	4846		0.34	0.41	0.27
2003	38044	46964	30787	11579	13811	9347	3610		0.38	0.46	0.29
2004	46503	57098	37854	12424	14794	10054	4206		0.37	0.46	0.29
2005	40153	48577	33160	12492	14970	10014	3485		0.33	0.41	0.26
2006	35960	43264	29880	12729	15331	10127	3225	727	0.29	0.36	0.22

Year	Recruitment			SSB (tonnes)			Landings	Discards	F		
	Age 1	High	Low		High	Low	tonnes	tonnes	Ages 3–6	High	Low
2007	53434	64220	44441	12959	15706	10212	3381	1220	0.27	0.34	0.2
2008	68264	84206	55325	13064	15919	10209	3278	888	0.26	0.33	0.2
2009	110669	132797	92173	14101	17127	11075	3124	1473	0.25	0.32	0.187
2010	167472	203269	138097	17083	20617	13549	3910	2412	0.21	0.27	0.16
2011	209111	253957	172315	23911	28692	19130	3291	1926	0.168	0.21	0.127
2012	111866	136730	91513	35669	42766	28572	3178	3043	0.136	0.171	0.101
2013	123708	151324	101197	47855	57660	38050	3604	2696	0.123	0.153	0.092
2014	186536	233300	149033	53506	64935	42077	3675	3325	0.124	0.154	0.094
2015	143106	187100	109382	54025	65718	42332	2957	2368	0.136	0.171	0.101
2016	74247	106628	51684	54787	66885	42689	3617	3090	0.158	0.198	0.118
2017	83165	132699	52165	51457	63971	38943	3689	4075	0.19	0.24	0.137
2018	114548	253860	51713	41845	53834	29856	3980	2846	0.23	0.32	0.148

Table 14.5.3.1.1. Plaice in 7.d: Management options for 2019 and their effects on the resident stock.

Variable	Value	Source	Notes
F ages 3–6 (2019)	0.23	AAP	Correspond to F_{2018} (status quo assumption)
SSB (2020)	40933	AAP	Short term forecast (STF), tonnes
Rage1 (2019-2020)	125134	GM 2013–2016	Thousands individuals
Catch (2019)	8189	AAP	STF, in tonnes (resident stock)
Landings (2019)	4524	AAP	STF, in tonnes; projection based on the average landing ratio (2016–2018) by age
Discards (2019)	3665	AAP	STF, in tonnes; projection based on the average landing ratio (2016–2018) by age

Table 14.5.3.1.1. (continued) Plaice in 7.d: Management options for 2019 and their effects on the resident stock.

	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	F_{total} (2020)	SSB (2021)	% SSB change	% change in wanted catch
EU MAP **: F_{MSY}	9073	4697	4376	0.25	41084	0.37	18
EU MAP **: F = $F_{MSY\ lower}$	6545	3389	3156	0.175	43874	7.2	-14.8
EU MAP **: F = $F_{MSY\ upper}$	12029	6225	5804	0.34	37864	-7.5	56
F = 0	0	0	0	0	51248	25	-100
F_{pa}	12510	6473	6037	0.36	37344	-8.8	63
F_{lim}	16468	8514	7954	0.5	33127	-19.1	114
SSB (2021) = B_{lim}	31231	16016	15215	1.22	18447	-55	300
SSB (2021) = B_{pa}	23575	12156	11420	0.8	25826	-37	210
SSB (2021) = MSY $B_{trigger}$	23575	12156	11420	0.8	25826	-37	210
F = F_{2019}	8498	4400	4099	0.23	41715	1.91	10.5

*** "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 2016–2018.**

**** EU multiannual plan (MAP) for the Western Waters (EU, 20196).**

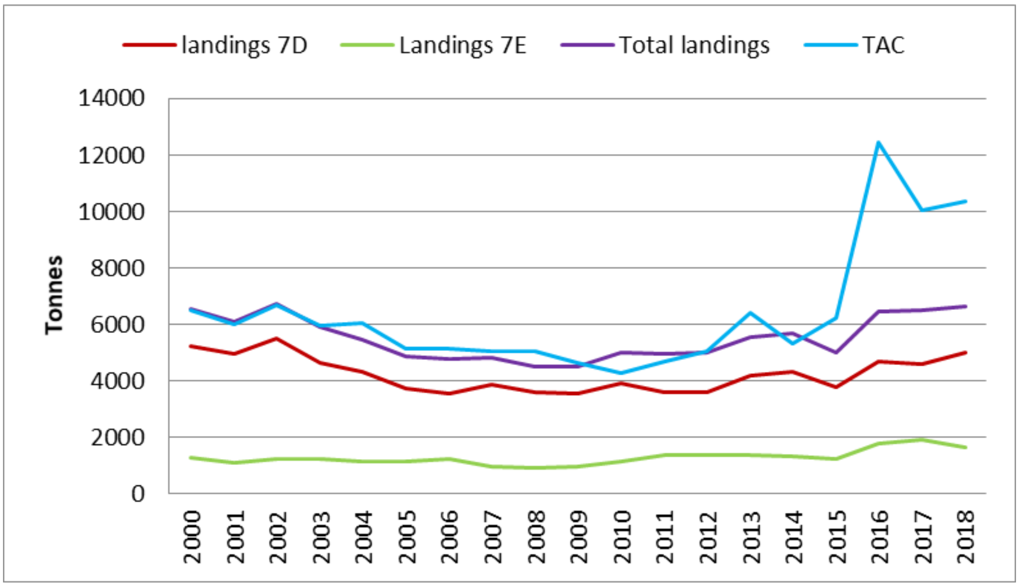


Figure 14.2.1.1. Plaice in 7.d. Official landings in 7.d and 7.e compared to the TAC: in 2018, the advice was given on catch rather than landings.

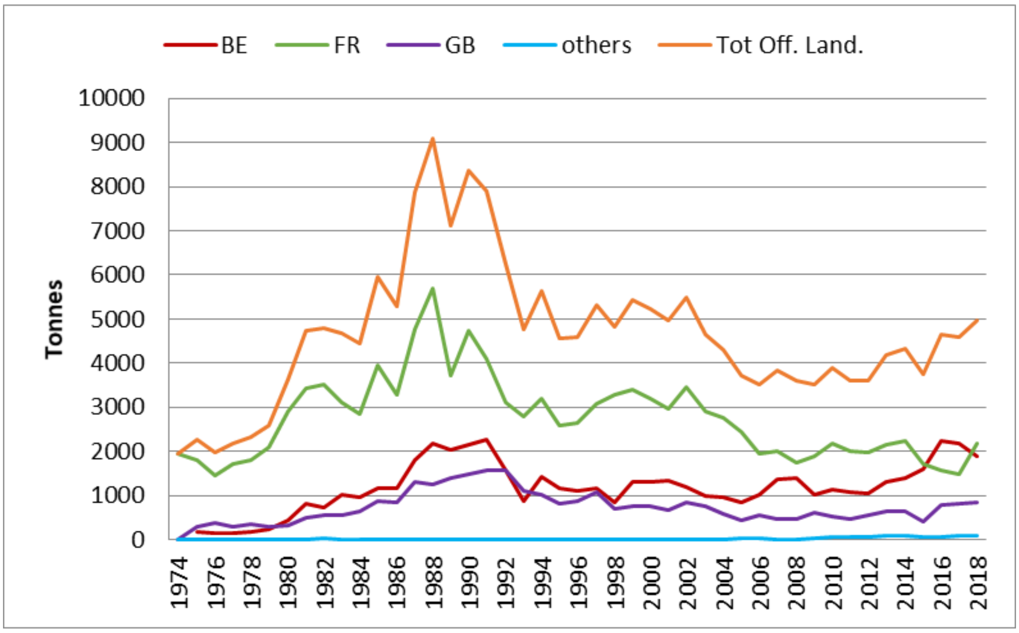


Figure 14.2.1.2. Plaice in 7.d: Official landings.

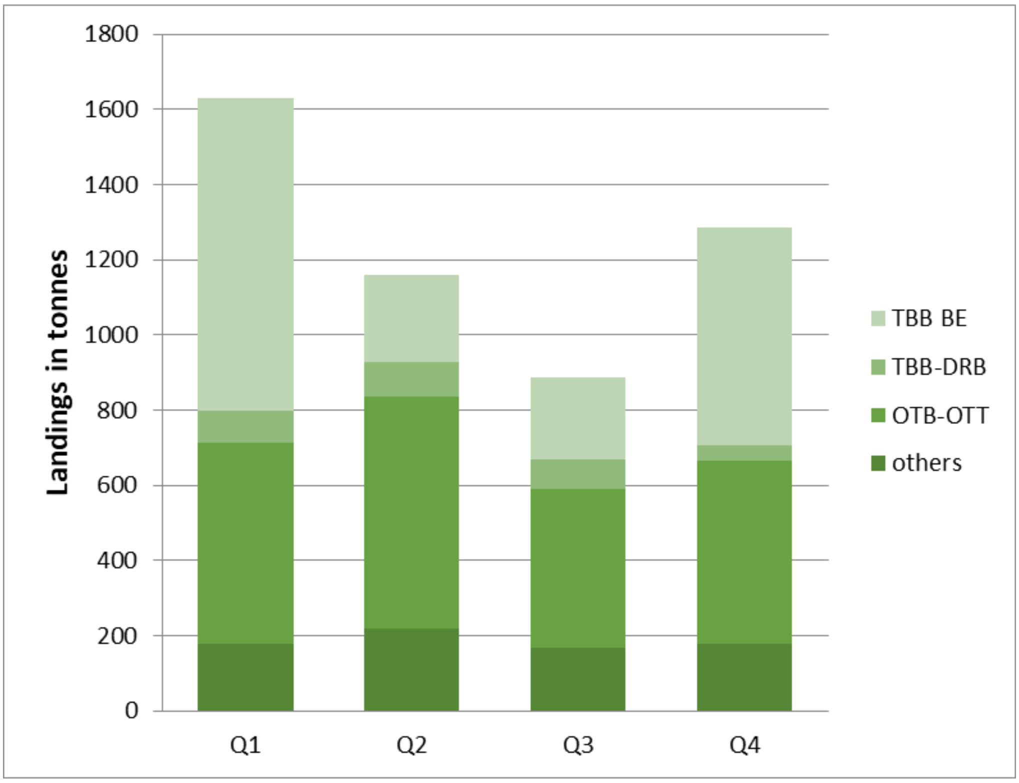


Figure 14.2.1.3. Plaice in 7.d: Landings per quarter.

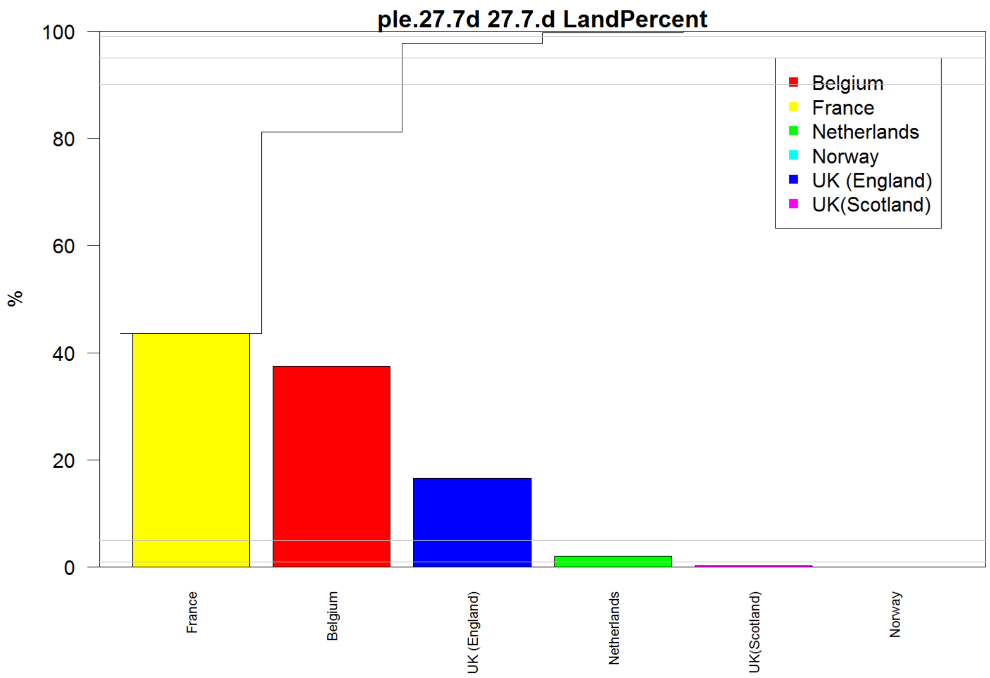


Figure 14.2.2.1. Proportions of total landings per country with and without age distribution provided.

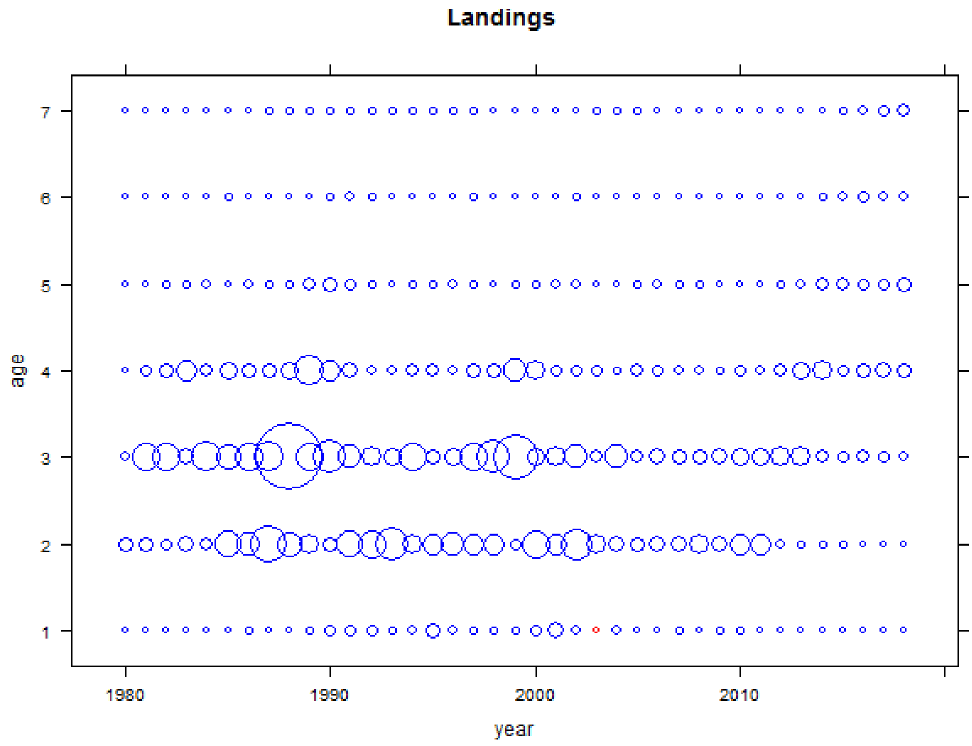


Figure 14.2.3.1. Plaice in 7.d: Age composition of the landings, missing data are presented in red.

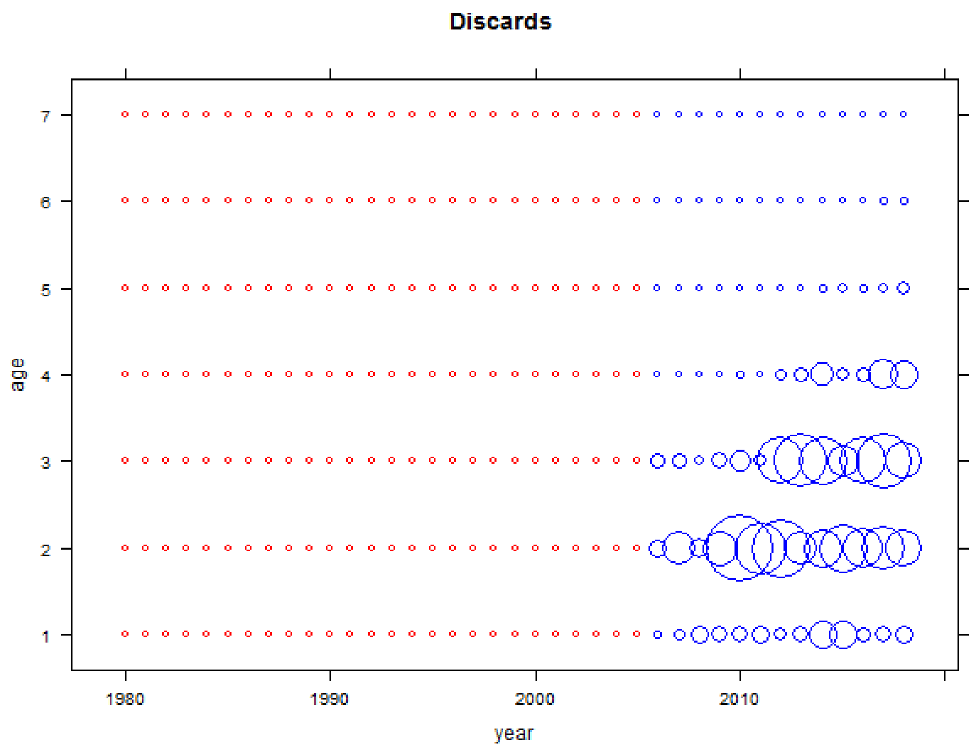
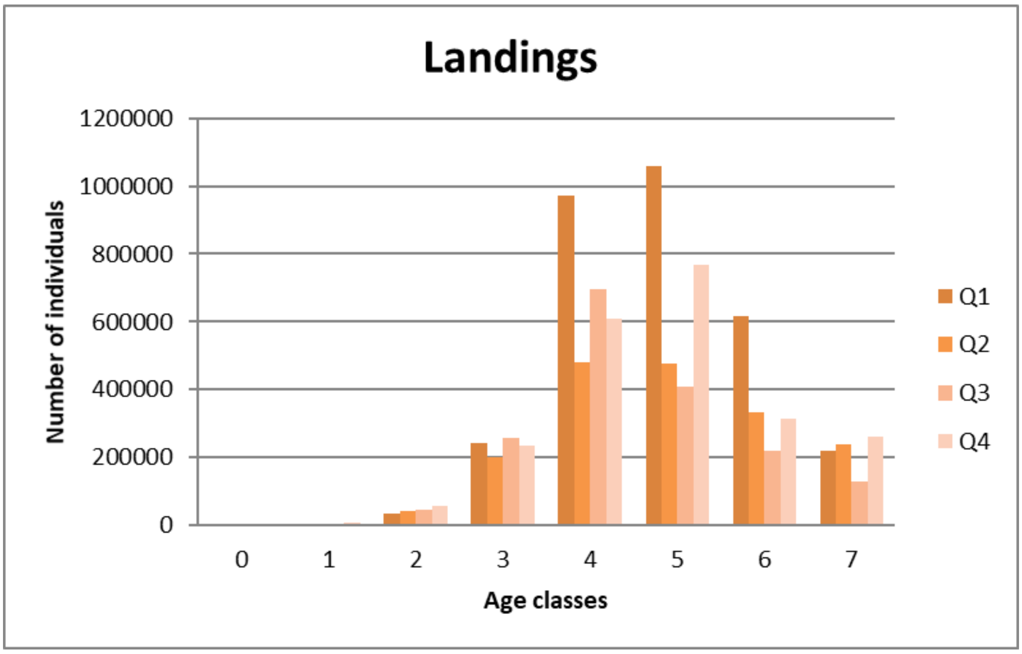


Figure 14.2.3.2. Plaice in 7.d: Age composition of the discards (data available from 2006 onward).



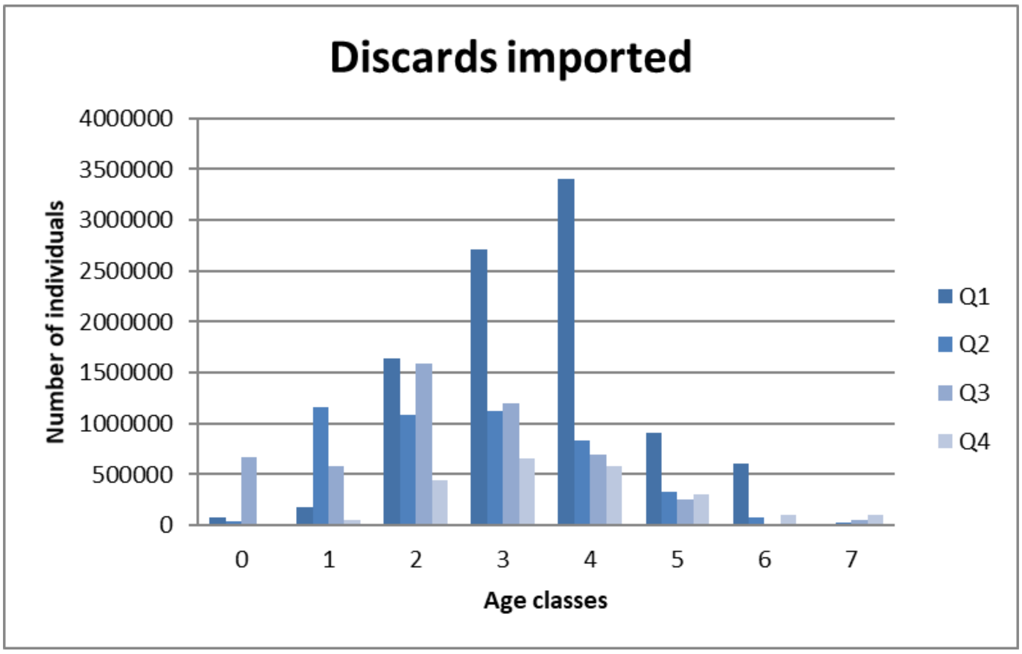


Figure 14.2.3.3. Plaice in 7.d: 2017 Age distribution in the sampled landings and discards per quarter.

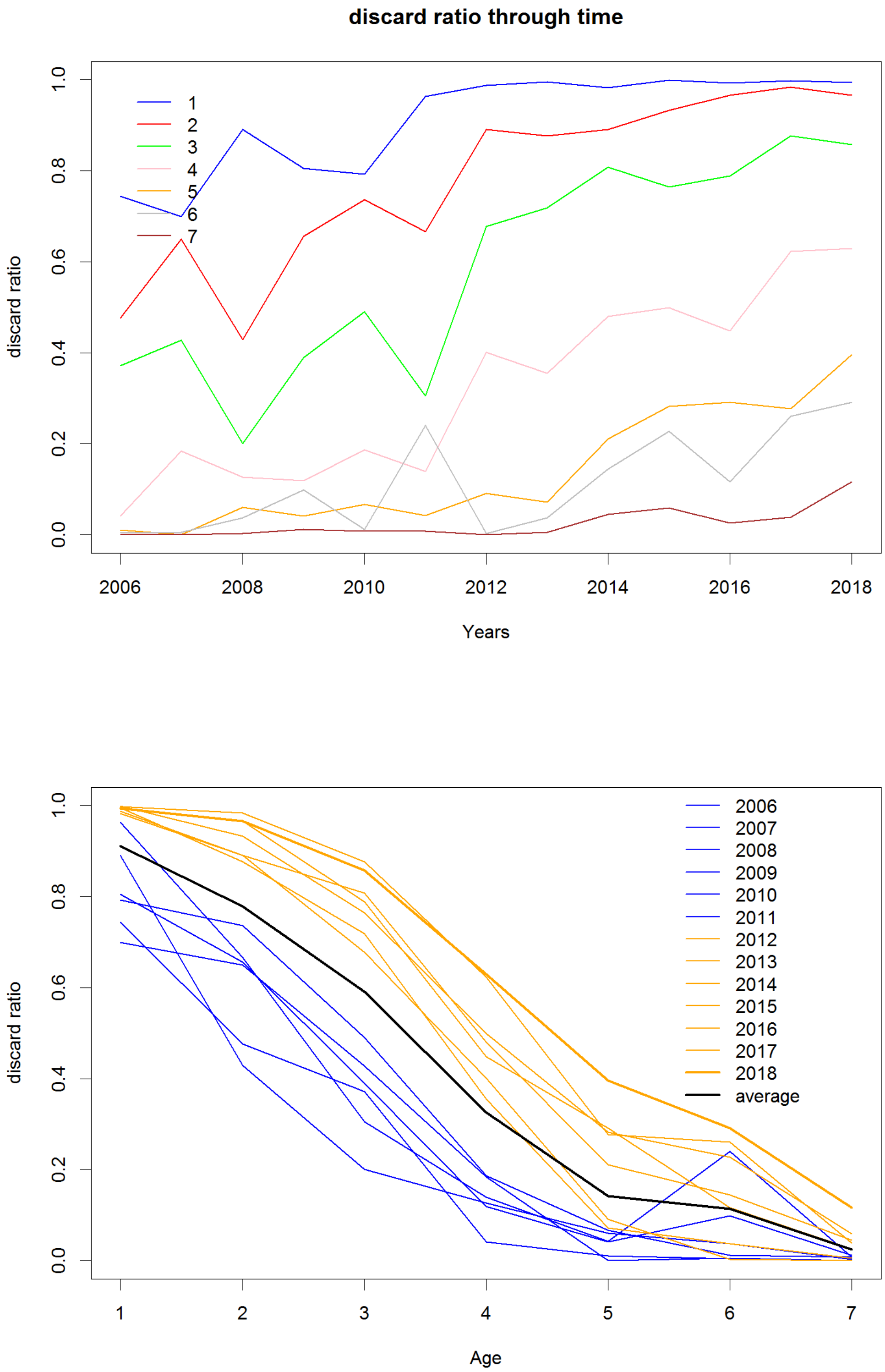


Figure 14.2.3.4. Plaice in 7.d: Discards at age ratio (discards numbers/landings numbers) per age and through time.

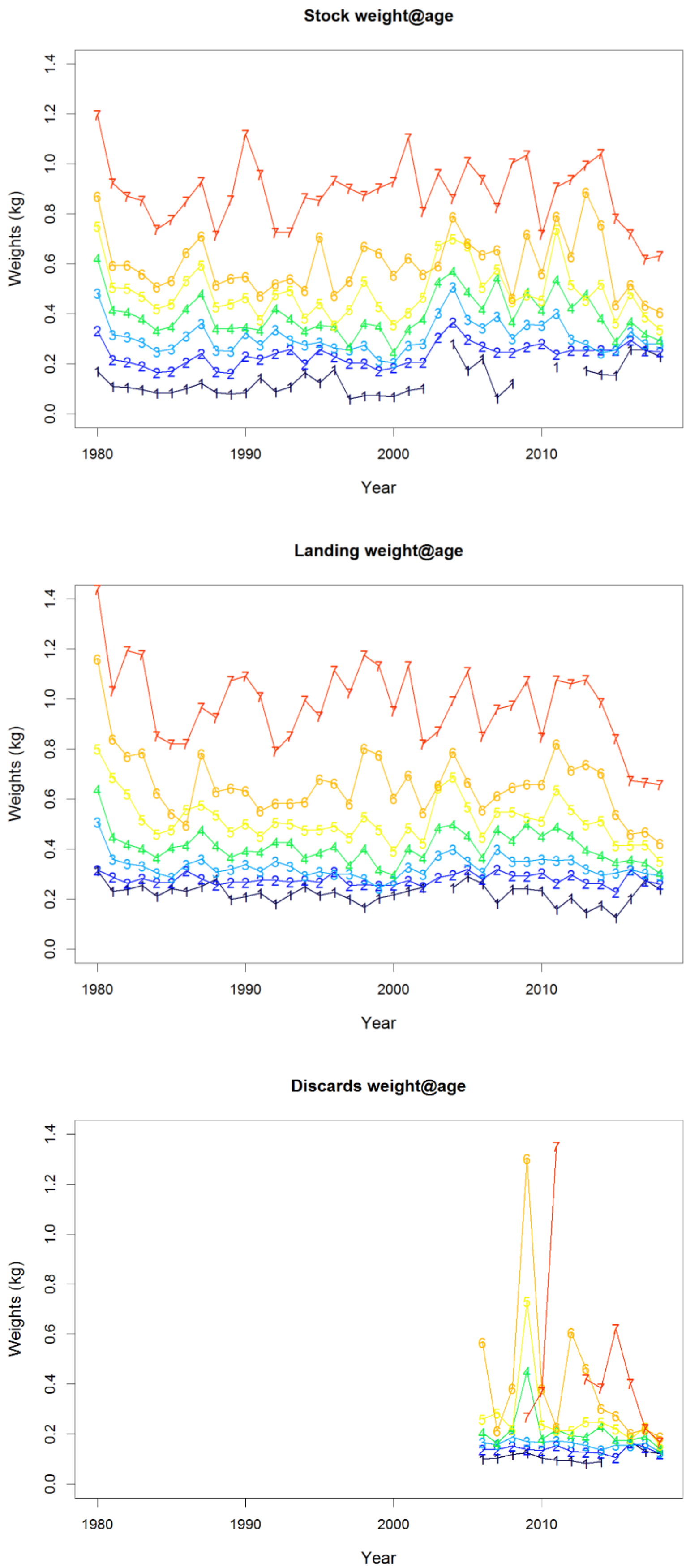


Figure 14.2.4.1. Plaice in 7.d: Stock, Landing and discard weights.

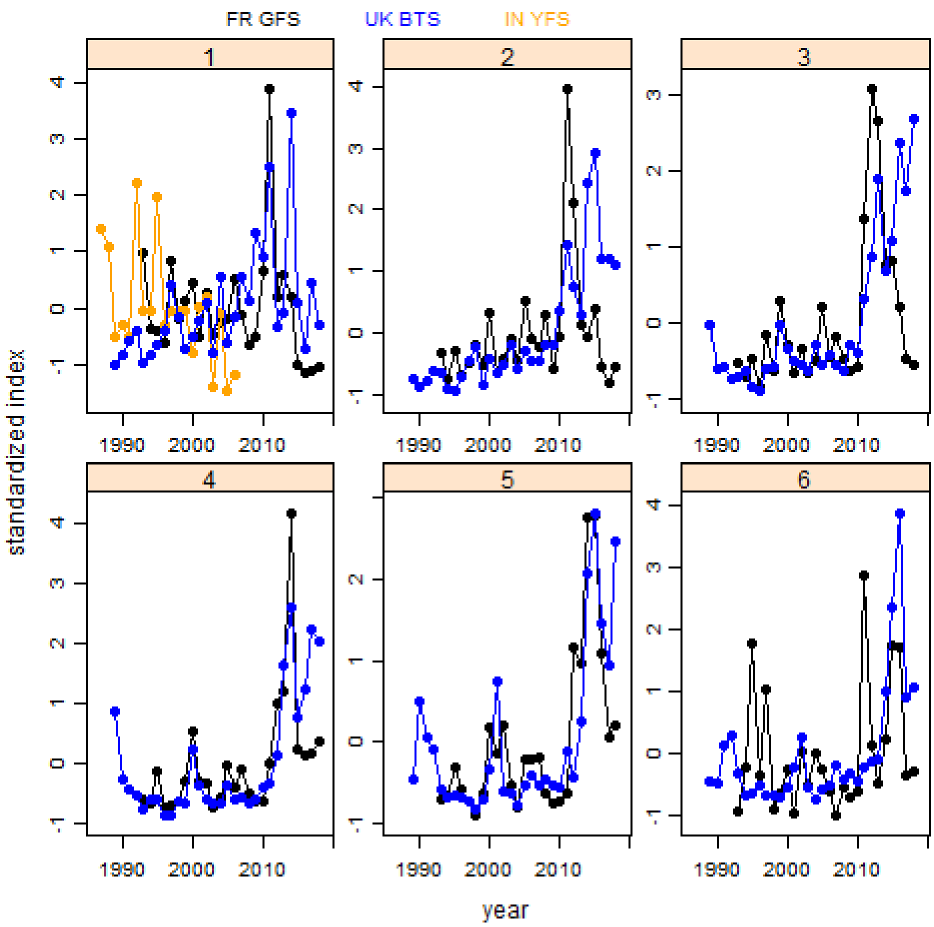


Figure 14.2.6.1. Plaice in 7.d: Survey Consistency: mean standardized indices by surveys for each age.

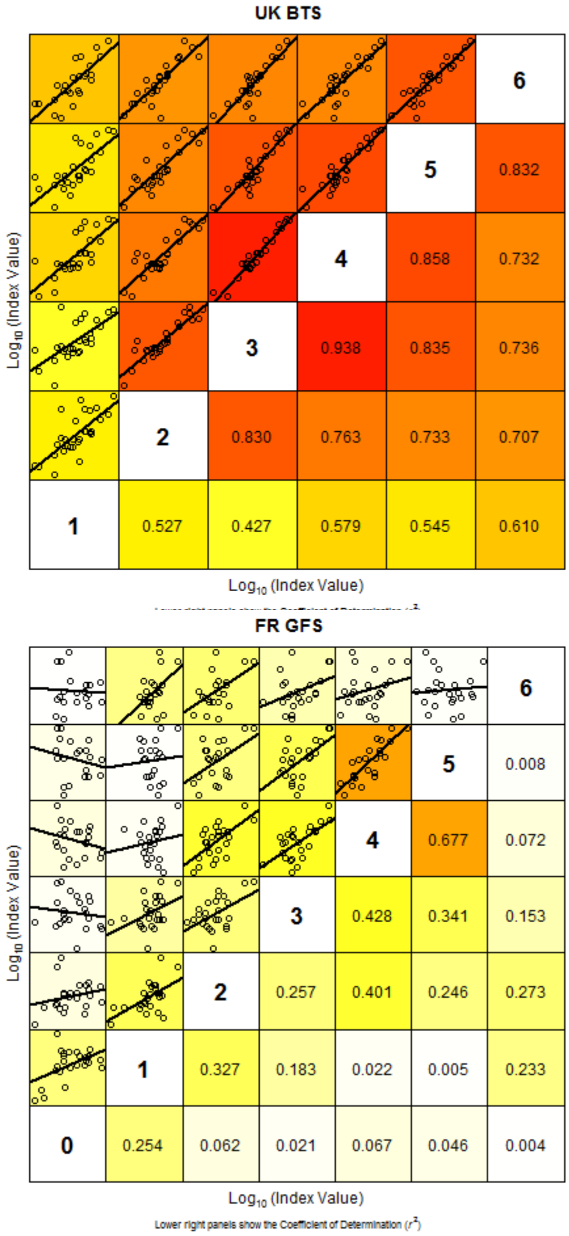


Figure 14.2.6.2. UK BTS and FR GFS indices consistencies.

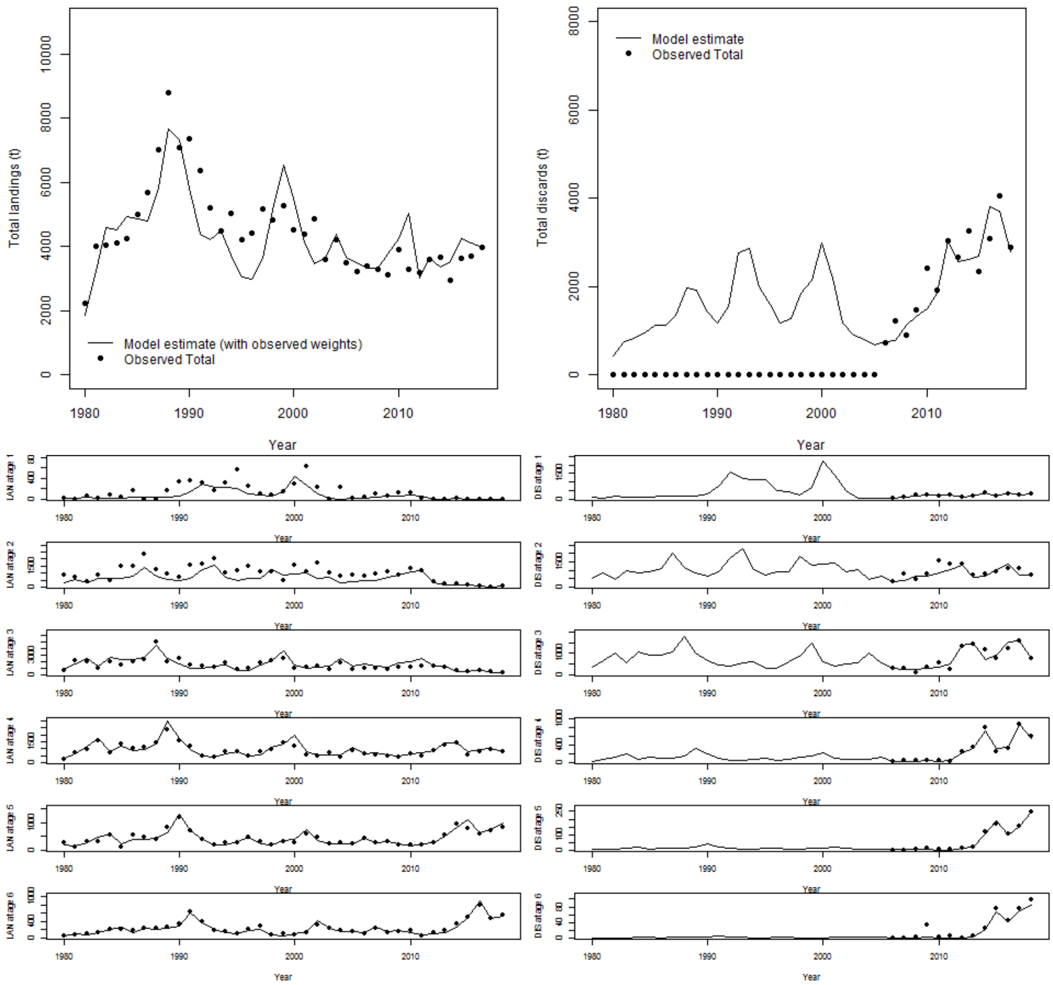


Figure 14.3.1.1. Plaice in 7.d: Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).

Figure 14.3.1.2. Plaice in 7.d: Survey residuals from the AAP assessment.

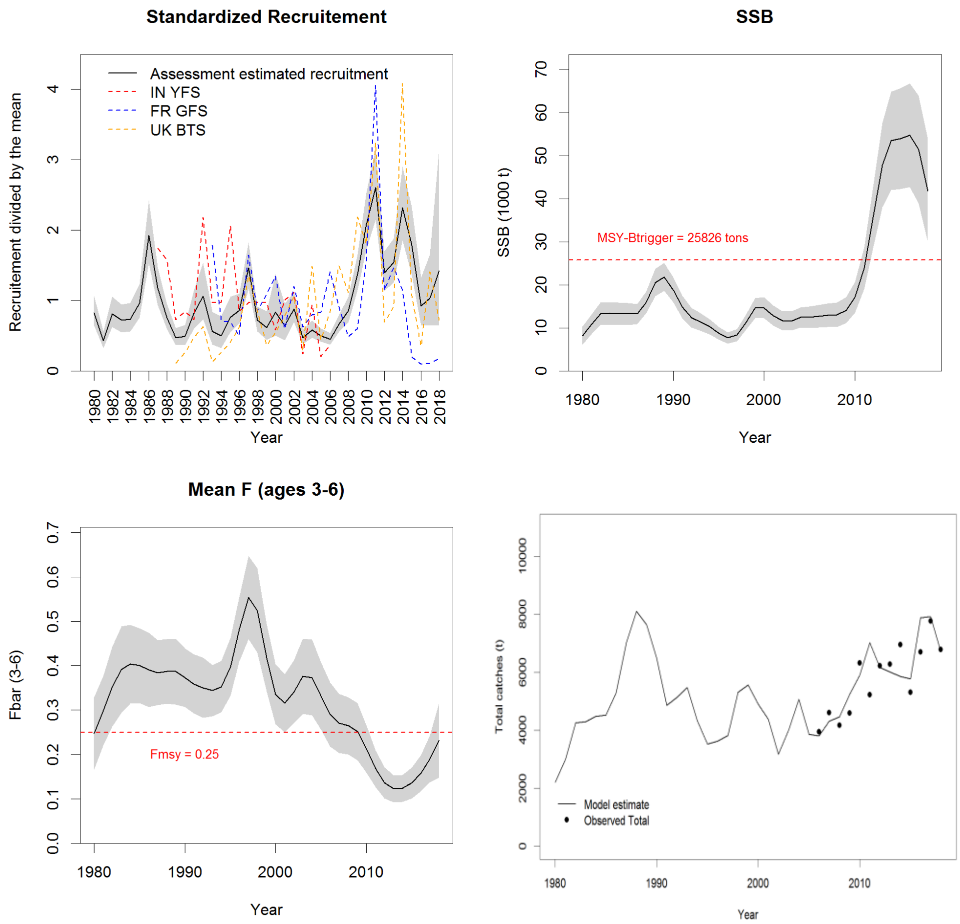


Figure 14.3.1.3. Plaice in 7.d: Summary of assessment results.

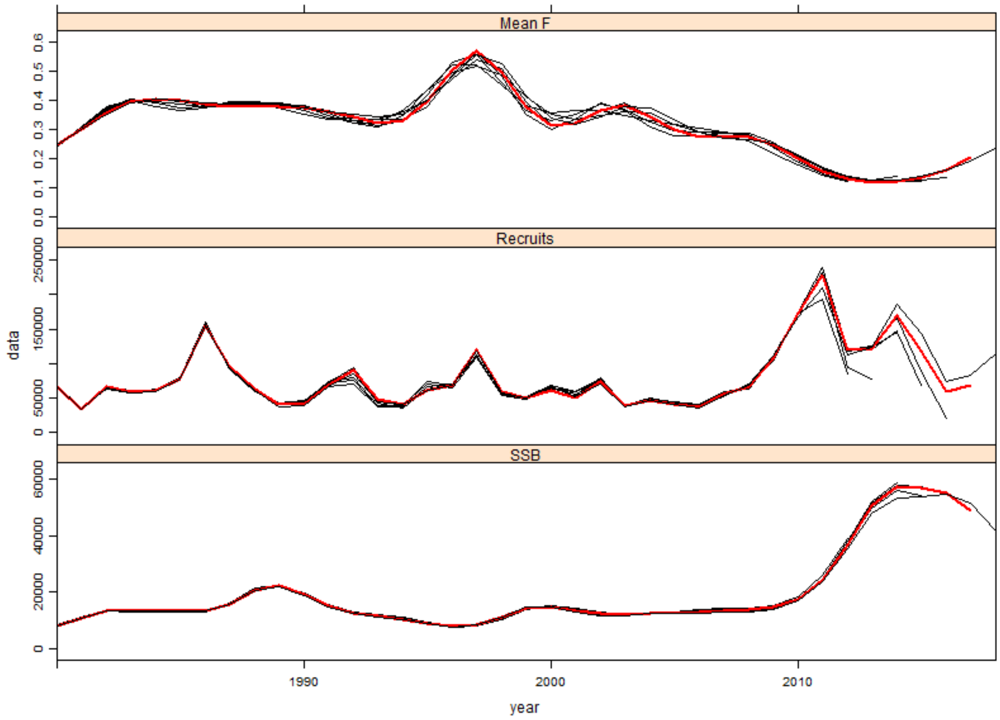


Figure 14.3.1.4: Plaice in 7.d. Retrospective patterns.

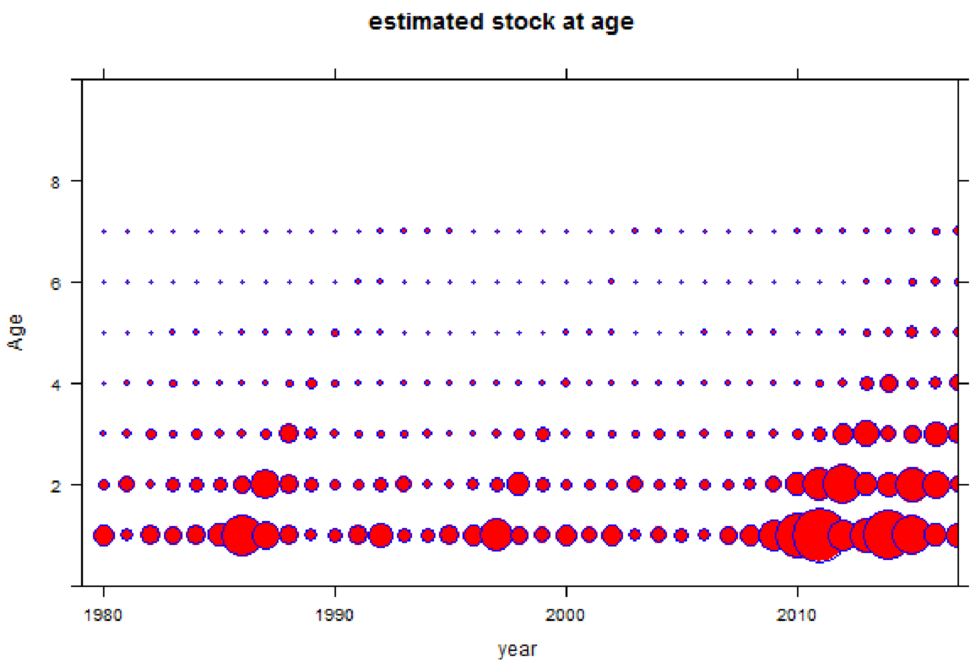


Figure 14.3.1.5: Plaice in 7.d. Estimated stock numbers.

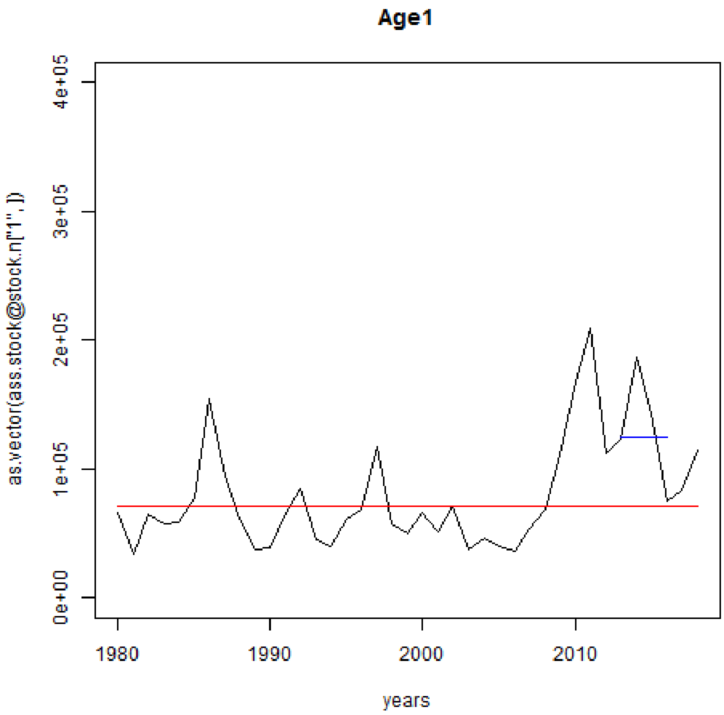


Figure 14.5.1.2. Plaice in 7.d: Number of individuals of age 1 as estimated by the assessment model (black), with the geometric mean over the whole time series (red), and the geometric mean over 2013–2016 (blue).

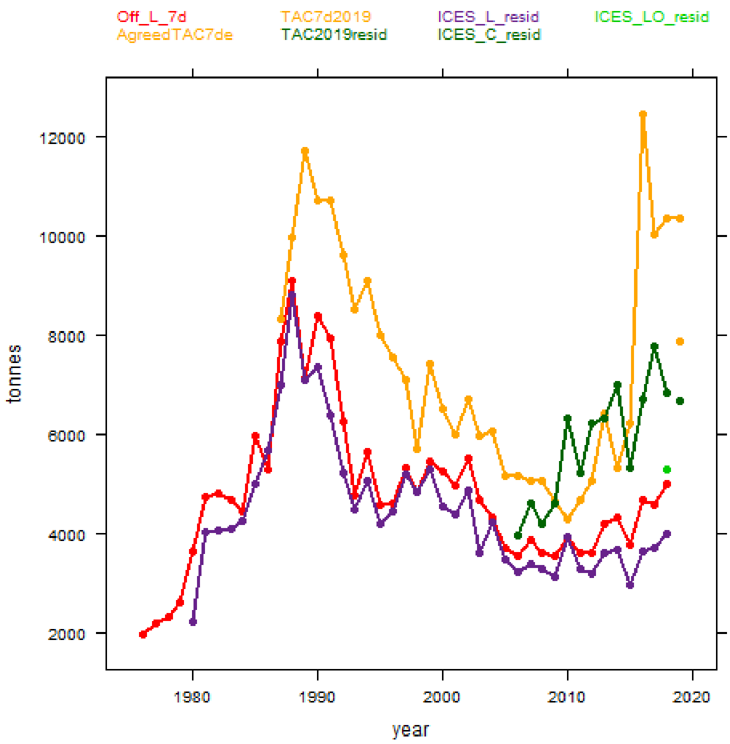


Figure 14.5.2.1. Plaice in 7.d. Official landings in 7.d (red line), ICES landings of resident plaice in 7d (purple line), ICES catches of resident plaice in 7d (dark green line) and agreed TAC for 7d,e plaice (orange line). The orange dot correspond to 7d proportion of 2019 TAC, the dark green dot is the resident plaice in 7d proportion of 2019 TAC, and the green dot is the landings of resident plaice in 7d in 2018 if plaice was under landing obligation in 2018 (ICES catches 2018 minus discards from exempted fleets).

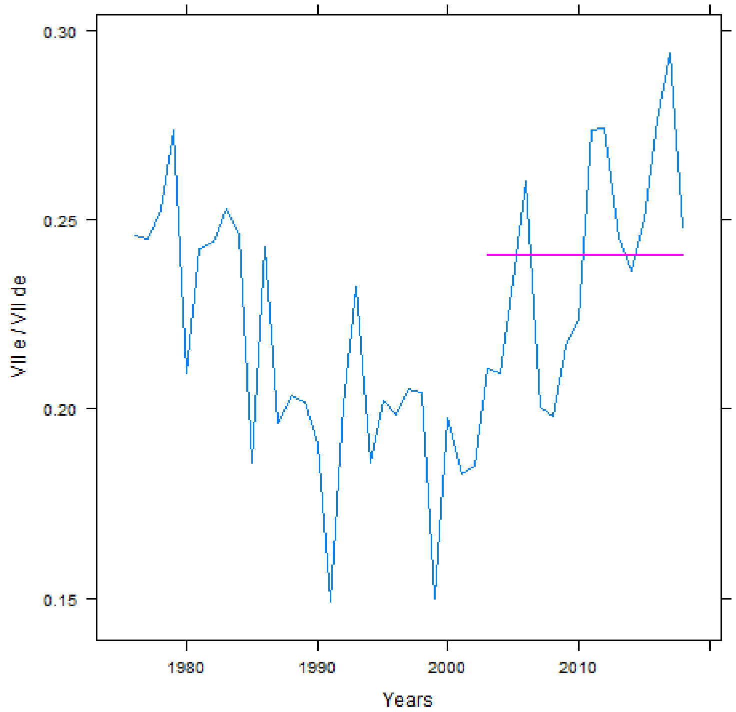


Figure 14.5.2.2. Plaice in 7.d: Time series of the proportion of the official landings in 7.e over the 7.d,e official landings, and the average used.

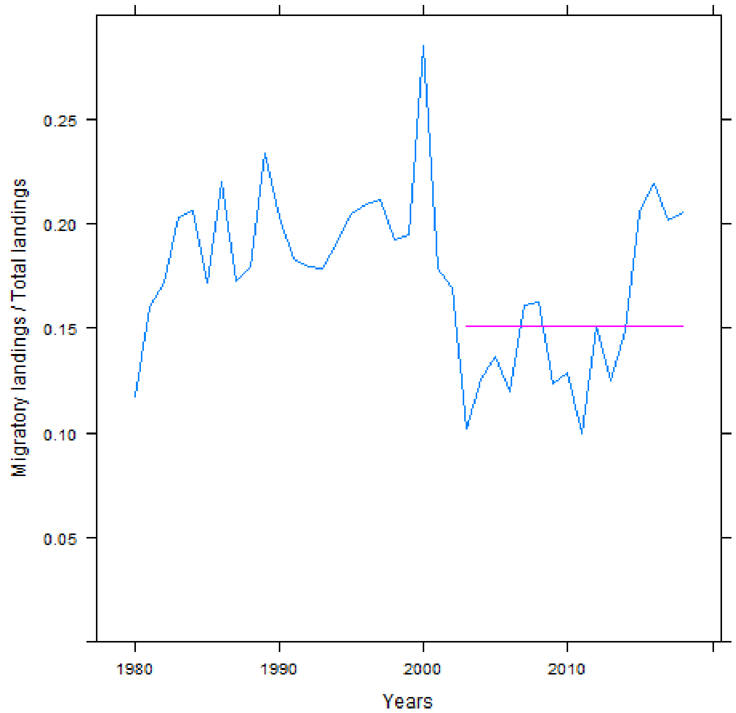


Figure 14.5.2.3. Plaice in 7.d: Time series of the proportion of the catch of fish coming from 7.e and 4 over the 7.d catch, and the average used.

15 Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea and Skagerrak)

15.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >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.

15.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including 7.d and 3.a). In the ICES advice, it was, however, decided to include 7.d Pollack in the Celtic Seas Ecoregion.

15.3 Management

For 4 and 3.a there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

15.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977, the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2017 in Division 3.a (Skagerrak/Kattegat) and Subarea 4 (North Sea) are shown in Table 15.1. Figure 15.1 shows total landings in Subarea 4 and Division 3.a from 1977–2017. 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 bycatch in various commercial fisheries. Norwegian catches peak in the months of March and April, and this may be associated with spawning aggregations. In 2018, 52% of the total landings were caught with gillnet and 41% with otter trawls in Division 3.a. In Subarea 4, 25% of the total landings were made with gillnets and 59% 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 small rate, and raised discards were estimated at 25.1 tonnes in total between division 3a and subarea 4 in 2018 (see Table 15.2 for total catches and Table 15.3 for estimated discards). Discard numbers were raised for all nations. Virtually all discards (>99 %) were reported by bottom trawl fleets with France the country reporting the largest number of discards (89 % of total). In 2018, below minmum size (BMS) landings and logbook reported discards were also reported to ICES for pollack. No BMS landings or logbook reported discards were reported and no 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).

15.5 Survey data / recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the CPUE was much higher in the 1970s. They are distributed mainly over the northern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat. Time series of abundance (average number per hour) in the IBTS are shown for Subarea 4 and Division 3.a separately, for quarter 1 (from 1983 onwards) and quarter 3 (from 1996 onwards) (Figure 15.2). The catches are small, and rather irregular, and no clear patterns emerge in 3 and 4.

15.5.1 Biological sampling

There has been some collection of length data in Subarea 4 and Division 3.a by Norway in the most recent years. Preliminary analysis of this data indicates that length ranges of pollack caught in gill net fisheries differ with mesh size and location. The majority of fish caught in western Norwegian fjords had a size range of 60–80 cm (Figure 15.3) compared to 50–70 cm in the Skagerrak (Figure 15.4).

15.5.2 Analysis of stock trends

In previous years the study by Cardinale *et al.* (2012), which analysed the spatial distribution and stock trends for the period 1906–2007, based on IBTS Q1 and commercial catches, was used to assess the stock for Division 3.a (Skagerrak and Kattegat) and it was found that there had a been large decline in stock size from approximately 1960 to 2000. However, during routine IBTS surveys in Subarea 4 and Subarea 3, pollack catches seem rather irregular and with no clear pattern. A spatial analysis of Norwegian fisheries data from 2013, showing total Pollack catches by ICES rectangle, indicates that the surveys do not cover the geographic distribution of the species adequately in both Subarea 4 and Division 3.a (Figures 15.5 and 15.6). The surveys may therefore not be very well suited for monitoring this species as trends in standardised CPUE likely are not a reliable indicator for the status of the stock. However, if the stock increases, it is arguably expected that present trawl surveys (e.g. IBTS) would be able to detect such a stock trend in a consistent manner (Cardinale *et al.*, 2012).

15.6 Living Issues List

15.6.1 Data

In order to get a better understanding of growth and maturity, WGNEW recommended that the collection of otoliths and maturity should be continued during the IBTS surveys for a few years. WGNSSK recommends also that the Norwegian biological data from commercial catches should be processed. An effort should also be made to see if biological information is available from other countries and whether such data can be used to establish future reference points for this stock.

15.6.2 Assessment

No assessment model exists for pollack.

15.6.3 Forecast

There is no forecast for pollack.

15.7 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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ICES 2012. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

Heino, M., Svåsand, T., Nordeide, J. T., Otterå, H., 2012. Seasonal dynamics of growth and mortality suggest contrasting population structure and ecology for cod, pollack, and saithe in a Norwegian fjord. – ICES Journal of Marine Science 69: 537–546

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S.,Wienerroither, R., 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway’s coastal tourist fishery. ICES Journal of Marine Science. 68: 1785–1791

Table 15.1. Pollack in Subarea 4 and Division 3.a. Landings (tonnes) by country as officially reported to ICES 1977–2017.

	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

ICES Division 3.a							
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Official Total
2015		190	14	1	138	48		390
2016		151	8	1	134	47		341
2017		185	10	4	117	43		359*
2018		226	10	1	105	64		406*

*** 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

ICES Subarea 4											
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
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	447		37	430	1174
2017	18	187		6	231	3	510		44	512	1511*
2018	14	139		23	154	2	739		30	484	1586*

*** Preliminary**

Table 15.2. Pollack in Subarea 4 and Division 3.a. Catches (tonnes) by country as estimated by the Working Group 2013–2018.

ICES Division 3.a						
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
Denmark	214	192	192	152	187	229
Germany	11	6	35	7	11	13
Netherlands	<0.5	0	0	1	5	2
Norway	174	156	138	135	117	108
Sweden	36	30	46	47	43	64
ICES Total	435	384	413	343	363	415
Official Total	420	383	389*	338*	359*	406*
Diff ICES-Off	15	1	24	5	4	9

* **Preliminary**

ICES Subarea 4						
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
Belgium	17	24	20	21	18	14
Denmark	150	122	183	127	187	139
France	2	32	2	2	8	46
Germany	59	145	216	107	267	151
Netherland.	3	1	2	2	2	2
Norway	379	481	466	440	508	738
Sweden	29	41	50	36	44	30
UK	456	377	626	423	508	488
Ices Total	1103	1227	1567	1159	1543	1608
Official Total	1080	1215	1594	1174	1511*	1586*
Diff ICES-Off	23	12	-27	-15	32	22

* **Preliminary**

Table 15.3. 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
2018		2.39				0.28		2.67

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
2018		0.026		22.49							22.47

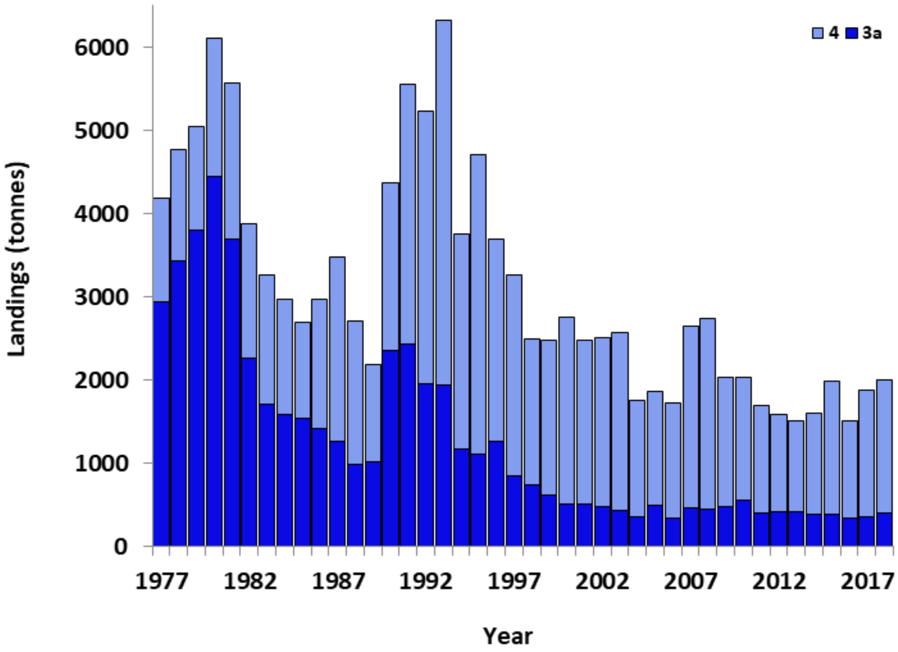

Figure 15.1. Pollack. Total landings of pollack from 2007–2018 in Division 3.a and Subarea 4 as officially reported to ICES.

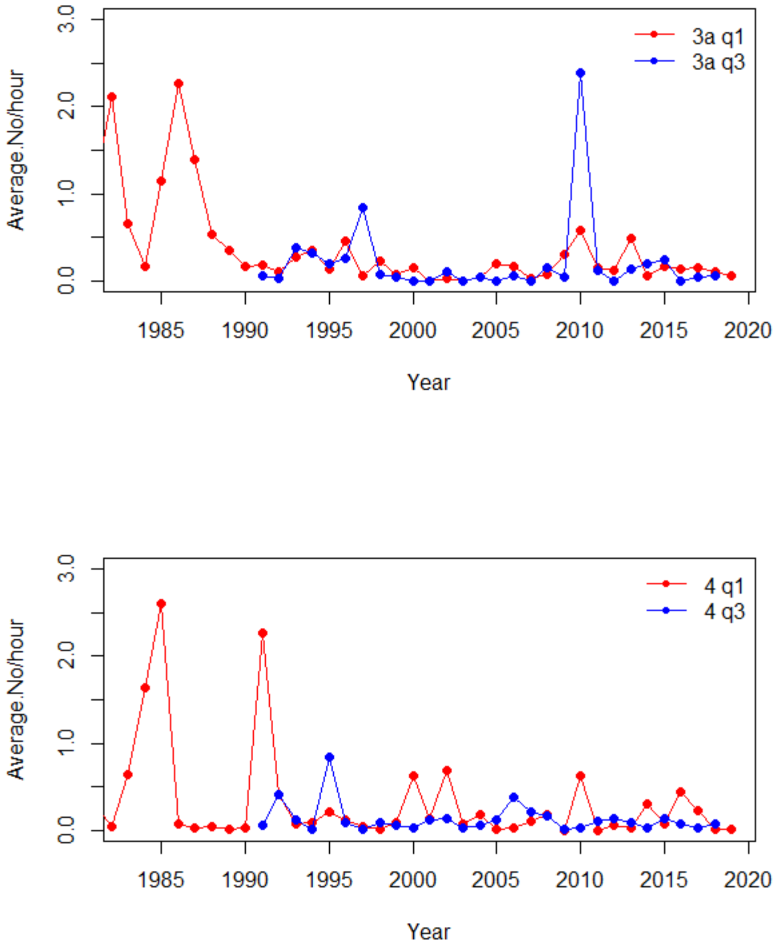

Figure 15.2. Time series of catches of pollack from 1983–2018 in ICES Division 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV-trawl. Data from Datras.

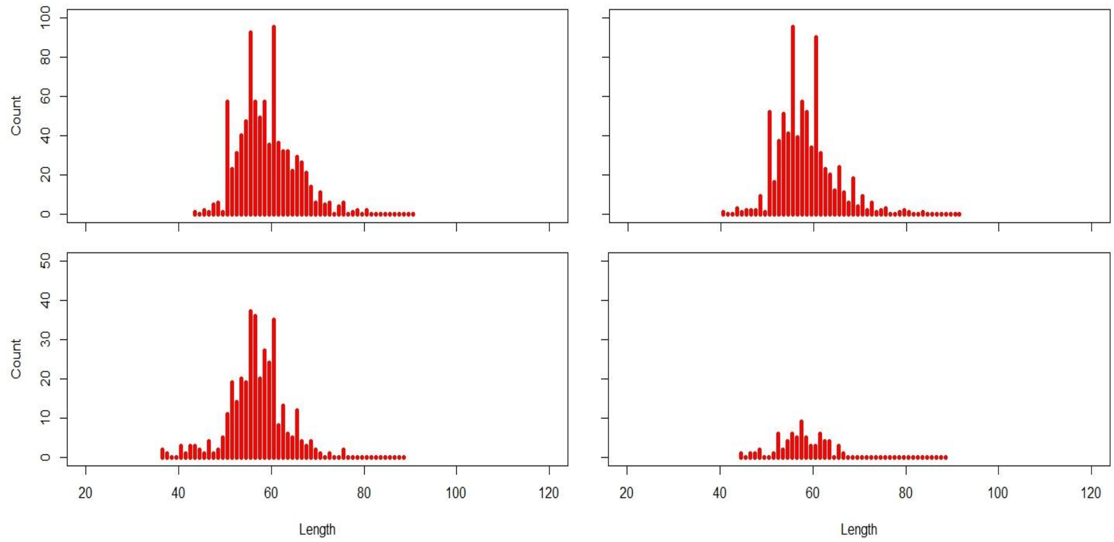

Figure 15.3 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a. The data is aggregated for gillnets with a 63 mm mesh size.

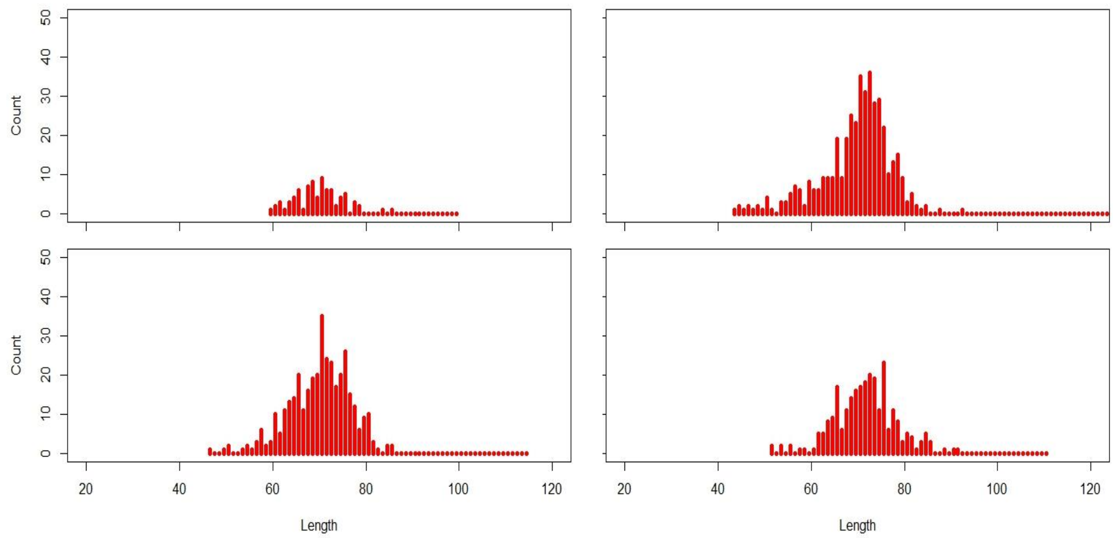

Figure 15.4 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70 mm mesh size.

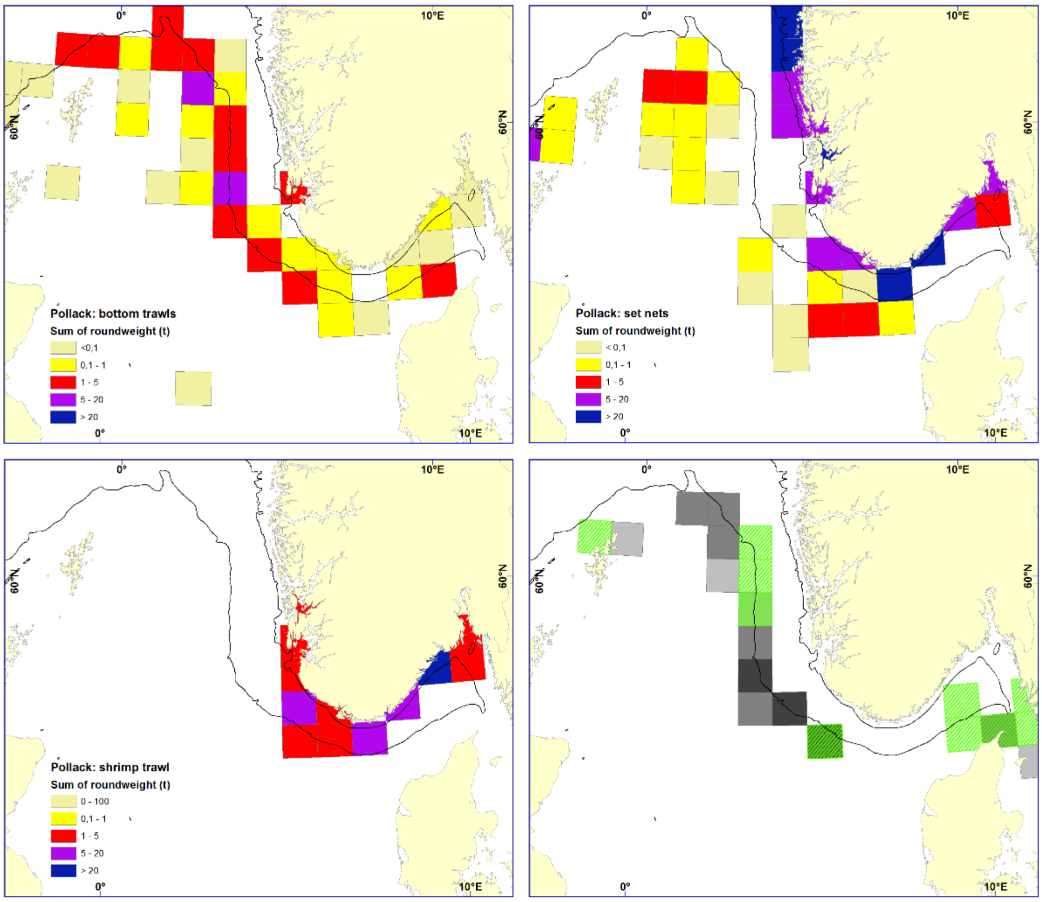

Figure 15.5 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

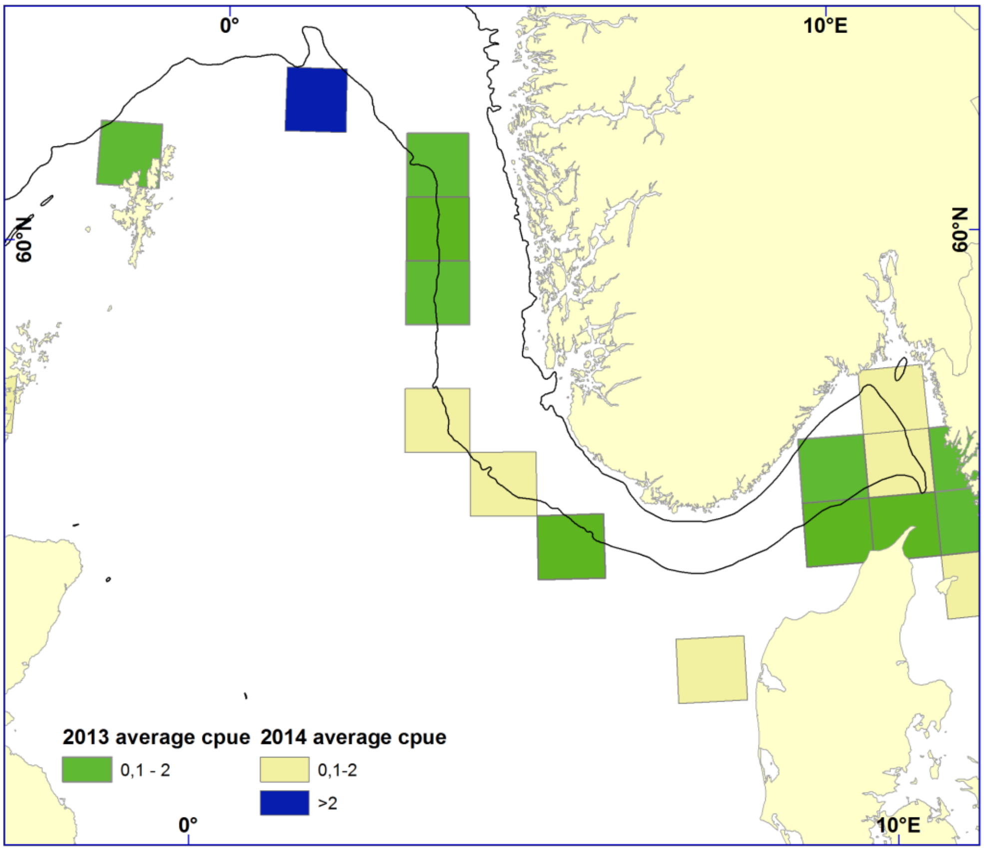

Figure 15.6 Pollack catches from IBTS surveys in 2013 (green) and 2014.

16 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 follows the protocol defined during the inter-benchmark in January 2019, which revised errors in the assessment code that existed from 2016–2018 and triggered a revised advice for 2018 (published 22 February 2019). With the code error corrected, the model produced lower biomass estimates in recent years, slightly different reference points, and a lower recommended TAC, which explain part of the retrospective pattern observed in the advice when comparing to past years' assessments.

16.1 General

16.1.1 Stock definition

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

16.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK in 2019. A summary of available information, prepared during WKBENCH 2011 (ICES WKBENCH, 2011), can be found in the Stock Annex.

16.1.3 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 in the areas fished by the three nations.

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 16.3.5). This change was only for one year; these vessels reverted to otter trawling in 2017 and 2018. 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. Discarding continued in 2018 in areas 4 and 3a despite a full landing obligation in place. In area 6 fisheries targeting saithe were under the landing obligation. Discards can also be high in a few Danish and Swedish fisheries in the Skagerrak because these fleets do not have sufficient quota allocations.

16.1.4 ICES Advice

The information in this section is taken from the Advice summary sheet from January 2019 (update of the 2018 advice).

Advice for 2019

"ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 103 327 tonnes."

The TAC was also updated in line with the ICES advice.

16.2 Management

Changes to the stock assessment and reference points during the benchmark in 2016 and the interbenchmark in 2019 imply a need to re-evaluate the EU-Norway management strategy to ascertain if it can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice will be given according to the ICES MSY approach. EU-Norway initiated consultations for new management strategies. ICES evaluated these management strategies and they are provided as additional options in forecasts and in the catch option table in the advice (See Section 16.7).

16.3 Data available

16.3.1 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) and ICES estimated discards and BMS landings are presented in Table 16.3.1. ICES estimates of landings are in 2018 lower in Subarea 6 and Subarea 4 than the official landings. ICES estimates correspond to the sum of products (SOP) uploaded to Intercatch (97.9%) in 2018.

85% of the discards were imported to Intercatch while 15% were raised (Table 16.3.2). Discard observations were not available for some of the fleets landing larger amounts of saithe (Figure 16.3.1). This is mainly the case for the Norwegian fleets. 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, discards for the Norwegian, French, and German trawler fleets (TR1) were raised using provided discard information from the French and German trawler fleets (i.e., targeted saithe fisheries; quarterly stratification). Trawler fleets (TR1) from other countries were raised with trawler fleets from these countries (by quarter and area). Discards for other fleets (all countries), were raised using a stratification by quarter and area (4/6 and 3.a were distinguished). Discard ratios above 0.5 were not used to raise discards for other fleets.

The complete time series of catch, landings, and discards as used in the assessment is summarized in Table 16.3.3 and illustrated in Figure 16.3.2. 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.

Targeted saithe fisheries were covered by the EU Landing Obligation since 2016. In 2018 saithe was under the landing obligation in all fleets in areas 4 and 3.a. Very few BMS landings and no logbook reported discards were reported into InterCatch in 2018 (Table 16.3.2).

16.3.2 Age compositions

International catch 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 91% of the total landings (Table 16.3.4; Figure 16.3.3). 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 (see ICES, 2016b). In 2018, the SOP provided for the main French fleets in Area 4 was exactly 80%, which is at the margin of acceptable quality for upload. This data was not used for generating age compositions for strata with missing age sampling. Nevertheless, the inclusion of the imported French data was a main contributor to the overall SOP of 97.9%. 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). This is because the fleets, particularly the target trawl fishery, are targeting the spawning fish in the first two quarters, while a wider range of age classes are captured in the latter part of the year. Smaller and younger fish are generally found in Division 3.a.

84 percent of the discards were sampled for age distributions (Table 16.3.3). Two countries provided mainly the age information for discards, Denmark and Scotland (Figure 16.3.4). These countries have also by far the largest amounts of discards. While the proportion of discards sampled for age distribution was high (Table 16.3.3), the number of age samples per metier is often low (ICES, 2016b). A stratification by quarter and area 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 16.3.5, while catch-at-age data for each catch component are given in Tables 16.3.6 and 16.3.7. Age 3 fish make up a smaller portion of the landings in recent years (Figure 16.3.5). 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, while 2018 appears to show a weak cohort entering in at age 3.

16.3.3 Weight-at-age

Weight-at-age from the catch and catch components for ages 3–10+ are presented in tables 16.3.8–16.3.10 and Figure 16.3.6. Catch weights are also used as stock weights in the assessment. There was a decreasing trend in mean weight for ages 6 and older, but that has stopped or been reversed (Figure 16.3.6). Weights-at-age for ages 3–5 have been relatively stable, with some variation, over the last decade.

16.3.4 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.

16.3.5 Catch per unit effort and research vessel data

Indices used in the final assessment are included in Table 16.3.11. 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, 1992–2018 (“IBTS-Q3”).

16.4 Data analyses

16.4.1 Exploratory survey-based analyses

Numbers-at-age for saithe ages 3 to 8 (IBTS–Q3) on the log–scale, linked by cohort, showed year effects (for example, low values around 2010) (Figure 16.4.1, top-left panel). The ability to track cohorts has been diminished in later years of the survey (post-2000) (Figure 16.4.1, top right panel). The survey catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages (Figures 16.4.1, top-right panel, and 16.4.2). 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 more ocean population (and fishery) until after age 5.

A high degree of uncertainty in the IBTS–Q3 index has been commented on previously (ICES 2016b), especially in terms of the influence of single samples that may influence the overall index, or lack of sampling of un-trawlable areas on the northern part of the shelf where dense aggregations are common. Despite this, the index is still currently used in the assessment, although it is clear that the assessment places more weight on the CPUE index, as observed in the leave-one-out analysis (see Section 16.4.4). IBTS–Q3 indices used in the final assessment are in Table 16.4.1.

16.4.2 Exploratory catch-at-age-based analyses

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 (ICES, 2017). Fleet restructuring has been occurring for several years within the German fleet and 2016 saw two vessels change to paired trawls (they are not included in the otter trawl CPUE index of 2016). In 2017 and 2018, 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 increased again in 2017 and only slightly decreased in 2018 (Figure 16.4.3).

16.4.3 Assessments

The assessment of North Sea saithe was carried out using a state-space stock assessment model (SAM; Nielsen and Berg 2014; Berg and Nielsen 2016). The assessment was an update assessment. Settings used in the final assessment are given in Table 16.4.2.

16.4.4 Final assessment

Estimated fishing mortality-at-age are given in Table 16.4.3 and Figure 16.4.4. 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. Also age 4 shows a declining trend in selectivity in recent years. For ages 5+, selectivity shows a slight dome shaped pattern, with highest selectivity for age 6 in recent years. With the lower fishing mortalities in recent years, fish have been allowed to increase in size (and age) and are likely targeted more than the younger age classes (as observed in Figure 16.4.4). Estimated population numbers-at-age are in Table 16.4.4.

The residuals are shown in Figure 16.4.5. 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, especially for age 6 and 7. The strength of the correlation between ages is strong between subsequent ages for all ages (Figure 16.4.6).

The retrospective analysis shows that SSB, F, and recruitment are well estimated for the last 5 years (Figure 16.4.7). Mohn's rho, estimated using the last 5 years, is 0.024 for SSB, -0.024 for F, and -0.023 for recruitment.

The final assessment and leave-one out results are in Figure 16.4.8. 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 2012.

16.5 Historic stock trends

The historic stock and fishery trends from the final assessment are presented in Figure 16.5.1 and Table 16.5.1. Because of the inter-benchmark in January 2019, the historic perception of the stock has changed. Recruitment has been low and highly variable since 1990. Both 2016 and 2017 show slightly higher recruitment than the average of the last ten years, while 2018 was the lowest estimate for the time series. The decline in SSB reversed in 2013 although increases have been moderate, and are slightly above the values of the early. The final year estimate of SSB is above B_{pa} and MSY $B_{trigger}$. Fishing mortality has generally declined since the mid–1980s and is currently estimated to be slightly below F_{MSY}.

16.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The 2009–2018 median value (83 040 000) used in the short-term forecast is a conservative assumption taking into account recent low recruitment. But the value of 83 040 000 is still nearly double the estimated recruitment for 2018 (45 672 000).

16.7 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 2018. The fishing mortality in the intermediate year was F status quo, as TAC has usually not been constraining in the recent past (with the exception of 2015). 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 past 10 years (2009–2018). The short-term projection was run in SAM.

The intermediate year assumptions for the short term forecast are given in Table 16.7.1. Given the options above results in an F_{2019} of 0.36 and a SSB in 2020 of 217 356 tonnes. Reference points and their technical basis are in Table 16.7.2.

The management options are given in Table 16.7.3a–b. Because reference points were re-estimated after the inter-benchmark, the management plan is no longer valid; therefore, the MSY approach is used as the basis for advice 16.7.3a. The advised total catch in 2020 is advised to be no more than 88 093 tonnes, where wanted catch is 80 676 tonnes; this is a 14.7% decrease when compared to the advised total catch in 2019. More catch options can be found in Table 16.7.3a. In addition, the catch options derived from proposed new EU management strategies are provided in Table 16.7.3b.

The contribution of the 2010–2016 year classes to landings in 2020 are shown in Table 16.7.4. The 2016, 2014 and 2013 year classes contribute the most to the forecasts. Recruitment at age 3 does not contribute greatly to the catches in 2020; rather, ages 4–7 are the main contributors (69% of total catches for 2020). This is clearly seen in the catch-at-age (Figure 16.3.5) and F at age (Figure 16.4.4).

16.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

16.9 Quality and benchmark planning

16.9.1 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. 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.

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 caught is low, and can be influenced by occasional large catches. The resulting survey index is uncertain.

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 estimated recruitment values in the final assessment year are highly uncertain. Estimates of recruitment for a given year class tend to be revised considerably with successive assessments.

16.9.2 Issues for future benchmark

16.9.2.1 Data

Stock definition

The North Sea saithe stock is influenced by migrations to and from the North Sea. This can potentially lead to the observed year effects in survey indices. It needs to be analyzed if the inclusion of spawning grounds north of 62°N could improve the assessment.

New survey indices

IMR-Norway has set-up a new hydro-acoustic survey targeting spawning aggregations in Quarter 1. Germany has also participated in this survey in recent years. The inclusion of this survey in the assessment should be evaluated once a sufficiently long time series has been developed.

Catch-per-effort index

The current commercial CPUE index is standardized for area and engine power effects. The inclusion of alternative explanatory variables (e.g. vessel effect) should be evaluated.

16.9.2.2 Assessment

Variance by age

The last inter-benchmark for saithe in 2019 revealed that uncoupling of the variance parameters for the observations by age (i.e. age 3 receiving a separate parameter) could improve the model fit statistics (e.g. log-likelihood, AIC). This should be investigated further.

16.9.2.3 Forecast

The SAM forecast assumption for recruitment is based on the median of resampled historical recruitment values from a defined number of historical years. Depending on the time-series, this may result in a bimodal distribution for the assumed recruitment in forecasted years. Forecasted numbers (and SSB) are likely be more smooth in their distribution due to forecast stochasticity, but the effect of this behaviour on advice should be investigated further. Use of a geometric mean of historical recruitment is not currently possible in SAM, but could be suggested in order to reduce this effect.

The setting of a random seed value is important for comparing between forecast scenarios. Forecast scenarios involving a prescribed F had consistent median recruitment; however, scenarios that solve for an F that results in a given stock size (e.g. $SSB_{(2021)} = B_{pa}$ or B_{lim} scenarios), which involve a further iteration process with additional random number generation, resulted in different median recruitment values. Again, these effects are likely less stark in terms of median SSB, but it may be suggested that median recruitment is generated before additional random number generation in order to improve reproducibility between scenarios.

16.10 Status of the stock

ICES assesses that fishing pressure on the stock is below F_{MSY}, F_{pa}, and F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

16.11 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 that 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.

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 and is 8% in 2018.

16.11.1 Evaluation of the management plan

Because reference points were re-estimated after the inter-benchmark, the management plan is no longer valid. New EU/Norway management strategies have been proposed and evaluated (ICES, 2019).

16.12 References

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Table 16.3.1. Saithe in subareas 4 and 6 and Division 3.a. Official nominal landings (tonnes) of saithe by nation, 2004–2018. 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***	**2018***
Belgium	22	28	15	18	7	27	15	2	2	3	5	6	16	15	14
Denmark	7991	7498	7471	5443	8068	8802	8018	6331	5171	5695	4913	4512	4084	5689	7016
Faroe Isl.	558	463	60	15	108	841	146	2	8	3	1	0	18	16	4
France	13628	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7910	11574	10794	10334	12598
Germany	9589	12401	14397	12791	14140	13410	11193	10234	8052	9690	8602	7954	6279	6629	7944
Greenland	403	1042	924	564	888	927	0	0	0	0	0	0	0	0	0
Ireland	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Lithuania	0	149	0	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	112	190	264
Norway	62783	68122	61318	45396	61464	57708	52712	46809	33288	35701	37519	35631	31596	49580	39133
Poland	0	1100	1084	1384	1407	988	654	584	0	0	0	0	0	0	0
Portugal			228	68											
Russia	0	35	2	5	5	13	0	0	0	0	0	0	0	0	0
Sweden	2249	2132	1746	1381	1639	1363	1545	1335	1306	1402	1329	1156	1198	1177	1316
UK (E/W/NI)	457	960	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	687	8888**	8561**	8573**	12415**
UK (Scotland)	5924	6170									7686				
Total reported	103608	111970	113354	91778	115414	103883	90755	89427	69241	71516	68695	69796	62658	82203	80704
Unallocated	−862	1418	−1509	824	57	2090	6012	2101	1623	−110	677	−393	-152	−633	-634
BMS landings														< 1	11
ICES estimate	102746	113388	111845	92602	115471	105973	96767	91528	70864	71406	69372	69403	62506#	81570#	80070#
TAC	190000	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696	100287ǂ	105793ǂ

*** Official values are preliminary.**
**** Scotland+E/W/NI combined.**
ǂ Includes top-up (4.1% in 2017, 12.57% in 2018)
 # Since 2016, landings correspond to wanted catch, which includes the Norwegian component of BMS landings.

Subarea 6															
Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017***	**2018***
Denmark	0	0	0	0	0	0	0	0	0	0	20	0	0	5	1
Faroe Islands	34	25	76	32	23	60	24	5	6	25	29	3	7	13	21
France	3053	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2299	3968	3626
Germany	4	373	532	580	148	298	257	0	9	0	0	0	9	< 1	<1
Ireland	95	168	267	322	288	407	520	359	364	313	128	105	185	124	231
Netherlands	0	0	3	36	1	0	0	0	0	0	0	6	12	3	70
Norway	16	20	28	377	78	68	121	240	5	715	442	677	555	631	955
Russia	6	25	7	2	50	4	2	0	0	0	9	1	0	2	0
Spain	2	3	6	3	4	8	18	31	13	21	9	15	15	4	7
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK (E/W/NI)	37	133	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	97	3286**	2770**	2641**	2684**
UK (Scotland)	1563	2922									3191				
Total reported	4810	7623	9759	7103	7717	6438	6118	7492	7558	8534	6829	7577	5852	7391	7595
Unallocated	172	−1167	−1191	−501	−1005	−144	145	−575	−9	119	191	−43	−279	−275	-841
BMS landings														0	31
ICES estimate	4982	6456	8568	6602	6712	6294	6263	6917	7549	8653	7020	7534	5573 ǂ	7116 ǂ	6754 ǂ
TAC	20000	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816	10404 ǂǂ	10215ǂǂ

*** Official values are preliminary.**

**** Scotland+E/W/NI combined.**

ǂ Does not include BMS landings.

ǂǂ Includes top-up (4.1% in 2017, 4.76% in 2018).

Subareas 4 and 6 and Division 3.a															
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
ICES estimate	107728	119844	121320	99204	122184	112267	103030	98446	78414	80059	76392	76936	68709 #	88686 #	86824 #
TAC	210000	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512	110691 ǂǂ	116008 ǂǂ

ǂǂ Agreed upon TAC including landings top-up.

 # Since 2016, landings correspond to wanted catch, which includes Norwegian component of BMS landings.

Table 16.3.2. Saithe in subareas 4 and 6 and Division 3.a. Catch data (all ages, not the sum over products for ages 3–10+ used in the assessment) 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	90.62	100
Discards	Imported data	6793	85
Discards	Raised discards	1229	15
Landings	Imported data	88604	100
Logbook registered discard	Imported data	0	0

Table 16.3.3. Saithe in subareas 4 and 6 and Division 3.a. Working Group estimates of catch components by weight (t) for ages 3–10+, as used in the assessment. Norway was under landings obligations since 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	101331	88339		12992	13
1968	134559	113741		20818	15
1969	150293	130580		19713	13
1970	270829	235012		35817	13
1971	309177	265356		43821	14
1972	296481	261914		34567	12
1973	275164	242513		32651	12
1974	337021	298347		38674	11
1975	304645	271610		33035	11
1976	423347	343898		79449	19
1977	239913	216393		23520	10
1978	176851	155124		21727	12
1979	142647	128352		14295	10
1980	145289	131897		13392	9
1981	148244	132273		15971	11
1982	202111	174336		27775	14
1983	203018	180040		22978	11
1984	240566	200843		39723	17
1985	273672	220870		52802	19
1986	232795	198605		34190	15
1987	192380	167503		24877	13
1988	154252	135176		19076	12
1989	124599	108892		15707	13
1990	124450	103831		20619	17
1991	130973	108071		22902	17
1992	115537	99745		15792	14

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
1993	132618	111499		21119	16
1994	126759	109621		17138	14
1995	141190	121795		19395	14
1996	128896	114968		13928	11
1997	120103	107348		12755	11
1998	117222	106126		11096	9
1999	119467	110531		8936	7
2000	93795	85781		8014	9
2001	102859	91741		11118	11
2002	129847	110911		18936	15
2003	121656	110282		11374	9
2004	113792	107356		6436	6
2005	121217	118625		2592	2
2006	128711	120414		8297	6
2007	106333	94958		11375	11
2008	129887	121618		8269	6
2009	114520	110972		3548	3
2010	104723	102128		2595	2
2011	102006	98034		3972	4
2012	87049	78144		8905	10
2013	87271	79859		7412	8
2014	82172	76057		6115	7
2015	81445	76748		4697	6
2016	77672	67620#	0	10052##	13
2017	94581.5	88010#	0.5	6571##	7
2018	94334	86540#	42	7752##	8

Since 2016, landings correspond to wanted catch, which includes the Norwegian component of BMS landings.

Since 2016, discards correspond to unwanted catch minus BMS landings from EU fleets officially reported in log-books.

Table 16.3.4. 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. Weight in tonnes corresponds to the catch in tonnes imported for all ages, and not to the SOP used in the assessment for ages 3–10+).

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	80946	91
Landings	Imported_Data	Estimated_Distribution	7659	9
Discards	Imported_Data	Sampled_Distribution	6727	84
Discards	Raised_Discards	Estimated_Distribution	1229	15
Discards	Imported_Data	Estimated_Distribution	65.26	1
S landing	Imported_Data	Estimated_Distribution	90.62	100

Table 16.3.5. 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

Year/Age	3	4	5	6	7	8	9	10+
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
2018	3113	15506	17865	7731	2208	1983	916	1272

Table 16.3.6. 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

Year/Age	3	4	5	6	7	8	9	10+
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	6179	5362	1876	820	1111
2018	2456	11921	15762	7361	2190	1970	914	1270

Table 16.3.7. 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

Year/Age	3	4	5	6	7	8	9	10+
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	1943	3850	978	69	2	0	0	2
2018	657	3585	2102	370	18	13	2	1

Table 16.3.8. 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

Year/Age	3	4	5	6	7	8	9	10+
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
2018	1.180	1.219	1.562	2.196	3.071	3.814	4.395	6.689

Table 16.3.9. 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

Year/Age	3	4	5	6	7	8	9	10+
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
2018	1.256	1.272	1.595	2.229	3.065	3.816	4.393	6.688

Table 16.3.10. 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

Year/Age	3	4	5	6	7	8	9	10+
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
2018	0.895	1.043	1.315	1.538	3.768	3.535	5.371	7.699

Table 16.4.1. 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.

Year	IBTS–Q3 (DATRAS standard index)						CPUE
	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	2.159
2001	21.475	6.169	3.936	0.356	0.444	0.113	2.409
2002	10.748	18.974	1.327	1.090	0.162	0.264	1.978
2003	19.272	23.802	13.402	0.393	0.439	0.168	1.843
2004	4.930	6.727	3.237	0.921	0.064	0.085	2.337
2005	8.916	7.512	4.428	1.914	1.082	0.104	2.556
2006	10.553	29.579	2.835	1.177	0.445	0.242	2.652
2007	34.006	5.578	11.700	1.016	0.743	0.358	2.206
2008	3.312	5.584	0.907	1.997	0.254	0.254	2.649
2009	1.346	1.703	0.568	0.101	0.229	0.200	2.084
2010	1.361	0.964	0.471	0.205	0.045	0.166	1.941
2011	4.520	8.451	1.059	1.114	0.426	0.080	1.922
2012	11.134	2.497	2.968	0.503	0.483	0.344	1.684
2013	14.701	16.279	1.830	1.858	0.308	0.146	1.849

Year	IBTS–Q3 (DATRAS standard index)						CPUE
	3	4	5	6	7	8	
2014	1.649	3.923	2.822	0.481	0.520	0.114	1.793
2015	11.001	5.613	4.611	1.581	0.289	0.285	2.024
2016	37.901	17.439	3.255	2.681	0.945	0.195	1.766
2017	11.447	13.102	3.068	1.267	0.942	0.473	2.018
2018	1.877	6.885	6.027	1.450	0.322	0.183	1.946

Table 16.4.2. 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 (catch, IBTSQ3 index, commercial CPUE index) and columns represent ages (-1 = not estimated):

```
 0  1  2  3  4  5  6  6
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Use correlated random walks for the fishing mortalities: (2=AR1)
2
Coupling of catchability PARAMETERS

```
-1 -1 -1 -1 -1 -1 -1 -1
 0  1  2  3  4  5 -1 -1
 6 -1 -1 -1 -1 -1 -1 -1
```

Coupling of power law model EXPONENTS (if used)

```
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Coupling of fishing mortality RW VARIANCES

```
 0  1  1  1  1  1  1  1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Coupling of log N RW VARIANCES
0 1 1 1 1 1 1 1
Coupling of OBSERVATION VARIANCES

```
 0  0  0  0  0  0  0  0
 1  1  1  1  1  1 -1 -1
 2 -1 -1 -1 -1 -1 -1 -1
```

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt)
0
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.

```
NA NA NA NA NA NA NA
NA NA NA NA NA -1 -1
NA -1 -1 -1 -1 -1 -1
```

Table 16.4.3. 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	0.263	0.383	0.357	0.355	0.314	0.283	0.318
1968	0.238	0.346	0.304	0.287	0.246	0.222	0.253
1969	0.252	0.370	0.325	0.314	0.278	0.254	0.280
1970	0.303	0.419	0.353	0.329	0.283	0.253	0.269
1971	0.370	0.467	0.376	0.345	0.307	0.284	0.299
1972	0.448	0.521	0.402	0.366	0.330	0.306	0.312
1973	0.530	0.573	0.425	0.377	0.343	0.318	0.318
1974	0.645	0.663	0.491	0.432	0.395	0.362	0.349
1975	0.662	0.693	0.531	0.472	0.440	0.408	0.384
1976	0.757	0.775	0.605	0.528	0.483	0.442	0.405
1977	0.632	0.709	0.595	0.540	0.510	0.474	0.428
1978	0.507	0.586	0.491	0.439	0.417	0.389	0.354
1979	0.422	0.521	0.459	0.423	0.412	0.384	0.346
1980	0.405	0.518	0.478	0.455	0.452	0.428	0.389
1981	0.361	0.493	0.470	0.461	0.470	0.460	0.422
1982	0.430	0.581	0.552	0.523	0.513	0.486	0.439
1983	0.510	0.697	0.672	0.629	0.603	0.560	0.495
1984	0.591	0.795	0.727	0.629	0.562	0.504	0.442
1985	0.634	0.878	0.775	0.623	0.537	0.480	0.434
1986	0.587	0.904	0.824	0.651	0.561	0.509	0.478
1987	0.535	0.849	0.797	0.629	0.549	0.508	0.493
1988	0.523	0.832	0.805	0.644	0.564	0.521	0.508
1989	0.516	0.815	0.785	0.627	0.535	0.481	0.466
1990	0.505	0.790	0.753	0.590	0.498	0.435	0.422
1991	0.469	0.751	0.723	0.563	0.476	0.413	0.409
1992	0.414	0.700	0.701	0.560	0.481	0.415	0.415
1993	0.390	0.682	0.711	0.602	0.562	0.501	0.509
1994	0.321	0.601	0.633	0.540	0.517	0.469	0.487
1995	0.273	0.554	0.620	0.560	0.573	0.541	0.563
1996	0.216	0.466	0.548	0.511	0.518	0.496	0.514
1997	0.183	0.404	0.477	0.447	0.444	0.431	0.449
1998	0.183	0.401	0.483	0.459	0.444	0.435	0.450
1999	0.176	0.400	0.503	0.499	0.483	0.484	0.500
2000	0.149	0.348	0.437	0.433	0.401	0.395	0.411
2001	0.146	0.337	0.414	0.405	0.361	0.349	0.360
2002	0.152	0.349	0.439	0.459	0.413	0.401	0.422
2003	0.160	0.353	0.435	0.481	0.444	0.431	0.458
2004	0.134	0.308	0.371	0.414	0.384	0.376	0.394
2005	0.132	0.309	0.374	0.414	0.379	0.364	0.367

Year/Age	3	4	5	6	7	8	9+
2006	0.150	0.337	0.393	0.422	0.383	0.362	0.354
2007	0.144	0.335	0.386	0.400	0.357	0.331	0.315
2008	0.152	0.374	0.446	0.456	0.407	0.381	0.357
2009	0.151	0.383	0.468	0.479	0.425	0.397	0.361
2010	0.138	0.366	0.458	0.468	0.423	0.401	0.361
2011	0.145	0.380	0.468	0.465	0.414	0.397	0.357
2012	0.125	0.352	0.440	0.440	0.389	0.374	0.337
2013	0.103	0.314	0.400	0.410	0.364	0.353	0.317
2014	0.089	0.285	0.378	0.394	0.349	0.338	0.306
2015	0.086	0.277	0.376	0.392	0.343	0.333	0.304
2016	0.077	0.264	0.365	0.387	0.345	0.340	0.313
2017	0.076	0.265	0.375	0.412	0.368	0.358	0.328
2018	0.078	0.270	0.379	0.415	0.367	0.356	0.327

Table 16.4.4. 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	141494	81481	57131	7131	4892	1146	744	681
1968	160626	92197	50317	31681	3710	2521	655	773
1969	285536	90478	54373	30934	20390	2821	1946	815
1970	293885	216636	49129	35291	18594	11654	1790	1617
1971	355289	191686	119203	24628	19377	11886	7787	2490
1972	223760	209584	103071	67403	14508	11350	7277	6457
1973	200829	111136	105428	63395	35802	8684	6326	8566
1974	199146	90275	48322	62833	42039	20559	5401	8518
1975	234629	76259	35408	24266	36225	25141	11993	8491
1976	406509	102400	29612	17413	12900	19121	13271	11595
1977	149305	148182	35603	12431	8676	7199	10752	14002
1978	120267	72278	58126	14227	5109	4003	3389	13147
1979	87312	53699	34718	29242	7776	2802	2203	9531
1980	85442	46938	25650	18673	16021	4010	1657	7662
1981	163244	41842	24890	12264	9589	8225	2119	5865
1982	140924	108598	23011	15057	6257	4787	3730	4044
1983	148454	69606	55018	11349	8257	3120	2505	3794
1984	255728	76322	30089	23898	4726	3467	1325	2777
1985	356651	108321	29498	12791	9463	2220	1589	2298
1986	290211	141919	32165	11771	6370	4481	1193	2261
1987	148978	164309	36253	10170	5141	3291	2287	1797
1988	138223	71546	61486	11394	4548	2595	1740	1924
1989	102269	69598	27708	21776	4705	2091	1242	1642

Year/Age	3	4	5	6	7	8	9	10+
1990	150675	47956	25750	11121	8376	2308	1026	1400
1991	175072	71075	17325	10286	5258	3795	1236	1384
1992	103616	89129	25736	6764	5225	2854	2055	1471
1993	175855	58579	34157	9100	2877	3177	1796	2232
1994	118210	96719	28345	13419	3394	1407	1472	2111
1995	213155	66024	42178	12913	6332	1570	908	1877
1996	118789	147986	29628	19499	6966	2440	681	1289
1997	149544	79273	90359	13117	9079	3411	1077	919
1998	87766	120365	45666	49183	7148	4531	1824	980
1999	116546	55371	73045	22753	26817	4193	2299	1519
2000	101190	97424	29195	37024	11137	12780	1952	1620
2001	206864	69233	65578	14289	17831	6325	6853	1509
2002	152635	142505	35455	34396	8330	9551	3822	4823
2003	158359	115758	82780	16545	16930	5368	5171	4810
2004	115926	104533	71299	47546	7915	8167	3275	4517
2005	146568	75397	65057	48319	27650	4937	4461	4242
2006	101835	127182	42249	36623	26878	14297	3069	4827
2007	157857	55619	80241	24571	19795	15301	7373	4434
2008	74781	100926	31919	50241	15505	11264	10427	8517
2009	57946	52572	45512	15148	26143	9594	6090	11009
2010	90504	37848	28228	20816	7364	13664	5726	10354
2011	81377	79598	22310	14195	10264	3771	6878	10753
2012	131577	46719	47960	11876	7388	5023	2071	9945
2013	92659	98723	22903	25978	6755	4004	2705	6892
2014	57989	69111	52548	12805	14085	4038	2102	5639
2015	97033	43574	46105	27315	7435	7293	2596	4616
2016	119787	66784	28327	24795	13203	4730	3917	4564
2017	83040	92815	38812	16817	14850	7282	2916	4849
2018	45672	66148	59663	22813	8731	7866	3952	4685

Table 16.5.1. 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 (F4–7), 1967–2018. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1967	141494	101082	198062	152179	120855	191621	0.352	0.276	0.450	412545	339101	501895
1968	160626	116566	221340	210140	169339	260771	0.296	0.233	0.377	578630	478685	699442
1969	285536	207066	393742	276167	225333	338468	0.322	0.259	0.399	711614	591863	855593
1970	293885	214420	402801	345470	286401	416722	0.346	0.282	0.425	910445	764858	1083744
1971	355289	261706	482335	460888	383072	554512	0.374	0.307	0.455	1056225	896699	1244132
1972	223760	165950	301708	489956	409772	585832	0.405	0.334	0.490	959130	822334	1118682
1973	200829	149071	270557	522340	436902	624484	0.430	0.357	0.517	894293	772573	1035191
1974	199146	147614	268668	577409	485262	687054	0.495	0.416	0.590	925721	804373	1065376
1975	234629	174799	314939	517619	434064	617259	0.534	0.450	0.634	857185	745039	986212
1976	406509	297875	554761	399536	333103	479219	0.598	0.503	0.711	813917	699084	947613
1977	149305	110455	201820	325613	271051	391157	0.589	0.489	0.708	612697	527839	711197
1978	120267	89239	162085	297541	246753	358782	0.484	0.404	0.579	520199	447769	604346
1979	87312	64545	118110	278406	233484	331971	0.454	0.378	0.544	482702	417453	558151
1980	85442	63160	115585	260341	220005	308074	0.475	0.399	0.566	438642	381193	504749
1981	163244	119776	222487	248847	211327	293028	0.473	0.396	0.565	492019	425205	569332
1982	140924	104600	189861	219732	189090	255341	0.542	0.461	0.638	530663	457485	615547
1983	148454	110112	200146	219760	188580	256096	0.650	0.553	0.764	508802	440731	587386
1984	255728	189223	345608	188629	162563	218875	0.678	0.580	0.792	516543	443923	601043
1985	356651	261261	486871	165846	143635	191491	0.703	0.603	0.821	528555	446961	625044
1986	290211	214876	391958	156491	135784	180356	0.735	0.624	0.866	491849	419480	576705
1987	148978	110405	201026	165328	143427	190573	0.706	0.604	0.825	404107	349142	467726
1988	138223	102799	185852	154642	132752	180143	0.711	0.609	0.832	349021	303078	401930
1989	102269	75961	137687	126330	108837	146635	0.691	0.590	0.809	292623	254052	337049
1990	150675	111710	203232	114429	98374	133104	0.658	0.561	0.771	301264	258644	350907

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1991	175072	130244	235328	107236	92695	124057	0.628	0.536	0.737	320604	273470	375861
1992	103616	77498	138535	112743	98009	129693	0.610	0.518	0.719	309899	266322	360607
1993	175855	131145	235807	119462	103043	138496	0.639	0.541	0.756	355130	303011	416214
1994	118210	88400	158072	123897	107047	143399	0.573	0.486	0.676	338056	289903	394208
1995	213155	157310	288825	143022	122926	166404	0.577	0.485	0.685	448988	378800	532181
1996	118789	87819	160681	154300	132920	179119	0.511	0.429	0.608	429939	365008	506419
1997	149544	109820	203637	192734	162971	227932	0.443	0.370	0.530	446762	381365	523373
1998	87766	64576	119285	190223	161867	223546	0.447	0.375	0.532	393673	339273	456796
1999	116546	85642	158601	199093	169351	234058	0.471	0.393	0.564	383414	332215	442503
2000	101190	74608	137244	191818	164679	223430	0.405	0.337	0.486	404937	351316	466742
2001	206864	152904	279866	199131	170473	232606	0.379	0.314	0.458	453786	391409	526105
2002	152635	112475	207133	220406	189607	256208	0.415	0.346	0.498	483538	416174	561806
2003	158359	116381	215478	208324	178165	243589	0.428	0.356	0.515	431140	372271	499318
2004	115926	85993	156279	261048	222818	305836	0.369	0.305	0.447	487469	423422	561205
2005	146568	107909	199075	255341	218652	298187	0.369	0.307	0.444	475009	413930	545100
2006	101835	73842	140440	273112	233550	319375	0.384	0.319	0.461	503276	439285	576589
2007	157857	114758	217143	254900	216950	299487	0.369	0.307	0.445	471003	409231	542100
2008	74781	55339	101054	260792	221428	307154	0.421	0.352	0.504	446542	388115	513764
2009	57946	42957	78165	258473	218460	305816	0.439	0.365	0.527	407859	354652	469048
2010	90504	66952	122342	240921	201556	287975	0.429	0.357	0.514	408837	354111	472020
2011	81377	59662	110994	190672	159208	228353	0.432	0.360	0.518	365080	315680	422211
2012	131577	97589	177402	171139	143650	203888	0.405	0.337	0.488	367048	315879	426506
2013	92659	68523	125298	175410	147594	208467	0.372	0.308	0.449	367650	317494	425730
2014	57989	42407	79296	197237	166740	233313	0.352	0.290	0.426	365189	316250	421702
2015	97033	70590	133381	203685	172413	240629	0.347	0.286	0.422	376034	325025	435049
2016	119787	85281	168254	191273	161174	226994	0.340	0.277	0.417	395714	337424	464075

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
2017	83040	55564	124105	217740	183226	258756	0.355	0.283	0.446	419861	353894	498124
2018	45672	25938	80422	223515	183899	271665	0.358	0.272	0.471	383325	309550	474682

Table 16.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2019)	0.36	Average exploitation pattern (2016-2018) scaled to F_{4-7} in 2018
SSB (2020)	217 356	SSB at the beginning of the TAC year, in tonnes
$R_{age\ 3}$ (2019, 2020)	83 040	Median recruitment re-sampled from the years 2009-2018, in thousands
Total catch (2019)	88 709	Short-term forecast, in tonnes
Wanted catch (2019)	81 897	Assuming average of 2016-2018 wanted catch fraction by age, in tonnes
Unwanted catch (2019)	6 812	Assuming average of 2016-2018 unwanted catch fraction by age, in tonnes

Table 16.7.2. 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 $B_{trigger}$	149 098 t	B_{pa}	ICES (2019a)
	F_{MSY}	0.363	EQsim analysis based on the recruitment period 1998–2017.	ICES (2019a)
Precautionary approach	B_{lim}	107 297 t	B_{loss}	ICES (2019a)
	B_{pa}	149 098 t	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2019a)
	F_{lim}	0.620	EQsim analysis based on the recruitment period 1998–2017.	ICES (2019a)
	F_{pa}	0.446	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	ICES (2019a)
Management plan*	MAP MSY $B_{trigger}$	149 098 t	MSY $B_{trigger}$	ICES (2019a)
	MAP B_{lim}	107 297 t	B_{lim}	ICES (2019a)
	MAP F_{MSY}	0.363	F_{MSY}	ICES (2019a)
	MAP range F_{lower}	0.210	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019a)
	MAP range F_{upper}	0.536	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019a)

Table 16.7.3a. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	Wanted catch*# 3a4	Wanted catch*# 6	F_{total} (ages 4-7) (2020)	F_{wanted} (ages 4-7) (2020)	$F_{unwanted}$ (ages 4-7) (2020)	SSB (2021)	% SSB change **	% TAC change ***	% advice change ^
ICES advice basis												
MSY approach: F_{MSY}	88093	80676	7417	73092	7584	0.36	0.33	0.032	213159	-1.93	-14.7	-14.7
Other scenarios												
F = MAP^^ $F_{MSY\ lower}$	54430	49936	4494	45242	4694	0.21	0.191	0.0190	245209	12.8	-47	-47
F = MAP^^ $F_{MSY\ upper}$	121041	110641	10400	100241	10400	0.54	0.49	0.048	182110	-16.2	17.1	17.1
F = 0	0	0	0	0	0	0.00	0.00	0.00	298215	37	-100	-100
F_{pa}	104446	95642	8804	86652	8990	0.45	0.41	0.040	197699	-9.0	1.08	1.08
F_{lim}	135413	123673	11740	112048	11625	0.62	0.56	0.055	168963	-22	31	31
$SSB_{2021} = B_{lim}$	203255	184872	18383	167494	17378	1.13	1.03	0.100	107297	-51	97	97
$SSB_{2021} = B_{pa}$	157456	143563	13893	130068	13495	0.76	0.70	0.068	149098	-31	52	52
SSB_{2021} = MSY $B_{trigger}$	157456	143563	13893	130068	13495	0.76	0.70	0.068	149098	-31	52	52
$F = F_{2019}$	86995	79683	7312	72193	7490	0.36	0.33	0.032	214145	-1.48	-15.8	-15.8
TAC_{2019}	103328	94616	8712	85722	8894	0.44	0.40	0.039	198740	-8.6	0	0
TAC_{2019} -15%	87828	80436	7392	72875	7561	0.36	0.33	0.032	213398	-1.82	-15.0	-15.0
TAC_{2019} +15%	118826	108650	10176	98437	10213	0.52	0.48	0.047	184174	-15.3	15.0	15.0
TAC_{2019} -20%	82662	75723	6939	68605	7118	0.34	0.31	0.030	218216	0.40	-20.0	-20.0
TAC_{2019} +25%	129159	117952	11207	106865	11087	0.58	0.53	0.052	174816	-19.6	25	25

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation.**

**** SSB2021 relative to SSB2020.**

***** Total catch in 2020 relative to the TAC in 2019 (103 327 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 2020 relative to the advice value 2019 (103 327 t).

^^ EU multiannual plan (MAP) for the North Sea (EU, 2016).

Table 16.7.3b. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios related to management strategies evaluated following an EU-Norway request (ICES, 2019). All weights are in tonnes.

Basis	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	Wanted catch*# 3a4	Wanted catch*# 6	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	% SSB change **	% TAC change ***	% advice change ^
A*	88093	80676	7417	73092	7584	0.36	0.33	0.032	213159	-1.93	-14.7	-14.7
A	75691	69382	6309	62860	6522	0.30	0.28	0.027	224935	3.5	-27	-27
B	93525	85623	7902	77574	8049	0.39	0.36	0.035	207816	-4.4	-9.5	-9.5
C	75691	69382	6309	62860	6522	0.30	0.28	0.027	224935	3.5	-27	-27
A+D	97462	89234	8228	80846	8388	0.41	0.37	0.036	204001	-6.1	-5.7	-5.7
B+E	92610	84785	7825	76815	7970	0.38	0.35	0.034	208743	-4.0	-10.4	-10.4
C+E	83358	76352	7006	69175	7177	0.34	0.31	0.030	217548	0.088	-19.3	-19.3
A+D_1	83358	76352	7006	69175	7177	0.34	0.31	0.030	217548	0.088	-19.3	-19.3
A*+D	88093	80676	7417	73092	7584	0.36	0.33	0.032	213159	-1.93	-14.7	-14.7

For footnotes, see Table 16.7.3a.

Management Strategies (ICES 2019)

A*: F_{target} = 0.363, $B_{trigger}$ = 149 098 t, no constraints on TAC variation
A: F_{target} = 0.35, $B_{trigger}$ = 250 000 t, no constraints on TAC variation
B: F_{target} = 0.39, $B_{trigger}$ = 200 000 t, no constraints on TAC variation
C: F_{target} = 0.35, $B_{trigger}$ = 250 000 t, no constraints on TAC variation
A+D: F_{target} = 0.41, $B_{trigger}$ = 210 000 t, constraints on TAC variation of +25% and 20%, where SSB at the start of the TAC year is above $B_{trigger}$
B+E: F_{target} = 0.39, $B_{trigger}$ = 220 000 t, constraints on TAC variation of +25% and 20%, where SSB at the start of the TAC year is above $B_{trigger}$
C+E: F_{target} = 0.36, $B_{trigger}$ = 230 000 t, constraints on TAC variation of +25% and 20%, where SSB at the start of the TAC year is above $B_{trigger}$
A+D1: F_{target} = 0.36, $B_{trigger}$ = 230 000 t, constraints on TAC variation of +15% and 15%, where SSB at the start of the TAC year is above $B_{trigger}$
A*+D: F_{target} = F_{MSY} = 0.363, $B_{trigger}$ = MSY $B_{trigger}$ = 149 098 t, constraints on TAC variation of +25% and 20%, where SSB at the start of the TAC year is above $B_{trigger}$
Note that A, B and C differ by the extent of reduction below B_{lim}; furthermore, stability elements D and E differ by the combination of constraints on interannual TAC variations and banking and borrowing scenarios (ICES, 2019).

Table 16.7.4. Saithe in subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2020.

Year class	Contribution to landings (%)
2017	5.2
2016	17.5
2015	12.4
2014	19.8
2013	19.2
2012	9.6
2011	4.1

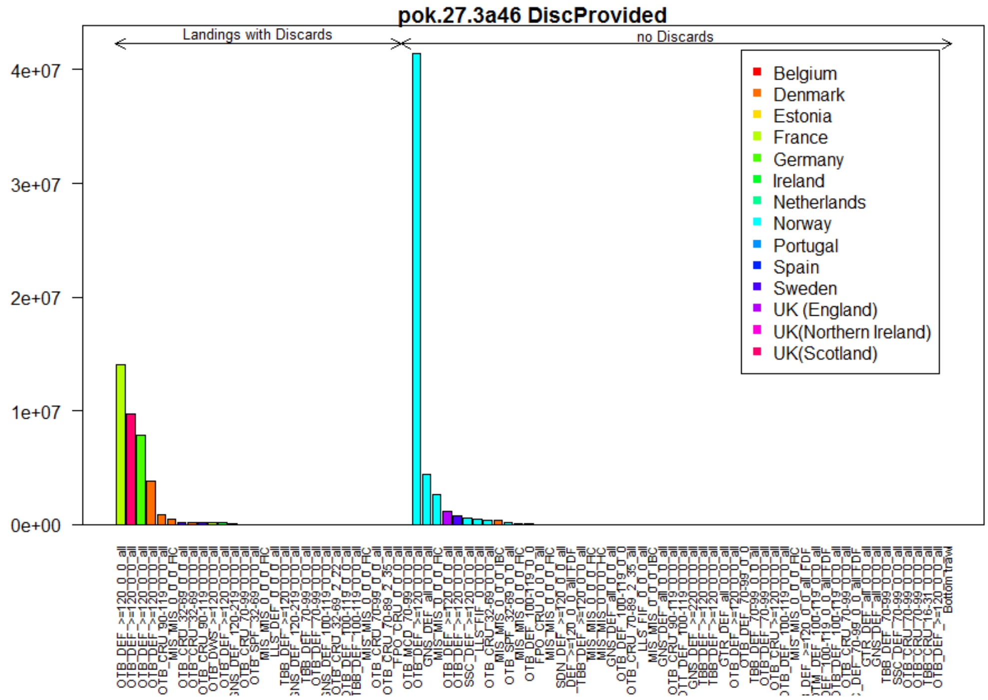

Figure 16.3.1. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier for 2018.

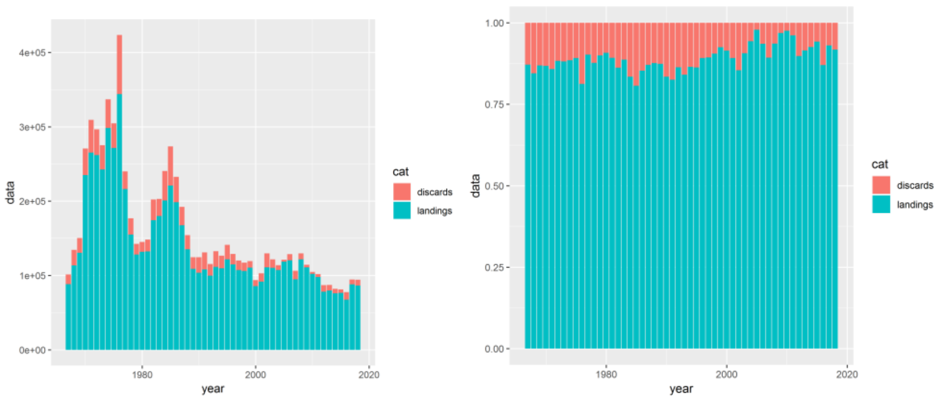

Figure 16.3.2. Saithe in subareas 4 and 6 and Division 3.a: Yield as stacked plot for landings and discards in tonnes (left panel) and as percent (right panel). Landings include BMS landings from Norway since 2016. Discards correspond to unwanted catch (discards + EU BMS) since 2016.

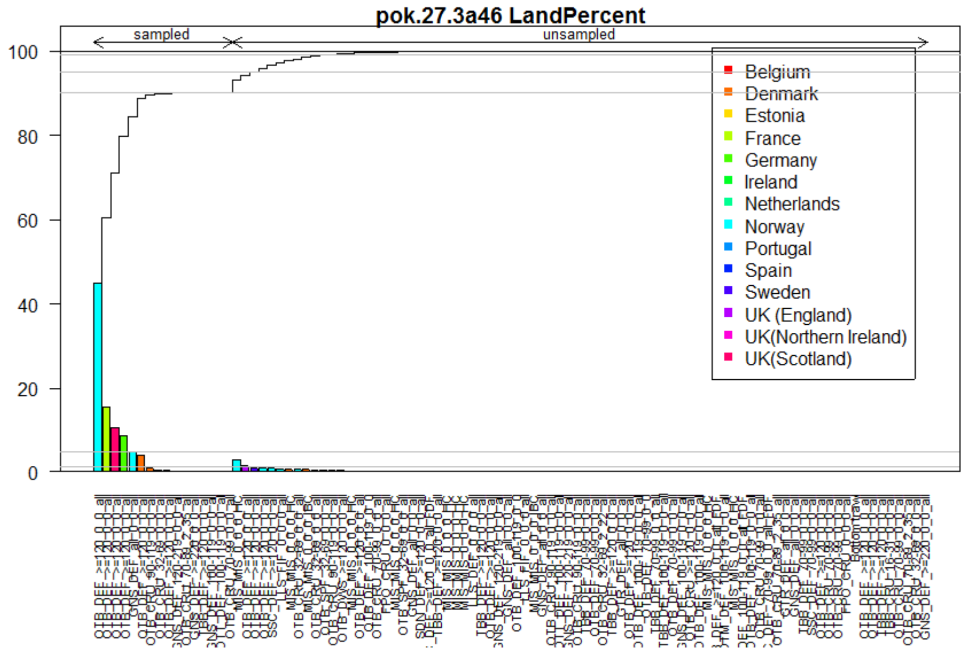

Figure 16.3.3. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier for 2018.

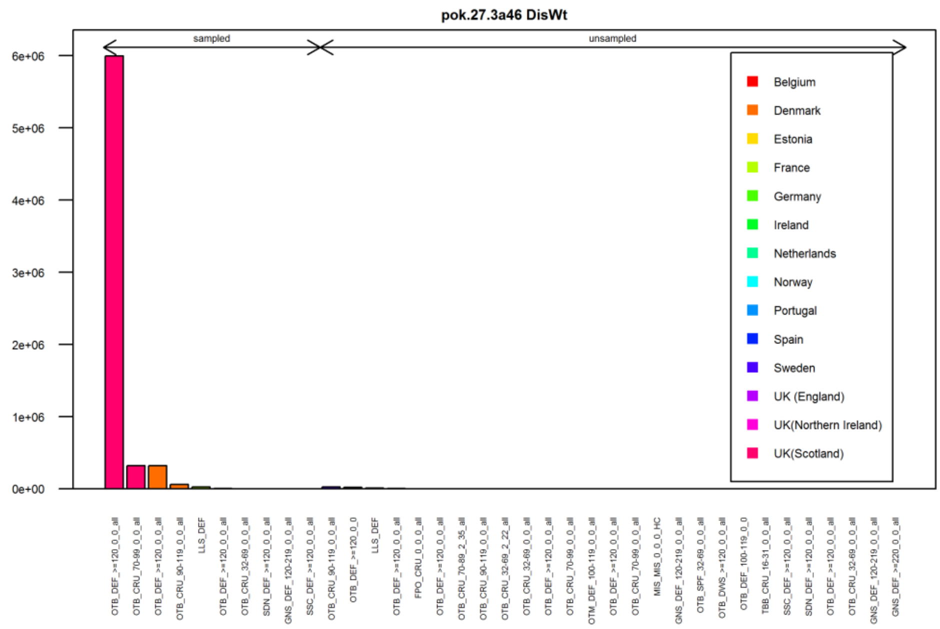

Figure 16.3.4. Saithe in subareas 4 and 6 and Division 3.a: Overview of age sampled and unsampled imported discards by country and métier for 2018.

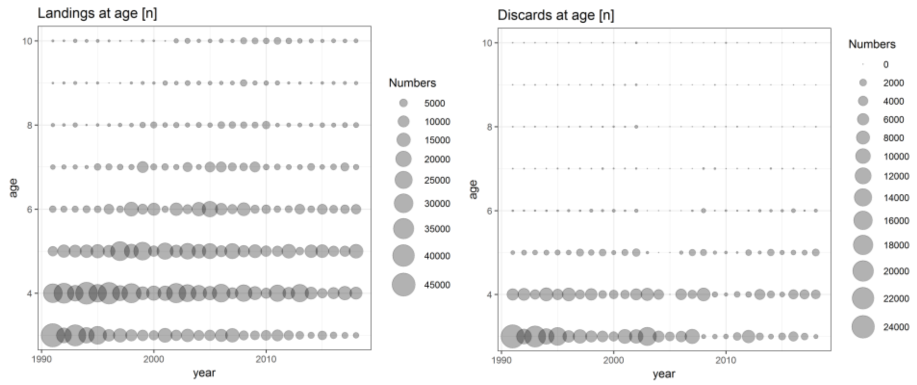

Figure 16.3.5. Saithe in subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2018. (Right) Discard numbers at age for saithe ages 3–10+, 1990–2018.

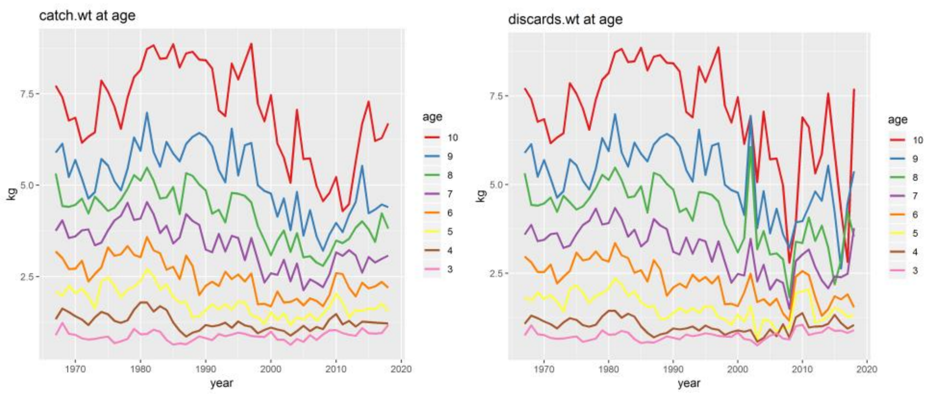

Figure 16.3.6. Saithe in subareas 4 and 6 and Division 3.a. Catch weight-at-age (kg) for saithe ages 3–10+, 1967–2018 (left panel). Catch weight-at-age are also stock weight-at-age in the assessment. Discard weights-at-age (kg) for saithe ages 3–10+, 1967–2017 (right panel).

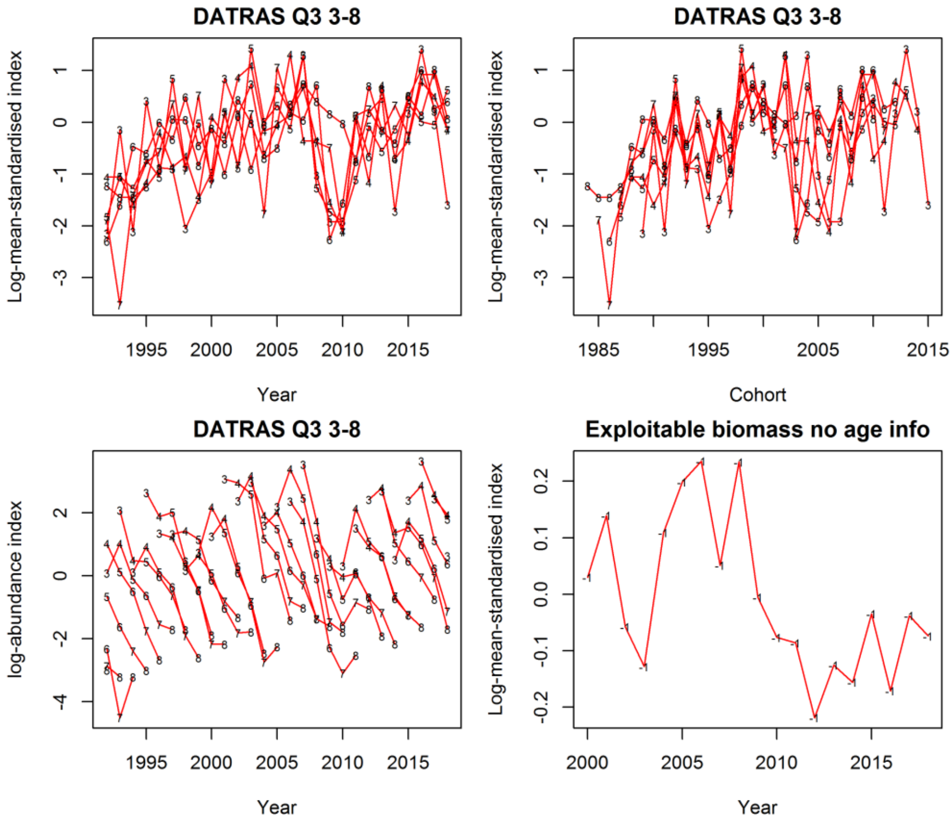

Figure 16.4.1. Saithe in subareas 4 and 6 and Division 3.a: Research survey index, IBTS–Q3, for ages 3 to 8, 1992–2018 is shown in terms of indices by age and year (top-left panel), indices by age and cohort (top-right panel), and log-catch curves by cohort (bottom-left panel). Commercial catch-per-unit-effort (CPUE) is shown in the bottom-right panel.

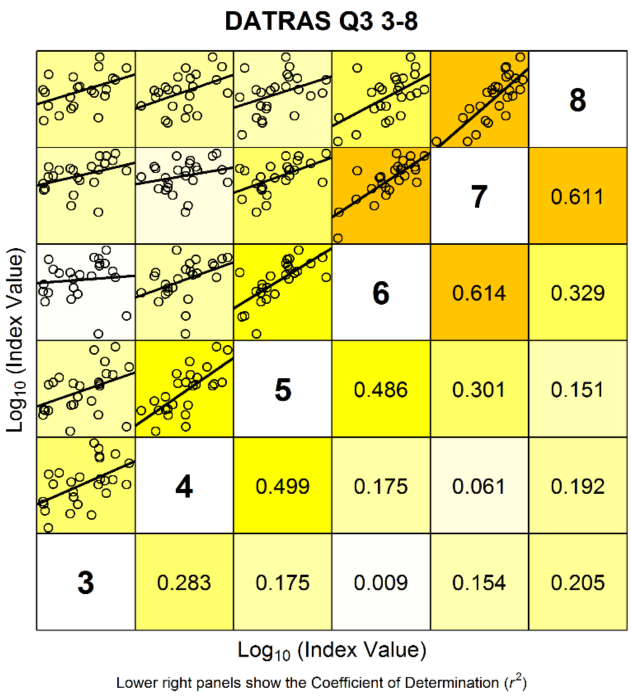

Figure 16.4.2. Saithe in subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2018 ages 3 to 8.

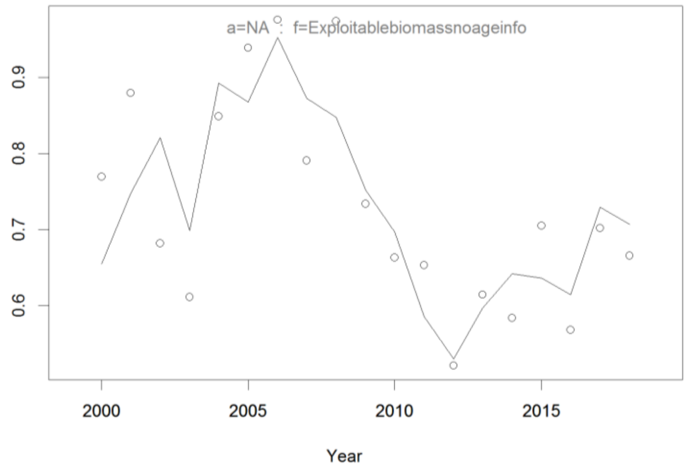

Figure 16.4.3. Saithe in subareas 4 and 6 and Division 3.a. Standardized combined CPUE index (year effects, open circles) and fit of model after tuning to the exploitable biomass, 2000–2018.

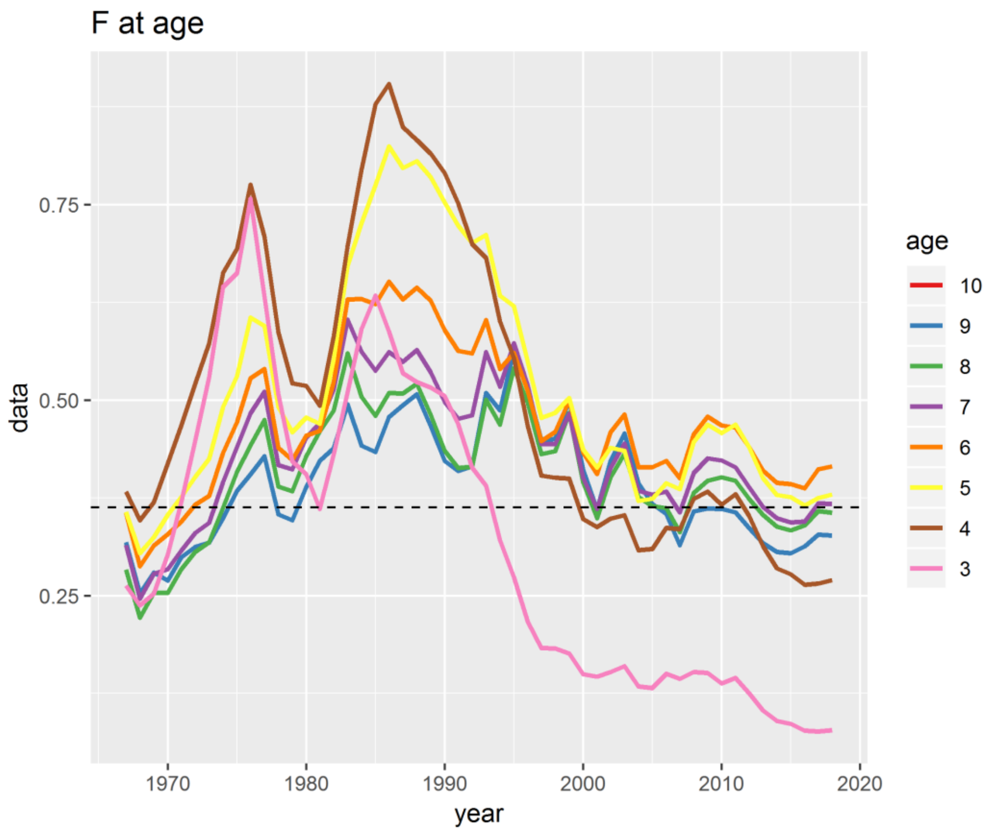

Figure 16.4.4. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortality at age for the final assessment model.

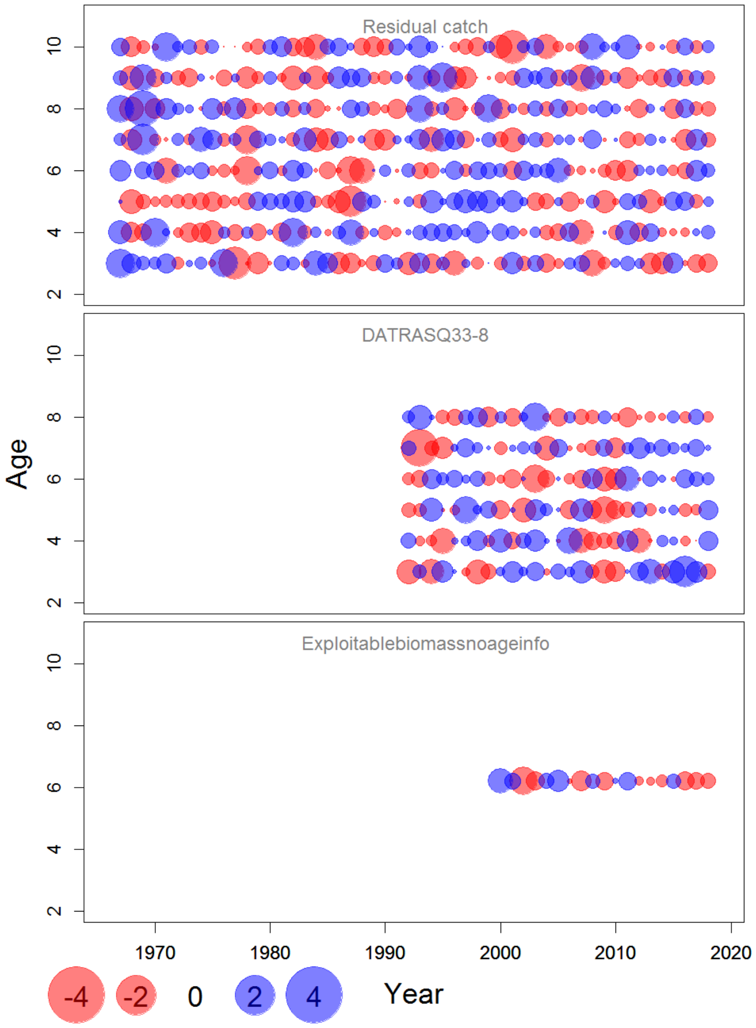

Figure 16.4.5. Saithe in subareas 4 and 6 and Division 3.a. Residual patterns for the final SAM model.

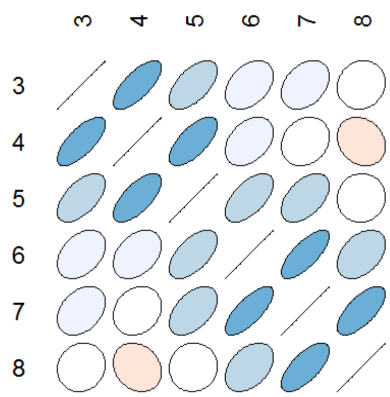

Figure 16.4.6. Saithe in subareas 4 and 6 and Division 3.a. Correlation between age classes within years for IBTS Q3 (ages 3–8). The darker the blue colour, the stronger the correlation.

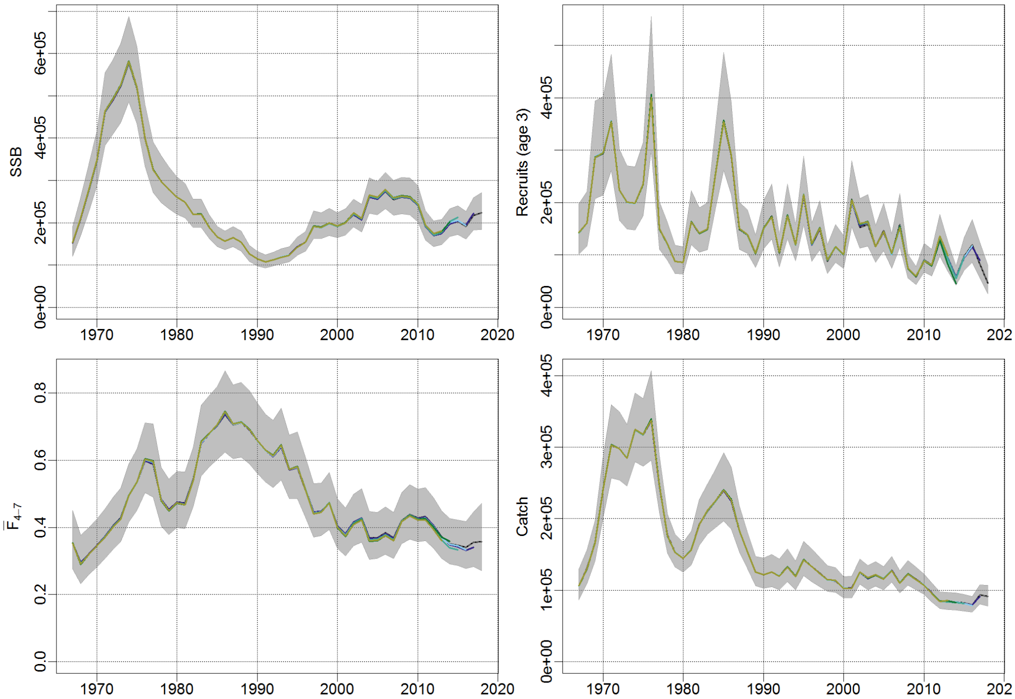

Figure 16.4.7. Saithe in subareas 4 and 6 and Division 3.a. Five year retrospective pattern in SSB, F_{4-7}, recruitment, and catches for the final assessment.

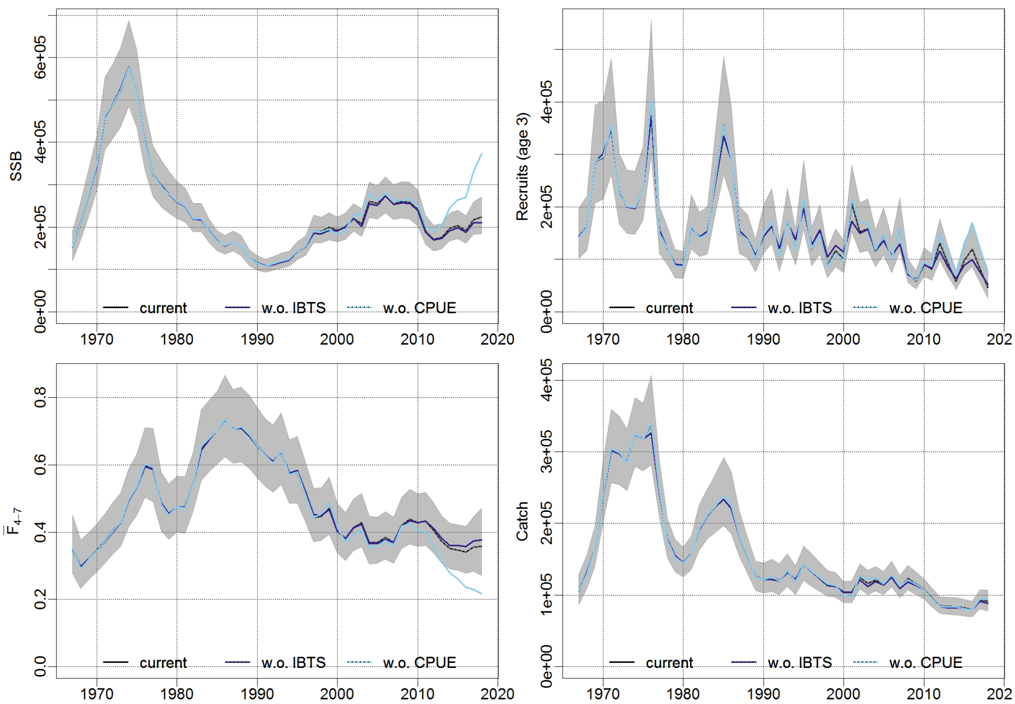

Figure 16.4.8. Saithe in subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, recruitment, and catches for the final assessment model. Black lines and grey-shaded confidence interval indicates the final assessment model, including the IBTS Q3 indices for ages 3–8 and the CPUE index. The cyan line is the assessment with only the IBTS Q3 tuning series, while the blue line is the assessment with only the CPUE index.

Figure 16.5.1. 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.

17 Sole (*Solea solea*) in Subarea 27.4 (North Sea)

The assessment of sole in Subarea 27.4 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 Stock Annex. Only a concise description of the methods are presented within this Section of the report. In 2019, there were no deviations from the Stock Annex.

17.1 General

17.1.1 Stock structure and definition

See Stock Annex.

17.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in Bergen (2019). All available information on ecological aspects can be found in the Stock Annex.

17.1.3 Fisheries

Many vessels in the beam trawl fleet, that is mainly targeting sole in the North Sea, have transitioned to using electrical pulse gears. 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.

The catch composition of these “advanced” gears are found to be different from the traditional beam trawl (ICES, 2018). The impact of this gear transition on the North Sea ecosystem has been evaluated by ICES (ICES, 2018). ICES recommends that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls are undertaken.

In 2019 the European Parliament decided to ban pulse fisheries in European waters. This ban on pulse fishing implies that ultimately only 5% of the fleet of each member state can continue its fishing activities with the pulse trawl until 1 July 2021, after which a total ban will apply. In this context, research into the effects of the pulse trawl on commercial stocks and wider ecosystem effects will continue.

17.2 Current ICES Advice

The information in this section is taken from the ICES Advice sheet (ICES, 2018) for catch advice in setting the TAC of 2019.

17.2.1 ICES advice on fishing opportunities

ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catch in 2019 that correspond to the F ranges in the MAP are between 7451 tonnes and 21 644 tonnes. According to the MAP, catch higher than those corresponding to F_{MSY} (12 801 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

17.2.2 Quality of the assessment

There has been a downward revision of the SSB in the latest assessment, however this revision is within the uncertainty bound of the assessment. In 2017 the fishery exploitation pattern has shifted towards targeting younger fish than in previous years. The forecast assumes an average exploitation pattern over the last three years, which may render the forecast marginally optimistic. This potential change in exploitation pattern will have to be confirmed next year to understand whether this represents a real change in targeting.

17.2.3 Issues relevant for the advice

Sole in Subarea 27.4 falls under the EU MAP for the North Sea. Ices was requested to provide advice based on the EU MAP.

Between 2014 and 2017 the use of pulse trawls in the main fishery operating in the North Sea has increased and less vessels are operating with traditional beam trawls. The pulse gear allows fishing of softer grounds and as a result the spatial distribution of the main fisheries has changed to the southern part of the Division 4.c. As a consequence a larger proportion of the sole catch is now taken in this area (ICES, 2018).

BMS landings of sole reported to ICES are currently much lower than the estimates of catch below the minimum conservation reference size (MCRS), 9.2% of the total catch from observer programmes.

17.3 Data available

17.3.1 Catch

For 2018, the official (reported to FAO) catch and TACs by country are presented next to the catch (landings and discards) submitted to InterCatch in Figure 17.3.1. A time-series of the official landings by country and overall total, the official BMS landings, the landings reported to ICES and the total TAC are presented in Table 17.3.1.

The TAC in 2018 was 12 555 tonnes. The preliminary catch statistics reported to FAO amounted to 10 828 tonnes (10 771 tonnes of commercial landings and 57 tonnes of below minimum size (BMS) landings). Catch (landings, discards, BMS landings, and logbook registered discards) reported to ICES were 12 255 tonnes in 2018. Some countries (e.g. the Netherlands and Belgium) reported a significant undershoot of their TAC in 2018.

Catch (landings and discards) in numbers by age and in total weights that are input for the assessment are presented in Table 17.3.2 and Table 17.3.3.

17.3.2 Catch data submitted to InterCatch

Catch data is submitted to InterCatch according to the ICES data call.

Age distributions from national catch sampling schemes were provided for 85% of the landings in 2018.

Discards estimates for 2018 were available for 85% of the landings. This implies that 15% of the discards were raised in InterCatch. Age distributions from national catch sampling schemes were provided for 90% of the discards in 2018.

Strata for logbook registered discards and BMS landings were provided in InterCatch but the total caton was 0 in 2018.

17.3.3 Discard raising in InterCatch

InInterCatch, the first step is to raise discard volumes for stratas (metiers) with landings without any associated discards.

Strata of metiers for which only yearly discard estimates have been imported are grouped with the same metiers with quarterly landings estimates. Then, discards were raised by grouping metiers with small meshes (16–99) apart from metiers with larger mesh sizes (100–120+, and by grouping passive gears (GNS, GTR, FPO) apart from active gears targeting sole (TBB), and active gears that do not target sole (OTB, SSC). All MIS (miscellaneous) gears were then raised with all available discard estimates.

17.3.4 Age allocation in InterCatch

The age information of sampled strata is used to allocate ages to unsampled strata in InterCatch.

For metiers where no age information was available, age compositions were allocated using the automatic allocations scheme in InterCatch.

17.3.5 InterCatch export of catch estimates

For the assessment, landings and discards are exported separately. The SOP for the export of catch, landings and discards is 0.99.

17.4 Landings

Total landings reported to ICES (InterCatch) for sole in Subarea 27.4 in 2018 was 11 199 tonnes. The landings decreased by 9.5% (compared to 2017). A time-series of total landings (in tonnes) are presented in Table 17.3.1 and Figure 17.4.1. Landings numbers at age are presented in Table 17.3.2 and Figure 17.4.2. Official reported landings (FAO) were 10 771 tonnes in 2018.

Since 2016, small mesh beamtrawlers (BT2) with discard rates around 10% are required to report BMS landings in Subarea 27.4. The official reported BMS landings (FAO) were 57 tonnes. For the assessment, BMS landings are considered to be below minimum landings size and thus treated as discards.

17.5 Discards

Discards numbers at age are presented in Table 17.3.3. Figure 17.4.1 presents a time-series of total landings, catch and discards reported to ICES (InterCatch). Discards at age are presented in Figure 17.4.3.

17.6 Catch

Since 2018 the majority of fleets catching (and targeting) sole are under the Landing obligation in Subarea 27.4. The advice is now presented as a catch advice (included wanted and unwanted catch) and the TAC amounts to the advised catch (minus volumes of catch exempted under de minimis exemptions and exemptions based on high survival).

In 2018, only 86% and 98% of the TAC was caught according to official reported catch (commercial landings and BMS landings) (FAO) and catch (landings and discards) reported to ICES (InterCatch) respectively.

17.7 Weight-at-age

Weights at age in the landings of sole in Subarea 27.4 (Table 17.7.1) come from the "weca" file of the InterCatch landings export. These are measured weights from the various national catch and market sampling programmes.

Discard weights at age (Table 17.7.2) are derived from the various national catch and discard programmes (observer and self-sampling). Discards weights at age come from the "weca" file of the InterCatch discards export.

The discards weights per age before 2006 are the average discards weights per age of 2006–2013. At the benchmark in 2015 discards were included in the assessment and subsequently the discard weights at age for years with no discard data (before 2006) are calculated as the average over 2006–2013.

Mean stock weights at age (Table 17.7.3.) are the average weights from the 2nd quarter landings and discards and are derived from the "Catch and Sample Data Table" file from InterCatch.

The mean stock weights of younger ages after 2006 are still slightly lower than the stock weights of younger ages before 2006. This is because the weights at age after 2012 are based on landings and discards weights and the weights at age before 2012 are only based on landings. During the benchmark in 2015 discards were included in the assessment and catch data was raised in InterCatch starting from data year 2006.

17.8 Maturity and natural mortality

A knife-edged maturity-ogive with full maturation at age 3 is assumed for sole in Subarea 27.4 (Table 17.8.1). No new data was presented at the working group in 2018.

Natural mortality at age (Table 17.8.1) 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). The estimate of 0.9 was based on an analysis of the CPUE in the fisheries targeting sole before and after the severe winter (ICES FWG, 1979).

17.9 Catch, effort and survey data

Two tuning series that take place in quarter 3 are used in the assessment:

- BTS–ISIS (Beam Trawl Survey on the RV Isis and RV Tridens (since 2016); ages 1–9, time-series 1985–2018
- SNS (Sole Net Survey on the RV Isis); ages 1–6, time-series 1970–2018

Although these surveys are both available on Datras, the indices of these two surveys used in the assessment of sole in Subarea 27.4 are not sourced Datras. The index calculation for both surveys is still conducted by the Netherlands.

A standardised comparison of the indices over the available time-series is presented on Figure 17.9.1. The internal consistency plots of the year class cohorts of the two indices is presented on Figure 17.9.2 and two graphs showing the mean standardised indices per cohort and by year are shown on Figure 17.9.3 and 17.9.4.

An additional survey index (the combined Belgian, German, and Dutch Demersal Fish Survey (DFS) estimates of age 0) is used for recruitment estimates in the RCT3 analysis.

All survey indices used in the assessment are presented in Table 17.9.1.

In autumn, in-year data becomes available from the BTS-ISIS and SNS surveys in quarter 3, the advice can be revised if significant changes in the assumptions of recruitment made at the working group are observed.

Recently, the Belgian BTS survey was made available on Datras. This survey covers the main fishing grounds of the main sole-targeting fishing fleets (Figure 17.9.5). 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.

17.10 Assessment

The model used is the Art and Poos model (AAP, Aarts and Poos (2009), for more details please refer to the Stock Annex). The table below gives an overview of data and parameters used in the AAP model.

Year of assessment:	2019
Assessment model:	AAP
Assessment software	FLR/ADMB
Fleets:	
BTS-ISIS Age range Year range	1–9 1985–2018
SNS Age range Year range	1–6 1970–2018
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.

A summary of the assessment results is presented in Table 17.10.1 and in Figure 17.10.1. Model diagnostics including standardized residuals of landings and discards, survey residuals and retrospective plots are illustrated in Figure 17.10.2, 17.10.3, and 17.10.4 respectively. There are no strong cohort patterns in the catch residuals: the model slightly underestimates age 2 in the landings. The survey residuals however, show strong patterns for the younger ages in the BTS-ISIS and for the older ages in the SNS index. Additionally, there are some year patterns in the survey residuals. This is likely caused by the lack of fitting from F-at-age-at-time smoother. The retrospective plots do not exhibit negative or positive pattern.

The sigmas for all the input information to the assessment is shown on Figure 17.10.5.

17.11 Recruitment estimates

For the short-term forecast of sole in Subarea 27.4 there are three different options for assumptions of recruitment (ages 0–2) in the assessment year (this is the intermediate year in the forecast).

Age 0: More specifically, the abundance estimate of age 1 in the year after the assessment year, i.e. in the advice year, needs to be assumed. Since there is no data available from surveys or other sources, the geometric mean of the time-series is used.

Age 1: For age 1 an RCT3 analysis is run which combines the assessment, the age 0 and age 1 of the SNS, age 0 of the DFS, and age 1 of the BTS-ISIS to predict the abundance of age 1 in 2019. 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: For age 1 an RCT3 analysis is run which combines the assessment, the age 0 and age 1 of the SNS, age 0 of the DFS, and age 1 of the BTS-ISIS to predict the abundance of age 2 in 2019. 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 for age 1 and 2 is presented in Table 17.11.1 and all the indices and recruitment from the assessment is shown on Figure 17.11.1. The results for age–1 and age–2 abundance estimates are presented in Table 17.11.2, and in Table 17.11.3 respectively.

An extremely strong 2018 year class (age 0 in 2018) was observed in SNS in 2018 (Figure 17.11.1, top). Also the DFS showed a larger than average signal (Figure 17.11.1, bottom). Because of the high weighting for DFS age0 in RCT3 analysis, this consequently gives extremely optimistic estimate for age 1 in 2019 (228 471.4 thousand).

In the end, the geometric mean of 1957–2015 was chosen for age 1 in 2019. For age 2 in 2019, the estimates from BTS age 1 and SNS age 0 have a relatively low standard error (compared to the other surveys). However, AAP is relatively strong in predicting age 2 survivors. Hence, AAP estimate was selected.

The recruitment estimates from the different sources are summarized in the text table below. Underlined values (in thousands) were used in the forecast. The relative contributions of the assumptions made on the year classes in the short-term forecast on catch, discards, landings, and SSB, and are shown on Figure 17.11.2.

Year Class	Age in 2019	AAP survivors	RCT3 thousands	GM(1957–2015) thousands
2017	2	85049.3	93695.6	99369.9
2018	1		228471.4	112787.8
2019	0			112787.8

There are indications (see above) that the 2018 year class may be stronger than the recruitment assumed in the forecast (recruitment estimate from RCT3 is almost double of geometric mean). If this is confirmed by the summer surveys in 2019 to be significantly different to the current recruitment assumption in the forecast, the forecast will be updated in the autumn.

17.12 Short-term forecasts

The short-term forecasts were carried out with FLR (FLAsh), projecting the stock forward for three years from the final data year (2018), into the intermediate year 2019 (the assessment year), the advice year (2020), and finally into 2021 (the "result" of the advice year). Weight-at-age in the stock and weight-at-age in the catch were taken to be the mean of the last three years.

The intermediate year Fwas assumed to be "F–status quo" (Fsq), that is, the exploitation was taken to be the mean value of the last three years. Since there was no strong increasing or decreasing trend of Fbar in the last few years (Figure 17.12.1), Fsq was not further scaled (to have equal Fbar as Fbar_2018). The exploitation pattern (relative proportions of landings versus discards) was taken to be the mean value of the last three years.

The option of assuming F to correspond to the TAC being fully caught in the intermediate year was abandoned because the TAC was not fully caught in previous years (2017 and 2018). Therefore no results for the TAC option are presented here.

Population numbers in the intermediate year for ages 2 and older are taken from the AAP survivor estimates. Numbers at age 1 in both 2019 and 2020 were taken from the geometric mean (1957–2015). Input to the short term forecast is presented in Table 17.12.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	$F_{(2–6)}$ 2019	SSB 2020	Recruitment 2019	Wanted catch 2019	Unwanted catch 2019
$F_{2019} = F_{sq}$	0.22	54766	112788	12519 t	1137 t

A series of F options were assumed for the TAC year (2020), assuming Fsq in the intermediate year (2019). Resulting management options for 2020 are given in Table 17.12.2.

17.13 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	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2015a)
	F_{lim}	0.63	EQsim analysis, based on the recruitment period 1958–2010	ICES (2016a)
	F_{pa}	0.44	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	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)

17.13.1 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 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: $F_{pa} = F_{lim} / \exp(1.645^* \text{ sigma})$, where sigma is the standard deviation of ln(F) in the final assessment year. F_{pa}(sigma) was estimated as 0.48.

17.14 Quality of the assessment

There has been a downward revision of the SSB in the latest assessment, however this revision is within the uncertainty bound of the assessment (Figure 17.10.4).

The main fishery targeting sole has gradually shifted fishing pressure to the southern North Sea. Currently no survey information about the area where the main part of the catch is taken is included in the assessment.

Indications are that the inclusion of survey information from this area would have a significant effect (lower SSB, and higher F) on the assessment of the North Sea sole stock (Figure 17.14.1) well beyond the uncertainty bounds of the current assessment.

The SNS, BTS-ISIS, and Belgian BTS indices generally show the same signals although some ages have contradicting signals (age 3 and 4) (Figure 17.14.2). The Workshop on Index Calculation based on DATRAS (WKICDAT) recommended to include the Belgian BTS in the assessment of sole in Subarea 27.4 by combining it with the SNS and BTS-ISIS through, for instance, the Delta-GAM method (Berg *et al*., 2014).

The Mohn’s Rho scores for Fbar (MeanF), SSB, and Recruitment are shown on Figure 17.14.3.

17.15 Status of the stock

Fishing mortality was estimated at 0.22 in 2018 which is well within biological limits but above F_{MSY}. The SSB in 2018 was estimated at about 51 459 tonnes which is well above precautionary limits (Figure 17.10.1).

17.16 Management considerations

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. 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, 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.

Additionally, no survey information from this part of the North Sea and the important fishing grounds is included in the assessment at the moment.

17.17 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.

17.18 Issues for future benchmarks

17.18.1 Data

The survey information currently included in the assessment is not covering the main fishing grounds. Furthermore, a mismatch between the area covered by surveys and the area where 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. Furthermore, the combining of surveys (e.g. within a Delta-GAM) should be explored.

17.18.2 Assessment

The parameter settings in the current assessment model result in residual patterns in catch as well as surveys. This is likely caused by the lack of fitting from F-at-age-at-time smoother. It is suggested to explore parameters settings to improve model fitting.

17.18.3 Forecast

The methodology and principles of RCT3 analysis was developed many years ago and might be no longer valid for the current stock situation. Therefore, the RCT3 analysis needs to be validated.

17.19 References

ICES. 2018. Report of the Working Group on Electric Trawling (WGELECTRA). ICES Report WGELECTRA 2018 17 - 19 April 2018. IJmuiden, the Netherlands. 155pp.

Table 17.3.1. Time-series of the official landings by country and overall total, the official BMS landings, the landings reported to ICES and the total TAC (figures rounded to the nearest tonne).

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	556	432	393	731	9155	513	0	11781	30	12370	16123
2018	408	368	432	717	8412	431	2	10771	57	11199	12555

Table 17.3.2. Time-series landings at age (in thousands) of sole in Subarea 27.4.

	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

	1	2	3	4	5	6	7	8	9	10
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
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
2018	331	11141	9184	11994	10095	3918	1096	1941	804	158

Table 17.3.3. Time-series discards at age (in thousands) of sole in Subarea 27.4.

	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
2018	2928	7760	1704	1448	1186	98	15	125	36	0

Table 17.7.1. Time-series landings at age of sole in Subarea 27.4.

	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

	1	2	3	4	5	6	7	8	9	10
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
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

	1	2	3	4	5	6	7	8	9	10
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	0.109	0.168	0.190	0.226	0.276	0.274	0.312	0.309	0.280	0.311
2018	0.123	0.165	0.198	0.233	0.256	0.263	0.242	0.258	0.268	0.285

Table 17.7.2. Time-series discards at age of sole in Subarea 27.4.

	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
2018	0.035	0.069	0.086	0.091	0.097	0.103	0.102	0.105	0.013	0

Table 17.7.3. Time-series of mean stock weights at age of sole in Subarea 27.4.

	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

	1	2	3	4	5	6	7	8	9	10
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
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

	1	2	3	4	5	6	7	8	9	10
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
2018	0.026	0.084	0.146	0.18	0.205	0.237	0.228	0.219	0.26	0.425

Table 17.8.1. Natural mortality at age and maturity ate age of sole in Subarea 27.4.

	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 17.9.1. Survey indices used in the assessment of sole in Subarea 27.4.

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

BTS-ISIS	1	2	3	4	5	6	7	8	9
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
2018	16.037	14.347	2.291	3.057	1.378	0.883	0.039	0.200	0.078

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

SNS	1	2	3	4	5	6
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
2018	1002.3	482.4	163.1	94.1	82.4	5.7

DFS0	0
1990	6.38
1991	167.56
1992	9.27
1993	15.32
1994	22.06
1995	7.06
1996	40.27
1997	26.94
1998	
1999	
2000	9.50
2001	51.42
2002	58.58
2003	10.61
2004	31.25

DFS0	0
2005	40.99
2006	12.57
2007	13.73
2008	11.77
2009	27.33
2010	42.86
2011	12.13
2012	11.23
2013	44.82
2014	23.62
2015	7.45
2016	12.28
2017	20.97
2018	56.75

Table 17.10.1. Assessment summary of sole in Subarea 27.4. "High"/"Low" indicate +/- 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment (Age 1)			SSB			Catch	Landings	Discards	F (Ages 2–6)		
	Thousands	Low	High	Tonnes	Low	High				Per year	Low	High
1957	133639	113421	157494	62890	54959	70821	13611	12878	734	71567	0.207	0.167
1958	117618	98852	139891	65799	57976	73622	14246	13505	741	77204	0.221	0.193
1959	437231	369696	516879	68451	61033	75869	17048	16042	1005	86831	0.240	0.210
1960	41880	35181	49899	68637	61489	75785	18906	17603	1303	97376	0.266	0.231
1961	69475	58230	82937	101462	91017	111903	29684	26945	2739	105851	0.299	0.266
1962	11063	9305	13151	85679	77043	94315	27922	26508	1414	90356	0.330	0.292
1963	12718	10588	15277	70883	63670	78096	23472	22673	798	71901	0.335	0.292
1964	600118	488463	737469	52267	45914	58618	16014	15698	316	68075	0.310	0.273
1965	145602	117482	180586	40890	34738	47042	11844	10874	970	120539	0.292	0.252
1966	54216	42408	69349	107458	91243	123677	37493	32562	4931	118035	0.309	0.263
1967	87066	65744	115206	101369	90515	112225	31951	29471	2479	112228	0.373	0.327
1968	127495	95485	170294	89656	80632	98680	34104	32360	1743	102449	0.468	0.411
1969	88735	65939	119315	70654	63334	77974	27170	24906	2264	88578	0.544	0.474
1970	199060	147243	268918	64660	57413	71907	25022	22630	2392	80304	0.554	0.493
1971	53209	40827	69349	55306	48925	61687	24706	21930	2776	82765	0.529	0.463
1972	109432	84923	140998	62591	54756	70426	25900	23740	2160	74037	0.515	0.451
1973	154175	119963	198206	46167	40959	51375	20480	18909	1571	66718	0.524	0.472
1974	129631	102796	163325	46478	41071	51885	22146	20047	2100	71130	0.538	0.478
1975	61849	48602	78636	49134	43513	54755	23182	20863	2320	68436	0.527	0.470
1976	135909	106090	174200	47305	42490	52120	20529	18714	1815	59896	0.496	0.447
1977	163006	129100	206006	36869	33531	40207	17600	15828	1772	60379	0.469	0.412
1978	60809	47804	77276	41892	37547	46237	20156	17897	2259	64234	0.464	0.412

Year	Recruitment (Age 1)			SSB			Catch	Landings	Discards	F (Ages 2–6)		
	Thousands	Low	High	Tonnes	Low	High				Per year	Low	High
1979	18040	14168	22968	50711	45158	56266	22318	20440	1879	59580	0.483	0.438
1980	190841	149693	243205	39777	36037	43517	17389	16387	1002	49762	0.519	0.463
1981	230091	173849	304388	26801	24658	28944	15342	13691	1652	61796	0.556	0.502
1982	205107	152211	276227	39906	34288	45524	26255	22345	3909	76952	0.591	0.537
1983	197096	150862	257270	50643	43031	58257	32250	27668	4581	86004	0.619	0.548
1984	91723	71386	117965	49977	43967	55987	30095	26186	3909	77670	0.623	0.562
1985	112527	90003	140702	46635	41307	51963	25777	23184	2592	62597	0.611	0.557
1986	169330	136574	210109	38637	35054	42220	19805	18057	1748	60516	0.589	0.529
1987	84736	67723	105960	35406	32052	38760	18537	16518	2019	63129	0.553	0.505
1988	669270	546276	820050	43237	38085	48389	20910	18691	2220	86866	0.517	0.470
1989	129322	106342	157248	38183	34558	41808	25617	21597	4019	124959	0.488	0.436
1990	244852	200290	299084	120834	102817	138843	52705	46490	6215	150342	0.474	0.432
1991	90455	74311	110193	88339	78605	98073	38418	35180	3238	123550	0.482	0.439
1992	441410	359065	542932	89904	81674	98136	37263	34408	2855	124685	0.509	0.460
1993	88004	70086	110472	60136	55423	64849	33872	30195	3677	115263	0.544	0.502
1994	67430	53332	85280	85614	74847	96381	39889	35561	4328	100176	0.584	0.537
1995	117215	92817	148097	63664	56765	70563	32742	30275	2467	78418	0.621	0.565
1996	75301	59404	95404	38059	35036	41082	21654	19849	1805	56756	0.646	0.599
1997	306980	244297	386103	32400	29148	35652	17855	16047	1808	57684	0.659	0.606
1998	145514	115939	182623	24221	21912	26530	19532	16540	2992	69761	0.660	0.601
1999	119335	94714	150449	48535	41046	56024	28175	24369	3806	71512	0.650	0.601
2000	149473	120685	185176	41415	36072	46758	24533	21641	2892	63581	0.637	0.582
2001	75840	62055	92616	34396	31073	37719	21755	19140	2615	56943	0.624	0.569

Year	Recruitment (Age 1)			SSB			Catch	Landings	Discards	F (Ages 2–6)		
	Thousands	Low	High	Tonnes	Low	High				Per year	Low	High
2002	211151	173006	257537	34996	31402	38590	18682	16734	1947	55038	0.611	0.567
2003	92102	76495	110971	26927	24448	29406	18481	15737	2744	58368	0.593	0.542
2004	48463	40324	58297	38962	34508	43416	19328	16758	2569	52503	0.564	0.516
2005	51785	43265	62000	31179	28186	34172	14193	12724	1469	40208	0.529	0.489
2006	191607	161366	227424	25058	23049	27067	11778	10681	1097	41426	0.497	0.451
2007	69113	57883	82440	18336	16963	19709	11759	9970	1789	47493	0.476	0.434
2008	73577	61557	87929	35888	31707	40069	15578	13626	1953	48910	0.465	0.428
2009	94379	79287	112327	30699	27708	33690	13740	12272	1469	44546	0.459	0.413
2010	211395	177201	251943	29193	26809	31577	13233	11725	1509	52035	0.453	0.408
2011	211307	177044	252167	27976	25325	30627	14034	12012	2022	64668	0.439	0.388
2012	54622	45379	65722	35215	30906	39524	17202	14912	2290	47378	0.408	0.346
2013	113335	92352	139057	42003	36342	47664	17000	15329	1671	49131	0.356	0.295
2014	202993	160412	256915	37922	31583	44261	14958	13513	1445	50203	0.300	0.240
2015	149480	113332	197189	39085	31655	46515	14294	12726	1567	62534	0.257	0.198
2016	73600	53195	101751	51331	41321	61341	14378	12937	1441	60378	0.231	0.177
2017	125181	82954	189087	53396	41965	64827	13956	12664	1292	60531	0.218	0.163
2018	98395	52210	185532	51459	38946	63972	12339	11187	1152	62898	0.217	0.140
2019	112788*			55591**								

*Geometric mean (1957-2015)
**From the short-term forecast.

Table 17.10.2. North Sea sole: Numbers-at-age

Year	1	2	3	4	5	6	7	8	9	10+
1957	133639	76230	90427	64137	17852	17673	31239	12492	3143	42649
1958	117618	120915	67958	64870	43886	12682	12263	21660	9296	34076
1959	437231	106421	107533	46859	44643	29943	8843	8845	15808	31652
1960	41880	395612	94357	71474	32091	29147	20743	6480	6293	33766
1961	69475	37893	349362	61425	47617	20052	19563	14842	4439	27447
1962	11063	62855	33288	227864	38624	28658	12571	12883	9655	20743
1963	12718	10006	54925	21874	135458	22762	16617	7405	8059	19015
1964	600118	11502	8716	35796	13082	80283	12879	9521	4708	17216
1965	145602	542918	10014	5466	23106	7973	48238	8235	6504	14976
1966	54216	131738	470926	5868	3753	14388	5167	34502	6003	15658
1967	87066	49053	112358	251733	4008	2309	9696	3887	25826	16214
1968	127495	78737	39833	54032	155570	2332	1547	7260	2872	31059
1969	88735	114641	57925	17231	28039	84394	1524	1123	5192	24268
1970	199060	77866	75054	23033	7832	14742	54277	1077	784	20564
1971	53209	173312	48468	28516	10636	4225	9515	38157	751	14882
1972	109432	47016	110202	18298	14149	5940	2729	6665	26663	10924
1973	154175	97575	31407	42709	9315	7890	3734	1859	4581	25835
1974	129631	137776	68140	12722	20957	4983	4688	2402	1225	20046
1975	61849	115789	98847	28834	5957	10742	2820	2852	1503	13304
1976	135909	55168	83313	43043	13580	3068	6139	1710	1721	8935
1977	163006	121121	39198	36757	21419	7330	1855	3893	1024	6383
1978	60809	145424	85620	17406	19179	12038	4635	1224	2355	4480
1979	18040	54434	105219	38291	9070	10767	7587	3058	750	4190
1980	190841	16197	40669	47052	19066	4905	6473	4821	1896	3064
1981	230091	171469	12212	17734	22122	9882	2772	3906	3019	3106
1982	205107	206082	124404	4976	8087	11318	5386	1616	2464	3864
1983	197096	182183	137592	46220	2270	4178	6108	3093	1020	3993
1984	91723	173732	113186	47883	21328	1174	2226	3453	1928	3124
1985	112527	81382	111287	39941	22217	10697	600	1216	2089	3056
1986	169330	100850	56930	41899	18503	10660	5220	317	711	3011
1987	84736	152508	75556	22744	19339	8750	5215	2779	184	2160
1988	669270	76431	117694	30846	10494	9571	4634	2972	1667	1406
1989	129322	603828	59537	48642	14380	5532	5534	2843	1866	1929
1990	244852	116653	472572	25702	23323	7825	3313	3503	1826	2438
1991	90455	220778	92011	222826	12866	12387	4485	2029	2214	2695
1992	441410	81475	174827	47185	114873	6446	6437	2536	1229	2972
1993	88004	396308	63910	93227	23993	54504	3042	3319	1463	2424
1994	67430	78259	301588	33370	44043	11165	24928	1478	1852	2169
1995	117215	58897	57030	148220	14243	20397	5162	11819	802	2184

Year	1	2	3	4	5	6	7	8	9	10+
1996	75301	101578	41524	26096	59198	6449	9485	2440	6168	1559
1997	306980	66233	71419	17994	10527	25367	2933	4507	1199	3798
1998	145514	273316	47110	30008	7536	4259	11260	1411	2098	2326
1999	119335	129848	195217	19671	12666	3002	1904	5523	650	2038
2000	149473	105703	91600	82544	8006	5248	1404	959	2667	1298
2001	75840	130246	72948	39422	32504	3495	2577	730	498	2060
2002	211151	65410	87973	31698	15958	14563	1755	1389	407	1426
2003	92102	183804	43683	38299	13986	7125	7275	981	817	1078
2004	48463	81152	123393	19198	18357	6232	3537	4181	596	1150
2005	51785	42935	55851	55965	9551	8431	3153	2058	2560	1069
2006	191607	45865	30548	26638	27745	4647	4442	1832	1248	2200
2007	69113	169086	33437	15353	13102	14253	2536	2558	1094	2058
2008	73577	60666	123874	17523	7720	6927	7847	1445	1515	1867
2009	94379	64280	44061	66710	9195	4111	3768	4429	855	2000
2010	211395	82360	46450	24030	36002	4912	2213	2107	2598	1675
2011	211307	185294	60396	25317	12820	19521	2680	1226	1202	2438
2012	54622	186173	139702	33164	13113	7160	11016	1479	676	2009
2013	113335	48142	143947	80309	17267	7618	4199	6157	811	1473
2014	202993	98922	37758	90701	45203	10490	4617	2432	3552	1318
2015	149480	173149	77913	25982	56614	28784	6577	2829	1528	3059
2016	73600	124049	135901	56348	17525	37790	18872	4315	1939	3143
2017	125181	60895	96380	98643	39455	12239	26239	13291	3174	3738
2018	98395	105727	46567	67732	69919	28712	9008	19683	10324	5369

Table 17.10.3. North Sea sole: Fishing mortality-at-age

Year	1	2	3	4	5	6	7	8	9	10+
1957	0.000	0.015	0.232	0.279	0.242	0.265	0.266	0.196	0.196	0.196
1958	0.000	0.017	0.272	0.274	0.282	0.261	0.227	0.215	0.215	0.215
1959	0.000	0.020	0.308	0.279	0.326	0.267	0.211	0.240	0.240	0.240
1960	0.000	0.024	0.329	0.306	0.370	0.299	0.235	0.278	0.278	0.278
1961	0.000	0.030	0.327	0.364	0.408	0.367	0.318	0.330	0.330	0.330
1962	0.000	0.035	0.320	0.420	0.429	0.445	0.429	0.369	0.369	0.369
1963	0.000	0.038	0.328	0.414	0.423	0.469	0.457	0.353	0.353	0.353
1964	0.000	0.039	0.367	0.338	0.395	0.409	0.347	0.281	0.281	0.281
1965	0.000	0.042	0.435	0.276	0.374	0.334	0.235	0.216	0.216	0.216
1966	0.000	0.059	0.526	0.281	0.386	0.295	0.185	0.190	0.190	0.190
1967	0.001	0.108	0.632	0.381	0.442	0.300	0.189	0.203	0.203	0.203
1968	0.006	0.207	0.738	0.556	0.512	0.325	0.220	0.235	0.235	0.235
1969	0.031	0.324	0.822	0.689	0.543	0.341	0.247	0.259	0.259	0.259
1970	0.039	0.374	0.868	0.673	0.517	0.338	0.252	0.261	0.261	0.261

Year	1	2	3	4	5	6	7	8	9	10+
1971	0.024	0.353	0.874	0.601	0.483	0.337	0.256	0.258	0.258	0.258
1972	0.015	0.303	0.848	0.575	0.484	0.364	0.284	0.275	0.275	0.275
1973	0.012	0.259	0.804	0.612	0.526	0.420	0.341	0.317	0.317	0.317
1974	0.013	0.232	0.760	0.659	0.568	0.469	0.397	0.369	0.369	0.369
1975	0.014	0.229	0.731	0.653	0.563	0.459	0.400	0.405	0.405	0.405
1976	0.015	0.242	0.718	0.598	0.517	0.403	0.355	0.413	0.413	0.413
1977	0.014	0.247	0.712	0.551	0.476	0.358	0.316	0.403	0.403	0.403
1978	0.011	0.224	0.705	0.552	0.477	0.362	0.316	0.389	0.389	0.389
1979	0.008	0.192	0.705	0.597	0.515	0.409	0.353	0.378	0.378	0.378
1980	0.007	0.182	0.730	0.655	0.557	0.471	0.405	0.368	0.368	0.368
1981	0.010	0.221	0.798	0.685	0.570	0.507	0.440	0.361	0.361	0.361
1982	0.019	0.304	0.890	0.685	0.561	0.517	0.455	0.360	0.360	0.360
1983	0.026	0.376	0.956	0.673	0.559	0.530	0.471	0.373	0.373	0.373
1984	0.020	0.345	0.942	0.668	0.590	0.571	0.505	0.403	0.403	0.403
1985	0.010	0.257	0.877	0.669	0.634	0.618	0.538	0.436	0.436	0.436
1986	0.005	0.189	0.818	0.673	0.649	0.615	0.530	0.444	0.444	0.444
1987	0.003	0.159	0.796	0.674	0.603	0.536	0.462	0.411	0.411	0.411
1988	0.003	0.150	0.784	0.663	0.540	0.448	0.389	0.366	0.366	0.366
1989	0.003	0.145	0.740	0.635	0.509	0.413	0.357	0.343	0.343	0.343
1990	0.003	0.137	0.652	0.592	0.533	0.457	0.390	0.359	0.359	0.359
1991	0.005	0.133	0.568	0.563	0.591	0.555	0.470	0.402	0.402	0.402
1992	0.008	0.143	0.529	0.576	0.646	0.651	0.562	0.450	0.450	0.450
1993	0.017	0.173	0.550	0.650	0.665	0.682	0.622	0.483	0.483	0.483
1994	0.035	0.216	0.610	0.751	0.670	0.671	0.646	0.511	0.511	0.511
1995	0.043	0.250	0.682	0.818	0.692	0.666	0.649	0.550	0.550	0.550
1996	0.028	0.252	0.736	0.808	0.747	0.688	0.644	0.610	0.610	0.610
1997	0.016	0.241	0.767	0.770	0.805	0.712	0.632	0.665	0.665	0.665
1998	0.014	0.237	0.773	0.763	0.820	0.705	0.612	0.675	0.675	0.675
1999	0.021	0.249	0.761	0.799	0.781	0.660	0.586	0.628	0.628	0.628
2000	0.038	0.271	0.743	0.832	0.729	0.611	0.554	0.555	0.555	0.555
2001	0.048	0.292	0.733	0.804	0.703	0.589	0.518	0.484	0.484	0.484
2002	0.039	0.304	0.732	0.718	0.706	0.594	0.482	0.431	0.431	0.431
2003	0.027	0.298	0.722	0.635	0.708	0.600	0.454	0.399	0.399	0.399
2004	0.021	0.274	0.691	0.598	0.678	0.581	0.441	0.390	0.390	0.390
2005	0.021	0.240	0.640	0.602	0.620	0.541	0.443	0.400	0.400	0.400
2006	0.025	0.216	0.588	0.610	0.566	0.506	0.452	0.416	0.416	0.416
2007	0.030	0.211	0.546	0.588	0.537	0.497	0.462	0.424	0.424	0.424
2008	0.035	0.220	0.519	0.545	0.530	0.509	0.472	0.425	0.425	0.425
2009	0.036	0.225	0.506	0.517	0.527	0.519	0.481	0.433	0.433	0.433
2010	0.032	0.210	0.507	0.528	0.512	0.506	0.491	0.461	0.461	0.461

Year	1	2	3	4	5	6	7	8	9	10+
2011	0.027	0.182	0.499	0.558	0.483	0.472	0.494	0.495	0.495	0.495
2012	0.026	0.157	0.454	0.553	0.443	0.434	0.482	0.500	0.500	0.500
2013	0.036	0.143	0.362	0.475	0.398	0.401	0.446	0.450	0.450	0.450
2014	0.059	0.139	0.274	0.371	0.351	0.367	0.390	0.365	0.365	0.365
2015	0.086	0.142	0.224	0.294	0.304	0.322	0.321	0.278	0.278	0.278
2016	0.090	0.152	0.220	0.256	0.259	0.265	0.251	0.207	0.207	0.207
2017	0.069	0.168	0.253	0.244	0.218	0.206	0.188	0.153	0.153	0.153
2018	0.046	0.189	0.313	0.243	0.182	0.157	0.138	0.112	0.112	0.112

Table 17.11.1. North Sea sole: Input table for RCT3 analysis.

Year class	Age 1	Age 2	DFS age 0	SNS age 0	SNS age 1	BTS age 1
1977	60808.8	54434.3	NA	1585	1547.7	NA
1978	18039.6	16197.1	NA	10370.5	93.8	NA
1979	190841	171469	NA	3922.7	4312.9	NA
1980	230091	206082	NA	5145.8	3737.2	NA
1981	205107	182183	NA	3240.7	5856.5	NA
1982	197096	173732	NA	2147	2621.1	NA
1983	91723	81382.2	NA	769.1	2493.1	NA
1984	112527	100850	NA	3334	3619.4	7.031
1985	169330	152508	NA	2713.4	3705.1	7.168
1986	84735.6	76430.6	NA	742	1947.9	6.973
1987	669270	603828	NA	13610.1	11226.7	83.111
1988	129322	116653	NA	522.7	2830.7	9.015
1989	244852	220778	NA	1743.4	2856.2	37.839
1990	90454.9	81475.3	6.38099979420552	50.8	1253.6	4.035
1991	441410	396308	167.562790818552	3639.7	11114	81.625
1992	88004	78258.5	9.26602772844516	302.9	1290.8	6.35
1993	67430	58896.6	15.3239778292221	231.3	651.8	7.66
1994	117215	101578	22.0632417416225	4692.7	1362.1	28.125
1995	75301.2	66233.3	7.0647780276121	1374.9	218.4	3.975
1996	306980	273316	40.2717398630735	2322.3	10279.3	169.343
1997	145514	129848	26.9395747980212	803	4094.6	17.108
1998	119335	105703	NA	327.9	1648.9	11.96
1999	149473	130246	NA	2187.9	1639.2	14.594
2000	75840.2	65410.4	9.5041330402662	70	970.3	7.998
2001	211151	183804	51.4241905001998	8340	7547.5	20.989
2002	92101.9	81152	58.582992521043	1127.7	NA	10.507
2003	48463	42934.8	10.6093395105163	NA	1369.5	4.192
2004	51785.3	45864.8	31.2517760468482	162	568.1	5.534

Year class	Age 1	Age 2	DFS age 0	SNS age 0	SNS age 1	BTS age 1
2005	191607	169086	40.9870116446901	305	2726.4	17.089
2006	69112.5	60666.4	12.5667007889326	16	848.6	7.498
2007	73577	64280	13.7274846340426	466.9	1259.1	15.247
2008	94379.1	82360.4	11.7676192904652	754.7	1931.6	15.95
2009	211395	185294	27.3315119316548	2291	2636.9	54.811
2010	211307	186173	42.8619685862924	333.9	1248	26.166
2011	54621.8	48142.3	12.1299798388105	136.3	226.6	5.149
2012	113335	98921.7	11.2261423473025	144.7	967.4	6.844
2013	202993	173149	44.8188382604357	237.3	2849	18.926
2014	149480	124049	23.616080619542	126	3192	21.099
2015	NA	NA	7.44835180402519	109.7	733.8	6.454
2016	NA	NA	12.2755392345859	373.2	956.7	16.279
2017	NA	NA	20.9656062744883	205.9	1002.3	16.037
2018	NA	NA	56.7482834387156	6574.9	NA	NA

Table 17.11.2. RCT3 results for age 1 of sole in Subarea 27.4

```
Analysis by RCT3 ver3.1 - R translation

Data for 4 surveys over 42 year classes : 1977 - 2018
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    0.2
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2018
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     dfs0 0.9895     8.631 0.5444  0.5575 23   4.039      12.63  0.6004     0.52460
     sns0 1.1065     4.302 1.6450  0.1446 37   8.791      14.03  1.7528     0.06155
     sns1     NA        NA     NA      NA NA      NA         NA      NA          NA
     bts1     NA        NA     NA      NA NA      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 38      NA      11.72  0.6760     0.41385

                  WAP logWAP int.se
yearclass:2018 228471  12.34 0.4349
```

Table 17.11.3. RCT3 results for age 2 of sole in Subsarea 27.4

```
Analysis by RCT3 ver3.1 - R translation


Data for 4 surveys over 42 year classes : 1977 - 2018
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    0.2
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 0.9891     8.501 0.5436  0.5584 23   3.043      11.51  0.5812     0.18258
     sns0 1.0835     4.333 1.6042  0.1516 37   5.327      10.11  1.6891     0.02161
     sns1 0.7654     5.831 0.4212  0.7312 37   6.910      11.12  0.4411     0.31694
     bts1 0.7770     9.585 0.4026  0.7128 31   2.775      11.74  0.4231     0.34451
 VPA Mean     NA        NA     NA      NA 38      NA      11.60  0.6775     0.13435

                 WAP logWAP int.se
yearclass:2017 93696  11.45 0.2483
```

Table 17.12.1. Input and assumptions for the intermediate year to the short–term forecast (F values presented are assuming F = Fsq) of sole in Subarea 27.4.

2019_ssb	2019_f2-6	2019_f_dis1-3	2019_f_hc2-6	2019_recruits	2019_landings	2019_discards	2019_catch	2019_TAC			
55591	**0.222**	**0.064**	**0.182**	**112788**	**12519**	**1137**	**13657**	**12555**			
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
1	2019	0.068	0.046	0.022	112788	0.065	0.125	0.035	0.019	0	0.1
2	2019	0.170	0.078	0.092	85049	0.125	0.169	0.072	0.075	0	0.1
3	2019	0.262	0.068	0.194	79223	0.167	0.196	0.086	0.143	1	0.1
4	2019	0.248	0.032	0.216	30816	0.214	0.232	0.091	0.180	1	0.1
5	2019	0.220	0.013	0.207	48071	0.256	0.266	0.103	0.223	1	0.1
6	2019	0.209	0.005	0.204	52731	0.267	0.271	0.112	0.242	1	0.1
7	2019	0.192	0.002	0.190	22209	0.274	0.276	0.112	0.238	1	0.1
8	2019	0.157	0.001	0.157	7104	0.286	0.287	0.146	0.232	1	0.1
9	2019	0.157	0.000	0.157	15923	0.291	0.291	0.171	0.238	1	0.1
10	2019	0.157	0.000	0.157	12695	0.310	0.310	0.070	0.358	1	0.1
1	2020	0.068	0.046	0.022	112788	0.065	0.125	0.035	0.019	0	0.1
2	2020	0.170	0.078	0.092	NA	0.125	0.169	0.072	0.075	0	0.1
3	2020	0.262	0.068	0.194	NA	0.167	0.196	0.086	0.143	1	0.1
4	2020	0.248	0.032	0.216	NA	0.214	0.232	0.091	0.180	1	0.1
5	2020	0.220	0.013	0.207	NA	0.256	0.266	0.103	0.223	1	0.1
6	2020	0.209	0.005	0.204	NA	0.267	0.271	0.112	0.242	1	0.1
7	2020	0.192	0.002	0.190	NA	0.274	0.276	0.112	0.238	1	0.1
8	2020	0.157	0.001	0.157	NA	0.286	0.287	0.146	0.232	1	0.1
9	2020	0.157	0.000	0.157	NA	0.291	0.291	0.171	0.238	1	0.1
10	2020	0.157	0.000	0.157	NA	0.310	0.310	0.070	0.358	1	0.1
1	2021	0.068	0.046	0.022	112788	0.065	0.125	0.035	0.019	0	0.1
2	2021	0.170	0.078	0.092	NA	0.125	0.169	0.072	0.075	0	0.1

2019_ssb	2019_f2-6	2019_f_dis1-3	2019_f_hc2-6	2019_recruits	2019_landings	2019_discards	2019_catch	2019_TAC			
55591	**0.222**	**0.064**	**0.182**	**112788**	**12519**	**1137**	**13657**	**12555**			
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
3	2021	0.262	0.068	0.194	NA	0.167	0.196	0.086	0.143	1	0.1
4	2021	0.248	0.032	0.216	NA	0.214	0.232	0.091	0.180	1	0.1
5	2021	0.220	0.013	0.207	NA	0.256	0.266	0.103	0.223	1	0.1
6	2021	0.209	0.005	0.204	NA	0.267	0.271	0.112	0.242	1	0.1
7	2021	0.192	0.002	0.190	NA	0.274	0.276	0.112	0.238	1	0.1
8	2021	0.157	0.001	0.157	NA	0.286	0.287	0.146	0.232	1	0.1
9	2021	0.157	0.000	0.157	NA	0.291	0.291	0.171	0.238	1	0.1
10	2021	0.157	0.000	0.157	NA	0.310	0.310	0.070	0.358	1	0.1

Table 17.12.2. Management options for 2020 for sole in Subarea 27.4.

Basis	Total catch* (2020)	Wanted catch** (2020)	Unwanted catch (2020)	F_{total}# (ages 2–6) (2020)	F_{wanted} (ages 2–6) (2020)	$F_{unwanted}$ (ages 1–3) (2020)	SSB (2021)	% SSB change***	% TAC change^	% Advice change^^
ICES advice basis										
EU MAP^^^: F_{MSY}	12317	11268	1049	0.202	0.166	0.058	55528	1.37	-1.90	-3.8
F = MAP $F_{MSY\ lower}$	7170	6562	609	0.113	0.093	0.033	60280	10.0	-43	-44
F = MAP $F_{MSY\ upper}$	20820	19038	1782	0.367	0.30	0.106	47717	-12.9	66	63
Other scenario										
MSY approach: F_{MSY}	12317	11268	1049	0.20	0.166	0.058	55528	1.37	-1.90	-3.8
F_{mp} (former management plan)	12205	11166	1039	0.20	0.165	0.058	55630	1.56	-2.8	-4.7
F = 0	0	0	0	0	0	0	66927	22	-100	-100
F_{pa}	24195	22119	2076	0.44	0.36	0.127	44633	-18.5	93	89
F_{lim}	32007	29244	2763	0.63	0.52	0.182	37537	-31	155	150
SSB (2021) = B_{pa}	32601	29785	2816	0.65	0.53	0.186	37000	-32	160	155
SSB (2021) = B_{lim}	44561	40664	3897	1.02	0.84	0.30	26300	-52	250	250
SSB (2021) = MSY $B_{trigger}$	32601	29785	2816	0.65	0.53	0.186	37000	-32	160	155
F = F_{2019}	13125	12007	1118	0.22	0.178	0.062	54783	0.0127	4.5	2.5
Rollover TAC	12555	11486	1069	0.21	0.170	0.059	55308	0.97	0	-1.92

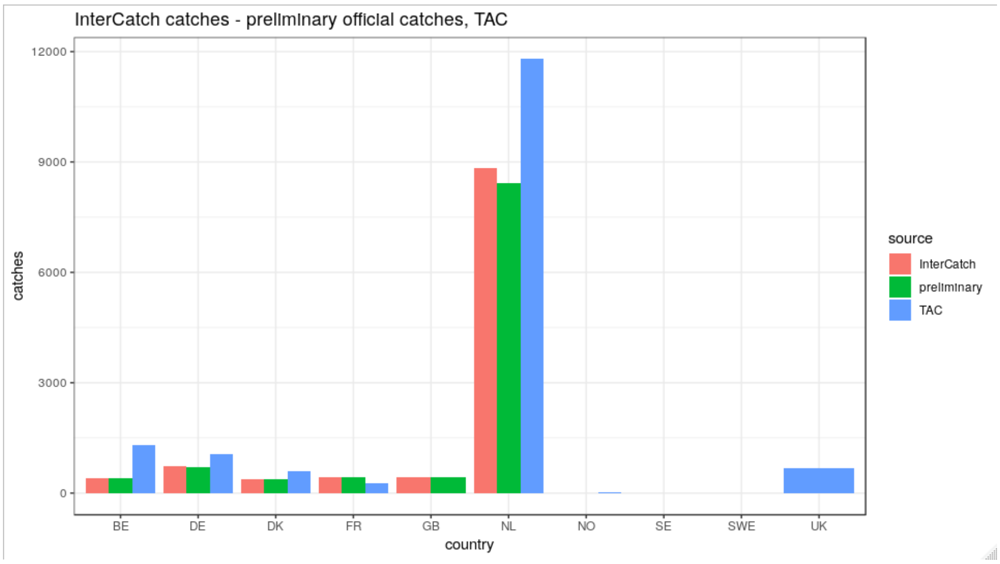

Figure 17.3.1. Catches (official (FAO) and TACs) by country are presented next to the catches submitted to InterCatch.

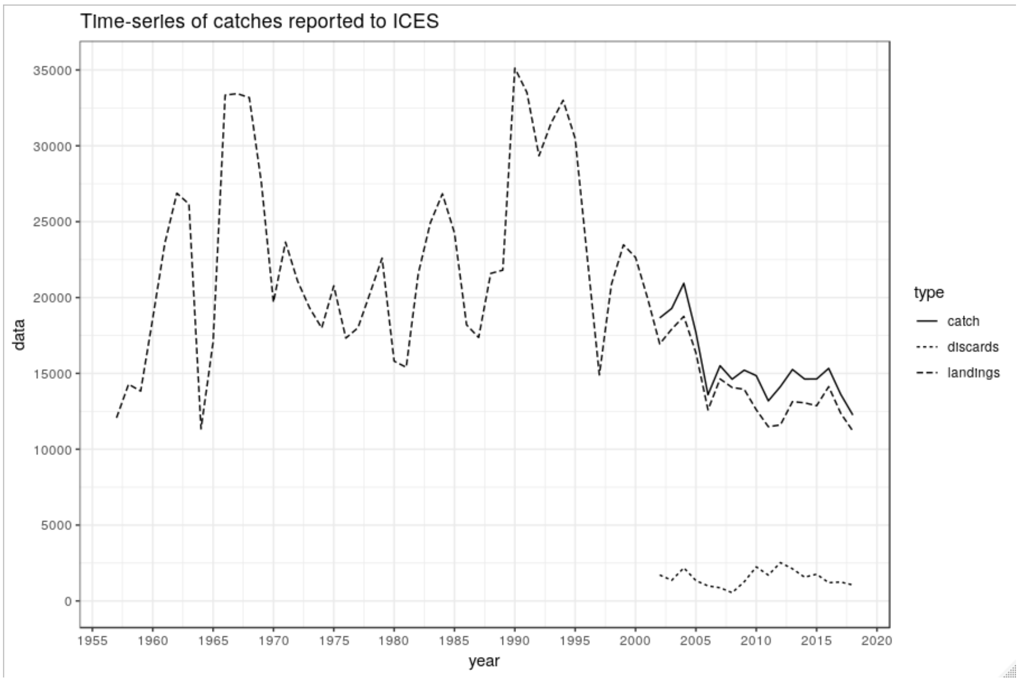

Figure 17.4.1. Time-series of catches (in tonnes) reported to ICES (InterCatch).

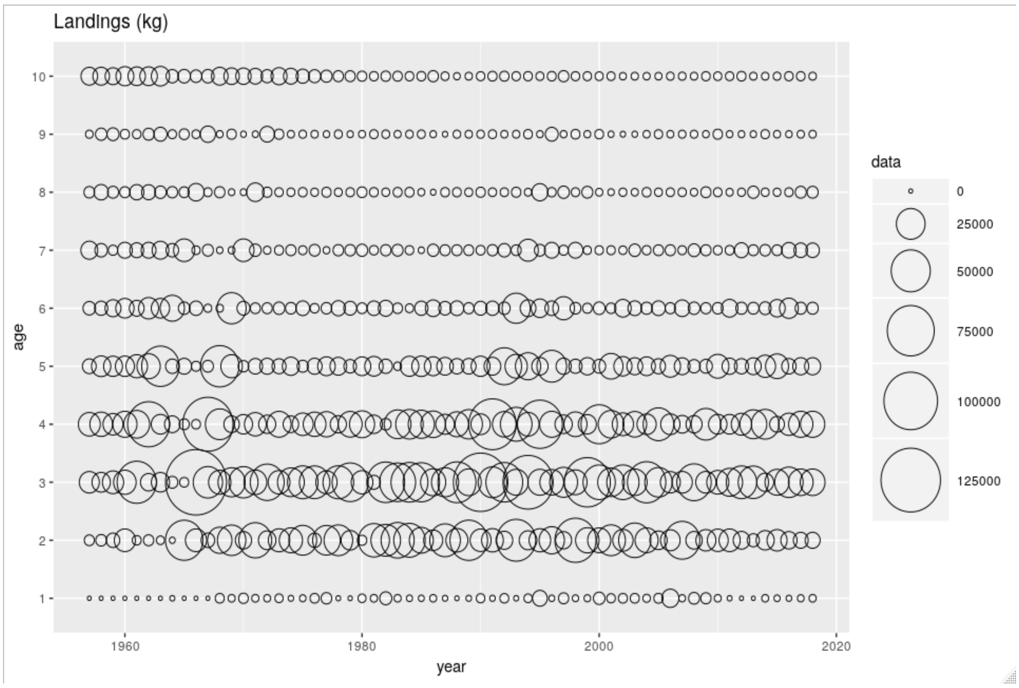

Figure 17.4.2. Time-series of landings at age.

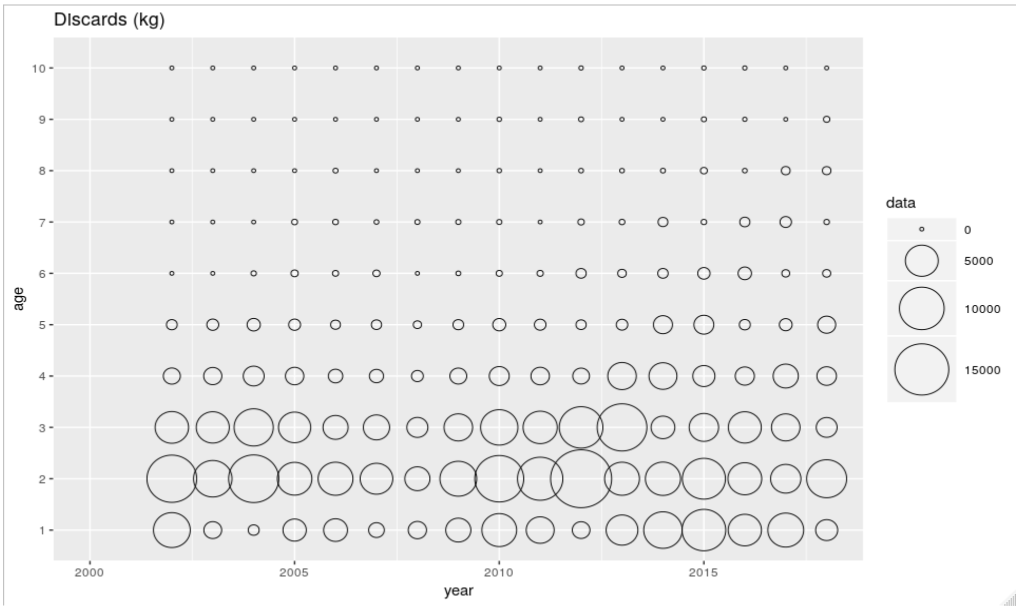

Figure 17.4.3. Time-series of discards at age.

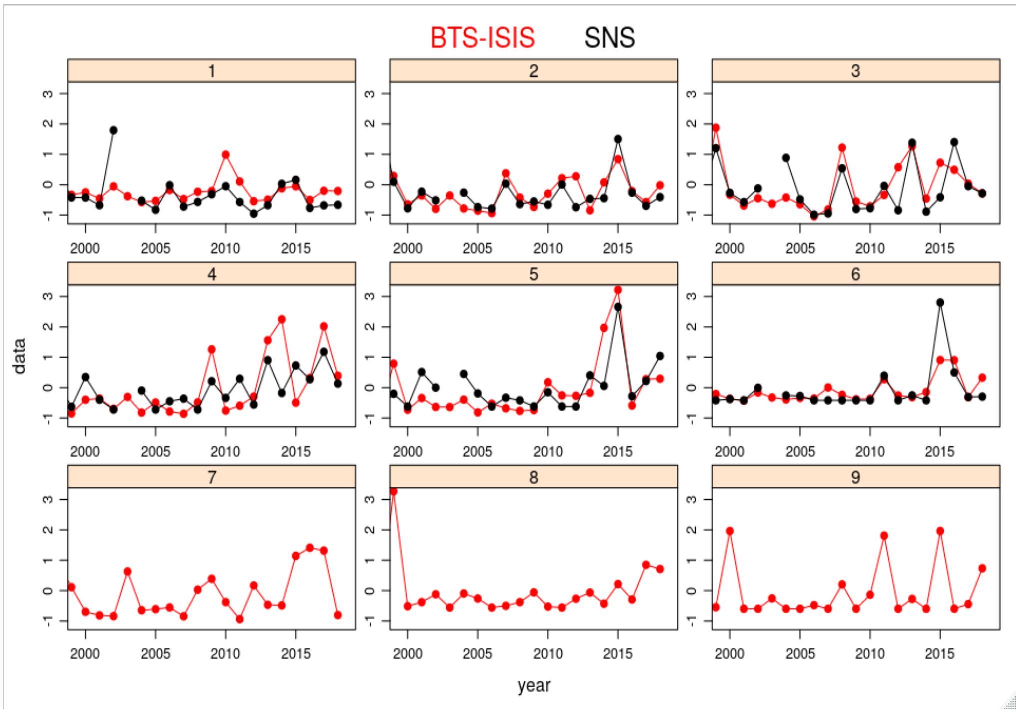

Figure 17.9.1. Standardized comparison of BTS-ISIS and SNS indices.

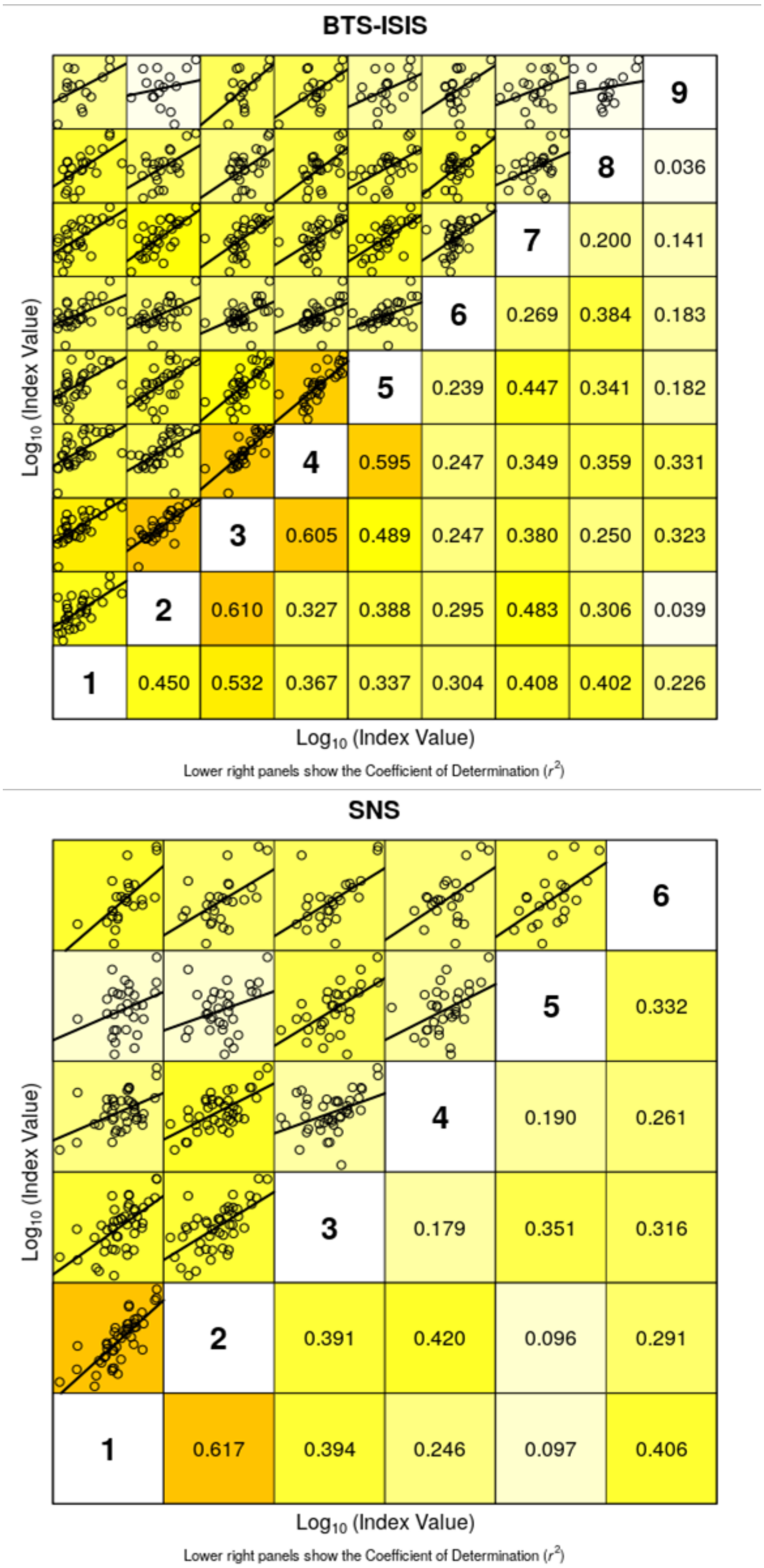

Figure 17.9.2. Internal consistency plots of BTS-ISIS (top) and SNS indices (bottom).

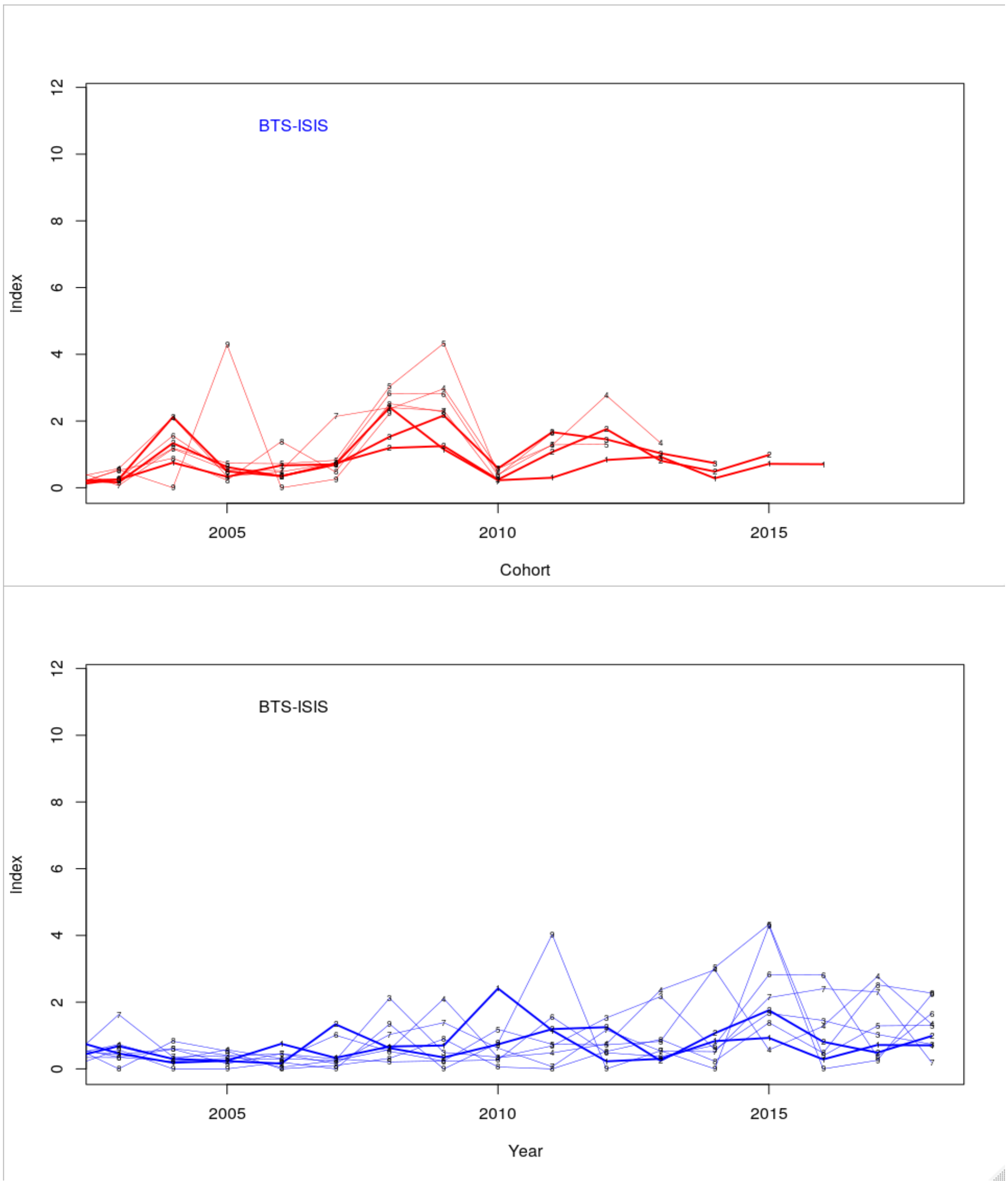

Figure 17.9.3. BTS-ISIS: mean standardised index by cohort (top) and by year (bottom).

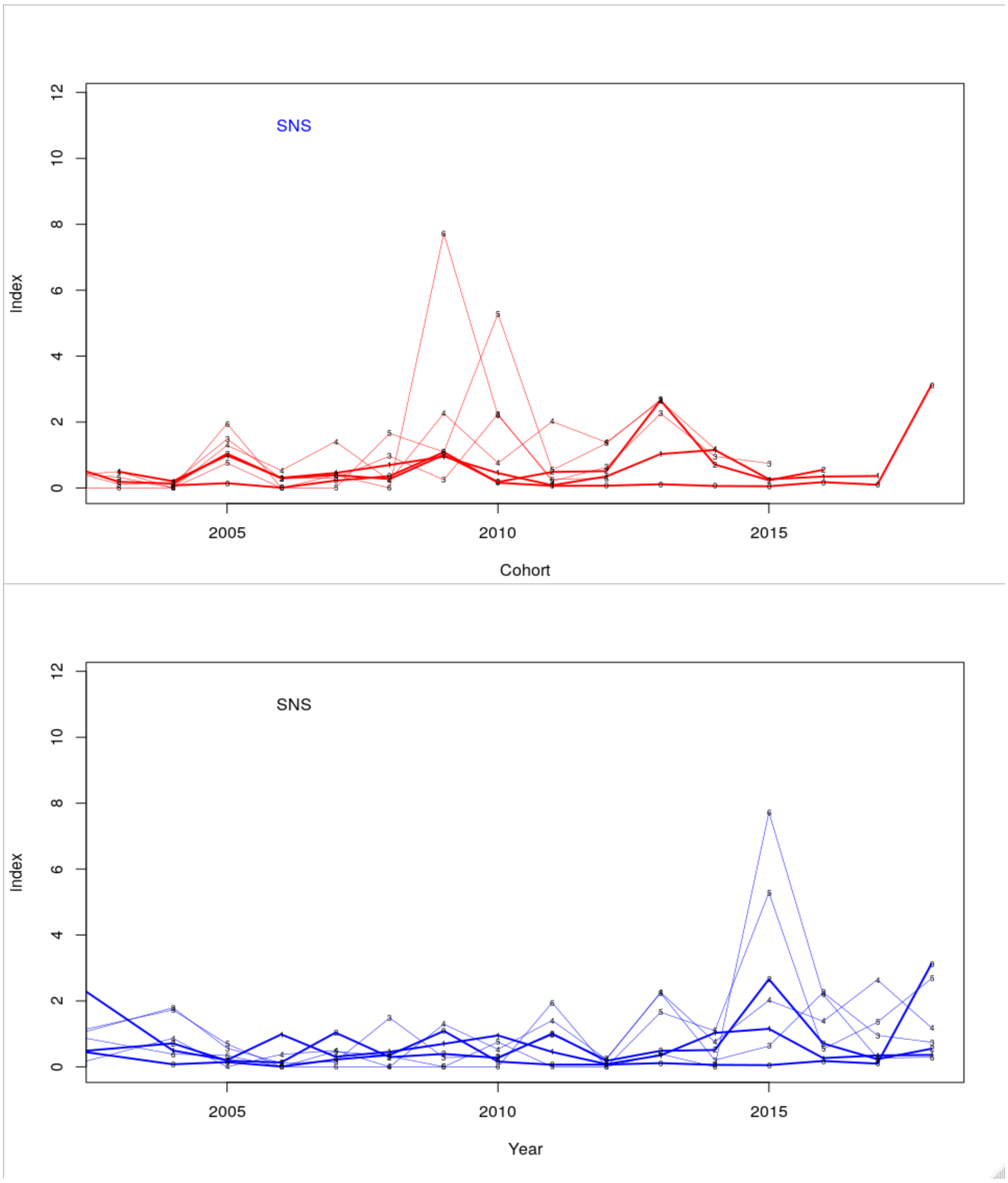

Figure 17.9.4. SNS: mean standardised index by cohort (top) and by year (bottom).

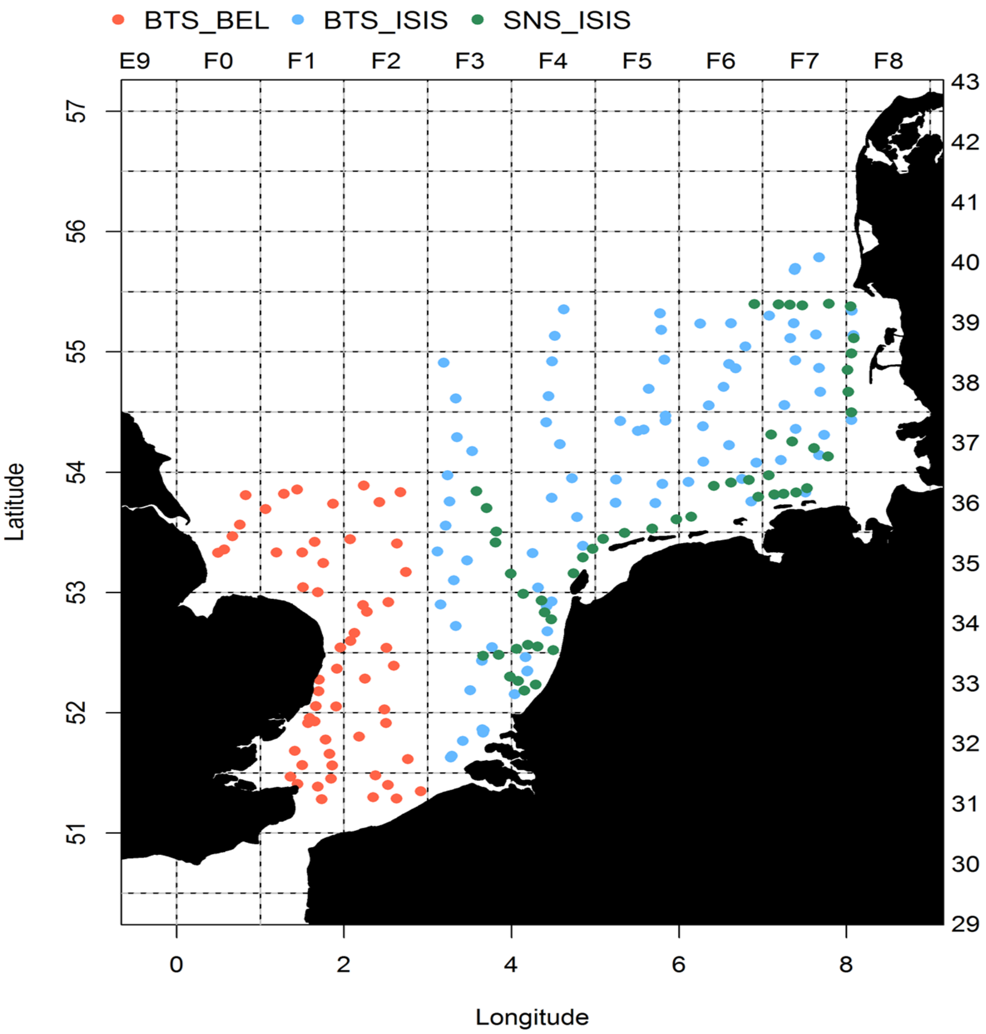

Figure 17.9.5. Survey area of three main surveys catching sole, BTS-ISIS (blue), SNS (green), and the Belgian BTS (red).

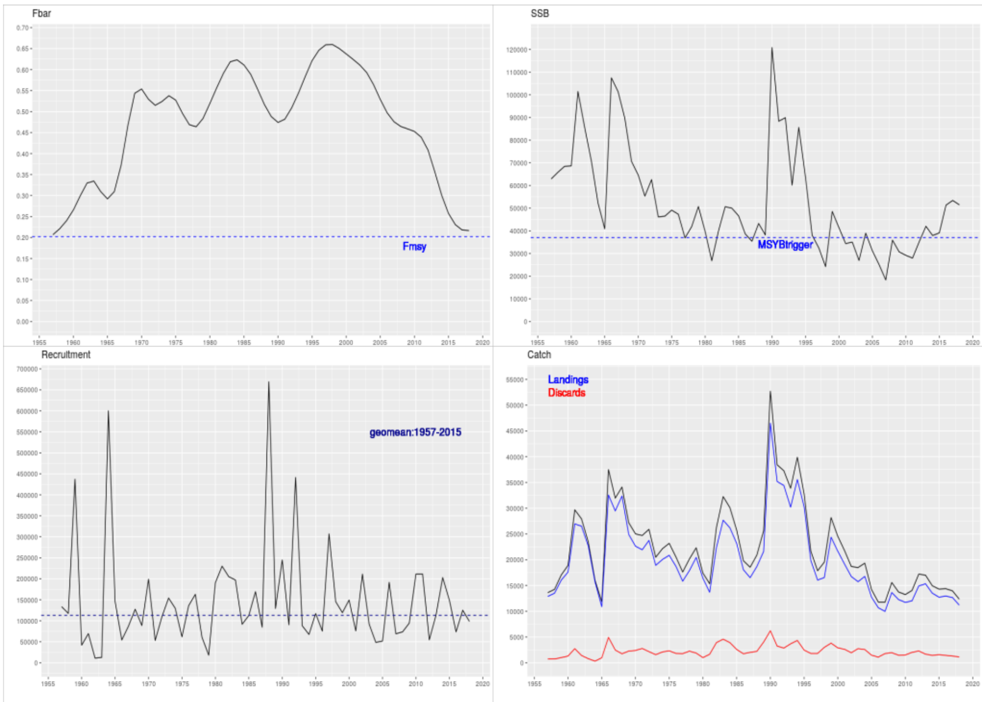

Figure 17.10.1. Current assessment summary of sole in Subarea 27.4. (From top to bottom: Fbar, SSB, Recruitment, Catches).

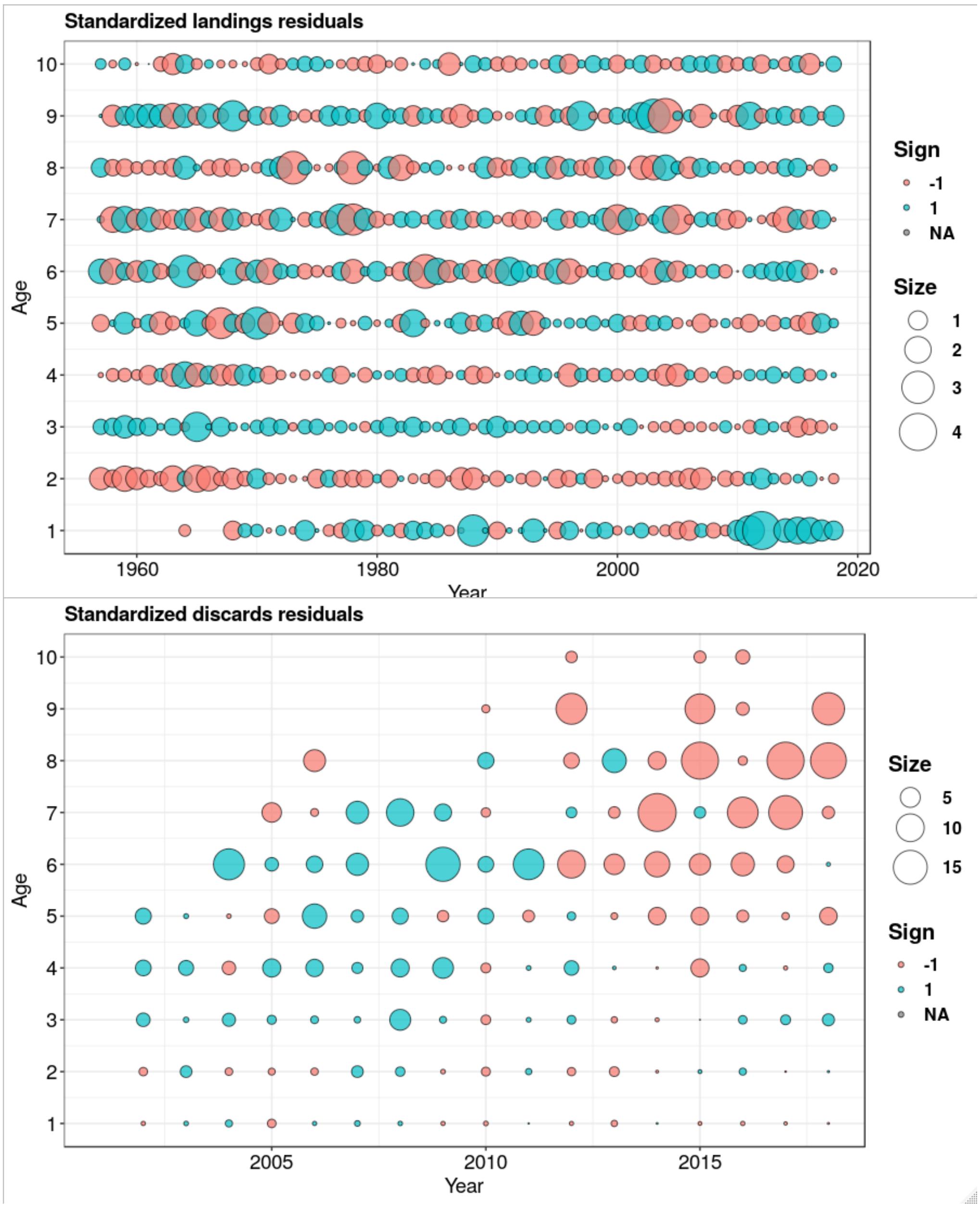

Figure 17.10.2. Landings (top) and discard (bottom) residuals of the assessment of sole in Subarea 27.4. (Observed – estimated, standardized by the standard error).

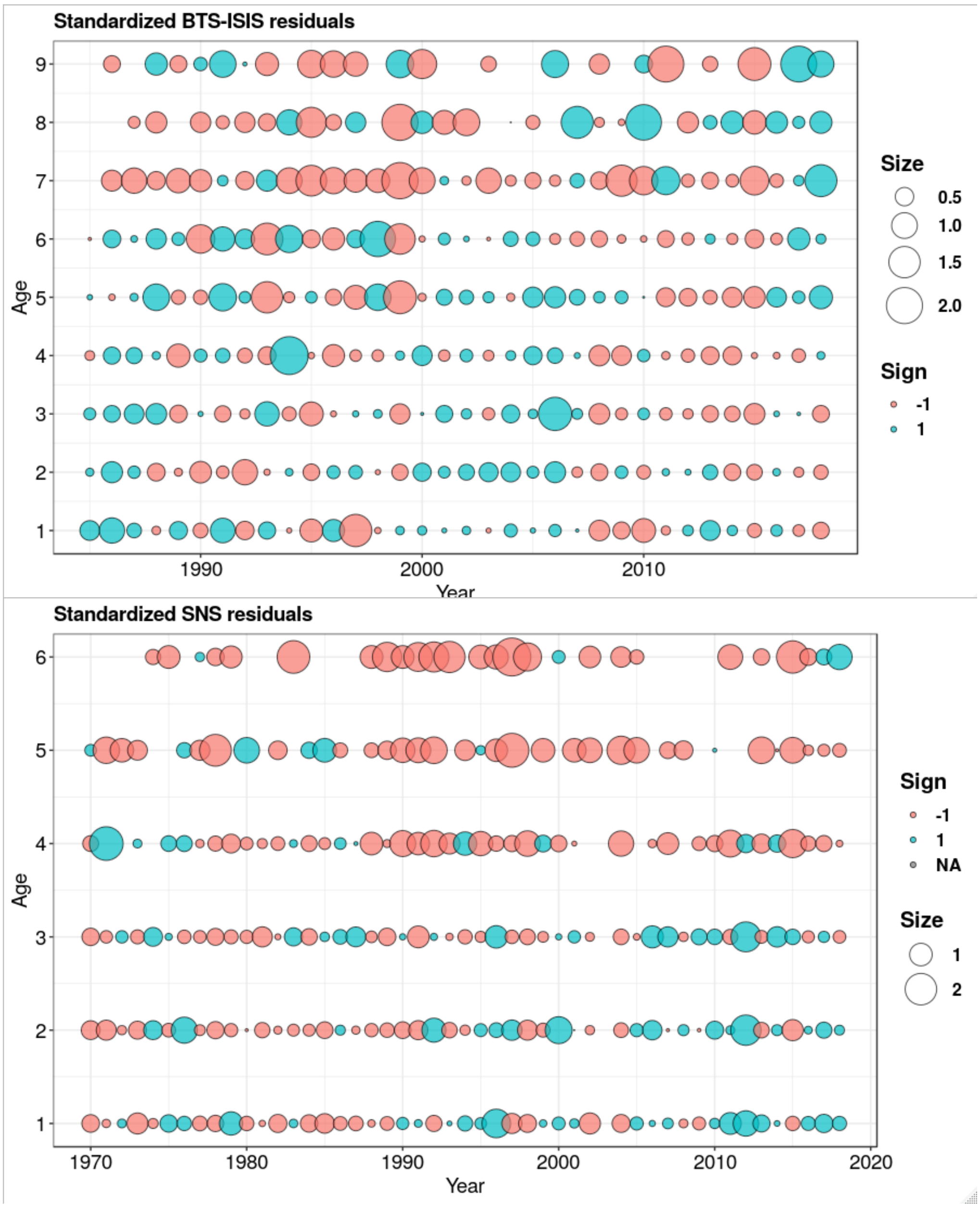

Figure 17.10.3. Residuals of the BTS-ISIS (top) and SNS (bottom) indices in the assessment of sole in Subarea 27.4. (Observed – estimated, standardized by the standard error).

Figure 17.10.4. Summary of retrospective of sole in Subarea 27.4.

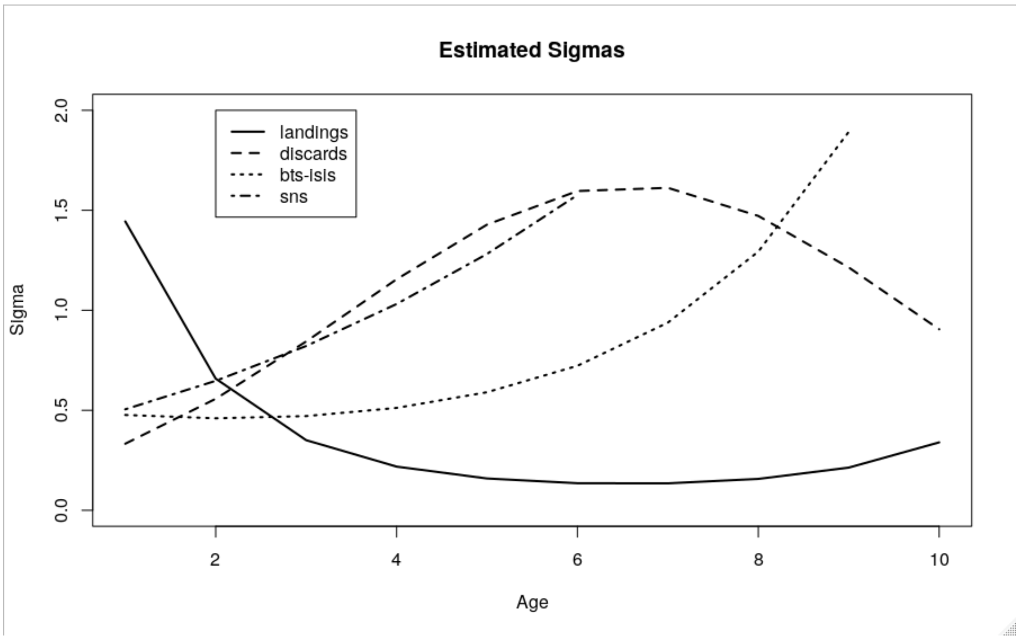

Figure 17.10.5. Summary of retrospective of sole in Subarea 27.4.

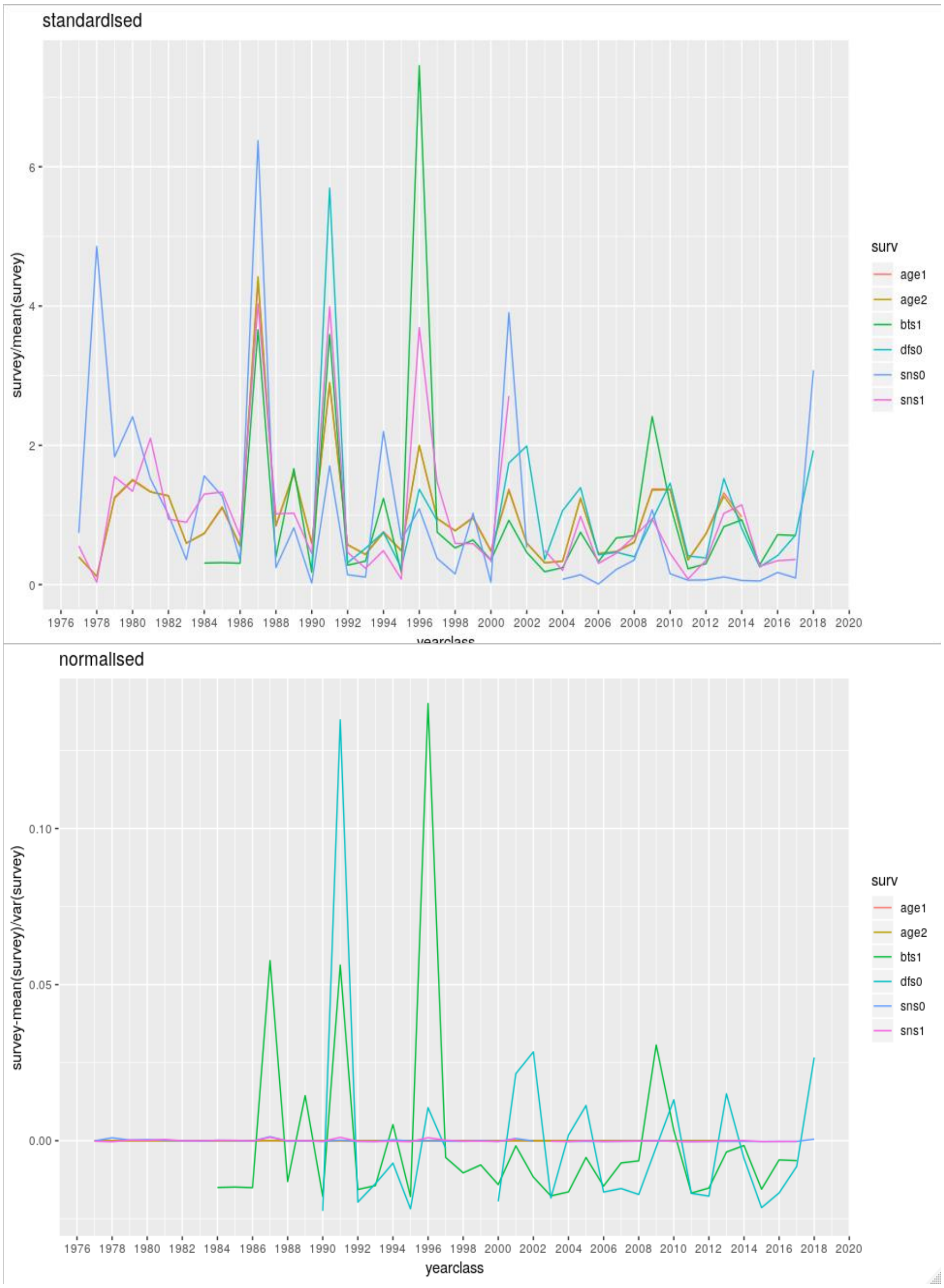

Figure 17.11.1. Plot of standardised (top) and normalised (bottom) input of RCT3 analysis in the short-term forecast of sole in Subarea 27.4.

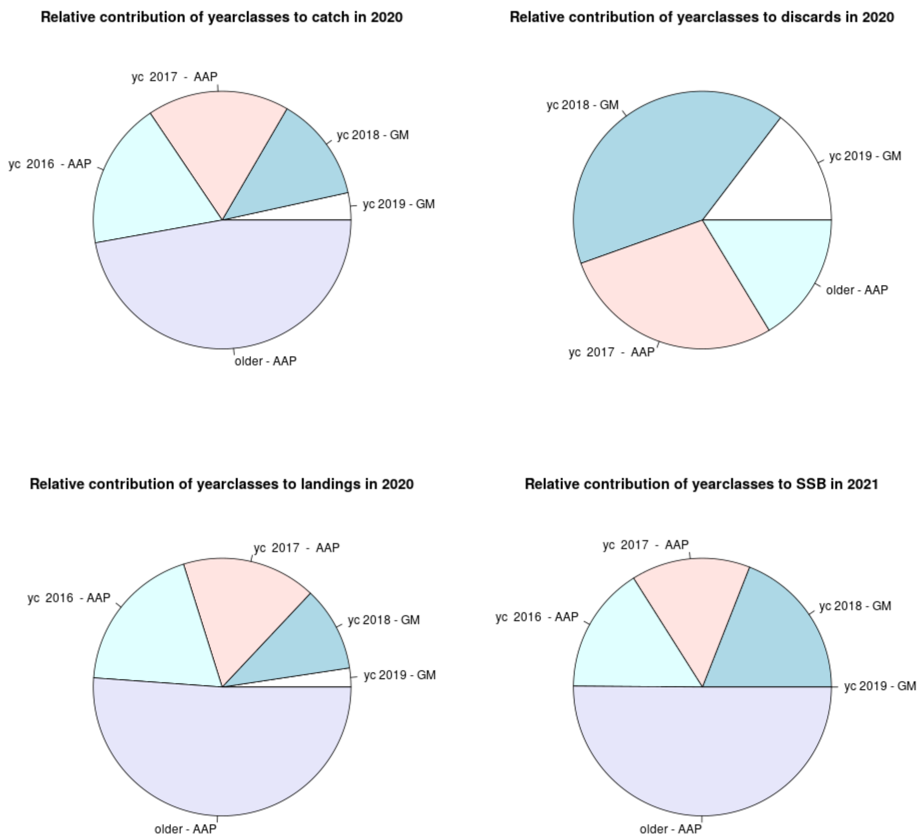

Figure 17.11.2. Relative contributions of the assumptions made on the year-classes in the short-term forecast of sole in Subarea 27.4 on catch, discards, landings, and SSB.

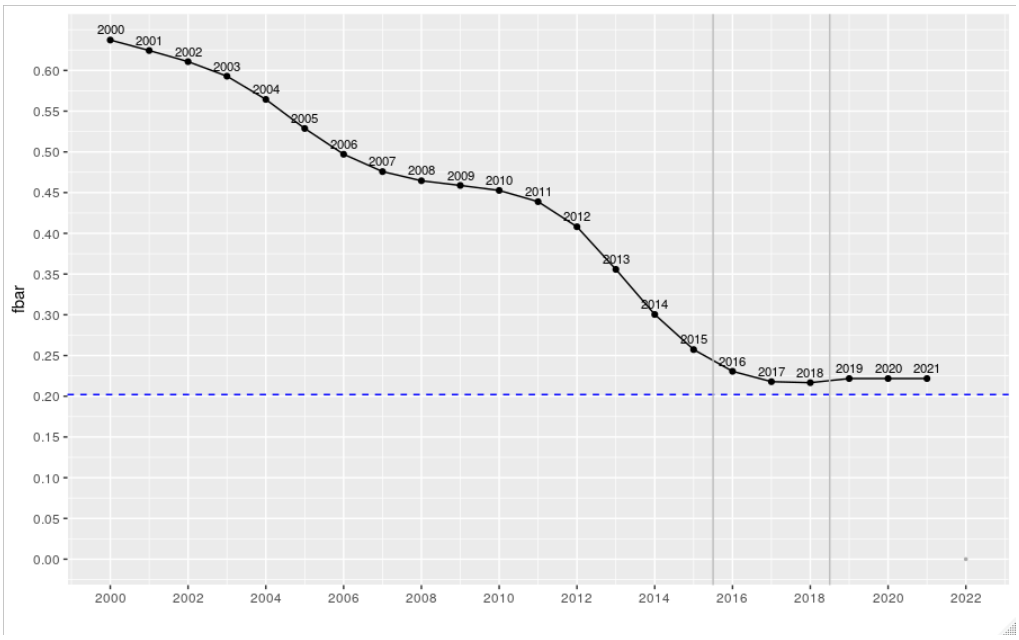

Figure 17.12.1. Trend of Fbar from 2000 to 2021 from short-term forecast of sole in Subarea 27.4. Last three years of the assessment are indicated between the grey lines lined (2016–2017).

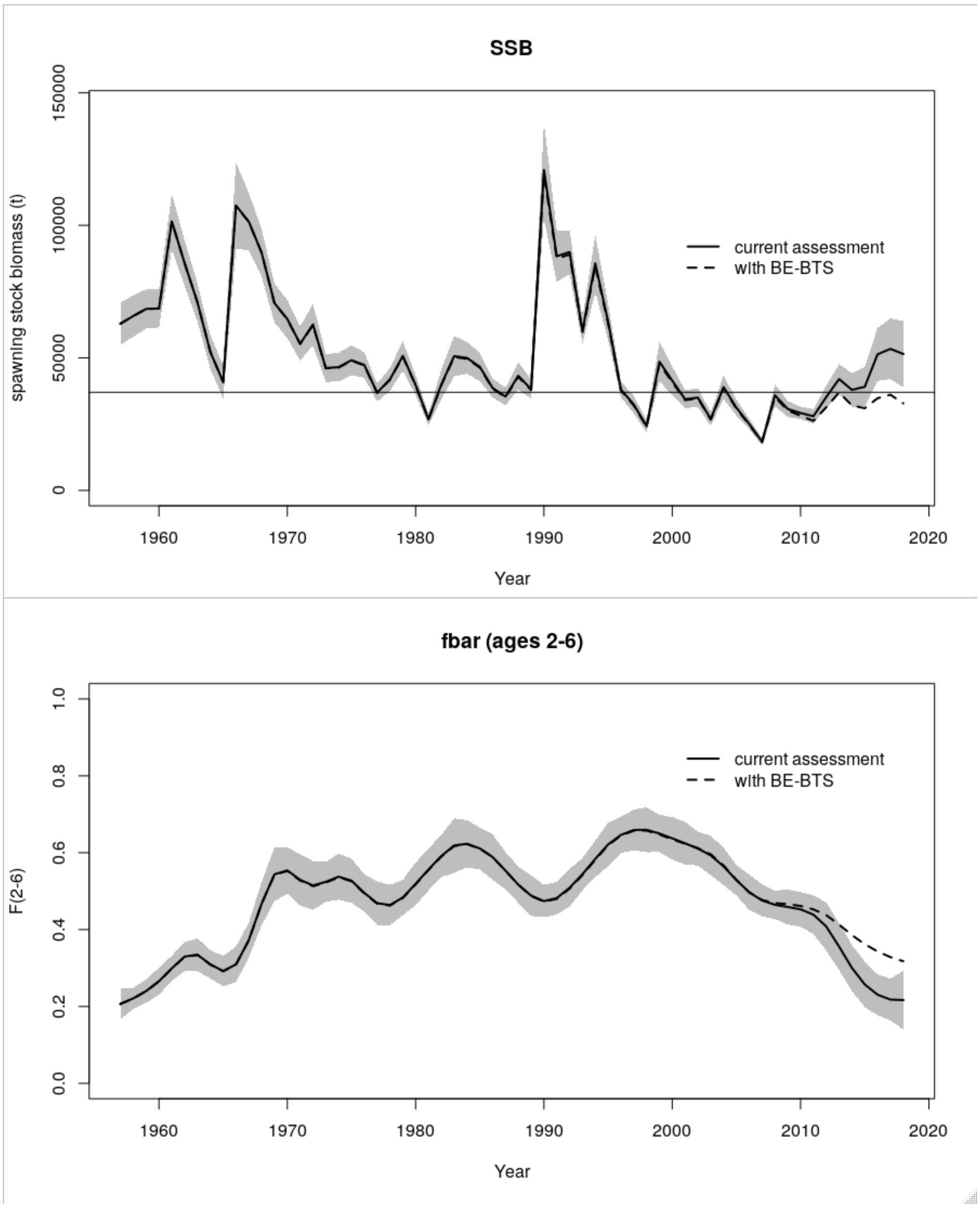

Figure 17.14.1. Effects of including the BE-BTS in the current assessment of sole in Subarea 27.4.

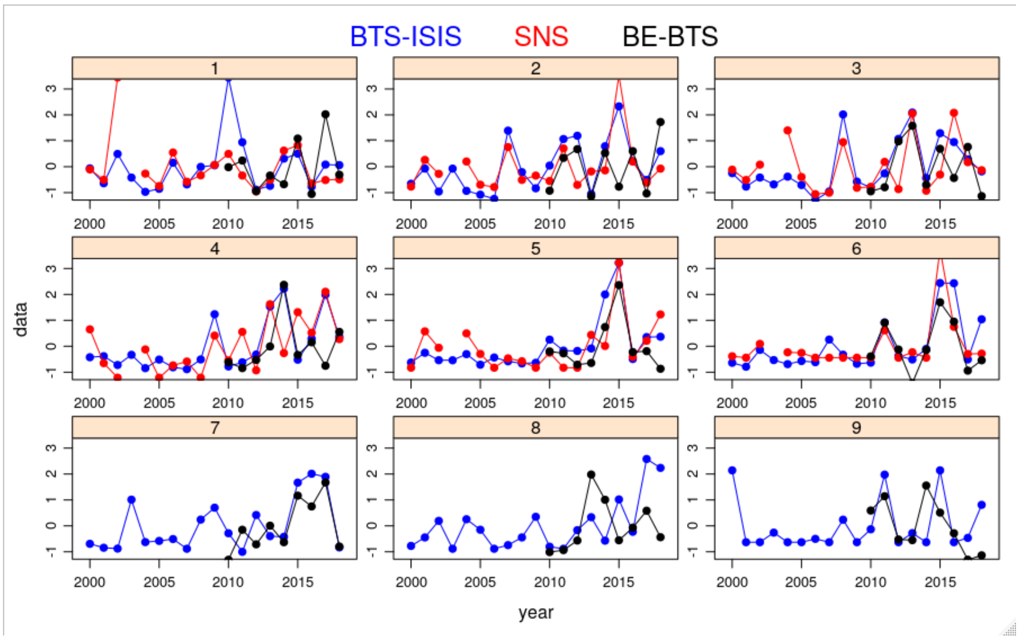

Figure 17.14.2. Standardized comparison of BTS-ISIS, SNS, and BE-BTS

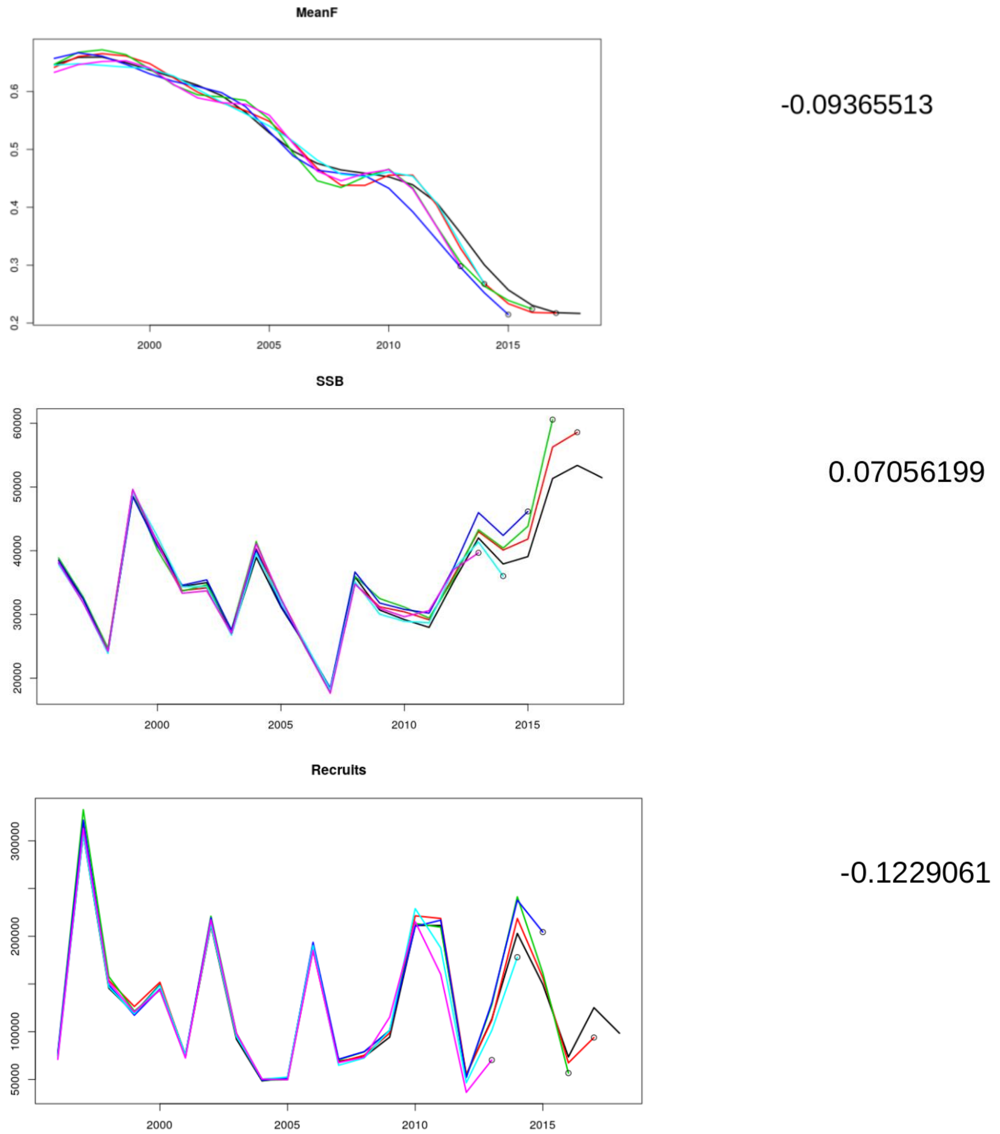

Figure 17.14.3. Mohn's Rho scores for Fbar (top), SSB (middle), and Recruitment (bottom) for the assessment of sole in Subarea 27.4.

18 Sole (*Solea* solea) in Division 27.7.d (Eastern English Channel)

This section of the report provides a comprehensive description of the methods and data used for the 2019 assessment of sole in Division 27.7.d. Additional background information can be found in the Stock Annex which was updated to this year's assessment.

The assessment and forecast of sole in Division 27.7.d presented at WGNSKK 2019 in Bergen (Norway) were not accepted. The main reason was that 2018 data were missing for one of the tuning fleets (the UK commercial beam trawl tuning fleet). Furthermore, the 2017 data had to be removed from this tuning fleet due to doubts on the correctness of the data. In August 2019, an inter-benchmark was organised to make a new UK CBT tuning fleet and integrate it in the assessment (ICES, 2019). Besides the new UK CBT, also a new Belgian CBT was constructed and integrated in the assessment. This resulted in an upward revision in SSB and downward revision in F, especially in more recent years. The primary cause of this upward revision in SSB was the result of treating the Belgian commercial index as a CPUE index instead of LPUE, and including the small fleet segment (≤221 kW) in this index.

However, subsequent investigation highlighted the hanging plus-group in XSA, based on the catch numbers in the plus-group, as a primary cause of a large increase in the TAC advice, when the assessment was treated as a Category 1 assessment. It was also found that French catch data was aggregated incorrectly for older ages for 2016 and 2017, which meant that the catch data was not reliable for these years. For this reason, the XSA assessment was not considered reliable in absolute terms, and the assessment was downgraded to Category 3 (indicative of trends only). This issue will be investigated during the next benchmark in 2020.

18.1 General

18.1.1 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).

18.1.2 Ecosystem aspects

A general description of the available information on ecological aspects can be found in the Stock Annex.

18.1.3 Fisheries

A general description of the fishery is presented in the Stock Annex.

18.1.3.1 Management regulations

Management of sole in 7.d is by TAC and technical measures.

From 2018 onwards, this stock is fully under the landing obligation (partially since 2016) (EU, 2018/2034). There are two exemptions in place which allow for discarding of undersized sole in Division 7.d: 1) a survival exemption for coastal otter trawlers outside nursery areas with cod end mesh size of 80–99 mm and 2) a *de minimis* exemption for vessels using trammel and gill nets (max. 3% of annual catches) and using TBB gear with a mesh size of 80–119 mm equipped with the Flemish panel (max. 3% of annual catches). The minimum landing size for sole is 24 cm.

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 (2000–2019); 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***	**2019***
TAC	4219	4852	5580	5900	4838	3483	3258	2724	3405	2515

*** 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 18.2.1 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 (Flemish panel), 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.

18.1.3.2 Additional information provided by the fishing industry

No additional information was provided this year.

18.1.4 ICES advice

18.1.4.1 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

18.1.4.2 ICES advice for 2019

The ICES advice for 2019 was:

ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 2571 tonnes.

In 2018, the stock status was presented as follows:

		Fishing pressure					Stock size			
		2015	2016	2017			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below	MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	O	✓	✓	Harvested sustainably	B_{pa},B_{lim}	O	✗	O	Increased risk
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

18.2 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.

18.2.1 Landings

Table 18.1 and Figure 18.1 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. In 2018, a small increase up to 2307 tonnes was observed. 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 18.2).

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, and 96% in 2014). In 2016 and 2017, official landings should no longer be compared to the TAC, as the latter represents catch data instead of only landings and the stock was only partially under the landing obligation. From 2018 onwards, the stock is fully under the landing obligation, but certain fleets are still allowed to discard due to 2 exemptions (see 18.1.3.1 and EU, 2018/2034). When comparing ICES catch estimates (InterCatch) with the TAC (catch), a total uptake of 88% was realized in 2016, 89% in 2017 and 77% in 2018 (Figure 18.3). Figure 18.4 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 18.5 summarises the proportion of landings for which samples (age) have been provided in InterCatch by country (86%; see also Table 18.2). Figure 18.6 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 (8%). 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/OTT/SSC/SDN and GTR/GNS. GNS/GTR, TBB and OTB/OTT/SSC/SDN contribute respectively 40%, 32% and 23% to the landings of sole in 27.7.d (Table 18.3).
- **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).

18.2.2 Discards

For the benchmark (ICES 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 18.7 shows that for the major part of the landings, discard weights are available (86%; 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 82% (Table 18.2). 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/OTT/SSC/SDN, but for the 2018 data, age coverage for the GTR/GNS group did not reach the threshold of 75%. Subsequently, this group was added to the 'overall' group.
- **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).

Belgian 2017 discard age distribution data were re-uploaded this year as Belgium noticed during the raising process that the multinomial logistic regression model did not make a good estimate of the age distribution for large discards (*i.e.* larger than the minimum landing size). This resulted in only minor changes to the discard numbers at age and discard mean weight at age.

18.2.3 Weight-at-age

Weights-at-age for discards and landings are shown in Figure 18.8 and 18.9 respectively and weights-at-age in the catch are given in Table 18.4.

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 18.10). 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).

Stock weights-at-age were calculated from the quarter 2 mean catch weights (Figure 18.11; Table 18.5). Note that for the current assessment, Belgium was able to provide quarterly data for the TBB_DEF_70-99 métier. Therefore, the Belgian data were taken into account for the calculation of the quarter 2 catch weights in InterCatch. For the years 2006–2007, 2012–2015 and now 2018, weights from this Belgian stratum were available and included.

18.2.4 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.

18.2.5 Tuning series

The assessment of sole in the Eastern English Channel is tuned with three survey (UK(E&W)-BTS-Q3, UK-YFS and FRA-YFS) and three commercial tuning series (FRA-COTB, UK(E&W)-CBT and BE-CBT). During the inter-benchmark, 2 tuning series used for the calibration of the assessment of sole in Division 27.7.d were modified.

First, the new UK CBT series was included. Due to database issues, it was no longer possible to provide an LPUE index based on kW. fishing hours. The new index is a modelled landings per activity days index from 1986-2018 disaggregated by age.

Secondly, a new Belgian commercial index was included (2004-2018). The previous index as calculated during the benchmark in 2017 focussed on the large fleet segment (>221 kW) and was an LPUE index. During the inter-benchmark (ICES, 2019), a CPUE index was constructed including the small fleet segment (≤221 kW), which gave us an index covering most of Division 7.d. The model accounted for potential misreporting of horse power by including a random vessel effect. There were two reasons to modify the index from a LPUE to a CPUE: 1) there is a pattern of increased discarding in the most recent years, and 2) having a second tuning fleet to tune age 2 in the assessment could put the UK-BTS-Q3, with spatial coverage restricted to inshore waters, into perspective.

The French commercial otter trawl series (from 2002 onwards) and the survey indices (FRA YFS from 1987 funded by EDF (Noursom), UK YFS from 1987–2006 and the UK BTS from 1989) were left unchanged. The series are presented in Tables 18.6–18.11.

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 18.12. All tuning fleets appear to track the year classes reasonably well. In general, the UK BTS gives the most optimistic estimates at age compared to the other tuning fleets. It shows two clear year classes entering the population: the 2014 and 2016 year class. The 2016 year class is not confirmed by the FRA YFS. Note that the spatial coverage of both tuning fleets is quite different. The UK BTS covers most of the coastal areas 7.d area, while the FRA YFS is confined in the Somme estuary (see stock annex). The new Belgian CBT tuning fleet is the only fleet confirming the strong year class of 2014 (*i.e.* age 3 in 2017). Next year, it will become clear whether the 2016 year class is the next new strong cohort coming in.

Internal consistency plots for the 3 commercial fleets and the UK beam trawl survey are presented in figures 18.13–18.16. The internal consistency of these three fleets is reasonable for the entire age-range.

18.3 Analyses of stock trends/Assessment

18.3.1 Review of last year's assessment

Last year, there were no major comments to the assessment and forecast. The few edits were directly provided to the stock coordinator and taken into account before the ADG.

18.3.2 Exploratory catch at age analysis

Catch, discard and landings numbers-at-age are shown in Figure 18.17, 18.18 and 18.19 respectively. Catch numbers have decreased over the time series and very low numbers are caught since 2015. In 2009–2010, a strong year class entered the stock and was found in the landings. In 2014, another less strong year class is observed in the discards, but not obvious from the landings. Catch proportions at age relative to the average proportion at age are shown in Figure 18.20. Proportionally, more older fish (especially in the plusgroup 11+) are present in the catch in more recent years than before. This trend was observed last year as well.

The catchability residuals of the tuning series for the proposed final XSA (see below) are shown in Figure 18.21. Some concern rises considering the UK(E&W)-BTS-Q3, which shows an age effect for age 1 (and is more effectively estimated by the UK(E&W)-YFS and the FRA-YFS) and a year effect in the most recent years. The residuals of the new Belgian CBT series and the new UK CBT series look acceptable, although the latter also showed a year effect for the most recent years.

Figure 18.22 presents the standardised mean log catchabilities for each tuning fleet included in the 2019 assessment.

18.3.3 Survivors estimates

In this year's assessment, the estimates for the year class 2017 (recruits (age 1) in 2018) were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of 44% and 43.8% respectively in the final year survivor estimates (Table 18.12). Shrinkage takes 12.2% 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 for this year class.

The 2016 year class is also estimated by the UK beam trawl survey and the French component of the Young Fish Survey, with a weighting of 82.7% and 13.4% respectively (Table 18.12). The UK BTS gives a very positive signal for this year class (Figure 18.12). Considering the large weighting percentage by this tuning fleet, the survivor estimates were set at 36 304. Shrinkage takes 3.9% of the weighting.

The 2015 year class is estimated by 5 tuning fleets and the F shrinkage (Table 18.12). The French COTB and UK BTS tuning fleets have the largest weighting percentages for this estimate.

The 2014 year class is also tuned by 5 tuning fleets and the F shrinkage. According to the UK BTS tuning fleet, this cohort represents a strong year class. Table 18.12 shows that this fleet also has the highest weighting (33.8%). The commercial tuning series estimate the survivors lower and get a slightly lower weighting than the UK BTS (BE-CBT 23.1%, FRA COTB 27.4% and UK CBT 12.4%; Table 18.12).

18.3.4 Final assessment

The final settings used in this year's assessment (using the XSA model) are specified in the Stock Annex and detailed below.

	2019 ASSESSMENT		
Fleets	Years	Ages	α-β
new BE_CBT_2004–2018 commercial	**04–18**	**3–8**	**0–1**
FR_COT commercial	02–18	3–8	0–1
new UK(E&W)_CBT commercial	**86–18**	**3–8**	**0–1**
UK(E&W)_BTS survey	89–18	1–6	0.5–0.75
UK_YFS survey	87–06	1–1	0.5–0.75
FR_YFS survey	87–18	1–1	0.5–0.75

-First data year	1982
-Last data year	2018
-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 18.12. A summary of the XSA results is given in Table 18.13 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 18.23 (red dashed line). Figure 18.23 also shows the other inter-benchmark runs. The WGNKSS 2019 baserun (black) shows the outcome of the assessment before the inter-benchmark, which includes the old UK CBT series with data up to 2016 and the old BE CBT series. The newUKoldBEL run (blue) includes the new UK CBT and the old BE CBT, while the newBELoldUK run (pink) includes the new BE CBT and the old UK CBT (up to 2016).

Retrospective patterns for the final run are shown in Figure 18.24. There appears to be no apparent retrospective bias. Recruitment estimates are uncertain. Mohn's Rho calculations for SSB, Mean F and Recruits were -0.030, 0.061 and -0.151 respectively, which are all within acceptable limits.

Subsequent investigation post-inter-benchmark highlighted an issue with the older ages and more specifically the plusgroup. The XSA model showed to have trouble with a very large plusgroup, which resulted in even larger estimates for the plusgroup. As illustrated below, when calculating the stock numbers for 2018 (N2018) based on 2017 stock numbers (N2017), natural mortality (M = 0.1) and fishing mortality (F) using the formula N2018 = N2017 x $e^{(-(M+F))}$, a plusgroup of 914 is expected. However, XSA gives an estimate of 7019.

INPUT 2017						
Age	N	M	F			
1	47967.47	0.1	0.013534	42819		
2	13953.09	0.1	0.083819	11610		
3	23451.55	0.1	0.10805	19047		
4	10216.32	0.1	0.199614	7571		
5	6722.21	0.1	0.184307	5059		
6	5350.95	0.1	0.208769	3929		
7	6607.99	0.1	0.138954	5203		
8	7054.76	0.1	0.131343	5598		
9	3173.35	0.1	0.144648	2485		
10	908.87	0.1	0.357022	**575**		
11	535.24	0.1	0.357022	**339**		
		fbar	0.167939		plusgroup	914
INPUT 2018						
Age	N	M	F			
1	17041	0.1	0.0381	14843		
2	42819	0.1	0.0651	36304		
3	11610	0.1	0.1471	9068		
4	19047	0.1	0.1438	14926		
5	7571	0.1	0.1424	5941		
6	5059	0.1	0.1524	3930		
7	3929	0.1	0.1664	3010		
8	5203	0.1	0.1315	4128		
9	5598	0.1	0.0850	4652		
10	2485	0.1	0.1534	**1929**		
11	7019	0.1	0.1534	**5448**		
					7376	

This issue was found to be the primary cause of large fluctuations in TAC advice over the past few years. It was also found that French catch data was aggregated incorrectly for older ages for 2016 and 2017, which meant that the catch data was not reliable for these years.

For this reason, the XSA assessment was not considered reliable in absolute terms, and the assessment was downgraded to Category 3 (indicative of trends only). This issue will be investigated in depth during the next benchmark in 2020.

A summary of the assessment in relative terms is given in Table 18.14.

18.3.5 Historical stock trends

Trends in catch, SSB, Fbar and recruitment are presented in Table 18.14 and Figure 18.25.

Catches have been 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 (including discard information). In more recent years, catches have decreased to approximately 2500 tonnes (2428 tonnes in 2017, 2625 tonnes in 2018).

For most of the time series, the *spawning-stock biomass* (SSB) has been fluctuating without trend since the 1980s around MSY $B_{trigger}$. From 2011 onwards, SSB exceeded MSY $B_{trigger}$, probably as a result of the decreased F. However, the weak recruitment of 2012, 2013 and 2014 probably contributed to reverse the increasing trend in SSB from 2013 onwards. In 2016, SSB was just below MSY $B_{trigger}$. In 2017, SSB increased again, probably as a result of the strong recruitment in 2015 and 2017 and a further reduction in the fishing mortality.

Fishing mortality (F) has been fluctuating between 0.70 and 1.47 prior to 2007, staying above F_{MSY} and occasionally exceeding F_{lim}. From 2007 onwards, fishing mortality has been decreasing and is below F_{MSY} since 2017. In 2018, F is at its lowest point over the entire time series.

Recruitment has been fluctuating without trend with occasional strong year classes. In recent years, two strong recruitments were observed (in 2015 and 2017) alternated by weaker recruitment (2016 and 2018).

18.4 Recruitment estimates and short-term forecast

18.4.1 Recruitment estimates

From the retrospective analysis it is clear that recruitment is highly variable in the most recent years. Age 1 is tuned by the French YFS and UK-BTS. Age 2 is only tuned by the UK-BTS. From age 3 onwards, the commercial tuning series give information. From one year to the next, recruitment can be revised markedly, creating instability in the forecast from one year to the next.

The IBP decided to change the settings of the forecast and more specifically the estimation of age 1, 2 and 3 in 2019 (ICES, 2019). Up until now, only age 1 was altered and estimated by an RCT3 estimate or the geometric mean minus the last 3 data years. By altering age 1, 2 and 3, we affect approximately 20% of the estimation of the catch in 2020 (Figure 18.26) and approximately 40% of the estimation of the SSB in 2021 (Figure 18.27). The IBP decided to use a *short* geometric mean for age 1, 2 and 3. The short geometric mean was calculated using the final data year -5 to the final data year -2 (in this case 2013-2016).

- For age 1, the geometric mean from 2013-2016 corresponded to 20753 thousand individuals (**GM 2013-2016@age1**).
- To obtain the stock numbers for age 2, this value was multiplied by the mortality (fishing mortality and natural mortality = Z) of age 1 in 2018 as follows: **GM 2013-2016@age1** * (e^{-Z} @age1 in 2018), giving 18077 thousand individuals.
- To obtain the stock numbers for age 3, the GM 2013-2016@age1 was multiplied by the mortality (Z) of age 1 in 2017 and by the mortality (Z) of age 2 in 2018 as follows: **GM 2013-2016@age1** * (e^{-Z} @age1 in 2017)* (e^{-Z} @age2 in 2018), giving 15707 thousand individuals.

The estimates of year-class strength used for prediction can be summarised as follows (in thousands individuals):

Year class	@ age in 2019	GM	Settings
2016	3	15707	GM 2013–2016
2017	2	18077	GM 2013–2016
2018	1	20753	GM 2013–2016
2019 & 2020	RECRUITS	20753	GM 2013–2016

Weights-at-age in the catch and in the stock are averages for the years 2016–2018.

For the advisory process, these settings were not used. Only data up to 2018 were used to give advice to make sure the issues concerning the plusgroup were not further projected (category 3 assessment).

18.4.2 Short-term forecast

There are two options to set the fishing mortality of the intermediate year: 1) F status quo (Fsq) set as the mean over the last three years scaled or not scaled to the last data year or 2) F set to constrain the TAC in the intermediate year. If the TAC is not fished (e.g. for sol 7d in 2018), we do not use the TAC constraint option. However, with the calculation of new reference points during this IBP, both options were explored.

1) Fsq:

   If the F shows an increasing or decreasing trend in the last three years, the Fsq should be scaled to the last data year (*i.e.* 2018). According to Figure 18.23, there is a decreasing trend in F. Therefore, F is set to 0.150. However, this resulted in an estimated catch in 2019 of 3444 tonnes. This means overshooting the current TAC in 2019 (2515 t) with 37%. The predicted catch for 2020 is 4180 tonnes when fishing at F_{MSY}. This results in an SSB of 19306 tonnes in 2020 and 18097 tonnes in 2021. This means a 66% increase compared to the TAC of 2019 and a 63% increase compared to the advice for 2019 (2571 tonnes).

SSB 2019	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
19654	0.150	0.034	0.137	20753
landings	**discards**	**catch**	**TAC**	
3229	215	3444	2515	

2) F TAC constraint:

   If we assume the TAC will be fished in 2019, the F in the intermediate year (2019) should be 0.107. The predicted catch for 2020 is 4398 tonnes when fishing at Fmsy. This results in an SSB of 20241 tonnes in 2020 and 18821 tonnes in 2021. This means a 75% increase compared to the TAC of 2019 and a 71% increase compared to the advice for 2019 (2571 tonnes).

SSB 2019	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
19654	0.107	0.024	0.097	20753
landings	**discards**	**catch**	**TAC**	
2360	155	2515	2515	

The output of the forecast, for the Fsq option (scaled to the last data year), is shown in the table below.

basis	catch	landings	discards	f3–7	f_hc3–7	f_dis1–3	SSB 2020	SSB 2021	SSB change	TAC change	Advice change
F_{MSY}	4180	3906	274	0.192	0.175	0.048	19306	18097	-6.3%	66%	63%
F_{MSY}_lower	2647	2478	169	0.116	0.106	0.029	19306	19624	1.65%	5.2%	3.0%
F_{MSY}_upper	6435	5997	438	0.319	0.29	0.080	19306	15855	-17.9%	156%	150%
F_{pa}	6120	5706	414	0.3	0.27	0.075	19306	16168	-16.3%	143%	138%
F_{lim}	8007	7445	562	0.421	0.38	0.105	19306	14297	-26%	218%	211%
SSB>B_{pa}	7225	6725	500	0.37	0.34	0.092	19306	15072	-22%	187%	181%
SSB>B_{lim}	11586	10704	882	0.71	0.65	0.178	19306	10766	-44%	361%	351%
TACsq	2515	2355	160	0.110	0.100	0.027	19306	19756	2.3%	0%	-2.2%

The output of the forecast, for the F TAC constraint option, is shown in the table below.

basis	catch	landings	discards	f3–7	f_hc3–7	f_dis1–3	SSB 2020	SSB 2021	SSB change	TAC change	Advice change
F_{MSY}	4398	4121	277	0.192	0.175	0.048	20241	18821	-7.0%	75%	71%
F_{MSY}_lower	2787	2615	172	0.116	0.106	0.029	20241	20425	0.91%	10.8%	8.4%
F_{MSY}_upper	6768	6323	445	0.319	0.29	0.080	20241	16467	-18.6%	169%	163%
F_{pa}	6437	6017	420	0.3	0.27	0.075	20241	16796	-17.0%	156%	150%
F_{lim}	8418	7848	570	0.42	0.38	0.105	20241	14833	-27%	235%	227%
SSB>B_{pa}	8176	7625	551	0.41	0.37	0.101	20241	15072	-26%	225%	218%
SSB>B_{lim}	12545	11614	931	0.75	0.68	0.187	20241	10766	-47%	399%	388%
TACsq	2515	2361	154	0.104	0.095	0.026	20241	20696	2.2%	0%	-2.2%

Both options assume very unlikely intermediate year settings. The Fsq scenario overshoots the TAC 37% and the TAC constraint option assumes that the TAC will be fished. The TAC was not restrictive the past 3 years and provisional official numbers indicate that this will most likely not be the case in 2019 either.

None of the scenarios above were used, because the WGNSSK decided to give category 3 advice for this stock by using the relative SSB estimated by the assessment model as an index of stock development. The advice is based on the ratio between the average of the two latest index values (index A: 2017-2018) and the average of the three preceding values (index B: 2014-2016), multiplied by the recent average catch (2016-2018).

The index is estimated to have increased by less than 20% and, thus, the uncertainty cap is not applied. The stock size is above and fishing mortality is below proxies for the MSY reference points (Figure 18.25), therefore the precautionary buffer is not applied.

Index A (2017–2018)		1.11
Index B (2014–2016)		1.03
Index ratio (A/B)		1.08
Uncertainty cap	Not Applied	-
Average catch for 2016-2018		2645 tonnes
Precautionary buffer	Not Applied	-
Catch advice**		2846 tonnes
% Advice change^		10.7 %

** Average catch for 2016-2018 × index ratio

^ Advice value for 2020 relative to advice value for 2019 [2571t].

18.5 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 inter-benchmark (more information is provided in the IBPsol7d report (ICES, 2019)). The management plan defined in the table is the EU multiannual plan (MAP) for the Western Waters (EU, 2019).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	15072 t	B_{pa}	ICES (2016, 2019)
	F_{MSY}	0.192	EQsim analysis based on the recruitment period 1982–2016	ICES (2016, 2019)
Precautionary approach	B_{lim}	10766 t	B_{loss}	ICES (2016, 2019)
	B_{pa}	15072 t	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2016, 2019)
	F_{lim}	0.421	EQsim analysis, based on the recruitment period 1982–2016	ICES (2016, 2019)
	F_{pa}	0.300	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	ICES (2016, 2019)
Management plan	MAP MSY $B_{trigger}$	15072 t	MSY $B_{trigger}$	ICES (2019)
	MAP B_{lim}	10766 t	B_{lim}	ICES (2019)
	MAP F_{MSY}	0.192	F_{MSY}	ICES (2019)
	MAP range F_{lower}	0.116–0.192	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019)
	MAP range F_{upper}	0.192–0.319	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019)

The relative reference points as used for the category 3 advice are shown below. All values are relative to the average of the time-series in the stock assessment (see Table 18.14).

Framework	Reference point	Relative value**	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.93	B_{pa}	ICES (2016, 2019)
	F_{MSY}	0.55	EQsim analysis based on the recruitment period 1982–2016	ICES (2016, 2019)
Precautionary approach	B_{lim}	0.67	B_{loss}	ICES (2016, 2019)
	B_{pa}	0.93	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2016, 2019)
	F_{lim}	1.21	EQsim analysis, based on the recruitment period 1982–2016	ICES (2016, 2019)
	F_{pa}	0.86	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	ICES (2016, 2019)
Management plan	MAP MSY $B_{trigger\ proxy}$	0.94	MSY $B_{trigger\ proxy}$	ICES (2016, 2019)
	MAP $F_{MSY\ proxy}$	0.55	$F_{MSY\ proxy}$	ICES (2016, 2019)
	MAP range $F_{lower\ proxy}$	0.33-0.55	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2016, 2019)
	MAP range $F_{upper\ proxy}$	0.55-0.92	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2016, 2019)

18.6 Quality of the assessment

Although the issues with the UK commercial beam trawl series are solved, this year's assessment revealed that the large catch numbers in the plus-group and XSA not being able to cope with this, resulted in the large increase in TAC advice, when the assessment was treated as a category 1 assessment. It was also found that French catch data was aggregated incorrectly for older ages for 2016 and 2017, which mean that the catch data was not reliable for these years. For these reasons, the XSA assessment was not considered reliable in absolute terms, and the assessment was downgraded to Category 3 (indicative of trends only). This issue will be investigated during the next benchmark in 2020.

18.7 Benchmark issue list

18.7.1 Data

Several issues with the data have come up:

- During this year's assessment working group, it became clear that France has provided their data with a plusgroup to InterCatch. 2018 data were corrected, but it is clear that 2016 and 2017 still contain this plusgroup. The French commercial otter trawl tuning fleet is also affected by this issue.
- Investigate the presence of large stock numbers in the older age groups in the data.
- This year, the French SMAC project will be finalised. The main aims of this project were to investigate connectivity within the stock (between the different nursery areas) and with the neighbouring sole stocks. The potential presence of subpopulations and migration from or to other stocks is an important issue to consider in the assessment.
- During the previous benchmark (ICES WKNSEA, 2017), decreasing mean weight and mean length at age were observed. This should be further investigated and followed up.

- The commercial tuning indices are distributed in different areas of the eastern English Channel (French COTB: along French coast; Belgian CBT: center; UK CBT: along UK coast). The French young fish survey is situated along the Somme estuary, while the UK BTS survey covers the coastal areas of the eastern English Channel area. Exploring the use of the delta GAM method to combine tuning fleets might give more insights in this matter.
- Misreporting in the Belgian fleet should be investigated. During the inter-benchmark it was highlighted that trips only fishing in the 7d area show different catch per unit of effort patterns compared to trips that also fish in other ICES areas.

18.7.2 Assessment

Currently, XSA is used as the assessment model for this stock. This VPA-based model calculates the population abundance at age directly from catch-at-age (treated as known and without error in every time step) and natural mortality, starting from the latest year and oldest true age for each cohort (excluding the plus group) (ICES, 2012). One of its limitations compared to statistical catch-at-age models, such as SAM, is that highly structured fishing mortality calculations allow less flexibility in distributing the goodness of fit. Moreover, issues with the plugroup in the raw catch data have shown to be problematic to produce an assessment of good quality this year based on XSA (§ 18.6). Other models should be further explored that are better equipped to appropriately handle the plusgroup.

18.7.3 Short-term forecast

From one year to the next, recruitment can be revised markedly, creating instability in the forecast from one year to the next. The inter-benchmark aimed to solve this problem by setting 2019 estimates for age 1, 2 and 3.

18.8 Management considerations

- Since 1 January 2016, sole fisheries in 27.7.d fall largely 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 exempted from the landing obligation (STECF-15-10). From 2018 onwards, all fleets active in Division 7.d fall under the sole landing obligation (STECF-17-13). However, the Commission delegated regulation (EU) 2018/2034 (EU, 2018) also describes two exemptions which allow for discarding of undersized sole in division 7.d: 1) a survival exemption for coastal otter trawlers outside nursery areas with cod end mesh size of 80–99 mm and 2) a *de minimis* exemption for vessels using trammel and gill nets (max. 3% of annual catches) and using TBB gear with a mesh size of 80–119 mm equipped with the Flemish panel (max. 3% of annual catches).
- 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.

18.9 References

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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 18.1: Sole 27.7.d - Official landings (tonnes) by country over the period 1974–2018; 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

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
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	651	1265	391	0.180	2307	2314	311	3405*
2019								2515*

Table 18.2: Sole 27.7.d - Summary of the InterCatch data in 2018 (imported vs. raised data; sampled vs. estimated data)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	2124	92
Landings	Imported_Data	Estimated_Distribution	190	8
Discards	Imported_Data	Sampled_Distribution	255	82
Discards	Imported_Data	Estimated_Distribution	20.23	7
Discards	Raised_Discards	Estimated_Distribution	35.76	11
BMS landing	Imported_Data	Estimated_Distribution	0	NA

Table 18.3: Sole 27.7.d - Landings percentages by gear type for 2015–2018 (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB/OTT/SSC/SDN = otter trawls and seines)

Landings by gear	2015	2016	2017	2018
GNS/GTR	46%	43%	43%	40%
TBB	34%	40%	39%	32%
OTB/OTT/SSC/SDN	15%	16%	17%	23%
Other	5%	1%	1%	4%

Table 18.4: 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	2018
1	0.115	0.149	0.081	0.081	0.039	0.039	0.048	0.067	0.110	0.096	0.094
2	0.151	0.130	0.142	0.120	0.097	0.105	0.128	0.122	0.135	0.130	0.122
3	0.207	0.206	0.192	0.199	0.179	0.180	0.174	0.174	0.184	0.173	0.180
4	0.243	0.257	0.235	0.245	0.231	0.237	0.224	0.227	0.238	0.210	0.212
5	0.159	0.301	0.275	0.295	0.259	0.295	0.262	0.268	0.262	0.253	0.272
6	0.299	0.313	0.316	0.329	0.299	0.305	0.322	0.282	0.276	0.306	0.292
7	0.377	0.354	0.337	0.334	0.342	0.378	0.335	0.321	0.324	0.309	0.306
8	0.392	0.388	0.354	0.382	0.322	0.432	0.393	0.340	0.376	0.344	0.288
9	0.420	0.385	0.417	0.378	0.381	0.392	0.408	0.405	0.351	0.422	0.329
10	0.449	0.384	0.462	0.430	0.443	0.462	0.475	0.355	0.407	0.415	0.380
11	0.492	0.376	0.433	0.470	0.373	0.481	0.450	0.461	0.546	0.573	0.409

Table 18.5: 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	2018
1	0.044	0.044	0.052	0.068	0.127	0.093	0.097
2	0.057	0.082	0.117	0.070	0.120	0.122	0.115
3	0.151	0.160	0.160	0.164	0.156	0.168	0.165
4	0.223	0.239	0.210	0.213	0.222	0.208	0.201
5	0.240	0.301	0.259	0.254	0.259	0.236	0.269
6	0.275	0.315	0.310	0.279	0.259	0.287	0.281
7	0.381	0.393	0.288	0.301	0.303	0.289	0.287
8	0.342	0.472	0.360	0.341	0.348	0.336	0.309
9	0.381	0.433	0.336	0.460	0.295	0.381	0.329
10	0.519	0.456	0.425	0.384	0.384	0.415	0.367
11	0.345	0.526	0.487	0.472	0.502	0.565	0.423

Table 18.6: Sole 27.7.d - Tuning series 1: new Belgian commercial beam trawl CPUE (2004–2018)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2004	1	0.89	0.34	0.5	0.18	0.04	0.04
2005	1	0.49	0.45	0.12	0.08	0.06	0.03
2006	1	0.4	0.34	0.32	0.13	0.13	0.06
2007	1	0.61	0.29	0.12	0.23	0.09	0.11
2008	1	0.74	0.69	0.16	0.11	0.09	0.05
2009	1	0.53	0.52	0.34	0.08	0.05	0.05
2010	1	0.56	0.18	0.29	0.15	0.05	0.03
2011	1	0.79	0.25	0.14	0.1	0.07	0.02
2012	1	1.1	0.7	0.19	0.06	0.07	0.07
2013	1	0.29	0.57	0.44	0.13	0.06	0.07
2014	1	0.34	0.44	0.53	0.31	0.08	0.04
2015	1	0.39	0.37	0.42	0.51	0.36	0.12
2016	1	0.39	0.24	0.3	0.28	0.29	0.22
2017	1	0.7	0.43	0.22	0.25	0.23	0.31
2018	1	0.41	0.6	0.24	0.19	0.15	0.13

Table 18.7: Sole 27.7.d - Tuning series 2: new UK (E&W) commercial beam trawl (1986–2018)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
1986	1	171.22	118.87	33.17	34.08	46.66	1.41
1987	1	82.19	111.33	76.97	14.45	11.32	29.19
1988	1	233.77	46.82	52.26	32.89	7.44	9.56
1989	1	61.08	112.8	14.25	24.82	18.1	3.97
1990	1	192.54	28.04	38.88	8.31	8.9	8.9
1991	1	55.52	77.84	3.34	12.25	2.02	2.95
1992	1	134.67	21.19	43.66	2.9	5.28	1.68
1993	1	65.63	64.57	10.2	15.54	1.55	3.16
1994	1	83.13	45.9	36.1	8.76	14.48	1.41
1995	1	33.68	69.43	33.89	29.8	5.78	11.81
1996	1	87.48	27.65	58.8	29.44	23.45	6.1
1997	1	105.66	50.58	13.53	39.95	16.22	15.54
1998	1	90.5	52.07	34.83	11.83	27.63	15.39
1999	1	175.68	61.84	25.52	18.62	7.19	15.38
2000	1	101.49	97.33	31.07	14.67	10.32	3.92
2001	1	117.47	44.26	49.06	19.29	8.31	8.59
2002	1	205.29	101.57	32.79	25.12	10.46	8.48
2003	1	115.03	77.87	33.78	14.16	16.69	7.82
2004	1	273.56	64.1	38.66	20.26	5.97	11.29
2005	1	87	183.72	33.87	35.26	17.26	8.5
2006	1	158.84	51.42	85.63	14.37	12.74	6.14

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2007	1	190.48	72.05	21.71	64.46	15.05	14.77
2008	1	262.12	79	17.39	10.55	14.63	5.37
2009	1	44.86	107.88	39.07	6.06	4.93	10.49
2010	1	100.94	33.81	67.16	22.56	7.91	5.19
2011	1	96.13	47.19	13.09	29.44	8.55	1.98
2012	1	233.87	43.07	24.81	4.25	11.55	6.17
2013	1	87.16	159.58	29.02	16.98	5.36	7.19
2014	1	60.03	135.7	78.68	11.74	7.04	0.85
2015	1	81.67	43.55	83.64	62.81	8.75	5.62
2016	1	120.21	71.72	24.84	48.74	34.57	10.1
2017	1	100.93	47.77	30.01	12.76	30.13	26.71
2018	1	56.73	114.67	24.33	15.75	6.5	15.35

Table 18.8: Sole 27.7.d - Tuning series 3: French commercial otter trawl (2002–2018)

	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	1.00	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	0.30	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	1.00	0.44	0.10
2012	1	7.82	5.60	1.36	1.30	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	1.20	1.18	0.76	0.49
2017	1	1.73	1.23	0.76	0.85	0.74	0.65
2018	1	0.90	1.45	0.73	0.54	0.56	0.56

Table 18.9: Sole 27.7.d - Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2018)

	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
2018	1	14.86	36.49	6.66	10.32	1.74	2.13

Table 18.10: 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 18.11: Sole 27.7.d - Tuning series 6: French young fish survey (1987–2018) 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

	Effort	Age1
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
2018	1	0.03

Table 18.12: Sole 27.7.d - XSA diagnostics of the 2019 assessment

FLR XSA Diagnostics 2019-10-04 19:39:49

CPUE data from indices

Catch data for 37 years. 1982 to 2018. Ages 1 to 11.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE-CBT-CPUE	3	8	2004	2018	0	1
2	UK(E&W)-CBT-new	3	8	1986	2018	0	1
3	FR-COTB	3	8	2002	2018	0	1
4	UK(E&W)-BTS-Q3	1	6	1989	2018	0.5	0.75
5	UK(E&W)-YFS	1	1	1987	2006	0.5	0.75
6	FR-YFS	1	1	1987	2018	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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.061	0.020	0.005	0.014	0.017	0.050	0.014	0.042	0.014	0.038
2	0.276	0.230	0.193	0.135	0.178	0.138	0.172	0.070	0.084	0.065
3	0.466	0.365	0.317	0.279	0.251	0.328	0.213	0.208	0.108	0.147
4	0.538	0.462	0.360	0.355	0.300	0.428	0.263	0.186	0.200	0.144
5	0.264	0.406	0.405	0.296	0.247	0.279	0.310	0.222	0.184	0.142
6	0.461	0.389	0.335	0.473	0.231	0.253	0.240	0.208	0.209	0.152
7	0.481	0.293	0.194	0.203	0.442	0.263	0.244	0.143	0.139	0.166
8	0.229	0.336	0.249	0.216	0.205	0.581	0.268	0.187	0.131	0.132
9	0.442	0.199	0.233	0.206	0.139	0.203	0.299	0.391	0.145	0.085
10	0.172	0.168	0.081	0.103	0.163	0.114	0.181	0.453	0.357	0.153
11	0.172	0.168	0.081	0.103	0.163	0.114	0.181	0.453	0.357	0.153

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10	11
2009	47041	23423	15423	17888	7785	2343	1928	2614	962	1200	2706
2010	60780	40040	16084	8756	9447	5409	1337	1078	1881	560	2320
2011	45802	53919	28781	10106	4991	5695	3316	902	698	1395	2369
2012	24117	41246	40234	18960	6381	3012	3687	2473	636	500	2939
2013	17456	21520	32614	27546	12024	4296	1699	2724	1802	468	1266
2014	21196	15522	16299	22961	18467	8499	3086	987	2009	1419	2844

2015	31164	18241	12234	10620	13548	12639	5969	2146	500	1484	1645
2016	16088	27799	13896	8946	7387	8994	8998	4230	1485	335	653
2017	47967	13953	23452	10216	6722	5351	6608	7055	3173	909	535
2018	17041	42819	11610	19047	7571	5059	3929	5203	5598	2485	7019

Estimated population abundance at 1st Jan 2019

age

year	1	2	3	4	5	6	7	8	9	10	11
2019	0	14843	36304	9068	14927	5942	3931	3011	4129	4653	1929

Fleet: BE-CBT-CPUE

Log catchability residuals.

year

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
3	0.121	0.192	0.188	-0.058	-0.034	0.319	0.286	0.026	0.004	-1.132	-0.243	0.127	-0.003	0.011	0.198
4	0.080	-0.185	0.237	0.275	0.522	0.053	-0.328	-0.189	0.209	-0.396	-0.414	0.108	-0.190	0.267	-0.049
5	0.502	-0.533	-0.078	-0.351	0.260	0.295	0.008	-0.083	-0.073	0.110	-0.118	-0.027	0.203	-0.031	-0.083
6	0.290	-0.690	0.039	0.167	0.135	0.181	-0.060	-0.542	-0.352	-0.046	0.151	0.246	-0.029	0.378	0.133
7	-0.281	-0.366	0.219	0.204	-0.223	-0.041	0.239	-0.381	-0.482	0.250	-0.142	0.693	0.019	0.093	0.199
8	-0.304	-0.062	-0.016	0.480	0.136	-0.462	-0.038	-0.305	-0.076	-0.179	0.449	0.629	0.518	0.323	-0.242

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	-10.3278	-10.1966	-10.1571	-10.1986	-10.2421	-10.2421
S.E_Logq	0.3014	0.3014	0.3014	0.3014	0.3014	0.3014

Fleet: UK(E&W)-CBT-new

Log catchability residuals.

year

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3	0.670	0.453	0.812	0.519	0.482	-0.114	-0.338	-0.890	-0.629	-0.852	-0.321	0.246	0.024	0.214	0.368	0.007	0.265	-0.006	0.445	-0.033
4	0.393	0.839	0.500	0.778	0.459	0.080	-0.502	-0.614	-0.767	-0.374	-0.471	-0.211	0.176	0.261	0.171	0.076	0.381	-0.261	0.041	0.549
5	0.398	0.571	0.819	0.189	0.568	-0.878	0.214	-0.533	-0.537	-0.335	0.146	-0.267	0.227	0.210	0.305	0.194	0.439	-0.005	-0.165	0.095
6	0.389	0.111	0.163	0.604	0.391	0.057	-0.399	-0.361	-0.141	-0.203	0.111	0.318	0.381	0.137	0.176	0.324	0.002	0.163	0.076	0.461
7	0.163	-0.164	0.078	0.005	0.144	-0.413	-0.128	-0.408	0.009	0.030	0.124	0.129	0.465	0.556	0.052	0.089	0.219	0.280	-0.065	0.507
8	-0.259	-0.096	0.007	-0.242	-0.497	-0.658	-0.167	-0.314	-0.104	0.045	0.483	0.061	0.411	0.156	0.352	0.074	0.339	0.180	0.549	0.795

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
3	0.768	0.281	0.431	-0.647	0.076	-0.577	-0.041	-0.831	-0.474	0.067	0.323	-0.423	-0.277
4	-0.022	0.512	-0.015	0.110	-0.370	-0.227	-0.949	-0.039	0.040	-0.402	0.232	-0.301	-0.074
5	0.496	-0.168	-0.067	0.024	0.438	-0.560	-0.216	-0.716	-0.133	0.252	-0.396	-0.131	-0.480
6	-0.193	0.866	-0.238	-0.428	0.017	0.206	-1.029	-0.111	-1.151	0.122	0.194	-0.627	-0.387
7	0.015	0.534	0.078	-0.240	0.513	-0.365	-0.166	-0.047	-0.455	-0.906	0.010	0.179	-0.822
8	-0.178	0.590	0.023	0.094	0.326	-0.500	-0.387	-0.336	-1.284	-0.314	-0.445	-0.011	-0.260

```
 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 -4.9234 -4.9187 -5.1421 -5.2617 -5.4524 -5.4524
S.E_Logq   0.4150  0.4150  0.4150  0.4150  0.4150  0.4150

 Fleet:  FR-COTB
 Log catchability residuals.
   year
age   2002   2003   2004   2005   2006   2007  2008   2009   2010   2011   2012  2013  2014   2015   2016   2017   2018
  3 -0.178 -0.041  0.060 -0.379 -0.386  0.177 0.095  0.349 -0.090  0.236  0.559 0.314 0.312 -0.319  0.204 -0.491 -0.423
  4 -0.292 -1.069 -0.258 -0.587 -0.141  0.343 0.175  0.223  0.727 -0.054  0.872 0.146 0.572  0.118 -0.093 -0.098 -0.583
  5 -0.123 -0.370 -0.509 -0.361 -0.106  0.037 0.047 -0.503  0.450  0.489  0.562 0.123 0.218  0.217  0.256 -0.124 -0.303
  6 -0.659 -0.672 -0.269 -0.463 -0.269  0.079 0.181  0.096 -0.063  0.354  1.317 0.313 0.231 -0.144  0.003  0.195 -0.230
  7 -0.660 -0.569  0.155 -0.740 -0.405 -0.213 0.335 -0.116  0.046  0.103  0.560 1.394 0.355  0.059 -0.373 -0.093  0.161
  8 -1.583 -0.968 -0.212  0.192 -0.273 -0.875 0.637 -0.336  0.974 -0.051 -0.010 0.811 1.291  0.285 -0.036 -0.292 -0.136

 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 -8.9209 -8.7804 -8.8247 -8.7920 -8.8869 -8.8869
S.E_Logq   0.4808  0.4808  0.4808  0.4808  0.4808  0.4808

 Fleet:  UK(E&W)-BTS-Q3
 Log catchability residuals.
   year
age   1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999  2000   2001   2002   2003   2004   2005   2006
2007   2008
  1 -0.647  0.115 -0.004 -2.224 -1.936 -0.164 -0.179 -0.256  0.868 -0.690  1.329 0.128 -0.158  1.145  0.338  0.663  1.206 -0.263
-1.018 -0.770
  2  0.260 -0.574  0.124 -0.371  0.046 -0.960 -0.123 -0.170 -0.185  0.170 -0.314 0.471  0.189 -0.209  0.518 -0.155 -0.449  0.665
0.147 -0.552
  3  0.699 -0.363 -0.243  0.061  0.054  0.047 -0.858 -0.280 -0.189 -0.456  0.193 0.189  0.398 -0.205 -0.230 -0.067 -0.526 -0.098
0.479 -0.218
  4  0.094  0.459 -0.128 -0.383  0.613  0.055 -0.262 -0.600 -0.333 -0.276 -0.276 0.276 -0.114  0.496 -0.366 -0.289  0.086  0.124
-0.251  0.506
  5  0.086 -0.005  0.266 -0.020  0.343  0.400 -0.272 -0.235 -1.090 -0.441 -0.271 0.319  0.219 -0.773  0.266  0.011  0.287  0.069
-0.127 -0.748
  6 -0.699  0.117  0.131  0.420  0.244 -0.629  0.106 -0.167 -0.613 -0.781  0.184 0.046  0.028 -0.252 -0.402  0.326 -0.012 -0.497
0.136  0.000
   year
age   2009   2010   2011   2012   2013  2014   2015  2016   2017   2018
  1  1.299 -0.111 -0.032 -1.440 -2.002 1.387  0.973 0.743  0.640  1.062
  2  0.334  0.243 -0.151 -0.999 -0.408 0.501  0.628 0.582  0.499  0.243
  3  0.225 -0.204  0.236 -0.795  0.096 0.640  0.137 0.621  0.411  0.246
  4  0.316 -0.270 -0.477 -0.354  0.250 0.716 -0.265 0.180 -0.112  0.582
  5  1.028  0.303 -0.670 -0.451  0.142 0.187  0.395 0.595  0.268 -0.080
  6 -0.070  0.874  0.747 -0.435  0.115 0.337 -0.340 0.354  0.187  0.545

 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 -8.0203 -7.2079 -7.5551 -7.9504 -8.1471 -8.1602
```

```
S.E_Logq   0.5554  0.5554  0.5554  0.5554  0.5554  0.5554

 Fleet:  UK(E&W)-YFS
 Log catchability residuals.
   year
age  1987  1988   1989   1990  1991   1992  1993  1994  1995   1996   1997   1998  1999  2000   2001  2002  2003  2004  2005
2006
  1 0.711 0.102 -0.507 -0.413 0.524 -0.385 0.267 0.421 0.835 -0.767 -0.509 -0.043 -0.15 0.044 -1.728 0.307 0.021 0.844 0.561 -
0.134

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time
                1
Mean_Logq -9.7394
S.E_Logq   0.6203

 Fleet:  FR-YFS
 Log catchability residuals.
   year
age   1987   1988  1989  1990  1991   1992   1993  1994  1995  1996   1997   1998  1999  2000  2001   2002  2003  2004  2005  2006
2007
  1 -0.003 -0.029 0.272 0.597 0.518 -0.037 -1.257 1.345 0.761 0.165 -1.861 -0.191 0.682 0.236 1.697 -1.056 0.784 0.213 1.226 1.154
-0.501
   year
age   2008  2009   2010  2011  2012   2013  2014   2015   2016   2017   2018
  1 -0.924 2.371 -1.236 0.201 0.937 -0.644 -1.08 -0.677 -0.809 -1.696 -1.157

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time
                 1
Mean_Logq -12.0067
S.E_Logq    1.0207

 Terminal year survivor and F summaries:
  Age 1 Year class =2017
source
               scaledWts survivors yrcls
UK(E&W)-BTS-Q3     0.440     42923  2017
FR-YFS             0.438      4667  2017
fshk               0.122     20600  2017

 Age 2 Year class =2016
source
               scaledWts survivors yrcls
UK(E&W)-BTS-Q3     0.947     46302  2016
fshk               0.053     17796  2016

 Age 3 Year class =2015
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.281     11049  2015
UK(E&W)-CBT-new     0.151      6874  2015
FR-COTB             0.333      5940  2015
```

```
UK(E&W)-BTS-Q3      0.225     11595  2015
fshk                0.010      5781  2015

 Age 4 Year class =2014
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.400     14207  2014
UK(E&W)-CBT-new     0.190     13856  2014
FR-COTB             0.141      8330  2014
UK(E&W)-BTS-Q3      0.259     26713  2014
fshk                0.010      7266  2014

 Age 5 Year class =2013
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.369      5466  2013
UK(E&W)-CBT-new     0.191      3678  2013
FR-COTB             0.271      4387  2013
UK(E&W)-BTS-Q3      0.159      5486  2013
fshk                0.010      3215  2013

 Age 6 Year class =2012
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.390      4487  2012
UK(E&W)-CBT-new     0.209      2670  2012
FR-COTB             0.172      3124  2012
UK(E&W)-BTS-Q3      0.217      6778  2012
fshk                0.011      2518  2012

 Age 7 Year class =2011
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.442      3673  2011
UK(E&W)-CBT-new     0.376      1324  2011
FR-COTB             0.168      3537  2011
fshk                0.014      1946  2011

 Age 8 Year class =2010
source
                scaledWts survivors yrcls
BE-CBT-CPUE         0.500      3242  2010
UK(E&W)-CBT-new     0.362      3183  2010
FR-COTB             0.119      3602  2010
fshk                0.019      1832  2010

 Age 9 Year class =2009
source
     scaledWts survivors yrcls
fshk         1      1551  2009

 Age 10 Year class =2008
source
```

```
     scaledWts survivors yrcls
fshk         1      2199  2008
```

Survivors

```
Age =  1 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2017

Fleet =  FR-YFS
                   1
Survivors   4667.000
Raw weights    0.896

Fleet =  fshk
                   1
Survivors   20600.00
Raw weights     0.25

Fleet =  UK(E&W)-BTS-Q3
                    1
Survivors   42923.000
Raw weights     0.899

     Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "FR-YFS"         "4667"       "1.037"   "Inf"     "Inf"     "1" "0.438"     "0.116"
[2,] "fshk"           "20600"      "1.962"   "Inf"     "Inf"     "1" "0.122"     "0.028"
[3,] "UK(E&W)-BTS-Q3" "42923"      "1.035"   "Inf"     "Inf"     "1" "0.44"      "0.013"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "14843"  ""       ""       ""        "0.038"

Age =  2 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2016

Fleet =  FR-YFS
                  1
Survivors   6656.00
Raw weights    0.86

Fleet =  fshk
                   2
Survivors   17796.00
Raw weights     0.25

Fleet =  UK(E&W)-BTS-Q3
                    2         1
Survivors   46302.000 68835.000
Raw weights     4.462     0.863

     Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "FR-YFS"         "6656"       "1.037"   "Inf"     "Inf"     "1" "0.134"     "0.312"
[2,] "fshk"           "17796"      "1.936"   "Inf"     "Inf"     "1" "0.039"     "0.129"
[3,] "UK(E&W)-BTS-Q3" "49376"      "0.419"   "0.146"   "0.348"   "2" "0.827"     "0.048"
```

```
 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "36304"  ""       ""       ""        "0.065"

Age =  3 .  Catchability constand w.r.t. time and dependant on age

 Year class =  2015

Fleet =  BE-CBT-CPUE

                    3

Survivors   11049.000

Raw weights     6.775

Fleet =  FR-COTB

                   3

Survivors   5940.000

Raw weights    8.014

Fleet =  FR-YFS

                   1

Survivors   4038.000

Raw weights    0.708

Fleet =  fshk

                  3

Survivors   5781.00

Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3

                    3        2         1

Survivors   11595.000 14939.00 19060.000

Raw weights     5.417     3.78     0.711

Fleet =  UK(E&W)-CBT-new

                  3

Survivors   6874.00

Raw weights    3.64

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F

[1,] "BE-CBT-CPUE"     "11049"      "0.357"   "Inf"     "Inf"     "1" "0.231"     "0.122"

[2,] "FR-COTB"         "5940"       "0.328"   "Inf"     "Inf"     "1" "0.274"     "0.217"

[3,] "FR-YFS"          "4038"       "1.037"   "Inf"     "Inf"     "1" "0.024"     "0.304"

[4,] "fshk"            "5781"       "1.858"   "Inf"     "Inf"     "1" "0.009"     "0.222"

[5,] "UK(E&W)-BTS-Q3"  "13236"      "0.289"   "0.111"   "0.384"   "3" "0.338"     "0.103"

[6,] "UK(E&W)-CBT-new" "6874"       "0.487"   "Inf"     "Inf"     "1" "0.124"     "0.19"

 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "9068"   ""       ""       ""        "0.147"

Age =  4 .  Catchability constand w.r.t. time and dependant on age

 Year class =  2014
```

```
Fleet =  BE-CBT-CPUE

                    4         3

Survivors   14207.000 15086.000

Raw weights     9.623     6.102


Fleet =  FR-COTB

                   4        3

Survivors   8330.000 9131.000

Raw weights    3.381    7.218


Fleet =  FR-YFS

                   1

Survivors   7585.000

Raw weights    0.665


Fleet =  fshk

                  4

Survivors   7266.00

Raw weights    0.25


Fleet =  UK(E&W)-BTS-Q3

                    4         3         2         1

Survivors   26713.000 22514.000 26714.000 39497.000

Raw weights     6.227     4.878     3.452     0.667


Fleet =  UK(E&W)-CBT-new

                    4        3

Survivors   13856.000 9781.000

Raw weights     4.572    3.279


     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F

[1,] "BE-CBT-CPUE"     "14542"      "0.23"    "0.029"   "0.126"   "2" "0.313"     "0.147"

[2,] "FR-COTB"         "8867"       "0.276"   "0.043"   "0.156"   "2" "0.211"     "0.231"

[3,] "FR-YFS"          "7585"       "1.037"   "Inf"     "Inf"     "1" "0.013"     "0.266"

[4,] "fshk"            "7266"       "1.861"   "Inf"     "Inf"     "1" "0.005"     "0.276"

[5,] "UK(E&W)-BTS-Q3"  "25726"      "0.229"   "0.07"    "0.306"   "4" "0.303"     "0.086"

[6,] "UK(E&W)-CBT-new" "11980"      "0.325"   "0.172"   "0.529"   "2" "0.156"     "0.176"


Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "14927"  ""       ""       ""        "0.144"


Age =  5 .  Catchability constand w.r.t. time and dependant on age

 Year class =  2013


Fleet =  BE-CBT-CPUE

                   5        4       3

Survivors   5466.000 7760.000 5922.00

Raw weights    9.636    7.892    4.53


Fleet =  FR-COTB

                   5        4        3

Survivors   4387.000 5385.000 7289.000
```

```
Raw weights    7.084    2.773    5.359

Fleet =  FR-YFS
                  1
Survivors   2018.00
Raw weights    0.43

Fleet =  fshk
                  5
Survivors   3215.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                   5        4         3         2         1
Survivors   5486.000 5311.000 11055.000 11131.000 23780.000
Raw weights    4.149    5.107     3.622     2.314     0.432

Fleet =  UK(E&W)-CBT-new
                   5       4        3
Survivors   3678.000 4399.00 8207.000
Raw weights    4.995    3.75    2.434

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "6299"       "0.185"   "0.112"   "0.605"   "3" "0.341"     "0.135"
[2,] "FR-COTB"         "5445"       "0.22"    "0.161"   "0.732"   "3" "0.235"     "0.154"
[3,] "FR-YFS"          "2018"       "1.037"   "Inf"     "Inf"     "1" "0.007"     "0.372"
[4,] "fshk"            "3215"       "1.863"   "Inf"     "Inf"     "1" "0.004"     "0.249"
[5,] "UK(E&W)-BTS-Q3"  "7384"       "0.209"   "0.2"     "0.957"   "5" "0.241"     "0.116"
[6,] "UK(E&W)-CBT-new" "4652"       "0.259"   "0.219"   "0.846"   "3" "0.173"     "0.179"

Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "5942"   ""       ""       ""        "0.142"

Age =  6 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2012

Fleet =  BE-CBT-CPUE
                   6        5       4        3
Survivors   4487.000 3809.000 3250.00 4461.000
Raw weights    8.609    7.935    6.59    3.762

Fleet =  FR-COTB
                   6        5        4       3
Survivors   3124.000 3471.000 3582.000 2857.00
Raw weights    3.795    5.833    2.315    4.45

Fleet =  FR-YFS
                   1
Survivors   2064.000
Raw weights    0.382

Fleet =  fshk
```

```
                 6
Survivors   2518.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                  6        5        4        3        2       1
Survivors   6778.000 5136.000 4707.000 4507.000 6485.000 531.000
Raw weights    4.796    3.417    4.264    3.007    1.988   0.383

Fleet =  UK(E&W)-CBT-new
                  6        5        4        3
Survivors   2670.000 3449.000 4957.000 4201.000
Raw weights    4.612    4.113    3.131    2.021

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "3947"       "0.161"   "0.075"   "0.466"   "4" "0.356"     "0.152"
[2,] "FR-COTB"         "3228"       "0.202"   "0.051"   "0.252"   "4" "0.217"     "0.183"
[3,] "FR-YFS"          "2064"       "1.037"   "Inf"     "Inf"     "1" "0.005"     "0.273"
[4,] "fshk"            "2518"       "1.853"   "Inf"     "Inf"     "1" "0.003"     "0.229"
[5,] "UK(E&W)-BTS-Q3"  "5182"       "0.19"    "0.168"   "0.884"   "6" "0.236"     "0.118"
[6,] "UK(E&W)-CBT-new" "3538"       "0.225"   "0.137"   "0.609"   "4" "0.183"     "0.168"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "3931"   ""       ""       ""        "0.152"

Age =  7 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2011

Fleet =  BE-CBT-CPUE
                  7        6        5        4       3
Survivors   3673.000 4392.000 3686.000 3353.000 2360.00
Raw weights    7.934    6.889    6.112    4.699    2.39

Fleet =  FR-COTB
                  7        6        5        4        3
Survivors   3537.000 3658.000 3890.000 3386.000 4114.000
Raw weights    3.019    3.037    4.493    1.651    2.828

Fleet =  FR-YFS
                  1
Survivors   7686.000
Raw weights    0.234

Fleet =  fshk
                 7
Survivors   1946.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                  6        5       4        3        2       1
Survivors   3628.000 5456.000 2310.00 5707.000 2002.000 714.000
Raw weights    3.838    2.632    3.04    1.911    1.214   0.235
```

```
Fleet =  UK(E&W)-CBT-new
                   7       6       5       4       3
Survivors   1324.000 1609.000 2026.000 2014.000 1874.000
Raw weights    6.744    3.691    3.168    2.232    1.284

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "3643"       "0.149"   "0.08"    "0.537"   "5" "0.381"     "0.139"
[2,] "FR-COTB"         "3752"       "0.196"   "0.032"   "0.163"   "5" "0.204"     "0.136"
[3,] "FR-YFS"          "7686"       "1.037"   "Inf"     "Inf"     "1" "0.003"     "0.069"
[4,] "fshk"            "1946"       "1.84"    "Inf"     "Inf"     "1" "0.003"     "0.247"
[5,] "UK(E&W)-BTS-Q3"  "3480"       "0.195"   "0.196"   "1.005"   "6" "0.175"     "0.146"
[6,] "UK(E&W)-CBT-new" "1619"       "0.197"   "0.091"   "0.462"   "5" "0.233"     "0.29"

Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "3011"   ""       ""       ""        "0.166"

Age =  8 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2010

Fleet =  BE-CBT-CPUE
                   8       7       6       5       4       3
Survivors   3242.000 4533.00 4012.000 4020.000 2730.000 1331.00
Raw weights    6.691    7.15    6.211    5.051    3.293    1.81

Fleet =  FR-COTB
                   8       7       6       5       4       3
Survivors   3602.000 3761.00 4142.000 5126.000 7315.000 5652.000
Raw weights    1.587    2.72    2.738    3.713    1.157    2.141

Fleet =  FR-YFS
                   1
Survivors   5045.000
Raw weights    0.187

Fleet =  fshk
                  8
Survivors   1832.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                  6       5       4       3       2       1
Survivors   5879.00 6128.000 8448.000 4542.000 1521.00 3999.000
Raw weights    3.46    2.175    2.131    1.447    0.96    0.187

Fleet =  UK(E&W)-CBT-new
                   8       7       6       5       4       3
Survivors   3183.000 4937.000 5012.000 5314.000 4296.000 1798.000
Raw weights    4.849    6.078    3.328    2.618    1.565    0.973

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "3536"       "0.144"   "0.132"   "0.917"   "6" "0.406"     "0.152"
```

```
[2,] "FR-COTB"         "4652"       "0.197"   "0.094"   "0.477"   "6" "0.189"     "0.118"
[3,] "FR-YFS"          "5045"       "1.037"   "Inf"     "Inf"     "1" "0.003"     "0.109"
[4,] "fshk"            "1832"       "1.873"   "Inf"     "Inf"     "1" "0.003"     "0.275"
[5,] "UK(E&W)-BTS-Q3"  "5400"       "0.201"   "0.201"   "1"       "6" "0.139"     "0.102"
[6,] "UK(E&W)-CBT-new" "4211"       "0.185"   "0.124"   "0.67"    "6" "0.261"     "0.129"

Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "4129"   ""       ""       ""        "0.132"

Age =  9 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2009

Fleet =  BE-CBT-CPUE
                   8       7        6        5        4        3
Survivors   6425.000 4740.00 5949.000 4135.000 3132.000 4671.000
Raw weights    6.147    6.54    5.505    4.615    3.419    1.828

Fleet =  FR-COTB
                   8        7        6        5        4        3
Survivors   3475.000 3204.000 4029.000 5784.000 5385.000 8133.000
Raw weights    1.458    2.488    2.427    3.393    1.201    2.162

Fleet =  FR-YFS
                   1
Survivors   1352.000
Raw weights    0.175

Fleet =  fshk
                  9
Survivors   1551.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                   6        5        4        3        2        1
Survivors   3312.000 5610.000 5976.000 2101.000 3999.000 4163.000
Raw weights    3.067    1.987    2.213    1.461    0.914    0.176

Fleet =  UK(E&W)-CBT-new
                   8        7       6        5        4        3
Survivors   4603.000 4698.000 5258.00 4074.000 4474.000 4466.000
Raw weights    4.455    5.559    2.95    2.392    1.624    0.982

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "4920"       "0.142"   "0.103"   "0.725"   "6" "0.404"     "0.081"
[2,] "FR-COTB"         "4803"       "0.195"   "0.144"   "0.738"   "6" "0.189"     "0.082"
[3,] "FR-YFS"          "1352"       "1.037"   "Inf"     "Inf"     "1" "0.003"     "0.266"
[4,] "fshk"            "1551"       "1.917"   "Inf"     "Inf"     "1" "0.004"     "0.236"
[5,] "UK(E&W)-BTS-Q3"  "4020"       "0.197"   "0.163"   "0.827"   "6" "0.141"     "0.098"
[6,] "UK(E&W)-CBT-new" "4639"       "0.183"   "0.032"   "0.175"   "6" "0.259"     "0.085"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
```

```
[1,] "4653"   ""       ""       ""        "0.085"

Age =  10 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2008

Fleet =  BE-CBT-CPUE
                   8        7        6        5        4        3
Survivors   3238.000 3858.000 2243.000 2153.000 2377.000 1979.000
Raw weights    4.697    4.517    3.751    3.247    2.276    1.171

Fleet =  FR-COTB
                   8        7        6        5      4        3
Survivors   1860.000 2045.000 2429.000 2181.000 4613.0 2442.000
Raw weights    1.114    1.719    1.653    2.387    0.8    1.385

Fleet =  FR-YFS
                    1
Survivors   20651.000
Raw weights     0.104

Fleet =  fshk
                 10
Survivors   2199.00
Raw weights    0.25

Fleet =  UK(E&W)-BTS-Q3
                   6        5        4        3        2        1
Survivors   2702.000 2222.000 1353.000 2442.000 2458.000 7069.000
Raw weights    2.089    1.398    1.473    0.936    0.564    0.104

Fleet =  UK(E&W)-CBT-new
                   8       7      6       5       4        3
Survivors   1236.000 780.000 610.00 942.000 746.000 1083.000
Raw weights    3.404   3.839   2.01   1.683   1.081    0.629

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "2753"       "0.144"   "0.109"   "0.757"   "6" "0.407"     "0.11"
[2,] "FR-COTB"         "2342"       "0.198"   "0.102"   "0.515"   "6" "0.188"     "0.128"
[3,] "FR-YFS"          "20651"      "1.037"   "Inf"     "Inf"     "1" "0.002"     "0.015"
[4,] "fshk"            "2199"       "1.852"   "Inf"     "Inf"     "1" "0.005"     "0.136"
[5,] "UK(E&W)-BTS-Q3"  "2203"       "0.199"   "0.135"   "0.678"   "6" "0.136"     "0.136"
[6,] "UK(E&W)-CBT-new" "882"        "0.186"   "0.111"   "0.597"   "6" "0.262"     "0.309"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "1929"   ""       ""       ""        "0.153"
```

Table 18.13: Sole 27.7.d - XSA summary

Year	Recruitment	SSB	Landings	Discards	F
	Age 1				Ages 3–7
	thousands	tonnes	tonnes	tonnes	Year^{-1}
1982	15248	10766	3190	183	0.29
1983	28446	13496	3458	100	0.31
1984	25146	14318	3575	131	0.37
1985	14134	16547	3837	219	0.24
1986	28716	16729	3932	139	0.26
1987	12260	16942	4791	179	0.43
1988	30665	17048	3853	188	0.34
1989	18852	19988	3805	171	0.51
1990	53750	16962	3647	300	0.35
1991	40044	15901	4351	317	0.45
1992	39988	19074	4072	251	0.35
1993	18525	18036	4299	247	0.29
1994	31843	15271	4383	123	0.31
1995	24092	15237	4420	249	0.35
1996	22190	16261	4797	166	0.41
1997	33687	16002	4764	143	0.50
1998	21170	13209	3363	120	0.37
1999	31109	14543	4135	227	0.41
2000	42905	14453	3476	180	0.32
2001	38902	14147	4025	280	0.31
2002	56244	14373	4733	390	0.30
2003	25507	21617	6977	473	0.47
2004	21726	16470	6283	308	0.45
2005	42350	16949	5056	319	0.35
2006	46040	15563	5040	229	0.34
2007	23280	13684	5588	379	0.48
2008	27205	16420	5256	256	0.43
2009	47041	15039	5251	360	0.44
2010	60780	13063	4269	438	0.38
2011	45802	16031	4225	477	0.32
2012	24117	16975	4131	533	0.32
2013	17456	20534	4372	466	0.29
2014	21196	19172	4655	528	0.31
2015	31164	15663	3443	294	0.25
2016	16088	14947	2538	344	0.19
2017	47967	15810	2228	200	0.17
2018	17041	19901	2314	311	0.15

Table 18.14: Sole 27.7.d - XSA summary in relative terms. Recruitment, SSB and F are relative to the mean of the time-series.

Year	Recruitment	SSB	Landings	Discards	F
	Age 1		tonnes	tonnes	Ages 3–7
1982	0.49	0.67	3190	183	0.84
1983	0.92	0.84	3458	100	0.90
1984	0.81	0.89	3575	131	1.06
1985	0.46	1.03	3837	219	0.70
1986	0.93	1.04	3932	139	0.76
1987	0.40	1.05	4791	179	1.24
1988	0.99	1.06	3853	188	0.98
1989	0.61	1.24	3805	171	1.47
1990	1.74	1.05	3647	300	1.02
1991	1.30	0.99	4351	317	1.29
1992	1.29	1.18	4072	251	1.00
1993	0.60	1.12	4299	247	0.83
1994	1.03	0.95	4383	123	0.91
1995	0.78	0.94	4420	249	1.01
1996	0.72	1.01	4797	166	1.18
1997	1.09	0.99	4764	143	1.43
1998	0.69	0.82	3363	120	1.08
1999	1.01	0.90	4135	227	1.17
2000	1.39	0.90	3476	180	0.93
2001	1.26	0.88	4025	280	0.88
2002	1.82	0.89	4733	390	0.86
2003	0.83	1.34	6977	473	1.35
2004	0.70	1.02	6283	308	1.29
2005	1.37	1.05	5056	319	1.02
2006	1.49	0.96	5040	229	0.98
2007	0.75	0.85	5588	379	1.38
2008	0.88	1.02	5256	256	1.25
2009	1.52	0.93	5251	360	1.27
2010	1.97	0.81	4269	438	1.10
2011	1.48	0.99	4225	477	0.93
2012	0.78	1.05	4131	533	0.93
2013	0.57	1.27	4372	466	0.85
2014	0.69	1.19	4655	528	0.89
2015	1.01	0.97	3443	294	0.73
2016	0.52	0.93	2538	344	0.56
2017	1.55	0.98	2228	200	0.48
2018	0.55	1.23	2314	311	0.43

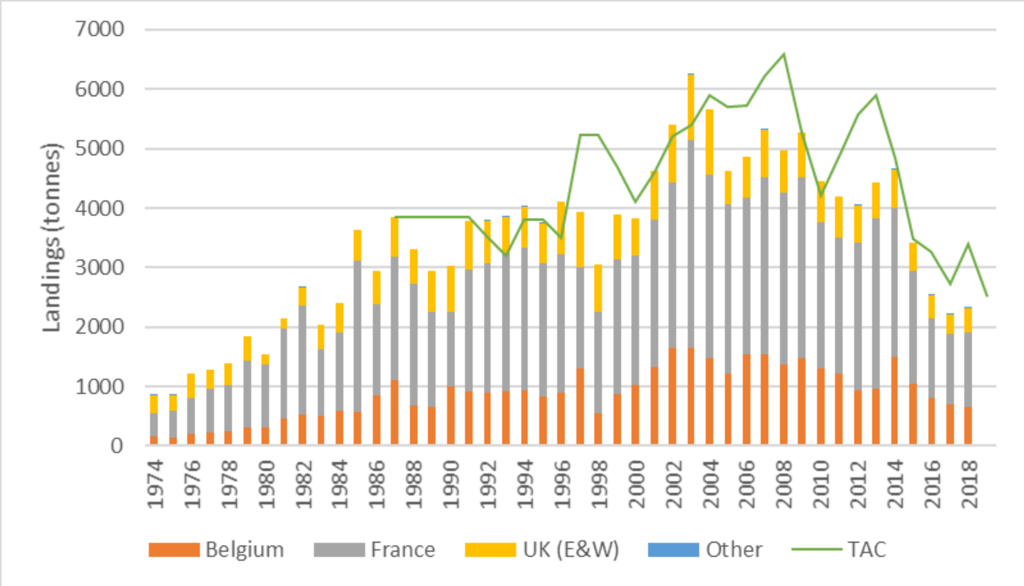

Figure 18.1: Sole 27.7.d - Official landings (tonnes) for sole in Division 27.7.d by country over the period 1974–2018, as officially reported (Rec 12) (stacked barplot; other represents landings from UK Scotland or The Netherlands); green line represents the official TAC (landings; Note that from 2016 onwards the TAC represents catch).

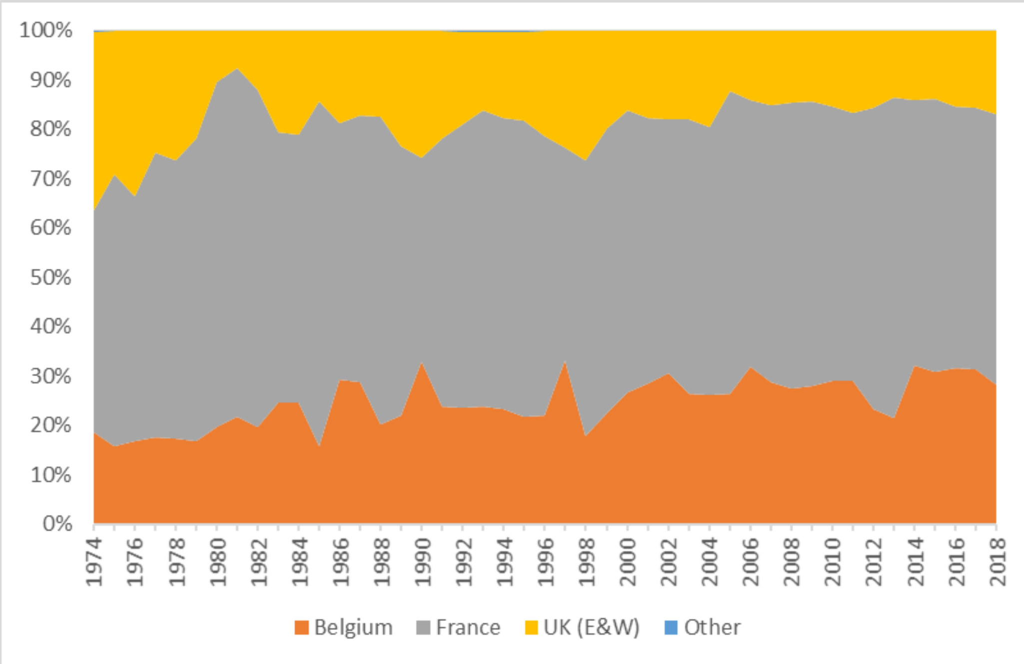

Figure 18.2: Sole 27.7.d - Relative contribution to the official landings of sole in Division 27.7.d for the main countries involved over the period 1974–2018.

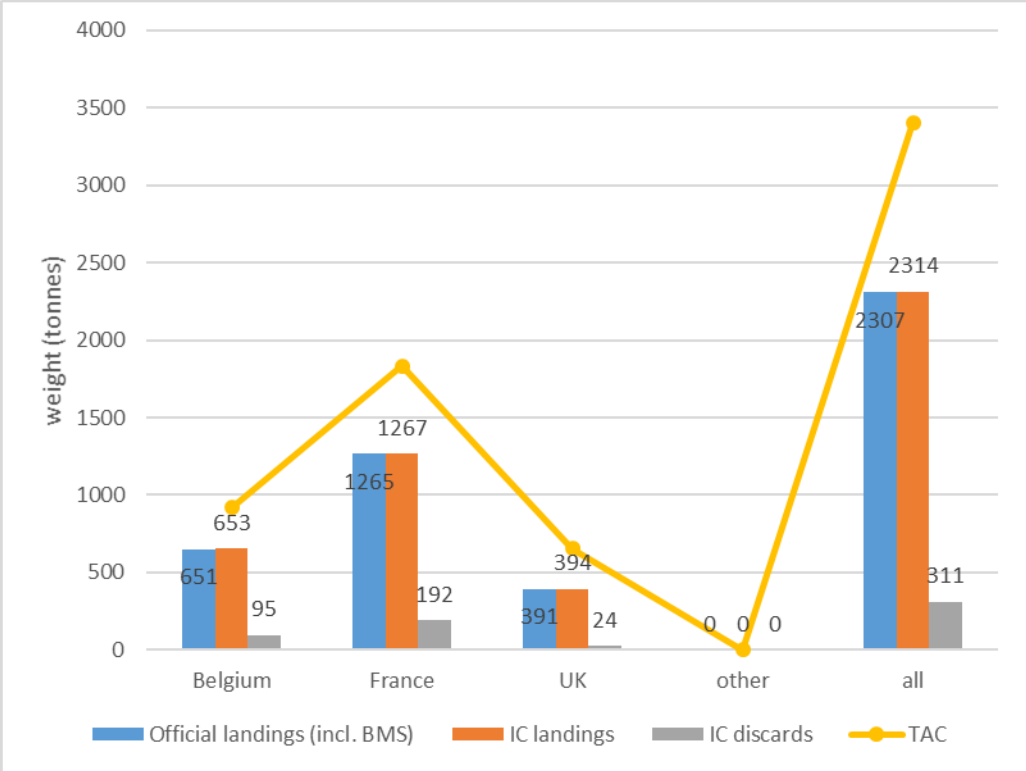

Figure 18.3: Sole 27.7.d - Uptake of the national quota and the total TAC of sole in 27.7.d in 2018.

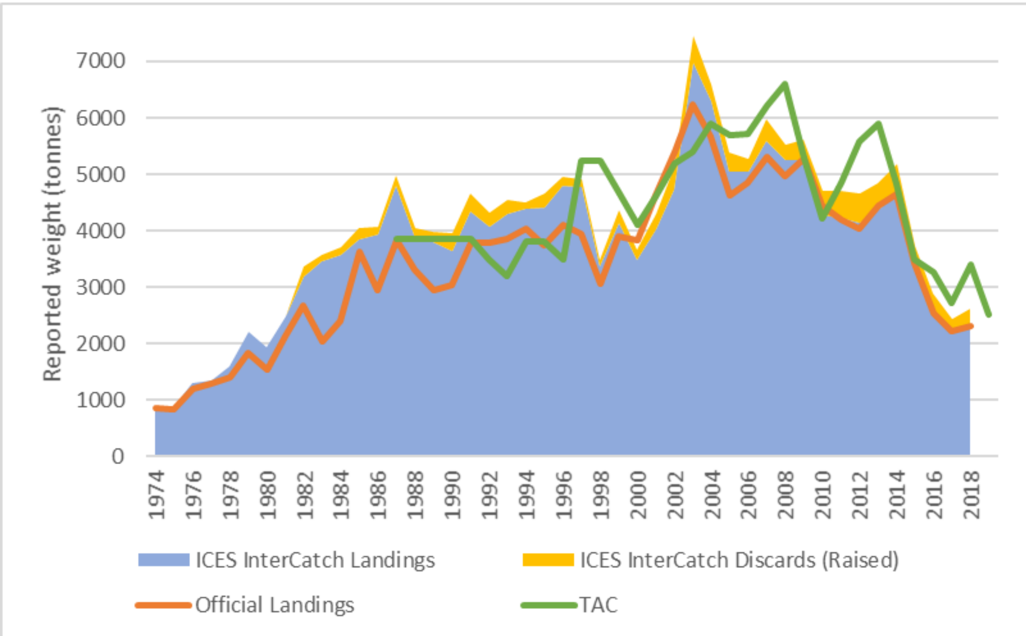

Figure 18.4: Sole 27.7.d - Historic overview (1974–2018) of the official landings, TAC and ICES estimates (InterCatch; including actual discards from 2004 onwards and extrapolated to years prior to 2004); Note that the TAC value represents catch from 2016 onwards.

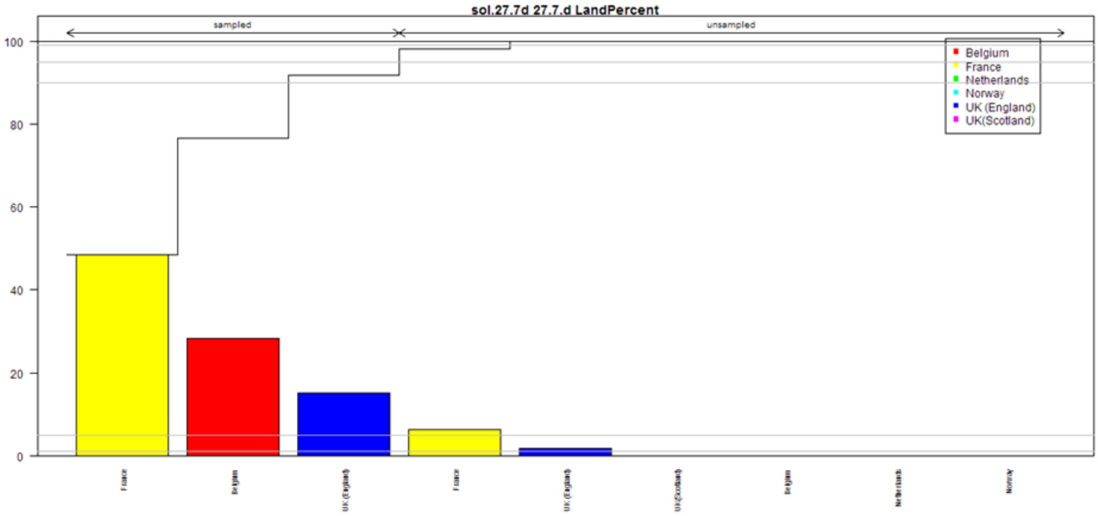

Figure 18.5: Sole 27.7.d - Overview of the proportion of 2018 landings of sole in Division 27.7.d for which samples (age) have been provided in InterCatch by country.

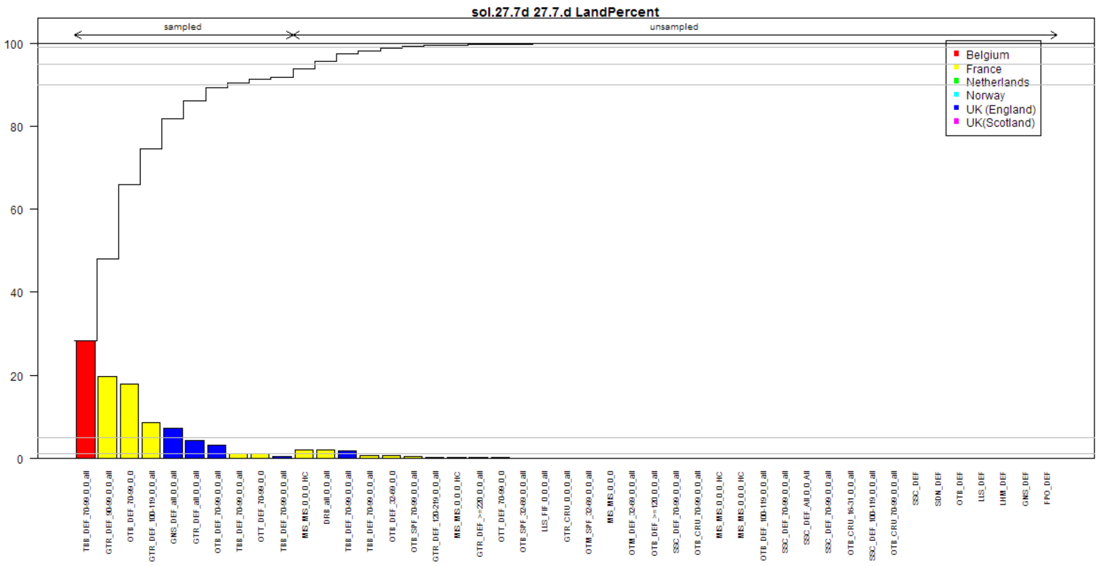

Figure 18.6: Sole 27.7.d - Overview of the proportion of 2018 landings of sole in Division 27.7.d for which samples have been provided in InterCatch by fleet and country.

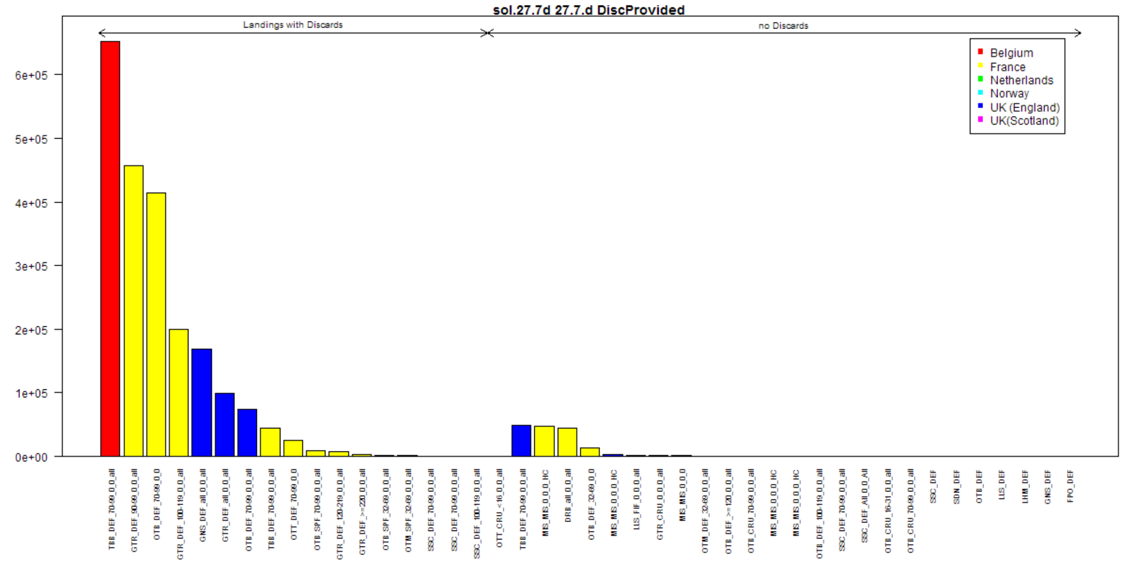

Figure 18.7: Sole 27.7.d - Overview of the 2018 landings with and without discards by fleet and country.

Figure 18.8: Sole 27.7.d - Discard weights-at-age (ages 1–5 are shown).

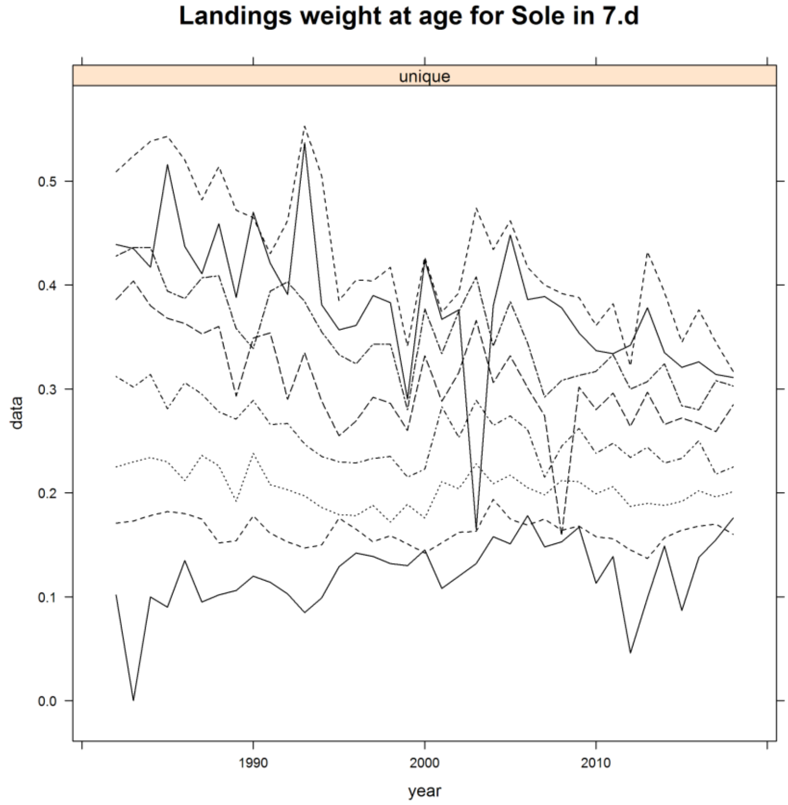

Figure 18.9: Sole 27.7.d - Landings weights-at-age (ages 1–8 are shown).

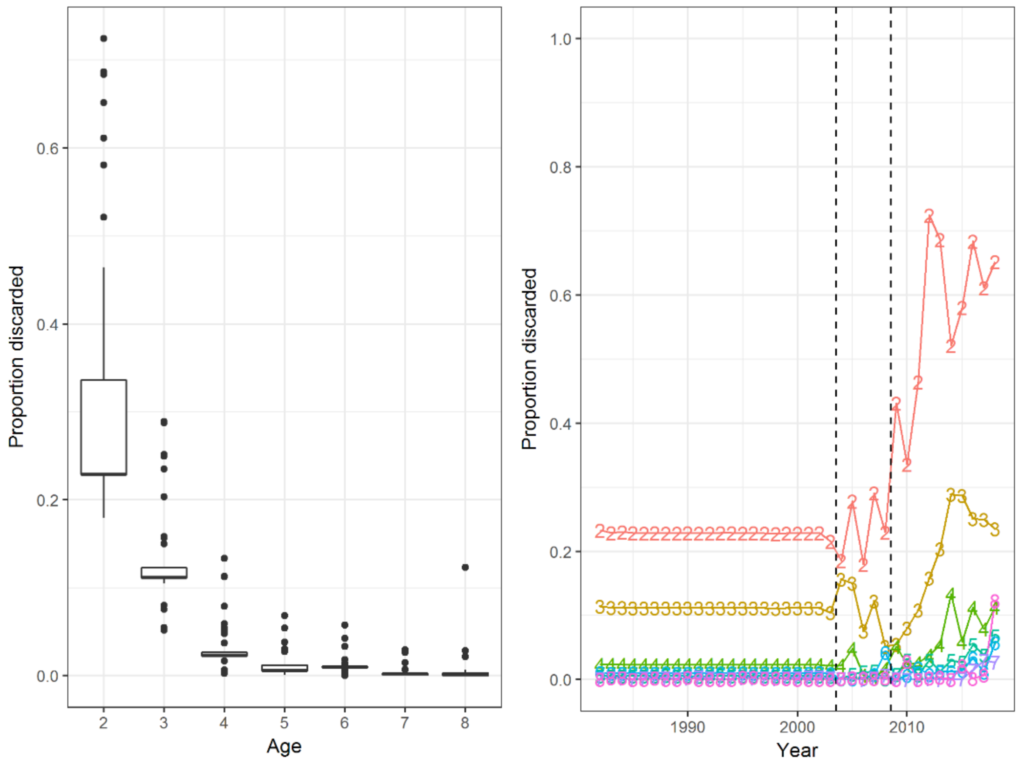

Figure 18.10: Sole 27.7.d - Proportion discarded (discard numbers/catch numbers) (data before 2004 are estimated based on an average ratio from 2004–2008 (indicated by dotted lines)) at age.

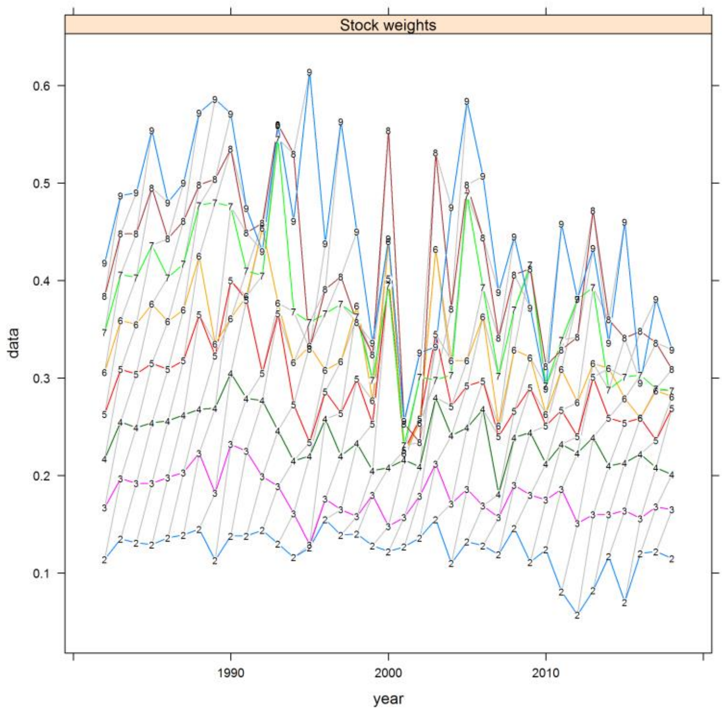

Figure 18.11: Sole 27.7.d - Stock weights (kg) at age (Q2) with indication of year classes (grey lines).

Figure 18.12: Sole 27.7.d - Standardized tuning indices at age.

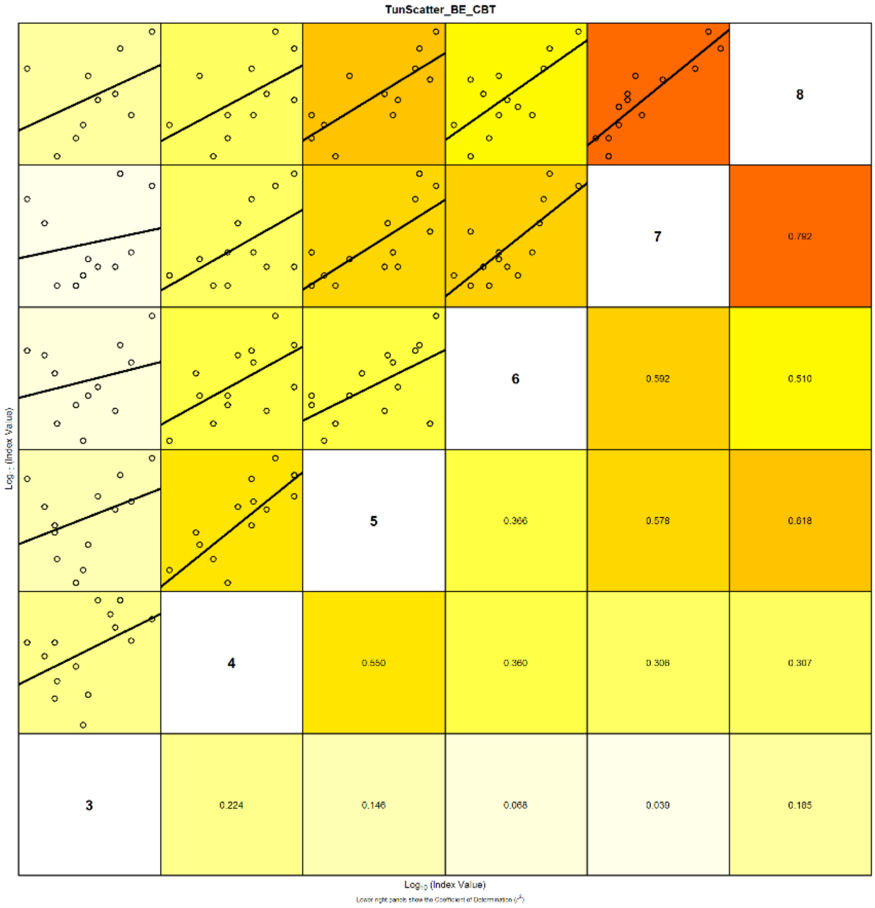

Figure 18.13: Sole 27.7.d - Internal consistency plot of the new BEL-CBT CPUE tuning series.

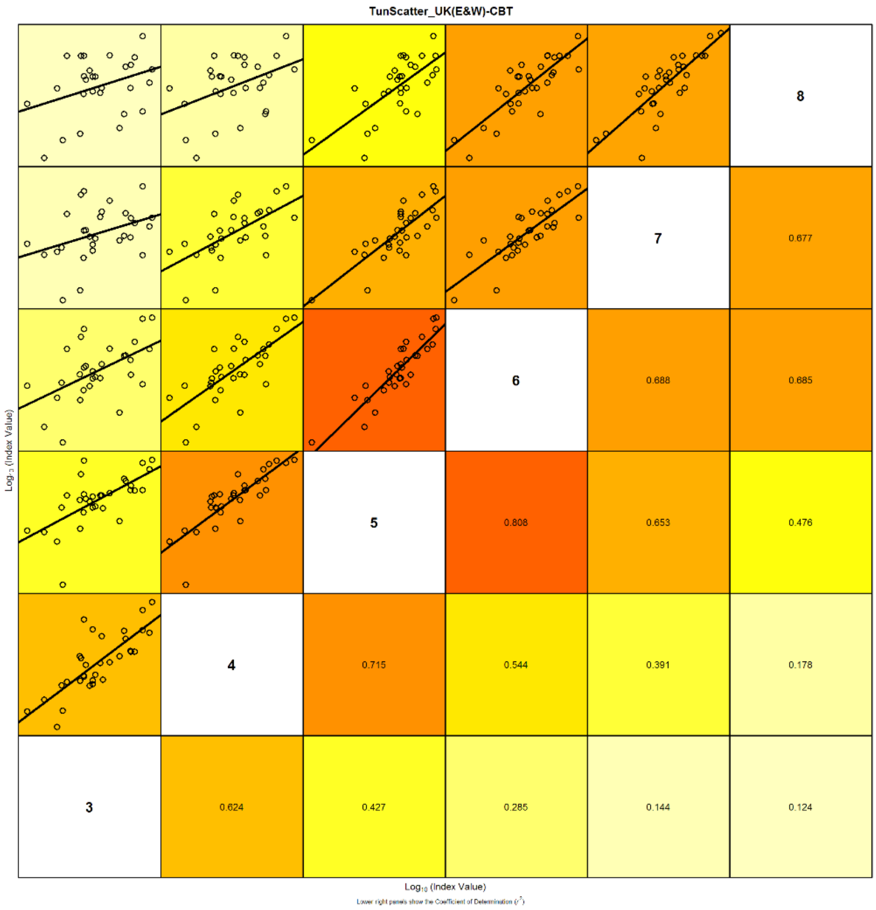

Figure 18.14: Sole 27.7.d - Internal consistency plot of the UK-CBT tuning series.

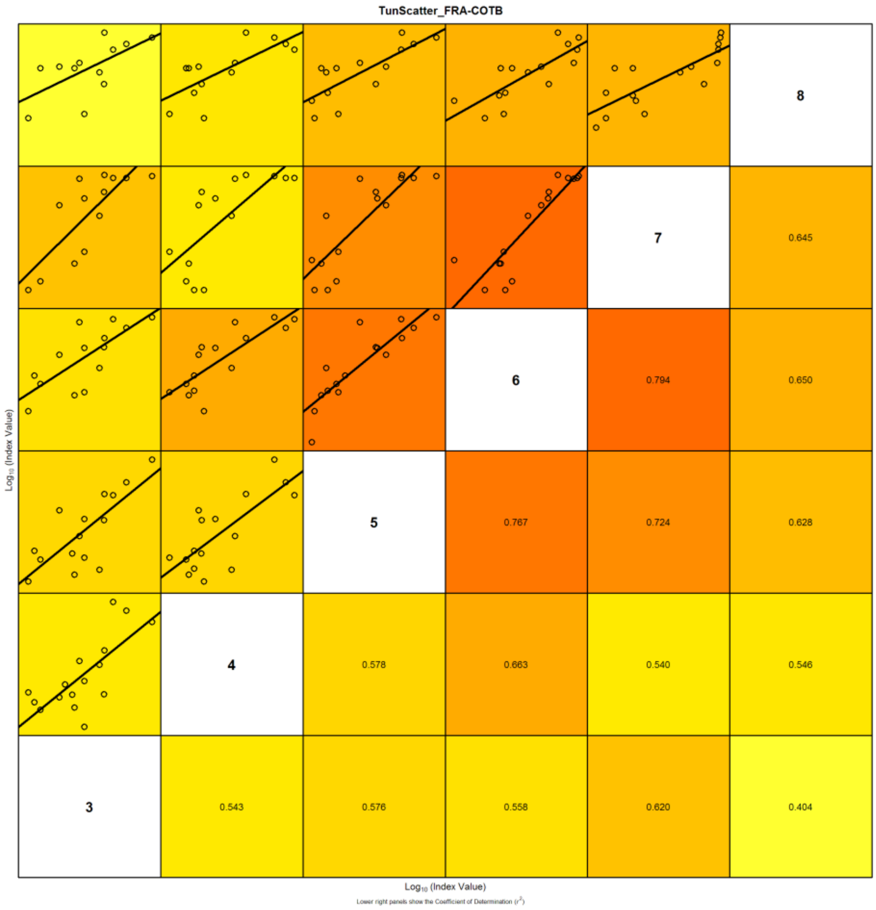

Figure 18.15: Sole 27.7.d - Internal consistency plot of the FRA-COT tuning series.

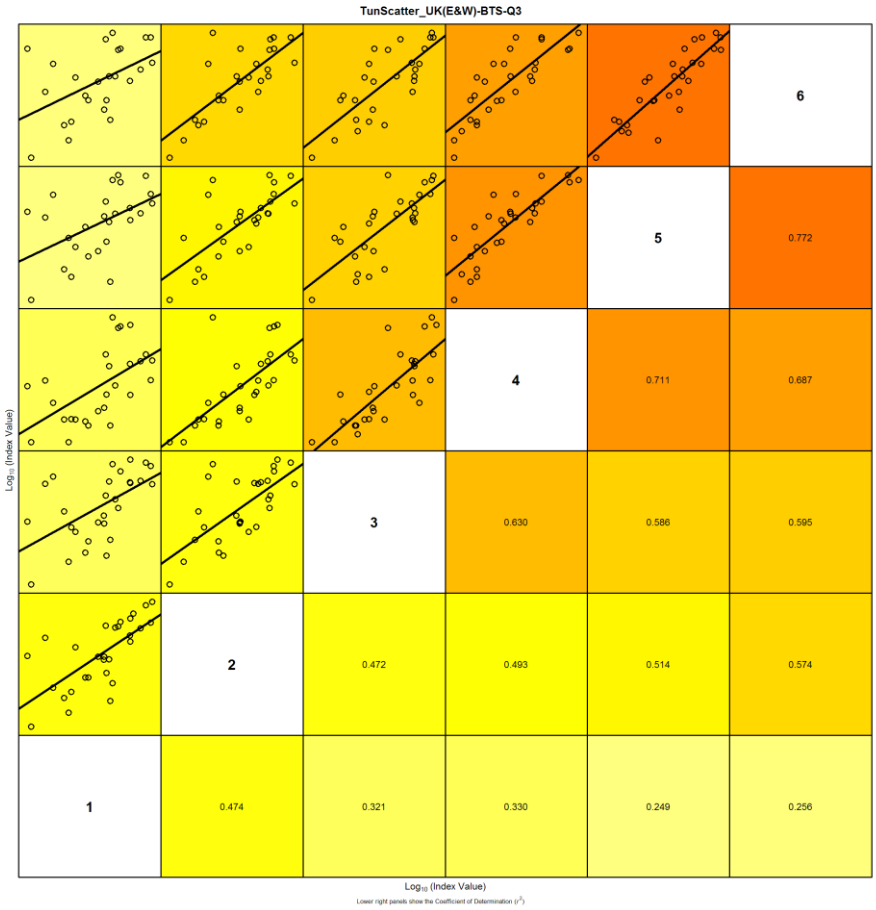

Figure 18.16: Sole 27.7.d - Internal consistency plot of the UK-BTS tuning series.

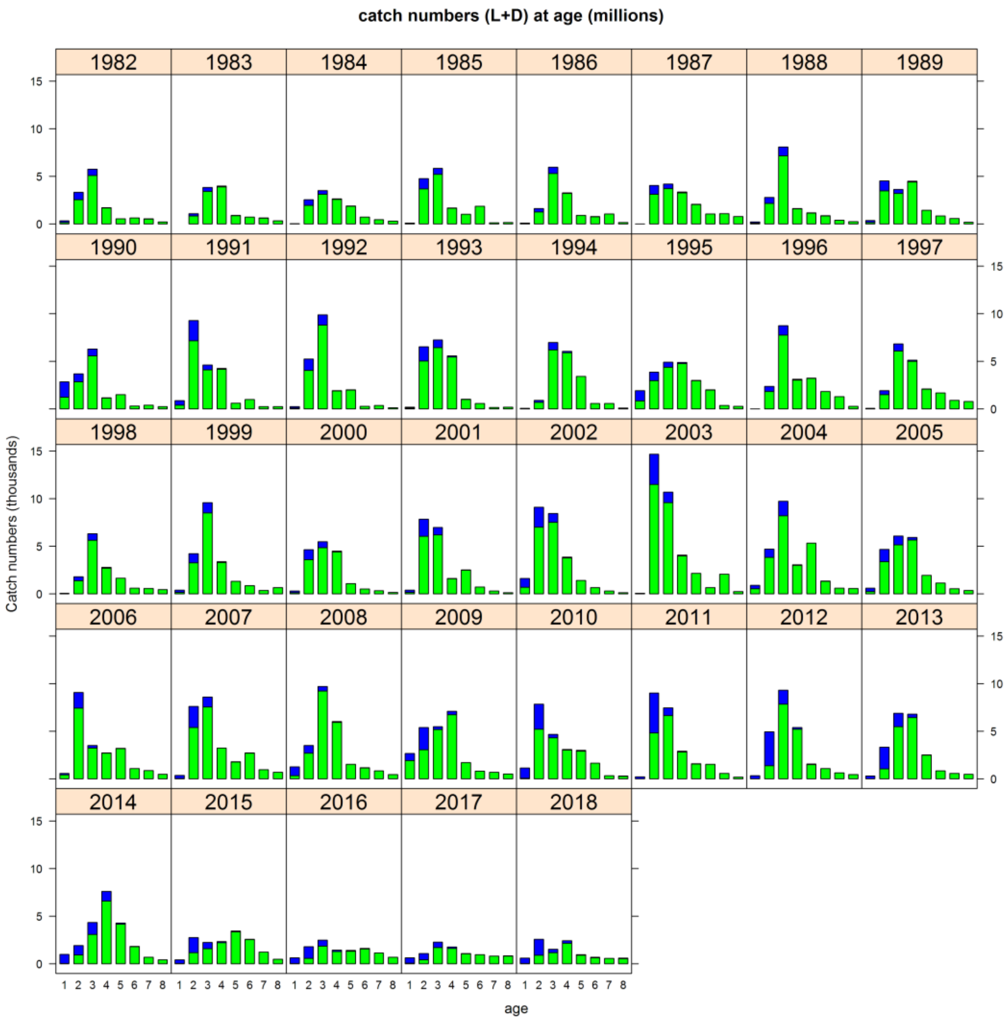

Figure 18.17: Sole 27.7.d - Catch numbers at age.

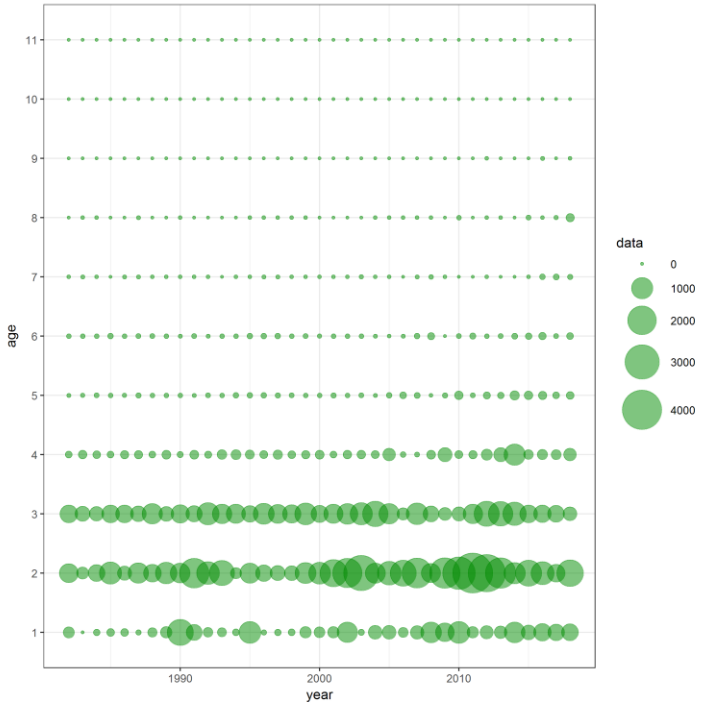

Figure 18.18: Sole 27.7.d – Discard numbers at age.

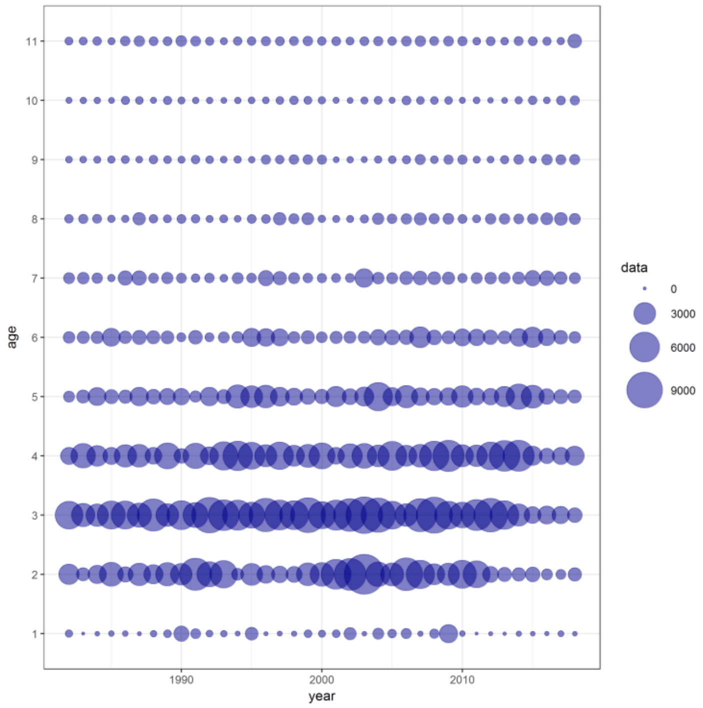

Figure 19.19: Sole 27.7.d – Landings numbers at age.

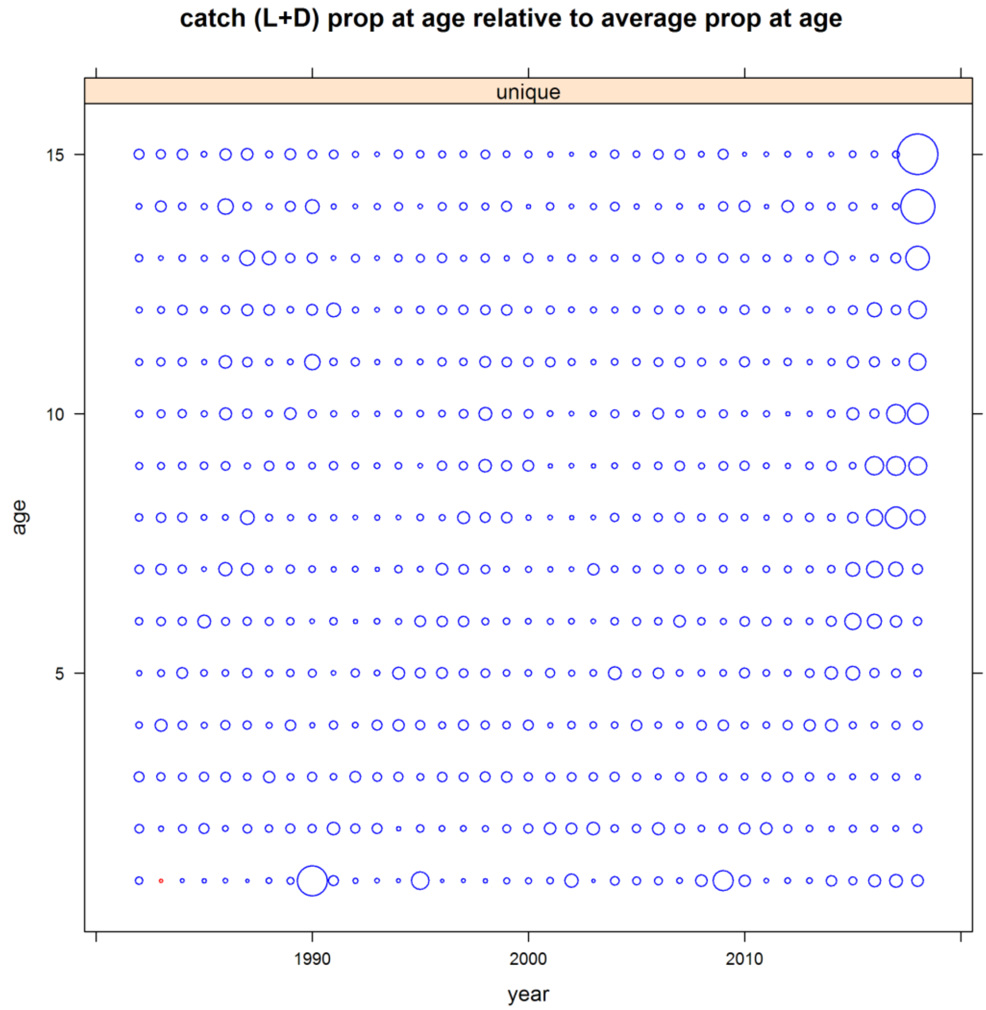

Figure 18.20: Sole 27.7.d - Catch proportion at age.

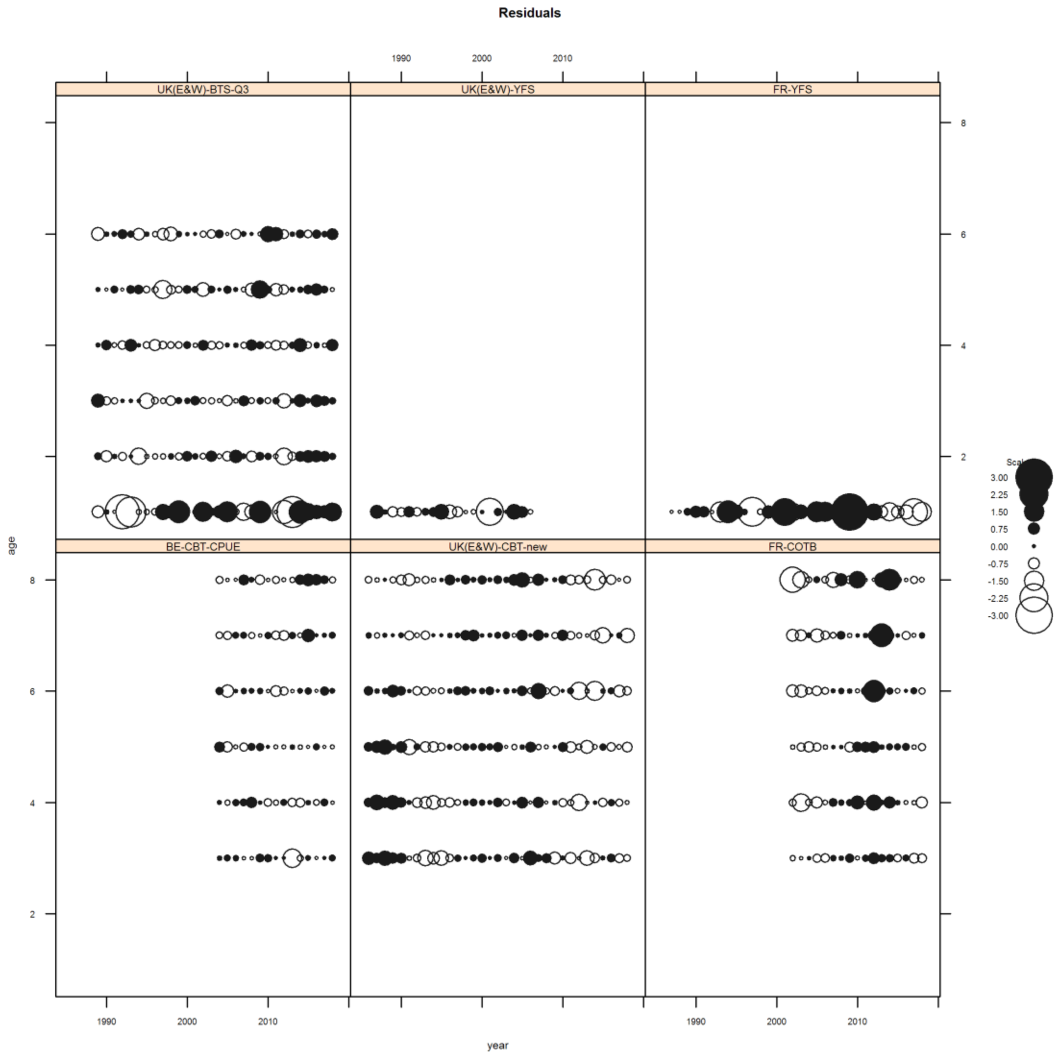

Figure 18.21: Sole 27.7.d - Catchability residuals for all tuning fleets used in the 2019 assessment.

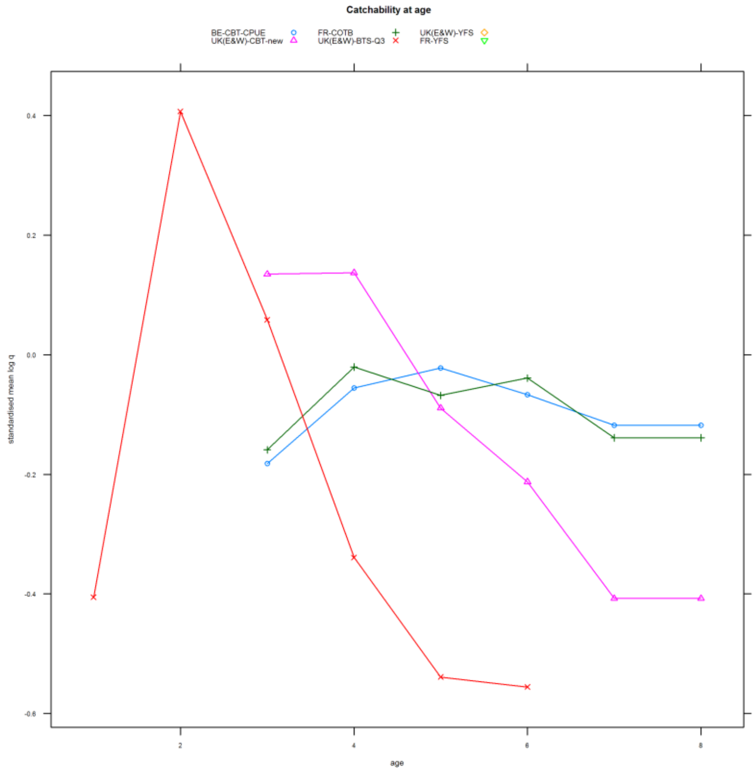

Figure 18.22: Sole 27.7.d – The standardized mean log catchability for all tuning fleets (note the YFS surveys only contain one age class).

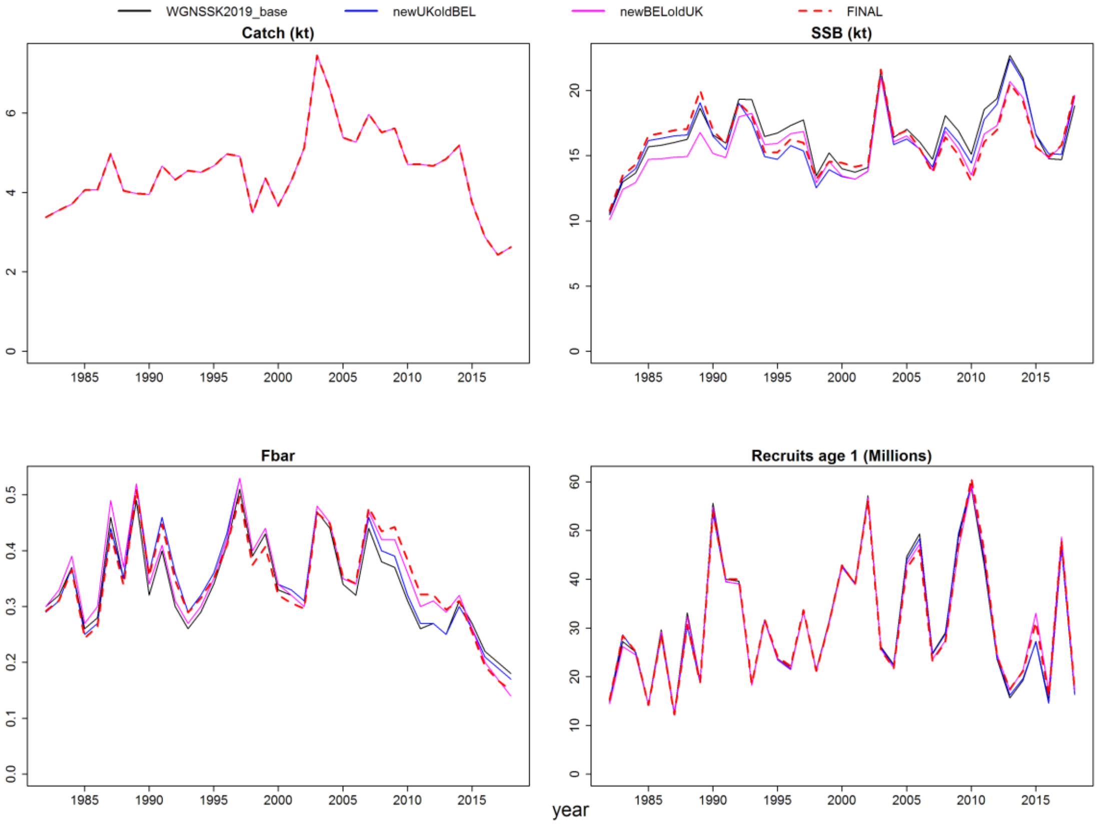

Figure 18.23: Sole 27.7.d - XSA summary: trends in catch, spawning stock biomass (SSB), Fbar and recruitment with indication of the 2019 WGNSSK baserun with the old UK CBT series up to 2016 (black line), the newUKoldBEL run including the new UK CBT and the old BE CBT (blue line), the newBELoldUK run including the new BE CBT and the old UK CBT (up to 2016) (pink line) and the 2019 assessment (dashed red line).

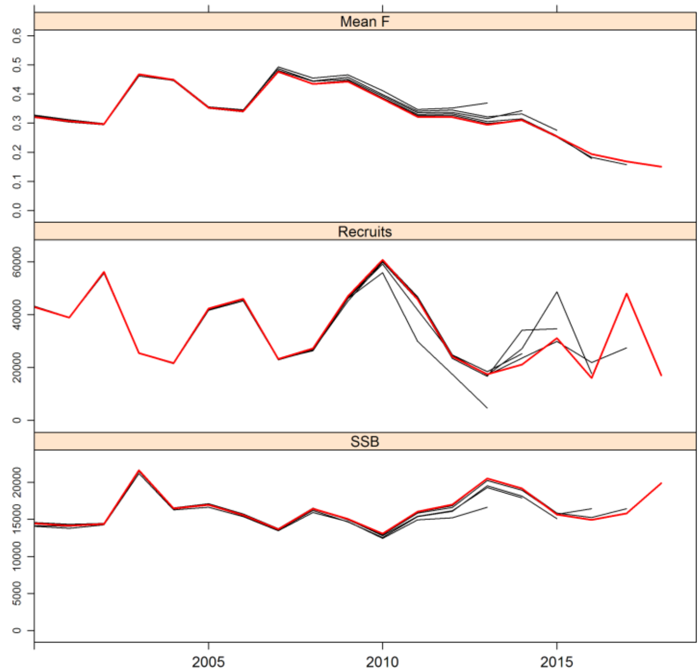

Figure 18.24: Sole 27.7.d - Retrospective pattern in F, recruitment and SSB.

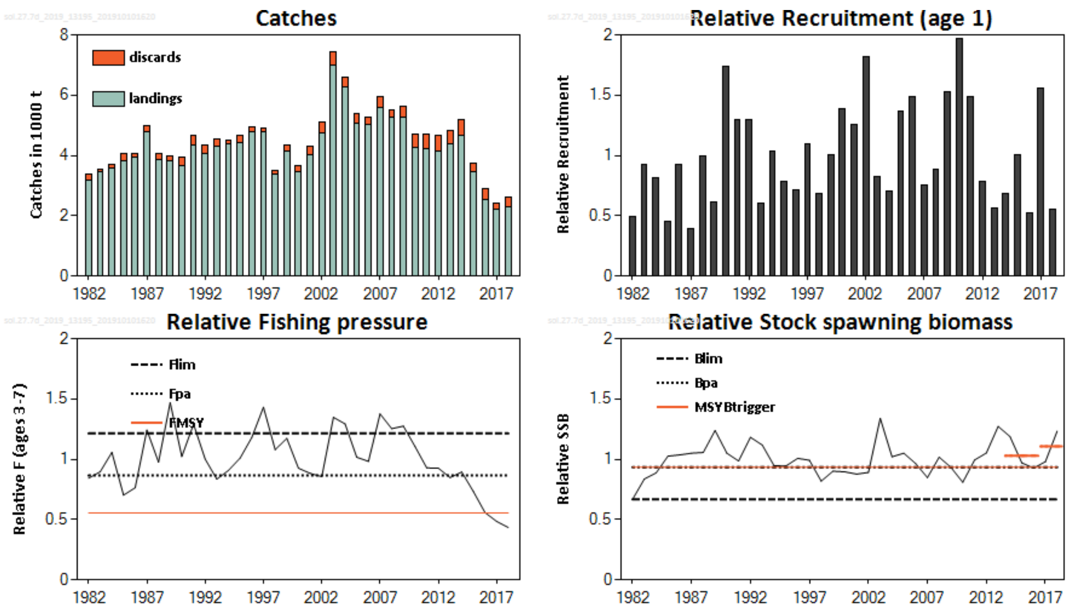

Figure 18.25: Sole 27.7.d – Summary of the 2019 assessment, Recruitment, F and SSB values are relative to the average of the time-series. The short orange lines in the relative SSB plot indicate the average values of the respective years (2014-2016 and 2017-2018). Reference points shown in the graphs are relative to the average of the time-series.

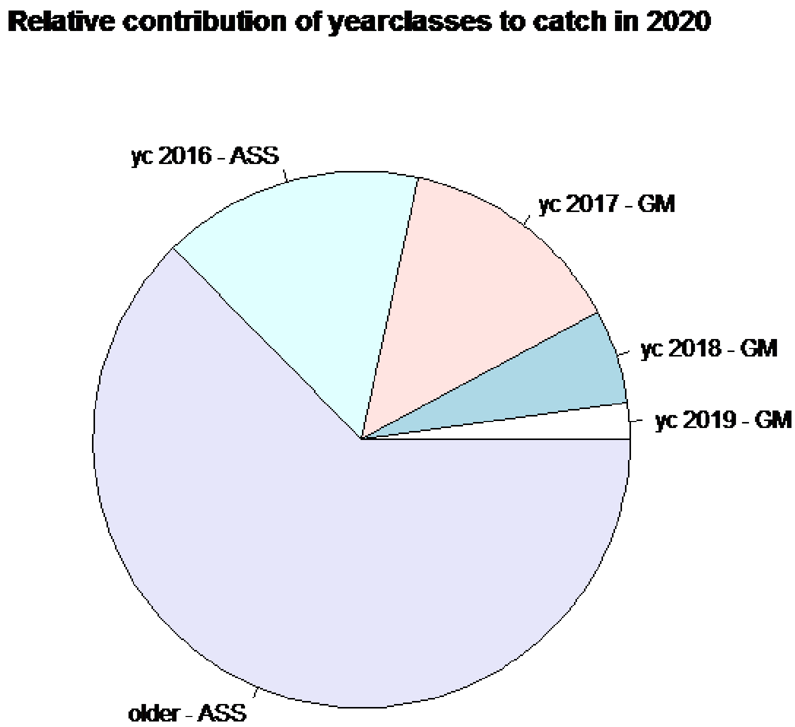

Figure 18.26: Sole 27.7.d - Relative contribution of year classes to catch in 2020 for TAC constraint option.

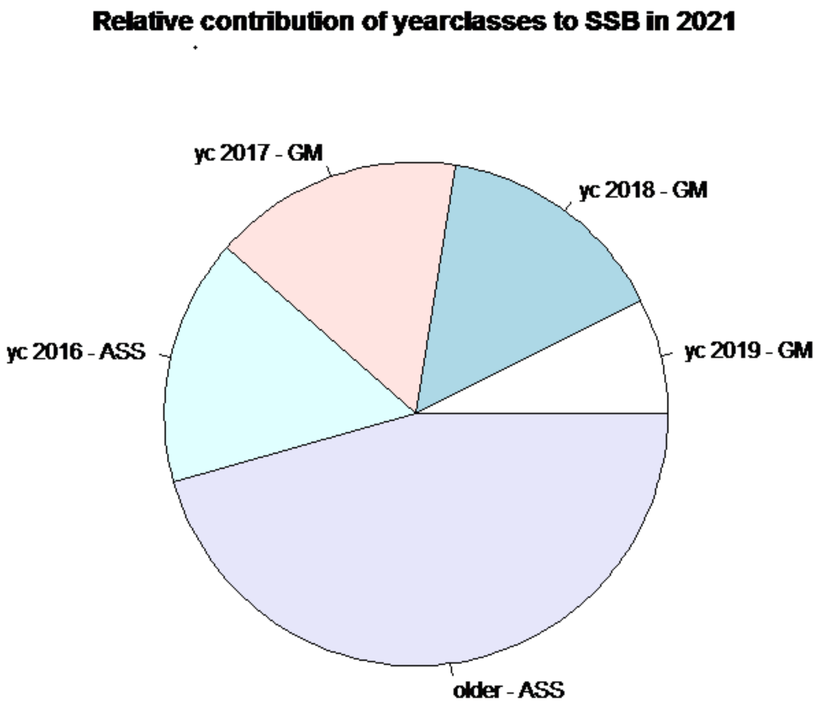

Figure 18.27: Sole 27.7.d - Relative contribution of year classes to SSB in 2021 for TAC constraint option.

19 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. 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 2018 have gradually decreased since 2015, the highest observed in the recent years. This decrease in landings follows the perception biomass estimated by the group. 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 2018 compared to the last 4 years. The structure of the population is still truncated and recent catches of this stock mainly consist of age 0 and age 1 fish. The fishery for striped red mullet would benefit from improved technical measures such as sorting grids, increased mesh size, and spatial and temporal closures. These measures could reduce the catches of small fish and contribute to more stable yields.

19.1 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.

19.2 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 has 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.

19.3 ICES advice

ICES has not been requested to provide advice on fishing opportunities for this stock.

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.

19.4 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.

19.5 Data available

19.5.1 Catch

Official landings data are shown by country in Table 19.5.1.1 and by area in Table 19.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 19.5.1.3 presents total official landings and ICES estimates over the period 2006–2017 as well as the predicted catch corresponding to advice. In 2018, 70% of the catches were made using demersal seines and 25% 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 2018 landings were provided under the ICES InterCatch format. Figure 19.5.1.1 shows that only landings from France in the Eastern Channel (representing around 25% of the total landings) were provided in 2014 to 2018 with an age structure, some landings made in area 4 were also provided from France with an age structure but only representing around 2% of the total landings. Figure 19.5.1.2 shows that IC data and official landings are consistent over years and countries.

Prior to 2009, no landings of age 0 were observed (Figure 19.5.1.3). 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.

19.5.2 Weight-at-age

Mean weight at age were computed as described in the Stock Annex and are presented in figures 19.5.2.1 and 19.5.2.2 and Table 19.5.2.1.

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.

19.5.3 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

19.5.4 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 19.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 19.5.4.2. 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, 2016 and 2017 and is in 2018 the second highest observed.

19.6 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 negligible.
Tuning indices	FR CGFS (since 2004 ages 0–4+)
Plus group	4
First tuning year	2004
Fishing mortality	~ s(year, k=7) + factor(age)
Survey catchability	~ factor(age)
Recruitment	~ factor(year)

Results from the assessment are presented in Figure 19.6.1. Log residuals of the model are presented in Figure 19.6.2 and observed and predicted catches in Figure 19.6.3 and indices in Figure 19.6.4.

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.

19.7 Length-based indicators screening

The ICES LBI were computed for three years of data (2014–2016 and 2018), using the length distributions from InterCatch (tables 19.7.1–2).

Most of the indicators appear outside the established references in 2018:

- 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 and 2018 (for Lc). This is directly linked with the good recruitment observed in 2014. The good recruitment observed in 2014 and 2018 decreased Lc and L25, but the two next years (2015–2016) 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 except for 2018 where the ratio is just above 1.

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 19.7.2).

Conclusions drawn from analyses:

The very good recruitment observed in 2014 was confirmed by the catches in 2015 and the remaining age 1 seen in 2015 during CGFS. There is no TAC on that species so the advice was not followed and the catches overshot the advice for 2015, 2016 and 2017 (4487, 2579, 2195 and 1650 tonnes against 460, 552, 552 and 465 tonnes respectively in the advice). In 2018, the recruitment as seen by CGFS seems to be the second highest since 2004. The population seems still aged truncated.

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016 and 2018) show in 2019 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

19.8 Issues List

Data and stock ID:

- Age (length) data from other countries than France need to be provided as everything is currently raised using the French catches in the Eastern Channel.
- No survey is available in the North Sea; IBTS/UK BTS should be investigated again. So work was done to assess the representativeness of the Eastern Channel data compared to the stock, but these should be investigated further.
- Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated

Assessment:

- With so few age classes exploited the a4a model used might not be the best model. Explore methods applied to "short lived species"?

Forecast and reference points:

- This stock is not category 1, so no forecast is done currently. This should be investigated if the assessment method is improved. However, there is no TAC for that stock so Forecast is not a priority, although reference points are still important.

19.9 References

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Gislason, H., Daan, N., Rice, J.C. and Pope, J.G. 2010. Size, growth, temperature and natural mortality of marine fish. Fish and Fisheries 11, 149–158.

ICES. 2015. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 2– 6 February 2015, Copenhagen, Denmark. ICES CM 2015/ACOM:32. 253 pp.

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ICES. 2017 (2). Report of the Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (2017), 26 April–5 May 2017, ICES HQ. ICES CM 2017/ACOM:21. 1248 pp.

Mahé K., Destombes A., Coppin F., Koubbi P., Vaz S., Leroy D. and Carpentier A. 2005. Le rouget barbet de roche Mullus surmuletus (L. 1758) en Manche orientale et mer du Nord, 186pp.

Table 19.5.1.1. 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

Year	Belgium	Denmark	France	Netherlands	UK	total
2014	79		765	912	246	2002
2015	250		1741	2657	679	5328
2016	147	0	556	1421	485	2609
2017	93	0.127	784	973	310	2160
2018	77	0.275	593	826	154	1650

1) No data reported by France in 1999.

2) ICES estimates.

Table 19.5.1.2. 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

Year	4	3.a	7.d	total
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
2018	384		1266	1650

[1)] **No data reported by France in 1999.**

Table 19.5.1.3. 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	1650	1648
2019	Precautionary approach	<465		
2020	No Advice	-		

Weights in tonnes.

Table 19.5.1.4. Striped red mullet landing numbers at age (thousands).

	0	1	2	3	4	5	6
2004	0	43076	1826	940	75	111	0
2005	0	16557	2448	262	56	199	0
2006	0	3900	2325	1674	109	78	0
2007	0	36872	1120	551	94	33	0
2008	0	1316	10459	1248	313	221	0
2009	45	13256	1075	540	83	0	0
2010	12971	13384	593	125	70	19	1
2011	0	9310	1453	639	76	4	0
2012	6	1337	1246	1479	181	2	0
2013	1170	2342	395	244	0	0	0
2014	9904	10556	1300	14	14	14	0
2015	1728	35360	5952	18	2	32	0
2016	38	3498	9680	2129	148	51	0
2017	872	10314	2974	1105	223	130	100
2018	1090	4869	2949	750	703	0	0

Table 19.5.2.1. Striped red mullet stock weights (kg).

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0,000	0,000	0,000	0,000	0,000	0,046	0,042	0,000	0,023	0,025	0,029	0,038	0,038	0,038	0,030
1	0,090	0,105	0,146	0,107	0,096	0,070	0,077	0,052	0,091	0,063	0,093	0,100	0,114	0,114	0,149
2	0,222	0,172	0,188	0,313	0,139	0,160	0,112	0,150	0,169	0,118	0,144	0,114	0,138	0,138	0,149
3	0,270	0,300	0,241	0,422	0,226	0,177	0,240	0,000	0,255	0,115	0,259	0,370	0,319	0,319	0,183
4	0,434	0,383	0,379	0,446	0,326	0,423	0,225	0,000	0,229	0,000	0,294	0,420	0,420	0,420	0,223
5	0,660	0,419	0,350	0,677	0,410	0,000	0,149	0,323	0,772	0,000	0,323	0,187	0,187	0,187	0,000
6	0,000	0,000	0,000	0,000	0,000	0,000	0,215	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Table 19.7.1. Striped red mullet 27.3a47d length based indicators.

Data Type	Value/Year	Source
Length at maturit	162 162 162	K. MahÃ©, 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. MahÃ©, 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 2018	Length data from IC
Length-weight relationship parameters for landings and discards	2014 2018	Mean weight at length from IC

Table 19.7.2. 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
2018	0.83	1.17	0.73	0.02	0.8	1.06

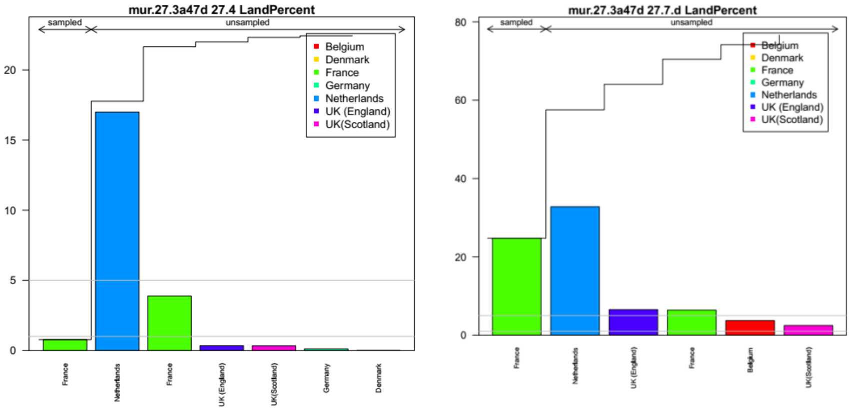


Figure 19.5.1.1. Striped red mullet in Subarea 4 and Division 7.d ICES landings by country (percentage over the total area).

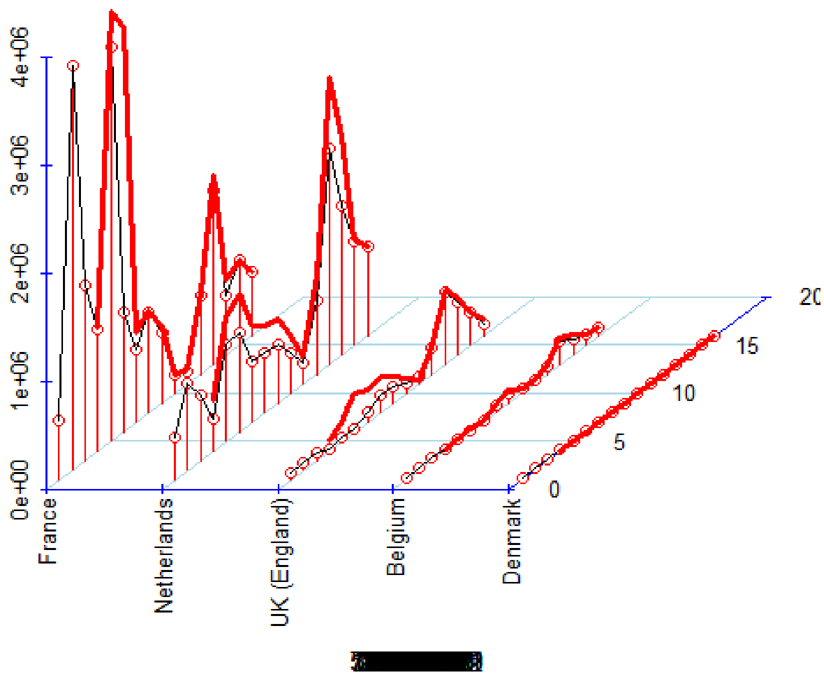


Figure 19.5.1.2. Striped red mullet in Subarea 7d and 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

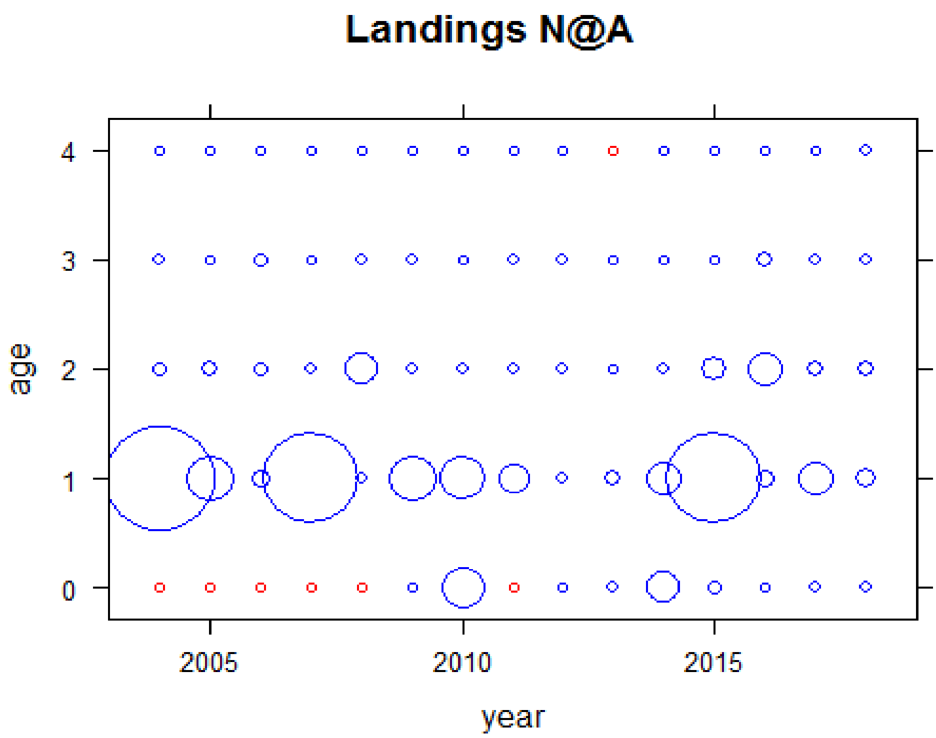


Figure 19.5.1.3. Striped red mullet age structure (in numbers) as provided in the landings.

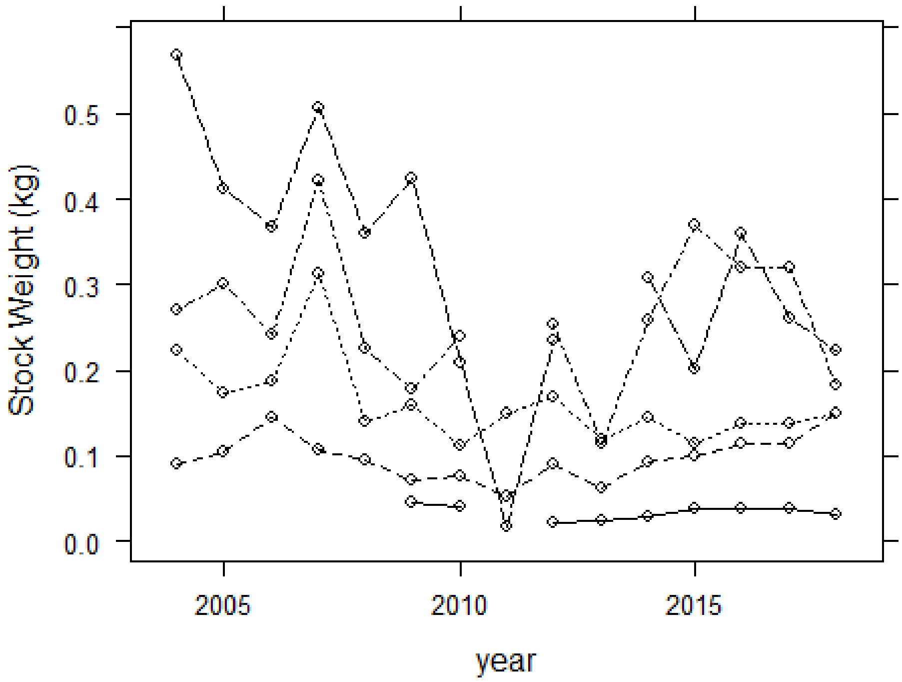


Figure 19.5.2.1. Weight at age in the stock.

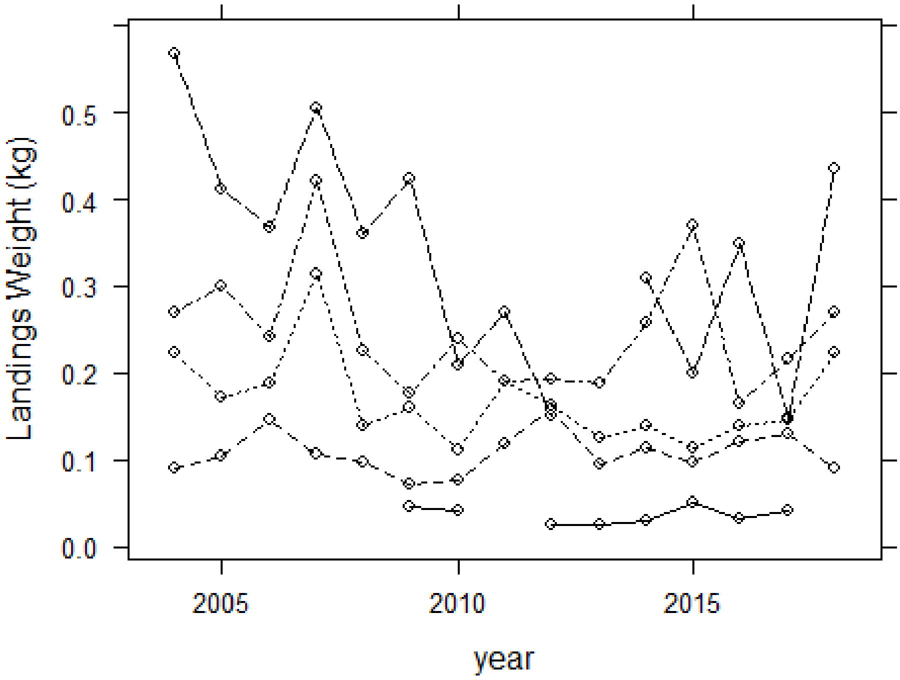


Figure 19.5.2.2. Weight at age in the landings.

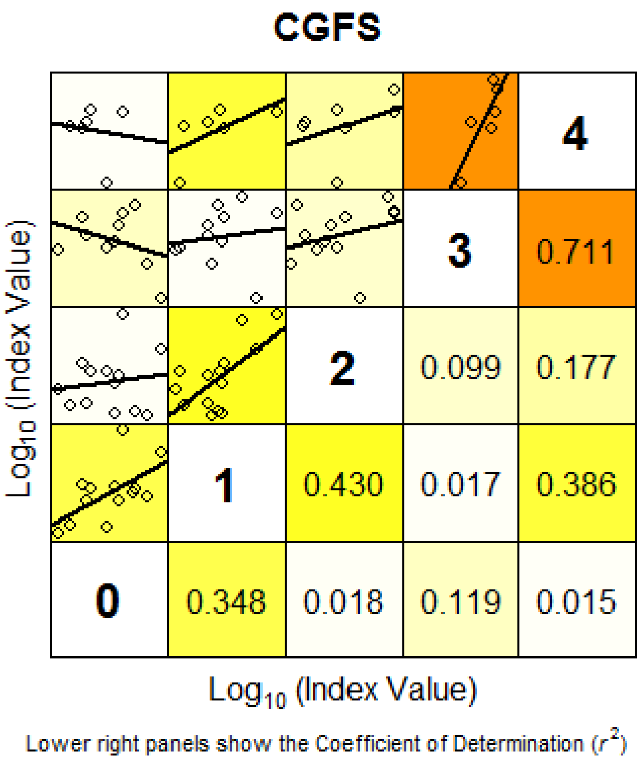


Figure 19.5.4.1. CGFS internal consistencies.

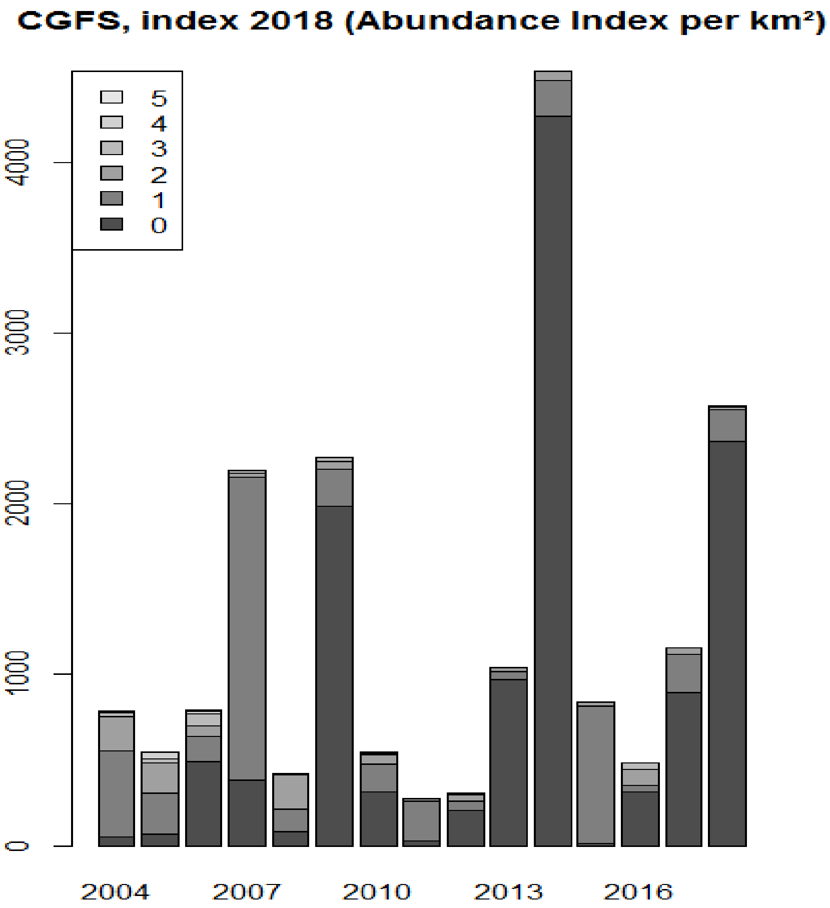


Figure 19.5.4.2. CGFS catch age composition.

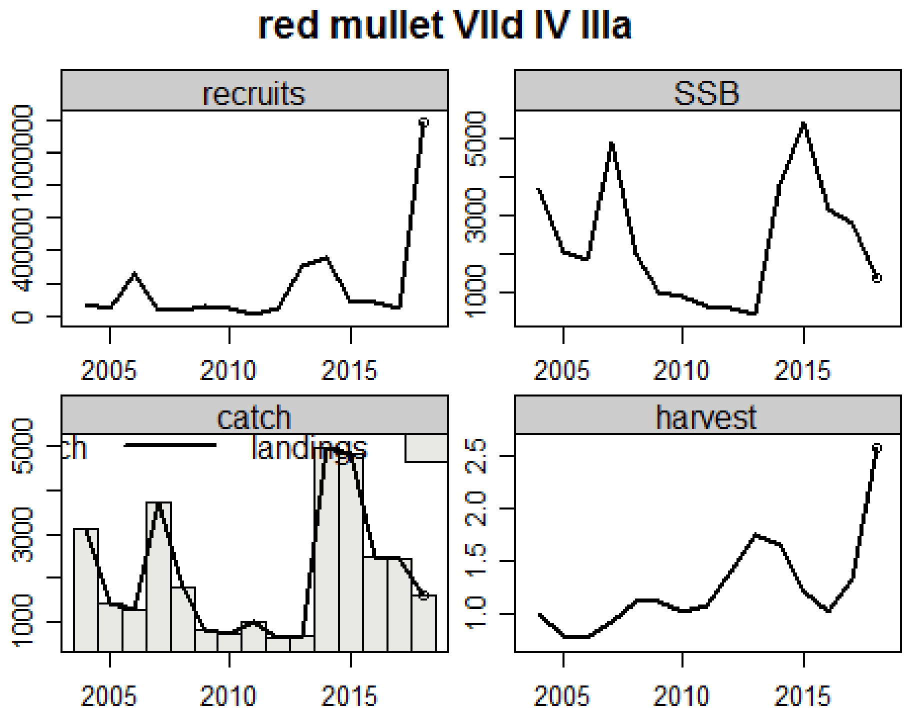


Figure 19.6.1. CGFS internal consistencies.

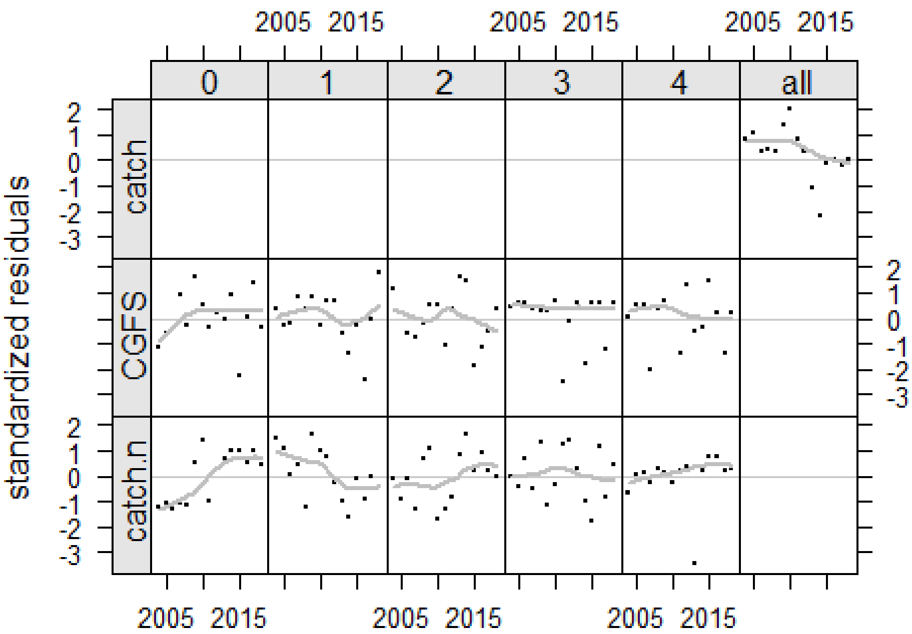


Figure 19.6.2. Log residuals of the assessment.

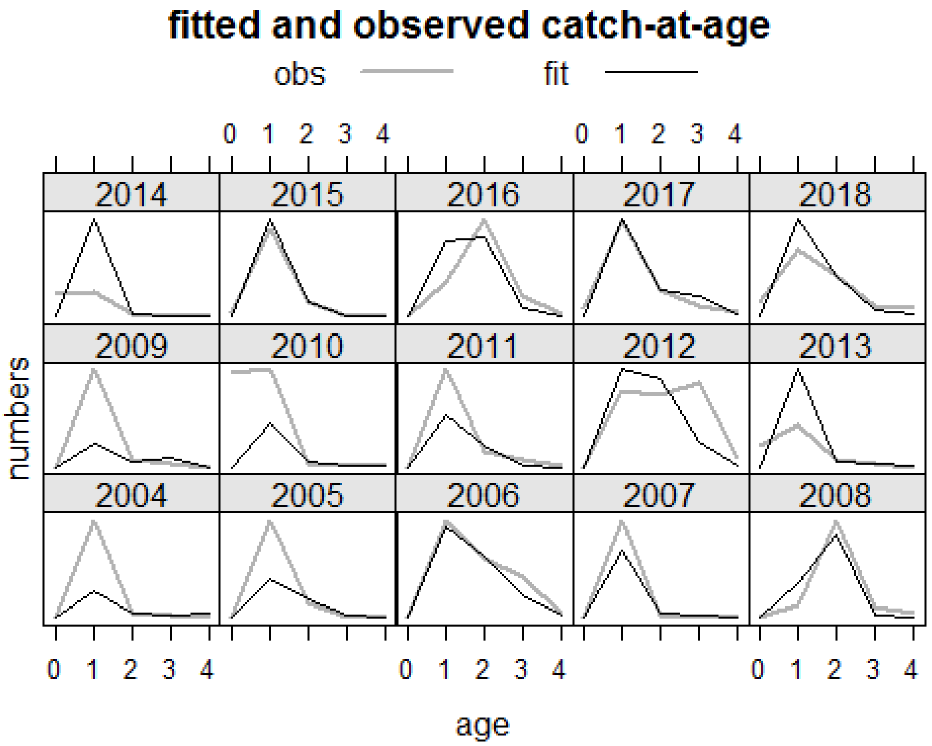


Figure 19.6.3. Observed (grey) and estimated (black) catch number-at-age.

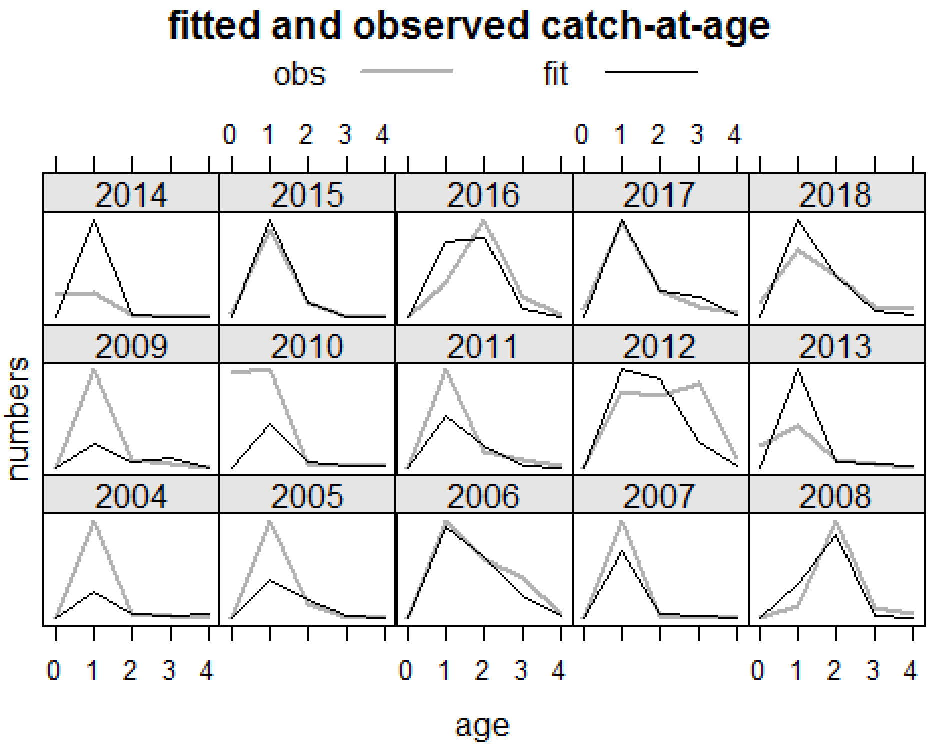


Figure 19.6.4. Observed (grey) and estimated (black) indices at age.

20 Turbot in 3.a (Kattegat, Skagerrak)

This stock is under a biennial advice, so no advice was issued for this stock in 2018. The last advice issued in 2017 was based on the 3:2 rule for category 3 stock, applied to the IBTS Q1 and Q3 biomass indices.

In 2019, ICES has not been requested to provide advice on fishing opportunities for this stock, so the advice sheet reports only on the status of the stock.

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 clear trends. In 2017, length-based indicators (LBI) and exploratory SPiCT runs had been run, pointing out that the stock may be exploited sustainably. In 2019, the LBI indicators were not updated due to poorer length information available following reduced sampling since 2017.

20.1 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, various restrictions and MLS for North Sea turbot have been applied by Dutch POs over time (see Section 14), which may also affect the Dutch discarding of turbot caught in Skagerrak.

20.2 Fisheries data

Turbot is now only caught as by-catch in the trawl and gillnet fisheries. Table 20.1 and Figure 20.1 summarize turbot landings in ICES area 3.a. Over the period 1950–2018, 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. Conversely, the lowest landings at the beginning of the period are also linked to an absence of catch records from Sweden in the period 1962–1974, the reasons of which are equally unclear.

The Danish catches which are present throughout the time series have fluctuated without trends around 100–200 t per year.

In the last decades, the total annual landings of turbot in 3.a declined from around 300 tonnes in the early nineties to around 100 t in the early 2010s, but have increased again in the most recent years. Total landings in 2018 were 150 tonnes, in the range observed in the 1950s.

2018 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. There are small differences in landings reported by Netherlands to InterCatch and in the official statistics.

Some length-based information was provided, but no age information.

Discard ratios were provided for strata summing up to 63% of the reported landings, which is a decrease compared to last year (Figure 20.2a). For those strata where information exist, discards ratios were estimated at 13% both in the Kattegat and in the Skagerrak.

In InterCatch, the raising was first done with the stock defined as age-based (to be exported as "LandingsOnlyStock") and then with the stock defined as length-based, to check the length information available.

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), Kattegat and Skagerrak separately. After raising, the discard ratio for the entire stock area was estimated at 12%, (Table 20.2), but can be substantially higher in some trawl fisheries.

Length distributions were also investigated. However, the stock has been poorly sampled for length distributions since 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 7% of the landings had length distribution sampled, against 65% in 2016. For discards, 69% of the discards had sampled length distribution, which is a higher level than in previous years where it was around 50%. (Table 20.3). As a result, landings showed a very poor SOP (17%) and the raised length distribution of landings is not considered reliable.

The length distribution of discards is considered more reliable. Turbot is fully discarded until 30 cm (Figure 20.3).

20.3 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 20.4 and Figure 20.4). 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 0.4 and 0.7. This rule is not used for advice anymore.

In 2019, an update of the 2017 SPiCT assessment was performed, using the same time series and settings. The results were very similar to those obtained in 2017, indicating that the stock did not seem to be overexploited (Figure 20.5)

This assessment had been accepted by the WGNSSK and the review Group in 2017, but was rejected later by the ADG. WGNSSK did not agreed with the decisions and comments brought by the ADG.

20.4 Issue list

The stock will be benchmarked in 2020.

The main issues to be investigated before and during the benchmark are:

- Stock identity. It remains highly uncertain whether the turbot in 3.a corresponds to a single stock or whether there are different populations, and whether such populations are connected with each other or with the outer bounds of the area in the North Sea or the Western Baltic. Similar investigations have been conducted in the recent years for e.g. plaice (in 2012, 2015, where it was concluded that there were different stocks in Skagerrak and Kattegat respectively), and for sole in 2018–2019 (where it was concluded that the stock should still be evaluated for the combined area Skagerrak–Kattegat). The data and information for turbot are more sparse; however, there is scope for an updated review of knowledge, including genetic findings (Einar *et al.*, 2004), as well as potential useful knowledge from other sources, including from the comprehensive Danish restocking programs which have investigated patterns of turbot migrations and spawning grounds (e.g. Støttrup *et al.*, 2010).

- Landings data: There is a major gap in the Swedish catch statistics between 1964 (before which the landings recorded where quite significant) and after 1972 (where reported landings dropped to very low levels and remained there afterwards). This historical gap contributes to a blurred picture on whether the stocks might have been in better condition in the past.
- There is also a need for a closer description of the spatial distribution of landings (ICES rectangle, depth) in relation to the coverage of the survey data.
- Recreational catches are expected to be substantial for that stock. Turbot is a popular target for recreational fisheries, which has also motivated important restocking programs in the past. An overview of the knowledge available on these catches would be useful.
- The amount of length distributions data have been significantly reduced since 2017. Discussions should take place within Denmark for options within the framework of the next data collection programs after 2021.
- Survey data are very noisy and there is no clear signal in the trends in abundance. These data should be investigated and mapped in more detail, including options for a combined delta-gam survey index for the entire stock area.
- Cardinale *et al.* (2009) reconstructed a long time series of survey data. It would be interesting to update this time series and investigate options to include it in exploratory SPiCT runs covering a longer time series than the current runs.
- SPiCT: A number of exploratory runs were performed in 2017. The assessment converged and produced reasonable outputs. However, this needs to be reviewed and consolidated. Also, the SPiCT model is currently only an R script, and should be moved to the http://stockassessment.org platform.

20.5 Summary

The perception of the stock remains largely uncertain, and has not changed since 2017.

A benchmark is scheduled in 2020.

Table 20.1. Turbot in 27.3a: Official landings by country from 1950 to 2018.

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

Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total
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
2018		0	109		23	8	10	150

Table 20.2. Turbot in 27.3a: Landings and discards (in kg) by year and area after discard raising in InterCatch (using CATON estimate). No BMS nor logbook registered discards reported in InterCatch.

	Discards	Landings	Total	discard ratio
2013	**7366**	**112960**	**120326**	**6.1%**
27.3.a.20	1905	78830	80735	2.4%
27.3.a.21	5461	34130	39591	13.8%
2014	**10508**	**120241**	**130749**	**8.0%**
27.3.a		0	0	
27.3.a.20	2712	80969	83681	3.2%
27.3.a.21	7796	39272	47068	16.6%
2015	**18274**	**183502**	**201776**	**9.1%**
27.3.a		1	1	0.0%
27.3.a.20	4639	145084	149723	3.1%
27.3.a.21	13635	38417	52052	26.2%
2016	**16349**	**188027**	**204376**	**8.0%**
27.3.a	3345	34530	37875	8.8%
27.3.a.20	9198	110710	119907	7.7%
27.3.a.21	3806	42787	46593	8.2%
2017	**30251**	**189801**	**220053**	**13.7%**
27.3.a	2411	17528	19939	12.1%
27.3.a.20	17107	122216	139323	12.3%
27.3.a.21	10734	50057	60791	17.7%
2018	**21145**	**152911**	**174056**	**12.1%**
27.3.a	4328	24842	29170	14.8%
27.3.a.20	11830	82883	94714	12.5%
27.3.a.21	4986	45186	50172	9.9%

Table 20.3: Turbot in 27.3a. Summary of the imported/Raised data for 2018. Stock exported without length allocation

Discards	**21145**	
Imported_Data	15411	73%
Raised_Discards	5734	27%
Landings	**152911**	
Imported_Data	152911	
Grand Total	**174056**	

Table 20.4. Turbot in 27.3a: Average CPUE (kg/hr) estimated from IBTS and BITS surveys

Year	IBTS Q1	IBTS Q3	BITS Q1	BITS Q4
1991	1.107	0.223		
1992	0.388	0.248		
1993	0.660	0.069		
1994	0.463	0.518		
1995	0.572	0.091		
1996	0.621	0.248	0.280	
1997	0.468	0.098	0.523	
1998	0.400	0.028		
1999	0.112	0.116	0.590	0.579
2000	0.253	0.000	0.194	0.161
2001	0.416	0.126	0.094	0.411
2002	0.160	0.359	0.207	0.271
2003	0.322	0.130	0.130	0.187
2004	0.360	0.102	0.366	2.076
2005	0.334	0.140	0.340	0.434
2006	0.750	0.348	0.598	0.104
2007	0.540	0.267	0.424	0.407
2008	0.102	0.656	0.507	0.315
2009	0.338	0.451	0.467	0.110
2010	0.325	0.338	0.138	0.510
2011	0.277	0.219	0.540	0.611
2012	0.500	0.412	0.471	0.348
2013	0.452	0.179	1.002	0.239
2014	0.093	0.432	0.067	0.303
2015	1.062	0.400	0.364	0.919
2016	0.708	0.380	1.550	0.800
2017	0.575	0.178	0.467	0.615
2018	0.507	0.259	0.388	0.279
2019	0.329		0.384	

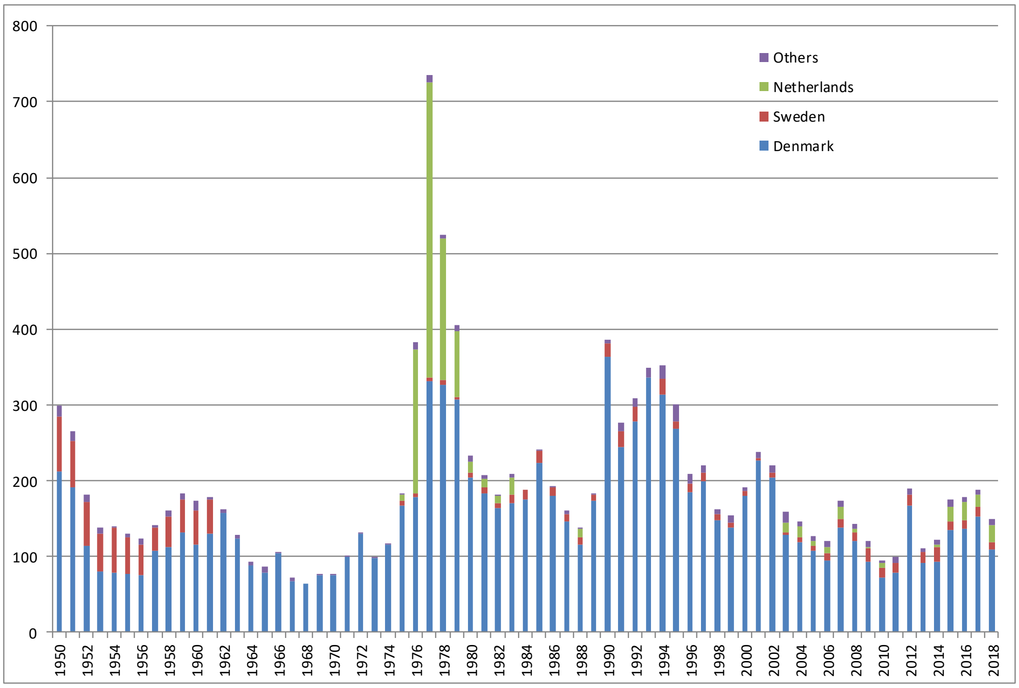


Figure 20.1. Turbot in 27.3a: official landings by country from 1950 to 2017

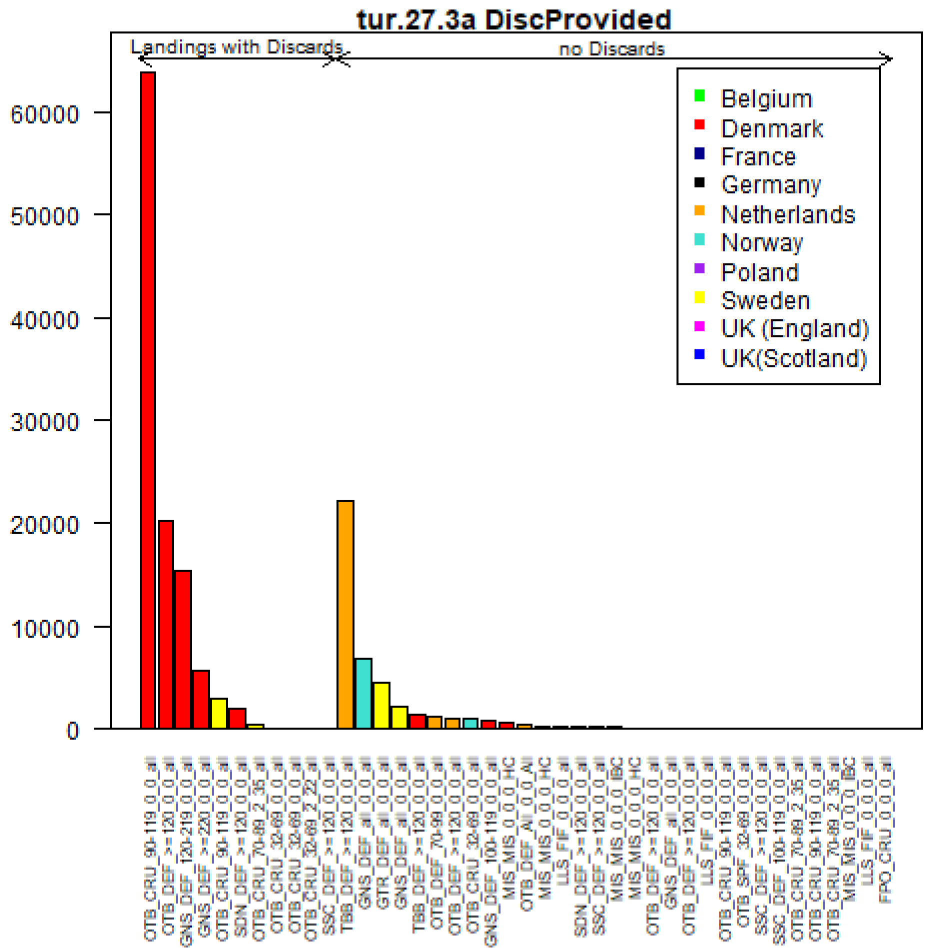


Figure 20.2a. Turbot in 27.3a. Summary of the information provided to InterCatch for 2018. Landings by metier and country, distinguishing between strata with and without corresponding discard information provided.

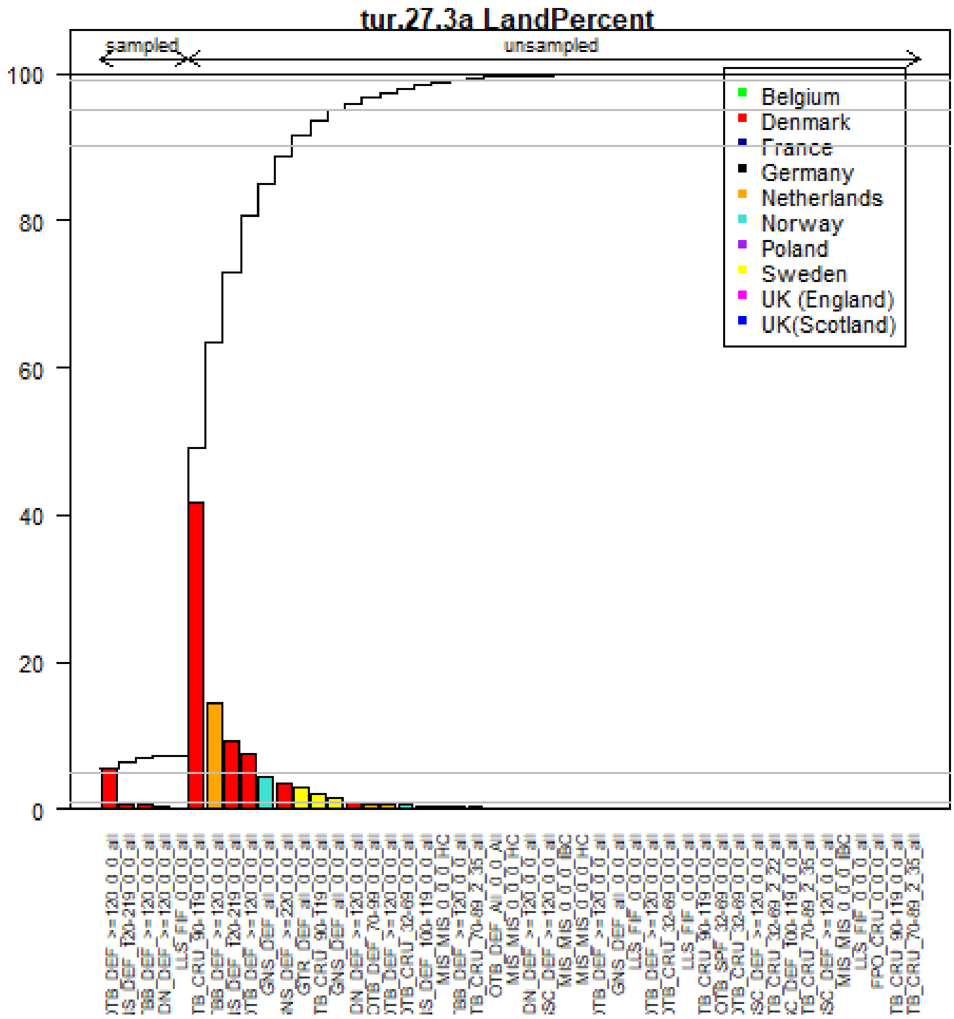
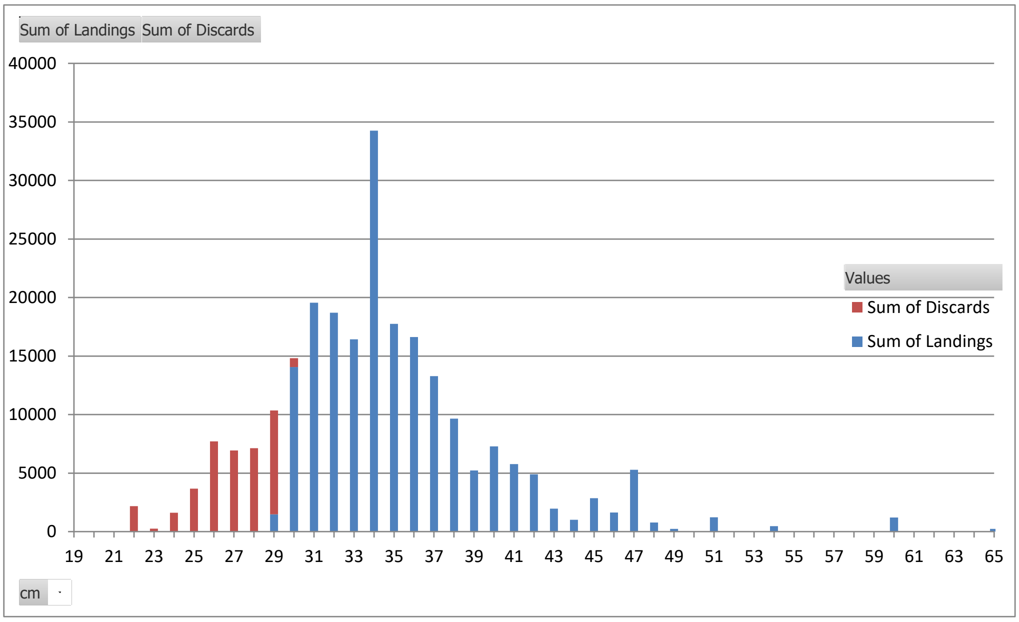


Figure 20.2b. Turbot in 27.3a. Summary of the information provided to InterCatch for 2018. Total landings by métier, sorted by sampled/unsampled for numbers at age in InterCatch.



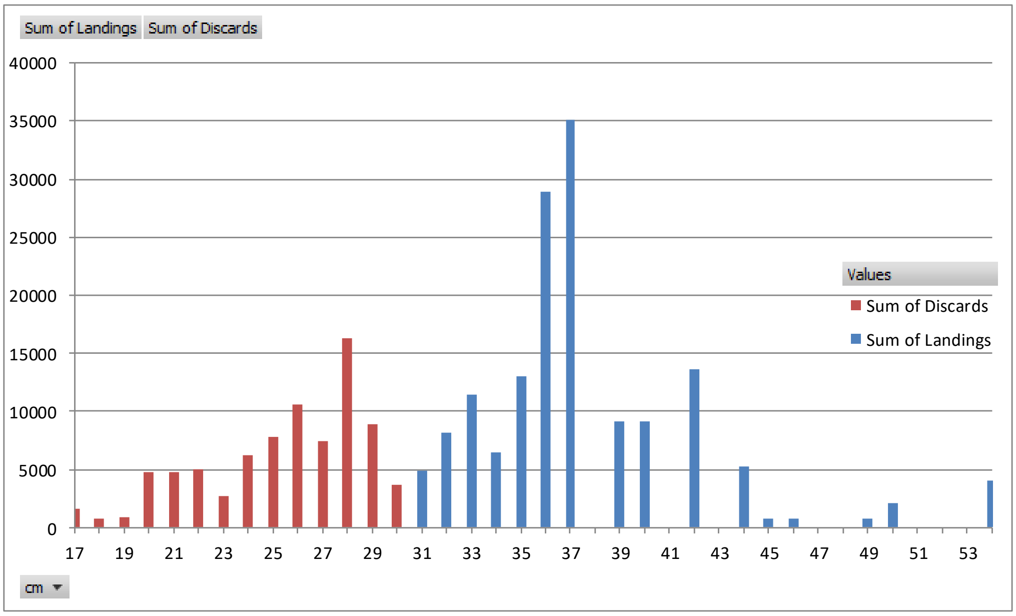


Figure 20.3. Turbot in 27.3a: Length distribution in landings and discards in 2016 (top) and 2017 (bottom), after raising in InterCatch.

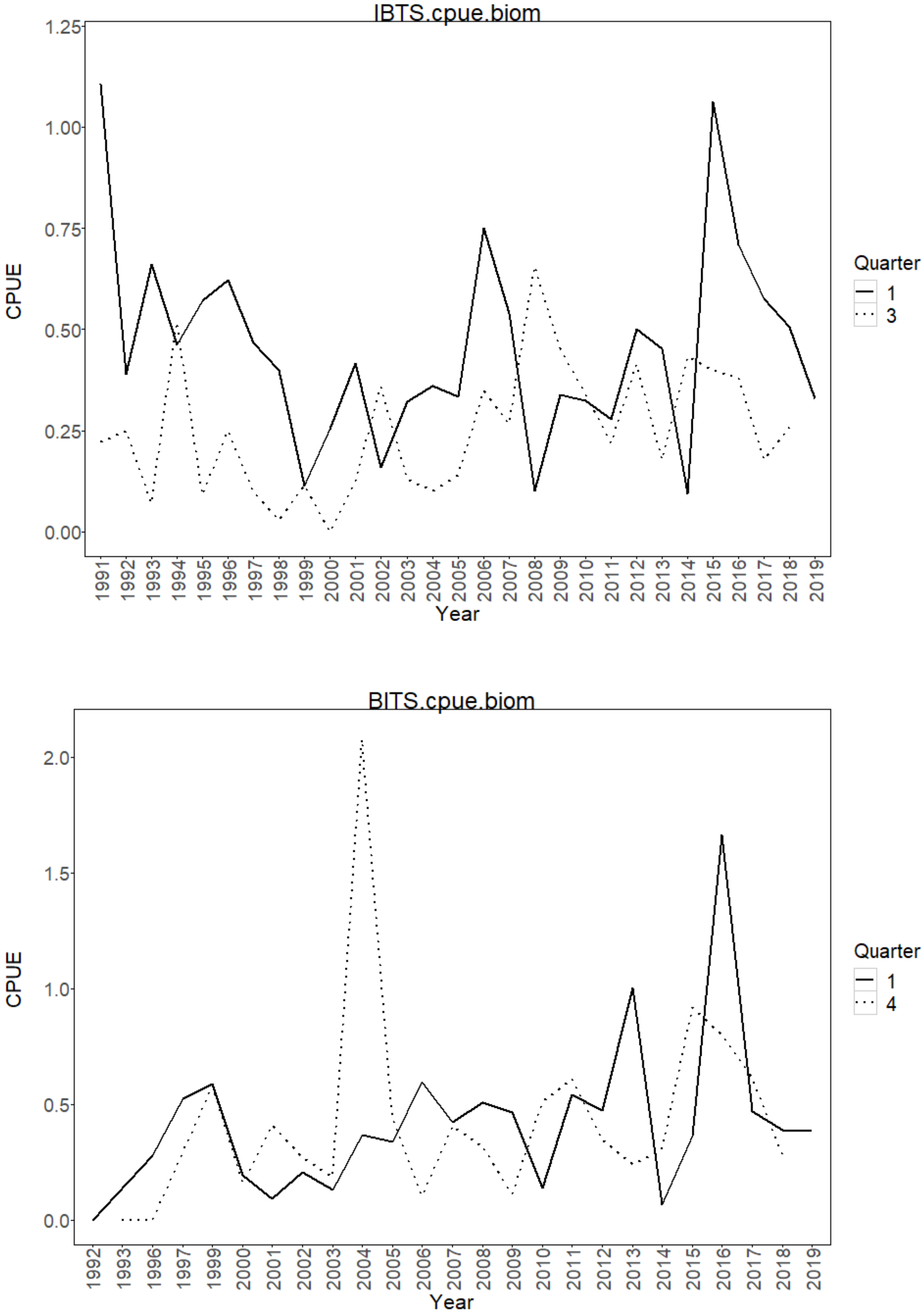


Figure 20.4. Turbot in 27.3a. IBTS and BITS biomass survey indices by quarter.

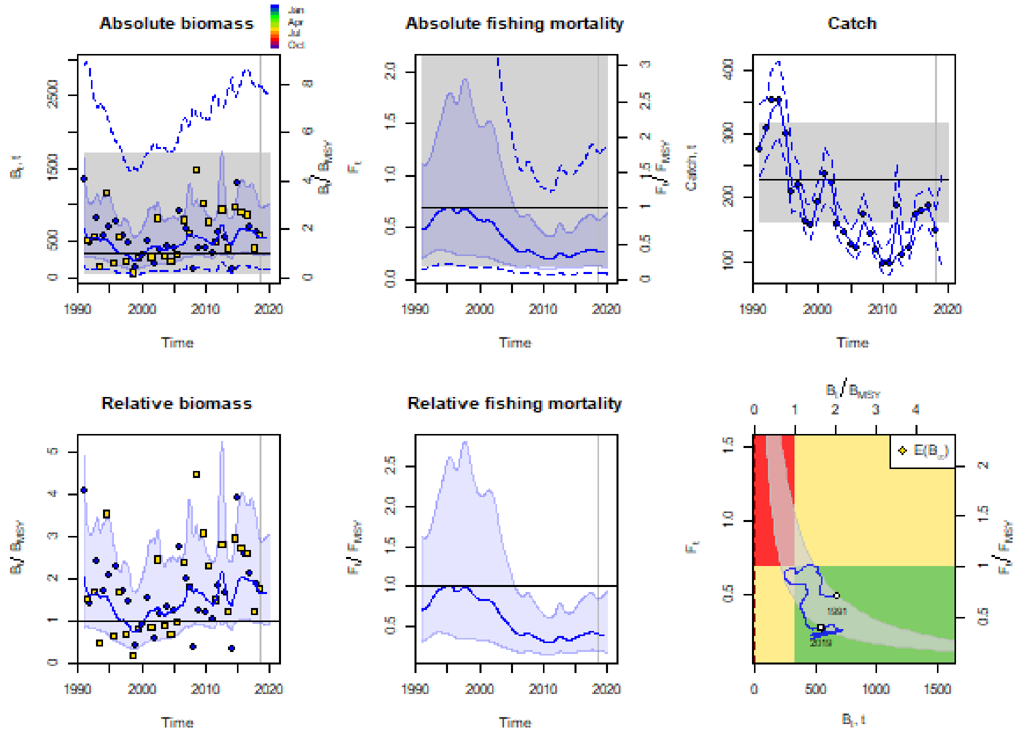


Figure 20.5. SPiCT assessment using same settings as in 2017.

21 Turbot in Subarea 4

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2019. Following an inter-benchmark procedure for this stock in 2015, a state-space assessment model SAM (Nielsen and Berg, 2014) is used. 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 in 2017 (ICES, 2017). 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.

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, i.e. as an index of SSB instead of exploitable biomass. The mistake led to questions on the persistence of the retrospective pattern on F and assessment category used to provide advice. As such, an inter-benchmark was organised in 2018. This inter-benchmark corrected the mistake in the 2017 inter-benchmark settings, checked the plus-group settings of the catch as well as surveys and re-evaluated the parameter bindings in the assessment configuration (ICES, 2018).

Under the new assessment resulting from the 2018 inter-benchmark the retrospective has improved substantially and F was deemed to be estimated reliably. Therefore, the inter-benchmark decided to upgrade turbot in 27.4 to a Category 1 stock. In this context, the inter-benchmark also estimated reference points for a Category 1 stock and provided a short-term forecast. During WGNSSK 2019, the assessment was conducted and advice for turbot in 27.4 was provided for 2020 based on the assessment configuration, reference points and short-term forecast derived during the 2018 interbenchmark.

21.1 General

21.1.1 Biology and ecosystem aspects

Turbot is broadly distributed from Iceland in the North, along the European coastline, to the Mediterranean and Adriatic Sea in the south. In general, turbot is a rather sedentary species, but there are some indications of migratory patterns. For example in the North Sea, migrations from the nursery grounds in the south-eastern part to more northerly areas have been recorded. IBPNEW (ICES, 2012a) concluded that turbot in the North Sea (Subarea 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).

21.1.2 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 (~5% of the total landings).

See the Stock Annex for more details.

21.1.3 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 in the past 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 to keep the landings in line with the national quota. In 2018, the TAC for turbot and brill was substantially increased, however, Dutch PO measures were still in place with a minimum landing size of 30 cm and a limiting the landings to 2000 kg wk^{-1}. During 2018, the PO measures were relaxed due to the sufficiently available quota.

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
2018	September	2500 kg	30 cm
2018	October	3000 kg	27 cm

21.2 Data used

Following the inter-benchmark conducted in the summer of 2018 (ICES, 2018), 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.

21.2.1 Catch data

Figure 21.2.1 shows the trend in total landings and discards over time. Landings of turbot decreased during the 1990s and for the last ten years have been stable around 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. In 2016 and 2017, landings have exceeded 3400 tonnes. In 2018, official landings in Subarea 4 decreased to 3168 tonnes (13%) and reached 45% of the 7102 tonnes of the combined TAC for turbot and brill.

Landings in numbers at age are presented in Table 21.2.1 and Figure 21.2.2, with weights-at-age in the landings presented in Table 21.2.2. 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 landings 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 landing data up to 2016 are raised using only the Dutch 80 mm TBB fleet, signals in landings at age data may not be accurate reflections of true removals from the population over time. In 2018, there is a decrease in landings of age 3. This decrease may suggest a weak 2015 year class. In 2018 more age 1 and 2 turbot are observed in the landings, potentially due to relaxed PO-measures.

21.2.2 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.

The discard rate (discards: 485 984 / (discards + landings: 3 626 372) was 13% in 2018. After the big increase in 2016, the discard rate has remained stable for 2017 and 2018. Still the discard rate is substantially higher compared to the period 2013–2015, when discard ratios were approximately 5%. No useable age structure information was submitted for the discard estimates.

21.2.3 BMS landings

In 2018, BMS landings were reported by Norway and the UK (England), however the submitted values were equal to zero. As such, they are not raised.

21.2.4 Logbook registered discards

In 2018, no logbook registered discards were reported to InterCatch. They are not raised.

21.2.5 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 for 2017 and 2018 for the TBB 79–99 and TBB >=120 fleet. All data (2267 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 21.2.3 shows the métiers with numbers at age samples for the landings in 2018. Approximately 58% 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, SSC and OTM 70-99	OTB and TBB 70-99
SSC and SDN > 100	OTB >=120
OTB and TBB CRU	TBB 70–99
TBB 70–99	TBB 70–99
OTB and TBB 100–119, >= 120	OTB 100–119 & >=120
Passive gears	All GNS
Others	All métiers

*** Unsampled fleet are those fleets for which no discards 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 4% of the discards in weight are sampled for age. Few fish were sampled in the discards of two Danish métiers (18 for OTB_DEF_>=120 and 4 for GNS_DEF_120-219) and the Belgian TBB 70–99 fleet (70 samples in 2018). Discards were raised by quarter, 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 486 tonnes of estimated discards, 415 (85%) was reported data and 71 tonnes is raised in InterCatch. The proportion of landings with discards associated (same strata) is 69%.

21.2.6 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 21.3.1–3 and Figure 21.2.4).

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 3 in 2017 and 4 in 2018) appear strong. In 2018 a lower recruitment (age 1) compared to 2017 is observed. The Dutch BT2 LPUE index shows a continuous gradual increase since 2000. However, in 2018, the LPUE decreased 20% to the level observed in 2012.

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 21.2.5). 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 disaggregated 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.

21.2.7 Biological data

All biological data used in the assessment are presented in tables 21.2.3–5.

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 21.2.6). 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 and are slightly lower than the weights observed in the 1970s.

Maturity

At IBPNEW (ICES, 2012a) turbot maturity data from the Netherlands was used to study some reproductive characteristics of turbot from the North Sea. A female 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, 2012a). Since turbot grows relatively fast compared to other flatfish species in the same areas, results indicate that natural mortality is higher. However, due to high variability for recorded values of K (an estimated growth parameter) for turbot, it proved difficult to find agreement on natural mortality values. Hence, after performing assessment test runs, a constant value of M = 0.2 for all ages and years was chosen for this stock. This is twice the level used in the sole and plaice assessments in the North Sea.

21.3 Stock assessment model

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.

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 inter-benchmark 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 considering the assessment as a category 3, is much improved. WGNSSK 2018 proposed to organise an new inter-benchmark in 2018 in which the parameter configuration, stock category including reference points and a short-term forecast, (when category 1) will be determined.

During the 2018 Inter-benchmark the following final SAM assessment configuration was agreed:

- Sensitivity runs were performed using a step-wise reduction of the catch-at-age plus-group from 10 to 6. It was decided to use an 8+ group as it provided a more consistent selectivity pattern throughout the time period of the assessment.
- A step-wise analysis for the reduction of the maximum age in both surveys was performed, resulting in keeping the ages 6 and 7 in the assessment for the SNS and BTS-ISIS, respectively.
- The fishing mortality states were given as much freedom as possible, binding the oldest two ages in the catch. This configuration is the same as agreed in the final run of IBP 2017.

- The correlated random walks for the fishing mortalities was set at 2 (= correlation between ages but declines following a power function when distance between ages increases). This run provided the best AIC.
- Coupling of catchability parameters: no changes compared to IBP 2017
- Coupling of fishing mortality random walk variances: Additional parameters in the model compared to 2017, choice is based on lowest AIC value
- Coupling of log N random walk variances: No changes compared to IBP 2017
- Coupling of observation variances: one parameter extra freedom in the catch and SNS; same for BTS and LPUE, compared to IBP 2017.
- LPUE time-series indicator: set to exploitable biomass.

Under the new assessment the retrospective has improved substantially and F is deemed to be estimated reliably, also in retrospect. Therefore, the inter-benchmark decided to upgrade turbot in 27.4 to a Category 1 stock.

For Category 1 stocks, a full set of reference points and short-term forecast procedure are necessary. The procedure and assumptions to estimate these are described in sections 6 and 7 respectively.

21.3.1 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 2018 Inter-benchmark report (see also Tables 21.3.4 and 5).

Assessment settings used in the final assessment

Year	2019
Model	SAM
First tuning year	1981
Last data year	2018
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 1991–2018 SNS 2004–2018
	Standardized NL-BT2 LPUE age-aggregated catchable biomass 1995–2018
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 2 3 3 4 4 5 5
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 2 3 3 4 4 5 5 6 6 7 8 8 8 0 0 9 9 9 10 11 11 11 0 12 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 ages)	0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 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

21.4 Assessment model results

The stock summary is given in Table 21.4.1, while fishing mortality at age and abundance at age estimated by the assessment model are presented in tables 21.4.2 and 21.4.3, respectively. Other key model outputs are given in tables 21.4.4–9 and plotted in figures 21.4.1–12.

21.4.1 Status of the stock

Since 2016 fishing mortality has been slightly below 0.36 and was estimated at 0.358 in 2018. Fishing mortality is just below F_{MSY} (0.36) and well below the long term geometric mean (0.51). The SSB in 2018 was estimated to be 9210 tonnes, a minor (0.28%) increase from 2017 which was estimated at 9183 tonnes. Both years are above MSY $B_{trigger}$ which is estimated at 6353 tonnes. The estimated recruitment (age 1) for 2018 (5763) is slightly larger than the estimated recruitment in 2017 (5140) and is above the geometric mean of the time series (4492). However, this estimate is based on very little data and is unlikely to be a reliable estimate.

21.4.2 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 21.4.1). 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 0.85, but then declined to ~0.61 in 1999, before rapidly increasing again to 0.76 in 2002. After 2002, there is a steep decline in F to 0.37 in 2008. After 2012, 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.

21.4.3 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 21.4.9–11. The retrospective plots in SSB, F and recruitment do not exhibit a strong negative or positive pattern. The Mohn's rho associated with this retrospective is –9.8% on SSB, 3.7% on F and -12.4% on recruitment, all considered to be low.

21.5 Model diagnostics

Model diagnostics are provided in tables 21.4.4–9 and figures 21.4.2–11.

The stability and estimatability of a stock assessment model depends on the degree of collinearity between the parameters. When parameters are co-linear or correlated the model can be sensitive to minor changes. A parameter correlation plot helps to identify the correlation between parameters. The correlation coefficient (varying between -1 and 1) is shown as a colour intensity as a function of the corresponding parameters. Ideally, the correlation between the parameters (except for a parameters with itself) should be 0, indicating the parameters are independent of each other. The parameter correlation plot for turbot shows some positive correlation between the catchability parameters (Fpar), but no strong correlation between the other parameters (Figure 21.4.2).

To see how the SAM model has converged on the observation variances, the estimated observation variance (CV) of each data source in the assessment is plotted against the coefficient of variance of the estimate (Figure 21.4.3). Ideally all parameters should have a low CV. For turbot the observation variance of the Dutch LPUE index as well as the landing at age 3 and 4 is lowest, while the associated CVs are highest. As such, the model assumes most information is available in these parameters giving them more weight in the assessment (Figure 21.4.4).

Please refer to the Turbot Inter-benchmark 2017 and 2018 reports for more detailed specifications on the model diagnostics. In particular for the configuration on the survey catchabilities for all surveys with more than 1 age group (see also Figure 21.4.5).

The estimated selectivity at age from 1981 to 2018 is shown in Figure 21.4.5. The selectivity at-age do show some trend in the past decade, whereby after 2013 selectivity has shifted slightly towards older ages (i.e. age 4). The values presented in Figure 21.4.6 are the actual F-at-age.

Residual plots of landings as well as of the SNS and BTS-ISIS survey do not show clear patterns in either positive or negative residuals (Figure 21.4.7 and 21.4.8).

21.6 Reference Points

Reference points were estimated using the R-script template provided by ICES which was developed early 2018 by D.C.M. Miller to ensure that a correct procedure in estimating reference points was followed.

The simulations were executed with the entire time-series of SR-pairs (1981–2017). In the period 1981–1986, the productivity of the stock was markedly lower than in more recent years, but these years were included as it provided overall better fits to the stock-recruitment models (Figure 21.6.1). Although productivity (in recruit per spawner) has gone down in recent years, we do not assume the stock to have a lower productivity potential. The trends in R/SSB mainly show a strong negative density dependent effect of SSB on recruitment success (Figure 21.6.2). Absolute recruitment fluctuates without trend over the whole time series while the SSB shows clear trends (Figure 21.6.3).

The simulations were run with 2000 iterations and applying a mixture of two SR-models, namely Segmented Regression and Ricker (sampling from 2000 fits) (Figure 21.6.1). The fit to the Beverton-Holt SRR showed no decline towards the origin. The models are weighted ~30–70%. Weight-at-age (Figure 21.2.6) and selectivity at-age (Figure 21.4.5) do show some trend in the past decade and hence the average over the 5 recent years were used in the simulations (excluding the most recent year), similar to the default settings. The cv on F, phi on F and cv on SSB were taken as the default values being in conformity with the WKMSYREF IV report (cv of F being 0.212 and phi F being 0.428, cv of SSB was set to 0).

B_{lim} was set at B_{loss} since there are no indications that the stock has encountered impaired recruitment in the time-series. At very similar SSBs the stock has produced among the highest and lowest year-classes which shows that there is no distinct SSB ~R relationship. This is also true for SSBs near the lower end of its distribution, right where the breakpoint of the segmented regression is estimated. No auto-correlation in recruitment was detected. B_{pa} was derived multiplying B_{lim} with exponent of sigmaSSB * 1.645. F_{lim} was derived from B_{lim} by simulating the stock with segmented regression S-R function with the point of inflection at B_{lim}. F_{lim} = the F that, in equilibrium, gives a 50% probability of SSB > B_{lim}. MSY $B_{trigger}$ was set to 0, Fcv, Fphi, SSBcv were set to 0 and rhoRec was set to FALSE. F_{pa} was derived multiplying F_{lim} with the exponent of –sigmaF * 1.645. Both sigmaF and sigmaSSB were set to the default values of 0.2045 (resulting into a multiplication factor of ~1.4 for B_{lim} and F_{lim} to derive B_{pa} and F_{pa}).

The initial F_{MSY} was calculated including stochasticity in the population and exploitation as well as assessment/advice error following WKLIFE IV with default values of 0.212 and 0.423 for F_{cv}

and F_{phi} respectively. From this run, also $F_{MSY\ upper}$ and $F_{MSY\ lower}$ were obtained. MSY $B_{trigger}$ was set to zero while B_{lim} and B_{pa} were included. Since F_{MSY} was lower than F_{pa}, F_{MSY} was taken as the point estimate from the simulation.

MSY $B_{trigger}$ was taken as the 5th percentile of SSB at MSY which was higher than B_{pa}. Given that the stock has been fished at or below F_{MSY} since 2012, and no MSY $B_{trigger}$ value was defined before, MSY $B_{trigger}$ was set at this 5th percentile.

Finally, $F_{P.05}$ was evaluated using the MSY $B_{trigger}$ estimate from the previous analysis. This value (0.86) was higher than $F_{MSY\ upper}$ (0.48) so a modification of the F_{MSY} range was not needed. During WGNSSK the $F_{P.05}$ value was deemed very high. This value was obtained including the ICES Advice Rule. It was requested to recalculate $F_{P.05}$ without the ICES Advice Rule, re-estimating the value at 0.47.

The table below shows the estimated reference points using the final IBP 2018 assessment.

Reference point	Estimate
1. MSY $B_{trigger}$	6353
2. B_{pa}	4163
3. B_{lim}	2974
4. F_{pa}	0.43
5. F_{lim}	0.61
6. $F_{P.05}$ (without AR)	0.47
7. F_{MSY}	0.36
8. $F_{MSY\ lower}$	0.25
9. $F_{MSY\ upper}$	0.48

21.7 Short-term-forecast

The short-term forecast was implemented in FLR using the fwd-routines. Terminal year estimates from the SAM assessment were used as starting conditions. Since there is no clear relationship between SSB and Rec, it was decided to assume recruitment to follow a geometric mean for the entire time-series, including the latest estimate.

Since stock and catch weight-at-age are modelled, we assume in the forecast that weights are identical to the weights used in the final assessment year. As such, we do not introduce a break in the smoothness of the weight-at-age time-series. Maturity at age and time of spawning are fixed over time, and these values are used in the forecast. Selectivity-at-age is with minimal trends in recent years, but has changed in the past decade. Hence, a 3-year average was used for future years in the simulations.

In recent years the TAC has never been exhausted and therefore using a % TAC was deemed inappropriate. Hence, the assumption for the intermediate year was made to not use a catch constraint but a status-quo F. This was also supported by the recent years in which F has been very stable around 0.36.

Assumptions made for the interim year and in the forecast:

Variable	Value	Notes
$F_{ages\ 2–6}$ (2019)	0.36	$F_{sq} = F_{average}$ of F (2016–2018)
SSB (2020)	8559	Tonnes, Short-term forecast
R_{age1} (2019, 2020)	4492	Thousands, Geometric mean (GM, 1981–2018)
Wanted catch (2019)	3147	Tonnes, Short-term forecast (STF), assuming an F status quo

The options table summarizes the outcomes of the short term forecast. The presented numbers are the rounded values, actual calculations are performed with the exact numbers.

Basis	Total catch * (2020)	Wanted catch ** (2020)	Unwanted catch ** (2020)	$F_{ages\ 2-6}$ (2020)	SSB (2021)	% SSB change ***	% Advice change ^
MSY approach: F_{MSY}	3649	3138	511	0.36	8575	0.185	-26
Precautionary approach: F_{pa}	4225	3633	592	0.43	8041	-6.1	-14.7
$F_{MSY\ upper}$ = 0.48	4614	3968	646	0.48	7683	-10.2	-6.8
$F_{MSY\ lower}$ = 0.25	2664	2291	373	0.25	9495	10.9	-46
F = 0	0	0	0	0	12019	40	-100
F_{pa}	4225	3633	592	0.43	8041	-6.1	-14.7
F_{lim}	5545	4768	777	0.61	6830	-20	12
F_{sq}	3617	3111	507	0.36	8605	0.53	-27
SSB (2021) = B_{lim}	9945	8552	1393	1.58	2974	-65	101
SSB (2021) = B_{pa}	8542	7346	1196	1.18	4163	-51	73
SSB (2021) = MSY $B_{trigger}$	6071	5220	850	0.69	6353	-26	23
Rollover advise	4952	4259	693	0.64	6636	-22	0
Multi-options table							
F = 0	0	0	0	0	12019	40	-100
F= 0.05	82	503	585	0.05	11460	34	-88
F = 0.10	1143	983	160	0.1	10930	28	-77
F = 0.15	1675	1440	235	0.15	10427	22	-66
F = 0.20	2181	1876	305	0.2	9949	16.2	-56
F = 0.25	2664	2291	373	0.25	9495	10.9	-46
F = 0.30	3125	2687	438	0.3	9064	5.9	-37
F = 0.35	3564	3065	499	0.35	8655	1.11	-28
F = 0.40	3983	3425	558	0.4	8266	-3.4	-19.6
F = 0.45	4383	3769	614	0.45	7896	-7.8	-11.5
F = 0.50	4764	4097	667	0.5	7544	-11.9	-3.8

*** (advised landings) / (1 – average discard rate); average discard rate 2016–2018 = 14.0%**

**** "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 2016–2018 (14.0%).**

***** SSB 2021 relative to SSB 2020.**

^ Total catch in 2020 relative to advice value for 2018 and 2019 (4952 t).

21.8 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.

21.8.1 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.

21.8.2 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.

21.8.3 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.

21.9 Industry Survey turbot and brill

The available scientific surveys used for the assessment of turbot in 27.4 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. A scientific survey with higher catch rates for turbot and a better internal consistency would be preferable. In this context, the Dutch producer organization VisNed and Wageningen Marine Research initiated an industry-based survey to monitor large flatfish such as brill and turbot in the North Sea. The survey took place in quarter 4 and 3 vessels were selected to monitor 3 different zones covering 5.5 ICES rectangles each (Figure 21.9.1). These zones were defined based on LPUE data and information from fishers. Per ICES statistical rectangle, 2 haul positions were set by scientists and 2 haul positions could be chosen by the fisher (22 hauls per zone in total; haul positions are shown in Figure 21.9.1). Two otoliths per cm class per rectangle were sampled.

Due to bad weather conditions one of the zones could not be monitored (purple zone in Figure 21.9.1). The numbers of brill caught during this survey were approximately 5 times higher than caught during the BTS-ISIS survey. Clear cohorts could be delineated, which added new information to the existing data from the commercial sampling and the fisheries independent surveys (Figure 21.9.2).

Once a period of 5 years is covered, the index of this new survey is a potential candidate to include in the brill assessment. However, there are some practical drawbacks which need to be sorted out to verify if this rather costly survey could be continued.

21.10 Issues for future benchmarks

21.10.1 Data

The available scientific surveys (SNS and BTS-ISIS Q3) have a low internal consistency especially for older ages leading to a low ability to track cohorts over time. Because of this, the assessment gets strongly influenced by the Dutch LPUE index. A scientific survey with higher catch rates for turbot and a better internal consistency would be preferable (See section 21.9).

The assessment gets strongly influenced by the Dutch LPUE index. More work should be done on getting LPUE data from other Member States. In future, the use of these data may be possible after standardization or weighting of the original values to account for the difference in gear and location. Obtaining standardised Belgian, UK and Danish LPUE data for use in the assessment model should be investigated.

Estimates of discards are available (e.g. Dutch discards are available for 1999-present); however, age-length information is very limited. Age-information is based on a few fish sampled in the discards of some of the Danish and Belgian fleets (at sea sampling). As a result, estimates of discards are highly uncertain, and not included in the current assessment. Future sampling effort needs to ensure a proper sampling coverage over the main fleets and countries for both landings and discards. Sampling should include age information for discards from all countries.

Currently, estimates of mean weights-at-age from the fishery and for the stock (from surveys) cannot be used directly in assessments without first smoothing these estimates, because of data gaps and poor sample sizes (the latter leading to highly variable and inconsistent estimates, particularly at the older ages). The smoothing techniques currently used add to any retrospective pattern present, because they re-estimate the entire time-series of smoothed weights whenever new data are added. It is therefore recommended that methods that produce more stable estimates of mean weights be investigated and their performance compared to current methods, or sampling be improved to allow raw weights to be used directly in assessments, or appropriately deal with smoothing of raw weights within the stock assessment model.

A delta GAM index combining different BTS surveys was tested. Currently such an index could not improve the assessment. However, age information in DATRAS was not available for the whole time-series, and errors seem to have occurred during the upload of additional data. Once the whole time-series of age information is available, a detailed analysis of delta GAM indices with various settings should be carried out.

21.10.2 Assessment

The Dutch LPUE data series receives a high weight in the assessment (higher than any other data source, and much higher than the survey indices of abundance); this weighting is, arguably, unrealistically high. The Dutch LPUE data are standardised by applying a statistical model that includes interactions in space, time and gear, and it may be possible to extract CVs associated with the estimates from this model. It is recommended that the use of such CVs in the SAM assessment be investigated to better deal with the weighting of the LPUE data series.

The Dutch LPUE data series (an aggregated biomass index) is associated with 60–70% of the total catch for turbot, but the current SAM assessment uses the selectivity estimated for the total catch to build an exploitable biomass estimate used to fit the Dutch LPUE data. This is not entirely representative and likely introduces some model misspecification. There is a fleet-based version of SAM that, given fleet-based data could be used to deal with this problem. It is therefore recommended that the use of such fleet-based data and a fleet-based SAM version be investigated to provide a more appropriate fit to the Dutch LPUE data.

21.10.3 Short term forecast

The forecast is performed using future landings. Catch advice is derived by dividing the estimated landings with one minus the average discard rate.

21.11 References

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Table 21.2.1. Turbot in Area 4. Catch in numbers (units: thousands) SOP corrected.

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0	284.709	718.914	506.572	436.109	166.636	63.798	101.886
1982	0	150.592	932.066	237.917	148.81	260.194	87.325	138.117
1983	0	359.429	601.73	428.274	98.351	101.033	160.938	181.502
1984	0	1194.467	1127.186	286.635	144.7	55.299	52.534	179.723
1985	0	621.466	1887.849	511.244	139.928	85.207	20.325	125.075
1986	0	321.575	1274.166	604.146	158.621	58.074	25.137	107.481
1987	12.635	629.804	530.668	657.018	153.563	50.54	18.466	68.034
1988	32.235	970.64	803.196	159.386	157.595	80.588	25.072	68.948
1989	0	667.344	1165.043	353.895	156.163	82.014	31.457	68.532
1990	44.337	986.761	1064.093	314.485	164.976	75.27	101.048	113.421
1991 – 1997	NO DATA							
1998	0	403.110	864.446	355.334	72.410	29.337	8.435	14.191
1999 – 2002	NO DATA							
2003	211.408	1923.262	463.990	299.297	71.261	33.176	20.824	20.666
2004	439.219	1999.216	800.044	139.605	83.226	9.754	7.607	6.130
2005	347.524	2003.250	729.431	232.797	25.070	22.086	2.626	19.400
2006	898.376	1670.213	819.830	120.938	35.645	8.020	16.422	18.408
2007	80.224	2840.462	629.540	291.175	41.166	29.720	8.434	16.256
2008	181.318	1379.783	839.270	225.050	199.499	48.155	13.169	10.447
2009	122.629	1128.737	1054.257	455.271	96.509	27.169	11.959	20.099
2010	280.955	1415.455	389.161	312.041	173.224	88.866	30.848	19.719
2011	214.748	1976.937	613.566	112.716	140.160	78.411	32.835	24.023
2012	0.000	1922.419	782.389	268.587	42.751	64.349	73.520	24.891
2013	173.092	1585.056	1084.643	326.336	91.235	26.058	42.128	25.962
2014	64.757	368.256	611.464	642.761	129.292	114.610	35.744	98.799
2015	38.590	1192.480	456.059	320.234	310.391	107.680	42.368	78.236
2016	0	1006.557	962.181	322.836	346.806	181.368	43.692	68.347
2017	6.604	315.483	1588.451	573.514	132.699	59.901	93.804	58.038
2018	174.667	711.678	463.835	862.812	245.049	62.490	37.374	63.502

Table 21.2.2. Turbot in Area 4. Modelled weights at age in the catch (units: kg).

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.350	0.747	1.287	1.943	2.686	3.485	4.314	5.942
1982	0.363	0.775	1.335	2.016	2.787	3.615	4.475	6.274
1983	0.375	0.802	1.382	2.087	2.885	3.743	4.632	6.360
1984	0.388	0.828	1.427	2.155	2.979	3.865	4.784	6.596
1985	0.399	0.853	1.470	2.220	3.069	3.982	4.928	7.023
1986	0.410	0.877	1.510	2.281	3.153	4.091	5.064	7.568
1987	0.420	0.898	1.547	2.337	3.230	4.191	5.187	7.936
1988	0.429	0.917	1.580	2.387	3.299	4.280	5.298	7.102
1989	0.437	0.933	1.609	2.429	3.358	4.357	5.393	7.570
1990	0.443	0.947	1.632	2.464	3.406	4.420	5.470	7.383
1991	0.448	0.957	1.649	2.491	3.443	4.467	5.528	7.644
1992	0.451	0.963	1.660	2.507	3.466	4.496	5.565	7.695
1993	0.452	0.966	1.664	2.514	3.475	4.508	5.580	7.715
1994	0.451	0.964	1.662	2.510	3.469	4.501	5.570	7.702
1995	0.449	0.958	1.651	2.494	3.447	4.473	5.536	7.655
1996	0.444	0.948	1.633	2.467	3.410	4.424	5.476	7.572
1997	0.437	0.933	1.608	2.429	3.357	4.355	5.391	7.454
1998	0.428	0.914	1.576	2.380	3.289	4.267	5.282	7.189
1999	0.418	0.892	1.537	2.322	3.209	4.164	5.154	7.127
2000	0.406	0.867	1.495	2.258	3.121	4.049	5.011	6.929
2001	0.394	0.841	1.449	2.189	3.025	3.925	4.858	6.717
2002	0.381	0.813	1.401	2.117	2.926	3.796	4.698	6.496
2003	0.367	0.785	1.353	2.043	2.824	3.664	4.535	6.285
2004	0.354	0.757	1.304	1.970	2.723	3.533	4.373	5.759
2005	0.341	0.729	1.257	1.898	2.623	3.404	4.213	5.413
2006	0.329	0.703	1.211	1.828	2.527	3.279	4.058	6.008
2007	0.317	0.677	1.167	1.762	2.436	3.160	3.911	5.261
2008	0.306	0.653	1.126	1.700	2.350	3.049	3.774	5.316
2009	0.295	0.631	1.088	1.643	2.271	2.946	3.647	5.108
2010	0.286	0.611	1.053	1.591	2.199	2.853	3.532	4.888
2011	0.278	0.594	1.023	1.545	2.136	2.771	3.430	4.439
2012	0.271	0.578	0.997	1.505	2.081	2.700	3.342	4.397
2013	0.265	0.566	0.975	1.473	2.035	2.641	3.269	4.203
2014	0.260	0.556	0.958	1.447	2.000	2.595	3.211	4.312
2015	0.257	0.549	0.946	1.429	1.975	2.562	3.171	4.414
2016	0.255	0.545	0.939	1.419	1.961	2.544	3.149	4.438
2017	0.255	0.545	0.939	1.418	1.959	2.542	3.147	4.412
2018	0.256	0.548	0.944	1.426	1.971	2.557	3.165	4.342

Table 21.2.3. Turbot in Area 4. Modelled weights at age in the stock (units: kg)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.339	0.724	1.248	1.885	2.605	3.380	4.183	5.762
1982	0.352	0.751	1.294	1.955	2.702	3.506	4.339	6.084
1983	0.364	0.778	1.340	2.024	2.797	3.629	4.492	6.167
1984	0.376	0.803	1.384	2.090	2.889	3.748	4.639	6.396
1985	0.387	0.827	1.426	2.153	2.976	3.861	4.779	6.810
1986	0.398	0.850	1.465	2.212	3.058	3.967	4.910	7.338
1987	0.408	0.871	1.500	2.266	3.132	4.064	5.030	7.695
1988	0.416	0.889	1.532	2.314	3.199	4.151	5.137	6.887
1989	0.424	0.905	1.560	2.356	3.256	4.225	5.229	7.341
1990	0.430	0.918	1.582	2.390	3.303	4.286	5.304	7.159
1991	0.434	0.928	1.599	2.415	3.338	4.331	5.361	7.413
1992	0.437	0.934	1.610	2.431	3.361	4.360	5.397	7.462
1993	0.438	0.937	1.614	2.438	3.369	4.372	5.411	7.482
1994	0.438	0.935	1.611	2.434	3.364	4.364	5.402	7.469
1995	0.435	0.929	1.601	2.418	3.343	4.337	5.368	7.423
1996	0.430	0.919	1.584	2.392	3.307	4.290	5.310	7.343
1997	0.424	0.905	1.559	2.355	3.255	4.223	5.227	7.228
1998	0.415	0.887	1.528	2.307	3.189	4.138	5.122	6.972
1999	0.405	0.865	1.491	2.252	3.112	4.038	4.998	6.911
2000	0.394	0.841	1.450	2.189	3.026	3.926	4.859	6.719
2001	0.382	0.815	1.405	2.122	2.934	3.806	4.711	6.514
2002	0.369	0.789	1.359	2.053	2.837	3.681	4.556	6.300
2003	0.356	0.761	1.312	1.981	2.739	3.553	4.398	6.094
2004	0.344	0.734	1.265	1.910	2.640	3.426	4.240	5.585
2005	0.331	0.707	1.219	1.840	2.544	3.301	4.085	5.249
2006	0.319	0.681	1.174	1.773	2.451	3.180	3.935	5.826
2007	0.307	0.657	1.131	1.709	2.362	3.065	3.793	5.102
2008	0.297	0.633	1.092	1.649	2.279	2.957	3.659	5.155
2009	0.287	0.612	1.055	1.593	2.202	2.857	3.536	4.954
2010	0.277	0.593	1.022	1.543	2.133	2.767	3.425	4.740
2011	0.269	0.576	0.992	1.498	2.071	2.687	3.326	4.304
2012	0.263	0.561	0.967	1.460	2.018	2.618	3.240	4.264
2013	0.257	0.549	0.945	1.428	1.974	2.561	3.170	4.075
2014	0.252	0.539	0.929	1.403	1.939	2.516	3.114	4.182
2015	0.249	0.532	0.917	1.385	1.915	2.485	3.075	4.281
2016	0.247	0.529	0.911	1.376	1.902	2.467	3.054	4.303
2017	0.247	0.528	0.910	1.375	1.900	2.465	3.051	4.279
2018	0.249	0.531	0.916	1.383	1.911	2.480	3.070	4.210

Table 21.2.4. 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 21.2.5. 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 21.3.1. 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	271.896	54.705	60.336	0.500	0.000	0.500
2018	118.210	84.248	16.844	21.938	8.645	3.184

Table 21.3.2. 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
2018	1.621	1.190	0.281	0.309	0.176	0.033	0.000

Table 21.3.3. 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	0.0441
2001	0.0457
2002	0.0454
2003	0.0469
2004	0.0477
2005	0.0471
2006	0.0484
2007	0.0642
2008	0.0666
2009	0.0659
2010	0.0583
2011	0.0590
2012	0.0730
2013	0.0746
2014	0.0739
2015	0.0861
2016	0.0957
2017	0.0917
2018	0.0730

Table 21.3.4. Turbot in Area 4. Stock object and SAM configuration settings

Configuration settings	2018 assessment
Model	SAM
First tuning year	1981
Last data year	2018
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 1991–2018 SNS 2004–2018
	Standardized NL-BT2 lpue age-aggregated catchable biomass 1995–2018

Table 21.3.5. Turbot in Area 4. SAM configuration settings

FLSAM.version	2.1.0
FLCore.version	2.6.8
R version	3.4.3 (2017-11-30)
Platform	i386-w64-mingw32/i386 (32-bit)
run.date	2019-04-27 15:50:43

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 3 3 4 4
5 5
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 3 3 4 4
5 5
6 6 7 8 8 8
0 0
9 9 9 10 11 11
11 0
12 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
1 1 1 1 1 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

Table 21.4.1a. Recruitment (Age 1) of turbot in Area 4. (Thousands)

Year	Value	Low	High
1981	2558	1854	3531
1982	4233	3133	5721
1983	6540	4799	8914
1984	5053	3626	7041
1985	2457	1765	3421
1986	3385	2507	4572
1987	3950	2917	5349
1988	3678	2681	5046
1989	4476	2937	6821
1990	5841	3590	9504
1991	5020	3203	7868
1992	4467	2846	7011
1993	4951	3222	7606
1994	3809	2491	5822
1995	4894	3384	7078
1996	3339	2412	4622
1997	2873	2047	4033
1998	4123	2853	5959
1999	3487	2355	5163
2000	5632	3861	8215
2001	3581	2386	5376
2002	5781	4219	7922
2003	4877	3646	6525
2004	6255	4728	8275
2005	4702	3585	6166
2006	6434	4868	8503
2007	5350	4067	7038
2008	3251	2411	4384
2009	4018	3000	5381
2010	5556	4248	7268
2011	6933	5056	9507
2012	4148	3110	5534
2013	3166	2382	4208
2014	6363	4839	8366
2015	8792	6514	11868
2016	3048	2218	4189
2017	5140	3473	7607
2018	5763	3318	10010

Table 21.4.1b. Total and Spawning stock Biomass of turbot in Area 4.

Year	TSB	Low	High	SSB	Low	High
1981	19753	15989	24404	15508	11971	20091
1982	18441	14849	22902	13841	10509	18228
1983	18598	15137	22849	12461	9372	16567
1984	19611	16271	23636	11478	8675	15188
1985	18903	15876	22506	11592	9043	14858
1986	16378	13633	19676	11040	8635	14115
1987	14885	12316	17988	9862	7578	12835
1988	13956	11635	16741	8126	6145	10745
1989	14297	11916	17153	8101	6167	10640
1990	14181	11434	17587	6982	5194	9385
1991	14077	10643	18618	5785	4073	8218
1992	13395	10053	17850	5400	3852	7571
1993	12184	9264	16025	4858	3541	6665
1994	10895	8447	14054	4064	2988	5526
1995	10076	8142	12470	3687	2844	4780
1996	9409	7756	11415	3238	2531	4142
1997	9054	7633	10739	3573	2922	4369
1998	8896	7577	10446	3814	3230	4502
1999	9102	7359	11258	3711	2898	4751
2000	10116	8170	12525	4100	3215	5229
2001	9906	8047	12194	3954	3125	5004
2002	9421	7878	11267	3770	3087	4604
2003	8806	7660	10124	3111	2608	3711
2004	8754	7658	10005	2931	2424	3545
2005	8748	7584	10091	3040	2483	3723
2006	9034	7796	10468	3342	2681	4165
2007	10170	8831	11713	4150	3361	5124
2008	10220	8847	11806	5021	4060	6210
2009	10176	8716	11879	6125	4971	7546
2010	9883	8335	11719	5839	4595	7419
2011	10705	8973	12771	5513	4255	7143
2012	11487	9655	13666	6060	4726	7770
2013	11440	9609	13618	7043	5584	8883
2014	12128	10106	14556	8224	6507	10395
2015	13663	11321	16490	8008	6121	10476
2016	14338	11917	17251	8233	6281	10793
2017	14119	11789	16910	9184	7227	11670
2018	13630	11022	16856	9210	7158	11850

Table 21.4.1c. Fbar (Ages 2–6) and landings (tonnes) of turbot in Area 4.

Year	Fbar	Low	High	Land	Land SOP
1981	0.388	0.312	0.483	4755	1
1982	0.374	0.304	0.460	4453	1
1983	0.411	0.337	0.501	4575	1
1984	0.458	0.377	0.557	5297	1
1985	0.502	0.412	0.611	6188	1
1986	0.477	0.389	0.585	5263	1
1987	0.489	0.398	0.601	4271	1
1988	0.471	0.379	0.586	4041	1
1989	0.597	0.490	0.727	4927	1
1990	0.730	0.583	0.914	5750	1
1991	0.779	0.615	0.987	6340	-0.007
1992	0.812	0.639	1.032	5933	-0.007
1993	0.841	0.666	1.061	5546	-0.008
1994	0.849	0.677	1.064	5244	-0.008
1995	0.823	0.661	1.026	4671	-0.009
1996	0.745	0.608	0.914	3644	-0.011
1997	0.682	0.543	0.856	3382	-0.012
1998	0.646	0.519	0.805	3086	1
1999	0.611	0.490	0.763	3187	-0.012
2000	0.633	0.509	0.789	4025	-0.009
2001	0.699	0.564	0.867	4100	-0.009
2002	0.764	0.603	0.968	3749	-0.010
2003	0.705	0.583	0.853	3374	1
2004	0.624	0.514	0.757	3317	1
2005	0.555	0.452	0.682	3195	1
2006	0.429	0.343	0.535	2976	1
2007	0.401	0.322	0.499	3509	1
2008	0.373	0.301	0.461	3005	1
2009	0.431	0.349	0.531	3089	1
2010	0.409	0.333	0.502	2692	1
2011	0.366	0.295	0.454	2771	1
2012	0.347	0.281	0.430	2914	1
2013	0.331	0.268	0.409	2982	1
2014	0.331	0.269	0.408	2834	1
2015	0.332	0.268	0.413	2922	1
2016	0.358	0.285	0.448	3493	1
2017	0.353	0.283	0.440	3441	1
2018	0.358	0.278	0.462	3140	1

Table 21.4.2. Turbot in Area 4. Estimated fishing mortality (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.002	0.118	0.619	0.534	0.355	0.314	0.232	0.232
1982	0.002	0.111	0.574	0.510	0.354	0.320	0.244	0.244
1983	0.003	0.134	0.605	0.559	0.399	0.358	0.276	0.276
1984	0.004	0.179	0.674	0.613	0.441	0.384	0.287	0.287
1985	0.005	0.207	0.732	0.676	0.486	0.406	0.290	0.290
1986	0.005	0.210	0.682	0.633	0.468	0.390	0.278	0.278
1987	0.006	0.246	0.727	0.630	0.462	0.378	0.273	0.273
1988	0.007	0.260	0.725	0.567	0.436	0.369	0.278	0.278
1989	0.010	0.333	0.930	0.718	0.556	0.448	0.352	0.352
1990	0.012	0.390	1.088	0.868	0.713	0.589	0.507	0.507
1991	0.014	0.416	1.144	0.931	0.771	0.633	0.557	0.557
1992	0.016	0.447	1.188	0.964	0.801	0.660	0.599	0.599
1993	0.019	0.492	1.238	0.991	0.814	0.669	0.626	0.626
1994	0.022	0.517	1.266	0.993	0.809	0.659	0.629	0.629
1995	0.022	0.509	1.220	0.965	0.784	0.639	0.626	0.626
1996	0.018	0.403	1.060	0.884	0.753	0.627	0.639	0.639
1997	0.014	0.325	0.903	0.810	0.736	0.636	0.678	0.678
1998	0.013	0.297	0.821	0.756	0.719	0.639	0.718	0.718
1999	0.016	0.320	0.774	0.714	0.663	0.585	0.665	0.665
2000	0.025	0.438	0.835	0.732	0.639	0.524	0.563	0.563
2001	0.040	0.602	0.937	0.799	0.656	0.501	0.506	0.506
2002	0.064	0.826	1.013	0.851	0.662	0.469	0.447	0.447
2003	0.066	0.806	0.922	0.783	0.601	0.415	0.380	0.380
2004	0.069	0.784	0.849	0.686	0.481	0.318	0.258	0.258
2005	0.062	0.690	0.782	0.598	0.415	0.290	0.242	0.242
2006	0.047	0.544	0.592	0.434	0.320	0.253	0.231	0.231
2007	0.040	0.516	0.533	0.403	0.304	0.248	0.222	0.222
2008	0.036	0.463	0.490	0.374	0.294	0.242	0.203	0.203
2009	0.049	0.622	0.585	0.415	0.297	0.235	0.195	0.195
2010	0.043	0.567	0.554	0.396	0.288	0.238	0.196	0.196
2011	0.034	0.488	0.496	0.364	0.262	0.219	0.179	0.179
2012	0.028	0.425	0.468	0.370	0.258	0.215	0.172	0.172
2013	0.023	0.383	0.433	0.367	0.258	0.214	0.164	0.164
2014	0.014	0.293	0.414	0.392	0.298	0.257	0.206	0.206
2015	0.011	0.258	0.404	0.406	0.324	0.270	0.209	0.209
2016	0.009	0.234	0.422	0.463	0.375	0.293	0.216	0.216
2017	0.008	0.212	0.422	0.470	0.374	0.286	0.207	0.207
2018	0.009	0.225	0.428	0.473	0.378	0.288	0.202	0.202

Table 21.4.3. Turbot in Area 4. Estimated population abundance (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	2558.35	3132.30	1625.30	1330.65	1785.86	722.72	361.62	603.06
1982	4233.31	2023.29	2313.10	677.77	633.59	1037.61	435.42	636.93
1983	6540.45	3473.78	1485.92	1071.77	331.04	366.94	623.89	696.66
1984	5052.61	5583.21	2532.06	687.65	491.75	180.99	211.55	814.07
1985	2457.27	4244.63	3800.08	1087.88	318.36	256.76	99.83	626.10
1986	3385.47	1872.84	2972.16	1411.89	442.53	163.24	137.48	447.94
1987	3950.38	2787.87	1163.00	1384.71	582.12	220.39	90.25	362.64
1988	3677.93	3289.20	1771.38	451.20	599.24	292.77	123.10	287.02
1989	4475.56	2923.40	2023.54	734.28	236.25	322.24	162.03	257.45
1990	5840.89	3613.24	1705.97	612.19	297.00	117.97	176.17	247.16
1991	5020.33	4880.60	2015.44	456.79	206.32	118.51	54.19	208.91
1992	4466.72	4135.67	2659.78	522.95	146.40	76.92	51.22	123.53
1993	4950.83	3568.76	2182.04	655.94	164.99	53.32	31.90	78.68
1994	3808.66	4060.80	1704.94	523.19	198.57	59.44	22.51	48.50
1995	4894.32	2870.10	1947.75	385.70	162.97	73.16	25.22	31.08
1996	3339.09	4038.87	1327.00	473.17	121.96	62.86	32.26	24.73
1997	2873.29	2762.78	2203.31	362.34	160.18	46.87	28.41	24.86
1998	4123.42	2303.71	1637.07	739.61	130.44	62.42	19.99	22.71
1999	3487.17	3361.27	1420.49	576.60	291.78	51.34	26.60	17.01
2000	5631.54	2683.16	2043.18	564.53	230.47	129.65	23.43	18.37
2001	3581.23	4491.93	1331.55	719.77	228.60	98.10	64.93	19.53
2002	5781.07	2675.38	2012.64	412.16	261.65	100.42	48.05	42.15
2003	4877.21	4476.98	899.18	601.12	138.30	108.27	52.56	48.29
2004	6255.09	3645.34	1605.99	293.40	224.49	57.87	57.25	54.35
2005	4701.74	4754.09	1353.25	547.18	113.57	111.28	32.34	73.43
2006	6433.88	3641.84	1960.91	432.52	231.97	59.22	68.96	69.36
2007	5350.28	5153.61	1747.79	931.50	229.43	142.32	38.09	88.29
2008	3251.10	4432.23	2543.57	827.03	499.97	141.28	91.77	80.63
2009	4017.91	2448.95	2412.40	1405.23	485.54	278.54	87.39	114.68
2010	5556.44	3302.39	997.44	1077.13	761.40	306.56	175.89	132.65
2011	6932.62	4371.78	1664.04	436.07	609.39	467.46	194.55	197.64
2012	4148.49	5807.63	2233.99	904.50	254.26	393.73	318.31	254.43
2013	3166.17	3362.50	3451.99	1155.03	521.04	169.75	269.50	380.69
2014	6362.80	2304.76	1949.43	2079.53	673.69	349.03	119.38	477.25
2015	8792.24	5205.32	1500.47	1090.79	1214.90	420.35	222.33	411.07
2016	3048.42	7388.66	3190.27	887.97	624.63	720.51	258.92	417.00
2017	5139.92	2283.40	4962.47	1642.03	455.26	337.32	438.36	428.67
2018	5763.25	4107.89	1479.48	2515.43	834.84	258.21	207.98	547.89

Table 21.4.4a. Turbot in Area 4. Predicted catch numbers at age (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	5.371	317.570	687.198	503.059	486.713	177.224	68.072	113.522
1982	8.216	193.770	923.782	247.643	172.147	259.243	85.665	125.311
1983	16.103	395.766	617.700	419.801	99.303	100.679	136.818	152.776
1984	18.030	829.841	1137.340	288.575	160.060	52.696	47.997	184.702
1985	10.610	720.939	1809.940	489.768	112.027	78.210	22.893	143.573
1986	14.924	322.973	1346.785	606.579	151.075	48.102	30.395	99.036
1987	21.350	553.898	551.388	593.058	196.673	63.306	19.622	78.840
1988	22.638	686.388	837.518	178.572	193.278	82.294	27.217	63.461
1989	38.504	754.386	1127.377	345.103	92.115	106.263	43.813	69.616
1990	62.673	1063.882	1043.780	326.648	138.828	48.080	64.033	89.836
1991	62.085	1515.440	1268.285	254.727	101.813	50.904	21.170	81.610
1992	64.368	1362.292	1708.034	297.869	74.089	34.042	21.132	50.969
1993	85.397	1267.689	1432.544	379.843	84.434	23.828	13.592	33.527
1994	74.367	1499.225	1132.386	303.433	101.171	26.296	9.623	20.737
1995	98.714	1045.863	1268.714	219.780	81.314	31.638	10.744	13.237
1996	52.943	1221.961	799.884	255.345	59.201	26.811	13.954	10.698
1997	36.701	698.874	1205.341	184.769	76.532	20.191	12.820	11.218
1998	49.710	539.535	842.002	359.949	61.366	26.995	9.392	10.672
1999	49.189	839.023	702.887	269.727	129.568	20.821	11.838	7.569
2000	126.060	868.748	1062.709	268.698	99.675	48.331	9.226	7.236
2001	128.768	1860.693	745.103	363.812	100.705	35.342	23.584	7.092
2002	326.495	1381.731	1181.091	217.016	116.110	34.338	15.809	13.869
2003	283.630	2274.955	498.338	299.583	57.194	33.574	15.140	13.912
2004	377.203	1819.167	844.723	133.476	78.321	14.354	11.839	11.238
2005	256.208	2173.036	674.064	225.336	35.220	25.486	6.325	14.363
2006	265.831	1396.622	802.054	139.094	57.887	12.031	12.963	13.038
2007	190.324	1898.154	660.520	281.854	54.737	28.459	6.886	15.962
2008	102.884	1500.345	900.516	235.550	115.973	27.648	15.331	13.470
2009	174.964	1038.380	977.642	435.287	113.555	53.168	14.065	18.457
2010	212.743	1307.280	388.141	321.564	173.686	59.053	28.437	21.446
2011	209.890	1542.398	594.609	121.373	127.916	83.686	29.016	29.477
2012	102.107	1836.805	762.259	255.254	52.697	69.339	45.835	36.637
2013	65.977	976.645	1107.680	323.367	107.740	29.703	37.139	52.462
2014	80.831	533.908	602.909	615.508	158.150	71.940	20.231	80.880
2015	83.390	1077.575	454.724	332.329	306.625	90.415	38.073	70.394
2016	24.427	1400.892	1003.380	300.734	178.151	166.533	45.722	73.638
2017	34.817	397.015	1559.735	562.809	129.642	76.475	74.697	73.047
2018	48.467	752.078	470.602	865.280	239.419	58.782	34.638	91.246

Table 21.4.4b. Turbot in Area 4. Catch at age residuals (units: na)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	0.000	0.871	2.820	2.129	0.224	0.258	0.464	0.449
1982	0.000	2.743	-0.026	-1.811	-2.291	-0.099	-1.782	0.021
1983	0.000	1.334	0.009	0.924	0.337	-0.110	0.120	-0.042
1984	0.000	2.170	-0.013	0.582	-0.097	-0.106	-0.256	-0.898
1985	0.000	-0.462	-0.287	0.625	0.946	-0.187	-0.764	-0.916
1986	0.000	-1.085	-0.416	-0.977	-0.033	0.213	-0.745	-0.218
1987	0.342	0.777	-1.802	1.355	-1.005	-1.079	-0.086	-0.681
1988	0.716	0.903	-0.741	-1.446	-0.014	-0.017	0.073	0.071
1989	0.000	-0.481	0.214	0.836	2.512	-0.332	-0.358	-0.007
1990	0.589	0.307	-0.145	-1.371	0.724	1.837	1.896	0.362
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	-0.110	-0.387	0.396	0.687	0.122	-0.149	0.779
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	1.257	0.415	-2.539	-0.193	-0.509	-1.153	0.214	0.806
2004	0.912	0.095	-1.112	-0.208	-0.440	-2.275	-2.093	-1.984
2005	0.183	-0.568	0.184	-0.758	-1.545	-0.395	-2.347	1.364
2006	1.355	0.453	-0.965	-3.157	-1.660	-0.841	1.198	0.963
2007	-1.228	1.197	-0.813	0.881	-0.431	0.849	0.501	-0.450
2008	0.006	-0.085	-0.293	-0.331	1.491	1.442	-0.777	-1.054
2009	-0.077	0.288	1.295	1.173	-0.506	-2.309	-0.535	0.199
2010	0.660	0.971	-1.119	-0.493	0.045	1.563	-0.002	-0.439
2011	-0.130	0.502	1.051	-1.045	0.187	-0.216	0.119	-0.921
2012	0.000	-0.095	0.168	1.624	-0.606	0.021	1.215	-1.642
2013	0.051	0.520	0.877	0.484	-0.290	0.132	0.341	-2.179
2014	-0.756	-2.405	0.701	1.978	0.137	2.025	1.907	0.514
2015	-0.959	0.373	1.086	0.462	0.716	0.490	-0.111	0.140
2016	0.000	-1.505	-0.077	1.929	2.285	0.057	-0.520	-0.339
2017	-1.410	-0.989	1.087	-0.116	0.001	-0.941	0.503	-0.769
2018	1.718	-0.500	-0.403	-0.609	0.105	0.307	0.129	-1.155

Table 21.4.5a. Turbot in Area 4. Predicted index at age SNS (units: na).

	Age					
Year	1	2	3	4	5	6
2004	109.473	38.524	10.193	1.082	0.957	0.277
2005	82.684	53.680	9.006	2.148	0.507	0.543
2006	114.374	45.605	14.920	1.905	1.107	0.296
2007	95.555	65.817	13.862	4.194	1.108	0.715
2008	58.248	58.746	20.797	3.799	2.431	0.712
2009	71.296	29.021	18.450	6.275	2.356	1.411
2010	99.019	40.682	7.795	4.872	3.716	1.551
2011	124.345	56.935	13.550	2.018	3.030	2.396
2012	74.747	79.045	18.557	4.167	1.268	2.024
2013	57.219	47.142	29.382	5.335	2.599	0.873
2014	115.733	34.426	16.820	9.434	3.266	1.742
2015	160.327	79.721	13.039	4.899	5.782	2.079
2016	55.652	115.119	27.358	3.831	2.868	3.506
2017	93.926	36.120	42.566	7.050	2.091	1.649
2018	105.182	64.409	12.634	10.783	3.827	1.261

Table 21.4.5b. Turbot in Area 4. Index at age residuals SNS

	Age					
Year	1	2	3	4	5	6
2004	0.591	-1.313	1.256	0.842	0.531	1.849
2005	-0.678	1.909	0.435	0.000	0.000	0.000
2006	0.908	1.003	-0.319	0.643	-0.365	0.000
2007	0.001	-0.090	1.805	0.452	-0.234	0.000
2008	-0.596	1.648	0.546	0.582	0.775	-0.230
2009	-1.266	-0.512	-1.253	1.789	0.495	0.000
2010	0.598	0.071	0.096	0.001	-0.054	1.404
2011	0.375	-0.524	0.000	0.000	0.000	-0.268
2012	-1.181	-0.089	-0.232	-0.722	0.000	0.000
2013	0.504	-1.708	0.422	-2.118	0.000	0.000
2014	1.082	-1.142	-0.184	0.023	0.605	-0.566
2015	1.722	-1.142	-2.096	0.398	0.000	0.000
2016	-1.323	0.942	-0.220	-0.680	-0.515	-1.514
2017	2.189	-0.671	0.138	-2.937	0.000	-0.557
2018	-0.245	0.333	0.165	0.452	0.441	0.512

Table 21.4.6a. Turbot in Area 4. Predicted index at age BTS-ISIS

	Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	1.655	1.212	0.187	0.049	0.018	0.012	0.006
1992	1.470	1.004	0.240	0.055	0.013	0.007	0.005
1993	1.626	0.840	0.190	0.068	0.014	0.005	0.003
1994	1.248	0.939	0.146	0.054	0.017	0.006	0.002
1995	1.604	0.667	0.172	0.041	0.014	0.007	0.002
1996	1.098	1.012	0.131	0.053	0.011	0.006	0.003
1997	0.947	0.731	0.243	0.043	0.015	0.005	0.003
1998	1.360	0.622	0.191	0.090	0.012	0.006	0.002
1999	1.148	0.893	0.171	0.073	0.028	0.005	0.003
2000	1.842	0.656	0.236	0.070	0.023	0.014	0.002
2001	1.159	0.978	0.143	0.085	0.022	0.011	0.007
2002	1.839	0.498	0.205	0.047	0.025	0.011	0.005
2003	1.549	0.844	0.098	0.072	0.014	0.012	0.006
2004	1.984	0.698	0.184	0.038	0.025	0.007	0.007
2005	1.498	0.973	0.162	0.075	0.013	0.014	0.004
2006	2.072	0.826	0.269	0.066	0.028	0.008	0.009
2007	1.731	1.193	0.250	0.146	0.028	0.018	0.005
2008	1.055	1.064	0.375	0.132	0.063	0.018	0.012
2009	1.292	0.526	0.333	0.219	0.061	0.036	0.012
2010	1.794	0.737	0.141	0.170	0.096	0.040	0.024
2011	2.253	1.032	0.244	0.070	0.078	0.062	0.026
2012	1.354	1.432	0.335	0.145	0.033	0.052	0.043
2013	1.037	0.854	0.530	0.186	0.067	0.022	0.037
2014	2.097	0.624	0.303	0.329	0.084	0.045	0.016
2015	2.905	1.445	0.235	0.171	0.149	0.053	0.030
2016	1.008	2.086	0.494	0.133	0.074	0.090	0.034
2017	1.702	0.654	0.768	0.246	0.054	0.042	0.058
2018	1.906	1.167	0.228	0.376	0.098	0.032	0.028

Table 21.4.6b. Turbot in Area 4. Index at age residuals BTS-ISIS

	Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	-0.568	0.730	-1.031	-2.316	-0.896	0.000	0.216
1992	-0.076	0.533	0.237	-1.268	-0.278	-0.223	-1.024
1993	0.245	0.805	-0.446	-0.761	0.984	-1.504	-1.720
1994	0.164	0.778	-1.536	-0.648	-0.879	-0.312	0.685
1995	0.014	-1.085	-0.928	-1.154	0.327	-0.141	0.000
1996	-1.523	1.849	-0.182	1.354	1.877	0.000	1.351
1997	-0.489	1.739	1.343	-0.544	1.245	1.190	1.619
1998	1.372	0.776	0.703	0.956	-1.130	0.000	-0.540
1999	-0.174	0.412	0.136	0.605	-0.358	-0.610	-0.782
2000	1.742	-0.660	0.732	1.284	1.038	1.804	0.000
2001	-1.334	-0.166	-1.653	0.357	0.000	0.000	2.158
2002	1.067	-1.660	-1.785	-0.702	-0.038	0.750	-1.600
2003	-0.530	-0.234	0.114	-0.621	0.000	-0.074	0.859
2004	-0.310	-0.334	1.378	0.000	0.995	0.675	0.000
2005	-0.774	0.519	2.167	0.388	0.926	-0.968	1.012
2006	-0.459	-0.107	0.577	1.030	-1.916	0.000	0.000
2007	-0.294	-0.169	2.507	1.230	1.361	1.285	0.000
2008	0.041	0.448	0.513	0.069	-0.004	-0.180	2.058
2009	0.089	-0.969	0.187	0.565	1.163	0.277	-1.037
2010	0.496	-0.992	-0.686	-1.240	-0.004	-1.134	-0.629
2011	0.040	0.218	-0.253	0.033	-0.094	-1.377	0.000
2012	-0.506	0.259	-0.060	1.111	-0.243	-0.022	0.691
2013	-1.663	0.240	0.756	0.138	-1.218	0.758	0.140
2014	1.232	-2.202	0.054	0.355	0.526	0.156	-0.046
2015	1.113	0.042	0.263	-0.736	-0.307	0.000	-0.896
2016	-1.436	0.360	-0.235	-1.398	-0.852	-0.906	-0.348
2017	0.764	-1.388	-0.102	-2.424	-1.566	-1.197	-0.492
2018	-0.687	-0.169	0.291	-0.495	0.531	-0.055	0.000

Table 21.4.7. Turbot in Area 4. Predicted index at age and index at age residuals of the Dutch LPUE

year	Index	Resid
1995	0.0412	0.526
1996	0.0378	-0.819
1997	0.0394	-1.544
1998	0.0357	-0.419
1999	0.0376	-0.354
2000	0.0444	-0.095
2001	0.0479	-0.226
2002	0.0440	0.223
2003	0.0440	1.041
2004	0.0467	-0.527
2005	0.0519	-2.309
2006	0.0531	-0.842
2007	0.0641	0.221
2008	0.0684	-0.117
2009	0.0634	0.158
2010	0.0554	1.546
2011	0.0612	0.524
2012	0.0732	1.583
2013	0.0749	1.816
2014	0.0707	2.118
2015	0.0726	2.609
2016	0.0826	1.733
2017	0.0867	0.267
2018	0.0796	-1.360

Table 21.4.8. Turbot in Area 4. Fit parameters

Name	value	std.dev
logFpar	-3.856	0.148
logFpar	-4.320	0.206
logFpar	-4.978	0.279
logFpar	-7.867	0.079
logFpar	-8.335	0.093
logFpar	-8.638	0.176
logFpar	-9.807	0.099
logSdLogFsta	-0.820	0.370
logSdLogFsta	-1.369	0.232
logSdLogFsta	-1.899	0.221
logSdLogN	-1.816	0.284
logSdLogN	-1.577	0.339
logSdLogObs	-0.829	0.171
logSdLogObs	-2.202	0.389
logSdLogObs	-0.131	0.221
logSdLogObs	-1.216	0.278
logSdLogObs	-2.303	0.457
logSdLogObs	-1.103	0.148
logSdLogObs	-1.032	0.156
logSdLogObs	-0.483	0.156
logSdLogObs	-0.245	0.182
transfIRARdist	0.140	0.134
itrans_rho	-0.899	0.097

Table 21.4.9. Turbot in Area 4. Negative Log-Likelihood

391.390

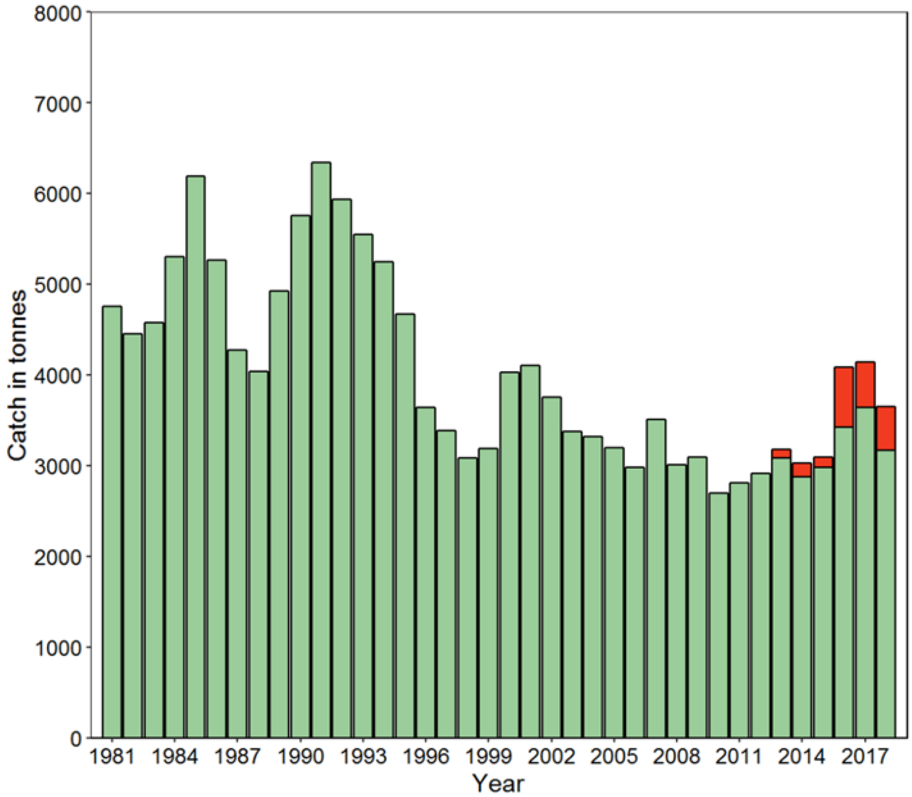


Figure 21.2.1. Turbot in 27.4.20. Total catches 1981–2018. Landings (green) are obtained from the ICES database of official landings. Discards (red) are obtained from Intercatch.

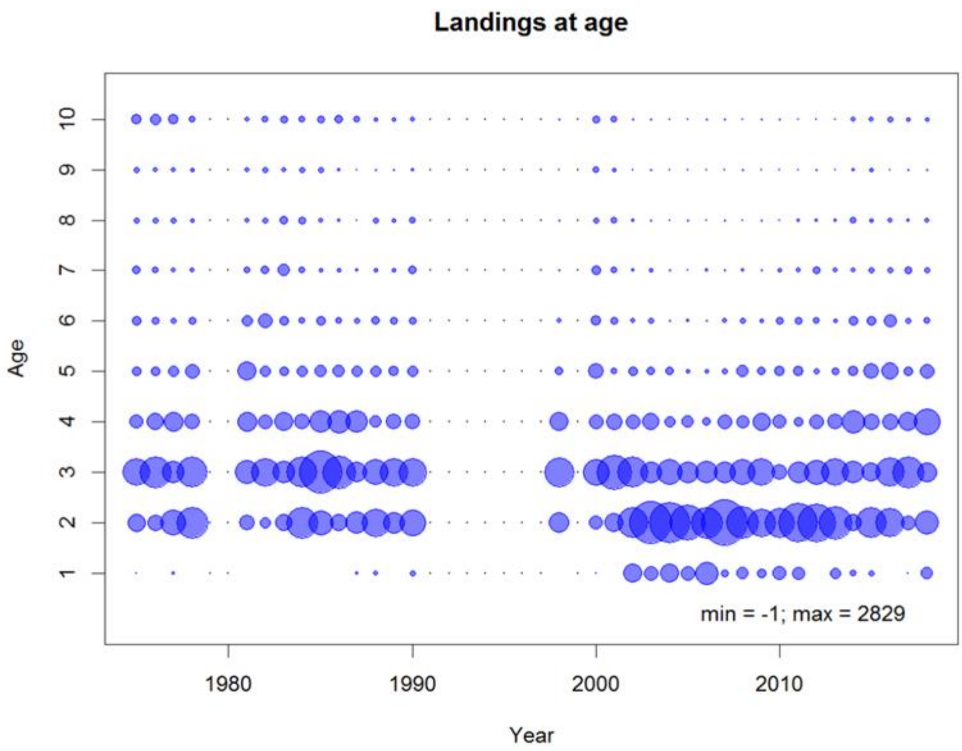


Figure 21.2.2. Turbot in 27.4.20. Landings at age for the years with available data between 1975–2018.

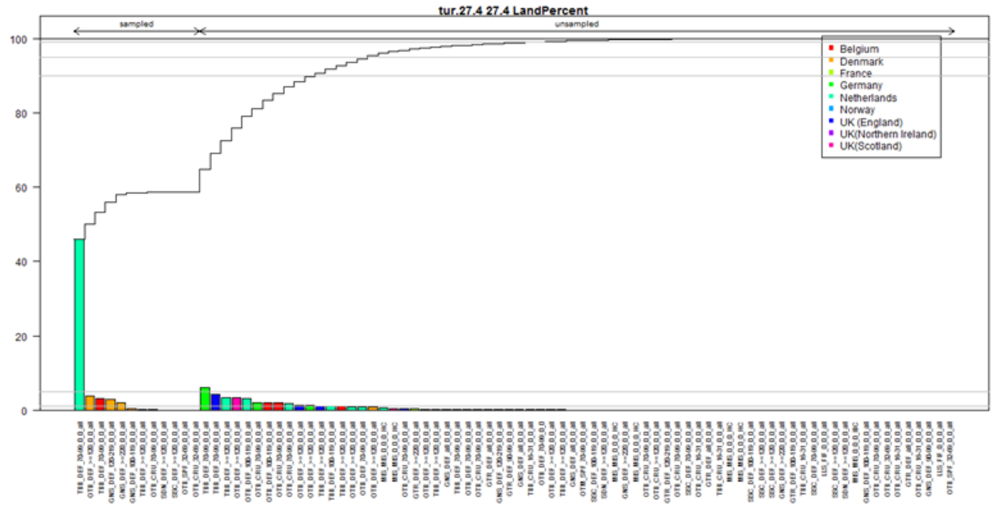


Figure 21.2.3. Turbot in 27.4.20: Total landings by métier in 2018 sorted by sampled/unsampled for numbers at age in InterCatch.

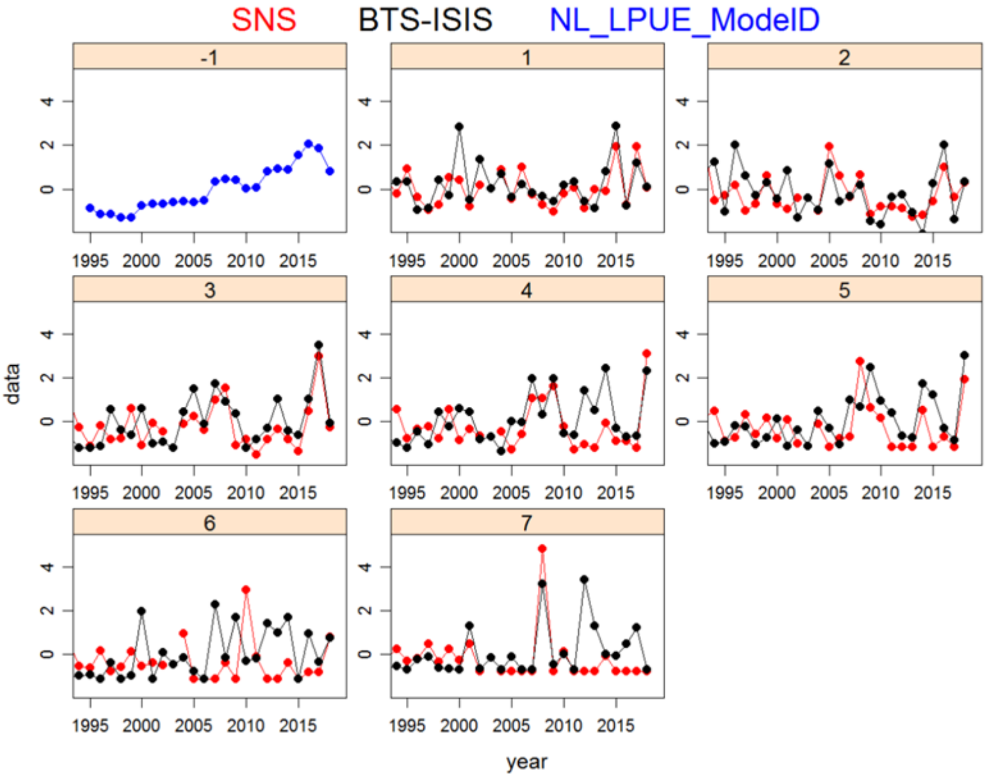


Figure 21.2.4. Turbot in 27.4.20. Time series of the standardized indices for ages 1 to 7 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE.

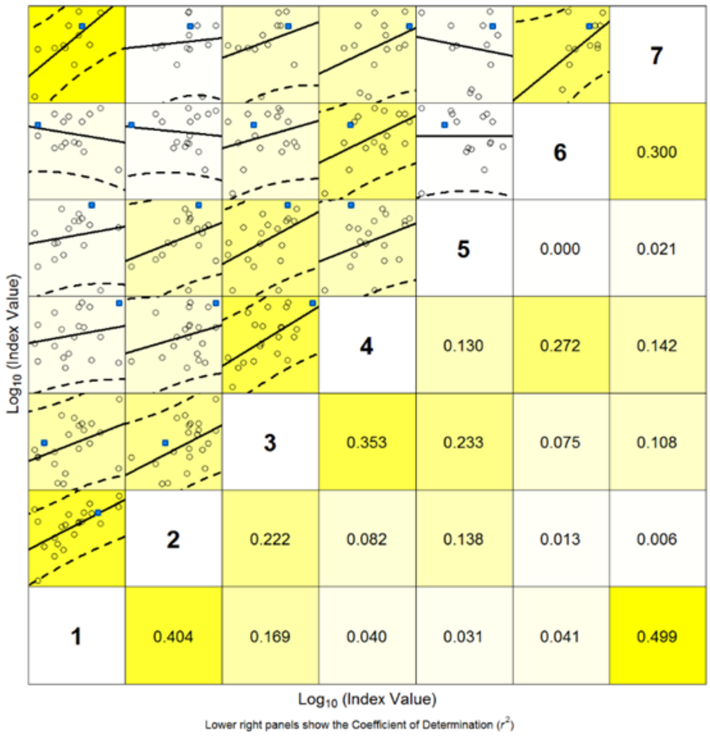
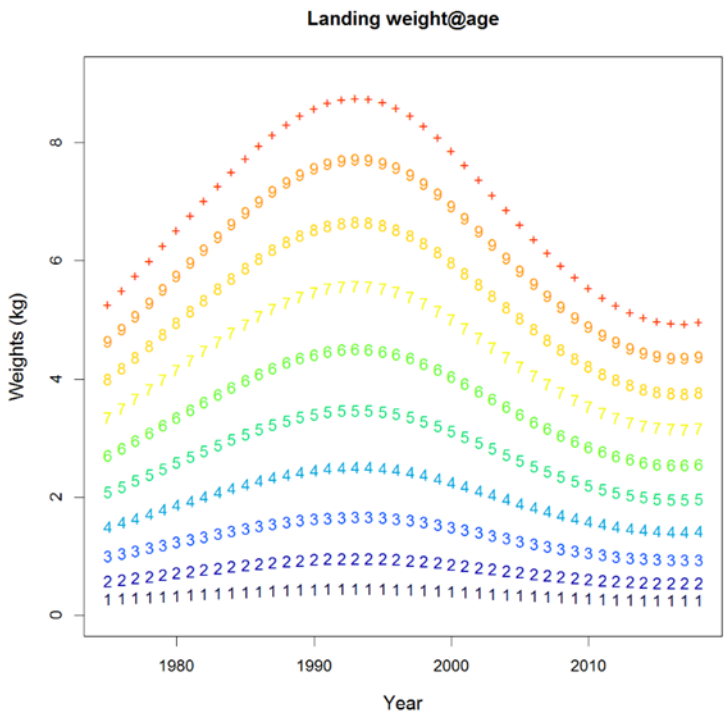


Figure 21.2.5. Turbot in 27.4.20. Internal consistency of the two tuning indices available for the assessment : BTS-ISIS from 1996–2018 (top), and SNS 2004–2018 (bottom).



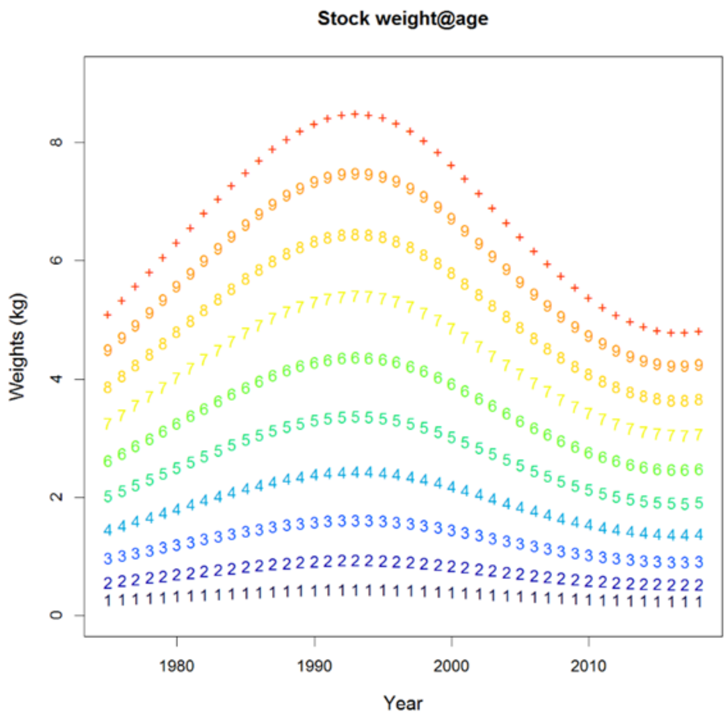


Figure 21.2.6. Landings (top) and stock (bottom) weight at age from modelled values (points).

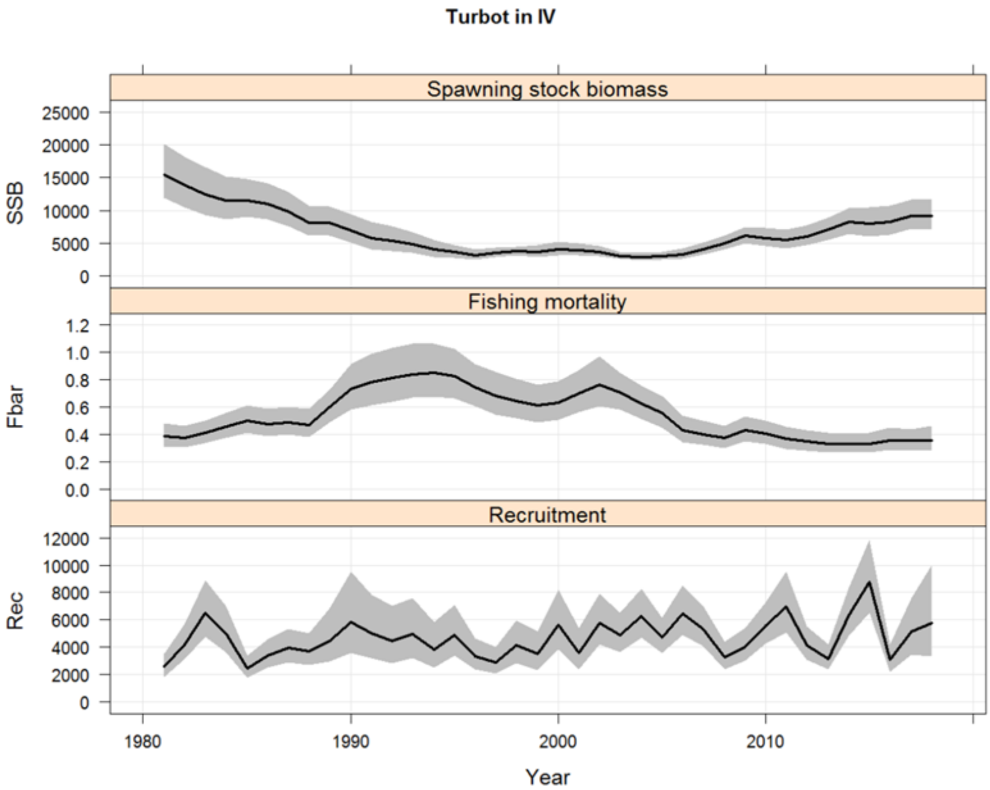


Figure 21.4.1. Summary plot of SSB, F and Recruitment, including the uncertainty bounds.

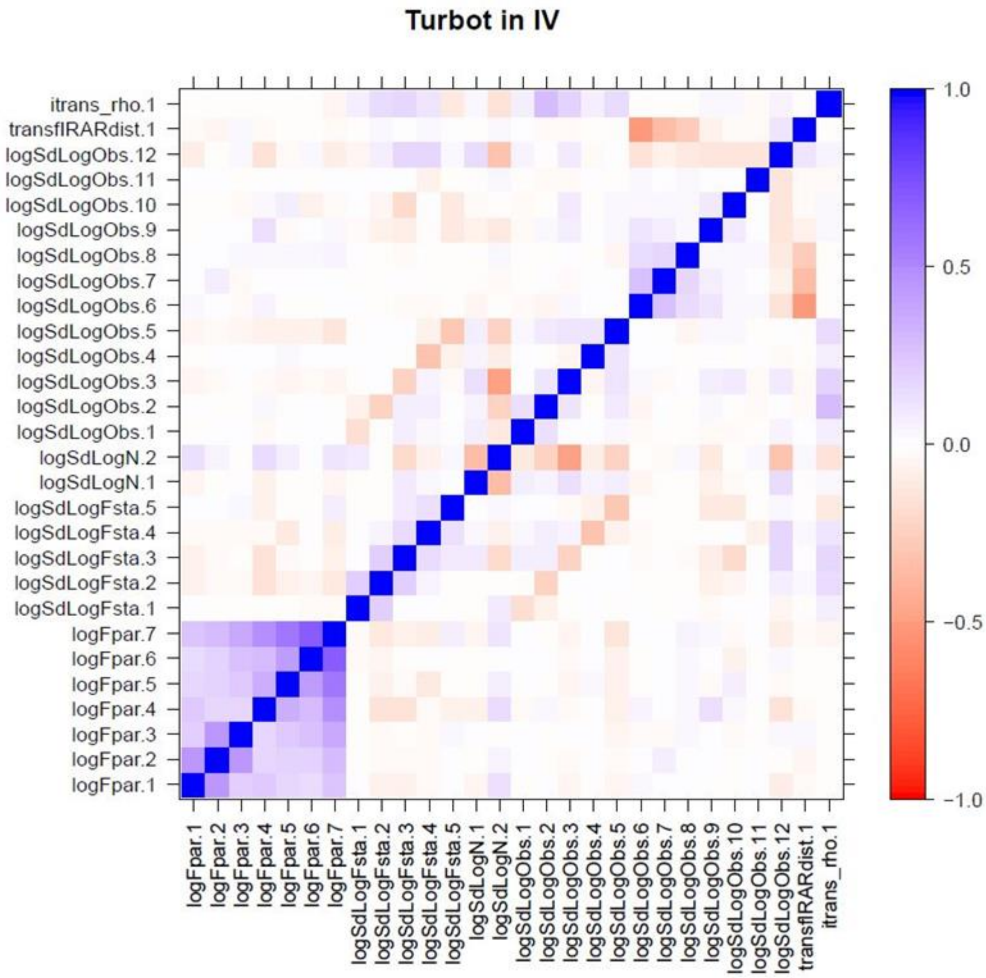


Figure 21.4.2. Parameter-correlation plot. It shows the correlation among all parameters that are estimated in the model. Fpar parameters refer to catchabilities, Fstates to the random walk in F, logN to the random walk in N, logObs to the observation variances, fRARdist to the auto-correlation in the surveys and trans_rho to the correlation in the F-random walks.

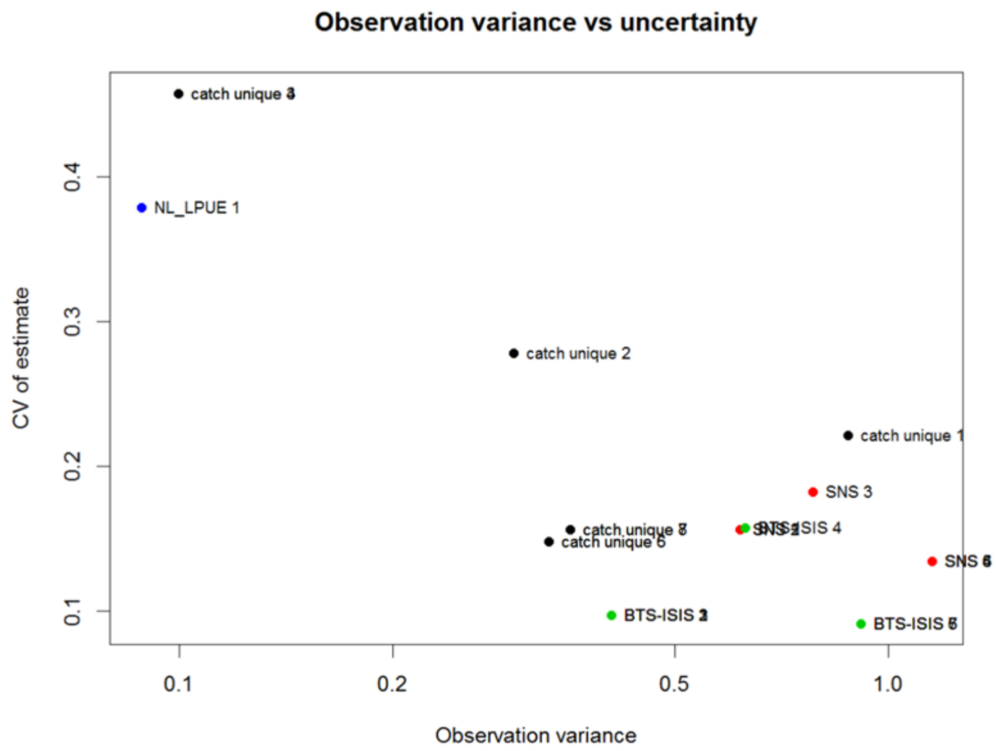


Figure 21.4.3. Plot showing the observation variance vs the CV of that estimate.

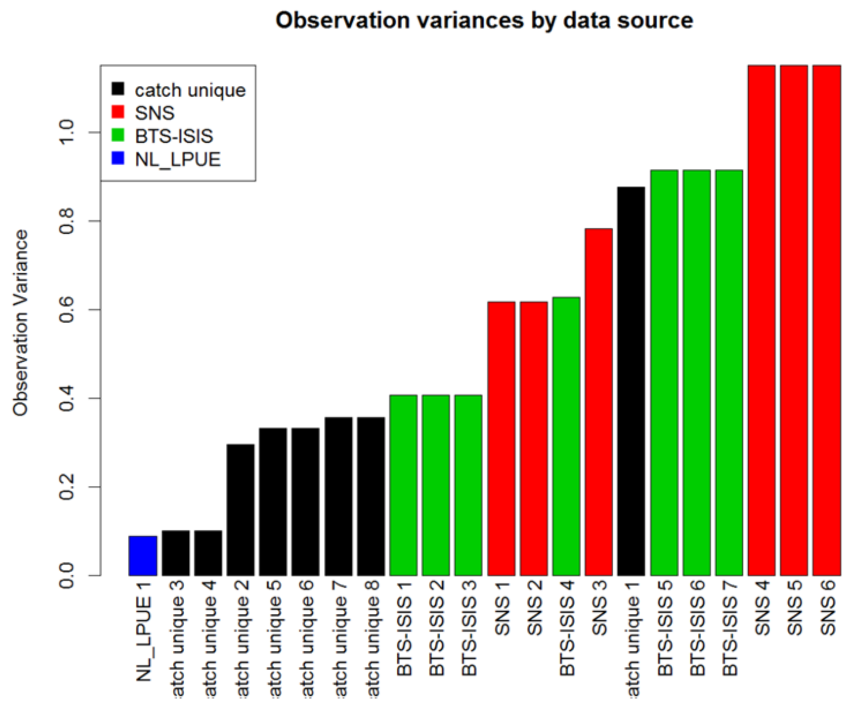


Figure 21.4.4. Estimated observation variances (scaling factor for each of the surveys), ordered from the best to the worst survey fit and has colour coding to show which bars belong to one dataset.

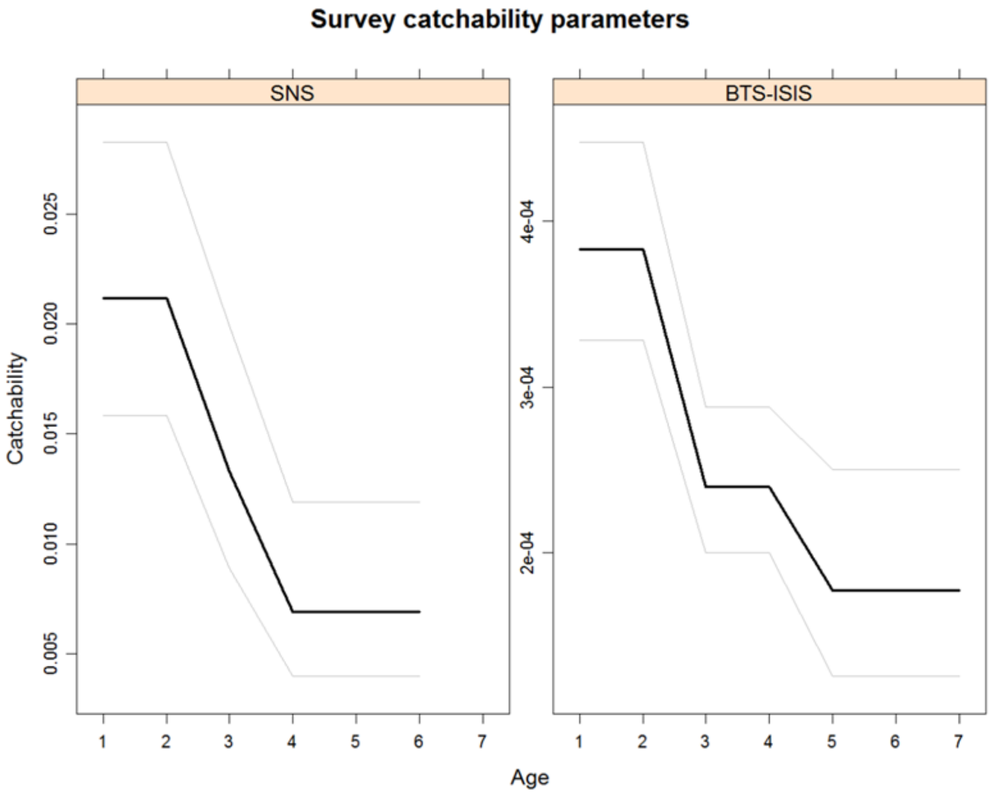


Figure 21.4.5. Catchabilities of the surveys for all surveys with more than 1 age-group.

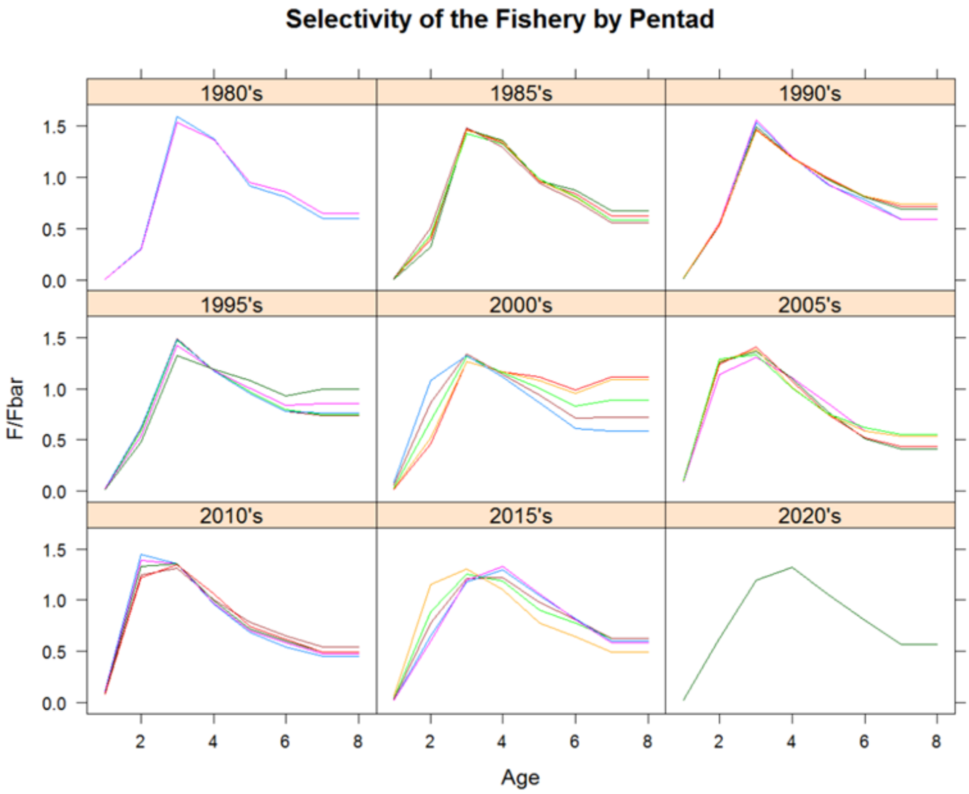


Figure 21.4.6. Estimated selectivity from 1981 to 2018, grouped by a 5-year period. Note the 1980s are 1981 and 1982, 2020s is only 2018. Values represent actual F-at-age.

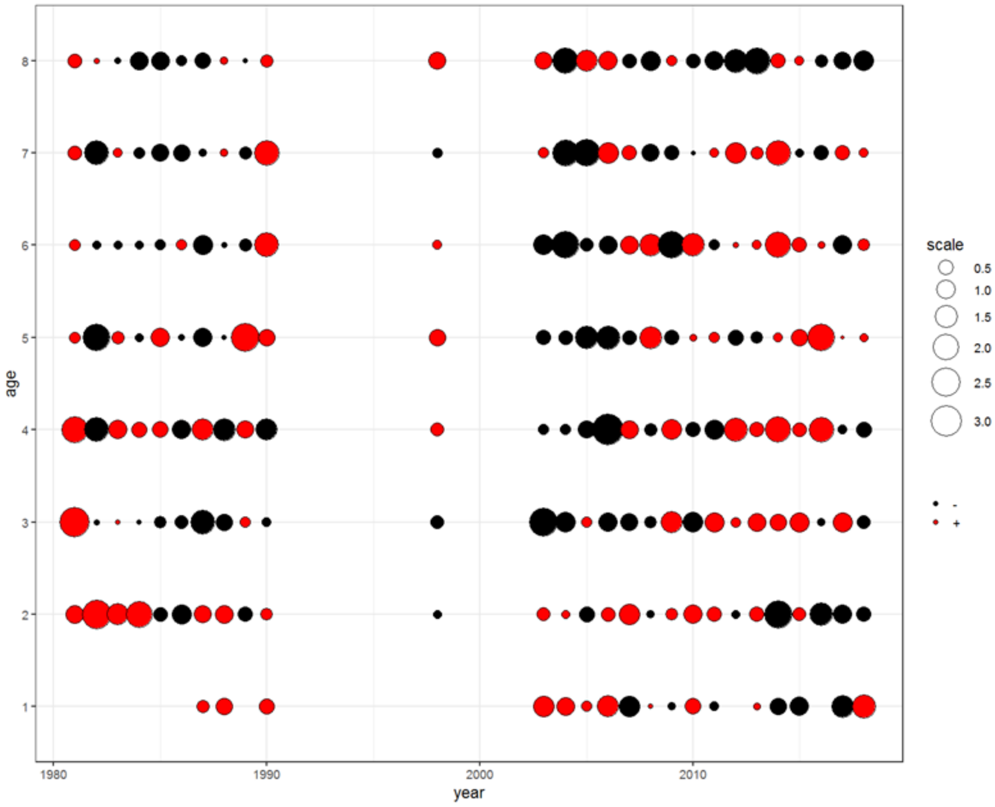


Figure 21.4.7. Residual bubble plot of landings

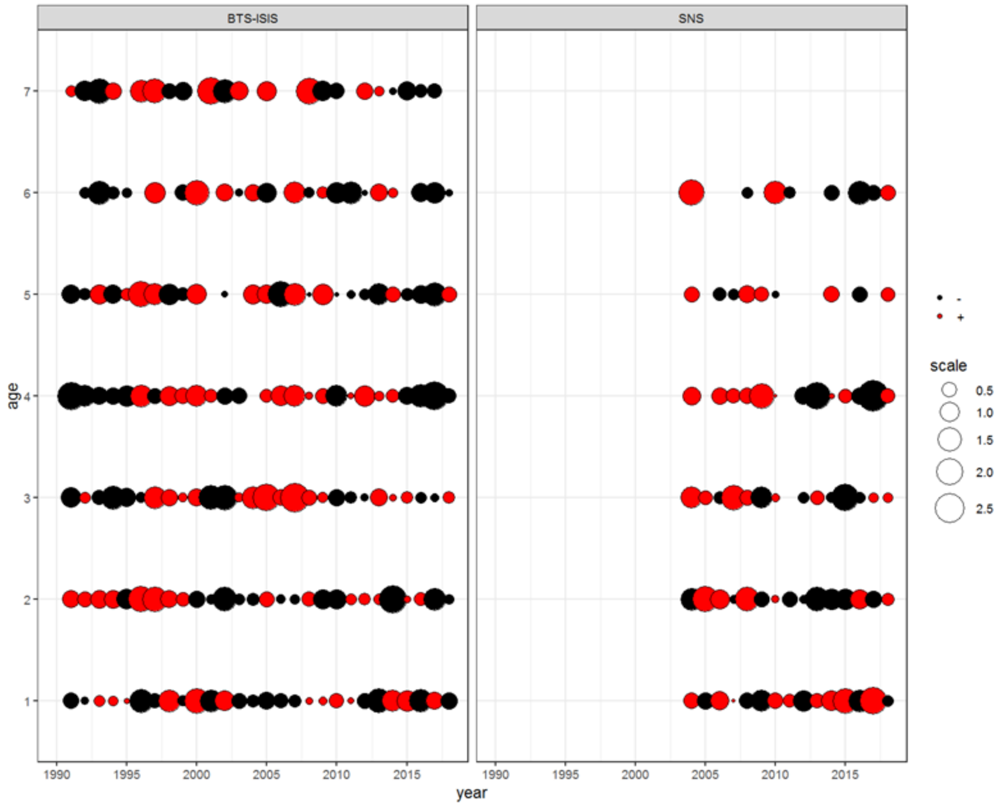


Figure 21.4.8. Residual bubble plot of SNS and BTS-ISIS survey.

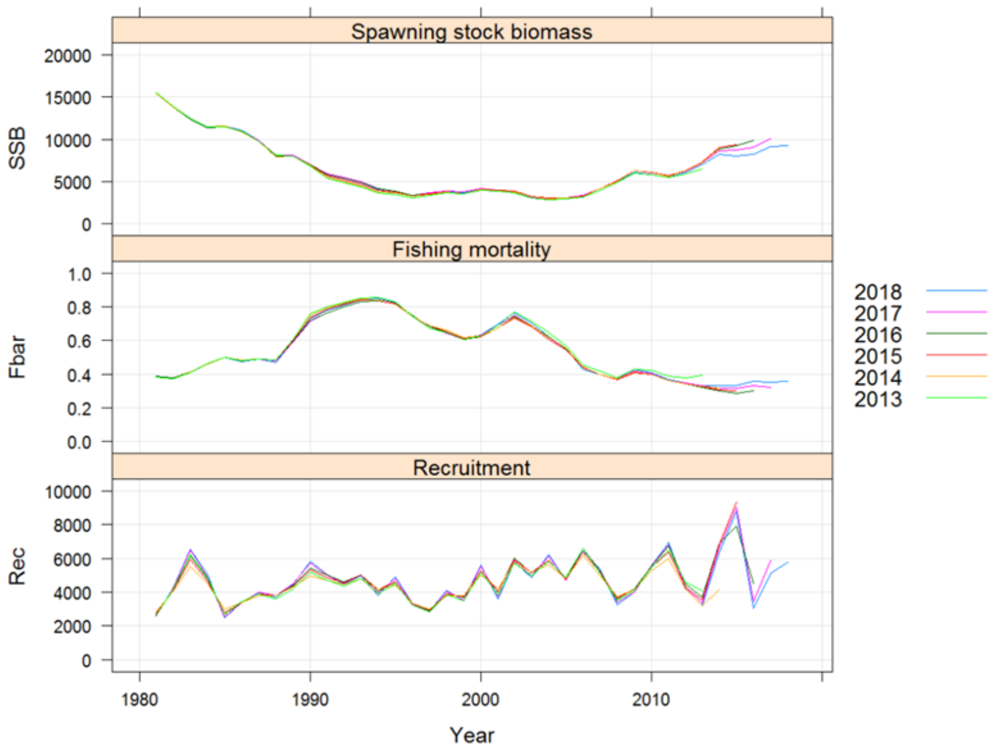


Figure 21.4.9. Retrospective analysis plot on SSB, F and R.

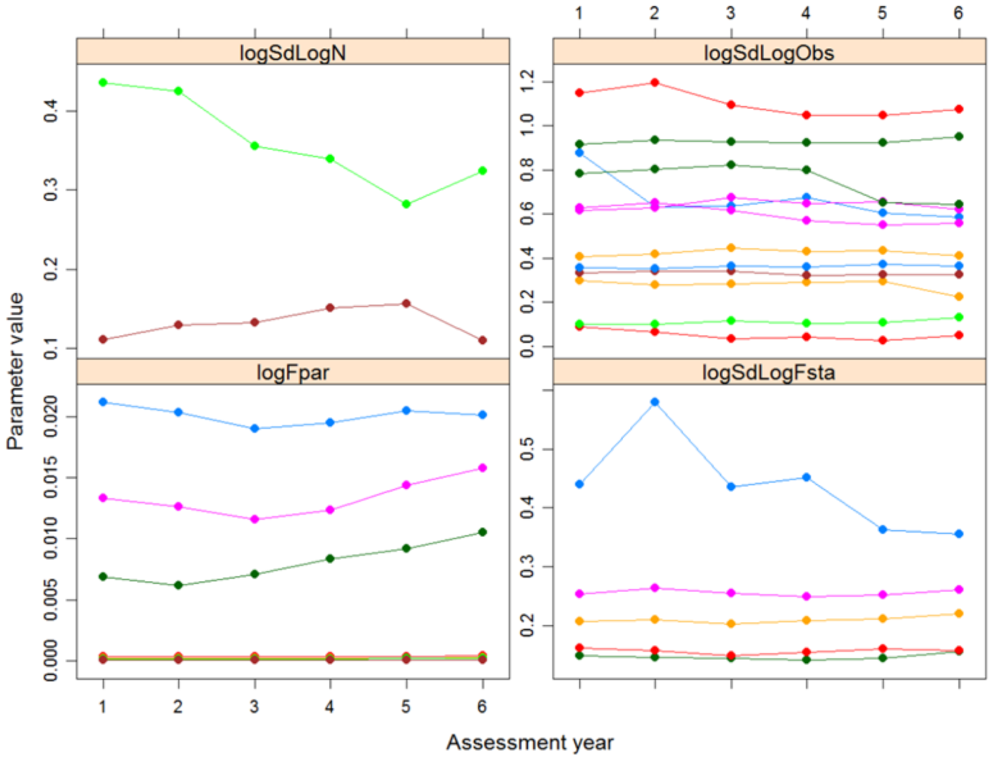


Figure 21.4.10. Retrospective analysis plot on the value of the estimated parameters, ideally, all show a flat line indicating that with reducing the model with a year's worth of data does not affect the parameters to be estimated: logSdLogN = the random walk in N, logSdLogObs is the observation variance in the surveys and catch, logFpar are the catchability parameters and logSdLogFsta are the sd's of the random walks in F.

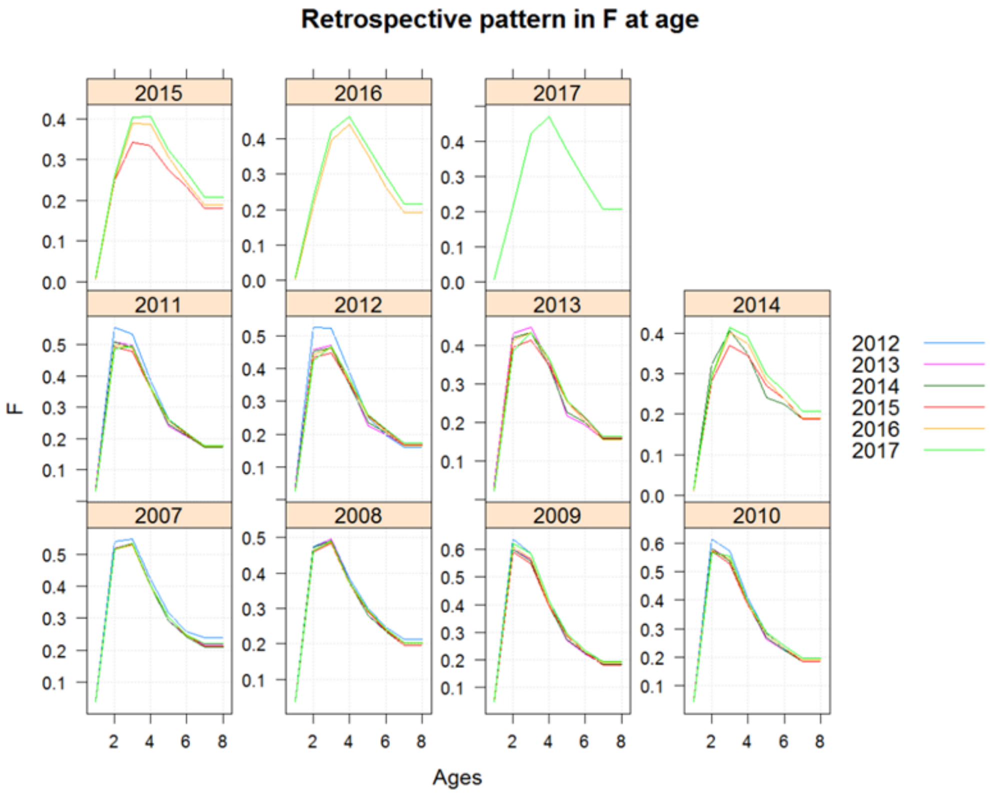


Figure 21.4.11. Retrospective analysis plot of selectivity pattern.

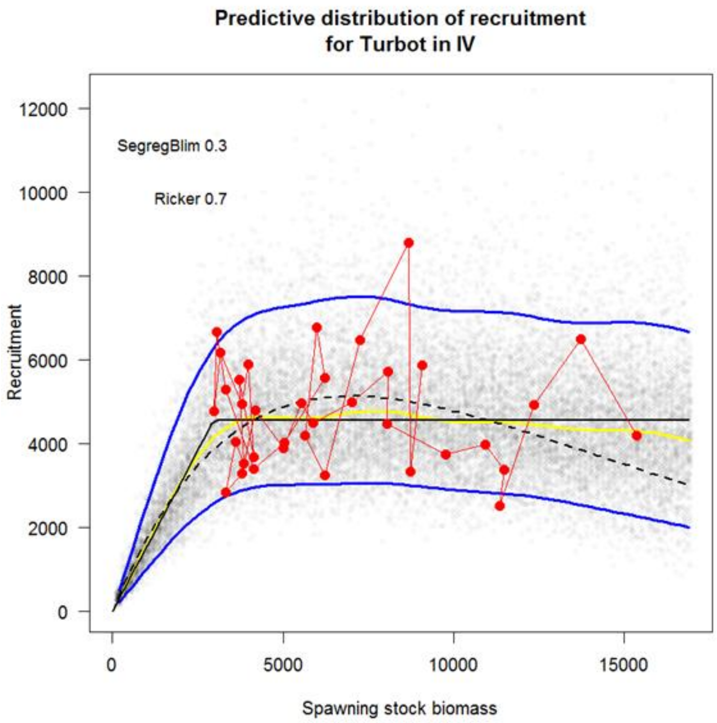


Figure 21.6.1. Stock recruitment pairs over time.

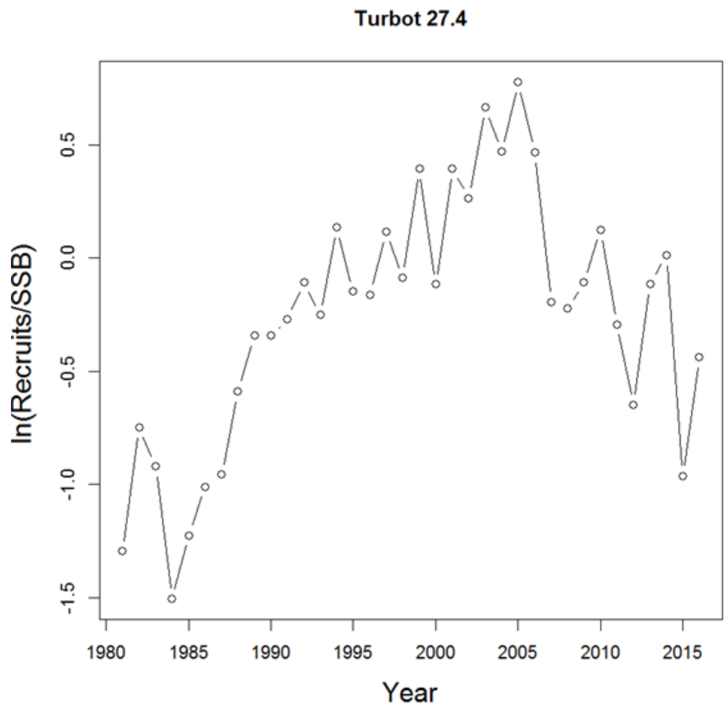


Figure 21.6.2 Productivity over time

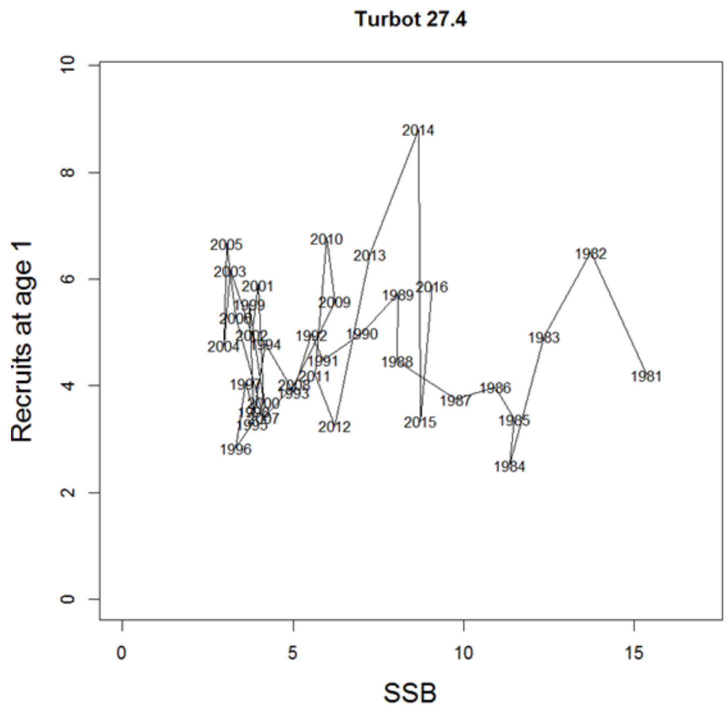


Figure 21.6.3. Stock recruitment pairs over time

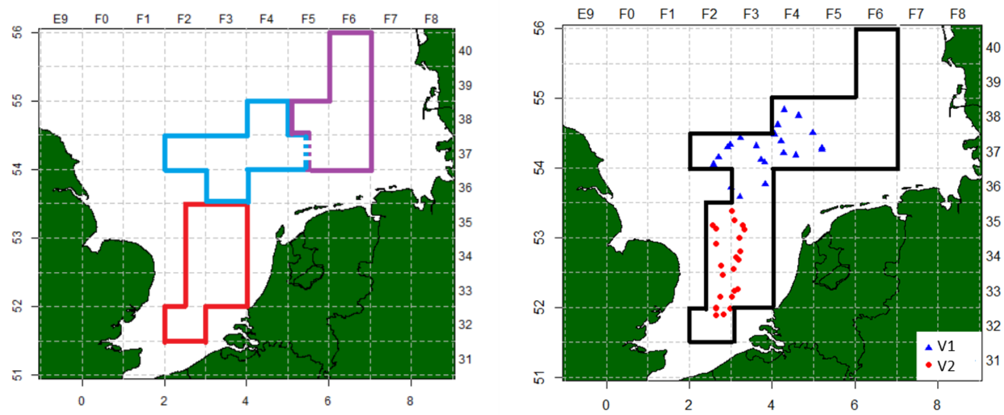


Figure 21.9.1. Map showing the 3 zones to be monitored during the new Dutch industry-based survey (left). Map showing the monitored stations per zone during the 2018 survey (right).

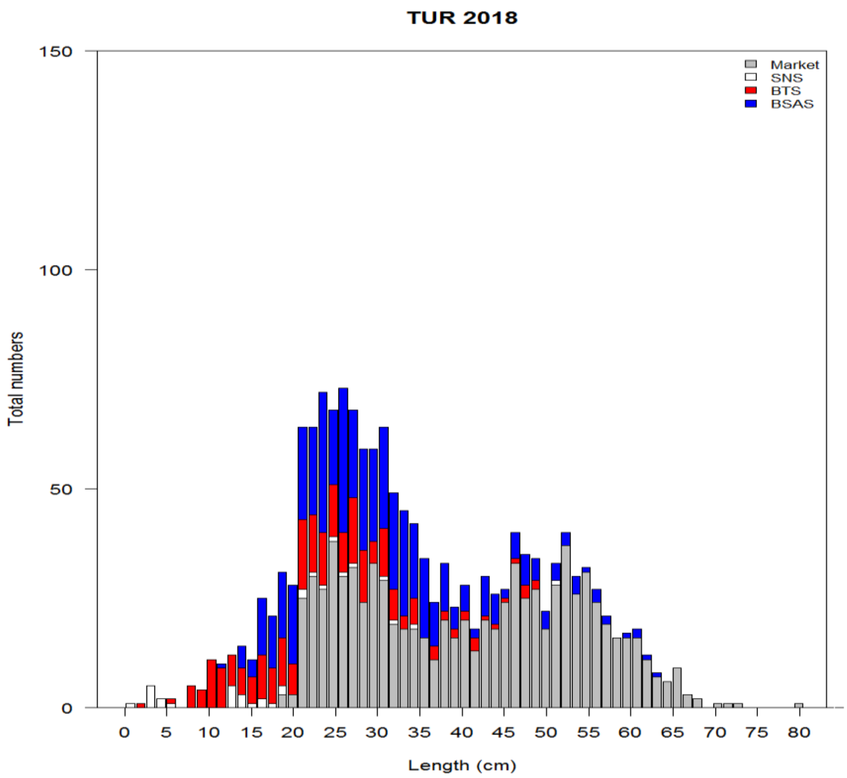


Figure 21.9.2 Length distribution showing all turbot samples collected in 2018 by the Netherlands. Commercial market samples are indicated in grey, fisheries independent survey data are shown in red (BTS) and white (SNS) and the industry-based survey samples are indicated in blue.

22 Whiting (*Merlangius merlangus*) in 3.a (Skagerrak, Kattegat)

22.1 General

22.1.1 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).

22.1.2 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).

22.1.3 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.

22.1.4 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, indicative of 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 3.a. Plots of the IBTS–Q1 and IBTS–Q3 per area are shown in Figure 22.1 and BITS–Q1 and Q4 in Figure 22.2. 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 22.3 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 22.4. 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).

22.2 Data analyses

22.2.1 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).

22.2.2 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.

22.2.3 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. The advice given by WGNSSK in 2019 for the years 2020 and 2021 is the same as the last advice given for the stock, i.e. 400 tonnes. No precautionary buffer is used as it was applied in 2017.

22.2.4 Issues for future benchmarks

Further exploration of biomass indices should be considered to investigate if alternative methods of calculation, e.g delta-GAM, can produce a reliable total biomass index that in combination with the total catch estimates from ICES can be the base of a production model assessment. The raising of the discards can be reevaluated. Currently, it is done using a simple method of raising all unreported with all reported, excluding industrial bycatch which is assumed to be zero. A future benchmark for the stock should investigate these issues further and propose an assessment method that could raise the category of the stock.

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.

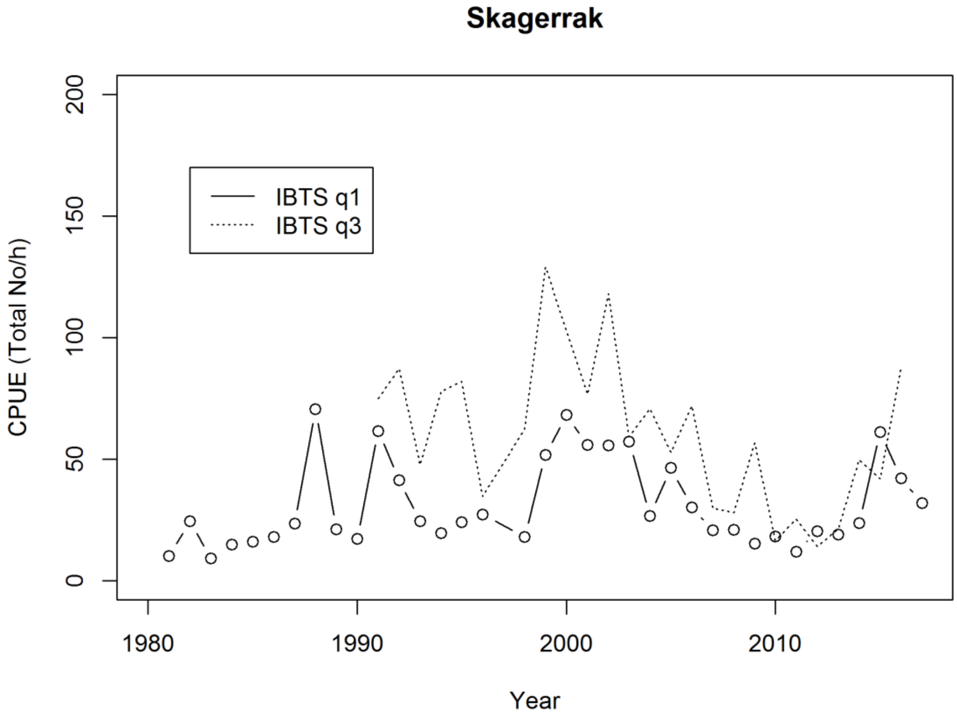
Table 22.1. Whiting in Division 3.a (Skagerrak and Kattegat): Nominal landings (t) as supplied by the Study Group on Division 3.a Demersal Stocks (ICES, 1992b) and updated by the Working Group, and WG estimate of Discards.

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

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
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
2017	217	163	380	8	33	6	427	1166
2018	175	156	331	5	33	2	372	1371

[1] **Values from 1992 updated by WGNSSK (2007).**

[2] **Values updated by WGNSSK (2011).**



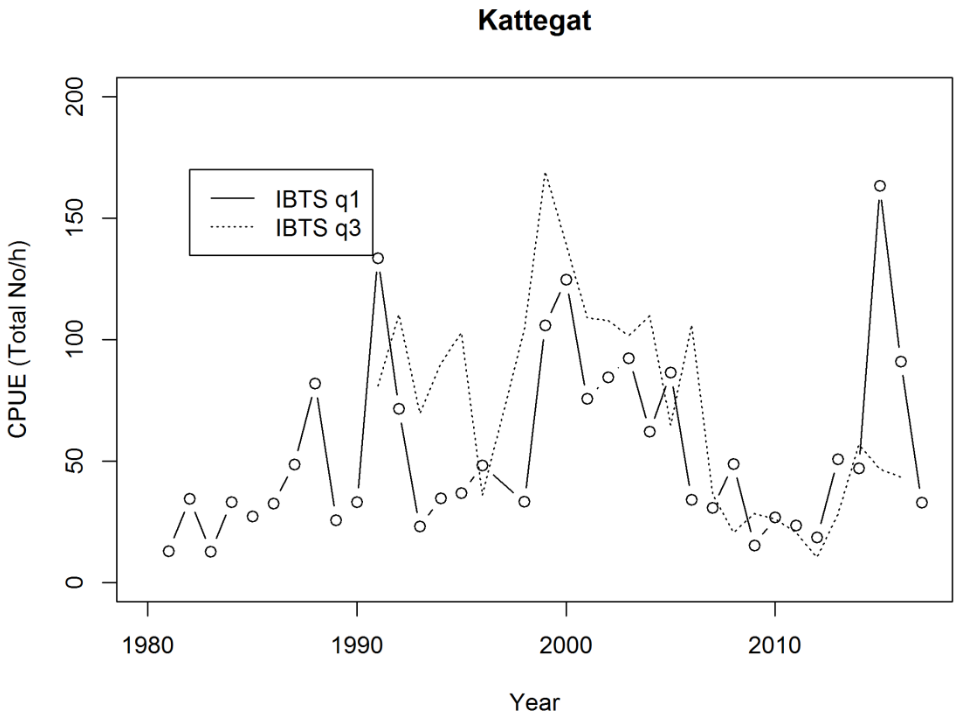


Figure 22.1. Whiting in Division 3.a (Skagerrak and Kattegat): IBTS CPUE for fish > 21 cm per area Q1 covering the years 1981–2017 and Q3 covering the years 1991–2016.

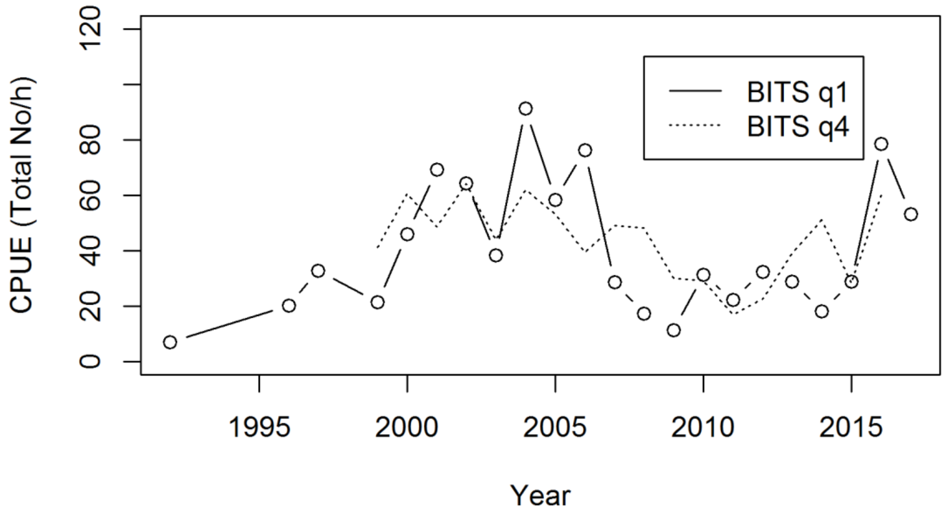


Figure 22.2. Whiting in Division 3.a S (Kattegat): BITS CPUE for fish > 21 cm per Q1 and Q4 covering the years 1992–2017 and 1999–2016, respectively.

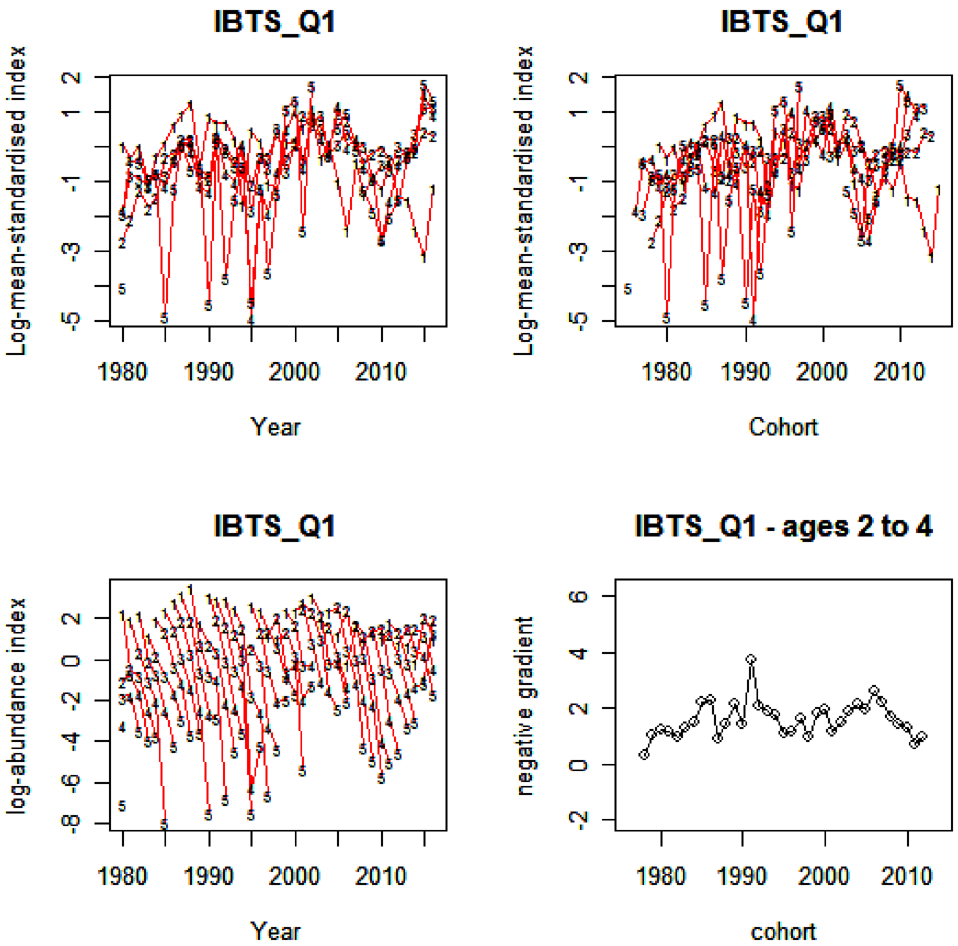


Figure 22.3. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta-GAM index).

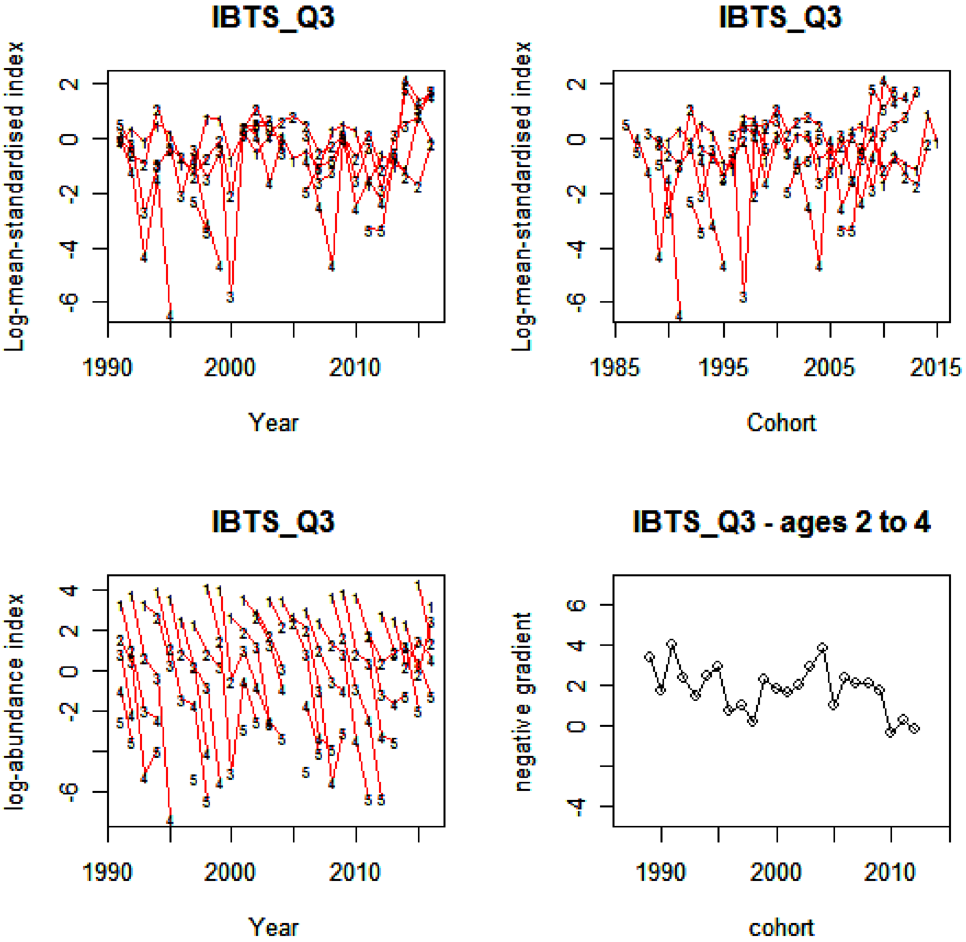


Figure 22.4. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

23 Whiting (*Merlangius merlangus*) in Subarea 4 (North Sea), Division 7.d (Eastern English Channel)

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.

23.1 General

23.1.1 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. 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 combined North Sea and Eastern Channel (27.4 and 27.7d). Exploratory SURBAR assessments were run for individual components (northern and southern component) and compared to the combined stock.

23.1.2 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).

23.2 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES WKNSEA (2018a).

23.3 ICES advice

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 November 2018, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 24 195 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 13 052 tonnes and human consumption catch of no more than 21 088 tonnes.

ICES advice for 2020

In May 2019, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 22 082 tonnes. If unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2016–2018), this implies wanted catch of no more than 12 737 tonnes and human consumption catch of no more than 19 354 tonnes.

23.4 Management

Management of whiting is implemented 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 and for 2017 the TAC was increased to 16 003 tonnes of wanted catch for human consumption. Since 2018, with introduction of the landing obligation the TAC accounts for total human consumption catch in Subarea 4, including discards and landings below minimum landings size (BMS) but excluding industrial bycatch (IBC). The TAC for 2018 was set to 22 057 tonnes and for 2019 was 17 191 tonnes. There is no separate TAC for Division 7.d; landings from this Division are counted against the TAC for Divisions 7.b–k combined (22 778 tonnes in 2016, 27 500 tonnes in 2017, 22 213 tonnes in 2018, 19 184 tonnes in 2019). There are no means to control how much of the Division 7.b–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 2018, 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. Some very minor catches in the Norwegian fishery currently reported as BMS may be considered industrial bycatch but are currently not reported as such.

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. In 2017 and 2018 there were no data submissions to Intercatch on discard rates from the FDF fleets for whiting.

23.5 Data available

23.5.1 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 2018, no logbook registered discards are submitted. Minor whiting landings have been reported as BMS landings into InterCatch since 2016. In 2018 data, these mostly originated from a Norwegian OTB_CRU métiers (699 t). A small proportion of other Norwegian BMS submissions may be considered industrial bycatch but are not reported as such. This is not considered here as the main métiers of OTB_CRU are unlikely to be landing IBC. Only very small amounts of BMS were reported by UK(Scotland, England) in 2018. Generally, BMS was treated as unwanted catch as in previous years.

In 2018 data, 73% 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 2018 are illustrated in Figure 23.1. 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 for fleets without imported discards. For other gear types, discards were raised by quarter using discard rates from all available fleets. The raised discards amounted to 21% of total discards (Table 23.3b). 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 23.2a shows métier specific landings in percent of the total landings in 2018 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 71% of the overall landings, from 15 métiers (Table 23.3.c).

However, although the unsampled fleets provide considerable landings overall (29%), 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 9.4% of the total landings, all of which 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, 79% were imported into InterCatch. 55% of the imported discards were sampled for age distributions. The 20 métiers providing discard samples and unsampled métiers are listed in Figure 23.2b.

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 for the North Sea (Subarea 4) and in Table 23.2 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 23.4–23.11. Unwanted catch represented 35% of the total catches. Figure 23.3 plots the trends in the commercial catch for each component in 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 23.4).

23.5.2 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). For the remaining gear types age compositions were allocated using all available samples.

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 23.4. Numbers for human consumption landings, unwanted, and industrial bycatch are given in tables 23.5 to 23.7. Total catches, and catch components, as estimated by ICES are listed in Table 23.12.

23.5.3 Weight at age

Mean weights at age (Subarea 4 and Division 7.d combined) in the catch are presented in Table 23.8. Mean weights at age (both areas combined) in human consumption landings are presented in Table 23.9, and for the unwanted catch and industrial by-catch in the North Sea in tables 23.10 and 23.11, respectively. Weights-at-age are depicted graphically in Figure 23.5, 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 age 0 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 (WKNSEA 2018, Figure 23.6).

Unsmoothed values of weights at age are used in the assessment (Table 23.13).

23.5.4 Maturity and natural mortality

Values for proportion mature at age are estimated using IBTS Q1, in Table 23.14 and Figure 23.7. 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. The same maturation proportion was assumed for individuals 6 years and older.

Estimates of natural mortality (M) are taken from the 2017 update key run from of the SMS multispecies model (ICES WGSAM, 2018) (Table 23.15 and Figure 23.8). At the benchmark WKNSEA 2018, the most recent estimates of natural mortality values were smoothed. The new natural mortality values for 2017 and 2018 are assumed to be the same as in 2016 (Figure 23.8). The same natural mortality was assumed for individuals 6 years and older.

23.5.5 Research vessel data

Survey tuning indices are presented in Table 23.16a and b. The indices used in the assessment are ages 1–5 from the IBTS–Q1 and ages 0–5 from IBTS–Q3 surveys, from 1983–2019 and 1991–2018, 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 23.9, survey distribution maps based on the IBTS–Q1 survey in the North Sea, for ages 1–3+ of the first quarter (Q1) 2015–2019, are presented. Figure 23.10, the third quarter is represented (Q3) for ages 0–3+ for the years 2015–2018. For ages 2–3+ CPUE is higher along the UK east coast. Whiting at age 0 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 and 2018 than in previous years. This is confirmed by the relatively low numbers at age 1 in Q1 in 2019.

23.6 Benchmark

The ICES Benchmark Workshop on North Sea Stocks 2018 (WKNSEA) was held at ICES in Copenhagen in early 2018. Analyses focused on a number of key issues (maturity, natural mortality, stock-weights at age, stock identity, assessment model) details can be found in WKNSEA report (ICES, 2018a) and stock annex.

No changes were made to the use of survey indices. Catch data was updated in Intercatch following a data call for 2009–2016. A new stratification design to allocate discard ratios and age distributions was introduced, details of the allocation scheme can be found in the Stock Annex and in Section 23.5. The assessment model was updated from XSA to SAM and new reference points were estimated.

As before, Area 27.4 represents the management unit with TAC advice to be given. 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 (see Section 23.15). The feasibility of combining Division 3.a with Subarea 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks.

23.7 Data analyses

23.7.1 Exploratory survey-based analyses

In Figure 23.11, 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 23.12. 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 23.13 and 23.14. These indicate that the IBTS–Q1 and Q3 surveys both show good internal consistency across ages. The log CPUE plots by survey (Figure 23.15) support the conclusion of good internal consistency. Only in recent years, age 1 differs somewhat from overall pattern.

Figures 23.16–23.18 summarize the results of a SURBAR analysis using the available IBTS 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. Mortality has been on a relatively lower level since the early 2000s. Recruitment (age 1) 2018 is estimated to have been relatively low, while SSB and TSB are at an intermediate level compared to the historical time series. The log survey residuals (Figure 23.17) suggest in most recent years some negative residuals in Q1 and positive residuals in Q3 that should be investigated if trends continue in the coming year.

23.7.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 23.19 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 2002–2011 year classes.

The negative gradients of log catches per cohort, averaged over ages 2–6 are given in Figure 23.20. The gradients (since the 2002 year class) appear to be have been decreasing since 1990 and are fluctuating around a mean level for more recent cohorts that is lower than the mean level prior to 1990. 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 23.21. 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 up to 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 23.19).

23.7.3 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 (figures 23.12–14, 23.19–21). However, beginning with the 2006 year class, the IBTS Q1 appears to be underestimating the abundance of age 1 whiting in some years (Figure 23.12). In previous assessments, this had implications for the estimation of recruitment and can result in a considerable retrospective bias in recruitment.

23.7.4 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 was agreed at WKNSEA and is detailed in the stock annex (ICES, 2018a). The assessment model, including input data, results and diagnostics can be found on www.stockassessment.org as "NSwhiting_2019".

The settings are provided below (further details can be found in the Stock Annex).

```
Catch-at-age data                                   1978-2018       ages 0-8+
Survey: IBTS Q1                                     1983-2019       ages 1-5
Survey: IBTS Q3                                     1991-2018       ages 0-5

$minAge
 0
$maxAge
 8
$maxAgePlusGroup
 1
$keyLogFsta
   0   1   2   3   4   5   6   7   7
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
$corFlag
2
$keyLogFpar
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1   0   1   2   3   3  -1  -1  -1
   4   5   6   7   8   8  -1  -1  -1
$keyQpow
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
$keyVarF
   0   0   0   0   0   0   0   0   0
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
$keyVarLogN
 0 1 1 1 1 1 1 1 1
$keyVarObs
   0   1   1   1   1   1   1   1   1
  -1   2   2   2   2   2  -1  -1  -1
   3   3   3   3   3   3  -1  -1  -1
$obsCorStruct
 "ID" "AR" "AR"
$keyCorObs
  NA  NA  NA  NA  NA  NA  NA  NA
  -1   0   1   1   1  -1  -1  -1
   2   2   3   3   3  -1  -1  -1
```

```
$stockRecruitmentModelCode
 0
$noScaledYears
 0
$keyScaledYears
$keyParScaledYA
$fbarRange
 2 6
$keyBiomassTreat
 -1 -1 -1
$obsLikelihoodFlag
 "LN" "LN" "LN"
$fixVarToWeight
 0
```

The results of the final assessment run are illustrated in Figure 23.22.

Fishing mortality estimates at age from final SAM run are presented in Table 23.17. Estimated stock numbers at age are given in Table 23.18. The assessment summaries are presented in Table 23.19 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 23.20.

Estimated correlations are illustrated in Figure 23.23. The correlations reflect SAM settings of autocorrelations and parameter coupling, assuming independence in the catch fleet and correlation between ages in each survey fleet coupled for ages 2+.

The joint–sample residuals for the unobserved processes (stock size N and fishing mortality F) show no apparent cohort effects across ages (Figure 23.24).

Standardized one-observation–ahead residuals are presented in Figure 23.25. 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 23.27 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 23.29. 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 is in some years lower and recruitment dynamics are less pronounced 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, in particular for recruitment, because only IBTS Q3 survey delivers indices for age 0.

A retrospective analysis is shown in Figure 23.30. 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 23.21 and confirm the relatively higher retrospective bias in recruitment. There is tendency to overestimate recruitment in the final year. Retrospective lines are generally covered by the confidence interval.

Final SAM run model parameters are given in Table 23.22.

The spawning stock recruitment relationship shows no apparent pattern, confirming that the assumed random walk in recruitment in the model is appropriate (Figure 23.31).

Finally, Figure 23.32 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 (at age 1) shows similar dynamics with more variability in SURBAR results. The mean Z (total mortality, ages 2–4) estimates from SURBAR show higher mortalities since 1990 than SAM and some increase in mortality in recent years, but the trends are similar. The relative constant mortality estimated by SAM in recent years follows the lower variability in SSB from SAM and relatively constant catches, data which are included only in the SAM assessment.

23.8 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 23.22. These show that mean F has been declining since 1990 and reached the minimum of time-series in 2005 of 0.163, but is slightly increasing since. In recent years fishing mortality decreased to levels around 0.2. The SSB was at extremely high levels before 1983 (no survey information included prior 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. Recruitment was relatively low in 2017 and 2018, which may hinder any further increase in SSB in the next years. 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 23.31 does not show a clear relationship between SSB and subsequent recruitment.

23.9 Biological reference points

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. An interbenchmark was performed for whiting in the North Sea and Division 7.d in early 2016 (ICES, 2016). This included Eqsim runs and MSE. 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 instead the MSY approach with target F of 0.15.

In the WKNSEA 2018 benchmark new data and assessment model were introduced, Eqsim was run to determine new reference points (ICES, 2018a). $F_{p.05}$ was calculated by running Eqsim 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 set to $F_{p.05}$ = 0.172. Current reference points are listed in Table 23.23.

23.10 Short-term forecasts

A short-term forecast was carried out based on the final SAM assessment. SAM survivors from 2018 were used as input population numbers for ages 0 and older in 2019. Recruitment assumptions are detailed in Table 23.24. In the intermediate and following two years the geometric mean of recruitment from 2002–2018 is used.

The exploitation pattern is chosen as the mean exploitation pattern over the most recent three years 2016–2018. The mean exploitation pattern was scaled to the mean F_{2-6} in 2018 for forecasts (Figure 23.33). 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 2016–

2018. The F at age used in the forecast is compared with the F at age estimates for 2016–2018 in Figure 23.33.

Mean weights at age are generally consistent over the recent period but there is variability at several ages (Figure 23.5 and 6). To avoid introducing bias, therefore, the average of estimates of 2016–2018 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 23.25, and results are presented in Table 23.26. As in previous years, the MFDP program was used to carry out the forecasts, accounting for separate fleet for industrial bycatch.

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_{2019} to equal mean F_{2018}, results in human consumption catches in the intermediate year 2019 of 26 131 tonnes from a total catch of 28 941 tonnes, giving an SSB in 2020 of 156 590 tonnes (Table 23.26).

Carrying the same fishing mortality forward into 2020 (the status quo F option, F_{sq}) would result in human consumption catches of 24 780 tonnes out of total catches of 27 461 tonnes, and would result in an SSB of 153 119 tonnes in 2021 (a 2.2% decrease in SSB relative to 2020).

Since SSB in 2020 are predicted to be lower than MSY $B_{trigger}$, following the MSY approach F_{MSY} needs to be reduced by factor SSB(2020)/MSY $B_{trigger}$ = 0.939 leading to an F_{target} of 0.162.

Applying the reduced F_{MSY} of 0.162 in 2020 would generate human consumption catches of 19 354 tonnes out of total catches of 22 082 tonnes, and result in an SSB of 156 981 tonnes in 2021 (a 8.77% decrease in SSB relative to 2020). In 2021, SSB would be above B_{lim} but still below MSY $B_{trigger}$. F of 0.162 would cause the TAC (relative to the TAC in 2019) to be changed by -12.5%.

23.11 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting.

23.12 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.

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. A recommendation was made to investigate the quality of age readings further.
The historical performance of the assessment is summarized in Figure 23.34. The difference in SSB is due to new benchmark model and input data. 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. Since 2018, recruitment is estimated at age 0 instead of age 1 such that previous assessment results are not plotted in Standardgraphs. Catch data and natural mortalities were updated. Estimates of fishing mortality remained at a similar level as before above F_{MSY}. Retrospective bias compared to the 2018 assessment is low.

23.13 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 (figures 23.22, 23.34). 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. 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 slightly 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. Low recruitment estimated for 2017 continued in 2018, stock biomass estimated for 2019 decreased and is now below MSY $B_{trigger}$.

23.14 Management considerations

In 1996, 2006, 2012, 2017 and 2018, the whiting stock produced the lowest recruitments in the series (below 10 billion). 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 28 083 tonnes in 2018, including discards and industrial bycatch).

Catch rates from localized fleets may not represent trends in the overall North Sea and English Channel. The localized distribution of the stock 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 straight- forward when stocks are managed via a series of single-species management plans that do not incorporate such mixed stocks considerations. WGMIXFISH monitors the consistency of the various single species management plans and TAC advice under current effort schemes, in order to estimate the potential risks of quota over and under shooting for the different stocks, and it was demonstrated that the current basis for whiting advice was not consistent with other single-stock management objectives. It is recommended that the ongoing discussions about the whiting management plan takes into account such mixed-fisheries considerations before implementation.

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 2015–2018 were low. In 2018, whiting was fully under Landings Obligation with a *de minimis* exemption for whiting caught with bottom trawls in ICES Division 4.c. Nevertheless, reported BMS was very low and discarding was still observed in the sampled fleets and are assumed to take place also in unsampled fleets. The amount of reported BMS is expected to increase in the next years as the landing obligation continues to be implemented.

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 2019 if this is the case for this year.

23.15 SURBAR Northern Southern stock component

Exploratory SURBAR assessments were run for individual components (northern and southern component) using component area-specific DATRAS survey indices provided by ICES (Figure 23.35, tables 23.27–28) and estimated area-specific maturity ogives (tables 23.29–30, Figure 23.37). Stock weights at age were assumed to be the same in northern, southern components and combined areas. The stock dynamics for the combined stock were more similar to the northern component and more variable on the southern one. Nevertheless, stock dynamics in northern and southern were comparable (recruitment, SSB in Figure 23.36). The SURBAR analyses indicate that the southern stock component is at a historically high level of SSB and unlikely to be negatively affected by management decisions based on the combined analyses dominated by the northern component.

23.16 Issues for future benchmarks

The stock was benchmarked in 2018, implementing a new assessment model, natural mortality estimates, maturity ogive estimation and stock weights at age estimation. The stock identity issue was revisited and decided to continue with the assessment area previously used (North Sea and Eastern Channel). The discard raising and age allocations method in Intercatch was revised to account for fleet differences (TR1/TR2, seasonal) in discard rate and age distributions.

23.16.1 Data and assessment

Stock weights at age are estimated each year by scaling the catch-at-weight time series by using the NS-IBTS quarter 1 weights at age (shorter time series). Even though the entire time series of stock weights at age is re-estimated each year, so far historical values did not change. If estimated stock weights at age in the historical time period differ significantly from one year to the next, the estimation should be reconsidered, i.e. only add newly estimated most recent data point (not an issue this year).

Natural mortality: When new natural mortality estimates (WGSAM) become available these data need to be included and potentially reference points may need to be revised (not an issue this year).

Stock identity: In the last benchmark, stock identity was considered for North Sea whiting distinguishing a northern and a southern stock component. Analysis (see Section 23.1.1) suggest similar dynamics in the northern and southern component with dynamics being dominated by the northern component. At this point in time, a separate assessment is not considered necessary from reviewed literature and SURBAR analyses.

23.16.2 Forecast

Forecast continues to be done in MFDP. A SAM forecast is being considered which allows fleet separation (human consumption and industrial bycatch fleet) and stochastic forecast.

Table 23.1. 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. *Before 2015, the official landings from Denmark are likely to exclude 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
faroe.4	26	0	16	7	2	21	0	6	1	1	0
france.4	4951	5188	5115	5502	4735	5963	4704	3526	1908	0	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
uk.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
england.wales.4	2338	2676	2528	2774	2722	2477	2329	2638	2909	2268	1782
scotland.4	27486	31257	30821	31268	28974	27811	23409	22098	16696	17206	17158
total.landings.4	41083	46606	47042	47301	42216	41400	35116	31573	23937	22110	24453
unallocated.landings.4	-1097	396	1832	691	346	850	-434	633	247	-3590	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	116	162	147	74
denmark.4	105	96	89	62	57	251	78	42	79	158	135
faroe.4	0	17	5	0	0	0	0	0	2	0	0
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	38	23	16	17	11	92	73	118	28
sweden.4	6	7	10	2	0	2	1	2	4	8	6
uk.4	NA	NA	NA	NA	NA	11632	12110	10391	8853	7845	8892
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
total.landings.4	18834	15608	11255	9491	8394	15660	16275	14451	12320	11690	12554
unallocated.landings.4	-426	738	805	541	-2286	563	609	972	-124	-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	2019
belgium.4	45	33	46	70	65	71	NA	NA
denmark.4	131	124	160	2375	4727	2803	2026	NA
faroe.4	0	0	0	0	8	1	NA	NA
france.4	1925	942	1884	1131	1232	952	918	NA
germany.4	25	44	31	73	111	81	99	NA
netherlands.4	471	495	464	581	644	687	679	NA
norway.4	94	560	918	1088	1150	993	1025	NA
sweden.4	4	1	2	0	6	11	8	NA
uk.4	9893	11162	10290	10015	9412	9120	10625	NA
england.wales.4	NA	NA	NA	NA	NA	NA	NA	NA
scotland.4	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.4	12588	13361	13795	15333	17355	14719	15380	NA
unallocated.landings.4	-356	-456	-52	2101	5113	2891	2611	NA
ices.landings.4	12944	13817	13847	13232	12242	11828	12769	NA
ices.unwanted.catch.4	9307	4608	7016	12265	10413	9799	7629	NA
ices.ibc.4	1117	1654	1623	2097	4551	2635	1698	NA
ices.catch.4	23368	20079	22486	27593	27206	24262	22160	NA
tac.4.2.a	17056	18932	16092	13678	13678	16003	22057	17191

Table 23.2. 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	0	0	5414	5032	6734	5202	4771	4532	4495	0	5875
netherlands.7.d	0	0	0	0	0	0	1	1	32	6	14
uk.7.d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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
total.landings.7.d	322	375	5923	5429	7088	5551	5056	4779	4765	189	6072
unallocat.landings.7.d	-3158	-5345	183	219	468	161	106	159	165	-4241	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	68	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
uk.7.d	NA	NA	NA	NA	NA	72	63	87	138	258	271
england.wales.7.d	134	112	109	99	90	NA	NA	NA	NA	NA	NA
scotland..7.d	0	0	0	0	0	NA	NA	NA	NA	NA	NA
total.landings.7.d	6614	5361	7005	5283	4901	3749	3391	3192	6569	6133	5464
unalloc.landings.7.d	814	-439	1295	933	111	306	137	-1279	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	2019
belgium.7.d	66	95	90	121	146	128	NA	NA
france.7.d	3093	3076	2126	3102	2771	2378	2720	NA
netherlands.7.d	437	650	663	565	556	584	467	NA
uk.7.d	261	472	345	379	259	354	283	NA
england.wales.7.d	NA	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.7.d	3857	4293	3224	4167	3732	3444	3470	NA
unalloc.landings.7.d	-556	-15	99	190	32	90	-156	NA
ices.landings.7.d	4413	4308	3125	3977	3700	3354	3626	NA
ices.unwanted.catch.7.d	2389	2186	2709	4627	2313	1550	2249	NA
ices.catch.7.d	6802	6494	5834	8604	6013	4904	5875	NA
tac.7b.k	19053	24500	20668	17742	22778	27500	22213	19184

Table 23.3.a. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure. SOP.

Catch Category	SOP
BMS landing	0.9983
Discards	0.9813
Landings (incl. IBC)	1.0170
Logbook Registered Discard	NA

Table 23.3.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
BMS landing	Imported	856.3	100
Discards	Imported	7329	79
Discards	Raised	1931	21
Landings (incl. IBC)	Imported	18130	100
Logbook Registered Discards	Imported	0	NA

Table 23.3.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
Logbook Registered Discard	Imported	Estimated	0	NA
Landings (incl. IBC)	Imported	Sampled	12953	71
Landings (incl. IBC)	Imported	Estimated	5177	29
Discards	Imported	Sampled	5075	55
Discards	Imported	Estimated	2254	24
Discards	Raised	Estimated	1931	21
BMS landing	Imported	Estimated	830.6	97
BMS landing	Imported	Sampled	25.71	3

Table 23.3d. 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 or Imported	Sampled or Estimated distribution	Area	CATON tonnes	percent
Landings	Imported	Sampled	27.7.d	2062	58
Landings	Imported	Estimated	27.7.d	1502	42
Discards	Imported	Sampled	27.7.d	1097	49
Discards	Raised	Estimated	27.7.d	980.8	43
Discards	Imported	Estimated	27.7.d	177.6	8
BMS landing	Imported	Estimated	27.7.d	0	NA
Landings	Imported	Estimated	27.4.c	31.76	100
Discards	Raised	Estimated	27.4.c	16.51	51
Discards	Imported	Estimated	27.4.c	15.64	49
Logbook Registered Discard	Imported	Estimated	27.4.b	0	NA
Landings	Imported	Estimated	27.4.b	42.92	100
Discards	Imported	Estimated	27.4.b	26.11	53
Discards	Raised	Estimated	27.4.b	23.23	47
BMS landing	Imported	Estimated	27.4.b	0	NA
Logbook Registered Discard	Imported	Estimated	27.4.a	0	NA
Landings	Imported	Estimated	27.4.a	2.499	100
Discards	Raised	Estimated	27.4.a	0.8115	100
BMS landing	Imported	Estimated	27.4.a	0	NA
Landings	Imported	Sampled	27.4	10891	75
Landings	Imported	Estimated	27.4	3598	25
Discards	Imported	Sampled	27.4	3978	57
Discards	Imported	Estimated	27.4	2035	29
Discards	Raised	Estimated	27.4	909.7	13
BMS landing	Imported	Estimated	27.4	830.6	97
BMS landing	Imported	Sampled	27.4	25.71	3

Table 23.4. 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. Model input.

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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	15387	16855	35365	23253	16163	6926	2563	1908	1501	32	159	38	0	0	0	0	1730

Table 23.5. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	0	810	9784	12514	11225	5241	2104	1612	1346	29	147	35	0	0	0	0	1557

Table 23.6. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	14652	15237	23724	9315	3838	1207	297	179	58	1	0	0	0	0	0	0	59

Table 23.7. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	735	808	1857	1424	1100	478	162	117	97	2	12	3	0	0	0	0	114

Table 23.8. 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. Model input.

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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	0.031	0.108	0.202	0.290	0.391	0.414	0.440	0.409	0.453	0.613	0.447	0.586	0.000	0.000	0.000	0.000	0.459

Table 23.9. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	0.037	0.192	0.255	0.336	0.438	0.443	0.451	0.418	0.461	0.624	0.447	0.586	0.000	0.000	0.000	0.000	0.466

Table 23.10. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	0.031	0.104	0.180	0.228	0.253	0.287	0.362	0.327	0.280	0.295	0.311	0.369	0.000	0.000	0.000	0.000	0.280

Table 23.11. 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

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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
2018	0.031	0.108	0.202	0.290	0.391	0.414	0.440	0.409	0.453	0.610	0.446	0.586	0.000	0.000	0.000	0.000	0.459

Table 23.12. Whiting in Subarea 4 and Division 7.d: Catch component as estimated by ICES in tonnes, model input. 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

Year	Catch	Wanted Catch	Unwanted Catch	IBC
2016	33396	16118	12726	4551
2017	29344	15361	11348	2635
2018	28083	16444	9942	1698

Table 23.13. 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. Model input.

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	0.157	0.248	0.386	0.413	0.482	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734
1979	0.003	0.033	0.084	0.173	0.233	0.371	0.439	0.509	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659
1980	0.004	0.025	0.088	0.169	0.254	0.304	0.441	0.475	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
1981	0.004	0.028	0.084	0.162	0.249	0.342	0.397	0.460	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
1982	0.010	0.02	0.092	0.169	0.243	0.340	0.461	0.522	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833
1983	0.005	0.036	0.096	0.183	0.252	0.347	0.411	0.468	0.608	0.608	0.608	0.608	0.608	0.608	0.608	0.608	0.608
1984	0.007	0.03	0.095	0.181	0.261	0.344	0.376	0.478	0.642	0.642	0.642	0.642	0.642	0.642	0.642	0.642	0.642
1985	0.005	0.031	0.096	0.190	0.257	0.362	0.420	0.511	0.497	0.497	0.497	0.497	0.497	0.497	0.497	0.497	0.497
1986	0.005	0.035	0.092	0.171	0.246	0.341	0.458	0.484	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709
1987	0.004	0.026	0.074	0.165	0.230	0.339	0.367	0.561	0.662	0.662	0.662	0.662	0.662	0.662	0.662	0.662	0.662
1988	0.004	0.018	0.073	0.149	0.233	0.312	0.409	0.524	0.786	0.786	0.786	0.786	0.786	0.786	0.786	0.786	0.786
1989	0.008	0.023	0.079	0.151	0.207	0.287	0.377	0.446	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
1990	0.005	0.028	0.069	0.140	0.195	0.252	0.397	0.515	0.673	0.673	0.673	0.673	0.673	0.673	0.673	0.673	0.673
1991	0.006	0.035	0.084	0.145	0.224	0.276	0.327	0.378	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453
1992	0.004	0.028	0.093	0.172	0.214	0.299	0.334	0.324	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578
1993	0.004	0.024	0.087	0.167	0.245	0.296	0.334	0.414	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429
1994	0.004	0.028	0.084	0.171	0.254	0.345	0.363	0.434	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488
1995	0.003	0.03	0.090	0.172	0.263	0.347	0.414	0.449	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475
1996	0.006	0.031	0.084	0.157	0.234	0.35	0.393	0.446	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
1997	0.009	0.032	0.089	0.162	0.228	0.302	0.371	0.4	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477
1998	0.006	0.03	0.09	0.158	0.217	0.284	0.328	0.345	0.418	0.418	0.418	0.418	0.418	0.418	0.418	0.418	0.418
1999	0.008	0.026	0.087	0.155	0.198	0.261	0.294	0.322	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331
2000	0.011	0.039	0.091	0.159	0.222	0.258	0.266	0.285	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
2001	0.008	0.034	0.096	0.163	0.218	0.241	0.288	0.294	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2002	0.003	0.023	0.078	0.146	0.211	0.274	0.338	0.355	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381
2003	0.004	0.019	0.059	0.129	0.200	0.27	0.342	0.398	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
2004	0.01	0.037	0.075	0.142	0.196	0.258	0.275	0.296	0.398	0.398	0.398	0.398	0.398	0.398	0.398	0.398	0.398
2005	0.011	0.041	0.100	0.16	0.194	0.255	0.294	0.308	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
2006	0.031	0.043	0.090	0.155	0.212	0.260	0.347	0.357	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358
2007	0.02	0.033	0.103	0.172	0.252	0.312	0.298	0.320	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363
2008	0.009	0.035	0.109	0.189	0.244	0.363	0.393	0.328	0.401	0.401	0.401	0.401	0.401	0.401	0.401	0.401	0.401
2009	0.014	0.030	0.107	0.191	0.286	0.338	0.36	0.356	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
2010	0.016	0.037	0.117	0.250	0.314	0.412	0.343	0.475	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
2011	0.016	0.038	0.107	0.199	0.289	0.375	0.409	0.377	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384
2012	0.013	0.035	0.098	0.208	0.344	0.371	0.415	0.443	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
2013	0.009	0.037	0.111	0.183	0.302	0.423	0.479	0.481	0.437	0.437	0.437	0.437	0.437	0.437	0.437	0.437	0.437
2014	0.018	0.045	0.114	0.197	0.256	0.399	0.449	0.485	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446
2015	0.015	0.042	0.109	0.205	0.285	0.349	0.453	0.48	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429
2016	0.010	0.040	0.105	0.195	0.309	0.351	0.4	0.505	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520
2017	0.009	0.026	0.106	0.214	0.317	0.394	0.47	0.460	0.499	0.499	0.499	0.499	0.499	0.499	0.499	0.499	0.499
2018	0.010	0.036	0.101	0.194	0.303	0.374	0.425	0.423	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520

Table 23.14. Whiting in Subarea 4 and Division 7.d: Estimated proportion mature at age as used in the assessment. Model input.

Age	0	1	2	3	4	5	6	7	8+
1978	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1980	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1981	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1982	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1983	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1984	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1985	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1986	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.190	0.830	0.990	1.000	1.000	1.000	1.000	1.000
1991	0.000	0.189	0.831	0.992	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.188	0.825	0.989	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.188	0.817	0.986	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.190	0.809	0.981	0.999	1.000	1.000	1.000	1.000
1995	0.000	0.192	0.800	0.976	0.997	0.999	1.000	1.000	1.000
1996	0.000	0.197	0.789	0.969	0.994	0.999	1.000	1.000	1.000
1997	0.000	0.204	0.778	0.961	0.991	0.998	1.000	1.000	1.000
1998	0.000	0.214	0.765	0.952	0.988	0.997	1.000	1.000	1.000
1999	0.000	0.227	0.750	0.942	0.985	0.996	1.000	1.000	1.000
2000	0.000	0.244	0.736	0.933	0.982	0.996	1.000	1.000	1.000
2001	0.000	0.262	0.727	0.928	0.981	0.996	1.000	1.000	1.000
2002	0.000	0.280	0.724	0.927	0.982	0.996	1.000	1.000	1.000
2003	0.000	0.296	0.728	0.929	0.983	0.997	1.000	1.000	1.000
2004	0.000	0.310	0.736	0.934	0.986	0.998	1.000	1.000	1.000
2005	0.000	0.322	0.748	0.940	0.988	0.998	1.000	1.000	1.000
2006	0.000	0.333	0.763	0.947	0.991	0.999	1.000	1.000	1.000
2007	0.000	0.341	0.778	0.954	0.993	0.999	1.000	1.000	1.000
2008	0.000	0.348	0.793	0.961	0.995	1.000	1.000	1.000	1.000
2009	0.000	0.354	0.806	0.966	0.996	1.000	1.000	1.000	1.000
2010	0.000	0.360	0.817	0.970	0.997	1.000	1.000	1.000	1.000
2011	0.000	0.364	0.826	0.973	0.998	1.000	1.000	1.000	1.000
2012	0.000	0.367	0.831	0.974	0.998	1.000	1.000	1.000	1.000
2013	0.000	0.368	0.833	0.975	0.998	1.000	1.000	1.000	1.000
2014	0.000	0.369	0.835	0.975	0.998	1.000	1.000	1.000	1.000
2015	0.000	0.369	0.836	0.975	0.998	1.000	1.000	1.000	1.000

Age	0	1	2	3	4	5	6	7	8+
2016	0.000	0.370	0.836	0.974	0.997	1.000	1.000	1.000	1.000
2017	0.000	0.368	0.834	0.973	0.997	1.000	1.000	1.000	1.000
2018	0.000	0.365	0.829	0.972	0.996	1.000	1.000	1.000	1.000

Table 23.15. Whiting in Subarea 4 and Division 7.d: Natural mortality at age estimates based on ICES WGSAM (2018b). Model input.

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

Age	0	1	2	3	4	5	6	7	8+
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
2018	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355

Table 23.16a. Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series used in the assessment and forecast; model input.

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

IBTS–Q1					
Age	1	2	3	4	5
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	1.192	2.360	0.754	0.334	0.097
2019	2.200	1.667	1.229	0.450	0.130

Table 23.16b. Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series used in the assessment and forecast, model input.

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

IBTS-Q3						
Age	**0**	**1**	**2**	**3**	**4**	**5**
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
2018	1.681	2.455	3.015	0.908	0.314	0.137

Table 23.17. Whiting in Subarea 4 and Division 7.d: Final fishing mortality estimates from SAM, model output.

Age	0	1	2	3	4	5	6	7	8+
1978	0.025	0.107	0.305	0.554	0.716	0.781	1.003	1.254	1.254
1979	0.026	0.114	0.326	0.586	0.715	0.772	0.900	1.049	1.049
1980	0.024	0.101	0.305	0.614	0.825	0.957	1.090	1.289	1.289
1981	0.024	0.104	0.287	0.575	0.800	0.975	1.150	1.319	1.319
1982	0.024	0.106	0.261	0.482	0.629	0.770	0.919	1.017	1.017
1983	0.028	0.134	0.327	0.572	0.701	0.824	0.965	1.101	1.101
1984	0.029	0.148	0.363	0.654	0.835	0.955	1.117	1.233	1.233
1985	0.025	0.126	0.294	0.553	0.792	0.972	1.165	1.372	1.372
1986	0.028	0.149	0.355	0.630	0.902	1.028	1.175	1.310	1.310
1987	0.026	0.143	0.375	0.682	0.998	1.218	1.356	1.486	1.486
1988	0.027	0.151	0.369	0.601	0.838	1.041	1.078	1.061	1.061
1989	0.024	0.131	0.355	0.588	0.835	1.184	1.255	1.317	1.317
1990	0.025	0.142	0.402	0.614	0.786	1.001	1.011	1.078	1.078
1991	0.021	0.115	0.334	0.503	0.637	0.840	0.871	1.056	1.056
1992	0.020	0.120	0.323	0.488	0.588	0.731	0.822	0.933	0.933
1993	0.020	0.123	0.336	0.532	0.667	0.770	0.858	0.975	0.975
1994	0.017	0.113	0.308	0.515	0.702	0.839	0.912	0.983	0.983
1995	0.015	0.099	0.274	0.462	0.632	0.799	0.895	0.983	0.983
1996	0.012	0.085	0.242	0.410	0.566	0.727	0.816	0.909	0.909
1997	0.010	0.075	0.215	0.349	0.470	0.575	0.612	0.689	0.689
1998	0.008	0.069	0.195	0.310	0.419	0.516	0.555	0.615	0.615
1999	0.008	0.074	0.221	0.356	0.476	0.581	0.595	0.647	0.647
2000	0.006	0.056	0.188	0.337	0.502	0.681	0.746	0.820	0.820
2001	0.004	0.042	0.129	0.225	0.356	0.538	0.619	0.701	0.701
2002	0.004	0.047	0.124	0.189	0.265	0.371	0.434	0.494	0.494
2003	0.006	0.076	0.161	0.185	0.213	0.255	0.275	0.292	0.292
2004	0.005	0.069	0.136	0.150	0.172	0.210	0.241	0.248	0.248

Age	0	1	2	3	4	5	6	7	8+
2005	0.005	0.070	0.138	0.148	0.154	0.174	0.203	0.214	0.214
2006	0.005	0.084	0.167	0.194	0.194	0.198	0.217	0.217	0.217
2007	0.004	0.072	0.149	0.191	0.202	0.192	0.205	0.213	0.213
2008	0.004	0.064	0.135	0.189	0.207	0.194	0.197	0.203	0.203
2009	0.003	0.056	0.119	0.186	0.236	0.252	0.285	0.304	0.304
2010	0.003	0.048	0.114	0.189	0.254	0.304	0.370	0.403	0.403
2011	0.003	0.046	0.108	0.176	0.224	0.258	0.307	0.332	0.332
2012	0.003	0.050	0.104	0.165	0.226	0.276	0.308	0.321	0.321
2013	0.002	0.041	0.090	0.151	0.219	0.289	0.294	0.291	0.291
2014	0.002	0.038	0.097	0.169	0.242	0.334	0.345	0.348	0.348
2015	0.002	0.041	0.118	0.204	0.270	0.355	0.361	0.370	0.370
2016	0.002	0.032	0.101	0.197	0.272	0.338	0.345	0.361	0.361
2017	0.002	0.026	0.082	0.161	0.239	0.279	0.296	0.340	0.340
2018	0.002	0.025	0.078	0.150	0.224	0.259	0.283	0.318	0.318

Table 23.18. Whiting in Subarea 4 and Division 7.d: Final abundance estimates from SAM, model output.

Age	0	1	2	3	4	5	6	7	8+
1978	31872376	7456175	1666843	715945	186076	20260	13190	2683	435
1979	24300701	8698137	1858353	638798	258342	57106	6109	3410	612
1980	13224104	6555998	2082556	707073	201567	80738	18207	1761	1041
1981	11865515	3227400	1776755	809764	221247	52212	19906	4537	534
1982	11271239	2969241	785741	783190	268605	58482	12373	4354	934
1983	15332814	2744767	724189	344288	303596	87552	17321	3314	1388
1984	12958941	3975936	655112	290284	111750	102106	23376	4734	1066
1985	21031885	3020313	990032	245364	88177	28636	26444	5093	1209
1986	18546170	5566023	731193	446839	86528	25196	6433	5902	1049
1987	15622505	4598189	1430966	278610	152357	20345	6095	1337	1315
1988	20391066	3689606	1307834	550304	83071	34533	3712	1104	387
1989	13357133	5271581	857929	544584	185948	21861	7715	836	386
1990	12423940	3102765	1528959	340219	187451	52629	3912	1468	214
1991	12864278	2871780	789083	596420	109018	50824	12934	913	398
1992	14719730	2975564	817420	295790	252506	33319	12989	4042	279
1993	14052649	3276962	764103	352478	108068	100002	9415	3434	1176
1994	12645504	3011290	856708	312629	124247	34384	30951	2545	1089
1995	10381631	2657618	803975	374916	110609	34839	9567	8118	878
1996	8469254	1968657	722388	366395	140241	35601	9628	2491	2143
1997	14017367	1478509	526755	340398	141122	50011	10450	2608	1157
1998	23317972	2285106	396244	233061	143163	54766	17339	3649	1162
1999	23935119	3699549	586020	184665	109669	54315	21416	6035	1653
2000	21240380	3415619	916186	254228	75722	40309	18906	7848	2561

Age	0	1	2	3	4	5	6	7	8+
2001	21620487	2806769	968681	389795	100461	25635	12579	5418	2863
2002	11246935	2730067	798414	538429	182788	38532	8014	4116	2434
2003	10798107	1278496	773528	439697	275689	85023	15330	2851	2254
2004	12223974	1198782	278946	359583	241094	134223	41226	7156	2152
2005	11389128	1312743	302785	130048	189690	127327	63833	19052	4315
2006	9711377	1279868	358904	140377	65814	103031	67056	30877	10811
2007	15398634	987848	328563	176422	63361	32811	52708	32605	20112
2008	14753261	1680245	285928	148711	86048	30134	16181	27270	25150
2009	13926062	1542768	483610	128503	67331	42000	15594	8754	28878
2010	13960028	1470604	406548	206619	63637	31542	20882	7450	19189
2011	10103265	1563471	444375	187392	90971	27469	14251	9174	11446
2012	7528980	1135816	532285	188605	86863	42039	12497	6796	9796
2013	12117709	778581	298159	263625	97551	41323	18159	5843	7997
2014	16080625	1441340	232649	147400	123360	45775	18397	8889	7294
2015	15024074	1890838	474130	108510	68720	56250	20132	8547	7870
2016	16177054	1700070	553502	211257	50350	31231	23294	9850	7640
2017	9029636	2149162	500969	231706	93017	23379	13297	11083	8767
2018	7965668	1140536	650215	229100	105924	40919	11080	7237	9247

Table 23.19. Whiting in Subarea 4 and Division 7.d: Final SAM summary table. Model output. Units are individuals and tonnes.

Year	R (age 0)	Low	High	SSB	Low	High	F (2–6)	Low	High	TSB	Low	High
1978	31872376	23704438	42854774	333397	293181	379130	0.672	0.584	0.772	614490	541754	696991
1979	24300701	18179137	32483614	378971	336231	427145	0.660	0.580	0.750	708295	621806	806814
1980	13224104	10016195	17459415	387148	342883	437128	0.758	0.670	0.858	608804	539905	686494
1981	11865515	8999485	15644279	354613	313812	400717	0.757	0.668	0.859	496636	442922	556863
1982	11271239	8560843	14839756	296925	263180	334997	0.612	0.536	0.699	467683	417479	523924
1983	15332814	11637523	20201480	254716	228358	284115	0.678	0.598	0.769	422422	379117	470675
1984	12958941	9803275	17130414	202088	181964	224438	0.785	0.694	0.887	394335	350879	443173
1985	21031885	15944811	27741952	190643	169573	214331	0.755	0.667	0.854	381389	337351	431177
1986	18546170	14099085	24395938	204610	182225	229745	0.818	0.725	0.922	466241	409256	531160
1987	15622505	11836403	20619665	201968	179166	227672	0.926	0.825	1.040	383097	339785	431928
1988	20391066	15399754	27000144	206030	181888	233376	0.786	0.695	0.888	364651	323712	410768
1989	13357133	10184796	17517581	208797	185703	234762	0.843	0.748	0.951	422259	374226	476456
1990	12423940	9524331	16206313	203358	180942	228551	0.763	0.674	0.863	357749	319005	401199
1991	12864278	9941815	16645820	203119	181080	227841	0.637	0.559	0.725	372351	332451	417040
1992	14719730	11391291	19020711	198615	178074	221525	0.590	0.517	0.674	344174	308901	383474
1993	14052649	10872926	18162264	188708	169711	209831	0.633	0.556	0.720	322222	289693	358404
1994	12645504	9771922	16364107	182616	164255	203031	0.655	0.576	0.746	319980	287061	356674
1995	10381631	7972398	13518928	185221	165905	206785	0.612	0.535	0.700	299314	268194	334045
1996	8469254	6398491	11210185	166690	149178	186257	0.552	0.480	0.636	281410	250977	315533
1997	14017367	10612584	18514489	151645	135457	169766	0.444	0.383	0.516	332379	288126	383429
1998	23317972	17639772	30823971	130558	116822	145909	0.399	0.342	0.465	334127	286791	389276
1999	23935119	18041503	31754003	131452	116562	148244	0.446	0.382	0.520	403119	340710	476959
2000	21240380	15945673	28293178	166681	145202	191337	0.491	0.412	0.584	531900	444146	636994
2001	21620487	16181175	28888227	185406	158004	217560	0.373	0.302	0.462	457647	383337	546363

Year	R (age 0)	Low	High	SSB	Low	High	F (2–6)	Low	High	TSB	Low	High
2002	11246935	8479754	14917125	188806	159931	222894	0.277	0.217	0.352	294791	252705	343886
2003	10798107	8220116	14184607	177787	150578	209912	0.218	0.173	0.275	255342	220059	296282
2004	12223974	9280505	16101013	172470	146457	203102	0.182	0.145	0.228	338418	289247	395949
2005	11389128	8630733	15029109	154258	131930	180366	0.163	0.132	0.203	321273	274396	376157
2006	9711377	7350911	12829817	142616	123105	165219	0.194	0.160	0.236	488581	402783	592653
2007	15398634	11670205	20318231	125806	109170	144978	0.188	0.155	0.228	457676	374660	559086
2008	14753261	11192502	19446832	129167	112784	147930	0.184	0.153	0.223	306918	261079	360804
2009	13926062	10551109	18380551	135173	117791	155120	0.215	0.178	0.260	370413	309877	442776
2010	13960028	10399538	18739521	159680	138363	184282	0.246	0.202	0.301	431813	357681	521309
2011	10103265	7613181	13407795	147580	127033	171450	0.215	0.174	0.264	355588	298049	424236
2012	7528980	5596469	10128806	154092	131772	180193	0.216	0.174	0.268	284027	240319	335684
2013	12117709	9011724	16294204	146939	124673	173181	0.208	0.166	0.261	284367	237794	340061
2014	16080625	11797096	21919505	140232	118235	166321	0.238	0.187	0.301	480393	382307	603645
2015	15024074	10802012	20896366	149798	124032	180917	0.262	0.203	0.338	427890	338588	540745
2016	16177054	11315142	23128042	158649	127855	196860	0.251	0.188	0.334	373128	291638	477389
2017	9029636	6087861	13392934	167485	130848	214381	0.212	0.153	0.292	290881	226119	374191
2018	7965668	4687677	13535888	172592	130218	228754	0.199	0.139	0.286	293190	218859	392767

Table 23.20. Whiting in Subarea 4 and Division 7.d: Final summary catch table estimated by SAM, model output. Units: tonnes.

Year	Catch	Low	High
1978	185482	156809	219397
1979	223514	192200	259929
1980	216809	186720	251747
1981	189837	163156	220882
1982	146300	125614	170393
1983	147728	128545	169773
1984	135655	118055	155878
1985	112354	97119	129979
1986	147924	127117	172138
1987	140132	120684	162713
1988	130630	111828	152593
1989	135609	116847	157384
1990	134085	114717	156722
1991	114413	98509	132885
1992	108137	93698	124801
1993	107886	93749	124154
1994	102637	89228	118060
1995	94211	81557	108827
1996	76775	66586	88523
1997	61974	53772	71427
1998	50423	44004	57780
1999	57223	49755	65812
2000	65238	56421	75431
2001	51705	44083	60645
2002	45629	39357	52901
2003	41707	36077	48216
2004	33923	29680	38773
2005	29844	26234	33949
2006	34076	29781	38991
2007	27921	24464	31867
2008	27423	24038	31285
2009	29281	25671	33398
2010	35195	30801	40215
2011	29652	25938	33899
2012	30260	26488	34568
2013	27092	23690	30982
2014	29182	25698	33138
2015	33404	29324	38052

Year	Catch	Low	High
2016	31792	27848	36294
2017	28955	25268	33179
2018	28385	24536	32839

Table 23.21. Whiting in Subarea 4 and Division 7.d: SAM model parameters.

	par	sd(par)	exp(par)	Low	High
logFpar_0	-6.395	0.088	0.002	0.001	0.002
logFpar_1	-5.327	0.086	0.005	0.004	0.006
logFpar_2	-5.286	0.085	0.005	0.004	0.006
logFpar_3	-5.459	0.085	0.004	0.004	0.005
logFpar_4	-6.348	0.100	0.002	0.001	0.002
logFpar_5	-5.409	0.097	0.005	0.004	0.005
logFpar_6	-5.242	0.096	0.005	0.004	0.006
logFpar_7	-5.421	0.095	0.004	0.004	0.005
logFpar_8	-5.640	0.097	0.004	0.003	0.004
logSdLogFsta_0	-1.572	0.130	0.208	0.160	0.269
logSdLogN_0	-1.101	0.159	0.333	0.242	0.457
logSdLogN_1	-2.259	0.155	0.105	0.077	0.143
logSdLogObs_0	0.199	0.129	1.220	0.944	1.578
logSdLogObs_1	-1.700	0.101	0.183	0.149	0.224
logSdLogObs_2	-0.649	0.088	0.523	0.438	0.624
logSdLogObs_3	-0.805	0.089	0.447	0.374	0.535
transfIRARdist_0	-0.710	0.334	0.492	0.252	0.958
transfIRARdist_1	-1.586	0.244	0.205	0.126	0.334
transfIRARdist_2	1.107	0.560	3.025	0.988	9.260
transfIRARdist_3	-1.851	0.294	0.157	0.087	0.283
itrans_rho_0	1.104	0.147	3.015	2.246	4.047

Table 23.22. Whiting in Subarea 4 and Division 7.d: Mohn's rho.

	Mohn's rho
R(age 0)	0.281
SSB	0.013
Fbar(2-6)	-0.017

Table 23.23. 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 (MSY $B_{trigger}$)
F_{pa}	0.330
$F_{p.05}$ (with $B_{trigger}$)	0.172 (final F_{MSY})

Table 23.24. Whiting in Subarea 4 and Division 7.d: Recruitment estimates as used in the short-term forecast.

Year	Geometric mean of recruitment Time series 2002–2018
2019	11883
2020	11883
2021	11883

Table 23.25. Whiting in Subarea 4 and Division 7.d: Short-term forecast inputs. Forecasted SSB in the intermediate year used average maturities and stock weights at age (2016–2018) and therefore differs from SAM estimates for 2019 (uses single year estimates).

MFDP version 1a						
Run: run						
Time and date: 09:38 26/04/2019						
Fbar age range (Total) : 2-6						
Fbar age range Fleet 1 : 2-6						
2019*						
Age	N	M	Mat	PF	PM	SWt
0	11883334	2.066	0	0	0	0.01
1	1034021	1.178	0.37	0	0	0.034
2	344574	0.71	0.83	0	0	0.104
3	285938	0.582	0.97	0	0	0.201
4	116454	0.548	1	0	0	0.309
5	46456	0.5	1	0	0	0.373
6	19153	0.355	1	0	0	0.432
7	5853	0.355	1	0	0	0.463
8	8414	0.355	1	0	0	0.513
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.041	0.00167	0.029		
1	0.00104	0.169	0.02179	0.099		

2	0.02003	0.256	0.05153	0.189		
3	0.07127	0.356	0.06671	0.242		
4	0.15062	0.435	0.04777	0.289		
5	0.16939	0.466	0.0671	0.284		
6	0.20472	0.484	0.04549	0.301		
7	0.21991	0.484	0.05781	0.317		
8	0.26008	0.461	0.01717	0.312		
IBC						
Age	Sel	CWt				
0	0.00016	0.029				
1	0.00211	0.102				
2	0.00685	0.208				
3	0.01458	0.3				
4	0.02312	0.4				
5	0.02667	0.413				
6	0.02814	0.447				
7	0.03031	0.447				
8	0.03078	0.453				
2020						
Age	N	M	Mat	PF	PM	SWt
0	11883334	2.066	0	0	0	0.01
1	.	1.178	0.37	0	0	0.034
2	.	0.71	0.83	0	0	0.104
3	.	0.582	0.97	0	0	0.201
4	.	0.548	1	0	0	0.309
5	.	0.5	1	0	0	0.373
6	.	0.355	1	0	0	0.432
7	.	0.355	1	0	0	0.463
8	.	0.355	1	0	0	0.513
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.041	0.00167	0.029		
1	0.00104	0.169	0.02179	0.099		
2	0.02003	0.256	0.05153	0.189		
3	0.07127	0.356	0.06671	0.242		
4	0.15062	0.435	0.04777	0.289		
5	0.16939	0.466	0.0671	0.284		
6	0.20472	0.484	0.04549	0.301		
7	0.21991	0.484	0.05781	0.317		
8	0.26008	0.461	0.01717	0.312		
IBC						

Age	Sel	CWt				
0	0.00016	0.029				
1	0.00211	0.102				
2	0.00685	0.208				
3	0.01458	0.3				
4	0.02312	0.4				
5	0.02667	0.413				
6	0.02814	0.447				
7	0.03031	0.447				
8	0.03078	0.453				
2021						
Age	N	M	Mat	PF	PM	SWt
0	11883334	2.066	0	0	0	0.01
1	.	1.178	0.37	0	0	0.034
2	.	0.71	0.83	0	0	0.104
3	.	0.582	0.97	0	0	0.201
4	.	0.548	1	0	0	0.309
5	.	0.5	1	0	0	0.373
6	.	0.355	1	0	0	0.432
7	.	0.355	1	0	0	0.463
8	.	0.355	1	0	0	0.513
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.041	0.00167	0.029		
1	0.00104	0.169	0.02179	0.099		
2	0.02003	0.256	0.05153	0.189		
3	0.07127	0.356	0.06671	0.242		
4	0.15062	0.435	0.04777	0.289		
5	0.16939	0.466	0.0671	0.284		
6	0.20472	0.484	0.04549	0.301		
7	0.21991	0.484	0.05781	0.317		
8	0.26008	0.461	0.01717	0.312		
IBC						
Age	Sel	CWt				
0	0.00016	0.029				
1	0.00211	0.102				
2	0.00685	0.208				
3	0.01458	0.3				
4	0.02312	0.4				
5	0.02667	0.413				
6	0.02814	0.447				

7	0.03031	0.447
8	0.03078	0.453
Input units are thousands and kg - output in tonnes		

Table 23.26. Whiting in Subarea 4 and Division 7.d: MFDP output table for short-term forecasts.

MFDP version 1a; Run: run1. Time and date: 09:38 26/04/2019; Basis: F(2019) = average exploitation (2016-2018), scaled to F(2018) = 0.199; Fbar age range: 2–6; Recruitment (2019–2021) = 11 883 million (geometric mean 2002–2018); TAC 27.4 (2019) = 17 191.

Output units in tonnes

2019																	
			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	0.149	0.2485
315912	167114	1	0.1988	28941	0.1232	16953	26131	20301	5830	0.0557	9178	1	0.0199	2810		

2020															**2021**		**2019 TAC 27.4**	**17191**	
			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	
314047	156590	0	0.020	2899	0.000	0	0	0	0	0.000	0	1	0.020	2899	330774	170621	-100.0%	9.0%	No HC fishery
.	156590	0.1	0.038	5529	0.012	1769	2653	2061	592	0.006	884	1	0.020	2876	328848	168725	-88.0%	7.7%	
.	156590	0.2	0.056	8118	0.025	3507	5265	4090	1175	0.011	1758	1	0.020	2853	326956	166863	-76.2%	6.6%	
.	156590	0.3	0.074	10669	0.037	5214	7838	6089	1749	0.017	2624	1	0.020	2831	325098	165035	-64.6%	5.4%	
.	156590	0.4	0.092	13178	0.049	6890	10370	8056	2314	0.022	3480	1	0.020	2808	323272	163240	-53.1%	4.2%	
.	156590	0.5	0.109	15649	0.062	8536	12863	9993	2870	0.028	4327	1	0.020	2786	321479	161477	-41.9%	3.1%	
.	156590	0.6	0.127	18085	0.074	10154	15320	11902	3418	0.033	5166	1	0.020	2765	319717	159745	-30.8%	2.0%	
.	156590	0.7	0.145	20481	0.086	11742	17738	13781	3957	0.039	5996	1	0.020	2743	317986	158044	-19.8%	0.9%	
.	156590	0.8	0.163	22843	0.099	13303	20121	15632	4489	0.045	6818	1	0.020	2722	316285	156373	-9.1%	-0.1%	
.	156590	0.9	0.181	25168	0.111	14836	22467	17455	5012	0.050	7631	1	0.020	2701	314614	154731	1.5%	-1.2%	
.	156590	1	0.199	27461	0.123	16343	24780	19252	5528	0.056	8437	1	0.020	2681	312971	153119	12.0%	-2.2%	Fsq

2020															2021		2019 TAC 27.4		17191
			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	
.	156590	1.1	0.217	29717	0.136	17823	27057	21021	6036	0.061	9234	1	0.020	2660	311358	151535	22.3%	-3.2%	
.	156590	1.2	0.235	31940	0.148	19277	29300	22763	6537	0.067	10023	1	0.020	2640	309772	149978	32.4%	-4.2%	
.	156590	1.3	0.253	34130	0.160	20705	31510	24480	7030	0.072	10805	1	0.020	2620	308213	148449	42.4%	-5.2%	
.	156590	1.4	0.270	36288	0.173	22109	33687	26171	7516	0.078	11578	1	0.020	2601	306681	146946	52.2%	-6.2%	
.	156590	1.5	0.288	38416	0.185	23489	35834	27839	7995	0.084	12345	1	0.020	2582	305175	145470	61.9%	-7.1%	
.	156590	1.6	0.306	40510	0.197	24845	37948	29482	8466	0.089	13103	1	0.020	2562	303695	144019	71.5%	-8.0%	
.	156590	1.7	0.324	42576	0.210	26177	40032	31101	8931	0.095	13855	1	0.020	2544	302240	142593	80.9%	-8.9%	
.	156590	1.8	0.342	44610	0.222	27486	42085	32696	9389	0.100	14599	1	0.020	2525	300810	141192	90.2%	-9.8%	
.	156590	1.9	0.360	46616	0.234	28773	44109	34268	9841	0.106	15336	1	0.020	2507	299404	139815	99.3%	-10.7%	
.	156590	2	0.378	48593	0.246	30038	46104	35818	10286	0.111	16066	1	0.020	2489	298021	138461	108.4%	-11.6%	
.	156590	0.75	0.154	21130	0.092	12111	18393	14290	4103	0.042	6282	1	0.020	2737	317580	157651	-16.9%	0.7%	$0.75*F_{sq}$
.	156590	0.79	0.162	22082	0.098	12737	19354	15036	4318	0.044	6617	1	0.020	2728	316897	156981	-12.5%	0.2%	F_{msy} SSB(2020)/MSYB$_{trigger}$
.	156590	1.25	0.244	32535	0.154	19605	29900	23230	6671	0.070	10295	1	0.020	2634	309408	149628	35.1%	-4.4%	$1.25*F_{sq}$
.	156590	0.77	0.157	21542	0.095	12380	18817	14612	4196	0.043	6428	1	0.020	2733	317286	157363	-15.0%	0.5%	15% TAC decr (27.4)
.	156590	1.06	0.209	28121	0.130	16705	25445	19770	5677	0.059	8742	1	0.020	2674	312570	152733	15.0%	-2.5%	15% TAC incr (27.4)
.	156590	0.91	0.183	24831	0.112	14543	22131	17191	4937	0.051	7585	1	0.020	2703	314928	155048	0.0%	-1.0%	Rollover TAC
.	156590	1.00	0.199	26855	0.123	15873	24169	18777	5392	0.056	8297	1	0.020	2685	313478	153624	9.2%	-1.9%	F_{sq}
.	156590	1.73	0.330	43554	0.214	26846	41018	31867	9151	0.097	14172	1	0.020	2535	301513	141876	85.4%	-9.4%	F_{pa}
.	156590	2.45	0.458	59870	0.302	37568	57482	44657	12824	0.136	19914	1	0.020	2389	289822	130397	159.8%	-16.7%	F_{lim}
.	156590	0.19	0.053	8298	0.023	3679	5446	4231	1215	0.010	1767	1	0.020	2852	326773	166708	-75.4%	6.4%	B_{pa}, MSY $B_{trigger}$
.	156590	3.09	0.573	74583	0.381	47236	72327	56190	16136	0.172	25091	1	0.020	2256	279280	119970	226.9%	-23.3%	B_{lim}
.	156590	0.77	0.158	21628	0.095	12438	18896	14680	4216	0.043	6458	1	0.020	2732	317222	157301	-14.6%	0.5%	$F_{msylower}$

2020															**2021**		**2019 TAC 27.4**	**17191**	
			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	
.	156590	0.45	0.100	14190	0.055	7550	11391	8850	2541	0.025	3840	1	0.020	2799	322552	162533	-48.5%	3.8%	A
.	156590	0.59	0.125	17456	0.073	9697	14687	11410	3277	0.033	4990	1	0.020	2770	320212	160235	-33.6%	2.3%	B
.	156590	0.45	0.100	14190	0.055	7550	11391	8850	2541	0.025	3840	1	0.020	2799	322552	162533	-48.5%	3.8%	C
.	156590	0.45	0.100	14263	0.055	7598	11464	8907	2558	0.025	3866	1	0.020	2798	322500	162482	-48.2%	3.8%	A+D
.	156590	0.56	0.119	16696	0.068	9197	13919	10814	3105	0.031	4722	1	0.020	2777	320756	160770	-37.1%	2.7%	B+E
.	156590	0.46	0.102	14506	0.057	7758	11709	9097	2612	0.026	3952	1	0.020	2796	322326	162311	-47.1%	3.7%	C+E
.	156590	0.85	0.172	23413	0.105	13611	20697	16079	4617	0.047	7086	1	0.020	2716	315944	156045	-6.5%	-0.3%	F_{msy},$F_{msyupper}$
.	156590	0.72	0.149	20445	0.089	11660	17713	13753	3949	0.040	6043	1	0.020	2743	318071	158134	-20.0%	1.0%	20% TAC decr (27.4)
.	156590	1.15	0.226	30314	0.142	18146	27654	21489	6171	0.064	9513	1	0.020	2654	310998	151190	25.0%	-3.4%	25% TAC incr (27.4)
.	156590	0.72	0.148	20406	0.088	11635	17663	13722	3941	0.040	6028	1	0.020	2743	318098	158160	-20.2%	1.0%	$F_{msylower}$ SSB(2020)/$MSYB_{trigger}$

Table 23.27 Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series for northern component used in the area-specific SURBAR analysis.

	Q1	North				Q3	North				
Age	1	2	3	4	5	0	1	2	3	4	5
1978	555.290	318.433	128.516	30.530	5.982						
1979	556.108	275.848	157.552	47.759	6.924						
1980	755.130	512.269	132.189	22.785	12.965						
1981	232.787	546.729	284.999	50.875	9.779						
1982	117.979	269.922	387.919	97.325	12.941						
1983	143.401	157.106	152.748	114.264	49.061						
1984	323.423	213.707	113.252	43.826	37.439						
1985	412.895	341.418	82.957	24.271	10.397						
1986	587.697	385.417	244.458	41.990	10.743						
1987	707.640	788.971	124.875	60.433	6.448						
1988	301.643	1116.375	440.969	45.957	16.437						
1989	2049.507	669.048	584.177	164.803	18.070						
1990	490.822	1251.634	263.556	140.553	30.405						
1991	760.511	844.196	633.854	78.510	46.224	189.820	306.528	127.838	89.973	13.089	4.674
1992	1205.419	828.037	322.090	217.590	13.583	1338.137	614.584	249.823	87.132	81.356	12.524
1993	1570.312	766.434	340.719	105.197	99.361	337.639	544.068	256.649	92.277	22.569	25.312
1994	1004.305	955.253	280.680	106.183	18.849	233.828	687.167	294.267	115.846	25.273	7.448
1995	882.445	649.157	357.802	82.751	18.532	329.047	764.895	371.290	151.961	30.821	8.015
1996	587.316	655.295	344.611	103.650	34.936	89.875	522.239	337.170	170.167	47.462	9.689
1997	379.884	489.729	233.879	88.821	26.393	2751.121	367.300	225.664	152.310	40.168	15.503
1998	754.234	210.571	182.915	81.152	24.010	2484.246	405.553	199.338	79.580	47.242	16.961
1999	878.887	402.173	132.768	86.295	39.477	1723.648	811.733	247.520	79.200	36.641	14.419
2000	1014.576	752.214	264.972	76.041	29.385	1456.711	768.188	348.970	77.929	19.147	9.611
2001	385.871	575.689	381.098	97.873	26.263	291.479	642.815	300.653	118.765	27.150	6.513
2002	507.592	412.986	386.754	96.796	31.426	105.617	603.663	303.033	180.371	49.657	8.077
2003	144.095	337.725	340.525	193.990	72.460	412.995	245.222	328.073	173.464	97.575	25.715
2004	252.710	119.857	251.237	149.248	73.628	211.007	191.008	77.617	93.027	66.118	39.386
2005	146.652	81.492	60.820	86.549	58.311	154.069	195.958	98.174	46.081	67.284	50.252
2006	230.579	118.993	63.601	24.541	39.987	44.878	191.499	111.441	47.060	19.840	34.032
2007	61.303	205.229	104.379	28.905	13.908	346.987	75.451	82.685	53.769	16.767	12.106
2008	199.538	195.365	90.723	34.280	11.746	848.142	336.234	78.518	46.428	21.775	6.772
2009	153.522	247.251	81.150	25.541	16.088	559.080	259.273	141.438	36.227	16.401	11.482
2010	293.519	269.314	322.706	128.852	39.080	70.104	248.339	182.193	66.673	17.570	8.550
2011	183.262	471.298	224.823	131.615	28.978	88.673	417.435	165.686	68.114	25.572	10.331
2012	265.054	788.376	157.835	68.203	48.193	316.872	238.025	273.052	95.597	32.515	15.905
2013	60.196	214.452	346.075	129.792	40.267	141.955	58.857	57.873	82.086	26.882	10.959
2014	357.400	263.689	173.793	117.704	42.453	2017.069	202.126	74.543	50.680	44.743	14.400

	Q1	North				Q3	North				
Age	1	2	3	4	5	0	1	2	3	4	5
2015	420.680	246.455	72.475	38.920	34.723	2113.574	247.030	208.374	57.846	34.407	28.884
2016	258.559	202.624	107.273	28.063	17.608	729.877	318.893	198.273	80.622	15.168	10.985
2017	460.427	244.961	143.739	43.208	12.419	148.347	634.444	216.476	108.107	36.844	10.482
2018	87.202	238.773	92.502	54.493	18.630	204.113	146.705	264.187	111.505	43.783	19.115
2019	273.609	191.308	161.854	65.678	20.927						

Table 23.28 Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series for southern component used in the area-specific SURBAR analysis.

	Q1	South				Q3	South				
Age	1	2	3	4	5	0	1	2	3	4	5
1978	469.545	137.431	16.925	4.534	0.543						
1979	169.514	117.558	21.961	3.773	1.070						
1980	370.468	122.965	101.877	31.167	1.667						
1981	195.122	302.102	122.914	35.814	8.210						
1982	168.681	169.366	97.828	28.562	8.647						
1983	85.450	100.019	53.562	20.857	5.342						
1984	582.354	96.477	45.202	4.665	3.043						
1985	114.689	331.412	32.338	12.963	1.224						
1986	155.459	93.200	218.839	57.445	7.728						
1987	542.619	87.725	27.973	28.422	3.451						
1988	487.546	263.669	52.847	5.863	6.860						
1989	292.416	234.855	78.636	5.580	0.772						
1990	470.354	119.872	90.594	34.877	4.839						
1991	1186.597	278.418	131.924	47.843	18.079	958.688	1381.237	175.463	47.274	15.511	5.590
1992	285.473	318.955	93.801	33.307	14.284	1193.245	479.872	310.683	35.743	8.295	5.434
1993	168.894	53.201	103.337	12.230	2.698	1621.699	707.495	51.325	26.961	1.932	1.246
1994	323.804	50.489	11.266	5.465	1.307	993.130	634.927	104.463	15.753	11.233	0.715
1995	300.326	153.749	64.217	25.953	0.398	1218.348	230.036	82.923	5.980	1.220	1.579
1996	342.428	196.791	76.612	7.980	1.528	537.775	495.443	122.021	35.206	5.288	1.119
1997	88.689	37.330	28.219	6.009	1.637	474.355	246.166	58.412	9.715	1.673	0.351
1998	115.783	55.443	17.594	6.032	0.875	2229.932	247.735	54.790	2.899	1.124	0.174
1999	289.598	143.932	32.474	3.648	1.045	2794.070	1731.958	57.898	3.432	0.097	0.014
2000	254.977	132.218	39.787	13.820	3.847	2456.096	1095.607	238.546	31.664	1.744	0.095
2001	833.393	491.957	130.949	94.276	25.445	8867.757	702.812	235.807	45.895	3.313	0.006
2002	429.667	156.987	32.634	13.271	3.822	385.905	995.512	127.287	26.288	3.773	0.074
2003	88.822	240.257	64.039	31.270	11.271	133.467	267.459	187.312	30.539	6.804	0.091
2004	39.814	44.143	48.120	16.591	6.412	1643.736	115.848	39.157	10.465	2.345	1.278
2005	40.762	105.475	39.428	12.281	4.920	207.539	55.444	7.843	1.645	0.825	0.591
2006	83.316	42.986	28.050	12.742	6.408	443.497	78.000	19.801	3.260	0.651	1.544

	Q1	South				Q3	South				
Age	**1**	**2**	**3**	**4**	**5**	**0**	**1**	**2**	**3**	**4**	**5**
2007	71.934	60.673	28.015	4.597	0.795	2204.215	152.219	19.458	1.947	0.093	0.027
2008	425.035	250.866	36.035	3.216	0.694	546.439	608.569	65.081	0.681	0.258	0.121
2009	394.339	451.761	133.929	35.160	5.837	634.897	1055.038	719.680	34.510	1.432	0.094
2010	400.368	148.687	97.511	33.584	11.497	914.230	154.604	52.752	19.821	1.235	0.144
2011	459.805	191.778	56.517	27.820	6.621	511.814	461.932	112.936	19.016	2.575	1.671
2012	212.622	198.796	64.781	20.288	3.822	208.426	297.863	108.418	17.163	2.369	0.671
2013	103.238	111.558	73.114	20.940	3.338	772.182	101.070	56.355	28.917	2.761	1.144
2014	622.597	503.309	193.383	34.248	2.866	1884.960	290.963	185.481	173.346	26.081	1.513
2015	278.761	418.783	175.590	42.262	9.030	1622.776	487.361	347.294	41.000	1.656	3.697
2016	567.313	729.145	134.105	15.876	1.539	1245.384	210.065	165.115	64.481	6.842	1.135
2017	984.083	290.483	49.836	10.063	0.449	206.524	1486.126	217.806	25.296	3.897	0.444
2018	164.868	211.434	64.528	19.637	3.338	112.076	372.461	402.044	75.336	12.217	5.589
2019	137.403	82.003	50.297	19.042	5.407						

Table 23.29 Whiting in Subarea 4 and Division 7.d: Maturity estimates for northern component used in the area-specific SURBAR analysis. Before 1991 used values of 1991.

Age	0	1	2	3	4	5	6	7	8+
1991	0.000	0.174	0.813	0.986	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.176	0.812	0.985	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.178	0.810	0.984	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.182	0.806	0.982	0.999	1.000	1.000	1.000	1.000
1995	0.000	0.187	0.801	0.979	0.998	0.999	1.000	1.000	1.000
1996	0.000	0.193	0.794	0.975	0.997	0.999	1.000	1.000	1.000
1997	0.000	0.202	0.786	0.969	0.995	0.998	1.000	1.000	1.000
1998	0.000	0.213	0.776	0.963	0.994	0.998	1.000	1.000	1.000
1999	0.000	0.227	0.765	0.956	0.992	0.998	1.000	1.000	1.000
2000	0.000	0.243	0.755	0.949	0.991	0.997	1.000	1.000	1.000
2001	0.000	0.260	0.748	0.945	0.990	0.997	1.000	1.000	1.000
2002	0.000	0.276	0.748	0.945	0.990	0.998	1.000	1.000	1.000
2003	0.000	0.289	0.752	0.946	0.990	0.998	1.000	1.000	1.000
2004	0.000	0.298	0.760	0.950	0.992	0.999	1.000	1.000	1.000
2005	0.000	0.304	0.772	0.955	0.993	0.999	1.000	1.000	1.000
2006	0.000	0.306	0.786	0.961	0.994	0.999	1.000	1.000	1.000
2007	0.000	0.306	0.801	0.968	0.996	1.000	1.000	1.000	1.000
2008	0.000	0.305	0.815	0.973	0.997	1.000	1.000	1.000	1.000
2009	0.000	0.304	0.827	0.978	0.998	1.000	1.000	1.000	1.000
2010	0.000	0.305	0.835	0.981	0.999	1.000	1.000	1.000	1.000
2011	0.000	0.306	0.841	0.983	1.000	1.000	1.000	1.000	1.000
2012	0.000	0.307	0.843	0.983	1.000	1.000	1.000	1.000	1.000
2013	0.000	0.306	0.843	0.983	1.000	1.000	1.000	1.000	1.000
2014	0.000	0.304	0.841	0.982	1.000	1.000	1.000	1.000	1.000
2015	0.000	0.304	0.838	0.981	1.000	1.000	1.000	1.000	1.000
2016	0.000	0.305	0.835	0.979	0.999	1.000	1.000	1.000	1.000
2017	0.000	0.307	0.830	0.976	0.998	1.000	1.000	1.000	1.000
2018	0.000	0.311	0.822	0.973	0.997	1.000	1.000	1.000	1.000
2019	0.000	0.314	0.813	0.970	0.996	1.000	1.000	1.000	1.000

Table 23.30 Whiting in Subarea 4 and Division 7.d: Maturity estimates for southern component used in the area-specific SURBAR analysis. Before 1991 used values of 1991.

Age	0	1	2	3	4	5	6	7	8+
1991	0.000	0.300	0.866	0.993	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.301	0.824	0.980	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.297	0.788	0.967	0.999	1.000	1.000	1.000	1.000
1994	0.000	0.290	0.761	0.955	0.996	1.000	1.000	1.000	1.000
1995	0.000	0.272	0.737	0.940	0.991	0.999	1.000	1.000	1.000
1996	0.000	0.246	0.709	0.919	0.981	0.994	0.998	0.999	0.999
1997	0.000	0.224	0.687	0.895	0.966	0.985	0.993	0.996	0.998
1998	0.000	0.217	0.676	0.867	0.945	0.972	0.985	0.993	0.996
1999	0.000	0.226	0.657	0.832	0.917	0.956	0.976	0.988	0.994
2000	0.000	0.247	0.622	0.792	0.890	0.941	0.968	0.984	0.992
2001	0.000	0.275	0.591	0.768	0.876	0.934	0.964	0.983	0.991
2002	0.000	0.306	0.580	0.766	0.878	0.937	0.966	0.984	0.993
2003	0.000	0.338	0.585	0.776	0.887	0.944	0.970	0.987	0.994
2004	0.000	0.368	0.601	0.792	0.899	0.952	0.975	0.990	0.996
2005	0.000	0.391	0.624	0.811	0.913	0.961	0.981	0.992	0.997
2006	0.000	0.415	0.654	0.835	0.928	0.970	0.987	0.995	0.999
2007	0.000	0.441	0.693	0.862	0.943	0.978	0.992	0.997	0.999
2008	0.000	0.467	0.733	0.890	0.958	0.985	0.996	0.999	1.000
2009	0.000	0.488	0.769	0.913	0.969	0.990	0.999	1.000	1.000
2010	0.000	0.503	0.796	0.930	0.976	0.993	1.000	1.000	1.000
2011	0.000	0.512	0.814	0.940	0.981	0.995	1.000	1.000	1.000
2012	0.000	0.517	0.819	0.944	0.982	0.996	1.000	1.000	1.000
2013	0.000	0.517	0.818	0.943	0.982	0.997	1.000	1.000	1.000
2014	0.000	0.516	0.822	0.945	0.982	0.997	1.000	1.000	1.000
2015	0.000	0.514	0.832	0.951	0.985	0.998	1.000	1.000	1.000
2016	0.000	0.502	0.841	0.957	0.988	0.998	1.000	1.000	1.000
2017	0.000	0.483	0.843	0.961	0.990	0.998	1.000	1.000	1.000
2018	0.000	0.458	0.833	0.961	0.991	0.997	1.000	1.000	1.000
2019	0.000	0.429	0.814	0.956	0.991	0.995	1.000	1.000	1.000

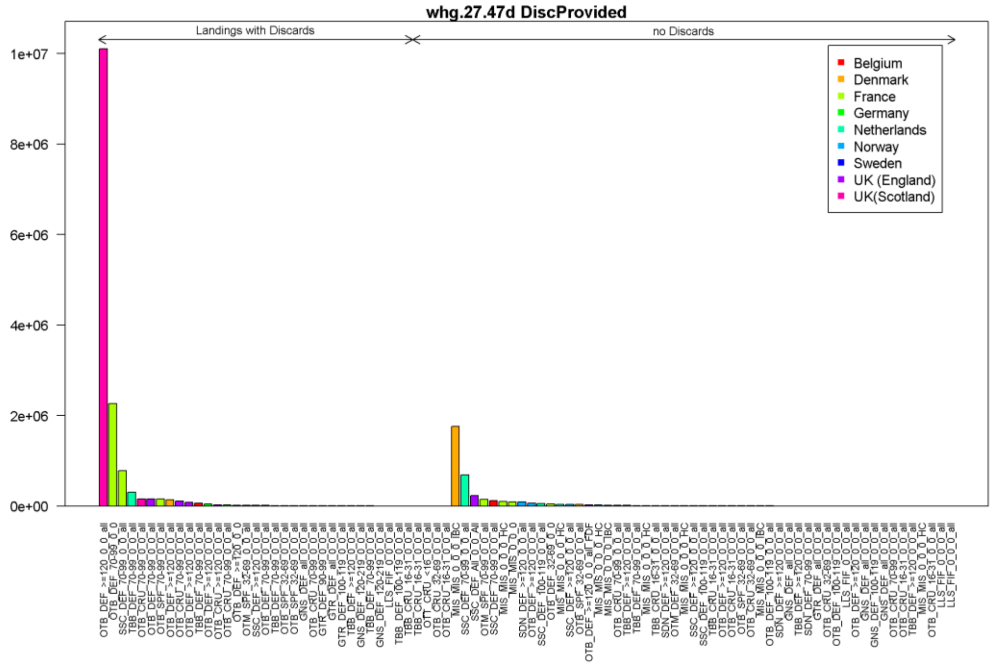


Figure 23.1. Whiting in Subarea 4 and Division 7.d: Landings with provided discards. Métier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

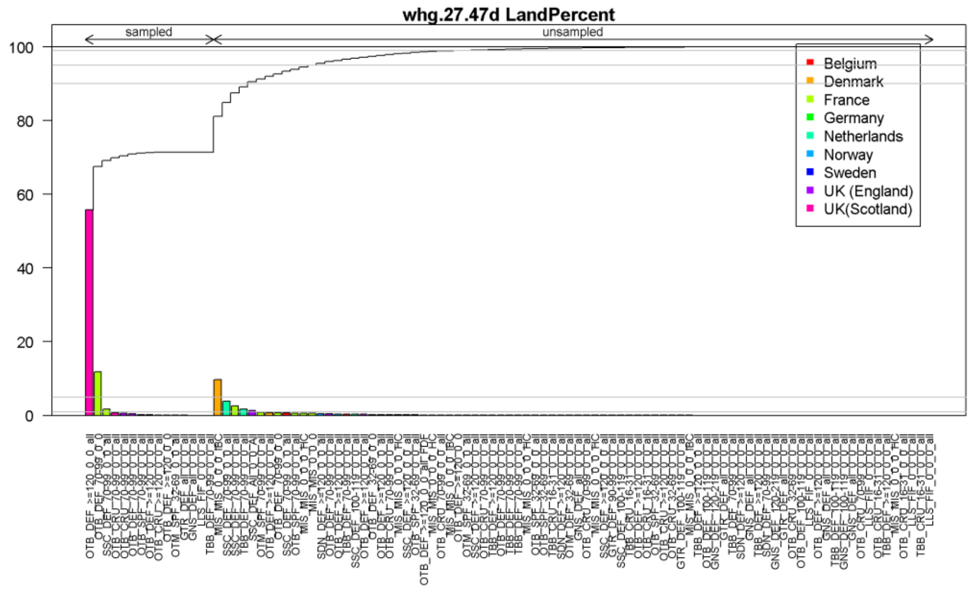


Figure 23.2a. Whiting in Subarea 4 and Division 7.d: Reported landings (in percent, colored bars) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

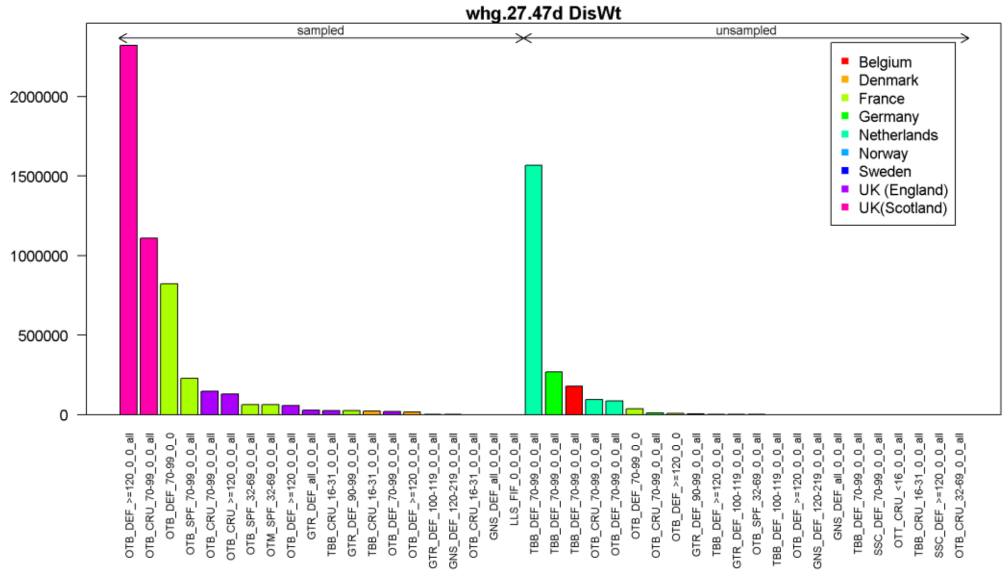


Figure 23.2b. Whiting in Subarea 4 and Division 7.d: Reported discards (in tonnes, colored bars) for each sampled and unsampled fleet, in descending order of yield.

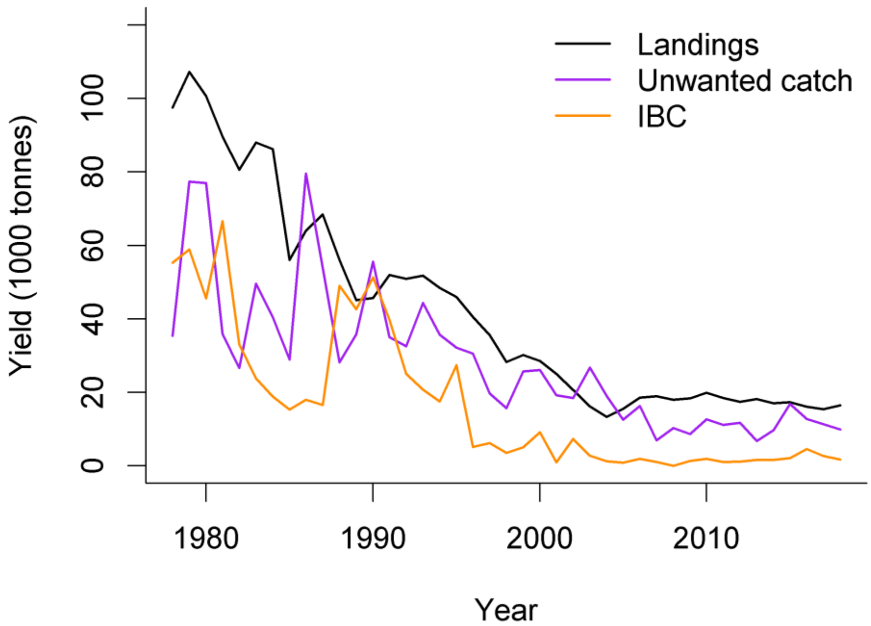


Figure 23.3. Whiting in Subarea 4 and Division 7.d: Yield by catch component. Unwanted catch includes discards and BMS landings as estimated by ICES.

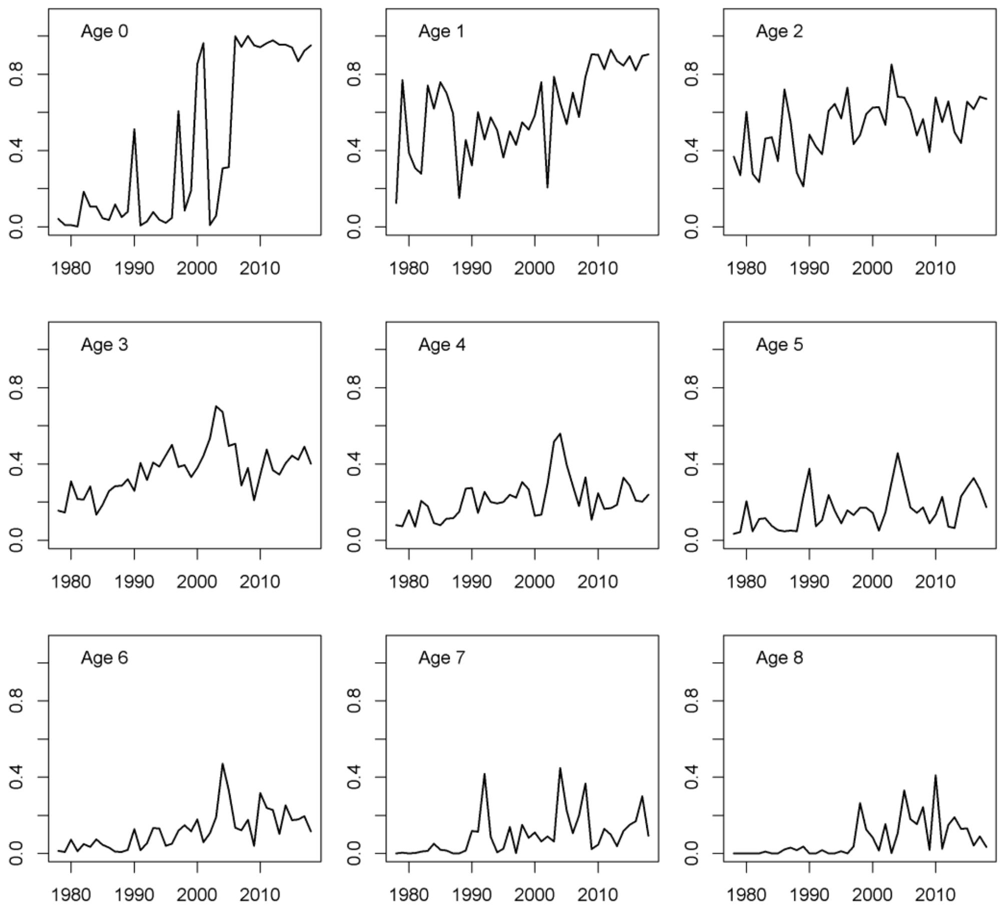


Figure 23.4. Whiting in Subarea 4 and Division 7.d: Proportion of unwanted catch in total catch, by age and year.

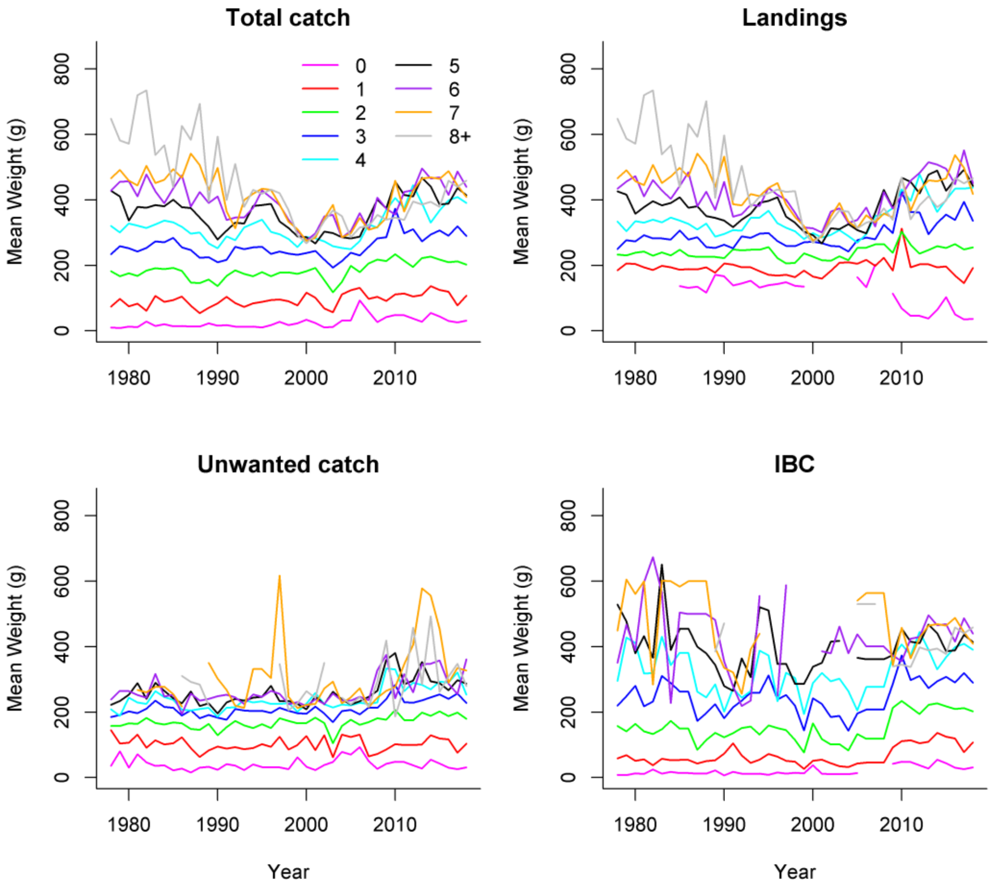


Figure 23.5. Whiting in Subarea 4 and Division 7.d: Mean weights-at-age (kg) by catch component (black lines, age 0-8+) and LOESS smoothers through each time-series of mean weights-at-age (red dashed lines).

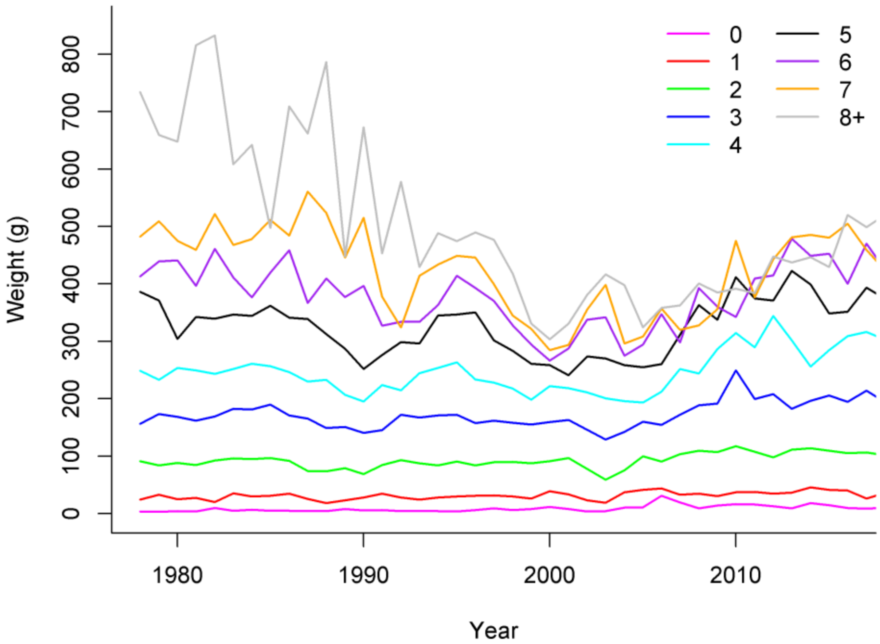


Figure 23.6. Whiting in Subarea 4 and Division 7.d: Stock mean weights-at-age (kg) by catch component (dots, age 0-8+) and smoothers through each time-series of mean weights-at-age (lines).

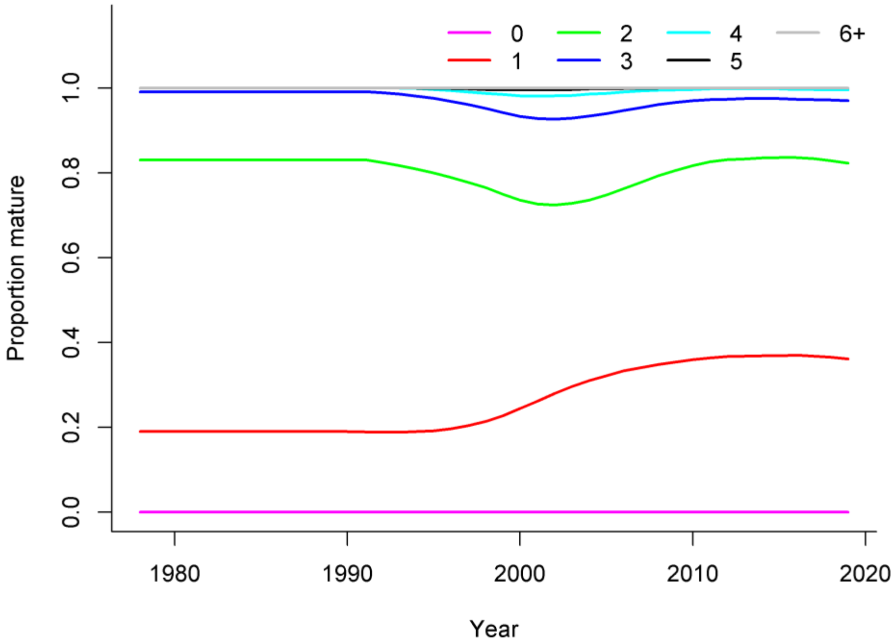


Figure 23.7. Whiting in Subarea 4 and Division 7.d: Maturity estimates from NS IBTS Q1 data. Ages 6-8+ have the same maturity values. Estimates prior 1991 are assumed constant using values of 1991.

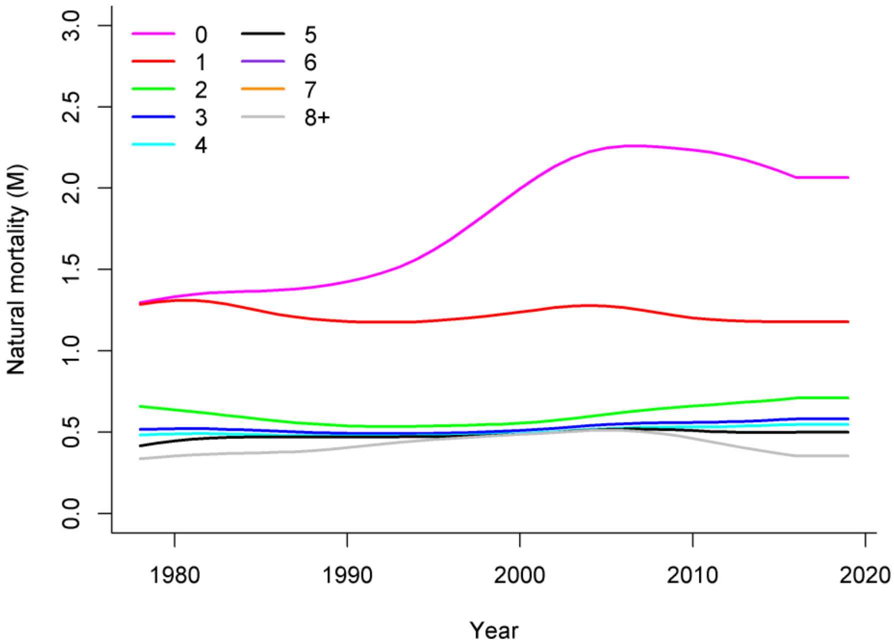


Figure 23.8. Whiting in Subarea 4 and Division 7.d: Natural mortality estimates from the 2017 update of SMS key run (WGSAM, 2018b) used in assessment. Ages 6–8+ have the same natural mortality.

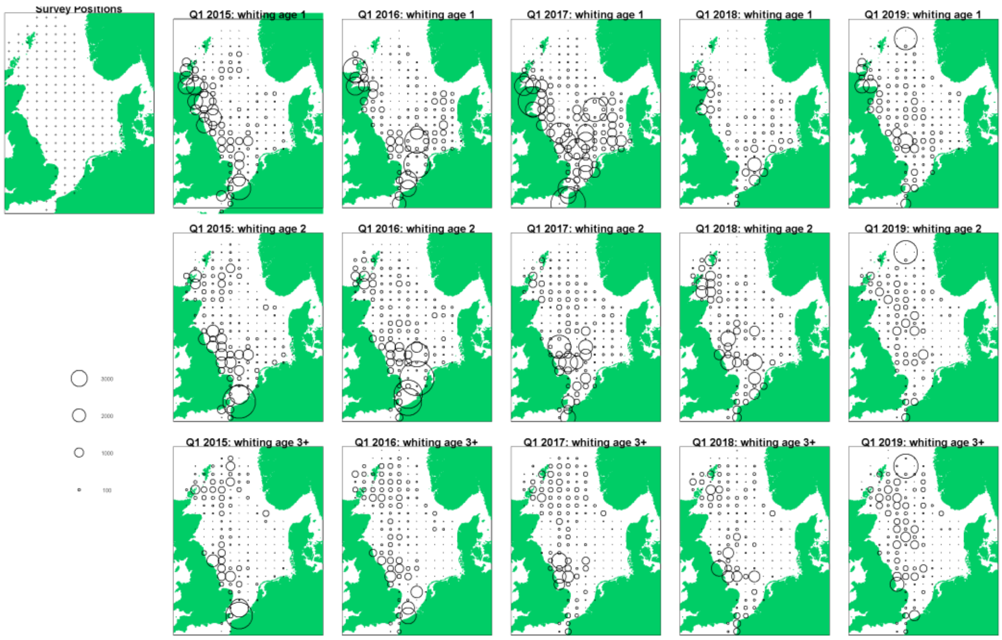


Figure 23.9. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for Ages 1–3+ Q1 2014–2018. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q1 survey in the North Sea.

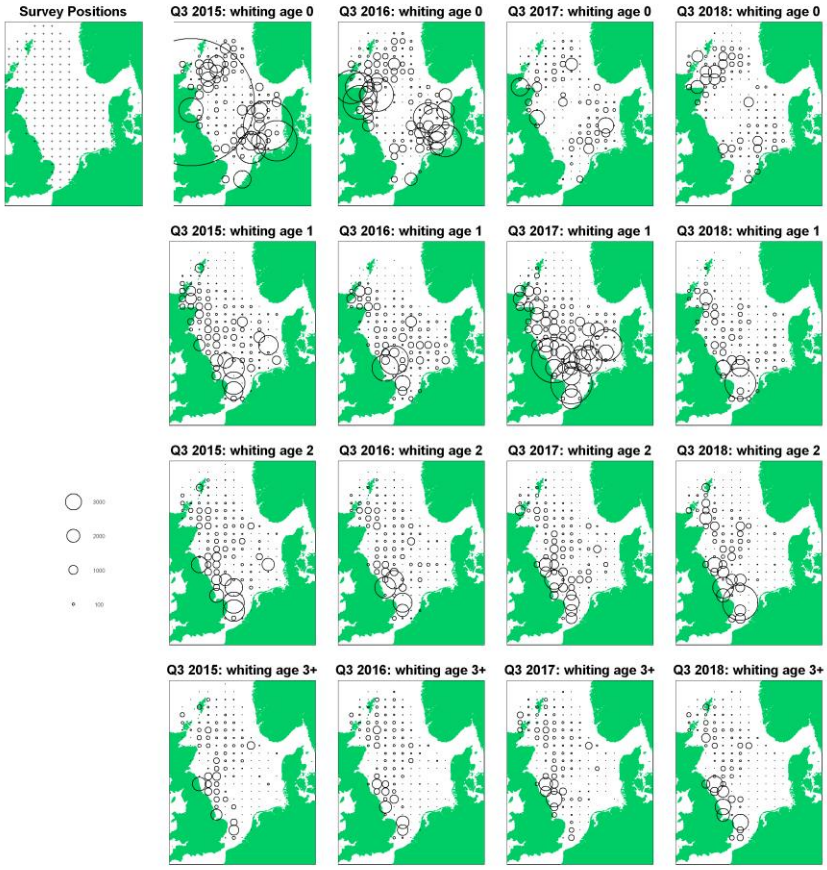


Figure 23.10. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for ages 0–3+ Q3 2014–2017. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q3 survey in the North Sea.

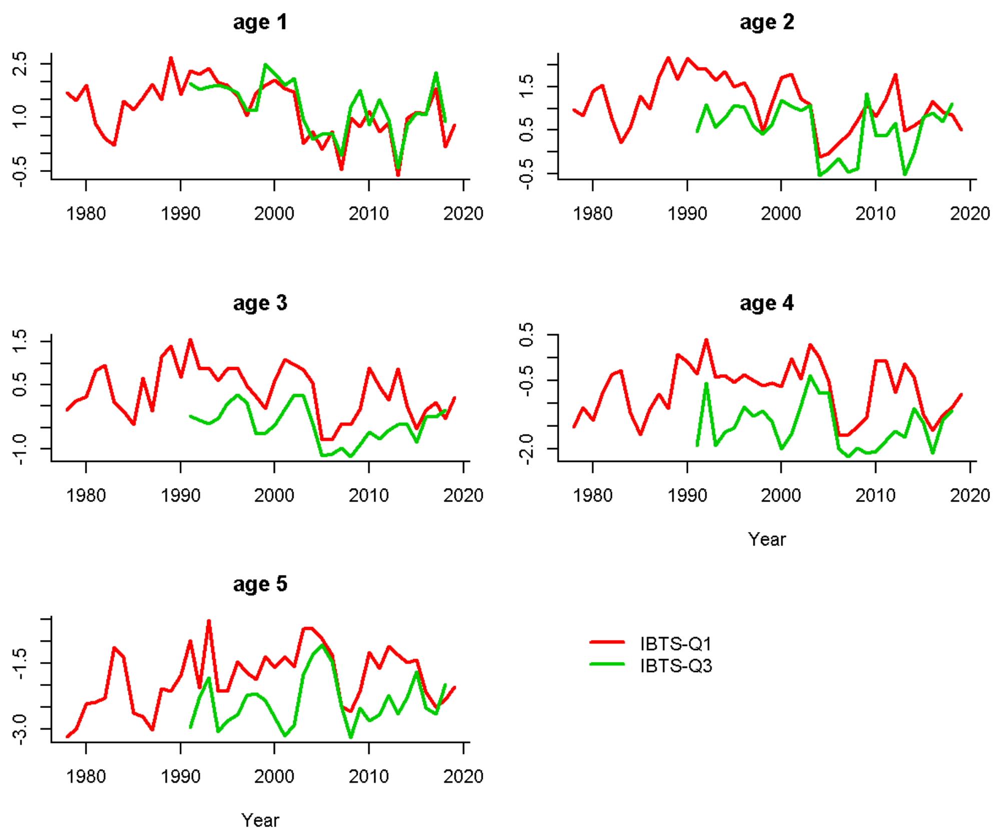


Figure 23.11. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) at age.

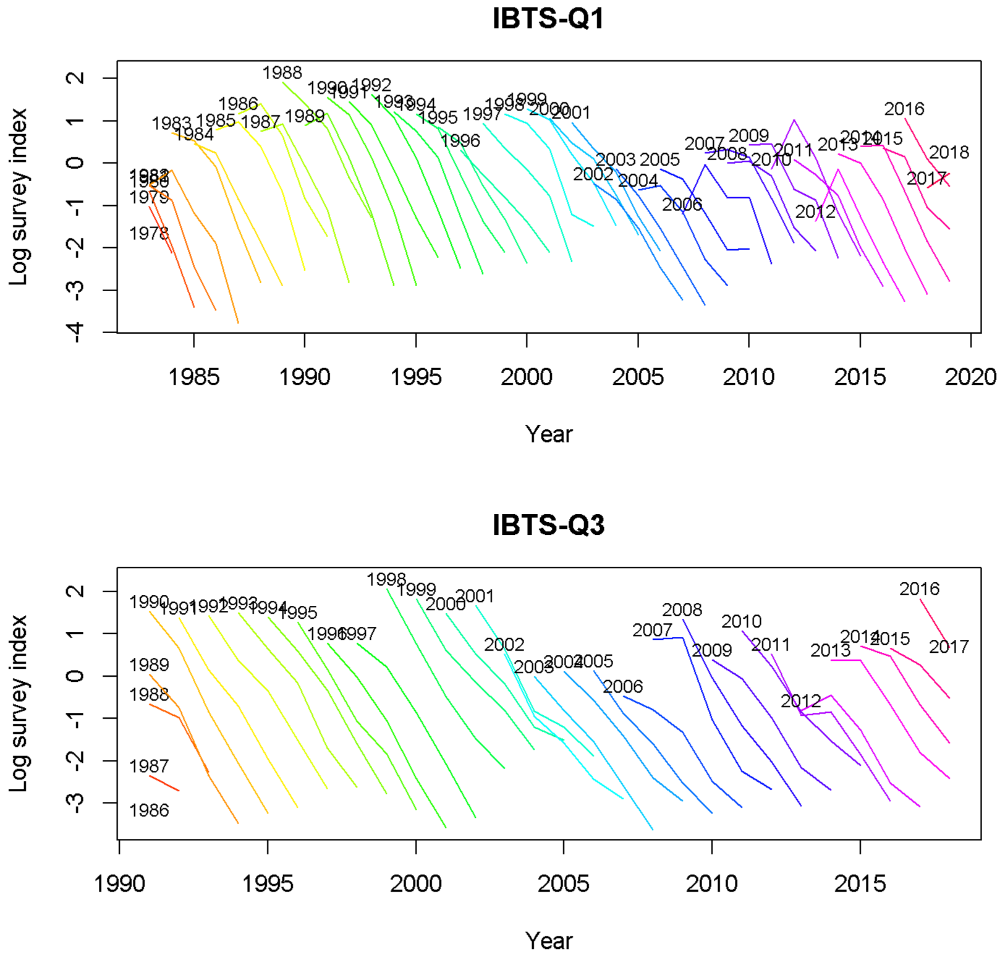


Figure 23.12. Whiting in Subarea 4 and Division 7.d: Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

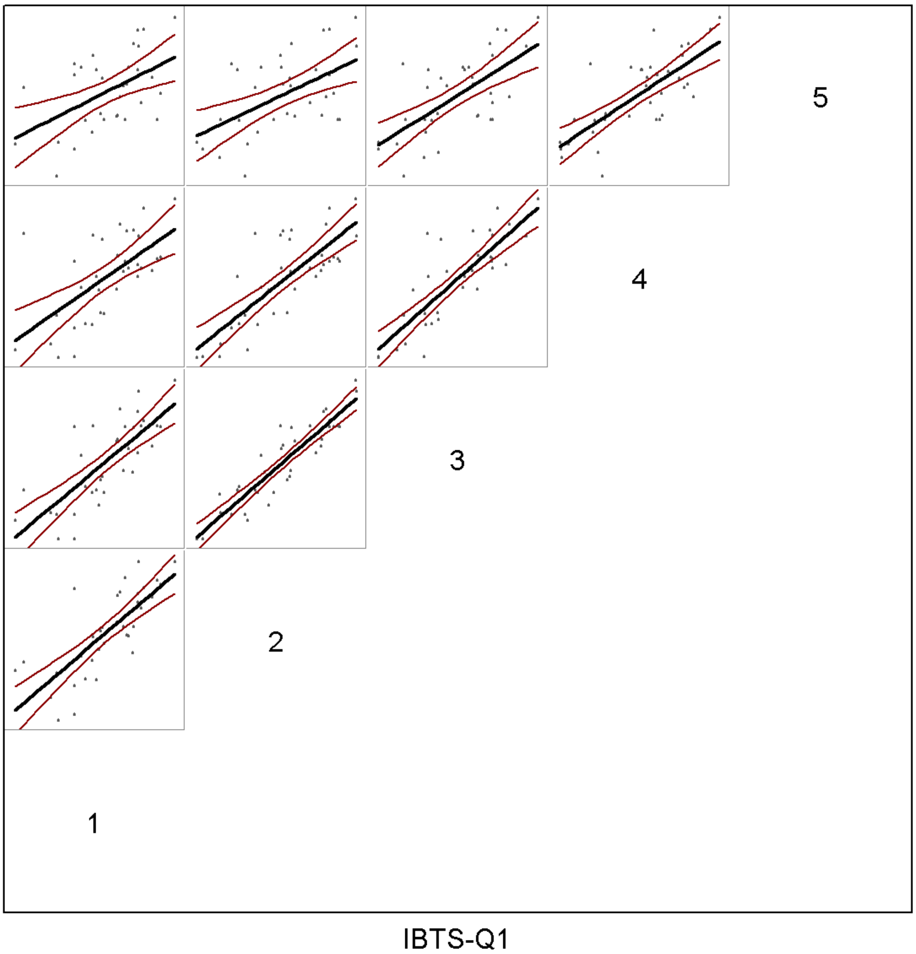


Figure 23.13. Within-survey correlations for the IBTS–Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximatee 95% confidence intervals for each fit are also shown.

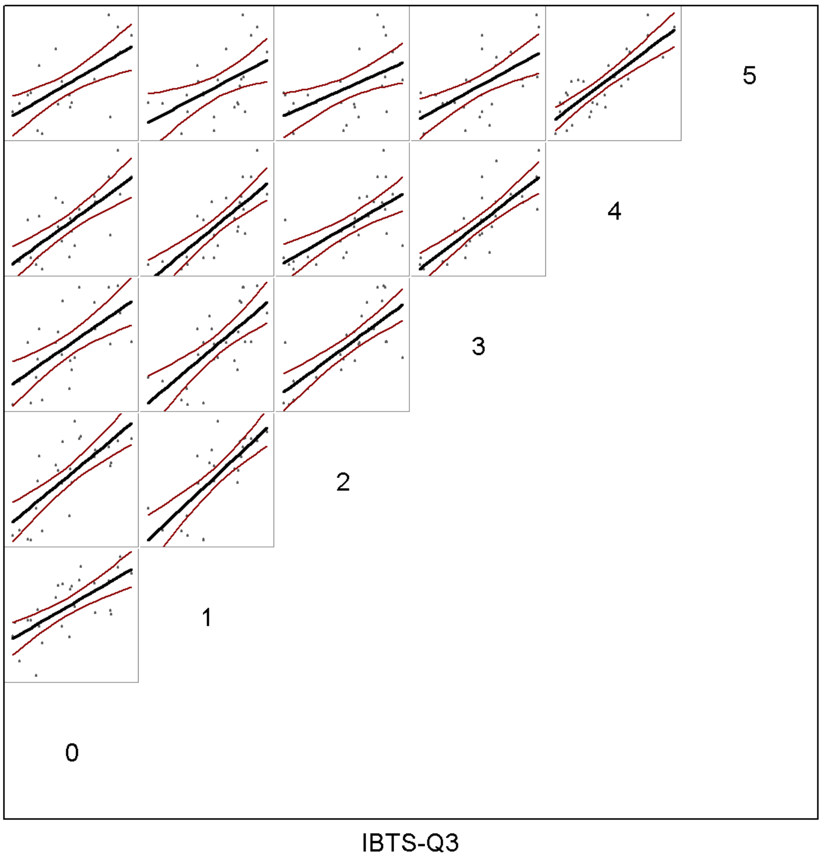


Figure 23.14. Within-survey correlations for the IBTS–Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

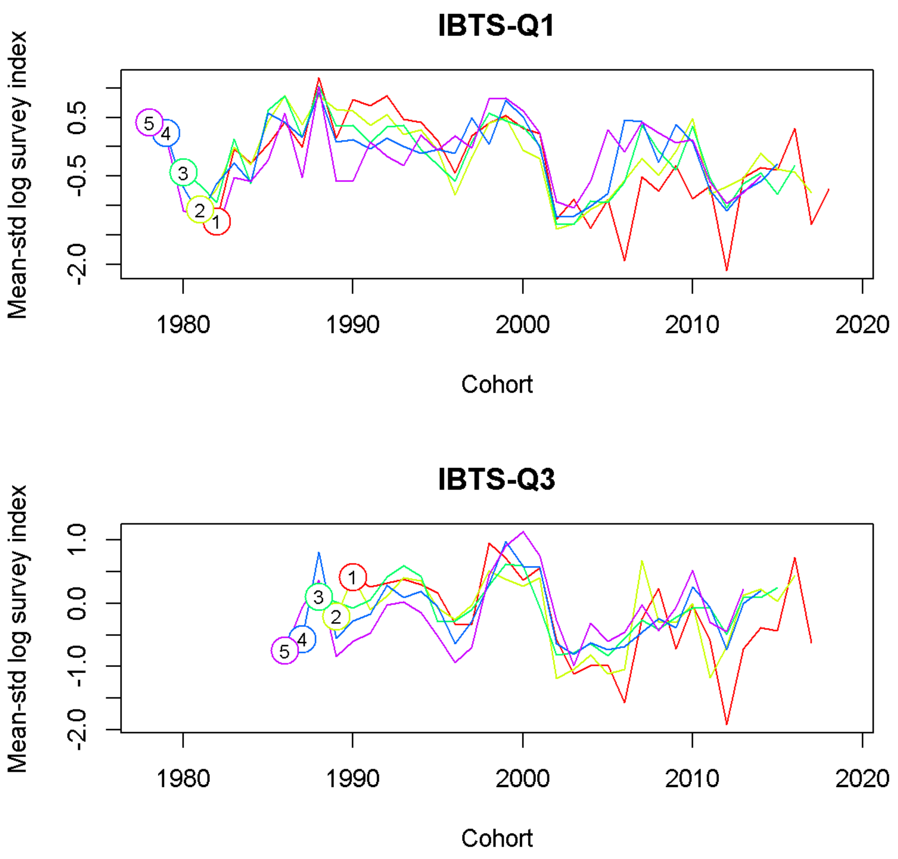


Figure 23.15. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) for the IBTS–Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

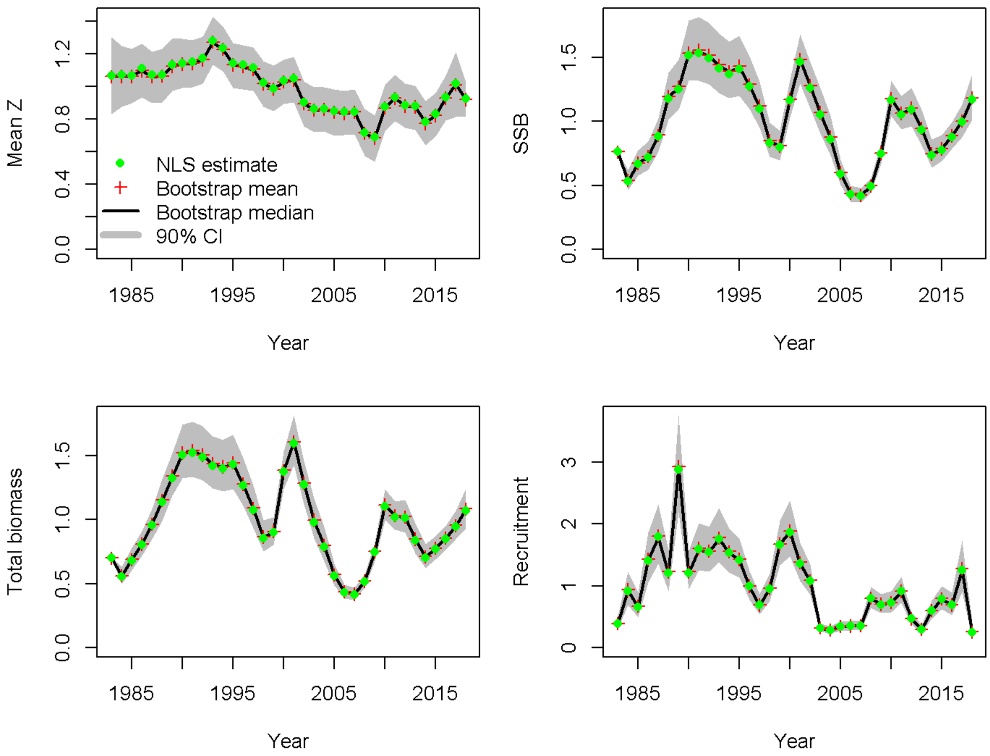


Figure 23.16. Whiting in Subarea 4 and Division 7.d: Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment (age 1). Shaded grey areas 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.

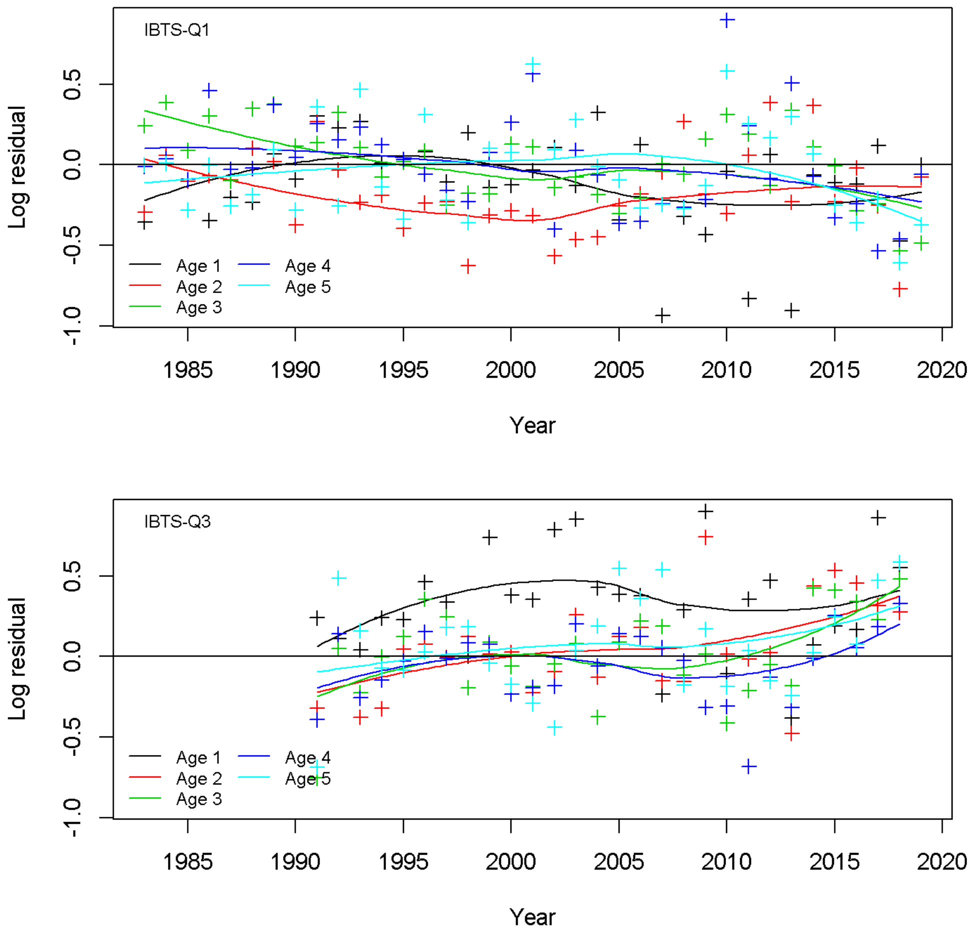


Figure 23.17. Whiting in Subarea 4 and Division 7.d: Log survey residuals from the SURBAR analysis. Ages are color-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

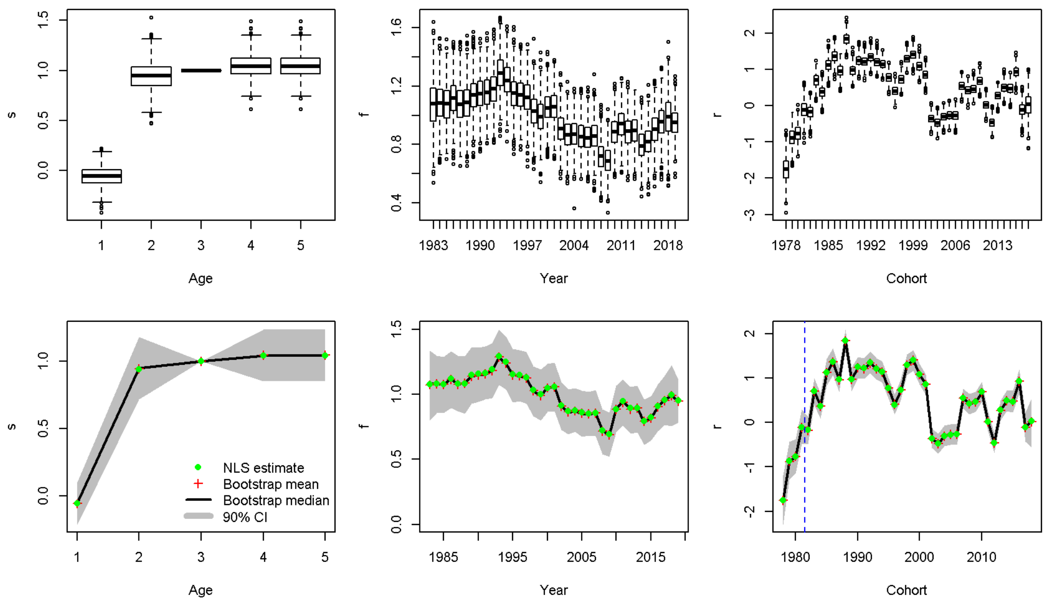


Figure 23.18. Whiting in Subarea 4 and Division 7.d: Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

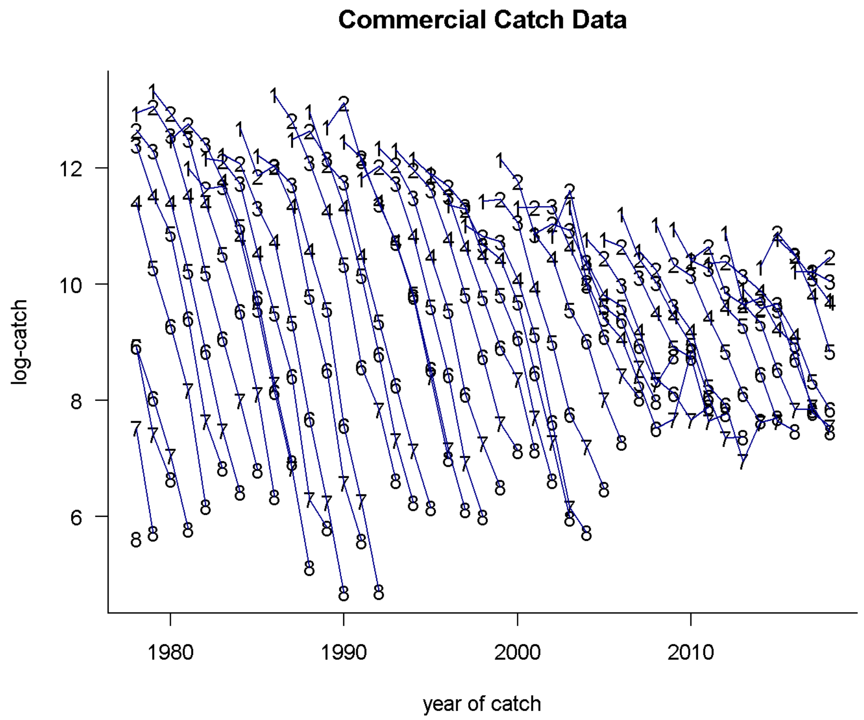


Figure 23.19. Whiting in Subarea 4 and Division 7.d: Log-catch curves by cohort for total catches (ages 1–8+).

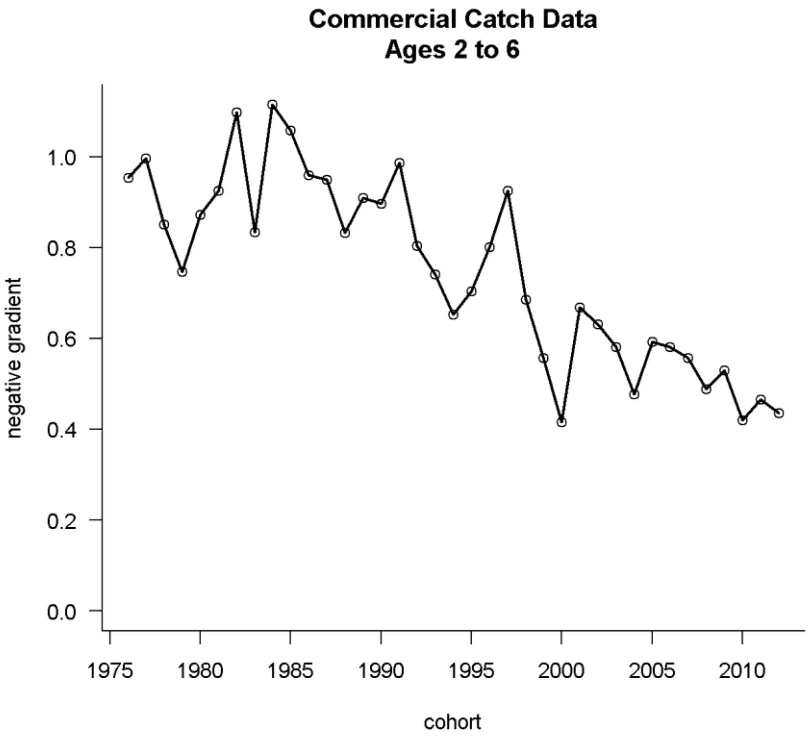


Figure 23.20. Whiting in Subarea 4 and Division 7.d: Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

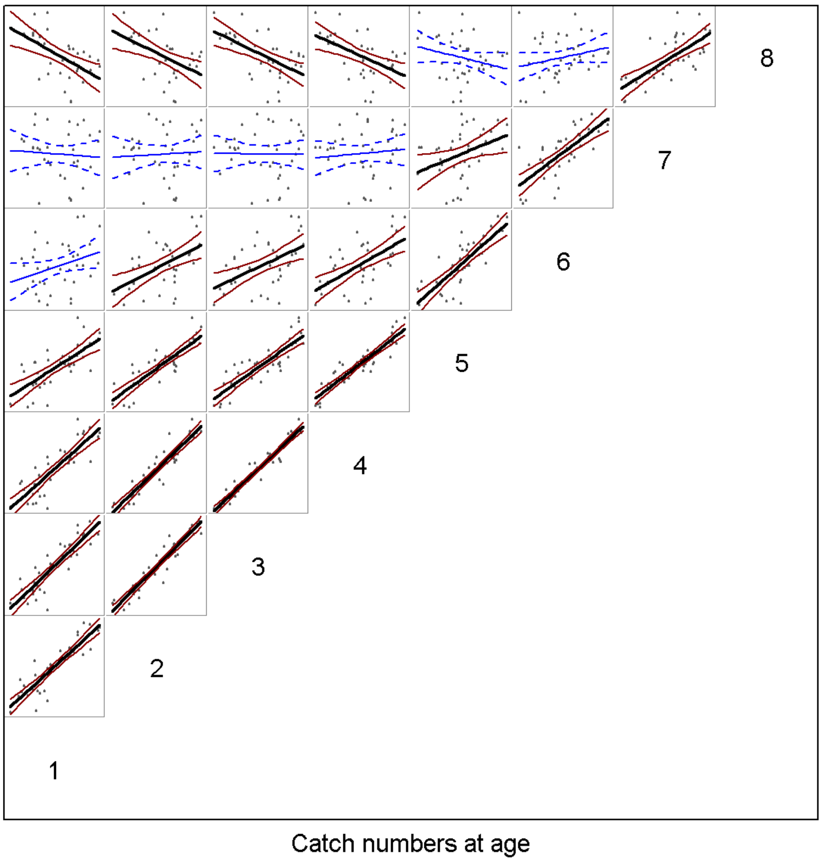


Figure 23.21. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black 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.

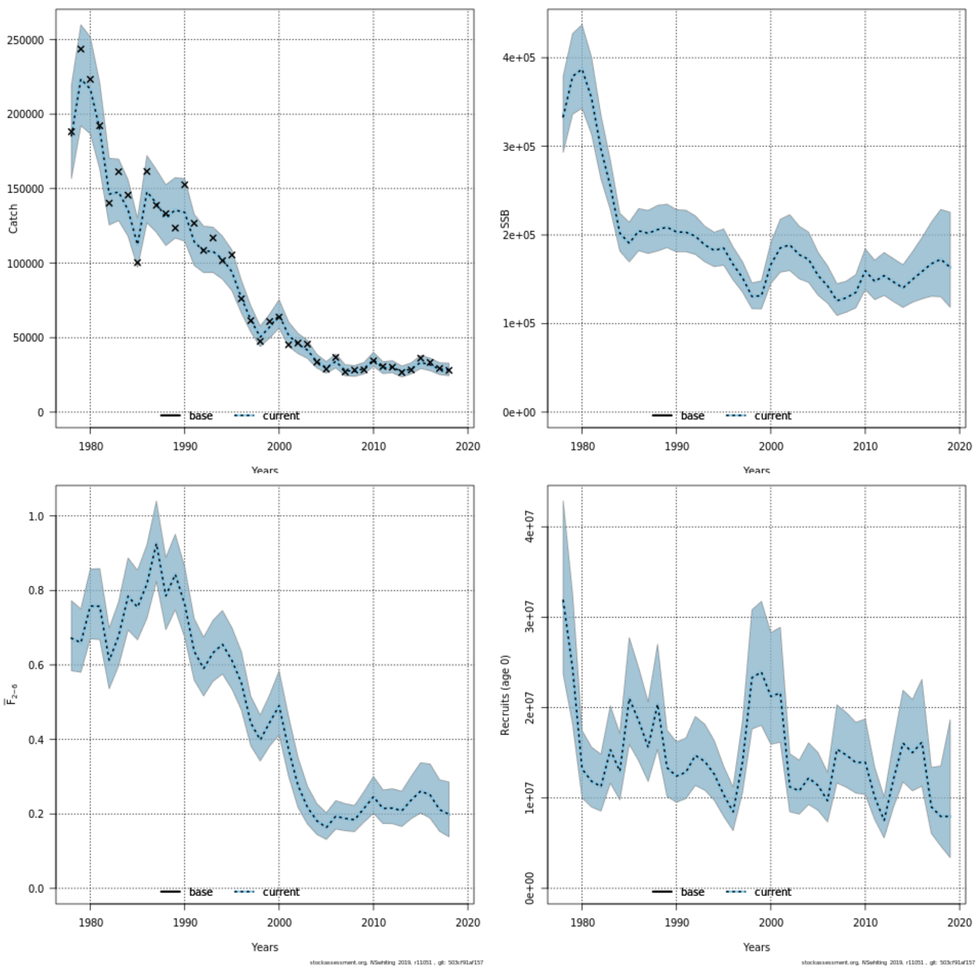


Figure 23.22. Whiting in Subarea 4 and Division 7.d: SAM assessment results using catch data series (1978–2017) with IBTS survey data starting in 1983 (Q1) and 1991 (Q3). Estimates with 95% Confidence intervals for total catch weight, SSB, mean fishing mortality and recruitment (at age 0).

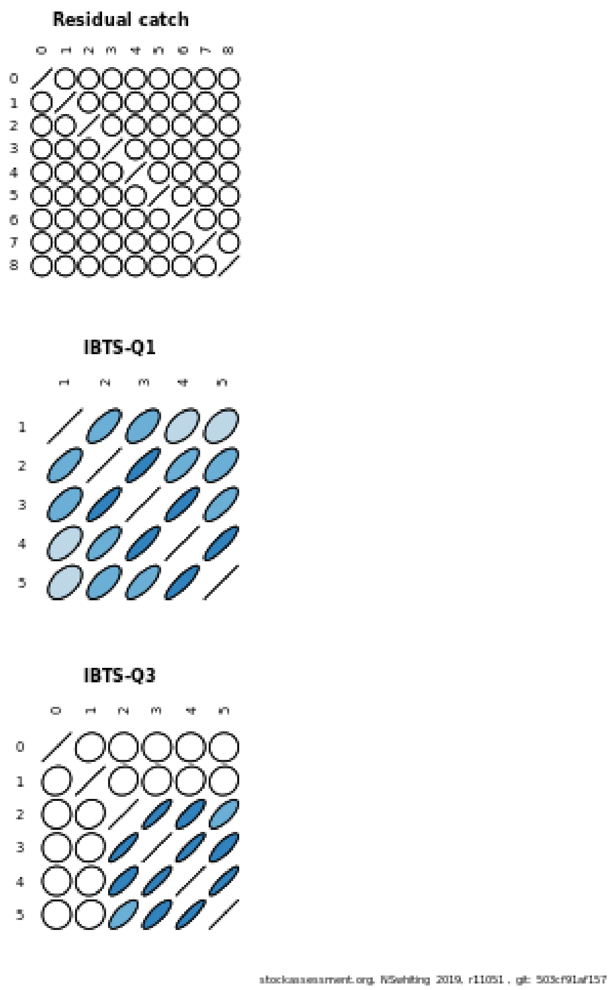


Figure 23.23. Whiting in Subarea 4 and Division 7.d: SAM estimated correlations between age groups for each fleet.

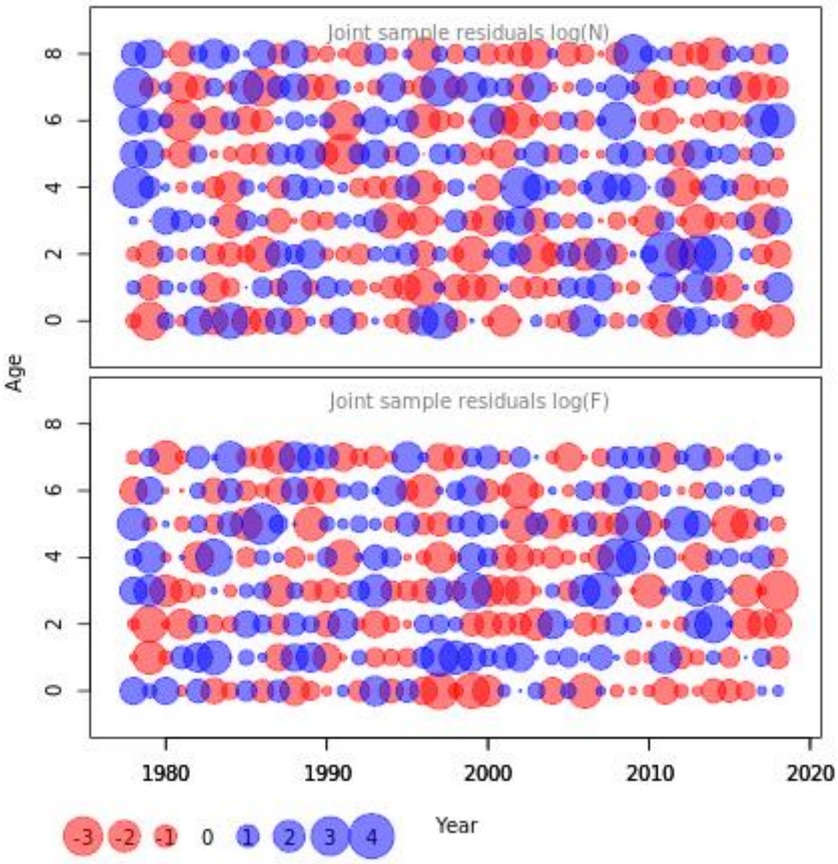


Figure 23.24. Whiting in Subarea 4 and Division 7.d: SAM standardised joint-sample residuals of process increments (for stock size N and fishing mortality F processes).

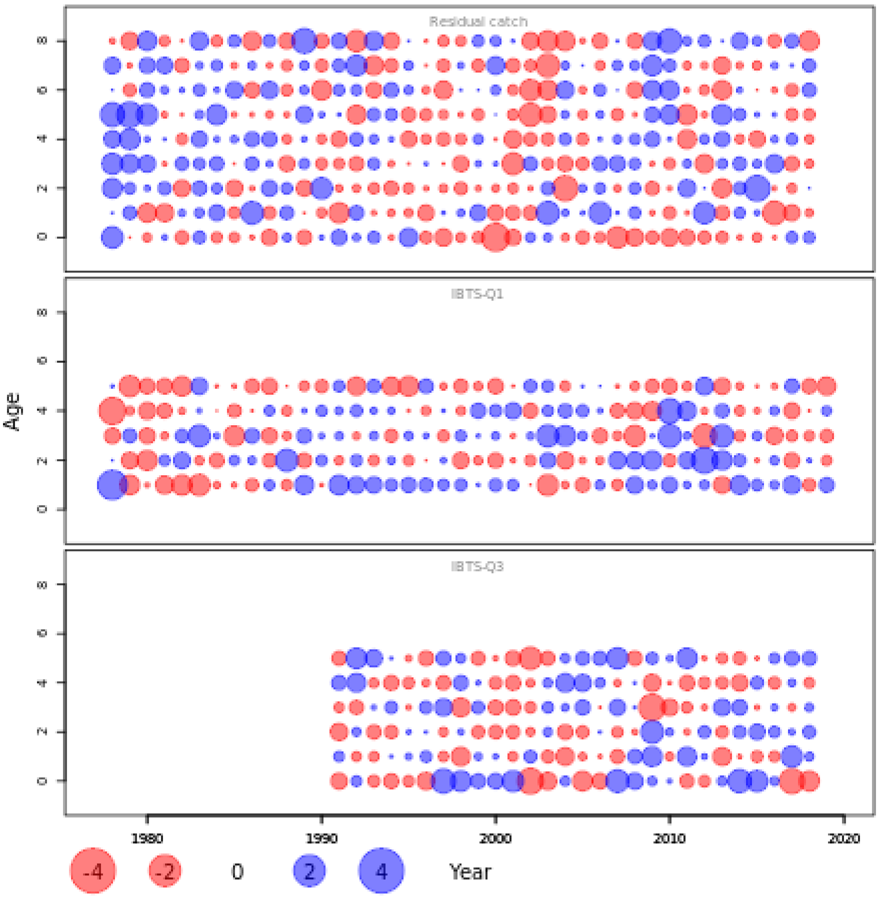


Figure 23.25. Whiting in Subarea 4 and Division 7.d: SAM standardized one-observation-ahead residuals.

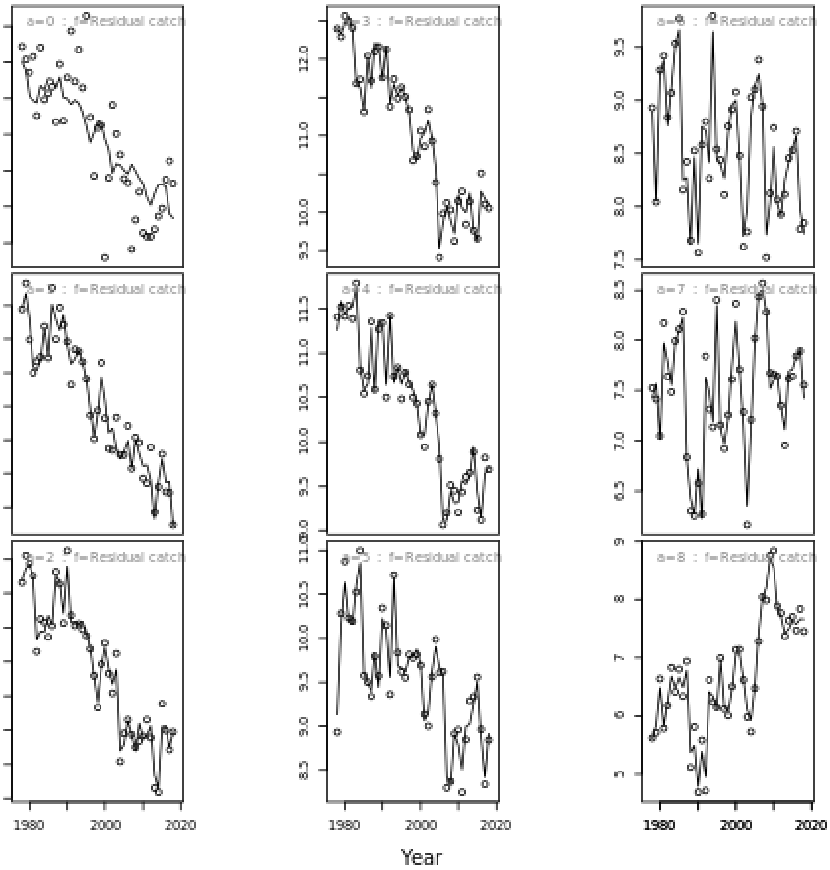


Figure 23.26. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale) for the catch fleet.

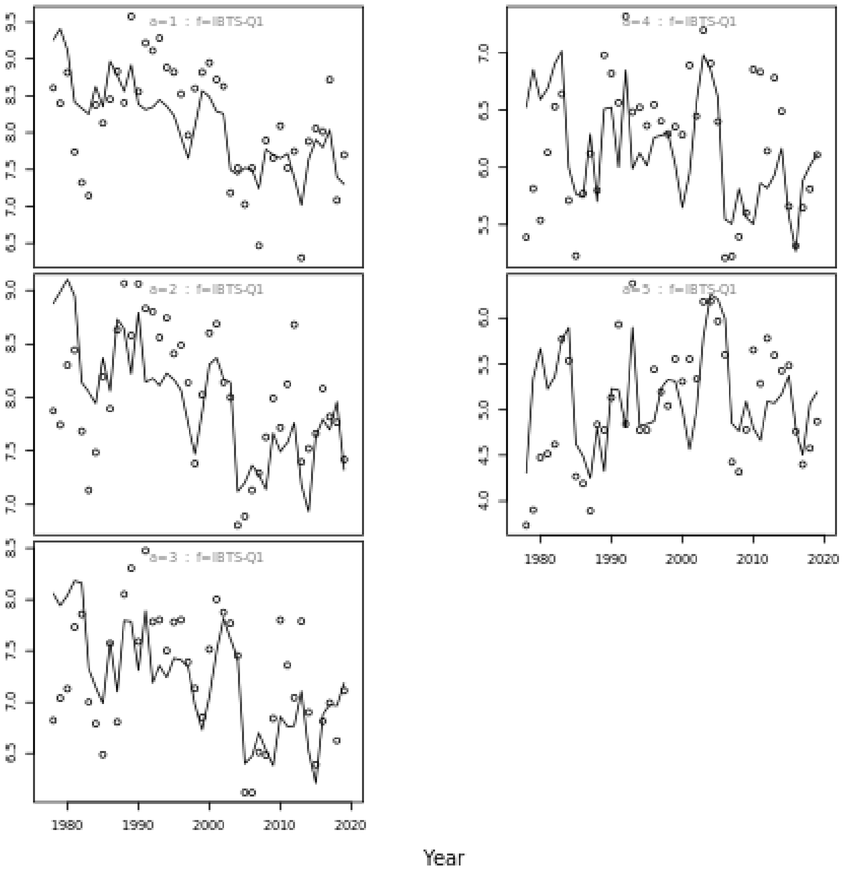


Figure 23.27. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q1.

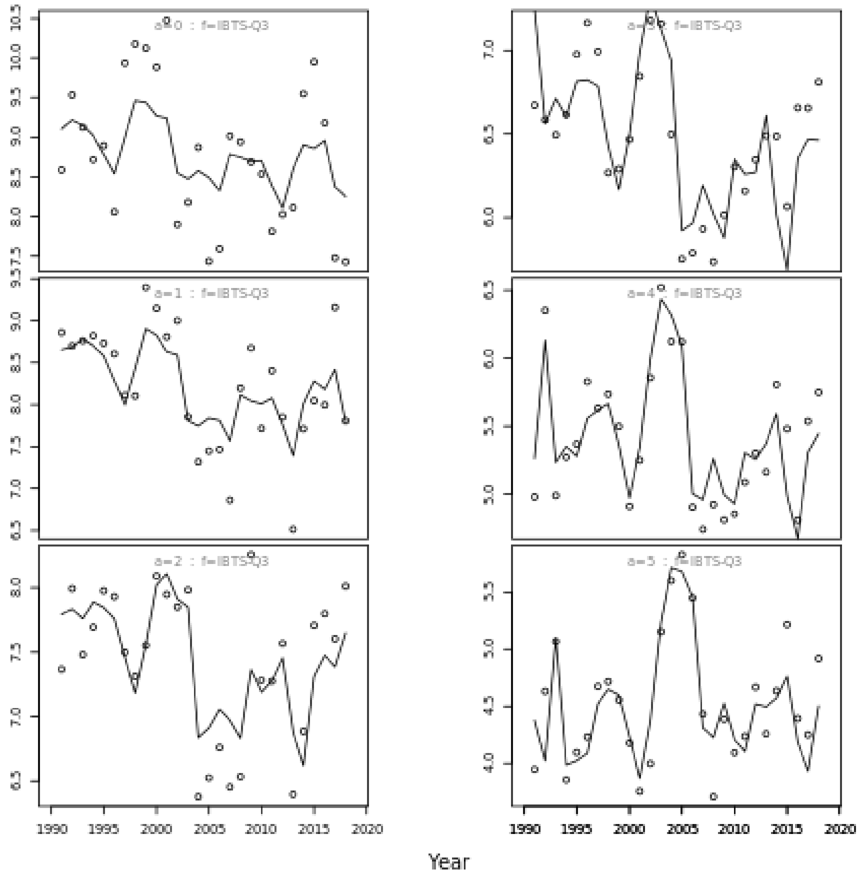


Figure 23.28. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q3.

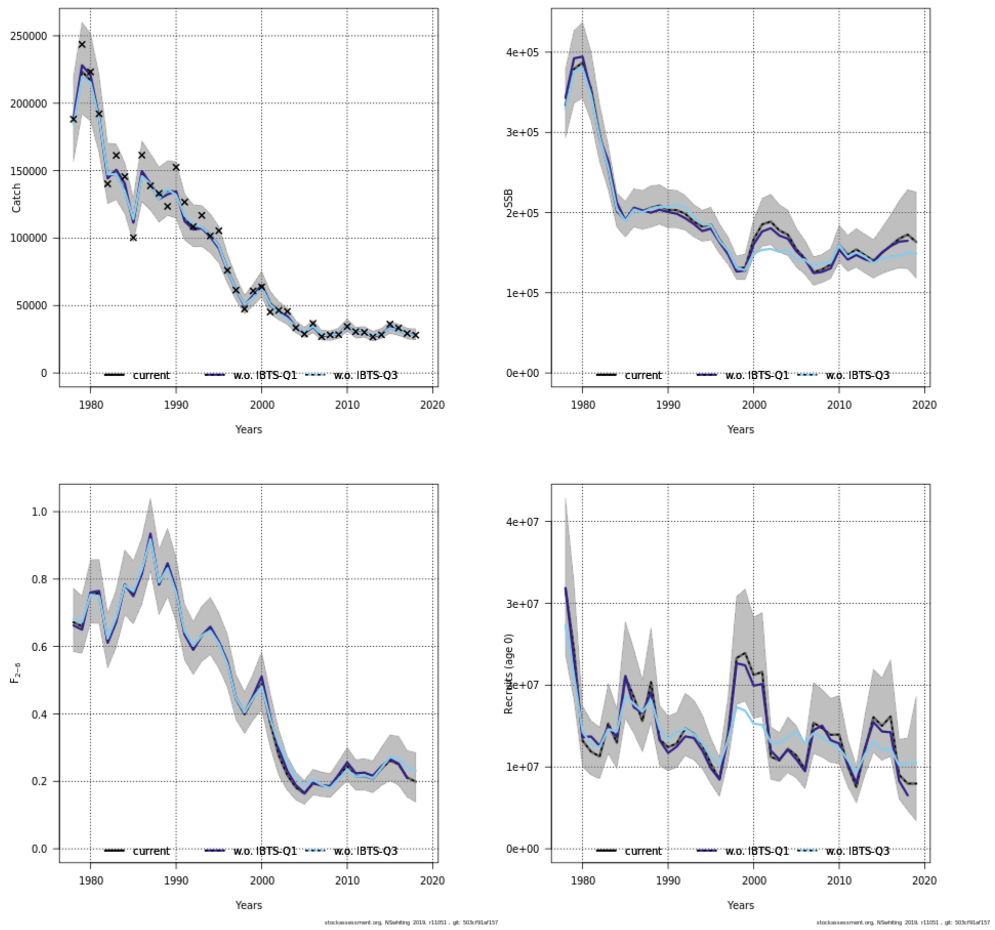


Figure 23.29. Whiting in Subarea 4 and Division 7.d: SAM leave-one-out diagnostics. Final run (black), run without IBTS Q1 (dark blue), run without IBTS Q3 (light blue).

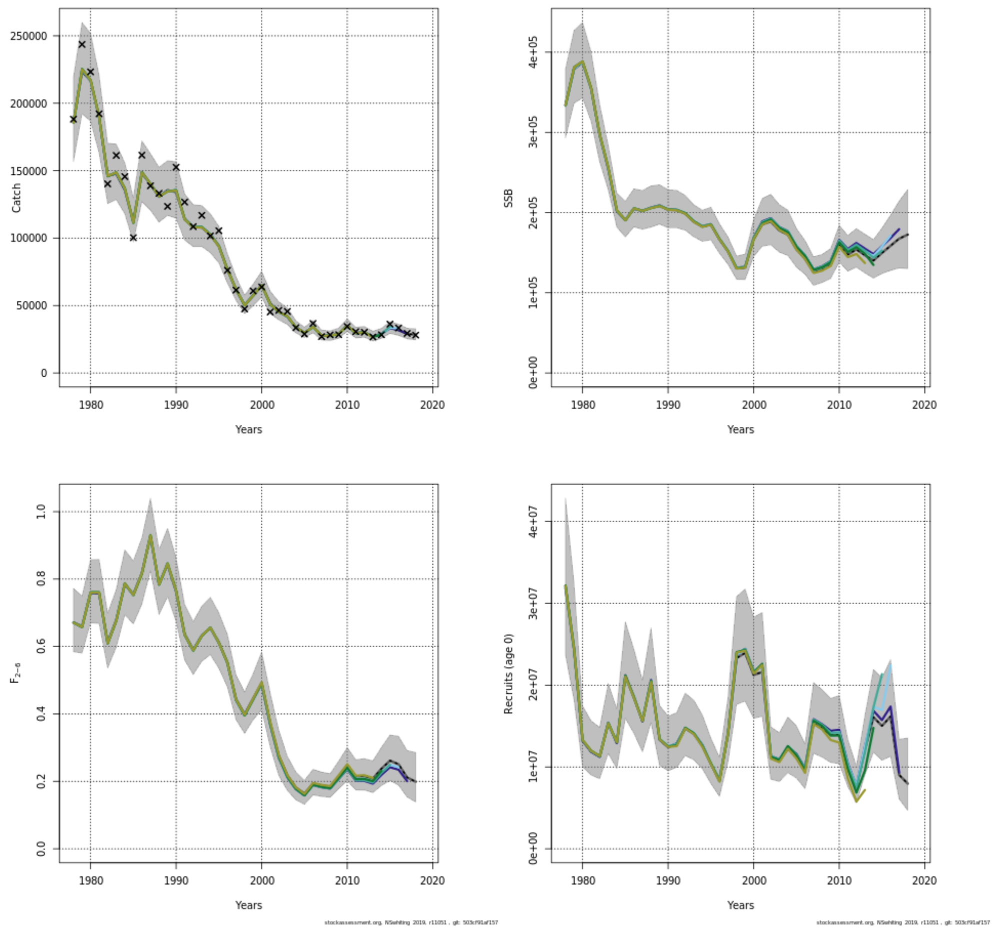


Figure 23.30. Whiting in Subarea 4 and Division 7.d: SAM Retrospective pattern in catch estimates, SSB, fishing mortality and recruitment.

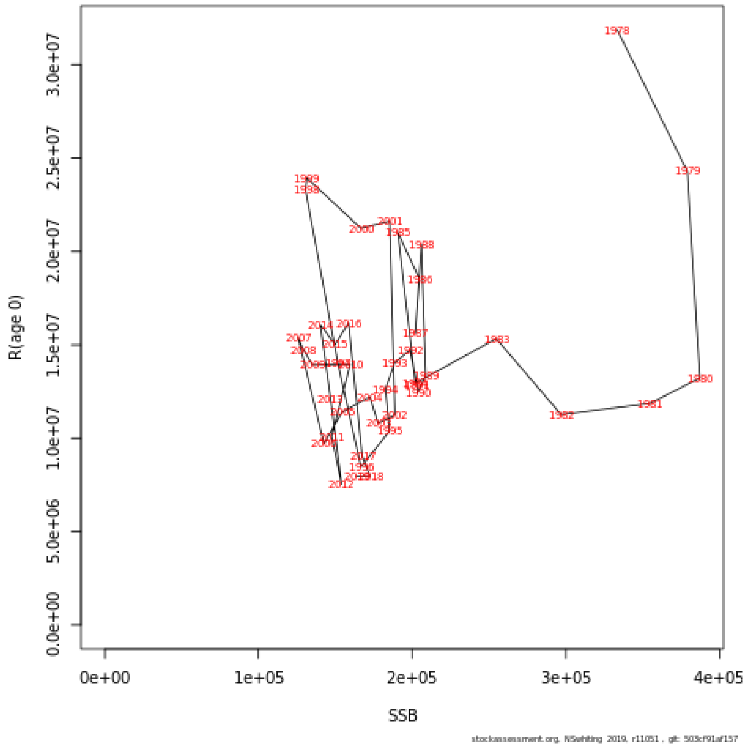


Figure 23.31. Whiting in Subarea 4 and Division 7.d: Stock-recruitment relationship.

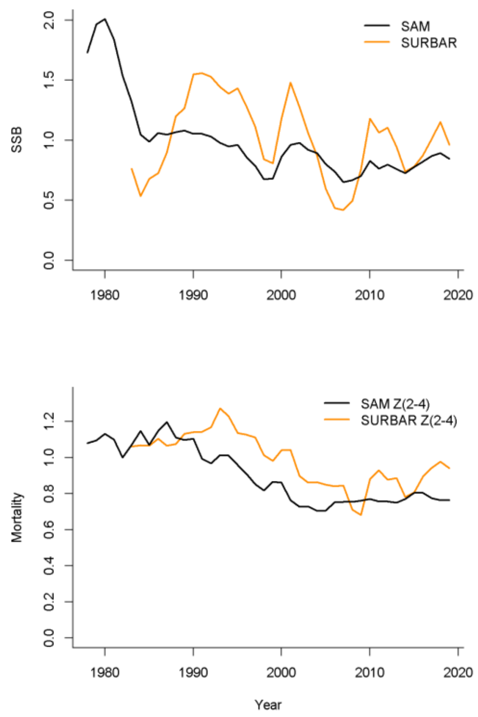


Figure 23.32. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final SAM (black) and SURBAR (orange) models. To facilitate comparison, recruitment and SSB values have been mean-standardised using the year range for which estimates are available from all three models. Mortality is presented as total mortality Z(2-4) for SAM and for SURBAR.

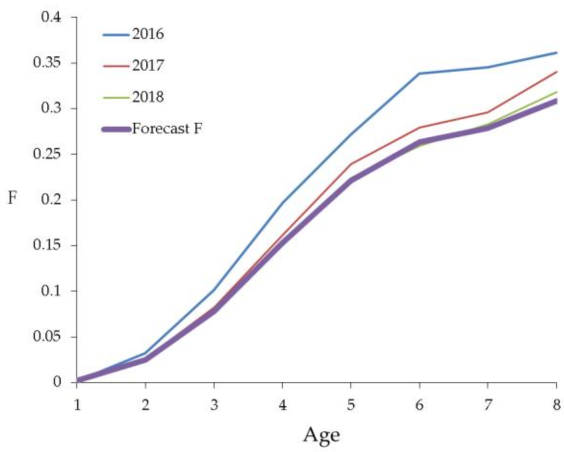


Figure 23.33. Whiting in Subarea 4 and Division 7.d: SAM F at age estimates for 2015–2017, along with scaled mean exploitation used for the forecast.

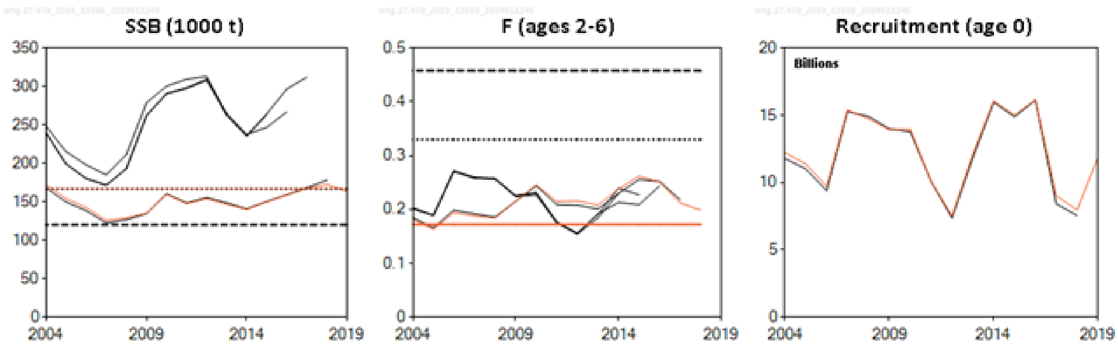


Figure 23.34. Whiting in Subarea 4 and Division 7.d: Historical assessments from Standard graphs.

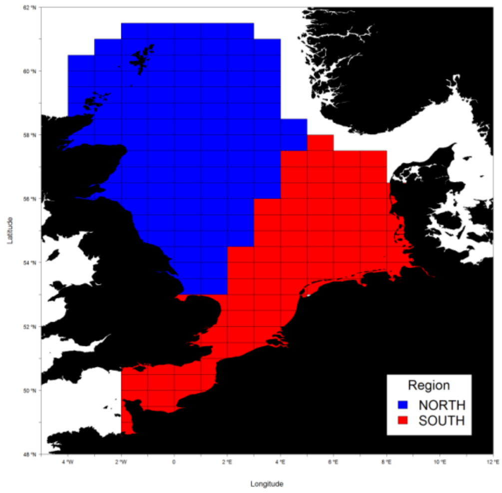


Figure 23.35. Whiting in Subarea 4 and Division 7.d: Components suggested by Holmes *et al*. (2014) to analyse spatial differences in maturation and SURBAR analysis.

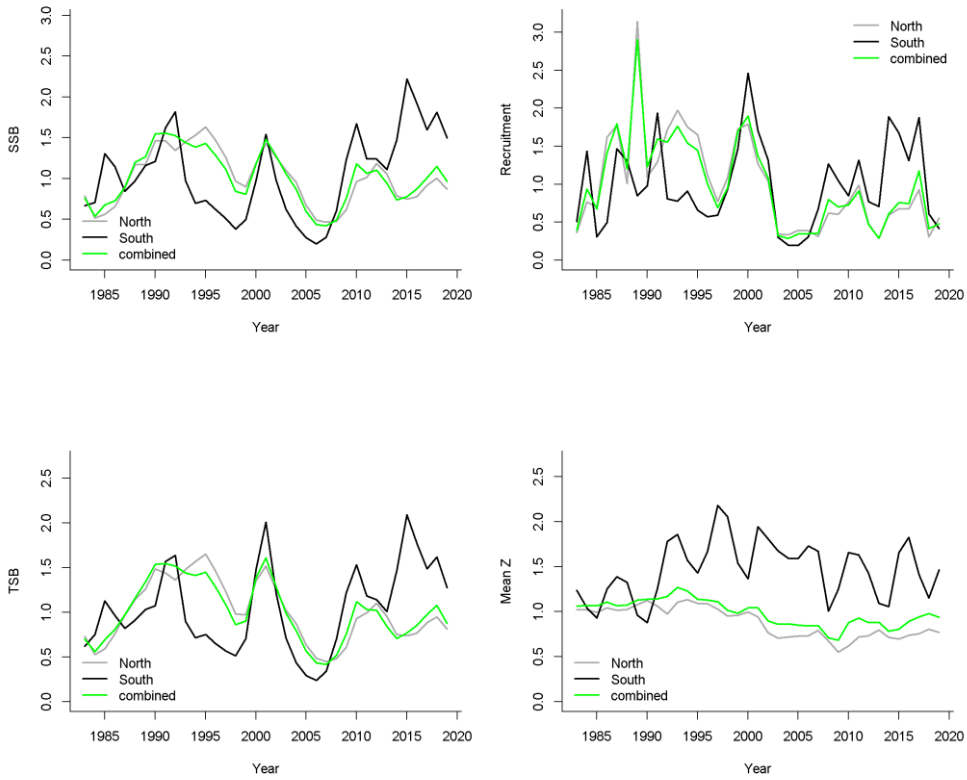


Figure 23.36. Whiting in Subarea 4 and Division 7.d: SURBAR results comparison combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018. Recruitment at age 1, total mortality is mean Z for ages 2–4.

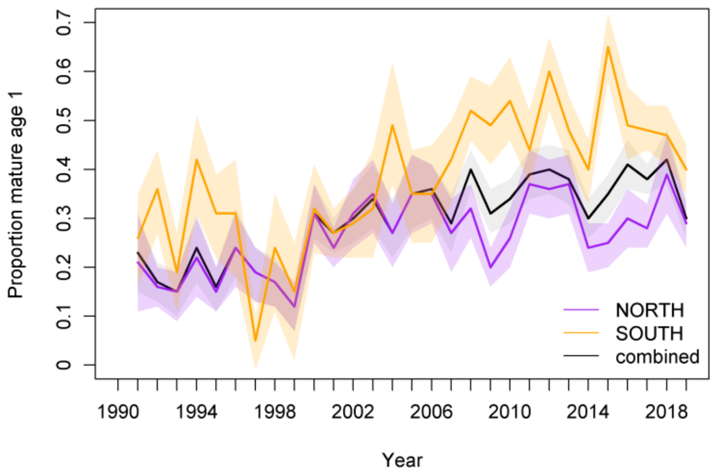


Figure 23.37. Whiting in Subarea 4 and Division 7.d: Trends in proportion mature individuals at age 1 for combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018.

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). The main task of WGNEW was to provide information on the new species of the MoU between ICES and the EC. 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 stock 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) suggested that fishing mortality was above potential F_{MSY} proxies. In 2015, witch flounder was included in 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 in order to provide 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. Following WKNSEA 2018 the stock became category 1. Hence a full analytical assessment was made at WGNSSK 2018 based on data up to 2017. However, being biennial, the advice was not re-opened in 2018. At WGNSSK 2019, the stock assessment was extended in order to include also 2018 data and a new advice was released. From 2019 onwards, the advice will be updated on an annual basis.

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 for 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 be planned at the next WGBIOP (Working Group on Biological parameters) 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 2.a and 4 together with lemon sole (*Microstomus kitt*). The TACs have been stable, varying around 6000 tonnes 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 mixed fisheries (although some limited seasonal target fisheries occurs in 3.a; see Feekings, 2011) thus a TAC alone may not be appropriate as a management tool. Hence, in 2018 it was advised that witch should be managed using a single-species TAC covering the stock distribution area (i.e. ICES Division 3.a, Subarea 4, and Division 7.d).

24.2 Data available

24.2.1 Historical landings

North Sea witch flounder landings have declined from a peak in the 1990s to a low at the end of 2000, but from 2011 a general increasing trend is observed (Figure 24.2.1.1). 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. In division 3.a, Denmark is landing the largest amount of witch flounder (Figure 24.1, upper plot), while in Subarea 4 it is Scotland having the largest portion of the landings (Figure 24.1, middle plot). 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 is mostly discarded (Figure 24.1 upper and middle plots). The landings of witch in Division 7.d reported by France and Belgium are negligible (Figure 24.1, lower plot).

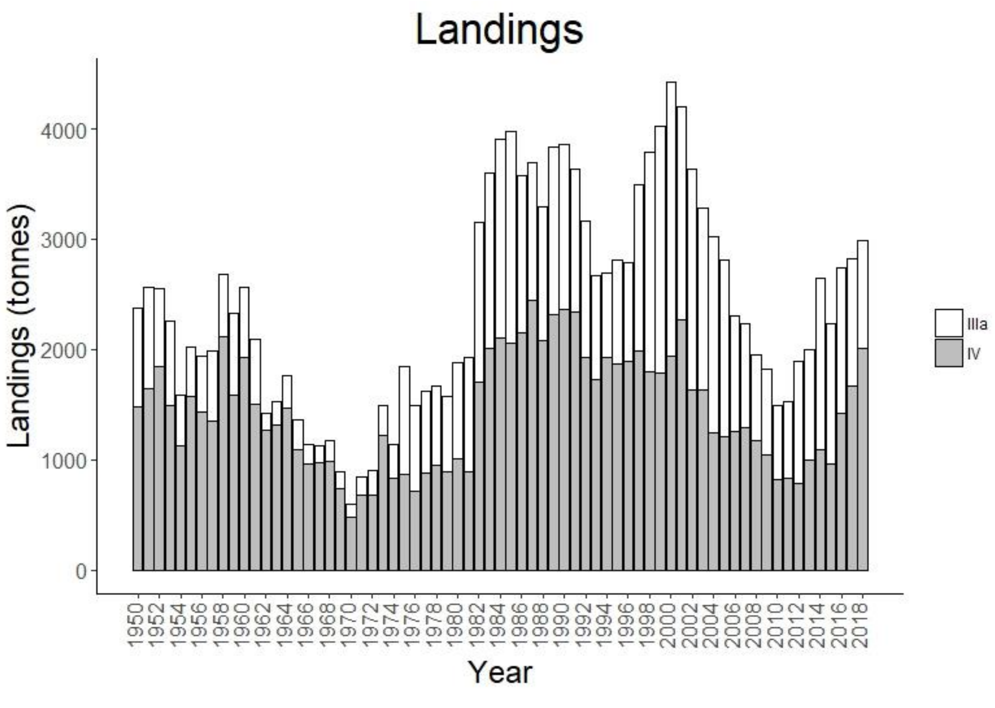


Figure 24.2.1.1. Witch flounder in Subarea 4 and Division 3.a: Total official landings (in tons).

24.2.2 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given in Table 24.1. Official landings data for each area separately are given in Table 24.2.

In preparation for the benchmark (WKNSEA, 2018) InterCatch was used for estimation of both landings and discards numbers, length composition (2002–2016) and age compositions (2009–2016). At WGNSSK 2018, landings, discards and total catch at age and mean weight at age were updated up to 2018.

The catch estimate for 2018 is 3209 tonnes, split as follows for the separate areas (tonnes):

Area	Landings	Discards	BMS landings*
3.a	980	36	1.4
4	1812	163	217
7.d	0.082	0.006	0
Total	2792	199	218

24.2.2.1 Age composition

Age compositions for landings and discards are provided yearly by Denmark, Scotland and Sweden (tables 24.3a and b).

Landings (including Norwegian BMS landings in 2018) in numbers at age for age groups 1–10+ for the period 2009–2018 are given in Table 24.4a. Discard numbers-at-age for age groups 0–10+ for the period 2009–2018 are shown in Table 24.4b. Total catch numbers-at-age for age groups 0–10+ for the period 2009–2018 are shown in Table 24.4c. These data form the basis for the catch at age analysis.

24.2.2.2 Intercatch

InterCatch, includes witch flounder data from 2002 and onwards, though biological data only from 2009. InterCatch was used for estimation of landings, discards and total catch at age and mean weight at age in 2018. Data co-ordinators from each nation uploaded input data into InterCatch, disaggregated to quarter and métier. Allocations of discard ratios and age compositions for unsampled strata were then performed in order to obtain the 2018 data required for the assessment.

The proportion of Landings with Discards associated (same strata) is 91 percent. In general, fleets using passive gears had no reported discards while fleets using selectivity devices (used only in Area 3.a) had always reported discards. The approach used for unmatched discard was to merge areas (3.aN, 4 and 7.d) and treat métiers separately, combined in two categories, i.e. fleets with and without selectivity devices (including passive and active gears). Then, within each of these two categories (ignoring country), where métiers had some samples these were pooled and allocated to unsampled records within that category. Quarters were merged for fleets with selectivity gears while kept separate for fleets without selectivity gear.

The landings and discards imported or raised for 2018 are as follows (Kg; note any differences in landings and discards values to those given above are due to SOP correction):

CatchCategory	RaisedOrImported	CATON	perc
BMS landing	Imported_Data	218359	100
Discards	Raised_Discards	8830	4
Discards	Imported_Data	190178	96
Landings	Imported_Data	2788058	100
Logbook Registered Discard	Imported_Data	0	NA

To allocate age compositions, landings and discards were handled separately; samples from landings were used only for landings and samples from discards were used only for discards. A similar approach to the discards raising, was used for allocating age compositions. Quarters were merged for fleets using selectivity gears while treated separately for fleets without selectivity gears.

The landings and discards imported or raised, with age distribution sampled or estimated for 2018 are as follows (Kg; note any differences in landings and discards values to those given above are due to SOP correction):

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	NA
Landings	Imported_Data	Sampled_Distribution	2574	91
Landings	Imported_Data	Estimated_Distribution	264.3	9
Discards	Imported_Data	Estimated_Distribution	154.6	78
Discards	Imported_Data	Sampled_Distribution	35.63	18
Discards	Raised_Discards	Estimated_Distribution	8.784	4
BMS landing	Imported_Data	Estimated_Distribution	225.1	100

For 2018, the largest amount of landings and discards in Subarea IV was reported by Scotland using respectively the métiers OTB_DEF_>=120_0_0_all and the OTB_CRU_70-99_0_0_all (figures 24.1 and 24.2 middle plots). In Division 3.a Denmark (landings) and Sweden (discards), both using the OTB_CRU_90-119_0_0_all métier, showed the highest amount (figures 24.1 and 24.2, upper plots). The total catch estimated with InterCatch in 2018 was 3209 tonnes, of which only 199 tonnes were discards and 218 were BMS (only Norway). The unwanted catches were thus 6% of the total catch.

Given the Norwegian regulation that has banned discards for many years, this nation has never provided discard estimates. However, in 2019 Norway has provided, for the first time, BMS landings for witch flounder, which were much higher than landings. For species presumed to be mainly captured for human consumption Norway has reported as BMS landings, that fraction which was landed for other purposes (meal and oil, fodder, bait etc.). For most species this is either consistent with what has been done in previous years or has little consequence and it is also consistent with the BMS definition used in the data call.

Concerning witch flounder, Norway has never been splitting BMS from regular landings, i.e. no BMS landings were submitted, before 2018. According to the Norwegian uploader, it was probably wrong to consider WIT as mainly captured for human consumption when generating the 2018 submission, and it is probably correct to compare “Landings” from 2017 to the sum of “BMS” and “Landings” for 2018. When the total fraction of BMS landings of WIT (under the definition used in 2018) was checked for some previous years, it seems the ratio of BMS to human consumption was not atypical in 2018. The change in the InterCatch submission thus seem to reflect a change in data compilation rather than a change in fisheries. Hence, after a discussion within the group and with the data uploader it was decided to consider Norwegian BMS landings as landings.

In general, the discard rate is moderately low except for 2002 (34%) where 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 6% in 2018. 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 (as estimated in InterCatch) showed a decline from 2002 to 2010, decreasing from 3800 to 1531 tonnes followed by an increase to over 3000 in 2018.

24.2.3 Weight at age

Mean weight at age data for landings (including Norwegian BMS landings in 2018), discards and catch, are given in tables 24.5a–c

The stock weights at age were estimated using IBTS quarter combined data from the period 2009–2017 and used constant for all years (Table 24.6)

24.2.4 Maturity and Natural mortality

Constant maturity ogives (Table 24.7), obtained using Swedish commercial samples 2009–2018 all quarters combined are used.

The assessment currently uses a constant natural mortality rate of 0.2 for all ages and years.

24.2.5 Survey data

During the benchmark in 2018, two survey for demersal fish species in the greater North Sea area were explored, in order to produce potential tuning indices useful for the witch 3a47d stock assessment model. Those surveys 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 4a, the Skagerrak (Division 3.aS) and Kattegat (Division 3.aS). The decision of the benchmark group was to include in the assessment total biomass indices for the first part and biomass indices by age for the last part of the time series. Total biomass indices (Table 24.1) were calculated for IBTS Q1 and combined BTS-IBTS Q3 using a delta-GAM approach (Q1: 1983–2008, Q3: 1991–2008). DATRAS-generated IBTS Q1 and Q3 indices by age, provided by the ICES DataCentre, were chosen due to their better internal and external consistencies.

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 24.2.5.1) 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 during the benchmark in 2018, but was not explored.

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.

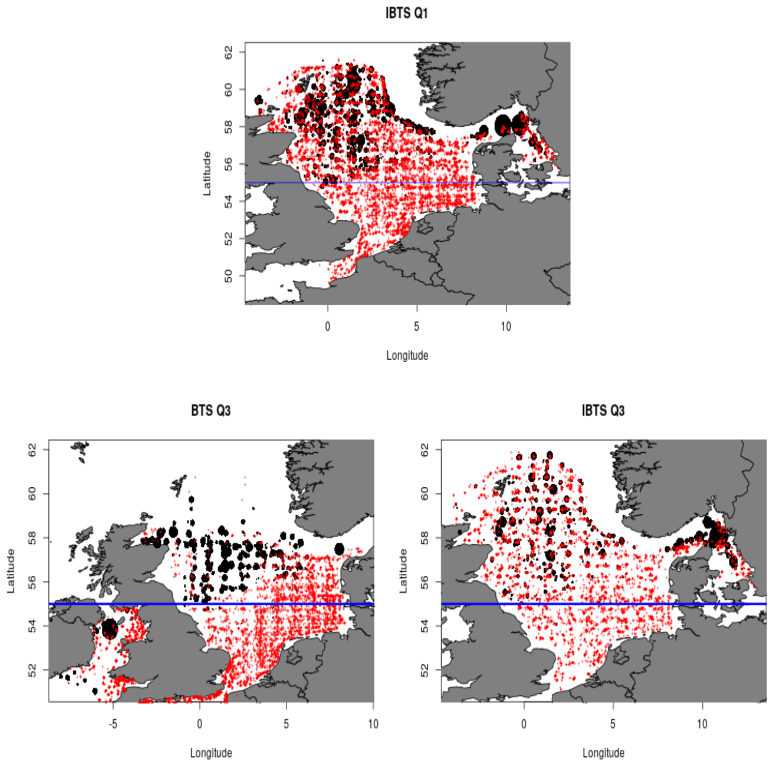


Figure 24.2.5.1. Witch flounder in Subarea 4 and Division 3.a: Aggregated distribution over the entire time series in the North Sea derived from IBTS–Q1 (upper) and Q3 (lower) using data collected between 1968 and 2018. The sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls. The area above the blue line was used to calculate the survey indices.

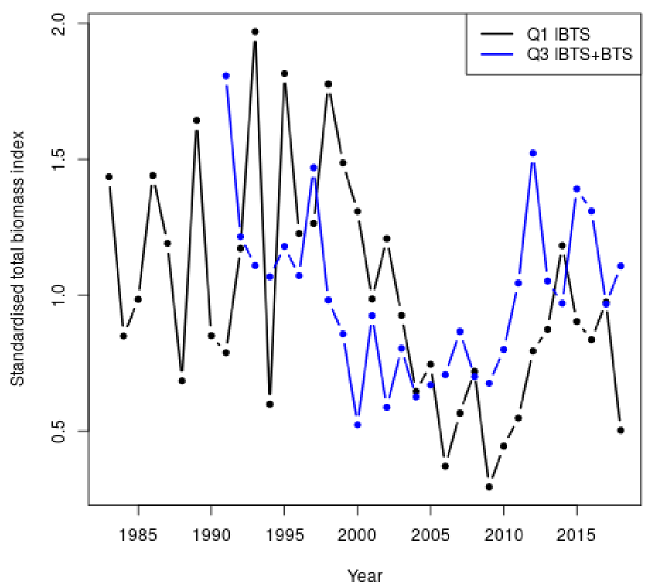


Figure 24.2.5.2. Witch flounder in Subarea 4 and Division 3.a: Q1 and Q3 indices of total biomass (rescaled to mean 1). The assessment includes only the time until 2008.

24.3 Data Analysis

The accepted assessment model during WKNSEA 2018 is 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 2019 including data up to 2018. The results are shown in figures 24.3.1–24.3.4

24.3.1 Assessment audit

24.3.2 Final assessment

The basic state-space assessment model (SAM) is described in Nielsen & Berg (2014). The current implementation (https://github.com/fishfollower/SAM) is an R-package based on Template Model Builder (TMB) (Kristensen *et al*., 2016). The data set used to assess witch uses catches at age and age-specific indices from two scientific surveys from 2009 to 2018. The complete age-specific data set only covers a relative short time period; therefore, the time series is extended using total landings (1950–2008) and fishable stock biomass (FSB) indices (IBTS Q1: 1983–2008, IBTS + BTSQ3: 1991–2008).

The added observation equation for the total landed weight (TLW) was:

$$\log TLW_y = \log\left(\sum_{a=1}^{10^+}\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right)\overline{\Psi}_{a,}\overline{W}_{a,}^{(l)}\right)+\varepsilon_y^{(tlw)},$$

where $\epsilon^{(tlw)}$ is normally distributed with mean zero and a standard deviation, which is computed via the delta method from the standard deviation parameters of the age-specific log-catches. No additional model parameters are required.

The observation equation for the fishable stock biomass (FSB) was:

$$logF\,SB_y = logQ^{(s)} + log\widehat{F\,SB}_y + \varepsilon_y{}^{(s)}$$

where $\boldsymbol{Q}^{(s)}$ is the survey specific catchability, $\boldsymbol{s}$ denotes the survey and $\boldsymbol{\epsilon}_{\boldsymbol{y}}^{(s)}$ is normally distributed with mean zero and a standard deviation specific to the survey.

The parameter estimation was done by maximizing the joint likelihood (of random effects and observations and inference was made using the marginal likelihood calculated by integrating out the random effects using the Laplace approximation.

In order to obtain convergence, artificial catch-at-age data were added in the beginning of the time series (1940–1944) and leaving a period of five years without data before the total landings series started in 1950. The artificial catches at age were chosen to be equal to the average of the observed period (2009–2016). Sensitivity analysis showed that there was no influence of the choice of the artificial catches during the assessment period (1950–2016).

In addition to the observations on catches and surveys a set of biological parameters are available, these include: Mean weight in stock, mean weight in catch, mean weight in landing, proportion mature, and an estimate of natural mortality. The stock weight at age is shown in Table 24.6 and the maturity ogive in Table 24.7. Both are assumed constant for the whole time series. Landing/discard/catch weight at age are shown in tables 24.5a–c. Natural mortality was assumed to be equal to 0.2 y^{-1} for all ages and years. The spawning stock biomass was calculated in the middle of the year, i.e. the proportion of F and M before spawning were set equal to 0.5.

During the WKNSEA 2018 benchmark an alternative SAM assessment was considered that only used the period where age information was available (2009–2016) termed as “standard”. The results of the “standard” assessment were consistent (but more optimistic) with the extended model during the period of the “standard” model.

The assessment estimates are shown in Figure 24.3.1 and summarized in Table 24.8 that shows the estimated recruitment, SSB, average F and total stock biomass. Estimated fishing mortality at age is shown in Table 24.9 and stock numbers at age in Table 24.10. The recruitment against the spawning-stock biomass is shown in Figure 24.3.2A. A yield per recruit analysis and estimated per-recruit reference points are shown in Figure 24.3.2B.

Standardized one-observation-ahead residuals are shown in Figure 24.3.3A for all input time series. Standardized process residuals for the two processes stock numbers per age and fishing mortality at age are shown in Figure 24.3.3B.

The assessment model, input data, results and diagnostics can be found on stockassessment.org with stock name wit.27.3a47d (Year 2019). The time series that were used as input and the configuration are shown below.

Catch at age	2009 – 2018	ages 1 – 10
Survey index IBTS Q1, by age	2009 – 2018	ages 1 – 7
Survey index IBTS Q3, by age	2009 – 2018	ages 1 – 6
Total landings	1950 – 2009	
Survey index IBTS Q1, FSB	1983 – 2008	
Survey index IBTS + BTS Q3, FSB	1991 – 2008	

Model Configuration:

```
$minAge
# The minimium age class in the assessment
 1

$maxAge
# The maximum age class in the assessment
 10

$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1

$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
   0   1   2   3   4   5   5   5   5   5
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2

$keyLogFpar
```

```
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered
by fishing mortality).
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
   0   1   2   3   4   5   5  -1  -1  -1
   6   7   8   9  10  10  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  11  -1  -1  -1  -1  -1  -1  -1  -1  -1
  12  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyQpow
# Density dependent catchability power parameters (if any).
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
   0   0   0   0   0   0   0   0   0   0
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
   0   0   0   0   0   0   0   0   0   0
   1   1   1   1   1   1   1  -1  -1  -1
   2   2   2   2   2   2  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
   3  -1  -1  -1  -1  -1  -1  -1  -1  -1
   4  -1  -1  -1  -1  -1  -1  -1  -1  -1

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). |
Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID" "ID" "ID" "ID"

$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  NA  NA  -1  -1  -1
  NA  NA  NA  NA  NA  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
```

```
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 0

$keyScaledYears
# A vector of the years where catch scaling is applied.


$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
# lowest and highest age included in Fbar
4 8

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1 4 2 2

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight,
1 fix variance to weight).
 0
```

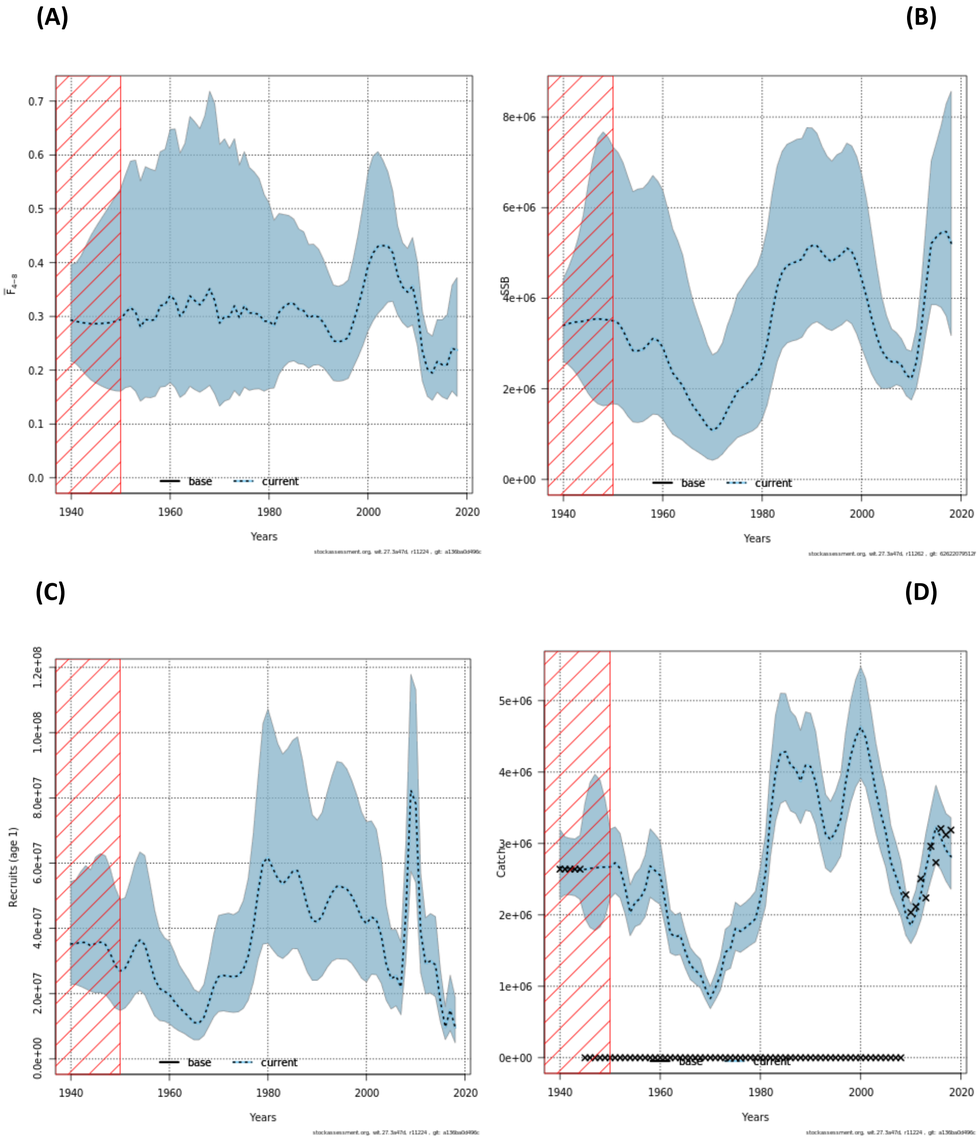


Figure 24.3.1. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model, fishing mortality (A), SSB (B), Recruits (C) and Catch (D). Median estimates (dashed lines) and point wise 95% confidence intervals (shaded area). The red line shaded area shaded is the period prior to the observations, used for initialization.

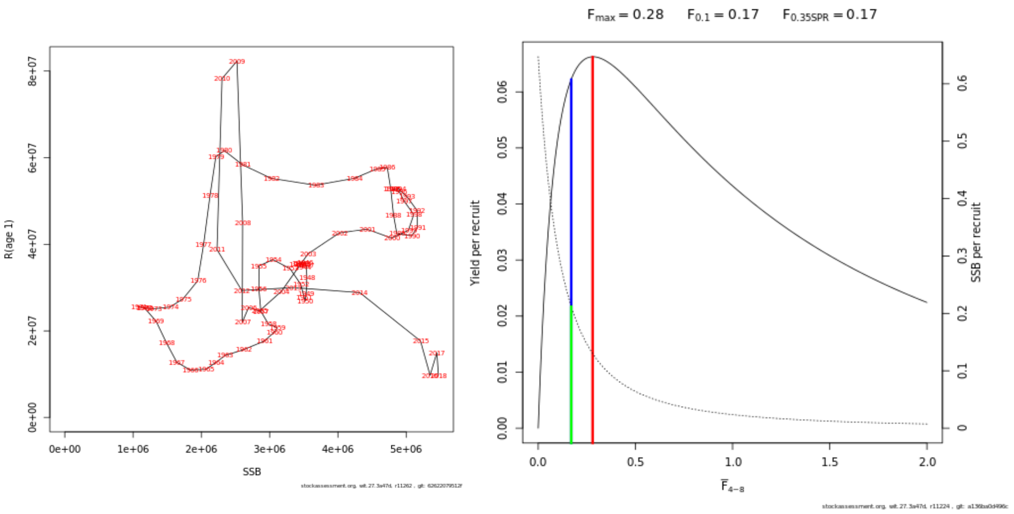


Figure 24.3.2. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Diagnostic, spawner-recruit (A) and Yield per recruit (B).

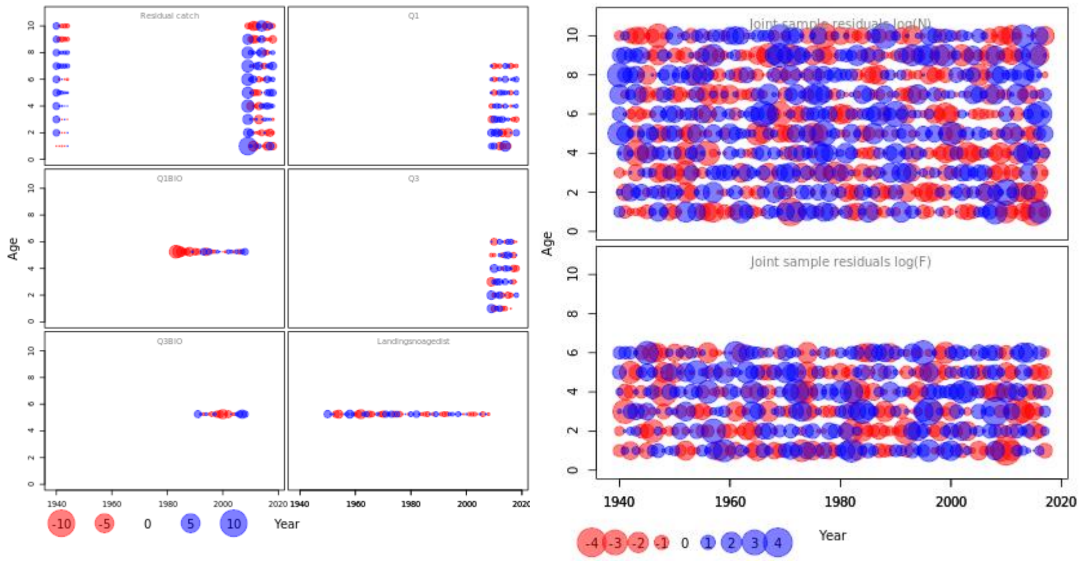


Figure 24.3.3. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Residuals plots, standardized one-observation-ahead residuals (left plot) and standardized single-joint-sample residuals of process increments (right plot).

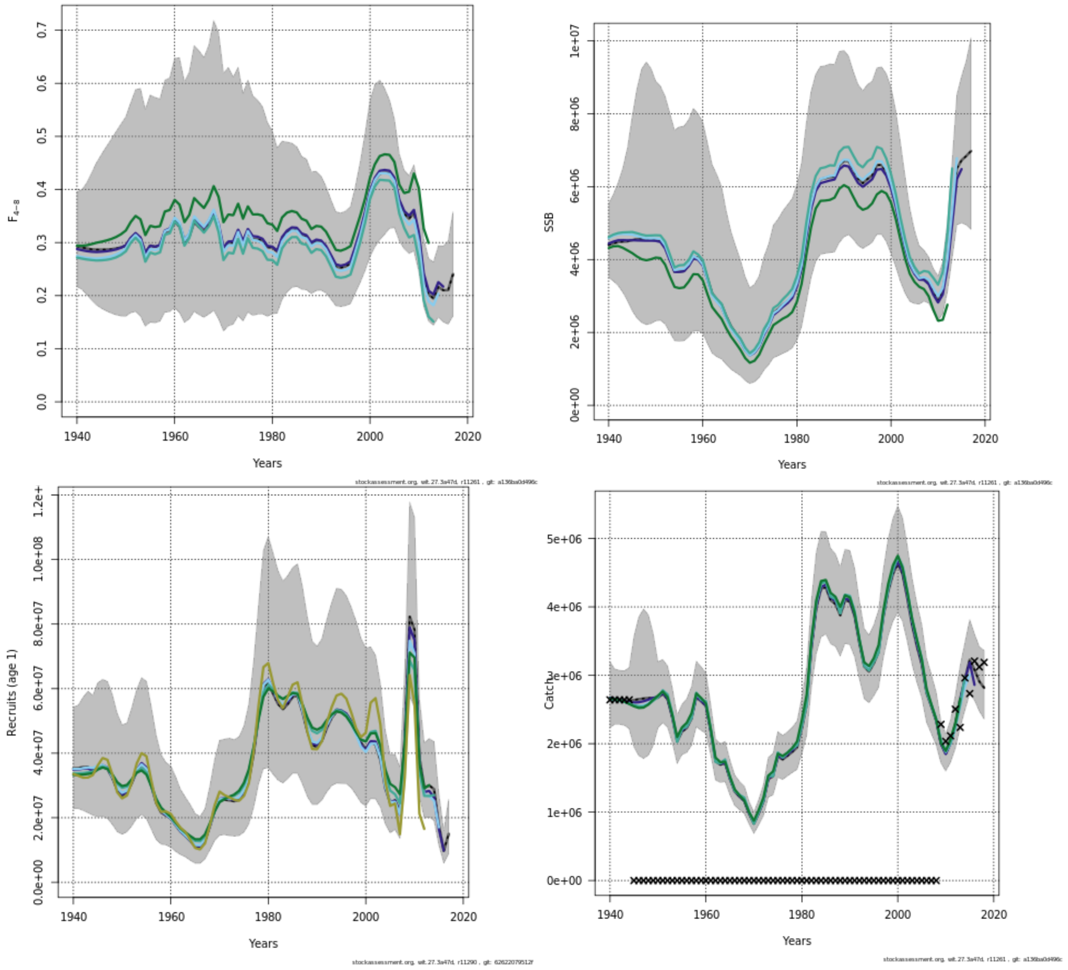


Figure 24.3.4. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Retrospective analysis, for fishing mortality (top left), spawning stock biomass (SSB, top right), recruits (bottom left) and catch (bottom right).

24.4 Biological 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 implemented in an R-script by D.C.M. Miller.

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.

The average mean weight at age and exploitation pattern from 2009–2016 was used. The total number of simulations was set to 1001.

Three stock-recruitment models (Ricker, Beverton-Holt and segmented regression) were applied to the time series (1940–2016) with Beverton-Holt weighted highest (0.92) of the three methods. The stock was categorised as Type 2: "Stocks with a wide dynamic range of SSB, and evidence that recruitment is or has been impaired". Furthermore, high autocorrelation was observed in the recruitment time series and was taken into account in the fitting of the segmented regression. B_{lim} was estimated as the change point of the segmented regression with autocorrelation equal to 3069 tonnes. B_{pa} was set equal to the 95th percentile of the distribution of the estimated SSB when SSB was set equal to B_{lim} (i.e. $B_{lim} * e^{-1.645\ sigmaSSB}$, where sigmaSSB is the standard deviation estimate of ln(SSB) in the final year of the assessment). Similarly, F_{pa} was calculated as the 95th percentile of the distribution of F, when F is equal to F_{lim} (i.e. $F_{lim} * e^{-1.645\ sigmaF}$, where sigmaF is the standard deviation estimate of ln(F) in the final year of the assessment).

The recommended default values of cvF = 0.212, phiF = 0.423 and cvSSB = 0 were applied to the simulation since no assessment/advice history is available for this stock. F_{MSY} was estimated equal to 0.154, which is below the originally-estimated F_{pa} (0.21) and the re-estimated F_{pa} (capped by $F_{P.05}$ without AR; 0.20).

MSY $B_{trigger}$ was set equal to B_{pa}, as it was not considered likely that the stock had been fished at F_{MSY} in the last 5 years.

The fishing mortality that leads to 5% probability of SSB falling below B_{lim} ($F_{P.05}$) was estimated during the benchmark meeting both including the ICES advice rule (AR), leading to 0.28 y^{-1}., and excluding the AR, leading to 0.20 y^{-1}. The former was greater than the originally estimated $F_{MSY\ upper}$, (0.21 y^{-1}) so was not used to cap $F_{MSY\ upper}$, but the latter was less than the originally-estimated F_{pa} (0.21 y^{-1}), and was therefore used to cap F_{pa}. All the reference points are shown in Table 24.4.1.

Table 24.4.1 Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Reference points estimated using EQSIM.

Reference Point	Estimate
MSY $B_{trigger}$	4745 tonnes
B_{lim}	3069 tonnes
B_{pa}	4745 tonnes
F_{MSY}	0.154 y^{-1}
$F_{MSY\ upper}$	0.21 y^{-1}
$F_{MSY\ lower}$	0.108 y^{-1}
F_{lim}	0.30 y^{-1}
F_{pa}*	0.20 y^{-1}
$F_{P0.5}$ (with AR)	0.28 y^{-1}
$F_{P0.5}$ (without AR)	0.20 y^{-1}

*** The original F_{PA} was 0.21, but this is greater than $F_{P.05}$ (without AR), and is therefore capped by the latter**

24.5 Short-term forecasts

Short-term forecasts were carried out based on the final SAM assessment. Recruitment in the intermediate year (2019) and the following two years was resampled from the recruitment estimates of the years 2010–2018; median was 28 852 thousand individuals (range: 9679–78 253 thousand individuals). The fishing mortality in 2019 is assumed to be equal to the last estimate ($F_{2018} = F_{2019} = 0.237\ y^{-1}$) and the corresponding catch was 2375 tonnes. The spawning stock biomass in the intermediate year was 4748 tonnes.

The weight at age in the forecast is assumed to be the average over the years 2016–2018. Natural mortality and maturity ogives were constant and equal to the ones used in the assessment. No TAC constraint is assumed for the intermediate year.

In total 11 forecast scenarios were run, and the summary of the results is shown in Table 24.11. The forecasted fishing morality, recruitment and catch of the two scenarios where the advice is based are shown in figures 24.5 (MSY) and 24.6 (PA).

24.6 Quality of the assessment

Age information is only available for the last 10 years of the assessment, i.e. 2009–2018, not allowing for an assessment based solely on age specific information. The estimates during the period prior to 2009 have higher uncertainty. The model is informed only by landings from 1950 to 1983, therefore, the results during that period should be considered with caution. Sensitivity tests during WKNSEA 2018 showed that there is minimal effect from the initialisation period (1940–1949) on the estimates during recent years, which are important for management of the stock. As the catch at age time series grows over the years, a pure age-based assessment should be considered as the final assessment. The catch in the intermediate year was a short term forecast using the

24.7 Status of the stock

Witch is being overfished; the fishing mortality in 2018 was equal to 0.237 y^{-1}, above F_{MSY} (0.154 y^{-1}) and above F_{PA} (0.20 y^{-1}). The biomass of the stock (5217 tonnes) was above the MSY $B_{trigger}$ (4745 tonnes) and the stock has full reproductive capacity, i.e. the biomass is above B_{lim} (3069 tonnes). The recruitment shows a decreasing trend since 2009 and catches have increased in the same period.

24.8 Management consideration

The decreasing recruitment in the last decade in connection with the increasing catches could potentially reduce the biomass of the stock below the biological reference point. The advice is based on the assumption that the recruitment will be in the range of the observed recruitment in the last decade, i.e. for each simulation the value of the recruitment is sampled randomly from the estimates of that period.

Witch and lemon sole are managed using a common TAC. Furthermore, the TAC area (Subarea 4 and Division 2.a) does not coincide with the stock area (Subarea 4 and divisions 3.a and 7.d). This increases the risk of both stocks of being overexploited.

24.9 Issues for future benchmarks

Witch was benchmarked in 2018, implementing a new assessment and raising from category to 3 to category 1. The available age time series will grow every year and a pure age based assessment could be basis for advice in the near future.

The choice of proportion of fishing mortality and natural mortality before spawning (F_{prop} and M_{prop}) to be equal to 0.5 should be evaluated for its biological reasoning.

The calculation of reference points is based on the whole time series (1940–2016), which includes the period before the data start (1940–1949) and the period where catch is the only available information (1950–1982). The adequacy of the assessment to estimate SSB and recruitment during that period should be evaluated.

24.10 References

Feekings, J. P. 2011. The impact of management regulations on fishers' behaviour: A case study using a satellite-based vessel monitoring system. MSc Thesis, Department of Marine Ecology, University of Gothenburg.

ICES.2013. Report of the Working Group on Assessment of New MoU Species (WGNEW), 18 -22 March 2013, ICES HQ, Copenhagen, Denmark. ACOM

ICES. 2018a. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA 2018), 5–9 February 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:33. 634 pp.

Kristensen, K., Nielsen, A., Berg, C. W., Skaug, H. J., & Bell, B. (2016). TMB: Automatic differentiation and laplace approximation. Journal of Statistical Software, 70(5), 1-21.

24.11 Tables and Figures

Table 24.1. Witch flounder in Subarea 4 and Division 3.a. Landings, discards and catches are in tons. The IBTS indices indicate fishable stock biomass in kg/hour, time series from 2009 onwards is not included in the assessment.

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS–Q1 index	IBTS–Q3 index	Discard rate
1968	1174						
1969	891						
1970	597						
1971	843						
1972	908						
1973	1494						
1974	1138						
1975	1841						
1976	1496						
1977	1618						
1978	1664						
1979	1572						
1980	1883						
1981	1933						
1982	3155						
1983	3606				0.26		
1984	3903				0.16		
1985	3979				0.18		
1986	3579				0.26		
1987	3700				0.22		
1988	3290				0.13		
1989	3841				0.29		
1990	3862				0.15		
1991	3641				0.14	0.25	
1992	3164				0.21	0.17	
1993	2673				0.35	0.15	
1994	2696				0.11	0.15	
1995	2810				0.33	0.17	
1996	2790				0.22	0.15	
1997	3494				0.23	0.22	
1998	3786				0.32	0.14	
1999	4024				0.27	0.12	
2000	4422				0.23	0.07	
2001	4206				0.18	0.13	
2002	3640	3813	5341	1529	0.21	0.08	0.343
2003	3281	3308	3657	349	0.16	0.11	0.095

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS–Q1 index	IBTS–Q3 index	Discard rate
2004	3029	3059	3428	369	0.12	0.09	0.108
2005	2813	2960	3379	419	0.13	0.09	0.124
2006	2303	2335	2631	296	0.07	0.1	0.112
2007	2236	2271	2470	199	0.1	0.12	0.081
2008	1953	1999	2317	318	0.13	0.1	0,137
2009	1818	1863	2319	455	0.051	0.09	0.196
2010	1490	1531	2090	559	0.077	0.11	0.268
2011	1530	1567	2114	547	0.094	0.14	0.259
2012	1895	1952	2507	555	0.137	0.21	0.222
2013	1993	2013	2267	254	0.151	0.14	0.112
2014	2646	2685	2992	307	0.2	0.13	0.103
2015	2359	2240	2690	449	0.156	0.19	0.167
2016	2658	2744	3135	390	0.144	0.18	0.125
2017	2855	2850	3086	236	0.168	0.13	0.076
2018	3001	3010**	3209	199	0.087	0.15	0.062

** including BMS Landings

Table 24.2. Witch flounder in Subarea 4 and Division 3.a : Official landings by Subarea 4 and Division 3.a. Landings in 2018 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

Year	3.a	4	Tot
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
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

Year	3.a	4	Tot
2010	675	815	1490
2011	693	837	1530
2012	1107	788	1895
2013	1000	993	1993
2014	1562	1085	2647
2015	1282	956	2238
2016	1317	1421	2738
2017	1190	1665	2855
2018	977	2024	3001

Table 24.3a. Witch flounder in Subarea 4 and Division 3.a and 7.d: Number of age measurements and samples by country per year (total for all fleets combined) for the landings.

	Number age measurements			Number age samples		
Year	Denmark	Sweden	UK(Scotland)	Denmark	Sweden	UK(Scotland)
2009	397	1224	160	2	5	6
2010	361	511	42	7	5	3
2011	576	661	0	4	4	0
2012	414	983	0	3	7	0
2013	605	491	277	5	4	21
2014	389	821	328	10	11	25
2015	567	454	150	17	7	10
2016	416	622	78	11	8	6
2017	725	320	360	19	7	23
2018	764	747	587	21	12	40

Table 24.3b. Witch flounder in Subarea 4 and Division 3.a and 7.d: Number of age measurements and samples by country per year (total for all fleets combined) for the discards.

	Number age measurements		Number age samples	
Year	Denmark	Sweden	Denmark	Sweden
2009	93	766	11	44
2010	265	777	17	37
2011	320	665	13	27
2012	187	950	19	30
2013	225	443	30	22
2014	272	451	24	22
2015	269	405	21	27
2016	323	542	36	35
2017	207	182	24	22
2018	268	284	45	20

Table 24.4a. Witch flounder in Subarea 4 and Division 3.a and 7.d: Landings (including Norwegian BMS landings in 2018) in numbers at age.

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	839									
2	10729		31496						248	3367
3	112969	273844	1398875	991222	58506	61059	46054	63613	244573	86125
4	1081271	272981	2188120	3964836	2157165	1320562	512531	754688	1040054	457707
5	1593368	1633260	429360	1604170	3168979	3012454	1608485	1730609	871149	2368711
6	1109013	890444	1208600	344544	880463	2510642	2287488	2204858	1628023	1615155
7	1372338	710391	378356	864146	441809	717430	1358635	2117310	2029597	1884605
8	1086432	884118	415466	222506	494246	564144	406780	934550	1472114	1254427
9	402427	300687	187914	112876	156215	530939	178735	299868	687934	441354
10	246197	250464	133150	134888	299857	1038283	402182	194683	740442	603917
TOTALNUM	7015584	5216189	6371336	8239188	7657239	9755515	6800891	8300180	8714132	8715367
TONSLAND	1863	1531	1567	1952	2013	2685	2240	2744	2850	3010

Table 24.4b. Witch flounder in Subarea 4 and Division 3.a and 7.d: Discards in numbers at age.

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	227071.7		2159.001	140360.4	132800.6			222.457		15611.68
1	1879734	2243128.03	439853.1	434615.1	659598.4	473985.9	438687.8	131888.4	485269.1	133318.2
2	2331522	9205742.77	4168591	1866105	1306878	874654.7	1583896	592166	300715	594121.5
3	1193491	2840438.01	3461515	3741759	728787.7	970373.3	1232374	1074974	513023.7	259275.4
4	1451883	348422.078	622519.5	1001757	247707.8	723796.9	1382552	1372226	908959.2	528631.1
5	157355.8	142404.001	103539.6	191487	175525.4	590058.4	391487.3	584973.8	2303382	360541.1
6	21610.77	13848.792	39379.61	28739.26	46088.32	45568.87	122795	206738.8	8379.229	127157.2
7	55800.8		0	1458.389	11089.94	380.6	1437.88	82770.42	4843.69	15958.52
8	50257.92		1582.694	4106.657	2240.097	1503.704	535.007	1779.669	4843.69	2751.734
9	38569.9							3764.519		10326.65
10	3506							2628		
TOTALNUM	7183730	14793984	8836980	7270028	3177915	3680322	5153765	4053909	4529416	2032081
TONSLAND	455	559	547	555	254	307	449	390	236	199

Table 24.4c. Witch flounder in Subarea 4 and Division 3.a and 7.d: Catch in numbers at age.

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	227071.7		2159.001	140360.4	132800.6			222.457		15611.68
1	1880573	2243128	439853.1	434615.1	659598.4	473985.9	438687.8	131888.4	485269.1	133318.2
2	2342251	9205743	4200087	1866105	1306878	874654.7	1583896	592166	300962.8	597820.9
3	1306459	3114282	4860390	4732981	787294.1	1031433	1278428	1138587	757596.8	350855.6
4	2533154	621402.9	2810639	4966594	2404872	2044359	1895083	2126914	1949013	1014348
5	1750724	1775664	532899.4	1795657	3344504	3602513	1999973	2315582	3174531	2886430
6	1130623	904292.7	1247980	373283.4	926551.2	2556211	2410283	2411597	1636402	1883862
7	1428139	710391.5	378355.6	865604.1	452898.8	717811.1	1360073	2200081	2034440	2056046
8	1136690	884118.4	417048.4	226612.9	496486	565648	407315.1	936329.5	1476957	1353651
9	440996.7	300686.8	187914.3	112875.7	156214.6	530939.1	178735.2	303632.7	687933.7	488023.8
10	249704	250464	133150	134888	299857	1038283	402182	197312	740442	652598
TOTALNUM	14199315	20010173	15208317	15509216	10835155	13435837	11954655	12354090	13243548	11416954
TONSLAND	2319	2090	2114	2507	2267	2992	2690	3135	3086	3209

Table 24.5a. Witch flounder in Subarea 4 and Division 3.a and 7.d: Landings (including Norwegian BMS landings in 2018) weights at age (kg).

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.122	0.000	0.091	0.000	0.000	0.000	0.000	0.000	0.026	0.122
3	0.149	0.149	0.161	0.167	0.142	0.140	0.161	0.138	0.188	0.146
4	0.160	0.163	0.189	0.197	0.197	0.194	0.223	0.240	0.199	0.185
5	0.203	0.226	0.232	0.253	0.239	0.225	0.267	0.262	0.252	0.252
6	0.261	0.321	0.295	0.293	0.290	0.300	0.331	0.326	0.327	0.309
7	0.291	0.354	0.391	0.338	0.320	0.312	0.392	0.395	0.362	0.353
8	0.344	0.304	0.398	0.408	0.399	0.351	0.415	0.420	0.392	0.414
9	0.345	0.341	0.467	0.466	0.445	0.331	0.472	0.407	0.373	0.396
10	0.466	0.446	0.521	0.462	0.438	0.347	0.470	0.540	0.424	0.473

Table 24.5b. Witch flounder in Subarea 4 and Division 3.a and 7.d: Discards weights at age (kg).

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0										0.005
1	0.012	0.014	0.013	0.012	0.031	0.011	0.010	0.012	0.010	0.016
2	0.035	0.032	0.048	0.036	0.077	0.032	0.028	0.033	0.024	0.038
3	0.094	0.064	0.075	0.094	0.096	0.090	0.081	0.072	0.078	0.085
4	0.118	0.095	0.105	0.102	0.114	0.127	0.130	0.113	0.125	0.129
5	0.129	0.123	0.106	0.122	0.146	0.148	0.231	0.143	0.028	0.150
6	0.185	0.113	0.139	0.140	0.154	0.162	0.246	0.189	0.153	0.185
7	0.219	0.000	0.000	0.155	0.143	0.418	0.298	0.158	0.188	0.253
8	0.314	0.000	0.146	0.116	0.180	0.202	0.358	0.152	0.360	0.221
9	0.277	0	0	0	0	0	0	0.163	0	0.178
10	0.462	0	0	0	0	0	0	0.135	0	0.000

Table 24.5c. Witch flounder in Subarea 4 and Division 3.a and 7.d: Catch weights at age (kg).

AGE/YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0.007	0.000	0.004	0.008	0.008	0.000	0.000	0.015	0.000	0.005
1	0.012	0.014	0.013	0.012	0.031	0.011	0.010	0.012	0.010	0.016
2	0.035	0.032	0.048	0.036	0.077	0.032	0.028	0.033	0.024	0.039
3	0.099	0.071	0.100	0.109	0.099	0.093	0.084	0.076	0.114	0.101
4	0.136	0.125	0.170	0.178	0.188	0.170	0.155	0.158	0.164	0.156
5	0.197	0.218	0.208	0.239	0.234	0.213	0.260	0.232	0.090	0.240
6	0.259	0.318	0.290	0.281	0.284	0.298	0.327	0.314	0.326	0.301
7	0.288	0.354	0.391	0.337	0.316	0.312	0.392	0.386	0.361	0.352
8	0.343	0.304	0.397	0.402	0.398	0.351	0.414	0.419	0.392	0.414
9	0.339	0.341	0.467	0.466	0.445	0.331	0.472	0.404	0.373	0.391
10	0.466	0.446	0.521	0.462	0.438	0.347	0.470	0.535	0.424	0.473

Table 24.6. Witch flounder in Subarea 4 and Division 3.a and 7.d: Stock weights at age (kg).

1	2	3	4	5	6	7	8	9	10
0.00547	0.03279	0.07720	0.15139	0.23394	0.33624	0.37684	0.42882	0.44348	0.49543

Table 24.7. Witch flounder in Subarea 4 and Division 3.a and 7.d: Constant maturity ogive.

1	2	3	4	5	6	7	8	9	10*	11*	12*
0	0	0.114	0.136	0.275	0.376	0.428	0.524	0.631	0.671	0.882	1

* The assessment uses age 10 as a plus group, therefore maturation of age 10 is the average of ages 10–12.

Table 24.8. Witch flounder in Subarea 4 and Division 3.a and 7.d: Summary of the assessment. Recruitment (R, number of individuals in thousands), spawning stock biomass (SSB, tonnes), fishing mortality (Fbar, mean of ages 4–8, y^{-1}), and total stock biomass (TSB, tonnes). Low and high refer to lower and upper 95% confidence bounds.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (4-8)	Low	High	TSB	Low	High
1950	26944	14871	48817	3504	1674	7335	0.294	0.161	0.537	13936	9299	20884
1951	27793	15646	49372	3456	1655	7217	0.307	0.168	0.564	13527	9037	20248
1952	30773	17465	54222	3297	1555	6994	0.316	0.17	0.588	12745	8383	19378
1953	34413	19798	59817	3049	1395	6665	0.309	0.161	0.59	11842	7628	18383
1954	36464	20971	63404	2843	1272	6352	0.28	0.142	0.551	11312	7215	17734
1955	35019	19682	62309	2842	1260	6411	0.295	0.15	0.578	11826	7623	18346
1956	29793	16341	54317	2871	1283	6426	0.292	0.149	0.574	12293	8027	18825
1957	24563	13227	45612	2981	1359	6541	0.294	0.152	0.571	12799	8485	19309
1958	21609	11797	39582	3114	1445	6709	0.32	0.169	0.606	13119	8773	19619
1959	20731	11578	37121	3070	1432	6581	0.322	0.17	0.611	12377	8227	18620
1960	19743	10808	36066	2919	1335	6382	0.339	0.177	0.647	11367	7450	17344
1961	17640	9517	32696	2622	1151	5969	0.33	0.168	0.648	9936	6389	15453
1962	15696	8564	28765	2352	1001	5526	0.3	0.15	0.603	8754	5587	13716
1963	14369	7836	26347	2216	931	5272	0.312	0.156	0.622	8249	5324	12781
1964	12766	6778	24044	2070	865	4955	0.338	0.17	0.671	7731	5014	11921
1965	11182	5873	21291	1839	766	4415	0.329	0.164	0.661	6844	4413	10615
1966	10978	5899	20428	1641	679	3963	0.321	0.159	0.649	6112	3925	9519
1967	12773	7162	22782	1490	613	3619	0.333	0.165	0.672	5584	3567	8740
1968	17221	9961	29773	1338	541	3312	0.351	0.172	0.718	5118	3209	8163
1969	22223	12933	38188	1170	461	2971	0.33	0.156	0.696	4730	2897	7724
1970	25286	14541	43970	1083	427	2750	0.288	0.134	0.62	4843	2975	7884
1971	25586	14757	44361	1150	469	2819	0.3	0.143	0.63	5714	3617	9028
1972	25417	14462	44670	1303	564	3013	0.299	0.146	0.612	6745	4369	10411
1973	25125	14283	44196	1544	700	3404	0.32	0.162	0.63	7898	5194	12010
1974	25542	14456	45131	1732	812	3695	0.297	0.152	0.581	8435	5588	12731
1975	27424	15524	48446	1947	929	4082	0.32	0.169	0.606	9161	6124	13704
1976	31600	18065	55277	2032	975	4235	0.306	0.163	0.577	9265	6212	13818
1977	39875	23181	68590	2127	1023	4420	0.306	0.165	0.568	9623	6490	14269
1978	51233	30481	86114	2212	1071	4565	0.303	0.166	0.556	10240	6970	15045
1979	60194	35236	102830	2337	1156	4723	0.291	0.161	0.527	11368	7884	16391
1980	61641	35446	107193	2600	1340	5045	0.291	0.166	0.51	13368	9561	18692

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (4-8)	Low	High	TSB	Low	High
1981	58389	33433	101975	3022	1652	5527	0.283	0.167	0.479	15827	11704	21402
1982	55230	31607	96509	3671	2135	6312	0.307	0.193	0.491	18817	14320	24728
1983	53634	30798	93401	4242	2602	6915	0.318	0.207	0.489	20595	15956	26583
1984	55235	32096	95055	4574	2891	7239	0.324	0.215	0.487	21096	16459	27038
1985	57446	33826	97559	4724	3016	7397	0.323	0.218	0.481	21013	16422	26888
1986	57725	33769	98674	4774	3058	7452	0.313	0.212	0.463	20727	16216	26493
1987	52809	30426	91660	4814	3086	7510	0.311	0.211	0.457	20727	16271	26402
1988	46776	26574	82338	4864	3143	7527	0.297	0.204	0.434	20713	16353	26237
1989	42465	24111	74791	5083	3327	7766	0.302	0.21	0.434	21301	16949	26769
1990	41986	24094	73164	5163	3436	7759	0.299	0.21	0.425	20938	16730	26205
1991	43865	25472	75541	5160	3485	7640	0.288	0.205	0.406	20174	16149	25203
1992	47786	28025	81480	5013	3416	7355	0.271	0.193	0.381	19099	15270	23889
1993	50974	29958	86734	4879	3333	7141	0.255	0.181	0.358	18462	14729	23142
1994	52920	30729	91137	4807	3289	7025	0.253	0.179	0.356	18471	14755	23123
1995	52717	30618	90767	4901	3354	7163	0.255	0.181	0.36	19254	15405	24063
1996	52098	30550	88844	4969	3418	7222	0.261	0.185	0.368	19931	16008	24815
1997	49996	29299	85312	5111	3519	7423	0.288	0.205	0.406	20881	16815	25930
1998	46864	27120	80980	5032	3440	7361	0.319	0.225	0.452	20845	16755	25933
1999	43244	24711	75677	4788	3215	7130	0.354	0.247	0.506	20153	16209	25058
2000	41436	23637	72639	4424	2908	6730	0.394	0.273	0.568	18991	15350	23496
2001	43501	25947	72932	4021	2621	6169	0.418	0.292	0.598	17527	14365	21386
2002	42636	25849	70324	3562	2332	5441	0.43	0.305	0.606	15880	13201	19104
2003	37802	23219	61543	3171	2134	4712	0.432	0.315	0.59	14552	12292	17228
2004	29129	18031	47057	2853	2010	4048	0.431	0.327	0.569	13555	11554	15902
2005	24642	15330	39611	2691	2005	3612	0.418	0.328	0.533	12787	10926	14964
2006	25433	16310	39658	2600	2031	3328	0.376	0.303	0.468	11842	10113	13866
2007	22011	13570	35702	2605	2094	3240	0.355	0.288	0.437	11259	9609	13193
2008	45048	30649	66212	2522	2048	3105	0.345	0.279	0.426	10517	8941	12370
2009	82315	57509	117821	2303	1846	2874	0.356	0.284	0.447	10400	8753	12355
2010	78253	54138	113109	2229	1756	2830	0.313	0.245	0.4	11740	9631	14311
2011	38770	26395	56948	2592	2020	3327	0.235	0.18	0.308	14854	11837	18639
2012	29349	19916	43249	3350	2584	4344	0.202	0.152	0.27	18056	14169	23008
2013	30023	20230	44556	4320	3273	5702	0.195	0.144	0.263	19271	15025	24717
2014	28852	19094	43596	5210	3859	7033	0.216	0.159	0.294	20301	15647	26338
2015	17677	11393	27426	5350	3858	7418	0.21	0.15	0.294	19554	14752	25920
2016	9761	5944	16029	5449	3799	7816	0.21	0.146	0.303	18859	13836	25704
2017	14992	8760	25658	5472	3612	8291	0.24	0.162	0.358	17609	12384	25037
2018	9679	4970	18848	5217	3177	8566	0.237	0.152	0.372	15402	10104	23478

Table 24.9. Witch flounder in Subarea 4 and Division 3.a and 7.d: Estimated fishing mortality at age. The assessment is using age information only for the years 2009–2018.

Year	1	2	3	4	5	6	7	8	9	10
1950	0	0	0	0.177	0.269	0	0.342	0.342	0.342	0.342
1951	0	0	0	0.185	0.281	0	0.357	0.357	0.357	0.357
1952	0	0	0	0.19	0.289	0	0.367	0.367	0.367	0.367
1953	0	0	0	0.185	0.282	0	0.358	0.358	0.358	0.358
1954	0	0	0	0.168	0.256	0	0.325	0.325	0.325	0.325
1955	0	0	0	0.177	0.27	0	0.342	0.342	0.342	0.342
1956	0	0	0	0.176	0.267	0	0.339	0.339	0.339	0.339
1957	0	0	0	0.177	0.269	0	0.342	0.342	0.342	0.342
1958	0	0	0	0.192	0.293	0	0.371	0.371	0.371	0.371
1959	0.028	0.093	0.115	0.194	0.295	0.374	0.374	0.374	0.374	0.374
1960	0.029	0.098	0.121	0.204	0.31	0.393	0.393	0.393	0.393	0.393
1961	0.028	0.095	0.118	0.198	0.302	0.383	0.383	0.383	0.383	0.383
1962	0.026	0.086	0.107	0.18	0.275	0.349	0.349	0.349	0.349	0.349
1963	0.027	0.09	0.111	0.187	0.285	0.362	0.362	0.362	0.362	0.362
1964	0.029	0.097	0.121	0.203	0.309	0.393	0.393	0.393	0.393	0.393
1965	0.028	0.095	0.118	0.198	0.301	0.382	0.382	0.382	0.382	0.382
1966	0.028	0.093	0.115	0.193	0.294	0.373	0.373	0.373	0.373	0.373
1967	0.029	0.096	0.119	0.2	0.305	0.387	0.387	0.387	0.387	0.387
1968	0.03	0.101	0.126	0.211	0.322	0.408	0.408	0.408	0.408	0.408
1969	0.028	0.095	0.118	0.198	0.302	0.383	0.383	0.383	0.383	0.383
1970	0.025	0.083	0.103	0.173	0.263	0.334	0.334	0.334	0.334	0.334
1971	0.026	0.086	0.107	0.18	0.274	0.348	0.348	0.348	0.348	0.348
1972	0.026	0.086	0.107	0.18	0.274	0.347	0.347	0.347	0.347	0.347
1973	0.027	0.092	0.114	0.192	0.293	0.371	0.371	0.371	0.371	0.371
1974	0.026	0.086	0.106	0.179	0.272	0.345	0.345	0.345	0.345	0.345
1975	0.027	0.092	0.114	0.192	0.293	0.371	0.371	0.371	0.371	0.371
1976	0.026	0.088	0.11	0.184	0.28	0.356	0.356	0.356	0.356	0.356
1977	0.026	0.088	0.109	0.184	0.28	0.356	0.356	0.356	0.356	0.356
1978	0.026	0.087	0.108	0.182	0.278	0.352	0.352	0.352	0.352	0.352
1979	0.025	0.084	0.104	0.175	0.267	0.338	0.338	0.338	0.338	0.338
1980	0.025	0.084	0.104	0.175	0.266	0.338	0.338	0.338	0.338	0.338
1981	0.024	0.081	0.101	0.17	0.259	0.328	0.328	0.328	0.328	0.328
1982	0.026	0.089	0.11	0.185	0.281	0.357	0.357	0.357	0.357	0.357
1983	0.027	0.092	0.114	0.191	0.291	0.369	0.369	0.369	0.369	0.369
1984	0.028	0.093	0.116	0.195	0.296	0.376	0.376	0.376	0.376	0.376
1985	0.028	0.093	0.116	0.194	0.296	0.376	0.376	0.376	0.376	0.376
1986	0.027	0.09	0.112	0.188	0.287	0.364	0.364	0.364	0.364	0.364
1987	0.027	0.089	0.111	0.187	0.284	0.361	0.361	0.361	0.361	0.361
1988	0.025	0.086	0.106	0.179	0.272	0.345	0.345	0.345	0.345	0.345

Year	1	2	3	4	5	6	7	8	9	10
1989	0.026	0.087	0.108	0.181	0.276	0.35	0.35	0.35	0.35	0.35
1990	0.026	0.086	0.107	0.18	0.274	0.347	0.347	0.347	0.347	0.347
1991	0.025	0.083	0.103	0.173	0.264	0.335	0.335	0.335	0.335	0.335
1992	0.023	0.078	0.097	0.163	0.248	0.315	0.315	0.315	0.315	0.315
1993	0.022	0.073	0.091	0.153	0.233	0.296	0.296	0.296	0.296	0.296
1994	0.022	0.073	0.09	0.152	0.231	0.293	0.293	0.293	0.293	0.293
1995	0.022	0.073	0.091	0.153	0.233	0.296	0.296	0.296	0.296	0.296
1996	0.022	0.075	0.093	0.157	0.239	0.303	0.303	0.303	0.303	0.303
1997	0.025	0.083	0.103	0.173	0.264	0.335	0.335	0.335	0.335	0.335
1998	0.027	0.092	0.114	0.192	0.292	0.37	0.37	0.37	0.37	0.37
1999	0.03	0.102	0.126	0.213	0.324	0.411	0.411	0.411	0.411	0.411
2000	0.034	0.113	0.141	0.237	0.36	0.457	0.457	0.457	0.457	0.457
2001	0.036	0.12	0.149	0.251	0.382	0.485	0.485	0.485	0.485	0.485
2002	0.037	0.124	0.154	0.259	0.394	0.5	0.5	0.5	0.5	0.5
2003	0.037	0.124	0.154	0.259	0.395	0.501	0.501	0.501	0.501	0.501
2004	0.037	0.124	0.154	0.259	0.394	0.501	0.501	0.501	0.501	0.501
2005	0.036	0.12	0.15	0.251	0.383	0.486	0.486	0.486	0.486	0.486
2006	0.032	0.108	0.135	0.226	0.344	0.437	0.437	0.437	0.437	0.437
2007	0.03	0.102	0.127	0.213	0.325	0.412	0.412	0.412	0.412	0.412
2008	0.03	0.099	0.123	0.207	0.316	0.401	0.401	0.401	0.401	0.401
2009	0.031	0.103	0.127	0.214	0.326	0.414	0.414	0.414	0.414	0.414
2010	0.027	0.09	0.112	0.188	0.286	0.363	0.363	0.363	0.363	0.363
2011	0.02	0.068	0.084	0.141	0.215	0.273	0.273	0.273	0.273	0.273
2012	0.017	0.058	0.072	0.122	0.185	0.235	0.235	0.235	0.235	0.235
2013	0.017	0.056	0.07	0.117	0.178	0.226	0.226	0.226	0.226	0.226
2014	0.019	0.062	0.077	0.13	0.198	0.251	0.251	0.251	0.251	0.251
2015	0.018	0.061	0.075	0.126	0.192	0.244	0.244	0.244	0.244	0.244
2016	0.018	0.061	0.075	0.126	0.192	0.244	0.244	0.244	0.244	0.244
2017	0.021	0.069	0.086	0.144	0.22	0.279	0.279	0.279	0.279	0.279
2018	0.02	0.068	0.085	0.143	0.217	0.276	0.276	0.276	0.276	0.276

Table 24.10. Witch flounder in Subarea 4 and Division 3.a and 7.d: Estimated stock numbers (in thousand individuals) at age. The assessment is using age information only for the years 2009–2018.

Year	1	2	3	4	5	6	7	8	9	10
1950	26944	22613	19681	16108	11212	6845	3973	2459	1432	1972
1951	27793	21158	16827	14611	11226	7128	4031	2332	1440	1998
1952	30773	21882	15595	12194	9964	6996	4120	2323	1342	1983
1953	34413	24476	16148	11192	8084	6027	3933	2326	1313	1878
1954	36464	27706	18302	11661	7406	4820	3348	2201	1313	1786
1955	35019	29665	21129	13643	8181	4773	2890	2001	1311	1853
1956	29793	28572	22710	15655	9282	5086	2768	1679	1162	1835
1957	24563	23923	21979	17052	10850	5811	2967	1614	980	1747
1958	21609	19381	18096	16603	12089	7021	3453	1748	945	1607
1959	20731	16947	14303	13236	11266	7374	3966	1952	988	1443
1960	19743	16532	12450	10324	8998	7008	4221	2255	1106	1380
1961	17640	15882	12293	8866	6739	5314	3830	2316	1241	1368
1962	15696	14050	11961	8939	5803	3939	2875	2087	1272	1426
1963	14369	12460	10558	8949	6258	3656	2297	1672	1214	1570
1964	12766	11515	9278	7743	6208	3983	2131	1329	964	1621
1965	11182	10179	8599	6669	5079	3667	2184	1174	733	1419
1966	10978	8719	7599	6293	4445	3035	2029	1215	654	1193
1967	12773	8480	6375	5571	4313	2742	1726	1152	689	1049
1968	17221	9897	6117	4538	3752	2653	1547	970	645	980
1969	22223	13789	7131	4267	2897	2165	1415	832	523	873
1970	25286	18092	10348	5042	2750	1674	1163	767	456	753
1971	25586	20629	13949	7828	3519	1754	991	687	452	715
1972	25417	20483	15821	10436	5396	2183	1012	572	397	674
1973	25125	20301	15437	11941	7409	3480	1280	590	332	625
1974	25542	19913	15171	11204	7918	4386	1929	717	332	536
1975	27424	20186	14890	11281	7916	5157	2611	1133	418	507
1976	31600	21569	14925	10750	7483	4752	2882	1468	639	521
1977	39875	24792	15963	10867	7311	4634	2735	1658	844	666
1978	51233	31697	18283	11555	7329	4513	2659	1572	952	868
1979	60194	41532	23702	13184	7731	4471	2574	1522	902	1043
1980	61641	49270	31775	17479	8993	4839	2610	1504	889	1136
1981	58389	49919	38025	23755	11932	5562	2801	1517	876	1176
1982	55230	46671	38206	29111	17201	7811	3341	1668	899	1220
1983	53634	43833	34980	28264	20048	10812	4524	1925	959	1220
1984	55235	42271	32541	25427	19008	12196	6118	2562	1090	1233
1985	57446	43917	31248	23651	17126	11598	6879	3450	1443	1308
1986	57725	46037	32748	22601	15861	10395	6524	3870	1942	1548
1987	52809	46783	34616	23915	15190	9727	5917	3718	2204	1988
1988	46776	42344	35611	25430	16088	9188	5485	3350	2112	2375

Year	1	2	3	4	5	6	7	8	9	10
1989	42465	37183	32116	26947	17964	10348	5438	3226	1960	2636
1990	41986	33357	27758	23678	18577	11238	6009	3151	1867	2662
1991	43865	33182	24713	20363	16290	11727	6577	3505	1832	2640
1992	47786	34768	24733	17932	13828	10138	6834	3844	2051	2616
1993	50974	38363	26105	18148	12219	8694	5987	4054	2286	2772
1994	52920	41010	29192	19260	12558	7777	5226	3609	2452	3047
1995	52717	42738	31473	22026	13613	8246	4790	3214	2214	3385
1996	52098	42262	32632	23489	15349	8716	4982	2903	1951	3382
1997	49996	41933	32135	24536	16712	10115	5356	3045	1767	3267
1998	46864	40085	31666	23568	16735	10458	5922	3139	1784	2949
1999	43244	37436	30036	23148	15790	10143	5888	3343	1773	2671
2000	41436	34118	27781	21779	15409	9356	5515	3201	1817	2415
2001	43501	32283	24886	19989	14303	8960	4915	2885	1669	2211
2002	42636	34790	23069	17473	12769	8019	4540	2487	1459	1963
2003	37802	34264	25527	15971	11009	7082	4005	2266	1239	1707
2004	29129	30579	25185	18078	9865	5997	3494	1981	1123	1460
2005	24642	22605	22721	18023	11578	5345	2952	1727	981	1279
2006	25433	18779	16128	16365	11478	6383	2588	1453	858	1117
2007	22011	20816	13335	11426	11224	6965	3474	1339	759	1028
2008	45048	14968	15853	9262	7434	6931	3923	1928	709	938
2009	82315	36522	9484	11782	5932	4384	4002	2245	1083	854
2010	78253	75026	27844	6129	7941	3290	2433	2170	1105	955
2011	38770	67663	57581	19282	3998	5374	1895	1438	1112	994
2012	29349	32410	52062	40509	12043	2805	3701	1249	859	1228
2013	30023	23545	23757	33988	25377	7010	2114	2575	867	1567
2014	28852	23393	19378	20051	23979	15435	4278	1552	1785	1969
2015	17677	23243	19813	16320	15701	15165	8813	2591	943	2165
2016	9761	13089	18768	16790	12668	11828	9426	5292	1684	1770
2017	14992	6849	9852	15279	13049	8983	8150	5706	3274	2393
2018	9679	12034	4995	7482	11994	8763	6180	5272	3195	3385

Table 24.11. Witch flounder in Subarea 4 and Division 3.a and 7.d: Short-term forecasting scenarios and results.

Basis	Total catch (2020)	Wanted catch (2020) *	Unwanted catch (2020) *	F_{total} ages 4–8 (2020 & 2021)	SSB (2020)	SSB (2021)	% SSB change **	% Advice change ***
ICES advice basis								
Precautionary approach: F_{pa}	1651	1608	43	0.20	4101	3622	−11.7	−31
Other scenarios								
MSY approach: F_{MSY}	1301	1266	35	0.154	4206	3915	−6.9	−46
$F_{MSY\text{-}upper}$	1651	1608	43	0.2	4101	3622	−11.7	−31
$F_{MSY\text{-}lower}$	938	913	25	0.108	4315	4229	−2	−61
F = 0	0	0	0	0	4578	5027	9.8	−100
F_{pa}	1651	1608	43	0.2	4101	3622	−11.7	−31
F_{lim}	2350	2286	64	0.3	3880	3061	−21	−1.66
F_{sq}	1924	1866	59	0.24	4011	3393	−15.4	−19.5
SSB (2021) = B_{lim}	2339	2275	64	0.3	3883	3069	−21	−2.1
SSB (2021) = B_{pa}	312	304	7	0.035	4492	4745	5.6	−87
SSB (2021) = MSY $B_{trigger}$	312	304	7	0.035	4492	4745	5.6	−87
Roll-over advice	2390	2326	64	0.31	3866	2846	−26	0

* "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 2016–2018.

** SSB in 2021 relative to SSB in 2020.

*** Total catch in 2020 relative to advice value 2019 (2390 t).

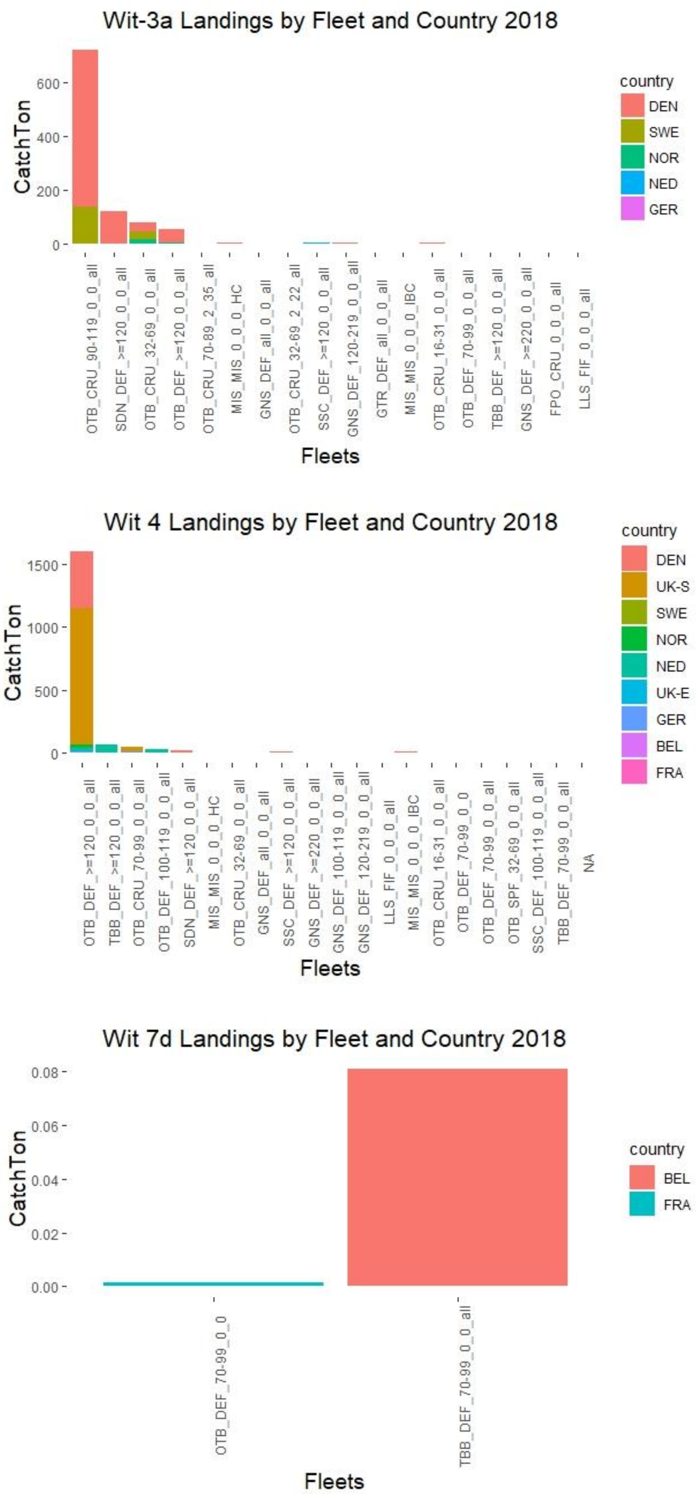


Figure 24.1. Witch flounder Division 3.a (upper plot), in Subarea 4 (middle plot) and Division 7.d (lower plot): Landings by métier and country in 2018.

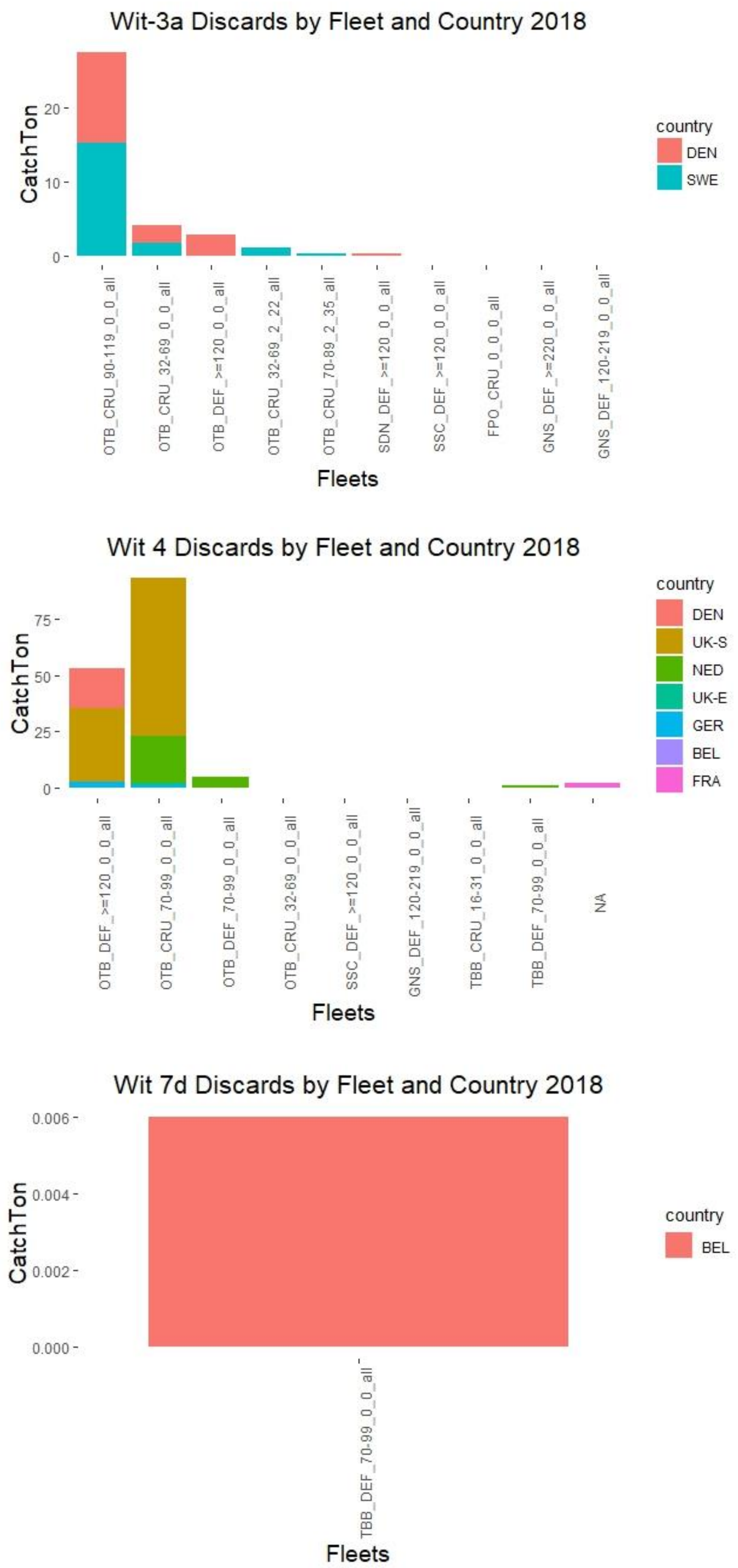


Figure 24.2. Witch flounder in Division 3.a (upper plot), Subarea 4 (middle plot) and Division 7.d (lower plot): Discards by métier and country in 2018.

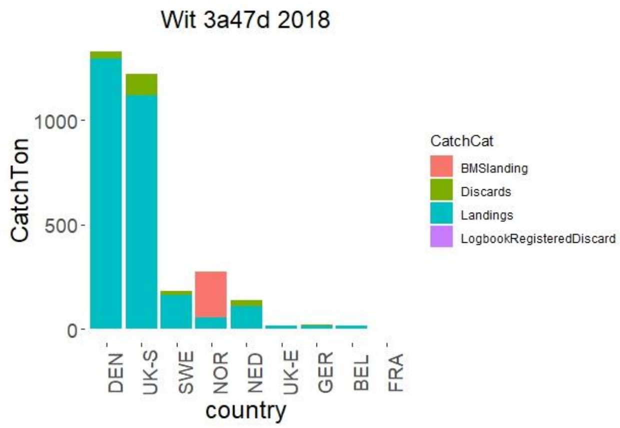


Figure 24.3. Witch flounder in Subarea 4 and Division 3.a: Estimated catch categories by countries in 2018.

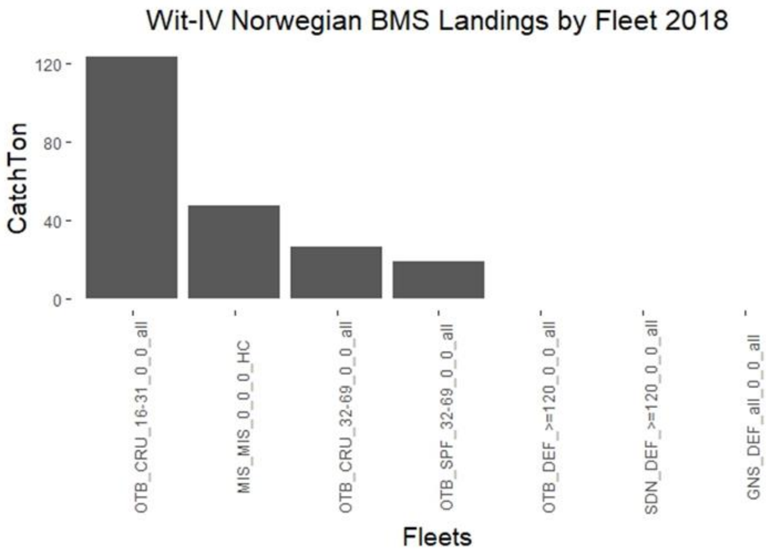


Figure 24.4. Witch flounder in Subarea 4 and Division 3.a: Norwegian BMS Landings by métier in 2018.

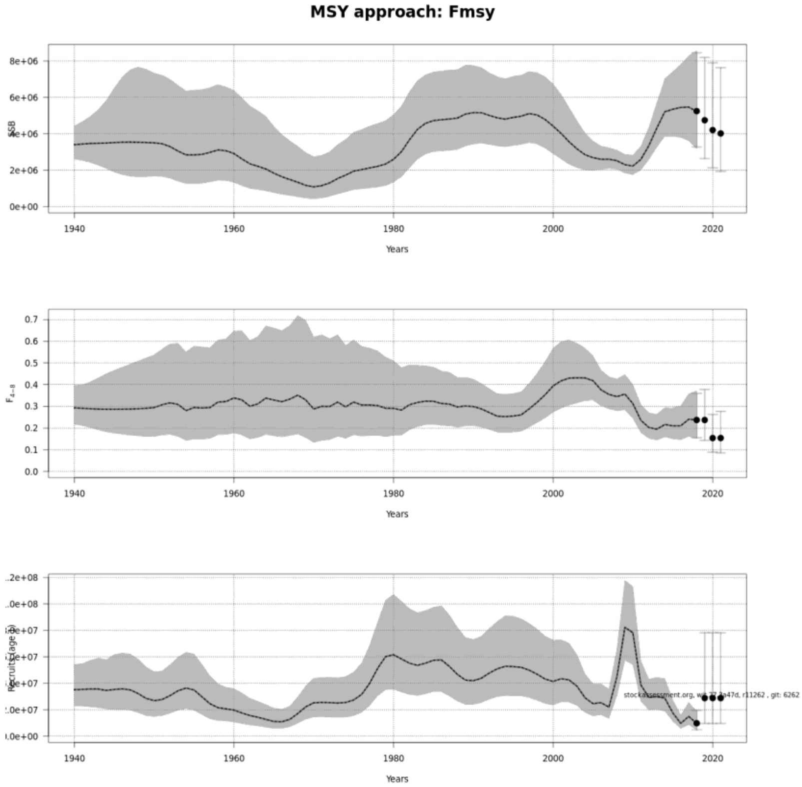


Figure 24.5. Witch flounder in Subarea 4 and Division 3.a: Short-term forecast under the MSY approach scenario (F_{2020} = F_{MSY} = 0.154 y^{-1}).

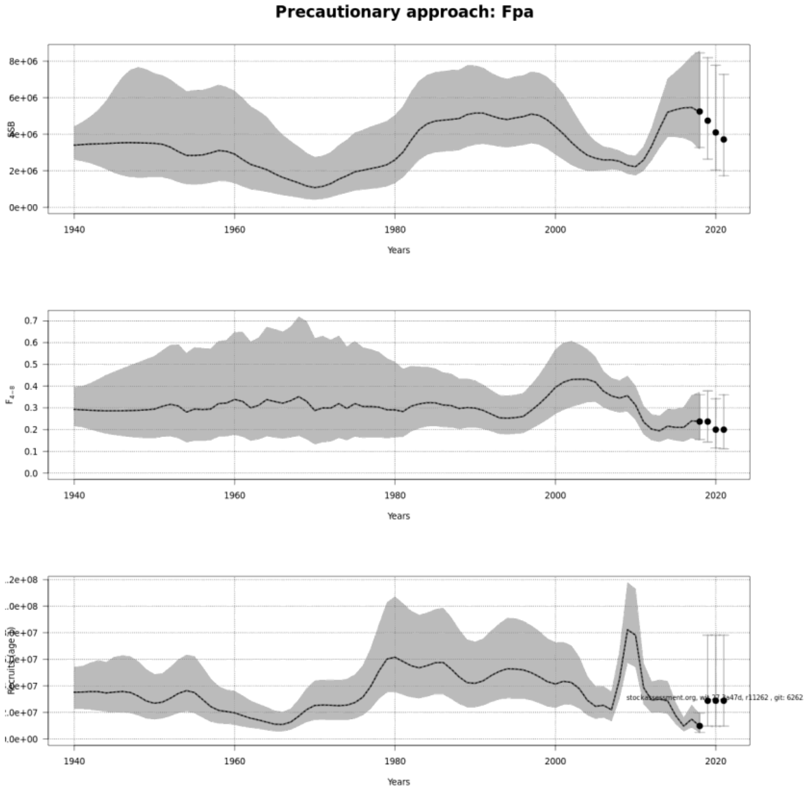


Figure 24.6. Witch flounder in Subarea 4 and Division 3.a: Short-term forecast under the MSY approach scenario (F_{2020} = F_{PA} = 0.2 y^{-1}).

Annex 1: Participants list

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Annex 2: Recommendations

This Annex details the response to recommendations made to WGNSSK during 2018/19 (Table A), and recommendations WGNSSK has put forward during the 2019 meeting (Table B).

Table A: Response to recommendations made to WGNSSK during 2018/19.

Recommendation	Source	Response:
Given new evidence on the proportion of removals by marine recreational fisheries (2-43%), the RCGs and ICES regional assessment groups (WGCSE. WGBIE, WGNSSK, WGBFAS) consider inclusion of recreational catches in a broader set of stock assessments and advice, and highlight where extended data collection is re-quired.	WGRFS	Yes if data are existing, available in consistent form and on a regular basis, and meet sampling and data quality requirements. Their inclusion requires a benchmark.
Create a list of minimum products for assessed species as output from a coordinated survey series. The product/format could be combined with the list of stocks using DATRAS data in their assessment as recommended by IBTS 2017.	WKDATR-NSCS	The context for this request is not clear. We already have the minimum information required from the surveys, and this has been communicated to the Datras team in the past. A survey sent out by ICES was not sent to all stock coordinators.
WGNEPS recommends that survey coverage be expanded to other important fisheries that are not currently assessed using fisheries-independent information (e.g. Botney Cut FU5 and Norwegian trench FU32). Additionally, the UWTV survey in FU33, which is currently conducted solely by Denmark, should continue beyond 2019. However, as financial restrictions may limit these activities, advice on the prioritisation of surveying these three FUs from ACOM would be highly desirable.	WGNEPS	We support this recommendation, but cannot initiate surveys ourselves, or prioritise across the FUs. There is an on-going prioritisation for surveys elsewhere (e.g. EU/STECF review of surveys in 2019), and it should be clarified whether Nephrops forms part of this.

Table B: Recommendations from WGNSSK 2019 meeting.

Recommendation	For follow up by:
There have been issues (reader conflicts) with regard to the age readings of North Sea whiting compared to other gadoids; in particular, age readings used for the IBTS indices. Age-reading techniques were reviewed and coordinated between countries in late 2016, but no further progress has been made. Until these investigations have been concluded, reported age readings continue to be used as in previous years. We recommend that that this issue be further investigated so that the assessment is based on appopriate age information.	WGBIOP
There are differences between countries in the recording of BMS in Intercatch and/or in official landings. Furthermore, there is some confusion about recording of BMS for Norway. BMS landings are becoming increasingly important to track, particularly in advice, given the full implementation of the landing obligation. Currently, there are no guidelines for how information on these landings should be recorded in the advice sheets, and shown in the plots (particularly Figure 1 and the final summary of the assessment table). It is recommended that such guidelines be provided to EGs.	ACOM
The use of LBI analysis to develop reference points for those Category 3 stocks that don't have a reliable biomass dynamic model (e.g. SPiCT), is relatively new for ICES. Basing the reference point on absolute values (e.g. mean length above Lc) is not recommended, and is inconsistent with those Category 3 assessment which rely on biomass dynamic models, for which these reference points are expressed on a relative basis. It is therefore recommended that LBI-based reference points be expressed on a relative basis. Furthermore, it is recommended that guidance be provided for the appropriate calculation of Lc to be used in the definition of these reference points (in terms of both how to calculate them and which time period to use).	ACOM, WKLIFE
The consistent use of fleet categories remains a substantial problem in Intercatch, with fleet codes specific to some countries and not others continuing to appear. This poses a substantial problem to stock coordinators that have to use these codes for raising information in Intercatch, because it is often not clear how to match these codes with other codes to ensure appropriate raising. It is recommended that a consistent list be developed and checked during the uploading, so that the metier associated with the code is clear, or alternatively guidelines be provide on how best to combine various gear codes.	Intercatch team, Datacall team, MIXFISH
Information collected in ICES (RCGs, WGCATCH, DCF Annual Report), reflecting the impact of the Landing Obligation on data quality, should be summarised and reported to WGNSSK. This should not be a TOR for WGNSSK.	ACOM, PGDATA
A common method for calculating biomass survey indices used for Category 3 advice should be developed and implemented in TAF. Furthermore, the current DATRAS methodology for calculating survey indices for Category 1 stocks should be made available in TAF to improve transparency.	DATRAS team, WGISDAA
There is concern about the decrease in the level of participation and in the discussion of stocks and more general discussion. There has also been a problem with finding somebody to chair WGNSSK. Institutes should be encouraged to support the important work of the EGs.	ACOM

Annex 3: ToRs for next meeting

The Terms of Reference (ToRs) for the next meeting are no longer included in the report.

Please go to www.ices.dk for up to date terms of reference for all ICES groups.

Annex 4: List of Stock Annexes

The table below provides an overview of the WGNSSK Stock Annexes. Stock annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year, ecoregion, species,* and *acronym* of the relevant ICES expert group.

Stock ID	Stock description	Last updated	Link
bll.27.3a47de	Brill (*Scophthalmus rhombus*) in Subarea 4 and divisions 3.a and 7.d-e (North Sea, Skagerrak and Kattegat, English Channel)	November 2019	bll.27.3a47de_SA.pdf
cod.27.47d20	Cod (*Gadus morhua*) in Subarea 4, Division 7.d, and Subdivision 20 (North Sea, eastern English Channel, Skagerrak)	May 2018	cod.27.47d20_SA.pdf
dab.27.3a4	Dab (*Limanda limanda*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	March 2016	dab.27.3a4_SA.pdf
fle.27.3a4	Flounder (*Platichthys flesus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	April 2019	fle.27.3a4_SA.pdf
gug.27.3a47d	Grey gurnard (*Eutrigla gurnardus*) in Subarea 4 and divisions 7.d and 3.a (North Sea, eastern English Channel, Skagerrak and Kattegat)	March 2014	gug.27.3a47d_SA.pdf
had.27.46a20	Haddock (*Melanogrammus aeglefinus*) in Subarea 4, Division 6.a, and Subdivision 20 (North Sea, West of Scotland, Skagerrak)	April 2019	had.27.46a20_SA.pdf
lem.27.3a47d	Lemon sole (*Microstomus kitt*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	April 2018	lem.27.3a47d_SA.pdf
mur.27.3a47d	Striped red mullet (*Mullus surmuletus*) in Subarea 4 and divisions 7.d and 3.a (North Sea, eastern English Channel, Skagerrak and Kattegat)	February 2015	mur.27.3a47d_SA.pdf
nep.27.4outFU	Norway lobster (*Nephrops norvegicus*) in Subarea 4, outside the functional units (North Sea)		
nep.fu.10	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 10 (northern North Sea, Noup)	April 2018	nep.fu.10_SA.pdf
nep.fu.32	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 32 (northern North Sea, Norway Deep)	May 2018	nep.fu.32_SA.pdf
nep.fu.33	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 33 (central North Sea, Horn's Reef)	April 2016	nep.fu.33_SA.pdf

Stock ID	Stock description	Last updated	Link
nep.fu.34	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 34 (central North Sea, Devil's Hole)	February 2013	nep.fu.34_SA.pdf
nep.fu.3-4	Norway lobster (*Nephrops norvegicus*) in Division 3.a, Functional units 3 and 4 (Skagerrak and Kattegat)	May 2014	nep.fu.3-4_SA.pdf
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)	July 2016	nep.fu.5_SA.pdf
nep.fu.6	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 6 (central North Sea, Farn Deeps)	March 2013	nep.fu.6_SA.pdf
nep.fu.7	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 7 (northern North Sea, Fladen Ground)	May 2015	nep.fu.7_SA.pdf
nep.fu.8	Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 8 (central North Sea, Firth of Forth)	May 2011	nep.fu.8_SA.pdf
nep.fu.9	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 9 (central North Sea, Moray Firth)	May 2011	nep.fu.9_SA.pdf
nop.27.3a4	Norway pout (*Trisopterus esmarkii*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	May 2017	nop.27.3a4_SA.pdf
ple.27.420	Plaice (*Pleuronectes platessa*) in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	May 2019	ple.27.420_SA.pdf
ple.27.7d	Plaice (*Pleuronectes platessa*) in Division 7.d (eastern English Channel)	May 2018	ple.27.7d_SA.pdf
pok.27.3a46	Saithe (*Pollachius virens*) in Subareas 4, 6 and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	February 2019	pok.27.3a46_SA.pdf
pol.27.3a4	Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	May 2019	pol.27.3a4_SA.pdf
sol.27.4	Sole (*Solea solea*) in Subarea 4 (North Sea)	February 2015	sol.27.4_SA.pdf
sol.27.7d	Sole (*Solea solea*) in Division 7.d (eastern English Channel)	October 2019	sol.27.7d_SA.pdf
tur.27.3a	Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)	October 2012	tur.27.3a_SA.pdf
tur.27.4	Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)	October 2018	tur.27.4_SA.pdf
whg.27.3a	Whiting (*Merlangius merlangus*) in Division 3.a (Skagerrak and Kattegat)	May 2014	whg.27.3a_SA.pdf
whg.27.47d	Whiting (*Merlangius merlangus*) in Subarea 4 and Division 7.d (North Sea and eastern English Channel)	April 2019	whg.27.47d_SA.pdf

Stock ID	Stock description	Last updated	Link
wit.27.3a47d	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	May 2019	wit.27.3a47d_SA.pdf

Annex 5: Audit Reports

Audits for stocks for which advice sheets were produced were conducted during and immediately following the WGNSSK 2019 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.

1.1 Audits for initial assessments (including Norway Pout and delayed assessments)

bll.27.3a47de (brill)

General

Brill is managed under a combined TAC with turbot. Given the lack of catch and landings data as well as survey-information brill is assessed as a Category 3 stock. This implies biennial advice using the 2 over 3 rule on the biomass index. This index is driven by an unstructured commercial LPUE of the Dutch large beam trawl fleet. A Spict model is run to determine the reference points for brill. In 2018 there was an inter-benchmark for turbot, upgrading the assessment to a Category 1 stock providing annual advice.

For single stock summary sheet advice:

1) **Assessment type:** Cat 3 with Biennial advice
2) **Assessment**: trends (2 over 3 rule) using the one commercial biomass index based on the LPUE from the Dutch Beam trawl fleet.
3) **Forecast**: /
4) **Assessment model**: SPiCT is used to calculate the reference points informing the assessor on the status of the stock in relation to reference point values.
5) **Data issues:** LPUE index from Dutch beam trawl fleet is used. This LPUE can be biased due to PO-measures. The lower valued brill will be high-graded when a cap is set on the maximum amount of turbot and brill that can be landed per trip.
6) **Consistency**: Consistent.
7) **Stock status**: F is below FMSY proxy; and SSB is above MSY Btrigger proxy. (Spict)
8) **Management Plan**: No management plan

General comments

This was a well documented, well ordered and considered section. The assessment is easy to follow and interpret. Input and output data was correct.

Technical comments

Turbot and brill are managed under a combined TAC. The official landings in 4 and 2.a turbot & brill presented in table 6 need to be aligned. However in 2017 there is a minor difference in between both advice sheets. Stock coordinators were in contact with each other to align the numbers in the table. For turbot the final landings statistics provided by the Member States are used, while in brill the preliminary are used.

The assessment relies solely on a biomass index derived from a the standardized lpue from the Dutch beam-trawl fleet for vessels > 221 kW. The LPUE in 2016 and 2017 will be influenced by the measures (i.e. increased MLS and a cap on landings per trip) taken by the Dutch Producer Organisations. These measures were still in place early 2018, but have been relaxed throughout the year. The current LPUE of the Dutch beam trawl fleet does not take shifts in fishing activities and catchabilities due to the change to pulse fishing in this fleet segment into account. The commercial LPUE index for turbot does, it would good to look at the potential of using the method used within the turbot assessment.

In table 2 of the advice the footnote referring to ^ should state : Advice value for 2020 relative to advice value for 2018 – 2019. It's biennial advice.

Within information from stakeholder the sentence "*Information on the market categories in the landings suggest that the smaller market categories were largely absent from the landings (2016 and 2017), while these smaller market categories were landed by flag vessels that were not under the Dutch PO measures*." was checked and approved by the Dutch demersal fisheries.

Conclusions

The assessment has been performed correctly

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 (once again 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 age groups. Variance of age 1 estimates of F separated from the other ages and the plus group is "decoupled" from the age group below

allowing for $F_5 \neq F_{6+}$. This year's assessment used the TMB implementation of SAM introduced last year instead of the ADMB implementation used last in 2017.

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/moderate). This is annoying, but not in any way invalidating assessment with results.

6) **Consistency**: Consistent with last year's assessment except for changes to historic values used as input (see 5). All settings and assumptions identical to 2018 assessment

7) **Stock status:** F is above F_{lim} and point estimate of spawning stock size is below B_{lim}.

8) **Man. Plan.**: There is currently (1. May 2019) no agreed management plan. Advice should be given according to ICES F_{MSY} approach, unless the parties agree on a new joint management plan before release of the advice. An additional table containing "the best candidates" of the recently evaluated harvest control rules should supplement the standard catch option table.

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 low fishing mortality for older fish. This dome shaped fishing mortality levels introduces a large fraction of the SSB being less available to fishing. This is likely to have an effect on TAC advice as it may represent a bias in the perception of stock status (relative to trigger points and reference points).

2019: The delta-GAM approach has now produced tuning indices for five 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 (2018) maturity ogives is shown in

	1	2	3	4	5	6	7
1963	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	91	-1	0	-1	0	0	0
1974	79	-1	0	-1	0	0	0
1975	67	0	0	-1	0	0	0
1976	49	0	0	-1	0	0	0
1977	27	0	0	-1	0	0	0
1978	2	0	-1	-1	0	0	0
1979	-23	0	-1	-1	0	0	0
1980	-41	0	-2	-1	0	0	0
1981	-50	1	-3	0	0	0	0

	1	2	3	4	5	6	7
1982	-47	1	-3	0	0	0	0
1983	-31	1	-3	0	0	0	0
1984	-4	1	-3	0	0	0	0
1985	26	1	-3	1	0	0	0
1986	55	1	-2	1	1	0	0
1987	75	0	-2	1	1	0	0
1988	85	-1	-2	0	1	0	0
1989	82	-2	-1	0	1	0	0
1990	68	-2	-1	0	1	0	0
1991	44	-3	0	0	1	0	0
1992	14	-3	1	-1	1	0	0
1993	-15	-3	1	-1	1	0	0
1994	-41	-3	2	-1	1	0	0
1995	-62	-3	2	-2	1	0	0
1996	-76	-3	3	-2	1	0	0
1997	-83	-3	2	-2	1	0	0
1998	-85	-3	2	-2	1	0	0
1999	-84	-3	1	-2	1	0	0
2000	-79	-3	0	-2	1	0	0
2001	-72	-3	-1	-2	1	0	0
2002	-64	-3	-1	-1	0	0	0
2003	-53	-2	-1	-1	0	0	0
2004	-41	-2	0	-1	0	0	0
2005	-27	-2	0	0	0	0	0
2006	-13	-2	1	0	0	0	0
2007	2	-1	1	0	0	0	0
2008	15	-1	1	0	0	0	0
2009	25	-1	0	0	0	0	0
2010	33	-1	-1	0	0	0	0
2011	36	-1	-1	0	0	0	0
2012	35	0	-2	0	0	0	0
2013	29	1	-2	0	0	0	0
2014	19	2	-2	0	0	0	0
2015	5	3	0	1	0	0	0
2016	-11	5	3	1	0	0	0
2017	-29	6	8	2	1	0	0
2018	-46	8	14	2	1	0	0

. The intense colouring 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

	1	2	3	4	5	6
1983	-3.2	-12.0	-3.8	-1.7	2.5	0.1
1984	-3.4	-12.3	-3.4	-0.4	2.5	-0.5
1985	-1.8	-12.5	-2.2	0.3	4.3	3.3
1986	-1.5	-17.3	-3.8	-1.1	1.1	4.5
1987	0.2	-7.7	-7.0	0.2	4.9	0.6
1988	-2.9	-9.6	-3.2	-1.0	4.4	1.0
1989	0.7	-7.8	-2.5	-4.7	9.6	-1.9
1990	0.3	-10.3	-2.4	0.1	1.3	0.2
1991	-0.1	-5.3	-1.7	0.6	1.4	-0.9
1992	-3.4	3.2	-1.9	0.4	2.1	0.9
1993	-1.1	-7.3	-3.2	0.1	2.8	-2.8
1994	-1.6	-4.6	-2.3	-0.2	0.5	-0.1
1995	-2.1	-4.1	-1.5	-0.1	5.5	-3.4
1996	-2.7	-2.0	1.5	2.6	1.5	0.6
1997	3.0	-3.0	-4.0	2.9	5.6	0.3

	1	2	3	4	5	6
1998	-1.6	-2.6	0.5	-0.2	3.5	-6.6
1999	0.4	-0.9	-3.4	7.0	1.3	0.8
2000	2.6	-4.2	-0.2	-0.1	-0.8	0.2
2001	-1.1	-4.2	-1.7	0.9	2.3	2.1
2002	-0.8	-1.4	0.2	0.3	0.3	3.0
2003	-1.0	-4.3	-2.2	0.1	1.9	2.3
2004	-0.5	-5.4	-1.7	1.5	2.3	4.9
2005	-0.7	-2.5	-2.0	0.6	1.4	3.3
2006	-2.0	-4.3	-1.1	0.0	0.4	2.7
2007	0.5	-4.1	-1.6	1.0	2.6	2.8
2008	-0.3	-4.0	-1.8	0.8	0.3	2.6
2009	-0.6	-3.1	-0.2	1.3	0.7	1.4
2010	-2.8	-1.6	-1.6	0.9	0.3	2.0
2011	-1.5	-3.2	-2.7	0.9	2.9	2.6
2012	2.4	-2.8	-1.6	0.1	0.1	1.6
2013	-0.5	1.6	-1.1	0.6	0.6	1.6
2014	1.2	-1.7	-0.6	0.8	0.1	1.8
2015	0.5	-1.2	-2.5	2.4	2.0	3.7
2016	6.4	0.1	-1.5	1.3	1.3	1.2
2017	-2.5	-1.2	0.4	5.5	2.0	-4.1
2018	0.8	-3.1	-2.2	2.3	1.8	4.6

and

	1	2	3	4	5	6
1992	9.8	4.6	2.3	9.5	-1.2	9.8
1993	9.6	4.9	3.4	7.5	-1.6	-5.2
1994	8.1	2.5	2.7	6.4	-5.0	-7.2
1995	7.3	5.4	4.0	5.8	-2.0	-6.3
1996	9.0	1.0	1.8	4.7	-5.4	-0.9
1997	5.0	0.4	1.2	5.6	-4.0	-8.4
1998	3.4	0.4	-3.5	0.5	-0.5	-6.5
1999	5.1	0.8	-0.7	5.2	-0.5	-2.5
2000	5.3	1.0	1.2	4.0	4.0	-6.5
2001	6.2	0.0	0.5	6.4	5.9	6.6
2002	10.0	-1.5	-0.9	3.9	-0.1	-2.7
2003	3.5	-2.3	-0.6	4.1	20.1	20.7
2004	4.0	-1.1	0.5	3.7	5.6	-1.6
2005	4.9	0.1	1.4	3.3	2.5	0.2
2006	2.2	1.8	-0.2	3.5	2.1	0.5
2007	5.5	0.8	1.1	5.3	2.7	1.1
2008	12.6	3.1	-0.6	3.8	2.0	5.4
2009	6.2	2.3	-1.9	1.4	2.4	3.7
2010	3.7	0.0	-1.0	3.7	-0.3	-1.5
2011	2.8	2.2	3.6	7.1	9.5	8.4
2012	6.4	2.5	2.9	4.5	1.7	6.9
2013	7.0	4.5	-0.4	-1.8	1.7	2.4
2014	5.2	1.9	4.8	6.5	1.8	1.7
2015	7.8	1.5	-0.6	2.8	-2.2	-3.7
2016	6.4	2.5	-1.3	3.6	3.2	0.9
2017	9.1	1.4	-1.0	2.9	2.8	3.1

. Some of the changes can not be attributed to the estimation but must be caused by changes to historic input as generated by DATRAS.

Assumed stock weights for the intermediate year (last year's advice) deviates some from this year's estimate of stock weights in 2018 (see

	1	2	3	4	5	6	7	8	9	10	11
2018	-10.5	-18.5	-13.6	-2.2	0.7	-1.6	-8.4	-0.2	-10.3	-37.8	-3.0

)

Table 1 Relative change (in percent) from last years smoothed maturity ogives.

	1	2	3	4	5	6	7
1963	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	91	-1	0	-1	0	0	0
1974	79	-1	0	-1	0	0	0
1975	67	0	0	-1	0	0	0
1976	49	0	0	-1	0	0	0
1977	27	0	0	-1	0	0	0
1978	2	0	-1	-1	0	0	0
1979	-23	0	-1	-1	0	0	0
1980	-41	0	-2	-1	0	0	0
1981	-50	1	-3	0	0	0	0
1982	-47	1	-3	0	0	0	0
1983	-31	1	-3	0	0	0	0
1984	-4	1	-3	0	0	0	0
1985	26	1	-3	1	0	0	0
1986	55	1	-2	1	1	0	0
1987	75	0	-2	1	1	0	0
1988	85	-1	-2	0	1	0	0
1989	82	-2	-1	0	1	0	0
1990	68	-2	-1	0	1	0	0
1991	44	-3	0	0	1	0	0
1992	14	-3	1	-1	1	0	0
1993	-15	-3	1	-1	1	0	0
1994	-41	-3	2	-1	1	0	0
1995	-62	-3	2	-2	1	0	0
1996	-76	-3	3	-2	1	0	0
1997	-83	-3	2	-2	1	0	0
1998	-85	-3	2	-2	1	0	0
1999	-84	-3	1	-2	1	0	0
2000	-79	-3	0	-2	1	0	0
2001	-72	-3	-1	-2	1	0	0
2002	-64	-3	-1	-1	0	0	0
2003	-53	-2	-1	-1	0	0	0
2004	-41	-2	0	-1	0	0	0
2005	-27	-2	0	0	0	0	0
2006	-13	-2	1	0	0	0	0
2007	2	-1	1	0	0	0	0
2008	15	-1	1	0	0	0	0
2009	25	-1	0	0	0	0	0
2010	33	-1	-1	0	0	0	0
2011	36	-1	-1	0	0	0	0
2012	35	0	-2	0	0	0	0
2013	29	1	-2	0	0	0	0
2014	19	2	-2	0	0	0	0
2015	5	3	0	1	0	0	0
2016	-11	5	3	1	0	0	0

	1	2	3	4	5	6	7
2017	-29	6	8	2	1	0	0
2018	-46	8	14	2	1	0	0

Table 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	-3.2	-12.0	-3.8	-1.7	2.5	0.1
1984	-3.4	-12.3	-3.4	-0.4	2.5	-0.5
1985	-1.8	-12.5	-2.2	0.3	4.3	3.3
1986	-1.5	-17.3	-3.8	-1.1	1.1	4.5
1987	0.2	-7.7	-7.0	0.2	4.9	0.6
1988	-2.9	-9.6	-3.2	-1.0	4.4	1.0
1989	0.7	-7.8	-2.5	-4.7	9.6	-1.9
1990	0.3	-10.3	-2.4	0.1	1.3	0.2
1991	-0.1	-5.3	-1.7	0.6	1.4	-0.9
1992	-3.4	3.2	-1.9	0.4	2.1	0.9
1993	-1.1	-7.3	-3.2	0.1	2.8	-2.8
1994	-1.6	-4.6	-2.3	-0.2	0.5	-0.1
1995	-2.1	-4.1	-1.5	-0.1	5.5	-3.4
1996	-2.7	-2.0	1.5	2.6	1.5	0.6
1997	3.0	-3.0	-4.0	2.9	5.6	0.3
1998	-1.6	-2.6	0.5	-0.2	3.5	-6.6
1999	0.4	-0.9	-3.4	7.0	1.3	0.8
2000	2.6	-4.2	-0.2	-0.1	-0.8	0.2
2001	-1.1	-4.2	-1.7	0.9	2.3	2.1
2002	-0.8	-1.4	0.2	0.3	0.3	3.0
2003	-1.0	-4.3	-2.2	0.1	1.9	2.3
2004	-0.5	-5.4	-1.7	1.5	2.3	4.9
2005	-0.7	-2.5	-2.0	0.6	1.4	3.3
2006	-2.0	-4.3	-1.1	0.0	0.4	2.7
2007	0.5	-4.1	-1.6	1.0	2.6	2.8
2008	-0.3	-4.0	-1.8	0.8	0.3	2.6
2009	-0.6	-3.1	-0.2	1.3	0.7	1.4
2010	-2.8	-1.6	-1.6	0.9	0.3	2.0
2011	-1.5	-3.2	-2.7	0.9	2.9	2.6
2012	2.4	-2.8	-1.6	0.1	0.1	1.6
2013	-0.5	1.6	-1.1	0.6	0.6	1.6
2014	1.2	-1.7	-0.6	0.8	0.1	1.8
2015	0.5	-1.2	-2.5	2.4	2.0	3.7
2016	6.4	0.1	-1.5	1.3	1.3	1.2
2017	-2.5	-1.2	0.4	5.5	2.0	-4.1
2018	0.8	-3.1	-2.2	2.3	1.8	4.6

Table 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	9.8	4.6	2.3	9.5	-1.2	9.8
1993	9.6	4.9	3.4	7.5	-1.6	-5.2
1994	8.1	2.5	2.7	6.4	-5.0	-7.2
1995	7.3	5.4	4.0	5.8	-2.0	-6.3
1996	9.0	1.0	1.8	4.7	-5.4	-0.9
1997	5.0	0.4	1.2	5.6	-4.0	-8.4
1998	3.4	0.4	-3.5	0.5	-0.5	-6.5
1999	5.1	0.8	-0.7	5.2	-0.5	-2.5
2000	5.3	1.0	1.2	4.0	4.0	-6.5
2001	6.2	0.0	0.5	6.4	5.9	6.6

	1	2	3	4	5	6
2002	10.0	-1.5	-0.9	3.9	-0.1	-2.7
2003	3.5	-2.3	-0.6	4.1	20.1	20.7
2004	4.0	-1.1	0.5	3.7	5.6	-1.6
2005	4.9	0.1	1.4	3.3	2.5	0.2
2006	2.2	1.8	-0.2	3.5	2.1	0.5
2007	5.5	0.8	1.1	5.3	2.7	1.1
2008	12.6	3.1	-0.6	3.8	2.0	5.4
2009	6.2	2.3	-1.9	1.4	2.4	3.7
2010	3.7	0.0	-1.0	3.7	-0.3	-1.5
2011	2.8	2.2	3.6	7.1	9.5	8.4
2012	6.4	2.5	2.9	4.5	1.7	6.9
2013	7.0	4.5	-0.4	-1.8	1.7	2.4
2014	5.2	1.9	4.8	6.5	1.8	1.7
2015	7.8	1.5	-0.6	2.8	-2.2	-3.7
2016	6.4	2.5	-1.3	3.6	3.2	0.9
2017	9.1	1.4	-1.0	2.9	2.8	3.1

Table 4 Percentage change to stock weights at age (assumed for last year's prediction versus observed in 2018).

	1	2	3	4	5	6	7	8	9	10	11
2018	-10.5	-18.5	-13.6	-2.2	0.7	-1.6	-8.4	-0.2	-10.3	-37.8	-3.0

Conclusions

The assessment has been run in accordance with the benchmark choices.

dab.27.3a4

General

Assessment completed in accordance with the specifications of the Stock Annex. Note, no catch advice has been requested for this stock, and advice for the stock is now on a 3-year cycle. An additional year of advice (for 2020) was needed because the last advice sheet, covering 2018 and 2019, did not fit in with the new 3-year cycle. New advice will be prepared in 2020 for the years 2021-3.

For single stock summary sheet advice:

1) **Assessment type:** update assessment
2) **Assessment**: Yes
3) **Forecast**: None
4) **Assessment model**: SPiCT
5) **Data issues:** None (although high number of discards poses an on-going problems for data-raising
6) **Consistency**: Update assessment, following specifications in the Stock Annex.
7) **Stock status**: Fishing pressure on the stock is below $F_{MSY\text{-}proxy}$ and the spawning stock size is above MSY $B_{trigger\text{-}proxy}$.

8) **Management Plan**: The EU multiannual plan (MAP) for stocks in the North Sea (EU, 2018) and adjacent waters applies to by-catches of this stock.

General comments

This was a well-documented and well-ordered assessment and advice.

Technical comments (advice sheet)

- Table 1 needs correcting to reflect the SPiCT assessment for stock status (both F and SSB) relative to reference point proxies $F_{MSY-proxy}$ and MSY $B_{trigger-proxy}$. The Qualitative evaluation row of the table should be removed.
- Table re-numbering required because Table 3 (former catch scenario table) is no longer needed and has been removed.
- Tabe 9: landings for 2002 do not match those from Table 8 (there is a 228 t difference when compared with the ICES estimates for landings summed across areas in Table 8).

Conclusions

The assessment has been performed correctly

fle.27.3a4 (flounder)

General

All information is present on the sharepoint. No advice was requested for this stock.

For single stock summary sheet advice:

1) **Assessment type: update/SALY**
2) **Assessment**: Survey trends-based assessment
3) **Forecast**: not presented
4) **Assessment model**: trend-based assessment
5) **Data issues:** No issues with the data.
6) **Consistency**: consistent with previous advice although not concistent with last year´s benchmark suggestion. The latter is because the SPiCT model proposed to be used during the benchmark was not accepted by WGNSSK.
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

There are some small discrepancies between the report and the advice in Table values for official landings. Specifically, check that official totals and landings by country match up in 2016 and 2018 for subarea 4 and for 2016 in division 3a. The relevant tables are 6.1 and 6.2 in the report and Table 8 in the advice.

Conclusions

The assessment has been performed correctly

had.27.46a20 (haddock)

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**: Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}
8) **Management Plan**: There is currently no agreed management plan for haddock for the full stock area. EU-Norway have requested an evaluation of multiple management strategies, which are currently under consideration. Scenarios are provided in the advice.

General comments

There was no deviation from the standard procedure. Data, assessment and forecast are done as specified in the stock annex.

Technical comments

The advice sheet is easy to read and clear. Here are few comments:

- Figure 1 seems to be missing in the advice sheet (If I choose no markup in review view I do not see it).
- Catch option table: missing tonnes for wanted, unwanted and industrial by catch
- Table 3 and 3b: apply ICES advice rule to percentage: 1X% needs to have 3 significant figures as 1X.X%

- In “Issues relevant for the advice”, it is mentioned that there are 4895 tonnes of discards in 2018. However, I see that there are total of 5032 t (discards) , 17 t BMS and 5t IBC in 2018. Does the 4895 refer to some other value or a subarea?
- In table 7a-7c, the sum of IBC from the 3 subareas is 1 t, which does not equal to 5t as reported in SAG and Table 10.
- In table 7a-7c, the sum of ICES estimated landing from the 3 subareas is 34343, which does not equal to 34470 as reported in SAG and Table 10.
- In the “Northern shelf ” panel of Table 9, the “ICES total catch” till “Total TAC” rows were not filled in correctly for 2018.

Conclusions

The assessment has been performed correctly.

lem.27.3a47d (lemon sole)

General

The assessment and advice was performed according to the benchmark winter 2017/2018. The eventual TAC for this stock is a combined TAC with witch flounder in the same area.

For single stock summary sheet advice:

1) **Assessment type:** update following benchmark during winter 2017/2018.
2) **Assessment**: Lemon sole has been defined as a category 3 species according to the ICES guidelines.
3) **Forecast**: presented.

   Assessment model: The stock assessment model used for the basis of the advice was SURBAR, including *ad hoc* adjustments for the observed low catchability of the available surveys for age 1 and 2 lemon sole. The advice is based on a comparison of the two latest index values (index A) with the three preceding values (index B), multiplied by the recent advised catch. Examinations of the data confirmed the approach and calculations.
4) **Data issues:** Tables with survey data were absent. Tables with the raw input data used to generate figure 9.3.4. (survey catch curves) would have been useful.
5) **Consistency:** Consistent with the benchmark.
6) **Stock status**: $F < F_{msy}$. Relative recruitment at age 1 shows a mostly downward trend since a peak in 2011.
7) **Management Plan**: None.

General comments

Based on delayed report.

Technical comments

No additional comments.

Conclusions

Use of appropriate L_∞ and L_{max} estimates in LBI analyses are adequately addressed in the assessment report. Specifically, an estimated L_∞ value of 284 mm was 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. Overall, the assessment has been performed correctly.

mur.27.3a47d (striped red mullet)

General

- mur.27.3a47d was benchmarked in 2015. The benchmark workshop agreed on the use of a4a as assessment model for this stock.
- Due to high uncertainties of the assessment, the DLS approach (2:3 rule) was applied to the a4a results and used as the basis for advice.
- During WGNSSK 2019 a SPiCT model was available. The uncertainties around the SPiCT model were too high, therefore it was concluded not to use SPiCT in the case of mur27.3a47d
- Length based indicators suggest that currently this stock might be exploited unsustainably. Thus, a precautionary buffer was applied with the DLS 2:3 rule.

For single stock summary sheet advice:

1) **Assessment type:** age based a4a model
2) **Assessment:** a4a model; trend based DLS approach (2:3 rule) as basis for advice; application of precautionary buffer based on length based indicators
3) **Forecast:** no forecast
4) **Assessment model:** a4a model
5) **Data issues:** only French age readings; survey tuning time series only available for the CGFS
6) **Consistency:** consistent with stock annex
7) **Stock status**: High catches has led to a depleted spawning stock. There are indications of strong recruitment in 2018.
8) **Management Plan**: no management plan

General comments

Input data is identical to last assessment with two years of additional data added. There were no deviations from the stock annex.

The chosen method indicates harvest rate below F_{MSY}. Can extreme growth overfishing trigger such results?

Conclusions

The assessment has been performed correctly.

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 2020 was presented. The advice for FU 3-4 may be updated once the results from the 2019 TV survey become available (subject to the advice reopening rules). This is unlikely to happen before ICES releases the summer advice (June/July 2019).
4) **Assessment model:** UWTV survey
5) **Data issues:** Discard data updated in summary tables 2009-2012
6) **Consistency:** This stock has been benchmarked by ICES in 2016 (WKNEPH, 2016).
7) **Stock status**:
   - Stock numbers as measured by the UWTV survey decreased with 4.2% between 2017 and 2018
   - Catch increased with 25% between 2017 and 2018
   - Level of discard has been variable between years due to changes in MCRS-regulations.
   - Landings in 2018 increased by 36% compared to 2017. Discards increased a similar 30% to render a total increase in catch by 35%.
   - The large increase in discard level by 300% between 2016 and 2017 may be due to strong recruitment events.
   - 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 years.
8) **Management Plan**: EU multiannual plan (MAP) for the North Sea (EU, 2016)

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.
- Change in advice was in large due to change in stock status
- Text on increase in Stock size due to increase in surveyed area from 2016-2017 was removed from Catch scenarios.

- Comment on increase on advice was removed from Catch scenarios
- Comment on Workshop on reference points planned for 2019 was deleted.
- Do assumptions on discard survival need to be backed up? Evidence from Nilsson and Valentinsson, but not reviewed by ICES.

Technical comments

- A number of minor edits were made to the advice sheet during plenary
- Explanation of line breaks in figure 1 included in figure legend.
- UWTV details are explained in SISP-manual. The group may think about removing "(for animals greater than 17 mm carapace length)" from the text on Figure 1 in the advice sheet
- Some rounding errors of landings and discards such that table 7 and 9 are not identical. 2009-2012 discards are substantially lower in table 7 (official ICES records)
- Table 7 is the controlled data and should be checked with the official data in advice tables and on SAG.

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 2020 was presented. The advice for FU 6 will be updated once the results from the 2019 TV survey become available. This is likely to happen in September 2019.
4) **Assessment model**: Underwater television (UWTV).
5) **Data issues:** Missing trips in 2017 and 2018 were included for this year's advice rendering higher than previously observed catches and harvest rate.
6) **Consistency**: This stock has been benchmarked by ICES in 2013 (WKNEPH, 2013) and the stock annex was updated.
7) **Stock status**:
    - Catch from missing trips due to sales slips not reaching ICES-database were unreported in 2017 and 2018. Landing in 2017 was revised to 1963t for FU6 representing an increase of 6% compared to 2016.
    - In 2018 1807 t were landed in FU6 area representing a decrease of 8% compared to 2017.

- The 2018 burrow density estimate (950 million) represented an increase of 5.3% compared to 2017 and is again above Btrigger
- With the revised catch data F2016-2018 was 10.4% and above the Fmsy (8.12%).
- F2018 was 8.4% also above Fmsy
- The short-term forecast based on MSY proxies suggests catches for 2020 of 1947 t in FU6 (assuming discarding to continue at recent average). This value will however be updated in June after the latest results from the 2019 UWTV survey become available.
- The advice is based on a HR of 8.1%, corresponding to the HR FMSY.
- A zero discards option was included in the advice as requested by the client

8) **Man. Plan.** EU multiannual plan (MAP) for the North Sea (EU, 2016). However, 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

- The report was not available at the time for this audit.
- Some comments and edits were added directly to the advice sheet where necessary using track changes.

Technical comments

- UWTV details are explained in SISP-manual. The group may think about removing "(UWTV) abundance for animals greater than 17 mm carapace length (used as F and SSB proxies)" from the text on Figure 1 in the advice sheet

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:** Annual assessment
2) **Assessment:** Analytical and temporal trends
3) **Forecast:** A short-term forecast for 2020 was presented. The results of the 2019 UWTV survey will be available by October, and the advice will be updated if needed before the end of the year.
4) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data

5) **Data issues:** None 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 $B_{trigger}$
- The harvest rate has slightly increased in 2017 and decreased in 2018. It is 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, although they increased in 2017 and 2018.
- The mean size of landings and catch decreased in 2017, probably due to a strong recruitment event. In 2018 the mean size of males and females increased again, although it did not reach the high values of 2016.

8) **Management Plan**: The EU MAP for the North Sea has been adopted and the F range 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, figures, and advice sheet were used for this audit.

Technical comments

Some comments and edits were added directly to the advice sheet where necessary using track changes.

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:** Annual assessment

2) **Assessment:** Analytical and temporal trends

3) **Forecast:** A short-term forecast for 2020 was presented. The results of the 2019 UWTV survey will be available by October, and the advice will be updated if needed before the end of the year.

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 $B_{trigger}$

- The harvest rate decreased abruptly in the late 1990s and since then it has been close to F_{MSY}. In 2018 the harvest rate is below the proxy of F_{MSY} and the F range proposed for the management plan.
- The size distribution of the stock in 2018 is similar to previous years

8) **Management Plan**: The EU MAP for the North Sea has been adopted and the F range 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, figures, and the advice sheet were used for the 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.

nep.fu.9

For single stock summary sheet advice:

1) **Assessment type:** Annual assessment

2) **Assessment:** Analytical and temporal trends

3) **Forecast:** A short-term forecast for 2020 was presented. The advice for FU 9 will be updated if needed once the results from the 2019 TV survey become available. This is likely to happen before the end of 2019

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 fluctuated around FMSY. In 2018 it is just below FMSY
- The mean size for males has increased in 2018 compared to 2017. The mean size for females is similar to 2017.
- The discard rate has been very low in 2017 and 2018.

8) **Management Plan**: The EU MAP for the North Sea has been adopted and the F range 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, figures, and the advice sheet were used for the 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.

nep.fu.33

General

The population density decreased by 41% from 2017 and 2018, and it has been recommended to reopen the advice for 2019 and 2020 to add the new information. The update of the advice is due to the change in the density estimate and landings. Mean weights have not been revised.

For single stock summary sheet advice:

1) **Assessment type:** Biennial
2) **Assessment**: Data-limited approach for Nephrops
3) **Forecast**: a table with the catch scenarios for 2019 and 2020 is included in the advice.
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 2018 (0.074 ind m^{-2}), multiplied by FU 33 habitat area (5737 km^2). 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 low. Due to the lack of discard data from this functional unit the advice is based on landings only. Two scenarios are presented in the advice sheet: 1) assuming zero discards; and 2) assuming 25% discard rate to estimate the harvest rates. The advice is based on the second scenario.
5) **Data issues:** Scarce sampling of catches. The mean weight of landings and discards were not updated since 2015
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, trends in size composition in Danish catches, and trends in population density estimated with the UWTV. In 2018 the Danish LPUE decreased considerably, from 0.8 kg/kW day in 2017 to 0.2 kg/kW day in 2018. However, confidence intervals of the Lpue are not available in the report. The population density also decreased from 0.127 Nephrops m^{-2} in 2017 to 0.074 Nephrops m^{-2} in 2018.
8) **Management Plan**: No management plan for this stock

General comments

The assessment was well-documented.

Technical comments

Edits were added directly to the advice sheet where necessary using track changes.

Conclusions

The advice is based on the average catches of the last 10 year period (2009-2018), which follows the precautionary approach for the stock and is well founded given the results of the assessment. Because the harvest rate is above the most conservative lower bound for MSY in other FUs (7.5 %), a 20% precautionary buffer was applied.

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.

nop.27.3a4 (Norway Pout)

General

Assessment and forecast completed in good time (under severe pressure) 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. Age reading errors in the Danish catches for 2019 were detected very late, and required the rerunning the assessment and conducting extra data checks.

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 has evaluated 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).

The report could do with some judicious pruning, with legacy material either referenced or moved to the stock annex. There were some errors in the advice sheet that were corrected.

Technical comments (advice sheet)

- Table 2 – it would be useful to specify the range of years used in the recruitment re-sampling.
- Table 3 - % SSB change was calculated incorrectly for some of the catch scenarios (5th percentile used instead of median). Furthermore, the 5th percentile and median SSB columns were switched for the F scenarios. These have all been corrected.
- The management plan description is far too long and not needed (see last year's advice sheet).
- Figure 2 – there should be some comment on the retro pattern that is now clearly present in the estimation of SSB.
- Table 7 – the official catches and ICES catch estimates should match up to those reported in Table 9 (I corrected them so they match for the most recent years).
- Table 8 was missing values, so I took these from Table 9.
- Table 11 headers should be as last year, including table footnotes.

Conclusions

The assessment has been performed correctly

ple.27.420 (plaice)

For single stock summary sheet advice:

1) **Assessment type:** update assessment
2) **Assessment**: analytical
3) **Forecast**: presented, deterministic forecast in FLR
4) **Assessment model**: update assessment, AAP age-structured assessment based Aarts & Poos (2009), using catch data in model and forecast, tuning by 6 survey indices (combined

BTS 1996–2018), BTS-Isis (1985–1995), SNS1 1970–1999, SNS2 2000–2018), IBTS Q1 (2007–2018), and IBTS Q3 (1997–2018).

5) **Data issues:** Some difficulty in estimating ages 1-3 and older individuals as surveys give conflicting information. Potentially individuals undergo northwards expansion, affecting estimates of older individuals. The issue list includes consideration of combined index (delta-GAM method), trial runs with alternative assessment model (SAM).
6) **Consistency**: Slightly higher estimate of SSB and lower F as compared to last year, potentially relating to data issues with the surveys.
7) **Stock status**: B>MSY $B_{trigger}$ marked increase since 2008, $F<F_{msy}<F_{pa}<F_{lim}$, Rec fluctuating around long-term average (since 1990).
8) **Management Plan**: Advice is based on MSY approach. The EU management plan (MAP), is not adopted by Norway and is given only as a catch option.

General comments

The draft report section for this stock was not available at time of the audit.

Audit was based on powerpoint presentation, stock annex, advice sheet, scripts and data files on the ICES sharepoint. Some minor edits necessary see technical comments below, otherwise input data and methods used as described in stock index.

Technical comments

Advice sheet:

- The unscaled average of fishing mortality in 2016-2018 are used in the intermediate year forecast (variation from presentation/stock annex where it is scaled to final year, explain in footnote).
- Explain in caption unshaded recruitment bar in Figure 1 (geometric mean 2006-2015).
- Advice sheet Table 3, correct the SSB%change column. Error potentially relating to wrong rounding of SSB(2020) before the calculation of SSB% change (script. process_STF_result_for_advice_sheet.R line 14)
- Advice sheet Table 5, check the MAP Blim, not the same value as Blim; MAP Flower=0.146, while the stock annex uses 0.15 for Flower (rounding?)

Stock annex:

- The stock annex list maturity at age 1 to be 0, age 1 and 2 is 0.5, and older is 1. The actual input is age 1 is zero, 2 and 3 is 0.5, older is 1. This looks like error in the stock annex as age 1 gets assigned to different values (correct stock annex).

Data:

- The stock object in WGMIXFISH folder does not contain assessment results? (stock.n, stock, F).

Conclusions

The assessment has been performed correctly.

A few clarifications in the advice sheet are recommended (see Technical comments).

ple.27.7d (plaice in the eastern English Channel)

General

The assessment and advice was performed according to the Stock Annex (SA). Also, assessment and forecast are on in the TAF. The eventual TAC for this stock is a combined TAC with plaice in 7e.

For single stock summary sheet advice:

1) **Assessment type:** update following benchmark in 2016
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical assessment (Aarts and Poos, 2009; ICES, 2018b) that uses catches in the model and in the forecast (ICES, 2019)
5) **Data issues:** Data was available as described in the SA
6) **Consistency:** Different assumption for intermediate year recruitment in forecast was used (Geometric mean 2013–2016, in thousands)
7) **Stock status**: SSB > MSYBtrigger, F < Fmsy, Recruitment around average of the last 10 years of the time series
8) **Management Plan**: EU multiannual management plan (MAP) plan for **the Western Waters** (EU, 2019), plan is considered to be precautionary
9)

General comments

Report not available at the time of the audit

Technical comments

Report not available at the time of the audit

Conclusions

Based on the assessment and forecast on TAF and the advice sheet on the sharepoint, the assessment has been performed correctly, the recruitment assumption for the intermediate year in the forecast deviates from what is used last year. SA is indecisive about the recruitment assumptions in the forecast, therefore the decisions taken at the 2019 working group are valid.

pok.27.3a46 (saithe)

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; New forecast assumption for recruitment is the median recruitment from 2009-2018.
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. There are some inconsistencies in figures and tables numbering. And, at the time of the review, some captions needs to be updated.

No major inconsistencies have been found.

Technical comments

Advice Sheet:

- Few inconsistencies were reported to the assessor and have already been fixed in the advice sheet.

Report (vs advice sheet):

Some inconsistencies in the table and figure numbering are present, and minor updates to the captions of tables and figures are needed (some comments and edits were added directly to the report draft where necessary using track changes). All the information contained in the report, tables and figures seem to reflect the ones in the advice sheet.

Assessment and forecast Configuration:

The assessment and forecast assumptions are the same as the ones reported in the stock annex. Only the intermediate year assumption for recruitment changed from median recruitment resampled from 1998–present to median recruitment from 2009-present. This needs to be changed in the stock annex.

Conclusions

The assessment has been performed correctly.

sol.27.4 (sole)

General

The assessment has been performed as described in the stock annex.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Art and Poos statistical catch at age model (AAP, Aarts and Poos (2009)) - tuning by 2 surveys (BTS-ISIS 1985-2018, ages 1-9 and SNS 1970-2018, ages 1-6)
5) **Data issues:** The data used in the assessment have been provided on TAF.
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**: All forecast F values between Fmsy_upper and Fmsy_lower are considered precautionary (i.e. SSB 2021 > Bpa = 37 000 t).

General comments

- The assessment was well-documented, but a few small inconsistencies were found.
- Either the language of the Stock Annex should be made clearer, or there is a small inconsistency with the assessment regarding how F status quo should be calculated (See technical comments below).
- All code has been provided to the Sharepoint. The assessment code has been provided to TAF, but forecast code is missing.
- Report needs to be updated on the Sharepoint.
- Summary of IC outputs still need to be added to data/intercatch folder.
- FLStock object for MIXFISH is mainly empty (besides catch), and should be updated with assessment output.
- The spatial distribution of the fishery is not longer completely consistent with the survey. Future benchmark will assess the additional of the Belgian BTS survey to provide better coverage.

Technical comments

- The SA states, "The exploitation pattern is taken to be the mean value of the last three years, scaled to the last years F". Table 2 states that the scaling has been done to the last 3 year average (2016-2018), but the forecast code (sol.27.4.STF.R) : Fsq <- mean(harvest(stf_Object)[ac(meanFages),ac(assyear)]). So the forecast appears to have been done correctly, but Table 2 is incorrect. Also, the SA sentence should be changed to "… scaled to the last **year's** F"

- The value for B_{MGT} is not presented other than as a check in Table 1.
- Table 3 has twitched the labels for Bpa and Blim scenarios.
- Natural mortality (M) is 0.9 for 1963 – please fix Table 6.
- If possible, could the assessor add comments to the assessment configuration settings so as to allow reviewers a clearer way of checking against the SA description.
- The selection pattern differs significantly for the final three years of the assessment – Although the forecast uses an average selectivity pattern over the past 3 years, the assessment model's sensitivity to this might be looked at in the future.

Conclusions

The assessment has been performed correctly according to the Stock Annex and catch options are consistent with the MAP.

sol.27.7d (sole in the eastern English Channel)

General

The input data, assessment and forecast settings and outputs were checked and seems correct. All change compare to the stock annex are well described in the report and the advice sheet.

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. Belgium and UK commercial indices were recently changed during the 2019 Inter-benchmark. 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:** Due to an issue with catch French data in 2016 and 2017
6) **Consistency:** the main change in stock perception is due to the large increase of the group plus numbers in the assessment that might be related to the catch data issue. The 2017 strong recruitment observed in UK-BTS index might also explain part of this change.
7) **Stock status**: SSB > $B_{trigger}$; F < F_{MSY}
8) **Management Plan**: EU multiannual plan agreed in 2019:

General comments

Audit was based on powerpoint presentation, stock annex, advice sheet, report, scripts and data files on the ICES sharepoint. Some minor edits necessary; see technical comments below. Otherwise, assessment and forecasts are well documented and ordered and follow the stock annex. Due to the impact of the data issue on the stock status perception, the group has decided to downgrade the stock assessment to category 3 and based the forecast on the trend produced by XSA.

Technical comments

No inconsistency was noticed.

Conclusions

The assessment has been performed correctly.

tur.27.3a (turbot in Skagerrak and Kattegat)

For single stock summary sheet advice:

1) **Assessment type:** **N**o assessment
2) **Assessment**: No assessment
3) **Forecast**: No forecast.
4) **Assessment model**: No assessment model was presented for turbot in 3a, due to extreme paucity of available data. Only landings and discard tonnages were presented, along with an illustrative SPiCT model run based on survey data.
5) **Data issues:** No age data from commercial landings and discards, very limited length data (the extent of which has reduced considerably over the last two years). Survey catch-at-age data exist from two surveys, but appear to be noisy and do not track cohort-strength signals.
6) **Consistency**: No comparative assessment in previous years.
7) **Stock status**: SPiCT analysis indicates that the stock is likely to be exploited sustainably.
8) **Management Plan**: No management plan exists for this stock. ICES have not been requested to provide management advice, so the WGNSSK report and advice sheet only summarise perceptions of stock status.

General comments

The draft report section for this stock was available at time of the audit. The report summarises stock status through landings and discards data, along with an illustrative SPiCT run (as last year).

Technical comments

Advice sheet:

- The advice sheet has been updated as required, and appears to cover the available information. No advice is requested for this stock, so the advice sheet only summarises catch and survey data.

Stock annex:

- Section A.1 (Stock definition) should be updated, as it refers to papers in preparation in 2012 which I presume are published by now (there is also no reference given to the Vandamme paper).
- Section A.3 (Ecosystem aspects): on what basis do the authors state that "survival rates of discarded turbot are likely to be high"? This needs to be justified.
- Section B.1 (Commercial catch): are there no length data in InterCatch that could be used? It seems odd that length data have "never been compiled". Also, the approach used in InterCatch raising is given in the stock section, but it should really also be indicated here.
- Section B.2 (Biological): Have the number of samples been enumerated yet? The text says it "remains to be investigated", but that was last updated in 2012.
- Section H.2: I don't understand the first sentence of this Section: it would benefit from revision.

Stock section:

- Section 21.2: why is raising in InterCatch done with the stock defined as age-based, when there are no available age data from commercial catches? Also, what is the reason for not treating all gears together in raising?
- Section 21.3: it would be helpful to see a short commentary on the results of the SPiCT assessment. It would also be useful to see a short note on why the ADG rejected the SPiCT assessment in 2017.

Conclusions

The available data have been presented as required by the Stock Annex. All tables and figures are presented correctly.

tur.27.4 (turbot)

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM, 2 survey tuning indices (SNS, BTS Isis) + 1 Dutch commercial LPUE index
5) **Data issues:** All data available,
6) **Consistency**: Update from the 2018 IBP assessment

7) **Stock status**: ICES assesses that fishing pressure on the stock is below F_{MSY}, F_{pa} and F_{lim}; and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

8) **Management Plan**: Part of the EU plan, treated as bycatch stock ➔ advice based on PA approach next to MSY approach

General comments

This was a well documented, well ordered and considered section. However, some parts are missing, especially the forecast input and output tables. Also a short discussion of the assessment diagnostics could provide information for the reader.

Technical comments

Assessment

Recommendation: Smoothed weights at age are used instead of the Intercatch values and afterwards an SOP correction is carried out with the numbers at age. This could lead to some bias especially in F estimates because the numbers given as input influence the calculation of F. At the next benchmark it could be checked whether at least for recent years the values for mean weight at age from Intercatch could be used directly or whether smoothing is still required. Another alternative could be to do the SOP corrections with the SOP coming out of Intercatch, This would result in a higher or lower catch in tonnes compared to the one imported to Intercatch but numbers at age would be no longer impacted.

Advice sheet

Is the Fsq intermediate year assumption really the average F of the last three years? Or is the exploitation pattern the average over the last three years scaled to the F in the final assessment year?

Potentially very small rounding issues when calculating total catch from wanted catch in some of the scenarios (e.g. SSB (2021) = MSY $B_{trigger}$). But could well be that it is correct when using the raw values to calculate total catch.

Rounding issues in table 8. The sum for area 4 is often 1-2 tonnes off compared to the sum of the single values by country. Footnote missing indicating preliminary data (in most cases last two years).

Report

Chapter 22.1.3: The stock is part of the EU plan. As bycatch stock not explicitly mentioned with F_{MSY} ranges but definitely covered. ➔ Advice based on the PA approach as requested by the Commission

Chapter 22.2.5: The table showing the grouping of gears/métiers is unclear as e.g., OTB and TBB is mentioned in more than one group.

Has discard raising been carried out also by quarter? Unclear from the text.

The table captions and the text often talk about catch, while landings are meant. This could create confusion by readers from outside the group.

The model diagnostics are not discussed and just shown. A few sentences could be added.

Mohn's Rho has not been calculated

Forecast input and results are not shown in the report (Tables or figures). This needs to be added.

Is the Fsq intermediate year assumption really the average F of the last three years? Or is the exploitation pattern the average over the last three years scaled to the F in the final assessment year?

Conclusions

The assessment has been performed correctly. The STF files on the sharepoint were checked and the forecast seems to be ok. owever, forecast input and output has not been presented in the report. Therefore, the audit is to some extent incomplete with regard to the forecast.

whg.27.3a (whiting in Skagerrak and Kattegat)

General

All information is present on the sharepoint in regards to the latest advice. However, I was unable to locate the stock annex for Whg in 27.3a on sharepoint.

For single stock summary sheet advice:

1) **Assessment type: update/SALY**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: no assessment
5) **Data issues:** No issues with the data.
6) **Consistency**: Consistent with previous advice.
7) **Stock status**: Stock and exploitation status cannot be assessed based on current data availability
8) **Management Plan**: No management plan exists

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

i) Tables in the report need to be updated with the latest numbers.

ii) In Table 2 in the advice, the advised catches should be for (2020-2021).

iii) In the advice, numbers from 2017 and 2018 in the table should be marked with an Asterix showing they are preliminary and an explanation should be added below the table explaining this.

iv) I was unable to locate the stock annex on sharepoint. Make sure it is there.

Conclusions

The assessment has been performed correctly

whg.27.47d (whiting)

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM, 2 survey tuning indices (IBTS q1 and q3)
5) **Data issues:** All data available, age reading may be uncertain/biased.
6) **Consistency**: Update from 2018 assessment
7) **Stock status**: ICES assesses that fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and B_{pa}, but above B_{lim}.
8) **Management Plan**: Part of the EU plan. Shared stock with Norway ➔ Advice based on the MSY approach

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret. However, the section would benefit from a shortening of some chapters (e.g., biological reference points, benchmark).

Technical comments

Advice sheet:

The table for the intermediate is unclear regarding the discard and industrial bycatch rate used (average last 3 years proportion of numbers at age in total catch?)

here is no description what happened with the Norwegian BMS. It could be considered to include footnotes describing in which catch component these are included.

Table 6: What age allocation has been made for industrial bycatch? A short sentence could be added.

Table 9a and b: ICES landings mean human consumption landings (without industrial bycatch), isn't it? Could be made more clear in the footnote.

Discrepancy between Table 8 and table 9a and b. The sum of ICES estimates from table 9a and b is 16395 Tonnes, in table 8, the wanted catch is 16444. Please check and if correct, please explain in a footnote the difference between the two numbers.

Table 8: Rounding issue, the catch components sum up to 28084 Tonnes.

Table 7 and table 8: The sum of total catch for area 4 and 7d in 2018 is 28035 in table 7, but 28084 in table 8. Please check or explain the discrepancy in a footnote.

Report:

The numbers in the tables and in the assessment for the different catch components seem to be the SOP and not the imported value in tonnes. This could be mentioned more explicitly.

Sometimes the numbering of tables and figures is not in line with the order the tables are referenced in the text.

Table 21.1.3b should be 23.1.3b.

The chapter on the last benchmark is very long and a reference to WKNSEA and the stock annex may be sufficient.

There is no table showing the final SAM settings. Given that the stock annex is often difficult to find and the detailed assessment input and output is not public, I prefer to have a table with the settings from the current assessment in the report.

Table 23.1.20: Please make clear in the heading that these are the SAM estimates and not the input.

Chapter on biological reference points could be shortened considerably.

Table 23.1.25. The sum over products of numbers at age*maturity*stock weight gives 167113.735 tonnes for 2019, while SAM estimates a median SSB of 163406. Is this because you use the average over the last three years for stock weight and maturity? Please check.

Conclusions

The assessment has been performed correctly. Survivors as start point for the short-term forecast need to be checked.

wit.27.3a47d (witch)

General

In 2018 a benchmark for witch has taken place. Within the benchmark it was decided to upgrade the stock to a Category 1 stock providing annual advice for Witch using SAM. The benchmark determined the reference points for the stock, but did not determine $F_{MSY\ upper}$ and $_{lower}$. In addition no short-term forecast was done during the benchmark.

Age-data are available since 2009, before only total biomass is available. Given SAM is an age-based model and to overcome this short time series of age data artificial catches-at-age are produced from the period 1940–1944. The artificial catches-at-age are the average catches-at-age for 2009–2016. Sensitivity runs were performed to ensure the artificial catches did not influence the assessment. The sensitivity runs showed no important influence in the 1950–2016 assessment period.

It is the first year a Category 1 advice will be presented for Witch.

For single stock summary sheet advice:

1) **Assessment type:** annual assessment
2) **Assessment**: Analytical
3) **Forecast**: A short-term forecast for 2020 was presented during WGNSSK using 9 different scenarios.
4) **Assessment model**: A SAM (State–space Assessment Model) was used tuning by 2 surveys indices by age from IBTS Q1 (ages 1–7) and IBTS Q3 (ages 1–6) for 2009–assessment year (2018); no age data exist prior to 2009, only total biomass is available.
5) **Data issues:** There were some issues concerning the use of BMS. Norway have uploaded large numbers of BMS for Witch. The assessors chose to allocate BMS as landings in Intercatch.
6) **Consistency**: Witch has been upgraded to a Category 1 assessment after the 2018 benchmark. It's the first year a Category 1 advice is given.
7) **Stock status**: SSB was below B_{lim} around 2010, but has increased and has been above MSY $B_{trigger}$ since 2013. Fishing mortality has been above F_{MSY} within the entire time-series, dropping below F_{pa} around 2010. In recent 2 years F has been at or above F_{pa}.
8) **Management Plan**: No agreed management plan

General comments

Presentations providing an overview of the assessment and forecast were available on the SharePoint of the working group. The presentations clearly state the procedures followed, reference points used and outcomes of both the assessment and forecast. Reference points in the advice and used for the forecast where checked with reference points in the benchmark and were the same. As such, the assessment is easy to follow and interpret. Input and output data was correct with slight deviations in table 3 of the advice which can be explained by the stochasticity used to perform the forecast for this stock.

During the audit the updated report as well as Stock Annex could not (yet) be consulted.

Technical comments

Standard assessment Graph for recruitment needs to be adapted. The last year of recruitment needs to be unshaded.

Table 3 needs to be checked: different numbers in presentation compared to presented in advice sheet. I contacted the stock coordinator about this, as I know something within the forecast changed. In addition, the forecast is stochastic so deviations in values is possible. A good check of the values is needed here.

In table 3 no Fmsy upper or lower are presented. These were not determined during the benchmark in 2018 and therefore also not peer-reviewed. Hence, the group accepted not to include this in the advice sheet.

In table 6 some the landings + discards do not entirely sum up to catches. This can be explained by the rounding used in the advice while calculations are done not using rounded numbers.

Table 7 in the advice needs to be completed. I understood the stock coordinator is still finalizing the advice sheet as well as the report. Hence tables in the advice and report cannot be compared.

Conclusions

The assessment has been performed correctly. The stock coordinator should look at the Stock Annex and see whether it has been properly updates since the benchmark in 2018. After the audit the stock coordinator processed the comments:

- Added unshaded last year of (assumed) recruitment
- Table 3 was updated again (sorry about that).
- The differences in recruitment between scenarios (which was one of the causes of difference between presentation) were known and STF was rerun with more correct setup. So there are new small differences, but everything is checked and is more correct now. Actually other stocks that use SAM and do stochastic forecasts will have a small issue with the differences of recruitment between scenarios. If the number of simulations is high it is so small that it does not matter. Again, given that the forecast is stochastic, deviations in values is possible.
- Two extra scenarios were added as asked by the group, i.e. a scenario with Fmsy upper and lower
- Table 6 mismatches are due to rounding
- Table 7 is now complete

1.2 Audits for update assessments

cod.27.47d20

General

The assessment is identical to May 2019 "final assessment" with one additional year of IBTS Q3 data added. This one year adding of data changed most indices upwards (the output from the delta-GAM used as input to the tuning).

For single stock summary sheet advice:

1) **Assessment type:** Update of May assessment.
2) **Data issues:** None detected beyond the IBTS Q3 change.
3) **Consistency**: Consistent with May 2019 assessment except for changes to historic values used as input (see 5). All settings and assumptions identical to May 2019 assessment
4) **Stock status:** Point estimate of F is above F_{lim} and point estimate of spawning stock size is below B_{lim}.
5) **Man. Plan.**: There is currently (October 2019) no agreed management plan. ACOM should have another look at the basis for advice given in June 2019. Has SSB=Blim been added in the guidelines for the ICES MSY approach? Is the change in perception of stock status and fishing mortality so large that it invalidates the ICES MSY approach?

General comments

The assessment is very well described and visualized.

Technical comments

Changes to the IBTS Q3 tuning series by adding one more year of data is illustrated in Table A1.2.1:

Table A1.2.1. 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	2.3	3.4	3.2	2.4	4.8	6.3
1993	3.5	5.4	5.2	3.0	5.3	7.1
1994	3.2	6.1	3.1	2.2	4.9	6.4
1995	2.2	4.4	3.8	2.2	4.4	8.9
1996	1.5	6.4	2.6	1.8	4.8	6.9
1997	1.4	4.1	2.5	1.6	4.5	5.6
1998	-2.6	6.3	1.1	2.6	1.8	3.0
1999	1.1	5.1	2.5	1.4	3.3	4.3
2000	0.7	4.8	3.3	1.6	3.9	4.0
2001	2.1	6.3	3.0	1.6	4.2	5.4
2002	0.2	8.8	3.4	1.7	4.4	4.9
2003	1.5	4.9	3.3	2.1	5.4	7.7
2004	0.1	4.6	3.1	2.6	4.1	5.8

2005	0.0	5.1	2.4	2.0	4.6	5.1
2006	0.8	4.8	3.8	3.4	4.7	5.7
2007	0.5	4.1	2.6	1.8	2.1	4.2
2008	-0.7	6.4	3.4	3.0	4.6	5.7
2009	-1.2	4.1	4.1	2.7	5.1	4.7
2010	-1.5	4.1	3.2	2.4	4.4	3.9
2011	1.3	5.4	4.1	3.2	4.5	5.3
2012	0.7	6.7	2.9	2.6	4.7	4.7
2013	-0.5	6.6	3.5	3.2	5.1	4.6
2014	1.4	4.4	5.6	3.3	4.8	4.9
2015	-1.5	4.0	4.1	3.4	4.9	4.5
2016	0.9	5.3	3.3	2.8	4.4	4.6
2017	0.9	5.9	0.1	1.5	4.4	4.7
2018	-0.1	6.0	-1.0	2.8	4.6	4.5

Conclusions

The assessment has been run in accordance with the benchmark choices.

had.27.46a20 (haddock)

For single stock summary sheet advice:

1) **Assessment type:** no assessment update since spring advice, only STF update
2) **Forecast**: updated
3) **Data issues:** No issues reported
4) **Consistency**: Update recruitment assumption for intermediate year, consistent between years.
5) **Stock status**: Fishing mortality (F) has declined since the beginning of the 2000s but it has been above F_{MSY} for the entire time-series. Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ in most of the years since 2002.
6) **Advice update:** The change in advice (from -11% to 23%) is due to an incoming year class that is significantly larger than the recruitment seen in the most recent years for this stock.

General comments

There was no deviation from the standard re-opening procedure. Data, and forecast were done as specified in the stock annex.

Technical comments

Table 10 seems to be just a summary table for assessment output, rather than assumptions in STF. Since the assessment model TSA does estimate recruitment for 2019, I am not sure if we need to update recruitment for 2019 in this Table.

Conclusions

The RCT3 analysis and updated forecast has been performed correctly.

nep.fu.6

For single stock summary sheet advice:

1) The advice was reopened following the UWTV-survey in 2019. Advice was revised with the updated survey index resulting in an increase in TAC.
2) Heading %-advice change of table 3 has 3 digits. One or two is sufficient.
3) Is the formulation "The change in the advice (-1.74% for the EU MAP FMSY scenario) from November 2018, is a result of updating landings, mean weights, discard rates and stock abundance." correct or should it be updated for October 2019 version and read 20.29%?

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

General

For single stock summary sheet advice:

1) **Forecast:** A short-term forecast for 2020 was presented based on the harvest rate. The advice was reopening to incorporate the results of the last UWTV.
2) **Assessment model:** Based on underwater TV survey linked to yield-per-recruit analysis from length data
3) **Data issues:** None found
4) **Consistency:** All input data used are identical with one more year added
5) **Stock status**: -
   - The stock size is above MSY $B_{trigger}$
   - The harvest rate has slightly increased in 2017 and decreased in 2018. It is 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, although they increased in 2017 and 2018.
   - The mean size of landings and catch decreased in 2017, probably due to a strong recruitment event. In 2018 the mean size of males and females increased again, although it did not reach the high values of 2016.

General comments

The available spreadsheets, figures, 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.

nep.fu.8

For single stock summary sheet advice:

1) **Forecast:** A short-term forecast for 2020 was presented based on the harvest rate. The advice was reopening to incorporate the results of the last UWTV.
2) **Data issues:** None found
3) **Consistency:** All input data used are identical with one more year added
4) **Stock status**: - The stock size is above MSY $B_{trigger}$
   - The harvest rate decreased abruptly in the late 1990s and since then it has been close to F_{MSY}. In 2018 the harvest rate is below the proxy of F_{MSY} and the F range proposed for the management plan.
   - The size distribution of the stock in 2018 is similar to previous years

General comments

The available spreadsheets, figures, and the advice sheet were used for the 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.

ple.27.420 (plaice)

For single stock summary sheet advice:

1) **Forecast**: presented, deterministic forecast in FLR, updated following re-opening in October 2019. The assessment is not updated.
2) **Data issues:** BTS-Q3 2019 survey information was included to re-estimate recruitment (age1) and numbers at age 2 in intermediate year 2019. The 2019 BTS-Q3 survey is incomplete without the 2019 UK BTS-Q3 data, which is uploaded to DATRAS only the following year. The lack of UK BTS data is expected to have minor influence on the final indices of younger ages 0-2 due to the spatial distribution.
3) **Advice update**: The autumn forecast update results in a change in advice of 17.1% as the result of the strong 2018 year-class, instead of -7.6% (spring advice).

General comments

Audit of the reopened forecast and advice is based on uploaded data, advice sheet, re-opening protocol in Annex 7 of the WGNSSK draft report. The forecast was updated following the re-opening procedure and stock annex, and advice sheets is updated correctly.

Age 1 and age 2 in the intermediate year are updated with RCT3 values to derive new short-term forecast estimates and used a basis for advice. An alternative option (option 2) with only RCT3 for age 1 updated and AAP survivors for age 2 in the intermediate year is presented for comparison in Annex 7.

Technical comments

Minor correction for Annex 7 of the draft report:

Update Table caption of reopening protocol (Table 7.6.7) should read "using RCT3 for age1, RCT3 for age 2" for option 1.

Conclusions

The reopening procedure was followed correctly. The advice sheet has been updated correctly with the new values.

sol.27.4 (sole)

General

The assessment has been performed as described in the stock annex.

For single stock summary sheet advice:

1) **Forecast**: presented following re-opening. The assessment is not updated.
2) **Data issues:** None, but the re-opening assessment and forecast code still needs to be provided to TAF. Furthermore, the introduction of the Belgian BTS index is to be explored in the next Benchmark.
3) **Consistency:** Recruitment of age 1 for the intermediate year has been updated with a substantially higher estimate (476 477, >4x the value from the spring advice estimate of 112788). Assessment year F and SSB are unaffected by the reopening.
4) **Advice update**: The autumn forecast update results in a change in advice of +37% as the result of the strong 2018 year-class, instead of -3.8% (spring advice).

General comments

- The re-opening was done correctly according to the protocol agreed to with the WG Chair. The re-opening only affects the forecast.

- The protocol for the re-opening and running of RCT3 needs to be better documented in the SA or elsewhere. As is, there is a two-step RCT3 protocol by which BTS indices are first used to identify inconsistencies between the spring recruitment assumption and the RCT3 prediction. If inconsistencies are found, a second RCT3 is run with all survey indices. The rationale for this procedure is not presented.
- The indices used in RTC3, as well as their time spans, are not entirely consistent with those used during the assessment tuning. Recruitment time series are also only spanning those years used in the calculation of the long-term geometric mean used during the spring advice (1976-2014). Rationale for not using the most recent years is lacking.

Technical comments

- Some few inconsistencies and rounding issues in the report document were found and communicated to the author (e.g. rounding issues). These have since been corrected.

Conclusions

The updated assessment has been performed correctly according to the guidelines agreed upon with the WG Chair and catch options presented are consistent with the MAP.

Annex 6: Benchmarks and prioritisation

A.1 Benchmarks

A.1.1 Executive Summaries of recent benchmarks and inter-benchmarks

A.1.1.1 Turbot in 4 (IBP Turbot 2018)

The IBP (inter-benchmark protocol) turbot 2018 meeting was held in Ijmuiden, the Netherlands, 30–31 July 2018, co-chaired by Alexander Kempf (Germany) and José De Oliveira (UK), to reconsider the results from the IBP turbot 2017 meeting in the light of an inappropriate treatment of the Dutch LPUE time series as an SSB index instead of an exploitable biomass index. This required reconsidering the configuration of the model and the setting of the plus-group in the assessment and maximum age in the survey data, reviewing the Categorisation of the stock in light of the new configuration, calculating reference points following the appropriate guidelines, and reviewing the settings for the short-term forecast if a Category 1 classification was made. This process did not revisit the input data.

A new configuration was derived, similar to the one derived for IBP turbot 2017, and keeping the plus-group at 8+. This new configuration led to a substantial improvement in the retrospective pattern, particularly on F, and this, together with acceptable model diagnostics, allowed the re-classification of the stock as Category 1. A new set of reference points was derived, leading to an FMSY of 0.36 and an MSY $B_{trigger}$ of 6353 tonnes.

The meeting also made some recommendations for future work that could potentially lead to further improvements. This included making an effort to include LPUE series from nations other than the Netherlands (Denmark, Belgium and the UK), exploring improvements to mean weight-at-age data (through improved sampling and/or modelling), exploring the use of externally-derived estimates of sampling CV for e.g. the Dutch LPUE series (which currently receives a very high weight in the absence of such CVs), developing a standardised survey with higher catch rates for large flatfish that could potentially improve the assessment for turbot, explore the use of fleet-based data and SAM assessment to better handle estimation of selectivity, and exploring Delta GAMs for combining BTS surveys once age information are more readily available through DATRAS.

A.1.1.2 Saithe in 3a, 4 and 6 (IBPNSsaithe 2019)

The Interbenchmark for North Sea saithe (IBPNSsaithe), chaired by Daniel Howell (Norway), was held by correspondence on the 28–29 January 2019 with one reviewer (David Miller). IBPNSsaithe was charged with reviewing and approving changes to the North Sea saithe assessment (pok.27.3a46) following the discovery of an error in the model code dealing with a CPUE tuning series, and revising the reference points and advice sheets accordingly. Work was tightly focussed on addressing this issue, with a more wide-ranging analysis of the model referred to the next full benchmark. A separate check was conducted and concluded that this code error only affected the variant of SAM used for the North Sea saithe assessment, and that no other ICES stock assessments are affected by this issue.

It was clear that the previous version of the assessment model was incorrect, and that the assessment should not be continued on that basis. The model with the code error fixed produced different estimated biomass, different reference points, and a lower recommended TAC. Changes to the assessment model therefore require a revision of the advice sheet and reference points.

IBPNSsaithe was presented with the option of either excluding the CPUE tuning series, or including this tuning series with the corrected code. The IBP recommends that the model including the CPUE tuning series with the corrected code be the basis of the assessment model in the future, and be used as the basis for the forthcoming MSE exercise in the North Sea (WKNSMSE). The IBP recommended that the settings for using this tuning series remain the same as at the last benchmark, and recommended a more detailed analysis at the next benchmark.

Full details of the model configuration are therefore still to be found in the last bench-mark report (WKNSEA 2016) and the stock annex, and are described in brief in this report. The revised stock trends, reference points and the analyses and diagnostics con-ducted are presented in this report.

A.1.1.3 Sole in 7d (IBPsol7d 2019)

The ICES Inter-Benchmark Protocol of sole in the Eastern English Channel stock 2019 (IBPsol7d 2019) convened at ILVO in Ostend, Belgium (20–21 August 2019). The reason for this IBP was the missing data for 2017 to 2018 in the UK beam trawl commercial index (UK-CBT) related to the recent change in the database system in UK. The goals of this IBP were to investigate the internal consistency of the new UK-CBT produced and to analyse its influence on sol.27.7d assessment. The model used to assess sol.27.7d stock is an extended survival analysis (XSA) and no other model was tested. During the IBP, it was decided to revise the Belgium beam trawl commercial index (BE-CBT) to move from a Landing Per Unit of Effort (LPUE) index to a Catch Per Unit of Effort (CPUE). This decision was motivated by the increase of sole age 2 discards in recent year and also to investigate the feasibility of adding a second indices to tune age 2 sole in the assessment and put UKBTS survey index into perspective.

The IBP investigated alternatives to calculate both new commercial indices. Originally, in the old UK-CBT a 10% threshold of sole in the landing was applied to select the vessels used in the index. The IBP decided to withdrawn that threshold to produce the new UK-CBT considering that all beam trawlers using an appropriate mesh size have sole at least in their by-catch. The new BE-CBT now include both small and large fleet segment in addition to the discards information. A vessel effect is applied to standardize the new BE-CBT index. Both index indices were calculated using mixed GLM.

Several assessment settings were tested replacing each new index one at a time. The IBP agreed to use the new UK-CBT and the new BE-CBT in the assessment of sol.27.7d stock. However age 2 of the new BE-CBT was dropped as the residual pattern of the model at age 2 was considered too high by the IBP (absolute value of 2 or above in a log-scale). The diagnostics of the assessment was considered good enough to use the assessment as basis for advice although some issues with input data remain. The final XSA assessment run included the revised UK-CBT and the revised BE-CBT and the FRA-COTB as commercial tuning series and the UK BTS, the FRA-YFS and the UK-YFS as survey tuning series. This resulted in a minor increase of the SSB and a decrease of F in recent years.

New reference points were estimated following ICES recommendation. Fmsy analyses were conducted with Eqsim.

Short-term forecast assumptions were investigated. Based on the retrospective pattern of the recruitment estimates, the IBP decided to replace up to the two last years of recruitment by a geometric mean.

Future research and the need for a full benchmark were identified, also by the external reviewer.

A.1.2 Benchmarks for 2020

A.1.2.1 Sole in 7.d (WKFlatNSCS 2020)

The issue list for sole in 7.d is given below. In bold are the issues of greatest priority for the benchmark, with the remaining issues to be handled as time allows.

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	**Resolve the issue with the plusgroup in the French data**	**France to provide new data**	**On the national level: France to upload data without plusgroup for both the French commercial otter trawl tuning series as the commercial sampling data.**	**French experts in data raising and tuning fleets**
	Presence of subpopulations in the eastern English Channel	Await the final outcome of the SMAC project	Await the final outcome of the SMAC project	French experts involved in the SMAC project.
Tuning series	There are 6 tuning series in the assessment. Most of them are only covering a small part of Division 7d.	Explore methods to combine tuning fleets (e.g. delta GAM).	Age disaggregated tuning fleets are available.	UK (E&W), French and Belgian survey and commercial tuning fleet experts; a delta GAM expert
Biological Parameters	Investigate the observed decrease in mean weight and mean length at age.	Analyse commercial and survey data	Commercial and survey data at age	Stock coordinator
Assessment method	**Move away from XSA**	**Explore other assessment models, such as SAM, AAP, …**		**Experts on SAM, AAP, …**
	Check if all tuning fleets should be retained in the assessment.	**Do several assessment runs.**		**Stock coordinator**
Biological Reference Points	**Determine MSY reference points**	**Run EqSim functions**	**Using the final assessment**	**Experts in computation of reference points**
Forecast	**Develop an appropriate forecast**	**Run the forecast**	**Using the final assessment**	**Stock coordinator**

A.1.2.2 Sole in 4 (WKFlatNSCS 2020)

The issue list for sole in 4 is given below.

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		
New data				
Tuning series	Evaluate Belgium BTS index, and other surveys (eg. German BTS) covering stock area not covered by other surveys currently in assessment (SNS, BTS-ISIS)	Analyse DATRAS data	Data available in DATRAS	Holger Haslob
	Explore combining surveys	Analyse data and construct index using Delta Gam GAM method		Casper Berg, Holger Haslob
Assessment	Residuals patterns age 2-3 in landings	Investigate residuals using different setting of AAP model		
Forecast	Review forecast procedure	Evaluate current RCT3 settings and autumn reopening	Data available in DATRAS – Demersal Fish Survey (DFS)	
Biological Reference Points	Determine MSY (proxy) reference points	Depending on the assessment method and available data	See issue 'assessment method'	

A.1.2.3 Turbot in 3a (WKFlatNSCS 2020)

The issue list for turbot in 3.a is given below.

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	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
Biological Reference Points				

A.1.2.4 Whiting in 3a (WKDEM 2020)

Data available/needed

Survey data for IIIa (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 IIIa, 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 IIIa.
2. The development of historical whiting biomass in IIIa

3. The development of the population age structure over time in IIIa, or in IIIaN and IIIaS, separately.
4. Growth development over time
5. Modelling of natural mortality
6. Choice of assessment model

Proposed working papers/analyses

1. The stock structure and historical biomass of whiting in IIIa

   There is a lack of knowledge on the population structure of whiting in IIIa (the Skagerrak-Kattegat area). However, available time series on whiting abundance and biomass in surveys and landing statistics back in time may give an opportunity of a tentative description of whiting stock structure.
2. Growth of whiting in IIIa

   Available growth data are scrutinized and von Bertalanffy growth modelling are made as to compare growth in IIIa with the growth of whiting in the North sea.
3. Selection of assessment modelling

   Length based assessment is conducted. Natural mortality rates are modelled.

Work plan for benchmark of WHG IIIa, WKKATWGH

- Working document on stock structure of whiting in IIIa is produced by IMR-SLU Sweden by March 2016
- The working document on stock structure Is evaluated by SIMWG by June 2016
- Working document on growth of whiting in IIIa is produced by IMR-SLU Sweden by June 2016
- Working document on selection of assessment model of whiting in IIIa is produced by DTU AQUA by September 2016
- Future assessment and category will be decided upon in benchmark WKKATWGH in February 2017

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
Assessment method				
Biological Reference Points				

A.1.3 Benchmarks for 2021 and beyond

There remain a few Category 3+ stocks that have not yet been benchmarked, namely bll.27.3a47de (brill), pol.27.3a4 (pollack) and gug.27.3a47d (grey gurnard). Of these, the only realistic prospects of benchmark in 2021 (related to available resources) are for brill and grey gurnard – pollack will only be possible in 2022 at the earliest. The remaining stocks being considered for benchmark in 2021 are cod.27.47d20 (cod) and had.27.46a20 (haddock), the former due to conflicting signals in the underlying data and a developing retrospective bias, and the latter due to a poor fit to the plus group, which is becoming increasingly important, and a model (TSA) that is not compatible with conducting large numbers of simulations and will no longer be supported after 2021. Full benchmark issue lists for these stocks will be developed in the coming year.

A.2 Benchmark prioritisation

Benchmark prioritisation was conducted according to the scheme described in Table A2.1. Table A2.2 provides a summarised list of benchmark issues for each stock, and applies the scoring scheme to each stock. The finfish stocks listed in Table A2.2 have been ordered from highest to lowest score. *Nephrops* have not been considered in this scheme as the benchmark process for *Nephrops* is handled separately.

Table A2.1. Prioritisation scoring used in Table A2.2.

Category	1. assessment quality	2. Opportunity to improve	3. Management importance	4. Perceived stock status	5. Time since last benchmark
Scoring / weight	0.4	0.3	0.1	0.1	0.1
5	Assessment judged to be inadequate to provide advice (e.g., bias, stock id, unreliable catches, major change in biological processes/productivity)	New approaches and new data sources will be available for the stock, and these are likely to address issues or change perception of stock dynamics	All 4 attributes: a) Advice on fishing opportunities is requested for the stock. b) Stock is the object of an agreed management plan. c) Stock is the object of a directed fishery. d) Stock is included in a mixed fishery analysis, is a likely choke stock, or the object of a pelagic fishery (meets 1 of the 3)	Most likely below B_{lim}, or stock is in rapid decline, or state of the stock unknown	Stock has never been benchmarked
4	Assessment has high potential & priority to be upgraded to Cat. 1 from Cat. 3 or to Cat. 3 from Cat. 5 and 6	New data sources or corrections in data, or new methods will be available for the stock, and these are likely to address issues or change perception of stock dynamics	3 attributes	Between B_{lim} and MSY $B_{trigger}$	Stock has been benchmarked 10 years or more ago
3	Assessment judged to have substantial deficiencies (models and/or data) but considered acceptable	Some improvement in data /modelling approaches will be available, and unclear whether they will address issues or change perceptions	2 attributes	About MSY $B_{trigger}$	Stock has been benchmarked between 5 and <10 years ago
2	Assessment has no substantial or only minor issues	Minor improvement in data or methods will be available	1 attribute	Above MSY $B_{trigger}$	Stock has been benchmarked between 1 and < 5 years ago
1	Assessment has no obvious issues	No change in data or models will be available	No attributes	Near highest on record	Stock was benchmarked in the last year

Table A2.2. Benchmark prioritisation scoring for WGNSSK finfish stocks along with issues. The weighting for the scoring categories is according to Table A2.1. Stocks have been ordered from highest to lowest total score.

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
whg.27.3a	Cat 5 PA	-construct biomass index -raise discards -explore stock ID	-upgrade to Category 3 -develop assessment (SPiCT)	-develop reference points -develop Category 3 advice	5	5	3	5	5	4.8
tur.27.3a	Cat 3 No TAC	- review of knowledge, including genetic findings, and the comprehensive Danish restocking programs, which have investigated patterns of turbot migrations and spawning grounds - dealing with the missing Swedish catches - description of spatial distribution of landings - overview of recreational catches - dealing with a reduction in sampling for length - survey data to be investigated and mapped in more detail (including options for a combined Delta-GAM index for the entire stock area) - update of Cardinale et al (2009) survey time series	-develop assessment (SPiCT)	-develop reference points	5	5	2	5	5	4.7
sol.27.7d	Cat 1 EU	- resolve issue with French data: plusgroup, - investigate issue with large stock numbers in the older age groups, - investigate the presence of sub-populations (end of SMAC project); - investigate decrease in mean	- move away from XSA to an approach that better handles plusgroup estimation	- uncertainty in recruitment and the large impact of the UK BTS on age 2 and the effect of the large stock numbers in the older ages on the forecast	5	4	5	2	2	4.1

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		weight and length at age; -explore the use of Delta-GAM to combine indices; -investigate misreporting in the Belgian fleet								
sol.27.4	Cat 1 EU	-evaluate Belgium BTS index, covering stock area not covered by other surveys -explore combining surveys	-include Belgian BTS to deal with potentially bias due to mismatch between survey coverage and important area for fishery -investigate residual patterns for landings ages 2-3	-validate RCT3 method	3	5	5	2	3	3.7
pol.27.3a4	Cat 5 No TAC	- Examine if data exist that allows the determination of age and size of maturity ; - Explore the potential availability of data that would allow the determination of size/age in catches and the possibility to determine reference points	-develop an assessment if possible	-develop reference points if possible	5	2	1	5	5	3.7
had.27.46a20	Cat 1 shared	-explore combining survey indices -derive time-varying maturity estimate -derive estimates of mean weights at age for stock -investigate indices of reproductive potential and methods to use them in management advice -explore stock id and structure, using otolith micro-chemistry, tagging data, and the spatial range of genetic data	-investigate poor fit in plus group in view of increasing relative importance of this age class -investigate alternative models which are compatible with high performance computing (simulation runs) -TSA support likely unavailable after 2021	-investigate extent of cohort effect on growth rate -ensure consistency between catch components for weight at age cohort modelling -investigate intermediate year recruitment assumption	3	4	5	2	3	3.4

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
ple.27.420	Cat 1 shared	explore combining survey indices	improve residual patterns in catches (age 1-3) and survey (year effect)	validate RCT3 method	3	4	5	2	2	3.3
cod.27.47d20	Cat 1 shared	-investigate the possibility of conducting assessments that allow for multiple stocks -investigate the significance of spawner age on reproductive potential and the effect of sampling intensity on variability in maturity -investigate perceived catchability problems in IBTS surveys (including conflicting information between surveys and catches) -include recreational catches	-investigate potential year effects in survey -investigate retrospective and residual patterns -investigate plusgroup	-explore potential biases in the forecast and how to deal with these -investigate intermediate-year recruitment assumption	3	3	5	5	2	3.3
nop.27.3a4	Cat 1 shared	No issues (previous age reading issues have now been addressed)	Investigate retrospective patterns among other in relation to Mohn´s Rho	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 has implications for setting of Blim levels.	3	4	3	2	3	3.2
pok.27.3a46	Cat 1 shared	Stock definition – The North Sea saithe stock is influenced by migrations to and from the North Sea. This can potentially lead to the observed year effects in survey indices. It needs to be analysed if the inclusion of spawning grounds north	Variance by age – The last inter-benchmark for saithe in 2019 revealed that uncoupling of the variance parameters for the observations by age (i.e. age 3 receiving a separate parameter) could improve the	The SAM forecast assumption for recruitment is based on the median of resampled historical recruitment values from a defined number of historical years. Depending on the time-series,	3	3	5	2	2	3

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		of 62°N could improve the assessment. New survey indices – IMR-Norway has set-up a new hydro-acoustic survey targeting spawning aggregations in Quarter 1. Germany has also participated in this survey in recent years. The inclusion of this survey in the assessment should be evaluated once a sufficiently long time series has been developed. Catch-per-effort index – The current commercial CPUE index is standardized for area and engine power effects. The inclusion of alternative explanatory variables (e.g. vessel effect) should be evaluated.	model fit statistics (e.g. log-likelihood, AIC). This should be investigated further.	this may result in a bimodal distribution for the assumed recruitment in forecasted years (often alternating between 2 values). Subsequently, forecasted numbers (and SSB) are likely be more smooth in their distribution due to forecast stochasticity, but the effect of this behaviour on advice should be investigated further. Use of a geometric mean of historical recruitment is not currently possible in SAM, but could be suggested in order to reduce this effect.						
lem.27.3a47d	Cat 3 PA	- The erroneous length data submitted to InterCatch for 2013 also needs to be corrected - Further work may indicate an alternative method of collating the survey data that could be more appropriate for lemon sole	- A new method of estimating age-based survey catchability coefficients is needed to help to address the problem of negative Z estimates.	- Reference points are currently based on length-based indicators, and further work could help derive more robust estimates.	3	3	1	5	2	2.9
gug.27.3a47d	Cat 3 No TAC	- investigate ways to raise discards for métiers with zero landings but no discards reported - investigate potentially better ways to deal with the "generic gurnard grouping" problem for some nations (e.g. Germany and the UK)	- currently no issues	- currently no issues	3	2	1	5	5	2.9

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
bll.27.3a47de	Cat 3 PA	- Investigate the availability of more data on this stock (including discards and BMS landings or historical catches); - Explore the availability of more appropriate tuning fleets (both commercial and survey); - investigate biological parameters - Check whether the current biomass index series can be extended, should include age 0 and 1, or should be age-structured (cfr. Turbot in 4 assessment); - 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);	- Explore whether other assessment methods can be used (SPiCT/SAM).	-calculate reference points based on any new assessment for the stock	2	3	3	2	5	2.7
tur.27.4	Cat 1 PA	-The available scientific surveys (SNS and BTS-ISIS Q3) have a low internal consistency especially for older ages leading to a low ability to track cohorts over time. - Estimates of discards are available (e.g. Dutch discards are available for 1999-present), however, age-length information is very limited. - More work needed on obtaining LPUE data from other Member States, given the heavy reliance of the assessment on the Dutch LPUE data.	- The over-reliance of the assessment on a single LPUE time series is potentially a problem that may need further investigation, for example by using CVs associated with the estimated index directly in the assessment. - Investigate the use of a more appropriate selectivity in the assessment to construct a model-equivalent index for LPUE	- uncertainty in recruitment and forecast based on landings instead of catches.	3	3	2	2	1	2.6

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		- A detailed analysis of delta GAM indices with various settings should be carried out once more age information becomes available. -alternatives to E17smoothing of mean weights-at-age from the fishery to be investigated								
fle.27.3a4	Cat 3 No TAC	- investigate ways to raise discards for métiers with zero landings but no discards reported - investigate ways to raise discards for shrimper fleets operating in coastal waters for which no suitable data are available	- Investigate what could be done/changed to improve the SPiCT model (e.g. include effort data) - Investigate the use of alternative stock indices (DYFS, DFS, others?) which are able to better reflect the stock status.	- Investigate again length based methods for the estimation of MSY proxies with the new data available (e.g. MLZ, LBI, LBSPR)	3	2	1	5	2	2.6
mur.27.3a47d	Cat 3 No TAC	- Age (length) data from other countries than France need to be provided as everything is actually raised using the French catches in the Eastern Channel. - No survey is available in the North Sea; IBTS/UK BTS should be investigated again. So work was done to assess the representativeness of the Eastern Channel data compared to the stock, but these should be investigated further - Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated	- With so few age classes exploited the a4a model used might not be the best model. Explore methods applied to "short lived species"?	- This stock is not category 1, so no forecast is done currently. This should be investigated if the assessment method is improved. However, there is no TAC for that stock so Forecast is not a priority, although reference points are still important.	3	2	1	5	2	2.6

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
ple.27.7d	Cat 1 EU	- evaluate FR GFS index, remove potential vessel affect from the data - investigate if new maturity data are available and useable - data required to update Q1 migration - investigate if new recruitment data are available and useable	- test new index produced and evaluate its impact on survey residuals and the assessment - investigate landings patterns for landings age 2-3 - test new maturity ogive and Q1 removal	- investigate the use of RCT3 including age 0-1 information from young fish survey if available	2	3	5	1	2	2.5
whg.27.47d	Cat 1 shared	-stock identity (SURBAR runs by component, not an issue yet) -historical stock weights at age re-estimated every year (reconsider if significant changes in historical time series, not issue yet) -include natural mortality estimates (WGSAM) when available (not an issue yet)	- no issue	-further investigate alternative SAM forecast (recruitment assumption, split of catches)	2	2	5	3	1	2.3
dab.27.3a4	Cat 3 No TAC	- investigate ways to raise discards for métiers with zero landings but no discards reported - investigate ways to raise discards for shrimper fleets operating in coastal waters for which no suitable data are available - Investigate extending the delta-GAM index with Belgian and German BTS data (prior to 2002).	- Investigate the use of DYFS, DFS inshore surveys to estimate a recruitment index - Investigate which effort data are available and if these could be used as further input for the SPiCT model	- no issues currently	3	2	1	1	2	2.2
wit.27.3a47d	Cat 1 PA	- no issues currently	-The choice of proportion of fishing mortality and natural mortality before spawning (F_{prop} and M_{prop}) to be equal to	- The calculation of reference points is based on the whole time series (1940 - 2016), which includes the period before the data start (1940 – 1949) and the	2	2	3	1	2	2

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
			0.5 should be evaluated for its biological reasoning.	period where catch is the only available information (1950 – 1982). The adequacy of the assessment to estimate SSB and recruitment during that period should be evaluated, especially concerning their use in estimating reference points.						

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 2019 to evaluate new information from the fisheries independent surveys carried out during 2019 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 2019 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:

- Cod in Subarea 4 and Division 7.d and Subdivision 20 [potential increase from 10 457 t to 13 686 t, i.e. +31%]
- Haddock in Subarea 4 and Division 6.a and Subdivision 20 [potential increase from 30 228 t to 41 818 t, i.e. +38%]
- Plaice in Subarea 4 and Subdivision 20 [potential increase from 131 439 t to 166 499 t, i.e. +27%]
- Sole in Subarea 4 [potential increase from 12 317 t to 17 545 t, i.e. +42%]
- *Nephrops* in FU 6 (Farn Deeps) [potential increase, based on F_{MSY}, from 1 947 t to 2 384 t, i.e. +22%]
- *Nephrops* in FU 7 (Fladen) [potential increase, based on F_{MSY}, from 13 162 t to 14 263 t, i.e. +8%]
- *Nephrops* in FU 8 (Firth of Forth) [potential decrease, based on F_{MSY}, from 3 724 t to 3 143 t, i.e. -15.6%]

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 2019 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 (2018) 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 2018 year-class at age 1	
Log WAP from RCT3 (R)	12.29
Log of recruitment assumed in spring (A)	11.82
Int SE of log WAP (S)	0.159
Distance D $\left(D = \frac{R-A}{S}\right)$	**2.939**

7.2.4 Conclusions from Protocol

As the distance D > 1.0, the protocol concludes that **the advisory process for North Sea cod should be reopened**. The autumn indices suggest that the size of the incoming year-class is significantly higher than what had been assumed in the forecast produced by WGNSSK in May 2019.

7.2.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea cod. The assessment and forecasts were re-run with the new Q3 time-series of survey data. Otherwise the settings and assumptions were unchanged from those used by WGNSSK in May 2019.

Outputs from the assessment re-run with the new Q3 data included are given in Table 7.2.4 and Figure 7.2.1, and the updated catch options in Table 7.2.5.

Following the ICES MSY approach to reach B_{lim} by 2021, the new short-term forecasts lead to an **increase in advised catch from 10 457 tonnes to 13 686 tonnes** (an increase of 3229 tonnes).

7.2.6 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 2019-10-02 14:47:10

1992	2019						
1	1	0.626752	0.626752				
1	6						
1	**18863.65**	**1827.674**	**410.2856**	**379.4302**	124.4252	48.5255	1992
1	**5010.8**	**4920.634**	**657.7449**	**140.0861**	97.3178	7.6776	1993
1	**19481.01**	**2520.615**	**1003.44**	**177.0594**	45.3986	34.6684	1994
1	**10304.09**	**7547.31**	**775.4368**	**332.7816**	35.9982	19.7615	1995
1	**5445.917**	**3167.362**	**1136.881**	**191.1151**	145.253	13.7929	1996
1	**31159.1**	**2145.408**	**768.2279**	**291.9334**	53.3705	36.1441	1997
1	**878.0589**	**9842.493**	**706.8999**	**203.1128**	123.4656	40.7306	1998
1	**3591.583**	**519.2585**	**2543.655**	**166.032**	44.3287	18.1184	1999
1	**6652.053**	**1031.664**	**122.6477**	**364.7167**	42.0382	32.2276	2000
1	**1490.239**	**2357.38**	**396.8584**	**84.193**	67.1631	40.3456	2001
1	**4135.547**	**978.4139**	**789.762**	**206.76**	55.4246	24.5051	2002
1	**982.7882**	**1353.039**	**257.4962**	**193.4961**	110.4512	81.9545	2003
1	**3212.815**	**812.9698**	**505.0657**	**101.6961**	77.3412	27.701	2004
1	**1097.379**	**789.0162**	**299.7974**	**126.3558**	28.7829	50.5857	2005
1	**5597.061**	**765.2706**	**633.3968**	**128.5496**	32.2535	20.5547	2006
1	**1922.391**	**2422.07**	**451.0596**	**188.3773**	106.5464	50.2293	2007
1	**2524.065**	**1305.357**	**1166.906**	**244.3877**	133.7239	35.909	2008
1	**1938.642**	**1026.769**	**305.1114**	**252.0723**	57.9082	27.8911	2009
1	**4579.101**	**1705.906**	**556.4281**	**193.4659**	117.9164	23.1106	2010
1	**1252.72**	**3030.068**	**954.7646**	**412.1373**	120.7941	114.0783	2011
1	**2208.57**	**1098.233**	**1307.912**	**399.5475**	111.5427	20.9969	2012
1	**3194.656**	**1166.568**	**499.9782**	**524.535**	148.8114	69.1658	2013
1	**3494.853**	**1542**	**660.4858**	**325.7142**	211.2214	102.3674	2014
1	**1889.843**	**3080.911**	**1087.659**	**489.1186**	143.7946	138.387	2015
1	**1451.414**	**1189.788**	**1694.109**	**881.0839**	217.7852	139.1996	2016
1	**7370.178**	**635.1009**	**459.3486**	**431.8298**	228.964	49.8015	2017
1	**1135.799**	**2210.55**	**369.4594**	**222.4096**	152.7987	103.7476	2018
1	**3049.628**	**476.9321**	**603.7383**	**115.2353**	74.9379	46.5042	2019

Table 7.2.2. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Inputs.

"yearclass"	"recruitment"	"DeltaGAMq11"	"DeltaGAMq31"
1982	784294	4270.7926	NA
1983	1436937	12958.196	NA
1984	350975	617.5056	NA
1985	1597931	12785.2035	NA
1986	609972	5266.8822	NA
1987	421805	2876.3338	NA
1988	733346	9900.2041	NA
1989	294268	2077.0025	NA
1990	341888	1743.4909	NA
1991	780266	9554.8252	18863.651
1992	395474	3321.5796	5010.7999
1993	951238	7254.4028	19481.006
1994	544657	7072.8116	10304.0942
1995	350372	1857.5759	5445.917
1996	1072352	16261.0681	31159.1001
1997	112966	649.5471	878.0589
1998	227641	1419.1249	3591.5834
1999	416935	3592.0718	6652.053
2000	152852	877.0476	1490.2393
2001	229713	2950.5875	4135.5474
2002	113961	359.9883	982.7882
2003	193972	2747.8454	3212.8154
2004	154826	1099.8309	1097.3785
2005	354524	3868.1369	5597.0612
2006	168447	1448.4935	1922.3914
2007	190527	2305.7803	2524.0651
2008	183333	1064.8071	1938.6418
2009	270365	2842.217	4579.1007
2010	131827	768.2266	1252.7198
2011	179746	1585.2672	2208.5698
2012	223389	1631.5042	3194.6558
2013	310228	2713.5834	3494.8527
2014	150660	1688.1447	1889.8428
2015	114185	956.062	1451.4138
2016	320063	8238.4462	7370.178
2017	77677	473.3051	1135.7987
2018	NA	1314.1717	3049.6284

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 37 years : 1982 - 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 prediction se.pred WAP.weights
 DeltaGAMq11 0.8712     5.829 0.4059  0.7833 36   7.181      12.09  0.4259      0.1461
 DeltaGAMq31 0.7215     6.538 0.1664  0.9433 27   8.023      12.33  0.1761      0.8539
    VPA Mean     NA        NA     NA      NA 36      NA      12.64  0.7607      0.0000

                  WAP logWAP int.se
yearclass:2018 217729  12.29 0.1592
```

Table 7.2.4. Cod in Subarea 4, Division 7.d and Subdivision 20. Assessment summary. Weights are in tonnes.

Year	Recruits age 1 ('000)	Low	High	TSB (tonnes)	Low	High	SSB (tonnes)	Low	High	Fbar 2-4	Low	High	Landings	Discards	Catch	Unaccounted	Total Removals	Low	High
1963	397358	288913	546508	464652	400648	538880	145535	114192	185482	0.48	0.42	0.56	106750	10712	117468	0	117468	104342	132246
1964	649992	473264	892714	592191	507809	690594	157114	125835	196168	0.52	0.46	0.60	134501	9397	143890	0	143890	130930	158134
1965	872227	637376	1193614	754115	652407	871679	192091	158570	232698	0.58	0.51	0.66	181424	16897	198307	0	198307	177375	221709
1966	1059941	775384	1448928	903513	782575	1043140	213402	177010	257277	0.58	0.52	0.66	214594	26053	240598	0	240598	215741	268318
1967	892007	652148	1220085	959248	839670	1095855	241906	201008	291126	0.62	0.55	0.70	260069	26168	286267	0	286267	256319	319714
1968	447823	326852	613566	820875	734778	917060	254516	217674	297594	0.66	0.58	0.74	276322	16731	293077	0	293077	266750	322003
1969	390619	283207	538768	680660	605566	765065	251145	212545	296754	0.62	0.55	0.70	215464	9287	224730	0	224730	208390	242350
1970	1319849	962778	1809350	1066276	888023	1280310	261836	222635	307939	0.66	0.59	0.74	231325	19719	251029	0	251029	220876	285299
1971	1742760	1265633	2399757	1206727	1022692	1423879	265495	226262	311531	0.75	0.67	0.84	292741	58585	351310	0	351310	301634	409168
1972	431948	313144	595825	866496	768628	976825	236386	201576	277207	0.81	0.72	0.90	329760	34533	364326	0	364326	319139	415910
1973	635757	461119	876535	692514	616318	778129	210532	185130	239419	0.80	0.71	0.89	234755	25407	260171	0	260171	237326	285215
1974	632557	458037	873573	664523	589086	749622	226167	198240	258028	0.76	0.68	0.85	209261	27105	236340	0	236340	211200	264471
1975	1094873	785558	1525980	750818	640524	880103	204444	177821	235053	0.82	0.73	0.91	210542	38167	248750	0	248750	216275	286102
1976	756248	538264	1062510	605879	532530	689331	172808	148422	201199	0.87	0.78	0.97	203524	46349	249830	0	249830	216503	288286
1977	1846061	1323463	2575019	906964	739276	1112689	146502	126175	170104	0.82	0.74	0.92	183252	82723	265873	0	265873	217366	325205
1978	1120987	800273	1570229	1025173	857461	1225689	145131	128606	163779	0.91	0.82	1.01	310657	49591	360288	0	360288	296677	437538
1979	1400018	1002983	1954220	957041	817428	1120498	143681	128273	160941	0.85	0.77	0.95	277348	64322	341625	0	341625	292055	399608
1980	2255066	1606857	3164763	1147941	953974	1381347	156336	140238	174281	0.93	0.84	1.03	292150	104800	396757	0	396757	327661	480424
1981	877061	626949	1226950	965608	837938	1112730	165099	149360	182497	0.94	0.86	1.04	343621	54154	397837	0	397837	339107	466739
1982	1417446	1023728	1962587	1014116	853545	1204895	163927	147723	181908	1.05	0.96	1.16	322180	62176	384361	0	384361	326207	452883
1983	784535	576429	1067772	803414	692994	931427	135145	121474	150355	1.05	0.95	1.15	285121	36745	321818	0	321818	274176	377739
1984	1441364	1059924	1960075	817438	687286	972238	117642	105492	131193	0.98	0.89	1.08	209686	68807	278572	0	278572	235822	329071
1985	350132	255078	480607	554254	490289	626564	116922	104776	130476	0.95	0.86	1.04	213737	28166	241897	0	241897	209237	279655
1986	1602115	1181165	2173085	738295	606569	898627	109436	99113	120835	1.00	0.91	1.10	169199	60137	229270	0	229270	191031	275164
1987	610103	451746	823971	697253	599866	810449	111285	100439	123301	0.98	0.89	1.08	226375	32823	259301	0	259301	218319	307978
1988	422176	312144	570996	517614	454272	589787	110679	101398	120808	1.00	0.91	1.10	192310	14763	207144	0	207144	183764	233498
1989	736309	541962	1000348	517817	438043	612120	102732	93589	112769	1.02	0.93	1.12	139153	41187	180300	0	180300	154802	209998
1990	294490	218450	397000	355192	312587	403603	90145	81612	99570	0.95	0.86	1.05	115716	23583	139309	0	139309	121549	159665
1991	341815	254245	459547	326984	284416	375923	88963	79807	99170	0.94	0.85	1.04	102650	16177	118861	0	118861	105416	134022
1992	783342	582086	1054182	504218	414708	613049	85641	76512	95860	0.93	0.83	1.04	109517	32184	141748	0	141748	119102	168700
1993	397564	297276	531684	397937	335518	471969	87995	74527	103897	0.94	0.83	1.06	130382	28703	159109	-11967	147142	119772	180767
1994	957405	704665	1300794	508525	412818	626419	94850	79686	112899	0.95	0.84	1.08	106803	43078	149896	2140	152036	121563	190147
1995	547175	406189	737097	545331	450158	660627	109455	91804	130499	1.00	0.88	1.13	131027	31721	162703	26145	188848	150142	237532
1996	350017	261263	468921	412793	346880	491231	110025	92344	131092	1.00	0.88	1.13	130727	20797	151553	3115	154668	125518	190587
1997	1076591	788728	1469516	614068	487311	773796	94447	79636	112012	0.97	0.86	1.10	132031	44151	176150	-24510	151639	119630	192214
1998	112193	82934	151776	319567	266813	382753	95062	79764	113294	1.00	0.89	1.14	144877	40911	185857	-51412	134445	107914	167498
1999	227409	170393	303504	216068	182373	255988	81331	67686	97727	1.06	0.93	1.20	94554	12813	107350	-15727	91623	74909	112066
2000	417384	312868	556815	268527	220754	326639	60708	50762	72603	1.05	0.93	1.19	72711	15920	88625	-9980	78645	63374	97595
2001	153623	114858	205470	189111	159721	223909	58904	49590	69967	0.98	0.86	1.10	44377	11335	55733	11271	67003	54650	82149
2002	229882	172494	306364	161366	135622	191996	53501	45037	63556	0.92	0.81	1.05	53225	11098	64321	-11549	52772	43352	64241
2003	114045	85167	152714	135954	115609	159879	55305	46528	65739	0.91	0.80	1.03	30991	4582	35582	14485	50067	40921	61257
2004	193753	147327	254809	118729	100724	139951	44466	37450	52797	0.86	0.75	0.98	27260	7449	34709	1625	36334	29827	44261
2005	154610	116008	206057	136803	117453	159340	47346	40715	55057	0.80	0.69	0.92	29789	11350	41134	-3522	37611	31139	45429
2006	354430	271411	462843	145551	122428	173041	44075	38652	50260	0.73	0.65	0.82	22484	9038	31523	0	31523	28011	35476
2007	168675	129327	219995	195404	171928	222085	76092	67370	85944	0.69	0.61	0.78	23843	28801	52638	0	52638	46069	60144
2008	190296	145831	248319	202943	177668	231813	83997	74481	94729	0.66	0.58	0.75	26925	25140	52059	0	52059	47460	57104
2009	183205	140044	239667	211352	184843	241663	90151	78995	102882	0.66	0.57	0.75	33066	21278	54348	0	54348	49278	59941
2010	270702	206398	355042	220369	189106	256800	89629	76548	104944	0.58	0.50	0.67	36061	12306	48362	0	48362	44078	53063
2011	132447	101105	173504	205010	175856	238998	96983	80120	117395	0.48	0.40	0.56	33907	10106	44006	0	44006	39924	48507
2012	180257	138071	235334	179019	152668	209919	94808	77119	116554	0.44	0.37	0.53	32428	7496	39923	0	39923	37088	42975
2013	222935	170667	291211	226202	192221	266190	101131	82153	124494	0.44	0.37	0.52	30805	10700	41496	0	41496	38297	44962
2014	310733	237715	406178	276946	234417	327191	107004	87230	131260	0.45	0.38	0.52	34774	10802	45575	0	45575	41711	49798
2015	149941	114918	195636	245937	210076	287919	119795	96542	148648	0.44	0.38	0.52	37965	12945	50907	0	50907	46449	55792
2016	113416	86910	148006	214346	183681	250129	118136	95542	146072	0.44	0.38	0.52	38690	12530	51224	0	51224	47734	54968
2017	313774	231300	425656	218059	183080	259721	107564	85431	135433	0.50	0.44	0.59	38514	9255	47762	0	47762	44560	51194
2018	78158	55764	109544	175062	144480	212118	101632	78067	132311	0.64	0.55	0.76	41433	9139	50573	0	50573	45703	55963
2019	181905	102264	323567				80475	57242	113137										

Table 7.2.5. Cod in Subarea 4, Division 7.d and Subdivision 20. Catch options. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar (2019)	0.5
SSB(2020)	83301
R(2019)	184342
R(2020)	183205
Catch(2019)	35358
Landings(2019)	29769
Discards(2019)	5589

Catch scenarios

Basis	Total catch (2020)	Wanted catch (2020)	Unwanted catch (2020)	F_{total} (2020)	F_{wanted} (2020)	$F_{unwanted}$ (2020)	SSB (2021)	%SSB change	%TAC change	%advice change
SSB(2021)=Blim	13686	10881	2805	0.170	0.131	0.039	107000	28	-61	-51
MSY HCR	13820	10986	2834	0.172	0.132	0.040	106871	28	-61	-51
MAP	9046	7196	1850	0.110	0.085	0.025	111678	34	-74	-68
F=0	0	0	0	0.00	0.00	0.00	121366	46	-100	-100
Fpa	28689	22756	5933	0.39	0.30	0.090	91399	9.7	-18.9	1.72
Flim	37587	29717	7870	0.54	0.42	0.125	82448	-1.02	6.3	33
SSB(2021)=Bpa	0	0	0	0.00	0.00	0.00	121366	46	-100	-100
SSB(2021)=Btrigger	0	0	0	0.00	0.00	0.00	121366	46	-100	-100
TAC(2019)-20%	28286	22428	5858	0.38	0.30	0.088	91851	10.3	-20.0	0.29
TAC(2019)-15%	30053	23840	6213	0.41	0.32	0.095	89893	7.9	-15.0	6.6
TAC(2019)-10%	31821	25186	6635	0.44	0.34	0.102	88282	6.0	-10.0	12.8
TAC(2019)-5%	33589	26579	7010	0.47	0.36	0.108	86473	3.8	-5.0	19.1
Constant TAC	35357	27966	7391	0.50	0.38	0.116	84777	1.77	0.00	25
TAC(2019)+5%	37125	29361	7764	0.53	0.41	0.123	82906	-0.47	5.0	32
TAC(2019)+10%	38893	30719	8174	0.56	0.43	0.130	81220	-2.5	10.0	38
TAC(2019)+15%	40661	32043	8618	0.60	0.46	0.137	79538	-4.5	15.0	44
TAC(2019)+20%	42429	33345	9084	0.63	0.48	0.145	77831	-6.6	20	50
F=F(2019)	35291	27914	7377	0.50	0.38	0.116	84852	1.86	-0.187	25
$F_{MSY\ lower}$	15718	12497	3221	0.198	0.152	0.046	105041	26	-56	-44
F_{MSY}	23558	18688	4870	0.31	0.24	0.072	96848	16.3	-33	-16.5

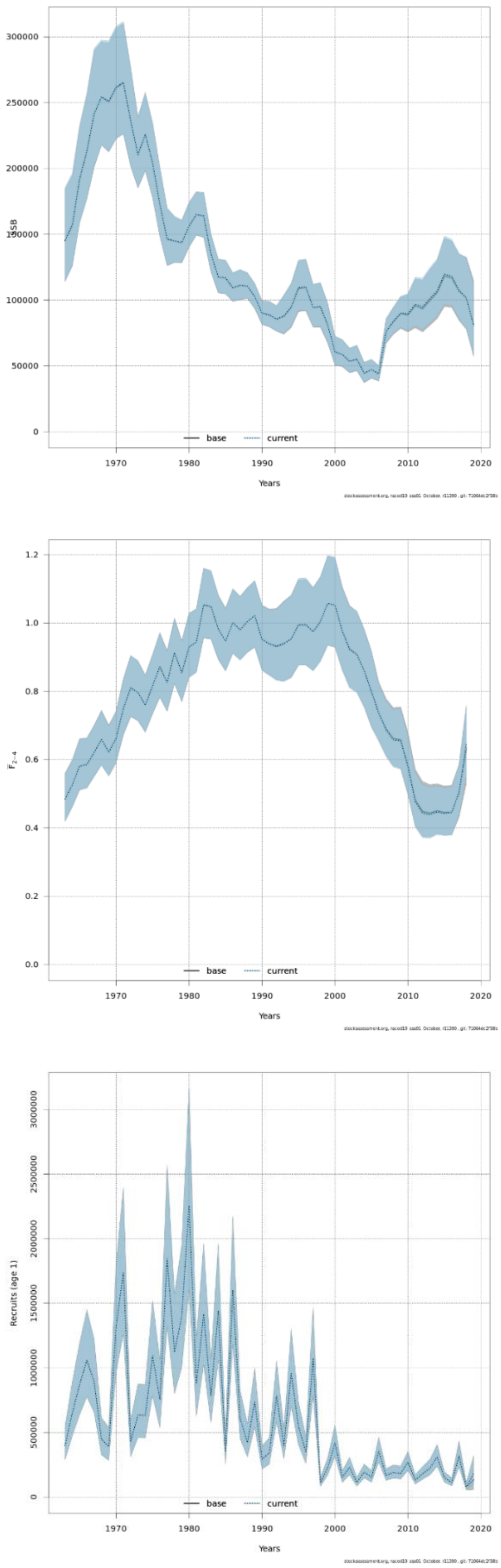

Figure 7.2.1. Cod in Subarea 4, Division 7.d and Subdivision 20. Summary of stock assessment with pointwise 95% confidence intervals. The SAM assessment produced by WGNSSK in May 2019 is plotted in black for comparison.

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 2019), 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 (2019) 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 2019 year-class at age 0	
Log WAP from RCT3 (R)	9.918
Log of recruitment assumed in spring (A)	8.098
Int SE of log WAP (S)	0.5147
Distance D $\left(D = \frac{R-A}{S}\right)$	**3.536**

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 higher than had been assumed in the forecast produced by WGNSSK in May 2019.

7.3.5 Updated forecast

The forecast from May 2019 was re-run with the same parameters and settings, apart from the assumed recruitment at age 0 in 2019 which was increased from 3287 million to 20 288 million, following the new RCT3 analysis reported above. Recruitment in 2020 and 2021 was assumed to be 3287 million, as before. A TAC constraint was again needed, as in May, for the 2019 intermediate year as a combined-area TAC overshoot of 8520 tonnes would have occurred with the updated recruitment estimate if a similar level of effort to 2018 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 2019 in given in Table 7.3.5. The new total catch forecast at F_{MSY} in 2019 is **41 818 tonnes** (an increase of 23% over the 2019 TAC), compared to the original total catch forecast of **30 228 tonnes** (a decrease of **11.1%** over the 2019 TAC). The difference of **11 590 tonnes** is caused by the updated recruitment assumption, which implies a significantly large incoming year class for 2019: the forecast settings are otherwise unchanged.

7.3.6 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (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 2019 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	6904.539	176.457	94.108	47.947	13.268	9.904
2000	1092.754	2504.185	44.3	19.502	10.287	4.264
2001	34.743	360.422	1099.293	30.29	6.371	3.648
2002	137.709	45.969	237.732	573.754	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	86.267	58.356	25.177	18.293	82.781	2.515
2014	747.545	48.207	58.51	5.216	9.093	51.625
2015	104.274	463.428	22.807	15.993	1.662	2.307
2016	352.014	94.977	220.721	8.166	3.731	0.41
2017	146.171	167.605	72.398	130.786	2.896	1.29
2018	123.141	74.11	94.752	22.692	32.776	0.724
2019	1940.393	164.608	53.427	63.534	12.388	18.324

Table 7.3.2. Haddock in Subarea 4 and Divisions 3.a and 6.a. RCT3 input file. Data from surveys in autumn 2019 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	15397.81	-11	403.079	-11	-11	-11
1982	9257.26	302.278	221.275	-11	-11	-11
1983	29956.74	1072.285	833.257	-11	-11	-11
1984	5814.89	230.968	266.912	-11	-11	-11
1985	9559.59	573.023	328.062	-11	-11	-11
1986	18058.15	912.559	677.641	-11	-11	-11
1987	331.75	101.691	97.372	-11	-11	-11
1988	1050.17	219.06	139.114	-11	-11	-11
1989	1979.35	217.448	134.076	-11	-11	22.921
1990	8687.18	680.231	331.044	-11	233.55	189.015
1991	9895.04	1141.396	519.521	718.479	595.235	140.146
1992	17124.7	1242.121	491.051	2741.14	605.99	262.643
1993	4295.18	227.919	201.069	577.382	195.331	106.642
1994	16997.41	1355.485	813.268	1781.191	1019.607	428.471
1995	4791	267.411	354.766	520.855	247.469	123.793
1996	6849.31	848.966	420.926	627.502	347.567	164.853
1997	4112.15	357.597	222.907	195.255	257.14	94.108
1998	3101.24	211.139	107.125	276.401	176.457	44.3
1999	46518.86	3734.2	2220.593	6904.539	2504.185	1099.293
2000	9077.86	893.46	473.461	1092.754	360.422	237.732
2001	899.61	57.309	39.261	34.743	45.969	31.171
2002	1220.44	89.981	79.256	137.709	69.348	40.556
2003	1371.76	71.745	51.885	163.931	69.539	45.54
2004	1345.3	70.189	46.081	183.977	67.605	27.543
2005	12761.2	1158.194	963.393	1412.973	547.284	385.791
2006	2712.35	109.44	107.39	191.608	149.743	89.934
2007	1806.88	61.357	141.444	111.475	86.627	79.994
2008	1271.67	75.068	71.132	126.428	77.703	59.017
2009	9243.72	674.962	781.507	909.334	557.39	344.508
2010	793.47	46.068	66.523	30.294	77.035	40.248
2011	82.16	14.103	24.585	30.64	31.515	25.177
2012	1117.75	58.249	104.034	68.068	58.356	58.51
2013	566.28	24.067	32.612	86.267	48.207	22.807
2014	5906.61	388.241	413.503	747.545	463.428	220.721
2015	1646.56	111.384	138.465	104.274	94.977	72.398
2016	2631.18	218.515	155.733	352.014	167.605	94.752
2017	-11	47.048	126.234	146.171	74.11	53.427
2018	-11	153.07	-11	123.141	164.608	-11
2019	-11	-11	-11	1940.393	-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 39 years: 1981–2019									
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:2019									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
ibtsq11	1.115	2.0219	0.5359	0.8687	35	NA	NA	NA	NA
ibtsq12	1.38	0.8509	0.5921	0.8448	36	NA	NA	NA	NA
ibtsq30	1.013	2.25	0.507	0.8783	26	7.571	9.918	0.5559	1
ibtsq31	1.288	1.3397	0.4523	0.8991	27	NA	NA	NA	NA
ibtsq32	1.447	1.4402	0.6567	0.8033	28	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	36	NA	8.184	1.3616	NA
	WAP	logWAP	int.se						
yearclass:2019	20288	9.918	0.5147						

Table 7.3.4. Haddock in Subarea 4 and Divisions 3.a and 6.a. Updated catch option table following RCT3 analysis.

Basis: F(2019) = F based on TAC constraint of 33 956 tonnes = 0.190; SSB (2019) =223.911; TAC 4 (2019) = 28.950; TAC 3.a (2019) = 1.780; TAC 6.a (2019) = 3.266; HC landings (2019) = 29.856; Discards+BMS (2019) = 4.100, IBC (2019) = 0.032; Recruitment (2019) = RCT3 = 20288 million. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 2021 relative to SSB 2020. 2) Total catch 2020 relative to TAC 2019.

Rationale	Total catch 2020	Wanted catch 2020	Unwanted catch 2020	IBC 2020	HC catch 2020	Total F 2020	F(land) 2020	F(disc) 2020	F(IBC) 2020	SSB 2021	% SSB (1)	% TAC change (2)
MSY approach: F_{MSY}	**41818**	**25630**	**16157**	**30**	**41788**	**0.194**	**0.163**	**0.030**	**0.00020**	**196886**	**-3.5%**	**23%**
F = MAP $F_{MSY\ lower}$	36257	22288	13939	30	36227	0.167	0.141	0.026	0.00020	201199	-1.39%	7%
F = MAP $F_{MSY\ upper}$	41818	25630	16157	30	41788	0.194	0.163	0.030	0.00020	196886	-3.5%	23%
F = 0 (IBC only)	32	0	0	32	0	0	0	0	0.00020	230173	12.8%	-100%
F_{pa}	57798	35099	22671	29	57769	0.274	0.23	0.043	0.00020	184689	-9.5%	70%
F_{lim}	78562	47057	31478	28	78534	0.384	0.32	0.060	0.00020	169349	-17.0%	131%
SSB (2021) = B_{lim}	175523	93613	81888	23	175501	1.06	0.89	0.166	0.00020	94000	-54%	417%
SSB (2021) = B_{pa} = MSY $B_{trigger}$	129303	74032	55247	25	129279	0.69	0.58	0.109	0.00020	132000	-35%	281%
F_{2019}	40938	25103	15805	30	40908	0.19	0.160	0.030	0.00020	197566	-3.2%	21%
Rollover TAC	33956	20899	13027	30	33926	0.156	0.131	0.024	0.00020	202994	-0.51%	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 28 June 2019.

Basis: F(2019) = F based on TAC constraint of 33 956 tonnes = 0.194; SSB (2019) =223.911; TAC 4 (2019) = 28.950; TAC 3.a (2019) = 1.780; TAC 6.a (2019) = 3.266; HC landings (2019) = 30.508; Discards+BMS (2019) = 3.448, IBC (2019) = 0.032; Recruitment (2019) = assessment model forecast = 3287.4 millions. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 2021 relative to SSB 2020. 2) Total catch 2020 relative to TAC 2019.

Rationale	Total catch 2020	Wanted catch 2020	Unwanted catch 2020	IBC 2020	HC catch 2020	Total F 2020	F(land) 2020	F(disc) 2020	F(IBC) 2020	SSB 2021	% SSB (1)	% TAC change (2)
MSY approach: F_{MSY}	**30228**	**25537**	**4662**	**30**	**30199**	**0.194**	**0.163**	**0.030**	**0.00020**	**196243**	**-3.4%**	**-11.1%**
F = MAP $F_{MSY\ lower}$	26269	22207	4032	30	26239	0.167	0.141	0.026	0.00020	200542	-1.33%	-23%
F = MAP $F_{MSY\ upper}$	30228	25537	4662	30	30199	0.194	0.163	0.030	0.00020	196243	-3.4%	-11.1%
F = 0 (IBC only)	32	0	0	32	0	0	0	0	0.00020	229410	12.9%	-100%
F_{pa}	41488	34971	6489	29	41460	0.274	0.23	0.043	0.00020	184091	-9.4%	22%
F_{lim}	55822	46886	8908	28	55794	0.384	0.32	0.060	0.00020	168805	-16.9%	64%
SSB (2021) = B_{lim}	114594	93181	21392	21	114573	1.06	0.89	0.166	0.00020	94000	-54%	237%
SSB (2021) = B_{pa} = MSY $B_{trigger}$	88573	73499	15049	24	88549	0.69	0.58	0.108	0.00020	132000	-35%	161%
F_{2019}	30257	25561	4666	30	30228	0.194	0.164	0.030	0.00020	196212	-3.5%	-11.0%
Rollover TAC	33985	28691	5265	29	33956	0.22	0.19	0.034	0.00020	192176	-5.4%	0%

7.4 Saithe in Subarea 4, 6 and Division 3a

7.4.1 New survey information

New survey data are available from the 2019 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, 2019), 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 Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES AGCREFA; ICES 2008) to provide an estimate of the abundance of the incoming 2016 age 3 and 2015 age 4 year-classes. In the past years, RTC3 settings included discounting extreme values via "shrinkage toward the mean" and down-weighing more historical values via a "tapered" weighting function. It was decided that these deviations from the protocol have not been adequately substantiated, and thus the RCT3 analysis presented here applies the standardized settings agreed to by AGCREFA, which is not to apply shrinkage or down-weighting. While there is evidence of shifts in the historical recruitment strength, there is little evidence of a shift in the quality of the IBTS Q3 index itself over time. Following the standard protocol, the new survey index is addressed using the same weight as all others in the time series in order to detect a deviation outside of the expected range of the prediction. The issue of adjustments to the standardized RCT3 protocol should be raised during the next benchmark in order to discuss if the protocol should be changed for future re-openings. The RCT3 input and output files of the current re-opening 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 2015/2016 year-classes:	**Age 3 2016 YC**	**Age 4 2015 YC**
log WAP from RCT3 (*R*)	11.004	10.799
log of recruitment assumed in spring (*A*)	11.327	10.457
Int. SE of log WAP (*S*)	0.44	0.40
Distance D $\left(D = \frac{R-A}{S}\right)$	-0.74	0.86

For both year classes, the RTC3 prediction is compared to the cohort numbers in 2019 (i.e. intermediate year) as calculated from the median values used in the forecast iterations (n = 1000) for age 4, and as resampled from the years 2009–2018 for age 3. Variation among the forecast iterations is derived from resampling of the variance-covariance matrix of estimated parameters from the assessment.

7.4.4 Conclusions from the 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 2019, but the deviation is smaller than the SE of the regression model (*D* = -0.74). Although age 3 is not yet fully-recruited to the North Sea, the most recent benchmark concluded the IBTS Q3 survey was representative of the year class strength; 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 = 0.295; Figure 7.4.1), the benchmark found no evidence that this age should be removed from the index. Thus, while the age 3 index value is uncertain, is still provides valuable information.

Although the assessment starts with age 3, age 4 is the first fully-recruited year class. Therefore, an RCT3 analysis for age 4 is also presented. Based on the age 4 IBTS Q3 survey index, the RCT3 regression predicts a somewhat larger age class than the median value assumed in the forecast; but, again, the deviation is smaller than the SE of the regression model (*D* = 0.86).

The overall conclusion is that **the advisory process for North Sea saithe should not be reopened.**

7.4.5 References

ICES (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 (2019). 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	-	-	71075	0.402
1988	175072	1.946	89129	2.76
1989	103616	1.077	58579	2.781
1990	175855	7.965	96719	1.615
1991	118210	1.117	66024	2.501
1992	213155	13.959	147986	6.533
1993	118789	3.825	79273	3.351
1994	149544	3.756	120365	4.134
1995	87766	1.181	55371	1.907
1996	116546	2.086	97424	8.836
1997	101190	3.479	69233	6.169
1998	206864	21.475	142505	18.974
1999	152635	10.748	115758	23.802
2000	158359	19.272	104533	6.727
2001	115926	4.93	75397	7.512
2002	146568	8.916	127182	29.579
2003	101835	10.553	55619	5.578
2004	157857	34.006	100926	5.584
2005	74781	3.312	52572	1.703
2006	57946	1.346	37848	0.964
2007	90504	1.361	79598	8.451
2008	81377	4.52	46719	2.497
2009	131577	11.134	98723	16.279
2010	92659	14.701	69111	3.923
2011	57989	1.649	43574	5.613
2012	97033	11.001	66784	17.439
2013	119787	37.901	92815	13.102
2014	83040	11.447	66148	6.885
2015	45672	1.877		3.192
2016		2.164		

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 2019.txt
RCT3 input for D calculations for sai3a46 age 3
Data for 1 surveys over 29 years :  1988 - 2016
Regression type = c
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.
yearclass = 2016
          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   0.59  10.33   0.40  0.487     28   1.15   11.00    0.436    1.000
                                 Assessment Mean =   11.62    0.382    0.000

 Year     Weighted      Log     Int
 Class     Average      WAP     Std
          Prediction           Error
 2016 60118.000000     11.00    0.44
```

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 2019.txt
RCT3 input for D calculations for sai3a46 age 4
Data for 1 surveys over 29 years :  1987 - 2015
Regression type = c
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression
Forecast/Hindcast variance correction used.

yearclass = 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   0.69   9.80   0.36  0.531     28   1.43   10.80    0.396    1.000
                                 Assessment Mean =   11.27    0.356    0.000

 Year     Weighted      Log     Int
 Class     Average      WAP     Std
          Prediction           Error
 2015 48955.000000     10.80    0.40
```

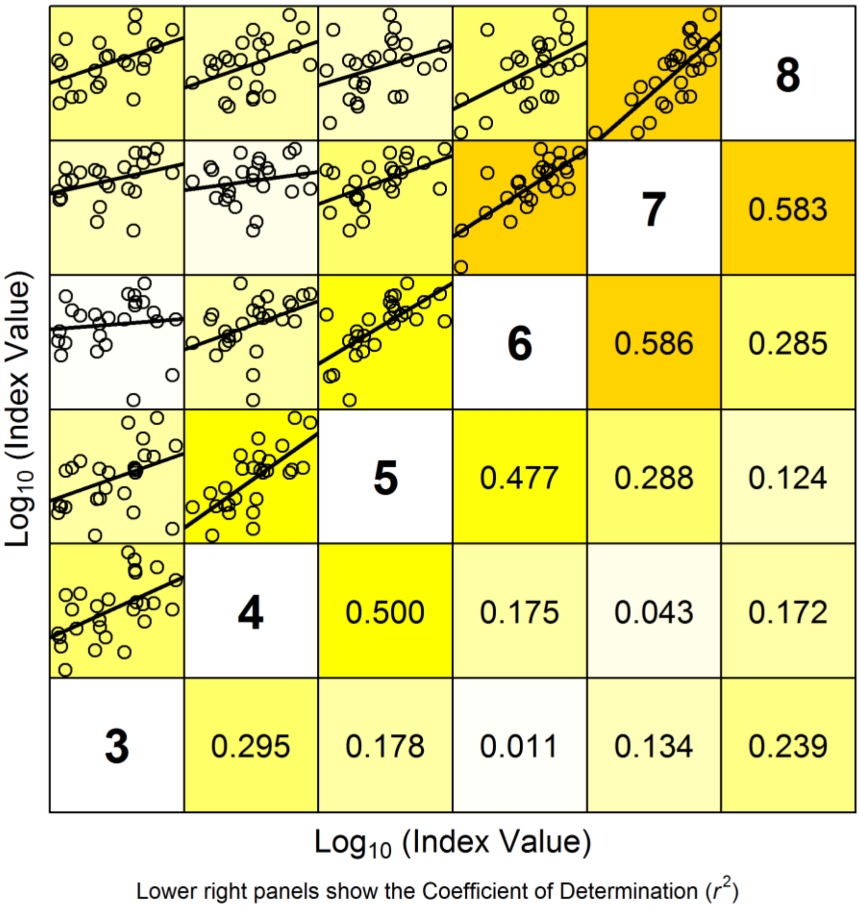

Figure 7.4.1. Saithe in subareas 4 and 6 and Division 3a. Internal consistencies between subsequent ages in the IBTS Q3 survey (1991–2019).

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, 2019), 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 (2019) year-class. The RCT3 input and output files are given in tables 7.5.2 and 7.5.3, respectively.

7.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2019 year-class at age 0	
Log WAP from RCT3 (R)	16.43
Log of recruitment assumed in spring (A)	16.291
Int SE of log WAP (S)	0.1601
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.8682**

7.5.4 Conclusions from protocol

The 2019 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 recruitment estimate from the survey is above the assumption done in spring, but well within 1 standard error of the prediction as calculated by the RCT3 software.

Hence, the protocol concludes that the original geometric mean does not overestimate the true size of the 2019 year-class by a significant amount.

The overall conclusion is that **the advisory process for North Sea whiting does not need to be reopened based on the RCT3 analysis.**

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 (2019). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2019/ACOM:.

Table 7.5.1. Whiting in Subarea 4 and Division 7.d. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2019 are highlighted.

Year	Age					
	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	334.259	67.454	60.115	65.796	17.505	7.08
2014	1401.012	223.402	97.974	65.567	33.285	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	204.113	146.705	264.187	111.505	43.783	19.115
2019	729.955	389.391	160.763	100.44	32.907	10.608

Table 7.5.2 Whiting in Subarea 4 and Division 7.d. RCT3 input file. Data from surveys in autumn 2019 are highlighted.

Year class	SAM Recruits at age 0	IBTS Q3 Age 0
1991	12864278	536.99
1992	14719730	1379.459
1993	14052649	919.193
1994	12645504	610.743
1995	10381631	729.246
1996	8469254	316.501
1997	14017367	2062.67
1998	23317972	2631.69
1999	23935119	2498.56
2000	21240380	1961.467
2001	21620487	3548.817
2002	11246935	269.275
2003	10798107	356.523
2004	12223974	714.27
2005	11389128	169.321
2006	9711377	198.949
2007	15398634	822.902
2008	14753261	764.759
2009	13926062	593.801
2010	13960028	510.123
2011	10103265	247.085
2012	7528980	306.812
2013	12117709	334.259
2014	16080625	1401.012
2015	15024074	2091.636
2016	16177054	971.786
2017	9029636	176.649
2018	7965668	204.113
2019	-11	729.955

Table 7.5.3. Whiting in Subarea 4 and Division 7.d. RCT3 output file.

Analysis by RCT3 ver4.0
Whiting
Data for 5 surveys over 31 years : 1989 - 2019
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:2019

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.6209	12.79	0.3995	0.3630	30	NA	NA	NA	NA
IBTSq12	0.9643	10.94	0.4880	0.2626	29	NA	NA	NA	NA
IBTSq30	0.3919	13.84	0.1802	0.7509	28	6.593	16.43	0.1903	1
IBTSq31	0.5962	12.87	0.3111	0.4935	29	NA	NA	NA	NA
IBTSq32	0.7905	12.35	0.3459	0.4149	29	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	30	NA	16.39	0.2963	0

	WAP	logWAP	int.se
yearclass: 2019	13616164	16.43	0.1601

7.6 Plaice in Subarea 4 and Subdivision 20

7.6.1 Short term forecast and June advice

At WGNSSK 2019 (ICES 2019), the following values were used for the intermediate year in the short-term forecast:

Year class	Age in 2019	AAP survivors	RCT3	GM 2006-2015	Accepted estimate
2017	2	827716	903568	997671	AAP survivors
2018	1		2084830	1287315	GM 2006–2015*
Year class	**Age in 2020**	**AAP survivors**	**RCT3**	**GM 2006-2015**	**Accepted estimate**
2019	1			1287315	GM 2006–2015

* GM of recent 10 years data, excluding the last 3 data years due to large uncertainty

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 IBPplaice (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 each time after the survey data is updated.

The 2019 BTS-Q3 survey included in the autumn re-opening analysis is incomplete because the 2019 UK BTS-Q3 is only uploaded to DATRAS the following year. Since the younger age plaices are distributed closer to the east of North Sea, the lack of UK BTS data is expected to have minor influence on the final indices of younger ages 0-2.

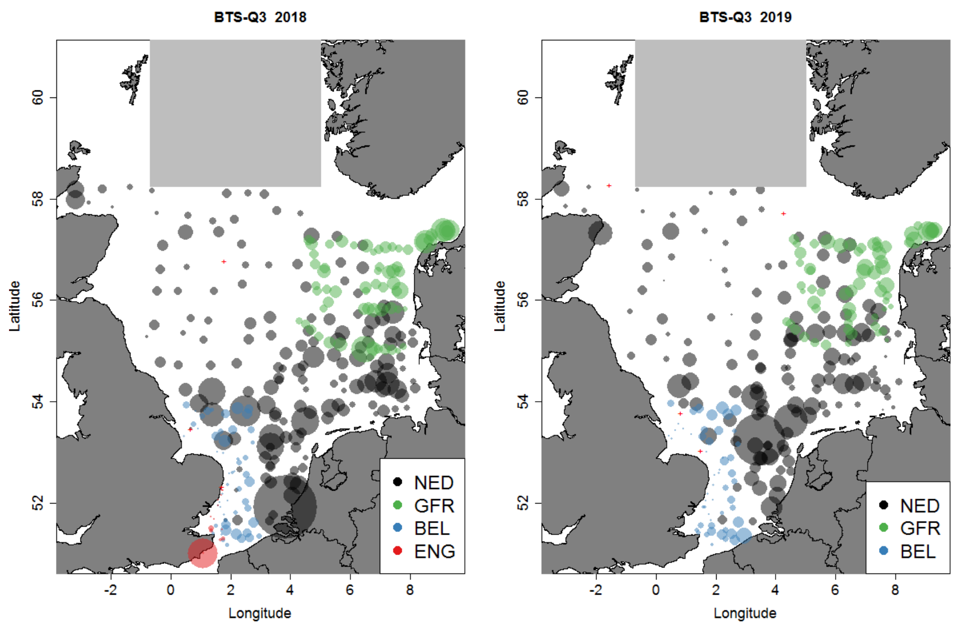

Figure 7.6.1. Biomass per haul in BTS by country in 2018 and 2019.

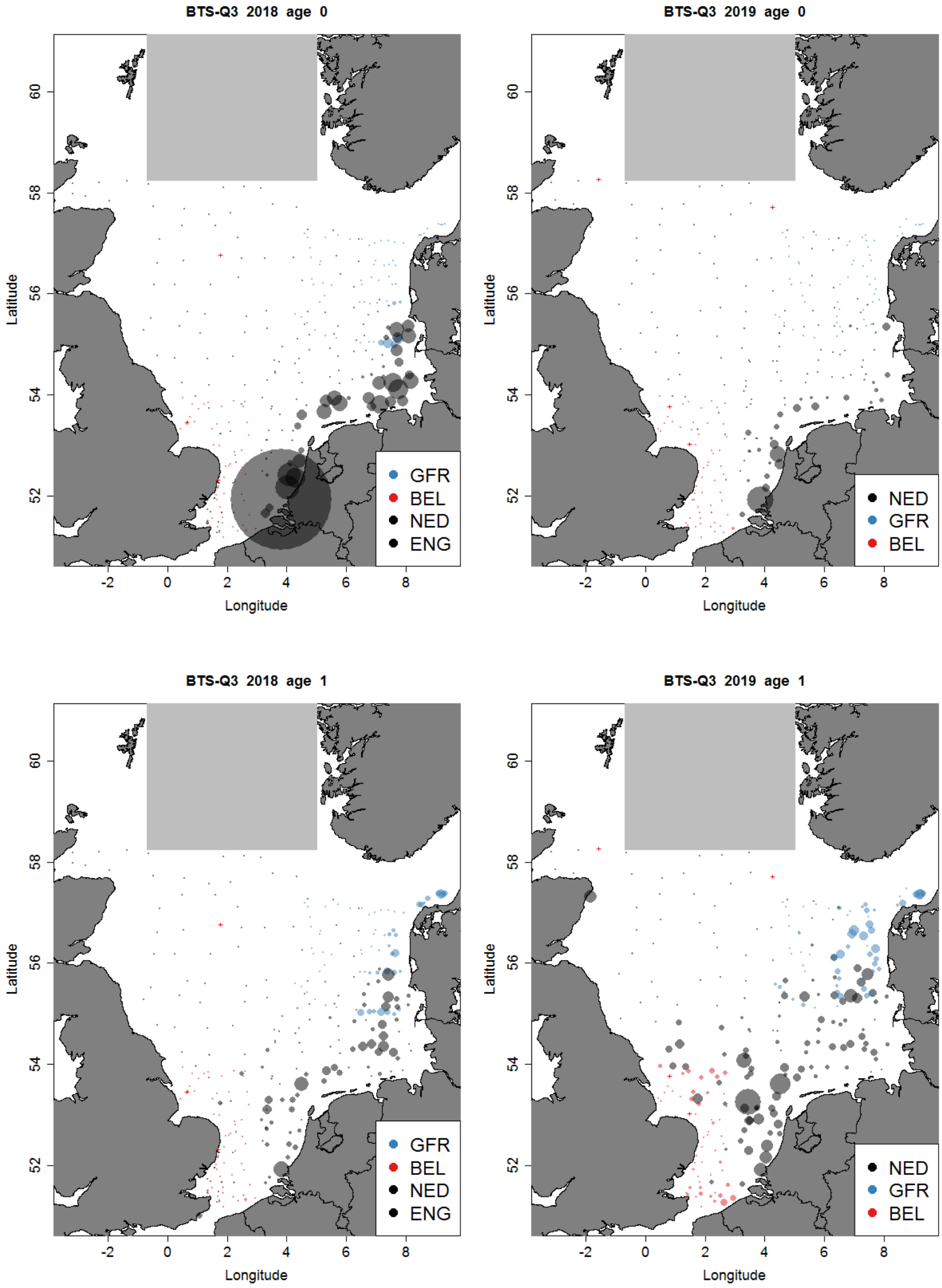

Figure 7.6.2. Number at age 0 and 1 per haul in BTS by country in 2018 and 2019.

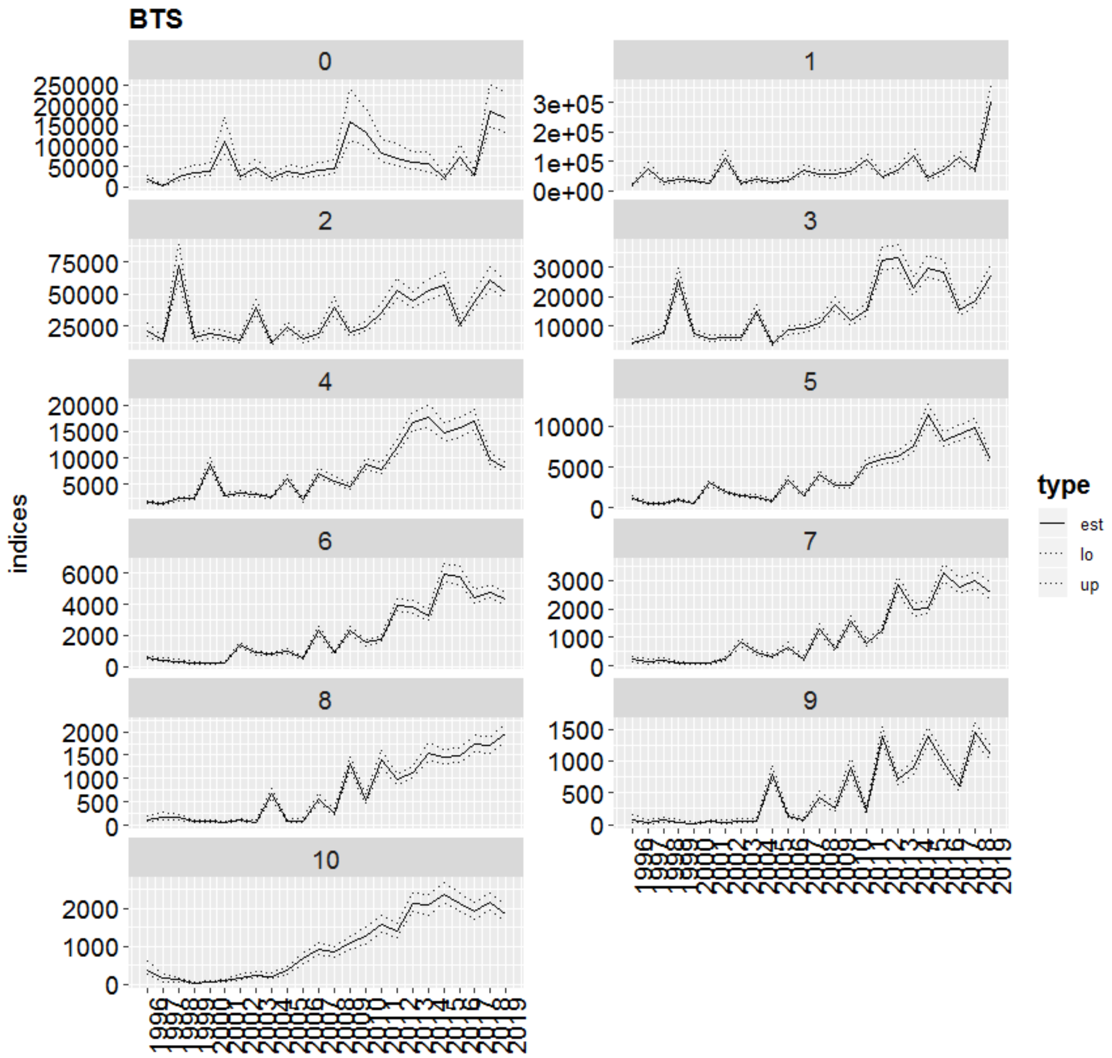

Figure 7.6.3. BTS indices, estimated from delta-gam method. Note that the indices per age are plotted on different scales.

7.6.3 RCT3 D-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 2019, the new data comprises age 1 of year class 2018 and age 2 of year class 2017. The last 4 years from the assessment estimates were removed from the time series.

Table 7.6.1 plaice 27.420 RCT3 input data

Year-class	AAP age 1	AAP age 2	SNS0	SNS1	SNS2	DFS0	BTSC1	BTSC2	IBTSQ3_1	IBTSQ3_2	IBTSQ1_1	IBTSQ1_2
1977	878573	553375	NA	NA	9829	NA	NA	NA	NA	NA	NA	NA
1978	921985	605875	NA	NA	12882	NA	NA	NA	NA	NA	NA	NA
1979	1087410	756982	NA	NA	18785	NA	NA	NA	NA	NA	NA	NA
1980	998312	722164	NA	NA	8642	NA	NA	NA	NA	NA	NA	NA
1981	1918150	1385660	NA	NA	13909	NA	NA	NA	NA	NA	NA	NA
1982	1366570	951873	NA	NA	10413	NA	NA	NA	NA	NA	NA	NA
1983	1314260	874272	NA	NA	13848	NA	NA	NA	NA	NA	NA	NA
1984	1818360	1181680	NA	NA	7580	NA	NA	NA	NA	NA	NA	NA
1985	4306660	2827550	NA	NA	32991	NA	NA	NA	NA	NA	NA	NA
1986	1866210	1274770	NA	NA	14421	NA	NA	NA	NA	NA	NA	NA
1987	1763250	1255600	NA	NA	17810	NA	NA	NA	NA	NA	NA	NA
1988	1278120	926940	NA	NA	7496	NA	NA	NA	NA	NA	NA	NA
1989	1112890	800409	NA	NA	11247	NA	NA	NA	NA	NA	NA	NA
1990	970053	688318	NA	NA	13842	440	NA	NA	NA	NA	NA	NA
1991	823400	586968	NA	NA	9686	332	NA	NA	NA	NA	NA	NA
1992	559267	408199	NA	NA	4977	180	NA	NA	NA	NA	NA	NA
1993	606864	457421	NA	NA	2796	217	NA	NA	NA	NA	NA	NA
1994	931026	722667	NA	NA	10268	283	NA	21543	NA	NA	NA	NA
1995	824369	651071	NA	NA	4473	146	21326	14284	NA	3298	NA	NA
1996	2369150	1874820	NA	NA	30242	620	74133	72038	3413	5099	NA	NA
1997	829033	651341	NA	NA	10272	229	29113	15764	1006	2276	NA	NA
1998	724979	564782	NA	NA	2493	NA	37748	18879	905	1754	NA	NA

Year-class	AAP age 1	AAP age 2	SNS0	SNS1	SNS2	DFS0	BTSC1	BTSC2	IBTSQ3_1	IBTSQ3_2	IBTSQ1_1	IBTSQ1_2
1999	836436	646646	NA	22855	2899	NA	35382	17488	908	3242	NA	NA
2000	606235	463267	24214	11511	1103	125	25024	14144	1129	2849	NA	NA
2001	1852180	1389210	99628	30809	NA	313	110259	39413	6026	4921	NA	NA
2002	611844	450941	31202	NA	1350	123	27483	11722	1318	2538	NA	NA
2003	1271770	933906	NA	18202	1819	239	37696	24229	2412	4753	NA	NA
2004	834323	618243	13537	10118	1571	127	31953	14764	1901	3079	NA	NA
2005	881839	660013	27391	12164	2134	86	35708	18721	2137	4695	NA	5573
2006	1494920	1125810	51124	14175	2700	168	70074	39704	5582	10768	2285	11504
2007	1226400	933240	40581	14706	2019	98	56870	20094	6073	5012	2327	7607
2008	1103570	857361	50179	14860	1812	130	55273	24413	2700	4958	2814	6015
2009	1431820	1139010	53259	11947	1143	142	65807	36037	3108	9081	1383	6210
2010	1632940	1321860	49347	18349	2929	180	104762	53381	6504	11088	1141	14293
2011	1364450	1113120	52643	5893	3021	93	48228	45066	2402	6890	1919	5365
2012	1514410	1231720	45027	15395	2258	181	71173	52665	2701	8998	1367	7530
2013	1607560	1287570	44328	17313	5040	169	117547	57039	5226	7367	2656	10309
2014	901948	711007	11722	16726	2434	108	42533	26655	1660	4938	834	5413
2015	NA	NA	30494	10385	1716	100	68145	43495	3124	4897	2063	6928
2016	NA	NA	44111	15936	5250	78	115525	61154	4012	6154	1949	5951
2017	NA	NA	27397	9465	NA	127	70047	52412	2179	NA	687	NA
2018	NA	NA	190208	NA	NA	219	298881	NA	NA	NA	NA	NA

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 = 5.76, a substantial positive signal (i.e. >1). Thus, BTS-Q3 2019 survey yields a substantial higher signal for age 1 than our GM assumption in spring WGNSSK. Therefore, age 1 assumption needs to be updated in the short-term forecast.

For age 2 the D value = 3.74 (D >1), thus, the new information of age 2 from BTS-Q3 2019 is statistically different than the AAP-survival assumption we used in spring. Therefore, age 2 assumption needs to be updated in the short-term forecast.

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 : 1977 - 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 prediction se.pred WAP.weights
    BTSC1 0.8683     4.556 0.2217  0.7584 20   12.61      15.50  0.3074           1
 VPA Mean     NA        NA     NA      NA 38      NA      13.96  0.4269           0

                   WAP logWAP int.se
yearclass:2018 5410044   15.5 0.2495

Spring assumption for age 1: 1287315; log(1287315) = 14.07
```

Calculations for 2018 year-class at age 1	
Log WAP from RCT3 (R)	15.50
Log of recruitment assumed in spring (A)	14.07
Int SE of log WAP (S)	0.249
Distance D $\left(D = \frac{R-A}{S}\right)$	**5.76**

D calculation North Sea plaice age 2

```
Data for 1 surveys over 42 years : 1977 - 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:2017
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
    BTSC2 0.7619     5.906 0.1431  0.8853 21   10.87      14.19  0.1598           1
 VPA Mean     NA        NA     NA      NA 38      NA      13.66  0.4217           0

                   WAP logWAP int.se
yearclass:2017 1448124  14.19 0.1494

Spring assumption for age 2: 827716; log(827716) = 13.63
```

Calculations for 2017 year-class at age 2	
Log WAP from RCT3 (R)	14.19
Log of recruitment assumed in spring (A)	13.63
Int SE of log WAP (S)	0.149
Distance D $\left(D = \frac{R-A}{S}\right)$	**3.74**

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 recalculated 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 (below).

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	Y
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

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 3 surveys over 42 years : 1977 - 2018
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates 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 prediction se.pred
    BTSC1 0.8683    4.5562 0.2217 0.75841 20  12.608      15.50  0.3074
     SNS0 0.8799    4.6976 0.3587 0.52844 14  12.156      15.39  0.5056
     DFS0 2.6935   -0.1081 1.3329 0.08436 23   5.391      14.41  1.4298
 VPA Mean     NA        NA     NA      NA 38      NA      13.96  0.4269
 WAP.weights
      0.5170
      0.1911
      0.0239
      0.2680

                   WAP logWAP int.se
yearclass:2018 3413221  15.04  0.221
```

Age 2

```
Data for 7 surveys over 42 years : 1977 - 2018
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates 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 0.9494     3.711 0.3963 0.50557 14  10.218      13.41  0.4476   0.066262
     SNS1 3.7007   -21.782 1.4088 0.05691 15   9.155      12.10  1.6325   0.004981
     DFS0 3.2898    -3.469 1.6470 0.06279 23   4.846      12.47  1.7785   0.004197
    BTSC1 0.8976     3.985 0.2286 0.75963 20  11.157      14.00  0.2502   0.212154
    BTSC2 0.7619     5.906 0.1431 0.88533 21  10.867      14.19  0.1598   0.519869
 IBTSQ3_1 0.7543     7.797 0.3136 0.63333 19   7.687      13.60  0.3404   0.114549
 IBTSQ1_1 3.0375    -8.768 1.3446 0.02624  9   6.533      11.07  1.9964   0.003331
 VPA Mean     NA        NA     NA      NA 38      NA      13.66  0.4217   0.074657

                   WAP logWAP int.se
yearclass:2017 1155558  13.96 0.1152
```

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. The new age 1 RCT3 is substantially larger than the spring estimate. Aditionally, the new age 2 RCT3 estimate was even further above AAP survivors compared to the spring RCT3.

Table 7.6.4 Updated recruitment choice table (without indication of used assumptions in forecasts).

Year class	Age in 2019	AAP survivors	RCT3	GM 2006-2015	Accepted estimate
2017	2	827716	~~903568 (spring)~~ 1155558	997671	
2018	1		~~2084830 (spring)~~ 3413221	1287315	
Year class	**Age in 2020**	**AAP survivors**	**RCT3**	**GM 2006-2015**	**Accepted estimate**
2019	1			1287315	

7.6.5.2 Updated forecasts

We have two options for the updated recruitment assumptions:

Option 1) update both age 1 and age 2 with the new values of RCT3 analysis

Option 2) update age 1 with new values of RCT3, keep age 2 with AAP survival

In this section we present the updated STF with option 1). STF with option 2) are presented in the Appendix to Section 7.6 (below). For option 1), 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, RCT3 for age 2).

Year class	Age in 2019	AAP survivors	RCT3	GM 2006-2015	Accepted estimate
2017	2	827716	1155558	997671	RCT3
2018	1		3413221	1287315	RCT3
Year class	**Age in 2020**	**AAP survivors**	**RCT3**	**GM 2006-2015**	**Accepted estimate**
2019	1			1287315	GM 2006–2015

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 Appendix.

When the MSY approach is applied, catches in 2020 should be no more than 166 499 tonnes (131 439 tonnes in spring forecasting).

Table 7.6.6 Plaice in Subarea 4 and Subdivision 20. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2–6}$ (2019)	0.193	Average exploitation pattern in 2016–2018.
SSB (2020)	1 184 762	Short-term forecast (STF), in tonnes
R_{age1} (2019)	3 413 221	RCT3, including BTS 2019 survey information, in thousands
R_{age1} (2020)	1 287 315	Geometric mean (GM, 2006–2015), in thousands
Total catch (2019)	138 919	Short-term forecast (STF), in tonnes
Wanted catch (2019)	76 721	Short-term forecast (STF), average landings rate by age 2016–2018, in tonnes
Unwanted catch (2019)	62 198	Short-term forecast (STF), average discard rate by age 2016–2018, in tonnes

Table 7.6.7 Updated forecast (using RCT3 for age1 and age 2).

Basis	Total Catch (2020)	Wanted catch * (2020)	Unwanted catch * (2020)	f2.6	f_hc2.6	f_dis2.3	SSB 2021	% SSB change **	% TAC change ***	% Advice change ^
F_{MSY}	166499	89216	77283	0.21	0.091	0.21	1237188	4.4	17.1	17.1
F_{MP}	229528	123550	105978	0.30	0.130	0.29	1180054	-0.40	61	61
Fsq*0	0	0	0	0.00	0.00	0.00	1390696	17.4	-100	-100
F_{pa}	274634	148348	126286	0.37	0.159	0.36	1139325	-3.8	93	93
F_{lim}	362341	197190	165151	0.52	0.22	0.51	1060536	-10.5	155	155
SSB > B_{lim}	1385413	946464	438949	9.3	4.0	9.1	207288	-83	870	870
SSB > B_{pa}	1278745	844386	434359	6.6	2.8	6.4	290203	-76	800	800
SSB > MSY $B_{trigger}$	935796	555440	380356	2.4	1.04	2.4	564599	-52	560	560
TACsq	142217	76072	66145	0.177	0.077	0.174	1259276	6.3	0	0
Fsq*1	154026	82462	71564	0.193	0.083	0.189	1248522	5.4	8.3	8.3
F_{MSY_high}	229528	123550	105978	0.30	0.130	0.29	1180054	-0.4	61	61
F_{MSY_low}	118554	63323	55231	0.146	0.063	0.143	1280808	8.1	-16.6	-16.6

*** "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 2016–2018. 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 2020. The subtracted value (836 t of wanted catch and 779 t of unwanted catch) is estimated based on the plaice catch advice for Division 7.d for 2020.**

**** SSB 2021 relative to SSB 2020.**

***** Total catch in 2020 relative to the combined TAC of Subarea 4 and Subdivision 20 in 2019 (142 217 t).**

^ Total catch in 2020 relative to advice value 2019 (142 217 t).

^^ F_{wanted} and $F_{unwanted}$ do not sum up to the F_{total} as they are calculated using different ages.

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, RCT3 for age 2). Detailed age structured forecast for F=Fsq forecast.

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
1	2019	0.101572	0.101556	1.65E-05	3413221	0.052354	0.126333	0.052333	0.032667	0	0.1	313981	16438	51	6	313930	16429	0
2	2019	0.18744	0.181689	0.00575	1155558	0.086075	0.246333	0.081	0.066333	0.5	0.1	188248	16204	5775	1423	182473	14780	38326
3	2019	0.252926	0.1968	0.056125	1080785	0.154677	0.268667	0.122	0.121667	0.5	0.1	230328	35627	51111	13732	179217	21865	65748
4	2019	0.226635	0.105938	0.120697	467173.7	0.222689	0.294	0.142	0.181333	1	0.1	90325	20114	48103	14142	42221	5995	84714
5	2019	0.174298	0.046725	0.127573	270530.9	0.289156	0.337667	0.153667	0.248333	1	0.1	41239	11924	30184	10192	11055	1699	67182
6	2019	0.122758	0.016444	0.106314	372793	0.355795	0.383667	0.175	0.312667	1	0.1	41025	14596	35529	13631	5496	962	116560
7	2019	0.076981	0.006472	0.070509	283361	0.413202	0.435	0.177667	0.355333	1	0.1	19992	8261	18311	7965	1681	299	100688
8	2019	0.041766	0.003545	0.038221	215689.7	0.478872	0.507	0.192333	0.419333	1	0.1	8399	4022	7686	3897	713	137	90446
9	2019	0.020473	2.39E-06	0.020471	226533.6	0.545643	0.545667	0.32	0.455667	1	0.1	4369	2384	4369	2384	1	0	103224
10	2019	0.020473	2.55E-06	0.020471	712593.1	0.680146	0.680232	0	0.556071	1	0.1	13745	9348	13743	9348	2	0	396252
1	2020	0.101572	0.101556	1.65E-05	1287315	0.052354	0.126333	0.052333	0.032667	0	0.1	118420	6200	19	2	118400	6196	0
2	2020	0.18744	0.181689	0.00575	2790119	0.086075	0.246333	0.081	0.066333	0.5	0.1	454529	39124	13945	3435	440584	35687	92539
3	2020	0.252926	0.1968	0.056125	866878.6	0.154677	0.268667	0.122	0.121667	0.5	0.1	184742	28575	40995	11014	143747	17537	52735
4	2020	0.226635	0.105938	0.120697	759391.4	0.222689	0.294	0.142	0.181333	1	0.1	146823	32696	78192	22988	68631	9746	137703
5	2020	0.174298	0.046725	0.127573	336994.5	0.289156	0.337667	0.153667	0.248333	1	0.1	51370	14854	37599	12696	13771	2116	83687
6	2020	0.122758	0.016444	0.106314	205632	0.355795	0.383667	0.175	0.312667	1	0.1	22629	8051	19598	7519	3031	530	64294
7	2020	0.076981	0.006472	0.070509	298349.3	0.413202	0.435	0.177667	0.355333	1	0.1	21050	8698	19280	8387	1770	314	106013
8	2020	0.041766	0.003545	0.038221	237398.7	0.478872	0.507	0.192333	0.419333	1	0.1	9245	4427	8460	4289	785	151	99549
9	2020	0.020473	2.39E-06	0.020471	187180.7	0.545643	0.545667	0.32	0.455667	1	0.1	3610	1970	3610	1970	0	0	85292
10	2020	0.020473	2.55E-06	0.020471	832536.4	0.680146	0.680232	0	0.556071	1	0.1	16058	10922	16056	10922	2	0	462949
1	2021	0.101572	0.101556	1.65E-05	1287315	0.052354	0.126333	0.052333	0.032667	0	0.1	118420	6200	19	2	118400	6196	0
2	2021	0.18744	0.181689	0.00575	1052309	0.086075	0.246333	0.081	0.066333	0.5	0.1	171428	14756	5259	1296	166169	13460	34902
3	2021	0.252926	0.1968	0.056125	2093097	0.154677	0.268667	0.122	0.121667	0.5	0.1	446064	68996	98983	26594	347080	42344	127330
4	2021	0.226635	0.105938	0.120697	609094.4	0.222689	0.294	0.142	0.181333	1	0.1	117764	26225	62716	18439	55048	7817	110449
5	2021	0.174298	0.046725	0.127573	547784.9	0.289156	0.337667	0.153667	0.248333	1	0.1	83503	24145	61118	20637	22385	3440	136033

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
6	2021	0.122758	0.016444	0.106314	256151.3	0.355795	0.383667	0.175	0.312667	1	0.1	28189	10029	24413	9366	3776	661	80090
7	2021	0.076981	0.006472	0.070509	164569	0.413202	0.435	0.177667	0.355333	1	0.1	11611	4798	10635	4626	976	173	58477
8	2021	0.041766	0.003545	0.038221	249955.8	0.478872	0.507	0.192333	0.419333	1	0.1	9734	4661	8907	4516	826	159	104815
9	2021	0.020473	2.39E-06	0.020471	206020.2	0.545643	0.545667	0.32	0.455667	1	0.1	3974	2168	3973	2168	0	0	93877
10	2021	0.020473	2.55E-06	0.020471	903979.9	0.680146	0.680232	0	0.556071	1	0.1	17436	11859	17434	11859	2	0	502677

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 IV (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 2016/ACOM.

Appendix to 7.6:

Table. STF result in spring WGNSSK2019.

Basis	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	^^ F_{total} ages 2–6 (2020)	F_{wanted} ages 2–6 (2020)	$F_{unwanted}$ ages 2–3 (2020)	SSB (2021)	% SSB change **	% TAC change ***	% Advice change ^
ICES advice basis										
MSY approach: F_{MSY}	131439	83536	47903	0.21	0.091	0.21	1128558	1.47	-7.6	-7.6
Other scenarios										
F = MAP $F_{MSY\ upper}$	181628	115827	65801	0.30	0.130	0.29	1081370	-2.8	28	28
F = MAP $F_{MSY\ lower}$	93382	59231	34151	0.146	0.063	0.143	1164489	4.7	-34	-34
F = 0	0	0	0	0.00	0.00	0.00	1254686	12.8	-100	-100
F_{pa}	217665	139194	78471	0.369	0.159	0.36	1047633	-5.8	53	53
F_{lim}	288072	185339	102733	0.516	0.22	0.51	982104	-11.7	103	103
SSB (2021) = B_{lim}	1199773	918919	280854	9.3	4.0	9.1	207288	-81	740	740
SSB (2021) = B_{pa}	1093919	816779	277140	6.6	2.8	6.4	290203	-74	670	670
SSB (2021) = MSY $B_{trigger}$	756458	520017	236441	2.3	1.00	2.3	564599	-49	430	430
Rollover TAC	142217	90441	51776	0.23	0.099	0.22	1118414	0.56	0	0
$F_{2020} = F_{2019}$	121529	77193	44336	0.193	0.083	0.189	1137903	2.3	-14.5	-14.5

STF result for option 2) recruitment assumption:

Year class	Age in 2019	AAP survivors	RCT3	GM 2006–2015	Accepted estimate
2017	2	827716	1155558	997671	AAP
2018	1		3413221	1287315	RCT3
Year class	**Age in 2020**	**AAP survivors**	**RCT3**	**GM 2006–2015**	**Accepted estimate**
2019	1			1287315	GM 2006–2015

When the MSY approach is applied, catches in 2020 should be no more than 157 769 tonnes (131 439 tonnes in spring forecasting).

Basis	catch	landings	discards	f2.6	f_hc2.6	f_dis2.3	ssb2021	ssb_change	% TAC change	% advice change
F_{MSY}	157769	85848	71921	0.21	0.091	0.21	1206551	3.1	10.9	10.9
F_{MP}	217723	118996	98727	0.30	0.130	0.29	1152828	-1.45	53	53
Fsq*0	0	0	0	0.00	0.00	0.00	1350343	15.4	-100	-100
F_{pa}	260698	142972	117726	0.37	0.159	0.36	1114456	-4.7	83	83
F_{lim}	344454	190290	154164	0.52	0.22	0.51	1040028	-11.1	142	142
SSB > B_{lim}	1347713	931921	415792	9.3	4.0	9.1	207288	-82	850	850
SSB > B_{pa}	1241169	829885	411284	6.6	2.8	6.4	290203	-75	770	770
SSB > MSY $B_{trigger}$	898290	540251	358039	2.4	1.04	2.4	564599	-52	530	530
TACsq	142217	77298	64919	0.188	0.081	0.184	1220529	4.3	0	0
Fsq*1	145919	79335	66584	0.193	0.083	0.189	1217195	4.1	2.6	2.6
F_{MSY_high}	217723	118996	98727	0.30	0.130	0.29	1152828	-1.45	53	53
F_{MSY_low}	112239	60887	51352	0.146	0.063	0.143	1247488	6.6	-21	-21

7.7 Sole in Subarea 4

7.7.1 Short term forecast and June advice

At WGNSSK 2019 (ICES, 2019), the following short-term forecast settings were used:

Year Class	Age in 2019	AAP thousands	RCT3 thousands	GM (1957–2014) thousands
2017	2	85049.3	93695.6	99369.9
2018	1		228471.4	112787.8
Year Class	**Age in 2020**	**AAP thousands**	**RCT3 thousands**	**GM (1957–2014) thousands**
2019	1			112787.8

Population numbers in the intermediate year (2019) for age 2 are taken from the AAP survivor estimates. Numbers at age 1 in 2019 are taken from the long-term geometric mean.

7.7.2 New survey information.

There is new survey information available from the quarter three Beam Trawl Survey (BTS Q3), 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. The RV Tridens was equipped with the original gear 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 thus 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 43 years including the assessment estimates are presented in Table 7.7.1. In the autumn of 2019, the new data derived from the recently conducted BTS-Isis survey comprises age 1 of year class 2018 and age 2 of year class 2017.

Table 7.7.1. North Sea sole RCT3 input data for age 1 and age 2

Year-class	N Age 1	N Age 2	DFS0	SNS0	SNS1	BTS1	BTS2
1976	163006	145424		464.6	3742.9		
1977	60809	54434.3		1585	1547.7		
1978	18040	16197.1		10370.5	93.8		
1979	190841	171469		3922.7	4312.9		
1980	230091	206082		5145.8	3737.2		
1981	205107	182183		3240.7	5856.5		
1982	197096	173732		2147	2621.1		
1983	91723	81382.2		769.1	2493.1		7.12
1984	112527	100850		3334	3619.4	7.03	5.18
1985	169330	152508		2713.4	3705.1	7.17	12.55
1986	84736	76430.6		742	1947.9	6.97	12.51
1987	669270	603828		13610.1	11226.7	83.11	68.08
1988	129322	116653		522.7	2830.7	9.02	24.49
1989	244852	220778		1743.4	2856.2	37.84	28.84
1990	90455	81475.3	6.38	50.8	1253.6	4.04	22.28
1991	441410	396308	167.56	3639.7	11114	81.62	42.35
1992	88004	78258.5	9.27	302.9	1290.8	6.35	7.12
1993	67430	58896.6	15.32	231.3	651.8	7.66	8.46
1994	117215	101578	22.06	4692.7	1362.1	28.12	7.63
1995	75301	66233.3	7.06	1374.9	218.4	3.98	4.92
1996	306980	273316	40.27	2322.3	10279.3	169.34	27.42
1997	145514	129848	26.94	803	4094.6	17.11	18.36
1998	119335	105703		327.9	1648.9	11.96	6.14
1999	149473	130246		2187.9	1639.2	14.59	9.96
2000	75840	65410.4	9.5	70	970.3	8	4.18
2001	211151	183804	51.42	8340	7547.5	20.99	9.95
2002	92102	81152	58.58	1127.7		10.51	4.35
2003	48463	42934.8	10.61		1369.5	4.19	3.40
2004	51785	45864.8	31.25	162	568.1	5.53	2.33
2005	191607	169086	40.99	305	2726.4	17.09	19.50
2006	69112	60666.4	12.57	16	848.6	7.5	9.06
2007	73577	64280	13.73	466.9	1259.1	15.25	5.00
2008	94379	82360.4	11.77	754.7	1931.6	15.95	10.71
2009	211395	185294	27.33	2291	2636.9	54.81	17.39
2010	211307	186173	42.86	333.9	1248	26.17	18.21
2011	54622	48142.3	12.13	136.3	226.6	5.15	3.56
2012	113335	98921.7	11.23	144.7	967.4	6.84	15.58
2013	202993	173149	44.82	237.3	2849	18.93	25.60
2014	149480	124049	23.62	126	3192	21.1	11.83

Year-class	N Age 1	N Age 2	DFS0	SNS0	SNS1	BTS1	BTS2
2015			7.45	109.7	733.8	6.45	7.10
2016			12.28	373.2	956.7	16.28	14.35
2017			20.97	205.9	1002.3	16.04	10.34
2018			56.75	6574.9		97.29	

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 **+4.4**, significantly different from the spring assumption (|D| > 1). The D-value for age 2 is **+0.65**, which is not significantly different from the spring assumption (|D| < 1).

Hence, **the short-term forecast should 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 ver3.1 - R translation



Data for 1 surveys over 43 year classes : 1976 - 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    0
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2018
    index slope intercept    se rsquare  n indices prediction se.pred WAP.weights
     bts1 0.768      9.73 0.392   0.721 31    4.58       13.3   0.439           1
 VPA Mean    NA        NA    NA      NA 39      NA       11.7   0.669           0

                  WAP logWAP int.se
yearclass:2018 568336   13.3  0.367
```

Spring assumption for age 1: 112788; log(112788) = 11.63

D - calculation for age 1	
Log WAP from RCT3 (R)	13.3
Log of recruitment assumed in spring (A)	11.63
Int SE of log WAP (S)	0.367
Distance D $\left(D=\frac{R-A}{S}\right)$	**4.40**

Age 2

```
Analysis by RCT3 ver3.1 - R translation


Data for 1 surveys over 43 year classes : 1976 - 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    0
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
     bts2 0.906      9.46 0.381    0.73 32    2.34       11.6   0.399           1
 VPA Mean    NA        NA    NA      NA 39      NA       11.6   0.670           0

                  WAP logWAP int.se
yearclass:2017 106227   11.6  0.343
```

Spring assumption for age 2: 85049; log(85049) = 11.35

D - calculation for age 2	
Log WAP from RCT3 (R)	11.6
Log of recruitment assumed in spring (A)	11.35
Int SE of log WAP (S)	0.343
Distance D $\left(D=\frac{R-A}{S}\right)$	**0.6484**

7.7.5 Conclusion from the protocol.

As the distance for both ages is D > 1 the protocol indicates that **the advisory process for North Sea sole should be reopened**. The autumn indices suggest that the size of the incoming year-class is significantly higher to what had been assumed in the forecast produced by WGNSSK in May 2019. Given -1 < D < 1 for the age2 prediction, only the prediction of recruitment for age1 will be updated in the forecast.

7.7.6 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea sole using the new estimate of recruitment in 2019 (467 million for the 2018 year-class at age 1). The settings and assumptions for the forecast were otherwise unchanged from those presented in ICES (2019). The survey information (fifth ever largest index of abundance for age 1) leads to a prediction of very high recruitment (third largest ever observed) for the 2018 year-class.

Table 7.7.3 North Sea sole RCT3 output for age 1 for short term forecast

```
Analysis by RCT3 ver3.1 - R translation



Data for 4 surveys over 43 year classes : 1976 - 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    0
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2018
    index slope intercept    se rsquare  n indices prediction se.pred WAP.weights
     dfs0 0.989      8.63 0.544   0.558 23    4.04       12.6   0.600      0.3351
     sns0 1.122      4.22 1.652   0.141 38    8.79       14.1   1.758      0.0391
     sns1    NA        NA    NA      NA NA      NA         NA      NA          NA
     bts1 0.768      9.73 0.392   0.721 31    4.58       13.3   0.439      0.6258
 VPA Mean    NA        NA    NA      NA 39      NA       11.7   0.669      0.0000

                  WAP logWAP int.se
yearclass:2018 476477   13.1  0.308
```

Table 7.7.4 shows the updated advice option table from the new October 2019 run. The previous advice option table from spring 2019 is given in Table 7.7.5.

Table 7.7.4 Sole in Subarea 4. Updated annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2020)	Wanted catch** (2020)	Unwanted catch (2020)	F_{total}# (ages 2–6) (2020)	F_{wanted} (ages 2–6) (2020)	$F_{unwanted}$ (ages 1–3) (2020)	SSB (2021)	% SSB change***	% TAC change^	% Advice change^^
ICES advice basis										
EU MAP^^^: F_{MSY}	17545	15117	2427	0.20	0.166	0.058	89527	63	40	37
F = MAP $F_{MSY\ lower}$	10192	8787	1406	0.113	0.093	0.033	96677	76	-18.8	-20
F = MAP $F_{MSY\ upper}$	29767	25625	4142	0.37	0.30	0.106	77682	42	137	133
Other scenarios										
MSY approach: F_{MSY}	17545	15117	2427	0.20	0.166	0.058	89527	63	40	37
F_{mp} (former management plan)	17386	14980	2405	0.20	0.165	0.058	89682	64	38	36
F = 0	0	0	0	0	0	0	106614	95	-100	-100
F_{pa}	34646	29814	4832	0.44	0.36	0.127	72969	33	176	171
F_{lim}	46007	39551	6456	0.63	0.52	0.182	62038	13.3	270	260
SSB (2021) = B_{pa}	72372	62040	10332	1.24	1.02	0.36	37000	-32	480	470
SSB (2021) = B_{lim}	83891	71796	12095	1.65	1.36	0.48	26300	-52	570	560
SSB (2021) = MSY $B_{trigger}$	72372	62040	10332	1.24	1.02	0.36	37000	-32	480	470
F = F_{2019}	18702	16113	2589	0.22	0.178	0.062	88404	61	49	46
Roll-over TAC	12555	10822	1733	0.141	0.116	0.041	94378	72	0.00	-1.92

Table 7.7.5 Sole in Subarea 4. Spring annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2020)	Wanted catch** (2020)	Unwanted catch (2020)	F_{total}# (ages 2–6) (2020)	F_{wanted} (ages 2–6) (2020)	$F_{unwanted}$ (ages 1–3) (2020)	SSB (2021)	% SSB change***	% TAC change^	% Advice change^^
ICES advice basis										
EU MAP^^^: F_{MSY}	12317	11268	1049	0.202	0.166	0.058	55528	1.37	−1.90	−3.8
F = MAP $F_{MSY\ lower}$	7170	6562	609	0.113	0.093	0.033	60280	10.0	−43	−44
F = MAP $F_{MSY\ upper}$	20820	19038	1782	0.367	0.30	0.106	47717	−12.9	66	63
Other scenarios										
MSY approach: F_{MSY}	12317	11268	1049	0.20	0.166	0.058	55528	1.37	−1.90	−3.8
F_{mp} (former management plan)	12205	11166	1039	0.20	0.165	0.058	55630	1.56	−2.8	−4.7
F = 0	0	0	0	0	0	0	66927	22	−100	−100
F_{pa}	24195	22119	2076	0.44	0.36	0.127	44633	−18.5	93	89
F_{lim}	32007	29244	2763	0.63	0.52	0.182	37537	−31	155	150
SSB (2021) = B_{pa}	32601	29785	2816	0.65	0.53	0.186	37000	−32	160	155
SSB (2021) = B_{lim}	44561	40664	3897	1.02	0.84	0.30	26300	−52	250	250
SSB (2021) = MSY $B_{trigger}$	32601	29785	2816	0.65	0.53	0.186	37000	−32	160	155
F = F_{2019}	13125	12007	1118	0.22	0.178	0.062	54783	0.0127	4.5	2.5
Roll-over TAC	12555	11486	1069	0.21	0.170	0.059	55308	0.97	0	−1.92

The baseline advice uses the MSY approach with a target F of 0.20. On this basis, predicted total catch in 2020 increases from 12 317 t (spring results) to 17 545 t (October results), while the corresponding TAC change is +40%.

7.7.7 References

ICES. 2019. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 2019, Bergen, Norway. ICES CM 2019/ACOM:22.

Shepherd, J. G. 1997. Prediction of year-class strength by calibration regression analysis of multiple recruit index series. *ICES Journal of Marine Science*, 54: 741–752.

7.8 North Sea *Nephrops*

7.8.1 *Nephrops* FU6 (Farn Deeps)

The annual underwater TV survey of the Farn Deeps area was undertaken 24–30 June 2019.

The survey was completed without any technical issues. 91 stations were completed with valid counts generated using the standard protocols for counting and quality assurance.

Total abundance in 2019 is estimated to be 1163 million with a 95% CI of 26 million (Table 7.8.1.1, Figure 7.8.1.1, 7.8.1.2). The advice in June 2019 was based upon the 2018 survey, which showed 950 million with a 95% CI of 23 million. The increase in abundance from 2018 to 2019 was 213 million, beyond the confidence envelope of the 2019 survey.

It is therefore recommended that the advice be reopened.

Catch and landing predictions for 2020 are given in the text table below. This assumes that the absolute abundance estimate made in June 2019 is relevant to the stock status for 2020.

Headline advice for total catch (assuming the current discarding patterns continue) is between 2 055 and 2 384 t (compared to the range 1 679-1 947 t in the June 2019 advice).

The updated catch scenarios are shown below:

Catch scenarios assuming recent discard rates

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}	2384	2347	2135	212	37	8.12%	20
F = MAP $F_{MSY\ lower}$	2055	2023	1841	182	32	7.00%	3.7
F = MAP $F_{MSY\ upper}$***	2384	2347	2135	212	37	8.12%	20
Other options							
MSY approach	2384	2347	2135	212	37	8.12%	20
F_{2018}	2452	2413	2196	218	38	8.4%	24
$F_{2016–2018}$	3060	3012	2741	271	48	10.4%	54

Catch scenarios assuming zero discards

	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**	% advice change
EU MAP^: F_{MSY}	2298	2058	240	8.12%	15.9
F = MAP $F_{MSY\ lower}$	1981	1774	207	7.00%	-0.047
F = MAP $F_{MSY\ upper}$***	2298	2058	240	8.12%	15.9
Other options					
MSY approach	2298	2058	240	8.12%	15.9
F_{2018}	2363	2116	247	8.4%	19.2
$F_{2016–2018}$	2950	2642	308	10.4%	49

^ EU multiannual plan (MAP) for the North Sea (EU, 2018).

*** Calculated for dead removals.**

**** Total catch 2020 relative to the F_{MSY} advice value 2019 (1982 tonnes).**

***** $F_{MSY\ upper}$ = 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
2019	91	Summer	0.37	1163	26	Geostatistics

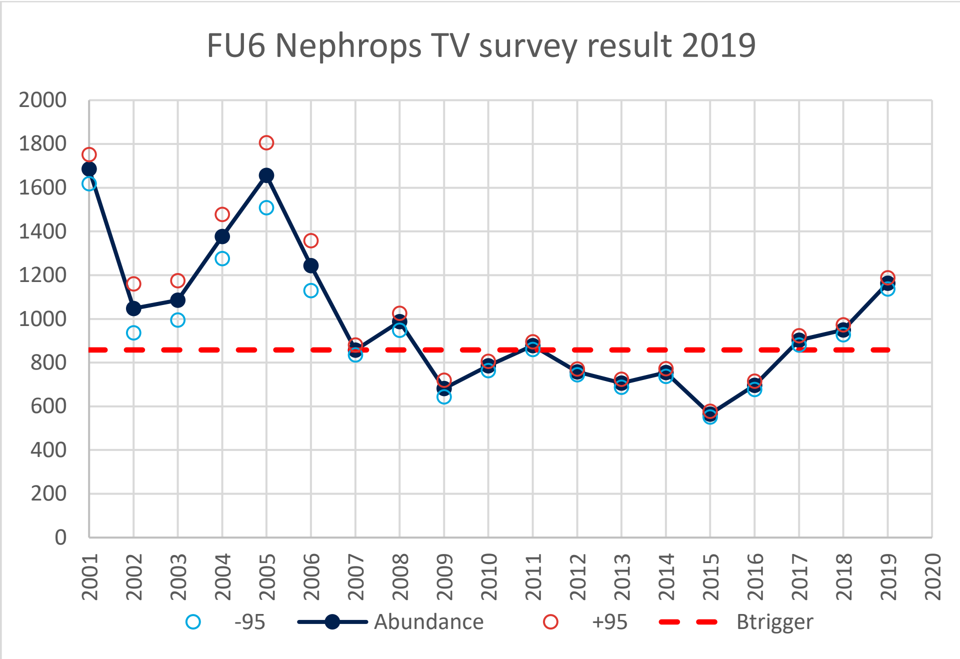

Figure 7.8.1.1. FU6 UWTV survey history

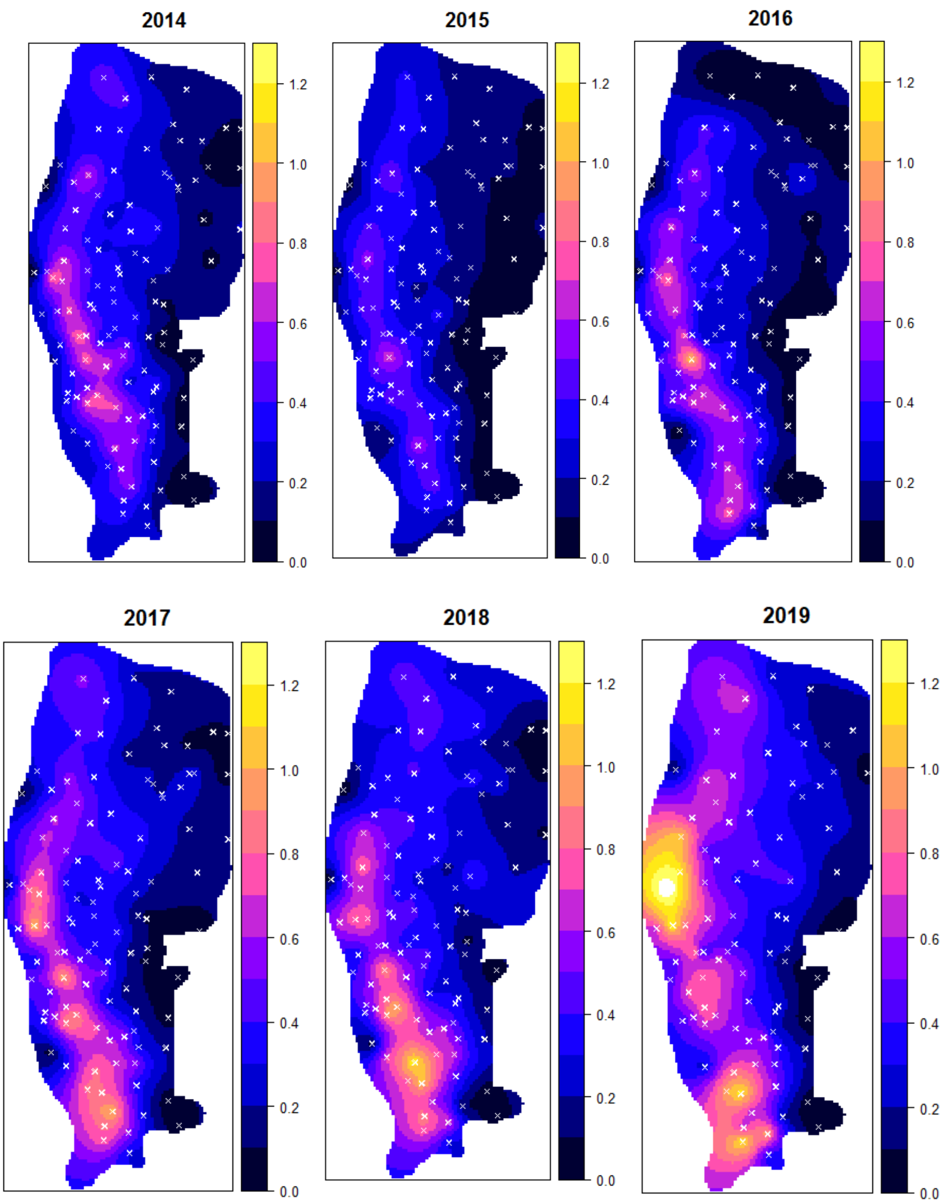

Figure 7.8.1.2. FU6 UWTV density maps (burrows·m^{-2}) 2014–2019

7.8.2 *Nephrops* FU7 (Fladen)

The most recent UWTV survey for this stock was carried out in June 2019. 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 2019 advice and based on the 2018 survey was 5656 million with a 95% CI of 689 million (Table 7.8.2.1; figures 7.8.2.1 and 2). The estimate from the 2019 summer survey is 6129 million (8% increase on the 2018 value). The 2019 value is significantly different from that of 2018 (ACOM specifies 1 SD, this is under 2 SD) and therefore **the advice for FU7 may be reopened**.

The advice for 2020 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2020 under the landing obligation and assuming discard rates and fishery selection patterns do not change from the long-term average of

2000–2018 (Table 7.8.2.2) following the MSY approach is 14263 tonnes (the June advice was 13162 tonnes). Catch scenarios assuming zero discards are also provided (Table 7.8.2.3). Mean weights and discard rates have not been revised in October 2019 (as this update has only new 2019 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 1992–2019 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	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
2019	70	6129	0.22	802

FU7 basis for the catch options

Variable	Value	Notes
Stock abundance	6129 million individuals	UWTV 2019
Mean weight in wanted catch	31.65 g	Average 2000–2018
Mean weight in unwanted catch	14.86 g	Average 2000–2018
Unwanted catch rate (total)	6.9%	Average 2000–2018 (proportion by number)
Discard survival ratio	25%	Proportion by number
Dead unwanted catch ratio (total)	5.3%	Average 2000–2018 (proportion by number)

Table 7.8.2.2. Catch scenarios assuming recent discard rates

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}	14263	14143	13783	360	120	7.5	8.2%
F = MAP $F_{MSY\ lower}$	12552	12446	12129	317	106	6.6	-4.8%
F = MAP $F_{MSY\ upper}$ ***	14263	14143	13783	360	120	7.5	8.2%
Other scenarios							
MSY approach	14263	14143	13783	360	120	7.5	8.2%
$F_{2016–2018}$	4563	4525	4410	115	38	2.4	-65%
F_{2018}	5325	5280	5146	134	45	2.8	-60%
$F_{35\%SpR}$	21298	21119	20582	537	179	11.2	62%
F_{max}	31187	30925	30138	787	262	16.4	137%

Table 7.8.2.3. Catch scenarios assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP ^: F_{MSY}	14016	13545	471	7.5	6.4%
F= MAP $F_{MSY\ lower}$	12334	11919	415	6.6	-6.4%
F = MAP $F_{MSY\ upper}$***	14016	13545	471	7.5	6.4%
Other scenarios					
MSY approach	14016	13545	471	7.5	6.4%
$F_{2016–2018}$	4485	4334	151	2.4	-66%
F_{2018}	5233	5057	176	2.8	-60%
$F_{35\%SpR}$	20931	20227	704	11.2	59%
F_{max}	30649	29618	1031	16.4	133%

^ EU multiannual plan (MAP) for the North Sea (EU, 2018).

*** Calculated for dead removals.**

**** Total catch 2020 relative to the F_{MSY} advice value 2019 (13 178 t).**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock.**

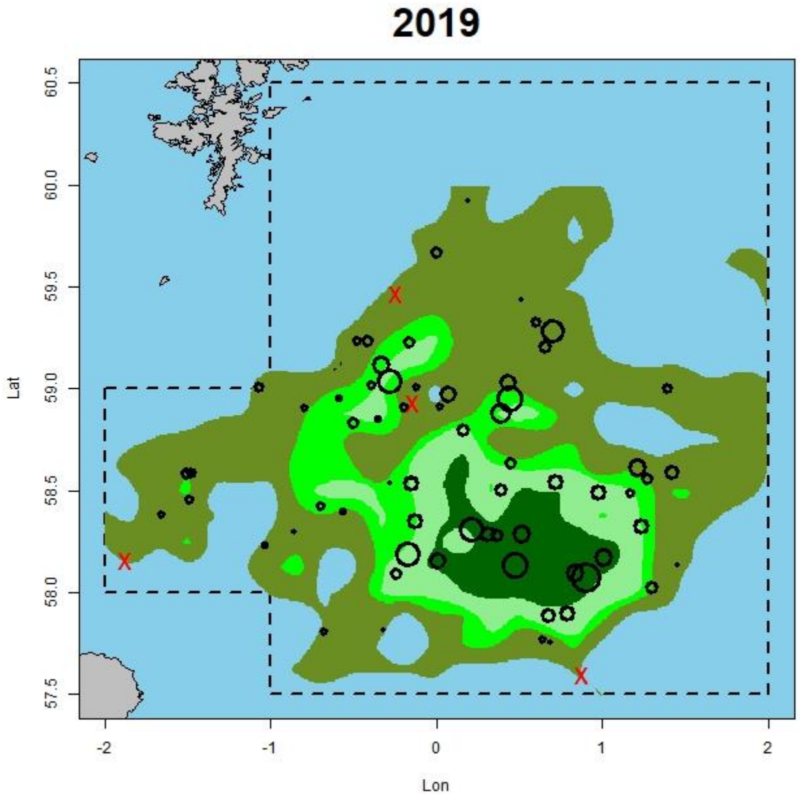

Figure 7.8.2.1. *Nephrops*, Fladen (FU 7). TV survey distribution and relative density in 2019. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

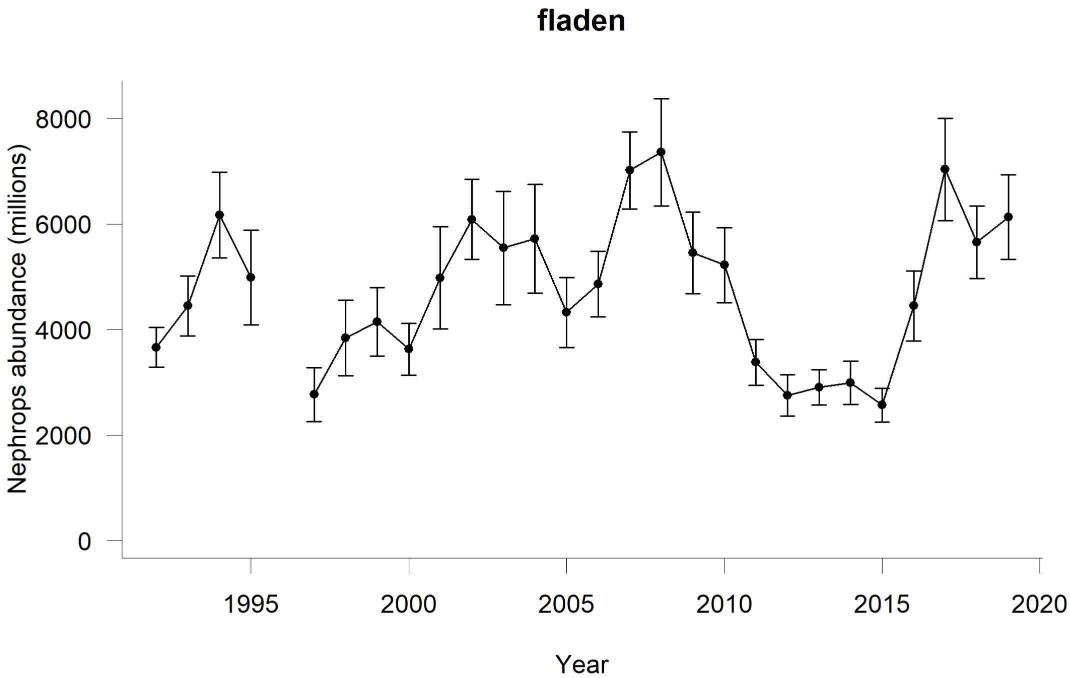

Figure 7.8.2.2. Nephrops, Fladen (FU 7): Results of the 1992–2019 TV surveys.

7.8.3 *Nephrops* FU8 (Firth of Forth)

The most recent UWTV survey for this stock was carried out in September 2019. 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 2019 advice and based on the 2018 survey was 1025 million with a 95 % CI of 190 million (Table 7.8.3.1; figures 7.8.3.1 and 2). The estimate from the 2019 summer survey is 865 million (16% decrease on the 2018 value). The 2019 value is significantly different from that of 2018 (ACOM specifies 1 SD, this is under 2 SD) and therefore **the advice for FU8 may be reopened**.

The advice for 2020 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2020 under the landing obligation and assuming discard rates and fishery selection patterns do not change from the average of 2016–2018 (Table 7.8.3.2) following the MSY approach is 3143 tonnes (the June advice was 3724 tonnes). Catch scenarios assuming zero discards are also provided (Table 7.8.3.3). Mean weights and discard rates have not been revised in October 2019 (as this update has only new 2019 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 1993–2019 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

Year	Stations	Mean Density	Abundance	95% conf interval
		burrows/m²	millions	millions
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
2019	50	0.95	865	135

FU8 basis for the catch options

Variable	Value	Notes
Stock abundance	865 million individuals	UWTV 2019
Mean weight in wanted catch	23.66 g	Average 2016–2018
Mean weight in unwanted catch	10.45 g	Average 2016–2018
Unwanted catch ratio (total)	17.9%	Average 2016–2018 (proportion by number)
Discard survival ratio	25%	Proportion by number
Dead unwanted catch ratio (total)	14.1%	Average 2016–2018 (proportion by number)

Table 7.8.3.2. Catch scenarios assuming recent discard rates

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}	3143	3074	2867	207	69	16.3	-11.9%
F= MAP $F_{MSY\ lower}$	2045	2000	1865	135	45	10.6	-43%
F = MAP $F_{MSY\ upper}$***	3143	3074	2867	207	69	16.3	-11.9%
Other scenarios							
MSY approach	3143	3074	2867	207	69	16.3	-11.9%
$F_{0.1}$	1812	1772	1653	119	40	9.4	-49%
F_{35SpR}	2449	2395	2234	161	54	12.7	-31%
F_{2018}	2488	2433	2269	164	55	12.9	-30%
$F_{2016–2018}$	2893	2829	2638	191	64	15	-18.9%

Table 7.8.3.3. Catch scenarios assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP ^: F_{MSY}	3003	2739	264	16.3	-15.9%
F= MAP $F_{MSY\ lower}$	1953	1781	172	10.6	-45%
F = MAP $F_{MSY\ upper}$***	3003	2739	264	16.3	-15.9%
Other scenarios					
MSY approach	3003	2739	264	16.3	-15.9%
$F_{0.1}$	1731	1579	152	9.4	-51%
F_{35SpR}	2339	2134	205	12.7	-34%
F_{2018}	2377	2168	209	12.9	-33%
$F_{2016–2018}$	2763	2520	243	15	-23%

^ EU multiannual plan (MAP) for the North Sea (EU, 2018).

*** Calculated for dead removals.**

**** Total catch 2020 relative to F_{MSY} advice value 2019 (3569 t).**

***** $F_{MSY\ upper}$ = F_{MSY} for this stock.**

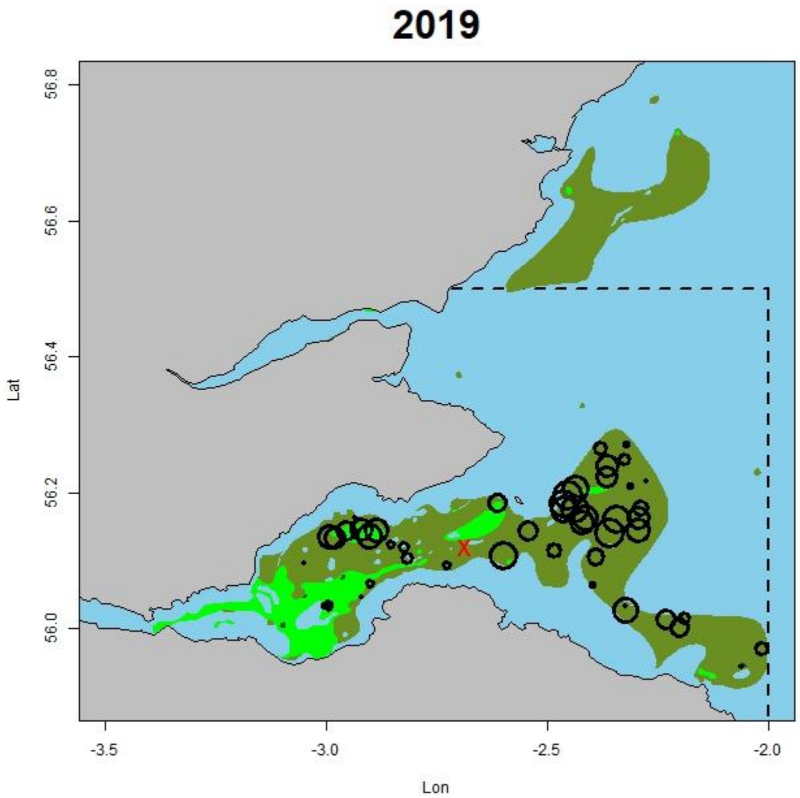

Figure 7.8.3.1. *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density in 2019. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

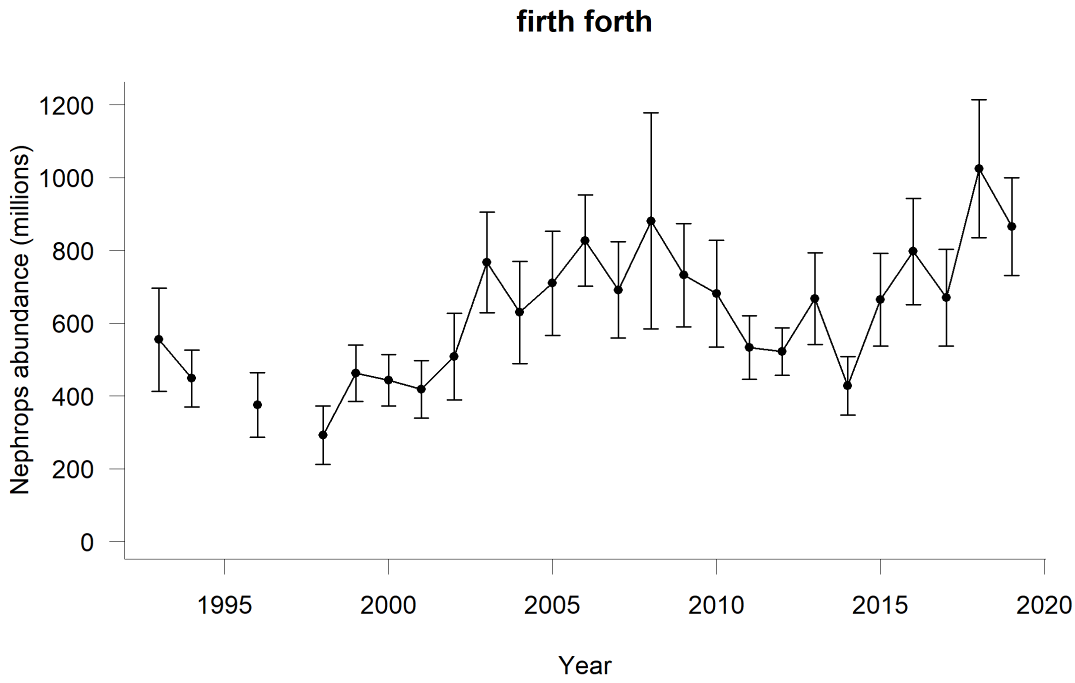

Figure 7.8.3.2. Nephrops, Firth of Forth (FU 8): Results of the 1992–2019 TV surveys.

7.8.4 *Nephrops* FU9 (Moray Firth)

The most recent UWTV survey for this stock was carried out in August 2019. 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 2019 advice and based on the 2018 survey was 417 million with a 95 % CI of 126 million (Table 7.8.4.1; figures 7.8.4.1 and 2). The estimate from the 2019 summer survey is 376 million (10% decrease on the 2018 value). The 2019 value is within 1 SD of the 2018 abundance estimate and therefore **the advice for FU9 should not be reopened**.

Table 7.4.8.1. *Nephrops*, Moray Firth (FU 9): Results of the 1993–2019 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
2018	55	0.19	417	126
2019	55	0.17	376	146

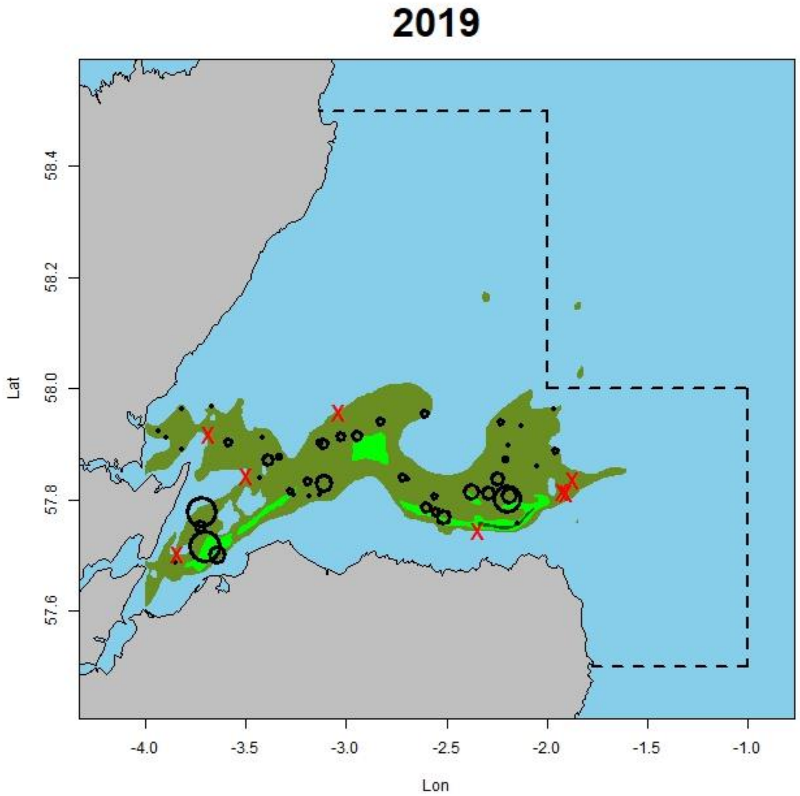

Figure 7.8.4.1. *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density in 2019. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

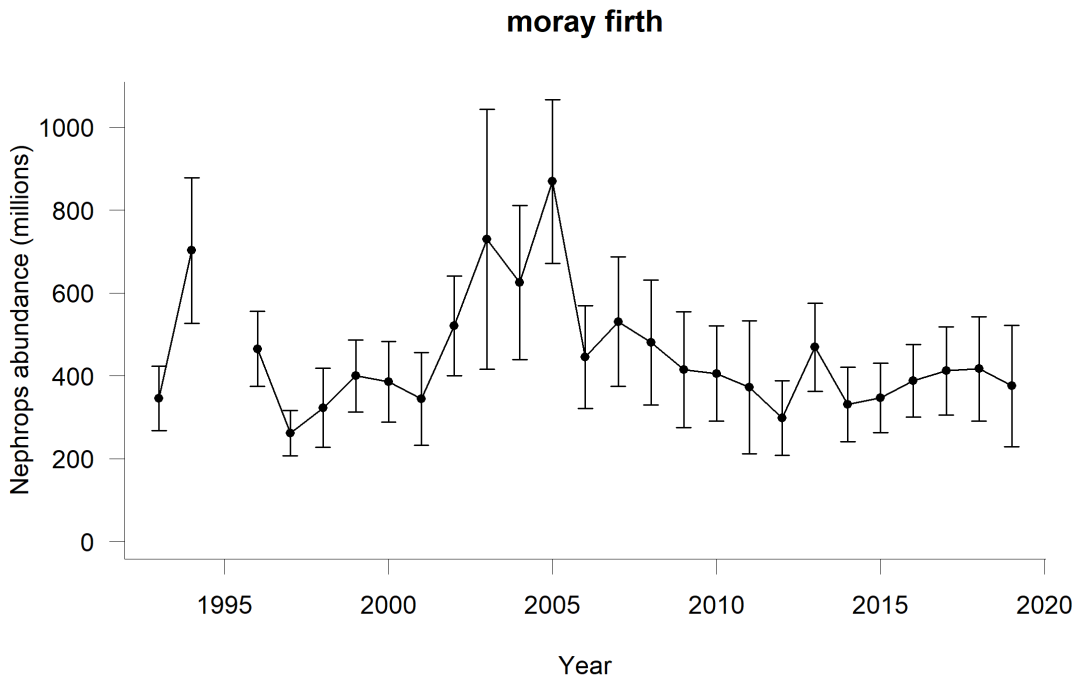

Figure 7.8.4.2. ***Nephrops*****, Moray Firth (FU 9): Results of the 1992–2019 TV surveys.**

Annex 8: Data call: Data submission for ICES fisheries advisory work

1 Scope of the Data call

ICES Member Countries are requested to provide the following for selected ICES fish, cephalopod, and shellfish stocks:

landings, discards, BMS (selected working groups), biological, and effort data from 2018, and other supporting information.

A list of stocks included in the data call are provided in Annex 1 and Table 7.7.1. **All countries that have catch or landings data on these stocks should submit data, even if they are not listed on the data request spreadsheets.** The countries listed on the data request spreadsheets were identified based on previous year catches therefore new fisheries (in 2018) are not detected. These should, however, 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

Generically, all the governments and intergovernmental commissions requesting and receiving advice from ICES have signed international agreements under UNCLOS 1995[1] Fish Stocks agreement article 5 and 6 to incorporate fisheries impacts on other components of marine ecosystems and WSSD 2002 article 30 to implement an ecosystem approach in relation to oceans policy including fisheries. These agreements include an obligation to collect and share data on, inter alia, vessel position (UNCLOS FSA art 5) and to support assessment of the impacts of fisheries on non-target species and the environment (UNCLOS FSA art 6).

Specifically, ICES has a standing request from the European Commission to advise and inform on the impacts of fisheries on the marine environment. Currently it provides advice on the impact of fishing on birds and mammals. It is required to expand this advice to the impact on benthic habitats.

For EU Member States, this data call is under the DCF regulation ((EC) No 2017/1004 and Commission Decision 2016/1251/EU) and in particular, Article 17(3) of regulation (EC) No 2017/1004 which states "..requests made by end-users of scientific data in order to serve as a basis for advice to fisheries management, Member States shall ensure that relevant detailed and aggregated data are updated and made available to the relevant end-users of scientific data within the deadlines set in the request,.."

ICES is thus mandated to request all fisheries dependent and independent data including VMS and logbook information used to provide this advice. This mandate is supported by international agreements and the current EU data collection framework (DCF).

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[1] United Nations (UN). 2011. Agreement related to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. Available at:
https://documents-dds-ny.un.org/doc/UNDOC/GEN/N95/274/67/PDF/N9527467.pdf?OpenElement

This Data call follows the principles of personal data protection, as referred to in paragraph (9) of the preamble in Council Regulation (EC) No 2017/1004.

4 Deadlines

ICES requests that the data are delivered by a date specific to each Working Group, 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), that takes place 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 the ICES acoustic database, or sent to data.call@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.

Working Group (WG)	Chair of the WG	Email Address	Data Submission Deadline
WKROCK	(to be decided)	Advice@ices.dk	11.03.2019
HAWG	Susan Lusseau & Valerio Bartolino	s.lusseau@marlab.ac.uk valerio.bartolino@slu.se	01.03.2019
WGBFAS	Mikaela Bergenius	mikaela.bergenius@slu.se	18.03.2019
WGBIE	Lisa Readdy & Ching Villanueva	lisa.readdy@cefas.co.uk ching.villanueva@ifremer.fr	21.03.2019
AFWG	Daniel Howell	daniel.howell@imr.no	29.03.2019
WGCEPH	Jean-Paul Robin & Graham Pierce	jean-paul.robin@unicaen.fr g.j.pierce@iim.csic.es	01.04.2019
WGNSSK	José De Oliveira	jose.deoliveira@cefas.co.uk	03.04.2019
NWWG	Kristjan Kristinsson	kristjan.kristinsson@hafogvatn.is	04.04.2019
WGDEEP	Pascal Lorance & Elvar Halldor Hallfredsson	pascal.lorance@ifremer.fr elvar.hallfredsson@imr.no	11.04.2019
WGCSE	Timothy Earl & Sofie Nimmegeers	timothy.earl@cefas.co.uk sofie.nimmegeers@ilvo.vlaanderen.be	17.04.2019
WGHANSA	Alexandra Silva	asilva@ipma.pt	14.05.2019 (and see section 7.9)
WGEF	Paddy Walker & Samuel Sheppard	paddy.walker@hvhl.nl Sam.Shephard@fisheriesireland.ie	17.05.2019
WGWIDE	Gudmundur Oskarsson	gjos@hafro.is	31.07.2019
NIPAG	Ole Ritzau Eigaard & Brian Healey	ore@aqua.dtu.dk Brian.Healey@dfo-mpo.gc.ca	18.10.2019
WGMIXFISH-Advice	Claire Moore	claire.moore@marine.ie	03.05.2019
WGCATCH	Kirsten Birch Håkansson & Ana Ribeiro Santos	kih@aqua.dtu.dk Ana.ribeirosantos@cefas.co.uk	See section 7.8

5 Data to report

ICES Member Countries are requested to supply data as specified on the Working Groups' data request spreadsheets (Annex 1 and 7.7.1) either to InterCatch, to ICES Secretariat via email (data.call@ices.dk), or to both. Data include:

landings, discards, biological data, and effort data from 2018, 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 and estimates of length compositions for landings and discards from:

The latest year (i.e. 2018) for stocks identified with "**DLS 1**",

The three most recent consecutive years (i.e. 2018, 2017, 2016) for stocks identified with "**DLS 3**".

supporting information on life history parameters (see Annex 2 and Appendix IV) should be submitted directly to data.call@ices.dk.

The list of species and stocks for which data should be submitted is given in Annex 1, Table 7.7.1 and Annex 7.7.1.

Data should be reported by the lowest subdivision possible. Aggregations should not be beyond the assessment area of individual stocks. If the format for data submission to data.call@ices.dk (see Annex 1) is not specified further through the provided templates, the format should be the same as was used in previous data calls and in previous years. If anything is unclear, please contact data.call@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 and 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 the codes used, 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 Annex 3. The codes for metiers/fleets and areas are listed in appendices 1, 2, and 3.

For stocks where discard data have been submitted to InterCatch in previous years, they should also be submitted for 2018 (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 (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[2]. An overview of the fields in the InterCatch commercial catch format is found in the InterCatch Format overview[3] , where valid codes are also listed.

To ease the process of converting the national data into the InterCatch format, Andrew Campbell from the Marine Institute (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 catch categories BMS Landings and Logbook Registered Discards** (see section 6.1.4.). The conversion tool "InterCatch-FileMaker" can be downloaded from the ICES webpage under 'Format conversion tools' (link). The download includes a spreadsheet in which the catch 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 (if 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 Age and length data in parallel in InterCatch

A small change has been implemented in the way InterCatch can work with age and length data in parallel. Previously it was important that length data were imported last, though the order in which catches with sample data (age/length) are now imported does not matter. In the current version it is important that, within a given stratum, a catch with samples is not imported before a catch without samples. So as an example; 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 a 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, together with the existing age samples. Then in a second import, include only the strata where there are catches with length samples.

6.1.3 Sample information on age and length data

When age or length data are imported, ICES requests that the following age and length sampling information fields are filled in 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

[2] http://www.ices.dk/marine-data/Documents/Intercatch/InterCatch%20User%20Manual%20Doc1-11.pdf

[3] http://dome.ices.dk/datsu/selRep.aspx?Dataset=76

assessors make allocations in InterCatch, and identify changes in sampling levels from one year to another.

The units of the samples in the record types “NumSamplesLngt” and “NumSamplesAge” of the species data record refer to 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 are any questions 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.

Discard, ‘D’

The ‘Discard’ catch category in InterCatch will cover the discard fraction based on fishery observer estimations. This category is the part of the catch, which is thrown overboard into the sea.

This component should be in the CATON field, and in the OffLandings field a “’-9” should be inserted (see table 2).

Data for this fraction should be reported even when discard values are low. Discard estimations for pelagic species based on demersal observer programs should also be reported. This is especially important for some small pelagic stocks.

BMS Landing, ‘B’

Relevant to stocks under landing obligations. The BMS landings consist of fish and crustaceans Below Minimum Size, as registered in the logbook or as estimated by fishery observers (see Table 2).

If the discard estimation includes the BMS a “-9” 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 (see Table 2).

Logbook Registered Discard, ‘R’

Relevant to stocks under landing obligations. This component corresponds to 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 “-9” has to be inserted in the CATON field as this component is already accounted for in the discard estimates (see Table 2).

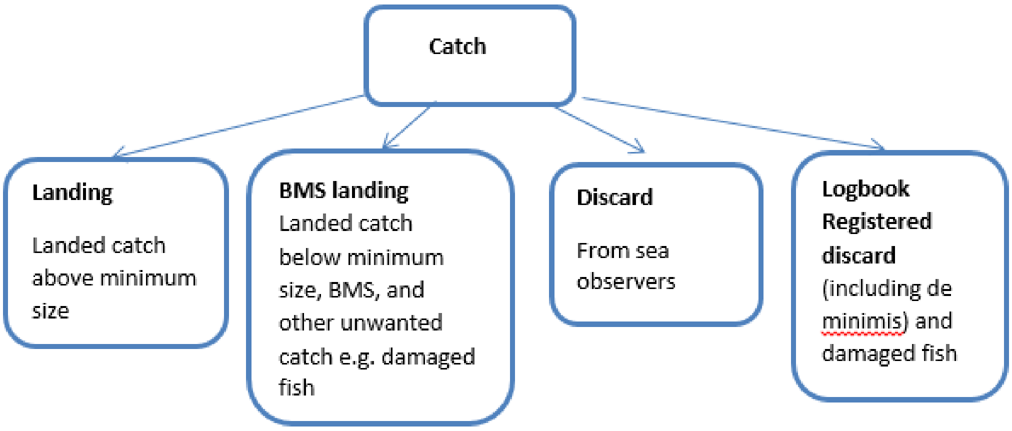

Figure 1. Description of the four current catch categories.

The following species under the relevant Working Groups should also submit data for BMS landings and logbook registered discards as specified in Annex 1:

HAWG: Herring and sprat.

NWWG: Capelin.

WGBFAS: Cod, and plaice.

WGBIE: Sole and hake.

WGCSE: Haddock, whiting, Norway lobster and plaice.

WGNSSK: Saithe, sole, cod, haddock, whiting, plaice, Norway lobster, striped red mullet, grey gurnard, lemon sole, Norway pout, dab, flounder, pollack, turbot and witch.

WGWIDE: Blue whiting, boarfish, horse mackerel and 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,(non-reported) please use Reporting Category N.

Table 2. The species information (SI) record in InterCatch – landing obligation example.

This example gives guidance on how to record the SI depending on the way BMS data are collected.

							Comments
Record number	10	11	12	13	19	20	
Field code	Species	Stock	Catch Category	Reporting Category	CATON (from observer estimates)	OffLandings	
	COD	NA	D	R	1300	−9	"CATON" field = **discards only** if possible to separate discards from BMS fraction. "CATON" field = **discards + BMS**, if not possible to separate the two fractions. "OffLandings" field = "-9"
	COD	NA	B	R	0.3	0.1	"CATON" field = **BMS** if possible to separate discards from BMS fraction. CATON" field = **"0"**, if not possible to separate the two fractions. "OffLandings" field = BMS from fishermen declaration(e.g. eLogs, sales notes, landing declaration).
	COD	NA	R	R	0	0.2	"OffLandings" field= Discards registered in the logbook (if any). CATON field = "0".

6.1.5 Effort data in InterCatch

Effort is recorded in position 11 of the InterCatch header information. Different units of effort are required by different WGs as specified in Table 3.

Table 3. Units of effort requested/accepted by WGs.

	KW-day	Days at sea
WGBFAS		X
WGCEPH	X	X
WGMIXFISH-Advice	X	X
All others	X	

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 data.call@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.

"2019 DC [expert group] [stock code/stock codes] [country] [type of data]"

(example: 2019 DC WGBFAS her.27.28 LV landings)

The files will be forwarded to the respective stock coordinators and the Expert Group chairs.

6.3 Métiers

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).

OTB_CRU_>=70_0_0_all

Bottom otter trawl_directed to crustaceans_(at least 70 mm)_with no selectivity device_no selectivity device mesh size_all vessel length classes

Figure 2. Explanation of the metier tag elements; an underscore separates each of the elements.

Metier tag elements

1. GEAR TYPE (gear types available under the DCF are shown in 2010/93/EU Appendix IV). Note that WGCSE, WGNSSK, WGBFAS, WGBIE and WGMIXFISH allow only specific metiers in specific areas (see appendices 1-3).
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 mesh size 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 under the DCF: 0: No selectivity device, 1: Exit window or panel, 2: Grid, 3: Square meshes (T90)). 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 though 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 into account 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 minimized.**

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 weight (in tonnes for fish and shellfish and in Kg for cephalopods), and at 1 cm length intervals for fish and cephalopods and at 1 mm intervals for Norway lobster and Northern prawn.

Effort (WGNSSK, WGCSE, WGBIE, WGDEEP, WGHANSA): kW days (in InterCatch).

Effort (WGBFAS): in days-at-sea, see further specifications in section 7.4).

Effort (WGCEPH): in days-at-sea or kW days, see further specifications in section 7.6).

Effort (WGMIXFISH-advice): in days-at-sea and kW days, see further specifications in section 7.3).

Year must be entered as four digits, e.g. "2018".

6.5 Zero catch

Zero should only be reported for discards and/or BMS from observer programs when zero is the result of an estimation.

6.6 NEAFC Areas and ICES subdivisions

For stocks with catches in areas within both 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 to stocks under WGDEEP, WGWIDE and WGEF.

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 data.call@ices.dk with a note about previous practices of data reporting. The respective Working Group chair (see e-mail addresses in Table 1) and ICES Secretariat (advice@ices.dk) should be informed accordingly.

7 Expert group specific uploading information

Only sections relevant to WGNSSK are given below.

7.3 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 2019. ICES is requesting that member countries submit 2018 data. WGMIXFISH operates both at the level of the DCF metier, as explained above, AND at the level of the fleet segment, consistent 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 carried out for the single stock advice in InterCatch. Data submitters should aggregate discard InterCatch submissions to the level considered most appropriate to 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).

7.3.1 WGNSSK: All stocks (2018 data requested)

Provide data by filling the spreadsheets described in section 7.3.5 and in Annex 1.

7.3.5 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:

A single .csv file reporting metier and vessel length disaggregated effort;

A single .csv file reporting metier and vessel length disaggregated catch.

Both files should be sent electronically as .csv files to data.call@ices.dk, clearly indicating in the subject of the file name "2019 WGMIXFISH-ADVICE" [country] [metier_catch/metier_effort]" (example: 2019 WGMIXFISH-ADVICE U_ 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.

7.8. WGCATCH specifications

For the Working Groups and stocks listed below, additional data on sampling quality and quantity are requested. This information should be provided through data.call@ices.dk following the template provided in Annex 7.8.1.

WGBFAS (**deadline for data submisison; 18 March 2019**): fle.27.22-23, ple.27.24-32, tur.27.22-32, dab.27.22-33

WGNSSK (**deadline for data submisison; 3 April 2019**): sol.27.4

WGHANSA (**deadline for data submisison; 14 May 2019**): pil.27.8abd7.9.

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: data.call@ices.dk.

Appendix I.

Gear coding (as defined under the DCF), 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 &	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_70-99_0_0_all
		TBB_DEF_>=120_0_0_all

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
27.7.d (Eastern Channel) Area Type = Div & 27.6.a (for saithe and haddock only) Area Type = Div	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
	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

* The use of metiers under the MIS_MIS category should be minimized.

Appendix IV.

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 2019 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 5. Supporting life history information.

Annex 9: Working Documents

No working documents were presented.

Annex 10: Reviews

No reviews were required or conducted.

Annex 11: Special Requests

There were no special requests targeted at WGNSSK for 2019, but there was an EU-Norway special request to ICES concerning long-term management strategies for several stocks covered by WGNSSK (cod.27.4720, had.27.46a20, whg.27.47d and pok.27.3a46). The work was conducted by WKNSMSE during 2018 and 2019, and the Executive Summary from the report is provided below.

WKNSMSE (Workshop on North Sea stocks Management Strategy Evaluation) took place over two physical meetings (19-21 November 2018 and 26-28 February 2019, but at ICES HQ, Copenhagen) and several WebEx meetings, was chaired by José De Oliveira (UK) and included 30 participants from Denmark, Germany, Netherlands, Norway, Sweden, UK and the European Com-mission, and two reviewers from South African and New Zealand. The purpose of this work was to evaluate long-term management strategies for jointly-managed stocks in the North Sea (cod, haddock, whiting, saithe and autumn-spawning herring) between the European Union and Nor-way, following a request from EU-Norway. The first physical meeting provided an ICES interpretation of the EU-Norway request, agreed the specifications of the MSE, decided on the tools and approaches to use, and developed a work plan, while the second meeting (and subsequent follow-up WebEx meetings) discussed results, developed conclusions, ensured the minimum requirements for conducting MSEs (developed by WKGMSE2) were met, and finalised the report. ICES were tasked to find "optimal" combinations of harvest control rule parameters (F_{target} and $B_{trigger}$) for management strategies with or without stability mechanisms (TAC constraints and banking and borrowing scenarios). "Optimal" combinations were defined as those combinations of F_{target} and $B_{trigger}$ that simultaneously maximised long-term yield while being precautionary (long-term risk3≤5%). The request also asked for sensitivity tests once the management strategies were "optimised". The approach adopted for all stocks was to include the assessment and fore-cast in a full-feedback MSE simulation, and to condition the baseline operating model on the benchmarked ICES assessment. The one exception was haddock, where it was not possible to include TSA in the full-feedback simulation because it was too slow to converge and requires manual intervention; SAM was used instead as a reasonable approximation. The approach also considered alternative operating models to capture a broader range of uncertainties. Full-feed-back simulations were computationally challenging and required the use of parallelisation and high-performance computing; it also meant that the timeframe for the work was extremely tight, and in some cases, analyses were restricted. Nonetheless, the work was completed for all stocks, and "optimal" combinations for most management strategies were found. There were some no-table issues that arose through this suite of MSEs, including that some management strategies that were precautionary in the long-term could have unsavoury and avoidable features in the short term (depending on the management strategy), and that reference points estimated by EqSim were, in many cases, no longer found to be precautionary in the MSE.