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

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Contents

i Executive summary

The Executive Summary was updated in October 2021

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 2020/2021

Full benchmarks were conducted during 2021 for WGNSSK stocks. These were on cod in 4, 7.d and 20 and sole in 7.d. There were an inter-benchmark protocol (IBP) meeting during 2021, for whiting in 4 and 7.d to include new natural mortality estimates and for witch in 3.a, 4 and 7.d to include new survey indices.

State of the Stocks

The main impression in recent years is that fishing pressure 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. The SSBs of cod in 4, 7.d and 20, sole in 7.d and saithe in 3.a, 4 and 6 are below MSY $B_{trigger}$ at the beginning of 2021. Several North Sea stocks are exploited at or below F_{MSY} levels (haddock in 4, 6.a and 20, plaice in 4 and 20, plaice in 7.d, turbot in 4, whiting in 4 and 7.d); however, several others are being fished above F_{MSY} (cod in 4, 7.d and 20, saithe in 3.a, 4 and 6, sole in 4, sole in 7.d, witch in 3.a, 4, 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 and whiting in 2019 and 2020. Recruitment in 2020 continues on a high level for flatfish stock of turbot in 4.

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) are being fished below F_{MSY} in 2020, 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 3.a), along with grey gurnard in 3.a, 4 and 7.d and 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, 2019 and 2021. Biennial advice is required on a different cycle for grey gurnard in 3.a, 4 and 7.d, and was not provided in 2021; instead, it was only necessary to determine whether the perception of the stocks has changed compared to 2020; because these perceptions have not changed, no reopening was needed for this stock. Triennial advice is now required for dab in 3.a and 4 (due in 2022) and pollack in 3.a and 4 (due in 2021).

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 is above F_{MSY} in 2020.

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 increased since 2017 but remains 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, decreased in 2020 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 above F_{MSY} in 2019 but below F_{MSY} in 2020 (calculated using an interpolated value for abundance, no survey index in 2020)

Category 4:

f) FU 32 (nep.fu.32): The available data is non-conclusive with regard to stock status, in recent years landings have relatively low.

g) 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 2017 to 2019. 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.

h) FU 34 (nep.fu.34): The current state of the stock is unknown.

i) FU 5 (nep.fu.5): The status of this stock is uncertain. Assuming the density has been constant since 2012, the harvest rate in 2018 and 2019, corresponding to the total landings, has decreased and now below the MSY proxy reference point.

j) FU 10 (nep.fu.10): The current state of the stock is unknown.

Category 5:

k) out of FU (nep.27.4outFU): The current state of the stock is unknown.

2) Cod (cod.27.47d20): Fishing pressure has increased since 2016, and is below F_{lim} in 2020. Spawning-stock biomass has decreased since 2016 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, but below 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 pressure has declined since the beginning of the 2000s, but it has been above F_{MSY} for most of the entire time-series. Only since 2019, fishing pressure has been below F_{MSY}. 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 and 2020 year-classes are estimated to be two of the largest since 2000. 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}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and has been above it since 2019. Fishing pressure has been below F_{MSY} since the early 2000s. Recruitment (R) has been fluctuating without trend, but the 2019

and 2020 year-classes are estimated to be the largest since 2002. 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}.

5) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ in 1996-2020. Fishing pressure has decreased and stabilized above F_{MSY} since 2000. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. 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}.

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 pressure since 1999. After a strong recruitment in 2019, the recruitment in 2020 is estimated to be the average. 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}.

7) Sole (sol.27.4): The spawning-stock biomass has fluctuated around B_{lim} since 2003, and has been estimated to be below MSY $B_{trigger}$ since 2000. In 2021, SSB is estimated to be above MSY $B_{trigger}$. Fishing pressure has declined since 1999 and is above F_{MSY} in 2020. Recruitment in 2019 is estimated to be one of the highest in the time series, while recruitment in 2020 is estimated to be relatively low. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.

8) Sole (sol.27.7d): This stock was downgraded from Category 1 to Category 3 following the Interbenchmark in 2019 and Benchmark in 2020. Following the benchmark in 2021, the stock is again assessed as category 1. The spawning-stock biomass (SSB) has been fluctuating without trend and has been below MSY $B_{trigger}$ since 2014. Fishing pressure (F) has shown a decreasing trend since 2009 and has been above F_{MSY} throughout the time series. Recruitment has been fluctuating without trend. In 2019, the recruitment is estimated to be one of the highest in the time series. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is below MSY $B_{trigger}$ and B_{pa}, but above B_{lim}.

9) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2019, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly below F_{MSY}. Recruitment in 2019 is currently estimated to be highest in the time series, while recruitment in 2020 is estimated to be the lowest value in 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}.

10) Turbot (tur.27.4): Recruitment is variable without a trend. In 2019 and 2020 recruitment is estimated to be above average of the time series. Fishing pressure has decreased since the mid-1990s, and has been at or 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 in 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 pressure 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 B_{lim} but below MSY $B_{trigger}$. Recruitment has increased in recent years and is currently at medium level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Fishing pressure on the stock is above F_{MSY} and at F_{pa}, but below F_{lim} in 2020, and spawning stock size is below MSY $B_{trigger}$ and B_{pa} and above B_{lim} in the beginning of 2021.

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 pressure declined between 1985 and 1995 and has been fluctuating at a lower level since 1995. Recruitment in 2018, 2019 and 2020 was above the long-term average, but was estimated to be low in 2021. 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 2021, new advice has been produced for bll.27.3a47de, fle.27.3a4, lem.27.3a47d, tur.27.3a (all Category 3 stocks) and mur.27.3a47d and pol.27.3a4 (Category 5). Advice was not provided for gug.27.3a47d, dab.27.3a4 and whg.27.3a (Category 3).

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

c) 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 recent years. Recruitment has shown a mostly downwards trend since a peak in 2011, but in recent years an increase in recruitment is estimated, with high recruitment estimated for 2020. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$. No reference points for stock size have been defined for this stock.

d) Striped red mullet (mur.27.3a47d): The assessment was rejected in 2021 and the stock is now category 5. Currently, fishing pressure on the stock is above F_{MSY}; no reference points for stock size have been defined for this stock.

e) Pollack (pol.27.3a4): ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because information to define reference points is not available.

f) Turbot (tur.27.3a): Catches peaked in the late 1970s and early 1990s and have been more stable in recent years. Relative exploitable biomass (B/B_{MSY}) declined towards 2000 with an increasing trend in recent years. Relative fishing pressure (F/F_{MSY}) peaked in the late 1970s and early 1990s without a trend in more recent years. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger}$.

Summary of retrospective analysis (WKFORBIAS decision tree)

To quantify retrospective patterns in the assessments of category 1 stocks, estimates of five-year retrospective peels are produced for fishing pressure, SSB and recruitment and plotted with confidence bounds of the current assessment. The retrospective statistics (Mohn's rho) are reported as a measure of quality. Following the decision tree formulated by WKFORBIAS (ICES 2020) to ensure more consistency in how advice is provided. Only stocks that showed significant retrospective patterns in SSB were sole in 4 (Mohn's rho above 0.2) and Norway pout in 3.a and 4 (Mohn's rho above 0.3 for short-lived stocks). For sole most of the retrospective peels fall outside the confidence bounds. The stock has recently undergone a benchmark and the retrospective pattern could not be solved yet. However, SSB in 2020 is estimated to be below B_{lim} and the target F (F_{MSY}) in the forecast for 2022 is well below the F_{05} estimated using EqSim, therefore advice is given as usual this year. For Norway pout all the retrospective peels fall inside the wide confidence bounds. Advice is given as usual this year. The retrospective pattern should be addressed at a future benchmark.

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	2021
Reporting year in cycle	1/1
Chairs	Raphaël Girardin, France
	Tanja Miethe, UK
Meeting venues and dates	21 April – 30 April 2021, Online meeting (38 participants)
	21 – 23 September 2021 (Norway pout), (7 participants)
	5 – 6 October 2021 (*Nephrops*), (11 participants)

1 General

1.1 Terms of Reference

Generic ToRs for Regional and Species Working Groups

2020/2/FRSG01 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 on the following for the fisheries relevant to the working group:

   i) descriptions of ecosystem impacts on fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

   i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.

   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 2020.

   iv) Estimate MSY reference points or proxies for the category 3 and 4 stocks

   v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

      1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

      2) b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

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

   Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

      1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data 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 associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention *(restricted access)* and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
iii) determine the prioritization score for benchmarks proposed for 2022–2023;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

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

Specific WGNSSK ToRs

WGNSSK – Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

2020/2/FRSG19 The **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak** (WGNSSK), chaired by Tanja Miethe, UK, and Raphaël Girardin, France, will meet in ICES HQ, Copenhagen, Denmark, 21–30 April 2021 and by correspondence in September 2021 to:

a) Address generic ToRs for Regional and Species Working Groups.
b) Assess Norway pout assessments by correspondence.
c) Report on reopened advice as appropriate;
d) Add ToR on Benchmark

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 2021 ICES data call.

WGNSSK will report by 14 May 2021, and by 25 September 2021 (Norway pout) for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

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, 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).

In 2020, in addition to the above procedure, coe.27.3a47de, hal.27.3a47de , and caa.27.3a47de were included to the data call to collect quarterly landings data for WGMIXFISH. An official data call was issued by ICES, with a deadline for data delivery of 1 April 2020, 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. During the meeting it was noticed that landings for Sweden for subarea 4 have not been uploaded to Intercatch. Amounts were generally low and were added manually for each affected stock to respective landings, and discards were raised using the discard ratio in area 4.

In 2021, the missing catches 2019 from Sweden have been submitted, and catch data was re-raised this year and included in the respective assessment. Due to sampling interruptions due to the Covid pandemic some reduction in samples occurred for quarters 2 to quarter 4 of 2020. Any changes in the approaches for raising catch data in Intercatch are listed in Annex 9.

1.2.2 Data raising and allocation to un-sampled 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 in May 2021, the status of InterCatch use was as follows:

Stock	Data Year	Working Group	Extracted	Exported	Status of Data filled in
bll.27.3a47de	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
caa.27.3a47de	2020	WGNSSK	No	No	Notfilled
cod.27.47d20	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
coe.27.3a47de	2020	WGNSSK	No	No	Notfilled
dab.27.3a4	2020	WGNSSK	Extracted	Exported	Notfilled
fle.27.3a4	2020	WGNSSK	Extracted	Exported	Notfilled
gug.27.3a47d	2020	WGNSSK	Extracted	Exported	Notfilled
had.27.46a20	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
hal.27.3a47de	2020	WGNSSK	No	No	Notfilled
lem.27.3a47d	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
mur.27.3a47d	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.27.4outFU	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.10	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.32	2020	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
nep.fu.33	2020	WGNSSK	No	No	Notfilled
nep.fu.34	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.3-4	2020	WGNSSK	Extracted	No	Notfilled
nep.fu.5	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.6	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.7	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.8	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.9	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
nop.27.3a4	2020	WGNSSK	No	No	Notfilled
ple.27.420	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
ple.27.7d	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
pok.27.3a46	2020	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
pol.27.3a4	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
sol.27.4	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment

Stock	Data Year	Working Group	Extracted	Exported	Status of Data filled in
sol.27.7d	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
tur.27.3a	2020	WGNSSK	Extracted	Exported	Notfilled
tur.27.4	2020	WGNSSK	Extracted	Exported	Notfilled
whg.27.3a	2020	WGNSSK	Extracted	No	Notfilled
whg.27.47d	2020	WGNSSK	Extracted	Exported	DataUsedForAssessment
wit.27.3a47d	2020	WGNSSK	Extracted	Exported	Notfilled

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 discards, 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 exceptions to this treatment of BMS landings as discards is for the saithe stock (pok.27.3a46), for which the Norwegian component of BMS landings are included with the ICES estimates of landings, and for the lemon sole stock (lem.27.3a47d), for which BMS landings were allocated discard length distributions in Intercatch but included in ICES estimates of landings.

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 2020 and 2021

No major concerns about corrections to DATRAS data were raised during the working group. New automated ALK filling methodology was introduced for DATRAS indices in early 2020. Indices for Q1 2020 and onwards are only available calculated using the new methodology. These indices are used either together with the historical index time-series historical indices will be updated during an inter-benchmark protocol or a benchmark process) or with an updated index time series using new methodology (if survey update and reference points were checked during WGNSSK).

In 2021, there was a large re-submission of IBTS data from France with many additional hauls and length information for the period 1999-2012. Until a stock undergoes an interbenchmark or benchmark, for the historical period the survey data as in WGNSSK 2020 will be used for the assessments. Only survey data for 2020 and 2021 have been updated.

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 2021 could be covered by the internal audit (Table 1.5.1). The audits are given in Annex 4 of the report.

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

Fish Stock	Internal Audit Spring	Internal Audit Autumn
bll.27.3a47de	X	
cod.27.47d20	X	
dab.27.3a4	*No new advice in 2021*	
fle.27.3a4	X	
gug.27.3a47d	*No new advice in 2021*	
had.27.46a20	X	
lem.27.3a47d	X	
mur.27.3a47d	X	
nep.27.4outFU	*No new advice in 2021*	
nep.fu.10	*No new advice in 2021*	
nep.fu.32	*No new advice in 2021*	
nep.fu.33	*No new advice in 2021*	
nep.fu.34	*No new advice in 2021*	
nep.fu.3-4	X	
nep.fu.5	No advice in spring	X
nep.fu.6	No advice in spring	X
nep.fu.7	No advice in spring	X
nep.fu.8	No advice in spring	X
nep.fu.9	No advice in spring	X
nop.27.3a4	No advice in spring	X
ple.27.420	X	
ple.27.7d	X	
pok.27.3a46	X	
pol.27.3a4	X	
sol.27.4	X	
sol.27.7d	X	

Fish Stock	Internal Audit Spring	Internal Audit Autumn
tur.27.3a	X	
tur.27.4	X	
whg.27.3a	*No new advice in 2021*	
whg.27.47d	X	
wit.27.3a47d	No advice in spring (need IBP)	X

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 2021 (WGMIXFISH-METH), and also in late October 2021 (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 2021 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 cannot be achieved simultaneously and 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.

1.10 Presentations

Two presentations were made to WGNSSK in 2021, as follows:

(1) Annual industry survey targeting turbot and brill

Jurgen Batsleer presented the annual industry survey targeting turbot and brill, which took place for the first time in Q4 of 2018 as a pilot, and subsequently, after survey design modifications, took place again in Q4 of 2019 with the intention of starting an annually updated time series.

Current surveys (BTS-ISIS (B2453) and SNS (B3498)) show poor internal consistency performance for these species, mainly for the older ages. The aim of the industry survey is to deliver a long-term annual survey using commercial fishing vessels fishing at randomly selected 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 Wageningen Marine Research (WMR).

The first iteration of the survey took place in Q4 of 2018. Three Dutch vessels were recruited to take part in the programme. The survey design of this pilot year was discussed at WGNSSK 2019, leading to modifications to improve the survey which were implemented in the survey carried out from 2019 onwards. An overview of the modifications and design of the survey is provided in ICES (2019), Schram *et al.* (2021).

The revised survey design considered the use of data on turbot and brill catches (LPUE) and beam trawl fleet data (VMS) in a step-wise process. First, the survey area was based on LPUE data for turbot in the southern North Sea over a 6-year period (2007–2009 and 2012–2014). By defining the positions were 60% of the LPUE is realized, the survey area covers the main high LPUE areas but also some areas around these. Inaccessible areas such as wind parks, Natura 2000 closures, etc. were removed from the survey area following discussions with the participating fishermen. A 5x5 km grid was overlaid onto the survey area.

Each grid cell in the survey area is a potential survey station. Each year 60 grid cells are to be randomly selected using an R-script. Because the cutting out of unfishable areas resulted in some cells having irregular shapes and smaller surface areas than regular 5x5 km grid cells, the probability of being randomly selected as survey station was made proportional to their surface areas. The selected survey stations are then equally distributed over the three participating vessels (~20 survey stations each) on the basis of their normal fishing grounds. Survey hauls are carried out similar to commercial hauls, taking approximately 100 to 120 minutes. Hauls may start anywhere in a designated grid cell, may then follow any route, and may exit the grid cell during the haul. Data collected include fishing conditions (e.g. haul list, gear description), and for each haul: counts of all turbot and brill; length, weight, and sex of all turbot and brill; a specified number of otoliths per length class (number required per length class currently under review).

A random selection of 60 grid cells was drawn.

The 2020 survey had to be adapted as boarding of the participating fishing vessels by two researchers was not possible under COVID-19 restrictions. Therefore, an alternative protocol was developed in liaison with ICES turbot and brill stock coordinators to ensure the continuity of the survey. In brief: the survey design remained unchanged but instead of direct on-board processing by researchers of the fish caught at the survey stations, the survey fish were sorted from the catches and then labelled per station and stored by the vessel's crews. At the end of the survey week all collected survey fish was handed over to a team of researchers for processing in the fish auction. The number of of otoliths per cm-class targeted per species, sex and length group during the 2019 and 2020 surveys are described in Schram *et al.* (2021).

The procedure for the random selection of survey stations and their assignment to the vessels remained unchanged from 2019 except for the number of selected stations. Instead of selecting the required 60 stations, a total of 75 stations were selected (Figure 1.10.1). Sixty stations were manually assigned to the vessels (20 each) and the remaining 15 stations were kept as 'spares', undisclosed to the skippers in case some of the stations were deemed unsuitable.

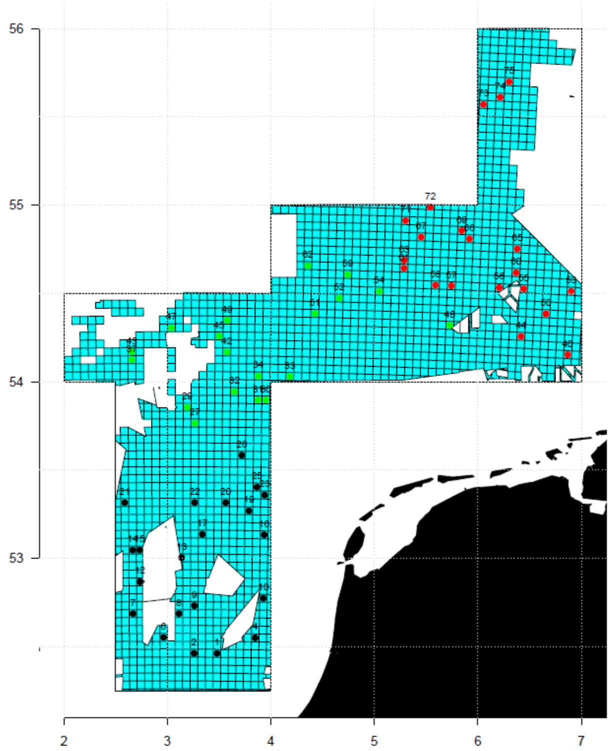

Figure 1.10.1: Randomly drawn survey locations for the 2020 survey.

During 2021 WGNSSK an overview of the 3 year of survey data was presented (Table 1.10.1).

Table 1.10.1: Descriptive statistics for industry survey 2018–2020 (BSAS) compared to the BTS-ISIS and SNS survey.

Species	Survey	Year	Total # caught	Total # hauls	Occurrence (%)	CPUE (#/h)
Turbot	BSAS	2018	1035	45	100.0	42.1
		2019	1709	50	98.0	57.8
		2020	1415	59	98.3	55.7
	BTS	2018	181	82	65.9	5.2
		2019	191	73	84.9	6.3
		2020	162	74	82.4	5.2
	SNS	2018	37	45	51.1	1.0
		2019	30	44	40.9	1.0
		2020	23	46	32.6	0.7
Brill	BSAS	2018	518	45	58.7	14.9
		2019	785	50	100	26.4
		2020	454	59	81.4	17.3
	BTS	2018	67	82	35.4	1.8
		2019	85	73	53.4	2.7
		2020	47	74	33.8	1.7
	SNS	2018	30	45	31.1	0.8
		2019	10	44	14	0.4
		2020	0	46	0	0.0

The 2019 and 2020 survey was presented and discussed at WGNSSK. The expectation from the programme partners is the new survey design will allow for the determination of an indicator to be used for the identification of trends over time. In this context, several points were raised that will be investigated further by the programme partners:

- The question was asked whether maturity is recorded on the survey. This is not currently the case, but the feasibility and the merits of adding this to the survey will be investigated further.
- An issue was raised about the overlap in spatial distribution of the survey area and the main distribution of brill. The stock area for brill is larger compared to turbot and includes divisions 3.a and 7.d–e. These divisions are not covered by the industry survey. An similar survey, e.g. set up by Belgium, could resolve this issue over time.
- Pending full analysis, age-length relations appeared to be as expected for females of both species and for brill males, but for brill females there were unexpectedly large age 1 specimens in the 2019 dataset. Brill, however, is a fast growing species and age-length data from Belgium showed similar large (>40 cm) females at age 1. Still, the issue will need further investigation by WMR.
- It is expected that by combining the age data of the different surveys the accuracy of the age-length relation will increase. However, more analyses are needed to determine whether the BSAS ALK in itself is sufficient for future use in the assessments or a combined ALK is more appropriate.

- A follow-up grant proposal for 3 years of further funding has been successfully submitted. The proposal includes exploring the potential of adding a German and Belgian vessel to the programme. Such addition will improve the coverage of the stock area for both species. Several conversations with German representatives (science and government) have taken place.

(2) Development of a Dutch Nephrops catch monitoring programme

Katinka Bleeker presented the Dutch *Nephrops norvegicus* catch monitoring programme which has commenced in 2019.

The Dutch *Nephrops* fleet target FU5 (Botney Cut), FU33 (Off Horn's Reef), and also fish out-FU, and there, areas are data-poor. Landings are well quantified using standard procedures. Discards are estimated from the Dutch demersal discards self-sampling programme, but the coverage and resolution are not sufficient. ICES WGNSSK has expressed concerns about data limitations, including lack of representative discard data in FU33. The aim of this project was to improve data for *Nephrops* stock assessments, and comprised of three phases: 1. Development of a Fully Catch-Monitored system (FCM), 2. Implementation of the FCM scheme by a reference fleet and 3. Data analysis and reporting including data sharing with ICES WGNSSK. The programme is a science-industry collaboration between the Dutch demersal fishing industry and Wageningen Marine Research (WMR).

The FCM system comprised of so-called load cells, installed to measure the total catch of a haul. The total discards weight of a haul is determined by subtracting the landings from that haul. In addition, the reference fleet participates in a self-sampling scheme in which discard samples 80 kg are taken from two hauls during a fishing trip. The 80 kg sample can be raised to the haul using the total discards weight of a haul. A sample of approximately 5 kg of Norway lobster landings is taken from these same hauls for length measurements of approximately 50 males and 50 females. Landings of commercial species will also be recorded per haul. The self-sampling scheme is validated with observer trips.

The reference fleet (2018–2020) consisted of three vessels. In 2019 two observer trips were executed and one in 2020. Due to COVID-19 restrictions, more observer trips were not possible. A total of 34 self-sampling trips have been carried out (12 in 2019 and 22 in 2020). The collected data provides valuable insight in catch composition, including in the length-frequency distribution, and fishing effort of the reference fleet in regard to the FUs. However, more data is needed to build a reliable time-series for these fisheries. WGNSSK has raised some concerns about how representative participating vessels are for Dutch fishing effort on *Nephrops*, as they are Dutch owned but foreign flagged. While skippers believe that in a 'regular year' (no COVID-19, no temporary Brexit quota) there are no differences, the question whether or not the current reference fleet is a good representation of the Dutch Norway lobster fishing fleet warrants further investigation. The full catch monitoring in the Dutch Norway lobster fishery will be continued in a follow-up programme in which outcomes of the current project will be taken into consideration. This includes expansion of the current reference fleet with three Dutch registered vessels. While the load cell currently used works reliable, it cannot be easily tranferred to other vessels and thereby hinders the ambitions to scale up the monitoring activities to a broader set of vessels. Therefore, the follow-up programme will explore alternative methods such as: using the proportion of discarded to landed *Nephrops*, considering that landings of each haul are already recorded as part of the practice of commercial fishing; using volume rather than weight of the total catch, a) by visual estimation, and b) through the use of 3D-imaging using a smartphone application with image processing on land; and developing a mobile version of the load cell that can be fitted to a vessel for an individual fishing trip. The overall aim of the follow-up programme is to improve data for *Nephrops* stock assessments, by continuing the current sampling scheme and expanding with three more vessels.

The research collaboration also provides an opportunity for improved exchanges with *Nephrops* fishers on developments in the fishery and how these affect landings. This is of particular importance to current assessments as they rely heavily on landings data. The skippers pointed out that fishing effort on *Nephrops*, and hence catch composition and landings in 2020 was influenced by COVID-19 and by the temporary Brexit quota allocations.

This project was funded under a science-fisheries partnership grant (*Partnerschappen Wetenschap en Visserij*) under the Dutch Operational Programme of the European Maritime and Fisheries Fund.

2 Overview

This Section was updated in October 2021

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. Main North Sea stocks targeted in the fisheries for industrial purposes are sandeel, Norway pout, and sprat.

(http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/FisheriesOverview_GreaterNorthSea_2020.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, 2017 and 2020 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. Natural mortalities taking into account multi-species interactions as estimated in specific research is also included in the single stock assessment for Norway pout being similar to the multi-species assessment values. 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 which in most cases are equipped with selective panels to reduce by-catches. 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 2020), 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 trammel net 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.

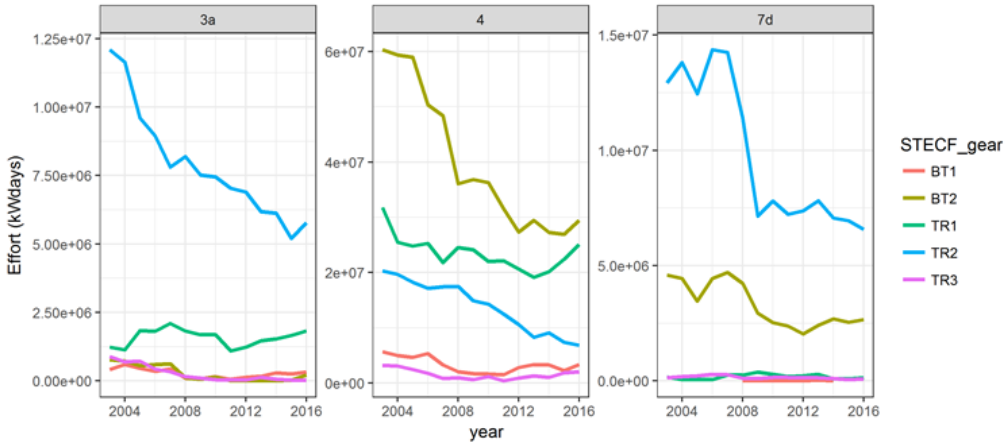

Figure 2.1.1. Trends in fishing effort for different STECF fishing gear groups in ICES Division 3.a, ICES Subarea 4 and ICES Division 7.d for the period 2003–2016 (STECF, 2017b). Regulated gears: BT1 are beam trawls with mesh sizes ≥ 120 mm. BT2 are beam trawls with mesh sizes ≥ 80 mm and < 120 mm. TR1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

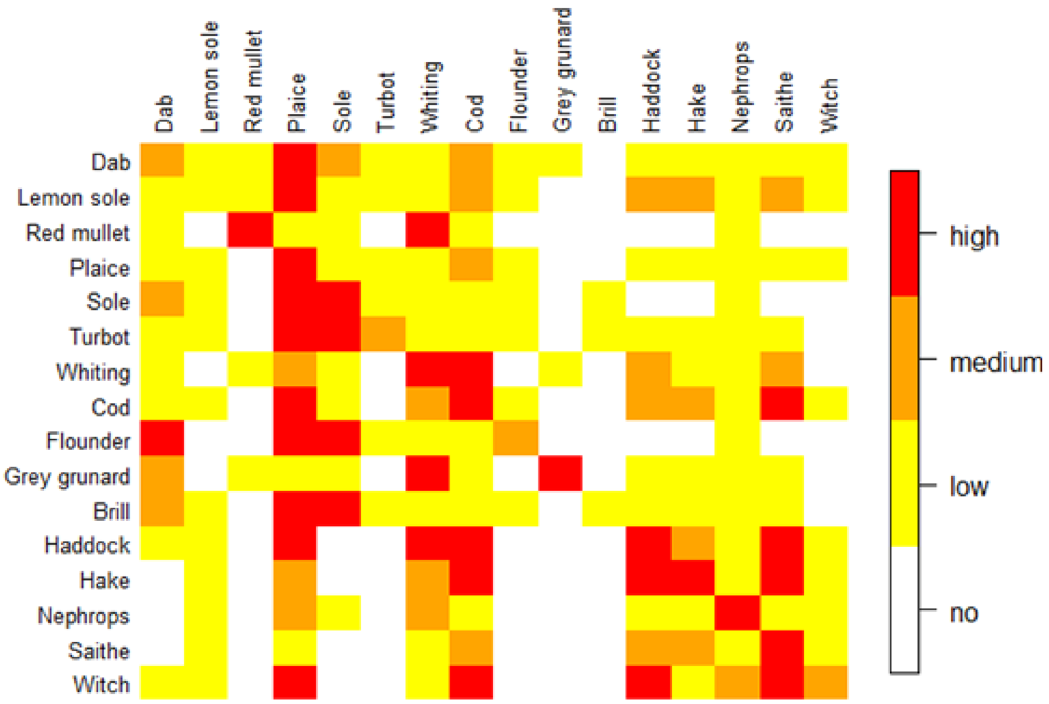

Figure 2.1.2. Technical interactions amongst North Sea demersal stocks (averaged over the years 2014–2015). Horizontal lines of the figure represent the target species of the fishery (species A) for which the interaction with species in each column (species B) was assessed. Red cells indicate that the 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 landing 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. In 2019, new updates were published for 2020–2021 (Regulation (EU) 2019/2238 and Regulation (EU) 2019/2239), to modify in part the details of 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) including maximum by-catch rates and technical measures on selective panels to reduce by-catch. 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 an 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.

Norway pout box

The Norway pout fishery intensified in the northern North Sea during the 1960s and 1970s, and the concerns raised here about bycatch of juvenile cod, whiting, haddock, and saithe led to the establishment of the “Norway pout box” closed management area along the Scottish coast to protect juvenile gadoids in particular. In 1977, the UK government decided to establish this area of closure to the small-mesh trawl fishery along the eastern Scottish coast in the northern North Sea (Bigné *et al.*, 2019). Since then, the small-mesh trawl fishery is completely forbidden in this area, with the declared aim of protecting juveniles of larger gadoid species (i.e. cod, haddock, and whiting).

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.

Some minor comments and suggestions for corrections:

On page 3, the following is stated: "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 enough information to be truly useful for scientists or decisions makers and no link/reference is provided to aid the reader finding more information. 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.

Figure 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".

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.

The word "crustaceans" should be replaced with *Nephrops* in Figure 5. 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 6). Also, this sentence on recreational fishing seems a bit of context, when considering the rest of the paragraph.

No flatfish are in the figure showing the North Sea food web. This is questionable, since flatfish are highly abundant in the North Sea.

Ideas for the next version of ecosystem overviews:

1. Trends in the condition and productivity (e.g. weight, recruitment etc.). This could be 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. Also, perhaps use biomass spectra time-series in combination with the large fish indicator.

2. Distribution of stocks and changes over time (incl. spawning and nursery areas) may become increasingly relevant as the number of areas closed to fishing increase (i.e. marine spatial planning and conservation issues). Also, how does it influence stock assessment models if parts of the stock is within "closed" areas.
3. Density dependence may become more important when stocks are recovering. This could have an impact on the appropriateness of current reference points.
4. Detailed information on changes in the North Sea food web over time, on descriptions of who eats whom.
5. A table highlighting which métiers/fisheries have the highest bycatch of a certain species could be an interesting addition for risk-based management approaches.
6. Discussions in the group 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 could be added (when information is available) either in the ecosystem overviews or as additional overview table.
7. A separation of natural fluctuations from impacts caused by anthropogenic pressures is recommended. Furthermore, time-series of relevant environmental variables (temperature, AMO, water flow etc.) could lead to a better understanding of past environmental regimes. Are maps of historic distributions of sea grass beds and rocky and biogenic reefs available?
8. 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. 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 as well.
9. The list of threatened and declining species according to OSPAR should be updated after discussions with OSPAR. It is debatable whether species like cod (at least at a whole North Sea level) and thornback and spotted ray still belongs to this list.
10. Approach stakeholders to learn about their main interests/needs in relation the an ecosystem overviews.

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/2020/2020/FisheriesOverview_GreaterNorthSea_2020.pdf). The Executive Summary is as follows:

This fisheries overview contains details of mixed fisheries considerations for North Sea demersal and Norway lobster stocks, and a description of the fisheries and their interactions within the ecoregion.

Mixed-fisheries considerations presents six example scenarios of fishing opportunities of eight fish stocks and ten Norway lobster stock units fished within the ecoregion: 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), turbot (tur 27.4), witch (wit.27.3a47d), and Norway lobster (functional units [FUs] 5–10, 32, 33, 34, and 4 outFU), taking into account the single-stock advice of those species. The most limiting total allowable catch (TAC) in 2020 will be the TAC for cod for particular fleets.

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). 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, turbot in 4 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 pressure 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. The SSBs of cod in 4, 7.d and 20, sole in 7.d and saithe in 3.a, 4 and 6 are below MSY $B_{trigger}$ at the beginning of 2021. Several North Sea stocks are exploited at or below F_{MSY} levels (haddock in 4, 6.a and 20, plaice in 4 and 20, plaice in 7.d, turbot in 4, whiting in 4 and 7.d); however, several others are being fished above F_{MSY} (cod in 4, 7.d and 20, saithe in 3.a, 4 and 6, sole in 4, sole in 7.d, 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 and whiting in 2019 and 2020. Recruitment in 2020 continues on a high level also for flatfish stock of turbot in 4.

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) are being fished below F_{MSY} in 2020, 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 3.a), along with grey gurnard in 3.a, 4 and 7.d and 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, 2019 and 2021. Biennial advice is required on a different cycle for grey gurnard in 3.a, 4 and 7.d, and was not provided in 2021; instead, it was only necessary to determine whether the perception of the stocks has changed compared to 2020; because these perceptions have not changed, no reopening was needed for this stock. Triennial advice is now required for dab in 3.a and 4 (due in 2022) and pollack in 3.a and 4 (due in 2021).

Biennial PA advice was provided for data-limited *Nephrops* stocks (Category 4: FU 5, 10, 32, 33, 34) for the first time in 2016, subsequently in 2018 and 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 given in 2020 (aligned with other data-limited *Nephrops* stocks). No advice is required for these stocks in 2021.

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 is above F_{MSY} in 2020.

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 increased since 2017 but remains 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, decreased in 2020 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 above F_{MSY} in 2019 but below F_{MSY} in 2020 (calculated using an interpolated value for abundance, no survey index in 2020).

Category 4:

f) FU 32 (nep.fu.32): The available data is non-conclusive with regard to stock status, in recent years landings have relatively low.

g) 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 2017 to 2019. 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.

h) FU 34 (nep.fu.34): The current state of the stock is unknown.

i) FU 5 (nep.fu.5): The status of this stock is uncertain. Assuming the density has been constant since 2012, the harvest rate in 2018 and 2019, corresponding to the total landings, has decreased and now below the MSY proxy reference point.

j) FU 10 (nep.fu.10): The current state of the stock is unknown.

Category 5:

k) out of FU (nep.27.4outFU): The current state of the stock is unknown.

2) Cod (cod.27.47d20): Fishing pressure has increased since 2016, and is below F_{lim} in 2020. Spawning-stock biomass has decreased since 2016 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, but below 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 pressure has declined since the beginning of the 2000s, but it has been above F_{MSY} for most of the entire time-series. Only since 2019, fishing pressure has been below F_{MSY}. 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 and 2020 year-classes are estimated to be two of the largest since 2000. 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}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and has been above it since 2019. Fishing pressure has been below F_{MSY} since the early 2000s. Recruitment (R) has been fluctuating without trend, but the 2019

and 2020 year-classes are estimated to be the largest since 2002. 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}.

5) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ in 1996-2020. Fishing pressure has decreased and stabilized above F_{MSY} since 2000. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. 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}.

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 pressure since 1999. After a strong recruitment in 2019, the recruitment in 2020 is estimated to be the average. 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}.

7) Sole (sol.27.4): The spawning-stock biomass has fluctuated around B_{lim} since 2003, and has been estimated to be below MSY $B_{trigger}$ since 2000. In 2021, SSB is estimated to be above MSY $B_{trigger}$. Fishing pressure has declined since 1999 and is above F_{MSY} in 2020. Recruitment in 2019 is estimated to be one of the highest in the time series, while recruitment in 2020 is estimated to be relatively low. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.

8) Sole (sol.27.7d): This stock was downgraded from Category 1 to Category 3 following the Interbenchmark in 2019 and Benchmark in 2020. Following the benchmark in 2021, the stock is again assessed as category 1. The spawning-stock biomass (SSB) has been fluctuating without trend and has been below MSY $B_{trigger}$ since 2014. Fishing pressure (F) has shown a decreasing trend since 2009 and has been above F_{MSY} throughout the time series. Recruitment has been fluctuating without trend. In 2019, the recruitment is estimated to be one of the highest in the time series. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is below MSY $B_{trigger}$ and B_{pa}, but above B_{lim}.

9) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2019, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly below F_{MSY}. Recruitment in 2019 is currently estimated to be highest in the time series, while recruitment in 2020 is estimated to be the lowest value in 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}.

10) Turbot (tur.27.4): Recruitment is variable without a trend. In 2019 and 2020 recruitment is estimated to be above average of the time series. Fishing pressure has decreased since the mid-1990s, and has been at or 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 in 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 pressure 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 B_{lim} but below MSY $B_{trigger}$. Recruitment has increased in recent years and is currently at a medium level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Fishing pressure on the stock is above F_{MSY} and at F_{pa}, but below F_{lim} in 2020, and spawning stock size is below MSY $B_{trigger}$ and B_{pa} and above B_{lim} in the beginning of 2021.

12) Category 3–6 finfish stocks: In 2021, new advice has been produced for bll.27.3a47de, lem.27.3a47d, fle.27.3a4, tur.27.3a (all Category 3 stocks) and mur.27.3a47d and pol.27.3a4 (Category 5). Advice was not provided for gug.27.3a47d, dab.27.3a4 and whg.27.3a (Category 3).

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) Flounder (fle.27.3a4): The available survey information indicates no clear trend in stock biomass, while the stock indicator is at relatively low level in recent years. Currently, fishing pressure on the stock is below FMSY; no reference points for stock size have been defined for this stock.
c) 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 recent years. Recruitment has shown a mostly downwards trend since a peak in 2011, but in recent years an increase in recruitment is estimated, with high recruitment estimated for 2020. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$. No reference points for stock size have been defined for this stock.
d) Striped red mullet (mur.27.3a47d): The assessment was rejected in 2021 and the stock is now category 5. Currently, fishing pressure on the stock is above F_{MSY}; no reference points for stock size have been defined for this stock.
e) Pollack (pol.27.3a4): ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because information to define reference points is not available.
f) Turbot (tur.27.3a): Catches peaked in the late 1970s and early 1990s and have been more stable in recent years. Relative exploitable biomass (B/Bmsy) declined towards 2000 with an increasing trend in recent years years. Relative fishing pressure (F/Fmsy) peaked in the late 1970s and early 1990s without a trend in more recent years. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger}$.

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.

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, 2019 and 2020 was above the long-term average, but was estimated to be low in 2021. 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.

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3 Brill in Subarea 27.4, Divisions 3.a, 27.7.d and 27.7.e (bll.27.3a47de)

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, 2021). For this stock, advice is provided based on the LPUE trends of the Dutch beam trawl fleet (vessels > 221 kW). From 2020 onwards, the European Commission requests annual advice for this stock instead of biennial.

3.1 General

3.1.1 Stock definition

The genetic structure of brill over its entire distribution area was 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. More information can be found in the Stock Annex.

3.1.2 Biology and ecosystem aspects

A general description of the available information on the biology and ecosystem aspects can be found in the Stock Annex.

3.1.3 Fisheries

Brill is mainly a high value bycatch species in fisheries for plaice and sole. Nine countries are involved in the fisheries: Belgium, Denmark, France, Germany, Ireland, The Netherlands, Norway, Sweden and UK (England, Northern Ireland, Scotland and the Channel Islands). The Netherlands landed most brill in 2020 (44%), followed by the UK (18.0%) and France (11.4%). Most brill is caught by the TBB fleet (61%), followed by the OTB fleet (29%) and the GTR fleet (8.3%).

3.1.3.1 Management

No explicit management objectives have been defined for the brill stock in 3.a, 4, 7.d, e, and no specific management objectives or plans are known to ICES. As a primarily bycatch species, regulations related to effort restrictions for the most important fleets catching brill (e.g. beam trawlers) are likely to impact 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).

A combined EU TAC for turbot and brill is set in areas 2.a and 4 and applies to EU fisheries (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	2010
TAC	9000	9000	6750	5738	4877	4550	4323	4323	5263	5263	5263
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
TAC	4642	4642	4642	4642	4642	4488	5924*	7102	8122	6498	

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

The 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. Moreover, turbot (27.4) and brill (27.3a47de) cover different stock areas and have quantitative single species advice, but there is a combined TAC. This impedes sustainable management of one or both stocks. In 2018, ICES was requested to evaluate the role of TAC in the management of turbot and brill in the North Sea (ICES, 2018). It was concluded that turbot and brill should be managed using single-species TACs covering an area appropriate to the relevant stock distribution (for brill: Subarea 4, and divisions 3.a and 7.d–e; for turbot: Subarea 4). A TAC combining two high-value species (turbot and brill) under a low TAC can, in some instances, lead to the highgrading of the lesser-valued species (brill). Additionally, 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 advice is applied in the wrong way, involving a greater 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 prevent further 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 inter-benchmark of turbot, a new advice (for 2018) was given, which meant a 148% increase against the previous TAC (2017)[1], b) similar to 2016, member states were asking an advance of their quota for next year (2018), c) 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, 2018, 2019 and 2020, and was undershot by 14%, 38%, 45% and 33% 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 Conservation Reference Sizes (MCRS) for brill. Dutch producer organizations increased the MCRS when the TAC was limiting (e.g. from 27 cm to 30 cm in 2016 and later even to 32 cm). Moreover, weekly landings of turbot and brill are often capped to stay within the TAC (especially when the TAC is limiting). Following increases in advice in 2018-2019, PO measures were relaxed. An overview is shown in the table below.

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

Dutch PO-measures			
Year	**Date**	**Max kg per week/trip**	**MCRS**
2016	January - March	-	27 cm
2016	April – May	-	30 cm
2016	May – September	-	32 cm
2016	October – November	375 kg	32 cm
2016	November – December	600 kg	32 cm
2017	January – February	-	32 cm
2017	March – October	800 kg	32 cm
2017	November - December	2000 kg	30 cm
2018	January – August	2000 kg	30 cm
2018	September - October	2500 kg	30 cm
2018	October - December	3000 kg	27 cm
2019	January – December	3000 kg	27 cm
2020	January - December	3000 kg	27 cm

Since 1 January 2019, brill is fully under the landing obligation. In 2020, Dutch producer organisations capped landings weekly for both turbot and brill to 3000 kg and had a MCRS of 27 cm. Belgium applied a MCRS of 30 cm from 1 January 2017. However, this was raised to 32 cm from 23/12/2020 onwards.

3.1.3.2 ICES advice

3.1.3.2.1 ICES advice for 2020

The ICES advice for 2020 was:

ICES advises that when the precautionary approach is applied, catches should be no more than 2559 tonnes in each of the years 2020 and 2021.

The stock status was presented as follows:

		Fishing pressure				Stock size		
		2016	2017	2018		2016	2017	2018
Maximum sustainable yield	F_{MSY}	✓	✓	✓ Below	MSY $B_{trigger}$	✓	✓	✓ Above
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓ Below possible reference points	B_{pa},B_{lim}	✓	✓	✓ Above possible reference points
Management plan	F_{MGT}	–	–	–	B_{MGT}	–	–	–

From 2020 onwards, the European Commission requests annual advice for the brill stock.

3.1.3.2.2 ICES advice for 2021

From 2020 onwards, the European Commission requests annual advice for the brill stock. Therefore, the previous biennial advice was replaced by the advice below.

The ICES advice for 2021 was:

ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 2047 tonnes.

The stock status was presented as follows:

	Fishing pressure				Stock size			
		2017	2018	2019		2017	2018	2019
Maximum sustainable yield	F_{MSY} proxy	✓	✓	✓ Below proxy	MSY $B_{trigger}$ proxy	✓	✓	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓ Below possible reference points	B_{pa},B_{lim}	✓	✓	✓ Above possible reference points
Management plan	F_{MGT}	–	–	–	B_{MGT}	–	–	–

3.2 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 calls from 2018 onwards, similarly both age and length data were requested from discards and landings.

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 by area can be consulted in Table 3.4 and Figure 3.2. Over the period 1950–1970, total landings remained constant under 1000 tonnes (range from 582 to 947 tonnes), followed by a gradual increase to 2121 tonnes in 1977. From 1978 onwards, total landings remained higher than 1500 tonnes (range: 1517-3141 tonnes). In 1993, a maximum of 3141 tonnes was caught. From 2010-2020, total annual landings fluctuated around an average of 2209 tonnes (range: 1895-2538 tonnes). In 2015, landings peaked at 2538 tonnes to decrease again to 1895 tonnes in 2020 as lowest point of the last decade.

Subarea 27.4 accounts for the major part of the landings (Figure 3.3), on average generating 67±7% 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±11% and 12±10% 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 2020, the relative proportion of landings in Subarea 27.4 consisted of 62% of the total landings, for Division 27.3a 9% and for Division 27.7.d, e 29% (Table 3.5).

From 2014 onwards, data are available in InterCatch. Figure 3.4 shows the ICES catch estimates (both discards and landings provided through InterCatch) and the official catch statistics by country for 2020. The Netherlands fished the majority of the catches (predominantly in Subarea 4), followed by the UK and Denmark (Table 3.6). Denmark is responsible for the majority of the landings in Division 27.3a. Belgium and UK (England) have the highest landings in Division 27.7d and 27.7e respectively (Table 3.6). The most important gear types landing brill are TBB and OTB, followed by GTR and GNS (Table 3.7). Industrial bycatch landings (MIS_MIS_0_0_0_IBC) were uploaded in 2020: 2003 kg from Denmark, Germany and Sweden. No discards were raised for these strata.

For the WGNSSK data call in 2017, available age and length data were requested through InterCatch for three years back in time (2014–2016). From 2018 onwards, the WGNSSK data call also asked for both age and length. For assessment purposes age/length allocations in InterCatch did not need to be performed. Data quality of age readings has been verified in 2019 by an international otolith exchange coordinated by WGBIOP and appeared very successful (ICES, 2019).

3.2.2 Discards

Due to its high value, brill is not expected to be discarded a lot by fishermen as long as the quota have not been fully taken. Since January 2019, the stock is completely under the landing obligation.

Discard data from 2014–2020 are available in InterCatch. The proportion of landings for which discard weights are available in 2020 was 59%, which is comparable to previous years (table below). The proportion of imported discards was however lower than in 2019 (44% in 2020 versus 68% in 2019). It is unclear whether this is due to the Covid-19 pandemic.

Catch category	Survey	CATON (kg)	Percentage
BMS landing	Imported data	9	100
Discards	Imported data	100443	44
	Raised discards	128376	56
Landings	Imported data	1872411	100
Logbook registered discard	Imported data	0	NA
TOTAL		**2101239**	

Discards 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

All discard rates were retained during the raising (none were excluded for example due to being higher than average). Raised discards by country for 2020 are shown in Figure 3.4.

An overview of the overall discards and discard rates from 2014–2020 are shown in Table 3.8 and for 2018-2020 broken down by country and Subarea/Division in Table 3.9 and 3.10 respectively. There is no obvious trend over the period 2014–2020. However, discard rates are overall higher in the years 2018-2019. Discard rates higher than the overall rate for e.g. Denmark (28% in 2020), Sweden (26% in 2020) and Norway (23% in 2020). Additionally, higher discard rates seem to be present in the northern part of the stock area (31% in 27.3a). It should however be noted that brill in the greater North Sea is still a data limited stock. This means that countries supply all data they have. For Germany, the larger discard rate in 2019 (41%) was influenced by 1 sampled trip having a very high discard rate. In a future benchmark, InterCatch raising procedures should be investigated. Furthermore, data quality should be checked when considering moving brill up to a category 1 stock.

For assessment purposes age/length allocations in InterCatch did not need to be performed. Data quality of age readings has been verified in 2019 by an international otolith exchange coordinated by WGBIOP and appeared very successful (ICES, 2019).

3.2.3 BMS landings

The brill stock is under the landing obligation since January 2019.

The official catch statistics have reported BMS landings from 2018 onwards, with 681 kg in 2018, 2036 kg in 2019 and 779 kg in 2020.

In InterCatch, only 4 kg were reported in 2019 (0 kg prior to 2019) and 9 kg in 2020. BMS landings are raised together with discards as is described in §3.2.2.

3.2.4 Logbook registered discards

No logbook registered discards were uploaded to InterCatch.

3.2.5 Tuning series

3.2.5.1 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 2021.

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. The recorded numbers per hour are low (max. 2.95 individuals per hour in 2014) and inter-annual variation is large. In the period 2001-2008, however, consistently lower catches were realised (approximately 1 individual per hour). After a low in 2017, the CPUE increased again in 2018 and 2019. However, in 2020 the CPUE decreased again to the level of approximately 1 individual per hour.

The numbers at length are shown in Figure 3.7 and the corresponding age–length key is illustrated in Figure 3.8 (from 1992 onwards). 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 (1987–2020), 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 2021 data point.

The quarter 1 index shows a gradual increase from 1996 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). In 2019-2021, approximately 4 fish per hour are caught. The quarter 4 index shows a gradual increase from 1999 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 in 2017 to just above 4 fish per hour. The highest point in the time series is observed in 2018 when almost 11 fish per hour are caught. In 2019, the index decreases to approximately 7 fish per hour. In 2020, a small increase to almost 8 fish per hour is observed. Although both indices have been showing more or less the same trend over the time series, the most recent years (2017-2020) show a contradictive pattern (Figure 3.14). The quarter 1 index showed an increase in 2017, while the quarter 4 index showed this peak one year later in 2018.

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. In some years, at least 2 cohorts are visible, e.g. 2018 in Q4.

Note that the BITS is performed using another research vessel since 2016 (Havfisken I and Havfisken II).

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).

3.2.5.2 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 and discussed for the first time during WGNEW 2013 (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 2021 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 56 to 40 kg/day). While in 2019, an increase in the LPUE index is observed up to 48 kg/day, 2020 noted again a decrease up to 41 kg/day.

3.2.5.3 Dutch industry survey

Available fisheries independent surveys have a low catchability for large flatfish, which does not benefit the turbot and brill assessments. In 2018, the Dutch fishermen's association, VisNed, together with Wageningen Marine Research initiated an industry survey to monitor turbot and brill in the North Sea.

After a trial year (2018), the survey design was optimised. The survey area in the central and southern North Sea was selected based on CPUE data. Areas not available for fishing (e.g. N2000, wind parks) were excluded (Figure 3.17). A 5 by 5 km grid was applied to the survey area and 60 grid cells were randomly selected from this grid (new selection every year). These 60 grid cells were divided among 3 vessels based on their regular fishing grounds (Figure 3.17). All vessels fished with the same gear (beam trawl) in autumn (quarter 3). Fishermen were allowed to start fishing at any location in the selected grid cell, they could fish any route and were allowed to exit the cell, but not the survey area. The haul duration was the same as for regular commercial hauls, 100-120 minutes.

In every haul, all turbot and brill were counted. Length, weight and sex were registered. Otoliths were collected per length class to determine age (the number of otoliths depended on sex and length class; Schram *et al.,* 2021). Fishing conditions were recorded, including a description of the gear and a list of all hauls.

In 2020, an alternative approach was used because no scientists could board the fishing vessels due to the Covid-19 pandemic. All sampled fish were therefore processed by the scientific team at the auction. In 2020, 59 of the 60 hauls could be realised, catching 454 brill. A comparison with previous years and surveys with research vessels is given in the table below (source Schram *et al.,* 2021). The numbers of brill caught during this industry survey were approximately 10 times higher than caught during the BTS (ISI/TRI Q3) survey.

Species	Survey	Year	Total N° caught	Total N° hauls	Occurrence (%)	CPUE (N°/h)
Brill	BSAS	2018	518	45	58.7	14.9
		2019	785	50	100	26.4
		2020	454	59	81.4	17.3
	BTS	2018	67	82	35.4	1.8
		2019	85	73	53.4	2.7
		2020	47	74	33.8	1.7
	SNS	2018	30	45	31.1	0.8
		2019	10	44	14	0.4
		2020	0	46	0	0.0

Length measurements ranged from 21 cm to 53 cm for brill in 2020 (Figure 3.18). Ageing was done for 454 brill, with most of them age 1 and 2 in 2020 (Schram *et al.,* 2021).

Once a period of 5 years is covered, the index of this new survey is a potential candidate to include in the brill assessment (indicative of trends).

3.3 Advice

3.3.1 Analyses of stock trends and potential status indicators

Advice is 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.

3.3.2 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. Last year, during the WGNSSK 2020, there was a 21% decrease when applying the 2:3 rule (capped by uncertainty cap, this resulted in a 20% decrease). This year (WGNSSK 2021), applying the 2:3 rule led to a 8.3% decrease. No uncertainty cap needed to be applied as the ratio did not imply a more than 20% change.

In order to decide whether the precautionary buffer should be applied, the Surplus Production in Continuous Time (SPiCT) model was run (see §3.3.3).

3.3.3 SPiCT

A Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was run during the WGNSSK 2021 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, 2017a), using the default priors.

A fishery independent survey time series (BTS_ISI_Q3 1987–2020; Table 3.11), a standardized LPUE from the Dutch beam-trawl fleet (with vessels > 221 kW; including age 0 and 1; 1995–2020; Table 3.14), and a catch time series (trimmed to 1987-2020; Table 3.15) were used as input for the model. The catch series includes official landings from 1987–2013 and InterCatch landings from 2014 onwards. The BITS surveys in quarter 1 and 4 were not used in the SPiCT run as was decided during WGNSSK 2017 (ICES, 2017a).

A summary of the SPiCT assessment is given in Figure 3.19 and in Table 3.16. The model diagnostics are shown in Figure 3.20. 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 stable pattern, with all peels within the confidence bounds (Figure 3.21). Moreover, the Mohn's Rho values for F/F_{MSY} (0.005) and B/B_{MSY} (-0.023) were low. It was concluded that the model performed well and that the estimated stock status with respect to reference points is consistent.

3.3.4 2022 catch advice summary

An overview of the 2022 catch advice for brill 27.3a47de is shown in the table below. The change in advice is the result of a decline in the biomass index.

Index A (2019–2020)		45 kg d^{-1}
Index B (2016–2018)		49 kg d^{-1}
Index ratio (A/B)		0.92
Uncertainty cap	Not applied	-
Advised catch for 2021		2047 tonnes
Discard rate (2018–2020)		14.1%
Precautionary buffer	Not applied	-
Catch advice **		**1878** tonnes
Projected landings corresponding to catch advice ***		1613 tonnes
% advice change^		-8.3%

*** The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.**
**** [Advised catch for 2021] × [Index ratio].**
***** [Advised catch for 2021] × [Index ratio] × [1 – discard rate].**
^ Advice value for 2022 relative to the advice value for 2021.

3.3.5 Alternative advice using SPiCT forecast

WKLIFE X (ICES, 2020) investigated the performance of harvest control rules across life-history types through simulation and management strategy evaluation (MSE) for data-limited stocks. Recommendations include the application of the SPiCT forecast to provide advice. For exploratory purposes only, the current way of providing advice for brill in 27.3a47de (2 over 3 rule) was compared with the recommendations from WKLIFE X.

More specifically, WKLIFE X recommends using the fractile rule with 35th percentile of the predicted catch distribution for stocks with an accepted SPiCT assessment. In theory, this should be more precautionary than the median rule suggested by WKMSYCat34 and the 2 over 3 rule (ICES, 2017b; 2020).

Four catch scenarios were explored, not specifying any intermediate year assumptions. Considering that the input data are only landings, the output of the forecast will also be landings advice. An overview is given in the table below. The Fsq scenario implies that the F process continues after the intermediate year. F_{MSY} is defined as F/F_{MSY} equal to 1.

F in 2022-2023	Landings advice 2022	B/B_{MSY} (2023)	F/F_{MSY} (2023)
F = 0	0	2.2	0.00
F = Fsq	2069	1.32	0.72
F_{MSY}	2592	1.08	1.00
F_{MSY} 35% fractile	**2444**	1.15	0.91

The SPiCT forecast resulted in a landings advice of 2444 tonnes, which is 52% higher than the current landings advice based on the 2:3 rule (1610 tonnes). The output of the SPiCT assessment suggest that the brill stock is currently in a good state compared to proxy reference points. Consequently, it is not unusual to expect higher advice using the SPiCT forecast. Furthermore, the Dutch LPUE index currently used for advice only covers a part of the stock area (only 27.4). It is also a raw index (not modelled), which could be improved considering the changes in the Dutch beam trawl fleet (introduction and phasing-out of pulse trawlers).

More information on this alternative advice can be found in the Working Document 2 (Annex 9).

3.4 Biological reference points

The table below summarises all known reference points for brill in area 27.3a47de 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 (2017a)
	$F_{MSY_{proxy}}$	$\frac{F}{F_{MSY}} = 1$	Relative value from SPiCT model. F_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2017a)
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		

3.5 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 were 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. As a result of the ban on the use of pulse gear from 2019 onwards, the composition of the Dutch fleet has gradually changed again. A modelled LPUE including these fleet characteristics as parameters in the model would benefit the brill assessment.

→ 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 (§3.1.3.1 Management).

→ The current surveys in this area are not designed for catching brill, especially large brill. A survey, both with adequate catchability of large flatfish and covering the entire distribution area of the stock, would improve the assessment. The Dutch industry survey initiative is a step in the right direction.

3.6 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, 2018). 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.

3.7 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 InterCatch, use model to bridge gaps in time series (cfr. Turbot assessment)	Data from all countries involved in brill fisheries.	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
	Make the Dutch commercial tuning series more robust to changes in the fleet composition. Check whether this series can be extended, should be age-structured and should include age 0 and 1.	Model Dutch LPUE series	Dutch catch, effort and fleet information	Dutch experts in LPUE modelling

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
	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
	Check the potential use of the recently initiated Dutch industry survey.	Analyse data	Data from the Dutch industry survey	Dutch experts on the brill-turbot industry survey
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 (L_{mat}), and length von Bertalanffy growth curve ($L_{inifinity}$) are needed. Determine the sex ratio in the stock area.	van der Hammen et al (2011) suggested values for L_{inf} and L_{mat} 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)	Experts on biological parameters, stock coordinator
Assessment method	Currently a biomass index is calculated in combination with a SPiCT assessment. Explore whether other assessment methods can be used/further developed (SPiCT/SAM).	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

3.8 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 1950–2020 (Source: ICES Fishstat); *Preliminary.

Year	BEL	GER	DNK	NLD	NOR	SWE	BMS	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	BMS	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	14		140
2007	0	1	119	3	15	22		160
2008	0	2	138	1	13	28		181
2009	0	1	98	1	14	32		146
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	9	9	17	<1	125
2019*	0	2	93	25	3	15	<1	139
2020*	0	1	112	29	3	17	<1	162

Table 3.2: BLL 27.3a47de – Official landings (tonnes) of brill in Subarea 27.4 by country, over the period 1950–2020 (Source: ICES Fishstat); *Preliminary.

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	BMS	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	BMS	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		1239
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		1499
2011	101	57	122	13	137	1061	6	0		1496
2012	110	71	126	12	122	1084	7	0		1532
2013	101	63	123	10	118	972	4	0		1390
2014	99	69	96	9	117	857	9	0		1255
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	98	80	96	6	100	805	2	0	<1	1188
2019*	116	132	90	5	110	922	1	0	2	1378
2020*	84	99	95	2	91	809	1	0	<1	1183

Table 3.3: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivisions 27.7.d, e (English Channel) by country, over the period 1950–2020 (Source: ICES Fishstat); *Preliminary.

Year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	BMS	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	BMS	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	14		648
2007	205	0	325	199	0	1	13		743
2008	155	0	224	199	0	2	16		595
2009	131	0	278	171	0	1	13		594
2010	145	0	340	198	0	1	15		700
2011	141	0	304	202	0	0	18		665
2012	120	0	263	228	0	1	12		624
2013	142	0	238	213	0	1	11		605
2014	166	0	245	219	0	1	13		645
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	248	1	2	55		714
2019*	103	0	284	262	0	3	2	<1	655
2020*	91	0	209	246	0	2	1	<1	550

Table 3.4: BLL 27.3a47de – Total official landings (tonnes) of brill in the 27.3a47de (Greater North Sea) over the period 1950–2020, subdivided into Subarea 27.4 and Divisions 27.3.a and 27.7.d, e (Source: ICES Fishstat). *Preliminary.

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	142	1508	678	2327
2001	98	1573	738	2409
2002	89	1302	716	2108
2003	129	1346	759	2233
2004	156	1249	666	2071
2005	133	1160	611	1904
2006	140	1175	648	1963
2007	160	1239	743	2142
2008	181	1004	595	1781
2009	146	1162	594	1902
2010	122	1499	700	2321
2011	131	1496	665	2292
2012	120	1532	624	2276
2013	92	1390	605	2088
2014	79	1255	645	1978
2015	145	1695	698	2537
2016	168	1526	721	2415
2017	170	1460	663	2292
2018	125	1188	714	2027
2019*	139	1378	655	2172
2020*	162	1183	550	1895

Table 3.5: BLL 27.3a47de – Overview of absolute landings per area over the last 11 years with an indication of the relative proportion by area (Source: ICES Fishstat).

	Absolute landings (tonnes)				Relative proportion		
Year	3a	4	7de	TOTAL	3a	4	7de
2010	122	1499	700	2321	0.05	0.65	0.30
2011	131	1496	665	2292	0.06	0.65	0.29
2012	120	1532	624	2276	0.05	0.67	0.27
2013	92	1390	605	2087	0.04	0.67	0.29
2014	79	1255	645	1979	0.04	0.63	0.33
2015	145	1695	698	2538	0.06	0.67	0.28
2016	168	1526	721	2415	0.07	0.63	0.30
2017	170	1460	663	2293	0.07	0.64	0.29
2018	125	1188	714	2027	0.06	0.59	0.35
2019	139	1378	655	2172	0.06	0.63	0.30
2020	162	1183	550	1895	0.09	0.62	0.29

Table 3.6: BLL 27.3a47de – Overview of 2020 catches reported to InterCatch (ICES) by country and area.

	3a		4			7d			7e		Total			
COUNTRY	DIS	LAN	BMS	DIS	LAN	BMS	DIS	LAN	DIS	LAN	BMS	DIS	LAN	ALL
Belgium	0	0		12	69		3	106	0	0		15	175	190
Denmark	66	112		15	95		0	0	0	0		81	207	288
France	0	0		1	3		4	37	45	173		50	213	263
Germany	0	1		14	99		0	0	0	0		14	100	114
Ireland	0	0		0	0		0	0	0	0		0	0	0
Netherlands	2	33		40	784		0	2	0	0		42	819	861
Norway	1	3		0	1		0	0	0	0		1	4	5
Sweden	6	17		0	0		0	0	0	0		6	17	22
UK (England)	0	0	0	5	69	0	3	13	10	232	0	18	314	332
UK (Northern Ireland)	0	0		0	0		0	0	0	0		0	0	0
UK (Scotland)	0	0		1	22		0	1	0	0		1	23	24
Total	74	166	0	89	1142	0	10	159	56	406	0	229	1872	**2101**

Table 3.7: BLL 27.3a47de – Overview of 2020 landings for the most important gear types per area (Source: InterCatch).

Gear type	3a	4	7d	7e	Total
DRB	0	0	5	1	6
FPO	0	0	0	0	0
GNS	12	43	5	8	68
GTR	1	2	6	80	88
LLS	0	0	0	0	0
MIS	4	12	8	14	38
OTB	116	283	17	112	528
SDN	2	1	0	0	3
SSC	0	4	2	0	6
TBB	32	796	116	190	1134
Total	**166**	**1142**	**159**	**406**	**1872**

Table 3.8: BLL 27.3a47de – Overall discards and discard rates (all countries and métiers) for brill over the period 2014–2020 (Source: InterCatch).

Year	Discards	Discard rate
2014	231	0.107
2015	230	0.085
2016	267	0.099
2017	208	0.086
2018	349	0.151
2019	417	0.163
2020	229	0.109

Table 3.9: BLL 27.3a47de – Discard rates for brill by country for 2018-2020 (source: InterCatch).

Country	Discard rate 2018	Discard rate 2019	Discard rate 2020
Belgium	0.090	0.063	0.079
Denmark	0.30	0.197	0.28
France	0.180	0.154	0.192
Germany	0.167	0.41	0.125
Ireland			
Netherlands	0.107	0.160	0.049
Norway	0.191	0.169	0.23
Sweden	0.30	0.40	0.26
UK (England)	0.128	0.065	0.053
UK (Northern Ireland)	0.34		0.21
UK(Scotland)	0.28	0.066	0.041
Overall	**0.151**	**0.163**	**0.109**

Table 3.10: BLL 27.3a47de – Discard rates for brill by area for 2018-2020 (Source: InterCatch).

Subarea/ Division	Discard rate 2018	Discard rate 2019	Discard rate 2020
27.3.a	0.41	0.28	0.31
27.4	0.120	0.186	0.072
27.7.d	0.20	0.073	0.059
27.7.e	0.092	0.087	0.121
Overall	**0.151**	**0.163**	**0.109**

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
1985	0.400	2003	1.084
1986	0.297	2004	0.938
1987	2.104	2005	0.696
1988	0.686	2006	0.963
1989	1.037	2007	1.244
1990	2.362	2008	0.588
1991	1.731	2009	1.556
1992	2.819	2010	2.435
1993	2.326	2011	2.677
1994	1.719	2012	1.177
1995	1.294	2013	0.833
1996	0.585	2014	2.950
1997	1.422	2015	1.930
1998	1.666	2016	1.070
1999	0.894	2017	0.870
2000	2.554	2018	1.448
2001	0.886	2019	2.000
2002	0.881	2020	0.935

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	1.778
1997	0.273
1998	0.500
1999	0.714
2000	1.071
2001	0.643
2002	1.929
2003	1.379
2004	2.000
2005	1.714
2006	3.867
2007	3.214
2008	2.733
2009	2.038
2010	2.897
2011	3.286
2012	2.533
2013	1.571
2014	2.857
2015	3.556
2016	4.857
2017	7.923
2018	1.077
2019	4.279
2020	3.619
2021	3.714

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	2.857
2000	0.316
2001	1.800
2002	2.071
2003	1.929
2004	3.310
2005	2.897
2006	4.759
2007	5.117
2008	4.400
2009	3.750
2010	4.839
2011	5.034
2012	3.000
2013	3.831
2014	6.090
2015	6.636
2016	4.667
2017	4.273
2018	10.870
2019	7.137
2020	7.815

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	22.150
2003	26.463
2004	27.062
2005	25.861
2006	26.557
2007	32.379
2008	39.580
2009	40.467
2010	50.008
2011	52.385
2012	55.820
2013	53.553
2014	45.612
2015	62.160
2016	56.210
2017	49.554
2018	39.956
2019	47.745
2020	41.360

Table 3.15: BLL 27.3a47de – Commercial landings (tonnes) for brill as input for SPiCT. Note that from 1987–2013 landings represent official landings. From 2014 onwards, landings as reported in InterCatch were used.

Year	Landings (tonnes)
1987	1568
1988	1638
1989	1824
1990	1564
1991	2251
1992	2419
1993	3141
1994	2628
1995	2143
1996	1967
1997	1564
1998	1866
1999	1677
2000	2328
2001	2409
2002	2107
2003	2234
2004	2071
2005	1904
2006	1963
2007	2142
2008	1781
2009	1902
2010	2321
2011	2292
2012	2276
2013	2088
2014	1920
2015	2470
2016	2444
2017	2207
2018	1956
2019	2147
2020	1872

Table 3.16: BLL 27.3a47de – SPiCT summary output from the analyses performed during the WGNSSK 2021.

```
Convergence: 0  MSG: both X-convergence and relative convergence (5)
Objective function at optimum: 6.3785146
Euler time step (years):  1/16 or 0.0625
Nobs C: 34,  Nobs I1: 34,  Nobs I2: 26

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    3.5607788    1.3688684 9.262502e+00  1.2699793
 alpha2    0.4778991    0.0491669 4.645147e+00 -0.7383556
 beta      0.1387485    0.0244980 7.858250e-01 -1.9750920
 r         0.7902021    0.2484809 2.512947e+00 -0.2354665
 rc        2.2076350    1.3626447 3.576613e+00  0.7919218
 rold      2.7812373    0.0753871 1.026075e+02  1.0228959
 m      2221.7690127 2078.3120859 2.375128e+03  7.7060590
 K      6526.9656512 3092.0564207 1.377765e+04  8.7836974
 q1        0.0007227    0.0004516 1.156500e-03 -7.2325430
 q2        0.0188862    0.0118365 3.013470e-02 -3.9693241
 n         0.7158811    0.2629858 1.948720e+00 -0.3342412
 sdb       0.1315298    0.0537620 3.217902e-01 -2.0285216
 sdf       0.2096083    0.1464058 3.000948e-01 -1.5625148
 sdi1      0.4683486    0.3635571 6.033453e-01 -0.7585423
 sdi2      0.0628580    0.0144104 2.741863e-01 -2.7668772
 sdc       0.0290828    0.0054610 1.548815e-01 -3.5376068

Deterministic reference points (Drp)
          estimate        cilow       ciupp   log.est
 Bmsyd 2012.804622 1228.3794562 3298.152233 7.6072844
 Fmsyd    1.103817    0.6813224    1.788306 0.0987746
 MSYd  2221.769013 2078.3120859 2375.128153 7.7060590
Stochastic reference points (Srp)
          estimate        cilow      ciupp   log.est  rel.diff.Drp
 Bmsys 2001.363309 1216.8773442 3291.58490 7.6015839 -0.0057167599
 Fmsys    1.103182    0.6835372    1.78046 0.0981989 -0.0005759005
 MSYs  2207.861016 2068.6619097 2356.42675 7.6997795 -0.0062993083

States w 95% CI (inp$msytype: s)
                  estimate        cilow       ciupp    log.est
 B_2020.94     2385.9432034 1364.1031577 4173.236414  7.7773498
 F_2020.94        0.7893766    0.4354516    1.430964 -0.2365117
 B_2020.94/Bmsy   1.1921590    0.8627742    1.647294  0.1757659
 F_2020.94/Fmsy   0.7155451    0.4884693    1.048182 -0.3347106

Predictions w 95% CI (inp$msytype: s)
                prediction        cilow       ciupp    log.est
 B_2022.00     2585.0374213 1441.7208789 4635.029268  7.8574953
 F_2022.00        0.7893769    0.3803339    1.638339 -0.2365114
 B_2022.00/Bmsy   1.2916383    0.8994567    1.854819  0.2559114
 F_2022.00/Fmsy   0.7155454    0.4045980    1.265467 -0.3347102
 Catch_2021.00 1976.4125636 1500.7469008 2602.841705  7.5890386
 E(B_inf)      2691.2676216           NA          NA  7.8977676
```

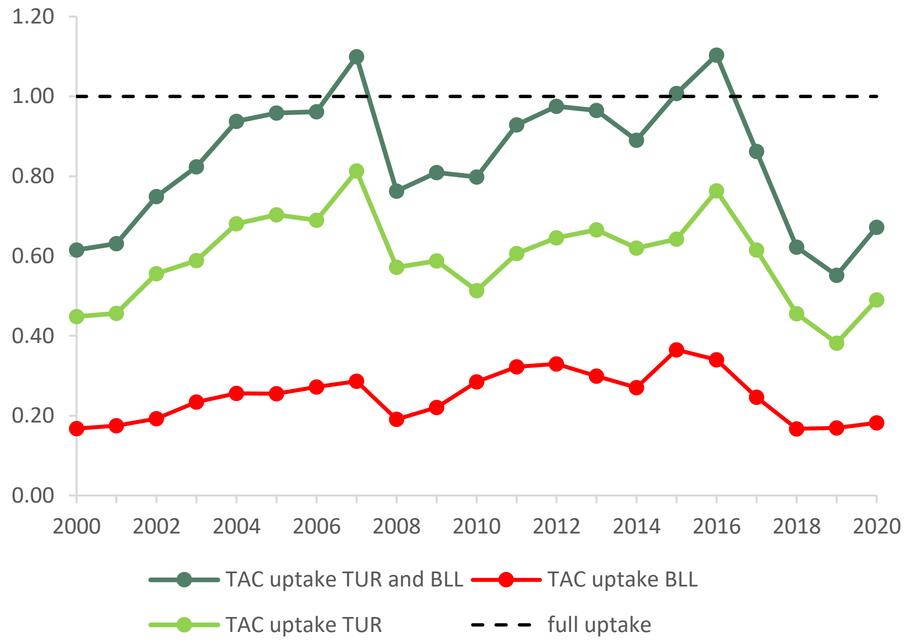

Figure 3.1: BLL 27.3a47de – TAC uptake for both brill and turbot in area 2.a and 4.

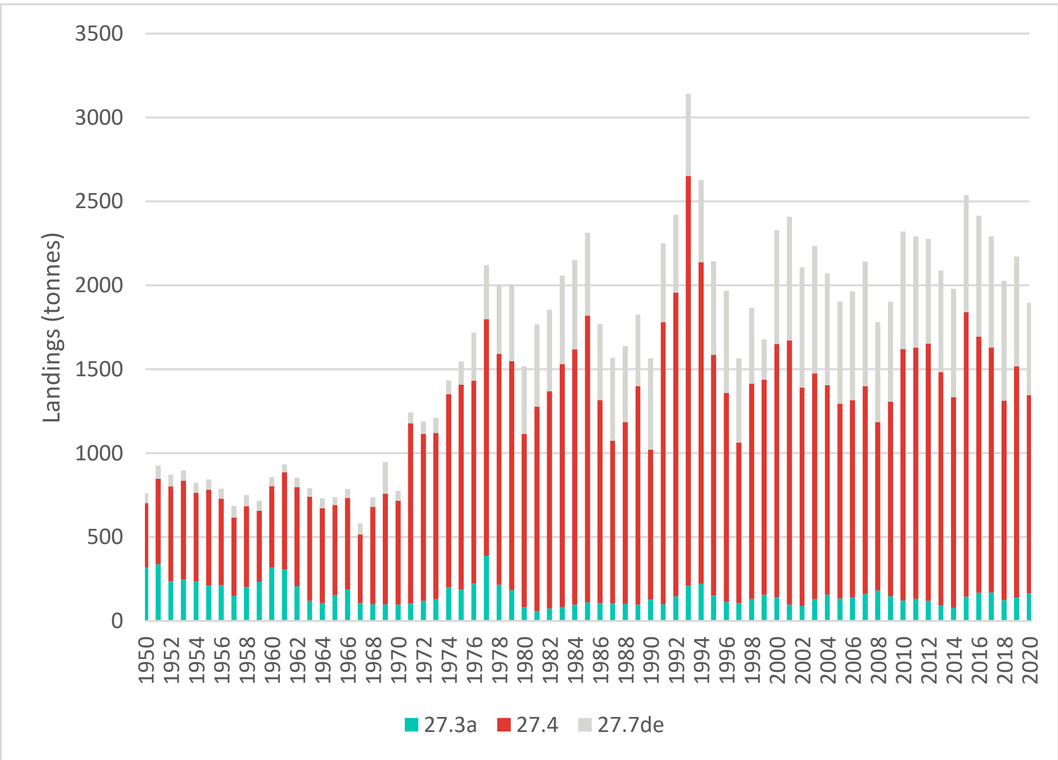

Figure 3.2: BLL 27.3a47de – Official landings (tonnes) over the period 1950–2020, as officially reported (Rec 12; ICES Fishstat).

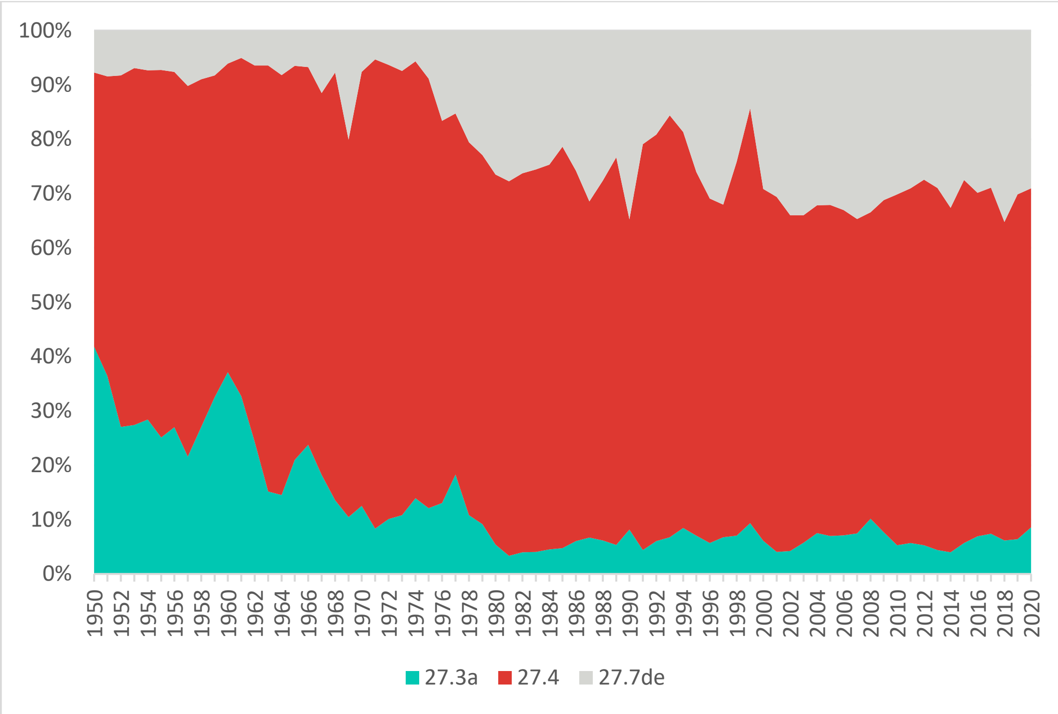

Figure 3.3: BLL 27.3a47de – Relative contribution of the official landings for brill from Subarea 27.4, Division 27.3.a and 27.7.d,e to the total international landings (tonnes) in the Greater North Sea over the period 1950–2020 (Source: ICES Fishstat).

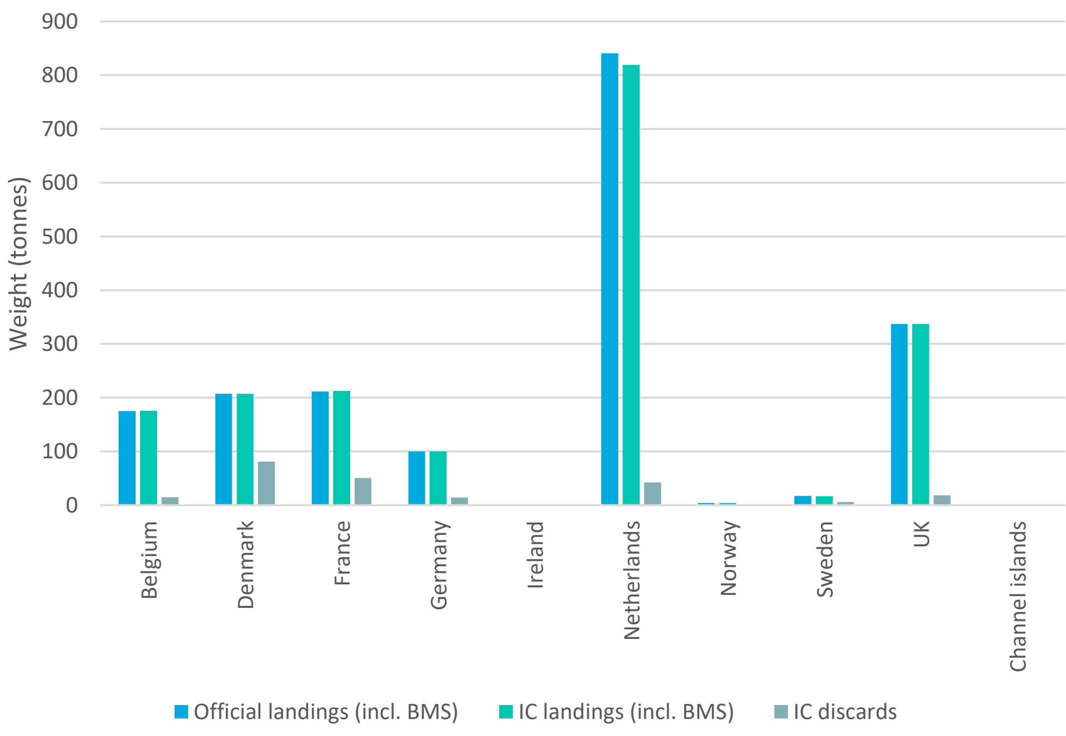

Figure 3.4: BLL 27.3a47de – Comparing ICES catch estimates (InterCatch, IC) to the official catch statistics by country for 2020.

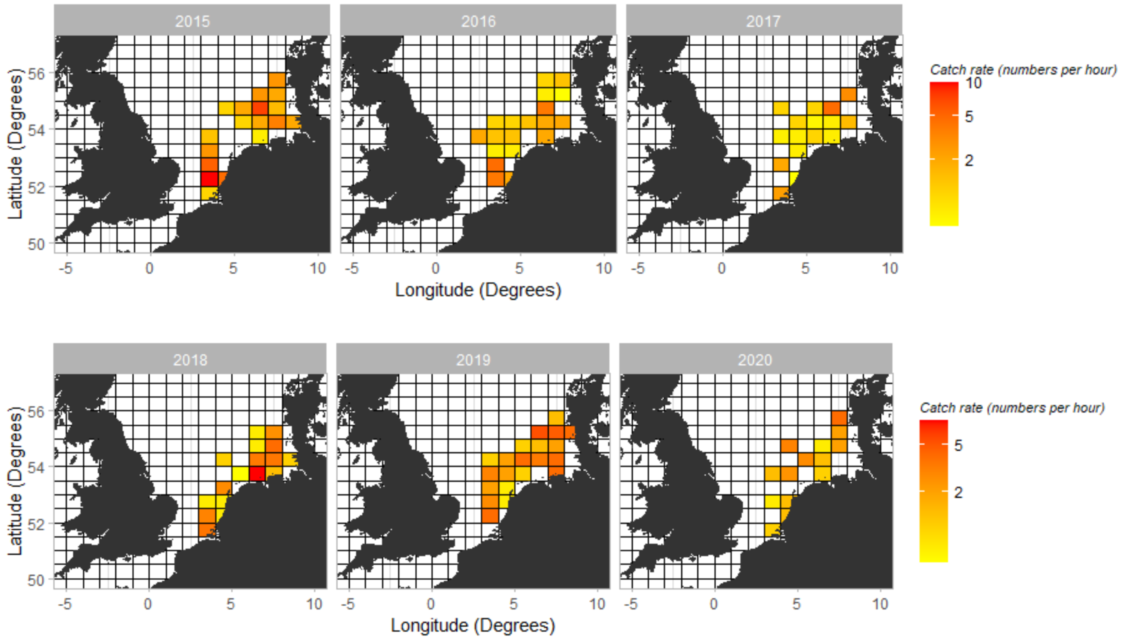

Figure 3.5: BLL 27.3a47de – Average numbers of brill caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (27.4) for 2015-2020; note the slightly different scales for the different graphs.

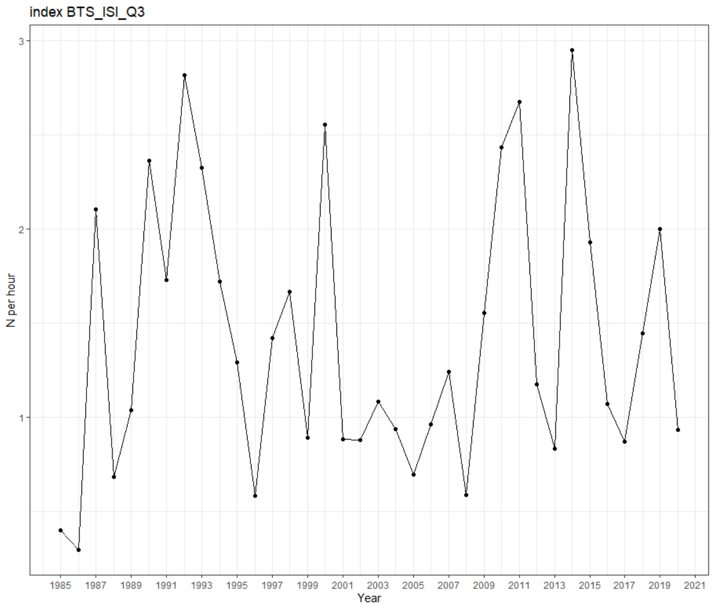

Figure 3.6: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BTS_ISI_Q3 in the North Sea (27.4) over the period 1985–2020.

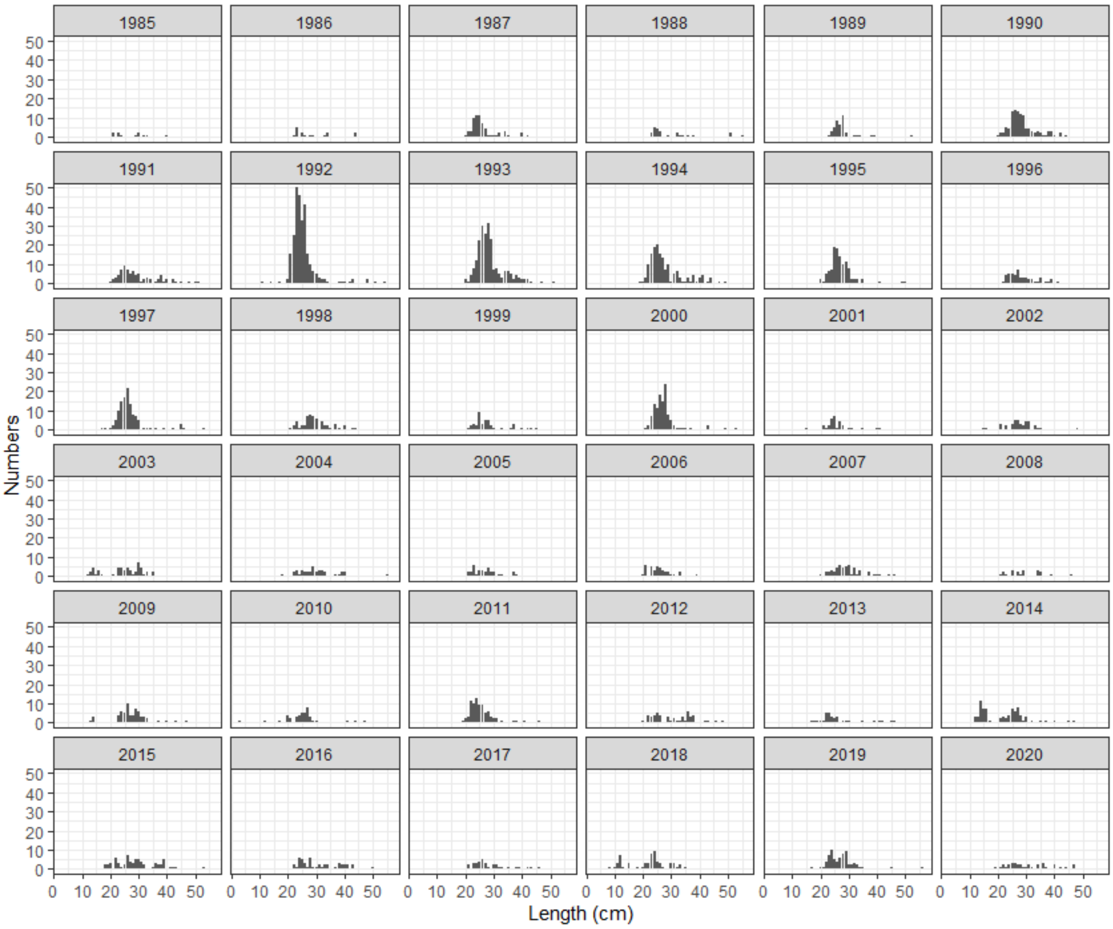

Figure 3.7: BLL 27.3a47de – Length distributions of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1985–2020).

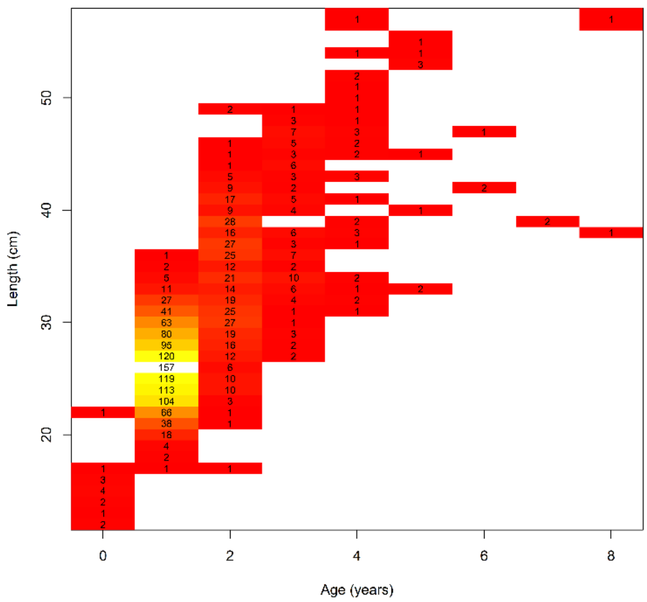

Figure 3.8: BLL 27.3a47de – Age-length key of brill in the North Sea (27.4) as documented by the BTS_ISI_Q3 (1992–2020).

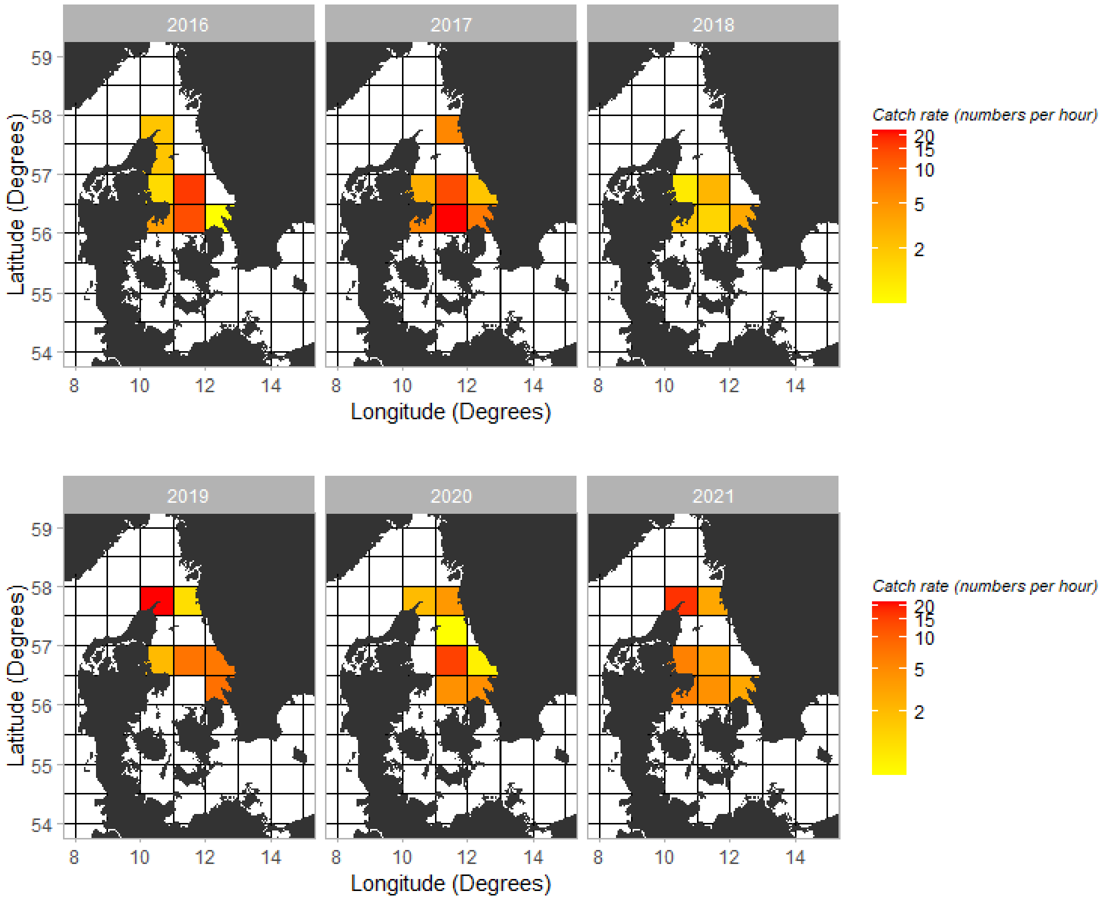

Figure 3.9: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q1 in the Kattegat (27.3.a21) in 2016-2021.

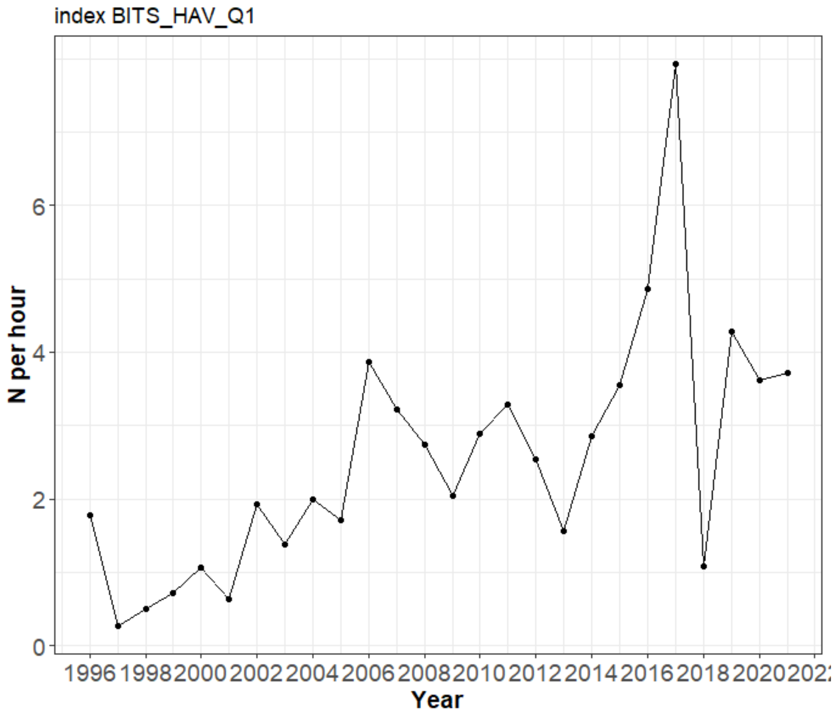

Figure 3.10: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q1) over the period 1996–2021.

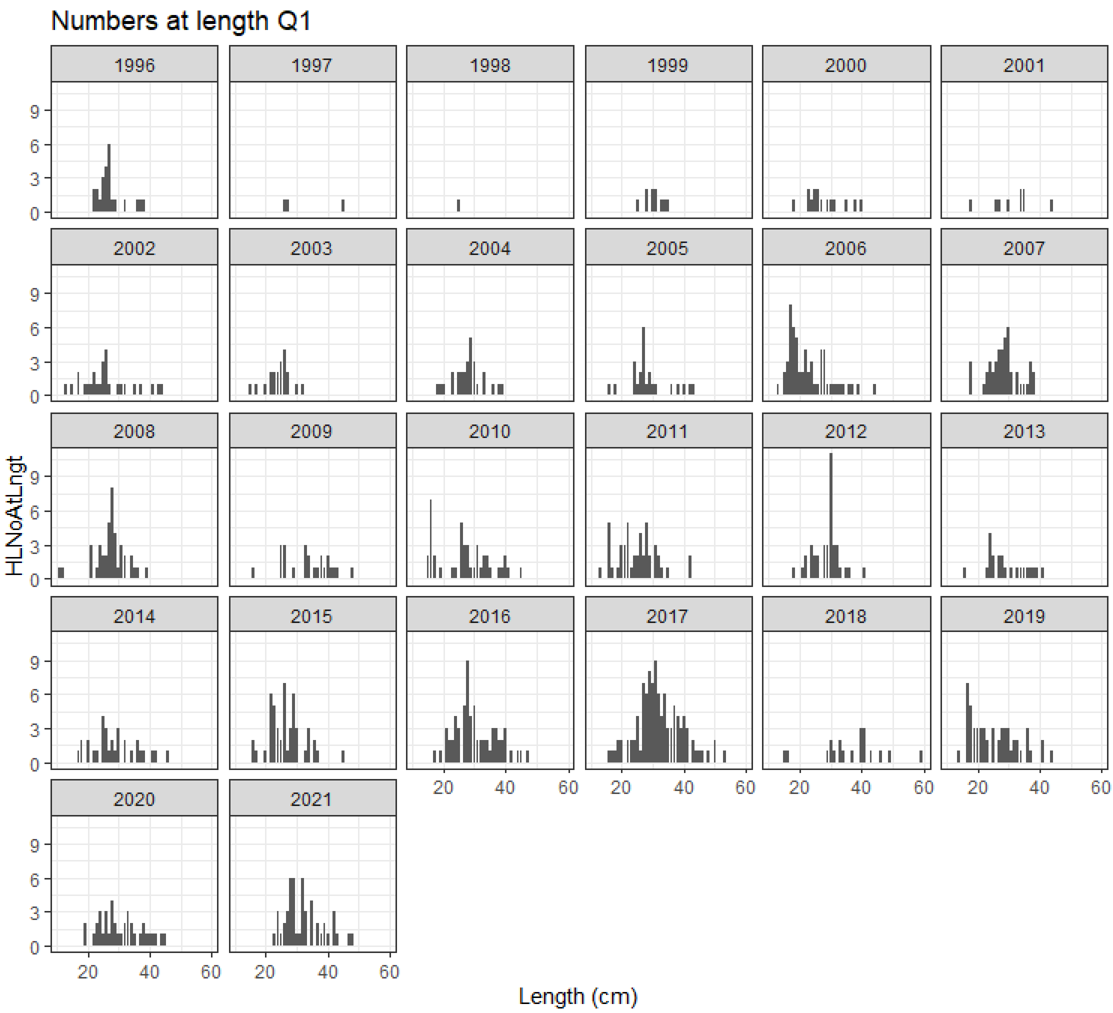

Figure 3.11: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q1 (1996–2021).

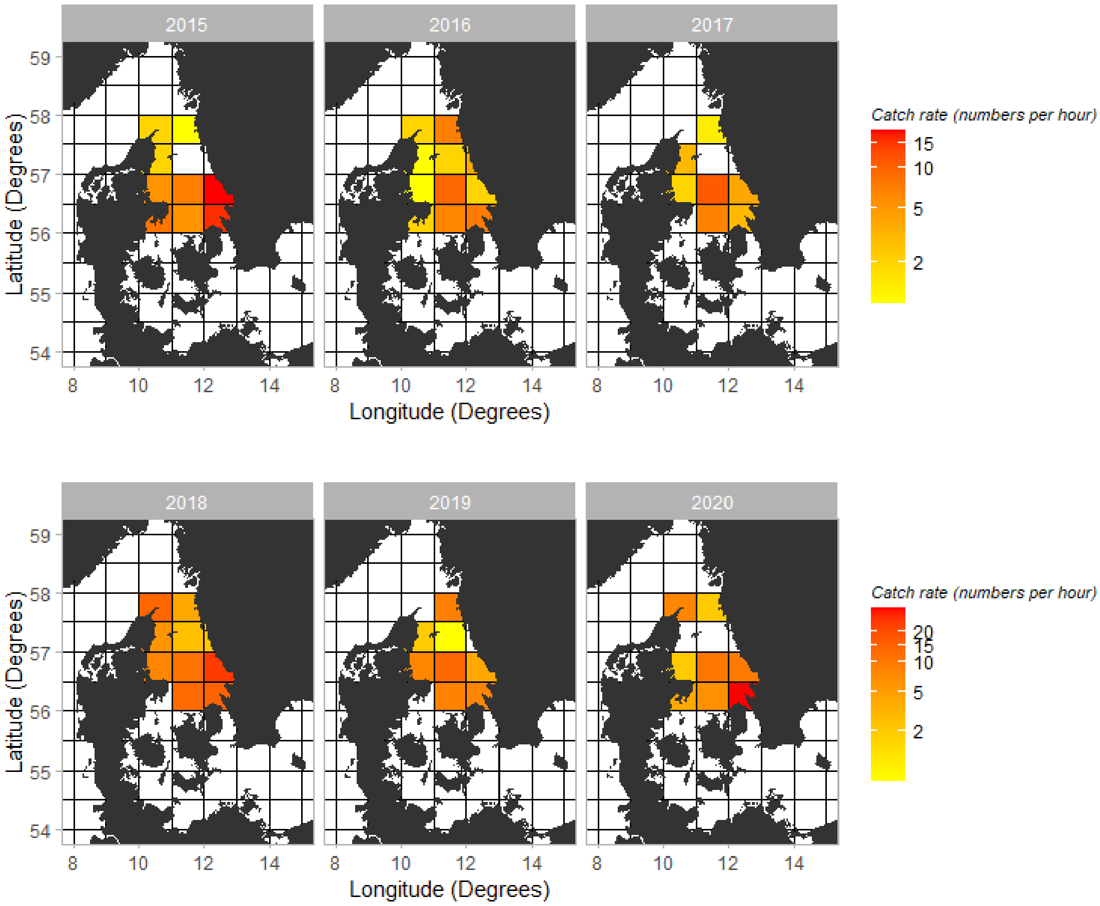

Figure 3.12: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q4 in the Kattegat (27.3.a21) in 2015-2020; note the slightly different scales for the different graphs.

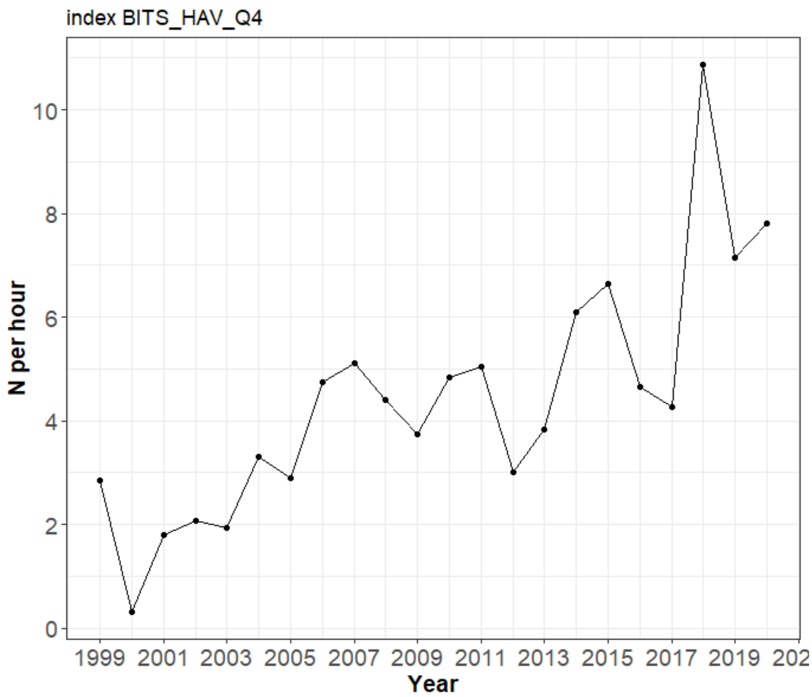

Figure 3.13: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q4) over the period 1999–2020.

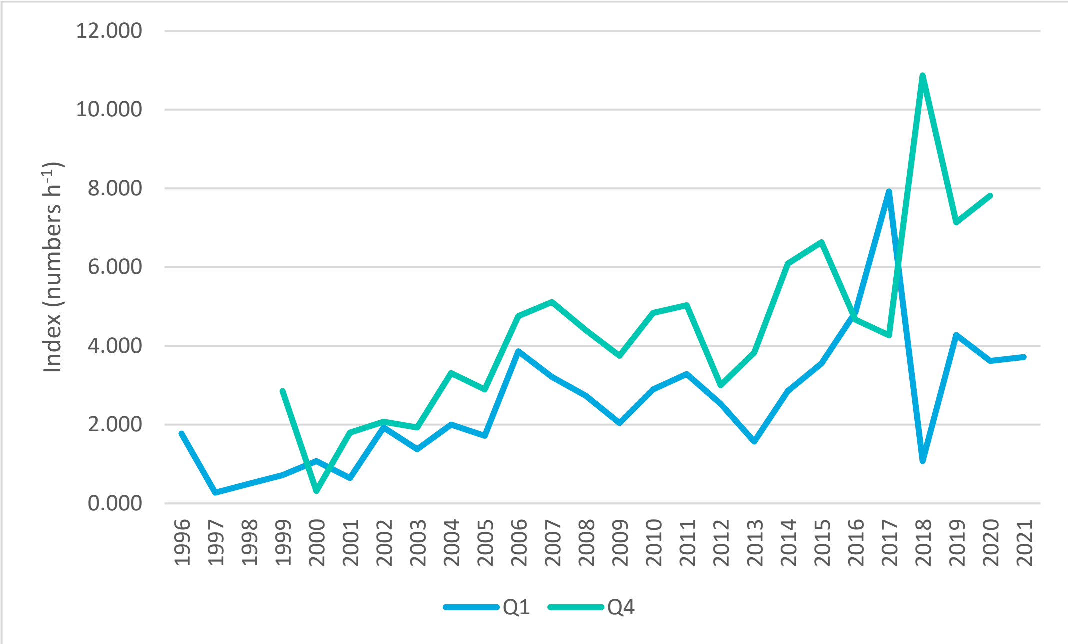

Figure 3.14: BLL 27.3a47de – Abundance indices (numbers caught per hour) of brill for both quarters (Q1 and Q4) of the BITS_HAF in the Kattegat over the period 1996–2021.

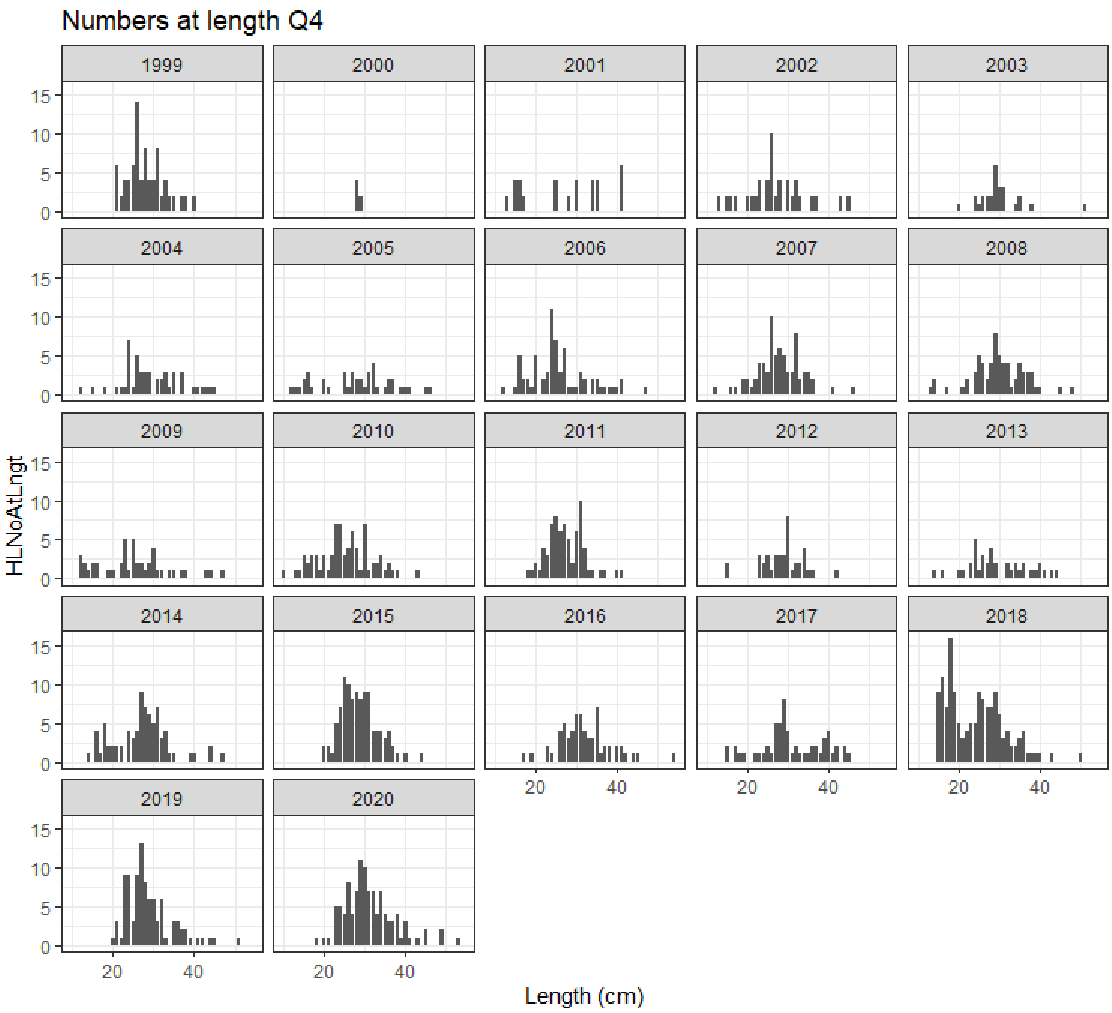

Figure 3.15: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q4 (1996–2020).

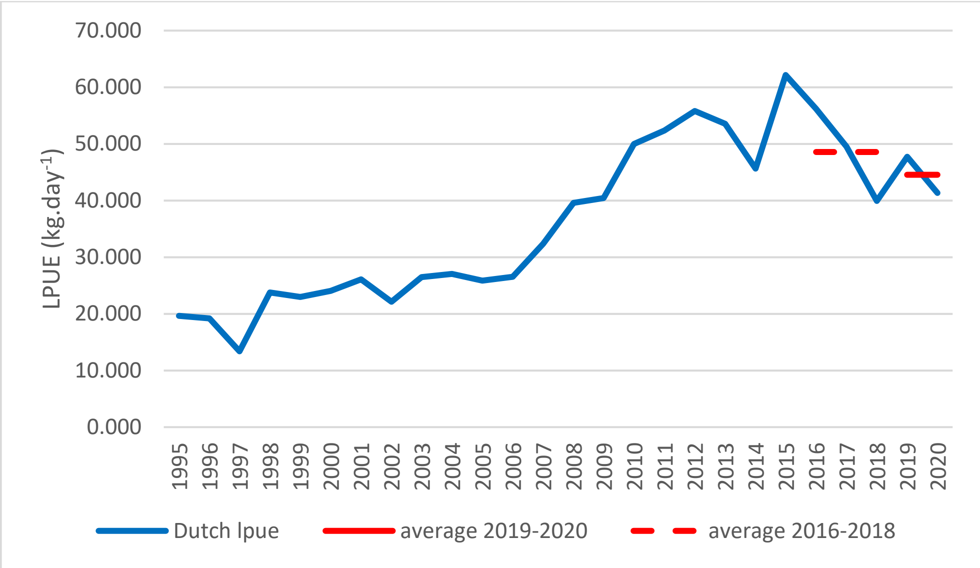

Figure 3.16: BLL 27.3a47de – Commercial LPUE (kg/day) of brill by the Dutch beam trawl fleet > 221 kW (standardized for engine power and corrected for targeting behaviour). The red lines are the averages of the last two (2019–2020) and the previous three (2016–2018) years.

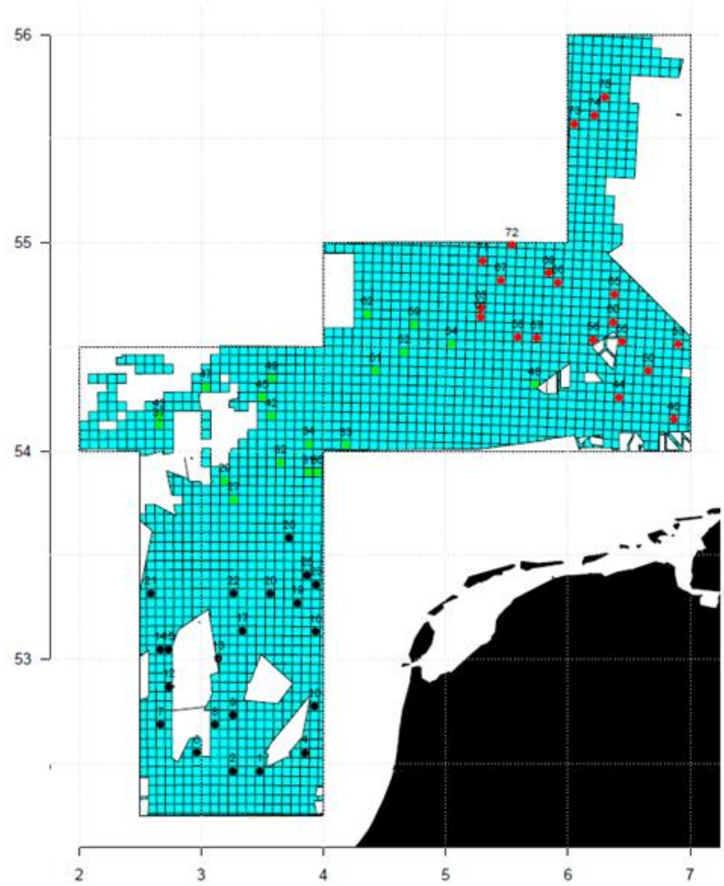

Figure 3.17: BLL 27.3a47de – Map showing the central and southern North Sea subject to monitoring by the Dutch industry survey. The area is divided in grid cells (5 x 5 km) and areas where no fishing is allowed are excluded (white areas). Twenty randomly selected grid cells were allocated to each of three vessels (vessel 1 = red, vessel 2 = black and vessel 3 = green). The selection of the grid cell varies every year. Map shows location of sampled stations for 2020. (source Schram *et al.,* 2021).

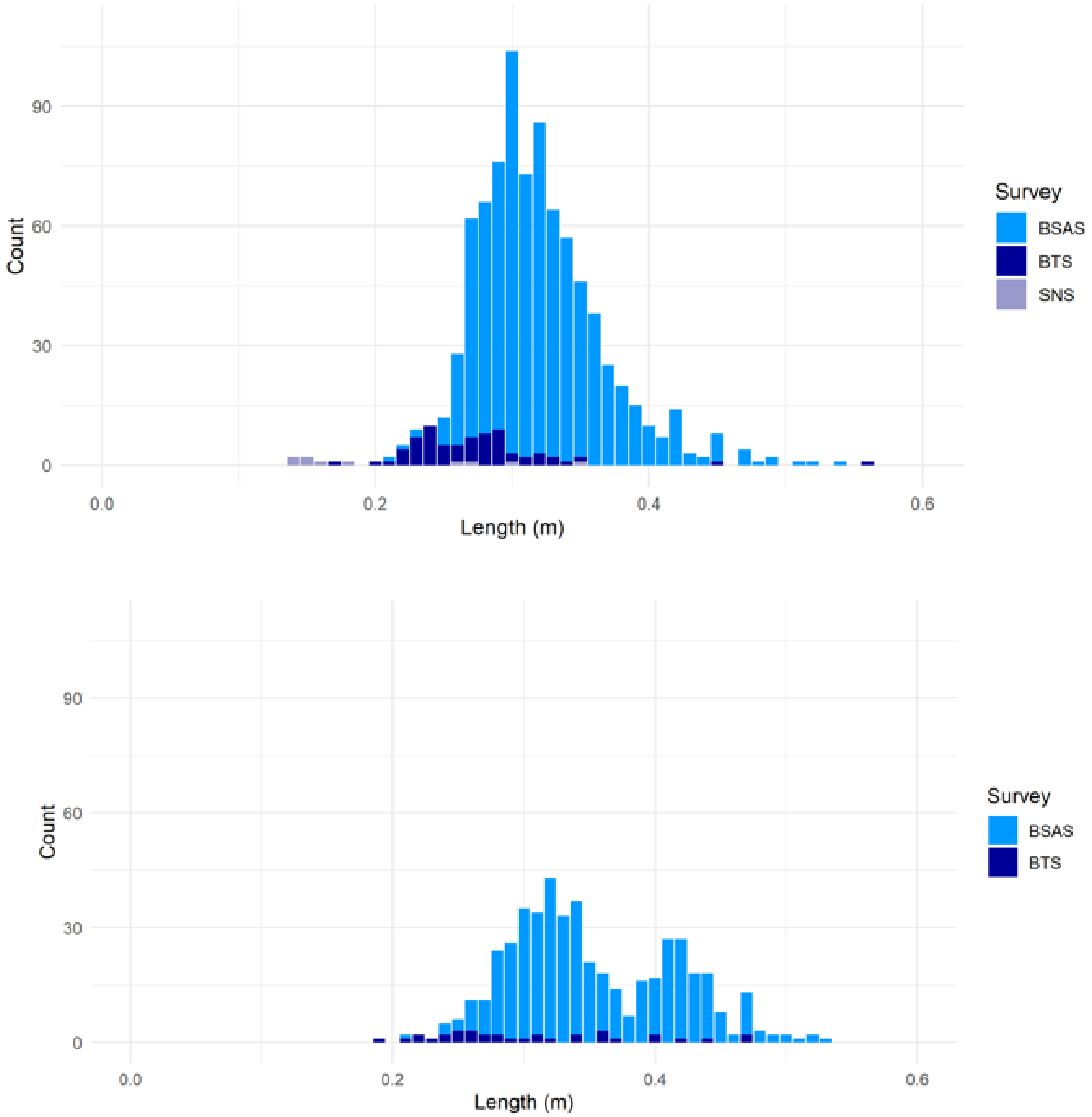

Figure 3.18: BLL 27.3a47de – Length distribution plot for brill as sampled during the Dutch industry survey (BSAS) in 2019 (top) and 2020 (bottom), Dutch BTS ISI/TRI Q3 (BTS) and Dutch coastal sole net survey (SNS).

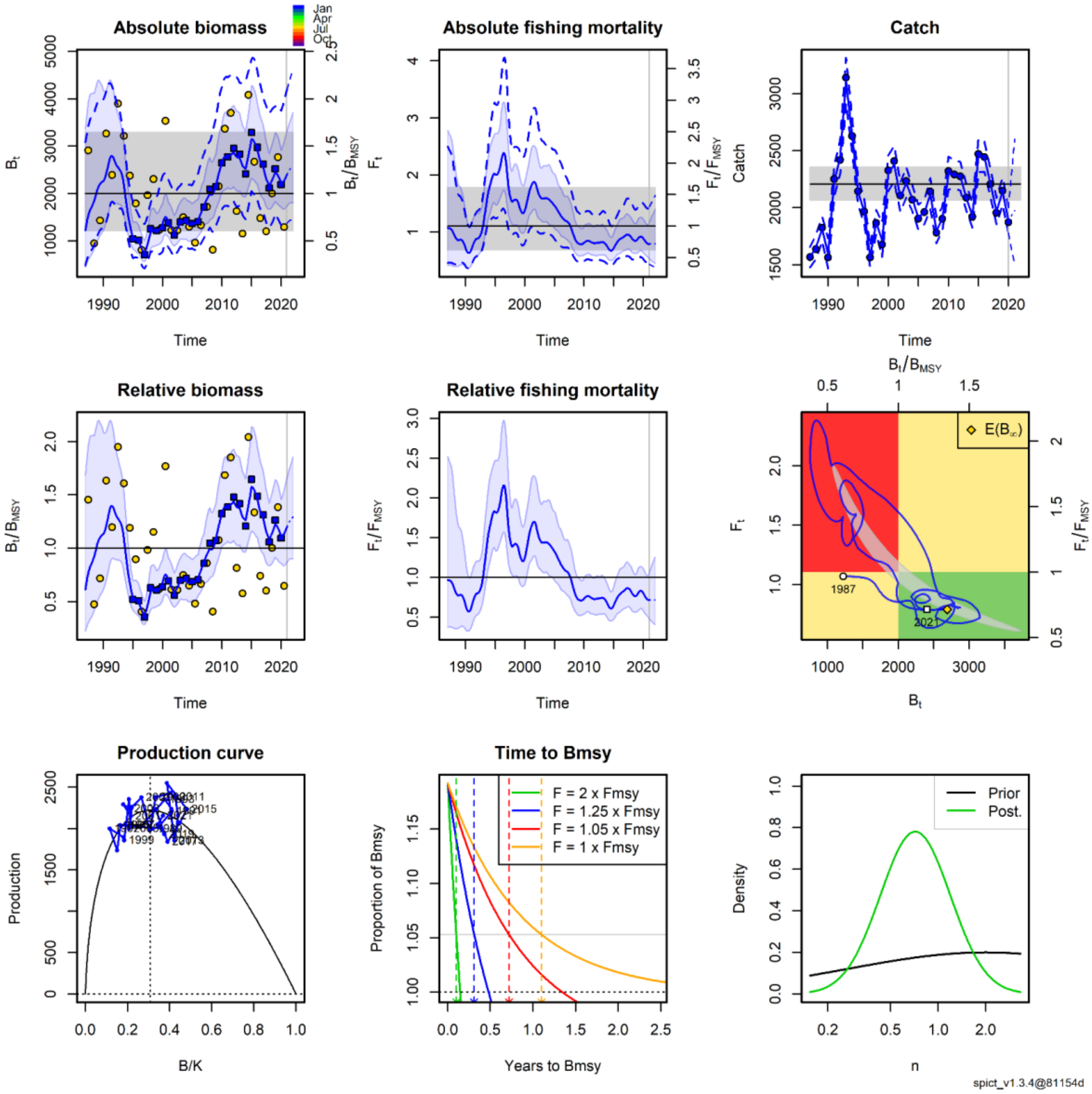

Figure 3.19: BLL 27.3a47de – SPiCT model results from WGNSSK 2021. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. 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).

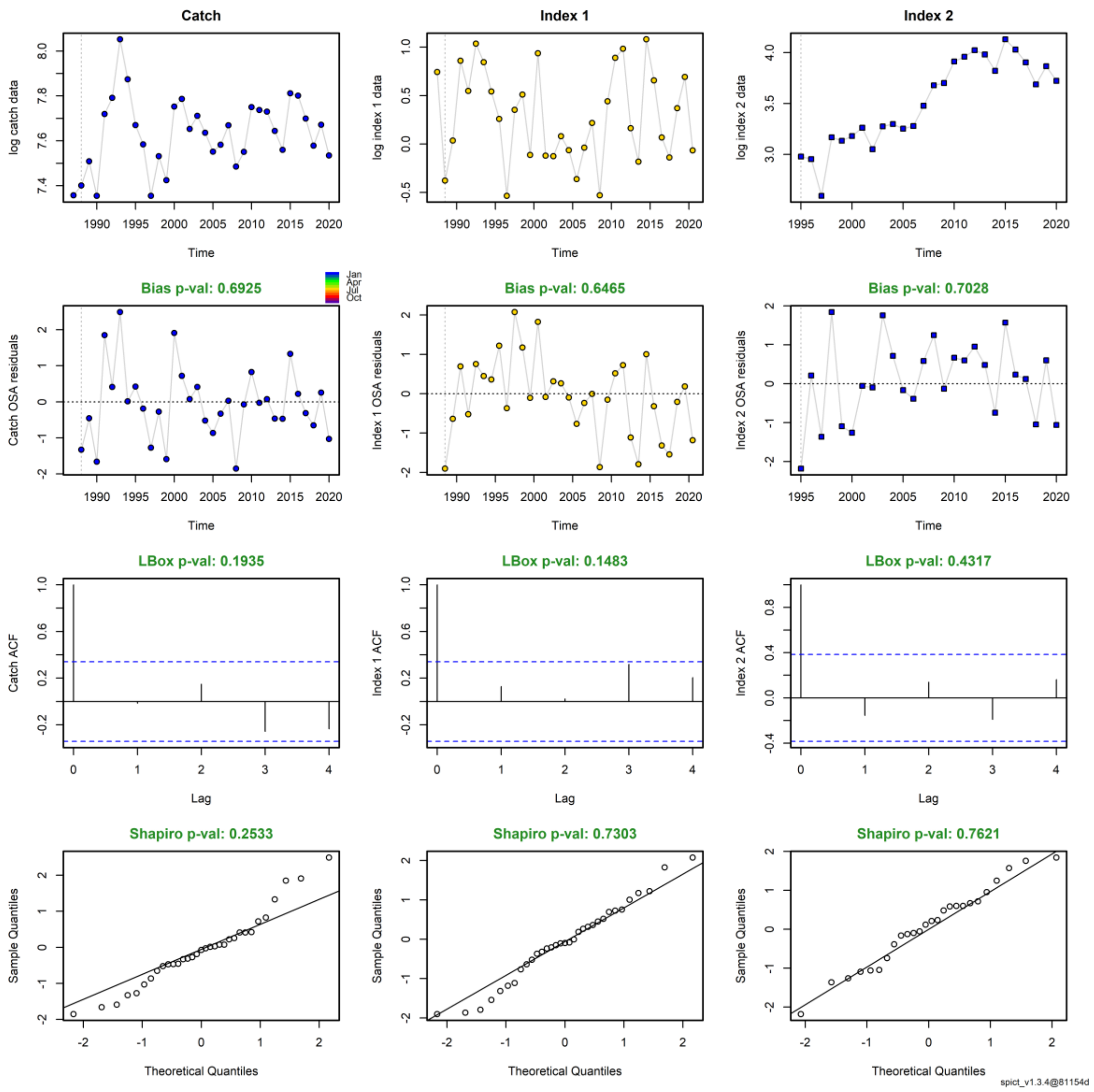

Figure 3.20: BLL 27.3a47de – SPiCT model diagnostics.

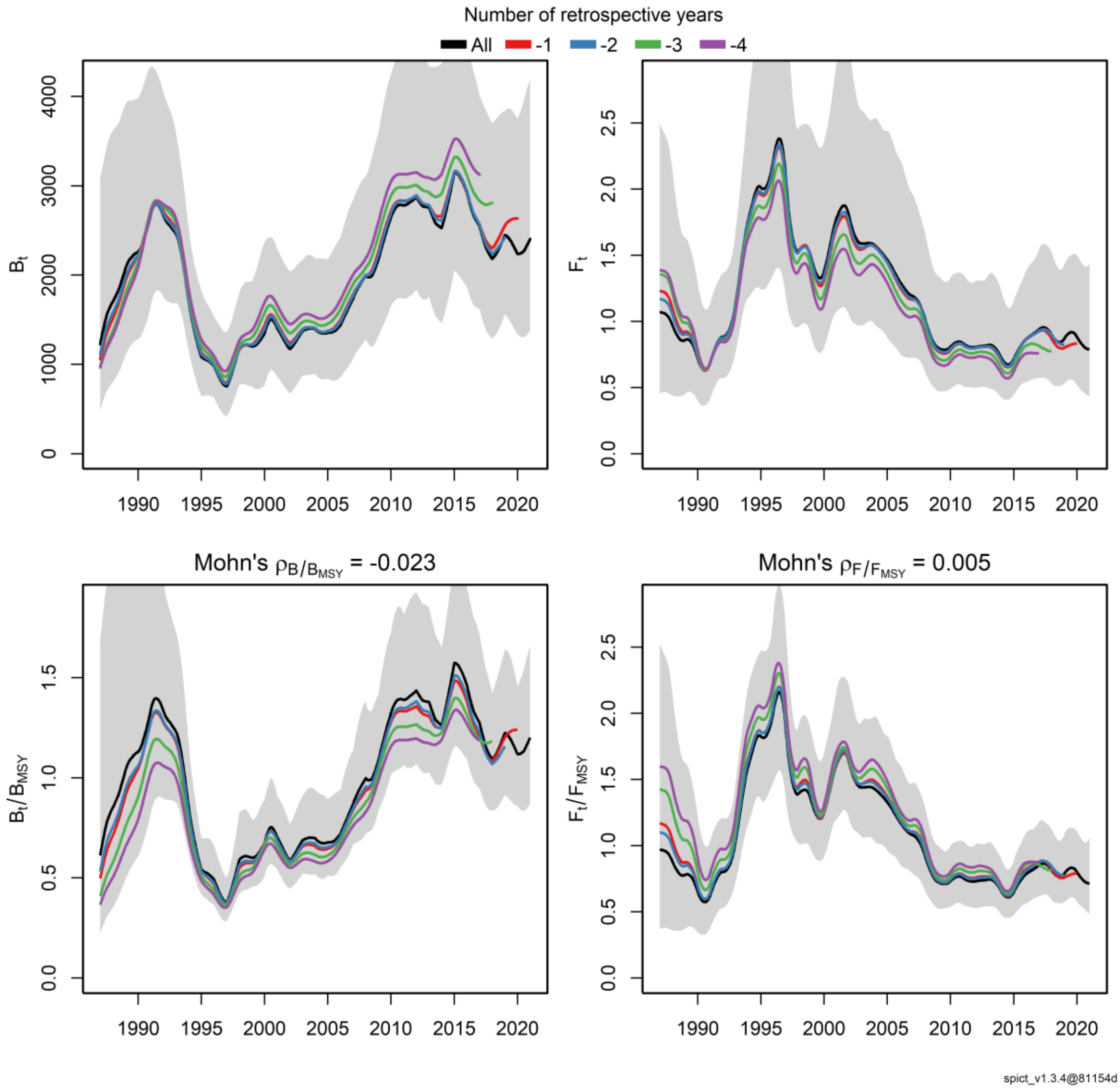

Figure 3.21: BLL 27.3a47de – Retrospective analysis of the SPiCT model from WGNSSK 2021. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.

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

4.1 General

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 assessment based on the revised assessment protocol specified by the 2021 meeting of WKNSEA (ICES WKNSEA, 2021).

A stock annex records more detail and references information on the stock definition, ecosystem aspects and the fisheries. This report section records only recent developments and new information presented to WGNSSK.

4.1.1 Stock definition

The North Sea stock consists of reproductively isolated populations of Viking and Dogger cod, with the Dogger population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a. A comprehensive summary of available information on stock definition can be found in ICES WKNSCodID (2020).

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. For example, a regime shift occurred in the North Sea in the mid-1980s and evidence suggests another from around 1998, a time from which North Sea cod recruitment has been low. 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 is 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 North Sea cod are primarily TR1 (mainly operated by Scotland and Denmark), but also GN1 (mainly Denmark and Norway), TR2 and BT1. Cod are also an important target for marine recreational fisheries. A summary of information on 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 a 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)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
20(Skagerrak)	3.8	3.8	4.0	4.2	4.8	5.7	8.0	4.2	2.1	1.9
2.a + 4	26.5	26.5	27.8	29.2	33.7	39.2	43.2	29.4	14.7	13.2
7.d	1.5	1.5	1.6	1.7	2.0	2.1	1.7	1.7	0.9	0.8

For 2012–2016, Council Regulations (EC) N°44/2012, N°297/2013, N°432/2014, N°2015/104 and N°2016/72 allocated different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size as stipulated by Council Regulation (EC) N°43/2009. The effort regime has now been discontinued, and the TACs for 2017–2020 are given in Council Regulations (EC) N°2017/127, N°2018/120, N°2019/124 and N°2020/123 respectively.

The EU landing obligation was implemented from 1 January 2017 for several gears, including otter trawlers with >100 mm mesh (TR1), beam trawlers with >120 mm mesh (BT1) and fixed gears. The EU landing obligation was fully implemented in the North Sea and Skagerrak from 1 January 2018 and in the eastern Channel from 1 January 2019, although a few exemptions exist. Council Regulation (EC) N°2019/2238 lists *de minimis* exemptions for cod caught in some bottom trawls targeting *Nephrops* or Northern prawn in Subdivision 20, mixed demersal fisheries using TR2 gears in Subarea 4 and beam trawls targeting brown shrimp in Divisions 4b-c. Council Regulations (EC) N°2019/2238 and N°2019/2239 respectively detail survivability exemptions for by-catch in pots and fyke nets in Subarea 4 and Subdivision 20 and for species caught using pots, traps and creels in Division 7.d.

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 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.

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 was 0.4 if SSB is above B_{pa}. Details of the 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.

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 landing obligation. Details of the amended cod management plan are given in EC 2016/2094.

In July 2018, the European Union agreed to a multiannual management plan for demersal fisheries in the North Sea (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.

In June 2018, EU-Norway requested an evaluation of multiple management strategies (ICES WKNSMSE, 2019); however, these are no longer consistent with the assessment and reference points following the benchmark in 2021.

Since 2015, advice has been given according to the ICES MSY approach.

4.2 Data available

4.2.1 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given for each area separately and combined in Table 4.1.

The catch estimate for 2020 (uploads in weight) is 24 224 tonnes, split as follows for the separate areas (tonnes):

	TAC	Landings	Discards	BMS*
20–Skagerrak	2103	2299	2113	0
4	14718	17192	2566	21
7.d	858	32	0	<1
Total	17679	19523	4701	

*** BMS landings uploaded to InterCatch.**

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 Subdivision 20–Skagerrak. Discard raising for 2002–2020 was performed in InterCatch, with the different nations providing information by area, quarter and métier. Sampling for discards and age compositions was poor in area 7.d in 2002–2003, and this necessitated combining areas 4 and 7.d in those years. The provision of discard information has vastly improved since the reform of the EU's data collection framework in 2008 (see http://datacollection.jrc.ec.europa.eu/) but was lower in 2020 (57% of the landings) than recent years, likely due to the COVID-19 pandemic. All nations apart from Norway now provide 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 2020 is provided in Table 4.2e, along with the contributions to total landings, discards and BMS from each area prior to raising.

Norwegian discarding is illegal, so although this nation has accounted for 7–15% of cod landings over the period 2002–2020 (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). The UK Buyers and Sellers legislation, introduced towards the end of 2005, is expected to have improved the accuracy of reported cod landings.

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. The figures shown in Table 4.2c and Figure 4.1a comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations apart from France and Northern Ireland for 2020 data. The sampling coverage for landings and discards age compositions for 2020 are reported in Table 4.2e, showing lower coverage in Subarea 4 in Q2, likely due to the COVID-19 pandemic.

Landings in numbers at age for age groups 1–11+ and 1963–2020 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 industrial fishery in Subdivision 20 and Subarea 4 (Table 4.1). During the last five years, an average of 64% 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 2020, age 1 cod comprised 51% of the total catch by number, age 2, 31% and age 3, 8%.

Discard numbers-at-age (including BMS landings from 2016) are shown in Table 4.2b. The proportions of the estimated numbers discarded for ages 1–4 and the proportion of the estimated total discards by weight and number are shown in Figure 4.1b. Estimated proportion of total numbers caught that were discarded (Figure 4.1b) had decreased from a peak of 84% in 2006 to 36% in 2019 but increased to 67% in 2020. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% but was estimated at 93% in 2020 due to the stronger 2019-year class. At ages 2 to 4 discard proportions increased to a maximum around 2006–10 but have subsequently declined to give 60% for age 2, 15% for age 3 and 1% for age 4 cod in 2020. 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 2020. Reported landings, estimated discards (including BMS landings from 2016) 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 (including BMS landings) and total catch at age and mean weight at age in 2020. 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 to obtain the data required for the assessment. 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 in weight or raised for 2020 are as follows (tonnes):

Catch Category	Raised or Imported	CATON	Percentage
BMS landing	Imported	21	100
Discards	Imported	2687	57
Discards	Raised	1992	43
Landings	Imported	19523	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. However, age compositions for Division 7.d had to be allocated from métiers in Subarea 4 as there was no age sampling in 7.d in 2020.

The landings and discards imported in weight or raised, with age distribution sampled or estimated for 2020 are as follows (tonnes):

Catch Category	Raised or Imported	Sampled or Estimated	CATON	Percentage
Logbook Registered Discard	Imported	Estimated	0	NA
Landings	Imported	Sampled	14665	75
Landings	Imported	Estimated	4859	25
Discards	Imported	Sampled	2645	57
Discards	Raised	Estimated	1992	43
Discards	Imported	Estimated	41	1
BMS landing	Imported	Sampled	21	99
BMS landing	Imported	Estimated	<1	1

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 2021).

Recreational catches

Recreational catches were estimated for 2010–2019 from data provided by Belgium, Denmark, Germany, Sweden, Norway, the Netherlands, and UK, but are considered provisional and not included in the assessment due to length of time series and unknown age structure and uncertainty. Further details are provided in the stock annex and ICES WKNSEA (2021). Estimates of commercial and recreational removals along with the percentage of recreational removals and percentage of recreational removals derived from imputation are as follows:

	commercial removals (t)			Recreational removals (t)				
Year	Landings	Discards	Total	Retained	Released	Total	% recr.	%imputed
2010	36762	12341	49103	1636	320	1955	3.8	56
2011	31979	8711	40689	1432	390	1822	4.3	87
2012	32124	8638	40762	1638	361	2000	4.7	90
2013	30474	10289	40763	2342	226	2569	5.9	80
2014	34651	10538	45190	3959	476	4434	8.9	60
2015	37373	12537	49910	2681	370	3051	5.8	82
2016	38104	12203	50307	2000	328	2327	4.4	15
2017	37668	8702	46371	1536	352	1888	3.9	37
2018	40153	7744	47898	2079	339	2418	4.8	3
2019	32361	3555	35917	1110	219	1330	3.6	36
Mean	35165	9526	44691	2041	338	2379	5.0	55

4.2.2 Weight-at-age

Mean weight at age data for landings, discards (including BMS landings from 2016) 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 2020. Long-term trends in mean catch weights-at-age by catch component for ages 1–7 are plotted in Figure 4.2a, which indicates an overall decline from around 2010 for ages 3 and above. Ages 1 and 2 show little absolute variation over the long term.

Stock mean weights are derived from the NS–IBTS–Q1 survey data for ages 1–2 and from the Q1 catch data for ages 3+. Stock mean weights are given in Table 4.5a and plotted in Figure 4.2b.

4.2.3 Maturity and natural mortality

Values for proportion mature at age are derived from an area-weighted maturity age key constructed from NS–IBTS–Q1 data from 1978. The calculation is described in the Stock Annex. In 2021, biological sampling in the Viking 20 (Skagerrak) and Southern subareas was low (<5 fish at each age) and necessitated pooling with samples from the Viking 4a and Northwestern subareas respectively (see Figure 4.16c for subarea definitions). The time-varying maturity ogive used as input to the assessment is given in Table 4.5b and illustrated in Figure 4.2c.

Table 4.5c and Figure 4.2d show estimates of M based on multi-species considerations adopted for the assessment. Estimates of natural mortality are derived from multispecies analyses 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 2020 with the new key run (ICES WGSAM, 2020).

An ad-hoc adjustment is made to the M values of ages 3+ to mimic a 15% emigration out of the assessment area from 2011 (Table 4.5c and Figure 4.2d). Full details of this adjustment are given in the Stock Annex.

4.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Therefore, 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 1976–2021. 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 1991–2020. 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 2005, 2009, 2013 and 2016 year-classes are apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 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 has declined over the past four years due to the weak 2017- and 2018-year classes. The 2019 year-class appears stronger (Figure 4.3a).

Standardised age-based survey indices for North Sea cod are calculated based on GAMs and Delta-distributions. 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. The Delta-GAM is fit to each survey separately. For the IBTS–Q1, the Delta-GAM is fit to ages 1–6+, with ages 1–5 retained and used in the assessment model. For the IBTS–Q3, the Delta-GAM is fit to ages 0–5+, with ages 1–4 retained and used as an index in the assessment. Because the first age in the assessment model is age 1, estimates of age 0 from the IBTS–Q3 indices are retained as a separate recruitment index forward shifted to 1st January the following year.

More details of the method used to produce the NS–IBTS Delta–GAM indices are provided in the stock annex and can be found in ICES WKNSEA (2021), as well as the above-mentioned publications. In summary, the final Delta–GAM models selected for NS–IBTS–Q1 and Q3 comprised a high resolution stationary spatial model with low resolution yearly independent deviations and included ship, year, depth, time of day and haul-duration effects. The NS–IBTS Delta–GAM indices and associated standard deviations used in the assessment are given in Table 4.6. Figures 4.3d-e compare the Q1 and Q3 NS–IBTS Delta–GAM indices to the corresponding NS–IBTS extended indices (calculated using the standard stratified mean methodology applied to an extended area; Figure 4.3c) and the Delta-GAM indices from the recent benchmark (which have one year fewer data; ICES WKNSEA 2021). Retrospective analyses with three peels give average Mohn's rho values of -0.01 and 0 across all ages for the IBTS–Q1 and IBTS–Q3 indices, respectively.

4.3 Data analyses

4.3.1 Assessment audit

The assessment audit for North Sea cod was completed and no significant issues found for the assessment itself. Additional checks on the forecast are carried out during the ICES WGMIXFISH meeting in 2021.

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 track cohort signals well (top right), although there is some loss of signal between the 2012 and 2013 cohorts associated with an apparent positive year effect in 2017 and disappearance of the strong 2013-year class from survey catches at older ages. The log abundance curves for each survey series had shown an increase in steepness in the most recent years (bottom left) with a substantial increase in the negative gradient for ages 2–4 following the 2015 year-class in the IBTS-Q1 (age 2 in 2017) and the strong 2013 year-class in the IBTS-Q3 (bottom right). However, a large drop in negative gradient is now observed in the IBTS–Q1, corresponding to the 2017 year-class that reached age 4 in 2021.

Figures 4.5a and b show within-survey consistency (in cohort strength) for the NS-IBTS Q1 and Q3 Delta–GAM survey indices, while Figures 4.5c and 4.5d show between survey consistencies (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning.

The SURBAR survey analysis model was fitted to both the Q1 and Q3 NS–IBTS Delta-GAM survey indices (ages 1–5). The summary plots are presented in Figure 4.6a.

Biomass: Spawning stock biomass reached the lowest level in the time series in 2005 and subsequently increased because of the stronger 2005- and 2009-year classes and reductions in mortality, reaching a peak in 2013. SSB has since declined rapidly with a slight, but more uncertain, increase estimated for 2020–2021. A similar 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 2018 and reaching the lowest value in the time-series by 2020.

Recruitment: the SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, but with stronger 1999-, 2005-, 2009-, 2013-, 2016- and 2019-year classes.

Residuals from the SURBAR analysis are positive for all ages in the NS-IBTS-Q1 in 2017 and negative for ages 2+ in the NS-IBTS-Q3 in 2017–2018 (Figure 4.6b).

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 clearly shows the contribution of the 2005-, 2009- and 2013-year classes to catches in recent years and indicates a relative increase in the number of older fish in the catches. The relatively strong 2016-year class does not appear strongly in the catches in 2020.

Catch curve cohort trends

The top panel of Figure 4.8 presents the log catch curve plot for the catch at age data. In 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. Although there are peaks in the negative gradients for the 2013- and 2015-year classes in the most recent period, these gradients still represent some of the lowest values in the time series, which is in contrast to equivalent plots for the survey indices. The sharp increase for the 2016-year class corresponds to lower-than-expected catches at age 4 in 2020.

4.3.4 Final assessment

The final assessment used SAM (State-space Assessment Model; Nielsen and Berg, 2014) run with R *stockassessment* package version 0.9.0/bioparprocess in R version 3.5.1. 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. Random walk processes are used to model recruitment and fishing mortality-at-age, where the random walks for fishing mortality are correlated among ages according to an AR(1) process. Correlations between ages in the IBTS surveys are modelled according to an AR(1) process that estimates a single parameter for the correlation between ages 1 and 2 and common correlation parameters between the older ages (Berg and Nielsen, 2016). Maturity is modelled as a Gaussian Markov Random Field (GMRF) process with cohort- and within year correlations. Model fitting diagnostics, parameter estimates, and associated correlation matrix are given in Table 4.7b.

Figure 4.9 shows summary plots of the final assessment in terms of population trends. Estimates of fishing mortality at age, stock numbers at age, catches at age and maturity at age are given in Tables 4.8–11 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, catches and F_{bar} (2–4) are given in Table 4.12a (along with 95% confidence bounds), and estimates of landings, discards and catches are given in Table 4.12b (and can be compared to the corresponding data in Table 4.4). Mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 4.10a and selectivity in F is shown in Figure 4.10b, while estimated maturity at age is shown in Figure 4.11. Estimated correlations between ages in the catch and survey indices are shown in Figure 4.12. These correlations reflect the couplings specified in the model configuration (Table 4.7a) assuming independence in the catch and correlation between ages in each of the IBTS surveys.

Residual plots are shown in Figures 4.13a-b, indicating no serious model misspecification, although residuals for the IBTS–Q1 are all positive in 2017 (bar a small negative residual for age 2) and all negative in 2018 while residuals for the IBTS–Q3 are all negative in 2017–2018. Retrospective plots for SSB, average fishing mortality, recruitment at age 1 and TSB are shown in Figure 4.14. Mohn's rho statistics based on a five-year peel are calculated as 0.150, -0.061, 0.109 and 0.131 for SSB, $F_{2–4}$, recruitment, and TSB respectively.

A comparison with the benchmark assessment (ICES WKNSEA, 2021) is provided in Figure 4.15a. 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 the delta-GAM indices. The addition of the new data results in a slight downscaling of SSB and an increase in Mohn's rho (from 0.077 to 0.150). It was demonstrated that better model diagnostics (likelihood, AIC and Mohn's rho for SSB) could be obtained by increasing the ad hoc adjustment on M from 15% to 20%, to mimic increased emigration. However, as the retrospective bias is within acceptable limits (ICES WKFORBIAS, 2020), and to avoid ad hoc tuning of the adjustment without appropriate ecological justification, the adjustment was maintained at 15%. A comparison with the SURBAR survey-based assessment is provided in Figure 4.15b and shows similar trends between models.

4.4 Historic stock trends

The historic stock and fishery trends are presented in Figures 4.9–10 and Tables 4.12a–b.

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, but with stronger 1999-, 2005-, 2009-, 2013-, 2016 and 2019-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 subsequently reversed with F increasing rapidly to a peak in 2018. F is now below both precautionary reference points, F_{lim} and F_{pa}, but above F_{MSY}.

SSB declined steadily during the 1970s and 1980s. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the mid-1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline to its lowest level in 2006. SSB subsequently increased with a decline in fishing mortality, reaching a peak in 2016, but has since declined rapidly and is now below B_{lim}.

The North Sea cod stock consists of reproductively isolated populations of Viking cod and Dogger cod, with the Dogger cod population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a (ICES WKNSCodID, 2020). These genetically different groups have different rates of maturity and growth. Trends in biomass and recruitment have been strongly correlated among subareas of the North Sea but have diverged in the last decade, with no apparent rebuilding in the South (Figures 4.16a-c). The low landings in 7.d (32 tonnes in 2020) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey may indicate a collapse of the stock in this area. Official nominal landings from 2020 are low in both divisions 4.c (72 tonnes) and 7.d (40 tonnes).

Figure 4.17 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.

4.5 Recruitment estimates

Recruitment in the intermediate year (2021) was sampled from a normal distribution about the assessment estimate and is reported as the median of those samples. Estimates of recruitment for subsequent years were resampled from the 1997–2020-year classes, reflecting recent low levels of recruitment, but including the relatively stronger 1999-, 2005-, 2009-, 2013-, 2016- and 2019-year classes.

4.6 MSY estimation

MSY estimation is performed with the EQSIM software (ICES WGMG, 2013), in accordance with the ICES guidelines. MSY estimation for North Sea cod was last performed during ICES WKNSEA (2021) based on a truncated recruitment time-series (1998–2020) and without the ad hoc adjustment on M. Details of the analysis are available in the expert group report (ICES WKNSEA, 2021).

A summary of the biological reference points (not including the advisory HCR in all but $F_{P.05}$) is provided in the following table.

Stock	
F_{MSY}	0.28
F_{MSY} lower	0.186
F_{MSY} upper	0.45
$F_{P.05}$ (5% risk to B_{lim}, with HCR included)	0.49
F_{MSY} upper precautionary	0.45*
MSY	51 541 t
Median SSB at F_{MSY}	163 738 t
Median SSB at F_{MSY} upper precautionary	92 668 t
Median SSB at F_{MSY} lower	247 255 t

*** Note that the FP0.5 value is 0.49 for an EQSIM run (with HCR included), 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 assessment and forecasts were conducted with R version 3.5.1; however, slightly different results are obtained when running the forecasts with newer versions of R because the routine to generate random seeds changed in R version 3.6.0.

At WGNSSK, the intermediate year assumption was taken as a 37% overshoot of the TAC, following a 37% overshoot of the TAC in 2020. This would result in an intermediate year F of 0.29. A status quo F assumption was considered but, given the 10% reduction in TAC for 2021, would have resulted in an assumed catch that exceeds the TAC by 16 208 tonnes (i.e., an extra 102% is taken in addition to the TAC). A proportion of F_{2020} (taken as F_{2020} / F_{2019} = 0.83) was also considered although the WG felt it was too early to judge a trend in F. This assumption would result in a catch that exceeds the TAC by 11 526 tonnes (i.e. an extra 72% is taken in addition to the TAC).

At the Advice Drafting Group, a reduction in F below historically observed levels was considered unrealistic. Therefore, as an intermediate year assumption, fishing mortality was assumed to be at the lowest level of the time series. It is recognized that this will give a 71% overshoot of the TAC. This will imply a reduction in fishing mortality (from 0.45 to 0.37) which was considered to be realistic given the technical measures in place in 2021.

Forecasts options are presented in tables 4.13 and 4.14. Forecast assumptions are as follows (note that the values that appear in the catch scenarios in tables 4.13 and 4.14 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	Forecasted according to the SAM GMRF process for maturity (Figure 4.11).
Natural mortality	Average of final three years of assessment data with M-adjustment.
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	Average of final three years of assessment data.
Exploitation pattern	Forecasted according to the SAM F processes.
Intermediate year assumptions	Median total catch in the intermediate year assuming either (1) a 37% overshoot of TAC or (2) an F of 0.37 in the intermediate year.
Stock recruitment model used	Recruitment for the intermediate (the year the WG meets) is sampled from a normal distribution of the SAM estimate and reported as the median. Recruitment for the TAC year onwards is sampled, with replacement, from 1998 to the intermediate year.
Procedures used for splitting projected catches	The final year landing fractions are used in the forecast period.

The October forecast

Since the final SAM model includes two indices from the IBTS Q3, the assessment is subject to the AGCREFA protocol for reopening of advice in the autumn (ICES AGCREFA, 2008; ICES WKNSROP, 2020). The reopening protocol for North Sea cod is:

1. Re-run the delta-GAM index for Q3 including the new data from the autumn survey.
2. Conduct an RCT3 check on age 1 for year classes *y*-1 and *y* including information from the IBTS Q3 only.
3. If a reopening is triggered:
    a) Rerun SAM with the updated Q3 indices;
    b) Populate and re-run the forecast procedure with the resulting assessment estimates, using the SAM estimate of recruitment in the TAC year (y+1) rather than a resampled recruitment, as done in May.

The current May forecast

Several scenarios were considered as follows (note, $B_{trigger}$ = B_{pa} = 97 777 tonnes, and F_{MSY} = 0.28; see Section 4.9):

1. MSY framework: F_{bar} (2022) = F_{MSY}×min{1; SSB_{2022}/$B_{trigger}$}
2. EU-MAP: F_{bar} (2022) = $F_{MSY\ lower}$×min{1; SSB_{2022}/$B_{trigger}$}
3. Zero catch: F_{bar} (2022) = 0
4. F_{pa}: F_{bar} (2022) = F_{pa} = $F_{P.05}$ = 0.49
5. $F_{p.05}$ without AR: F_{bar} (2022) = 0.41
6. F_{lim}: F_{bar} (2022) = F_{lim} = 0.58
7. SSB (2023) = B_{lim}: F corresponding to SSB (2023) = B_{lim}
8. SSB (2023) = $B_{trigger}$ = B_{pa}: F corresponding to SSB (2023) = $B_{trigger}$ = B_{pa}
9. Lower TAC constraint: F_{bar} (2022) such that TAC (2022) = 0.8×TAC (2021)
10. Rollover TAC 15%: F_{bar} (2022) such that TAC (2022) = 0.85×TAC (2021)
11. Rollover TAC 10%: F_{bar} (2022) such that TAC (2022) = 0.9×TAC (2021)
12. Rollover TAC 5%: F_{bar} (2022) such that TAC (2022) = 0.95×TAC (2021)
13. Rollover TAC: F_{bar} (2022) such that TAC (2022) = TAC (2021)
14. Rollover TAC + 5%: F_{bar} (2022) such that TAC (2022) = 1.05×TAC (2021)
15. Rollover TAC + 10%: F_{bar} (2022) such that TAC (2022) = 1.1×TAC (2021)
16. Rollover TAC + 15%: F_{bar} (2022) such that TAC (2022) = 1.15×TAC (2021)
17. Upper TAC constraint: F_{bar} (2022) such that TAC (2022) = 1.2×TAC (2021)
18. Status quo – constant F: F_{bar} (2022) = F_{bar} (2021)
19. $F_{MSY\ lower}$: F_{bar} (2022) = $F_{FMY\ lower}$ = 0.186
20. F_{MSY}: F_{bar} (2022) = F_{FMY} = 0.28
21. $F_{MSY\ upper}$: F_{bar} (2022) = $F_{FMY\ upper}$ = 0.45

Forecasts for the SAM final run are given in Tables 4.13 and 4.14. The working group raised concerns regarding the intermediate year assumption on F given the restrictiveness of the 2021 TAC and because cod are a choke species in mixed fisheries. Figure 4.18 presents catch forecasts for the MSY approach (i.e. F = F_{MSY}×SSB_{2022}/$B_{trigger}$) assuming different multipliers on F(2020) in the intermediate year, and show a wide range of potential advised total catches for 2022 (12 672–23 882 tonnes).

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 WKNSEA (2021). Biological reference points and their technical basis are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	97 777 t	B_{pa}; in tonnes	ICES WKNSEA (2021)
	F_{MSY}	0.28	Stochastic simulations (EqSim) based on recruitment period 1998–2020	ICES WKNSEA (2021)
Precautionary approach	B_{lim}	69 841 t	B_{pa} / 1.4; in tonnes	ICES WKNSEA (2021)
	B_{pa}	97 777 t	Highest observed SSB (1998) based on the recruitment period 1998–2020 with 2019 as the last year of catch data; in tonnes.	ICES WKNSEA (2021)
	F_{lim}	0.58	The F that on average leads to B_{lim}	ICES WKNSEA (2021)
	F_{pa}	0.49	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with AR)	ICES WKNSEA (2021)

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 1993–2005 to have inaccuracies but no longer estimates a catch multiplier in the SAM assessment to account for this (ICES WKNSEA, 2021).

The proportion of landings sampled for ages was lower in 2020 (75%) than in 2019 (89%), primarily due to lower sampling in Subarea 4 in Q2 (Table 4.2e) and therefore likely due to the COVID-19 situation. Weights at age in the catch and selectivity patterns however did not exhibit unreasonable deviations from the previous years.

Stock identity remains an issue with this assessment, with multiple populations inhabiting the North Sea and extending to neighbouring areas (ICES WKNSCodID, 2020). The 2021 benchmark introduced an ad hoc adjustment to account for emigration of North Sea cod to the West of Scotland area (ICES WKNSEA, 2021), which is currently not included in the assessment area.

The estimated CVs for observed catch at age 1, for the NS–IBTS–Q1, Q3 and Q3 recruitment indices at age 1 and the stock-recruitment relationship are all large: 59%, 235%, 233%, 243% and 80%, respectively. These large CVs suggest that these sources of information are somewhat ignored in the SAM recruitment estimation, which might therefore be more influenced by age 2 abundance estimates and model assumptions about F-at-age 1. The CV of the survival process is assumed to be the same for all non-recruiting ages (estimated at 12%) and this might have an impact on recruitment estimates (and, hence, age 1 catch and survey residuals) because it constrains the changes permitted between abundance at ages 1 and 2 of a cohort.

Conflicts between the information from catches and surveys, as indicated by the negative gradients, are becoming more apparent. The high correlation (0.95) 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.

A reduction of the plus group from 7+ to 6+ following the 2015 benchmark (ICES WKNSEA, 2015) 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.

There is general agreement across both models presented (SAM and SURBAR) of a recent sharp decline in SSB and a corresponding peak in total mortality, and stronger 2005-, 2009-, 2013-, 2016- and 2019-year classes (Figure 4.15b). The slight increase in SSB predicted by SURBAR in 2020–2021 is not observed in SAM, which shows a further decline.

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 below B_{lim}.

Fishing mortality has declined from a peak in 2018 and is now below both the precautionary reference points, F_{lim} and F_{pa}, but above 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 last larger recruitment observed during this period was the 2019-year class.

4.12 Management considerations

Cod has been fully under the EU landing obligation since 2018 in Subarea 4 and Subdivision 20, and since 2019 in Division 7d although there are some *de minimis* exemptions in Subarea 4 and Subdivision 20 (see Section 4.1.4). 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.

It is uncertain whether if and to what extent, the discontinuation of the days-at-sea regulation in 2017, which was part of the cod recovery plan, has had an impact on the recent decline of the cod stock.

There is a need to reduce fishing induced mortality on North Sea cod, particularly for younger ages, to allow more fish to reach maturity and increase the probability of good recruitment. Discards currently contribute 20% of the total catch by weight and 67% of the catch by number with 93% of 1 year old, 60% of 2-year-old and 15% of 3-year-old cod being discarded.

Because the fishery is at present so dependent on incoming year classes, fishing mortalities on these year classes remain high. 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 North Sea cod stock consists of reproductively isolated populations of Viking cod and Dogger cod, with the Dogger cod population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a (ICES WKNSCodID, 2020). Because these genetically different groups have different rates of maturity and growth, management measures that ensure sustainable exploitation of substocks may be needed in addition to management for the stock as a whole. In particular, the low landings in 7.d in 2020 (32 tonnes in 2020) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey may indicate a collapse of the stock in this area. Official nominal landings from 2020 are low in both divisions 4.c (72 tonnes) and 7.d (40 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. 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 TACs 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, to estimate the potential risks of quota over- and undershooting for the different stocks.

The catch scenarios presented assume either a 37% overshoot of the TAC in 2021, following a 37% overshoot of the TAC in 2020, or an F of 0.37, the lowest in the time series. The former implies a reduction of catches in 2021 because the TAC in 2021 is 10% lower than the TAC in 2020. Both assumptions give a lower fishing mortality than assuming *status quo* for the intermediate year and may be too optimistic considering entrance of the larger 2019-year class to the fishery and potential for non-compliance to the landing obligation caused by cod becoming a choke species in mixed fisheries.

Both the WG estimates, and official landings reported to ICES show a substantial overshoot of the TAC in 2020, particularly in Subarea 4. The reasons for this are unknown but banking and borrowing or inter-area flexibility could be possibilities.

The forecasting procedure uses the assessment estimate of recruitment in 2021. This remains to be confirmed by the IBTS-Q3 survey and a reopening of the advice may be triggered in October.

4.13 Issues for future benchmarks

The stock was last benchmarked in 2021 and there are initial plans for another benchmark in 2023. Below is a list of issues that were either left unresolved from the last benchmark or have arisen during the subsequent WGNSSK meeting. 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	5	1	3.5

4.13.1 Data

Stock identity

Stock identity is an issue for this assessment, with multiple populations inhabiting the North Sea and extending to neighbouring areas (ICES WKNSCodID, 2020). The ICES Workshop on Stock Identification of North Sea Cod (ICES WKNSCodID, 2020) recommended that stock assessments recognise and account for Viking and Dogger cod populations and consider accounting for phenotypic stocks within the Dogger cod population. However, the ability of the last benchmark to reflect the new paradigm of cod stock structure was limited by (1) the challenges of disaggregating historic fisheries data spatially; (2) unexplained differences between the spatially aggregated and disaggregated fisheries data; and (3) the decision to consider connectivity of cod between 6.aN and 4.aW in a future benchmark workshop (ICES WKNSEA, 2021). Trends in sub-stock biomass will continue to be monitored in the meantime.

Maturity

ICES WKNSEA (2015) 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.

Survey

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. While there is some evidence to support emigration of North Sea cod to the West of Scotland, age reading issues may also contribute and should be investigated.

Recreational catches

Recreational catches are estimated to account for 5% of the total removals of this stock but are not included in the assessment due to length of time series and unknown age structure and uncertainty (Section 4.2.1). Work on standardisation of recreational inputs should be given relevance for future consideration in the assessment.

4.13.2 Assessment

A range of spatial approaches to stock assessment methods should be considered, including a single-area assessment of the current advisory unit, fleets-as-areas, spatially structured assessments, fully separated subarea assessments and survey-based assessments; ideally with simulation testing to evaluate the relative performance of these alternatives (ICES WKNSCodID, 2020; ICES WKNSEA, 2021).

4.13.3 Forecast

Walker (2020) explored the perception that short-term forecasts in a given year tend to be more optimistic than realised values in subsequent years; however, results of this analysis were largely driven by the retrospective pattern in the former assessment. Similar analyses should be conducted to gain a better idea of potential biases in the forecast procedure.

4.14 References

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

Sub-area IV

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	2,470	2,616	1,482	1,627	1,722	1,309	1,008	894	946	666
Denmark	8,358	9,022	4,676	5,889	6,291	5,105	3,430	3,831	4,402	5,686
Faroe Islands	9	34	36	37	34	3	-	16	45	32
France	717	1,777	620	294	664	354	659	573	950	782
Germany	1,810	2,018	2,048	2,213	2,648	2,537	1,899	1,736	2,374	2,844
Greenland	.	.	.	.	35	23	17	17	11	-
Netherlands	3,574	4,707	2,305	1,726	1,660	1,585	1,523	1,896	2,649	2,657
Norway	4,369	5,217	4,417	3,223	2,900	2,749	3,057	4,128	4,234	4,495
Poland	18	39	35	-	-	-	1	2	3	-
Sweden	661	463	252	240	319	309	386	439	378	362
UK (E/W/NI)	4,087	3,112	2,213	1,890	1,270	1,491	1,587	1,546	2,383	2,553
UK (Scotland)	15,640	15,416	7,852	6,650	4,936	6,857	6,511	7,185	9,052	11,567
Others	0	0	0	0	0	786	-	-	-	-
Danish industrial by-catch *	.	105	22	17	21	11	23	1	72	12
Norwegian industrial by-catch *	.	.	.	.	.	48	101	22	4	201
Total Nominal Catch	41,713	44,526	25,958	23,806	22,500	23,119	20,102	22,262	27,497	31,657
Unallocated landings	-740	-2,333	-1,875	-1,277	356	-2,041	-1,046	-605	136	-677
WG estimate of total landings	**40,973**	**42,193**	**24,083**	**22,529**	**22,855**	**21,078**	**19,056**	**21,657**	**27,634**	**30,980**
Agreed TAC	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**

Division VIId

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	93	51	54	47	51	80	84	154	73	57
Denmark	-	-	-	-	-	-	-	-	-	-
France	1,677	1,361	1,730	810	986	1,124	1,743	1,326	1,779	1,606
Netherlands	17	6	36	14	9	9	59	30	35	45
UK (E/W/NI)	249	145	121	103	184	267	174	144	133	127
UK (Scotland)	-	-	-	-	-	1	12	7	3	1
Total Nominal Catch	2,036	1,563	1,941	974	1,230	1,480	2,073	1,662	2,023	1,836
Unallocated landings	-463	1,576	190	40	29	-2	74	-33	-135	-128
WG estimate of total landings	**1,573**	**3,139**	**2,131**	**1,014**	**1,259**	**1,479**	**2,147**	**1,629**	**1,887**	**1,708**
Agreed TAC									**1,678**	**1,955**

Division IIIa (Skagerrak)**

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	5,900	5,525	3,067	3,038	3,019	2,513	2,246	2,553	3,024	3,286
Germany	32	83	49	99	86	84	67	52	55	56
Norway	762	645	825	856	759	628	681	779	440	375
Sweden	1,035	897	510	495	488	372	370	365	459	458
Others	-	-	27	24	21	373	385	13	2	26
Danish industrial by-catch *	687	20	5	4	2	3	2	7	2	10
Total Nominal Catch	7,729	7,170	4,483	4,516	4,375	3,972	3,751	3,769	3,982	4,211
Unallocated landings	-643	-316	-504	-602	-376	-715	-731	-376	-188	-154
WG estimate of total landings	**7,086**	**6,854**	**3,979**	**3,914**	**3,998**	**3,258**	**3,020**	**3,393**	**3,794**	**4,057**
Agreed TAC	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**

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

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Nominal Catch	51,478	53,260	32,382	29,296	28,104	28,572	25,926	27,693	33,502	37,704
Unallocated landings	-1,846	-1,074	-2,189	-1,839	9	-2,757	-1,703	-1,014	-187	-958
WG estimate of total landings	**49,632**	**52,186**	**30,193**	**27,457**	**28,113**	**25,815**	**24,223**	**26,679**	**33,315**	**36,746**

** 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Danish industrial by-catch *	687	-	-	-	-	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	48	101	22	4	201
Total	**687**	**.**	**.**	**.**	**.**	**48**	**101**	**22**	**4**	**201**

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	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	653	862	1,075	1,258	1,223	1,103	695	817	727	666
Denmark	4,863	4,803	4,536	5,457	6,026	6,713	6,119	5,493	4,964	3,064
Faroe Islands	-	-	-	-	-	-	-	-	0	.
France	619	369	287	637	517	391	401	583	450	265
Germany	2,211	2,385	1,921	2,257	2,133	2,083	2,300	1,510	822	755
Greenland	-	-	-	-	-	2	1	-	.	.
Netherlands	1,928	1,955	1,344	1,242	1,403	1,365	653	515	716	590
Norway	4,898	4,601	4,080	4,600	5,404	5,627	5,521	5,539	4,518	2,330
Poland	2	-	-	-	-	-	-	-	.	.
Sweden	316	471	332	401	415	373	387	274	344	354
UK (E/W/NI)	2,169	1,629	2,129	2,962	.	.	.	.	.	.
UK (Scotland)	10,141	10,565	10,619	10,517	.	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	14,889	16,603	18,523	21,265	15,589	9,061
Others	-	-	-	-	-	-	-	-	-	-
Danish industrial by-catch	0	0	2	24	0	5	147	0	2	11
Norwegian indust by-catch *	1	.	.	.	.	.	.	.	.	.
Total Nominal Catch	27,800	27,640	26,324	29,355	32,012	34,265	34,746	35,997	28,130	17,095
Unallocated landings	-1,125	-1,013	-1,009	-805	-768	-1,230	-1,637	-1,553	428	98
BMS landings	-	-	-	-	-	-	1	8	41	32
WG estimate of total landings	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**	**33,109**	**34,444**	**28,558**	**17,192**
Agreed TAC	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**33,651**	**39,220**	**43,156**	**29,437**	**14,718**

Division VIId

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	56	40	53	72	78	39	18	8	3	8
Denmark	-	-	-	-	-	-	-	-	.	.
France	1,078	885	768	1,270	1,142	279	92	35	15	10
Netherlands	51	40	38	50	52	40	22	10	3	2
UK (E/W/NI)	125	99	100	156	.	.	.	.	.	.
UK (Scotland)	1	-	-	-	.	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	162	102	48	39	17	20
Others	-	-	-	-	-	-	<0.5	-	<0.5	-
Total Nominal Catch	1,311	1,064	959	1,548	1,434	459	180	92	37	40
Unallocated landings	8	56	-43	-112	-36	-38	-10	-8	-2	-8
BMS landings	-	-	-	-	-	-	-	-	-	<0.5
WG estimate of total landings	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**	**170**	**84**	**36**	**32**
Agreed TAC	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**1,961**	**2,059**	**1,733**	**1,715**	**858**

Division IIIa (Skagerrak)**

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	3,118	3,178	3,033	3,430	3,344	3,696	3,665	4,222	2,740	1,857
Germany	60	78	69	84	87	94	67	87	53	35
Norway	421	615	575	533	500	551	486	288	152	94
Sweden	518	520	529	570	571	641	557	670	354	223
Others	-	-	33	28	26	25	37	58	40	18
Danish industrial by-catch	0	1	1	5	5	0	40	7	1	13
Total Nominal Catch	4,117	4,391	4,240	4,650	4,533	5,006	4,852	5,333	3,338	2,239
Unallocated landings	-161	-64	-86	37	31	-232	-137	151	140	61
BMS landings	-	-	-	-	-	-	1	4	3	4
WG estimate of total landings	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**	**4,715**	**5,484**	**3,478**	**2,299**
Agreed TAC	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**4,807**	**5,744**	**7,995**	**4,205**	**2,103**

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Nominal Catch	33,228	33,095	31,523	35,554	37,978	39,730	39,778	41,422	31,506	19,373
Unallocated landings	-1,277	-1,022	-1,138	-880	-773	-1,500	-1,784	-1,410	566	150
BMS landings	.	.	.	.	.	.	2	12	44	36
WG estimate of total landings	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**	**37,994**	**40,012**	**32,072**	**19,523**

*** 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	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Norwegian indust by-catch *	1	.	.	.	.	.	.	.	.	.
Total	**1**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**

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	115873	125408	180127	220225	251707	286921	199753	224989	326451	352200	237851	213204
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	204215	232994	208370	295645	268342	292656	333047	300723	256815	226904	213422	203242
SOPCOF %	100	100	100	100	101	100	100	99	100	100	100	101

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	215356	183223	138881	124144	101122	111932	119323	109279	134091	124598	122453	144603
SOPCOF %	100	100	100	99	100	99	99	99	98	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	94431	69586	48446	52187	30194	27457	28113	25815	24223	26679	33315	36746
SOPCOF %	100	100	100	98	99	99	100	101	100	99	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	1099	665	683	2240	686	167	351	170	886	790
2	4540	2230	2688	4207	6384	2035	2240	6004	1856	2861
3	4046	5367	3063	4376	4903	5644	3233	3599	6019	1675
4	1408	1963	2592	1605	1933	3150	3495	2039	1097	1482
5	610	633	865	1286	745	1012	1660	1776	928	440
6	451	248	190	332	584	277	385	780	496	279
7	48	139	84	64	144	188	94	282	338	115
8	27	15	38	38	22	44	78	67	82	47
9	5	4	5	6	6	9	24	45	62	11
10	2	4	1	2	1	5	9	15	4	11
+gp	2	1	1	0	2	2	2	9	6	0
TOTALNUM	12237	11269	10208	14156	15411	12534	11571	14789	11774	7712
TONSLAND	31950	32074	30386	34673	37205	38230	37994	40012	32072	19523
SOPCOF %	100	100	100	100	100	100	101	100	99	101

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	12186	4707	29104	37918	23320	17487	4792	17838	83968	33678	30038	39607
SOPCOF %	100	101	100	100	100	100	101	101	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	36874	72474	139296	32432	162293	294455	57474	54047	21890	151003	31326	138529
SOPCOF %	100	100	100	100	100	100	101	100	102	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	27729	10655	61650	26770	18306	36244	21425	98358	31714	14061	33155	40089
SOPCOF %	100	101	100	100	101	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	13916	13370	13523	11911	4081	8802	10087	12011	30450	25080	20965	12488
SOPCOF %	102	100	100	100	102	101	102	101	100	100	101	101

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	3936	11149	6188	7756	3980	3067	9767	2771	4101	11163
2	7851	5190	6055	6504	8935	4942	2814	9039	1614	4331
3	925	1422	856	1434	1965	3110	1271	737	915	287
4	81	115	397	163	180	257	493	147	16	9
5	6	5	83	58	55	31	96	8	4	0
6	4	1	40	5	64	1	9	0	0	0
7	1	1	16	0	15	0	1	0	0	0
8	1	0	0	0	5	0	1	0	0	0
9	0	0	0	0	3	0	0	2	0	0
10	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0
TOTALNUM	12804	17884	13635	15921	15201	11409	14453	12704	6650	15791
TONSDISC	8745	8689	10324	10666	12562	12315	8731	7824	3607	4701
SOPCOF %	100	101	100	101	100	101	100	101	101	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	128058	130116	209232	258143	275028	304408	204544	242827	410420	385878	267890	252811
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	305468	347666	328077	430635	587111	390521	354770	278705	377907	244748	341771
SOPCOF %	100	100	100	100	101	100	100	100	100	100	100	101

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	243085	193878	200531	150914	119428	148176	140748	207637	165805	138659	155608	184692
SOPCOF %	100	100	100	100	100	99	100	100	99	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	108347	82956	61969	64098	34274	36259	38200	37826	54673	51759	54280	49234
SOPCOF %	101	100	100	99	100	99	100	101	100	100	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	5035	11815	6871	9995	4666	3234	10118	2942	4986	11953
2	12391	7420	8743	10711	15319	6977	5054	15043	3470	7192
3	4970	6789	3919	5810	6869	8754	4504	4337	6935	1962
4	1489	2077	2989	1768	2113	3408	3987	2186	1113	1492
5	616	638	949	1345	800	1044	1756	1784	932	440
6	455	249	229	337	648	279	395	780	496	279
7	49	139	100	64	159	188	95	282	338	115
8	28	15	38	38	27	44	79	67	82	47
9	5	4	5	6	9	9	24	47	62	11
10	2	4	2	2	1	5	9	15	4	11
+gp	2	1	1	0	2	2	2	9	6	0
TOTALNUM	25041	29153	23844	30076	30612	23942	26024	27493	18425	23503
TONSLAND	40695	40763	40710	45339	49767	50544	46725	47836	35679	24224
SOPCOF %	100	100	100	100	100	100	101	100	99	101

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 2020.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	23	54	146	539	28	790
2	228	472	953	1166	43	2862
3	284	643	474	255	19	1675
4	380	430	369	289	15	1483
5	102	157	117	60	5	441
6	96	75	69	36	3	279
7	46	33	19	15	1	114
8	7	11	16	12	1	47
9	5	2	2	1	0	10
10	3	2	4	1	0	10
+gp	0	0	0	0	0	0
TOTALNUM	1174	1879	2169	2374	115	7711

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	1244	1835	1907	3447	2730	11163
2	1054	561	1146	1136	433	4330
3	26	34	112	69	46	287
4	1	1	2	0	4	8
5	0	0	0	0	0	0
6	0	0	0	0	0	0
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	2325	2431	3167	4652	3213	15788

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	1267	1889	2053	3987	2758	11954
2	1283	1032	2099	2302	476	7192
3	310	677	586	324	65	1962
4	381	432	371	290	18	1492
5	102	157	117	60	5	441
6	96	75	69	36	3	279
7	46	33	19	15	1	114
8	7	11	16	12	1	47
9	5	2	2	1	0	10
10	3	2	4	1	0	10
+gp	0	0	0	0	0	0
TOTALNUM	3500	4310	5336	7028	3327	23501

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 2020, 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, discards and BMS in each area (by weight) to the total for that catch category (before raising is conducted).

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	76%	23%	61%	79%	27%
27.3.a.20	51%	50%	63%	39%	-
27.7.d	40%	-	16%	53%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	91%	36%	81%	89%	27%
27.3.a.20	94%	94%	84%	94%	-
27.7.d	-	-	-	-	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	90%	71%	98%	98%	100%
27.3.a.20	100%	100%	100%	100%	-
27.7.d	-	-	-	-	-

Contribution to total (before raising)

Area/Type	Landings	Discards	BMS
27.4	88%	67%	100%
27.3.a.20	12%	33%	0%
27.7.d	0%	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	1.067	0.788	0.715
2	0.935	1.021	1.004	0.996	1.079	1.072	1.160	1.200	1.182	1.389	1.412	1.292
3	1.663	1.747	2.303	1.844	1.895	2.089	1.952	2.239	2.365	2.456	2.674	2.671
4	3.305	3.216	3.663	3.735	3.347	3.252	3.647	3.894	4.050	4.063	4.145	4.223
5	5.726	4.903	5.871	5.537	5.757	5.184	5.244	5.676	6.053	6.224	6.119	6.049
6	7.403	7.488	7.333	8.006	6.694	7.438	7.225	7.234	8.250	7.393	7.490	8.299
7	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.243	9.262	9.651	8.968	9.472
8	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477	10.015	11.489	11.447	11.631
9	11.600	10.894	12.062	11.888	11.518	11.857	12.015	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	11.716	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/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.862	0.938	0.883	0.699	0.596	0.800	0.753	0.607	0.764	0.759
2	1.328	1.369	1.240	1.213	1.206	1.315	1.119	1.065	1.119	1.358
3	2.525	2.354	2.461	2.390	2.291	2.342	2.379	1.943	2.136	1.925
4	4.596	4.175	4.164	4.180	4.112	3.862	3.906	3.838	3.707	3.809
5	6.481	6.391	6.187	5.678	5.935	5.744	5.393	5.633	5.505	5.424
6	7.843	8.115	8.347	7.435	6.920	7.342	6.897	6.829	7.188	6.729
7	9.681	9.092	9.817	9.191	8.775	7.928	8.906	7.683	7.764	8.964
8	9.629	11.799	9.486	9.180	9.622	8.717	8.664	8.867	9.684	8.671
9	10.845	12.548	11.364	11.469	10.654	10.367	9.586	8.481	6.788	11.459
10	14.436	11.436	10.935	16.456	13.838	11.926	17.579	8.972	11.466	16.458
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.796	14.596

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/YEAF	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/YEAF	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/YEAF	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/YEAF	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/YEAF	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.277	0.234	0.334	0.311	0.326	0.364	0.231	0.281	0.328	0.220
2	0.677	0.556	0.796	0.742	0.759	0.939	0.771	0.607	0.557	0.456
3	2.057	1.867	1.493	1.772	1.617	1.767	1.881	1.410	1.382	0.842
4	4.099	3.803	3.375	3.128	3.158	3.092	3.002	2.662	2.286	2.578
5	5.576	6.456	4.048	3.826	3.983	4.687	3.629	3.560	2.641	0.000
6	6.071	8.579	8.419	4.642	5.303	5.439	5.172	0.000	0.000	0.000
7	8.264	9.733	7.086	4.423	6.940	0.000	5.313	0.000	0.000	0.000
8	6.213	0.000	0.000	0.000	8.390	0.000	4.577	0.000	0.000	0.000
9	11.617	0.000	0.000	0.000	4.087	0.000	0.000	9.790	0.000	0.000
10	0.000	16.370	16.370	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

Table 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch weights at age (kg).

Catch weights at age (kg)

AGE/YEAF	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/YEAF	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/YEAF	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/YEAF	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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/YEAF	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.405	0.274	0.388	0.398	0.366	0.387	0.249	0.300	0.405	0.256
2	0.915	0.800	0.932	0.927	0.945	1.049	0.925	0.790	0.857	0.815
3	2.438	2.252	2.249	2.237	2.098	2.138	2.238	1.853	2.036	1.766
4	4.569	4.154	4.060	4.083	4.031	3.803	3.794	3.759	3.687	3.802
5	6.472	6.392	5.999	5.598	5.802	5.712	5.296	5.624	5.493	5.424
6	7.829	8.117	8.360	7.392	6.761	7.332	6.857	6.829	7.188	6.729
7	9.656	9.095	9.385	9.190	8.602	7.928	8.850	7.683	7.764	8.964
8	9.461	11.799	9.486	9.180	9.410	8.717	8.618	8.867	9.684	8.671
9	10.853	12.548	11.364	11.469	8.663	10.367	9.586	8.546	6.788	11.459
10	14.436	11.754	11.680	16.456	13.838	11.926	17.579	8.972	11.466	16.458
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.796	14.596

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 2020 (note, any differences in the +gp values between Tables 4.3a–c and Table 4.3d are due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.702	0.753	0.713	0.774	0.77	0.759
2	0.946	1.293	1.314	1.495	1.517	1.358
3	1.793	1.437	2.14	2.886	2.157	1.925
4	3.355	3.44	3.912	4.823	3.854	3.809
5	5.03	4.765	6.026	6.65	5.547	5.424
6	6.297	6.577	7.226	7.249	6.708	6.729
7	8.679	8.794	9.875	9.044	9.269	8.964
8	7.942	9.788	8.652	8.083	8.619	8.671
9	10.996	11.433	12.196	12.532	11.496	11.459
10	16.863	17.762	14.569	21.285	16.99	16.458
+gp	15.53	15.947	15.643	15.398	11.734	14.597

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.16	0.163	0.265	0.249	0.218	0.22
2	0.319	0.516	0.564	0.357	0.688	0.456
3	0.839	1.007	0.84	0.666	0.991	0.842
4	2.229	2.86	3.444	2.683	2.028	2.578
5	0	0	0	0	0	0
6	0	0	0	0	0	0
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	0.169	0.18	0.297	0.32	0.223	0.256
2	0.431	0.871	0.905	0.933	0.762	0.815
3	1.712	1.416	1.891	2.413	1.335	1.766
4	3.351	3.438	3.909	4.819	3.469	3.802
5	5.03	4.765	6.026	6.65	5.547	5.424
6	6.297	6.577	7.226	7.249	6.708	6.729
7	8.679	8.794	9.875	9.044	9.269	8.964
8	7.942	9.788	8.652	8.083	8.619	8.671
9	10.996	11.433	12.196	12.532	11.496	11.459
10	16.863	17.762	14.569	21.285	16.99	16.458
+gp	15.53	15.947	15.643	15.398	11.734	14.597

Table 4.4. Cod in Subarea 4, Division 7.d and Subdivision 20: Reported landings, estimated discards (including BMS landings from 2016) 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.

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	40153	7744	47898
2019	32361	3555	35917
2020	19373	4700	24072

Table 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Stock weights at age (kg). Values for 2021 are derived from NS–IBTS–Q1 survey data for ages 1–2 and taken as a three-year average for ages 3+.

	Age					
Year	1	2	3	4	5	6+
1963	0.060	0.533	2.278	3.996	6.117	9.590
1964	0.068	0.501	2.036	4.029	5.805	8.651
1965	0.060	0.593	1.975	4.014	6.549	10.379
1966	0.060	0.550	2.097	3.709	6.327	10.367
1967	0.062	0.572	2.061	2.805	6.125	10.159
1968	0.063	0.558	1.906	3.643	4.809	8.302
1969	0.080	0.497	1.830	3.427	5.146	7.184
1970	0.086	0.556	1.745	3.560	5.520	8.618
1971	0.060	0.549	1.883	3.788	5.877	9.120
1972	0.057	0.480	1.790	3.530	5.412	8.682
1973	0.064	0.461	1.646	3.360	4.941	8.476
1974	0.058	0.593	1.898	3.698	5.559	9.658
1975	0.058	0.500	2.020	3.760	5.766	8.975
1976	0.038	0.475	2.107	4.072	5.847	8.626
1977	0.056	0.443	1.831	4.098	6.045	9.694
1978	0.083	0.489	1.722	3.689	5.879	9.224
1979	0.056	0.596	2.075	3.935	5.923	9.562
1980	0.049	0.604	1.676	3.916	5.500	9.230
1981	0.063	0.506	1.881	4.106	6.343	9.389
1982	0.068	0.598	1.597	3.675	6.109	8.979
1983	0.077	0.581	1.578	3.452	5.844	8.837
1984	0.058	0.606	1.855	3.534	5.573	9.043
1985	0.060	0.527	1.835	3.705	5.694	8.906
1986	0.056	0.515	1.568	3.118	5.609	9.278
1987	0.084	0.509	1.682	3.248	5.449	8.957
1988	0.089	0.496	1.699	2.836	5.395	8.824
1989	0.070	0.614	1.558	3.190	4.748	8.273
1990	0.073	0.454	1.863	3.373	5.340	9.287
1991	0.075	0.585	1.717	3.533	5.476	8.125
1992	0.076	0.639	2.191	3.757	5.624	8.942
1993	0.062	0.557	2.131	4.049	5.888	8.603
1994	0.058	0.519	1.883	3.978	6.453	8.487
1995	0.080	0.506	1.898	3.820	6.501	9.268
1996	0.083	0.547	1.803	3.589	5.976	8.830
1997	0.074	0.525	1.822	3.400	5.607	8.388
1998	0.071	0.417	1.396	3.110	4.850	8.000
1999	0.061	0.482	1.209	2.941	5.155	7.567
2000	0.068	0.595	1.503	2.861	4.414	7.832
2001	0.071	0.399	1.801	3.259	5.286	8.067
2002	0.057	0.289	1.467	3.448	4.922	7.749
2003	0.058	0.431	1.565	3.037	5.256	7.706
2004	0.056	0.242	1.427	2.762	4.705	7.474
2005	0.060	0.445	1.324	2.946	4.528	7.084
2006	0.058	0.498	1.484	3.379	5.046	7.833
2007	0.072	0.436	1.689	3.465	5.527	8.276
2008	0.083	0.681	1.889	3.546	5.404	7.404
2009	0.056	0.734	1.908	3.663	5.525	8.076
2010	0.073	0.569	2.188	3.852	5.539	8.897
2011	0.062	0.479	2.094	4.238	5.841	7.547
2012	0.062	0.621	1.910	3.673	5.923	8.107
2013	0.068	0.466	1.889	3.774	5.707	8.283
2014	0.064	0.540	1.873	3.516	5.211	7.420
2015	0.068	0.587	1.756	3.406	4.973	6.787
2016	0.071	0.553	1.712	3.253	5.143	7.215
2017	0.057	0.551	1.818	3.229	4.689	7.933
2018	0.059	0.460	1.682	3.276	5.173	6.909
2019	0.056	0.421	1.682	3.410	4.707	7.408
2020	0.059	0.457	1.712	3.351	5.030	7.424
2021	0.078	0.444	1.692	3.346	4.970	7.272

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

	Age					
	1	2	3	4	5	6+
1978	0.016	0.098	0.148	0.483	0.683	1.000
1979	0.000	0.047	0.217	0.524	0.615	1.000
1980	0.003	0.068	0.119	0.255	0.619	1.000
1981	0.003	0.035	0.168	0.412	0.506	1.000
1982	0.000	0.036	0.120	0.434	0.553	1.000
1983	0.000	0.035	0.174	0.392	0.761	1.000
1984	0.006	0.031	0.254	0.436	0.673	1.000
1985	0.000	0.026	0.158	0.508	0.685	1.000
1986	0.001	0.100	0.151	0.313	0.581	1.000
1987	0.000	0.028	0.258	0.537	0.815	1.000
1988	0.003	0.047	0.176	0.445	0.528	1.000
1989	0.232	0.179	0.272	0.529	0.770	1.000
1990	0.004	0.088	0.255	0.432	0.707	1.000
1991	0.000	0.068	0.322	0.445	0.745	1.000
1992	0.000	0.190	0.460	0.827	0.678	1.000
1993	0.000	0.075	0.356	0.618	0.747	1.000
1994	0.000	0.146	0.470	0.783	0.897	1.000
1995	0.004	0.042	0.342	0.733	0.874	1.000
1996	0.000	0.159	0.462	0.825	0.880	1.000
1997	0.000	0.191	0.590	0.659	0.792	1.000
1998	0.023	0.120	0.530	0.816	0.948	1.000
1999	0.014	0.385	0.467	0.709	0.981	1.000
2000	0.009	0.250	0.670	0.825	0.879	1.000
2001	0.016	0.189	0.454	0.777	0.974	1.000
2002	0.012	0.345	0.553	0.865	1.000	1.000
2003	0.000	0.198	0.455	0.705	0.961	1.000
2004	0.000	0.224	0.788	0.761	0.869	1.000
2005	0.005	0.218	0.626	0.843	0.928	1.000
2006	0.012	0.224	0.495	0.792	0.844	1.000
2007	0.017	0.188	0.594	0.823	0.979	1.000
2008	0.034	0.385	0.725	0.825	0.946	1.000
2009	0.016	0.246	0.696	0.870	0.918	1.000
2010	0.008	0.182	0.710	0.826	0.963	1.000
2011	0.082	0.157	0.731	0.898	0.985	1.000
2012	0.004	0.250	0.523	0.803	0.949	1.000
2013	0.018	0.096	0.474	0.855	0.900	1.000
2014	0.017	0.150	0.511	0.882	0.951	1.000
2015	0.018	0.279	0.441	0.786	0.865	1.000
2016	0.033	0.144	0.290	0.688	0.817	1.000
2017	0.013	0.144	0.496	0.747	0.859	1.000
2018	0.000	0.145	0.441	0.761	0.978	1.000
2019	0.000	0.312	0.607	0.779	0.971	1.000
2020	0.010	0.168	0.684	0.862	0.917	1.000
2021	0.000	0.089	0.331	0.602	0.837	1.000

Table 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Natural mortality by age-group (left). The values on the right show the final Ms after application of the ad-hoc adjustment to mimic emigration of older cod to 6.aN.

	Age									
y	1	2	3	4	5	6+	3	4	5	6+
1963	1.176	0.711	0.216	0.2	0.2	0.2				
1964	1.176	0.711	0.216	0.2	0.2	0.2				
1965	1.176	0.711	0.216	0.2	0.2	0.2				
1966	1.176	0.711	0.216	0.2	0.2	0.2				
1967	1.176	0.711	0.216	0.2	0.2	0.2				
1968	1.176	0.711	0.216	0.2	0.2	0.2				
1969	1.176	0.711	0.216	0.2	0.2	0.2				
1970	1.176	0.711	0.216	0.2	0.2	0.2				
1971	1.176	0.711	0.216	0.2	0.2	0.2				
1972	1.176	0.711	0.216	0.2	0.2	0.2				
1973	1.176	0.711	0.216	0.2	0.2	0.2				
1974	1.176	0.711	0.216	0.2	0.2	0.2				
1975	1.185	0.706	0.218	0.2	0.2	0.2				
1976	1.195	0.701	0.221	0.2	0.2	0.2				
1977	1.204	0.697	0.223	0.2	0.2	0.2				
1978	1.213	0.694	0.226	0.2	0.2	0.2				
1979	1.220	0.693	0.228	0.2	0.2	0.2				
1980	1.226	0.694	0.231	0.2	0.2	0.2				
1981	1.228	0.696	0.233	0.2	0.2	0.2				
1982	1.228	0.700	0.235	0.2	0.2	0.2				
1983	1.223	0.705	0.237	0.2	0.2	0.2				
1984	1.216	0.709	0.240	0.2	0.2	0.2				
1985	1.207	0.715	0.242	0.2	0.2	0.2				
1986	1.197	0.721	0.244	0.2	0.2	0.2				
1987	1.186	0.728	0.246	0.2	0.2	0.2				
1988	1.176	0.736	0.249	0.2	0.2	0.2				
1989	1.167	0.745	0.251	0.2	0.2	0.2				
1990	1.158	0.754	0.253	0.2	0.2	0.2				
1991	1.151	0.763	0.256	0.2	0.2	0.2				
1992	1.144	0.771	0.259	0.2	0.2	0.2				
1993	1.139	0.779	0.263	0.2	0.2	0.2				
1994	1.135	0.787	0.268	0.2	0.2	0.2				
1995	1.131	0.796	0.275	0.2	0.2	0.2				
1996	1.128	0.806	0.283	0.2	0.2	0.2				
1997	1.124	0.818	0.293	0.2	0.2	0.2				
1998	1.122	0.833	0.305	0.2	0.2	0.2				
1999	1.121	0.849	0.317	0.2	0.2	0.2				
2000	1.121	0.866	0.330	0.2	0.2	0.2				
2001	1.125	0.886	0.343	0.2	0.2	0.2				
2002	1.133	0.906	0.355	0.2	0.2	0.2				
2003	1.144	0.926	0.365	0.2	0.2	0.2				
2004	1.157	0.945	0.371	0.2	0.2	0.2				
2005	1.170	0.961	0.374	0.2	0.2	0.2				
2006	1.183	0.973	0.373	0.2	0.2	0.2				
2007	1.194	0.981	0.368	0.2	0.2	0.2				
2008	1.202	0.984	0.362	0.2	0.2	0.2				
2009	1.209	0.985	0.354	0.2	0.2	0.2				
2010	1.213	0.982	0.346	0.2	0.2	0.2				
2011	1.215	0.978	0.339	0.2	0.2	0.2	0.501	0.364	0.363	0.363
2012	1.215	0.972	0.332	0.2	0.2	0.2	0.495	0.364	0.363	0.363
2013	1.212	0.965	0.327	0.2	0.2	0.2	0.489	0.363	0.363	0.363
2014	1.208	0.958	0.322	0.2	0.2	0.2	0.485	0.362	0.363	0.363
2015	1.201	0.951	0.318	0.2	0.2	0.2	0.481	0.362	0.363	0.363
2016	1.192	0.943	0.314	0.2	0.2	0.2	0.476	0.362	0.363	0.363
2017	1.181	0.935	0.310	0.2	0.2	0.2	0.472	0.361	0.363	0.363
2018	1.168	0.928	0.305	0.2	0.2	0.2	0.468	0.361	0.363	0.363
2019	1.154	0.920	0.301	0.2	0.2	0.2	0.463	0.361	0.363	0.363
2020*	1.154	0.920	0.301	0.2	0.2	0.2	0.463	0.361	0.363	0.363

***A new key run was performed in 2020 with data up to 2019 (ICES WGSAM 2020), so the 2020 M–value is assumed equal to 2019.**

Table 4.6. Cod in Subarea 4, Division 7.d and Subdivision 20: Survey tuning indices and standard deviations for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices). A third index for recruits is derived from the IBTS–Q3 index. Data used in the assessment are highlighted in bold font.

IBTS_Q1_gam							Standard deviations					
1983	2021											
1	1	0	0.25									
1	5						1	2	3	4	5	6
1	**2674.51**	**9372.77**	**1508.59**	**820.87**	**305.58**	357.84	**0.17121**	**0.162327**	**0.159281**	**0.151419**	**0.146367**	0.164608
1	**6972.16**	**3411.35**	**1508.61**	**347.07**	**293.53**	197.82	**0.142034**	**0.138351**	**0.137004**	**0.137331**	**0.132737**	0.168787
1	**355.71**	**9316.45**	**1449.02**	**755.41**	**176.45**	215.10	**0.190364**	**0.134476**	**0.147048**	**0.164459**	**0.153467**	0.158229
1	**7105.06**	**1893.44**	**2219.76**	**854.99**	**339.21**	227.79	**0.137337**	**0.151683**	**0.130318**	**0.135354**	**0.130594**	0.153709
1	**3346.76**	**10158.58**	**427.82**	**529.70**	**152.25**	172.50	**0.160451**	**0.130339**	**0.119753**	**0.129798**	**0.136498**	0.145897
1	**2569.24**	**2665.09**	**2286.51**	**220.25**	**237.02**	202.97	**0.21821**	**0.13973**	**0.129584**	**0.184525**	**0.126226**	0.161927
1	**4965.85**	**2420.04**	**1749.81**	**821.05**	**112.18**	218.73	**0.159509**	**0.14538**	**0.134254**	**0.132961**	**0.131523**	0.151184
1	**1119.71**	**5268.56**	**738.13**	**333.47**	**280.43**	139.79	**0.195351**	**0.142666**	**0.144718**	**0.141827**	**0.127872**	0.161901
1	**1278.44**	**2071.47**	**1373.12**	**326.31**	**153.16**	210.28	**0.192053**	**0.165878**	**0.139011**	**0.134145**	**0.131379**	0.143365
1	**4924.82**	**1943.98**	**475.30**	**359.74**	**88.68**	110.71	**0.156177**	**0.13786**	**0.134348**	**0.168743**	**0.146944**	0.165391
1	**2420.54**	**6388.10**	**727.63**	**262.54**	**155.43**	74.34	**0.201261**	**0.136821**	**0.132595**	**0.128039**	**0.129807**	0.178458
1	**4094.16**	**1368.78**	**1092.73**	**355.09**	**151.12**	113.45	**0.153496**	**0.125945**	**0.141694**	**0.145772**	**0.131523**	0.169281
1	**3635.40**	**7540.02**	**1221.71**	**478.60**	**133.68**	79.66	**0.167583**	**0.125215**	**0.125636**	**0.141122**	**0.13007**	0.171617
1	**1228.18**	**4118.23**	**1681.02**	**305.39**	**188.15**	88.22	**0.177322**	**0.146252**	**0.123466**	**0.122954**	**0.119249**	0.172271
1	**7505.75**	**2182.25**	**802.12**	**377.15**	**127.05**	97.48	**0.125834**	**0.125081**	**0.124821**	**0.13715**	**0.144191**	0.159604
1	**488.67**	**8006.43**	**831.07**	**383.01**	**192.49**	114.08	**0.203631**	**0.125158**	**0.109629**	**0.114331**	**0.123362**	0.148072
1	**1089.59**	**389.95**	**2454.37**	**355.43**	**155.06**	122.09	**0.225126**	**0.153109**	**0.107442**	**0.12159**	**0.119334**	0.162547
1	**1585.77**	**2051.18**	**376.06**	**704.38**	**118.03**	142.47	**0.143901**	**0.157479**	**0.131521**	**0.115556**	**0.126061**	0.137861
1	**842.60**	**2845.02**	**596.18**	**127.80**	**91.64**	65.11	**0.24825**	**0.122854**	**0.113907**	**0.122919**	**0.126438**	0.153015
1	**2265.90**	**1131.53**	**1308.84**	**216.99**	**47.64**	60.95	**0.200791**	**0.145206**	**0.118384**	**0.12296**	**0.14837**	0.18484
1	**199.58**	**1260.10**	**416.03**	**366.38**	**134.96**	57.56	**0.236958**	**0.136127**	**0.122607**	**0.124128**	**0.13472**	0.166778
1	**2400.15**	**757.34**	**583.11**	**126.58**	**140.63**	72.85	**0.240358**	**0.143797**	**0.125351**	**0.136734**	**0.154618**	0.17949
1	**721.52**	**1211.98**	**311.47**	**247.35**	**53.82**	89.20	**0.18888**	**0.165578**	**0.133146**	**0.126833**	**0.147025**	0.181043
1	**2502.26**	**598.39**	**428.61**	**104.40**	**64.77**	85.61	**0.190684**	**0.170804**	**0.149003**	**0.157775**	**0.153092**	0.202816
1	**987.14**	**2180.39**	**485.92**	**169.04**	**60.73**	71.29	**0.216625**	**0.13637**	**0.123368**	**0.157332**	**0.178198**	0.204811
1	**972.59**	**620.90**	**866.79**	**178.38**	**123.83**	45.17	**0.182186**	**0.152158**	**0.138311**	**0.127037**	**0.128664**	0.170657
1	**617.21**	**908.60**	**390.80**	**325.02**	**81.96**	78.18	**0.237196**	**0.145953**	**0.130808**	**0.161**	**0.146481**	0.1858
1	**1589.44**	**1300.79**	**558.82**	**171.95**	**136.20**	64.03	**0.169477**	**0.140874**	**0.126118**	**0.143035**	**0.139864**	0.168131
1	**479.34**	**1956.73**	**551.85**	**233.93**	**113.49**	99.42	**0.249574**	**0.136886**	**0.143517**	**0.156179**	**0.142923**	0.161764
1	**1216.70**	**949.28**	**1727.01**	**481.52**	**147.98**	64.56	**0.269806**	**0.12727**	**0.153996**	**0.158367**	**0.134056**	0.168505
1	**822.73**	**1272.30**	**596.74**	**541.41**	**270.27**	88.37	**0.203169**	**0.190724**	**0.135574**	**0.15281**	**0.128377**	0.158666
1	**1064.65**	**1416.63**	**615.87**	**293.01**	**290.25**	95.34	**0.158362**	**0.172295**	**0.166104**	**0.197782**	**0.171224**	0.208267
1	**707.16**	**2553.08**	**1152.85**	**372.70**	**112.00**	94.55	**0.174261**	**0.136166**	**0.149995**	**0.147115**	**0.135674**	0.171971
1	**364.83**	**819.26**	**1578.64**	**590.51**	**231.70**	133.25	**0.209209**	**0.159942**	**0.14763**	**0.146061**	**0.127282**	0.153827
1	**3031.70**	**672.07**	**997.03**	**919.66**	**438.28**	149.43	**0.137393**	**0.144636**	**0.162742**	**0.147671**	**0.135348**	0.163009
1	**218.36**	**2082.72**	**457.93**	**306.56**	**191.36**	174.40	**0.220113**	**0.139307**	**0.161877**	**0.187114**	**0.140586**	0.172574
1	**512.41**	**330.92**	**728.16**	**104.61**	**76.40**	58.23	**0.184504**	**0.150636**	**0.153033**	**0.170518**	**0.176651**	0.2251
1	**1775.00**	**758.90**	**204.90**	**247.97**	**48.83**	40.64	**0.222628**	**0.165745**	**0.155274**	**0.164744**	**0.180004**	0.230383
1	**775.34**	**2050.59**	**807.91**	**207.27**	**103.93**	83.21	**0.201331**	**0.155313**	**0.139645**	**0.148406**	**0.14671**	0.196378
IBTS_Q3_gam												
1992	2020											
1	1	0.50	0.75									
1	4						1	2	3	4	5	
1	**11777.76**	**1596.03**	**439.69**	**188.94**	132.66		**0.115752**	**0.164296**	**0.144226**	**0.137533**	0.204894	
1	**2413.87**	**3095.88**	**479.26**	**140.92**	145.35		**0.13038**	**0.154644**	**0.178685**	**0.164204**	0.228848	
1	**13893.16**	**1833.52**	**806.84**	**145.66**	99.48		**0.119566**	**0.118989**	**0.147819**	**0.171911**	0.213895	
1	**6999.25**	**4680.32**	**660.50**	**239.43**	78.20		**0.123698**	**0.132664**	**0.155702**	**0.163253**	0.237897	
1	**3298.00**	**1900.24**	**632.52**	**167.30**	126.45		**0.129797**	**0.161972**	**0.152668**	**0.163528**	0.203844	
1	**22663.22**	**2519.02**	**598.12**	**188.31**	111.80		**0.154691**	**0.20272**	**0.232101**	**0.282932**	0.304471	
1	**707.16**	**6874.58**	**509.07**	**130.11**	127.27		**0.174424**	**0.136099**	**0.148425**	**0.165146**	0.212455	
1	**3022.61**	**433.49**	**1174.24**	**113.95**	48.36		**0.171852**	**0.153902**	**0.129057**	**0.137381**	0.23701	
1	**4671.57**	**917.01**	**89.05**	**226.76**	60.19		**0.303547**	**0.284456**	**0.198715**	**0.238074**	0.275464	
1	**1299.49**	**1618.00**	**284.43**	**56.25**	94.81		**0.190555**	**0.134853**	**0.143585**	**0.170899**	0.259845	
1	**3670.73**	**808.23**	**591.77**	**190.41**	64.99		**0.192295**	**0.156213**	**0.130756**	**0.157388**	0.191585	
1	**531.33**	**917.57**	**186.32**	**162.47**	170.46		**0.160981**	**0.148622**	**0.165106**	**0.178769**	0.217594	
1	**2983.60**	**579.54**	**356.69**	**72.92**	81.36		**0.213332**	**0.139702**	**0.155934**	**0.182029**	0.20704	
1	**970.45**	**693.03**	**189.39**	**92.12**	65.58		**0.176493**	**0.157074**	**0.140239**	**0.153904**	0.204611	
1	**3786.96**	**613.00**	**457.53**	**85.78**	38.20		**0.154053**	**0.160097**	**0.183677**	**0.171477**	0.221705	
1	**1637.32**	**2123.97**	**362.78**	**145.89**	121.69		**0.195152**	**0.160014**	**0.171978**	**0.177843**	0.184009	
1	**1913.66**	**802.47**	**841.31**	**176.89**	108.77		**0.183765**	**0.161421**	**0.166164**	**0.141374**	0.175992	
1	**1657.02**	**665.65**	**221.77**	**217.63**	85.65		**0.212095**	**0.157782**	**0.190957**	**0.202218**	0.229473	
1	**1932.37**	**1273.76**	**403.55**	**137.44**	104.88		**0.128214**	**0.139855**	**0.135951**	**0.141194**	0.157453	
1	**842.50**	**2310.73**	**1041.85**	**280.66**	187.86		**0.157709**	**0.138222**	**0.184163**	**0.147875**	0.175628	
1	**1643.78**	**775.36**	**977.05**	**308.49**	114.01		**0.190998**	**0.156907**	**0.134796**	**0.139792**	0.180599	
1	**1579.41**	**843.06**	**386.23**	**431.56**	195.94		**0.154015**	**0.154163**	**0.148663**	**0.150165**	0.169378	
1	**1930.07**	**1196.54**	**529.12**	**220.40**	286.32		**0.129759**	**0.135498**	**0.142651**	**0.137433**	0.153693	
1	**960.87**	**2178.51**	**858.18**	**348.23**	249.39		**0.164959**	**0.135799**	**0.134125**	**0.133938**	0.164663	
1	**682.14**	**796.95**	**1087.79**	**598.01**	263.39		**0.168021**	**0.140532**	**0.131396**	**0.120015**	0.138242	
1	**3653.17**	**468.80**	**385.96**	**357.64**	268.32		**0.130521**	**0.143285**	**0.16501**	**0.145131**	0.161576	
1	**503.96**	**1533.71**	**282.42**	**182.48**	209.43		**0.14945**	**0.141404**	**0.133804**	**0.155399**	0.173805	
1	**1215.29**	**335.20**	**438.11**	**88.91**	111.29		**0.134072**	**0.150792**	**0.155422**	**0.165294**	0.205624	
1	**2172.76**	**874.14**	**137.06**	**167.78**	96.88		**0.159774**	**0.138606**	**0.168275**	**0.163209**	0.204947	

Table 4.6 condt. Cod in Subarea 4, Division 7.d and Subdivision 20: Survey tuning indices and standard deviations for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices). A third index for recruits is derived from the IBTS–Q3 index. Data used in the assessment are highlighted in bold font.

IBTS_Q3_gam_age0_y+1

1993	2021			
1	1	0	0	
1	1			1
1	**5832.18**			**0.259682**
1	**5334.16**			**0.276146**
1	**11376.22**			**0.274945**
1	**5909.27**			**0.294992**
1	**15047.11**			**0.280689**
1	**136.68**			**0.423235**
1	**7924.63**			**0.429592**
1	**1868.37**			**0.354192**
1	**1085.32**			**0.810498**
1	**9431.83**			**0.426878**
1	**312.72**			**0.618655**
1	**4041.62**			**0.469566**
1	**1896.52**			**0.624468**
1	**2991.29**			**0.301513**
1	**2219.77**			**0.429719**
1	**5140.50**			**0.457959**
1	**636.23**			**0.559663**
1	**936.45**			**0.486799**
1	**133.32**			**0.536685**
1	**6163.59**			**0.678114**
1	**693.00**			**0.655943**
1	**279.25**			**0.498571**
1	**413.34**			**0.476929**
1	**26.58**			**0.748053**
1	**3199.94**			**0.265731**
1	**230.95**			**0.576461**
1	**174.23**			**0.53508**
1	**2087.59**			**0.431797**
1	**863.89**			**0.394011**

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

```
# Configuration saved: Thu Apr 22 17:54:35 2021
#
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
# Negative numbers indicate that the parameter is not included in the model
#
$minAge
# The minimium age class in the assessment
 1

$maxAge
# The maximum age class in the assessment
 6

$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 0 0 0

$keyLogFsta
# Coupling of the fishing mortality states processes for each age (normally only
# the first row (= fleet) is used).
# Sequential numbers indicate that the fishing mortality is estimated individually
# for those ages; if the same number is used for two or more ages, F is bound for
# those ages (assumed to be the same). Binding fully selected ages will result in a
# flat selection pattern for those ages.
   0   1   2   3   4   5
  -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,
# 2 AR(1), 3 separable AR(1).
# 0: independent means there is no correlation between F across age
# 1: compound symmetry means that all ages are equally correlated;
# 2: AR(1) first order autoregressive - similar ages are more highly correlated than
# ages that are further apart, so similar ages have similar F patterns over time.
# if the estimated correlation is high, then the F pattern over time for each age
# varies in a similar way. E.g if almost one, then they are parallel (like a
# separable model) and if almost zero then they are independent.
# 3: Separable AR - Included for historic reasons . . .  more later
 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
   0   1   2   3   4  -1
   5   6   7   8  -1  -1
   9  -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

$keyVarF
```

```
# Coupling of process variance parameters for log(F)-process (Fishing mortality
# normally applies to the first (fishing) fleet; therefore only first row is used)
   0   1   1   1   1   2
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1

$keyVarLogN
# Coupling of the recruitment and survival process variance parameters for the
# log(N)-process at the different ages. It is advisable to have at least the first age
# class (recruitment) separate, because recruitment is a different process than
# survival.
 0 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
# First row refers to the coupling of the variance parameters for the catch data
# observations by age
# Second and further rows refers to coupling of the variance parameters for the
# index data observations by age
   0   1   2   2   2   2
   3   4   4   4   4  -1
   5   6   6   6  -1  -1
   7  -1  -1  -1  -1  -1

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstruc-
tured). | Possible values are: "ID" "AR" "US"
 "ID" "AR" "AR" "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).
#V1 V2 V3 V4 V5
  NA  NA  NA  NA  NA
   0   1   1   1  -1
   2   3   3  -1  -1
  -1  -1  -1  -1  -1

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton-Holt, and
3 piece-wise constant).
 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 higest age included in Fbar
 2 4

$keyBiomassTreat
```

```
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index,
3 total catch, 4 total landings and 5 TSB index).
 -1 -1 -1 -1

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "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

$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0

$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0

$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of
t(3) distribution used in the distribution of that fleet
 0 0 0 0

$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year
is included in the left interval. (This option is only used in combination with stock-
recruitment code 3)


$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations.
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  NA
  -1  -1  -1  -1  NA  NA
  NA  NA  NA  NA  NA  NA

$stockWeightModel
# Integer code describing the treatment of stock weights in the model (0 use as known, 1
use as observations to inform stock weight process (GMRF with cohort and within year
correlations))
 0

$keyStockWeightMean
# Coupling of stock-weight process mean parameters (not used if stockWeightModel==0)
 NA NA NA NA NA NA

$keyStockWeightObsVar
# Coupling of stock-weight observation variance parameters (not used if stockWeight-
Model==0)
 NA NA NA NA NA NA

$catchWeightModel
# Integer code describing the treatment of catch weights in the model (0 use as known, 1
use as observations to inform catch weight process (GMRF with cohort and within year
correlations))
 0

$keyCatchWeightMean
# Coupling of catch-weight process mean parameters (not used if catchWeightModel==0)
```

```
 NA NA NA NA NA NA

$keyCatchWeightObsVar
# Coupling of catch-weight observation variance parameters (not used if catchWeight-
Model==0)
 NA NA NA NA NA NA

$matureModel
# Integer code describing the treatment of proportion mature in the model (0 use as known,
1 use as observations to inform proportion mature process (GMRF with cohort and within
year correlations on logit(proportion mature)))
 1

$keyMatureMean
# Coupling of mature process mean parameters (not used if matureModel==0)
 0 1 2 3 4 5

$mortalityModel
# Integer code describing the treatment of natural mortality in the model (0 use as known,
1 use as observations to inform natural mortality process (GMRF with cohort and within
year correlations))
 0

$keyMortalityMean
#
 NA NA NA NA NA NA

$keyMortalityObsVar
# Coupling of natural mortality observation variance parameters (not used if mortali-
tyModel==0)
 NA NA NA NA NA NA

$keyXtraSd
# An integer matrix with 4 columns (fleet year age coupling), which allows additional
uncertainty to be estimated for the specified observations
```

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
680.602	38	-1285.2

	value	std.dev	logFpar_0	logFpar_1	logFpar_2	logFpar_3	logFpar_4	logFpar_5	logFpar_6	logFpar_7	logFpar_8	logFpar_9	logSdLogF	logSdLogF	logSdLogF	logSdLogN	logSdLogN	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	transfIRAR	transfIRAR	transfIRAR	transfIRAR	itrans_rho_	logPhiMO_	logPhiMO_	logSdProcl	meanLogit	meanLogit	meanLogit	meanLogit	meanLogit	meanLogit	logSdMO_
logFpar_0	-5.29	0.08	1																																					
logFpar_1	-3.69	0.05	0.14	1																																				
logFpar_2	-3.08	0.04	0.06	0.46	1																																			
logFpar_3	-2.83	0.05	0.06	0.25	0.51	1																																		
logFpar_4	-2.68	0.06	0.07	0.17	0.32	0.59	1																																	
logFpar_5	-4.01	0.08	0.16	0.15	0.08	0.07	0.09	1																																
logFpar_6	-3.22	0.05	0.12	0.22	0.15	0.14	0.18	0.34	1																															
logFpar_7	-2.92	0.05	0.08	0.14	0.23	0.24	0.29	0.18	0.53	1																														
logFpar_8	-2.8	0.06	0.08	0.14	0.21	0.35	0.45	0.14	0.34	0.61	1																													
logFpar_9	-4.95	0.19	0.08	0.06	0.03	0.03	0.03	0.09	0.06	0.04	0.04	1																												
logSdLogFsta_0	-1.73	0.2	-0.03	0.01	0	0	0	-0.01	0	0.01	0.01	-0.01	1																											
logSdLogFsta_1	-2.09	0.12	-0.01	-0.03	-0.04	-0.04	-0.06	-0.02	-0.05	-0.04	-0.06	-0.01	0.49	1																										
logSdLogFsta_2	-1.7	0.18	-0.03	-0.05	-0.08	-0.13	-0.2	-0.04	-0.08	-0.12	-0.19	-0.01	0.15	0.32	1																									
logSdLogN_0	-0.22	0.11	-0.04	-0.01	-0.01	-0.01	0	-0.02	0	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	1																								
logSdLogN_1	-2.09	0.11	-0.03	0	-0.02	-0.02	0.01	-0.01	0.03	-0.04	-0.04	-0.03	-0.03	-0.05	-0.04	0.24	1																							
logSdLogObs_0	-0.53	0.11	0	-0.01	0	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.08	-0.01	0.01	-0.08	-0.08	1																						
logSdLogObs_1	-1.51	0.13	-0.02	-0.04	0	0	-0.01	-0.03	-0.01	0	-0.01	-0.01	-0.01	0.02	0.01	-0.03	-0.06	0.06	1																					
logSdLogObs_2	-2.75	0.22	0	0	-0.01	-0.02	-0.05	0	-0.01	-0.02	-0.03	0.01	-0.09	-0.17	-0.04	-0.07	-0.38	0.06	-0.02	1																				
logSdLogObs_3	0.85	0.13	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.02	0.03	0.01	0.01	0	-0.15	-0.19	0.03	0.01	0.06	1																			
logSdLogObs_4	0.62	0.07	0.02	0.03	0.03	0.02	0.02	0.01	0	0.03	0.03	0.01	0.01	-0.02	0	-0.06	-0.11	0.02	0	-0.03	0.04	1																		
logSdLogObs_5	0.85	0.16	0.03	0	-0.01	-0.01	-0.03	0.02	-0.03	-0.01	-0.02	0.03	0.03	0.02	0.02	-0.18	-0.26	0.05	-0.02	0.09	0.16	0.06	1																	
logSdLogObs_6	0.44	0.1	0.04	0.06	0.07	0.11	0.16	0.05	0.09	0.13	0.18	0.02	0.02	-0.03	-0.06	-0.03	-0.04	-0.02	-0.03	-0.09	0.01	0.05	0.02	1																
logSdLogObs_7	0.89	0.13	0	0	-0.01	-0.01	-0.01	0	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01	-0.04	-0.07	0	-0.01	0.02	0.05	0.01	0.07	0	1															
transfIRARdist_0	3.41	864.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1														
transfIRARdist_1	0.15	0.25	0	-0.03	-0.03	-0.01	-0.01	-0.02	-0.02	0	-0.01	0	0.03	0.04	0	-0.02	-0.03	0	-0.01	-0.07	0	-0.45	0.02	0.01	0.02	0	1													
transfIRARdist_2	0.74	0.71	0.03	0.02	0.03	0.04	0.05	0	-0.02	0.03	0.05	0.01	0.01	-0.01	-0.02	-0.1	-0.08	-0.01	-0.04	-0.02	0.06	0.05	-0.11	0	0.02	0	0.05	1												
transfIRARdist_3	0.03	0.34	-0.01	-0.02	-0.03	-0.05	-0.07	-0.02	-0.05	-0.08	-0.08	0	0	0.03	0.03	0	0.01	0	-0.06	-0.05	0	0	0.03	-0.47	0.02	0	0.03	0.02	1											
itrans_rho_0	1.83	0.23	-0.01	-0.01	-0.02	-0.03	-0.03	-0.02	0	-0.04	-0.05	-0.01	0.16	0.35	0.15	0.02	0.12	0.13	0.08	0.09	-0.02	-0.02	-0.02	-0.04	-0.01	0	-0.01	-0.02	-0.01	1										
logPhiMO_0	6.27	1.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1									
logPhiMO_1	5.97	1.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.65	1								
logSdProcLogitMO_0	2.31	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.79	1							
meanLogitMO_0	-5.01	0.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.03	-0.06	-0.05	1						
meanLogitMO_1	-2.06	0.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	-0.05	-0.05	0.93	1					
meanLogitMO_2	-0.55	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.05	-0.04	-0.05	0.92	0.97	1				
meanLogitMO_3	0.63	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	-0.05	-0.05	0.9	0.96	0.97	1			
meanLogitMO_4	1.68	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.03	-0.05	-0.04	0.89	0.94	0.96	0.97	1		
meanLogitMO_5	5.89	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	-0.03	-0.04	0.78	0.87	0.89	0.9	0.91	1	
logSdMO_0	-3.47	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.1	-0.25	-0.04	-0.15	-0.03	-0.01	0.01	0.02	0.23	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	0.088	0.444	0.508	0.461	0.458	0.415	0.471
1964	0.099	0.483	0.561	0.507	0.502	0.472	0.517
1965	0.115	0.536	0.622	0.549	0.534	0.507	0.569
1966	0.12	0.548	0.631	0.548	0.535	0.514	0.576
1967	0.132	0.588	0.676	0.587	0.581	0.581	0.617
1968	0.145	0.626	0.713	0.619	0.609	0.612	0.653
1969	0.135	0.591	0.666	0.58	0.577	0.567	0.613
1970	0.154	0.642	0.704	0.598	0.584	0.561	0.648
1971	0.196	0.754	0.804	0.673	0.65	0.644	0.744
1972	0.232	0.839	0.873	0.728	0.703	0.725	0.813
1973	0.233	0.827	0.838	0.694	0.666	0.66	0.786
1974	0.228	0.8	0.793	0.656	0.637	0.624	0.75
1975	0.26	0.871	0.855	0.703	0.681	0.68	0.81
1976	0.296	0.948	0.917	0.738	0.712	0.718	0.868
1977	0.279	0.902	0.871	0.695	0.686	0.693	0.823
1978	0.318	0.991	0.983	0.787	0.776	0.819	0.92
1979	0.282	0.896	0.903	0.715	0.693	0.69	0.838
1980	0.316	0.972	0.999	0.793	0.751	0.776	0.921
1981	0.313	0.971	1.015	0.808	0.752	0.785	0.931
1982	0.354	1.07	1.146	0.922	0.848	0.94	1.046
1983	0.339	1.045	1.125	0.915	0.832	0.917	1.028
1984	0.308	0.976	1.051	0.869	0.79	0.858	0.965
1985	0.285	0.928	1.001	0.843	0.762	0.818	0.924
1986	0.305	0.984	1.08	0.931	0.838	0.944	0.998
1987	0.285	0.948	1.051	0.921	0.825	0.928	0.974
1988	0.287	0.959	1.078	0.949	0.843	0.955	0.995
1989	0.291	0.972	1.1	0.983	0.874	1.01	1.018
1990	0.262	0.906	1.025	0.92	0.816	0.914	0.95
1991	0.247	0.874	1.007	0.925	0.832	0.944	0.935
1992	0.23	0.837	0.98	0.914	0.821	0.915	0.91
1993	0.244	0.881	1.058	0.981	0.877	1.001	0.973
1994	0.226	0.84	1.038	0.949	0.845	0.94	0.942
1995	0.197	0.772	0.974	0.88	0.782	0.832	0.875
1996	0.193	0.769	1.012	0.927	0.85	0.946	0.902
1997	0.189	0.763	1.046	0.98	0.908	1.027	0.93
1998	0.233	0.892	1.268	1.209	1.118	1.362	1.123
1999	0.228	0.883	1.295	1.253	1.171	1.442	1.144
2000	0.227	0.884	1.313	1.285	1.204	1.477	1.161
2001	0.156	0.672	0.991	0.974	0.915	0.979	0.879
2002	0.198	0.796	1.192	1.167	1.082	1.222	1.052
2003	0.129	0.579	0.864	0.835	0.769	0.731	0.76
2004	0.14	0.614	0.921	0.873	0.806	0.765	0.803
2005	0.145	0.628	0.942	0.878	0.827	0.783	0.816
2006	0.129	0.57	0.845	0.776	0.75	0.679	0.731
2007	0.112	0.51	0.769	0.706	0.688	0.585	0.662
2008	0.104	0.482	0.742	0.681	0.682	0.582	0.635
2009	0.097	0.457	0.718	0.664	0.671	0.555	0.613
2010	0.076	0.379	0.603	0.562	0.572	0.435	0.515
2011	0.054	0.293	0.468	0.446	0.466	0.327	0.403
2012	0.048	0.269	0.432	0.415	0.436	0.292	0.372
2013	0.047	0.263	0.43	0.412	0.431	0.282	0.368
2014	0.048	0.266	0.441	0.42	0.441	0.286	0.376
2015	0.049	0.268	0.451	0.434	0.468	0.314	0.384
2016	0.048	0.267	0.453	0.431	0.464	0.3	0.384
2017	0.057	0.299	0.516	0.488	0.523	0.351	0.434
2018	0.079	0.38	0.67	0.624	0.677	0.508	0.558
2019	0.075	0.367	0.652	0.607	0.673	0.501	0.542
2020	0.058	0.305	0.539	0.499	0.557	0.376	0.448

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).

Year/Age	1	2	3	4	5	6+	Total
1963	446529	180484	20288	10373	8278	5804	671755
1964	727964	125464	52141	11555	5257	7505	929887
1965	985009	214875	40464	22970	6209	5808	1275333
1966	1193302	264645	67817	16357	9345	6377	1557842
1967	1012126	322778	72880	28447	7953	8191	1452375
1968	500385	279617	90064	28690	14272	6980	920008
1969	435718	132267	72765	34112	11401	10114	696376
1970	1479665	123107	39001	32378	15391	8546	1698087
1971	1956201	403257	33559	14920	15962	10418	2434316
1972	479664	507918	90500	12043	5910	12251	1108286
1973	698722	114146	106004	29796	4930	6847	960444
1974	689808	170487	23734	36375	10912	5452	936768
1975	1197898	163510	36861	9646	16298	6870	1431083
1976	820106	288393	33920	13562	3771	9336	1169088
1977	2002052	174274	51226	10714	5053	5757	2249075
1978	1177574	457184	30885	18608	5573	4194	1694018
1979	1478518	263506	81472	8887	7266	3274	1842922
1980	2370072	312464	59406	24556	3949	4293	2774739
1981	931094	497921	59579	17610	8671	3259	1518134
1982	1459702	191346	93973	17070	6539	4939	1773568
1983	831936	308201	34119	21284	5479	3908	1204927
1984	1526121	178040	52373	8149	6749	3386	1774818
1985	376392	330357	33551	14909	2816	3761	761785
1986	1825626	87368	57597	10405	5570	2570	1989135
1987	701797	420715	16490	15338	3033	2901	1160274
1988	471493	161989	72250	5378	4877	1987	717974
1989	846975	108077	31153	16991	1828	2492	1007516
1990	340447	193230	20302	7805	4946	1366	568096
1991	398707	81787	31014	5904	2605	2485	522501
1992	957698	98286	15861	8627	1984	1686	1084141
1993	436538	222505	19216	5262	2848	1313	687682
1994	1078364	108545	36377	5388	1663	1360	1231696
1995	687763	255870	22879	9517	1681	994	978703
1996	469770	168386	42290	6044	3404	1174	691069
1997	1542688	130570	32001	11202	2183	1566	1720210
1998	144395	415464	27880	8802	3750	1179	601470
1999	312967	38327	63484	6010	2218	1317	424323
2000	452949	79405	8942	10285	1503	800	553885
2001	183390	125746	13225	1981	1928	479	326749
2002	265362	51186	27530	4189	639	764	349671
2003	120876	64278	9028	5832	891	326	201231
2004	241790	37547	14360	2930	1921	437	298986
2005	192080	62102	8746	3586	1030	869	268412
2006	423208	53151	13430	2203	1092	726	493811
2007	190907	112919	10988	4182	971	645	320613
2008	214364	48978	25562	3266	1608	793	294571
2009	240060	56682	12052	7995	1410	930	319128
2010	302150	67827	14327	4127	3349	934	392714
2011	143866	89265	17161	5011	1934	2229	259466
2012	222046	42719	25541	7068	2133	1920	301427
2013	251482	60921	13820	10298	3231	1818	341570
2014	313474	74510	19248	5878	4570	2201	419882
2015	147284	99594	24106	7315	2474	3523	284296
2016	102928	43049	30169	11286	3304	2470	193206
2017	313264	30118	14071	11643	5151	2480	376727
2018	67402	79236	10161	5521	4288	3490	170099
2019	145193	19138	17753	2935	2142	2912	190073
2020	271264	44490	5694	4708	1172	1791	329120
2021	185468	80510	13696	2356	1839	1323	285191

Table 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated catches at age (thousands).

Year/Age	1	2	3	4	5	6+
1963	22288	47508	7335	3501	2779	1798
1964	40720	35398	20353	4200	1896	2580
1965	63761	65773	17039	8877	2349	2111
1966	80152	82515	28860	6311	3540	2343
1967	74686	106283	32592	11568	3207	3302
1968	40167	96483	41833	12125	5963	2927
1969	32664	43723	32222	13736	4572	4005
1970	125803	43293	17950	13334	6233	3355
1971	208970	159555	16912	6700	6988	4532
1972	59752	216475	48147	5714	2737	5795
1973	87292	48168	54913	13678	2197	3031
1974	84369	70352	11853	16037	4708	2318
1975	164552	71665	19319	4465	7381	3106
1976	126329	133930	18578	6492	1762	4386
1977	290932	78412	27122	4921	2300	2639
1978	191885	218983	17618	9309	2761	2155
1979	215429	118274	44054	4164	3329	1496
1980	381743	147883	34149	12340	1913	2127
1981	148643	235216	34546	8963	4205	1626
1982	259443	95952	58369	9458	3435	2771
1983	142842	152037	20961	11735	2844	2159
1984	241541	84005	30915	4347	3385	1793
1985	55693	150541	19225	7796	1378	1929
1986	288198	41254	34479	5796	2905	1445
1987	104862	193475	9711	8488	1565	1613
1988	71053	74796	43141	3032	2554	1125
1989	129670	50181	18800	9784	979	1459
1990	47623	85430	11744	4316	2534	753
1991	53024	35171	17732	3276	1352	1397
1992	119813	40910	8912	4748	1020	930
1993	57727	95665	11288	3024	1530	765
1994	133247	45036	21077	3033	872	762
1995	75119	99687	12725	5106	837	516
1996	50225	65178	23998	3349	1791	661
1997	162087	50059	18449	6421	1198	927
1998	18391	176629	17815	5681	2329	813
1999	39159	16080	40829	3951	1413	933
2000	56496	33132	5764	6846	973	573
2001	16131	42834	7236	1128	1064	275
2002	29035	19570	16697	2649	390	498
2003	8787	19246	4491	3015	439	155
2004	19015	11680	7425	1559	976	215
2005	15540	19526	4581	1916	532	433
2006	30338	15446	6562	1087	529	328
2007	11891	29947	5048	1935	443	261
2008	12399	12378	11487	1474	729	320
2009	12994	13716	5311	3548	631	362
2010	12875	14059	5579	1622	1336	301
2011	4385	14817	5143	1533	613	526
2012	6072	6574	7189	2039	640	412
2013	6720	9229	3885	2951	962	377
2014	8533	11419	5534	1713	1384	463
2015	4089	15451	7071	2188	786	803
2016	2850	6664	8895	3362	1042	542
2017	10163	5173	4612	3829	1789	622
2018	3028	16805	4064	2191	1806	1184
2019	6255	3950	6979	1141	898	977
2020	9164	7832	1940	1575	427	476

Table 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated maturity at age.

Year/Age	1	2	3	4	5	6+
1963	0.004	0.064	0.238	0.505	0.744	0.995
1964	0.004	0.064	0.237	0.504	0.743	0.995
1965	0.004	0.064	0.237	0.504	0.743	0.995
1966	0.003	0.063	0.236	0.503	0.742	0.995
1967	0.003	0.063	0.235	0.501	0.742	0.995
1968	0.003	0.062	0.234	0.5	0.741	0.995
1969	0.003	0.062	0.232	0.498	0.74	0.995
1970	0.003	0.061	0.231	0.497	0.738	0.995
1971	0.003	0.061	0.229	0.494	0.737	0.995
1972	0.003	0.06	0.226	0.492	0.735	0.995
1973	0.003	0.059	0.224	0.489	0.734	0.995
1974	0.003	0.058	0.22	0.485	0.732	0.995
1975	0.003	0.057	0.216	0.48	0.729	0.995
1976	0.003	0.056	0.211	0.472	0.726	0.995
1977	0.003	0.056	0.205	0.462	0.719	0.995
1978	0.004	0.06	0.192	0.458	0.699	0.995
1979	0.003	0.057	0.193	0.446	0.671	0.995
1980	0.004	0.057	0.177	0.367	0.654	0.994
1981	0.003	0.055	0.186	0.402	0.612	0.994
1982	0.003	0.055	0.178	0.427	0.637	0.994
1983	0.003	0.056	0.195	0.42	0.701	0.994
1984	0.004	0.055	0.213	0.439	0.69	0.994
1985	0.004	0.058	0.195	0.458	0.691	0.995
1986	0.004	0.069	0.202	0.419	0.679	0.995
1987	0.005	0.068	0.233	0.471	0.724	0.995
1988	0.006	0.08	0.231	0.476	0.678	0.995
1989	0.007	0.106	0.264	0.5	0.73	0.995
1990	0.007	0.11	0.293	0.494	0.732	0.995
1991	0.006	0.113	0.348	0.533	0.744	0.995
1992	0.006	0.127	0.398	0.673	0.752	0.996
1993	0.006	0.116	0.397	0.666	0.801	0.996
1994	0.006	0.123	0.423	0.713	0.847	0.997
1995	0.008	0.116	0.406	0.719	0.86	0.997
1996	0.008	0.153	0.446	0.741	0.867	0.997
1997	0.009	0.171	0.513	0.729	0.87	0.998
1998	0.014	0.179	0.514	0.777	0.901	0.998
1999	0.016	0.253	0.521	0.771	0.92	0.998
2000	0.016	0.238	0.592	0.809	0.917	0.998
2001	0.017	0.228	0.54	0.828	0.941	0.999
2002	0.015	0.256	0.546	0.82	0.965	0.999
2003	0.011	0.234	0.546	0.778	0.939	0.999
2004	0.011	0.221	0.638	0.784	0.913	0.999
2005	0.015	0.216	0.594	0.812	0.911	0.999
2006	0.018	0.232	0.555	0.809	0.909	0.998
2007	0.02	0.25	0.593	0.811	0.926	0.998
2008	0.021	0.303	0.649	0.821	0.923	0.999
2009	0.018	0.272	0.66	0.841	0.923	0.999
2010	0.017	0.238	0.658	0.842	0.932	0.999
2011	0.016	0.213	0.637	0.847	0.937	0.999
2012	0.014	0.215	0.558	0.822	0.929	0.999
2013	0.014	0.175	0.52	0.814	0.917	0.999
2014	0.014	0.18	0.497	0.803	0.914	0.998
2015	0.014	0.198	0.46	0.762	0.896	0.998
2016	0.013	0.181	0.425	0.73	0.881	0.998
2017	0.012	0.178	0.479	0.744	0.886	0.998
2018	0.009	0.183	0.486	0.759	0.912	0.998
2019	0.008	0.198	0.54	0.765	0.913	0.998
2020	0.008	0.155	0.542	0.777	0.899	0.998
2021	0.007	0.131	0.424	0.715	0.884	0.998

Table 4.12a. 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 pointwise 95% confidence intervals. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), catches 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	Catches (tonnes)	Low	High	Fbar 2-4	Low	High
1963	446529	321966	619281	316909	261051	384719	131187	78755	218526	117862	104623	132777	0.471	0.403	0.55
1964	727964	526131	1007225	360719	305841	425444	140120	84982	231032	144765	131138	159808	0.517	0.45	0.595
1965	985009	715333	1356350	459169	396157	532205	163823	99526	269660	198425	177139	222269	0.569	0.495	0.654
1966	1193302	867006	1642398	545229	475283	625469	183167	113104	296630	241275	215839	269709	0.576	0.503	0.658
1967	1012126	735076	1393595	609506	533557	696267	206032	130737	324690	288624	257746	323202	0.617	0.543	0.702
1968	500385	362511	690696	590165	523317	665552	210716	131869	336705	294748	267336	324972	0.653	0.572	0.744
1969	435718	313878	604853	481914	424717	546814	209070	138341	315962	224898	207616	243619	0.613	0.539	0.696
1970	1479665	1072818	2040800	537469	472586	611259	213550	148068	307991	251648	221126	286382	0.648	0.574	0.731
1971	1956201	1413516	2707235	647446	570832	734344	219837	160622	300883	353767	303802	411950	0.744	0.663	0.834
1972	479664	346319	664352	614171	544896	692252	201530	146718	276820	368362	322287	421025	0.813	0.726	0.912
1973	698722	505031	966697	454365	412698	500238	166750	116695	238274	258676	235578	284038	0.786	0.701	0.882
1974	689808	497909	955667	434111	390720	482322	177838	130971	241477	234352	209688	261918	0.75	0.667	0.843
1975	1197898	857767	1672902	417838	375503	464946	168209	131812	214656	245668	214644	281176	0.81	0.724	0.905
1976	820106	583430	1152792	397450	354752	445286	145059	115967	181451	248870	215895	286882	0.868	0.775	0.971
1977	2002052	1433422	2796253	413843	367141	466485	121682	97348	152097	260972	215794	315607	0.823	0.735	0.92
1978	1177574	841376	1648111	514224	452393	584505	116822	96448	141500	358503	297035	432691	0.92	0.825	1.027
1979	1478518	1058000	2066177	517641	466379	574538	117511	96765	142704	331362	285250	384929	0.838	0.751	0.936
1980	2370072	1688976	3325825	562222	500545	631499	117719	98074	141300	387096	322733	464295	0.921	0.829	1.024
1981	931094	664966	1303729	580859	517420	652077	127896	107717	151856	392571	335308	459613	0.931	0.839	1.033
1982	1459702	1054901	2019840	511429	463432	564397	129629	110076	152656	377364	322879	441044	1.046	0.946	1.157
1983	831936	616716	1122263	436977	392001	487113	108283	92559	126678	314373	269535	366670	1.028	0.93	1.136
1984	1526121	1140924	2041366	391175	354339	431840	96066	81840	112765	273083	233922	318801	0.965	0.873	1.067
1985	376392	273971	517103	362934	325796	404305	91854	78291	107766	238404	207562	273829	0.924	0.835	1.022
1986	1825626	1368117	2436128	325102	292355	361517	80288	68428	94203	232018	194681	276516	0.998	0.904	1.102
1987	701797	523942	940026	392845	346697	445135	82608	70233	97164	270149	228515	319369	0.974	0.882	1.074
1988	471493	348063	638694	304219	278635	332152	77578	64911	92718	210121	186344	236931	0.995	0.902	1.098
1989	846975	629030	1140434	257290	233387	283641	74208	63813	86296	181107	156103	210116	1.018	0.923	1.123
1990	340447	252205	459563	215906	195246	238753	65876	56785	76423	141315	123517	161677	0.95	0.858	1.053
1991	398707	298956	531742	186391	170401	203882	65972	57037	76306	120877	107154	136358	0.935	0.846	1.034
1992	957698	732453	1252210	228508	205096	254593	67467	58919	77256	144934	122774	171092	0.91	0.826	1.003
1993	436538	336918	565612	241493	217065	268669	69739	59985	81080	158451	137430	182686	0.973	0.883	1.073
1994	1078364	831267	1398912	231406	210393	254519	72155	62368	83477	148967	129216	171737	0.942	0.854	1.039
1995	687763	531786	889489	284550	256061	316209	77792	67297	89922	169224	146144	195949	0.875	0.79	0.969
1996	469770	362453	608862	259678	237385	284065	92444	80222	106528	157791	139975	177873	0.902	0.817	0.997
1997	1542688	1189378	2000950	304147	271637	340548	94210	83217	106655	181845	153885	214884	0.93	0.845	1.023
1998	144395	108078	192916	277619	246474	312700	98224	83813	115113	187054	161863	216166	1.123	1.028	1.228
1999	312967	236541	414085	153330	142422	165073	79094	69186	90422	110270	100633	120829	1.144	1.049	1.247
2000	452949	347232	590851	133653	120656	148050	55878	49499	63078	91567	79541	105411	1.161	1.059	1.272
2001	183390	139227	241562	107549	97306	118870	43323	37406	50177	59831	52724	67897	0.879	0.794	0.973
2002	265362	201122	350121	93931	86412	102103	46869	41046	53519	62427	56242	69291	1.052	0.95	1.164
2003	120876	91416	159831	73721	67063	81041	34964	30509	40070	38694	34605	43265	0.76	0.676	0.853
2004	241790	183054	319372	63619	57870	69940	33092	29148	37569	35194	31921	38803	0.803	0.72	0.896
2005	192080	145231	254040	72196	64972	80223	31978	27683	36938	41959	37057	47509	0.816	0.732	0.91
2006	423208	325278	550622	89534	79754	100513	34362	29372	40199	32938	29138	37233	0.731	0.649	0.823
2007	190907	145525	250440	106752	95226	119674	45667	38811	53735	53443	46925	60865	0.662	0.584	0.75
2008	214364	164414	279489	125550	112952	139553	65201	55828	76147	51990	47276	57176	0.635	0.557	0.724
2009	240060	181712	317144	122692	109037	138058	66101	56388	77487	54558	49373	60288	0.613	0.531	0.708
2010	302150	233401	391149	134667	117956	153746	69172	57747	82857	48930	44447	53865	0.515	0.442	0.601
2011	143866	108669	190462	136933	117432	159671	77527	62887	95574	43131	39262	47381	0.403	0.346	0.468
2012	222046	168037	293415	143177	123153	166456	81688	66134	100901	39255	36400	42335	0.372	0.319	0.433
2013	251482	191761	329801	143987	123680	167627	82352	66727	101635	41035	37810	44534	0.368	0.317	0.428
2014	313474	241919	406192	157206	136285	181339	80119	64988	98773	44769	41032	48847	0.376	0.325	0.434
2015	147284	112986	191993	171985	149155	198309	85085	68605	105522	50160	45920	54792	0.384	0.335	0.441
2016	102928	78587	134808	154273	134088	177496	85860	69782	105641	50072	46612	53789	0.384	0.334	0.441
2017	313264	237280	413582	141555	122628	163404	84416	69067	103177	46439	43322	49780	0.434	0.38	0.497
2018	67402	51419	88354	121840	104680	141813	73006	59223	89997	48834	44816	53212	0.558	0.486	0.641
2019	145193	109871	191869	87765	73477	104830	56169	44019	71672	36757	34093	39629	0.542	0.461	0.637
2020	271264	183492	401022	81174	66670	98834	39390	29794	52077	24188	21645	27030	0.448	0.365	0.549
2021	185468	86218	398970	100006	77144	129643	37912	27703	51884						

Table 4.12b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated landings, discards (including BMS landings from 2016) and catch (=landings + discards). Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch.

Year	Landings	Discards	Catch
1963	106849	11007	117862
1964	134922	9845	144760
1965	180696	17743	198424
1966	214339	26992	241279
1967	261140	27446	288619
1968	277361	17367	294752
1969	215470	9454	224903
1970	231458	20198	251641
1971	293846	59938	353770
1972	333207	35115	368355
1973	233853	24813	258675
1974	208360	26018	234353
1975	208966	36659	245664
1976	203987	44929	248874
1977	182343	78729	260975
1978	310373	48103	358511
1979	272946	58448	331356
1980	290702	96574	387097
1981	341344	51164	392568
1982	319806	57550	377363
1983	279876	34549	314379
1984	208486	64524	273082
1985	211387	27018	238401
1986	170430	61659	232020
1987	235355	34681	270146
1988	195020	15027	210119
1989	139127	42019	181104
1990	117057	24245	141312
1991	104187	16657	120879
1992	111157	33728	144934
1993	130389	28041	158456
1994	105822	43129	148966
1995	135126	34141	169219
1996	134938	22819	157788
1997	134669	47213	181846
1998	145269	41716	187055
1999	95923	14364	110271
2000	75000	16572	91566
2001	47219	12588	59830
2002	51240	11189	62426
2003	33421	5263	38695
2004	27246	7948	35195
2005	30039	11923	41957
2006	23014	9922	32937
2007	24022	29423	53439
2008	26864	25131	51990
2009	32943	21606	54554
2010	36248	12691	48935
2011	33449	9686	43129
2012	32065	7191	39256
2013	30545	10495	41032
2014	34396	10374	44769
2015	37640	12518	50154
2016	38129	11941	50073
2017	37674	8772	46440
2018	40476	8348	48829
2019	32737	4031	36760
2020	19883	4298	24186

Table 4.13. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios based on the SAM assessment and assuming a 37% overshoot of the TAC in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2021)	0.288
SSB(2022)	53406
R(2021)	186075
R(2022)	222046
Catch(2021)	21798
Landings(2021)	16747
Discards(2021)	5051

Catch scenarios

Basis	Catch (2022)	Landings (2022)	Discards (2022)	F_{total} (2022)	$F_{landings}$ (2022)	$F_{discards}$ (2022)	SSB (2023)	% SSB change	% TAC change	% advice change	Risk
MSY approach	16311	13573	2738	0.156	0.125	0.031	79031	48	2.5	10.5	0.28
MAP	11111	9252	1859	0.103	0.083	0.0200	83308	56	-30	-25	0.199
F=0	0	0	0	0.00	0.00	0.00	92503	73	-100	-100	0.070
Fpa	44319	36540	7779	0.49	0.39	0.097	56552	5.9	179	200	0.81
FP.05 wo AR	38341	31693	6648	0.41	0.33	0.081	61164	14.5	141	160	0.72
Flim	50556	41494	9062	0.58	0.46	0.115	51836	-2.9	220	240	0.89
SSB(2023)=Blim	27714	22953	4761	0.28	0.22	0.056	69841	31	74	88	0.50
SSB(2023)=Btrigger=Bpa	0	0	0	0.00	0.00	0.00	92503	73	-100	-100	0.070
TAC(2021)-20%	12729	10597	2132	0.119	0.096	0.023	82025	54	-20.0	-13.7	0.23
TAC(2021)-15%	13524	11258	2266	0.127	0.102	0.025	81449	53	-15.0	-8.3	0.25
TAC(2021)-10%	14321	11924	2397	0.135	0.109	0.026	80796	51	-10.0	-2.9	0.26
TAC(2021)-5%	15115	12588	2527	0.143	0.115	0.028	80141	50	-5.0	2.4	0.27
Constant TAC	15911	13245	2666	0.151	0.122	0.029	79386	49	0.00	7.8	0.28
TAC(2021)+5%	16707	13901	2806	0.160	0.128	0.032	78649	47	5.0	13.2	0.30
TAC(2021)+10%	17502	14556	2946	0.168	0.135	0.033	78007	46	10.0	18.6	0.32
TAC(2021)+15%	18298	15223	3075	0.176	0.141	0.035	77393	45	15.0	24	0.33
TAC(2021)+20%	19093	15885	3208	0.185	0.148	0.037	76781	44	20.0	29	0.35
F=F2021	28387	23525	4862	0.29	0.23	0.057	69286	30	78	92	0.52
Fmsy lower	19220	15992	3228	0.186	0.149	0.037	76673	44	21	30	0.35
Fmsy	27752	22984	4768	0.28	0.22	0.055	69808	31	74	88	0.50
Fmsy upper	41374	34115	7259	0.45	0.36	0.089	58811	10.1	160	180	0.77

Table 4.14. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios based on the SAM assessment and assuming an F of 0.37 (lowest observed F in the time series) in the intermediate year as used to give advice. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2021)	0.37
SSB(2022)	49433
R(2021)	186075
R(2022)	222046
Catch(2021)	27153
Landings(2021)	20790
Discards(2021)	6363

Catch scenarios

Basis	Catch (2022)	Land-ings (2022)	Dis-cards (2022)	F_{total} (2022)	F_{land} (2022)	$F_{discard}$ (2022)	SSB (2023)	% SSB change	% TAC change	% advice change	Risk
MSY approach	14276	11779	2497	0.144	0.115	0.029	75484	52.7	-10.3	-3.2	0.369
MAP	9701	8011	1690	0.095	0.076	0.019	79425	60.7	-39.0	-34.3	0.285
F=0	0	0	0	0	0	0	87254	76.5	-100.0	-100.0	0.137
Fpa	41914	34250	7664	0.49	0.393	0.097	53444	8.1	163.4	184.1	0.864
FP.05 wo AR	36231	29674	6557	0.41	0.329	0.081	57902	17.1	127.7	145.6	0.786
Flim	47805	38801	9004	0.58	0.465	0.115	49118	-0.6	200.5	224.0	0.922
SSB(2023)=Blim	21340	17598	3742	0.222	0.178	0.044	69841	41.3	34.1	44.6	0.500
SSB(2023)=Btrigger=Bpa	0	0	0	0	0	0	87254	76.5	-100.0	-100.0	0.137
TAC(2021)-20%	12729	10493	2236	0.127	0.102	0.025	76741	55.2	-20.0	-13.7	0.353
TAC(2021)-15%	13524	11158	2366	0.135	0.109	0.026	76100	53.9	-15.0	-8.3	0.359
TAC(2021)-10%	14320	11816	2504	0.144	0.115	0.029	75445	52.6	-10.0	-2.9	0.370
TAC(2021)-5%	15116	12473	2643	0.153	0.122	0.031	74779	51.3	-5.0	2.4	0.379
Constant TAC	15912	13131	2781	0.161	0.129	0.032	74116	49.9	0.0	7.8	0.399
TAC(2021)+5%	16707	13788	2919	0.17	0.136	0.034	73494	48.7	5.0	13.2	0.413
TAC(2021)+10%	17502	14447	3055	0.179	0.144	0.035	72843	47.4	10.0	18.6	0.429
TAC(2021)+15%	18298	15112	3186	0.188	0.151	0.037	72197	46.1	15.0	24.0	0.448
TAC(2021)+20%	19093	15760	3333	0.197	0.158	0.039	71572	44.8	20.0	29.4	0.467
F=F2021	33282	27259	6023	0.37	0.297	0.073	60299	22.0	109.2	125.6	0.750
Fmsy lower	18130	14971	3159	0.186	0.149	0.037	72341	46.3	13.9	22.9	0.441
Fmsy	26169	21575	4594	0.28	0.225	0.055	65905	33.3	64.5	77.4	0.597
Fmsy upper	39128	31980	7148	0.45	0.361	0.089	55565	12.4	145.9	165.2	0.839

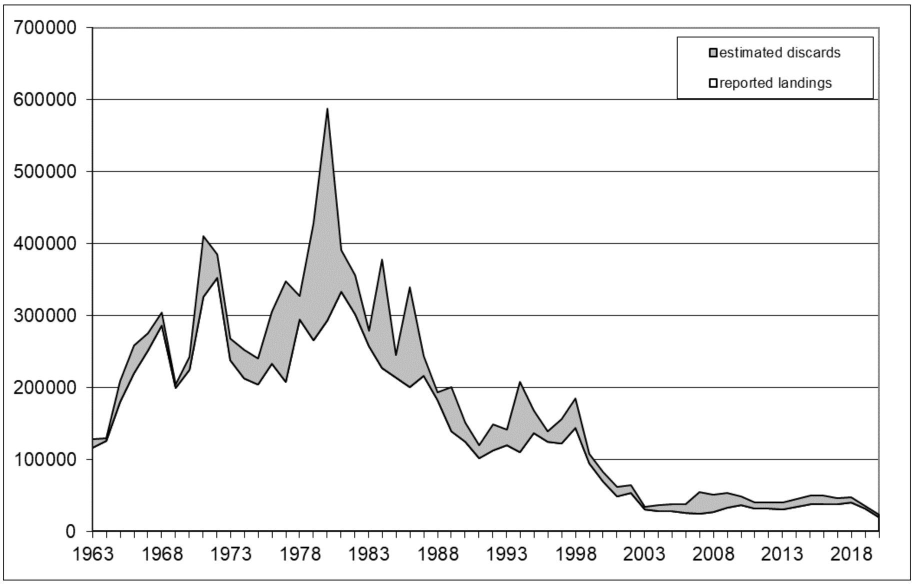


Figure 4.1a. Cod in Subarea 4, Division 7.d and Subdivision 20: stacked area plot of reported landings and estimated discards (including BMS landings; in tonnes).

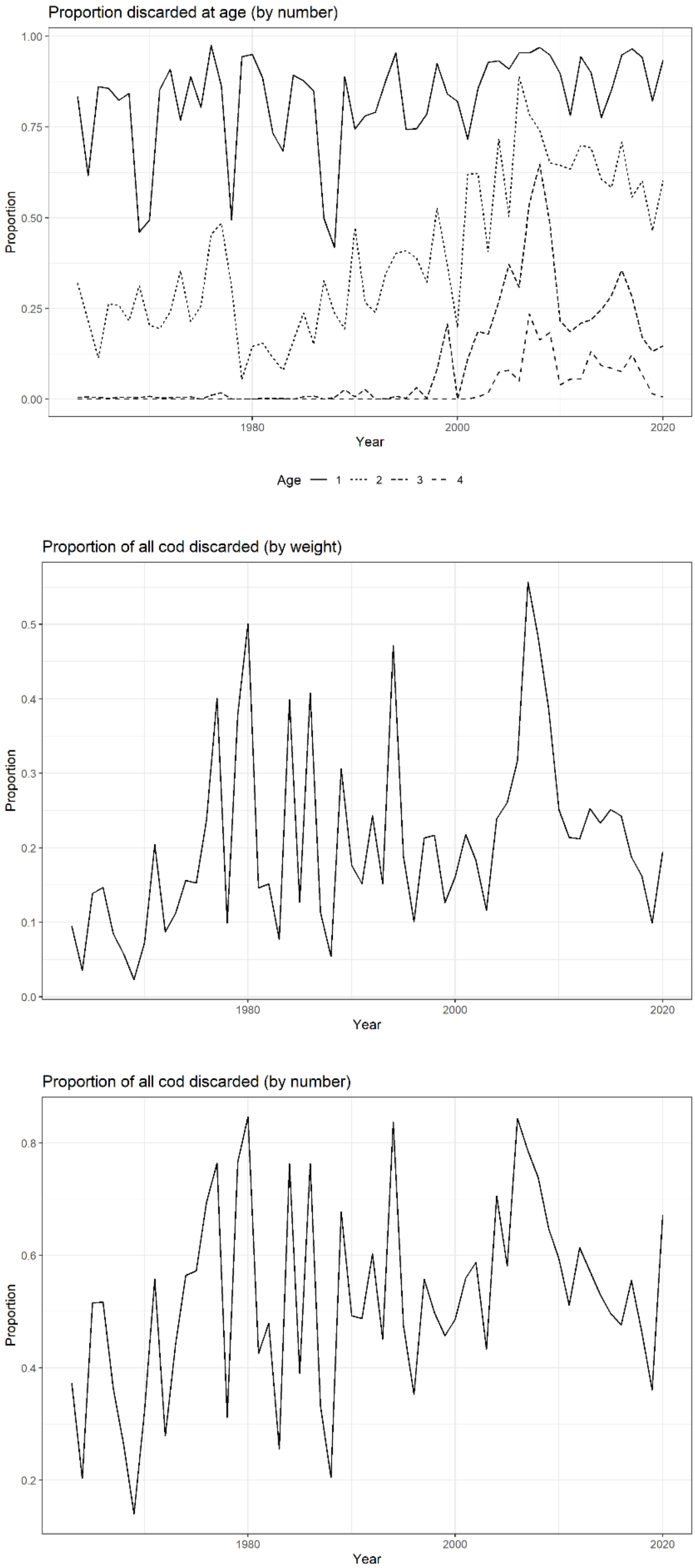


Figure 4.1b. Cod in Subarea 4, Division 7.d and Subdivision 20: (top) proportion of total numbers caught at age that are discarded; (middle) proportion of total weight caught that is discarded; and (bottom) proportion of the total numbers caught that are discarded.

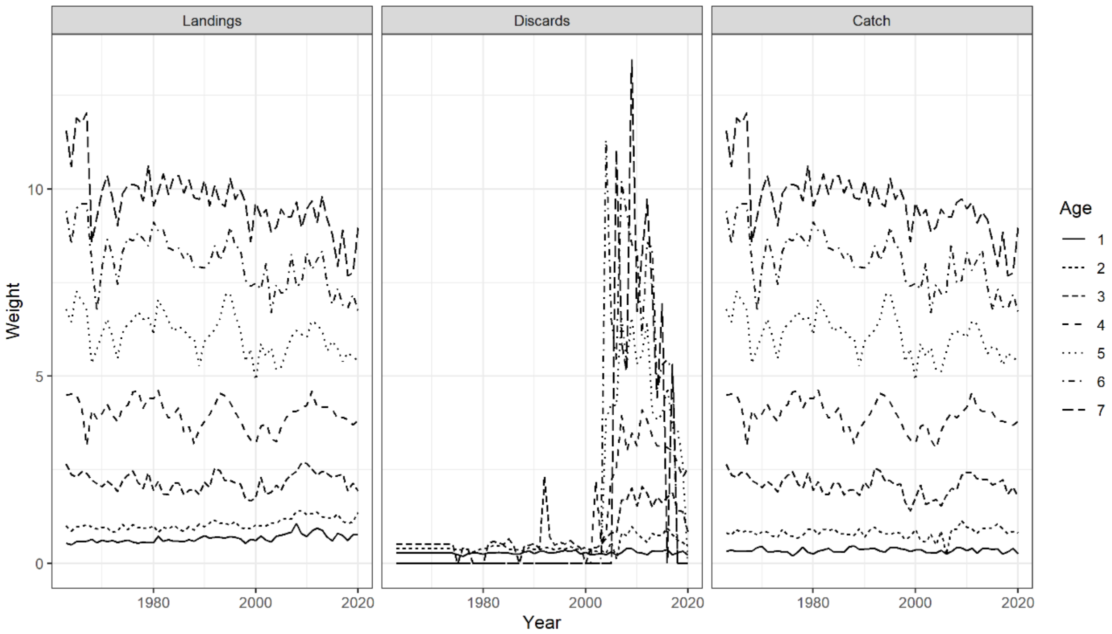


Figure 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weights at age by catch component for ages 1–7.

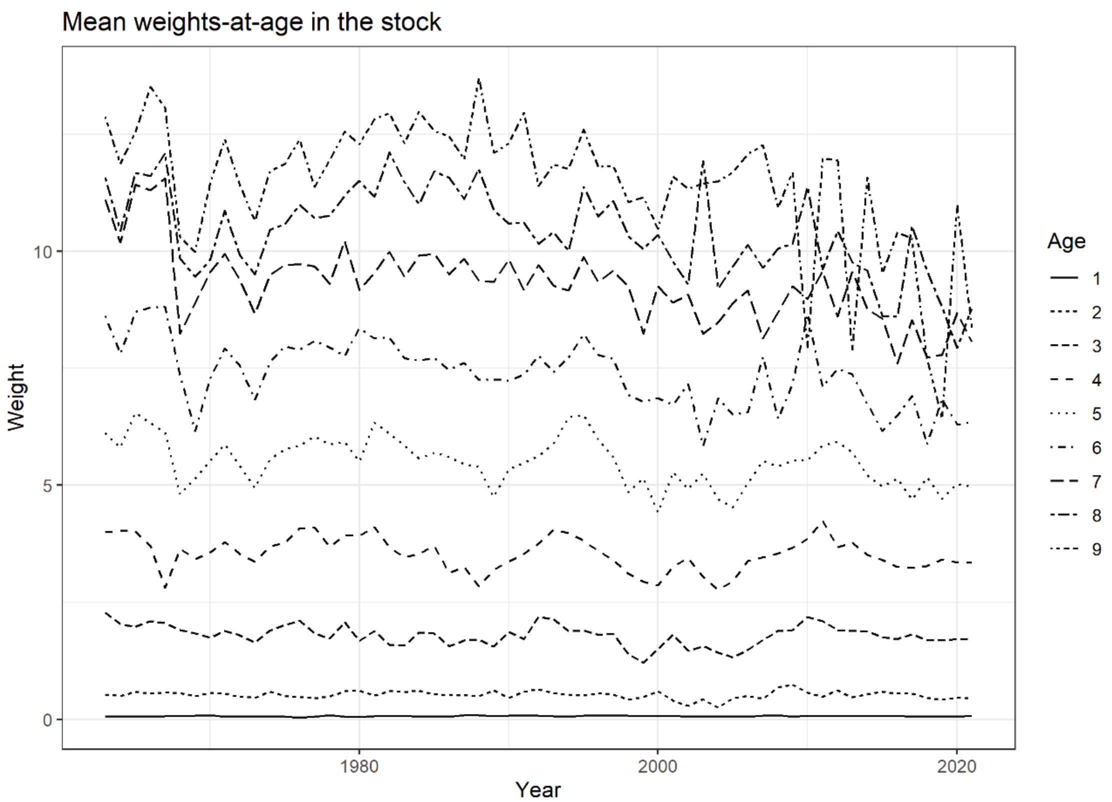


Figure 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weights at age in the stock.

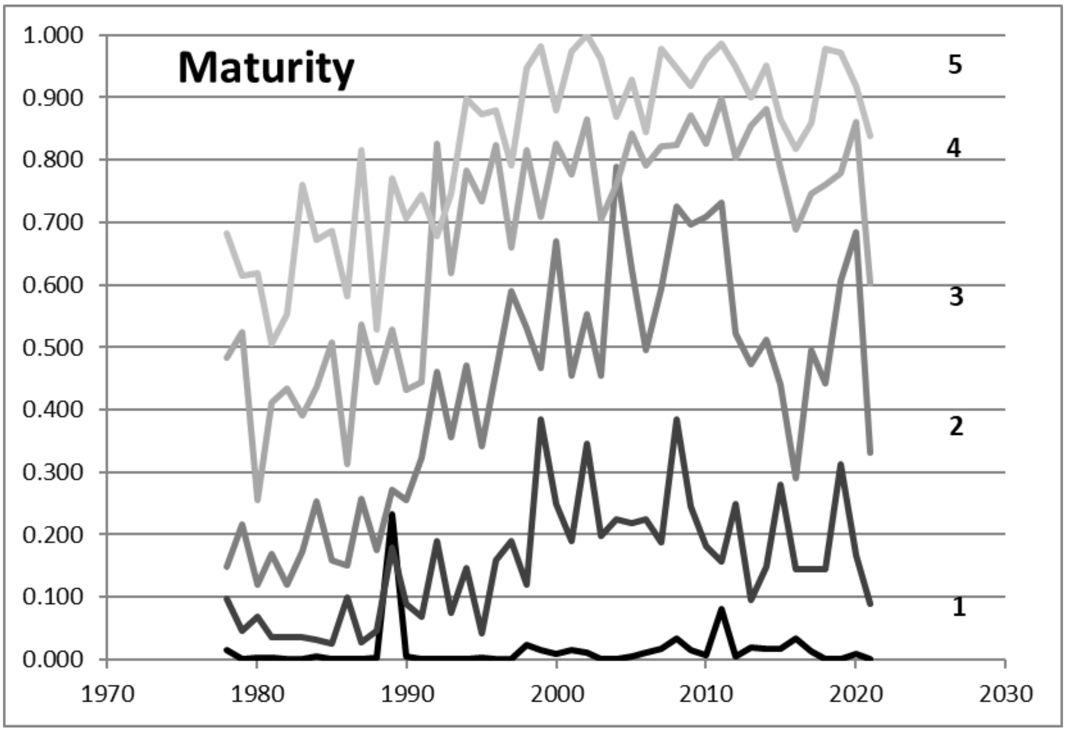


Figure 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Annually varying maturity-at-age.

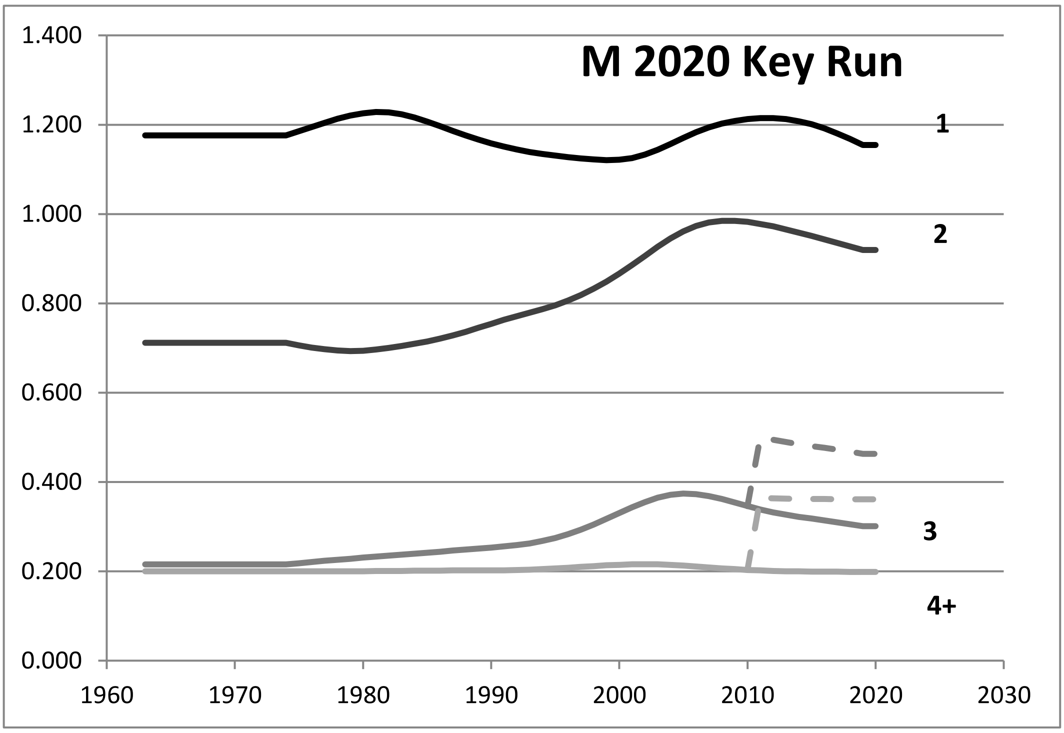


Figure 4.2d. Cod in Subarea 4, Division 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2020 key run (solid lines; ICES WGSAM, 2020). Values for 1963–1973 are set equal to the 1974 value, while values for 2020 are set equal to 2019. An ad hoc adjustment is made for ages 3+ to mimic a 15% emigration from the assessment area from 2011 (dashed lines).

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 2002–2021 in the North Sea.

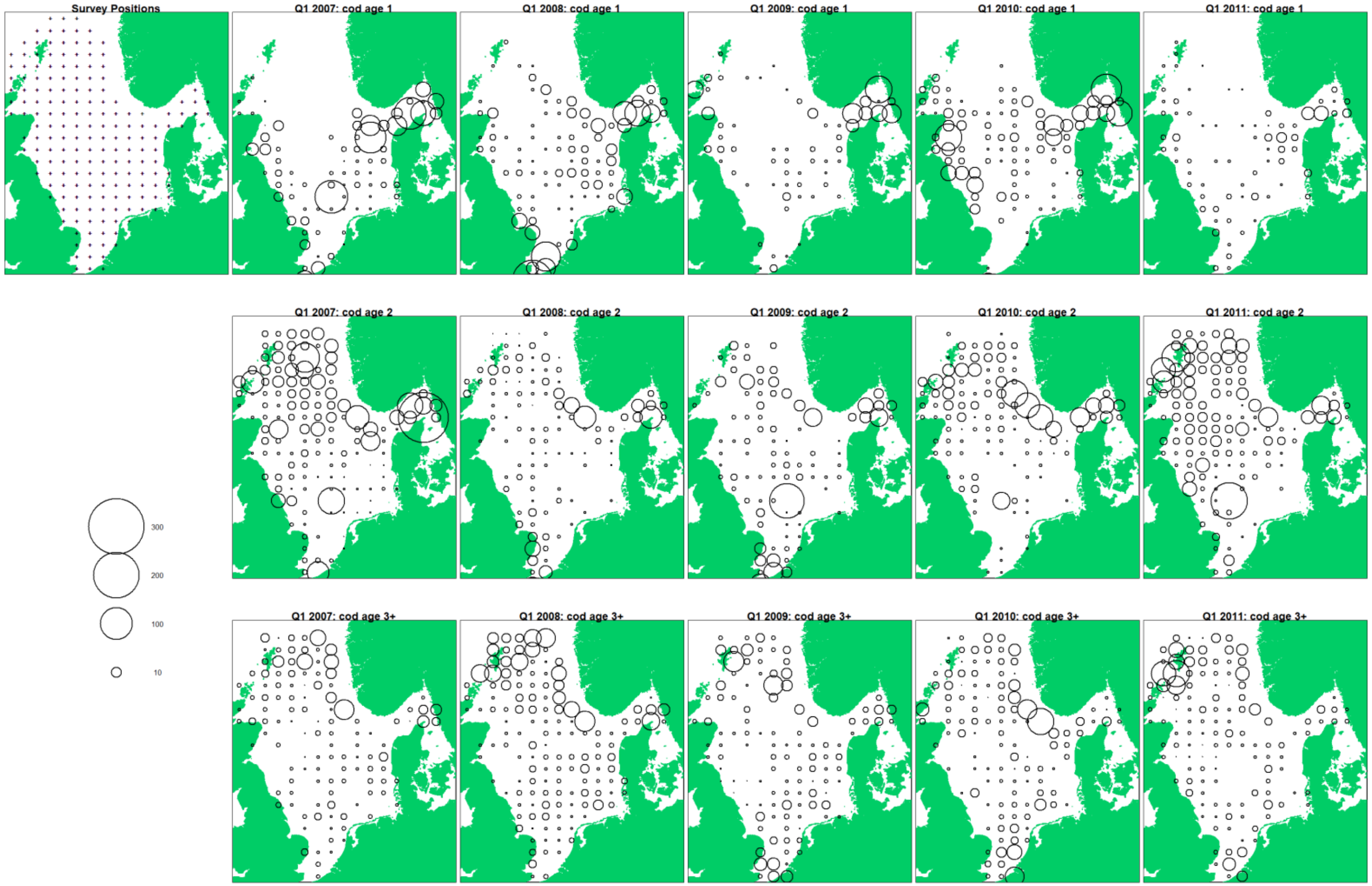


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

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 2002–2021 in the North Sea.

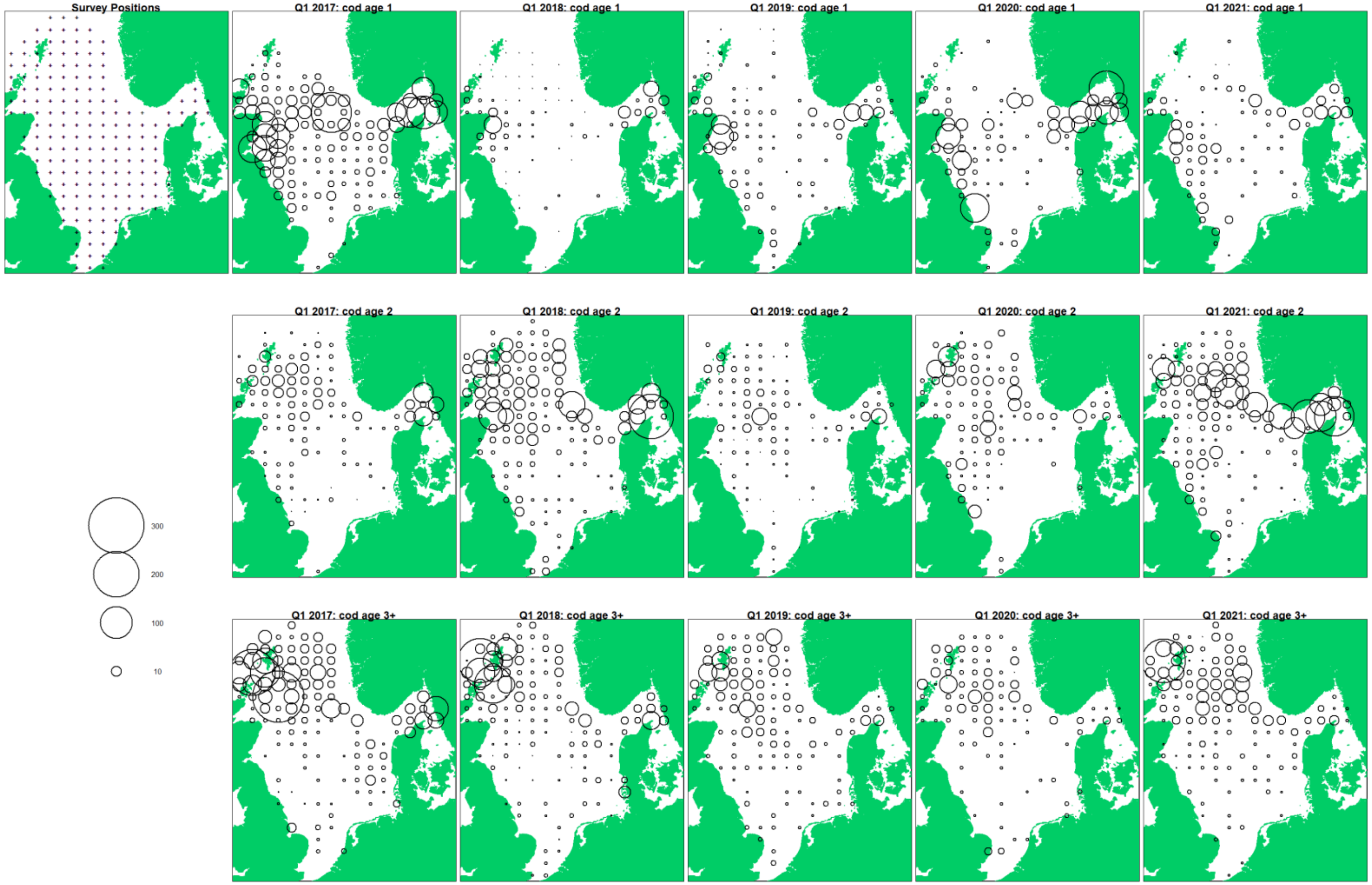


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

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 2002–2020 in the North Sea.

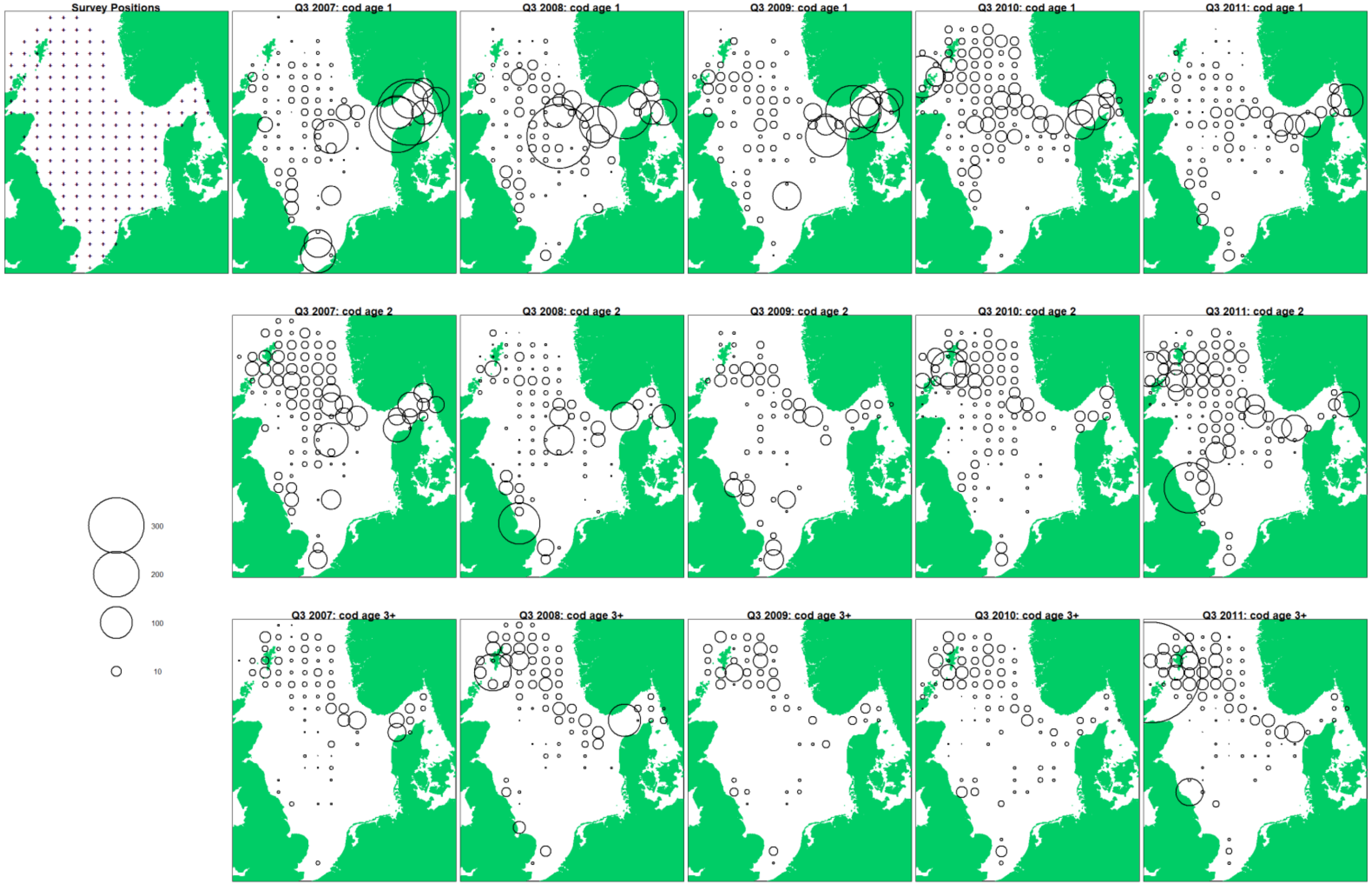


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

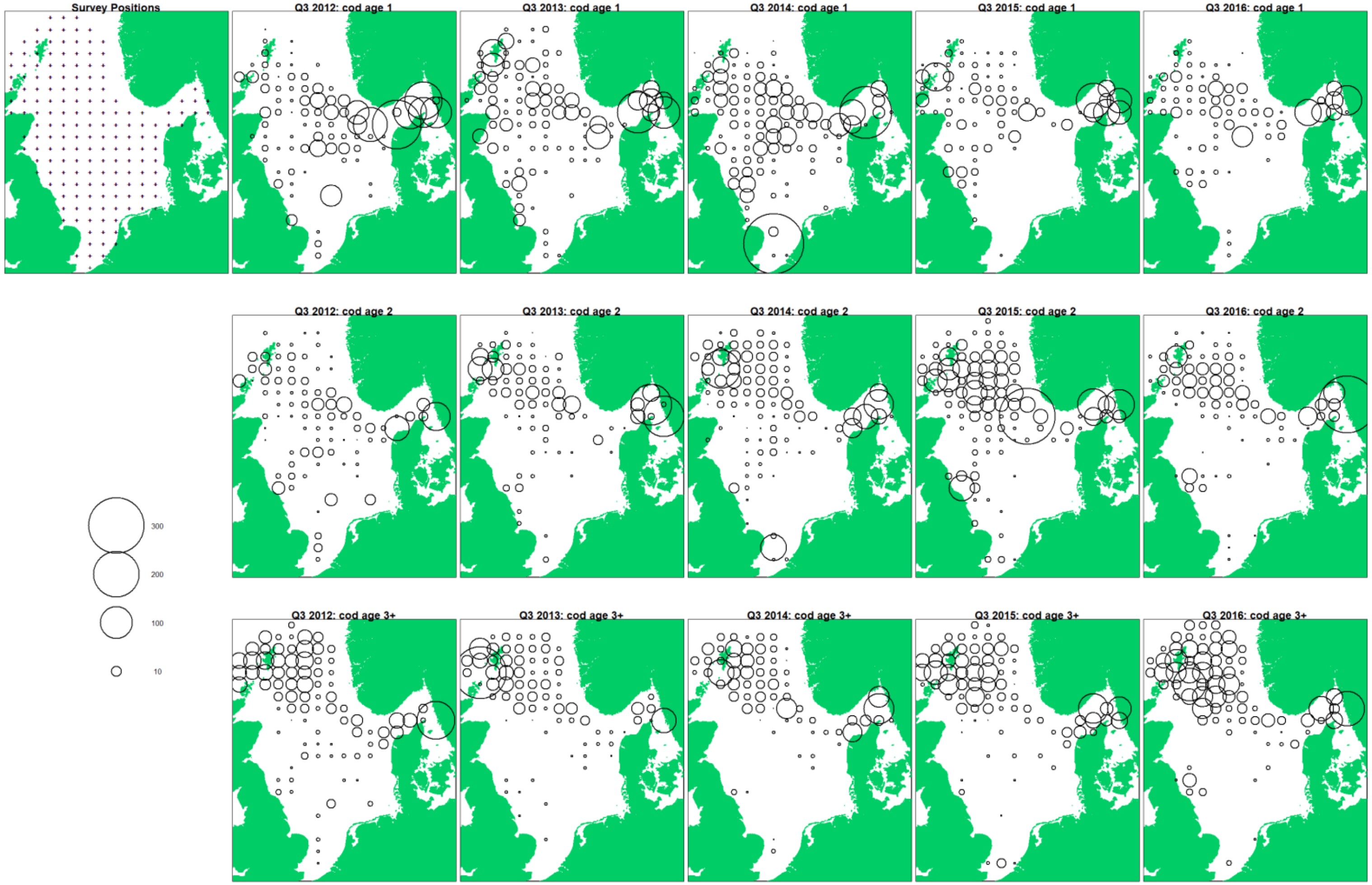


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

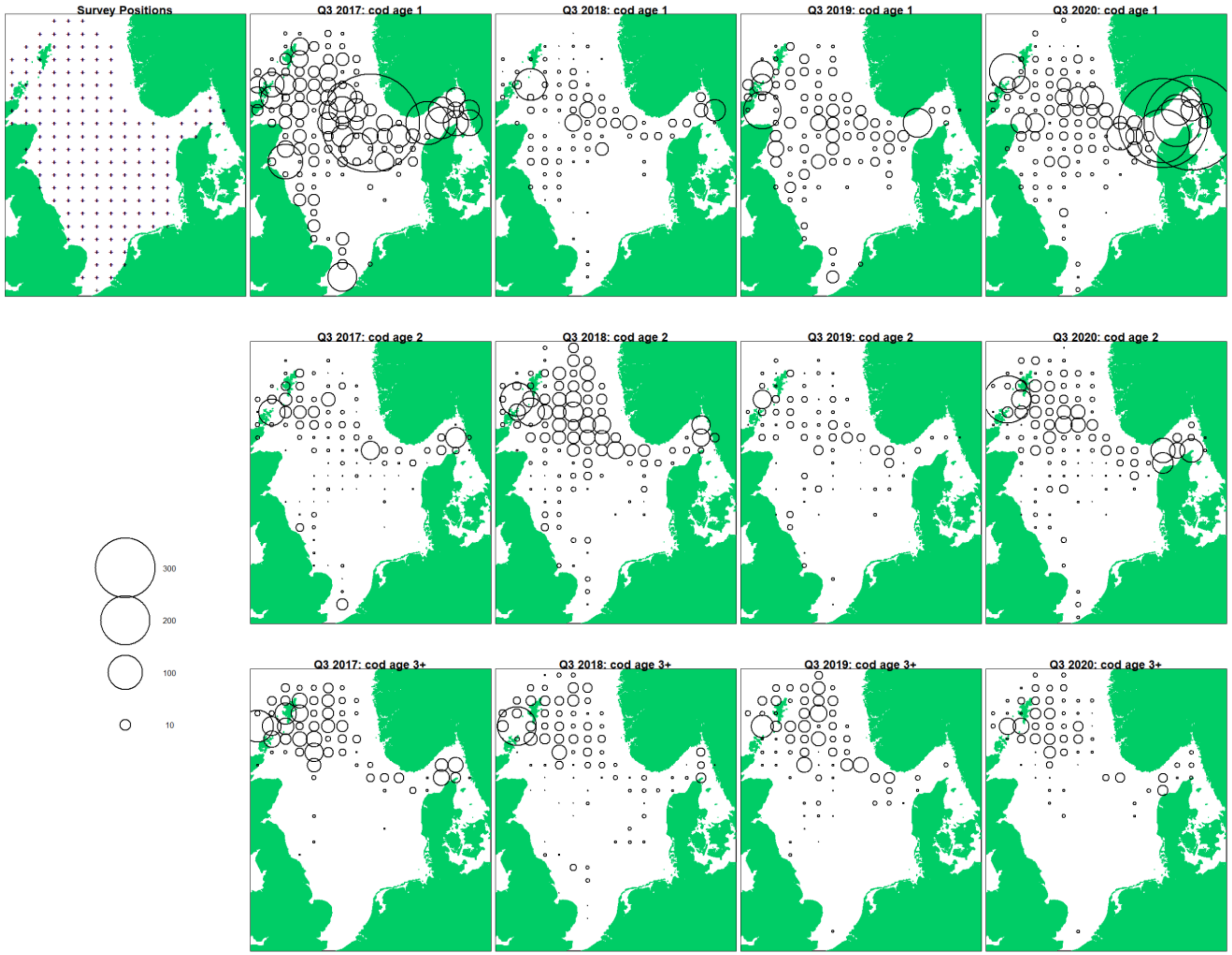


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

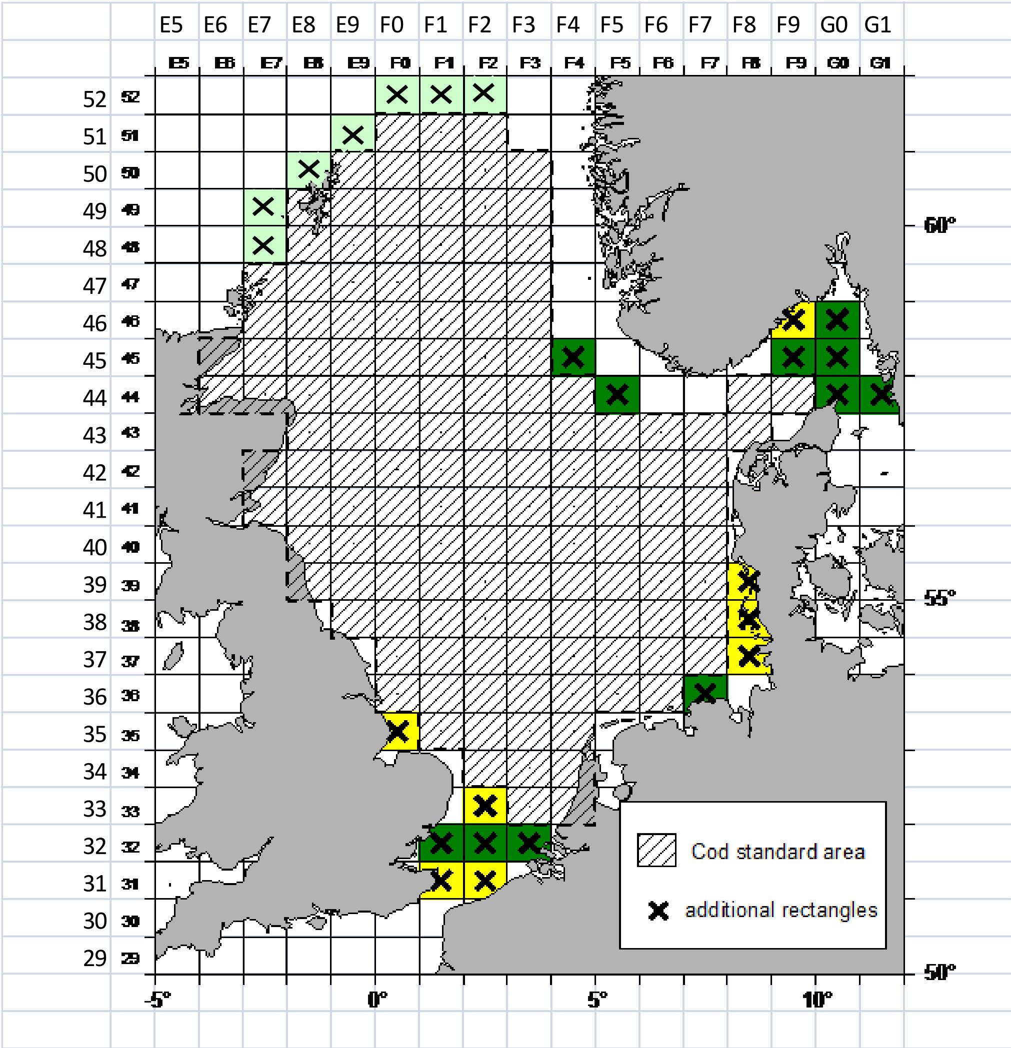


Figure 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND, 2009; ICES WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is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

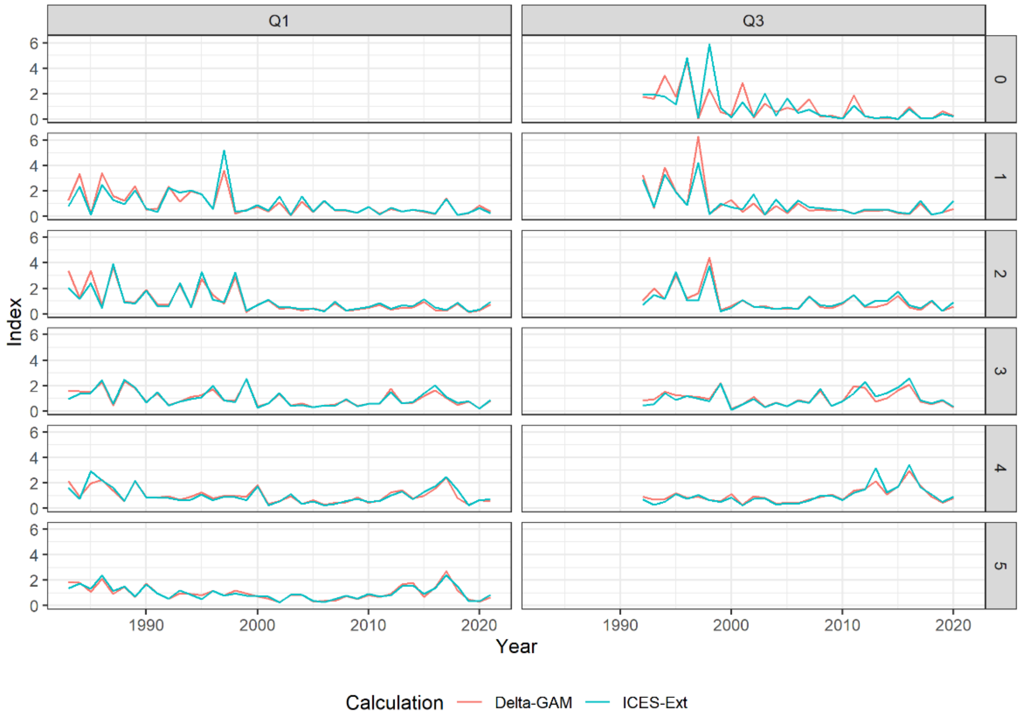


Figure 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS Delta–GAM indices used in the assessment to the corresponding NS–IBTS extended indices (ICES-Ext). The indices are mean-standardised. Note the index for age 0 is forward shifted to represent age 1 in the assessment.

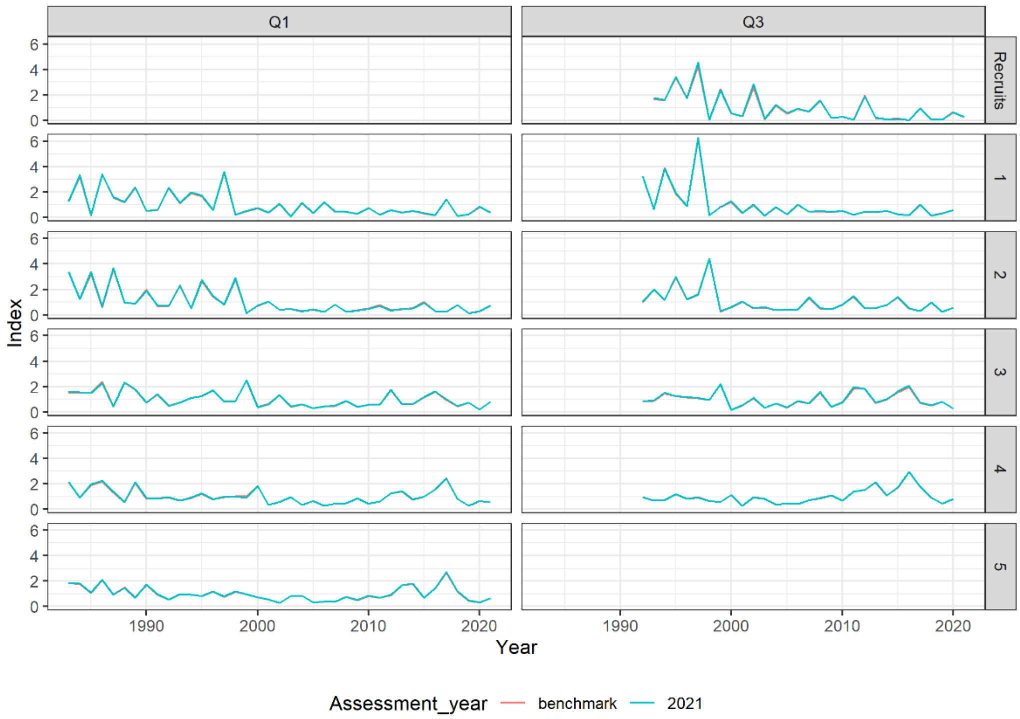


Figure 4.3e. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS Delta–GAM indices used in the assessment to the corresponding Delta-GAM indices used in the 2021 benchmark (ICES WKNSEA 2021). The indices are mean-standardised.

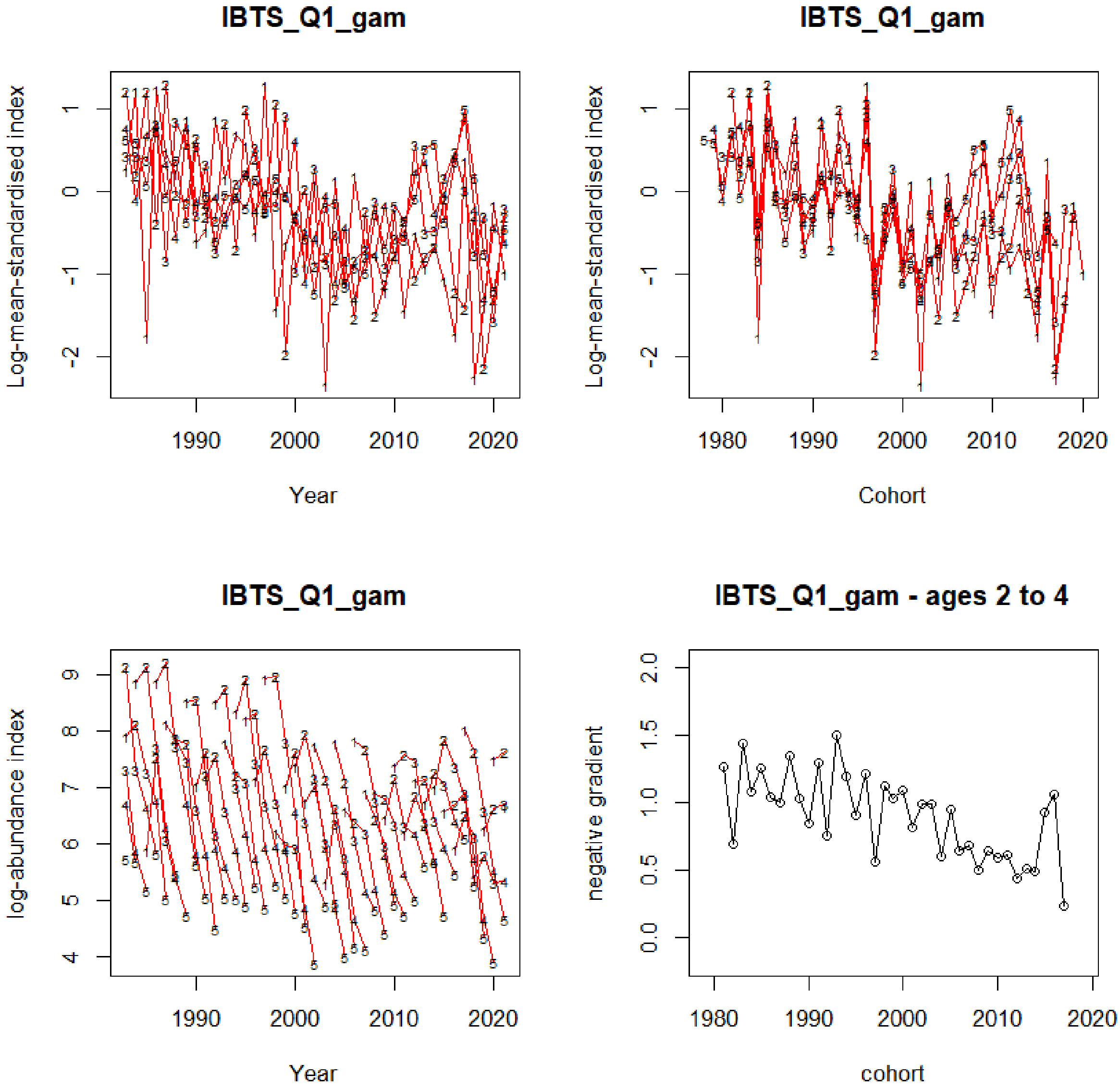


Figure 4.4a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

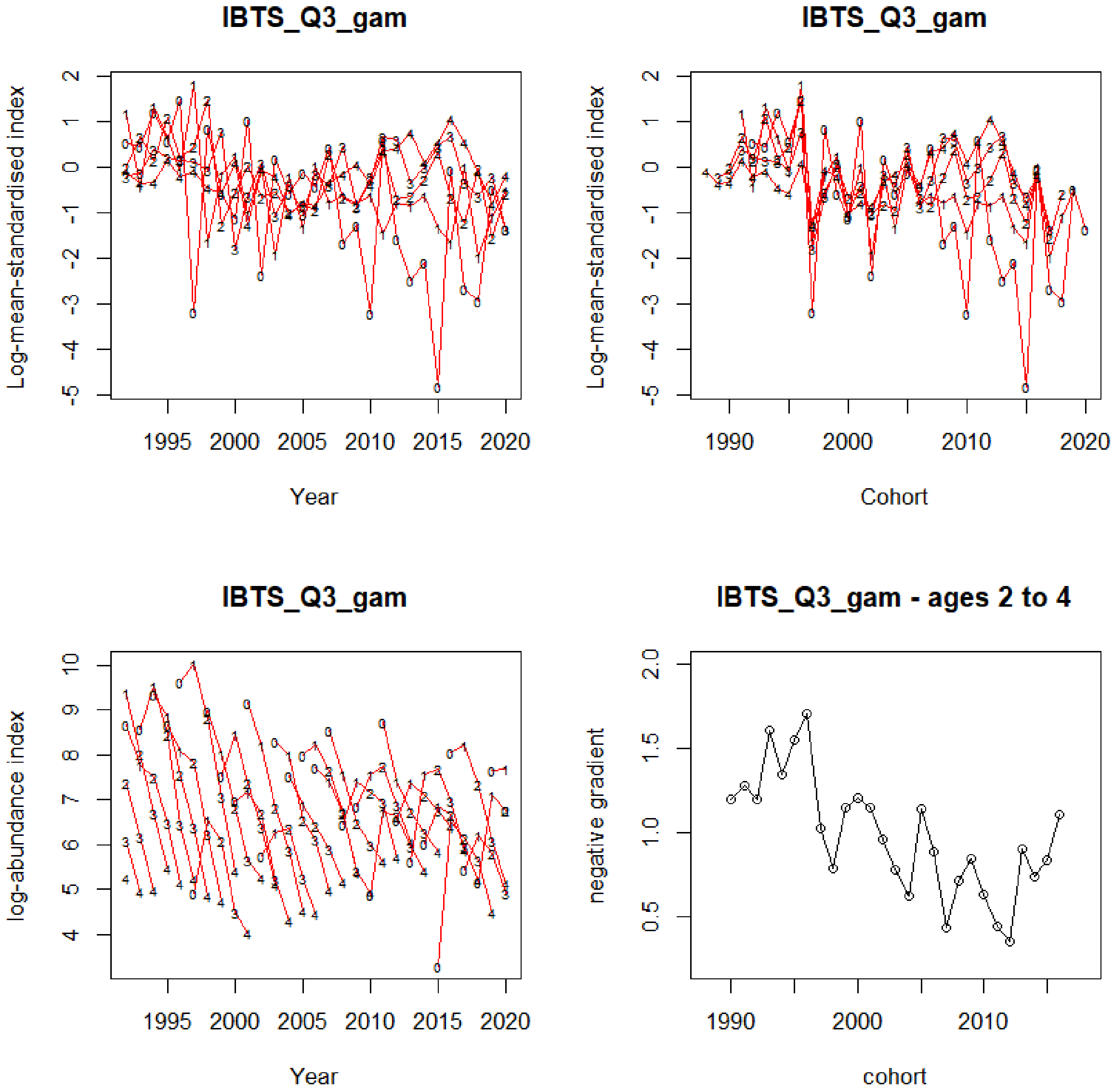


Figure 4.4b. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

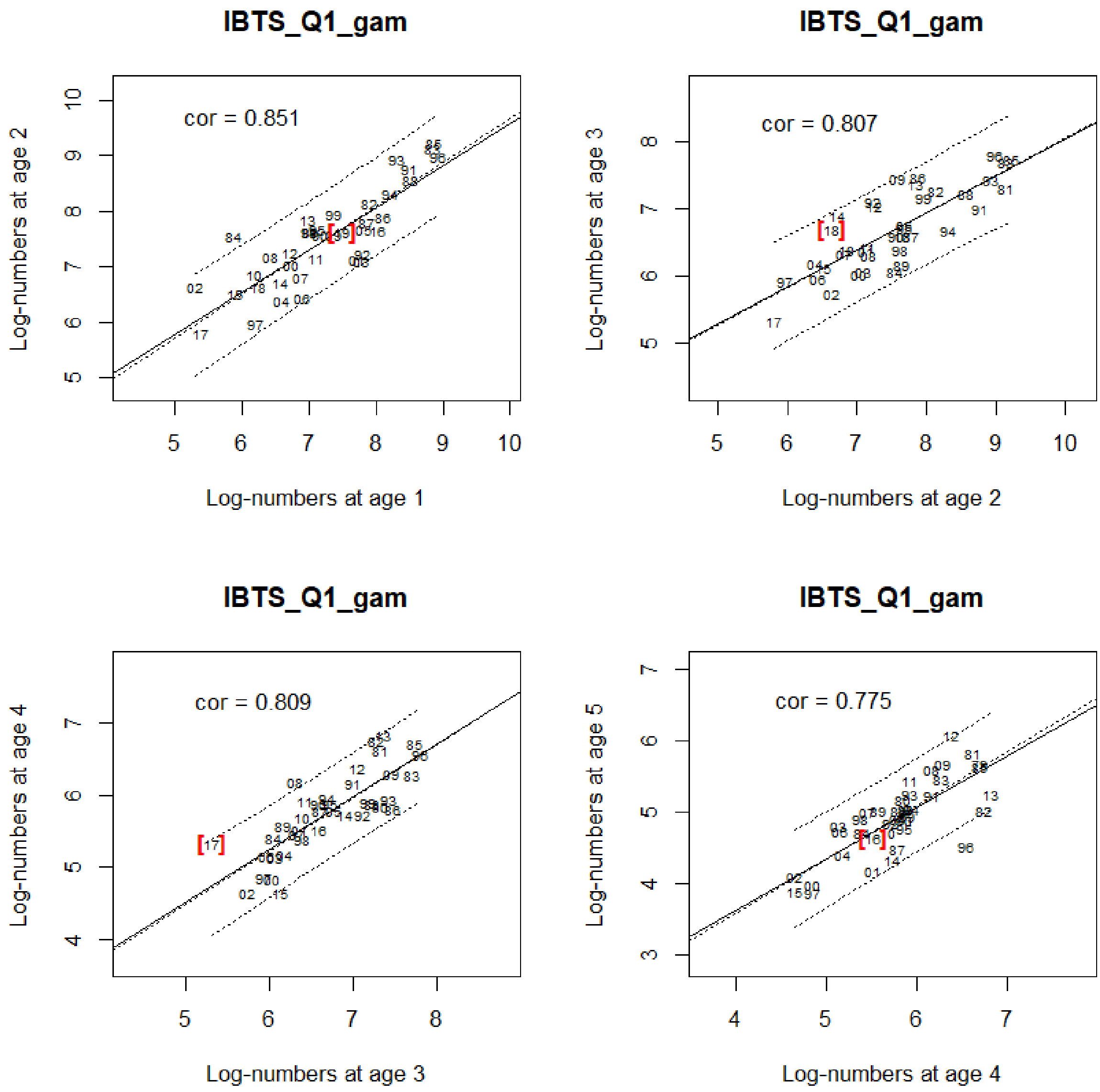


Figure 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2021. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

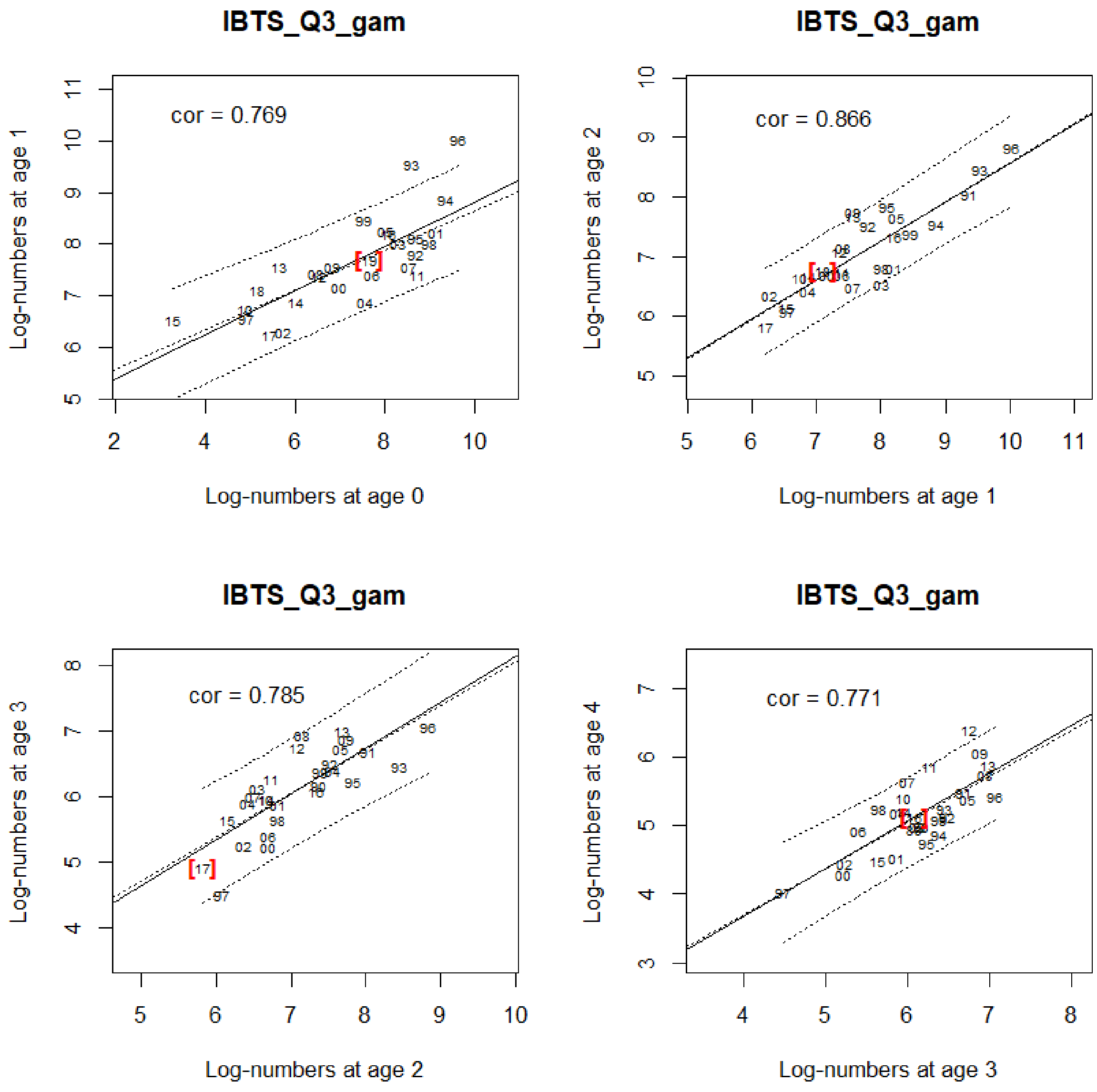


Figure 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2020. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

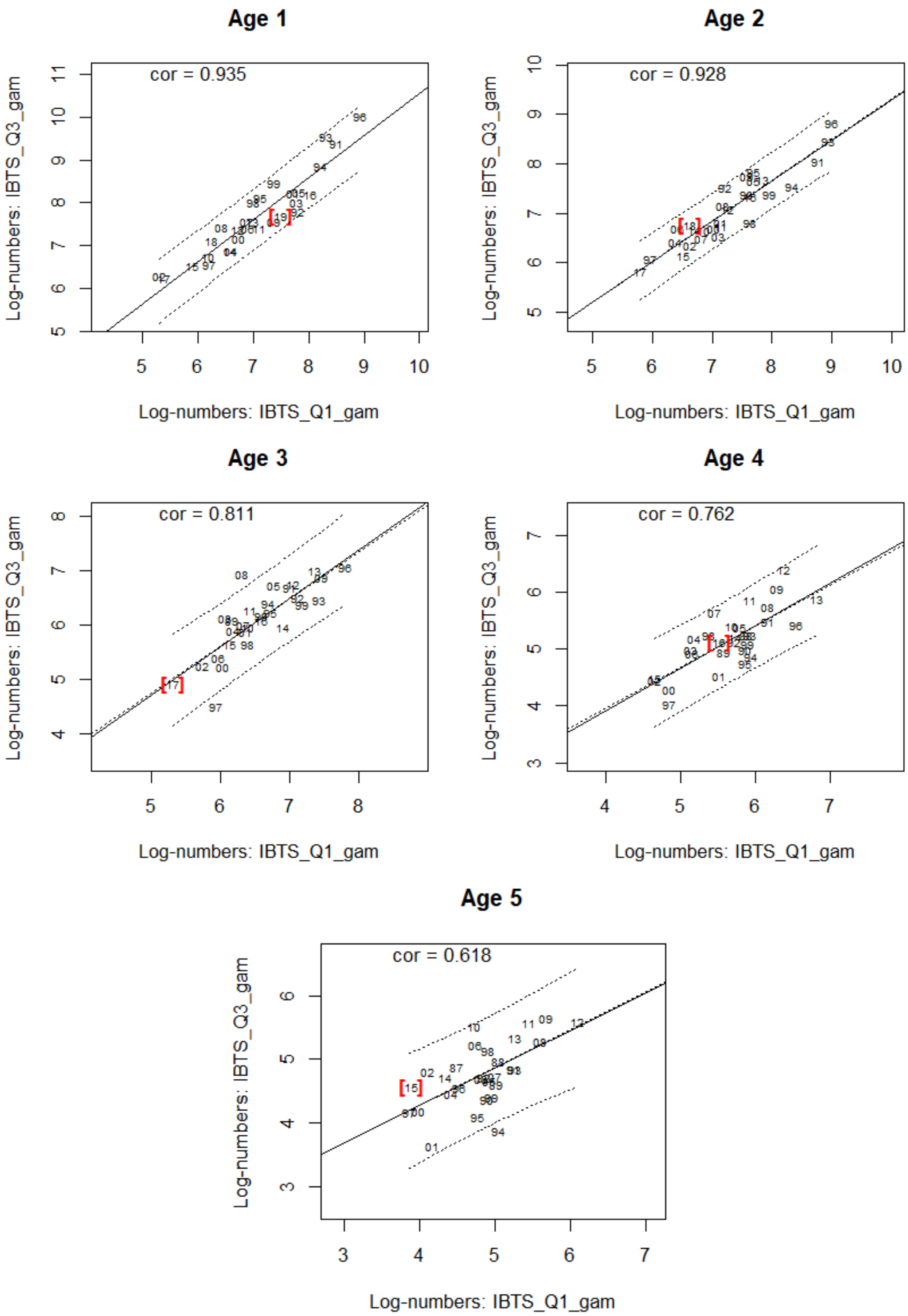


Figure 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2020. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

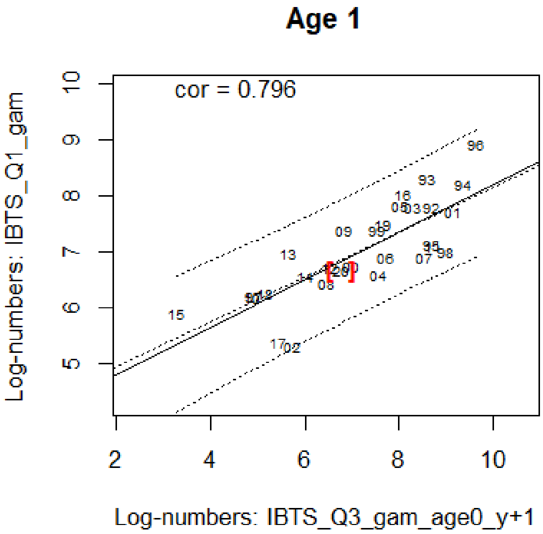


Figure 4.5d. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for the IBTS–Q1 age 1 and IBTS–Q3 recruitment indices (age 0 forward shifted to 1st January the following year) for the period 1993–2021. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

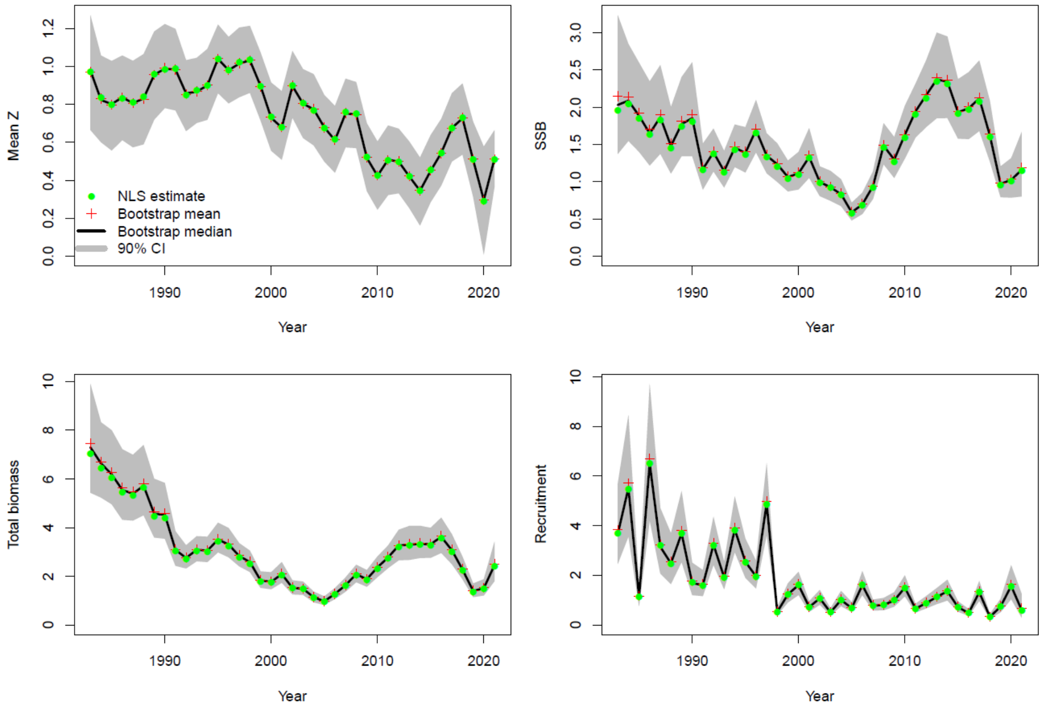
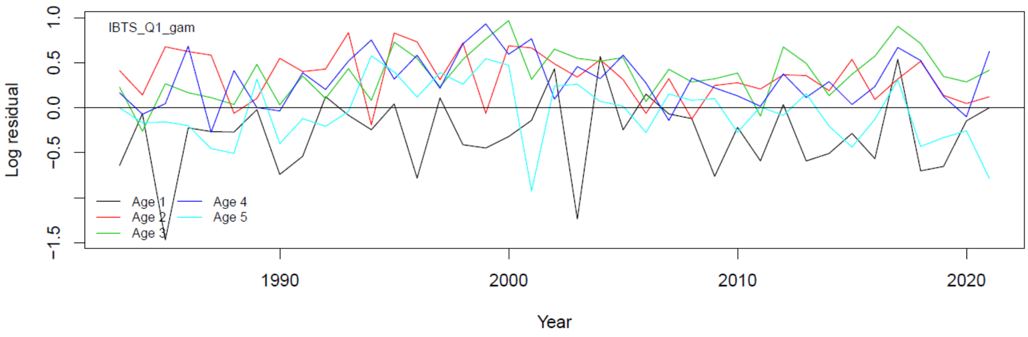


Figure 4.6a. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to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



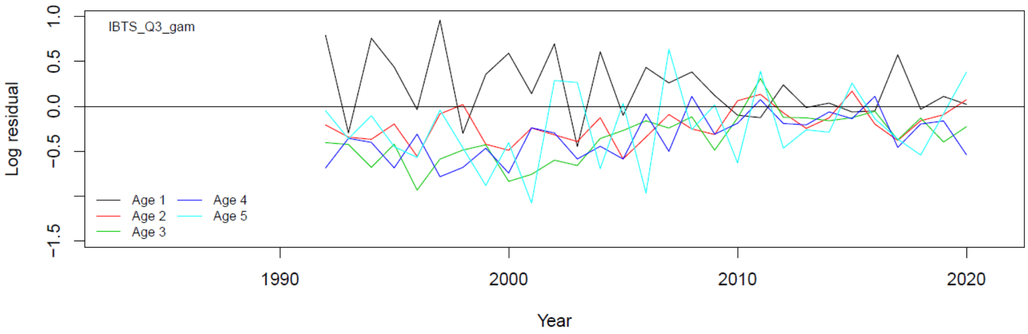


Figure 4.6b. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR residual plots for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3.

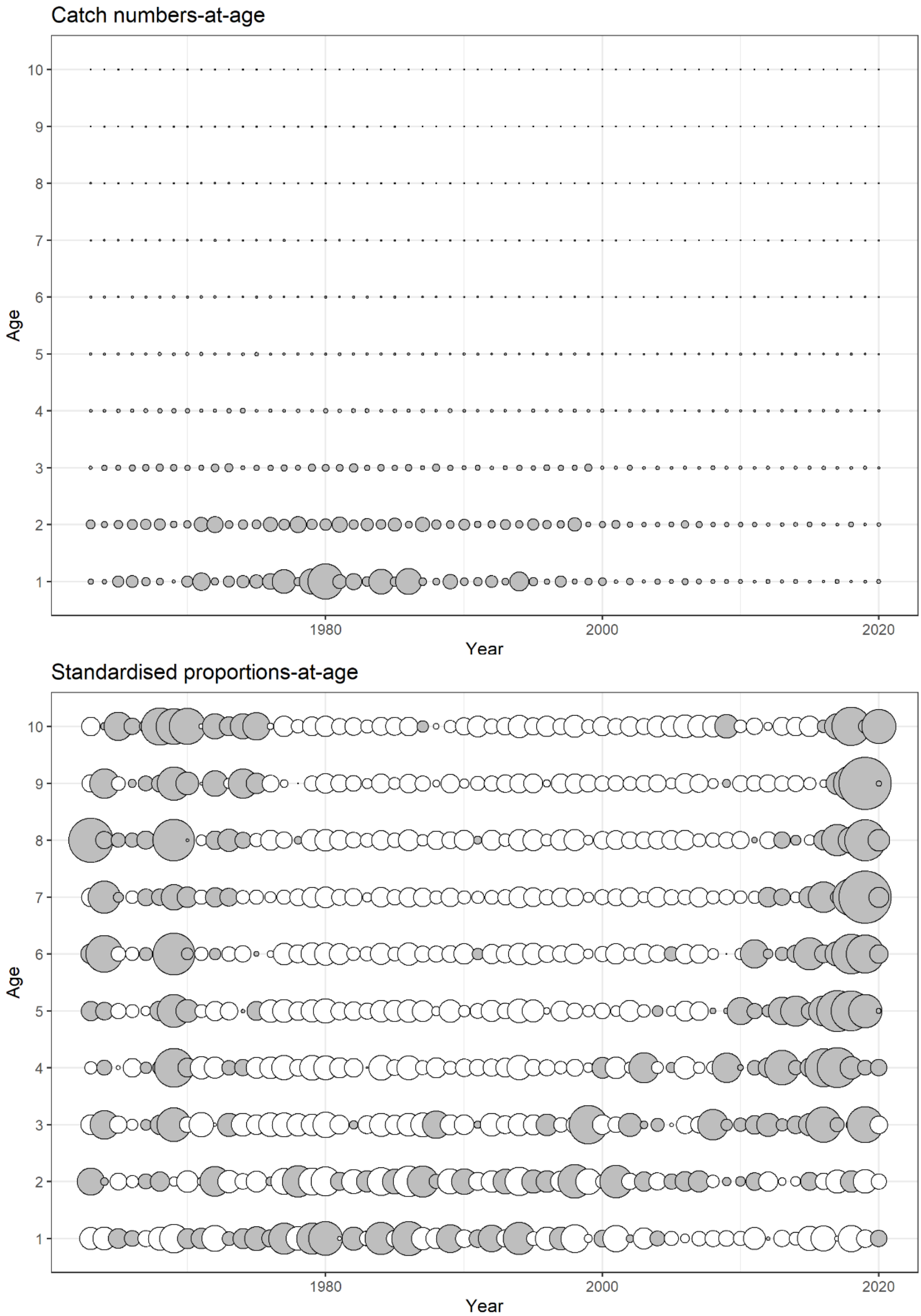


Figure 4.7. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catch-at-age matrix expressed as (top) numbers-at-age and (bottom) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing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

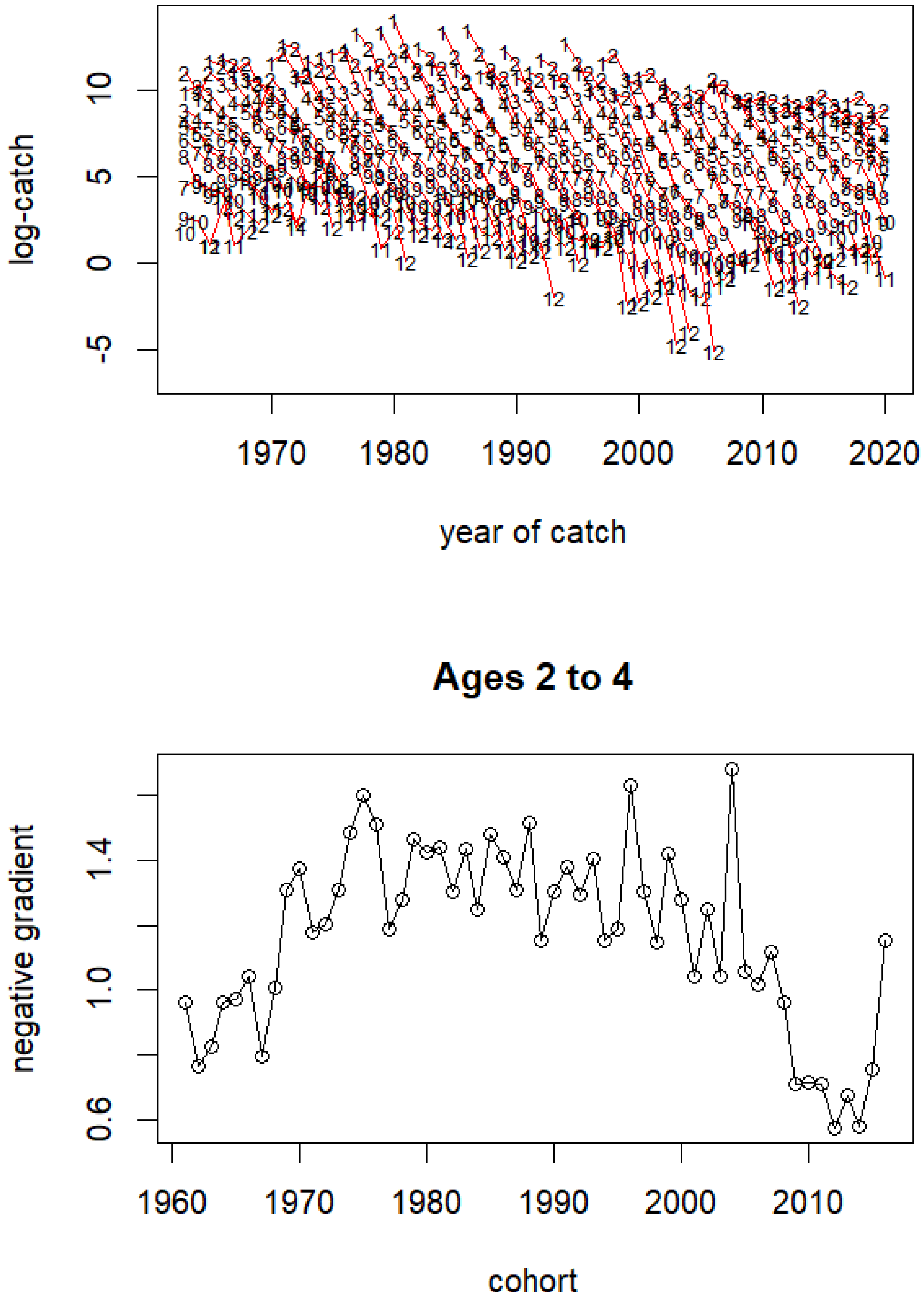


Figure 4.8. Cod in Subarea 4, Division 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

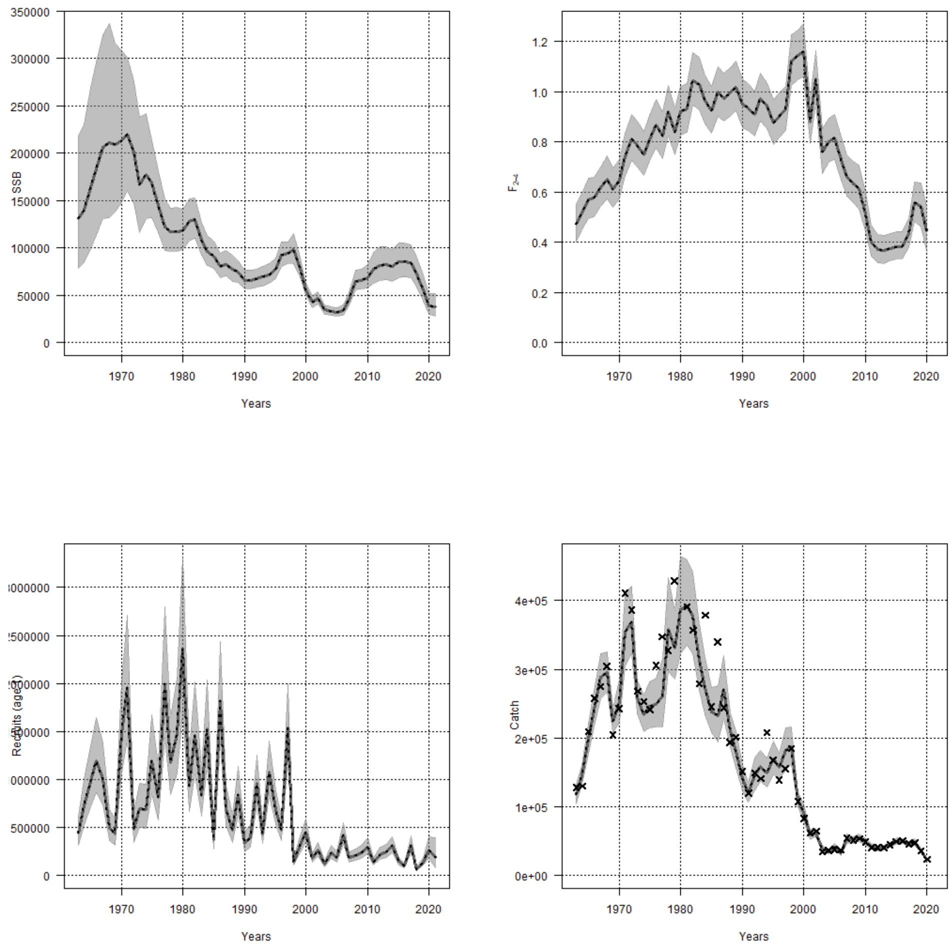


Figure 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and catch from the SAM assessment (black lines = estimate and shaded area = corresponding pointwise 95% confidence intervals).

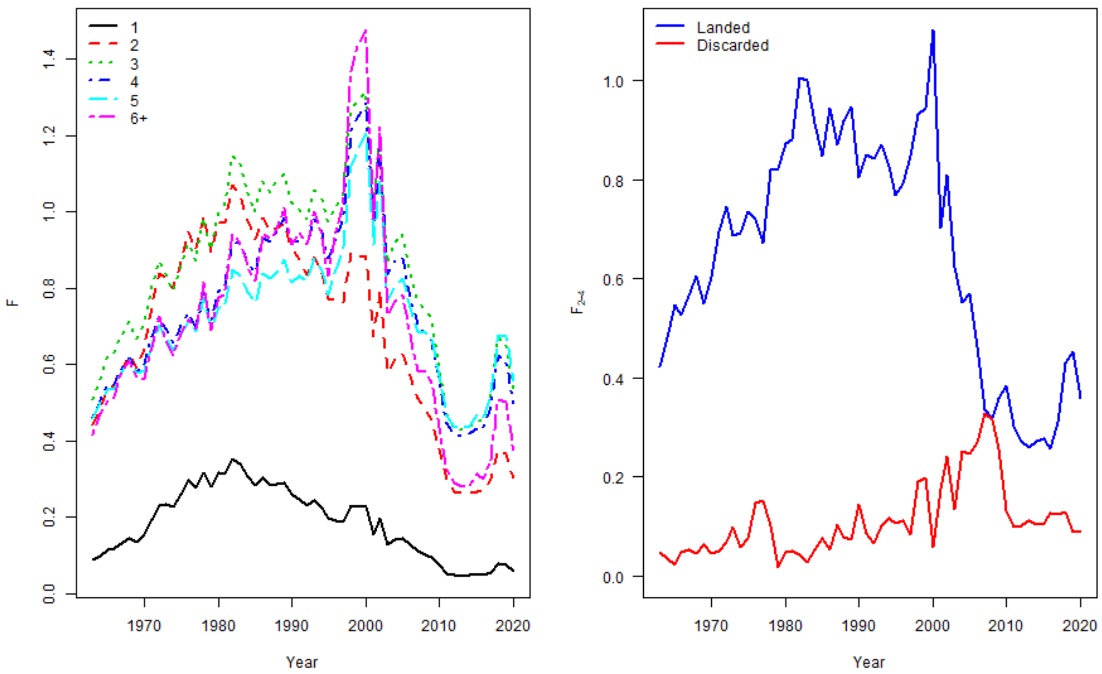


Figure 4.10a. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of fishing mortality. The left panel shows fishing mortality for each age while the right panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.9) but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data.

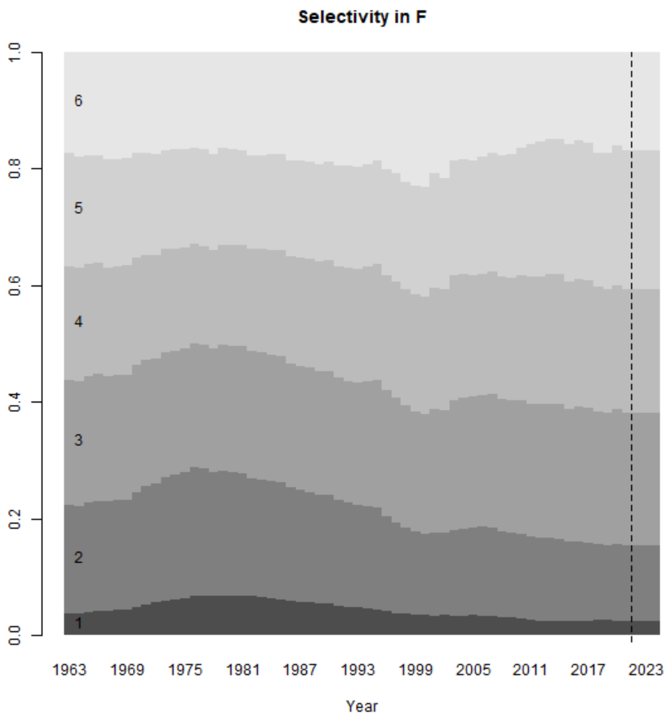


Figure 4.10b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of selectivity derived as the proportions of total fishing mortality at age over time. The dashed line represents the beginning of the forecast period.

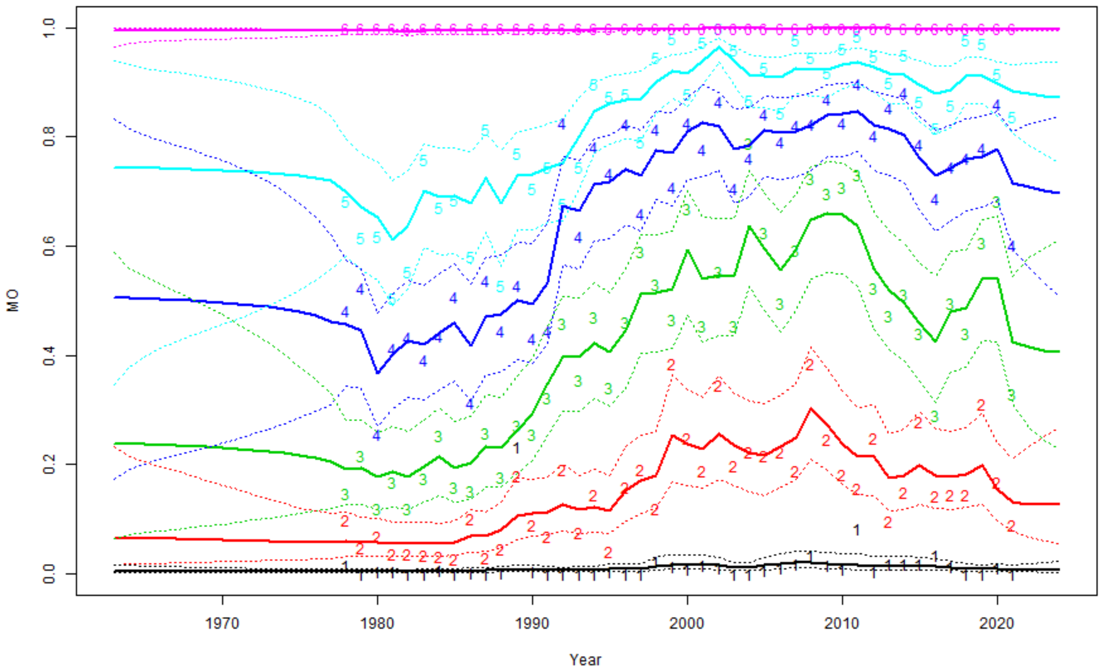


Figure 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM fits to maturity data. Numbers are the input data shown in Table 4.5b and Figure 4.2c. The solid lines are the SAM estimates of maturity-at-age, extending to the forecast period, with the dotted lines showing 95% confidence intervals.

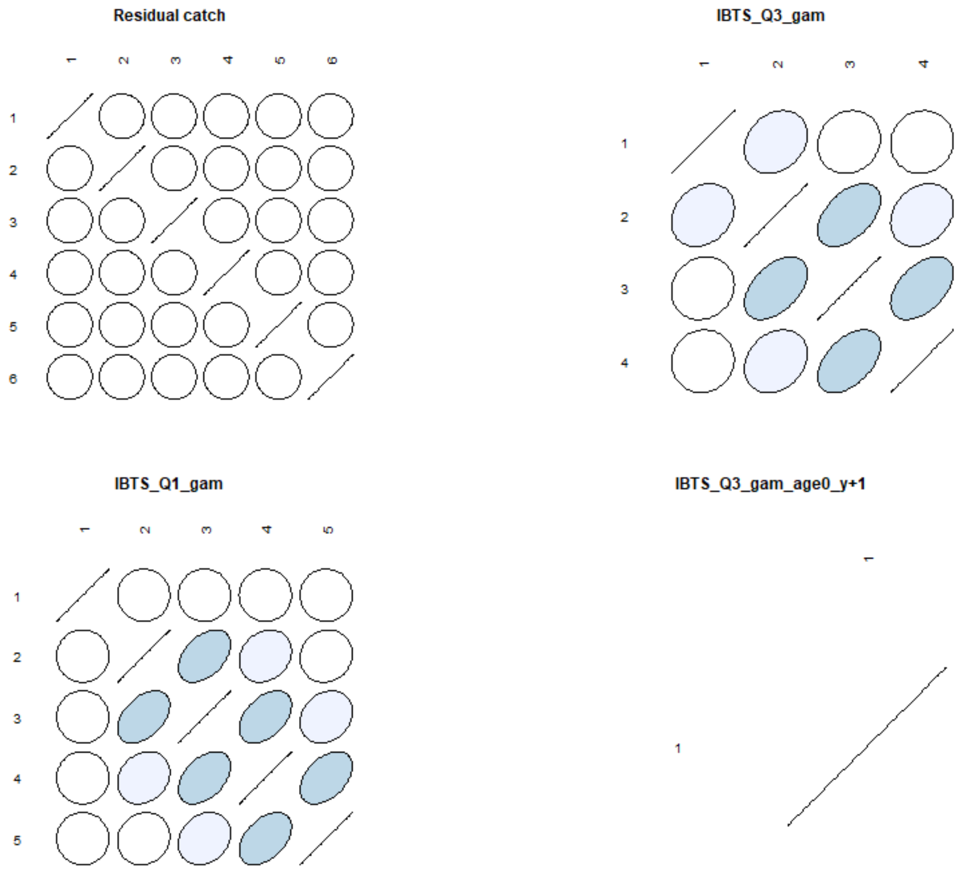


Figure 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated correlation matrices between ages for the (top left) total catch, (bottom left) IBTS–Q1, (top right) IBTS–Q3 and (bottom right) the IBTS–Q3 recruitment index.

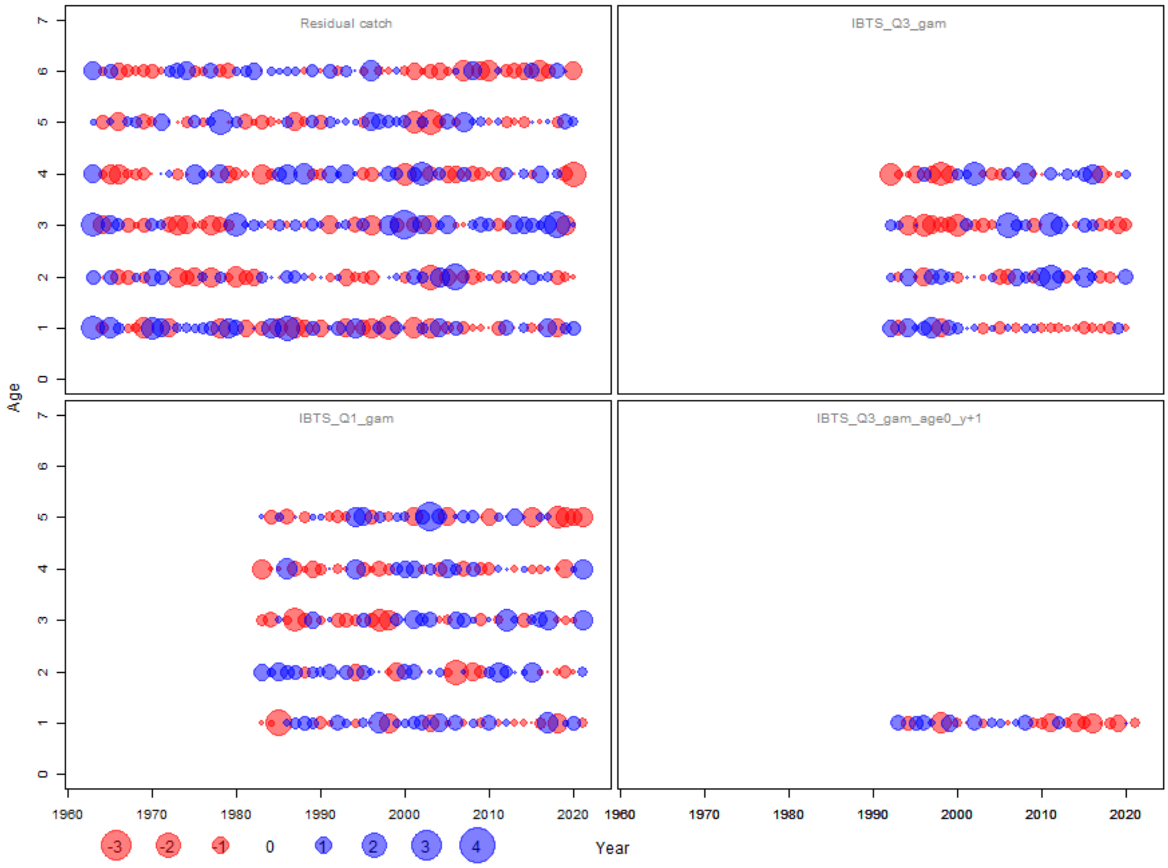


Figure 4.13a. Cod in Subarea 4, Division 7.d and Subdivision 20: One step ahead (OSA) residuals for the SAM assessment for (top left) total catch, (bottom left) IBTS–Q1, (top right) IBTS–Q3 and (bottom right) the IBTS–Q3 recruitment index. Blue circles indicate a positive residual and red circles a negative residual.

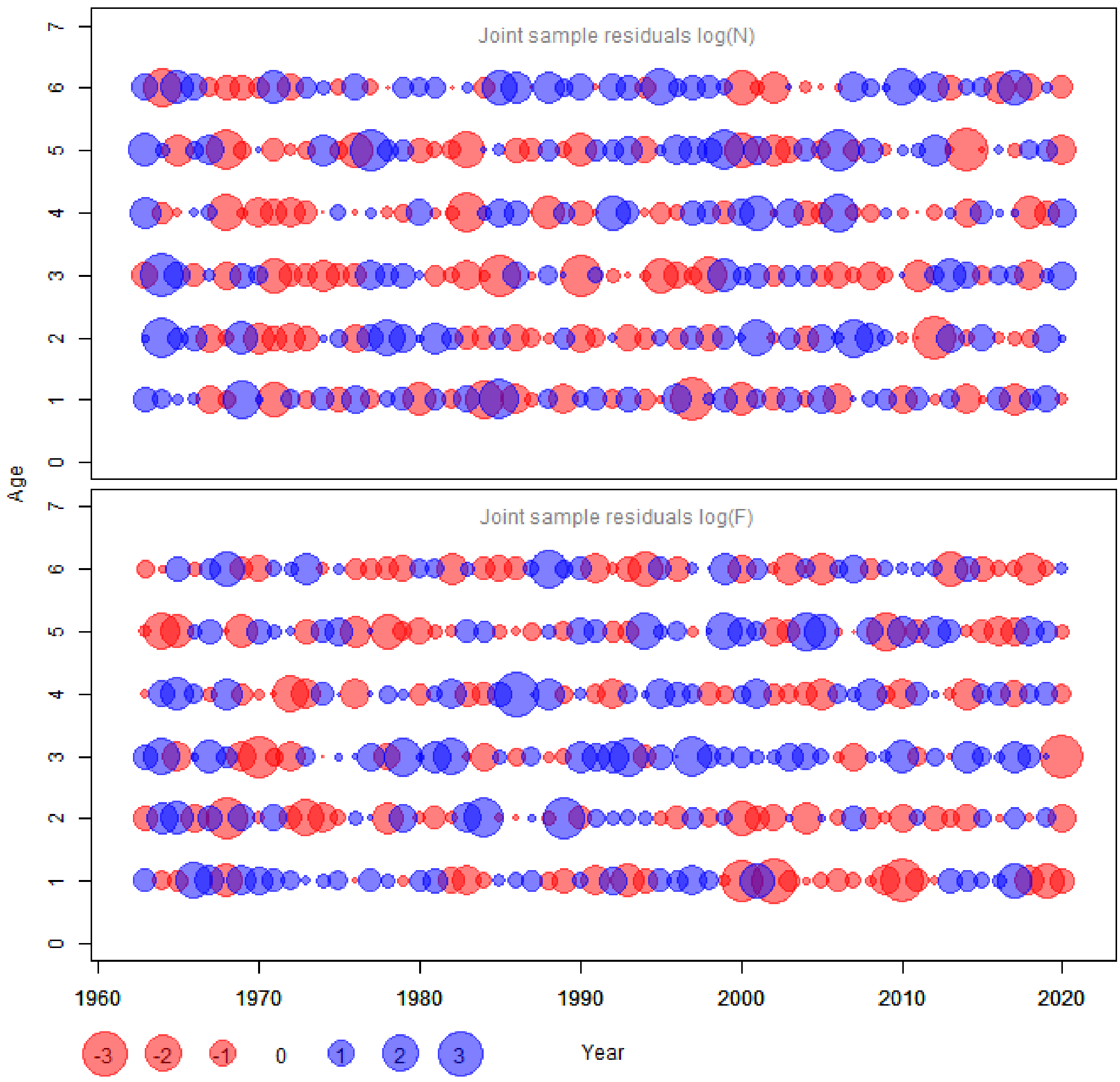


Figure 4.13b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM standardised joint-sample residuals of process increments for (top) stock numbers and (bottom) fishing mortality. Blue circles indicate a positive residual and red circles a negative residual.

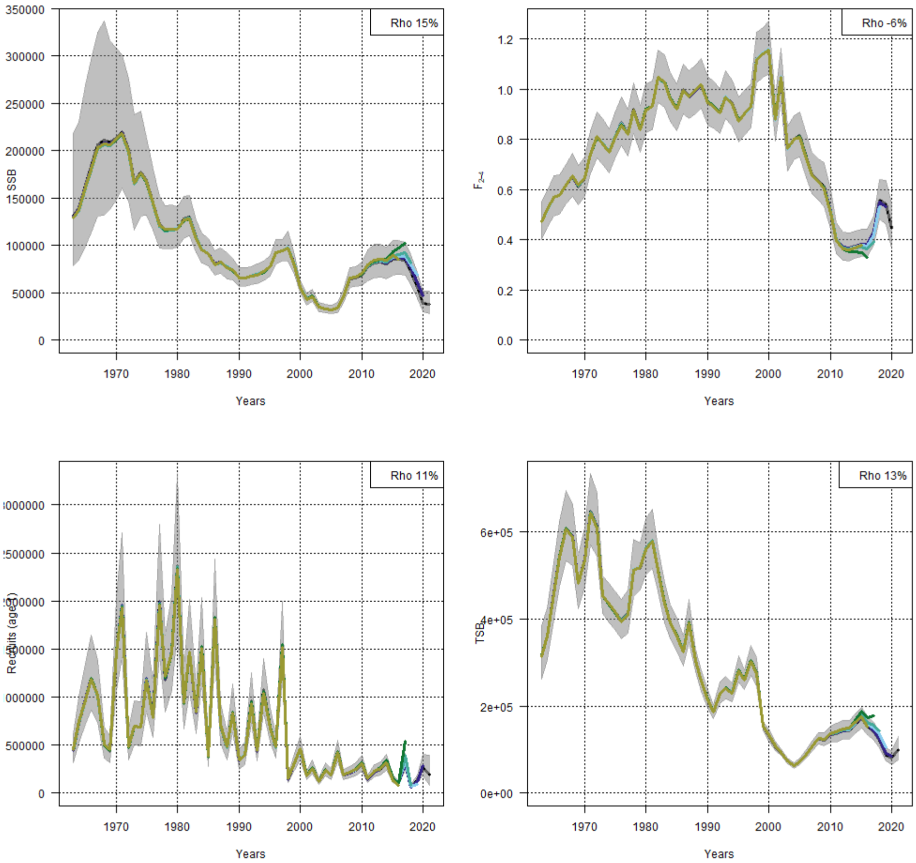


Figure 4.14. Cod in Subarea 4, Division 7.d and Subdivision 20: Retrospective estimates (5 years) from the SAM assessment. Estimated yearly SSB (top left), average fishing mortality (top right), recruitment age 1 (bottom left) and TSB (bottom right), together with corresponding pointwise 95% confidence intervals.

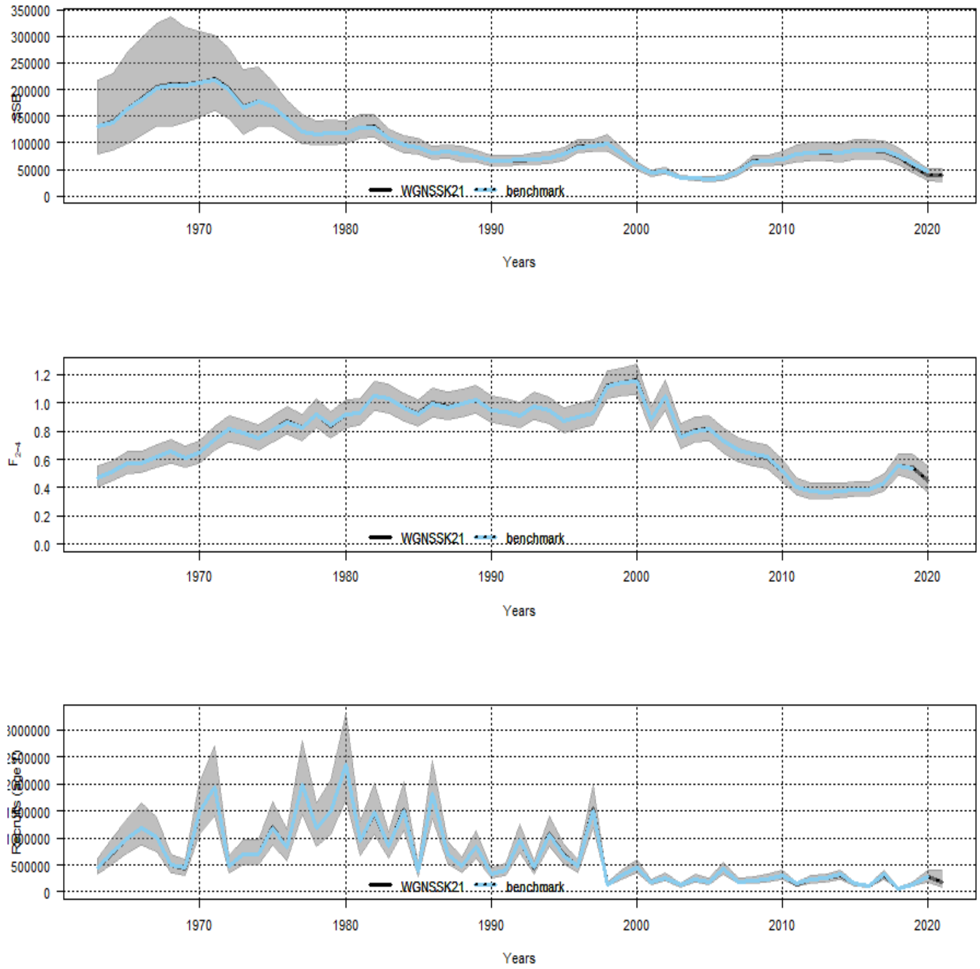


Figure 4.15a. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the final SAM assessment for 2021 with the final SAM benchmarked assessment (ICES WKNSEA 2021). Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding pointwise 95% confidence intervals.

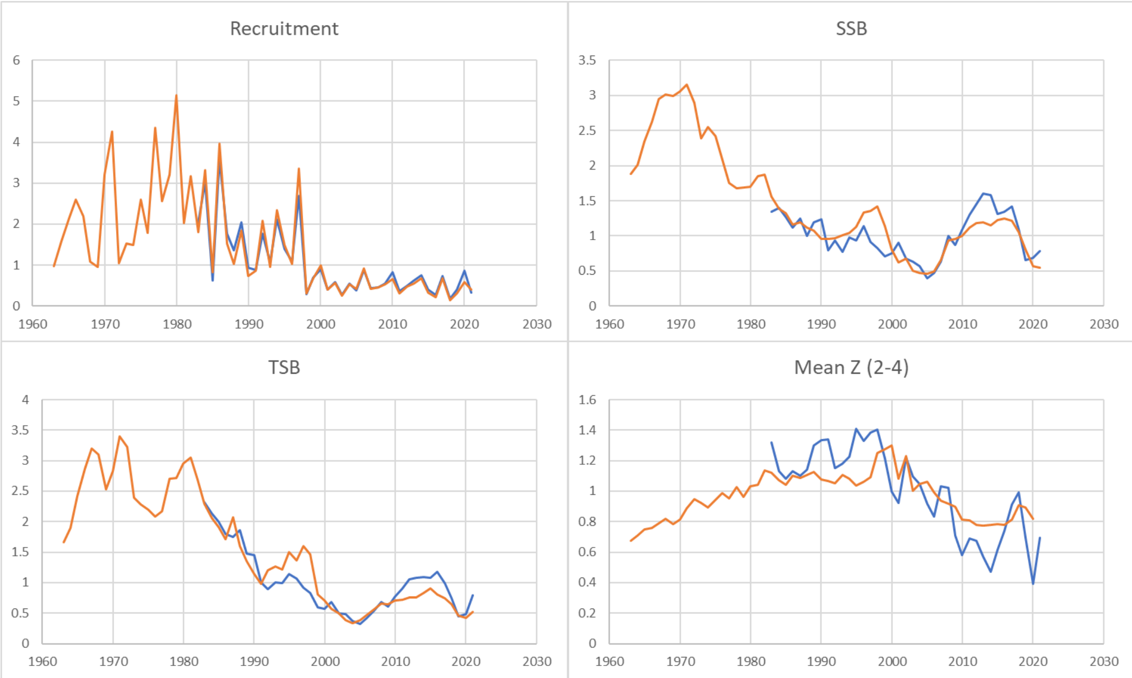


Figure 4.15b. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the final SAM assessment for 2021 (orange) with the SURBAR survey-based assessment (blue). All values have been mean-standardised using the year range for which estimates are available for both models.

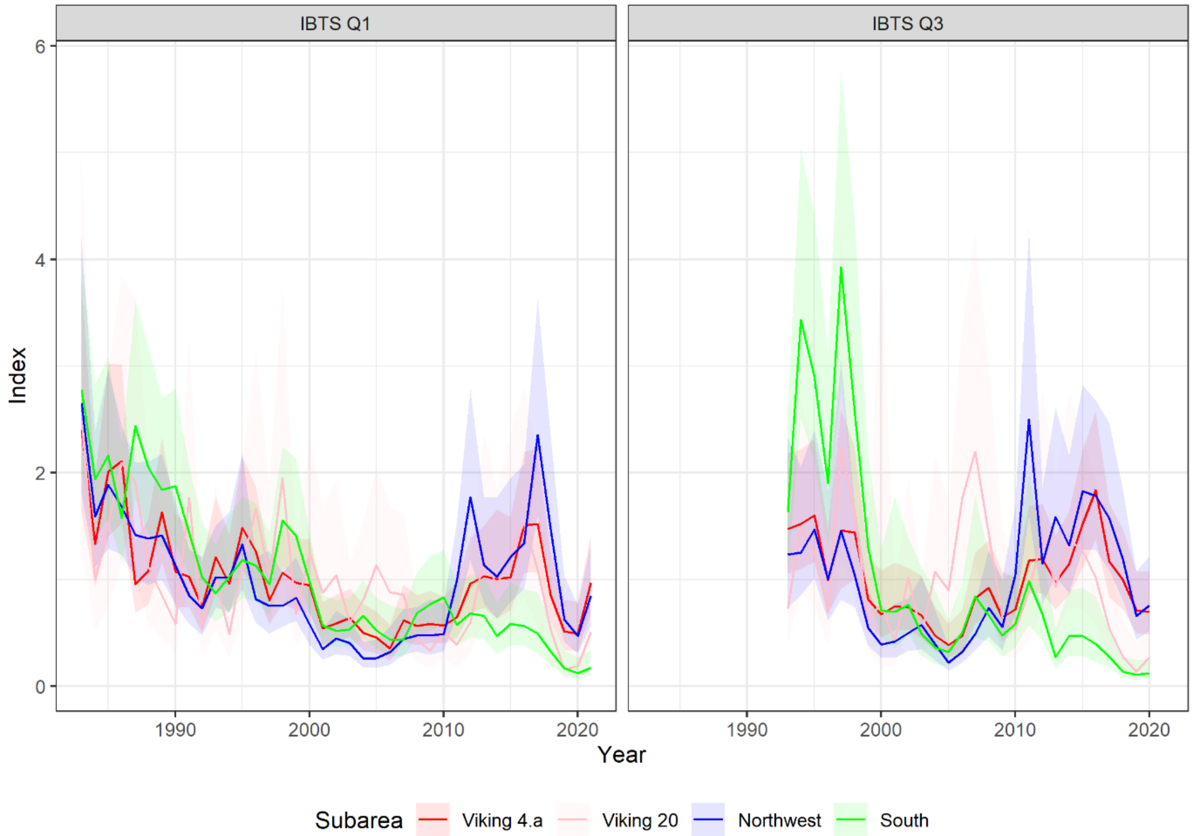


Figure 4.16a. Cod in Subarea 4, Division 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model to numbers-at-age for the entire dataset and integrating the fitted abundance surface over each of the subregions to obtain indices-at-age by area. These are then multiplied by smoothed weight-at-age estimates and summed to get the biomass indices. Shading represents 95% confidence intervals. Indices and confidence intervals are standardised by the mean of the index for each subregion.

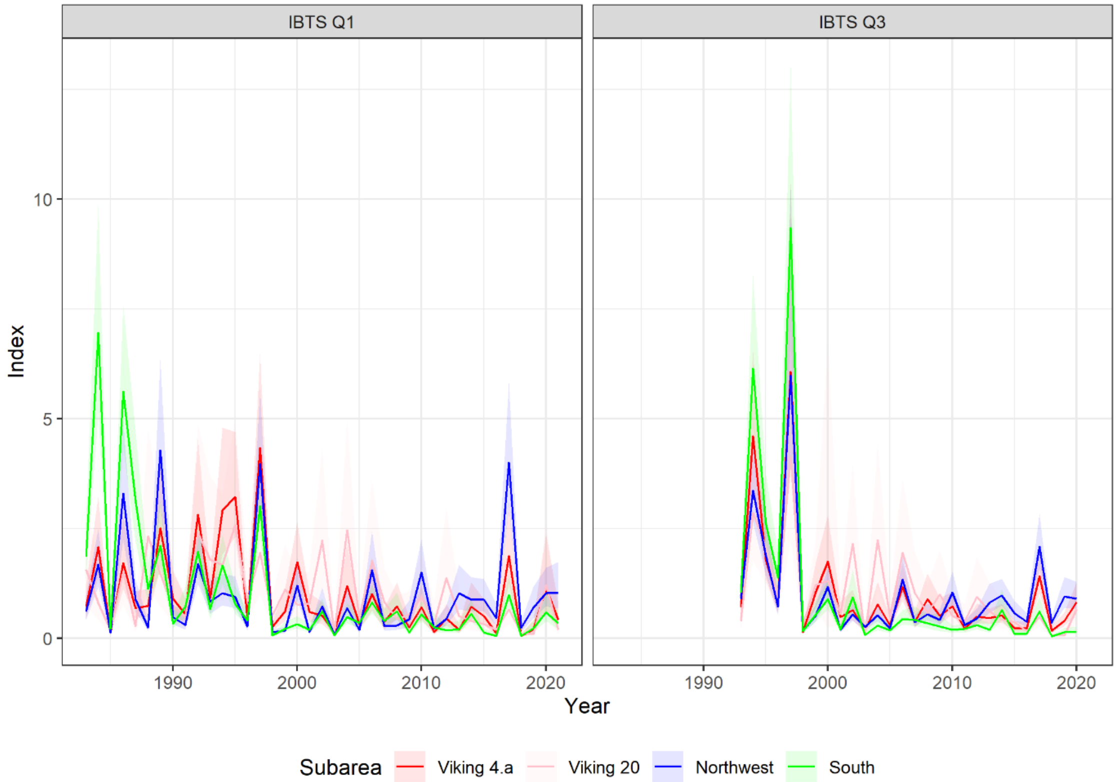


Figure 4.16b. Cod in Subarea 4, Division 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. Indices and confidence intervals are standardised by the mean of the index for each subregion.

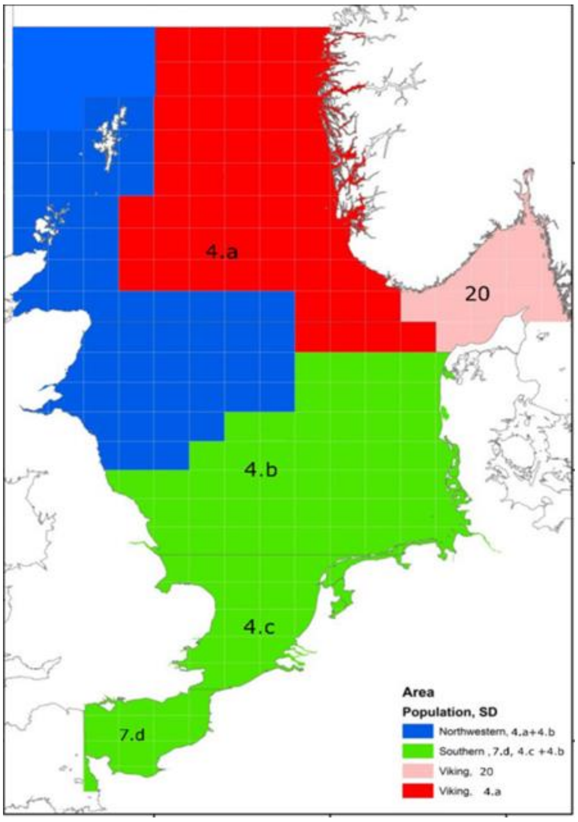


Figure 4.16c. Cod in Subarea 4, Division 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

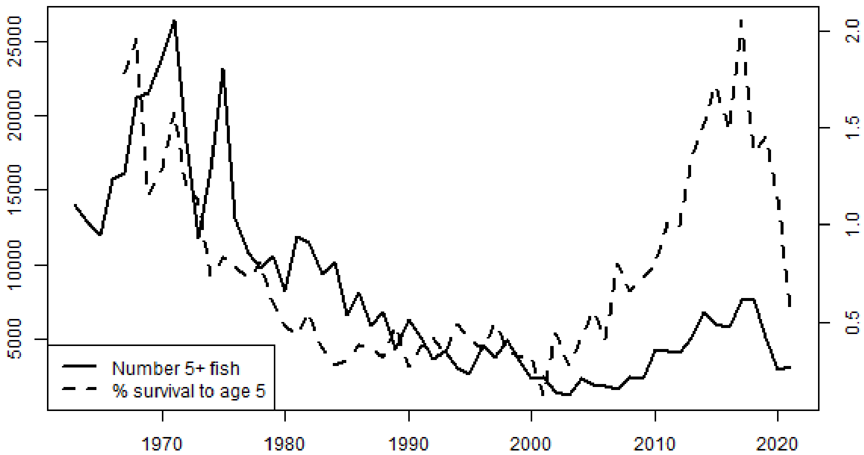


Figure 4.17. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimates of the number of 5-year-old and older cod in the population (solid line; thousands) and the percentage of 1-year olds by number that have survived to age 5 in the given year (hashed line).

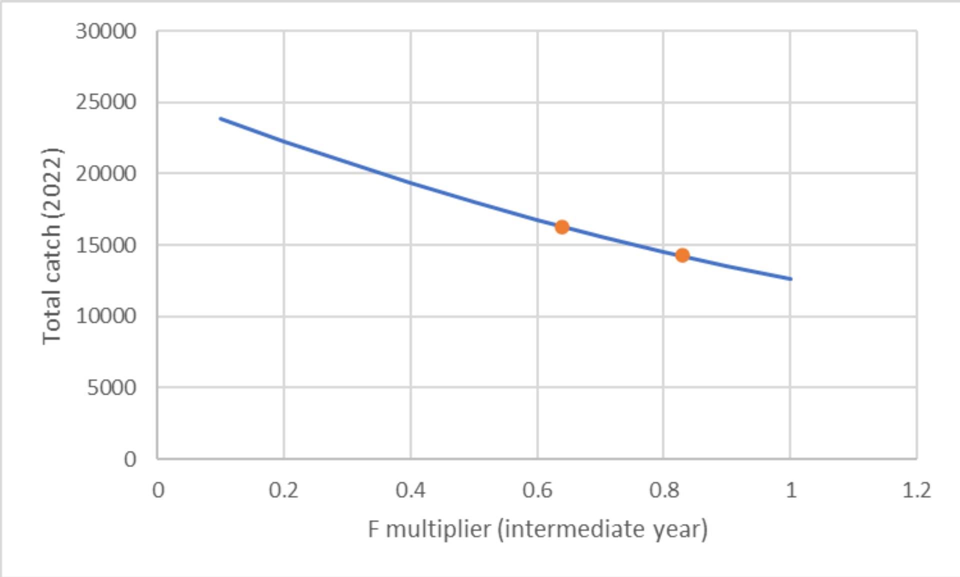


Figure 4.18. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catches in 2022 corresponding to the MSY approach (i.e. $F=F_{MSY} \times SSB_{2022}/B_{trigger}$) assuming different multipliers on F(2020) in the intermediate year. The orange dots correspond to a 37% overshoot of the TAC in 2021 (F multiplier of 0.64) and an F of 0.37 (F multiplier of 0.83).

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 for the most recent years. Catch data, indices and the SURBAR assessment were updated and also an updated SPiCT assessment was updated during the WGNSSK2021. In 2020, catches increased to 44 340 tonnes (compared to 40 725 tonnes in 2019). The relative SSB value decreased slightly, but is still on a comparable high level. Recruitment showed a consistently decreasing trend from 2015 to 2020. 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. In conclusion the perception of the stock did not change compared to the previous year.

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 official catch statistics, annual landings of dab in ICES Subarea 4 and Division 3.a has been increasing above 10 000 tonnes since 1979 (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. However, since 1999 total landings for both areas (Subarea 4 and Division 3.a) steadily decreased. This trend continued until 2017 with total official landings of 3529 tonnes. In 2020 the official landings decreased to 3976 tonnes compared to 5053 tonnes in 2019.

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 (STECF, 2016). The largest part of the landings in Subarea 4 is taken by the Netherlands, followed by Denmark, the UK, and Belgium (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 the North Sea. 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).

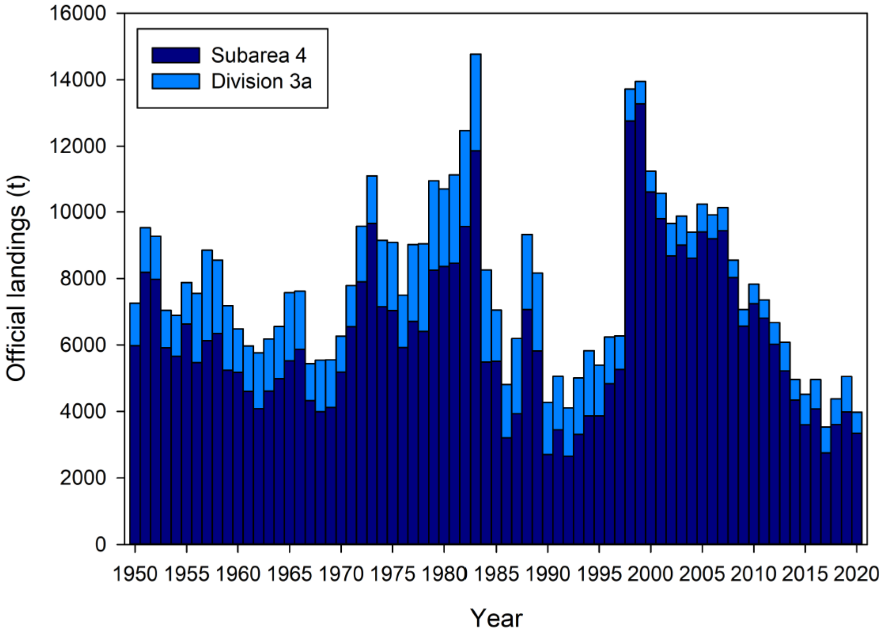


Figure 5.1. Dab in Subarea 4 and Division 3.a: Total official landings of dab in Subarea 4 and Division 3.a in 1950–2020.

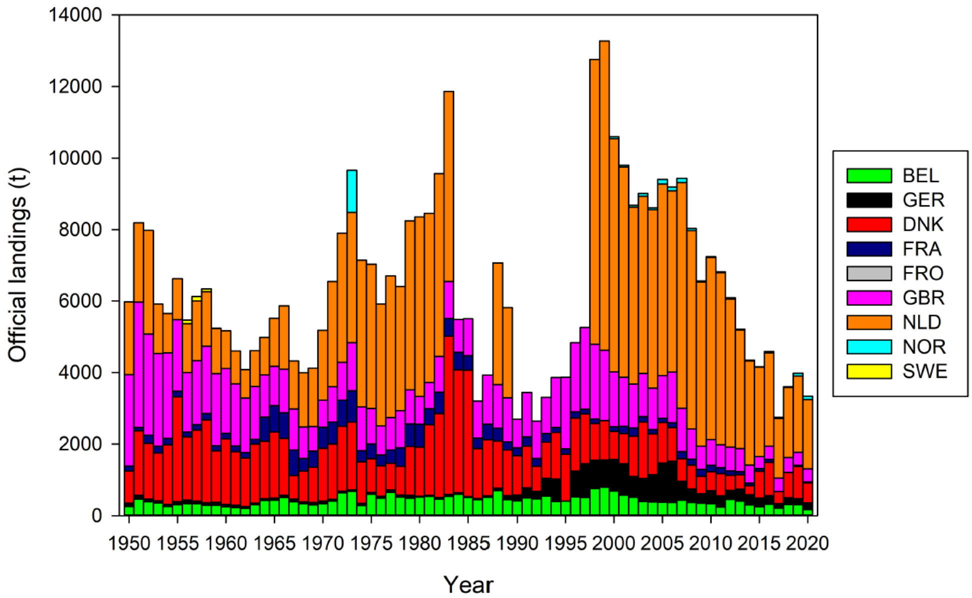


Figure 5.2. Dab in Subarea 4 and Division 3.a: Official landings of dab in Subarea 4 by country 1950 to 2020.

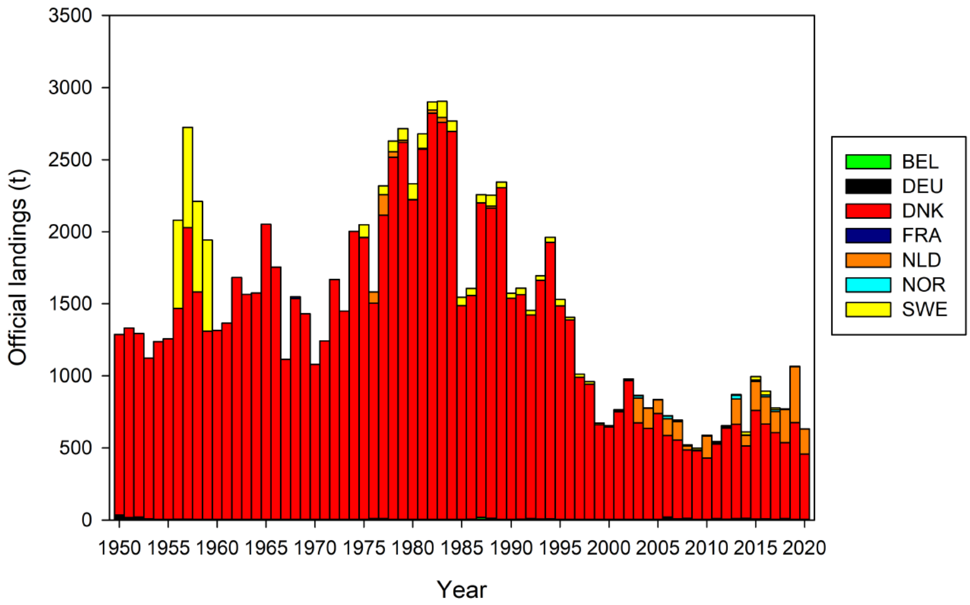


Figure 5.3. Dab in Subarea 4 and Division 3.a: Official landings of dab in Division 3.a by country 1950–2020.

5.2.2 InterCatch

For the current assessment year, dab landing and discard data from 2002–2020 were available in the InterCatch system. Discard information for 2020 was provided for only 54% (compared to 76% in 2019) of total landings in relation to weight (Figure 5.4).

In 2020, the largest catch (landings and discards) was 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 2020 was taken by The Netherlands (24 034 tonnes in total) followed by Germany with 7136 tonnes. All other countries did catch less than 6000 tonnes (Figure 5.7). The total dab catch estimated with InterCatch for 2020 was 44 340 tonnes (+ 3 615 tonnes compared to 2019) from which 3808 tonnes were landings and 40 532 tonnes discards (91% of the 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 total catch and information on discard weights was provided for every quarter for this 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 2020 data discard raising:

Group 1: MIS_MIS_HC all area (3.a and 4) raised with all other métiers because no specific MIS_MIS_HC all data were available in 2020 data (some métiers excluded due to unrealistic high discard ratios).

Group 2: passive gears area 4 raised with all passive gears area 4 and 3a (some métiers excluded due to unrealistic high discard ratios).

Group 3: OTB_CRU_70-99_all raised with OTB_CRU_70-99_all -> remove UK fleets from rasing and created own group (group 14).

Group 4: OTB_CRU_70-89_2_35 raised with OTB_CRU_70-89_2_35.

Group 5: OTB_CRU_90-119 raised with OTB_CRU_90-119.

Group 6: OTB_DEF_>120_all area 4 raised with all OTB_DEF_>120_all area 4.

Group 7: OTB_DEF_>120_all area 3a raised with all OTB_DEF_>120_all area 3a.

Group 8: SSC_SDN_DEF>120_all areas raised with SSC_SDN_DEF_>=120_all.

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

Group 10: TBB_DEF_100-119_>=120 all areas raised with TBB_DEF_100-119_>=120.

Group 11: OTB_DEF_100-119_0_0_all raised with OTB_DEF_100-119_0_0_all.

Group 12: SSC_DEF_100-119_0_0_all (including SSC_DEF_All_0_0_All ENG) raised with OTB_DEF_100-119_0_0_all.

Group 13: OTB_SSC_SDN_DEF_70-99_all raised with Dutch OTB_DEF_70-99_all and all TBB_DEF_70-99_0_0_all fleets.

Group 14: OTB_CRU_70-99_all UK raised with OTB_CRU_70-99_all UK.

Group 15: passive gears 3a raised with passive gears 3a. Excluded extreme high value of one métier (SWE) and FPO métiers.

Group 16: all other métiers (except MIS_MIS_0_0_0_IBC) raised by all métiers.

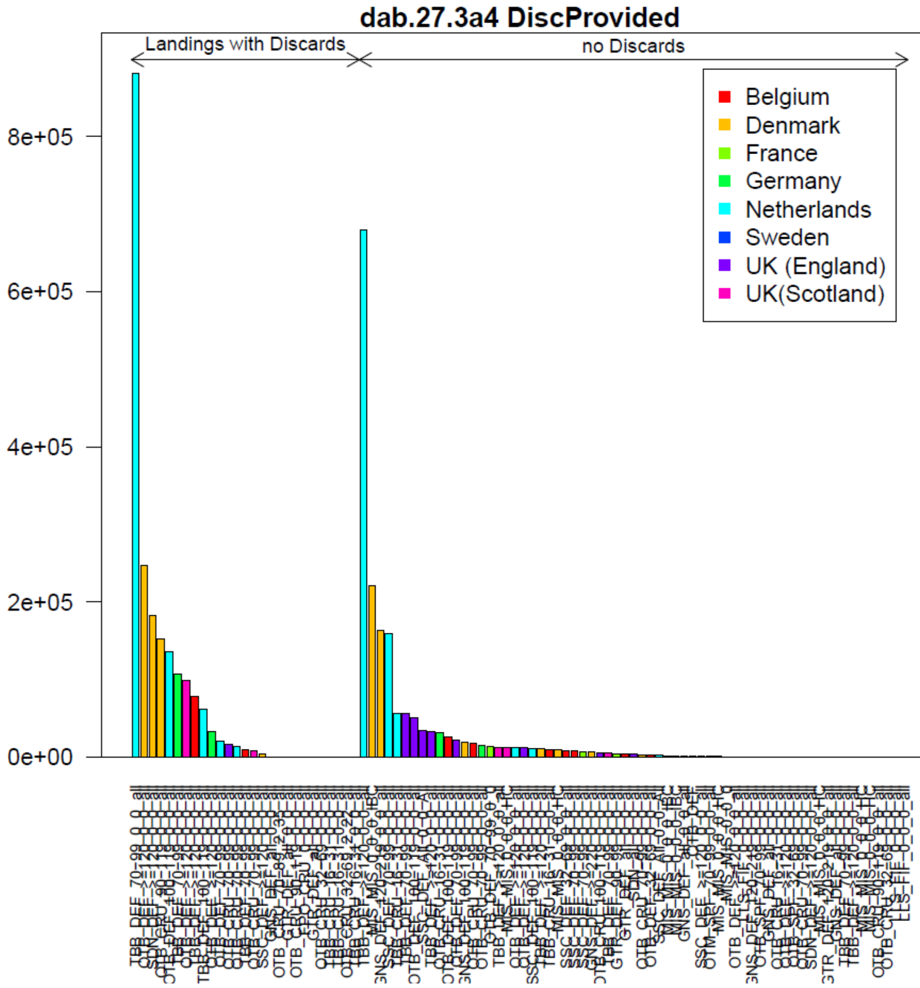


Figure 5.4. Dab in Subarea 4 and Division 3.a: Dab landings and discards (kg) provision for Subarea 4 and Division 3.a by métier and country in 2020 as uploaded into InterCatch.

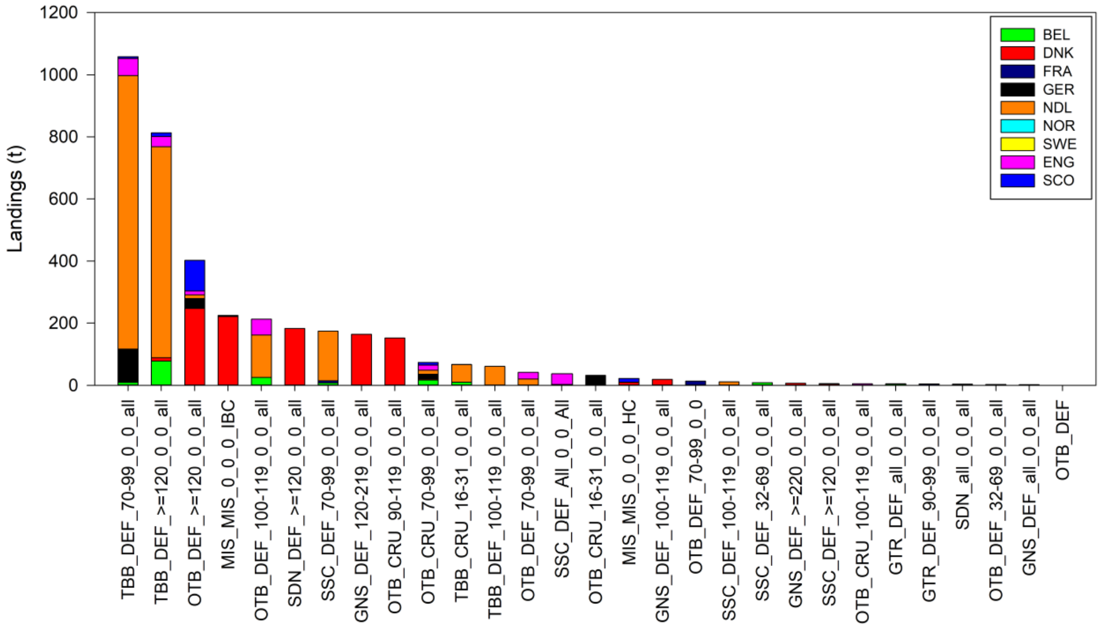


Figure 5.5. Dab in Subarea 4 and Division 3.a: Dab landings (tonnes) for Subarea 4 and Division 3.a by métier and country in 2020 as uploaded to InterCatch.

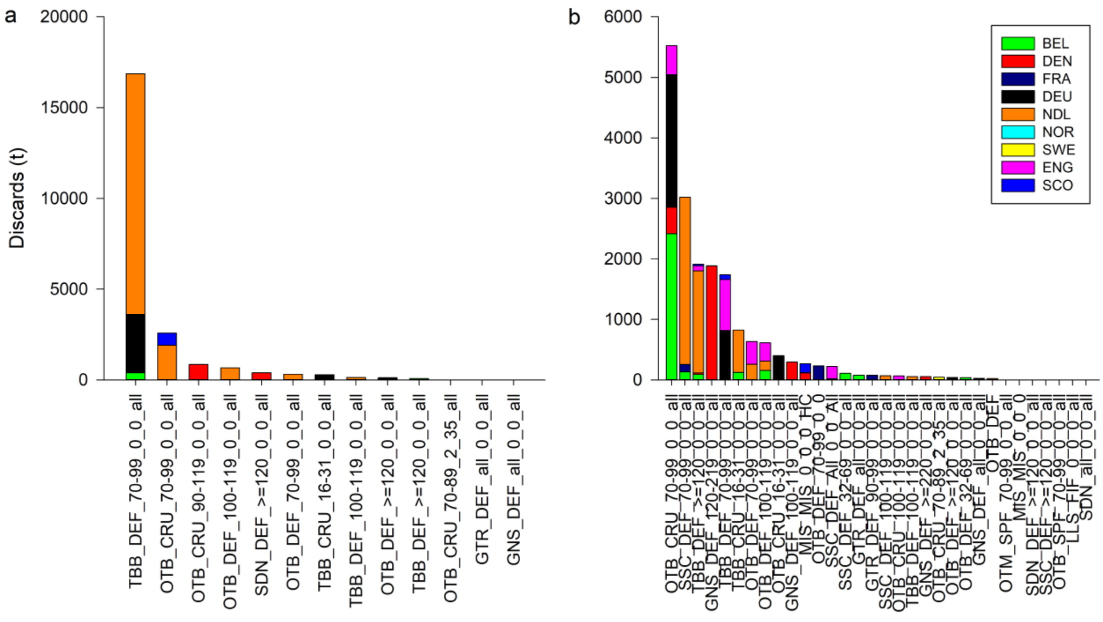


Figure 5.6. Dab in Subarea 4 and Division 3.a: Dab discards for Subarea 4 and Division 3.a by métier and country in 2020. Reported discards (a), raised discards (b).

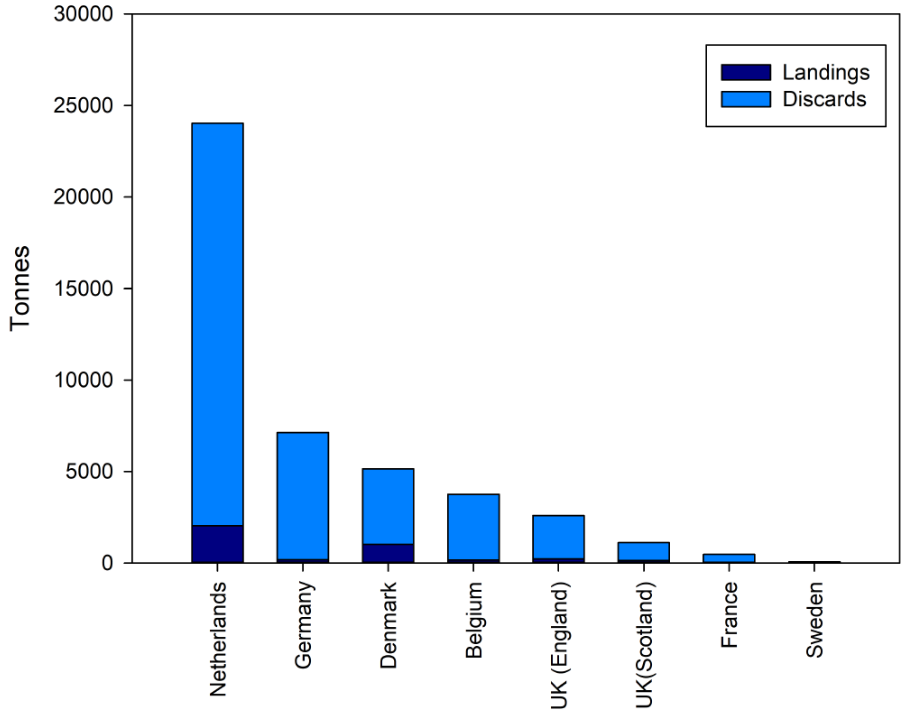


Figure 5.7. Dab in Subarea 4 and Division 3.a: Dab landings and estimated discards for Subarea 4 and Division 3.a by countries in 2020.

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 clear trend is visible in the RV Belgica survey data. A strong decrease was observed for the RV Solea survey for the year 2015, and again for 2019. 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 years 2015–2016. The three recent values from the Tridens, covering the whole area now, varies strongly but on a comparably high level.

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 and dropped again in 2020. 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, this abundance index steadily 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 since 2016 for the age groups 1–5 (Figure 5.15).

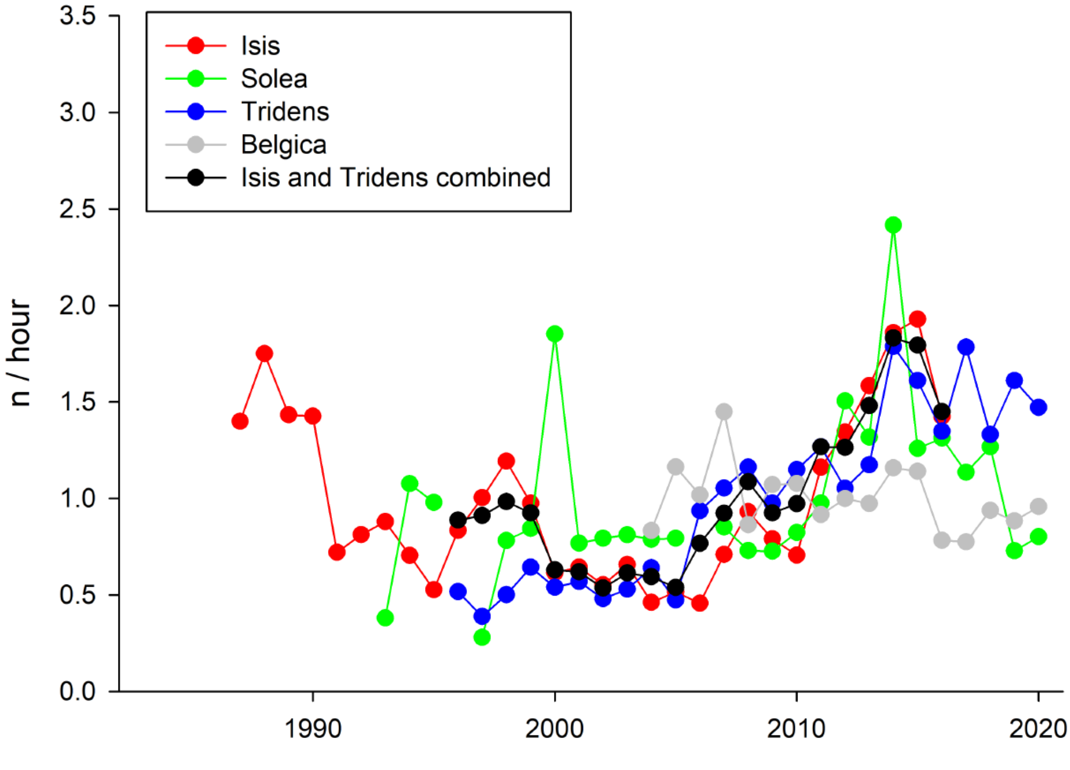


Figure 5.8. Dab in Subarea 4 and Division 3.a: Standardized dab beam trawl survey indices (n/hour) in Subarea 4.

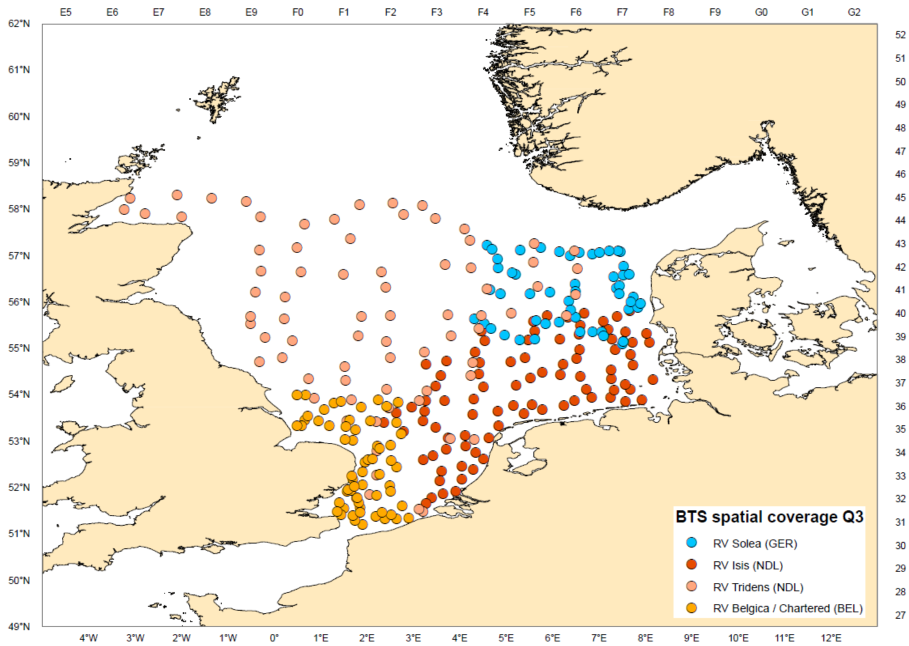


Figure 5.9. Dab in Subarea 4 and Division 3.a: Spatial coverage of the different beam trawl surveys in the North Sea. Since 2017, the survey area from RV Isis is also covered by RV Tridens.

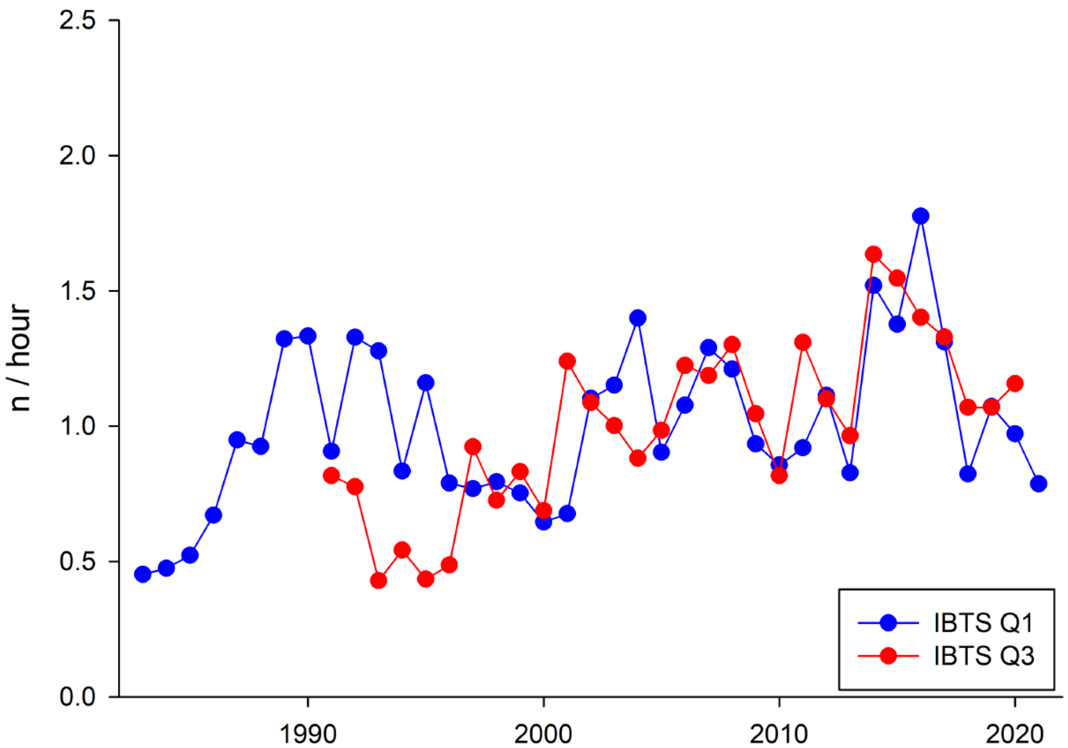


Figure 5.10. Dab in Subarea 4 and Division 3.a: Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

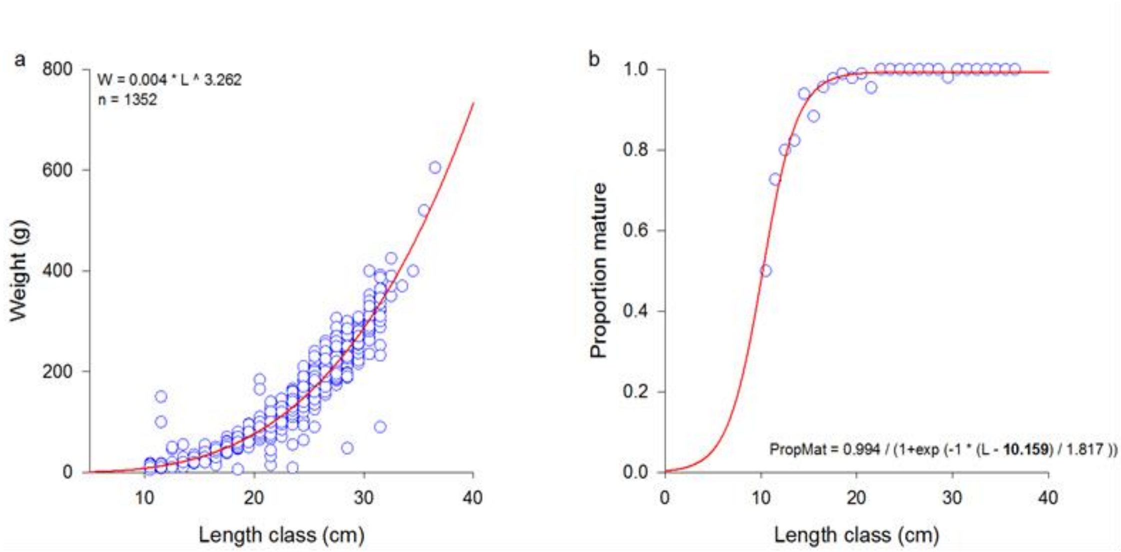


Figure 5.11. Dab in Subarea 4 and Division 3.a: Length weight relation (a) and length-based maturity ogive (b) obtained from survey data (IBTS–Q1).

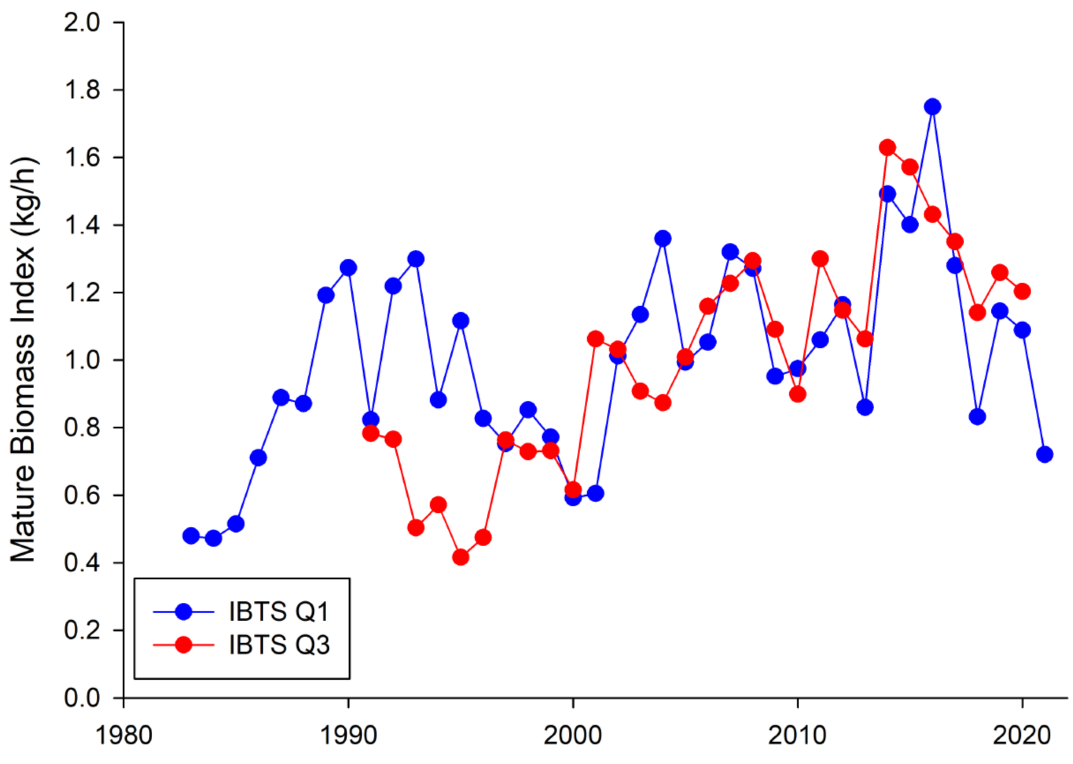


Figure 5.12. Dab in Subarea 4 and Division 3.a: Mature biomass index IBTSQ1 and IBTSQ3.

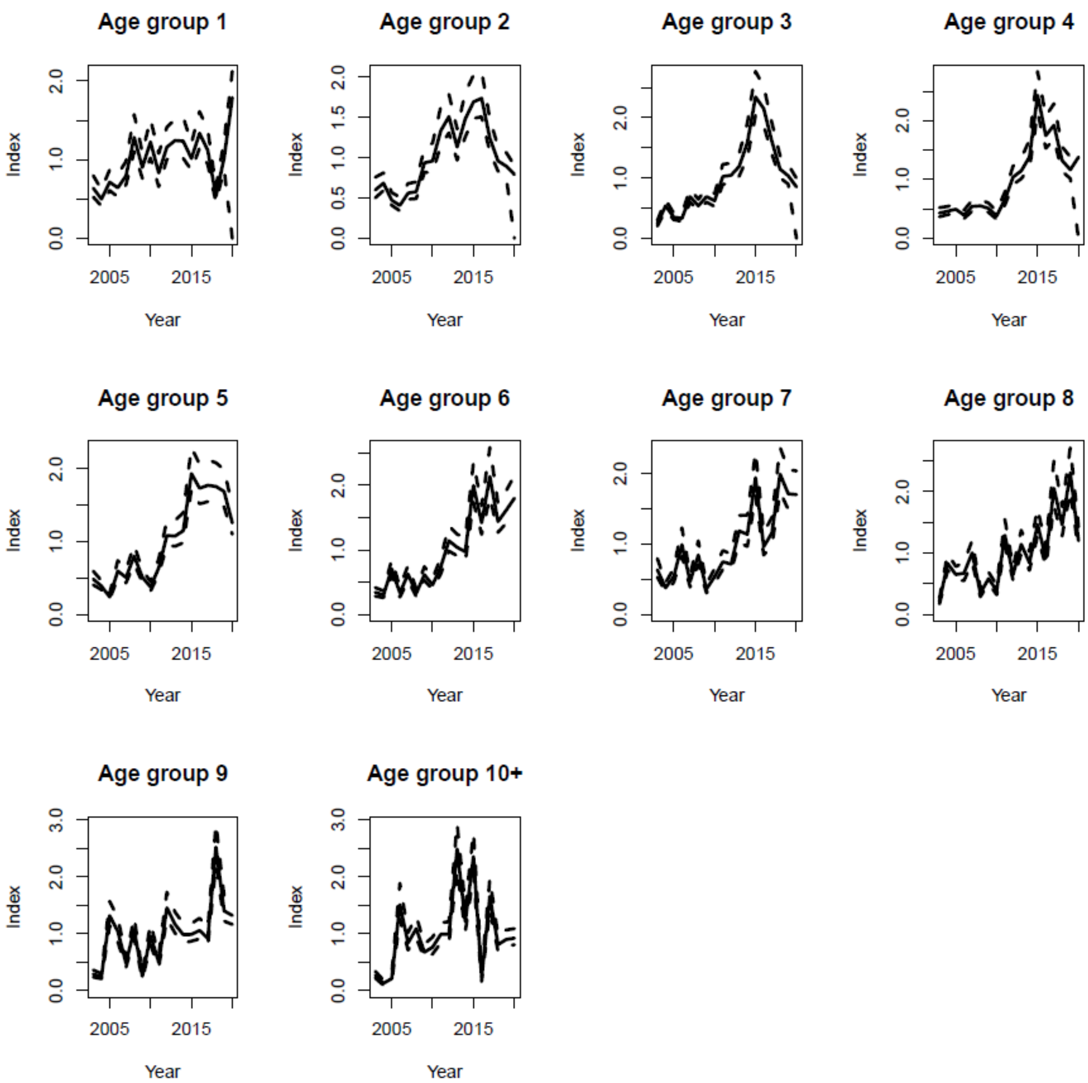


Figure 5.13. Dab in Subarea 4 and Division 3.a: Combined beam trawl index by age groups (2003–2020). Age group = age group -1.

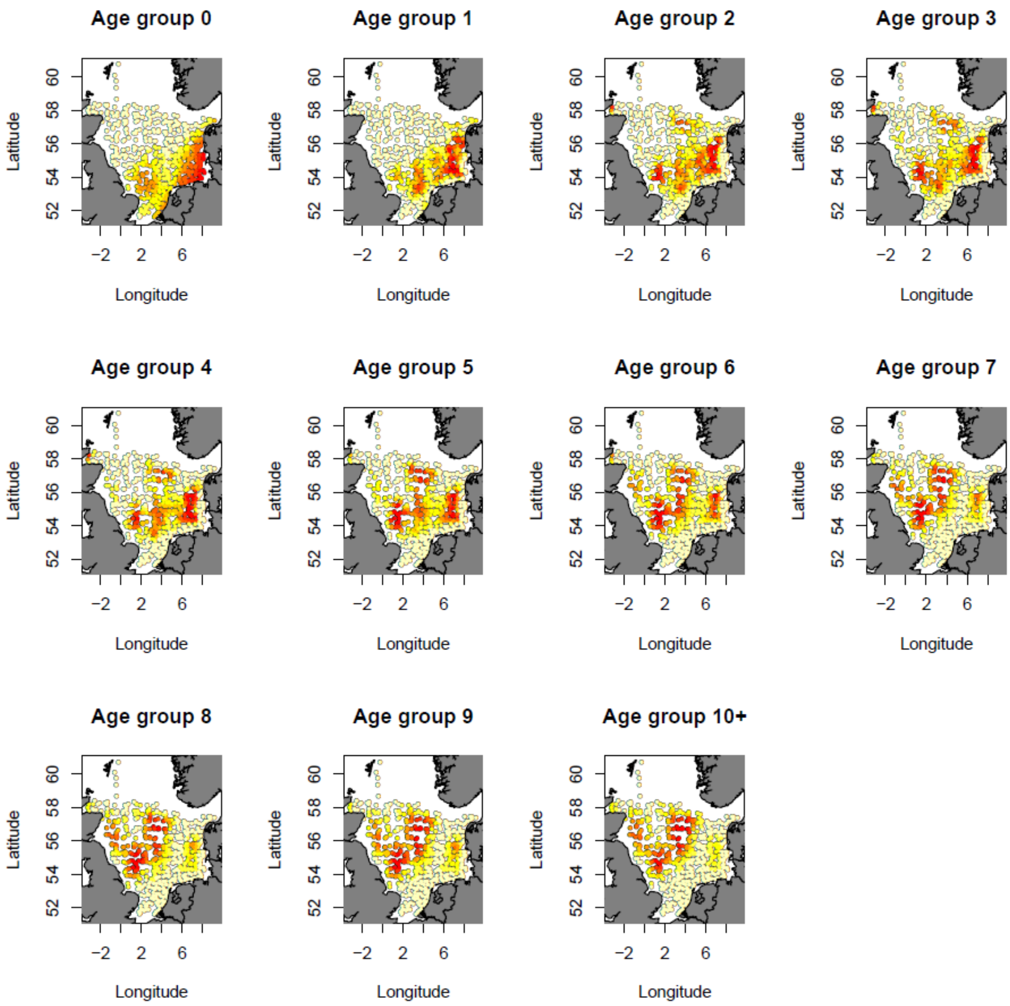


Figure 5.14. Dab in Subarea 4 and Division 3.a: Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys.

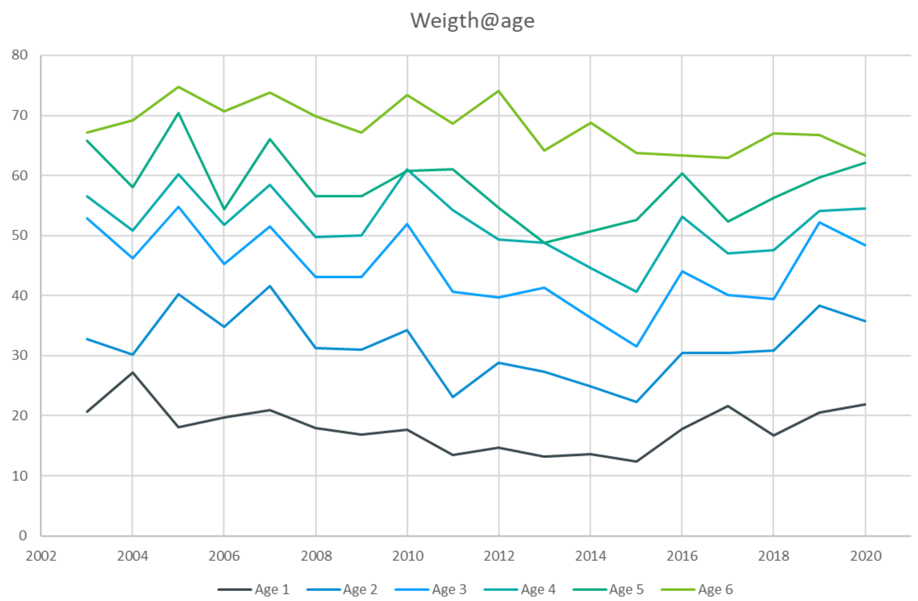


Figure. 5.15 Dab in Subarea 4 and Division 3.a: Weight at age derived from beam trawl survey data 2003–2020).

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 no clear trend in total mortality for the years 2003–2020 (Figure 5.16, upper left panel) while the spawning stock biomass (relative biomass) increased for the years 2003–2016 (Figure 5.16, upper right panel), but decreases since then. The total stock biomass follows the trend of the SSB. The recruitment increased by a factor of 2.6 from 2003 to 2014, but decreased since 2015 (Figure 5.16, lower right panel). No pattern was detected in the log residual pattern of the age-based survey indices (Figure 5.17). There is a strong pattern in the retrospective for total mortality (Figure 5.21).

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)

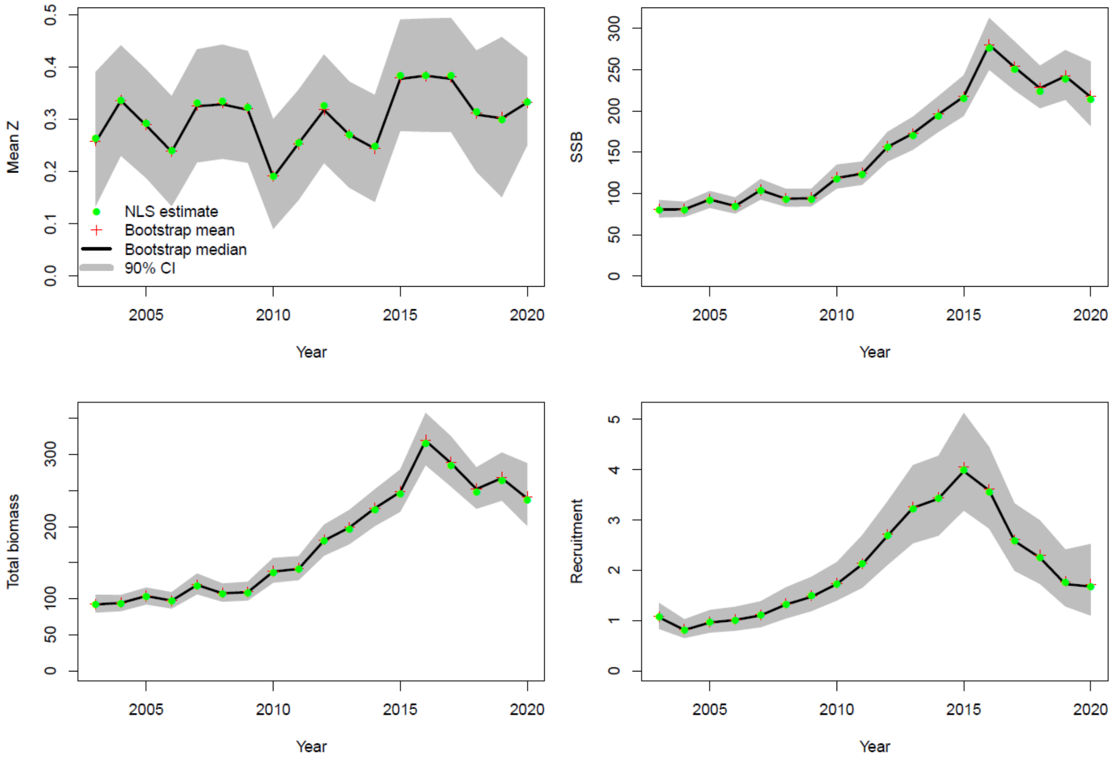


Figure 5.16. Dab in Subarea 4 and Division 3.a: SURBAR model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

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

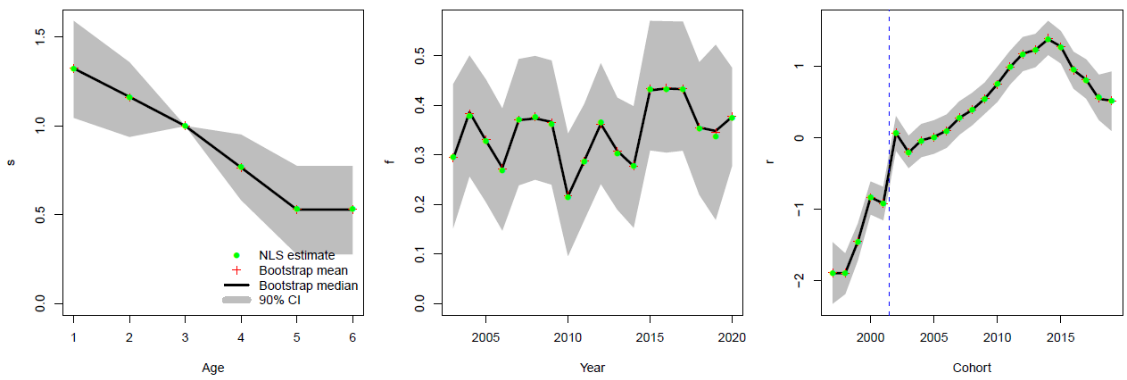


Figure 5.18. Dab in Subarea 4 and Division 3.a: SURBAR model results displaying the age, year and cohort effects.

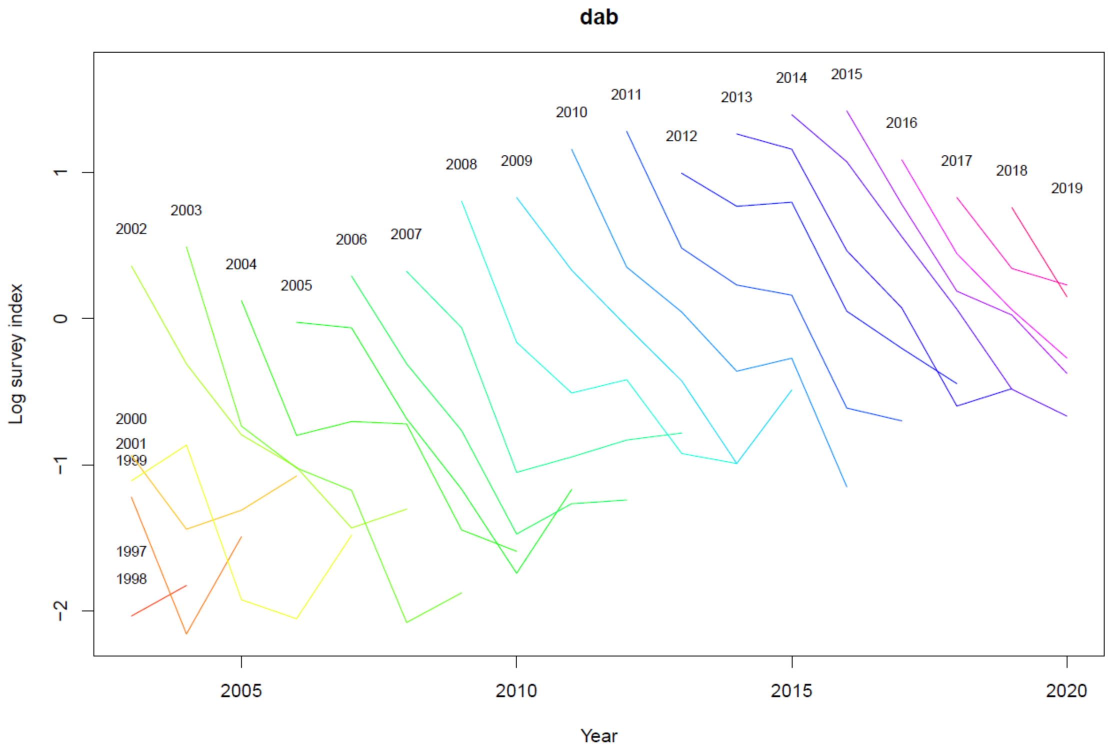


Figure 5.19. Dab in Subarea 4 and Division 3.a: SURBAR model results: catch curves.

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

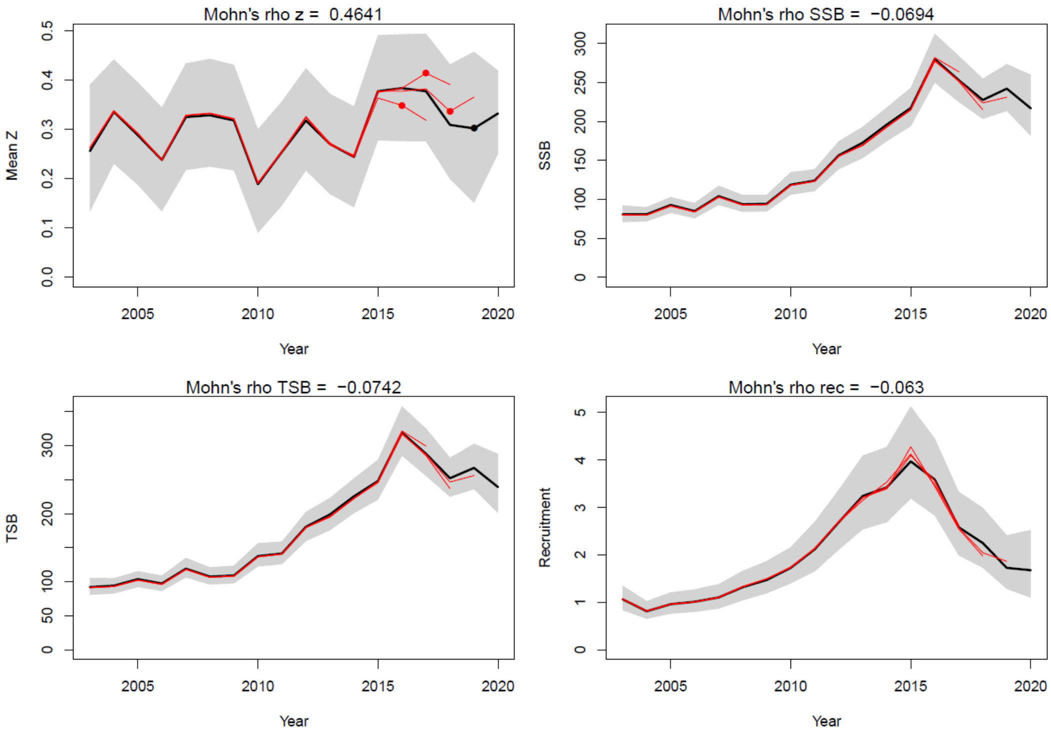


Figure 5.21. Dab in Subarea 4 and Division 3.a: SURBAR Retrospective runs with corresponding Mohn's rho values.

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 (2002–2020) 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 2002–2020
BTS Isis	1987–2002, >12 cm
BTS Tridens	1996–2002, >12 cm
Combined BTS (Isis, Tridens, Solea)	2003–2020, 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 5.22–5.27.

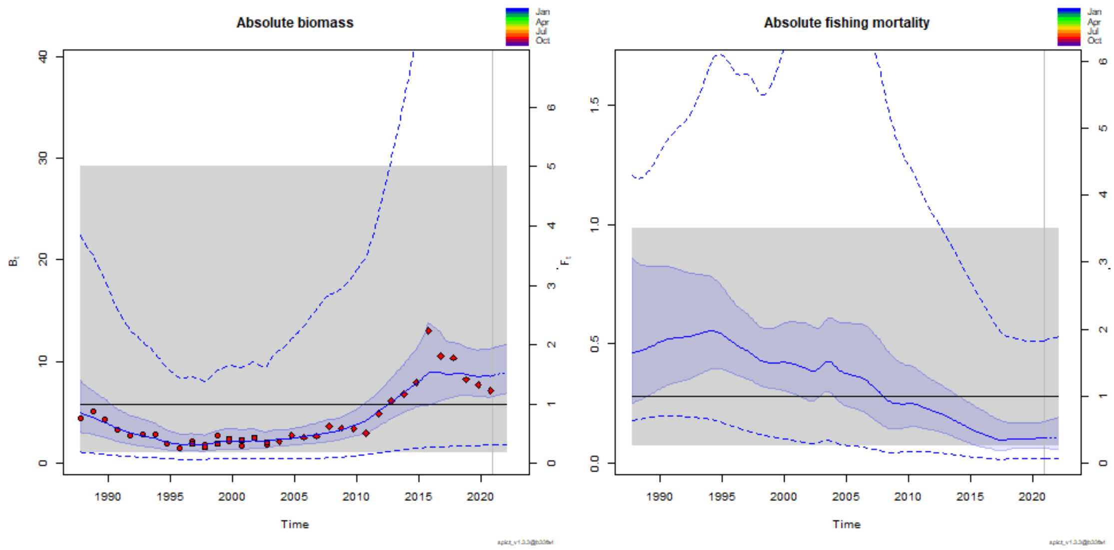


Figure 5.22. Dab in Subarea 4 and Division 3.a: SPiCT results. Absolute biomass (left panel) and absolute fishing mortality (right panel).

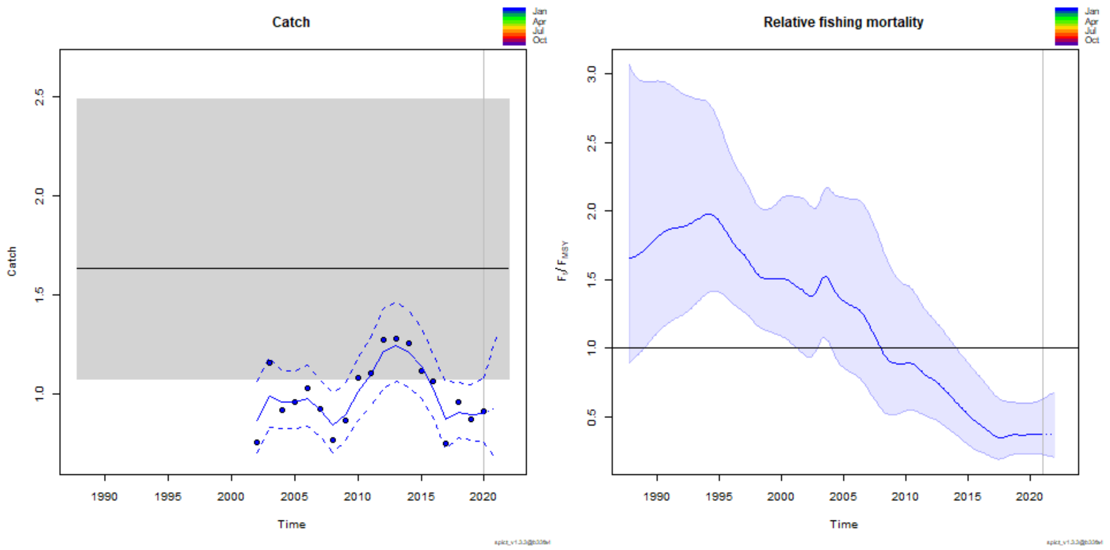


Figure 5.23. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch time series (left panel) and relative fishing mortality (right panel).

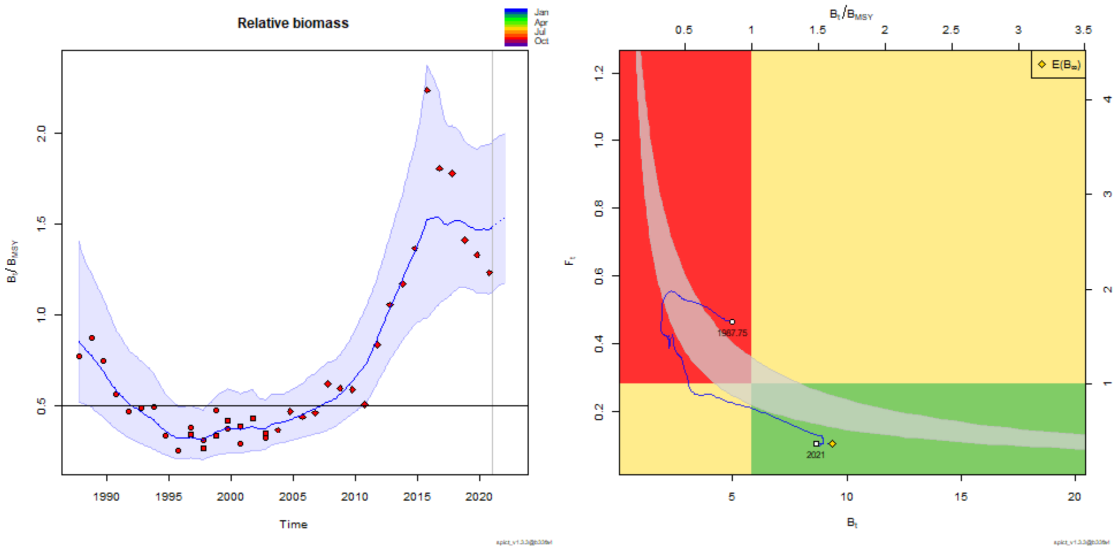


Figure 5.24. Dab in Subarea 4 and Division 3.a: SPiCT results. Relative biomass (left panel) and Kobe plot of relative fishing mortality over biomass estimate (right panel).

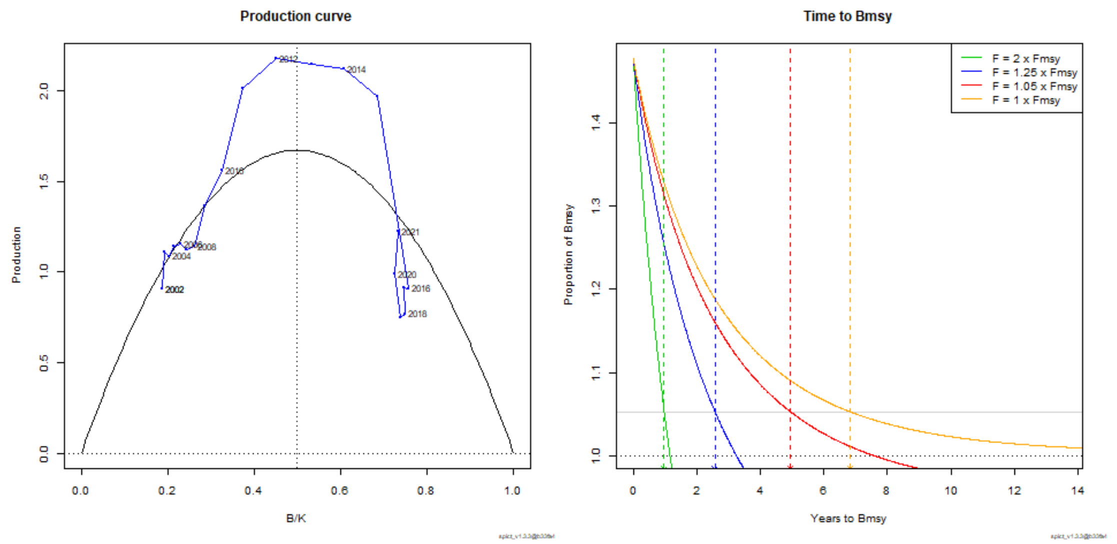


Figure 5.25. Dab in Subarea 4 and Division 3.a: SPiCT results. Production curve (left panel) and estimated time to B_{MSY} (right panel).

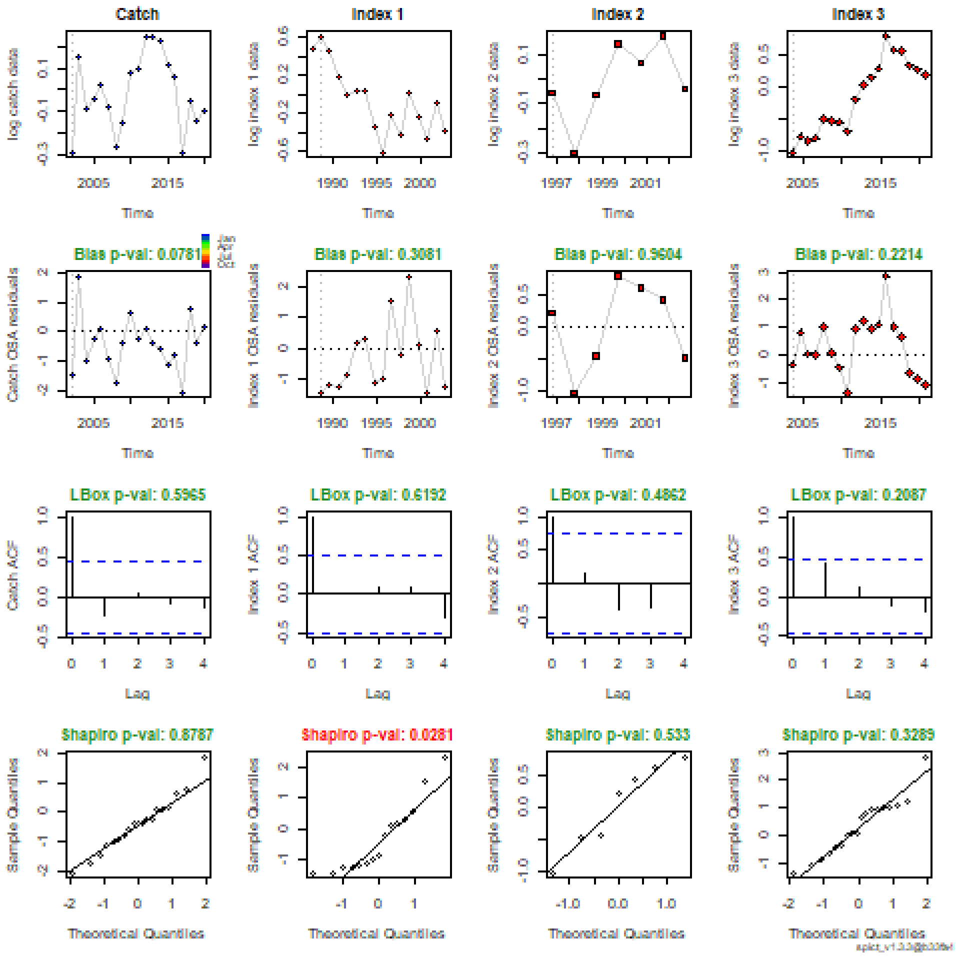


Figure 5.26. Dab in Subarea 4 and Division 3.a: SPiCT diagnostics.

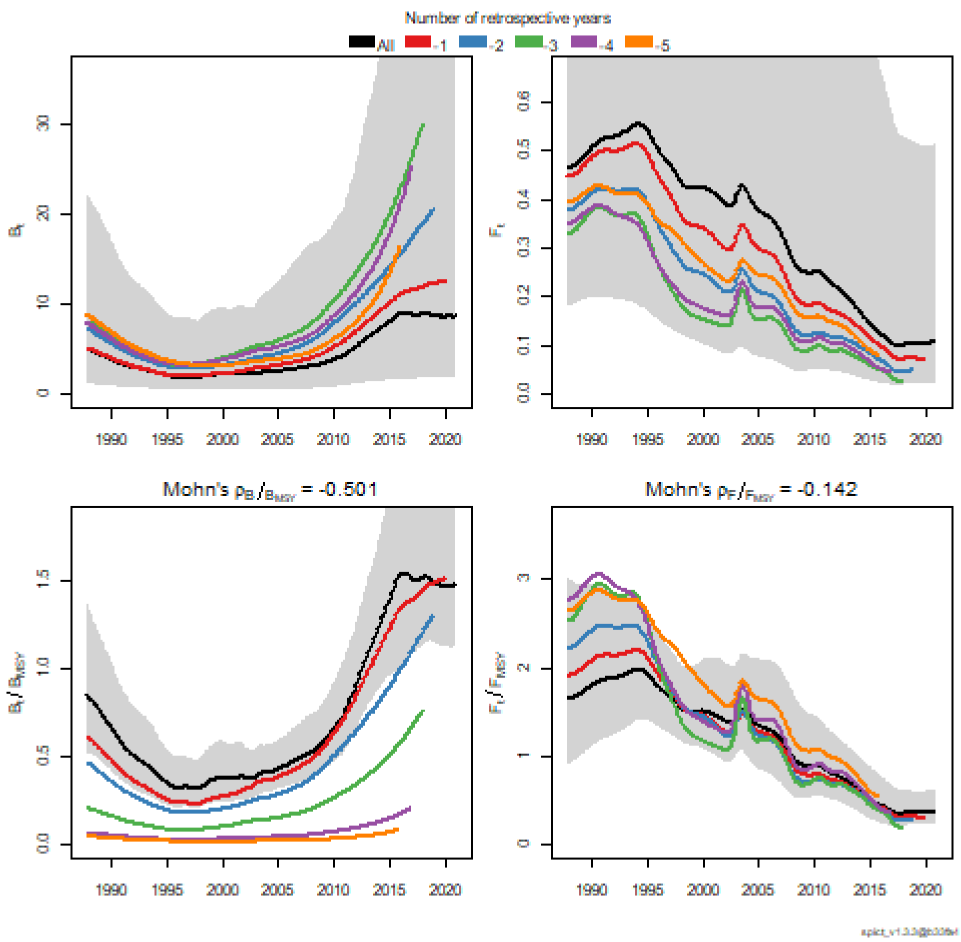


Figure 5.27. Dab in Subarea 4 and Division 3.a: SPiCT retrospective plots.

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

Year	Subarea 4	Division 3.a	Total
1950	5971	1287	7258
1951	8190	1332	9522
1952	7976	1294	9270
1953	5915	1123	7038
1954	5652	1237	6889
1955	6623	1257	7880
1956	5468	2081	7549
1957	6127	2724	8851
1958	6342	2210	8552
1959	5239	1943	7182
1960	5168	1314	6482
1961	4602	1367	5969
1962	4082	1683	5765
1963	4615	1565	6180
1964	4982	1575	6557
1965	5519	2052	7571
1966	5862	1755	7617
1967	4324	1115	5439
1968	3995	1548	5543
1969	4122	1430	5552
1970	5183	1079	6262
1971	6546	1242	7788
1972	7901	1669	9570
1973	9657	1449	11106
1974	7146	2003	9149
1975	7033	2049	9082
1976	5917	1583	7500
1977	6702	2318	9020
1978	6407	2630	9037
1979	8243	2716	10959
1980	8357	2333	10690
1981	8454	2679	11133
1982	9565	2902	12467
1983	11865	2906	14771
1984	5482	2769	8251
1985	5502	1545	7047
1986	3205	1608	4813
1987	3931	2258	6189
1988	7067	2254	9321

Year	Subarea 4	Division 3.a	Total
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	788	3529
2018	3607	830	4377
2019*	3987	1066	5053
2020*	3342	634	3976

*** 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
2019*	309	166	897	31	0	367	2132	85	0	3987
2020*	171	188	557	25	0	368	1943	84	6	3342

*** 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	3	601	0	157	14	13	788
2018	0	10	586	0	230	2	2	830
2019*	0	1	675	0	387	1	2	1066
2020*	0	1	457	0	173	0	3	634

*** Preliminary catch statistics**

Table 5.6. Dab in Subarea 4 and Division 3.a.: InterCatch landings, discards and total catch (2002–2020).

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%
2019	5024	26330	9372	35702	40725	88%
2020	3808	22291	16575	38866	42673	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. Catch advice for flounder was prepared for 2018 and 2019 during the WGNSSK 2017 (ICES, 2017a). However, later 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 for the years 2020 and 2021. 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). However, updating the SPiCT assessment model new available data since then increased the uncertainties to unacceptable levels. Therefore, the LBI method was used again instead, as it was done for the previous advice (ICES, 2017b). In 2021 precautionary catch advice was again requested for the flounder North Sea stock. Therefore, catch data, survey indices, and the LBI method were updated and presented during the WGNSSK2021 meeting. As in previous years the NS-IBTS Q1 index was used as stock indicator on which the 2 over 3 rule was applied (ICES, 2012). The LBI method showed that the fishing pressure is below F_{MSY} proxy. However, the trend of the index was decreasing for the last years, with the lowest observed value in 2020, therefore the precautionary buffer was applied. This resulted in a catch advice of 1650 tonnes, based on the average catch of the recent three years, and corresponding landings of 1171 tonnes (discard rate = 29% last three year average).

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 since 2000 (STECF, 2016). The lowest official landings were reported for 2017, since then it increases slightly again. For 2020, total official landings were reported with 1767 tonnes, compared to 1668 tonnes in 2019. In Division 3.a, annual landings in general have decreased sharply from mid of the 1980s until 2015. Official landings increased slightly since then, 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.

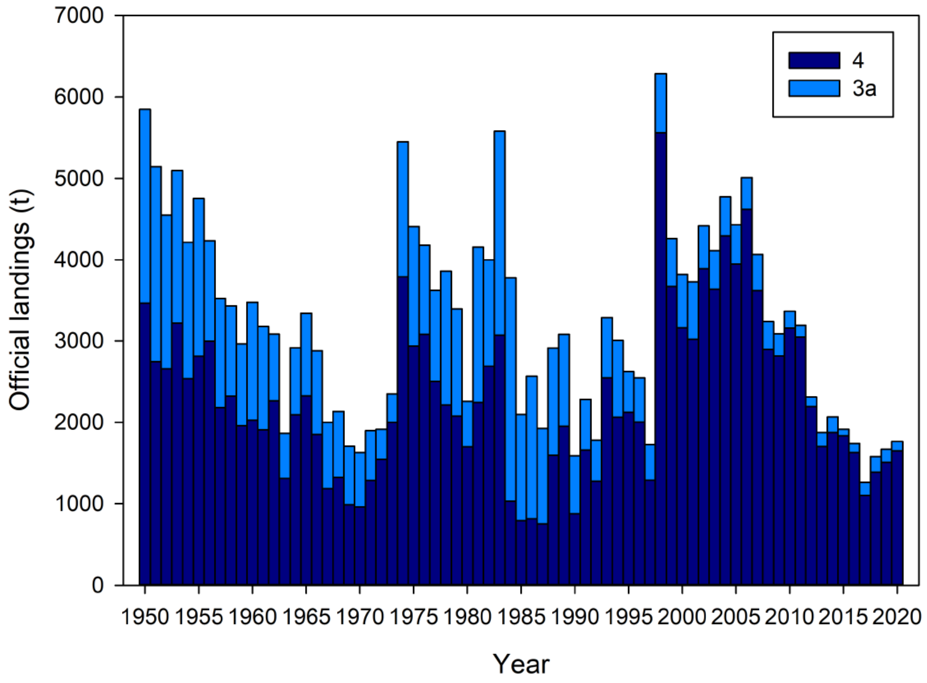

Figure. 6.1. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder by area 1950–2020.

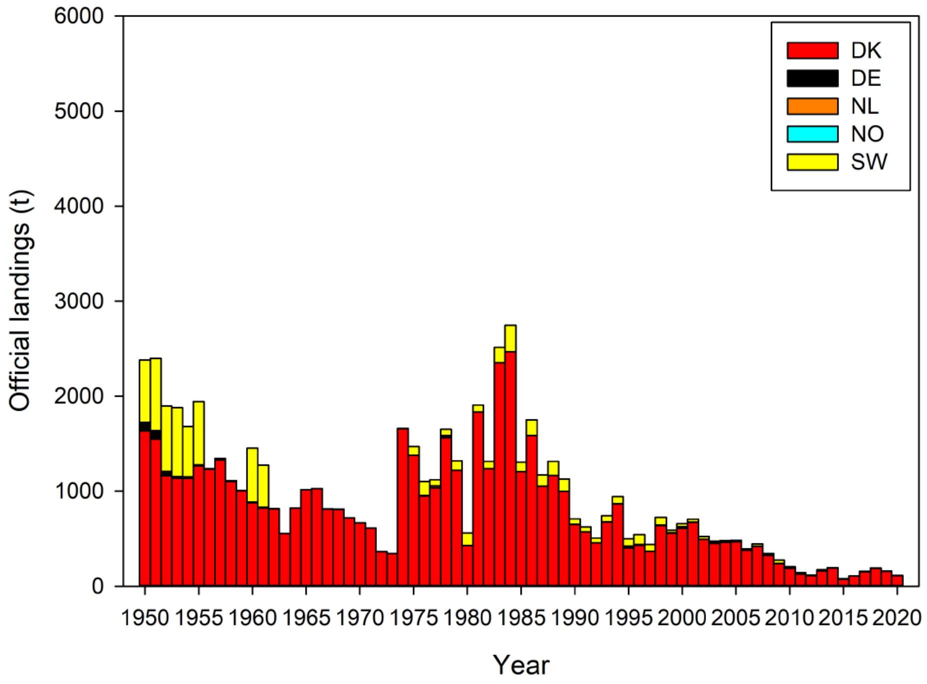

Figure 6.2. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder in ICES Division 3.a by country 1950–2020.

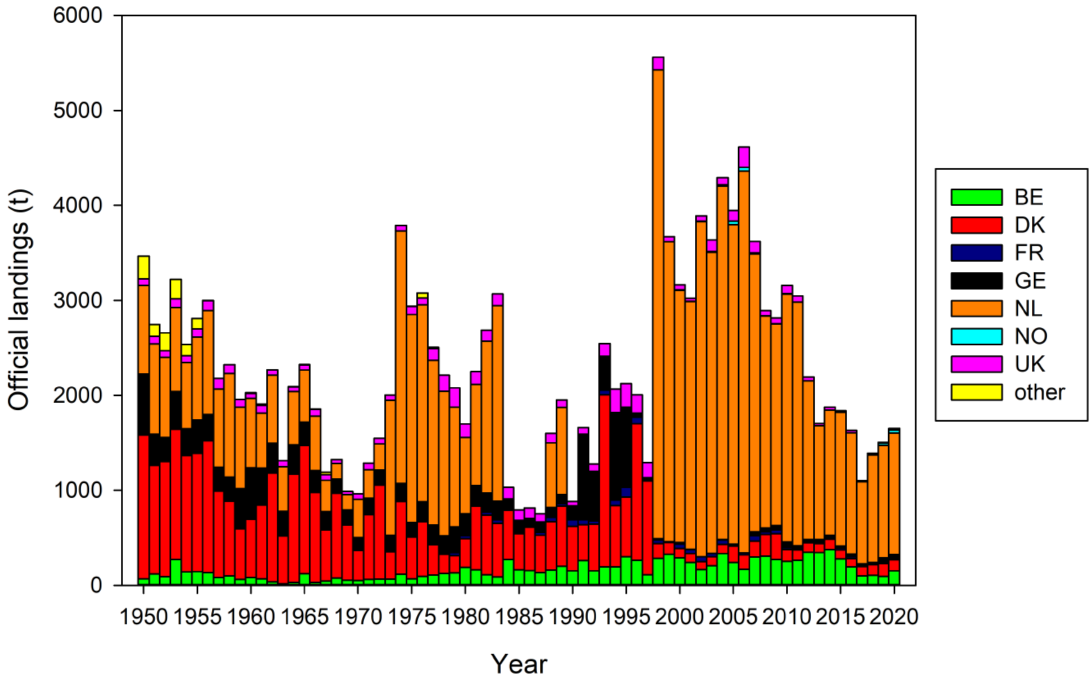

Figure 6.3. Flounder in Subarea 4 and Division 3.a: Official landings of flounder in ICES Subarea 4 by country 1950–2020.

6.2.2 InterCatch

Flounder landings and discards data from 2002–2020 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 85% of all métiers in 2020 (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.

In 2020, by far the largest proportion of landings (1351 tonnes, ~79% of total landings) was reported by Dutch beam trawlers (TBB_DEF_70_99_0_0_all), followed by the Belgium TBB_DEF_70-99_0_0_all metier (136 tonnes) and the Danish GNS_DEF_120-219_0_0_all (100 tonnes). Also the Dutch and Belgium shrimper fleets (TBB_CRU_16-31_0_0_all) landed a considerable amount of flounder with 87 tonnes in total. All other métiers did not land more than 15 tonnes each (Figure 6.5). The highest amount of discards in 2020 was reported for the Dutch TBB_DEF_70_99_0_0_all metier (150 tonnes) and the German shrimper fleet (104 tonnes; TBB_CRU_16-31_0_0_all). The Danish and Swedish OTB_CRU_90-119_0_0_all metiérs reported 94 tonnes discards together (Figure 6.6), the Scottish OTB_CRU_70-99_0_0_all reported 89 tonnes of discards.

The largest total catch estimated in 2020 was taken by the Netherlands (1413 tonnes), followed by Denmark (427 tonnes), Belgium (202 tonnes) and Germany (178 tonnes). All other countries catch less than 100 tonnes each (Figure 6.7). The total catch estimated with InterCatch was 2394 tonnes from which 1715 tonnes were landings (compared to 1767 tonnes reported official landings) and 679 tonnes discards (28% 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. Further, no data from Norway were imported into InterCatch for 2020, while official landings are reported with 30 tonnes.

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 2020 data discard raising:

Group 1: TBB_DEF_70-99_0_0_all and TBB_DEF_100-119_0_0_all raised with all other TBB_DEF_70-99_0_0_all

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

Group 3: all OTB, SSC, SDN, 70 – 119 raised with all other métiers of same mesh sizes.

Group 4: All passive gears raised with all passive gears (only SWE discard data available)

Group 5: OTB_DEF>=120 with all OTB_DEF_>=120

Group 6: SDN_SSC_DEF_>=120 with all other SDN_SSC_DEF_>120

Group 7: TBB_DEF_>=100_0_0_0_all raised with all TBB_DEF métiers

Group 8: all other métiers were raised with all métiers.

Length allocations for 2020 data: one discard group (including BMSL and LogBook D, excluding TBB_CRU_16-31_0_0_all data) and one landing group. In addition, one separate group for TBB_CRU_16-31_0_0_all discards.

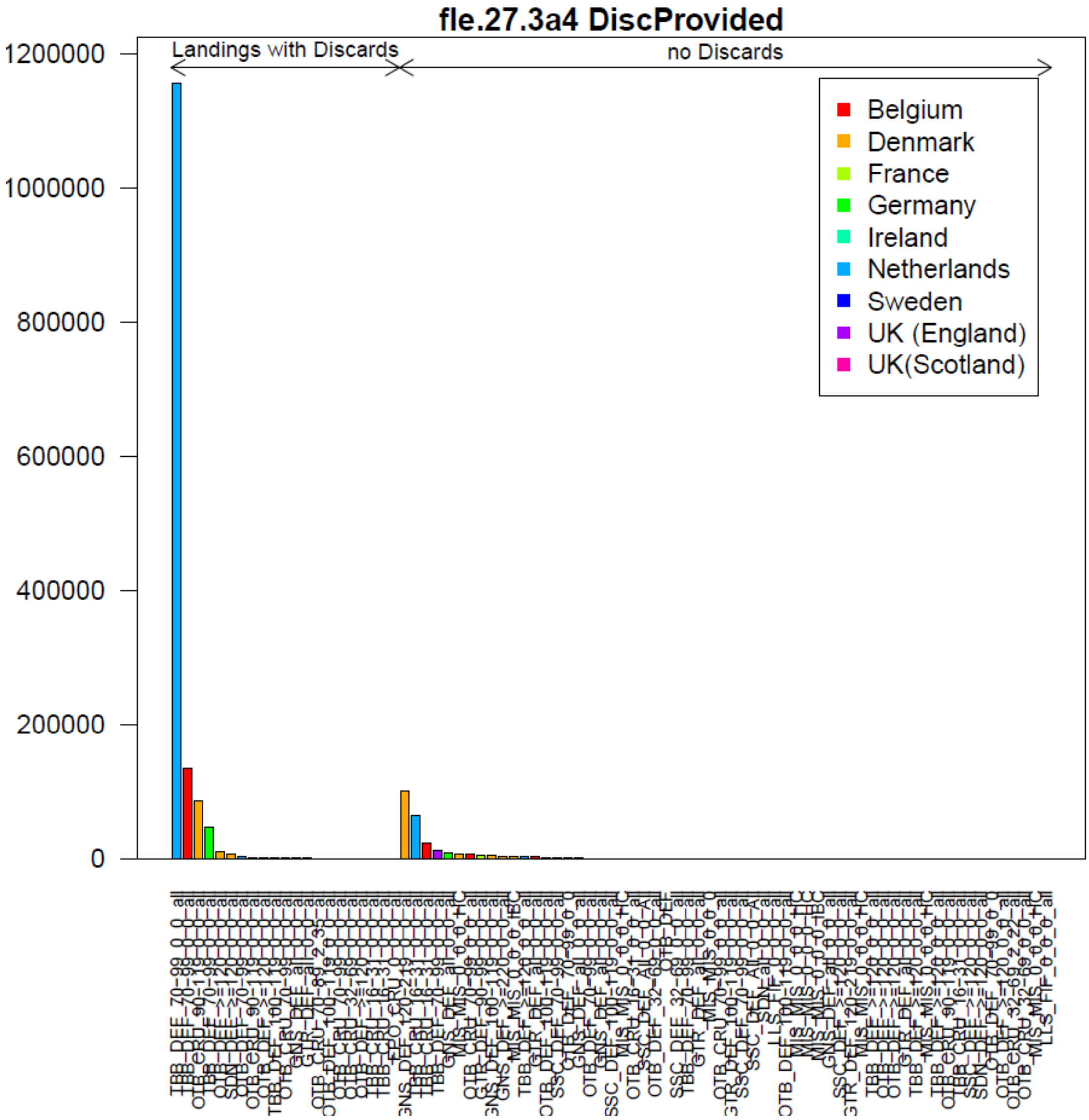

Figure 6.4. Flounder in Subarea 4 and Division 3.a: Provision of discards information by country and fleets imported to InterCatch for 2020 data.

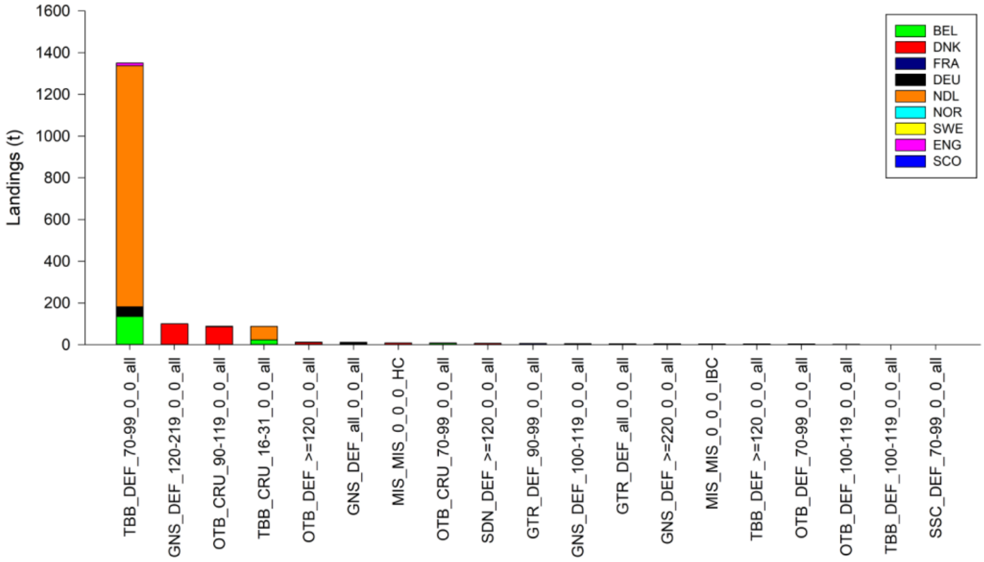

Figure 6.5. Flounder in Subarea 4 and Division 3.a: Flounder landings by métier and country in 2020 as uploaded to InterCatch.

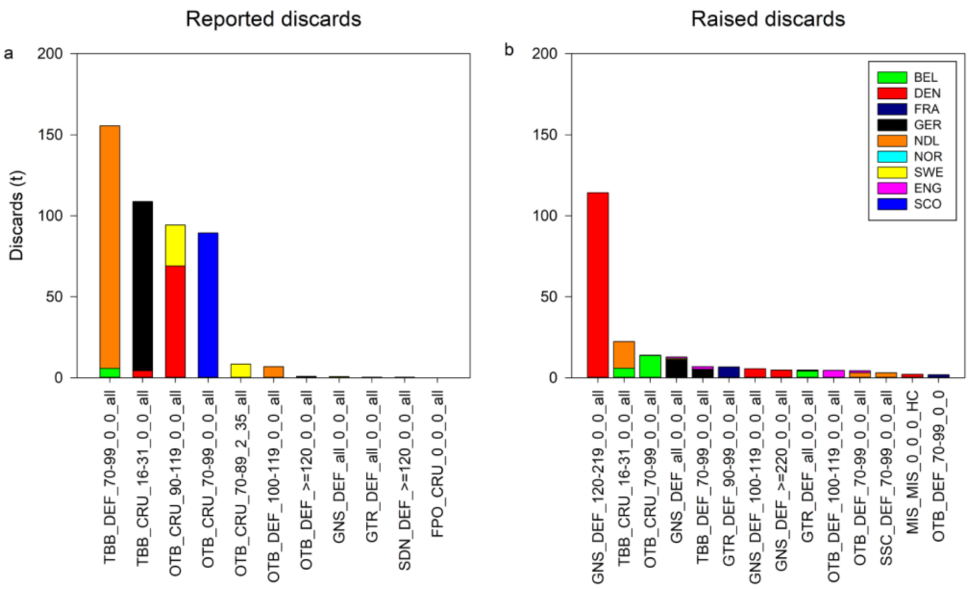

Figure 6.6. Flounder in Subarea 4 and Division 3.a: Flounder discards by métier and country in 2020. Reported discards panel (a), raised discards panel (b).

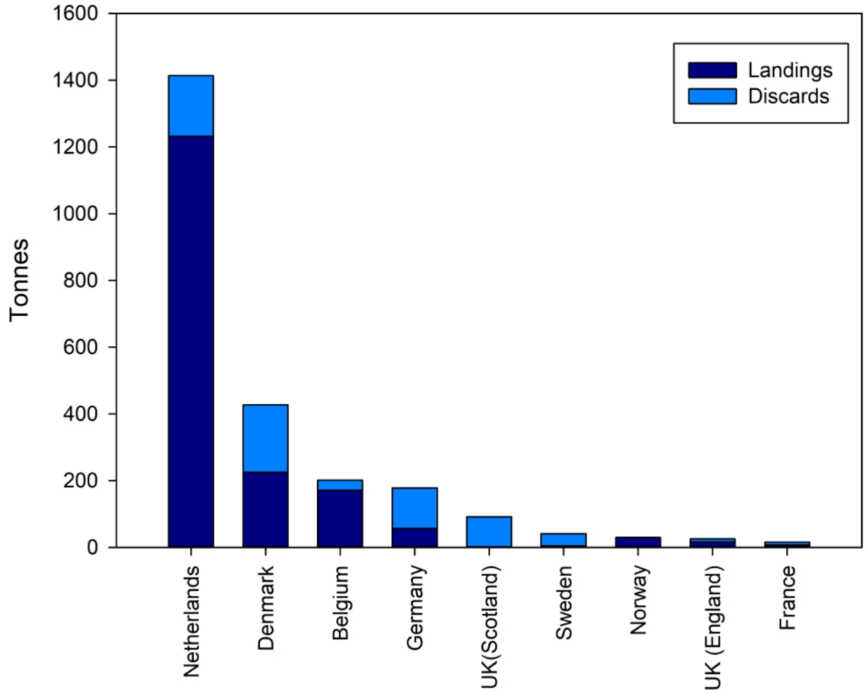

Figure 6.7. Flounder in Subarea 4 and Division 3.a: Flounder landings and discards by country in 2020 estimated with InterCatch.

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 North Sea International Bottom Trawl Survey in quarter 1 (NS-IBTSQ1) 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 (BTS). However, the NS-IBTSQ1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. Further, it should be noted here that the NS-IBTSQ1 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 is distributed in more coastal, shallow and brackish waters in the river estuaries and the wadden sea areas. Biological data available from the NS-IBTSQ1 survey is displayed in Figure 6.9. and Figure 6.10.

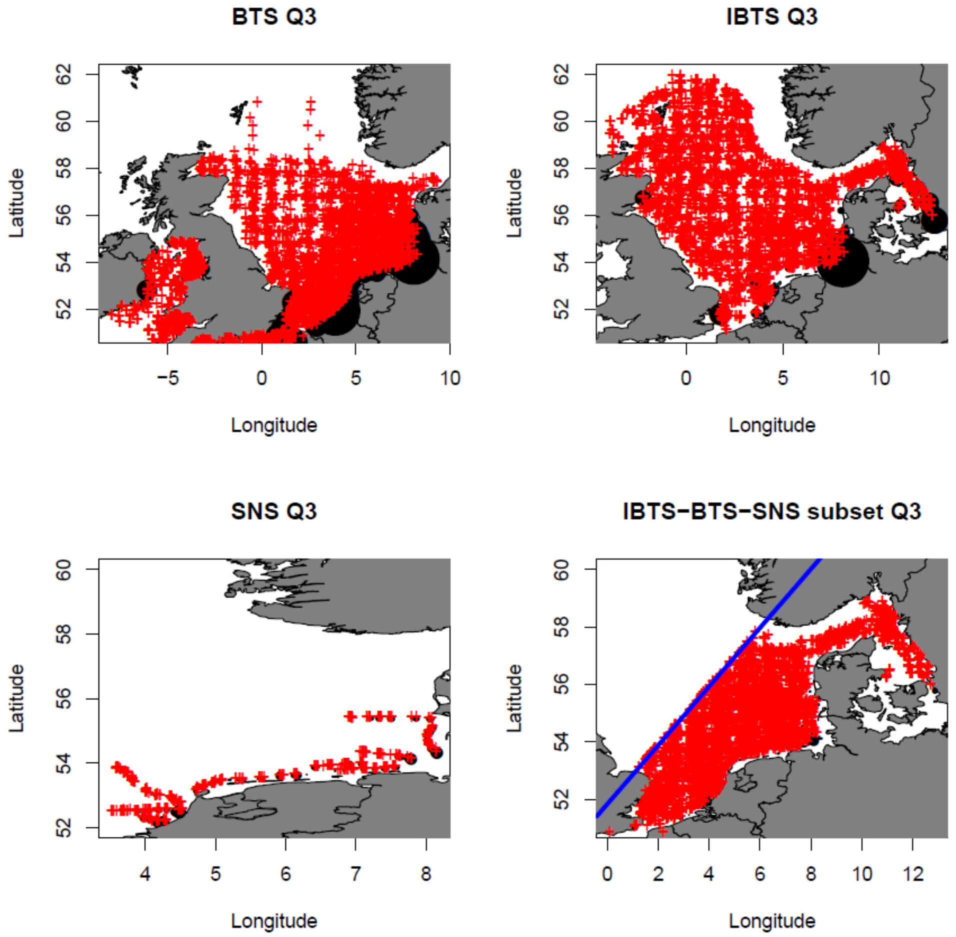

Figure 6.8. Flounder in Subarea 4 and Division 3.a: Distribution of flounder derived from different bottom trawl surveys in Subarea 4 and Division 3.a and the defined index area (lower right panel).

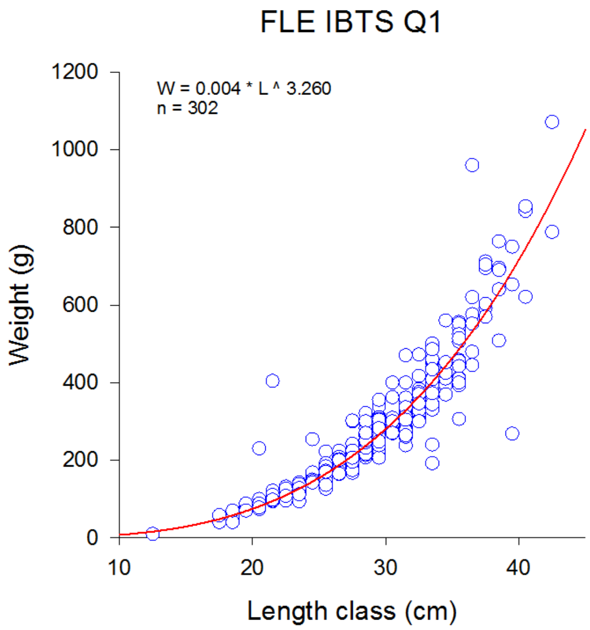

Figure 6.9. Flounder in Subarea 4 and Division 3.a: Length weight relationship of flounder derived from NS-IBTSQ1 data.

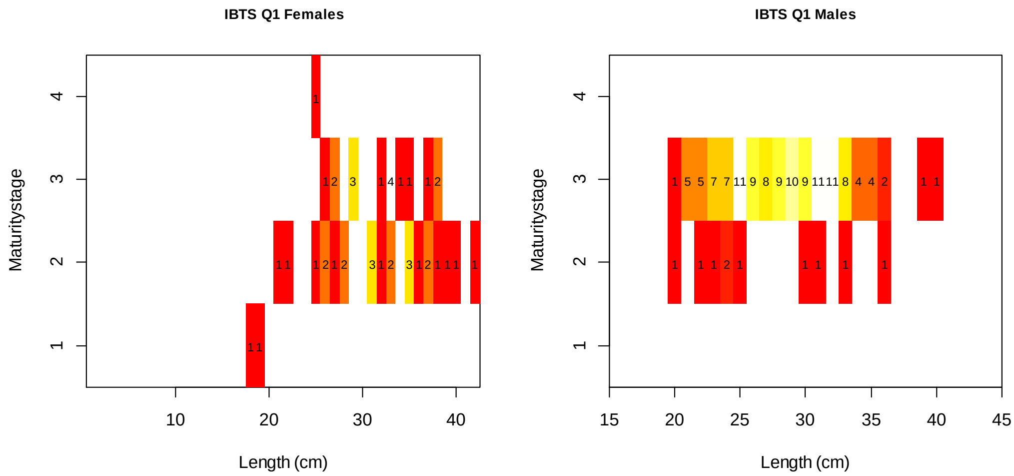

Figure 6.10. Flounder in Subarea 4 and Division 3.a: Maturity at length of female and male flounder derived from IBTS–Q1 data.

Survey indices

The flounder assessment was benchmarked in 2018 and two survey indices were constructed: a NS-IBTSQ1 and a combined quarter 3 index (IBTS, BTS, SNS), both indices modelled with the deltaGAM method (Berg *et al.*, 2014). For both indices the index area was defined, based on the species distribution from the hauls (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 NS-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 NS-IBTSQ1 index shows higher values at the beginning of the time series (Figure 6.11 blue line). Since 2000, the index was increasing again until 2008. Since then, the index was in general decreasing, with the lowest observed value in 2020. The combined quarter 3 index (Figure 6.11 red line) does not show any clear trends and follows the trend of the NS-IBTSQ1 index only partly. However, it seems that the overall trend of both indices is similar with higher observed values at the beginning of the time series and an overall decreasing trend from 2008 onwards.

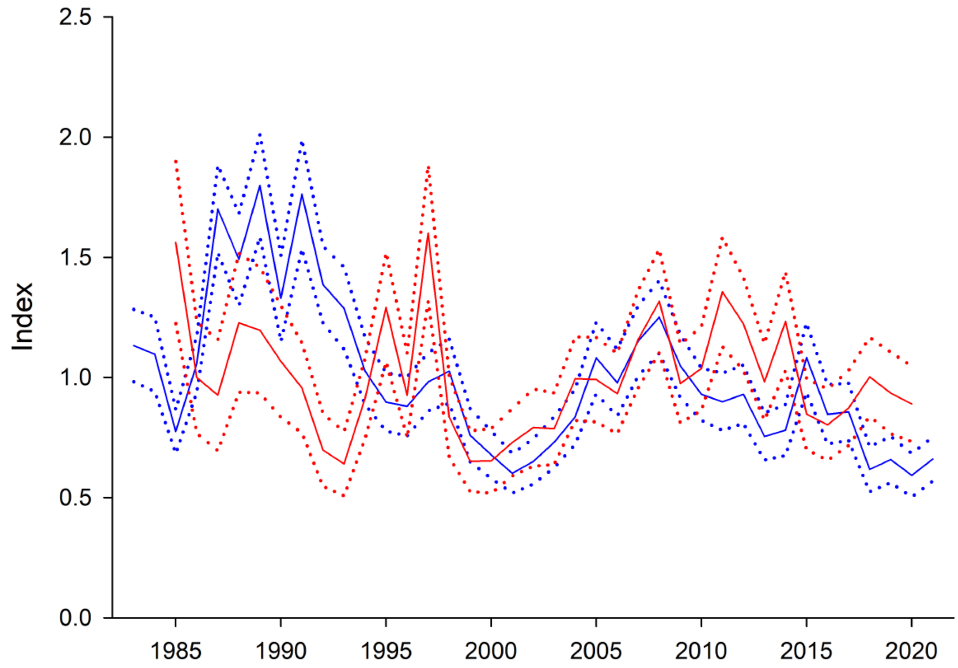

Figure 6.11. Flounder in Subarea 4 and Division 3.a: IBTS Quarter 1 biomass index (blue line) and combined quarter 3 biomass index (red line). Dotted lines display sd.

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

6.4.1 Length based indicators

Flounder length samples (sex combined) from commercial catches were provided in InterCatch format for the years 2014–2020. 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 6.12). 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 20 mm length classes. The method also requires growth parameters, which were taken either from literature (Froese and Sampang, 2013; Table 6.1) or estimated based on the available survey or InterCatch data. The L_{inf} was recalculated this year using InterCatch length distribution and the empirical formula by Garcia et al. (2016):

$$\log_{10}L_{\infty} = 0.068260\ (\pm 0.010451) + 0.969112\ (\pm 0.006318)\ \log 10 L_{max},$$

where L_{max} is defined as the 99% percentile of the commercial length distribution (39.5 cm; Figure 6.13). This resulted in the applied L_{inf} of 41.3cm.

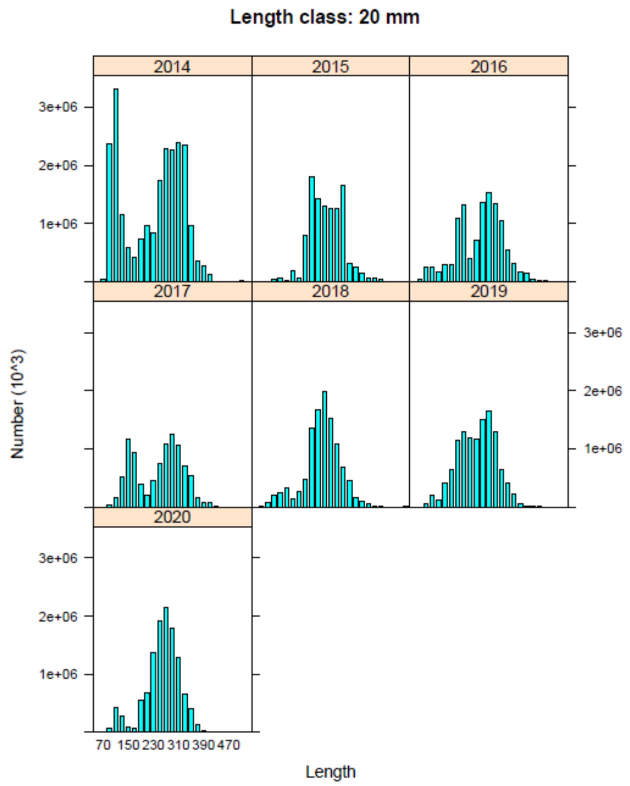

Figure 6.12. Flounder in Subarea 4 and Division 3.a. Left panel: Length distribution (20 mm length classes) from InterCatch 2014–2019. Right panel: Binned to 20 mm and reduced by incoming recruits (>150 mm, right panel) as used in the analyses.

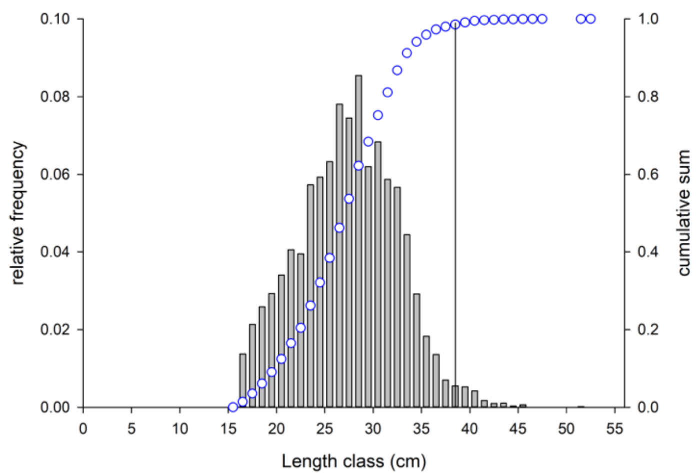

Figure 6.13. Flounder in Subarea 4 and Division 3.a. InterCatch relative length distribution (2014–2020) with the cumulative sum. Vertical line displays the 99% percentile of the distribution (39.5 cm).

The results of the LBI method showed that most of the indicators are above the reference points for 2020 (Table 6.2). Only the P_{mega} indicator decreased since 2014 and dropped below the 30% reference point since 2018. The L_C / L_{mat} ratio fluctuated around 1 but was above in 2020. 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)	41.3
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

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 2014–2020.

	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
2014	0.90	1.21	0.93	0.42	1.05	1.18
2015	1.10	1.12	0.94	0.36	1.05	1.05
2016	0.90	1.02	0.96	0.35	1.01	1.13
2017	0.81	1.17	0.93	0.37	1.02	1.22
2018	1.10	1.17	0.91	0.26	1.03	1.03
2019	0.90	1.02	0.89	0.24	0.98	1.10
2020	1.10	1.17	0.87	0.23	1.02	1.02

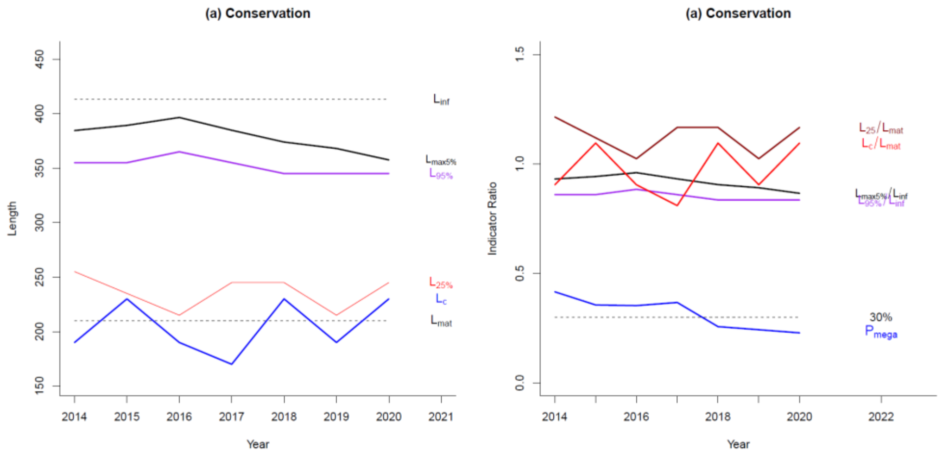

Figure 6.14. Flounder in Subarea 4 and Division 3.a. Conservation indicators (left panel) and indicator ratios (right panel).

Figure 6.15. Flounder in Subarea 4 and Division 3.a. Optimum yield indicators (left panel) and indicator ratios (right panel).

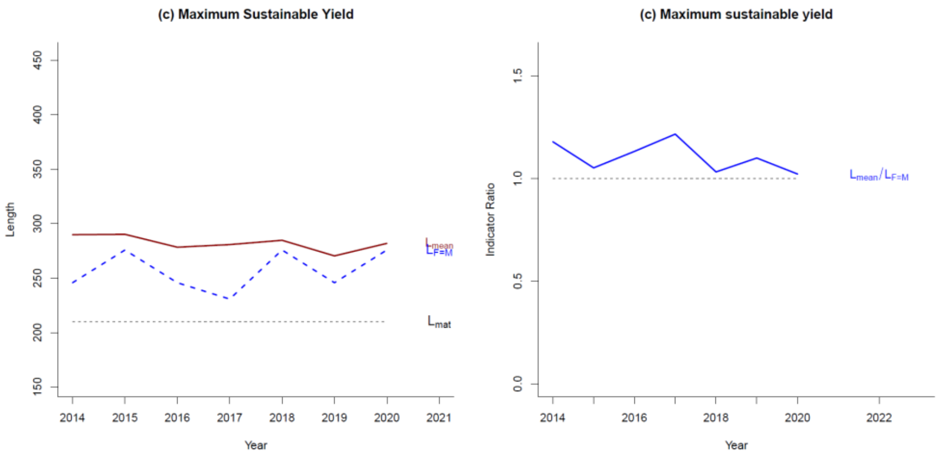

Figure 6.16. Flounder in Subarea 4 and Division 3.a. Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

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. Raising highly uncertain for these fleets. What is the possible impact on catch estimation? Is there another way to estimate the discards of these fleets?
- Investigate what could be done/changed to improve the SpiCT model.
- Investigate the use of alternative stock indices (DYFS, DFS, others?) which are able to better reflect the stock status.
- Investigate the HCR rules based on life history parameters suggested by WKLIFE X (ICES, 2020)

6.6 References

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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
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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
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
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	192	87	20	27	1277	0	25	0	1628
2017	97	101	0	28	943	1	14	0	1184
2018	104	114	n.a.	23	1130	1	18	0	1390
2019*	94	136	9	48	1186	19	15	0	1507
2020*	154	114	7	48	1280	30	18	0	1651

***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
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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
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
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
2019*	156	0	2	0	3	161
2020*	111	0	0	0	5	116

*** 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
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

Year	Division 3.a	Subarea 4	Total
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
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	1628	1737
2017	159	1184	1343
2018	192	1398	1590
2019*	161	1507	1668
2020*	116	1651	1767

*** 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%
2019*	1668	1653	727	2380	33.55%
2020*	1767	1715	679	2395	28.35%

***preliminary catch statistics**

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 (InterCatch data 2012–2019) are available. Official landings data are incomplete or were not reported specifically for grey gurnard in the past. 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 in recent years. New advice was not due for 2022. During the WGNSSK 2021, new available discard and landings data and the current assessment was updated.

7.1.1 Biology and ecosystem aspects

Grey gurnard (*Eutrigla gurnardus*) 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 the Skagerrak/Kattegat, grey gurnard is an abundant demersal species. In the North Sea, the species may form dense semi-pelagic aggregations in winter to the northwest of the Dogger Bank, whereas in summer it is more widely distributed. The species is less abundant in the Channel, the Celtic Sea and in the Bay of Biscay. Spawning takes place in spring and summer. There do not seem to be clear nursery areas.

Grey gurnard 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). A 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 2019 the official landings in 2020 with 1756 tonnes were on a rather constant level (1621 tonnes in 2019; Table 7.8). The average official landings for the last ten years (2011–2020) was 1417 tonnes. Official landings data from 1950 to 2005 were taken from the "ICES catch statistics 1950 to 2010" (https://www.ices.dk/data/Documents/CatchStats/HistoricalLandings1950-2010.zip). Data from 2006 to 2018 were taken from the "ICES catch statistics 2006 to 2018" (https://www.ices.dk/data/Documents/CatchStats/OfficialNominalCatches.zip). Data for 2019 and 2020 were taken from the preliminary catch statistics provided by ICES (http://data.ices.dk/rec12/login.aspx).

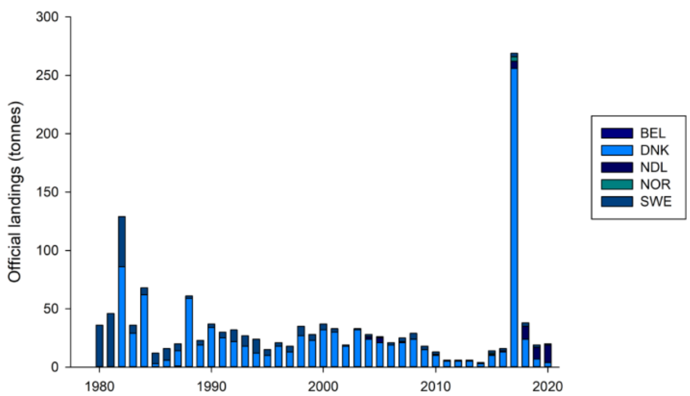

Figure 7.1. Grey gurnard in Subarea 4, Division 3.a and Division 7.d: Official landings of grey gurnard in Division 3.a 1980–2020.

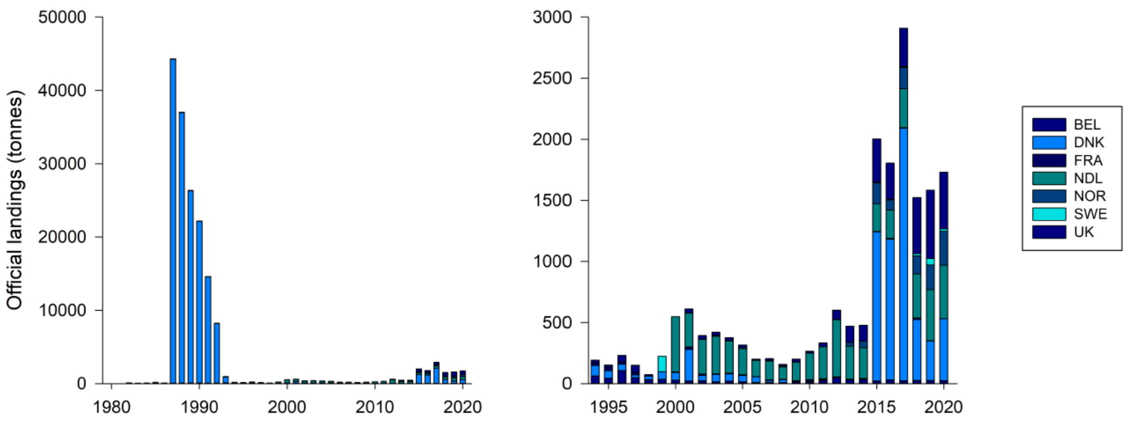

Figure 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Subarea 4 by country for the years 1980 - 2020 (a), and official landings of grey gurnard by country in Subarea 4 for the years 1994 - 2020 (b).

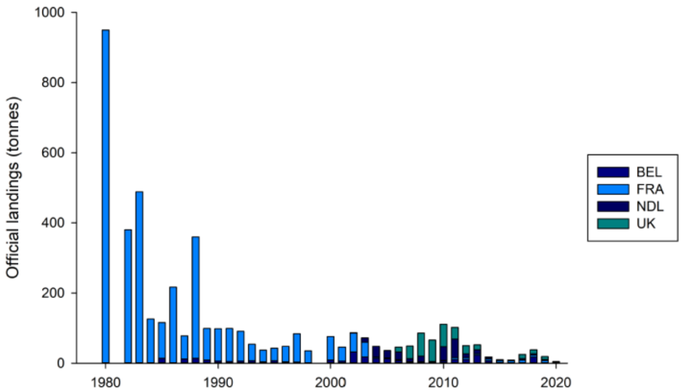

Figure 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings by country of grey gurnard in Division 7.d for the years 1980–2020.

7.2.2 InterCatch data

InterCatch contains now data for the years 2012–2020. The largest amount of landings in 2020 was reported by Denmark as industrial bycatch (502 tonnes, MIS_MIS_0_0_0_IBC). Considerable amounts of landings were also reported by Scotland for the OTB_DEF_>=120_0_0_all métier (366 tonnes), and by Norway for the same métier (235 tonnes). For all countries, except for Norway, the amount of discards exceeded the amount of landings (Figure 7.5). The largest amounts of discards were reported for the Scottish OTB_DEF_>=120_0_0_all métier (630 tonnes), the Dutch TBB_DEF_70-99_0_0_all métier (620 tonnes), and the Dutch OTB_CRU_70-99_0_0_all métier (420 tonnes).

The largest amount of discards was estimated for the Dutch SSC_DEF_70-99_0_0_all métier (2282 tonnes), the UK (England) OTB_DEF_70-99_0_0_all metier (444 tonnes), and the Dutch TBB_DEF_>=120_0_0_all métier (407 tonnes). The total catch estimated with InterCatch for the year 2020 was 10 226 tonnes from which 1 971 tonnes were landings (24%) and 8 249 tonnes estimated discards (76% of total catch). The Netherlands took the largest proportion of the total catch in 2020 with a high amount of discards, followed by UK England, and UK Scotland.

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 2020 data discard raising:

Group 1: all passive gears -> raised with all other passive métiers.

Group 2: MIS_MIS_0_0_0_HC -> no discard data available for this métier. Raised with all other métiers.

Group 3: TBB_DEF_70-99_0_0_all -> raised with TBB_DEF_70-99_0_0_all

Group 4: TBB_DEF_>=120_0_0_all -> raised with TBB_DEF_>=120_0_0_all

Group 5: OTB_CRU_70-99_0_0_all -> raised with OTB_CRU_70-99_0_0_all

Group 6: OTB_DEF_120_0_0_all -> raised with OTB_DEF_120_0_0_all

Group 7: 7 OTB_DEF_100-119_0_0_all, SSC_DEF_100-119_0_0_all -> raised with

Group 8: OTB_DEF_70-99_0_0, SSC_DEF_70-99_0_0_all, SDN_DEF_70-99_0_0_all, OTM_SPF and OTB_SPF_70-99_0_0_all -> raised with OTB_DEF_70-99_0_0_all

Group 9: 9 SSC and SDN_DEF_>=120_0_0_all -> raised with SSC and SDN_DEF_>=120_0_0_all

Group 10: OTB_CRU_100-119_0_0_all -> raised with OTB_CRU_100-119_0_0_all (one ENG métier) and OTB_CRU_90-119_0_0_all (exclude two DEN métiers because of exceptional high discard ratios)

Group 11: OTB_CRU_32-69_0_0_all -> raised with OTB_CRU_32-69_0_0_all (no discards)

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

- MIS_MIS_0_0_0_IBC (8 métiers)
- DRB_all_0_0_all (1 métier)
- OTB_SPF_32-69_0_0_all (9 métiers)
- OTB_CRU_16-31_0_0_all (3 métiers)
- PS_SPF_0_0_0 (2 métiers)
- TBB_CRU_16-31_0_0_all (3 métiers)

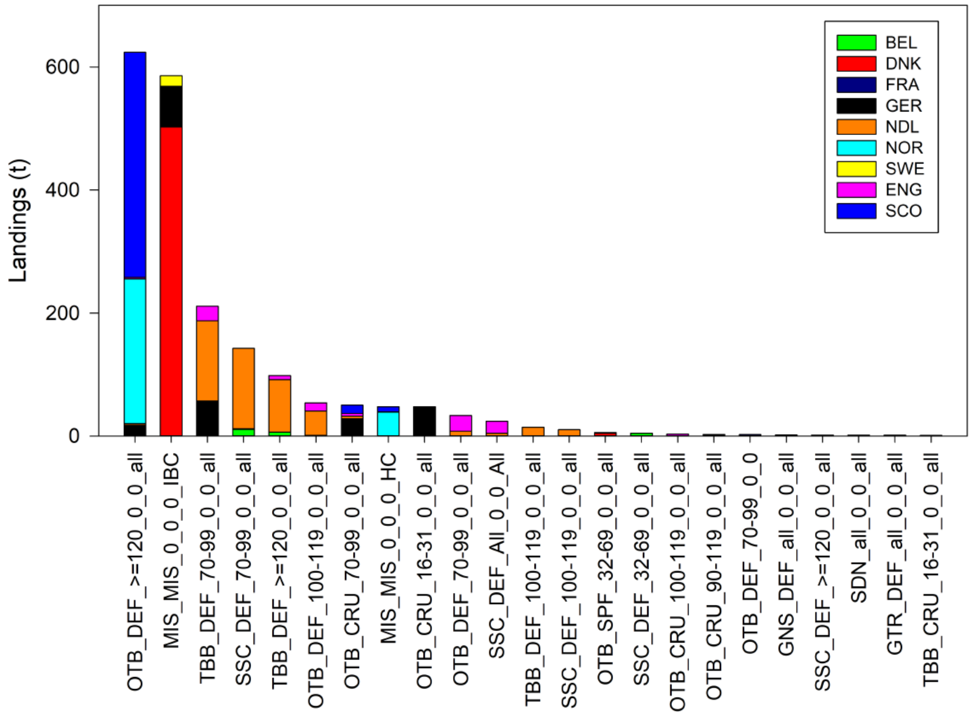

Figure 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard landings in 2020 by métier and country as uploaded into InterCatch.

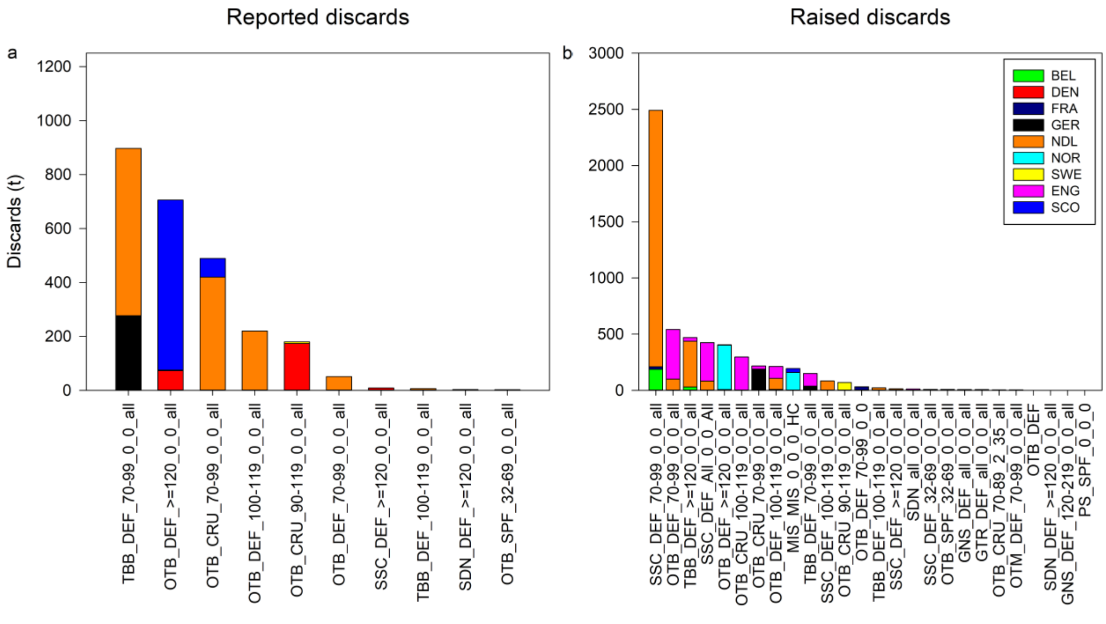

Figure 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard discards in 2020 by métier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

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 métiers, with highest values observed for the SSC_DEF métiers. German discard data from an observer programme indicate that the proportion of discarded gurnard in German demersal trawl fisheries ranges between 76.6% and 93.0% (Ulleweit *et al.*, 2010).

Table 7.1 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Discards per hour of grey gurnard by different métiers 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).

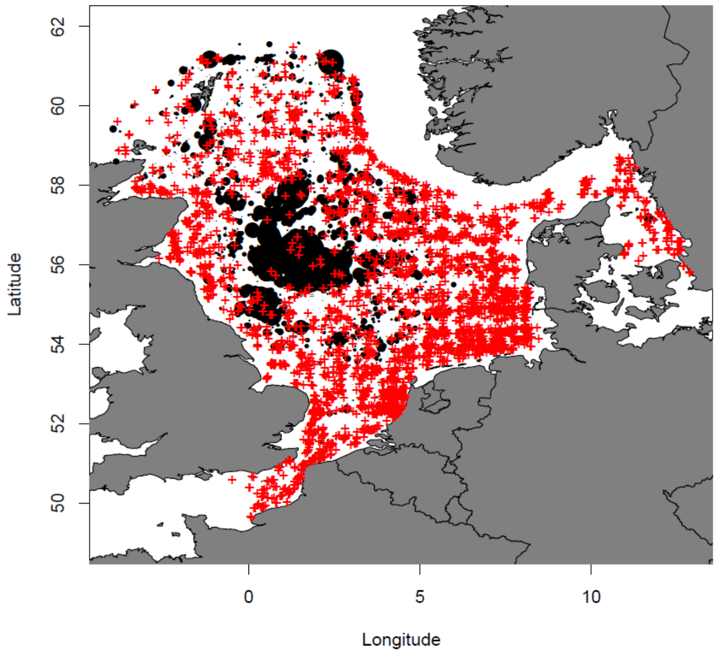

Figure 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Spatial distribution of grey gurnard from IBTS–Q1 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

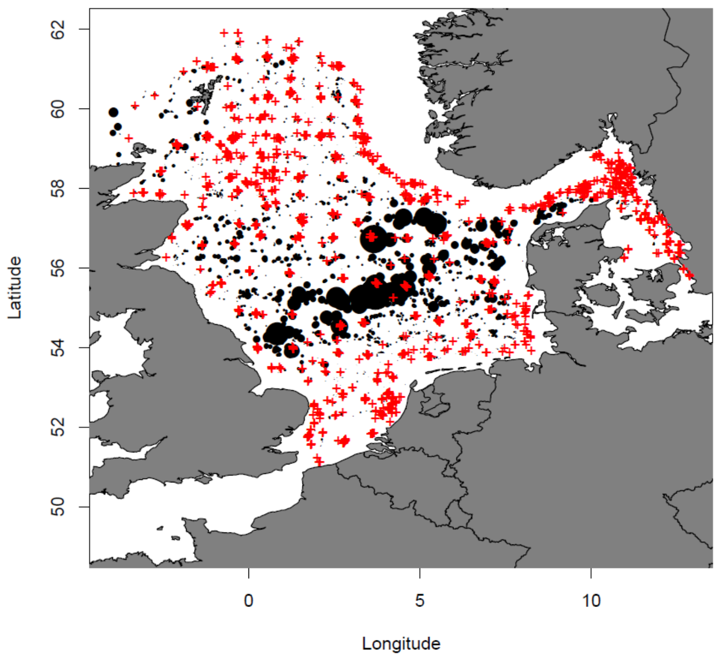

Figure 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q3 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

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 (IBTS Q1 and Q3 2010-2018 data; 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.

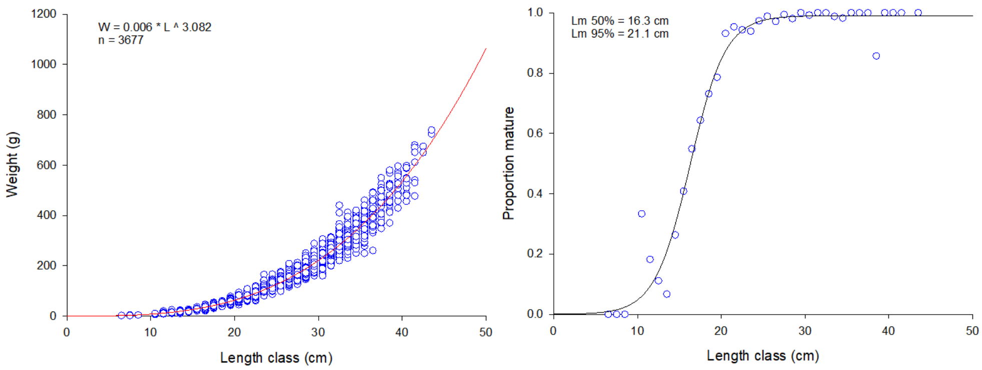

Figure 7.8 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length-weight relationship from IBTS Q1 and IBTS Q3 CA data (left panel); maturity ogive obtained from IBTS Q1 CA data (right panel).

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.

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 7.4).

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, and it dropped slightly again in 2020 and also 2021. 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, but increased in 2019 and 2020. 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.

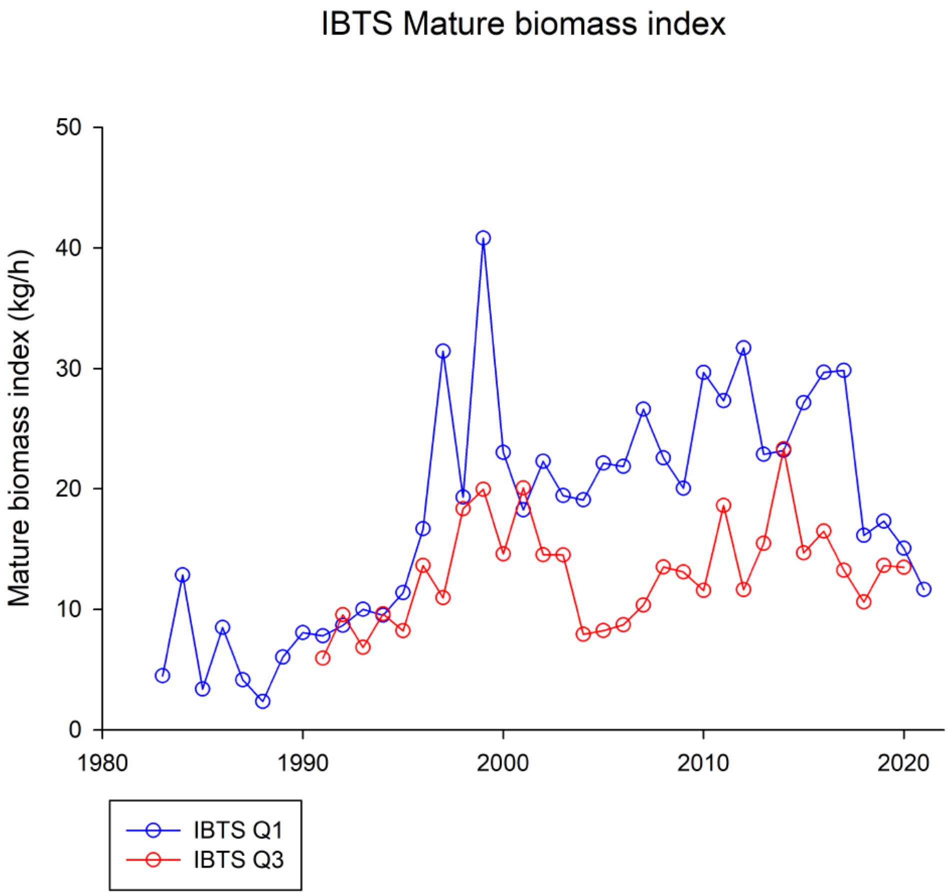

Figure 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: IBTS–Q1 and IBTS–Q3 grey gurnard mature biomass index.

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} and L_{mat} (16.3 cm). During the WGNSSK2021 L_{inf} was updated (38.2 cm compared to 37.2cm in previous year). How these values were estimated is described in detail in the WGNSSK 2018 report (ICES, 2018) and in the stock annex. The available length frequency distributions from InterCatch were binned into 20 mm size classes and all show a unimodal distribution (Figure 7.10). The change in L_{inf} resulted in different results for the LBI indicators compared to the previous years. However, the results show that with respect to conservation the indicators are still above the reference points for LC / L_{mat} and $L_{25\%}$ / L_{mat} for all the data years (Figure 7.11 and Table 7.2 and Table 7.3). For the $L_{max5\%}$ / L_{inf} reference point the indicator is above the reference point for the last four years. The P_{mega} was for all years below the reference of 30%. With respect to MSY the indicator is above the reference points for the last four data years (Figure 7.13). It was concluded, that the exploitation for this stock was still below F_{MSY} in the year 2020.

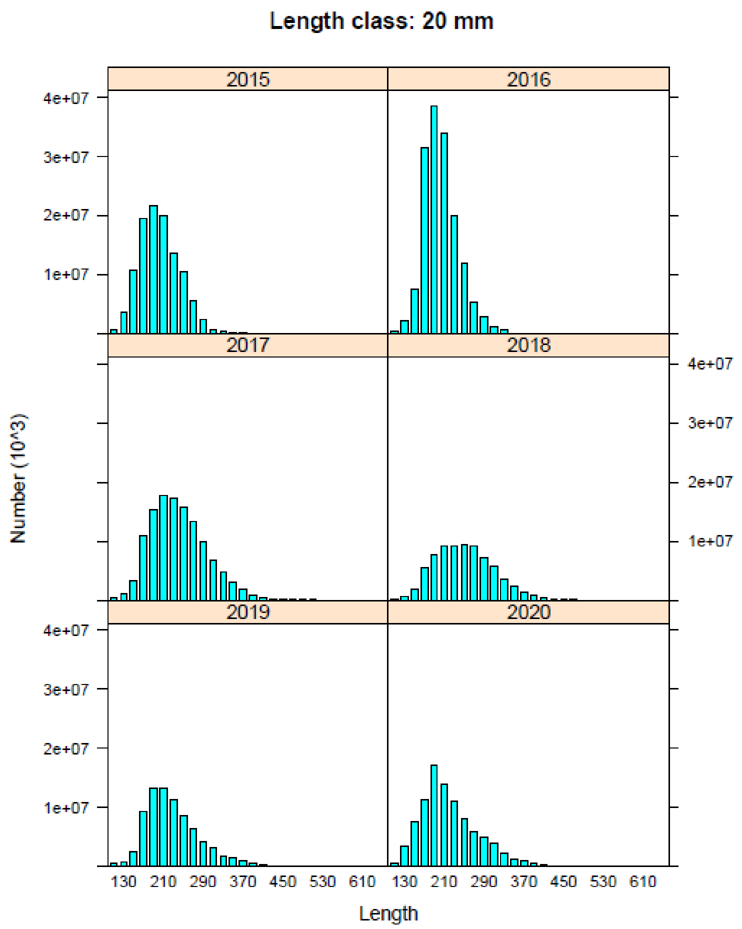

Figure 7.10 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Obtained length frequency distributions binned into 20 mm size classes.

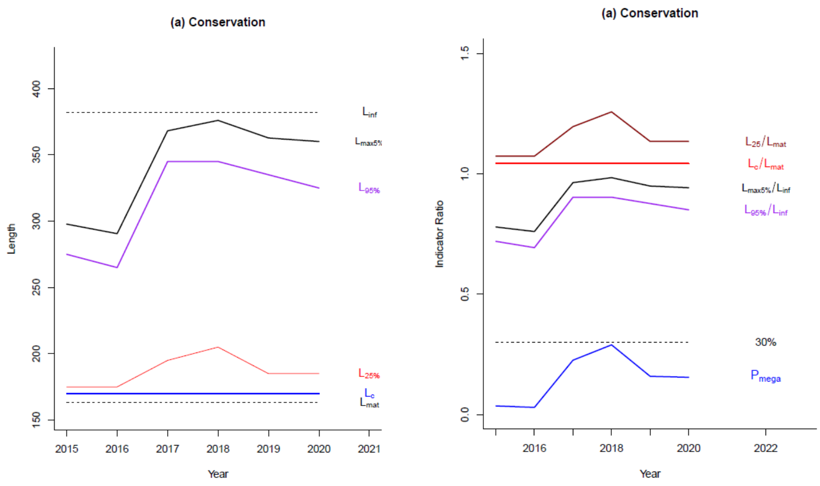

Figure 7.11 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Conservation indicators (left panel) and indicator ratios (right panel).

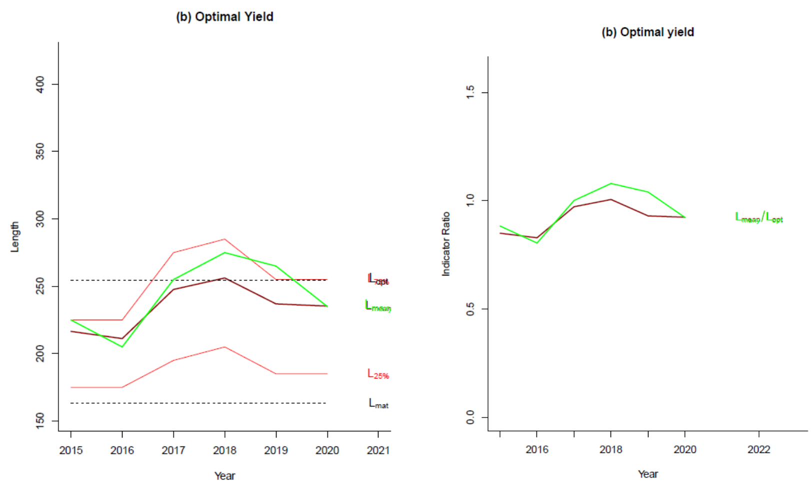

Figure 7.12 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Optimum yield indicators (left panel) and indicator ratios (right panel).

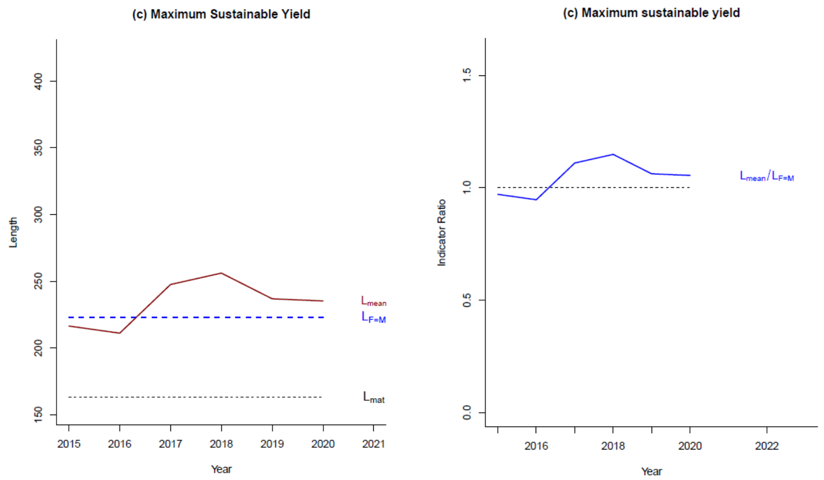

Figure 7.13 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

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	223	225	163	254.67	382	297.77
2016	225	175	195	245	265	211.17	170	223	205	163	254.67	382	290.57
2017	275	195	235	315	345	247.62	170	223	255	163	254.67	382	368.15
2018	285	205	245	325	345	256.17	170	223	275	163	254.67	382	376.01
2019	255	185	215	305	335	236.91	170	223	265	163	254.67	382	362.73
2020	255	185	205	305	325	235.31	170	223	235	163	254.67	382	360.06

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
	L_C/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1(>0.9)**	**≥1**
2015	**1.04**	**1.07**	0.78	0.04	0.85	0.97
2016	**1.04**	**1.07**	0.76	0.03	0.83	0.95
2017	**1.04**	**1.20**	**0.96**	0.23	**0.97**	**1.11**
2018	**1.04**	**1.26**	**0.98**	0.29	**1.01**	**1.15**
2019	**1.04**	**1.13**	**0.95**	0.16	**0.93**	**1.06**
2020	**1.04**	**1.13**	**0.94**	0.16	**0.92**	**1.06**

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 (2012–2019).

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

The available data (landings, discards, length samples) are uploaded into InterCatch for the years 2012-2019 and are used for the assessment. It should be investigated if this data series could possibly be extended to cover more years in the past.

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 compiled during a benchmark assessment.

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 (tonnes).

Year	BE	DK	NL	NO	SE	Total
1980	0	0	0	0	36	36
1981	0	0	0	0	46	46
1982	0	86	0	0	43	129
1983	0	29	0	0	7	36
1984	0	62	0	0	6	68
1985	0	3	0	0	9	12
1986	0	6	0	0	10	16
1987	1	13	0	0	6	20
1988	0	59	0	0	2	61
1989	0	19	0	0	4	23
1990	0	34	0	0	3	37
1991	0	25	0	0	5	30
1992	0	22	0	0	10	32
1993	0	18	0	0	9	27
1994	0	12	0	0	12	24
1995	0	10	0	0	5	15
1996	0	18	0	0	3	21
1997	0	13	0	0	5	18
1998	0	27	0	0	8	35
1999	0	23	0	0	5	28
2000	0	32	0	0	5	37
2001	0	30	0	0	3	33
2002	0	18	0	0	1	19
2003	0	32	0	0	1	33
2004	0	24	2	0	2	28
2005	0	21	4	0	1	26
2006	0	19	0	0	2	21
2007	0	21	1	0	3	25
2008	0	24	0	0	5	29
2009	0	15	0	0	3	18
2010	0	10	1	0	2	13
2011	0	5	0	0	1	6
2012	0	5	0	0	1	6
2013	0	5	0	0	1	6
2014	0	3	0	0	1	4
2015	0	10	0	1	2	14
2016	0	13	1	0	2	16
2017	0	256	6	4	3	269

Year	BE	DK	NL	NO	SE	Total
2018	0	24	11	0	3	38
2019	0	7	10	0	2	19
2020	0	4	15	0	1	20

Table 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Subarea 4 (tonnes).

Year	BE	DK	FR	NL	NO	SE	UK	Total
1980	0	0	43	0	0	0	0	43
1981	0	0	0	0	0	0	0	0
1982	0	0	100	0	0	0	0	100
1983	0	0	64	0	0	0	0	64
1984	0	0	71	0	0	0	0	71
1985	88	0	85	0	0	0	0	173
1986	0	27	66	0	0	0	0	93
1987	63	44205	56	0	0	0	0	44324
1988	72	36887	43	0	0	0	22	37024
1989	73	26230	45	0	0	0	0	26348
1990	85	22041	42	0	0	0	0	22168
1991	70	14514	28	0	0	0	0	14612
1992	98	8113	21	0	0	0	10	8242
1993	106	822	27	0	0	0	24	979
1994	63	87	21	0	0	0	22	193
1995	43	63	26	0	0	0	21	153
1996	108	52	18	0	0	0	54	232
1997	49	23	22	0	0	0	57	151
1998	33	29	13	0	0	0	0	75
1999	35	63	0	0	0	127	0	225
2000	28	63	5	452	0	0	0	548
2001	22	258	20	277	0	1	33	611
2002	23	45	10	285	0	1	29	393
2003	16	60	5	307	0	6	26	420
2004	21	59	6	264	0	3	23	376
2005	16	52	5	213	0	8	22	316
2006	10	46	2	133	2	0	7	200
2007	11	16	3	155	5	0	14	204
2008	8	24	2	104	5	3	12	158
2009	15	6	2	154	1	1	22	201
2010	14	8	10	218	1	0	14	266
2011	26	6	7	263	1	0	31	334
2012	49	3	4	467	2	0	77	602
2013	30	4	2	268	33	1	131	470

Year	BE	DK	FR	NL	NO	SE	UK	Total
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
2019	26	324	3	416	203	51	560	1583
2020	25	506	1	438	276	20	465	1731

Table 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 7.d (tonnes).

Year	BE	FR	NL	UK	Total
1980	0	950	0	0	950
1981	0	0	0	0	0
1982	0	380	0	0	380
1983	0	489	0	0	489
1984	0	126	0	0	126
1985	14	102	0	0	116
1986	0	217	0	0	217
1987	12	66	0	0	78
1988	14	346	0	0	360
1989	9	90	0	0	99
1990	6	92	0	0	98
1991	5	94	0	0	99
1992	6	85	0	0	91
1993	7	47	0	0	54
1994	4	33	0	0	37
1995	7	36	0	0	43
1996	4	44	0	0	48
1997	3	81	0	0	84
1998	1	34	0	0	35
1999	1	0	0	0	1
2000	9	67	0	0	76
2001	6	40	0	0	46
2002	32	54	1	0	87
2003	18	42	12	0	72
2004	14	3	31	0	48
2005	13	2	21	0	36
2006	8	2	22	14	46
2007	3	1	9	36	49
2008	1	3	16	66	86
2009	1	1	3	61	66

Year	BE	FR	NL	UK	Total
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
2019	1	7	3	8	19
2020	1	2	1	1	5

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
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

Year	IBTS–Q1	IBTS–Q3
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	16.49
2017	29.84	13.24
2018	16.14	10.61
2019	17.32	13.64
2020	15.07	13.49
2021	11.64	

Table 7.8. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Summary of the assessment done during the WGNSSK 2021 with updated values (Official BMS landings, ICES landings (incl. IBC), discards (incl. BMS), and catches in tonnes).

Year	Official landings	Official BMS 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					

Year	Official landings	Official BMS landings	ICES Landings	ICES catches	ICES discards	Discard rate
2005	378					
2006	267					
2007	279					
2008	273					
2009	285					
2010	390					
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	1831		2156	12129	9973	0.82
2017	3203		3451	17121	13670	0.80
2018	1600		1137	11418	10281	0.90
2019	1621	13	1709	9295	7586	0.82
2020	1756	6	1971	10226	8255	0.81

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 2018, 2019 and 2020 year-classes formed the bulk of haddock catches in 2020. The entry of the large 2019 year-classes into the fishery has led to an increase in the discarding rate for 2020, and the similar 2020 year-class may lead to a further increase in discards from 2021 onwards. Previous changes in discarding rates may also have been due to other measures related to the Scottish Conservation Credits scheme which concluded in 2016 (CCS; see Section 8.1.4).

Specific information on changes in the Scottish fleet during 2011–2020 was not provided to WGNSSK in 2021, and 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 were likely to have reduced bycatch (and therefore discards) of haddock in the *Nephrops* fishery in particular. The inclusion of Scottish vessels in the CCS was mandatory during the period 2009–2016, and compliance was 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 were. 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 were exempt from some effort restrictions and were allocated additional cod quota: in return, they had to carry monitoring cameras and land all cod caught. It is not clear what the impact was 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. 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. A new Scottish FDF scheme started in 2017, which was run along similar lines and which was intended to monitor discarding of saithe and monkfish: this proved to be short-lived and was terminated after one year..

8.1.2.2 Additional information provided by the fishing industry

No specific additional information on haddock was provided by the relevant fishing industries in 2021.

8.1.3 ICES advice

8.1.3.1 ICES advice for 2020

Subarea 4, Division 6.a and Subdivision 20

The advice for 2020 was updated in November 2019:

ICES advises that when the MSY approach is applied, total catches in 2020 should be no more than 41 818 tonnes.

8.1.3.2 ICES advice for 2021

Subarea 4, Division 6.a and Subdivision 20

The advice for 2021 was updated in August 2020:

ICES advises that when the MSY approach is applied, total catches in 2021 should be no more than 69 280 tonnes.

ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

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 occur 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 to high-abundance areas, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the haddock stock is unclear.

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 2020 and 2021 TACs for haddock in this area were 35 653 tonnes and 42 785 tonnes respectively. The second is Division 3.a (EU waters), for which the TACs for 2019 and 2020 were 2193 tonnes and 2630 tonnes respectively. The third is Division 6.a, for which the TACs in 2019 and 2020 were 3973 tonnes and 4767 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 ICES 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. However, the proportion of landings that have been sampled is less than in previous years due to the impact of the covid-19 pandemic (in particular, there was no sampling at all of landings or discards during Q2 in 2020). 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 majority of haddock landings (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 LRD in InterCatch was introduced in 2016 in accordance with the implementation of the EU landing obligation. However, BMS data from Scotland were not submitted in 2017 resulting in no samples of the BMS landings by weight for that year. 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). In 2019 91% of the total BMS landings were sampled: however, in 2020 (due to the impact of covid-19) only 6% of BMS landings were sampled for age. Age compositions for the overall 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 and Figure 8.2.4. The total landed yield of the international fishery has been relatively stable since 2007. The ICES 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 in 2017 (17%) and 2018 (13%). In 2019, the discard rate has increased again to 15%, and further to 23% in 2020 (probably because of two large incoming year-classes). 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. 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 2020 are 0.56% of the total catch which is significantly lower than the discard estimate of 23% of total catch. This suggests that fish caught below MCRS are not being reported as BMS.

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, although the estimate for 2020 is the highest since 2003 and may be due to an increase in effort in the Norway pout fishery.

Previously, estimated discard rates could 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 increase in discards in 2019 and 2020 is thought to be due to the entry of the large 2018- and 2019-year classes to the fishery. In the past, vessels have only very seldom exhausted their quota in this fishery, and previous discarding behaviour is thought to have been 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). The results from the 2020 WGSAM key run have not been used this year: this implementation has been delayed until the forthcoming benchmark meeting (2021–22).

8.2.5 Catch, effort and research vessel data

The available survey data 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 cover too small a proportion of the overall stock area to be considered reliable indicators of overall Northern Shelf 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 previously met in early October when the collated IBTS Q3 survey index 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.

In 2020, ICES updated the method used to produce the IBTS Q1 and Q3 survey indices by automating the age-length key fill-ins which had been done previously on a manual basis. A comparison of the stock assessment results using these new survey indices to the results of WGNSSK 2019 revealed significant differences in the estimated SSB for the last 20 years (a 20-30% reduction). As a result, the decision made was to continue to use the existing survey indices rather than adopting the new survey indices as input data. However, the survey indices will only be produced using the new method from 2020. As a result, the existing survey indices will be used as input data up until 2019 after which survey indices produced using the new method will be used until further examination of the full time series of new survey indices can take place during the next benchmark.

Survey 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 large incoming 2019 and 2020 year-classes can be seen in both the North Sea surveys, although they are not apparent in the West of Scotland surveys. Both North Sea surveys show a concentration of these year-classes further to the south than usually seen, particularly when very young, and this change in geographical extent possibly accounts for the lack of synchrony between the North Sea and West of

Scotland surveys for these year-classes. 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 large 2019- and 2020-year-classes.

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), indicate partial recruitment to the fishery for most cohorts up to age 2 (shown by hooks towards the top of the catch curves). 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, or covid-19 impacts on sampling). 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

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.

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 (see also Figure 8.3.10).

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 estimates for total mortality, and relative estimates for biomass and recruitment. The SURBAR residual plot in Figure 8.3.6 shows that there remains an indication of some conflict (mostly positive residuals for Q1 and negative residuals for Q3). The plot of survey catch curves also shows reasonable consistency (Figure 8.3.7), although there are indications are reduced catchability for cohorts in IBTS Q1 from the 2010. 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 SURBAR are consistent for the most part with those from TSA and SAM, although there is some offset in years of higher mean Z. 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.

In 2021, the WG decided not to treat the 2019 or 2020 year-classes as "large year-classes" in the TSA settings. There is good evidence that these are the largest year-classes since the 1999 year-class. However, inspection of the estimated recruitment time-series (Figure 8.3.13) shows that even these larger year-classes are much smaller than the 1974, 1979 and 1999 that are currently treated as "large" by TSA (meaning that they are given higher variance when fitting the random-walk recruitment parameter). Furthermore, the Stock Annex states that a benchmark or inter-benchmark process would be needed to assess the amount of evidence in favour of classifying any particular year class as significantly large enough to warrant a change to the TSA settings. No changes were made to the TSA settings this year on account of the 2019- and 2020-year classes and the issue will be discussed at the next benchmark.

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 lower in general. Furthermore, the size of sporadic, larger year classes has diminished since the large 1999 year-class, though the 2019- and 2020-year classes suggest this trend may have reversed. Figure 8.3.14 summarizes the observed and fitted discards (discard+bycatch+BMS) proportions by age.

TSA residuals 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). Overall these indicate reasonably good fits to data, although the TSA model overpredicts landings at age 8 in recent years (this needs to be investigated at the next benchmark).

Figures 8.3.19 to 8.3.21 give the corresponding 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). 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-class, 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: none of the retrospective run falls outside an approximate pointwise 95% confidence intervals of the full time-series assessment for any of the summaries. 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 -6%, -2% and -23% respectively. The Mohn's rho value for recruitment is high, but the values for SSB and mean F are small and lie well within the ±20% limits specified by WKFORBIAS (ICES, 2020).

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 2005, 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 2020 fluctuates between 0.2 and 0.4 and is now just below the F_{MSY} value of 0.194 in 2020. Fluctuations around the previous F(target) 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. The 2019 and 2020 year-classes are estimated to be the largest since the 1999 year-class, and are very unusual for a haddock stock in that they occur consecutively. These recruitment events do not yet have any impact on estimated SSB, as that assumes a knife-edge maturity at age 3, but will impact significantly on the short-term forecast for 2022 and 2023 (see Section 8.6).

8.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2021) and in the quota year (IY + 1 = 2022) are based on the TSA estimate of forecasted recruits at age 0 in the intermediate year, as this ensures consistency between assessment and forecast. This stock is subject to the reopening process later in the year, following the completion of the IBTS Q3 survey, where the TSA recruitment estimate may be updated with a recruitment estimate resulting from an RCT3 analysis (according to the standard ICES update protocol).

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

Year class	Age in 2021	TSA estimate (millions)	TSA forecast (millions)
2019	2	1419	
2020	1	4877	
2021	0		6640
2022	Age 0 in 2022		6640
2023	Age 0 in 2023		6640

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 summarised 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 2020) 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 (2018–2020) means by age are used for all forecast years for the IBC component.

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 30 643 t (given that quota uptake for this stock very seldom exceeds 80-90%). The combined-area human consumption TAC for 2021 is 50 182 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 2018–2020) 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 a TAC-constrained F of 0.117 in 2021, SSB is expected to be 236 322 tonnes in 2021, before increasing in 2022 to 573 051 tonnes (the rapid increase in SSB is due to the 2019-year class and the assumption of knife-edge maturity at age 3). In this case, projected wanted catch (human consumption yield) in 2021 would be 34 514 tonnes with associated projected unwanted catch (discards + BMS) of 15 668 t. IBC would be 849 tonnes.

Several alternative options for 2022 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_{2020}, $F_{MSY\text{-}upper}$, and

$F_{MSY-lower}$. Under the assumption of F_{MSY}, the 2022 total catch is forecast to be 128 708 tonnes, which corresponds (if 2021 discard+BMS rates remain unchanged) to a wanted-catch yield of 101 908 tonnes and unwanted catch of 25 339 tonnes. This advised catch represents a 154% increase on the 2021 TAC. This exploitation is forecast to lead in turn to an SSB in 2023 of 723 334 tonnes, an increase of 26% on the value forecast above for 2021.

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 previously performed for North Sea haddock (Needle, 2008a, b) and West of Scotland haddock (Needle, 2010, while management strategy evaluations for Northern Shelf haddock were conducted in 2019 in response to a request for advice on a proposed EU-Norway management plan (ICES 2019a, b).

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 an IBP following 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. The former period is currently 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. However, the size of the 2019- and 2020-year classes may lead to this assumption being reassessed at the next benchmark

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 (see Figure 8.2.2). 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 were updated natural mortality values for WGNSSK 2018, reference points have not been modified as a result There were no discernible differences in assessment parameters, and therefore it was assumed that the reference points previously derived at WGNSSK 2017 remain applicable. In WGNSSK 2021, F_{pa} was revised as the F that provides a 95% probability for SSB to be above

B_{lim} ($F_{p.05}$ with AR). Reference points will be revisited at the benchmark during 2021/22.

The reference points in full from these analyses are given below:

Variable	WKHAD (2014)	IBPHaddock (2016)	WGNSSK 2017–2020	WGNSSK 2021
B_{lim}	63 kt	94 kt	94 kt	94 kt
B_{pa}	88 kt	132 kt	132 kt	132 kt
F_{lim}	n/a	0.38	0.384	0.384
F_{pa}	n/a	0.27	0.274	0.194
F_{MSY}	0.37	0.19	0.194	0.194
$F_{MSY\ lower}$	n/a	0.18	0.167	0.167
$F_{MSYupper}$	n/a	0.19	0.194	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 is very low, and well within the WKFORBIAS guidelines.

8.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2020 and is now fluctuating around the historical minimum, and this is just below the estimate of F_{MSY} (0.194). Discard rates have increased above the historical minimum observed in 2013. The 2010–2013 year-classes were estimated to be weak, following the relatively strong 2009 year-class, but the 2014 year-class was slightly larger than the recent average and the incoming 2019- and 2020-year classes appear to be the largest since 1999. Spawning stock biomass is currently well above B_{pa} (132 kt) and is predicted to increase rapidly over the next few years as the 2019- and 2020-year-classes mature.

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 each relate to only a part of the full stock area. Discussions took place during 2019–20 between the EU and Norway to try and establish a new management strategy on the basis of the Northern Shelf stock, but no agreement has yet been reached, and further work would also need to include the UK. In the meantime, the principal basis for management of this haddock stock is the ICES 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. The current estimate is just below 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 with two substantial year classes occurring in 2019 and 2020. Other recent cohorts have been very weak. SSB is expected to increase over the next few years as the 2019 and 2020 year-classes mature and its impact on SSB is expected to be the most significant in the available time-series (see Figure 8.11.1).

Keeping fishing mortality close to the target MSY level would be preferable to encourage the sustainable exploitation of the recent larger year-classes. Estimated discard rates are now increasing as large numbers of small fish enter the population, and this needs to be monitored and mitigated. In particular, discard rates 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 previous 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 "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

8.12.1 Data and stock ID

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. Ensure consistency in catch data used in assessment and advice sheet (SOP issues in InterCatch data).

8.12.2 Assessment

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 shows some bias in prediction errors for Age 0 IBTS Q3 survey. TSA support likely unavailable after 2021/22 so need to consider alternative models. Exploratory assessment model SURBAR – develop likelihood profiling for *ad hoc* parameters, and catchability estimation model based on catch curves. If TSA is retained, objective criteria are needed to decide if a year class is significantly large to warrant special treatment in TSA. Alternatively, some exploration of modelling techniques for sporadic recruitment is needed (mixed distributions etc.).

8.12.3 Forecast

Investigate extent of cohort effect on growth rate. Ensure consistency between catch components for weight at age cohort modelling. Investigate intermediate year recruitment assumption. Forecast value for recruitment would benefit from including information on the probability of large year classes occurring.

8.13 References

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Table 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Nominal landings (000 t) during 2008–2020, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2019 and 2020 are preliminary. Quota uptake estimates are also given, calculated as the ICES estimates of landings divided by available quota before 2018. Quota uptake from 2018 onwards is calculated as the ICES estimates of total catch divided by available quota (following the implementation of the Landing Obligation). Reporting of BMS landings started in 2016.

Subdivision 20											
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DE	65	102	120	90	114	103	125	56	31	30	12
DK	1139	1661	1916	1456	1763	1059	908	852	542	458	448
NL	1	0	0	6	6	4	0	20	4	4	1
NO	81	125	303	223	86	63	70	65	36	27	0
PT	0	0	0	0	0	0	0	0	0	0	15
SE	126	198	210	217	219	202	129	104	140	93	56
UK	0	0	0	3	0	0	0	0	0	0	0
Subarea 4											
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BE	78	106	78	78	98	47	53	30	29	29	40
DE	634	575	548	677	677	599	554	609	347	311	331
DK	725	697	947	1283	1079	1442	1244	1185	1117	1203	1683
FO	5	0	0	0	0	0	0	0	0	1	0
FR	276	320	175	177	209	100	121	140	201	189	144
NL	41	71	191	172	99	44	146	75	89	162	175
NO	1126	1195	1006	1662	2743	2003	1499	2164	1431	1517	3171
SE	90	128	103	113	154	136	118	181	99	111	114
UK	24983	23343	27378	33013	29851	25905	26427	25667	25880	21930	20452
Division 6.a											
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DE	1	0	0	0	0	0	0	0	0	0	0
DK	0	0	0	0	0	0	2	2	1	9	4
ES	28	36	15	14	19	9	33	28	28	64	26
FO	0	0	0	0	0	0	0	<1	0	0	0
FR	89	73	32	51	67	41	62	68	66	57	86
IE	396	290	845	746	667	768	1034	641	758	562	441
NL	0	0	0	0	0	11	28	31	15	54	13
NO	9	4	0	6	2	7	5	1	7	10	2
UK	2415	1364	4123	3878	3261	3051	3101	2480	3295	2789	2081
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Official landings	32308	30288	37990	43830	40945	35520	35614	32290	34083	29610	29425
ICES landings	31940	36570	38162	43734	41143	35295	35058	32827	34404	30743	30176
ICES discards	13071	13067	5032	3305	5090	6255	7749	6936	4871	5524	9335
ICES IBC	431	24	1	54	65	21	37	19	5	186	1077
ICES BMS	-	-	-	-	-	-	201	93	155	179	314
ICES total catch	45442	49661	43195	47093	46298	41571	43045	39875	39435	36632	40558
TAC 4	35794	34057	39000	45041	38284	40711	61933	33643	41767	28950	35653
TAC 3.a	2201	2100	2095	2770	2355	2504	3926	2069	2569	1780	2193
TAC 6.a	2670	2005	6015	4211	3988	4536	6462	3697	4654	3226	3973
Total TAC	40665	38162	47110	52022	44627	47751	72321	39409	48990	33956	41819
ICES quota uptake	79%	96%	81%	84%	92%	74%	48%	83%	80%	108%	82%

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 for 2020.

Catch category	Raised or imported	Weight (tonnes)	Proportion
BMS landings	Imported	222	100
Discards	Imported	6217	68
Discards	Raised	2889	32
Landings	Imported	29278	100
Logbook registered discards	Imported	0	NA

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 for 2020.

Catch category	Raised or imported	Sampled or estimated	Weight (tonnes)	Proportion
Logbook registered discards	Imported	Estimated	0	NA
Landings	Imported	Sampled	22245	76
Landings	Imported	Estimated	7033	24
Discards	Imported	Sampled	5845	64
Discards	Raised	Estimated	2889	32
Discards	Imported	Estimated	372	4
BMS landings	Imported	Estimated	208	94
BMS landings	Imported	Sampled	14	6

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 for 2020.

Catch category	Raised or imported	Sampled or estimated	Area	Weight (tonnes)	Proportion
Logbook registered discards	Imported	Estimated		0	NA
Landings	Imported	Sampled	27.6.a	2389	89
Landings	Imported	Estimated	27.6.a	300	11
Discards	Imported	Sampled	27.6.a	545	75
Discards	Raised	Estimated	27.6.a	177	25
BMS landings	Imported	Sampled	27.6.a	16	99
BMS landings	Imported	Estimated	27.6.a	<1	1
Logbook registered discards	Imported	Estimated		0	NA
Landings	Imported	Sampled	27.4	19539	75
Landings	Imported	Estimated	27.4	6514	25
Discards	Imported	Sampled	27.4	5104	63
Discards	Raised	Estimated	27.4	2620	32
Discards	Imported	Estimated	27.4	369	5
BMS landings	Imported	Estimated	27.4	193	93
BMS landings	Imported	Sampled	27.4	14	7
Logbook registered discards	Imported	Estimated		0	NA
Landings	Imported	Sampled	27.3.a.20	317	59
Landings	Imported	Estimated	27.3.a.20	219	41
Discards	Raised	Estimated	27.3.a.20	196	68
Discards	Imported	Sampled	27.3.a.20	91	31
Discards	Imported	Estimated	27.3.a.20	3	1
BMS landings	Imported	Estimated	27.3.a.20	0	NA

Table 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. ICES 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. **Note that BMS data for all areas are collated together here, and listed under the Combined column.

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

Year	Subarea 4					Subdivision 20					Division 6.a				Combined				
	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
2000	46.1	48.8		8.1	103	1.5				1.5	7.0	6.3		13.2	54.6	55.1		8.1	117.7
2001	39	118.3		7.9	165.2	1.9				1.9	6.7	8.5		15.2	47.6	126.8		7.9	182.3
2002	54.2	45.9		3.7	103.8	4.1				4.1	7.1	9.4		16.5	65.4	55.3		3.7	124.4
2003	40.1	23.5		1.1	64.8	1.8	0.2			2	5.3	4.5		9.8	47.2	28.2		1.1	76.5
2004	47.3	15.4		0.6	63.2	1.4	0.1			1.6	3.2	4.5		7.7	51.9	20.0		0.6	72.5
2005	47.6	8.4		0.2	56.2	0.8	0.2			1	3.1	3.8		6.9	51.5	12.4		0.2	64.1
2006	36.1	16.9		0.5	53.6	1.5	1			2.5	5.7	5.2		10.9	43.3	23.1		0.5	66.9
2007	29.4	27.8		0	57.3	1.5	0.8			2.3	3.7	4.0		7.8	34.6	32.6		0	67.3
2008	28.9	12.5		0.2	41.6	1.4	0.6			2	2.8	1.3		4.1	33.1	14.4		0.2	47.7
2009	31.3	10		0.1	41.3	1.5	0.6			2.1	2.8	1.8		4.6	35.6	12.4		0.1	48.1
2010	27.8	9.5		0.4	37.7	1.3	0.6			1.9	2.9	2.9		5.8	32.0	13.0		0.4	45.4
2011	26.3	10.2		0	36.5	9.9	1.7			11.6	1.7	1.5		3.3	37.9	13.4		0	51.4
2012	30.3	3.7		1.2	35.0	2.6	0.7			3.4	5.1	0.5		5.6	38.0	4.9		1.2	44.1
2013*	38.9	2.0		0.1	41.0						4.7	1.1		5.8	43.7	3.0		0.1	46.8
2014	34.9	4.1		0.1	39.1	2.3	0.1			2.4	4.0	0.8		4.8	41.1	5.1		0.1	46.3
2015	30.2	4.2		0.0	34.3	1.4	0.1			1.5	3.9	1.3		5.2	35.3	6.3		0.0	41.6
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	3.3	0.1	0.0	32.7	0.8	0.1	0.0		0.8	4.3	1.2	0.0	5.5	34.3	4.5	0.2	0.0	39.0
2019	25.5	3.0	0.2	0.2	28.8	0.6	0.1	0.0		0.7	3.6	1.8	0.0	5.4	29.7	4.8	0.2	0.2	34.9
2020	26.4	8.4	-	1.2	36.1	0.4	0.3	-	0.2	0.9	2.8	0.8	-	3.6	30.2	9.1	0.3**	1.0	40.6

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 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	650218	368560	16491	721514	36301	4954	2245	626	118	97	47	0	0	0	0	0	262
1966	1672925	1007517	26186	7536	459941	11903	1109	633	222	90	23	2	0	0	0	0	337
1967	345371	856339	108401	5814	3850	202830	2843	223	231	61	34	0	0	0	0	0	326
1968	11133	1226448	477603	22671	2303	3210	60034	1052	84	22	5	0	0	0	0	0	111
1969	75301	20554	3736629	313593	9029	2678	2894	23704	392	32	7	0	0	0	0	0	431
1970	941790	272467	218881	2003201	60200	1350	1285	401	6539	81	13	19	0	0	0	0	6652
1971	337277	1881729	74866	50845	480381	10916	589	201	167	1767	176	3	5	0	0	0	2119
1972	255110	696714	671965	43309	23547	211817	4067	241	53	27	475	11	0	0	0	0	566
1973	79461	412305	587335	260080	6450	5689	72652	1406	140	34	234	49	5	0	0	0	462
1974	665110	1283252	187149	342628	60523	1956	1795	22380	345	57	63	4	7	4	0	0	480
1975	51796	2276937	673960	62175	112242	17691	1078	718	6168	339	70	11	0	8	0	0	6596
1976	171400	192030	1127520	225532	11538	32677	5864	228	84	1863	64	3	5	0	0	0	2019
1977	119506	263702	109480	426291	45756	4984	6757	1608	163	40	460	8	0	1	0	0	672
1978	281785	223294	130963	31141	144703	11791	1582	2322	740	122	33	275	16	2	0	0	1188
1979	844410	261156	220200	45487	7978	38097	3069	377	629	181	57	13	52	3	0	0	935
1980	374573	439674	374310	80225	11364	2040	11143	827	143	168	96	34	9	7	1	0	457
1981	645352	116229	430149	180553	17044	2225	497	3320	164	78	26	32	5	1	4	0	311
1982	275508	217834	89989	390347	49835	4275	820	551	1072	60	28	8	2	2	0	0	1172
1983	513034	148158	222772	83199	166812	20055	2365	338	255	385	93	21	4	4	0	0	763
1984	95862	483045	139887	143821	29321	56077	6238	967	127	84	185	19	5	1	1	0	423
1985	127003	161400	441785	80605	41508	7082	18393	1929	296	56	29	144	9	0	0	1	535
1986	45703	137091	144075	328016	29497	10595	1686	4421	581	156	56	47	37	16	4	1	898
1987	10249	253236	259369	56407	92705	6214	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	16679	33092	424014	96795	17161	27728	2030	874	368	1076	95	21	12	13	17	1	1603
1989	19587	51743	43162	216359	21015	4189	7671	763	285	170	469	69	8	3	2	1	1007
1990	19286	82571	78881	17811	60888	4373	1104	1839	254	100	54	13	12	1	4	2	439
1991	128703	188087	101425	24822	4706	17618	1388	684	1024	171	65	11	11	1	2	2	1287
1992	277933	166550	255051	43257	7162	1486	6376	611	337	401	149	22	6	2	0	0	918
1993	136841	302610	269220	123469	11822	1986	669	2050	215	210	188	84	4	4	0	0	706
1994	89104	91674	339428	106673	35056	3381	601	366	746	132	48	36	26	5	0	0	992
1995	200151	336460	119210	182969	33802	9237	898	161	155	151	21	8	6	2	1	0	345
1996	167032	46797	505401	73987	66245	11159	4058	1080	75	72	37	9	8	3	1	0	205
1997	36954	162449	107657	251339	18037	18288	2762	937	121	16	18	5	4	4	2	0	170
1998	21919	88387	224037	60861	128348	7110	4590	850	263	60	7	8	3	2	1	1	345
1999	90634	69455	119094	110046	28510	45221	2700	2047	438	53	8	3	3	2	0	0	507
2000	12630	397390	110381	61263	33137	7254	9935	765	367	53	13	2	1	1	0	0	438
2001	3518	95086	633162	34548	12078	5573	2094	1611	257	89	28	3	4	0	0	0	382
2002	50927	36063	99685	372036	7812	2801	1615	729	603	283	25	8	5	0	0	0	923
2003	7082	13136	15234	48729	127241	2166	786	339	144	100	48	5	1	0	0	0	299

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2004	3758	25698	24627	8958	38784	97827	1010	248	82	42	37	12	1	0	0	0	174
2005	8779	17695	24596	15085	5446	27745	61457	371	132	38	11	8	4	1	0	0	193
2006	3229	122537	30995	20657	11284	6078	16415	32978	156	56	20	7	4	1	0	0	243
2007	2046	20565	171600	16796	8187	4782	2237	6876	7254	75	8	14	3	1	0	0	7355
2008	3780	15005	31864	75341	4757	2050	1516	566	1432	2570	5	8	1	1	0	0	4017
2009	10483	11042	15303	20764	78513	1860	845	567	239	276	569	6	2	0	0	0	1092
2010	2930	108139	17377	17834	11301	38134	853	416	160	83	85	148	9	0	0	3	488
2011	3003	6082	66355	17091	14138	11495	23124	677	282	95	17	5	60	0	0	0	459
2012	1319	3389	5260	66109	5388	3670	2416	7900	157	178	68	44	57	24	4	0	532
2013	1285	11998	4394	4838	68899	2269	1539	879	3896	37	7	8	2	2	2	0	3954
2014	3537	7504	19838	4818	7799	46760	1104	980	390	1706	14	6	1	1	0	2	2121
2015	3820	27637	15799	17624	1730	5166	22109	1059	433	437	782	107	0	0	0	0	1759
2016	1845	10258	61899	8780	5537	646	507	10150	262	151	9	146	8	0	0	1	57
2017	2593	12665	23033	55077	3214	1517	142	373	1482	509	5	20	5	1	0	1	2023
2018	3627	5530	24051	16957	34909	958	526	206	103	985	25	1	3	3	1	1	1122
2019	3173	18334	11863	25879	7208	21264	427	370	20	46	139	5	1	4	1	10	225
2020	2556	43607	30169	12260	14743	3303	7932	177	164	62	61	20	0	0	0	0	309

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+ and years 1972–2020 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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1983	0	7669	114118	57151	152477	19147	2201	338	255	385	93	21	4	4	0	0	763
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706
1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381
2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284
2008	0	299	6472	50965	4461	1986	1378	563	1402	2566	5	8	1	1	0	0	3983
2009	0	486	4605	9666	61972	1775	793	521	239	276	566	6	2	0	0	0	1088
2010	0	1089	5150	12597	10176	35718	828	416	146	83	85	147	9	0	0	3	473
2011	0	224	16505	15260	13321	11383	22889	677	282	95	16	5	60	0	0	0	458
2012	0	261	3286	52091	4884	3660	2408	7885	157	178	68	44	57	24	4	0	532
2013	0	983	2493	4338	66123	2240	1526	867	3868	37	6	8	2	2	2	0	3924
2014	0	232	12630	3832	7626	42509	1100	965	382	1703	14	6	1	1	0	2	2110
2015	0	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	107	11991	15085	33153	954	525	202	103	980	25	1	3	3	1	1	1117
2019	0	282	5074	21822	6964	20335	421	366	19	46	137	5	1	4	1	10	222
2020	0	1013	16559	10309	14228	3002	7795	177	164	62	61	20	0	0	0	0	309

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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	5757	111654	4897	141863	3704	4	1	0	0	0	0	0	0	0	0	0	0
1966	13832	445648	12742	1197	24643	35	2	0	0	0	0	0	0	0	0	0	0
1967	46372	408281	62831	1032	219	1576	9	0	0	0	0	0	0	0	0	0	0
1968	67	741402	244976	3512	97	15	186	0	0	0	0	0	0	0	0	0	0
1969	4475	5234	1273332	39179	432	16	8	0	0	0	0	0	0	0	0	0	0
1970	68905	99125	78340	306391	2663	13	4	0	0	0	0	0	0	0	0	0	0
1971	14189	1275394	37883	9623	25648	66	2	0	0	0	0	0	0	0	0	0	0
1972	18446	444794	380988	6846	1236	1212	13	0	0	0	0	0	0	0	0	0	0
1973	38129	287558	363916	50108	354	33	123	0	0	0	0	0	0	0	0	0	0
1974	88456	982287	99148	59143	2869	6	4	0	0	0	0	0	0	0	0	0	0
1975	7479	1653311	377845	16385	13423	143	0	0	0	0	0	0	0	0	0	0	0
1976	6418	122012	698428	41183	200	137	0	0	0	0	0	0	0	0	0	0	0
1977	16364	107748	47070	79922	664	9	0	0	0	0	0	0	0	0	0	0	0
1978	1193	83683	63997	4214	19568	248	80	0	0	0	0	0	0	0	0	0	0
1979	4795	119245	82074	5734	142	365	0	0	0	0	0	0	0	0	0	0	0
1980	258	146751	197725	4726	96	0	0	0	0	0	0	0	0	0	0	0	0
1981	442	15023	225773	47838	157	1	0	0	0	0	0	0	0	0	0	0	0
1982	505	36063	35089	94315	2293	0	0	0	0	0	0	0	0	0	0	0	0
1983	24327	76672	94323	20914	12092	905	164	0	0	0	0	0	0	0	0	0	0
1984	3275	361946	48893	23714	1623	3317	0	0	0	0	0	0	0	0	0	0	0
1985	4924	146668	156400	3624	115	1	16	0	0	0	0	0	0	0	0	0	0
1986	13007	84333	75071	39219	23	1	0	0	0	0	0	0	0	0	0	0	0
1987	1996	159860	134988	9142	2795	2	0	0	0	0	0	0	0	0	0	0	0
1988	7399	27412	244105	10535	427	10	0	0	24	0	0	0	0	0	0	0	24
1989	10673	43756	23611	67102	1048	23	35	0	2	0	2	0	0	0	0	0	4
1990	16290	69073	30530	1772	4932	28	25	0	0	0	0	0	0	0	0	0	0
1991	11794	143967	40697	1163	17	107	0	0	0	0	0	0	0	0	0	0	0
1992	36231	82605	115933	4063	97	0	6	0	0	0	0	0	0	0	0	0	0
1993	12346	191714	163172	17474	170	1	0	3	0	0	0	0	0	0	0	0	0
1994	19197	75840	254112	20271	2069	30	0	0	0	0	0	0	0	0	0	0	0
1995	2118	231490	84163	67644	2539	199	0	0	0	0	0	0	0	0	0	0	0
1996	22563	35010	413599	28996	10344	36	0	0	0	0	0	0	0	0	0	0	0
1997	15260	114893	69948	106789	1700	425	0	0	0	0	0	0	0	0	0	0	0
1998	2936	77065	162251	15801	20732	88	11	0	0	0	0	0	0	0	0	0	0
1999	20814	57336	83205	46764	1905	2561	49	0	0	0	0	0	0	0	0	0	0
2000	8472	320463	55818	24661	5703	321	201	0	0	0	0	0	0	0	0	0	0
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0

	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	3627	5415	11488	1831	1623	3	0	4	0	3	0	0	0	0	0	0	3
2019	3173	17855	6448	3600	168	706	1	0	0	0	0	0	0	0	0	0	0
2020	2556	42138	13341	1823	468	300	136	0	0	0	0	0	0	0	0	0	0

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+ and years 2016–2020 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
2019	0	194	285	218	0	2	0	0	0	0	0	0	0	0	0	0	0
2020	0	455	270	128	47	1	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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	644461	254237	7686	183288	2365	592	118	6	0	0	0	0	0	0	0	0	0
1966	1659093	548835	6546	1007	15861	755	25	2	0	0	0	0	0	0	0	0	0
1967	298999	392510	5539	155	24	2264	12	0	0	0	0	0	0	0	0	0	0
1968	11066	462938	81153	2029	46	19	738	1	0	0	0	0	0	0	0	0	0
1969	70826	15178	1703617	98650	632	380	126	252	0	0	0	0	0	0	0	0	0
1970	872884	170914	88509	485275	3967	153	61	2	0	0	0	0	0	0	0	0	0
1971	323088	570391	9972	3390	6381	299	6	0	0	0	0	0	0	0	0	0	0
1972	236664	238566	57010	1023	146	439	0	0	0	0	0	0	0	0	0	0	0
1973	41332	117470	12402	11	11	196	0	0	0	0	0	0	0	0	0	0	0
1974	576654	275266	32267	46862	4600	82	112	224	0	0	0	0	0	0	0	0	0
1975	44317	594854	84620	4761	5203	141	5	0	5	0	0	0	0	0	0	0	5
1976	164982	66973	183064	29188	46	2946	17	0	0	0	0	0	0	0	0	0	0
1977	103142	147019	29352	67628	2355	238	240	0	0	0	0	0	0	0	0	0	0
1978	280592	125698	11330	809	1480	64	6	5	0	0	0	0	0	0	0	0	0
1979	839615	125834	17671	1507	84	379	16	0	0	0	0	0	0	0	0	0	0
1980	374315	281436	21820	8258	1291	54	86	7	0	1	0	0	0	0	0	0	1
1981	644910	99247	30358	4613	440	6	2	0	0	0	0	0	0	0	0	0	0
1982	275003	174147	14740	13540	1810	464	0	0	0	0	0	0	0	0	0	0	0
1983	488707	63818	14331	5134	2242	3	0	0	0	0	0	0	0	0	0	0	0
1984	92587	98257	10644	4702	368	535	0	0	0	0	0	0	0	0	0	0	0
1985	122079	11672	17826	1739	547	223	17	0	0	0	0	0	0	0	0	0	0
1986	32696	40023	1831	802	103	7	0	0	0	0	0	0	0	0	0	0	0
1987	8253	82226	3797	295	138	0	0	0	0	0	0	0	0	0	0	0	0
1988	9280	3309	12819	2462	620	202	0	0	0	0	0	0	0	0	0	0	0
1989	8914	2541	1751	2789	460	37	86	10	0	0	0	0	0	0	0	0	0
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0
1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198033	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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
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
2019	0	2	31	132	42	123	3	2	0	0	1	0	0	0	0	0	1
2020	0	36	591	368	508	107	278	6	6	2	2	1	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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	1.691
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	1.877
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	1.979
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	2.179
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	1.904
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	1.450
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	1.355
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	1.693
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	1.660
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	1.502
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	1.076
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	1.300
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	1.584
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	1.446
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	1.418
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	1.664
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	1.612
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	1.523
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	1.555

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	1.847
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	1.845
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	1.654
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	1.339
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	1.156
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	1.322
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	1.768
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	1.419
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	1.746
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	1.646
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	1.439
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	1.368
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	1.617
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	1.548
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	1.210
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	0.914
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	1.083
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	1.573
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	1.508
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	1.535
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	1.507
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	1.263
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	1.277
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	0.749
2008	0.030	0.170	0.256	0.366	0.593	0.662	0.714	0.928	0.924	0.878	1.689	1.970	0.988	0.224	3.792	3.024	0.898
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	1.162
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	1.396
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	0.930
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	1.402
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	0.768
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	0.831
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	0.781
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	1.002
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	0.935
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	4.661	0.970
2019	0.044	0.150	0.310	0.463	0.629	0.579	1.013	0.983	2.271	2.652	1.337	3.551	3.491	2.628	4.051	5.041	1.944
2020	0.046	0.128	0.347	0.498	0.580	0.839	0.613	1.641	2.339	2.319	3.309	1.616	1.266	0.000	0.000	0.000	2.479

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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	1.691
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	1.877
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	1.979
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	2.179
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	1.904
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	1.450
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	1.355
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	1.693
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	1.660
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	1.502
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	1.077
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	1.300
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	1.584
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	1.446
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	1.418
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	1.664
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	1.612
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	1.523
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	1.555
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	1.847
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	1.845
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	1.654
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	1.339
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	1.173
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	1.316
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	1.776
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	1.419
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	1.747
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	1.646
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	1.439
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	1.368
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	1.617
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	1.548
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	1.210
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	0.914
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	1.083
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	1.576
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	1.508
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	1.535

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	1.507
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	1.265
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	1.326
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	0.753
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	0.902
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	1.165
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	1.429
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	0.925
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	1.402
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	0.767
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	0.832
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	0.781
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	1.002
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	0.937
2018	0.000	0.418	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	4.664	0.970
2019	0.000	0.776	0.436	0.492	0.637	0.587	1.013	0.983	2.271	2.652	1.337	3.551	3.491	2.628	4.051	5.040	1.944
2020	0.000	0.359	0.450	0.533	0.588	0.882	0.617	1.641	2.339	2.319	3.309	1.616	1.266	0.000	0.000	0.000	2.479

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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	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	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	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	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	0.000
1970	0.057	0.131	0.210	0.239	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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	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	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	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	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	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	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	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	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	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	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	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	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	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	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	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	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	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	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	0.000
1990	0.047	0.189	0.229	0.248	0.264	0.290	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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	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	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	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	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	0.000
1996	0.047	0.133	0.218	0.279	0.297	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	0.000
2016	0.048	0.149	0.245	0.357	0.361	0.876	0.457	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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	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	0.000
2019	0.044	0.139	0.211	0.293	0.301	0.358	0.567	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.046	0.122	0.220	0.317	0.371	0.404	0.377	0.000	0.000	0.000	0.000	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+ and years 2016–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	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	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	0.000
2019	0.089	0.185	0.271	0.298	0.408	0.382	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.000	0.220	0.267	0.259	0.365	0.792	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+ and years 1972–2020 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.023	0.067	0.136	0.255	0.288	0.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.035	0.068	0.141	0.246	0.327	0.396	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.022	0.058	0.150	0.260	0.359	0.579	0.277	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.020	0.039	0.173	0.275	0.267	0.413	0.585	0.000	0.585	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.585
1976	0.012	0.046	0.181	0.304	0.473	0.360	0.725	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.013	0.042	0.184	0.307	0.490	0.352	0.442	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.317
1978	0.011	0.040	0.174	0.286	0.372	0.473	0.411	0.456	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.345
1979	0.009	0.039	0.177	0.285	0.384	0.461	0.735	1.234	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.333
1980	0.012	0.039	0.176	0.268	0.623	0.722	1.102	1.591	0.000	1.796	0.000	0.000	0.000	0.000	0.000	0.000	1.796
1981	0.009	0.040	0.176	0.371	0.467	0.858	1.200	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.346
1982	0.010	0.040	0.206	0.379	0.636	0.751	1.225	1.233	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1983	0.008	0.047	0.173	0.428	0.584	1.006	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.318
1984	0.009	0.045	0.211	0.414	0.626	0.751	1.225	1.234	1.315	1.319	1.400	1.400	0.000	0.000	0.000	0.000	1.356
1985	0.009	0.043	0.186	0.371	0.550	0.563	0.565	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.319
1986	0.010	0.040	0.186	0.375	0.626	1.259	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.328
1987	0.006	0.038	0.258	0.442	0.908	1.171	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1988	0.018	0.077	0.196	0.274	0.455	0.549	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.330
1989	0.015	0.165	0.251	0.347	0.670	0.923	1.065	1.492	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.329
1990	0.005	0.104	0.229	0.506	0.609	0.842	0.829	0.796	0.956	1.319	0.000	0.000	0.000	0.000	0.000	0.000	0.956
1991	0.027	0.058	0.206	0.357	0.472	0.477	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1992	0.015	0.059	0.217	0.422	0.552	0.615	0.548	1.234	0.621	0.820	0.000	0.000	0.000	0.000	0.000	0.000	0.659
1993	0.008	0.053	0.206	0.399	0.521	0.578	1.225	0.582	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.315
1994	0.011	0.055	0.155	0.435	0.595	0.698	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.012	0.045	0.193	0.285	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.018	0.077	0.136	0.162	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.007	0.076	0.149	0.309	0.419	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.020	0.075	0.166	0.291	0.351	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.018	0.064	0.177	0.304	0.416	0.309	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.058	0.070	0.113	0.176	0.370	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.014	0.086	0.133	0.110	0.353	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.016	0.064	0.178	0.283	0.374	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.031	0.056	0.231	0.326	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2004	0.000	0.116	0.183	0.255	0.276	0.446	0.539	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.107	0.187	0.239	0.268	0.287	0.598	0.619	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.127	0.232	0.273	0.273	0.280	0.283	0.286	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.287
2007	0.035	0.141	0.192	0.290	0.315	0.370	0.427	0.342	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.368
2008	0.042	0.146	0.291	0.388	0.454	0.526	0.414	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.047	0.180	0.252	0.247	0.279	0.410	0.417	0.413	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.400
2010	0.000	0.080	0.244	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000	0.421
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	2.233
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	0.767
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	0.832
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	0.781
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	1.003
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	0.936
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	0.967
2019	0.000	0.776	0.436	0.492	0.637	0.587	1.013	0.983	2.271	2.652	1.337	3.551	3.491	2.628	4.051	5.098	1.945
2020	0.000	0.359	0.450	0.533	0.588	0.882	0.617	1.641	2.339	2.319	3.309	1.616	1.266	0.000	0.000	0.000	2.479

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). Ages 0–7 and 8+ and years 1972–2020 are used in the assessment.

	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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	1.485	1.464	0.534	0.390	0.295	0.243	0.221	0.212	0.204	0.204	0.202	0.224	0.224	0.224	0.224	0.224
1984	1.483	1.402	0.510	0.377	0.289	0.241	0.219	0.210	0.204	0.204	0.202	0.222	0.222	0.222	0.222	0.222
1985	1.479	1.337	0.487	0.365	0.284	0.239	0.218	0.209	0.204	0.204	0.202	0.219	0.219	0.219	0.219	0.219
1986	1.470	1.275	0.467	0.355	0.280	0.238	0.216	0.209	0.204	0.204	0.203	0.217	0.217	0.217	0.217	0.217
1987	1.455	1.222	0.451	0.345	0.277	0.237	0.215	0.208	0.203	0.204	0.203	0.215	0.215	0.215	0.215	0.215
1988	1.433	1.179	0.437	0.337	0.274	0.236	0.214	0.207	0.203	0.204	0.203	0.213	0.213	0.213	0.213	0.213
1989	1.404	1.146	0.426	0.329	0.272	0.235	0.214	0.207	0.203	0.204	0.203	0.211	0.211	0.211	0.211	0.211
1990	1.370	1.125	0.417	0.322	0.270	0.234	0.214	0.207	0.203	0.203	0.203	0.210	0.210	0.210	0.210	0.210
1991	1.334	1.113	0.409	0.316	0.268	0.234	0.213	0.207	0.203	0.203	0.202	0.208	0.208	0.208	0.208	0.208
1992	1.302	1.110	0.402	0.311	0.267	0.234	0.213	0.207	0.203	0.202	0.202	0.207	0.207	0.207	0.207	0.207
1993	1.278	1.112	0.397	0.308	0.266	0.235	0.213	0.207	0.203	0.202	0.201	0.207	0.207	0.207	0.207	0.207
1994	1.263	1.117	0.392	0.306	0.266	0.236	0.214	0.207	0.203	0.201	0.201	0.206	0.206	0.206	0.206	0.206
1995	1.257	1.125	0.388	0.305	0.267	0.238	0.215	0.208	0.203	0.201	0.201	0.205	0.205	0.205	0.205	0.205
1996	1.257	1.132	0.385	0.306	0.268	0.242	0.217	0.208	0.204	0.201	0.200	0.204	0.204	0.204	0.204	0.204
1997	1.263	1.138	0.382	0.309	0.270	0.246	0.220	0.209	0.204	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1998	1.272	1.144	0.381	0.313	0.273	0.250	0.224	0.209	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
1999	1.284	1.153	0.381	0.318	0.276	0.255	0.228	0.210	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2000	1.296	1.166	0.384	0.323	0.280	0.261	0.232	0.211	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2001	1.306	1.185	0.390	0.330	0.284	0.266	0.237	0.212	0.204	0.200	0.199	0.203	0.203	0.203	0.203	0.203
2002	1.308	1.208	0.398	0.336	0.289	0.272	0.242	0.214	0.204	0.201	0.199	0.204	0.204	0.204	0.204	0.204
2003	1.300	1.232	0.407	0.340	0.293	0.277	0.248	0.216	0.205	0.201	0.199	0.205	0.205	0.205	0.205	0.205
2004	1.280	1.252	0.417	0.343	0.297	0.281	0.253	0.219	0.205	0.203	0.199	0.206	0.206	0.206	0.206	0.206
2005	1.251	1.263	0.427	0.344	0.299	0.283	0.257	0.222	0.206	0.204	0.199	0.208	0.208	0.208	0.208	0.208
2006	1.216	1.266	0.437	0.342	0.300	0.284	0.259	0.225	0.207	0.207	0.199	0.209	0.209	0.209	0.209	0.209
2007	1.181	1.261	0.448	0.338	0.299	0.283	0.261	0.228	0.208	0.209	0.200	0.212	0.212	0.212	0.212	0.212
2008	1.147	1.250	0.458	0.333	0.297	0.282	0.261	0.231	0.209	0.212	0.201	0.214	0.214	0.214	0.214	0.214
2009	1.118	1.238	0.470	0.327	0.295	0.280	0.261	0.235	0.210	0.216	0.202	0.216	0.216	0.216	0.216	0.216
2010	1.094	1.227	0.482	0.320	0.292	0.278	0.260	0.239	0.211	0.220	0.203	0.219	0.219	0.219	0.219	0.219
2011	1.074	1.221	0.496	0.314	0.288	0.276	0.258	0.243	0.213	0.223	0.205	0.219	0.219	0.219	0.219	0.219
2012	1.054	1.221	0.510	0.307	0.284	0.273	0.255	0.248	0.215	0.226	0.208	0.219	0.219	0.219	0.219	0.219
2013	1.035	1.225	0.526	0.302	0.279	0.269	0.252	0.252	0.217	0.229	0.211	0.219	0.219	0.219	0.219	0.219
2014	1.017	1.234	0.542	0.297	0.274	0.265	0.248	0.257	0.220	0.231	0.214	0.219	0.219	0.219	0.219	0.219
2015	0.999	1.245	0.560	0.292	0.268	0.260	0.244	0.262	0.223	0.233	0.217	0.219	0.219	0.219	0.219	0.219
2016	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
2017	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
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
2019	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
2020	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	2021				
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	390.813	32.707	29.979	3.889	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
100	2355.810	162.481	61.292	55.104	8.536
100	1510.405	1442.539	104.955	23.759	28.491

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	2020					
1	1	0.50	0.75			
0	5					
100	718.479	233.55	22.921	2.842	0.507	1.561
100	2741.14	595.235	189.015	10.529	1.583	0.396
100	577.382	605.99	140.146	37.604	2.36	0.372
100	1781.191	195.331	262.643	32.423	8.383	0.381
100	520.855	1019.607	106.642	97.383	8.06	3.131
100	627.502	247.469	428.471	30.426	20.215	2.649
100	195.255	347.567	123.793	149.048	6.672	5.282
100	276.401	257.14	164.853	53.69	42.66	3.093
100	6904.539	176.457	94.108	47.947	13.268	9.904
100	1092.754	2504.185	44.3	19.502	10.287	4.264
100	34.743	360.422	1099.293	30.29	6.371	3.648
100	137.709	45.969	237.732	573.754	9.826	2.485
100	163.931	69.348	31.171	199.259	368.665	2.942
100	183.977	69.539	40.556	23.119	82.685	154.82
100	1412.973	67.605	45.54	16.254	9.845	37.095
100	191.608	547.284	27.543	11.709	3.612	3.352
100	111.475	149.743	385.791	10.354	5.35	1.126
100	126.428	86.627	89.934	174.968	5.206	2.253
100	909.334	77.703	79.994	38.131	73.972	1.643
100	30.294	557.39	59.017	34.214	25.186	53.33
100	30.64	77.035	344.508	27.159	12.209	9.196
100	68.068	31.515	40.248	132.237	7.344	4.397
100	86.267	58.356	25.177	18.293	82.781	2.515
100	747.545	48.207	58.51	5.216	9.093	51.625
100	104.274	463.428	22.807	15.993	1.662	2.307
100	352.014	94.977	220.721	8.166	3.731	0.41
100	146.171	167.605	72.398	130.786	2.896	1.29
100	123.141	74.11	94.752	22.692	32.776	0.724
100	1940.393	164.608	53.427	63.534	12.388	18.324
100	1345.814	1468.487	93.95	26.789	25.321	5.049

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	1972–2020
Discards	Ages	0–8+
	Years	1972, 1978–2020
Industrial bycatch	Ages	0–8+
	Years	1972, 1978–2020
BMS landings	Ages	0–8+
	Years	2016–2020
Survey: NS IBTS Q1	Ages	1–5
	Years	1983–2021
Survey: NS IBTS Q3	Ages	0–5
	Years	1991–2020
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 =7
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	0.0421	0.005	0.1	TRUE	FALSE
F age 1	0.0894	0.05	0.3	TRUE	FALSE
F age 2	0.8719	0.6	1.5	TRUE	FALSE
F age 7	1.3378	1	1.4	TRUE	FALSE
sd F	0.183	0.01	0.2	TRUE	FALSE
sd U	0.0749	0.01	0.15	TRUE	FALSE
sd V	0.1274	0.01	0.2	TRUE	FALSE
sd Y	0.1764	0.01	0.25	TRUE	FALSE
cv landings	0.1503	0.05	0.3	TRUE	FALSE
cv discards	0.284	0.1	0.4	TRUE	FALSE
log mean recruitment at start	6.9433	5	9	TRUE	FALSE
sd of random walk	0.0375	0	0.25	TRUE	FALSE
recruitment cv	0.5627	0.3	0.6	TRUE	FALSE
discards sd transitory	0	0	0.35	TRUE	TRUE
discards sd persistent	0.3261	0.125	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2982	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.7129	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.7429	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5309	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4522	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.3363	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.1105	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.0979	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2516	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3879	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5793	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.4894	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3691	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.3145	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.2458	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.0992	0	0.3	TRUE	FALSE
NSQ3 omega	0.0662	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 2021 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
1972	0.040	0.085	0.599	1.028	0.968	0.919	1.015	1.050	0.977	0.865
1973	0.034	0.091	0.577	0.902	0.861	0.899	0.998	1.033	1.113	0.780
1974	0.032	0.087	0.619	0.724	0.873	0.772	0.907	0.978	0.983	0.739
1975	0.036	0.091	0.693	0.899	0.991	0.949	1.115	1.091	1.078	0.861
1976	0.034	0.092	0.541	0.980	0.862	1.073	0.976	0.998	1.004	0.794
1977	0.033	0.104	0.622	0.733	1.107	0.995	0.990	0.948	0.981	0.821
1978	0.026	0.127	0.670	0.962	1.107	1.109	1.088	1.090	1.134	0.913
1979	0.032	0.103	0.715	1.063	1.013	1.031	1.044	1.052	1.059	0.930
1980	0.037	0.084	0.499	1.066	1.140	0.803	0.920	0.973	0.974	0.902
1981	0.032	0.075	0.316	0.786	0.923	0.754	0.430	0.732	0.695	0.675
1982	0.022	0.075	0.382	0.566	0.679	0.574	0.591	0.707	0.614	0.542
1983	0.021	0.087	0.457	0.845	0.868	0.924	0.761	0.749	0.768	0.723
1984	0.024	0.120	0.505	0.942	1.105	0.819	0.839	0.806	0.806	0.851
1985	0.024	0.124	0.451	0.912	1.030	0.879	0.830	0.772	0.777	0.798
1986	0.018	0.127	0.672	0.924	1.120	0.825	0.665	0.670	0.722	0.905
1987	0.025	0.098	0.764	1.008	0.949	0.877	0.885	0.815	0.784	0.907
1988	0.024	0.122	0.596	1.168	1.112	0.948	0.854	0.776	0.820	0.959
1989	0.022	0.125	0.657	0.942	1.128	0.880	0.853	0.782	0.788	0.909
1990	0.017	0.121	0.755	0.982	1.002	0.872	0.725	0.681	0.701	0.913
1991	0.019	0.168	0.714	1.021	0.939	0.787	0.775	0.738	0.697	0.891
1992	0.021	0.125	0.643	0.973	0.991	0.651	0.857	0.690	0.716	0.869
1993	0.024	0.170	0.818	0.992	1.012	0.966	0.822	0.815	0.833	0.941
1994	0.016	0.128	0.736	1.020	0.976	1.025	0.965	0.900	0.817	0.911
1995	0.021	0.100	0.586	0.905	0.932	0.809	0.905	0.694	0.690	0.808
1996	0.019	0.097	0.515	0.855	1.000	0.958	0.946	0.680	0.673	0.790
1997	0.014	0.119	0.479	0.619	0.729	0.883	0.767	0.583	0.566	0.609
1998	0.014	0.152	0.623	0.663	0.858	0.793	0.768	0.581	0.565	0.715
1999	0.012	0.127	0.672	0.898	0.820	1.056	0.827	0.628	0.595	0.797
2000	0.011	0.098	0.734	0.938	0.938	0.773	0.810	0.556	0.532	0.870
2001	0.010	0.080	0.398	0.663	0.676	0.623	0.548	0.387	0.371	0.579
2002	0.006	0.110	0.258	0.333	0.452	0.424	0.377	0.251	0.249	0.348
2003	0.005	0.045	0.200	0.200	0.244	0.298	0.247	0.158	0.154	0.215
2004	0.004	0.050	0.203	0.226	0.228	0.280	0.213	0.133	0.130	0.219
2005	0.003	0.060	0.287	0.345	0.261	0.307	0.284	0.148	0.143	0.298
2006	0.005	0.052	0.420	0.518	0.549	0.510	0.359	0.235	0.191	0.496
2007	0.005	0.055	0.232	0.500	0.505	0.473	0.359	0.198	0.192	0.412
2008	0.003	0.037	0.177	0.220	0.324	0.296	0.245	0.130	0.128	0.240
2009	0.002	0.032	0.126	0.186	0.257	0.233	0.171	0.104	0.094	0.190

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
2010	0.003	0.034	0.166	0.238	0.221	0.257	0.167	0.101	0.093	0.208
2011	0.003	0.040	0.129	0.408	0.393	0.362	0.257	0.135	0.112	0.310
2012	0.002	0.036	0.135	0.176	0.251	0.223	0.151	0.093	0.080	0.187
2013	0.002	0.042	0.179	0.175	0.256	0.213	0.141	0.082	0.083	0.203
2014	0.002	0.037	0.325	0.340	0.342	0.361	0.164	0.110	0.102	0.336
2015	0.003	0.037	0.439	0.544	0.364	0.468	0.285	0.151	0.131	0.449
2016	0.002	0.034	0.182	0.439	0.359	0.292	0.161	0.121	0.097	0.327
2017	0.002	0.025	0.179	0.239	0.301	0.233	0.120	0.080	0.077	0.240
2018	0.002	0.023	0.124	0.269	0.236	0.199	0.110	0.076	0.065	0.210
2019	0.001	0.024	0.113	0.204	0.207	0.206	0.104	0.061	0.054	0.175
2020	0.001	0.017	0.155	0.214	0.202	0.167	0.116	0.056	0.051	0.190
2021*	0.001	0.022	0.138	0.221	0.214	0.189	0.111	0.059	0.059	0.191

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	8738660	13105860	2083200	78790	44810	394550	7110	430	1170
1973	32331910	1942820	2682540	484150	17120	11150	117940	2050	460
1974	50765470	7182920	393940	650670	118250	4800	3440	34600	720
1975	3121860	13848620	1467570	106350	187410	33450	1670	1100	10660
1976	5393140	947620	2836760	347620	27500	48520	10240	460	3400
1977	11907540	1531010	213590	818220	83890	8390	13490	3270	1250
1978	24519910	2930620	284270	64850	257570	21090	2660	4550	1560
1979	48276390	5737140	538710	77790	16240	63430	5360	760	1770
1980	8994400	11113830	1069930	141620	18090	4630	18870	1670	790
1981	15261810	2009880	2130450	341760	33670	4640	1610	6210	810
1982	9232000	3414350	399370	785680	99350	10460	1740	640	2540
1983	29543510	2064610	693900	162430	298000	37680	4690	790	1390
1984	5949750	6530860	438310	261000	48530	93400	12020	1810	830
1985	9642390	1464680	1415310	159400	71470	12440	30260	4250	910
1986	17814510	2214240	340000	545920	45380	19790	4140	10690	1920
1987	210740	3830570	544550	110330	149900	11520	6750	1620	4760
1988	1115120	338360	1023020	161940	29320	43420	3850	2320	2360
1989	1853400	532410	103140	364160	36030	7540	13380	1350	1750
1990	8410270	728210	148020	35210	104280	9140	2550	4760	1210
1991	9933570	2194320	209020	41990	9600	30250	3150	1030	2530
1992	16817750	2563120	605740	68020	11280	2710	9690	1160	1360
1993	4286520	4476960	740440	213460	17880	3180	1080	3360	1040
1994	16989810	1167370	1228650	218320	58610	5000	980	390	1660
1995	4782850	4730370	336860	394640	58570	16930	1440	310	770

	0	1	2	3	4	5	6	7	8+
1996	6840430	1335210	1389900	127710	118510	17750	6000	490	460
1997	4193100	1911890	391550	564930	40230	33650	5420	1930	410
1998	3077120	1162200	543000	166100	223780	14900	10910	2070	1100
1999	46584030	874850	317680	196950	62840	72700	5270	4060	1490
2000	9156130	12750000	243710	108840	56780	20950	19460	1860	2500
2001	920370	2478580	3601710	80210	30320	16470	7420	6870	2130
2002	1164420	344290	700580	1643470	29260	11570	6760	3420	5090
2003	1326730	392060	92320	364220	843470	13840	5780	3670	5480
2004	1192400	421150	109370	50400	212350	492850	7760	3530	6420
2005	13297300	418340	114460	58860	28530	125530	279450	4850	7100
2006	2738270	3794870	111550	56100	29580	16320	69500	160880	8350
2007	1799180	817690	1015950	47450	23850	12740	7420	37530	106390
2008	1221120	580230	219390	515140	20620	10730	6000	4020	95720
2009	9633460	459700	159800	116290	295470	11110	6040	3640	71180
2010	804220	3142750	129170	88250	69770	170160	6670	3940	55320
2011	65560	317540	890860	67660	50590	41850	99930	4360	43680
2012	1082830	117750	90060	477060	32490	25600	22170	59920	34640
2013	457360	425580	33560	47260	294070	18950	15610	14820	68550
2014	6285130	258080	119860	16260	29350	172190	11710	10560	61450
2015	1557360	2268410	72490	50100	8310	15860	92400	7770	51950
2016	2910960	597660	629660	26760	21240	4370	7670	54640	41680
2017	1257280	1088980	164330	294880	12910	11320	2540	5150	67360
2018	2402110	500190	301840	77280	174300	7340	6970	1780	53470
2019	13559850	905450	138860	149240	44330	105800	4670	4920	41260
2020	13682500	5079920	251040	69640	91360	27750	66760	3310	34740
2021	6640480	4887130	1418980	120860	42260	57510	18210	46800	28730

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 discard+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	384498	42458	234140	229325	25245	173903	155174	30018	0.865	0.066	293120	29753	2549107	253372	8738656	1908495
1973	344581	369688	50040	207383	214678	20637	137198	155010	38931	0.780	0.073	274699	18971	2535351	214931	32331910	3608970
1974	397158	245670	28723	167655	157691	13964	229503	87978	22334	0.739	0.076	321906	23111	2606670	253561	50765467	7929697
1975	494390	294164	39644	160380	164182	13875	334009	129982	34334	0.861	0.086	157703	11430	2035828	245356	3121856	1468059
1976	401969	329184	48444	184244	209270	23551	217725	119915	35755	0.794	0.084	193539	15380	1029557	114038	5393141	1481165
1977	240259	197587	21380	156534	161078	17911	83726	36509	8781	0.820	0.091	348050	29166	806978	63931	11907538	1742686
1978	146700	140557	13614	102940	104295	10289	43760	36262	7321	0.913	0.093	158339	14004	805046	52703	24519908	1895940
1979	149260	143572	15935	97884	87589	9422	51376	55983	10326	0.931	0.095	93237	11365	1215888	69281	48276386	4708282
1980	202640	186599	19075	111375	105618	10395	91265	80981	14043	0.902	0.088	103372	11034	1406827	86738	8994401	1014186
1981	226585	215411	20297	147920	146684	14483	78665	68727	11212	0.675	0.068	192108	12776	1012495	53463	15261807	1593909
1982	256302	202972	15493	195572	162386	13234	60730	40585	6643	0.542	0.047	426693	20168	885895	36640	9232003	816112
1983	253185	227631	16730	188735	180450	13067	64451	47181	7550	0.723	0.055	295226	15263	1102986	44489	29543509	2113889
1984	247238	226394	22974	158181	150042	11231	89057	76352	17312	0.851	0.062	237031	14989	1356718	71918	5949746	1564530
1985	247430	222399	17985	183055	162977	13553	64375	59423	9605	0.798	0.058	166700	8413	898827	38255	9642389	1269050
1986	223854	205856	14940	185119	163249	12333	38735	42607	6929	0.905	0.062	285507	16086	1056334	54849	17814510	1861474
1987	195046	177455	14621	135000	124688	9383	60046	52767	9265	0.907	0.064	161662	8575	786353	40148	210743	1409162
1988	179911	167410	13851	126181	121675	10759	53729	45735	7257	0.959	0.069	125842	8432	465170	82104	1115116	1783240
1989	127679	118366	9919	92801	93480	8575	34878	24886	4431	0.909	0.069	177242	11178	379530	58547	1853396	1505492
1990	86743	79145	7584	61584	57752	5186	25159	21394	4223	0.913	0.069	85160	5764	604079	66111	8410272	1562071
1991	97205	92005	13057	55211	45239	4546	41993	46767	10731	0.891	0.069	51828	3934	798219	41082	9933569	781733
1992	134993	124983	12213	81572	70611	7157	53421	54372	8533	0.869	0.054	55015	2696	821348	37053	16817751	1303128
1993	180206	214971	22530	98697	111627	10883	81509	103344	17467	0.941	0.059	117925	7490	862062	44726	4286522	384027
1994	169472	231712	22917	95175	131126	13819	74297	100586	15223	0.911	0.061	138404	9797	888949	38972	16989806	1146679
1995	168893	172410	17313	89858	102709	10771	79035	69701	11668	0.807	0.059	195770	14138	857004	40275	4782853	381901
1996	204687	197568	18624	92632	98545	8955	112055	99023	14331	0.790	0.057	125611	7211	779302	33275	6840430	571373
1997	170051	162429	14878	95448	94500	8892	74603	67929	10335	0.609	0.049	255801	14980	750875	34172	4193095	481512
1998	161971	159179	13794	95513	92680	7741	66457	66499	9538	0.715	0.056	186995	9773	586359	25161	3077120	332864
1999	123421	127416	11016	75974	73850	6155	47446	53566	7533	0.797	0.063	145643	8832	1534890	89615	46584026	3404932
2000	126870	166779	30965	54476	56149	5161	72395	110630	28492	0.870	0.067	95954	6549	2177213	122934	9156133	619922
2001	173526	271281	38687	47549	99069	14674	125978	172212	30888	0.579	0.052	66008	4698	1156597	67646	920372	838475
2002	155145	179150	21372	65399	96393	11913	89745	82757	15123	0.348	0.036	550753	37165	786724	41549	1164424	503802
2003	74415	94942	11130	47266	73570	9262	27149	21372	4159	0.215	0.024	482786	28945	567180	31382	1326733	432518
2004	72511	75084	9348	51925	64059	8474	20586	11024	1960	0.219	0.024	338047	23230	469119	28796	1192405	386153

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
2005	64116	65952	7907	51542	56273	7224	12573	9679	1549	0.298	0.031	254992	20481	1070998	47191	13297296	743284
2006	66955	66467	8315	43333	45866	5552	23622	20601	4617	0.496	0.043	177633	16643	802363	36841	2738267	365118
2007	67430	76365	8374	34680	46120	5372	32751	30245	4857	0.412	0.038	148434	16671	584632	33847	1799180	560169
2008	47733	56200	5985	33037	41606	4556	14697	14593	2565	0.240	0.026	301827	19888	493264	26442	1221123	477595
2009	47943	44713	4618	35569	36754	3946	12374	7959	1258	0.190	0.020	250312	18980	841903	33278	9633460	510176
2010	45412	44490	4818	31937	35578	3784	13474	8912	1802	0.208	0.023	232743	18370	527946	27581	804222	869226
2011	49658	57304	5587	36572	40937	3825	13086	16367	2884	0.310	0.032	165311	11919	442504	22554	65563	755557
2012	43196	46349	4780	38164	40935	4224	5032	5414	1122	0.187	0.021	334919	18368	431195	25179	1082830	459212
2013	47066	43888	4717	43712	40511	4384	3354	3377	700	0.204	0.021	263066	13914	366078	21929	457363	456063
2014	46317	51172	5215	41165	46209	4811	5152	4963	882	0.335	0.032	190277	11749	542023	20454	6285135	355184
2015	41594	48583	5054	35306	39137	3804	6287	9446	2308	0.449	0.040	149626	10533	557052	25183	1557364	354040
2016	43053	49622	5413	35060	39078	4414	7994	10543	1915	0.327	0.032	127240	10549	586943	22229	2910963	206836
2017	39898	43200	4394	32843	36604	3820	7055	6595	1195	0.240	0.025	224216	12777	491051	21152	1257282	217269
2018	39435	40605	3903	34404	35300	3464	5031	5305	886	0.210	0.023	200462	11512	480902	22268	2402113	305498
2019	36453	35865	3582	30743	31218	3103	5710	4647	894	0.175	0.021	247936	15239	1018075	50343	13559848	1000008
2020	40608	41795	4698	30176	31703	3125	10412	10092	2447	0.190	0.024	243433	16328	1610171	84726	13682503	1385521
2021*		85669	23889		61947	17688		23722	8279	0.191	0.056	256765	16910	1708322	186726	6640480	3799667

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

MFDP version 1a							
Run: 04	Uses Fmult = 0.605754 (see text)						
Time and date: 16:29 27/04/2020							
Fbar age range (Total): 2-4							
Fbar age range Fleet 1: 2-4							
Fbar age range Fleet 2: 2-4							
2021							
Age		N	M	Mat	PF	PM	SWt
	0	6640480	0.981	0	0	0	0.044
	1	4887130	1.258	0	0	0	0.139
	2	1418980	0.577	0	0	0	0.337
	3	120860	0.288	1	0	0	0.483
	4	42260	0.263	1	0	0	0.633
	5	57510	0.255	1	0	0	0.732
	6	18210	0.24	1	0	0	0.979
	7	46800	0.267	1	0	0	0.782
	8	28730	0.376	1	0	0	1.903
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.001	0.044		
	1	0	0.518	0.022	0.132		
	2	0.067	0.452	0.07	0.226		
	3	0.188	0.516	0.03	0.313		
	4	0.204	0.577	0.008	0.401		
	5	0.179	0.709	0.008	0.458		
	6	0.109	0.931	0.001	0.486		
	7	0.058	0.695	0	0.48		
	8	0.058	1.862	0	0.776		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.5175				
	2	0.001	0.4517				
	3	0.0025	0.5162				
	4	0.0028	0.589				
	5	0.0024	0.8314				
	6	0.0015	0.8871				
	7	0.0008	1.2563				
	8	0.0008	2.0155				

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

2022							
Age		N	M	Mat	PF	PM	SWt
	0	6640480	0.981	0	0	0	0.044
	1	.	1.258	0	0	0	0.139
	2	.	0.577	0	0	0	0.337
	3	.	0.288	1	0	0	0.488
	4	.	0.263	1	0	0	0.635
	5	.	0.255	1	0	0	0.787
	6	.	0.24	1	0	0	0.87
	7	.	0.267	1	0	0	1.14
	8	.	0.376	1	0	0	1.735
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.001	0.044		
	1	0	0.518	0.022	0.132		
	2	0.067	0.452	0.07	0.226		
	3	0.188	0.516	0.03	0.316		
	4	0.204	0.589	0.008	0.402		
	5	0.179	0.634	0.008	0.491		
	6	0.109	0.813	0.001	0.537		
	7	0.058	1.05	0	0.555		
	8	0.058	1.668	0	0.88		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.5175				
	2	0.001	0.4517				
	3	0.0025	0.5162				
	4	0.0028	0.589				
	5	0.0024	0.8314				
	6	0.0015	0.8871				
	7	0.0008	1.2563				
	8	0.0008	2.0155				

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

2023							
Age		N	M	Mat	PF	PM	SWt
	0	6640480	0.981	0	0	0	0.044
	1	.	1.258	0	0	0	0.139
	2	.	0.577	0	0	0	0.337
	3	.	0.288	1	0	0	0.488
	4	.	0.263	1	0	0	0.581
	5	.	0.255	1	0	0	0.787
	6	.	0.24	1	0	0	0.942
	7	.	0.267	1	0	0	1.008
	8	.	0.376	1	0	0	1.218
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.001	0.044		
	1	0	0.518	0.022	0.132		
	2	0.067	0.452	0.07	0.226		
	3	0.188	0.516	0.03	0.316		
	4	0.204	0.589	0.008	0.34		
	5	0.179	0.831	0.008	0.491		
	6	0.109	0.692	0.001	0.581		
	7	0.058	0.917	0	0.616		
	8	0.058	1.069	0	0.59		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.5175				
	2	0.001	0.4517				
	3	0.0025	0.5162				
	4	0.0028	0.589				
	5	0.0024	0.8314				
	6	0.0015	0.8871				
	7	0.0008	1.2563				
	8	0.0008	2.0155				

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 (2022)	Projected landings* (2022)	Projected discards** (2022)	IBC*** (2022)	HC catch (2022)	F_{total} (ages 2-4) (2022)	$F_{projected\ landings}$ (ages 2-4) (2022)	$F_{projected\ discards}$ (ages 2-4) (2022)	F_{IBC} (ages 2-4) (2022)	SSB (2022)	% SSB change^	% TAC change^^	% Advice change^^^
ICES advice basis													
MSY approach: F_{MSY}	128708	101908	25339	1460	127248	0.194	0.155	0.037	0.0021	723334	26%	154%	86%
Other scenarios													
$F = F_{MSY\ lower}$	111702	88316	21909	1477	110225	0.167	0.133	0.031	0.0021	740295	29%	120%	61%
$F = F_{MSY\ upper}$#	128708	101908	25339	1460	127248	0.194	0.155	0.037	0.0021	723334	26%	154%	86%
F = 0 (no HC fishery)	1586	0	0	1586	0	0	0	0	0.0021	850838	48%	-100%	-98%
F(p05) with AR	128708	101908	25339	1460	127248	0.194	0.155	0.037	0.0021	723334	26%	154%	86%
F(p05) without AR	109812	86806	21527	1479	108333	0.164	0.131	0.031	0.0021	742179	30%	116%	59%
F_{lim}	248379	197557	49482	1340	247039	0.384	0.309	0.073	0.0021	603983	5.4%	392%	259%
SSB (2022) = B_{lim}	759578	606204	152547	826	758751	1.194	0.964	0.227	0.0021	94000	-84%	1412%	996%
SSB (2022) = B_{pa} = MSY $B_{trigger}$	721485	575754	144866	864	720620	1.133	0.916	0.215	0.0021	132000	-77%	1336%	941%
F_{2021}	79958	62944	15504	1509	78448	0.117	0.093	0.022	0.0021	771954	35%	56%	15%
Rollover TAC	51719	40368	9814	1537	50182	0.072	0.057	0.013	0.0021	800133	40%	0%	-25%

*** Marketable landings.**

**** Including BMS landings, assuming recent discard rate.**

***** IBC = Industrial bycatch, HC = Human Consumption. F(IBC) is assumed to be constant in all scenarios at status quo value**

^ SSB 2023 relative to SSB 2022.

^^ Human consumption fishery (HCF) catch in 2022 relative to TAC in 2021: Subdivision 20 (2630 t) + Subarea 4 (42 785 t) + Division 6.a (4767 t) = 50 182 t.

^^^ Total catch 2022 relative to the advice value 2021 (69 280 t).

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

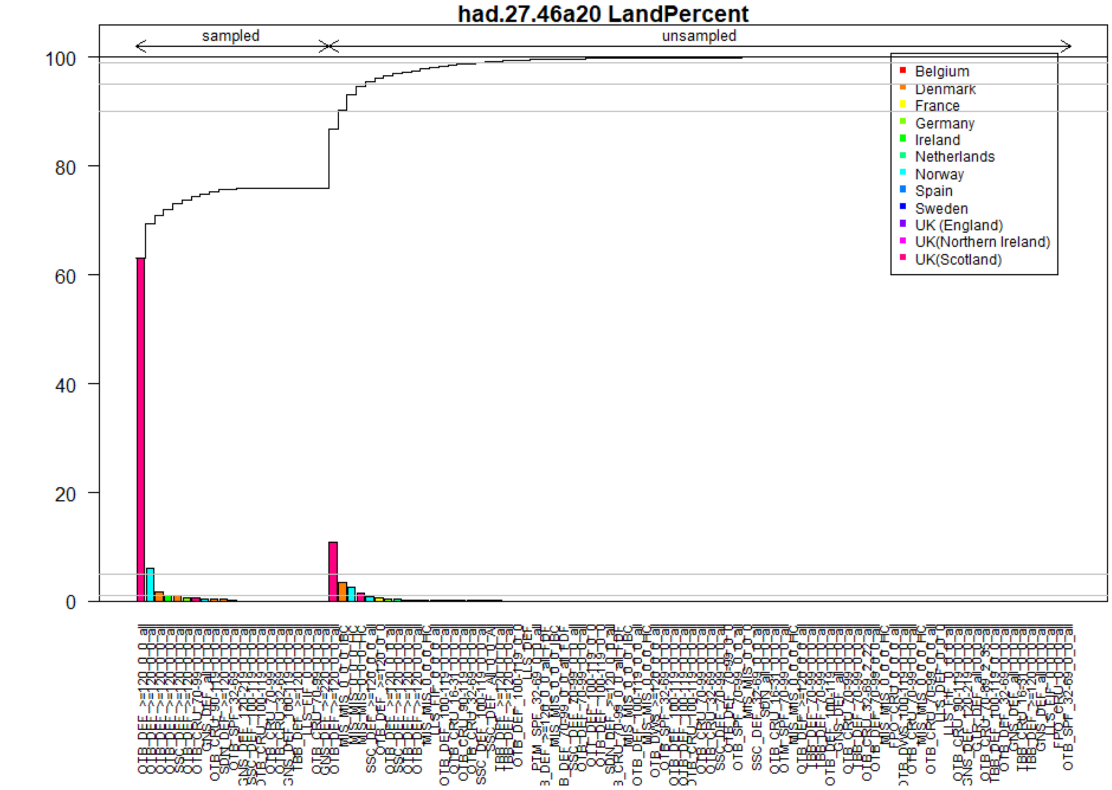


Figure 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

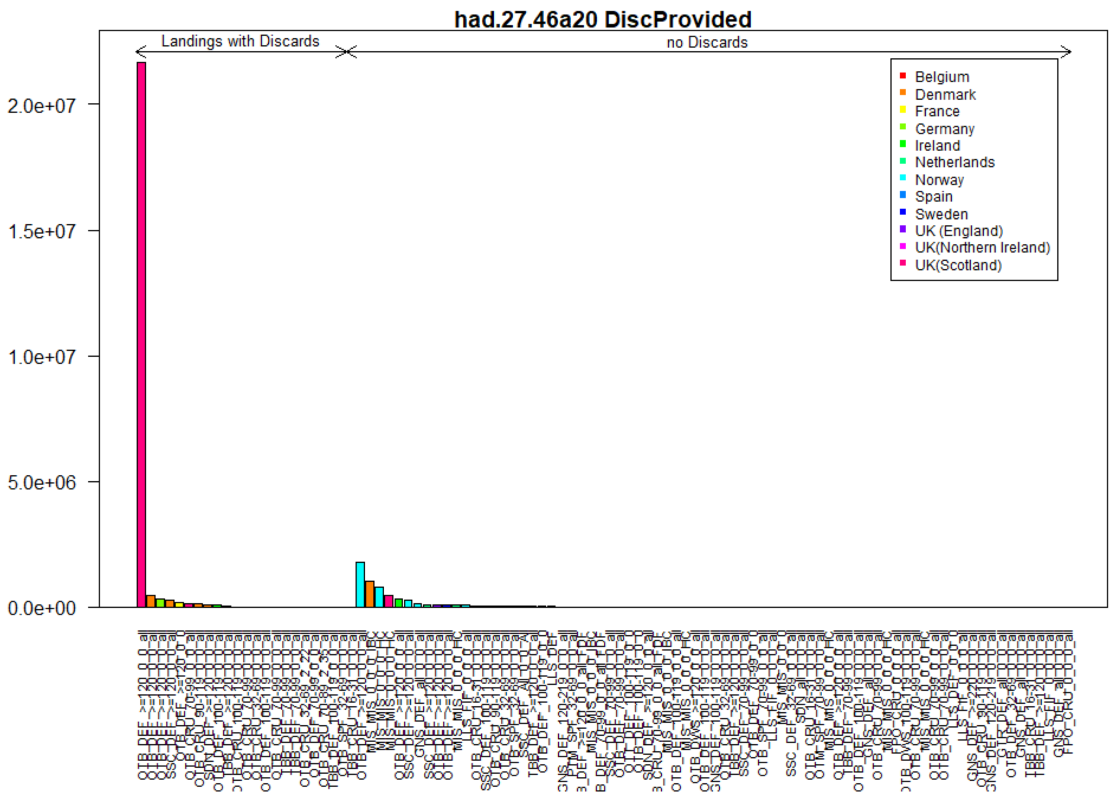


Figure 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary of landings for fleets with and without discard estimates.

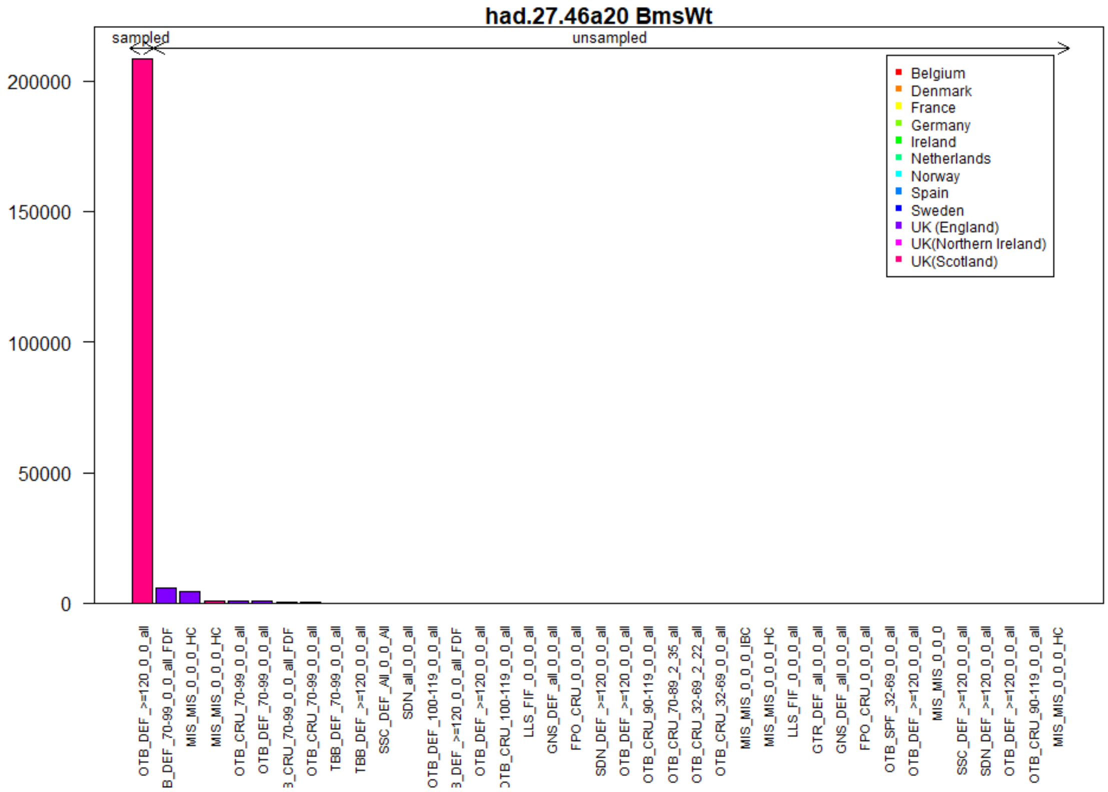


Figure 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported BMS landings for each sampled and un-sampled fleet in the full stock area, in descending order of yield.

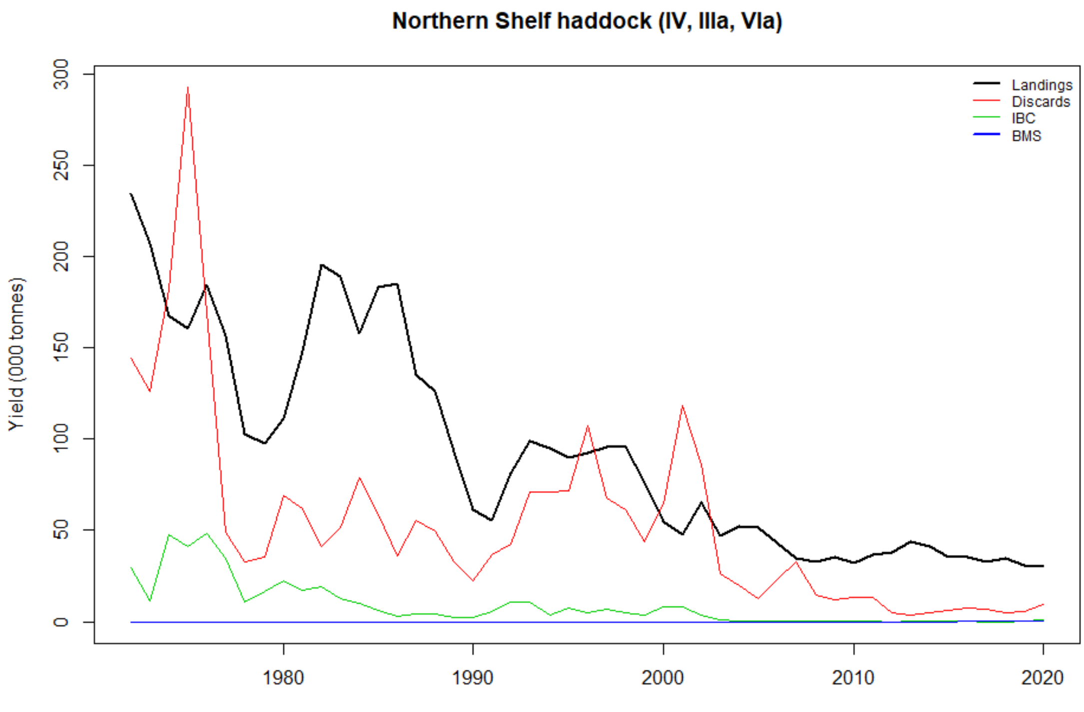


Figure 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Yield by catch component.

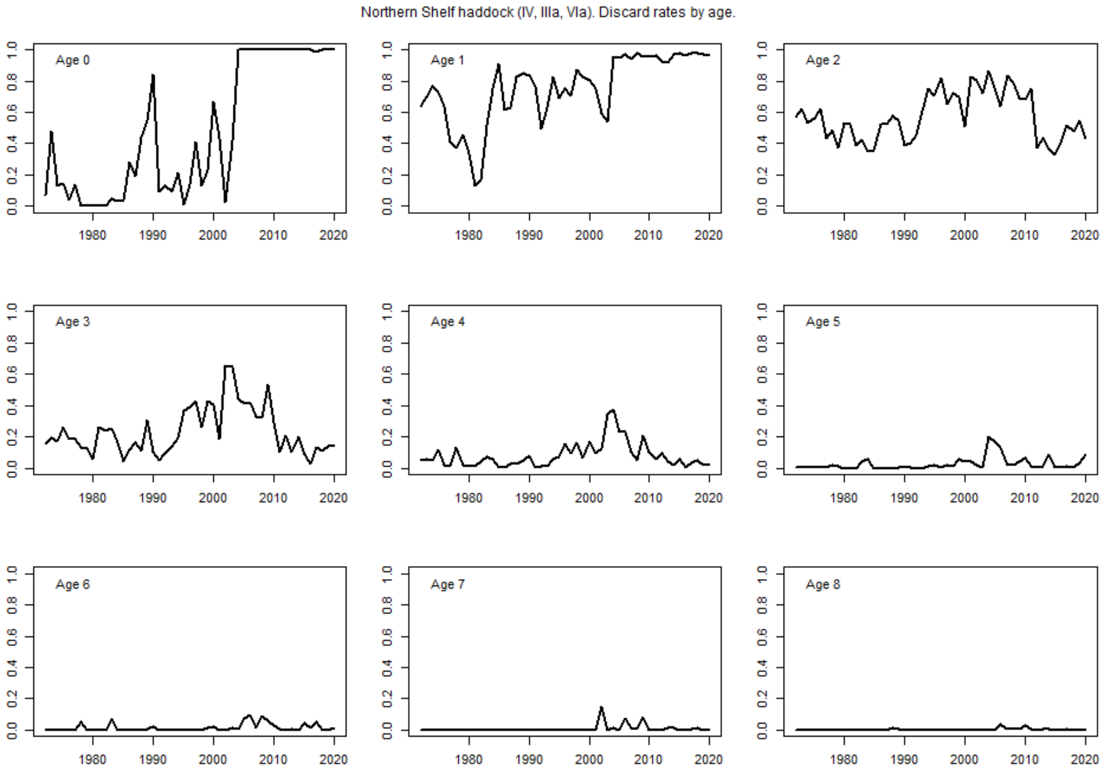


Figure 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of total catch discarded, by age and year.

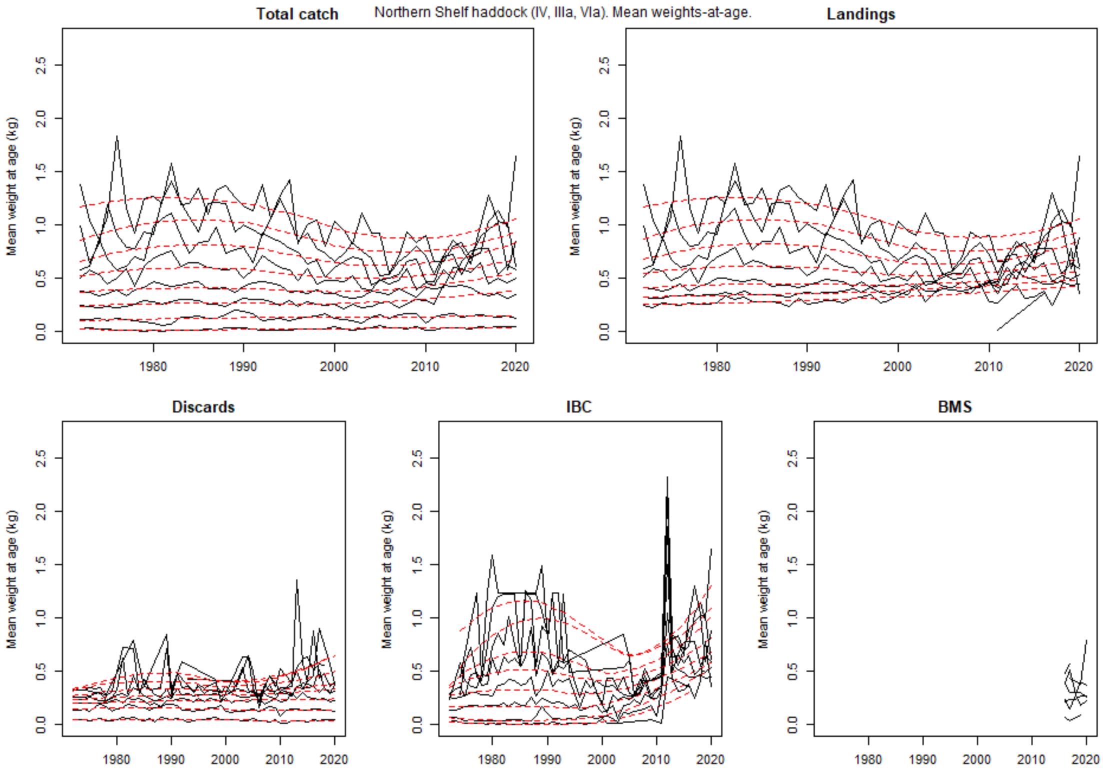


Figure 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age, to show underlying trends.

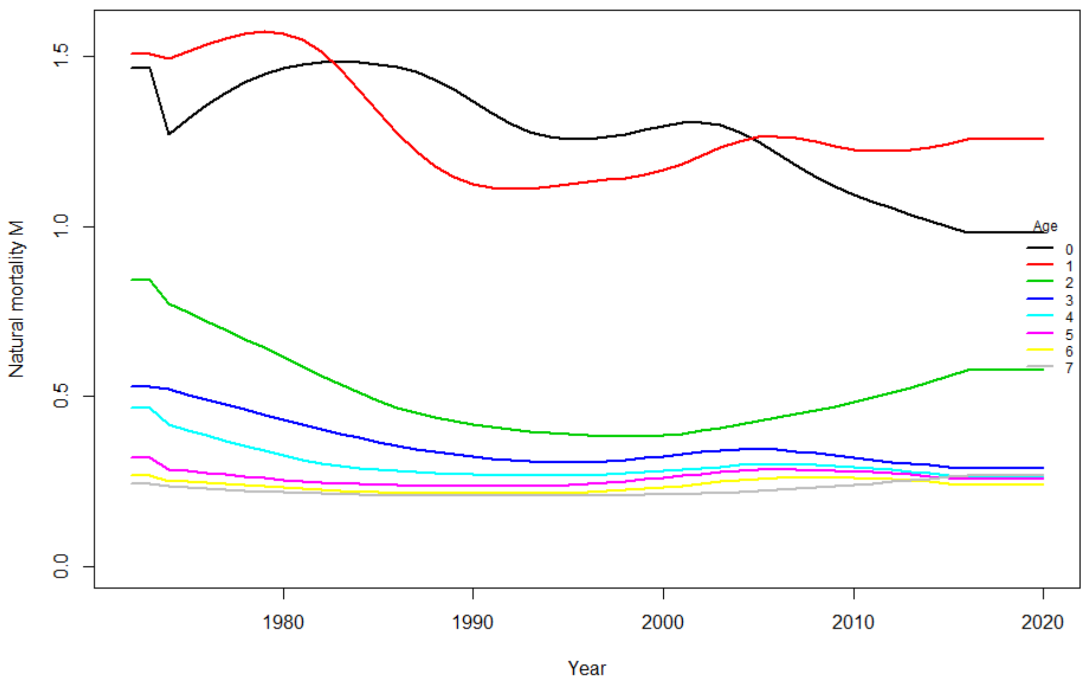


Figure 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time series of estimated natural mortality at age, from ICES WGSAM (2014).

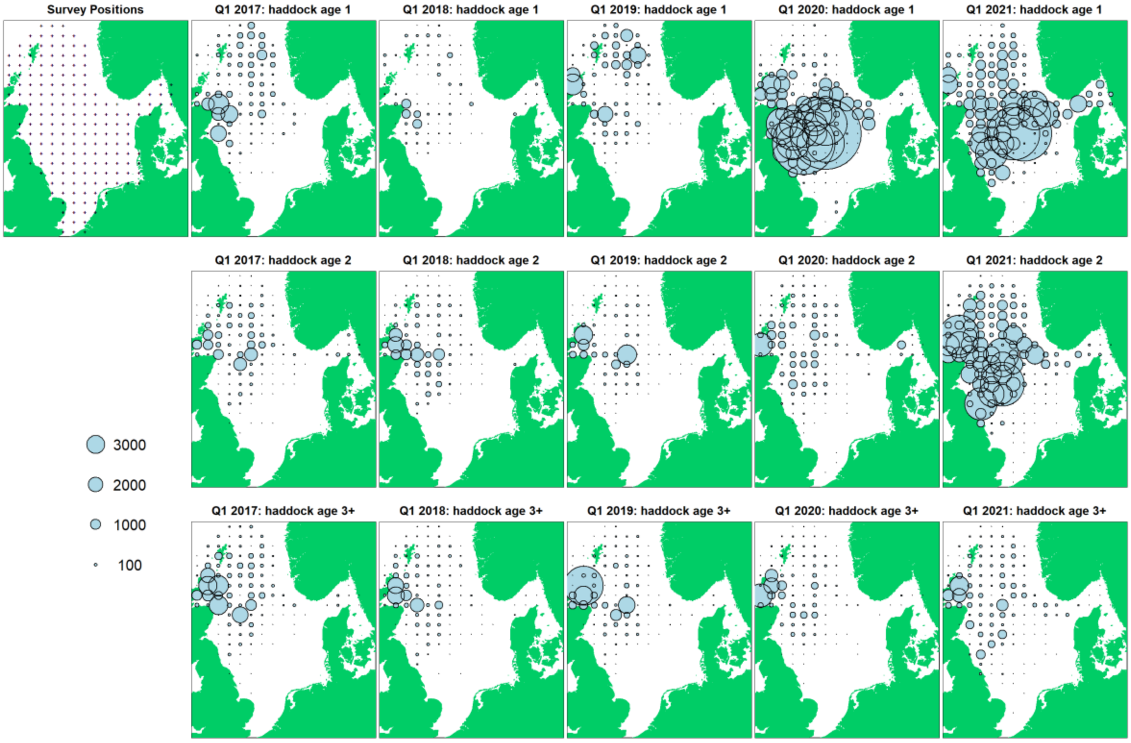


Figure 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q1 survey (North Sea).

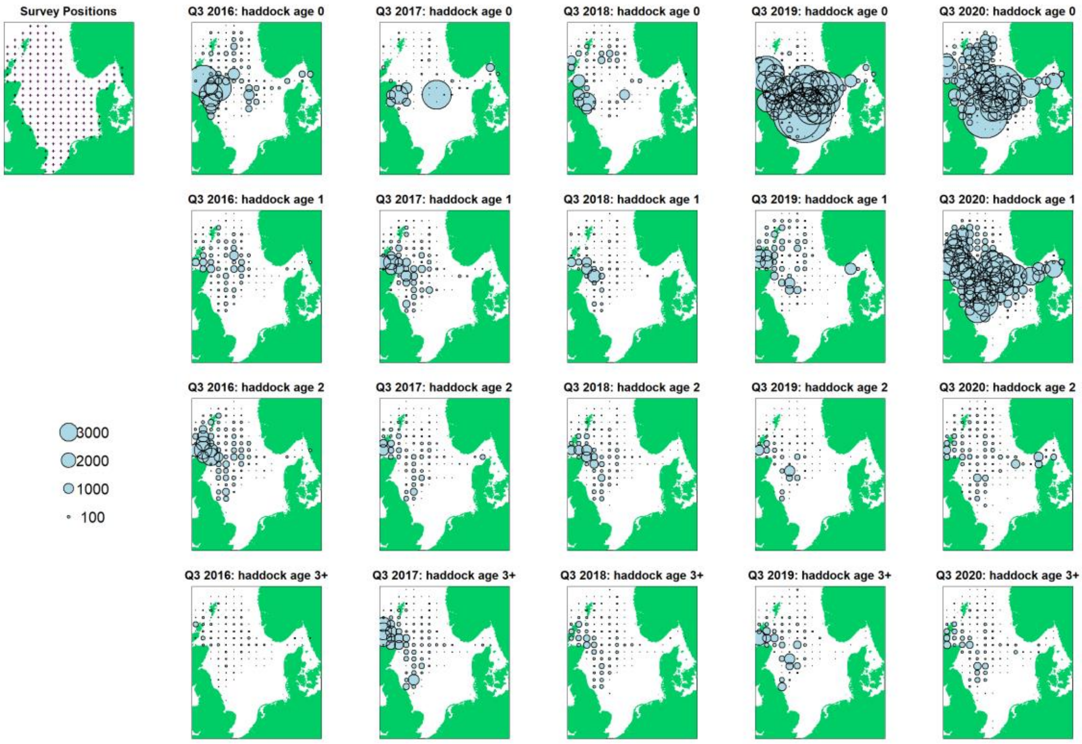


Figure 8.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q3 survey (North Sea).

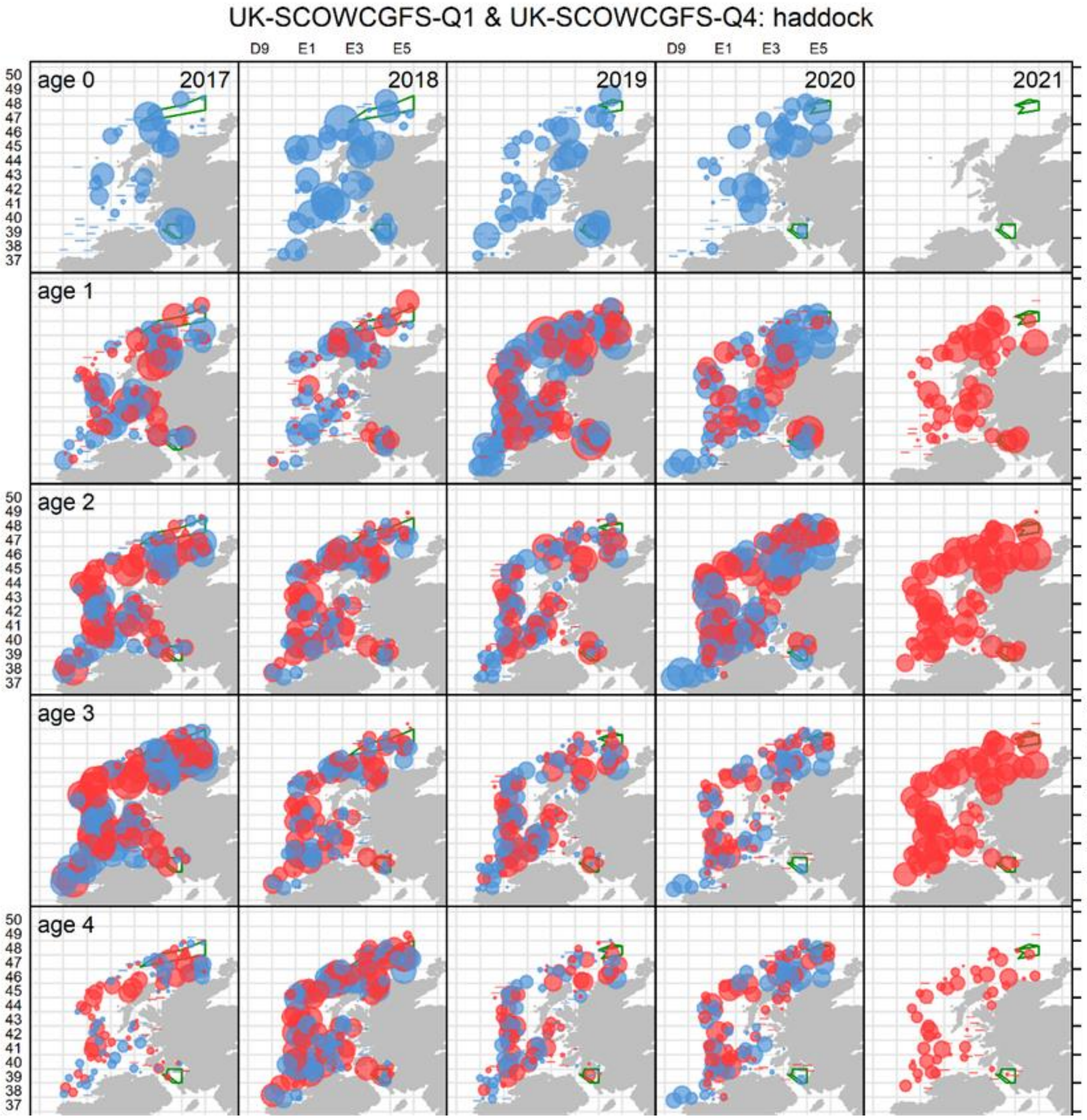


Figure 8.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age and quarter for the Scottish West Coast Q1 and Q4 survey (West of Scotland).

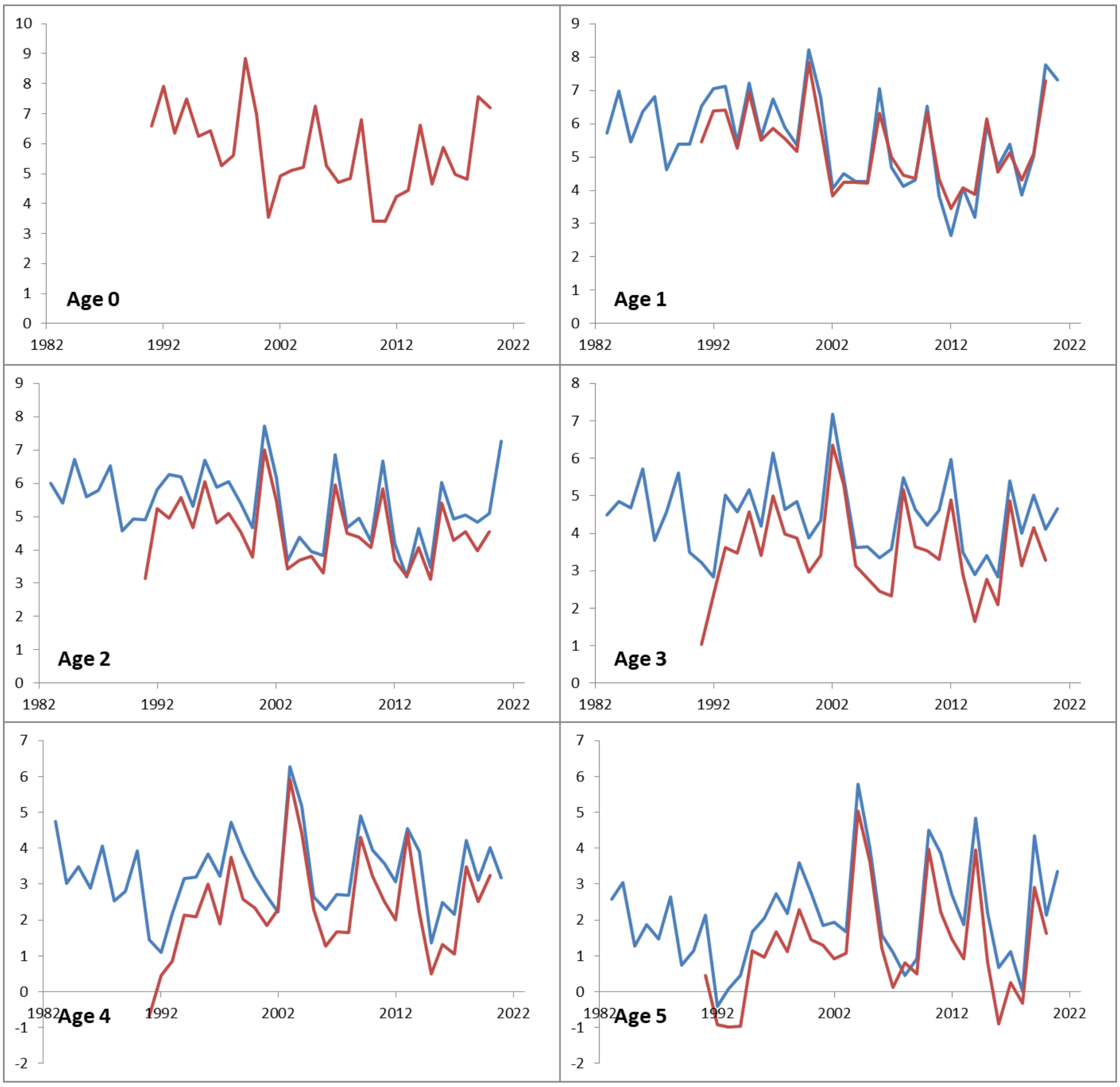


Figure 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey log CPUE (catch per unit effort) at age.

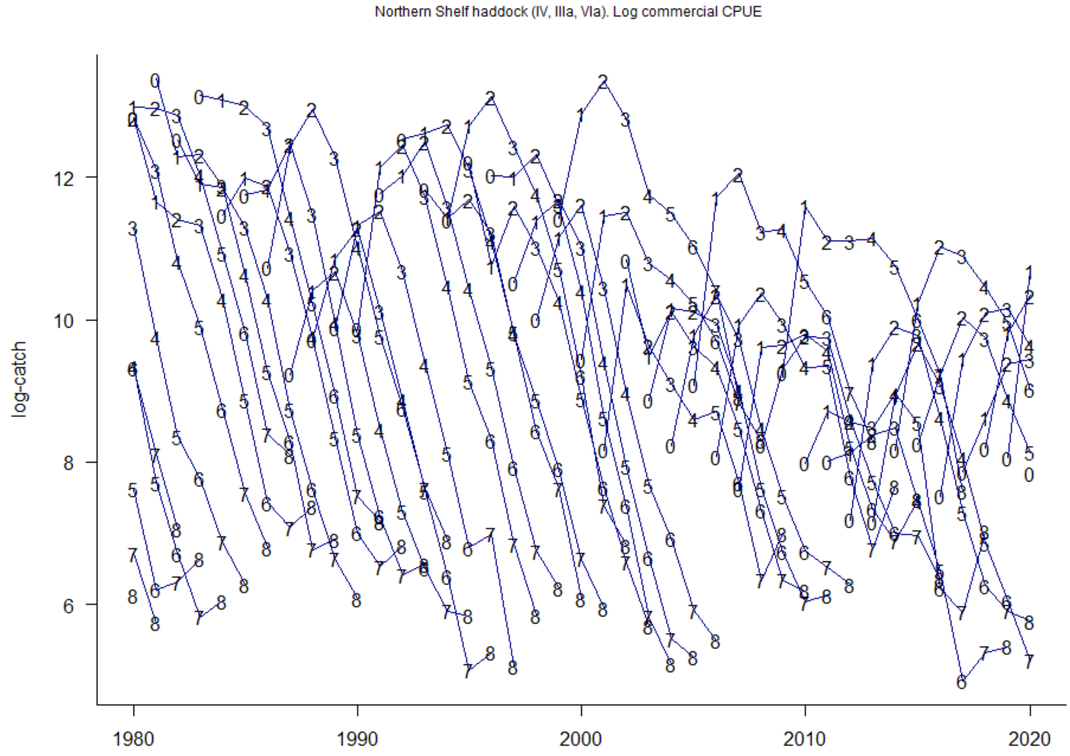


Figure 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log catch curves by cohort for total catches.

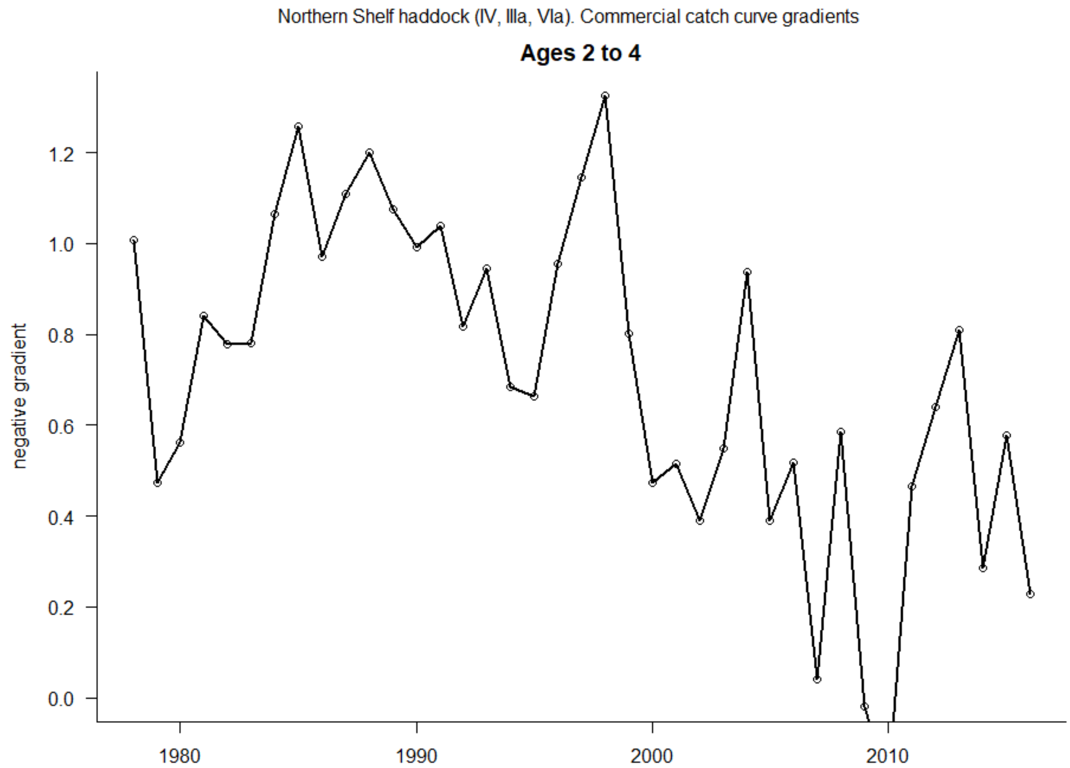


Figure 8.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Negative gradients of log catches per cohort, averaged over ages 2–4. The x-axis represents the spawning year of each cohort.

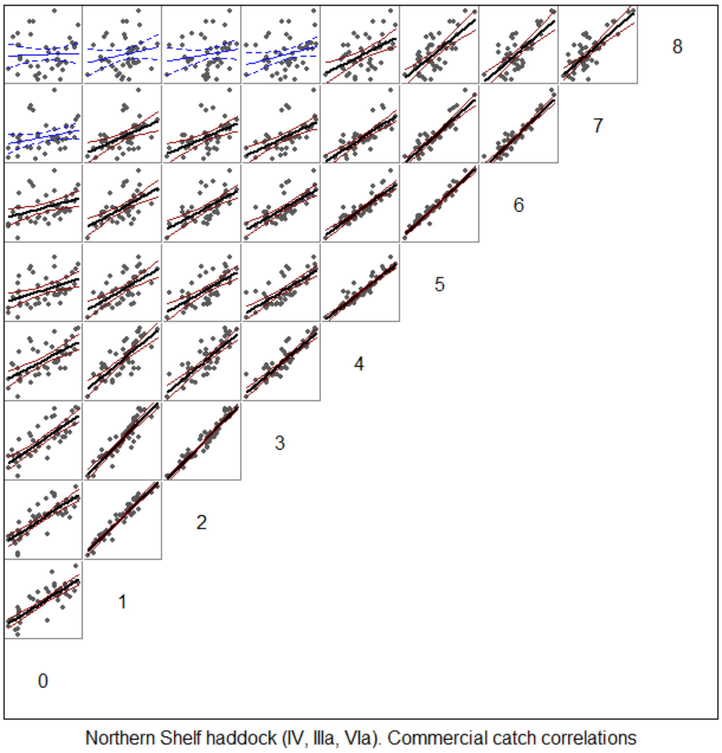


Figure 8.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and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

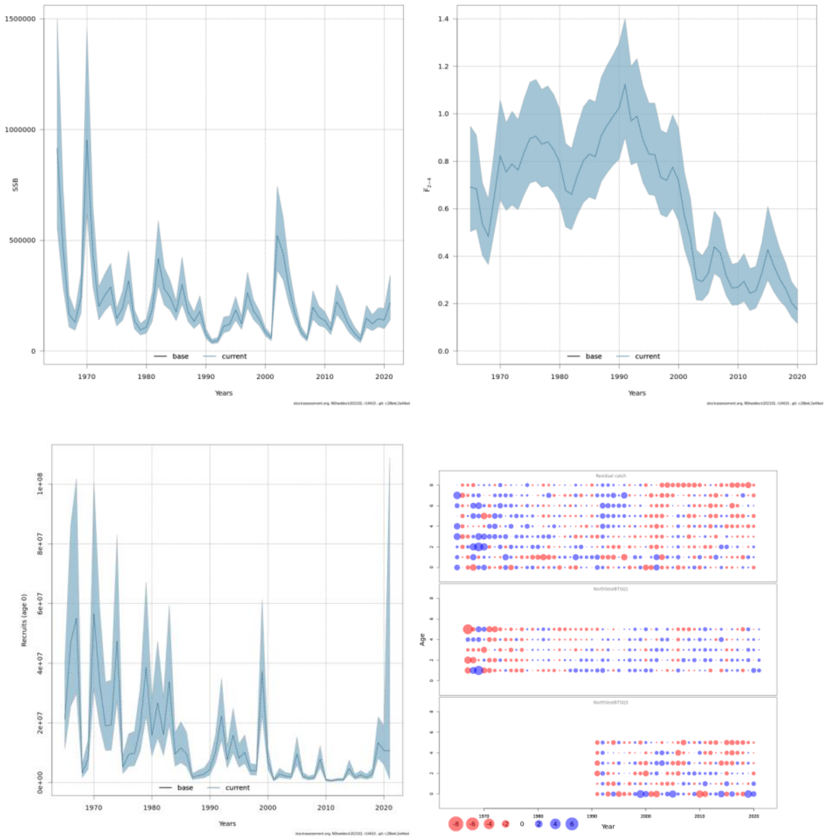


Figure 8.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SAM assessment. Time-series of estimated mean F (2–4) (top left), SSB F(2–4) (top right) and recruitment (bottom left) are shown with approximate pointwise 95% confidence intervals. Model residuals (bottom right) are depicted with a clear blue circle for a positive residual, and a solid red circle for a negative residual.

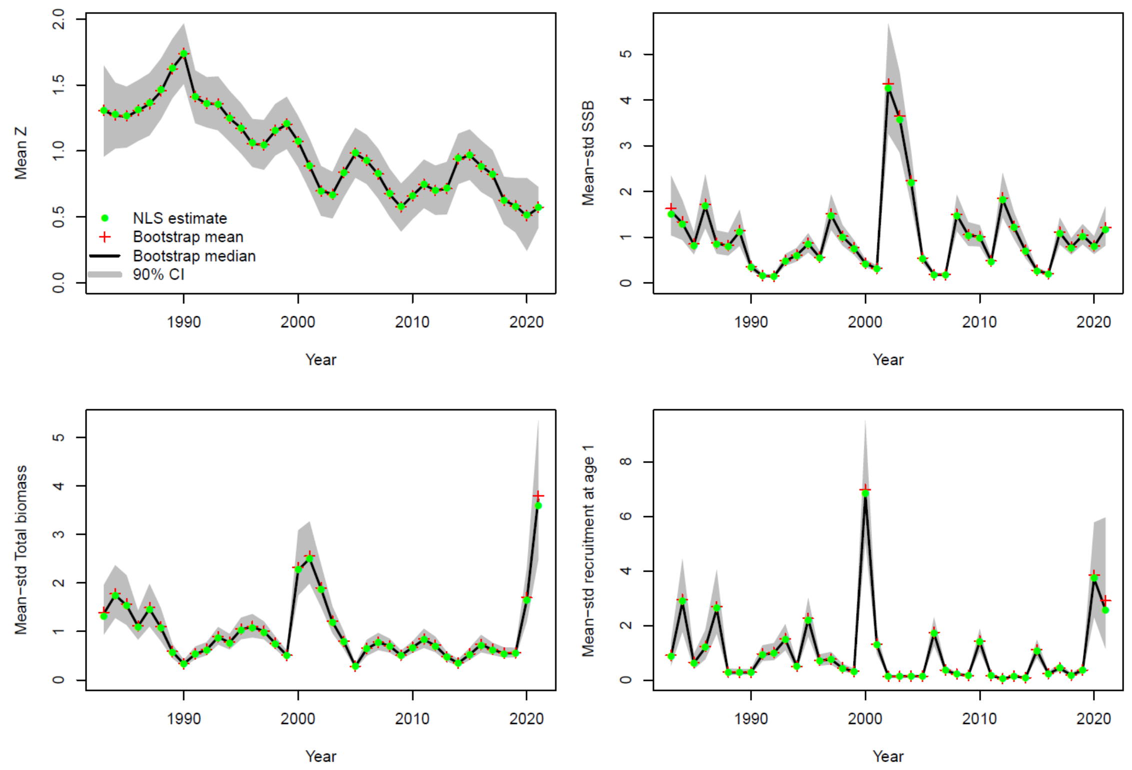
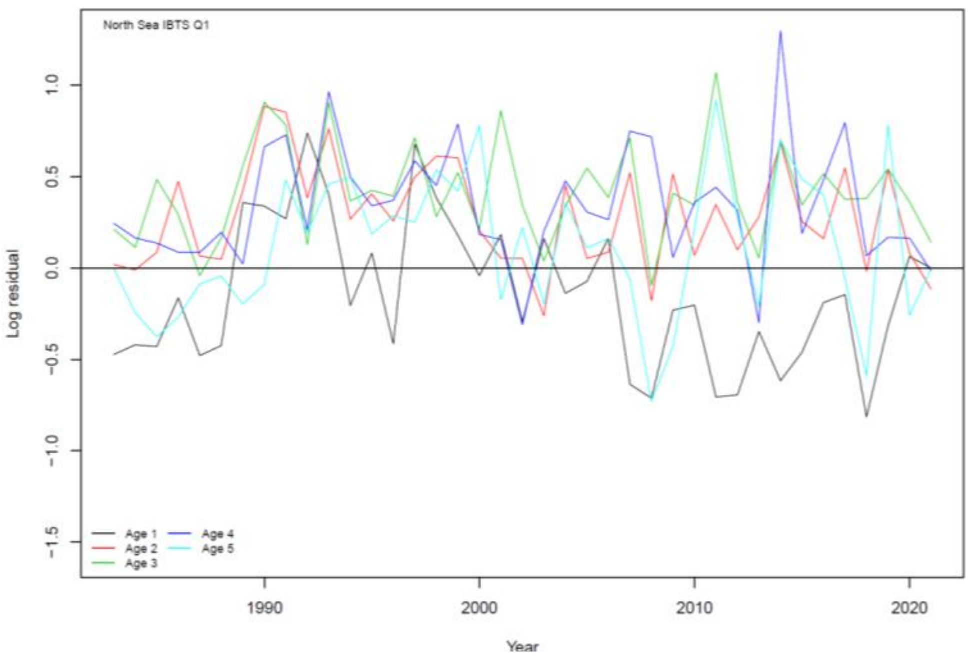


Figure 8.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded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



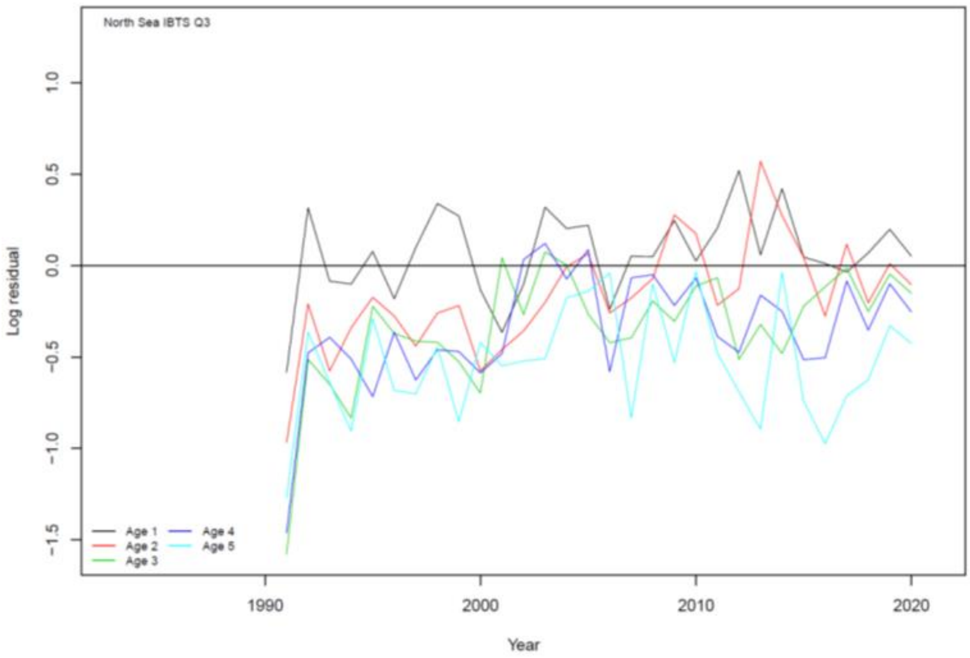


Figure 8.3.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).

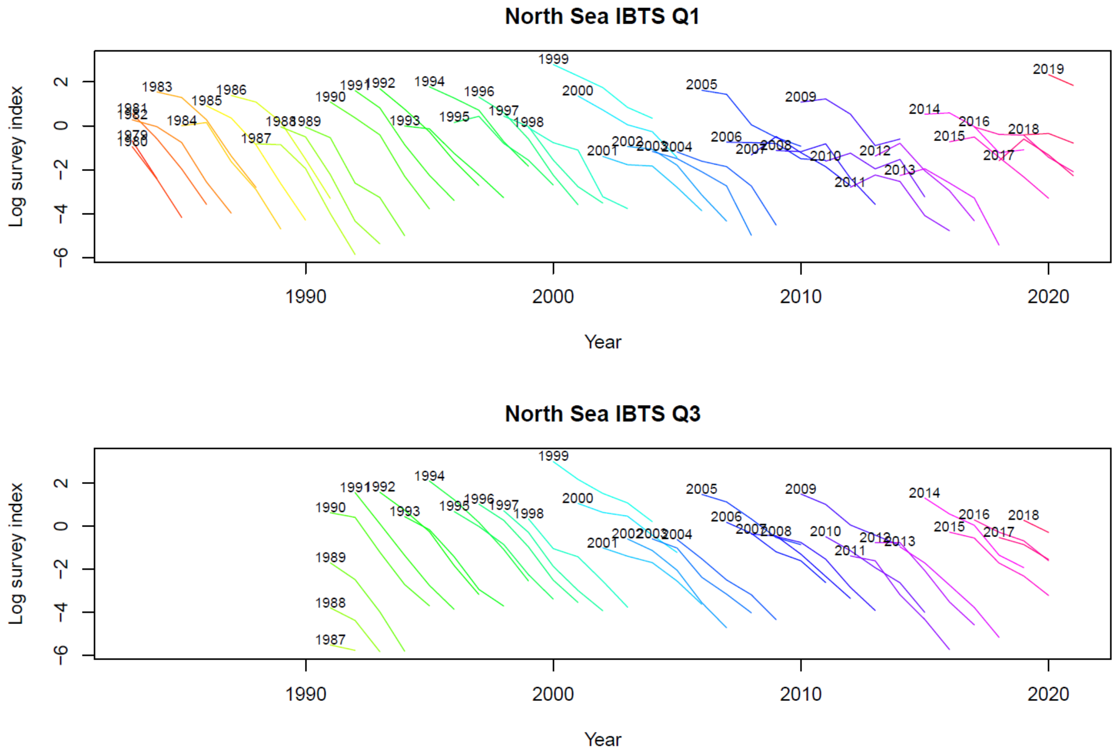


Figure 8.3.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey “catch curves”) for each of the survey indices.

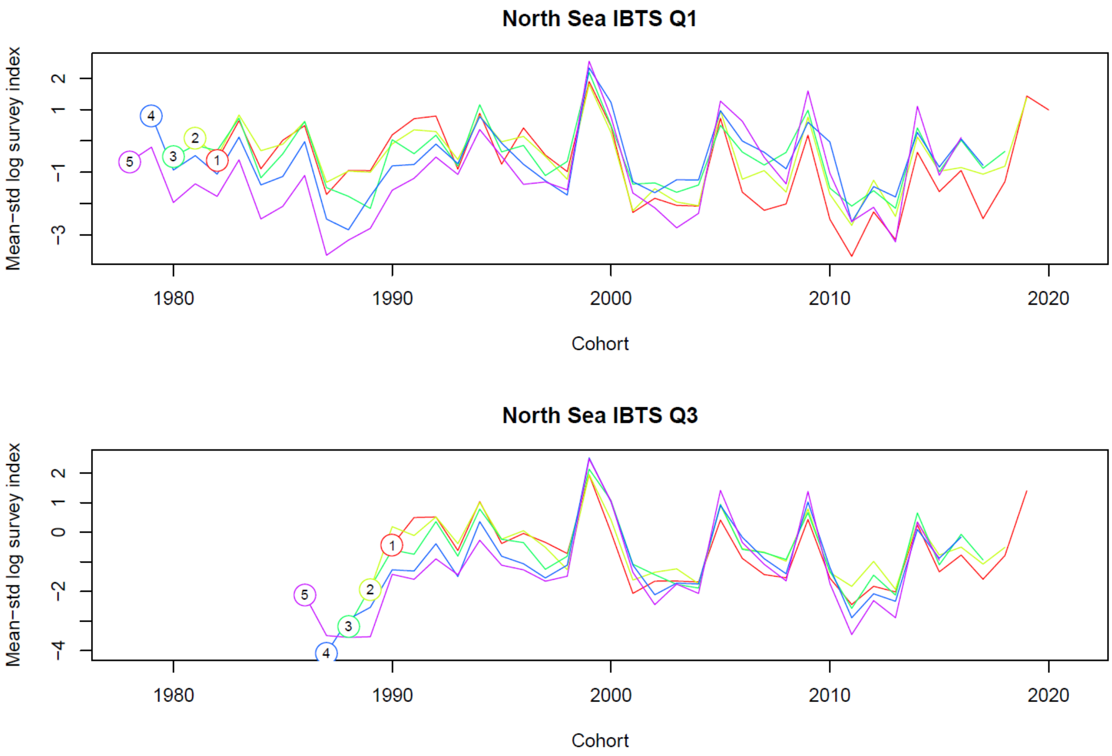
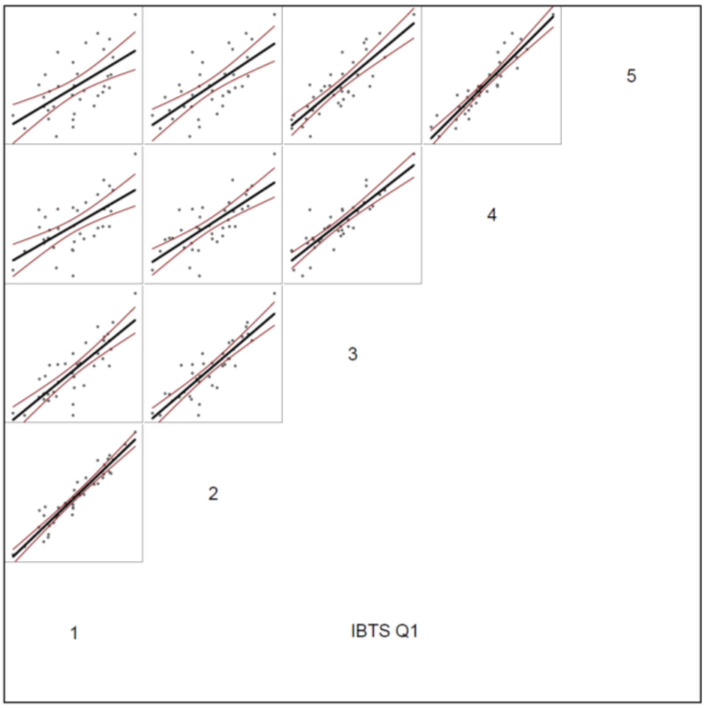


Figure 8.3.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.



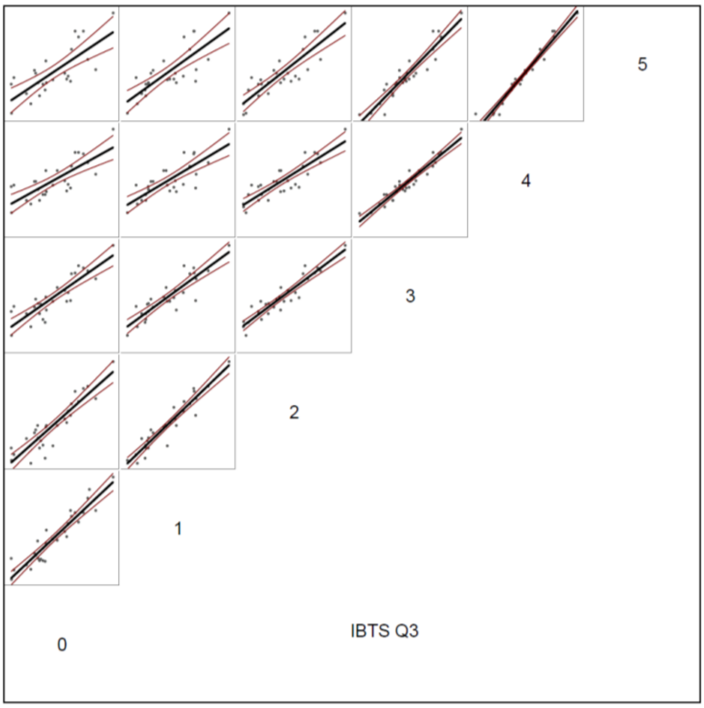


Figure 8.3.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line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

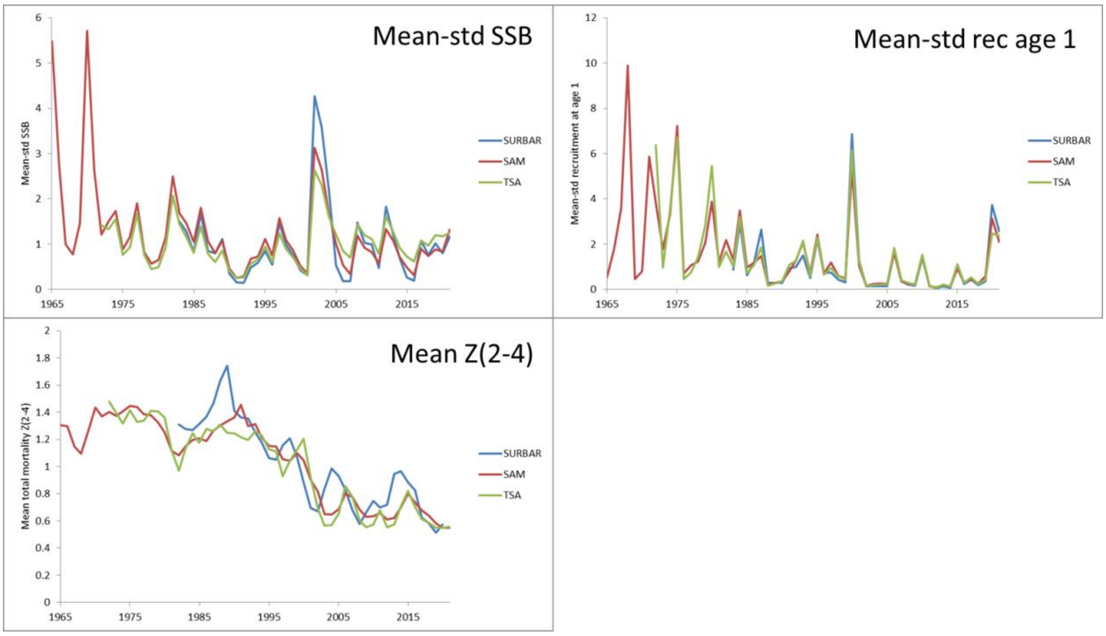


Figure 8.3.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Comparisons of stock summary estimates from TSA (green), SAM (red) and SURBAR (blue) models. To facilitate comparison, SSB and recruitment values have been mean-standardised using the year range for which estimates are available from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

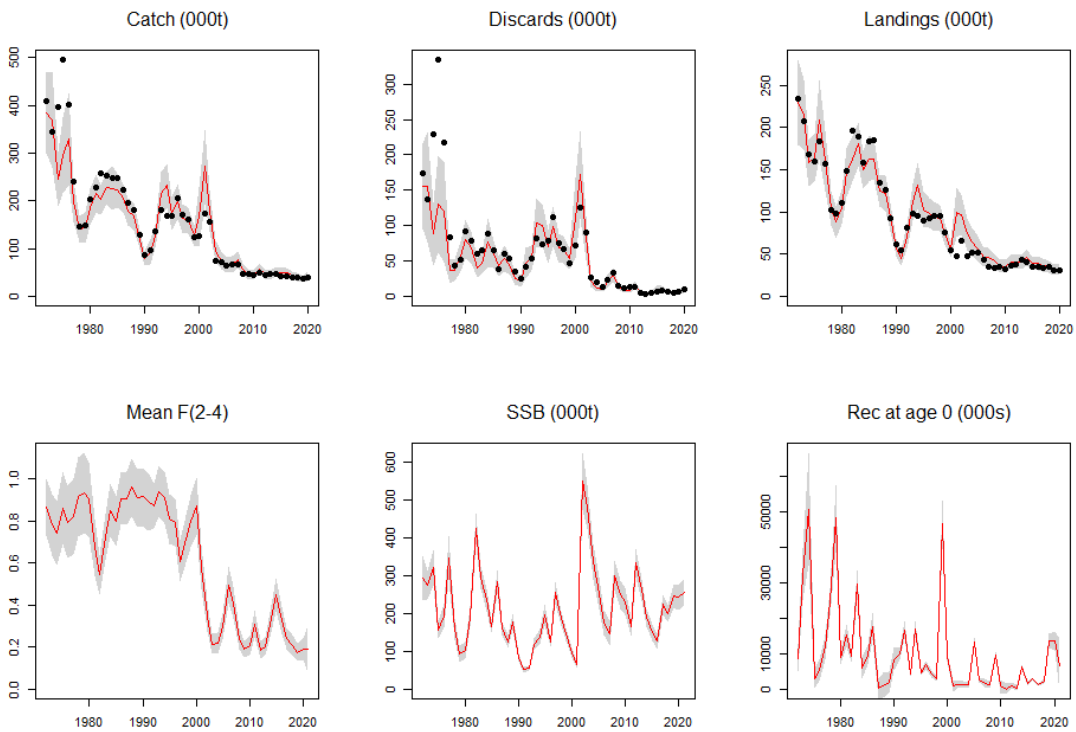


Figure 8.3.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary from final TSA. Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values for catch, discards (discards+IBC+BMS), and landings.

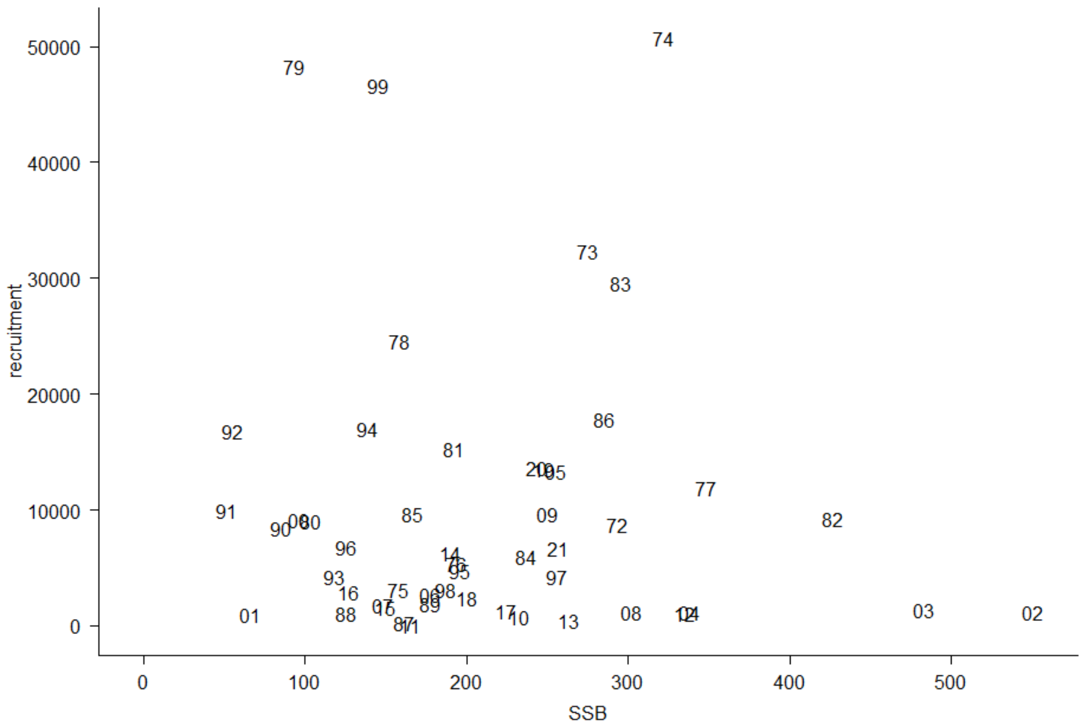


Figure 8.3.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

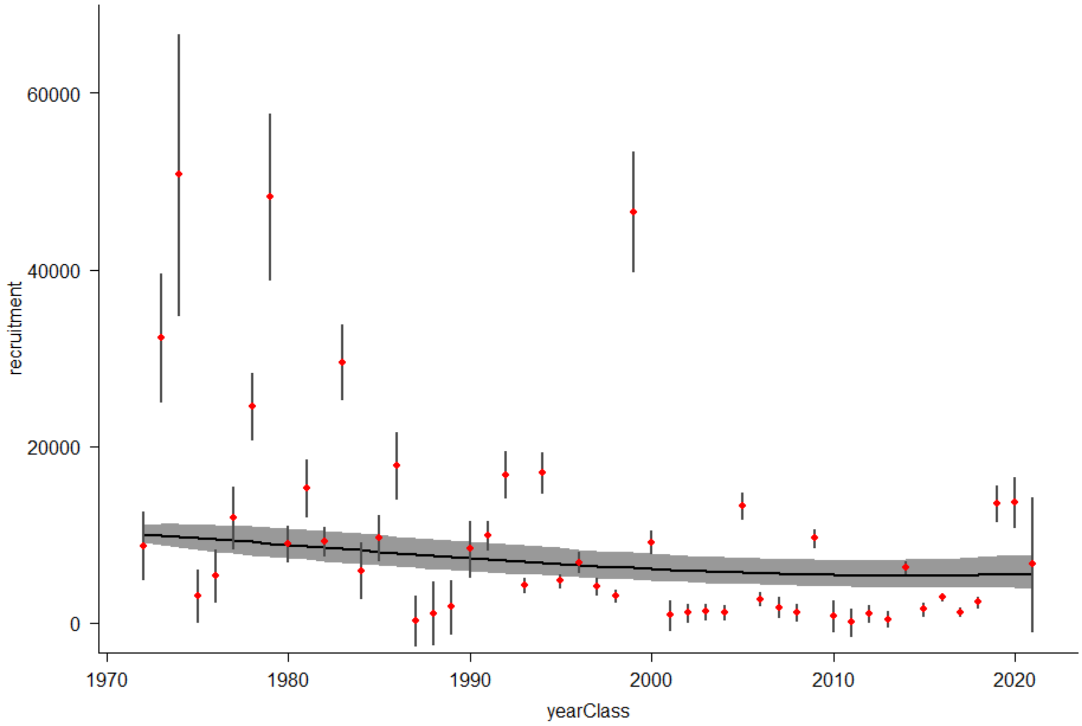


Figure 8.3.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk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

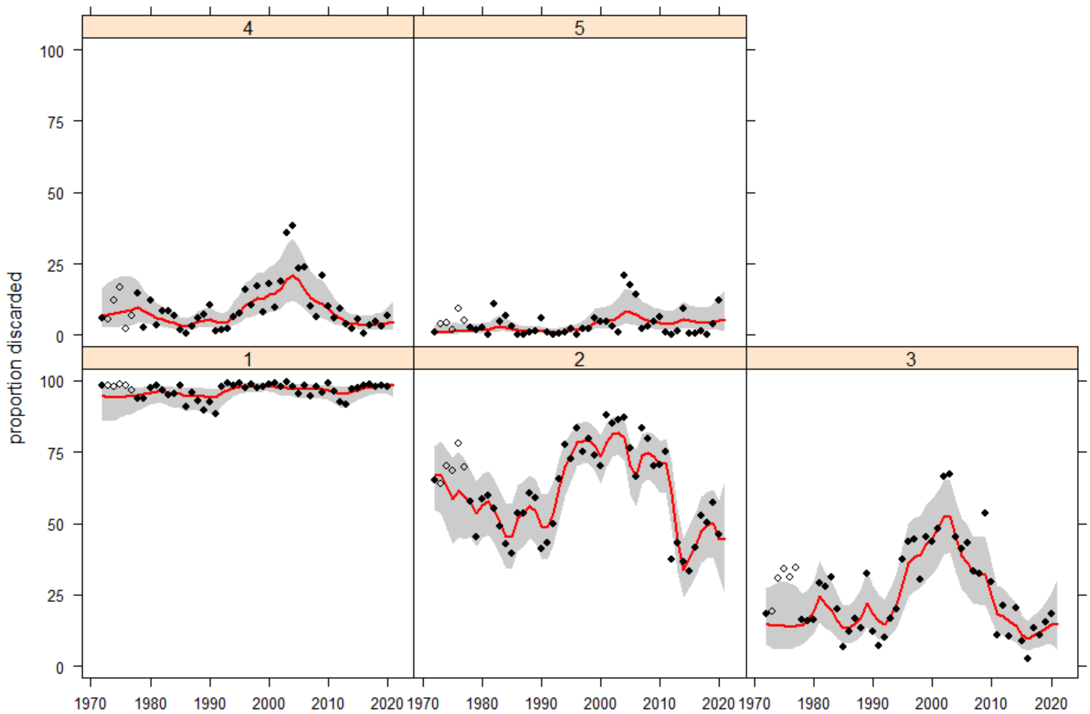


Figure 8.3.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch + BMS. The open points for the years 1973–1977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

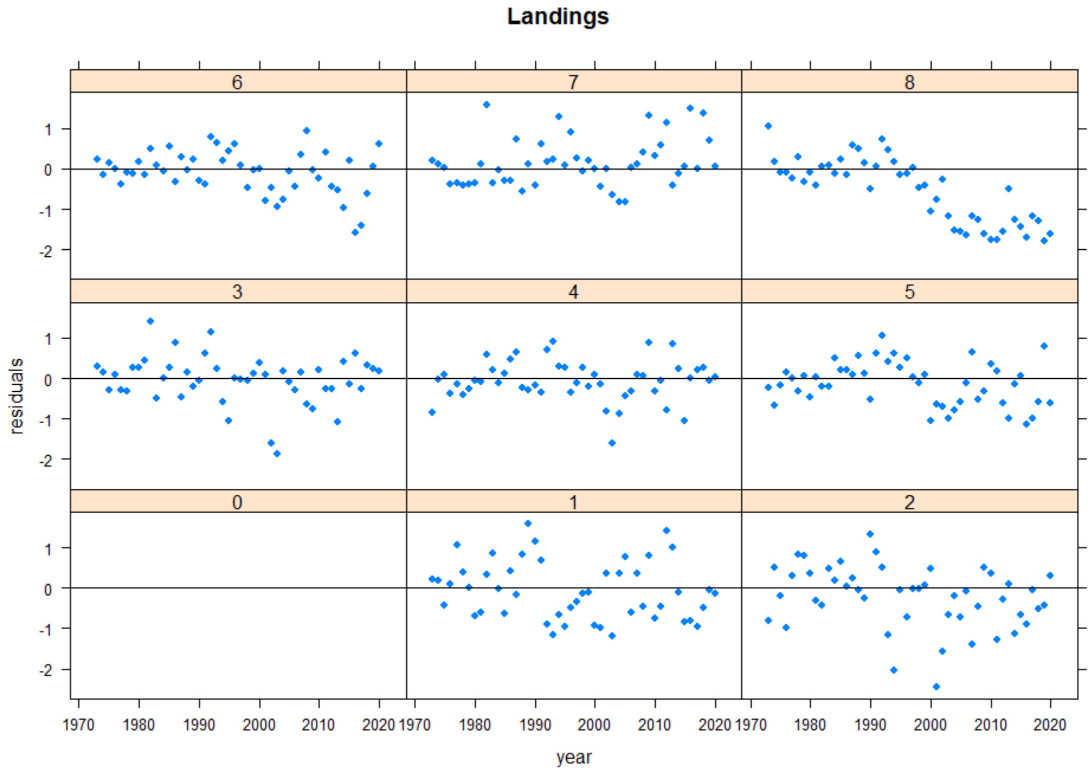


Figure 8.3.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA landings residuals by age.

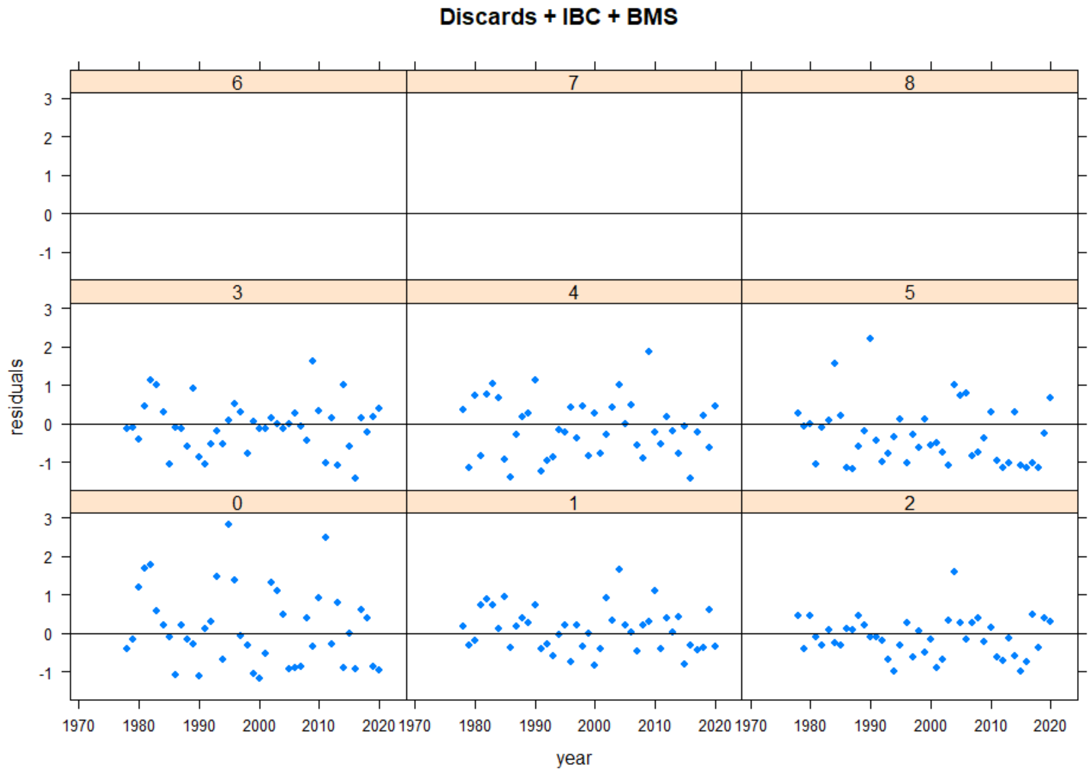


Figure 8.3.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA discards + IBC + BMS residuals by age.

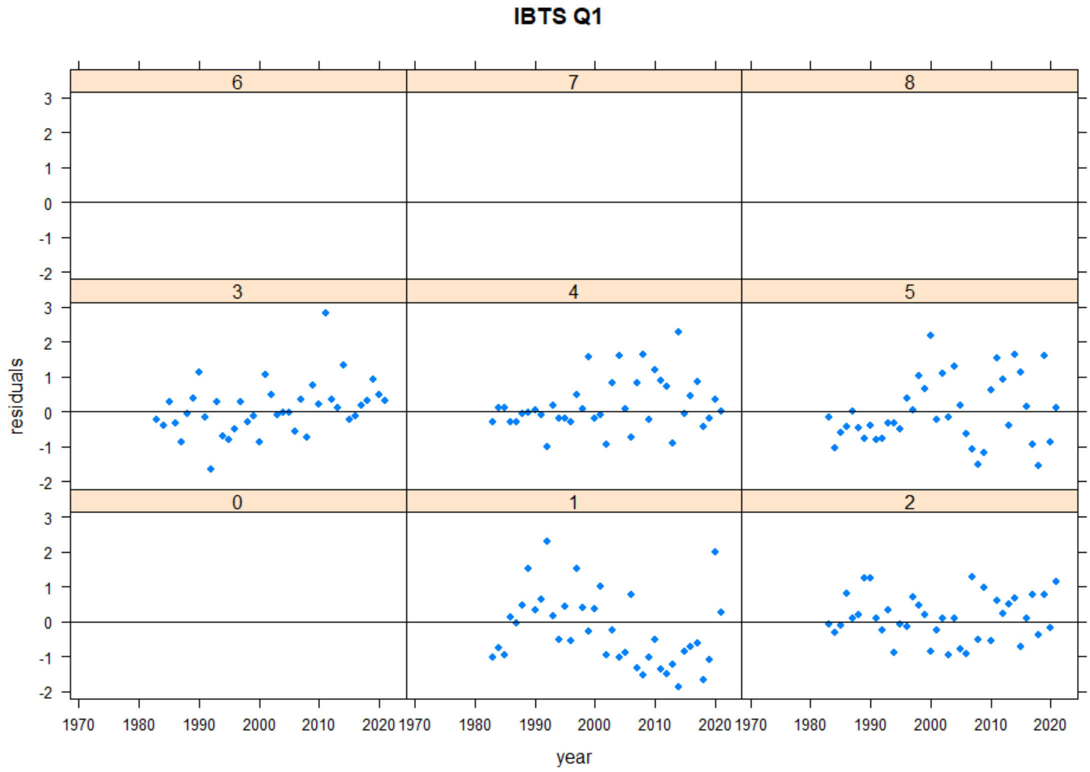


Figure 8.3.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA residuals by age for the IBTS Q1 survey index.

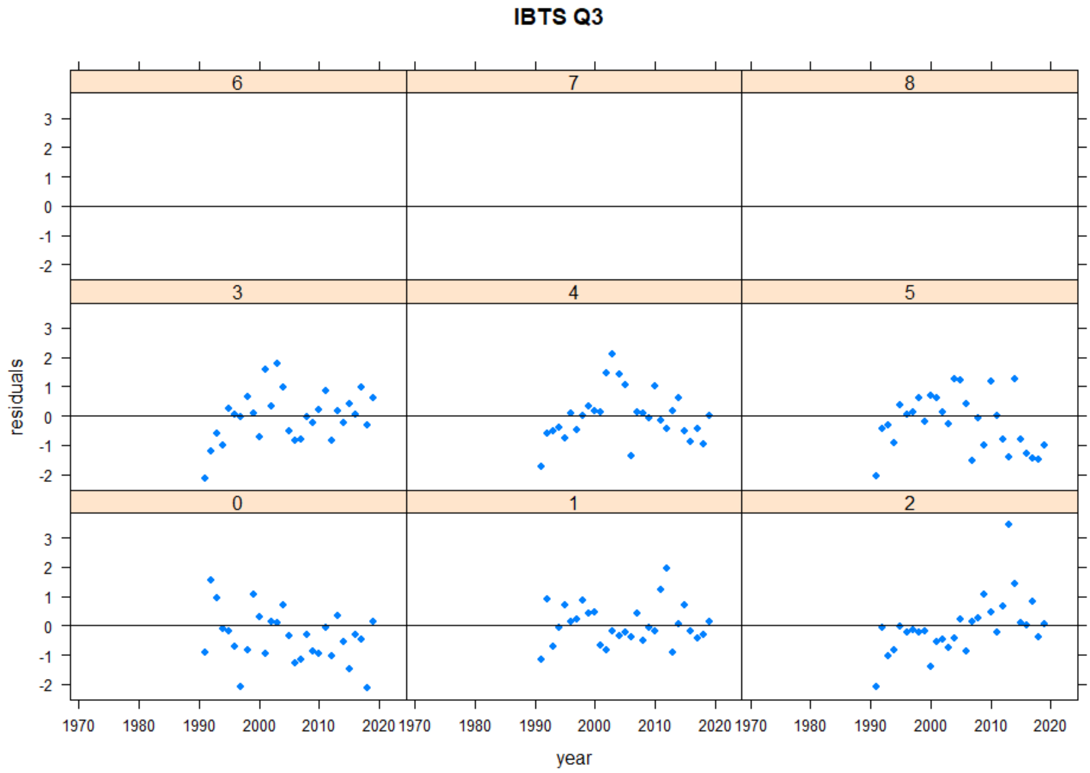


Figure 8.3.18. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA residuals by age for the IBTS Q3 survey index.

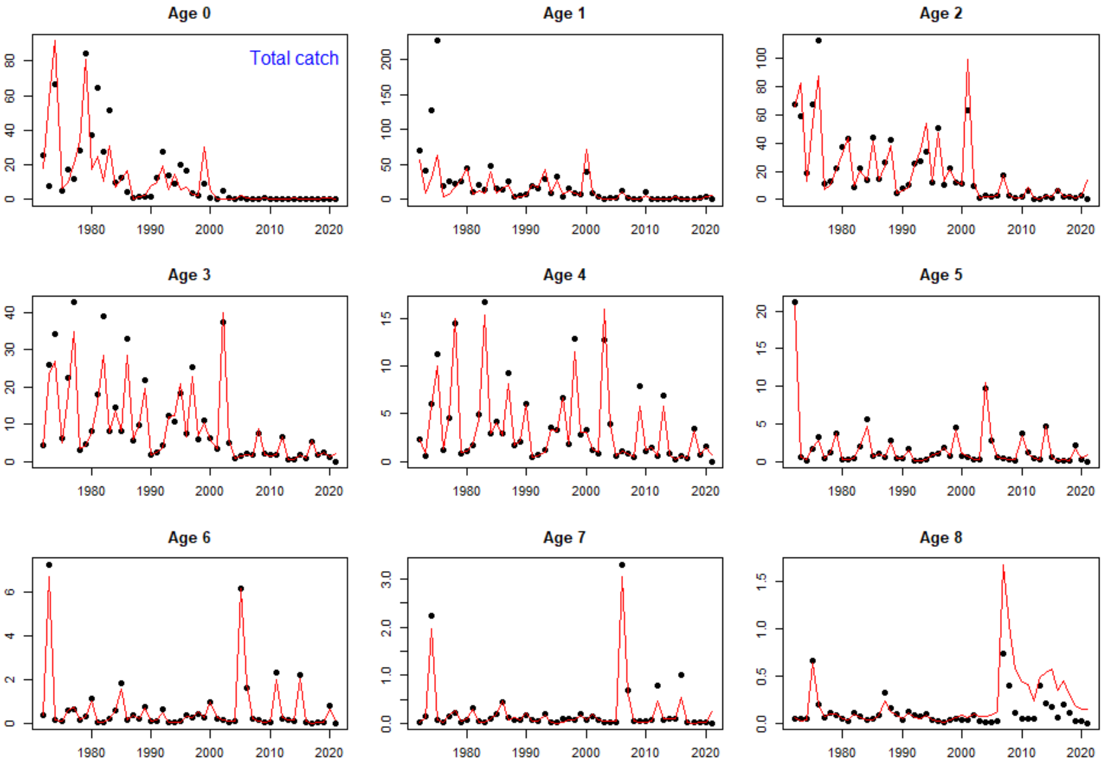


Figure 8.3.19. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for total catch, by age.

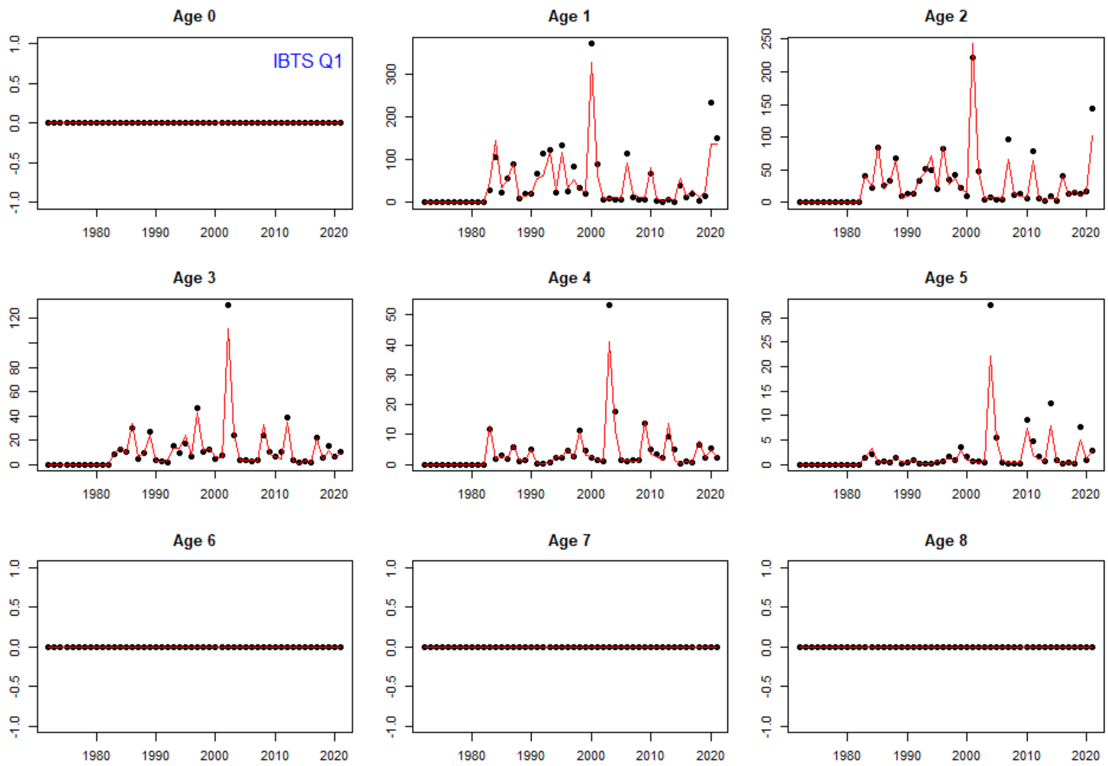


Figure 8.3.20. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

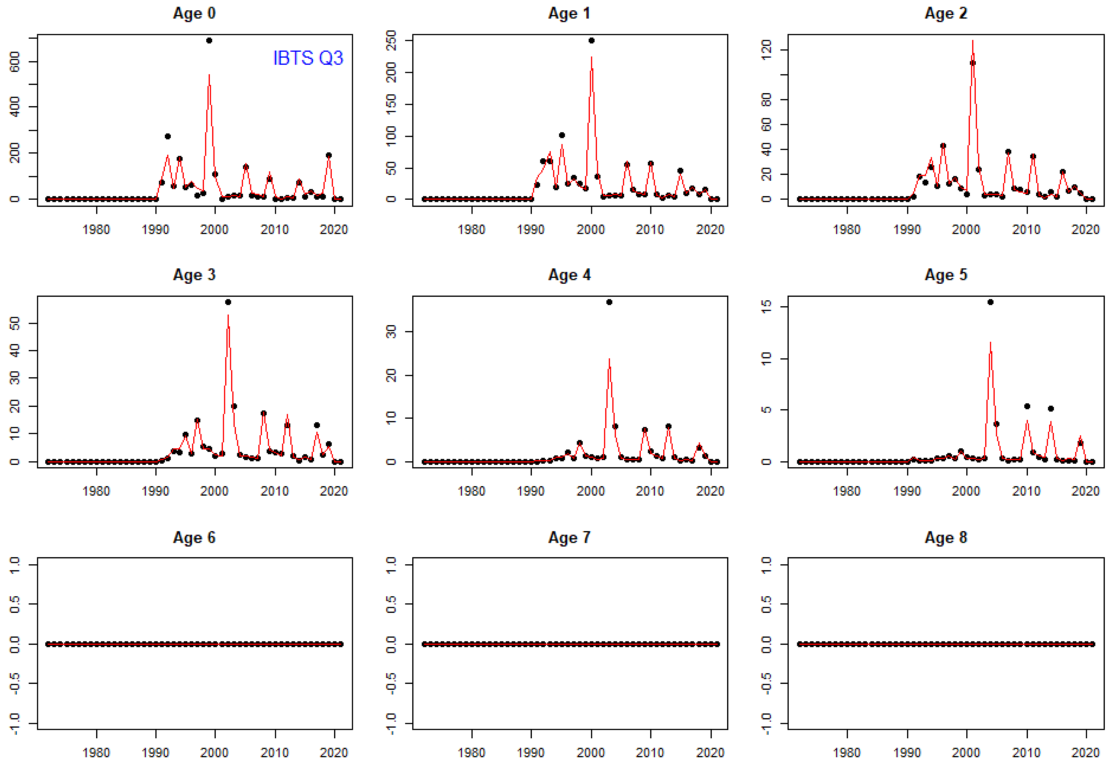
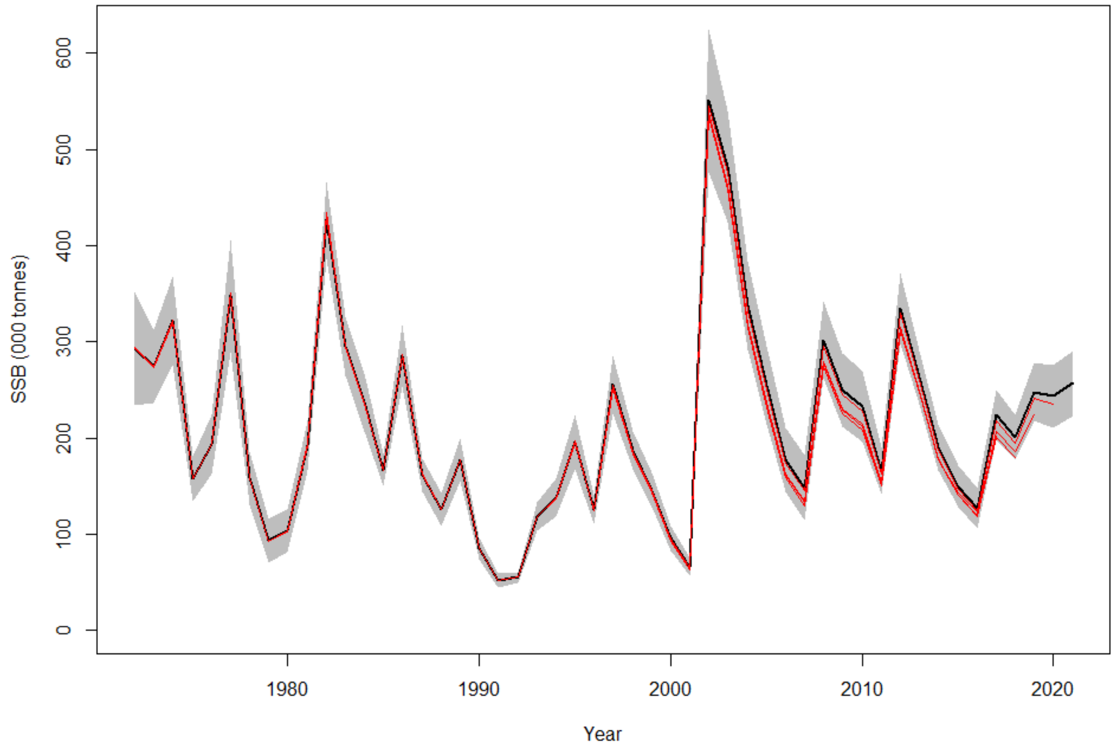
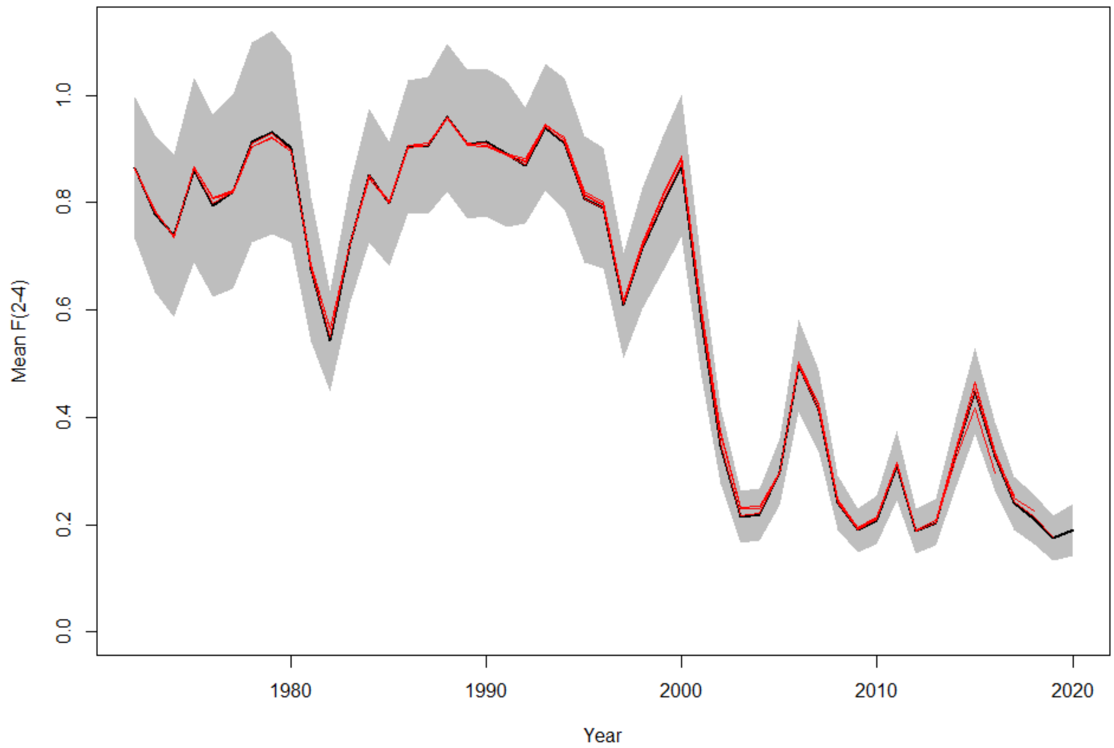


Figure 8.3.21. Haddock in Subarea 4, Division 6.a and Subdivision 20 Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.


SSB (000 tonnes)
0
100
200
300
400
500
600
1980
1990
2000
2010
2020
Year


Mean F(2-4)
0.0
0.2
0.4
0.6
0.8
1.0
1980
1990
2000
2010
2020
Year

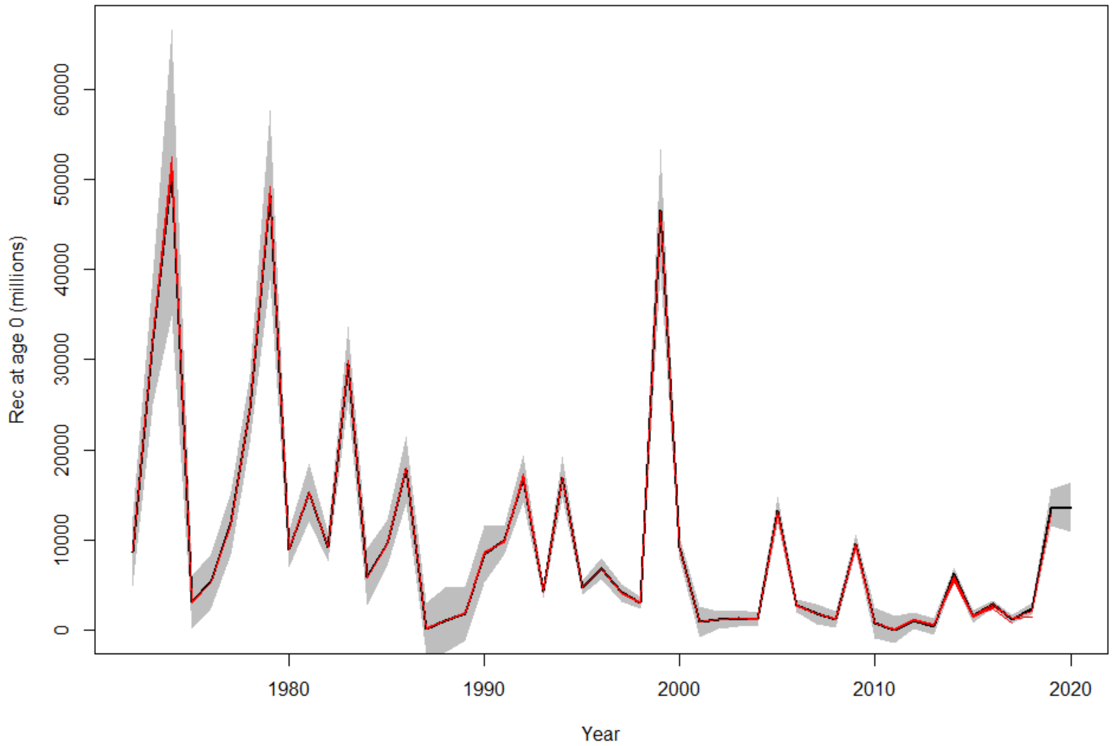


Figure 8.3.22. Haddock in Subarea 4, Division 6.a and Subdivision 20. Retrospective plots for the TSA assessment. The final-year run is shown in red with the approximate pointwise 95% confidence interval in grey, while retrospective peels are shown with black lines. Mohn's rho estimates are -6% (SSB), -2% (mean F), and -23% (recruitment).

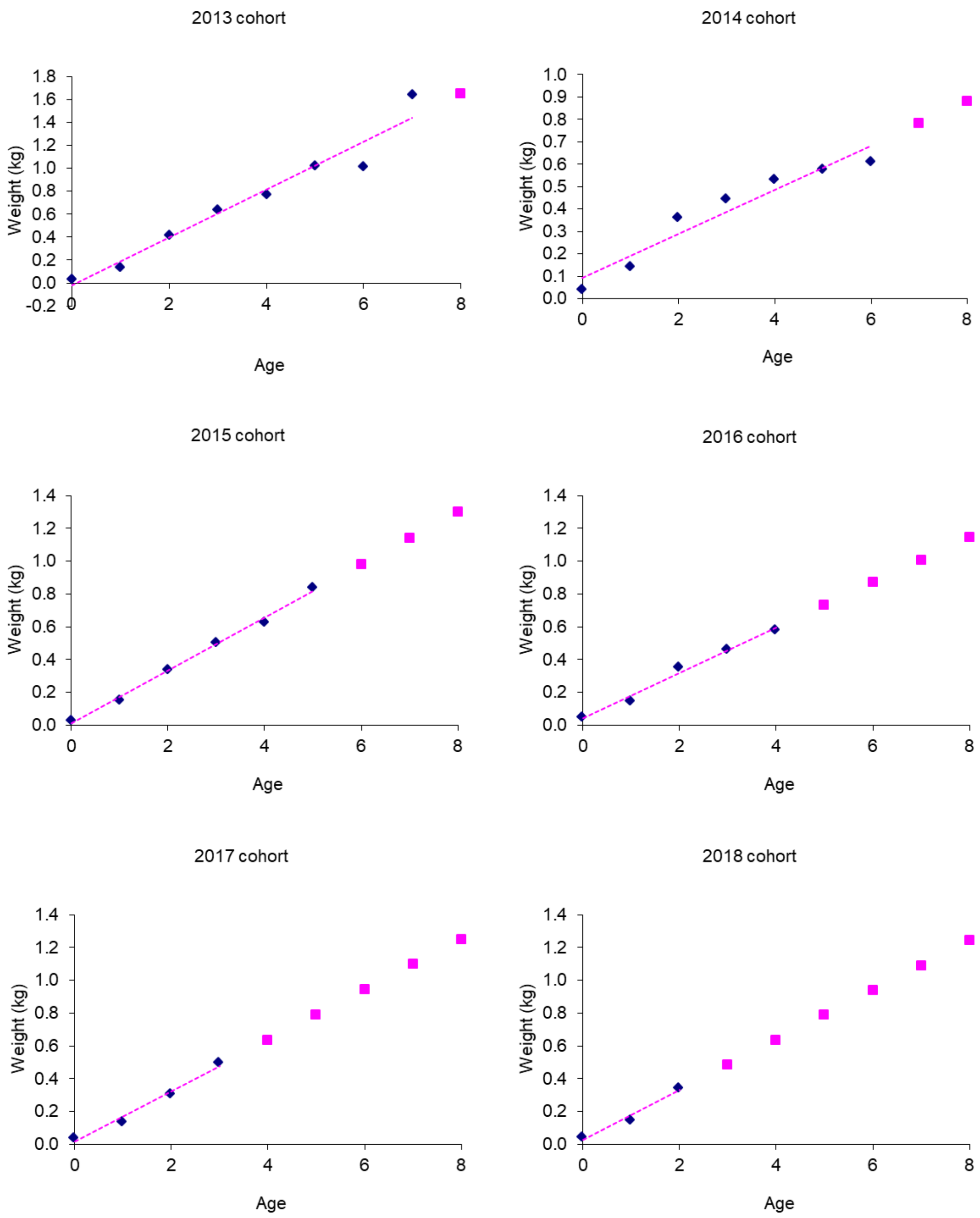


Figure 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski, 2011). Cohorts 2013–2018 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

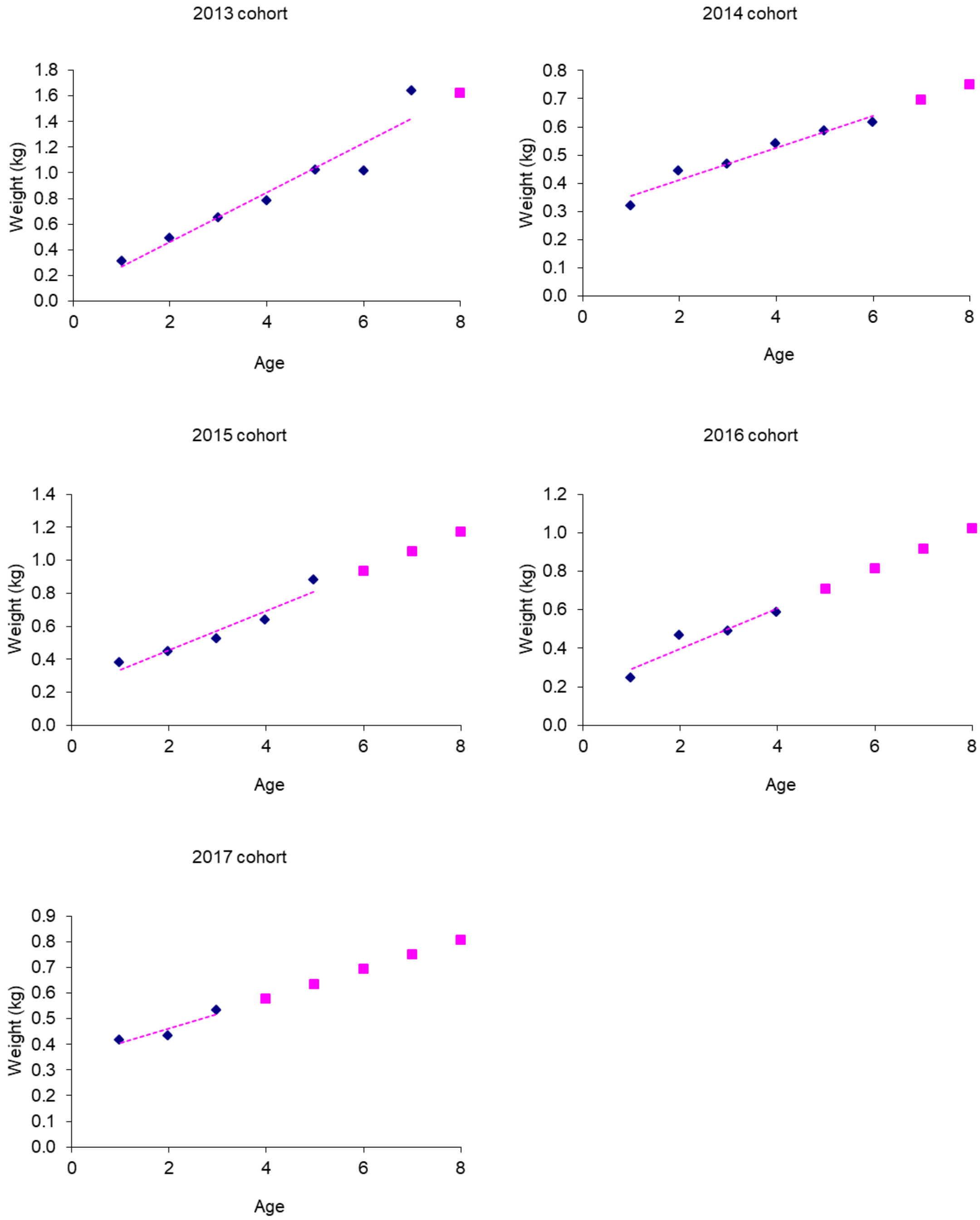


Figure 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for wanted catch (landings) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2013–2017 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

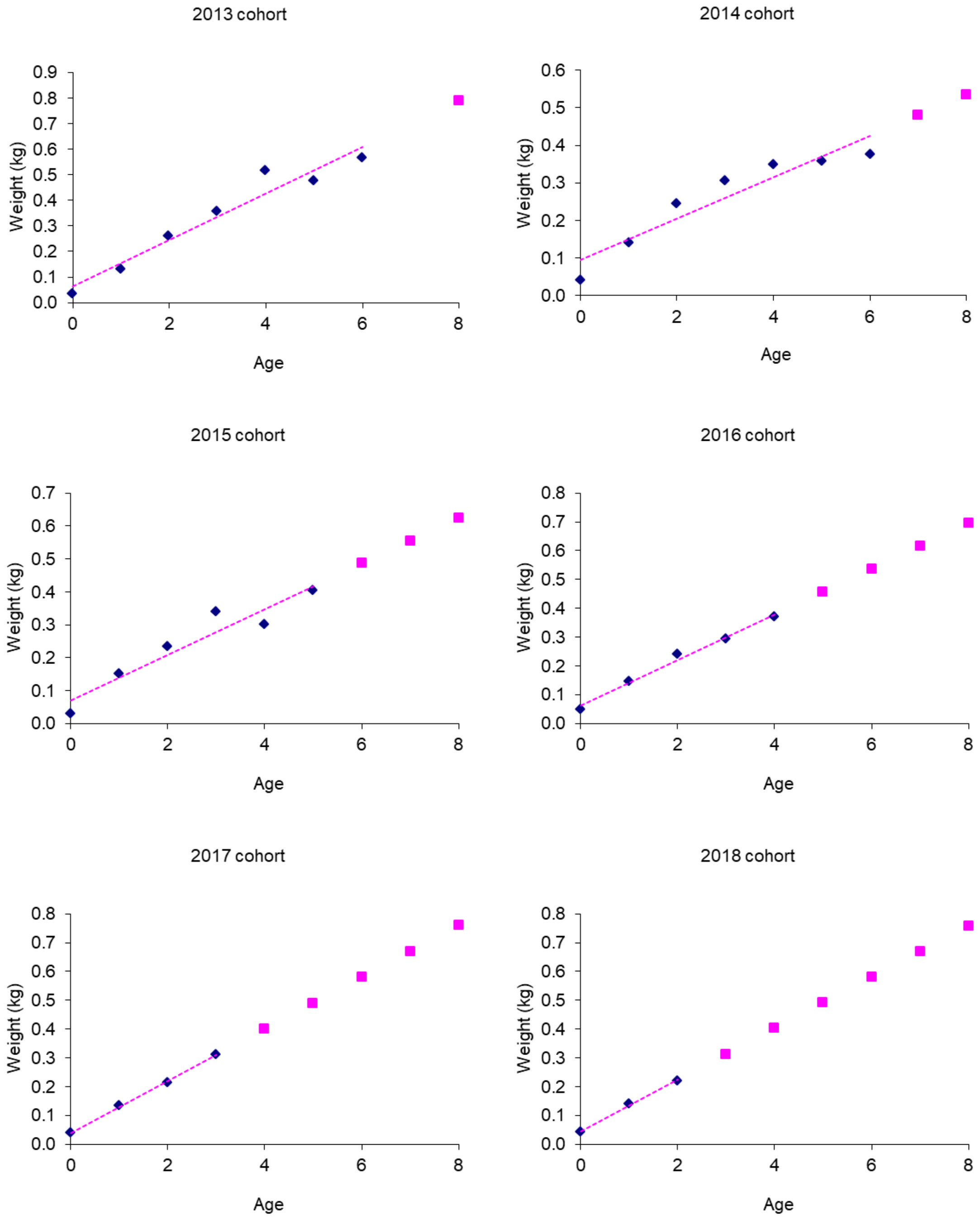
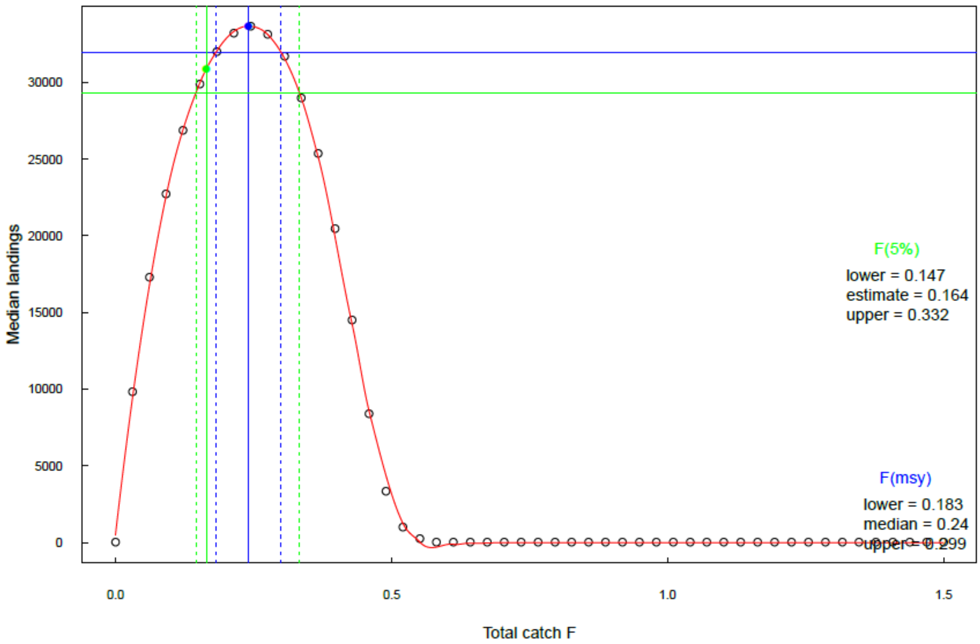


Figure 8.6.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for unwanted catch (discards + BMS) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2013–2018 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.



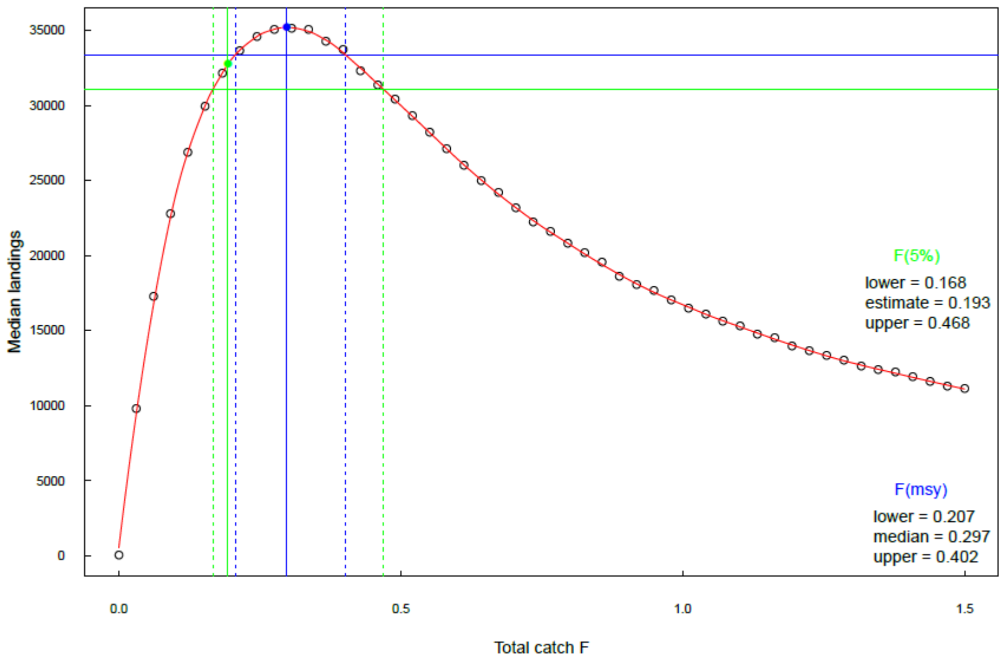


Figure 8.8.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSim estimation from IBPhaddock 2016 of $F_{(MSY)}$ with the advice error but no rule (top) and of F_{p05} with both advice error and rule (bottom).

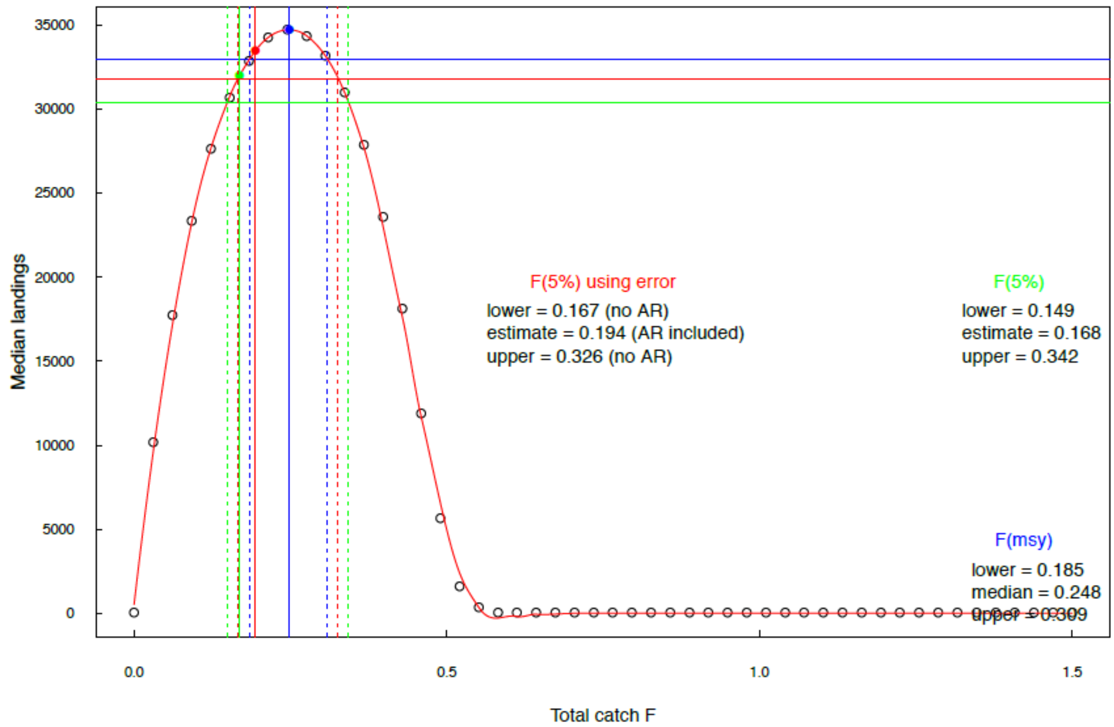


Figure 8.8.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSim estimation run for ADGNS 2017 following updated guidance (WKMSYREF4).

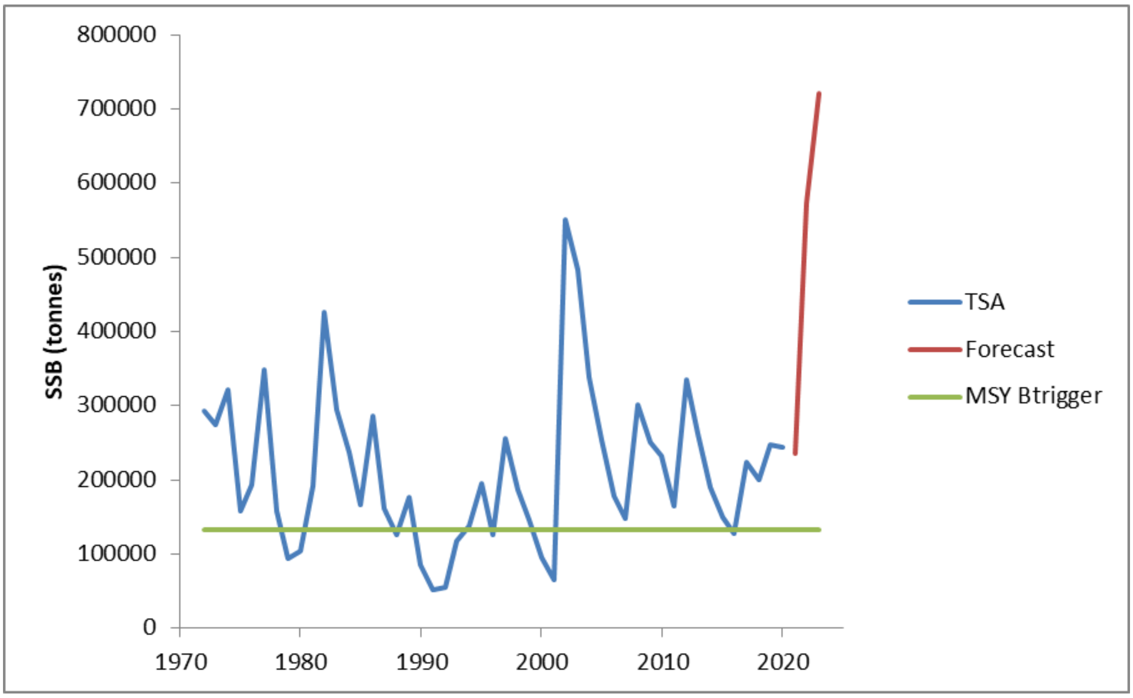


Figure 8.11.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Spawning stock biomass estimates from the TSA assessment (blue) along with short-term forecast under the ICES MSY approach (red) and the current MSY $B_{trigger}$ value (green).

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 seventh year in which the stock status for lemon sole has been evaluated by WGNSSK. Lemon sole has been defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). The assessment presented in the 2019 WGNSSK report (ICES, WGNSSK 2019) provided the basis for advice for 2020 and 2021. Subsequently, advice on lemon sole has been requested on an annual basis. The outcome of the current assessment will be used to provide new catch advice for 2022.

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, at higher salinities and lower temperatures 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 (including the Skagerrak and eastern English Channel areas), 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

Both 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-based data.

Commercial catch data were raised to fleet and country level using InterCatch. 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.

Both BMS (Below Minimum Size) landings and logbook-recorded discards were included with discards for length-allocation purposes as the length distributions are likely to be similar. For both 2019 and 2020, there were no submissions for logbook-recorded discards (0 tonnes). Only Scotland provided submissions of BMS landings for 2019 (a total of 0.224 tonnes for area 4), whilst only England submitted data for 2020 (a total of 0.216 tonnes for area 4).

Revised Swedish data for 2019 were provided in 2021. Therefore, the InterCatch estimation for 2019 was recalculated to include these new data, which led to a minor change (0.13%). The updated 2019 data were used for subsequent analysis.

InterCatch summary plots are given in Figures 9.2.5 to 9.2.8. The resultant estimates for landings and discards for 2002-2020, along with official landings for 1968–2020, are given in Table 9.2.5 and Figure 9.2.9. We note that the official landings for 2012 did not include estimates for the UK, which is why they are considerably lower than the new InterCatch estimates. It can also be seen that the 2013 discard estimate is very high – the problem appears to originate in the discard estimates provided by the Netherlands, which unfortunately have 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 removing the 2013 data, but this issue has not yet been addressed for the yield analysis.

In the North Sea, eastern English Channel and Skagerrak, lemon sole are manged using a combined TAC with witch flounder (see Section 27). The ICES estimates of landings for lemon sole and witch are compared with the joint TAC in Figure 9.2.10, which shows that the joint TAC is underutilised for most years since 2006. However, as in recent years, ICES recommends that a joint TAC for lemon sole and witch is unlikely to be effective in controlling mortality on either species.

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 (2021) and IBTS Q3 data (2020: the years used are is given as examples, 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. These are slightly different for several ages from the values estimated by the 2019 WG, due to small changes in several of the weight entries in the SMALK dataset. The reasons for these are unknown, but are likely to be due to updated weight-length keys used within DATRAS. We also note that estimates for 2021 are included here: these are not currently used in the stock assessment which concludes in 2020, but they are included for completeness.

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 Table 9.3.2 and Figures 9.3.3 (bivariate scatterplots), 9.3.4 (catch curves), 9.3.5 (time series by age and cohort), and 9.3.6 (inter-series comparisons). The first three summaries indicate that the ability of the survey indices (particularly Q1) to track year-class strength is very limited. For example, in Figure 9.3.3, most of the pairwise comparisons do not show significant correlations (and some comparisons are negative). Figure 9.3.6 shows that the comparisons between the survey series are rather more consistent.

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 will 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 at the 2019 meeting, and this has been continued in 2021.

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. This correction is intended to reduce the impact on the analysis of the observed pronounced "hooks" at the top of the survey catch curves for this stock (see Figure 9.3.4). A proposal for a systematic method of determining catchability corrections to straighten catch curves prior to SURBAR assessment was presented at the WGNSSK 2020 meeting. While promising, this method remains in development and will be revisited in a future WGNSSK meeting.
- No downweighting of ages in the SURBAR SSQ estimation was used.

The SURBAR stock summary is given in Table 9.4.1, and the corresponding output plots are given in Figures 9.4.1 to 9.4.4. 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 mean Z_{3-5}. Both SSB and TSB are estimated with more certainty than mean Z_{3-5}, and both show steady declines since 2016. Finally, recruitment at age 1 has fluctuated without trend for much of the time series, with indications of an increase in 2019 (although the uncertainty about that estimate is large).

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.

The retrospective analysis in Figure 9.4.4 shows little retrospective bias or noise for SSB or TSB. Mohn's rho is high for both mean Z_{3-5} and (especially) recruitment. The final mean Z_{3-5} estimate in each year's assessment is based on a three-year average of preceding years, and is likely to be updated the following year (hence the retrospective noise). 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 higher recruitment estimate in 2020 should be considered to be uncertain.

Finally, the run presented here assumes a lambda smoother of 3.0. A low lambda setting ($\lambda = 1.0$) results in large interannual variations in all outputs, driven by survey noise and the difficulty in following cohorts. Increasing the lambda smoother leads to less variation, as expected, and the outputs for $\lambda = 3.0$ and $\lambda = 5.0$ are very similar, increasing confidence that the setting $\lambda = 3.0$ is probably reasonable (increasing lambda further doesn't lead to much change). Further methodological work on systematically defining the appropriate lambda smoother for a given assessment is underway, and will be presented at a future WGNSSK meeting.

9.5 Application of advice rule

North Sea lemon sole are currently managed according to the following advice, given in June 2020:

ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 3742 tonnes.

Management of lemon sole and and witch under a combined species TAC prevents effective control of the single-species explotation rates and could lead to the overexploitation of either species. ICES advises that management should be implemented at the species level in the entire stock distribution area (Subarea 4 and divisions 3.a. and 7.d).

Following the release of the 2019 advice, ICES has been requested to issue annual advice for North Sea lemon sole.

The application of the DLS 3.2 rule, based on the most recent advised catch (for 2021), is given in Figure 9.5.1. The change ratio of the abundance index was -17.65%, which implies that catches for 2022 should be **3081 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. Similarly, no precautionary buffer was required for the advice for 2022 with the last application being in 2019.

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 WKLIFE VI, 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 2002–2020.

The original InterCatch length distributions are given in Figure 9.6.1, from which 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 2013 data were removed from the analysis (this has no impact on the final conclusions). 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 130 mm, which is the equivalent estimate produced by WGNSSK in 2020.

Figure 9.6.5 shows an estimated L_{∞} value of 282 mm, derived from all available survey data (the corresponding value from WGNSSK 2020 was 283 mm). WGNSSK was concerned that the survey-derived value of 282 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 longest fish observed in the commercial fishery landings data (685 mm), and a trimmed alternative based on the 99%ile of the commercial catch length distribution (385 mm, 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}	685 mm	642 mm
Survey data	-	282 mm

WGNSSK conclude that L_∞ should be set to 375 mm (as for last year), 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 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 below L_{mat} for the full time-series, which indicates many 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 all years in the time-series, which indicates 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 greater than 1.0 throughout the time-series would suggest that F_{MSY} is **not** being exceeded for this stock.

9.7 Conclusions and further work

Although the SURBAR estimates for SSB are uncertain, the median values indicate a declining trend since 2016 which is reflected in the reduced advice for 2022. The estimate also suggests that the 2019 and 2020 recruitment may be larger than recent years, although retrospective noise problems indicates that this should be treated as being very uncertain.

The estimation of status relative to F_{msy} proxies indicates that fishing is occurring at or below F_{msy}, which was also the conclusion in the WGNSSK meetings in 2017–2020.

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 2022 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.

9.8 Issues list

9.8.1 Data and assessment

The current survey indices used for North Sea lemon sole are not able to track cohort strength on a consistent basis, and they exhibit generally poor catchability characteristics which limit the reliability of the advice based thereon. It would be very beneficial to be able to include commercial catch data in the assessment in order to improve reliability and reduce variability. Unfortunately, age data are lacking from commercial catch data, so a (spatial) length-based assessment using both catch and survey data should be explored (for example, Stock Synthesis 3).

Natural mortality is assumed to be time-invariant in the current assessment. The potential of using key MSVPA runs to provide time-varying natural mortality estimates for North Sea lemon sole should be explored.

9.8.2 Forecast

Lemon sole advice is currently based on the DLS 3.2 approach. If a length-based assessment can be generated, then there may be a requirement (and opportunity) to develop a forecast methodology, and this will need to be addressed when appropriate.

9.9 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					
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	2019	329	2805	104	3238
1985	793	6435	347	7575	2020	340	2219	95	2655

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								
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	2019	49	0	27	6	23	0	104
1985	117	0	164	0	66	0	347	2020	46	0	25	6	18	0	95

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										
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	2019	467	671	8	46	473	13	1122	4	2805
1985	989	555	157	26	0	0	4703	5	6435	2020	376	497	9	32	385	5	910	6	2219

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								
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	2019	0	293	1	29	5	1	329
1985	0	729	0	0	64	0	793	2020	0	288	3	44	4	1	340

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	331	3376	9.79%
2019	3238	3273	605	3878	15.60%
2020	2655	2653	391	3044	12.86%

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	0.0877	0.0741	0.1173	0.2215	0.3001	0.3449	0.3803	0.2155	0.2633
2006	0.0777	0.0747	0.1211	0.2242	0.3051	0.3378	0.3693	0.2348	0.261
2007	0.0684	0.0748	0.1238	0.2253	0.3077	0.3318	0.3603	0.2551	0.2622
2008	0.0599	0.074	0.1251	0.2249	0.3081	0.3268	0.3533	0.2753	0.266
2009	0.0521	0.0727	0.1254	0.223	0.3064	0.3225	0.3479	0.2955	0.2727
2010	0.0448	0.0709	0.1246	0.2195	0.3021	0.3186	0.3434	0.3148	0.2819
2011	0.0382	0.0685	0.1226	0.2141	0.2959	0.3156	0.3411	0.3363	0.2953
2012	0.0321	0.0654	0.1194	0.2074	0.2868	0.3139	0.3422	0.3552	0.3078
2013	0.0274	0.0614	0.1147	0.1986	0.2743	0.3133	0.3451	0.3747	0.3266
2014	0.0251	0.0579	0.1104	0.1875	0.2645	0.3153	0.3541	0.394	0.3456
2015	0.0225	0.0543	0.1058	0.1787	0.2546	0.3191	0.3643	0.4079	0.3526
2016	0.0199	0.0515	0.1014	0.1696	0.2455	0.3185	0.367	0.4115	0.3518
2017	0.0177	0.0488	0.0967	0.1625	0.2366	0.3168	0.3649	0.4074	0.3454
2018	0.0157	0.0467	0.0923	0.1558	0.2283	0.3134	0.36	0.3976	0.3337
2019	0.014	0.0448	0.0879	0.1503	0.2207	0.3088	0.3527	0.3816	0.3168
2020	0.0125	0.0433	0.0836	0.1456	0.2137	0.3036	0.3433	0.3595	0.2939
2021	0.0113	0.04212	0.0795	0.1422	0.2077	0.2974	0.3314	0.3316	0.2646

Table 9.3.2. Lemon sole in areas 4, 7.d and 3.a. GAM-estimated survey indices for Q1 (upper: NS IBTS) and Q3 (lower: NS IBTS + BTS). Data used in the assessment is highlight in bold.

NS Lemon Sole: IBTS Q1; Last group is NOT a plus-group. Calculations made on 22/04/2021 at 09:59:00.				
2007	2021			
1	1	0.09164804	0.09164804	
2	5			
1	128.5955	525.4095	443.1093	950.053
1	350.917	489.5737	257.0786	259.3079
1	343.1154	253.4795	273.229	112.7514
1	442.4642	677.1069	915.4798	229.6984
1	554.6513	1018.0489	602.9027	537.4863
1	1774.6929	1993.7594	675.3875	312.951
1	555.9307	777.763	917.0621	372.1282
1	658.3365	1294.4395	924.0509	205.1571
1	384.4856	1700.2849	1133.4635	349.2428
1	906.9785	1650.6593	981.9899	403.2208
1	636.2537	1010.4937	1063.7176	394.3887
1	444.8309	740.4127	313.5275	302.0084
1	692.7892	1523.3923	828.0682	255.4757
1	762.1216	1315.4097	711.3283	275.6707
1	378.4485	820.7201	1196.25	185.3992

NS Lemon Sole: BTS & IBTS Q3; Last group is NOT a plus-group. Calculations made on 22/04/2021 at 09:59:00										
2005		2020								
1	1	0.6213935		0.6213935						
1	10									
1	203.3971	1596.5504	1750.8707	1619.6242	844.4385	1247.1648	508.7407	346.2973	531.9478	527.3128
1	129.284	1025.5664	1781.1944	1455.247	1475.3374	799.905	1209.4689	422.4152	200.4711	950.2557
1	722.1517	1613.0016	2124.6291	1750.107	1476.1872	1525.62	662.9034	826.7673	367.3843	768.4939
1	258.3927	2126.9125	2216.3341	1653.0906	1632.9107	745.6956	1093.3353	430.7593	400.3247	689.6695
1	592.0146	1518.9025	2534.4519	1558.6956	1034.2903	1040.9899	322.7608	682.8938	86.1345	774.8048
1	531.3581	1282.3393	2002.5613	1692.6984	2013.5499	1458.2887	1376.6898	556.3658	591.8736	629.1284
1	185.6848	2977.9689	3444.635	1988.176	2400.8841	1877.7232	865.4003	1278.9611	360.8428	1332.0103
1	454.0838	2328.0943	3215.4712	2495.2206	1743.8305	1329.4933	991.5343	717.0816	943.9445	1219.2577
1	12.3323	352.2942	2010.2667	3360.7555	2190.1292	2116.2592	1857.8176	1243.156	472.8761	1843.2137
1	438.1932	995.9492	2462.0234	3251.9733	3094.6666	2051.2798	1040.2114	899.9692	457.6814	1428.4659
1	43.2154	2219.1183	3660.37	3449.5804	2978.7394	1638.6165	927.0533	851.0846	627.6804	1068.3748
1	287.3964	1829.7776	3101.3691	2286.2135	2700.5277	2348.7785	1451.616	726.0363	727.042	1290.8178
1	51.7892	1162.7871	2486.8561	2381.3963	2583.0924	2195.0933	1470.5847	1052.4571	617.0264	837.2548
1	127.0669	1512.963	2158.3877	2053.9065	2326.9947	1865.6064	1463.4391	978.0559	538.6722	773.4331
1	315.6598	1438.0069	2589.4112	1863.1726	1434.458	1597.9202	1586.6928	1137.2113	700.3659	1256.2965
1	629.5958	1545.0032	2371.9828	2320.6581	1570.4525	1458.3711	1302.1879	992.1502	1070.5919	1771.0653

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 mean-standardised 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	-0.109	0.183	0.49	0.671	0.84	1.176	0.49	0.69	0.96
2006	-0.052	0.20	0.43	0.721	0.891	1.187	0.52	0.71	0.98
2007	0.169	0.41	0.64	0.76	0.911	1.188	0.67	0.96	1.34
2008	0.131	0.38	0.61	0.631	0.761	0.98	0.55	0.76	1.04
2009	-0.25	-0.023	0.195	0.529	0.64	0.82	0.66	0.88	1.18
2010	-0.23	0.0020	0.22	0.735	0.869	1.098	0.87	1.17	1.59
2011	-0.096	0.143	0.38	0.915	1.093	1.412	0.87	1.18	1.55
2012	0.024	0.26	0.50	0.983	1.191	1.545	0.78	1.1	1.49
2013	0.021	0.25	0.47	0.938	1.129	1.44	0.63	0.83	1.13
2014	-0.072	0.157	0.38	0.916	1.09	1.384	0.79	1.07	1.43
2015	-0.154	0.069	0.28	0.957	1.144	1.481	0.51	0.69	0.92
2016	-0.060	0.170	0.39	1.027	1.257	1.624	0.59	0.82	1.15
2017	0.0170	0.25	0.48	0.998	1.213	1.593	0.55	0.8	1.14
2018	-0.063	0.156	0.37	0.866	1.042	1.369	0.6	0.91	1.35
2019	-0.167	0.121	0.37	0.825	0.975	1.262	0.71	1.17	2
2020	0.058	0.174	0.29	0.753	0.953	1.333	1	2.26	5.6

Table 9.4.1. 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				Optimising yield	MSY
	L_c/L_{mat}	L_{25}/L_{mat}	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/F_{F=M}$
Year	**>1**	**>1**	**>0.8**	**>30%**	**~1(>0.9)**	**≥1**
2002	0.692	1.808	1.001	0.588	1.107	1.716
2003	1.154	1.731	0.997	0.481	1.074	1.302
2004	1.769	1.885	1.001	0.609	1.202	1.128
2005	1.923	1.885	0.910	0.383	1.126	1.001
2006	0.846	1.885	0.962	0.555	1.106	1.569
2007	0.846	1.885	0.975	0.501	1.085	1.539
2008	1.462	1.731	0.996	0.477	1.105	1.170
2009	0.538	1.731	0.994	0.479	1.064	1.819
2010	0.692	1.808	1.005	0.518	1.112	1.724
2011	0.231	1.346	0.959	0.285	0.919	1.976
2012	0.538	1.500	0.948	0.267	0.939	1.606
2013	NA	NA	NA	NA	NA	NA
2014	0.538	1.500	0.988	0.325	0.962	1.645
2015	0.231	1.577	0.995	0.284	0.963	2.070
2016	0.692	1.577	1.005	0.449	1.038	1.609
2017	0.538	1.577	1.023	0.499	1.041	1.779
2018	2.077	1.962	1.076	0.698	1.291	1.090
2019	0.538	1.500	1.024	0.433	1.032	1.764
2020	1.154	1.654	1.034	0.518	1.081	1.310

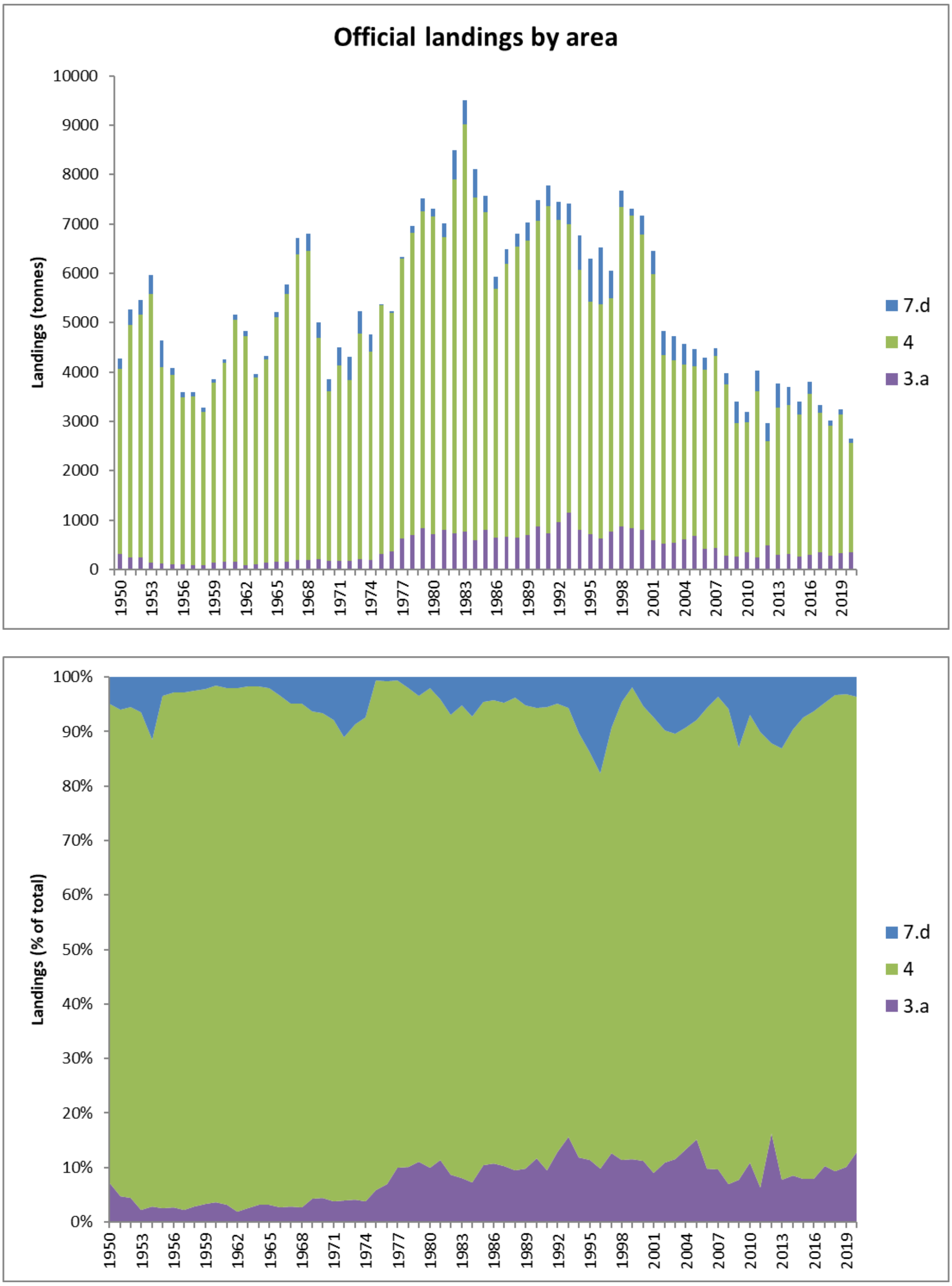
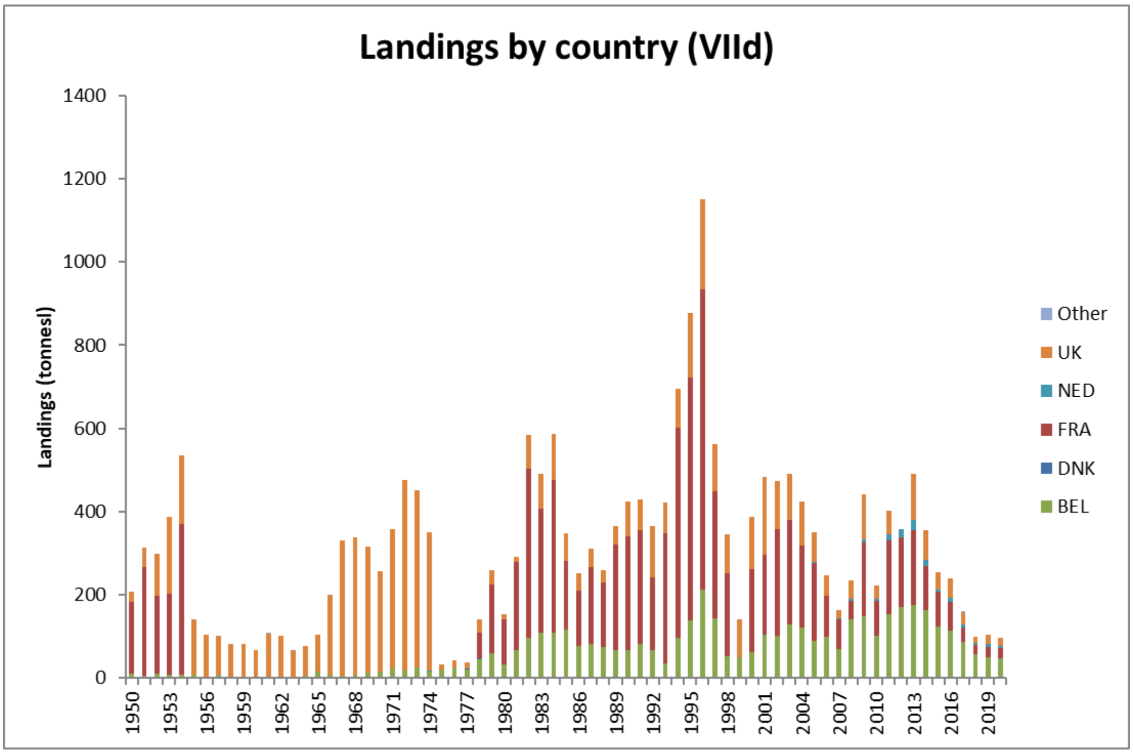


Figure 9.2.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Officially-reported landings of lemon sole by area in the greater North Sea. Upper plot: landings in tonnes. Lower plot: landings by area as a percentage of the full area.



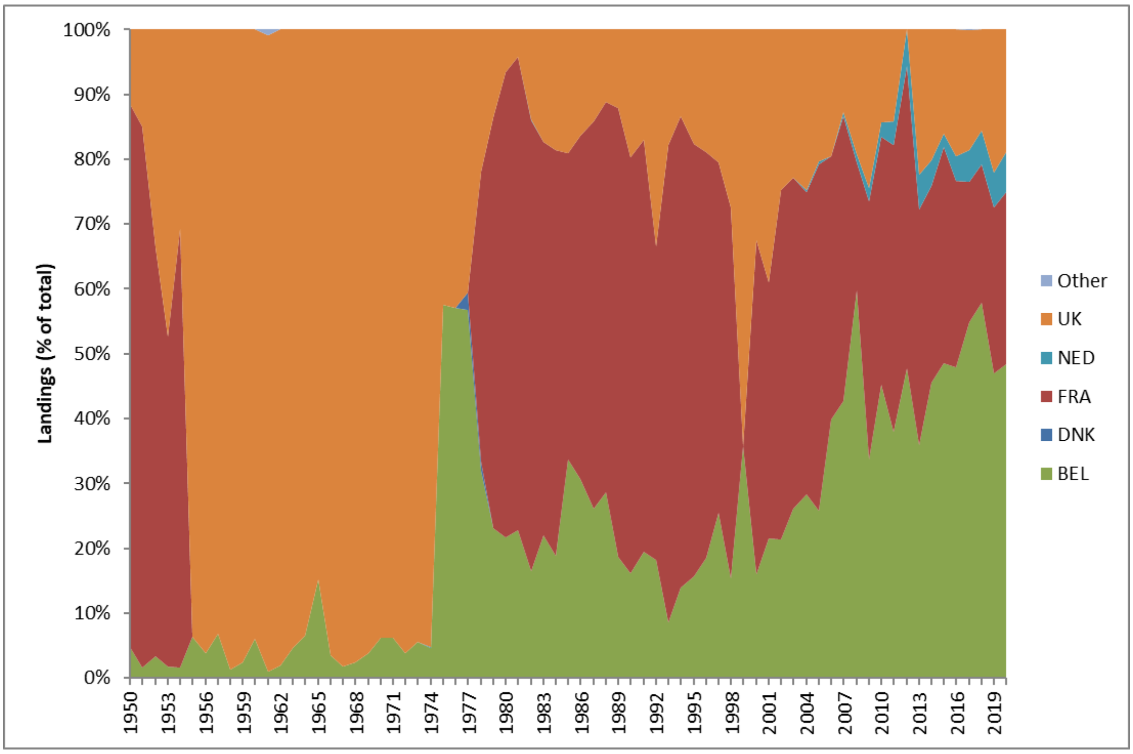


Figure 9.2.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings of lemon sole in area 7.d by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 7.d landings.

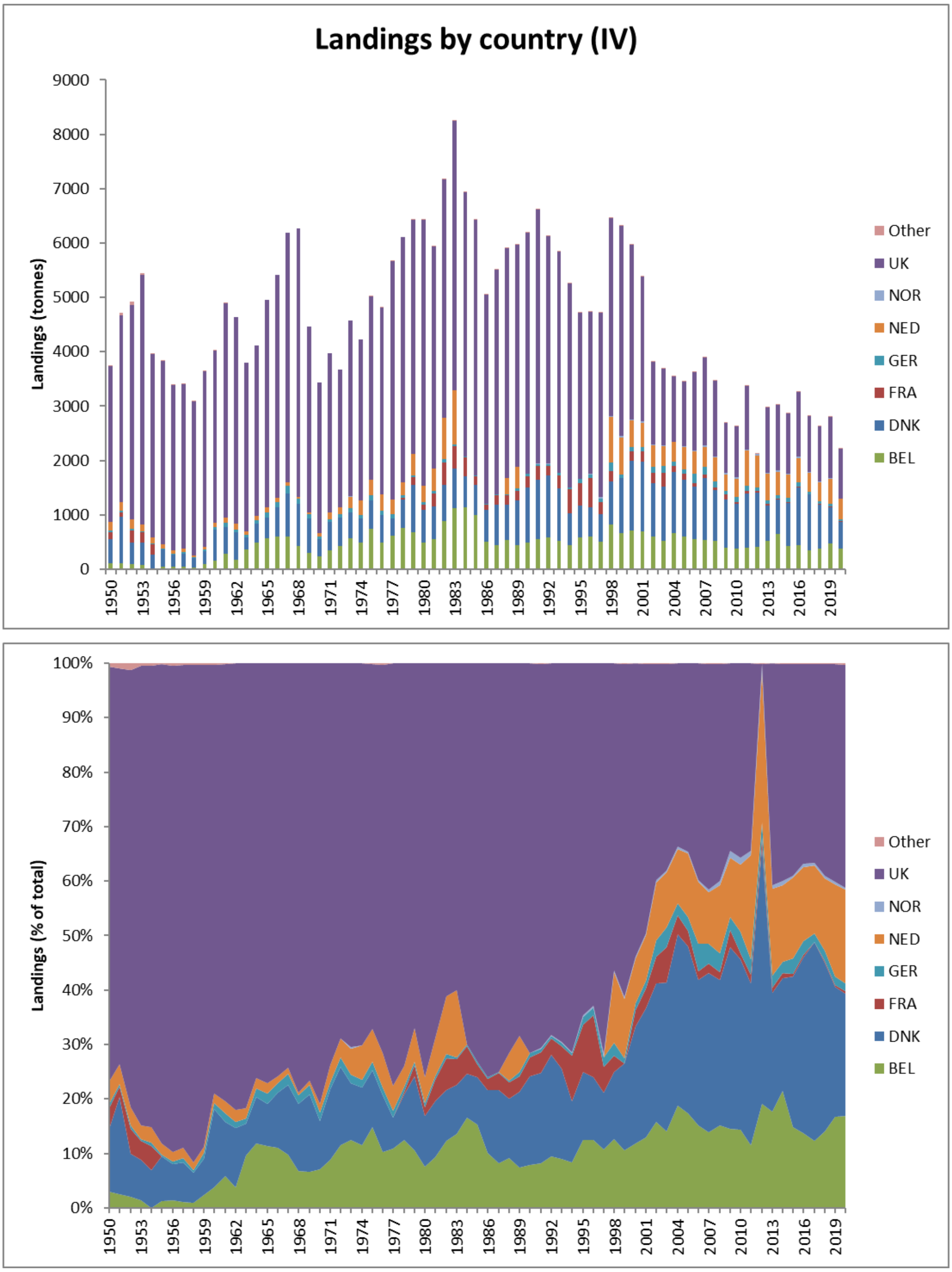
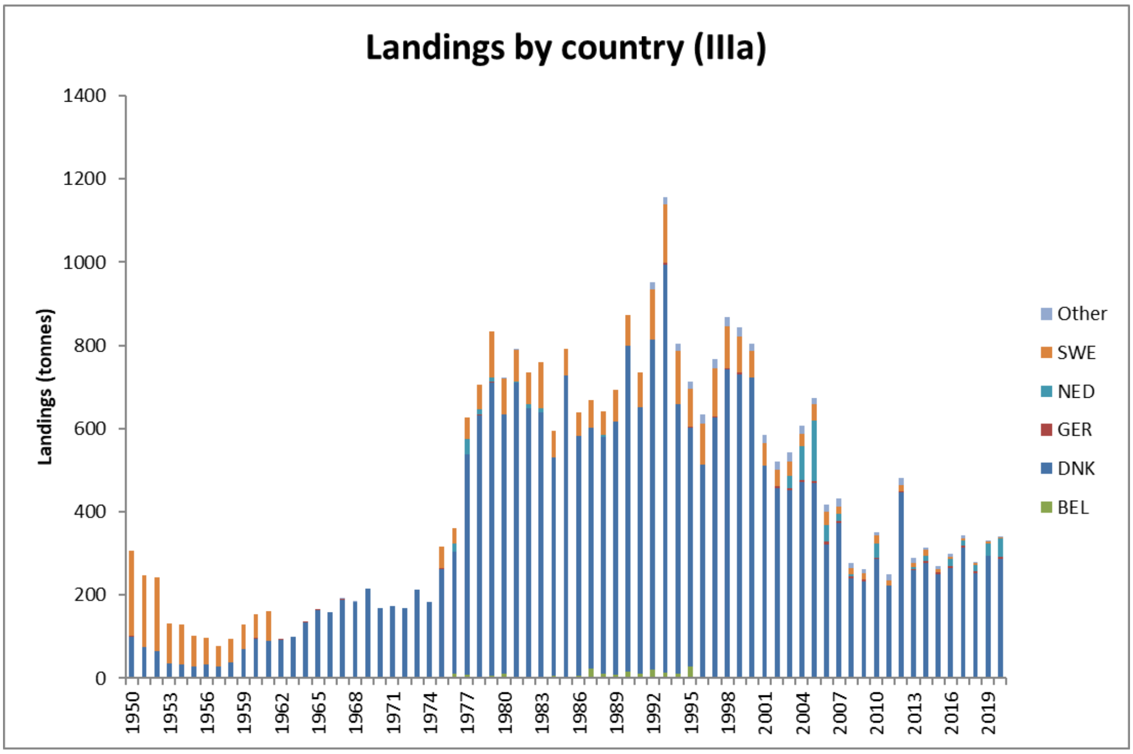


Figure 9.2.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings of lemon sole in area 4 by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 4 landings.



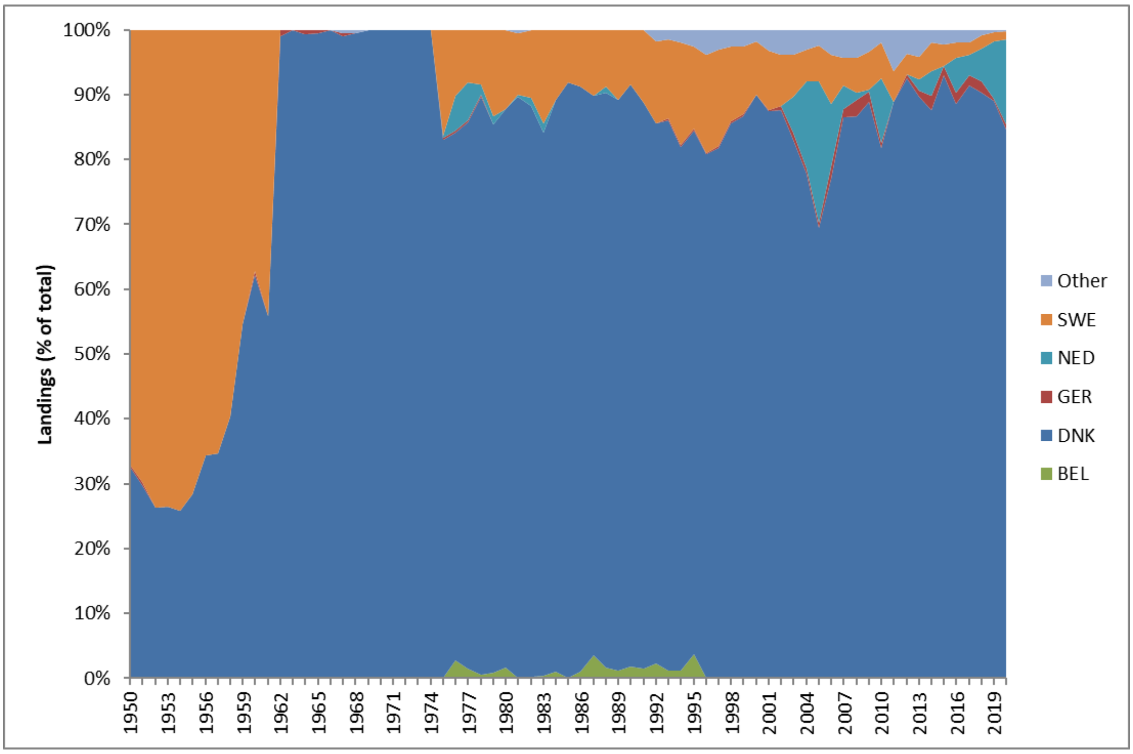


Figure 9.2.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings of lemon sole in area 3.a by country. Upper plot: landings in tonnes. Lower plot: landings by country as a percentage of the total area 3.a landings.

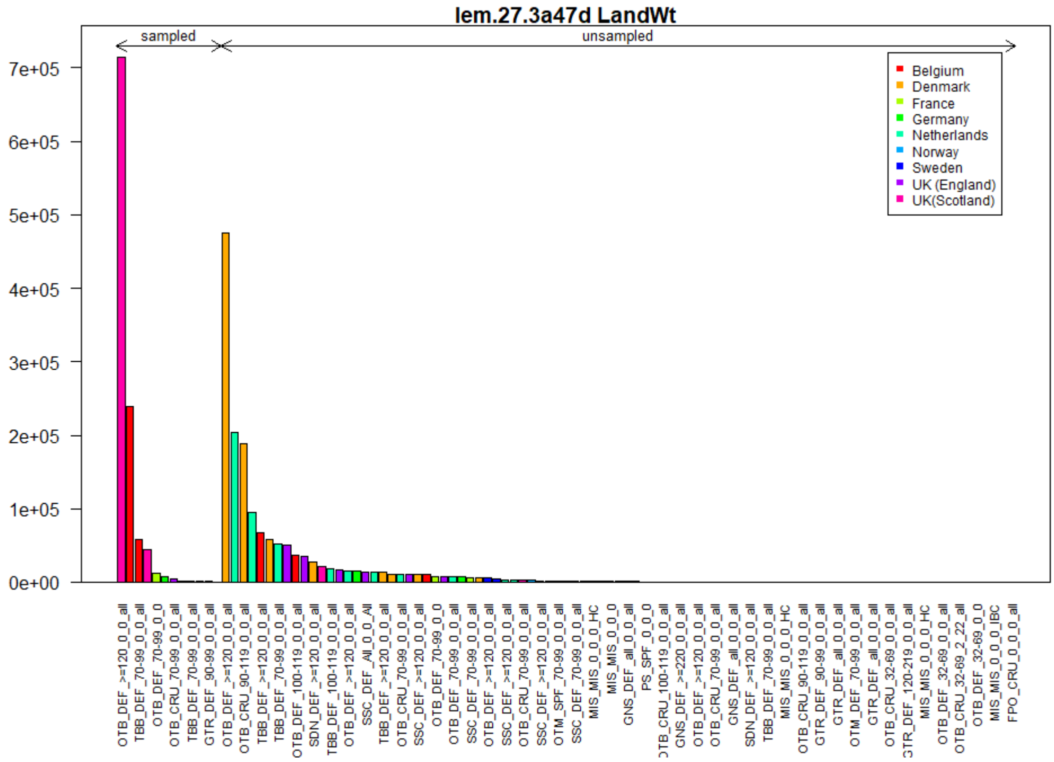


Figure 9.2.5. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (tonnes).

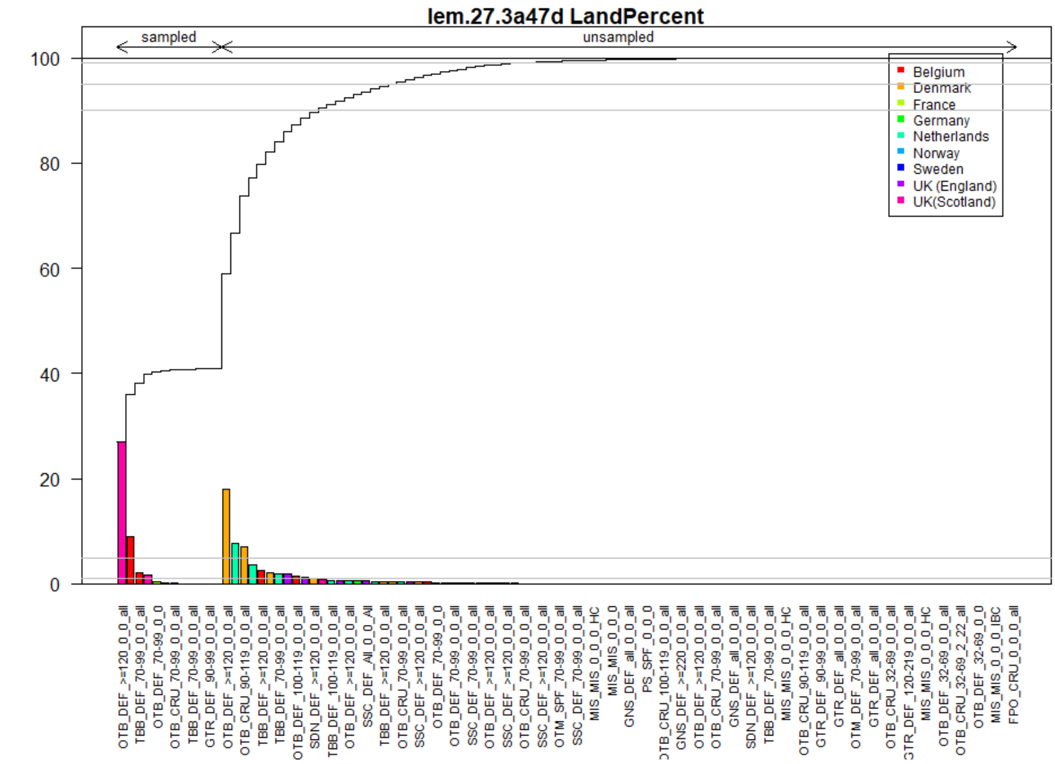


Figure 9.2.6. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (cumulative contribution).

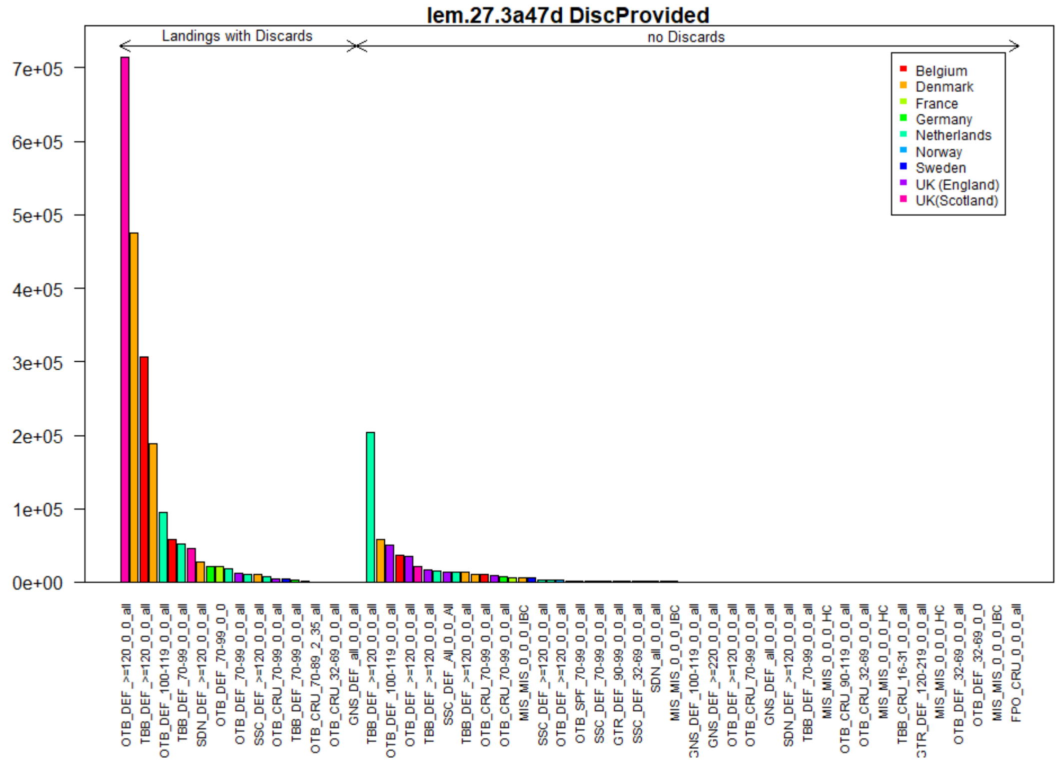


Figure 9.2.7. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. InterCatch summary plots. Fleets provided with and without discard estimates.

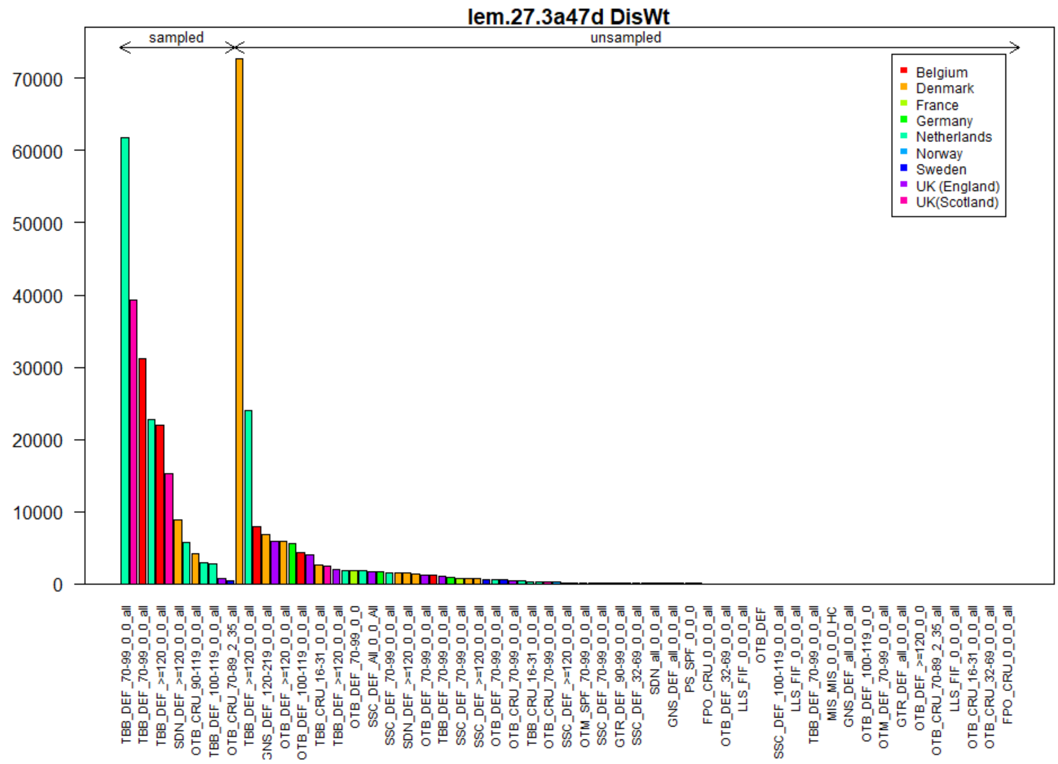


Figure 9.2.8. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. InterCatch summary plots. Sampled and unsampled fleets for discard yield estimation.

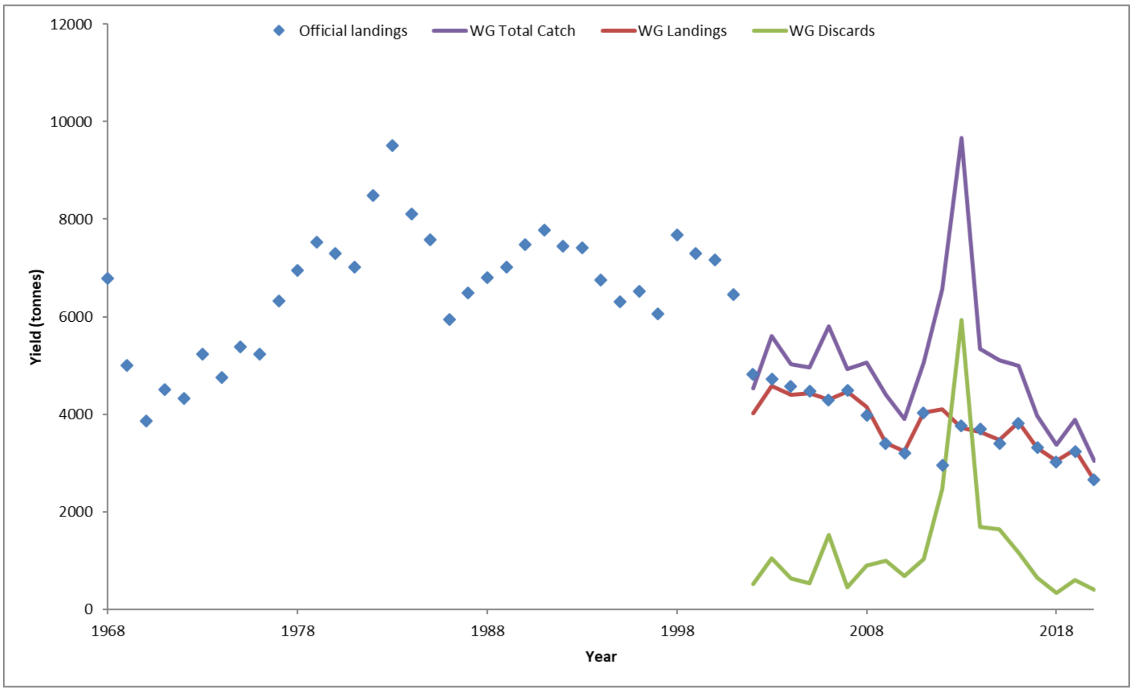


Figure 9.2.9. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of official landings (dots) along with ICES WG estimates of total catch (purple line), landings (red line) and discards (green line).

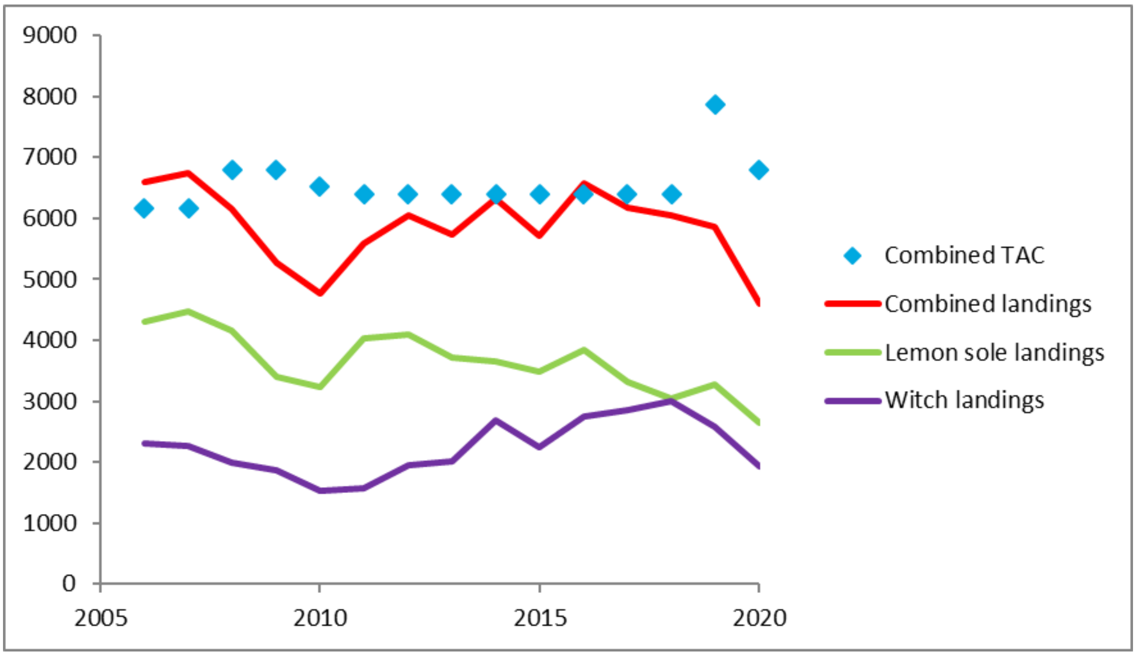


Figure 9.2.10. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of ICES WG estimates of landings for lemon sole (green line), witch (purple line) and combined (red line), along with the joint lemon sole-witch TAC (dots).

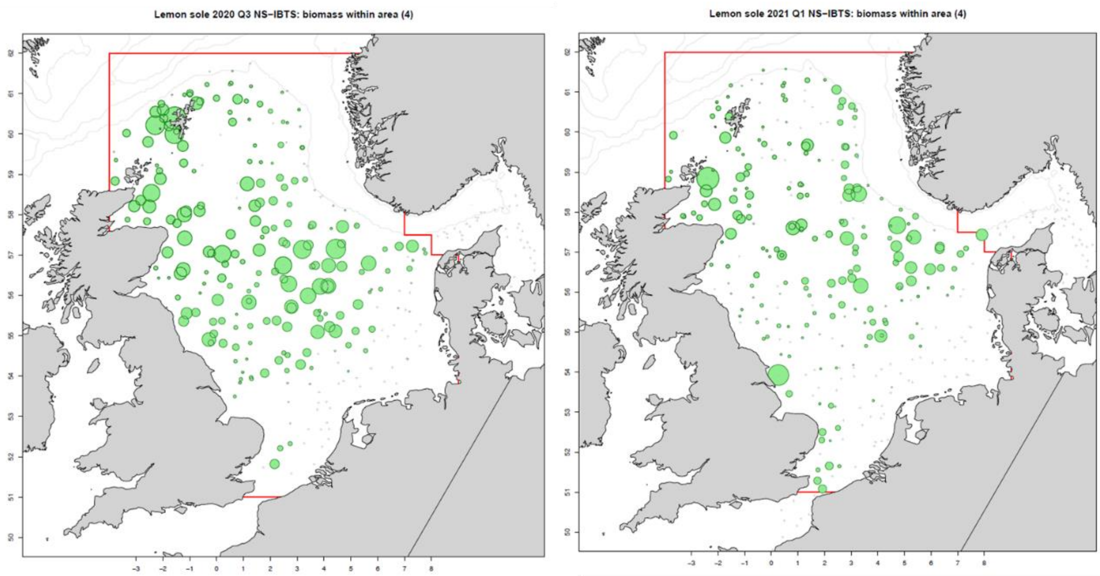


Figure 9.3.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Distribution of lemon sole in the North Sea derived from IBTS Q3 2020 (left) and IBTS Q1 2021 (right). The sizes of the circles are proportional to the square root of the estimated weight of lemon sole caught in each haul.

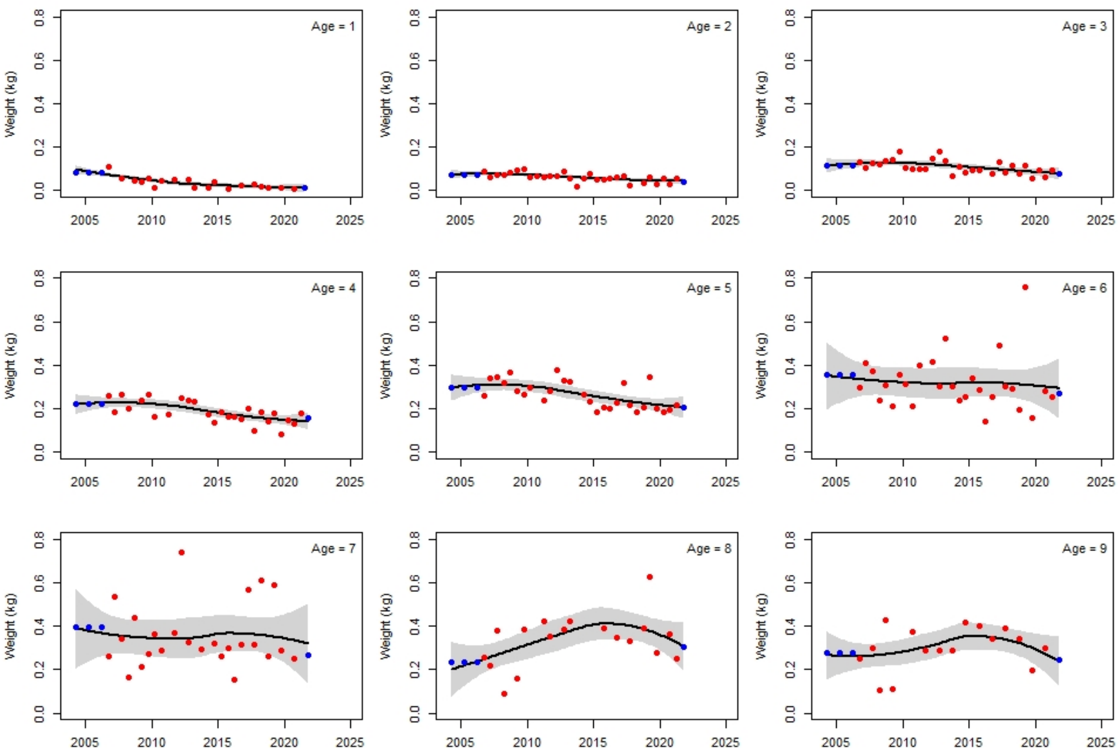


Figure 9.3.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of mean weight-at-age estimates (red dots) from IBTS Q1 and Q3 surveys, summarised by a loess smoother (span = 1) for each year (the grey band gives a 95% confidence interval about the loess smoother). The blue dots show averages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

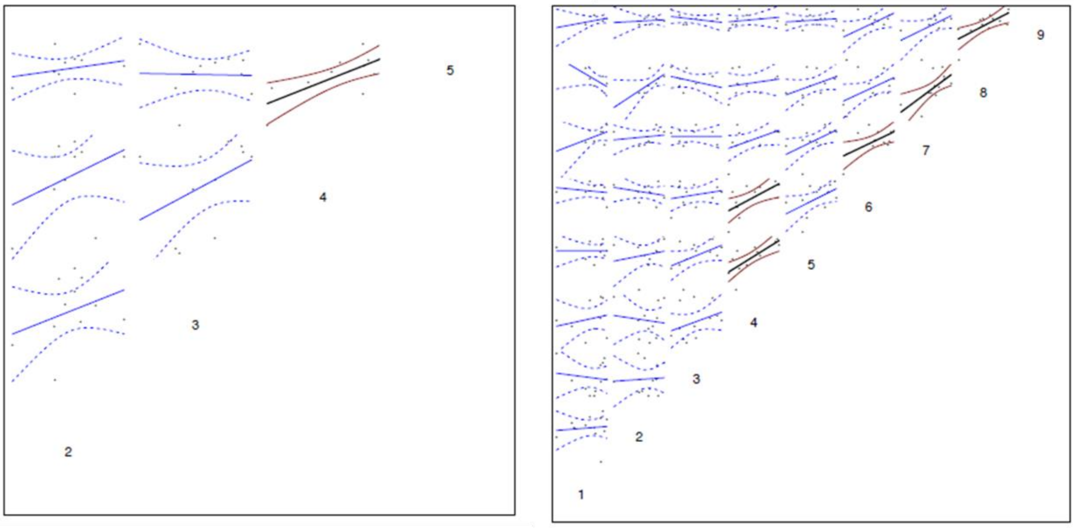


Figure 9.3.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Bivariate scatterplots showing consistency in cohort-strength estimation, for Q1 (left: IBTS) and Q3 (right: IBTS and BTS).

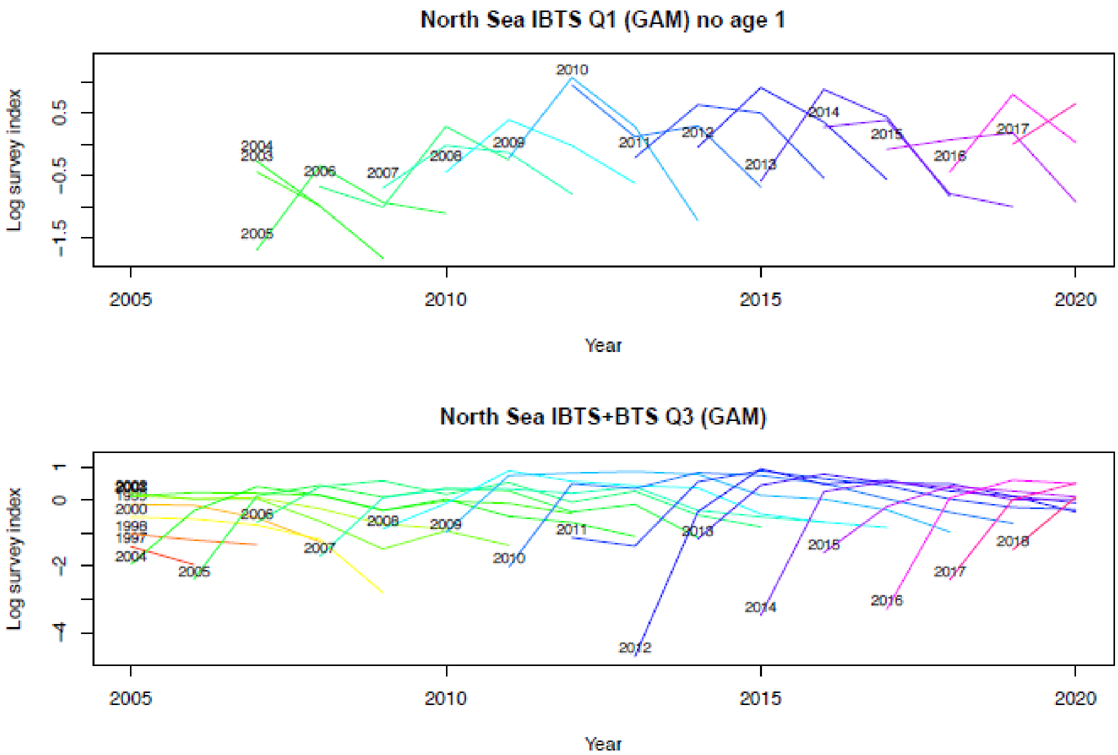


Figure 9.3.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Survey catch curves, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

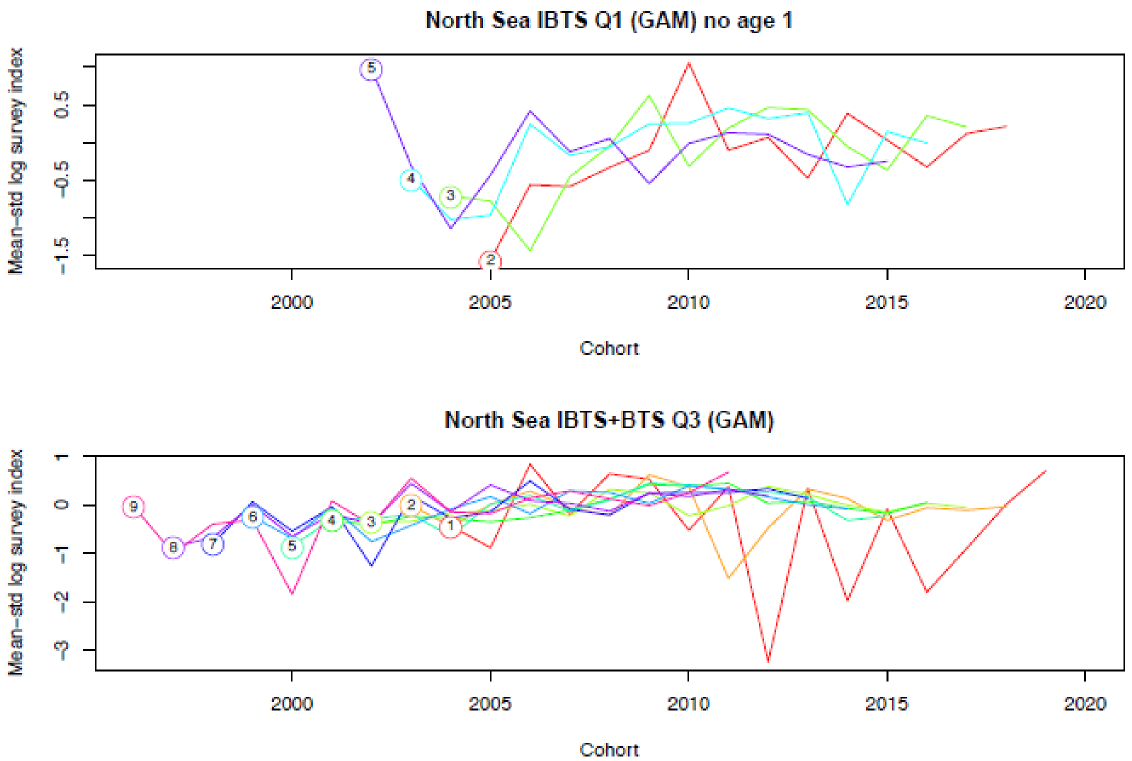


Figure 9.3.5. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Survey indices by age, cohort and year, for Q1 (upper: IBTS) and Q3 (lower: IBTS and BTS).

Figure 9.3.6. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Mean-standardised survey indices for Q1 (IBTS, blue lines) and Q3 (IBTS+BTS, red lines), shown as time-series for each age. Solid lines indicate data that are used in the assessment.

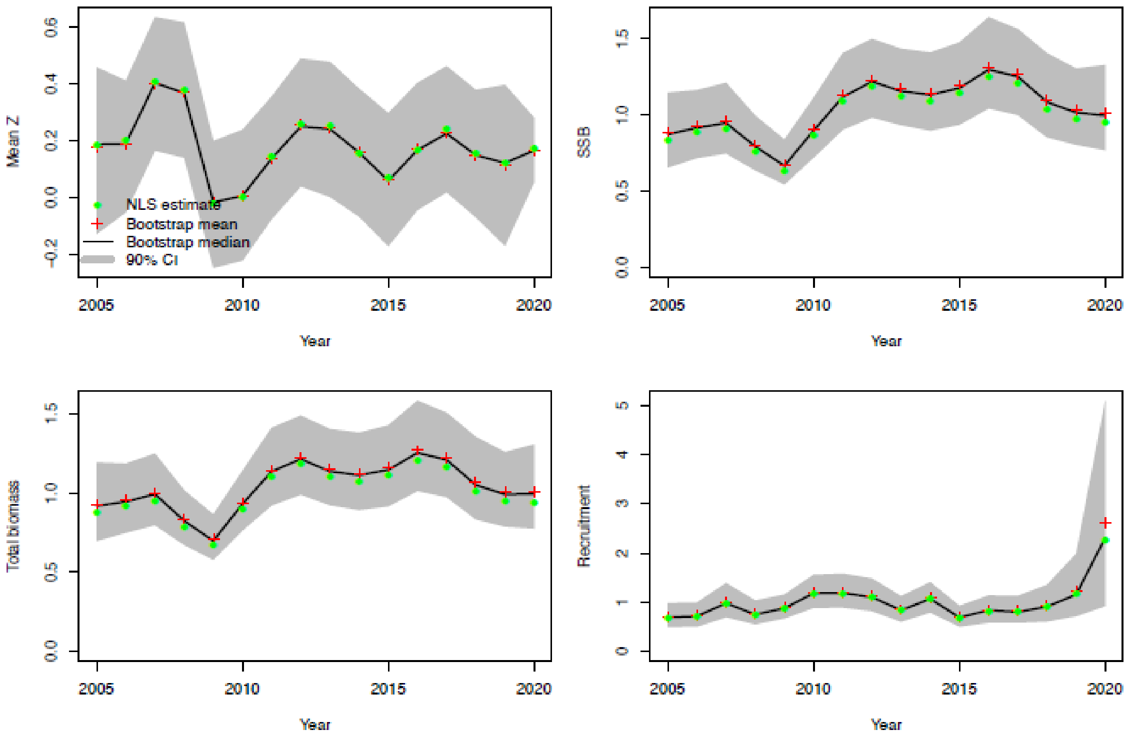


Figure 9.4.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. SURBAR stock summary (clockwise from upper left: mean Z(3-5), relative SSB, relative recruitment at age 1, relative total biomass). In each plot, the green dots give the nonlinear least-squares estimates, the red crosses give the uncertainty-estimation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

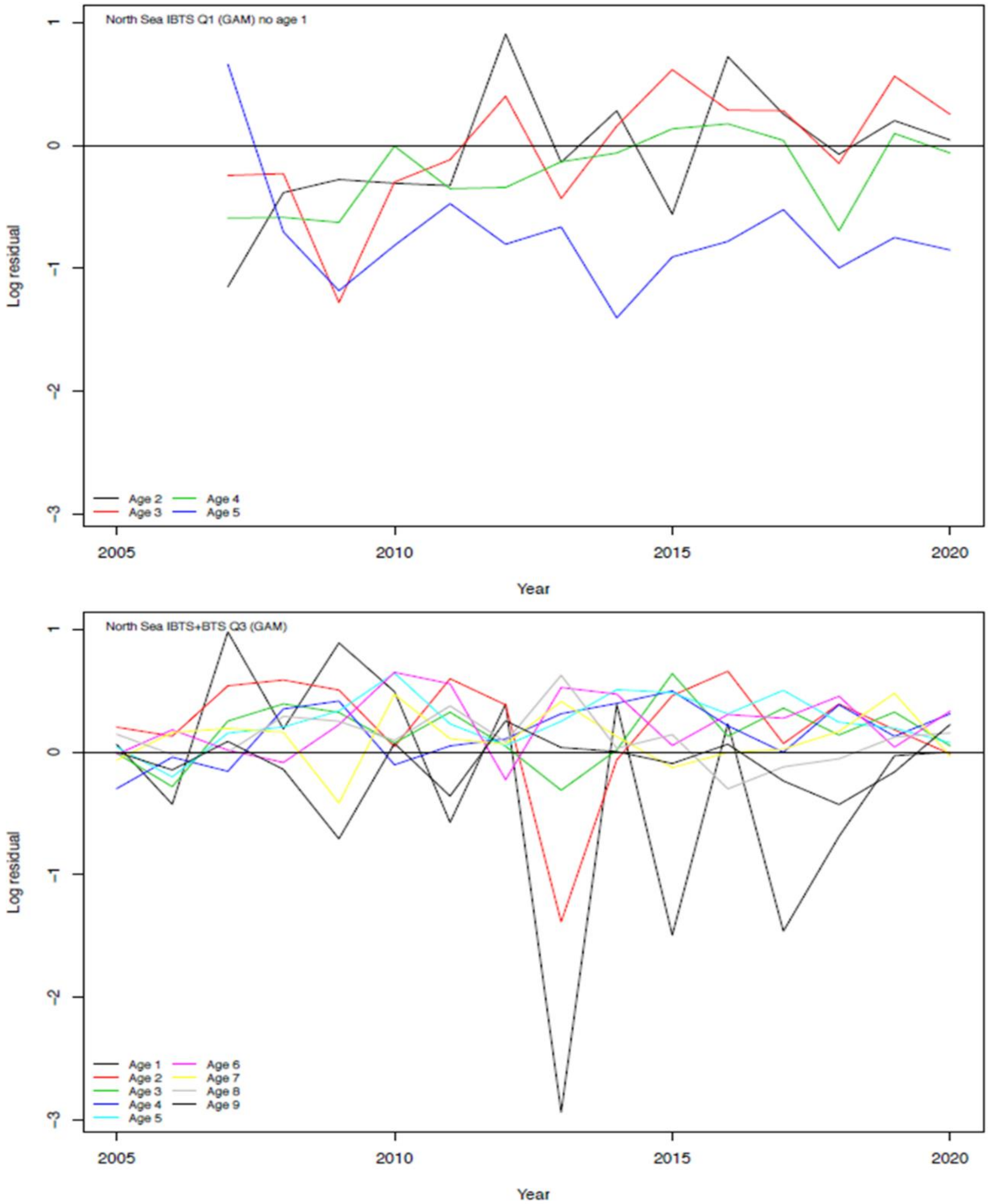


Figure 9.4.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Upper: Log SURBAR residuals for Q1 (IBTS). Lower: Log SURBAR residuals for Q3 (IBTS+BTS).

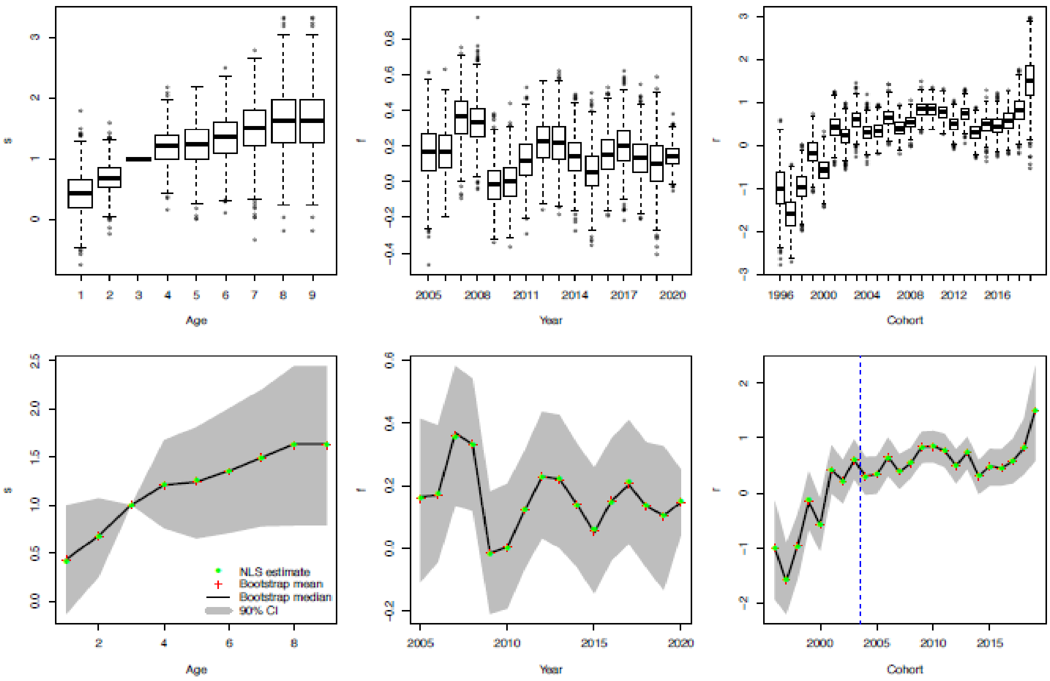


Figure 9.4.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Estimated SURBAR parameters: age effects (*s*) and year effects (*f*) of total mortality, and cohort effects (*r*). Upper: box-and-whisker plots of bootstrap distributions. Lower: the green dots give the nonlinear least-squares estimates, 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.

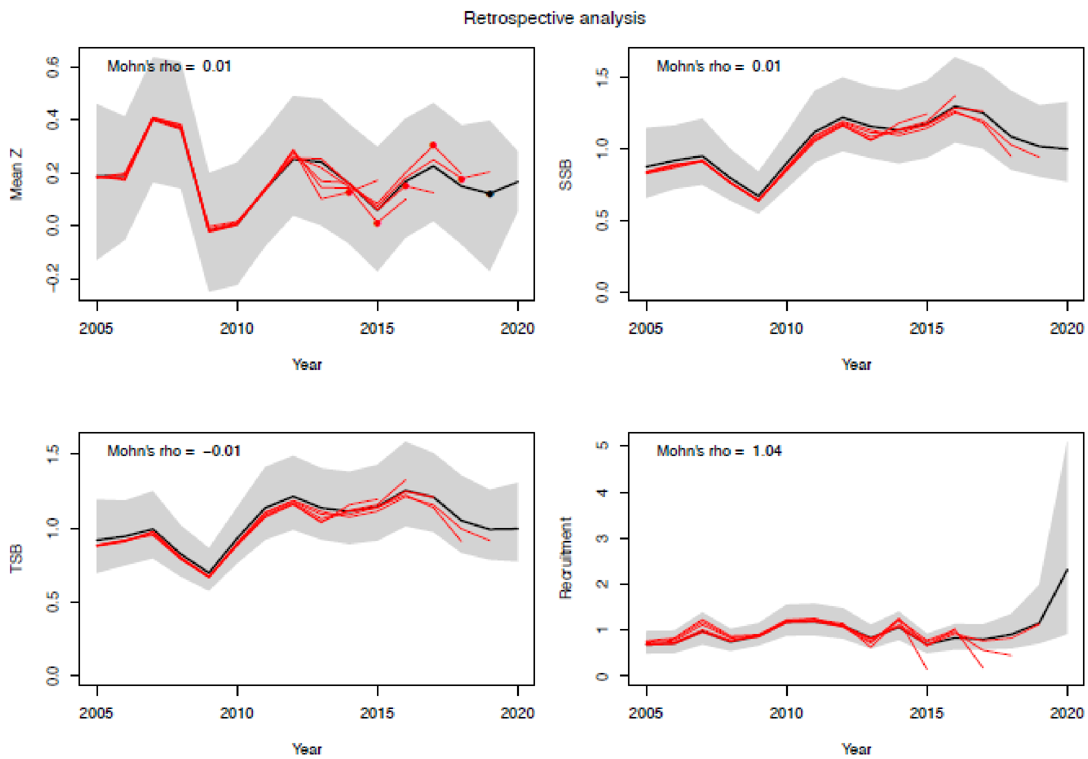


Figure 9.4.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Retrospective SURBAR analysis (clockwise from upper left: mean Z(3-5), relative SSB, relative total biomass, relative recruitment at age 1). Black lines give final-year estimates (with 90% confidence interval in grey), while red lines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

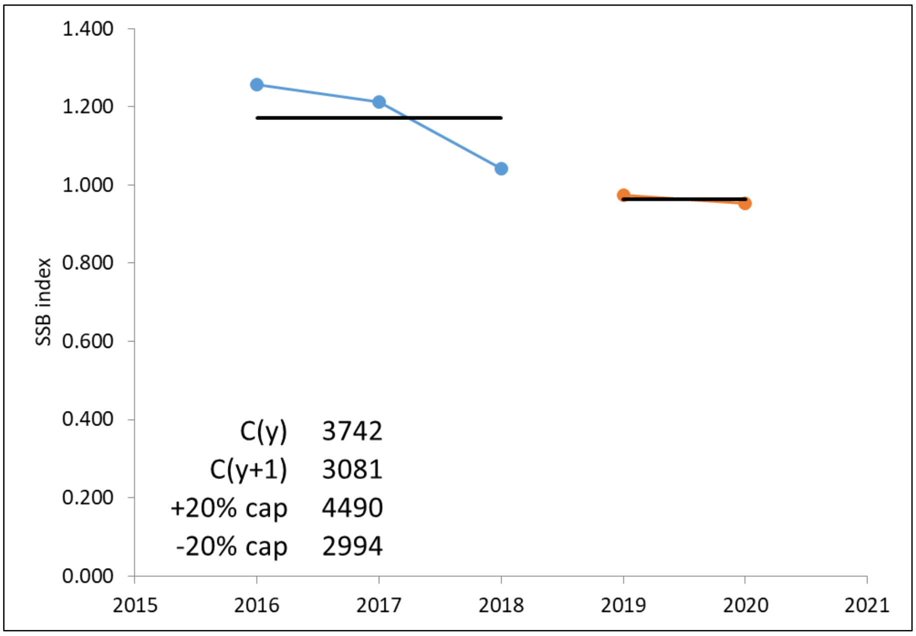


Figure 9.5.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Application of the DLS 3.2 rule, using the last five years of the relative SSB estimate given in Figure 9.4.1.

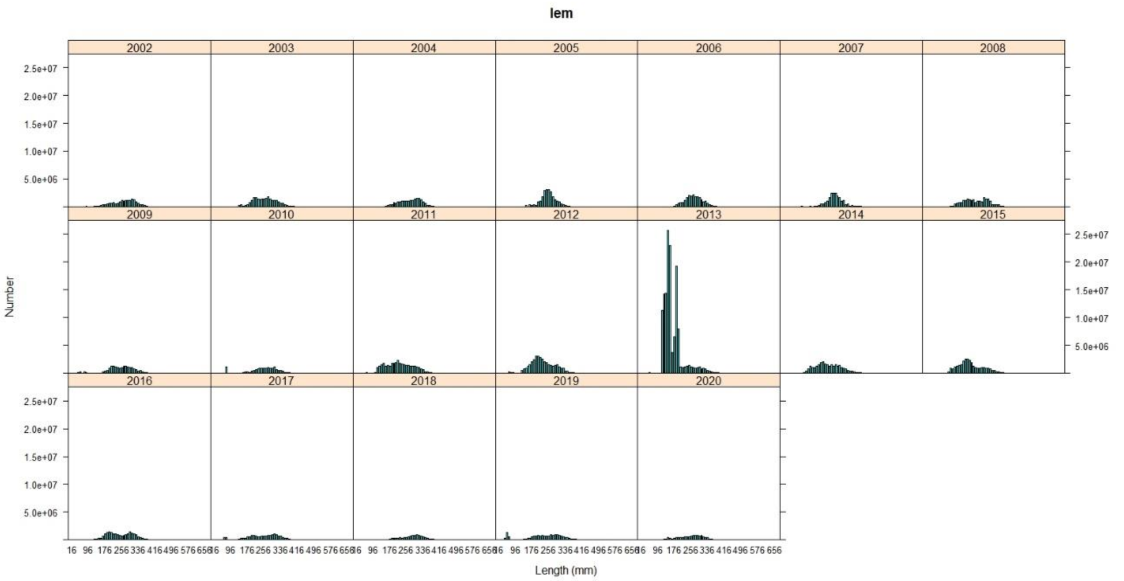


Figure 9.6.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year.

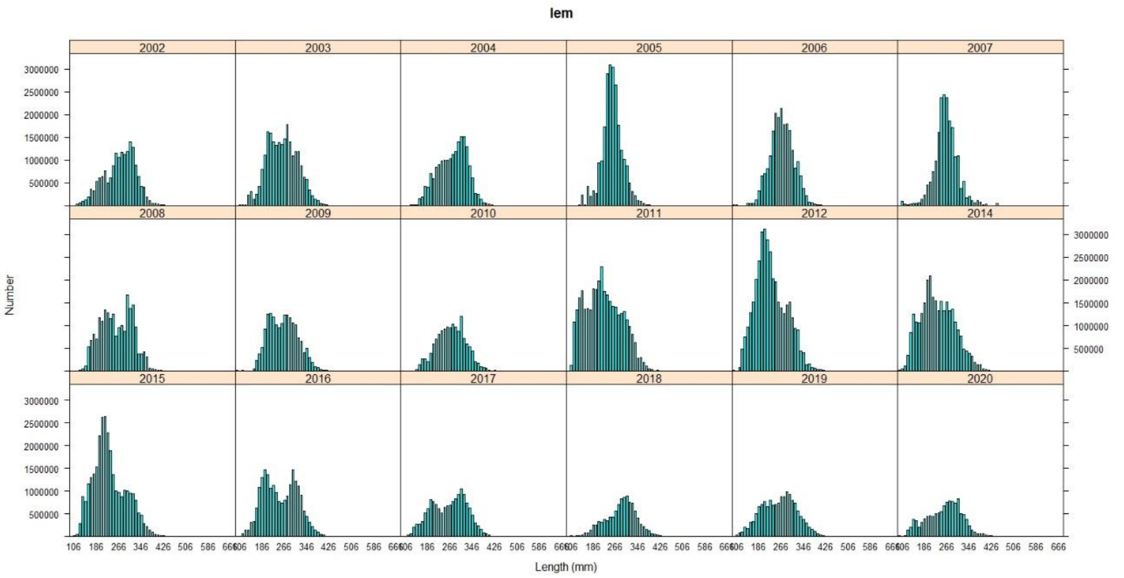


Figure 9.6.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Length distributions in commercial catches (landing and discards) submitted to InterCatch, by year, with 2013 data removed due to erroneous data submissions, and all fish <100 mm removed for all years.

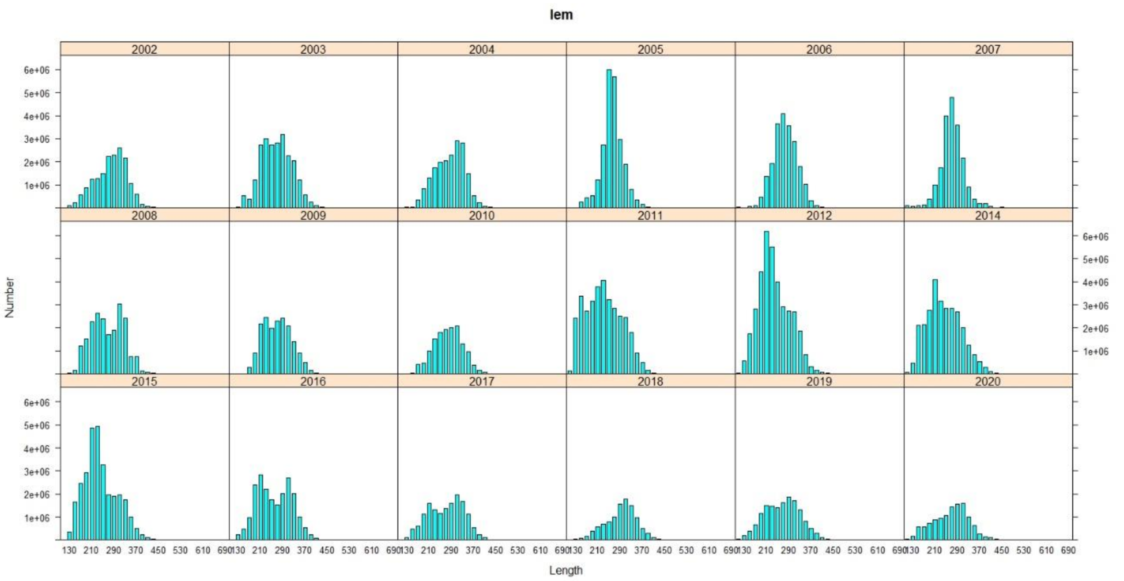


Figure 9.6.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. As for Figure 9.6.2, with bin widths doubled (to 20 mm).

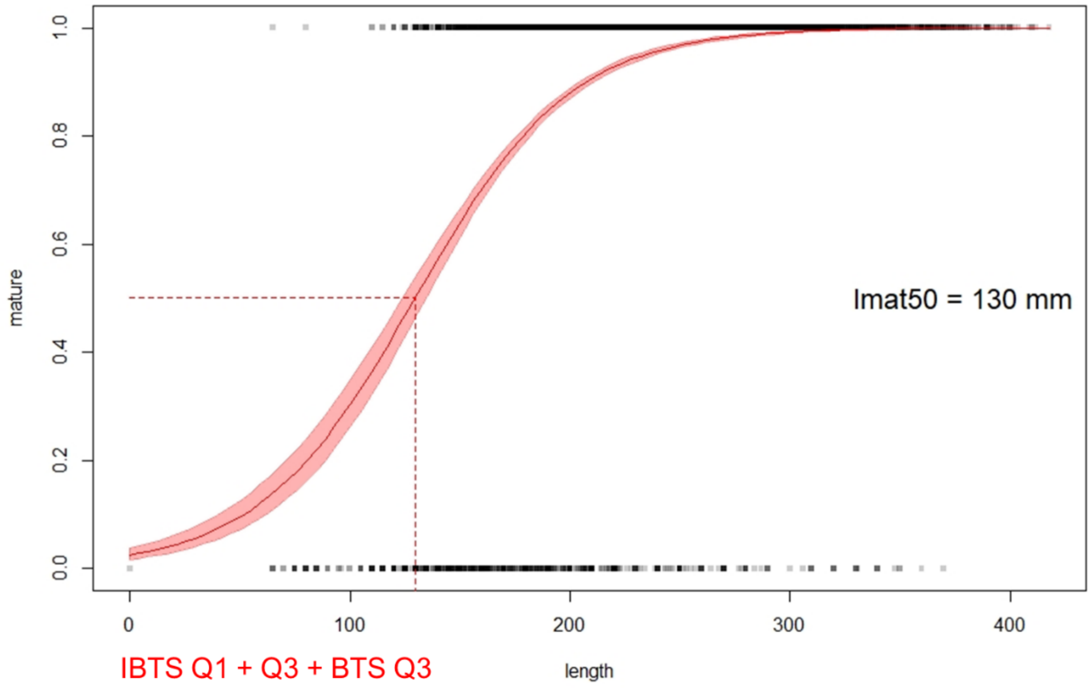


Figure 9.6.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Fitted maturity-at-age estimates from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using maturity-length observations from all available years (2007-2021). Maturity indices (0 = not mature, 1 = mature) are shown as shaded dots. The solid red line gives the fitted maturity ogive with 95% confidence interval (red band), while dotted red lines highlight the length of 50% mature ($L_{50\%mat}$ = 130 mm)

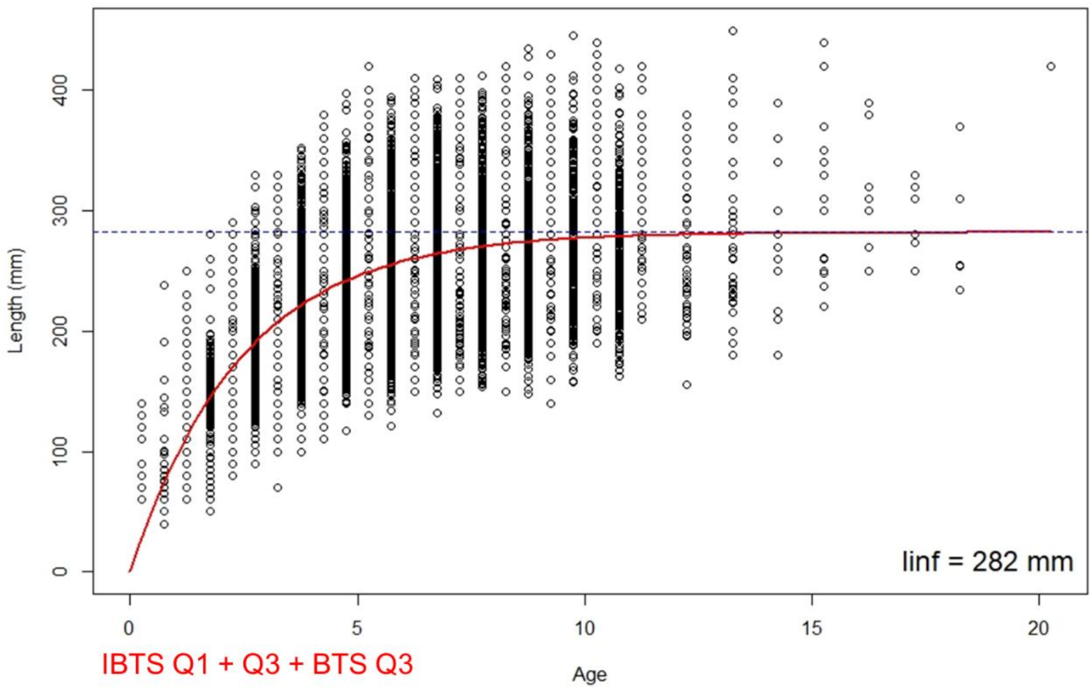


Figure 9.6.5. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Length-at-age data from Q1 (IBTS) and Q3 (IBTS & BTS) survey series, using data from all available years (2007-2021). To account for seasons, Q1 lengths are plotted at *a* + 0.25, Q3 lengths at *a* + 0.75. The red line gives a fitted von Bertalanffy growth curve (L_∞ = 282.806 mm, K = 0.4114, t_0 = 0).

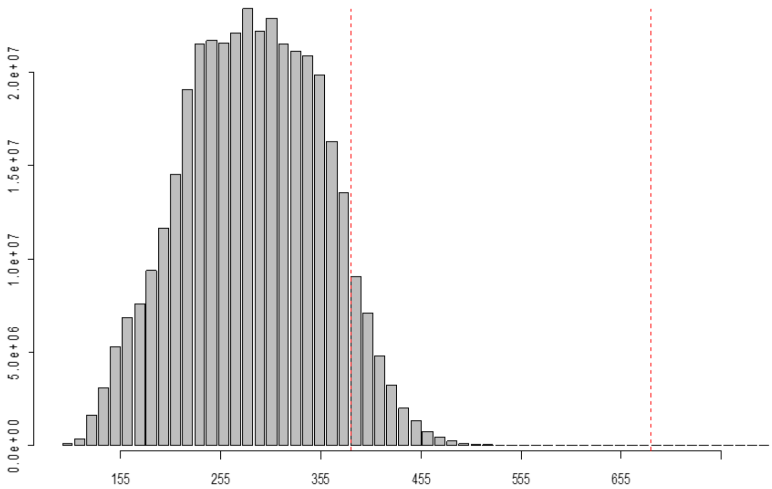


Figure 9.6.6. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Length distribution of the commercial catch data submitted to InterCatch, collated over all available years (2002–2020). The red lines give (from left to right) the 99%ile of the distribution (385 mm) and the longest observed fish (685 mm).

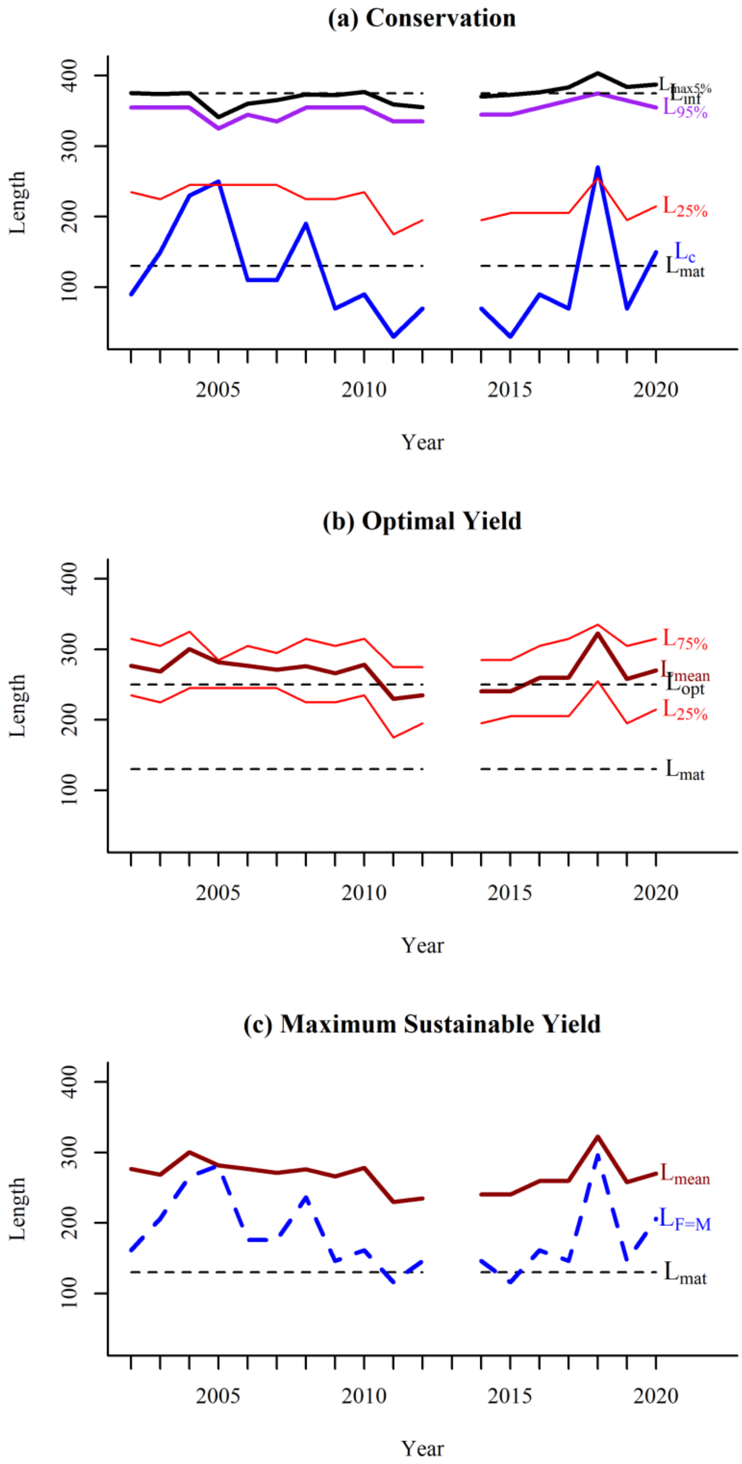


Figure 9.6.7. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Results of LBI analysis (absolute estimates).

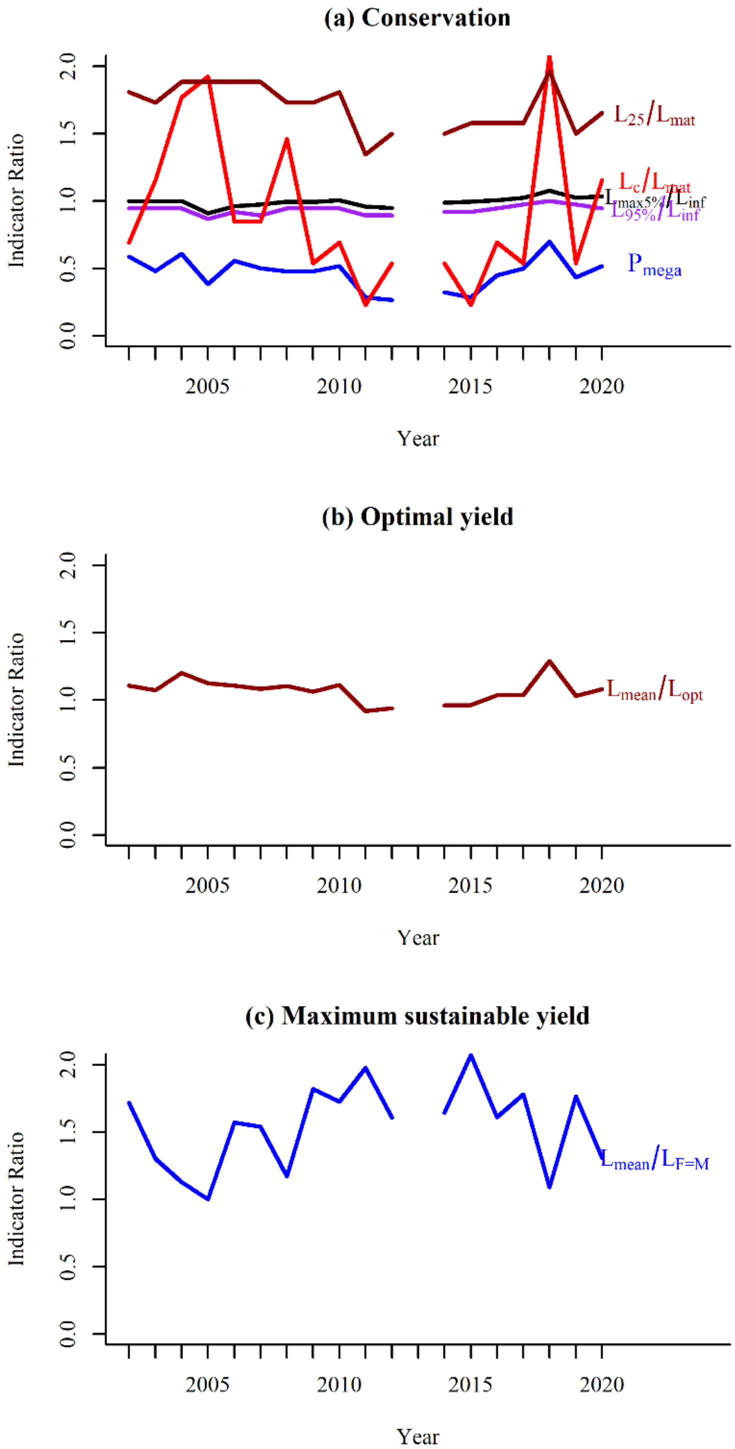


Figure 9.6.8. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Results of LBI analysis (ratio estimates).

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

10.1 *Nephrops* in Division 3.a

10.1.1 General

At present, there are two functional units in Division 3.a: Skagerrak (3.a.20) and Kattegat (3.a.21). This separation was based on observed differences between Skagerrak and Kattegat regarding *Nephrops* size composition in catches in the 1980s and 1990s. However, the distribution of *Nephrops* is almost continuous from southern Kattegat into Skagerrak, and the exchange of pelagic larvae between the southern and northern areas is very likely. With the longer data series now available, it seems the differences in size composition between the two areas are more likely to be random or caused by factors from fishing operations. The assessment is therefore conducted on *Nephrops* in 3.a as one stock.

Ecosystem aspects

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

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of 3.a in late summer, where unusually high catch rates of *Nephrops* were observed. The increasing amount of dead specimens in the catches led to the conclusion of severe oxygen deficiency in especially the Kattegat (3.a.21) in late 1988 (Bagge *et al*., 1990).

No information is available on the extent to which larval mixing occurs between *Nephrops* stocks, but the similarity in stock indicator trends between 3.a.20 and 3.a.21 for both Denmark and Sweden indicates that recruitment has been similar in both areas. These observations suggest they may be related to environmental influences.

ICES Advice

The most recent advice for *Nephrops* in 3.a was given in 2020. 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, 13 733 tonnes in 2019 and 2020 and 12360 tonnes in 2021. 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. Since 2017, the discard proportion has been around 30% (Figure 10.2.1.1). The reduction in MLS has reduced the proportion of the catch discarded considerably. Furthermore, it is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. A discard ban was implemented in EU waters from 1 January 2015. The discard ban became applicable to *Nephrops* from 1 January 2016, however an exemption for high survivability was introduced. New technical measures have also been agreed upon and have been implemented since 1 February 2013.

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

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

Landings

Division 3.a includes FU 3 and 4, which are assessed together. Total *Nephrops* landings by FU and country are shown in Table 10.2.1.1 and Table 10.2.1.2.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 61 % and 35 % by weight of the landings in 2020, 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). In 2020, landings were 3368 tonnes (Table 10.2.1.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2020, Denmark accounted for about 76% of total landings in FU4, while Sweden took 24 % (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 previous 50-year period (Figure 10.2.2.3). From 2010 till 2015, landings show a decreasing trend. Landings have increased since 2015 reaching 3128 tonnes in 2019, the maximum observed in the time series. A general trend of reduced landing of *nephrops* during 2020 was observed also in Kattegat with a catch in 2020 of 2531 tonnes.

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991–2019. 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 from 2005 till 2015 but are observed to be at lower level in recent years.

For Kattegat, size distributions of both the landings and discards are available from Sweden for 1990–2019, and from Denmark for 1992–2020. 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 2019. 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:	$L\infty$ = 73 mm CL, k = 0.138.
Immature females:	$L\infty$ = 73 mm CL, k = 0.138.
Mature females:	$L\infty$ = 65 mm CL, k = 0.10, Size at 50% maturity = 29 mm CL.

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

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

Catch and effort data–FU3

Effort data for the Swedish fleet are available from logbooks for 1978–2020 (Figure 10.2.2.1 and Table 10.2.2.2). During the period 1998 to 2005, twin trawlers shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in LPUE during this period (Table 10.2.2.2). Since 2005, LPUE for twin trawls has increased. The LPUE for single trawls has shown and increasing trend throughout the entire time series. The long-term trend in LPUEs is similar in the Swedish and Danish fisheries (Figure 10.2.2.1). Total Swedish trawl effort shows a decreasing trend since 1992 and has been fluctuating without trend since 2003. From 2007 onwards, total Swedish trawl effort has been estimated from LPUEs from the single trawl with a grid (targeting only *Nephrops*).

Danish effort figures for the Skagerrak (Table 10.2.2.3 and Figure 10.2.2.1) were estimated from logbook data. For the whole period, it is assumed that effort is exerted mainly by vessels using twin trawls. The overall trend in effort for the Danish fleet is similar to that in the Swedish fishery. After having been at a relatively low level in 1994–1998, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2017. Also, the trend in LPUE is similar to that in the Swedish single trawl fishery, however with a much more marked increase in the Danish LPUE for 2007 and 2008. This high LPUE level is likely to be a consequence of the national (Danish) management system introduced in 2007.

It has not been possible to explicitly incorporate 'technological creeping' in a further evaluation of the Danish effort data. However, since 2000 the Danish logbook data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/LPUE, e.g. vessel size (Figure 10.2.2.3).

Catch and effort data–FU4

Swedish total effort has been relatively stable over the period 1978–1990. 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 and 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 2020. A similar survey design has been applied for both national surveys: a fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in 3.a. VMS data from the Swedish and Danish fishery from 2010 were used (Figure 10.2.3.3) and are described in more detail in ICES (2011). The area estimates for each Subarea are defined in Table 10.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS (ICES 2013).

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in 3.a divided into subareas Figure 10.2.3.2 is shown in Table 10.2.3.1 and Figure 10.2.3.4.

In WK*NEPH (*2009), a number of bias sources were highlighted relating to the "counted" density from the TV surveys. These bias sources are not easily estimated and are largely based on expert opinion. For the *Nephrops* stock in 3.a, it is assumed that the largest source of perceived bias is the "edge effect", due to the relative large sizes of the burrow systems. The cumulative biases result in a correction factor to take the raw counts to absolute densities. The correction factor for

3.a was set to be 1.1, meaning that the raw TV survey is likely to overestimate *Nephrops* abundance by 10 %. TV survey results are presented as absolute values (i.e. the bias already taken into account).

FU	Area	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
3 and 4	Skagerrak and Kattegat	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 2020. Additional used information was trends in total combined (Denmark and Sweden) LPUE, and discards (numbers) as a proxy for recruitment during the period 1990–2020.

Combined relative effort declined slightly over the period 1990 to 2020 (Figure 10.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level but decreased slightly in 2020 (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	> F_{max}	$F_{35\%SpR}$	F_{max}	F_{max}
	F_{max} - $F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$	F_{max}
	< $F_{0.1}$	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Unknown	$F_{0.1}$	$F_{35\%SpR}$	$F_{35\%SpR}$
Stock size estimates	Variable	$F_{0.1}$	$F_{0.1}$	$F_{35\%}$
	Stable	$F_{0.1}$	$F_{35\%SpR}$	F_{max}
Knowledge of biological parameters	Poor	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Good	$F_{35\%SpR}$	$F_{35\%SpR}$	F_{max}
Fishery history	Stable spatially and temporally	$F_{35\%SpR}$	$F_{35\%SpR}$	F_{max}
	Sporadic	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Developing	$F_{0.1}$	$F_{35\%SpR}$	$F_{35\%SpR}$

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 2020 this corresponds to a TAC of 14512 tonnes. 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
F_{max}	6.8%	10.0%	7.9%
$F_{0.1}$	4.9%	7.6%	5.6%
$F_{35\%SpR}$	8.1%	12.9%	10.5%

The harvest 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):

Catch scenarios assuming recent discard rates

Basis	Total catch	Dead removals	Projected landings	Projected dead discards	Projected surviving discards	% harvest rate *	% advice change **
	PL + PDD + PSD	PL + PDD	PL	PDD	PSD	for PL+ PDD	
ICES advice basis							
MSY approach	14514	13896	12042	1854	618	7.9	-15.9
Other scenarios							
F = F_{MSY}	14514	13896	12042	1854	618	7.9	-15.9
F = $F_{MSY\ lower}$	10288	9850	8536	1314	438	5.6	-40
F = $F_{MSY\ upper}$ ***	14514	13896	12042	1854	618	7.9	-15.9
F= $F_{35\%SpR}$	19290	18469	16005	2464	821	10.5	11.8
F = F_{2020}	7083	6781	5876	905	302	3.9	-59

*** Calculated in numbers for dead removals.**

**** Advice basis values for 2022 relative to the 2021 advice values (17 255 tonnes).**

***** FMSY upper = FMSY for this stock.**

A summary of the results from the TV survey 2020 is presented in Table 10.2.3.1. The estimated abundance index was 0.304 resulting in a total abundance of 43797 million individuals. Total removals (landings + dead discards) were estimated to 146 million individuals resulting in a harvest rate of 3.9%.

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 over-exploitation 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

Estimating size composition for the Swedish creel and trawl fleets for 2020

From on-board sampling of size composition of catches, size distributions are raised to total landings. This is an important step of the stock assessment which builds on the combination of counts of individuals, and mean sizes of individuals in the population. The routine is that on-board sampling of catches is performed regularly for the Swedish and Danish trawling fleets, as well as for the Swedish creel fleet. The raising of size composition is done for the fleets separately. For German and Norwegian fleets, the combined size composition from Swedish and Danish fleets is raised to the landing.

Due to Covid-19 restrictions part of the on-board catch sampling programs could not be completed in 2020. The Danish on-board sampling program seem to have had a wider coverage (Table 10.1.1) and was deemed feasible for use in the 2021 assessment. However, observers were only able to join a very limited number of Swedish *Nephrops* fishing trips in both Skagerrak and Kattegat (Table 10.1.1).

Table 10.1.1. Number of observer trips on vessels targeting *Nephrops* in Skagerrak or Kattegat during 2020.

	Sweden				Denmark			
Quarter	2017	2018	2019	2020	2017	2018	2019	2020
1	15	16	11	13	20	30	25	15
2	16	14	16		20	32	27	25
3	16	15	13	1	30	30	40	29
4	13	14	15	2	17	15	21	10

Size data was available for the Swedish fleet for quarter 1 but not for the rest of the year. Available size data for other years was scrutinized to investigate if it could be applicable for 2020 circumstances and be used to make the necessary raising.

Size structure depending on discarding routines

Minimum landing size (MLS) for *Nephrops* in FU 3 and 4 was changed from 40 mmCL to 32 mmCL in 2016. However, discarding is still allowed above the MLS due to an exemption from the landing obligation because of high survival. This change in regulation hade very different effects on the Danish and the Swedish trawl fleets. The Danish fleet used to discard a large proportion of it catch but changed its discarding pattern after the change in regulation (Figure 10.1.1.a). The Swedish fleet also lowered its discard rate in 2016. Since 2018, however, the Swedish fleet discard large proportions of *Nephrops*, except in quarter 2, driven in large part by market prices (Figure 10.1.1.b.) 2018 and 2019 were the two years with most stable discard patterns for both Swedish and Danish fleets.

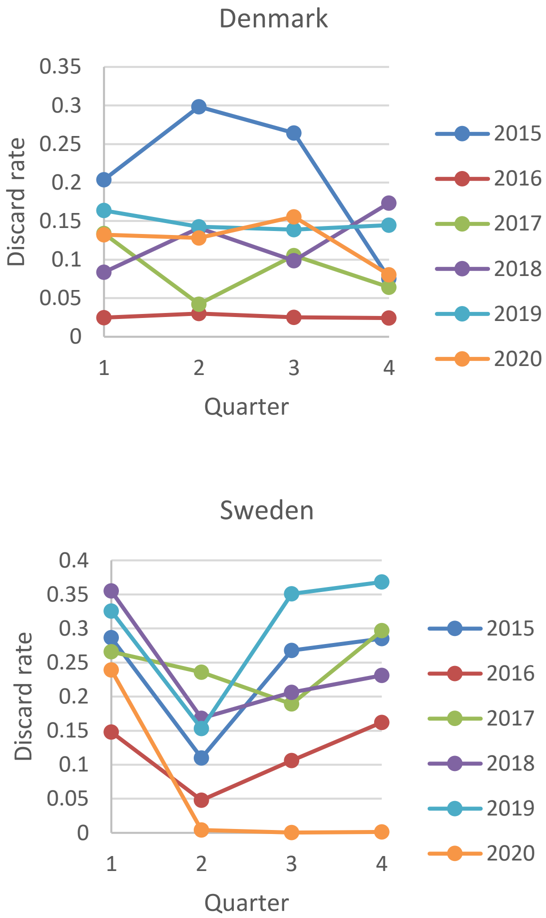


Figure 10.1.1. Discard rates by weight by quarter for the a) Danish and b) Swedish trawl fleets 2015–2020, as reported to Intercatch.

The following scenarios on how to pool data for the Swedish fleets were suggested:

1. Use only 2020 size data, for each fleet separately (default routine)
2. Use Danish data for 2020
3. Use Swedish data pooled for 2019–2020
4. Use Swedish data pooled for 2018–2020
5. Use Swedish data pooled for 2017–2020
6. Use relative discard rates DK:SE to transform Danish size data for 2020 to resemble Swedish size data.

For each scenario, the data were pooled and used to raise to the total landings. The size composition was used to calculate the average size of landed and discarded individuals and the total number of dead removals. These are the main components influencing the forecast and advice of the stock.

In order to perform scenario 6 relative discard rates had to be calculated. The fleets have different discarding patterns as described above (Figure 10.1.1). Discard rates by numbers can only be done for on-board samples, but comparing discard rates by weights can be done for both Intercatch reported landings and discards as well as for the on-board sampling. Discard rates by weight by quarter for on-board sampling of 2018–2019 (Figure 10.1.2) repeats the pattern of discards between the Danish and the Swedish trawl fleets seen in the Intercatch data.

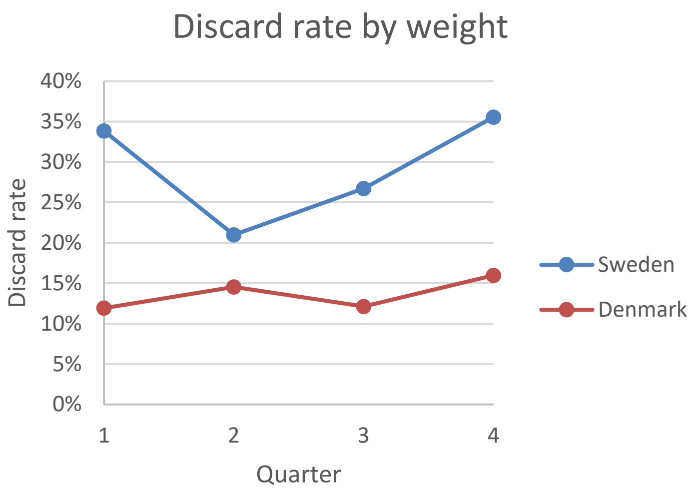


Figure 10.1.2. Discard rate by weight by quarter from on-board sampling of 2018–2019.

The on-board sampling data on counts of individuals was used to calculate the relative discard rate between the Danish fleet and the Swedish fleet simply by dividing the discard rate by quarter for the Swedish fleet with the discard rate by quarter for the Danish fleet. The proportion was then used to transform the numbers of discards per size class in the sampling of the Danish fleet to resemble the discard pattern of the Swedish fleet. The resulting size composition of each fleet was then used to raise sizes to the landings data in the default manner. The resulting parameters are given in Table 10.1.2.

Through this exercise and for all scenarios the generic raising procedure for the stock was maintained. The only change between scenarios were the assumptions of input sampling data to be used for raising.

Table 10.1.2. Raising factors by quarter for the transformation of size composition data from the Danish trawl fleet to the Swedish trawl fleet.

Quarter	Raising factor
1	2.32
2	1.09
3	1.69
4	1.65

Results on key parameters for the different scenarios are given in Table 10.1.3. The changes in parameters was generally small. All scenarios including Danish data for 2020 resembled each other, and the scenarios not including Danish data for 2020 resembled each other. Transforming Danish sampling data to resemble the Swedish trawl fleet discard pattern did not result in parameters similar to sampled data for the Swedish fleet from previous years.

Table 10.1.3. Resulting values of mean sizes, discard rate, Removals and other parameters following the scenarios on different assumptions on data used for calculations.

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year average	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year average	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year average	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

It was decided that Scenario 4 was the most feasible option for two main reasons. First, not any case involving the Danish sampled data (scenario 1, 2 and 6) resembled any of the cases with only Swedish data. Secondly 2018 and 2019 showed a stabilizing trend in discard pattern following the changed regulation of MLS in 2016 (Figures 10.1.1 and 10.1.2).

Thus, for the Swedish trawl and creel fleets separately, on-board sampling data was aggregated for 2018-2020 to reflect size composition of landings and discards in 2020.

Apart from 2020, 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 2019 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.

10.1.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the tenth year (2011–2020; new Subarea 7 only in 2014–2020 and new Subarea 9 in 2017 and 2019) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 10.2.4.4).

The average 2016–2020 harvest rate was estimated to be relatively low (3.3 % 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.

Table 10.1.4. Status of the stock traffic light plot given by Stock Assessment Graphs. Removed from Advice sheet in 2021.

	Fishing pressure				Stock size			
		2018	2019	2020		2018	2019	2020
Maximum sustainable yield	F_{MSY}	✓	✓	✓ Appropriate	MSY $B_{trigger}$	?	?	? Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	? Undefined	B_{pa},B_{lim}	?	?	? Unknown
Management plan	F_{MGT}	–	–	– Not applicable	B_{MGT}	–	–	– Not applicable

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 exemption of landing obligation for *Nephrops* in 3.a during 2016 to 2020.

Table 10.1.5. Definition of *Nephrops* Functional Units in Division 3.a and Subarea 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, 1981–2020.

Year	FU 3	FU 4	Total
1981	992	1728	2720
1982	1470	1828	3298
1983	2205	1472	3677
1984	2675	2036	4711
1985	2191	1798	3989
1986	2018	1807	3825
1987	2441	1605	4046
1988	2363	1364	3727
1989	2564	1313	3877
1990	2866	1475	4341
1991	2924	1304	4228
1992	1893	1012	2905
1993	2288	924	3212
1994	1981	893	2874
1995	2429	998	3427
1996	2695	1285	3980
1997	2612	1594	4206
1998	3248	1808	5056
1999	3194	1755	4949
2000	2894	1816	4710
2001	2282	1774	4056
2002	2977	1471	4448
2003	2126	1641	3767
2004	2312	1653	3965
2005	2546	1488	4034
2006	2392	1280	3672
2007	2771	1741	4512
2008	2851	2025	4876
2009	3004	1842	4846
2010	2938	2185	5123
2011	2511	1475	3986
2012	2536	1893	4429
2013	2147	1613	3760
2014	2856	1294	4150
2015	2123	1228	3350
2016	3238	1652	4890
2017	3129	2082	5211

Year	FU 3	FU 4	Total
2018	4222	2878	7100
2019	4625	3128	7753
2020	3367	2548	5915

Table 10.2.1.2. Division 3.a: Total *Nephrops* landings (tonnes) by country, 1991–2020.

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
2019	5697	112	1944	0	7753	1719	9472
2020	3977	124	1796	17	5915	683	6597

Table 10.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2020.

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
2019	3295	86	26	112	920	298	1217	0	4625
2020	2053	84	41	124	897	292	1190	0	3367

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 specialized *Nephrops* trawlers, 1991–2020. (* Include only *Nephrops* trawls with grid and square mesh codend+ Seltra traws).

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
2019*	287	224	12.7	22.5	17.6
2020*	275	215	12.0	22.9	17.9

Table 10.2.2.2 (cont'). *Nephrops* Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish specialized *Nephrops* trawlers, 1991–2020. (* Include only *Nephrops* trawls with grid and square mesh codend+ Seltra trawls).

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
2019*	847	662	23.7	35.8	28.0
2020*	851	665	23.7	35.9	28.0

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, 1991–2020.

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
2019	2666092	8980	8513	387
2020	2277212	7343	6842	300

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2020.

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
2019	32.5	31.8	42.1	41.7	38.8	38.5
2020	33.0	31.5	42.4	41.2	38.9	36.0

Table 10.2.2.5. *Nephrops* Kattegat (FU 4): Landings (tonnes) by country, 1991–2020.

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
2019	2401	694	33	726	0	3128
2020	1924	606	26	632	17	2574

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, 1991–2020 (* Include only specialized *Nephrops* trawls with grid and square mesh codend + Seltra trawls).

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
2019*	92	71	4.6	20.0	15.5
2020*	61	48	3.4	18.0	13.9

Table 10.2.2.6 (cont'). Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2020 (* Include only specialized *Nephrops* trawls with grid and square mesh codend + Seltra trawls).

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
2019*	760	589	20.0	38.0	29.4
2020*	682	528	20.0	34.1	26.4

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, 1991–2020.

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	2204244	12294	9035	243
2019	2477989	12294	9587	250
2020	2367713	11680	8977	214

Table 10.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991–2020. 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
2019	32.6	32.2	43.6	41.0	37.8	34.7
2020	32.9	32.6	42.7	40.2	39.6	36.7

Table 10.2.3.1. Summary output of the TV-survey in 3.a from 2020.

Subarea	**Area (km^2)**	**Number of stations**	**Absolute mean density**	**Population numbers (mill.)**
1	2575	30	0.275	707.833
2	1958	39	0.400	784.059
3	2613	37	0.297	775.086
4	962	12	0.356	342.272
5	996	19	0.425	423.662
6	1719	23	0.235	404.772
7	1295	13	0.122	157.362
8		5	0.084	
9	385	3	0.524	201.740
Total	12503	181	0.310	3796.786
			Harvest rate	0.0386
Removals 2020 (landings + dead discards**)				146.39

*** In millions**

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

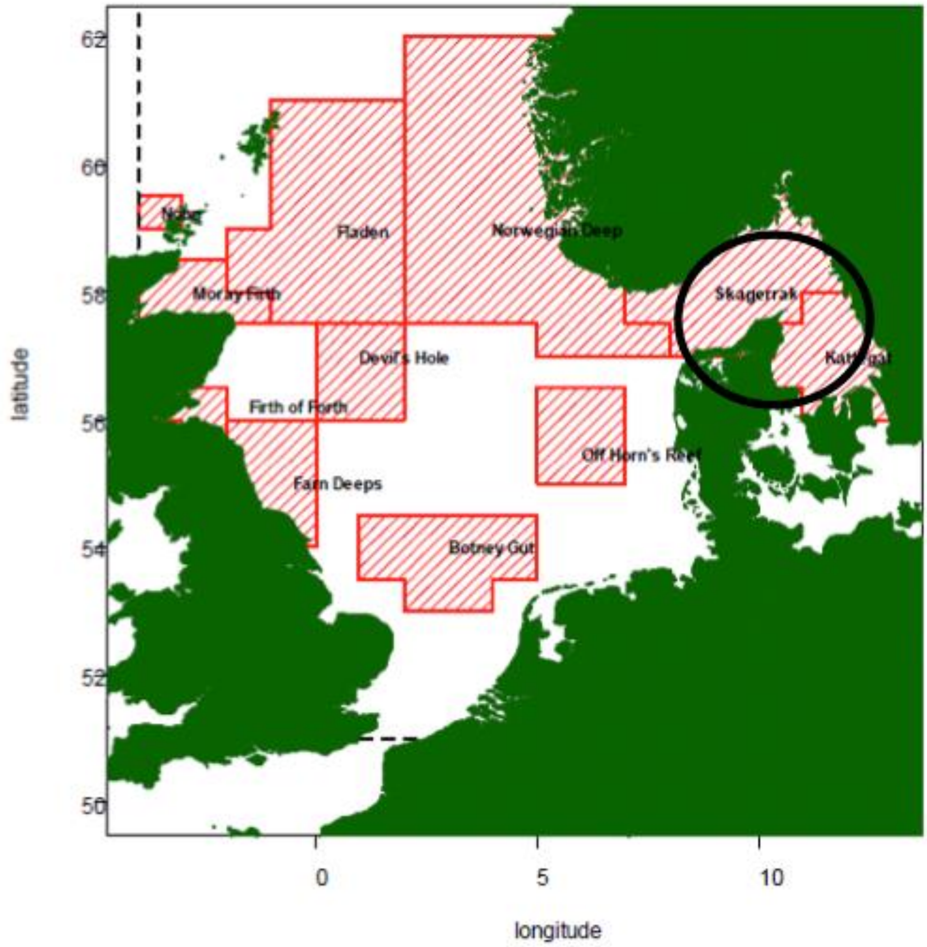


Figure 10.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

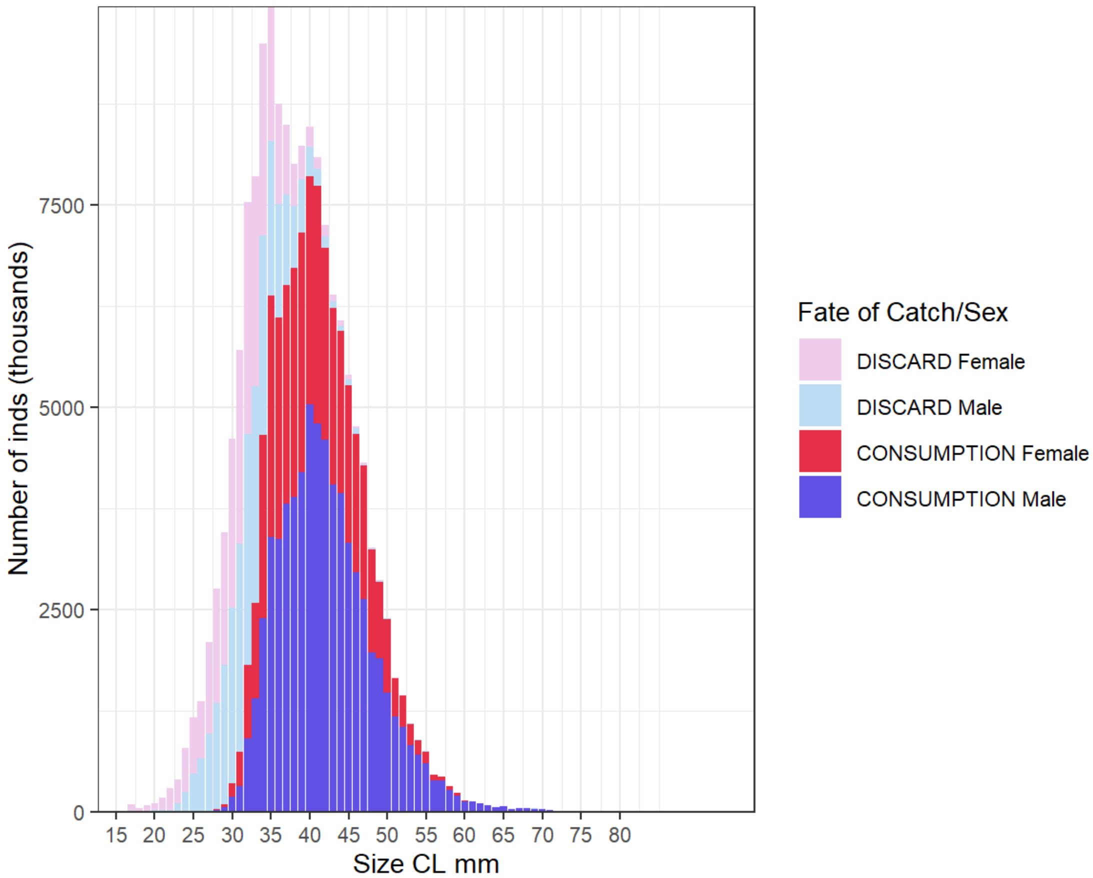


Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2020.

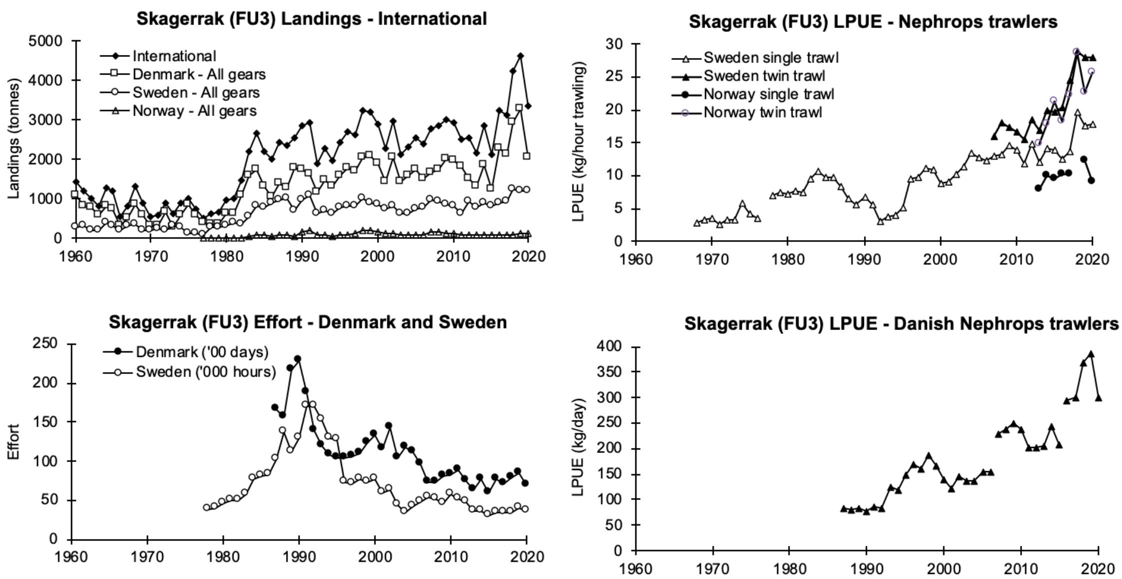


Figure 10.2.2.1. *Nephrops* Skagerrak (FU 3): Long-term trends in landings, effort, and LPUEs.

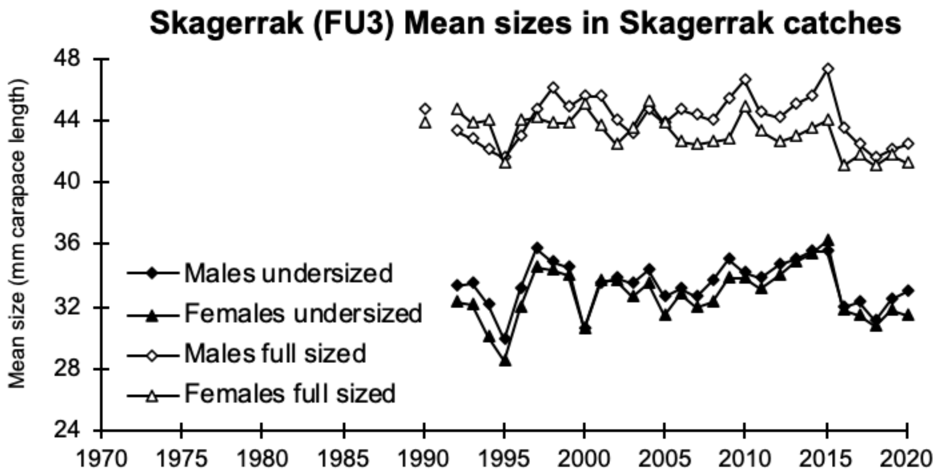


Figure 10.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

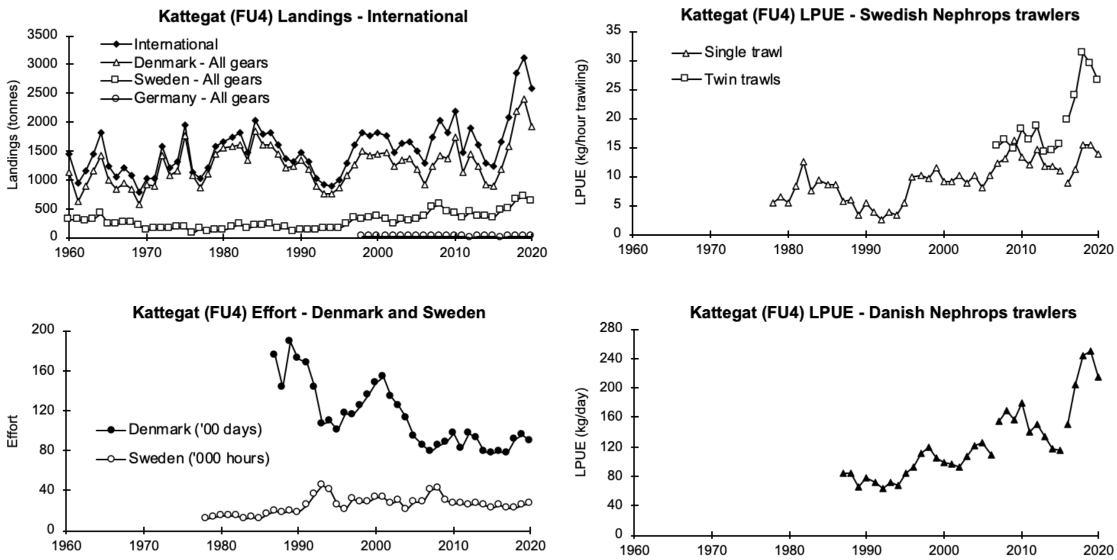


Figure 10.2.2.3. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort and LPUEs.**

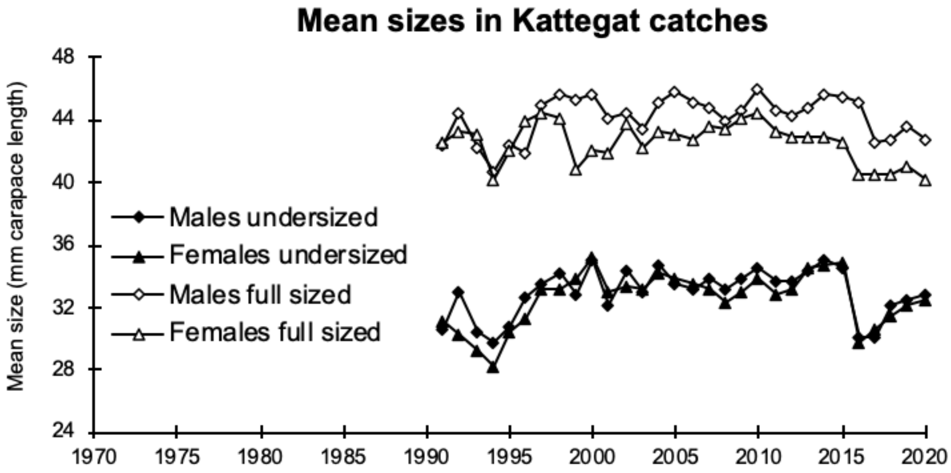


Figure 10.2.2.4. *Nephrops* in FU 4: Mean sizes in the catches.

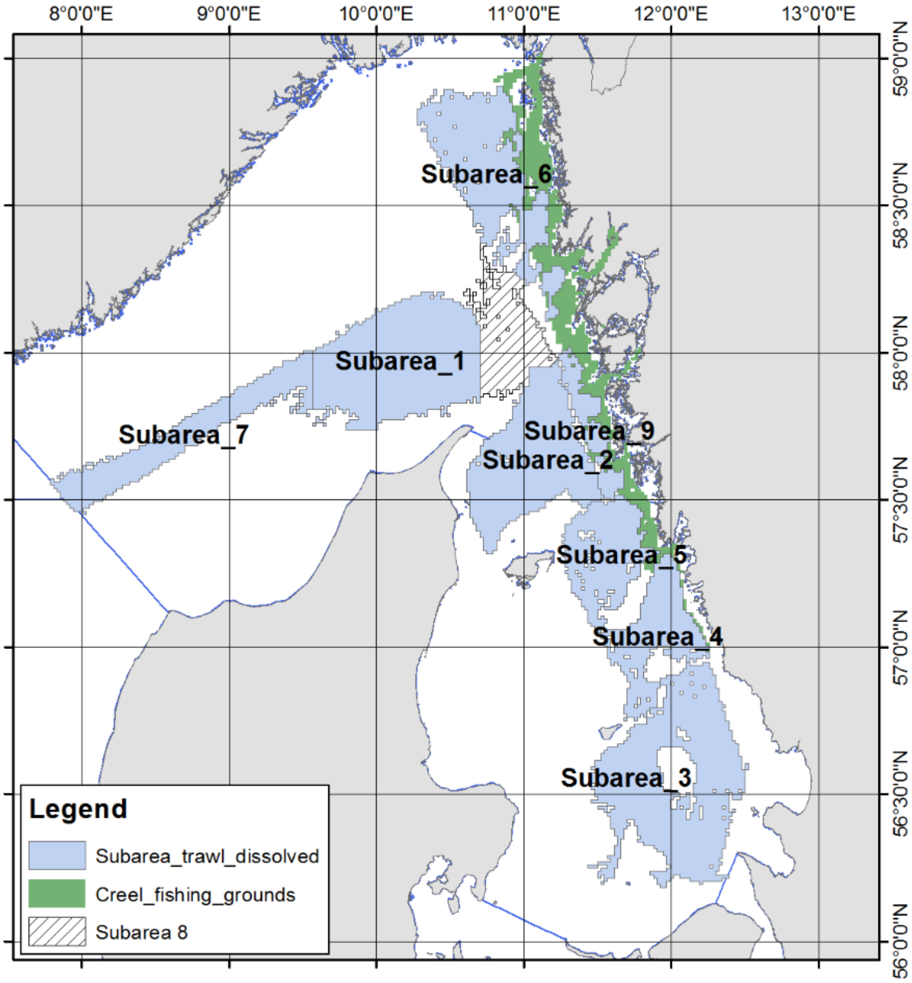


Figure 10.2.3.2. The defined subareas of the *Nephrops* stock in 3.a.

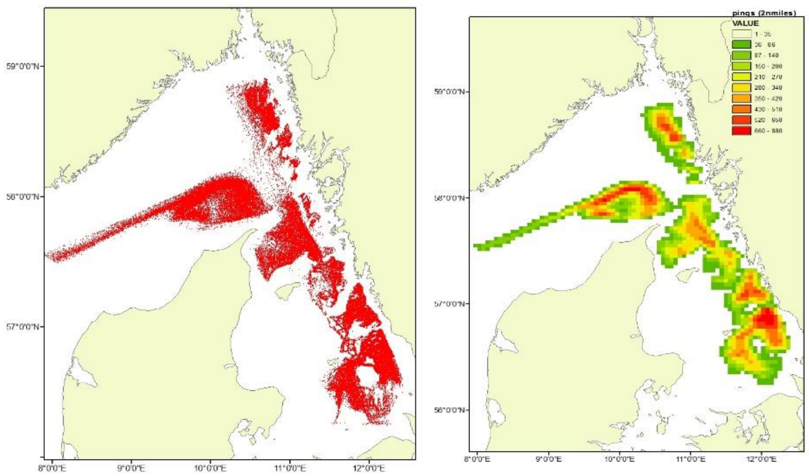


Figure 10.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

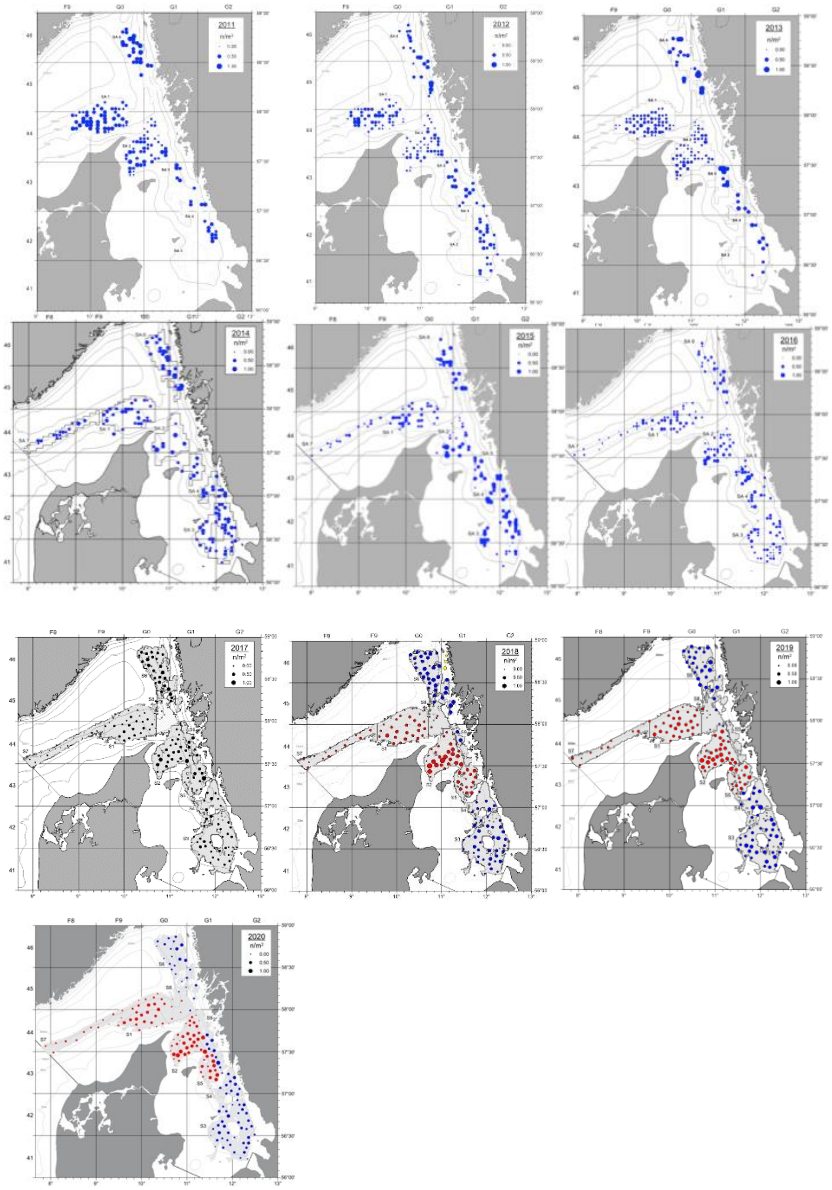


Figure 10.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations), 2016 (176 stations), in 2017 (171 stations), 2018 (177 stations), 2019 (173) and 2020 (176).

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

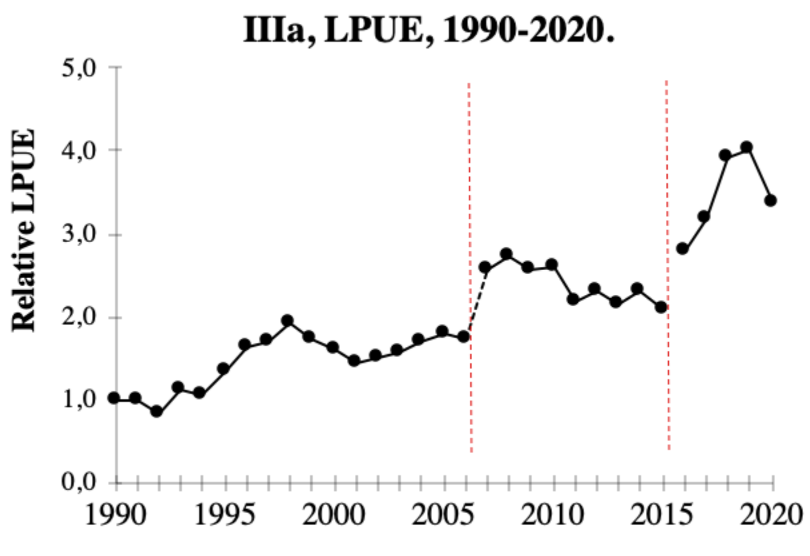


Figure 10.2.4.2 *Nephrops* in Area 3.a: Combined LPUE for FU 3 and 4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.

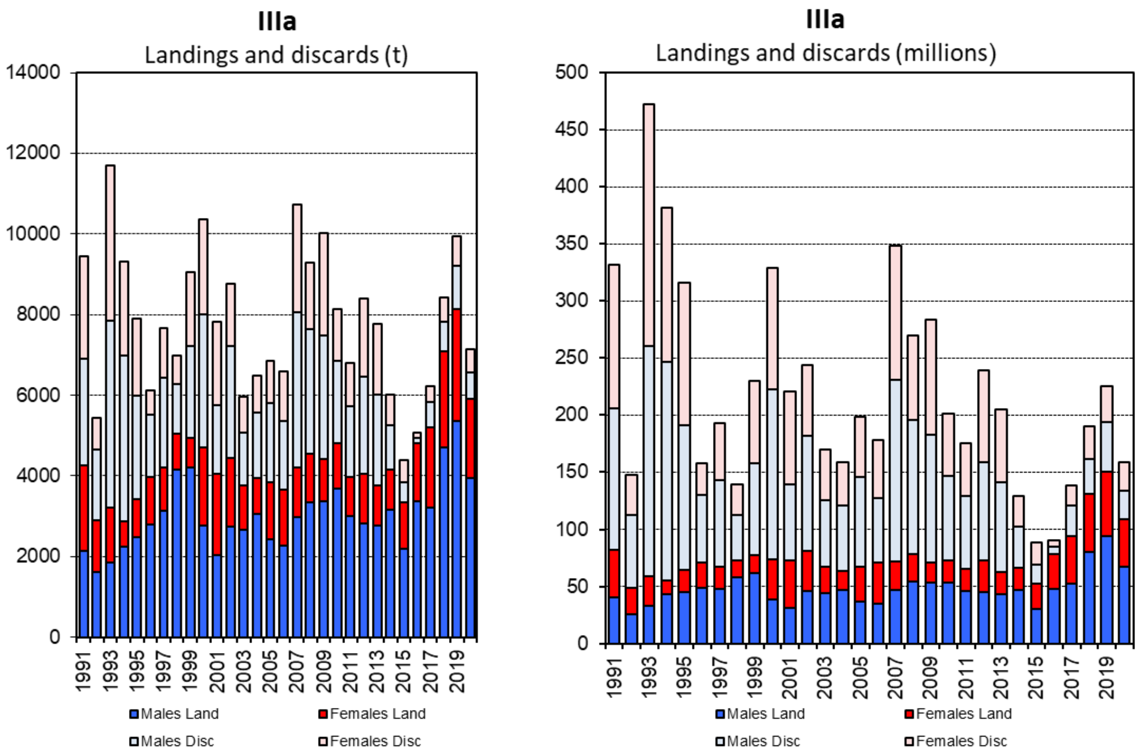


Figure 10.2.4.3. ***Nephrops*** **in 3.a: Catch by sex and size category in biomass and numbers.**

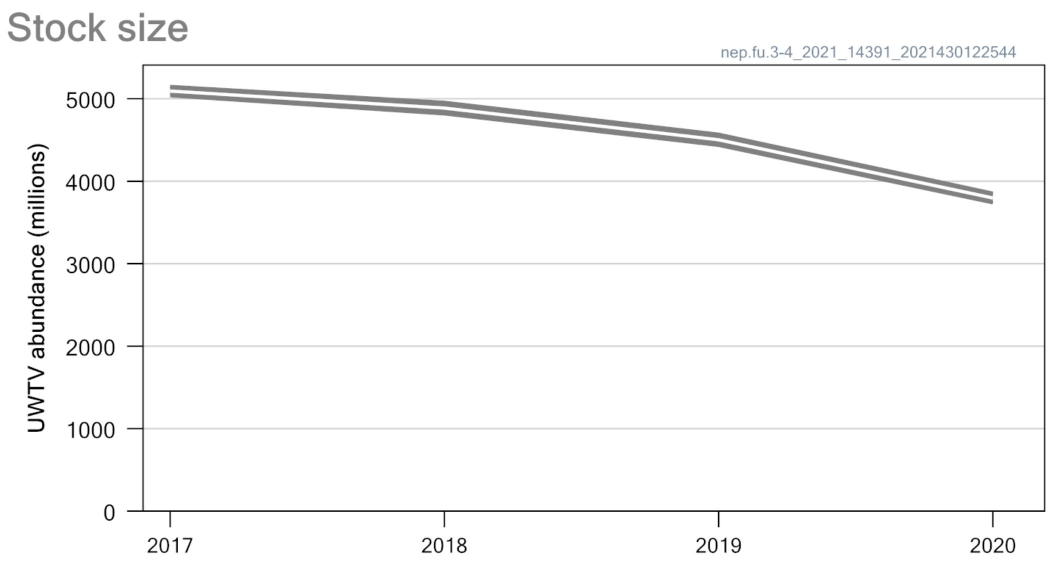


Figure 10.2.4.4. Mean abundance in 3.a by year: Error bars indicate the 95% confidence intervals.

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

The Section was added to the report in November 2021

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 and 2020, EC TAC, this was decreased to 22 103 tonnes in EC waters and 600 tonnes in Norwegian waters. For 2021 the EC TAC in Norwegian waters was further decreased to 200 tonnes.

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 and Sweden applied a national MLS of 40 mm up to 2015 but this was changed to 32 mm from 1 January 2016. Norway still has a MLS of 40 mm.

Days-at-sea regulations and recently introduced effort allocation schemes (kW*day) have reduced opportunities for directed whitefish fishing. STECF 2010 stated that the overall effort (kW*days) by demersal trawls, seines and beam trawls shows a substantial reduction since 2002. However, there have also been substantial changes in the usage of the different mesh size categories by the demersal trawls. In particular there has been a sharp reduction in usage of gears with a mesh size of between 100 mm and 119 mm (targeting whitefish), but only a gradual decline in the effort of *Nephrops* vessels (TR2).

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops,* the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70–99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double. 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 2020 are 13 687 tonnes (including 9 tonnes of BMS landings), 37% lower than in 2019 (21 808 tonnes), 4% higher than in 2018 (13 164 tonnes), and 44% lower than the peak observed in 2009 (24 597 tonnes). All countries except Sweden decreased their landings in 2020 compared to 2019. UK is the main producer country (reporting 83% of the total landings in 2020), followed by Netherlands (6.8%), Belgium (4.9%) and Denmark (2.3%).

Table 11.2.2 shows landings by FU as reported to the WG. The most productive functional units are 7 (41% of the total landings), followed by 6 (14%), 8 (13%) and 33 (9%). 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 531 tonnes in 2020.

11.3 Botney Cut (FU 5)

11.3.1 The fishery in 2019 and 2020

Nephrops Functional Unit 5 is an offshore stock that encompasses an area of 1850 km^2 in Division 27.4.b (Central North Sea) and Division 27.4.c (Southern North Sea).

There is no creeling in the area, and *Nephrops* are caught through trawling by five 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 the year, the main activity takes places during the summer.

The highest landings from FU 5 were reached in 2016, with a value on record of 2535 tonnes (Figure 11.3.1). The landings in 2017 were also high at 2109 tonnes, but decreased in 2018 to a more representative value of 1004 tonnes, primarily due to a 76% decrease in UK landings compared with 2017. In 2019, especially Dutch and German landings increased again, with total annual landings of 1172 tonnes. The total international landings in 2020 were 540 tonnes, the lowest recorded value since 1994, most likely due to the restrictions and reduced market during the Covid-19 pandemic.

ICES advice in 2018

FU 5 is assessed every two years, with the last advice given 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 landings

Landings by country for FU 5, including Belgium, Denmark, Germany, Netherlands, and the UK, are available since 1991 (Table 11.3.1 and Figure 11.3.1). Landings increased from around 800 tonnes in the early 1990s to around 1200 tonnes in the early 2000s, reaching 1443 tonnes in

2001. Then followed a period of general decline, with a low of 729 tonnes in 2009. From there, landings have increased again to over 2000 tonnes in 2016 and 2017. In 2018 and 2019, landings decreased again to more long-term representative values of 1004 and 1172 tonnes, respectively. Since then, landings have been uncharacteristically low due to the ongoing Covid-19 pandemic.

Between 1991 and 1995, the Belgian fleet took more than 75% of the international *Nephrops* landings from this functional unit. Since then, Belgian landings have declined drastically, and since 2006 there has been no directed *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, the Netherlands and the UK have accounted for most of the landings from this functional unit, the large increase in 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. Since 2017, the UK reduced their participation in the fishery, catching only 14% of the total landings in 2018, and 12% in 2019. The strong decline in landings in 2020 was mainly due to reduced landings by the Netherlands, Germany, and the UK, while Belgian landings remained the same at just over 190 tonnes.

Length composition

The length composition of landings by sex has been provided by The 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 intensity of the Dutch catch sampling programme is fairly low. Between 2005 and 2009, the average numbers measured in landings were > 10,000 individuals per year. However, the sampling measurements dropped to around 2500–3000 individuals per year since 2010. For the period 2015–2018, the number of 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.

Until the 2018 assessment, the sampling data from 2015 onwards were pooled and used to estimate the length composition of the total catch. However, during WGNSSK 2020, it was decided that, with the exception of 2015, the coverage of the samples is insufficient to raise landings and discards of unsampled strata, defined by gear type and quarter (see table below). This is either due to a small component of the total landings that are represented by the samples (as in 2016–2018), or by a small number of samples that represent a large component of the total sampled landings (as in 2019). For that reason, no discard rates or mean sizes were calculated for 2019.

***Nephrops* FU 5. Dutch landed weights (LWs) by gear type and quarter, for which length samples were taken in a given year, as absolute values in tonnes, or as percentage of the total annual Dutch landings. Also listed are the number of samples (NoS) and the landed weight per sample (LWpS) in percent of the total sampled landings.**

Sampled Landings	Fleet	OTB_CRU_70-99			OTB_DEF_70-99				TBB_DEF_70-99
	Quarter	2	3	4	1	2	3	4	1
2015 414 t of 681 t (60.8%)	LW [t]		324.3	11.5	14.3	16.1		48.2	
	LW [%]		47.6	1.7	2.1	2.4		7.1	
	NoS		7	1	2	2		3	
	LWpS [%]		11.2	2.8	1.7	1.9		3.9	
2016 21 t of 801 t (2.6%)	LW [t]					13.0	0.8	7.6	
	LW [%]					1.6	0.1	0.9	
	NoS					2	2	3	
	LWpS [%]					30.4	1.9	11.8	
2017 42 t of 745 t (5.7%)	LW [t]				15.6	14.0	2.3	10.3	
	LW [%]				2.1	1.9	0.3	1.4	
	NoS				3	8	1	4	
	LWpS [%]				12.3	4.2	5.5	6.1	
2018 9 t of 429 t (2.2%)	LW [t]					3.4			6.0
	LW [%]					0.8			1.4
	NoS					3			1
	LWpS [%]					12.1			63.6
2019 174 t of 551 t (31.5%)	LW [t]	157.8				6.2	9.8		
	LW [%]	28.6				1.1	1.8		
	NoS	1				3	4		
	LWpS [%]	90.8				1.1	1.4		

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. *Nephrops* directed effort is estimated by taking into account only TR2 gear, with a *Nephrops* catch component of ≥ 25%. The TR2 class is defined as containing Otter trawl gears (codes OT (unspecified), OTB (bottom trawls), OTT (twin trawls)), as well as *Nephrops* bottom trawls (TBN), with mesh sizes of 70–99 mm. On the basis of available data for this functional unit, effort is calculated for all English and Welsh vessels landing outside the UK, together with all UK vessels (including also Scottish and Northern Irish vessels) landing into England and Wales. Due to the lack of detailed information about *Nephrops* targeting vessels, the fleets of other nations are not considered for directed effort calculations. FU 5 is an offshore stock, and most of the vessels are greater than 15 m. The under-10 m fleet is completely absent in this fishing ground.

The relative contribution of UK landings to the total international landings has fluctuated over time and has generally decreased from the highest value of 53% in 2008, to the lowest value of 12% in 2019 (ignoring the unusual situation in 2020; Figure 11.3.2). To a large extent, these fluctuations have been mirrored by the number of UK trawlers that target *Nephrops* in FU 5.

Although an LPUE (tonnes per days fishing) estimate has been calculated for previous years, it was decided during WGNSSK 2020 that the UK landings component during recent years was not high enough to be able to calculate an LPUE measure that would be representative of the entire fleet targeting this functional unit.

UWTV survey

There were no new surveys in FU 5 since 2012. Details of the 2010 and 2012 surveys are given in the 2013 WGNSSK report.

11.3.3 InterCatch

The ICES InterCatch database has been used as the main data submission tool for *Nephrops* from 2011 onwards, whereby all countries participating in the fishery within a particular functional unit submit at least quarterly landings by fleet.

Annual discard data have been available since 2015 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 has been no data collection from the Belgian *Nephrops* landings. In addition, Netherlands has provided length distributions for landings and discards by fleet where available. However, as discussed in Section 11.3.2, contrary to previous years, during WGNSSK 2020, the overall raised length distribution for catch from Dutch sampling were deemed insufficient for the fishery as a whole. The raising procedure for landings and discards, as described in previous assessment reports, was therefore not carried out for this assessment.

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 that the length composition of catch is the same for all fleets, and the discard pattern (retention at length) is the same as in FU 6. Due to the lack of recent estimates of the stock size, the assessment also assumes that the stock density has not changed since the last UWTV survey in 2012.

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 generally decreased over time. Due to the small contribution of UK vessels to the total international landings, and in the absence of detailed information about the other national fleets, an LPUE estimate was not calculated for 2019. Similarly, a pooled length distribution was not determined for 2019, as the number of available length samples was poor and unlikely to be representative of the actual length profile of the catch.

Following the procedure outlined in Section 10.1.2, an estimate of all *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in this functional unit, and to 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 m^2. Estimating the harvest rate since then is associated with two main sources of uncertainty. One is the inevitable change in abundance, the other is the lack of adequate sampling data to establish reliable estimates of individual mean weights in landings. Therefore, to increase confidence in at least the qualitative evolution of recent harvest rates, three different scenarios were considered (Figure 11.3.3). For all three scenarios, the individual mean weights in landings and discards from 2015, the year with the best sampling data, were used. For the years 2017–2020, discard rates by number were calculated as three-year averages ending in a given year. In the first scenario, the abundance was assumed to be constant since 2012. In the second scenario, the abundance from FU 6 was used, scaled to the FU 5 abundance in 2012. In the third scenario, the abundance for the years 2017–2020 was assumed to be the FU 5 abundance minus the scaled standard deviation from FU 6 for the years 2012–2020. The scaling factor is the ratio of the abundances in the two functional units in 2012. Based on all three scenarios, the harvest rate has steadily declined since 2017. In 2020, it was between 1.7–3.1%, well below the MSY proxy of 7.5%.

11.3.6 Short term forecasts

The short term forecasts and the quota advice for this stock are updated every two years. Catch and landing predictions for 2021 and 2022 were estimated for WGNSSK 2020 and are given in the table below. This assumes that the absolute abundance estimate made in 2012 is relevant to the stock status for 2021 and 2022.

The ICES framework for category 4 Norway lobster stocks was applied. In the absence of a full analytical assessment, ICES bases its advice for Norway lobster on the most recent advice. Maximum sustainable yield (MSY) harvest rates estimated for other FUs vary between 7.5% and 16%. ICES uses the lower boundary as an upper limit for its advice on data-limited Norway lobster stocks. As long as the harvest rate is less than 7.5%, the default basis for advice is that catches can be increased gradually by applying the 20% uncertainty cap to the previous advice. The precautionary buffer was last applied in 2016. Stock size in relation to reference points is unknown. Therefore, the precautionary buffer has been applied this year. Applying this approach, catches in 2021 and 2022 should be no more than 1570 tonnes. This implies that landings should be no more than 1031 tonnes, assuming recent discard rates.

***Nephrops* FU 5. Catch options assuming discarding continues at recent average. All weights are in tonnes. Harvest rates in percent are calculated for a range of densities, with values above the MSY proxy of 7.5% highlighted in grey.**

Basis	Total Catch	Projected landings	Projected discards	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 (2010–2019)	1070	703	368	45.3%	22.7%	11.3%	7.6%	5.7%	4.5%	3.8%	3.2%	2.8%
0.5 x average landings (2017–2019)	1088	715	374	46.1%	23.1%	11.5%	7.7%	5.8%	4.6%	3.8%	3.3%	2.9%
(Advice 2018 +20% cap) −20% buffer	1570	1031	539	66.6%	33.3%	16.6%	11.1%	8.3%	6.7%	5.5%	4.8%	4.2%
Advice 2018	1636	1074	562	69.3%	34.7%	17.3%	11.6%	8.7%	6.9%	5.8%	5.0%	4.3%
Advice 2018 +20%	1963	1289	674	83.2%	41.6%	20.8%	13.9%	10.4%	8.3%	6.9%	5.9%	5.2%
Average landings (2010–2019)	2140	1405	735	90.7%	45.3%	22.7%	15.1%	11.3%	9.1%	7.6%	6.5%	5.7%
Average landings (2017–2019)	2177	1429	748		46.1%	23.1%	15.4%	11.5%	9.2%	7.7%	6.6%	5.8%
MSY proxy harvest rate	2478	1627	851		52.5%	26.3%	17.5%	13.1%	10.5%	8.8%	7.5%	6.6%
Average landings (2010–2019) +20%	2568	1686	882		54.4%	27.2%	18.1%	13.6%	10.9%	9.1%	7.8%	6.8%
Maximum landings	3861	2535	1326		81.8%	40.9%	27.3%	20.5%	16.4%	13.6%	11.7%	10.2%

*** Density assumed for this stock.**

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 assessing stock development, the exploitation of this stock should be monitored closely.

11.4 Farn Deeps (FU 6)

11.4.1 Fishery in 2019 and 2020

Nephrops Functional Unit 6 is situated in Division 27.4.b (Central North Sea), off the northeast coast of England.

Since the beginning of the time-series, the UK fleet has accounted for virtually all landings (≥ 98%) from the Farn Deeps (Table 11.4.1 and Figure 11.4.1). The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March. The most recent 2020 data therefore comprise the end of the 2019–2020 fishery and the start of the 2020–2021 fishery.

The total international landings in 2020 were 1912 tonnes, significantly lower than the unusually high landings of 4364 tonnes in 2019, and within the range of landings during the 2016–2018 period (Table 11.4.1 and Figure 11.4.1). While the combined relative contribution to total international landings from English, Welsh, and Northern Irish vessels has increased from 79% in 2019 to 86% in 2020, the contribution from Scottish vessels has decreased from 20% to 12%.

The discard rate (estimated as percentage of biomass), has increased from 5.0% in 2019 to 7.8% in 2020, and is the highest since 2016. However, as described in Section 11.4.4, there is a greater uncertainty around the estimation of discards in 2020, due to the reduced sampling at sea during quarters two to four.

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 updated advice in November 2020

"ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1991 tonnes and 2310 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that 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 2020 assessment

"The forecast has been performed correctly with no deviations from the standard procedure for this stock."

11.4.3 Data available

Catch, effort and research vessel data

Three types of sampling occur on this stock: landings, catch, and discard, providing information on size distribution and sex ratio. The sampling intensity is considered to be generally good, although concern 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 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). A fixed discard ogive on the catch length distributions has therefore been used 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 functional unit.

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. 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 11.4.2). Additionally, the mean annual increment of the larger female mode of around 2 mm is considerably lower than the annual growth that would be expected based on the growth parameters available for this stock. A high year class strength is therefore unlikely to be the cause of this phenomenon. The predominance of large females in the catches means they were foraging for food, at a time when they would be expected to be brooding 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 high abundance observed in the UWTV survey in 2018 and 2019 (continuing the increase since 2015), 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 carapace length of large females (≥ 35 mm) in the landings have gradually increased over the period 2000–2017 (Figure 11.4.1). Since 2017, the mean length of large females as declined again. For large males, the mean length increased over the period 2002–2013, and has generally decreased since. The mean lengths of small females and males (< 35 mm) in the landings do not show any clear temporal pattern.

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 resulted in a noticeable change in the level of reported metrics. A comparison between the periods before and since 2006 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 Northern Irish vessels. The total number of vessels in the fishery (which land into England and Wales) has fluctuated between ~100 and ~250 since 2006 (Figure 11.4.4), but overall the fleet size had been declining until 2018. A temporary increase in 2019, resulting in more than doubling of the landings of the previous year, was then followed by a decline in the active fleet size in 2020, back to the 2018 level. 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 and Northern Ireland for the period between 2011–2014, and again in 2019. In contrast, the size fleet for the 10–15 m sector has remained fairly constant since 2006, with the exception of a temporary increase in the number of active Scottish vessels in 2019. The size of the under-10 m sector has generally declined since 2006.

Directed effort is calculated taking into account only TR2 gear, with a *Nephrops* catch component of ≥ 25%. The TR2 class is defined as containing Otter trawl gears (codes OT (unspecified), OTB (bottom trawls), OTT (twin trawls)), as well as *Nephrops* bottom trawls (TBN), with mesh sizes of 70–99 mm. On the basis of available data for this functional unit, effort is calculated for all English and Welsh vessels landing outside the UK, together with all UK vessels (including also Scottish and Northern Irish vessels) landing into England and Wales. The unit of fishing effort is kWd.

Fishing effort calculated in this fashion for vessels ≤ 15 m has been fairly consistent since 2006. The main changes in total landings – including the sharp decline between 2006–2008, the intermittently high values in 2012–2014, and the high value in 2019 – were driven primarily by fluctuations in the fishing effort of the > 15 m fleet (Figure 11.4.1). Directed effort is highest in quarters one and four, without a consistent relative fishing intensity between these quarters (Figure 11.4.5). A notable exception is the relatively high effort in the summer of 2016. Landings per unit effort (LPUE) of males tend to be highest during the winter months, whereas LPUE of females is typically highest in quarter three.

The use of LPUE as an index of stock abundance for *Nephrops* is confounded by changes in availability of *Nephrops* to fishing gears, depending upon environmental factors such as tide and light levels, plus changes to emergence behaviour induced by mating and predator avoidance. Therefore, the temporal trend of LPUE can only be used as an indicator of trends of abundance, if the catchability of *Nephrops* is assumed to be constant over the years.

LPUE for the entire directed *Nephrops* fleet, as defined above, has fluctuated between 0.6–1.0 kg/kWd since 2006, and has generally decreased since 2013 (Table 11.4.3).

Traditionally, males tend to predominate the landings, averaging about 70% (with a range of 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 (in catches by number) for Farn Deeps *Nephrops* since the winter of 2005. Prior to this, the ratios were generally steady, with small (~10%) seasonal fluctuations. Since then, there have been significant interannual swings, with whole years being dominated by landings of females (2006, 2010, 2013–2014, Figure 11.4.6). 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). However, in 2019, for the first time since 2013, a larger number of females was caught in the fourth quarter, followed by an even larger proportion in the first quarter of 2020. Due to the poor sampling situation during the remaining part of 2020, sex-ratios in landings beyond quarter one could not be determined.

UWTV

Underwater TV (UWTV) 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 11.4.7 and Table 11.4.4. The procedure used to work up the UWTV 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 biased the estimate upwards. In addition, the distance covered by the UWTV 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 the determination of a considerably more robust estimate of viewed distance. The abundance estimate is now obtained through a geostatistical procedure, in which the burrow density estimates are first fitted by a semi-variogram model. Then, an interpolated surface of burrow density is created using Kriging on a 500 m by 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. From 2008 to 2015, the abundance gradually declined, attaining the lowest value of 578 million in 2015. The UWTV 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. From 2015 until 2019, mean density and total abundance have increased again, with values of 0.37 individuals per m^2, and 1163 million individuals in 2019 (±26 million 95% CI). However, the latest UWTV surveys in July 2020 and May 2021 indicate that total abundance has decreased. In 2021, it was 982 million individuals (±22 million 95% CI), with a density of 0.31 individuals per m^2. The spatial pattern of burrow density is similar through time with the highest density ground running along the western edge of the mud-patch (Figure 11.4.8).

11.4.4 InterCatch

In 2020, landings data by fleet were provided via the ICES InterCatch database by England, Scotland, and the Netherlands. Discard data were provided by England and Scotland. Length distributions for landings and discards by fleet and quarter were provided by England and Scotland. England reported 463 kg of BMS landings.

As in previous years, unreported discards for the reported landings were calculated in InterCatch based on the UK discard ratios. Following this procedure, initially 116 tonnes of discards (32% of the reported plus calculated total) were raised. However, closer inspection of the InterCatch data revealed that the annual discard rate in 2020 was biased primarily towards quarter one, due to the complete absence of reported discards in quarters two and three. Discarding in 2019 was also uncharacteristic in that it did not show the clear and consistent seasonal cycle that the discard rate followed during the years 2016–2018, with highest values in quarter one, a sharp decline in quarters two and three, and an increase again in quarter four. Assuming that discarding in 2020 followed a typical seasonal cycle, raised discards were recalculated based on quarterly average discard rates of the 2016–2018 period, scaled to the discard rate in quarter one of 2020. This reduced the raised amount of discards to 60 tonnes (19% of the reported plus calculated total), primarily due to lower calculated discards in quarters two and three.

The length distributions imported by England and Scotland represented 69% of the landings, which is lower than usual (80–92% in 2012–2016, 2019), but higher than in 2017 (66%), and only slightly below the sampled proportion in 2018 (70%). All reported discards were sampled. Length frequencies for unsampled landings, or strata without reported discards, were generated from the pooled sampling data. Strata are defined by quarter and metier.

11.4.5 Biological parameters

Biological parameter values, such as natural mortality and maturity at age, are included in the Stock Annex which was updated at the 2013 benchmark.

11.4.6 Exploratory analyses of RV data

A comprehensive review of the use of UWTV 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 UWTV 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 UWTV survey from the assessment year is assumed to be representative of the fishing opportunities for the forecast year. Whilst the main ICES assessment is completed in April to May, the UWTV survey for FU 6 is typically undertaken between late May and July. This means that the initial assessment and advice relies upon the UWTV survey from almost two years ago, although both the assessment and advice are usually updated for the revised advice in the autumn. The validity of using the UWTV survey to determine advice for the following year was explored by looking at how the UWTV survey predicts metrics such as catch rate and landings in the following year. Significant relationships exist between UWTV abundances and LPUE, Effort and Landings in the following year (Figure 11.4.9), whereas there are no significant relationships when using the UWTV survey in the same year as the fishery metrics. This suggests that, for FU 6, the UWTV survey is a valid predictor of fishery activity the following year.

Final Assessment

The estimated abundance in 2021 was 982 million individuals (±22 million 95% CI, Table 11.4.4), an 11% decrease from 2020, but still above the 2007 estimate of 858 million, which is used as MSY $B_{trigger}$. The estimated harvest rate for 2020 was 9.1% (Table 11.4.5), a significant decrease from 16.2% in 2019, but still above the MSY proxy level of 8.1%.

11.4.7 Historical stock trends.

The time series of UWTV surveys is 20 consecutive years although the new geostatistical method has only been applied retrospectively to 2007. Whilst a small over-estimation of abundance using the previous technique is expected, it is likely that the reduction in stock abundance observed between the two periods of estimation procedure is real.

Estimates of historical harvest rate (the proportion of the stock which is removed) range from 5.9% in 2008 to 24.3% in 2006 (Table 11.4.5, Figure 11.4.10). The harvest rate jumped from around 11% in 2004–2005 to the historical maximum in 2006, when the new reporting legislation came into effect. Since 2001, the harvest rate has only been below the MSY level once, during the historical minimum in 2008.

11.4.8 MSY considerations

Considerations for setting harvest rates 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 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 ratio in the catches has fluctuated widely between 2005 and 2014, with periods of high female catch ratios during the winter. This might be due to sperm limitation or ovary resorption, leading to more mature but unfertilised females becoming available to the fishery.
- Although the time series of observed harvest rates is relatively short, there has been a fair degree of fluctuation (6–24%). The observed harvest rate is, of course, confounded by the change in reporting levels considered to have occurred around 2006.

The following table shows the mean F, implied harvest rate and resulting spawner per recruit values (expressed as percentage of a virgin stock) for the range of F_{MSY} proxies suggested for *Nephrops*. 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 2010–2014 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 (SpR)	
		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 be the harvest rate equivalent to F35% on males for this stock (8.1%).

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

11.4.9 Short term forecasts

Catch and landing predictions for 2022 are given in the table below. This assumes that the absolute abundance estimate from May 2021 is relevant to the stock status for 2022.

In November 2016, ICES advised on fishing opportunities assuming that discarding would only occur below the minimum conservation reference size (MCRS). Observations from the fishery since then indicate that discarding above the MCRS continues, and practices have not changed markedly (Figure 11.4.3). Consequently, ICES has provided advice based on average discard rates observed over the last three years, which is considered to be a more realistic assumption than zero discards above MCRS. A table with the catch and landing predictions assuming zero discards is also presented for comparison.

A deviation from the normal procedure was agreed during WGNSSK 2021, to address the reduced sampling level in quarters two to four of 2020 due to Covid-19 restrictions. For *Nephrops* stocks, the adopted procedure calculates the average mean individual weights in landings and discards during the period 2017–2019, scaled such that the quarter one values of the three-year reference period are identical to those in quarter one of 2020. As described in Section 11.4.4, in FU 6, the commercial activity in 2019 was unusual not only by the magnitude of annual landings, but also by uncharacteristically high discard rates by weight in quarters two and three. As the unusual discarding practice in 2019 might have affected the length sampling for FU 6, in contrast with the other *Nephrops* stocks, it was decided to calculate averages for the reference period 2016–2018 and scale those to quarter one values in 2020. As usual, discard rates by number were calculated from landed and discarded numbers, given by the total landed and discarded weights divided by the respective mean individual weights.

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 2022 that correspond to the F ranges in the EU multi-annual plan (MAP) for the North Sea are between 1673 tonnes and 1940 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	982 million individuals	UWTV 2021
Mean weight in projected landings	26.90 g	Average 2018–2020
Mean weight in projected discards	11.55 g	Average 2018–2020
Projected discard rate (total)	22.0%	Average 2018–2020 (percentage by number)
Discard survival rate	15.0%	Percentage by number (only applies in scenarios where discarding is allowed)
Dead projected discard ratio	19.3%	Percentage by number, calculated from total discard rate and discard survival rate (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	Projected landings	Projected dead discards	Projected surviving discards	Harvest rate*
	PL + PDD + PSD	PL+PDD	PL	PDD	PSD	for PL+PDD
Fmsy Lower	1673	1646	1492	153	27	7.0%
F0.1 Male	1699	1671	1516	156	27	7.1%
Fmsy	1940	1909	1731	178	31	8.1%
F35% Male	1940	1909	1731	178	31	8.1%
Fmsy Upper	1940	1909	1731	178	31	8.1%
F0.1 Combined	2074	2040	1850	190	34	8.7%
F_{final} (2020)	2180	2145	1945	200	35	9.1%
F35% Combined	2662	2619	2375	244	43	11.1%
Fcurrent(2018-2020)	2701	2657	2410	247	44	11.3%
Fmax Male	2772	2727	2473	254	45	11.6%
F0.1 Female	3350	3296	2989	307	54	14.0%
F35% Female	3630	3571	3238	332	59	15.2%
Fmax Combined	3656	3597	3262	335	59	15.3%
Fmax Female	5161	5078	4605	473	83	21.6%

Catch options assuming zero discard rates

Basis	Total catch	Projected landings	Projected discards **	Harvest rate *
Fmsy Lower	1617	1443	174	7.0%
F0.1 Male	1643	1466	177	7.1%
Fmsy	1876	1674	202	8.1%
F35% Male	1876	1674	202	8.1%
Fmsy Upper	1876	1674	202	8.1%
F0.1 Combined	2006	1790	216	8.7%
F_{final} (2020)	2108	1881	227	9.1%
F35% Combined	2574	2297	277	11.1%
Fcurrent(2018-2020)	2612	2330	281	11.3%
Fmax Male	2680	2392	289	11.6%
F0.1 Female	3240	2890	349	14.0%
F35% Female	3510	3132	378	15.2%
Fmax Combined	3535	3154	381	15.3%
Fmax Female	4991	4453	538	21.6%

*** Calculated for dead removals.**

**** Represents the amount that otherwise would have been discarded but is now landed under the landing obligation.**

11.4.10 BRPs

Suggestions for proxies of biological reference points are shown in the catch option table and discussed in 11.4.8.

11.4.11 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 tonnes 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.

Normally, 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 vessel observer sampling programme are also normally considered robust. However, the unusual situation in 2020 resulted in missing sampling data in quarters two to four. These data gaps have been filled in according to the procedure described in Section 11.4.9. The impact on the assessment due to missing sampling data is unknown.

The UWTV survey in this area has a high density of survey stations compared to other 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 2021 survey abundance continues the pattern observed in other years, with the spine of high density on the western edge of the ground remaining a regular feature.

11.4.12 Status of stock

The 2019 UWTV survey indicates that the size of the stock has increased from 2018, followed by a decrease in 2020 and 2021. The abundance remains above the MSY $B_{trigger.}$ The harvest rate, estimated as the proportion of the stock that has been fished (including dead discards), significantly increased from 2018 to 2019. Although in 2020 the harvest rate decreased again to between the values of 2017–2018, it remains above the $F_{MSYtrigger}$.

The abundance indicates that the status of the stock since 2019 has been better than during the 2007–2018 period. This improvement is probably due to strong recruitment. However, since recruitment is affected by many environmental factors in addition to fishing, it is highly variable and could decrease again in the coming years.

11.4.13 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. Only insignificant amounts of *Nephrops* (463 kg in 2020, on the order of one permille of the reported discards) were recorded as below MCRS (BMS category) in FU 6, despite catches having been observed below the MCRS.

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 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 2020

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (total landings of 5543 tonnes in 2020), with Denmark taking 18 tonnes, and England 2 tonnes (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. Some vessels spent time fishing in the Farne Deeps (FU 6) and Devil's Hole (FU 34). The Covid-19 pandemic had a significant impact in the 2020 Nephrops fishing season with vessels having to deal with strict requirements from shellfish processors (buyers) in terms of amounts landed, grade sizes and demand abroad. In May 2020 there was an industry led tie up scheme to stabilise market prices for *Nephrops* and demersal fish (the *Nephrops* sector were compliant with the tie up scheme). 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/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 larger mesh sizes 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 2020

The ICES advice in 2020 (for 2021) (Single-stock exploitation boundaries) was as follows:

MSY approach

"*ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the MAP are between 8430 tonnes and 9579 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.*

To ensure that the stock in Functional Unit (FU) 7 is exploited sustainably, management should be implemented at the functional unit level. The catch in FU 7 has been lower than advised in recent years, 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. Historically most *Nephrops* vessels used to operate TR2 gears (≥ 70 and < 100 mm) which were 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 2021

The assessment of *Nephrops* in 2021 is based on examining trends in the UWTV survey data (1992–2021) 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 2021 followed the process of 2020, 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.

It was decided by ICES prior to the 2021 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. The assessment presented in this report was concluded in October 2021 and incorporates the most recent *Nephrops* UWTV survey (2021).

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 2020 were 5543 tonnes (38% decrease in comparison with the 2019 total), consisting mostly of Scottish landings with 20 tonnes landed by other countries (England and Denmark). *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) or logbook registered discards were reported for FU 7 in 2020.

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 2020 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 (2007–2018) shown in Figure 11.5.8. In this period, a decreasing number of trips have been taking place in FU 7 and since 2015, the south of the ground was the area where most fishing took place (no VMS data for 2019–2020 was analysed at the time of the WG meeting). In 2020 there was a slight decrease in effort 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 2019, the Scottish LPUE increased markedly and is currently at a similar level to that observed in the late 2010s. Danish LPUE data (1991–2020) 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. In 2020, the Danish LPUE showed an increase. This is in agreement with the trend observed in the Scottish LPUE which also seems to support a higher availability of *Nephrops* in the Fladen grounds.

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 male percentages in catches (by number) have varied between 40–80%. In 2013–2016 the male proportion in quarter 2 was higher than previously observed. This may have been 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 was 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. In 2020 due to the Covid-19 pandemic and the suspension of the on-board observer programme, discards were only sampled in quarters 1 and 4. The discarding rate average from 2000 is approximately 6% by number in this FU. From 2011 to 2016, discard rates dropped below the long-term average and were 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). From 2017 catches increased in FU 7 but discarding remained at a relatively low level. The discard rate in 2020 was estimated at 1.4% by number.

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 2020 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 2021 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. In 2020 there were only discard data imported for quarters 1 and 4. Discard rates and allocations for length frequencies in quarters 2 and 3 were all based in the available data for quarters 1 and 4. No BMS or logbook registered discard data were reported for this FU in 2020. Since 2017, observer sampling from the Scottish-Science observer sampling scheme was extended to include *Nephrops* catches in FU 7. In 2020, all quarter 4 sampling data available for this FU were collected by industry observers.

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 2020. 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 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 2020, length distributions were generally similar to 2017–2019 for males while there was an increase in the relative number of large females and a slight shift in the female length distributions to the right. In 2018 and 2020, a second peak (mode) was detected in the length distribution of females, implying possibly a large cohort moving through the population. Figure 11.5.1 and Table 11.5.4 show the series of mean sizes of larger *Nephrops* (>35 mm) in the landings. This parameter might be expected to reduce in size if overexploitation were taking place but there is no evidence of this. The mean size of smaller animals (<35 mm) in the catch is fairly stable through time until 2010 when an increase is noticeable which may be associated with lower recruitments combined with the increasing use of more selective gears. In 2017, the mean size in catches <35 mm decreased sharply followed by an increase in 2018–2020 and is now around 31 mm CL for females and 32 mm CL for males. The discard rate in 2020 was estimated to have decreased from the 2017 high value (4.4%) and is now 1.4% by number. Quantitative information on trends in gear changes is not currently available but a shift from TR2 to TR1 gears was observed from 2010. No major gear changes were noted in recent years suggesting the current 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 (1990–2020) 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 2020, the mean weight in landings increased from 28.3 g to 35.3 g and is now similar to the values observed in the early 2010's.

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 66 stations have been considered valid each year. There were 61 stations completed in the 2020 survey and 70 stations in 2021. 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 (2016–2021) with the size of the symbol reflecting the *Nephrops* burrow density. The abundance in 2021 increased 38% from 2020. 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 (U6028), 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 decade. 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 2009–2021 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 fluctuations 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 observed in the period 2011–2015 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 on average higher than those in the north. The density increase recorded from 2016 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) and medium coarse (MC) sediments 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 misidentification 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 increased 38% in 2021. The stock is above the average abundance over the time series and is well above the biomass trigger. The harvest ratio in 2020 (3.7%, calculated as dead removals/TV abundance) is 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 markedly in 2019 and is approximately at the same high level as recorded in 2011–2012. The low LPUEs observed prior to 2006 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 decreased in 2017. This suggests a period of lower recruitment between 2010 and 2015 followed by a strong recruitment event in 2016–2017. In 2019–2020, the observed recruitment pulse seems to be moving up in the length distributions as suggested by a decrease in the discard rate and an increase in the mean sizes of catches below 35 mm CL from 2017.

Historical Stock trends

The UWTV survey estimates of abundance for *Nephrops* in FU 7 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 2021, the abundance remains at a relatively high level estimated to be 6336 million (Table 11.5.8).

Table 11.5.8 also shows the estimated harvest ratios from 1992–2020. 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 2020, landings and abundance fell by 38% and 25% respectively, as such, the harvest ratio has decreased slightly and was estimated to be at 3.7% (5.6% in 2019), well below the F_{MSY} proxy (7.5%).

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 1.4% by number in 2020.

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 2012–2014 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 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 2022 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 11.5.9 of this report and the harvest ratio in 2020 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 landing obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as projected discards) have been added to the catch options table. The advice given in 2021 considers that *Nephrops* discarding is allowed to continue as before 2016. Under this scenario the harvest rate is assumed to include landings (projected landings) plus dead discards (Projected dead discards). The catch options table includes projected surviving discards (discards survival for *Nephrops* in FU 7 is assumed to be 25%). Projected discards (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. There is a survivability exemption in place for *Nephrops* in the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears due to high survival rates. The forecast includes an extra catch options table assuming a discard ban for 2022. The main difference in this scenario is that there is no survival assumed for the projected discards.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The prediction for 2022 is that catches should be no more than 14803 tonnes, assuming recent discard rates. 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 11.5.9.

The inputs to the landings forecast were as follows:

FU 7 basis for the catch options

Variable	Value	Notes
Stock abundance	6336	Underwater TV (UWTV) survey 2021; millions
Mean weight in projected landings	31.38	Average 2018–2020; grammes
Mean weight in projected discards	13.16	Average 2018–2020; grammes
Projected total discard rate	2.2	Average 2018–2020 (percentage by number)
Discard survival rate	25	Percentage by number
Projected dead discard rate	1.66	Average 2018–2020 (percentage by number)

Catch scenarios assuming recent discard rates

Basis	Total catch	Dead removals	Projected landings	Projected dead discards	Projected surviving discards	Harvest rate * for PL+PDD	% advice change **
	PL + PDD + PSD	PL + PDD	PL	PDD	PSD		
ICES advice basis							
MSY approach	14803	14768	14664	104	35	7.5	55
Other scenarios							
F_{MSY} lower	13026	12996	12905	91	30	6.6	36
F_{MSY} upper***	14803	14768	14664	104	35	7.5	55
F_{2020}	7208	7191	7140	51	17	3.7	-25
$F_{2018–2020}$	7894	7876	7821	55	18	4	-17.6
$F_{35\%SpR}$	22106	22054	21899	155	52	11.2	131
F_{max}	32369	32293	32066	227	76	16.4	240

Catch scenarios assuming zero discards

Basis	Total catch	Projected landings	Projected discards ^	Harvest rate * for PL + PD	% advice change **
	PL + PD	PL	PD		
ICES advice basis					
MSY approach	14722	14584	138	7.5	54
Other scenarios					
F_{MSY} lower	12955	12834	121	6.6	35
F_{MSY} upper***	14722	14584	138	7.5	54
F_{2020}	7263	7195	68	3.7	-24
$F_{2018–2020}$	7851	7778	73	4	-18
$F_{35\%SpR}$	21983	21778	205	11.2	129
F_{max}	32191	31890	301	16.4	240

^ Represents the amount that otherwise would have been discarded but is now landed under the landing obligation.
*** Calculated for dead removals.**
**** Advice basis values for 2022 relative to the 2021 advice values (MAP F_{MSY} advice of 14263 tonnes).**
***** $F_{MSY\ upper}$ = F_{MSY} for this stock.**

Biological Reference points

Biological reference points have not been defined for this stock.

11.5.11 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately. Discard sampling in 2020 was impacted by the Covid-19 pandemic and only samples for quarters 1 and 4 are available. The proportion of landings with discards associated (same strata) is 55% in 2020 (91% of the discards were imported and 45% 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 2013–2020.

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 with the current abundance being close to the highest value recorded in 2008. The stock abundance is well above the MSY $B_{trigger}$ level. Landings taken from this FU in 2020 (5543 tonnes) were lower than the 2019 total catch advice (for 2020) of 14263 tonnes. The harvest rate decreased in 2020 (in relation to the previous year) to 3.7% and remains below F_{MSY}. Length frequencies in the caches have evolved towards larger animals, suggesting a selectivity change and/or lower recruitment in the period 2010–2015. In 2017, length distributions in catches showed a decrease in the mean size and discard rates (previously estimated to be zero) increased. In the last two years, there is again some evidence of larger animals in the length distributions with increases recorded in the mean size and mean weight of catches.

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 is a *de minimis* exemption in place for *Nephrops* in the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears, according to the Marine Management Organization (MMO, 2020). The exemption applies to catches of Norway lobster below the minimum conservation reference size, which shall not exceed 2% of the total annual catches of that species. In 2020, no *Nephrops* were recorded as below the minimum size (BMS) in FU 7. This is consistent with the discard rates estimated for this FU which have been low.

References:

MMO, 2020. Fishing gear requirements and Landing Obligation exemptions 2021. Applicable to the Nephrops Fishery in UK waters of the North Sea. Document No.: V1. Date of Issue: December 2020.

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 sandeel is located further offshore to the north and east of the Firth.

11.6.2 The fishery in 2020

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 12 m 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 16 tonnes in 2020. The low market price for *Nephrops* was biggest issue faced by the fishery in 2020. Prices have, to an extent, crashed compared to previous years. In April/May there were no *Nephrops* buyers and the situation only improved in the early summer. Fuel prices have been reported as similar to previous years. The predominant trawl gear mesh sizes are 80 mm and 95 mm 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. There were no *Nephrops* landings by creel vessels in FU 8 in 2020 – 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 2020

The ICES advice in 2020 (for 2021) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the plan are between 2556 tonnes and 3931 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 8 is exploited sustainably, management should be implemented at the functional unit level."

11.6.4 Management

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

11.6.5 Assessment

Approach in 2021

The assessment in 2021 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 2021 followed the process of 2020, 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.

It was decided by ICES prior to the 2021 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. The assessment presented in this report was concluded in October 2021 and incorporates the most recent *Nephrops* UWTV survey (2021).

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 generally accounting for less than 1% of the total (no creel landings were recorded in 2020). Reported landings rose from 1100 to over 2650 tonnes between 2003 and 2009 and have fluctuated since then around 2000 tonnes. The value for 2020 of 1787 tonnes represents a 31% decline from 2019 and is below the ten-year average (2140 tonnes). *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) or logbook registered discards were reported for FU 8 in 2020.

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 increased again in recent years reaching the highest level of the time series in 2018.

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 2000s 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 previous years, 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. In 2020 due to the Covid-19 pandemic and the suspension of the on-board observer programme, discards were only sampled in quarter 1. 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 7% and 55% of the catch by number (2011–2020 average 21%). In 2020, the discard rate was recorded at 7% (based on quarter 1 only), the lowest value in the time series. 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 2020 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 2021 WG. Output data for landings were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. In 2020 there were only discard data imported for quarter 1. Analyses were carried out to visualize the relationship between discard rates and season – this showed that discard rates in FU8 are highly variable with no clear seasonality patterns. As such, discard rates and allocations for length frequencies in quarters 2-4 were estimated as follows: calculations were performed to obtain the mean discard rate (and mean length frequency distributions for males and females separately) in the last 3 years (2017-2019) for quarters 2-4 (avQ2-4) and quarter 1 (avQ1); then, the 2020 discard rates for Q2-4 were estimated according with the formula: avQ2-4*(Q1_2020/avQ1). This results in a mean discard length distribution for each of quarters 2, 3 and 4 which is scaled to the 2020 Q1 estimate (the only available for 2020). Borrowing discard rates from previous years is not a feature allowed in Intercatch, as such the procedure described below was performed outside Intercatch. No BMS or logbook registered discard data were reported for this FU in 2020.

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 2020. 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. There was a shift to the right in the length distributions in 2020, implying a higher relative number of large animals present in the catches (Figure 11.6.3). This coincides with an increase in the mean size of animals below 35 mm (Figure 11.6.1) and a decrease in the discard rate in 2020. However, given the limited discard sampling in 2020 (only quarter 1 coverage) caution should be taken in the interpretation of these results and this does not necessarily imply clear recruitment changes in FU 8, particularly given that discard rates are known to be variable throughout the year.

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, although there is an increase in the 2020 value which derives from the presence of larger animals in the catches.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 11.6.4. On average, about 44 stations have been considered valid each year. In recent years the aim of the survey is to sample 50 stations. The number of sampled stations in 2020 was 41. The timing of the FU 8 survey in 2020–2021 was changed due to limitations related with the research vessel's availability. Henceforth the survey was carried out in June (it is normally conducted in August) together with other Functional Units to the west of Scotland (FU 11, FU 12 and FU 13) and in the North Sea (FU 7, FU 9 and FU 34). 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 western 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 (U6028), 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 again in recent years and in 2020 reached the highest point of the time series. In 2021 the abundance was estimated at 837 million. The stock is currently above the average abundance over the time series and remains well above the biomass trigger. The calculated harvest ratio in 2020 (dead removals/TV abundance) decreased and is below F_{MSY} (previously above F_{MSY}). This is the result of a 29% increase in stock abundance (in 2020) and landings in 2020 decreasing by 31% in relation to 2019. The mean size of individuals >35 mm in the catch show no strong trend in recent years. The mean size of individuals below 35 mm has shown a slight increasing trend since 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 generally with the exception of 2020, 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 1993–2021 are shown in Table 11.6.6. The stock is currently estimated to consist of 837 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 6–29% 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 2020 is 6.1% which is below the estimated value at F_{MSY} (16.3%) and the lowest value estimated in the time series.

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 2008–2010 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

Biological reference points have not been defined for this stock.

11.6.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. Discard sampling in 2020 was impacted by the Covid-19 pandemic and only samples for quarter 1 are available with discard rates and length distribution for quarters 2–4 borrowed from years 2017–2019. The proportion of landings with discards associated (same strata) is 15% in 2020 (15% of the discards were imported and 85% 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 2013–2020.

11.6.11 Status of the stock

The stock has shown an increasing trend since 2014 and is above the average abundance and well above the MSY $B_{trigger}$ level. The abundance value calculated for 2021 is 837 million. Landings taken from this FU in 2020 (1787 tonnes) were lower than the 2019 total catch advice (for 2020) of 3143 tonnes. The harvest rate decreased in 2020 to 6.1% (a combination an increasing stock abundance and reduced landings in 2020) and is now below F_{MSY}. Length frequencies in the catches have been relatively stable.

11.6.12 Management considerations

Catches in 2018 increased to levels above ICES advice for 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 in the past do not appear to have adversely affected the stock, in recent years they have occasionally been 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 *de minimis* exemption in place for *Nephrops* in the UK waters of the North Sea (ICES Division 2.a and Subarea 4) with certain gears, according to the Marine Management Organization (MMO, 2020). The exemption applies to catches of Norway lobster below the minimum conservation reference size, which shall not exceed 2% of the total annual catches of that species. In 2020, no *Nephrops* were recorded as below the minimum size (BMS) in FU 8 despite catches have been observed below the MCRS and this being a Functional unit that historically have shown high discard rates.

References:

MMO, 2020. Fishing gear requirements and Landing Obligation exemptions 2021. Applicable to the Nephrops Fishery in UK waters of the North Sea. Document No.: V1. Date of Issue: December 2020.

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 2020

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 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. At the end of March 2020 *Nephrops* fleet had to deal with the effects of the Covid-19 pandemic. The majority of shellfish processors did not purchase *Nephrops* between April and May, leaving the fleet tied up in this period. Prices of *Nephrops* were relatively low in 2020 compared with previous years due to an oversupply of the market, particularly in the early days of the pandemic. 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 7 tonnes landed in 2020) as grounds are in open water and gear conflicts with trawl vessels are likely to happen. A squid fishery took place as usual 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. 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 2020

The ICES advice in 2020 (for 2021) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the plan are between 1008 tonnes and 1307 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit 9 is exploited sustainably, management should be implemented at the functional unit level."

11.7.4 Management

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

11.7.5 Assessment

Approach in 2020

The assessment in 2021 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 2021 followed the process of 2020, 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.

It was decided by ICES prior to the 2021 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. The assessment presented in this report was concluded in October 2021 and incorporates the most recent *Nephrops* UWTV survey (2021).

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 2020 for Scotland were 963 tonnes (a decrease of 29% in relation to 2019) 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) or logbook registered discards were reported for FU 9 in 2020.

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 was higher than in the recent past. In 2016–2020, 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. In 2020 due to the Covid-19 pandemic and the suspension of the on-board observer programme, discards were only sampled in quarter 1. 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 2020 the observed rate by number (based on quarter 1 only) was at a low level, approximately 5.5% by number, suggesting that recruitment to the fishery is likely to be at a low level. 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 2020 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 2021 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. In 2020 there were only discard data imported for quarter 1. Discard rates and allocations for length frequencies in quarters 2, 3 and 4 were all based in the available data for quarter 1. No BMS or logbook registered discard data were reported for this FU in 2020.

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 2020. 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. This parameter is however slightly above average over the last four years, which is consistent with the recent decrease in the discard rate and that is likely related with the trend found in the length frequency distributions (Figure 11.7.3) suggesting a series of poor recruitments in recent 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, 46 stations were sampled in 2021. The timing of the FU 9 survey in 2021 was changed due to limitations related with the research vessel's availability. Henceforth the survey was carried out in June (it is normally conducted in August) together with other Functional Units to the west of Scotland (FU 11, FU 12 and FU 13) and in the North Sea (FU 7, FU 8 and FU 34). 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

The UWTV survey did not cover FU 9 in 2020 due to a decreased sampling schedule caused by limited time at sea available related with the Covid-19 pandemic. 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 (U6028), with the size of the symbol reflecting the *Nephrops* burrow density. In recent years the abundance appears to be highest at the western inshore and to the east of the FU, with lower densities in the central areas. Table 11.7.4 and Figure 11.7.5 show the time series of estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

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

Final assessment

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

The abundance in the Moray Firth has declined markedly in 2005 having remained stable around 400 million until 2019. In 2021 the abundance increased sharply and is now estimated at 658 million, an increase of 75% compared with the 2019 value. The stock is currently above the average abundance over the time series and remains well above the biomass trigger. The calculated harvest ratio in 2019 (dead removals/TV abundance) was above F_{MSY} (previously at F_{MSY}). There was no UWTV survey in 2020, as such an interpolated abundance estimate (average of 2019 and 2021) was used to calculate a harvest rate. Following this approach, the harvest ratio in 2020 was 7.4%, which is 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 4 years suggests a recent low recruitment period in relation to 2014–2016. 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 until a sharp increase (75%) in 2021. The abundance estimates from 1993–2021 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.

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 2008–2010 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 2022 was made for the Moray Firth (FU 9) 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 11.7.8 of this report and the harvest ratio in 2020 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 projected discards) have been added to the catch options table. The advice given in 2021 considers that *Nephrops* discarding is allowed to continue as before 2016. Under this scenario the harvest rate is assumed to include landings (projected landings) plus dead discards (Projected dead discards). The catch options table includes projected surviving discards (discards survival for *Nephrops* in FU 7 is assumed to be 25%). Projected discards (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. There is a survivability exemption in place for *Nephrops* in the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears due to high survival rates. The forecast includes an extra catch options table assuming a discard ban for 2022. The main difference in this scenario is that there is no survival assumed for the projected discards.

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The prediction for 2022 is that catches should be no more than 2062 tonnes, assuming recent discard rates. 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 11.7.8.

The inputs to the landings forecast were as follows:

FU 9 basis for the catch options

Variable	Value	Notes
Stock abundance	658 million individuals	UWTV 2021
Mean weight in projected landings	26.87 g	Average 2018–2020
Mean weight in projected discards	9.1 g	Average 2018–2020
Projected discard rate (total)	2.8%	Average 2018–2020 (percentage by number)
Discard survival ratio	25%	Percentage by number
Dead projected discard ratio (total)	2.1%	Average 2018–2020 (percentage by number)

Catch scenarios assuming recent discard rates

Basis	Total catch PL + PDD + PSD	Dead removals PL + PDD	Projected landings PL	Projected dead discards PDD	Projected surviving discards PSD	Harvest rate * for PL+PDD	% advice change **
ICES advice basis							
MSY approach	2062	2057	2042	15	5	11.8	75
Other scenarios							
F_{MSY} lower	1591	1587	1575	12	4	9.1	35
F_{MSY} upper***	2062	2057	2042	15	5	11.8	75
F_{2020}^^	1284	1281	1272	9	3	7.4	8.8
$F_{0.1}$	1363	1360	1350	10	3	7.8	15.5
$F_{2018–2020}$^^	1975	1970	1956	14	5	11.3	67
F_{max}	2604	2598	2579	19	6	14.9	121

Catch scenarios assuming zero discards

Basis	Total catch PL + PD	Projected landings PL	Projected discards ^ PD	Harvest rate * for PL + PD	% advice change **
ICES advice basis					
MSY approach	2048	2028	20	11.8	74
Other scenarios					
F_{MSY} lower	1579	1564	15	9.1	34
F_{MSY} upper***	2048	2028	20	11.8	74
F_{2020}^^	1275	1263	12	7.4	8.1
$F_{0.1}$	1353	1340	13	7.8	14.7
$F_{2018-2020}$^^	1961	1942	19	11.3	66
F_{max}	2586	2561	25	14.9	119

^ Represents the amount that otherwise would have been discarded but is now landed under the landing obligation.
*** Calculated for dead removals.**
**** Advice basis values for 2022 relative to the 2021 advice values (MAP F_{MSY} advice of 1180 tonnes).**
***** $F_{MSY\ upper}$ = F_{MSY} for this stock.**

^ The harvest rate in 2020 was calculated using an interpolated value for abundance (average of 2019 and 2021).

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. Discard sampling in 2020 was impacted by the Covid-19 pandemic and only samples for quarter 1 are available. The proportion of landings with discards associated (same strata) is 16% in 2020 (17% of the discards were imported and 83% were raised discards).

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 from 1993 to 2019 (no surveys in 1995 and 2020). 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 2013–2020.

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 75% in 2021 (to 658 million) and is approximately at the same level as in the early 2000s. The stock size is above the MSY $B_{trigger}$ level. Landings taken from this FU in 2020 (963 tonnes) were lower than the 2019 total catch advice (for 2020) of 1307 tonnes. The harvest rate decreased in 2020 to 7.4% and is now below F_{MSY} (11.8%). Length frequencies in the catches have been relatively stable.

11.7.12 Management considerations

Catches in 2019 were above ICES advice in 2018 (for 2019), 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 *de minimis* exemption in place for *Nephrops* in the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears, according to the Marine Management Organization (MMO, 2020). The exemption applies to catches of Norway lobster below the minimum conservation reference size, which shall not exceed 2% of the total annual catches of that species. In 2020, 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.

References:

MMO, 2020. Fishing gear requirements and Landing Obligation exemptions 2021. Applicable to the Nephrops Fishery in UK waters of the North Sea. Document No.: V1. Date of Issue: December 2020.

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 brown crab fishing areas and fish populations (mixed demersal species) are important in the locality.

11.8.2 The fishery in 2019 and 2020

The Noup currently supports a relatively small fishery. Few vessels target *Nephrops* regularly in this area. In Orkney there are currently only three part-time vessels (one under 10 m and two over 10 m) fishing seasonally for *Nephrops* (mostly around summer) 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 2020, only 11 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 2020

The advice provided in 2020 was biennial and valid for 2021 and 2022.

"ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should not exceed 46 tonnes, assuming recent discard rates.

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 2020 were 11 tonnes, a decrease of 10 tonnes from 2019. *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 Figure 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 years the LPUE have been relatively stable.

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, 2018 and 2020, two sampling trips in 2016, one trip in 2017 and one trip in 2019. 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 2020 were successfully uploaded into InterCatch prior to the 2021 WG meeting according with the deadline proposed. The 2020 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, 2007 and 2014). In 2019, Noup was re-visited by the summer Scotia UWTV survey after five 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 2019, 11 stations were successfully surveyed. The most recent survey gives an estimate of population size of 90 million

(0.22 burrows/m^2) similar to that found in 1999 which is significantly higher than the previous survey (51 million, 0.13 burrows/m^2). 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. There was no survey carried out in FU 10 in 2020.

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 and remained at a lower level on the following surveyed years until 2019 when the abundance increased again. Landings fluctuated between 200 and 400 tonnes between 1995 and 2002, and declined markedly from then. Recent landings for this FU have been low, 21 tonnes in 2019 and 11 tonnes in 2020.

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 as the latest advice released in 2020 is valid for 2021 and 2022.

11.8.7 Quality of the assessment

The time-series of UWTV survey data is incomplete, and the last survey was conducted in 2019. Given the low number of vessels involved in the fishery and the fact that some vessels were not targeting *Nephrops*, caution should be exercised when interpreting the effort data for this FU and the 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 presented in recent years were 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 the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears, according to the Marine Management Organization (MMO, 2020).

References:

MMO, 2020. Fishing gear requirements and Landing Obligation exemptions 2020. Applicable to the Nephrops Fishery in the North Sea. Document No.: V2. Date of Issue: March 2020.

11.9 Norwegian Deep (FU 32)

11.9.1 Ecosystem aspects.

See stock annex (Section A.3).

11.9.2 The fishery in 2018-2020

The annual spatial distribution of the Danish and Norwegian fisheries in FU 32 are shown in figures 11.9.1, 11.9.2 and 11.9.3. The Danish fishery is still largely confined to the southernmost part of the functional unit. The Norwegian large vessel trawl fisheries (large mesh bottom trawl and small mesh shrimp trawl) with *Nephrops* as bycatch declined from 2012 to 2013. In 2013–2015, these trawl fisheries were confined to the southernmost part of the functional unit as well as an area just west of the city Stavanger, while from 2016 onwards trawling has again taken place along the western rim of the Norwegian Trench. The Norwegian creel fishery is concentrated in outer coastal areas from Stavanger to Bergen.

See also stock annex (Section A.2).

11.9.3 Advice in 2020

Advice for *Nephrops* in FU 32 is biennial and was last updated in 2020. This advice applied for 2021 and 2022. The stock is not subject to the reopening procedure.

The ICES conclusions in 2018 in relation to state of the stock were as follows:
The state of this stock is unknown. Catches have been decreasing since 2006. Discarding has been low in the last four years.

ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because the reference points are undefined.

ICES did not formulate any conclusions regarding the state of the stock in 2020, as an abbreviated advice was issued due to the COVID-19 disruption.

The ICES advice in 2020 (for 2021 and 2022) (single-stock exploitation boundaries) was as follows:

ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should be no more than 381 tonnes. If this stock is not under the Norwegian discard ban in 2021 and 2022, and discard rates do not change from the recent average, this implies landings of no more than 379 tonnes.

11.9.4 Management

An overview of the management of *Nephrops* in FU 32 is given in the stock annex (Section A.2). There is a minimum mesh size of 120 mm for large mesh bottom trawls in the Norwegian EEZ in the North Sea. For *Nephrops*, the MLS is 40 mm CL in Norwegian waters. The EU fisheries are managed by a separate TAC for this FU, decided by the annual Norway–EU negotiations. The agreed TAC for EU vessels has decreased from 1300 tonnes in 2008 to 200 tonnes in 2021 (Table 11.9.1). 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 2020 have been uploaded using InterCatch. Estimated discards and length samples exist only from the Danish landings (Figures 11.9.4, 11.9.5).

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 11.9.6). Since then, landings declined due to a reduction of Danish landings, to only 137 tonnes in 2018, the lowest figure since 1990. In 2019 and 2020, total landings increased again, to 191 and 179 tonnes respectively. 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, while in 2019 and 2020, due to Danish landings more than doubling compared to 2018, Denmark landed 45–48% of the total landings. Norwegian landings decreased from 2008 to 2014 (62 tonnes), but have increased since, to 90–100 tonnes the last five years. In 2017–2018, 90% of Norwegian landings were from creels; only 9 and 10 tonnes were landed from the shrimp and mixed trawl fisheries. Norwegian trawl landings increased slightly in 2019 and 2020, resulting in approximately 75% creel landings.

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Table 11.9.1) and length measurements. In 2017, only a small number of *Nephrops* was length measured (stock annex, Section B.1). The 2017 observer data were considered not representative and were therefore not used as part of the information going into the harvest rate table used in the 2020 advice (see below). Danish sampling was again low in 2020, and there was no discard sampling.

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 2014–2020 estimated Danish discards were between 0.2 and 6 tonnes, resulting in very low Danish discard rates of between 1% and 5%. The low discards the last seven years may indicate low recruitment to the stock. Discards were low also in FUs 3–4 in 2014–2016, but increased in 2017–2019. There are no Norwegian discard data, and Norwegian discards are assumed to be zero (stock annex, Section A.3). As the Norwegian fishery is now basically a creel fishery, with high survival of discarded *Nephrops*, this is a valid assumption at least for the last six years (Table 11.9.1).

Length composition

The average size of *Nephrops* in Danish landings (≥ 40 mm = MLS) showed a general increasing trend for both males and females in the period 2005–2012 (Figure 11.9.6). This increase coincided 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, increased further until 2018, and then dropped to the 2012-level in 2019 and 2020. The average size of landed females, on the other hand, remained at the low 2013-level until 2019, but showed a very high value in 2020. The mean size of discards (< 40 mm) has fluctuated without trend since 2002. There was no sampling of discards in 2020. 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*. The Danish fishery has shown a gradual contraction into the southern part of the functional unit, but with no abrupt change from 2012 to 2013. It is also unclear why it is only the landed females (not the males) that have shown a decreased size since 2013. Furthermore, the very high mean size of females in 2020 seems odd.

Mean size of the Danish catches from the years 2007, 2010, 2012, 2014, 2016, 2017, and especially 2018, 2019 and 2020, were larger compared with former years (Figure 11.9.7). The high 2018 mean size was due to the high mean size of the males, while the high 2020 mean size was due to the high mean size of the females as well as the lack of length sampling of discards. 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.

Effort, LPUE and scientific survey data

Effort figures for the period 1989–2020 are available from Danish logbooks (Table 11.9.2, Figure 11.9.6). 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 effort increased from 2004 to 2006, but showed a strong decline in 2007 and continued decreasing, to 313 kW days in 2018, the lowest observed effort in the time series. The effort more than doubled from 2018 to 2019, however, and remained at this level also in 2020 (628 kW days) (Table 11.9.2). 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 Danish LPUE index based on kW days shows a stepwise decreasing trend (Figure 11.9.6). However, due to changes in the management regime, changes in the LPUE index do not necessarily imply stock size changes. 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 11.9.6). 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 finfish 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 finfish 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 had reasonably good catch rates in 2013–2015. Environmental changes resulting in lower *Nephrops* densities in the whole functional unit cannot be ruled out. The likely low recruitment to the stock in 2014–2020 may imply continuing low catch rates.

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 creel fishery which is carried out by small vessels, not obliged to fill out logbooks. A new Norwegian reference fleet of creel fishers established in 2019 will, however, enable estimation of a new CPUE time series from this fishery. There is no information on total effort of the creel fishery.

The annual Norwegian shrimp bottom trawl survey covers all of Skagerrak and the Norwegian Deep. *Nephrops* is distributed in areas deeper than 100 m in FU 32 (Figure 11.9.8). (Areas shallower than 100 m are not covered by the survey). Catches of *Nephrops* in the survey trawl are small and variable within and between years. The 2016 benchmark (ICES, 2016) analysed the *Nephrops* data from the shrimp survey with the aim of establishing a fishery independent stock size index.

Data analysis

The advice in 2019 was based on the average catches of the last 10-year period (2010–2019), 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 0.9%, 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 fluctuated without trend around this lower level until 2015. The last five years have seen a further downward trend, with the index reaching its minimum value in 2021 (Table 11.9.3, Figure 11.9.9). The Danish LPUE has similarly decreased since 2008–2009 (Figure 11.9.6). 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 survey index is based on few observations (Figure 11.9.8). However, in lack of an UWTV survey, the benchmark considered that the index should be presented and updated as part of the biennial assessment of the FU 32 stock.

Final assessment

No assessment model exists for *Nephrops* in FU 32. The state of the stock was judged on the basis of basic fishery data and a biomass index from the Norwegian shrimp 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 since 2007. The introduction of a new Danish effort index (kW days) in 2013 resulted in a stepwise declining trend in the LPUE index, from the mid–1990s until present. The survey biomass index has declined since 2015.

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 2014–2020, indicating low recruitment these years.

11.9.8 Forecasts

The ICES framework for category 4 Norway lobster stocks was applied (ICES, 2012). In the absence of a full analytical assessment, ICES base its advice for Norway lobster on the most recent advice. Maximum sustainable yield (MSY) harvest rates estimated for other FUs vary between 7.5% and 16%. ICES use the lower boundary as an upper limit for advice for data-limited Norway lobster stocks. As long as the harvest rate is less than 7.5%, the default basis for advice is that catches can be increased gradually, by applying the 20% uncertainty cap to the previous advice. The precautionary buffer has not been applied previously. Stock size in relation to reference points is unknown. Therefore, the precautionary buffer has been applied this year. Following the precautionary approach, catches in each of the years 2021 and 2022 should be no more than 381 tonnes. If this stock is not under the Norwegian discard ban in 2021 and 2022, and discard rates do not change from the recent average, this implies landings of no more than 379 tonnes.

Basis for the catch scenarios.

Variable	Value	Notes
Density in TV assessment	0.1 *Nephrops* m^2	Minimum value from FU 7
Mean weight in projected landings	75 g	Average of 2016, 2018 and 2019; poor sampling in 2017
Mean weight in projected discards	43 g	Average of 2016, 2018 and 2019; poor sampling in 2017
Projected discard rate (total)	0.8%	Average of 2016, 2018 and 2019 (percentage by numbers)
Discard survival rate	25%	
Surface area estimate	3613 km^2	Benchmark estimate WKNEP (2016)

Sensitivity analysis of harvest rates for a range of potential densities. All weights in tonnes.

Discarding allowed

Basis	Total catch	Projected surviving discards	Projected dead discards	Projected 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 (2010–2019)	236	0	1	235	236	1.7%	0.9%	0.4%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%
0.5 × Average landings (2010–2019)	118	0	0	118	118	0.9%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
2018 advice -20%	312	0	1	311	312	2.3%	1.2%	0.6%	0.4%	0.3%	0.2%	0.2%	0.2%	0.1%
(2018 advice +20% cap) – 20% PA buffer	381	0.4	1.3	379	380	2.8%	1.4%	0.7%	0.5%	0.4%	0.3%	0.2%	0.2%	0.2%
2018 advice	390	0	1	389	390	2.9%	1.4%	0.7%	0.5%	0.4%	0.3%	0.2%	0.2%	0.2%
2018 advice +20%	470	1	2	467	469	3.5%	1.7%	0.9%	0.6%	0.4%	0.3%	0.3%	0.2%	0.2%
Maximum landings	1195	1	4	1190	1194	8.8%	4.4%	2.2%	1.5%	1.1%	0.9%	0.7%	0.6%	0.6%
FMSY	2029	2	7	2020	2027	15.0%	7.5%	3.8%	2.5%	1.9%	1.5%	1.3%	1.1%	0.9%

*** A density of 0.1 *Nephrops* m^{-2} is among the lowest observed densities in the North Sea in FU 7 (Fladen Ground).**

11.9.9 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.

A growing part of the Norwegian *Nephrops* landings come from the coastal creel fishery. A reference fleet of creel fishers was established in 2019 and will provide information on this fishery, as well as provide biological information about the coastal part of the stock.

The advice is based on calculation of potential catch options and harvest rates, given the estimated surface area of *Nephrops* habitat and assumed densities of the functional unit. The area of the *Nephrops* grounds in FU 32 is based on the distribution of the current Danish trawl fishery; this estimate does not include the *Nephrops* habitat along the Norwegian coast where the 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 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 the fishery, or whether the decrease to some extent also reflects stock changes. The recent Danish landings from the stock are small, but are fished in a restricted area. The low LPUE in 2013–2020 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 seven 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 213 tonnes (2011–2020), while the short-term average landings are 166 tonnes (2016–2020).

11.9.12 Issues for future benchmarks

Data

Sampling of trawl catches by the Norwegian Coast Guard should be improved by sampling discards and landings components separately to enable discards estimations. The sampled *Nephrops* should also be sexed. An UWTV survey should be carried out in this functional unit to explore and map distribution and density.

Assessment

Assessment methods for data poor species should be explored for this *Nephrops* stock.

11.9.13 Ecosystem and fisheries productivity

Stock indices indicate that the density of *Nephrops* may be lower in recent years, but there is no information on actual density in the functional unit, neither present nor past. The 2016 benchmark (ICES, 2016) concluded that catch rates (LPUE) declined especially in northern parts of the functional unit from 2005–2015. The catch advice has always been based on a density of 0.1 m^{-2}

in the harvest rates table (the lowest observed density in the neighboring FU 7 (Fladen Ground)). It is unknown why density seems to be lower in recent time. Estimated discards are used as a proxy for recruitment for *Nephrops* stocks. Discards in FU 32 have been low the last seven years, indicating low recruitment to the stock, which may be part of the explanation. The area of *Nephrops* grounds in the harvest rates table was changed in the 2016 benchmark, from an estimate of the area of the whole functional unit to an estimate of the area of the distribution of the present Danish trawl fishery.

11.9.14 Management considerations

ICES provide catch advice for FU 32. As discarding is not illegal, advice in 2020 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 in Section 11.9.8) was calculated. The biomass estimates imply low harvest rates in FU 32, even in former years with high landings (1000–1200 tonnes).

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. In 2019, Danish annual landings increased to 220 tonnes, however, this value is still lower than the average for the last 10 years (346 tonnes from 2010 to 2019). The other countries reporting landings from the FU are Belgium, Netherlands, Germany and the UK, all showing an increase of landings from this FU in 2019 relatively to 2018. 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 2019, Dutch landings were the highest on record at 599 tonnes. Belgium and German landings having increased throughout the time period and in 2019 were the highest landings recorded for this FU, 462 and 329 tonnes, respectively. UK landings were highest in 2009 (170 tonnes) and have since decreased dramatically, reporting 2 tonnes from this FU. 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. Total landings in 2019 have returned to levels of the previous years with the second highest total landings on record, 1612 tonnes (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 too scarce to be used for providing catch advice. No length data were available from Denmark from 2017–2019. In 2015, Dutch discards were recorded in InterCatch, however, length information was missing. Between 2016 and 2019, Dutch discards included length information. Due to a National minimum landing size, a large majority (94% in 2019) 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 2001–2005 and 2009–2016 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 2019, length distributions were only available from Dutch catches.

Natural mortality, maturity at age and other biological parameters

No data available

Catch and effort data

Figure 11.10.1 shows 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 for 2005–2019 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. In 2019, Dutch effort was approximately 1 550 000 kW days, the highest recorded since the beginning of the time series, and maybe attributed to the redefinition of métiers in the Netherlands.

From the beginning of the time-series until 2016, the Danish LPUE showed an increasing trend, and in 2016, was the highest in the time series at around 1.7 kg/kW day. This increase in LPUE observed from 2011–2016 could reflect an increase in gear efficiency (technological creep) or in fishers’ ability to exploit the stock. However, in recent years the Danish LPUE has decrease considerably, to 0.8 kg/kW day and 0.2 kg/kW day, in 2017 and 2018, respectively. In 2019, the Danish LPUE increased to 0.7 kg/kW day. The low Danish LPUE values observed in recent years may be explained by the low number of Danish vessels exploiting this FU. This may also 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.

Research vessel data

An underwater TV (UWTV) survey for this FU has been conducted since 2017. Figure 11.10.3 shows the distribution of stations in the UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. The number of stations sampled per year has been relatively high, with 59, 85 and 60 stations in 2017, 2018 and 2019, respectively. The most recent survey gives an estimated density (0.07 burrows per m^2) similar to that found in 2018. The estimated density in the past two years is lower than what was estimated in 2017. The results of the UWTV surveys are shown in Figure 11.10.4 and Table 11.10.2.

11.10.1 Historic stock trends

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

The TV survey estimate of abundance for *Nephrops* in Off Horn's Reef suggests that the population declined from the first survey in 2017 to 2018 and remained at a lower level on the following surveyed year. In general, over the entire time-series landings have shown an increasing trend. Since 2001, landings have fluctuated without trend from around 800 to 1600 tonnes. Landings in 2019, were the second highest on record.

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

The ICES framework for category 4 Norway lobster stocks was applied (ICES, 2012). In the absence of a full analytical assessment, ICES bases its advice for Norway lobster on the most recent advice. Maximum sustainable yield (MSY) harvest rates estimated for other FUs vary between 7.5% and 16%. ICES uses the lower boundary as an upper limit for advice for data-limited Norway lobster stocks. As long as the harvest rate is less than or equal to 7.5%, the default basis for advice is that catches can be increased from the previous advice, within the 20% uncertainty cap. The precautionary buffer was applied in 2019 and therefore has not been applied this year. Following the precautionary approach, landings in each of the years 2021 and 2022 should not exceed 956 tonnes. ICES cannot quantify the corresponding total catches.

Basis for the catch scenarios.

Variable	Value	Notes
Mean observed density	0.073 *Nephrops* m^{-2}	Density in UWTV 2019. The UWTV survey was not conducted in 2020.
Mean weight in projected landings	40.57 g	Estimated in 2015.
Mean weight in projected discards	17.2 g	Assumed mean discard weight for the calculation of the harvest rate only. Mean weight in Danish discards in 2015.
Projected discard rate (total)	25%	Assumed maximum discard rate for the calculation of the harvest rate only.
Discard survival rate	0%	ICES (2019).
Surface area estimate	5737 km^2	Estimate from the underwater TV (UWTV) survey. WGNEPS (ICES, 2017).

Sensitivity analysis of harvest rates for a range of potential densities (assuming discard rate of 25%). Shaded cells indicate harvest ratios above the MSY proxy harvest rate for this stock of 7.5%. All weights are in tonnes.

Basis	Total catch	Projected landings	Projected discards	Range of potential densities (*Nephrops* m^{-2})									
				0.05	0.073*	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
				Harvest rate in %									
0.5 × Average landings (2010–2019)	666	584	82	6.7	4.6	3.3	1.67	1.11	0.84	0.67	0.56	0.48	0.42
Advice for 2020 −20%	820	718	102	8.2	5.6	4.1	2.1	1.37	1.03	0.82	0.69	0.59	0.51
Average landings (2010–2019) −20%	1066	934	132	10.7	7.3	5.3	2.7	1.78	1.34	1.07	0.89	0.76	0.67
MSY proxy harvest rate	1091	956	135	11.0	7.5	5.5	2.7	1.83	1.37	1.10	0.91	0.78	0.68
Average landings (2010–2019)	1332	1167	165	13.4	9.2	6.7	3.3	2.2	1.67	1.34	1.11	0.96	0.84
Maximum	1867	1636	231	18.7	12.8	9.4	4.7	3.1	2.3	1.87	1.56	1.34	1.17

*** A density of 0.073 *Nephrops* m^{-2} is the observed density in the UWTV survey 2019 for this functional unit, which is the most recent survey undertaken.**

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 and 2019, the observed densities were lower than what was observed in 2017 at 0.073 *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 high-grading 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.

References

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ICES. 2019. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports, 1:7. 1271 pp. http://doi.org/10.17895/ices.pub.5402.

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 2020 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 11.11.5 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 2019 and 2020

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 2020

Advice provided in 2020 was biennial for 2021 and 2022.

"ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should not exceed 566 tonnes, assuming recent discard rates.

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 (Category 1) in the near future.

Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2020 are presented in Table 11.11.1 and Figure 11.11.1. Landings gradually increased from 378 tonnes in 2005 to approximately 1305 tonnes in 2009 followed by a decline in the following years to 121 tonnes in 2013. In recent years landings increased again and in 2020, 980 tonnes were recorded (a 20% decrease in relation to 2019).

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 11.11.2 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 decreased from the start of the time series until 2011 after which it has shown a fluctuating trend. LPUE increased until 2009, decreasing in the early 2010s to around 400 kg/day and in 2019 a marked increase was recorded in line with the landings rise.

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 the last ten years, 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 following years only a few fishing trips were sampled. Mean sizes in the catch and landings from 2006 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 2020 were successfully uploaded into InterCatch prior the 2021 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 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 11.11.7). 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.

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 15 years. Since 2009, VMS data (Figure 11.11.6) 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, 2016 and 2020 but the survey has continued in 2014, 2015, 2017–2019 and 2021. The most recent survey, conducted in the summer of 2021 (10 TV stations completed) gives an estimate of density of 0.28 burrows/m^2, a slight 3% decrease in relation to the previous 2019 estimate. A density distribution map of these surveys is shown in Figure 11.11.3 with the size of the symbol reflecting the *Nephrops* burrow density. Table 11.11.4 and Figure 11.11.4 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 with 2019 being the second highest figure recorded in the time series. Estimates of mean density in the stock show an increasing trend since 2016.

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 as the latest advice released in 2020 is valid for 2021 and 2022.

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, 2017–2019 and 2021.

Catch options (when provided) 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 the UK waters of the North Sea (ICES division 2.a and Subarea 4) with certain gears, according to the Marine Management Organization (MMO, 2020).

References:

MMO, 2020. Fishing gear requirements and Landing Obligation exemptions 2020. Applicable to the Nephrops Fishery in the North Sea. Document No.: V2. Date of Issue: March 2020.

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 the Netherlands, Germany, Scotland, and Belgium, followed by England, Denmark and Sweden (Figure 11.12.1, Table 11.12.1). Annual landings by Sweden have been consistently below one tonne and have therefore been omitted from the figure. *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 were 755 tonnes in 2011, the first year with data. They then declined, reaching a minimum of 392 tonnes in 2014. This was followed by an increase to 1190 tonnes 2017. Except Scotland and Sweden, all countries decreased their landings in 2018 by 50–60% in comparison to 2017, while Scottish landings increased from 158 to 181 tonnes. Landings in 2019 increased again to 724 tonnes, primarily due to increased landings by the Netherlands and Germany.

Discards have been reported by Denmark since 2012, and by Netherlands since 2016. Scotland also reported discards in 2016, 2017, and 2019. Since 2016, Dutch reported annual discards have accounted for 94–100% of all reported discards. The discards reported in 2019 were 607 tonnes, followed in magnitude by 553 tonnes in 2016 (Table 11.12.2). In other years since 2016, discards have been below 200 tonnes.

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 that *"the state of Nephrops outside the functional units is unknown".*

No new information has emerged that would warrant a change to the previous advice:

"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.

Catch scenarios

The ICES framework for category 5 stocks was applied (ICES, 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented, unless ancillary information clearly indicates that the current level of exploitation is appropriate for the stock. The precautionary buffer has never been applied before and was therefore applied to the advice this year.

Basis for the catch scenarios.

Advised landings for 2021–2022		376 tonnes
Discard rate		Unknown
Precautionary buffer	Applied	0.8
Landings advice *		301 tonnes
% advice change **		−20%

*** Advised wanted catch for 2018–2020.**

**** Advice value for 2021–2022 relative to the advice value for 2018–2020.**

Table 11.2.1. Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2020, 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, 1984–2020, 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	14066	11108
Total	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20857	16824	13695

Table 11.2.1 (continued). Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2020, as officially reported to ICES.

	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	303	494	349	880	1109	635	752	675
Denmark	387	624	515	755	594	100	343	307
Faeroe Islands	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	70	17
Germany	425	418	435	862	923	557	804	258
Ireland	0	1	0	0	0	0	1	0
Netherlands	910	1154	1113	1464	1418	803	1390	931
Norway	63	63	81	98	94	103	103	97
Sweden	0		0	1	0	0	0	3
UK (Eng + Wales + NI)	-							
UK (Scotland)	-							
UK	10685	13905	9457	13511	16317	13243	22176	11397
Total	10713	13965	9318	13397	16049	13164	21808	13687

*** Landings data for 2019 and 2020 are preliminary.**

Table 11.2.2. Summary of *Nephrops* landings from the ICES area, by Functional Unit, 1981–2020.

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981		1073	372	1007	1416	35				76	3980
1982		2524	421	1195	1119	19				157	5437
1983		2078	693	1724	941	16				101	5551
1984		1479	646	2134	1169	111				88	5628
1985		2027	1147	1968	2081	22				139	7386
1986		2015	1543	2263	2143	67			23	204	8236
1987		2191	1695	1675	1992	45			5	195	7791
1988		2495	1575	2529	1959	76			2	364	8995
1989		3098	2299	1888	2576	84			28	233	10176
1990		2498	2540	1931	2037	218			26	222	9442
1991	862	2063	4223	1405	1520	197			85	560	10827
1992	612	1473	3363	1756	1591	188			106	401	9385
1993	721	3030	3492	2368	1809	376	339	160	44	434	12730
1994	503	3683	4568	1850	1537	494	755	137	129	703	14233
1995	869	2569	6419	1762	1279	279	489	164	132	844	14715
1996	679	2483	5210	1687	1451	345	952	77	129	808	13699
1997	1149	2189	6170	2193	1447	317	760	276	100	662	15163
1998	1111	2177	5136	2144	1032	256	836	350	88	694	13735
1999	1244	2391	6518	2207	1009	278	1119	724	202	988	16479
2000	1121	2178	5570	1785	1539	274	1084	597	184	900	15050
2001	1443	2574	5542	1527	1401	177	1190	791	271	1268	15915
2002	1231	1954	7245	1340	1132	403	1170	861	343	1383	16705
2003	1144	2245	6294	1127	1080	336	1089	929	675	1390	15633
2004	1070	2153	8730	1657	1333	228	922	1268	488	1224	18587
2005	1099	3094	10684	1989	1605	165	1089	1050	378	1120	21897
2006	974	4903	10791	2458	1805	133	11033	1288	448	1249	24627
2007	1294	2966	11911	2651	1843	153	755	1467	717	1637	24678
2008	963	1220	12239	2450	1515	172	675	1444	937	1673	22352
2009	728	2713	13327	2663	1067	87	477	1163	1305	2367	24593
2010	958	1443	12968	1950	1063	39	407	806	865	709****	20846
2011	1053	2072	7559	1889	1391	68	395	1191	432	755^	16805
2012	1240	2460	4415	2129	866	13	310	1084	597	532	13556
2013	1050	2982	2951	1503	623	16	191	946	120	409	10791
2014	1416	2503	4147	2384	1253	15	205	1146	320	392	13765
2015	1517	1371	1784	1897	816	15	192	1003	440	610	9657

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
2016	2535	1854	2399	1937	1146	23	178	1636	780	966	13454
2017	2109	1993	5155	2554	1143	9	147	1472	548	1190	16078
2018	1004	1881	4420	2698	1397	4	137	776	318	612	13239
2019	1172	4364	8931	2585	1356	21	191	1612	1167	724	22381
2020 *	540	1912	5543	1787	963	11	179	1186	980	531	13632

*** 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*, 1991–2020, as reported to the WG.

	Belgium	Denmark	Netherlands	Germany	UK	Total*	Discards**
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	958	
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	506	1517	1352
2016	233	0	801	442	1059	2535	708
2017	416	0	745	374	574	2109	786
2018	234	1	429	204	136	1004	537
2019	194	0	551	284	143	1172	155
2020	191	0	284	52	13	540	230

na = not available
*** Totals for 1991–94 exclusive of landings by the Netherlands**
**** Reported Dutch discards, not raised**

Table 11.4.1. *Nephrops* in FU 6: Nominal Landings (tonnes) of *Nephrops*, 1981–2020, as reported to the WG.

Year	UK England & N. Ireland	UK Scotland	UK total	Other countries*	Total
1981	1006	67	1073	0	1073
1982	2443	81	2524	0	2524
1983	2073	5	2078	0	2078
1984	1471	8	1479	0	1479
1985	2009	18	2027	0	2027
1986	1987	28	2015	0	2015
1987	2158	33	2191	0	2191
1988	2390	105	2495	0	2495
1989	2930	168	3098	0	3098
1990	2306	192	2498	0	2498
1991	1884	179	2063	0	2063
1992	1403	60	1463	10	1473
1993	2941	89	3030	0	3030
1994	3530	153	3683	0	3683
1995	2478	90	2568	1	2569
1996	2386	96	2482	1	2483
1997	2109	80	2189	0	2189
1998	2029	147	2176	1	2177
1999	2197	194	2391	0	2391
2000	1947	231	2178	0	2178
2001	2319	255	2574	0	2574
2002	1739	215	1954	0	1954
2003	2031	214	2245	0	2245
2004	1952	201	2153	0	2153
2005	2936	158	3094	0	3094
2006	4430	434	4864	39	4903
2007	2525	437	2962	4	2966
2008	976	244	1220	0	1220
2009	2299	414	2713	0	2713
2010	1258	185	1443	0	1443
2011	1806	251	2057	15	2072
2012	2177	257	2434	26	2460
2013	2666	305	2971	11	2982
2014	2104	345	2449	54	2503
2015	1187	174	1361	10	1371

Year	UK England & N. Ireland	UK Scotland	UK total	Other countries*	Total
2016	1726	125	1851	3	1854
2017	1685	290	1975	18	1993
2018	1557	304	1861	20	1881
2019	3456	853	4309	55	4364
2020	1644	234	1878	34	1912

*** Other countries includes NL, BE, DK, and SE**

Table 11.4.2. *Nephrops* in FU 6: Mean carapace lengths (mm) 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

Year	Catches		Landings	
	Males	Females	Males	Females
2015	31.5	31.7	33.9	34.9
2016	31.2	31.3	33.3	34.3
2017	32.4	32.1	34.1	34.7
2018	32.2	32.4	33.6	34.6
2019	32.1	32.8	33.4	34.6
2020	30.3	30.9	31.9	33.4

Table 11.4.3. *Nephrops* in FU 6: Landings and effort by UK vessels targeting *Nephrops*

Year	Landings (tonnes)	Effort (kWd)	LPUE (kg/kWd)	Number of trips	Landings per trip (kg)	Days at sea	Landings per day at sea (kg)
2006	3046	3232136	0.942	7647	398	12577	242
2007	2208	2933270	0.753	6082	363	10893	203
2008	1207	1772977	0.681	4636	260	7313	165
2009	2267	2827506	0.802	6596	344	9685	234
2010	1438	1948707	0.738	4821	298	7017	205
2011	1816	1941503	0.935	5756	316	7776	234
2012	1997	2136594	0.935	6038	331	8410	237
2013	2315	2432936	0.952	6259	370	8787	263
2014	2032	2324575	0.874	5702	356	8022	253
2015	1139	1691667	0.673	4347	262	5925	192
2016	1519	1754167	0.866	5622	270	7555	201
2017	1178	1393107	0.845	4744	248	6032	195
2018	911	1398222	0.652	4258	214	5302	172
2019	1834	2410208	0.761	5860	313	7542	243
2020	833	1314862	0.634	3689	226	4721	177

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
2019	86	Summer	0.37	1163	26	Geostatistics
2020	110	Summer	0.35	1102	24	Geostatistics
2021	110	Summer	0.31	982	22	Geostatistics

Table 11.4.5. *Nephrops* in FU 6: Individual mean weights in landings and discards, and observed harvest rate.

Year	UWTV abundance	Landings	Discards	Dead discards	Mean weight in landings (g)	Mean weight in discards (g)	Individuals landed	Individuals discarded	Individuals removed	Discard rate	Dead discard rate	Observed harvest rate
	millions	tonnes	tonnes	tonnes			millions	millions	millions	% by number	% by number	% by number
2001	1685	2574	2393	2034	20.60	9.62	125	249	336	66.6	56.6	20.0
2002	1048	1954	795	676	20.01	9.50	98	84	169	46.1	39.2	16.1
2003	1085	2245	716	608	21.89	9.56	103	75	166	42.2	35.9	15.3
2004	1377	2153	615	523	23.14	9.22	93	67	150	41.8	35.5	10.9
2005	1657	3094	715	608	23.58	10.32	131	69	190	34.6	29.4	11.5
2006	1244	4903	1051	893	22.53	10.58	218	99	302	31.3	26.6	24.3
2007	858	2966	432	367	24.95	10.89	119	40	153	25.0	21.3	17.8
2008	987	1220	166	141	26.63	10.97	46	15	59	24.9	21.1	5.9
2009	682	2713	461	392	24.45	10.54	111	44	148	28.3	24.1	21.7
2010	785	1443	201	171	25.18	11.74	57	17	72	23.0	19.5	9.2
2011	878	2072	246	209	27.05	11.02	77	22	96	22.6	19.2	10.9
2012	758	2460	345	293	27.34	10.16	90	34	119	27.4	23.3	15.7
2013	706	2982	450	383	27.60	9.79	108	46	147	29.9	25.4	20.8
2014	755	2503	199	169	29.93	13.59	84	15	96	14.9	12.7	12.7
2015	565	1371	190	162	29.39	9.99	47	19	63	29.0	24.6	11.1
2016	697	1854	272	231	27.97	10.23	66	27	89	28.6	24.3	12.8
2017	902	1993	200	170	29.38	10.28	68	19	84	22.3	18.9	9.4
2018	950	1881	195	166	28.14	11.22	67	17	82	20.6	17.5	8.6
2019	1163	4364	453	385	28.07	11.71	155	39	188	19.9	16.9	16.2
2020*	1102	1912	310	264	24.49	11.72	78	26	101	25.3	21.5	9.1
2021	982											

*** Discard rates and mean weights in landings and discards are adjusted according to the procedure described in Section 11.4.9.**

Table 11.5.1. ***Nephrops*****, Fladen (FU 7), Nominal Landings (tonnes) of** ***Nephrops*****, 1983–2020, 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	2862	2290	0	5152	1	2	5155
2018	2282	2133	0	4415	1	4	4420
2019	6702	2203	0	8905	7	19	8931
2020*	3532	1991	0	5523	18	2	5543

*** provisional na = not available**
****Other countries includes Belgium, Norway, Netherlands, 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, 2000–2020.

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	5152	15205	338.8
2018	4415	14431	305.9
2019	8905	15244	584.2
2020*	5523	13543	407.8

*** 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, 1991–2020.

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
2019	172904	0.038
2020	126608	0.139

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, 1993–2020.

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
2019	30.8	29.1	30.9	29.2	38.8	39.4
2020	31.6	30.5	31.8	30.7	40.1	39.6

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
2019	28.31	21.81	25.13	35.83	33.01
2020	35.26	28.75	26.63	36.20	Na
Mean (2018–2020)	31.38	24.95	26.87	31.76*	-

*** 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 1992–2021 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
2019	70	6129	0.22	802
2020	61	4589	0.16	688
2021	70	6336	0.23	697

Table 11.5.7. *Nephrops*, Fladen Ground (FU 7): Summary of TV results for most recent 3 years (2019–2021) 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
2019 TV survey							
>80	3248	9	0.396	0.014	1286	16484	0.103
55<80	4967	14	0.264	0.014	1314	25529	0.159
40<55	4304	12	0.249	0.021	1071	33002	0.205
<40	15634	35	0.157	0.012	2458	85744	0.533
Total	28153	70			6129	160760	1
2020 TV survey							
>80	3248	10	0.196	0.002	637.6	2255	0.019
55<80	4967	11	0.224	0.008	1113.7	17548	0.148
40<55	4304	11	0.16	0.012	689.7	19867	0.168
<40	15634	29	0.138	0.009	2148.4	78539	0.664
Total	28153	61			4589.4	118209	1
2021 TV survey							
>80	3248	9	0.299	0.007	973	8540	0.07
55<80	4967	13	0.301	0.010	1497	20118	0.165
40<55	4304	13	0.274	0.010	1180	15191	0.125
<40	15634	35	0.172	0.011	2687	77714	0.639
Total	28153	70			6336	121563	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 1992–2021.

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	7.0	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	12.0	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	7.0	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	0.024	34.90	NA	0.0181
2014	2990	412	3.5	102	3	104	4147	37	28	2.5	43.11	13.9	1.92

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	2569	320	1.97	51	0	51	1784	0	0	0	36.7	NA	0
2016	4449	662	1.43	63	0	63	2399	0	0	0.022	39.43	NA	0.0167
2017	7036	968	3.1	212	10	219	5155	115	86	4.4	25.37	11.66	3.4
2018	5656	689	2.8	155	5	159	4420	68	51	2.9	30.58	14.42	2.2
2019	6129	802	5.6	338	8	344	8931	100	75	2.2	28.31	13.32	1.64
2020	4589	688	3.7	166	2	168	5543	28	21	1.4	35.26	11.74	1.06
2021	6336	697											

Table 11.6.1 *Nephrops*. Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981–2020, as reported to the WG.

Year	UK Scotland					UK	Total **
	***Nephrops* trawl**	**Other trawl**	**Creel**	**BMS**	**Sub-total**	**(E, W & NI)**	
1981	947	60	0	0	1007	0	1007
1982	1138	57	0	0	1195	0	1195
1983	1681	43	0	0	1724	0	1724
1984	2078	56	0	0	2134	0	2134
1985	1907	61	0	0	1968	0	1968
1986	2204	59	0	0	2263	0	2263
1987	1583	90	2	0	1675	0	1675
1988	2455	74	0	0	2529	0	2529
1989	1834	53	0	0	1887	1	1888
1990	1900	30	0	0	1930	1	1931
1991	1362	43	0	0	1405	0	1405
1992	1715	41	0	0	1756	0	1756
1993	2349	17	0	0	2366	2	2368
1994	1827	17	0	0	1844	6	1850
1995	1707	53	0	0	1760	2	1762
1996	1621	66	0	0	1687	0	1687
1997	2136	55	0	0	2191	2	2193
1998	2105	37	0	0	2142	2	2144
1999	2193	10	1	0	2204	3	2207
2000	1775	9	0	0	1784	1	1785
2001	1484	34	0	0	1518	9	1527
2002	1302	31	1	0	1334	6	1340
2003	1116	8	0	0	1124	3	1127
2004	1650	4	0	0	1654	3	1657
2005	1974	0	4	0	1978	11	1989
2006	2438	3	12	0	2453	5	2458
2007	2627	10	7	0	2644	7	2651
2008	2435	2	8	0	2445	5	2450
2009	2620	8	26	0	2654	9	2663
2010	1923	5	13	0	1941	9	1950
2011	1789	6	89	0	1884	5	1889
2012	1944	17	126	0	2087	42	2129
2013	1409	24	58	0	1491	12	1503
2014	2344	4	14	0	2362	22	2384
2015	1784	2	43	0	1829	68	1897

Year	UK Scotland					UK	Total **
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	
2016	1786	1	116	1.5	1905	32	1937
2017	2472	11	10	0	2493	61	2554
2018	2646	7	4	0	2657	41	2698
2019	2531	10	5	0	2546	39	2585
2020*	1768	3	0	0	1771	16	1787

*** 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, 2000–2020.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	1784	10508	169.8
2001	1518	11513	131.9
2002	1333	10394	128.2
2003	1124	8279	135.8
2004	1654	9505	174.0
2005	1974	7704	256.2
2006	2441	6174	395.4
2007	2637	6409	411.5
2008	2437	6440	378.4
2009	2628	5852	449.1
2010	1928	5054	381.5
2011	1795	4614	389.0
2012	1961	5058	387.7
2013	1433	4029	355.7
2014	2348	6812	344.7
2015	1786	6024	296.5
2016	1787	5224	342.1
2017	2483	5261	472.0
2018	2653	4886	543.0
2019	2541	5116	496.7
2020*	1771	4159	425.8

*** 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, 1981–2020.

Year	Catches		Landings			
	<35 mm CL		<35 mm CL		>35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31.0	39.7	38.7
1982	na	na	30.4	30.1	40.0	39.1
1983	na	na	31.1	30.8	40.2	38.7
1984	na	na	30.3	29.7	39.4	38.4
1985	na	na	30.6	29.9	39.4	38.2
1986	na	na	29.7	29.2	39.1	38.5
1987	na	na	29.9	29.6	39.1	38.2
1988	na	na	28.5	28.5	39.1	39.0
1989	na	na	29.2	28.9	38.7	38.9
1990	28.9	27.8	29.8	28.6	38.3	38.8
1991	28.7	27.5	29.8	28.7	38.3	38.7
1992	29.5	27.9	30.2	28.7	38.1	38.7
1993	28.7	28.0	30.3	29.5	39.0	38.6
1994	25.7	25.1	29.1	28.5	38.8	37.8
1995	27.9	27.1	29.4	28.9	38.7	37.9
1996	28.0	27.4	29.8	28.8	38.6	38.6
1997	27.2	27.0	29.2	28.7	38.8	38.2
1998	27.7	26.4	29.0	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38.0	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011	28.6	27.5	30.0	28.3	38.8	38.2
2012	28.4	28.0	30.4	29.3	39.0	38.1
2013	28.3	27.4	29.6	28.8	38.8	37.9
2014	29.6	29.1	31.1	30.3	38.6	38.1
2015	27.9	28.3	29.5	29.3	39.6	38.5

Year	Catches		Landings			
	<35 mm CL		<35 mm CL		>35 mm CL	
	Males	Females	Males	Females	Males	Females
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
2019	28.1	27.0	29.7	28.1	39.2	38.5
2020	30.5	29.7	31.4	30.3	39.5	39.4

na = not available

Table 11.6.4. *Nephrops*, Firth of Forth (FU 8): Results of the 1993–2021 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

Year	Stations	Mean Density	Abundance	95% conf interval
		Burrows/m^2	millions	millions
2018	50	1.12	1025	190
2019	50	0.95	865	135
2020	34	1.22	1119	180
2021	41	0.92	837	107

Table 11.6.5. *Nephrops*, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2019–2021) 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
2019 TV survey							
M & SM	170	8	0.950	0.243	162	886	0.196
MS(west)	139	9	0.593	0.246	82	529	0.117
MS(mid)	211	12	1.264	0.306	266	1130	0.25
MS(east)	395	21	0.898	0.266	355	1982	0.438
Total	915	50			865	4527	1
2020 TV survey							
M & SM	170	6	1.438	0.795	245.1	3852	0.475
MS(west)	139	5	1.407	0.339	195.4	1309	0.162
MS(mid)	211	8	1.41	0.358	296.9	1986	0.245
MS(east)	395	15	0.967	0.092	381.9	954	0.118
Total	915	34			1119.3	8102	1
2021 TV survey							
M & SM	170	6	1.017	0.097	173	470	0.165
MS(west)	139	5	0.654	0.173	91	666	0.234
MS(mid)	211	12	0.865	0.175	182	644	0.227
MS(east)	395	18	0.989	0.123	391	1062	0.374
Total	915	41			837	2843	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 1993–2021.

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	97	49	134	2368	426	426	33	24.3	11.64	27
1994	448	78	51	95	180	230	1850	1188	1188	66	19.51	8.79	59
1995	NA	NA	NA	90	59	134	1762	465	465	40	19.55	10.54	33
1996	375	88	37	81	78	140	1687	697	697	49	20.81	11.85	42
1997	NA	NA	NA	116	56	158	2193	371	371	33	18.87	8.79	27
1998	292	81	56	118	60	163	2144	434	434	34	18.23	9.6	28
1999	463	78	40	110	97	183	2207	704	704	47	20.05	9.63	40
2000	443	70	34	82	90	150	1785	774	774	52	21.83	11.42	45
2001	419	79	25	72	45	106	1527	327	327	39	21.22	9.59	32
2002	508	119	21	68	52	107	1340	316	316	43	19.62	8.16	36
2003	767	138	12.4	51	59	95	1127	546	410	54	22.31	9.25	47
2004	630	140	16.4	74	40	103	1657	406	304	35	22.45	10.25	29
2005	710	143	19.4	89	65	138	1989	602	452	42	22.33	9.28	35
2006	827	126	27	115	142	221	2458	1510	1133	55	21.43	10.67	48
2007	692	132	23	126	43	159	2651	614	461	25	20.97	14.34	20
2008	881	297	21	142	58	186	2450	796	597	29	17.23	13.65	24
2009	732	142	26	137	71	190	2663	573	430	34	19.41	8.09	28
2010	682	147	19.2	99	43	131	1950	407	305	30	19.76	9.55	24
2011	533	87	22	100	24	118	1889	231	173	19.5	19.75	9.56	15.3
2012	522	64	25	100	38	129	2129	379	284	27	21.66	10.10	22
2013	668	126	15.6	81	31	104	1503	301	226	27	19.30	9.82	22
2014	428	80	29	102	30	124	2384	353	265	23	24.30	11.66	18.3

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	664	127	16.8	90	29	112	1897	311	234	24	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	2554	280	210	20	23.07	10.07	15.8
2018	1025	190	12.9	114	24	132	2698	275	206	17.4	24.29	11.42	13.6
2019	865	135	18.3	127	42	158	2585	411	308	25	21.81	9.76	19.9
2020	1119	180	6.1	64	5	68	1787	53	40	6.9	28.75	10.83	5.5
2021	837	107											

Table 11.7.1. *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981–2020, 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	943	191	8	1142	1	1143
2018	1203	183	9	1395	2	1397
2019	1150	191	13	1354	2	1356
2020*	800	154	7	961	2	963

*** 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, 2000–2020

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	1134	5044	224.8
2018	1386	4579	302.7
2019	1341	4343	308.8
2020*	954	3518	271.2

*** 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, 1981–2020.

Year	Catches <35 mm CL		Landings <35 mm CL		Landings =>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
2019	30.1	29.6	30.3	29.7	40.3	38.5
2020	30.4	29.4	31.0	30.0	40.1	38.3

na = not available

Table 11.7.4. *Nephrops*, Moray Firth (FU 9): Results of the 1993–2021 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
2020			no survey	
2021	46	0.30	658	153

Table 11.7.5. *Nephrops*, Moray Firth (FU 9): Summary of TV results for most recent 3 years (2018–2021) 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
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
2019 TV survey							
M & SM	169	2	0.39	0.23	66	3279	0.615
MS(west)	682	20	0.12	0.03	84	754	0.141
MS(mid)	698	17	0.18	0.01	123	339	0.064
MS(east)	646	16	0.16	0.04	103	963	0.18
Total	2195	55			376	5335	1
2021 TV survey							
M & SM	169	3	0.42	0.01	71	92	0.016
MS(west)	682	17	0.22	0.07	148	1892	0.322
MS(mid)	698	12	0.31	0.03	214	1151	0.196
MS(east)	646	14	0.35	0.09	225	2738	0.466
Total	2195	46			658	5872	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 1993–2021.

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	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	14.0
1995	NA	NA	NA	62	72	116	1279	502	376	54	20.59	6.93	47
1996	465	90	21	68	41	98	1451	492	369	37	21.4	12.11	31
1997	262	55	33	71	22	87	1447	230	172	24	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	12.0	21.79	8.63	9.3
2000	386	98	20	61	23	78	1539	269	201	27	25.44	11.73	22
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	40	27.68	8.18	33
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	33	27.57	11.62	27
2005	869	198	8.8	67	12	76	1605	122	92	15.0	23.84	10.31	11.7
2006	445	124	20	81	12	90	1805	117	87	12.8	22.34	9.86	9.9
2007	531	156	16.0	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	1143	12	9	2.6	26.34	10.74	1.99
2018	417	126	11.7	48	0	49	1397	4	3	0.87	28.86	9.58	0.66
2019	376	146	14.8	55	1	56	1356	10	8	1.86	25.13	9.84	1.40
2020	NA	NA	7.4	36	2	38	963	17	13	5.5	26.63	7.88	4.2
2021	658	153											

Table 11.8.1. *Nephrops*, Noup (FU 10): Nominal landings (tonnes) of *Nephrops*, 1981–2020, 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

Year	*Nephrops* Trawl	Other trawl	Creel	Sub Total	Other UK	Total
2017	0	9	0	9	0	9
2018	0	4	0	4	0	4
2019	0	21	0	21	0	21
2020*	0	11	0	11	0	11

*** 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, 2000–2020.

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
2019	21	642	32.7
2020*	11	339	32.4

*** 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, 1997–2019. No females in samples in 2010 and no sampling in 2015, 2018 and 2020.

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
2019	32.6	32.0	38.6	46.0
2020	na	na	na	na

na = not available

Table 11.8.4. *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006, 2007, 2014 and 2019 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		
2019	11	0.22	90	46
2020		no survey		

Table 11.9.1. *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993–2020, estimated Danish discards (2003–2020), and TAC (EU) (2004-2021).

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	91	1	0	22	78#	100	0	0	0	191	600
2020*	81	1	0	25	69#	94	3	1	0	179	600
2021											200

*** 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*, 1993–2020.

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
2019	712	996	888	128
2020	628	892	773	129

Table 11.9.3. *Nephrops* Norwegian Deep (FU 32): Biomass index from Norwegian bottom trawl survey (shrimp survey) in FU 32 (mean, SD, 25th percentile, median, and 75th percentile), for 2006–2021. Data from the 2016 survey were discarded due to technical problems with the gear that year.

Year	mean	SD	25th percentile	median	75th percentile
2006	1341	690	856	1198	1633
2007	942	305	727	900	1116
2008	299	116	217	279	358
2009	281	103	207	266	334
2010	585	180	459	556	678
2011	392	119	306	375	458
2012	723	295	511	674	882
2013	421	138	322	400	500
2014	366	322	166	274	458
2015	644	293	434	585	790
2016	na	na	na	na	na
2017	287	116	204	267	346
2018	414	122	327	400	482
2019	288	93	222	273	337
2020	169	59	128	161	199
2021	140	49	105	133	166

Table 11.10.1 *Nephrops* in FU 33: (Off Horns Reef) Landings (tonnes) by country, 1993–2020.

Year	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
2019	462	220	329	599	2	1612
2020	397	164	128	489	7	1186

na = not available; + < 0.5 tonnes

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

Table 11.10.2. *Nephrops*, Off Horn's Reef (FU 33): Results of the 2017 to 2019 TV surveys (absolute conversion factor = 1.1, from FU 3 & 4).

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	millions
2017	59	0.13	728	70
2018	85	0.07	427	43
2019	60	0.07	417	59

Table 11.11.1. ***Nephrops*****, Devil's Hole (FU 34): Nominal landings (tonnes) of** ***Nephrops*** **1986–2020 as reported to the WG. Scottish data only from 1986 to 2009.**

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-total				
1986	20	3	0	23				23
1987	2	3	0	5				5
1988	1	1	0	2				2
1989	15	13	0	28				28
1990	20	6	0	26				26
1991	64	21	0	85				85
1992	78	28	0	106				106
1993	23	21	0	44				44
1994	79	50	0	129				129
1995	37	95	0	132				132
1996	40	89	0	129				129
1997	30	70	0	100				100
1998	15	73	0	88				88
1999	80	122	0	202				202
2000	89	95	0	184				184
2001	159	112	0	271				271
2002	240	103	0	343				343
2003	518	157	0	675				675
2004	398	90	0	488				488
2005	253	125	0	378				378
2006	359	89	0	448				448
2007	649	68	0	717				717
2008	844	93	0	937				937
2009	1297	8	0	1305				1305
2010	816	22	0	838	25	1	1	865
2011	406	16	0	422	6	4		432
2012	546	4	0	550	37	10		597
2013	65	41	0	106	11	3		120
2014	293	14	0	307	13			320
2015	383	18	0	401	39	<0.5		440
2016	738	6	0	744	36			780
2017	398	122	0	520	28			548
2018	218	86	0	304	14			318
2019	1027	103	0	1130	37			1167
2020*	855	55	0	910	70			980

*** 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, 2000–2020.

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	520	1088	477.9
2018	304	620	490.3
2019	1130	1291	875.3
2020*	910	1152	789.9

*** 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, 2006–2020. 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
2019	32.2	31.4	39.8	40.9
2020	32.0	30.6	39.9	41.9

na = not available

Table 11.11.4. *Nephrops*, Devil's Hole (FU 34): Results of the TV surveys (2003–2021).

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
2019	20	0.29	0.09
2020		no survey	
2021	10	0.28	0.11

Table 11.12.1. *Nephrops* landings from Subarea 27.4 outside FUs.

Year	Belgium	Denmark	France	Germany	Netherlands	Sweden	UK (England)	UK (Scotland)	Total
2011	-	53.1	-	207.7	136.9	-	35.5	321.5	754.8
2012	-	27.1	-	131.7	128.0	-	43.5	202.0	532.4
2013	31.1	7.8	-	83.8	151.5	-	56.8	78.3	409.3
2014	50.6	30.9	-	115.1	69.2	-	28.4	98.2	392.4
2015	173.0	24.6	-	104.9	154.5	-	36.0	117.4	610.3
2016	217.0	22.9	-	218.6	289.7	-	53.3	164.0	965.5
2017	269.8	29.3	-	352.0	319.3	-	60.9	158.3	1189.6
2018	121.2	16.3	-	143.4	117.8	-	32.9	180.7	612.3
2019	95.7	25.4	-	190.5	183.9	-	34.1	194.1	723.8
2020	82.9	44.7	-	76.6	112.0	-	55.3	159.5	531.0

Table 11.12.2. *Nephrops* reported discards from Subarea 27.4 outside FUs.

Year	Belgium	Denmark	France	Germany	Netherlands	Sweden	UK (England)	UK (Scotland)	Total
2012	-	18.2	-	-	-	-	-	-	18.2
2013	-	-	-	-	-	-	-	-	-
2014	-	0.5	-	-	-	-	-	-	0.5
2015	-	1.4	-	-	-	-	-	-	1.4
2016	-	0.1	-	-	550.6	-	-	1.8	552.5
2017	-	0.1	-	-	133.2	-	-	8.2	141.5
2018	-	0.1	-	-	176.4	-	-	-	176.5
2019	-	0.3	-	-	605.7	-	-	0.7	606.7
2020	-	0.3	-	-	114.9	-	-	-	115.2

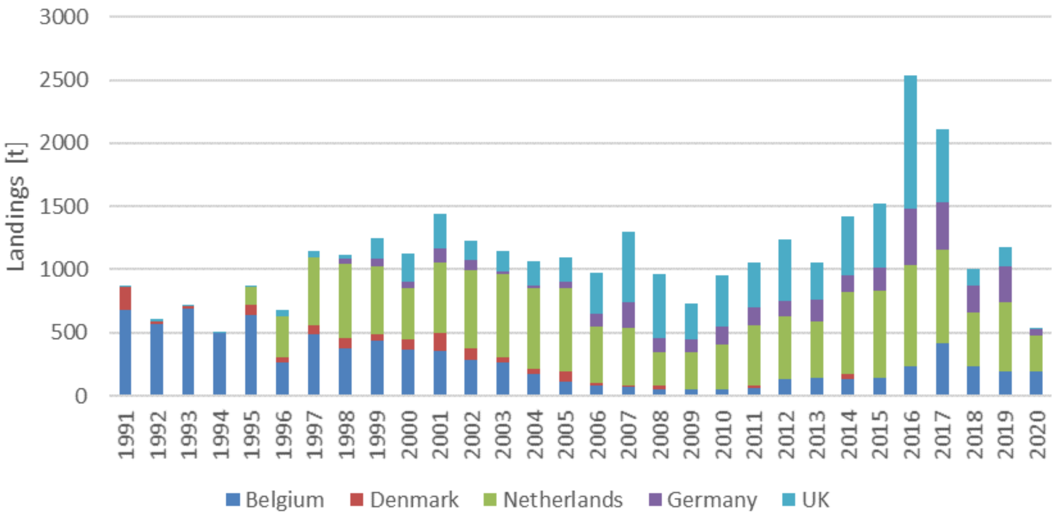


Figure 11.3.1. FU 5 Botney Cut/Silver Pit: Annual landings by country

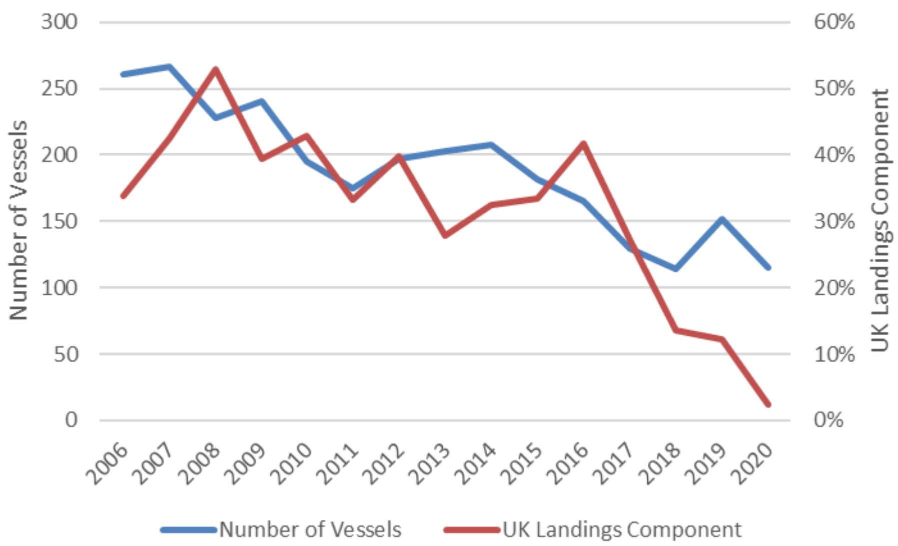


Figure 11.3.2. FU 5 Botney Cut/Silver Pit: Annual UK landings as percent of total international landings (blue), and number of UK *Nephrops* directed trawlers (red).

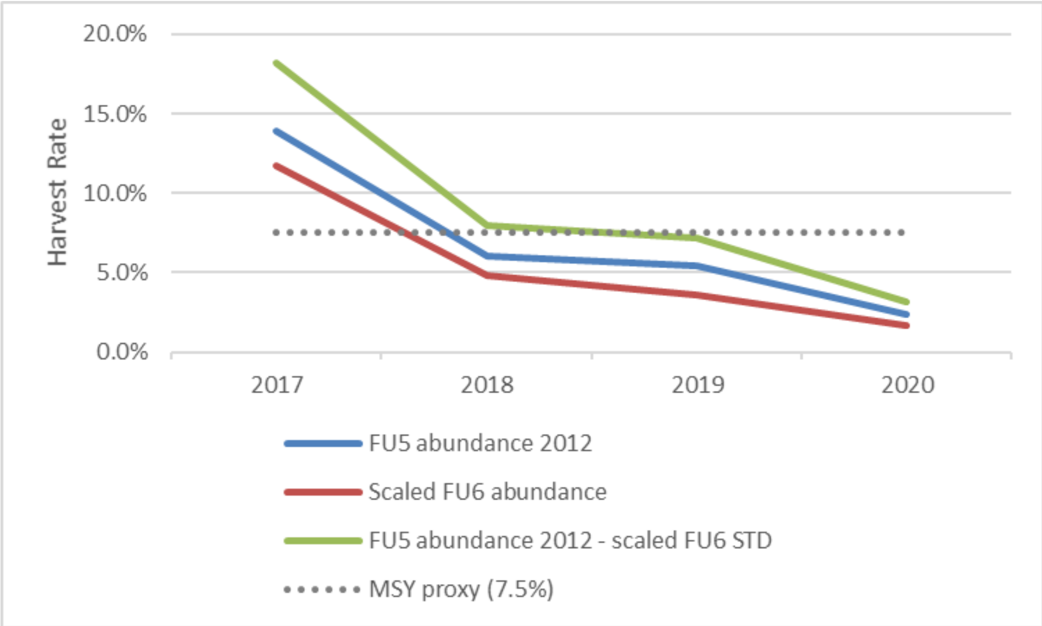


Figure 11.3.3. FU 5 Botney Cut/Silver Pit: Harvest rates based on annual landings and dead discards, together with 2015 mean weights in landings and discards, and the 2012 abundance in FU 5 (blue line), or the scaled annual abundance in FU 6 (red line), or the 2012 abundance in FU 5 minus the scaled standard deviation from FU 6 (green line) (see Section 11.3.5).

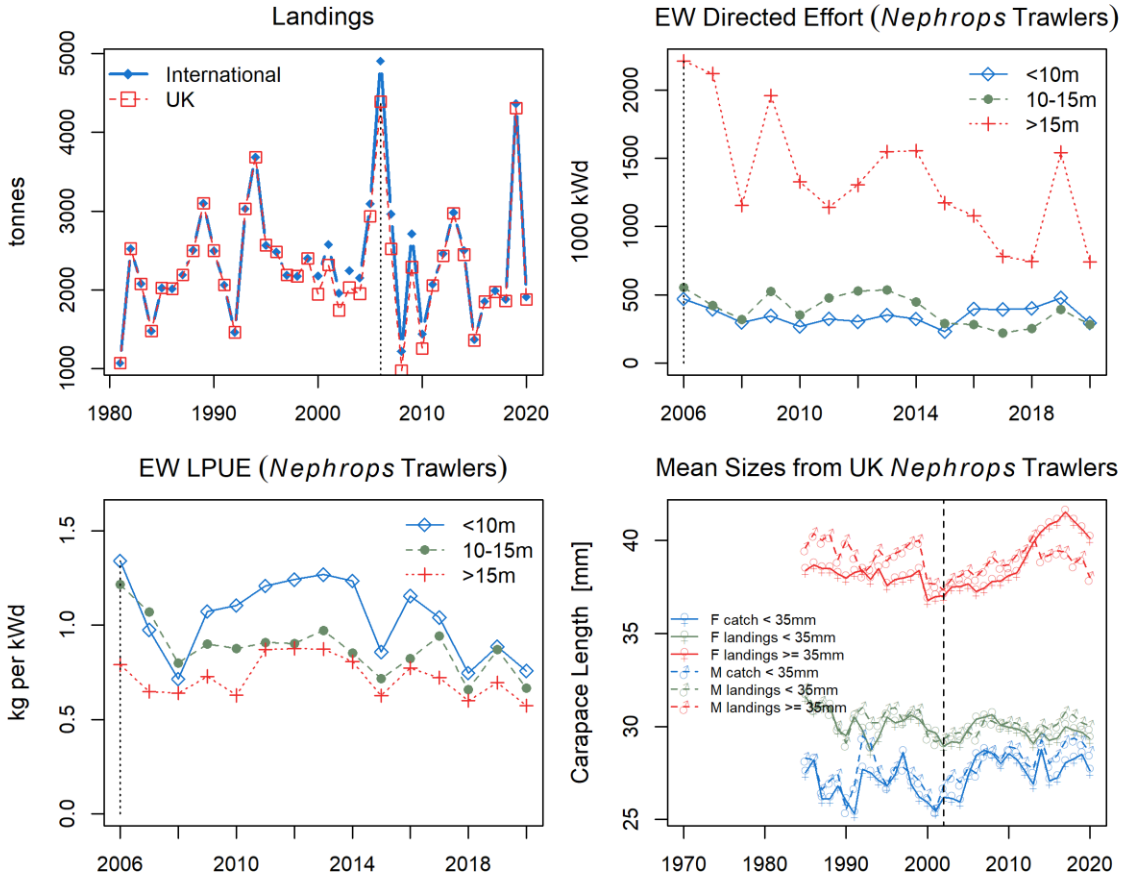


Figure 11.4.1. *Nephrops* in FU 6: Landings, directed effort, directed LPUE and mean sizes of different catch components.

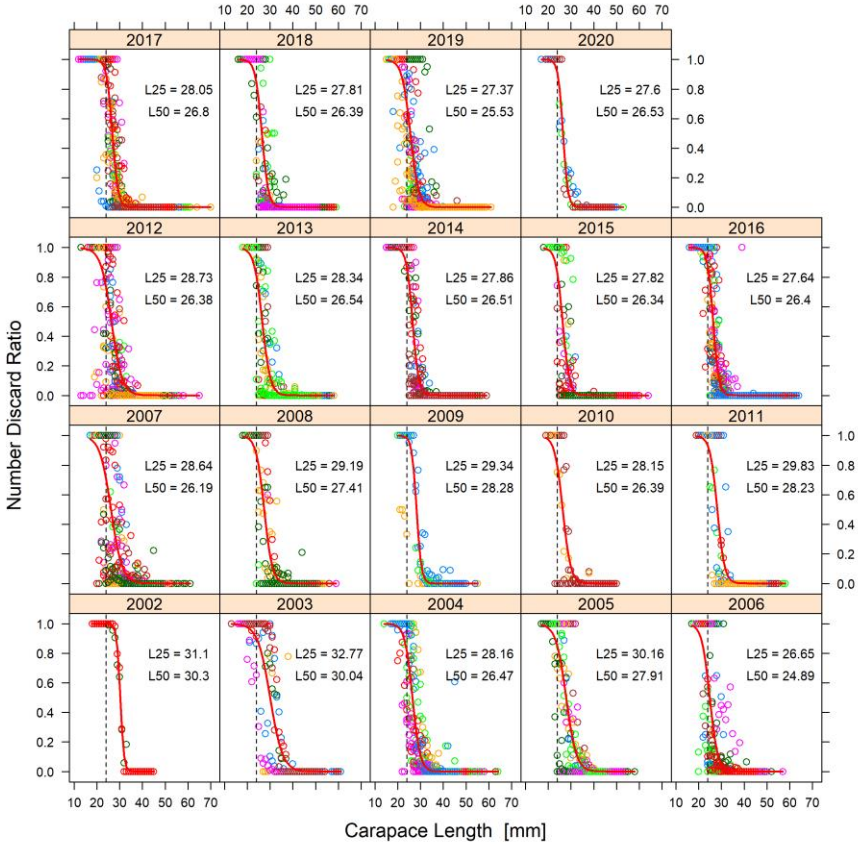


Figure 11.4.2. ***Nephrops*** **in FU 6, annual discard ogives: The different point shapes represent different sampling trips within any year.**

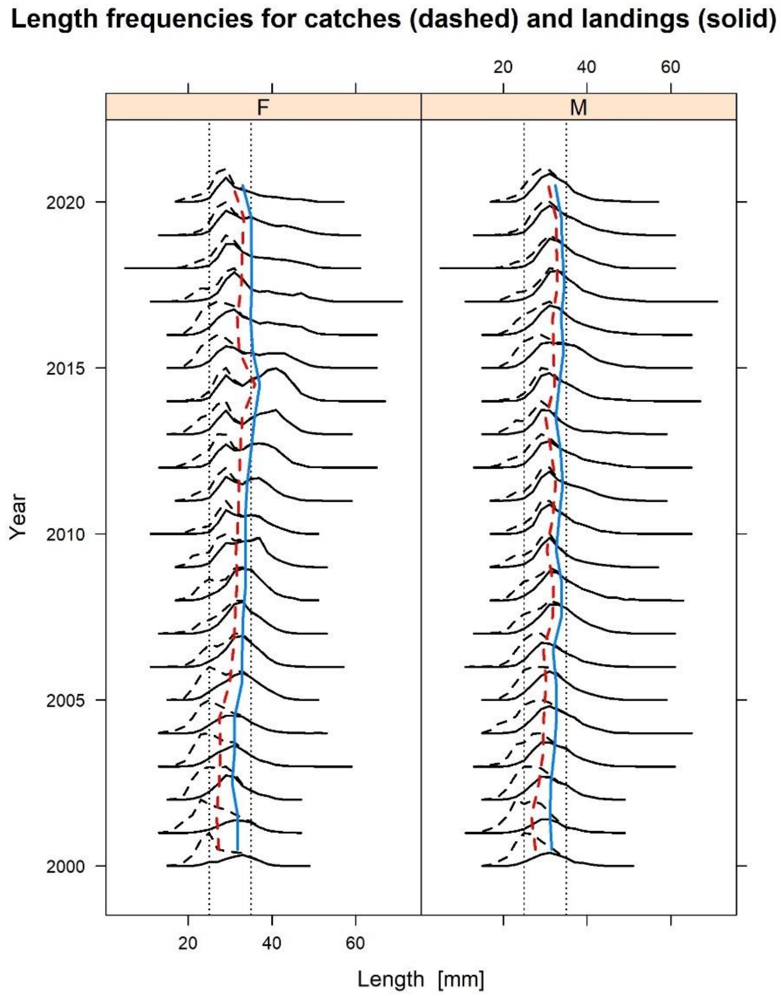


Figure 11.4.3. ***Nephrops*** **in FU 6: Annual length frequencies for landings and catch by sex, together with mean size of the landings (blue line) and catch (red line).**

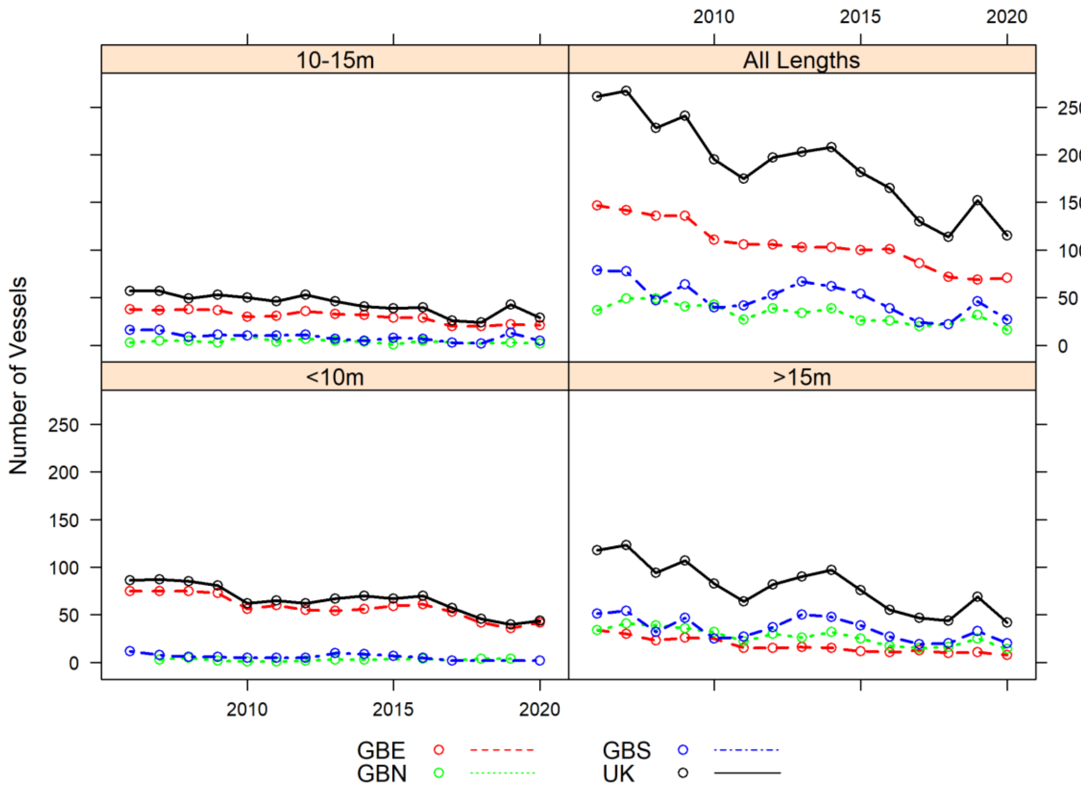


Figure 11.4.4. ***Nephrops*** **in FU 6: Number of participating UK vessels by length class.**

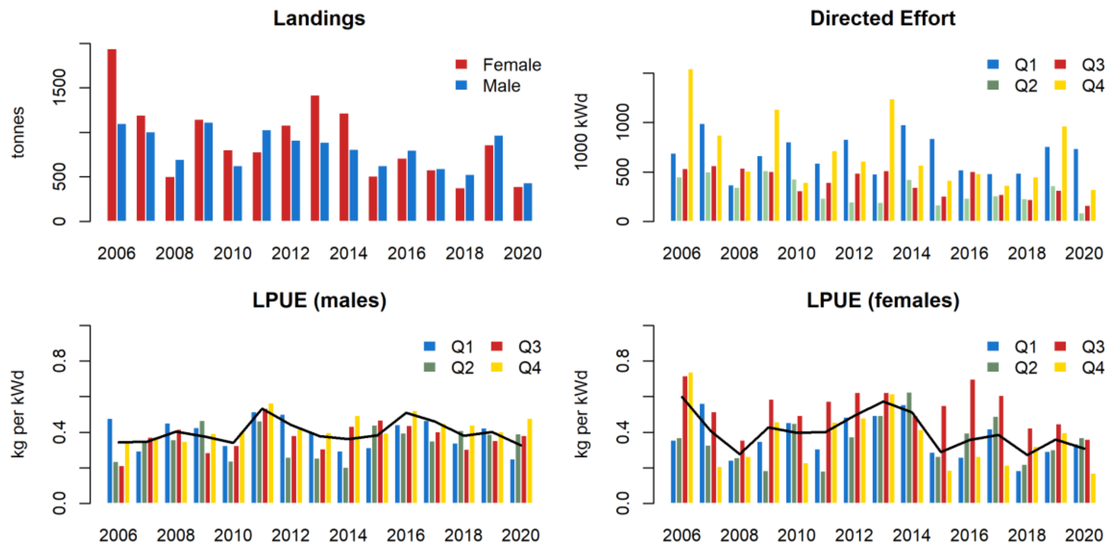


Figure 11.4.5. ***Nephrops*** **in FU 6: Annual landings by sex, directed effort by quarter, and LPUE by sex and quarter.**

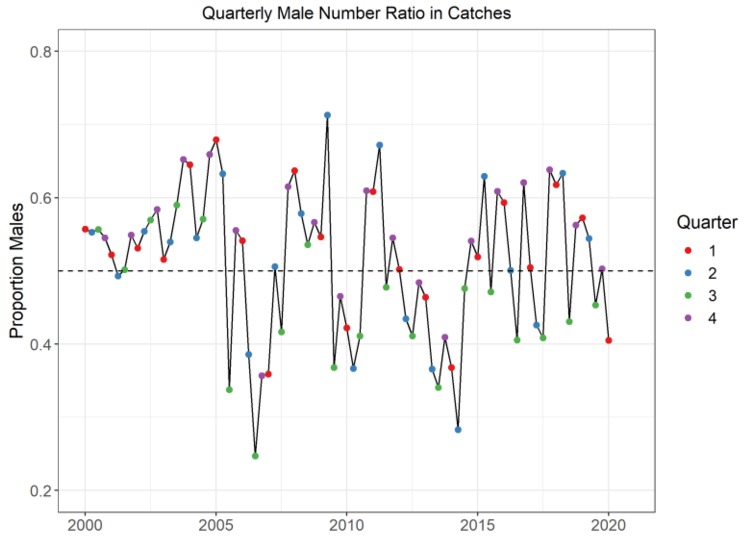


Figure 11.4.6. ***Nephrops*** **in FU 6: Quarterly sex ratio in the catches. Insufficient sampling data are available for quarters 2 to 4 in 2020.**

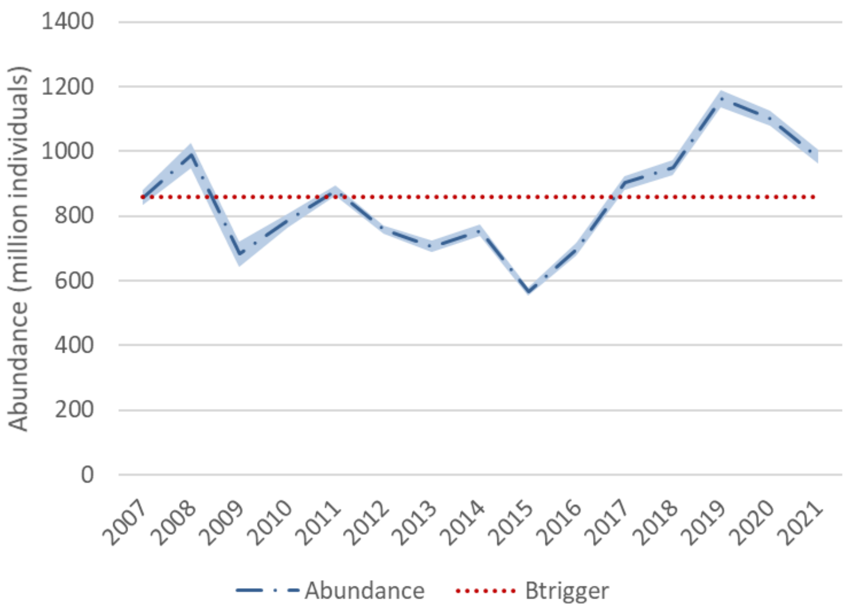


Figure 11.4.7. ***Nephrops*** **in FU 6: Time series of UWTV results. The dotted red line is the proxy for MSY $B_{trigger}$, defined as the abundance estimate for 2007. The blue shading around the abundance line indicates the 95% confidence interval from random resampling (bootstrapping).**

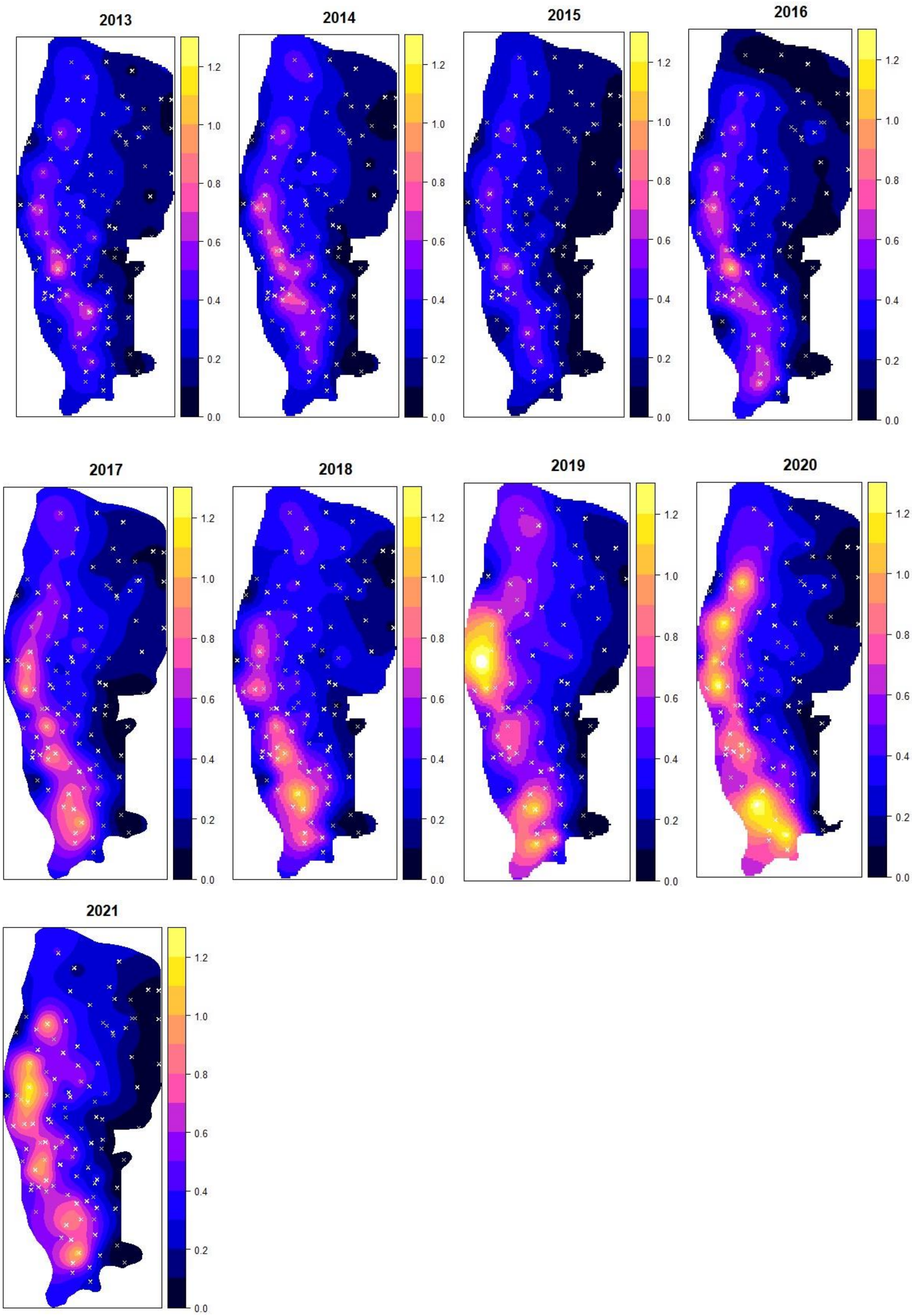


Figure 11.4.8. ***Nephrops*** **in FU 6: Number density (burrows per m²) from the UWTV survey.**

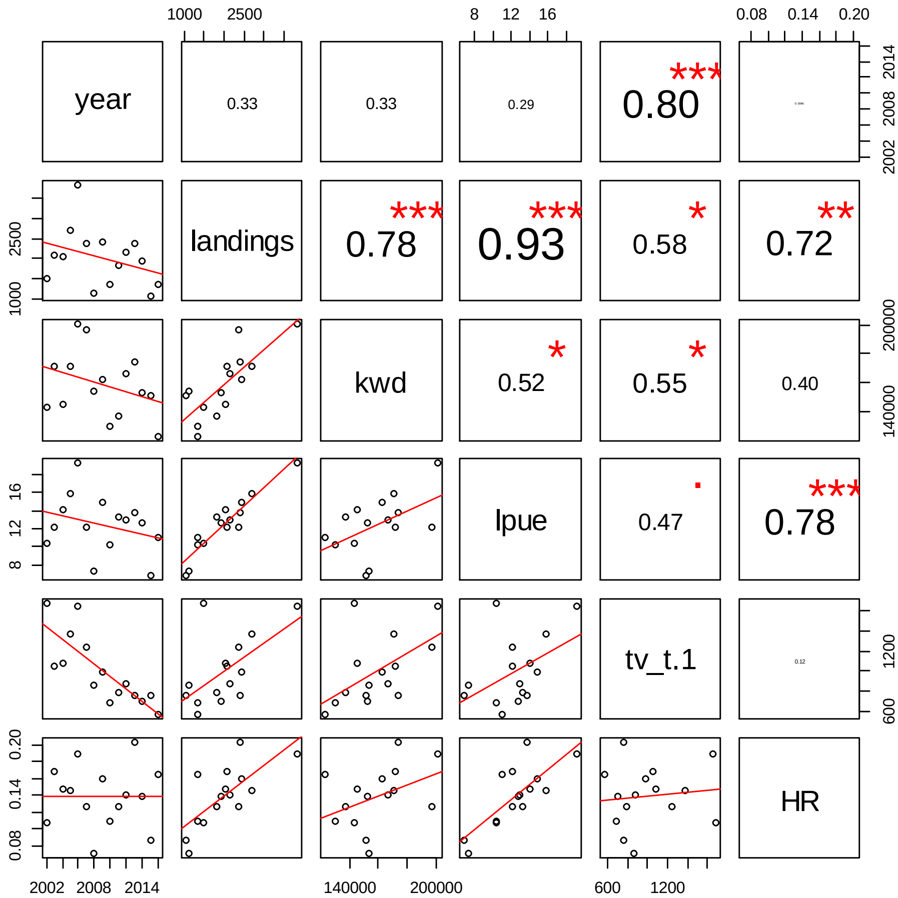


Figure 11.4.9. ***Nephrops*** **in FU 6. Scatterplot matrices of** ***Nephrops*** **metrics, where the UWTV survey lagged by 1 year (i.e., UWTV survey in the year preceding the fishery statistics).**

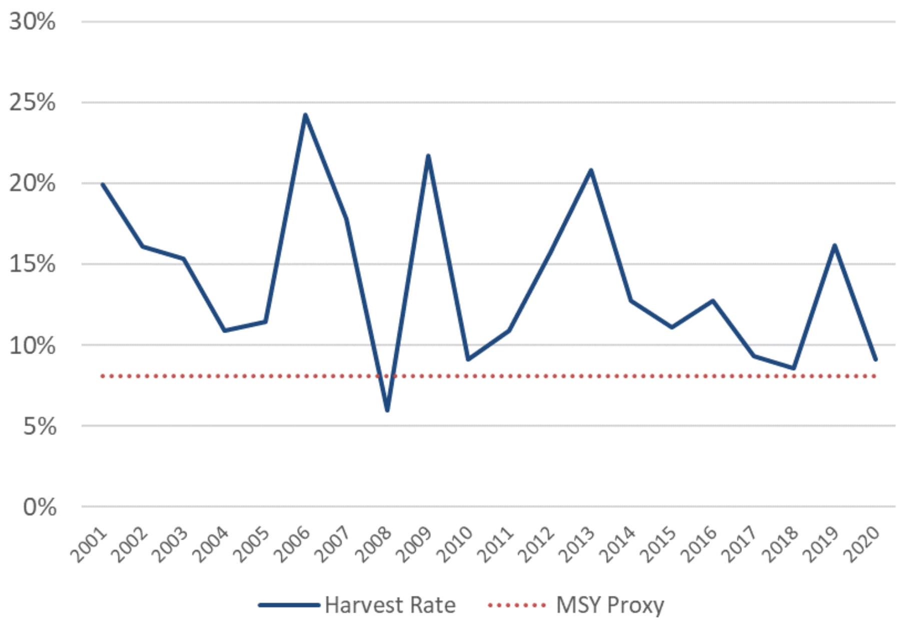


Figure 11.4.10. ***Nephrops*** **in FU 6: Observed harvest rate (total removals divided by abundance estimate).**

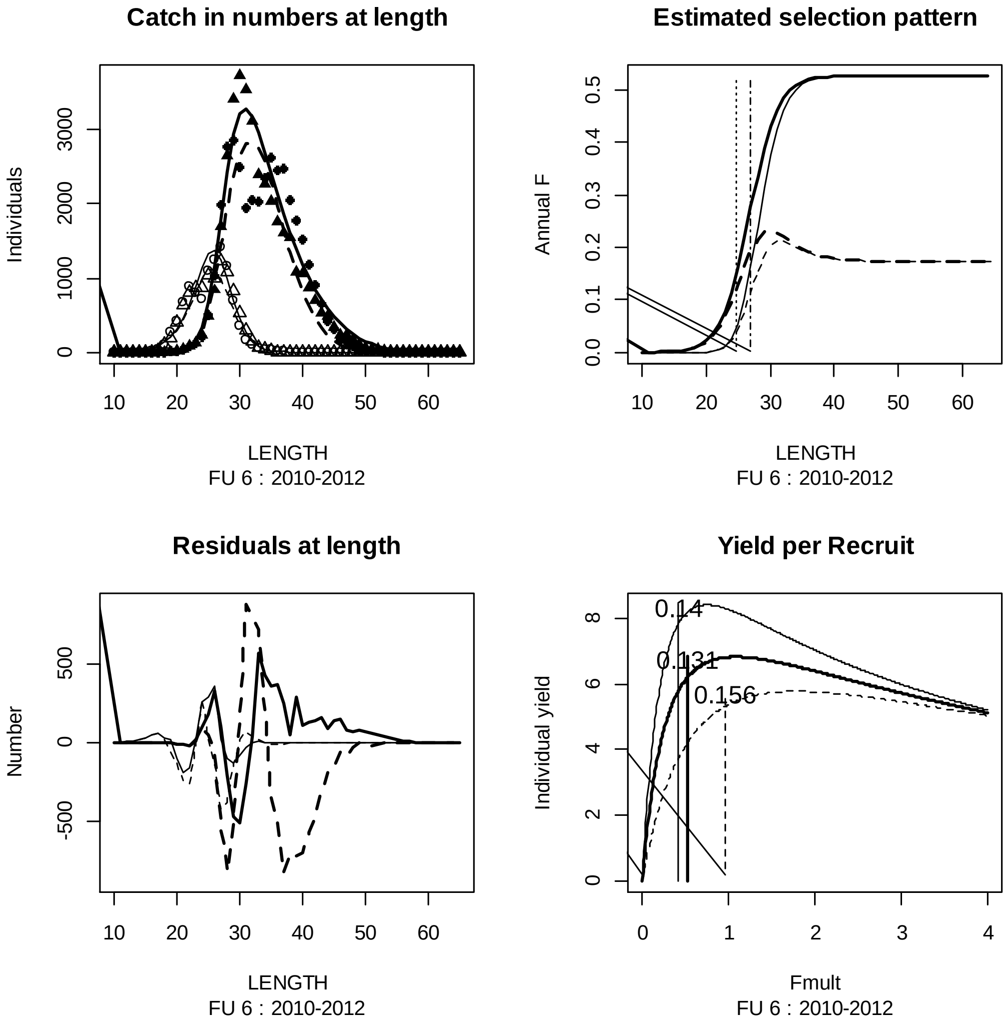


Figure 11.4.11. *Nephrops* in FU 6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards 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.

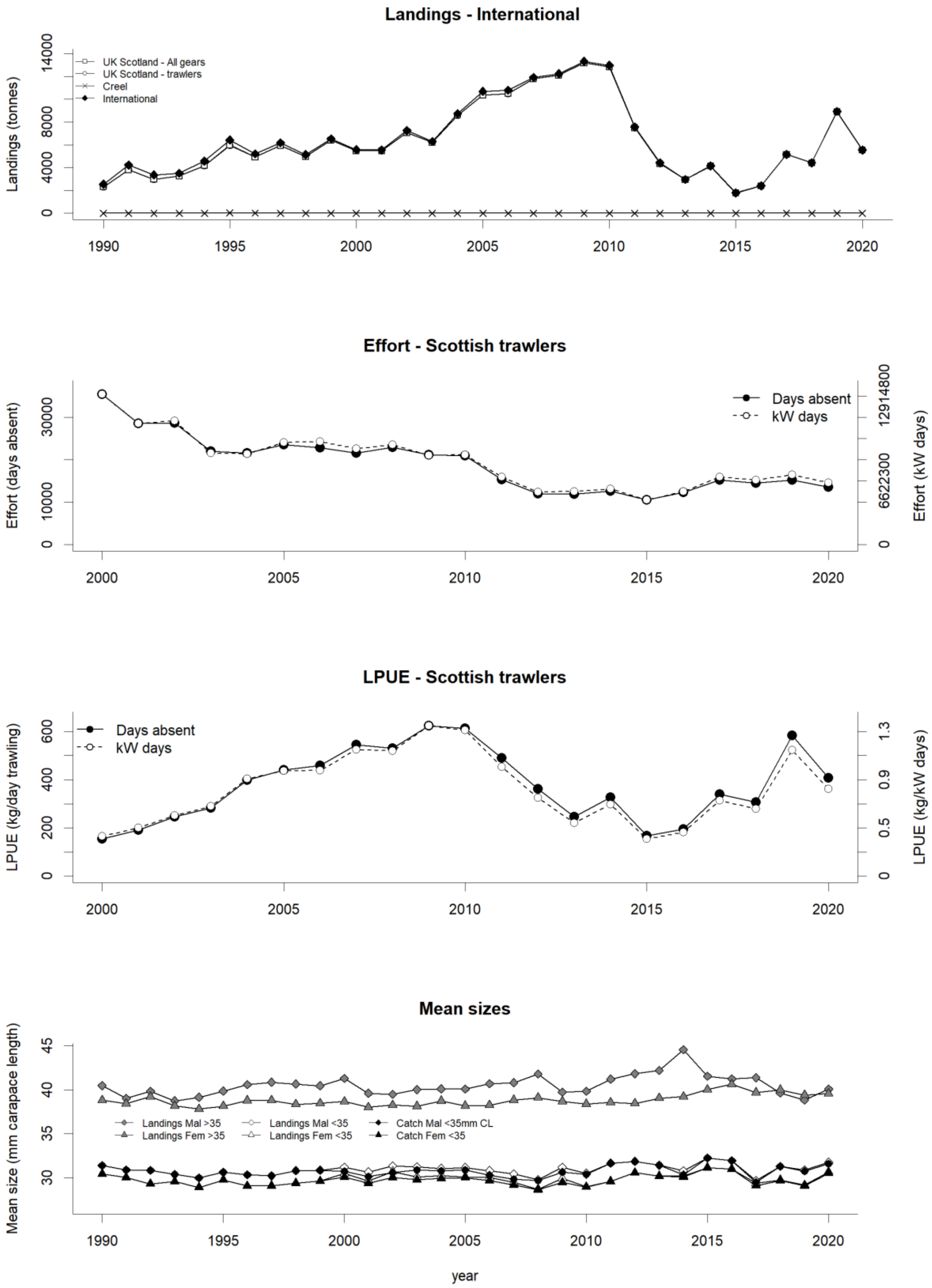
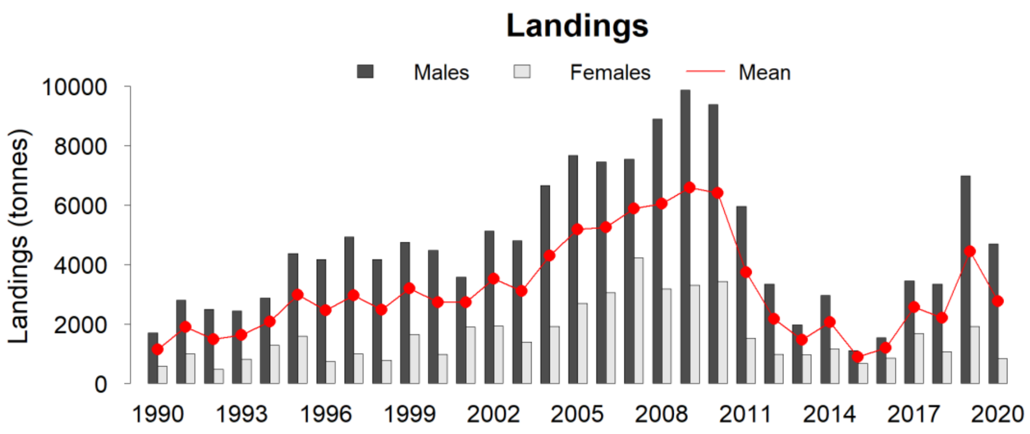


Figure 11.5.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2020.**



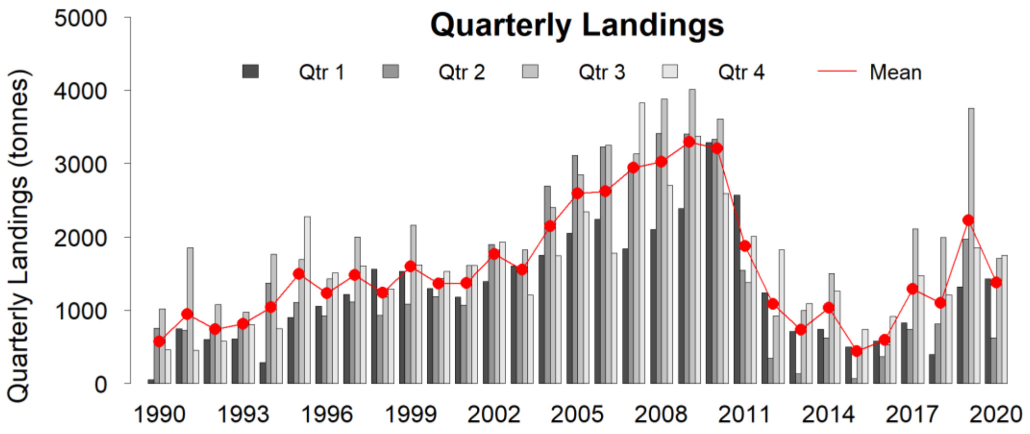


Figure 11.5.2 *Nephrops*, Fladen (FU 7), Landings by quarter and sex from Scottish *Nephrops* trawlers.

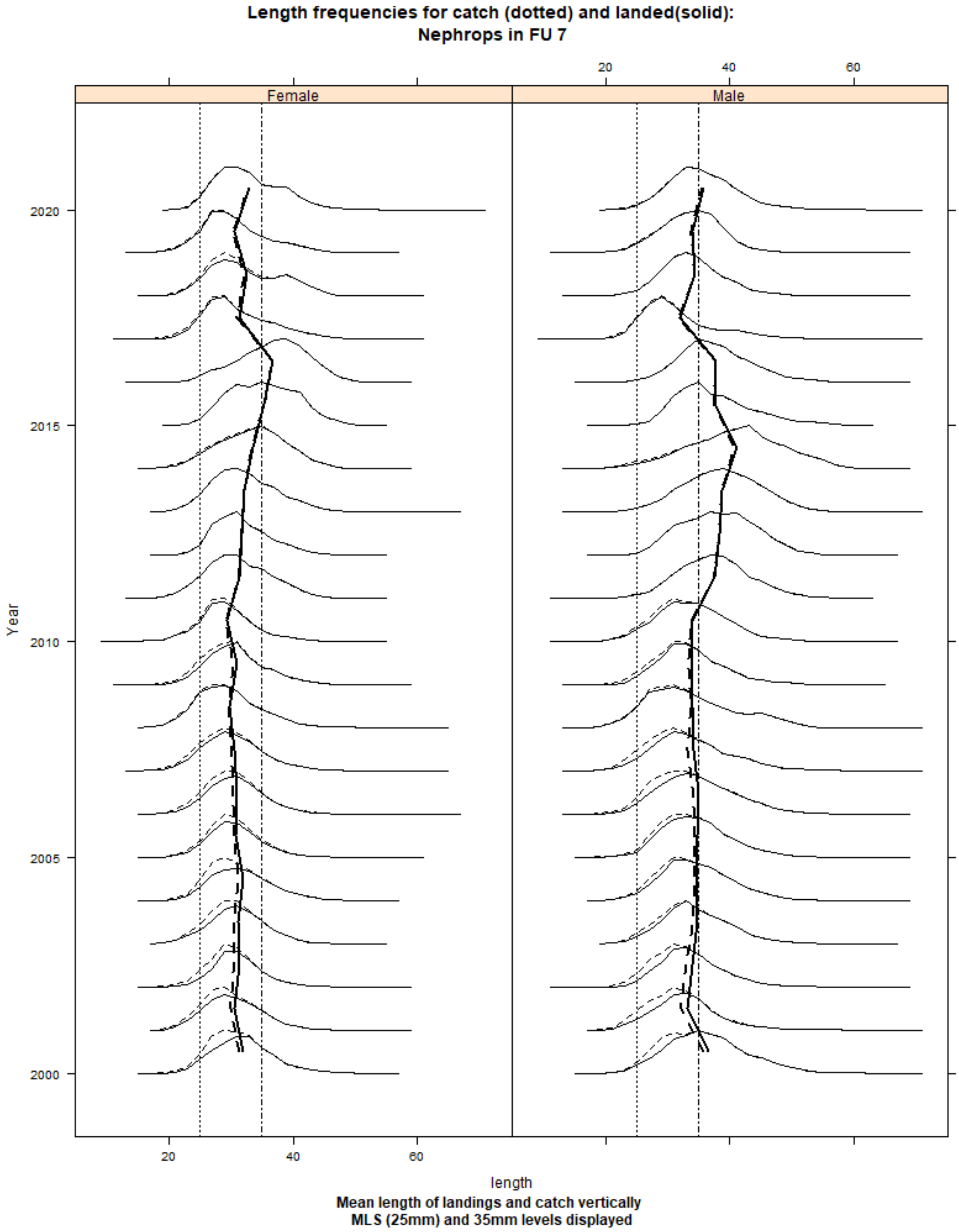
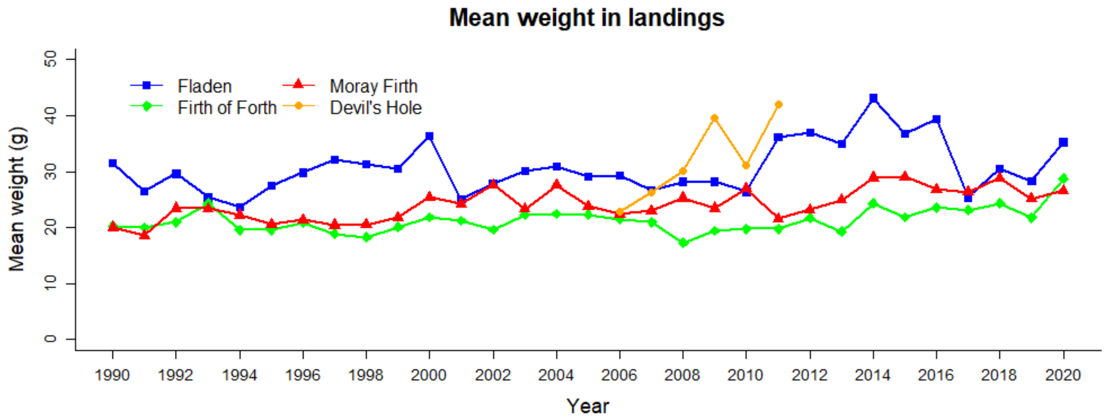


Figure11.5.3 *Nephrops* Fladen Ground (FU 7) Length composition of catch of males (right) and females left from 2000 (bottom) to 2020 (top). Mean sizes of catch and landings are displayed vertically.



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 1990–2020 (Scottish market sampling data). FU 34 data only shown for 2006–2011.**

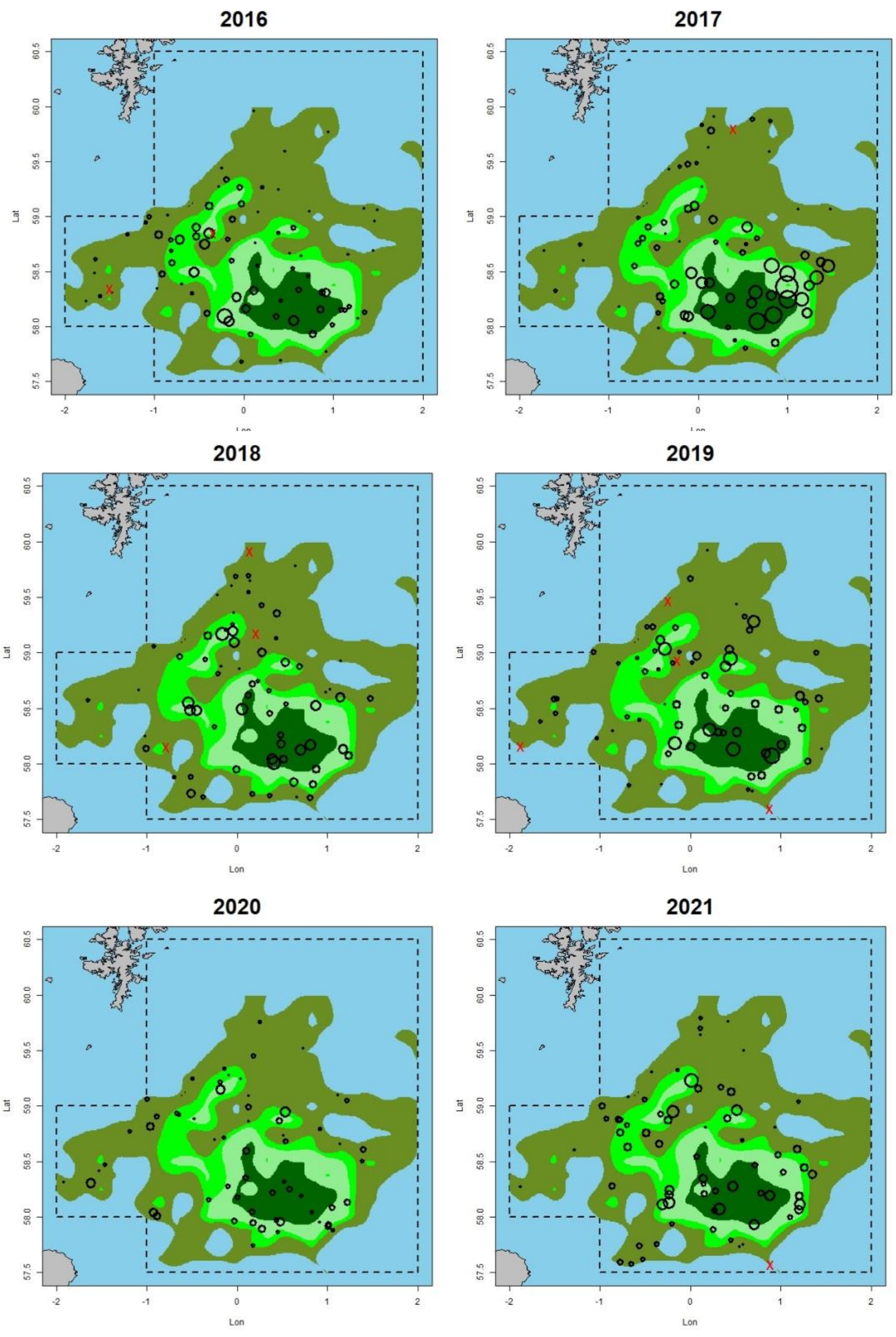


Figure 11.5.5 *Nephrops*, Fladen (FU 7). TV survey distribution and relative density (2016–2021). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

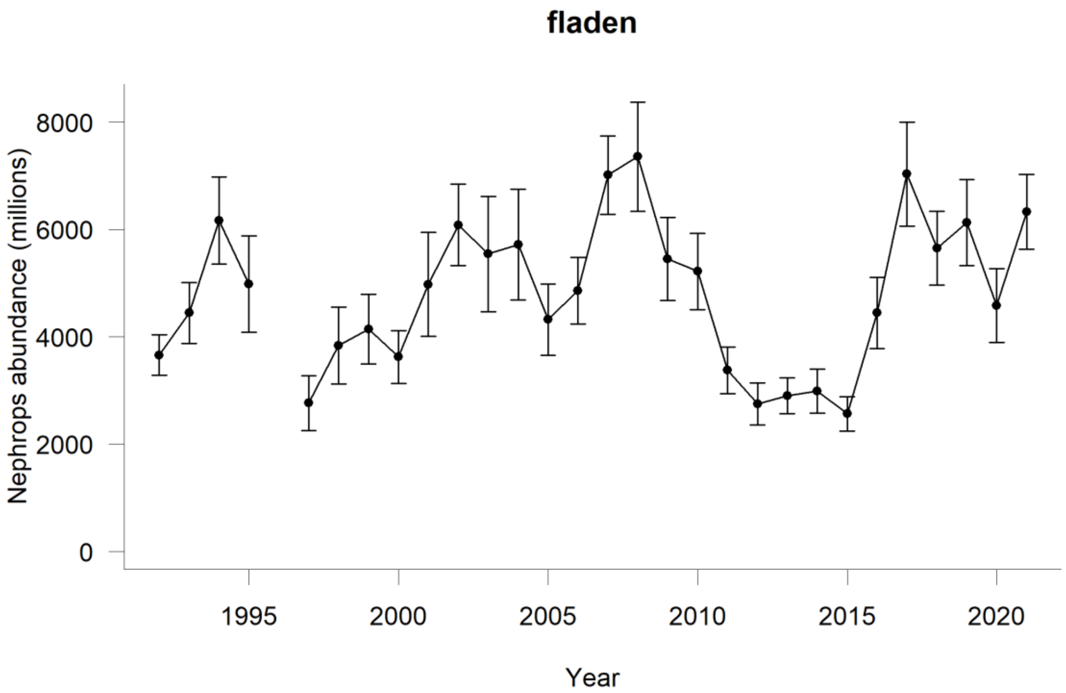


Figure 11.5.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates with 95% confidence intervals, 1992–2021.**

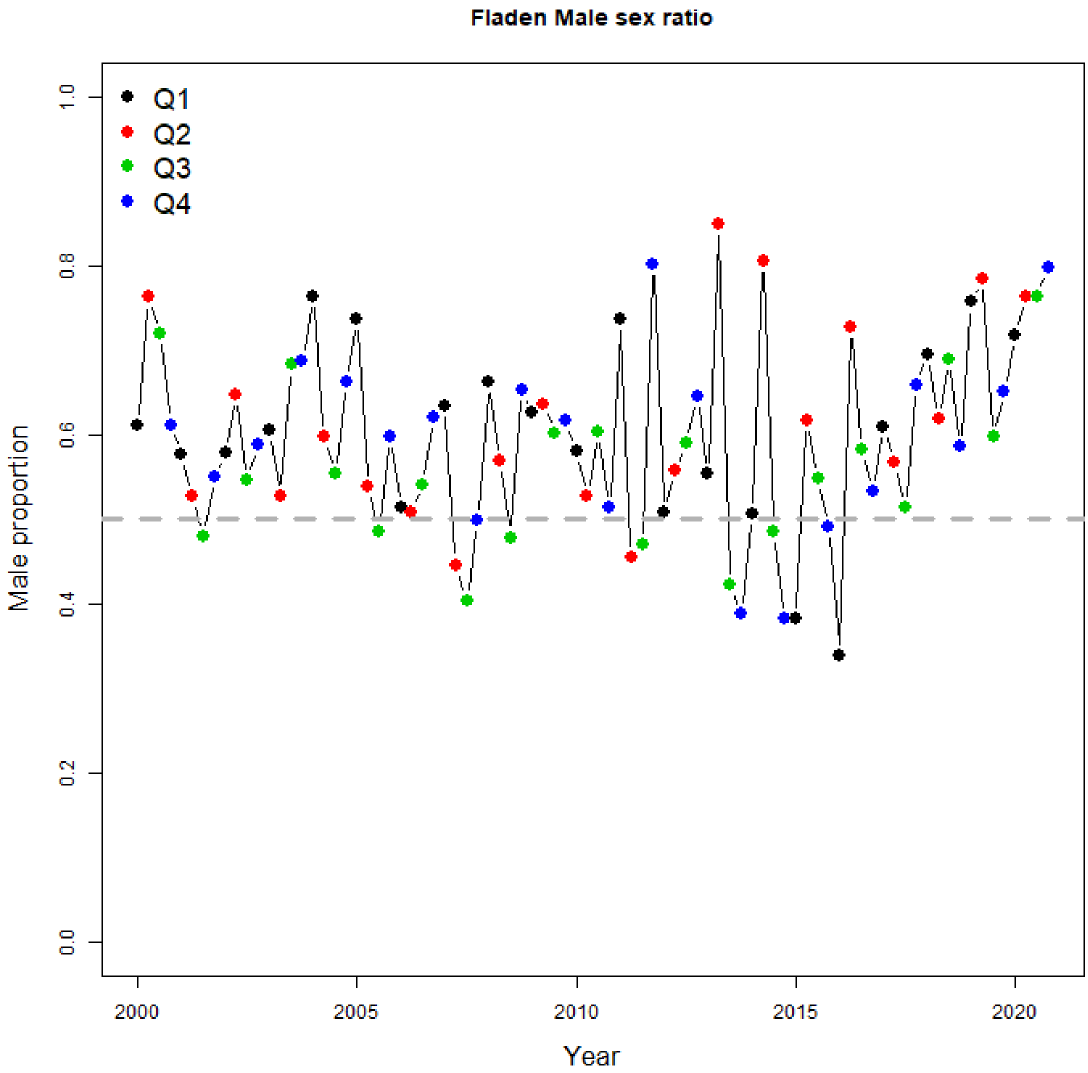


Figure 11.5.7 *Nephrops*, Fladen (FU 7), Quarterly sex ratio (by number) in catches.

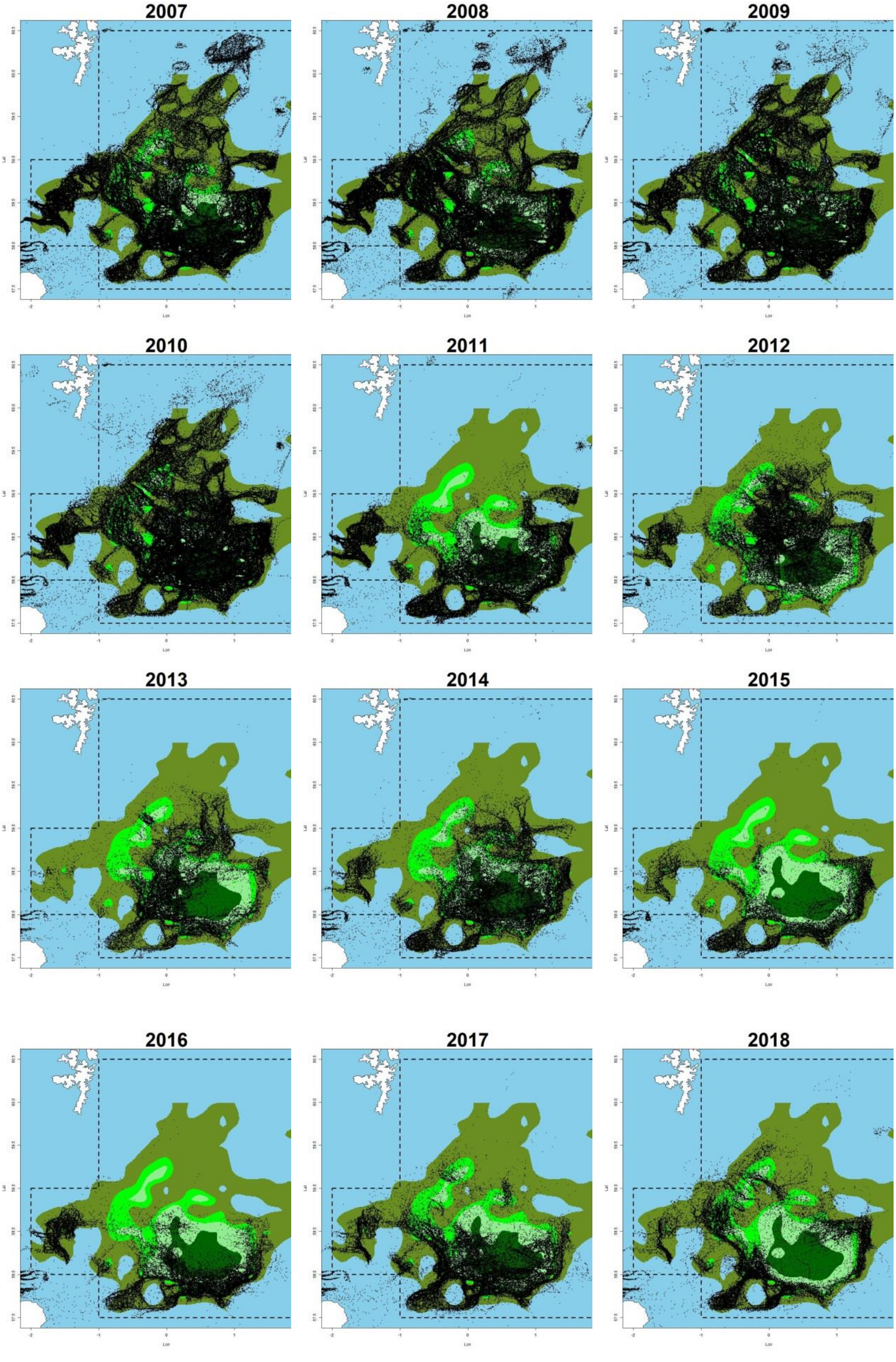


Figure 11.5.8 *Nephrops*, Fladen (FU 7), VMS distribution of vessels in Fladen (2007–2018). Points in figure correspond to fishing pings (speed < 5 kn) associated with trips made by otter trawlers landing more than 25% of *Nephrops* by weight.

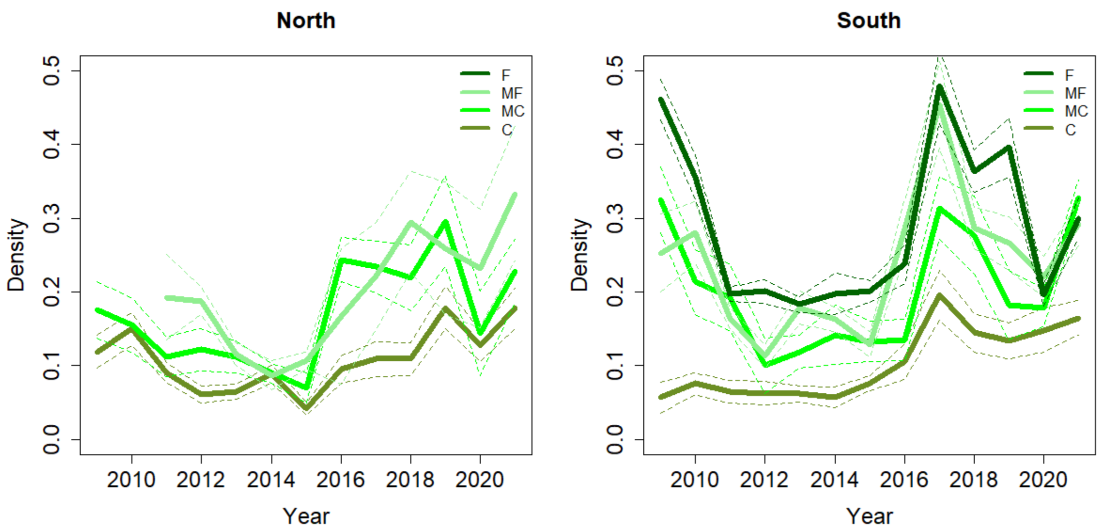


Figure 11.5.9 ***Nephrops*****, Fladen (FU 7), UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt and clay > 80%); MF: medium fine sediment (55% < silt and clay < 80); MC: medium coarse sediment (40% < silt and clay < 55); C: coarse sediment (silt and clay < 40%).**

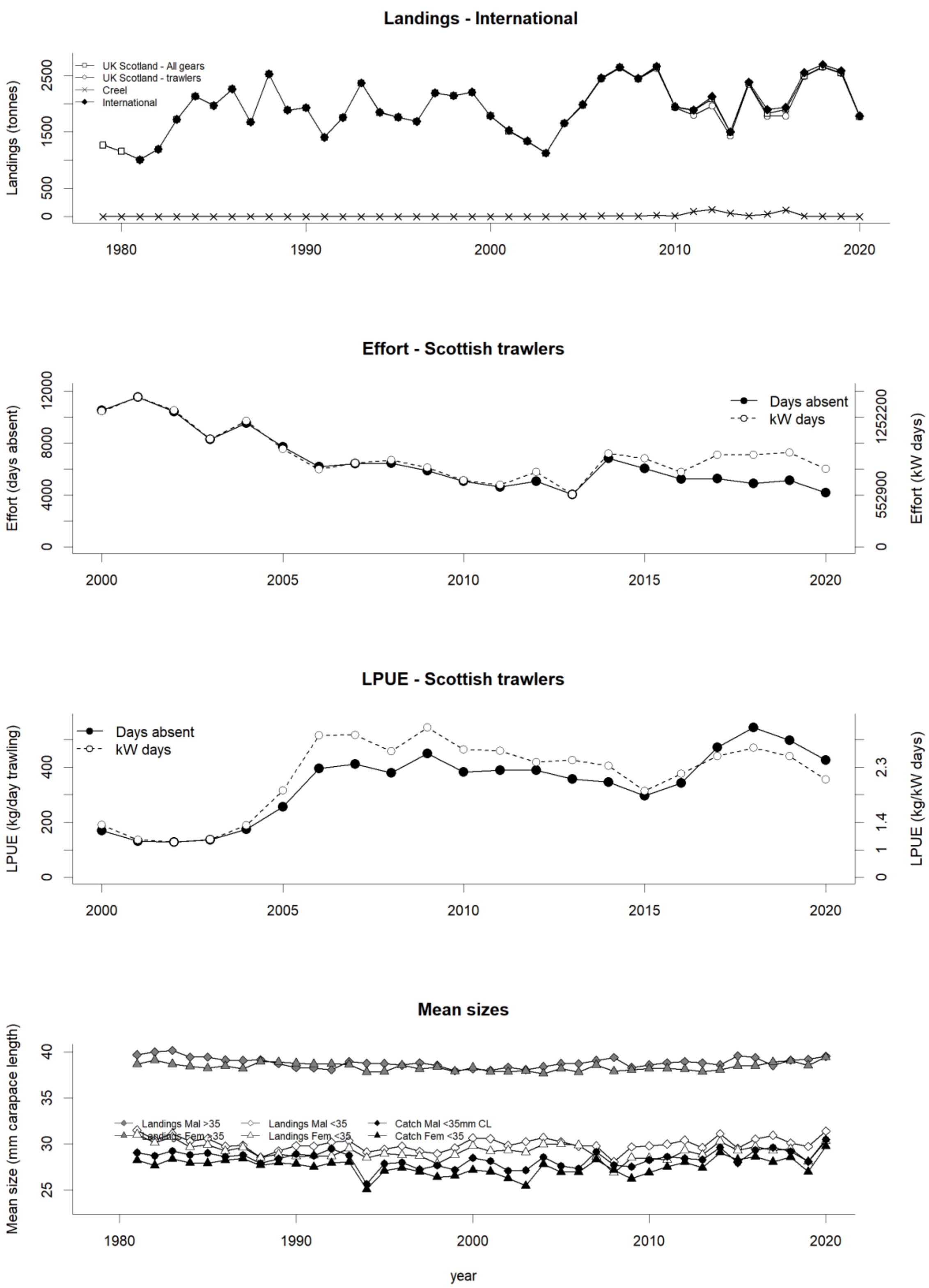
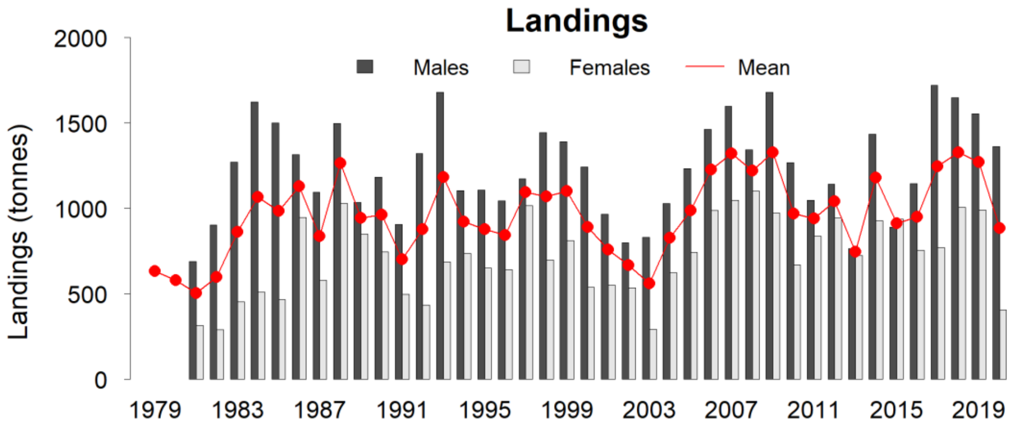


Figure 11.6.1 ***Nephrops*, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2020.**



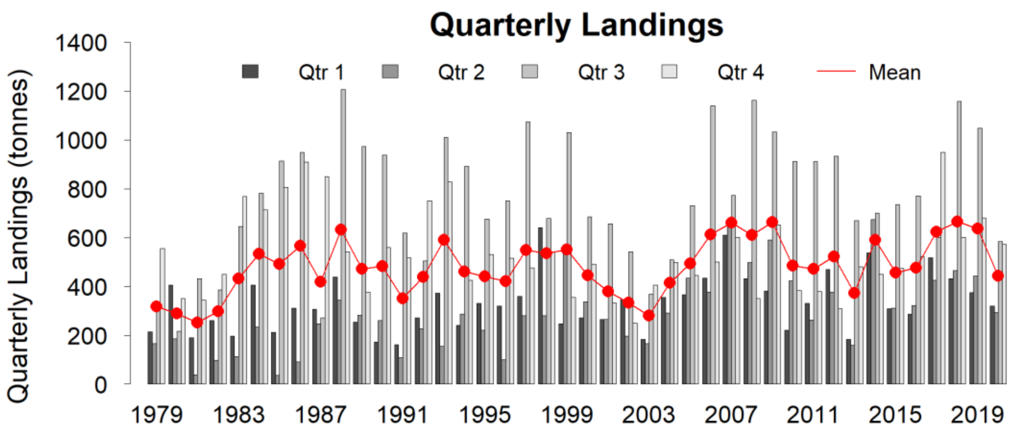


Figure 11.6.2 *Nephrops*, Firth of Forth (FU 8), Landings by quarter and sex from Scottish *Nephrops* trawlers.

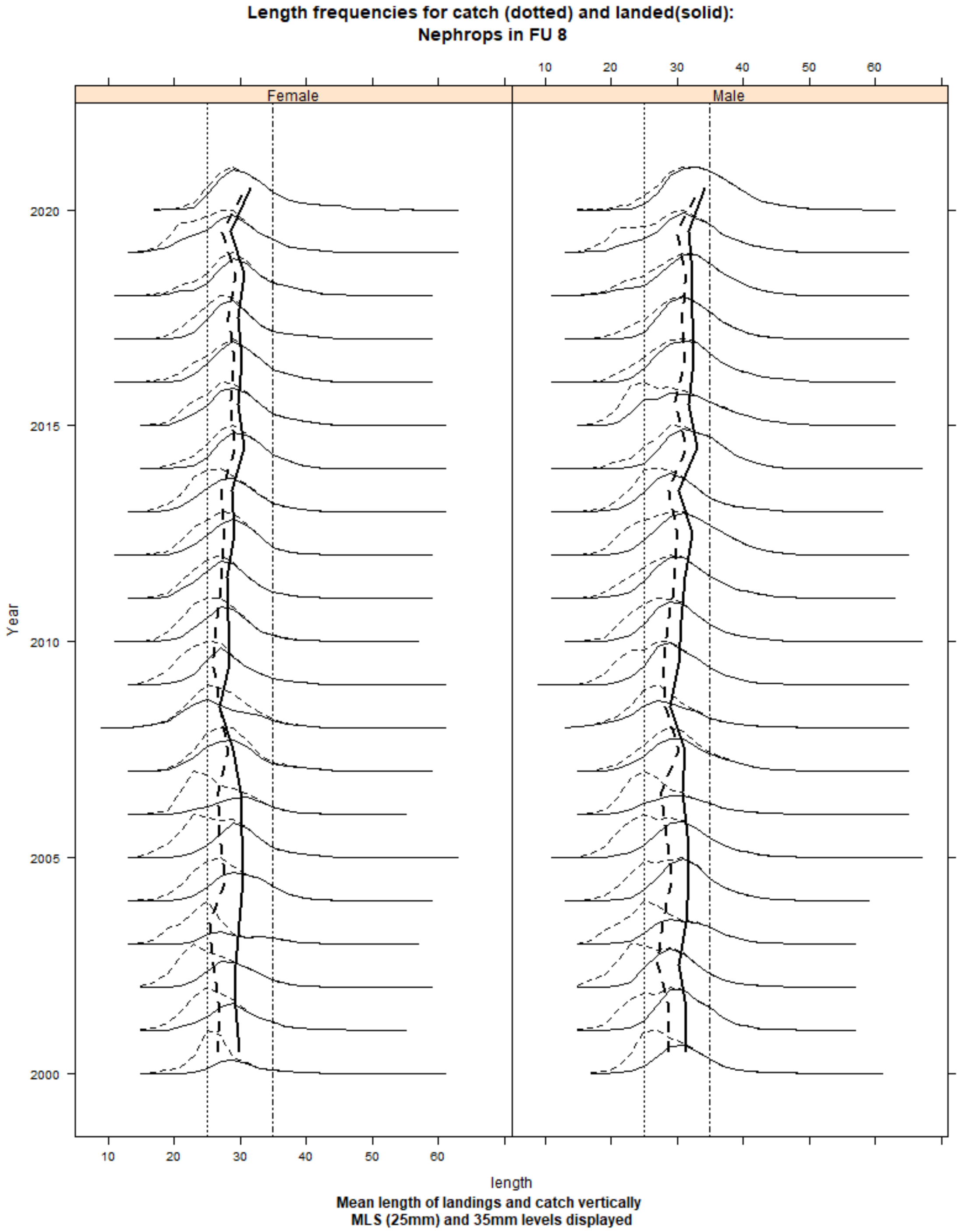


Figure 11.6.3 ***Nephrops*** **Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2020 (top). Mean sizes of catch and landings are displayed vertically.**

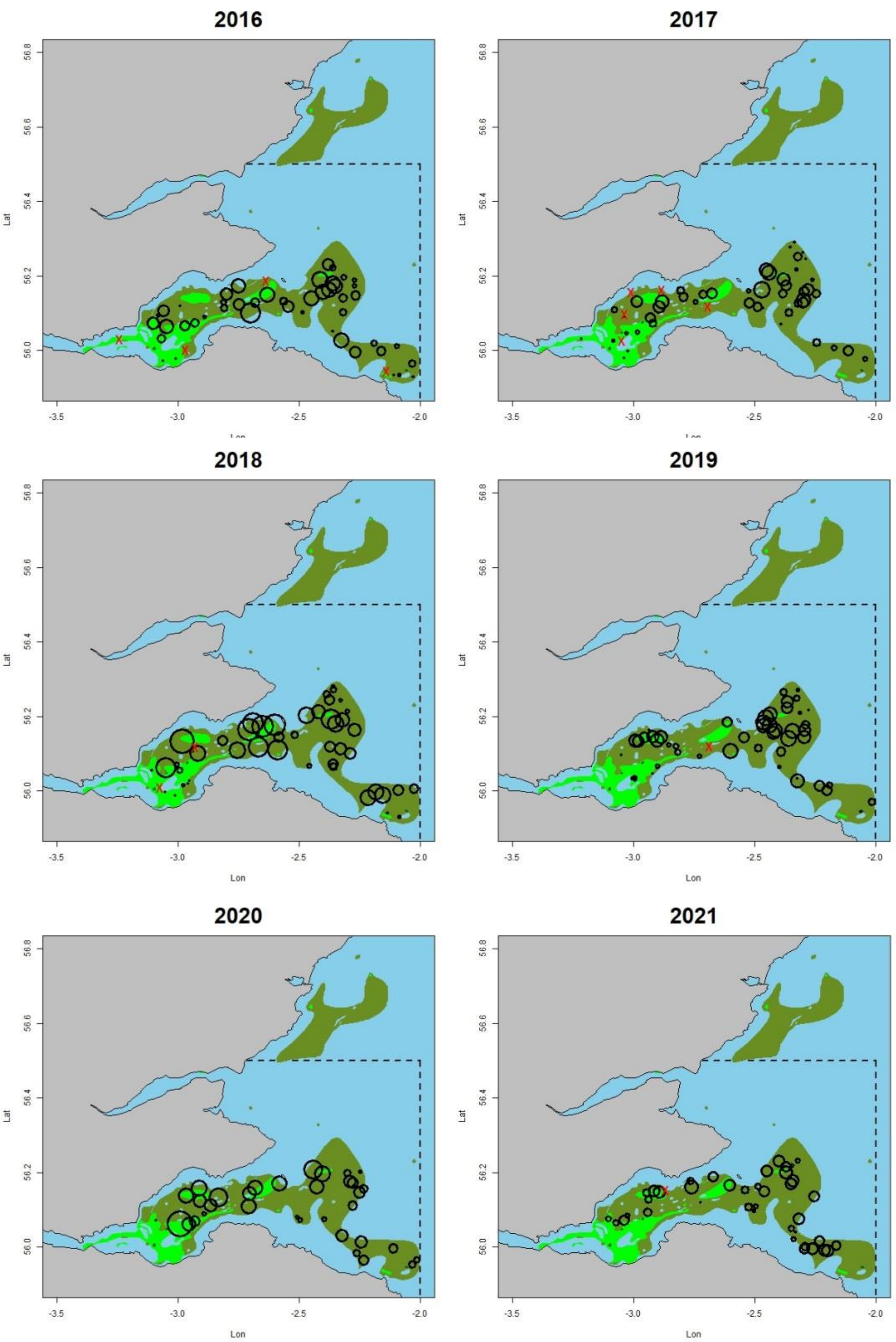


Figure 11.6.4 *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density (2016–2021). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

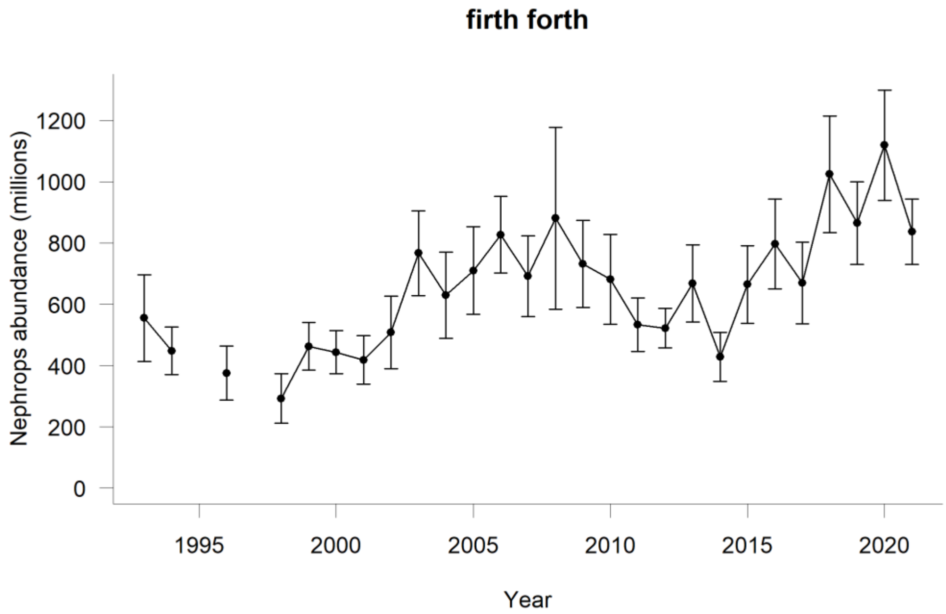


Figure 11.6.5 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2021.**

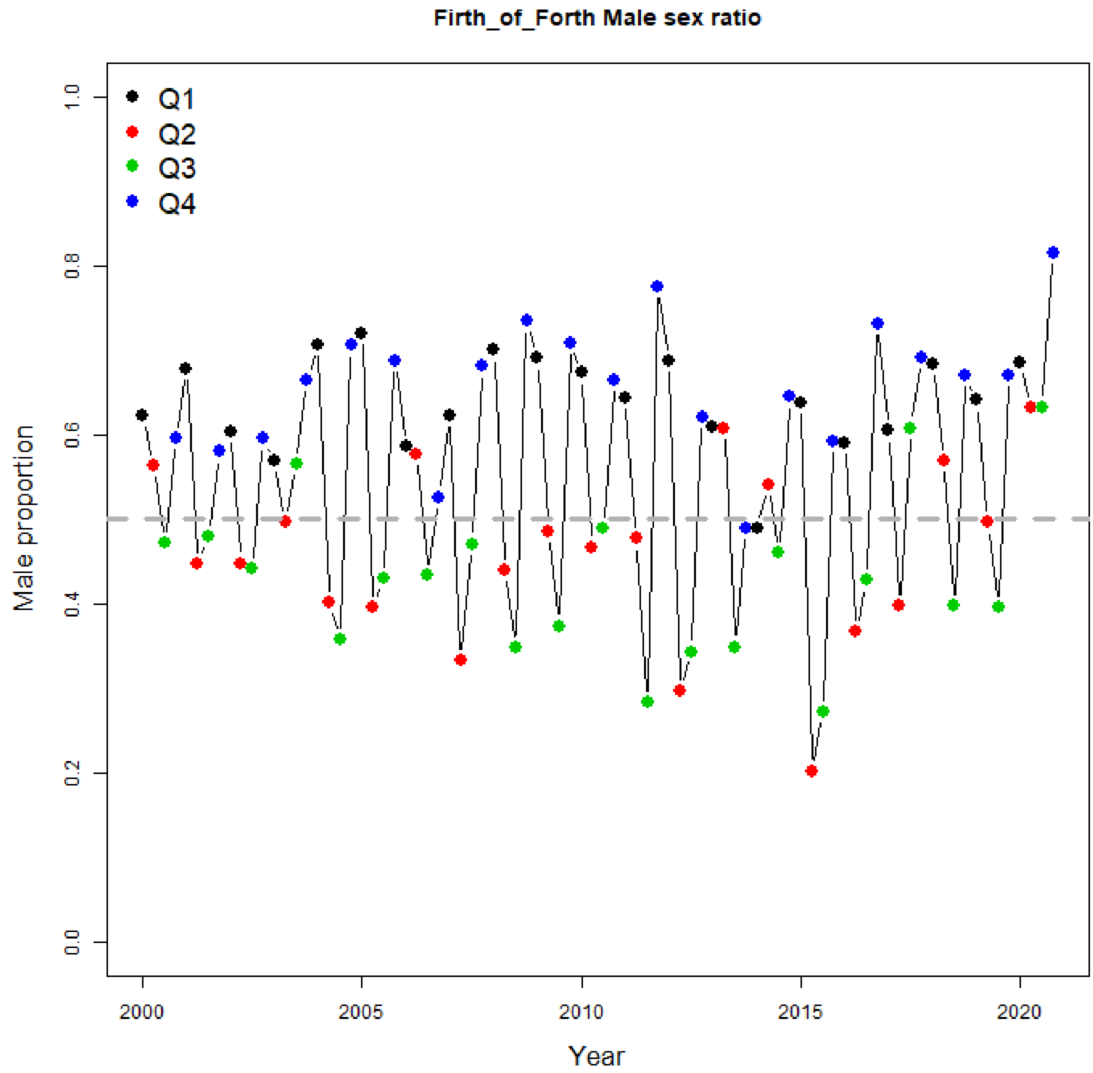


Figure 11.6.6 *Nephrops*, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.

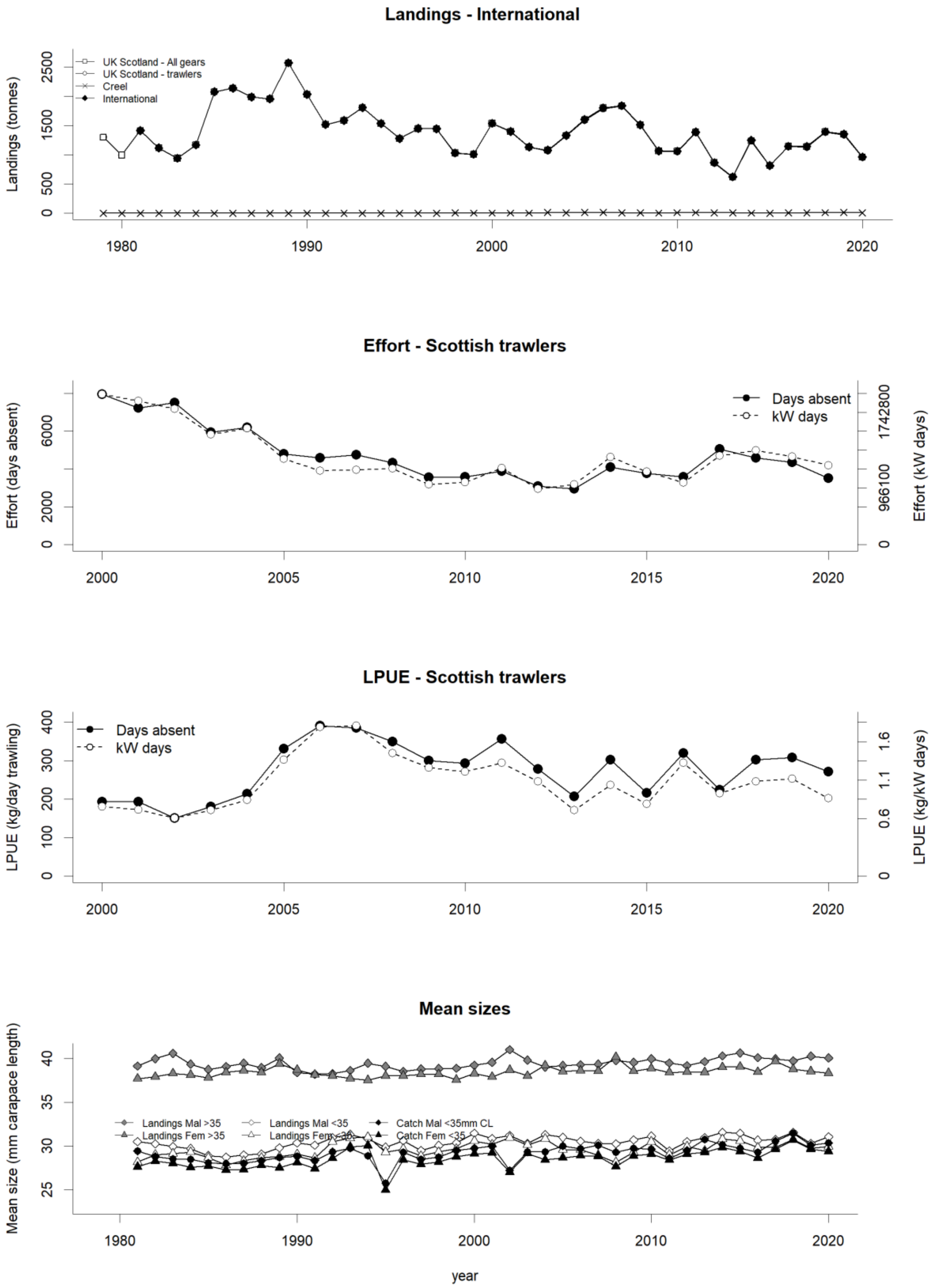
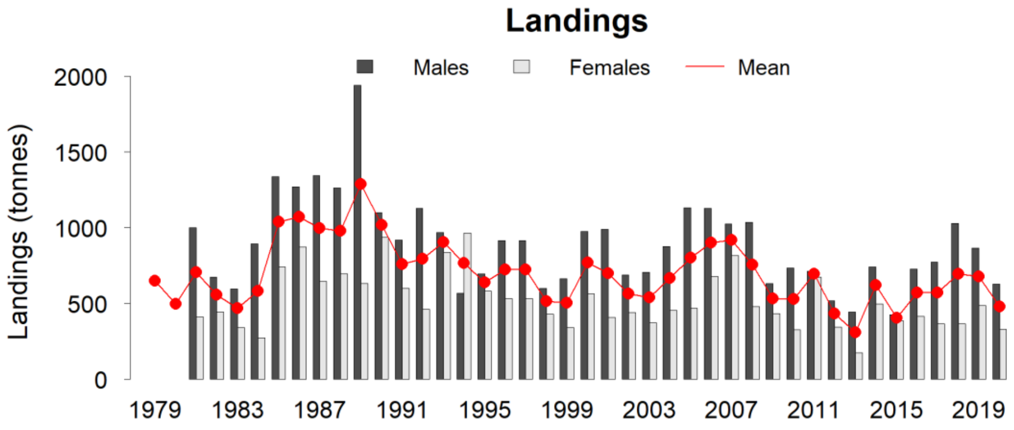


Figure 11.7.1 *Nephrops*, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2020.



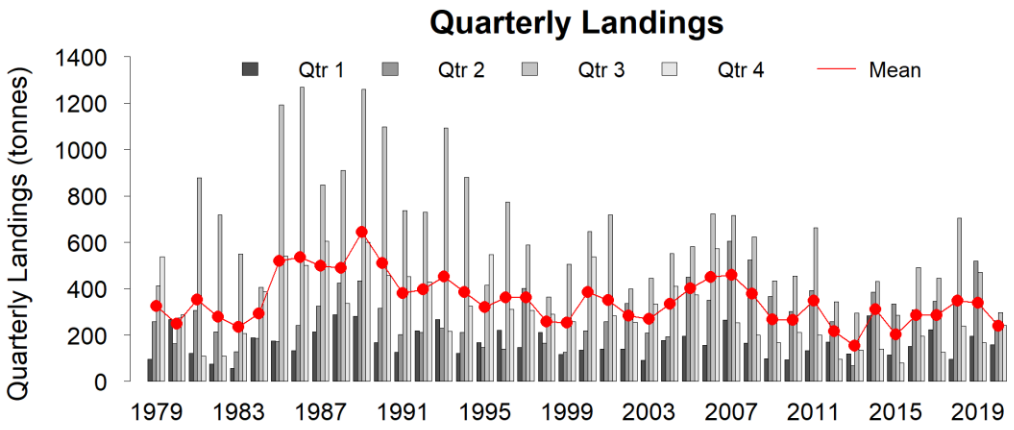


Figure 11.7.2 *Nephrops*, Moray Firth (FU 9), Landings by quarter and sex from Scottish *Nephrops* trawlers.

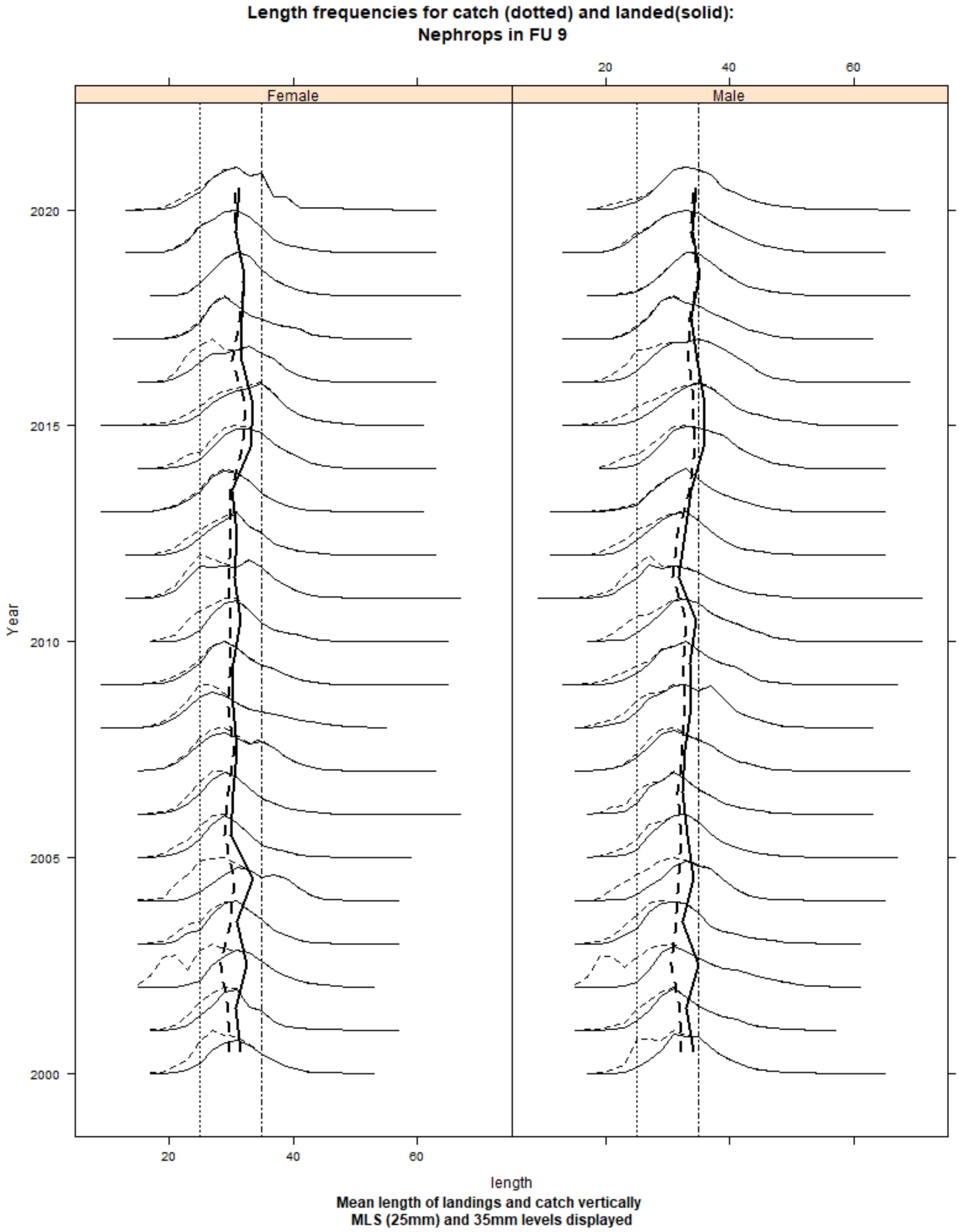


Figure 11.7.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2020 (top). Mean sizes of catch and landings are displayed vertically.**

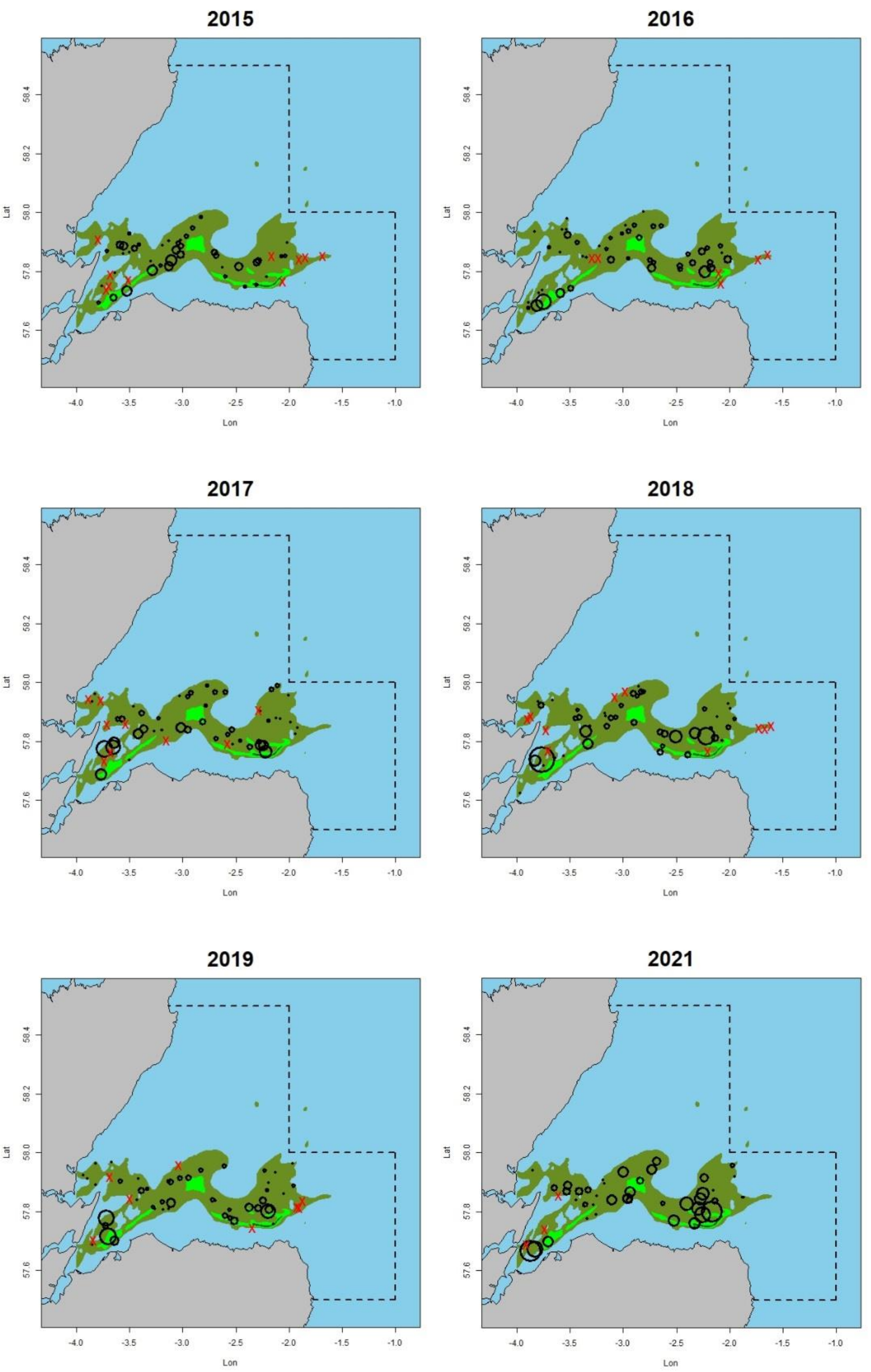


Figure 11.7.4 ***Nephrops*****, Moray Firth (FU 9). TV survey distribution and relative density (2015–2021). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

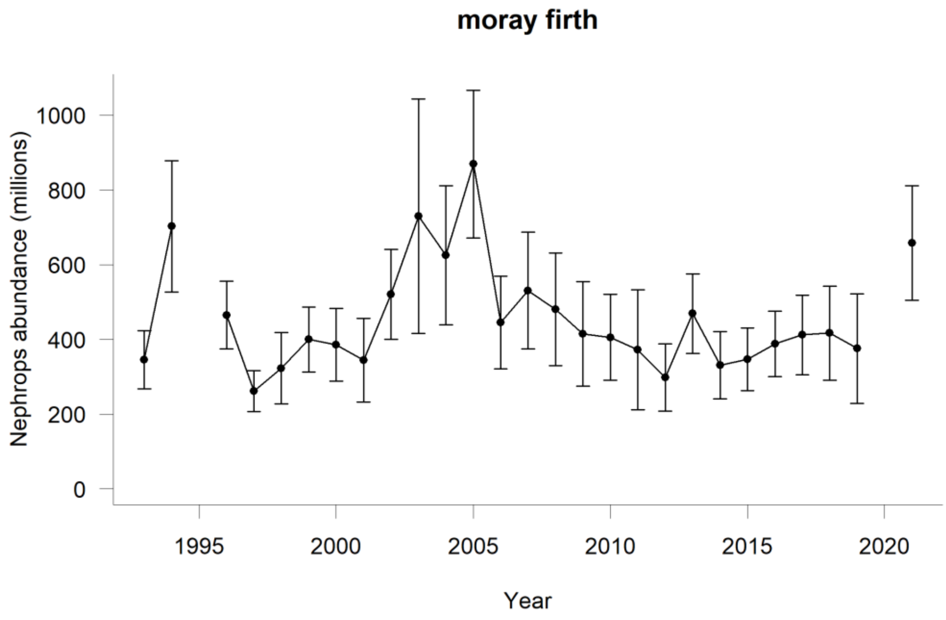


Figure 11.7.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2021.

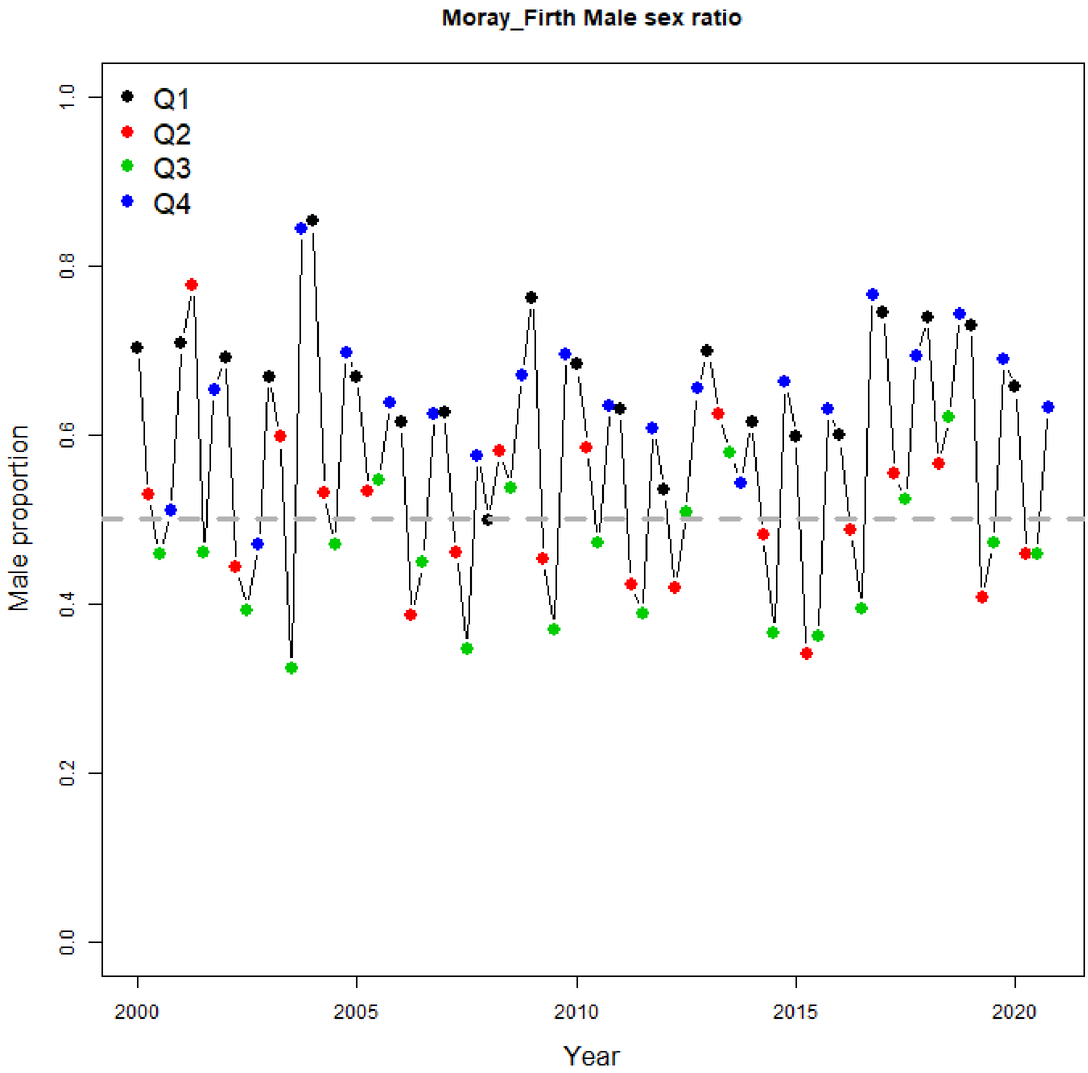


Figure 11.7.6 *Nephrops*, Moray Firth (FU 9), Quarterly sex ratio (by number) in catches.

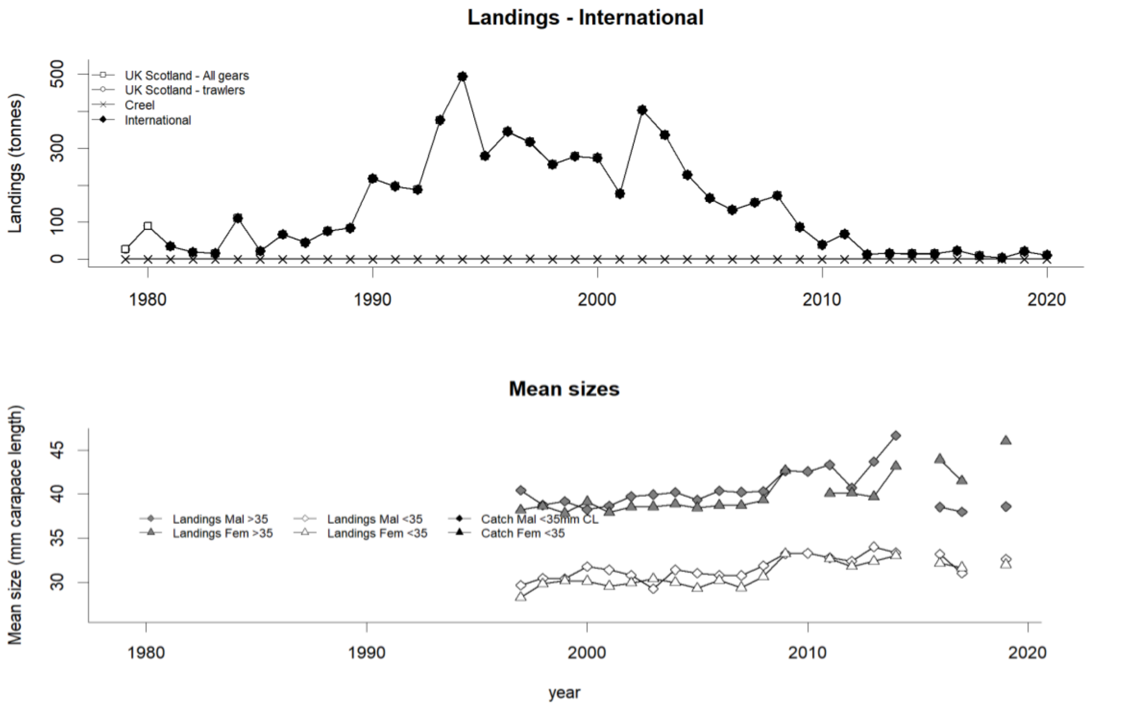


Figure 11.8.1 ***Nephrops*****, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010 and no samples in 2015, 2018 and 2020).**

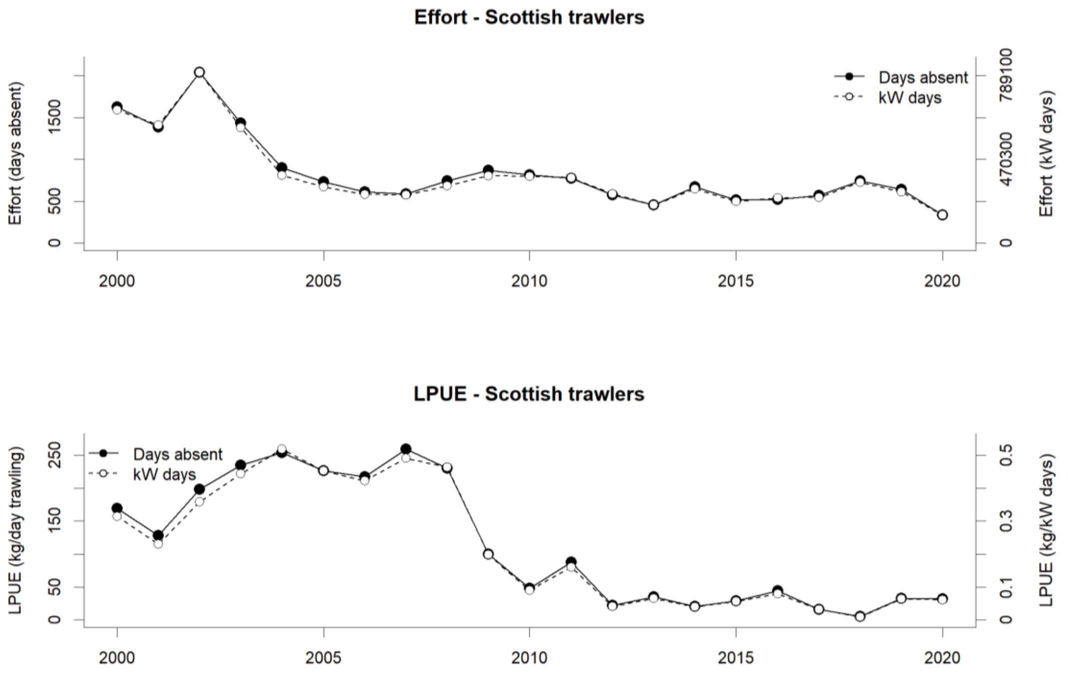


Figure 11.8.2 ***Nephrops*****, Noup (FU 10), Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

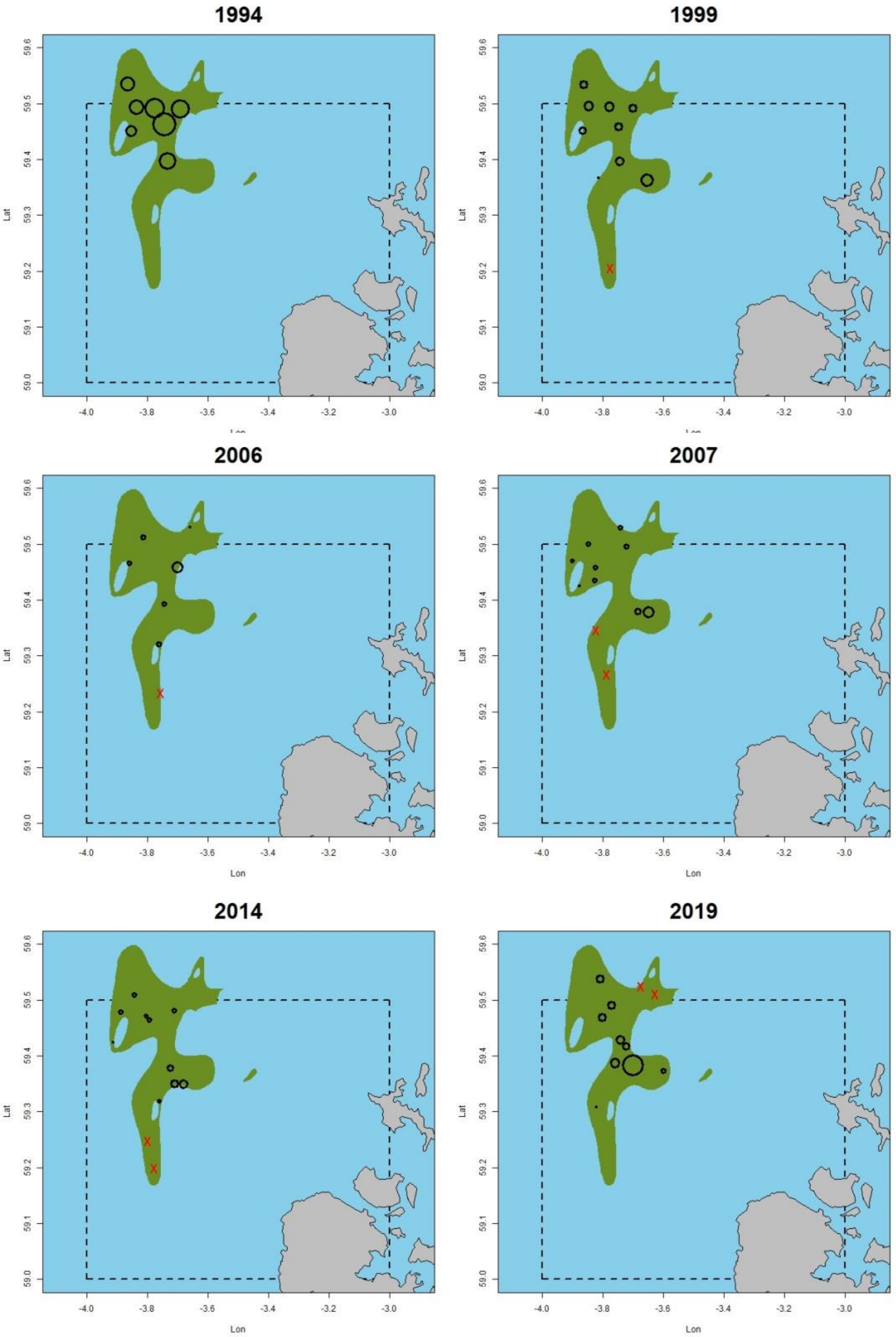


Figure 11.8.3 ***Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007, 2014 and 2019). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

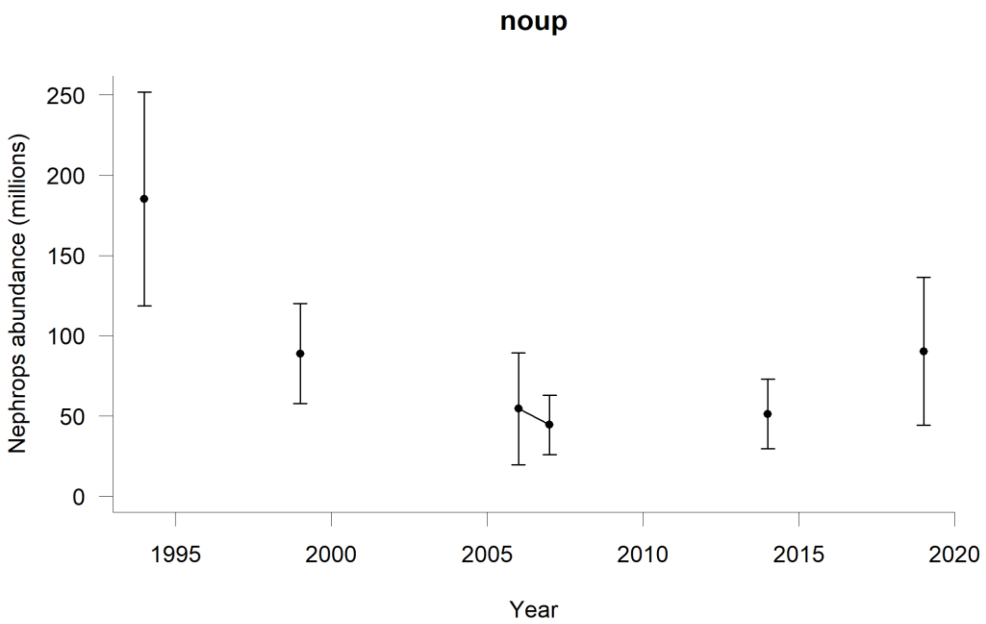


Figure 11.8.4 *Nephrops*, Noup (FU 10), Time series of TV survey abundance estimates (absolute conversion factor = 1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007, 2014 and 2019.

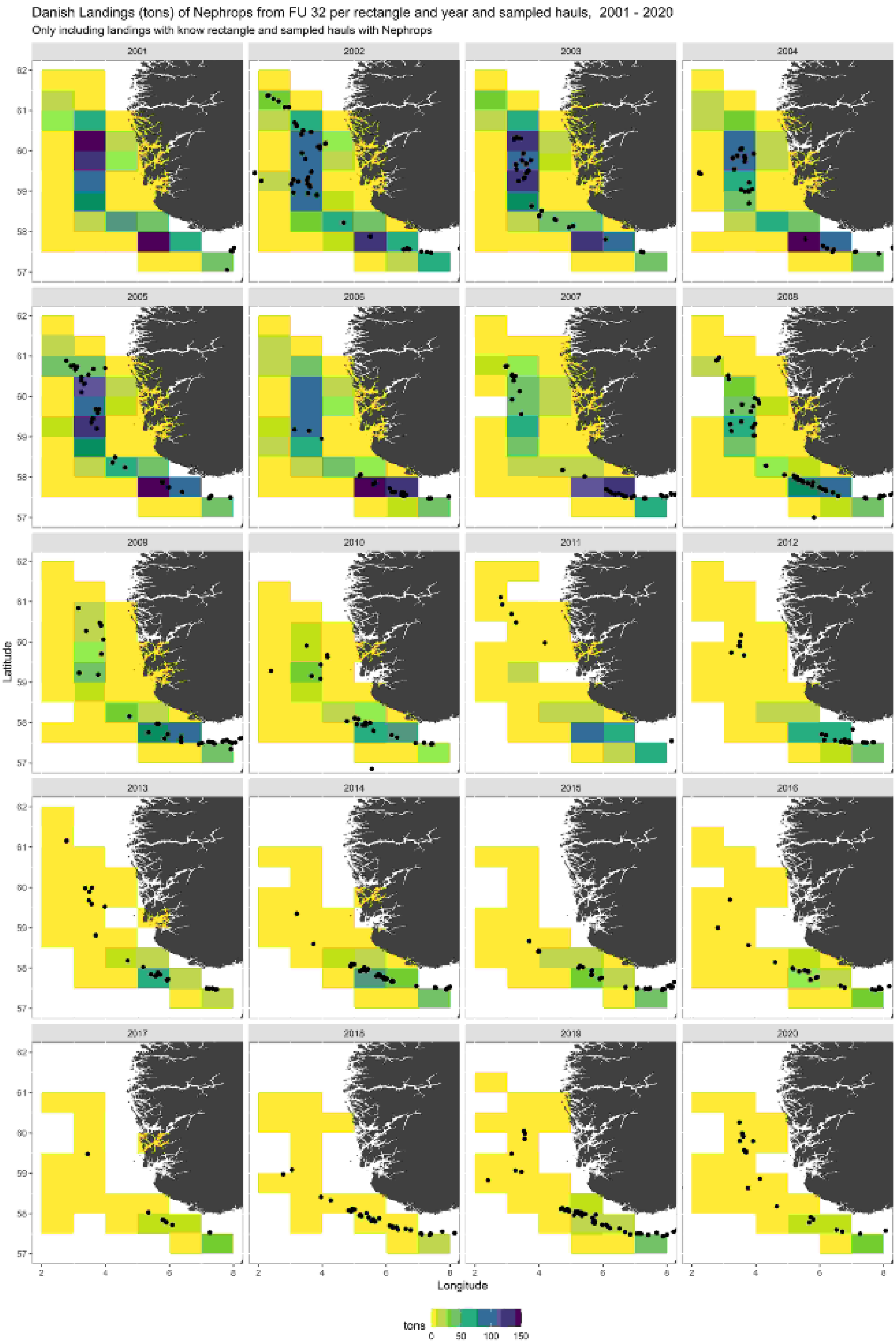


Figure 11.9.1. ***Nephrops*** **Norwegian Deep (FU 32). Danish landings of** ***Nephrops*** **by ICES statistical square, 2000–2020. Dots represent hauls with** ***Nephrops*** **from the Danish at-sea-sampling program.**

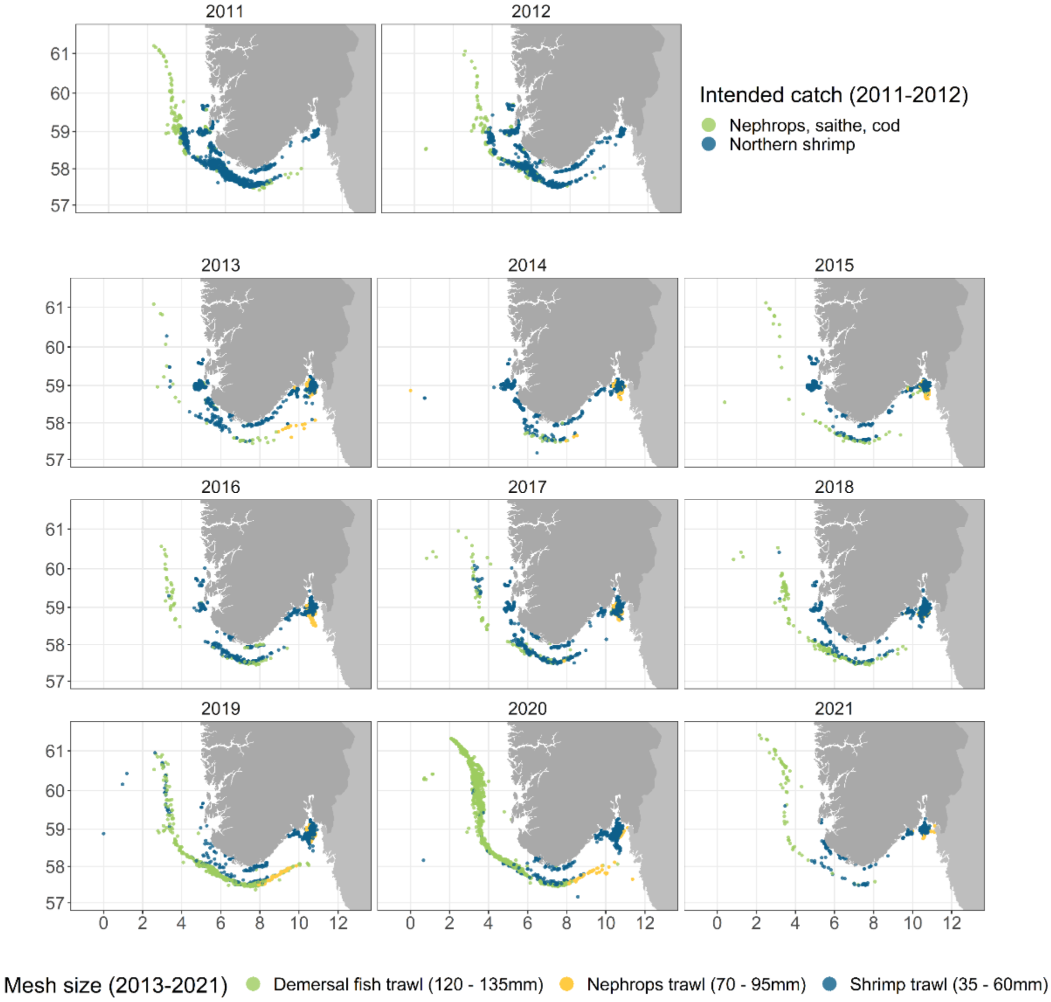


Figure 11.9.2. *Nephrops* Norwegian Deep (FU 32): Positions of trawl hauls with *Nephrops* in the catch from Norwegian bottom trawlers ≥ 15 m (large mesh and small mesh shrimp trawlers), 2011–2021. Information on mesh size was not available in 2011–2012, and type of trawl was determined from information on intended catch. Data from 2021 are from January–March.

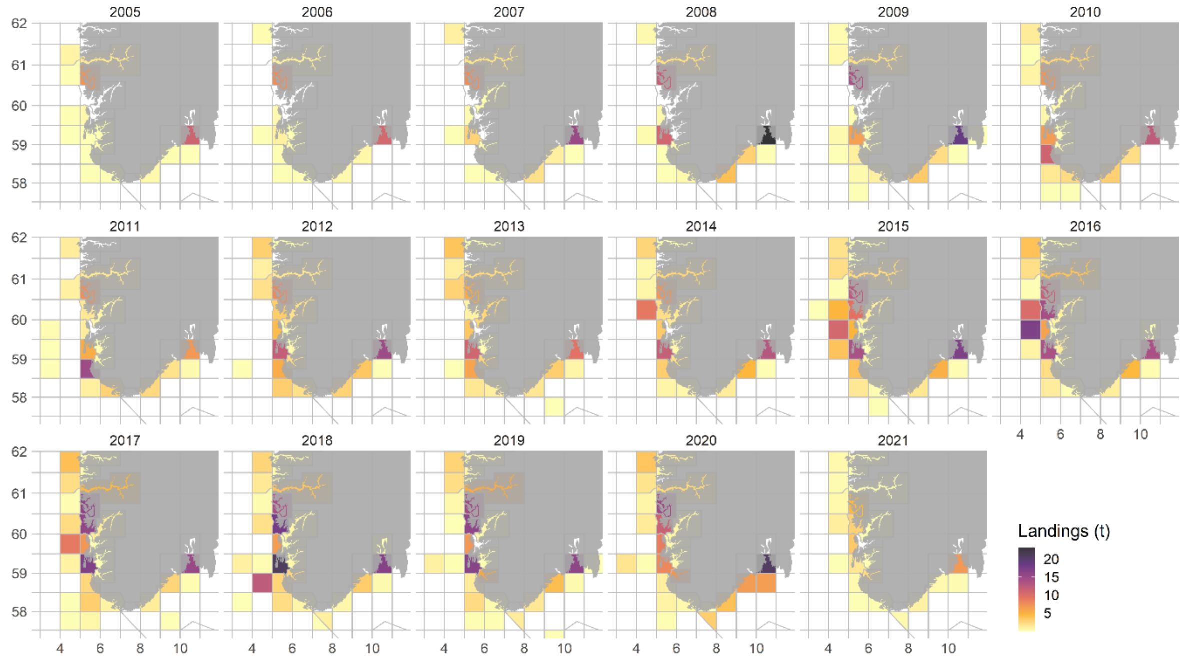


Figure 11.9.3. ***Nephrops*** **Norwegian Deep (FU 32): Norwegian creel landings by ICES statistical square, 2009–2021. Data from 2021 are from January–March.**

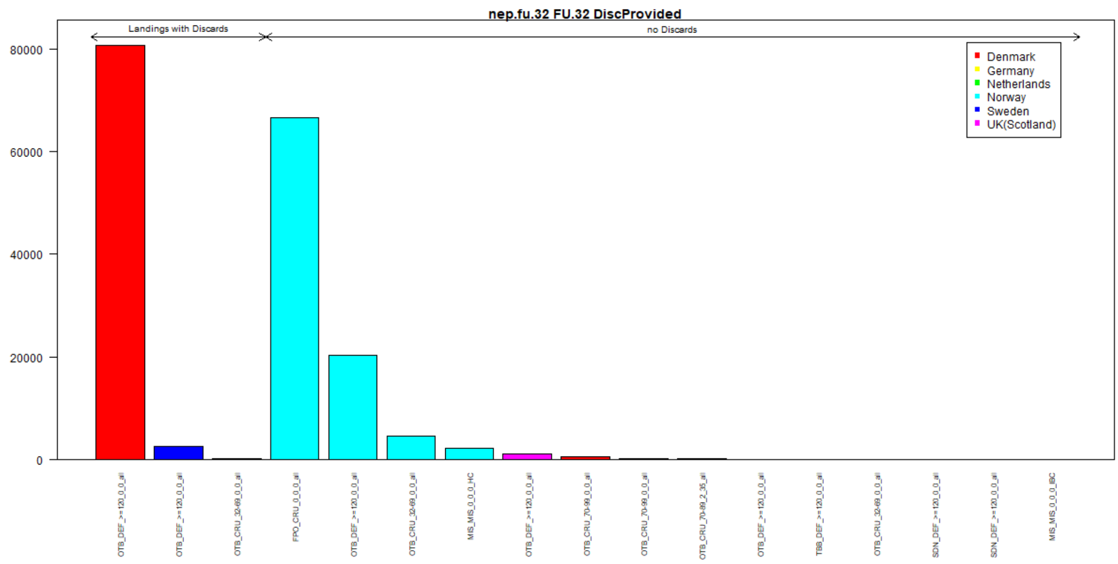


Figure 11.9.4. ***Nephrops*** **Norwegian Deep (FU 32): Landings (kg) by country and métier in 2020 associated with discards as uploaded into InterCatch.**

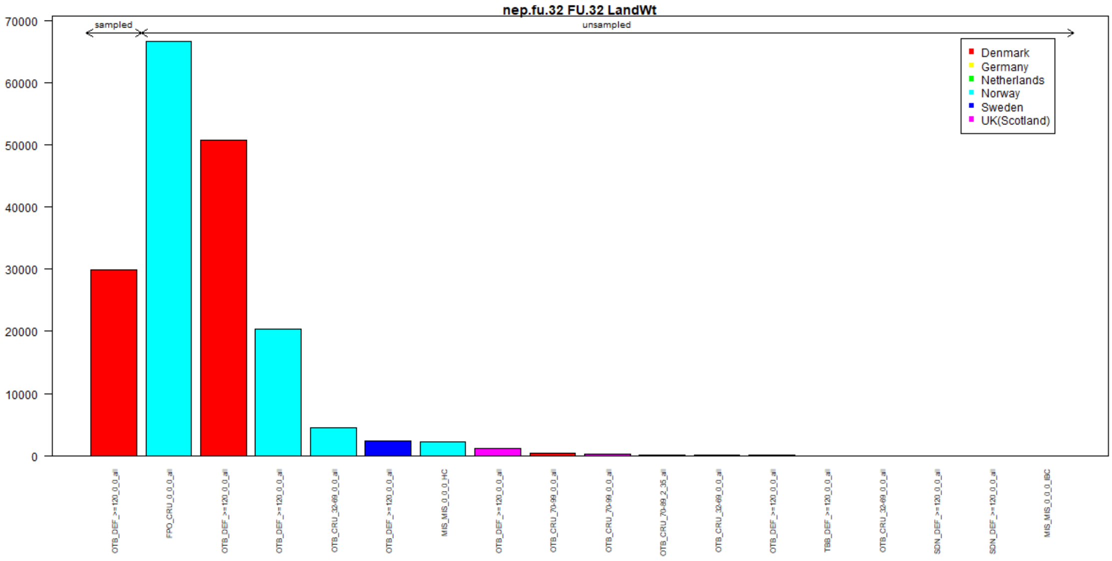


Figure 11.9.5. *Nephrops* Norwegian Deep (FU 32): Landings (kg) by country and métier in 2020 with length samples as uploaded into InterCatch.

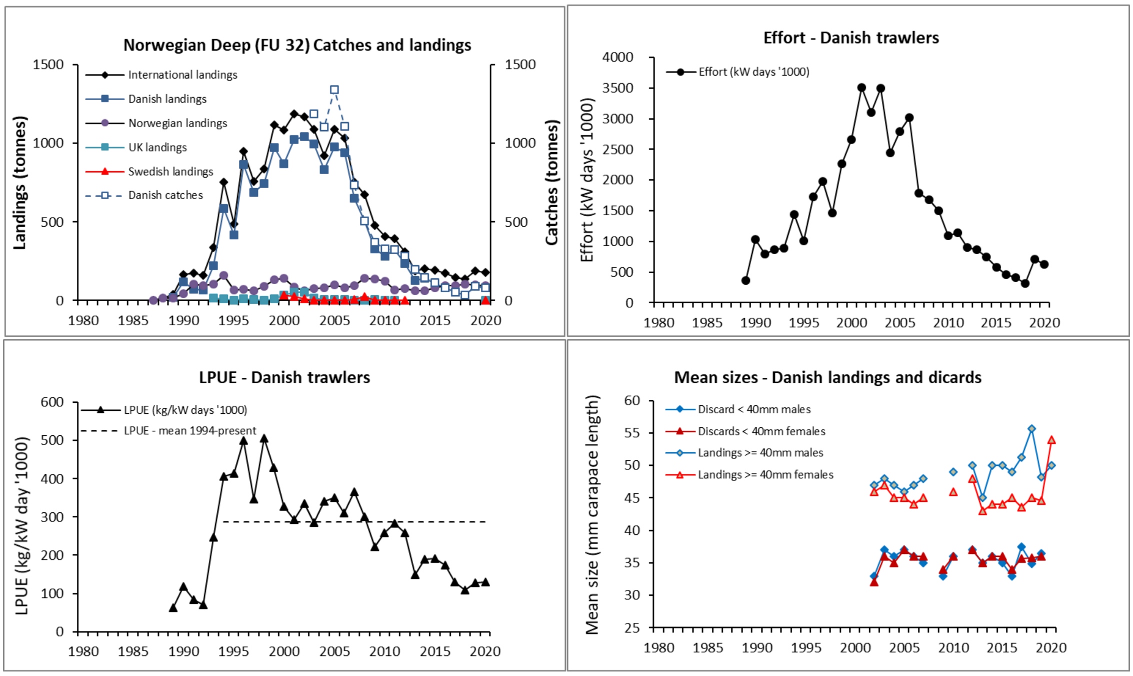


Figure 11.9.6. *Nephrops* Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards (< 40 mm) and landings (≥ 40 mm).

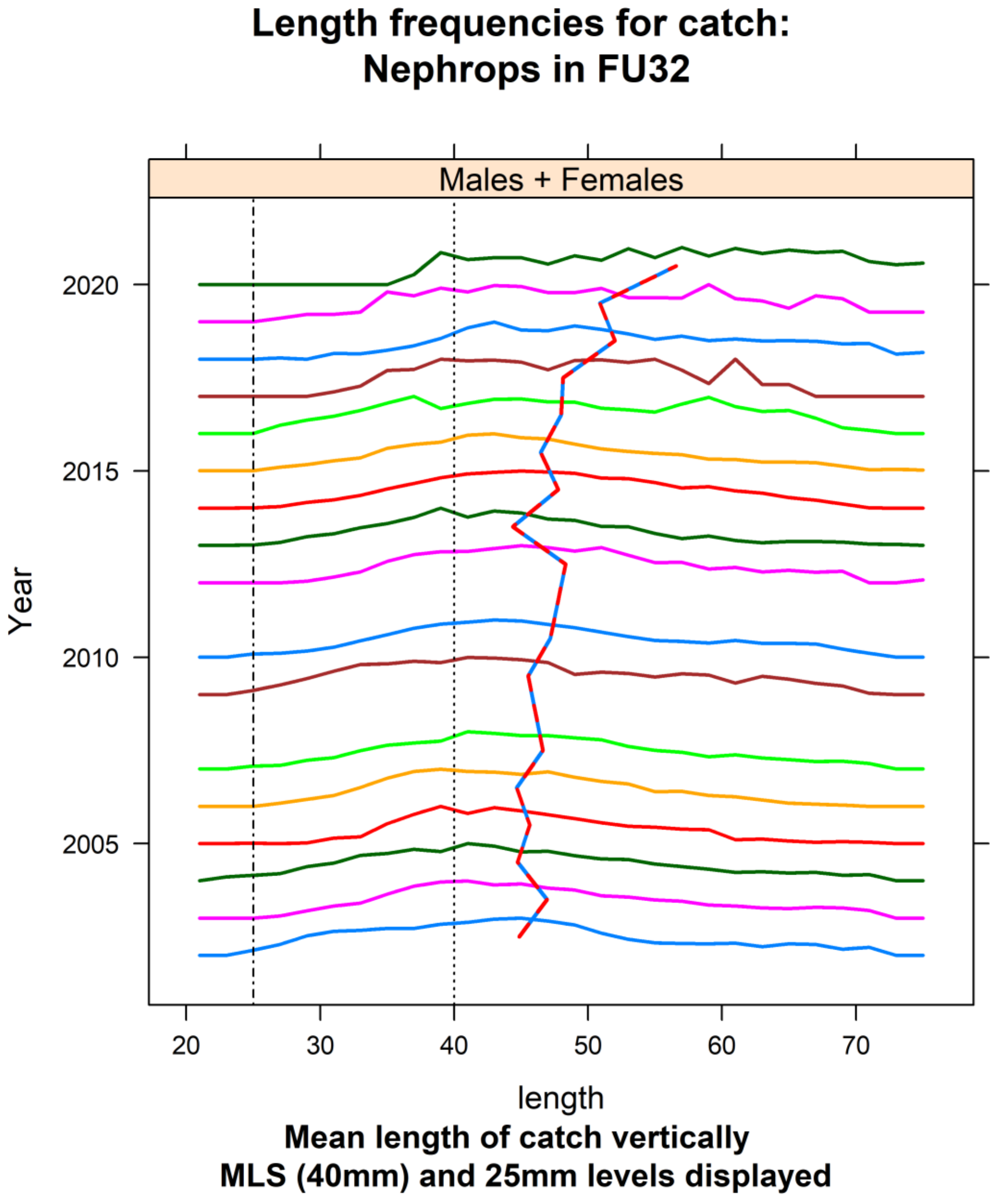


Figure 11.9.7. ***Nephrops*** **Norwegian Deep (FU 32): Size distribution in Danish catches, 2002–2020.**

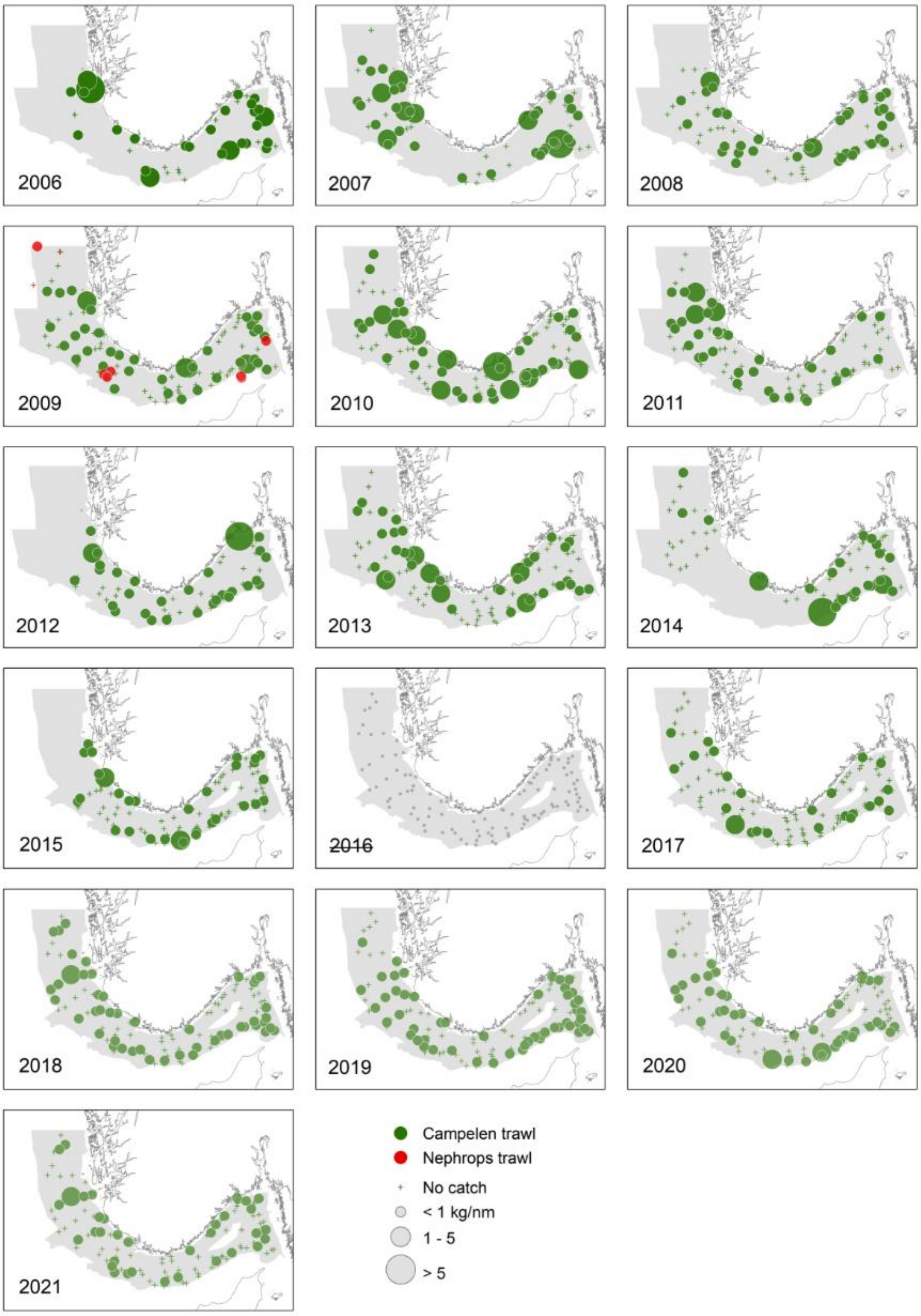


Figure 11.9.8. ***Nephrops*** **Norwegian Deep (FU 32): Distribution of** ***Nephrops*** **in Norwegian bottom trawl shrimp survey, 2006–2021. The 2016-data are omitted from the time series due to technical problems with the trawl gear in this year's survey.**

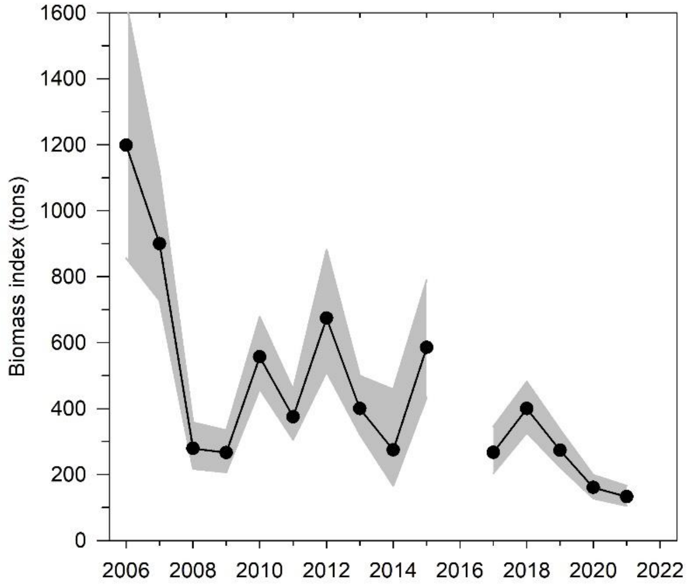


Figure 11.9.9. ***Nephrops*** **Norwegian Deep (FU 32): Biomass index (tonnes) (2006–2021) from the Norwegian bottom trawl shrimp survey. The 2016–data are omitted from the time series due to technical problems with the trawl gear at this year's survey.**

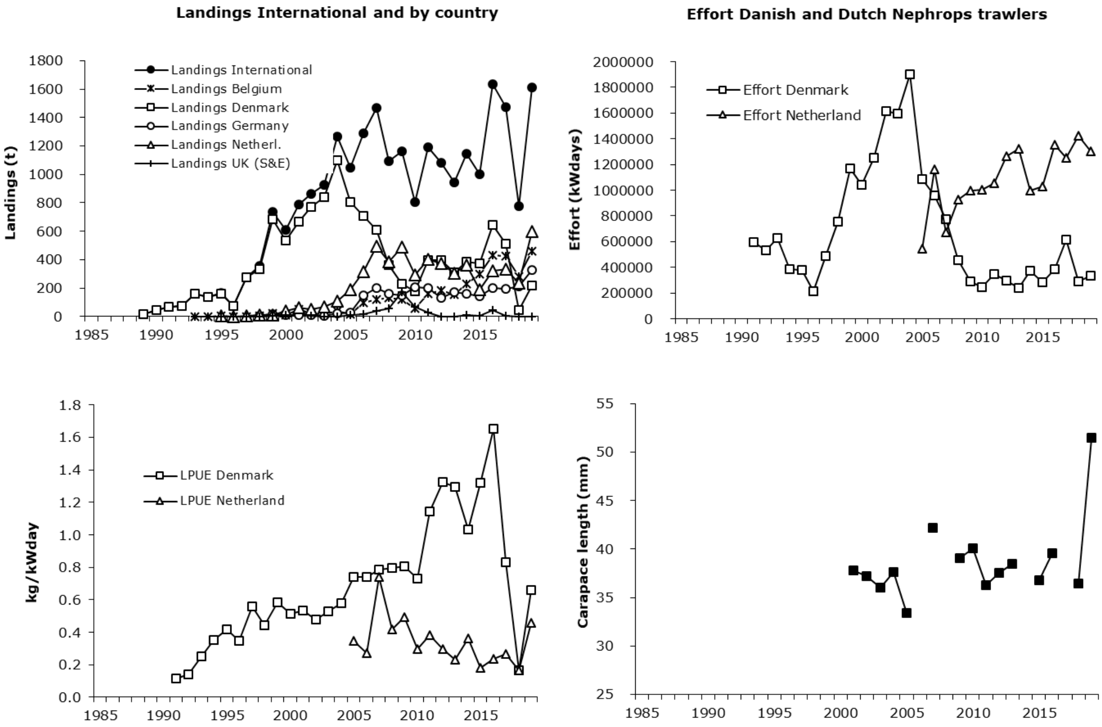


Figure 11.10.1. ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort, LPUE and mean size.**

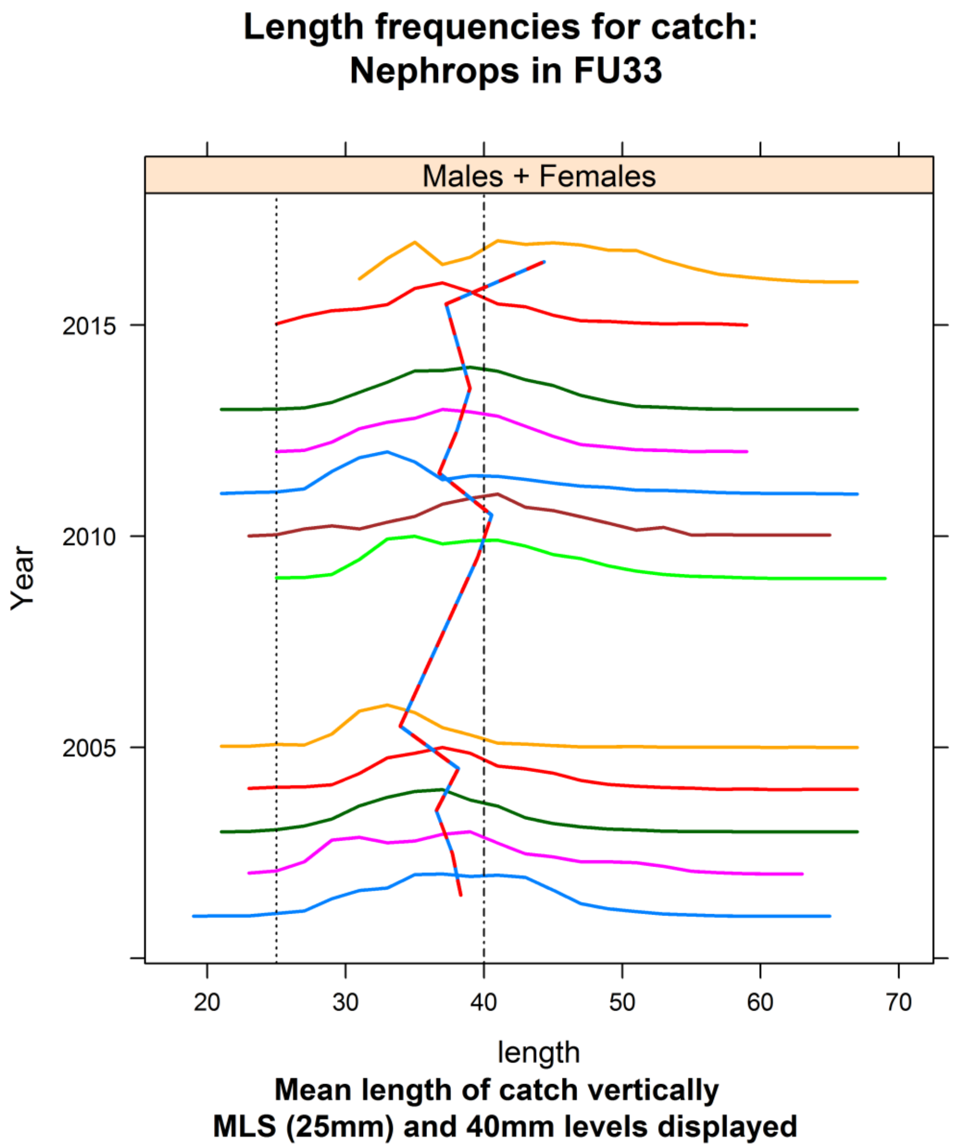


Figure 11.10.2. ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

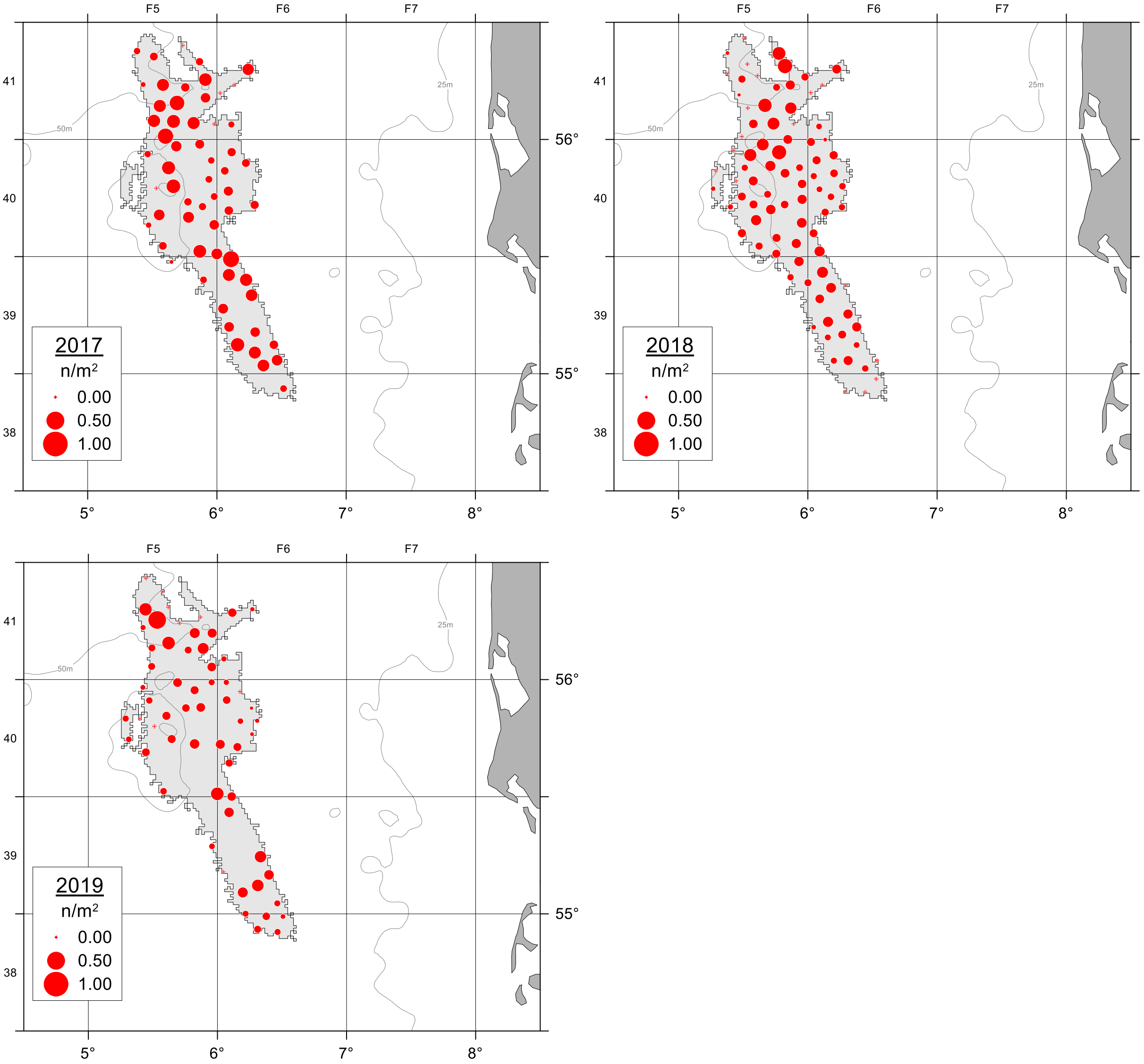


Figure 11.10.3. FU 33 (Off Horn's Reef) *Nephrops* burrow density by station for each year.

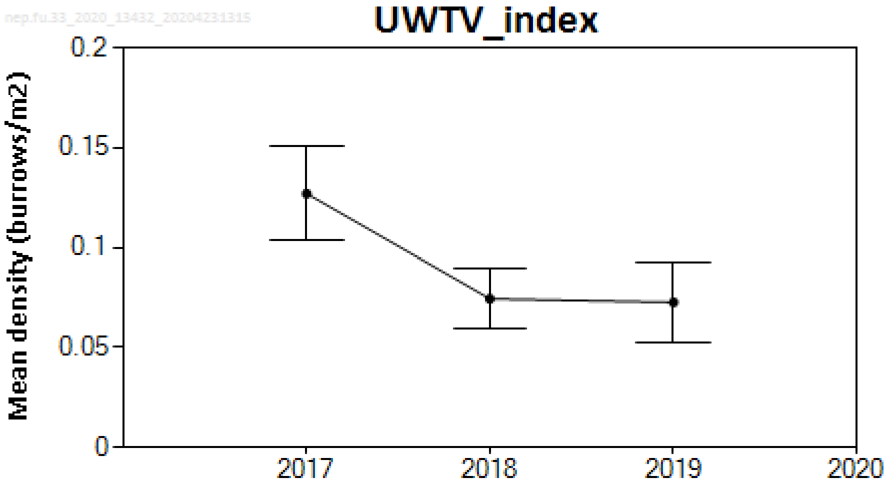


Figure 11.10.4. ***Nephrops*****, Off Horn's Reef (FU 33), Time series of TV survey abundance estimates (absolute conversion factor = 1.1, from FU 3 and 4), with 95% confidence intervals, from 2017 to 2019.**

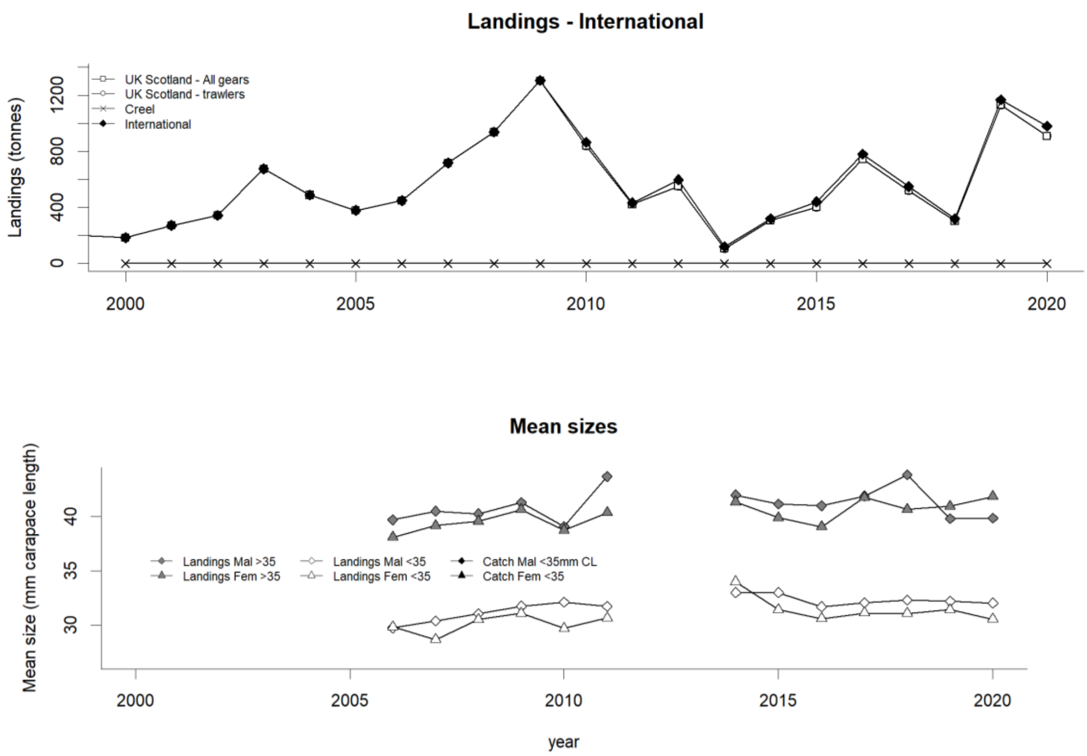


Figure 11.11.1. ***Nephrops*****, Devil's Hole (FU 34). Long term landings and mean sizes, data from year 2000.**

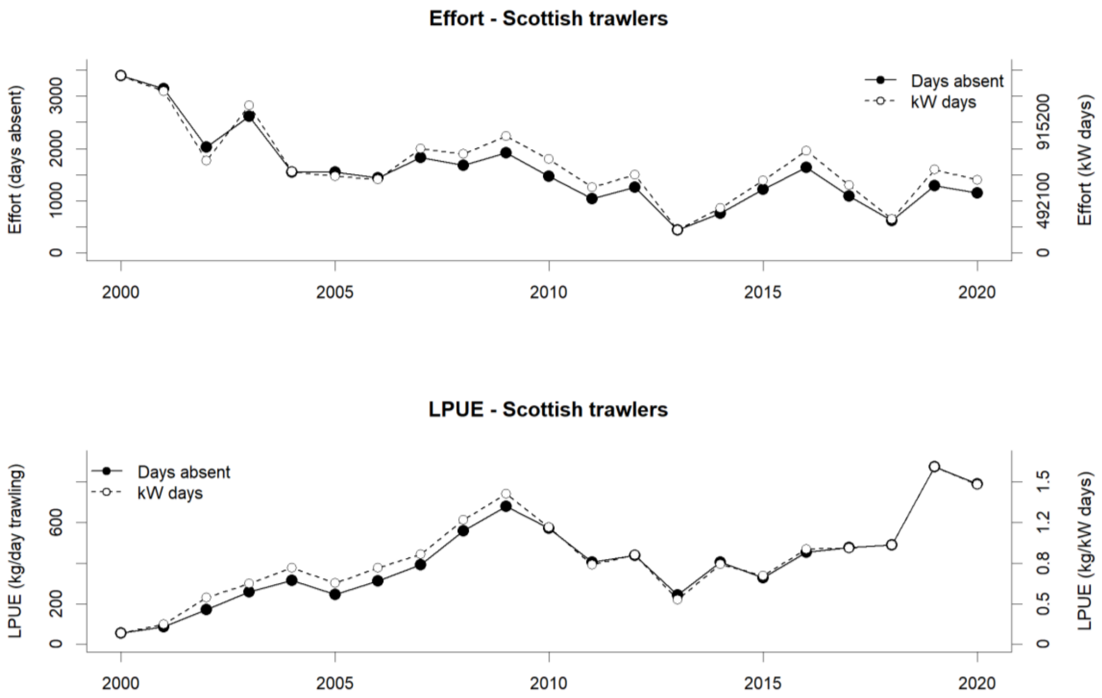


Figure 11.11.2. *Nephrops*, Devil's Hole (FU 34). Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.

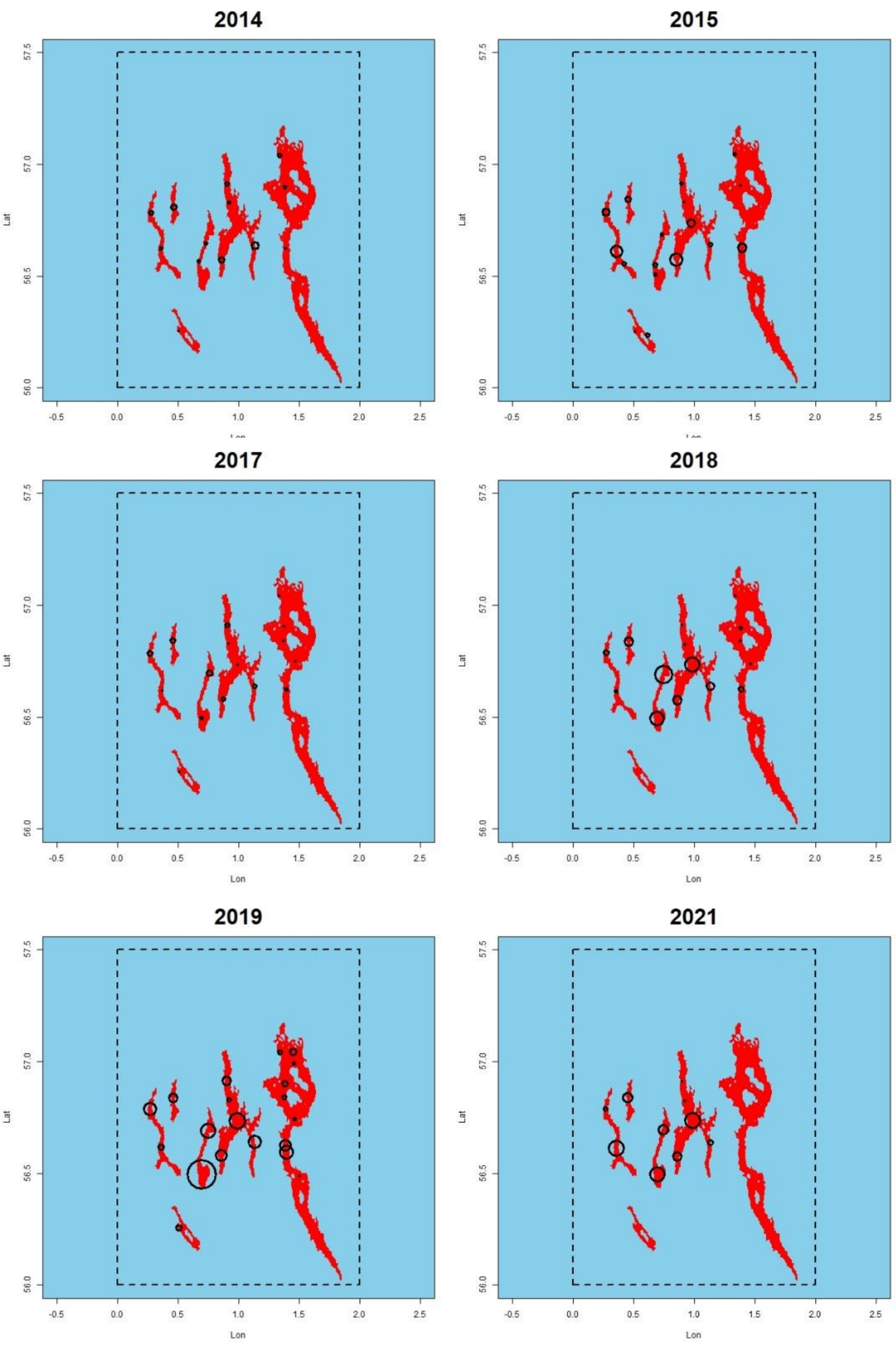


Figure 11.11.3. ***Nephrops*****, Devil's Hole (FU 34). UWTV survey distribution and relative density (2012–2019). No surveys in 2013 and 2016. Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

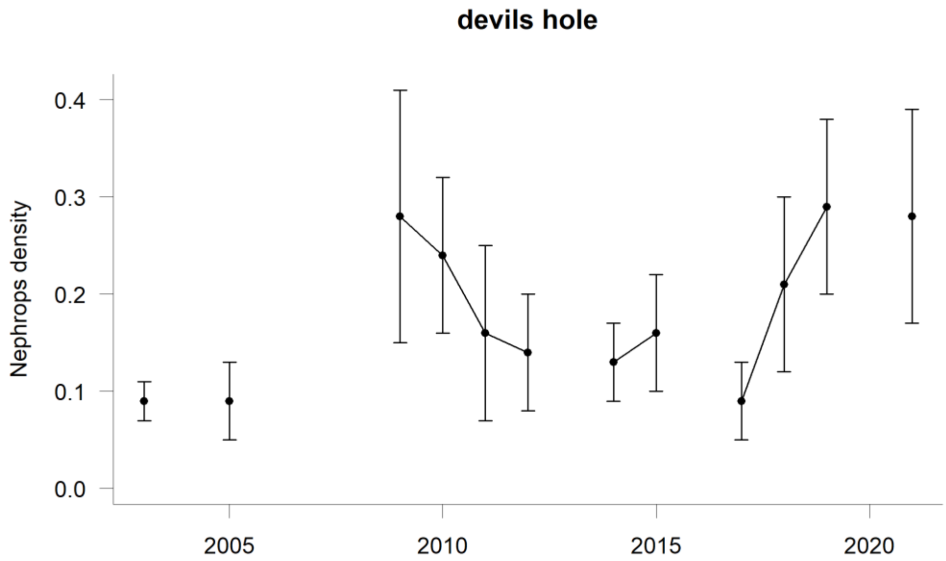


Figure 11.11.4. ***Nephrops*, Devil's Hole (FU 34). Time series of UWTV survey density estimates with 95% confidence intervals, 2003, 2005, 2009–2019.**

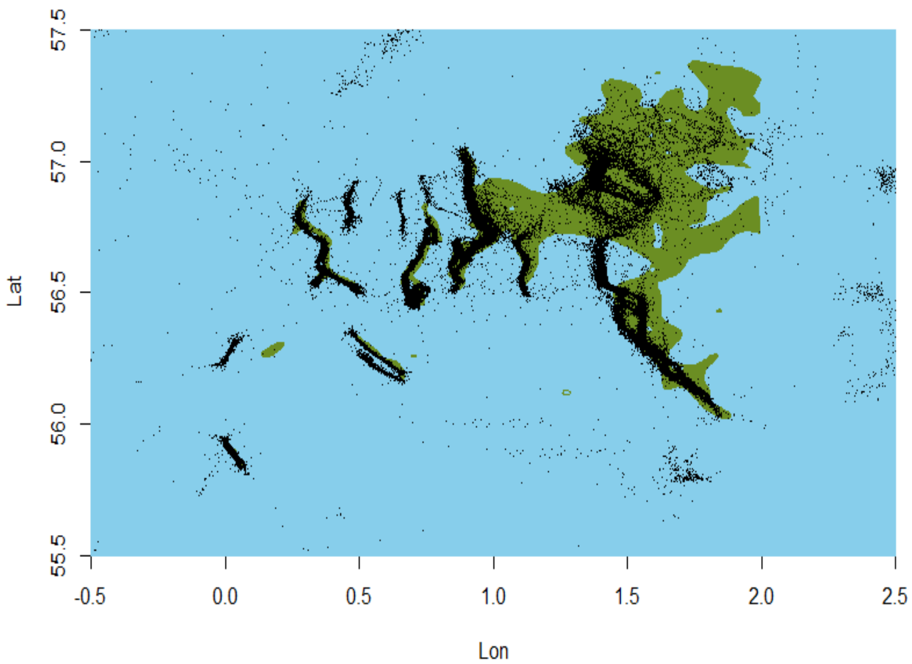


Figure 11.11.5. ***Nephrops*, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for *Nephrops* landings > 30% of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

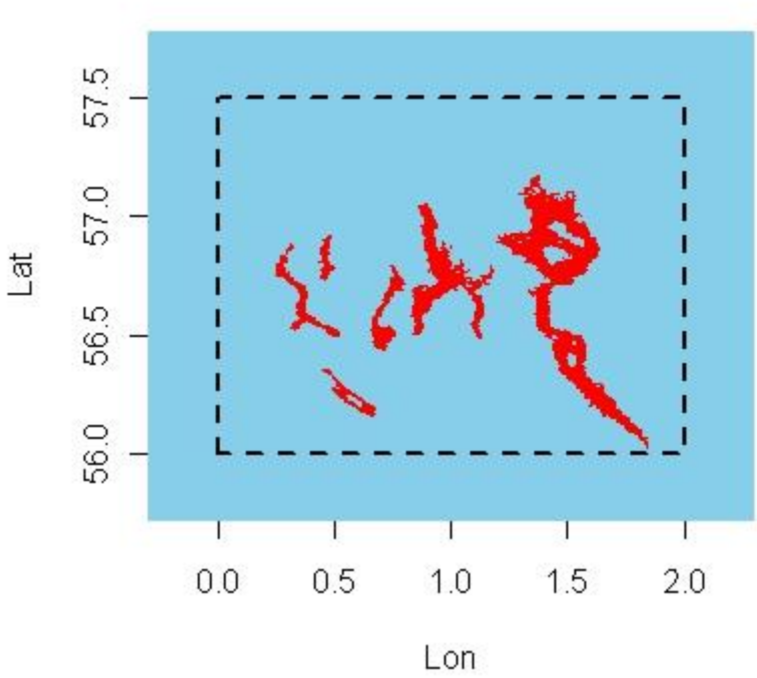


Figure 11.11.6. ***Nephrops*****, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for *Nephrops* landings > 30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

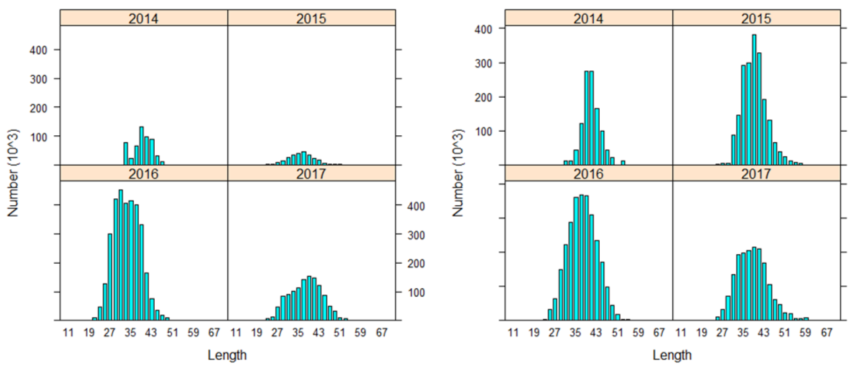


Figure 11.11.7. ***Nephrops*****, Devil's Hole (FU 34). Landings length distributions for females (left) and males (right) obtained from Intercatch and used to run the LBI screening methods (2014–2017).**

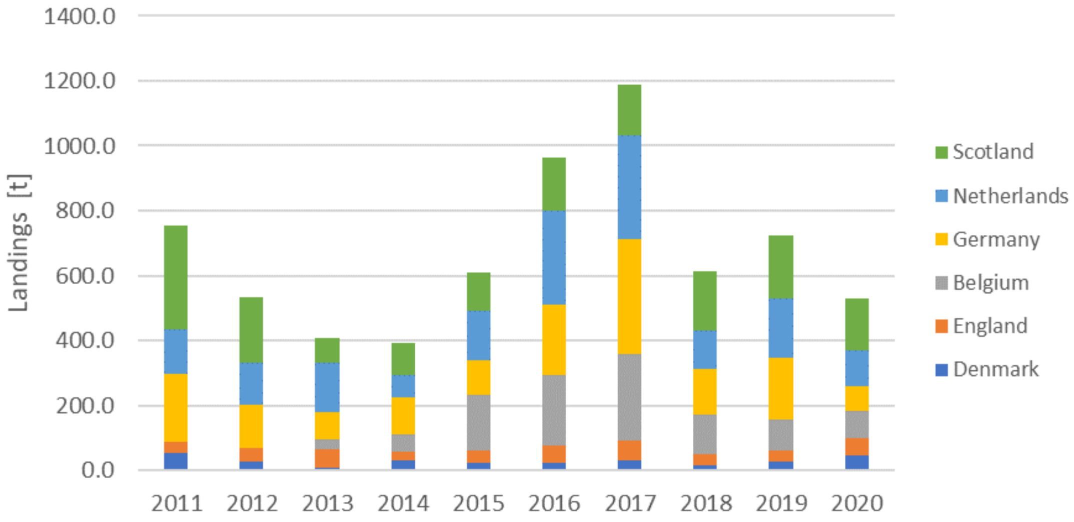


Figure 11.12.1. ***Nephrops*****, Subarea 27.4 outside FUs. Annual landings by country.**

12 Norway pout in ICES Subarea 4 and Division 3.a

The Section was added to the report in October 2021

Introduction: Benchmark assessment

The September 2021 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, 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, 2012c) with respect to the population dynamic parameter settings for natural mortality, maturity at age and mean weight at age. The previous settings in the assessment were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The new settings according to the inter-benchmark (from May 2012 onwards) include constant quarterly and yearly natural mortality, but with varying M by age, 20% maturity for the 1-group, and slightly changed levels of constant mean weight at ages in the stock which have been calculated from long term averages of mean weight at age in the catch. These parameters have impact on the predictions and estimates of the SSB because the stock consists of very few year classes. Due to introduction of revised IBTS (International Bottom Trawl Survey) quarter 1 (Q1) and quarter 3 (Q3) indices for the full survey time series for all age groups of Norway pout by ICES in 2020 (https://github.com/ices-tools-prod/DATRAS/tree/master/ALK_substitution) the sustainability of the MSY $B_{trigger} = B_{lim}$ and $F_{cap} = 0.7$ reference points were evaluated in Brooks and Nielsen (2020). Despite only a slight change in B_{lim} of less than 10% from B_{lim} = 39 447 t (Benchmark ICES WKPOUT 2016 estimate) to B_{lim} = 42 573 t by running the benchmark assessment with the new IBTS indices (Brooks and Nielsen, 2020), the WGNSSK 2020 working group decided to switch to the new B_{lim} reference point, and on this basis to calculate a new B_{pa} reference point. The sustainability of the currently implemented $F_{cap} = 0.7$ was accordingly evaluated with this new B_{lim} reference point (Brooks and Nielsen, 2020). These evaluations showed that the current F_{cap} was also sustainable with the slightly revised B_{lim} reference point (Brooks and Nielsen, 2020). See also Section 12.7 below. The assessment is a "real time" monitoring and management run up to 1 October 2021, and includes new information from 2nd half year 2020 and for the quarters 1, 2 and 3 in 2021. The assessment includes the new 3rd quarter 2021 survey information also covering the 0-group 2021 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 2021 and 1 November 2022 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 and 4). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al*., 2009; Nash *et al*., 2012; Huse *et al.*, 2008; See review in Nielsen, 2016, Section 4).

Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al.* (2009) show that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), gave no evidence for a stock separation in the whole northern area, and this conclusion is supported by the results in Lambert *et al.* (2009) and in Nash *et al.* (2012). (See also review in Nielsen, 2016, Section 3).

Ecological role: The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short life span of the species (Nielsen *et al.*, 2012; ICES WGSAM, 2011; ICES WGSAM, 2014; Sparholt *et al.*, 2002a, b; Lambert *et al.*, 2009). Norway pout natural mortality is likely influenced by spawning and maturity having implications for 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 an important food source for the species saithe, haddock, cod, whiting, and mackerel and predation mortality is significant (ICES-SGMSNS, 2006; ICES WGSAM, 2011; ICES WGSAM, 2014; Cormon *et al*., 2016; see review in Nielsen, 2016, Section 6). Especially the more recent high abundance of saithe predators and the more constant high stock level of northern mackerel as likely predators on smaller Norway pout are likely to significantly affect the Norway pout population dynamics. Interspecific and intraspecific density patterns in Norway pout mortality and maturity has been documented (Nielsen *et al*., 2012; Lambert *et al.*, 2009; Cormon *et al.*, 2016; see review in Nielsen, 2016). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES WGSAM, 2011; ICES WGSAM, 2014), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used based on the results from Nielsen *et al.* (2012).

Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

Ecosystem impacts of fishery: In order to protect other species (cod, haddock, whiting, saithe and herring as well as mackerel, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, by-catch regulations, minimum mesh size, and minimum landing size. A review of regulations on the Norway pout stock and be found in Nielsen *et al.* (2016a).

12.1.2 Fisheries

The fishery is nearly exclusively performed by Danish and Norwegian vessels using small mesh trawls in the north-western North Sea, especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. Recent catches in 1st quarter are relatively low. 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 include the long-term trends in average exploitation pattern. Recently, the Danish large vessel pelagic fleet fishery has been analysed in Paoletti *et al*. (2021) which also provide yearly, seasonal and geographical fishing patterns with respect to effort allocation, catches and value of landings for the part of the Norway pout fishery conducted by this fleet for the period 2015–2020.

Landings have been relatively low since 2001 except for 2010 and recently in 2019–2020, and the 2003–2004 landings were the lowest on record (Tables 12.2.1–3). The directed fishery for Norway pout was closed in 2005, in the first half of 2006, and in 2007 as well as in the first half of 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery around 5 kt, as well as in a small experimental fishery in 2007 (1 kt). In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low. Catches were above 100 kt in 2010, but have in the period 2012–2018 been well below 100 kt, while they increased again to be around or above 100 kt in 2019-2020. The quota has not been taken in those years. The landings in 2019 and 2020 were 97.7 kt and 129.5 kt, respectively. The fishery has in these periods mainly been based on the 2008, 2009, 2012, 2014, 2016, 2018, 2019 and 2020 year classes being above the long term average level. The TAC was not taken in 2008–2010 and 2012–2021, while the small TAC in 2011 was taken. The lack of full quota uptake is 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 herring and whiting bycatch) have an impact (see details in Nielsen *et al.*, 2016a). Late opening of the fishery at the end of quarter 3 in 2012, and individual quotas for the Danish fishery in general, as well as the recent implementation of a general herring by-catch quota in the North Sea, 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 (Bigné, Nielsen and Bastardie, 2019; 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 relatively 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 of by-catch of other species in the Norway pout fishery also appears from Table 12.2.1. However, here it can also be observed, that the by-catches have increased slightly in 2019–2020 because the total Norway pout catches (and fishing effort targeting Norway pout) have increased in those years compared to the previous years. Trends in by-catch levels in the samples from monitoring of the Danish and Norwegian commercial Norway pout fishery should also be analysed in future benchmark assessments. 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. From April 2020 onwards, the sampling intensity of the Danish Norway pout fishery has increased where every landing is now sampled, and the number of required samples increase with the landing weight from a minimum of 6 to a maximum of 24 per landing. 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 2020, the advice on North Sea Norway pout was updated. Based on the estimates of SSB in September 2020, 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 forecast is stochastic and uncertainties in the assessment and forecast are directly taken into account to ensure the SSB stays above B_{lim} with 95% probability according to the ICES MSY and Precautionary Approach for short lived species. 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). The B_{lim} value was adjusted in the benchmark assessment in 2016 and again in the MSE in 2020 due to changed IBTS indices (Brooks and Nielsen, 2020). 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 yearly 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 to 31 October. In recent years the escapement strategy has been practiced in reality in management.

The ICES advice in September 2020 was that with catches up to 254 kt in the directed Norway pout fishery in the period 1 November 2020 to 31 October 2021 corresponding to a F around 0.70 taking into account a F_{cap} of 0.70 and that the 5th percentile of the spawning-stock biomass in the 4th quarter 2020 will remain above a reference level of B_{lim} (42 573 t). The SSB was expected to remain high during 2020 and 2021 due to the high 2018, 2019 and 2020 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, 2018, 2019 and 2020, as well as a just below average recruitment in 2015 and 2017, the fishery has remained open for all of 2013–2021. The quota uptake has been low in recent years (Nielsen *et al*. 2016a). The quota uptake in 2019 was below 75%, and below 80% in 2020.

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 (0.35) as estimated from the assessment in September 2021.

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 2022 (up to 31 October) is provided for the stock in autumn 2021 as well.

ICES advises that there is a need to ensure that the stock remains high enough to provide food for a variety of predator species. It is advised that by-catches of other species should also be taken into account in management of the fishery. Also, it is advised that existing measures to protect other species should be maintained.

12.1.4 Management up to 2020

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the MSY approach for short lived species in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing on marine ecosystems.

ICES advised in 2005 real time management of this stock. In previous years, the advice was produced in relation to a precautionary TAC, which was set to 198 000 t in the EC zone and 50 000 t in the Norwegian zone. On basis of the real time management advice from ICES, EU and Norway agreed to close the directed Norway pout fishery in 2005, first part of 2006, all of 2007 and in first part of 2011 and 2012. In 2005 and 2007, the TAC was 0 in the EC zone and 5000 t in the Norwegian zone – the latter to allow for by-catches of Norway pout in the directed Norwegian blue whiting fishery. The final TAC set for 2008 was 115 kt (EU), 116 kt (EU) for 2009, 163 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, 173 kt for 2018, and 137 kt for 2019, however, the TACs were not taken during this period except for the small TAC in 2011. The TAC advice for 2021 up to now has been 167.1 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 on. Long term management strategies have been evaluated again in September 2012 and June 2013 based on new joint EU-Norway requests (ICES, 2012b) in spring 2012 and spring 2013 to be available for the September 2012 and September 2013 ICES advice, respectively. These MSEs have been presented in a 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 could not be used anymore for long term management plans of the stock (including the F_{cap} estimates made there).

Long term management strategy evaluation according to the new assessment and the revised reference levels as established from the benchmark assessment in August 2016, have been requested in a joint EU-Norway request from November 2017. Based on this EU / Norway request ICES on 29 May 2018 released its advice evaluating long-term management strategies for Norway pout in area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) which is based on the work from the ICES WKNPOUT (2018) (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. This is summarized below.

ICES has evaluated sustainability of a range of harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TAC_{max}) and upper (TAC_{max}) bounds on TAC and optional use of upper fishing mortality values (F_{cap}) (ICES WKNPOUT, 2018). Several HCRs were identified that combined TAC_{max} in the range of 20 000–40 000 t and TAC_{max} less than or equal to 200 000 t (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 furthermore simulated to be restricted by a combination of TAC lower bounds (TAC_{max}) and upper bounds (TAC_{max}). For some HCRs, an upper $_{lim}$it 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 TAC_{max}, TAC_{max}, 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 advice 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 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 area 4 and 3.a. Here ICES was requested to assess, following MSY $B_{escapement}$:

→ *which scenarios of TAC_{max} and TAC_{max} would be precautionary, if the F_{cap} is set at 0.7 (building on request part 2 and 3, pages 3 and 4 of the advice).*

→ *which scenarios of TAC_{max} and TAC_{max} would be precautionary, if an inter-annual flexibility of +/-10% (both banking and borrowing) was introduced for Norway pout (building on request part 2 and 3, pages 3 and 4 of the advice, plus including precautionary scenarios with an F_{cap} of 0.7 – following from paragraph 1 of this request).*

On this basis, ICES has evaluated additional harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TAC_{max}) and upper (TAC_{max}) 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 WKNPOUT, 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 TAC_{max} in the range of 20 000–40 000 t and TAC_{max} less than or equal to 200 000 t, 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 TAC_{max}.

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 inter-annual quota flexibility of ±10% is not considered precautionary.

ICES has changed the historical IBTS Q1 and IBTS Q3 DATRAS indices for demersal species in the North Sea including the Norway pout indices based on introduction of a new calculation method for the indices. Brooks and Nielsen (2020) evaluate potential change in the MSY and PA sustainability reference points of using the revised IBTS survey indices in DATRAS compared to the previously used indices, and presents output from exploratory Management Strategy Evaluation (MSE) with consequences for the precautionary Fcap of changed biomass reference points. That is, whether the F_{cap} of 0.7 is still sustainable with the changed biomass reference points for the stock resulting from this revision of survey data. The conclusions in Brooks and Nielsen (2020) is that with no limits on TAC, then the assumption of a maximum implementable F has a stronger effect on the simulated stock dynamics. When the maximum implementable F is near F_{cap}, then F_{cap} has very little effect on the stock dynamics. If we assume that the maximum implementable F is extremely large (2.0 which is more than double the maximum estimated value), then the effect of F_{cap} can be seen again. With maximum implementable F at either its maximum historical estimate or at 1.0, then all risk statistics still show F_{cap} = 0.7 to be precautionary. Furthermore, even with the unrealistically high maximum implementable F, then the only risk that goes above 0.05 (when rounded to the nearest 0.01 units) is risk3.long.Q4 for a F_{cap} = 0,7. The type 3 risk statistics may require more replicates to converge to the true value expected from infinite replicates; if needed, this could be investigated in a benchmark. However, the overall result is that risk 1 statistics all indicate precautionarity even under extreme assumptions for high fishing effort.

No decision on long-term management plans are currently available for the Norway pout in area 4 and 3.a based on the identified sustainable scenarios. The stock is still managed according to the escapement strategy with a F_{cap} of 0.7 and with no TAC_{max} or TAC_{max} set. See also Section 12.7 below.

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 (126 kt), 2019 (98 kt) and 2020 (129 kt). 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 2021 include Danish and Norwegian catches up to 15th September 2021. Catches in the last 15 days of 3rd quarter 2021 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 in numbers 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.

A full-scale Norway pout age reading check and otolith exchange program was made in 2018 with participation of 14 readers from seven countries (Denmark, Norway, Scotland, UK, France, Netherlands and Germany) (ICES WGBIOP, 2018). 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% (ICES WGBIOP, 2018). 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) (ICES WGBIOP, 2018). Further details on the age reading checks and analyses can be found in Section 12.11 below.

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, 2019, 2020 as well as for quarter 1 to quarter 3 2021. Relative low mean weights at age have been observed for age groups 1–2 in quarter 1–2 in 2019–2020. Danish data and age readings have been checked according this. Very small fish were 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 (ICES IBPNorwayPout, 2012c) introduced revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009). The same mean weight at age in the stock is used for all years, and mean weight at age in the 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 (ICES IBPNorwayPout, 2012c) introduced revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM, 2011; ICES WGSAM, 2014). In Nielsen (2016) and in the Stock Annex a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment where maturity and natural mortality used in the assessment is described. Proportion mature and natural mortality by age and quarter used in the assessment is given in Table 12.2.6.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a paper by Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, then variable natural mortality between ages have been introduced in the 2012 ICES IBPNorwayPout inter-benchmark assessment (ICES, 2012c) and the present assessment. The revision of the natural mortality parameters 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, 2012c)

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 (ICES, 2016) 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 1984–2021 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), in Johnsen *et al.* (2016) and in Paoletti *et al*. (2021).

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 2021 IBTS and the 3rd quarter 2020 IBTS research surveys have been included in this September 2021 assessment as well as the 3rd quarter 2021 EGFS and SGFS research survey information. The survey data time series including the new information is presented in Table 12.2.11, as well as trends in survey indices in Figure 12.2.2. Surveys covering the Norway pout stock are described in detail in ICES WKPOUT (2016), Nielsen (2016) and in Johnsen and Søvik (2016) as well as in the Stock Annex. Survey data time series used in tuning of the Norway pout stock assessment are described below.

From 2009 and onwards, the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted sub-area 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 2015–2016, 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 2015–2016 data 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 2017–2021 and, accordingly, no new 15 min hauls have been conducted and included in the Q3 2017–2021 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 evaluations of and conclusions on 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). 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 2017–2021, 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 2017–2021 indices used in the assessment. By comparison it appears that the survey trends seem similar with or without prime 77 in the EGFS for 2017–2021. In the 2020 and 2021 EGFS survey, all 77 prime stations were successfully fished aimed at 30 minute tows, though with some reduced to at least 20 minute tows for operational reasons.

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 was very small and typically around 1–3% increase and obviously were 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. In the SGFS 2020 survey, there was only one invalid haul, and the SGFS 2021 survey was conducted as planned.

Additionally, 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.

In 2020, the IBTS quarter 1 (Q1) and quarter 3 (Q3) indices have been substantially revised (https://github.com/ices-tools-prod/DATRAS/tree/master/ALK_substitution) also covering the full Norway pout index time series for all age groups. The changes in the survey indices and their influence on assessment results as well as sustainability reference points are shown, described and evaluated in Brooks and Nielsen (2020). See also further details in Section 12.1.4 above and section 12.7 below.

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 (ICES, 2016) and its Annexes**.**

The overall assessment period has been changed by cutting off the first assessment year (1983), so the assessment period is from 1984–2021, 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 IBPNorwayPout, 2012c) with respect to the population dynamic parameter settings in the assessment for natural mortality, maturity at age and mean weight at age in the stock (see also Table 12.3.1).

12.3 Catch at Age Data Analyses

12.3.1 Review of assessment

The September 2020 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 as well in the following meetings, but no major issues and problems were pointed at, and it was concluded that the assessment has been performed correctly and performs relatively 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 2021 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 2021 assessment under "NP_Sep2021_v1" 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 is 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 reduces 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 2021 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 2021 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 (0.35, 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 2013–2020, 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 2019 the quota uptake was below 75%, and below 80% in 2020. 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, 2018, 2019 and 2020 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, 2019, 2020 and 2021 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-1980s. The recruitment in 2008, 2009, 2012, 2014, 2016, 2018, 2019 and 2020 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 was slightly below long-term average (46 billion), but because of the strong 2012, 2014, 2016, 2018, 2019 and 2020 year classes the SSB has been well above B_{pa} (= MSY $B_{escapement}$) by 1 January 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021 even with a high yearly TAC in 2014–2021 (up to 3rd quarter) considering growth, high natural mortality, and 20% maturation at age 1. The 2021 recruitment is about half (24 billion) of the long-term average (46 billion) and will reduce the stock biomass, but because of the strong 2018, 2019 and 2020 recruitment the stock is expected to remain above B_{pa} by the end of 2021.

12.3.3 Comparison with 2015–2020 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 (ICES, 2016). 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 2021 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 2021 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. For the latest years it converge for SSB, but for a few previous years to this the convergence is not as high. No strong retrospective patterns are observed for SSB, however, the Mohns rho values are relatively high for SSB (34%) which just above the threshold of 0.3 for short lived species. However, for the most recent years the convergence is high for SSB and for all years the retrospective patterns are within the confidence limits of the estimates for both SSB, F and R (Figure 12.3.8). There is a strong positive retrospective pattern for recruitment with a tendency to overestimate recruitment in the terminal assessment year. This is due to not full consistency between in-year-0-group indices and 1-group-indices the following year for the EGFS and SGFS Q3 surveys. It should be noted that there is some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments.

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, there is a tendency to overestimate recruitment in the terminal assessment year. According to the benchmark assessments, the SXSA estimates of fishing mortality is within the confidence limits of the SESAM estimates of fishing mortality. 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 was observed a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10 % in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter. This is shown in the ICES IBPNorwayPout Report (ICES, 2012c) and the Stock Annex.

In the 2021 assessment, the SSB and R values for 2020 have decreased compared to last year's assessment because of the retrospective patterns. Especially the SSB value in 2020 has changed with a consistent increase in SSB over the years, as well as a smaller consistent decrease in $F_{bar(1–2)}$, because of the introduction of the revised IBTS Q1 and Q3 index time series for Norway pout of all age groups in 2020 (Brooks and Nielsen, 2020). The changes are not affecting TSB (Total Stock Biomass) and recruitment very much. This is because the changes have been relatively higher for the indices of the older mature age groups in the population.

Recruitment Estimates

The long-term average recruitment (age 0, 2nd quarter) is 46 billion (arithmetic mean) for the period 1984–2021 (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, 2019 and 2020 was high. Recruitment in 2011 and 2013 was very low, and the recruitment in 2015 and 2017 and 2021 has been below long-term average (46 billion).

12.5 Short-term prognoses

The short-term forecast is stochastic based on the SESAM September 2021 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 2021 recruitment (Q3 2021) in the SSB estimate by 4th quarter 2021. The recruits in 2022 do not become a part of SSB by 4th quarter (1 October) 2022 because they have not reached maturity yet by 4th quarter 2022, but will do that by 1 January 2023 (20% mature as 1-group here). However, the forecast is just run up to 4th quarter 2022, and the recruits in 2022 is accordingly not used (and shall not be that) in the forecast SSB estimate in Q4 2022.

5. Find Gt such that the 5th (or any other) percentile of the catches (total mass) in the projections equal some desired level such as B_{lim} (optional).

Forecasting weight-at-age in the catches

There is substantial variation in weight-at-age in the commercial catches from year to year, which means that usual methods of using running averages will be quite sensitive to the bandwidth of the running average. This is important, since TAC estimates calculated in step 5 above depend directly on the catch weight-at-age.

The following model is used:

$$E(\sqrt{CW_{a,q,t}}) = \mu_{a,q} + s(cohort, a) + U_t$$

where $\mu a,q$ is a mean for each combination of quarter and age, s( ) is tensor product smoothing spline, and U_t are normal distributed random effects. The square root transform is used to achieve variance homogeneity in the residuals. See Figure 1 in ICES WKPOUT (2016, WD6, Nielsen and Berg, 2016).

The projected mean weight at ages in the catch used in the forecast are shown in Table 12.6.1.

Forecasts

The first forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1 October as explained below in Section 12.7. The purpose of the first forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2022) equals B_{lim}, i.e. where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%. The results of the forecast are presented in Table 12.6.2 and Figure 12.6.1, and this results in a catch up to 118 kt (118 273 t) in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.473 and a SSB at 130 kt (130 020 t) by 1 October 2022.

The purpose of the second forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to zero. The results of the forecast are presented in Table 12.6.3 and Figure 12.6.2 resulting in no catch in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.00 and a SSB at 203 kt (202 990 t) by 1 October 2022.

The purpose of the third forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to F status quo for previous year up to 1 October 2021. The results of the forecast are presented in Table 12.6.4 and Figure 12.6.3 where catches up to 63 kt (63 193 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.230 and a SSB at 162 kt (161 790 t) by 1 October 2022.

The purpose of the fourth forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled such that the median of the SSB distribution one year a head (1 October 2022) equals B_{lim}. The results of the forecast are presented in Table 12.6.5 and Figure 12.6.4 where catches up to 309 kt (308 842 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 2.005 and a SSB of 42 kt (42 573 t) by 1 October 2022.

The purpose of the fifth forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled such that SSB one year a head (1 October 2022) equals B_{pa}. The results of the forecast are presented in Table 12.6.6 and Figure 12.6.5 where catches up to 239 kt (238 733 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 1.253 and a SSB of 70 kt (70 000 t = B_{pa}) by 1 October 2022.

The purpose of the sixth forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to 0.3, i.e. with a F_{cap} = 0.3. The results of the forecast are presented in Table 12.6.7 and Figure 12.6.6 where catches up to 80 kt (80 473 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.300 and a SSB of 152 kt (151 810 t) by 1 October 2022.

The purpose of the seventh forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to 0.4, i.e. with a F_{cap} = 0.4. The results of the forecast are presented in Table 12.6.8 and Figure 12.6.7 where catches up to 103 kt (103 130 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.403 and a SSB of 139 kt (138 740 t) by 1 October 2022.

The purpose of the eight forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to 0.5, i.e. with a F_{cap} = 0.5. The results of the forecast are presented in Table 12.6.9 and Figure 12.6.8 where catches up to 124 kt (123 900 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.503 and a SSB of 127 kt (126 860 t) by 1 October 2022.

The purpose of the ninth forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to 0.6, i.e. with a F_{cap} = 0.6. The results of the forecast are presented in Table 12.6.10 and Figure 12.6.9 where catches up to 143 kt (143 323 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.605 and a SSB of 117 kt (116 760 t) by 1 October 2022.

The purpose of the tenth forecast is to calculate the catch of Norway pout from 1 October 2021 to 31 October 2022 with F scaled to 0.7, i.e. with a F_{cap} = 0.7. The results of the forecast are presented in Table 12.6.11 and Figure 12.6.10 where catches up to 162 kt (161 545 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.703 and a SSB of 108 kt (107 550 t) by 1 October 2022.

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 area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) it was shown that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is only precautionary with the addition of an F_{cap} at 0.7. See also Section 12.1.4 above and Section 12.7 below.

12.6 Medium-term projections

No medium-term projections are performed for this stock. The stock contains only a few age groups and is highly influenced by recruitment.

12.7 Biological reference points

As explained in the ICES WKPOUT 2016 Report (ICES, 2016), Section 3.8, the benchmark has recommended that the B_{lim} = Bloss should be the lowest SSB estimated in quarter 4, because this is closest to the beginning of the fishing season (1 November), and would be the most appropriate to use as a B_{lim} reference point, because the probability of SSB being below B_{lim} can then be evaluated immediately after the fishing season for which a TAC is being calculated. It was argued that the quarter 4 SSB (an existing output of the SESAM model) was adequate for this purpose because any attempt to calculate an SSB corresponding to 1 November would require further assumptions and would effectively only be an interpolation between the quarter 4 and subsequent quarter 1 SSBs, thus unnecessarily complicating the calculation of the SSB. The forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1 October. Accordingly, it is recommended that this TAC is used for the management year 1 November–

31 October. This is an approximation and will be sustainable unless radical changes occur in the seasonal fishing pattern used in the forecast. In the period between 1 October and 1 November in the forecast year there will be provided a new assessment.

In Table 12.6.12, quarterly minima of the estimated SSB time series (1984–2016) are shown from the SESAM Benchmark Assessment Baseline Run from the Norway pout benchmark assessment in 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 (ICES, 2016). In Table 12.6.13, the same minima for the same period is shown using the new IBTS Q1 and Q3 survey indices introduced in the assessment from 2020 onwards. See also Section 12.1.4 above and Section 12.7 below.

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 an age class shift by 1 January, i.e. the 0-group becomes 1-group and 20% of those become mature, and the 1-group becomes 2-group and 100% of those become mature. This is in the forecast calculated into the SSB available for spawning in 1 quarter of the forecast year.

The fishing pattern has not changed in the most recent years. Accordingly, the use of B_{lim} by Q4 should be sustainable.

It should be noted that there is a tendency towards the retrospective analyses for SSB do not fully converge even though being at the same level (see also Section 12.3 above). 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.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{escapement}$	Not defined*		
	F_{MSY}	Not defined		
	F_{cap}	0.70	A long-term mananagement strategy evaluation, indicating that an escapement strategy for Norway pout is only precautionary with the addition of an upper limit on fishing mortality = F_{cap} ($F_{bar[1–2]}$) at 0.7	ICES (2020)
Precautionary approach	B_{lim}	42 573 tonnes (4th quarter)	B_{lim} = B_{loss}, the lowest observed biomass in 2005 (as estimated in the updated benchmark assessment)	ICES (2020)
	B_{pa}	69 736 tonnes (4th quarter)	$B_{pa} = B_{lim}\ e^{0.3 \times 1.645}$	ICES (2020)
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	SSB_{MGT}	Not applicable		
	F_{MGT}	Not applicable		

*** MSY $B_{escapement}$ has not been defined, as the escapement strategy uses directly the 95% probability of SSB being above B_{lim}.**

No F-based reference points are advised for this stock except for an F_{cap} (see below and 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 limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short-lived species.

On this basis, advice on yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is considered sustainable. That is where F is scaled such that the fifth percentile of the SSB distribution one year a head (1 October in forecast year) equals B_{lim}. According to the long term management strategy evaluation based on the joint EU-Norway request from November 2017 and the resulting released advice by ICES in May 2018 evaluating long-term management strategies for Norway pout in area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) it was shown that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5% is only precautionary with the addition of an F_{cap} at 0.7 (see also Section 12.1.4 above).

B_{pa} has been calculated from

$$B_{pa} = B_{lim}\ e^{0.3*1.645}\ (SD).$$

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} (42 573 and 69 736 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 2012c; 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 $B_{lim} = B_{loss}$ = 42 573 t (quarter 4) is based on the lowest observed SSBs in 2005.

Revision of Reference points in 2020

Due to introduction of revised IBTS (International Bottom Trawl Survey) quarter 1 (Q1) and quarter 3 (Q3) indices for the full survey time series for all age groups of Norway pout by ICES in 2020 (https://github.com/ices-tools-prod/DATRAS/tree/master/ALK_substitution) the long term sustainability of the B_{lim} and F_{cap} = 0.7 reference points were during summer 2020 evaluated and presented in Brooks and Nielsen (2020).

The analyses showed a slight change in B_{lim} of less than 10% from B_{lim} = 39 447 t (Benchmark ICES WKPOUT, 2016 estimate) to B_{lim} = 42 573 t by running the benchmark assessment with the new IBTS indices (Brooks and Nielsen, 2020).

Furthermore, Brooks and Nielsen (2020) 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 based on the new B_{lim} value and simulated to be restricted by a combination of an upper limit on F values (F_{cap}), different F_{max} values (between the historical observed F_{max} of 0.67, i.e. the $F_{historical}$ for the assessment using the revised IBTS data, and up to a F_{max} value of 2) as well as different TAC upper bounds (TAC_{max}) for setting the TAC. The TAC_{max} values evaluated was from 200 kt up to infinite (i.e. with no upper TAC bound). The sustainability of the current F_{cap} = 0.7 was through long term management strategy evaluation simulations evaluated with the new B_{lim} reference point and according to the different F_{max} and TAC_{max} values applied as described above and detailed in Brooks and Nielsen (2020)

These evaluations showed that the currently implemented F_{cap} of 0.7 is also precautionary and sustainable with the slightly revised B_{lim} reference point (Brooks and Nielsen, 2020).

This is the case also in extremely unrealistic scenarios of an infinite TAC_{max} and with F_{max} values between 0.67 and up to 2 (Brooks and Nielsen, 2020). All scenarios for F_{max} = 0.67 and for a very unrealistic high F_{max} = 1 with infinite TAC_{max} are sustainable. Even with the totally unrealistically high maximum implementable F of 2 then the risk only goes above 0.05 with an F_{cap} = 0.7 (when rounded to the nearest 0.01 units) for the risk3.long.Q4. All other scenarios for F_{max} = 2 values are sustainable (Brooks and Nielsen, 2020). This means that if there were a totally unrealistic high F_{max} of around 1.6 which is similar to the natural mortality level for the stock then all scenarios of F_{cap} = 0.7 would obviously be sustainable.

The WGNSSK working group has on this basis decided to switch to the new B_{lim} reference point, and on this basis to calculate a new B_{pa} reference point, and continue with the currently implemented F_{cap} of 0.7. It should again be noted that no TAC_{max} or TAC_{max} boundaries have been implemented in the management (see also Section 12.1.4).

In Table 12.6.13 quarterly minima of the estimated SSB time series (1984–2016) are shown from the SESAM updated Benchmark Assessment Run (Run: NP_Sep17_fixC_Benchmark2016Data_NewIBTS, www.stockassessment.org) with new IBTS Q1 and Q3 survey indices for Norway pout made available in 2020 (Brooks and Nielsen, 2020). The estimates are quarterly minima estimated at the beginning of the season. The lowest observed biomasses in the assessment period are still in 2005. The estimates are B_{loss} estimates which equals B_{lim} which by 1 October is B_{lim} = 42 573 t, i.e. 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 year's assessment, except that SSB has consistently increased and F_{bar} has consistently decreased because of introduction of the new IBTS Q1 and Q3 indices in 2020 (see Section 12.7 above). 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 2021, with terminal assessment year ranging from 2016–2021, is 34% for SSB, -13% for F_{bar}, and 91% 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 (see also Sections 12.3.3 and 12.4 above).

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 2021, ICES classifies the stock at full reproductive capacity.

With F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2022) 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% catches up to 118 kt (118 273 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.473 and a SSB at 130 kt (130 020 t) by 1 October 2022. This is due to the strong 2018, 2019 and 2020 recruitment being above the long-term average recruitment (46 billion) and a 2021 recruitment around half (24 billion) of the long-term average, 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 (0.35). However, if the advised catch is taken, the F is expected increase to above this average for the period 1 October 2021 to 31 October 2022. 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 2013–2020. Here, the fishing mortality was low in 2008 and 2011, moderate in 2009 and 2010, and on a higher level in 2013–2020, but still well below the long-term average. The TACs have not been fished up in any of these recent years. Less than 75% of the quota was taken in 2019, and less than 80% in 2020.

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, 2019 and 2020 was high well above the long-term average (46 billion). Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015, 2017 and 2021 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 a F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2022) 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% catches up to 118 kt (118 273 t) can be taken in the directed Norway pout fishery in the period 1 October 2021 to 31 October 2022 which corresponds to a $F_{bar(1–2)}$ of 0.473 and a SSB at 130 kt (130 020 t) by 1 October 2022. This is due to the strong 2018, 2019 and 2020 recruitment being above the long-term average recruitment (46 billion) and a 2021 recruitment around half (24 billion) of the long-term average, 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. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short-lived species.

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock from the 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 relatively 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 of by-catch of other species in the Norway pout fishery also appears from Table 12.2.1. However, here it can also be observed, that the by-catches have increased slightly in 2019–2020 because the total Norway pout catches (and fishing effort targeting Norway pout) have increased in those years compared to the previous years.

Sorting grids in combination with square mesh panels have been shown to reduce by-catches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen, 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. ICES suggests, that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. The implementation of these technical measures shall be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing by-catch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the Stock Annex.

12.2.1Long 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 up-dated stock information. In September 2012, ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100–250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the result that an initial TAC between 25–50 kt and a fixed F = 0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference between the MSE 1 and 2–3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2–3), while the minimum TAC in MSE 1 can be applied all year. As a follow up on this, ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1 November–31 October rather than from 1 January to 31 December, and one annual advice from the September assessment, with the result that a minimum TAC up to 20 kt with maximum TAC of 100 kt ($F_{max/cap}$ = 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 these 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 area 4 and 3.a (http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/eu-no.2018.07.pdf) which is based on the work from the ICES WKNPOUT (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 (TAC_{max}) and upper (TACmax) bounds on TAC and optional use of upper fishing mortality values (F_{cap}). Several HCRs were identified that combined TAC_{max} in the range of 20 000–40 000 t and TAC_{max} less than or equal to 200 000 t (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 (TAC_{max}) 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 TAC_{max}, TAC_{max}, 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 and 6 September 2018, the advice was presented by ICES and in the following discussions, certain limited additional elements, to be reviewed by ICES, came up. This resulted in an additional EU / Norway request from September 2018 on evaluation of additional elements concerning the ICES advice evaluating long-term management strategies for Norway pout in area 4 and 3.a. Here ICES is requested to assess, following MSY $B_{escapement}$:

→ *- which scenarios of TAC_{max} and TACmax would be precautionary, if the F_{cap} is set at 0.7 (building on request part 2 and 3, pages 3 and 4 of the advice).*

→ *-which scenarios of TAC_{max} and TACmax would be precautionary, if an inter-annual flexibility of +/-10% (both banking and borrowing) was introduced for Norway pout (building on request part 2 and 3, pages 3 and 4 of the advice, plus including precautionary scenarios with an F_{cap} of 0.7 – following from paragraph 1 of this request).*

On this basis, ICES has evaluated additional harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TAC_{max}) and upper (TAC_{max}) 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 WKNPOUT, 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 TAC_{max} in the range of 20 000–40 000 t and TACmax less than or equal to 200 000 t, 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 TAC_{max}.

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 area 4 and 3.a based on the identified sustainable scenarios.

Due to introduction of revised IBTS (International Bottom Trawl Survey) quarter 1 (Q1) and quarter 3 (Q3) indices for the full survey time series for all age groups of Norway pout by ICES in 2020 (https://github.com/ices-tools-prod/DATRAS/tree/master/ALK_substitution) the long term sustainability of the B_{lim} and F_{cap} = 0.7 reference points were during summer 2020 evaluated and presented in Brooks and Nielsen (2020).

The analyses showed a slight change in B_{lim} of less than 10% from B_{lim} = 39 447 t (Benchmark ICES WKPOUT, 2016 estimate) to B_{lim} = 42 573 t by running the benchmark assessment with the new IBTS indices (Brooks and Nielsen, 2020).

Furthermore, the working documents 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 based on the new B_{lim} value and simulated to be restricted by a combination of an upper limit on F values (F_{cap}), different F_{max} values (between the historical observed F_{max} of 0.67, i.e. the Fhistorical for the assessment using the revised IBTS data, and up to a F_{max} value of 2) as well as different TAC upper bounds (TAC_{max}) for setting the TAC. The TAC_{max} values evaluated was from 200 kt up to infinite (i.e. with no upper TAC bound). The sustainability of the current F_{cap} = 0.7 was through long term management strategy evaluation simulations evaluated with the new B_{lim} reference point and according to the different F_{max} and TAC_{max} values applied as described above and detailed in Brooks and Nielsen (2020).

These evaluations showed that the currently implemented F_{cap} of 0.7 is also precautionary and sustainable with the slightly revised B_{lim} reference point (Brooks and Nielsen, 2020).

This is the case also in extremely unrealistic scenarios of an infinite TAC_{max} and with F_{max} values between 0.67 and up to 2 (Brooks and Nielsen, 2020). All scenarios for F_{max} = 0.67 and for a very unrealistic high F_{max} = 1 with infinite TAC_{max} are sustainable. Even with the totally unrealistically high maximum implementable F of 2 then the risk only goes above 0.05 with an F_{cap} = 0.7 (when rounded to the nearest 0.01 units) for the risk3.long.Q4. All other scenarios for F_{max} = 2 values are sustainable (Brooks and Nielsen, 2020). This means that if there were a totally unrealistic high F_{max} of around 1.6 which is similar to the natural mortality level for the stock then all scenarios of F_{cap} = 0.7 would obviously be sustainable.

The WGNSSK working group has on this basis decided to switch to the new B_{lim} reference point, and on this basis to calculate a new B_{pa} reference point, and continue with the currently implemented F_{cap} of 0.7. It should again be noted that no TAC_{max} or TAC_{max} boundaries have been implemented in the management (see also Section 12.1.4).

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 WGBIOP, the first official SmartDots exchange (ICES WGBIOP, 2018). 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 (ICES WGBIOP, 2018).

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. (ICES WGBIOP, 2018).

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 InterBenchmark Assessment if required. Due to difficulties with sample collection and the WebGR age reading platform delays were encountered. A revised timetable was proposed in line with the launch of the BETA version of the new age reading tool – SmartDots, making the results available for the Norway pout stock assessment in Spring 2018. The exchange took place from January to March 2018 and 14 readers from seven countries participated (Scotland, UK, France, Norway, Denmark, Netherlands and Germany). Different methods 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 (ICES WGBIOP, 2018).

Results based on sectioned otoliths were exceptional with an overall percentage agreement based on modal age of 99% and an average CV of 3% (ICES WGBIOP, 2018). 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 (ICES WGBIOP, 2018).

In conclusion, there is an overall high level of agreement between readers of the Norway pout - nop.27.3a4 stock (ICES WGBIOP, 2018). 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. (ICES WGBIOP, 2018).

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.

Trends in by-catch levels in the samples from monitoring of the Danish and Norwegian commercial Norway pout fishery should also be analysed in future benchmark assessments.

It will be relevant to investigate retrospective patterns in the SESAM assessment among other in relation to the Mohn´s Rho values for recruitment, SSB and F, as well as to conduct further analyses of the uncertainty and residuals in the assessment.

12.3 References

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Table 12.2.1. Norway pout 4 and 3.a. Nominal landings (tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas 4 and 3.a in the period 2010–2020, 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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	51	2	118	6.945	538	2.220	918	110	159	1.125 *	5.585 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Norway	711	-	-	147	9	41	82	72	6	6 *	16 *
Sweden	10	-	-	1	1	1	1	4	1	181 *	125 *
Germany	-	-	-	-	-	-	-	2	-	-	-
Total	772	2	118	7.093	548	2.262	1.001	188	166	1.312	5.726

*Preliminary.

Norway pout ICES area IVa

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	71.032	4.038	25.431	31.375	27.894	10.760	21.125	12.312	10.367	35.647 *	59.402 *
Faroe Islands	-	-	-	-	-	5.270	3.156	-	-	3034 *	- *
Netherlands	18	-	-	-	-	17	8	1	2	- *	88 *
Germany	-	-	-	-	-	22	27	1	-	- *	4 *
Norway	64.303	3.189	4.528	45.839	18.647	43.742	35.959	21.275	25.498	59.546 *	63.726 *
Sweden	+	1	3	4	1	12	-	-	4	32 *	354 *
UK(Scotland)	29	-	-	-	8	3	12	-	-	- *	825 *
Latvia	-	-	-	-	-	-	-	-	-	-	23 *
Total	135.382	7.228	29.962	77.218	46.550	59.826	60.287	33.589	35.871	98.259	124.399

*Preliminary.

Norway pout ICES area IVb

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	229	32	9	43	16	53	1463	45	20	573 *	620 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	13	3	- *	- *
Netherlands	-	-	-	-	-	1	-	-	-	1 *	- *
Norway	620	21	59	615	8	577	11	10	-	109 *	35 *
Sweden	-	-	-	0	0	714	1	2	-	25 *	3 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	3 *
UK (Scotland)	-	-	-	-	6	-	18	-	-	- *	- *
Total	849	53	68	658	30	1.345	1.493	70	23	708	661

*Preliminary.

Norway pout ICES area IVc

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	-	-	-	-	-	-	1	-	-	-	-
France	-	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	1	0	0	0	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	71.312	4.072	25.558	38.363	28.448	13.033	23.507	12.467	10.546	37.345	65.607
Faroe Islands	0	0	0	0	0	5.270	3.156	0	0	3.034	0
Norway	65.634	3.210	4.587	46.601	18.664	44.360	36.052	21.357	25.504	59.661	63.777
Sweden	10	1	3	5	2	727	2	6	5	238	482
Netherlands	18	0	0	0	0	18	8	1	2	1	88
Germany	0	0	0	0	0	22	27	16	3	0	4
UK	29	0	0	0	14	3	30	0	0	0	828
Total nominal landings	137.003	7.283	30.148	84.969	47.128	63.433	62.782	33.847	36.060	100.279	130.786
By-catch of other species and other	-11.048	-759	-3.075	-2.869	-2.958	-33	618	86	87	-2.625	-1.289
ICES estimate of total landings (IV+IIIaN)	125.955	6.524	27.073	82.100	44.170	63.400	63.400	33.933	36.147	97.654	129.497
Agreed TAC (EU)	162.950 x	4.500 x	70.683 x	165.700 x	128.250 x	150.000 x	150.000 x	141.950 x	85.265 x	55.000 x	65.000 x
TAC (Norway)	86.000	3.000	25.000	157.000	108.000	178.000	210.000	204.235	90.978	82.230	98.053

* 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 Agreed TAC

Table 12.2.2. Norway pout 4 and 3.a. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, 3.aS) by country, for 1961–2020 (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	-	-	+	79,8
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
2019	36,8	1,1	+	59,8	+	+	+	97,7
2020	60,1	5,6	+	63,8	+	+	+	129,5

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.
** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 12.2.3. Norway pout 4 and 3.a. National landings (tonnes) by quarter of year 2004–2021 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
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	947	-	947	-	5.347	1	-	5.348	6.295	32.326	32.326	38.621
	4	-	-	-	-	28.208	567	-	28.775	28.775	18.586	18.586	47.361
	Total	1.125	-	1.125	-	36.204	568	-	36.772	37.897	59.757	59.757	97.654
2020	1	-	-	-	111	3.432	-	-	3.543	3.543	282	282	3.825
	2	2.343	-	2.343	-	1.288	-	-	1.288	3.631	7.333	7.333	10.964
	3	3.018	-	3.018	-	3.574	2	-	3.576	6.594	40.868	40.868	47.462
	4	225	-	225	129	51.570	33	-	51.732	51.957	15.289	15.289	67.246
	Total	5.586	-	5.586	240	59.864	35	-	60.139	65.725	63.772	63.772	129.497
2021	1	-	-	-	-	6.650	-	-	6.650	6.650	64	64	6.714
	2	1.036	-	1.036	-	606	1	-	607	1.643	12.787	12.787	14.430
	3	699	-	699	-	1.389	362	-	1.751	2.450	13.847	13.847	16.297

Table 12.2.3a. Norway pout in 4 and 3.aN (Skagerrak). Observed and SESAM model predicted total catches in tonnes by quarter.

	year	observed	predicted
1	1984.00	56790	66931
2	1984.25	56532	29211
3	1984.50	152291	104418
4	1984.75	110942	94494
5	1985.00	57467	43844
6	1985.25	15509	15764
7	1985.50	62489	59895
8	1985.75	92017	60798
9	1986.00	37773	25427
10	1986.25	7657	9951
11	1986.50	45085	37500
12	1986.75	89993	42372
13	1987.00	33883	27337
14	1987.25	15435	9270
15	1987.50	38729	36592
16	1987.75	60847	58571
17	1988.00	22181	22988
18	1988.25	3559	7221
19	1988.50	21793	19372
20	1988.75	61762	30839
21	1989.00	15379	13863
22	1989.25	13234	10526
23	1989.50	55066	35717
24	1989.75	82880	45302
25	1990.00	27984	24673
26	1990.25	39713	17982
27	1990.50	26156	31498
28	1990.75	45242	48323
29	1991.00	42722	28791
30	1991.25	20786	19899
31	1991.50	62518	59053
32	1991.75	64380	63080
33	1992.00	64218	48285
34	1992.25	27973	27357
35	1992.50	114122	86530
36	1992.75	96177	83234
37	1993.00	36214	45767
38	1993.25	29291	25693
39	1993.50	62290	55752

	year	observed	predicted
40	1993.75	53470	45320
41	1994.00	34575	24085
42	1994.25	15373	14272
43	1994.50	53799	42459
44	1994.75	79838	41845
45	1995.00	36942	27176
46	1995.25	28019	18752
47	1995.50	69763	73109
48	1995.75	97048	62837
49	1996.00	21888	27213
50	1996.25	13366	16068
51	1996.50	74631	62634
52	1996.75	46194	42713
53	1997.00	15320	17327
54	1997.25	8708	11903
55	1997.50	78809	59529
56	1997.75	54100	51717
57	1998.00	19502	18906
58	1998.25	11836	12190
59	1998.50	20866	31337
60	1998.75	22830	26038
61	1999.00	7827	7663
62	1999.25	12533	6875
63	1999.50	41445	23256
64	1999.75	30497	31915
65	2000.00	10207	12156
66	2000.25	11589	13099
67	2000.50	44173	44314
68	2000.75	119001	63435
69	2001.00	21400	14521
70	2001.25	11778	8859
71	2001.50	4630	20090
72	2001.75	26565	32753
73	2002.00	8553	5962
74	2002.25	6686	4102
75	2002.50	32922	16019
76	2002.75	28947	20718
77	2003.00	3190	3521
78	2003.25	3106	1995
79	2003.50	10833	10843

	year	observed	predicted
80	2003.75	7518	8289
81	2004.00	2040	1994
82	2004.25	667	843
83	2004.50	4018	5771
84	2004.75	6762	7863
85	2005.00	8	5
86	2005.25	8	5
87	2005.50	13	10
88	2005.75	13	12
89	2006.00	2205	1849
90	2006.25	2848	2492
91	2006.50	6551	8405
92	2006.75	34949	25637
93	2007.00	1428	403
94	2007.25	1100	1193
95	2007.50	2430	5004
96	2007.75	838	2804
97	2008.00	361	270
98	2008.25	1840	1544
99	2008.50	8532	5630
100	2008.75	24111	4463
101	2009.00	538	225
102	2009.25	2105	2924
103	2009.50	36661	14458
104	2009.75	6509	9464
105	2010.00	198	388
106	2010.25	40322	5379
107	2010.50	57487	22121
108	2010.75	33071	17202
109	2011.00	0	0
110	2011.25	222	2073
111	2011.50	3749	7449
112	2011.75	2872	7384
113	2012.00	29	66
114	2012.25	281	806
115	2012.50	469	2345
116	2012.75	26168	10544
117	2013.00	79	143
118	2013.25	10460	2516
119	2013.50	24444	12093

	year	observed	predicted
120	2013.75	47126	34250
121	2014.00	1324	345
122	2014.25	3212	3968
123	2014.50	13384	14181
124	2014.75	26244	20042
125	2015.00	594	404
126	2015.25	7364	6076
127	2015.50	26804	24224
128	2015.75	22655	32718
129	2016.00	1089	618
130	2016.25	8846	6275
131	2016.50	23849	24024
132	2016.75	26457	24819
133	2017.00	735	515
134	2017.25	3475	5305
135	2017.50	13623	18970
136	2017.75	16107	24914
137	2018.00	379	268
138	2018.25	4143	4766
139	2018.50	9316	13550
140	2018.75	22292	15111
141	2019.00	495	329
142	2019.25	11179	6562
143	2019.50	38621	21822
144	2019.75	47373	33802
145	2020.00	3808	854
146	2020.25	10958	14436
147	2020.50	47467	34596
148	2020.75	67100	60605
149	2021.00	6292	1450
150	2021.25	14430	15826
151	2021.50	16299	20899

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	4
0		0	0	7	11	0	0	24	638	0	0	97	1007
1		39	159	319	515	1	114	111	261	47	519	1629	1767
2		1	25	127	87	21	84	140	385	10	284	97	64
3		0	4	40	7	1	8	17	0	4	29	4	0
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		735	3474	13623	16107	379	4143	9316	22291	495	11179	38627	47372
Age	Year	2020				2021							
	Quarter	1	2	3	4	1	2	3					
0		0	0	29	127			0					
1		288	353	1774	2439	1	323	505					
2		270	266	247	183	312	318	197					
3		2	20	9	3	11	21	4					
4+		0	0	0	0	0	0	0					
SOP		3807	10959	47471	67211	6725	14429	16298					

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 1984–2021, 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	4
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	10,44	5,28	6,70
2	30,95	25,85	34,38	37,59	15,78	25,21	39,50		13,58	17,67	21,12	21,54
3	23,69	27,21	41,52	49,92	28,59	30,13	48,75		33,40	25,40	36,12	40,29
4											50,79	
Year	2020				2021							
Quarter of year	1	2	3	4	1	2	3					
Age 0			5,18	5,85								
1	5,88	14,68	21,87	24,70	14,38	16,64	20,04					
2	7,64	19,64	33,05	33,33	19,13	26,39	30,65					
3	20,10	28,78	36,99		29,97	32,53	38,24					
4												

Mean weights at age from Danish and Norwegian landings from 2005-2008 uncertain because of few observations and use of values from 2004 and from adjacent quarters in the same year where observations have been missing. No mean weight at age data delivered by Norway in 2007-2008.
In general, mean weights at age are uncertain for quarters and countries where only very few fish have been caught. This problem is met by always calculating and using weighted mean weights at age, i.e. weighted by the catch number by country (Denmark and Norway) and quarter of year.

Table 12.2.6. Norway pout 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 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 (1987–2021) 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	46	325	409	17	24	52	60	58
2020		72	35	25	346	477	50	30	41	69	73
2021		31	3	0		34	17	5			17

Table 12.2.8. Norway pout 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2021) 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		1	23		24		10,0	24,1		23,5
2011	OTB_DEF_16-31_2_40		5	75		80		20,2	29,2		28,6
2012	OTB_DEF_16-31_0_0			3	24	27			15,7	35,4	33,2
2012	OTB_DEF_16-31_2_40			0	74	74				38,9	38,9
2013	OTB_DEF_16-31_0_0		101	163	99	363		31,3	29,9	47,2	35,0
2013	OTB_DEF_16-31_2_40		224	341	227	792		30,7	31,1	60,8	39,5
2014	OTB_DEF_16-31_0_0		62	64	57	183		18,2	35,1	33,9	29,0
2014	OTB_DEF_16-31_2_40		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		125	198	15	338		28,7	22,5	25,6	24,9
2017	OTB_DEF_16-31_2_40		1	105	87	193		8,8	37,8	51,2	43,7
2018	OTB_DEF_16-31_0_0		128	163	43	334		23,5	22,4	19,1	22,4
2018	OTB_DEF_16-31_2_40		17	112	233	362		27,8	35,3	45,0	41,2
2019	OTB_DEF_16-31_0_0		243	526	112	881		31,6	37,9	34,1	35,7
2019	OTB_DEF_16-31_2_40		44	272	220	536		36,1	40,5	54,0	45,7
2020	OTB_DEF_16-31_0_0	2	172	445	67	686	25,0	38,5	38,6	24,7	37,2
2020	OTB_DEF_16-31_2_40	6	24	474	131	635	24,3	40,5	37,9	79,3	46,4
2021	OTB_DEF_16-31_0_0		266	228		494		28,4	30,1		29,2
2021	OTB_DEF_16-31_2_40		114	92		206		30,0	24,5		27,6

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 (1987–2021) 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		102	227	34	47	410	68	36	59	70	58
2020		156	182	34	106	477	44	43	89	109	73
2021		8	26			34	24	13			17

Table 12.2.10. Norway pout 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2021) 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		24		0	24		23,5			23,5
2011	OTB_DEF_16-31_2_40		20		60	80		18,3		32,1	28,6
2012	OTB_DEF_16-31_0_0	0	17	4	6	27		34,8	13,75	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		273	75	15	363		34,4	30,9	65,3	35,0
2013	OTB_DEF_16-31_2_40		162	130	500	792		23,2	34,10332	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		228	106	175	509		33,7	42,7	40,8	38,0
2015	OTB_DEF_16-31_2_40		0	103	367	470			49,7	47,0	47,6
2016	OTB_DEF_16-31_0_0		207	136	246	589		25,5	21,0	23,0	23,4
2016	OTB_DEF_16-31_2_40		18	72	407	497		28,3	42,8	37,6	38,0
2017	OTB_DEF_16-31_0_0		123	107	108	338		24,7	21,4	28,6	24,9
2017	OTB_DEF_16-31_2_40		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	144	232	171	334	881	27,3	29,5	32,4	45,3	35,7
2019	OTB_DEF_16-31_2_40	7	8	118	403	536	57,7	56,4	45,5	45,3	45,7
2020	OTB_DEF_16-31_0_0	146	133	118	289	686	28,1	33,9	31,8	45,5	37,2
2020	OTB_DEF_16-31_2_40	4	3	94	534	635	37,5	60,5	36,0	48,3	46,4
2021	OTB_DEF_16-31_0_0	91	115	126	162	494	28,6	25,8	23,8	36,1	29,2
2021	OTB_DEF_16-31_2_40	0	0	0	206	206				27,6	27,6

Table 12.2.11. Norway pout 4 and 3.aN (Skagerrak). Research vessel indices (CPUE in catch in number per trawl hour) of abundance for Norway pout.

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1971	1,556	22	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	2,589	856	8	-	-	-	-	-	-	-	-	-	-	-	-
1973	4,207	438	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	25,559	388	24	-	-	-	-	-	-	-	-	-	-	-	-
1975	5,067	1,850	36	-	-	-	-	-	-	-	-	-	-	-	-
1976	4,422	328	35	-	-	-	-	-	-	-	-	-	-	-	-
1977	6,122	238	44	-	-	-	-	-	-	-	-	-	-	-	-
1978	1,480	565	56	-	-	-	-	-	-	-	-	-	-	-	-
1979	2,737	316	76	-	-	-	-	-	-	-	-	-	-	-	-
1980	3,274	552	30	-	-	-	-	-	1,928	346	12	-	-	-	-
1981	1,092	377	14	-	-	-	-	-	185	127	9	-	-	-	-
1982	4,511	266	81	-	-	-	-	8	991	44	22	-	-	-	-
1983	2,252	592	13	-	-	-	-	13	490	91	1	-	-	-	-
1984	5,000	956	89	-	-	-	-	2	615	69	8	-	-	-	-
1985	2,342	1,401	98	-	-	-	-	5	636	173	5	-	-	-	-
1986	2,066	386	19	-	-	-	-	38	389	54	9	-	-	-	-
1987	3,171	475	63	-	-	-	-	7	338	23	1	-	-	-	-
1988	123	710	25	-	-	-	-	14	38	209	4	-	-	-	-
1989	2,017	254	170	-	-	-	-	2	382	21	14	-	-	-	-
1990	1,295	712	70	-	-	-	-	58	206	51	2	-	-	-	-
1991	2,428	693	157	-	-	-	-	10	732	42	6	7,523	515	486	6
1992	5,060	860	33	2,975	6,116	1,710	303	12	1,715	221	24	2,560	4,106	740	151
1993	2,574	2,643	346	3,706	3,582	1,706	108	2	580	329	20	4,080	1,506	921	92
1994	1,532	374	99	9,487	1,148	147	25	136	387	106	6	3,196	685	114	21
1995	5,951	757	85	5,478	8,374	282	62	37	2,438	234	21	2,864	4,106	860	134
1996	915	2,626	233	8,241	1,326	378	9	127	412	321	8	4,559	672	419	41
1997	9,633	1,557	674	441	6,295	372	102	1	2,154	130	32	490	3,308	345	76
1998	1,009	5,332	268	1,391	377	340	3	2,628	938	127	5	2,931	791	745	23
1999	3,522	601	668	10,985	1,175	40	29	3,603	1,784	179	37	7,854	2,316	230	106
2000	8,034	1,563	98	2,267	9,730	264	2	2,094	6,656	207	23	1,644	7,556	590	14
2001	1,306	2,805	288	2,243	1,434	1,344	31	759	727	710	26	2,089	1,164	938	57
2002	1,784	812	864	4,939	1,137	58	18	2,559	1,192	151	123	1,974	749	76	52
2003	1,241	573	94	323	572	75	5	1,767	779	126	1	1,812	1,015	193	8
2004	903	364	37	278	557	109	6	731	719	175	19	773	590	209	14
2005	698	123	38	3,395	414	67	15	3,073	343	132	18	2,679	395	104	18
2006	3,400	113	23	1,813	1,996	124	20	1,127	1,285	69	9	1,391	1,800	197	14
2007	1,287	769	31	1,610	1,181	720	43	5,003	1,023	395	8	4,151	1,186	430	40
2008	2,438	461	154	628	1,340	411	104	3,456	1,263	263	57	3,035	1,610	267	98
2009	5,553	1,582	123	4,871	3,500	306	5	5,835	1,750	202	16	5,899	2,454	358	14
2010	4,954	1,439	143	103	4,257	559	13	1,449	5,101	930	29	842	4,780	812	37
2011	545	2,126	347	290	555	1,050	40	1,895	226	935	38	1,801	474	1,114	64
2012	1,002	327	527	3,946	505	99	59	10,067	1,070	159	216	6,416	829	217	139
2013	4,469	508	102	498	2,592	117	19	1,754	2,888	107	22	1,317	2,759	186	18
2014	818	936	48	10,157	483	268	17	24,896	537	149	0	10,238	480	253	13
2015	6,638	570	130	1,415	4,320	60	15	10,208	6,568	118	0	3,511	3,911	191	47
2016	2,404	909	41	7,199	1,710	314	4	14,830	1,696	290	0	8,965	1,386	279	14
2017	4,332	421	173	1,280	5,061	134	38	7,478	1,906	77	2	4,235	2,502	158	25
2018	1,139	850	147	5,096	586	144	12	20,632	674	246	3	6,115	578	201	7
2019	3,892	303	55	4,286	1,308	68	8	17,856	3,888	86	3	6,464	2,204	134	19
2020	6,099	1,124	83	3,126	5,343	227	8	36,298	3,417	530	0	8,463	3,858	612	10
2021	3,823	1,535	165	428	2,868	544	12	13,785	2,870	402	3				

[1]International Bottom Trawl Survey (IBTS), 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 and 2020 (see documentation on ICES DATRAS). The revised Q1 and Q3 IBTS survey indices introduced in 2020 are given, and used in the assessment. [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 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 2016-2021 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	2007-2015 ASSESSMENTS	2016-2021 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2021)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2021)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	3+ (SESAM) (1984-2021)
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	1984-2021
	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	1992-2021
	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	1998-2021
	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	1991-2020
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

Table 12.3.2. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal stochastic assessment model. Settings and tuning fleets.

SURVIVORS ANALYSIS OF: Norway pout stock in September 2021

Run: September 2021 (NP_Sep2021_v1, www.stockassessment.org)

The following parameters were used:

Year range:	1984–2021
Seasons per year:	4
The last season in the last year is season:	3
Youngest age:	0
Oldest age:	2
Plus age:	3
Recruitment in season:	3
Spawning in season:	1

The following tuning fleets were included:

Fleet 2:	ibtsq1	(Age 1-3)
Fleet 3:	egfsq3	(Age 0-1)
Fleet 4:	sgfsq3	(Age 0-1)
Fleet 5:	ibtsq3	(Age 2-3)

Table 12.3.3. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated stock numbers in start of quarterly and yearly season.

Time\Age	0	1	2	3
1984	0	44188	9551	569
1984.25	0	30114	5185	325
1984.5	39017	20919	3056	190
1984.75	0	11984	1325	111
1985	0	21204	5901	565
1985.25	0	14404	2816	313
1985.5	28466	10213	1605	184
1985.75	0	6088	673	106
1986	0	15126	3058	305
1986.25	0	10317	1578	174
1986.5	47858	7459	961	106
1986.75	0	4726	475	64
1987	0	27472	2577	252
1987.25	0	19804	1354	144
1987.5	10064	14681	825	88
1987.75	0	9843	427	54
1988	0	5166	5573	209

Time\Age	0	1	2	3
1988.25	0	3907	3284	119
1988.5	44522	3055	2195	72
1988.75	0	2239	1318	44
1989	0	24582	1435	712
1989.25	0	17833	918	443
1989.5	46754	13040	605	280
1989.75	0	8777	347	179
1990	0	25231	5354	305
1990.25	0	18493	3138	186
1990.5	59141	13356	1876	114
1990.75	0	9182	1063	72
1991	0	32355	5897	618
1991.25	0	23444	3459	361
1991.5	100538	17387	2131	215
1991.75	0	12145	1200	135
1992	0	55862	8110	734
1992.25	0	40176	5039	480
1992.5	52895	29248	3340	320
1992.75	0	19444	1989	201
1993	0	28519	12289	1300
1993.25	0	19920	7017	812
1993.5	46475	13980	4199	513
1993.75	0	8875	2182	315
1994	0	24460	5429	1283
1994.25	0	17144	3270	764
1994.5	130771	12247	2046	462
1994.75	0	8366	1187	285
1995	0	73020	5582	898
1995.25	0	53711	3529	598
1995.5	51186	39295	2268	400
1995.75	0	26886	1361	254
1996	0	26202	17804	1013
1996.25	0	19429	11086	645
1996.5	110818	14284	7188	411
1996.75	0	10103	4357	258
1997	0	62385	7130	2895
1997.25	0	45675	4569	1845
1997.5	21685	35240	2989	1176
1997.75	0	25099	1769	747
1998	0	12054	17633	1541

Time\Age	0	1	2	3
1998.25	0	9002	11089	951
1998.5	40118	6653	7072	586
1998.75	0	4929	4304	373
1999	0	23403	3528	2890
1999.25	0	17870	2382	1840
1999.5	93621	13568	1568	1163
1999.75	0	10031	936	729
2000	0	54953	7225	987
2000.25	0	41996	4915	617
2000.5	25528	32662	3327	383
2000.75	0	23399	2112	245
2001	0	13727	15437	1416
2001.25	0	9899	9652	907
2001.5	24942	7133	6113	578
2001.75	0	5135	3993	369
2002	0	14419	3495	2647
2002.25	0	10712	2212	1636
2002.5	20313	7742	1447	1019
2002.75	0	5291	898	643
2003	0	10454	3391	900
2003.25	0	7258	2150	547
2003.5	8135	5035	1368	332
2003.75	0	3408	806	209
2004	0	4473	2295	562
2004.25	0	3213	1504	357
2004.5	7770	2414	1001	227
2004.75	0	1683	618	144
2005	0	4356	1120	447
2005.25	0	3214	770	297
2005.5	31020	2392	528	197
2005.75	0	1812	358	128
2006	0	17549	1403	322
2006.25	0	12893	996	212
2006.5	21885	9605	689	138
2006.75	0	7086	439	88
2007	0	12231	4661	306
2007.25	0	9019	3047	209
2007.5	32311	6590	1982	143
2007.75	0	4835	1288	93
2008	0	18520	3678	928

Time\Age	0	1	2	3
2008.25	0	14107	2558	604
2008.5	47789	10709	1740	393
2008.75	0	8214	1132	248
2009	0	29994	6074	897
2009.25	0	22920	4110	565
2009.5	69441	17865	2743	353
2009.75	0	13615	1687	225
2010	0	41196	10503	1221
2010.25	0	32529	7845	789
2010.5	6277	24457	5448	505
2010.75	0	17354	3528	321
2011	0	3605	12074	2460
2011.25	0	2696	7747	1550
2011.5	10754	2096	5234	983
2011.75	0	1577	3457	627
2012	0	6207	1185	2744
2012.25	0	4713	820	1824
2012.5	54216	3659	577	1212
2012.75	0	2875	396	795
2013	0	31116	2074	767
2013.25	0	23576	1472	493
2013.5	16320	17016	1012	314
2013.75	0	11777	638	200
2014	0	8977	7474	479
2014.25	0	6582	4701	302
2014.5	91604	4820	2923	189
2014.75	0	3534	1729	118
2015	0	49588	2397	1053
2015.25	0	35005	1562	675
2015.5	34277	24310	1003	429
2015.75	0	15672	569	267
2016	0	18276	9676	476
2016.25	0	12723	6130	302
2016.5	58513	8595	3772	189
2016.75	0	5405	2174	117
2017	0	31216	3226	1273
2017.25	0	21436	2080	806
2017.5	20336	14673	1328	504
2017.75	0	9522	781	317
2018	0	10376	5892	637

Time\Age	0	1	2	3
2018.25	0	7451	3651	387
2018.5	73952	5250	2198	231
2018.75	0	3741	1263	142
2019	0	39963	2511	748
2019.25	0	29127	1732	473
2019.5	102408	20807	1099	291
2019.75	0	14753	657	181
2020	0	57797	9782	496
2020.25	0	42413	6365	317
2020.5	56504	31111	3963	198
2020.75	0	22253	2346	126
2021	0	29418	14795	1397
2021.25	0	22280	9755	898
2021.5	24117	16612	6187	565
2021.75	0	12057	3871	358

Table 12.3.4. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated fishing mortalities by quarter of year. (The last 2021 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	0.365	1.019	0.434
1984.25	0.000	0.252	0.625	0.307
1984.5	0.009	0.995	1.792	0.329
1984.75	0.176	1.599	2.333	0.060
1985	0.001	0.404	1.130	0.481
1985.25	0.000	0.195	0.482	0.237
1985.5	0.009	0.916	1.651	0.303
1985.75	0.170	1.542	2.251	0.058
1986	0.001	0.358	1.000	0.426
1986.25	0.000	0.147	0.365	0.180
1986.5	0.006	0.657	1.183	0.217
1986.75	0.132	1.203	1.755	0.045
1987	0.000	0.311	0.869	0.370
1987.25	0.000	0.125	0.308	0.152
1987.5	0.005	0.522	0.941	0.173
1987.75	0.132	1.203	1.755	0.045
1988	0.000	0.247	0.689	0.293
1988.25	0.000	0.113	0.280	0.138
1988.5	0.004	0.407	0.733	0.134
1988.75	0.098	0.895	1.305	0.034
1989	0.000	0.201	0.561	0.239

Year\Age	0	1	2	3+
1989.25	0.000	0.153	0.378	0.186
1989.5	0.004	0.450	0.811	0.149
1989.75	0.091	0.823	1.201	0.031
1990	0.000	0.223	0.622	0.265
1990.25	0.000	0.191	0.472	0.232
1990.5	0.004	0.402	0.724	0.133
1990.75	0.075	0.681	0.994	0.026
1991	0.000	0.233	0.650	0.277
1991.25	0.000	0.169	0.419	0.206
1991.5	0.004	0.405	0.729	0.134
1991.75	0.069	0.624	0.911	0.023
1992	0.000	0.216	0.604	0.257
1992.25	0.000	0.149	0.369	0.182
1992.5	0.004	0.411	0.740	0.136
1992.75	0.065	0.595	0.868	0.022
1993	0.000	0.193	0.539	0.230
1993.25	0.000	0.145	0.358	0.176
1993.5	0.004	0.448	0.806	0.148
1993.75	0.066	0.599	0.874	0.023
1994	0.000	0.180	0.502	0.214
1994.25	0.000	0.128	0.316	0.156
1994.5	0.004	0.406	0.732	0.134
1994.75	0.051	0.462	0.674	0.017
1995	0.000	0.131	0.366	0.156
1995.25	0.000	0.109	0.270	0.133
1995.5	0.003	0.309	0.556	0.102
1995.75	0.044	0.396	0.577	0.015
1996	0.000	0.100	0.278	0.118
1996.25	0.000	0.081	0.200	0.098
1996.5	0.003	0.334	0.602	0.110
1996.75	0.040	0.359	0.524	0.014
1997	0.000	0.081	0.226	0.096
1997.25	0.000	0.062	0.154	0.076
1997.5	0.003	0.323	0.582	0.107
1997.75	0.042	0.381	0.557	0.014
1998	0.000	0.074	0.206	0.088
1998.25	0.000	0.071	0.175	0.086
1998.5	0.003	0.274	0.493	0.090
1998.75	0.042	0.379	0.554	0.014
1999	0.000	0.063	0.175	0.075

Year\Age	0	1	2	3+
1999.25	0.000	0.074	0.184	0.091
1999.5	0.003	0.273	0.492	0.090
1999.75	0.046	0.421	0.614	0.016
2000	0.000	0.059	0.165	0.070
2000.25	0.000	0.062	0.154	0.076
2000.5	0.002	0.209	0.377	0.069
2000.75	0.051	0.462	0.675	0.017
2001	0.000	0.064	0.179	0.076
2001.25	0.000	0.056	0.138	0.068
2001.5	0.001	0.154	0.277	0.051
2001.75	0.048	0.435	0.635	0.016
2002	0.000	0.060	0.169	0.072
2002.25	0.000	0.047	0.115	0.057
2002.5	0.002	0.227	0.408	0.075
2002.75	0.055	0.496	0.725	0.019
2003	0.000	0.045	0.126	0.054
2003.25	0.000	0.037	0.091	0.045
2003.5	0.002	0.217	0.392	0.072
2003.75	0.046	0.415	0.606	0.016
2004	0.000	0.038	0.106	0.045
2004.25	0.000	0.025	0.063	0.031
2004.5	0.002	0.189	0.340	0.062
2004.75	0.045	0.413	0.603	0.016
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	0.020	0.080	0.029
2006.25	0.000	0.042	0.126	0.061
2006.5	0.001	0.119	0.297	0.059
2006.75	0.038	0.544	0.841	0.018
2007	0.000	0.003	0.012	0.004
2007.25	0.000	0.017	0.048	0.022
2007.5	0.000	0.040	0.104	0.020
2007.75	0.002	0.038	0.060	0.001
2008	0.000	0.002	0.007	0.002
2008.25	0.000	0.018	0.050	0.023
2008.5	0.000	0.058	0.151	0.029
2008.75	0.004	0.066	0.103	0.002
2009	0.000	0.001	0.004	0.001

Year\Age	0	1	2	3+
2009.25	0.000	0.018	0.050	0.023
2009.5	0.000	0.095	0.245	0.048
2009.75	0.004	0.080	0.125	0.002
2010	0.000	0.001	0.003	0.001
2010.25	0.000	0.021	0.059	0.027
2010.5	0.000	0.090	0.233	0.045
2010.75	0.006	0.116	0.182	0.003
2011	0.000	0.001	0.003	0.001
2011.25	0.000	0.010	0.029	0.013
2011.5	0.000	0.063	0.163	0.032
2011.75	0.008	0.147	0.231	0.004
2012	0.000	0.001	0.003	0.001
2012.25	0.000	0.013	0.035	0.016
2012.5	0.000	0.057	0.147	0.029
2012.75	0.018	0.324	0.507	0.009
2013	0.000	0.001	0.004	0.001
2013.25	0.000	0.024	0.067	0.030
2013.5	0.000	0.115	0.296	0.058
2013.75	0.024	0.442	0.693	0.012
2014	0.000	0.002	0.008	0.003
2014.25	0.000	0.028	0.078	0.035
2014.5	0.001	0.156	0.403	0.078
2014.75	0.022	0.407	0.638	0.011
2015	0.000	0.003	0.010	0.003
2015.25	0.000	0.035	0.098	0.045
2015.5	0.001	0.195	0.505	0.098
2015.75	0.022	0.404	0.632	0.011
2016	0.000	0.003	0.011	0.004
2016.25	0.000	0.045	0.125	0.057
2016.5	0.001	0.206	0.532	0.103
2016.75	0.023	0.432	0.677	0.012
2017	0.000	0.002	0.009	0.003
2017.25	0.000	0.046	0.128	0.058
2017.5	0.001	0.192	0.495	0.096
2017.75	0.023	0.434	0.681	0.012
2018	0.000	0.003	0.011	0.004
2018.25	0.000	0.060	0.166	0.075
2018.5	0.001	0.183	0.473	0.092
2018.75	0.024	0.452	0.708	0.013
2019	0.000	0.005	0.017	0.006

Year\Age	0	1	2	3+
2019.25	0.000	0.077	0.213	0.097
2019.5	0.001	0.189	0.489	0.095
2019.75	0.023	0.425	0.666	0.012
2020	0.000	0.006	0.024	0.008
2020.25	0.000	0.070	0.194	0.088
2020.5	0.001	0.163	0.421	0.082
2020.75	0.023	0.434	0.680	0.012
2021	0.000	0.004	0.017	0.005
2021.25	0.000	0.068	0.190	0.086
2021.5	0.000	0.122	0.316	0.061
2021.75	0.023	0.434	0.680	0.012

Table 12.3.5. Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Estimated catchabilities by survey tuning fleet.

Index	Fleet number	Age	Catchability	Low	High
1	2	1	0.12523	0.07472	0.20991
2	2	2	0.19121	0.10266	0.35612
3	2	3	0.19954	0.07903	0.50381
4	3	0	0.06593	0.03693	0.11771
5	3	1	0.19160	0.10494	0.34980
6	4	0	0.18039	0.09773	0.33298
7	4	1	0.19745	0.10459	0.37274
8	5	2	0.21573	0.10032	0.46394
9	5	3	0.11029	0.04140	0.29382

Table 12.3.5 (cont.). Norway pout 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Likelihood values.

Model	Negative log likelihood	Number of parameters
Base	1278.88	19
Current	1278.88	19

Table 12.3.6. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2021. 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	Re-cruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1984				341090	153397	528782	659244	330431	988058	1.122	0.619	2.034
1984.25				218150	94546	341754	507240	237150	777329			
1984.5	39017	20661	73681	238242	102678	373806	656626	296249	1017003			
1984.75				119321	41919	196724	359016	144705	573327			
1985				208308	82735	333881	360977	173459	548495	1.071	0.575	1.995
1985.25				120615	44444	196787	258891	116834	400948			
1985.5	28466	15033	53902	126324	50288	202360	330584	149455	511713			
1985.75				63547	19825	107268	185312	73141	297483			
1986				115862	44162	187562	224772	101411	348133	0.833	0.457	1.520
1986.25				72903	25146	120659	171944	72088	271800			
1986.5	47858	24932	91862	82091	30574	133607	231283	97253	365313			
1986.75				46323	14286	78361	140842	53332	228351			
1987				123972	52444	195499	321771	141163	502379	0.754	0.407	1.399
1987.25				88568	35172	141964	278688	113919	443456			
1987.5	10064	5084	19923	111714	45830	177598	405338	164916	645760			
1987.75				69471	25619	113323	266342	101174	431509			
1988				156974	51514	262434	194171	76878	311464	0.584	0.328	1.040
1988.25				97424	27126	167721	134933	50660	219207			
1988.5	44522	23169	85557	107405	28504	186306	168509	64878	272140			
1988.75				66463	12620	120306	111254	37426	185081			
1989				108594	41082	176106	285582	118959	452205	0.572	0.320	1.021
1989.25				87887	30728	145046	259081	103578	414585			
1989.5	46754	24259	90109	106169	39384	172954	366975	145751	588199			
1989.75				68153	22692	113614	243701	91303	396100			
1990				191468	78023	304912	373133	169365	576901	0.539	0.298	0.972
1990.25				132153	50639	213667	309682	132190	487175			
1990.5	59141	30600	114303	148693	56458	240927	415817	171403	660231			
1990.75				92581	30951	154210	276233	106045	446422			
1991				230364	94073	366656	463322	206377	720267	0.518	0.283	0.947
1991.25				160803	61337	260269	385866	161384	610349			
1991.5	100538	51661	195655	185040	70698	299382	532791	216613	848968			
1991.75				116557	39240	193874	359462	136042	582882			
1992				332650	136250	529050	734859	315121	1154598	0.494	0.265	0.921
1992.25				246389	91930	400847	632082	252332	1011832			
1992.5	52895	27398	102119	299007	107879	490135	883968	342521	1425416			
1992.75				188445	56868	320022	577334	203964	950703			
1993				410538	138319	682757	615875	245516	986233	0.495	0.246	0.997
1993.25				263849	79225	448474	455079	172124	738035			
1993.5	46475	23847	90576	268653	80848	456458	548261	209650	886871			

Time	Re-cruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1993.75				149961	34593	265329	327470	109913	545027			
1994				231058	75555	386561	407173	158265	656081	0.425	0.214	0.846
1994.25				161093	46565	275621	325680	118704	532655			
1994.5	130771	66229	258211	170757	51442	290071	415707	152487	678928			
1994.75				105843	24933	186753	273176	86981	459370			
1995				306894	112188	501600	832638	311052	1354224	0.339	0.169	0.681
1995.25				247048	83657	410438	762673	268467	1256879			
1995.5	51186	25742	101780	311212	104522	517903	1097109	378527	1815692			
1995.75				203649	59546	347752	741371	232252	1250491			
1996				532779	161262	904295	721433	259723	1183144	0.310	0.152	0.631
1996.25				356025	97890	614160	542548	187688	897407			
1996.5	110818	55059	223048	383641	100989	666292	669326	230042	1108611			
1996.75				239751	42862	436639	441824	124474	759174			
1997				406354	119317	693390	855523	294090	1416956	0.296	0.143	0.613
1997.25				316093	86770	545416	754577	250349	1258805			
1997.5	21685	10743	43771	366332	107956	624708	1071129	352848	1789410			
1997.75				239560	57900	421220	741544	211178	1271911			
1998				524151	131725	916578	610941	178978	1042904	0.278	0.134	0.579
1998.25				346371	79872	612871	432788	124174	741403			
1998.5	40118	20325	79187	351275	77480	625071	484332	142582	826082			
1998.75				218420	31952	404889	317004	75217	558791			
1999				245926	54944	436908	414428	128785	700070	0.287	0.136	0.605
1999.25				194439	39309	349568	365995	111177	620813			
1999.5	93621	46981	186562	200320	46843	353798	471689	151493	791886			
1999.75				129861	25532	234189	330490	93350	567629			
2000				319013	98493	539533	714677	247553	1181801	0.271	0.125	0.585
2000.25				254493	75286	433699	657649	217937	1097362			
2000.5	25528	12704	51297	319357	93954	544760	972598	310116	1635079			
2000.75				215662	54096	377229	683651	194375	1172927			
2001				467279	112433	822125	566116	160840	971392	0.242	0.109	0.541
2001.25				310387	67493	553280	405417	111991	698842			
2001.5	24942	12398	50177	314880	66413	563346	457539	130672	784405			
2001.75				206795	32134	381455	309500	75615	543385			
2002				219195	41387	397002	323013	85439	560586	0.281	0.121	0.655
2002.25				162794	27062	298526	265625	68558	462692			
2002.5	20313	9738	42372	157738	31331	284146	312585	90370	534800			
2002.75				99645	15632	183658	205467	52903	358032			
2003				139588	32913	246263	214860	63490	366230	0.241	0.099	0.586
2003.25				98501	22060	174943	168180	49851	286509			
2003.5	8135	3950	16753	99774	24406	175142	200474	63554	337395			
2003.75				61409	12017	110802	129575	36120	223029			

Time	Re-cruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2004				87920	20811	155028	120126	34453	205799	0.222	0.086	0.571
2004.25				63157	13564	112750	93999	26112	161885			
2004.5	7770	3795	15909	65718	14680	116756	114000	33088	194912			
2004.75				41482	7104	75861	75145	18716	131575			
2005				53707	11386	96027	85069	23720	146418	0.001	0.000	0.001
2005.25				41836	8301	75370	72691	20056	125326			
2005.5	31020	15090	63767	44896	9780	80012	92742	27073	158411			
2005.75				30829	6534	55125	67081	19100	115062			
2006				79538	27190	131887	205891	68536	343247	0.259	0.092	0.729
2006.25				66448	21553	111343	190223	61204	319242			
2006.5	21885	10552	45389	83837	26302	141372	275948	86082	465814			
2006.75				58100	16068	100132	199832	55715	343948			
2007				150767	34258	267275	238829	68518	409140	0.040	0.016	0.102
2007.25				108268	24261	192274	194848	55538	334158			
2007.5	32311	15626	66812	120810	26958	214662	252622	71468	433775			
2007.75				81052	15832	146272	177763	45882	309643			
2008				162413	44972	279855	295756	92704	498808	0.057	0.024	0.134
2008.25				127998	33361	222634	263429	78504	448353			
2008.5	47789	22953	99501	146718	37441	255995	360902	103381	618424			
2008.75				100736	22440	179032	265023	66497	463550			
2009				241705	66431	416979	457662	142617	772708	0.077	0.033	0.183
2009.25				185994	50466	321522	406028	123558	688497			
2009.5	69441	33605	143495	220213	59443	380984	577519	170082	984957			
2009.75				148609	34877	262341	420907	109084	732730			
2010				385568	104878	666259	682177	212812	1151543	0.088	0.038	0.206
2010.25				313663	77008	550317	625938	179713	1072162			
2010.5	6277	2999	13140	370479	86139	654819	859626	236417	1482835			
2010.75				246501	47069	445933	593596	145975	1041218			
2011				406748	91577	721919	432705	103920	761490	0.081	0.033	0.197
2011.25				277634	58804	496465	303513	70796	536229			
2011.5	10754	5238	22080	278811	54800	502822	320743	73536	567950			
2011.75				182526	27536	337517	214067	40940	387194			
2012				150572	23781	277363	195261	43554	346968	0.136	0.054	0.340
2012.25				123004	15999	230009	168252	35814	300690			
2012.5	54216	26351	111544	114114	16394	211834	187291	45534	329048			
2012.75				76284	9338	143229	133796	30167	237425			
2013				138551	38345	238757	362588	109191	615986	0.205	0.077	0.546
2013.25				118031	31984	204078	344362	100346	588378			
2013.5	16320	7982	33370	144382	41187	247577	484702	145307	824096			
2013.75				96025	25300	166749	331569	94708	568429			
2014				222184	54321	390047	286816	83928	489705	0.215	0.082	0.564

Time	Re-cruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2014.25				148437	37180	259693	211628	65020	358236			
2014.5	91604	42785	196126	152364	38683	266045	248776	79086	418466			
2014.75				93663	17919	169407	164348	44413	284283			
2015				191311	52461	330160	548343	155335	941350	0.235	0.086	0.641
2015.25				156790	44163	269417	492833	144412	841255			
2015.5	34277	15888	73950	187441	56249	318632	673652	206606	1140698			
2015.75				116577	31283	201871	430029	124086	735972			
2016				293830	76183	511478	425418	129199	721637	0.254	0.092	0.702
2016.25				198898	52594	345202	321035	101164	540907			
2016.5	58513	27060	126526	205205	54059	356350	377107	121593	632620			
2016.75				120767	21423	220111	228864	61359	396369			
2017				187741	46859	328622	412498	118920	706076	0.249	0.092	0.674
2017.25				143716	36511	250920	349504	104886	594122			
2017.5	20336	9782	42275	156745	43401	270089	450216	140820	759612			
2017.75				97242	22173	172311	287687	82019	493356			
2018				191474	46740	336207	266185	80195	452174	0.257	0.098	0.677
2018.25				128521	32343	224700	200047	63543	336551			
2018.5	73952	36193	151104	128035	32308	223761	233047	75998	390097			
2018.75				77451	14550	140352	152275	42768	261781			
2019				164637	49385	279889	452368	146921	757815	0.260	0.103	0.657
2019.25				136844	41669	232019	416463	135635	697291			
2019.5	102408	50482	207746	165436	51360	279511	581584	188386	974782			
2019.75				110513	29606	191420	405574	117162	693987			
2020				368411	107653	629169	784552	260578	1308525	0.249	0.095	0.651
2020.25				276768	83609	469927	683936	226277	1141594			
2020.5	56504	26467	120630	325954	97457	554451	948180	301918	1594442			
2020.75				212380	52898	371861	657441	180991	1133891			
2021				478690	106983	850397	690500	198572	1182427			
2021.25				342233	73147	611320	556118	158307	953929			
2021.5	24117	8266	70362	364442	69100	659784	696690	185037	1208344			
2021.75				236634	30338	442930	477772	100493	855050			

Table 12.3.6 (cont). Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2021. Long term arithmetic means of yearly recruitment (millions), quarterly spawning stock biomass SSB (t), quarterly total stock biomass TSB (t) and yearly fishing mortality for ages 1-2 (Fbar=F12) for the period 1984–2021. (Numbers are given for start of the season).

Avg. recruitment	46377.47
Avg SSB Q 1	251784.79
Avg SSB Q 2	181426.93
Avg SSB Q 3	200637.41
Avg SSB Q 4	127073.35
Avg TSB Q 1	443085.63
Avg TSB Q 2	367617.51
Avg TSB Q 3	484947.03
Avg TSB Q 4	323771.98
Avg. FBAR	0.35

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	2.656	6.662	4.800	6.242
1	7.339	11.263	21.325	23.415
2	18.337	21.392	29.285	32.246
3	28.392	28.693	35.444	38.649

Table 12.6.2. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year ahead (1st October 2022) equals Blim.

Basis:

Fbar (2021 up to Q4) = estimated from in year assessment 1st October 2021, F(age1-2, quarter4 2020 & quarter1,2,3 2021), Table 12.3.4.

SSB (2021 up to Q4) = estimated from in year assessment 1st October 2021 (start Q4) = 236 634 tonnes;

R(2021) = estimated / observed from in year assessment 1st July 2021 (age 0 in start of Q3) = 24 117 million, Table 12.3.6;

Biological parameters (2021-2022): 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 2021 - Q4 2022): (i) Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years. (ii) Assume that log F_t = log F_{t-4} + log G_t, for all future values of t where G_t is some chosen vector of multipliers of the F-process. If G_t = 1 for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year. (iii) Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution. (iv) Find G_t such that the fifth (or any other) percentile of the catches (total mass) in the projections equals some desired level such as B_{lim} (optional).

	F12	SSB	SSB 5th quantile	median catch
2021.75	1.15	241.44	120.04	83071.50
2022	0.02	293.96	108.74	1311.39
2022.25	0.27	217.31	80.38	13277.37
2022.5	0.45	210.99	75.66	20613.14
2022.75		130.02	42.57	
Sum				118273.40

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 2021 to 1st October 2022.

Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2021.75	0.00	241.44	120.04	0.00
2022	0.00	380.81	188.35	0.00
2022.25	0.00	285.36	135.34	0.00
2022.5	0.00	294.64	133.62	0.00
2022.75		202.99	88.17	
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 2021.

Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2021.75	0.56	241.44	120.04	43290.18
2022	0.01	334.51	144.54	723.53
2022.25	0.13	247.28	104.90	7346.88
2022.5	0.22	247.67	102.12	11832.16
2022.75		161.79	61.82	
Sum				63192.74

Table 12.6.5. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year a head (1st October 2022) equals Blim.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	4.86	241.44	120.04	235370.12
2022	0.10	149.00	30.70	2958.95
2022.25	1.15	110.74	25.35	29728.68
2022.5	1.91	92.19	21.11	40784.11
2022.75		42.57	8.00	
Sum				308841.86

Table 12.6.6. Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that SSB one year a head (1st October 2022) equals Bpa.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	3.04	241.44	120.04	176656.77
2022	0.06	202.91	50.77	2455.18
2022.25	0.72	150.75	39.19	24370.68
2022.5	1.19	134.03	34.82	35250.63
2022.75		70.00	15.35	
Sum				238733.25

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 (Fcap = 0.3) for the period 1st October 2021 to 1st October 2022.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	0.73	241.44	120.04	55566.19
2022	0.01	321.50	132.85	908.62
2022.25	0.17	237.73	96.73	9250.66
2022.5	0.29	235.56	93.66	14747.16
2022.75		151.81	55.82	
Sum				80472.64

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 2021 to 1st October 2022.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	0.98	241.44	120.04	71885.02
2022	0.02	304.43	117.51	1154.09
2022.25	0.23	225.80	86.37	11705.14
2022.5	0.38	220.86	82.69	18386.24
2022.75		138.74	48.08	
Sum				103130.49

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 2021 to 1st October 2022.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	1.22	241.44	120.04	87211.29
2022	0.02	290.28	105.15	1368.41
2022.25	0.29	214.38	78.07	13842.73
2022.5	0.48	207.30	73.70	21477.67
2022.75		126.86	41.10	
Sum				123900.09

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 2021 to 1st October 2022.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	1.47	241.44	120.04	101757.97
2022	0.03	276.24	93.53	1565.14
2022.25	0.35	203.04	70.47	15729.39
2022.5	0.57	194.48	65.83	24270.32
2022.75		116.76	35.00	
Sum				143322.82

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 2021 to 1st October 2022.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2021.75	1.71	241.44	120.04	115496.13
2022	0.03	261.96	83.09	1748.05
2022.25	0.40	193.77	64.18	17538.74
2022.5	0.67	182.15	59.49	26762.37
2022.75		107.55	30.33	
Sum				161545.29

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 with previous to 2020 IBTS Q1 and Q3 survey indices. The estimates are quarterly minima in tonnes estimated at the beginning of the season. The estimates are Bloss estimates which equals Blim according to the ICES WKPOUT 2016 benchmark assessment which by 1st October is Blim=39 450 t.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

Table 12.6.13. Norway pout 4 and 3.aN (Skagerrak). The quarterly minima of the estimated SSB time series (1984-2016) from the SESAM updated Benchmark Assessment Run (Run: NP_Sep17_fixC_Benchmark2016Data_NewIBTS, www.stockassessment.org) with new IBTS Q1 and Q3 survey indices made available in 2020. The estimates are quarterly minima in tonnes estimated at the beginning of the season. The estimates are Bloss estimates which equals Blim according to the assessment run above which by 1st October is Blim=42 573 t.

SSB	Quarter	Year
77586	1	2005
59514	2	2005
62543	3	2005
42573	4	2005

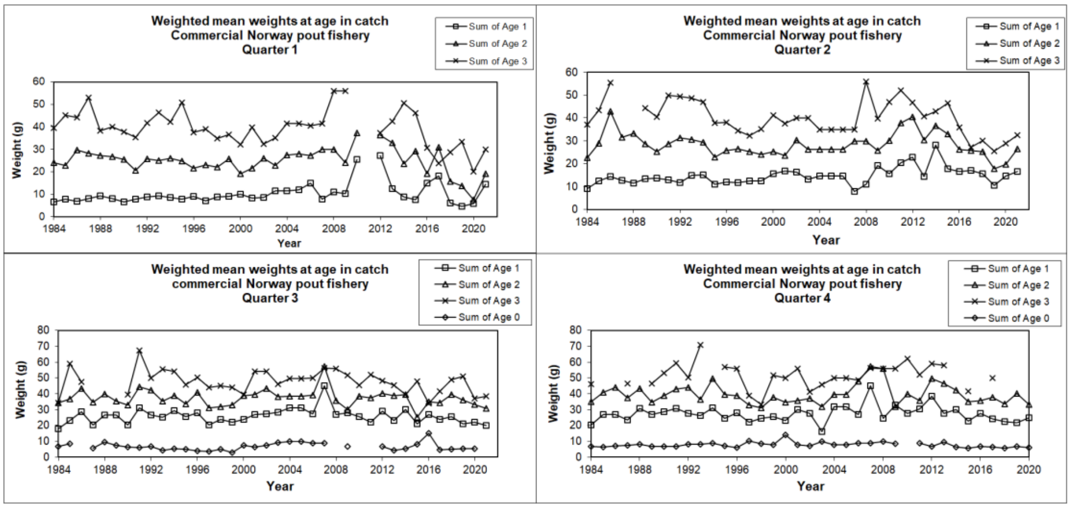


Figure 12.2.1. Norway pout in Subarea 4 and Division 3.a. Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1984–2021.

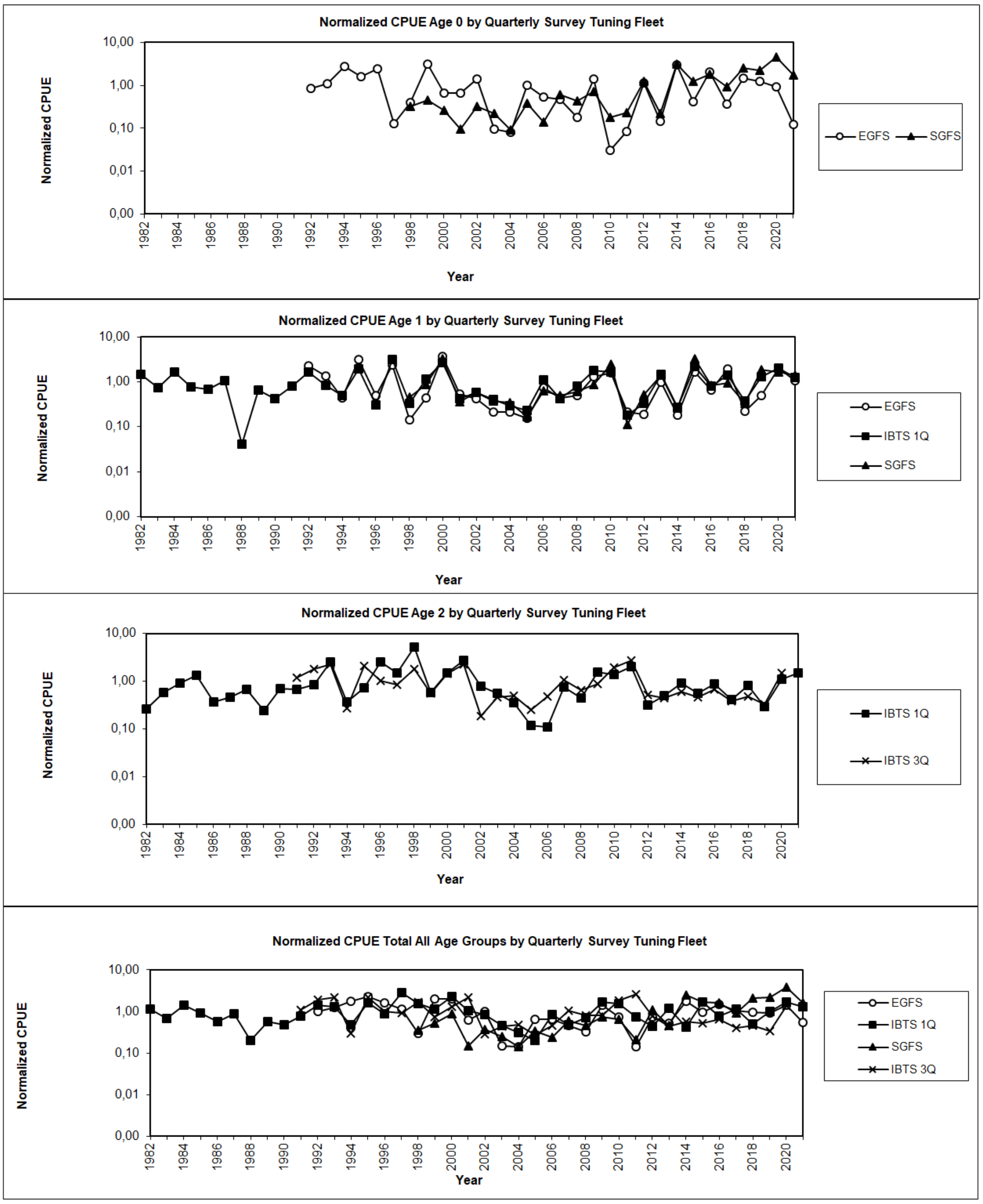


Figure 12.2.2. Norway pout in Subarea 4 and Division 3.a. Trends in CPUE (normalized to unit mean) by quarterly survey tuning fleet used in the Norway pout assessment for each age group and all age groups together.

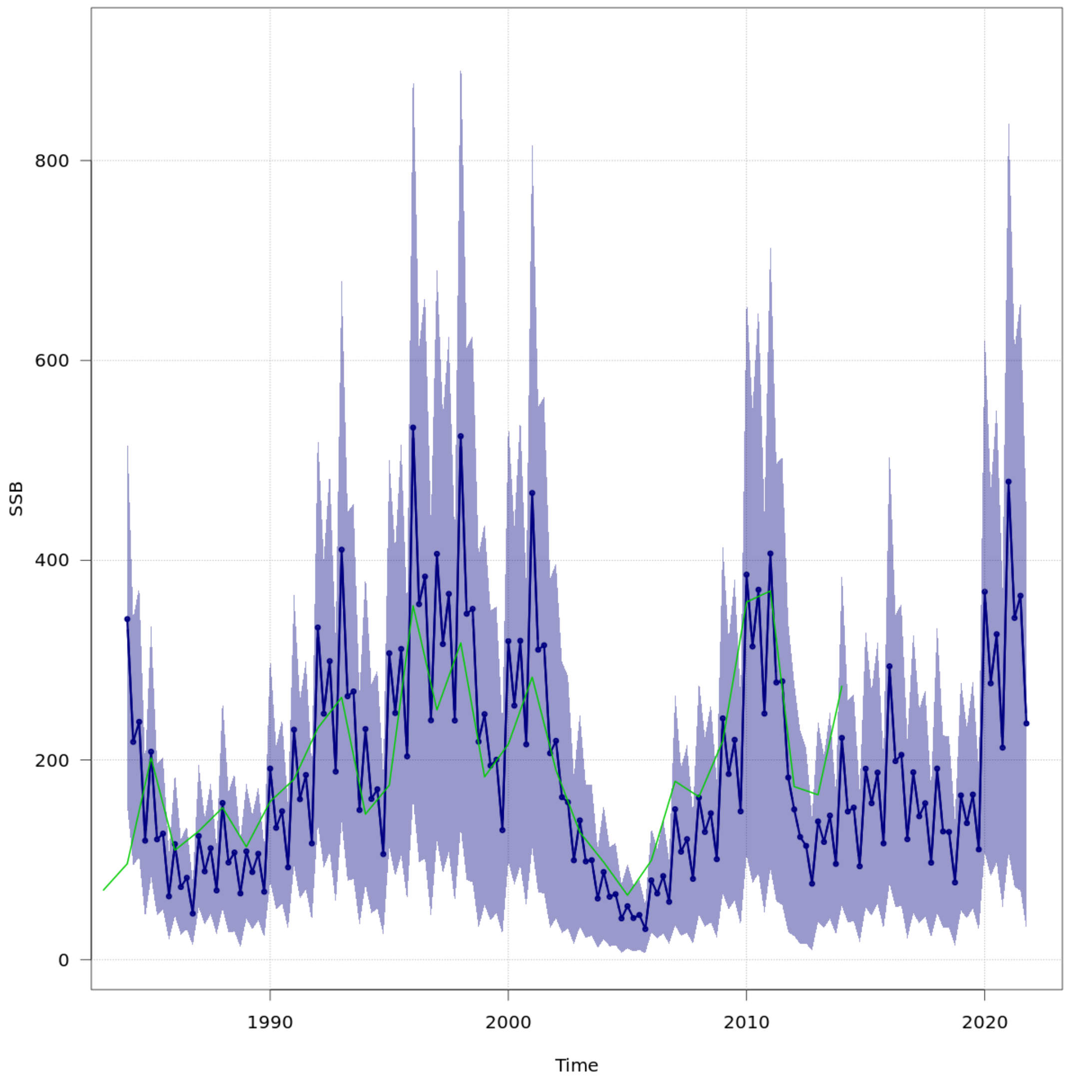


Figure 12.3.1. Norway pout in Subarea 4 and Division 3.a. Stock Summary Plots: SSB (t), quarterly. SESAM baseline run September 2021. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only – connecting lines are interpolations).

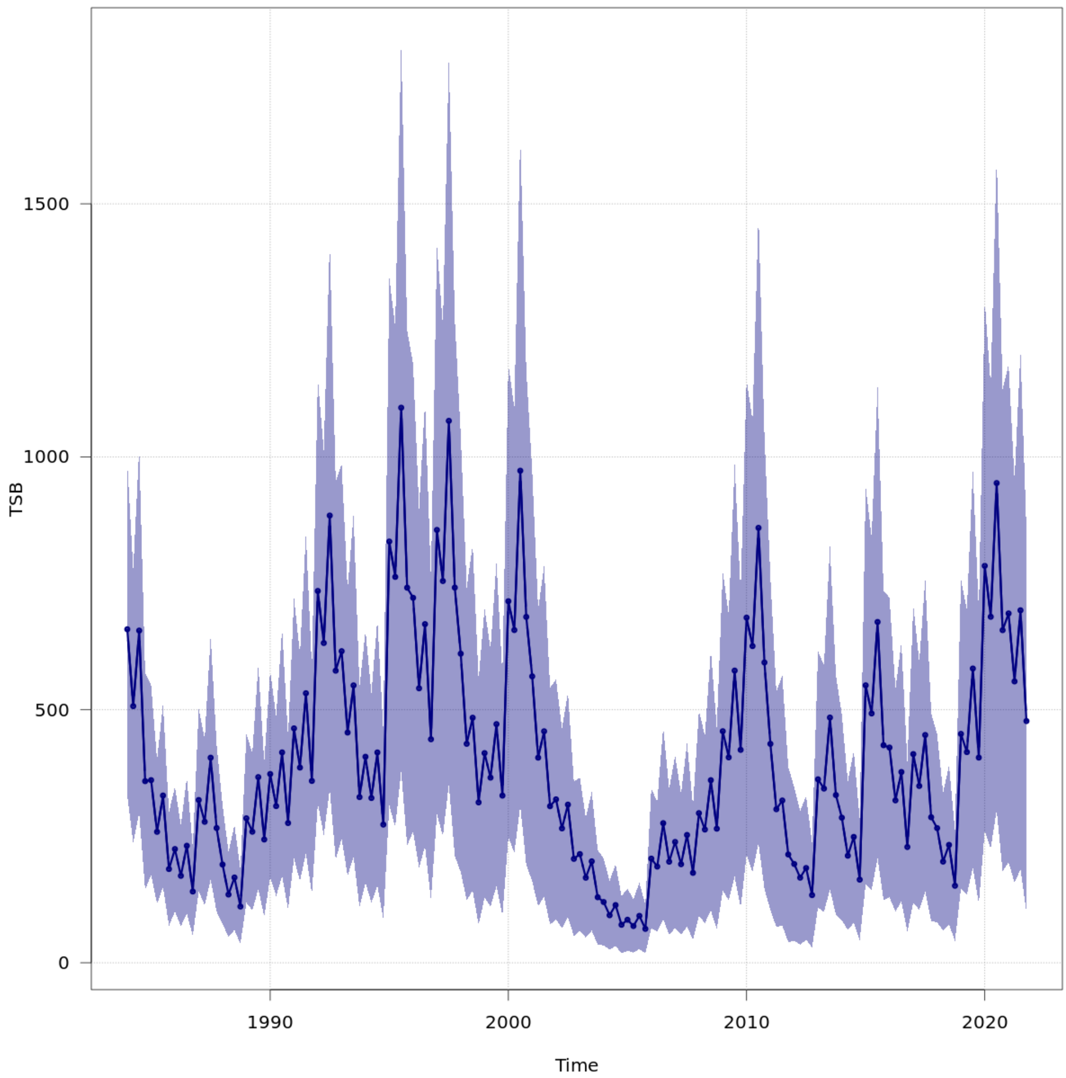


Figure 12.3.2. Norway pout in Subarea 4 and Division 3.a. Stock Summary Plots: TSB (t), quarterly. SESAM baseline run September 2021.

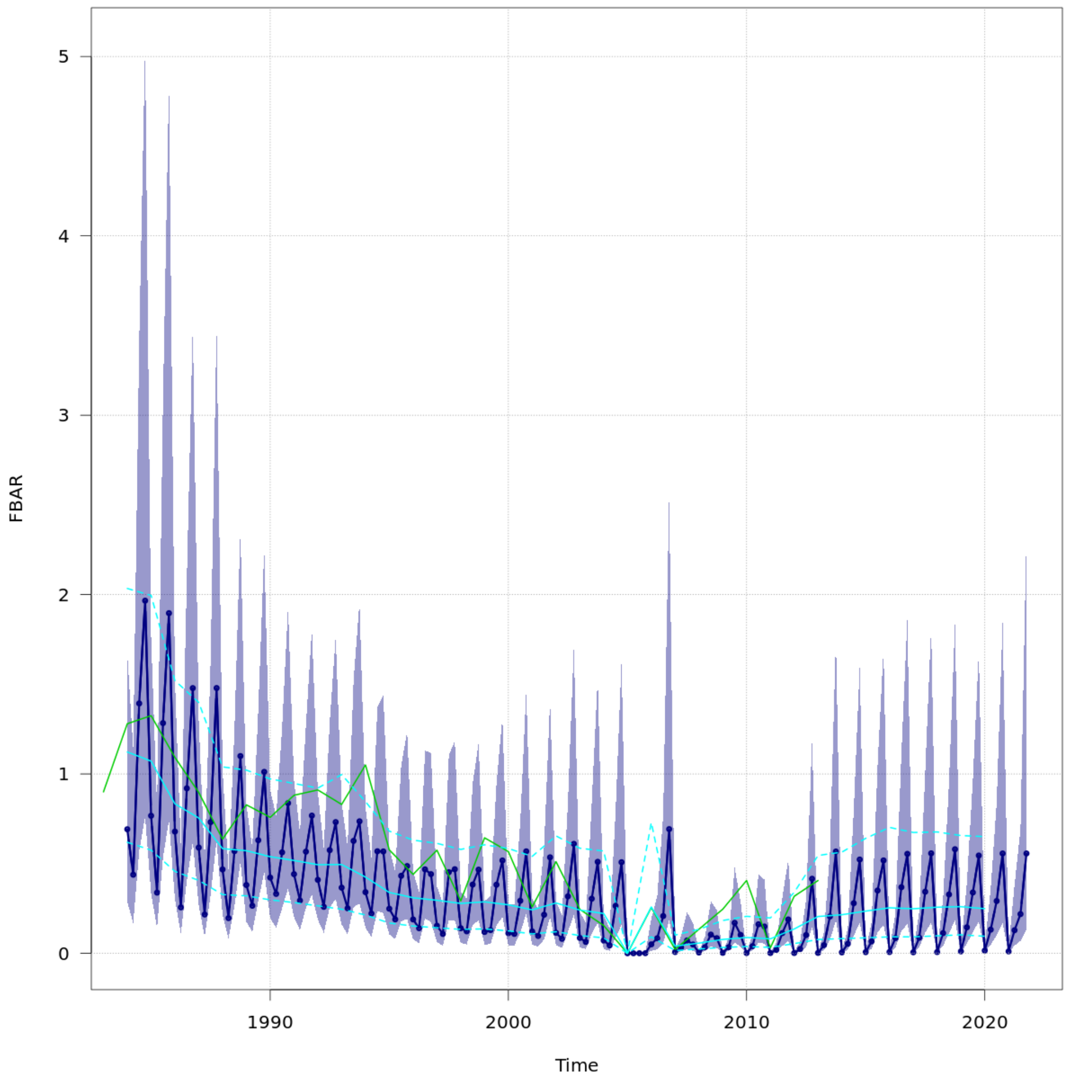


Figure 12.3.3. Norway Pout in Subarea 4 and Division 3.a. Stock Summary Plots: F1-2=Fbar, quarterly. SESAM baseline run September 2021. Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

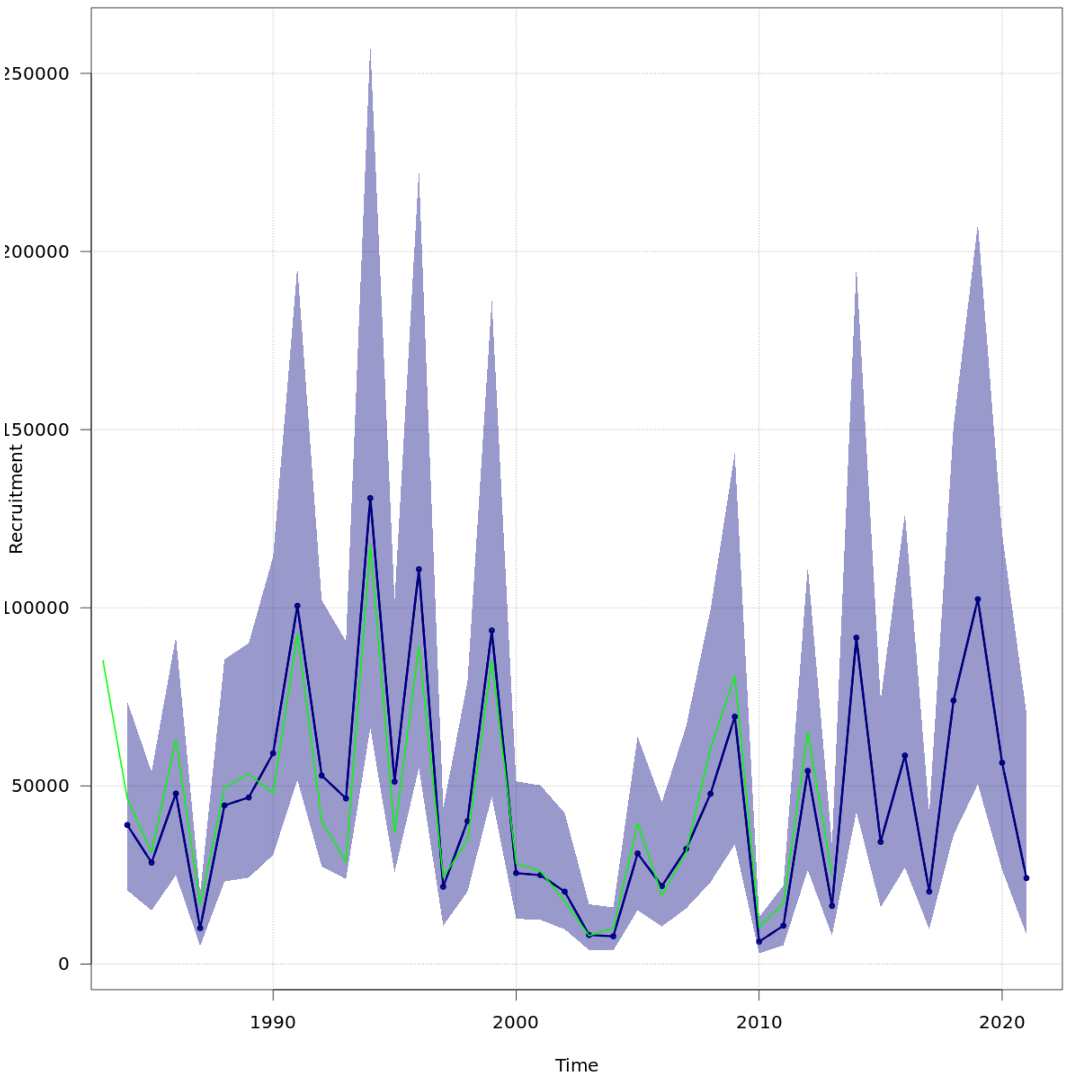


Figure 12.3.4. Norway Pout in Subarea 4 and Division 3a. Stock Summary Plots: Recruitment (millions), yearly. SESAM baseline run September 2021. Blue is SESAM, green is SXSA.

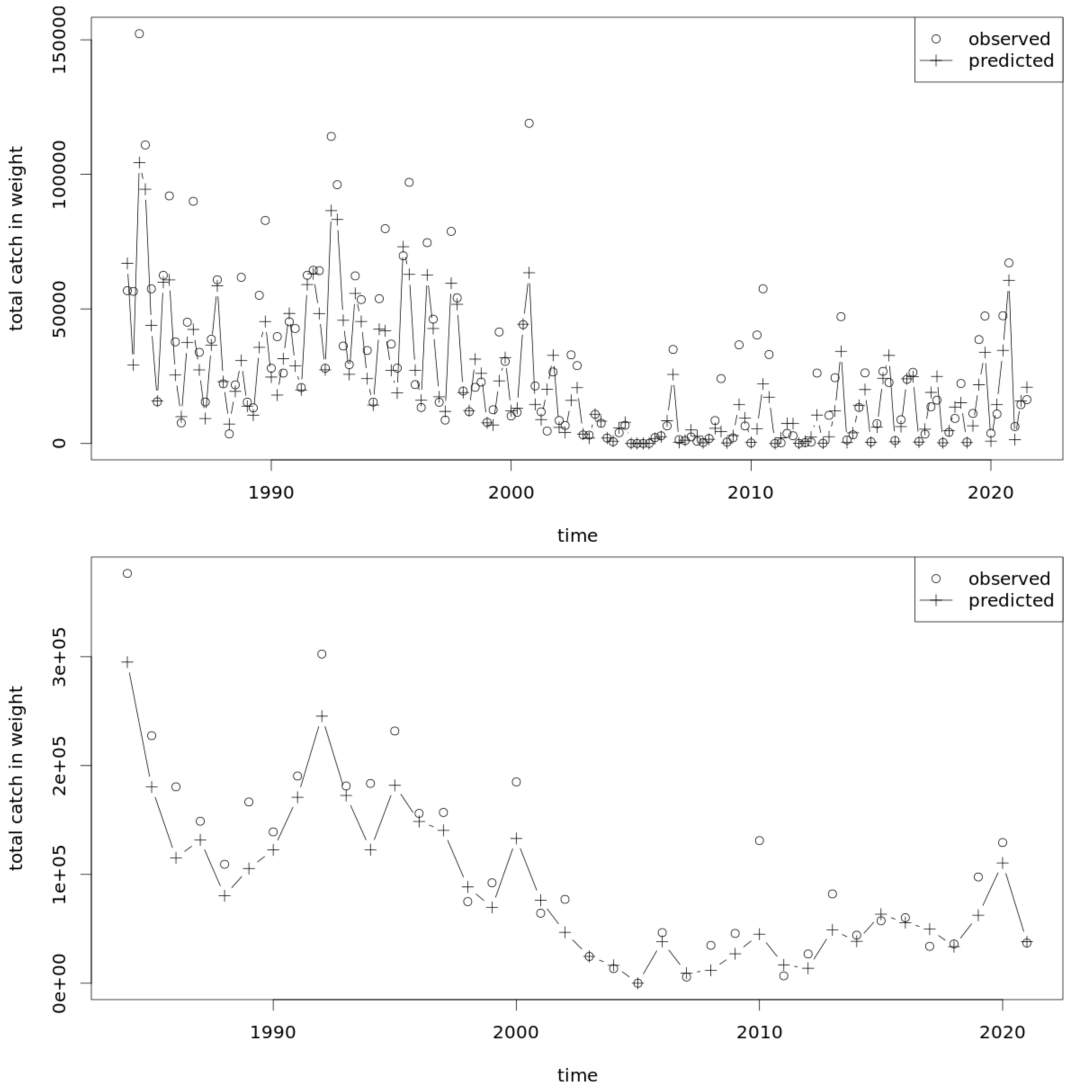


Figure 12.3.5. Norway Pout in Subarea 4 and Division 3.a. Stock Summary Plots: Yield = Total Catch (t), quarterly and yearly. SESAM baseline run September 2021.

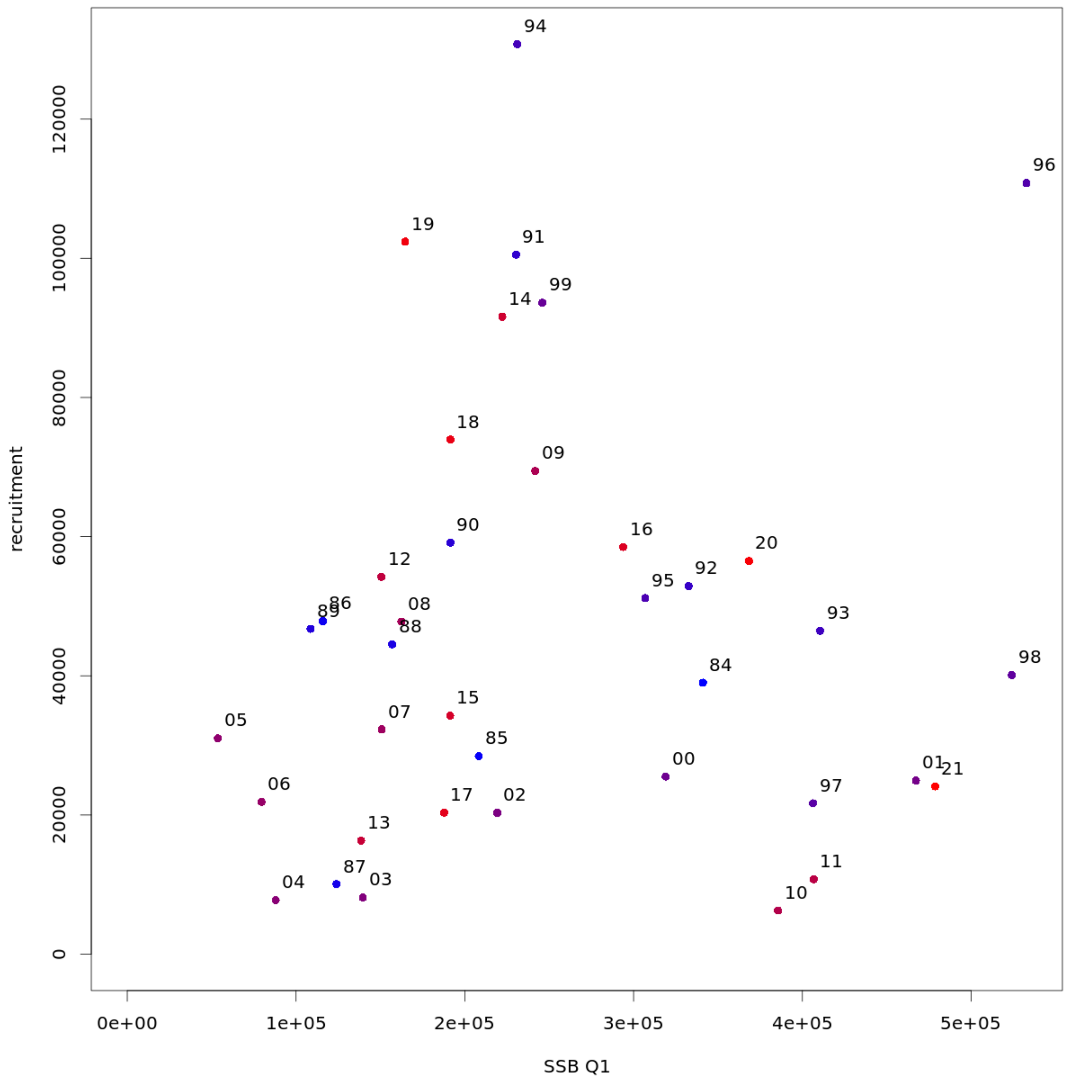


Figure 12.3.6. Norway Pout in Subarea 4 and Division 3.a. Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 1. SESAM baseline run September 2021.

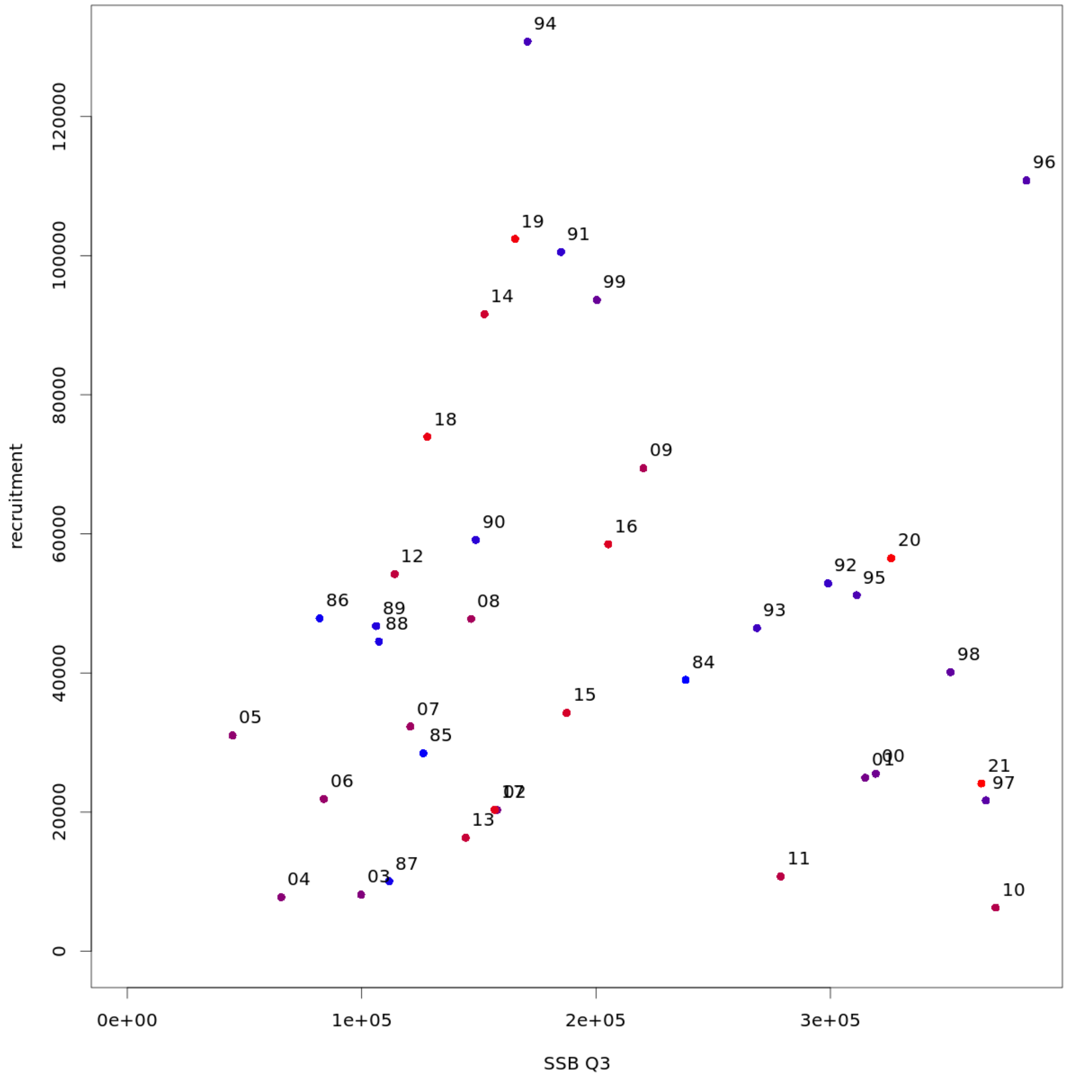


Figure 12.3.7. Norway Pout in Subarea 4 and Division 3.a. Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 3. SESAM baseline run September 2021.

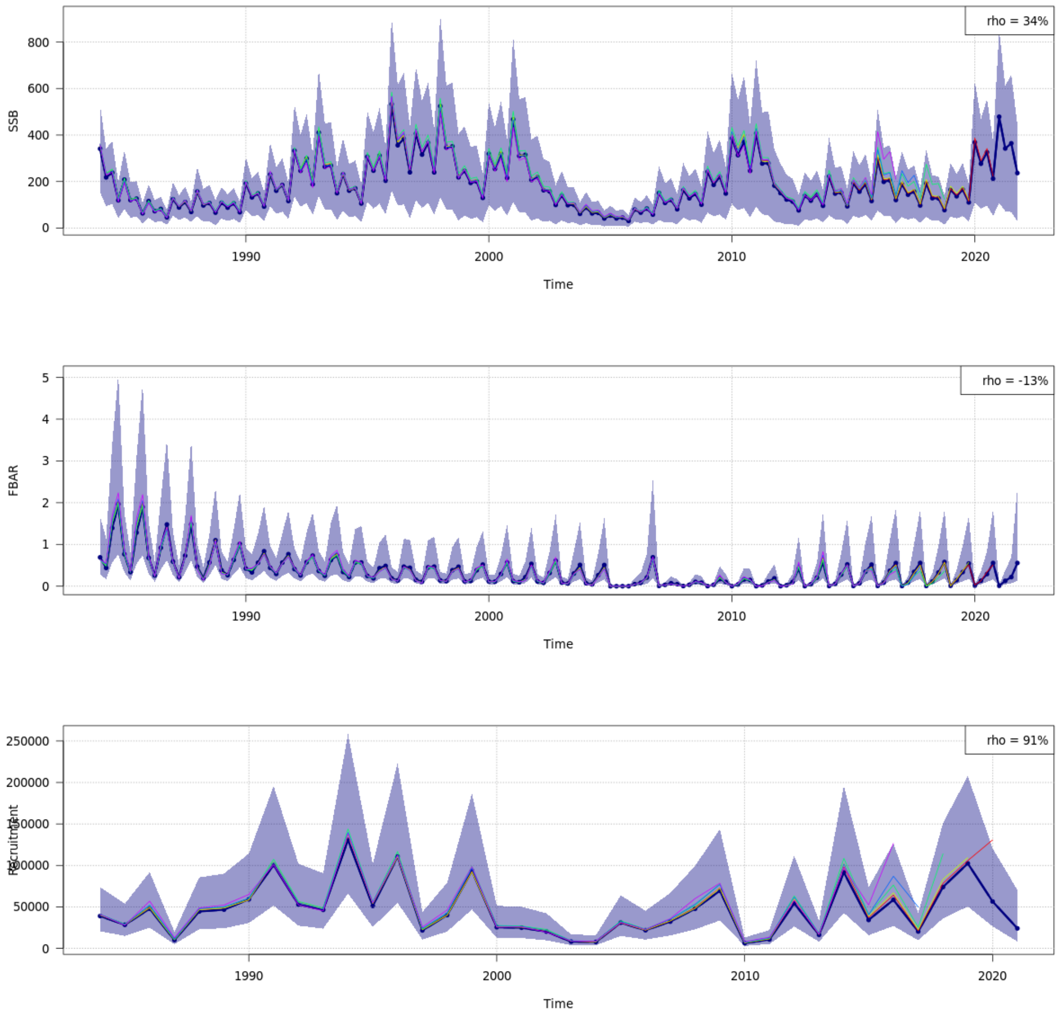


Figure 12.3.8. Norway pout in Subarea 4 and Division 3.a. Retrospective plots of baseline SESAM assessment September 2021, with terminal assessment year ranging from 2016–2021. Represent 5-year retrospective runs.

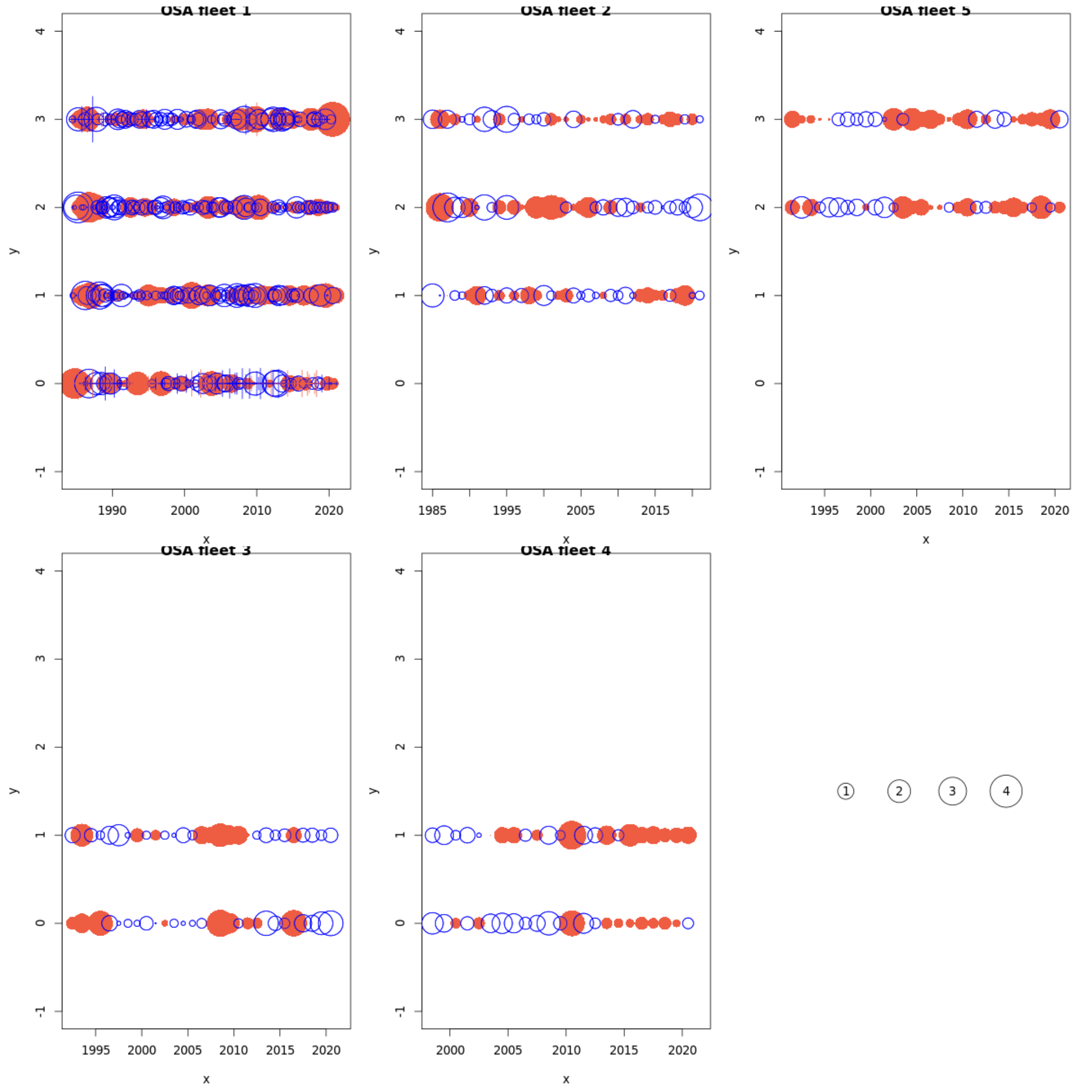


Figure 12.3.9. Norway Pout in Subarea 4 and Division 3.a. Assessment Diagnostics Plots by fleet: One step ahead residuals (see Berg and Nielsen 2016). SESAM baseline run September 2021.

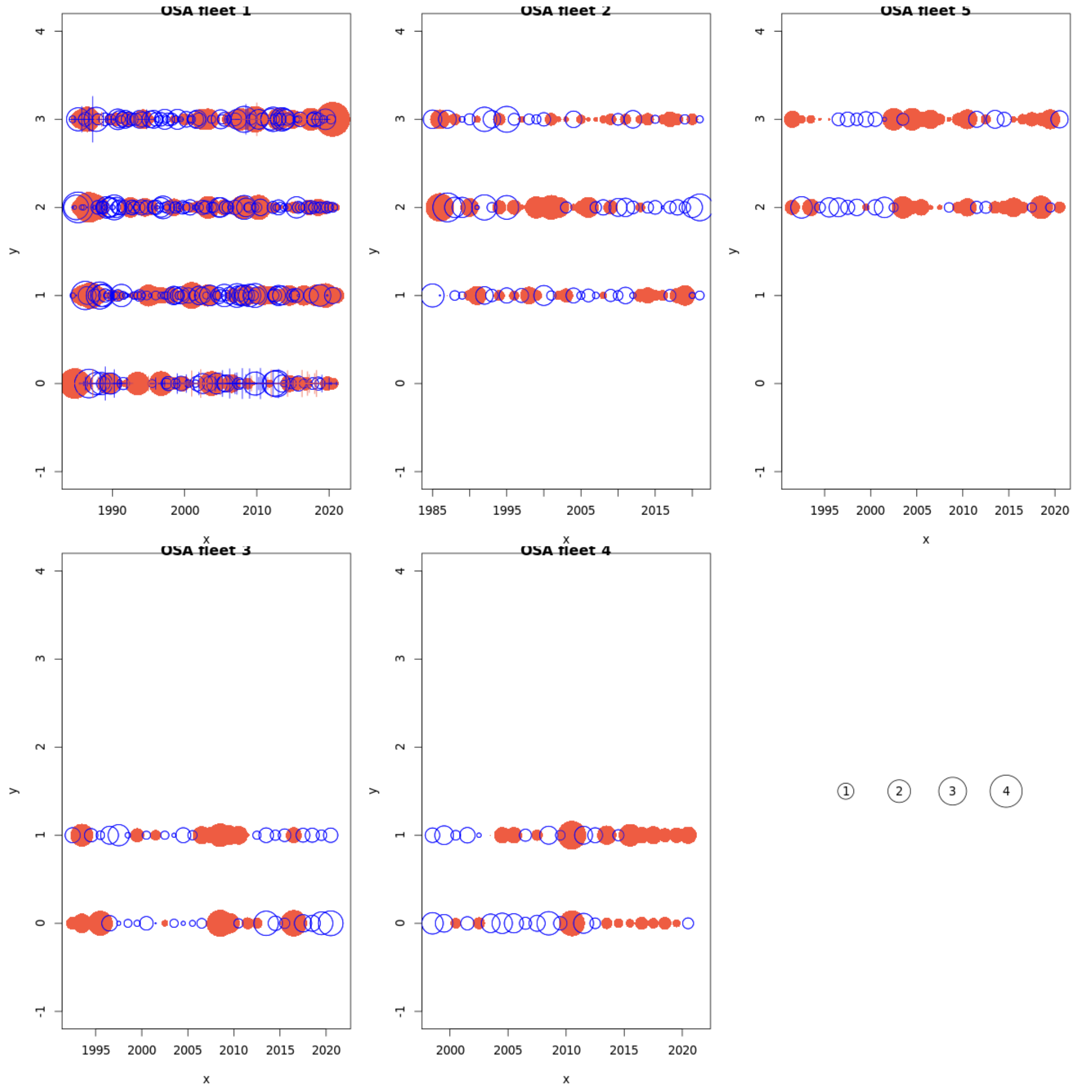


Figure 12.3.10. Norway Pout in Subarea 4 and Division 3.a. Assessment Diagnostics Plots: Full conditional residuals or auxiliary residuals (see Berg and Nielsen 2016). SESAM baseline run September 2021.

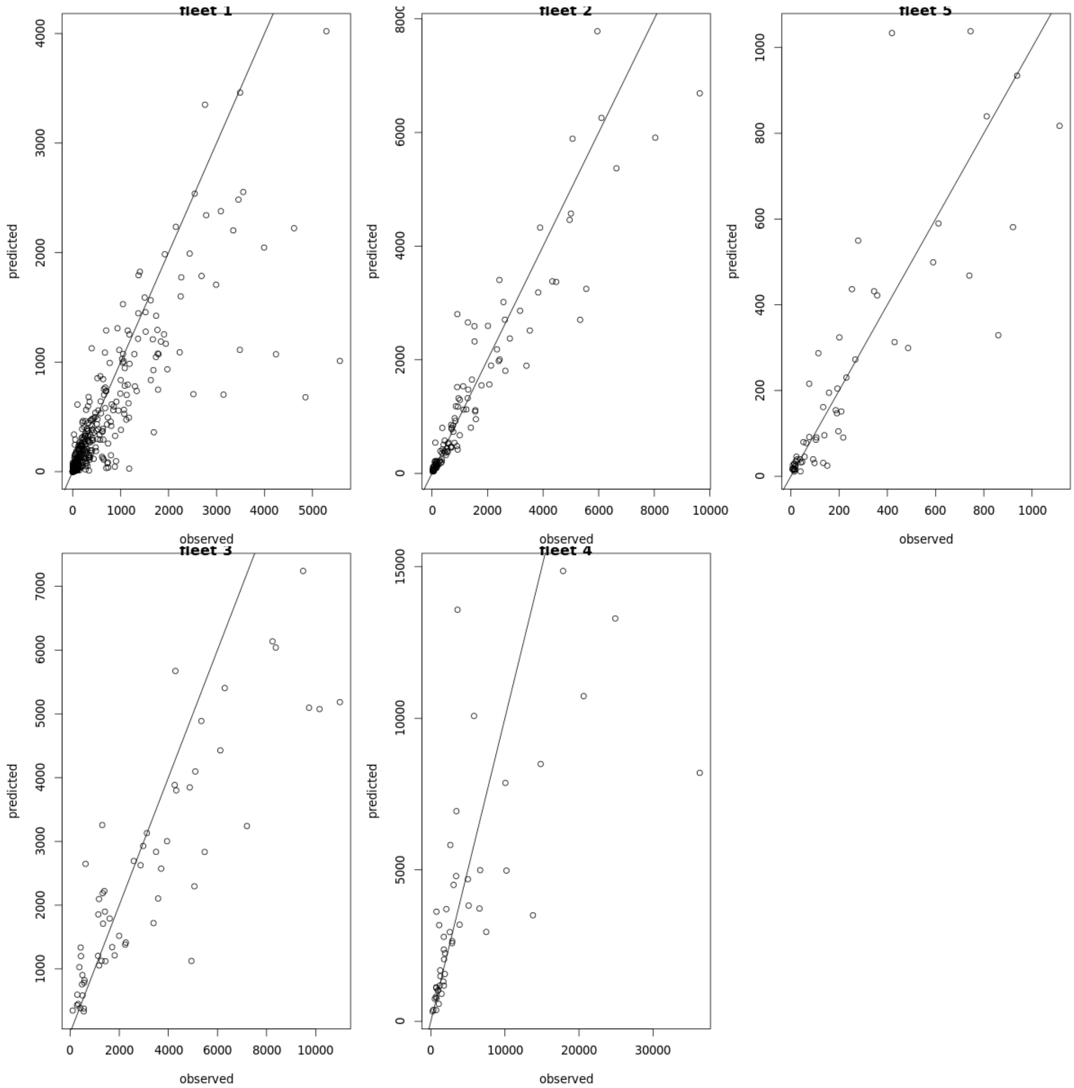


Figure 12.3.11. Norway Pout in Subarea 4 and Division 3.a. Assessment Diagnostics Plots by fleet. SESAM baseline run September 2021.

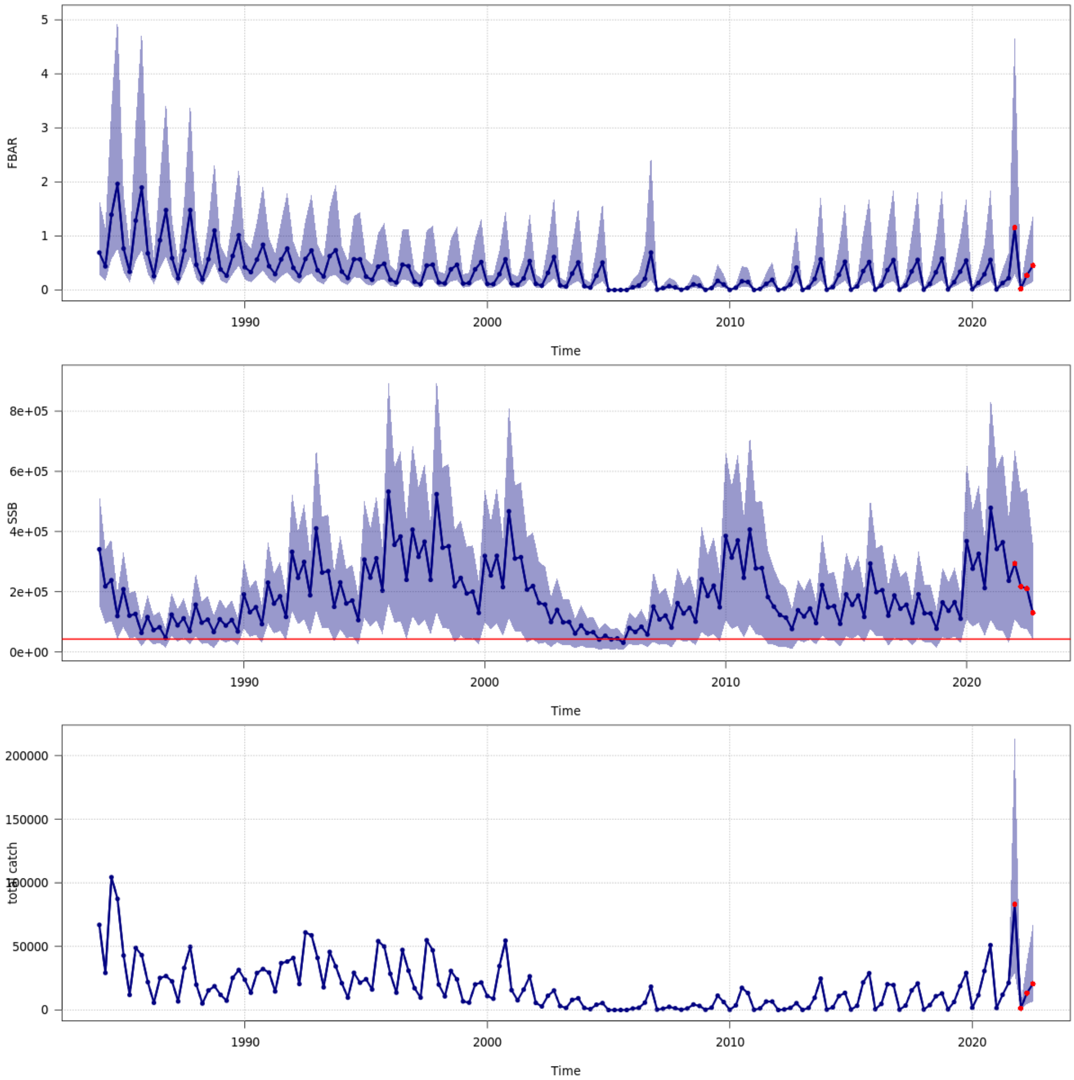


Figure 12.6.1. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year a head (1st October 2021) equals B_{lim}.

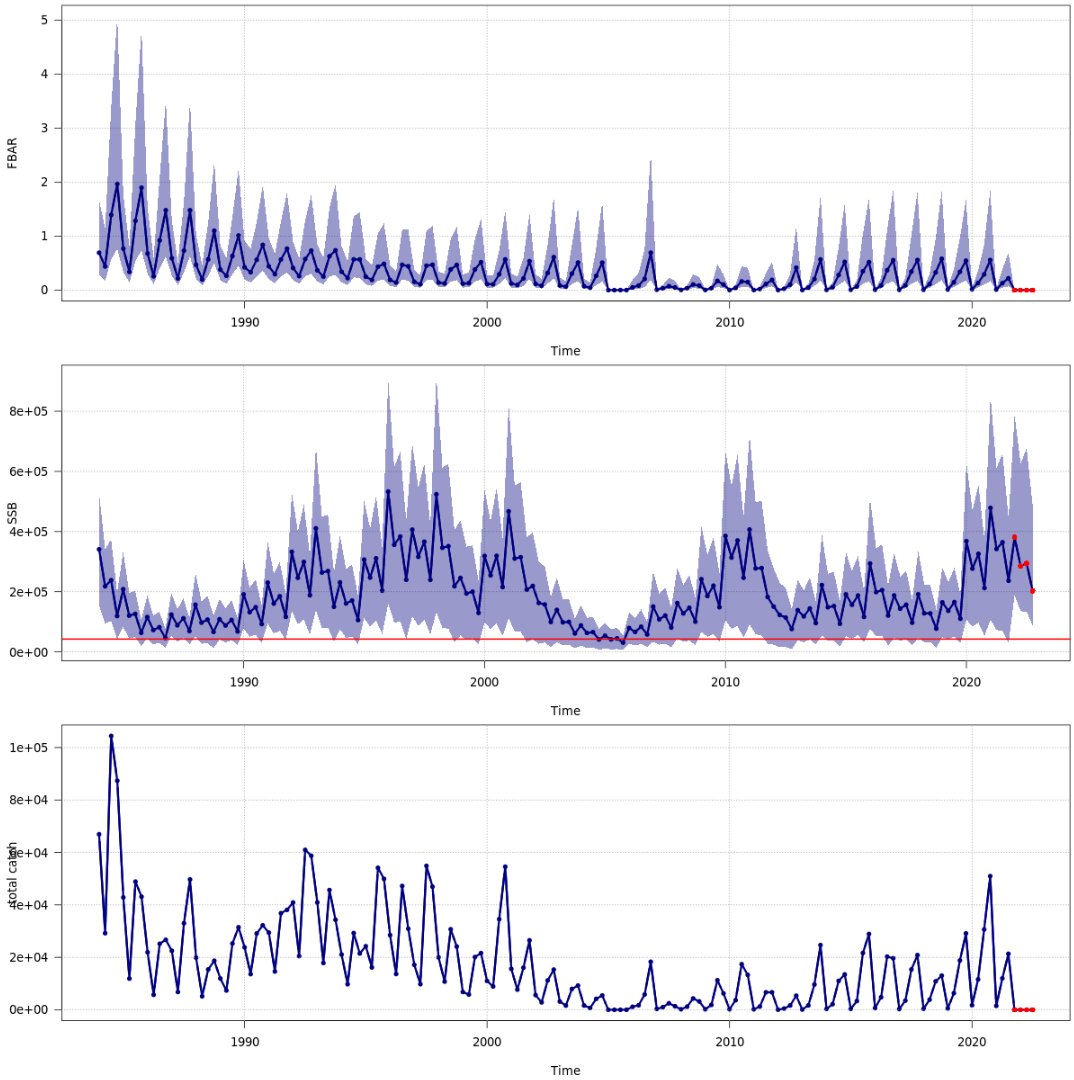


Figure 12.6.2. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2021 to 1st October 2022.

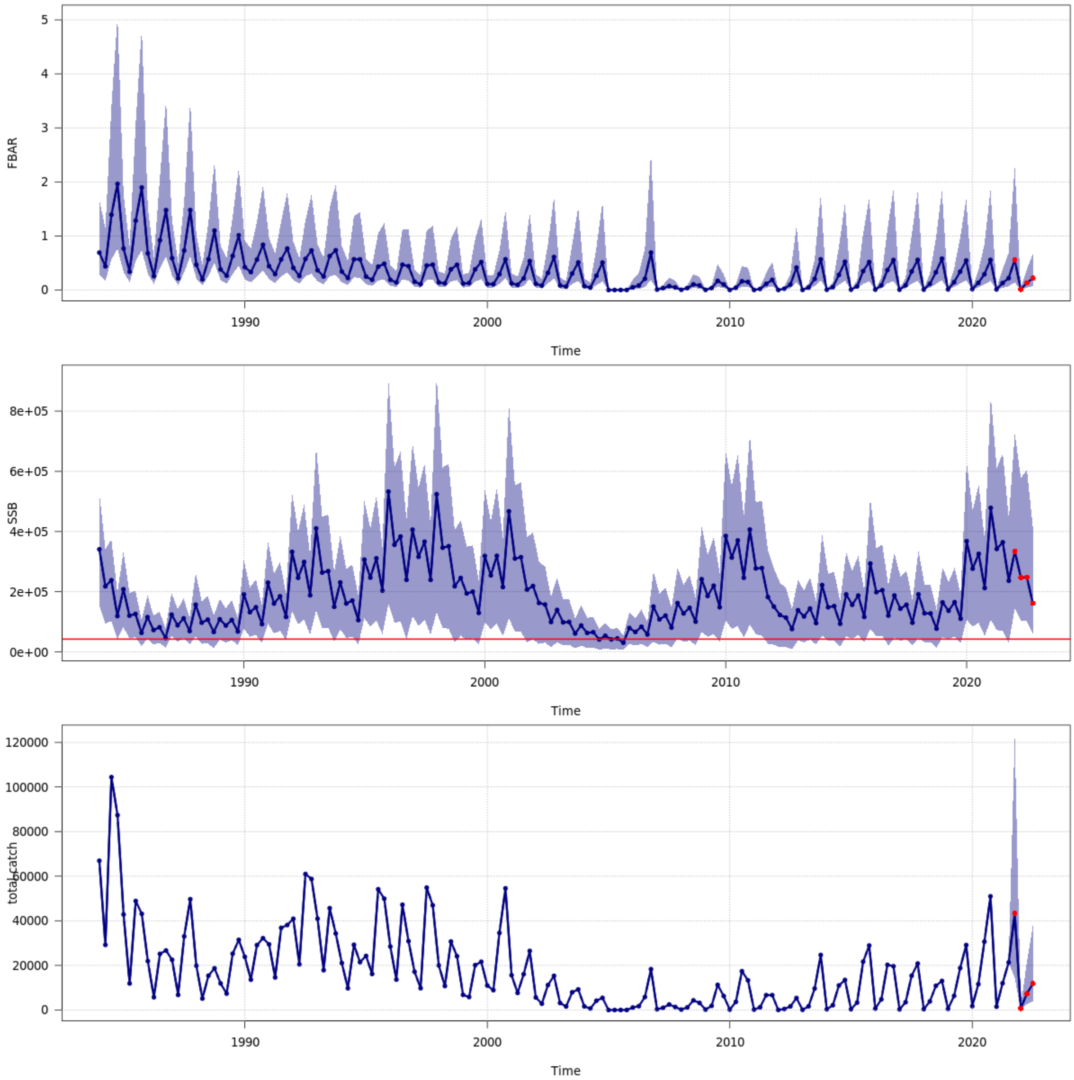


Figure 12.6.3. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year to 1st October 2021.

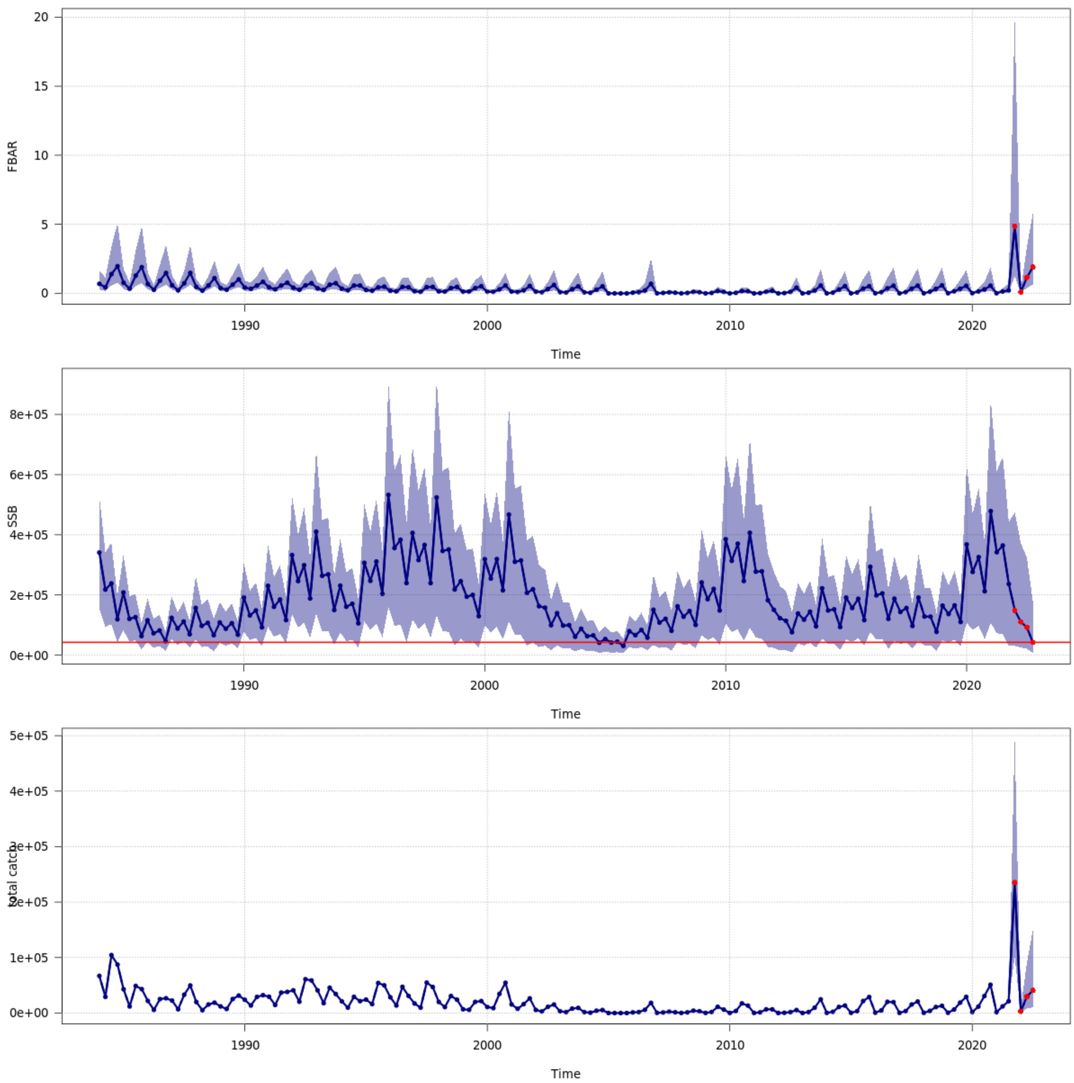


Figure 12.6.4. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year a head (1st October 2022) equals B_{lim}.

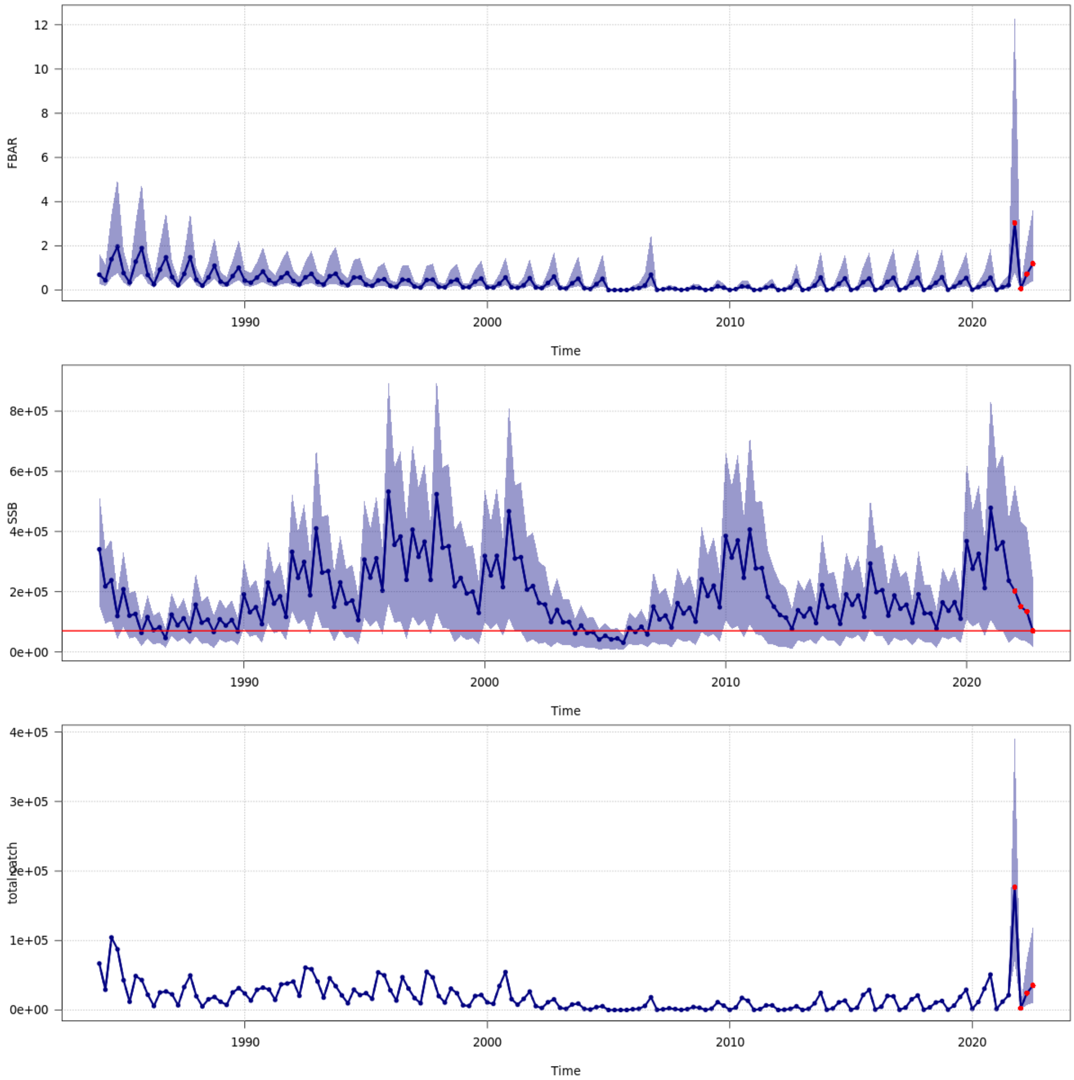


Figure 12.6.5. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the SSB distribution one year a head (1st October 2022) equals B_{pa}.

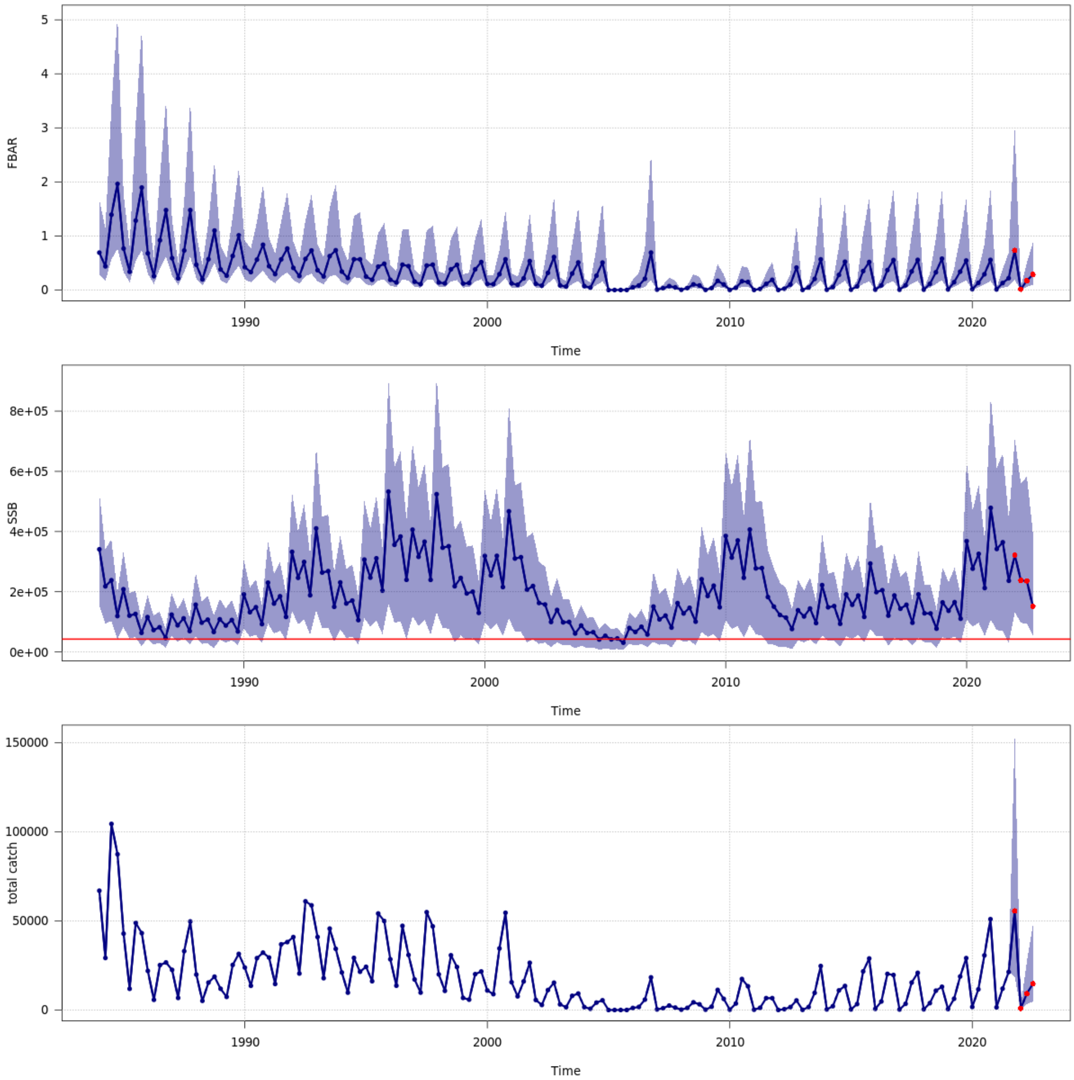


Figure 12.6.6. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.3 (F_{cap} = 0.3) for the period 1st October 2021 to 1st October 2022.

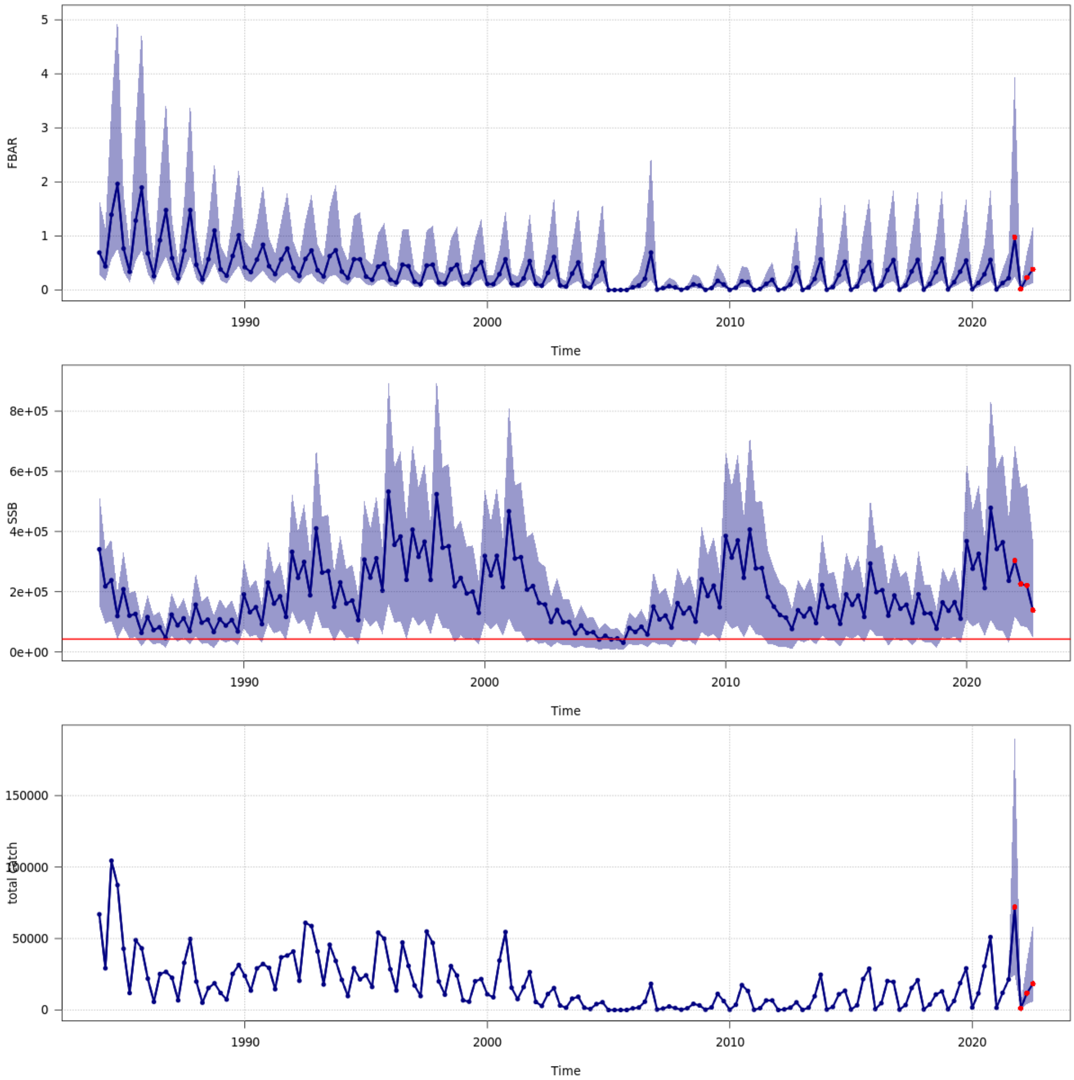


Figure 12.6.7. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.4 (F_{cap} = 0.4) for the period 1st October 2021 to 1st October 2022.

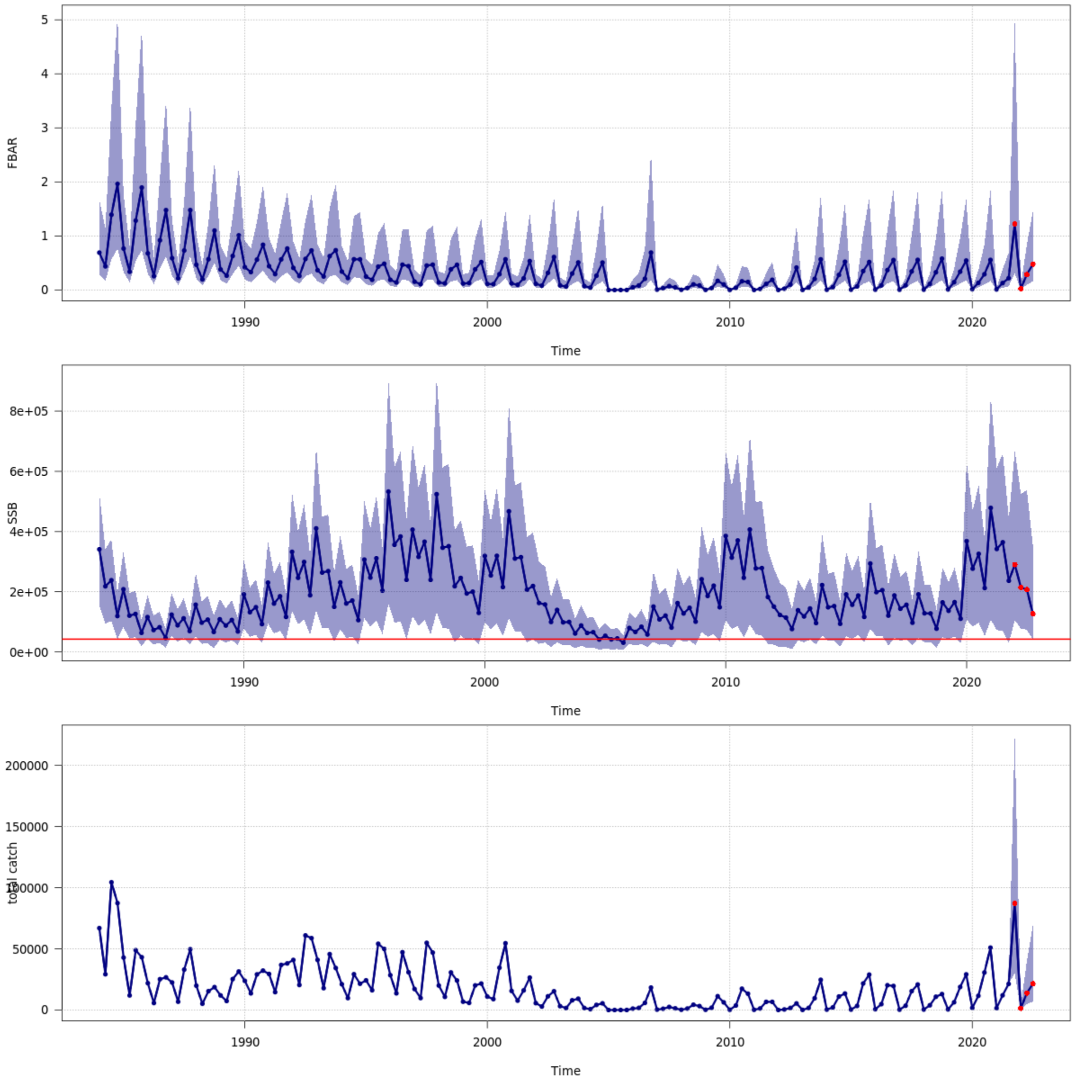


Figure 12.6.8. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (F_{cap} = 0.5) for the period 1st October 2021 to 1st October 2022.

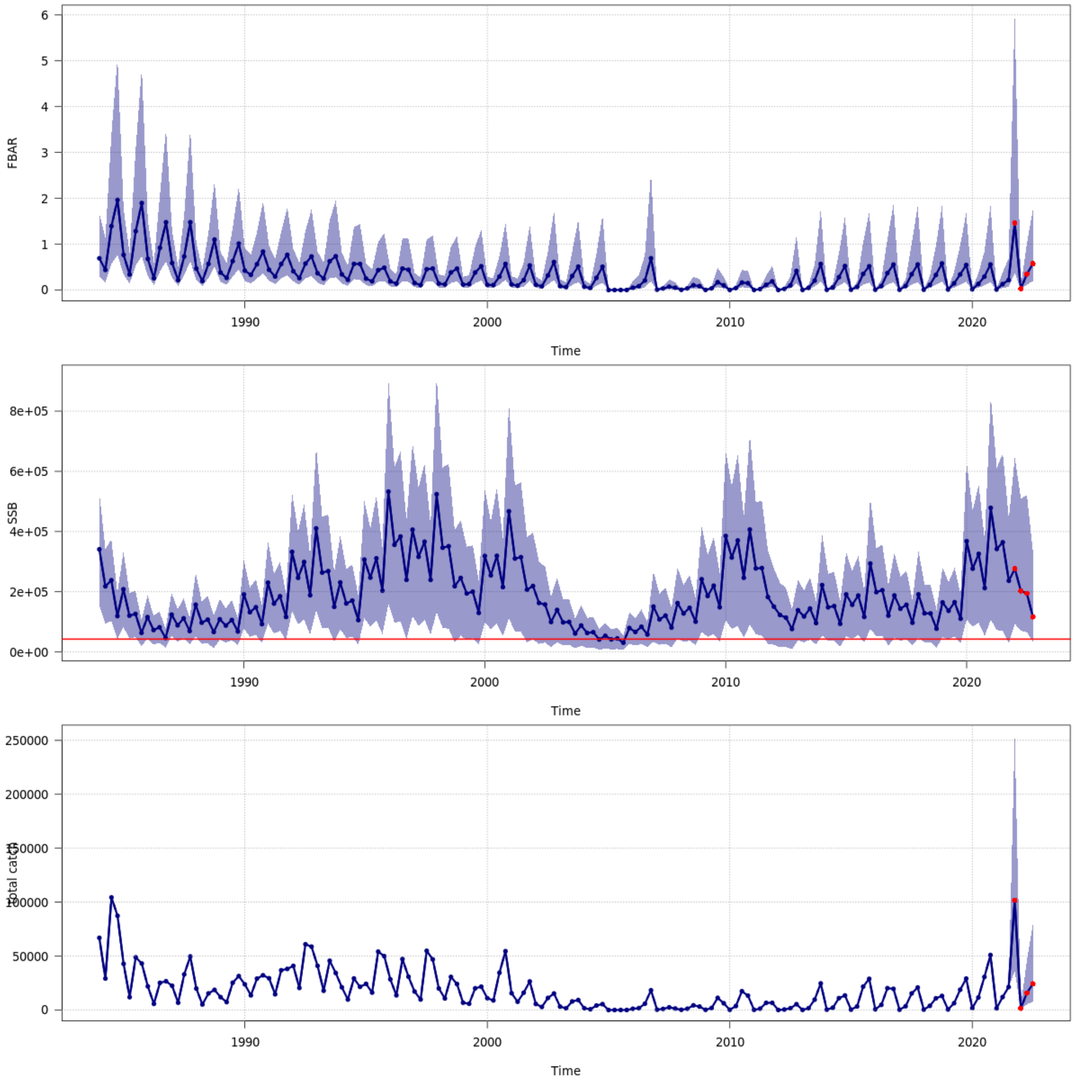


Figure 12.6.9. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.6 (F_{cap} = 0.6) for the period 1st October 2021 to 1st October 2022.

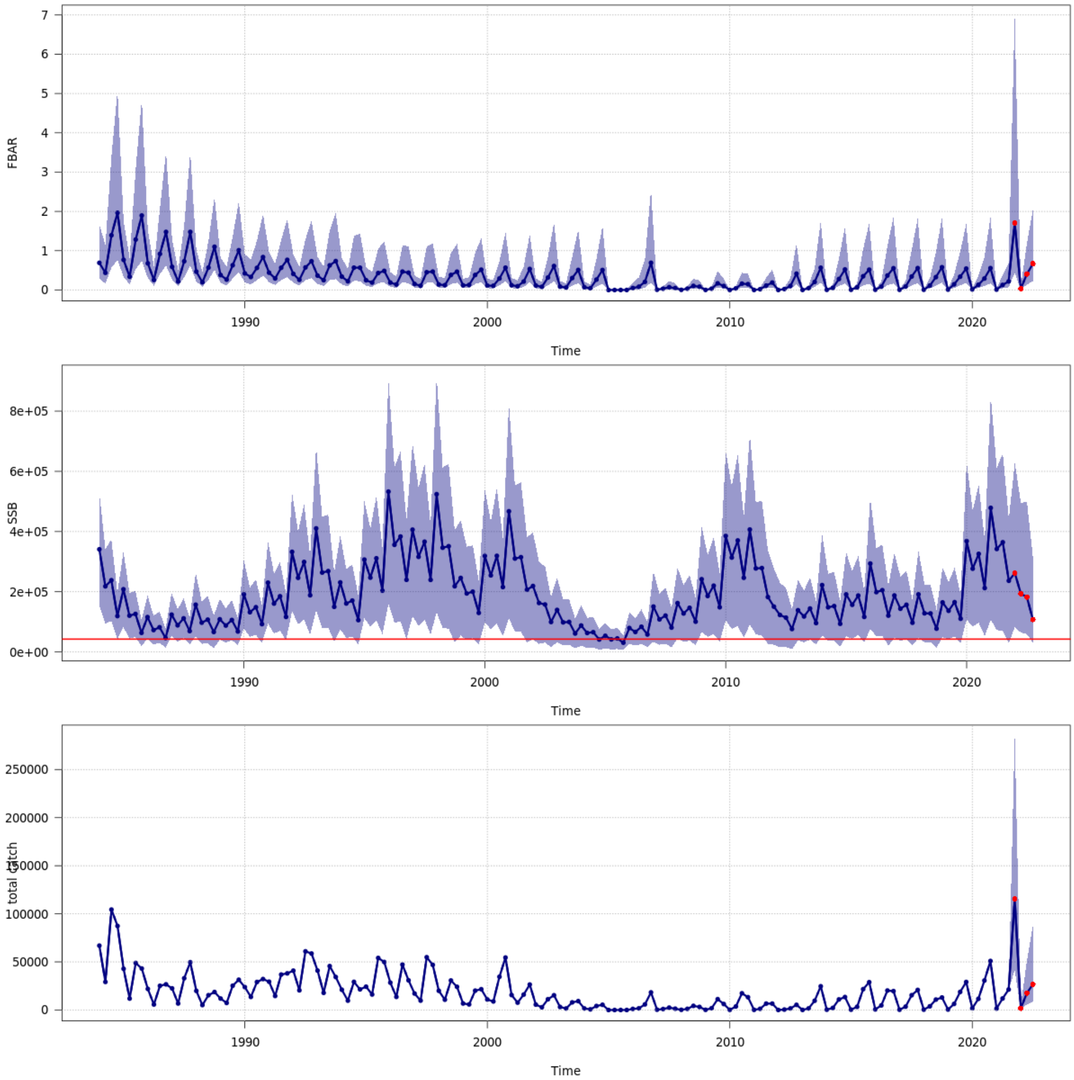


Figure 12.6.10. Norway Pout in Subarea 4 and Division 3.a. Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.7 (F_{cap} = 0.7) for the period 1st October 2021 to 1st October 2022.

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 a 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 2021:

ICES advises that when the MSY approach is applied, catches in 2022 should be no more than 142 508 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.

The WKFlatCSNS benchmark in 2020 highlighted several changes in age structure (e.g. ALK) and discards estimates in French national raising procedure. This leads to modifications to 2019 as well as French historical data. Since the French plaice catch is extremely small in the stock, the historical data were not re-processed in Intercatch.

The 2020 covid19 pandemic has led to a reduced fishing effort in quarter 2 from the major Dutch fleet TBB with mesh size 70–99. Despite of this, the overall landing and discards sampling coverage were kept at similar level as previous years. Thus, covid19 impact on catch data precision were marginal.

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 72% and 58% 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 and metier, a similar metier type (from the same quarter) or all other quarters (from the same metier) were used. Allocations to calculate the age compositions were done separately for discards and landings.

Summary of the imported/Raised/SampledOrEstimated data by area.

CatchCategory	RaisedOrImported	SampledOrEstimated	Area	CATON	perc
Landings	Imported_Data	Sampled_Distribution	27.4	23588	72
Landings	Imported_Data	Estimated_Distribution	27.4	9148	28
Discards	Imported_Data	Sampled_Distribution	27.4	24279	68
Discards	Raised_Discards	Estimated_Distribution	27.4	10285	29
Discards	Imported_Data	Estimated_Distribution	27.4	1184	3
BMS landing	Imported_Data	Estimated_Distribution	27.4	25	100
Landings	Imported_Data	Sampled_Distribution	27.3.a.20	4533	58
Landings	Imported_Data	Estimated_Distribution	27.3.a.20	3293	42
Discards	Imported_Data	Sampled_Distribution	27.3.a.20	1335	57
Discards	Raised_Discards	Estimated_Distribution	27.3.a.20	1027	43
Discards	Imported_Data	Estimated_Distribution	27.3.a.20	0	NA
BMS landing	Imported_Data	Estimated_Distribution	27.3.a.20	0	NA

Grouping strategies to raise discards and allocate age structures.

Group for discards raising and age allocation*	quarter + area	description
TBB<100(excluding CRU_16-31)	Each quarter + 4/320	Beam trawl, smaller mesh size
TBB>=100	Each quarter + 4/320	Beam trawl, larger mesh size
TBB/OTB_CRU_16-31	Each quarter + all area	shrimper
OTB/OTM-CRU/DEF/SPF<100(excluding CRU_16-31)	Each quarter + all area	Otter trawl, smaller mesh size
OTB/OTM-CRU/DEF/SPF>=100	Each quarter + all area	Otter trawl, larger mesh size
SSC/SDN<100	Each quarter + all area	Seines, smaller mesh size
SSC/SDN>=100	Each quarter + all area	Seines, larger mesh size
GNS/GTS/GTR<100	Each quarter + all area	Gillnet, smaller mesh size
GNS/GTS/GTR>=100	Each quarter + all area	Gillnet, larger mesh size
Others	All quarter + all area	All other metiers

*** all_0_0 are treated as >=100. TBB/OTB_CRU_16-31 is raised from OTB_CRU<100, because several countries have extremely high discard rates and their fisheries might have different regulations.**

For Subarea 4, 68% of the total discards in 2020 were obtained from sampling. For Subdivision 20, 43% of the total discards were obtained from sampling. BMS landings, where reported, were included with discards as unwanted catch in the assessment since 2016.

13.2.2 Landings

Plaice in Subarea 4 has been under the landing obligation since 2016 for the large mesh trawlers (TR1 and BT1). Since 2019, the fleets (BT2 and TR2), contributing most to the total plaice discards, fell under the landing obligation in Subarea 4. However, several survivability exemptions are in place: 1) the survivability exemption in Subarea 4 for plaice caught with nets, Danish seines and bottom trawls; 2) the survivability in Subarea 4 for undersized plaice caught by beam trawls using 80-119mm mesh size (BT2). According to ICES data, in 2020, BMS landings were 25.1 tonnes and UK was the only country to report to ICES. Meanwhile the official reported BMS landings were 189.5 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 2020 was 40 888 tonnes. Of these 32 736 tonnes came from the Subarea 4, 7826 tonnes came from Subdivision 20, and 326 tonnes came from 7.d. The landings in Subarea 4 decreased 18% (of 2019). The landings in Subdivision 20 decreased 3% (of 2019). 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 3–6.

13.2.3 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2020, 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 13.2.1 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 catches of 2020 in Subarea 4 reached 47% of the 146 852 tonnes catch TAC for 2020. The catches of 2020 in Subdivision 20 reached 52% of the 19 647 tonnes catch TAC for 2020. 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); (1996–2020); Age 1–9;
- 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); (2000–2020); Age 1–6
- IBTS–Q1 plaice index; 2007–2020; Age 1–7;
- IBTS–Q3 plaice index; 1997–2020; 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 2020 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. Figure 13.3.7 illustrates the yearly estimated indices for the 3 surveys. The deviation of historical year indices were small for BTS and IBTS-Q3, while large deviations appear in older ages in IBTS-Q1. The robustness of GAM method on this survey needs to be further investigated.

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 centre 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 observed. A very strong 2018 year class was observed. 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. The catch and survey data are plotted together in Figure 13.2.15.

Before WGNSSK 2021, additional survey indices were used for recruitment estimates in the RCT3 analysis for short term forecast

- Demersal Fish Survey (DFS); (1990–2019); age–0;
- Sole Net Survey (SNS); (2000–2019); age-0

Information on these survey indices are described in Section 13.5. During WKNSROP 2020, it was decided that RCT3 analysis is only applicable during autumn update when new survey indices of the assessment year are available. Thus, RCT3 analysis on recruitment indices from these two surveys are no longer conducted in the WGNSSK May forecast.

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 3.6.1.

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	2021
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 1996–2020; 1–9 SNS1 1970–1999; 1–6 SNS2 2000-2020 (excl. 2003); 1–6 IBTS-Q1 2007–2020; 1–7 IBTS-Q3 1997–2020; 1–9
Plus group	10
Last data year	2020
Survey 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 are age and year patterns in both catch and survey residuals, implying a possible lack of fitting from the splines. Further investigations will be conducted in the coming benchmark in 2021/2022. The retrospective plot for SSB does not exhibit negative or positive pattern. There seems to be upward scaling pattern for F and downward scaling pattern for recruitment.

13.4.2 Assessment results

Figure 13.2.3 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 1989onwards, increasing slowly but steadily since 2007, and decreasing again since 2016. 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 2020 is 905 056 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 2020 is 0.149 year^{-1}, and it has been around F_{MSY} since 2009. The estimated recruitment in 2020 is 1 390 640 thousand.

The estimated model parameters are presented in Table 13.3.1. The estimated fishing mortality and stock numbers are shown in Tables 13.3.2–13.3.3 and Figure 13.3.5, respectively.

The stock dynamics are partly affected by the occurrence of strong year-classes. In recent years, recruitment has been flucturating around geometric mean of the entire time series. A high 2019 recruitment has been detected in survey, but not shown in catches. The increased stock size in recent years is could 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. 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 13.6. 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.

During WKNSROP 2020, it was decided that RCT3 analysis is only applicable during autumn update when new survey indices of the assessment year are available. Thus, RCT3 analysis on recruitment were no longer considered in WGNSSK forecast. The geometric mean of 2008–2017 (last 10 years excluding recent 3 years) was chosen for age 1 in 2021. For age 2 in 2021, 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 2021	AAP survivors	RCT3	GM	Accepted estimate
2019	2	1166596	1082119	1005624	AAP survivors
2020	1		1070938	1263949	GM 2008–2017*
2021	0			1263949	GM 2008–2017*

*** 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 2020 (the last data year) into 2021 (the intermediate year in which the assessment is done); into 2022 (the TAC year) and finally into 2023 (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 an increasing trend of F_{bar} since 2017, F_{sq} was further re-scaled to have equal F_{bar} as Fbar_2020. 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 2021and 2022 were taken from the geometric mean (2008–2017). 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	$F_{(2–6)}$ 2021	SSB 2022	Recruitment 2021	Landings 2021	Discards 2021
F2021 = Fsq-rescaled	0.149	1093696 t	1263949 thousand	51458 t	46140 t

A series of F options were assumed for the TAC year. Resulting management options for 2022 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. 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 value 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.

The reference points used prior to 2017 benchmark are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	230000 t	Default to value of B_{pa}	
	F_{MSY}	0.19	Combined stock	ICES (2014)
Precautionary approach	B_{lim}	160000 t	B_{loss} = 160000 t, the lowest observed biomass in 1997 as assessed in 2004	ICES (2004)
	B_{pa}	230000 t	1.44 × B_{lim}	ICES (2004)
	F_{lim}	0.63	The F that in equilibrium will maintain the stock above B_{lim} with a 50% probability	ICES (2016a)
	F_{pa}	0.45	$F_{pa} = F_{lim} \times \exp(-1.645\sigma_F)$; σ_F = 0.20	ICES (2016a)

A series of discussions have been carried out on the value of the new MSY $B_{trigger}$: F has been below (at) F_{MSY} in more than 5 years, which triggers a revision of MSY $B_{trigger}$. According to ICES guidelines the new MSY $B_{trigger}$ should in this case be the 5th percentile of the current SSB. The benchmark came up with an alternative solution: "Estimating SSB from a period with a substantially lower fishing mortality and higher SSB i.e. year 1962" (i.e. 481.5 kt). This deviation from the guidelines was questioned within the WG. The ADG that followed the WG noted that SSB has not stabilized, and could increase even more or decline as a consequence of e.g. density dependent growth or maturity. The ADG decided to follow the guidelines because they felt there was insufficient reason to deviate from the guidelines. The MSY $B_{trigger}$ value shown in the table below reflects this decision. MSY $B_{trigger}$ is therefore the maximum of the following: B_{pa}, or the 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} till WGNSSK2020	0.369	$F_{pa} = F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	WKNSEA 2017; WKMSYREF4
	F_{pa} since WGNSSK 2021	0.769	Fp.05 with AR	

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 $B_{trigger}$)	0.769
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

13.7.5 Update of F_{pa} reference point in WGNSSK 2021

Consistent with ACOM's 2020 decision, the basis for F_{pa} should be $F_{p.05}$ calculated with advice rule. During WGNSSK 2021, the F_{pa} value was then updated as 0.769, which turned out to be higher than F_{lim} (0.516).

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. With the abandoning of RCT3 recruitment assumption in short term forecast, a new method needs to be considered to include SNS and DYFS age 0 indices in assessment model to predict recruitment in the intermediate year.

Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies inhomogeneous age distributions, i.e. older fishes are more likely distributed at 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.

A sensitivity analysis on assessment was conducted by leaving out each survey and comparing the assessment performances (Figure 13.3.8). The leave-one-out results show significantly reduced SSB estimates after leaving out IBTS-Q3. These surprising results were contradictory to the current perception that BTS is the survey with the highest weights in assessment and thus should play the major role in estimating the stock. The leave-out-one results also seem not to be consistent with the runs conducted during 2016 benchmark. Further investigations are needed to understand the contribution of surveys in the assessment. 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 23% of the total catch in 2020was 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 2020 is estimated around 905 096 tonnes which is well above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Fishing mortality in 2020 is estimated to be at a value of 0.149 (below F_{pa} of 0.769, 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 increasing up again since 2016. In 2020, discards ratio was approximately 48% 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.

13.11 Issues for future benchmarks

13.11.1 Data

- The delta-gam IBTS-Q1 age ≥5 indices showed upward revision since 2017. This is likely causing the upscaling SSB in empirical retrospective analysis (as shown in advice sheet). The quality of IBTS-Q1 data (e.g., age reading) and the cause of the upward revision needs to be investigated.
- Plaice have heterogenous age distributions in the North Sea: younger ages are distributed more closely to coastal area while older ages are distributed towards north-west of the North Sea. In recent years, strong younger age signals appeared in IBTS-Q3 survey around Scotland coast. The accuracy and uncertainty of these signals need to be investigated, e.g., age readings, gear selectivity (Scottish gear has a different selectivity).
- Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies that older fishes are likely migrating or expanding to the north western part of the North Sea (ICES, 2019a). Further investigations are needed to confirm the spatial changes. If so, the current several surveys with not fully overlapped spatial coverages are no longer suitable for stock assessment. A combined survey index, or survey with time-varying spatial random effects might need to be considered.
- The perception of the stock size from industry is not as large as estimated by ICES. Is it possible that the major fishing efforts are not in the same area where plaice stock were located. Further investigation on (spatial) LPUE needs to be conducted.
- Explain stock ID trend and differences between North Sea and north west of North Sea, including genetics, maturity, mortality, sex-ratio, growth rate, etc.

13.11.2 Assessment

- Residual age and year patterns in catches and surveys needs to be solved.
- Sensitivity leave-one-out analysis on individual survey functions on the assessment
- Reduce "error" in discards estimation by including non-zero survival in assessment

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

ICES 2016. ICES Special Request Advice Northeast Atlantic Ecoregion. Published 4 February 2016.

ICES 2018a. ICES Special Request Advice Greater North Sea Ecoregion. Published 30 May 2018. https://doi.org/10.17895/ices.pub.4379.

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.

Needle, Coby. (2015). Using self-testing to validate the SURBAR survey-based assessment model. Fisheries Research. 171. 10.1016/j.fishres.2015.03.001.

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
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

	North Sea													Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000	8789	6400
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250	9110	1400
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000	9090	9500
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000	6764	7600
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441	9565	7600
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261	8747	8500
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000	8657	9300
2009	3474	NA*	NA*	2931	29142	1116	1	13143	-	NA*	-	54973	55500	6748	9300
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825	9057	9300
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400	8251	7900
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410	7611	7900
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070	6911	9142
2014	7105	12003	276	4203	29306	577	5	17370	-	69179	1668	70847	111631	9004	10056
2015	5522	14401	223	5171	32074	169	7	17240	-	74807	156	74963	128376	10171	10056
2016	6659	16398	169	4371	32227	94	9	18731	-	78659	2400	81059	131714	10883	11766
2017	5317	12518	151	2526	28775	67	5	14993	0	64352	1090	65442	129917	8467	17639
2018	4894	9666	112	2580	22586	69	3	9603	0	49513	1270	50783	112643	5958	15343
2019	3912	6583	61	2059	19289	57	3	7410	0	39374	596	39970	125435	4614	16782
2020	2560	5636	25	1396	16870	37	5	5582	0	32110	626	32736	146852	5179	19647

*** 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.

year	age									
	1	2	3	4	5	6	7	8	9	10
1957	0	4792	66428	49659	35282	9867	12248	10026	5522	12059
1958	0	7581	23612	65979	36274	20836	8696	8507	6497	13981
1959	0	16914	31085	26040	41988	23432	14173	6547	6739	16530
1960	0	5998	62285	51359	21462	27510	14280	9073	5121	15253
1961	0	2299	33913	68965	33209	12958	14909	9900	6089	14889
1962	0	2075	34677	64548	48387	19939	8757	8733	5081	12373
1963	0	4424	21886	78412	55414	32413	13096	6965	7183	16912
1964	0	14818	40789	65219	57837	37368	15937	6644	4010	17012
1965	0	9913	42438	53486	43919	30320	18464	8602	4237	17686
1966	0	4220	66196	52428	37336	27870	16801	10981	6585	15201
1967	0	6101	30905	115157	42204	22490	16496	8163	6861	11397
1968	0	9750	41883	39251	127220	17638	10642	10396	4039	13754
1969	3	15892	47819	38185	37657	107955	11016	6440	8669	17029
1970	74	16850	49861	54712	39642	34174	76862	6149	4078	14459
1971	20	30568	49876	34580	26919	23659	17471	30711	6626	17468
1972	2296	37561	63958	54402	23695	17479	14787	11211	19111	16094
1973	1332	33342	62095	76769	44397	14517	9335	10347	6392	25194
1974	2305	23972	57595	43677	42588	20391	8300	6554	5773	22790
1975	1042	29877	65465	33211	27004	22509	12613	6292	4362	20923
1976	2892	34497	79621	98846	14129	10156	9352	6553	3022	12871
1977	3225	57061	43359	66120	83841	9157	5922	5030	4068	9206
1978	1102	58412	60114	52398	48310	34240	5728	3232	2333	7201
1979	1316	57933	118662	48879	47805	39864	24187	4154	2802	9272
1980	996	66095	136274	79035	25548	18321	14018	8621	1898	5497
1981	259	103354	125928	59565	36670	12750	9805	8295	5005	6091
1982	3373	48354	212188	71167	29191	16975	7704	5551	4539	8775
1983	1214	119696	115332	100473	29591	12960	8238	4224	3013	8308
1984	108	63507	280481	62835	41492	15417	6842	5593	2729	6551
1985	120	72806	146839	201629	37939	17106	7441	3780	2813	5830
1986	1669	66935	165986	106461	101684	27971	9839	4704	2834	7083
1987	1	85153	118416	120782	81304	44590	13539	4669	2346	5610
1988	1	15200	253815	85347	59950	31492	19347	6198	3434	6402
1989	1254	46810	108272	238243	58767	21667	11605	8025	2321	5806
1990	1546	33766	104796	119829	169465	29946	9053	4689	3803	4206
1991	1425	43064	87196	122233	76075	78728	15410	5390	3215	5634
1992	3386	43769	86358	81470	88534	37542	30444	7229	3295	6976
1993	3416	53555	99805	80856	63275	35042	14745	11500	3704	5883

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2019	0	6528	43711	32251	18781	18124	11446	6948	3924	4055
2020	80	5638	19007	44780	19082	10224	11645	7614	4813	6395

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
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

year	age							
	1	2	3	4	5	6	7	8
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
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
2019	134628	115294	119574	29706	11845	8536	3134	1412
2020	93983	191175	64298	55815	9809	3645	4399	1189

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
1964	66035	168092	104945	99044	60848	37691	15937	6644	4010	17012
1965	43708	435934	101700	56890	44842	30587	18464	8602	4237	17686
1966	38496	167345	415554	66827	38738	27995	16801	10981	6585	15201
1967	20199	139646	118437	267653	42827	22750	16496	8163	6861	11397
1968	73971	81942	88222	65781	149656	17696	10642	10396	4039	13754
1969	85195	83270	64566	57519	38430	109979	11016	6440	8669	17029
1970	123643	169330	77608	55999	44703	34335	76862	6149	4078	14459
1971	69357	127536	92230	37255	27345	23740	17471	30711	6626	17468
1972	72298	93031	97857	60116	24262	17552	14787	11211	19111	16094
1973	133684	83157	66103	77442	45686	14584	9335	10347	6392	25194
1974	213444	332383	61247	43962	43199	20500	8300	6554	5773	22790
1975	246011	310007	256001	38018	27257	22632	12613	6292	4362	20923
1976	186771	175418	150675	116859	14303	10197	9352	6553	3022	12871
1977	259853	160757	122676	99672	93158	9286	5922	5030	4068	9206
1978	227974	212525	87371	63173	49554	34810	5728	3232	2333	7201
1979	294482	273017	176240	67261	48394	40174	24187	4154	2802	9272
1980	227367	188656	137206	79722	25741	18407	14018	8621	1898	5497
1981	134401	296595	127778	59938	37101	12805	9805	8295	5005	6091
1982	414680	252926	216812	72276	29407	17073	7704	5551	4539	8775
1983	262614	556027	146048	102708	30395	13032	8238	4224	3013	8308
1984	310783	376997	333132	87364	42984	15486	6842	5593	2729	6551
1985	405505	302014	182405	203850	38139	17184	7441	3780	2813	5830
1986	1119014	557900	214496	132931	103135	28117	9839	4704	2834	7083
1987	361520	1459355	299385	122209	82652	44838	13539	4669	2346	5610
1988	348598	623309	713200	146514	60832	31669	19347	6198	3434	6402
1989	214545	532655	301448	324001	65991	21782	11605	8025	2321	5806
1990	146860	313064	273470	147931	174476	30123	9053	4689	3803	4206
1991	184551	344639	228763	162972	81603	79667	15410	5390	3215	5634
1992	142141	263388	180939	115818	92841	38422	30444	7229	3295	6976
1993	99787	207638	147893	92822	64910	35258	14745	11500	3704	5883
1994	63497	140257	141566	88030	48399	27824	17279	6661	5449	5458

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2019	134628	121822	163285	61957	30626	26660	14580	8360	3924	4055
2020	94063	196813	83305	100596	28891	13869	16044	8803	4813	6395

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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2019	0.022	0.063	0.117	0.173	0.240	0.261	0.352	0.391	0.415	0.443
2020	0.026	0.058	0.114	0.163	0.208	0.248	0.323	0.351	0.424	0.458

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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2019	NA	0.249	0.258	0.295	0.349	0.388	0.431	0.488	0.504	0.601
2020	0.211	0.236	0.264	0.269	0.302	0.333	0.372	0.422	0.451	0.562

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
1965	0.038	0.072	0.166	0.192	0.212	0.221	0.231	0.000	0.000	0.000
1966	0.038	0.101	0.125	0.194	0.205	0.231	0.231	0.244	0.000	0.000
1967	0.036	0.105	0.158	0.169	0.220	0.220	0.244	0.244	0.000	0.000
1968	0.060	0.096	0.156	0.191	0.192	0.244	0.220	0.000	0.000	0.000
1969	0.052	0.146	0.162	0.186	0.211	0.212	0.000	0.231	0.000	0.000
1970	0.049	0.114	0.179	0.189	0.196	0.000	0.220	0.231	0.000	0.000
1971	0.057	0.110	0.183	0.200	0.212	0.000	0.000	0.231	0.000	0.000
1972	0.061	0.147	0.173	0.211	0.211	0.244	0.000	0.000	0.000	0.000
1973	0.043	0.131	0.179	0.195	0.211	0.244	0.000	0.000	0.000	0.000
1974	0.054	0.106	0.173	0.212	0.220	0.231	0.244	0.000	0.000	0.000
1975	0.068	0.136	0.162	0.206	0.221	0.244	0.244	0.000	0.000	0.000
1976	0.085	0.153	0.176	0.195	0.220	0.000	0.244	0.000	0.000	0.000
1977	0.069	0.160	0.186	0.196	0.198	0.220	0.000	0.000	0.000	0.000
1978	0.069	0.143	0.197	0.205	0.211	0.213	0.231	0.000	0.000	0.000
1979	0.066	0.158	0.185	0.204	0.220	0.231	0.221	0.244	0.000	0.000
1980	0.055	0.149	0.191	0.212	0.231	0.000	0.000	0.000	0.000	0.000
1981	0.048	0.135	0.179	0.212	0.220	0.000	0.000	0.000	0.000	0.000
1982	0.054	0.126	0.182	0.203	0.231	0.244	0.244	0.000	0.000	0.000
1983	0.051	0.126	0.180	0.205	0.211	0.244	0.000	0.000	0.000	0.000
1984	0.053	0.127	0.172	0.211	0.205	0.000	0.244	0.000	0.000	0.000
1985	0.054	0.139	0.177	0.197	0.231	0.244	0.000	0.000	0.000	0.000
1986	0.049	0.124	0.181	0.196	0.220	0.244	0.244	0.000	0.000	0.000
1987	0.043	0.105	0.166	0.205	0.220	0.231	0.000	0.000	0.000	0.000
1988	0.043	0.098	0.153	0.185	0.220	0.244	0.000	0.000	0.000	0.000
1989	0.046	0.102	0.163	0.181	0.196	0.000	0.000	0.000	0.000	0.000
1990	0.051	0.111	0.157	0.186	0.212	0.231	0.000	0.000	0.000	0.000
1991	0.055	0.130	0.161	0.185	0.203	0.221	0.231	0.231	0.000	0.000
1992	0.050	0.122	0.167	0.188	0.204	0.212	0.231	0.244	0.000	0.000
1993	0.056	0.121	0.171	0.197	0.211	0.231	0.244	0.000	0.000	0.000
1994	0.060	0.140	0.175	0.194	0.213	0.244	0.244	0.221	0.000	0.000

year	age									
	1	2	3	4	5	6	7	8	9	10
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
2019	0.044	0.083	0.118	0.135	0.146	0.148	0.158	0.172	0.182	0.194
2020	0.054	0.079	0.119	0.133	0.146	0.148	0.154	0.164	0.159	0.166

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
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

year	age									
	1	2	3	4	5	6	7	8	9	10
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
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
2019	0.044	0.092	0.155	0.218	0.270	0.311	0.372	0.435	0.504	0.601
2020	0.054	0.083	0.152	0.194	0.249	0.284	0.312	0.387	0.451	0.562

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	24131.0	23724.3	5110.0	1824.9	1397.1	588.7	247.8	143.9	64.2
1997	86228.1	15967.3	6526.0	1618.4	510.8	384.3	131.2	160.6	30.7
1998	34124.8	85886.3	9654.2	2700.7	651.9	379.6	225.4	190.3	73.7
1999	31204.4	23943.0	36472.5	3056.2	1171.7	270.0	101.1	87.1	41.3
2000	41121.4	22701.5	9096.8	9991.0	619.3	214.1	105.3	92.4	16.4
2001	29427.6	21105.8	7048.9	3550.8	3529.9	276.4	90.4	72.6	57.0
2002	126025.9	16831.4	7373.3	4060.5	2275.6	1680.2	299.9	145.4	49.2
2003	31685.4	47186.9	7204.4	3610.6	1729.4	1011.4	988.8	77.4	55.5
2004	44035.3	15320.8	18112.6	3135.6	1634.3	959.8	540.9	844.2	51.1
2005	41788.6	29442.0	5031.4	7324.9	1057.8	1135.0	390.6	94.5	897.5
2006	46122.2	19124.9	9434.9	2455.4	3924.4	645.4	773.3	113.2	151.3
2007	69994.1	22634.7	11144.4	7969.3	1778.8	2664.6	318.7	651.8	79.6
2008	70536.2	43460.1	12300.3	6405.6	4486.6	991.5	1571.2	304.5	473.4
2009	63296.6	25530.1	19968.9	5367.5	3308.7	2579.7	668.5	1480.3	287.9
2010	76156.5	28329.8	14317.4	10397.4	3189.5	1788.1	1782.3	621.7	1013.6
2011	119965.7	41702.7	18859.4	9428.7	6268.1	2032.5	917.5	1609.5	236.8
2012	55272.0	62135.3	39045.0	14146.9	6958.4	4525.5	1412.5	1121.7	1552.3
2013	81421.3	52754.4	40417.7	20026.0	7449.7	4447.1	3216.6	1299.1	797.3
2014	133710.3	61041.3	27867.4	20986.7	8758.7	3710.3	2227.1	1768.9	1000.4
2015	48851.1	67154.6	35592.0	17558.2	13359.2	6969.3	2315.1	1694.6	1557.2
2016	77603.9	32060.1	33726.2	18749.8	9775.7	6768.7	3719.9	1723.0	1110.2
2017	130588.6	50607.7	18491.0	20040.7	10608.3	5163.0	3101.9	1986.9	683.9
2018	79604.5	71794.9	22864.8	11704.4	11462.0	5574.8	3378.7	1944.7	1618.4
2019	311556.7	59019.2	32052.5	9909.3	6933.7	4958.2	2922.0	2259.3	1231.9
2020	153502.2	125092.0	28588.4	17536.6	5314.7	3320.3	2430.9	1762.6	1122.3

	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	2019	28309	1886	1533	338	196	62
1990	25037	7496	3160	816	422	48.8	2020	11393	3931	283	607	118	5
1991	57221	11247	1518	1077	128	74.4							
1992	46798	13842	2268	613	176	52.0							
1993	22098	9686	1006	98	60	58.8							
1994	19188	4977	856	76	23	2.7							
1995	24767	2796	381	97	38	0.0							
1996	23015	10268	1185	45	47	0.0							
1997	95901	4473	497	32	0	13.3							
1998	33666	30242	5014	50	10	0.0							
1999	32951	10272	13783	1058	17	0.0							

IBTS–Q3	1	2	3	4	5	6	7	8	9
1997	3567.9	3312.1	1979.6	564.8	228.0	170.2	90.4	85.6	25.7
1998	1052.5	5086.1	1716.4	841.9	318.7	139.3	85.5	93.7	42.1
1999	948.2	2326.6	4377.7	734.6	315.7	133.6	50.4	45.3	26.4
2000	944.2	1773.4	1967.3	2163.6	225.9	126.3	54.0	42.4	12.5
2001	1160.7	3304.5	2112.4	1136.5	1165.4	176.7	78.5	64.8	50.8
2002	6104.0	2867.3	2352.9	1286.0	680.9	442.9	102.5	94.2	44.2
2003	1377.6	4975.4	1692.0	1035.3	466.4	276.7	276.7	51.5	53.6
2004	2528.3	2580.9	4063.4	940.1	616.1	310.8	187.5	232.0	42.8
2005	1962.2	4725.5	1601.0	2322.0	409.4	501.8	235.4	81.3	230.7
2006	2219.9	3075.7	3770.0	1109.1	1237.8	399.2	403.6	156.8	83.8
2007	5697.5	4676.2	3717.9	3238.4	831.2	1314.2	330.8	455.4	116.7
2008	6133.0	10655.9	5051.6	3408.4	2196.5	738.4	738.0	312.1	270.1
2009	2794.2	5041.5	7677.9	2798.6	1720.3	1205.4	454.9	735.4	191.7
2010	3224.6	4957.9	5390.7	4900.2	1628.7	1156.7	1081.6	477.2	653.2
2011	6616.6	8966.4	7380.9	4830.3	3442.5	1284.2	858.2	1058.4	267.3
2012	2427.4	10892.2	11291.3	6362.4	3581.7	2478.2	1110.7	894.2	913.2
2013	2685.1	6750.1	9584.5	6410.2	3379.9	2083.1	1561.1	728.1	479.2
2014	5239.4	8877.7	7681.2	6439.5	3245.8	1507.2	1062.6	763.1	476.1
2015	1701.2	7393.9	8343.9	6068.7	4623.3	2583.3	1297.6	953.6	783.6
2016	3165.8	4957.1	7400.3	5624.7	3098.9	2362.9	1548.3	984.1	761.9
2017	4065.4	4879.4	3513.3	4481.0	2918.2	1773.9	1143.0	881.1	511.8
2018	2205.1	6088.9	3973.0	2509.2	2458.8	1615.0	1239.0	760.4	635.8
2019	6016.1	5415.7	4211.8	2094.9	1354.4	1063.9	751.4	635.5	345.9
2020	3231.7	7311.2	3617.9	2806.7	1294.5	900.5	760.3	694.3	396.9

IBTS–Q1	1	2	3	4	5	6	7
2007	2394.7	5344.7	5693.8	6178.2	2138.4	1104.0	604.9
2008	2354.8	11155.4	7599.4	3583.4	2701.6	733.7	731.1
2009	2995.6	7480.2	13046.7	4288.9	2237.2	917.8	496.0
2010	1474.9	5843.6	9477.3	8219.6	3604.8	1447.3	1016.9
2011	1167.1	5946.8	6492.0	6618.3	5264.5	1813.2	967.9
2012	2018.4	13641.9	15601.4	7267.6	5093.1	3408.9	1439.6
2013	1415.6	5162.6	10272.8	6831.1	3366.7	1943.8	1017.1
2014	2730.2	7401.4	9056.7	8934.0	5046.5	1806.5	1127.1
2015	902.2	9943.4	10948.0	8698.9	6244.7	2893.0	1275.7
2016	2178.9	5134.9	9507.6	7572.7	5266.5	2493.8	1437.7
2017	1973.1	6501.1	4190.8	7094.0	4728.9	3002.1	1534.4
2018	700.8	5927.7	6201.6	2274.1	3204.8	1911.1	1390.1
2019	4164.2	4237.0	6711.6	3289.4	1763.4	1459.9	1375.9
2020	2062.9	8636.2	4506.5	3830.8	1826.7	1274.4	1143.5

Table 13.3.1. Plaice in Subarea 4 and Subdivision 20: Estimated parameters from AAP model in final run.

Number of parameters = 281 Objective function value = 217.518 Maximum gradient component = 0.000181604
logsigmaC:
-0.617168 -0.504893 0.0422849

logsigmaU:
-0.398622 -0.282866 0.0375541
-1.51585 -0.161800 0.0300500
-1.30868 0.414907 -0.0213647
-1.00014 0.0336696 0.0391202
-0.541302 -0.407085 0.0398088
-0.502623 -0.532421 0.0685190

log_sel_coff1:
-1.14845 -0.790063 -0.882113 -1.36330 -1.34300 -0.553643 -0.372125 -0.407433 0.138556 0.204755 -0.198657 -0.164703 0.0429292 -0.0208952 -0.375456 -0.171662 -0.509110 -0.880786 -0.642861 -0.691668 -0.324114 -0.434331 -0.593532 -0.834888 -1.21691 -0.808113 -0.284115 0.174487 0.136545 0.452858 0.215830 0.274090 0.310372 0.410668 0.477524 0.483239 0.791621 0.660336 0.556787 0.788738 0.656899 0.743389 0.560400 1.03471 0.614959 0.694405 0.832496 0.415033 0.206078 -0.274193 -0.253639 -0.483025 0.0345331 0.176056 0.207598 0.294340 0.317467 0.157742 0.284479 0.591867 0.538992 0.541659 0.676357 0.779778 0.697360 0.836758 0.773416 0.722060 0.841587 0.850017 1.01833 0.788133 0.491736 0.204251 -0.252286 -0.178688 -0.286798 -0.486129 -0.336882 0.0871279 0.146532 0.374482 0.253555 0.301352 0.287460 0.431558 0.410647 0.504132 0.517375 0.424557 0.552227 0.951506 0.754840 1.09170 0.733692 1.06359 0.840380 0.871323 0.536812 -0.105554 -0.600446 -0.839690 -0.557283 -1.06969 -0.248331 -0.236107 -0.126631 0.0527021 -0.0587154 0.0273478 0.187473 0.210259 0.319445 0.207893 0.417785 0.223737 0.267476 0.620925 0.466408 0.685283 0.894453 0.727803 0.629787 0.252136 0.334137 -0.572027 -0.879499 -1.31407 -1.54656 -1.32402 -0.429474 -0.163230 -0.437111 -0.156522 -0.206041 -0.294187 0.0504182 0.133846 0.283964 -0.0134519 0.0660383 0.166361 0.0357094 0.322994 0.231511 0.512736 0.470302 0.582455 0.277824 0.0585613 -0.949345 -1.14180 -2.36786 -2.21846 -2.38198 -2.51956

log_sel_cofU:
-8.10531 -7.75360 -8.72695 -9.94052 -10.7785 -10.6427
-2.80415 -2.85981 -3.25314 -3.50186 -3.83948 -3.99434
-3.33270 -3.38615 -4.51724 -7.02904 -8.25618 -8.64899
-4.22922 -5.28119 -6.57403 -7.65278 -8.74884 -8.84951
-5.96899 -5.19467 -4.48819 -4.49424 -4.77819 -4.63514
-6.49587 -5.32359 -4.03061 -4.21779 -4.11257 -4.52632

log_initpop:
12.5095 12.7968 12.3129 11.8923 11.0174 11.0438 10.8072 10.3789 11.1393 13.0723 13.4735 13.6826 13.5776 13.6882 13.3297 13.3243 14.7078 13.4123 13.2703 12.9561 12.9379 13.4177 13.4240 12.9855 12.8038 14.1209 13.9008 13.5991 13.4299 13.8283 13.6736 13.7297 13.9013 13.8301 14.4708 14.1159 14.0667 14.4140 15.2893 14.4665 14.3588 14.0315 13.9235 13.8145 13.6139 13.1860 13.3021 13.7672 13.6157 14.6544 13.6249 13.5071 13.6713 13.3255 14.4313 13.3273 14.0550 13.6471 13.6977 14.1967 13.9720 13.8863 14.2181 14.4104 14.0952 14.2808 14.5981 13.7333

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	0.103	0.176	0.263	0.306	0.255	0.212	0.225	0.229	0.206	0.206
1958	0.115	0.210	0.306	0.329	0.291	0.246	0.222	0.220	0.233	0.233
1959	0.127	0.242	0.343	0.347	0.324	0.281	0.224	0.214	0.247	0.247
1960	0.137	0.260	0.358	0.353	0.344	0.310	0.239	0.213	0.231	0.231
1961	0.139	0.261	0.356	0.350	0.350	0.331	0.265	0.219	0.199	0.199
1962	0.125	0.260	0.368	0.355	0.355	0.350	0.294	0.234	0.187	0.187
1963	0.098	0.266	0.419	0.381	0.370	0.370	0.313	0.257	0.216	0.216
1964	0.075	0.271	0.477	0.412	0.389	0.387	0.318	0.274	0.265	0.265
1965	0.068	0.261	0.479	0.422	0.401	0.389	0.308	0.268	0.275	0.275
1966	0.078	0.241	0.419	0.403	0.399	0.380	0.292	0.243	0.236	0.236
1967	0.102	0.238	0.369	0.375	0.386	0.373	0.290	0.232	0.204	0.204
1968	0.142	0.271	0.365	0.354	0.369	0.377	0.316	0.254	0.211	0.211
1969	0.188	0.322	0.390	0.347	0.357	0.386	0.353	0.296	0.244	0.244
1970	0.210	0.345	0.408	0.360	0.361	0.387	0.367	0.324	0.280	0.280
1971	0.199	0.325	0.407	0.392	0.383	0.379	0.350	0.321	0.301	0.301
1972	0.188	0.308	0.415	0.439	0.420	0.381	0.336	0.317	0.321	0.321
1973	0.202	0.331	0.454	0.493	0.467	0.409	0.353	0.337	0.353	0.353
1974	0.243	0.379	0.501	0.534	0.506	0.446	0.386	0.367	0.383	0.383
1975	0.299	0.413	0.507	0.532	0.511	0.458	0.399	0.375	0.382	0.382
1976	0.352	0.413	0.467	0.495	0.484	0.439	0.383	0.353	0.347	0.347
1977	0.377	0.409	0.443	0.468	0.464	0.426	0.373	0.334	0.311	0.311
1978	0.353	0.433	0.483	0.485	0.478	0.452	0.397	0.343	0.299	0.299
1979	0.304	0.473	0.573	0.537	0.513	0.495	0.440	0.371	0.306	0.306
1980	0.262	0.494	0.654	0.596	0.538	0.505	0.454	0.390	0.325	0.325
1981	0.239	0.477	0.673	0.633	0.535	0.465	0.424	0.385	0.344	0.344
1982	0.237	0.445	0.638	0.641	0.524	0.424	0.384	0.365	0.349	0.349
1983	0.259	0.419	0.579	0.621	0.526	0.419	0.366	0.343	0.331	0.331
1984	0.295	0.412	0.533	0.595	0.548	0.453	0.379	0.336	0.313	0.313
1985	0.323	0.433	0.537	0.593	0.591	0.527	0.430	0.363	0.326	0.326
1986	0.323	0.478	0.596	0.623	0.650	0.628	0.519	0.431	0.379	0.379
1987	0.297	0.507	0.658	0.657	0.697	0.708	0.593	0.493	0.433	0.433
1988	0.255	0.479	0.656	0.662	0.698	0.703	0.583	0.484	0.429	0.429
1989	0.222	0.428	0.611	0.639	0.670	0.652	0.527	0.437	0.395	0.395
1990	0.214	0.413	0.587	0.612	0.654	0.642	0.507	0.423	0.400	0.400
1991	0.233	0.450	0.607	0.593	0.664	0.702	0.557	0.471	0.469	0.469
1992	0.251	0.480	0.625	0.589	0.679	0.763	0.628	0.539	0.538	0.538
1993	0.233	0.434	0.591	0.601	0.672	0.735	0.651	0.561	0.507	0.507
1994	0.191	0.366	0.553	0.628	0.651	0.657	0.630	0.540	0.422	0.422

year	age									
	1	2	3	4	5	6	7	8	9	10
1995	0.153	0.357	0.595	0.663	0.638	0.620	0.617	0.526	0.385	0.385
1996	0.131	0.433	0.764	0.700	0.648	0.658	0.627	0.534	0.419	0.419
1997	0.125	0.515	0.920	0.727	0.674	0.703	0.605	0.511	0.455	0.455
1998	0.135	0.465	0.817	0.734	0.708	0.673	0.505	0.415	0.404	0.404
1999	0.156	0.350	0.596	0.717	0.728	0.595	0.396	0.308	0.297	0.297
2000	0.171	0.304	0.495	0.676	0.701	0.546	0.355	0.254	0.210	0.210
2001	0.172	0.357	0.554	0.616	0.621	0.549	0.393	0.253	0.158	0.158
2002	0.172	0.455	0.665	0.550	0.525	0.539	0.432	0.257	0.127	0.127
2003	0.189	0.482	0.650	0.485	0.442	0.456	0.370	0.219	0.105	0.105
2004	0.218	0.420	0.522	0.422	0.371	0.339	0.255	0.158	0.087	0.087
2005	0.224	0.357	0.420	0.358	0.303	0.249	0.177	0.112	0.066	0.066
2006	0.190	0.328	0.383	0.298	0.238	0.197	0.143	0.087	0.046	0.046
2007	0.155	0.305	0.358	0.251	0.189	0.161	0.126	0.073	0.033	0.033
2008	0.148	0.261	0.302	0.222	0.160	0.131	0.109	0.063	0.026	0.026
2009	0.157	0.211	0.238	0.208	0.147	0.109	0.091	0.056	0.024	0.024
2010	0.149	0.178	0.205	0.204	0.147	0.099	0.076	0.048	0.024	0.024
2011	0.114	0.169	0.211	0.206	0.157	0.104	0.066	0.041	0.024	0.024
2012	0.090	0.174	0.234	0.210	0.168	0.114	0.062	0.036	0.024	0.024
2013	0.099	0.184	0.242	0.213	0.171	0.117	0.064	0.037	0.024	0.024
2014	0.140	0.197	0.234	0.217	0.167	0.112	0.069	0.041	0.024	0.024
2015	0.179	0.216	0.241	0.229	0.169	0.112	0.075	0.044	0.023	0.023
2016	0.160	0.240	0.287	0.254	0.186	0.123	0.075	0.041	0.020	0.020
2017	0.117	0.251	0.341	0.278	0.204	0.135	0.073	0.036	0.018	0.018
2018	0.090	0.228	0.337	0.275	0.199	0.132	0.072	0.035	0.017	0.017
2019	0.080	0.177	0.268	0.244	0.169	0.111	0.073	0.039	0.017	0.017
2020	0.076	0.128	0.190	0.205	0.134	0.086	0.075	0.045	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	477589	265152	362528	223911	150134	60466	63124	49513	31182	68065
1958	709851	389833	201292	252104	149240	105262	44279	45625	35633	73115
1959	875663	572482	285865	134082	164181	100908	74489	32104	33138	77935
1960	812141	697798	406470	183487	85749	107392	68958	53864	23461	78479
1961	862591	640794	486816	257067	116681	55004	71272	49149	39392	73244
1962	612897	679124	446444	308493	163920	74423	35730	49478	35718	83560
1963	605848	489191	473827	279520	195680	104040	47455	24096	35432	89508
1964	2471860	497104	339192	282047	172851	122320	65009	31385	16866	91043
1965	664338	2074150	342972	190411	169063	105954	75196	42784	21582	74936
1966	577369	561345	1446180	192310	113011	102436	64951	50012	29620	66359
1967	428580	483405	399139	860571	116323	68632	63380	43887	35487	68611
1968	418924	350202	344754	249836	535416	71530	42784	42910	31501	76808
1969	675320	328845	241745	216498	158678	334877	44385	28232	30124	79395
1970	677563	506340	215715	148109	138407	100422	205900	28224	18997	77621
1971	422011	496836	324605	129815	93542	87307	61729	129109	18471	66078
1972	358303	312797	324905	195417	79384	57710	54102	39370	84705	56597
1973	1430910	268639	207971	194137	113956	47176	35679	34971	25940	92762
1974	1103680	1057490	174624	119562	107245	64636	28364	22675	22598	75484
1975	793459	783294	654865	95741	63443	58532	37438	17449	14218	60502
1976	664145	532389	468857	356922	50866	34440	33487	22732	10854	46140
1977	1026960	422568	318867	266059	196876	28356	20093	20661	14451	36466
1978	873543	637479	253978	185329	150832	112059	16753	12523	13386	33760
1979	916945	555218	374006	141776	103275	84659	64532	10188	8039	31650
1980	1095220	611970	312942	190812	74952	55921	46695	37622	6363	26438
1981	1008700	762694	337888	147213	95148	39593	30545	26822	23049	21450
1982	1927830	718740	428257	156027	70738	50421	22502	18094	16515	28555
1983	1351750	1376230	416820	204705	74376	37904	29860	13870	11366	28766
1984	1291040	944009	818719	211459	99584	39771	22567	18738	8906	26068
1985	1838730	869413	565537	434665	105536	52098	22866	13980	12117	23139
1986	4434690	1204010	510170	299196	217354	52863	27832	13455	8796	23037
1987	1902910	2904700	675555	254405	145191	102636	25518	14993	7915	19716
1988	1745920	1279700	1582610	316440	119350	65462	45743	12756	8290	16210
1989	1251170	1223590	717440	742903	147756	53738	29332	23096	7113	14434
1990	1110280	907073	721887	352446	354688	68384	25325	15672	13506	13134
1991	1001720	811474	542928	363145	173002	166943	32562	13795	9289	16165
1992	839808	717979	468084	267677	181569	80589	74874	16884	7792	14410
1993	535299	590993	402127	226811	134458	83349	34015	36164	8912	11732
1994	575317	383550	346320	201485	112525	62124	36166	16044	18666	11253

year	age									
	1	2	3	4	5	6	7	8	9	10
1995	1001170	430272	240689	180318	97296	53103	29153	17422	8457	17745
1996	925946	777539	272569	120082	84042	46500	25835	14236	9316	16140
1997	2390280	734655	456099	114896	53972	39797	21796	12482	7550	15155
1998	791741	1907960	397031	164393	50255	24902	17836	10765	6775	13040
1999	714473	625754	1084870	158661	71381	22406	11494	9740	6435	11975
2000	891133	553307	398885	540915	70097	31194	11183	6999	6475	12376
2001	638896	679270	369551	220038	249012	31451	16349	7095	4912	13827
2002	1791150	486789	430128	192082	107503	121073	16439	9989	4985	14476
2003	589990	1364880	279549	200241	100318	57558	63892	9661	6989	15515
2004	1308480	441778	762934	132078	111610	58358	33006	39934	7021	18329
2005	913606	951945	262580	409750	78396	69673	37639	23133	30850	21033
2006	927631	660776	602912	156179	259059	52390	49153	28528	18713	43926
2007	1461350	694327	430713	372132	104881	184687	38944	38548	23665	54105
2008	1210210	1132120	463170	272498	261999	78539	142202	31076	32435	68098
2009	1128760	944618	788829	309792	197531	202034	62322	115405	26396	88612
2010	1501900	873162	692367	562503	227746	154292	164010	51495	98781	101587
2011	1641860	1170560	661497	510442	415237	177923	126444	137527	44412	177034
2012	1334070	1324980	894869	484502	375985	321211	145084	107054	119485	195620
2013	1389650	1102860	1007640	640583	355266	287464	259243	123365	93419	278278
2014	1460730	1139330	829946	715873	468327	270905	231357	220094	107584	328208
2015	911173	1149000	846304	594421	521530	358715	219106	195304	191120	384957
2016	952119	689096	837781	601528	427881	398629	290315	184005	169139	509616
2017	1314950	734071	490516	568903	422198	321487	319096	243702	159854	601931
2018	862519	1058220	516620	315584	390004	311515	254141	268448	212670	677106
2019	2147830	713098	762619	333663	216867	289150	247106	214060	234510	791772
2020	1390640	1794520	540325	527815	236439	165636	234226	207947	186365	913237

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	477589	342242.0	79036.17	71457.35	7579	0.242	0.201	0.095	0.21
1958	709851	354957.3	88179.41	73694.47	14485	0.277	0.202	0.172	0.21
1959	875663	362346.4	103825.90	77266.75	26559	0.308	0.196	0.210	0.21
1960	812141	381625.8	118124.88	88881.96	29243	0.325	0.239	0.201	0.23
1961	862591	393621.2	121275.42	86158.12	35117	0.330	0.222	0.258	0.22
1962	612897	483269.9	126872.45	90557.01	36315	0.338	0.214	0.260	0.19
1963	605848	441065.8	139097.23	102495.22	36602	0.361	0.226	0.308	0.23
1964	2471860	431487.8	146393.16	110614.37	35779	0.387	0.247	0.270	0.26
1965	664338	385724.5	153390.84	106798.10	46593	0.390	0.276	0.267	0.28
1966	577369	404834.3	164484.09	99111.31	65373	0.368	0.230	0.294	0.24
1967	428580	472633.7	152056.81	102239.15	49818	0.348	0.203	0.250	0.22
1968	418924	459737.7	147671.06	119515.48	28156	0.347	0.221	0.215	0.26
1969	675320	404958.2	146736.78	123290.55	23446	0.361	0.262	0.181	0.30
1970	677563	373089.9	141874.70	115928.55	25946	0.372	0.270	0.228	0.31
1971	422011	360246.0	143335.53	118807.90	24528	0.377	0.283	0.217	0.33
1972	358303	361648.7	144405.02	126218.90	18186	0.393	0.317	0.164	0.35
1973	1430910	300940.7	146255.33	128782.16	17473	0.431	0.382	0.113	0.43
1974	1103680	302185.2	160410.84	116054.04	44357	0.473	0.394	0.191	0.38
1975	793459	306688.5	174911.26	99485.29	75426	0.484	0.319	0.375	0.32
1976	664145	328091.6	179908.39	125126.13	54782	0.459	0.332	0.276	0.38
1977	1026960	323400.3	160775.42	105045.49	55730	0.442	0.290	0.275	0.32
1978	873543	324663.5	170763.21	123013.06	47750	0.466	0.353	0.232	0.38
1979	916945	305422.1	173685.72	120974.82	52711	0.518	0.375	0.280	0.40
1980	1095220	323063.1	191527.23	155898.28	35629	0.557	0.490	0.163	0.48
1981	1008700	290623.8	188425.91	153720.12	34706	0.557	0.490	0.160	0.53
1982	1927830	280775.2	192238.15	145297.29	46941	0.534	0.456	0.187	0.52
1983	1351750	334268.6	207560.10	140903.91	66656	0.513	0.417	0.225	0.42
1984	1291040	363589.8	221523.66	158217.56	63306	0.508	0.385	0.214	0.44
1985	1838730	396845.2	246113.16	180927.63	65186	0.536	0.447	0.217	0.46

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1986	4434690	415131.3	291872.08	172536.27	119336	0.595	0.457	0.278	0.42
1987	1902910	474638.4	322437.30	161323.16	161114	0.645	0.466	0.438	0.34
1988	1745920	416753.0	309030.60	165064.90	143966	0.639	0.403	0.445	0.40
1989	1251170	441587.5	280002.20	181001.97	99000	0.600	0.395	0.391	0.41
1990	1110280	398656.6	247035.63	171565.86	75470	0.581	0.408	0.365	0.43
1991	1001720	365521.0	227780.74	152935.84	74845	0.603	0.409	0.385	0.42
1992	839808	315454.2	199798.75	139008.83	60790	0.627	0.437	0.363	0.44
1993	535299	277411.4	172998.11	136970.43	36028	0.607	0.484	0.257	0.49
1994	575317	233483.3	142756.26	119822.02	22934	0.571	0.489	0.195	0.51
1995	1001170	229063.2	132362.84	109581.79	22781	0.575	0.503	0.171	0.48
1996	925946	214554.6	140475.15	98561.90	41913	0.640	0.508	0.302	0.46
1997	2390280	213890.4	160368.86	85793.69	74575	0.708	0.483	0.553	0.40
1998	791741	241452.4	165705.00	72027.43	93678	0.679	0.403	0.516	0.30
1999	714473	228090.0	162327.70	92833.91	69494	0.597	0.380	0.345	0.41
2000	891133	249438.2	150193.87	103515.09	46679	0.544	0.388	0.277	0.41
2001	638896	255574.2	131986.09	68336.69	63649	0.539	0.276	0.372	0.27
2002	1791150	243596.5	144076.95	87845.65	56231	0.547	0.358	0.397	0.36
2003	589990	273685.9	148008.80	72743.61	75265	0.503	0.308	0.393	0.27
2004	1308480	268931.4	137137.77	80616.44	56521	0.415	0.256	0.332	0.30
2005	913606	299784.3	115413.30	61893.42	53520	0.337	0.175	0.297	0.21
2006	927631	340644.9	112416.30	62340.15	50076	0.289	0.166	0.264	0.18
2007	1461350	353441.9	103987.46	59192.10	44795	0.253	0.131	0.252	0.17
2008	1210210	449571.5	110889.71	63540.60	47349	0.215	0.133	0.188	0.14
2009	1128760	551533.9	112732.80	67811.58	44921	0.182	0.107	0.162	0.12
2010	1501900	673527.0	115935.01	73004.46	42931	0.166	0.097	0.136	0.11
2011	1641860	700043.3	117974.13	73322.40	44652	0.169	0.089	0.139	0.10
2012	1334070	747104.1	129994.05	80945.77	49048	0.180	0.093	0.164	0.11
2013	1389650	850183.8	137796.16	95152.64	42644	0.186	0.104	0.167	0.11
2014	1460730	977691.8	135224.16	84663.02	50561	0.185	0.083	0.183	0.09

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
2015	911173	905332.3	136029.67	90930.29	45099	0.193	0.090	0.198	0.10
2016	952119	966389.0	137035.81	89218.44	47817	0.218	0.095	0.227	0.09
2017	1314950	1019256.6	131797.52	87326.24	44471	0.242	0.102	0.250	0.09
2018	862519	959080.3	105586.44	61364.66	44222	0.234	0.090	0.246	0.06
2019	2147830	871071.1	95232.79	56444.66	38788	0.194	0.078	0.182	0.06
2020	1390640	905056.2	82933.60	44068.05	38866	0.149	0.058	0.136	0.05

Table 13.5.1. Plaice in Subarea 4 and Subdivision 20: Input to the short-term forecast (F values presented are for Fsq).

2021_ssb	2021_f2–6	2021_f_dis2–3	2021_f_hc2–6	2021_recruits	2021_landings	2021_discards	2021_catch	2021_TAC	2022_ssb		
1002918	0.149	0.145	0.058	1263949	51458	46140	97598		1093696		
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
1	2021	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263948.79436245	0.052054735774307	0.126	0.052	0.028	0	0.1
2	2021	0.13760020251068	0.132518831229392	0.0050813712812881	1166596.42728568	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1
3	2021	0.205331168973982	0.1579625008625	0.0473686681114822	1428408.05615736	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1
4	2021	0.187068911922825	0.0979112196481534	0.0891576922746715	404108.663304055	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1
5	2021	0.129824653290575	0.0457084503639847	0.08411620292659	388937.959410118	0.257906483342958	0.319	0.147	0.221	1	0.1
6	2021	0.0847783633019378	0.0202659510484261	0.0645124122535117	187037.895591254	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1
7	2021	0.0564456719734424	0.0107976905106002	0.0456479814628422	137490.979267804	0.354707238403159	0.401	0.157	0.334	1	0.1
8	2021	0.0306326343248842	0.00337389106324375	0.0272587432616404	196707.855535053	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1
9	2021	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	179880.247809606	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1
10	2021	0.0130794435706331	1.40236432406562e-06	0.0130780412063091	977909.446378149	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1
1	2022	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263949	0.052054735774307	0.126	0.052	0.028	0	0.1
2	2022	0.13760020251068	0.132518831229392	0.0050813712812881	NA	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1
3	2022	0.205331168973982	0.1579625008625	0.0473686681114822	NA	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1
4	2022	0.187068911922825	0.0979112196481534	0.0891576922746715	NA	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1
5	2022	0.129824653290575	0.0457084503639847	0.08411620292659	NA	0.257906483342958	0.319	0.147	0.221	1	0.1
6	2022	0.0847783633019378	0.0202659510484261	0.0645124122535117	NA	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1
7	2022	0.0564456719734424	0.0107976905106002	0.0456479814628422	NA	0.354707238403159	0.401	0.157	0.334	1	0.1
8	2022	0.0306326343248842	0.00337389106324375	0.0272587432616404	NA	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1
9	2022	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	NA	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1
10	2022	0.0130794435706331	1.40236432406562e-06	0.013078041206309	NA	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1
1	2023	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263949	0.052054735774307	0.126	0.052	0.028	0	0.1
2	2023	0.13760020251068	0.132518831229392	0.0050813712812881	NA	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1
3	2023	0.205331168973982	0.1579625008625	0.0473686681114822	NA	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1

2021_ssb	2021_f2–6	2021_f_dis2–3	2021_f_hc2–6	2021_recruits	2021_landings	2021_discards	2021_catch	2021_TAC	2022_ssb		
1002918	0.149	0.145	0.058	1263949	51458	46140	97598		1093696		
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**
4	2023	0.187068911922825	0.0979112196481534	0.0891576922746715	NA	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1
5	2023	0.129824653290575	0.0457084503639847	0.08411620292659	NA	0.257906483342958	0.319	0.147	0.221	1	0.1
6	2023	0.0847783633019378	0.0202659510484261	0.0645124122535117	NA	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1
7	2023	0.0564456719734424	0.0107976905106002	0.0456479814628422	NA	0.354707238403159	0.401	0.157	0.334	1	0.1
8	2023	0.0306326343248842	0.00337389106324375	0.0272587432616404	NA	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1
9	2023	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	NA	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1
10	2023	0.0130794435706331	1.40236432406562e-06	0.013078041206309	NA	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1

Table 13.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short-term forecast assuming $F_{2021} = F_{\text{-status quo}}$ (rescaled).

Basis	Total catch (2022)	Projected landings * (2022)	Projected discards ** (2022)	F_{total} ages 2–6 ^^^ (2022)	$F_{projected\ landings}$ ages 2–6 (2022)	$F_{projected\ discards}$ ages 2–3 (2022)	SSB (2023)	% SSB change ***	% advice change ^^
ICES advice basis									
MSY approach: F_{MSY}	142508	82622	59886	0.21	0.082	0.20	1112676	1.74	-15.1
Other scenarios									
F =$F_{MSY\ upper}$	195622	113764	81858	0.30	0.117	0.29	1063091	-2.8	16.6
F = $F_{MSY\ lower}$	101854	58940	42914	0.146	0.057	0.142	1150784	5.2	-39
F = 0	0	0	0	0.00	0.00	0.00	1247700	14.1	-100
F_{pa}	411268	243345	167923	0.77	0.30	0.75	864628	-21	145
~~$F_{p.05}$ without AR~~	~~263213~~	~~153754~~	~~109459~~	~~0.427~~	~~0.166~~	~~0.42~~	~~1000256~~	~~-8.5~~	~~57~~
~~F_{lim}~~	~~306148~~	~~179427~~	~~126721~~	~~0.516~~	~~0.20~~	~~0.50~~	~~960638~~	~~-12.2~~	~~82~~
SSB (2023) = B_{lim}	1198527	860596	337931	11.3	4.4	11.0	207288	-81	610
SSB (2023) = B_{pa}	1093596	759527	334069	7.8	3.0	7.6	290203	-73	550
SSB (2023) = MSY $B_{trigger}$	753542	470359	283183	2.3	0.91	2.3	564599	-48	350
Rollover advice	167785	97392	70393	0.25	0.098	0.25	1089081	-0.42	0
$F_{2022} = F_{2021}$	103816	60080	43736	0.149	0.058	0.145	1148941	5.1	-38

*** "projected" landing and discards 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 2018–2020. Both projected landing and projected discards refer to Subarea 4 and Subdivision 20, calculated as the projected total stock catch (including Division 7.d) deducted by the catch of plaice from Subarea 4 taken in Division 7.d in 2022. The subtracted value (445 t of projected landing and 530 t of projected discards) is estimated based on the plaice catch advice for Division 7.d for 2022.**

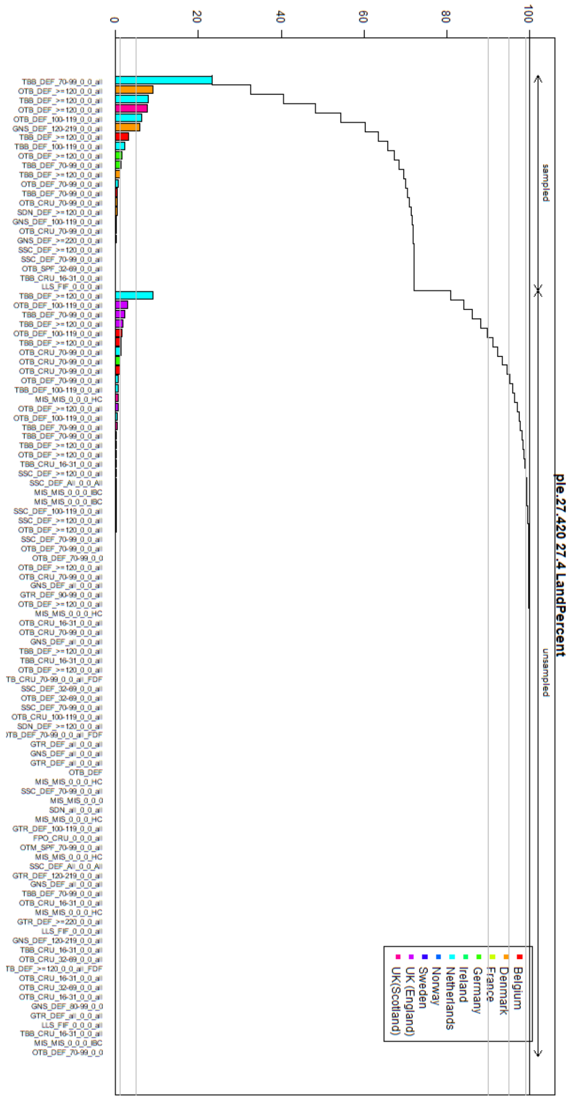
*** Marketable landings.**

Table 13.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming $F_{2021} = F_{\text{-status quo}}$, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	landings.n	discards.n
1	2021	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263948.79436245	0.052054735774307	0.126	0.052	0.028	0	0.1	73916	28	73888
2	2021	0.13760020251068	0.132518831229392	0.0050813712812881	1166596.42728568	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1	142878	5276	137602
3	2021	0.205331168973982	0.1579625008625	0.0473686681114822	1428408.05615736	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1	252750	58308	194442
4	2021	0.187068911922825	0.0979112196481534	0.0891576922746715	404108.663304055	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1	65713	31319	34394
5	2021	0.129824653290575	0.0457084503639847	0.08411620292659	388937.959410118	0.257906483342958	0.319	0.147	0.221	1	0.1	45111	29229	15883
6	2021	0.0847783633019378	0.0202659510484261	0.0645124122535117	187037.895591254	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1	14478	11017	3461
7	2021	0.0564456719734424	0.0107976905106002	0.0456479814628422	137490.979267804	0.354707238403159	0.401	0.157	0.334	1	0.1	7184	5810	1374
8	2021	0.0306326343248842	0.00337389106324375	0.0272587432616404	196707.855535053	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1	5649	5027	622
9	2021	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	179880.247809606	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1	2225	2224	0
10	2021	0.0130794435706331	1.40236432406562e-06	0.0130780412063091	977909.446378149	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1	12094	12093	1
1	2022	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263949	0.052054735774307	0.126	0.052	0.028	0	0.1	73916	28	73888
2	2022	0.13760020251068	0.132518831229392	0.0050813712812881	1073423.35212914	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1	131467	4855	126612
3	2022	0.205331168973982	0.1579625008625	0.0473686681114822	919882.1364693	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1	162769	37550	125219
4	2022	0.187068911922825	0.0979112196481534	0.0891576922746715	1052564.33198777	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1	171161	81576	89585
5	2022	0.129824653290575	0.0457084503639847	0.08411620292659	303267.392075142	0.257906483342958	0.319	0.147	0.221	1	0.1	35175	22791	12384
6	2022	0.0847783633019378	0.0202659510484261	0.0645124122535117	309078.469181684	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1	23925	18206	5719
7	2022	0.0564456719734424	0.0107976905106002	0.0456479814628422	155482.453067496	0.354707238403159	0.401	0.157	0.334	1	0.1	8124	6570	1554
8	2022	0.0306326343248842	0.00337389106324375	0.0272587432616404	117579.257447241	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1	3376	3005	372
9	2022	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	172619.029897456	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1	2135	2135	0
10	2022	0.0130794435706331	1.40236432406562e-06	0.013078041206309	1033998.48184487	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1	12787	12786	1

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	landings.n	discards.n
1	2023	0.0633878483001354	0.0633639062645193	2.39420356161043e-05	1263949	0.052054735774307	0.126	0.052	0.028	0	0.1	73916	28	73888
2	2023	0.13760020251068	0.132518831229392	0.0050813712812881	1073423.52676924	0.0879775846510634	0.242666666666667	0.082	0.0616666666666667	0.5	0.1	131467	4855	126612
3	2023	0.205331168973982	0.1579625008625	0.0473686681114822	846413.501188268	0.151879960232242	0.260333333333333	0.119333333333333	0.115666666666667	0.5	0.1	149769	34551	115218
4	2023	0.187068911922825	0.0979112196481534	0.0891576922746715	677842.107027169	0.206148271618396	0.283666666666667	0.135	0.167	1	0.1	110226	52534	57692
5	2023	0.129824653290575	0.0457084503639847	0.08411620292659	789907.440596167	0.257906483342958	0.319	0.147	0.221	1	0.1	91618	59362	32257
6	2023	0.0847783633019378	0.0202659510484261	0.0645124122535117	240998.388116879	0.30805714153338	0.359	0.149333333333333	0.261666666666667	1	0.1	18655	14196	4459
7	2023	0.0564456719734424	0.0107976905106002	0.0456479814628422	256933.379338993	0.354707238403159	0.401	0.157	0.334	1	0.1	13425	10857	2568
8	2023	0.0306326343248842	0.00337389106324375	0.0272587432616404	132965.169606823	0.420562832660396	0.452333333333333	0.171666666666667	0.369333333333333	1	0.1	3818	3398	421
9	2023	0.0130794435706331	1.41232803661026e-06	0.0130780312425965	103180.512549431	0.464635376037072	0.464666666666667	0.179	0.417	1	0.1	1276	1276	0
10	2023	0.0130794435706331	1.40236432406562e-06	0.013078041206309	1077605.6148818	0.594833927777538	0.5948981792046	0	0.499404488100942	1	0.1	13327	13325	1

(a)


ple.27.420 27.4 LandPercent
sampled
unsampled
0
20
40
60
80
100
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(b)

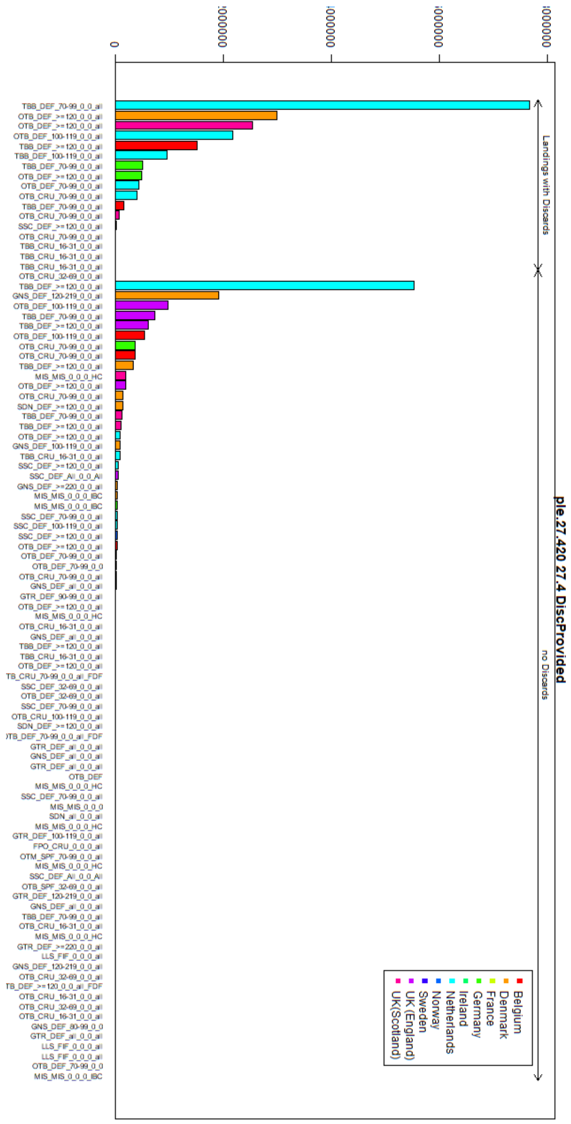
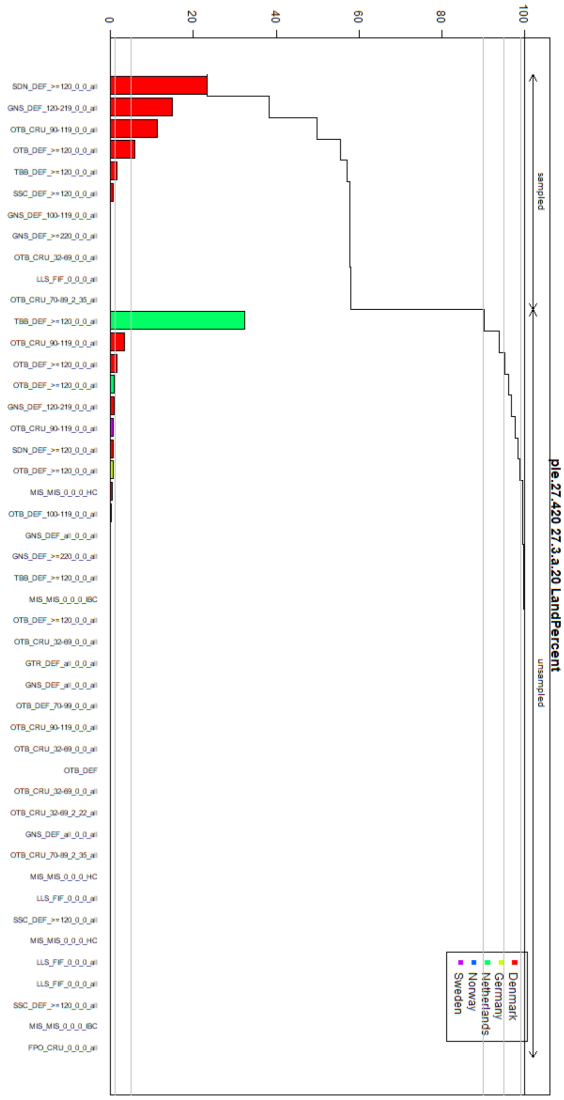


Figure 13.2.1. Summary of data upload in Intercatch for Subarea 4: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

(a)



ple.27.420 27.3.a.20 LandPercent
sampled
unsampled
0
20
40
60
80
100
Denmark
Germany
Netherlands
Norway
Sweden
SDN_DEF_>=120_0_0_all
GNS_DEF_120-219_0_0_all
OTB_CRU_90-119_0_0_all
OTB_DEF_>=120_0_0_all
TBB_DEF_>=120_0_0_all
SSC_DEF_>=120_0_0_all
GNS_DEF_100-119_0_0_all
GNS_DEF_>=220_0_0_all
OTB_CRU_32-69_0_0_all
LLS_FIF_0_0_0_all
OTB_CRU_70-89_2_35_all
TBB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
OTB_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
GNS_DEF_120-219_0_0_all
OTB_CRU_90-119_0_0_all
SDN_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
OTB_DEF_100-119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_>=220_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_IBC
OTB_DEF_>=120_0_0_all
OTB_CRU_32-69_0_0_all
GTR_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_DEF_70-99_0_0_all
OTB_CRU_90-119_0_0_all
OTB_CRU_32-69_0_0_all
OTB_DEF
OTB_CRU_32-69_0_0_all
OTB_CRU_32-69_2_22_all
GNS_DEF_all_0_0_all
OTB_CRU_70-89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
SSC_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
LLS_FIF_0_0_0_all
SSC_DEF_>=120_0_0_all
MIS_MIS_0_0_0_IBC
FPO_CRU_0_0_0_all

(b)

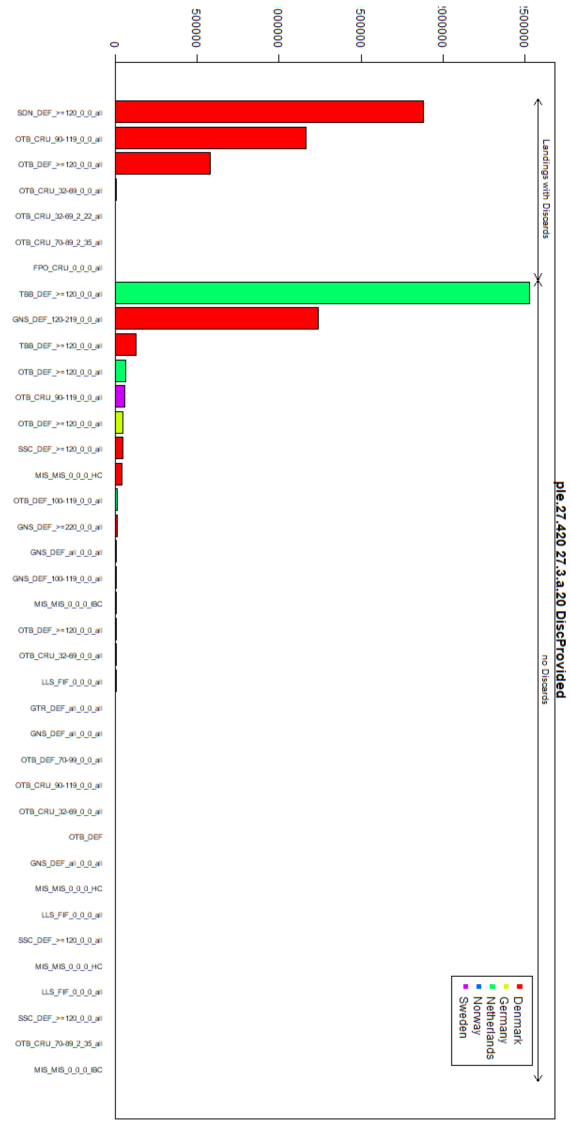


Figure 13.2.2. Summary of data upload in Intercatch for Subdivision 20: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

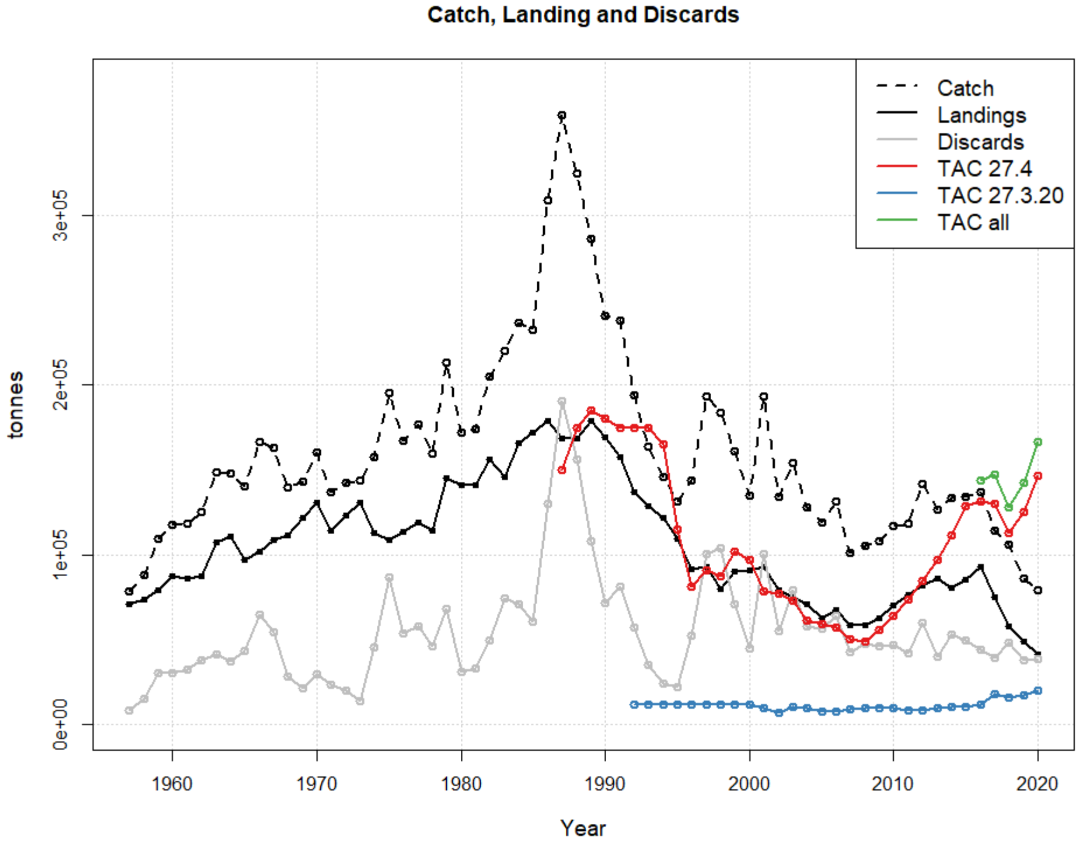


Figure 13.2.3. Plaice in Subarea 4 (including Subdivision 20 and 7.d Q1): Time series of catch (dashed line), landings (solid black line) and discards (gray line) estimates. TAC for Subarea 4 (red) , Subdivision 20 (blue) and combined area (green) are also plotted,. Discards before 2000 were reconstructed using a model-based method. Landing TAC was given before 2019 and catch TAC was given since 2019.

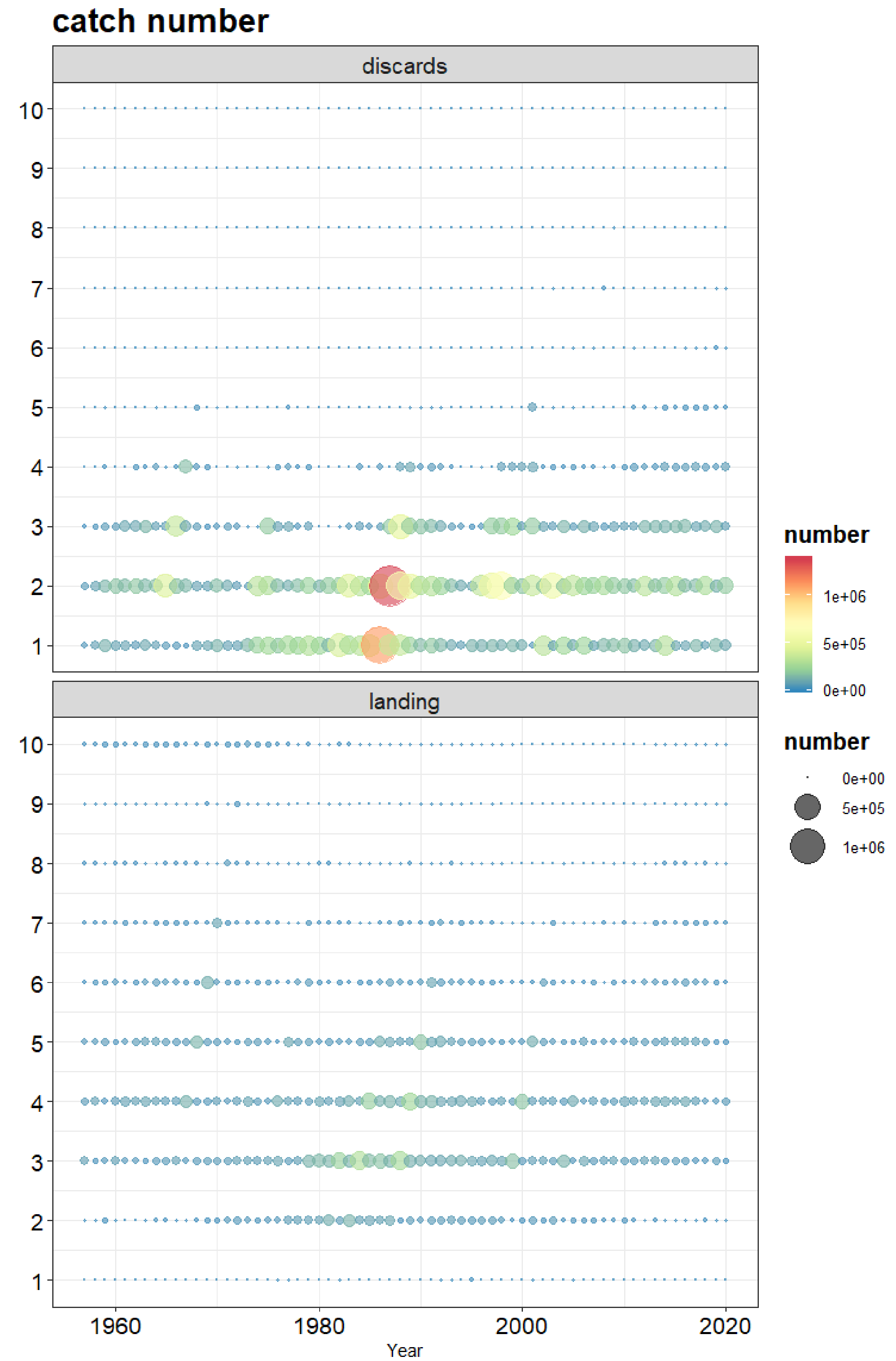


Figure 13.2.4. Plaice in Subarea 4 and Subdivision 20: Discards numbers-at-age (top) and landings numbers-at-age (down). Discards before 2000 were reconstructed using a model-based method.

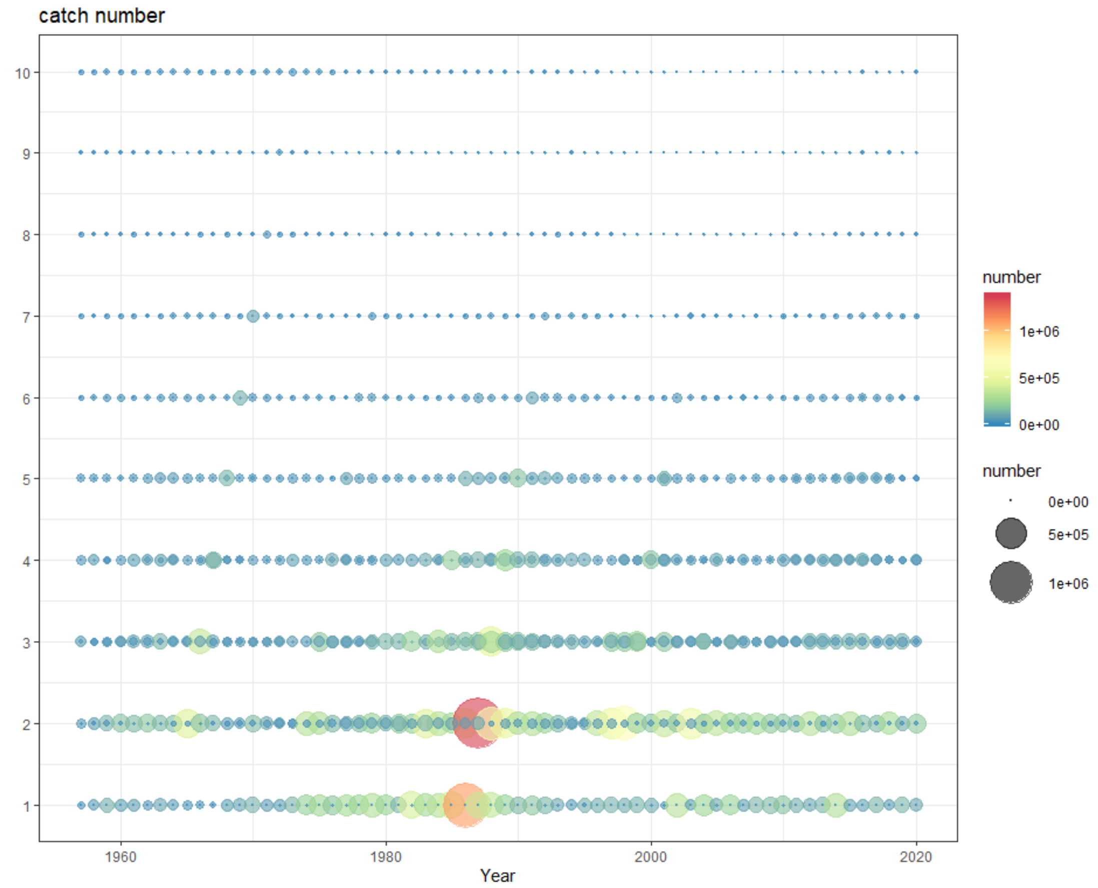


Figure 13.2.5. Plaice in Subarea 4 and Subdivision 20. Catch numbers-at-age: Discards before 2000 were reconstructed using a model-based method.

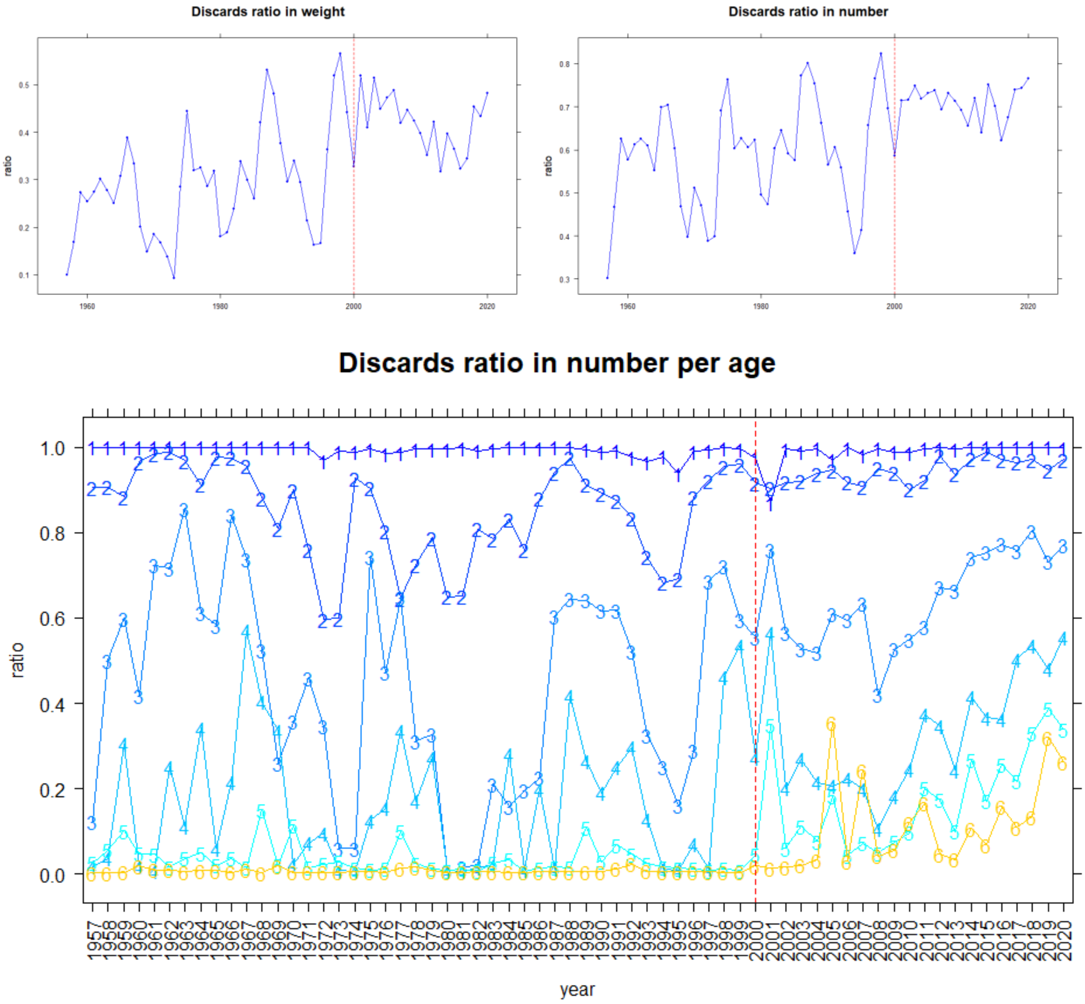


Figure 13.2.6. Discards ratio. Discards before 2000 were reconstructed using a model-based method.

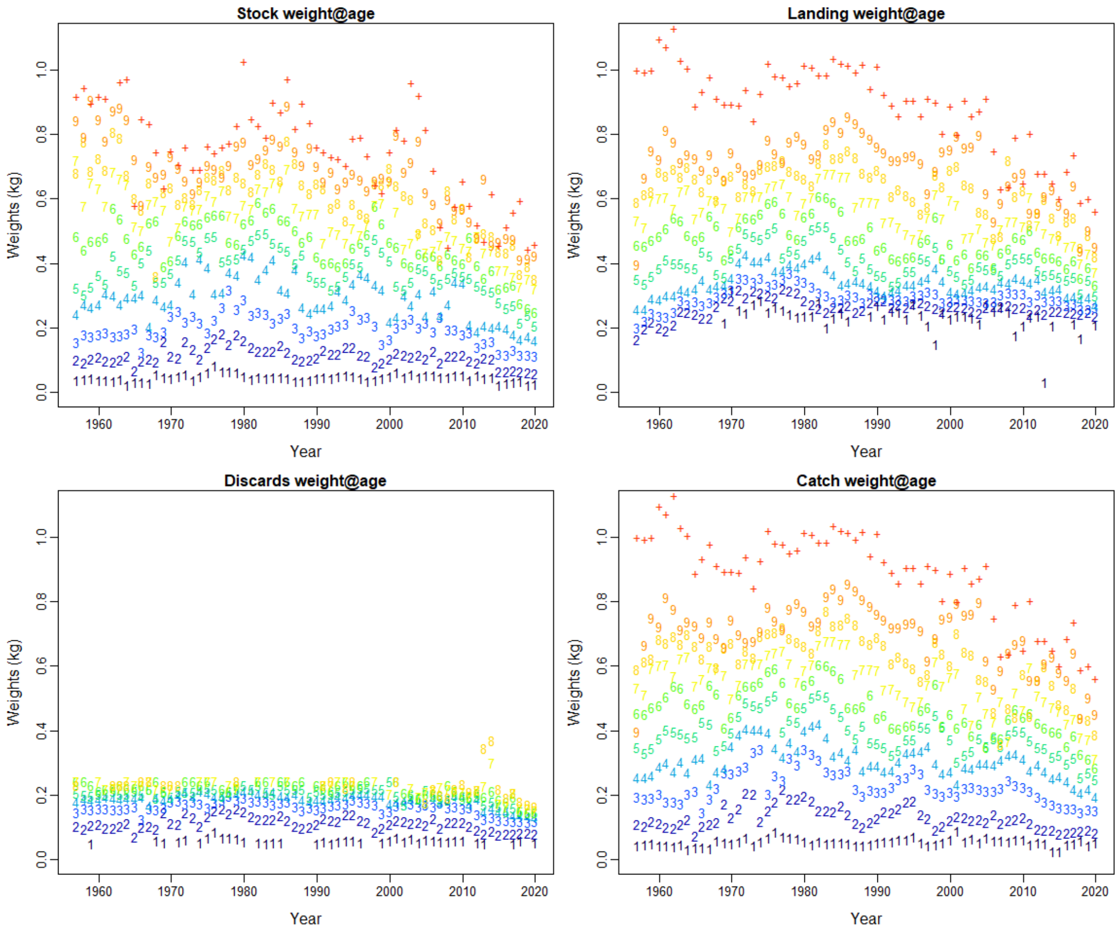


Figure 13.2.7. Plaice in Subarea 4 and Subdivision 20: Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

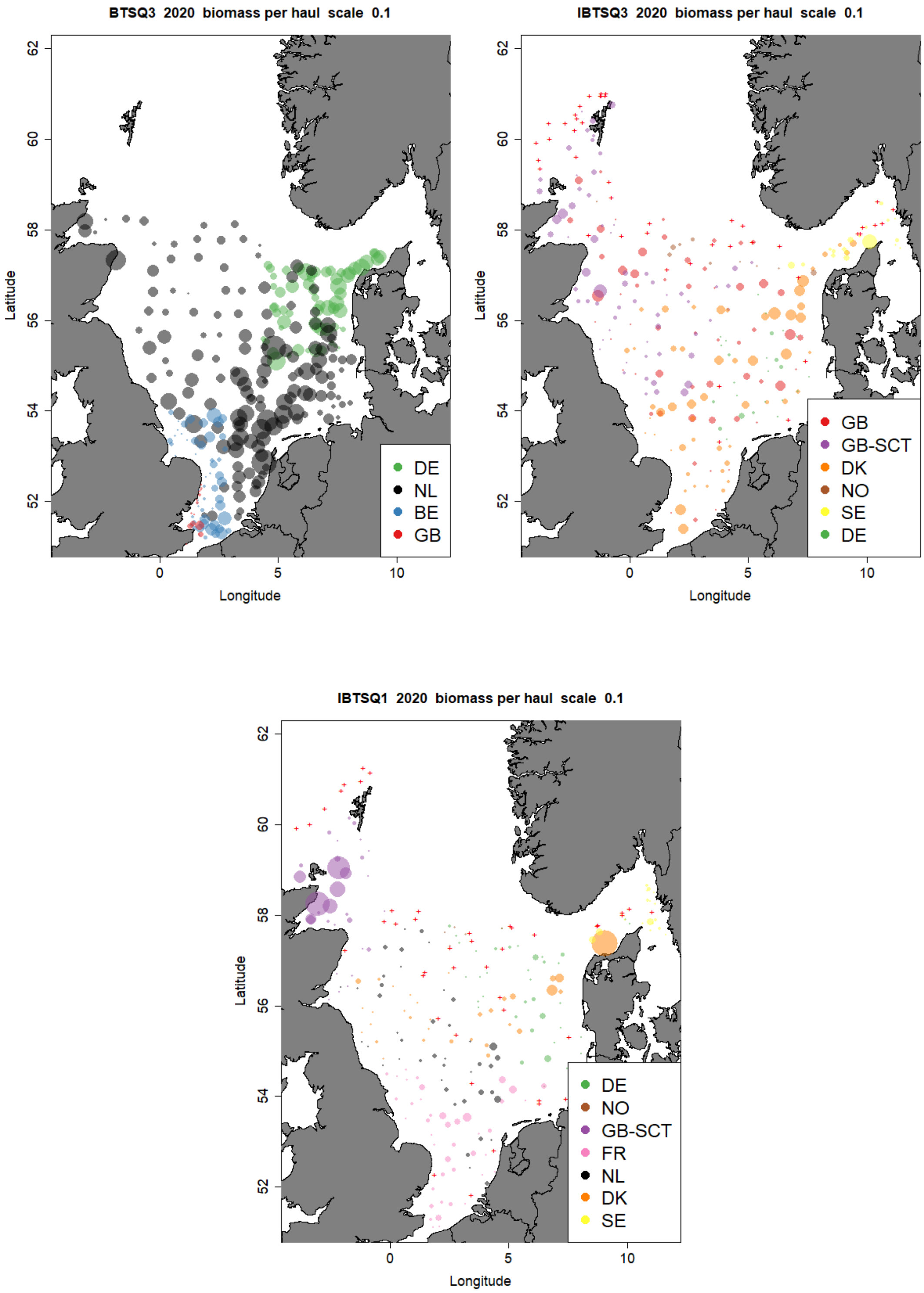
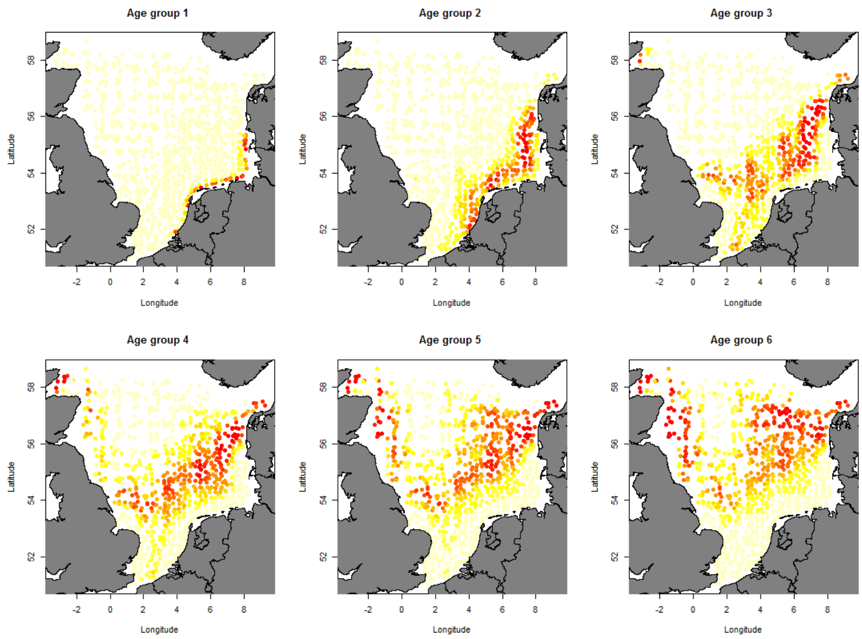
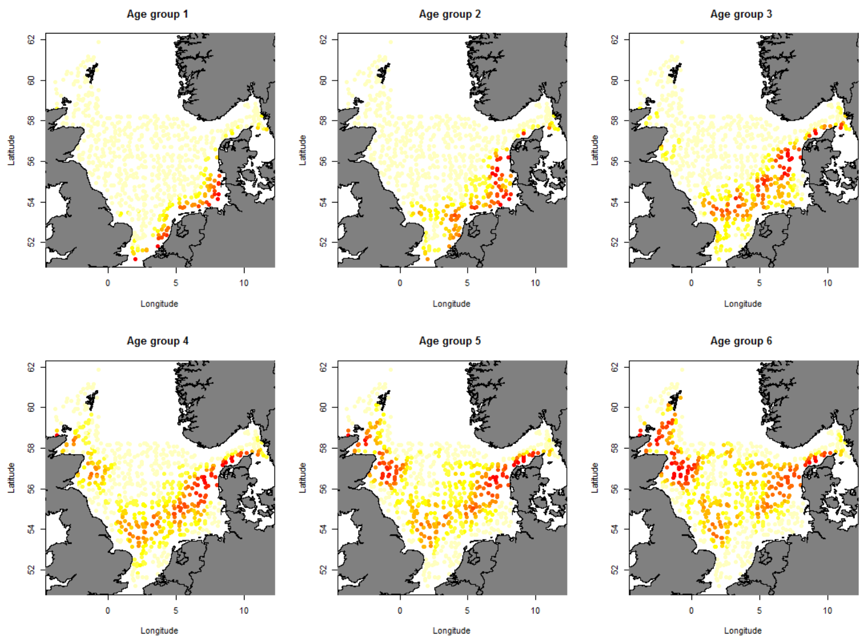


Figure 13.2.8. Spatial distribution of biomass per haul for BTS-Q3, IBTS-Q3 and IBTS-Q1 surveys in 2020. Indices for these 3 surveys were extracted using the delta-GAM method. Samples in grey area were excluded due to low coverage.

(a) BTS-Q3



(b) IBTS-Q3



(c) IBTS-Q1

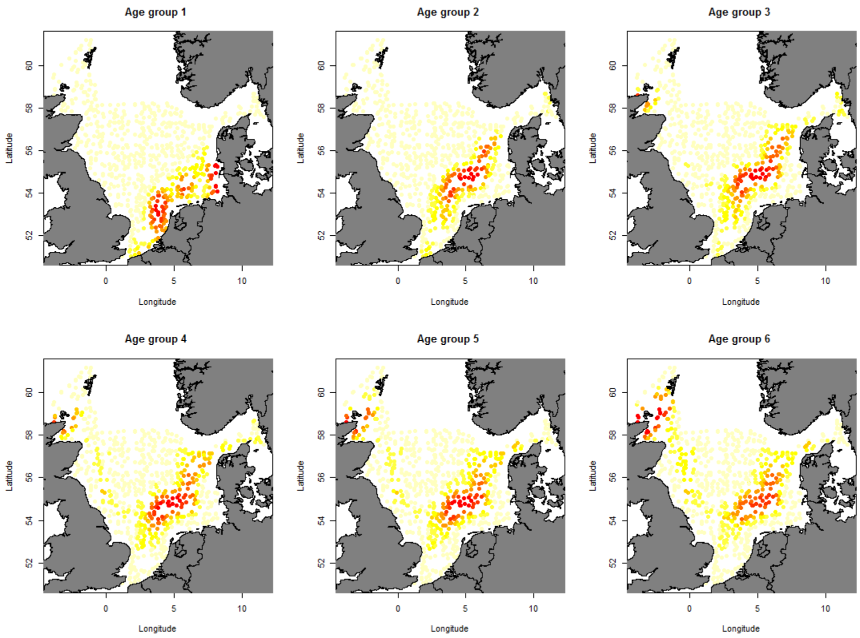


Figure 13.2.9. The estimated spatial age distribution for (a) BTS-Q3, (b) IBTS-Q3 and (c) IBTS-Q1, estimated using delta-GAM method. Age group 1–6 refers to age 0–5. Abundance decreasing from red to white colour.

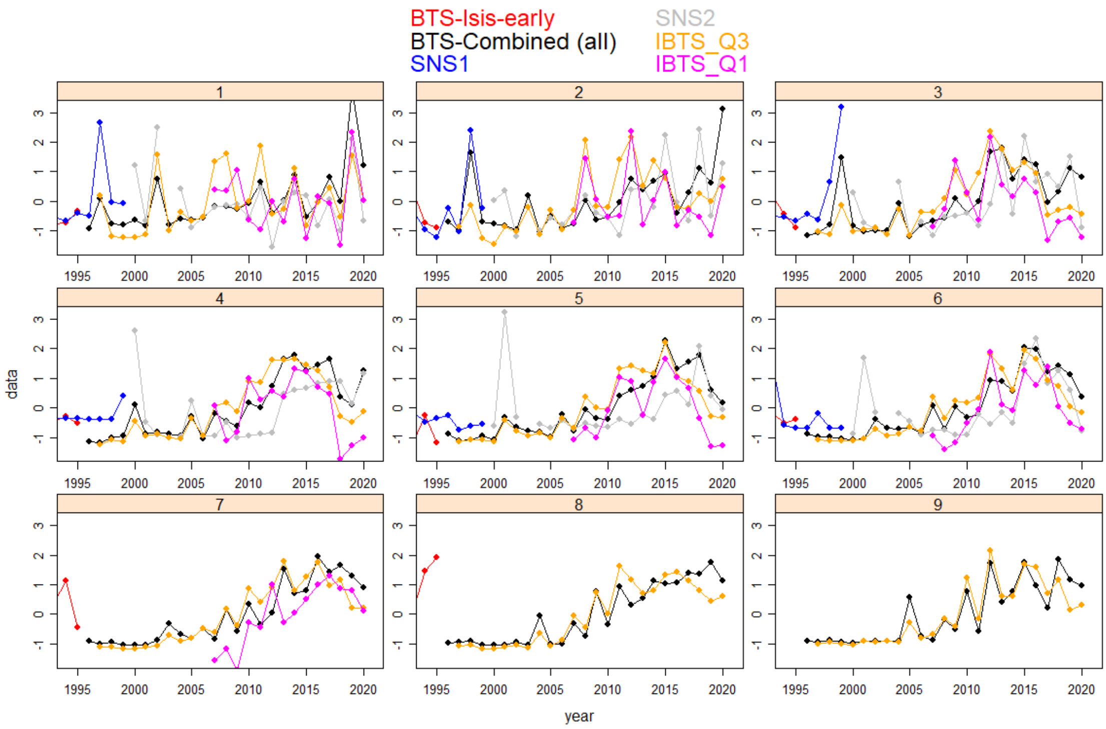


Figure 13.2.10. Plaice in Subarea 4 and Subdivision 20. Standardized survey tuning indices used for tuning stock assessment model: BTS–combined (1996–2020, black), BTS–Isis-early (1985–1995, red) SNS–1 (1970–1999, blue), SNS–2 (2000–2020, grey), IBTS–Q3 (1997–2020, yellow) and IBTS–Q1 (2007-2020, pink). Note: only ages used in the assessment are presented. The BTS–combined index combines BTS–Tridens and BTS–Isis indices.

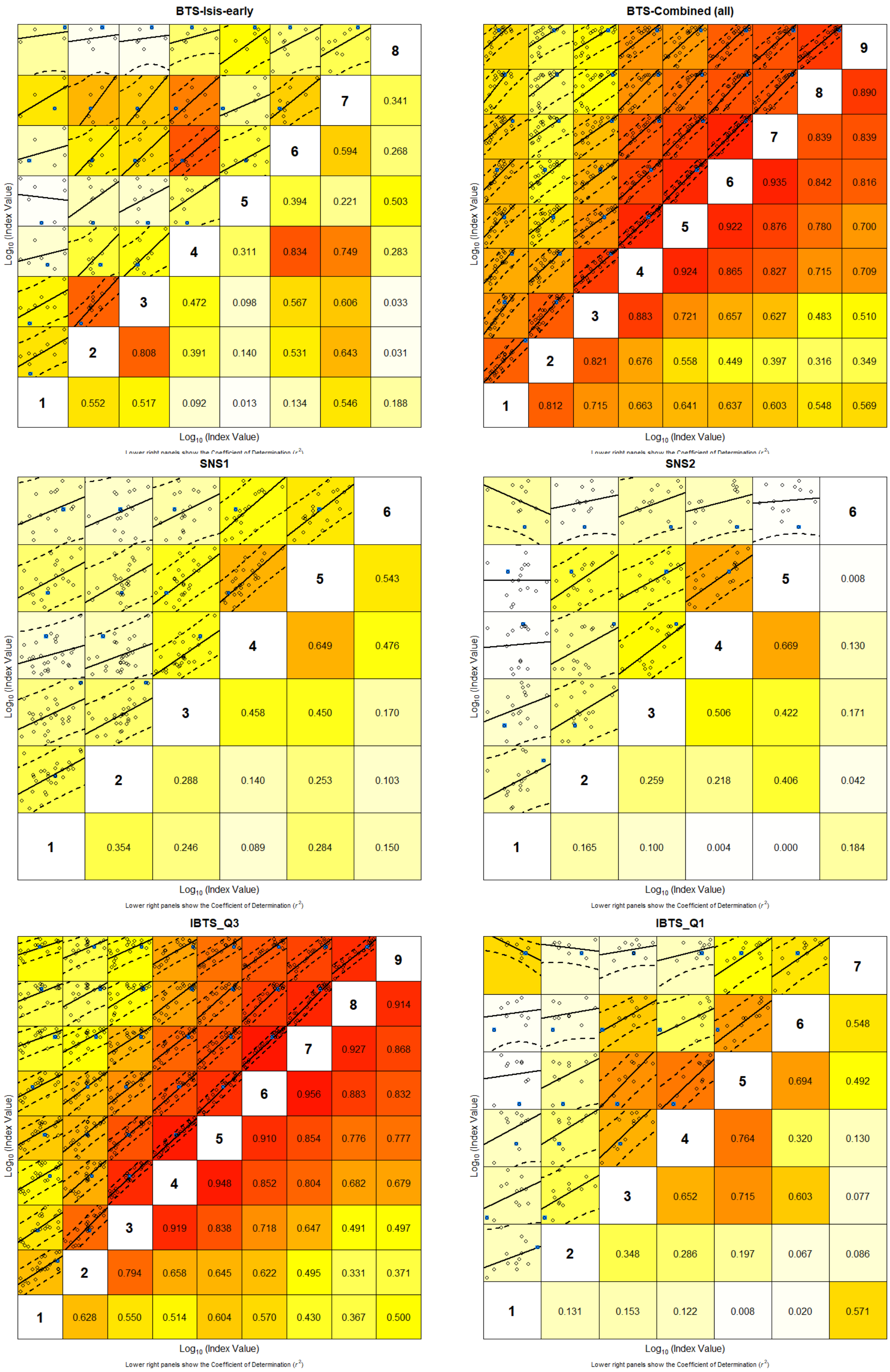


Figure 13.2.11. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for surveys.

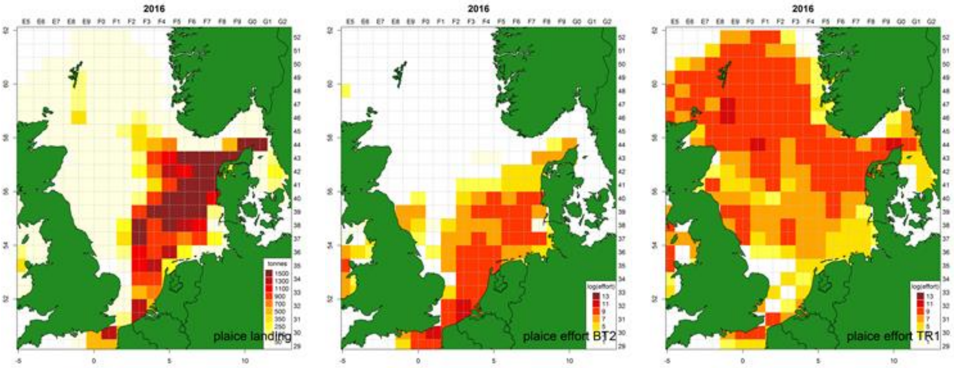


Figure 13.2.12. (a) Spatial distribution (by ICES rectangle) of landed plaice in 2016; (b) Spatial distribution of log-transformed TB2 fishing effort in 2016; (c) Spatial distribution of log-transformed TR1 fishing effort in 2016. Data were extracted from STECF FDI dataset. TB2 and TR1 are the two major gears in catching plaice in North Sea.

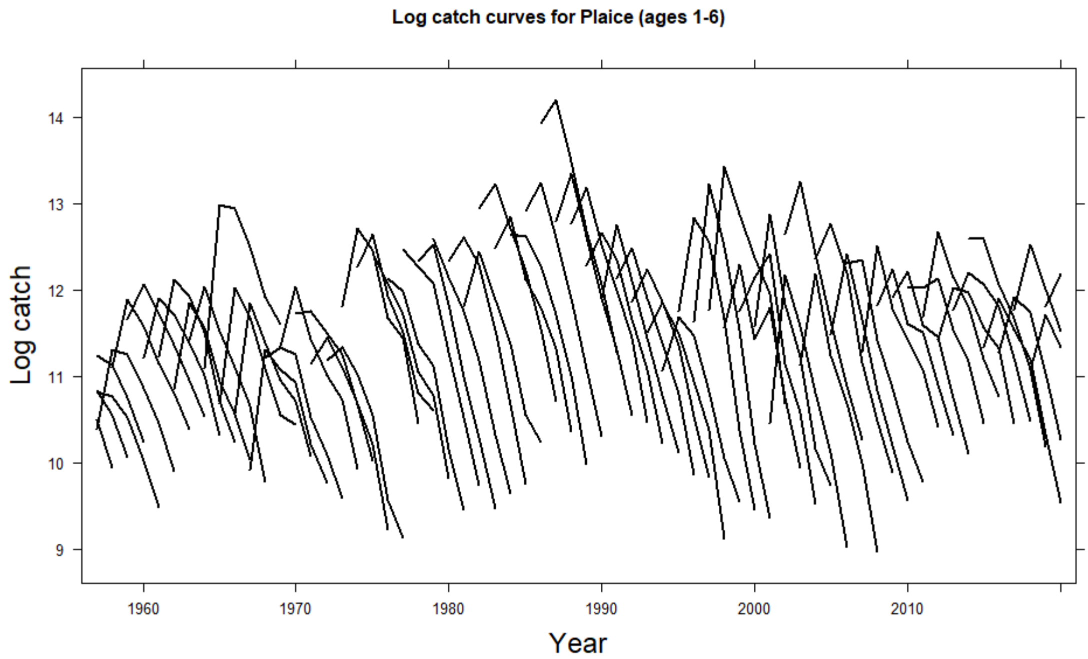


Figure 13.2.13. Catch curves for catches in age 1–6.

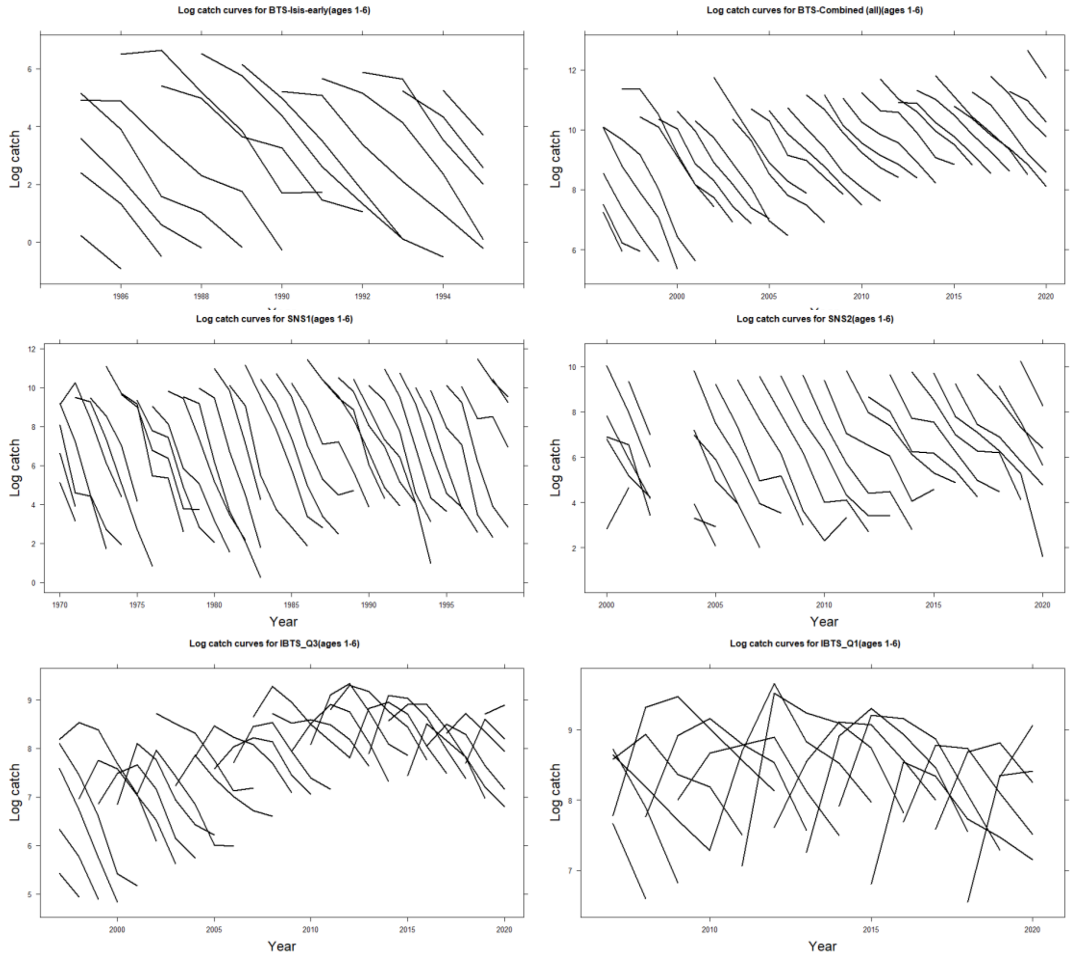
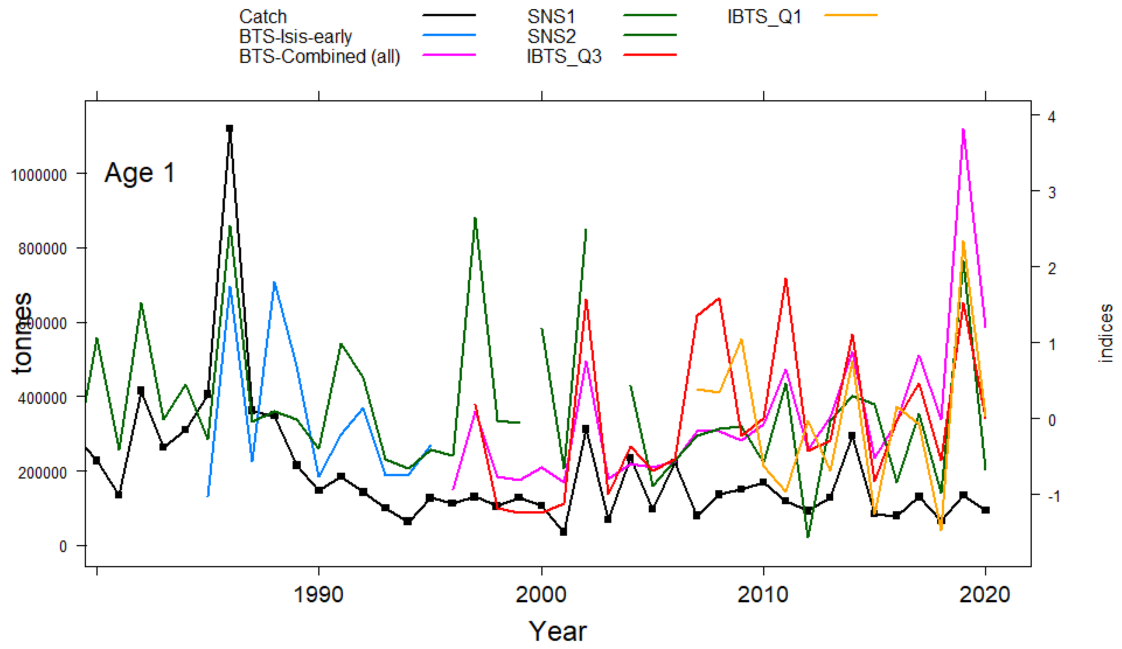
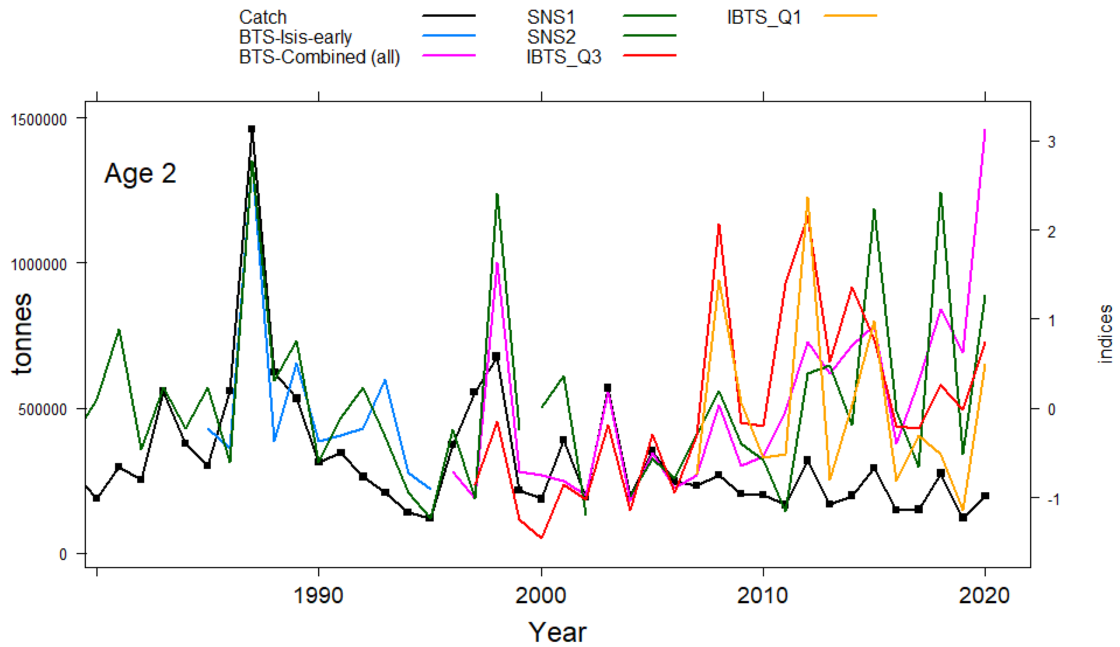
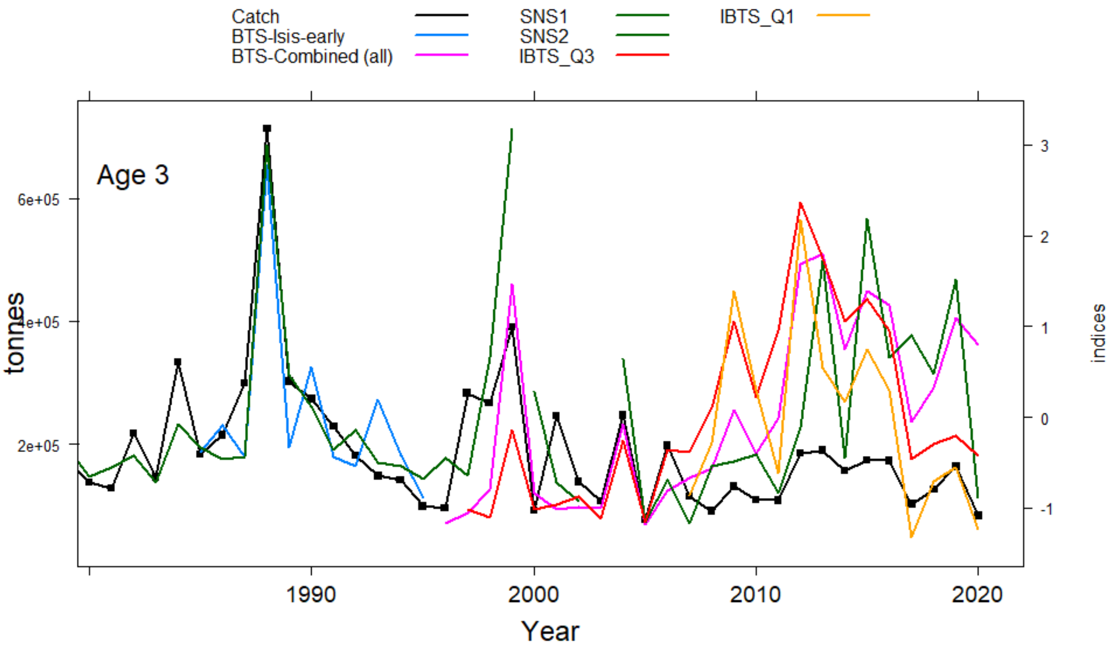
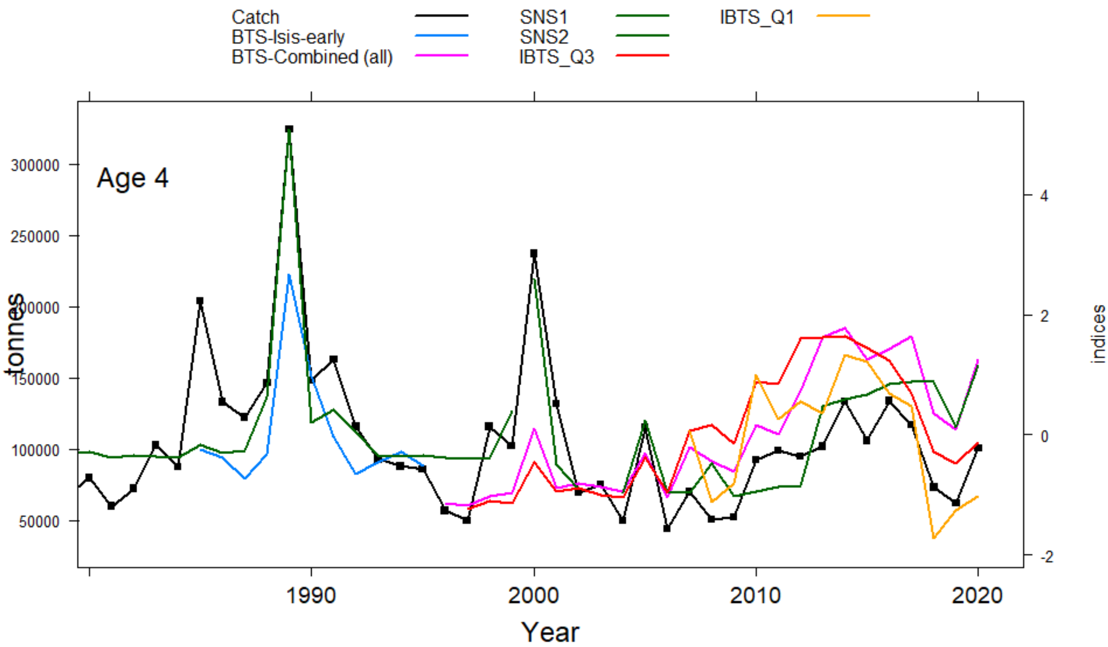


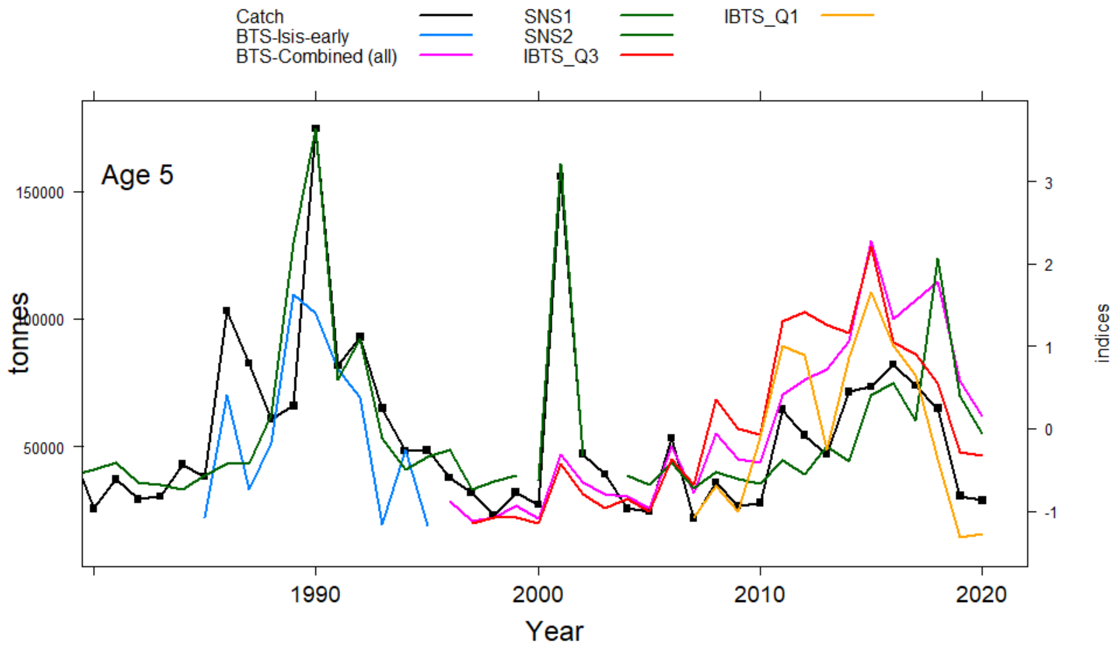
Figure 13.2.14. Catch curves for Surveys in age 1–6.


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 1
tonnes
indices
Year
0
200000
400000
600000
800000
1000000
1990
2000
2010
2020


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 2
tonnes
indices
Year
0
500000
1000000
1500000
1990
2000
2010
2020


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 3
tonnes
indices
Year
1990
2000
2010
2020
6e+05
2e+05
3
2
1
0
-1


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 4
tonnes
indices
Year
1990
2000
2010
2020
300000
250000
150000
100000
50000
4
2
0
-2



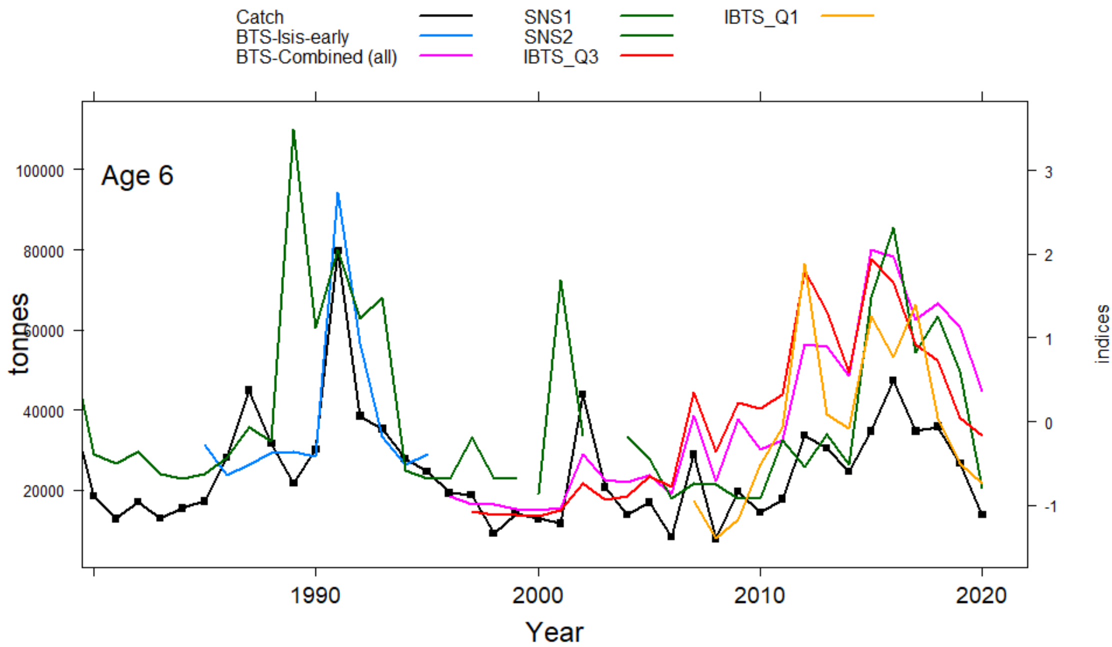


Figure 13.2.15: Catches vs. standardized survey indices by age (1–6).

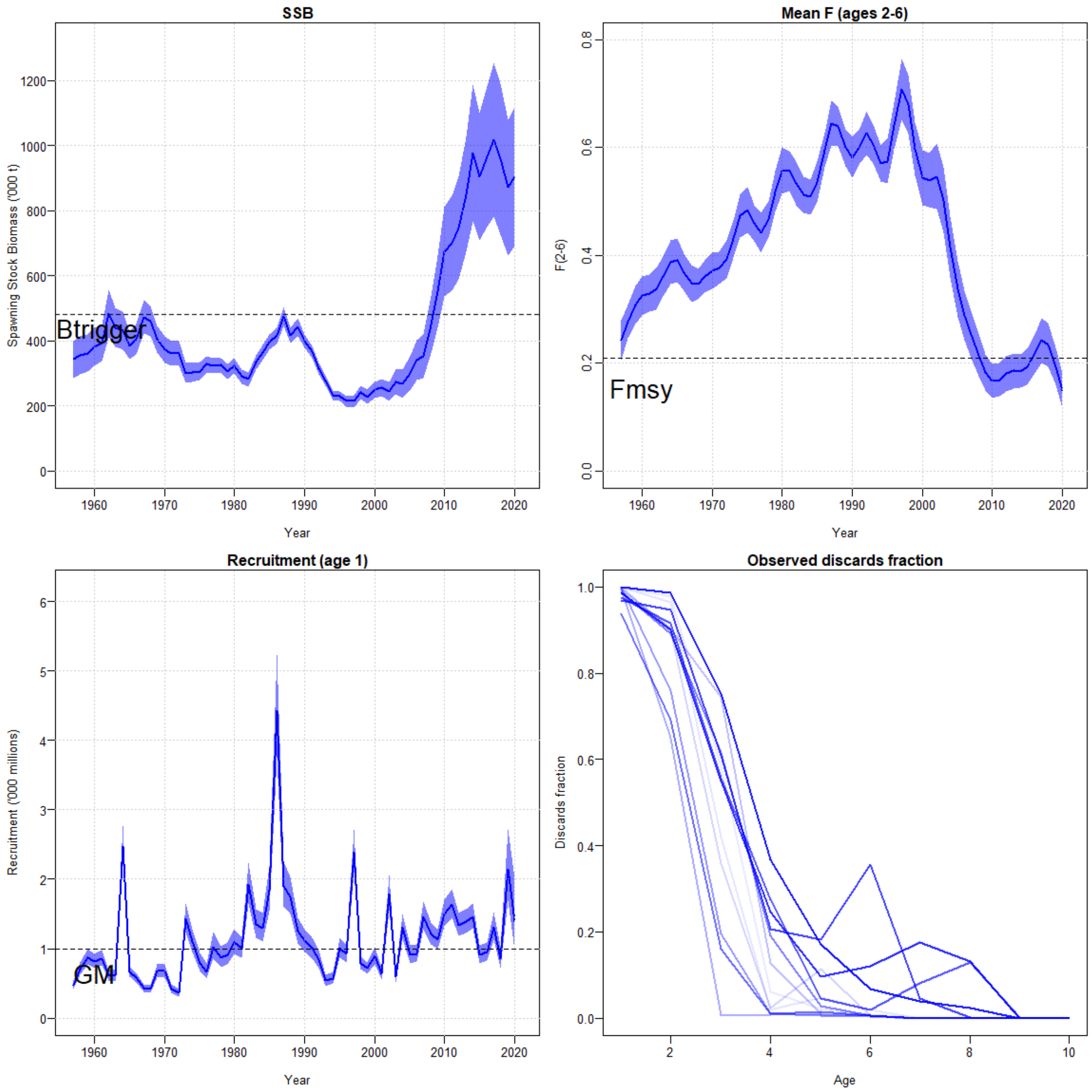


Figure 13.3.1. Stock assessment output for ple.27.420. SSB (top left), fishing mortality (top right), recruitment (bottom left) estimates of the assessment and the observed discards fraction (bottom right).

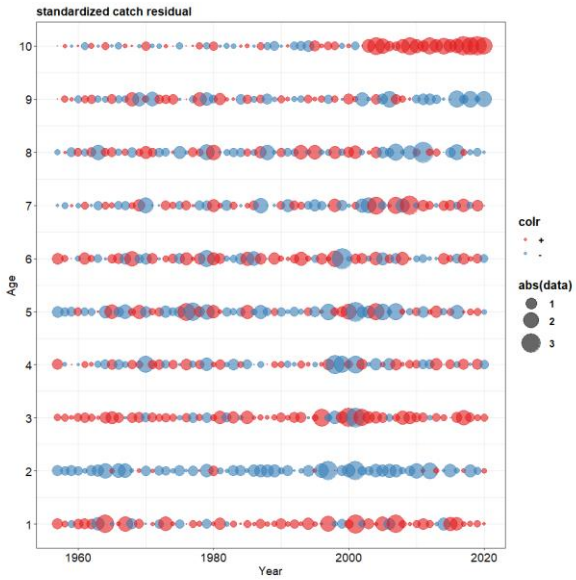


Figure 13.3.2. Log-catch residuals (observed minus estimated), standardized by the standard error of catch. Positive values are in red and negative values are in blue.

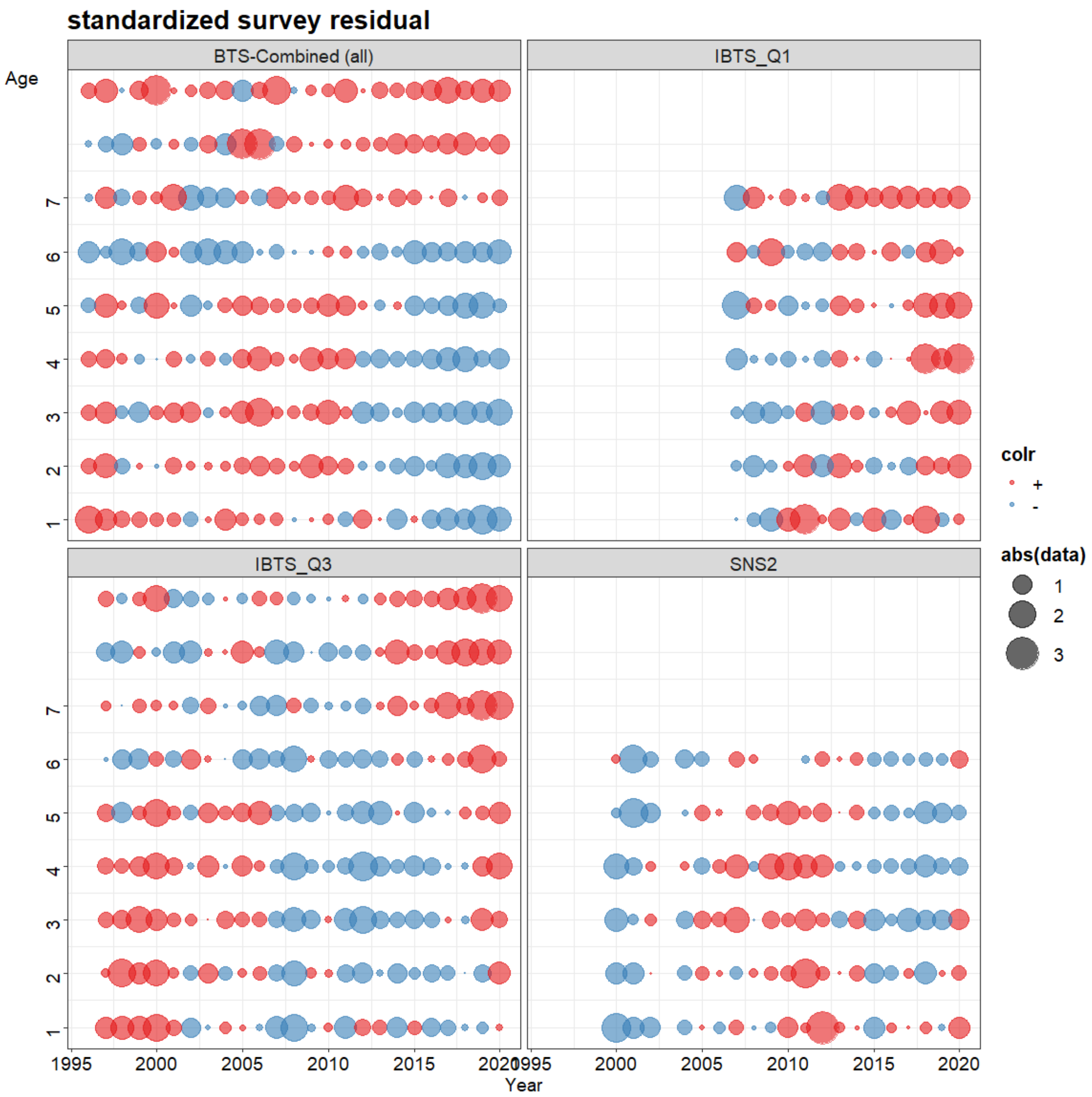


Figure 13.3.3. Log-survey indices residuals (observed minus estimated), standardized by the standard error of indices. Positive values are in red and negative values are in blue.

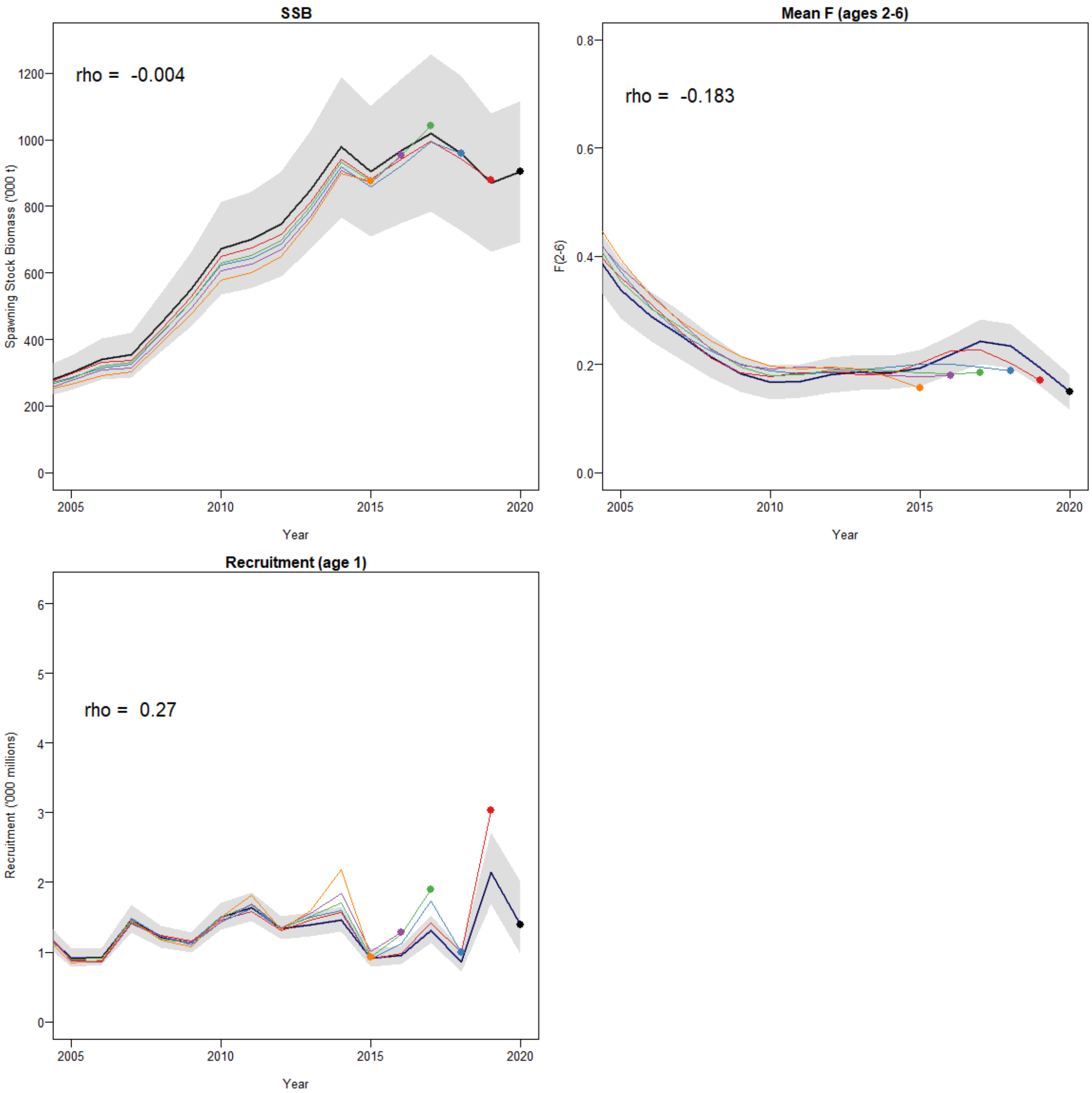


Figure 13.3.4. Retrospective pattern of the final AAP run with respect to SSB, recruitment and F.

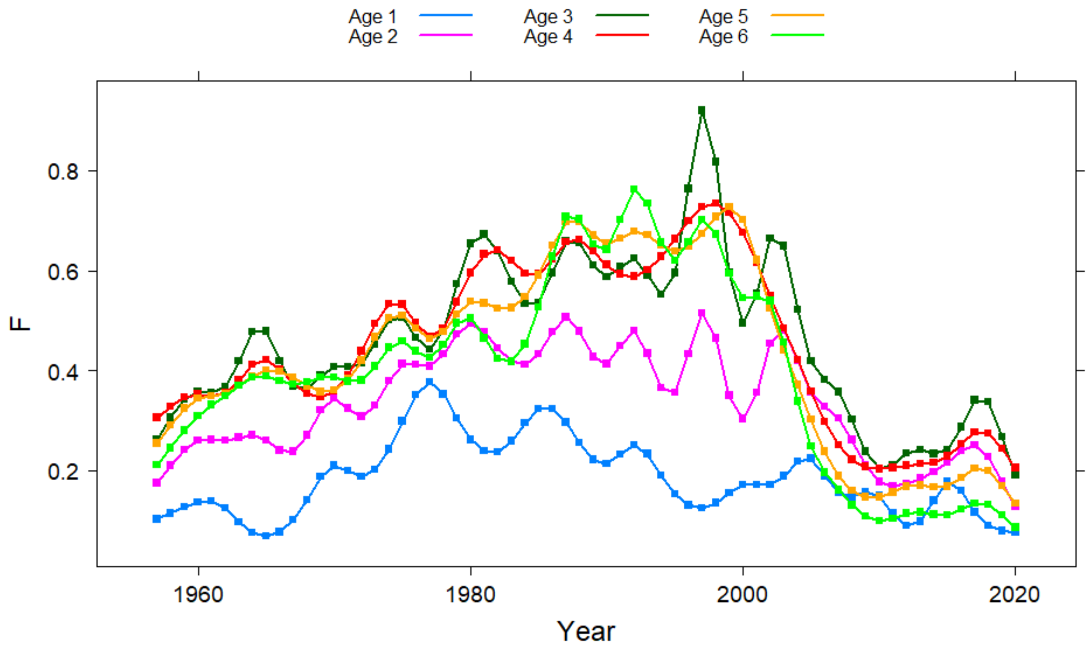


Figure 13.3.5. Estimated fishing mortality by age.

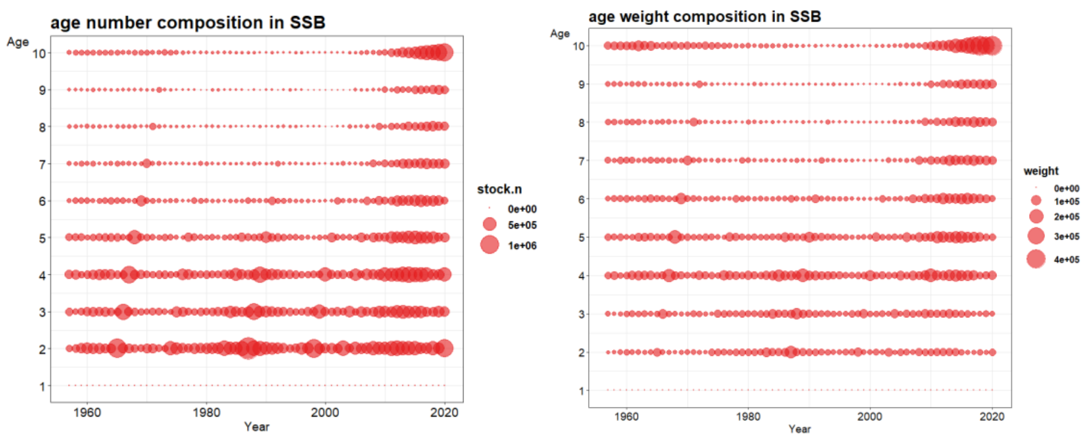
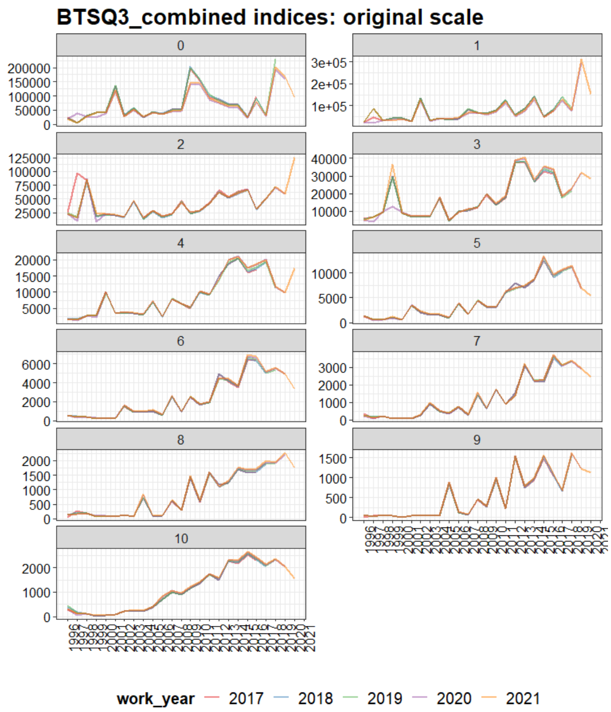
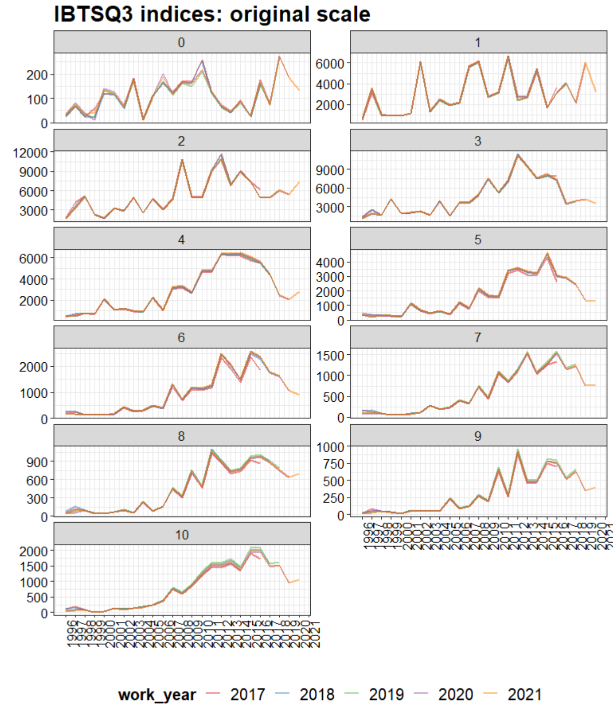


Figure 13.3.6. Age compositions in the estimated SSB.


BTSQ3_combined indices: original scale
work_year 2017 2018 2019 2020 2021


IBTSQ3 indices: original scale
work_year 2017 2018 2019 2020 2021

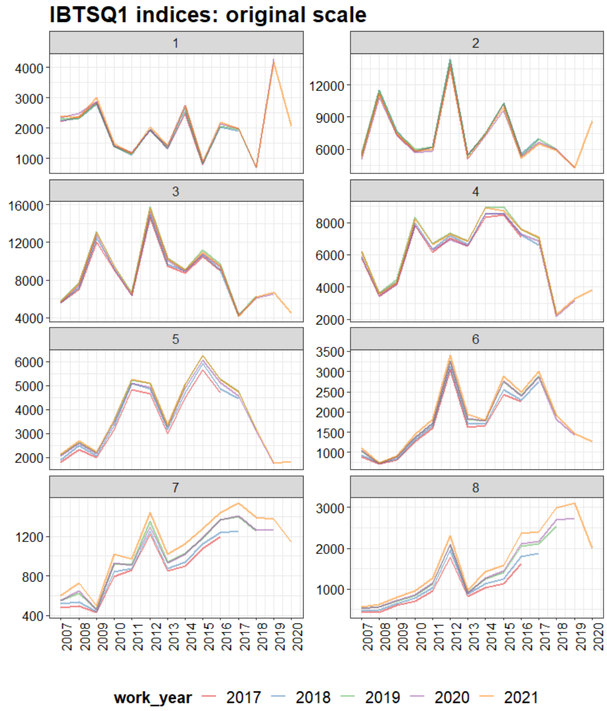
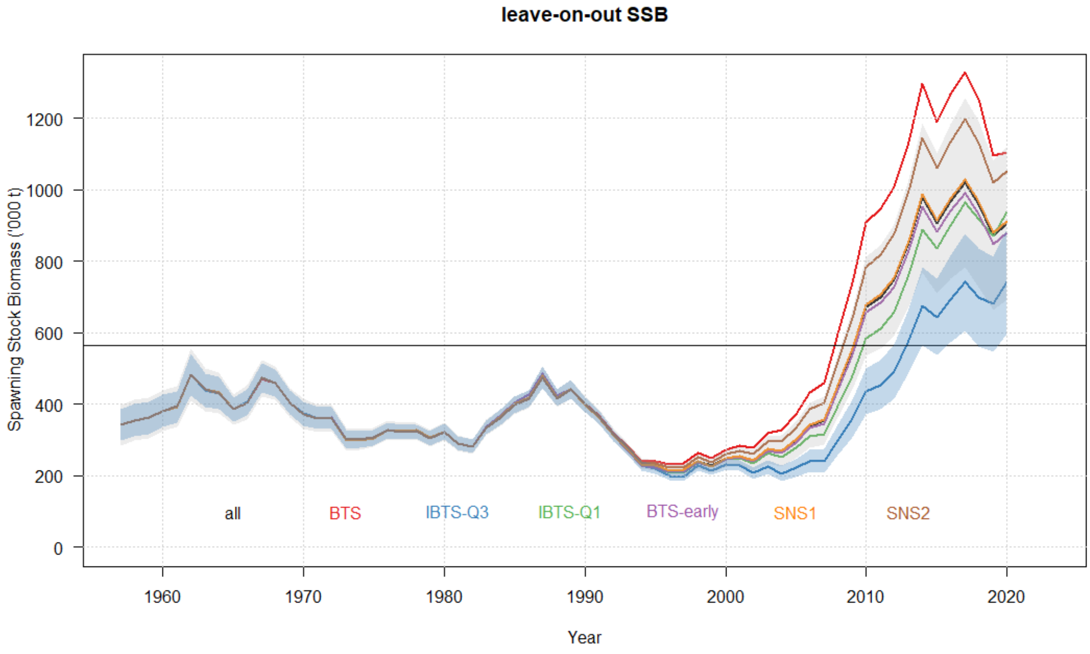
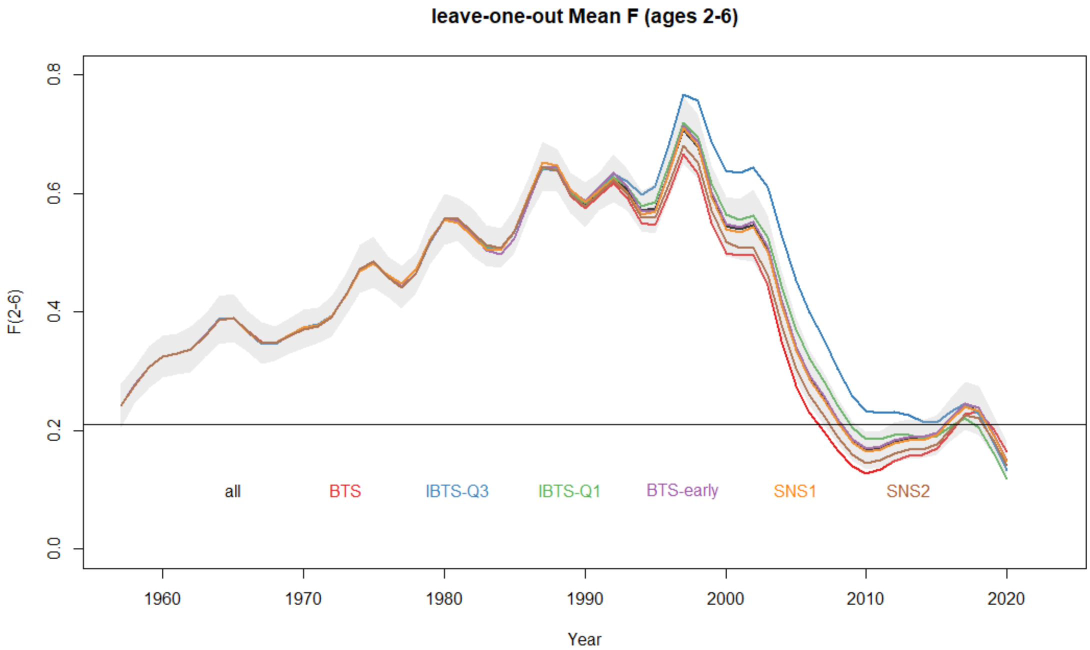


Figure 13.3.7. Yearly estimated delta-GAM indices for BTS, IBTS-Q3 and IBTS-Q1 since 2017.



leave-on-out SSB
Spawning Stock Biomass ('000 t)
0
200
400
600
800
1000
1200
1960
1970
1980
1990
2000
2010
2020
Year
all
BTS
IBTS-Q3
IBTS-Q1
BTS-early
SNS1
SNS2



leave-one-out Mean F (ages 2-6)
F(2-6)
0.0
0.2
0.4
0.6
0.8
1960
1970
1980
1990
2000
2010
2020
Year
all
BTS
IBTS-Q3
IBTS-Q1
BTS-early
SNS1
SNS2

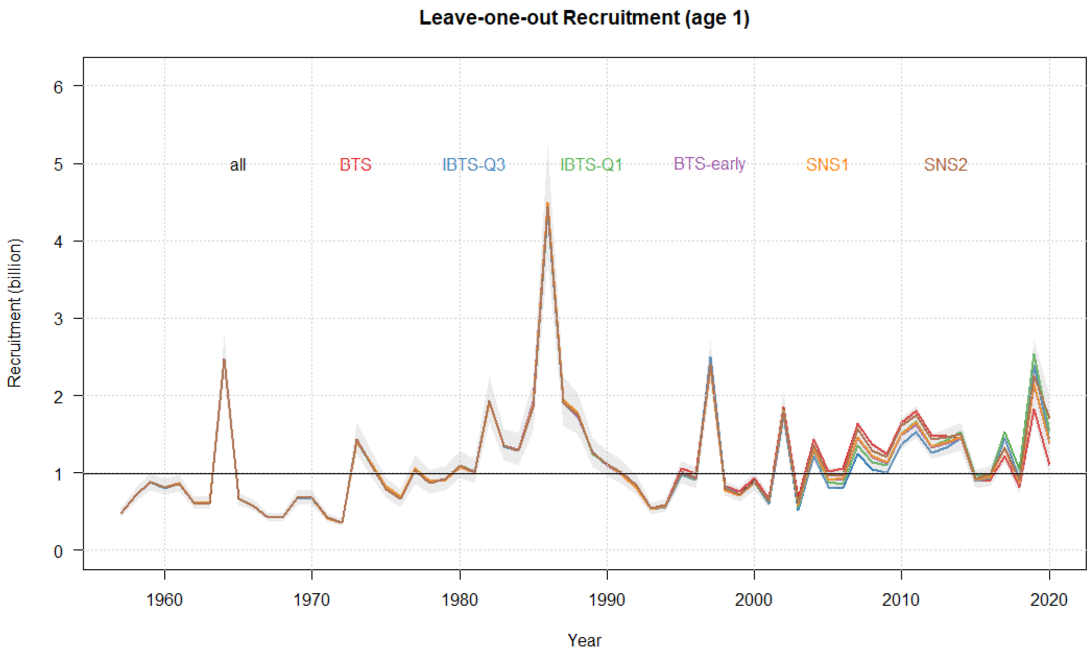


Figure 13.3.8. Leave one out runs.

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 2020. 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

2019 advice: ICES advises that when the EU multiannual plan (MAP) for the Western Waters is applied, catches from the Division 7.d plaice stock in 2020 that correspond to the F ranges are 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.

2020 advice: ICES advises that when the EU multiannual plan (MAP) for the Western Waters is applied, catches from the Division 7.d plaice stock in 2021 that correspond to the F ranges are between 6066 tonnes and 11 130 tonnes. According to the MAP, catches higher than those corresponding to FMSY (8402 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

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 2020 landings of 2120 tonnes are below the catch level of the past 10 years (between 3500 and 5000 tonnes). France, as before 2015 (46%), is the highest contributor to the total 7.d landings in 2020, with Belgium contributing for 35% and UK for 16%.The Belgian TBB and the French OTB recorded the highest landings.

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. In 2020, the discard number decreased by 55% (from 40 774 082 in 2019 to 18 196 846 in 2020) to be of the same order of magnitude as for the period 2010–2017.

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 85% 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. For 2020, Belgium landings data were transmitted per quarter except for the TBB fleet which was submitted per year. Allocations to calculate age structures for the remaining landings were done per quarter, using the groups below.

Unsampled fleet*	Sampled fleet**
All nets	All nets
All OTB, OTT, TBB and Seines	All OTB, OTT and TBB
Others (MIS, OTM, DRB, FPO and LLS)	All métiers

*** Unsampled fleet are those fleets for which no age structure is known.**

**** Sampled fleet are those fleets for which the age structure is known.**

Discards data have also been provided under the ICES InterCatch format by France, Belgium, and the UK since WKPLE (ICES, 2015). In 2020, 53 % 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 35% of the total discards. Allocations to calculate age structures of discards were done per quarter, using the groups below.

Unsampled fleet*	Sampled fleet**
All nets	All Nets
OTB, OTT, TBB and Seines	OTB, OTT and TBB
Others (MIS, OTM, DRB, FPO 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 62% of the total discards (imported + raised).

Due to a lack of samples, a different approach was used to calculate age structures for the remaining discards for the following quarters: i/ Q1 Nets Discards were raised by samples from Q4, ii/ Q2 Nets Discards were raised by samples from Q3 and Q4, iii/ Q2, Q3, and Q4 of trawls Discards were raised by samples from Q1 and iv/ Q2 of Other Discards were raised samples from Q1.

The method used to process French fisheries data was modified in 2020 to solve some issues that went undetected until data submission of sol.27.7d full time series for WKFlatNSCS benchmark (ICES, 2020). The new procedure was used to submit 2018 and 2019 datasets into InterCatch for all stocks. The main changes in the method consist in i) using a multinomial model to fill the gaps for the Age-Length Keys used for deriving landings and discards at age, and ii) using landings as an auxiliary variable instead of fishing effort to estimate the amount of discards. The new method had a significant impact on discards which in 2018 increased by 81% from 3425 t to 6215 t.

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.

Figures 14.2.3.3 and 14.2.3.4 present the discards at age ratios (i.e. discards numbers / landings numbers) per age and through time over the sampled period 2006–2020. From 2013, the ratio is higher for the ages 4 and 5. The ratio for ages 1 to 3 remains stable between 2018 and 2020.

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 2013–2020 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

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) (G3425), 1993–present and the UK beam trawl survey (UK BTS) (B2453), 1989–present (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 during 2016 WGNSSK meeting (ICES, 2016).

In 2020, due to the COVID-19 pandemic, only the French waters of the English Channel were sampled during the CGFS survey which has an impact on the FR GFS index used in the assessment. In addition, issues in the calculation of the FR GFS index were reported (some hauls with no catch were dropped in the calculation of the index). The effect of those issues have been investigated during 2020 WGNSSK meeting by i) testing the impact of removing UK sampling stations in the calculation of the index (Figure 14.2.6.3), and ii) testing the impact of removing the FR GFS index in 2020 (Figure 14.2.6.4). The results did not show significant impacts on assessment outputs.

The new index presented in the Figure 14.2.6.3 (without calculation issue) was only used for testing purposes.

The consistencies between ages are good for the UK-BTS survey, and correct for ages 2 to 6 (Figure 14.2.6.2). However, for the FR GFS survey the consistencies between ages is less robust in comparison to UK-BTS survey.

14.3 Assessment

The model used is the Aarts and Poos model (AAP, Aarts and Poos, 2009, for more details please refer to the Stock Annex).

Year of assessment:		**2020**
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 – 2020
Discards data		2006–2020
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 since 2012.

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 tend to overestimate 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 2016–2019 (Figure 14.3.1.3). After the decline in recruitment in 2016-2017, the recruitment in 2018 and 2019 is increasing. In 2020, the recruitment estimated by the model is very low, it dropped from 169412 in 2019 to 2720 in 2020. This important decrease is explained by a strong decline in the catch and discard number of age 1 individuals (Figure 14.3.1.4). In addition, both indices UK BTS and FR GFS present an important decline for age 1 individuals (Figure 14.2.6.1). There is a high uncertainty in the estimation of 2020 recruitment which could be explained by the lack of sampling for discards of trawlers during the quarters 2, 3 and 4 because of COVID-19 pandemic.

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 3 and older in 2021 are AAP survivors estimates.

14.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated. The recruitment of 2020 was replaced by the lowest estimated recruitment in the time series (1980–2019). For the previsions (2021, 2022 and 2023), the recruitment was calculated as the geometric mean recruitment over the period 1980–2019. The group decided to consider the entire time series since the information from indices and catch data point in the direction of a steep drop of the recruitment (the 2020 estimate was not used due to the high uncertainty of 2020 recruitment) (Figure 14.5.1.2). In 2018, the geometric mean over the entire time series was used given the drop in the recruitment in 2016–2017. With the increase of recruitment in 2018 and 2019, 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 2020 (status quo). Plaice in 7.d are under landing obligation since the 1 January 2019. To assess if the TAC in 2021 will be fully taken, we compared ICES catches of resident plaice in 7.d in 2020 to the catch advice in 2020 since there is only a provisional TAC (the TAC of 2020 has not yet been set during the WGNSSK 2021 meeting). The comparison of ICES catches of resident plaice in 7.d in 2021 (6470 tonnes) to the catch advice in 2020 (8402 tonnes) leads to the decision that the usual fully taken TAC assumption was inappropriate.

14.5.3 Management options tested

14.5.3.1 Calculation of STF

Potential TACs for 2022 were calculated using the MSY approach Alternative options (e.g. $F_{MSY\ lower}$ and $F_{MSY\ upper}$) were also tested. Results are presented in Table 14.5.3.1.1 for the resident stock.

Following the MSY approach catches from the Division 7.d plaice stock in 2022 should be no more than 6365 tonnes. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2020, this will correspond to catches of plaice in Division 7.d in 2022 of no more than 7566 tonnes.

14.6 Quality of the assessment

The sampling for plaice in 7.d are considered to be at a reasonable level. Nevertheless, a lack of sampling for discards of trawlers during the quarters 2, 3 and 4 was reported due to COVID-19 pandemic.

The quality of the assessment is considered to have improved in 2015 following the change of assessment model and the inclusion of discards.

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}, F_{pa} and F_{lim} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim} (Figure 14.3.1.3).

	Fishing pressure					Stock size				
		2018	2019	2020			2019	2020	2021	
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}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

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 investigations are needed to evaluate if a vessel effect is significant in the data and test the possibility of splitting the FR GFS time series.

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.

A problem was reported in the calculation of the FR GFS index (some trawls with no catch were dropped in the calculation of the index). The calculation of the index need to be updated.

14.9.2 Assessment

Residual patterns in the FR GFS residuals and the year effect (from 2016) in landings residuals could be corrected by the use of a new survey index for FR GFS. 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

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Table 14.2.1.1. Plaice in 7.d: Nominal landings (tonnes) as officially reported to ICES, 1976–2020.

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 (3)	Agreed TAC (4)
1976	147	1439	376		1962	1	1963		640	
1977	149	1714	302		2165	81	2246		702	
1978	161	1810	349		2320	156	2476		784	
1979	217	2094	278		2589	28	2617		977	
1980	435	2905	304		3644	-994	2650		1178	
1981	815	3431	489		4735	34	4769		1676	
1982	738	3504	541	22	4805	60	4865		1878	
1983	1013	3119	548		4680	363	5043		1714	
1984	947	2844	640		4431	730	5161		1758	
1985	1148	3943	866		5957	65	6022		1677	
1986	1158	3288	828		5274	1560	6834		2078	
1987	1807	4768	1292		7867	499	8366		2272	8300
1988	2165	5688	1250		9103	1317	10420		2835	9960
1989	2019	3713	1383		7115	1643	8758		2742	11700
1990	2149	4739	1479		8367	680	9047		2985	10700
1991	2265	4082	1566		7913	-100	7813		2183	10700
1992	1560	3099	1572	1	6232	105	6337		1882	9600
1993	877	2792	1102		4771	560	5331		1614	8500
1994	1418	3199	1007	9	5633	488	6121		1404	9100
1995	1157	2598	814		4569	561	5130		1247	8000
1996	1112	2630	856		4598	795	5393		1266	7530
1997	1161	3077	1078		5316	991	6307		1583	7090
1998	854	3276	700		4830	932	5762		1346	5700
1999	1306	3388	743		5437	889	6326		1543	7400

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7.d (1)	Estim.discards 7.d (2)	Tot. land. rep. in 7.e (3)	Agreed TAC (4)
2000	1298	3183	754		5235	779	6014		1625	6500
2001	1346	2962	660		4968	298	5266		1310	6000
2002	1204	3450	841	1	5496	281	5777		1472	6700
2003	998	2893	756	3	4650	-564	4086		1387	5970
2004	954	2766	582	10	4312	438	4750		1337	6060
2005	832	2432	421	21	3706	285	3991		1319	5150
2006	1024	1935	550	16	3525	121	3646	749	1411	5151
2007	1355	2017	463	10	3845	156	4001	1252	1146	5050
2008	1386	1740	471	12	3609	255	3864	936	1112	5050
2009	1002	1892	612	16	3522	38	3560	1528	1024	4646
2010	1123	2190	517	62	3892	519	4411	2511	1208	4274
2011	1067	1994	472	60	3593	56	3649	2025	1417	4665
2012	1045	1962	542	63	3612	111	3723	3336	1492	5062
2013	1295	2159	641	87	4182	-55	4127	2955	1472	6400
2014	1389	2229	633	76	4327	-7	4320	3886	1490	5322
2015	1600	1702	392	54	3748	-21	3727	2821	1424	6223
2016	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	4999	6215	1644	10360
2019	1277	1688	628	87	3681	40	3721	7064	1520	10354
2020	750	1007	342	52	2120	32	2152	2191	1276	-

(1) As provided to ICES through InterCatch

(2) Raised with InterCatch from BE, UK and FR estimated discards data.

(3) As officially reported to ICES

(4) 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

Year	Total Landings	Q1 Remov.	Landings as used by WG (1)	Estim. discards	Discards Q1 remov.	Discards as used by WG (1)
2018	4999	1024	3975	6215	1255	4960
2019	3721	885	2836	7064	854	6210
2020	2152	424	1727	2191	290	1901

(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
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

year	age						
	1	2	3	4	5	6	7+
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	18	217	1045	2852	2482	1316	2410
2019	41	233	1506	1256	1681	1462	1424
2020	14	459	499	855	768	822	1229

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	4500	11034	12209	7137	2437	807	371
2019	8145	12050	13508	3940	2001	859	271
2020	162	7418	5098	3534	1250	512	222

Table 14.2.4.1. Plaice in 7.d: Weights in the landings.

	1	2	3	4	5	6	7
1980	0.314	0.317	0.508	0.638	0.801	1.159	1.439
1981	0.231	0.288	0.36	0.448	0.687	0.839	1.032
1982	0.237	0.263	0.342	0.418	0.62	0.77	1.193
1983	0.254	0.282	0.333	0.401	0.517	0.784	1.178
1984	0.211	0.267	0.304	0.364	0.46	0.624	0.852
1985	0.241	0.264	0.286	0.406	0.477	0.541	0.82
1986	0.231	0.312	0.338	0.414	0.557	0.496	0.823
1987	0.25	0.281	0.359	0.475	0.575	0.78	0.967
1988	0.279	0.256	0.307	0.413	0.536	0.629	0.926
1989	0.199	0.266	0.318	0.367	0.469	0.643	1.073
1990	0.209	0.266	0.338	0.392	0.501	0.633	1.091
1991	0.223	0.275	0.309	0.387	0.451	0.552	1.009
1992	0.181	0.276	0.35	0.427	0.506	0.582	0.791
1993	0.217	0.268	0.331	0.426	0.5	0.583	0.853
1994	0.248	0.276	0.294	0.364	0.476	0.588	0.996
1995	0.215	0.267	0.309	0.385	0.478	0.678	0.932
1996	0.228	0.31	0.299	0.409	0.49	0.664	1.115
1997	0.201	0.254	0.3	0.335	0.446	0.582	1.024
1998	0.167	0.257	0.281	0.401	0.529	0.803	1.175
1999	0.204	0.253	0.243	0.316	0.477	0.776	1.133
2000	0.217	0.256	0.273	0.296	0.392	0.603	0.953
2001	0.233	0.273	0.328	0.401	0.484	0.695	1.133
2002	0.246	0.248	0.299	0.364	0.424	0.545	0.819
2003	NA	0.286	0.376	0.485	0.643	0.654	0.872
2004	0.245	0.297	0.399	0.498	0.688	0.786	0.993
2005	0.29	0.318	0.351	0.452	0.568	0.666	1.109
2006	0.261	0.279	0.306	0.364	0.447	0.557	0.85
2007	0.182	0.318	0.398	0.477	0.546	0.613	0.959
2008	0.24	0.293	0.351	0.434	0.549	0.647	0.975
2009	0.24	0.291	0.35	0.498	0.526	0.66	1.073
2010	0.232	0.305	0.359	0.451	0.512	0.658	0.847
2011	0.159	0.264	0.354	0.487	0.637	0.82	1.076
2012	0.204	0.297	0.358	0.452	0.559	0.715	1.062
2013	0.145	0.263	0.321	0.395	0.498	0.738	1.077
2014	0.176	0.26	0.295	0.373	0.514	0.704	0.986
2015	0.126	0.227	0.303	0.346	0.413	0.538	0.842
2016	0.203	0.317	0.319	0.356	0.415	0.46	0.673

	1	2	3	4	5	6	7
2017	0.276	0.272	0.301	0.344	0.417	0.468	0.667
2018	0.236	0.248	0.27	0.291	0.341	0.403	0.593
2019	0.244	0.264	0.285	0.316	0.337	0.386	0.567
2020	0.223	0.260	0.267	0.294	0.340	0.388	0.521

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	0.126	0.118	0.119	0.141	0.157	0.179	0.18
2019	0.140	0.141	0.158	0.169	0.173	0.197	0.224
2020	0.113	0.08	0.107	0.125	0.143	0.155	NA

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
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.727

year	1	2	3	4	5	6	7
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	0.258	0.294	0.326	0.368	0.481	0.516	0.719
2017	0.256	0.253	0.28	0.319	0.387	0.434	0.619
2018	0.174	0.201	0.244	0.256	0.308	0.386	0.519
2019	0.132	0.239	0.262	0.289	0.332	0.394	0.531
2020	NA	0.296	0.292	0.351	0.407	0.450	0.597

Table 14.2.6.1. Plaice in 7.d: Tuning fleets.

UK BTS						
1989 2020						
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
1	117.5	81.7	55.3	37.3	18.2	11.7
1	20.7	109.1	60.2	25.1	15.1	7.6

Table 14.2.6.1. (cont.) Plaice in 7.d: Tuning fleets.

FR GFS						
1993 2020						
1 1 0.75 1						
1 6						
1	867.43	344.90	125.85	31.96	8.66	10.30
1	347.49	147.88	67.59	26.22	11.65	23.90
1	336.48	364.13	142.06	101.13	27.19	62.22
1	243.75	180.66	26.61	12.91	15.07	21.62
1	800.74	267.09	245.82	20.78	8.55	48.01
1	415.33	406.18	93.74	29.26	0.00	10.91
1	529.12	254.13	391.97	76.07	12.41	16.14
1	653.63	655.41	201.13	192.59	50.45	23.23
1	290.78	187.48	81.58	75.12	35.37	10.07
1	584.85	302.58	189.71	69.78	51.40	29.15
1	304.00	459.99	81.81	16.76	17.21	18.51
1	388.30	280.74	137.02	39.96	4.34	28.61
1	405.86	745.78	360.04	114.18	32.07	23.45
1	684.33	447.44	152.03	61.40	32.69	16.70
1	445.96	395.42	237.19	105.11	33.52	9.36
1	234.96	641.59	140.12	46.79	12.23	17.93
1	293.83	223.12	94.63	27.80	6.82	14.70
1	745.47	466.77	109.54	28.99	7.46	16.74
1	1973.88	2370.24	734.33	116.83	12.96	83.19
1	557.31	1503.57	1282.02	257.87	97.02	30.54
1	716.38	566.94	1148.16	288.40	88.07	19.33
1	556.22	470.05	542.65	708.58	172.21	32.59
1	96.75	682.98	556.48	152.76	173.23	61.86
1	44.90	243.12	367.00	136.91	93.37	61.19
1	53.59	108.57	147.10	142.44	44.55	21.43
1	83.82	241.83	119.56	170.23	52.43	22.54
1	616.76	407.32	315.51	127.85	187.87	109.15
1	114.34	276.87	99.66	51.79	26.83	32.15

Table 14.3.1.1. Plaice in 7.d: Landings residuals.

age	1	2	3	4	5	6	7
1980	-0.46520161	0.88970583	-0.4423328	-0.3274067	0.20627283	-0.0358111	-0.12929792
1981	-1.47789983	0.13305273	0.3677051	0.34633728	-0.08825682	-0.16862785	0.30304758
1982	0.26090593	0.04435968	-0.12439742	-0.03159485	0.0898823	0.35529314	-0.27705369
1983	-0.74980696	0.08014317	-0.28312326	0.12803078	-0.31365326	-0.25111285	-0.04438231
1984	0.80138616	-0.27050341	-0.13617249	0.14517909	0.1039799	0.10371014	0.2617751
1985	-0.01559111	0.86088855	-0.19974607	0.1903487	-0.55297737	-0.03907537	-0.01345838
1986	0.97664195	0.45091983	-0.11009348	0.12821191	0.1849702	0.61261622	-0.52740934
1987	-2.03839416	0.24778209	-0.28690455	0.03223852	0.12870216	-0.35010899	0.23594807
1988	-2.61530692	0.16861661	-0.01792067	-0.00644877	-0.16527342	-0.08992792	0.04058105
1989	1.01128597	0.18396915	-0.35448094	-0.16258507	0.27468803	-0.08931561	-0.08708763
1990	1.09130592	0.14054169	0.36171203	-0.05240227	-0.16658384	-0.01819035	0.23025557
1991	0.02487588	0.76373132	0.39632915	0.29749045	0.09484221	0.0627667	0.00709502
1992	-0.44706855	0.10863763	0.27132677	0.01240531	0.0147341	0.15815064	0.07961585
1993	-0.63951434	-0.00300057	-0.35957479	-0.12453471	-0.1947109	-0.19162771	-0.23486979
1994	0.12376428	0.04963816	0.04772661	0.28664462	0.31746348	0.15012356	0.03837464
1995	0.52159818	0.56794908	-0.05010905	-0.07021762	-0.13350339	-0.35753041	-0.14642308
1996	-0.12149835	0.33587209	0.34733757	-0.0884111	0.06478811	0.04859524	0.03405871
1997	-0.99084921	0.22121993	0.42618955	0.73386364	0.51251026	0.48218609	0.41197184
1998	-0.17434358	-0.24023802	0.33285129	-0.03963779	-0.06004136	-0.25529715	-0.2762137
1999	0.33879001	-0.55107123	-0.03246091	0.34392796	-0.02508242	0.25511606	0.00780543
2000	0.34273458	0.65484289	-0.47627804	-0.3042011	-0.13794145	-0.18134785	0.03712917
2001	0.7543012	-0.080928	-0.13534954	-0.37020773	-0.12801325	-0.26931691	-0.04533638
2002	-0.44239026	0.61226072	0.16212508	0.17317393	0.65647827	0.00545509	0.16179957
2003	-5.64992449	-0.1338791	-0.44677782	0.23319902	-0.16149486	0.08691377	0.26997161
2004	1.9552751	0.62162374	-0.20764417	-0.38704432	-0.07209821	-0.13032168	-0.15982775
2005	0.15504029	0.53973547	-0.43754719	-0.15325244	0.02194449	0.00097075	-0.01335862
2006	0.71808127	0.59553577	-0.37415175	0.15364169	0.1727927	-0.30110713	-0.00517333
2007	0.87533451	0.47467952	-0.518273	-0.26938856	0.14149726	-0.02472657	-0.02426863
2008	-0.09590583	0.27837349	-0.33972671	-0.06251595	0.13389938	-0.02761127	-0.20897922
2009	0.25067533	-0.00926208	-0.36722068	-0.11358972	0.08421379	-0.00938371	-0.0845141
2010	0.35878779	0.14120887	-0.36872886	0.16661662	0.29654175	0.50414177	0.12392362
2011	-1.31590921	0.01964095	-0.66275155	-0.45743727	-0.2017185	-0.71958247	-0.6080618
2012	-0.03892963	-0.00463856	-0.07616774	0.04841707	0.10075259	0.25296971	-0.10586227
2013	-0.10171543	0.12958971	-0.00958234	0.03010612	0.19198596	0.25324777	-0.29910322
2014	0.018733	0.16913312	0.50510819	0.06372401	0.13037318	0.2126255	-0.36838881
2015	0.06753176	-0.12463663	-0.16866291	-0.27079245	-0.19269664	0.09963054	0.0296811
2016	-0.23171107	-0.37680307	-0.35976781	-0.16796586	-0.01402927	-0.07799035	-0.41493999
2017	-0.20834759	0.08856092	-0.23180913	-0.10002784	-0.0404457	-0.03053184	-0.52867966

age	1	2	3	4	5	6	7
2018	0.14756535	0.3829284	0.40546286	0.31422915	0.17351663	0.3636928	0.0509722
2019	0.10974922	0.2169667	0.59024332	0.07782568	0.0268691	0.19149145	-0.24646714
2020	-0.13461437	-0.41456551	-0.4810263	-0.18641204	-0.1417609	0.04318512	-0.33703748

Table 14.3.1.2. Plaice in 7.d: Discards residuals.

age	1	2	3	4	5	6	7
2006	-0.042977583	0.026700107	-0.017905509	-0.751717597	-0.743776	0.104218405	0.466944243
2007	-0.10612578	0.619403303	0.069253169	0.471033872	-2.553923195	0.115129625	0.641739007
2008	0.169987571	-0.477080362	-0.840482772	0.242612136	0.99948764	1.756182478	1.11311516
2009	-0.153822086	0.165637017	0.064141535	0.119058883	0.58018813	2.743458931	2.083847874
2010	-0.124904705	0.693413892	0.473155486	0.927351208	1.262519107	1.250091384	1.978650688
2011	0.131315474	0.241239975	-0.608036746	-0.046971842	0.340966869	3.095037934	1.52331607
2012	-0.018335202	-0.004235881	-0.075940349	0.049432847	0.120361879	1.384474371	3.909695201
2013	-0.065641324	0.130277358	-0.009372159	0.03076927	0.203502398	0.355186412	0.471794276
2014	0.023881102	0.169793163	0.505415936	0.064117387	0.132604381	0.22603133	-0.267379118
2015	0.163924507	-0.123886026	-0.168212778	-0.269862771	-0.191188223	0.103650043	0.054864015
2016	-0.202062785	-0.375032366	-0.359459929	-0.167241509	-0.01206622	-0.073376734	-0.377966758
2017	-0.123908058	0.091837919	-0.231429297	-0.09967159	-0.038743906	-0.027268336	-0.513481339
2018	0.167706189	0.384758013	0.405907553	0.31450205	0.174080049	0.365220123	0.053821415
2019	0.118789415	0.218670737	0.590569132	0.078381793	0.027592444	0.192915272	-0.242523996
2020	-0.102722302	-0.413607004	-0.480071215	-0.185685541	-0.14046834	0.045595121	-0.33223779

Table 14.3.1.3. Plaice in 7.d: Survey residuals.

UK BTS						
age	**1**	**2**	**3**	**4**	**5**	**6**
1989	-1.391225667	-0.645114201	-0.084323843	0.308560051	-0.119956874	0.094725344
1990	-0.484191267	-0.616197826	-0.508684573	-0.2105364	0.148661637	-0.360981186
1991	-0.443671335	-0.062018604	0.12045895	-0.014879445	0.18506908	-0.221717498
1992	-0.413984254	-0.134854711	-0.223280883	0.31867487	0.448470603	0.294765148
1993	-1.220329606	-0.378074382	-0.412131552	-0.286308503	0.149229398	-0.070231819
1994	-0.305650476	-0.470741237	-0.332437975	0.131473394	0.071151331	-0.684735623
1995	-0.427066669	-0.620889094	-0.540935646	0.005798783	-0.059062869	-0.180308739
1996	-0.220088898	-0.267586005	-1.201764493	-0.81594256	-0.142847394	0.11796309
1997	-0.056239854	-0.070380018	-0.153161121	-0.542422967	0.502743613	-0.61425855
1998	0.23596892	-0.446702233	-0.423339487	-0.002219365	-0.192570038	0.405187254
1999	-0.376363723	-0.945231758	-0.221118207	-0.498020108	-0.192667849	-0.016463919
2000	-0.062571578	0.424334515	0.17463169	0.257136352	0.365709891	0.228590543
2001	0.377948014	0.036253797	0.324319527	0.330848636	0.641838281	0.365920747
2002	0.236274125	0.364129149	0.265962513	0.191016286	-0.298042181	0.171097082
2003	-0.394008643	0.207159608	0.047607566	0.045687414	0.003787025	-0.512269347
2004	0.99093489	0.15663231	0.085612738	0.113622394	-0.555266947	-1.234622272
2005	-0.079451315	0.380668588	0.055457004	0.110645729	0.406376367	-0.007414268
2006	0.646254635	0.314897423	0.073627158	0.012169643	-0.070154203	0.169677648
2007	0.871059976	0.433457156	-0.05145896	-0.21009716	0.026124852	0.117240038
2008	0.398918473	0.455871268	-0.048487295	-0.381821928	-0.08903728	0.009543242
2009	0.580446908	0.226559831	0.304536645	0.062376552	-0.092978324	-0.10807703
2010	-0.07679886	0.180133268	-0.127894842	0.141429	-0.005045706	-0.227368692
2011	0.269589669	0.227645181	0.047966059	-0.055414479	0.409846099	0.354361783
2012	-0.609190041	-0.349961448	-0.17856633	-0.136593019	-0.404387001	0.111991663
2013	-0.439735978	0.016529228	-0.02055845	0.127518838	-0.218057537	-0.182846552
2014	0.598545405	0.861581212	0.062355025	0.13198319	0.11963684	0.084186991
2015	-0.599228524	0.537272913	0.198890205	0.05009136	0.036075769	0.043994353
2016	-1.249572864	0.12021902	0.256593375	0.217690567	0.249297017	0.160313275
2017	0.088923015	0.588599779	0.220588419	0.211357802	-0.030075774	-0.148184481
2018	-0.815456964	0.500353211	0.986206282	0.348816895	0.198408237	-0.062285917
2019	0.512471781	0.098279786	0.228857378	0.486664272	-0.085774777	-0.20844601
2020	2.936588212	0.20247199	0.061613608	0.037875816	0.219493479	-0.423156159

Table 14.3.1.3. (cont.) Plaice in 7.d: Survey residuals.

			FR GFS			
age	**1**	**2**	**3**	**4**	**5**	**6**
1993	1.538991916	0.18840095	0.23237757	0.138433336	-0.514074017	-0.424610881
1994	0.842856948	0.10476826	-0.516230394	-0.345966302	0.016350538	0.931191272
1995	0.243193764	1.133524686	0.951310391	0.888095888	0.553643189	2.172851928
1996	-0.309003421	-0.24386862	-0.58404205	-0.220571733	0.060409173	1.014441288
1997	0.24696506	-0.184452778	0.812612108	0.309762439	0.46917356	1.830628731
1998	0.332175322	-0.436928708	-0.510778619	-0.149857938	-1.016308762	1.363526561
1999	0.829724471	-0.132199264	0.246562469	0.322437933	0.033985058	1.76604459
2000	0.952548836	1.178982662	0.424126021	0.497814828	0.770208151	1.178464435
2001	0.248918231	-0.021268554	-0.012446439	0.355661731	-0.383305231	-0.14471688
2002	0.482097446	0.52893263	0.877886688	0.712182938	0.722527018	-0.032704085
2003	0.437851676	0.316049097	0.05440211	-0.563282948	0.142209319	0.324517557
2004	0.459040363	0.309492573	-0.163539304	0.236063237	-0.86496138	1.196008558
2005	0.64522355	1.023128544	1.232025926	0.513468763	0.800246082	1.115618813
2006	1.242095723	0.681419563	0.131730004	0.320548929	0.05407692	0.79720616
2007	0.476609089	0.691254564	0.774549453	0.569878499	0.450444208	-0.500466236
2008	-0.336944517	0.865710313	0.405178308	-0.033261481	-0.764867251	0.386519813
2009	-0.609894415	-0.398029657	-0.318977924	-0.391861981	-1.078076369	-0.129450222
2010	-0.153517176	-0.219642741	-0.464140937	-0.714665929	-0.892315339	0.118541997
2011	0.581589171	0.887024666	0.77607548	0.308015675	-0.814003134	1.724533595
2012	-0.023336711	0.1728151	0.73808612	0.41301576	0.741723932	0.381061449
2013	0.131350093	-0.152482569	0.319238362	-0.093398747	-0.032240326	-0.367526905
2014	-0.583212285	-0.434575678	0.203707212	0.48421303	0.014317922	-0.559509124
2015	-2.172653769	-0.517539552	0.149753011	-0.396570905	-0.280565636	-0.537774638
2016	-2.46150151	-1.392569921	-0.683592908	-0.55815499	-0.2197984	-0.809773667
2017	-2.333999175	-1.723172436	-1.403889374	-0.907431693	-0.95953043	-1.089295905
2018	-2.134279077	-0.968309976	-1.140559458	-0.522293351	-1.167470313	-1.054995376
2019	-0.34784831	-0.680503849	-0.239075034	-0.323886414	0.306687188	0.072333041
2020	2.14683828	-1.248557938	-1.63775299	-1.255010891	-1.079419244	-0.90074529

Table 14.3.1.4. Plaice in 7.d: Fishing mortality (F) at age.

	1	2	3	4	5	6	7
1980	0.0109339	0.115886	0.391995	0.322733	0.179057	0.102495	0.102495
1981	0.0183824	0.148677	0.443773	0.383806	0.231088	0.140972	0.140972
1982	0.0269246	0.183122	0.501113	0.443073	0.282874	0.183525	0.183525
1983	0.0299319	0.207879	0.562988	0.481978	0.311505	0.21405	0.21405
1984	0.0233668	0.211701	0.625299	0.484572	0.299144	0.216468	0.216468
1985	0.0160512	0.20179	0.669238	0.4653	0.27104	0.205522	0.205522
1986	0.0133733	0.191976	0.668691	0.448274	0.259486	0.205479	0.205479
1987	0.017594	0.193258	0.610862	0.450542	0.286488	0.236309	0.236309
1988	0.0330287	0.210222	0.535169	0.460079	0.337572	0.288317	0.288317
1989	0.069257	0.248653	0.484576	0.453088	0.368198	0.32204	0.32204
1990	0.129466	0.319746	0.483983	0.412732	0.330095	0.29106	0.29106
1991	0.202359	0.424118	0.525402	0.363441	0.262002	0.22911	0.22911
1992	0.268371	0.536666	0.587502	0.337148	0.217923	0.186138	0.186138
1993	0.306015	0.6019	0.64261	0.355921	0.221471	0.182207	0.182207
1994	0.297718	0.584847	0.669339	0.419582	0.271484	0.212377	0.212377
1995	0.242163	0.496154	0.656051	0.511509	0.358461	0.263501	0.263501
1996	0.163084	0.372836	0.60008	0.598241	0.455999	0.311887	0.311887
1997	0.104719	0.275066	0.532726	0.645711	0.5213	0.333396	0.333396
1998	0.0825468	0.235758	0.494467	0.635513	0.515308	0.317306	0.317306
1999	0.101132	0.274761	0.514871	0.565168	0.426147	0.266264	0.266264
2000	0.167434	0.400592	0.588221	0.470143	0.313074	0.208954	0.208954
2001	0.231854	0.540683	0.663167	0.394	0.236033	0.173086	0.173086
2002	0.167194	0.501376	0.663943	0.357932	0.210597	0.170444	0.170444
2003	0.064718	0.31929	0.586031	0.355661	0.225055	0.198962	0.198962
2004	0.0242023	0.19401	0.504691	0.363258	0.252333	0.239949	0.239949
2005	0.0160221	0.158015	0.471124	0.357405	0.258607	0.25928	0.25928
2006	0.0215751	0.187809	0.490276	0.330564	0.230095	0.237045	0.237045
2007	0.0361198	0.251206	0.527014	0.296231	0.189722	0.194284	0.194284
2008	0.0441348	0.285155	0.538448	0.266069	0.15597	0.152456	0.152456
2009	0.032079	0.242023	0.497571	0.243262	0.133657	0.119781	0.119781
2010	0.0194886	0.17518	0.41843	0.22302	0.119016	0.0951627	0.0951627
2011	0.0146181	0.126334	0.323951	0.201413	0.109292	0.0769669	0.0769669
2012	0.0163926	0.101012	0.240128	0.179518	0.103669	0.0650436	0.0650436
2013	0.0221487	0.0901861	0.187536	0.164682	0.103671	0.0613239	0.0613239
2014	0.027654	0.0894568	0.170969	0.16295	0.11181	0.0691963	0.0691963
2015	0.0274805	0.0969169	0.189849	0.177603	0.130542	0.0945844	0.0945844
2016	0.0251426	0.109379	0.230035	0.203892	0.15783	0.136741	0.136741
2017	0.0256583	0.122066	0.26604	0.233348	0.187604	0.178378	0.178378
2018	0.0333479	0.129777	0.267186	0.255805	0.211327	0.188286	0.188286
2019	0.0522082	0.132756	0.24024	0.270765	0.22821	0.168997	0.168997
2020	0.0897064	0.13321	0.204389	0.281622	0.241295	0.139873	0.139873

Table 14.3.1.5. Plaice in 7.d: Stock numbers from the assessment.

	1	2	3	4	5	6	7
1980	67426.8	30032.2	9989.34	2431.68	1958.91	650.536	1855.18
1981	34880.9	46852.7	18789.2	4741.83	1237.07	1150.54	1588.8
1982	65744.4	24057.7	28367.1	8468.99	2269.4	689.741	1671.37
1983	56889.5	44959	14072.7	12073.6	3819.96	1201.47	1380.59
1984	58127.3	38786.8	25655.8	5630.21	5238.01	1965.28	1464.38
1985	77771.7	39891.7	22049.3	9644.34	2436.29	2728.35	1940.4
1986	164360	53765.2	22903.3	7932.28	4254.47	1305.17	2670.51
1987	97590.4	113930	31172.9	8244.02	3559.31	2305.7	2274.17
1988	60960.2	67362.3	65971.7	11888.7	3690.81	1877.57	2540.25
1989	38270.2	41433.6	38350.3	27138.6	5272	1849.98	2326.18
1990	38369.7	25086.1	22699.4	16594.8	12118.9	2562.83	2126.02
1991	69664.8	23681.7	12800.3	9828.21	7715.69	6120.08	2462.13
1992	93671.5	39974.3	10886.1	5317.31	4800.48	4170.99	4794.56
1993	45043.1	50316	16419.5	4249.84	2666.38	2712.02	5228.64
1994	36068.3	23301.2	19362.2	6066.37	2091.46	1501.03	4649.17
1995	60612	18813.9	9120.81	6964.91	2801.29	1119.94	3493.86
1996	71346.5	33422.5	8047.33	3324.8	2933.73	1375.09	2490.42
1997	126940	42579.2	16172.2	3102.35	1284.11	1306.27	1987.95
1998	59451.7	80310.4	22718.9	6668.99	1142.65	535.618	1658.1
1999	46753.4	38456.1	44569.1	9734.07	2481.48	479.478	1122.09
2000	54089.1	29685.4	20525.3	18710.2	3885.94	1138.38	862.103
2001	51664	32139.9	13970.7	8007.15	8213.89	1996.09	1140.35
2002	77484.3	28783.7	13148.6	5056.61	3793.3	4557.13	1853.18
2003	38619.3	46052.5	12247.6	4755.36	2483.49	2158.77	3797.58
2004	46540.2	25430.1	23509.2	4788.42	2340.85	1393.07	3429.43
2005	40083.2	31913	14714.4	9970.19	2339.28	1277.72	2665.11
2006	37308	27711.2	19142.3	6453.36	4899.31	1268.88	2137.25
2007	53031.8	25649.7	16134	8236.06	3257.43	2734.37	1887.84
2008	63750.2	35933.5	14016.4	6691.32	4302.48	1892.91	2673.77
2009	103454	42851.4	18980.6	5747.01	3602.55	2586.02	2754.48
2010	163745	70382.7	23632.3	8107.14	3165.52	2214.19	3328.23
2011	206618	112812	41498.9	10925.3	4556.82	1974.28	3540.14
2012	107287	143044	69845.6	21086.1	6274.98	2869.77	3586.94
2013	118639	74144.5	90834.6	38592.5	12379	3974.11	4250.25
2014	189290	81519.1	47595.1	52900	22995	7839.91	5434.01
2015	164328	129351	52367.2	28181.4	31574.6	14445.3	8701.58
2016	104162	112312	82476.2	30427	16576	19466.8	14793.3
2017	108674	71357.5	70725.4	46033.7	17432.5	9944.59	20992
2018	138182	74410.2	44368.8	38079.1	25608.5	10151.6	18182.5
2019	169412	93889.7	45911.6	23861.1	20713	14563.2	16488.8
2020	2719.57	112959	57758.2	25365.2	12786.4	11582	18422.4

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		Ages 3–6	High	Low
1980	67427	87849	51773	8223	10436	6010	1856	425	0.249	0.336	0.162
1981	34881	46548	26154	10956	13323	8589	3261	789	0.300	0.382	0.218
1982	65744	87106	49668	13307	16039	10575	4661	908	0.353	0.445	0.261
1983	56890	75505	42875	13261	15948	10574	4512	1039	0.393	0.494	0.291
1984	58127	76935	43883	13073	15708	10438	4839	1132	0.406	0.499	0.314
1985	77772	100970	59959	12942	15502	10382	4654	1091	0.403	0.488	0.318
1986	164360	208689	129495	13004	15379	10629	4631	1317	0.395	0.482	0.309
1987	97590	123914	76931	15952	18476	13428	5955	2139	0.396	0.475	0.317
1988	60960	78126	47568	20941	24256	17626	8342	2193	0.405	0.481	0.330
1989	38270	49935	29305	21745	25086	18404	7599	1588	0.407	0.487	0.327
1990	38370	51990	28317	18308	21240	15376	5747	1302	0.379	0.451	0.308
1991	69665	99040	48958	14378	16968	11788	4146	1852	0.345	0.408	0.282
1992	93672	140764	62390	12011	14291	9731	3932	3139	0.332	0.397	0.267
1993	45043	67642	29972	11341	13390	9292	4437	2875	0.351	0.415	0.287
1994	36068	53817	24165	10454	12277	8631	4040	1873	0.393	0.455	0.331
1995	60612	87223	42099	8589	10108	7070	3296	1776	0.447	0.519	0.375
1996	71347	95301	53380	7217	8485	5949	3042	1752	0.492	0.570	0.413
1997	126940	162973	98781	7678	9002	6355	3389	2001	0.508	0.592	0.425
1998	59452	76726	46074	10716	12457	8975	4557	1947	0.491	0.585	0.396
1999	46753	62594	34947	14616	16966	12266	6250	1775	0.443	0.530	0.356
2000	54089	76932	37999	15039	17539	12539	5718	1827	0.395	0.470	0.320
2001	51664	76694	34836	12884	15223	10545	4534	2110	0.367	0.445	0.289
2002	77484	105244	57066	11384	13598	9170	3837	2022	0.351	0.430	0.272
2003	38619	48727	30639	11066	13246	8886	3559	1309	0.341	0.417	0.266
2004	46540	57241	37835	11711	14014	9408	3764	791	0.340	0.421	0.260
2005	40083	48564	33102	12091	14501	9681	3471	644	0.337	0.419	0.254
2006	37308	45229	30777	12368	14870	9866	3610	747	0.322	0.398	0.246
2007	53032	63719	44168	12451	15071	9831	3496	848	0.302	0.376	0.228
2008	63750	77780	52280	12402	15092	9712	3350	1256	0.278	0.348	0.209
2009	103454	124107	86258	13255	16104	10406	3499	1330	0.249	0.308	0.189
2010	163745	197829	135515	15972	19289	12655	3815	1396	0.214	0.267	0.160
2011	206618	252445	169236	22488	26924	18052	4792	1825	0.178	0.224	0.132
2012	107287	130294	88296	33955	40599	27311	3062	3143	0.147	0.183	0.111
2013	118639	144428	97486	45882	55143	36621	3659	2604	0.129	0.162	0.097
2014	189290	229829	155891	51526	62379	40673	3378	2614	0.129	0.162	0.095
2015	164328	200912	134508	52389	63537	41241	3656	2691	0.148	0.184	0.112
2016	104162	130593	83130	54351	65905	42797	4793	4237	0.182	0.226	0.138
2017	108674	138278	85390	52913	64656	41170	4737	4532	0.216	0.272	0.161

Year	Recruitment			SSB (tonnes)			Landings	Discards	F		
	Age 1	High	Low		High	Low	Tonnes		Ages 3–6	High	Low
2018	138182	191534	99626	45401	56381	34421	3598	3553	0.231	0.290	0.171
2019	169412	281639	101887	37775	47728	27822	2791	4728	0.227	0.292	0.162
2020	34881			33782	43579	23985	2093	2757	0.217	0.298	0.136
2021	74235			39308							

Table 14.5.3.1.1. Plaice in 7.d: Management options for 2020 and their effects on the resident stock.

Variable	Value	Source	Notes
F ages 3–6 (2021)	0.22	AAP	Correspond to F_{2020} (status quo assumption)
SSB (2022)	39151	AAP	Short term forecast (STF), tonnes
$R_{age\ 1}$ (2020)	34 881	Lowest recruitment observed over 1980–2019.	The model estimate has been replaced due to large uncertainty
Rage1 (2021–2022)	74235	GM 1980–2019	Thousands individuals
Catch (2021)	5996	AAP	STF, in tonnes (resident stock)
Landings (2021)	2937	AAP	STF, in tonnes; projection based on the average landing ratio (2018–2020) by age
Discards (2021)	3060	AAP	STF, in tonnes; projection based on the average landing ratio (2018–2020) by age

Table 14.5.3.1.1. (continued) Plaice in 7.d: Management options for 2020 and their effects on the resident stock.

	Total catch (2022)	Projected landings* (2022)	Projected discards** (2022)	F_{total} (ages 3–6 2022)	SSB (2023)	% SSB change	% change in projected catches
MSY approach: F_{MSY}	6365	3266	3099	0.25	31393	-15.4	75
$F = F_{MSY\ lower}$	4594	2360	2234	0.175	33609	-9.4	27
$F = F_{MSY\ upper}$	8435	4323	4111	0.344	28837	-22	132
F = 0	0	0	0	0	39461	6.4	-100
F_{pa} ($F_{P.05}$ with AR)F_{pa}	9955	5097	4858	0.418	26983	-27	174
F_{lim}	11536	5900	5636	0.5	25078	-32	218
SSB (2023) = B_{lim}	17229	8765	8464	0.85	18447	-50	375
SSB (2023) = B_{pa}	10913	5584	5329	0.47	25826	-30	201
SSB (2023) = MSY $B_{trigger}$	10913	5584	5329	0.47	25826	-30	201
$F = F_{2021}$	5594	2872	2722	0.217	32354	-12.8	54

*** Marketable landings**

**** Including BMS landings (EU stocks), assuming recent discard rate**

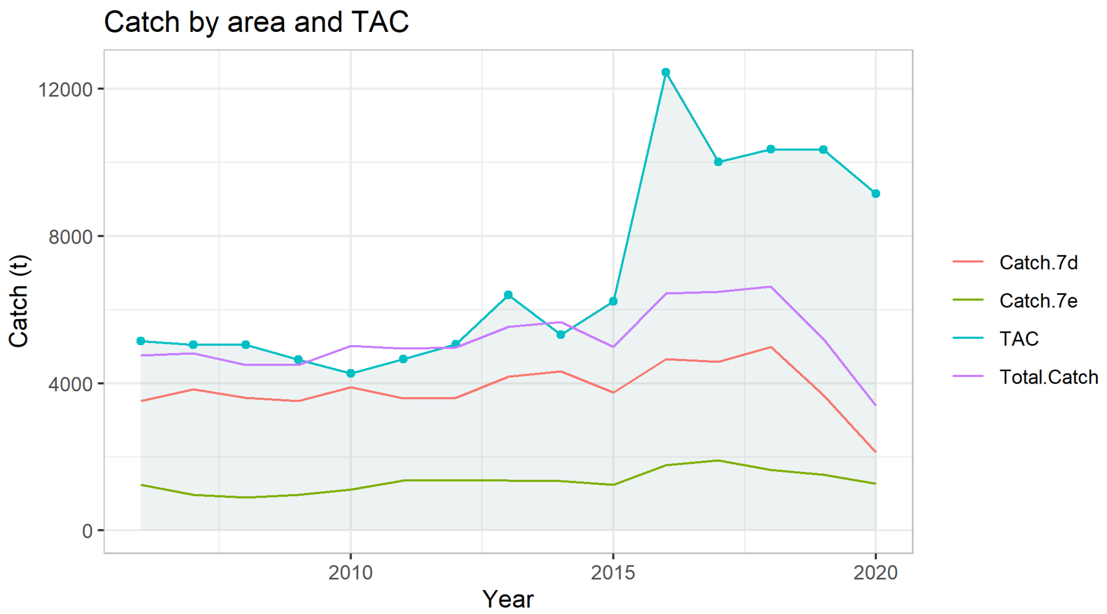


Figure 14.2.1.1. Plaice in 7.d. Official landings in 7.d and 7.e compared to the TAC: since 2019, the advice was given on catch rather than landings.

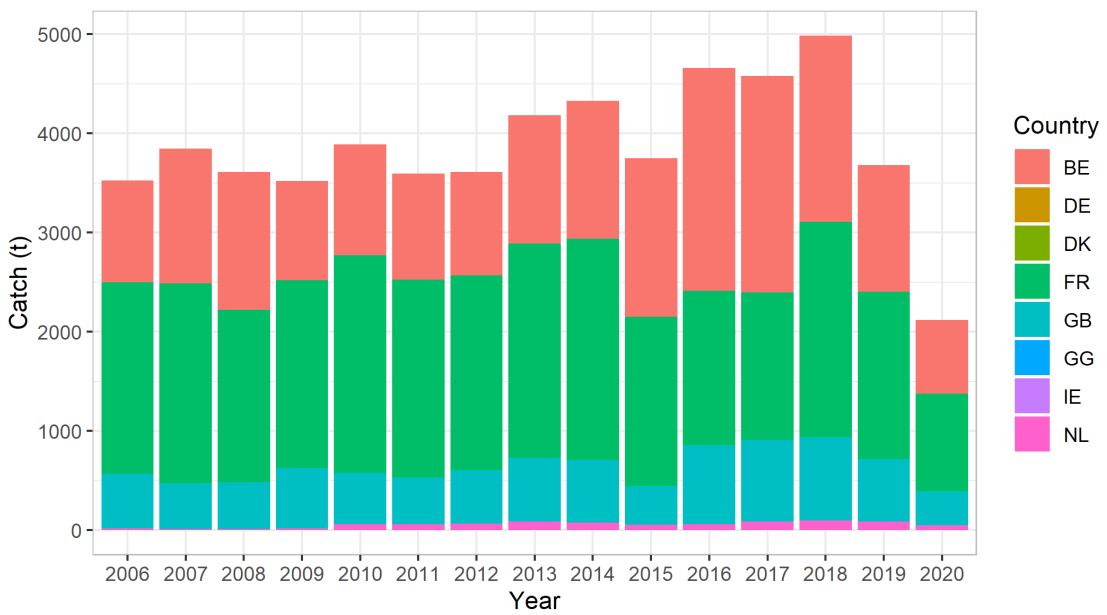


Figure 14.2.1.2. Plaice in 7.d: Official landings.

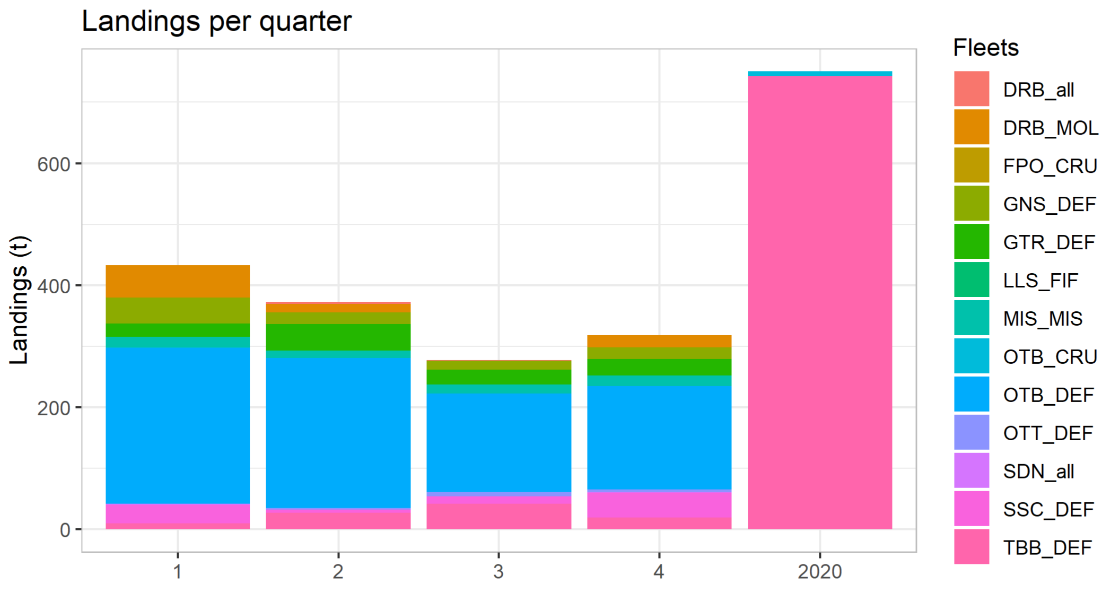


Figure 14.2.1.3. Plaice in 7.d: Landings per quarter.

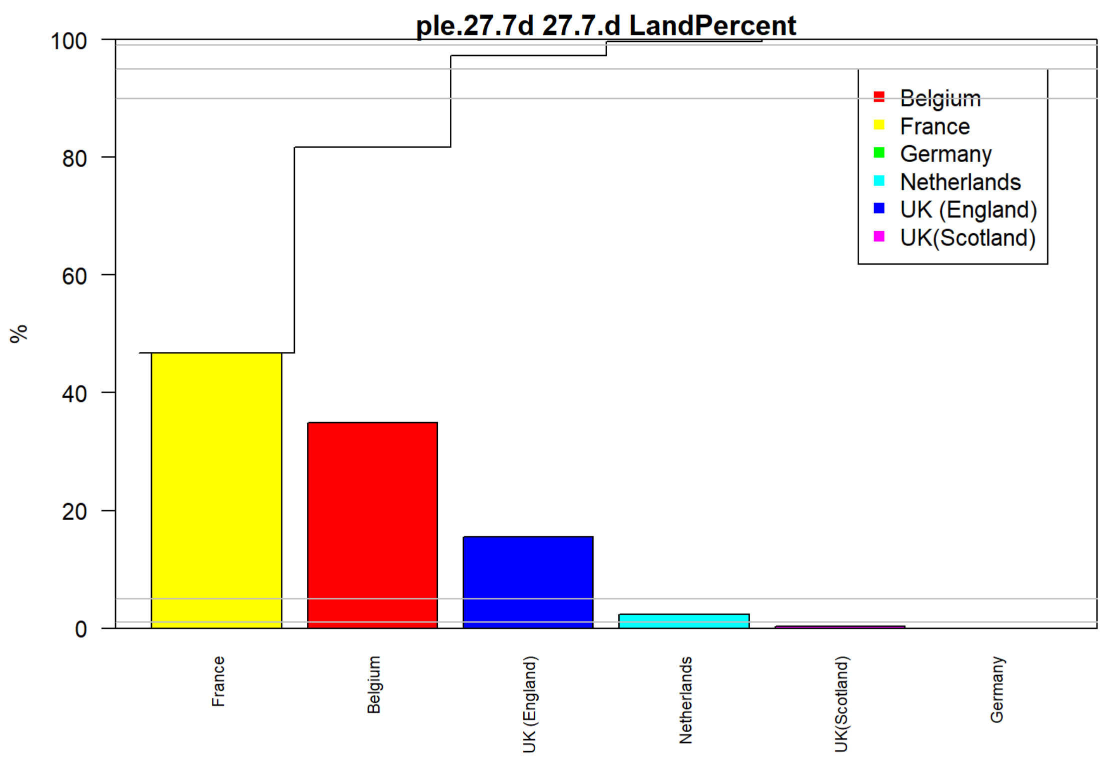


Figure 14.2.2.1. Proportions of total landings per country with and without age distribution provided.

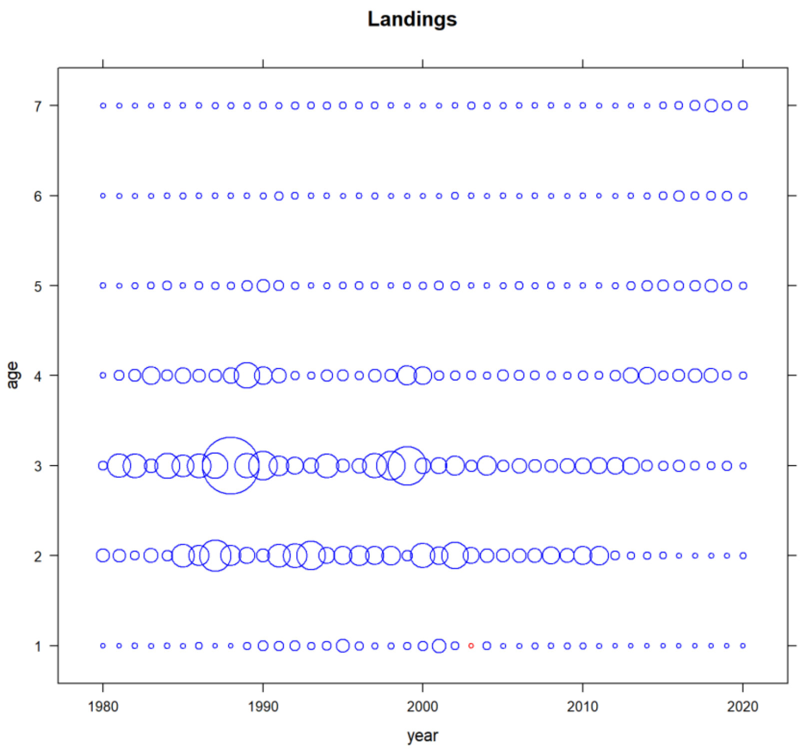


Figure 14.2.3.1. Plaice in 7.d: Age composition of the landings, missing data are presented in red.

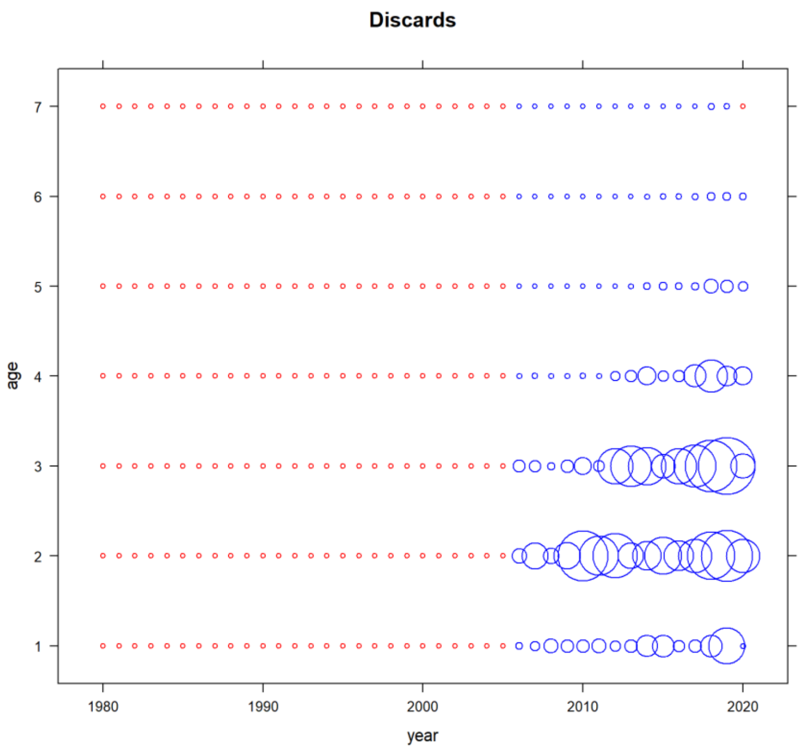


Figure 14.2.3.2. Plaice in 7.d: Age composition of the discards (data available from 2006 onward).

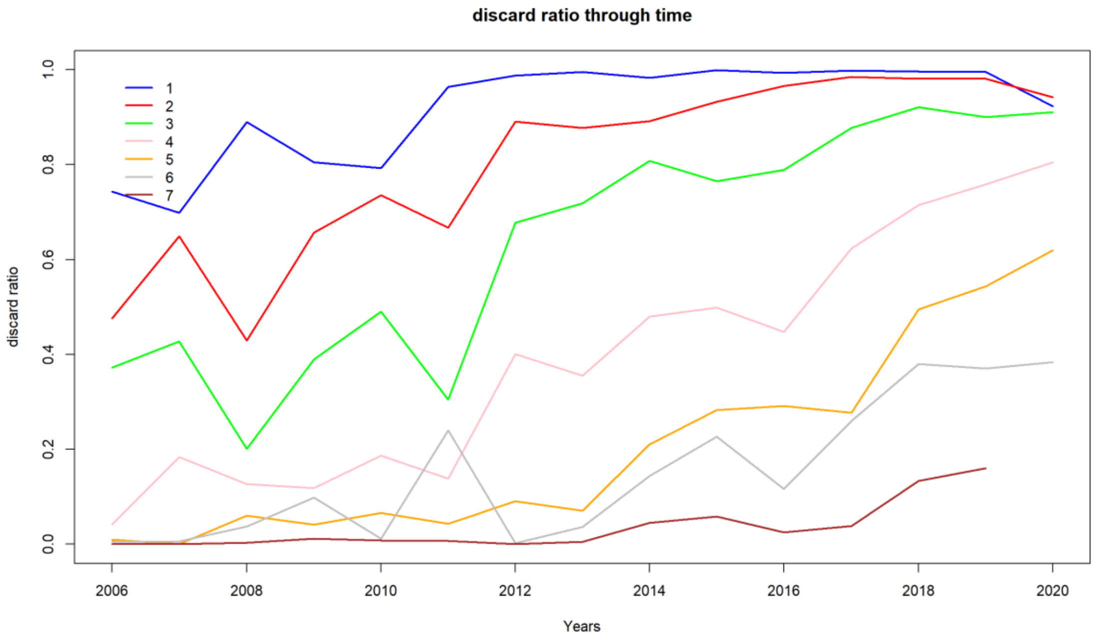


Figure 14.2.3.3: Plaice in 7.d: Discards at age ratio (discards numbers/landings numbers) per age.

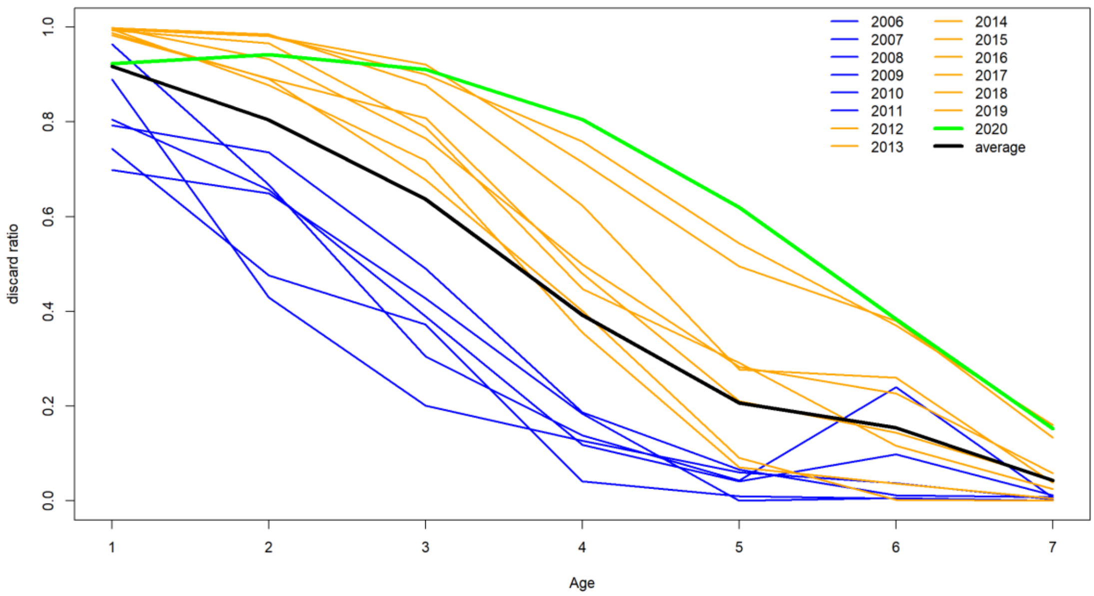
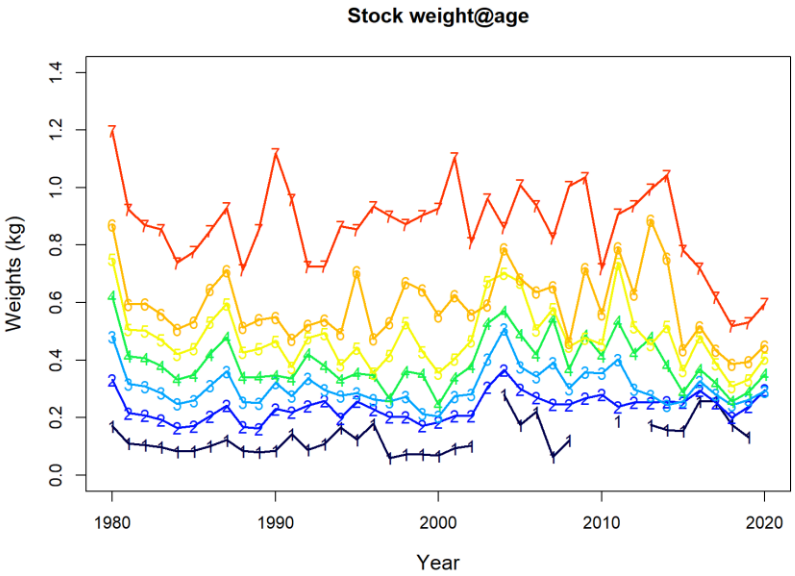


Figure 14.2.3.4. Plaice in 7.d: Discards at age ratio (discards numbers/landings numbers) through time.


Stock weight@age
Weights (kg)
Year


Landing weight@age
Weights (kg)
Year

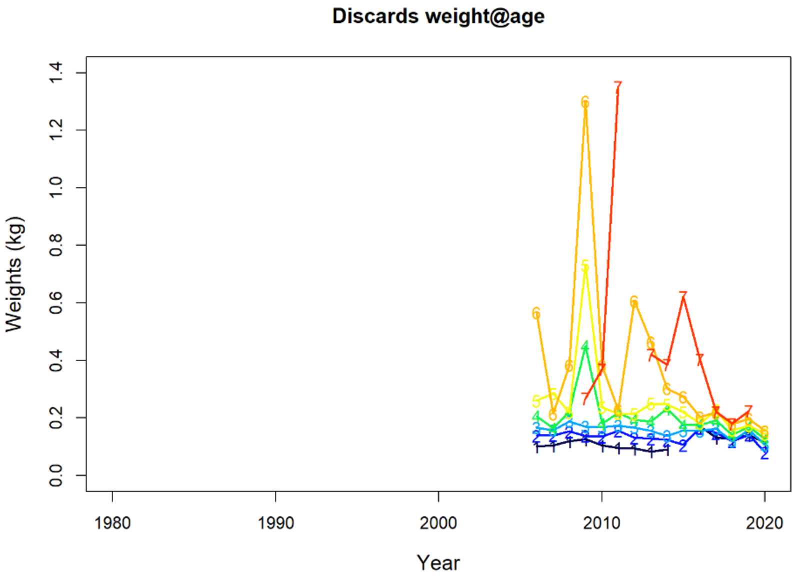


Figure 14.2.4.1. Plaice in 7.d: Stock, Landing and discard weights.

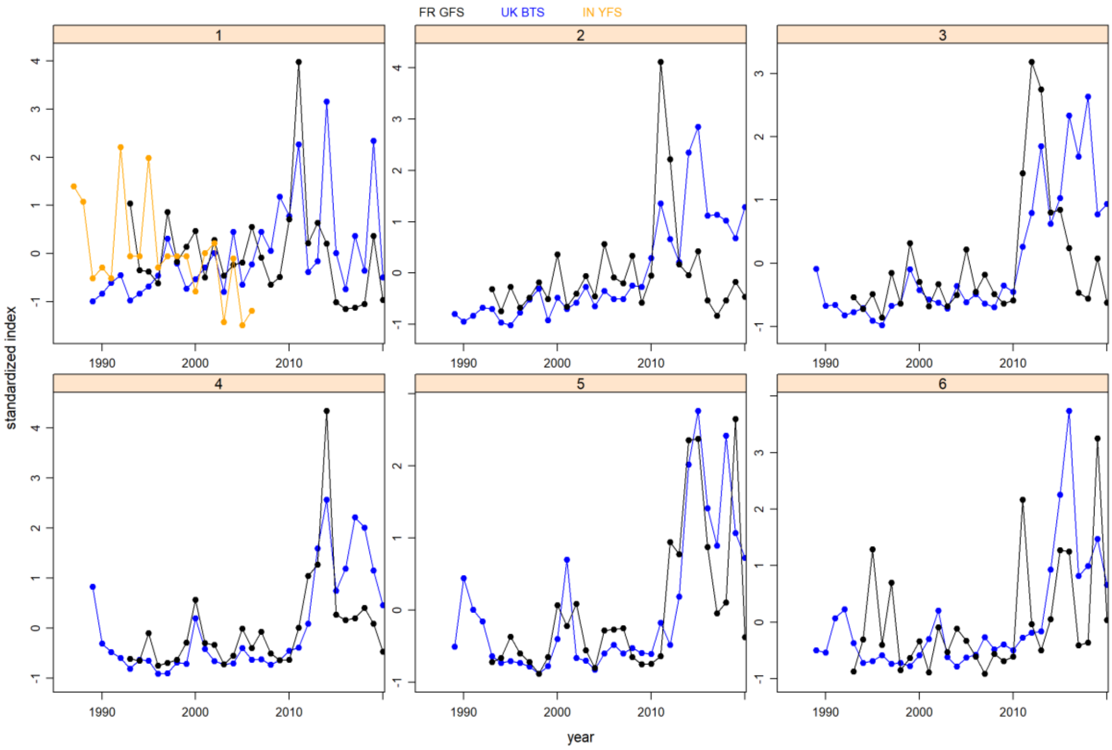


Figure 14.2.6.1. Plaice in 7.d: Survey Consistency: mean standardized indices by surveys for each age.

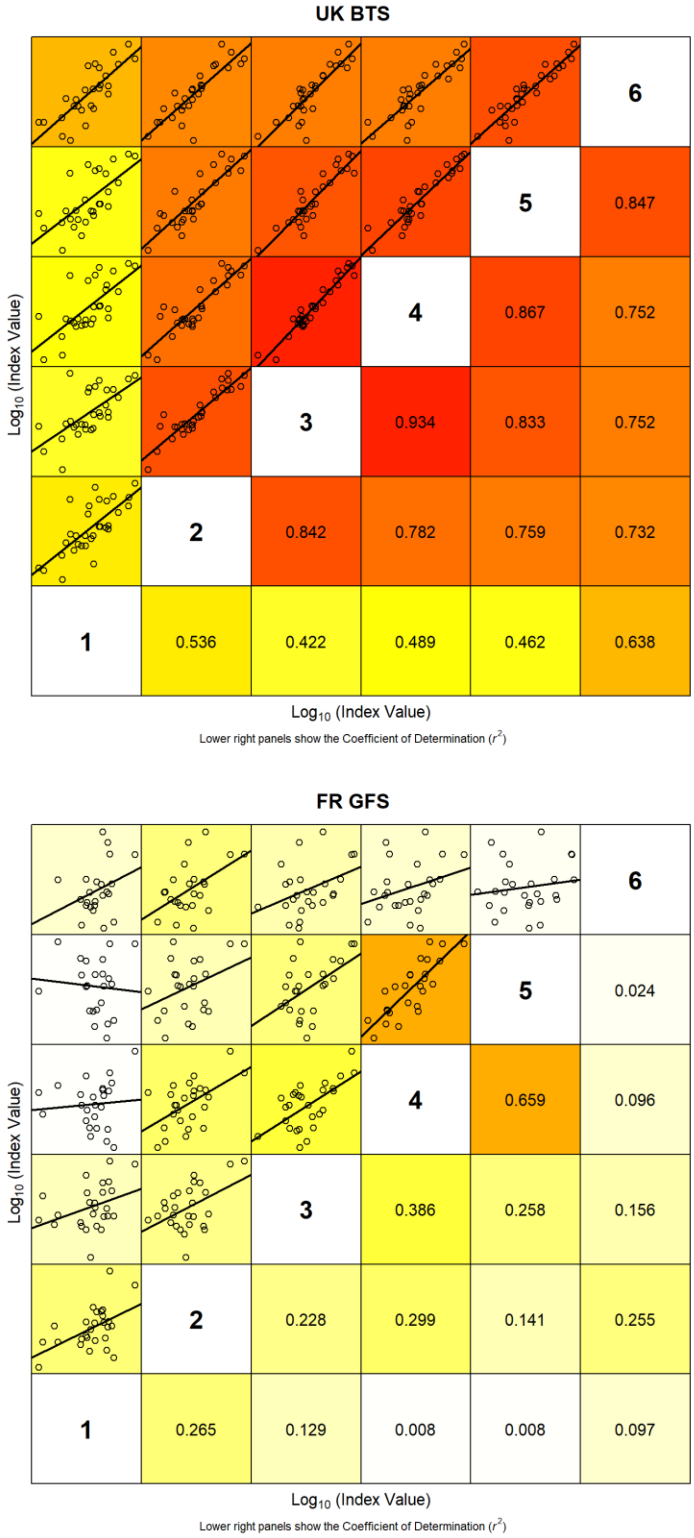


Figure 14.2.6.2. UK BTS and FR GFS indices consistencies.

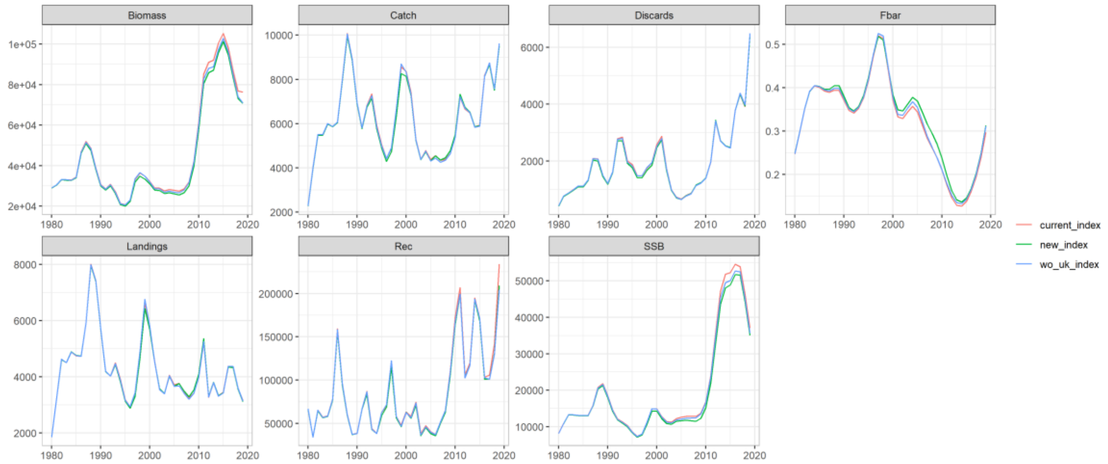


Figure 14.2.6.3. Several runs to test i) the impact of the lack of sampling during FR GFS (index calculated without UK sampling stations in blue), ii) the impact of the calculation issues of the FR GFS index (current index in red) and iii) the new index (in green) on assessment outputs of plaice in 7d.

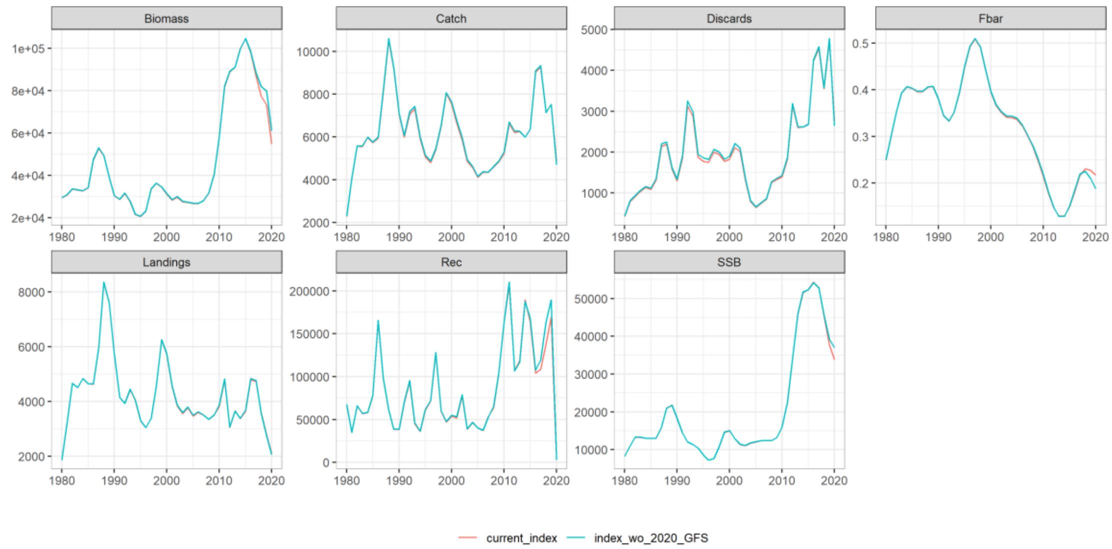


Figure 14.2.6.4. Test of the impact of removing the FR GFS index in 2020 on assessment outputs of plaice in 7d. (in blue, the assessment without 2020 the FR GFS index)

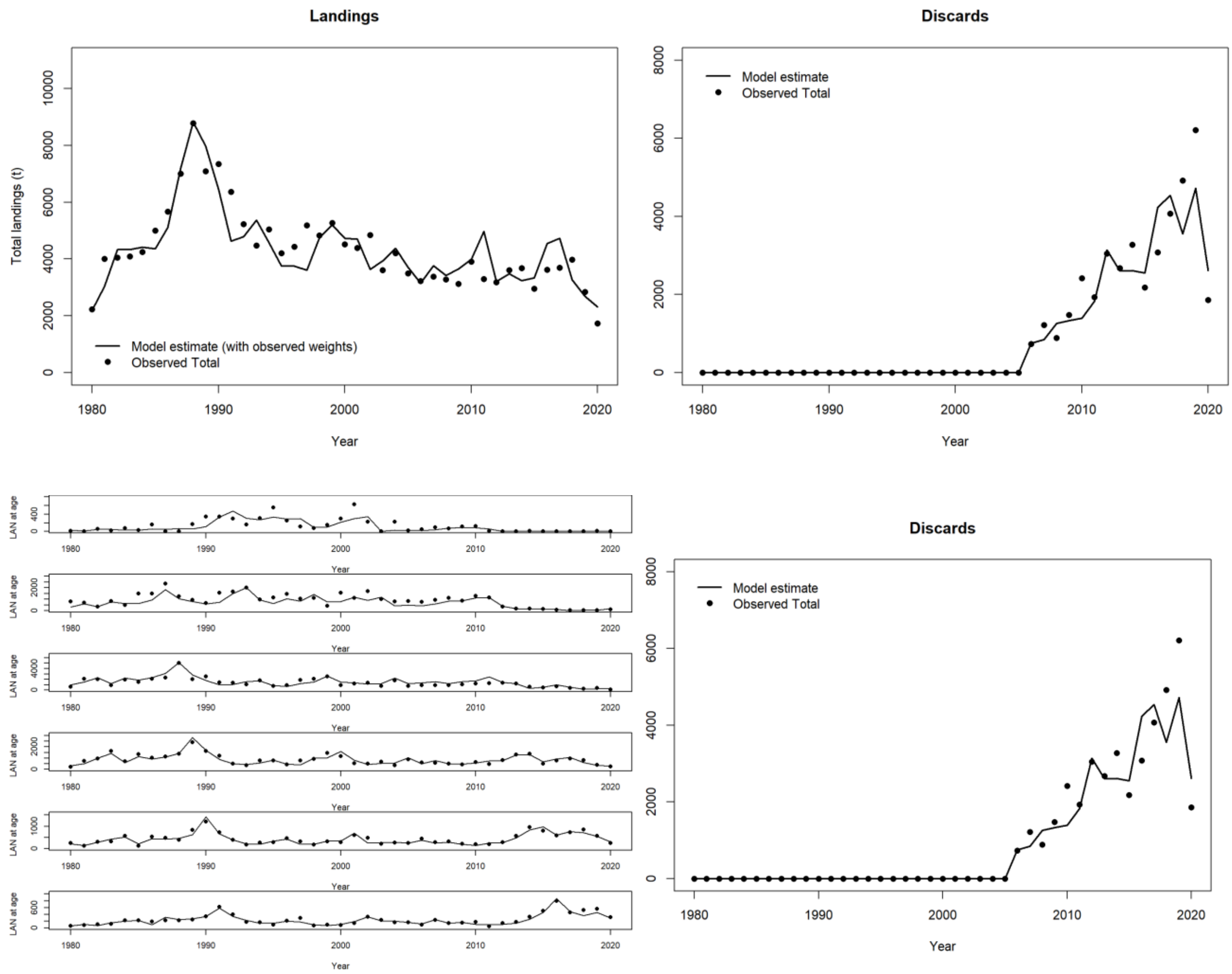


Figure 14.3.1.1. Plaice in 7.d: Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).

Figure 14.3.1.2. Plaice in 7.d: Survey residuals from the AAP assessment.

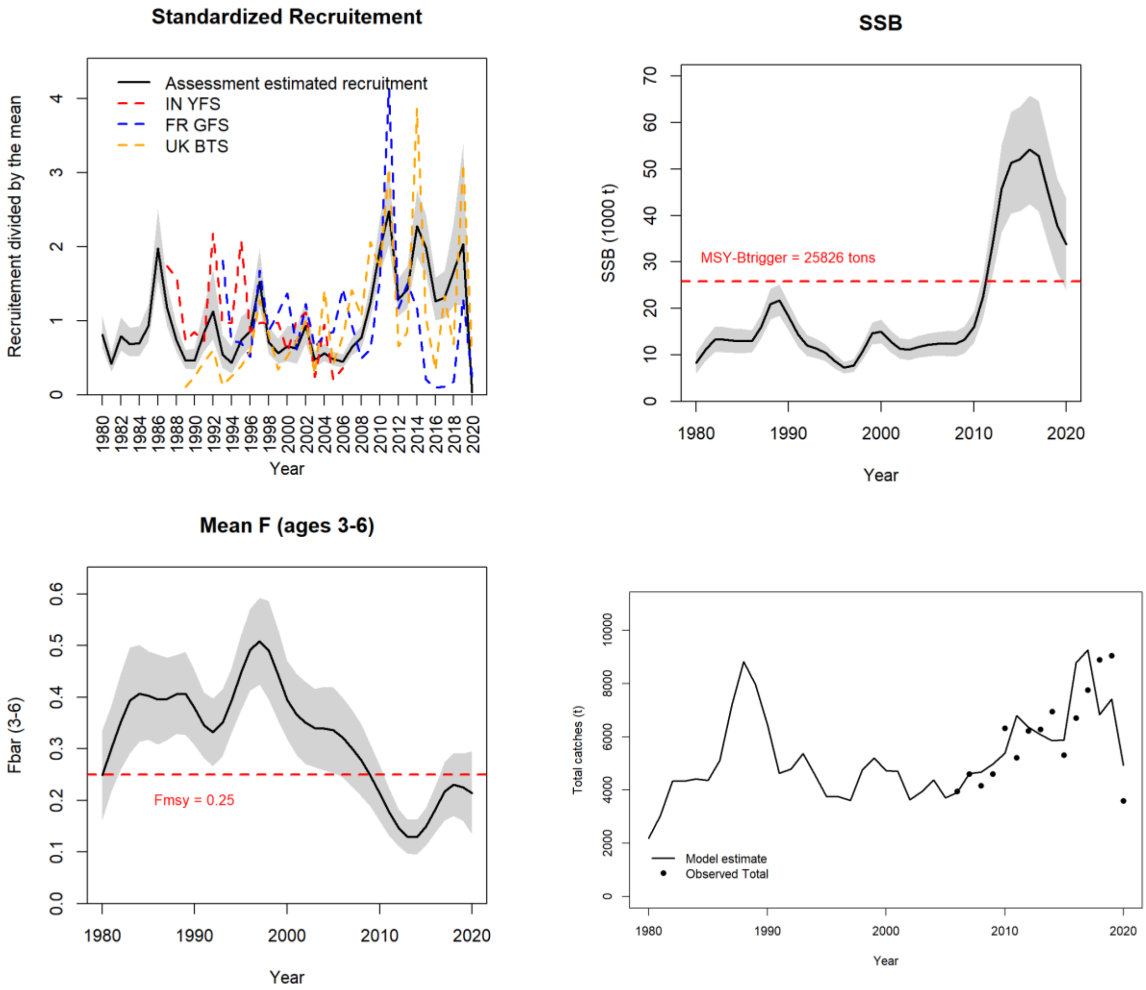


Figure 14.3.1.3. Plaice in 7.d: Summary of assessment results.

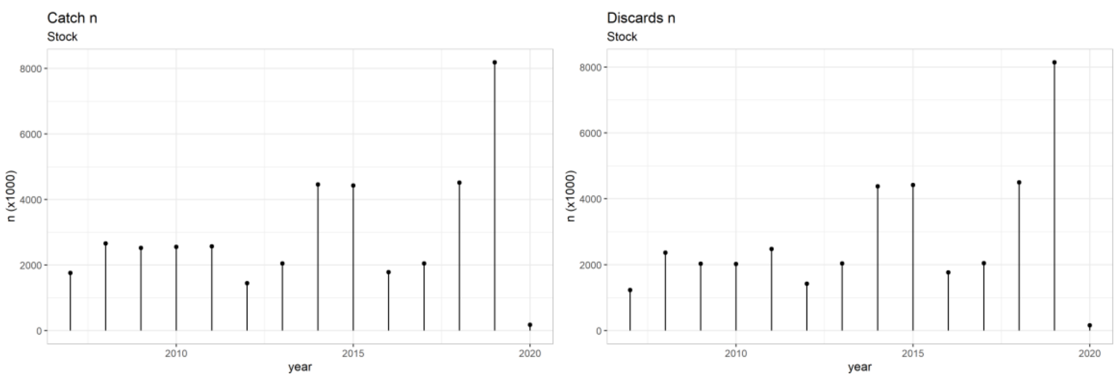


Figure 14.3.1.4. Catch and discards number for age 1 from the stock object.

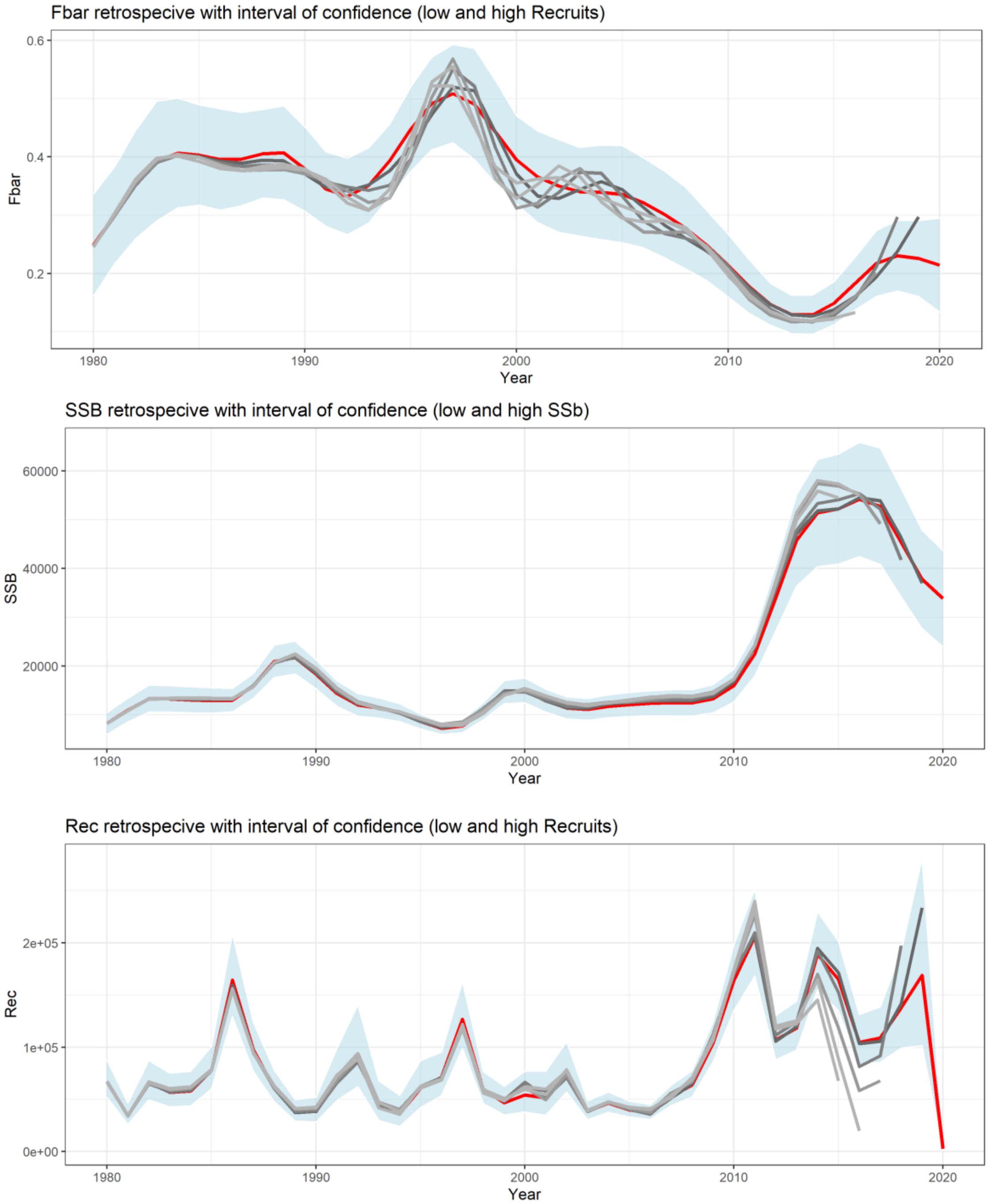


Figure 14.3.1.4: Plaice in 7.d. Retrospective patterns (Mohn's Rho F_{bar} = 0.0168, Mohn's Rho SSB = -0.024, Mohn's Rho Rec = -0.192).

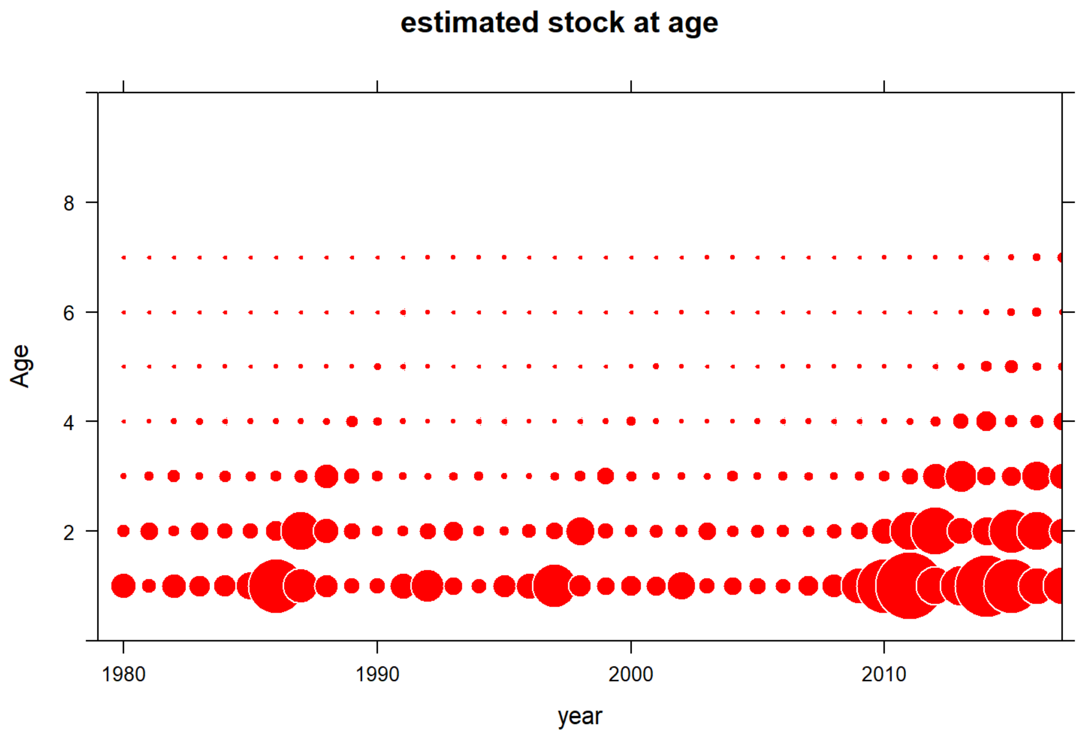


Figure 14.3.1.5: Plaice in 7.d. Estimated stock numbers.

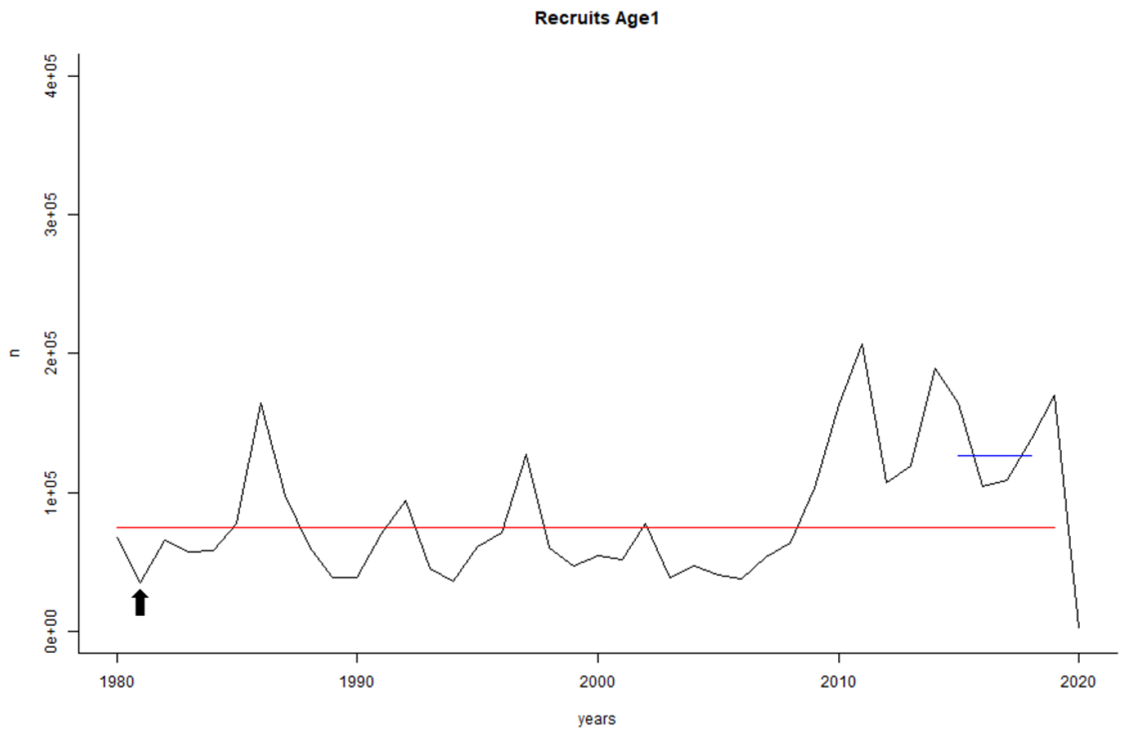


Figure 14.5.1.2. Plaice in 7.d: Number of individuals of age 1 as estimated by the assessment model (black), with the geometric mean over the period 1980–2019 (red), and the geometric mean over 2014–2017 (blue). The black arrow corresponds to the lowest recruitment observed over 1980–2019.

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 1977–2020 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 1977–2020. Two periods with high landings can be seen, and generally the total landings for both areas have declined. In Division 3.a, landings have been low but stable since 2000, although the landings for 2020 were the lowest on record. In Subarea 4 landings fluctuated over the same period, but have now been increasing in 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 2020, 46% of the total landings were caught with gillnet and 41% with otter trawls in Division 3.a. In Subarea 4, 18% of the total landings were made with gillnets and 72% with otter trawls. The geographical distribution of Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower. Discards are now considered by ICES to be known to take place, although at a seemingly small rate, and discards were estimated at 2.6 tonnes in total between division 3a and subarea 4 in 2020 (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 UK Scotland and Denmark the countries reporting the largest number of discards (95% of total). In 2020, below minimum size (BMS) landings and logbook reported discards were also reported to ICES for pollack. No BMS landings or logbook reported discards were reported in Intercatch whereas 70 kg of 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, e.g. age readings of pollack otoliths, from commercial catches should be processed. An effort is underway to see if biological information from commercial catches, especially length information, is available from other countries, especially UK – Scotland, Denmark and Germany, and whether such data can be used to establish future reference points for this stock. Other surveys than IBTS should also be explored to evaluate their usefulness as potential indices for pollack stock size and/or recruitment. Potential candidates are, but not limited to, the annual shrimp survey taking place in the Norwegian trench in January, and the beach seine survey in the autumn along the Norwegian Skagerrak coast.

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 1977–2020.

	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	7	4	117	44		357
2018		226	10	1	105	64		406
2019		196	5	1	81	30		313*
2020		163	5	18	47	17		251*

*** 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

ICES Subarea 4											
	Belgium	**Denmark**	**Faeroes**	**France**	**Germany**	**Netherl.**	**Norway**	**Poland**	**Sweden**	**UK**	**Total**
2006	18	152		4	80	1	545		12	587	1399
2007	18	192		130	137	2	754		43	905	2181
2008	15	150		129	114	1	840		46	999	2294
2009	13	121	2	6	50	1	668		32	658	1551
2010	12	163		10	129	0	599		32	540	1485
2011	12	106	0	10	67	0	580	0	35	489	1299
2012	17	123	0	3	102	1	433		42	443	1164
2013	17	128	0	2	66	4	371	0	29	463	1080
2014	24	121		32	145	1	476		40	377	1215
2015	20	183		3	237	3	473		50	627	1594
2016	21	127		2	107	2	447		37	430	1174
2017	18	187		8	269	3	510		44	511	1551
2018	14	139		23	154	2	739		30	486	1588
2019	20	184		24	159	6	894		38	557	1881*
2020	22	241		20	262	9	1128		71	619	2373*

*** Preliminary**

Table 15.2. Pollack in Subarea 4 and Division 3.a. Catches (tonnes) by country as estimated by the Working Group 2013–2020.

ICES Division 3.a								
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Denmark	214	192	192	152	187	229	196	163
Germany	11	6	35	7	11	13	5	5
Netherlands	<0.5	0	0	1	5	2	1	18
Norway	174	156	138	135	117	108	81	48
Sweden	36	30	46	47	43	64	30	17
ICES Total	435	384	413	343	363	415	307	251
Official Total	420	383	389	338	357	406	314*	251*
Diff ICES-Off	15	1	24	5	6	9	-6	0

*** Preliminary**

ICES Subarea 4								
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Belgium	17	24	20	21	18	14	20	22
Denmark	150	122	183	127	187	139	184	241
France	2	32	2	2	8	46	24	20
Germany	59	145	216	107	267	151	159	262
Netherland.	3	1	2	2	2	2	4	8
Norway	379	481	466	440	508	738	901	1129
Sweden	29	41	50	36	44	30	38	71
UK	456	377	626	423	508	488	569	621
Ices Total	1103	1227	1567	1159	1543	1608	1899**	2374
Official Total	1080	1215	1594	1174	1551	1588	1881*	2373*
Diff ICES-Off	23	12	-27	-15	-8	20	18	1

*** Preliminary**

****Swedish catches for Subarea 4 were added manually to the data after exporting the data from Intercatch.**

Table 15.3. Pollack in Subarea 4 and Division 3.a. Discards (tonnes) by country estimated by the Working Group, 2013–2020.

	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
2019			0.856					0.86
2020		0.72	0.025		0.26	0.122		1.13

	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
2019		0.341		1.65							1.99
2020	0.057	0.022		0.0138	0.023	0.009	0.55		0.048	0.70	1.42

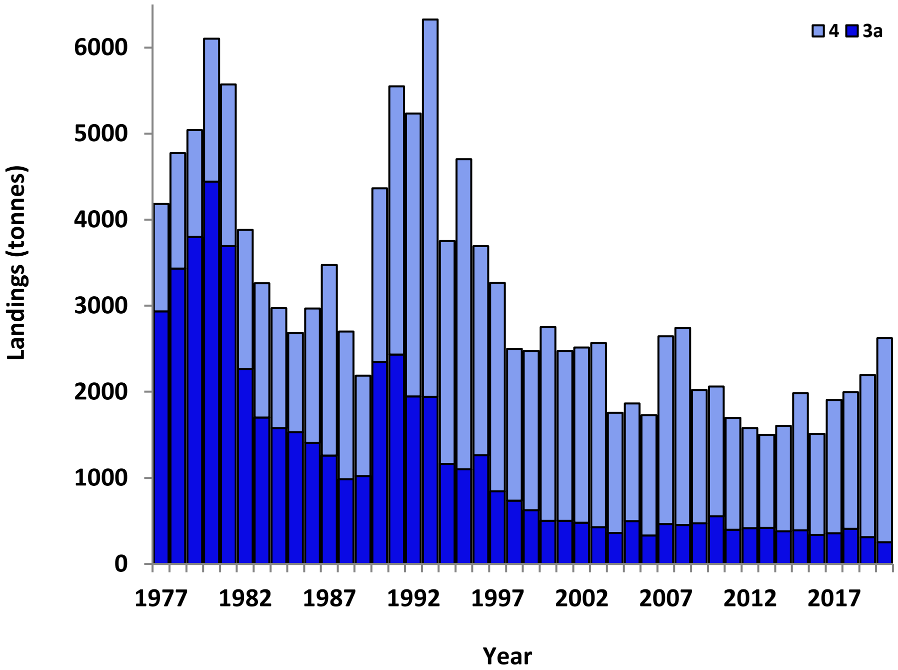
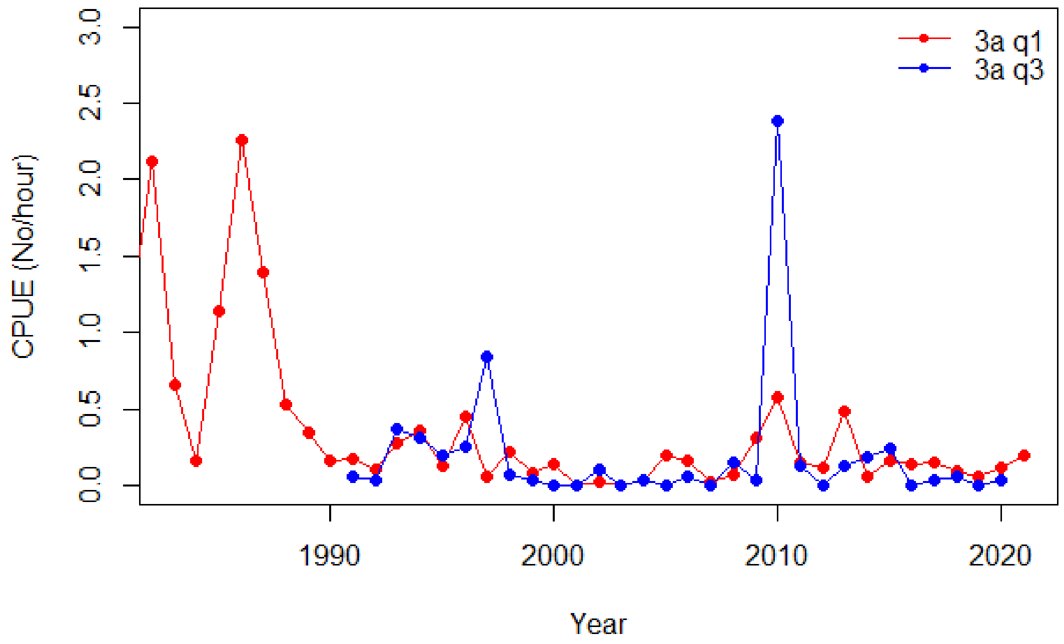


Figure 15.1. Pollack. Total landings of pollack from 1977–2020 in Division 3.a and Subarea 4 as officially reported to ICES.



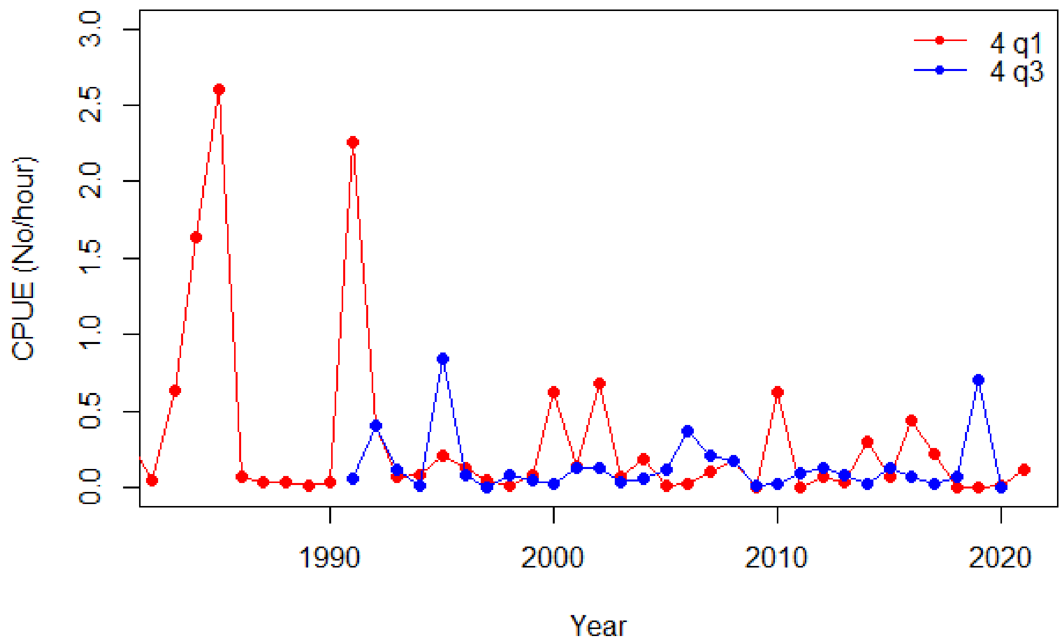


Figure 15.2. Time series of catches of pollack from 1983–2021 in ICES Division 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV-trawl. Data from Datras.

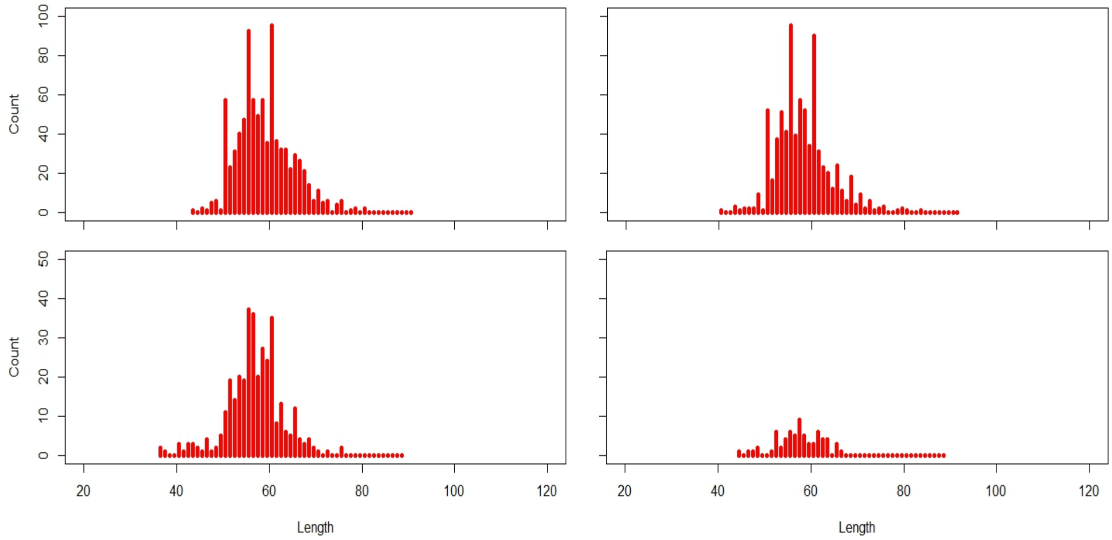


Figure 15.3 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a. The data is aggregated for gillnets with a 63 mm mesh size.

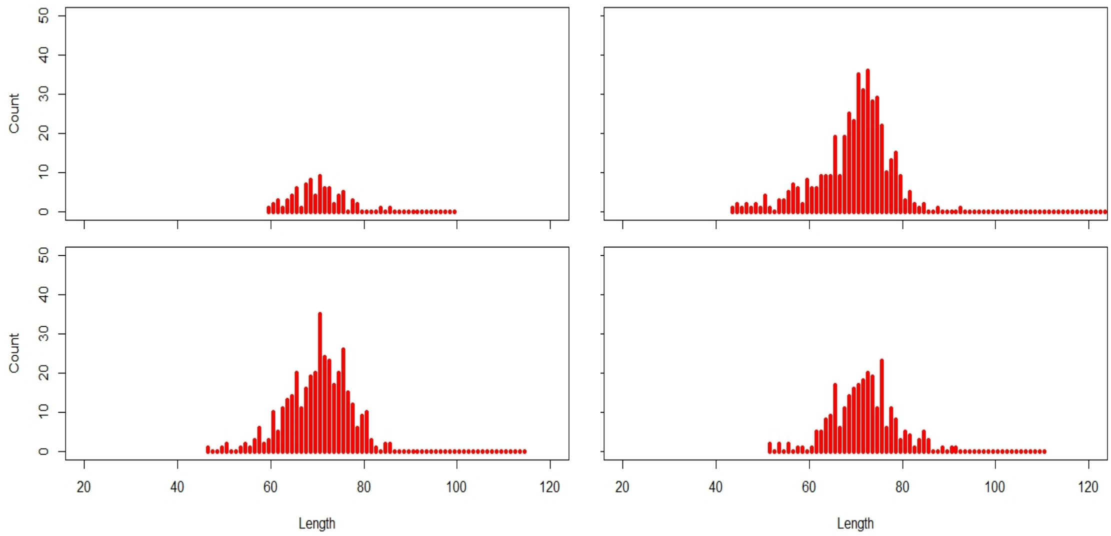


Figure 15.4 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70 mm mesh size.

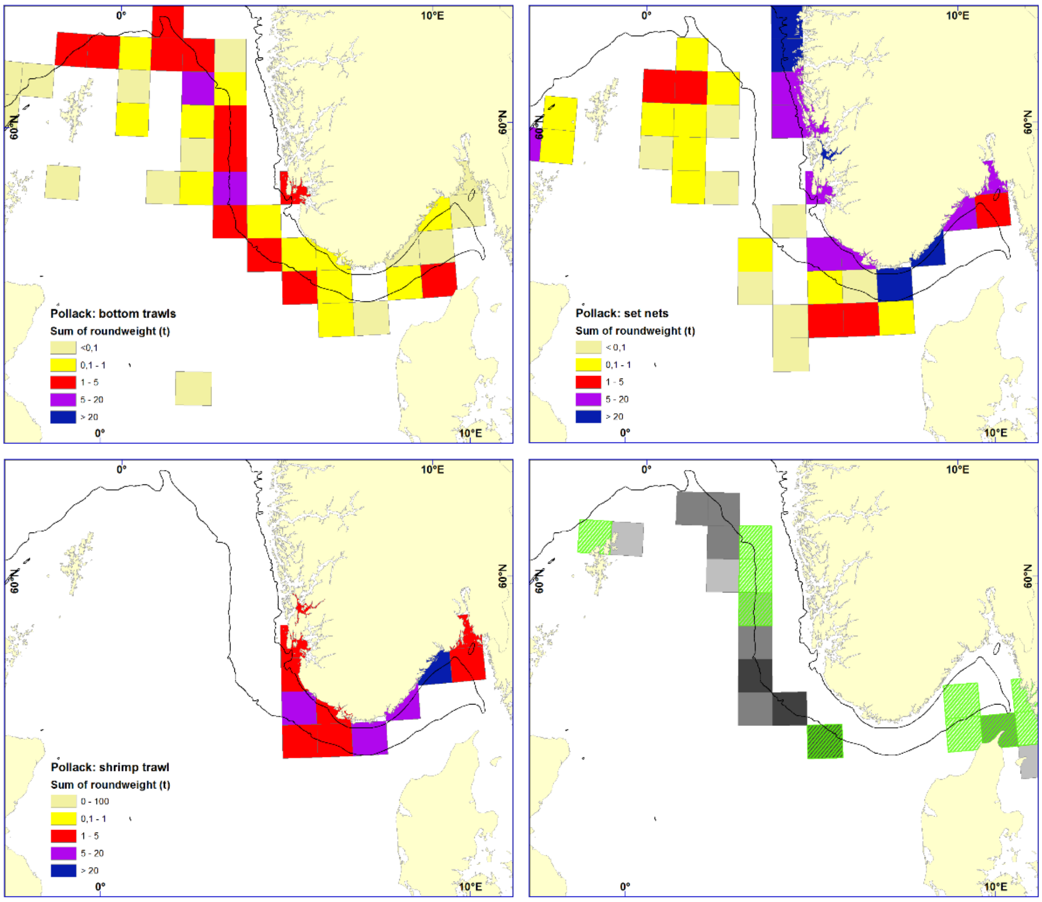


Figure 15.5 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

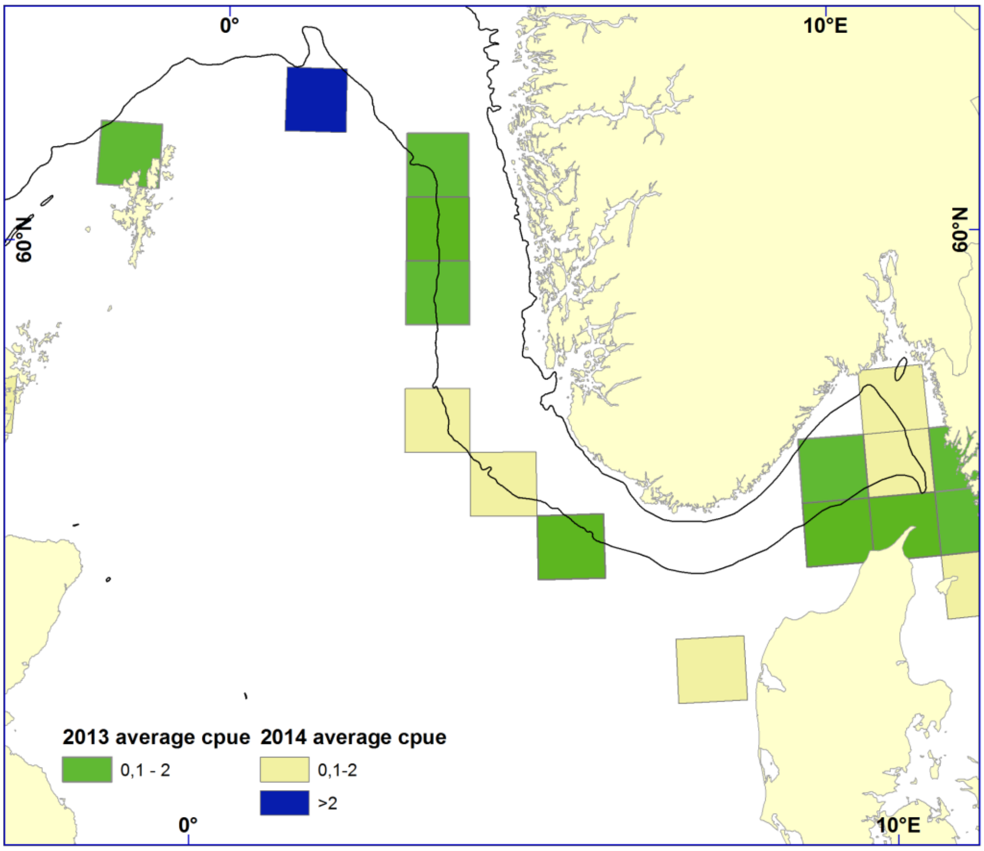


Figure 15.6 Pollack catches from IBTS surveys in 2013 (green) and 2014.

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 prior to 2018.

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 2021. 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. In 2019, two new vessels entered the German fleet while 2 old vessels left. CPUE index calculations with and without the two new vessels were very similar. 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, a large part of which is then discarded due to lack of quota. Discarding continued in 2020 in areas 4 and 3.a 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 2020 Advice sheet.

Advice for 2021

"ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 65 687 *tonnes."*

The agreed TAC (trilateral agreement) was 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, further corrected during WGNSSK 2021 (this document), 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.

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. No resubmission of earlier data to Intercach occurred, and only 2020 estimates were appended.

In 2020, official landings and ICES estimates were very close in both 3.a-4 and 6. ICES estimates correspond to the sum of products (SOP) uploaded to Intercatch and present a good match for overall catch (100.1%).

In 2020, 92% of discards were imported to Intercatch while 8% 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 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). Because of the absence of discard sampling in Q4 within these fleets, discards in Q4 were raised using sampling in Q1, expected to be the most similar season. Trawler fleets (TR1) from other countries were raised with trawler fleets from these countries. Because of lack of sampling data in 2020, likely linked to the Covid-19 situation, all seasons were raised together for this segment. Discards for other fleets (all countries), were raised using a stratification by quarter and area (4/6 and 3.a were distinguished). Information on discarding from Scottish métiers were not included when raising discards for active gears because rates were typically high.

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. Since 2018 saithe is 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 since 2018 (Table 16.3.2). Sampled and estimated discard rates as well, show a reduction after 2018.

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 68% of the total landings in 2020 (Table 16.3.4; Figure 16.3.3), down from ≥90% in the previous years. This was mostly due to the French OTB_DEF_>=120_0_0 stratum (reported without selectivity device suffix) not being sampled in 2020, unlike previous years, and is likely due to the Covid-19 situation. Although this may induce some noise, it is not believed to impair substantially the quality of the assessment. A large number of fleets do not provide samples for the landings, but these do not usually 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). Stratification for age compositions was by quarter and area 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.

99 percent of the discards were sampled for age distributions in 2020 (Table 16.3.4). All age information from discards were from Denmark and Scotland (Figure 16.3.4) which also have by far the largest amounts of discards. While the proportion of discards sampled for age distribution was high (Table 16.3.4), the number of age samples per metier is often low (ICES, 2016b). Due to a very uneven spatial and temporal coverage, especially poor in area 3 and 6, catch-at-age information was estimated for areas 3 and 6 based on all information available (all areas and seasons together), and for area 4 for all seasons together. This is however believed not to be a critical issue for the quality of assessment as discards are typically low. 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 2018–2020 appears to show weak cohorts entering in at age 3.

16.3.3 Weight-at-age

Weight-at-age from the catch, landing and discard 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 after 2008 (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 (integrating Year, Quarter, Nation Power and Area effects, without interactions), 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, 1992–2019 ("IBTS-Q3").

Errors were found in 2021, which affected (*i*) the SAS code formerly used to calculate the CPUE index and (*ii*) previously submitted French data for the CPUE index. The code issue was a wrong coding of the quarter, based on the month, causing some records to be attributed to the wrong season. Despite a slight but noticeable offset (Figure 16.3.7 left), the correction was shown to have a negligible impact on the previous year's assessment, with deviations on the final year's estimates and management scenarios outcomes typically well below 1%. A nearly exact replication of the former SAS-based estimates could moreover be achieved by replicating the error in the new R implementation (Figure 16.3.7 right), demonstrating the innocuity of changing the software, and the R implementation was therefore retained for instilling further corrections and assessment purpose. The mistakes in French data were linked to a wrong discretization of the engine power (>75% of vessels misclassified; Figure 16.3.8 top-left) and an error in the estimate of percent saithe in the catch (in weight), which lead to about two thirds of the data entries to be formerly dismissed (Figure 16.3.8 top-right). Although a much more remarkable downscaling of the index while using the corrected series of data, the trends were still quite similar (Figure 16.3.8 bottom) and the impact on last year's stock assessment outcomes (corrected French data up to 2019) fairly mild. The figures regarding the MSY scenarios, for instance, deviated by just about 1.5% for catch advices and forecasted SSB (after the TAC year), and by 0.6-1.5% for population-wide estimates (SSB, TSB, F_{bar}, recruitment) in the final year. WGNSSK agreed that the whole series should be updated for consistency.

The absence of effect of the above-mentioned corrections on the reference points estimates was further investigated and presented to the group (see dedicated section, 16.7.1 and working document in Annex 8).

The CPUE index continued to exhibit, in 2020, the decline observed over the last years (Figure 16.3.9), but not as steeply as the year before. Although the model was still performing decently, it showed once again signs of strains on assumptions, such as the absence of Year:Nation or Year:Area interactions. The inability of the model to account for spatial-temporal interactions, in particular, lead to strong residual patterns in space, fluctuating through time (Figure 16.3.10) which are in breach of the modelling assumptions regarding residuals independence and may lead to biases. A leave-one-nation-out analysis (Figure 16.3.11) shows a good consistency in the trends exhibited by data from different countries, except for a few years. The downwards trends in the last years of the series, in particular, is consistently captured by all three fleets, although with different magnitudes, and the observed variations may be linked to differences in spatial coverage among fleets (making the absence of Year:Nation interactions a minor concern).

Inspection of the commercial CPUE model assumptions and consideration of alternative modelling approaches have consequently been kept on the list of issues for the next benchmark, and mention to spatial-temporal modelling explicitly added.

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 consistently fully represented in the survey ("hook" patterns at age 3 in the abundances of some cohort: Figure 16.4.1, bottom-left); fish begin migrating out of the inshore nursery areas at age 3, but do not fully recruit to the more oceanic 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 limited ability to render annual variations between 2010–2016, but then reflects well the index increase again in 2017 as well as the substantial decline in the following years (Figure 16.4.3). In addition to changes in resource abundance, the CPUE index may also reflect changes in the spatial distribution of the effort and/or resource, as well as a possible drift in fishing strategy and experience, which are not accounted for in the model and may in turn contribute to the weaker fit over some periods.

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 0.1, while F for the older age classes has also decreased slightly until 2016. The change in F at age 3 occurred when the catches in the purse seine fishery declined. Age 4 moreover shows a declining trend in relative catchability in recent years (Figure 16.4.4, right panel). For ages 5+, catchability shows a dome shaped pattern, with highest catchability for age 6 in recent years. With the lower fishing mortalities up to 2016, fish have been allowed to increase in size (and age) and are likely targeted more than the younger age classes up to age 4 (as observed in Figure 16.4.4). Fishing mortality, in the last four years has however increased again for age classes 4+ (with a slight decrease in 2020, more pronounced for older ages), but recruitment was also very low from 2018 to 2020. Estimated population numbers-at-age are in Table 16.4.4.

The survey index at age fit and residuals are shown in Figure 16.4.5. They exhibit strong patterns, with a consistent underestimation over the last years. After accounting for the correlation between ages within years, the IBTS–Q3 residuals show less of a pattern (one-step ahead residuals, Figure 16.4.6). Even then, the DATRAS series reveals rather positive residuals for ages 4–7 in the last years, while the CPUE residuals shows consistent overestimation over the same period. This is likely due to conflicting signals borne by both sources of information. The strength of the correlation between survey residuals is strong between subsequent ages for all ages (Figure 16.4.7).

The retrospective analysis shows a retrospective pattern for SSB and F while recruitment is well estimated for the last 5 years (Figure 16.4.8). Although SSB tends to be overestimated and F to be underestimated, the peels for SSB all fall within the confidence intervals of the most recent assessment. For F, however, two out of five peels fall out of the confidence interval of the whole series, which may be due to the persistent mismatch of signals carried by the CPUE and survey indices. Mohn's rho, estimated using the last 5 years, is 0.112 for SSB, -0.147 for F, and -0.034 for recruitment, all within acceptable limits.

The final assessment and leave-one out results are in Figure 16.4.9. Removing the IBTS Q3 indices leads to a slightly lower SSB and higher F, especially in the last 5 years. Conversely, using only the IBTS Q3 indices gives a distinctly more optimistic view of the stock and its exploitation level; the estimated SSB an F then fall outside of the 95% confidence interval of the final assessment in the three or four final years. Recruitment, on the other hand, is not as severely affected by the choice of data series and mostly exhibits slightly less optimistic estimates in "good recruitment years" when leaving the IBTS series out.

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 2015 and 2016 show slightly higher recruitment than the average of the last ten years, while 2018, 2019 and 2020 were the lowest estimates for the time series. SSB, has fluctuated around 195 000 tonnes in the 2010s, which is below the average of the 2000s (around 235 000 tonnes). Short term variations show a decline since 2017. The final year estimate of SSB is just above B_{pa} and MSY $B_{trigger}$, while survivors from 2020 amount for an SSB in 2021 below $B_{trigger}$ (not dependent on recruitment forecast assumption as the proportion mature at age 3 is null) but still above B_{lim}. Fishing mortality has generally declined since the mid–1980s but has exhibited a distinct raise over the last four years. Its hike seems to have been stopped in 2020 though. It is currently estimated to be above F_{MSY} but below F_{pa}.

16.6 Recruitment estimates

Currently, no independent survey provides an estimate of incoming recruitment. The resampling among 2011–2020 values (with a geometric mean about 71 million individuals) used in the short-term forecast is a conservative assumption taking into account recent low recruitment, although still considerably higher than the estimated recruitments for 2018–2020 (between 31 and 53 million individuals).

16.7 Short-term forecasts and reference points

16.7.1 Reference points update

While investigating possible effects of the corrected CPUE index on the reference points, mistakes were found in the way the reference points were evaluated during the last interbenchmark protocol (ICES, 2019a; hereafter referred to as "2019 IBP report"). Some reference point values (F_{lim}, F_{pa} and $F_{MSY\ upper}$) were based on EqSim simulations using the 2016 assessment results with 10 years of selectivity patterns, while the 2019 IBP report documented the decision of basing all reference points on the 2018 assessment outputs together with a limitation to selectivity patterns from the last five years (2013–2017). Investigations and corrections of mistakes from the 2019 IBP report are documented in the working document in Annex 8.

ICES (2021) further prescribed consistent used of "the fishing mortality including the advice rule that […] would lead to SSB ≥ B_{lim} with a 95% probability" ($F_{p.05}$) as the value for F_{pa}. The technical basis for F_{pa} was therefore changed accordingly and is also described in Annex 8.

The reference point reported in Table 16.7.2 reflect these changes.

16.7.2 Short-term forecast

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 2020. The fishing mortality in the intermediate year was F status quo, which, in 2021, leads to projected catches only a few tonnes away from the agreed TAC (65 687 tonnes; https://ec.europa.eu/oceans-and-fisheries/system/files/2021-03/2021-eu-uk-norway-fisheries-consultations_en.pdf). Population numbers-at-age for ages 4 and older in 2021 were survivor estimates, while numbers at age 3 were resampled from the past 10 years (2011–2020). 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_{2021} of 0.45 and a SSB in 2022 of 127 092 tonnes, below MSY $B_{trigger}$ (149 098 tonnes). Reference points and their technical basis are in Table 16.7.2.

The management options are given in Table 16.7.3. Because reference points were re-estimated during the last inter-benchmark and Brexit, the management plan for this shared stock (EU, Norway and the UK – as of early 2021) is no longer in use (a new EU-Norway-UK management plan is under discussion); therefore, the MSY approach is used as the basis for advice. The total catch in 2022 is advised to be no more than 49 614 tonnes, where wanted catch is 46 644 tonnes; this is a 24% decrease when compared to the advised total catch in 2021, in part because of the standard advice rule being triggered due to the low projected SSB in 2022 (< $B_{trigger}$). More catch options can be found in Table 16.7.3.

The contribution of the 2013–2019 year-classes to landings in 2022 are shown in Table 16.7.4. The2016-2019 year-classes are expected to contribute the most to the landings in numbers, while landings weights should be dominated by the year-classes 2016-2018. The weaker 2015 year-class is expected to contribute substantially less. Recruitment at age 3 is not expected to contribute greatly to the catches in 2022; rather, ages 4–6 are the main contributors (59% of projected landings for 2022). 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 years' assessment still hold.

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 and a retrospective pattern observed.

The fraction of fish at 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. An intended tagging study (IMR) may help inform on this issue, although results would most probably not be available by the next benchmark.

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.

The inclusion of the summer acoustic series (Noracu – IMR), dropped from the assessment in 2016 on account of now addressed inconsistencies, should also be re-evaluated.

Catch-per-effort index

The current commercial CPUE index is standardized for fleet, area, quarter and engine power effects. The explanatory variables included should be reviewed (e.g. examine need for a vessel random effect) and alternative modelling approaches evaluated. The model in its current formulation cannot account for different dynamics in space (Figure 16.3.10). The prospect to include spatial-temporal interactions in the model should therefore also be evaluated. Furthermore, different countries seem to report data with different levels of aggregation (although this is difficult to formally investigate, given the sensitive nature of the commercial data). Weighting of observations (*e.g.*, based on effort) could therefore be additionally considered, and the associated risks of bias (or absence thereof) evaluated.

Maturity ogive

A constant over time maturity ogive is currently used in the assessment and exploration of recent data indicates possible deviations from this ogive. The assumption should be re-evaluated, especially in the light of improved sampling during the spawning season (Q1 acoustic survey).

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 and reference points

Forecast

The SAM forecast assumption for recruitment is based on resampling from 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 to be smoother 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. $SSB_{(2022)} = B_{pa}$ or B_{lim} scenarios), which involve a further iteration process with additional random number generation, resulted in different median recruitment values. This is a reporting issue that arise from instability of the median value resampled from an even number of values (while a reported geometric mean would be more stable, and often more informative). It does not affect the quality of the assessment, only the consistency of reported figures. We have therefore made the choice, since the 2020 assessment, to report the geometric mean of resampled recruitments values in the forecast assumption (not to be mistaken for the use of a geometric mean in the forecast).

Reference points

The effect of the current low productivity regime of the stock (i.e. lower recruitment) on reference points should be investigated.

16.10 Status of the stock

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 between 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.

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, 2019b).

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, 2005–2020. ICES estimates are landings reported to ICES and the Working Group.

	Subarea 4 and Division 3.a															
Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019***	**2020***
Belgium	28	15	18	7	27	15	2	2	3	5	6	16	15	14	7	5
Denmark	7498	7471	5443	8068	8802	8018	6331	5171	5695	4913	4512	4084	5690	7017	5275	3777
Faroe Isl.	463	60	15	108	841	146	2	8	3	1	0	18	16	4	5	28
France	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7910	11574	10794	10334	12598	11366	9487
Germany	12401	14397	12791	14140	13410	11193	10234	8052	9690	8602	7954	6279	7943	7952	7048	6853
Greenland	1042	924	564	888	927	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	1	0	0	0	0	0	0	0	0	0	<1	4
Lithuania	149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Netherlands	40	28	5	3	16	3	24	34	168	43	75	112	191	267	178	181
Norway	68122	61318	45396	61464	57708	52712	46809	33288	35701	37519	35631	31596	49580	38787	50311	39630
Poland	1100	1084	1384	1407	988	654	584	0	0	0	0	0	0	0	0	0
Portugal		228	68											0		0
Russia	35	2	5	5	13	0	0	0	0	0	0	0	0	0	0	0
Sweden	2132	1746	1381	1639	1363	1545	1335	1306	1402	1329	1156	1198	1186	1316	1409	1181
UK (E/W/NI)	960	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	687	8888**	8561**	8640**	12575**	11875**	8557**
UK (Scotland)	6170									7686						
Total reported	111970	113354	91778	115414	103883	90755	89427	69241	71516	68695	69796	62658	83594	80531	87473	69705
Unallocated	1418	−1509	824	57	2090	6012	2101	1623	−110	677	−393	-154	−2024	1335	176	153
BMS landings													< 1	11	20	10
ICES estimate	113388	111845	92602	115471	105973	96767	91528	70864	71406	69372	69403	62504#	81570#	81866#	87649#	69858
TAC	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696	100287ǂ	105793ǂ	93614	79813

*** 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	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019***	**2020***
Denmark	0	0	0	0	0	0	0	0	0	20	0	0	5	1	7	0
Faroe Islands	25	76	32	23	60	24	5	6	25	29	3	7	13	21	7	3
France	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2299	3968	3626	1335	1263
Germany	373	532	580	148	298	257	0	9	0	0	0	9	< 1	<1	<1	0
Ireland	168	267	322	288	407	520	359	364	313	128	105	185	171	231	109	125
Netherlands	0	3	36	1	0	0	0	0	0	0	6	12	3	100	4	<1
Norway	20	28	377	78	68	121	240	5	715	442	677	555	633	955	478	1
Russia	25	7	2	50	4	2	0	0	0	9	1	0	2	0	2	0
Spain	3	6	3	4	8	18	31	13	21	9	15	15	4	7	24	15
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK (E/W/NI)	133	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	97	3286**	2770**	2652**	2764**	2822**	2666**
UK (Scotland)	2922									3191						
Total reported	7623	9759	7103	7717	6438	6118	7492	7558	8534	6829	7577	5852	7453	7706	4787	4074
Unallocated	−1167	−1191	−501	−1005	−144	145	−575	−9	119	191	−43	−279	−337	-1065	88	7
BMS landings													0	31	<1	<1
ICES estimate	6456	8568	6602	6712	6294	6263	6917	7549	8653	7020	7534	5573 ƚ	7116 ƚ	6641 ƚ	4875 ƚ	4081 ƚ
TAC	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816	10404 ƚƚ	10215ƚƚ	9713	8280

*** Official values are preliminary.**

**** Scotland+E/W/NI combined.**

ƚ Does not include BMS landings.

ƚƚ Includes top-up (4.1% in 2017, 4.76% in 2018).

	Subareas 4 and 6 and Division 3.a															
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ICES estimate	119844	121320	99204	122184	112267	103030	98446	78414	80059	76392	76936	68709 #	88686 #	88507 #	92524 #	73938 #
TAC	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512	110691 ⱡⱡ	116008 ⱡⱡ	103327	88093 ⱡⱡ

ⱡⱡ 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 (2020; 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.

		2020	
Catch Category	**Raised or Imported**	**Weight (tonnes)**	**Proportion**
BMS landing	Imported data	5.2	100
Discards	Imported data	2933	92
Discards	Raised discards	248	8
Landings	Imported data	73868	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
1993	132618	111499		21119	16

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
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	95447	88328[#]	42	7076[##]	7
2019^	96634	92390[#]	19.85	4224[##]	4
2020	76820	73791	10	3019[##]	4

 # Since 2016, landings include the Norwegian component of BMS landings.

Since 2016, discards minus BMS landings from EU fleets officially reported in logbooks.

^ Includes 937 tonnes of missing Swedish landings and corresponding 109 tonnes of discards (based on discard rate estimated in division 4.a).

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 (2020) 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	2020	
			Weight	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	0
Landings	Imported_Data	Sampled_Distribution	49998	68
Landings	Imported_Data	Estimated_Distribution	23871	32
Discards	Imported_Data	Sampled_Distribution	2919	92
Discards	Raised_Discards	Estimated_Distribution	247 5	8
Discards	Imported_Data	Estimated_Distribution	13.94	<1
BMS landing	Imported_Data	Sampled_Distribution	0	0
BMS landing	Imported_Data	Estimated_Distribution	5.243	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
1991	71710	35719	8016	3669	1733	976	376	463

Year/Age	3	4	5	6	7	8	9	10+
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	2603	16250	18858	7376	2142	2027	978	1178
2019	6240	8570	14841	10394	2881	1127	1027	1236
2020	2511	11823	7627	7436	4246	967	381	627

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	2017	12994	16936	7043	2125	2016	976	1177
2019	5456	8125	13826	9797	2842	1116	1025	1235
2020	1997	10870	7243	7326	4113	959	377	619

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

Year/Age	3	4	5	6	7	8	9	10+
1988	18079	5169	2596	91	19	26	20	7
1989	12280	6020	969	260	15	17	11	5
1990	22647	3833	832	112	27	18	7	4
1991	25593	5847	549	85	17	22	9	5
1992	10213	6580	937	76	15	16	13	5
1993	20990	4077	871	74	15	36	21	11
1994	11076	7868	958	102	9	8	11	9
1995	14797	5096	1087	90	34	16	14	9
1996	6141	7607	866	184	31	19	5	5
1997	8344	3778	2218	87	26	24	7	3
1998	5751	6072	1203	382	22	28	14	3
1999	5233	2716	1961	199	99	55	23	7
2000	3920	3386	657	293	31	76	16	5
2001	8908	3454	1648	80	35	42	41	3
2002	8439	5710	2451	425	64	324	121	96
2003	15288	7106	234	0	0	0	0	0
2004	5605	4407	0	0	0	0	0	0
2005	3498	0	0	0	0	0	0	0
2006	5114	5282	394	0	0	0	0	0
2007	9433	3152	1762	97	0	0	0	0
2008	696	7682	1610	745	111	9	0	0
2009	831	1158	395	30	93	16	14	11
2010	886	390	266	117	1	11	0	38
2011	2636	1470	129	44	7	25	1	8
2012	7305	1341	1377	58	7	1	4	1
2013	2268	4801	339	224	4	0	0	1
2014	955	2205	1816	220	77	4	0	1
2015	2163	931	704	232	17	3	0	2
2016	3874	3867	905	573	26	7	1	0
2017	1943	3850	978	69	2	0	0	2
2018	586	3256	1922	333	17	11	2	1
2019	785	445	1016	597	39	11	1	1
2020	514	953	383	110	133	8	4	8

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	1.095	1.239	1.549	2.234	3.112	3.867	4.465	6.708
2019	1.133	1.442	1.809	2.320	3.081	3.897	4.677	6.613
2020	1.061	1.529	1.914	2.439	3.106	4.038	4.918	6.985

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

Year/Age	3	4	5	6	7	8	9	10+
1989	0.895	1.036	1.420	1.998	3.914	5.018	6.430	8.431
1990	0.844	1.196	1.583	2.247	3.242	4.858	6.315	8.416
1991	0.791	1.158	1.752	2.365	3.165	4.222	6.066	8.191
1992	0.964	1.189	1.607	2.242	3.668	4.330	5.413	7.046
1993	0.899	1.260	1.754	2.636	3.185	3.980	5.080	6.891
1994	0.944	1.119	1.601	2.434	3.618	4.787	6.548	8.326
1995	1.002	1.294	1.816	2.562	3.555	4.767	5.267	7.891
1996	0.967	1.187	1.807	2.368	2.952	4.705	6.092	8.382
1997	0.905	1.145	1.452	2.587	3.556	4.525	6.158	8.866
1998	0.892	0.966	1.393	1.744	2.949	3.883	4.996	7.227
1999	0.881	1.061	1.211	1.754	2.337	3.493	4.844	6.745
2000	1.027	1.127	1.539	1.684	2.594	3.084	4.773	7.462
2001	0.802	1.072	1.313	2.095	2.546	3.485	4.141	6.141
2002	0.923	1.035	1.478	1.769	2.947	3.426	4.407	5.674
2003	0.833	0.980	1.173	1.810	2.368	3.176	3.768	5.065
2004	0.918	1.084	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.921	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.945	1.069	1.514	1.906	2.424	3.058	4.318	5.734
2007	0.837	1.143	1.317	1.840	2.328	2.887	3.600	4.975
2008	0.944	1.193	1.565	1.720	2.226	2.795	3.206	4.565
2009	1.036	1.340	1.664	1.992	2.563	3.085	3.648	4.793
2010	1.036	1.479	2.034	2.597	3.164	3.488	3.968	5.199
2011	1.007	1.207	1.783	2.573	3.068	3.404	3.717	4.284
2012	1.015	1.321	1.408	2.201	3.223	3.536	4.177	4.482
2013	0.898	1.156	1.614	1.976	3.078	3.841	4.541	5.648
2014	1.126	1.300	1.607	2.384	2.617	4.013	5.530	6.679
2015	0.977	1.244	1.625	2.190	3.043	3.796	4.228	7.287
2016	0.998	1.292	1.628	2.283	2.892	3.453	4.333	6.208
2017	1.047	1.302	1.809	2.361	2.988	4.232	4.473	6.292
2018	1.153	1.287	1.575	2.266	3.107	3.868	4.463	6.707
2019	1.147	1.448	1.829	2.343	3.094	3.905	4.680	6.616
2020	1.066	1.542	1.938	2.447	3.132	4.043	4.912	6.984

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	0.894	1.049	1.318	1.554	3.770	3.715	5.371	7.697
2019	1.033	1.336	1.537	1.932	2.162	2.991	2.816	2.969
2020	1.042	1.379	1.456	1.937	2.306	3.448	5.480	7.101

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	2.240
2001	21.475	6.169	3.936	0.356	0.444	0.113	2.155
2002	10.748	18.974	1.327	1.090	0.162	0.264	1.824
2003	19.272	23.802	13.402	0.393	0.439	0.168	1.687
2004	4.930	6.727	3.237	0.921	0.064	0.085	2.064
2005	8.916	7.512	4.428	1.914	1.082	0.104	2.149
2006	10.553	29.579	2.835	1.177	0.445	0.242	2.265
2007	34.006	5.578	11.700	1.016	0.743	0.358	1.961
2008	3.312	5.584	0.907	1.997	0.254	0.254	2.165
2009	1.346	1.703	0.568	0.101	0.229	0.200	1.775
2010	1.361	0.964	0.471	0.205	0.045	0.166	1.644
2011	4.520	8.451	1.059	1.114	0.426	0.080	1.740
2012	11.134	2.497	2.968	0.503	0.483	0.344	1.611
2013	14.701	16.279	1.830	1.858	0.308	0.146	1.725
2014	1.649	3.923	2.822	0.481	0.520	0.114	1.556
2015	11.001	5.613	4.611	1.581	0.289	0.285	1.865
2016	37.901	17.439	3.255	2.681	0.945	0.195	1.630
2017	11.447	13.102	3.068	1.267	0.942	0.473	1.852
2018	1.877	6.885	6.027	1.450	0.322	0.183	1.708
2019	2.143	3.189	3.071	0.999	0.194	0.077	1.372
2020	1.445	2.8	1.618	1.115	0.644	0.188	1.285

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	0.385	0.357	0.355	0.314	0.283	0.318
1968	0.237	0.347	0.305	0.287	0.247	0.222	0.253
1969	0.252	0.371	0.325	0.314	0.278	0.254	0.279
1970	0.303	0.420	0.353	0.329	0.284	0.254	0.269
1971	0.370	0.469	0.377	0.346	0.308	0.285	0.299
1972	0.449	0.522	0.403	0.368	0.331	0.307	0.313
1973	0.529	0.573	0.426	0.379	0.344	0.319	0.319
1974	0.644	0.661	0.492	0.434	0.396	0.364	0.350
1975	0.661	0.691	0.531	0.472	0.441	0.409	0.385
1976	0.758	0.773	0.605	0.528	0.484	0.443	0.407
1977	0.633	0.708	0.594	0.539	0.510	0.474	0.429
1978	0.507	0.586	0.491	0.439	0.417	0.390	0.354
1979	0.421	0.522	0.459	0.423	0.411	0.383	0.347
1980	0.405	0.520	0.479	0.455	0.451	0.427	0.389
1981	0.361	0.495	0.471	0.461	0.469	0.459	0.421
1982	0.431	0.583	0.553	0.523	0.513	0.485	0.438
1983	0.511	0.699	0.673	0.629	0.602	0.559	0.495
1984	0.591	0.795	0.727	0.630	0.562	0.505	0.443
1985	0.633	0.875	0.774	0.624	0.539	0.481	0.435
1986	0.587	0.900	0.822	0.652	0.562	0.510	0.479
1987	0.535	0.847	0.796	0.629	0.550	0.509	0.494
1988	0.524	0.833	0.805	0.645	0.566	0.522	0.508
1989	0.517	0.816	0.786	0.629	0.538	0.483	0.468
1990	0.506	0.791	0.755	0.593	0.501	0.439	0.425
1991	0.469	0.752	0.725	0.566	0.480	0.417	0.413
1992	0.413	0.701	0.702	0.562	0.485	0.419	0.419
1993	0.390	0.685	0.713	0.605	0.565	0.505	0.512
1994	0.320	0.602	0.634	0.541	0.519	0.471	0.489
1995	0.273	0.557	0.622	0.561	0.574	0.542	0.564
1996	0.216	0.470	0.551	0.513	0.520	0.498	0.514
1997	0.182	0.407	0.480	0.449	0.445	0.433	0.450
1998	0.181	0.402	0.484	0.460	0.444	0.435	0.450
1999	0.174	0.400	0.501	0.498	0.481	0.482	0.497
2000	0.149	0.351	0.437	0.433	0.400	0.394	0.408
2001	0.147	0.343	0.419	0.412	0.368	0.356	0.367
2002	0.155	0.358	0.450	0.471	0.425	0.413	0.436
2003	0.164	0.365	0.451	0.500	0.463	0.452	0.481
2004	0.138	0.319	0.387	0.434	0.406	0.401	0.424
2005	0.136	0.321	0.391	0.436	0.405	0.395	0.404

Year/Age	3	4	5	6	7	8	9+
2006	0.155	0.349	0.413	0.445	0.410	0.394	0.393
2007	0.148	0.346	0.405	0.421	0.381	0.359	0.350
2008	0.157	0.386	0.468	0.481	0.435	0.413	0.398
2009	0.154	0.393	0.488	0.501	0.450	0.424	0.397
2010	0.139	0.373	0.473	0.484	0.443	0.423	0.390
2011	0.145	0.385	0.481	0.476	0.428	0.412	0.378
2012	0.126	0.358	0.452	0.450	0.399	0.384	0.351
2013	0.104	0.321	0.416	0.423	0.377	0.364	0.330
2014	0.091	0.295	0.399	0.413	0.367	0.353	0.320
2015	0.088	0.291	0.403	0.418	0.366	0.350	0.317
2016	0.080	0.283	0.405	0.426	0.378	0.364	0.329
2017	0.082	0.296	0.438	0.480	0.428	0.402	0.357
2018	0.090	0.318	0.475	0.523	0.464	0.431	0.378
2019	0.105	0.354	0.523	0.571	0.503	0.460	0.397
2020	0.098	0.336	0.493	0.528	0.454	0.405	0.344

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	141089	81065	57130	7130	4903	1149	747	683
1968	161066	92033	50272	31616	3684	2504	655	773
1969	284618	90317	54269	30911	20405	2825	1951	812
1970	292306	217382	49066	35395	18565	11604	1788	1612
1971	354885	191047	119393	24464	19360	11878	7772	2502
1972	223862	209224	102548	67440	14438	11331	7261	6458
1973	201393	111015	105072	63167	35676	8647	6290	8567
1974	199985	90312	48159	62773	42087	20473	5387	8475
1975	234780	76303	35335	24181	36250	25201	11954	8475
1976	409407	102826	29661	17404	12873	19095	13255	11561
1977	148463	148465	35692	12445	8689	7218	10759	13978
1978	120589	72218	58167	14194	5085	3997	3381	13116
1979	87000	53647	34749	29273	7786	2795	2198	9495
1980	85247	46705	25637	18711	16070	4010	1658	7671
1981	162764	41543	24779	12235	9600	8258	2121	5905
1982	140710	108765	22957	15072	6248	4788	3726	4054
1983	147846	69202	55182	11349	8303	3123	2512	3786
1984	257046	76112	29949	23980	4714	3470	1320	2759
1985	359692	108645	29458	12746	9444	2214	1583	2291
1986	289076	142918	32171	11776	6368	4469	1192	2261
1987	148255	165108	36228	10132	5138	3296	2287	1799

Year/Age	3	4	5	6	7	8	9	10+
1988	137847	71191	61897	11334	4538	2597	1747	1920
1989	102041	69393	27646	21858	4673	2083	1240	1634
1990	151289	47776	25620	11102	8342	2293	1019	1390
1991	175748	71276	17222	10195	5238	3757	1226	1376
1992	102977	89442	25782	6694	5157	2843	2031	1460
1993	177601	58088	34068	9139	2823	3142	1796	2224
1994	118545	97302	28209	13424	3392	1381	1452	2110
1995	212660	66060	42237	12841	6320	1583	905	1872
1996	117718	147221	29446	19673	6911	2430	682	1286
1997	151334	78059	89496	12995	9176	3346	1068	917
1998	89503	122009	44749	48899	7135	4533	1804	975
1999	118060	56140	74686	22574	26806	4202	2305	1519
2000	101270	100567	29618	38007	11110	12800	1958	1622
2001	201421	67858	66134	14049	17673	6299	6768	1485
2002	150151	139906	34269	34306	8066	9419	3771	4726
2003	157142	112890	80518	15770	16724	5080	5021	4670
2004	111772	101846	68991	45616	7429	7798	3072	4251
2005	139655	71930	62518	45835	25991	4603	4146	3884
2006	98787	122319	40142	34896	25160	13189	2812	4359
2007	153319	53306	78043	23359	18777	14123	6662	3948
2008	72344	95871	30077	47601	14668	10590	9489	7565
2009	56582	51324	42848	14136	24540	9274	5592	9810
2010	88254	36978	27482	19600	6879	12963	5424	9291
2011	81176	78841	21886	13948	9804	3569	6478	10000
2012	133296	46561	47628	11597	7282	4864	1962	9458
2013	91239	98514	22342	25584	6578	3904	2603	6572
2014	56033	66830	50914	12320	13604	3887	2020	5361
2015	94763	41759	44497	26340	7127	6918	2496	4410
2016	117456	63611	26639	23513	12519	4467	3684	4366
2017	80693	90270	34796	15051	13456	6736	2686	4481
2018	41095	64433	55447	18343	7001	6422	3509	4012
2019	52781	32399	38702	26602	8003	3333	3219	3877
2020	31492	40439	19797	18841	12646	3686	1613	3258

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 ($F_{4–7}$), 1967–2020. 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	141089	100544	197983	152157	120638	191910	0.353	0.276	0.451	411713	337816	501774
1968	161066	116612	222467	209694	168688	260670	0.296	0.233	0.377	578449	477541	700681
1969	284618	206037	393169	275978	224821	338775	0.322	0.259	0.400	710282	589890	855245
1970	292306	212952	401232	345461	286009	417271	0.347	0.282	0.426	909843	763316	1084498
1971	354885	261078	482397	460472	382230	554731	0.375	0.308	0.457	1054869	894593	1243860
1972	223862	165791	302274	488880	408450	585148	0.406	0.335	0.491	957444	820014	1117906
1973	201393	149313	271640	520691	435100	623120	0.431	0.358	0.518	892648	770340	1034375
1974	199985	148133	269986	576387	483969	686454	0.496	0.417	0.591	925284	803243	1065867
1975	234780	174771	315393	517286	433304	617547	0.534	0.450	0.634	856928	744098	986867
1976	409407	299762	559158	399145	332407	479281	0.598	0.502	0.711	815959	700234	950809
1977	148463	109687	200946	325855	270916	391934	0.588	0.489	0.707	612669	527235	711947
1978	120589	89354	162743	297083	246003	358769	0.483	0.403	0.580	519943	446970	604831
1979	87000	64220	117858	278199	232986	332185	0.454	0.378	0.544	482135	416395	558255
1980	85247	62920	115497	260607	219921	308819	0.476	0.399	0.567	438407	380519	505102
1981	162764	119306	222053	249047	211186	293697	0.474	0.397	0.566	491226	424110	568964
1982	140710	104305	189821	219768	188935	255631	0.543	0.461	0.639	530640	457085	616033
1983	147846	109526	199573	220003	188655	256559	0.651	0.554	0.765	508023	439827	586792
1984	257046	190065	347632	188325	162185	218677	0.679	0.580	0.793	516905	443938	601865
1985	359692	263320	491334	165577	143317	191294	0.703	0.602	0.820	530506	448283	627810
1986	289076	213931	390617	156663	135871	180637	0.734	0.623	0.864	492079	419561	577132
1987	148255	109764	200245	165372	143409	190699	0.706	0.604	0.825	404197	349005	468117
1988	137847	102428	185512	154784	132796	180414	0.712	0.609	0.833	348777	302705	401861
1989	102041	75721	137511	126134	108610	146484	0.693	0.591	0.811	292055	253426	336570
1990	151289	112084	204206	113904	97896	132530	0.660	0.563	0.774	300988	258158	350924

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1991	175748	130564	236570	106632	92153	123388	0.631	0.538	0.740	320601	273134	376318
1992	102977	76888	137917	112232	97527	129154	0.613	0.520	0.721	309080	265319	360059
1993	177601	132235	238529	118955	102689	137796	0.642	0.543	0.758	355607	302763	417676
1994	118545	88373	159018	123621	106671	143263	0.574	0.486	0.678	338524	289262	396176
1995	212660	157029	287999	142904	122667	166480	0.578	0.487	0.687	448433	377968	532036
1996	117718	86949	159375	154032	132550	178994	0.513	0.431	0.611	427902	363170	504173
1997	151334	111016	206296	191359	162074	225935	0.445	0.372	0.533	445381	379849	522218
1998	89503	64569	124065	189136	160564	222792	0.447	0.376	0.533	394805	339534	459073
1999	118060	86591	160966	200308	169886	236177	0.470	0.393	0.562	387199	334799	447801
2000	101270	74419	137810	194362	166377	227054	0.406	0.338	0.487	410834	355246	475120
2001	201421	146321	277270	197910	170281	230022	0.385	0.320	0.465	447354	384765	520124
2002	150151	110448	204126	216544	186167	251877	0.426	0.354	0.512	474972	407528	553578
2003	157142	115460	213873	202253	172643	236942	0.445	0.370	0.535	421092	363796	487412
2004	111772	82749	150975	249787	213372	292415	0.387	0.320	0.467	468984	407869	539255
2005	139655	102193	190850	241160	207860	279794	0.388	0.324	0.466	450717	393219	516622
2006	98787	71790	135938	256097	220262	297763	0.404	0.338	0.484	477820	417842	546407
2007	153319	108779	216096	239997	205880	279767	0.388	0.324	0.465	449115	389954	517252
2008	72344	53538	97754	243151	208951	282949	0.442	0.372	0.526	420631	367378	481602
2009	56582	41830	76535	241012	205553	282588	0.458	0.384	0.546	385652	337111	441184
2010	88254	65157	119538	226343	191689	267263	0.443	0.372	0.528	389816	338795	448521
2011	81176	59022	111644	182692	154849	215541	0.443	0.371	0.528	355778	308059	410887
2012	133296	98563	180270	166751	140970	197246	0.415	0.346	0.497	363792	312627	423332
2013	91239	67460	123400	170951	144687	201983	0.384	0.319	0.463	361304	311876	418566
2014	56033	41047	76489	189913	161200	223741	0.369	0.306	0.445	352306	305427	406381
2015	94763	69318	129548	195498	165918	230351	0.370	0.306	0.446	362588	313564	419276
2016	117456	86077	160276	181261	153559	213960	0.373	0.309	0.451	378904	326203	440118

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
2017	80693	58556	111197	199348	168693	235572	0.411	0.339	0.497	393465	341750	453006
2018	41095	29411	57421	194749	165769	228795	0.445	0.365	0.542	340876	297672	390350
2019	52781	35995	77394	184317	155858	217971	0.488	0.391	0.608	316615	272368	368051
2020	31492	18121	54730	159269	130225	194791	0.453	0.348	0.590	263951	217092	320924

Table 16.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2021)	0.45	Average exploitation pattern (2018-2020) scaled to $F_{4–7}$ in 2020
SSB (2022)	127092	SSB at the beginning of the TAC year, in tonnes
$R_{age\ 3}$ (2021)	71483	Geometric mean of the recruitment re-sampled from the years 2011–2020, in thousands
$R_{age\ 3}$ (2022)	71215	Geometric mean of the recruitment re-sampled from the years 2011–2020, in thousands
Total catch (2021)	65704	Short-term forecast, in tonnes
Landings (2021)	62233	Assuming 2018–2020 average landing fraction by age from numbers, in tonnes
Discards (2021)	3471	Assuming 2018–2020 average discards fraction by age from numbers, 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}	0.668	Eqsim analysis based on the recruitment period 1998–2017.*	ICES (2019a)
	F_{pa}	0.576	$F_{p.05}$ with AR; the F that leads to SSB ≥ B_{lim} with 95% probability. Eqsim analysis based on the recruitment period 1998–2017.	ICES (2021)
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}	0.564	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY.*	ICES (2019a)

*** updated in 2021 following detection of mistakes in the 2019 IBP analyses (ICES, 2019a). See working document in Annex 8.**

Table 16.7.3. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	Projected landings (2022)	projected discards (2022)	Projected landings# 3a4	Projected landings# 6	F_{total} (ages 4-7) (2022)	$F_{projected\ landings}$ (ages 4-7) (2022)	$F_{projected\ discards}$ (ages 4-7) (2022)	SSB (2023)	% SSB change *	% TAC change **	% advice change ^
ICES advice basis												
MSY approach: F_{MSY} × SSB (2022) /MSY $B_{trigger}$	49614	46644	2970	42259	4385	0.31	0.29	0.0170	153272	21	-24	-24
Other scenarios												
F = $F_{MSY\ lower}$ × SSB (2022) /MSY $B_{trigger}$	30204	28397	1807	25728	2669	0.179	0.169	0.0100	170840	34	-54	-54
F_{MSY}	57046	53596	3450	48558	5038	0.363	0.34	0.0200	146645	15.4	-13.2	-13.2
F = $F_{MSY\ lower}$	35009	32911	2098	29817	3094	0.210	0.198	0.0120	166510	31	-47	-47
F = $F_{MSY\ upper}$	82159	77129	5030	69879	7250	0.564	0.53	0.032	124350	-2.2	25	25
F = 0	0	0	0	0	0	0.00	0.00	0.00	198814	56	-100	-100
F_{pa} ($F_{p.05}$ with AR)	83556	78420	5136	71049	7371	0.576	0.54	0.032	123198	-3.1	27	27
$F_{p.05}$ without AR	73736	69267	4469	62756	6511	0.49	0.46	0.028	131729	3.6	12.3	12.3
F_{lim}	93718	87921	5797	79656	8265	0.668	0.63	0.037	114361	-10.0	43	43
SSB_{2023} = B_{lim}	102288	95980	6308	86958	9022	0.75	0.71	0.042	107297	-15.6	56	56
SSB_{2023} = B_{pa}	54770	51467	3303	46629	4838	0.35	0.33	0.0190	149098	17.3	-16.6	-16.6
SSB_{2023} = MSY $B_{trigger}$	54770	51467	3303	46629	4838	0.35	0.33	0.0190	149098	17.3	-16.6	-16.6
F = F_{2021}	68786	64585	4201	58514	6071	0.45	0.43	0.025	136046	7.0	4.7	4.7
TAC_{2021}	65687	61675	4012	55878	5797	0.43	0.40	0.024	138834	9.2	0.00	0.00
TAC_{2021} −15%	55835	52458	3377	47527	4931	0.35	0.33	0.0200	147736	16.2	-15.0	-15.0
TAC_{2021} +15%	75540	70969	4571	64298	6671	0.51	0.48	0.029	130131	2.4	15.0	15.0
TAC_{2021} −20%	52551	49373	3178	44732	4641	0.33	0.31	0.0180	150648	18.5	-20.0	-20.0
TAC_{2021} +25%	82110	77084	5026	69838	7246	0.56	0.53	0.032	124392	-2.1	25	25

*** SSB2023 relative to SSB2022. ** Total catch in 2022 relative to the TAC in 2021 (65 687 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 2022 relative to the advice value 2021 (65 687 t).**

Table 16.7.4. Saithe in subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2022.

Year class	Contribution to landings (%)	
	Numbers	Weight
2019	16.1	9.1
2018	40.5	29.1
2017	14.4	12.9
2016	13.9	16.5
2015	5.1	7.9
2014	4.6	9.2
2013	3.0	7.2

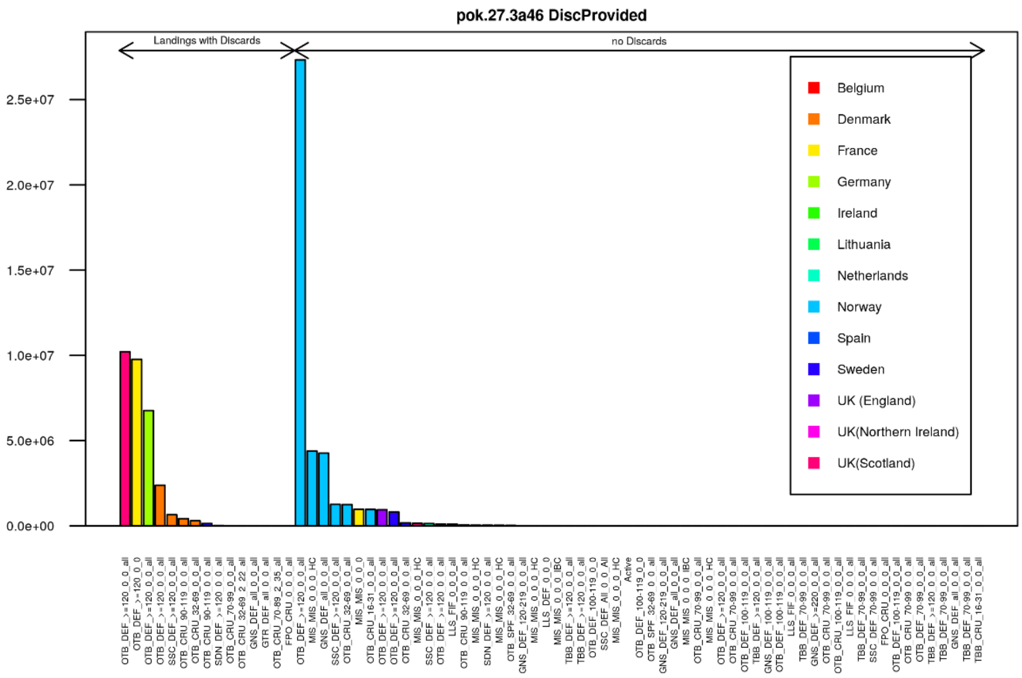

Figure 16.3.1. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier for 2020.

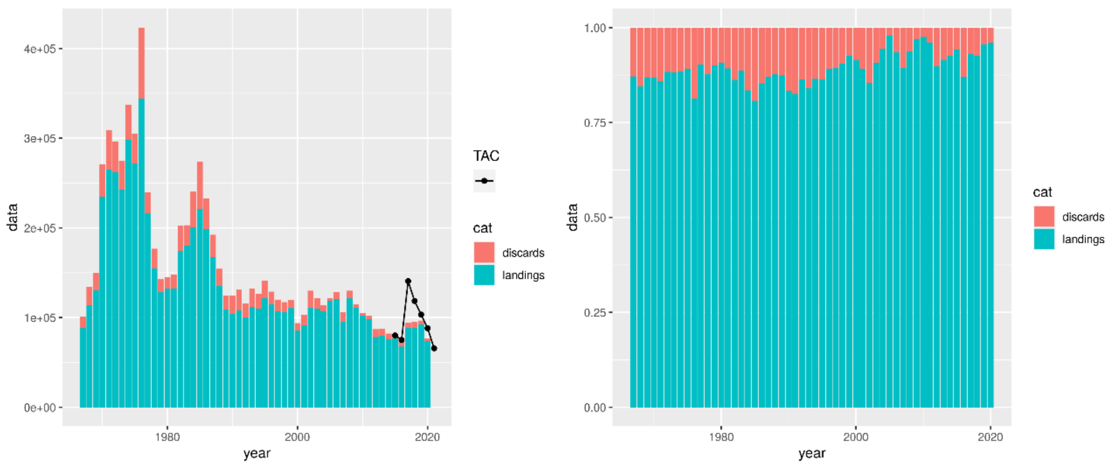

Figure 16.3.2. Saithe in subareas 4 and 6 and Division 3.a: Yield as stacked plot for landings and discards in tonnes (left panel) and as percent (right panel). Landings include BMS landings from Norway since 2016. Discards correspond to unwanted catch (discards + EU/UK BMS) since 2016.

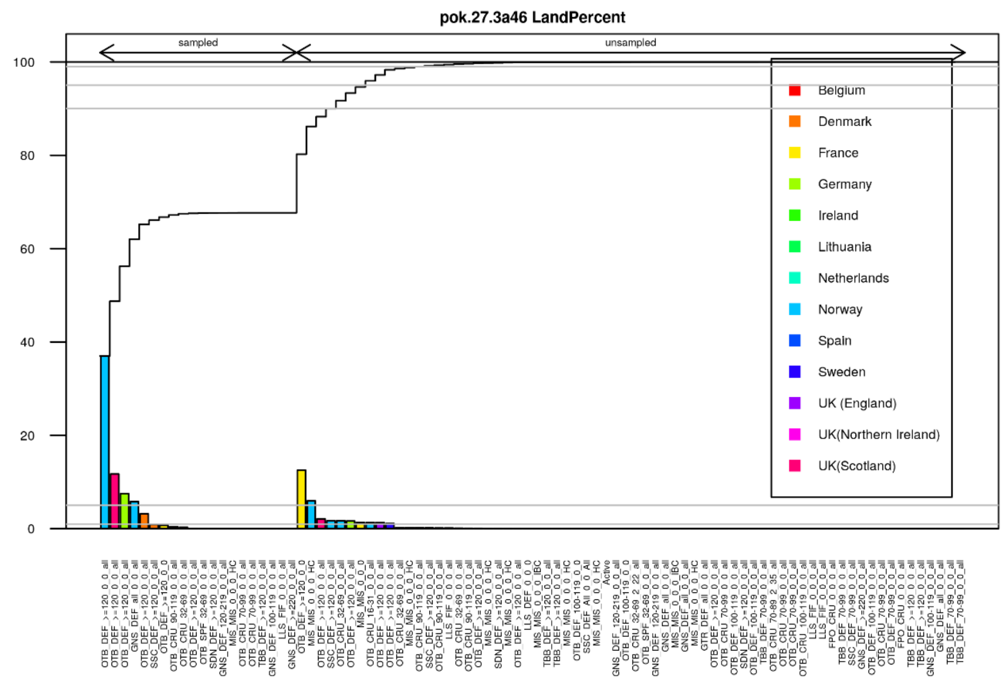

Figure 16.3.3. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier for 2020.

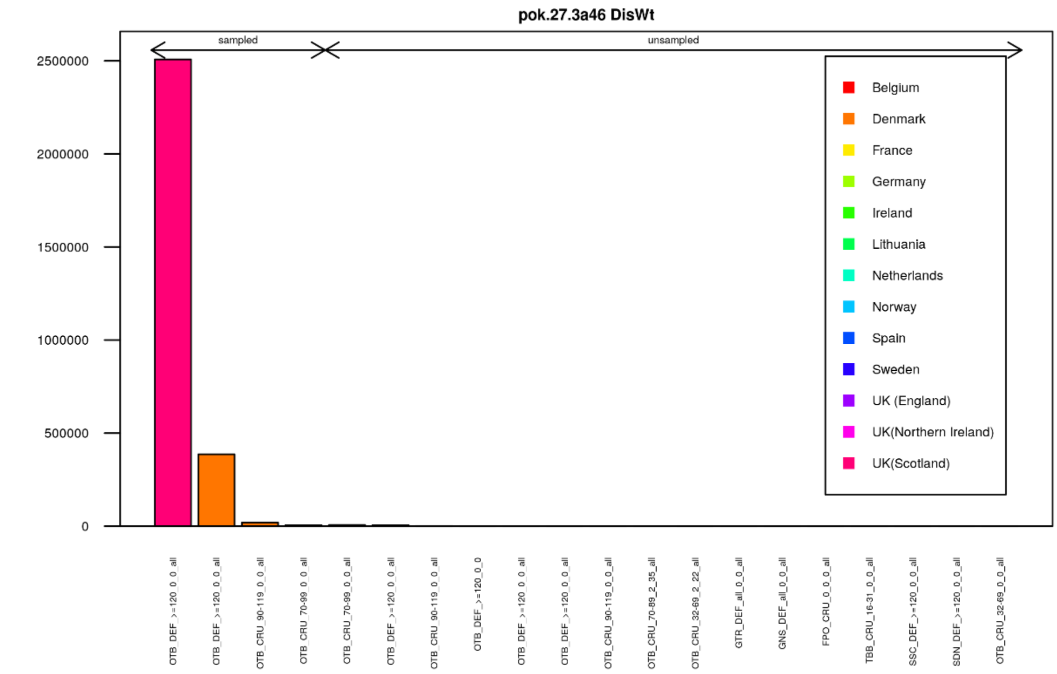

Figure 16.3.4. Saithe in subareas 4 and 6 and Division 3.a: Overview of age sampled and unsampled imported discards by country and métier for 2020.

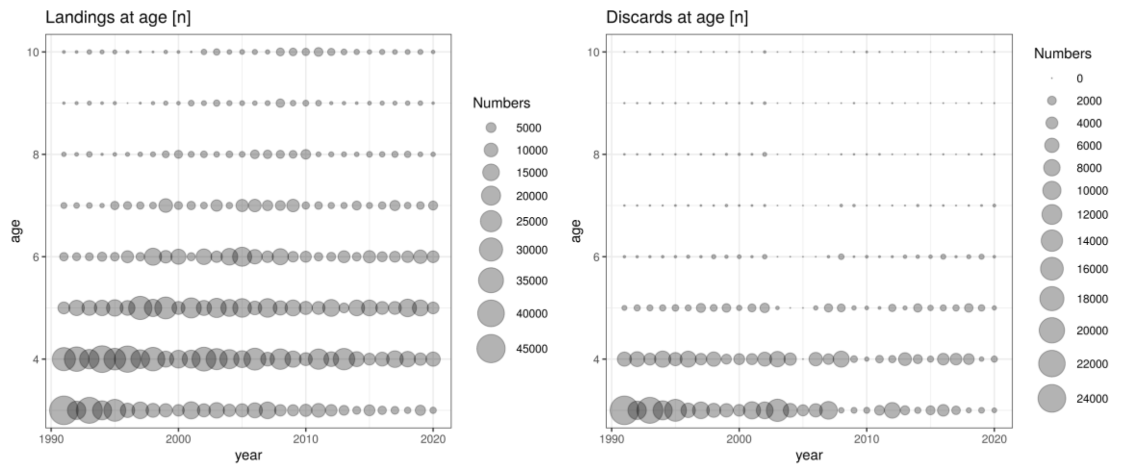

Figure 16.3.5. Saithe in subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2020. (Right) Discard numbers at age for saithe ages 3–10+, 1990–2020.

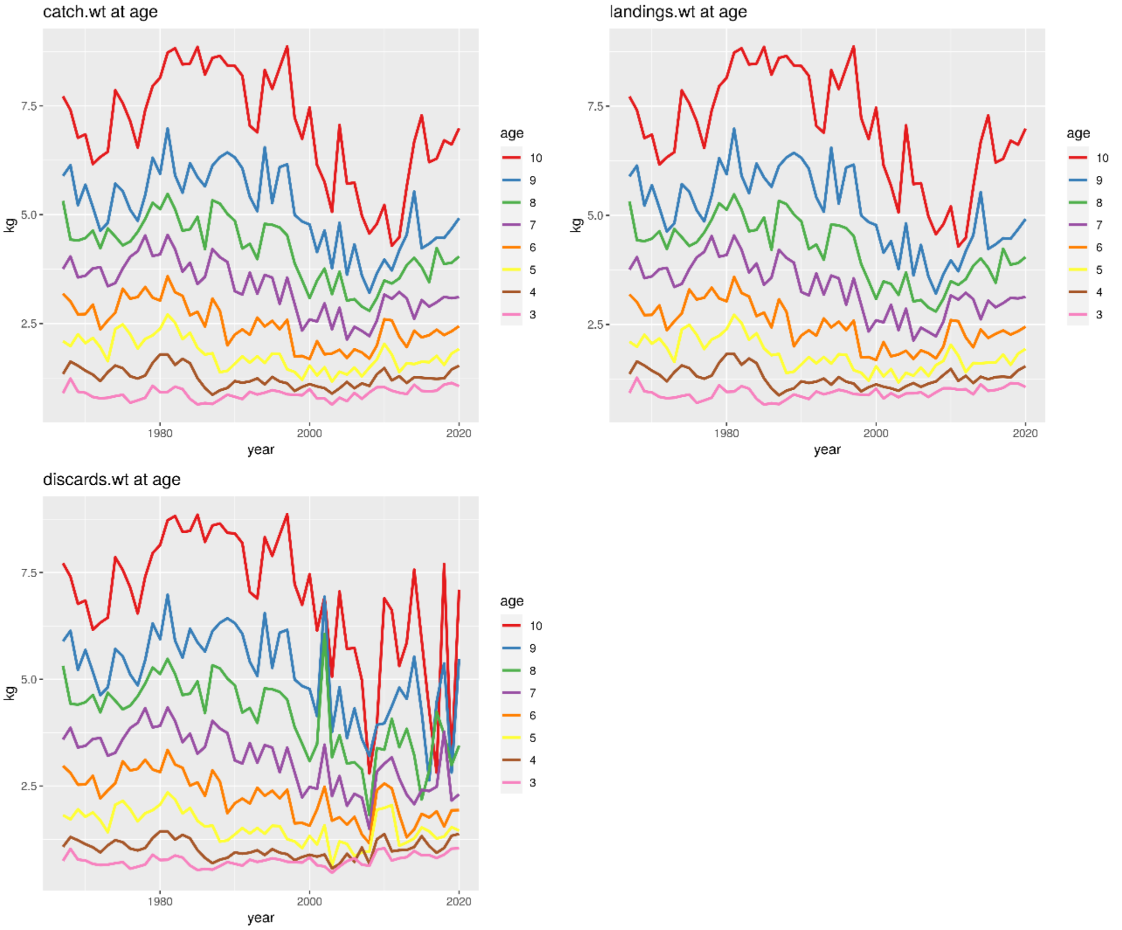

Figure 16.3.6. Saithe in subareas 4 and 6 and Division 3.a. Catch weight-at-age (top left pane), landing weight-at-age (bottom left panel) and discard weights-at-age (bottom right panel), in kilograms, for saithe ages 3–10+, 1967–2020.

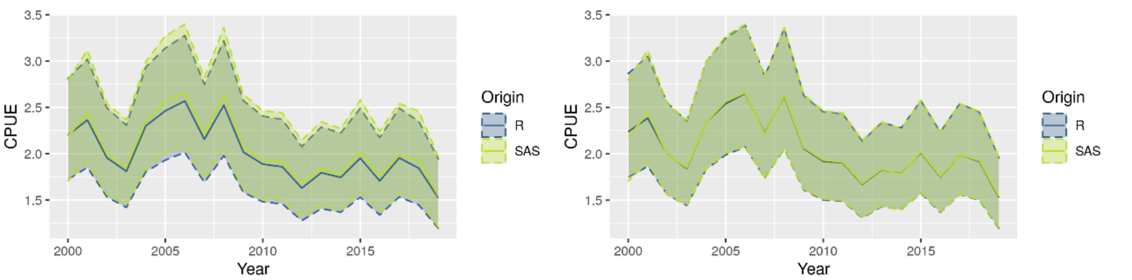

Figure 16.3.7. Saithe in subareas 4 and 6 and Division 3.a. CPUE index based on (uncorrected) data 2000–2019. Left panel: comparison of the series used in the 2020 assessment (SAS; including error on the quarter coding) and using the corrected R implementation. Right panel: replication of the quarter coding mistake in R, that shows there is only negligible influence of the software. Mean + 95% confidence intervals.

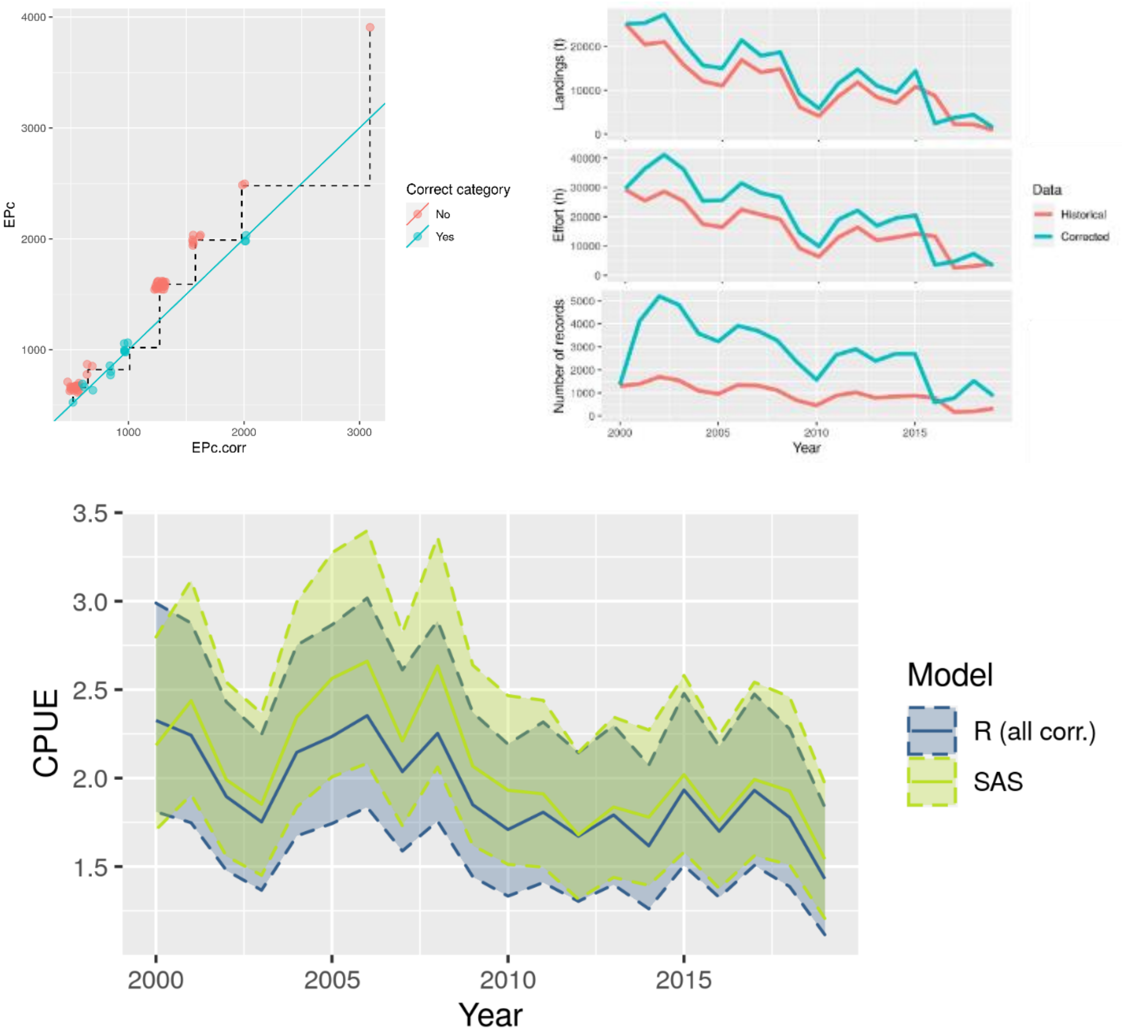

Figure 16.3.8. Saithe in subareas 4 and 6 and Division 3.a. Illustration of French data errors and repercussions on the CPUE index series. Top left: jittered corrected engine power (kW) category (x-axis) vs. historical category (y-axis) with one to one line. Top right sum of entries, effort and landings, per year, compared between historical and corrected data. Bottom: CPUE series (2000–2019) including all corrections (R (all corr.)), compared to the series used in the 2020 assessment (SAS); mean + 95% confidence intervals.

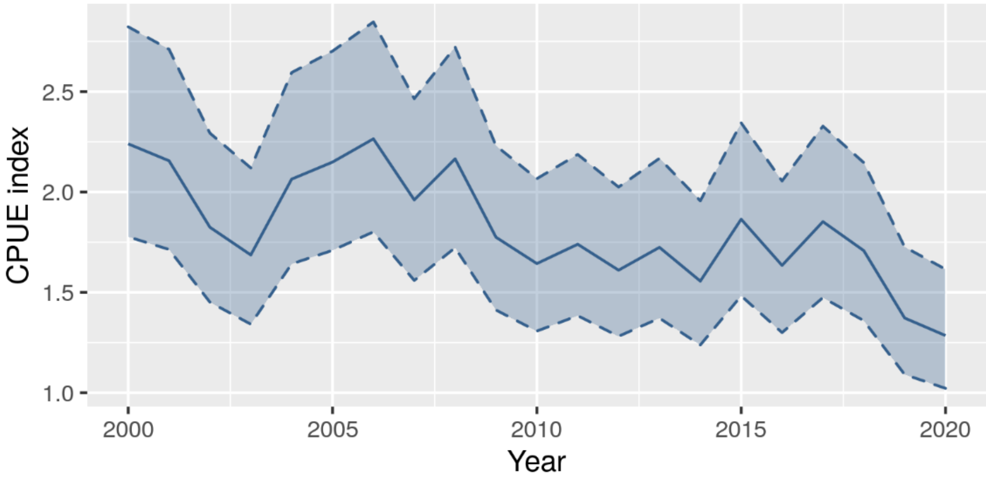

Figure 16.3.9. Saithe in subareas 4 and 6 and Division 3.a: Standardised commercial CPUE index time series and 95% confidence interval. Based on logbook data from France, Germany and Norway.

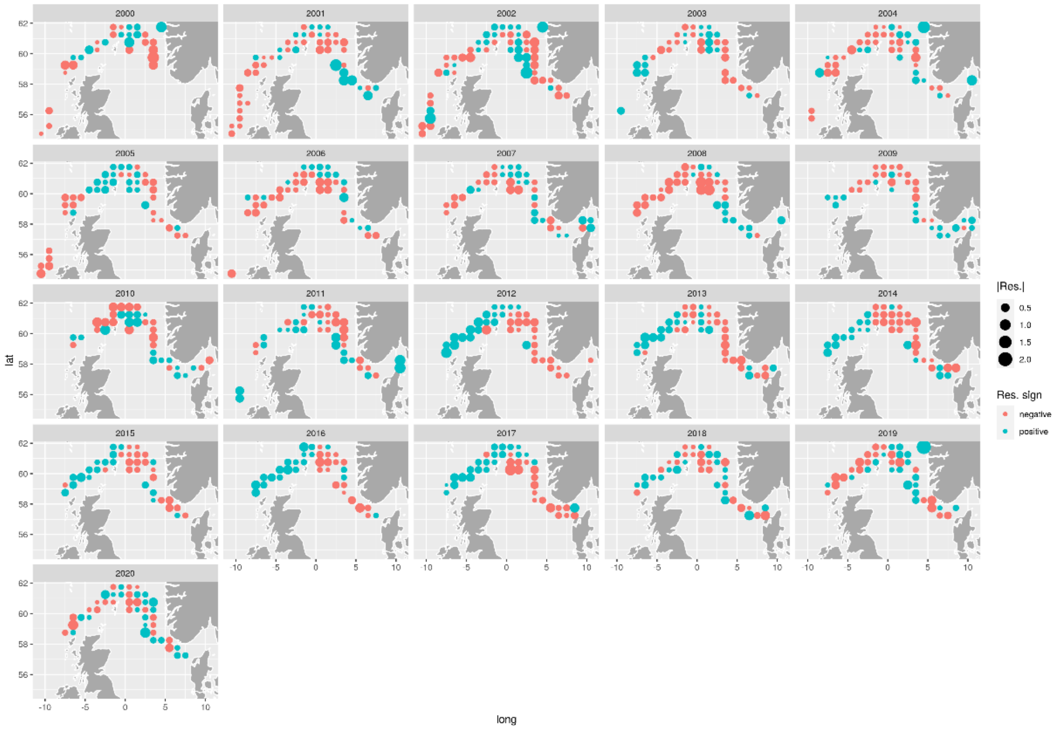

Figure 16.3.10. Saithe in subareas 4 and 6 and Division 3.a. Maps of mean residuals from the CPUE index model per 0.5°x0.5° grid cell, per year (2000–2020).

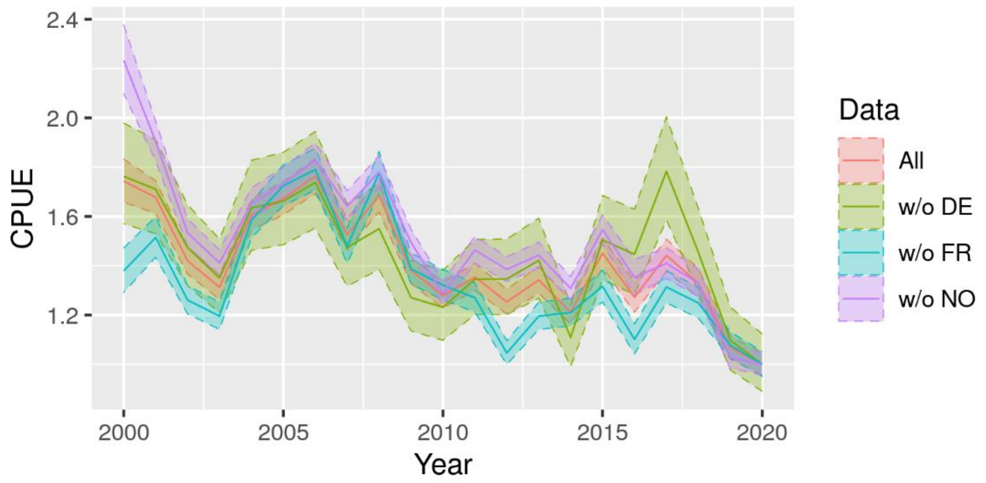

Figure 16.3.11. Saithe in subareas 4 and 6 and Division 3.a: Commercial CPUE index (standardized to one in 2020) fitted with data from one nation sequentially taken out, compared to all data (leave-one-nation-out analysis).

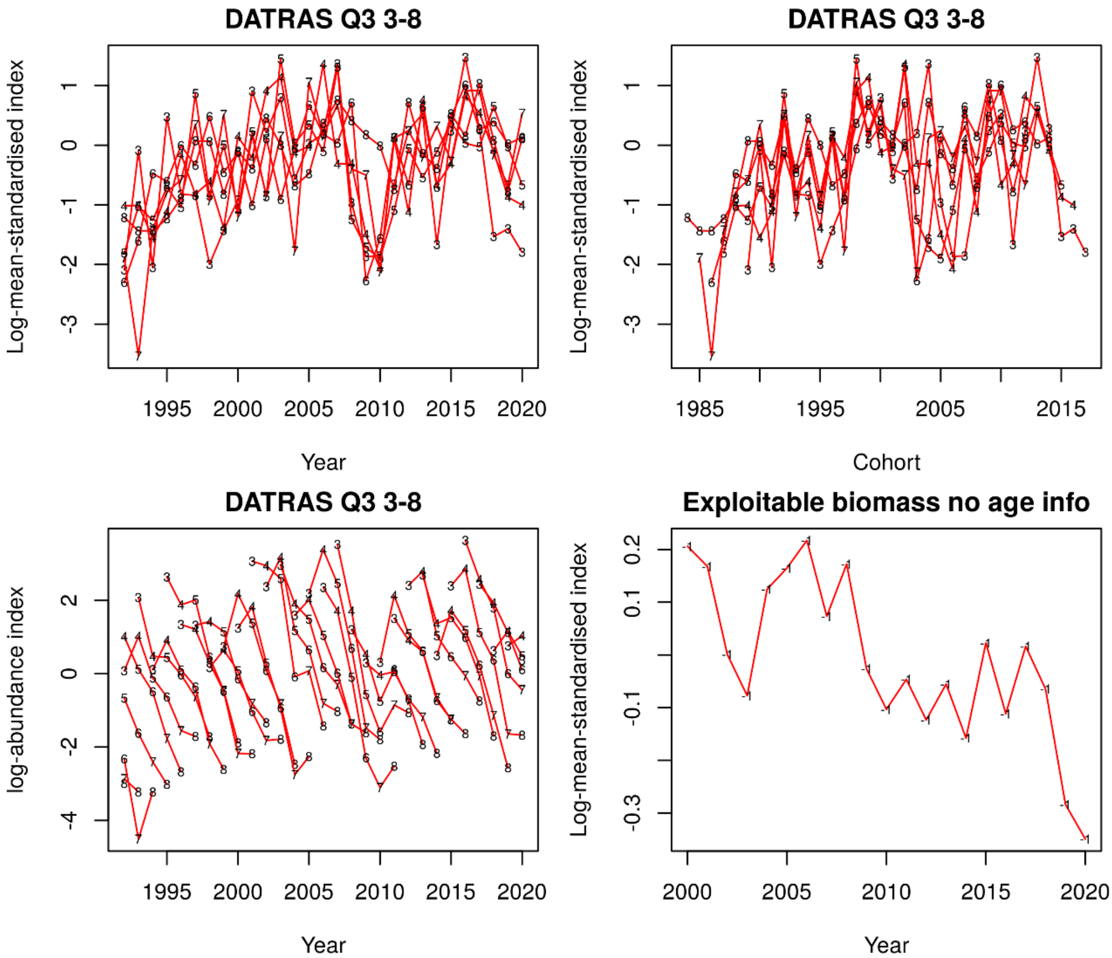

Figure 16.4.1. Saithe in subareas 4 and 6 and Division 3.a: Research survey index, IBTS–Q3, for ages 3 to 8, 1992–2020 is shown in terms of indices by age and year (top-left panel), indices by age and cohort (top-right panel), and log-catch curves by cohort (bottom-left panel). Commercial catch-per-unit-effort (CPUE) is shown in the bottom-right panel.

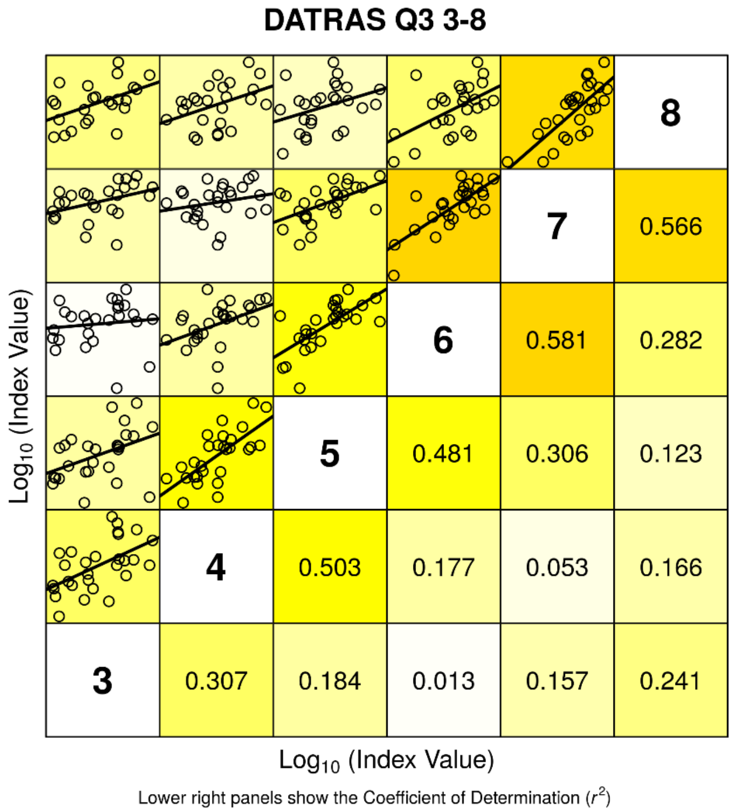

Figure 16.4.2. Saithe in subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2020 ages 3 to 8.

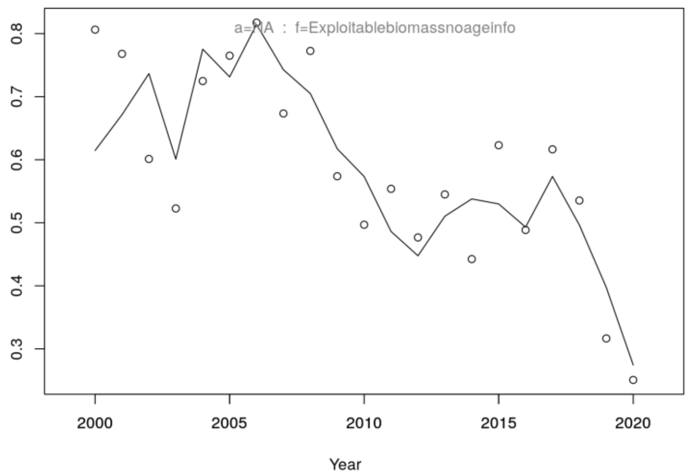

Figure 16.4.3. Saithe in subareas 4 and 6 and Division 3.a. Standardized combined CPUE index (year effects, open circles) and fit of model after tuning to the exploitable biomass (solid line), 2000–2020.

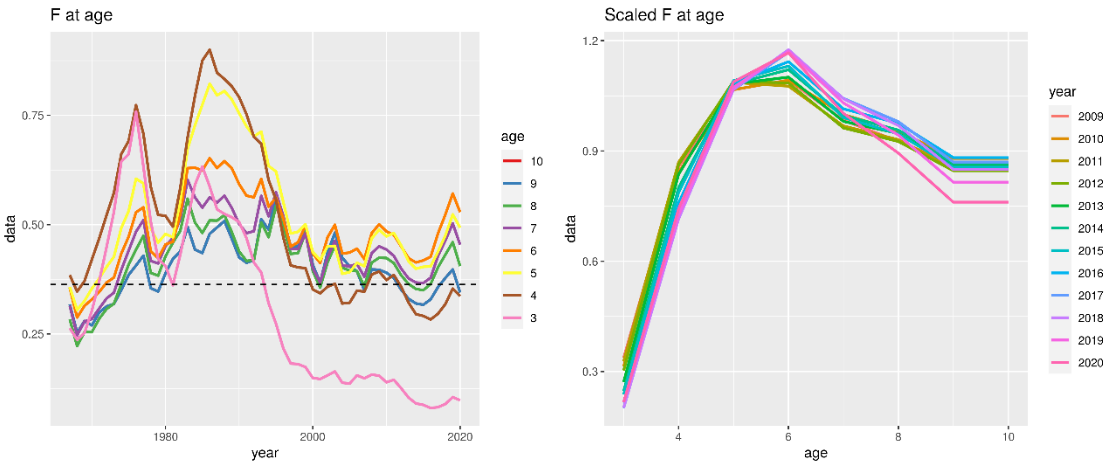

Figure 16.4.4. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortality at age for the final assessment model. Time series (left panel) and scaled at $F_{4\text{-}7}$ for the last 12 years (right panel).

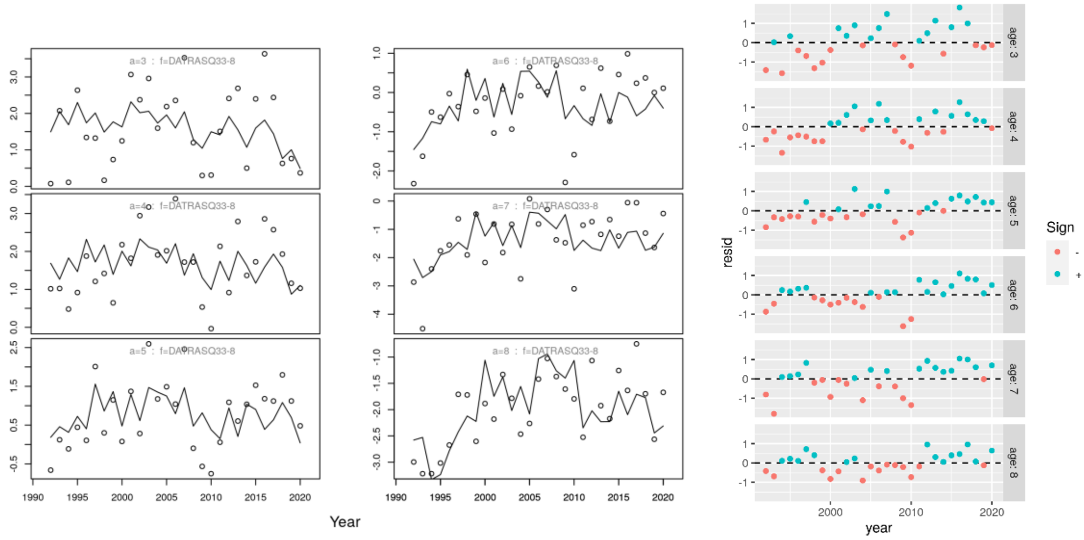

Figure 16.4.5. Saithe in subareas 4 and 6 and Division 3.a. Left: DATRAS Q3 index at age (age 3-8, open circles) and model fit (solid line), 1992–2020. Right: residuals (conditioned on all the data)

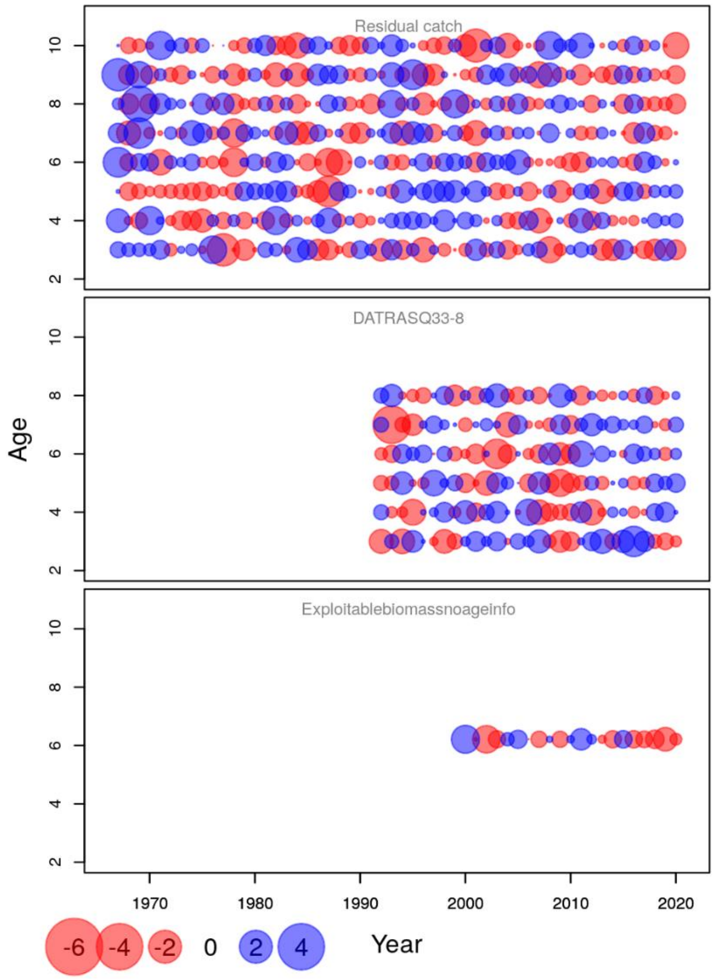

Figure 16.4.6. Saithe in subareas 4 and 6 and Division 3.a. One-step ahead (serially independent) residual patterns of observations for the final SAM model.

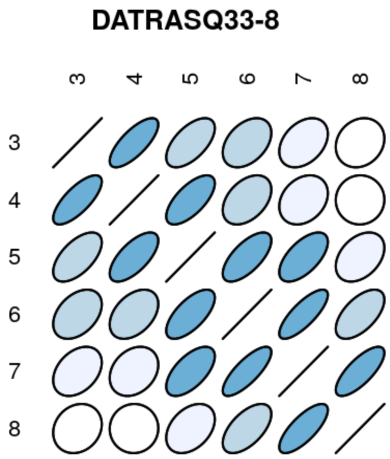

Figure 16.4.7. Saithe in subareas 4 and 6 and Division 3.a. Correlation between age classes within years for IBTS Q3 (ages 3–8). The darker the blue colour, the stronger the correlation.

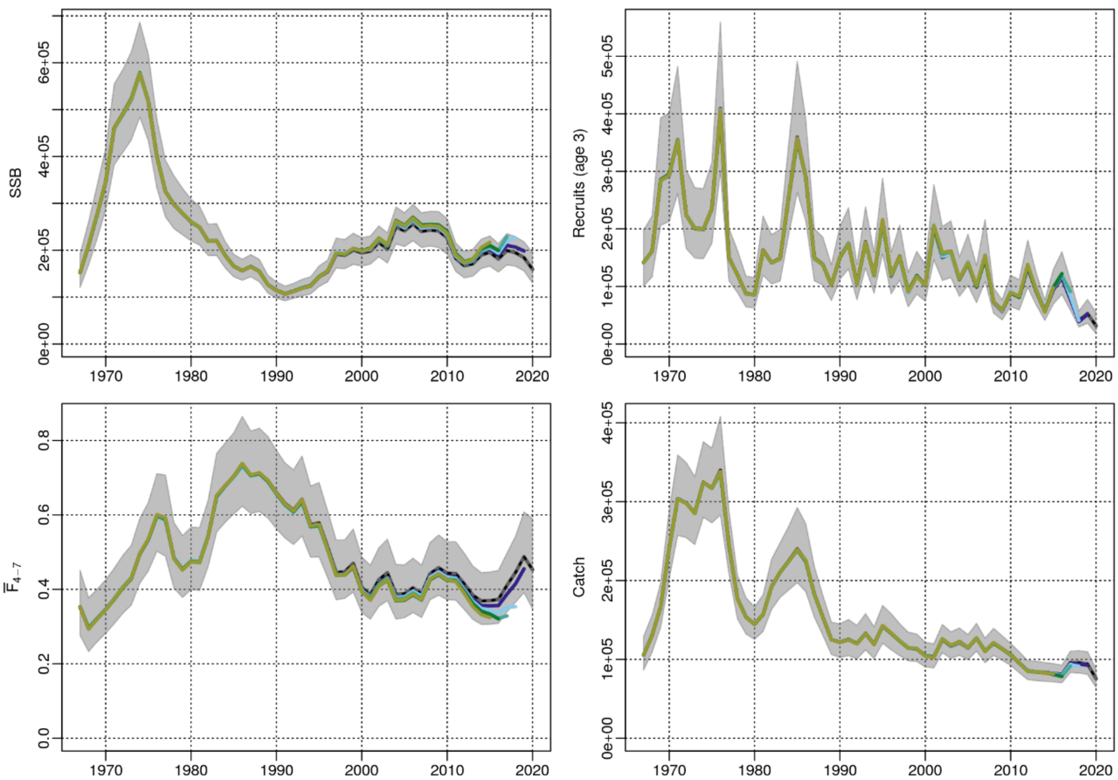

Figure 16.4.8. Saithe in subareas 4 and 6 and Division 3.a. Five-year retrospective pattern in SSB, F_{4-7}, recruitment, and catches for the final assessment.

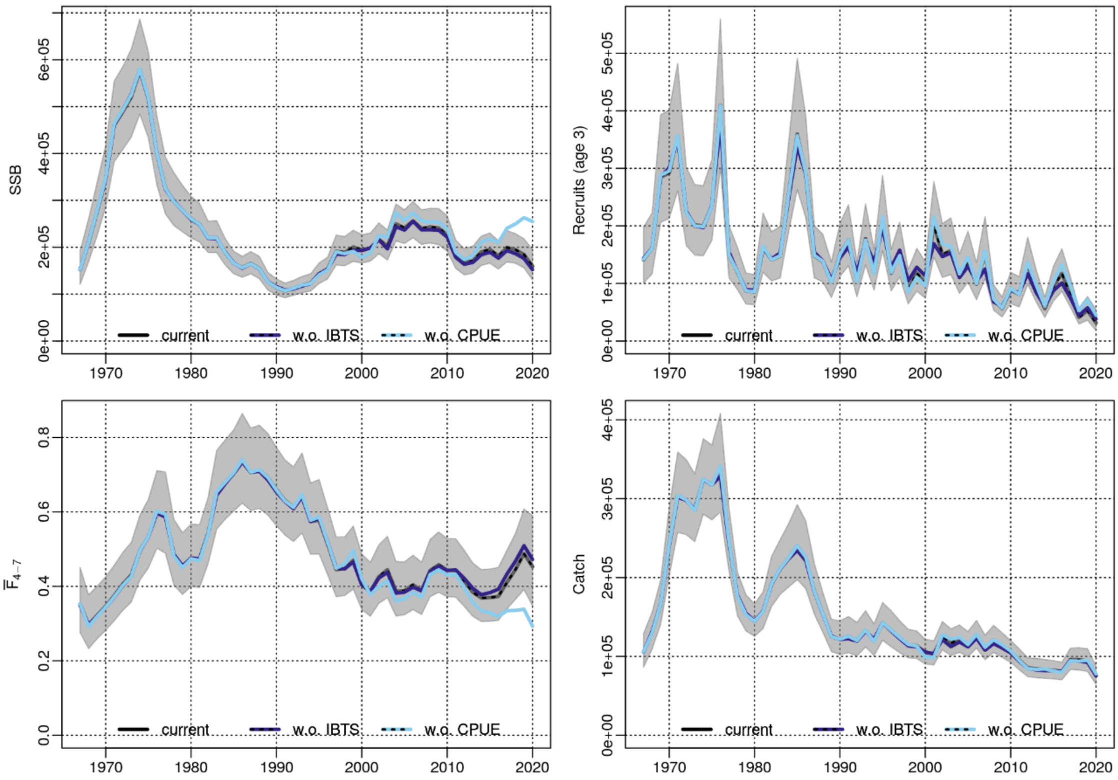

Figure 16.4.9. Saithe in subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, $F_{4–7}$, recruitment, and catches for the final assessment model. Black lines and grey-shaded confidence interval indicate the final assessment model, including the IBTS Q3 indices for ages 3–8 and the CPUE index. The light blue line is the assessment with only the IBTS Q3 tuning series, while the dark blue one is the assessment with only the CPUE index.

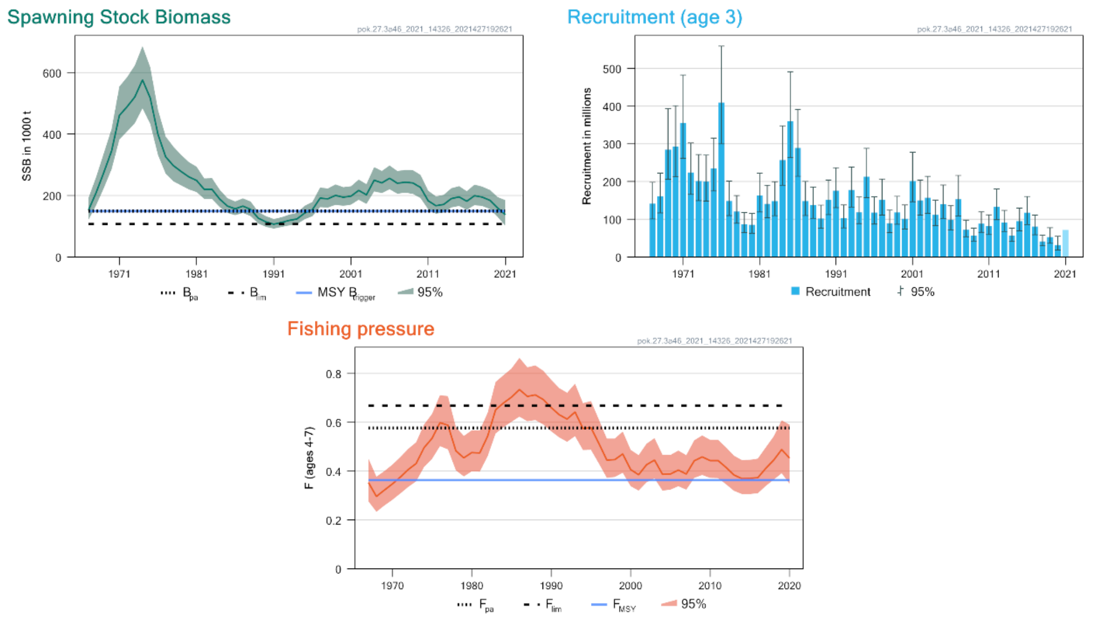

Figure 16.5.1. Saithe in subareas 4 and 6 and Division 3.a. Summary of stock assessment in relation to reference points for SSB and F. Predicted recruitment values are light shaded. Shaded areas (F, SSB) and error bars (R) indicate point-wise 95% confidence intervals.

17 Sole (*Solea solea*) in Subarea 27.4 (North Sea)

17.1 Sole (*Solea solea*) in Subarea 27.4 (North Sea) General

The assessment of sole in Subarea 27.4 is an update of last year's model run. This is the result of applying the methodology agreed at the last benchmark, carried out in February 2020 (ICES WKFLATNSCS, 2020). The adopted assessment model is the AAP statistical catch-at-age model of Aarts & Poos (2009), already applied in the past. The model uses two indices of abundance: The Sole Net Survey (SNS), covering the coastal areas of the Southern North Sea, and a combined index based on the BTS Q3 survey, including data from The Netherlands, Belgium and Germany. This index covers the full area of distribution of the stock. Further details about the implementation of the BTS survey and changes to the stock assessment model can be found in the benchmark report (ICES WKFLATNSCS, 2020).

The benchmark agreed on the settings to be applied to the AAP model for the assessment of sol.27.4 and for the forecasts providing annual advice on catch limits. North Sea sole has been defined as a category 1 stock according to ICES guidelines, and the advice presented in this section refers to catch limits for 2022.

17.1.1 Stock structure and definition

North Sea sole is assumed to consist of a single stock unit.

17.1.2 Ecosystem aspects

North Sea sole is commonly distributed along the Southern half of the North Sea. Spawning takes place in shallow waters on the Southern coasts of the North Sea. Episodic large recruitment events take place at irregular intervals, the most recent being the strong 2018-year class.

17.1.3 Fisheries

Many vessels in the beam trawl fleet, targeting sole in the North Sea, transitioned in the past decade to using electrical pulse gears. In 2011, approximately 30 derogation licenses for pulse trawls were taken into operation, a number than then increased to 42 in 2012.

The catch composition of these gears has been 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 recommended that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls were undertaken.

Between 2014 and 2017 the use of pulse trawls in the main fishery operating in the North Sea increased and less vessels were 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 Division 4.c. As a consequence, a larger proportion of the sole catch is now taken in this area (ICES, 2018).

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 has still continued. The precise response to the fleet to the ban is still to be observed, but it appears it is not simply a return to the gear configurations in use before the advent of pulse.

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 programs.

17.1.4 Management regulations

ICES is requested to provide advice based on the MSY approach. ICES advises that when the MSY approach is applied, total catch in 2022 should equal that corresponding to the level expected to impose a fishing mortality equal to F_{MSY}, 15 330 tonnes.

17.2 Fisheries data

17.2.1 Official catches

For 2020, the official landings are presented next to the landings and discards data submitted to Intercatch in Figure 1. A time-series of the official landings by country and overall total, the officially reported BMS landings, the landings reported to ICES and the agreed TAC are presented in Table 2.

17.2.2 Intercatch processing

Data submitted on landings and discards at age by métier and quarter has been extracted from Intercatch. Figures 6, 7 and 8 show the coverage of the landings, as tonnage and as a cumulative percentage, and discards information, respectively, as available in Intercatch. The allocation of discards and age samples to unsampled strata has followed, in overall terms, the following grouping strategy:

- *TBB_DEF* and *OTB_DEF* < 100, separately and by quarter if possible.
- *TBB_DEF* and *OTB_DEF* > 100, separately and by quarter if possible.
- *TBB_CRU* and *OTB_CRU* < 100.
- *TBB_CRU* and *OTB_CRU* > 100.
- *GTR_DEF* and *GNS_DEF*.
- *FPO*, *LLS*, and *MIS*.

17.2.3 ICES estimates of landings and discards

Figure 2 presents the time series of total catches, landings and discards over the 1957–2020 period. Landings, in numbers by age, as used as input for the assessment, are presented in Table 3 and Figure 3. Total landings reported to ICES for sole in Subarea 27.4 in 2020 amounted to 10 490 tonnes, an increase of around 17% compared to the values reported for 2019.

Since 2016, small mesh beam trawlers (BT2) with discard rates of around 10%, are required to report BMS landings in Subarea 27.4. The official reported BMS landings in 2020 were 35 tonnes. For incorporation in the assessment, BMS landings are merged with the estimated discards.

Discards, in numbers at age, as used as input for the assessment, are presented in Table 4 and Figure 4. The proportions of caught fish at age that are discarded Figure over the 2002–2020 period, over which data on discards is available, is presented in Figure 5.

In 2020, official catches amounted to 48.6% of the TAC, while landings reported to ICES were 50.4% of the TAC. If both landings and discards estimates are used, total catch in 2020 was 59.8% of the agreed TAC.

17.3 Weights-at-age

Weights-at-age in the landings of sole in Subarea 27.4 can be found in Table 5 and Figure 9. These are measured weights from the various national catch and market sampling programs. Discard weights at age (Table 6) are derived from the various national catch and discard programs (both observer and self-sampling).

Mean weight-at-age in the discards for the 1957–2002 period, when discards-at-age are reconstructed by the AAP model, are the average over the years 2006 to 2013. Sampling levels were substantially lower before 2006.

Mean weights-at-age in the stock (Table 7) are the average weights from the 2nd quarter landings and discards as constructed by Intercatch. The mean stock weights-at-age have shown a continuous downward trend, returning to values similar to those observed at the start of the time series (Figure 10). Mean weights at age for younger ages has also been decreasing in recent years.

17.4 Maturity and natural mortality

A knife-edged maturity-ogive with full maturation at age 3 is assumed for sole in Subarea 27.4 (Table 8). No new data was presented at the working group in 2021. Natural mortality at age is assumed to be constant at 0.1, except for the year 1963 where a value of 0.9 was used to take into account the effect of the severe winter of 1962–1963. The estimate of 0.9 was based on an analysis of the CPUE in the fisheries targeting sole before and after that period (ICES FWG, 1979).

17.5 Survey data

Two survey series are used in the assessment of North Sea sole:

- Quarter 3 Beam Trawl Survey (BTS), covering the 1985–2020 period and containing samples for ages 1 to 10+.
- Quarter 3 Sole Net Survey (SNS), extending from 1970 to 2020, with the exception of 2003, and with samples including ages 1 to 6.

An index of abundance is assembled based on the BTS Q3 samples collected by The Netherlands, Belgium and Germany (Figure 12), available in the Datras database. A standardized age-based index is calculated using a delta-lognormal GAM model, using the methodology presented in Berg *et al.* (2014). Please refer to the WKFlatNSCS report (ICES, 2020) for further details on the analysis[1]. This index substitutes the previous one that only utilized samples taken by RV-Isis and, since 2016, by RV-Tridens on the same locations and with the same gear. Ages included in the index are 1 to 10, the last being a plusgroup.

The SNS index is calculated by The Netherlands based on the mean densities across all sampled stations.

A standardized comparison of the two indices over the available time-series is presented on 13, while Figures 14 and 17 present each individual index in their actual scales. The internal

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[1] Input data, source code and output of the index standardization is available at the https://github.com/ices-taf/2021_sol.27.4_survey/ TAF repository.

consistency plots of the year class cohorts of the two indices are presented in Figures 15 and 18, while the mean standardized indices per cohort and by year are shown on Figures 16 and 19. The actual values of the two survey indices used in the assessment are presented in Tables 9 and 10.

A retrospective analysis was carried out for the standardization procedure used to generate the BTS Q3 index of abundances. The same model was applied to a total of 5 1-year *peels*. The resulting indices (Figure 20, as total biomass) were then used in the stock assessment retrospective analysis.

17.6 Assessment

The model applied to North Sea sole is the Aarts and Poos statistical catch-at-age model (AAP; Aarts and Poos, 2009), in use for this stock since the 2015 benchmark (ICES WKNSEA, 2015). AAP models recruitment as an independent yearly factor, informed by the age-1 abundances of both surveys, and uses splines to model yearly patterns of the selectivity and fishing mortality-at-age. Discards-at-age are reconstructed through an estimate of changes in the discard fraction by age and year. The table below gives an overview of data and parameters used in the AAP model, as endorsed by the benchmark (ICES WKFlatNSCS, 2020).

Table 1: Settings of the 2020 AAP stock assessment model for sole in Subarea 27.4.

Setting	Value
Plus-group	10
First tuning year	1970
Catchability catches constant for age >=	9
Catchability surveys constant for ages >=	8
Spline for selectivity-at-age survey, no. knots	6
Tensor spline for F-at-age, ages, no. knots	8
Tensor spline for F-at-age, years, no. knots	28

A summary of the assessment results (recruitment, F and SSB, including confidence bounds) is presented in Figure 21. The estimates of spawning biomass and corresponding recruitment at age 1 are shown in Figure 22. The proportion of spawning biomass estimated to be accounted for by age and year is presented in Figure 23. A plot of log-standardized residuals of the model fit to the four data sources employed (the two indices of abundance, landings, and discards at age) is presented in Figure 24. The runs test for both indices (Carvalho *et al.*, 2021) are presented in Figure 26 for the overall biomass, and Figure 27 for the numbers at age. Patterns were found to be non-random for ages 2 and 3 on the BTS survey only.

The retrospective patterns for recruitment, spawning biomass and fishing mortality are summarized in Figure 28. Figure 29 presents the results of an analysis of prediction skills by means of hindcasting cross-validation (carried out following Carvalho et al, 2021). A leave-one-out analysis of model fit over the two indices of abundance can be found in Figure 30. The estimated standard deviations of the lognormal likelihood for each age and data source are presented in Figure 31.

Yearly estimates of abundances and fishing mortality-at-age obtained by the model run are presented in Tables 11 and 12, respectively.

17.7 Recruitment estimates

The short-term forecast for the stock requires an assumption about recruitment in the intermediate year, 2021. This has been set to the geometric mean of the 1957–2019 time series of recruitment estimates, 113,711 million fish.

17.8 Short-term forecasts

Short-term forecasts were carried out from the abundances estimated by the assessment model in 2020, with the following settings

- Natural mortality, maturity and weights-at-age in landings, discards and stock for 2021–2022 set as the average of the last five years (2014–2019).
- Selectivity-at-age for 2021–2022 set as the average of the last five years (2014–2019).
- Ratio of discards to landings at age as the average over the last three years (2016–2019).
- Recruitment in 2021 and 2022 set as 113,711 million fish.
- Population numbers in the intermediate year for ages 2 and older are taken from the AAP survivors estimates.

Fishing mortality in the intermediate year, 2021, was set as equal to that estimated in 2020.

Forecasts were carried out using the FLR toolset[2] (Kell *et al.*, 2007), and in particular the FLasher package[3] (Scott and Mosqueira, 2016). Source code for this analysis is available at the corresponding TAF repository[4]

The projections carried out were those necessary to populate the stock catch options table, as summarized here:

- F_{MSY}: F_{bar} (2021) = 0.207
- $F_{MSY\ lower}$: F_{bar} (2021) = 0.123
- $F_{MSY\ upper}$: F_{bar} (2021) = 0.311
- Zero catch: F_{bar} (2021) = 0
- F_{pa}: F_{bar} (2021) = 0.311
- F_{lim}: F_{bar} (2021) = 0.42
- B_{pa}: SSB (2022) = 4.2838 *10^4
- F_{lim}: SSB (2022) = 3.0828 *10^4
- MSY $B_{trigger}$: SSB (2022) = 4.2838 *10^4
- F_{2020}: F_{bar} (2021) = 0.256
- F_{mp}: F_{bar} (2021) = 0.20
- Roll-over TAC: Catch (2021) = 17 545 t

17.9 Reference points

The reference points for sole in Subarea 4 have been updated at the recent benchmark (ICES WKFlatNSCS, 2020), following the procedures of ICES WKMSYREF3 (2014). The definition of F_{pa} was updated in 2021. All values are derived from the run of the AAP model including data up to 2018. The reference points in use for the stock are as follows:

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[2] https://flr-project.org

[3] https://flr-project.org/FLasher

[4] https://github.com/ices-taf/2021_sol.27.4_forecast/

Reference point	Value	Technical basis
MSY $B_{trigger}$	42838 t	B_{pa}
F_{MSY}	0.207	EQsim analysis based on the recruitment period 1958–2015
B_{lim}	30828 t	Break-point of hockey stick stock-recruit relationship, based on the recruitment period 1958–2018
B_{pa}	42838 t	$B_{lim} \cdot \exp(1.645 \cdot 0.2)$
F_{lim}	0.42	EQsim analysis, based on the recruitment period 1958–2018
F_{pa}	0.311	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{p.05}$ with AR).
MSY $B_{trigger}$	42838 t	MSY
MSY range F_{lower}	0.123–0.207	Consistent with ranges provided by ICES (2017a), resulting in no more than 5% reduction in long-term yield compared with MSY
MSY range F_{upper}	0.21–0.311	Consistent with ranges provided by ICES (2017a), resulting in no more than 5% reduction in long-term yield compared with MSY

An error on the value selected for the upper limit of the F_{MSY} range has been corrected. The upper value should have been limited by the value of F_{pa}.

17.10 Quality of the assessment

The assessment presents a strong retrospective pattern (SSB Mohn's rho > 0.20 and 3 out of 5 peels outside of the model confidence intervals) for which no clear explanation has yet been found (Figure 28). The retrospective analyses has been carried out including retrospective fits of the GAM standardization of the BTS index of abundance (Figure 17.20). They were shown to have no effect on the assessment retrospective metric. The model estimates of fleets selectivity at age show changes on the retrospective peels that are necessary to accommodate the discrepancies between catches of older ages and the information on those ages from the abundance indices in recent years.

The decision tree proposed by WKFORBIAS (2019) was applied by the WG. It was not deemed possible to carry out an interbenchmark prior to the issuing of advice. As the stock biomass is currently estimated below B_{lim}, F_{hcr} is two thirds of $F_{p.05}$, and the SSB retrospective value is negative, the decision tree indicates that advice should be given despite the possible problems in the model leading to this large retrospective pattern.

The uncertainty in the forecasted values of biomass, that form the basis for advice, was quantified by carrying out a stochastic forecast (Figure 32). The uncertainty in current status, introduced by parameter estimation, was incorporated through a Markov chain Monte Carlo (McMC) run of the stock assessment model. A single McMC chain was run for 100 000 iterations, thinned down every hundred. The probability quantiles obtained were comparable to those computed from the model estimated variances. Uncertainty in future recruitment was then added by resampling with replacement over the recruitment estimates of the last ten years.

17.11 Status of the stock

The stock appears to have increased in size in 2020, while fishing mortality has decreased as catches have remained stable. The estimated spawning biomass in 2020, 29 141 t, is still lower than B, although is expected to move above that level as the 2018 year-class becomes mature in 2021. Recruitment in 2019 is estimated to be among the largest ever observed, 415 million fish.

17.12 Management considerations

The proposed TAC for 2022 is a substantial decrease from the advice for 2021. This is due to the re-estimation of the strength of the 2018 year-class. The advised catch level should ensure the stock is above precautionary levels (SSB > MSY $B_{trigger}$) with a high probability. The 2022 TAC is still higher than catches in recent years, where TAC update was less than 100%, although there are some indications that catches at the start of 2021 have been higher than in 2020.

17.13 Issues for future benchmarks

The stock has gone through the benchmark process in 2020 (ICES WKFLATNSCS, 2020). Work during the benchmark concentrated on the two main issues in the ICES WGNSSK (2019) issue list: develop an index of abundance that includes samples from multiple countries of the BTS Q3 survey, and improvements on the residual patterns of the model fit.

Limitations on time and data did now allow any work on the effect and suitability of the current assumptions on natural mortality and maturity at age to be carried out for this year's benchmark. A general revision of the biological assumptions and processes in this stock would be a useful contribution to a future benchmark. Long and short-term changes in the stock weights at age, for example, should have an effect on natural mortality on all ages.

Possible reasons for the strong retrospective pattern will need to be investigated, even before the next benchmark. Changes in growth patterns could be expected to have an effect on natural mortality. The impact of the current assumption of constant M over time and for all ages would need to be evaluated.

17.14 References

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Table 2: 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	Official	BMS	ICES	TAC
1982	1900	524	686	266	17686	403	2.00	21467		21579	21000
1983	1740	730	332	619	16101	435	0.00	19957		24927	20000
1984	1771	818	400	1034	14330	586	1.00	18940		26839	20000
1985	2390	692	875	303	14897	774	3.00	19934		24248	22000
1986	1833	443	296	155	9558	647	2.00	12934		18201	20000
1987	1644	342	318	210	10635	676	4.00	13829		17368	14000
1988	1199	616	487	452	9841	740	28.00	13363		21590	14000
1989	1596	1020	312	864	9620	1033	50.00	14495		21805	14000
1990	2389	1427	352	2296	18202	1614	263.00	26543		35120	25000
1991	2977	1307	465	2107	18758	1723	271.00	27608		33513	27000
1992	2058	1359	548	1880	18601	1281	277.00	26004		29341	25000
1993	2783	1661	490	1379	22015	1149	298.00	29775		31491	32000
1994	2935	1804	499	1744	22874	1137	298.00	31291		33002	32000
1995	2624	1673	640	1564	20927	1040	312.00	28780		30467	28000
1996	2555	1018	535	670	15344	848	229.00	21199		22651	23000
1997	1519	689	99	510	10241	479	204.00	13741		14901	18000
1998	1844	520	510	782	15198	549	339.00	19742		20868	19100
1999	1919	828		1458	16283	645	501.00	21634		23475	22000
2000	1806	1069	362	1280	15273	600	539.00	20929		22641	22000
2001	1874	772	411	958	13345	597	394.00	18351		19944	19000
2002	1437	644	266	759	12120	451	292.00	15969		16945	16000
2003	1605	703	728	749	12469	521	363.00	17138		17920	15900
2004	1477	808	655	949	12860	535	544.00	17828		18757	17000
2005	1374	831	676	756	10917	667	357.00	15579		16355	18600
2006	980	585	648	475	8299	910	0.00	11933		12594	17700
2007	955	413	401	458	10365	1203	5.00	13800		14635	15000
2008	1379	507	714	513	9456	851	15.00	13435		14071	12800
2009	1353	476		555	12038	951	1.00	14898		13952	14000
2010	1268	406	621	537	8770	526	1.38	12129		12603	14100
2011	857	346	539	327	8133	786	2.00	10990		11485	14100
2012	593	418	633	416	9089	599	3.00	11752		11602	16200
2013	697	497	680	561	9987	867	0.00	13291		13137	14000
2014	920	314	675	642	9569	840	0.00	12547		13060	11900
2015	933	271	532	765	8899	804	0.00	12203		12867	11900
2016	767	355	362	861	9600	705	0.00	12651		14127	13262

Year	BE	DK	FR	DE	NL	UK	Other	Official	BMS	ICES	TAC
2017	556	432	393	731	9155	513	0.00	11781	30	12370	16123
2018	408	368	432	717	8412	431	2.00	10771	57	11199	15694
2019	259	116	110	616	7212	334	1.00	8339	48	8658	12555
2020	240	123	37	914	6675	540	0.00	8529	35	10490	17545

Table 3: Time-series of landings at age (in thousands) of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	0.0	1472	10556	13150	3913	3041	6780	1803.0	529.0	6541.0
1958	0.0	1863	8482	14240	9547	3501	3023	4461.0	2264.0	6590.0
1959	0.0	3694	12139	10499	9060	5823	1217	2044.0	2598.0	5668.0
1960	0.0	11965	14043	16691	9248	8313	4815	1583.0	1049.0	7851.0
1961	0.0	972	50470	19403	12574	4760	3998	4338.0	847.0	7355.0
1962	0.0	1584	6173	58836	15254	10478	4797	4087.0	2074.0	7450.0
1963	0.0	670	8271	8485	45823	8420	6603	2403.0	3365.0	8316.0
1964	53.0	150	2041	5518	3680	16749	3020	1749.0	790.0	2913.0
1965	0.0	45180	1045	1534	4798	2381	11990	1494.0	1463.0	3077.0
1966	0.0	12145	132170	979	1168	3649	736	6255.0	694.0	2424.0
1967	0.0	3769	26260	87039	1998	548	1962	777.0	5160.0	2978.0
1968	1034.0	17093	13852	24894	48417	461	244	1639.0	323.0	6502.0
1969	404.0	24404	21884	5433	12638	25646	338	249.0	1214.0	5379.0
1970	1299.0	6141	25996	8236	1784	3231	11961	246.0	140.0	5234.0
1971	425.0	33765	14596	12909	4538	1459	2355	7300.0	194.0	4649.0
1972	354.0	7511	36356	6997	4911	1548	517	1218.0	4654.0	2772.0
1973	716.0	12459	13025	16493	4101	2368	1013	779.0	1241.0	5899.0
1974	100.0	15171	21248	5412	6965	1896	1563	649.0	396.0	4750.0
1975	267.0	23193	28833	11839	2110	3870	798	916.0	513.0	3481.0
1976	1064.0	3619	28571	14316	4923	987	1950	562.0	434.0	2721.0
1977	1780.0	22747	12299	15593	7580	1812	325	1133.0	261.0	2155.0
1978	27.0	24921	29163	6102	6610	4231	1730	608.0	643.0	1595.0
1979	9.0	8280	41681	16259	3033	3262	1769	826.0	244.0	1546.0
1980	650.0	1233	12762	18138	7444	1479	2241	1437.0	374.0	1227.0
1981	434.0	29983	3344	7046	8439	3757	973	909.0	786.0	932.0
1982	2697.0	26799	46375	1868	3584	4855	1701	623.0	613.0	1295.0
1983	391.0	34545	41551	21273	626	1383	1958	982.0	388.0	1181.0
1984	192.0	30839	44081	22631	8821	744	857	1047.0	526.0	897.0
1985	163.0	16449	42773	20079	9307	3520	207	375.0	631.0	965.0

year	1	2	3	4	5	6	7	8	9	10
1986	372.0	9304	18381	17591	7698	5480	2256	109.0	281.0	1671.0
1987	93.0	28896	21927	8851	6477	3102	1559	898.0	81.0	690.0
1988	10.0	13206	47135	15217	4377	3878	1549	890.0	523.0	317.0
1989	115.0	45652	17973	22295	4551	1627	1414	637.0	451.0	459.0
1990	854.0	11816	103380	9667	9099	3315	1032	1186.0	548.0	837.0
1991	118.0	12938	24985	76580	6609	3612	1706	707.0	718.0	1072.0
1992	965.0	6730	43713	15961	37745	2440	2995	730.0	393.0	1163.0
1993	53.0	49870	16575	31047	13709	23758	1472	1170.0	456.0	833.0
1994	709.0	7710	86349	13387	18513	5642	11174	458.0	905.0	897.0
1995	4766.0	12674	16700	68073	6262	7254	1981	5971.0	293.0	665.0
1996	170.0	18609	16005	16770	26946	3814	4725	932.0	3267.0	976.0
1997	1574.0	5987	23418	7253	5058	12667	1189	2303.0	330.0	1672.0
1998	242.0	56162	15011	14806	3466	1924	4727	787.0	1022.0	838.0
1999	284.0	15601	71730	8103	6049	1200	657	1964.0	328.0	804.0
2000	2329.0	14929	32425	42394	3257	2453	796	431.0	922.0	708.0
2001	857.0	25045	20925	19260	16211	1383	808	266.0	163.0	701.0
2002	1046.0	10958	32570	12185	8145	6393	667	592.0	88.0	362.0
2003	1047.0	32295	17479	16072	5814	3902	2427	400.0	128.0	451.0
2004	516.0	14960	48003	9531	7462	2167	902	962.0	389.0	389.0
2005	1131.0	7254	22633	28875	4168	3861	1491	602.0	768.0	392.0
2006	7008.0	9966	10397	9606	10943	1617	1577	724.0	373.0	553.0
2007	315.0	39643	10820	6407	5706	5479	819	725.0	498.0	541.0
2008	1959.0	6325	37427	5996	2928	2393	2613	448.0	491.0	459.0
2009	1630.0	10417	10771	26548	3278	1652	1591	1532.0	312.0	864.0
2010	371.0	11659	13354	8530	13623	1817	907	809.0	1196.0	690.0
2011	44.0	11992	19788	8379	5070	6436	983	431.0	283.0	765.0
2012	1.0	6439	28605	11069	4285	2146	4072	587.0	286.0	1028.0
2013	0.0	2741	28189	21500	5643	2042	1532	2246.0	242.0	471.0
2014	371.0	8111	6916	22942	11440	2591	1808	620.0	840.0	459.0
2015	201.0	10512	16589	4738	14756	6157	1470	562.0	393.0	545.0
2016	119.0	6151	24249	11489	4475	8994	4495	774.0	278.0	854.0
2017	416.0	4928	17641	16818	5909	2118	3745	2005.0	443.0	498.0
2018	331.0	11141	9184	11994	10095	3918	1096	1942.0	804.0	436.0
2019	488.4	6238	15757	6237	5383	4784	1485	695.6	1623.2	472.7
2020	121.8	18091	10055	10650	2648	2131	1499	562.4	152.2	1258.5

Table 4: Time-series of discards at age (in thousands) of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
2002	6461	12606	5212	1029	272.0	0.0	0.0	0.00	0.00	0.000
2003	1156	7152	5059	1212	381.0	0.0	0.0	0.00	0.00	0.000
2004	293	12832	7449	1719	518.0	12.0	0.0	0.00	0.00	0.000
2005	2256	5622	4796	1258	375.0	63.0	22.0	0.00	0.00	0.000
2006	2390	5727	2705	654	197.0	28.0	18.0	7.00	0.00	0.000
2007	818	4923	3010	619	226.0	57.0	4.0	0.00	0.00	0.000
2008	1230	2704	1764	371	106.0	0.0	8.0	0.00	0.00	0.000
2009	2695	6480	3652	999	266.0	5.0	9.0	0.00	0.00	0.000
2010	5687	12164	6670	1544	493.0	31.0	10.0	2.00	2.00	0.000
2011	3457	10298	5482	1273	354.0	33.0	0.0	0.00	0.00	0.000
2012	1132	19556	9444	984	230.0	232.0	36.0	4.00	7.00	1.000
2013	4653	5733	12558	3649	340.0	125.0	19.0	3.00	0.00	0.000
2014	7162	5836	2371	3488	1366.0	238.0	198.0	6.00	0.00	0.000
2015	9454	9166	3913	1991	1528.0	415.0	15.0	50.00	8.00	1.000
2016	5145	5338	5048	1393	291.0	536.0	226.0	4.00	1.00	1.000
2017	6083	4171	3633	2712	469.0	89.0	342.0	138.00	0.00	0.000
2018	2928	7760	1704	1448	1186.0	98.0	15.0	125.00	36.00	0.000
2019	12596	8610	5486	1640	788.6	793.9	233.1	18.53	79.48	0.812

Table 5: Time-series of the mean weights-at-age in the landings of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	0.15	0.15	0.18	0.20	0.25	0.28	0.29	0.34	0.44	0.41
1958	0.15	0.14	0.18	0.22	0.25	0.27	0.31	0.32	0.39	0.41
1959	0.15	0.16	0.19	0.23	0.26	0.30	0.33	0.32	0.37	0.43
1960	0.15	0.15	0.18	0.23	0.25	0.28	0.30	0.31	0.38	0.42
1961	0.15	0.15	0.17	0.21	0.26	0.29	0.32	0.30	0.35	0.42
1962	0.15	0.15	0.17	0.21	0.24	0.29	0.32	0.32	0.33	0.41
1963	0.15	0.16	0.17	0.22	0.26	0.31	0.32	0.39	0.38	0.48
1964	0.15	0.17	0.21	0.25	0.27	0.31	0.33	0.35	0.39	0.48
1965	0.15	0.17	0.21	0.25	0.29	0.28	0.34	0.38	0.40	0.48
1966	0.15	0.18	0.19	0.18	0.30	0.33	0.43	0.40	0.45	0.50
1967	0.15	0.19	0.20	0.25	0.28	0.39	0.42	0.34	0.42	0.49
1968	0.16	0.19	0.21	0.27	0.33	0.34	0.35	0.46	0.47	0.51
1969	0.15	0.19	0.20	0.26	0.31	0.37	0.55	0.40	0.47	0.52
1970	0.15	0.21	0.22	0.28	0.35	0.40	0.44	0.46	0.44	0.53

year	1	2	3	4	5	6	7	8	9	10
1971	0.14	0.19	0.24	0.32	0.36	0.42	0.42	0.49	0.53	0.55
1972	0.17	0.20	0.25	0.33	0.43	0.42	0.53	0.48	0.56	0.63
1973	0.15	0.21	0.24	0.35	0.40	0.45	0.55	0.57	0.51	0.59
1974	0.16	0.19	0.23	0.34	0.42	0.45	0.52	0.56	0.61	0.65
1975	0.13	0.18	0.23	0.32	0.41	0.46	0.53	0.59	0.63	0.67
1976	0.14	0.19	0.22	0.31	0.39	0.44	0.51	0.56	0.67	0.66
1977	0.15	0.19	0.24	0.31	0.37	0.42	0.43	0.52	0.56	0.62
1978	0.15	0.20	0.23	0.31	0.37	0.43	0.47	0.42	0.57	0.67
1979	0.14	0.21	0.25	0.32	0.39	0.45	0.53	0.54	0.61	0.76
1980	0.14	0.20	0.24	0.33	0.37	0.42	0.50	0.55	0.60	0.68
1981	0.14	0.19	0.23	0.32	0.38	0.42	0.44	0.52	0.54	0.63
1982	0.14	0.19	0.22	0.31	0.37	0.41	0.44	0.49	0.58	0.66
1983	0.13	0.18	0.22	0.30	0.39	0.42	0.47	0.49	0.51	0.64
1984	0.15	0.17	0.22	0.29	0.36	0.39	0.47	0.56	0.57	0.63
1985	0.12	0.19	0.22	0.29	0.36	0.43	0.45	0.54	0.61	0.64
1986	0.14	0.18	0.21	0.30	0.36	0.41	0.48	0.54	0.57	0.61
1987	0.14	0.18	0.20	0.28	0.36	0.38	0.43	0.48	0.39	0.66
1988	0.13	0.17	0.22	0.27	0.35	0.43	0.48	0.52	0.56	0.71
1989	0.12	0.17	0.22	0.29	0.34	0.38	0.46	0.49	0.47	0.61
1990	0.12	0.18	0.23	0.29	0.37	0.41	0.41	0.51	0.48	0.62
1991	0.13	0.19	0.21	0.26	0.32	0.44	0.44	0.47	0.51	0.56
1992	0.15	0.18	0.21	0.26	0.30	0.38	0.41	0.46	0.49	0.56
1993	0.10	0.17	0.20	0.24	0.26	0.30	0.34	0.44	0.50	0.60
1994	0.14	0.18	0.20	0.23	0.26	0.30	0.32	0.43	0.41	0.51
1995	0.15	0.19	0.20	0.25	0.27	0.32	0.34	0.36	0.44	0.59
1996	0.16	0.18	0.20	0.23	0.27	0.28	0.32	0.37	0.39	0.59
1997	0.15	0.18	0.21	0.24	0.27	0.30	0.32	0.31	0.38	0.44
1998	0.13	0.18	0.19	0.25	0.26	0.29	0.34	0.29	0.34	0.50
1999	0.16	0.18	0.21	0.23	0.29	0.32	0.35	0.37	0.37	0.45
2000	0.14	0.17	0.20	0.25	0.29	0.30	0.32	0.37	0.40	0.43
2001	0.14	0.18	0.20	0.27	0.28	0.33	0.39	0.41	0.43	0.49
2002	0.14	0.18	0.21	0.24	0.28	0.31	0.37	0.32	0.57	0.54
2003	0.14	0.18	0.21	0.26	0.27	0.32	0.34	0.34	0.50	0.43
2004	0.13	0.18	0.21	0.25	0.26	0.28	0.38	0.37	0.33	0.42
2005	0.17	0.18	0.21	0.24	0.24	0.28	0.27	0.38	0.32	0.40
2006	0.16	0.19	0.22	0.26	0.29	0.32	0.29	0.36	0.40	0.40

year	1	2	3	4	5	6	7	8	9	10
2007	0.15	0.18	0.20	0.24	0.25	0.27	0.29	0.30	0.28	0.33
2008	0.15	0.18	0.22	0.24	0.27	0.32	0.31	0.30	0.31	0.42
2009	0.14	0.18	0.20	0.26	0.28	0.28	0.33	0.33	0.30	0.40
2010	0.16	0.18	0.22	0.24	0.27	0.31	0.28	0.31	0.36	0.38
2011	0.15	0.16	0.19	0.23	0.24	0.27	0.27	0.29	0.34	0.35
2012	0.10	0.17	0.18	0.23	0.26	0.23	0.27	0.26	0.28	0.27
2013	0.12	0.17	0.18	0.22	0.25	0.27	0.30	0.28	0.31	0.47
2014	0.15	0.19	0.21	0.23	0.26	0.27	0.25	0.28	0.32	0.35
2015	0.14	0.17	0.20	0.24	0.26	0.27	0.30	0.29	0.33	0.32
2016	0.14	0.17	0.20	0.24	0.27	0.28	0.27	0.29	0.33	0.30
2017	0.11	0.17	0.19	0.23	0.28	0.27	0.31	0.31	0.28	0.35
2018	0.12	0.17	0.20	0.23	0.26	0.26	0.24	0.26	0.27	0.28
2019	0.14	0.16	0.18	0.22	0.23	0.22	0.25	0.23	0.21	0.31
2020	0.15	0.16	0.18	0.21	0.24	0.24	0.21	0.24	0.22	0.21

Table 6: Time-series of the mean weights-at-age in the discards of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1958	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1959	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1960	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1961	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1962	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1963	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1964	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1965	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1966	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1967	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1968	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1969	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1970	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1971	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1972	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1973	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1974	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1975	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14

year	1	2	3	4	5	6	7	8	9	10
1976	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1977	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1978	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1979	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1980	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1981	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1982	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1983	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1984	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1985	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1986	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1987	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1988	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1989	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1990	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1991	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1992	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1993	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1994	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1995	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1996	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1997	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1998	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
1999	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
2000	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
2001	0.06	0.08	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.14
2002	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.14	0.14
2003	0.05	0.09	0.10	0.11	0.11	0.11	0.12	0.14	0.14	0.14
2004	0.07	0.09	0.10	0.11	0.12	0.10	0.12	0.14	0.14	0.14
2005	0.07	0.09	0.10	0.11	0.11	0.10	0.11	0.14	0.14	0.14
2006	0.07	0.08	0.10	0.11	0.11	0.12	0.11	0.12	0.14	0.14
2007	0.07	0.09	0.10	0.10	0.11	0.10	0.12	0.14	0.14	0.14
2008	0.06	0.09	0.10	0.11	0.12	0.11	0.11	0.14	0.14	0.14
2009	0.07	0.09	0.10	0.11	0.11	0.13	0.10	0.14	0.14	0.14
2010	0.07	0.08	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12
2011	0.05	0.08	0.09	0.10	0.11	0.10	0.11	0.12	0.13	0.13

year	1	2	3	4	5	6	7	8	9	10
2012	0.06	0.07	0.09	0.10	0.11	0.08	0.12	0.12	0.12	0.12
2013	0.04	0.07	0.09	0.10	0.12	0.09	0.11	0.12	0.12	0.12
2014	0.05	0.08	0.09	0.10	0.11	0.10	0.12	0.10	0.15	0.15
2015	0.03	0.08	0.10	0.09	0.10	0.12	0.13	0.12	0.16	0.16
2016	0.02	0.07	0.09	0.10	0.11	0.11	0.12	0.22	0.21	0.21
2017	0.05	0.07	0.09	0.09	0.10	0.12	0.11	0.11	0.29	0.29
2018	0.04	0.07	0.09	0.09	0.10	0.10	0.10	0.10	0.01	0.01
2019	0.04	0.07	0.08	0.09	0.10	0.11	0.11	0.10	0.12	0.13
2020	0.05	0.07	0.08	0.09	0.09	0.10	0.11	0.13	0.11	0.11

Table 7: Time-series of the mean weights-at-age in the stock of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	0.03	0.07	0.15	0.19	0.21	0.25	0.26	0.35	0.39	0.37
1958	0.03	0.07	0.16	0.20	0.23	0.23	0.30	0.32	0.39	0.42
1959	0.03	0.07	0.16	0.20	0.24	0.27	0.29	0.28	0.30	0.43
1960	0.03	0.07	0.16	0.21	0.23	0.24	0.27	0.24	0.36	0.43
1961	0.03	0.07	0.15	0.21	0.23	0.23	0.26	0.27	0.28	0.40
1962	0.03	0.07	0.15	0.19	0.24	0.30	0.29	0.28	0.27	0.44
1963	0.03	0.07	0.15	0.19	0.24	0.28	0.31	0.36	0.33	0.47
1964	0.03	0.07	0.16	0.21	0.24	0.29	0.30	0.31	0.36	0.47
1965	0.03	0.14	0.20	0.22	0.25	0.30	0.34	0.36	0.53	0.46
1966	0.03	0.07	0.16	0.15	0.39	0.31	0.41	0.38	0.39	0.50
1967	0.03	0.18	0.16	0.23	0.24	0.40	0.36	0.28	0.38	0.46
1968	0.03	0.12	0.17	0.25	0.31	0.28	0.63	0.42	0.41	0.49
1969	0.03	0.14	0.17	0.25	0.32	0.36	0.58	0.41	0.47	0.52
1970	0.03	0.14	0.20	0.28	0.34	0.37	0.42	0.46	0.39	0.55
1971	0.03	0.15	0.21	0.31	0.36	0.41	0.43	0.47	0.48	0.53
1972	0.04	0.15	0.22	0.31	0.42	0.44	0.44	0.44	0.51	0.60
1973	0.04	0.15	0.23	0.32	0.37	0.43	0.45	0.47	0.45	0.54
1974	0.04	0.15	0.22	0.33	0.41	0.43	0.50	0.56	0.54	0.62
1975	0.04	0.15	0.21	0.31	0.40	0.45	0.51	0.58	0.58	0.65
1976	0.04	0.14	0.20	0.30	0.38	0.46	0.51	0.52	0.64	0.66
1977	0.04	0.15	0.20	0.29	0.36	0.41	0.48	0.49	0.53	0.64
1978	0.04	0.14	0.21	0.29	0.36	0.43	0.43	0.39	0.54	0.64
1979	0.04	0.15	0.21	0.30	0.35	0.43	0.52	0.56	0.57	0.74
1980	0.04	0.16	0.20	0.30	0.34	0.39	0.49	0.54	0.58	0.65

year	1	2	3	4	5	6	7	8	9	10
1981	0.05	0.14	0.20	0.30	0.36	0.40	0.45	0.52	0.56	0.62
1982	0.05	0.13	0.19	0.27	0.36	0.41	0.43	0.48	0.58	0.64
1983	0.05	0.14	0.20	0.28	0.33	0.43	0.46	0.48	0.51	0.64
1984	0.05	0.13	0.20	0.27	0.35	0.39	0.49	0.59	0.57	0.66
1985	0.05	0.13	0.18	0.27	0.32	0.38	0.38	0.63	0.55	0.64
1986	0.05	0.13	0.19	0.28	0.34	0.42	0.49	0.49	0.59	0.69
1987	0.05	0.15	0.19	0.26	0.36	0.38	0.41	0.45	0.33	0.62
1988	0.05	0.13	0.19	0.26	0.34	0.41	0.42	0.47	0.49	0.65
1989	0.05	0.13	0.20	0.29	0.35	0.34	0.41	0.47	0.42	0.59
1990	0.05	0.15	0.20	0.29	0.36	0.45	0.40	0.49	0.48	0.65
1991	0.05	0.14	0.18	0.25	0.30	0.41	0.45	0.52	0.55	0.57
1992	0.05	0.16	0.19	0.26	0.31	0.40	0.41	0.47	0.50	0.54
1993	0.05	0.13	0.18	0.23	0.27	0.29	0.34	0.48	0.44	0.58
1994	0.05	0.14	0.17	0.21	0.26	0.33	0.35	0.40	0.49	0.46
1995	0.05	0.15	0.18	0.24	0.25	0.32	0.36	0.36	0.55	0.55
1996	0.05	0.15	0.18	0.21	0.27	0.27	0.32	0.38	0.40	0.55
1997	0.05	0.15	0.19	0.23	0.25	0.30	0.32	0.33	0.36	0.42
1998	0.05	0.14	0.17	0.23	0.27	0.28	0.33	0.27	0.34	0.45
1999	0.05	0.13	0.19	0.22	0.26	0.30	0.34	0.32	0.37	0.46
2000	0.05	0.14	0.18	0.23	0.26	0.28	0.29	0.34	0.39	0.38
2001	0.05	0.14	0.18	0.22	0.26	0.32	0.33	0.42	0.41	0.53
2002	0.05	0.14	0.20	0.24	0.27	0.27	0.30	0.31	0.43	0.44
2003	0.05	0.15	0.19	0.24	0.26	0.29	0.33	0.31	0.51	0.47
2004	0.05	0.14	0.20	0.24	0.24	0.30	0.32	0.45	0.36	0.60
2005	0.05	0.15	0.19	0.23	0.24	0.26	0.28	0.40	0.37	0.43
2006	0.05	0.15	0.20	0.25	0.27	0.32	0.29	0.34	0.41	0.46
2007	0.05	0.15	0.18	0.22	0.24	0.24	0.28	0.25	0.26	0.36
2008	0.05	0.15	0.20	0.21	0.24	0.30	0.28	0.23	0.27	0.40
2009	0.05	0.14	0.18	0.23	0.26	0.28	0.28	0.33	0.30	0.39
2010	0.05	0.15	0.20	0.23	0.27	0.31	0.34	0.34	0.36	0.41
2011	0.05	0.14	0.18	0.22	0.26	0.28	0.32	0.36	0.44	0.39
2012	0.03	0.06	0.14	0.20	0.23	0.21	0.25	0.23	0.33	0.22
2013	0.03	0.07	0.12	0.19	0.25	0.26	0.31	0.24	0.33	0.56
2014	0.02	0.08	0.14	0.19	0.21	0.23	0.23	0.29	0.34	0.60
2015	0.07	0.07	0.14	0.15	0.23	0.24	0.26	0.29	0.37	0.39
2016	0.01	0.07	0.15	0.19	0.23	0.25	0.24	0.26	0.22	0.28

year	1	2	3	4	5	6	7	8	9	10
2017	0.02	0.07	0.13	0.17	0.23	0.24	0.25	0.22	0.23	0.37
2018	0.03	0.08	0.15	0.18	0.20	0.24	0.23	0.22	0.26	0.42
2019	0.03	0.07	0.13	0.15	0.19	0.17	0.18	0.22	0.19	0.25
2020	0.04	0.08	0.14	0.17	0.22	0.21	0.20	0.25	0.17	0.24

Table 8: Assumed values of maturity and natural mortality-at-age in the stock of sole in Subarea 27.4.

Age	Maturity	M
1	0.0	0.1
2	0.0	0.1
3	1.0	0.1
4	1.0	0.1
5	1.0	0.1
6	1.0	0.1
7	1.0	0.1
8	1.0	0.1
9	1.0	0.1
10	1.0	0.1

Table 9: Index of abundance, based on the BTS Q3 survey samples from The Netherlands, Germany and Belgium, used in the assessment of sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1985	1147.90	893.90	794.08	435.93	207.43	97.56	0.00	0.00	26.26	51.69
1986	3708.08	1857.88	683.78	431.81	295.94	112.59	61.37	0.00	30.51	77.25
1987	997.75	1698.81	775.77	194.49	251.07	155.82	261.52	101.64	89.66	102.61
1988	7873.08	938.66	836.63	252.08	96.75	90.46	72.03	45.51	18.12	30.22
1989	2307.32	6570.03	673.11	579.89	113.92	66.51	53.25	2.01	51.26	37.03
1990	2963.42	2672.31	4928.17	397.87	250.22	146.37	38.75	32.51	16.70	27.47
1991	2628.83	3828.73	814.21	1661.92	106.72	101.14	87.16	58.51	81.85	175.93
1992	17663.40	3458.09	3784.51	755.50	1174.56	20.73	58.03	13.86	7.92	17.21
1993	4408.88	9297.47	531.04	1538.81	626.79	1104.96	46.44	70.00	22.48	97.85
1994	3967.93	2901.15	6700.93	90.66	394.22	68.47	343.66	56.64	12.77	106.53
1995	7802.81	2599.14	1892.68	2090.61	219.22	296.34	83.45	161.66	26.08	50.51
1996	1868.54	2915.09	543.11	520.69	826.40	114.35	123.13	21.25	71.10	39.06
1997	17361.00	1203.99	915.06	216.39	247.14	176.81	26.82	17.96	16.17	22.53
1998	2805.04	5919.79	497.80	226.33	96.36	58.95	221.08	44.98	43.36	68.25
1999	3310.51	1979.41	2291.29	70.15	161.57	27.51	18.25	76.77	12.36	50.22

year	1	2	3	4	5	6	7	8	9	10
2000	2574.50	1187.14	674.59	527.75	150.99	41.17	22.96	9.12	58.48	48.38
2001	353.12	2287.71	718.25	815.20	443.18	109.56	24.25	41.04	39.01	130.80
2002	3525.22	723.13	629.13	239.51	112.35	128.66	20.37	12.13	8.36	28.94
2003	2975.94	1590.91	419.34	280.81	85.99	64.65	66.65	6.40	6.43	12.31
2004	1261.23	1070.50	936.42	190.18	159.19	42.97	22.40	17.25	1.66	20.31
2005	1662.83	938.45	584.81	403.53	100.70	78.49	40.75	8.25	6.35	18.72
2006	4408.90	849.69	274.08	447.42	212.51	53.76	57.14	31.27	15.40	12.08
2007	2332.35	3261.94	423.16	132.68	166.64	149.56	33.01	29.24	16.41	17.99
2008	2600.17	1516.39	1485.77	256.58	86.44	88.15	109.10	13.86	18.36	32.13
2009	3185.58	1379.74	737.26	842.77	129.63	43.97	95.14	66.64	15.49	26.27
2010	3557.20	1630.87	529.52	287.34	265.79	83.62	24.31	21.04	22.97	33.52
2011	3122.18	3019.17	752.99	254.05	208.71	196.65	31.89	15.68	24.08	33.09
2012	1485.28	4223.76	1583.27	370.05	179.44	104.40	55.30	22.18	8.22	28.16
2013	1780.92	951.65	2169.06	639.35	210.34	55.47	57.84	48.67	12.92	46.40
2014	4314.21	2428.55	502.22	920.10	401.30	88.71	28.19	30.80	20.17	7.37
2015	3282.96	2835.05	1479.34	405.20	735.46	237.76	106.11	26.87	22.77	36.79
2016	1733.71	2253.86	1478.74	742.72	222.01	380.95	107.18	24.45	3.19	38.34
2017	7123.50	1541.35	1377.82	682.12	290.16	96.68	126.90	57.48	3.11	20.55
2018	3705.67	2449.13	674.31	649.68	217.12	144.37	49.83	71.57	8.75	6.61
2019	15545.52	2009.21	1315.83	350.90	264.05	87.33	72.73	23.78	29.00	12.54
2020	2044.95	6281.58	1213.01	594.83	145.67	140.02	56.03	26.13	16.83	29.45

Table 10: Index of abundance, based on the SNS survey, used in the assessment of sole in Subarea 27.4.

year	1	2	3	4	5	6
1970	5410.30	734.40	237.70	35.40	4.00	0.00
1971	902.70	1831.10	113.40	2.90	28.90	0.00
1972	1454.70	272.30	148.60	0.00	28.30	0.00
1973	5587.20	935.30	83.80	37.30	13.00	0.00
1974	2347.90	361.40	65.20	0.00	0.00	4.40
1975	525.40	864.50	177.00	17.50	0.00	17.10
1976	1399.40	73.60	229.10	26.70	5.70	0.00
1977	3742.90	776.10	103.80	43.10	31.70	3.90
1978	1547.70	1354.70	294.10	28.00	99.40	13.30
1979	93.80	408.30	300.80	76.90	0.00	16.70
1980	4312.90	88.90	109.30	61.30	3.30	0.00
1981	3737.20	1413.10	50.00	20.00	0.00	0.00

year	1	2	3	4	5	6
1982	5856.50	1146.20	227.80	6.70	10.00	0.00
1983	2621.10	1123.30	120.60	39.90	0.00	19.70
1984	2493.10	1099.90	318.30	74.40	8.00	0.00
1985	3619.40	715.60	167.10	49.30	4.40	0.00
1986	3705.10	457.60	69.20	31.40	16.70	0.00
1987	1947.90	943.70	64.80	21.30	0.00	0.00
1988	11226.70	593.80	281.60	81.50	10.20	15.50
1989	2830.70	5005.00	207.60	53.10	18.20	18.60
1990	2856.20	1119.50	914.30	100.40	49.60	12.50
1991	1253.60	2529.10	513.80	623.90	27.20	35.80
1992	11114.00	144.40	360.40	194.90	284.80	20.00
1993	1290.80	3419.60	153.80	212.80	0.00	191.70
1994	651.80	498.30	934.10	10.20	59.30	0.00
1995	1362.10	223.70	142.80	411.10	7.10	31.10
1996	218.40	349.10	29.60	35.50	90.00	10.00
1997	10279.30	153.60	189.80	26.50	58.10	230.00
1998	4094.60	3126.40	141.70	98.70	0.00	10.00
1999	1648.90	971.80	455.60	10.00	20.70	0.00
2000	1639.20	125.90	166.30	118.00	0.00	2.00
2001	970.30	655.40	106.70	35.50	56.20	0.00
2002	7547.50	379.00	195.30	0.00	30.80	19.20
2003						
2004	1369.50	624.40	393.00	68.90	53.10	7.50
2005	568.10	162.90	124.00	0.00	21.30	6.70
2006	2726.40	117.10	25.00	30.00	0.00	0.00
2007	848.60	911.00	33.30	39.50	14.40	0.00
2008	1259.10	258.50	325.30	0.00	10.00	0.00
2009	1931.60	344.40	61.70	102.70	0.00	0.00
2010	2636.90	237.10	67.10	42.20	23.20	0.00
2011	1248.00	883.90	211.30	111.80	0.00	38.00
2012	226.60	159.50	54.00	18.00	0.00	0.00
2013	967.40	426.60	490.50	179.30	50.80	7.60
2014	2849.00	448.20	44.80	60.00	33.60	0.00
2015	3192.00	2333.90	137.80	159.90	162.40	150.60
2016	733.80	623.30	494.60	109.80	16.70	42.90
2017	956.70	204.30	209.60	209.70	41.60	5.20

year	1	2	3	4	5	6
2018	1002.30	482.40	163.10	94.10	82.40	5.70
2019	7896.70	476.30	375.20	60.70	6.70	50.90
2020	284.70	1938.10	103.20	128.50	48.40	0.00

Table 11: Time series of abundances at age (in thousands) estimated by the AAP stock assessment for sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	138072	75741	86234	62958	17664	18446	35631.3	17108.6	2925.4	44923
1958	124168	124931	66128	63830	41750	11882	13254.0	25227.1	13664.2	35014
1959	440056	112351	109471	47721	44708	28333	8365.0	9584.7	19096.7	37102
1960	40568	398173	98451	76738	33969	29946	19456.6	6057.2	6744.4	43287
1961	65642	36706	346515	66770	52217	21442	19904.7	13587.8	3890.9	37076
1962	10645	59392	31516	228529	41279	30192	13741.8	12965.4	8130.6	27841
1963	12340	9631	50432	20683	133163	23229	18811.6	8432.9	7951.3	22887
1964	590229	11164	8160	33625	12577	79646	14341.2	11540.0	5722.5	20221
1965	147277	533984	9410	5460	21917	7881	49773.3	9309.1	8469.3	18430
1966	58616	133258	439821	6075	3695	13372	5065.9	34936.8	7016.8	20513
1967	97853	53037	104202	261503	4055	2094	8814.8	3733.4	26003.1	21696
1968	133640	88533	37787	54197	158590	2154	1388.4	6472.1	2637.3	37032
1969	86571	120554	55833	16816	27598	82752	1415.6	978.9	4260.1	29099
1970	198783	75465	70797	22892	7623	14840	53898.3	970.0	637.5	23126
1971	57812	171482	45562	29871	10891	4312	9642.0	37361.2	671.4	16278
1972	119604	51285	108144	19671	15231	6304	2782.9	6762.1	26735.5	11602
1973	154900	107303	32450	43748	9895	8540	3986.0	1913.4	4637.4	25589
1974	121881	139279	68121	12299	20777	5241	5231.1	2638.8	1214.7	19582
1975	60649	109141	93131	27779	5680	10704	3101.7	3376.4	1660.3	13536
1976	149488	53638	77490	43431	13155	2972	6205.1	1993.3	2215.0	10173
1977	185679	132036	38527	37719	21720	7130	1749.5	4000.3	1290.4	8390
1978	62229	166377	90895	17458	19822	12127	4377.6	1127.5	2335.3	6440
1979	17158	56077	110095	38326	9204	11068	7629.2	2797.8	604.4	5680
1980	188537	15462	38067	48253	18870	4923	6822.1	4783.5	1614.4	4008
1981	246510	169446	10871	17630	21879	9609	2880.8	4166.6	3063.2	3593
1982	213218	220644	117108	4810	8026	11167	5313.5	1711.8	2730.3	4311
1983	195632	190174	142988	45282	2326	4241	5897.7	3074.6	1074.0	4603
1984	92239	173903	117599	50206	22047	1230	2169.0	3322.1	1835.6	3649
1985	113453	81924	109774	42449	22727	11086	619.3	1194.4	1967.5	3358
1986	168703	101552	54287	42507	18141	10887	5595.3	339.9	725.0	3105

year	1	2	3	4	5	6	7	8	9	10
1987	81665	152198	70135	21962	19087	8781	5619.9	3152.3	214.1	2216
1988	594016	73819	108917	29465	10670	9670	4720.7	3306.5	2047.6	1460
1989	115034	536772	54681	48757	14608	5619	5481.5	2902.4	2173.7	2251
1990	221793	103665	407943	26730	23620	7781	3314.8	3445.0	1888.8	2986
1991	96198	199468	79298	219219	12986	12241	4572.9	2028.6	2167.9	3280
1992	513732	86776	150114	45845	111353	6331	6802.5	2569.5	1216.3	3435
1993	116665	463791	62937	88008	23778	51769	3254.9	3447.5	1500.9	2702
1994	82564	104816	319060	34338	43462	11139	25098.3	1563.2	2055.7	2377
1995	124049	72334	69162	152467	15376	20578	5207.6	11993.7	933.5	2525
1996	79634	106990	48196	29301	61993	6895	9366.5	2514.4	6470.1	1949
1997	321124	70316	73856	19175	11253	25193	3095.7	4585.2	1125.5	4544
1998	149368	287098	48778	28869	7347	4419	11477.7	1546.7	1952.5	2865
1999	117211	133747	191166	19314	11521	3079	2089.2	5874.1	774.5	2323
2000	134219	104464	84938	79022	8030	5082	1493.4	1086.6	3303.0	1588
2001	67292	117877	66223	37477	33350	3431	2448.7	778.5	592.0	2962
2002	198789	57969	77446	30991	16055	13546	1622.0	1280.9	388.7	2400
2003	97390	172629	39775	37300	13899	6726	6394.6	867.0	647.1	1866
2004	54357	86174	121309	19143	17712	6377	3256.0	3535.9	482.8	1511
2005	56589	48392	59403	57318	9345	8676	3228.7	1850.7	2100.6	1069
2006	179299	50162	31434	27819	27806	4661	4620.4	1860.2	1108.5	1676
2007	67472	157621	31996	15507	13504	13977	2575.4	2670.0	1113.9	1539
2008	74996	59203	109014	17694	7799	6957	7817.1	1481.7	1637.7	1528
2009	96592	65943	43826	64590	9211	4131	3869.6	4453.5	924.3	1869
2010	180750	84814	48390	24667	33417	4936	2266.9	2173.8	2699.0	1651
2011	174621	158038	58506	23938	12272	17762	2679.2	1246.5	1227.6	2533
2012	46597	152652	107458	28806	11531	6375	9673.6	1421.5	658.7	2151
2013	90798	40880	111174	62362	13969	5863	3528.0	4886.1	733.4	1590
2014	154745	79269	31201	72531	31817	7229	3273.1	1704.6	2531.7	1318
2015	111779	131030	59755	20486	39931	17617	3983.4	1554.1	891.8	2206
2016	64412	89896	94870	36824	11751	23204	9463.6	1928.8	813.9	1751
2017	133579	52358	64371	53531	20250	6632	12210.7	4852.1	994.6	1340
2018	106136	113896	38603	34523	27060	10621	3521.5	6816.4	2524.9	1114
2019	414583	92287	86941	21802	17720	14248	5994.2	2167.3	3902.8	1848
2020	48158	358663	72254	56058	13023	10544	8877.7	4050.3	1444.3	3599

Table 12: Time series of fishing mortality at age estimated by the AAP stock assessment for sole in Subarea 27.4.

year	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.036	0.201	0.311	0.296	0.231	0.245	0.125	0.212	0.212
1958	0.000	0.032	0.226	0.256	0.288	0.251	0.224	0.178	0.172	0.172
1959	0.000	0.032	0.255	0.240	0.301	0.276	0.223	0.251	0.161	0.161
1960	0.000	0.039	0.288	0.285	0.360	0.308	0.259	0.343	0.200	0.200
1961	0.000	0.052	0.316	0.381	0.448	0.345	0.329	0.414	0.286	0.286
1962	0.000	0.064	0.321	0.440	0.475	0.373	0.388	0.389	0.352	0.352
1963	0.000	0.066	0.305	0.397	0.414	0.382	0.389	0.288	0.322	0.322
1964	0.000	0.071	0.302	0.328	0.367	0.370	0.332	0.209	0.242	0.242
1965	0.000	0.094	0.338	0.291	0.394	0.342	0.254	0.183	0.171	0.171
1966	0.000	0.146	0.420	0.304	0.468	0.317	0.205	0.195	0.138	0.138
1967	0.000	0.239	0.554	0.400	0.532	0.311	0.209	0.248	0.153	0.153
1968	0.003	0.361	0.710	0.575	0.550	0.320	0.250	0.318	0.210	0.210
1969	0.037	0.432	0.792	0.691	0.520	0.329	0.278	0.329	0.266	0.266
1970	0.048	0.405	0.763	0.643	0.470	0.331	0.266	0.268	0.278	0.278
1971	0.020	0.361	0.740	0.574	0.447	0.338	0.255	0.235	0.279	0.279
1972	0.009	0.358	0.805	0.587	0.479	0.358	0.275	0.277	0.304	0.304
1973	0.006	0.354	0.870	0.645	0.536	0.390	0.312	0.354	0.334	0.334
1974	0.010	0.302	0.797	0.673	0.563	0.425	0.338	0.363	0.329	0.329
1975	0.023	0.242	0.663	0.647	0.548	0.445	0.342	0.322	0.301	0.301
1976	0.024	0.231	0.620	0.593	0.512	0.430	0.339	0.335	0.290	0.290
1977	0.010	0.273	0.692	0.543	0.483	0.388	0.339	0.438	0.308	0.308
1978	0.004	0.313	0.764	0.540	0.483	0.363	0.348	0.524	0.335	0.335
1979	0.004	0.287	0.725	0.609	0.526	0.384	0.367	0.450	0.350	0.350
1980	0.007	0.252	0.670	0.691	0.575	0.436	0.393	0.346	0.348	0.348
1981	0.011	0.269	0.715	0.687	0.573	0.492	0.421	0.323	0.334	0.334
1982	0.014	0.334	0.850	0.627	0.538	0.538	0.447	0.366	0.325	0.325
1983	0.018	0.381	0.947	0.620	0.537	0.571	0.474	0.416	0.342	0.342
1984	0.019	0.360	0.919	0.693	0.587	0.587	0.497	0.424	0.391	0.391
1985	0.011	0.311	0.849	0.750	0.636	0.584	0.500	0.399	0.439	0.439
1986	0.003	0.270	0.805	0.701	0.626	0.561	0.474	0.362	0.447	0.447
1987	0.001	0.235	0.767	0.622	0.580	0.521	0.430	0.331	0.409	0.409
1988	0.001	0.200	0.704	0.602	0.541	0.468	0.386	0.319	0.344	0.344
1989	0.004	0.174	0.616	0.625	0.530	0.428	0.364	0.330	0.293	0.293
1990	0.006	0.168	0.521	0.622	0.557	0.432	0.391	0.363	0.296	0.296
1991	0.003	0.184	0.448	0.577	0.618	0.488	0.476	0.412	0.361	0.361
1992	0.002	0.221	0.434	0.556	0.666	0.565	0.580	0.438	0.443	0.443

year	1	2	3	4	5	6	7	8	9	10
1993	0.007	0.274	0.506	0.606	0.658	0.624	0.633	0.417	0.470	0.470
1994	0.032	0.316	0.638	0.703	0.648	0.660	0.638	0.416	0.463	0.463
1995	0.048	0.306	0.759	0.800	0.702	0.687	0.628	0.517	0.473	0.473
1996	0.024	0.271	0.822	0.857	0.800	0.701	0.614	0.704	0.517	0.517
1997	0.012	0.266	0.839	0.859	0.835	0.686	0.594	0.754	0.582	0.582
1998	0.010	0.307	0.826	0.819	0.770	0.649	0.570	0.592	0.630	0.630
1999	0.015	0.354	0.783	0.778	0.718	0.624	0.554	0.476	0.568	0.568
2000	0.030	0.356	0.718	0.763	0.750	0.630	0.551	0.507	0.402	0.402
2001	0.049	0.320	0.659	0.748	0.801	0.649	0.548	0.595	0.293	0.293
2002	0.041	0.277	0.631	0.702	0.770	0.651	0.526	0.583	0.302	0.302
2003	0.022	0.253	0.631	0.645	0.679	0.625	0.492	0.485	0.409	0.409
2004	0.016	0.272	0.650	0.617	0.614	0.581	0.465	0.421	0.523	0.523
2005	0.021	0.331	0.659	0.623	0.596	0.530	0.451	0.413	0.537	0.537
2006	0.029	0.350	0.607	0.623	0.588	0.493	0.448	0.413	0.493	0.493
2007	0.031	0.269	0.492	0.587	0.563	0.481	0.453	0.389	0.451	0.451
2008	0.029	0.201	0.423	0.553	0.535	0.487	0.463	0.372	0.427	0.427
2009	0.030	0.209	0.475	0.559	0.524	0.500	0.477	0.401	0.426	0.426
2010	0.034	0.271	0.604	0.598	0.532	0.511	0.498	0.471	0.441	0.441
2011	0.034	0.286	0.609	0.630	0.555	0.508	0.534	0.538	0.459	0.459
2012	0.031	0.217	0.444	0.624	0.576	0.492	0.583	0.562	0.469	0.469
2013	0.036	0.170	0.327	0.573	0.559	0.483	0.627	0.558	0.467	0.467
2014	0.066	0.183	0.321	0.497	0.491	0.496	0.645	0.548	0.457	0.457
2015	0.118	0.223	0.384	0.456	0.443	0.521	0.625	0.547	0.471	0.471
2016	0.107	0.234	0.472	0.498	0.472	0.542	0.568	0.562	0.549	0.549
2017	0.059	0.205	0.523	0.582	0.545	0.533	0.483	0.553	0.640	0.640
2018	0.040	0.170	0.471	0.567	0.541	0.472	0.385	0.458	0.578	0.578
2019	0.045	0.145	0.339	0.415	0.419	0.373	0.292	0.306	0.369	0.369
2020	0.067	0.125	0.216	0.261	0.284	0.278	0.215	0.183	0.196	0.196

Table 13: Time series of spawning stock biomass and mean fishing mortality, plus lower and upper confidence intervals, estimated by the AAP stock assessment for sole in Subarea 27.4.

Year	SSB	SSB lower	SSB upper	F	F lower	F upper
1957	65745	57072	74418	0.215	0.173	0.256
1958	68162	59286	77038	0.211	0.183	0.238
1959	71890	63271	80509	0.221	0.188	0.254
1960	74847	66080	83614	0.256	0.222	0.290
1961	106950	95615	118285	0.308	0.267	0.350
1962	89727	80439	99015	0.335	0.289	0.380
1963	72381	64434	80328	0.313	0.275	0.351
1964	54265	47127	61403	0.288	0.244	0.331
1965	43969	36782	51156	0.292	0.251	0.332
1966	105140	90775	119505	0.331	0.281	0.381
1967	104470	93358	115582	0.407	0.351	0.463
1968	92616	83289	101943	0.503	0.438	0.568
1969	71403	63928	78878	0.553	0.472	0.633
1970	64885	57766	72004	0.522	0.457	0.587
1971	55621	49422	61820	0.492	0.418	0.565
1972	63699	56221	71177	0.517	0.456	0.579
1973	47266	41905	52627	0.559	0.485	0.633
1974	46484	41229	51739	0.552	0.489	0.615
1975	48190	42578	53802	0.509	0.452	0.566
1976	47368	42532	52204	0.477	0.419	0.536
1977	38478	34960	41996	0.476	0.423	0.528
1978	44399	39234	49564	0.493	0.424	0.562
1979	52828	46915	58741	0.506	0.452	0.560
1980	40157	36379	43935	0.525	0.465	0.584
1981	26815	24626	29004	0.547	0.490	0.604
1982	38826	33389	44263	0.577	0.515	0.640
1983	51811	44005	59617	0.611	0.536	0.686
1984	51958	45466	58450	0.629	0.568	0.691
1985	47459	41785	53133	0.626	0.555	0.697
1986	38541	35298	41784	0.593	0.539	0.646
1987	34467	31124	37810	0.545	0.486	0.604
1988	41698	37240	46156	0.503	0.453	0.553
1989	37706	34277	41135	0.474	0.427	0.522
1990	108460	93714	123206	0.460	0.411	0.509
1991	85409	76677	94141	0.463	0.423	0.504

Year	SSB	SSB lower	SSB upper	F	F lower	F upper
1992	84047	77115	90979	0.489	0.436	0.541
1993	58217	53868	62566	0.534	0.487	0.581
1994	88988	77394	100582	0.593	0.531	0.655
1995	67536	60712	74360	0.651	0.590	0.711
1996	41123	37666	44580	0.690	0.631	0.750
1997	33626	30025	37227	0.697	0.630	0.764
1998	24543	22190	26896	0.674	0.619	0.730
1999	47780	39820	55740	0.651	0.581	0.722
2000	39774	35279	44269	0.643	0.591	0.696
2001	33416	30167	36665	0.635	0.577	0.694
2002	32846	29639	36053	0.606	0.556	0.656
2003	25750	23451	28049	0.567	0.519	0.614
2004	38227	33560	42894	0.547	0.495	0.599
2005	31950	28844	35056	0.548	0.503	0.593
2006	25314	23362	27266	0.532	0.476	0.588
2007	17997	16679	19315	0.479	0.439	0.518
2008	32908	29150	36666	0.440	0.396	0.484
2009	30180	27552	32808	0.453	0.412	0.494
2010	29099	26689	31509	0.503	0.457	0.549
2011	26757	24404	29110	0.517	0.466	0.569
2012	28825	25980	31670	0.471	0.433	0.509
2013	33067	30230	35904	0.422	0.380	0.465
2014	29169	26878	31460	0.397	0.363	0.432
2015	27564	25366	29762	0.405	0.359	0.451
2016	33064	29835	36293	0.444	0.390	0.497
2017	28847	25805	31889	0.478	0.407	0.549
2018	23340	20346	26334	0.444	0.358	0.530
2019	23413	19231	27595	0.338	0.262	0.415
2020	29141	22717	35565	0.233	0.158	0.308

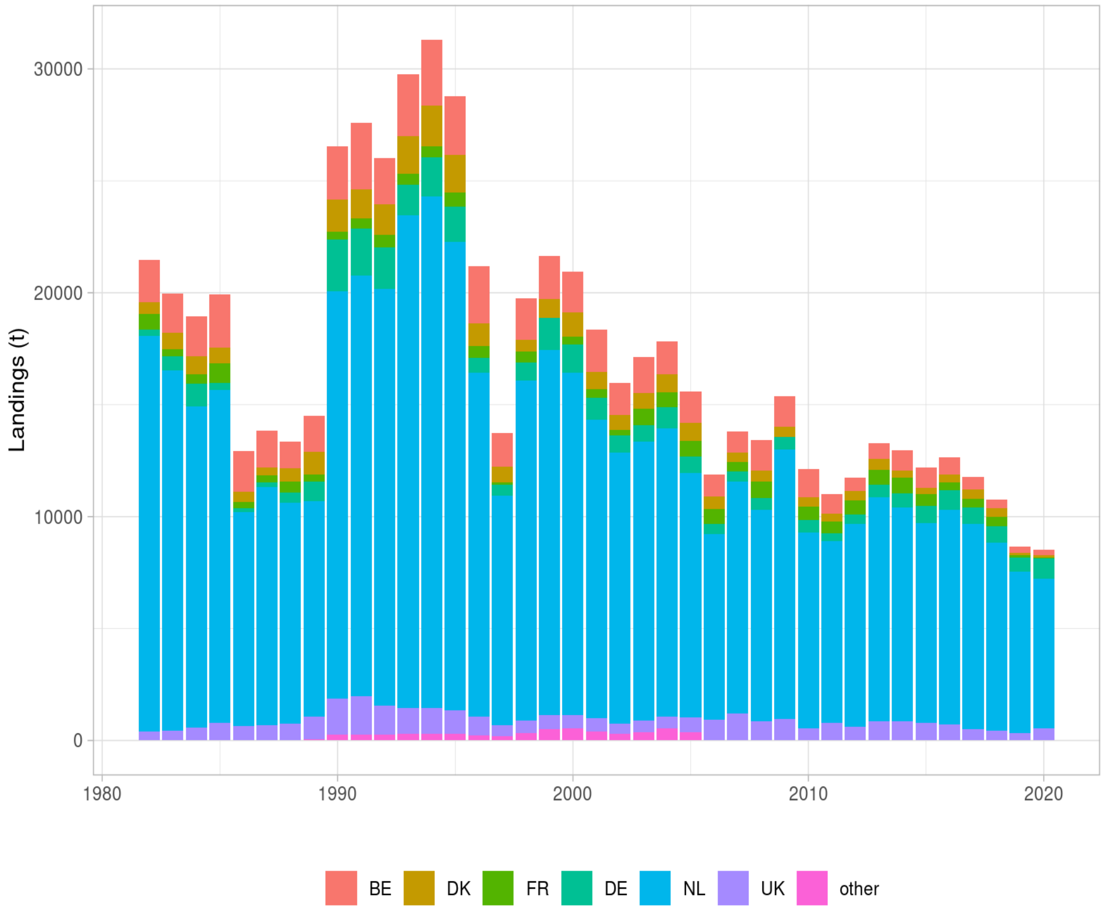


Figure 1: Sole in 27.4. Official landings reported to ICES by country in 2020.

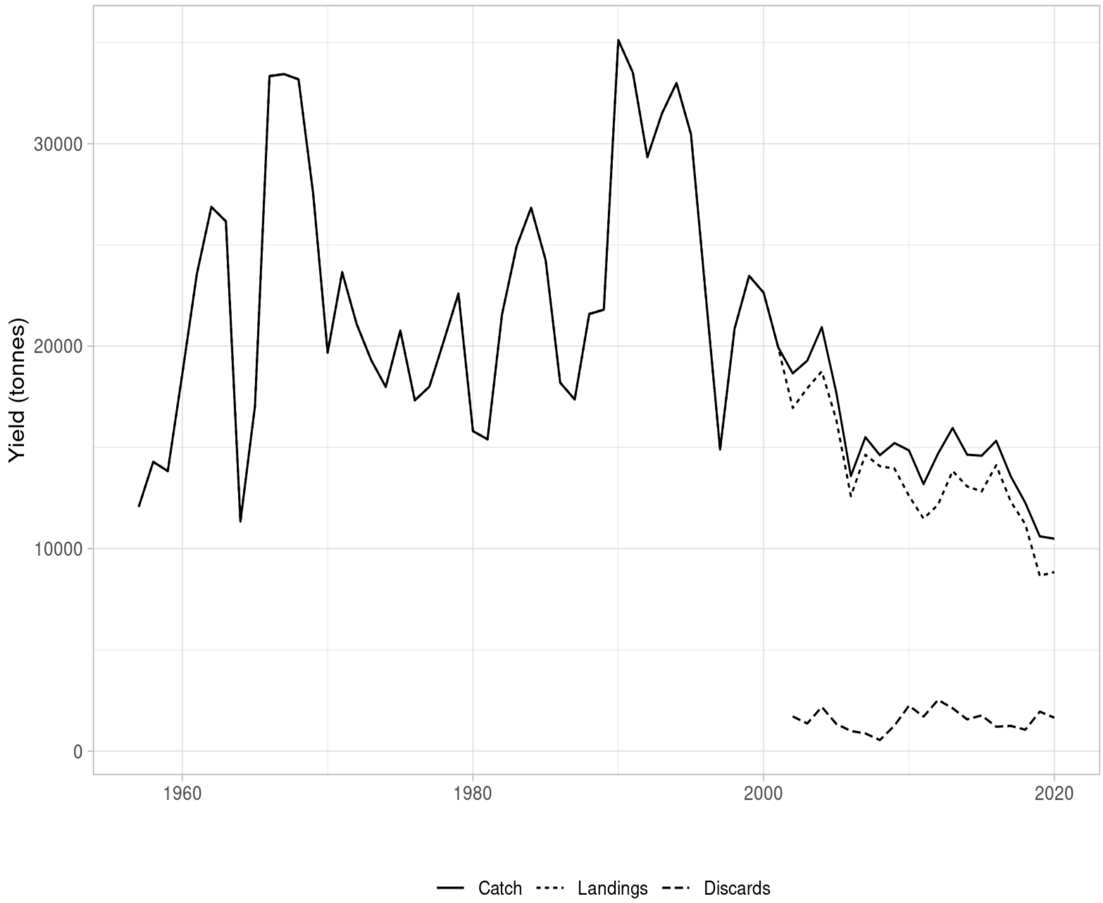


Figure 2: Sole in 27.4. Time series of catches, landings and discards (in tonnes) reported to ICES Intercatch.

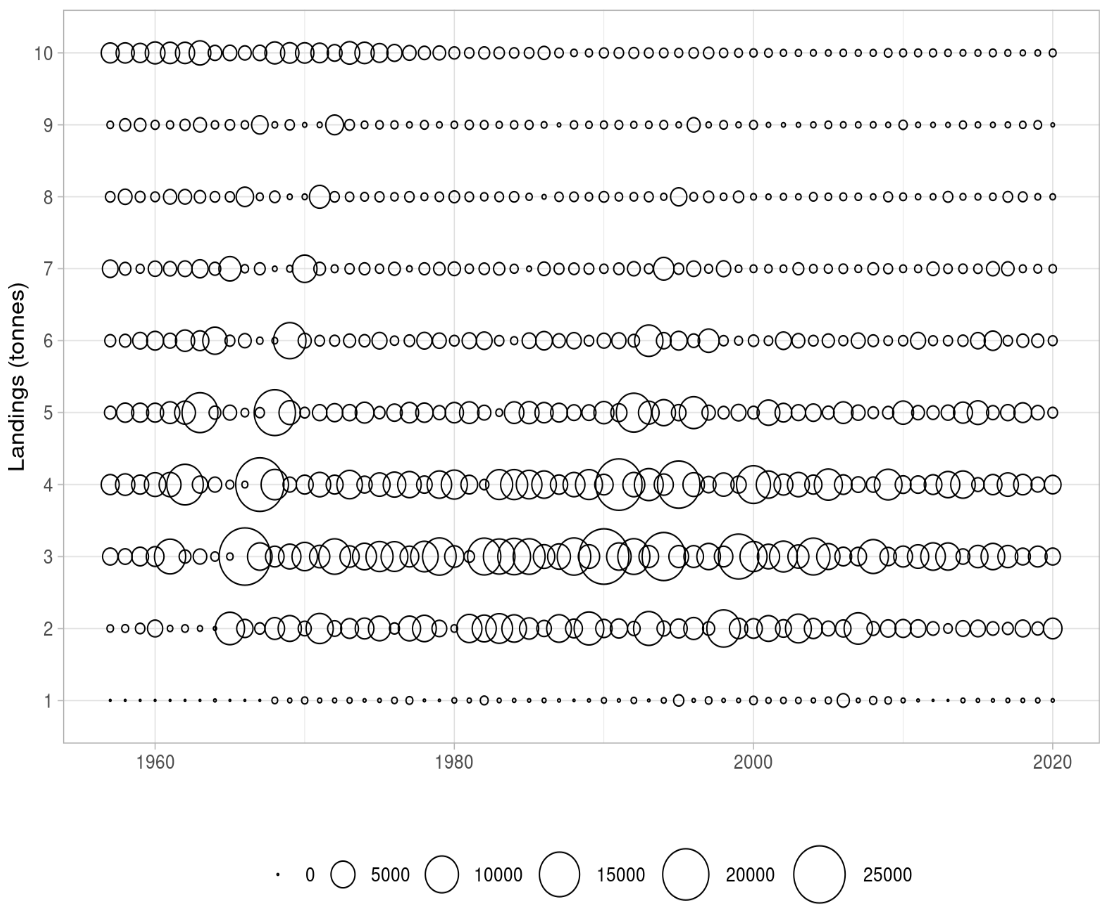


Figure 3: Sole in 27.4. Time series of landings at age (in thousands).

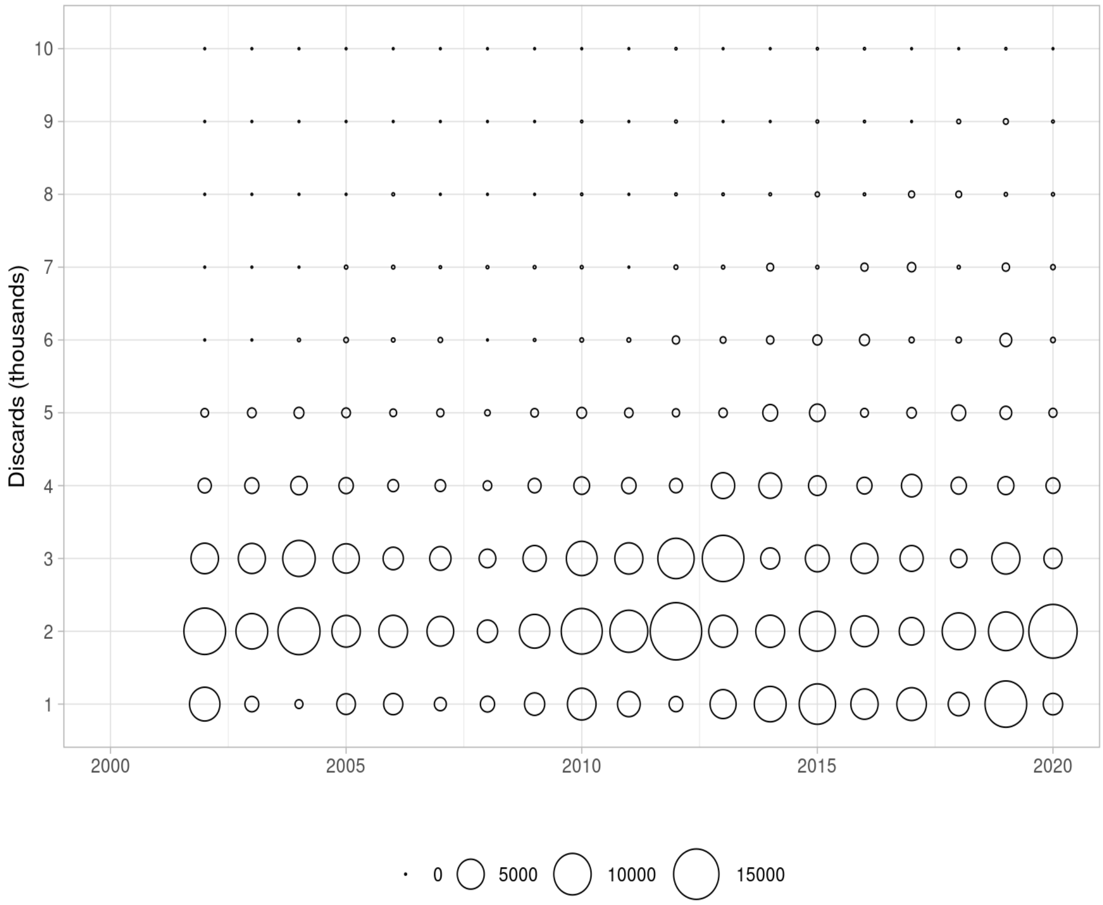


Figure 4: Sole in 27.4. Time series of discards at age (in thousands).

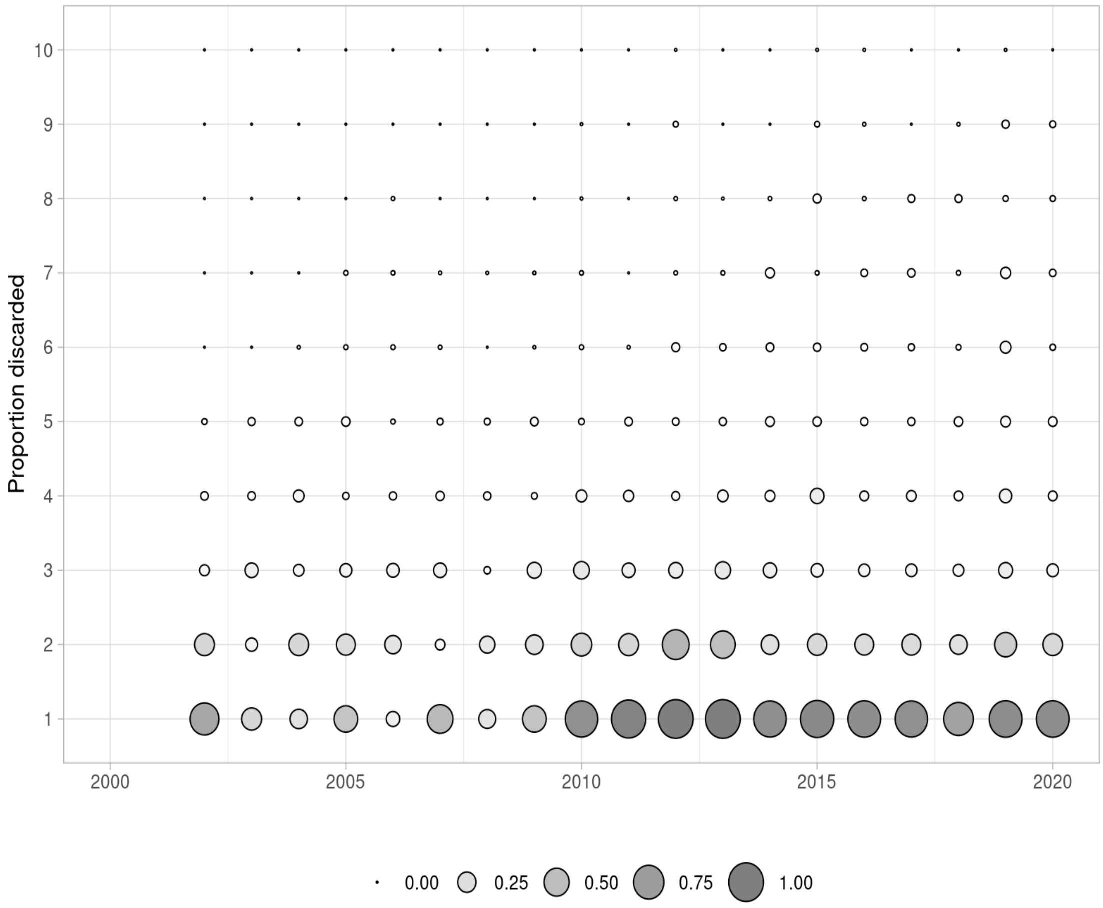


Figure 5: Sole in 27.4. Proportions of fish discarded by age over the 2002–2020 period.

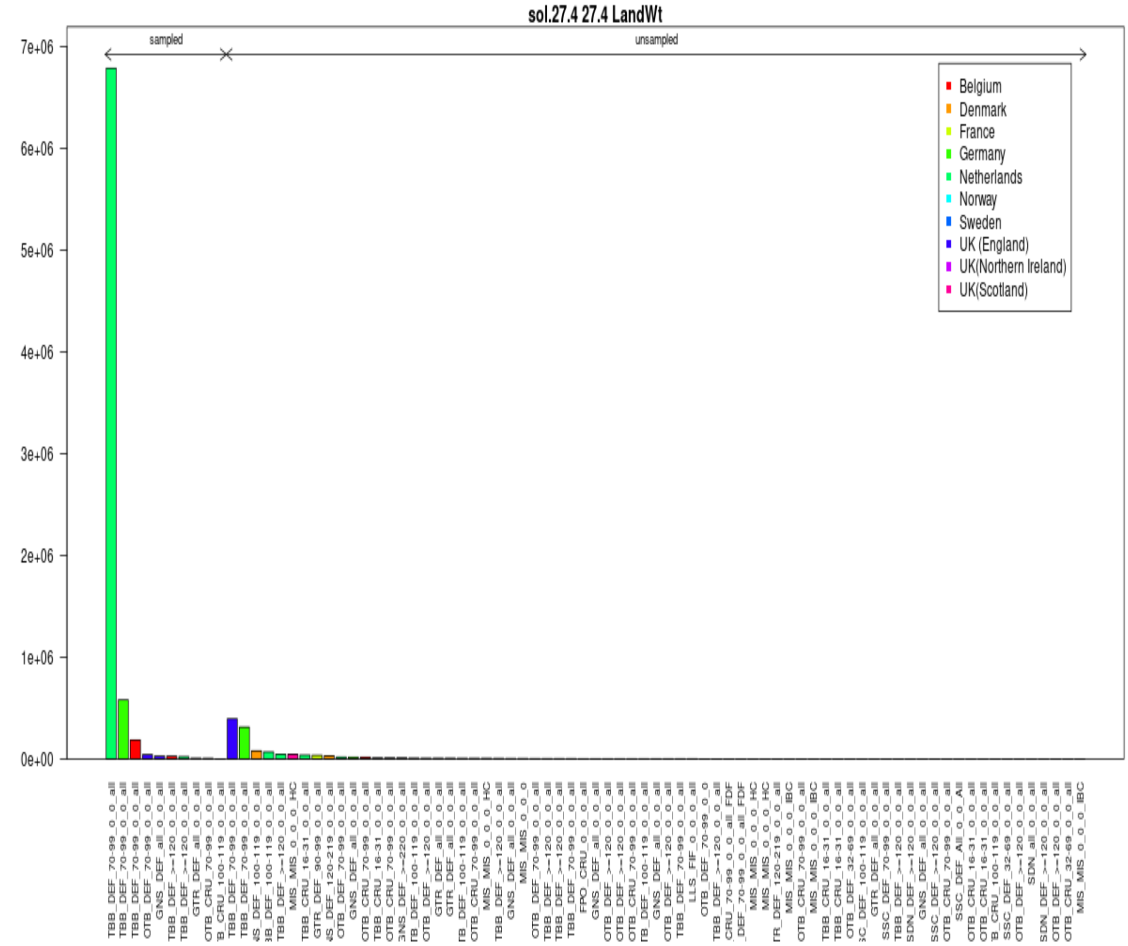


Figure 6: Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (tonnes).

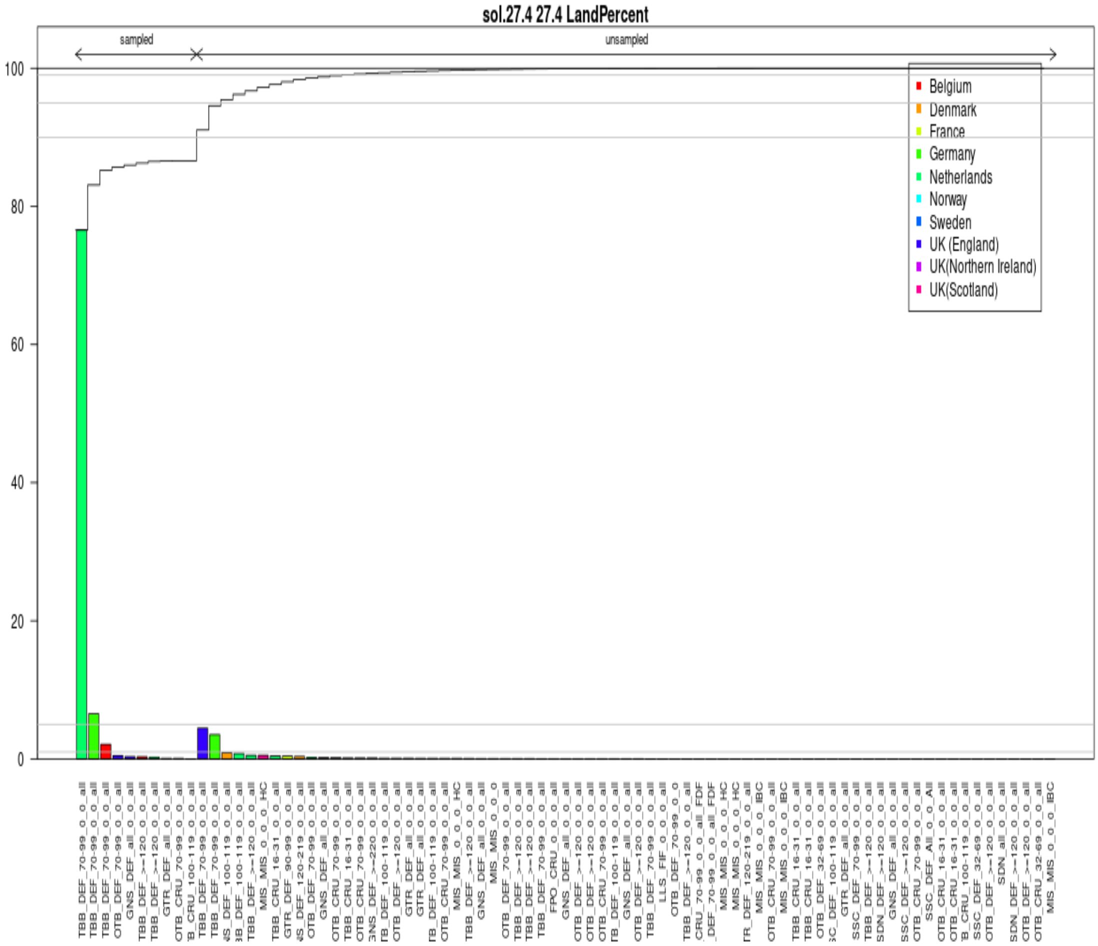


Figure 7: Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (cumulative percentage).

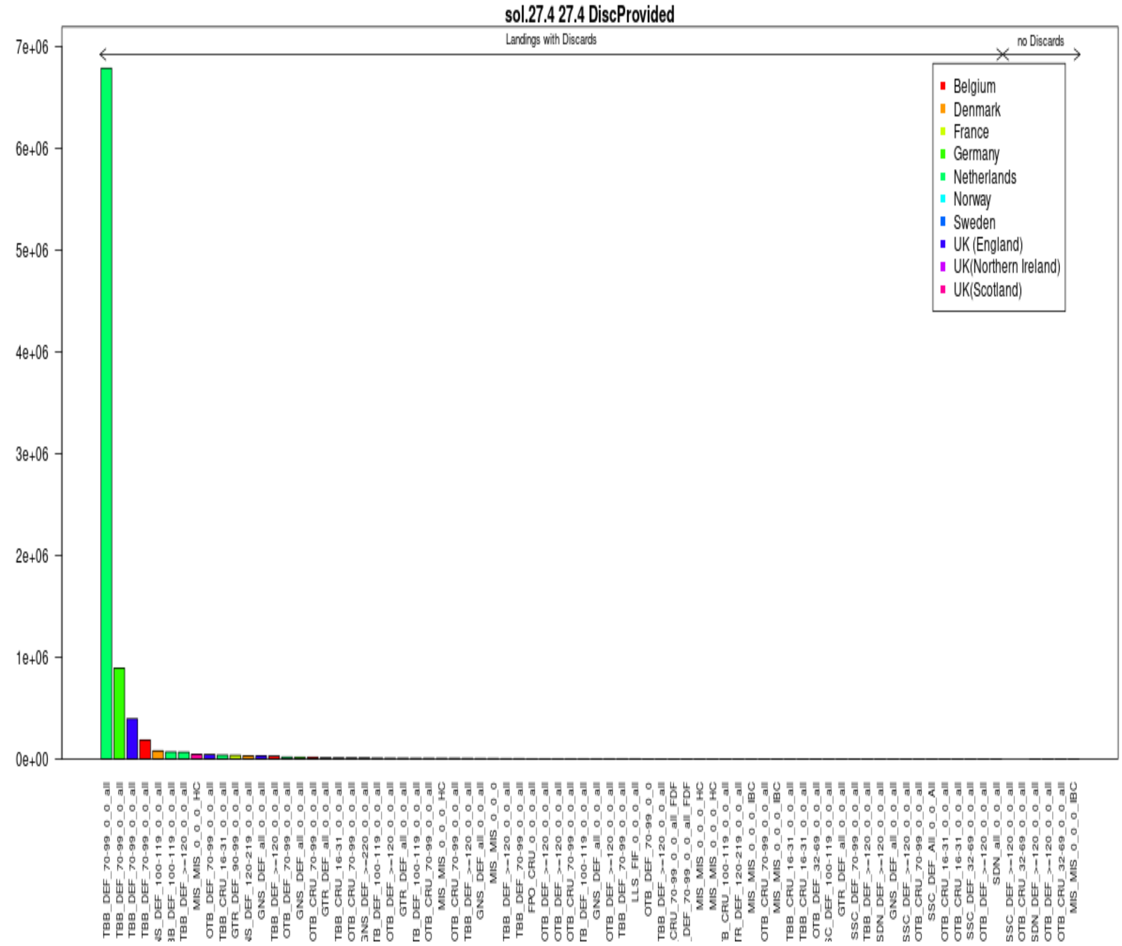


Figure 8: Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for discards yield estimation (tonnes).

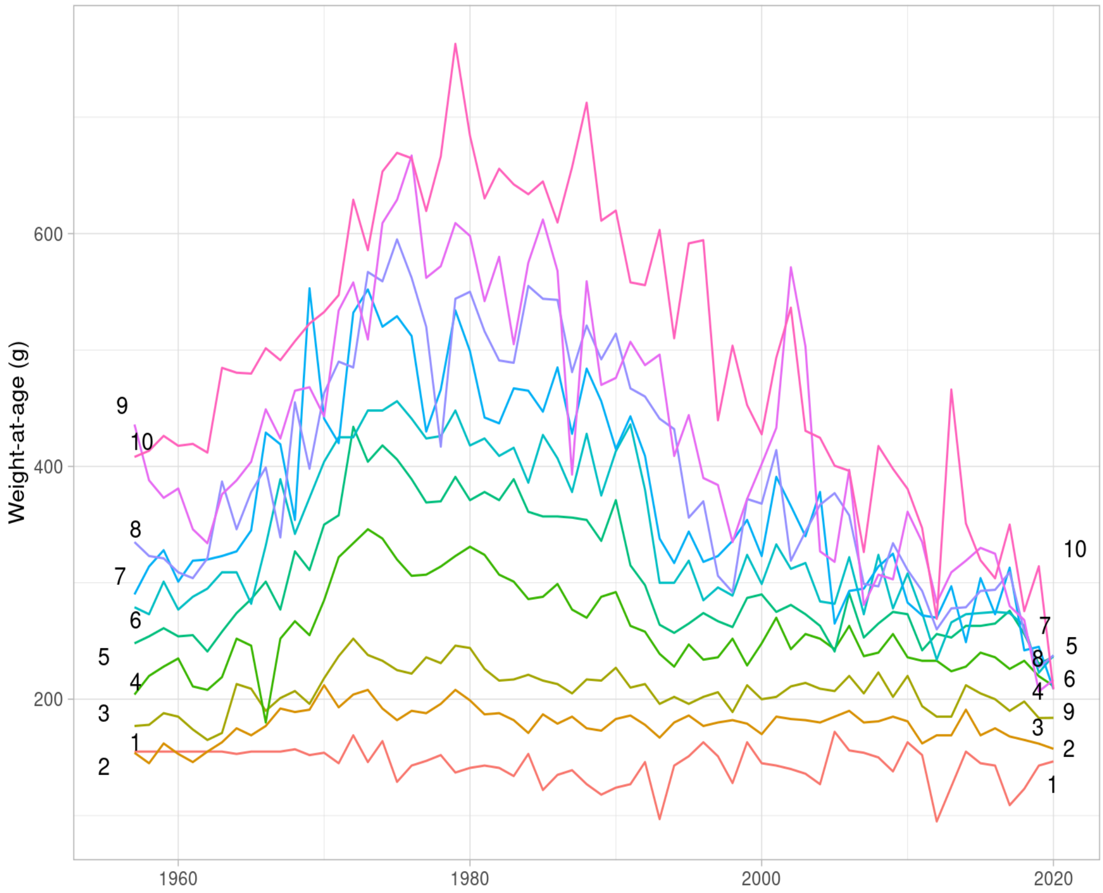


Figure 9: Sole in 27.4. Time series of mean weight-at-age in the landings (in grammes).

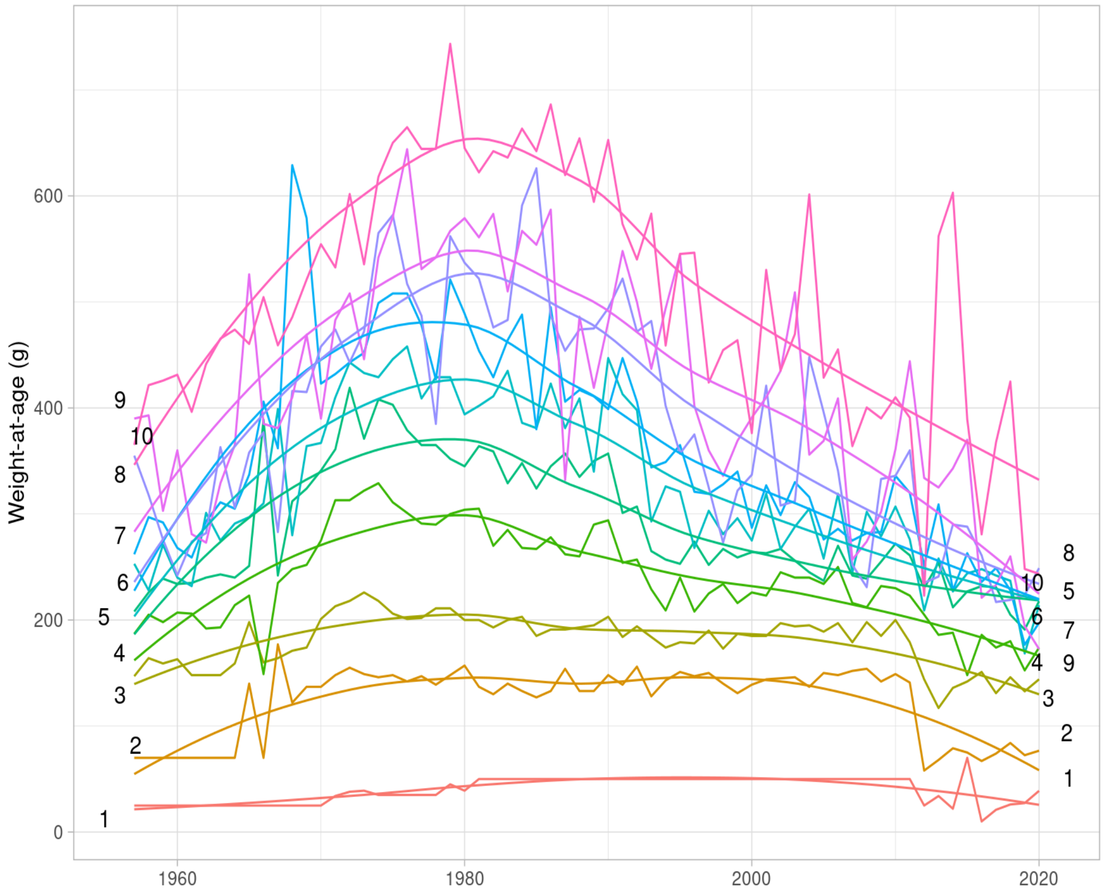


Figure 10: Sole in 27.4. Time series of mean weight-at-age in the stock (in grammes).

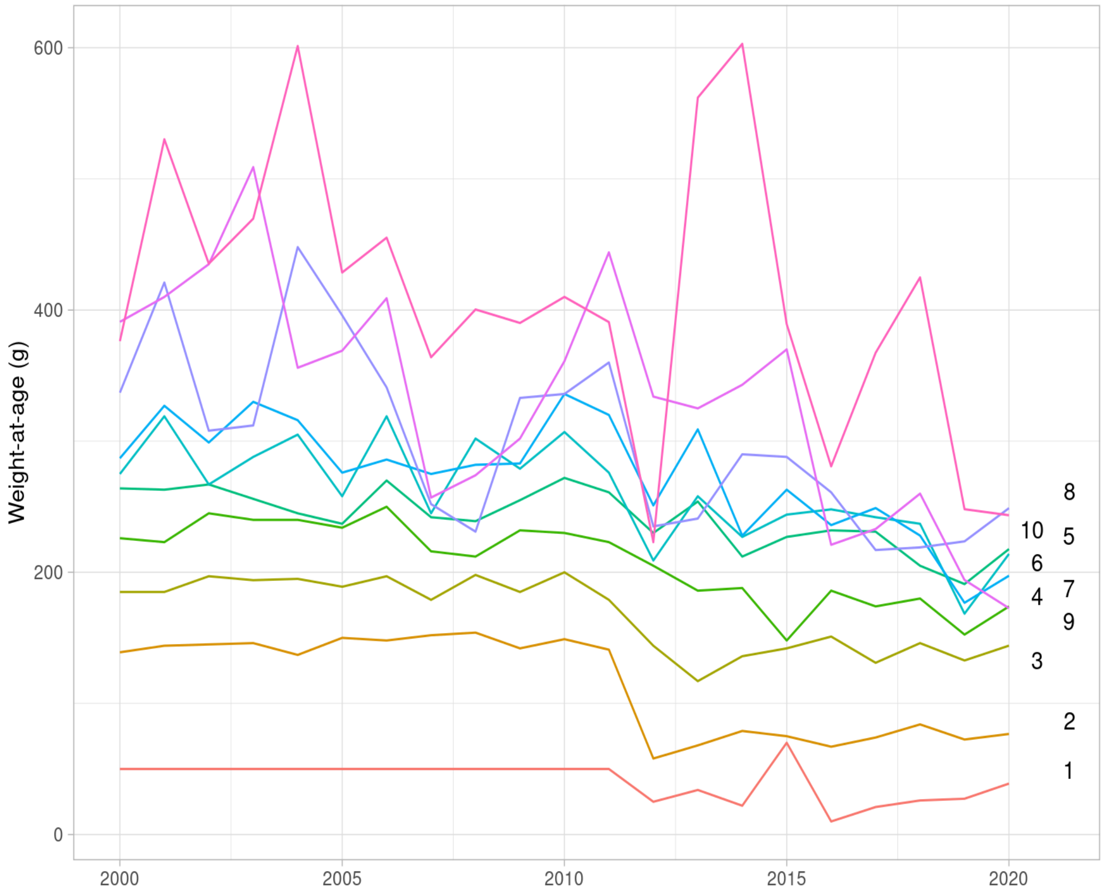


Figure 11: Sole in 27.4. Recent values of the time series of mean weight-at-age in the stock (in grammes).

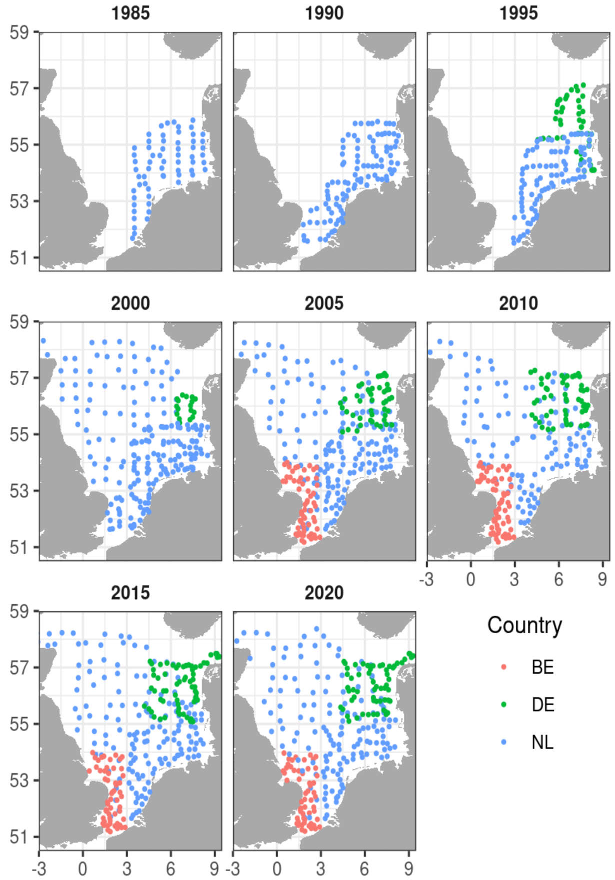


Figure 12: Sole in 27.4. Location of stations sampled during the BTS Q3 survey and included in the BTS index of abundance.

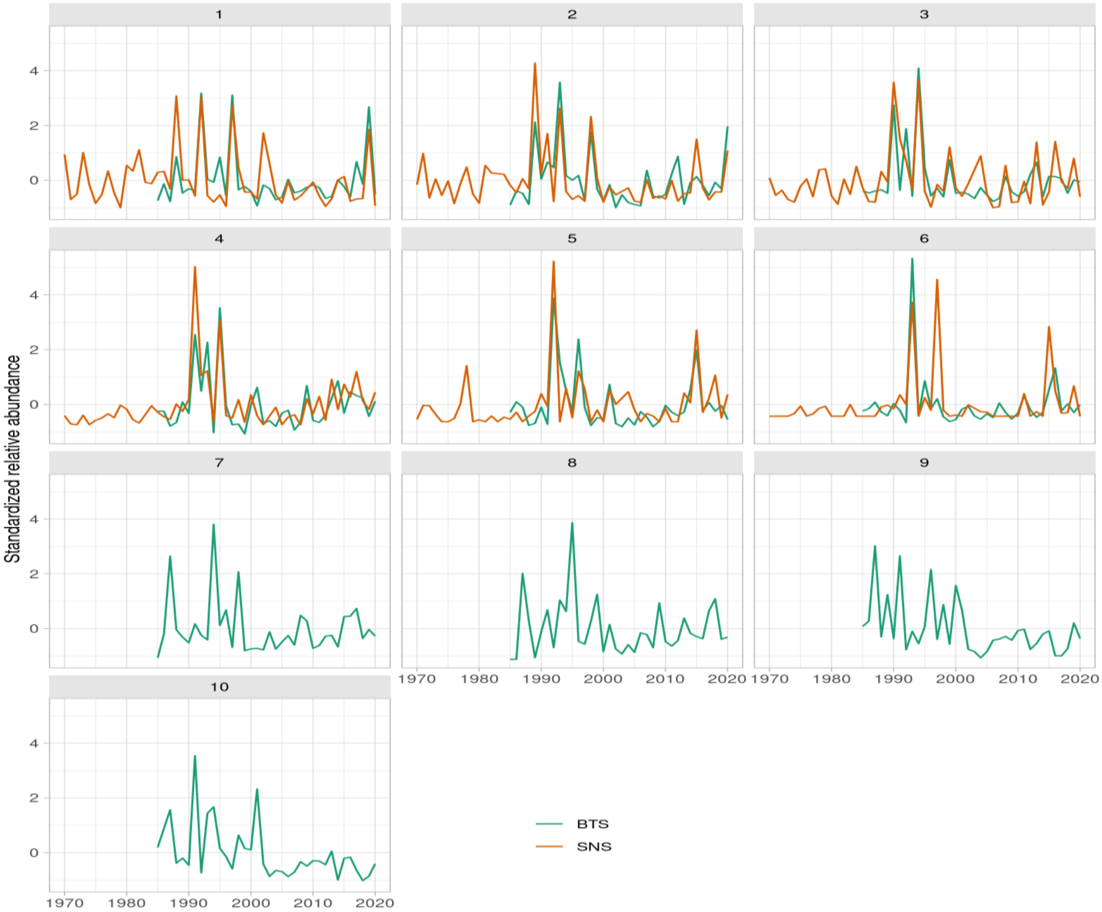


Figure 13: Sole in 27.4. Comparison of the time series of relative abundance at age from the BTS Q3 delta-lognormal GAM standardized (1985–2020) and SNS (1970–2020) indices of abundance.

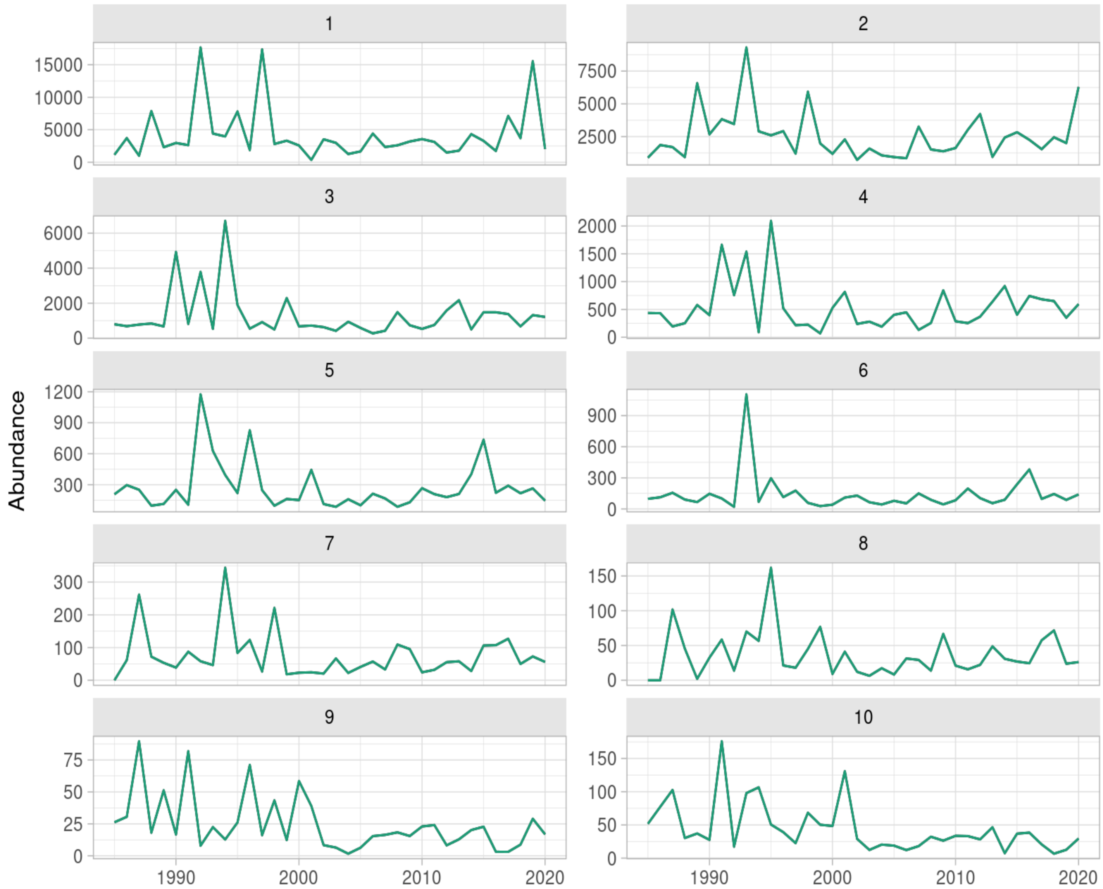


Figure 14: Sole in 27.4. Time series of relative abundance at age from the BTS Q3 delta-lognormal GAM standardized index of abundance (1985–2020).

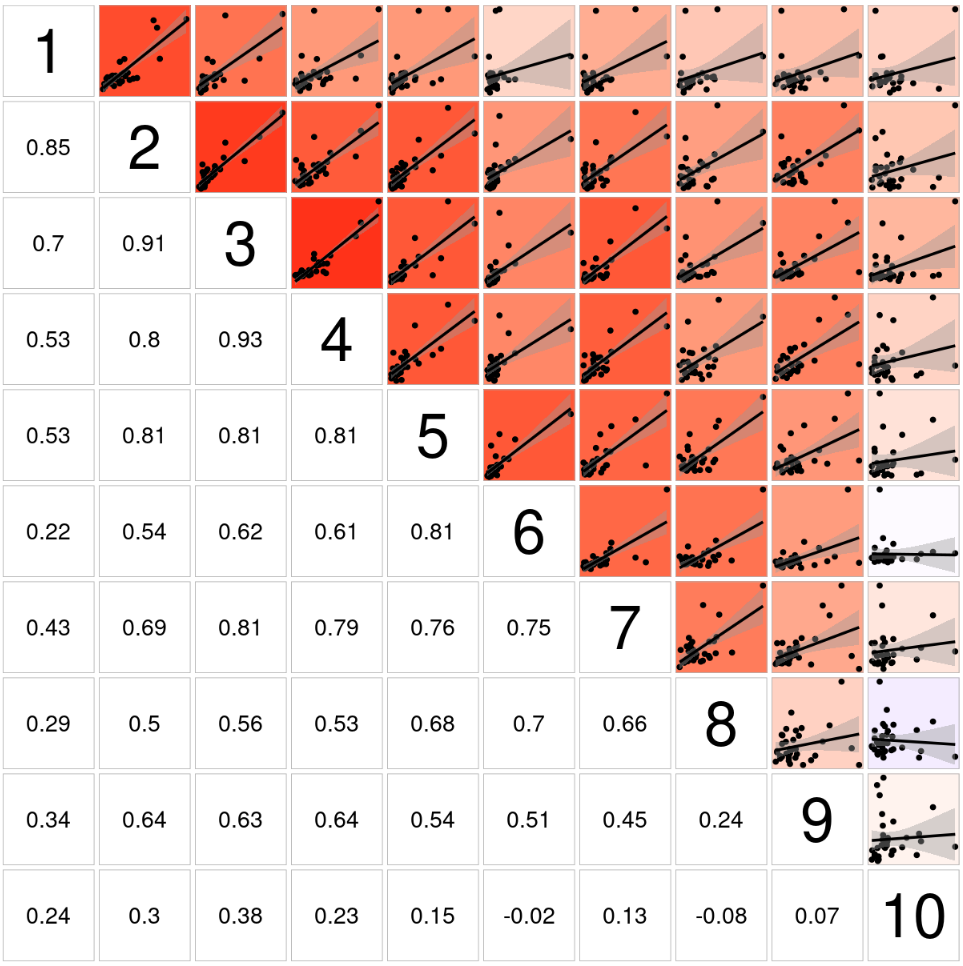


Figure 15: Sole in 27.4. Bivariate cross-correlation plots showing the internal consistency in signals by cohort for the BTS Q3 delta-lognormal GAM standardized index of abundance (1985–2020).

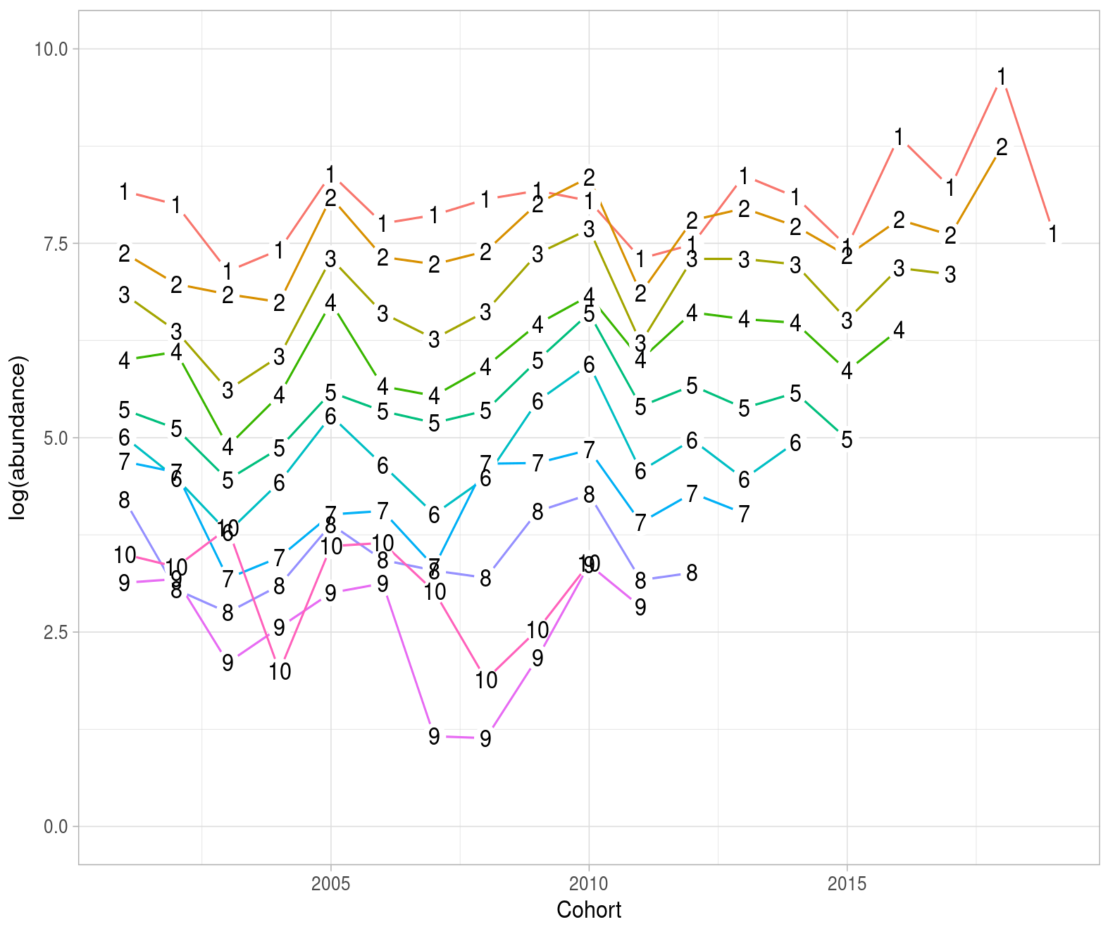


Figure 16: Sole in 27.4. Abundance in log scale by cohort (in the x axis) and age (coloured lines) for the BTS Q3 delta-lognormal GAM standardized index of abundance (2001–2020).

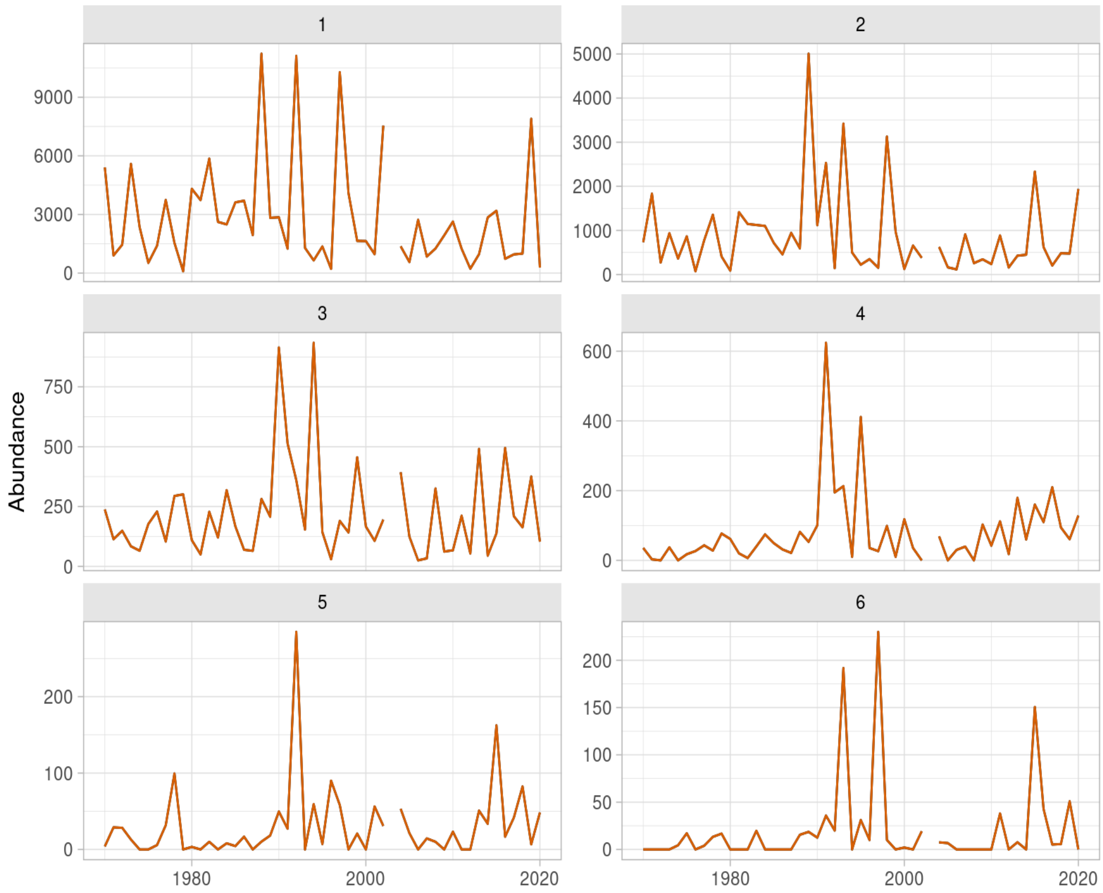


Figure 17: Sole in 27.4. Time series of relative abundance at age from the SNS index of abundance (1970–2020).

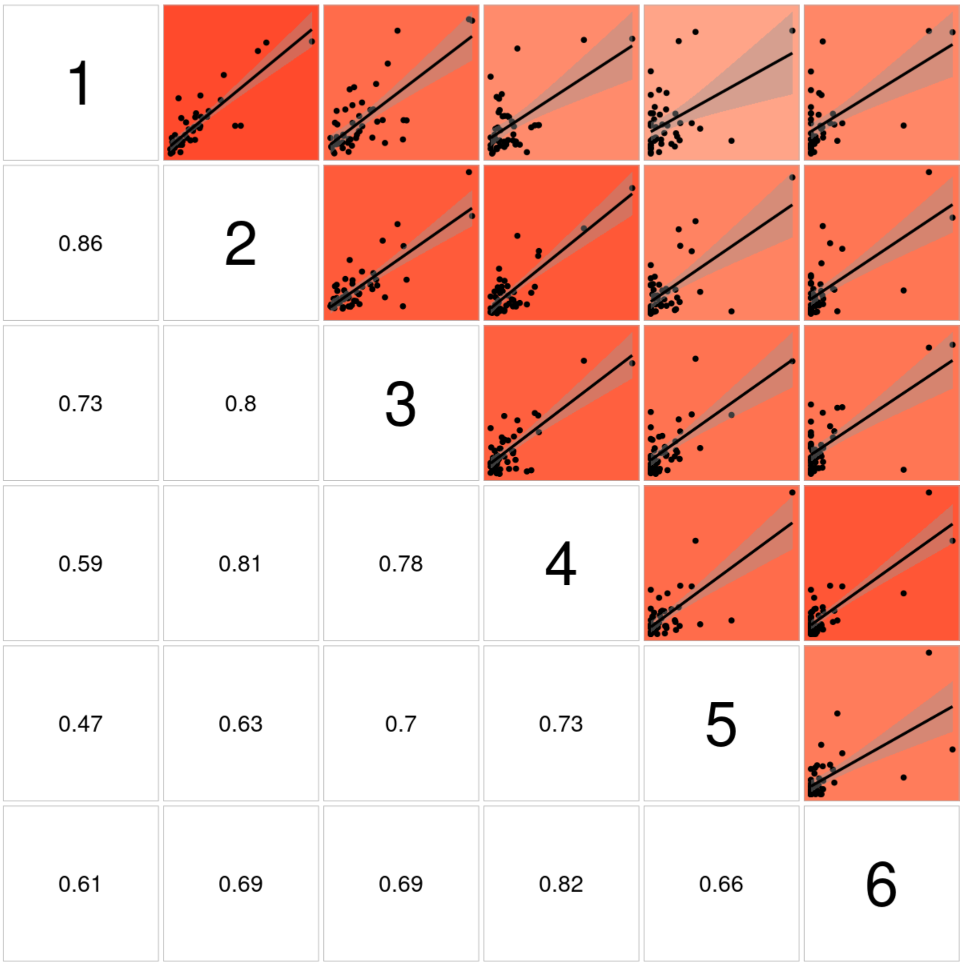


Figure 18: Sole in 27.4. Bivariate cross-correlation plots showing the internal consistency in signals by cohort for the SNS index of abundance (1970–2020).

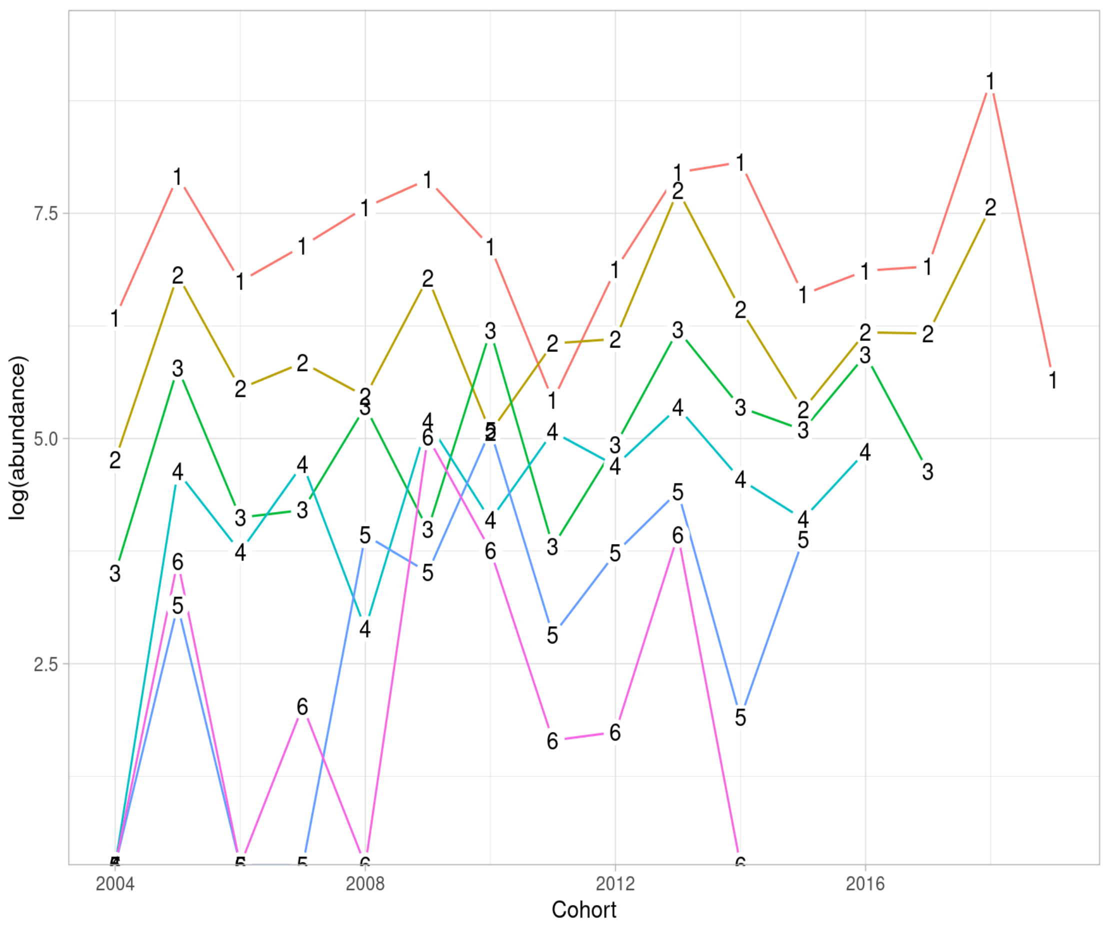


Figure 19: Sole in 27.4. Abundance in log scale by cohort (in the x axis) and age (coloured lines) for the SNS index of abundance (2004–2020).

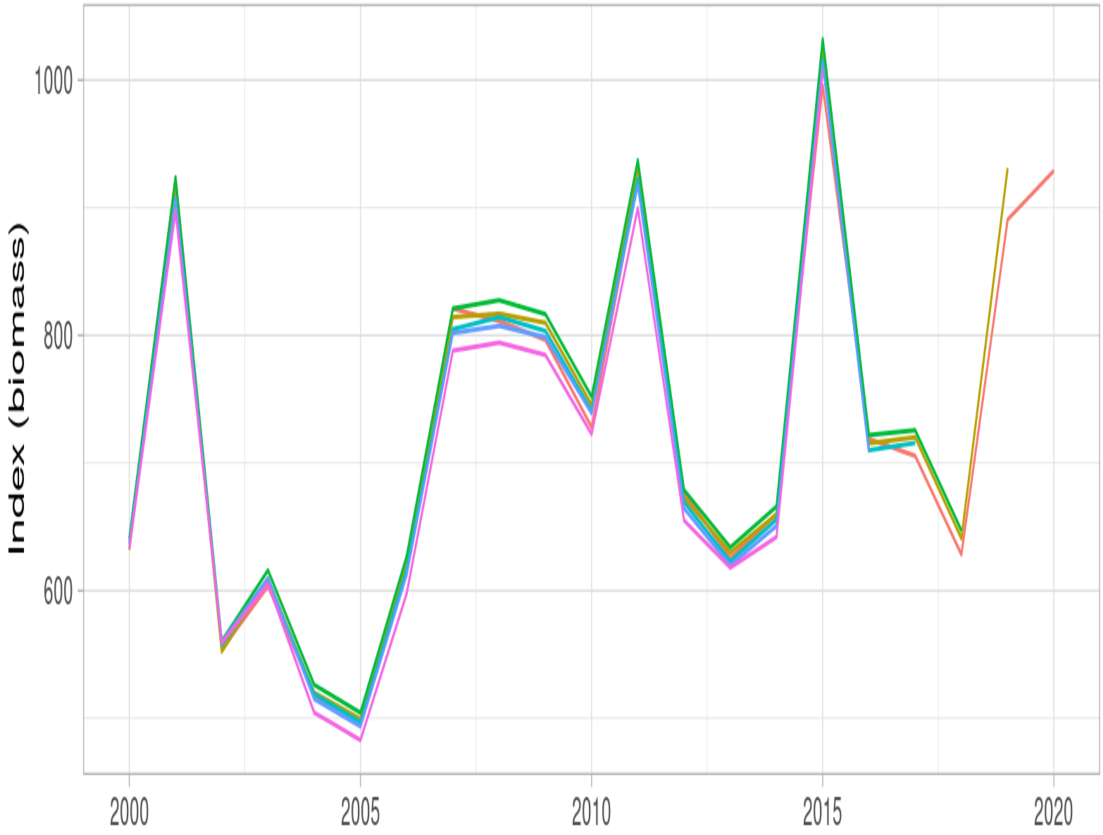


Figure 20: Sole in 27.4. Retrospective pattern in lognormal GAM-standardized BTS Q3 index of abundance.

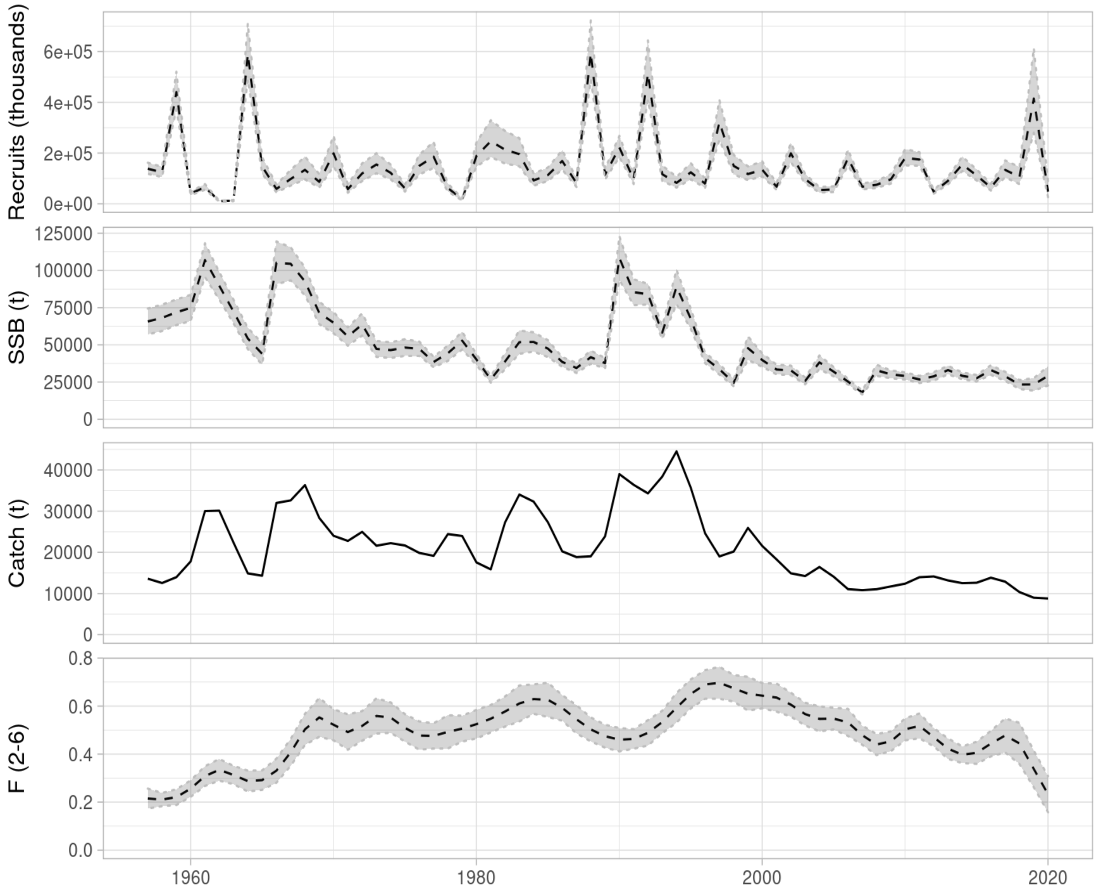


Figure 21: Sole in 27.4. Estimates time series of recruitment at age 1 (in thousands), spawning biomass (in tonnes) and fishing mortality (as average of ages 2 to 6), together with total catch (in tonnes). Grey bands show the 95% uncertainty estimate, computed as two times the standard deviation.

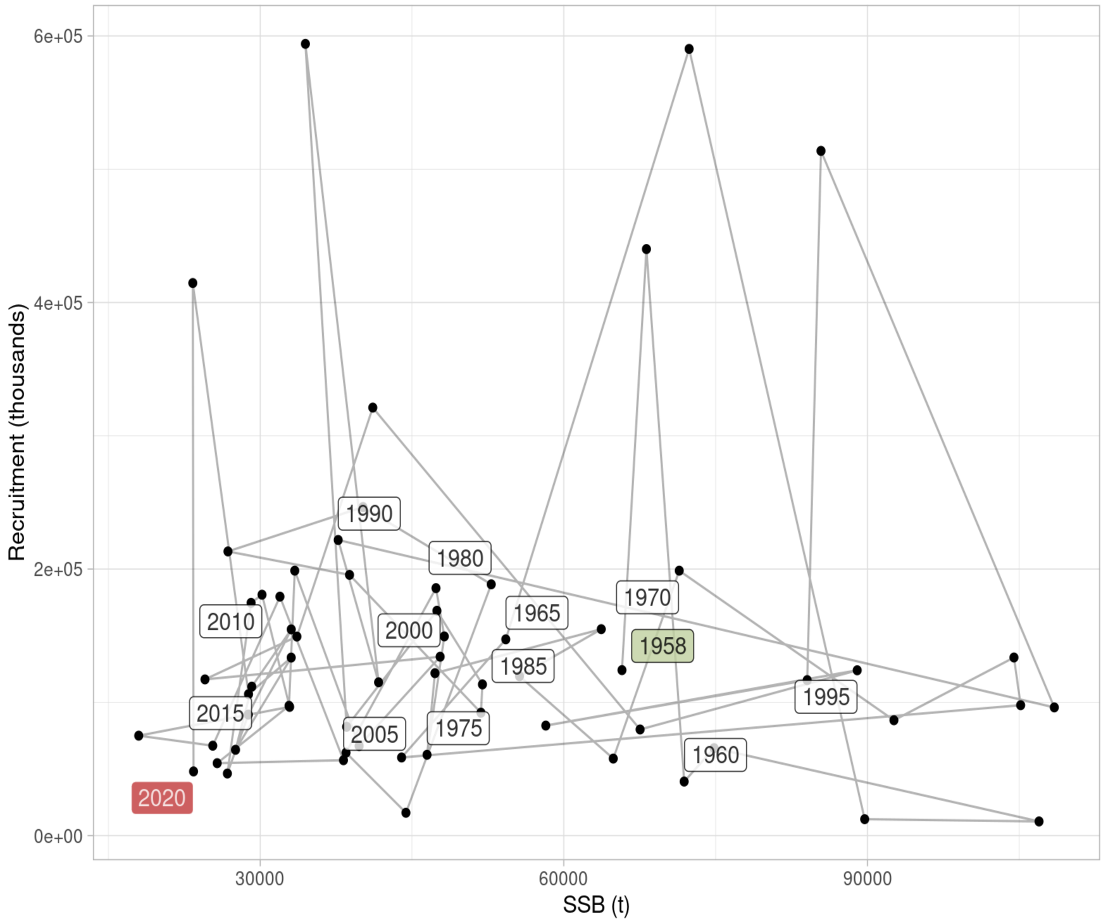


Figure 22: Sole in 27.4. Estimates of recruitment at age 1 (in thousands) and spawning biomass (in tonnes), connected in time. Labels refer to the year in which recruitment was observed.

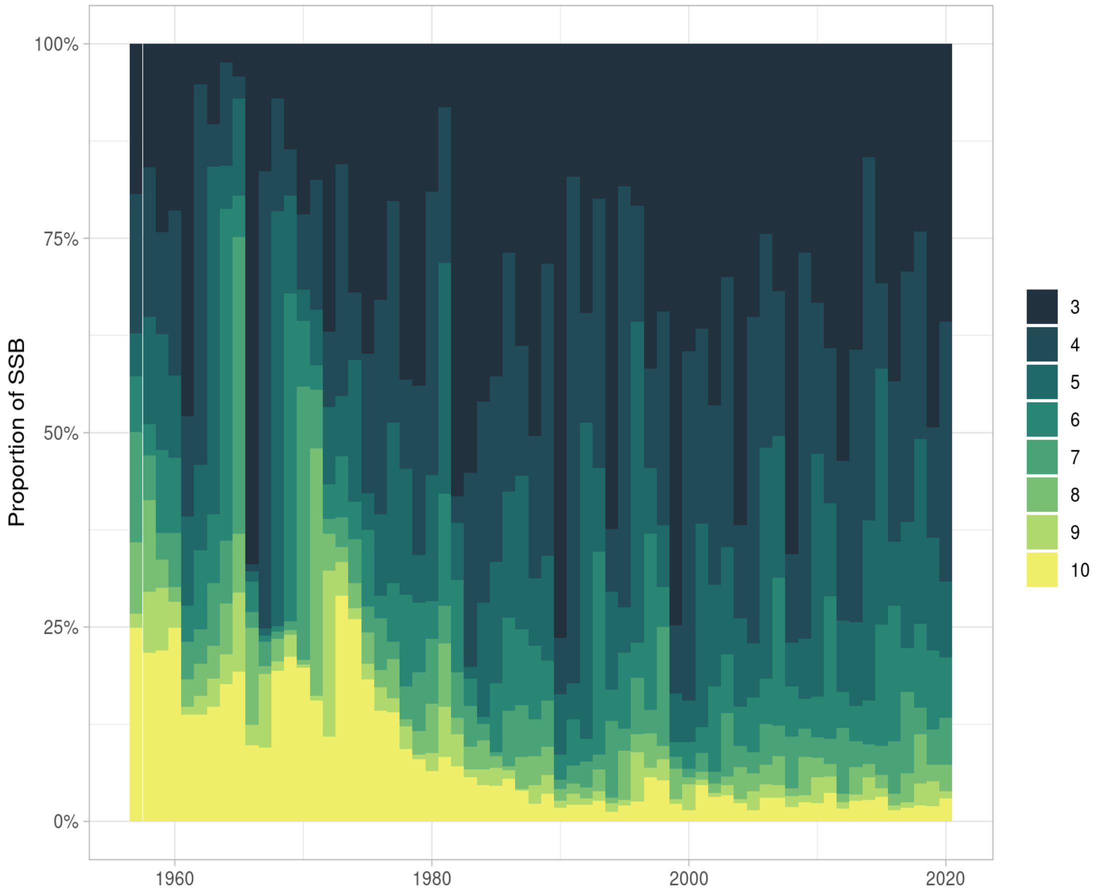


Figure 23: Sole in 27.4. Estimated proportions of spawning biomass by age and year.

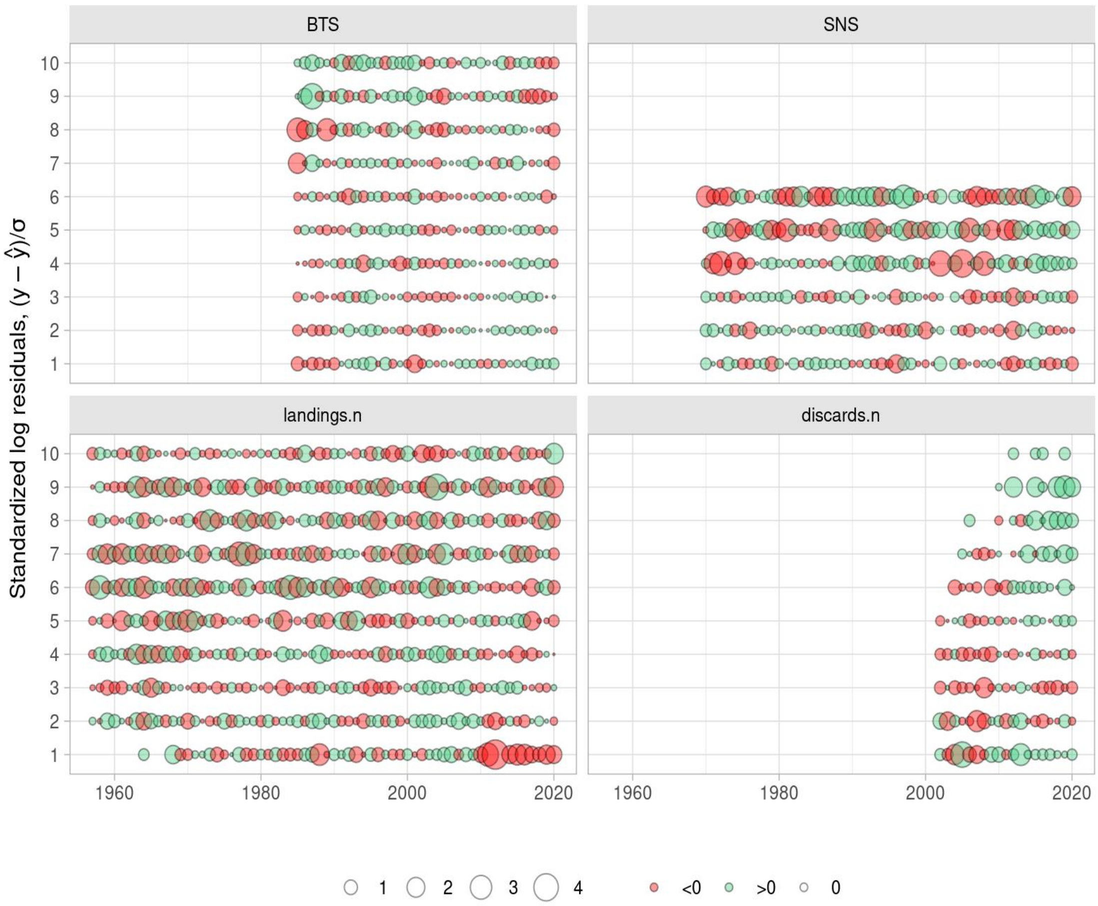


Figure 24: Sole in 27.4. Residuals of model fit to the four sources of data: BTS and SNS indices of abundance, landings-at-age (landings.n) and discards-ta-age (discards.n). Residuals in log scale are standardized by the estimated standard deviation.

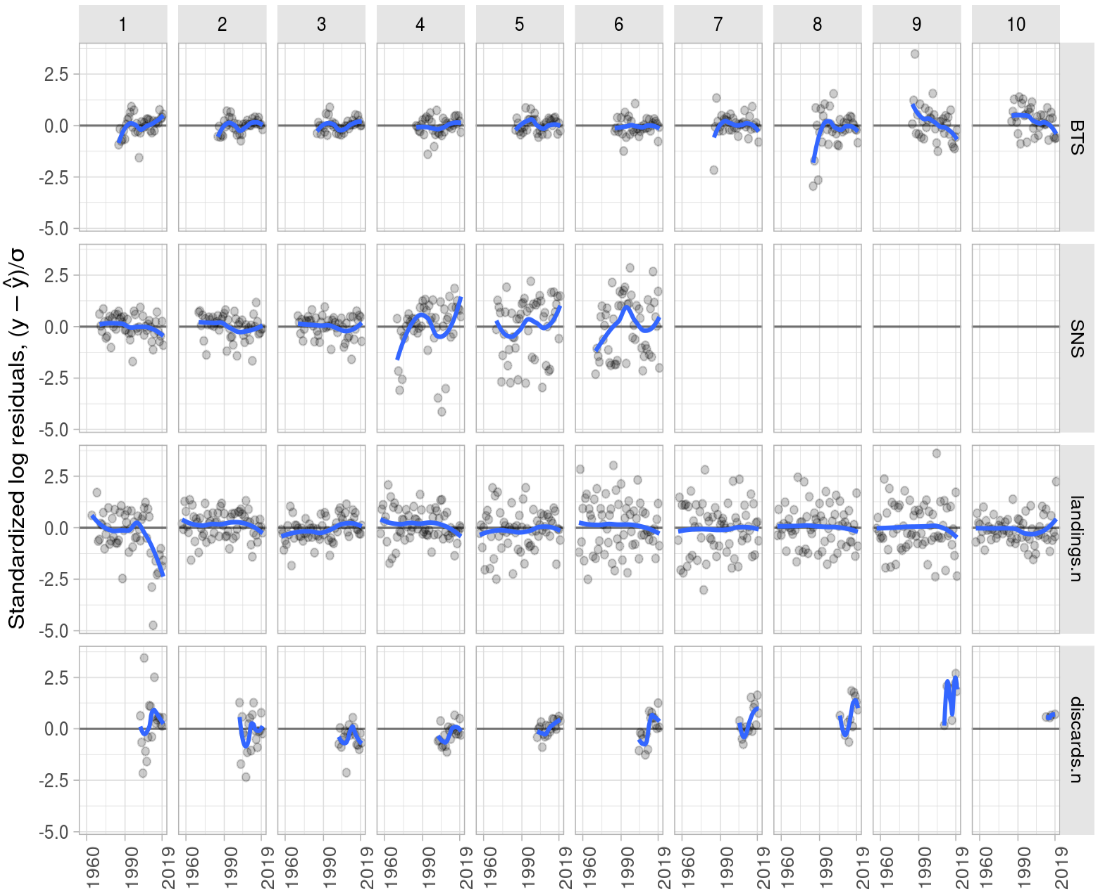


Figure 25: Sole in 27.4. Residuals of model fit to the four sources of data: BTS and SNS indices of abundance, landings-at-age (landings.n) and discards-ta-age (discards.n). Residuals in log scale are standardized by the estimated standard deviation.

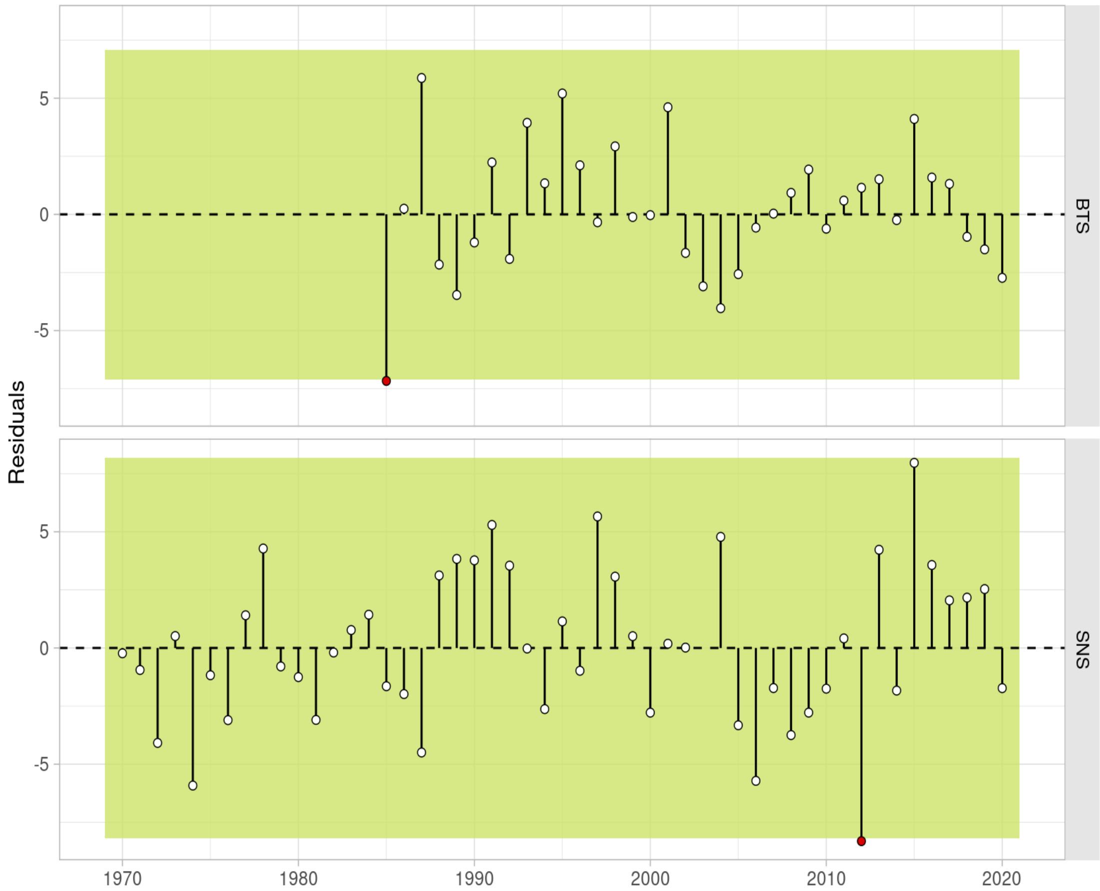


Figure 26: Sole in 27.4. Runs test of model fit to index vulnerable biomass for the two indices of abundance: BTS and SNS. Green shading indicates no evidence and red shading evidence to reject the hypothesis of a randomly distributed time-series of residuals, respectively. The shaded area spans three residual standard deviations to either site from zero, and the red points outside of the shading violate the 'three-sigma limits' for that series.

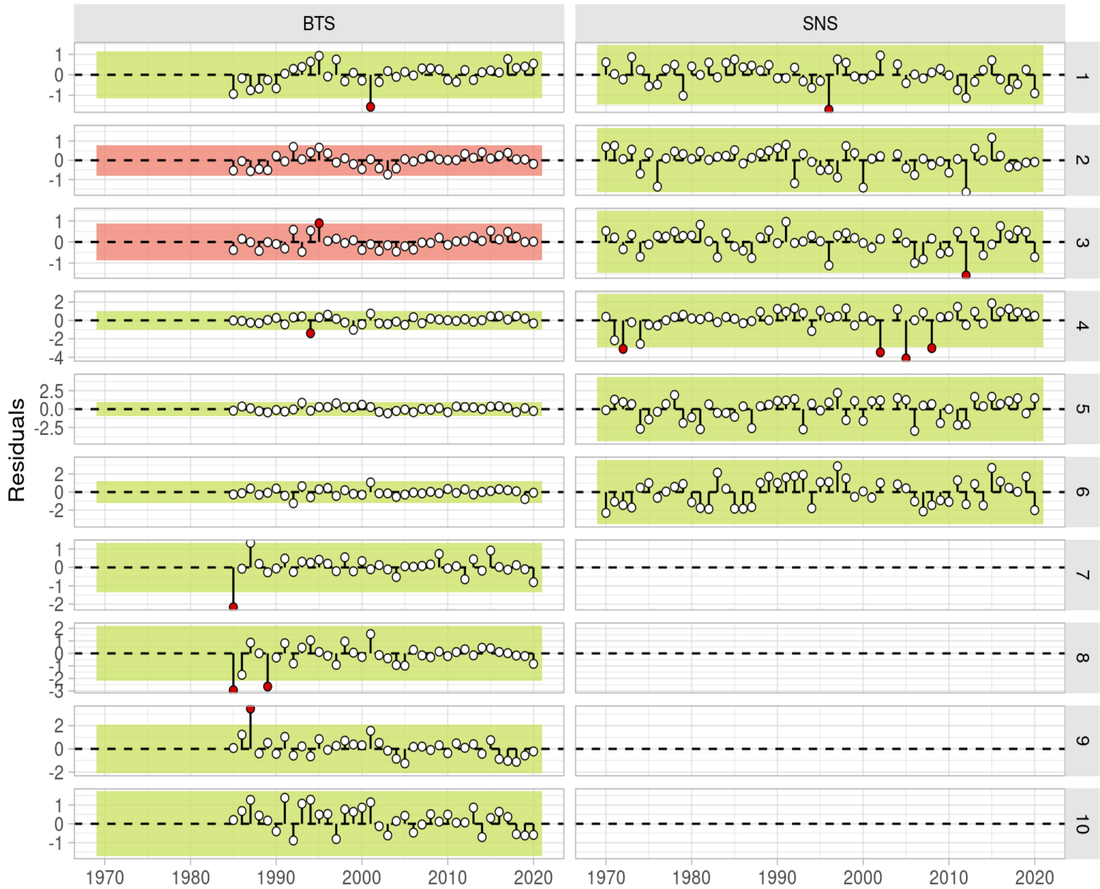


Figure 27: Sole in 27.4. Runs test of model fit to the sampled abundances at age for the two indices of abundance: BTS and SNS. Green shading indicates no evidence and red shading evidence to reject the hypothesis of a randomly distributed time-series of residuals, respectively. The shaded area spans three residual standard deviations to either site from zero, and the red points outside of the shading violate the 'three-sigma limits' for that series.

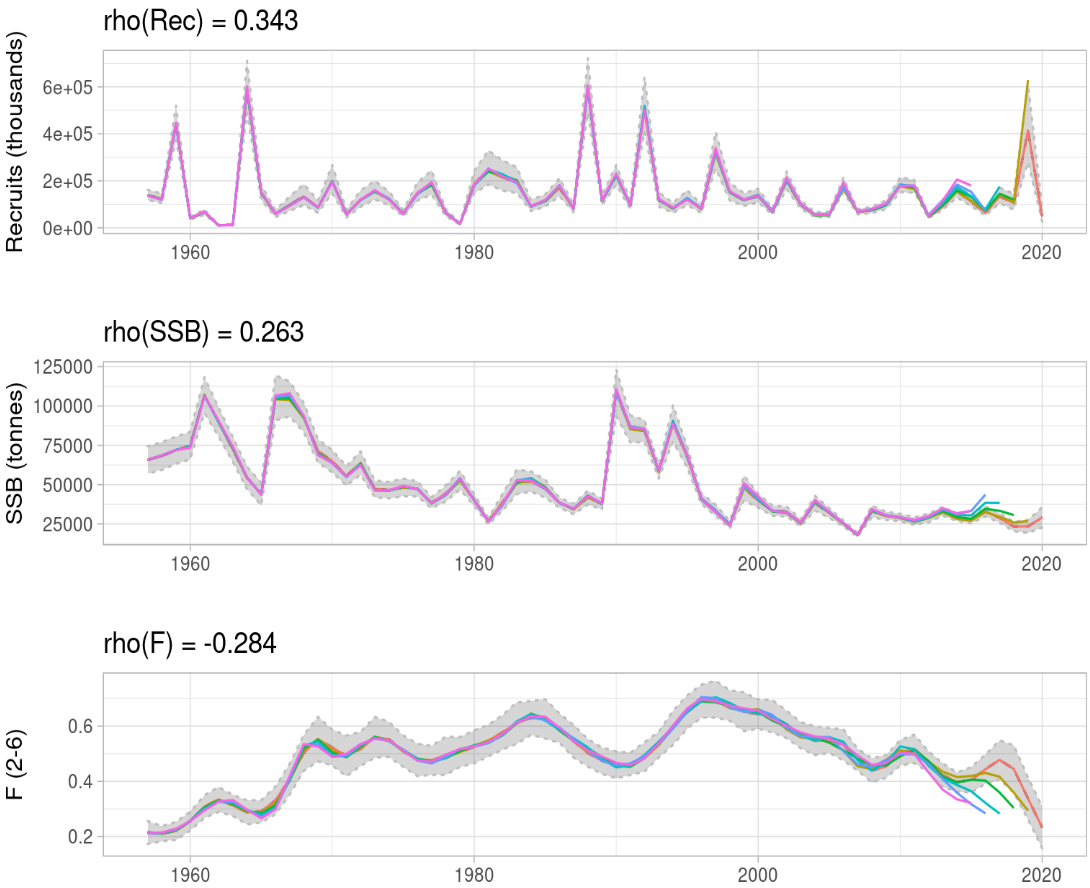


Figure 28: Sole in 27.4. Retrospective patterns in estimated age 1 recruitment, spawning biomass and mean fishing mortality, computed over five one-year steps.

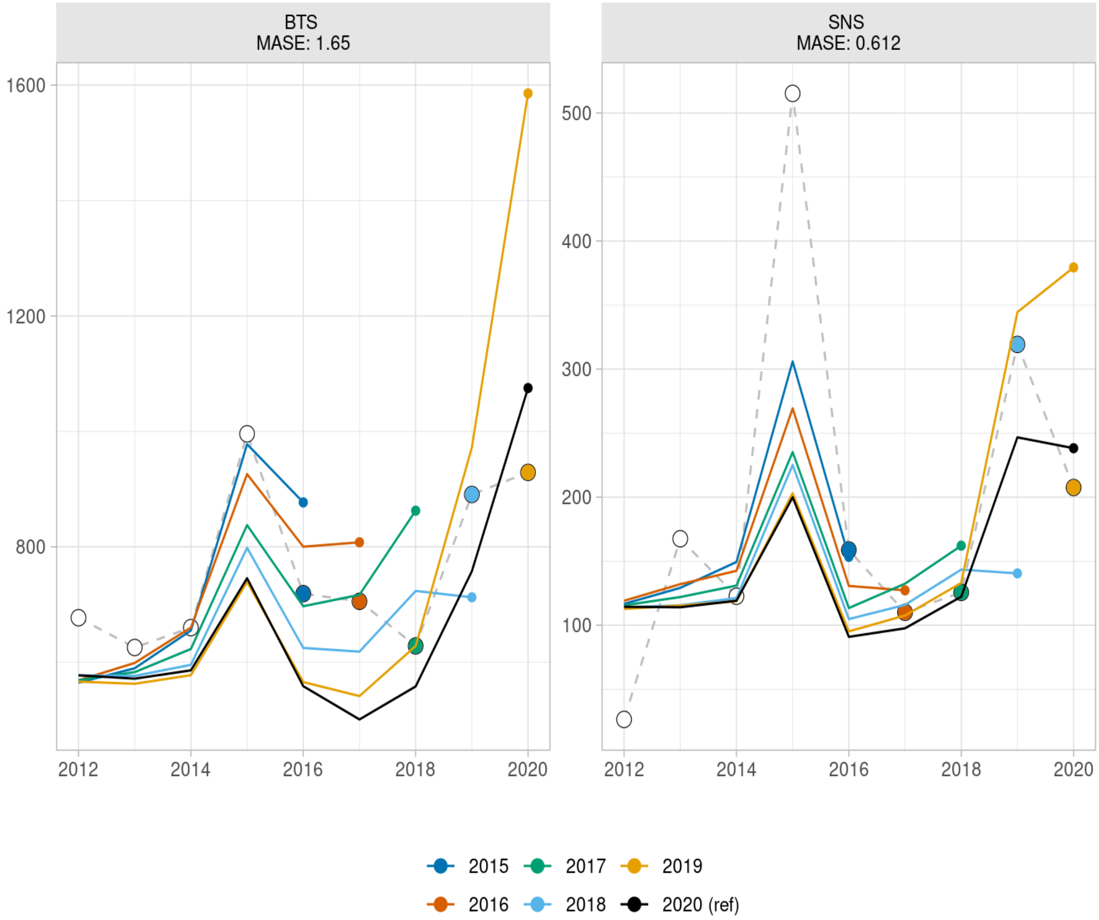


Figure 29: Sole in 27.4. Hindcasting cross-validation of indices of abundance to estimate assessment model prediction skill.

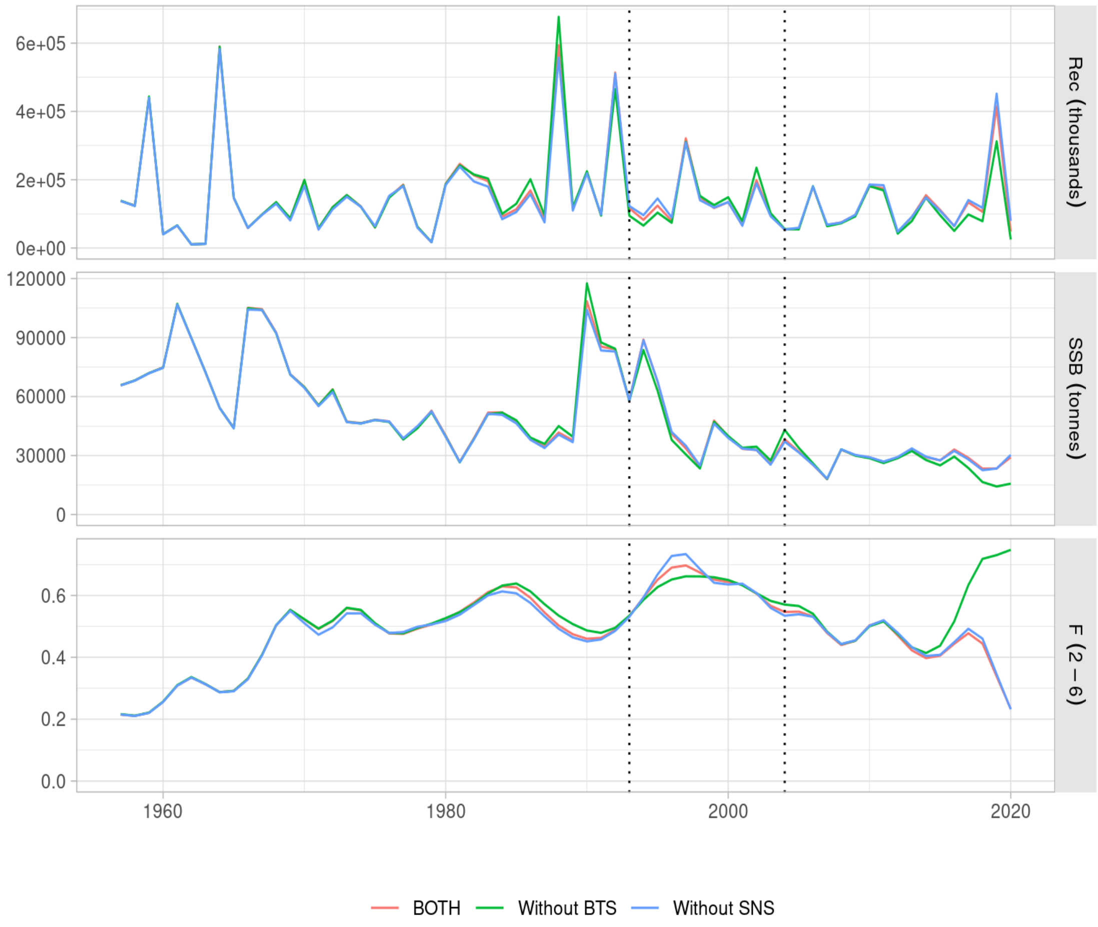


Figure 30: Leave-one-out analysis of the AAP model run.

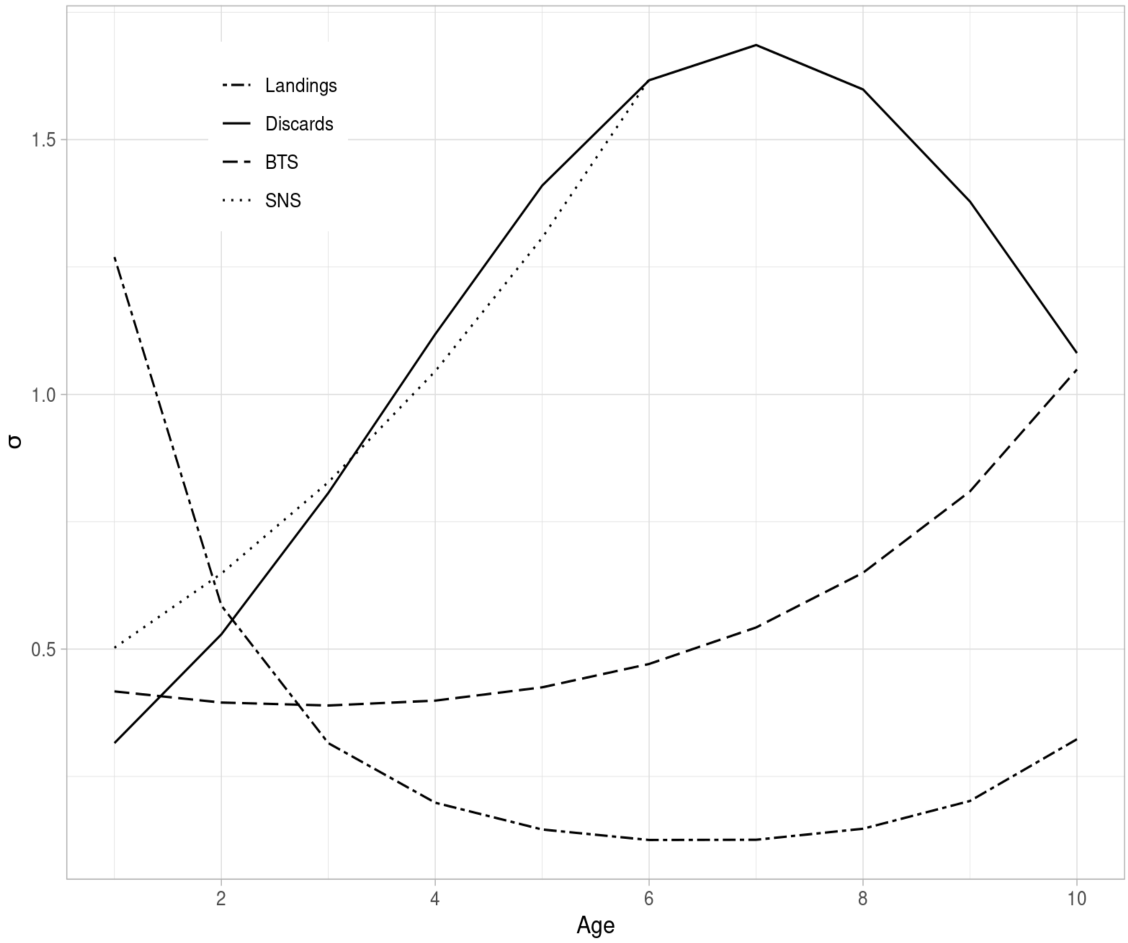


Figure 31: Sole in 27.4. Estimated standard deviations of the partial model likelihood by age and per each component.

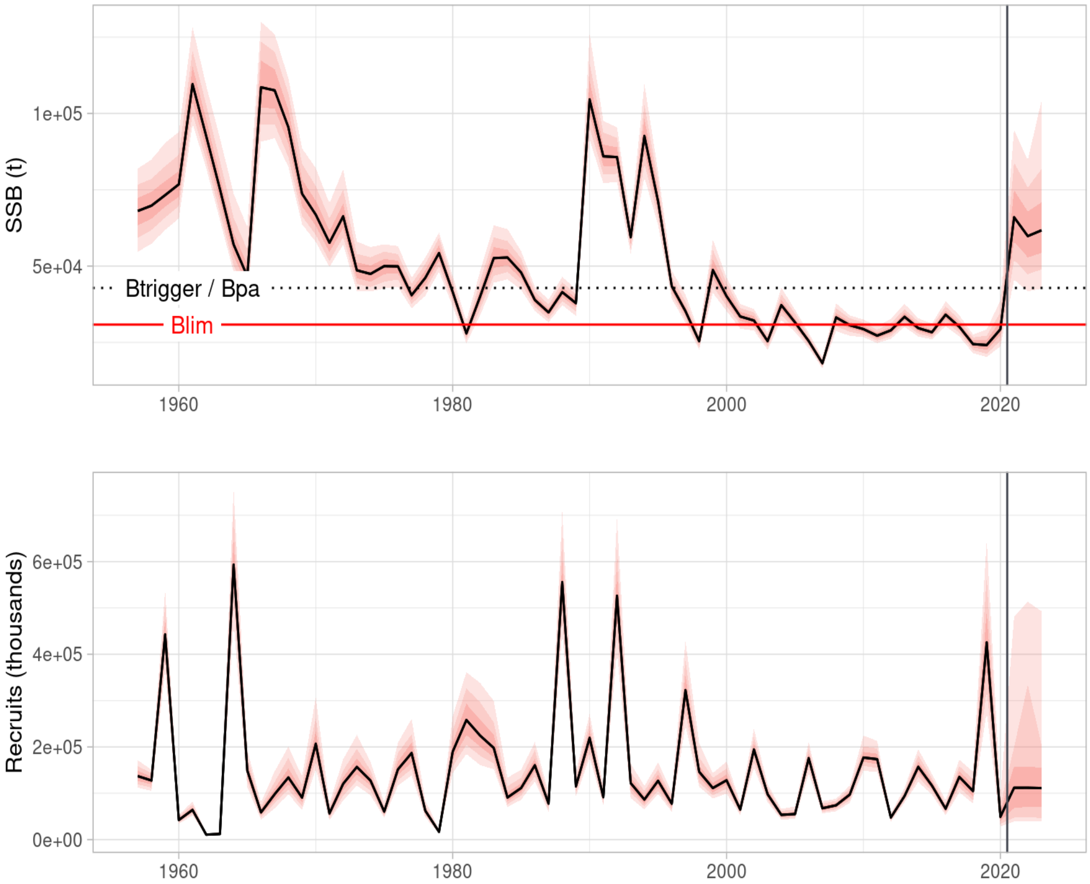


Figure 32: Sole in 27.4. Stochastic forecast of spawning stock biomass (SSB) against the corresponding reference points, and recruitment variability applied in it. The black line shows the median value, which is not exactly equal to the predicted values used in the advice. Darker and lighter red ribbons present the 95% and 50% quantiles, respectively.

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 2021 assessment of sole in Division 27.7.d. Additional background information can be found in the Stock Annex which was updated after the benchmark in February 2021.

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 larvae, juveniles and adults (Archambault *et al.*, 2016; Lecomte *et al.*, 2020; Randon *et al.*, 2018; 2020). More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES, 2021).

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.

The minimum landing size for sole is 24 cm (EU legislation). Sole in the eastern English Channel is fully under the landing obligation since 2018 (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 small coastal otter trawlers (<10 m and <221 kW) fishing less than 90 minutes in areas with a depth less than 30 m (outside nursery areas) and with cod-end mesh size of 80–99 mm.

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).

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 (2000–2020); Note: TAC represents catch from 2016 onwards (landing obligation)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TAC	4100	4600	5200	5400	5900	5700	5720	6220	6590^	5274	4219
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016***	**2017***	**2018***	**2019***	**2020***	
TAC	4852	5580	5900	4838	3483	3258	2724	3405	2515	2797	

*** Catch TAC**

^ The exact value from EU Regulation is 6593 tonnes

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 18.2.1.1 TAC uptake). Note that initial quota are compared regardless of quota exchanges among countries.

In response to the drop in SSB and the poorer recruitment in 2012-2016 (exception 2015), the main countries participating in the fishery implemented additional conservation measures. For Belgian beam trawlers in 27.7.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 also increased to 25 cm. This MCRS is still used up until now (dd. May 2021). 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

In 2019, the French fishing industry provided input on their perceived status of the stock.

The French gillnet fishers state that they have trouble catching sole in the eastern part of the eastern English Channel. The French otter trawl fishers operating mainly in the south-western part of the eastern English Channel have reported a decline in catches in 2016 and 2017, followed by an increase in catches since 2018 to the ten-year average level.

18.1.4 ICES advice

18.1.4.1 ICES advice for 2020

The ICES advice for 2020 was:

ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 2846 tonnes. Note that advice was given as for Category 3 stocks for which no estimation of the SSB in 2019 is provided.

In 2019, the stock status was presented as follows:

		Fishing pressure				Stock size		
		2016	2017	2018		2016	2017	2018
Maximum sustainable yield	F_{MSY} proxy	✗	✓	✓ Below proxy	MSY $B_{trigger}$ proxy	✓	✓	✓ Above
Precautionary approach	F_{pa}, F_{lim}	✓	✓	✓ Harvested sustainably	B_{pa}, B_{lim}	✓	✓	✓ Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓ Below	MAP MSY $B_{trigger}$	✓	✓	✓ Above proxy

18.1.4.2 ICES advice for 2021

The ICES advice for 2021 was:

ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 3248 tonnes. Note that advice was given as for Category 3 stocks for which no estimation of the SSB in 2020 is provided.

In 2020, the stock status was presented as follows:

		Fishing pressure				Stock size		
		2017	2018	2019		2017	2018	2019
Maximum sustainable yield	F_{MSY} proxy	✓	✓	✓ Below proxy	MSY $B_{trigger}$ proxy	✓	✓	✓ Above proxy
Precautionary approach	F_{pa}, F_{lim}	✓	✓	✓ Harvested sustainably	B_{pa}, B_{lim}	✓	✓	✓ Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓ Below proxy	B_{MGT}	✓	✓	✓ Above proxy

18.2 Data

As a result of the data call for the 2021 WKNSEA benchmark (ICES, 2021), new landings and discard time series were uploaded by France and Belgium. Data were processed in InterCatch from 2004 onwards.

18.2.1 Catches

18.2.1.1 TAC uptake

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. However, in 2019 and 2020, landings decreased further to 1762 and 1706 tonnes respectively. Over the last *ca.* 20 years, the contribution to the landings of the three main countries involved in this fishery has remained rather stable over time (~30% Belgium, ~15% UK, and ~55% France) (Figure 18.2).

Since 2010, full uptake of the sole 27.7.d TAC has not been realized. However, in 2014, the 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 2015 was 98% (official landings; for comparison: 72% in 2012, 75% in 2013, and 96% in 2014). Note that initial quota are compared with uptake not taking into account quota exchange among countries during the year.

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 82% was realized in 2017, 78% in 2018, 82% in 2019 and 70% in 2020 (Figure 18.3). Figure 18.4 presents a historic overview of TAC levels compared to official landings and ICES estimates (both landings and discards).

18.2.1.2 ICES catch estimates (InterCatch)

New ICES estimates were uploaded and processed in InterCatch from 2004 onwards as a result of the WKNSEA 2021 benchmark. The new upload involved a thorough revision of the French and Belgian time series (more information in the WKNSEA 2021 benchmark report: ICES, 2021). The proportion of landings with discards has gradually increased over the years 2004–2012 (Figure 18.5). From 2012 onwards, this increasing trend leveled off and showed a decrease in 2020 to 54% most likely due to the Covid-19 pandemic. The age coverage for landings increased from 2004–2011 and remained stable around 80% (Figure 18.5). The age coverage for 2020 is 82% and shown by country and by fleet in Figure 18.6 and 18.7 respectively. The age coverage for discards fluctuates around 60% over the whole time series and is at 52% in 2020 (Figure 18.5).

A detailed overview of imported or raised data and sampled or estimated distributions for 2020 is given in Table 18.2.

Discards are included in the assessment from working year 2017 onwards. If discards are unavailable for a particular year-quarter-country-métier combination, they are assumed to be unknown (non-zero) and therefore raised (InterCatch). The weighting factor for raising the discards was '*Landings CATON*' (landings catch).

Discard raising was performed on a **gear level** regardless of season or country. The following groups were distinguished based on gear:

- *TBB*
- *OTB including OTB, OTT, SSC, SDN*
- *GTR including GTR and GNS*

The remaining gears were combined in a REST group (including MIS, FPO, DRB, LHM, LLS).

The GNS/GTR, TBB and OTB/OTT/SSC/SDN contribute respectively 28%, 36% and 33% to the landings of sole in 27.7.d (Table 18.3).

Raising within a gear group was performed when the proportion of landings for which discard weights are available was **equal or larger than 50%** compared to the total landings of that group. For the 2020 data, this was only the case for the TBB gear group. When the threshold was not reached for a gear group, it was pooled with the REST group to raise discards based on all available information.

To **allocate age** compositions, landings and discards were handled separately; samples from landings were used only for landings and *vice versa*. When age distributions (both landings and discards) had to be borrowed from other strata, allocations were performed on a **gear level**. The same gear groups (TBB, OTB, GTR and REST) as used for discard raising were applied. When the **threshold of 50%** was reached for the proportion of landings or discards covered by age, allocation of age occurred with all available information within that gear group. For the 2020 landings data, this threshold was reached for all gear groups. For the 2020 discards, this was only the case for the TBB group. When the threshold was not reached, unsampled data were pooled in the REST group and ages were allocated using all sampled data. The weighting factor was '*Mean Weight weighted by numbers at age*'.

From 2018 onwards, **BMS landings** and **logbook registered discards** were available in InterCatch. However, all were zero up to 2020. In 2020, 247 kg of BMS was reported from the English GNS_DEF_all Q4 and OTB_DEF_70-99 Q4 strata. Logbook registered discards were not considered for the age allocations. Age allocation of BMS landings was done together with discards.

The official catch statistics have reported BMS landings in 2017 (144 kg), 2019 (2.8 kg) and 2020 (249 kg). No BMS landings were reported in 2018.

18.2.1.3 Reconstruction of discards

Due to the lack of discard information prior to 2004, discards were reconstructed for the period 1982-2003 (ICES, 2021). Similarly, as during the WKNSEA 2017 benchmark, an average discard proportion at age was calculated for the period 2004–2008. This decision was motivated by the fact that discard behaviour at age changed after 2008 and a general increase in discarding was found in the most recent years (Figure 18.8).

First, the InterCatch information from the most recent years (2004–2019) on discards and landings numbers-at-age, weights-at-age and overall tonnage was SOP corrected as follows. Numbers were multiplied with weights and summed per year. Then the ratio between the overall tonnage from InterCatch and this sum was calculated. This gave a SOP factor by year which was then multiplied by the numbers-at-age per year.

Subsequently, only the numbers-at-age were retained for the period 2004–2008 and the mean numbers-at-age were calculated. The ratio of the discards mean numbers-at-age and the landings mean numbers-at-age for 2004–2008 was then multiplied by the old landings numbers-at-age, which were also SOP corrected. This finally resulted in discards numbers-at-age for the period 1982–2003.

Discards weights-at-age were calculated in the same way. A ratio between discards and landings weight-at-age for the period 2004–2008 was calculated and multiplied by the landings weight-at-age for the period 1982–2003. This resulted in discards weight-at-age for the period 1982–2003.

18.2.1.4 Discard rate

The discard rate, calculated as the ratio between ICES discard estimates (tonnes) and ICES catch estimates (tonnes), fluctuates between 3 and 10% over the time series (Figure 18.9). However, in the last two years this rate increased to 20%. This is a lot for a target species such as sole, but is most likely due to the strong 2018-year class. However, the extent to which this 2020 discard rate is biased by the lower discard ratio coverage (§18.2.1.2) due to the Covid-19 pandemic is unclear.

Usually most of the imported discards originate from France (62% in 2018) followed by Belgium (34% in 2018) and England (4% in 2018). However, in 2020, 66% of the imported discards originated from Belgium and only 34% from France. This was the result of the reduced sampling by France due to the pandemic. Belgium only submits discard data from the TBB group, while France usually provides a mix of GTR, OTB and TBB strata. Following the discard raising procedures (§18.2.1.2), the threshold of raising the OTB and GTR group using only OTB and GTR strata respectively was not met for the 2020 data (in contrast to the three preceding years). Consequently, these strata were raised in a REST group including BEL TBB_DEF_70-99 (DR = 0.22), FRA GTR_DEF_100-119 Q1 (DR = 0.023), Q3 (DR = 0.018), Q4 (DR = 0.010), FRA GTR_DEF_90-99 Q1 (DR = 0.044), FRA OTB_DEF_70-99 Q3 (DR = 0.326) and ENG OTB_DEF_70-99 Q1 (DR = 0). The French OTB_DEF_70-99 Q1 stratum was not included because the discard rate exceeded 50% (DR = 0.514).

Consequently, the Belgian discard samples had a higher impact for the 2020 data compared to previous years. In 2020, Belgian discard rates were unusually high (22% versus 12% in 2018 and 14% in 2019). The Belgian observer programme was not hampered by the Covid-19 pandemic. Therefore, this high discard rate was considered representative and most likely the result of the larger 2018-year class.

18.2.1.5 Numbers-at-age

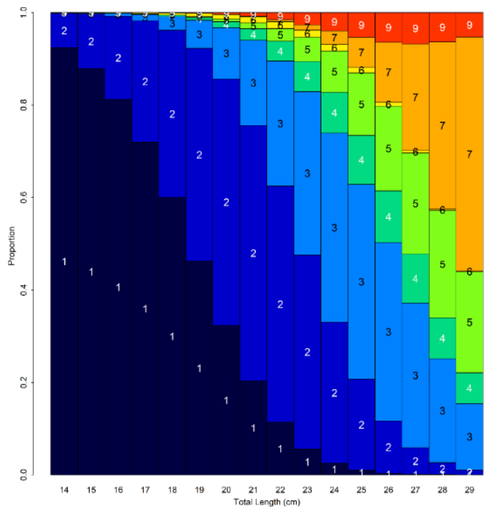
Catch, landings and discards numbers-at-age are shown in Figure 18.10, 18.11, 18.12, 18.13 and Table 18.4.

Catch numbers have decreased over the time series and lower numbers are caught since 2015 (Figure 18.10). In 2008–2009, a strong year class entered the stock and was found in the landings from age onwards. The 2018-year class is the first since 2008-2009 that seems large enough to be observed in the landings. However, very few 2-year olds have been observed in the landings.

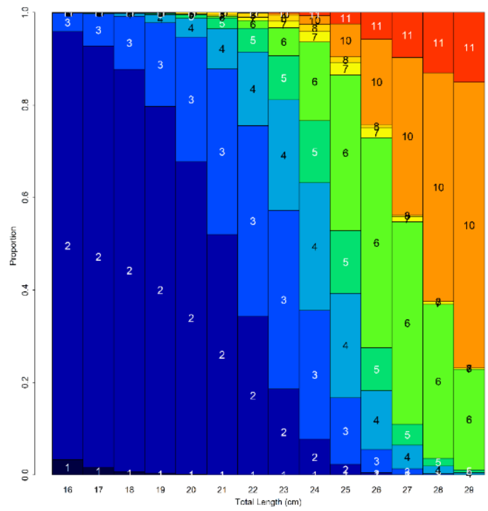
Almost half of the 2- and 3-year-old fish were discarded in 2020. In contrast to another period with a strong year class (e.g. 2001-year class), it is apparent that proportionally more 2-year olds end up in the discard fraction (Figure 18.10).

Additionally, Figure 18.13 shows a considerable amount of old discards, especially in 2019 and 2020. Considering the larger impact of the Belgian samples in 2020, Belgian age-length keys (modelled) were investigated (see graphs below showing the proportion per age per length class). Discards up to 29 cm were aged and while in 2019 over 40% were younger than age 6, in 2020 this was less than 5%. This confirms the pattern of decreasing length-at-age also found in the UK BTS survey data (ICES, 2021).

2019



2020



18.2.1.6 Weight-at-age

Weights-at-age for discards and landings are shown in Figure 18.14 and 18.15 respectively and weights-at-age in the catch are given in Figure 18.16 and Table 18.5. Catch weights-at-age have gradually declined over the past 10 years, especially in the younger ages (age 1–5). Furthermore, although discards of older ages are being caught (up to age 8 and older), their mean weight-at-age varied around 100 grams. This points to a trend of decreasing weight-at-age and thus smaller (§18.2.1.5) and thinner fish.

18.2.2 Stock weight-at-age

Stock weights-at-age were revised during the WKNSEA 2021 benchmark (ICES, 2021). Quarter 1 weight-at-age was extracted from InterCatch for the period 2004–2019. Note that Belgian catch information (numbers and mean weight-at-age) was added manually because Belgian data were uploaded per year (not quarter, with the exception of 2018). Subsequently, the mean proportion at age was calculated between the catch weight-at-age in quarter 1 and the overall catch weight-at-age for the period 2004–2019. This ratio was then multiplied by the catch weight-at-age for the period 1982–2003 to get the quarter 1 catch weight-at-age for 1982–2003 (Figure 18.17; Table 18.6).

18.2.3 Maturity and natural mortality

During the WKNSEA 2017 benchmark (ICES, 2017), the knife-edged maturity ogive with full maturation from age 3 onwards was revised. 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, 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 constant over ages and years at 0.1. English and French tagging data were investigated (prior to the WKNSEA 2021 benchmark), but two problems were encountered. First, most of the tagging data dated back to before the beginning of the sole 7.d time series. Second, in the most recent years, there were too little recaptures which inhibited the calculation of a new estimate for natural mortality (Lecomte *et al.*, 2020).

18.2.4 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 WKNSEA 2021 benchmark, the Belgian commercial beam trawl index and the French commercial otter trawl index were revised (ICES, 2021). The UK commercial beam trawl index was revised during the 2019 inter-benchmark (ICES, 2019). All three commercial tuning fleets were included in the assessment as fishable biomass indices (aggregated over all age) (Figure 18.18). The Belgian and French index follow the same trend with the exception of the last data year (2020) where the Belgian index gives an increase and the French index a further decrease. The UK commercial index gives information back up to 1986 and shows an opposite trend around 2005 and in 2008–2014 compared to the Belgian and French index. The opposite trends could be explained by the specific area where the UK beam trawl fleet is fishing (along the southern English coasts). In recent years, trends are similar.

The survey tuning fleets are included as age-disaggregated indices, with the UK beam trawl survey (BTS) providing information from age 1–6 and the UK and French Young fish surveys for age 1 (Figure 18.19).

18.2.4.1 Belgian commercial beam trawl LPUE index

For the Belgian index (2004–present), both the data and method to derive a tuning series were revised. In consistence with the correction of the Belgian catch data, the index was calculated using data from fishing trips in which fishing activity, as registered in the electronic logbooks, was restricted to the eastern English Channel (division 27.7d). To reduce the noise generated by the unbalanced sampling design of the logbook data, only observations from (*i*) fishing vessels that fished at least 5 years in the eastern English Channel, and (*ii*) ICES statistical rectangles that where fished at least twice per year on average during the study period (2004–2019), were included in the analysis.

The statistical model used to standardize the landings and effort data was also modified. A logistic regression was applied to model the presence/absence of sole in the landings, whereas a lognormal model was used to standardize the positive catch rate. Both models included an intercept, a seasonal trend, and annual trend. The seasonal trend was introduced by means of a penalized smoothing spline and constrained to be cyclic. To reduce the number of parameters, the same seasonal model was used for both the presence/absence and positive catch rate model. The annual trend in both models was assumed to be a first order autoregressive process such that the year effects in both models were estimated as random effects. The model for the positive catch also included random effects (IID) on the ICES statistical rectangles and vessel reference number to account for respectively, spatial variation, and variation caused by skipper effects or technical characteristics of the vessel. Finally, an index was derived by multiplying the probability of having a positive catch, and the expected positive catch rate for each year (Table 18.7).

18.2.4.2 French commercial otter trawl LPUE index

Prior to the WKNSEA 2017 benchmark, no French commercial tuning series was included in the assessment. During the WKNSEA 2017 benchmark, a raw LPUE index was calculated based on the OTB_DEF_70-99 fleet, which targets sole seasonally and mainly along the French coast. During the WKNSEA 2021 benchmark, this index was also recalculated according to the revision of the French catch data and a model was applied (ICES, 2021). To account for dependencies in the landings and effort data, the new FRA commercial otter trawl index was developed (2005-present) based on a selected number of vessels practicing the OTB_DEF_70_99 métier. Only vessels accounting for the top 95% sole landings of OTB_DEF_70-99 were kept in the analysis and they had to be active in the fishery at least two thirds of the time series (*i.e.* 10 years as of 2019).

To standardize the LPUE, a hurdle lognormal mixed model (occurrence and lognormal model) is used to correct for vessels, seasonality and spatial effects. The best hurdle model formulation used a first order random walk to fit temporal trends in the main year effect and the spatio-temporal interaction, and the spatial correlation is constrained by a neighbourhood structure using a Besag model. The biomass index is shown in Table 18.8.

18.2.4.3 UK commercial beam trawl LPUE index

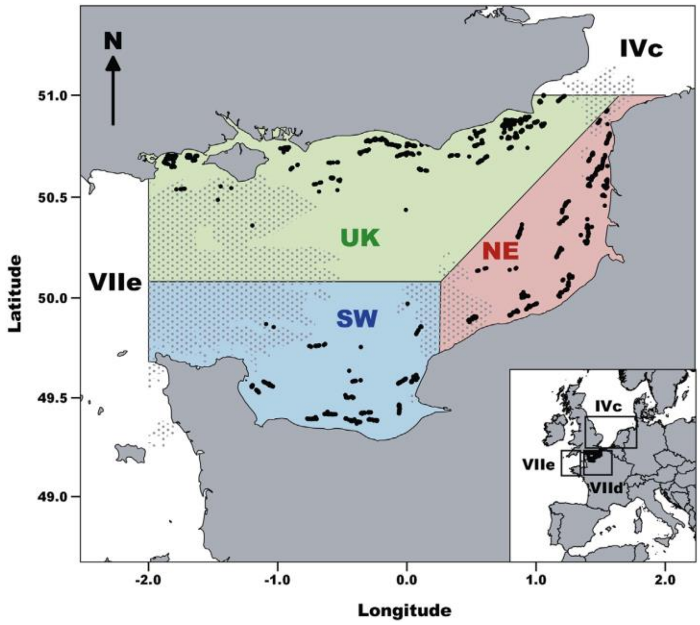
Due to database issues, it was no longer possible to provide an LPUE index based on kW. fishing hours for the UK CBT. The new index is a modelled landings per activity days index from 1986–present (ICES, 2019; Table 18.9).

18.2.4.4 Survey tuning indices

The UK BTS (Table 18.10) tracks the year classes reasonably well and shows a good internal consistency (Figure 18.20). The UK BTS index has an erratic pattern with large variation from year to year (Figure 18.19). The French YFS (Table 18.12) shows a rather constant and low index in the period 2014–2018. In 2019 and 2020 an increase in recruitment is measured concurring the increase of the UK BTS. Note that the spatial coverage of both tuning fleets is quite different. The UK BTS covers most of the coastal areas of Division 27.7.d, while the FRA YFS is confined in the

Somme estuary (see stock annex). The UK YFS (Table 18.11) stopped in 2006 and was situated along the southern English coasts.

During the WKNSEA 2021 benchmark, evidence for the presence of three subpopulations was investigated (Lecomte *et al.*, 2020; Randon *et al.*, 2018, 2020; indicated on map below). The UK BTS data was further analysed and higher abundances of sole were found in the south-western population (Seine Bay), followed by the northern UK subpopulation (especially age 1–3). Lowest abundances were found in the French NE subpopulation, where the FRA YFS takes place. Nevertheless, trends over all subpopulations were similar with only minor differences in most recent years. Considering the UK BTS is concentrated in the coastal zones and in quarter 3, further investigation is necessary considering the dynamics of these subpopulations and their impact on the overall stock (ICES, 2021).



18.3 Analyses of stock trends/Assessment

18.3.1 Review of last year's assessment

During WGNSSK working groups, several issues had been encountered with this stock resulting in an inter-benchmark in 2019, a benchmark in 2020 and another benchmark in 2021. During WGNSSK 2020, the XSA assessment was not considered reliable in absolute terms, but it was perceived indicative of trends. Therefore, category 3 advice was provided using the 2 over 3 rule applied to the SSB estimates. The audit of last year's assessment was completed and no significant issues were found. Minor changes were made prior to the ADG North Sea. The ADG requested to add some extra tables to fully understand the issues with this stock in this case concerning the large stock numbers for the older ages.

18.3.2 Final assessment

During the WKNSEA 2021 benchmark, the XSA framework was replaced by a SAM model to run the sole in Division 27.7d assessment (ICES, 2021).

The SAM model input and configuration are shown in the table below and in Figure 18.21 and Table 18.13.

Settings	
Model	SAM
First data year	1982
Last data year	2020
Ages	1–11+
Plus group	Yes
Stock weights-at-age	Q1 catch weight-at-age; reconstructed for 1982-2003
Discards Numbers- and weight-at-age	Reconstructed for 1982-2003
Abundance indices	Commercial: BEL CBT LPUE (2004-present); FRA COTB LPUE (2005-present); UK CBT LPUE (1986-present)
	Survey: UK (E&W) BTS (1989-present); UK YFS (1987-2006); FRA YFS (1987-present)
Natural mortality	0.1
Maturity ogive	Age1 = 0.00; Age2 = 0.53; Age3 = 0.92; Age4 = 0.96; Age5 = 0.97; Age6-11+ = 1.00
Number of parameters describing F-at-age in catch (keyLogFsta) (columns represent ages)	0 1 2 3 4 5 5 6 6 7 7 (catch)
Correlation of F across ages (corFlag)	0 (independent)
Number of parameters describing F-at-age in surveys (keyLogFpar) (columns represent ages)	0 (BEL CBT LPUE; FSB) 1 (UK CBT LPUE; FSB) 2 (FRA COTB LPUE; FSB) 3 4 5 6 7 7 (UK BTS; age 1 -6) 8 (UK YFS; age 1) 9 (FRA YFS; age 1)
Density dependent catchability power parameters (keyQpow)	None
Coupling of process variance parameters for F (keyVarF)	0 0 0 0 0 0 0 0 0 0 0
Coupling of process variance parameters for log(N) (keyVarLogN)	0 1 1 1 1 1 1 1 1 1 1
Coupling of variance parameters on the observations (keyVarObs) (columns represent ages)	0 1 2 2 2 2 2 2 2 2 2 (catch; age 1 – 11+) 3 (BEL CBT LPUE; FSB) 4 (UK CBT LPUE; FSB) 5 (FRA COTB LPUE; FSB) 6 7 8 8 8 8 (UK BTS; age 1 - 6) 9 (UK YFS; age 1) 10 (FRA YFS; age 1)
Covariance structure per fleet (obsCorStruct) (columns represent fleets: catch, BEL CBT LPUE, UK CBT LPUE, FRA COTB LPUE, UK BTS, UK YFS, FRA YFS) ID = independent AR = autocorrelated	AR ID ID ID AR ID ID
Coupling of correlation parameters (keyCorObs) (columns represent ages)	0 1 1 1 1 1 1 1 1 1 (catch; age 1/2 – 10/11+) 2 3 3 3 3 (UK BTS; age 1/2 – age 5/6)

Stock recruitment code (stockRecruitmentModelCode)	0 (random walk)
Number of years where catch scaling is applied (noScaledYears)	None
Vector of years where catch scaling is applied (keyScaledYears)	None
Matrix specifying coupling of scale parameters (keyParScaledYA)	None
Fbar ranges	3-7
Type of biomass index (keyBiomassTreat)	2 (fishable stock biomass, FSB)
Option for observational likelihood (obsLikelihoodFlag)	LN LN LN LN LN LN LN
Treatment for weight attribute (fixVarToWeight)	/
Fraction of t(3) distribution used in log(F) increment distribution	/
Fraction of t(3) distribution used in log(N) increment distribution	/
Vector describing fraction for fleets (fracMixObs)	/
Vector describing break year between recruitment (constRecBreaks)	/
Coupling of parameters used in prediction-variance link for observations (predVarObsLink)	None

The SAM model fitting diagnostics and survey catchabilities are shown in Table 18.14 and Table 18.15 respectively. The assessment summary is given in Table 18.16 and Figure 18.22.

The *catches* predicted by SAM corroborate the observed catches, except for the period 1995–2000 and 2005–2010 where SAM estimates the catches to be significantly lower in some years. In the final years of the assessment, the estimated catches are higher than the observed catches.

The model estimates that the *SSB* ranged between 10 000 and 17 000 tonnes during the period 1982–2020. In the most recent years, the SSB estimated to be at one of its lowest levels since the start of the observations. SSB in 2019 was high for ages 3 and 5 (Table 18.19). However, in 2020, SSB was highest for ages 2 and 3 as a result of the 2018-year class entering the mature population and for age 4 as a continuation of the high SSB estimate for age 3 in 2019.

The *fishing mortality* (F_{bar}) remained rather stable over time with values ranging between ~0.4 and ~0.44. Since 2010, F_{bar} has gradually declined, from ~0.40, to ~0.336 in 2020, the lowest level of the time series. The *fishing mortality-at-age* shows that the age 1 group is hardly caught by the fishery (Figure 18.23; Table 18.18), which is in strong contrast with all other age groups. The highest fishing mortality is exerted on age groups 3 to 11. Nevertheless, the F-at-age shows that the selectivity of the fishery changed remarkably over time. Before 2005, fishing mortality was always highest for age groups 3, 4 and 5, while in the most recent years, fishing mortality for these ages declined strongly to the level of fishing mortality for age groups 6 to 11+. In contrast, the fishing mortality for ages 6 and 7 remained rather stable over time, while fishing mortality increased for ages 8-11+.

The *recruitment* (age 1) is estimated to range between 12 000 and 43 000 individuals, and does not show clear trends over time. Since the large recruitment in 2010, recruitment has been low, with the exception of the recruitment in 2019. Stock numbers show the larger 2018-year class at age 1 in 2019 and age 2 in 2020 (Table 18.17)

The process residuals do not indicate any problems with respect to the model configuration (Figure 18.24).

The one step ahead residuals for the catch data do not indicate strong patterns within the ages, except for age 2 and 3 (Figure 18.25). The same pattern is visible in the OSA residuals for the UK-BTS data. In addition, the UK-BTS data indicate a clear bias in the most recent years for all age groups. Additionally, the UK CBT index shows some clear patterns over the years, which could be explained by the different trend this index shows compared to the other commercial tuning fleets.

The retrospective analysis does not indicate large problems with the model with respect to the SSB, Fbar and recruitment estimates (Figure 18.26). All peels fall within the confidence bounds and Mohn's Rho values are within limits as defined at WKFORBIAS (Mohn's Rho SSB = 0.090; Fbar = -0.0070 and recruitment = 0.150; ICES, 2020).

The leave-one-out runs indicates no strong dependency for one of the tuning fleets (Figure 18.27). However, removing the UK BTS gives a lower SSB and higher F_{bar}, but all within the levels of confidence.

Figure 18.28 gives the model summary compared to the final outcome from the WKNSEA 2021 benchmark. SSB is estimated lower and F_{bar} is estimated higher than during the benchmark.

18.3.3 Historical stock trends

Trends in catch, SSB, F_{bar} and recruitment are presented in Table 18.16 and Figure 18.29.

Catches have been fluctuating around 4000 tonnes up to the year 2000. Catches fluctuating around 5000 tonnes were registered for the period 2000–2014. From 2015 onwards catches dropped below 4000 tonnes and dropped further below 3000 tonnes in 2016 and below 2000 tonnes in 2020 (1971 tonnes).

The *spawning-stock biomass* (SSB) has been fluctuating without trend since the 1980s between MSY $B_{trigger}$ and B_{lim}. In 2019, the SSB (10 936 tonnes) was just above B_{lim} (10 811 tonnes). In 2020, SSB increased to 11 394 tonnes. In 2021, SSB is estimated to have increased to 14 461 tonnes, which is just below MSY $B_{trigger}$ (15 135 tonnes), as a result of the stronger 2018-year class ending up in the mature part of the population.

Fishing mortality (F) has been fluctuating around F_{lim} (0.422) for the major part of the time series (1982–2009). From 2010 onwards, F decreased to below F_{pa} (0.379), however still remaining far above F_{MSY} (0.193) but reaching its lowest point of the time series in 2020 (0.336).

Recruitment has been fluctuating without trend with occasional strong year classes. After a period of very low recruitment (2012–2016), recruitment increased with one of the strongest year classes coming in in 2018.

18.4 Short-term forecast

Since the last benchmark (WKNSEA 2021), the short term forecast of sole in Division 27.7d is performed using the *stockassessment* package. Stock weights-at-age for the next three years were assumed to be the mean stock weight-at-age of the last five years (2016–2020). Selectivity of the fishery for the next three years was assumed to be the mean selectivity of the last five years (2016–2020). Recruitment in the future years is resampled from the entire past recruitment estimates except for the last year (1982–2019). A stochastic forecast was conducted implying that the projections of the numbers and fishing mortality-at-age are characterized by process noise. The number of simulations was set at 5001.

The fishing mortality (F_{bar}) estimated in the last data year (2020) was used to project the stock into 2021.

There are two options to set the fishing mortality of the intermediate year: 1) F status quo (F_{sq}) 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. Both options were explored.

1. F_{sq}:
If the F shows an increasing or decreasing trend in the last three years, the F_{sq} should be scaled to the last data year (*i.e.* 2020). According to Figure 18.22 and Table 18.16, there is a decreasing trend in F over the last three years (relative F_{2018} = 0.339, F_{2019} = 0.3362, F_{2020} = 0.3356). Therefore, F in the intermediate year (2021) is set to 0.336 (=F_{2020} rounded) (see table below).

SSB 2022	F_{bar} (age 3–7)	F_{dis}	F_{lan}	recruits (age 1; thousands)
14352 t	0.336	0.042	0.294	23489
landings	**discards**	**catch**	**TAC**	**Catch advice 2021**
3330 t	411 t	3741 t	?	3248 t

However, the SSB in 2022 was below MSY $B_{trigger}$, which means that according to the ICES advice rule, F_{MSY} (for the advice year) should be rescaled to F_{MSY} × SSB 2022 / MSY $B_{trigger}$, in this case 0.183 (MSY approach). This resulted in a catch advice for 2022 of 2196 tonnes.

The output of the forecast, for the F_{sq} option (scaled to the last data year), is shown in the table below.

basis	catch	landings	discards	$F_{3–7}$	F_lan	F_dis	SSB 2022	SSB 2023	SSB change	Advice change
F_{target}	2196	1973	223	0.183	0.16	0.023	14352	16062	11.9%	-32%
F_{MSY}	2305	2070	235	0.193	0.169	0.024	14352	15934	11.0%	-29%
F_{MSY_lower}	1400	1259	141	0.113	0.099	0.014	14352	17020	18.6%	-57%
F_{MSY_upper}	3710	3330	380	0.331	0.29	0.041	14352	14278	-0.52%	14.2%
F = 0	0	0	0	0	0	0	14352	18681	30%	-100%
F_{pa}	4160	3733	427	0.379	0.332	0.047	14352	13748	-4.2%	28%
F_{lim}	4546	4077	469	0.422	0.369	0.053	14352	13306	-7.3%	40%
SSB = B_{pa}	2985	2682	303	0.258	0.225	0.033	14352	15135	5.5%	-8.1%
SSB = B_{lim}	6653	5942	711	0.691	0.605	0.086	14352	10811	-25%	105%

However, this resulted in an estimated catch in 2021 of 3741 tonnes. This means overshooting the previous advice for 2021 (3248 tonnes) with 15.1%. This is unrealistic given that the TAC in 2020 was undershot by 30%. Therefore, the TAC constraint option was preferred.

2. $F_{TAC\ constraint}$:
Given the absence of a TAC for the whole year (2021), the TAC for this option was assumed to be equal to the catch advice for 2021 (3248 tonnes). If we assume the advised catch will be fished in 2021, the F in the intermediate year (2021) should be 0.284 (see table below).

SSB 2022	$F_{3–7}$	F_dis	F_lan	recruits (age 1; thousands)
14945	0.284	0.035	0.249	23489
landings	**discards**	**catch**	**TAC**	**Catch advice 2021**
2894	354	3248	?	3248

However, the SSB in 2022 was below MSY $B_{trigger}$, which means that according to the ICES advice rule, F_{MSY} (for the advice year) should be rescaled to F_{MSY} × SSB 2022 / MSY $B_{trigger}$, in this case 0.191 (MSY approach). This resulted in a catch advice for 2022 of 2380 tonnes.

The output of the forecast, for the F $_{TAC\ constraint}$ option, is shown in the table below.

basis	catch	landings	discards	F3–7	F_lan	F_dis	SSB 2022	SSB 2023	SSB change	Advice change
F_{target}	2380	2139	241	0.191	0.167	0.024	14945	16450	10.1%	-27%
F_{MSY}	2407	2164	243	0.193	0.169	0.024	14945	16418	9.9%	-26%
F_{MSY_lower}	1462	1315	147	0.113	0.099	0.014	14945	17528	17.3%	-55%
F_{MSY_upper}	3877	3480	397	0.331	0.29	0.041	14945	14693	-1.69%	19.4%
F = 0	0	0	0	0	0	0	14945	19250	29%	-100%
F_{pa}	4347	3899	448	0.379	0.33	0.047	14945	14159	-5.3%	34%
F_{lim}	4751	4260	491	0.422	0.37	0.052	14945	13697	-8.4%	46%
SSB = B_{pa}	3500	3144	356	0.29	0.26	0.037	14945	15135	1.27%	7.8%
SSB = B_{lim}	7227	6458	769	0.73	0.64	0.091	14945	10811	-28%	123%

The catch advice for 2022 is 2380 tonnes, which is a 27% decrease compared to the catch advice for 2021 (3248 tonnes). This decrease in advice is the result of a downward revision of the SSB and an upward revision of the fishing mortality as a result of the WKNSEA benchmark (ICES, 2021).

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 WKNSEA 2021 benchmark (ICES, 2021).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	15135	B_{pa}; in tonnes.	ICES (2021)
	F_{MSY}	0.193	Stochastic simulations (EqSim) with segmented regression fixed at B_{lim} based on recruitment period 1982–2018.	ICES (2021)
Precautionary approach	B_{lim}	10811	B_{loss}, lowest observed SSB (1999) with 2019 as the last year of catch data; in tonnes.	ICES (2021)
	B_{pa}	15135	B_{lim} × 1.4; in tonnes.	ICES (2021)
	F_{lim}	0.422	The F that on average leads to B_{lim} from EqSim.	ICES (2021)
	F_{pa}	0.379	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with AR)	ICES (2021)
F_{MSY} ranges	F_{lower}	0.113–0.193	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}	ICES (2016, 2021)
	F_{upper}	0.193–0.331	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}	ICES (2016, 2021)

18.6 Quality of the assessment

The sole in Division 27.7d stock was thoroughly reviewed during the WKNSEA 2021 benchmark (ICES, 2021). This is the first assessment and advice since this benchmark. No significant issues were encountered.

18.7 Benchmark issue list

18.7.1 Data issues

During the benchmark, it was noted that sole in Division 27.7d exhibited a declining trend in the in the weights and lengths-at-age in recent years and more apparent in the older ages. It is not clear what mechanism is driving such decline. Future work should look into the potential causes for this declining trend.

Maturity estimates were not investigated during the last benchmark (WKNSEA 2021; ICES, 2021). Therefore, maturity estimates as calculated during the WKNSEA 2017 benchmark are used. These are derived from both commercial landings and survey data. Using commercial data could potentially introduce bias. When maturity estimates are revised, only fishery independent data should be considered (if available) to ensure that they align with contemporary stock dynamics. Future work should also revisit growth and natural mortality. However, for the latter data are currently inadequate (Lecomte *et al.*, 2020).

The subpopulation structure in this stock should be investigated further.

To improve estimation of discards in the assessment, discard mortality by gear type could be considered.

18.7.2 Assessment issues

Biological and environmental processes should be explored for potential use in a model.

18.7.3 Short-term forecast issues

Currently no issues.

18.8 Management considerations

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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Table 18.1: Sole 27.7.d - Official landings (tonnes) by country over the period 1974–2020; 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. * including BMS

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	196	
1983	502	1120	419		2041	3458	101	
1984	592	1309	505		2406	3575	141	
1985	568	2545	520		3633	3837	242	
1986	858	1528	551		2937	3932	145	
1987	1100	2086	655		3841	4791	197	3850
1988	667	2057	578		3302	3853	198	3850
1989	646	1610	689		2945	3805	192	3850
1990	996	1255	785		3036	3647	342	3850
1991	904	2054	826		3784	4351	368	3850
1992	891	2187	706	10	3794	4072	275	3500
1993	917	2322	610	13	3862	4299	273	3200
1994	940	2382	701	15	4038	4383	122	3800
1995	817	2248	669	9	3743	4420	282	3800
1996	899	2322	877		4098	4797	174	3500
1997	1306	1702	933		3941	4764	147	5230
1998	541	1703	803		3047	3363	127	5230
1999	880	2251	769		3900	4135	247	4700
2000	1021	2190	621		3832	3476	201	4100
2001	1313	2482	822		4617	4025	317	4600
2002	1643	2780	976		5399	4733	444	5200
2003	1657	3475	1114	1	6247	6977	584	5400
2004	1485	3070	1112		5667	5819	258	5900
2005	1221	2832	567		4620	4748	344	5700
2006	1547	2627	658	0.000	4832	4830	315	5720
2007	1530	2981	801	1.000	5313	5421	332	6220
2008	1368	2880	724	0.000	4972	4963	183	6593
2009	1475	3047	760	0.000	5282	4828	287	5274
2010	1294	2476	679	0.000	4449	4108	273	4219

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
2011	1222	2281	700	0.000	4203	4136	342	4852
2012	941	2475	627	0.250	4043	4058	445	5580
2013	952	2884	605	0.000	4441	4295	180	5900
2014	1496	2507	648	0.100	4651	4626	216	4838
2015	1048	1895	468	0.000	3411	3385	263	3483
2016	799	1337	392	0.044	2528	2433	106	3258
2017	697	1178	349	0.154	2224	2090	156	2724
2018	653	1265	394	0.180	2312	2395	263	3405
2019	603*	914	245*	0.043	1762	1648	404	2515
2020	686*	827	193*	0.058	1706	1562	409*	2797

Table 18.2: Sole 27.7.d - Summary of the InterCatch data in 2020 (imported vs. raised data; sampled vs. estimated data)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	1289	82
Landings	Imported_Data	Estimated_Distribution	273.8	18
Discards	Imported_Data	Sampled_Distribution	146.8	36
Discards	Imported_Data	Estimated_Distribution	72.55	18
Discards	Raised_Discards	Estimated_Distribution	188.9	46
BMS landing	Imported_Data	Estimated_Distribution	0.247	100

Table 18.3: Sole 27.7.d - Landings percentages by gear type for 2015–2020 (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB/OTT/SSC/SDN = otter trawls and seines)

Landings by gear	2015	2016	2017	2018	2019	2020
GNS/GTR	47%	46%	46%	44%	33%	28%
TBB	35%	34%	31%	28%	33%	36%
OTB/OTT/SSC/SDN	15.1%	15.9%	17.6%	24%	30%	33%
Other	3.8%	4.5%	4.7%	4.5%	3.7%	2.8%

Table 18.4: Sole 27.7.d - Catch numbers at age (in thousands)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	375	0	59	122	122	22	236	405	3092	952	261	211	77
2	3432	1136	2630	4961	1685	4197	2910	4686	3836	9646	5446	6769	934
3	5688	3812	3476	5795	5904	4158	7995	3586	6214	4575	9794	7179	6912
4	1710	3971	2630	1675	3259	3336	1633	4482	1172	4242	1925	5551	6017
5	558	895	1890	1032	911	2068	1167	1443	1505	608	2006	1015	3427
6	636	731	736	1863	771	1046	859	842	302	1000	289	565	586
7	535	624	454	145	1062	1095	390	574	392	258	370	163	570
8	233	330	313	158	155	785	255	201	260	247	135	188	109
9	118	107	134	156	190	111	256	166	129	258	171	116	147
10	81	88	98	69	212	163	83	224	126	92	95	62	93
11+	196	191	235	128	372	459	275	282	489	382	231	129	258

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	2082	22	60	82	417	343	418	1756	57	121	771	412	168
2	4006	2456	2004	1855	4395	4831	8136	9431	15482	4164	6957	6942	7620
3	4874	8650	6761	6259	9470	5412	6905	8367	10669	11013	5185	4285	8307
4	4857	3094	5106	2761	3369	4485	1627	3839	4069	3682	4777	3097	3169
5	2987	3227	2096	1649	1319	1084	2509	1422	2168	4595	1256	3316	1794
6	1986	1830	1676	612	871	507	731	657	656	1670	920	1207	2769
7	377	1289	920	562	352	320	291	299	2068	379	636	1128	1010
8	278	271	776	443	672	148	128	129	229	394	392	579	753
9	88	319	239	354	351	328	56	97	73	291	211	239	450
10	106	112	169	239	192	150	81	57	134	254	104	233	194
11+	241	344	267	301	359	248	265	197	285	443	266	383	473

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	826	1270	585	353	739	40	372	300	144	565	1643	664	7
2	2872	4446	5827	6148	3759	1150	1244	2131	1145	1060	3378	2341	2736
3	8562	4494	4255	6938	8544	5951	3502	2101	2185	2467	1846	3086	2683
4	5679	6164	2953	2854	5253	6595	6639	2303	1253	1447	2626	1086	2223
5	1452	2500	3034	1562	1433	2539	4259	3496	1308	826	1022	1476	812
6	1086	808	1621	1469	930	762	1853	2555	1553	876	736	481	915
7	758	719	320	562	563	545	687	1194	1059	850	619	312	427
8	410	664	277	178	414	535	417	463	598	698	821	227	166
9	157	277	288	147	98	205	374	142	188	287	451	392	131
10	168	239	102	132	46	59	145	238	211	139	286	282	182
11+	276	425	376	179	259	129	255	272	322	194	292	230	331

Table 18.5: Sole 27.7.d - Catch weights at age (kg)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.078	0.000	0.076	0.068	0.103	0.073	0.078	0.081	0.091	0.087	0.078	0.065	0.076
2	0.155	0.157	0.162	0.166	0.164	0.159	0.138	0.140	0.162	0.146	0.139	0.134	0.136
3	0.215	0.220	0.224	0.220	0.203	0.226	0.216	0.184	0.228	0.199	0.194	0.189	0.178
4	0.309	0.299	0.311	0.279	0.303	0.292	0.276	0.269	0.287	0.264	0.265	0.245	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	0.427	0.435	0.435	0.393	0.386	0.406	0.408	0.357	0.339	0.393	0.402	0.383	0.354
7	0.439	0.434	0.416	0.515	0.436	0.410	0.458	0.387	0.469	0.421	0.390	0.536	0.380
8	0.509	0.524	0.538	0.543	0.520	0.482	0.514	0.472	0.465	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+	0.672	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	0.099	0.109	0.106	0.101	0.099	0.110	0.082	0.091	0.101	0.097	0.123	0.133	0.095
2	0.160	0.150	0.139	0.145	0.137	0.129	0.138	0.147	0.148	0.147	0.158	0.150	0.158
3	0.171	0.170	0.180	0.165	0.181	0.169	0.202	0.195	0.218	0.181	0.191	0.192	0.175
4	0.228	0.227	0.231	0.233	0.213	0.221	0.281	0.251	0.286	0.238	0.262	0.233	0.201
5	0.254	0.268	0.291	0.285	0.259	0.331	0.287	0.315	0.365	0.269	0.353	0.286	0.267
6	0.332	0.323	0.342	0.343	0.280	0.376	0.333	0.375	0.407	0.293	0.434	0.338	0.280
7	0.356	0.360	0.389	0.382	0.290	0.424	0.367	0.376	0.165	0.410	0.455	0.394	0.339
8	0.385	0.405	0.404	0.417	0.341	0.427	0.374	0.393	0.474	0.449	0.490	0.425	0.387
9	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.424	0.390	0.566	0.562	0.452
10	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.504	0.487	0.648	0.497	0.424
11+	0.654	0.585	0.651	0.616	0.535	0.680	0.544	0.531	0.565	0.664	0.550	0.552	0.570

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.121	0.113	0.101	0.089	0.058	0.095	0.098	0.077	0.093	0.094	0.081	0.058	0.091
2	0.156	0.155	0.152	0.148	0.121	0.141	0.134	0.127	0.136	0.143	0.121	0.118	0.114
3	0.207	0.201	0.192	0.201	0.181	0.189	0.176	0.168	0.199	0.184	0.171	0.175	0.152
4	0.243	0.252	0.241	0.245	0.233	0.241	0.231	0.223	0.242	0.229	0.214	0.230	0.197
5	0.258	0.268	0.276	0.301	0.270	0.297	0.267	0.266	0.266	0.252	0.268	0.244	0.224
6	0.311	0.322	0.322	0.330	0.312	0.301	0.325	0.282	0.285	0.291	0.289	0.274	0.243
7	0.370	0.316	0.334	0.357	0.375	0.384	0.328	0.330	0.320	0.293	0.289	0.290	0.271
8	0.397	0.383	0.337	0.424	0.354	0.402	0.389	0.329	0.371	0.362	0.250	0.318	0.312
9	0.433	0.383	0.367	0.389	0.424	0.415	0.413	0.408	0.361	0.432	0.327	0.272	0.382
10	0.511	0.430	0.520	0.425	0.544	0.463	0.494	0.372	0.358	0.479	0.362	0.338	0.285
11+	0.509	0.484	0.502	0.534	0.521	0.572	0.527	0.480	0.436	0.525	0.409	0.394	0.417

Table 18.6: Sole 27.7.d - Stock weights at age (kg)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.077	0.078	0.075	0.067	0.102	0.072	0.077	0.080	0.090	0.086	0.077	0.064	0.075	0.098	0.108
2	0.167	0.169	0.175	0.179	0.177	0.172	0.149	0.151	0.175	0.157	0.150	0.145	0.147	0.173	0.162
3	0.243	0.248	0.253	0.248	0.229	0.255	0.244	0.208	0.257	0.225	0.219	0.213	0.201	0.193	0.192
4	0.352	0.340	0.354	0.318	0.345	0.332	0.314	0.306	0.327	0.301	0.302	0.279	0.265	0.260	0.258
5	0.424	0.444	0.417	0.404	0.399	0.388	0.395	0.322	0.383	0.389	0.318	0.368	0.316	0.280	0.295
6	0.472	0.481	0.481	0.435	0.427	0.449	0.451	0.395	0.375	0.435	0.445	0.424	0.392	0.367	0.357
7	0.488	0.482	0.462	0.572	0.485	0.456	0.509	0.430	0.521	0.468	0.434	0.596	0.422	0.396	0.400
8	0.441	0.454	0.466	0.471	0.451	0.418	0.445	0.409	0.403	0.373	0.400	0.479	0.438	0.334	0.351
9	0.486	0.520	0.512	0.575	0.486	0.450	0.536	0.499	0.472	0.420	0.445	0.499	0.469	0.475	0.421
10	0.481	0.606	0.587	0.618	0.543	0.559	0.585	0.568	0.538	0.497	0.481	0.796	0.515	0.513	0.483
11+	0.720	0.676	0.766	0.861	0.646	0.662	0.713	0.754	0.604	0.607	0.606	0.718	0.662	0.701	0.629

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.105	0.100	0.098	0.109	0.081	0.090	0.100	0.097	0.123	0.136	0.087	0.115	0.113	0.101	0.089
2	0.150	0.156	0.148	0.139	0.149	0.159	0.160	0.142	0.154	0.142	0.140	0.141	0.148	0.129	0.119
3	0.203	0.186	0.204	0.191	0.228	0.220	0.246	0.179	0.189	0.182	0.168	0.190	0.196	0.193	0.188
4	0.263	0.265	0.242	0.252	0.320	0.286	0.326	0.225	0.262	0.241	0.220	0.246	0.264	0.260	0.250
5	0.320	0.314	0.285	0.365	0.316	0.347	0.402	0.265	0.361	0.316	0.282	0.249	0.288	0.292	0.313
6	0.378	0.379	0.310	0.416	0.368	0.415	0.450	0.285	0.443	0.352	0.315	0.338	0.344	0.363	0.338
7	0.432	0.425	0.322	0.471	0.408	0.418	0.183	0.409	0.466	0.398	0.346	0.333	0.304	0.363	0.371
8	0.350	0.361	0.295	0.370	0.324	0.341	0.411	0.510	0.514	0.465	0.443	0.435	0.438	0.371	0.481
9	0.487	0.469	0.347	0.372	0.477	0.454	0.411	0.391	0.598	0.574	0.496	0.373	0.352	0.421	0.409
10	0.493	0.452	0.389	0.477	0.531	0.436	0.524	0.514	0.704	0.496	0.397	0.713	0.437	0.542	0.458
11+	0.700	0.661	0.577	0.727	0.585	0.569	0.608	0.692	0.588	0.632	0.613	0.472	0.606	0.537	0.561

age	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.057	0.092	0.097	0.075	0.090	0.094	0.081	0.060	0.093
2	0.104	0.104	0.093	0.102	0.101	0.135	0.111	0.104	0.097
3	0.177	0.163	0.144	0.177	0.211	0.176	0.177	0.177	0.142
4	0.228	0.244	0.235	0.244	0.273	0.229	0.247	0.232	0.203
5	0.275	0.339	0.283	0.296	0.294	0.267	0.296	0.272	0.263
6	0.331	0.340	0.346	0.308	0.331	0.305	0.324	0.305	0.273
7	0.387	0.439	0.396	0.373	0.367	0.323	0.343	0.307	0.317
8	0.384	0.416	0.429	0.336	0.448	0.384	0.332	0.352	0.369
9	0.467	0.431	0.442	0.398	0.537	0.478	0.371	0.286	0.459
10	0.548	0.416	0.592	0.380	0.456	0.508	0.407	0.361	0.346
11+	0.573	0.683	0.541	0.519	0.580	0.575	0.463	0.457	0.495

Table 18.7: Sole 27.7.d - Tuning series 1: revised Belgian commercial beam trawl LPUE (2004–2020)

	Effort	Biomass index
2004	1	13.04908383
2005	1	13.17546195
2006	1	14.59174809
2007	1	15.11469609
2008	1	13.95894842
2009	1	17.30446216
2010	1	17.56280957
2011	1	15.69879123
2012	1	16.69190654
2013	1	16.65896094
2014	1	22.50532121
2015	1	16.39183913
2016	1	12.98930787
2017	1	10.84007895
2018	1	11.51739034
2019	1	10.53361895
2020	1	12.01102801

Table 18.8: Sole 27.7.d - Tuning series 2: revised French commercial otter trawl LPUE (2005–2020)

	Effort	Biomass index
2005	1	13.20979756
2006	1	22.10236771
2007	1	17.39759302
2008	1	20.88080129
2009	1	19.00234136
2010	1	24.53120802
2011	1	24.1150877
2012	1	18.56187733
2013	1	20.09457265
2014	1	26.20591323
2015	1	17.83224505
2016	1	16.55529377
2017	1	14.23633031
2018	1	20.00615458
2019	1	15.83889135
2020	1	11.7305773

Table 18.9: Sole 27.7.d - Tuning series 3: UK (E&W) commercial beam trawl LPUE (1986–2020)

	Effort	Biomass index
1986	1	138.2173875
1987	1	143.4966343
1988	1	132.9034081
1989	1	106.0962858
1990	1	108.2129908
1991	1	70.07915692
1992	1	64.44203282
1993	1	53.14439034
1994	1	55.00230316
1995	1	65.06373763
1996	1	90.10348001
1997	1	87.337661
1998	1	99.83572569
1999	1	93.17155489
2000	1	92.08279038
2001	1	96.51608642
2002	1	126.1136216
2003	1	116.4869855
2004	1	123.9681528
2005	1	139.1737988
2006	1	123.7590054
2007	1	119.2396821
2008	1	106.6062563
2009	1	83.80571502
2010	1	85.5590586
2011	1	81.73874661
2012	1	76.38565519
2013	1	80.53872883
2014	1	85.29358112
2015	1	90.707409
2016	1	94.95646532
2017	1	74.44287085
2018	1	75.0577068
2019	1	71.23749144
2020	1	84.99157214

Table 18.10: Sole 27.7.d - Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2020)

	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
2019	1	56.54	31.08	19.53	1.18	4.01	2.53
2020	1	1.87	42.73	8.01	4.62	1.15	1.84

Table 18.11: 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 18.12: Sole 27.7.d - Tuning series 6: French young fish survey (1987–2020) funded by EDF (noursom)

	Effort	Age1
1987	1	0.07
1988	1	0.17
1989	1	0.14
1990	1	0.54
1991	1	0.38
1992	1	0.22
1993	1	0.03
1994	1	0.7
1995	1	0.28
1996	1	0.15
1997	1	0.03
1998	1	0.1
1999	1	0.35
2000	1	0.31
2001	1	1.21
2002	1	0.11
2003	1	0.32
2004	1	0.15
2005	1	0.82
2006	1	0.83
2007	1	0.08
2008	1	0.06
2009	1	2.78
2010	1	0.1
2011	1	0.32
2012	1	0.35
2013	1	0.052
2014	1	0.04
2015	1	0.09
2016	1	0.04
2017	1	0.05
2018	1	0.03
2019	1	0.45
2020	1	0.38

Table 18.13: Sole 27.7.d – SAM model configuration of the 2021 assessment

```
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive

$minAge
# The minimum age class in the assessment
 1
$maxAge
# The maximum age class in the assessment
 11
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1 0 0 0 0 0 0

$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    1    2    3    4    5    5    6    6     7     7
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -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))
 0
$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered
by fishing mortality).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]    0   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]    1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]    2   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]    3    4    5    6    7    7   -1   -1   -1    -1    -1
[6,]    8   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]    9   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$keyQpow
# Density dependent catchability power parameters (if any).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row is used)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    0    0    0    0    0    0    0    0     0     0
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -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 1
$keyVarObs
# Coupling of the variance parameters for the observations.
    [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    1    2    2    2    2    2    2    2     2     2
[2,]    3   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]    4   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]    5   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]    6    7    8    8    8    8   -1   -1   -1    -1    -1
[6,]    9   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   10   -1   -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"
 AR ID ID ID AR 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 10-11
[1,]   0   1   1   1   1   1   1   1    1     1
[2,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[3,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[4,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[5,]   2   3   3   3   3  -1  -1  -1   -1    -1
[6,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[7,]  -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.
 Numeric(0)
$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
<0 x 0 matrix>
$fbarRange
# lowest and highest age included in Fbar
 3 7
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 = SSB index; 1 = catch index; 2 = FSB index; 3 =
total catch; 4 = total landings; 5 = TSB index).
 -1  2  2  2 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 LN 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
$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0


$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0
$fracMixObs
```

```
# A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet
0 0 0 0 0 0 0
$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year is included in the left interval. (This option is only used in combination with stock recruitment code =3)
numeric(0)
$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[3,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[4,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[5,]   -1   -1   -1   -1   -1   -1   NA   NA   NA    NA    NA
[6,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[7,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
```

Table 18.14: Sole 27.7.d – SAM model fitting diagnostics of the 2021 assessment

Model fitting		
log(Lik)	#par	AIC
-449.2736	28	954.5472

Table 18.15: Sole 27.7.d – SAM model survey catchability of the 2021 assessment

estimate	1	2	3	4	5	6	7	8	9	10	11
BE-CBT-LPUE	-4.38001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-CBT	-2.50806	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-COTB-model	-4.13173	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-BTS-Q3	-7.80476	-6.94983	-7.31572	-7.72347	-7.85485	-7.85485	NA	NA	NA	NA	NA
UK(E&W)-YFS	-9.5288	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-YFS	-11.7543	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

sd	1	2	3	4	5	6	7	8	9	10	11
BE-CBT-LPUE	0.06507	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-CBT	0.065116	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-COTB-model	0.075317	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-BTS-Q3	0.18258	0.089625	0.087192	0.085713	0.076772	0.076772	NA	NA	NA	NA	NA
UK(E&W)-YFS	0.141949	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-YFS	0.179673	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 18.16: Sole 27.7.d – Assessment summary

Year	Recruitment			Spawning stock biomass			Landings	Discards*	Fishing mortality		
	Age 1	High	Low	SSB	High	Low			F_{3-7}	High	Low
	thousands			tonnes			tonnes	tonnes			
1982	15632	22170	11023	14114	17111	11641	3190	196	0.40	0.46	0.34
1983	23137	32460	16492	13991	16629	11772	3458	101	0.40	0.46	0.35
1984	22206	31083	15864	13808	16133	11818	3575	141	0.40	0.46	0.36
1985	15173	21224	10848	14128	16393	12176	3837	242	0.41	0.46	0.36
1986	25535	35580	18326	13131	15243	11312	3932	145	0.42	0.46	0.37
1987	12831	17778	9260	12775	14758	11058	4791	197	0.42	0.47	0.38
1988	25102	33863	18608	12393	14313	10731	3853	198	0.42	0.47	0.38
1989	15408	20751	11440	10928	12445	9595	3805	192	0.42	0.47	0.38
1990	41139	55334	30586	11901	13578	10432	3647	342	0.42	0.47	0.38
1991	32382	43459	24129	12301	14039	10779	4351	368	0.42	0.47	0.38
1992	28182	37969	20918	14077	16275	12175	4072	275	0.42	0.46	0.38
1993	12528	16966	9250	15255	17575	13241	4299	273	0.42	0.46	0.38
1994	23215	31262	17239	13343	15365	11587	4383	122	0.42	0.47	0.38
1995	20345	27616	14989	11921	13628	10427	4420	282	0.43	0.47	0.39
1996	19041	25694	14111	11352	12977	9930	4797	174	0.43	0.48	0.39
1997	28876	39703	21001	11062	12589	9720	4764	147	0.43	0.48	0.39
1998	17758	23911	13189	11182	12718	9832	3363	127	0.43	0.48	0.39
1999	31444	42157	23453	10721	12307	9339	4135	247	0.43	0.47	0.39
2000	32596	43715	24305	11910	13538	10479	3476	201	0.42	0.47	0.38
2001	25073	34005	18487	13831	15826	12088	4025	317	0.42	0.46	0.38
2002	40433	54466	30016	14386	16458	12576	4733	444	0.42	0.46	0.38
2003	19167	25610	14344	16063	18397	14026	6977	584	0.42	0.46	0.38
2004	17970	24507	13177	12922	14678	11376	5819	258	0.41	0.46	0.37
2005	41116	54834	30831	13723	15495	12154	4748	344	0.41	0.45	0.37
2006	38375	50564	29124	12979	14641	11506	4830	315	0.41	0.46	0.37
2007	18624	25012	13867	13361	15082	11836	5421	332	0.41	0.46	0.37
2008	21535	28907	16043	13899	15728	12283	4963	183	0.41	0.45	0.36
2009	40926	54879	30521	13436	15206	11872	4828	287	0.40	0.45	0.36
2010	43026	57055	32447	13567	15336	12002	4108	273	0.39	0.44	0.35
2011	36287	49043	26849	14962	16935	13220	4136	342	0.38	0.43	0.34
2012	19886	26939	14680	15595	17717	13727	4058	445	0.37	0.42	0.33
2013	13903	19037	10153	16810	19097	14797	4295	180	0.37	0.41	0.33
2014	18200	24881	13314	14921	17044	13062	4626	216	0.36	0.40	0.32
2015	23489	32327	17067	13282	15178	11623	3385	263	0.35	0.40	0.31
2016	12891	17958	9253	13379	15269	11724	2433	106	0.35	0.40	0.30
2017	26029	36137	18748	11638	13355	10141	2090	156	0.34	0.40	0.29
2018	24297	35158	16790	11206	12976	9676	2395	263	0.34	0.40	0.29

Year	Recruitment			Spawning stock biomass			Landings	Discards*	Fishing mortality		
	Age 1	High	Low	SSB	High	Low			$F_{3\text{-}7}$	High	Low
	thousands			tonnes			tonnes	tonnes			
2019	42617	71280	25480	10936	12842	9313	1648	404	0.34	0.40	0.28
2020	17791	46567	6797	11394	13756	9438	1562	409^	0.34	0.41	0.28
2021	23489**			14461***	19062	11074					

*** Discard estimates prior to 2004 assume the average discard proportion by age for 2004–2008 (WKNSEA; ICES, 2021).**

**** Median recruitment resampled from the years 1982–2019.**

***** Survivors from the assessment**

^ including 247 kg BMS

Table 18.17: Sole 27.7.d – Stock numbers for the 2021 SAM assessment (in thousands).

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	15632	23137	22206	15173	25535	12831	25102	15408	41139	32382	28182	12528	23215	20345	19041
2	19191	13823	20910	20125	13373	23491	11195	23054	13508	37445	28505	26045	11013	20701	17720
3	22564	14083	10247	15626	14797	9776	17544	7935	17317	9895	28050	20903	19617	8535	15671
4	5416	13255	7873	5684	8708	7838	5174	9340	4067	9728	5485	15903	11919	10888	4762
5	3482	2946	7806	4406	3245	4912	4272	2885	5143	2168	5473	3192	9003	6670	6167
6	3354	2344	1829	5420	2855	2068	3028	2537	1667	2962	1277	3136	1924	5232	3915
7	1950	2176	1528	1058	3431	1832	1295	1891	1617	1079	1787	831	2005	1311	3217
8	915	1229	1426	1000	661	2145	1135	809	1191	1027	717	1095	543	1271	898
9	593	619	814	1009	709	457	1447	764	544	804	694	512	722	380	861
10	400	416	434	559	709	500	326	1003	515	362	525	457	353	485	264
11+	957	942	952	966	1098	1280	1232	1091	1464	1341	1136	1100	1069	977	1000

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	28876	17758	31444	32596	25073	40433	19167	17970	41116	38375	18623	21535	40926	43026	36287
2	17302	26892	15670	28330	29239	22455	36622	16976	15529	36738	34818	16570	19097	36165	38850
3	13069	13463	21241	11592	21027	20987	16148	25883	12279	11022	26221	25714	12635	14102	26410
4	8288	6746	7272	12022	6186	11781	11637	8665	14465	7321	6330	15557	16016	7949	8691
5	2692	4502	3658	4126	7076	3664	6903	7003	5049	8430	4272	3493	8838	9301	4691
6	3606	1569	2574	2116	2449	4094	2129	4006	3973	3009	4918	2622	2065	5181	5552
7	2460	2293	995	1577	1323	1558	2716	1420	2485	2476	1903	2853	1586	1249	2957
8	1959	1574	1513	638	991	826	988	1599	977	1582	1493	1188	1729	939	776
9	659	1233	1040	1003	432	682	556	686	1030	659	1046	917	731	1077	561
10	576	474	792	681	641	298	483	401	459	680	435	683	594	446	666
11+	859	964	989	1183	1255	1242	1031	1009	944	942	1075	987	1097	1107	985

age	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	19886	13903	18200	23489	12891	26029	24297	42617	17791
2	32723	17548	12493	16198	21333	11196	23614	21465	38846
3	30069	26610	13830	9792	12294	17041	8452	18227	16413
4	16394	20161	18785	9126	6592	7881	12063	5531	12152
5	5121	9684	12559	11683	5777	4269	4912	7708	3563
6	2952	3193	6032	7755	7105	3595	2780	3151	4808
7	3270	1879	2064	3763	4822	4399	2220	1743	2046
8	1760	2058	1189	1331	2355	3051	2828	1373	1097
9	487	1035	1300	748	841	1491	1958	1828	893
10	328	307	629	830	503	556	972	1285	1172
11+	1073	886	786	900	1066	966	963	1210	1604

Table 18.18: Sole 27.7.d – Fishing mortality (F) at age for the 2021 SAM assessment.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
2	0.203	0.202	0.203	0.205	0.205	0.206	0.206	0.204	0.203	0.200	0.197	0.194	0.189	0.187	0.188
3	0.464	0.476	0.488	0.498	0.512	0.518	0.520	0.515	0.503	0.496	0.488	0.489	0.499	0.515	0.526
4	0.484	0.474	0.474	0.473	0.477	0.480	0.479	0.483	0.483	0.482	0.478	0.479	0.484	0.482	0.486
5	0.326	0.334	0.335	0.346	0.362	0.380	0.398	0.416	0.425	0.427	0.435	0.437	0.438	0.442	0.445
6	0.352	0.354	0.363	0.362	0.364	0.367	0.362	0.355	0.350	0.350	0.346	0.344	0.348	0.351	0.356
7	0.352	0.354	0.363	0.362	0.364	0.367	0.362	0.355	0.350	0.350	0.346	0.344	0.348	0.351	0.356
8	0.269	0.268	0.266	0.267	0.267	0.268	0.273	0.281	0.288	0.294	0.295	0.295	0.291	0.292	0.295
9	0.269	0.268	0.266	0.267	0.267	0.268	0.273	0.281	0.288	0.294	0.295	0.295	0.291	0.292	0.295
10	0.269	0.270	0.271	0.269	0.276	0.281	0.282	0.283	0.284	0.284	0.282	0.282	0.289	0.294	0.300
11+	0.269	0.270	0.271	0.269	0.276	0.281	0.282	0.283	0.284	0.284	0.282	0.282	0.289	0.294	0.300

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.012
2	0.188	0.191	0.199	0.204	0.212	0.216	0.218	0.217	0.214	0.208	0.201	0.193	0.187	0.180	0.171
3	0.531	0.527	0.511	0.507	0.494	0.488	0.484	0.464	0.443	0.427	0.405	0.389	0.375	0.361	0.345
4	0.485	0.479	0.469	0.453	0.439	0.432	0.429	0.432	0.437	0.444	0.450	0.444	0.440	0.431	0.421
5	0.451	0.446	0.442	0.441	0.448	0.452	0.446	0.444	0.430	0.422	0.414	0.413	0.404	0.400	0.394
6	0.352	0.352	0.353	0.354	0.357	0.355	0.367	0.365	0.371	0.384	0.393	0.394	0.396	0.388	0.380
7	0.352	0.352	0.353	0.354	0.357	0.355	0.367	0.365	0.371	0.384	0.393	0.394	0.396	0.388	0.380
8	0.302	0.306	0.308	0.303	0.290	0.284	0.284	0.302	0.319	0.331	0.345	0.355	0.364	0.373	0.378
9	0.302	0.306	0.308	0.303	0.290	0.284	0.284	0.302	0.319	0.331	0.345	0.355	0.364	0.373	0.378
10	0.304	0.307	0.306	0.306	0.310	0.318	0.330	0.338	0.339	0.341	0.344	0.344	0.341	0.337	0.334
11+	0.304	0.307	0.306	0.306	0.310	0.318	0.330	0.338	0.339	0.341	0.344	0.344	0.341	0.337	0.334

age	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.012	0.012
2	0.163	0.158	0.154	0.153	0.151	0.151	0.151	0.151	0.151
3	0.330	0.317	0.311	0.304	0.299	0.290	0.289	0.286	0.286
4	0.409	0.396	0.386	0.373	0.362	0.357	0.351	0.348	0.344
5	0.386	0.381	0.379	0.374	0.367	0.359	0.358	0.360	0.363
6	0.371	0.365	0.360	0.359	0.355	0.352	0.348	0.343	0.343
7	0.371	0.365	0.360	0.359	0.355	0.352	0.348	0.343	0.343
8	0.376	0.365	0.351	0.338	0.331	0.328	0.323	0.320	0.316
9	0.376	0.365	0.351	0.338	0.331	0.328	0.323	0.320	0.316
10	0.335	0.337	0.342	0.352	0.357	0.354	0.349	0.344	0.341
11+	0.335	0.337	0.342	0.352	0.357	0.354	0.349	0.344	0.341

Table 18.19: Sole 27.7.d – Spawning stock biomass (SSB; tonnes) at age for the 2021 SAM assessment.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1699	1238	1939	1909	1255	2141	884	1845	1253	3116	2266	2002	858	1898	1521
3	5044	3213	2385	3565	3117	2293	3938	1518	4095	2048	5652	4096	3628	1515	2768
4	1830	4327	2676	1735	2884	2498	1560	2744	1277	2811	1590	4260	3032	2718	1180
5	1432	1269	3157	1726	1256	1849	1637	901	1911	818	1688	1140	2760	1812	1765
6	1583	1127	880	2358	1219	928	1366	1002	625	1288	568	1330	754	1920	1398
7	952	1049	706	605	1664	835	659	813	843	505	775	495	846	519	1287
8	403	558	664	471	298	896	505	331	480	383	287	525	238	424	315
9	288	322	417	580	345	206	776	381	257	338	309	255	338	180	363
10	192	252	255	346	385	279	191	570	277	180	252	364	182	249	127
11+	689	637	729	832	709	848	878	823	885	814	689	789	707	685	628

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1375	2223	1229	2087	2309	1892	3106	1278	1267	2765	2583	1238	1498	2473	2450
3	2441	2304	3987	2037	4411	4248	3655	4262	2135	1845	4053	4495	2278	2504	4568
4	2093	1716	1689	2908	1900	3235	3642	1872	3638	1694	1337	3674	4059	1984	2086
5	836	1371	1011	1461	2169	1233	2692	1800	1768	2584	1169	844	2469	2634	1424
6	1363	595	798	880	901	1699	958	1142	1760	1059	1549	886	710	1881	1876
7	1063	975	320	743	540	651	497	581	1158	985	658	950	482	453	1097
8	686	568	446	236	321	282	406	816	502	735	661	517	757	349	373
9	321	578	361	373	206	310	229	268	616	378	519	342	257	453	229
10	284	214	308	325	340	130	253	206	323	337	173	487	259	242	305
11+	601	638	570	860	734	707	627	698	555	595	659	465	665	594	553

age	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0	0	0	0	0	0	0	0	0
2	1804	967	616	876	1142	801	1389	1183	1997
3	4896	3990	1832	1595	2386	2759	1376	2968	2144
4	3588	4722	4238	2138	1728	1733	2860	1232	2368
5	1366	3184	3448	3354	1647	1106	1410	2034	909
6	977	1086	2087	2388	2352	1097	901	961	1312
7	1265	825	817	1404	1770	1421	762	535	649
8	676	856	510	447	1055	1172	939	483	405
9	228	446	575	298	452	713	726	523	410
10	180	128	373	315	229	282	396	464	406
11+	614	605	425	467	618	555	446	553	795

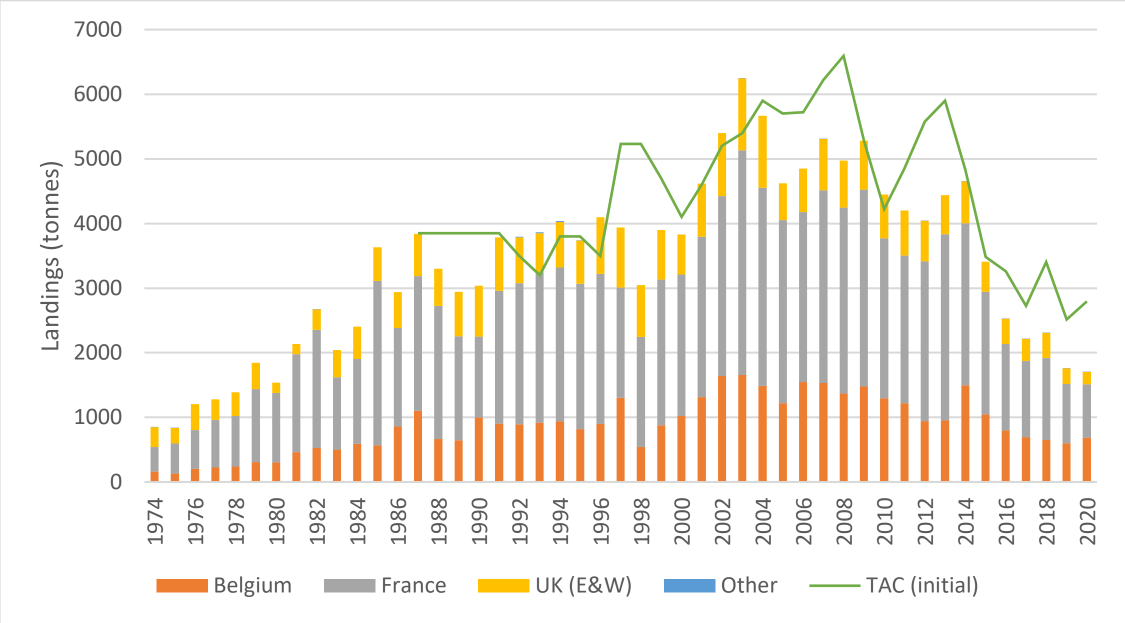

Figure 18.1: Sole 27.7.d - Official landings (tonnes) for sole in Division 27.7.d by country over the period 1974–2020, as officially reported (Rec 12) (stacked barplot; other represents landings from e.g. UK Scotland or The Netherlands); green line represents the official TAC (landings; Note that from 2016 onwards the TAC represents catch).

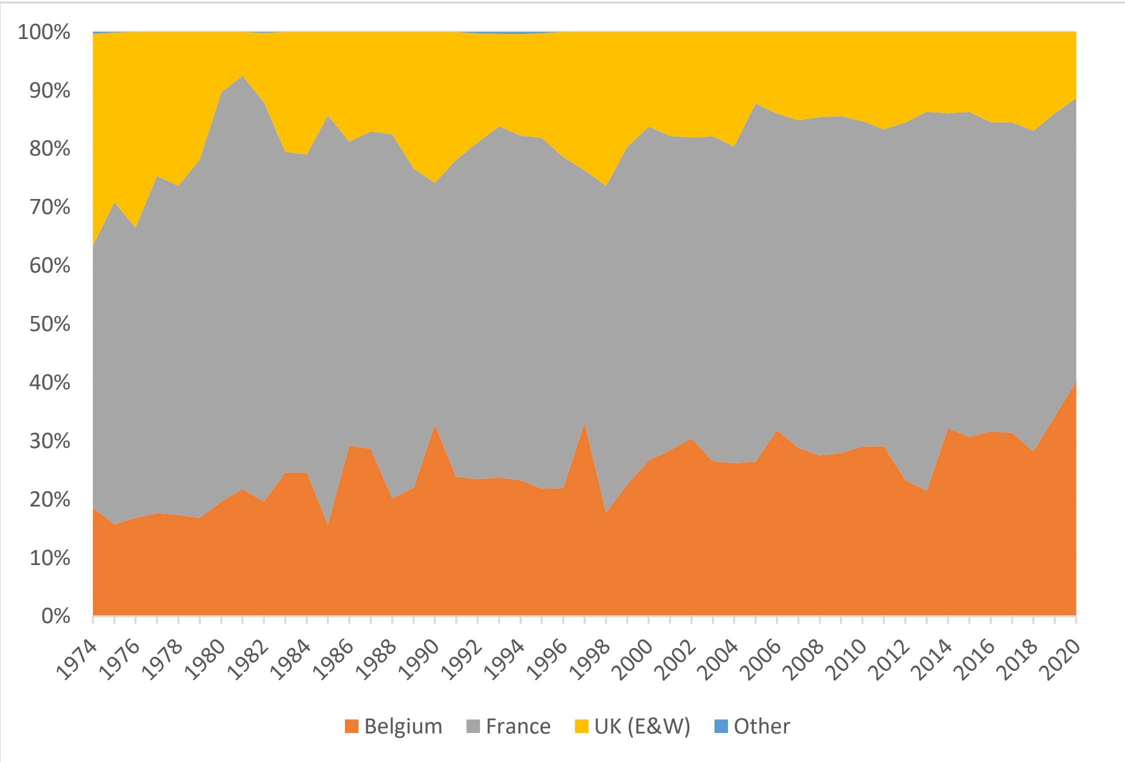

Figure 18.2: Sole 27.7.d - Relative contribution to the official landings of sole in Division 27.7.d for the main countries involved over the period 1974–2020.

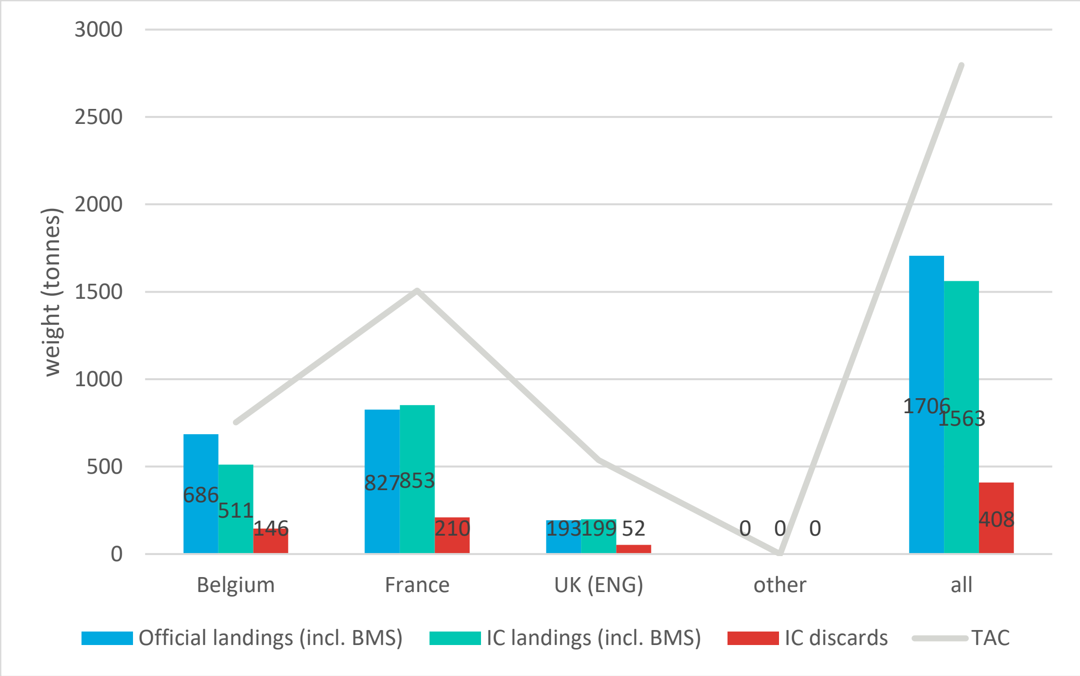

Figure 18.3: Sole 27.7.d - Uptake of the national quota and the total TAC of sole in 27.7.d in 2020 in comparison with the InterCatch landings (incl. BMS) and raised discards.

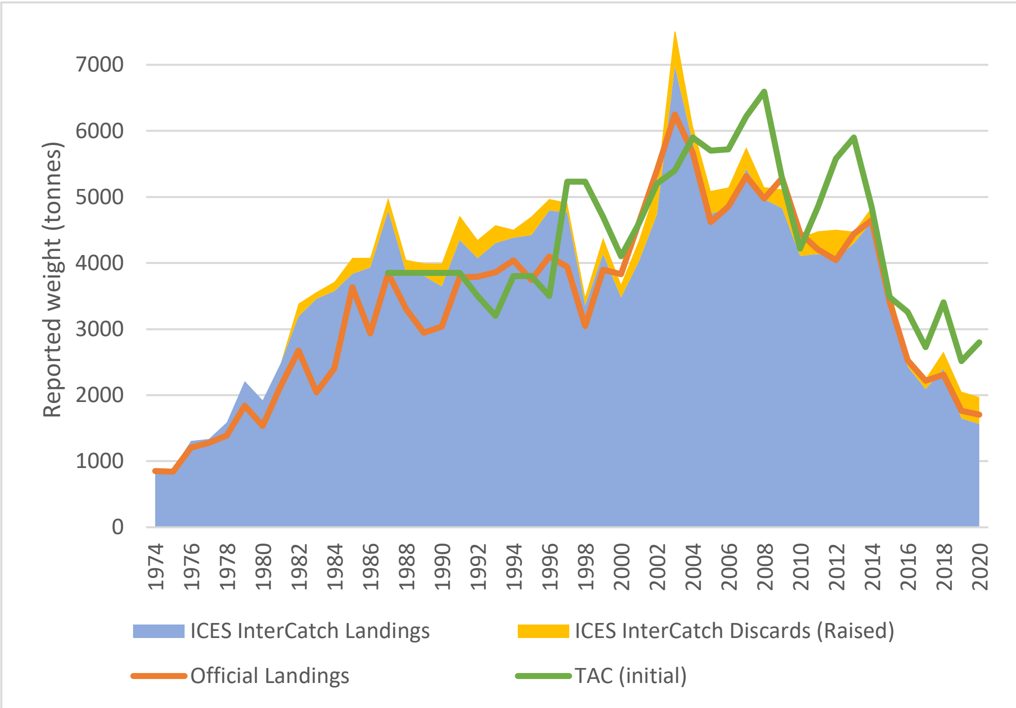

Figure 18.4: Sole 27.7.d - Historic overview (1974–2020) of the official landings, TAC and ICES estimates (InterCatch; including actual discards from 2004 onwards and extrapolated to years prior to 2004); Note that the TAC value represents catch from 2016 onwards.

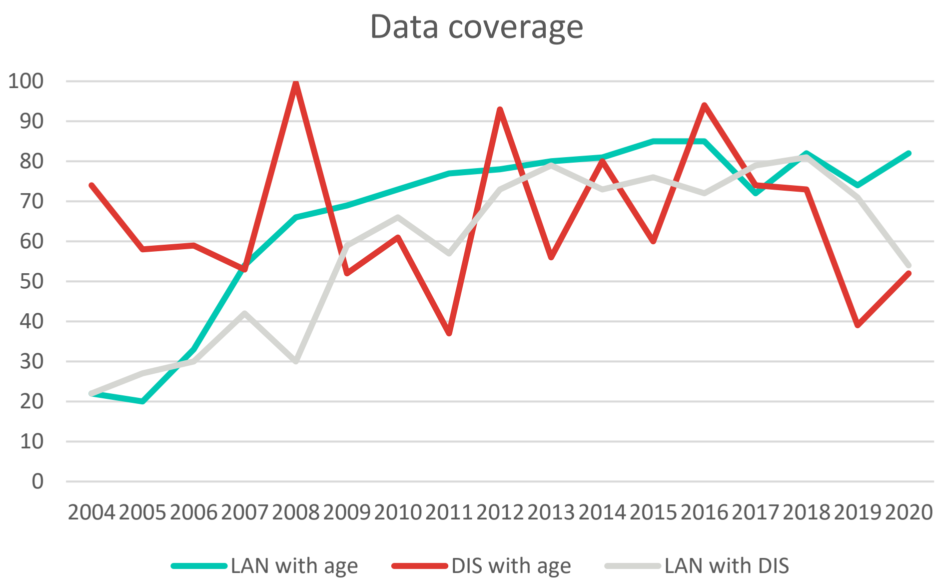

Figure 18.5: Sole 27.7.d - Overview of data coverage for data uploaded to InterCatch (from 2004 onwards).

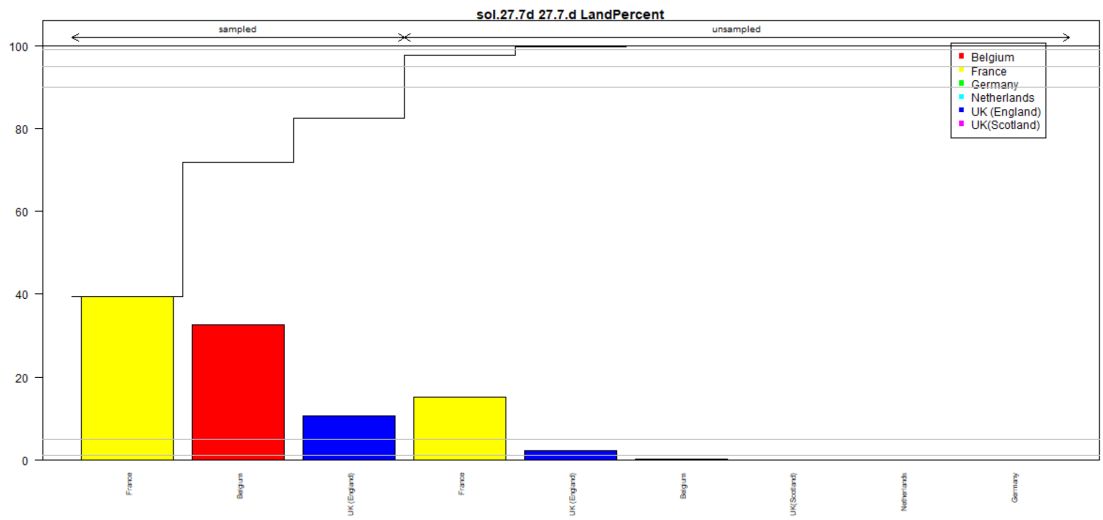

Figure 18.6: Sole 27.7.d - Overview of the proportion of 2020 landings of sole in Division 27.7.d for which samples (age) have been provided in InterCatch by country.

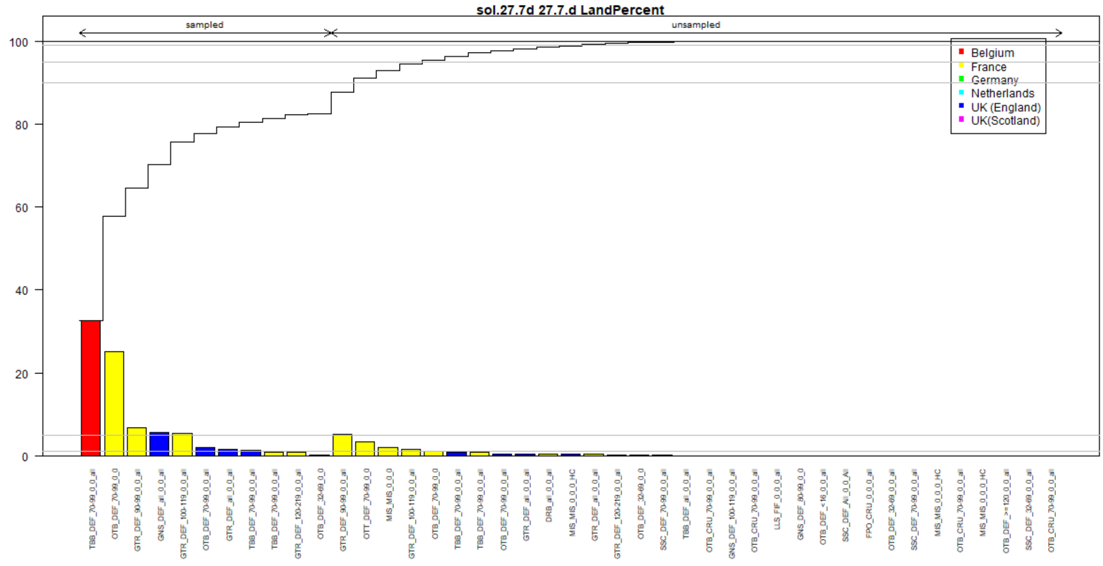

Figure 18.7: Sole 27.7.d - Overview of the proportion of 2020 landings of sole in Division 27.7.d for which samples have been provided in InterCatch by fleet and country.

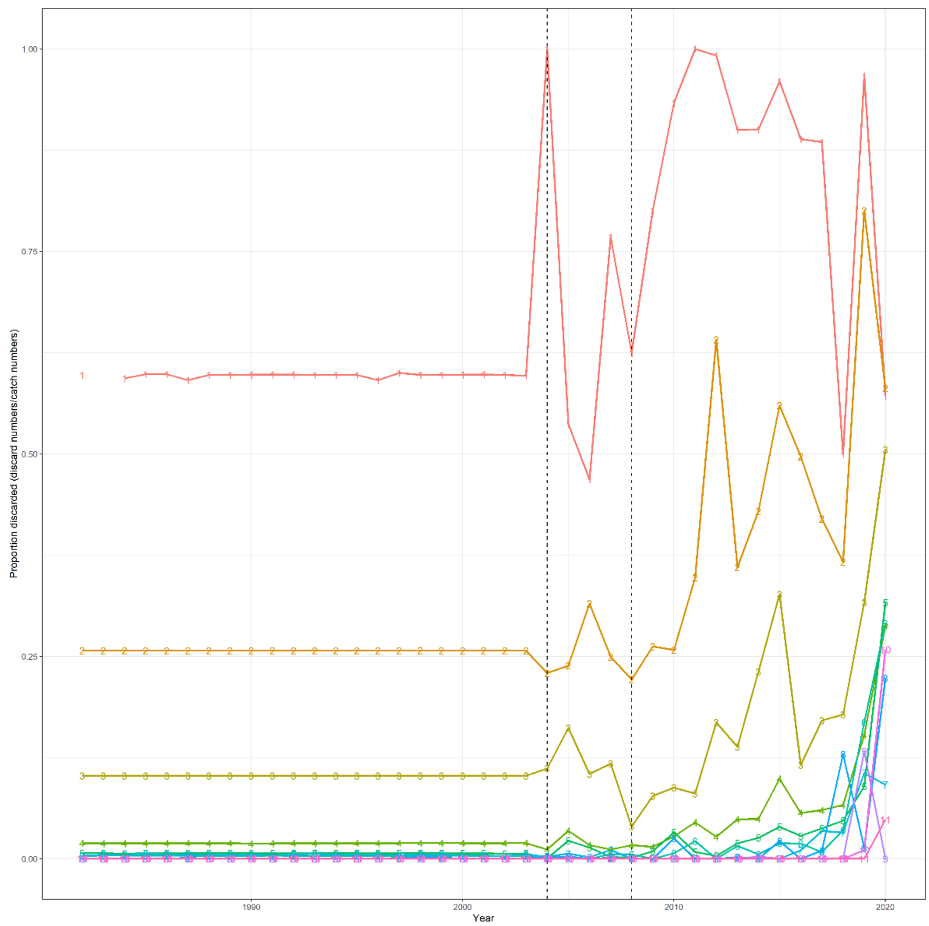

Figure 18.8: Sole 27.7.d - Proportion discarded (discard numbers at age/catch numbers at age) (data prior to 2004 are estimated using an average discard proportion at age for the period 2004-2008 (indicated by dotted lines)).

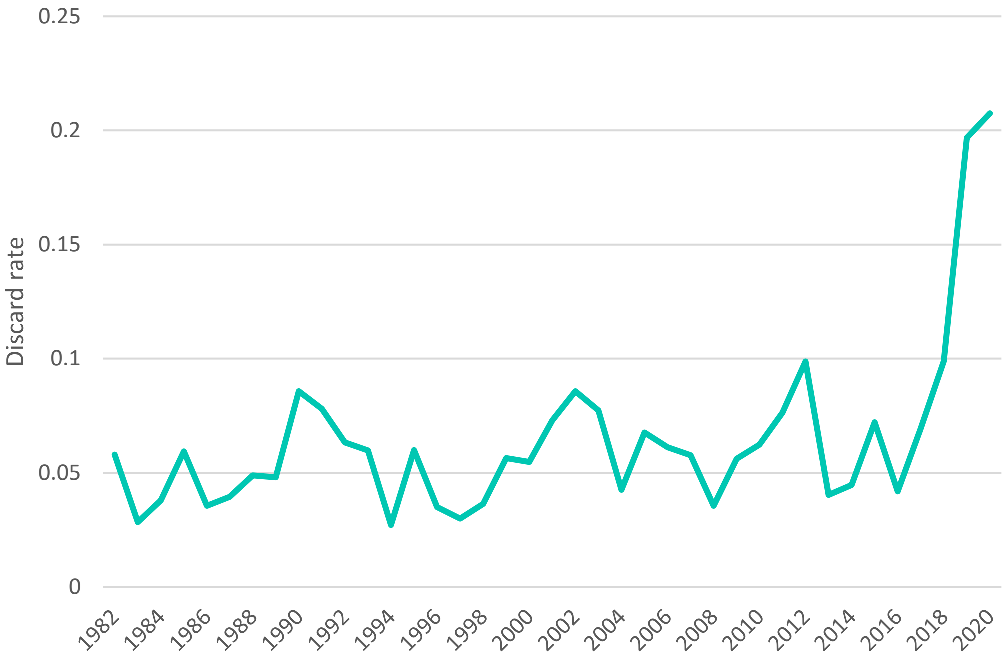

Figure 18.9: Sole 27.7.d – Discard rate (1982–2020).

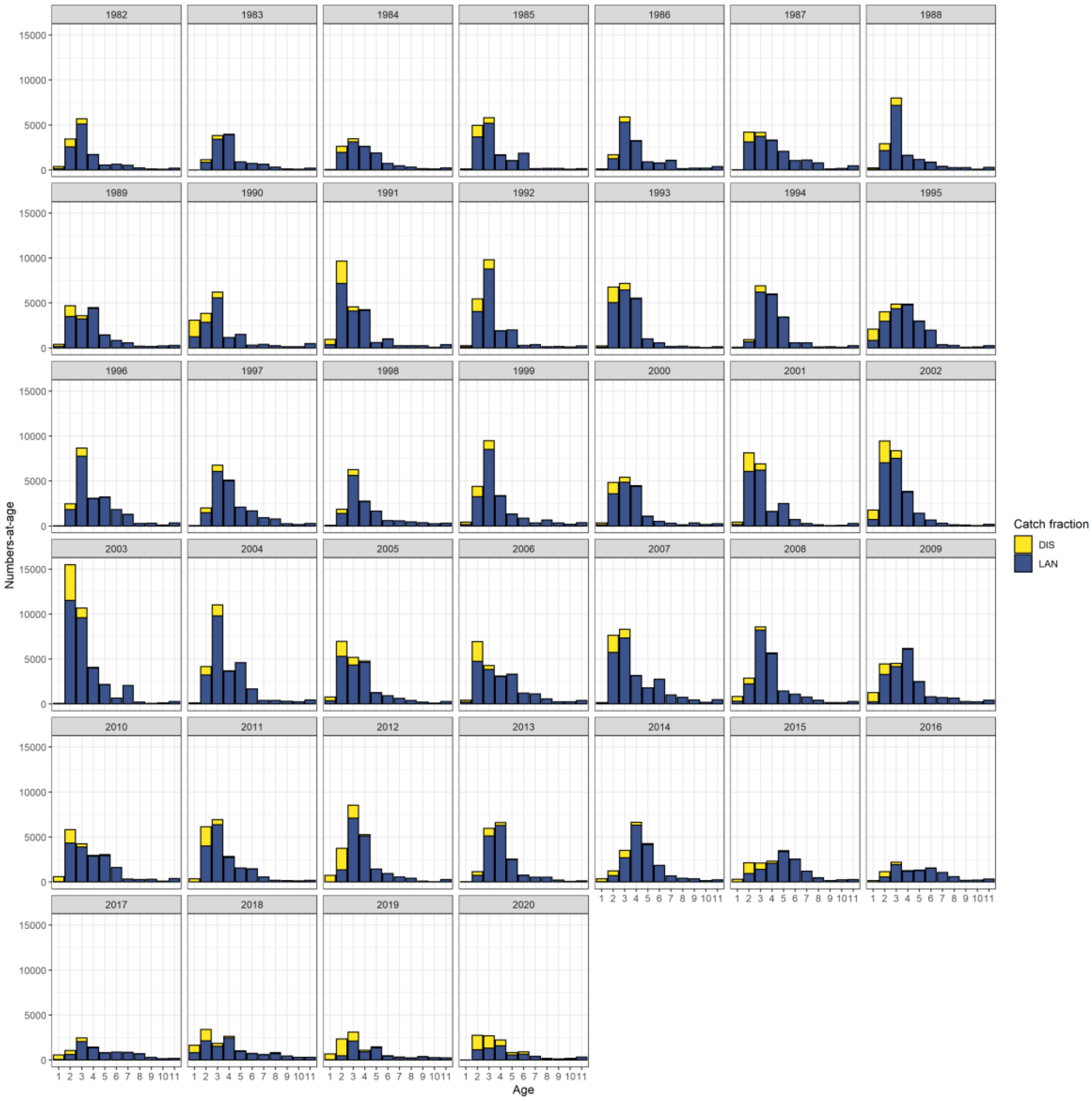

Figure 18.10: Sole 27.7.d – Landings (blue) and discard (yellow) numbers-at-age over the time series 1982–2020 for all ages (age 11 is a plusgroup).

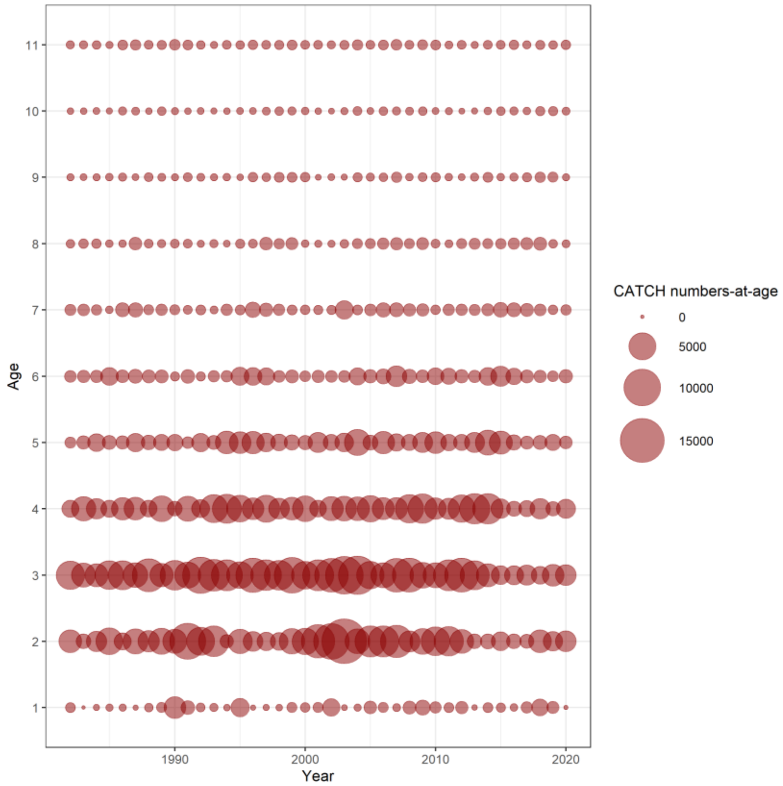

Figure 18.11: Sole 27.7.d – Catch numbers-at-age over the time series 1982–2020 for all ages (age 11 is a plusgroup).

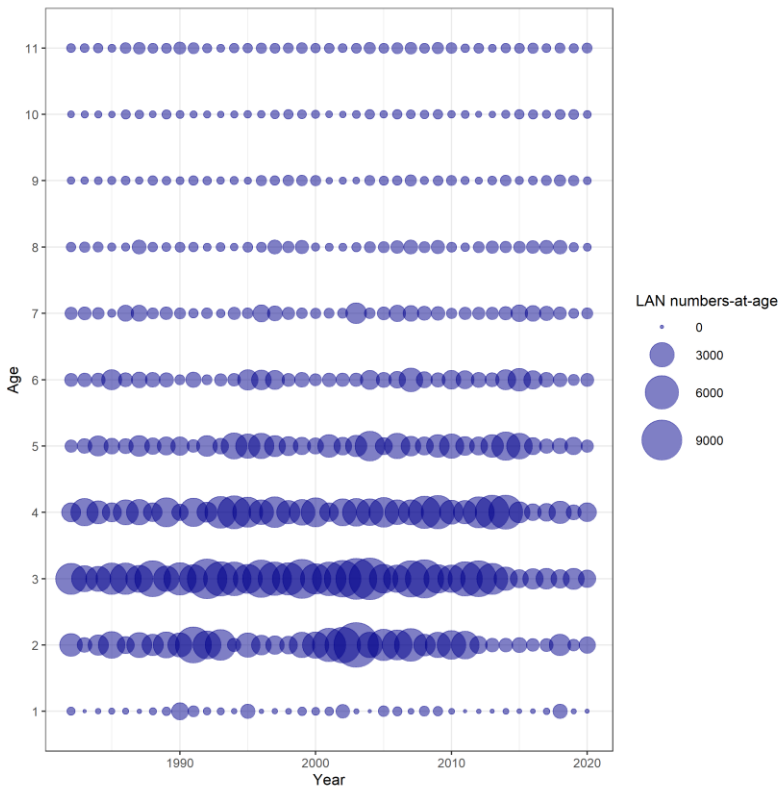

Figure 18.12: Sole 27.7.d – Landings numbers-at-age over the time series 1982–2020 for all ages (age 11 is a plusgroup).

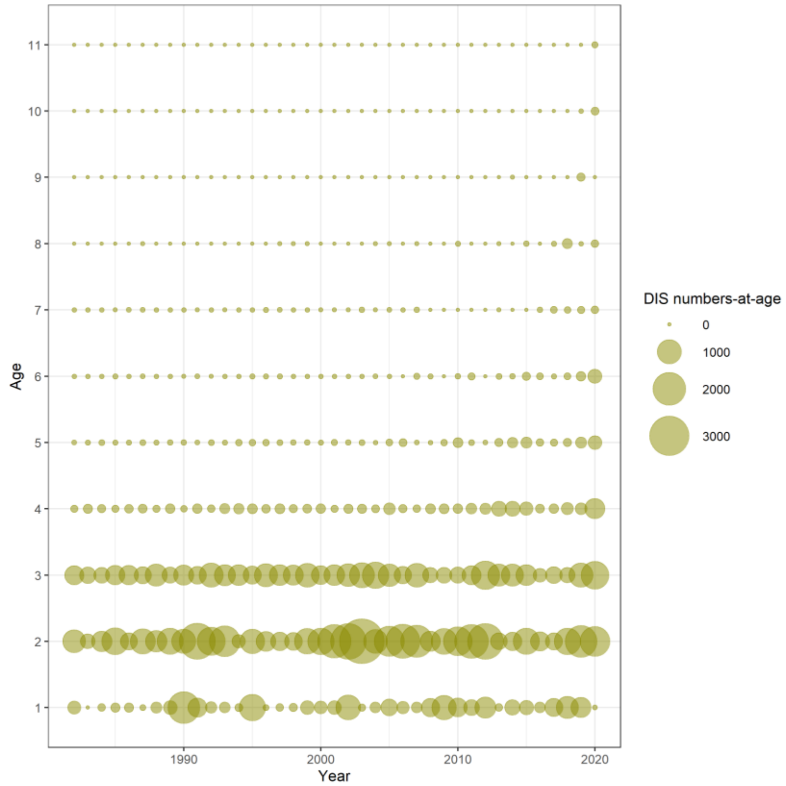

Figure 18.13: Sole 27.7.d – Discard numbers-at-age over the time series 1982–2020 for all ages (age 11 is a plusgroup).

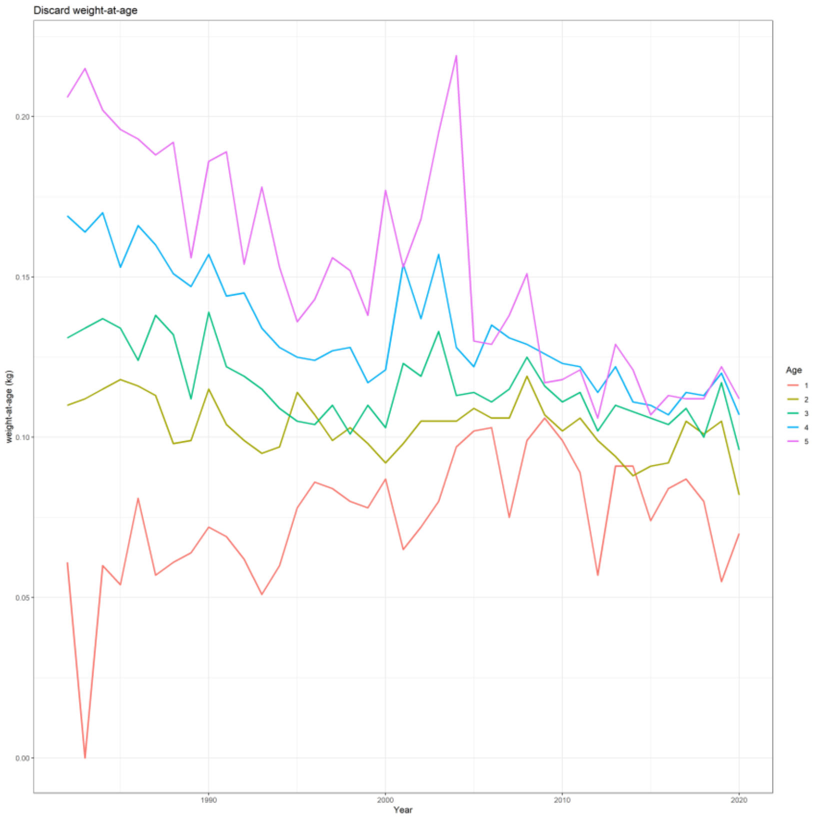

Figure 18.14: Sole 27.7.d - Discard weights-at-age (ages 1–5 are shown).

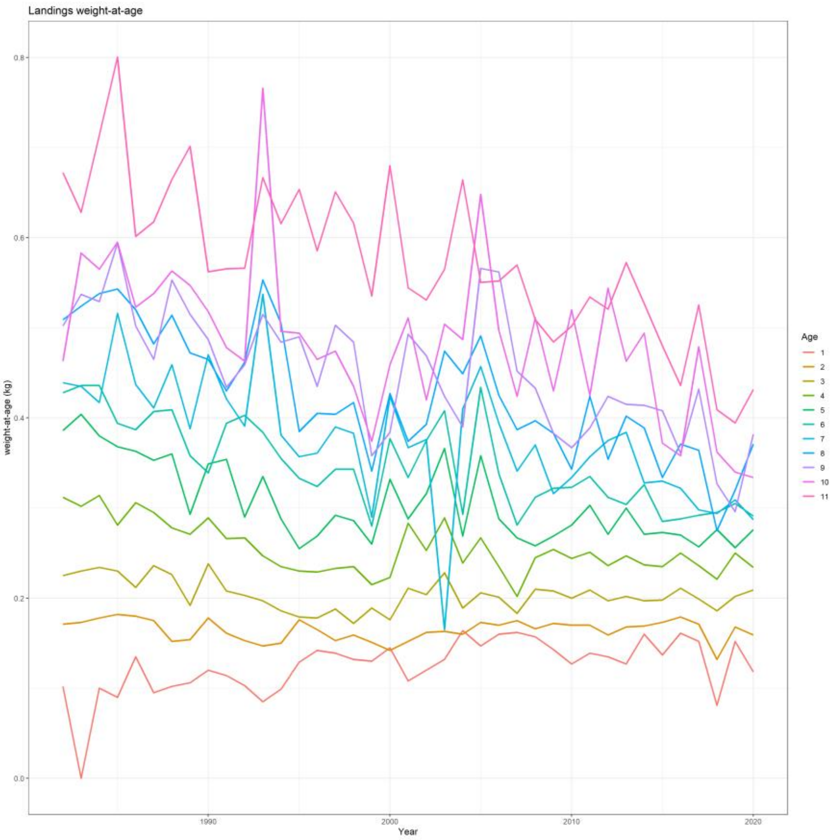

Figure 18.15: Sole 27.7.d - Landings weights-at-age (age 11 is a plusgroup).

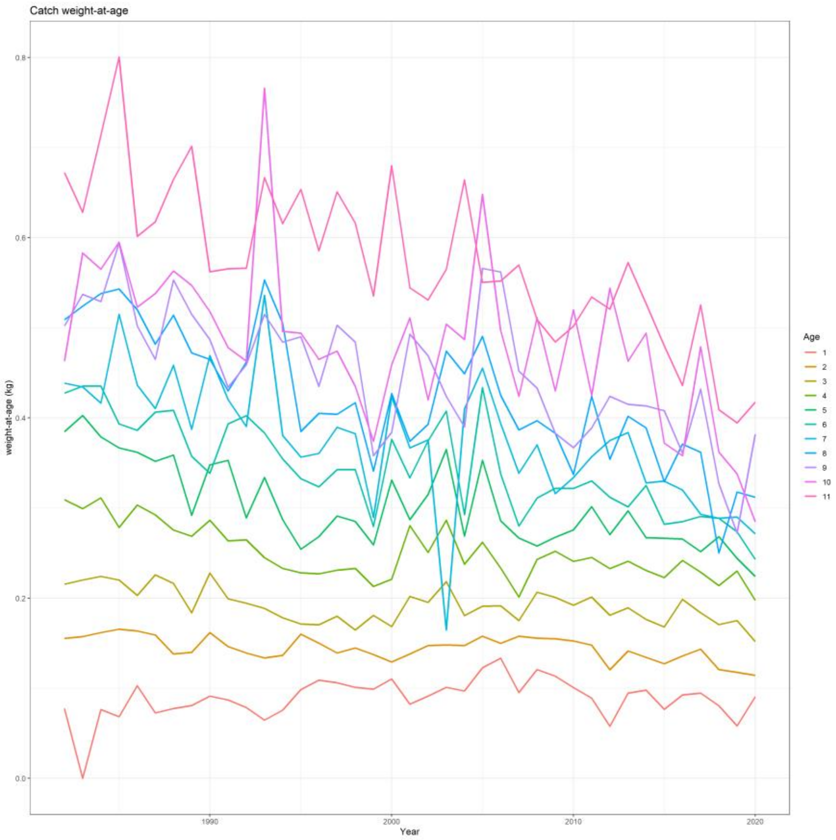

Figure 18.16: Sole 27.7.d - Catch weights-at-age (age 11 is a plusgroup).

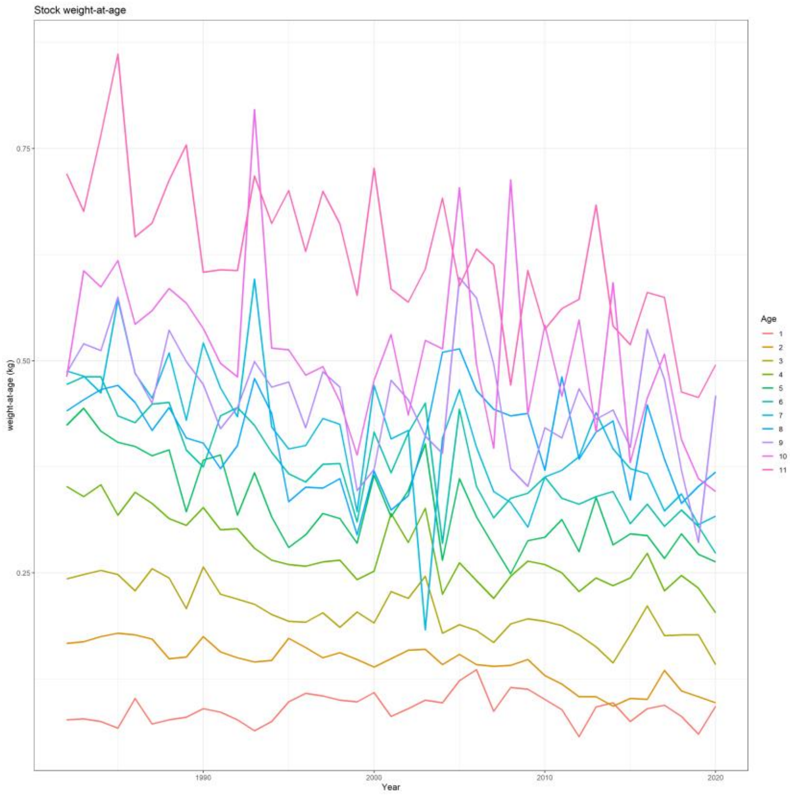

Figure 18.17: Sole 27.7.d – Quarter 1 stock weights-at-age (kg) (reconstructed for the period 1982–2003 using the ratio of quarter 1 catch weight-at-age and the overall catch weight-at-age for the period 2004–2019 multiplied by the overall catch weight-at-age for 1982–2003).

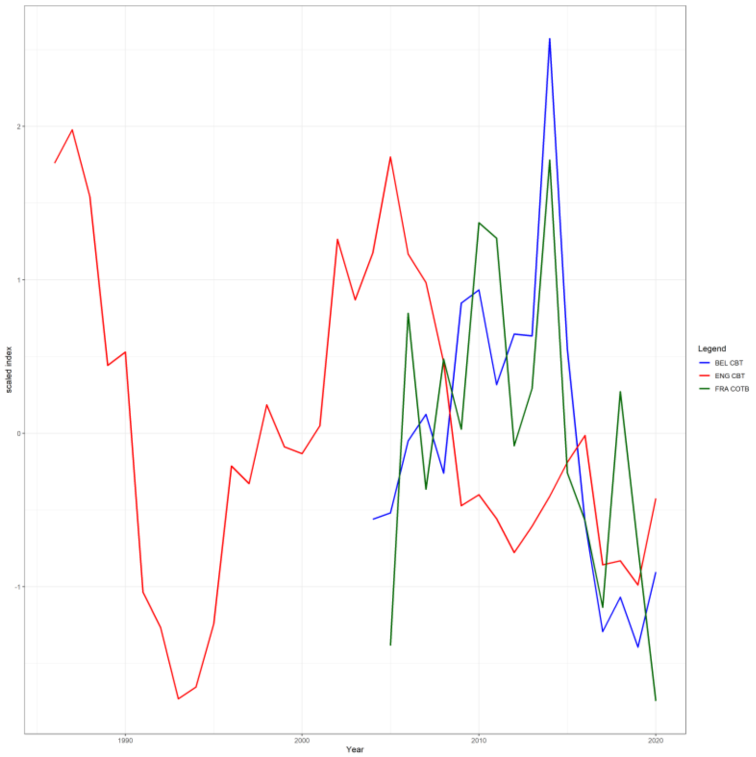

Figure 18.18: Sole 27.7.d – Scaled commercial tuning indices: Belgian (blue) and UK (red) commercial beam trawl series and French commercial otter trawl series (green).

Figure 18.19: Sole 27.7.d – Scaled survey tuning indices: UK (E&W) beam trawl survey (red), UK Young fish survey (yellow) and French Young fish survey (green).

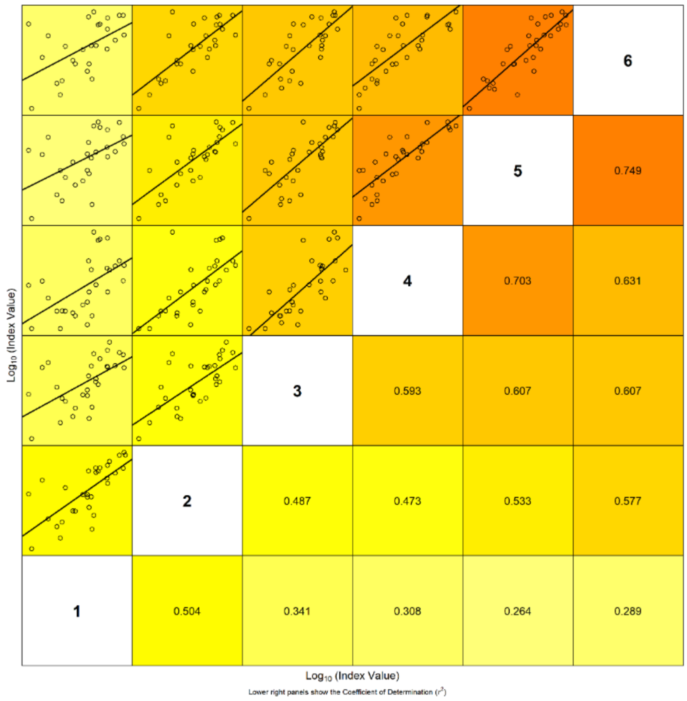

Figure 18.20: Sole 27.7.d - Internal consistency plot of the UK-BTS tuning series.

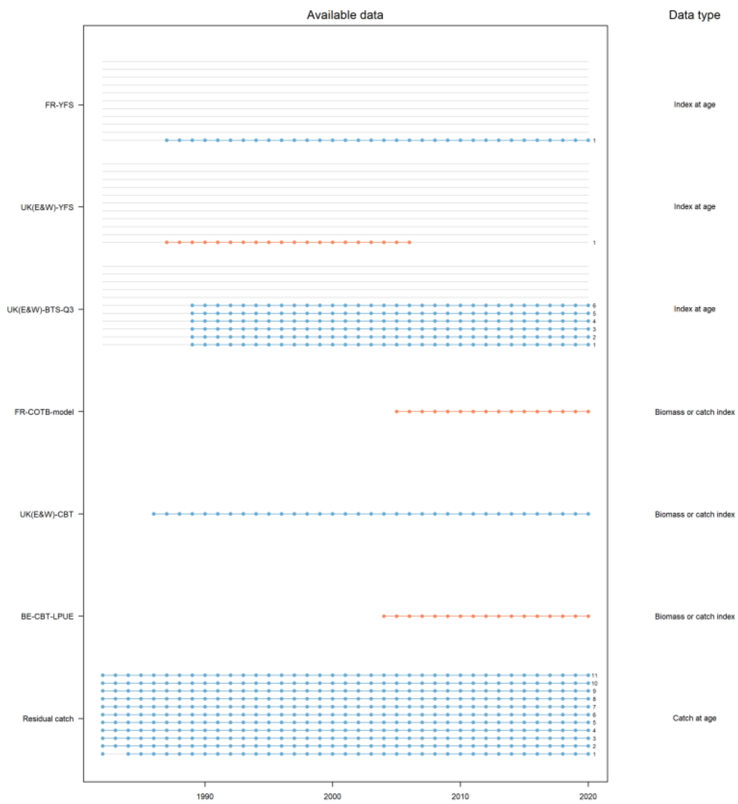

Figure 18.21: Sole 27.7.d – SAM model input.

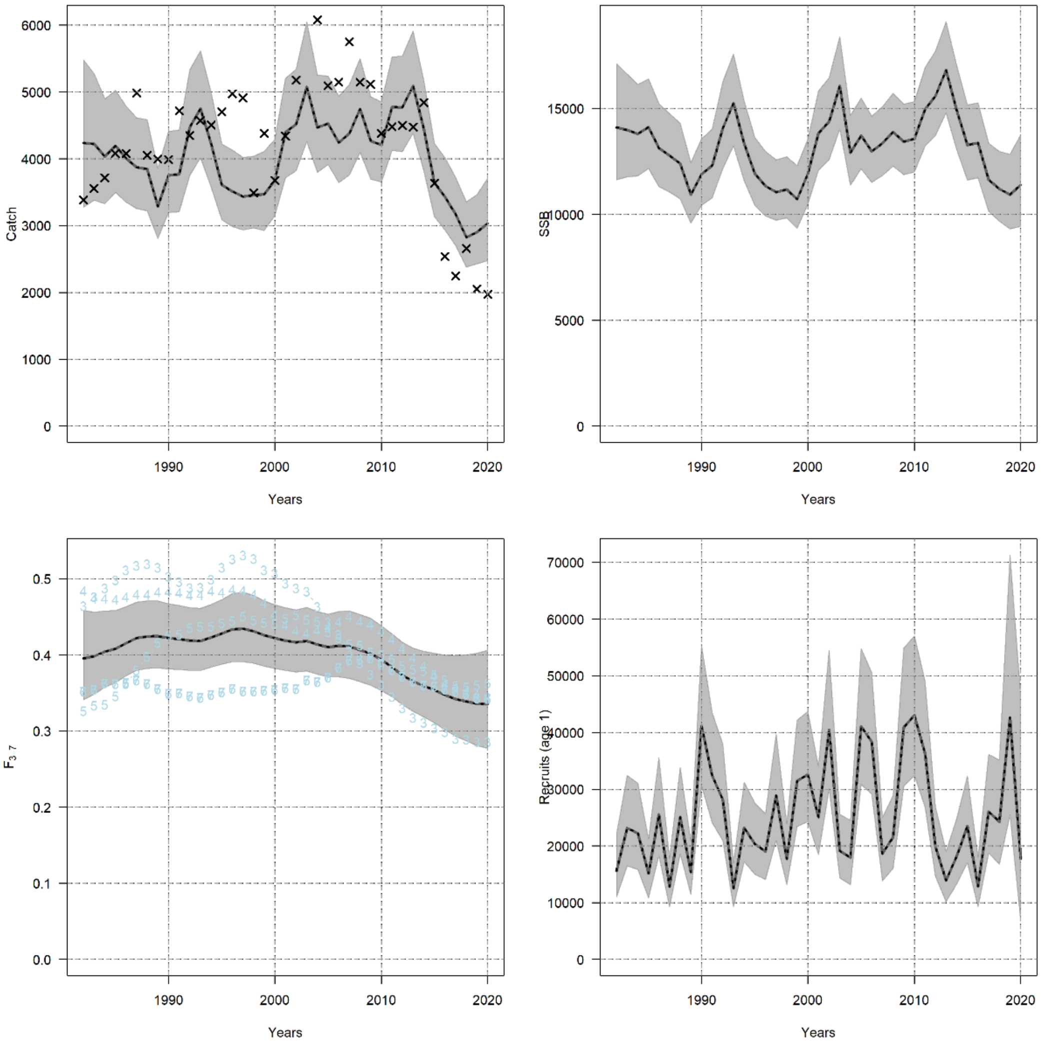

Figure 18.22: Sole 27.7.d – SAM model summary: trends in catch, spawning stock biomass (SSB), F_{bar} and recruitment are shown with relevant confidence intervals.

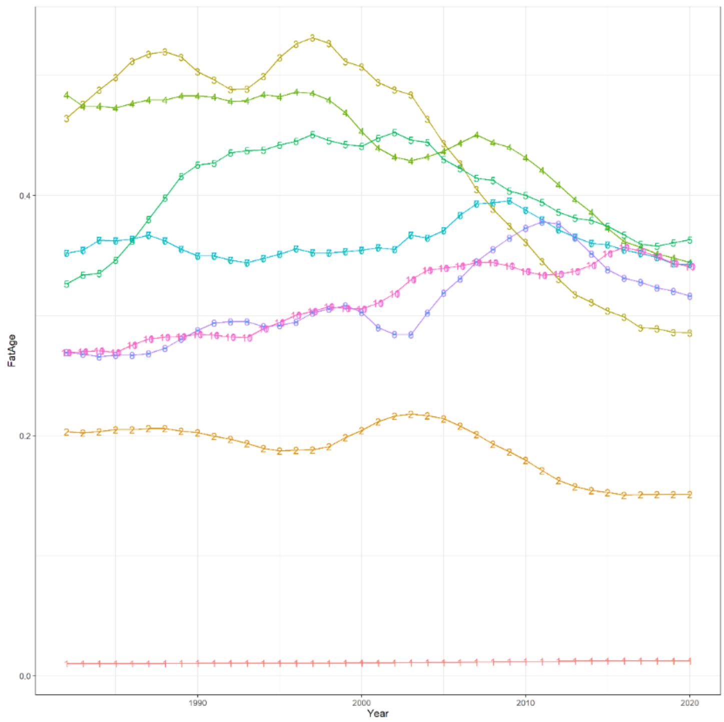

Figure 18.23: Sole 27.7.d – Fishing mortality at age as estimated by the SAM assessment; Note that age 6 and 7, 8 and 9 and 10 and 11+ overlap.

Figure 18.24: Sole 27.7.d – Process residuals for the survival (logN) and fishing mortality (logF) processes.

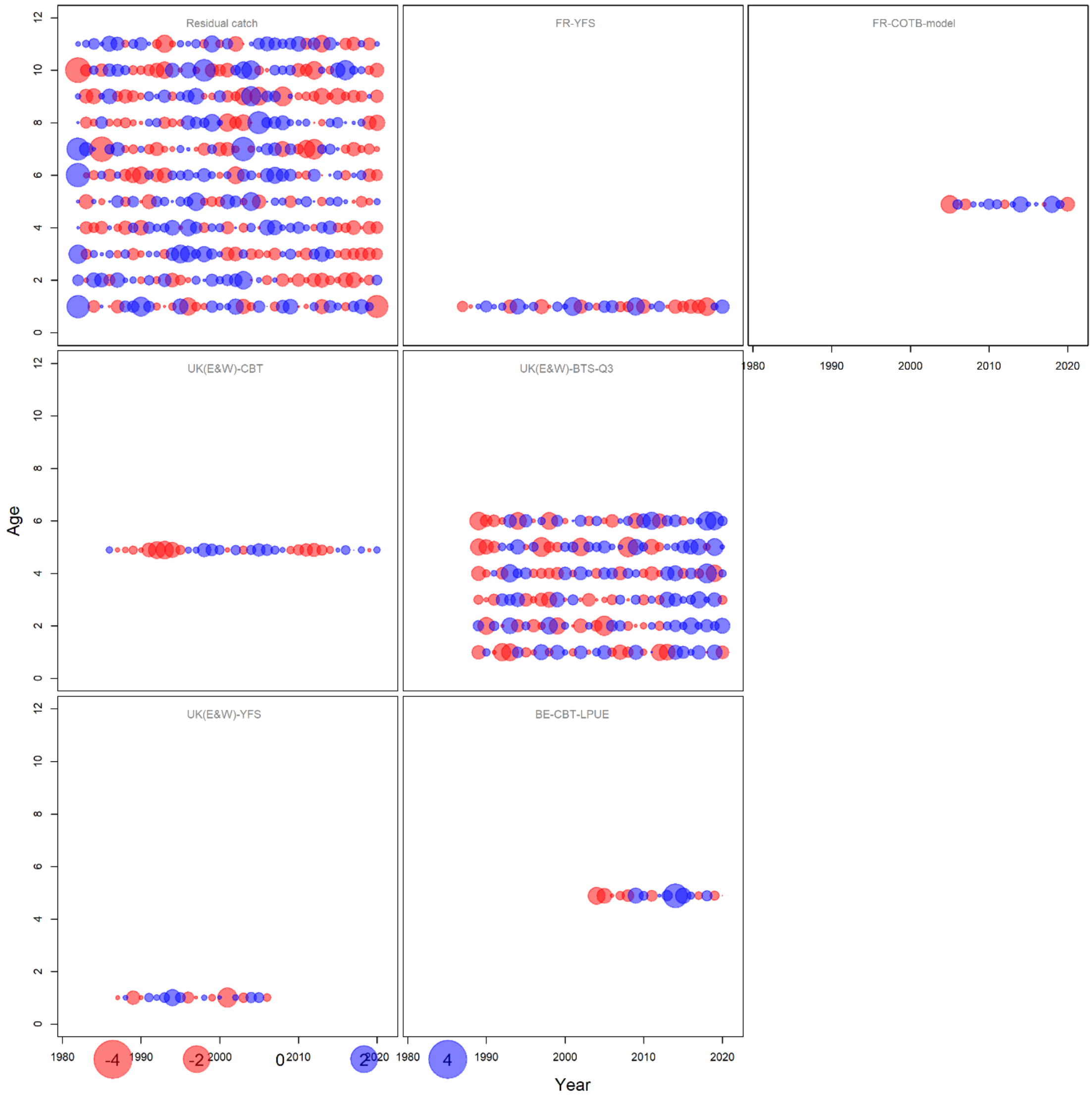

Figure 18.25: Sole 27.7.d – One step ahead residuals by data stream.

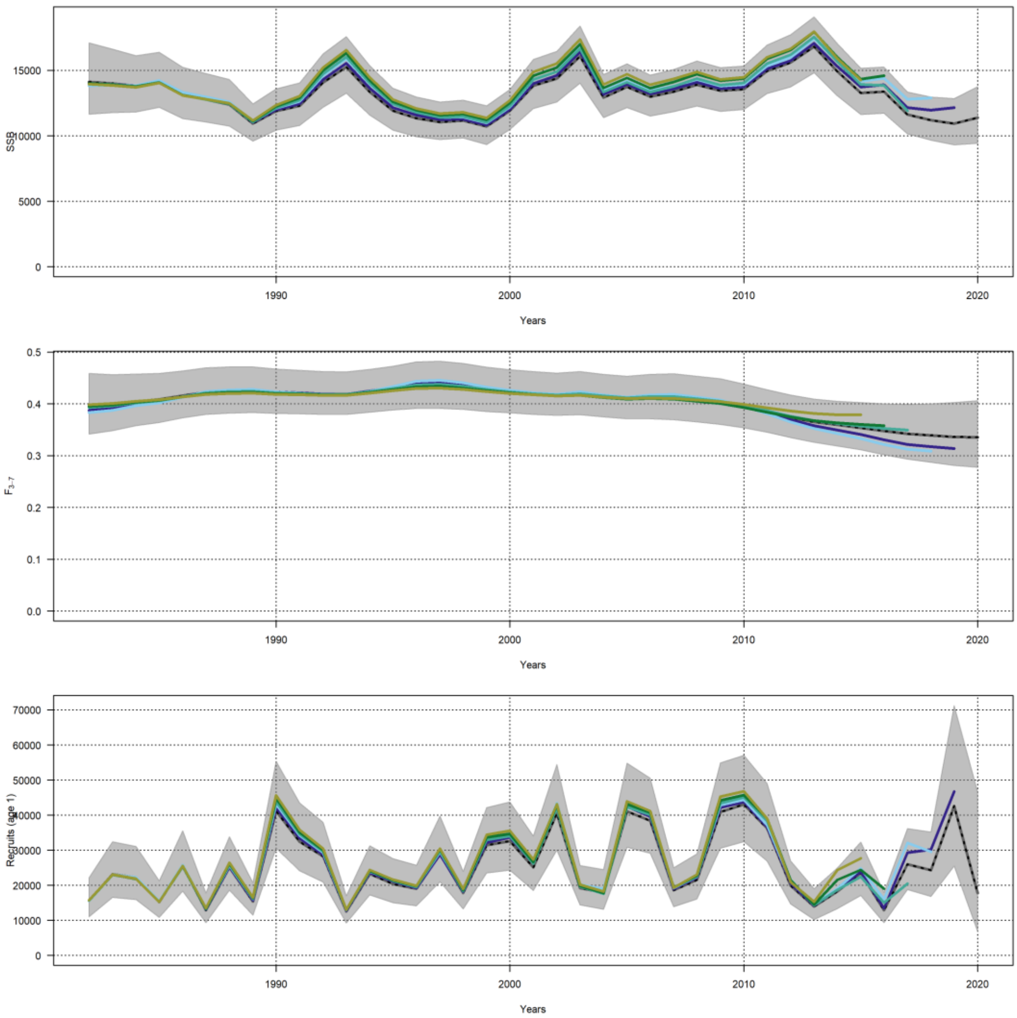

Figure 18.26: Sole 27.7.d - Retrospective pattern in SSB (Mohn's Rho = 0.089791656), F_{bar} (Mohn's Rho = -0.006954624) and recruitment (Mohn's Rho = 0.149881766). The grey shades represent the 95% confidence intervals of the model including all data years.

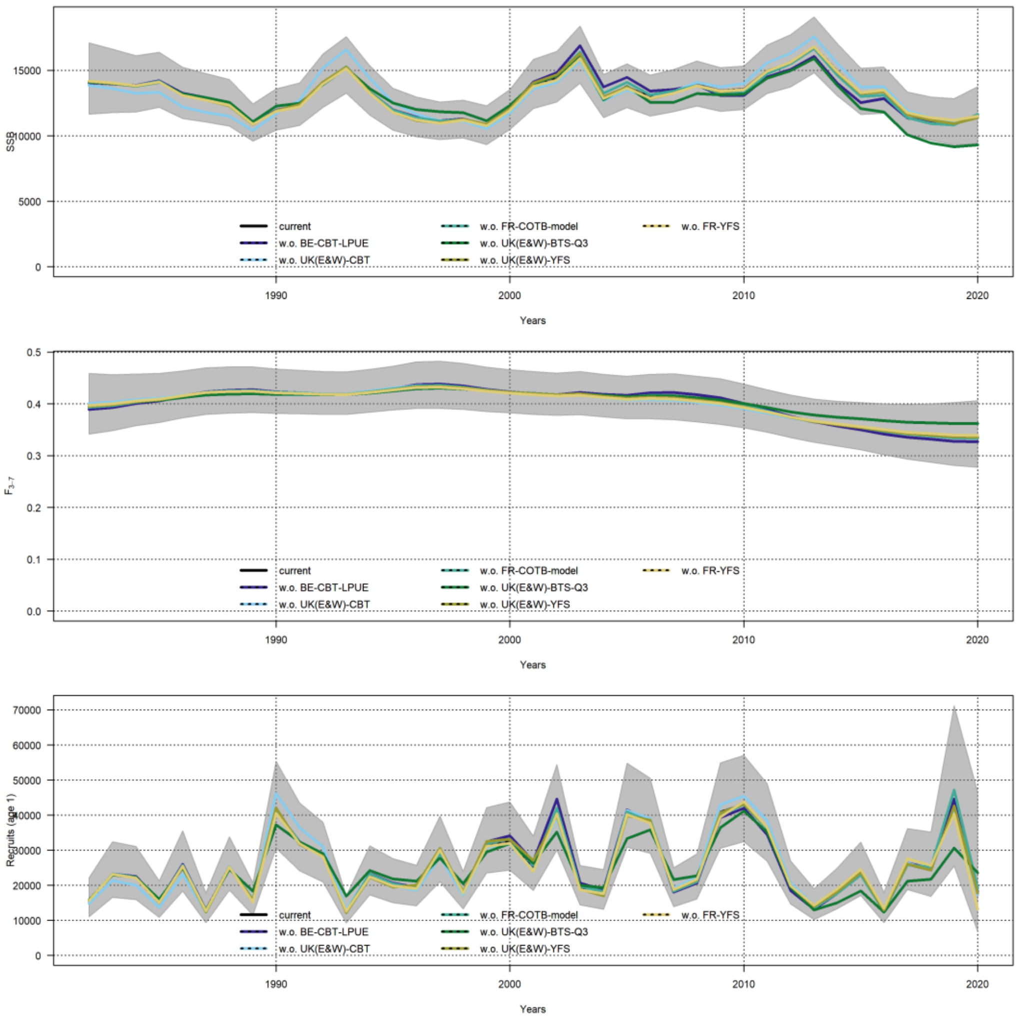

Figure 18.27: Sole 27.7.d – Leave-one-out analysis. Each coloured line refers to a model fit without the respective tuning fleet. The grey shades represent the 95% confidence intervals of the model including all tuning fleets.

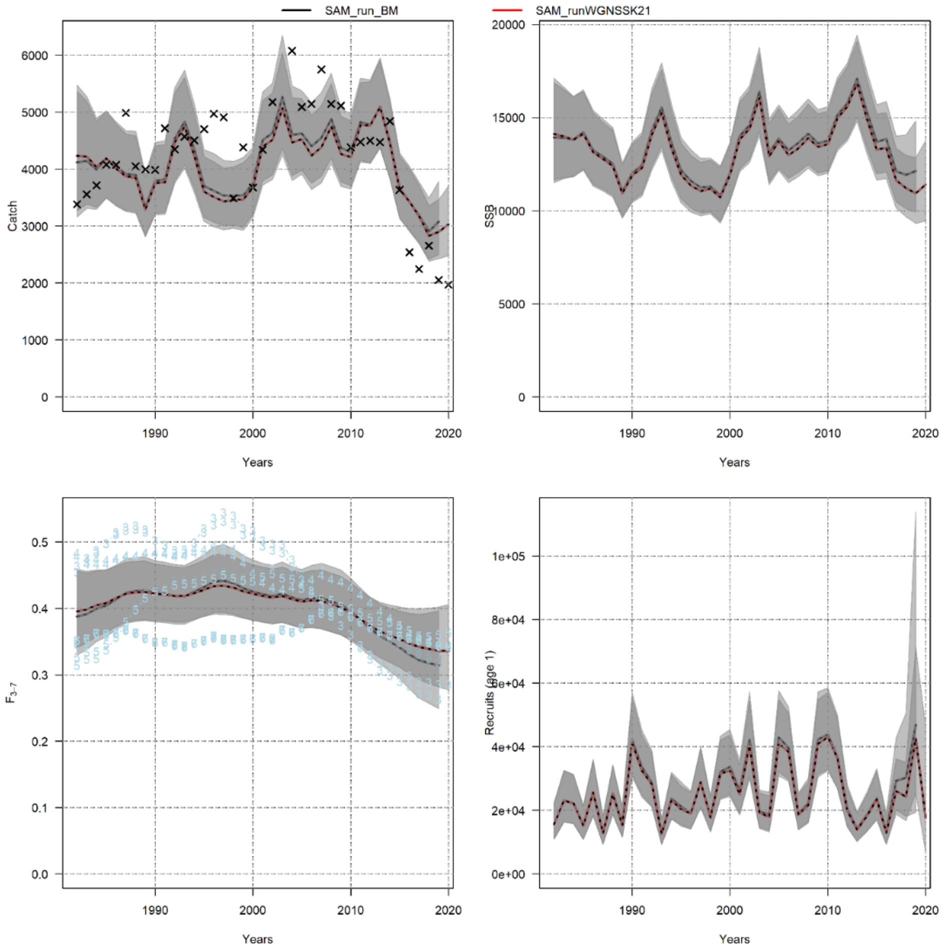

Figure 18.28: Sole 27.7.d – SAM model summary showing the current model in red and the WKNSEA 2021 benchmark model in black. Trends in catch, spawning stock biomass (SSB), F_{bar} and recruitment are shown with relevant confidence intervals.

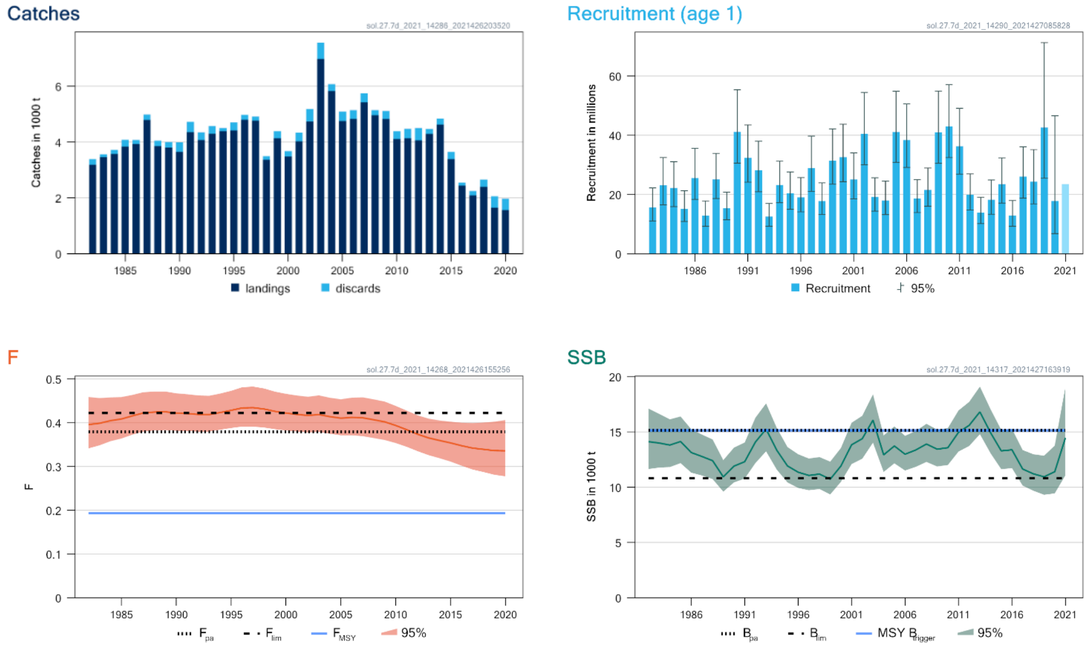

Figure 18.29: Sole 27.7.d – Summary of the 2021 assessment. Discards are reconstructed prior to 2004. Plots show the relevant confidence intervals. The assumed recruitment value for 2021 is shaded in a lighter colour.

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. In 2021, fishing opportunities advice was again requested following the precautionary approach. Due to incomplete survey sampling in 2020, issues with calculation of survey indices, the lack of length and age samples from the main fleets, including other areas and nations, and problems with model formulation; ICES stock data category of striped red mullet in Subarea 4 and divisions 7.d and 3.a was downgraded from category 3 to category 5. ICES advice on fishing opportunities was based on the average ICES catches (considering discards negligible) over the period 2004–2020. Based on length-based indicators (LBI) analysis, fishing mortality is estimated above MSY reference points, the stock size relative to reference point is unknown. For that reasons, the precautionary buffer was applied.

The general perception is that the landings have gradually decreased since 2015, the highest observed in the recent years, up to 2018. In 2019, landings have increased near to the level of 2015, mainly due to the exploitation of the strong 2018 cohort. In 2020, landings decreased slightly, 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)).

A recent review of striped red mullet stock structure in the greater North Sea was realised by CEFAS and presented to WGNSSK 2020 (Ellis, 2020). This review does not support the current stock definition used by ICES. Indeed, survey data from IBTS might indicate that striped red mullet in Division 3.a should be considered as a separate stock from the North Sea one. In addition, survey data and commercial data have highlighted migration pattern between the Western English Channel and the southern North Sea, with striped red mullet concentrating and mixing in the southern North Sea during summer. Thus, assessment of stripped red mullet in subarea 4 and division 7.d-e may need to be assessed as a single stock or a complex one with two sub-population mixing during summer.

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

Advice for 2022 and 2023.

The ICES framework for category 5 stocks was applied (ICES 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented where there is no ancillary information clearly indicating that the current level of exploitation is appropriate for the stock. Discarding is considered negligible.

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 2017, was applied again in this assessment.

ICES advises that when the precautionary approach is applied, catches should be no more than 1950 tonnes in each of the years 2022 and 2023. All catches are assumed to be landed.

Advice for 2020 and 2021.

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 2004–2020 as well as the predicted catch corresponding to advice. In 2020, 77% of the catches were made using demersal seines and 17% 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 2020 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 11% of the total landings in 2020) were provided in 2014 to 2020 with an age structure. In 2020, some landings made in area 4 were also provided by France with an age structure but only representing around 3% of the total landings in area 4. 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, and Table 19.5.1.4). 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 structured information for the area 27.7.d and 4, all landings are then raised using French age structures. Age sampling has usually a low coverage for this stock, however in 2020, the COVID-19 pandemic significantly impacted the market sampling reducing the overall age sampling coverage of landings to 8%. To account for the lack of sampling in 2020, all quarters were raised with all samples available, except for quarter 4 that was raised using only samples from quarter 4.

19.5.2 Weight-at-age

Mean weights 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 weights do not show this slight decrease of age 3 and 4+ 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

Survey index defined during the last benchmark.

During the las benchmark in 2015, 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.

Issues regarding CGFS survey index in 2020.

In 2020, CGFS survey design was impacted by COVID-19 pandemic and issues regarding historical index calculation were uncovered. In this section, we describe the two different issues that impact 2021 stock assessment. In the next section, the impact of the different issues on the assessment were evaluated using data up to 2019.

- Issue with sampling coverage in 2020

In 2020, due to the COVID-19 pandemic and the lockdown in France, CGFS JNC Cruise application form was unfortunately not processed in a timely manner by the French Foreign Ministry. By consequence, the formal authorisation to operate in UK waters was not received before the starting of the 2020 CGFS survey. Therefore, only the French waters of the English Channel were sampled covering 70% of the sampling design (Figure 19.5.4.3) (ICES IBTSWG, 2021 (*in prep*)).

- Issue with historical index calculation

In order to improve data quality and storage, and consequently to the deployment of a new software used on board during sea surveys, the format of survey data collected by IFREMER has evolved from 2017 onwards. This evolution is associated with data quality check at several steps of the process from data collection to storage. To handle this change but also to be prepared for the coming integration of indices' calculation within DATRAS for some species sampled by IBTS North-Eastern Atlantic surveys, new scripts have been produced to compute abundance indices using this new data format.

Whilst writing the R scripts, discrepancies were found between the resulting indices and the ones calculated historically (Figure 19.5.4.4). An error was found in the historical scripts as some hauls with absence of a species were not included in the average abundance per stratum. A new preliminary index was produced to correct the error; however, some work is still required to compute properly the survey age-length key used for the new index calculation. At the moment, some age at length are still missing in the preliminary new index calculations.

19.6 Trend based assessment

19.6.1 Assessment model agreed on during the last benchmark

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.

Sensitivity runs were explored in 2020 and different numbers of knots (from 6 to 9) were tested for the spline used to estimate fishing mortality (ICES, 2020). F_{bar} (age 1–2) estimates for 2019 remain in absolute value above 3 in all the scenarios. Scenario with 6 knots was disregarded as F for age 3 was unrealistic. It was agreed to add one more knot to the spline as compared to 2019 assessment, however other configuration of a4a needs to be investigated if we want to keep using this model as an indicator of the stock status in the future.

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=8) + factor(age)
Survey catchability	~ factor(age)
Recruitment	~ factor(year)

Results from the assessment are presented in Figure 19.6.1.3. Log residuals of the model are presented in Figure 19.6.1.4 and observed and predicted catches in Figure 19.6.1.5 and indices in Figure 19.6.1.6.

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.

19.6.2 Exploratory runs with a4a

Several formulations of a4a were tested to constrain the model. Splines were added to characterize the selectivity of catches and survey. In addition, fishing mortality at age 0 was modelled separately as the catch at age 0 remains lower than age 1 or 2. Finally, splines were added to estimates the variance at age of F and the survey indices.

The final settings tested 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=10) + s(age, k=3) + s(year, k=5, Age 0)
Survey catchability	~ s(age, k=3)
Recruitment	~ factor(year)
Variance	F ~ s(age, k=3) & Survey ~ s(age, k=3)

Results from the alternative assessment model are presented in Figure 19.6.2.1. Log residuals of the model are presented in Figure 19.6.2.2 and observed and predicted catches in Figure 19.6.2.3 and indices in Figure 19.6.2.4.

With this new model formulation, residual patterns at age 0 for the catches have improved as compared to the model formulation decided during the benchmark. Adding a spline to characterise selectivity seems to allow a more realistic representation of the fishing pressure. However,

F_{bar} estimated by the alternative model remains high and the uncertainty around F_{bar} and SSB is still relatively important.

More exploratory runs are required to fix the different issues of the current model used as indicative of the stock status (to test different a4a formulation, and more models).

19.6.3 Impact of survey index issues

To assess the impact of survey index issues on the age-based assessment, three separate analyses were performed using commercial and survey age structured data from 2004 to 2019. The a4a settings were the same as the one used in section 19.6.1. All the runs describe below were compared with the baseline assessment produced in 2020 (ICES, 2020).

Issues with CGFS survey index	Runs	Description	Hypothesis tested
Missing UK hauls in 2020	woUK	Run the assessment with a survey index calculated without all the UK stations in the historical CGFS survey time series. The methods used is the one agreed upon during the last benchmark and include error in the index calculation.	Model is influenced by CGFS survey station in the UK EEZ.
	wo2019	Run the assessment with survey index agreed upon during the last benchmark without the last data year (2004-2018 period).	Last survey data year has a strong influenced on the assessment outcome.
Missing some hauls with no stripped red mullet	newindex	Run the assessment with the preliminary new index including all the hauls in the index calculation.	Omitting some hauls without stripped red mullet during the index calculation as a strong influence on assessment outcome and the model cannot account for the changes through a change in survey catchability estimation.

Estimates of recruitment, SSB and F_{bar} (1–2) from the different runs are presented in Figure 19.6.3.1. Removing CGFS survey hauls within UK EEZ during the age structure index calculation has little effect on the assessment outcomes and the model is able to capture the change in index through the survey catchability estimation. However, removing the last survey data year or using the preliminary new CGFS index have a strong impact on the fishing mortality estimates as well as the estimates of the final year recruitment and SSB in 2019.

19.6.4 Striped red mullet trend-based assessment conclusion

Due to incomplete survey sampling in 2020, issues with calculation of survey indices, the lack of length and age samples from the main fleets, including other areas and nations, and problems with model formulation, the stripped red mullet trend-based assessment was rejected. Therefore, the ICES stock data category of striped red mullet in Subarea 4 and divisions 7.d and 3.a was downgraded from category 3 to category 5.

19.7 Length-based indicators screening

The ICES LBI were computed for five years of data (2014–2016 and 2018–2020), using the length distributions from InterCatch (Tables 19.7.1).

Most of the indicators appear outside the established references in 2020:

- Length at first catch Lc and Length of 25% of catches are above Lmat (16 cm) in 2015, 2016, 2019 and 2020. These indicators are below Lmat in 2014 and 2018 (for Lc). This is directly linked with the good recruitment observed in 2014 and 2018. The good recruitment observed in 2014 and 2018 decreased Lc and L25, but the next years (2015–2016 and 2019–2020) no good recruitment was observed and Lc and L25 increased to be above Lmat.
- ratio of the Lmax5, mean length of 5% largest catches, to Linf (40 cm) around 0.6/0.7 over the two periods 2014–2016 and 2018–2020 clearly show the lack of big/old fish in the population
- Lmean/Lopt around 0.8 give the same picture as Lmax5, exploitation is not optimal.
- Lmean/$L_{F=M}$ below 1 tend to show that this stock is not exploited sustainably 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 and 2019–2020) show 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 (Table 19.7.2).

Conclusions drawn from analyses:

The very good recruitment observed in 2014 and 2018 was confirmed by the catches in 2015 and 2019 respectively and the remaining age 1 seen in 2015 and 2019 during CGFS. There is no TAC on this species so the advice was not followed and the catches overshot the advice for 2015-2019 (5328, 3438, 2856, 1651 and 4044 tonnes against 460, 552, 552, 465 and 465 tonnes respectively in the advice). In 2018, the recruitment as seen by CGFS appears to be the second highest since 2004 and was confirmed by the catches in 2019 and the age 1 in CGFS survey. The stock age distribution appears to be still truncated.

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016 and 2018–2020) show in 2021 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 actually raised using the French catches in the Eastern Channel and part of North Sea.
- 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
- CGFS survey data issues in index calculation needs to be fixed. GAM or GLMM methods such as the method developed by Berg et al. (2014) or Thorson et al. (2015) should be explored to account for missing data UK haul in 2020 and also better account for the change in vessel in 2014.
- Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated

- Based on Ellis, J. R. (2020) stock ID should be reinvestigated.

Assessment:

- Assessment model was rejected in 2021 and a category 5 advice is given for this stock, new methods should be investigated.

- Explore methods applied to "short lived species" (two stages model)?
- New model formulations need to be explored to solve the issue relative to the recent high F estimate for 2019
- SPiCT should be explore again either as basis for advice or to estimate the stock status.
- Other models should be also explored (SAM, SURBAR, length-based models…)

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 a forecast is not a priority, although reference points are still important.

19.9 References

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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	17	0	3982	1147	182	5328
2008	20	0	3723	1270	353	5366
2009	17	0	827	889	293	2026
2010	80	0	947	802	338	2167
2011	97	0	704	771	243	1815
2012	51	0	170	525	146	892
2013	40	0	122	260	40	462

Year	Belgium	Denmark	France	Netherlands	UK	total
2014	79	0	765	912	246	2002
2015	250	0	1741	2657	679	5327
2016	184	0	690	2024	540	3438
2017	120	0	887	1443	406	2856
2018	92	0.044	665	1112	167	2036
2019	232	0.037	1401	1821	589	4043
2020	220	0.124	723	1752	787	3482

1) No data reported by France in 1999.

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 2)
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

Year	4	3.a	7.d	Total [2)]
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	642	0	1083	1725
2007	1546	0	3782	5328
2008	1830	0	3536	5366
2009	910	0	1115	2025
2010	699	0	1468	2167
2011	609	0	1206	1815
2012	387	0	505	892
2013	196	0	266	462
2014	526	0	1476	2002
2015	1601	0	3727	5328
2016	1649	0.03	1789	3438
2017	1304	0	1552	2856
2018	769	0.002	1267	2036
2019	1282	0.022	2761	4043
2020	1379	0.157	2103	3482

[1)] No data reported by France in 1999.

[2)] Differ from Table 19.5.1.1 and Table 19.5.1.3 due to rounding.

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 [1)]	ICES Estimates
2004			5445	4674
2005			2997	2350
2006		-	1725	1476
2007		-	5328	4604
2008		-	5366	2064
2009		-	2025	1513
2010		-	2167	1919
2011		-	1815	1511
2012	No increase in catch	-	892	726
2013	No increase in catches (average 2009–2010)	< 1700	462	408
2014	Reduce catches by 36% compared to 2012	< 460	2002	1718
2015	No new advice, same as for 2014	< 460	5328	4487
2016	Precautionary approach	<552	3438	2579
2017	Precautionary approach	<552	2856	2195
2018	Precautionary approach	<465	2036	1640
2019	Precautionary approach	<465	4044	4048

Year	ICES Advice	Predicted catch corresp. to advice	Official landings [1)]	ICES Estimates
2020	No Advice	-	3483	3503
2021	No Advice	-		
2022	Precautionary approach	<1950		
2023	Precautionary approach	<1950		

Weights in tonnes.

[1)] Differ from Table 19.5.1.1 and Table 19.5.1.2 due to rounding.

Table 19.5.1.4. Striped red mullet landing numbers at age (thousands).

	0	1	2	3	4	5	6	4+
2004	0	43076	1826	940	75	111	0	186
2005	0	16557	2448	262	56	199	0	255
2006	0	3900	2325	1674	109	78	0	187
2007	0	36872	1120	551	94	33	0	127
2008	0	1316	10459	1248	313	221	0	534
2009	45	13256	1075	540	83	0	0	83
2010	12971	13384	593	125	70	19	1	90
2011	0	9310	1453	639	76	4	0	80
2012	6	1337	1246	1479	181	2	0	183
2013	1170	2342	395	244	0	0	0	0
2014	9904	10556	1300	14	14	14	0	28
2015	1728	35360	5952	18	2	32	0	34
2016	38	3498	9680	2129	148	51	0	199
2017	872	10314	2974	1105	223	130	100	453
2018	511	6630	3017	234	140	0	0	140
2019	1582	31105	1511	466	119	0	0	119
2020	590	27386	512	31	0	0	0	0

Table 19.5.2.1. Striped red mullet stock weights (kg).

	0	1	2	3	4	5	6	4+
2004	0	0.09	0.222	0.27	0.434	0.66	0	0.569
2005	0	0.105	0.172	0.3	0.383	0.419	0	0.411
2006	0	0.146	0.188	0.241	0.379	0.35	0	0.367
2007	0	0.107	0.313	0.422	0.446	0.677	0	0.506
2008	0	0.096	0.139	0.226	0.326	0.41	0	0.361
2009	0.046	0.07	0.16	0.177	0.423	0	0	0.423
2010	0.042	0.077	0.112	0.24	0.225	0.149	0.215	0.209
2011	0	0.052	0.15	0	0	0.323	0	0.016
2012	0.023	0.091	0.169	0.255	0.229	0.772	0	0.235
2013	0.025	0.063	0.118	0.115	0	0	0	0
2014	0.029	0.093	0.144	0.259	0.294	0.323	0	0.309

	0	1	2	3	4	5	6	4+
2015	0.038	0.1	0.114	0.37	0.42	0.187	0	0.2
2016	0.038	0.114	0.138	0.319	0.42	0.187	0	0.360
2017	0.038	0.114	0.138	0.319	0.42	0.187	0	0.260
2018	0.046	0.143	0.166	0.273	0.315	0	0	0.315
2019	0.033	0.111	0.144	0.158	0.156	0	0	0.156
2020	0.038	0.114	0.110	0.320	0	0	0	0

Table 19.7.1. Striped red mullet 27.3a47d length-based indicators.

Data Type	Value/Year	Source
Length at maturity	162 162 162	Mahé *et al.*, 2013
von Bertalanffy growth parameter (Linf)	400 400 400	Mahé *et al.*, 2013
Catch at length by year	2014–2016 2018–2020	Length data from IC
Length-weight relationship parameters for landings	2014–2016 2018–2020	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	0.01	0.8	1.06
2019	1.2	1.11	0.64	0	0.81	0.87
2020	1.2	1.17	0.62	0	0.8	0.87

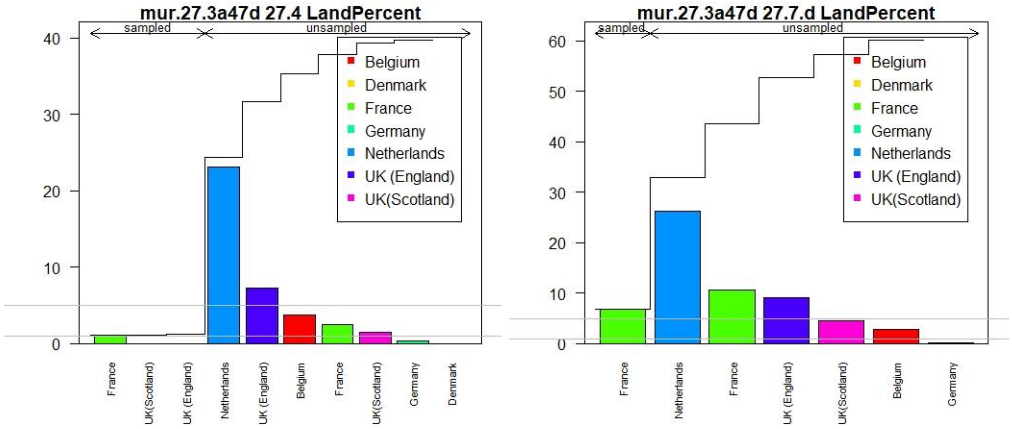

Figure 19.5.1.1. Striped red mullet in Subarea 4 and Division 7.d ICES landings by country (percentage over the total area).

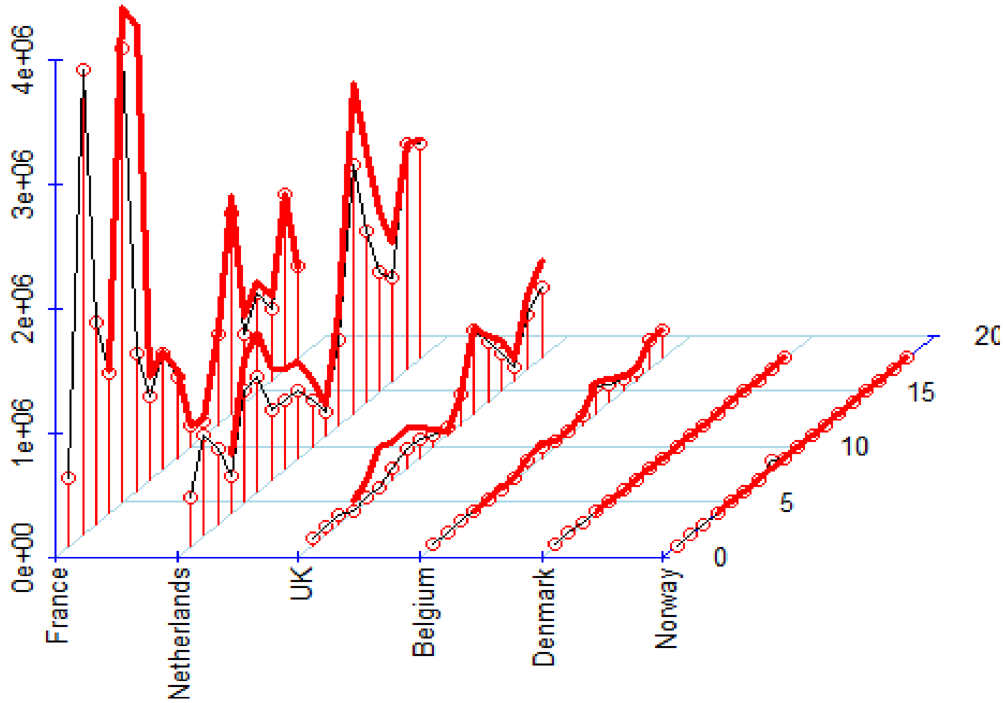

Figure 19.5.1.2. Striped red mullet in Subarea 7d and 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

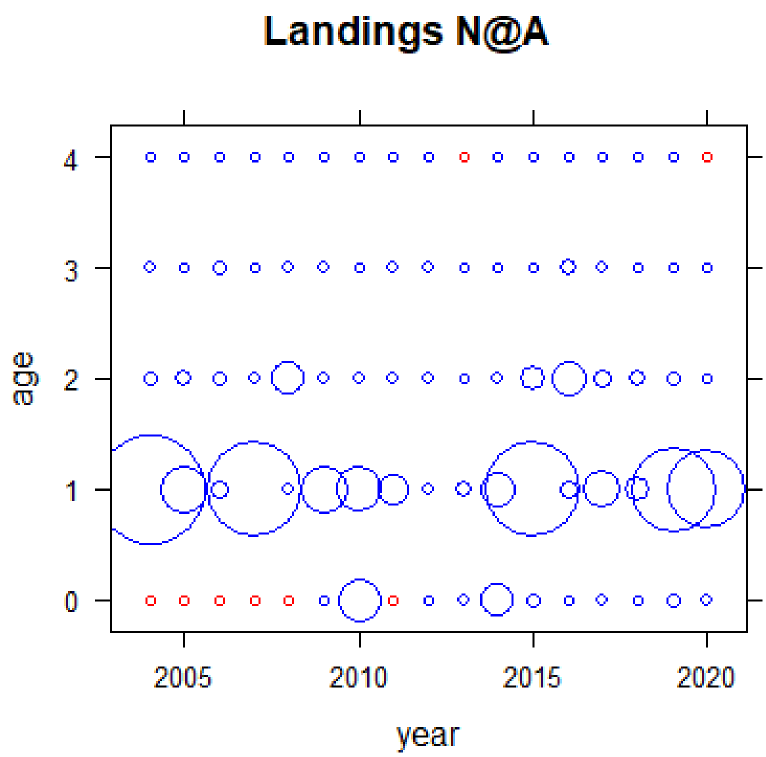

Figure 19.5.1.3. Striped red mullet age structure (in numbers) as provided in the landings.

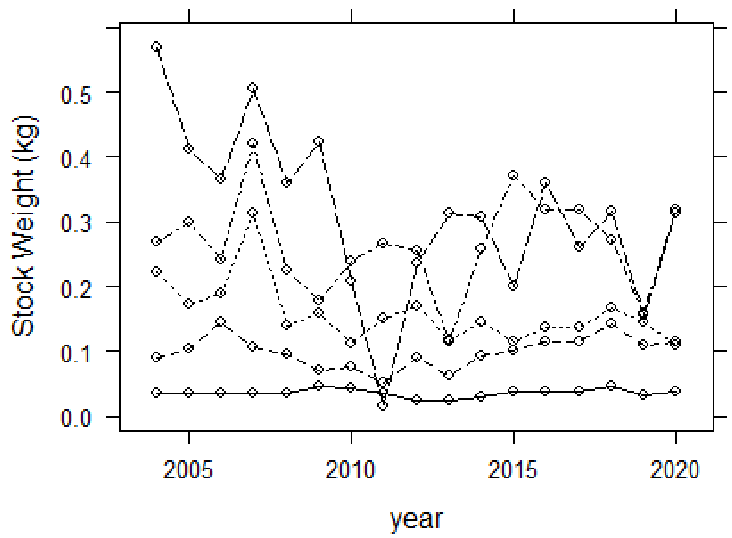

Figure 19.5.2.1. Weight at age in the stock.

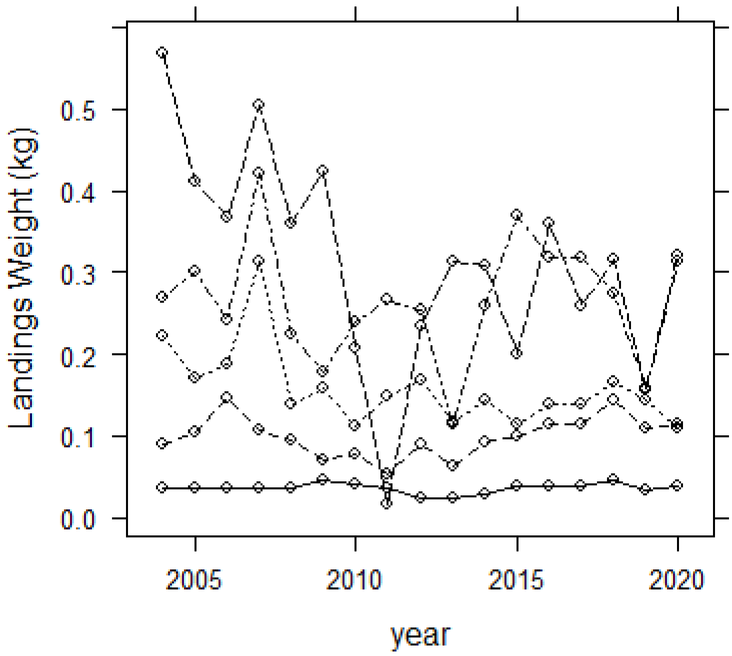

Figure 19.5.2.2. Weight at age in the landings.

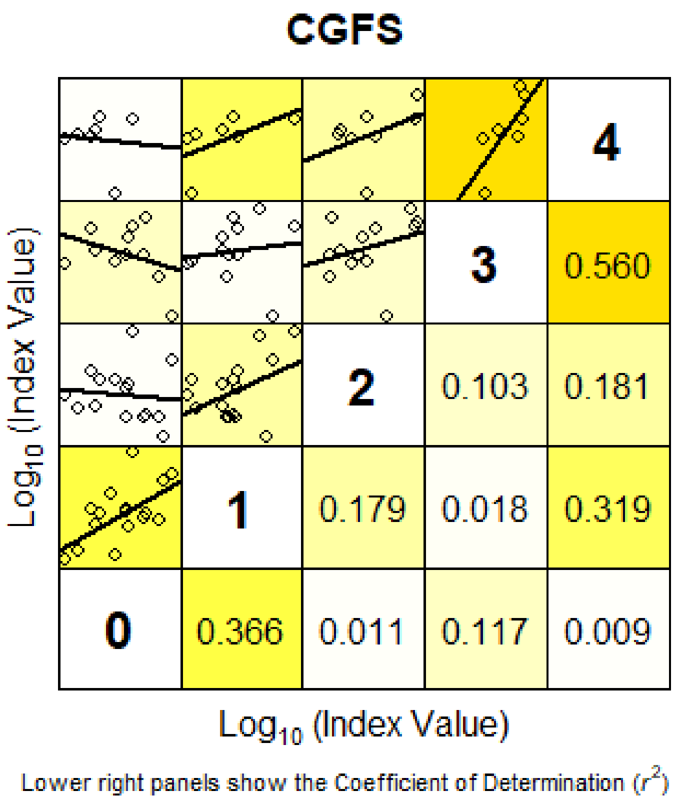

Figure 19.5.4.1. CGFS internal consistencies.

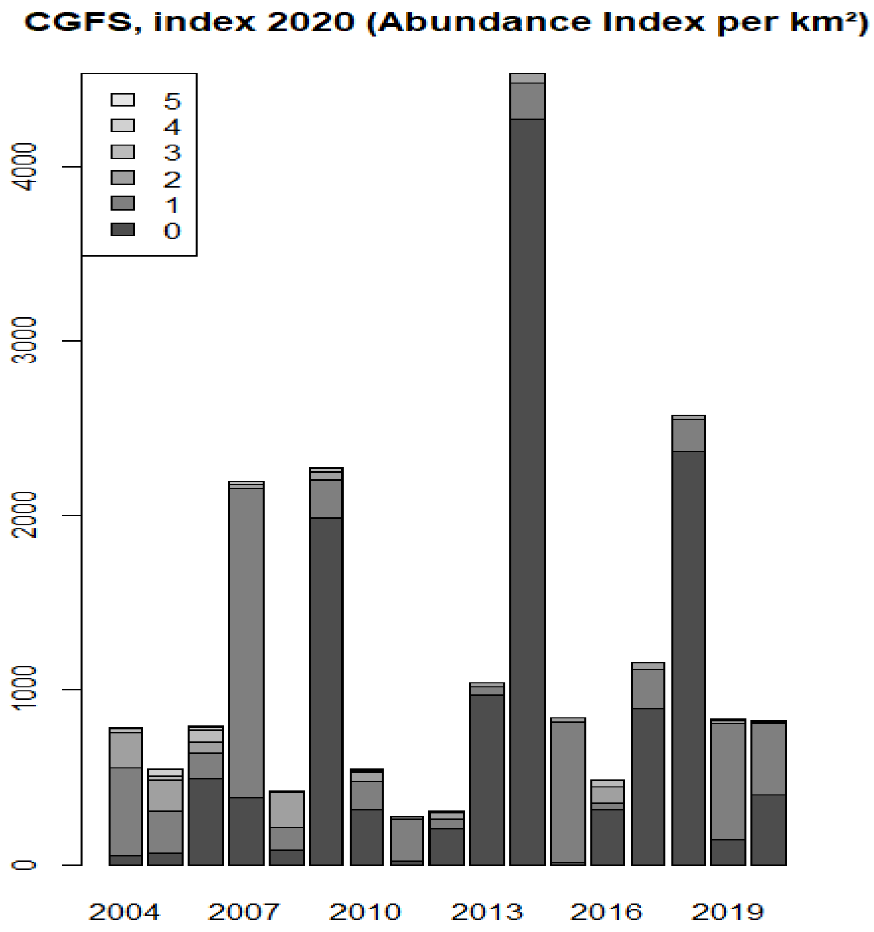

Figure 19.5.4.2. CGFS catch age composition.

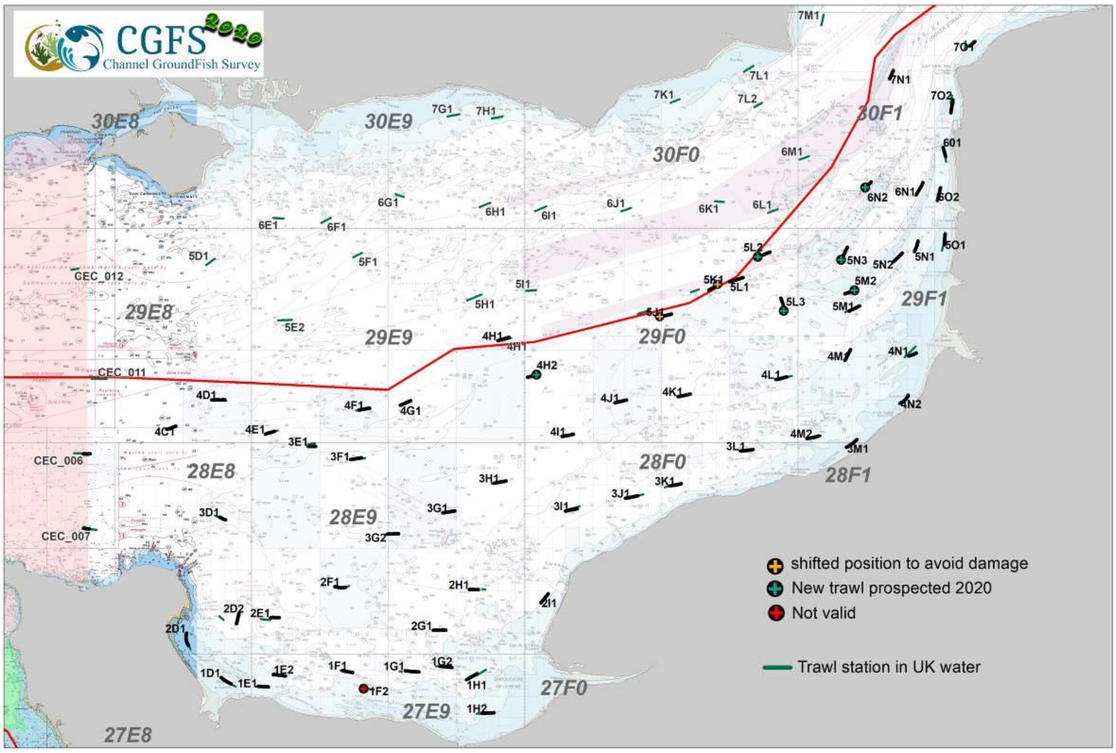

Figure 19.5.4.3. CGFS hauls positions in 2020, north of the redline is the UK EEZ with stations not sampled in 2020 (ICES IBTSWG, 2021 (*in prep*).

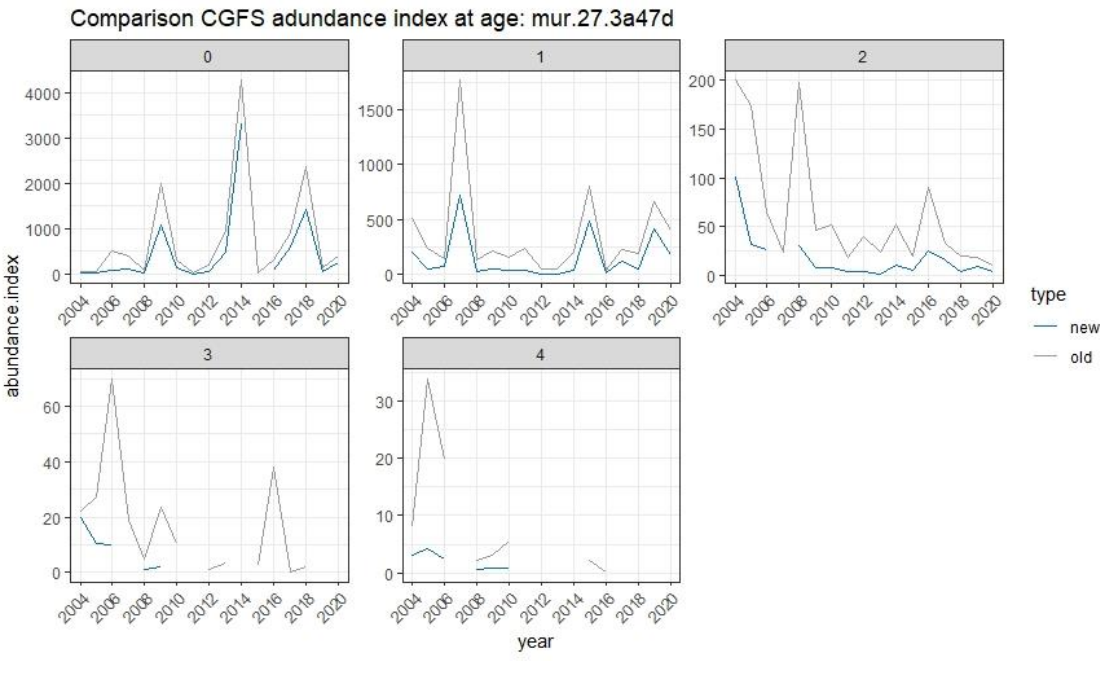

Figure 19.5.4.3. CGFS stripped red mullet index at age. Comparison between the methodology approved during the last benchmark in grey excluding in the index calculation some sampled hauls without stripped red mullet and the preliminary new index including all the hauls in blue. Age-length key calculation in the preliminary new index needs to be improved as some age at length are still missing in the calculation.

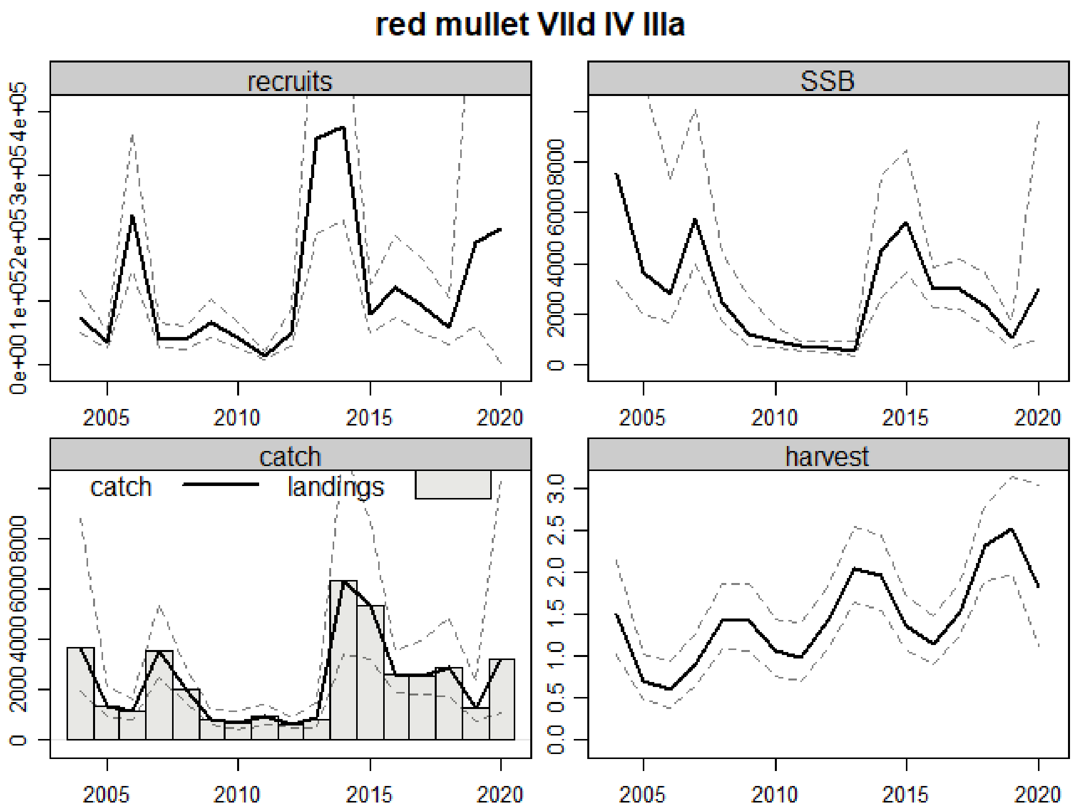

Figure 19.6.1.3. Absolute value of recruitment, SSB, catch and $F_{bar(1-2)}$ estimate using a4a model formulation approved during the last benchmark.

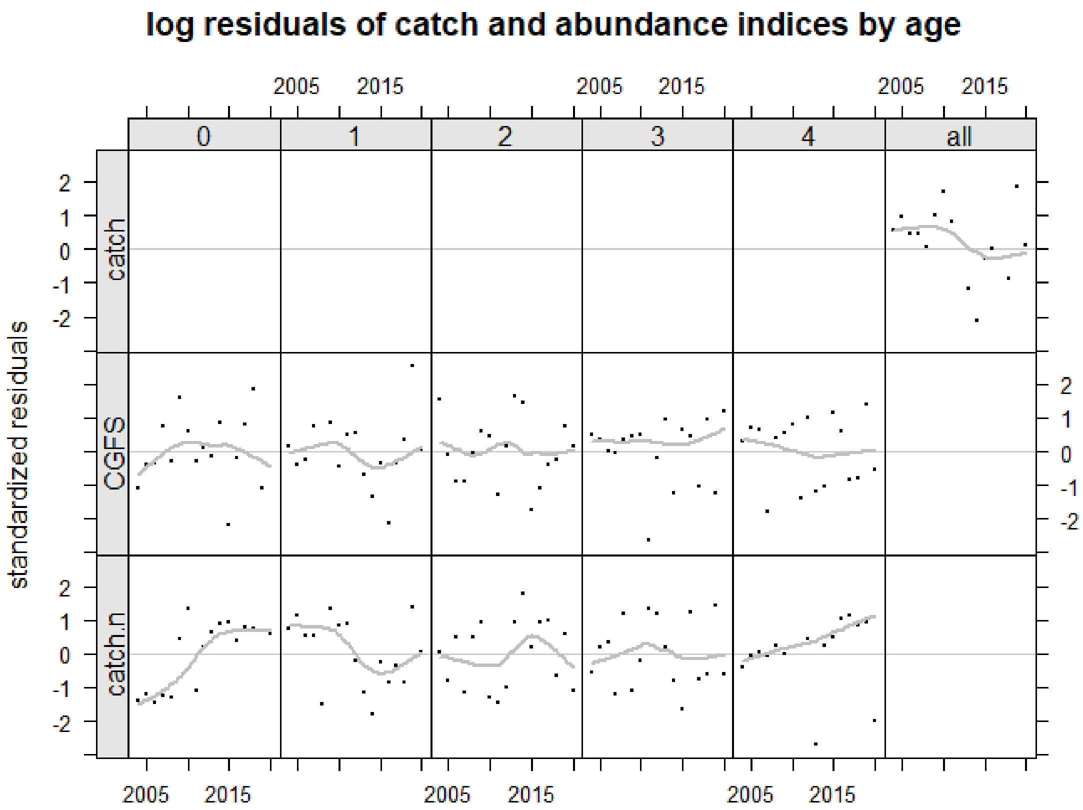

Figure 19.6.1.4. Log residuals of the assessment.

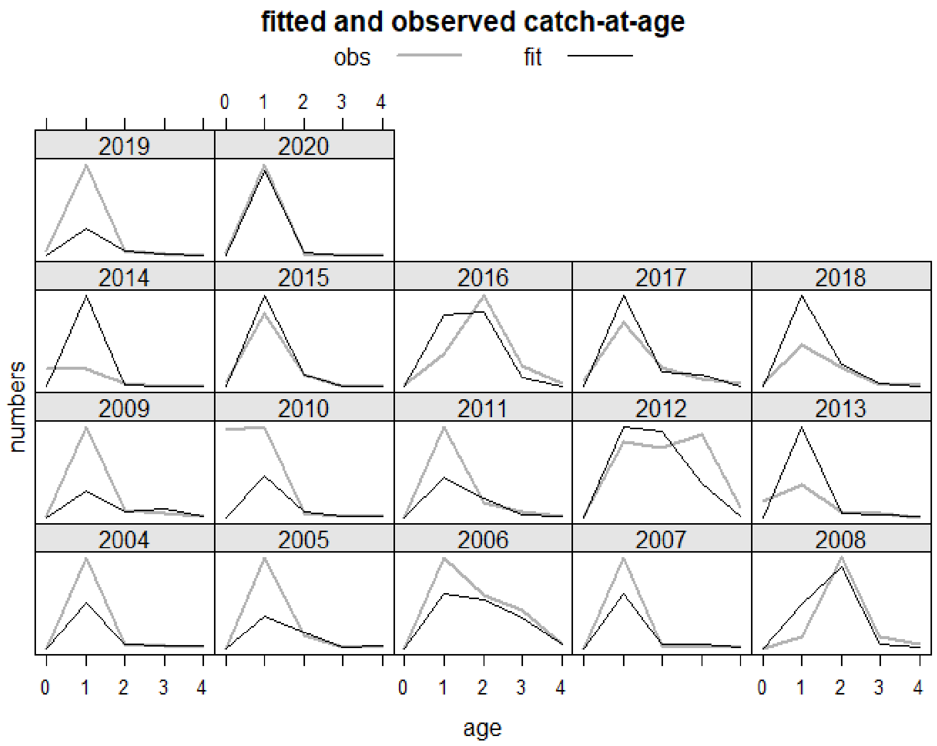

Figure 19.6.1.5. Observed (grey) and estimated (black) catch number-at-age.

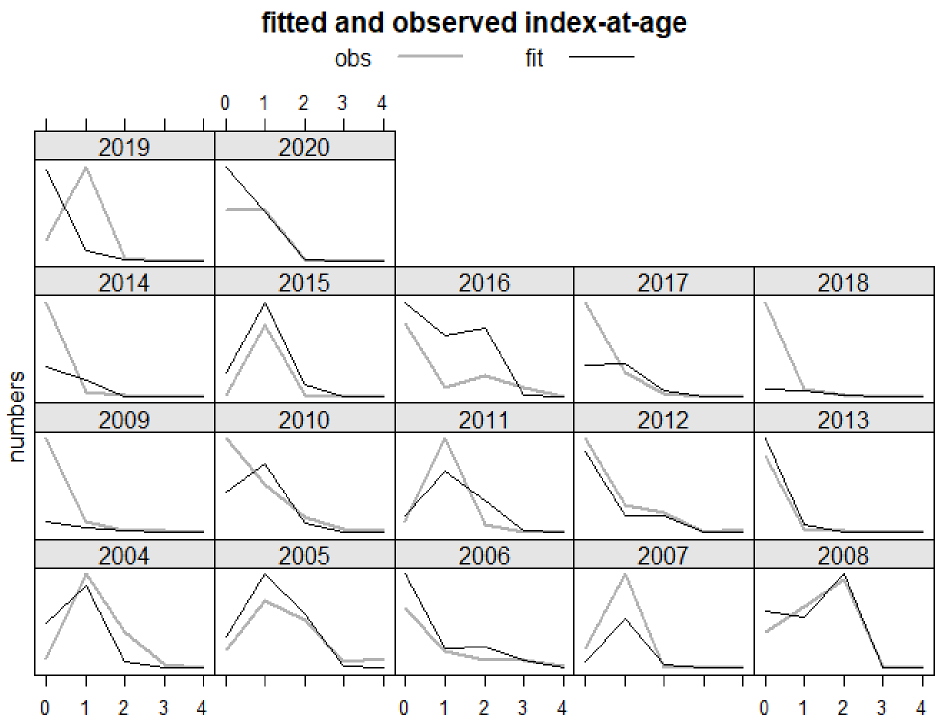

Figure 19.6.1.6. Observed (grey) and estimated (black) indices at age.

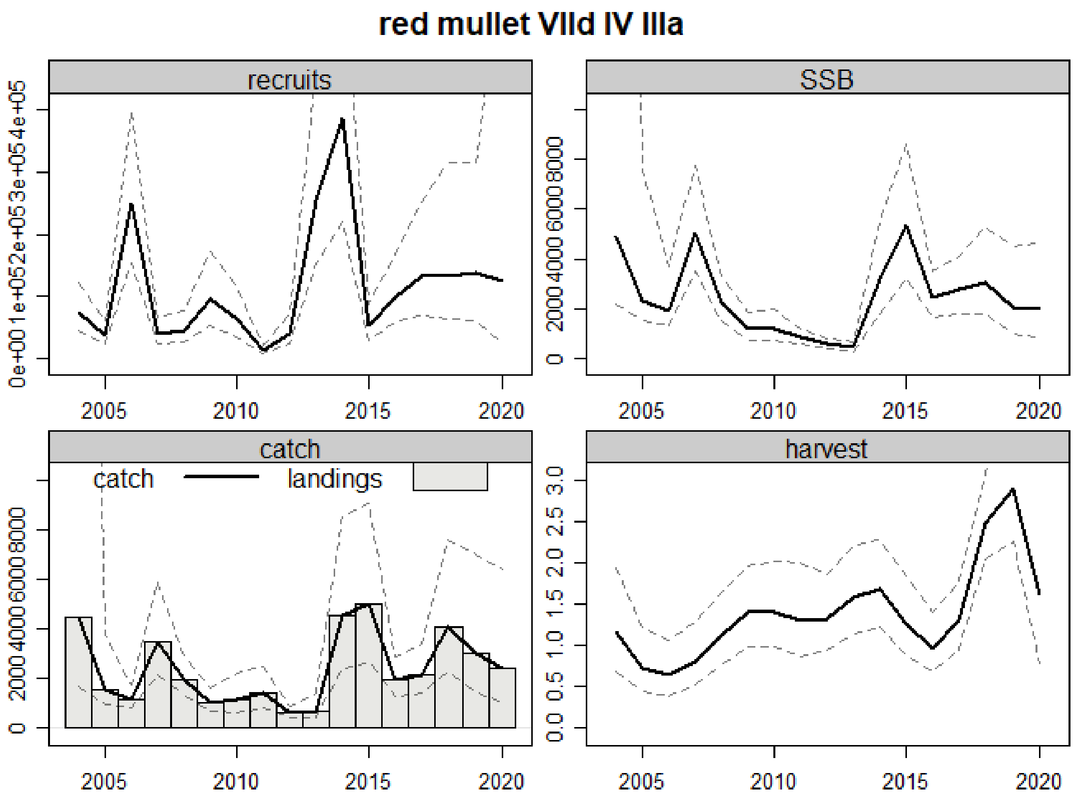

Figure 19.6.2.1. Absolute value of recruitment, SSB, catch and $F_{bar(1-2)}$ estimate using alternative formulation of a4a to constrain selectivity at age and consider variance at age.

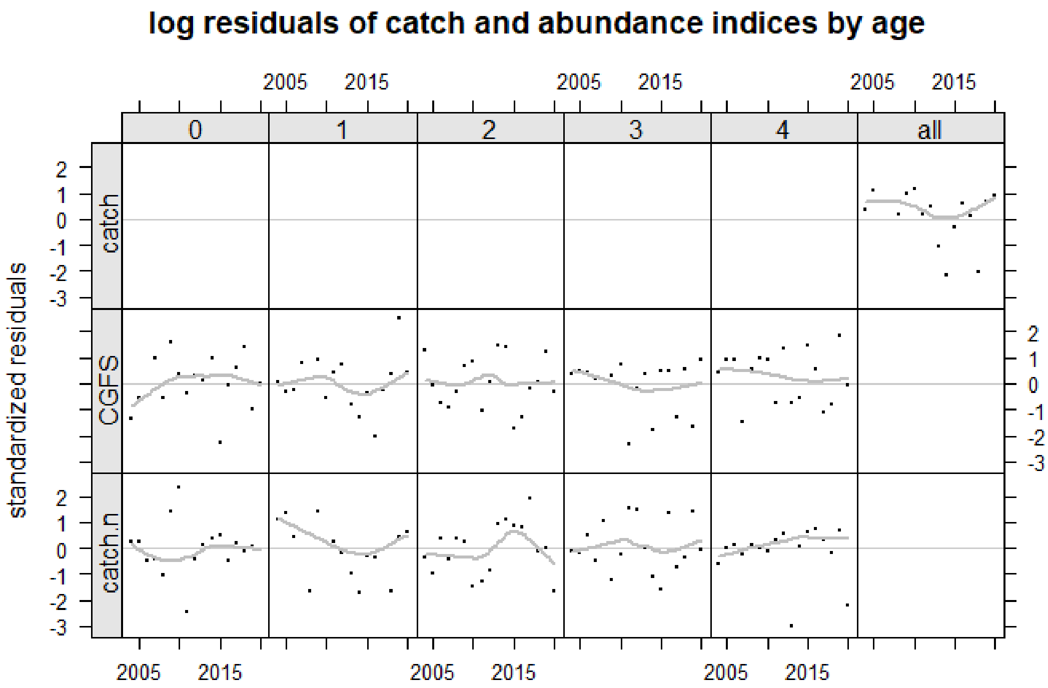

Figure 19.6.2.2. Log residuals of the alternative a4a model.

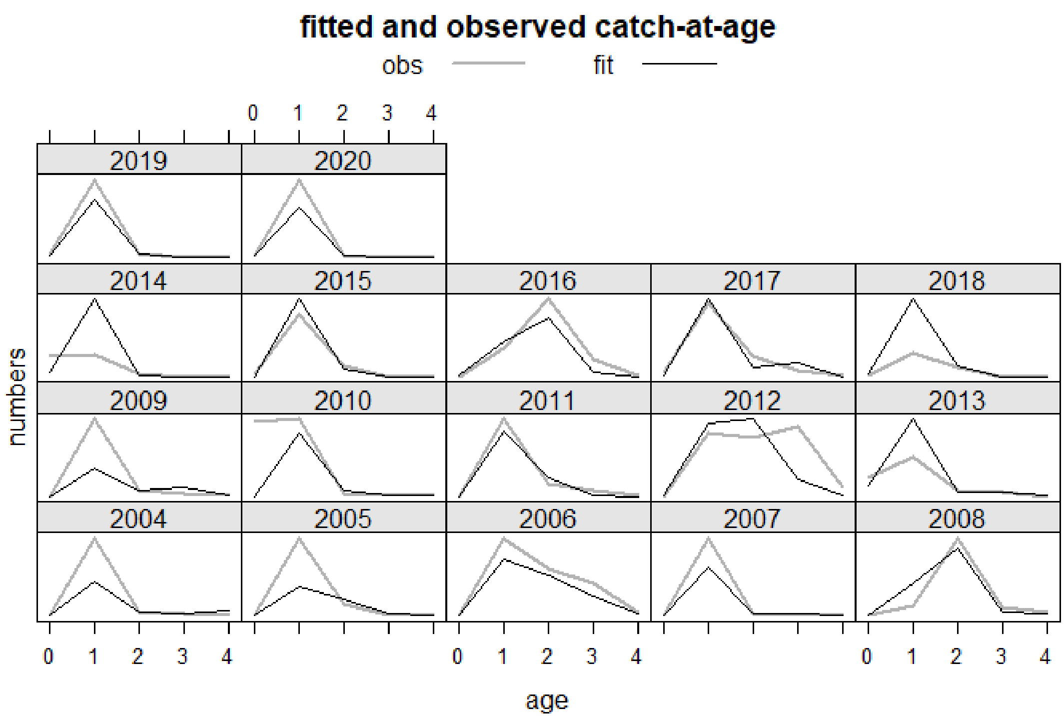

Figure 19.6.2.3. Observed (grey) and estimated by the alternative a4a model (black) catch number-at-age.

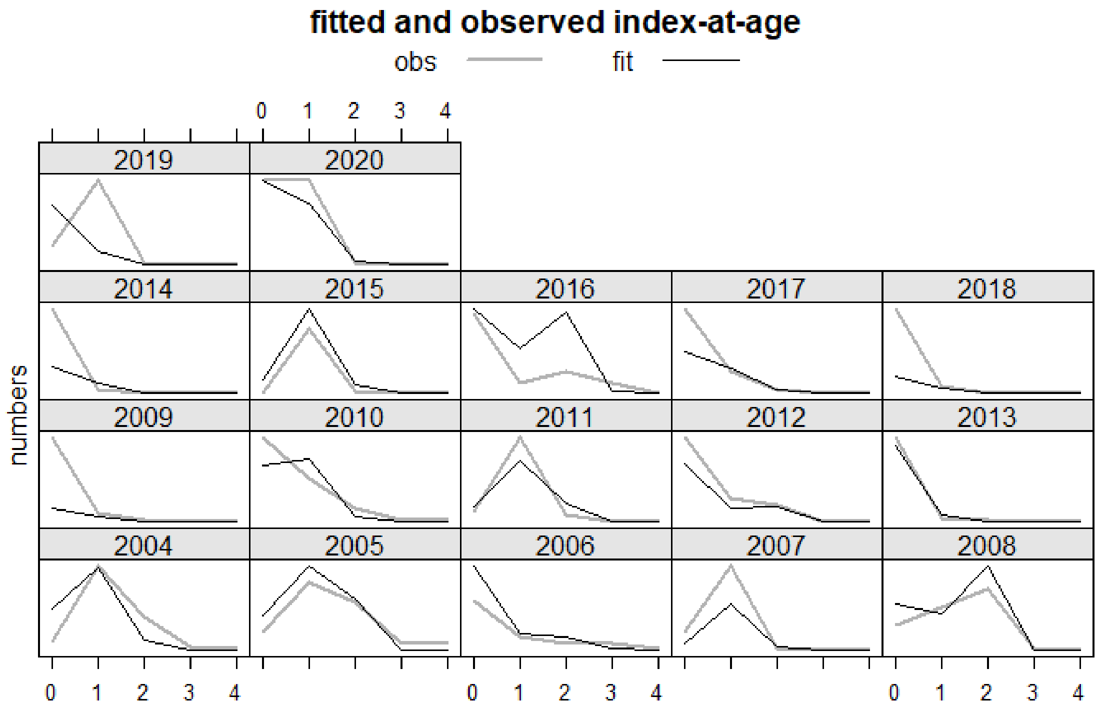

Figure 19.6.2.4. Observed (grey) and by the alternative a4a model (black) indices at age.

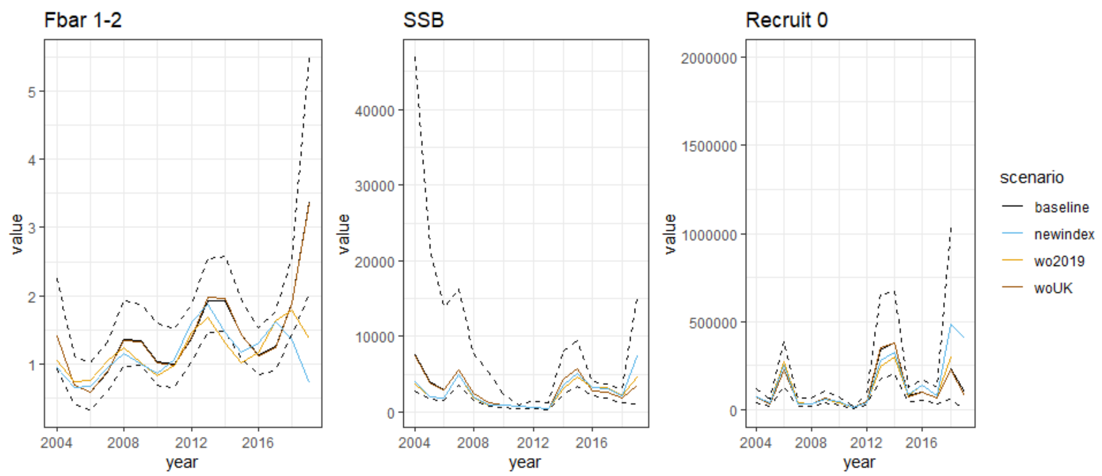

Figure 19.6.3.1. Evaluation of the impact of CGFS survey index issues on stripped red mullet assessment estimation of recruitment, SSB, catch and $F_{bar\ (1–2)}$. All the assessment used the settings from WGNSSK 2020 assessment (ICES, 2020) and data from 2004–2019. The baseline (in black), the run wo2019 (in yellow) and the run woUK (in brown) used the methodology agreed upon during the last benchmark and omits some survey hauls without stripped red mullet in the calculation of the index. The baseline is the assessment from WGNSSK 2020 (ICES, 2020). The run wo2019 is the assessment without CGFS survey data year 2019. woUK is the assessment run that used an index calculated on CGFS survey hauls within the French EEZ. The blue line are the outputs from the assessment using the new preliminary CGFS survey index that still requires age-length key calculation improvement.

20 Turbot in 3.a (Kattegat, Skagerrak)

The last advice issued in 2017 for the years 2018 and 2019 was based on the “2/3 rule” for category 3 stocks, applied to the IBTS Q1 and Q3 biomass indices. In 2019 and 2020, ICES was not requested to provide advice on fishing opportunities for this stock, so the advice sheet reported only on the status of the stock. In 2021, ICES was requested to provide advice again.

The general perception is that landings have fluctuated without trends over a long period. In 2019, the survey indices were of poor quality, with low catch rates and large annual fluctuations, and they showed no clear trends. In 2017, length-based indicators (LBI) and exploratory SPiCT runs were examined, 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. The stock went through benchmark in 2020 where a SPiCT assessment was accepted to provide stock status (ICES, 2020). That assessment was further used in 2021 to provide catch advice according to the precautionary approach.

20.1 Management regulations

Turbot in 3.a. is not managed using a TAC. ICES was requested to provide advice for 2022. The last advice from ICES was for 2019.

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, 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 Division 3.a. Over the period 1975–2020, total landings (3.a) ranged from 95 t to 736 t per year. The lowest landings were recorded in the 1960s and the highest peaks are observed in the late 1970s and in the early 1990s. The peak in the 1970s is linked to exceptionally high records from the Netherlands for four years.

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 300–400 tonnes in the early 1990s to around 100 t in the early 2010s, but have increased again in the most recent years. In 2020, the total landings were 191 tonnes.

The stock was benchmarked in early 2020, which included a data call for turbot in Division 3.a that lead to new landings and discard data being uploaded into InterCatch. This allowed a compilation of information by area and metier. During the benchmark, reported discard ratios were available across 2002–2018, and the average discard ratio (10.49%) was used to reconstruct the discards for earlier years (1950–2001). Details of the benchmark are provided in the associated report (ICES, 2020).

Discard coverage in 2020 was lower this year in subdivision 3a.20 (47%), but comparable to previous years in 3a.21 (59%). The beam trawl fleet from the Netherlands and the gillnet fleet from Denmark are the largest metiers without discard information (Figure 20.2). Discarding is clearly related to fish size, most individuals below 30cm are being discarded (Figure 20.3).

As turbot in 3a is mainly a bycatch species, a change in catch over time can be influenced by changes in effort levels and targeting of the fleets in the area that catch it. Further investigation is needed into targeting of the species in the area trough time.

20.3 Survey data, recruit series and analysis of stock trends

During the benchmark, a new index for exploitable biomass was developed. The index was based on a compilation of five surveys covering Division 3a. Specifically, the surveys included the beam trawl survey (BTS), the North Sea International Bottom Trawl Survey (NS-IBTS), the Baltic International Trawl Survey (BITS), a Danish national survey targeting cod and the Danish part of a Swedish-Danish survey targeting sole, all covering parts of Division 3.a. (ICES, 2020). Since the index was intended for use in SPiCT, only the vulnerable sizes of the individuals caught in the surveys were included in the calculation of the index, leading to an exploitable biomass index. The standardised exploitable biomass index is shown in Figure 20.4, along with 3 retrospective runs, calculated by leaving out the last 1–3 years of available data. The SPiCT model combined the new exploitable biomass index and updated fisheries data and was approved during the benchmark (ICES, 2020).

20.4 Assessment – short term forecast

The surplus production model in continuous time (SPiCT, Pedersen and Berg 2017) is used for the assessment of the stock. The main settings are as following:

Fixed values

Shaefer model (shape parameter n=2)

Priors

Initial depletion: log(bkfrac)~N (log(0.5), 0.5^2)

Uncertainty ratio of index (observation) to biomass process: log(alpha)~N (log(1), 2^2)

Ratio of catch (observation to fishing mortality process uncertainty: log(beta)~N(log(1), 2^2)

Catch: 1975–2020

Index (estimated for Q1): 1983—2020

Discretisation time step (dteuler): 1/16 year

A short-term forecast is performed using SPiCT. The assumption for the short term forecast intermediate year (2021) is that the fishing mortality process continues, essentially keeping status quo fishing mortality. This leads to the following short-term forecast in the intermediate year:

Variable	Value	Notes
F_{2021}/F_{MSY}	0.88	Status quo F
B_{2022}/B_{MSY}	1.11	Short term forecast (STF) under status quo F
Catch (2021)	218	STF of catch under status quo F
Discard rate (2021, 2022)	12.1%	Average 2018—2020. Percentage
Projected landings (2021)	192	Based on the average discard rate
Projected discards (2021)	26	Based on the average discard rate

The assessment results are shown in Figure 20.5 and summarised in Table 20.5. The diagnostics of the goodness of fit of the model are based on the one-step-ahead residuals (Figure 20.6). There are some issues with autocorrelation of the residuals of the index time series. This is a result of including an already smoothed biomass index based on a GAM model. During the benchmark of the stock in 2020, an approach of removing every other index observation was used as an attempt to alleviate the autocorrelation issue. The results showed improvement in the autocorrelation, but only small differences in the estimated stock status. The decision was to include all data as it created issues with the retrospective analysis and would cause issues with the short-term forecast. Another issue with the assessment is the low estimated observation error for the exploitable biomass index ($\sigma_I = 0.019$) which is probably unrealistic, but stems from the fact that a smoothed index is used.

The retrospective analysis shows that the relative process estimates have acceptable retrospective bias: Mohn's rho was 0.123 for B/B_{MSY}, 0.208 for F/F_{MSY} (20.7).

To provide advice following the precautionary approach, the recommendation of WKLIFEX (ICES, 2020) is followed. The basis for the advice assumes fishing mortality $F=F_{MSY}$, then the TAC advice is the 35th percentile of the projected catch distribution. The use of that percentile instead of the median leads to a more precautionary advice, with no loss of long-term yield. For 2022, the catch advice is 224 tonnes. The results for the baseline scenario and alternatives that are included in the advice sheet are shown in Figure 20.8 and Table 20.4.

Alternative basis for advice

During the assessment working group meeting, an alternative option was explored, to base the advice on the 2/3 rule using the survey index (Figure 20.9). That rule requires a baseline catch, suggested to be the average catch over 2015–2020, equal to 214 tonnes (20.10). The 2/3 ratio for was equal to 0.92, following the downward trend of the index and not applying the precautionary buffer (multiplier 0.8) as the SPiCT assessment indicates that the stock is in good status and not being overexploited: alternative TAC_{2022} = 214 x 0.92 = 197 t.

20.5 Issue list

The stock was benchmarked in 2020, but a number of issues remain:

- Stock identity. The benchmark indicated that Division 3.a is not a separate stock, but connected to both the North Sea and the Baltic Sea. There is genetic differentiation between the North Sea and the Baltic Sea with a genetic hybrid zone within Division 3.a The new exploitable biomass index and the landings data indicated elevated abundances and landings on the borders between Division 3.a and the North Sea and the Baltic Sea, further supporting connectivity between Division 3.a and neighbouring areas. The stock identity of Division 3.a should therefore be evaluated.
- The amount of length distributions data has been significantly reduced since 2017. Discussions should take place within Denmark for options within the framework of the next data collection programs after 2021. Denmark is responsible for approximately 3/4 of the turbot landings in Division 3.a.
- The application of the new exploitable biomass index via SPiCT indicated residual autocorrelation issues that should be addressed.
- The index includes only Danish part of the cod survey in subdivision 3a. In the future the Swedish data should be also included.
- 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 further SPiCT runs. The paper indicated historic declines in abundance and maximum body sizes of turbot in Division 3.a.

20.6 Summary

The turbot stock in Division 3.a was benchmarked in 2020, and the resulting SPiCT model was used for the present assessment and report. A major improvement for the SPiCT model was the development of a new index for the relative exploitable biomass based on five different surveys covering Division 3.a. The analyses indicated that the relative exploitable biomass (B/B_{MSY}) remained above the reference point of 0.5 and relative fishing mortality (F/F_{MSY}) below the reference point of 1.

Table 20.1. Turbot in 27.3a. History of commercial landings 1975–2020; official values are presented by area for each country participating in the fishery. All weights are in tonnes.

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
1975	0	2	167	0	7	0	7	183
1976	7	2	178	0	190	0	6	383
1977	7	4	331	0	389	0	5	736
1978	2	4	327	0	186	0	6	525
1979	8	0	307	0	87	0	4	406
1980	7	0	205	1	14	0	6	233
1981	2	0	183	2	12	0	8	207
1982	1	0	164	1	9	0	7	182
1983	4	0	171	0	24	0	10	209
1984	0	0	176	0	0	0	12	188
1985	1	0	224	0	0	0	16	241
1986	2	0	180	0	0	0	11	193
1987	5	0	147	0	0	0	9	161
1988	2	0	115	0	11	0	10	138
1989	2	0	173	0	0	0	9	184
1990	5	0	363	0	0	0	18	386
1991	4	0	244	0	0	7	21	276
1992	4	0	278	0	0	8	19	309
1993	3	2	336	0	0	10	0	351
1994	2	1	313	0	0	15	22	353
1995	4	1	268	0	0	17	11	301
1996	0	1	185	0	0	13	11	210
1997	0	0	200	0	0	9	11	220
1998	0	1	148	0	0	7	8	164
1999	0	1	139	0	0	10	6	156
2000	0	1	180	0	0	6	6	193
2001	0	0	227	0	0	8	3	238
2002	0	1	205	0	0	11	5	222
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	167	0	0	8	14	189
2013	0	0	91	0	0	5	15	111

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
2014	0	1	94	0	3	6	18	122
2015	0	0	135	0	20	8	11	174
2016	0	0	137	0	25	6	11	179
2017	0	0	154	0	16	7	12	189
2018	0	0	109	0	23	8	10	150
2019	0	0	118	0	68	5	7	198
2020	0	0	124	0	55	5	7	191

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.

Year	Discards	Landings	Total	discard ratio
2002	**17593**	**214745**	**232338**	**7.60%**
27.3.a	9	135	144	6.20%
27.3.a.20	906	152506	153412	0.59%
27.3.a.21	16679	62104	78783	21%
2003	**15273**	**153228**	**168501**	**9.10%**
27.3.a	1468	14080	15548	9.40%
27.3.a.20	227	83702	83929	0.27%
27.3.a.21	13578	55446	69024	19.70%
2004	**9463**	**146736**	**156199**	**6.10%**
27.3.a	990	15674	16664	5.90%
27.3.a.20	2524	72802	75326	3.40%
27.3.a.21	5950	58260	64210	9.30%
2005	**10672**	**125757**	**136429**	**7.80%**
27.3.a	516	6928	7444	6.90%
27.3.a.20	3277	73824	77101	4.30%
27.3.a.21	6880	45005	51885	13.30%
2006	**11600**	**116895**	**128495**	**9.00%**
27.3.a	833	8838	9671	8.60%
27.3.a.20	246	55105	55351	0.44%
27.3.a.21	10522	52952	63474	16.60%
2007	**32300**	**171442**	**203742**	**15.90%**
27.3.a	1597	16098	17695	9.00%
27.3.a.20	880	100442	101322	0.87%
27.3.a.21	29823	54902	84725	35%
2008	**7183**	**139685**	**146868**	**4.90%**
27.3.a	172	4635	4807	3.60%
27.3.a.20	0	91024	91024	0.00%
27.3.a.21	7011	44026	51037	13.70%

Year	Discards	Landings	Total	discard ratio
2009	**9363**	**120692**	**130055**	**7.20%**
27.3.a	142	2661	2803	5.10%
27.3.a.20	727	73619	74346	0.98%
27.3.a.21	8494	44412	52906	16.10%
2010	**11264**	**96525**	**107789**	**10.50%**
27.3.a	658	6346	7004	9.40%
27.3.a.20	163	43069	43232	0.38%
27.3.a.21	10443	47110	57553	18.10%
2011	**25532**	**94354**	**119886**	**21%**
27.3.a	59	258	317	18.60%
27.3.a.20	4192	54053	58245	7.20%
27.3.a.21	21281	40042	61323	35%
2012	**22621**	**194736**	**217357**	**10.40%**
27.3.a	29	289	318	9.10%
27.3.a.20	3562	164297	167859	2.10%
27.3.a.21	19030	30150	49180	39%
2013	**7110**	**110945**	**118055**	**6.00%**
27.3.a	0	2	2	0.00%
27.3.a.20	1469	75803	77272	1.90%
27.3.a.21	5641	35140	40781	13.80%
2014	**14520**	**122406**	**136926**	**10.60%**
27.3.a	0	0	0	0.00%
27.3.a.20	3874	82446	86320	4.50%
27.3.a.21	10646	39960	50606	21%
2015	**33938**	**179737**	**213675**	**15.90%**
27.3.a	0	1	1	0.00%
27.3.a.20	8426	141894	150320	5.60%
27.3.a.21	25511	37842	63353	40%
2016	**19246**	**190829**	**210075**	**9.20%**
27.3.a	3492	34530	38022	9.20%
27.3.a.20	9617	111770	121387	7.90%
27.3.a.21	6136	44529	50665	12.10%
2017	**31669**	**191667**	**223336**	**14.20%**
27.3.a	2928	17528	20456	14.30%
27.3.a.20	17404	122493	139897	12.40%
27.3.a.21	11337	51646	62983	18.00%
2018	**22528**	**153398**	**175926**	**12.80%**
27.3.a	4000	24842	28842	13.90%
27.3.a.20	11506	82913	94419	12.20%
27.3.a.21	7022	45643	52665	13.30%

Year	Discards	Landings	Total	discard ratio
2019	**41903**	**204356**	**246259**	**17.00%**
27.3.a	15857	74430	90287	17.60%
27.3.a.20	21409	102564	123973	17.30%
27.3.a.21	4637	27362	31999	14.50%
2020	**13458**	**201698**	**215156**	**6.3%**
27.3.a	4673	65140	69813	6.7%
27.3.a.20	3210	106819	110029	2.9%
27.3.a.21	5575	29740	35315	15.8%

Table 20.3: Turbot in 27.3a. Summary of the imported/Raised data for 2020. Stock exported without length allocation. Weights are in kilograms.

Discards	**13499**	
Imported Data	4856	36.1%
Raised Discards	8593	63.9%
Landings	**201698**	
Imported Data	201698	
Grand Total	**215147**	

Table 20.4: Turbot in 27.3a. Forecast table for the baseline and alternative scenarios. The percent biomass change refers to the biomass in 2023 relative to 2022.

Basis	Total catch (2022)	Projected landings (2022)	Projected discards (2022)	Fishing mortality F_{2022}/F_{MSY}	Stock size B_{2023}/B_{MSY}	% B change
Precautionary approach (35th percentile of predicted catch distribution under $F = F_{MSY}$)	224	197	27	0.90	1.11	-0.120
Other scenarios						
$F = F_{MSY}$	248	218	30	1.00	1.10	-1.08
$F = F_{sq}$	218	192	26	0.88	1.11	0.103
F = 0	0	0	0	0	1.21	8.1
$F = F_{MSY}$, all fractiles	194	171	23	0.77	1.13	1.07

Table 20.5: Turbot in 27.3a. Assessment results, summary table. The 2021 biomass is the short-term forecast during the intermediate year, assuming that the F process continues unchanged from the last year with observations (Fsq).

Year	Relative exploitable biomass			Landings	Discards	Relative fishing pressure		
	B/B_{MSY}	High	Low	tonnes	tonnes	F/F_{MSY}	High	Low
1975	1.55	2.8	0.87	183	22	1.05	2.3	0.49
1976	1.47	2.5	0.85	383	46	1.25	2.4	0.64
1977	1.38	2.3	0.83	736	88	1.37	2.7	0.69
1978	1.29	2.1	0.79	525	63	1.33	2.6	0.68
1979	1.22	1.99	0.76	406	49	1.19	2.3	0.62
1980	1.18	1.91	0.73	233	28	1.04	2.0	0.53
1981	1.16	1.88	0.72	207	25	0.93	1.88	0.46
1982	1.16	1.87	0.72	182	22	0.86	1.74	0.43
1983	1.18	1.90	0.73	209	25	0.81	1.62	0.41
1984	1.21	1.95	0.75	188	23	0.78	1.56	0.39
1985	1.26	2.0	0.78	241	29	0.76	1.57	0.37
1986	1.31	2.1	0.81	193	23	0.76	1.69	0.34
1987	1.33	2.1	0.83	161	19	0.82	1.93	0.35
1988	1.29	2.1	0.80	138	17	0.99	2.2	0.44
1989	1.19	1.91	0.73	184	22	1.29	2.6	0.66
1990	1.06	1.70	0.65	386	46	1.56	2.9	0.85
1991	0.94	1.51	0.58	276	33	1.59	2.8	0.91
1992	0.89	1.44	0.55	309	37	1.50	2.5	0.89
1993	0.90	1.46	0.56	351	42	1.43	2.4	0.85
1994	0.92	1.48	0.57	353	42	1.42	2.4	0.85
1995	0.9	1.46	0.56	301	36	1.44	2.4	0.84
1996	0.86	1.39	0.54	210	25	1.47	2.5	0.85
1997	0.80	1.29	0.50	220	26	1.46	2.5	0.83
1998	0.76	1.22	0.47	164	20	1.37	2.4	0.78
1999	0.74	1.19	0.46	156	19	1.31	2.3	0.76
2000	0.74	1.2	0.46	193	23	1.29	2.2	0.77
2001	0.75	1.21	0.47	238	28	1.27	2.1	0.76
2002	0.78	1.25	0.48	215	18	1.09	1.88	0.64
2003	0.82	1.33	0.51	153	15	0.88	1.58	0.49
2004	0.88	1.42	0.54	147	9	0.75	1.38	0.41
2005	0.93	1.49	0.57	126	11	0.67	1.30	0.34
2006	0.97	1.57	0.60	117	12	0.72	1.31	0.40
2007	1.00	1.62	0.62	171	32	0.77	1.37	0.43
2008	0.96	1.56	0.60	140	7	0.69	1.31	0.36
2009	0.89	1.43	0.55	121	9	0.64	1.25	0.32

Year	Relative exploitable biomass			Landings	Discards	Relative fishing pressure		
	B/B_{MSY}	High	Low	tonnes	tonnes	F/F_{MSY}	High	Low
2010	0.85	1.36	0.52	97	11	0.63	1.24	0.32
2011	0.88	1.41	0.54	94	26	0.74	1.28	0.43
2012	0.97	1.56	0.60	195	23	0.70	1.22	0.40
2013	1.08	1.74	0.67	111	7	0.56	1.13	0.28
2014	1.17	1.89	0.73	122	15	0.64	1.17	0.35
2015	1.23	1.99	0.76	180	34	0.74	1.32	0.42
2016	1.25	2.0	0.77	191	19	0.77	1.40	0.43
2017	1.22	1.96	0.75	192	32	0.77	1.46	0.40
2018	1.16	1.87	0.72	153	23	0.82	1.54	0.43
2019	1.12	1.80	0.69	204	42	0.90	1.62	0.50
2020	1.11	1.80	0.69	202	13	0.88	1.68	0.46
2021	1.11	1.81	0.69					

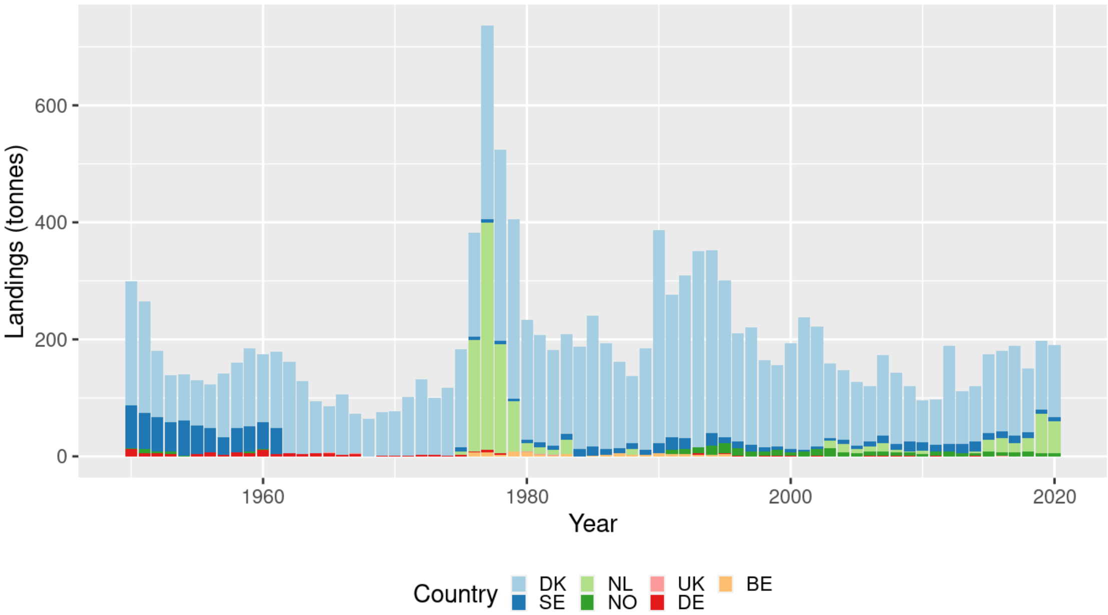

Figure 20.1. Turbot in 27.3a: Official landings by country from 1975 to 2020.

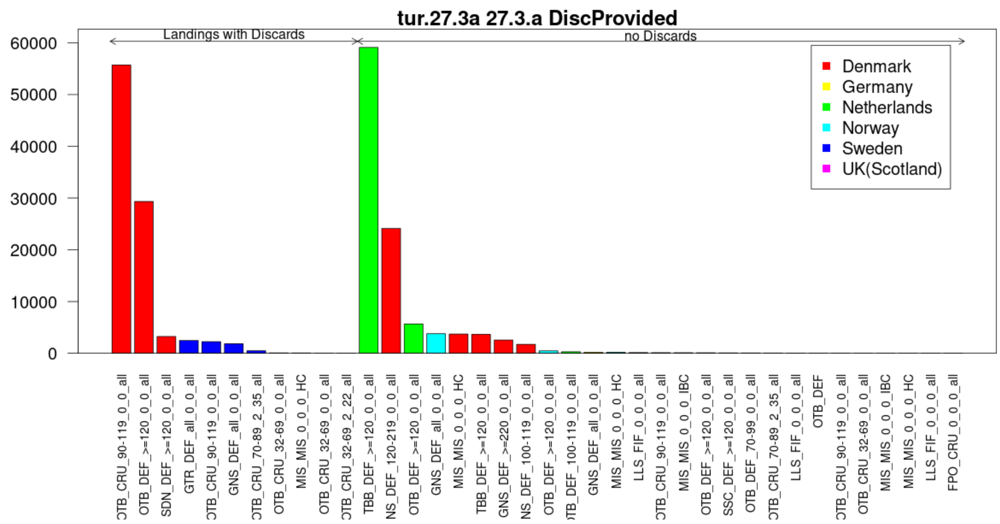

Figure 20.2. Turbot in 27.3a. Summary of the information provided to InterCatch for 2020. Landings by metier and country, distinguishing between strata with and without corresponding discard information provided.

Figure 20.3. Turbot in 27.3a: Length distribution in landings and discards across 2002–2019. Most individuals below 30 cm are discarded (vertical dashed line).

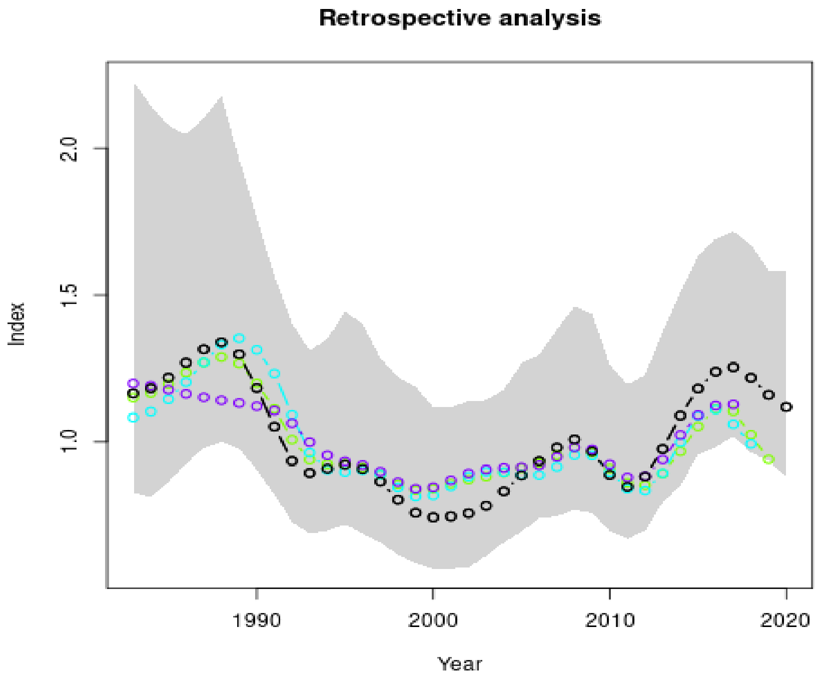

Figure 20.4. Turbot in 27.3a. Exploitable biomass survey index (black) and 3 retrospective fits (green, teal, purple). The shaded area shows 95% confidence intervals of the base run. The indices are rescaled to have mean 1.

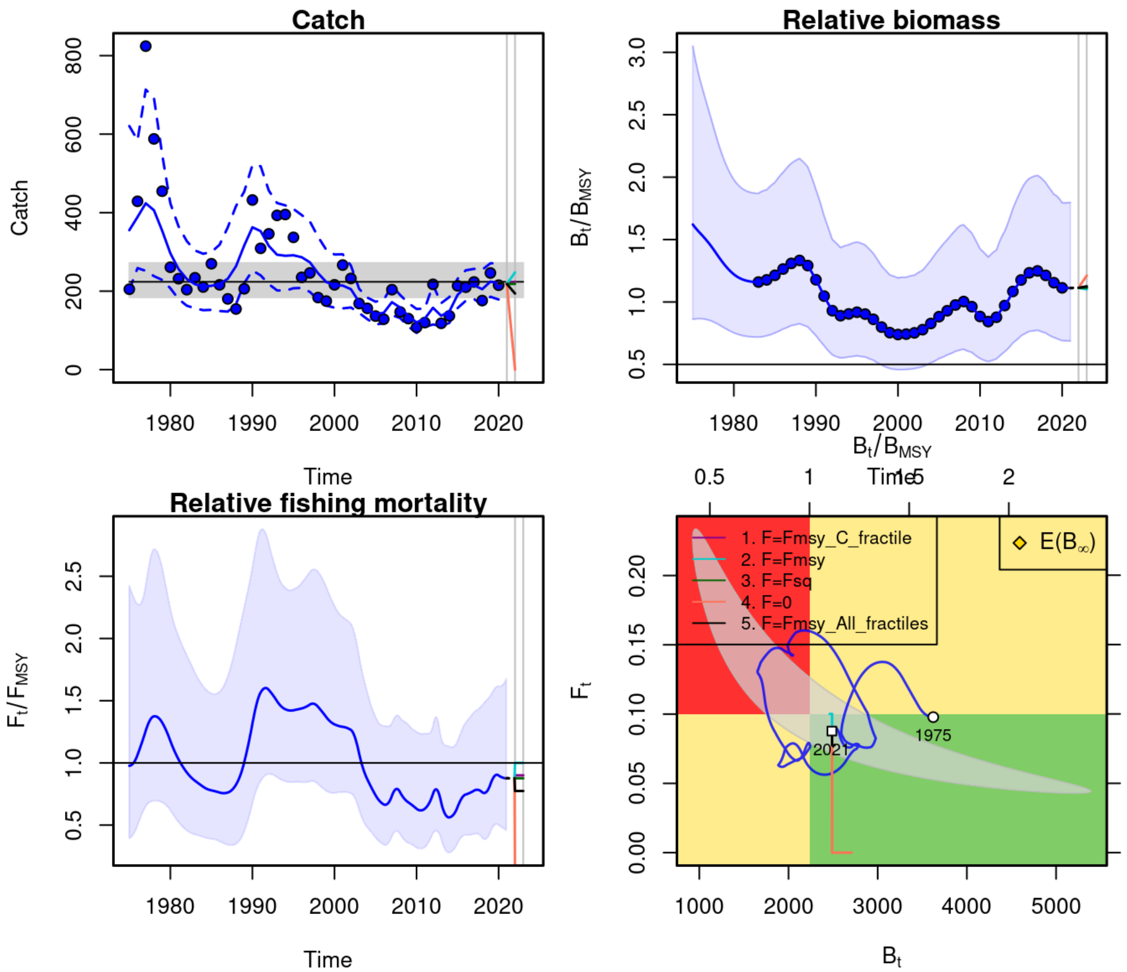

Figure 20.5. Turbot in 27.3a. SPiCT assessment running to the end of 2020, with 5 different short term forecast scenarios. The vertical grey lines in the catch, relative biomass and relative fishing mortality plots indicate the intermediate year (2021) and the horizontal lines show the corresponding reference points (MSY, B/B_{MSY}=0.5 and F/F_{MSY}=1). The shaded areas and dashed lines in all plots show 95% confidence intervals. The assessment is based on settings agreed upon during the benchmark (ICES, 2020).

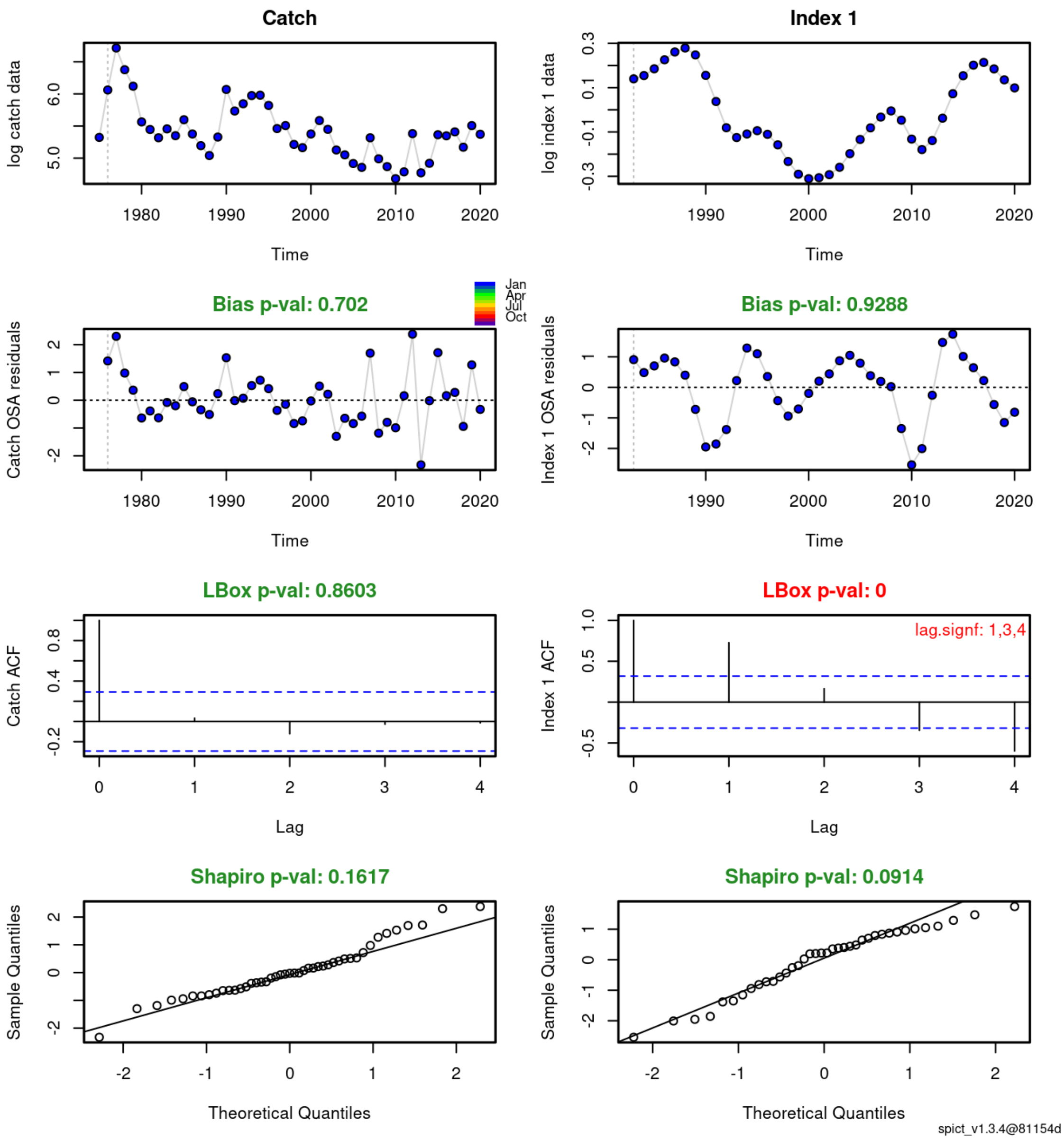

Figure 20.6. Turbot in 27.3a. Evaluation of SPiCT assessment running to the end of 2020. The residual diagnostics are shown for the two input time series (catch: left, exploitable biomass index: right). From the top to bottom it is shown: the log-transformed input time series, the one-step-ahead residuals with a bias test, the autocorrelation function with a Ljung-Box test, and a QQ-plot with a Shapiro test for normality. The application of the new exploitable biomass index via SPiCT indicated residual autocorrelation issues.

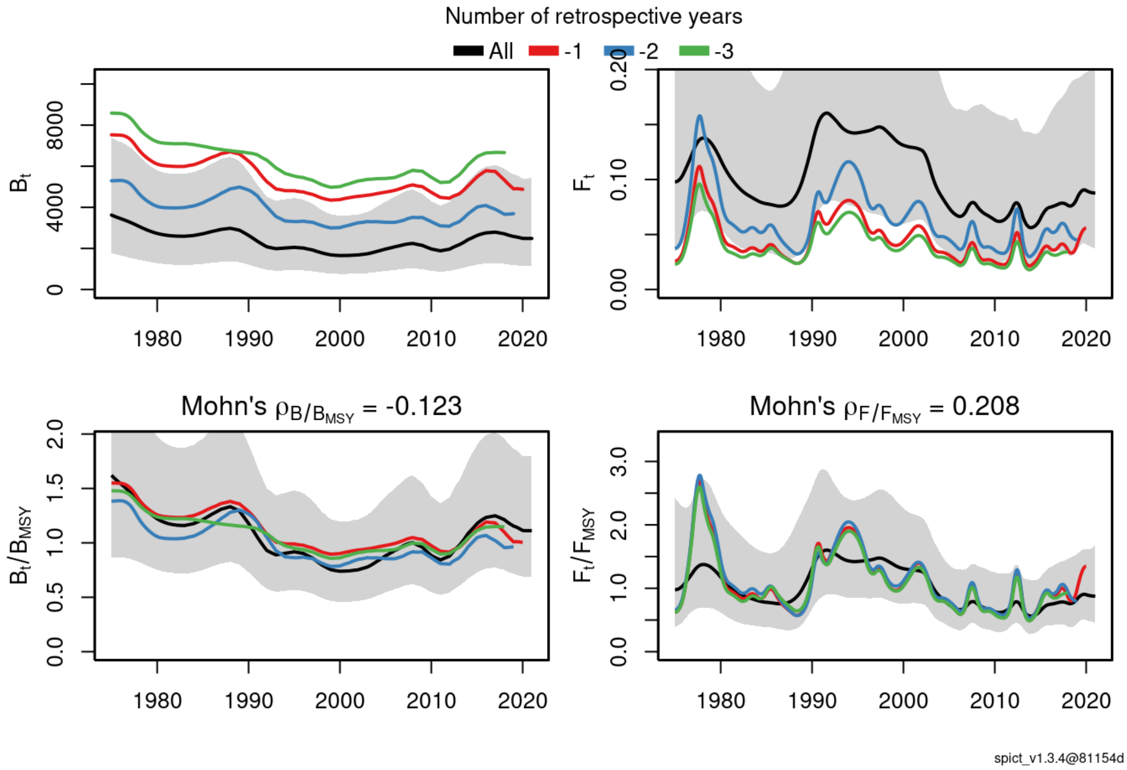

Figure 20.7. Turbot in 27.3a. Retrospective analysis showing the baseline (black lines) with 95% confidence intervals (shaded area) and 5 peels in different colours. The Mohn's rho for the relative quantities is shown on top of their corresponding panels.

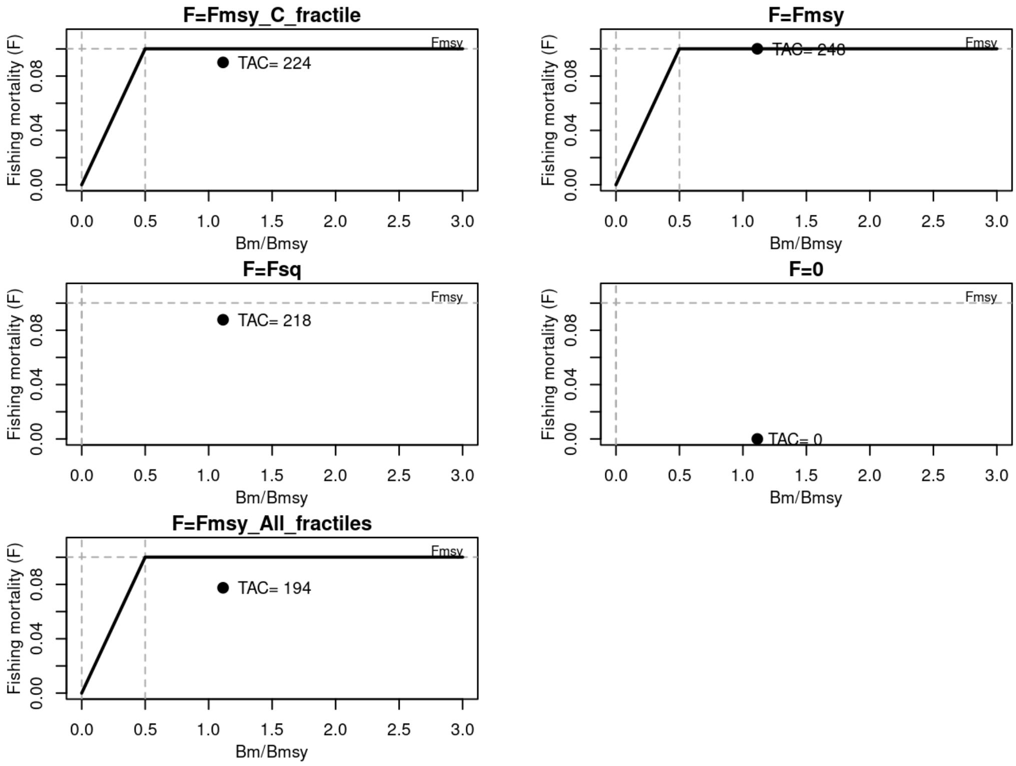

Figure 20.8. Turbot in 27.3a management scenarios. The solid line shows the harvest control rule for each scenario. Scenarios that are based on a specific fishing mortality (F = Fsq and F = 0) do not have a HCR. The vertical lines show B_{lim} and $B_{trigger}$. The basis for the advice follows that recommendation of WKLIFE X (ICES, 2020) and is shown in the top left corner.

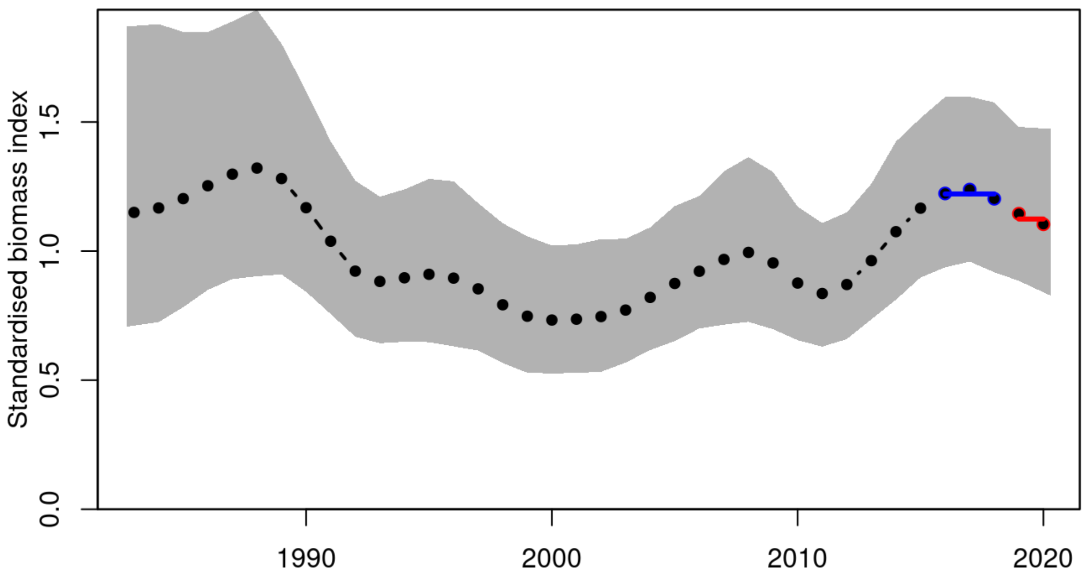

Figure 20.9. Turbot in 27.3a. Standardised exploitable biomass index. The average of the index in the last 2 and previous 3 years are shown horizontal lines in red and blue, respectively.

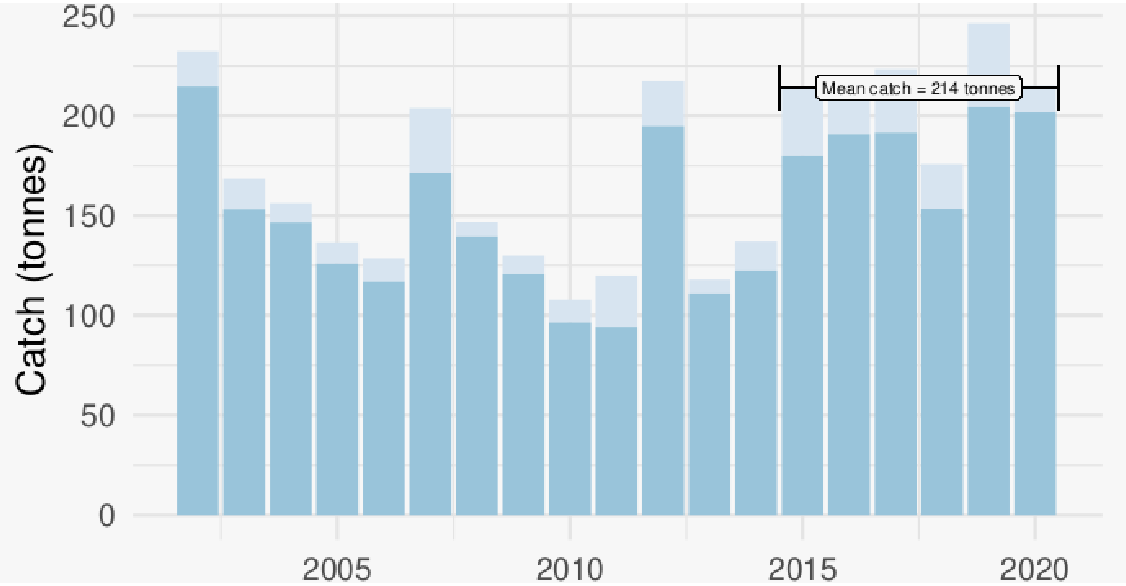

Figure 20.10. Turbot in 27.3a. Catch in 2002–2020 comprised of Intercatch landings (darker blue) and imported and raised discards (lighter blue). The mean catch in 2015–2020 is 214 tonnes; that could be used for basing a TAC advice with the 2/3 rule.

21 Turbot in Subarea 4

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2021. Following an inter-benchmark procedure for this stock in 2015, a state-space assessment model SAM (Nielsen and Berg, 2014) is used (ICES 2016). 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), screening all available input data, 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.

During WGNSSK 2018 a mistake was found in the inter-benchmark 2017 results. The mistake 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. Therefore, 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 inter-benchmark.

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. However, recent genetic studies and species distribution mapping show that the Skagerrak part of the stock could potentially be merged with the North Sea stock and the Kattegat with the Baltic Sea stock (ICES, 2020).

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.

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 (~60%). In most countries, turbot is caught in trawls of mixed fisheries, 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 (~4 % of the total landings in 2019 and 2020).

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 (POs) have introduced a minimum landings size of 27 cm in 2013. In 2016 catches of turbot increased substantially and the minimum landing size was increased to 30 cm at first, followed by a further increase to 32 cm in May 2016. 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 available 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 limiting the landings to 2000 kg wk^{-1}. During 2018, the PO measures were relaxed due to the sufficiently available quota and were continued in 2019 and 2020.

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 - March	-	27 cm
2016	April – May	-	30 cm
2016	May – September	-	32 cm
2016	October – November	375 kg	32 cm
2016	November – December	600 kg	32 cm
2017	January – February	-	32 cm
2017	March – October	800 kg	32 cm
2017	November - December	2000 kg	30 cm
2018	January – August	2000 kg	30 cm
2018	September - October	2500 kg	30 cm
2018	October - December	3000 kg	27 cm
2019	January – December	3000 kg	27 cm
2020	January - December	3000 kg	27 cm

21.1.4 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.

21.1.5 Catch data

Figure 21.2.1 shows the trend in total landings (InterCatch) and discards (InterCatch) over time. ICES estimated landings of turbot decreased during the 1990s and 2000s, and for the last ten years have been around 3000 tonnes. In this period, 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 been slightly higher, exceeding 3400 tonnes. Since 2018, official landings in Subarea 4 decreased slightly. In 2020, 3187tonnes has been officially reported in Division 2a and Subarea 4. In the last 4 years, the combined TAC for turbot and brill has not been fully utilized. In 2020, only 67% of the combined TAC (6498 tonnes) was taken of which turbot had the largest share (49%).

Landings in numbers at age are presented in Table 21.2.1 and Figure 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. This proportion has been decreasing in recent years due to some poor year classes in 2012, 2013 and 2016. Since turbot are only fully mature at age 4, a high proportion of immature fish are in the landings. Since 2015, however, a larger proportion of age 5+ fish in the landings is observed; these are now of 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 2020, there is a decrease in landings of age 5 which may result from the weak 2016-year class. In 2020, age 2 and 3 are the dominant age classes in the landings coming from relatively good year classes in 2018 and 2019.

The weights at age in the landings of turbot in Subarea 27.4 (Table 21.2.2a) come from the "weca" file of the InterCatch landings export. These are measured weights from the various national catch and market sampling programmes. Mean stock weights at age (Table 21.2.3a) are the average weights from the 2nd quarter landings and are derived from the "Catch and Sample Data Table" file from InterCatch. As discards are not included in this assessment, discard weight-at-age are not imported. Given the lack of weight data in the period 1991-2003, modelling[1] was required to infer the trend in stock and landings weight-at-age data (Table 21.2.2b and 21.2.3b).

[1] see Stock Annex for turbot 27.4 for full details

21.1.6 Discards

The assessment of this stock does not include discards as there is very limited age sampling of the discards. In 2018, 4% of the imported discard data were sampled, coming from discards of some Danish (< 8 fish per métier) and Belgian beam trawl fleet (138 fish). These data were considered insufficient to be used in the age allocation of international discards. In 2019 and 2020, no age structure information was submitted for the discard estimates. Sample sizes were too low to be submitted to InterCatch.

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 indicate 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. 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: 198 715 / (discards + landings: 3 303 033) was 6% in 2020. This is lower compared to the period 2016–2018 with an average of 14%. The discard rate in 2019 and 2020 is more in line with the discard rate observed in the period 2013–2015, when discard ratios were approximately 5%.

In 2020, BMS landings were reported by the UK (England); however, the submitted values were very low (46 kg) and were therefore not raised in InterCatch.

21.1.7 Logbook registered discards

In 2020, no logbook registered discards were reported to InterCatch. They are not raised.

21.1.8 InterCatch

InterCatch was used for the first time for the North Sea turbot stock at WGNSSK 2014, and has been used since.

In 2020, most countries provided estimates of discards to InterCatch. Where possible, discards were raised within métier by quarter. In the towed gear group, a distinction was made between otter trawlers, 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 métiers which did not fit in any of the above groups or, were then raised with all available discard estimates.

Unsampled fleet*	Sampled fleet**
TBB < 100mm	Within metier, by quarter
TBB > 100 mm	Within metier, all quarter
OTB/TBB < 70 mm (DEF and CRU)	Within metier, all quarter
OTB < 100 mm	Within metier, all quarter
OTB > 100 mm	Within metier, by quarter
SSC/SDN > 100 mm	Within metier, all quarter
SSC/SDN < 100 mm	TBB/OTB < 100 mm
Passive gears (GNS/GTR)	All métiers, all quarter
Others	All métiers, all quarter

*** Unsampled fleet are those fleets for which no discards are submitted.**

**** Sampled fleet are those fleets for which discards ratios are known.**

Out of the 199 tonnes of estimated discards, 145 tonnes (73%) was reported data and 53 tonnes are raised in InterCatch. The proportion of landings with discards associated (same strata) is 68%.

For the landings, Dutch (for data from 2004–present), Danish (2014–present) and Belgian (2017–present) samples, accounting for auctions, quarters and market categories, are provided. The number of age samples of the landings (5750) increased compared to 2018 (2267) and 2019 (4186) and is mainly due to an increase in sampling of landings in different Danish métiers. In total, Denmark supplied 5169 samples collected in various metiers, while the Dutch (479) and Belgian (102) samples mainly consist of the TBB_DEF_70-99 fleet,. All data 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 2020. Approximately 57% 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 within métier per quarter where possible. If by quarter was not possible, available quarters were grouped. As no age structure information for discards was available in 2020, the allocation for discards were done separately, making use of available age samples of the landings.

Unsampled fleet*	Sampled fleet**
TBB < 100mm	Within metier, by quarter
TBB > 100 mm	Within metier, by quarter
OTB/TBB < 70 mm (DEF and CRU)	Within metier, by quarter
OTB < 100 mm	Within metier, by quarter
OTB > 100 mm	Within metier, by quarter
SSC/SDN < 100 mm	TBB/OTB < 100 mm, by quarter
SSC/SDN > 100 mm	Within metier, by quarter
Passive gears (GNS/GTR)	Within metier, by quarter
Others	All métiers, all quarter

*** Unsampled fleet are those fleets for which no age structure is known.**

**** Sampled fleet are those fleets for which age structure is known.**

21.1.9 Survey data and commercial LPUE

Two survey abundance indices, the Sole Net Survey (SNS (B3498)) and the Beam Trawl Survey (BTS ISIS (B2453)), and one standardised commercial LPUE unstructured 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 since 2005. 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. Before 2015 no strong year classes have been observed. Since 2015, with the exception of 2016, relatively strong year classes are seen, resulting in an increase of fish of age 2, 4 and 6 to appear in the survey catches. In 2020 a slightly lower recruitment (age 1) compared to 2019 is observed. Recruitment however is still larger compared to the long-term mean. The Dutch BT2 LPUE index shows a continuous gradual increase since 2000. After two years of decline (2017 and 2018), the LPUE increases slightly in 2020. The LPUE is higher compared to the LPUE's observed before 2012.

There is fairly close agreement between the two survey indices regarding 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 for cohort from one age to the next. 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, but is still lacking sufficient older fish leading to a poor tracking of the cohorts over time.

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 shortening the time-series of the LPUE-index considerably, because 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.

21.1.10 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 the 2015 Interbenchmark, a method was developed to model the growth parameters over time, allowing smooth changes over the time series (see Stock Annex for full details) (ICES, 2016). 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

See Stock Annex for full details.

Natural mortality

A constant value of M = 0.2 for all ages and years is applied for this stock. See Stock Annex for full details.

21.2 Stock assessment model

After the inter-benchmark protocol of 2017 and 2018, a new assessment model (SAM, FLSAM) is used. More details on the data used, assumptions made and the assessment model settings can be found in the Stock Annex, in the inter-benchmark protocol report (ICES, 2018a and b) as well as on the github website (https://github.com/ices-eg/wg_IBPTur.27.4).

21.2.1 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 (ICES, 2018).

Assessment settings used in the final assessment

Year	2020
FLSAM version	2.1.1
FLCORE version	2.6.15
R version	4.0.2 (2020-06-02)
Platform	x86_64-w64-mingw32
Run date	2021-04-24

Model	SAM
First tuning year	1981
Last data year	2020
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–present SNS 2004–present
	Standardized NL-BT2 LPUE age-aggregated catchable biomass 1995– present
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

21.3 Assessment model results

The stock summary is given in Table 21.4.1a-c, 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.

21.3.1 Status of the stock

Fishing mortality has been below 0.36 (F_{MSY}) since 2012. In 2018 and 2019, fishing mortality was estimated at 0.363 and 0.367, respectively, being just above F_{MSY}, but well below the long-term geometric mean (0.51). In 2020, fishing mortality dropped to 0.350. The SSB in 2020 was estimated to be 8343 tonnes, a very minor decrease (0.91%) from 2019 which was estimated at 8420 tonnes (Table 21.4.1b). SSB has been above MSY $B_{trigger}$ (6353 tonnes) since 2013. The estimated recruitment (age 1) for 2020 (6374 thousand). The 2019 recruitment estimate was revised downward from 8095 to 7094, but still remain the second highest recruitment in the time-series (9134 in 2015). The estimated recruitment is well above the geometric mean of the time series (4566 thousand) (Table 21.4.1c). However, this estimate is based on limited amount of data and is unlikely to be a reliable estimate.

21.3.2 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 estimated SSB was in 2004; 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 the long term mean and do now contribute to the increase in SSB.

Mean F peaked in 1994 at 0.83, but then declined to 0.62 in 1999, before rapidly increasing again to 0.76 in 2002. After 2002, there is a steep decline in F to 0.41 in 2010. Between 2012 and 2017, F has fluctuated around 0.34. In the last two years F has slightly increased to F_{MSY} level. 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). Since 2017, recruitment has been above the long-term geometric mean of the time series.

21.3.3 Retrospective assessments

The results of five retrospective assessments, using the same model settings but removing one year of data from the end of the time series, are plotted in Figures 21.4.2–4. 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 -9.0% on SSB, 6.5% on F and -15.6% on recruitment, all considered to be low.

21.4 Model diagnostics

Model diagnostics are provided in Tables 21.5.1–6 and Figures 21.5.1–7.

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 parameter 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 (F_{par}), but no strong correlation between the other parameters (Figure 21.5.1).

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 21.5.2). 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 21.5.3).

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 21.5.4).

The estimated selectivity at age from 1981 to 2020 is shown in Figure 21.5.5. The selectivity at-age do show some trend in the past decade, whereby after 2013 the selectivity has shifted slightly towards older ages (i.e. age 4). The values presented in Figure 21.4.5 are the actual F-at-age.

Residual plots of landings as well as of the SNS and BTS-ISIS survey do not show clear systematic patterns in either positive or negative residuals (Figure 21.5.6 and 21.5.7).

21.5 Reference Points

Reference points were estimated during the 2018 inter-benchmark using the R-script template provided by ICES, which was developed during early 2018 to ensure that a correct procedure in estimating reference points was followed.

The simulations were executed during IBPTurbot (ICES, 2018b) with the entire time-series of SR-pairs (1981–2017) and 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). Productivity and stock-recruit pairs over time are shown in Figures 21.6.2–3.

In 2020, ACOM decided that the basis of F_{pa} should be $F_{p.05}$ (with Advice rule). $F_{p.05}$ is the value of F, including modification with biomass criteria that, if applied as target in the advice rule would lead to SSB ≥ B_{lim} with a 95% probability. $F_{P.05}$ provides an upper F limit that is considered precautionary for management plans and MSY rules. However, for turbot the $F_{p.05}$ value (0.856) is well above the value of F_{lim} (0.606).

The table below shows the estimated reference points using the final IBP 2018 assessment. [See the IBPTurbot report (ICES, 2018b) for more details.]

Reference point	Estimate
1. MSY $B_{trigger}$	6353
2. B_{pa}	4163
3. B_{lim}	2974
4. F_{lim}	0.606
5. F_{pa} = $F_{p.05}$ with AR	0.856
6. $F_{p.05}$ without AR	0.473
7. F_{MSY}	0.361
8. $F_{MSY\ lower}$	0.252
9. $F_{MSY\ upper}$	0.482

21.6 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 the past 4 years, the TAC has not been exhausted, i.e. on average 68% of the combined TAC was used, 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 (F_{sq}) instead. This was also supported by the recent years in which F has been relatively stable at around 0.36.

Assumptions made for the interim year and in the forecast. All weights are in tonnes, recruitment in thousands :

Variable	Value	Notes
$F_{ages\ 2–6}$ (2021)	0.36	F_{sq} = $F_{average}$ of F (2018–2020)
SSB (2022)	9336	Short-term forecast (STF) at *status quo* (F_{sq})
R_{age1} (2021, 2022)	4566	Geometric mean (GM, 1981–2020)
Projected landings (2021)	3328	STF assuming an F *status quo* (F_{sq})

The options table summarizes the outcomes of the short-term forecast. The numbers presented are the rounded values; actual calculations are performed with the exact numbers.

Basis	Total catch * (2022)	Projected landings ** (2022)	Projected discards *** (2022)	F (2-6) (2022)	SSB (2023)	% SSB change ^	% advice change ^^
MSY approach: F_{MSY}	3609	3291	318	0.361	9012	-3.5	-8.6
F_{MSY} upper = 0.48	4564	4162	402	0.482	8095	-13.3	15.6
F_{MSY} lower = 0.25	2634	2401	232	0.252	9957	6.6	-33
F = 0	0	0	0	0	12545	34	-100
F_{pa} ($F_{p.05}$ with AR)	6984	6368	616	0.856	5821	-38	77
$F_{p.05}$ without AR	4489	4093	396	0.473	8167	-12.5	13.7
F_{lim}	5487	5003	484	0.606	7219	-23	39
F_{sq}	3609	3291	318	0.360	9012	-3.5	-8.6
SSB (2022) = B_{lim}	10180	9282	897	1.70	2974	-68	158
SSB (2022) = B_{pa}	8812	8035	777	1.27	4163	-55	123
SSB (2022) = MSY $B_{trigger}$	6410	5845	565	0.76	6353	-32	62
Rollover advise	3948	3600	348	0.40	8686	-7	0
Multi-options table							
F = 0	0	0	0	0	12648	34	-100
F= 0.05	583	532	51	0.05	12070	28	-85
F = 0.10	1139	1039	100	0.10	11522	22	-71
F = 0.15	1669	1522	147	0.15	11001	16.8	-58
F = 0.20	2174	1982	192	0.20	10507	11.5	-45
F = 0.25	2656	2421	234	0.25	10037	6.6	-33
F = 0.30	3115	2840	275	0.30	9591	1.82	-21
F = 0.35	3553	3240	313	0.35	9166	-2.7	-10
F = 0.40	3972	3622	350	0.40	8763	-7.0	0.6
F = 0.45	4371	3986	385	0.45	8380	-11.0	10.7
F = 0.50	4752	4333	419	0.50	8015	-14.9	20

*** (projected landings) / (1 – average discard rate); average discard rate 2018–2020 = 8.8%**

**** Marketable landings**

***** Including BMS landings (EU stocks), assuming recent discard rate.**

^ SSB 2023 relative to SSB 2022.

^^ Total catch in 2022 relative to advice value for 2021 (3948 t).

21.7 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. Since 2019 turbot falls under the landing obligation. The joint recommendation suggests a survivability exemption in 2020 for turbot caught by TBB gears with a cod end more than 80 mm in ICES Subarea 4 (Commission Delegated Regulation (EU) 2019/2238).

21.7.1 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 effort limitations for the recovery of the cod stock. In 2008, 25 vessels were decommissioned.

21.7.2 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, while at the same time potentially 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 no more than 24 m. In the 12 nautical mile zone and in the plaice box, the maximum aggregated beam-length is 9 m.

21.7.3 Combined TAC

At present the EU provides a combined TAC for turbot and brill in the North Sea. This TAC seems largely ineffective at 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 should not be used.

21.8 Industry Survey turbot and brill

The available scientific surveys used for the assessment of turbot in 27.4 generally have a weak internal consistency, especially for older ages, leading to a poor ability to track cohorts over time. Because of this, the assessment is strongly influenced by the 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 started in 2018, and the set up and first results were presented during the 2019 WGNSSK. The group considered the survey valuable, but provided recommendations to make the survey more adequate for future use in the assessment; therefore, the first year of the survey (2018) is seen as a pilot year. An update of the survey was provided in WGNSSK 2020 and 2021.

In 2020, the survey took place in quarter 3 and 3 traditional beam trawl vessels were selected. The survey area is based on LPUE data over a 6-year period (2007–2009 (before pulse) and 2012–2014 (first years with pulse fisheries)). By defining the positions were 60% of the LPUE is realized, the survey area covers the main high LPUE areas but also some areas around these. Inaccessible areas such as wind parks, Natura 2000 closures, etc were removed from the survey area following discussions with the participating fishermen. A 5x5 km grid was overlaid onto the survey area.

Each grid cell in the survey area is a potential survey station. Each year 60 grid cells are to be randomly selected using an R-script. Because the cutting out of unfishable areas resulted in some cells having irregular shapes and smaller surface areas than regular 5x5 km grid cells, the probability of being randomly selected as survey station was made proportional to their surface areas. The selected survey stations are then equally distributed over the three participating vessels (~20 survey stations each) on the basis of their normal fishing grounds. Survey hauls are carried out similar to commercial hauls, taking approximately 100 to 120 minutes. Hauls may start anywhere in a designated grid cell, may then follow any route, and may exit the grid cell during the haul. Data collected include fishing conditions (e.g. haul list, gear description), and for each haul: counts of all turbot and brill; length, weight, and sex of all turbot and brill; a specified number of otoliths per length class (Schram *et al.,* 2021).

Due to COVID-19 restrictions it was not possible for researchers to board the participating vessels. An alternative method was used, whereby, the survey fish were sorted from the catches and then labelled per station and stored by the vessel's crews. At the end of the survey week all collected survey fish was handed over to a team of researchers for processing in the fish auction. This method proved to be practically feasible and there were no indications of (noticeable) irregularities in sample collection.

The procedure for the random selection of survey stations and their assignment to the vessels remained unchanged from 2019 except for the number of selected stations. Instead of selecting the required 60 stations, a total of 75 stations were selected (Figure 21.8.1). Sixty stations were manually assigned to the vessels (20 each) and the remaining 15 stations were kept as 'spares', undisclosed to the skippers in case some of the stations were deemed unsuitable.

In total, 59 hauls were sampled in the 2020 survey, catching 454 brill and 1415 turbot. The numbers of turbot caught during this survey were approximately 9 times higher than caught during the BTS-ISIS survey. Length measurements ranged from 17 cm to 68 cm for turbot and 21 cm to 54 cm for brill in both 2019 and 2020 survey (Figure 21.8.2). Ageing was done over 1 cm-classes for 126 brill and 148 turbot, showing that most of the fish caught are within ages 1 to 3 (Figure 21.8.3.). Further analysis of the survey data is needed to update the new information and align these with existing commercial sampling and independent fisheries survey data.

The aim of the survey is to become an additional index, strengthening the fisheries independent surveys for turbot. Once a period of 5 years is covered, the index of this new survey is a potential candidate to include in the turbot as well as brill assessments. In this context, it is import to develop the age-structured index in advance and make a trial assessment including the "new" index into the assessment.

21.9 Issues for future benchmarks

21.9.1 Data

The available scientific surveys (SNS and BTS-ISIS Q3) have weak internal consistency, especially for older ages, leading to a poor ability to track cohorts over time. Because of this, the assessment is 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 is 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 patterns 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 be compared to current methods, or sampling be improved to allow raw weights to be used directly in assessments, or to 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.

The procedure to create an age-structured index series from the BTS-ISIS needs to be checked. Currently, the procedure first links the individual fish from which otoliths are taken to the length sample. This allows direct ageing of the fish in the index. Those fish for which no direct age sample is available are then assigned to ages using the age–length key based on all fish in the period 1991–present. This method may be flawed as combining an ALK over many years, so that the same ALK is used each year may smear any cohort signals in the data.

21.9.2 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.

21.9.3 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.

21.10 References

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Table 21.2.1. Turbot in Area 4. Observed landings in numbers (units: thousands) SOP corrected.

Year	Age							
	1	2	3	4	5	6	7	8
1981	0	282.330	712.906	502.339	432.465	165.243	63.264	101.034
1982	0	149.504	925.331	236.198	147.734	258.314	86.694	137.119
1983	0	357.292	598.153	425.728	97.766	100.433	159.981	180.423
1984	0	1186.851	1119.999	284.808	143.777	54.947	52.199	178.577
1985	0	618.015	1877.367	508.405	139.151	84.734	20.212	124.380
1986	0	320.569	1270.178	602.254	158.124	57.892	25.058	107.144
1987	12.619	629.016	530.004	656.196	153.371	50.477	18.443	67.949
1988	32.245	970.934	803.439	159.434	157.642	80.613	25.079	68.969
1989	0	668.968	1167.878	354.756	156.543	82.213	31.534	68.699
1990	44.560	991.727	1069.449	316.068	165.806	75.649	101.556	113.992
1991–1997				NO DATA				
1998	0	404.599	867.639	356.646	72.678	29.446	8.467	14.243
1999–2002				NO DATA				
2003	209.891	1909.456	460.659	297.149	70.750	32.938	20.675	20.517
2004	435.038	1980.187	792.429	138.276	82.434	9.662	7.534	6.072
2005	343.884	1982.262	721.789	230.358	24.808	21.854	2.599	19.197
2006	888.352	1651.577	810.682	119.588	35.247	7.931	16.239	18.203
2007	79.305	2807.922	622.328	287.839	40.695	29.379	8.337	16.069
2008	179.475	1365.758	830.739	222.762	197.471	47.665	13.035	10.340
2009	121.514	1118.472	1044.670	451.131	95.631	26.922	11.850	19.916
2010	279.068	1405.944	386.546	309.944	172.060	88.269	30.641	19.587
2011	213.741	1967.663	610.688	112.187	139.502	78.043	32.681	23.910
2012	0.000	1920.526	781.619	268.323	42.709	64.285	73.448	24.867
2013	173.657	1590.229	1088.182	327.401	91.533	26.143	42.265	26.046
2014	65.496	372.461	618.447	650.101	130.768	115.918	36.152	99.928
2015	39.278	1213.722	464.183	325.938	315.920	109.598	43.122	79.630
2016	0.000	1032.477	986.958	331.150	355.737	186.039	44.817	70.107
2017	6.834	326.483	1643.832	593.509	137.326	61.989	97.075	60.062
2018	178.575	699.012	471.674	904.819	251.281	67.844	45.107	71.201
2019	171.184	1055.714	876.447	261.154	356.688	121.478	22.750	63.521
2020	211.476	1565.534	830.666	389.777	142.518	144.393	41.958	41.116

Table 21.2.1b. ICES estimated landings (tonnes) SOP corrected and discards of turbot in Area 4.

Year	Landings	Landing SOP	Discards	Year	Landings	Landing SOP	Discards
1981	4755	1		2020	3104	1	199
1982	4453	1					
1983	4575	1					
1984	5297	1					
1985	6188	1					
1986	5263	1					
1987	4271	1					
1988	4041	1					
1989	4927	1					
1990	5750	1					
1991	6340	-0.007					
1992	5933	-0.007					
1993	5546	-0.008					
1994	5244	-0.008					
1995	4671	-0.009					
1996	3644	-0.011					
1997	3382	-0.012					
1998	3086	1					
1999	3187	-0.012					
2000	4025	-0.009					
2001	4100	-0.009					
2002	3749	-0.010					
2003	3374	1					
2004	3317	1					
2005	3195	1					
2006	2976	1					
2007	3509	1					
2008	3005	1					
2009	3089	1					
2010	2692	1					
2011	2771	1					
2012	2914	1					
2013	2982	1	97				
2014	2834	1	158				
2015	2922	1	112				
2016	3493	1	666				
2017	3441	1	496				
2018	3140	1	486				
2019	3046	1	230				

Table 21.2.2a. Turbot in Area 4. Raw weights at age in the landings (units: kg).

Year	Age							
	1	2	3	4	5	6	7	8
1981	0	0.90	1.00	1.70	2.60	3.60	4.40	6.90
1982	0	0.90	1.10	1.80	2.60	3.20	4.50	5.50
1983	0	0.90	1.20	2.00	2.80	3.60	4.00	5.53
1984	0	0.80	1.30	2.20	3.20	3.80	4.50	6.17
1985	0	0.70	1.10	2.00	3.20	4.20	5.00	6.33
1986	0	1.00	1.30	2.10	3.00	3.70	6.30	5.87
1987	0.70	1.10	1.60	2.10	3.80	4.60	6.10	7.83
1988	0.70	1.00	1.60	2.80	3.10	4.60	6.00	6.90
1989	0	1.00	1.50	2.70	3.90	4.70	6.90	8.00
1990	0.90	1.00	1.60	2.70	3.40	5.40	5.60	7.30
1991–1997				NO DATA				
1998	0	0.830	1.26	2.12	3.34	4.92	5.38	6.78
1999–2002				NO DATA				
2003	0.50	0.62	1.15	1.78	2.24	2.74	2.59	3.72
2004	0.43	0.69	1.20	2.12	3.17	3.76	5.15	7.71
2005	0.44	0.62	1.13	1.89	2.89	3.47	4.60	5.87
2006	0.41	0.66	1.31	1.92	3.37	5.09	2.70	3.31
2007	0.34	0.70	1.25	1.75	3.27	3.72	4.17	2.92
2008	0.37	0.68	1.27	1.78	1.79	2.76	4.91	5.69
2009	0.41	0.62	1.25	1.76	2.95	4.83	5.47	5.06
2010	0.35	0.61	1.07	1.62	2.19	2.67	2.65	5.19
2011	0.48	0.55	1.06	1.79	1.97	3.25	4.48	4.64
2012	0	0.60	0.91	1.46	2.58	3.01	3.47	5.28
2013	0.61	0.61	1.00	1.64	2.23	3.41	2.27	5.19
2014	0.41	0.59	1.07	1.42	1.67	1.85	3.03	3.40
2015	0.41	0.59	1.10	1.30	1.67	2.12	2.78	3.23
2016	0	0.66	0.93	1.33	1.22	1.94	2.93	4.01
2017	0.54	0.98	1.18	1.74	2.15	2.37	3.07	3.68
2018	0.34	0.59	0.98	1.36	1.41	1.90	2.86	3.18
2019	0.44	0.58	0.94	1.50	1.77	2.11	3.63	2.46
2020	0.44	0.63	0.96	1.29	1.48	2.01	2.87	3.18

Table 21.2.2b. Turbot in Area 4. Modelled weights at age in the catch (units: kg).

Year	Age 1	2	3	4	5	6	7	8
1981	0.355	0.757	1.303	1.964	2.709	3.508	4.333	5.947
1982	0.368	0.785	1.351	2.036	2.809	3.638	4.494	6.275
1983	0.380	0.812	1.397	2.106	2.906	3.763	4.648	6.357
1984	0.392	0.838	1.441	2.173	2.997	3.881	4.794	6.584
1985	0.404	0.861	1.482	2.234	3.082	3.991	4.931	6.996
1986	0.414	0.883	1.520	2.291	3.161	4.093	5.056	7.520
1987	0.423	0.903	1.554	2.343	3.232	4.185	5.169	7.867
1988	0.431	0.920	1.584	2.387	3.293	4.265	5.268	7.038
1989	0.438	0.935	1.609	2.425	3.345	4.332	5.351	7.482
1990	0.443	0.947	1.629	2.455	3.387	4.386	5.417	7.285
1991	0.447	0.955	1.643	2.477	3.417	4.424	5.465	7.528
1992	0.450	0.960	1.652	2.490	3.435	4.448	5.494	7.568
1993	0.450	0.961	1.654	2.494	3.440	4.455	5.503	7.580
1994	0.449	0.959	1.650	2.488	3.433	4.445	5.491	7.563
1995	0.447	0.953	1.640	2.473	3.412	4.418	5.457	7.517
1996	0.442	0.944	1.624	2.448	3.377	4.373	5.402	7.441
1997	0.436	0.931	1.601	2.414	3.330	4.312	5.326	7.336
1998	0.428	0.914	1.572	2.370	3.269	4.233	5.229	7.091
1999	0.418	0.893	1.537	2.317	3.197	4.139	5.113	7.043
2000	0.408	0.871	1.498	2.258	3.115	4.033	4.982	6.863
2001	0.396	0.846	1.455	2.194	3.026	3.918	4.840	6.667
2002	0.384	0.820	1.410	2.126	2.932	3.797	4.690	6.461
2003	0.371	0.793	1.364	2.056	2.836	3.672	4.536	6.261
2004	0.358	0.765	1.317	1.985	2.738	3.546	4.380	5.750
2005	0.346	0.738	1.270	1.915	2.641	3.420	4.225	5.413
2006	0.333	0.712	1.224	1.846	2.546	3.297	4.073	6.001
2007	0.321	0.686	1.180	1.779	2.455	3.179	3.926	5.263
2008	0.310	0.662	1.138	1.716	2.367	3.065	3.787	5.313
2009	0.299	0.639	1.099	1.657	2.285	2.959	3.655	5.100
2010	0.289	0.617	1.062	1.601	2.209	2.861	3.534	4.872
2011	0.280	0.598	1.029	1.551	2.140	2.771	3.423	4.416
2012	0.272	0.581	0.999	1.506	2.077	2.690	3.323	4.359
2013	0.265	0.565	0.973	1.466	2.023	2.619	3.236	4.148
2014	0.259	0.552	0.950	1.433	1.976	2.559	3.161	4.230
2015	0.254	0.542	0.932	1.405	1.939	2.510	3.101	4.300
2016	0.250	0.534	0.918	1.384	1.910	2.473	3.055	4.288
2017	0.248	0.528	0.909	1.371	1.891	2.448	3.025	4.224
2018	0.246	0.526	0.905	1.364	1.882	2.437	3.010	4.115
2019	0.247	0.527	0.906	1.366	1.884	2.440	3.014	4.092
2020	0.249	0.531	0.913	1.376	1.899	2.459	3.037	4.206

Table 21.2.3a. Turbot in Area 4. Raw weights at age in the stock estimated as the catch weights in Q2,(units: kg)

Year	Age							
	1	2	3	4	5	6	7	8
1981	0	0.9	0.8	1.48	2.59	3.23	5.66	6.52
1982	0	0.59	1.01	1.8	2.53	3.33	4.88	6.19
1983	0	0.61	1.13	1.99	2.77	3.38	3.97	4.88
1984	0	0.66	1.04	2.07	2.87	4.25	4.93	6.34
1985	0	0.59	1.02	1.83	2.95	4.46	5.99	6.04
1986	0	0.91	1.12	1.98	3.08	3.48	7.02	6.10
1987	0.7	0.72	1.25	1.87	3.6	3.24	5.36	8.19
1988	0.7	1.16	1.65	2.65	3.31	5.78	7.24	7.38
1989	0	0.81	1.48	2.96	5.3	5.77	8.26	8.31
1990	0.9	0.84	1.79	3.09	3.02	5.34	3.47	8.65
1991–1997								NO DATA
1998	0	0.8	1.03	1.67	3.08	5.06	2.57	7.49
1999–2002								NO DATA
2003	0	0.5	1.14	1.99	2.45	2.82	4.14	2.54
2004	0	0.52	1.1	1.9	2.47	2.91	5.35	6.41
2005–2006								NO DATA
2007	0	0.59	1.1	1.57	2.58	2.71	1.72	4.87
2008	0	0.65	1.14	1.44	2.1	5.16	6.01	7.12
2009	0	0.44	0.80	1.51	1.65	3.55	4.70	4.78
2010	0	0.45	1.04	1.62	2.3	2.38	2.71	5.37
2011	0	0.39	0.95	1.88	2.01	4.00	4.42	5.16
2012	0	0.51	0.85	1.42	2.2	2.67	2.58	3.73
2013	0	0.59	0.95	1.60	2.18	3.30	2.51	3.95
2014	0.38	0.57	0.95	1.24	1.50	1.72	1.84	2.82
2015	0.41	0.49	0.89	0.93	1.46	1.4	1.37	4.45
2016	0.41	0.58	0.78	1.3	0.8	1.49	4.78	2.71
2017	0.39	0.38	0.92	1.6	2.04	2.31	2.87	3.21
2018	0.27	0.45	1.03	1.46	1.64	2.72	2.37	4.19
2019	0.44	0.39	0.86	1.37	2.04	2.25	4.25	3.07
2020	0.44	0.56	1.16	1.39	2.39	2.31	3.21	2.80

Table 21.2.3b. Turbot in Area 4. Modelled weights at age in the stock (units: kg)

Year	Age 1	2	3	4	5	6	7	8
1981	0.355	0.757	1.303	1.964	2.709	3.508	4.333	5.947
1982	0.368	0.785	1.351	2.036	2.809	3.638	4.494	6.275
1983	0.380	0.812	1.397	2.106	2.906	3.763	4.648	6.357
1984	0.392	0.838	1.441	2.173	2.997	3.881	4.794	6.584
1985	0.404	0.861	1.482	2.234	3.082	3.991	4.931	6.996
1986	0.414	0.883	1.520	2.291	3.161	4.093	5.056	7.520
1987	0.423	0.903	1.554	2.343	3.232	4.185	5.169	7.867
1988	0.431	0.920	1.584	2.387	3.293	4.265	5.268	7.038
1989	0.438	0.935	1.609	2.425	3.345	4.332	5.351	7.482
1990	0.443	0.947	1.629	2.455	3.387	4.386	5.417	7.285
1991	0.447	0.955	1.643	2.477	3.417	4.424	5.465	7.528
1992	0.450	0.960	1.652	2.490	3.435	4.448	5.494	7.568
1993	0.450	0.961	1.654	2.494	3.440	4.455	5.503	7.580
1994	0.449	0.959	1.650	2.488	3.433	4.445	5.491	7.563
1995	0.447	0.953	1.640	2.473	3.412	4.418	5.457	7.517
1996	0.442	0.944	1.624	2.448	3.377	4.373	5.402	7.441
1997	0.436	0.931	1.601	2.414	3.330	4.312	5.326	7.336
1998	0.428	0.914	1.572	2.370	3.269	4.233	5.229	7.091
1999	0.418	0.893	1.537	2.317	3.197	4.139	5.113	7.043
2000	0.408	0.871	1.498	2.258	3.115	4.033	4.982	6.863
2001	0.396	0.846	1.455	2.194	3.026	3.918	4.840	6.667
2002	0.384	0.820	1.410	2.126	2.932	3.797	4.690	6.461
2003	0.371	0.793	1.364	2.056	2.836	3.672	4.536	6.261
2004	0.358	0.765	1.317	1.985	2.738	3.546	4.380	5.750
2005	0.346	0.738	1.270	1.915	2.641	3.420	4.225	5.413
2006	0.333	0.712	1.224	1.846	2.546	3.297	4.073	6.001
2007	0.321	0.686	1.180	1.779	2.455	3.179	3.926	5.263
2008	0.310	0.662	1.138	1.716	2.367	3.065	3.787	5.313
2009	0.299	0.639	1.099	1.657	2.285	2.959	3.655	5.100
2010	0.289	0.617	1.062	1.601	2.209	2.861	3.534	4.872
2011	0.280	0.598	1.029	1.551	2.140	2.771	3.423	4.416
2012	0.272	0.581	0.999	1.506	2.077	2.690	3.323	4.359
2013	0.265	0.565	0.973	1.466	2.023	2.619	3.236	4.148
2014	0.259	0.552	0.950	1.433	1.976	2.559	3.161	4.230
2015	0.254	0.542	0.932	1.405	1.939	2.510	3.101	4.300
2016	0.250	0.534	0.918	1.384	1.910	2.473	3.055	4.288
2017	0.248	0.528	0.909	1.371	1.891	2.448	3.025	4.224
2018	0.246	0.526	0.905	1.364	1.882	2.437	3.010	4.115
2019	0.247	0.527	0.906	1.366	1.884	2.440	3.014	4.092
	0.249	0.531	0.913	1.376	1.899	2.459	3.037	4.206

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							Age					
Year	**1**	**2**	**3**	**4**	**5**	**6**	**Year**	**1**	**2**	**3**	**4**	**5**	**6**
2004	186.52	27.029	18.76	4.09	3.00	3.42	2020	85.59	65.38	57.96	5.55	2.14	5.00
2005	75.39	155.55	23.66	0.00	0.00	0.00							
2006	196.15	97.47	14.87	3.61	1.09	0.00							
2007	89.74	55.60	33.78	11.84	1.32	0.00							
2008	52.09	99.74	40.83	11.87	10.92	1.20							
2009	26.27	20.31	5.65	14.47	5.09	0.00							
2010	96.02	35.81	9.27	5.37	3.70	6.76							
2011	116.69	36.89	0.00	0.00	0.00	1.69							
2012	39.86	33.51	9.46	1.23	0.00	0.00							
2013	110.16	16.12	15.64	0.44	0.00	0.00							
2014	102.71	18.31	9.45	6.16	4.74	1.20							
2015	273.79	45.87	2.00	2.00	0.00	0.00							
2016	52.83	115.69	26.71	2.00	1.31	0.50							
2017	271.90	54.70	60.34	0.50	0.00	0.50							
2018	118.21	84.25	16.84	21.94	8.64	3.18							
2019	148.66	81.43	17.07	1.53	4.37	0.83							

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	1.622	1.190	0.281	0.309	0.176	0.033	0.000
2019	2.899	1.116	0.386	0.036	0.110	0.016	0.000
2020	1.836	1.241	0.392	0.128	0.032	0.055	0.041

Table 21.3.3. Turbot in Area 4. Dutch_BT2_LPUE survey index (biomass)

Year	
1995	0.0426
1996	0.0371
1997	0.0375
1998	0.0347
1999	0.0349
2000	0.0444
2001	0.046
2002	0.0456
2003	0.0472
2004	0.0483
2005	0.0479
2006	0.049
2007	0.0652
2008	0.0681
2009	0.0671
2010	0.0584
2011	0.0604
2012	0.0744
2013	0.0767
2014	0.0747
2015	0.0859
2016	0.0954
2017	0.0936
2018	0.0786
2019	0.0834
2020	0.0860

Table 21.4.1a. Fbar (Ages 2–6) of turbot in Area 4.

Year	Fbar	Low	High	Year	Fbar	Low	High
1981	0.388	0.314	0.480	2020	0.350	0.279	0.440
1982	0.377	0.308	0.460				
1983	0.413	0.341	0.500				
1984	0.458	0.379	0.553				
1985	0.498	0.412	0.603				
1986	0.479	0.393	0.583				
1987	0.488	0.400	0.596				
1988	0.475	0.385	0.586				
1989	0.589	0.486	0.715				
1990	0.711	0.573	0.884				
1991	0.759	0.604	0.952				
1992	0.792	0.629	0.997				
1993	0.822	0.657	1.028				
1994	0.832	0.670	1.033				
1995	0.817	0.661	1.009				
1996	0.746	0.614	0.907				
1997	0.684	0.550	0.850				
1998	0.652	0.528	0.805				
1999	0.619	0.503	0.763				
2000	0.640	0.521	0.787				
2001	0.697	0.572	0.850				
2002	0.761	0.612	0.947				
2003	0.716	0.599	0.856				
2004	0.638	0.533	0.764				
2005	0.566	0.469	0.682				
2006	0.443	0.362	0.543				
2007	0.410	0.335	0.502				
2008	0.380	0.312	0.462				
2009	0.429	0.352	0.521				
2010	0.410	0.338	0.497				
2011	0.368	0.300	0.452				
2012	0.348	0.285	0.425				
2013	0.330	0.270	0.402				
2014	0.325	0.271	0.402				
2015	0.324	0.270	0.406				
2016	0.348	0.289	0.442				
2017	0.350	0.291	0.438				
2018	0.363	0.298	0.454				
2019	0.367	0.288	0.468				

Table 21.4.1b. Total and Spawning stock Biomass of turbot in Area 4 (tonnes).

Year	TSB	Low	High	SSB	Low	High
1981	19641	15965	24164	15393	11941	19842
1982	18334	14836	22658	13728	10488	17969
1983	18454	15094	22563	12331	9341	16278
1984	19434	16196	23318	11333	8632	14878
1985	18749	15817	22226	11448	8996	14568
1986	16266	13614	19434	10915	8600	13852
1987	14757	12276	17740	9716	7522	12550
1988	13887	11634	16576	8014	6113	10506
1989	14233	11923	16990	7989	6136	10402
1990	14115	11456	17392	6934	5211	9226
1991	13967	10669	18286	5769	4115	8089
1992	13283	10085	17495	5394	3893	7474
1993	12090	9324	15678	4891	3603	6639
1994	10812	8543	13684	4106	3062	5506
1995	9970	8219	12095	3724	2935	4724
1996	9221	7729	11001	3240	2573	4080
1997	8856	7551	10388	3504	2901	4231
1998	8740	7487	10203	3749	3193	4401
1999	8894	7280	10865	3619	2848	4599
2000	9878	8139	11990	3999	3184	5024
2001	9602	7989	11540	3817	3075	4739
2002	9321	7903	10994	3656	3046	4389
2003	8797	7730	10011	3042	2593	3569
2004	8532	7546	9647	2851	2407	3377
2005	8331	7326	9473	2905	2430	3473
2006	8703	7641	9912	3162	2606	3837
2007	9960	8830	11235	3961	3301	4753
2008	10007	8833	11337	4830	4019	5803
2009	10009	8738	11466	5954	4963	7141
2010	9685	8352	11232	5681	4606	7007
2011	10415	8895	12194	5322	4231	6694
2012	11238	9631	13113	5854	4691	7306
2013	11288	9668	13179	6863	5586	8432
2014	12159	10401	14215	8141	6663	9948
2015	13945	11841	16423	8101	6442	10187
2016	14580	12448	17078	8362	6670	10485
2017	14131	12113	16484	9272	7596	11317
2018	13383	11359	15767	9187	7444	11338
2019	13640	11535	16128	8420	6677	10619
2020	14035	11646	16913	8343	6529	10662

Table 21.4.1c. Recruitment (Age 1) of turbot in Area 4. (Thousands)

Year	Value	Low	High	Year	Value	Low	High
1981	2559.23	1850.64	3539.13	2018	5829.87	4434.50	7664.30
1982	4205.67	3111.83	5684.02	2019	7094.35	5111.81	9845.78
1983	6446.80	4726.48	8793.28	2020	6374.03	3799.60	10692.78
1984	5010.25	3620.87	6932.74				
1985	2487.28	1790.65	3454.92				
1986	3395.51	2514.63	4584.96				
1987	3972.87	2933.69	5380.16				
1988	3748.36	2734.84	5137.48				
1989	4502.16	2971.49	6821.31				
1990	5778.43	3602.16	9269.49				
1991	5008.73	3233.42	7758.79				
1992	4413.22	2849.21	6835.76				
1993	4899.31	3253.24	7378.26				
1994	3794.25	2517.67	5718.10				
1995	4754.23	3358.77	6729.46				
1996	3310.14	2405.46	4555.05				
1997	2839.96	2039.57	3954.44				
1998	4050.76	2856.11	5745.10				
1999	3442.49	2355.61	5030.87				
2000	5433.53	3836.58	7695.19				
2001	3586.80	2424.32	5306.68				
2002	5862.00	4325.24	7944.76				
2003	4836.85	3635.57	6435.07				
2004	5905.79	4516.50	7722.43				
2005	4505.88	3466.47	5856.96				
2006	6355.54	4879.88	8277.45				
2007	5278.08	4050.23	6878.16				
2008	3253.31	2419.99	4373.59				
2009	3970.37	3008.51	5239.76				
2010	5425.11	4181.33	7038.87				
2011	6838.45	5092.24	9183.47				
2012	4181.95	3148.94	5553.85				
2013	3300.38	2497.51	4361.33				
2014	6713.69	5114.09	8813.61				
2015	9134.54	6802.49	12266.06				
2016	3114.57	2316.26	4188.01				
2017	5044.40	3846.96	6614.57				

Table 21.4.2. Turbot in Area 4. Estimated fishing mortality

Year	Age							
	1	2	3	4	5	6	7	8
1981	0.002	0.118	0.615	0.532	0.358	0.316	0.229	0.229
1982	0.002	0.112	0.575	0.513	0.358	0.324	0.243	0.243
1983	0.003	0.135	0.607	0.560	0.402	0.360	0.278	0.278
1984	0.004	0.178	0.673	0.611	0.442	0.385	0.289	0.289
1985	0.005	0.206	0.728	0.669	0.484	0.405	0.290	0.290
1986	0.005	0.211	0.687	0.634	0.470	0.392	0.279	0.279
1987	0.006	0.244	0.725	0.628	0.464	0.381	0.273	0.273
1988	0.007	0.259	0.725	0.573	0.443	0.374	0.281	0.281
1989	0.009	0.328	0.909	0.710	0.553	0.448	0.360	0.360
1990	0.012	0.383	1.05	0.846	0.698	0.579	0.536	0.536
1991	0.014	0.409	1.103	0.906	0.754	0.621	0.596	0.596
1992	0.016	0.440	1.143	0.940	0.786	0.649	0.652	0.652
1993	0.019	0.483	1.190	0.968	0.804	0.662	0.692	0.692
1994	0.022	0.508	1.217	0.975	0.803	0.656	0.701	0.701
1995	0.023	0.505	1.186	0.960	0.789	0.644	0.707	0.707
1996	0.017	0.398	1.038	0.888	0.767	0.641	0.743	0.743
1997	0.014	0.321	0.890	0.814	0.746	0.649	0.797	0.797
1998	0.013	0.298	0.821	0.765	0.727	0.649	0.849	0.849
1999	0.015	0.318	0.778	0.724	0.675	0.602	0.801	0.801
2000	0.025	0.440	0.842	0.741	0.646	0.533	0.646	0.646
2001	0.040	0.588	0.929	0.800	0.660	0.509	0.572	0.572
2002	0.067	0.821	1.006	0.846	0.662	0.473	0.487	0.487
2003	0.072	0.824	0.934	0.789	0.610	0.425	0.412	0.412
2004	0.074	0.796	0.864	0.699	0.498	0.333	0.275	0.275
2005	0.063	0.673	0.788	0.616	0.440	0.312	0.269	0.269
2006	0.047	0.530	0.605	0.457	0.346	0.277	0.264	0.264
2007	0.040	0.510	0.542	0.416	0.319	0.264	0.244	0.244
2008	0.036	0.457	0.496	0.384	0.306	0.255	0.221	0.221
2009	0.050	0.603	0.577	0.415	0.304	0.245	0.208	0.208
2010	0.045	0.558	0.549	0.398	0.296	0.247	0.210	0.210
2011	0.035	0.477	0.494	0.368	0.272	0.230	0.193	0.193
2012	0.028	0.417	0.463	0.369	0.266	0.224	0.183	0.183
2013	0.024	0.376	0.427	0.362	0.264	0.220	0.169	0.169
2014	0.015	0.290	0.403	0.378	0.298	0.257	0.211	0.211
2015	0.011	0.259	0.391	0.386	0.319	0.264	0.205	0.205
2016	0.010	0.242	0.411	0.437	0.367	0.286	0.210	0.210
2017	0.009	0.229	0.417	0.447	0.372	0.283	0.201	0.201
2018	0.014	0.263	0.435	0.453	0.380	0.286	0.192	0.192
2019	0.019	0.304	0.447	0.446	0.369	0.269	0.167	0.167
2020	0.021	0.310	0.425	0.419	0.347	0.249	0.146	0.146

Table 21.4.3. Turbot in Area 4. Estimated population abundance (units: thousands)

Year	Age							
	1	2	3	4	5	6	7	8
1981	2559.23	3105.04	1612.05	1319.61	1764.83	714.68	361.13	600.79
1982	4205.67	2019.03	2292.67	673.44	628.24	1023.88	429.87	637.14
1983	6446.80	3453.25	1479.90	1061.78	328.09	362.60	614.33	693.78
1984	5010.25	5522.17	2518.12	684.82	486.80	178.98	208.75	804.65
1985	2487.28	4217.49	3770.16	1083.14	318.16	254.10	98.65	617.96
1986	3395.51	1887.94	2959.08	1404.15	442.15	163.55	136.14	442.83
1987	3972.87	2797.07	1168.95	1373.87	576.47	219.13	90.24	358.52
1988	3748.36	3312.00	1781.05	454.36	594.93	288.71	122.00	284.54
1989	4502.16	2978.42	2043.50	740.26	238.51	317.95	158.49	254.33
1990	5778.43	3634.89	1746.74	628.82	302.54	119.96	174.03	241.32
1991	5008.73	4833.35	2036.46	485.38	216.42	122.59	55.71	199.14
1992	4413.22	4134.29	2651.21	550.54	159.22	82.06	53.65	115.04
1993	4899.31	3517.16	2201.78	683.42	177.65	58.75	34.38	72.01
1994	3794.25	4023.95	1687.96	556.34	211.59	64.63	24.96	43.68
1995	4754.23	2854.20	1949.14	399.98	177.13	78.50	27.51	27.96
1996	3310.14	3915.24	1317.21	486.62	125.87	68.19	34.48	22.46
1997	2839.96	2742.63	2145.43	367.51	163.71	47.26	30.49	22.40
1998	4050.76	2271.72	1638.44	733.94	131.74	63.10	19.71	20.09
1999	3442.49	3304.19	1388.60	576.03	287.15	51.44	26.65	13.90
2000	5433.53	2642.53	2031.19	551.49	229.65	126.80	23.09	14.91
2001	3586.80	4317.35	1293.88	702.88	220.84	97.42	63.09	16.34
2002	5862.00	2672.46	1982.13	402.14	255.30	96.78	47.58	37.21
2003	4836.85	4553.82	895.89	596.74	134.73	105.34	50.45	43.86
2004	5905.79	3592.19	1589.01	286.34	221.15	55.29	54.88	49.13
2005	4505.88	4429.05	1308.74	527.42	108.42	106.72	30.15	67.24
2006	6355.54	3478.48	1871.79	415.36	219.31	54.97	64.48	62.26
2007	5278.08	5123.76	1715.84	894.10	217.42	132.35	34.63	78.82
2008	3253.31	4371.17	2515.11	806.45	476.87	132.92	84.40	71.17
2009	3970.37	2448.42	2408.79	1392.12	472.92	262.83	81.35	102.55
2010	5425.11	3264.90	1001.42	1077.09	750.94	297.46	164.63	119.55
2011	6838.45	4241.66	1648.69	435.12	603.91	455.03	186.01	179.12
2012	4181.95	5746.57	2221.94	900.48	252.95	387.40	307.56	233.72
2013	3300.38	3385.67	3479.51	1161.46	521.59	168.40	264.59	357.24
2014	6713.69	2388.79	2007.12	2142.17	685.82	351.31	118.72	461.13
2015	9134.54	5546.04	1574.84	1162.53	1293.74	433.32	225.82	405.85
2016	3114.57	7735.89	3374.36	943.99	680.49	766.30	268.43	419.04
2017	5044.40	2316.67	5181.65	1746.06	490.04	368.97	465.91	436.20
2018	5829.87	4010.77	1479.34	2662.57	892.97	276.00	229.31	564.31
2019	7094.35	4694.91	2575.89	789.99	1402.99	501.18	168.45	522.99
2020	6374.03	5666.68	2778.41	1288.28	424.65	787.51	316.44	464.85

Table 21.5.1a. Turbot in Area 4. Predicted catch numbers at age (units: thousands)

Year	Age							
	1	2	3	4	5	6	7	8
1981	5.01	314.72	677.97	498.11	484.10	176.53	67.28	5.01
1982	7.66	194.57	917.78	247.09	172.52	258.42	84.50	7.66
1983	15.00	394.83	616.73	416.33	99.00	100.05	135.82	15.00
1984	17.03	818.14	1130.32	286.81	158.71	52.18	47.65	17.03
1985	10.30	713.06	1789.17	484.25	111.52	77.14	22.62	10.30
1986	14.51	326.17	1348.02	603.65	151.47	48.35	30.15	14.51
1987	20.68	550.74	553.10	586.99	195.41	63.27	19.61	20.68
1988	22.55	687.89	842.45	181.24	194.39	82.24	27.24	22.55
1989	37.84	758.55	1122.12	345.05	92.66	104.84	43.71	37.84
1990	60.98	1055.77	1047.10	330.01	139.32	48.25	66.00	60.98
1991	61.22	1481.53	1255.24	266.05	105.15	51.91	22.90	61.22
1992	63.11	1344.06	1667.68	308.84	79.60	35.91	23.55	63.11
1993	84.17	1231.93	1415.22	390.36	90.14	26.07	15.74	84.17
1994	73.93	1464.07	1098.08	319.05	107.26	28.50	11.53	73.93
1995	96.99	1033.69	1250.67	227.23	88.73	34.12	12.78	96.99
1996	51.97	1172.49	784.15	263.41	61.88	29.56	16.58	51.97
1997	35.38	685.65	1162.94	188.06	78.98	20.67	15.38	35.38
1998	48.48	533.70	842.80	360.13	62.45	27.59	10.37	48.48
1999	47.67	819.12	689.05	272.14	129.15	21.31	13.49	47.67
2000	123.73	858.04	1062.65	264.89	100.13	47.90	10.06	123.73
2001	128.65	1755.65	720.40	355.33	97.73	35.53	25.16	128.65
2002	344.69	1374.59	1158.31	210.93	113.26	33.31	16.77	344.69
2003	303.50	2348.45	500.38	298.89	56.30	33.26	15.54	303.50
2004	382.57	1811.07	845.15	132.03	79.28	14.26	12.00	382.57
2005	248.83	1989.10	655.34	221.98	35.22	26.04	6.47	248.83
2006	262.57	1309.31	778.07	139.15	58.45	12.11	13.63	262.57
2007	189.72	1870.27	656.98	277.61	54.13	27.94	6.81	189.72
2008	104.18	1463.65	899.31	234.40	114.54	27.28	15.21	104.18
2009	174.64	1015.45	965.90	431.27	112.83	51.94	13.88	174.64
2010	214.75	1277.33	387.14	322.59	175.40	59.29	28.39	214.75
2011	210.90	1468.81	587.02	122.09	130.97	85.00	29.72	210.90
2012	105.71	1787.22	752.71	253.64	53.87	70.67	46.64	105.71
2013	71.20	968.28	1103.95	321.72	110.05	30.23	37.45	71.20
2014	87.73	547.38	607.49	615.32	160.97	72.49	20.50	87.73
2015	91.73	1151.44	465.01	339.58	321.81	91.51	38.02	91.73
2016	28.37	1511.45	1038.23	305.17	190.53	173.37	46.24	28.37
2017	42.33	430.82	1611.31	575.05	138.95	82.83	77.27	42.33
2018	74.14	844.61	475.97	885.45	257.62	62.50	36.47	74.14
2019	122.67	1121.05	847.53	259.48	394.73	107.60	23.50	122.67
2020	121.49	1376.05	877.40	402.25	113.62	158.09	39.15	121.49

Table 21.5.1b. Turbot in Area 4. Catch at age residuals

Year	Age							
	1	2	3	4	5	6	7	8
1981	0.000	-2.011	0.028	3.131	0.594	0.139	0.979	2.839
1982	0.000	1.548	0.204	-1.282	-1.574	-1.426	-0.396	0.100
1983	0.000	1.356	-0.003	0.946	0.368	-0.096	0.127	-0.043
1984	0.000	2.226	0.016	0.580	-0.081	-0.098	-0.268	-0.908
1985	0.000	-0.436	-0.246	0.605	0.968	-0.178	-0.771	-0.907
1986	0.000	-1.101	-0.435	-0.982	-0.060	0.189	-0.727	-0.192
1987	0.340	0.783	-1.856	1.356	-1.022	-1.133	-0.080	-0.686
1988	0.740	0.937	-0.740	-1.477	-0.048	-0.044	0.083	0.070
1989	0.000	-0.466	0.234	0.838	2.581	-0.327	-0.334	-0.025
1990	0.595	0.316	-0.157	-1.377	0.747	1.864	1.960	0.314
1991–1997	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.000	-0.104	-0.294	0.437	0.611	0.054	-0.403	0.905
1999–2002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	1.297	0.495	-2.586	-0.352	-0.613	-1.216	0.178	0.930
2004	0.903	0.142	-1.170	-0.363	-0.485	-2.416	-2.205	-1.910
2005	0.162	-0.512	0.349	-0.694	-1.579	-0.503	-2.383	1.487
2006	1.360	0.509	-0.775	-3.060	-1.692	-0.873	1.213	0.949
2007	-1.299	1.221	-0.933	0.932	-0.391	0.941	0.584	-0.481
2008	0.015	-0.111	-0.657	-0.406	1.577	1.568	-0.686	-0.946
2009	-0.067	0.313	1.164	1.130	-0.488	-2.348	-0.499	0.333
2010	0.692	1.007	-1.285	-0.603	-0.014	1.556	0.036	-0.314
2011	-0.127	0.551	0.935	-1.158	0.114	-0.300	0.065	-0.806
2012	0.000	-0.053	0.217	1.583	-0.657	-0.062	1.165	-1.618
2013	0.062	0.509	0.691	0.520	-0.281	0.109	0.290	-2.165
2014	-0.756	-2.388	0.545	1.931	0.152	2.088	1.919	0.564
2015	-0.937	0.480	0.919	0.452	0.705	0.526	-0.157	0.220
2016	0.000	-1.497	-0.209	1.931	2.297	0.036	-0.555	-0.229
2017	-1.403	-0.976	1.204	-0.050	-0.048	-1.032	0.439	-0.709
2018	1.802	-0.655	-0.318	-0.394	0.004	0.341	0.336	-1.079
2019	1.047	0.119	0.106	-0.191	-0.172	0.157	-0.619	-0.790
2020	0.662	0.159	-1.043	-0.807	0.743	-0.467	-0.039	-1.215

Table 21.5.2a. Turbot in Area 4. Predicted index at age SNS

Year	Age					
	1	2	3	4	5	6
2004	101.9713758	37.27367	10.39421	0.98663	0.878012	0.246618
2005	78.4203839	50.11841	9.031047	1.927375	0.448503	0.483163
2006	111.8808308	43.53593	14.69522	1.697349	0.969329	0.255064
2007	93.3190143	65.07126	14.08081	3.761427	0.979238	0.619744
2008	57.702534	57.62735	21.32104	3.470473	2.16756	0.626101
2009	69.741006	29.10799	19.29649	5.861288	2.153241	1.247414
2010	95.636122	40.07481	8.178085	4.588868	3.436935	1.409369
2011	121.40602	55.14558	14.00279	1.893667	2.811617	2.182516
2012	74.575881	77.92917	19.27814	3.914247	1.182319	1.866035
2013	59.0291537	47.24071	30.97389	5.074878	2.442759	0.813454
2014	120.890327	35.42543	18.17231	9.254036	3.135176	1.652959
2015	164.873924	84.06128	14.37909	4.994649	5.827962	2.028981
2016	56.257636	118.6818	30.37531	3.912172	2.963522	3.533791
2017	91.166999	35.86981	46.46704	7.184153	2.125656	1.704576
2018	105.004822	60.6107	13.09959	10.91294	3.852159	1.272469
2019	127.318811	68.93351	22.61299	3.25379	6.100735	2.338492
2020	114.231177	82.84973	24.77583	5.408684	1.874693	3.726025

Table 21.5.2b. Turbot in Area 4. Index at age residuals SNS

	Age					
Year	1	2	3	4	5	6
2004	0.417	-1.468	1.155	0.991	1.062	1.637
2005	-0.619	2.058	0.365	0.000	0.000	0.000
2006	1.032	1.107	-0.334	0.849	-0.299	0.000
2007	0.044	-0.074	1.804	0.669	-0.173	0.000
2008	-0.622	1.698	0.454	0.778	0.893	-0.183
2009	-1.286	-0.503	-1.249	2.015	0.586	0.000
2010	0.608	0.011	0.000	0.114	-0.009	1.581
2011	0.382	-0.593	0.000	0.000	0.000	-0.211
2012	-1.208	-0.082	-0.279	-0.697	0.000	0.000
2013	0.497	-1.824	0.383	-2.183	0.000	0.000
2014	1.046	-1.282	-0.233	0.086	0.673	-0.530
2015	1.718	-1.283	-2.202	0.467	0.000	0.000
2016	-1.406	0.962	-0.362	-0.675	-0.557	-1.605
2017	2.202	-0.765	0.031	-3.098	0.000	-0.543
2018	-0.215	0.405	0.056	0.542	0.458	0.513
2019	0.207	0.056	-0.488	-0.526	0.090	-0.936
2020	-0.867	-0.245	1.569	-0.612	0.134	0.255

Table 21.5.3a. Turbot in Area 4. Predicted index at age BTS-ISIS

Year	Age 1	2	3	4	5	6	7
1991	1.657	1.209	0.192	0.052	0.019	0.012	0.005
1992	1.457	1.012	0.243	0.058	0.014	0.008	0.005
1993	1.614	0.835	0.195	0.071	0.015	0.005	0.003
1994	1.248	0.940	0.147	0.057	0.018	0.006	0.002
1995	1.562	0.668	0.173	0.042	0.015	0.007	0.002
1996	1.092	0.988	0.130	0.053	0.011	0.006	0.003
1997	0.939	0.731	0.235	0.042	0.014	0.004	0.003
1998	1.340	0.615	0.188	0.088	0.012	0.006	0.002
1999	1.137	0.882	0.164	0.071	0.027	0.005	0.002
2000	1.782	0.647	0.230	0.067	0.022	0.013	0.002
2001	1.164	0.953	0.138	0.082	0.021	0.010	0.006
2002	1.867	0.500	0.200	0.045	0.024	0.010	0.005
2003	1.536	0.851	0.095	0.070	0.013	0.012	0.006
2004	1.872	0.684	0.177	0.036	0.023	0.006	0.007
2005	1.440	0.920	0.154	0.070	0.012	0.013	0.004
2006	2.054	0.799	0.250	0.062	0.026	0.007	0.008
2007	1.713	1.195	0.240	0.137	0.026	0.016	0.004
2008	1.059	1.058	0.363	0.126	0.057	0.016	0.011
2009	1.280	0.534	0.329	0.213	0.057	0.033	0.010
2010	1.756	0.736	0.139	0.167	0.091	0.037	0.021
2011	2.229	1.012	0.238	0.069	0.074	0.057	0.024
2012	1.369	1.431	0.328	0.142	0.031	0.049	0.040
2013	1.084	0.867	0.527	0.184	0.064	0.021	0.035
2014	2.219	0.650	0.309	0.336	0.083	0.044	0.015
2015	3.027	1.543	0.245	0.181	0.153	0.053	0.029
2016	1.033	2.179	0.517	0.142	0.078	0.093	0.034
2017	1.674	0.658	0.791	0.261	0.056	0.045	0.060
2018	1.928	1.113	0.223	0.396	0.101	0.034	0.030
2019	2.337	1.265	0.385	0.118	0.161	0.062	0.022
2020	2.097	1.521	0.422	0.196	0.049	0.098	0.042

Table 21.5.3b. Turbot in Area 4. Index at age residuals BTS-ISIS

Year	Age						
	1	2	3	4	5	6	7
1991	-0.590	0.734	-1.027	-2.236	-0.958	0.000	0.197
1992	-0.085	0.517	0.207	-1.291	-0.390	-0.290	-1.036
1993	0.246	0.800	-0.474	-0.776	0.901	-1.594	-1.741
1994	0.168	0.783	-1.571	-0.678	-0.931	-0.389	0.650
1995	0.015	-1.099	-0.984	-1.188	0.252	-0.191	0.000
1996	-1.544	1.877	-0.214	1.228	1.846	0.000	1.391
1997	-0.500	1.762	1.450	-0.463	1.273	1.198	1.701
1998	1.386	0.764	0.728	0.988	-1.026	0.000	-0.392
1999	-0.167	0.428	0.159	0.606	-0.235	-0.505	-0.636
2000	1.780	-0.671	0.780	1.251	1.112	1.917	0.000
2001	-1.348	-0.147	-1.651	0.357	0.000	0.000	2.313
2002	1.085	-1.688	-1.775	-0.674	-0.006	0.816	-1.498
2003	-0.531	-0.280	0.078	-0.575	0.000	-0.051	0.930
2004	-0.209	-0.288	1.470	0.000	1.012	0.727	0.000
2005	-0.720	0.592	2.399	0.503	1.055	-0.860	1.113
2006	-0.384	-0.010	0.867	1.164	-1.720	0.000	0.000
2007	-0.268	-0.133	2.720	1.337	1.552	1.483	0.000
2008	0.022	0.403	0.602	0.167	0.119	-0.032	2.228
2009	0.059	-1.022	0.236	0.582	1.262	0.426	-0.868
2010	0.476	-1.078	-0.725	-1.153	0.036	-1.060	-0.497
2011	0.005	0.158	-0.305	0.007	-0.079	-1.327	0.000
2012	-0.548	0.213	-0.057	1.036	-0.210	0.018	0.752
2013	-1.753	0.175	0.713	0.123	-1.192	0.786	0.183
2014	1.154	-2.357	-0.022	0.271	0.518	0.163	-0.007
2015	1.032	-0.083	0.146	-0.764	-0.350	0.000	-0.878
2016	-1.540	0.253	-0.364	-1.407	-0.933	-0.971	-0.369
2017	0.708	-1.461	-0.149	-2.335	-1.635	-1.269	-0.546
2018	-0.684	-0.129	0.327	-0.493	0.515	-0.091	0.000
2019	0.275	-0.549	0.016	-1.587	-0.315	-1.401	0.000
2020	-0.449	-0.459	-0.116	-0.603	-0.426	-0.607	-0.011

Table 21.5.4. Turbot in Area 4. Predicted index and residuals of the Dutch LPUE

year	Index	Residuals
1995	0.042	0.380
1996	0.038	-0.963
1997	0.038	-1.515
1998	0.035	-0.359
1999	0.036	-0.311
2000	0.044	0.026
2001	0.047	-0.283
2002	0.045	0.112
2003	0.046	0.927
2004	0.048	-0.813
2005	0.050	-2.661
2006	0.052	-0.725
2007	0.064	0.732
2008	0.069	-0.016
2009	0.066	0.189
2010	0.057	1.461
2011	0.062	0.354
2012	0.075	1.795
2013	0.078	2.052
2014	0.074	2.313
2015	0.079	2.708
2016	0.090	1.308
2017	0.092	-0.263
2018	0.082	-1.335
2019	0.081	0.933
2020	0.085	0.492

Table 21.5.5. Turbot in Area 4. Fit parameters

Name	value	std.dev
logFpar	-3.866	0.135
logFpar	-4.279	0.195
logFpar	-5.037	0.247
logFpar	-7.864	0.073
logFpar	-8.352	0.088
logFpar	-8.674	0.164
logFpar	-9.762	0.089
logSdLogFsta	-0.802	0.400
logSdLogFsta	-1.405	0.233
logSdLogFsta	-1.982	0.217
logSdLogN	-1.900	0.273
logSdLogN	-1.527	0.291
logSdLogObs	-0.866	0.166
logSdLogObs	-2.194	0.334
logSdLogObs	-0.174	0.225
logSdLogObs	-1.205	0.276
logSdLogObs	-2.265	0.369
logSdLogObs	-1.130	0.139
logSdLogObs	-1.066	0.157
logSdLogObs	-0.505	0.147
logSdLogObs	-0.227	0.172
transfIRARdist	0.086	0.122
itrans_rho	-0.906	0.091

Table 21.5.6. Turbot in Area 4. Negative Log-Likelihood

414.262

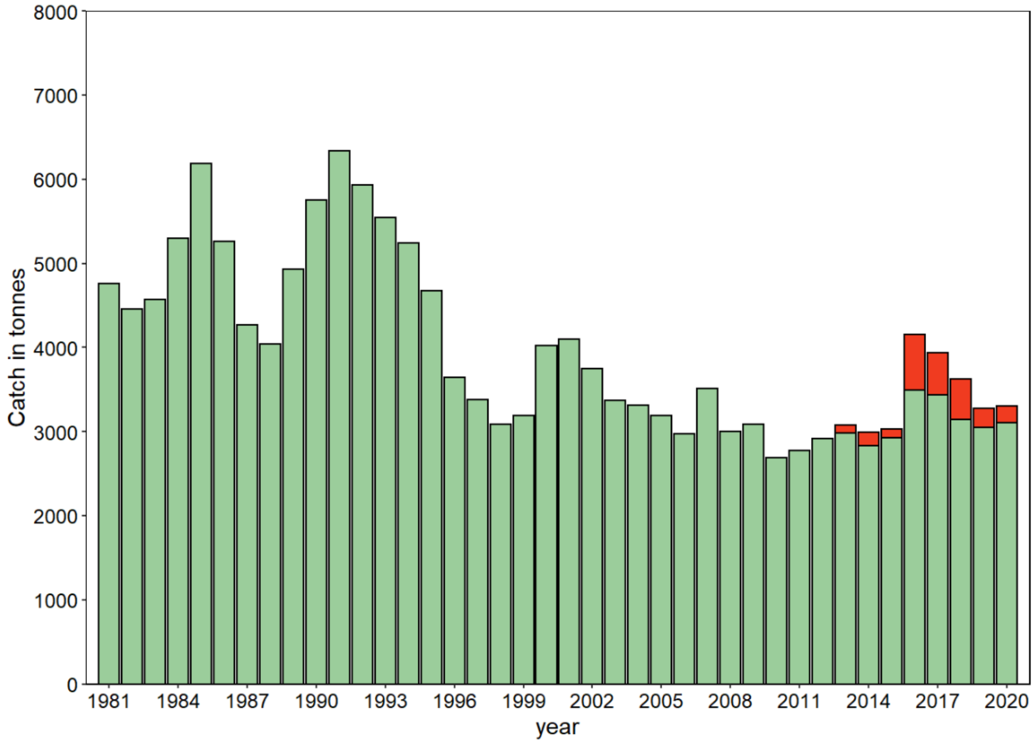


Figure 21.2.1. Turbot in 27.4.20. Total catches 1981–2020. ICES estimated landings (green) and discards (red).

Figure 21.2.2. Turbot in 27.4.20. Landings at age for the years with available data between 1975–2020. Data for 1991–1997 and 1999–2002 are missing.

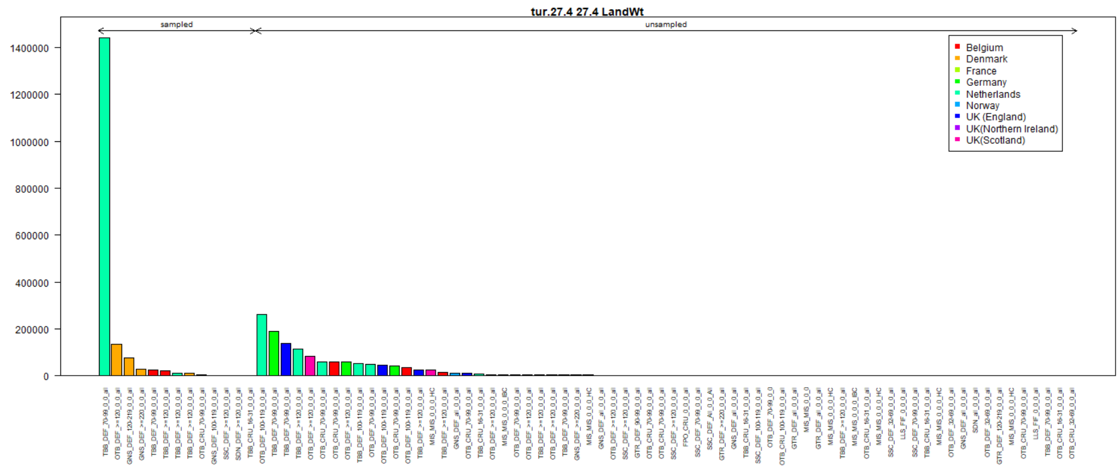


Figure 21.2.3. Turbot in 27.4.20: Total landings by métier in 2020 sorted by sampled/unsampled for numbers at age in InterCatch.

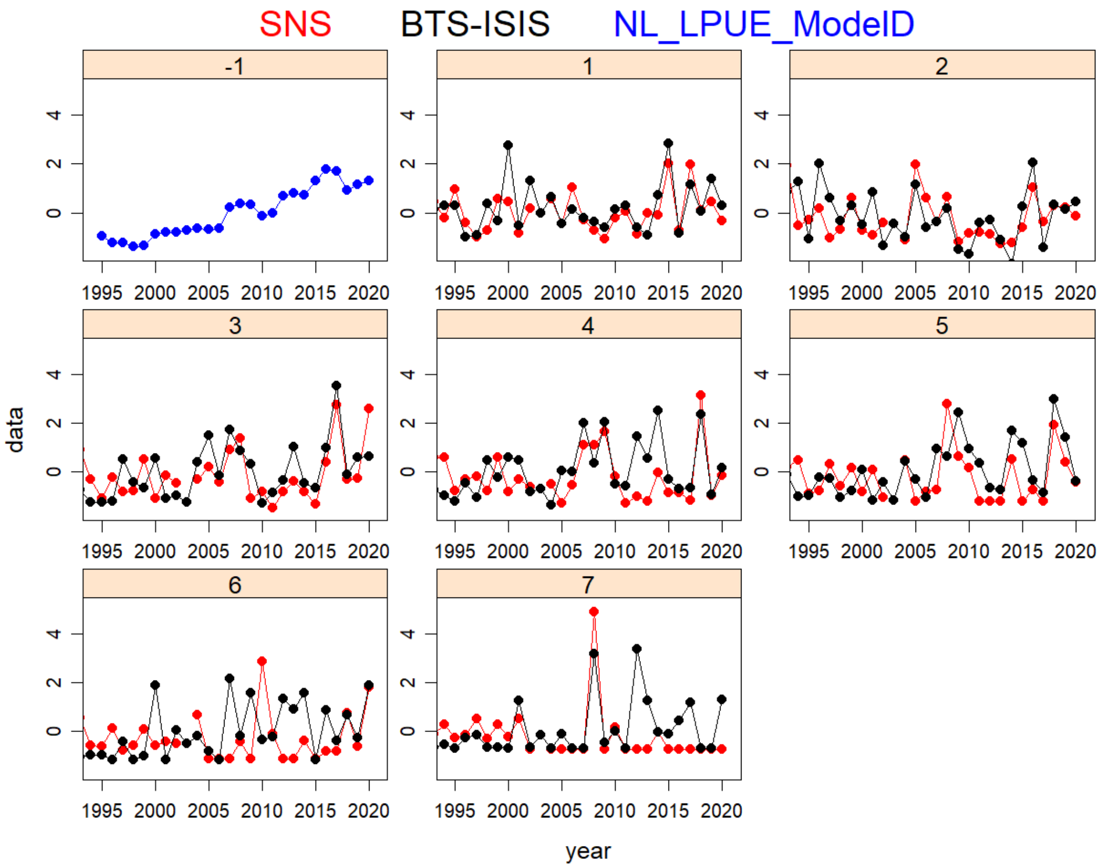
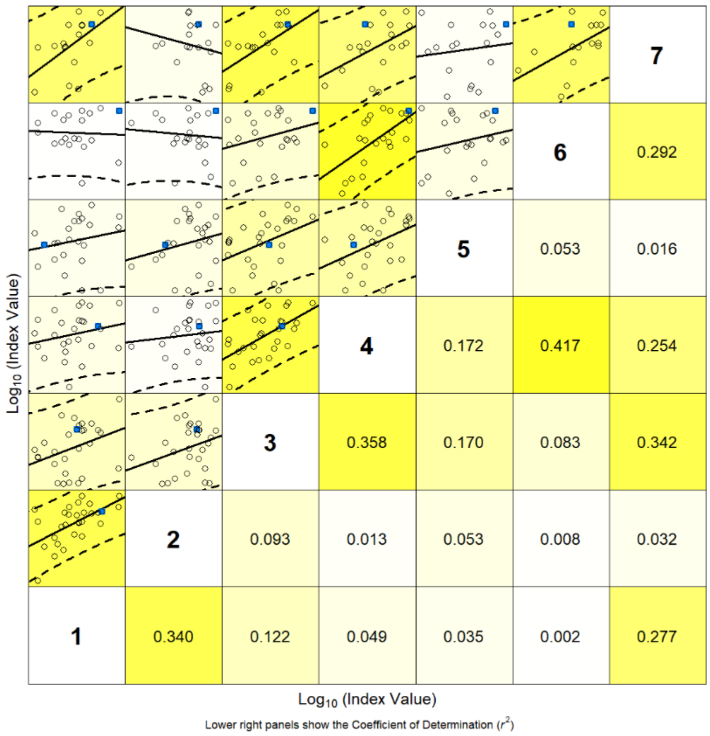


Figure 21.2.4. Turbot in 27.4.20. Time series of the standardized indices for ages 1 to 7 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE (shown in the "-1" panel).



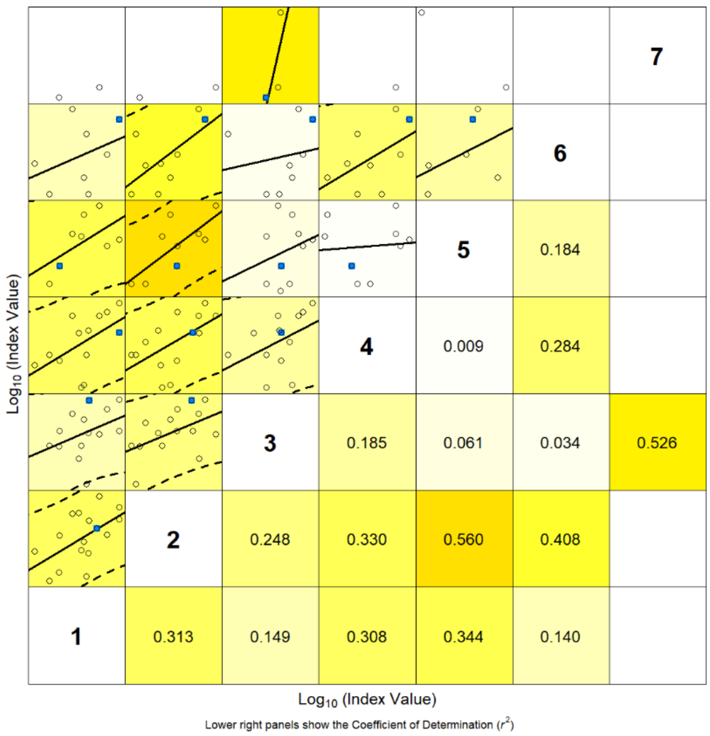


Figure 21.2.5. Turbot in 27.4.20. Internal consistency of the two tuning indices available for the assessment: BTS-ISIS from 1991–2020 (top), and SNS 2004–2020 (bottom).

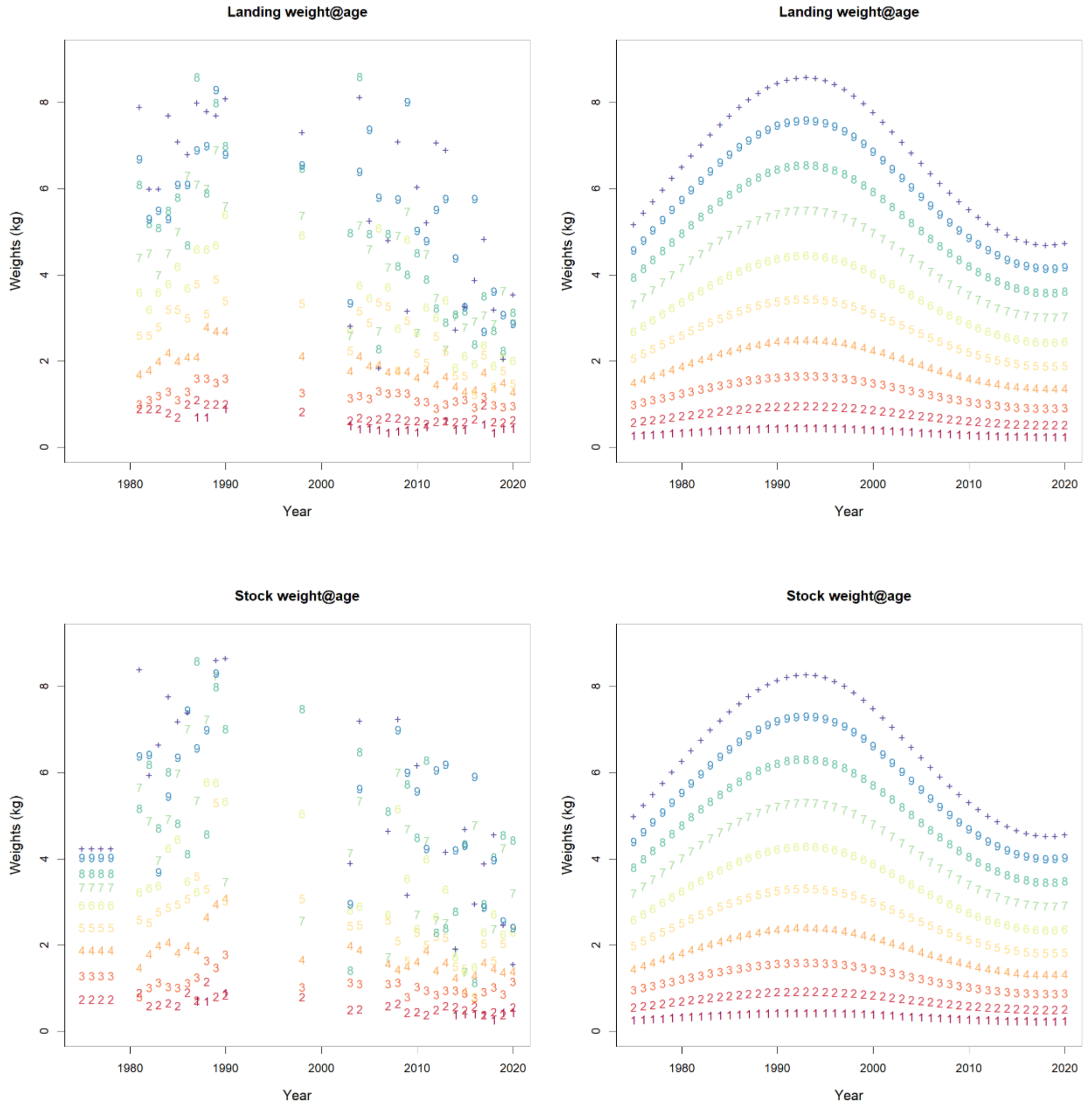


Figure 21.2.6. Raw landings (top-left), modelled landings (top right) and raw stock (bottom left) and modelled (bottom right) weight at age.

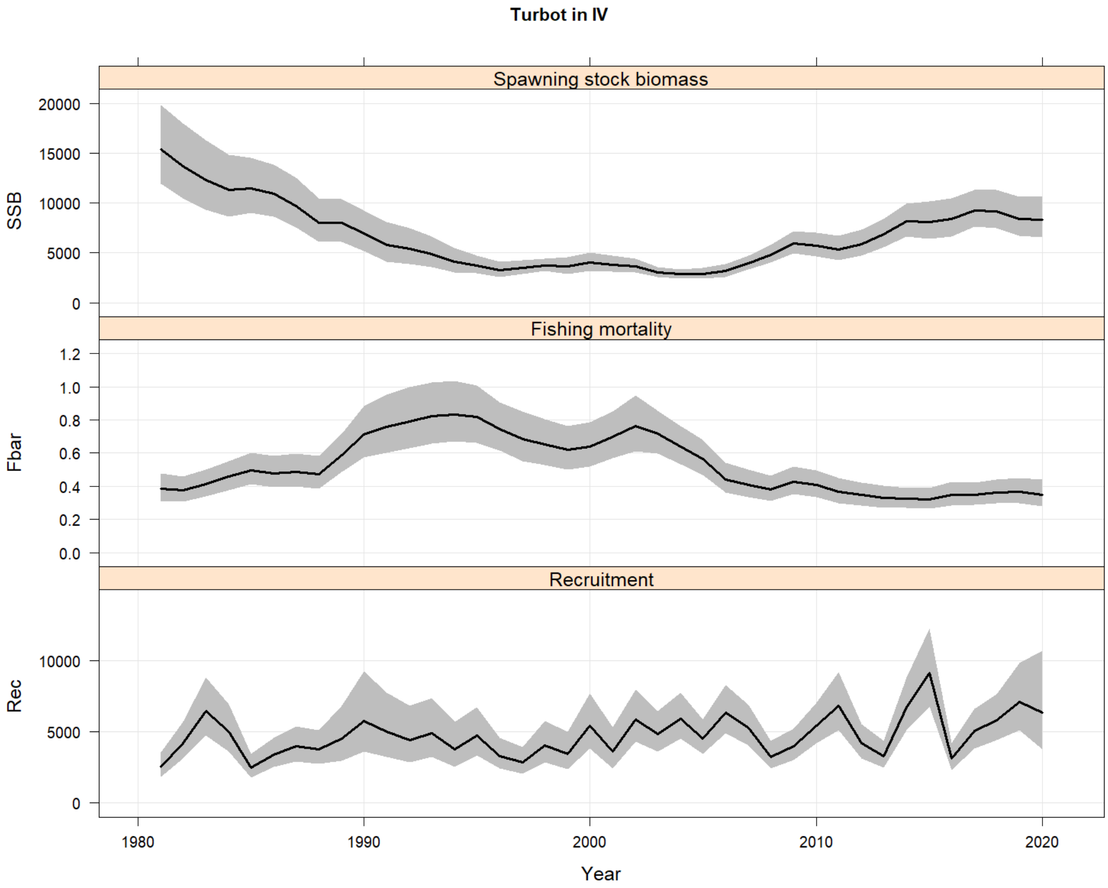


Figure 21.4.1. Summary plot of SSB, F and Recruitment, including the uncertainty bounds.

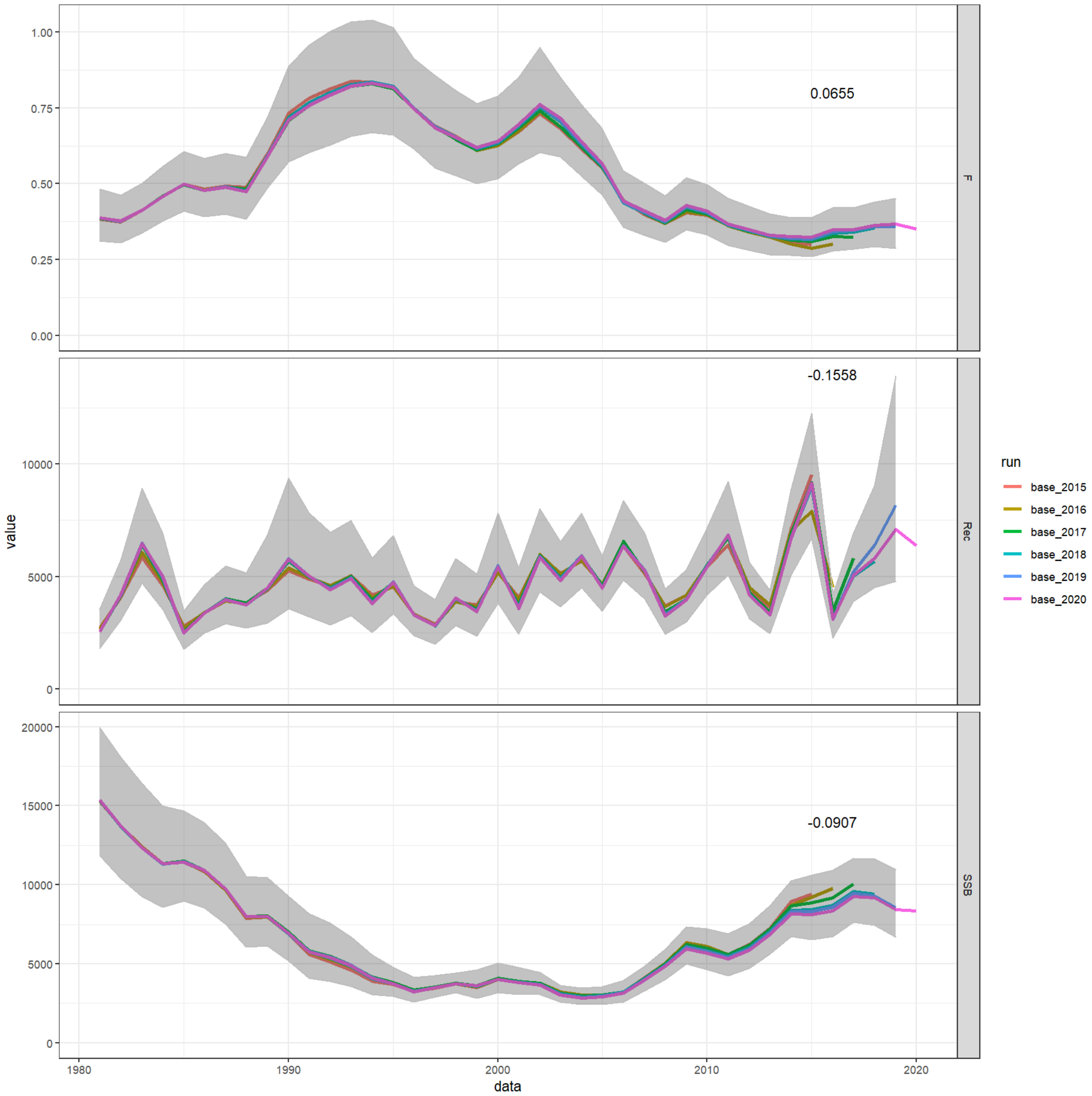


Figure 21.4.2. Retrospective analysis plot on SSB, F and R including confidence band last year assessment and Mohn's rho values.

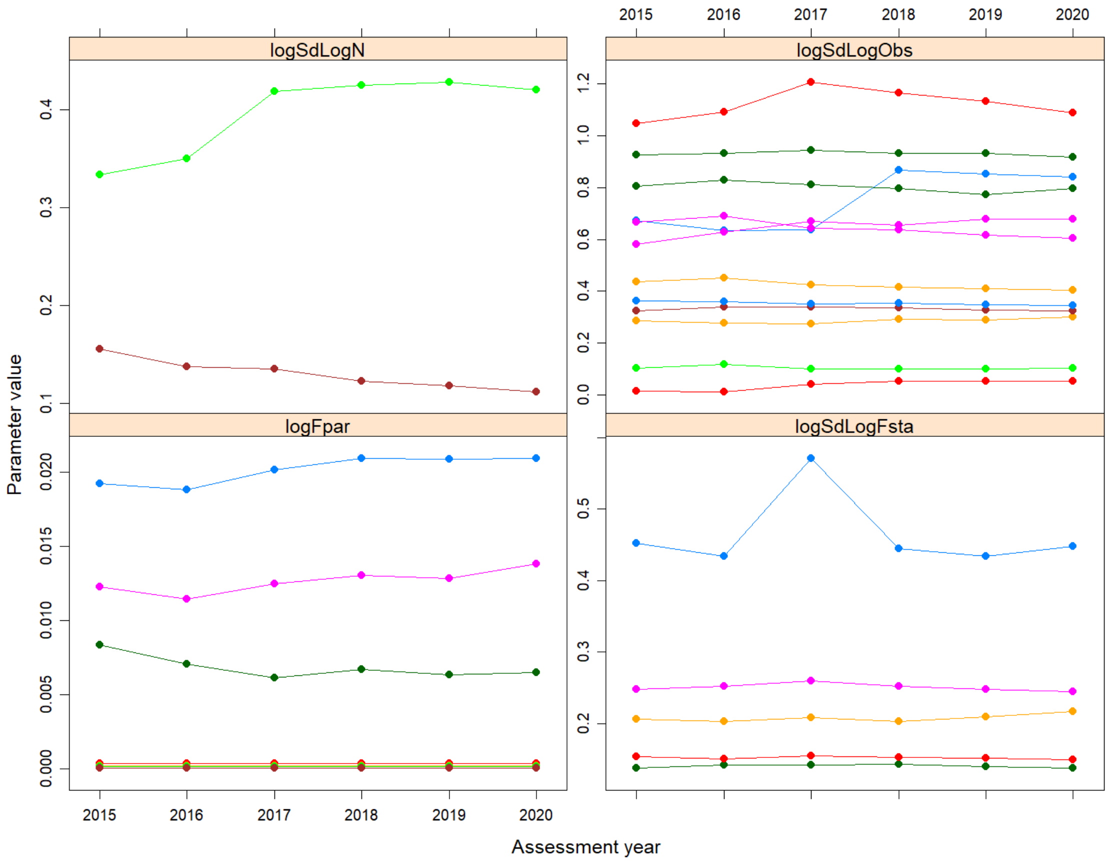


Figure 21.4.3. Retrospective analysis plot on the value of the estimated parameters, ideally, all show a flat line indicating that with reducing the model with a year's worth of data does not affect the parameters to be estimated: logSdLogN = the random walk in N, logSdLogObs is the observation variance in the surveys and catch, logFpar are the catchability parameters and logSdLogFsta are the sd's of the random walks in F.

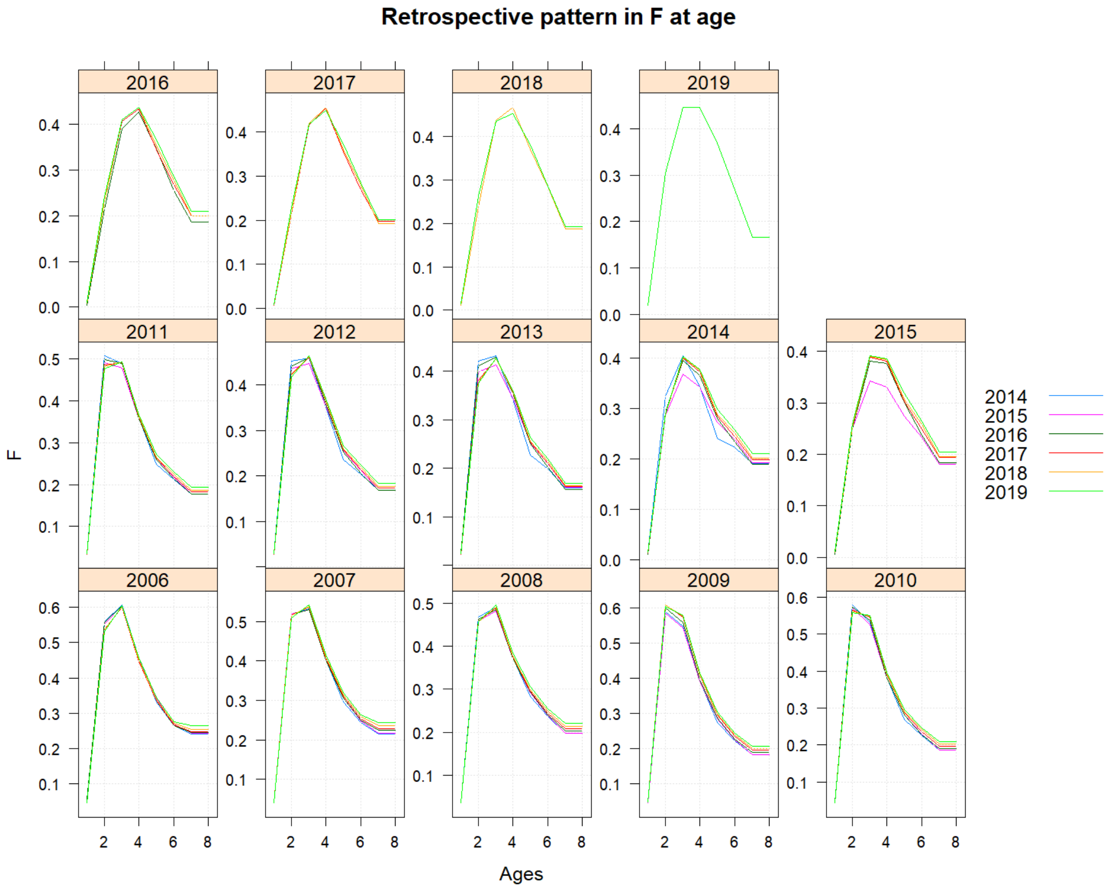


Figure 21.4.4. Retrospective analysis plot of selectivity pattern.

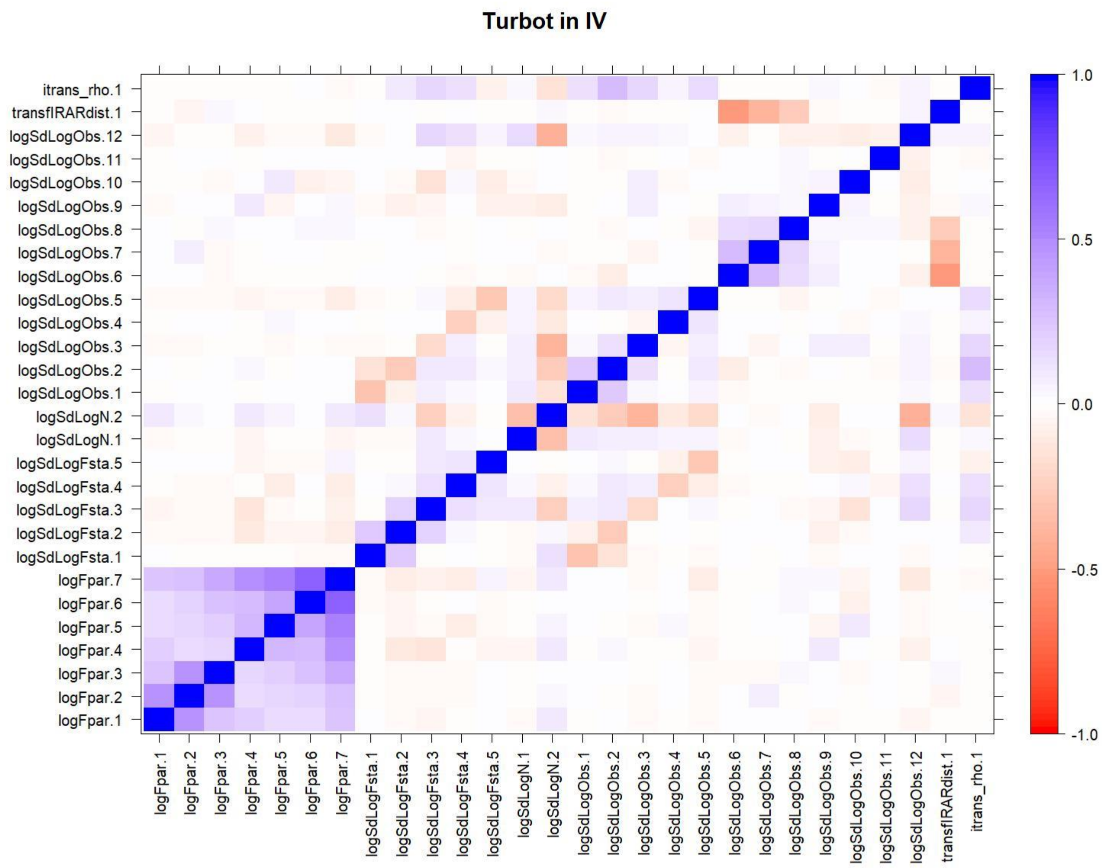


Figure 21.5.1. Parameter-correlation plot. It shows the correlation among all parameters that are estimated in the model. Fpar parameters refer to catchabilities, Fstates to the random walk in F, logN to the random walk in N, logObs to the observation variances, fRARdist to the auto-correlation in the surveys and trans_rho to the correlation in the F-random walks.

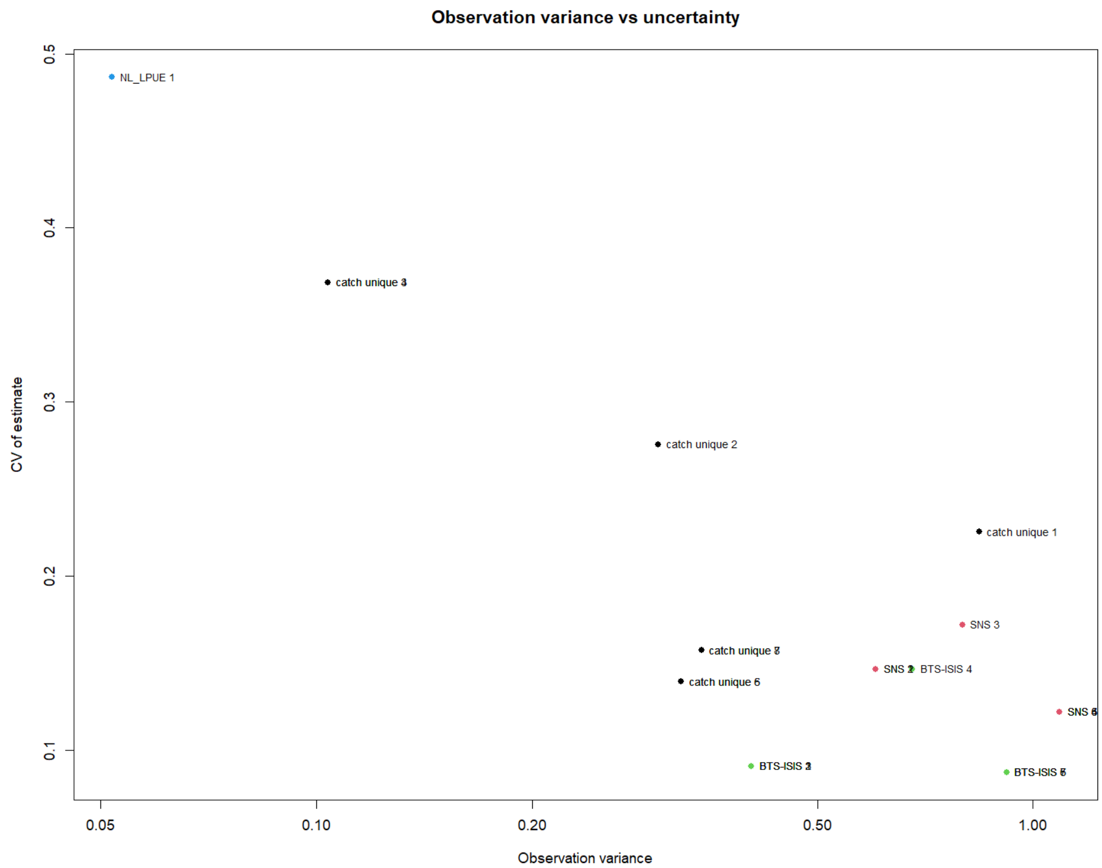


Figure 21.5.2. Plot showing the observation variance vs the CV of that estimate.

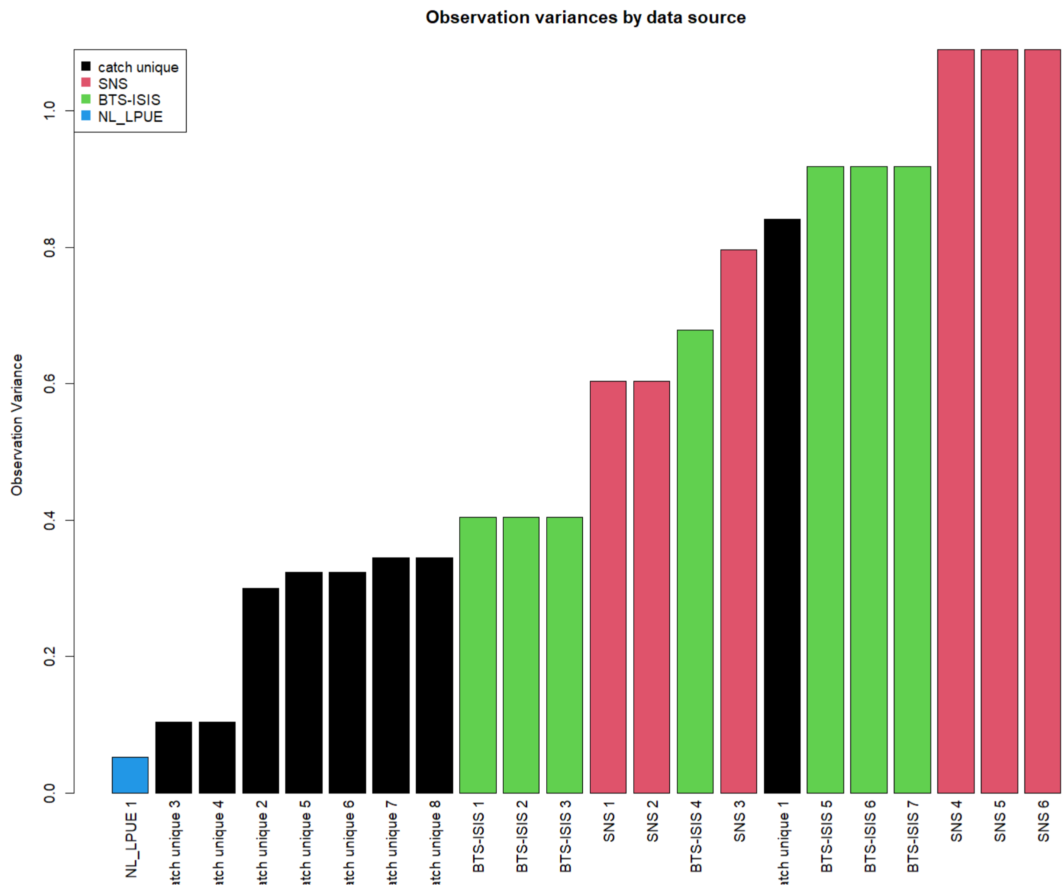


Figure 21.5.3. Estimated observation variances (scaling factor for each of the surveys), ordered from the best to the worst survey fit and has colour coding to show which bars belong to one dataset.

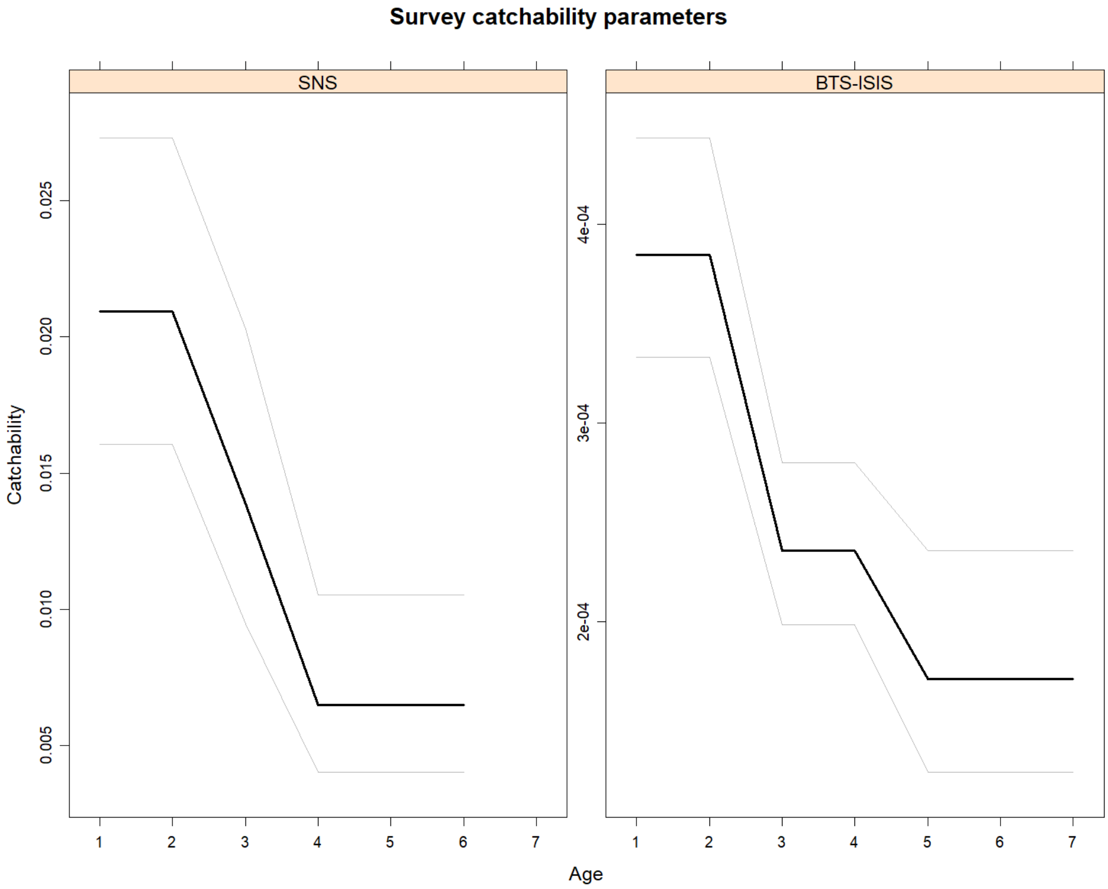


Figure 21.5.4. Catchabilities of the surveys for all surveys with more than 1 age-group.

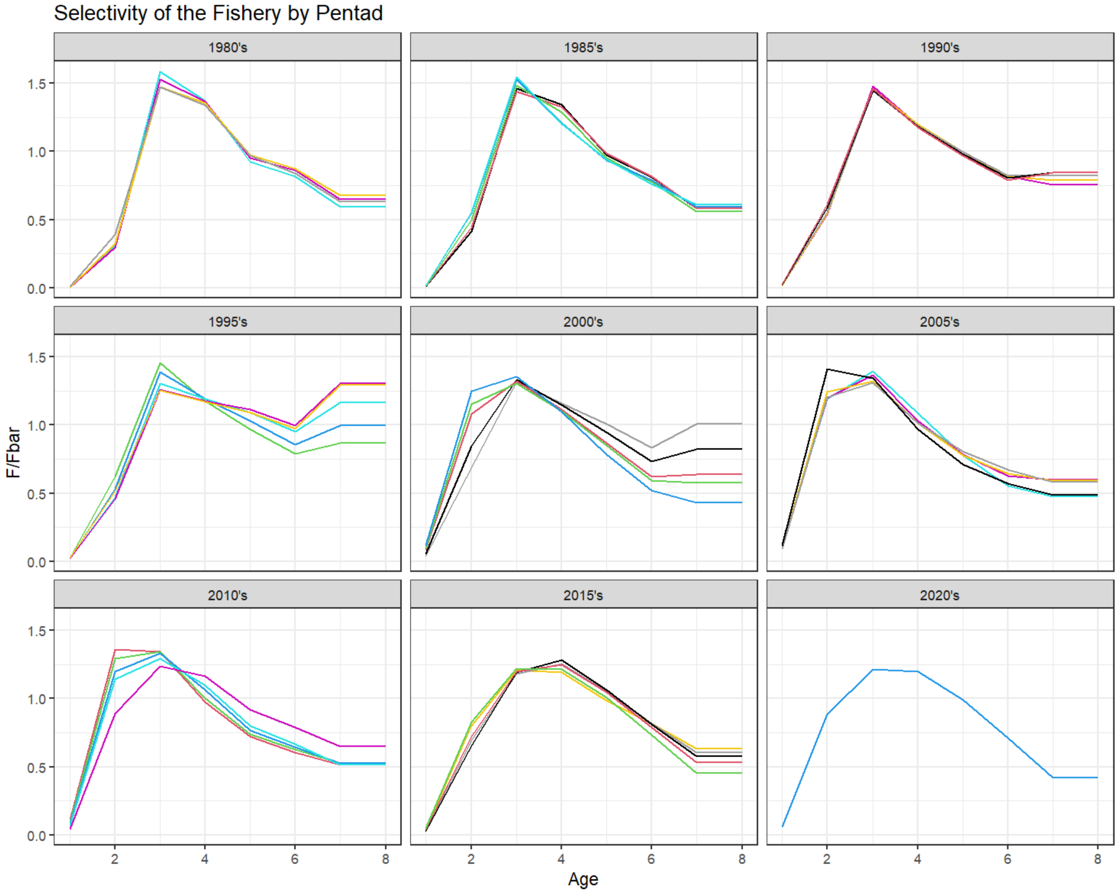


Figure 21.5.5. Estimated selectivity from 1981 to 2020, grouped by a 5-year period. Note the 1980s are 1981 up to 1984, 2015s is 2015 up to 2019. Values represent actual F-at-age.

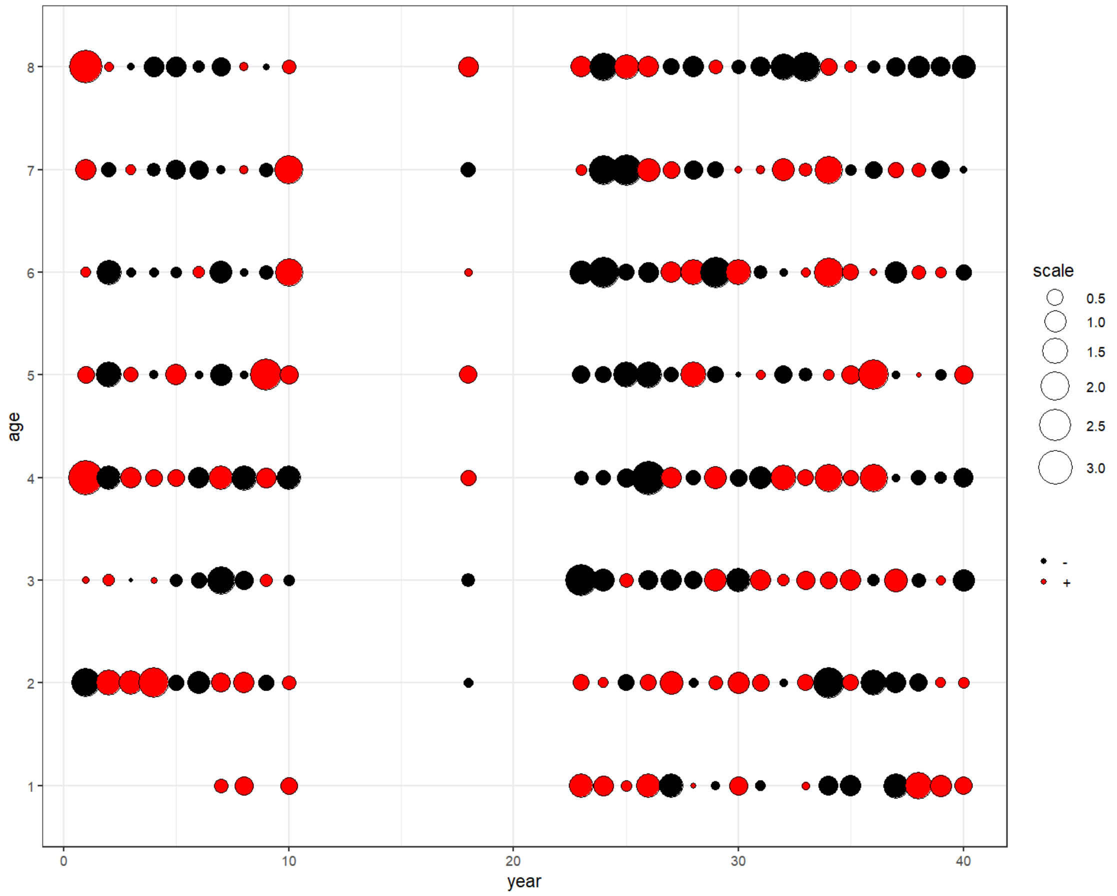


Figure 21.5.6. Residual bubble plot of landings

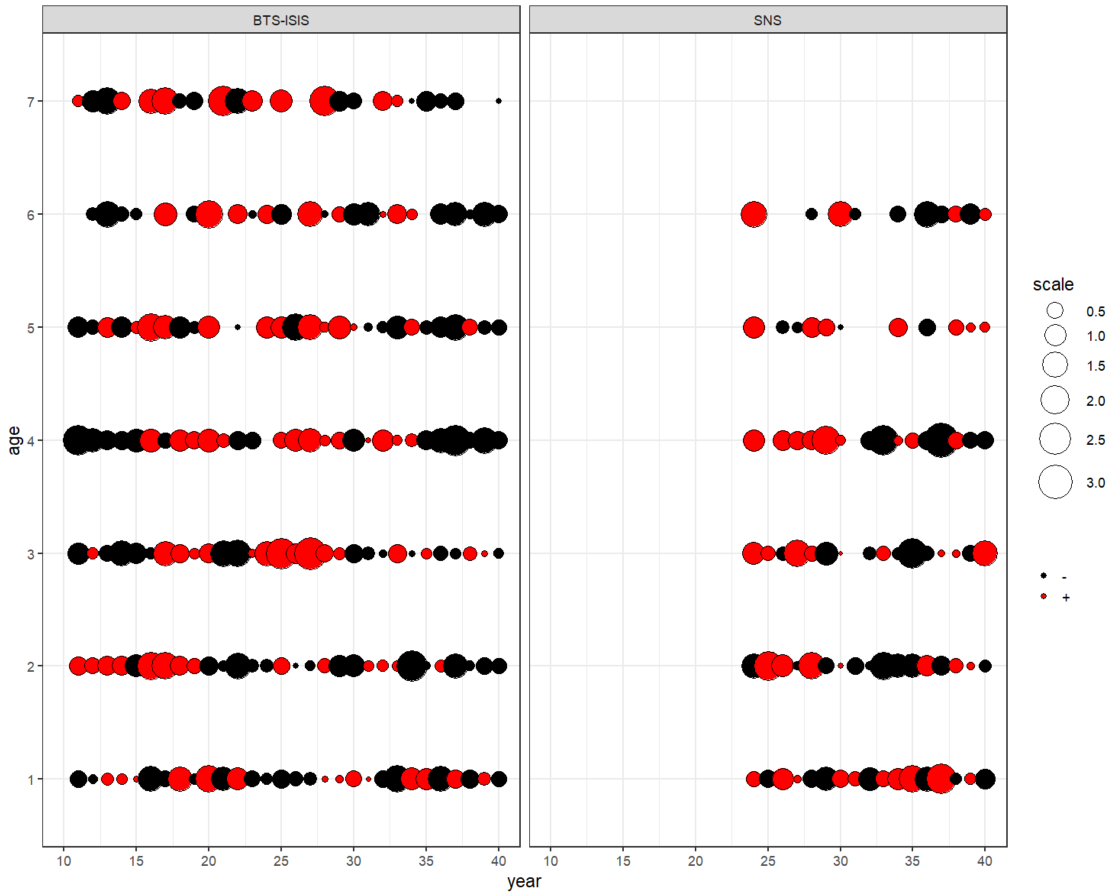


Figure 21.5.7. Residual bubble plot of SNS and BTS-ISIS survey.

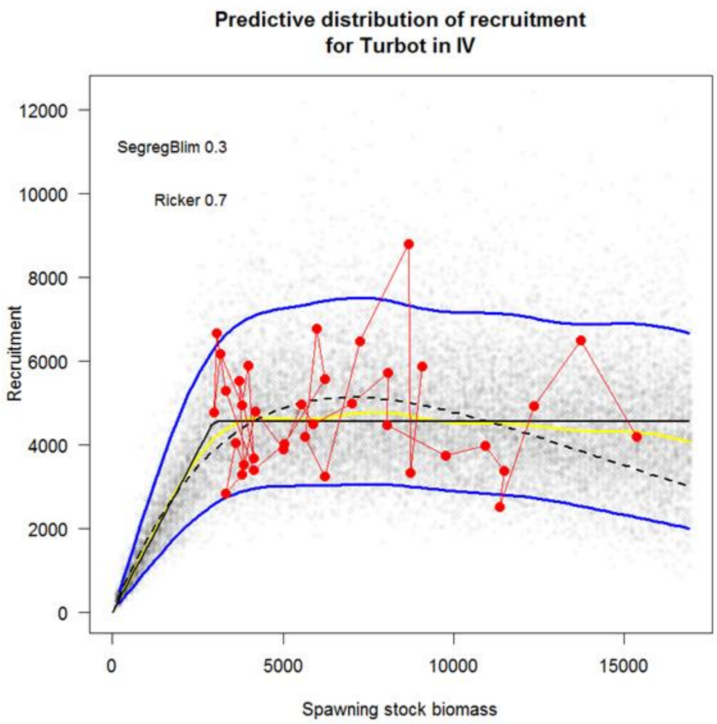


Figure 21.6.1. Stock recruitment pairs over time.

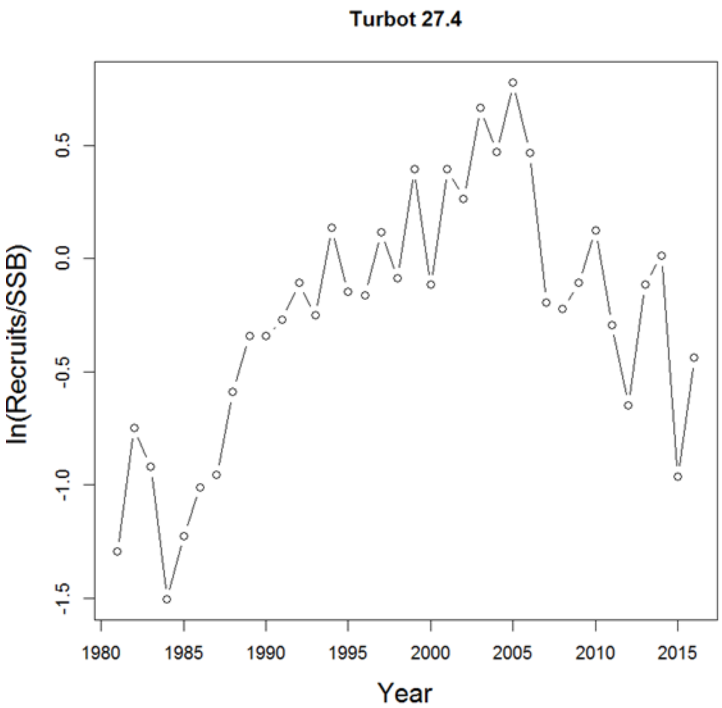


Figure 21.6.2 Productivity over time

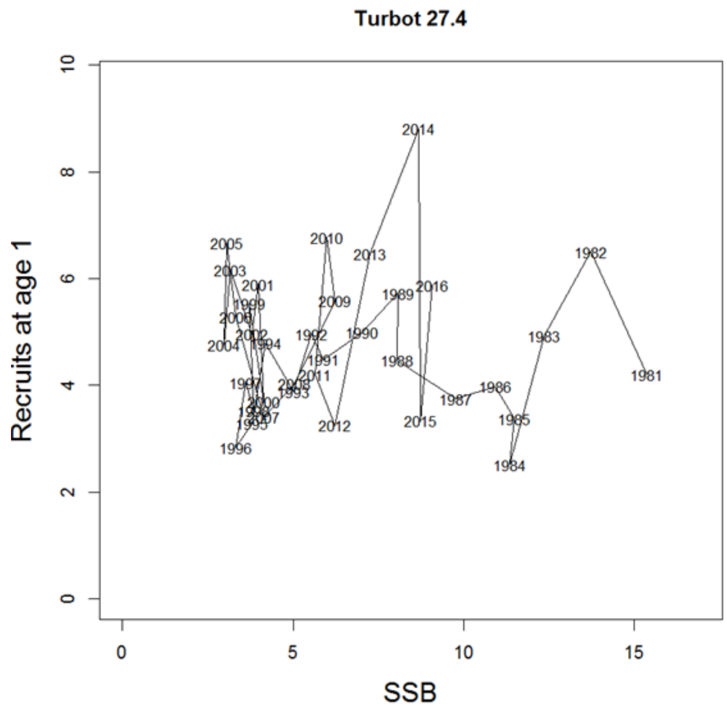


Figure 21.6.3. Stock recruitment pairs over time

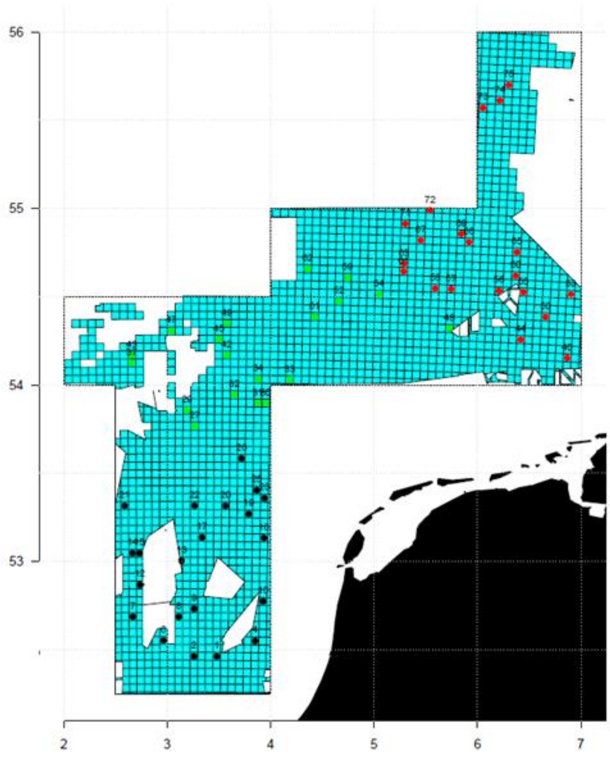


Figure 21.8.1. Map showing the area survey design to be monitored during the new Dutch industry-based survey. The squares are 5 x 5 km zones. Map showing the 75 randomly selected monitored stations during the 2020 survey.

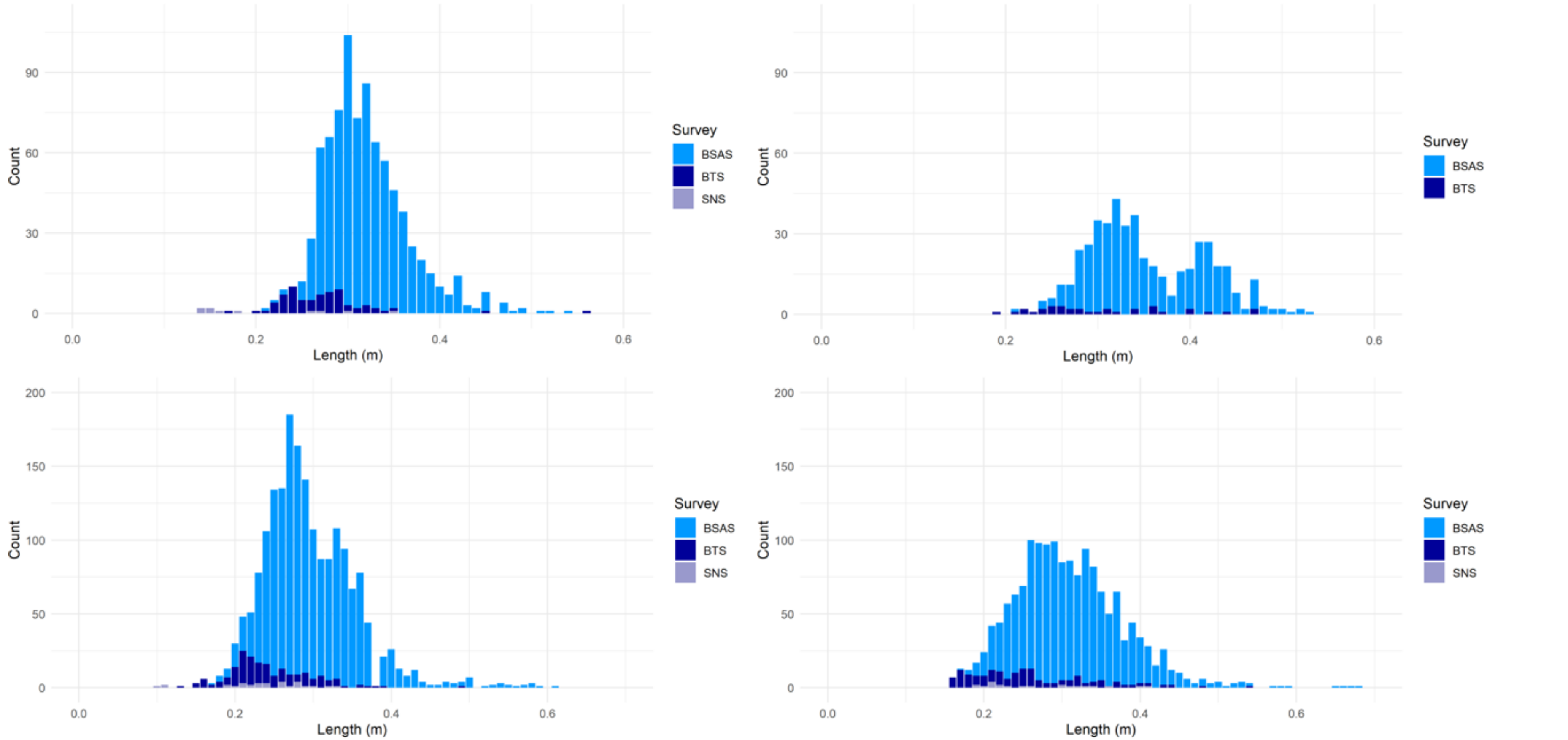


Figure 21.8.2 Length composition (1cm-classes) of individuals of brill (top) and turbot (lower) sampled within the Dutch industry survey compared to the BTS and SNS in 2019 (left) and 2020 (right).

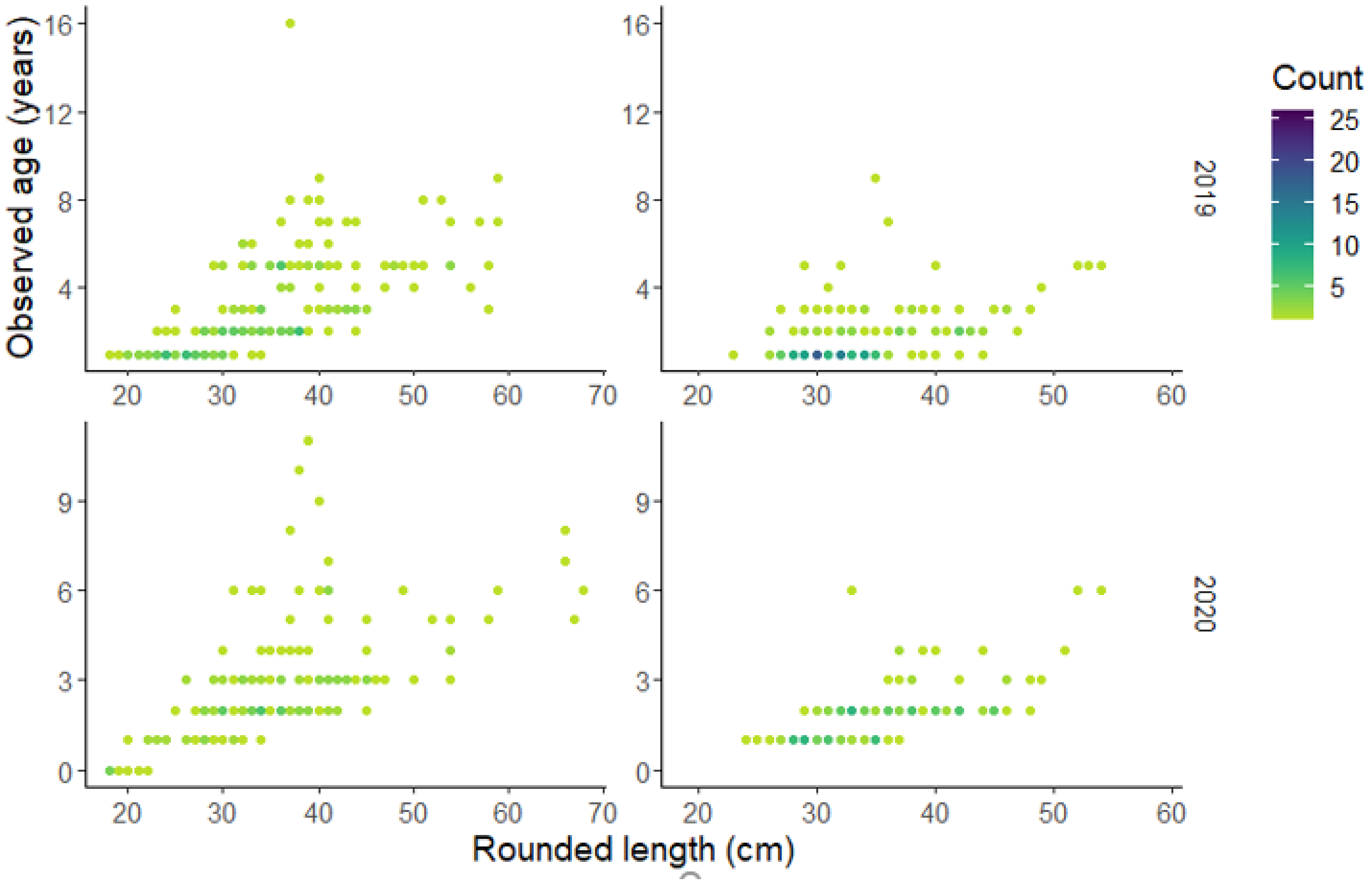


Figure 21.8.3 age-length distribution of turbot (left) and brill (right) sampled in the 2019 and 2020 industry survey.

22 Whiting (*Merlangius merlangus*) in Division 3.a (Skagerrak and Kattegat)

This section was last updated in 2020, as WGNSSK was not requested to provide updated advice on this stock in 2021.

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 last updated at ICES WKDEM (ICES, 2020).

22.1.3 Fisheries

Whiting landings in Division 3.a have declined in recent decades from over 20 000 tonnes in the 1980s to 179 tonnes in 2019. Denmark is catching most of the whiting in the area; Sweden and Norway follow with considerably less amounts. The Danish industrial fleet (main target species: sprat) is landing 40–80% of whiting in the area. Information was uploaded to InterCatch by Sweden, Denmark, Norway, Germany and the Netherlands. Discard estimates are available since 2002. A summary of available information on fisheries and information on derivation of discards is presented in the Stock Annex (last updated during the WKDEM 2020 benchmark (ICES, 2020).

22.2 Data available

22.2.1 Catch

The estimation of discards is done using InterCatch data. In 2019, ICES estimated catch was equal to 806 tonnes and are split to landings and discards (imported or raised) as follows:

Catch category	Imported or Raised	Catch (tonnes)	Percent
Landings	Imported	179	100%
Discards	Imported	596	95%
Discards	Raised	31	5%
Logbook registered discard	Imported	0	
BMS landing	Imported	0	

The raising of discards for unsampled strata was done assuming a discard rate equal to a weighted mean of reported discard rates, with weights equal to the total landings in tonnes. The raising is done by grouping all fleets by area. The industrial fleet, responsible for a substantial part of the landings (42% in 2019), does not have any discards. The landings and estimated discards are shown in Table 22.1.

22.2.2 Survey index

A combined survey index was derived using four bottom trawl surveys that operate in the area, namely the two international bottom trawl surveys (NS-IBTS (Q1 and Q3) and BITS (Q1 and Q4)) and two Danish national bottom trawl surveys targeting cod and sole both conducted in Q4.

The survey index calculation is described in the stock annex, here a short description is given. Predictions of a Tweedie Generalised Additive model on a fine grid are used to estimate the biomass index. The model is described by the following equation

$$\log(\mu i) = Gear(i) + f_1(lon_i, lat_i) + f_2(timeOfYear_i, lon_i, lat_i) + f_3(time_i, lon_i, lat_i) + f_4(depth_i) + U(i)_{ship:gear} + \log(HaulDur_i)$$

that includes a time-invariant spatial effect (f_1), a seasonal repeating pattern (f_2), a space-time interaction effect (f_3) that can capture smooth changes over longer time scales, a smooth function of depth (f_4), a fixed gear effect and random effects for the interaction between ship and gear. Finally, the model includes an offset term of the logarithm of haul duration that corresponds to the assumption that catch is proportional to haul duration.

The prediction of the biomass index in Q1 is used for giving advice and is shown in Figure 22.1.

22.3 Data analyses

22.3.1 Exploratory survey-based analysis

Previously, an exploratory SURBAR analysis has been performed and showed that internal consistency was virtually absent, impeding cohort analysis for the stock (ICES, 2016). The main conclusion from the SURBAR analysis was that the lack of internal consistency in the available survey indices (Figure 12.1.6 in ICES 2016) prevents an 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.

During the WKDEM 2020 benchmark (ICES, 2020) there was an attempt to do an assessment using the surplus production model in continuous time (SPiCT). The estimated uncertainty was very high, therefore none of the scenarios deemed adequate to be used to provide advice for the stock.

22.3.2 Advice

In the last benchmark of whiting in Division 3.a. in 2020 (ICES WKDEM, 2020) the stock was raised from category 5 to category 3 (ICES, 2018). The advice, starting from 2020, will be based on the trends of new combined survey index, which was first introduced in the benchmark, using the "2-over-3 rule". According to the rule, the advice for the next 2 years will be equal to the last given advice multiplied by the ratio of the average index in the last 2 years to the average index during the 3 years prior. An uncertainty cap should be used; this means that the next advice cannot be more than 20% increase or decrease compared to the last advice. Finally, a precautionary buffer of 20% should be applied if it was not applied in the last 2 years and there is no indication of the stock status.

For the first advice using the new approach in 2020, the average catch during the last 10 years ($C_{2010–2019}$ =1203 tonnes) is used instead of the last advice. Additionally, the precautionary buffer is applied in 2020 as it was last applied in 2017. The "2-over-3" ratio was equal to 0.97 (Figure 22.1). The advice is then equal to the average catch multiplied by the ratio multiplied by the precautionary buffer (0.8).

For whiting in Division 3.a, ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should be no more than 929 tonnes. This corresponds to projected landings corresponding to the advice equal to 242 tonnes.

22.3.3 Issues for future benchmarks

During the last benchmark of whiting in Division 3.a (ICES, 2020) there was an attempt to assess the stock using the surplus production model in continuous time (SPiCT) and several scenarios of data input were considered. The conclusion was that there was no model that could be used to provide advice. Future research is needed to improve the assessment model. More specifically, SPiCT cannot deal at the moment with biomass indices that combine multiple surveys from different quarters of the year and an extension to the model is needed to allow for such autocorrelated time series.

In the routine surveys, IBTS quarter 1 and quarter 3 in Division 3.a, biological data are collected for this species, in particular otoliths for aging and maturation information. These can be used in a future benchmark to understand growth and maturity patterns of the population in this area.

22.4 References

ICES. 2018. Advice basis. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, Book 1, Section 1.2. https://doi.org/10.17895/ices.pub.4503.

ICES. 2020. Benchmark Workshop for Demersal Species (WKDEM). ICES Scientific Reports. 2:31. 136 pp. http://doi.org/10.17895/ices.pub.5548

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 WGNSSK in 2007. The estimates of discards for 2002–2018 were updated in WKDEM2020 (ICES, 2020).

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	164	1347	1510	23	134	1	1669	2373
2003	104	641	745	20	72	2	839	1837
2004	252	954	1206	17	74	1	1298	2782
2005	110	853	962	13	73	0	1048	1625
2006	71	410	481	11	86	0	578	1497
2007	57	275	332	14	82	1	429	1524
2008	54	286	340	14	52	0	407	795
2009	73	172	245	10	34	0	289	778
2010	49	158	207	10	30	1	248	803

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
2011	40	44	85	8	20	0	114	937
2012	30	7	37	16	10	1	63	377
2013	29	130	159	8	15	1	183	687
2014	49	346	395	5	37	2	439	649
2015	75	570	645	6	56	5	712	820
2016	129	334	463	13	62	5	543	1307
2017	189	193	382	8	33	7	431	1185
2018	175	156	332	5	34	2	372	1357
2019	78	75	153	5	20	1	179	627

[1] Values from 1992 updated by WGNSSK (2007), WGNSSK (2011).

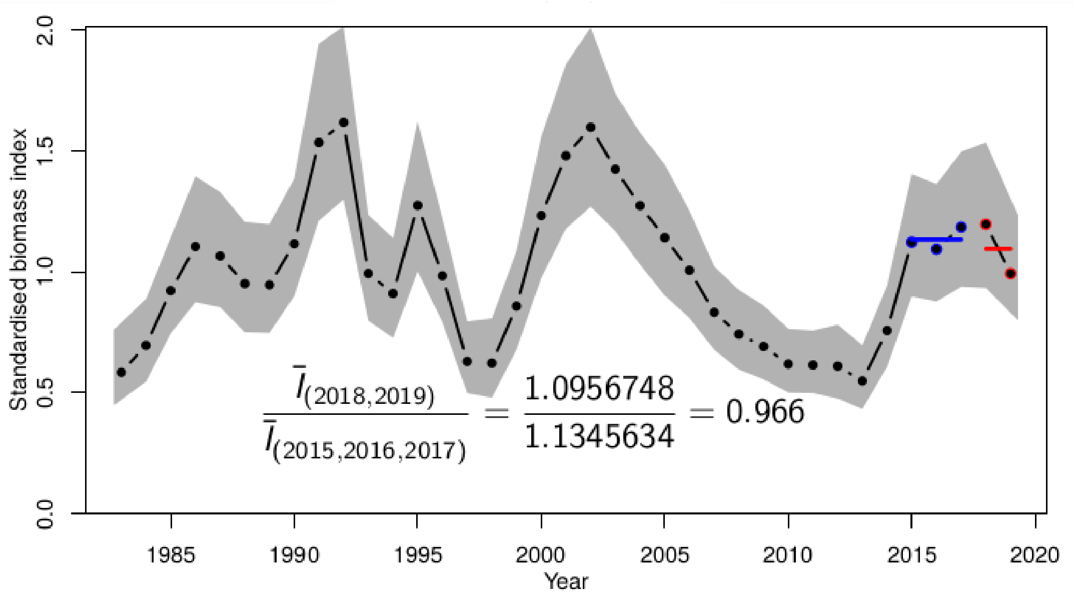


Figure 22.1. Whiting in Division 3.a (Skagerrak and Kattegat): Combined biomass index (Q1) using survey data from the two international bottom trawl surveys and two Danish national surveys. The average of the last two years (red line) and the average of the three years before that (blue line) are used to calculate the “2-over-3” ratio shown inside the figure.

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. An interbenchmark was carried out in 2021 to assess the impact of new natural mortality estimates on the assessment, and the reference points were updated as a result (ICES, 2021a). The assessment in 2021 follows the stock annex and the decisions made during the benchmark in 2018 and the interbenchmark in 2021. However, since 2020, survey indices are recalculated using a new automated substitution procedure to fill ALK key in areas with low sample size. This new automated method is seen as an improvement to data quality and transparency of the procedure. For the 2021 assessment of whiting in 27.4 and 7.d, the historical time series of survey indices obtained with the new automated substitution procedure are used.

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 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 discard and industrial bycatch rates do not change from the average of the last 3 years (2015–2017), this implies landings 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 2020 should be no more than 22 082 tonnes. If discard and industrial bycatch rates do not change from the average of the last 3 years (2016–2018), this implies landings of no more than 12 737 tonnes and human consumption catch of no more than 19 354 tonnes.

ICES advice for 2021

In April 2020, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 26 304 tonnes. If discard and industrial bycatch rates do not change from the average of the last 3 years (2017–2019), this implies landings of no more than 14 487 tonnes and human consumption catch of no more than 24 071 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 in Subarea 4 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 landings 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 in Subarea 4 for 2020 was set to 17 158 tonnes and for 2021 was 21 306 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, 10 863 in 2020, for 2021 no TAC value available). 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 2020, 81% of the total landings originated from Subarea 4.

The minimum landing size for whiting in Subarea 4 and Division 7.d is 27 cm. The minimum mesh size for targeting whiting in Subarea 4 is 120 mm and in Division 7.d is 80 mm.

Whiting are a by-catch in some *Nephrops* fisheries that use a mesh size of 80 mm, 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. In 2016–2018, some very minor catches in the Norwegian fishery have been reported as BMS may be considered industrial bycatch but were 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. Since 2017 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 2020 data, no logbook registered discards are submitted. Minor whiting landings have been reported as BMS landings into InterCatch since 2016. In 2020 data, these mostly originated from Scotland OTB_DEF métiers (36 t). Generally, BMS was treated as discards as in previous years.

2019 Swedish landing data in area 4 were missing from the submission to InterCatch in 2020 and the Swedish catches (6 tonnes) were added manually in the assessment. In 2021, Swedish catch data for 2019 was submitted to InterCatch. InterCatch data was therefore raised for both 2019 and 2020. In 2020 data, 47% 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 2020 are illustrated in Figure 23.1. Discards were raised from discard ratios from Subarea 4 and Division 7.d combined. Normally, the data are stratified by gear type (TR1 and TR2) and quarter to raise discards for fleets without imported discards, while for other gear types discards are raised using discard rates from all available fleets. However, unlike previous years, no stratification by quarter was done in 2021 due to poorer sampling caused by COVID-19 during 2020, and raising was done annually instead. The raised discards amounted to 60% 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 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 2020 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 50% of the overall landings, and are available for 9 métiers (Table 23.3.c).

However, although the unsampled fleets provide considerable landings overall (50%), most métiers provide 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% 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 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, 40% were imported into InterCatch. 17% of the discards were sampled for age distributions (Table 23.3c). The 12 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, discards and industrial bycatch) are given in tables 23.4–23.11. In 2020, discards represented 35% of the total catches (Table 23.12). 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 discards were based on samples provided by France, UK (England, Scotland) and Denmark. Normally, age compositions are applied to landings with splitting of fleets on the basis of quarter (1,2 vs 3,4) and gear type (TR1 and TR2), while discards age compositions are allocated using all discard samples with splitting of fleets on the basis of gear type (TR1) and quarter (1,2 vs 3,4). However, unlike previous years, no stratification by quarter was done in 2021 due to poorer sampling caused by COVID-19 during 2020, and raising was done annually instead. 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 (landings and discards) 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 discards.

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, discards, 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 discards 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, discards 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 (ICES 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 2020 update key run from of the SMS multispecies model (ICES WGSAM, 2021b) (Table 23.15 and Figure 23.8). At the 2021 interbenchmark (ICES, 2021a), the most recent estimates of natural mortality values were smoothed. The new natural mortality values for 2020 are assumed to be the same as in 2019 (Figure 23.8). The same natural mortality was assumed for individuals 8 years and older.

23.5.5 Research vessel data

Up until 2019, the historical time series of survey indices has been calculated using a manual substitution procedure. The data obtained with this manual procedure is only available until Q3 2019. Since 2020, survey indices are recalculated using a new automated substitution procedure to fill ALK key in areas with low sample size. This new automated method is seen as an improvement to data quality and transparency of the procedure. A comparison of the historical survey indices obtained with the old manual method and the historical survey indices recalculated with the new automated method show that the new method revealed that assessment outputs obtained with the new methods result in lower Mohn's rho values for SSB, F and recruitment. The new data series therefore appear to lead to more consistent assessment results (see Annex 9). As a result, for the 2021 assessment on whiting in 27.4 and 7d it was decided to use the historical time series of survey indices obtained with the new automated substitution procedure.

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 1983–2021 and 1991–2020, 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.

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) 2017–2021, are presented. Figure 23.10, the third quarter is represented (Q3) for ages 0–3+ for the years 2017–2020 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 low in 2017 and 2018, but is higher in 2019 and 2020.

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.

In April 2021, an interbenchmark was carried out to assess the impact of new natural mortality estimates from WGSAM (ICES, 2021b) on the assessment, and the reference points previously defined during the 2018 benchmark were updated as a result (ICES, 2021a).

23.7 Data analyses

23.7.1 Exploratory survey-based analyses

In Figure 23.11, time-series of survey log CPUE at age (ages 1–5+) 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) in 2020 is estimated to have been much higher than in recent years and on par with historical high values, while SSB and TSB, although at an intermediate level compared to the historical time series, are increasing. 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 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, suggesting a fishing mortality likely to be lower than in the past for the cohorts 2000 to 2010. 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. However, for the last 3 cohorts (2011, 2012 and 2013), a strong and continuous increase in the gradient can be observed which suggests an increase in fishing mortality in recent years.

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 (stockassessment.org) fitted to the combined landings, discards 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_2021”.

The settings as given by the configuration file decided during the benchmark are provided below (further details can be found in the Stock Annex).

```
Catch-at-age data                                              1978-2019      ages 0-8+
Survey: IBTS Q1                                                1983-2020      ages 1-5
Survey: IBTS Q3                                                1991-2019      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, although in the final year the residuals (for log(N)) are quite large with some tendency for a year effect (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 visible in 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 3 years of recent data, but when removing 4 years two of the peels ended outside the confidence intervals for SSB and recruitment. Despite some retrospective bias in recruitment and SSB, there is very low retrospective bias in catches and fishing mortality. Mohn's rho measures the retrospective bias, values are given in Table 23.21 and confirm the relatively higher retrospective bias in recruitment and SSB, although Mohn's Rho values are below the acceptable threshold of 0.2 set by WKFORBIAS (ICES, 2020a). Retrospective peels are generally covered by the confidence interval, apart from two peels for both SSB and recruitment.

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 2020 of 0.185. 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, although the recent increase in SSB indicate that SSB is trending towards this level, with the 2020 SSB estimate being on par with what was observed in the mid-1990s. Recruitment is fluctuating around a recent (post 2001) lower average but is showing an increase in recent years. The levels of high recruitment which occurred between 1998 and 2001 have not been reached since. Recruitment was relatively low in 2017 and 2018, but is estimated to be relatively higher in 2019 and slightly higher still in 2020. In the most recent year, landings, discards and industrial bycatch have also all remained at or around a recent average. The stock–recruitment plot in Figure 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.

At WGNSSK 2020, it was recommended to use new survey indices provided by DATRAS for the whiting assessment in 2020 and onwards (see Section 23.5.5). At the benchmark 2018, the reference points B_{lim} = 119 970 and F_{MSY} = 0.172 were set for North Sea whiting and are suggested to remain unchanged (ICES, 2018a). The new indices resulted in minor changes of assessment results, with the level of estimated SSB and F generally remaining the same over the time series. Retrospectives and Mohn's rho indicated that using the complete new survey indices leads to more consistent assessments with lower retro than using a survey series combining old (up to 2019) and new method (Q1 2020) (Annex 9, see ICES (2020b)).

The use of both new and old survey indices would lead to higher but similar F_{MSY} reference points if recalculated using EqSim this year. Even though new survey indices would have led to a slight increase in the reference points even when used with benchmark data, it was not recommended to change the reference points due to the issue of precautionarity. Previous management strategy evaluations indicated that the current F_{MSY} may not be precautionary (WKNSMSE 2018). A further increase in the reference point F_{MSY} by recalculating F_{MSY} with EqSim was therefore not recommended at the time (Annex 9 for more details, see ICES, 2020b).

In April 2021, an interbenchmark was carried out to include new natural mortality estimates from WGSAM (ICES, 2021b). Eqsim was run to determine new reference points, and the reference points previously defined during the 2018 benchmark were updated as a result (ICES, 2021a). The new F_{MSY} value is 0.371 and the new B_{lim} value is 103 560. 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 2020 were used as input population numbers for ages 1 and older in 2021. Recruitment assumptions are detailed in Table 23.24. In the intermediate and following two years the geometric mean of recruitment from 2002–2020 is used.

The exploitation pattern is chosen as the mean exploitation pattern over the most recent three years 2018–2020. The mean exploitation pattern was scaled to the mean $F_{2\text{–}6}$ in 2020 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 2018–2020. The F at age used in the forecast is compared with the F at age estimates for 2018–2020 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 2018–2020 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_{2021} equal to mean F_{2020} (using the average selectivity over the last 3 historical years) results in human consumption catches in the intermediate year 2021 of 34 753 tonnes from a total catch of 37 295 tonnes, giving an SSB in 2021 of 225 375 tonnes (Table 23.26).

Carrying the same fishing mortality forward into 2022 (the status quo F option, F_{sq}) would result in human consumption catches of 41 681 tonnes out of total catches of 44 890 tonnes, and would result in an SSB of 269 861 tonnes in 2023 (a 2.96% increase in SSB relative to 2022).

Since SSB in 2022 is predicted to be higher than MSY $B_{trigger}$, following the MSY approach allows for applying F_{MSY} leading to an F_{target} of 0.371.

Applying the F_{MSY} of 0.371 in 2022 would generate human consumption catches of 85 460 tonnes out of total catches of 88 426 tonnes, and result in an SSB of 238 600 tonnes in 2023 (a 9% decrease in SSB relative to 2022). In 2023, SSB would be above B_{lim} and MSY $B_{trigger}$. F of 0.371 would cause the TAC (relative to the TAC in 2021) to be changed by +224.9%.

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, WKARWHG2, took place in late 2016, to improve consistency in preparation techniques and readings (ICES, 2016b). 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 Standard graphs. Catch data and natural mortalities were updated. Estimates of fishing mortality remained at a similar level as before. Retrospective bias compared to the 2020 assessment is high, owing to the update of the natural mortality estimates employed.

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} (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 2002, fishing mortality has been below F_{MSY} = 0.371. While landings have been relatively stable and even decreased slightly in recent years, discards and industrial bycatch increased in recent years slightly. The development of whiting biomass depends on the size of recruitment. Recruitment is varying around a recent mean, but that mean is lower relative to recruitment in the late 1990s. Recruitment in 2014–2016 was above the average of recent years, however recruitment in 2017 2018 was lower. Recruitment in 2019 and 2020 is estimated to be higher still and on par with early 2000s levels. Stock biomass estimated for 2021 increased and is now well above 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 13 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 35 123 tonnes in 2020, 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 2015–2019 were low. In 2020, 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 2021 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 in 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. An inter-benchmark was performed in 2021 to include new mortality estimates from WGSAM (ICES, 2021b), and reference points were updated accordingly (ICES, 2021a).

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.

Survey indices: There has been a new French data upload for the historical time series. The use of a delta GAM method to calculate indices should be explored.

SAM assessment: the use of unsmoothed maturity and natural mortality estimates as input for the assessment model, in order to use the new SAM method to estimate missing historical values, should be explored.

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.

23.17 References

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ICES. 2021b. Working Group on Multispecies Assessment Methods (WGSAM; outputs from 2020 meeting). ICES Scientific Reports. 3:10. 231 pp. https://doi.org/10.17895/ices.pub.7695

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.discards.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.discards.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	2020
belgium.4	45	33	46	70	65	71	71	141	211
denmark.4	131	124	160	2375	4727	2804	2026	2357	3606
faroe.4	0	0	0	0	8	1	0	80	25
france.4	1925	942	1884	1131	1232	952	918	890	677
germany.4	25	44	31	73	111	82	99	81	277
netherlands.4	471	495	464	581	644	791	684	853	780
norway.4	94	560	918	1088	1150	993	1025	1102	1674
sweden.4	4	1	2	0	6	11	8	18	28
uk.4	9893	11162	10290	10015	9412	9263	10689	11897	12177
england.wales.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
scotland.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.4	12588	13361	13795	15333	17355	14968	15520	17419	19475
unallocated.landings.4	-356	-456	-52	2101	5113	3140	2942	1885	3694
ices.landings.4	12944	13817	13847	13232	12242	11828	12578	15534	15781
ices.discards.4	9307	4608	7016	12265	10413	9799	8026	7581	10034
ices.ibc.4	1117	1654	1623	2097	4551	2635	1658	1864	3132
ices.catch.4	23368	20079	22486	27593	27206	24262	22263	24979	28947
tac.4.2.a	17056	18932	16092	13678	13678	16003	22057	17191	17158

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.discards.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.discards.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	2020
belgium.7.d	66	95	90	121	146	128	138	144	45
france.7.d	3093	3076	2126	3102	2771	2378	2720	2095	1309
netherlands.7.d	437	650	663	565	556	593	484	603	330
uk.7.d	261	472	345	379	259	358	283	259	287
england.wales.7.d	NA	NA	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.7.d	3857	4293	3224	4167	3732	3457	3625	3101	1971
unalloc.landings.7.d	-556	-15	99	190	32	103	143	126	114
ices.landings.7.d	4413	4308	3125	3977	3700	3354	3482	2975	1857
ices.discards.7.d	2389	2186	2709	4627	2313	1550	2562	2499	4195
ices.catch.7.d	6802	6494	5834	8604	6013	4904	6044	5474	6052
tac.7b.k	19053	24500	20668	17742	22778	27500	22213	19184	10863

Table 23.3.a. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure. SOP.

Catch Category	SOP
BMS landing	1.065
Discards	1.318
Landings (incl. IBC)	1.024
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 (uploads in weight)

Catch Category	Raised or Imported	CATON tonnes	Percent
BMS landing	Imported_Data	35.92	100
Discards	Raised_Discards	6472	60
Discards	Imported_Data	4297	40
Landings	Imported_Data	21177	100
Logbook Registered Discard	Imported_Data	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 (uploads in weight).

Catch Category	Raised or Imported	Sampled or estimated distribution	CATON tonnes	Percent
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	NA
Landings	Imported_Data	Estimated_Distribution	10572	50
Landings	Imported_Data	Sampled_Distribution	10605	50
Discards	Raised_Discards	Estimated_Distribution	6472	60
Discards	Imported_Data	Estimated_Distribution	2481	23
Discards	Imported_Data	Sampled_Distribution	1817	17
BMS landing	Imported_Data	Sampled_Distribution	32.82	91
BMS landing	Imported_Data	Estimated_Distribution	3.101	9

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 (uploads in weight).

Catch Category	Raised or Imported	Sampled or Estimated distribution	Area	CATON tonnes	Percent
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.7.d	0	NA
Landings	Imported_Data	Estimated_Distribution	27.7.d	1143	59
Landings	Imported_Data	Sampled_Distribution	27.7.d	798	41
Discards	Raised_Discards	Estimated_Distribution	27.7.d	2689	87
Discards	Imported_Data	Sampled_Distribution	27.7.d	275.3	9
Discards	Imported_Data	Estimated_Distribution	27.7.d	125.6	4
BMS landing	Imported_Data	Estimated_Distribution	27.7.d	0.052	100
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4.c	0	NA
Landings	Imported_Data	Estimated_Distribution	27.4.c	731.7	100
Discards	Raised_Discards	Estimated_Distribution	27.4.c	1007	99
Discards	Imported_Data	Estimated_Distribution	27.4.c	14.88	1
BMS landing	Imported_Data	Estimated_Distribution	27.4.c	0	NA
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4.b	0	NA
Landings	Imported_Data	Estimated_Distribution	27.4.b	925.7	100
Discards	Raised_Discards	Estimated_Distribution	27.4.b	370.2	98
Discards	Imported_Data	Estimated_Distribution	27.4.b	7.441	2
BMS landing	Imported_Data	Estimated_Distribution	27.4.b	0	NA
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4.a	0	NA
Landings	Imported_Data	Estimated_Distribution	27.4.a	1007	100
Discards	Raised_Discards	Estimated_Distribution	27.4.a	175.9	100
BMS landing	Imported_Data	Estimated_Distribution	27.4.a	0	NA
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4	0	NA
Landings	Imported_Data	Sampled_Distribution	27.4	9807	59
Landings	Imported_Data	Estimated_Distribution	27.4	6765	41
Discards	Imported_Data	Estimated_Distribution	27.4	2333	38

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
2001	18012	52567	83085	52076	20800	9256	4826	2233	896	246	124	2	0	0	0	0	1268

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
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	15656	17302	41274	26023	17040	6786	1437	1013	803	36	163	38	0	0	0	0	1040
2019	4515	29380	24143	39670	17364	7152	3087	1063	554	274	76	0	0	0	0	0	904
2020	27979	39439	30168	30241	20146	6623	2312	636	531	35	1	1	0	0	0	0	568

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	1264	12061	13819	11797	5389	1159	798	729	33	150	35	0	0	0	0	947
2019	0	2387	6217	21428	13320	6133	2529	963	500	227	69	0	0	0	0	0	796
2020	509	3918	9055	13072	13103	4989	1898	449	447	26	1	1	0	0	0	0	475

Table 23.6. Whiting in Subarea 4 and Division 7.d: Discards numbers at age (thousands), as estimated by ICES. Age 8 is a plus–group. Data used to calculate the discard 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	14985	15331	27274	10665	4071	914	172	145	13	1	0	0	0	0	0	0	14
2019	4130	25433	16810	15830	2913	453	342	18	21	34	0	0	0	0	0	0	55
2020	26180	33498	18836	14421	4744	805	107	110	11	5	0	0	0	0	0	0	16

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	671	707	1939	1539	1172	483	106	70	61	2	13	3	0	0	0	0	79
2019	385	1560	1116	2411	1131	565	216	82	34	12	7	0	0	0	0	0	53
2020	1290	2023	2277	2748	2299	830	306	77	72	4	0	0	0	0	0	0	76

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 1978–2020 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	0.029	0.108	0.197	0.275	0.373	0.407	0.514	0.458	0.485	0.598	0.448	0.583	0.000	0.000	0.000	0.000	0.487
2019	0.021	0.106	0.204	0.279	0.354	0.42	0.436	0.44	0.368	0.355	0.577	0.736	0	0	0	0	0.382
2020	0.101	0.105	0.242	0.289	0.377	0.429	0.484	0.553	0.411	0.495	0.665	0.564	0	0	0	0	0.417

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	0.035	0.171	0.239	0.318	0.416	0.427	0.529	0.480	0.488	0.607	0.448	0.583	0.000	0.000	0.000	0.000	0.489
2019	0.033	0.194	0.269	0.324	0.375	0.429	0.458	0.438	0.373	0.351	0.577	0.736	0	0	0	0	0.384
2020	0.141	0.214	0.332	0.36	0.419	0.447	0.495	0.609	0.415	0.539	0.665	0.564	0	0	0	0	0.423

Table 23.10. Whiting in Subarea 4 and Division 7.d: Discards 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	0.029	0.103	0.178	0.219	0.247	0.292	0.411	0.340	0.316	0.296	0.311	0.369	0.000	0.000	0.000	0.000	0.315
2019	0.021	0.098	0.18	0.219	0.259	0.297	0.27	0.544	0.251	0.384	0	0	0	0	0	0	0.333
2020	0.1	0.092	0.198	0.224	0.259	0.319	0.295	0.325	0.235	0.266	0	0	0	0	0	0	0.245

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	0.029	0.108	0.196	0.275	0.373	0.407	0.514	0.458	0.485	0.594	0.448	0.583	0.000	0.000	0.000	0.000	0.485
2019	0.021	0.107	0.204	0.279	0.354	0.42	0.435	0.44	0.369	0.355	0.577	0.736	0	0	0	0	0.393
2020	0.101	0.105	0.242	0.289	0.377	0.429	0.484	0.553	0.41	0.494	0.665	0.564	0	0	0	0	0.414

Table 23.12. Whiting in Subarea 4 and Division 7.d: Catch component as estimated by ICES in tonnes, model input. Discards include BMS.

Year	Catch	Landings	Discards	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	Landings	Discards	IBC
2016	33396	16118	12726	4551
2017	29344	15361	11348	2635
2018	28407	16160	10588	1658
2019	30523	18579	10080	1864
2020	35123	17762	14229	3132

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	0.092	0.161	0.254	0.389	0.410	0.481	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761
1979	0.003	0.033	0.085	0.178	0.238	0.374	0.435	0.508	0.684	0.684	0.684	0.684	0.684	0.684	0.684	0.684	0.684
1980	0.004	0.025	0.089	0.174	0.259	0.306	0.437	0.474	0.672	0.672	0.672	0.672	0.672	0.672	0.672	0.672	0.672
1981	0.004	0.028	0.085	0.167	0.254	0.345	0.393	0.459	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
1982	0.010	0.020	0.093	0.174	0.248	0.342	0.457	0.521	0.864	0.864	0.864	0.864	0.864	0.864	0.864	0.864	0.864
1983	0.005	0.036	0.097	0.188	0.257	0.349	0.408	0.467	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631
1984	0.007	0.030	0.096	0.187	0.266	0.346	0.373	0.477	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
1985	0.005	0.031	0.098	0.196	0.262	0.365	0.416	0.510	0.516	0.516	0.516	0.516	0.516	0.516	0.516	0.516	0.516
1986	0.005	0.035	0.093	0.176	0.251	0.344	0.455	0.483	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736
1987	0.004	0.026	0.075	0.170	0.235	0.341	0.364	0.560	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686
1988	0.004	0.018	0.074	0.154	0.238	0.315	0.406	0.523	0.815	0.815	0.815	0.815	0.815	0.815	0.815	0.815	0.815
1989	0.008	0.023	0.080	0.155	0.211	0.289	0.374	0.445	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464
1990	0.005	0.028	0.070	0.145	0.199	0.254	0.393	0.514	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698
1991	0.006	0.035	0.085	0.150	0.228	0.278	0.324	0.377	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
1992	0.004	0.028	0.094	0.177	0.219	0.301	0.331	0.323	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599
1993	0.004	0.024	0.088	0.172	0.250	0.298	0.331	0.413	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445
1994	0.004	0.028	0.085	0.176	0.259	0.347	0.360	0.433	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506
1995	0.003	0.030	0.091	0.177	0.269	0.349	0.411	0.448	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492
1996	0.006	0.031	0.085	0.162	0.239	0.353	0.389	0.445	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508
1997	0.009	0.032	0.090	0.167	0.233	0.304	0.367	0.399	0.495	0.495	0.495	0.495	0.495	0.495	0.495	0.495	0.495
1998	0.006	0.030	0.091	0.163	0.222	0.285	0.325	0.344	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434
1999	0.008	0.026	0.088	0.160	0.202	0.263	0.292	0.321	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343
2000	0.011	0.039	0.092	0.164	0.227	0.260	0.264	0.284	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
2001	0.008	0.034	0.098	0.168	0.223	0.243	0.285	0.293	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2002	0.003	0.023	0.079	0.150	0.216	0.275	0.335	0.354	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
2003	0.004	0.019	0.060	0.133	0.205	0.272	0.339	0.398	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432
2004	0.010	0.037	0.076	0.147	0.200	0.260	0.273	0.295	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
2005	0.011	0.042	0.101	0.165	0.198	0.256	0.292	0.308	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336
2006	0.031	0.044	0.091	0.159	0.216	0.262	0.345	0.356	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371
2007	0.020	0.033	0.105	0.177	0.257	0.314	0.296	0.319	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376
2008	0.009	0.035	0.111	0.194	0.249	0.365	0.389	0.327	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416
2009	0.014	0.030	0.108	0.197	0.292	0.340	0.357	0.355	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2010	0.016	0.037	0.119	0.257	0.321	0.415	0.340	0.474	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407
2011	0.016	0.038	0.109	0.205	0.295	0.377	0.406	0.376	0.398	0.398	0.398	0.398	0.398	0.398	0.398	0.398	0.398
2012	0.013	0.035	0.099	0.214	0.352	0.374	0.412	0.442	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464
2013	0.009	0.037	0.113	0.188	0.308	0.425	0.475	0.480	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454
2014	0.018	0.046	0.115	0.203	0.261	0.402	0.445	0.484	0.463	0.463	0.463	0.463	0.463	0.463	0.463	0.463	0.463
2015	0.015	0.042	0.111	0.212	0.291	0.351	0.449	0.479	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445
2016	0.010	0.040	0.107	0.200	0.315	0.354	0.397	0.504	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539
2017	0.009	0.026	0.108	0.220	0.323	0.396	0.466	0.459	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517
2018	0.010	0.036	0.100	0.189	0.295	0.370	0.492	0.473	0.572	0.572	0.572	0.572	0.572	0.572	0.572	0.572	0.572
2019	0.007	0.036	0.104	0.192	0.280	0.382	0.417	0.455	0.449	0.449	0.449	0.449	0.449	0.449	0.449	0.449	0.449
2020	0.034	0.035	0.123	0.199	0.298	0.390	0.463	0.571	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490

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	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1980	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1981	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1982	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1983	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1984	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1985	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1986	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1991	0.000	0.186	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.187	0.829	0.992	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.188	0.820	0.987	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.190	0.810	0.982	0.998	1.000	1.000	1.000	1.000
1995	0.000	0.194	0.800	0.975	0.996	0.999	1.000	1.000	1.000
1996	0.000	0.199	0.788	0.968	0.994	0.998	1.000	1.000	1.000
1997	0.000	0.206	0.776	0.960	0.991	0.998	1.000	1.000	1.000
1998	0.000	0.216	0.764	0.951	0.988	0.997	1.000	1.000	1.000
1999	0.000	0.229	0.750	0.942	0.985	0.997	1.000	1.000	1.000
2000	0.000	0.245	0.738	0.935	0.983	0.996	1.000	1.000	1.000
2001	0.000	0.262	0.730	0.930	0.982	0.996	1.000	1.000	1.000
2002	0.000	0.279	0.728	0.929	0.983	0.996	1.000	1.000	1.000
2003	0.000	0.294	0.731	0.931	0.984	0.997	1.000	1.000	1.000
2004	0.000	0.309	0.739	0.935	0.986	0.998	1.000	1.000	1.000
2005	0.000	0.321	0.750	0.941	0.988	0.998	1.000	1.000	1.000
2006	0.000	0.332	0.763	0.947	0.990	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	0.349	0.792	0.960	0.995	1.000	1.000	1.000	1.000
2009	0.000	0.356	0.805	0.965	0.996	1.000	1.000	1.000	1.000
2010	0.000	0.362	0.816	0.969	0.997	1.000	1.000	1.000	1.000
2011	0.000	0.366	0.825	0.972	0.998	1.000	1.000	1.000	1.000
2012	0.000	0.369	0.831	0.974	0.998	1.000	1.000	1.000	1.000
2013	0.000	0.370	0.834	0.975	0.998	1.000	1.000	1.000	1.000
2014	0.000	0.370	0.836	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	0.366	0.835	0.975	0.997	1.000	1.000	1.000	1.000
2017	0.000	0.360	0.830	0.974	0.997	1.000	1.000	1.000	1.000
2018	0.000	0.352	0.822	0.972	0.997	1.000	1.000	1.000	1.000
2019	0.000	0.341	0.811	0.969	0.996	1.000	1.000	1.000	1.000
2020	0.000	0.328	0.798	0.966	0.995	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 (2021b). Model input.

Age	0	1	2	3	4	5	6	7	8+
1978	1.351	1.420	0.833	0.546	0.514	0.454	0.434	0.296	0.243
1979	1.378	1.406	0.814	0.537	0.507	0.450	0.428	0.295	0.244
1980	1.406	1.392	0.795	0.529	0.499	0.446	0.422	0.295	0.245
1981	1.429	1.377	0.776	0.520	0.491	0.442	0.417	0.294	0.246
1982	1.446	1.357	0.756	0.512	0.484	0.437	0.412	0.292	0.247
1983	1.455	1.334	0.736	0.504	0.476	0.433	0.408	0.290	0.248
1984	1.459	1.311	0.715	0.496	0.469	0.430	0.405	0.289	0.249
1985	1.460	1.291	0.695	0.489	0.462	0.427	0.403	0.288	0.251
1986	1.463	1.278	0.676	0.484	0.457	0.425	0.402	0.291	0.254
1987	1.469	1.271	0.660	0.480	0.454	0.424	0.402	0.296	0.257
1988	1.480	1.268	0.645	0.477	0.451	0.424	0.404	0.304	0.261
1989	1.499	1.266	0.633	0.474	0.449	0.425	0.406	0.316	0.265
1990	1.524	1.266	0.623	0.472	0.447	0.426	0.408	0.329	0.269
1991	1.556	1.267	0.615	0.469	0.445	0.426	0.410	0.343	0.274
1992	1.595	1.270	0.610	0.466	0.444	0.425	0.412	0.356	0.279
1993	1.642	1.276	0.607	0.464	0.442	0.425	0.413	0.368	0.285
1994	1.696	1.285	0.606	0.462	0.441	0.424	0.413	0.377	0.292
1995	1.758	1.296	0.606	0.462	0.441	0.424	0.414	0.385	0.302
1996	1.827	1.311	0.608	0.463	0.441	0.424	0.414	0.393	0.314
1997	1.900	1.328	0.609	0.465	0.442	0.424	0.415	0.399	0.329
1998	1.978	1.347	0.612	0.468	0.444	0.425	0.416	0.405	0.346
1999	2.057	1.366	0.616	0.472	0.446	0.427	0.418	0.410	0.362
2000	2.137	1.384	0.622	0.477	0.449	0.429	0.420	0.415	0.378
2001	2.217	1.400	0.630	0.483	0.454	0.432	0.424	0.420	0.392
2002	2.293	1.411	0.639	0.490	0.459	0.436	0.428	0.424	0.405
2003	2.360	1.411	0.648	0.497	0.464	0.440	0.432	0.427	0.416
2004	2.415	1.399	0.656	0.503	0.469	0.444	0.436	0.429	0.425
2005	2.457	1.378	0.661	0.508	0.472	0.446	0.439	0.429	0.432
2006	2.486	1.351	0.663	0.510	0.474	0.447	0.439	0.425	0.435
2007	2.505	1.321	0.662	0.511	0.474	0.447	0.438	0.418	0.436
2008	2.516	1.290	0.659	0.510	0.472	0.446	0.434	0.408	0.433

Age	0	1	2	3	4	5	6	7	8+
2009	2.522	1.258	0.654	0.508	0.470	0.445	0.429	0.394	0.427
2010	2.526	1.229	0.649	0.507	0.468	0.443	0.421	0.378	0.418
2011	2.523	1.204	0.645	0.505	0.466	0.442	0.412	0.362	0.405
2012	2.508	1.184	0.641	0.505	0.466	0.442	0.401	0.345	0.390
2013	2.478	1.169	0.638	0.505	0.466	0.442	0.391	0.328	0.372
2014	2.433	1.158	0.637	0.505	0.467	0.443	0.381	0.314	0.353
2015	2.370	1.152	0.638	0.506	0.467	0.444	0.371	0.302	0.332
2016	2.289	1.150	0.642	0.507	0.468	0.445	0.362	0.294	0.312
2017	2.192	1.151	0.647	0.508	0.468	0.446	0.353	0.288	0.292
2018	2.083	1.151	0.652	0.510	0.469	0.447	0.344	0.283	0.273
2019	1.967	1.151	0.658	0.511	0.469	0.448	0.336	0.278	0.255
2020	1.967	1.151	0.658	0.511	0.469	0.448	0.336	0.278	0.255

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
1983	1.265	1.211	1.078	0.765	0.337
1984	4.265	1.645	0.805	0.276	0.267
1985	3.243	3.449	0.617	0.171	0.079
1986	4.511	2.826	2.127	0.349	0.093
1987	6.680	5.395	0.864	0.428	0.060
1988	4.329	8.312	2.998	0.308	0.173
1989	14.246	5.205	3.946	1.033	0.172
1990	5.140	8.397	1.992	0.988	0.201
1991	9.341	7.593	3.660	0.735	0.336
1992	9.984	4.501	2.423	0.748	0.573
1993	10.613	5.507	1.928	0.880	0.392
1994	7.317	5.711	1.922	0.677	0.135
1995	6.563	4.709	2.040	0.643	0.135
1996	4.796	4.686	2.174	0.676	0.351
1997	3.165	2.610	1.598	0.820	0.235
1998	5.107	1.621	1.175	0.484	0.220
1999	6.108	2.638	1.461	0.672	0.274
2000	8.133	4.628	1.857	0.317	0.181
2001	6.462	5.632	2.507	0.723	0.289
2002	5.347	3.505	2.588	0.484	0.124
2003	1.370	2.729	2.468	1.264	0.444
2004	1.874	0.932	1.599	0.778	0.435
2005	1.284	0.753	0.511	0.425	0.287

IBTS–Q1					
Age	**1**	**2**	**3**	**4**	**5**
2006	1.931	1.052	0.476	0.223	0.160
2007	0.638	1.485	0.640	0.217	0.112
2008	2.571	1.993	0.556	0.183	0.095
2009	2.115	2.873	0.681	0.173	0.162
2010	3.379	1.961	1.721	0.515	0.735
2011	1.751	3.521	1.350	0.708	0.188
2012	2.204	5.620	1.001	0.396	0.293
2013	0.525	1.629	2.447	0.670	0.346
2014	2.585	1.873	0.978	0.607	0.337
2015	3.241	2.032	0.510	0.244	0.225
2016	3.510	2.933	0.849	0.241	0.140
2017	5.651	2.333	1.012	0.305	0.111
2018	1.215	2.304	0.736	0.328	0.121
2019	2.175	1.749	1.169	0.442	0.129
2020	5.190	2.023	0.785	0.526	0.164
2021	5.994	7.009	1.139	0.405	0.154

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	5.065	6.776	1.478	0.858	0.297	0.169
1992	13.232	5.468	2.504	0.709	0.539	0.316
1993	8.781	6.247	1.803	0.426	0.246	0.169
1994	5.687	6.932	2.358	0.494	0.186	0.106
1995	7.035	6.252	2.730	0.712	0.209	0.090
1996	2.832	4.446	3.279	1.267	0.347	0.099
1997	19.735	2.902	1.655	1.192	0.265	0.202
1998	25.563	3.176	1.386	0.539	0.315	0.124
1999	23.860	11.486	1.775	0.521	0.226	0.102
2000	18.681	8.953	3.048	0.582	0.172	0.084
2001	34.265	6.447	2.677	0.845	0.220	0.081
2002	2.566	7.703	2.390	1.275	0.344	0.075
2003	3.481	2.502	2.735	1.193	0.676	0.189
2004	6.800	1.377	0.597	0.629	0.428	0.246
2005	1.639	1.451	0.810	0.314	0.429	0.315
2006	1.894	1.653	0.775	0.287	0.228	0.183
2007	7.773	0.853	0.611	0.336	0.155	0.082
2008	7.281	3.425	0.615	0.294	0.131	0.066

IBTS-Q3						
Age	0	1	2	3	4	5
2009	5.553	5.414	3.361	0.504	0.131	0.089
2010	4.725	2.160	1.336	0.433	0.125	0.123
2011	2.311	4.031	1.360	0.593	0.191	0.082
2012	2.828	2.494	2.097	0.630	0.215	0.146
2013	3.083	0.627	0.575	0.624	0.198	0.072
2014	19.385	2.073	0.908	0.580	0.329	0.097
2015	19.307	2.926	2.093	0.539	0.265	0.176
2016	9.005	2.752	2.226	0.663	0.200	0.089
2017	1.710	8.764	1.926	0.825	0.260	0.114
2018	1.687	2.363	2.842	0.807	0.317	0.210
2019	13.649	4.285	1.461	0.831	0.220	0.150
2020	12.224	14.487	2.086	0.594	0.424	0.346

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	0.020	0.086	0.278	0.537	0.656	0.756	1.002	1.325	1.325
1979	0.021	0.094	0.300	0.574	0.671	0.761	0.913	1.123	1.123
1980	0.020	0.088	0.291	0.617	0.790	0.956	1.124	1.389	1.389
1981	0.020	0.091	0.279	0.594	0.784	0.984	1.194	1.436	1.436
1982	0.020	0.094	0.254	0.502	0.633	0.786	0.957	1.110	1.110
1983	0.024	0.121	0.319	0.597	0.709	0.842	1.003	1.196	1.196
1984	0.025	0.137	0.358	0.682	0.840	0.971	1.148	1.329	1.329
1985	0.022	0.118	0.295	0.583	0.795	0.989	1.198	1.472	1.472
1986	0.024	0.141	0.355	0.660	0.901	1.051	1.217	1.417	1.417
1987	0.023	0.135	0.376	0.713	0.991	1.243	1.412	1.613	1.613
1988	0.023	0.142	0.369	0.629	0.836	1.066	1.132	1.164	1.164
1989	0.021	0.126	0.359	0.617	0.837	1.212	1.321	1.440	1.440
1990	0.022	0.136	0.409	0.642	0.780	1.022	1.078	1.194	1.194
1991	0.018	0.113	0.346	0.543	0.638	0.846	0.927	1.167	1.167
1992	0.018	0.117	0.340	0.525	0.609	0.758	0.893	1.045	1.045
1993	0.018	0.120	0.355	0.586	0.677	0.799	0.936	1.095	1.095
1994	0.015	0.110	0.329	0.581	0.721	0.858	0.980	1.090	1.090
1995	0.013	0.098	0.294	0.526	0.662	0.825	0.972	1.094	1.094
1996	0.010	0.085	0.263	0.472	0.610	0.766	0.904	1.030	1.030
1997	0.009	0.076	0.236	0.406	0.519	0.617	0.687	0.788	0.788
1998	0.007	0.071	0.218	0.363	0.474	0.564	0.627	0.704	0.704
1999	0.007	0.078	0.254	0.425	0.547	0.640	0.674	0.741	0.741
2000	0.005	0.061	0.225	0.420	0.598	0.776	0.867	0.961	0.961

Age	0	1	2	3	4	5	6	7	8+
2001	0.004	0.047	0.161	0.298	0.462	0.663	0.778	0.889	0.889
2002	0.004	0.052	0.155	0.255	0.363	0.492	0.594	0.687	0.687
2003	0.006	0.081	0.197	0.248	0.297	0.352	0.394	0.432	0.432
2004	0.005	0.073	0.162	0.198	0.238	0.293	0.346	0.372	0.372
2005	0.004	0.075	0.161	0.185	0.206	0.241	0.288	0.318	0.318
2006	0.005	0.090	0.192	0.232	0.239	0.258	0.293	0.309	0.309
2007	0.004	0.080	0.175	0.228	0.236	0.234	0.261	0.287	0.287
2008	0.004	0.075	0.164	0.226	0.237	0.221	0.233	0.256	0.256
2009	0.003	0.066	0.148	0.226	0.267	0.275	0.315	0.352	0.352
2010	0.003	0.058	0.141	0.234	0.297	0.334	0.403	0.448	0.448
2011	0.003	0.056	0.135	0.216	0.265	0.295	0.342	0.368	0.368
2012	0.003	0.061	0.130	0.204	0.267	0.316	0.348	0.355	0.355
2013	0.002	0.050	0.113	0.190	0.261	0.333	0.337	0.329	0.329
2014	0.002	0.047	0.122	0.216	0.294	0.390	0.399	0.395	0.395
2015	0.002	0.051	0.149	0.261	0.333	0.430	0.429	0.427	0.427
2016	0.002	0.040	0.131	0.264	0.345	0.427	0.426	0.424	0.424
2017	0.002	0.031	0.107	0.228	0.317	0.359	0.364	0.387	0.387
2018	0.002	0.028	0.101	0.215	0.284	0.284	0.259	0.249	0.249
2019	0.002	0.029	0.103	0.230	0.289	0.271	0.238	0.206	0.206
2020	0.001	0.025	0.093	0.211	0.249	0.209	0.165	0.127	0.127

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	40685696	10135429	1856647	783155	224526	19201	13703	2559	407
1979	29725244	10682227	2302890	609966	270452	68797	5931	3218	569
1980	16872504	7534857	2329517	745127	198272	86485	20491	1585	968
1981	15512459	3811087	1923959	766746	230062	53410	20844	4495	479
1982	13682956	3623434	856387	740194	247728	62313	12589	4083	868
1983	17859789	3026042	824499	322827	292046	81696	18093	3084	1280
1984	15453599	4235214	699022	285993	104484	99183	22612	4524	983
1985	24019471	3276047	1017094	234145	86046	27327	26320	4659	1137
1986	21586680	5840793	771173	415862	81247	25292	6335	5522	959
1987	18674788	4910838	1452117	267694	141443	19904	6172	1236	1210
1988	23358277	4056000	1332388	513751	79126	33877	3688	1029	348
1989	16125958	5553425	898937	511036	173432	21738	7668	775	353
1990	14036807	3452284	1486206	331210	177085	51015	3888	1350	192
1991	15476111	2893236	836403	513206	109208	50746	12649	842	353
1992	17444205	3260795	733581	312960	191507	37827	13016	3732	249
1993	16984436	3474216	770903	286900	119489	79583	10064	3205	1042

Age	0	1	2	3	4	5	6	7	8+
1994	15190205	3245816	830585	279168	104589	37647	26640	2493	967
1995	12269889	2827643	792840	320776	99009	31962	10025	6949	812
1996	10244438	2023882	703555	322692	120759	33559	8949	2432	1803
1997	16164421	1560879	484094	298241	124351	45172	9720	2313	1025
1998	25976121	2300418	369646	205336	119939	49649	15664	3281	1016
1999	26831680	3611434	518342	164083	93064	47188	19341	5349	1459
2000	23379703	3366837	774320	208410	63725	34970	16467	6945	2231
2001	23526676	2689760	827301	300099	75939	21754	10494	4474	2368
2002	13420546	2570236	657601	414537	135023	28529	6267	3142	1816
2003	12824947	1306682	632134	328984	200012	61788	10831	2029	1538
2004	14273340	1197301	254060	266521	168761	95134	29246	4883	1432
2005	13621487	1266667	271501	111732	132107	88732	45234	13202	2848
2006	11103414	1254679	307963	118603	57957	69921	48426	21958	7392
2007	16492418	890528	297277	139760	56968	27150	38273	23924	14374
2008	16688831	1399920	236674	127704	69571	28216	13734	20644	18954
2009	15740978	1355192	365065	102053	60108	37216	14719	7615	23163
2010	14995406	1267280	346670	157967	46410	32180	19123	7035	16256
2011	11290558	1247605	366604	159487	72432	21590	14138	8351	10131
2012	8475192	941499	408602	156083	74548	35126	10439	6506	8879
2013	12894319	640183	243716	200150	79910	37252	15693	4855	7432
2014	16988265	1123213	192168	114793	97053	40230	16634	7517	6531
2015	15535141	1467288	364689	92171	53431	45927	17679	7343	6867
2016	16713651	1337227	417956	161007	43944	24302	19046	8108	6548
2017	10381577	1769328	385401	178764	72045	19939	9892	8397	7194
2018	12047844	1125534	542138	179182	82194	32992	8841	4799	6914
2019	20392302	1518853	355548	242050	88598	37977	15166	5096	6338
2020	21546571	2993774	454358	172116	109652	43641	18339	7850	6654

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	40685696	29546563	56024311	386906	337466	443589	0.646	0.558	0.747	757040	659015	869645
1979	29725244	21873198	40396017	431278	378897	490901	0.644	0.563	0.735	839157	726223	969653
1980	16872504	12579090	22631317	425283	372830	485116	0.755	0.665	0.858	688678	604931	784020
1981	15512459	11635856	20680593	370703	325231	422532	0.767	0.675	0.872	542764	480289	613365
1982	13682956	10302114	18173290	299759	263855	340548	0.627	0.547	0.718	507434	448661	573907
1983	17859789	13470623	23679087	260308	232027	292036	0.694	0.61	0.789	452059	402227	508065
1984	15453599	11637221	20521541	206037	184448	230153	0.8	0.706	0.906	423747	373738	480448
1985	24019471	18056916	31950916	193794	171254	219301	0.772	0.681	0.875	407284	356904	464776
1986	21586680	16298756	28590204	206303	182755	232885	0.837	0.741	0.945	494035	430326	567177
1987	18674788	14120885	24697299	203570	179600	230739	0.947	0.841	1.066	406475	358192	461266
1988	23358277	17544018	31099439	205977	181104	234266	0.807	0.712	0.914	384644	339201	436175
1989	16125958	12252942	21223191	209005	185259	235795	0.869	0.77	0.982	451641	397323	513386
1990	14036807	10676400	18454904	202350	179305	228355	0.786	0.693	0.891	374291	331878	422125
1991	15476111	11892267	20139981	198712	176443	223792	0.66	0.579	0.752	385870	342372	434894
1992	17444205	13418199	22678177	188442	168199	211120	0.625	0.546	0.715	352134	313979	394926
1993	16984436	13061636	22085371	179289	160691	200039	0.671	0.589	0.764	329477	294392	368745
1994	15190205	11670293	19771769	173863	155895	193902	0.694	0.609	0.79	328331	292752	368235
1995	12269889	9387893	16036631	174951	156233	195911	0.656	0.574	0.749	300090	267874	336180
1996	10244438	7728233	13579884	156241	139564	174911	0.603	0.525	0.692	283572	252074	319005
1997	16164421	12225838	21371829	139483	124646	156087	0.493	0.427	0.57	343018	295437	398263
1998	25976121	19638008	34359844	119526	107341	133093	0.449	0.387	0.521	340457	290960	398373
1999	26831680	20252384	35548362	119493	106679	133847	0.508	0.44	0.586	412233	347604	488877
2000	23379703	17580250	31092306	147410	130009	167141	0.577	0.496	0.672	534589	446257	640405

Year	R (age 0)	Low	High	SSB	Low	High	F (2–6)	Low	High	TSB	Low	High
2001	23526676	17629583	31396346	156643	135673	180854	0.472	0.397	0.562	438621	368179	522540
2002	13420546	10151042	17743112	152446	132010	176047	0.372	0.306	0.453	259321	226168	297334
2003	12824947	9741900	16883695	137920	119795	158788	0.298	0.244	0.363	221007	193769	252073
2004	14273340	10803764	18857153	132546	115006	152760	0.247	0.202	0.304	319696	271405	376579
2005	13621487	10283663	18042688	121497	105549	139855	0.216	0.176	0.265	311546	262986	369072
2006	11103414	8394158	14687095	115618	101179	132117	0.243	0.201	0.294	506130	411974	621803
2007	16492418	12508263	21745613	105168	92191	119972	0.227	0.188	0.274	458566	372502	564514
2008	16688831	12648928	22019027	109132	96275	123705	0.216	0.18	0.26	298363	252130	353074
2009	15740978	11911612	20801416	113282	99884	128477	0.246	0.206	0.295	369836	306493	446269
2010	14995406	11228779	20025526	134649	117991	153659	0.282	0.233	0.341	419745	346237	508860
2011	11290558	8515571	14969835	124574	108504	143025	0.251	0.206	0.305	344256	287429	412319
2012	8475192	6305955	11390641	129010	111833	148826	0.253	0.207	0.31	265552	224780	313718
2013	12894319	9643492	17241003	121940	105006	141606	0.247	0.2	0.304	263292	220763	314013
2014	16988265	12491228	23104306	115837	99128	135362	0.284	0.228	0.354	465581	368674	587961
2015	15535141	11338423	21285200	121574	101941	144988	0.32	0.251	0.409	396475	315285	498572
2016	16713651	12139349	23011622	125946	103138	153798	0.318	0.24	0.423	336226	268631	420830
2017	10381577	7461287	14444847	132785	106337	165812	0.275	0.198	0.383	260938	210021	324199
2018	12047844	8485333	17106051	138838	109454	176110	0.229	0.161	0.324	292974	230842	371828
2019	20392302	13665200	30431022	144019	111847	185444	0.226	0.159	0.323	331535	252665	435025
2020	21546571	12816023	36224555	177993	134419	235693	0.185	0.128	0.269	990378	648221	1513139

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	190120	159808	226182
1979	224969	192863	262421
1980	220121	188477	257078
1981	189178	161831	221147
1982	144336	123408	168813
1983	146549	126995	169113
1984	134462	116550	155126
1985	111363	96090	129063
1986	145047	124161	169446
1987	137144	117723	159770
1988	128239	109437	150272
1989	133785	115049	155572
1990	131293	111935	153999
1991	112526	96672	130979
1992	104486	90324	120869
1993	104973	90890	121238
1994	100727	87304	116213
1995	92732	80075	107390
1996	75974	65690	87867
1997	61328	53042	70909
1998	49915	43472	57314
1999	56389	48874	65060
2000	64385	55547	74630
2001	51781	44052	60866
2002	45677	39272	53127
2003	41130	35434	47741
2004	33578	29317	38459
2005	29561	25928	33703
2006	33554	29235	38511
2007	27621	24138	31607
2008	27011	23604	30911
2009	28661	25092	32739
2010	34818	30412	39862
2011	29720	25910	34091
2012	30253	26397	34673
2013	27066	23598	31043
2014	29081	25549	33101
2015	33241	29104	37965

Year	Catch	Low	High
2016	32047	27984	36699
2017	29887	25925	34456
2018	28160	24380	32527
2019	30658	26454	35529
2020	32819	28165	38242

Table 23.21. Whiting in Subarea 4 and Division 7.d: SAM model parameters.

	par	sd(par)	exp(par)	Low	High
logFpar_0	-13.125	0.082	0	0	0
logFpar_1	-12.008	0.079	0	0	0
logFpar_2	-11.919	0.078	0	0	0
logFpar_3	-12.089	0.077	0	0	0
logFpar_4	-13.295	0.1	0	0	0
logFpar_5	-12.228	0.098	0	0	0
logFpar_6	-11.963	0.096	0	0	0
logFpar_7	-12.122	0.095	0	0	0
logFpar_8	-12.157	0.095	0	0	0
logSdLogFsta_0	-1.579	0.128	0.206	0.159	0.266
logSdLogN_0	-1.149	0.16	0.317	0.23	0.437
logSdLogN_1	-2.216	0.179	0.109	0.076	0.156
logSdLogObs_0	0.173	0.125	1.189	0.925	1.528
logSdLogObs_1	-1.669	0.101	0.188	0.154	0.231
logSdLogObs_2	-0.793	0.081	0.452	0.384	0.532
logSdLogObs_3	-0.754	0.085	0.47	0.397	0.557
transfIRARdist_0	-0.346	0.351	0.707	0.35	1.427
transfIRARdist_1	-0.654	0.259	0.52	0.31	0.873
transfIRARdist_2	1.03	0.49	2.8	1.05	7.466
transfIRARdist_3	-0.824	0.31	0.439	0.236	0.816
itrans_rho_0	1.101	0.146	3.006	2.246	4.023

Table 23.22. Whiting in Subarea 4 and Division 7.d: Mohn’s rho.

Mohn’s rho	
R(age 0)	0.131
SSB	0.1616
Fbar(2-6)	-0.1387

Table 23.23. Whiting in Subarea 4 and Division 7.d: Reference points as determined in the interbenchmark 2021 (ICES, 2021a).

Reference point	value
B_{lim}	103 560 t (B_{loss})
F_{lim}	0.718
B_{pa}	143 905 t (MSY $B_{trigger}$)
F_{pa}	0.385
$F_{p.05}$ (with $B_{trigger}$)	0.385
F_{MSY}	0.371

Table 23.24. Whiting in Subarea 4 and Division 7.d: Recruitment estimates (in millions) as used in the short-term forecast.

Year	Geometric mean of recruitment Time series 2002–2020
2021	14140
2022	14140
2023	14140

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 (2018–2020).

MFDP version 1a						
Run: Run 3						
Time and date: 14:34 27/04/2021						
Fbar age range (Total) : 2-6						
Fbar age range Fleet 1 : 2-6						
Fbar age range Fleet 2 : 2-6						
2021*						
Age	N	M	Mat	PF	PM	SWt
0	14140017	2.00552	0	0	0	0.016862
1	3004698	1.15114	0.3402	0	0	0.035622
2	961254	0.65589	0.8105	0	0	0.108881
3	207670	0.51064	0.9689	0	0	0.193609
4	86543	0.46921	0.9959	0	0	0.29072
5	50683	0.44769	1	0	0	0.380568
6	22633	0.3387	1	0	0	0.457446
7	11116	0.27989	1	0	0	0.499628
8	9778	0.26069	1	0	0	0.503683
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00001	0.069667	0.00123	0.05		
1	0.00204	0.193	0.02087	0.097667		
2	0.02454	0.28	0.05722	0.185333		
3	0.09588	0.334	0.08199	0.220667		
4	0.16798	0.403333	0.05113	0.255		
5	0.17671	0.434333	0.02348	0.302667		
6	0.15481	0.494	0.0175	0.325333		
7	0.13259	0.509	0.01839	0.403		
8	0.14516	0.432	0.00574	0.297667		
IBC						
Age	Sel	CWt				
0	0.00008	0.050333				
1	0.00117	0.106333				
2	0.00487	0.214333				
3	0.01344	0.281				
4	0.01975	0.368				
5	0.02024	0.418667				
6	0.01746	0.478				
7	0.0148	0.483667				
8	0.01488	0.428667				
2022						

Age	N	M	Mat	PF	PM	SWt
0	14140017	2.00552	0	0	0	0.016862
1	.	1.15114	0.3402	0	0	0.035622
2	.	0.65589	0.8105	0	0	0.108881
3	.	0.51064	0.9689	0	0	0.193609
4	.	0.46921	0.9959	0	0	0.29072
5	.	0.44769	1	0	0	0.380568
6	.	0.3387	1	0	0	0.457446
7	.	0.27989	1	0	0	0.499628
8	.	0.26069	1	0	0	0.503683
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00001	0.069667	0.00123	0.05		
1	0.00204	0.193	0.02087	0.097667		
2	0.02454	0.28	0.05722	0.185333		
3	0.09588	0.334	0.08199	0.220667		
4	0.16798	0.403333	0.05113	0.255		
5	0.17671	0.434333	0.02348	0.302667		
6	0.15481	0.494	0.0175	0.325333		
7	0.13259	0.509	0.01839	0.403		
8	0.14516	0.432	0.00574	0.297667		
IBC						
Age	Sel	CWt				
0	0.00008	0.050333				
1	0.00117	0.106333				
2	0.00487	0.214333				
3	0.01344	0.281				
4	0.01975	0.368				
5	0.02024	0.418667				
6	0.01746	0.478				
7	0.0148	0.483667				
8	0.01488	0.428667				
2023						
Age	N	M	Mat	PF	PM	SWt
0	14140017	2.00552	0	0	0	0.016862
1	.	1.15114	0.3402	0	0	0.035622
2	.	0.65589	0.8105	0	0	0.108881
3	.	0.51064	0.9689	0	0	0.193609
4	.	0.46921	0.9959	0	0	0.29072
5	.	0.44769	1	0	0	0.380568
6	.	0.3387	1	0	0	0.457446

7	.	0.27989	1	0	0	0.499628
8	.	0.26069	1	0	0	0.503683
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00001	0.069667	0.00123	0.05		
1	0.00204	0.193	0.02087	0.097667		
2	0.02454	0.28	0.05722	0.185333		
3	0.09588	0.334	0.08199	0.220667		
4	0.16798	0.403333	0.05113	0.255		
5	0.17671	0.434333	0.02348	0.302667		
6	0.15481	0.494	0.0175	0.325333		
7	0.13259	0.509	0.01839	0.403		
8	0.14516	0.432	0.00574	0.297667		
IBC						
Age	Sel	CWt				
0	0.00008	0.050333				
1	0.00117	0.106333				
2	0.00487	0.214333				
3	0.01344	0.281				
4	0.01975	0.368				
5	0.02024	0.418667				
6	0.01746	0.478				
7	0.0148	0.483667				
8	0.01488	0.428667				
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: Run3. Time and date: 14:34 27/04/2021; Basis: F(2021) = average exploitation (2018–2020), scaled to F(2020) = 0.185; Fbar age range: 2–6; Recruitment (2021-2023) = 14 140 million (geometric mean 2002–2020); TAC 27.4 (2021) = 21 306.

Output units in tonnes

2021																
			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	0.139	0.231875
555612	225375	1	0.1855	37295	0.124	19629	34753	28153	6600	0.0463	15124	1	0.0152	2542		

2022																**2023**		**2021 TAC 27.4**	**21306**	
			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**		
567211	262094	0	0.015	3439	0.000	0	0	0	0	0.000	0	1	0.015	3439	598594	299843	-100.0%	14.4%		No HC fishery
.	262094	0.1	0.032	7952	0.012	2762	4538	3676	862	0.005	1776	1	0.015	3414	595222	296534	-82.7%	13.1%		
.	262094	0.2	0.049	12405	0.025	5483	9015	7303	1712	0.009	3532	1	0.015	3390	591902	293277	-65.7%	11.9%		
.	262094	0.3	0.066	16797	0.037	8161	13431	10880	2551	0.014	5270	1	0.015	3366	588633	290070	-48.9%	10.7%		
.	262094	0.4	0.083	21132	0.050	10800	17790	14412	3378	0.019	6990	1	0.015	3342	585414	286913	-32.4%	9.5%		
.	262094	0.5	0.100	25408	0.062	13398	22090	17895	4195	0.023	8692	1	0.015	3318	582245	283806	-16.0%	8.3%		
.	262094	0.6	0.117	29629	0.074	15957	26334	21333	5001	0.028	10377	1	0.015	3295	579124	280746	0.1%	7.1%		
.	262094	0.7	0.134	33792	0.087	18477	30520	24724	5796	0.032	12043	1	0.015	3272	576051	277734	16.0%	6.0%		
.	262094	0.8	0.151	37902	0.099	20960	34653	28072	6581	0.037	13693	1	0.015	3249	573024	274768	31.8%	4.8%		
.	262094	0.9	0.168	41956	0.112	23405	38730	31375	7355	0.042	15325	1	0.015	3226	570044	271848	47.3%	3.7%		
.	262094	1	0.186	45958	0.124	25813	42754	34635	8119	0.046	16941	1	0.015	3204	567109	268973	62.6%	2.6%		Fsq
.	262094	1.1	0.203	49908	0.136	28186	46726	37853	8873	0.051	18540	1	0.015	3182	564218	266142	77.7%	1.5%		

2022																2023		2021 TAC 27.4	21306
			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	
.	262094	1.2	0.220	53806	0.149	30523	50646	41028	9618	0.056	20123	1	0.015	3160	561371	263354	92.6%	0.5%	
.	262094	1.3	0.237	57653	0.161	32825	54515	44163	10352	0.060	21690	1	0.015	3138	558567	260609	107.3%	-0.6%	
.	262094	1.4	0.254	61451	0.174	35093	58334	47256	11078	0.065	23241	1	0.015	3117	555805	257906	121.8%	-1.6%	
.	262094	1.5	0.271	65201	0.186	37328	62105	50311	11794	0.069	24777	1	0.015	3096	553084	255243	136.1%	-2.6%	
.	262094	1.6	0.288	68901	0.198	39529	65826	53326	12500	0.074	26297	1	0.015	3075	550405	252622	150.3%	-3.6%	
.	262094	1.7	0.305	72554	0.211	41698	69500	56302	13198	0.079	27802	1	0.015	3054	547765	250040	164.3%	-4.6%	
.	262094	1.8	0.322	76161	0.223	43835	73127	59240	13887	0.083	29292	1	0.015	3034	545165	247497	178.0%	-5.6%	
.	262094	1.9	0.339	79720	0.236	45940	76707	62140	14567	0.088	30767	1	0.015	3013	542603	244993	191.7%	-6.5%	
.	262094	2	0.356	83236	0.248	48015	80243	65005	15238	0.093	32228	1	0.015	2993	540079	242526	205.1%	-7.5%	
.	262094	0.75	0.143	35036	0.093	19159	31772	25738	6033	0.035	12613	1	0.015	3264	575228	276937	20.8%	5.7%	0.75 * Fsq
.	262094	3.88	0.676	159745	0.481	94179	157178	127330	29848	0.179	62999	1	0.015	2567	483806	187388	497.6%	-28.5%	Fmsy SSB(2020)/MSYBtrigger
.	262094	1.25	0.228	54961	0.155	31145	51808	41970	9838	0.058	20663	1	0.015	3153	560622	262629	97.0%	0.2%	1.25 * Fsq
.	262094	0.52	0.103	25672	0.064	13524	22355	18110	4245	0.024	8832	1	0.015	3316	582096	283664	-15.0%	8.2%	15% TAC decrease (27.4)
.	262094	0.71	0.136	33518	0.088	18245	30246	24502	5744	0.033	12001	1	0.015	3273	576342	278028	15.0%	6.1%	15% TAC increase (27.4)
.	262094	0.61	0.120	29595	0.076	15884	26300	21306	4994	0.028	10416	1	0.015	3294	579219	280846	0.0%	7.2%	Rollover TAC
.	262094	1.00	0.185	44890	0.124	25087	41681	33766	7915	0.046	16594	1	0.015	3209	568004	269861	58.5%	3.0%	Fsq
.	262094	2.17	0.385	91703	0.269	53247	88755	71900	16855	0.100	35508	1	0.015	2947	533687	236247	237.5%	-9.9%	Fpa
.	262094	1.73	0.310	74148	0.215	42687	71102	57600	13502	0.080	28415	1	0.015	3046	546556	248852	170.3%	-5.1%	Fp05 without AR
.	262094	4.13	0.718	169645	0.512	100134	167133	135395	31739	0.191	66999	1	0.015	2512	476549	180279	535.5%	-31.2%	Flim
.	262094	5.39	0.933	219997	0.669	130424	217767	176413	41354	0.249	87343	1	0.015	2230	439637	143905	728.0%	-45.0%	Bpa, MSY Btrigger
.	262094	6.80	1.173	276086	0.843	164164	274169	222104	52065	0.314	110004	1	0.015	1917	398519	103560	942.4%	-60.4%	Blim
.	262094	1.63	0.293	70169	0.202	40293	67101	54359	12742	0.075	26808	1	0.015	3068	549473	251709	155.1%	-4.0%	Fmsylower

2022																2023		2021 TAC 27.4	21306
			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	
.	262094	2.09	0.371	88426	0.259	51276	85460	69231	16229	0.097	34184	1	0.015	2966	536089	238600	224.9%	-9.0%	Fmsy
.	262094	2.17	0.385	91703	0.269	53247	88755	71900	16855	0.100	35508	1	0.015	2947	533687	236247	237.5%	-9.9%	Fmsyupper
.	262094	0.48	0.097	24364	0.060	12737	21040	17045	3996	0.022	8303	1	0.015	3324	583054	284603	-20.0%	8.6%	20% TAC decrease (27.4)
.	262094	0.78	0.148	36134	0.096	19818	32876	26633	6243	0.036	13057	1	0.015	3258	574425	276150	25.0%	5.4%	25% TAC increase (27.4)
.	262094	3.05	0.534	126494	0.378	74176	123741	100242	23498	0.141	49565	1	0.015	2753	508182	211264	370.5%	-19.4%	Fmsylower SSB(2020)/MSYBtrigger
.	262094	1.63	0.293	70169	0.202	40293	67101	54359	12742	0.075	26808	1	0.015	3068	549473	251709	155.1%	-4.0%	Fmsylower

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
1983	143.401	154.856	150.829	113.598	50.897						
1984	323.567	212.552	106.415	41.278	40.292						
1985	412.895	341.159	81.823	23.344	11.227						
1986	587.697	385.153	239.606	39.83	12.625						
1987	707.64	788.303	122.369	57.297	8.179						
1988	301.643	1115.424	435.943	44.031	23.551						
1989	2049.504	668.536	580.893	160.983	20.942						
1990	490.822	1251.354	261.582	138.013	29.097						
1991	754.334	999.549	477.884	76.369	31.452	190.132	285.241	124.822	88.607	26.92	13.102
1992	1384.302	545.011	317.356	90.528	78.729	1357.232	615.218	191.926	84.976	65.436	33.848
1993	1529.746	810.122	269.711	122.998	52.18	339.611	578.148	248.966	55.832	30.695	21.417
1994	1058.43	853.101	299.173	105.475	20.999	237.937	712.663	324.467	57.501	16.051	11.43
1995	894.427	651.711	308.658	95.983	19.891	330.847	810.471	360.665	101.783	28.238	12.829
1996	603.663	651.987	314.636	96.581	45.633	83.743	444.379	388.123	165.359	48.308	13.145
1997	445.667	378.412	240.241	117.637	32.536	2750.385	330.418	225.354	161.952	35.658	29.341
1998	744.221	222.632	173.569	73.104	32.244	2484.246	405.455	197.391	75.867	44.141	17.651
1999	858.032	335.233	193.737	96.323	41.596	1723.648	810.794	242.511	74.55	33.258	15.492
2000	1127.728	652.372	272.851	45.871	27.249	1456.711	767.782	342.896	73.195	20.076	11.358
2001	413.843	588.073	343.71	77.607	29.033	291.479	642.804	296.602	111.774	25.051	9.898
2002	513.057	428.163	386.74	72.702	17.767	105.617	603.626	300.637	173.636	46.367	10.344
2003	156.456	311.894	344.993	184.118	64.629	413.41	245.277	326.312	166.634	88.931	24.592
2004	270.146	130.282	237.838	116.137	65.129	211.061	190.845	76.868	90.696	63.2	36.431
2005	160.63	70.445	71.669	61.544	43.237	154.069	195.852	97.403	45.119	64.845	47.659
2006	261.558	86.555	64.824	30.563	22.823	44.878	190.902	104.718	40.801	34.285	27.364

	Q1	North				Q3	North				
Age	**1**	**2**	**3**	**4**	**5**	**0**	**1**	**2**	**3**	**4**	**5**
2007	62.938	202.914	93.486	31.871	16.757	346.981	74.776	78.557	48.2	22.754	12.043
2008	198.753	195.499	78.913	27.568	14.458	848.142	334.74	72.776	39.989	18.66	9.79
2009	156.742	239.482	72.965	20.13	20.976	560.618	257.218	134.847	32.409	13.392	10.651
2010	302.33	269.377	239.438	76.001	110.69	70.104	248.174	175.906	57.992	16.82	16.516
2011	185.922	504.592	198.931	105.466	28.249	94.343	411.617	163.839	65.764	23.956	11.099
2012	266.626	796.159	145.62	58.537	44.488	316.803	238.565	268.773	84.896	30.912	21.17
2013	59.098	212.457	350.904	98.115	52.337	141.998	58.759	57.269	79.205	26.334	9.801
2014	367.829	274.711	147.237	91.846	51.213	2017.069	202.053	73.682	48.725	42.318	13.446
2015	423.217	250.756	67.447	34.917	33.132	2113.574	244.567	195.931	55.372	37.056	25.098
2016	263.992	199.177	97.841	31.325	18.422	729.877	318.709	194.394	72.089	26.372	11.006
2017	455.449	241.933	136.348	43.761	15.935	148.347	633.78	210.029	107.555	34.8	16.409
2018	84.998	236.167	92.087	52.645	20.466	204.112	147.061	258.238	97.385	39.992	27.824
2019	268.933	201.402	156.042	63.584	19.824	749.566	375.037	145.446	99.861	28.428	20.008
2020	473.6	186.579	100.513	70.269	21.467	654.4	1011.846	188.023	69.895	43.277	30.275
2021	483.541	830.134	143.297	54.078	21.874						

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
1983	85.45	99.851	52.686	19.987	5.019						
1984	593.881	84.243	43.152	4.049	2.825						
1985	114.689	330.4	30.889	11.822	3.018						
1986	155.459	93.19	215.536	54.7	7.664						
1987	542.592	86.81	27.029	26.761	3.098						
1988	487.545	262.104	50.705	6.855	6.541						
1989	291.589	229.438	71.118	4.646	11.552						
1990	470.323	118.887	87.744	32.48	4.558						
1991	1106.472	287.446	151.874	66.871	37.686	958.688	1334.419	170.203	64.644	31.132	22.847
1992	265.104	258.351	117.67	56.676	27.94	1200.775	406.283	311.477	40.846	30.723	26.147
1993	140.264	59.43	62.389	31.774	23.154	1626.475	671.101	63.728	21.692	15.256	9.817
1994	191.711	156.048	25.782	8.463	4.159	951.75	640.529	84.975	43.115	25.091	10.09
1995	222.579	239.969	49.752	19.783	6.47	1219.269	222.51	80.845	7.972	6.656	1.232
1996	231.472	233.724	70.389	33.571	37.795	499.52	417.706	205.879	47.99	11.737	6.928
1997	67.325	43.278	13.87	22.699	10.577	480.258	227.918	35.787	32.328	8.812	2.345
1998	95.505	56.861	23.986	6.323	8.272	2229.932	238.089	36.015	15.326	9.628	3.981
1999	153.527	147.624	127.128	30.833	6.278	2794.07	1724.311	49.323	13.413	4.241	0.809
2000	219.275	151.941	55.605	10.679	3.761	2456.096	1090.356	226.153	30.001	12.365	2.95
2001	942.456	448.546	84.966	70.175	31.13	8867.757	697.026	218.85	36.408	18.91	5.883
2002	457.447	120.386	34.448	13.216	7.754	385.891	989.146	113.49	32.153	12.349	3.461
2003	96.052	216.304	81.629	29.913	8.828	227.231	288.794	171.351	28.265	26.959	8.576
2004	38.818	53.641	34.87	14.43	10.014	1641.775	81.054	65.172	14.855	5.381	3.609
2005	89.895	67.155	22.92	11.112	9.571	208.437	54.154	4.017	2.917	2.161	1.504
2006	48.506	67.392	25.404	10.769	8.899	443.497	74.551	15.069	4.141	3.422	2.752
2007	77.838	58.664	12.349	5.486	3.344	2203.686	142.166	20.52	6.177	1.968	0.942
2008	427.504	247.607	26.007	4.196	2.12	546.391	596.203	54.246	16.16	4.215	0.806
2009	438.147	459.551	74.428	18.35	15.819	634.897	1044.568	664.476	76.08	11.132	6.005
2010	508.82	81.019	64.927	17.96	9.475	914.23	154.524	49.117	12.785	3.941	3.783
2011	465.753	207.833	44.203	12.609	5.268	511.566	444.079	87.814	51.98	10.342	2.203
2012	244.074	196.178	21.112	13.571	10.862	208.426	295.544	101.813	22.997	3.231	1.612
2013	137.181	93.381	52.843	10.687	10.847	772.182	100.621	55.296	26.365	5.548	1.584
2014	1129.913	147.201	35.603	17.16	13.996	1884.952	283.798	169.738	124.258	70.136	15.764
2015	340.564	393.71	134.634	21.941	19.974	1622.776	462.836	309.691	79.912	13.378	5.747
2016	633.544	643.699	111.985	27.244	15.101	1245.384	208.678	157.555	55.207	9.166	6.349
2017	989.077	266.91	52.213	10.761	6.419	229.522	1442.214	199.056	49.837	12.495	3.198
2018	185.133	192.633	47.576	21.585	11.409	111.591	391.478	376.988	65.935	19.927	9.468
2019	152.457	74.143	38.974	21.925	3.684	2247.084	335.335	87.211	68.268	12.984	5.108
2020	531.834	171.636	32.179	24.304	10.195	2381.991	1827.924	242.773	51.621	49.584	51.996
2021	816.285	443.336	66.142	15.374	5.066						

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	0.172	0.82	0.986	1	1	1	1	1
1992	0	0.175	0.817	0.985	1	1	1	1	1
1993	0	0.178	0.813	0.984	1	1	1	1	1
1994	0	0.183	0.807	0.981	0.999	1	1	1	1
1995	0	0.188	0.801	0.978	0.998	0.999	1	1	1
1996	0	0.195	0.793	0.974	0.997	0.999	1	1	1
1997	0	0.204	0.785	0.968	0.995	0.998	1	1	1
1998	0	0.215	0.776	0.962	0.994	0.998	1	1	1
1999	0	0.228	0.766	0.956	0.992	0.998	1	1	1
2000	0	0.244	0.757	0.951	0.991	0.997	1	1	1
2001	0	0.26	0.751	0.947	0.99	0.997	1	1	1
2002	0	0.274	0.751	0.946	0.99	0.998	1	1	1
2003	0	0.287	0.755	0.948	0.991	0.998	1	1	1
2004	0	0.296	0.763	0.951	0.992	0.999	1	1	1
2005	0	0.302	0.774	0.956	0.993	0.999	1	1	1
2006	0	0.305	0.787	0.961	0.994	0.999	1	1	1
2007	0	0.306	0.801	0.967	0.996	1	1	1	1
2008	0	0.306	0.814	0.973	0.997	1	1	1	1
2009	0	0.307	0.825	0.977	0.998	1	1	1	1
2010	0	0.308	0.834	0.98	0.999	1	1	1	1
2011	0	0.309	0.84	0.982	1	1	1	1	1
2012	0	0.309	0.843	0.983	1	1	1	1	1
2013	0	0.308	0.843	0.983	1	1	1	1	1
2014	0	0.306	0.842	0.982	1	1	1	1	1
2015	0	0.303	0.839	0.981	1	1	1	1	1
2016	0	0.3	0.835	0.98	0.999	1	1	1	1
2017	0	0.297	0.828	0.977	0.998	1	1	1	1
2018	0	0.293	0.818	0.974	0.997	1	1	1	1
2019	0	0.288	0.805	0.97	0.996	1	1	1	1
2020	0	0.281	0.791	0.966	0.995	1	1	1	1
2021	0	0.274	0.775	0.961	0.994	1	1	1	1

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	0.297	0.864	0.995	1	1	1	1	1
1992	0	0.297	0.824	0.981	1	1	1	1	1
1993	0	0.293	0.789	0.968	0.999	1	1	1	1
1994	0	0.285	0.762	0.954	0.995	1	1	1	1
1995	0	0.269	0.737	0.938	0.989	0.998	1	1	1
1996	0	0.247	0.709	0.917	0.979	0.992	0.997	0.998	0.999
1997	0	0.228	0.687	0.892	0.963	0.983	0.992	0.996	0.998
1998	0	0.222	0.673	0.865	0.943	0.971	0.985	0.992	0.996
1999	0	0.23	0.653	0.831	0.918	0.957	0.977	0.988	0.994
2000	0	0.25	0.621	0.795	0.893	0.943	0.969	0.985	0.992
2001	0	0.276	0.594	0.773	0.88	0.937	0.965	0.983	0.992
2002	0	0.305	0.584	0.769	0.881	0.939	0.967	0.985	0.993
2003	0	0.337	0.589	0.778	0.889	0.945	0.97	0.987	0.994
2004	0	0.366	0.604	0.793	0.9	0.952	0.975	0.99	0.996
2005	0	0.391	0.626	0.812	0.913	0.961	0.981	0.992	0.997
2006	0	0.415	0.656	0.835	0.927	0.969	0.987	0.995	0.998
2007	0	0.442	0.693	0.862	0.942	0.977	0.992	0.997	0.999
2008	0	0.467	0.731	0.888	0.956	0.984	0.996	0.998	1
2009	0	0.487	0.765	0.91	0.967	0.989	0.999	1	1
2010	0	0.501	0.792	0.927	0.975	0.993	1	1	1
2011	0	0.51	0.81	0.938	0.98	0.995	1	1	1
2012	0	0.514	0.818	0.943	0.982	0.996	1	1	1
2013	0	0.514	0.819	0.944	0.982	0.997	1	1	1
2014	0	0.513	0.823	0.947	0.983	0.997	1	1	1
2015	0	0.511	0.833	0.952	0.985	0.997	1	1	1
2016	0	0.503	0.842	0.958	0.988	0.998	1	1	1
2017	0	0.491	0.845	0.962	0.99	0.998	1	1	1
2018	0	0.479	0.84	0.962	0.991	0.998	1	1	1
2019	0	0.468	0.829	0.959	0.991	0.998	1	1	1
2020	0	0.458	0.816	0.955	0.99	0.998	1	1	1
2021	0	0.447	0.802	0.95	0.99	0.999	1	1	1

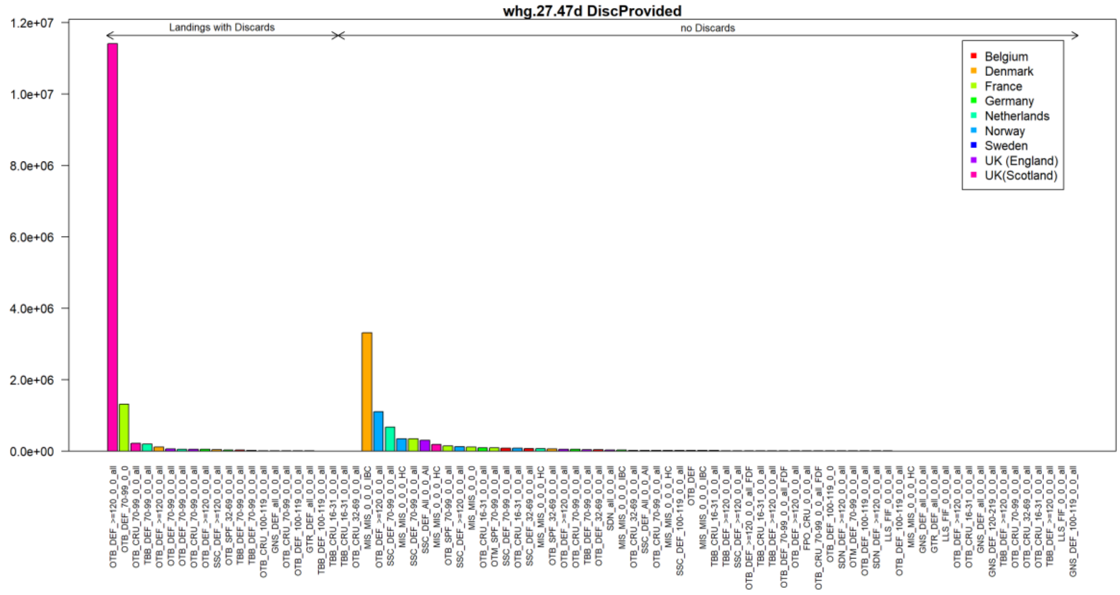


Figure 23.1. Whiting in Subarea 4 and Division 7.d: Landings with provided discards. Métier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

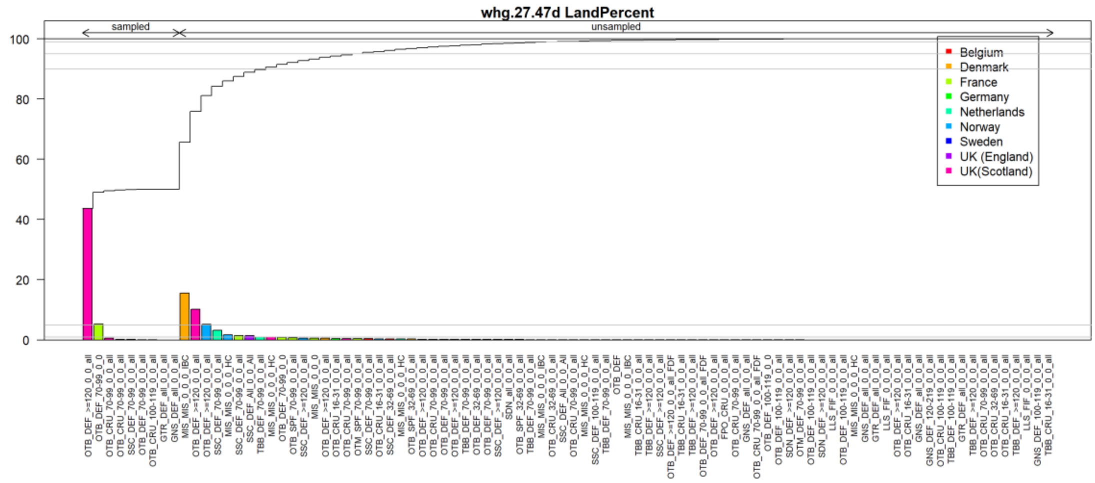


Figure 23.2a. Whiting in Subarea 4 and Division 7.d: Reported landings (in percent, colored bars) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

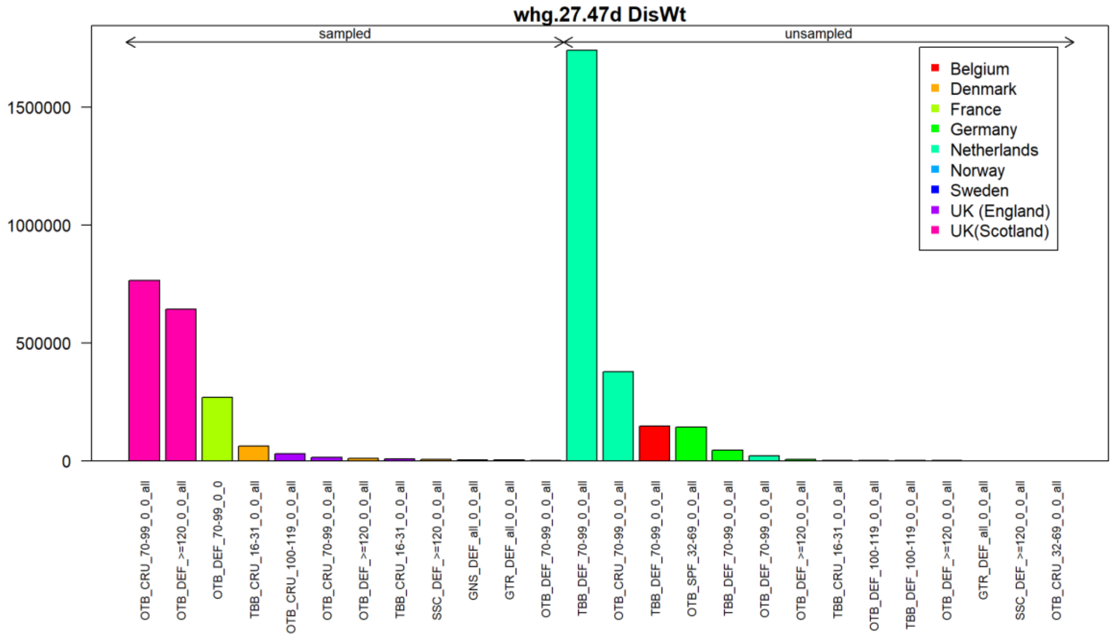


Figure 23.2b. Whiting in Subarea 4 and Division 7.d: Reported discards (in tonnes, colored bars) for each sampled and unsampled fleet, in descending order of yield.

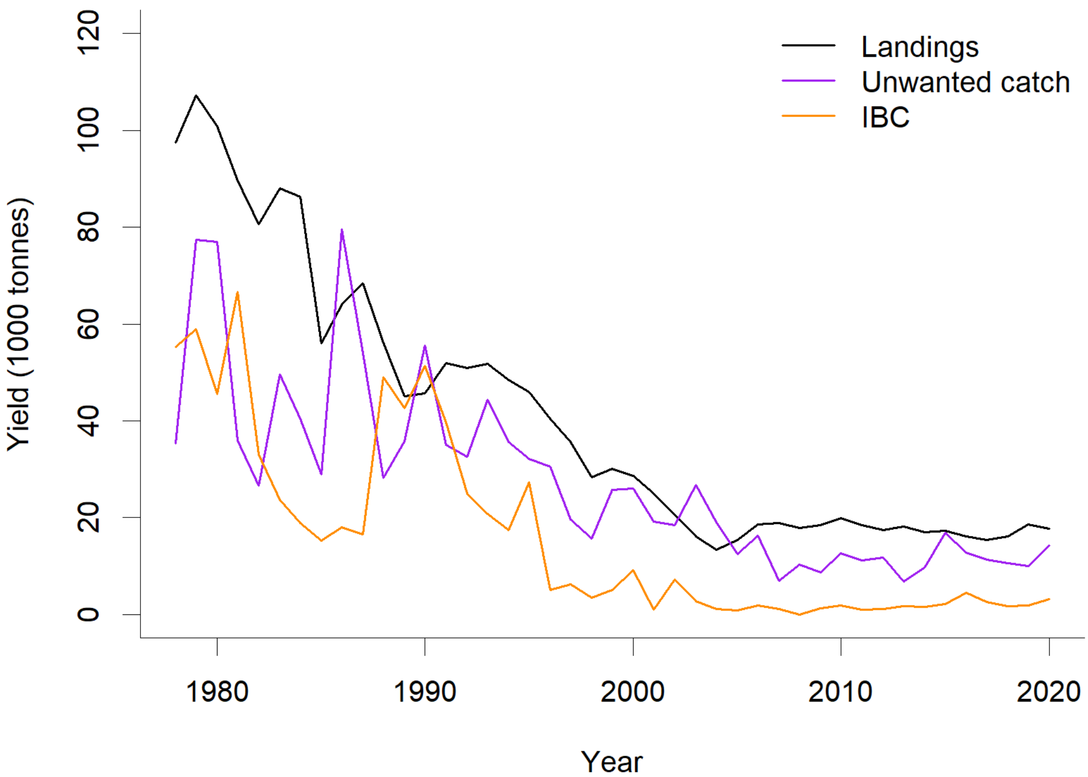


Figure 23.3. Whiting in Subarea 4 and Division 7.d: Yield by catch component. Unwanted catch or discards include BMS landings as estimated by ICES.

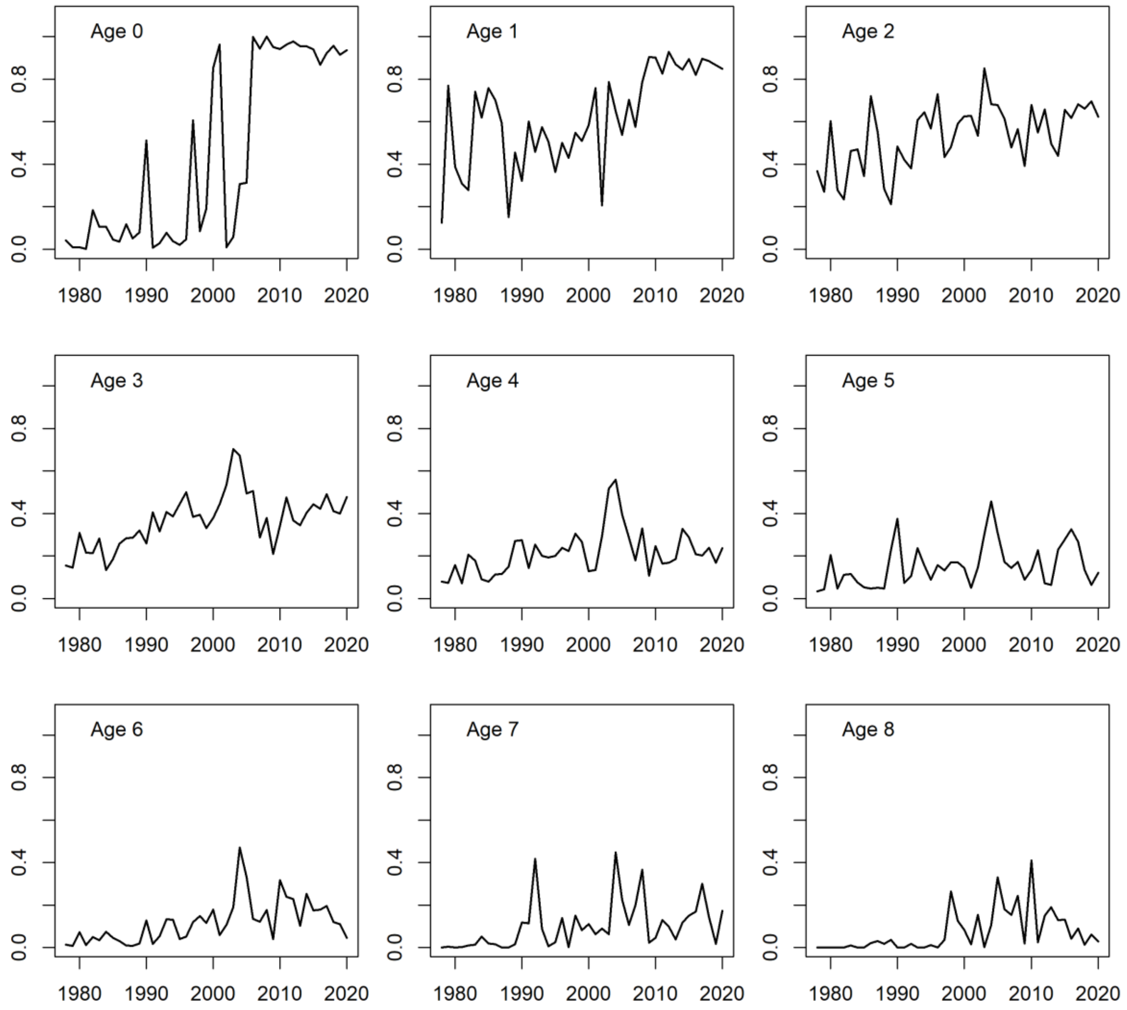


Figure 23.4. Whiting in Subarea 4 and Division 7.d: Proportion of discards in total catch, by age and year.

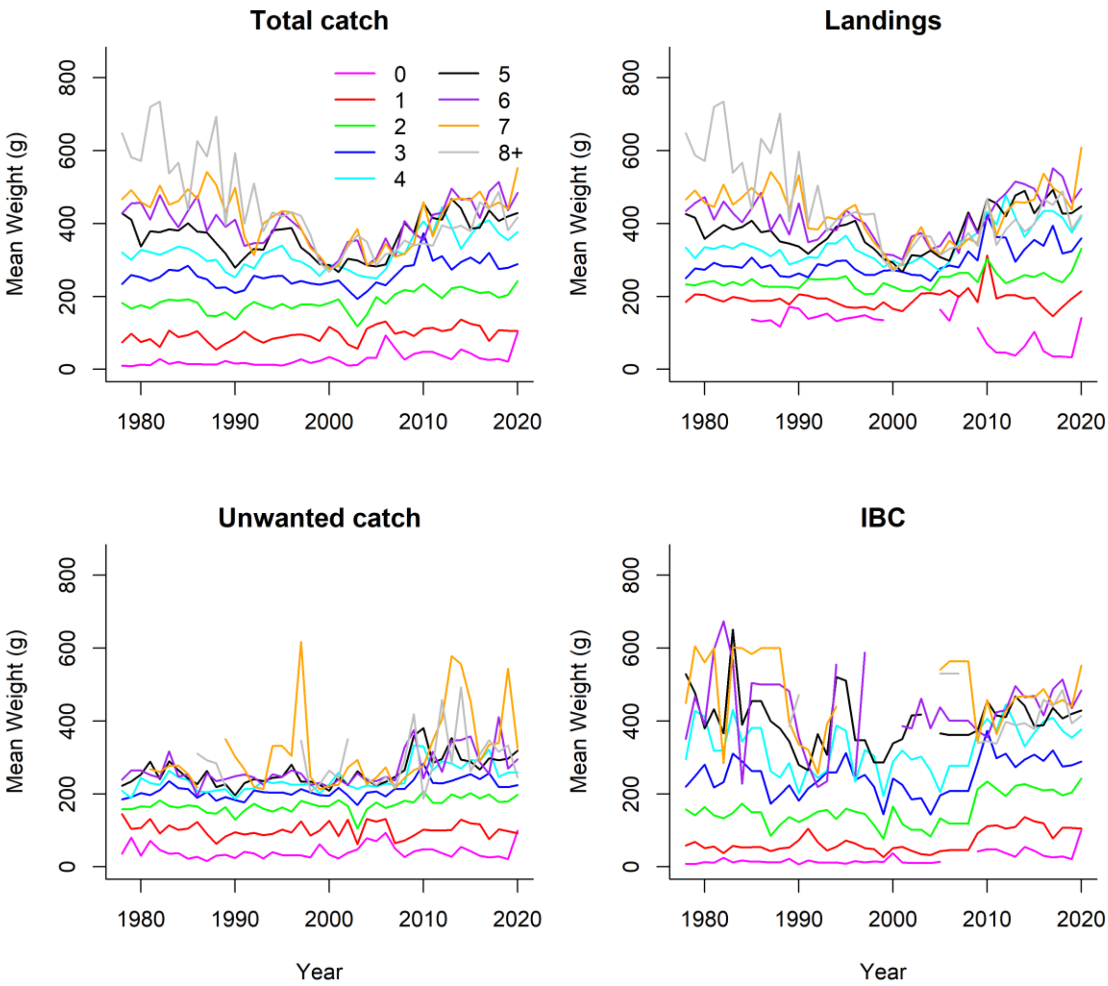


Figure 23.5. Whiting in Subarea 4 and Division 7.d: Mean weights-at-age (g) by catch component (black lines, age 0–8+).

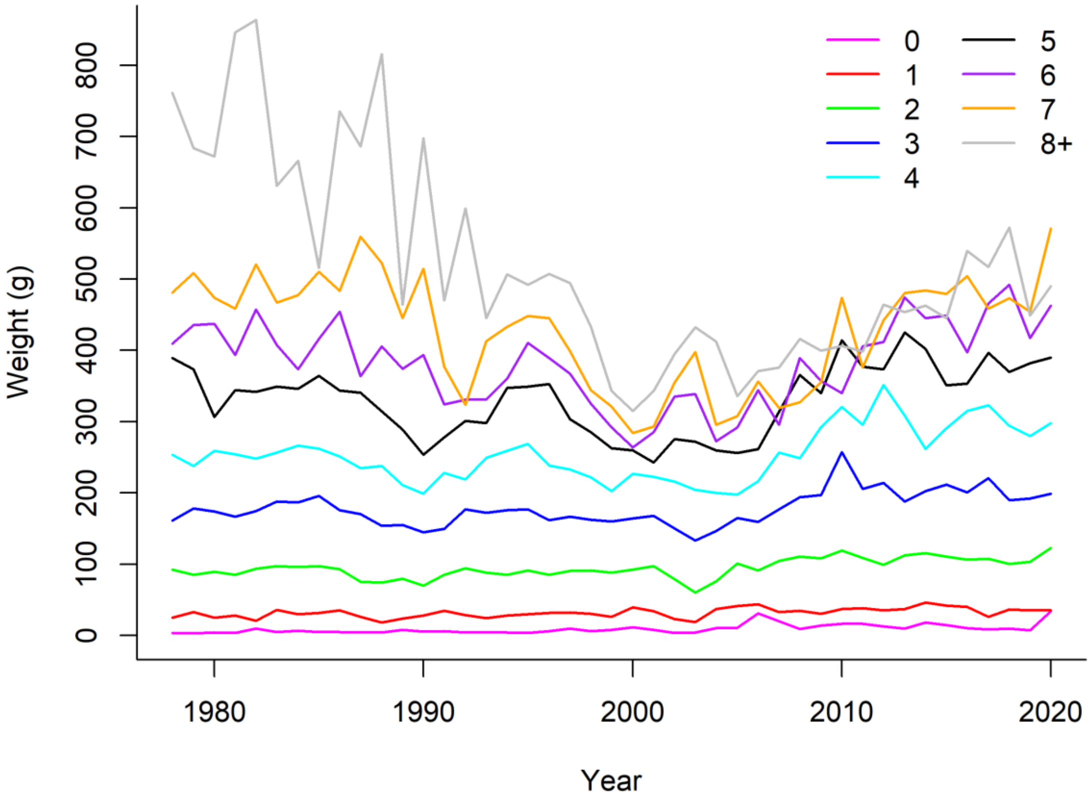


Figure 23.6. Whiting in Subarea 4 and Division 7.d: Stock mean weights-at-age (g) (age 0–8+).

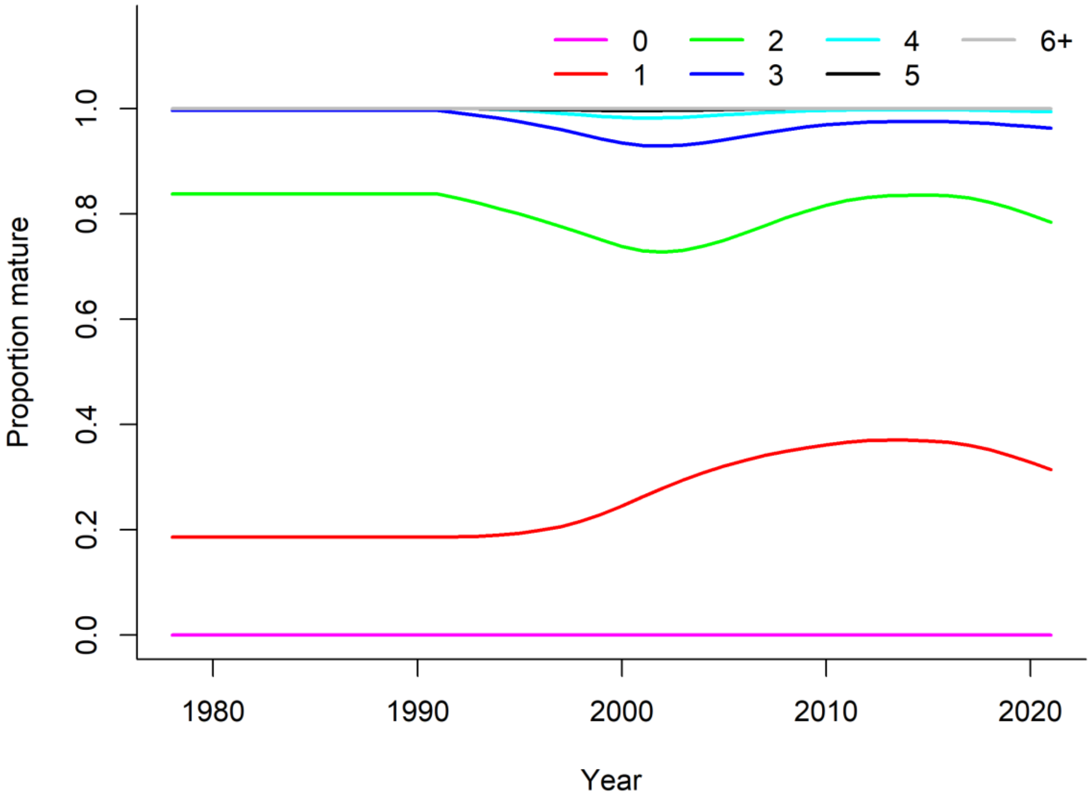


Figure 23.7. Whiting in Subarea 4 and Division 7.d: Maturity estimates from NS IBTS Q1 data. Ages 6–8+ have the same maturity values. Estimates prior 1991 are assumed constant using values of 1991.

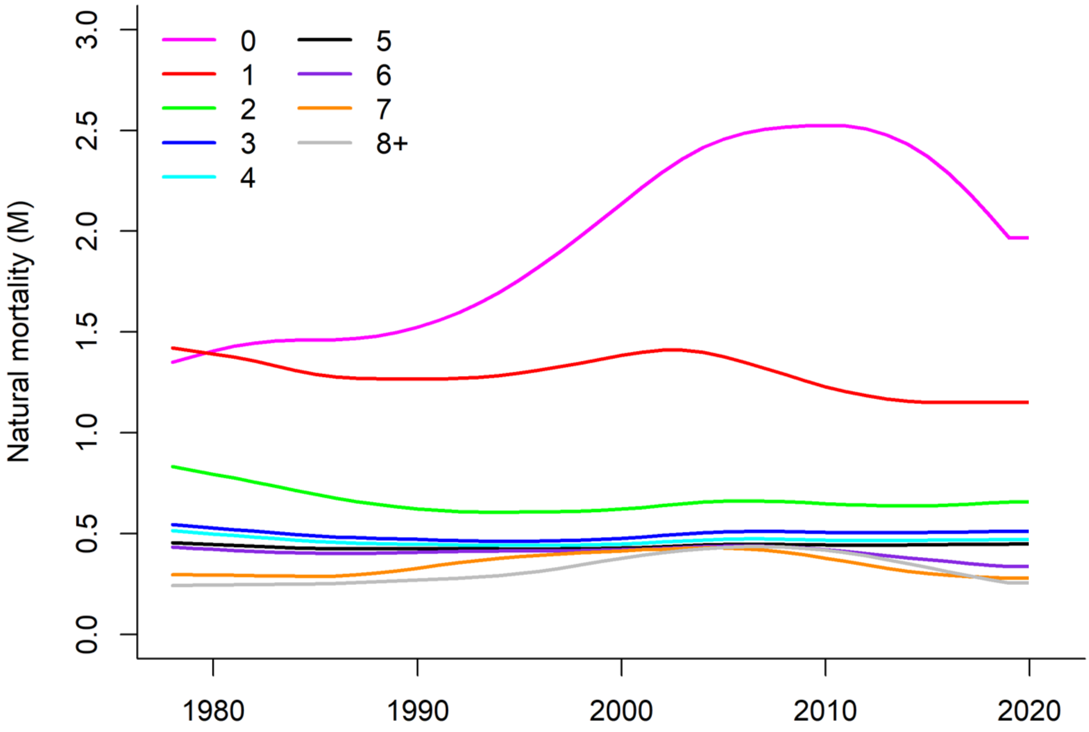


Figure 23.8. Whiting in Subarea 4 and Division 7.d: Natural mortality estimates from the 2020 update of SMS key run (WGSAM, 2021b) used in assessment.

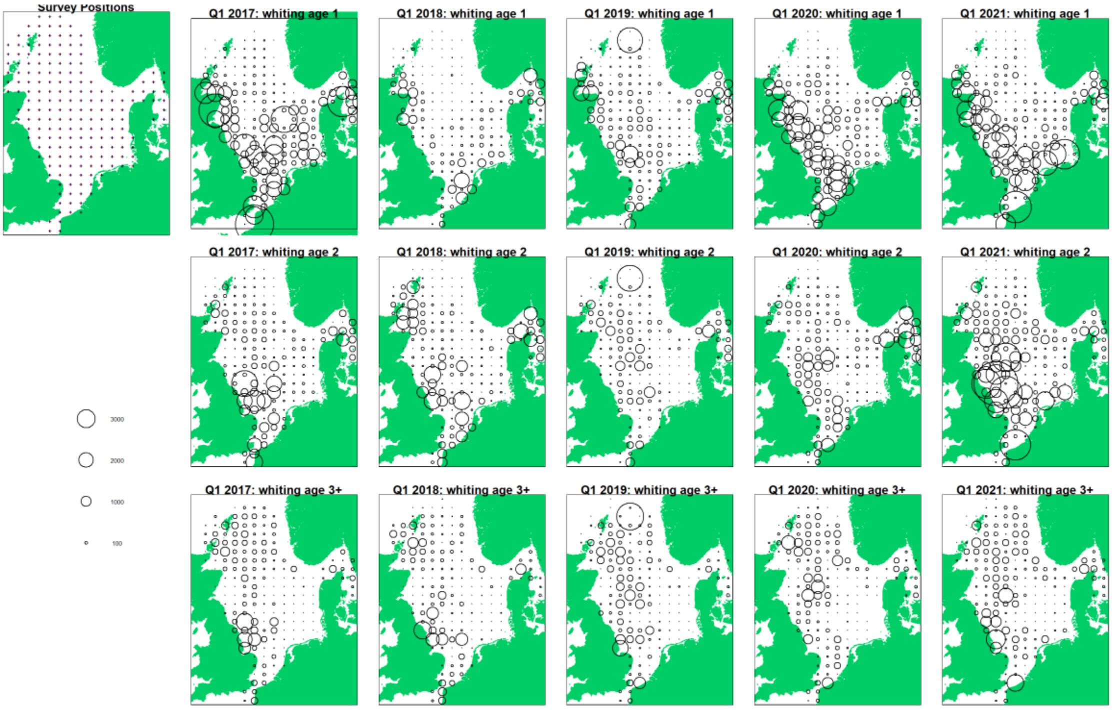


Figure 23.9. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for Ages 1–3+ Q1 2017–2021. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q1 survey in the North Sea.

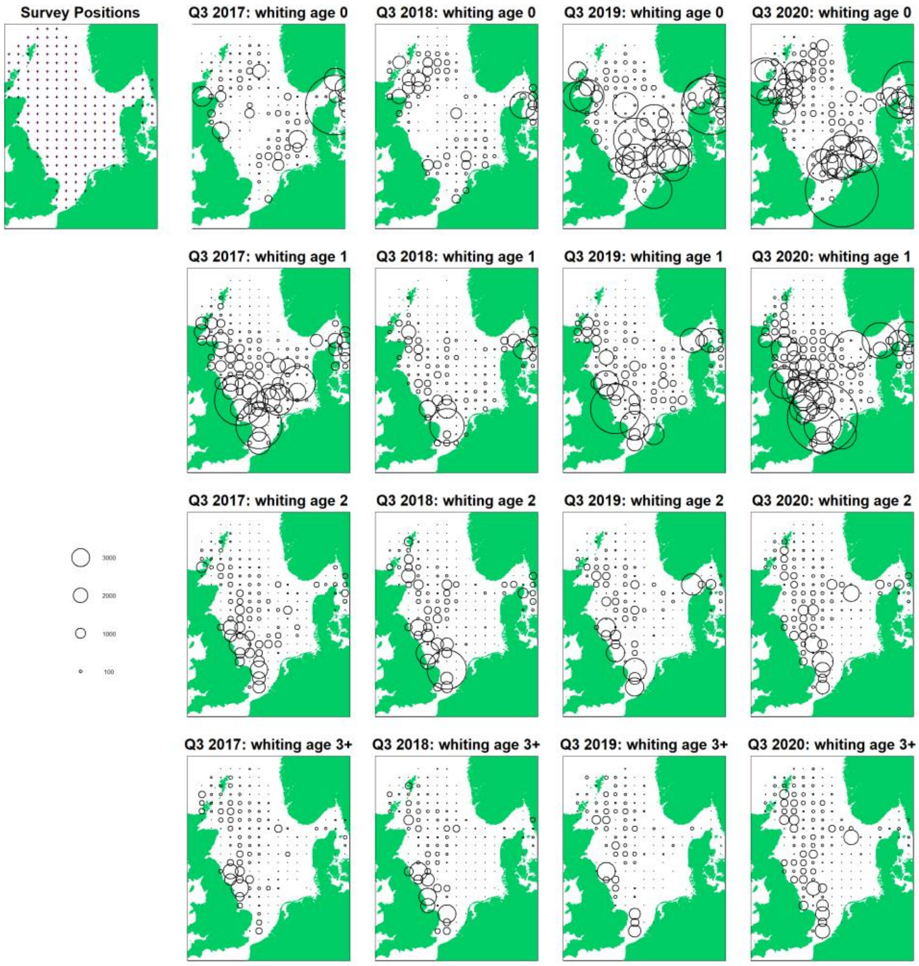


Figure 23.10. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for ages 0–3+ Q3 2017–2020. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q3 survey in the North Sea.

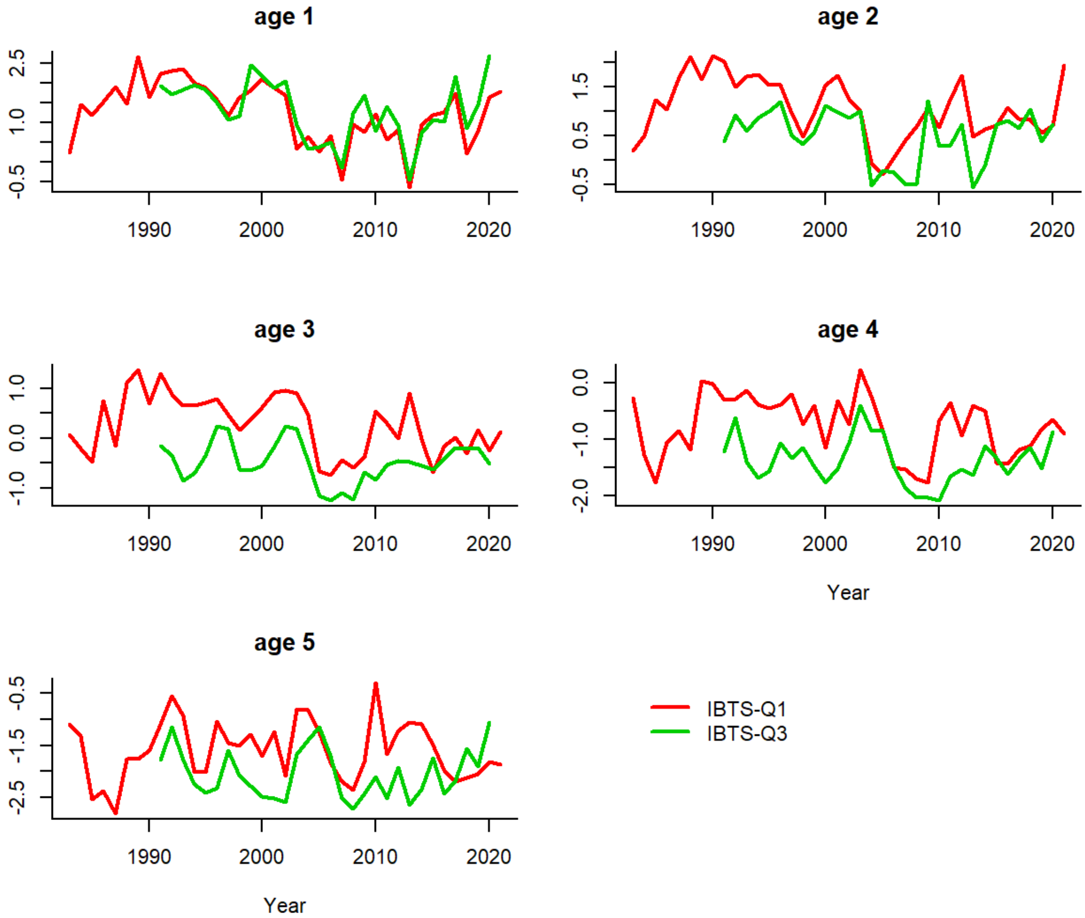


Figure 23.11. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) at age.

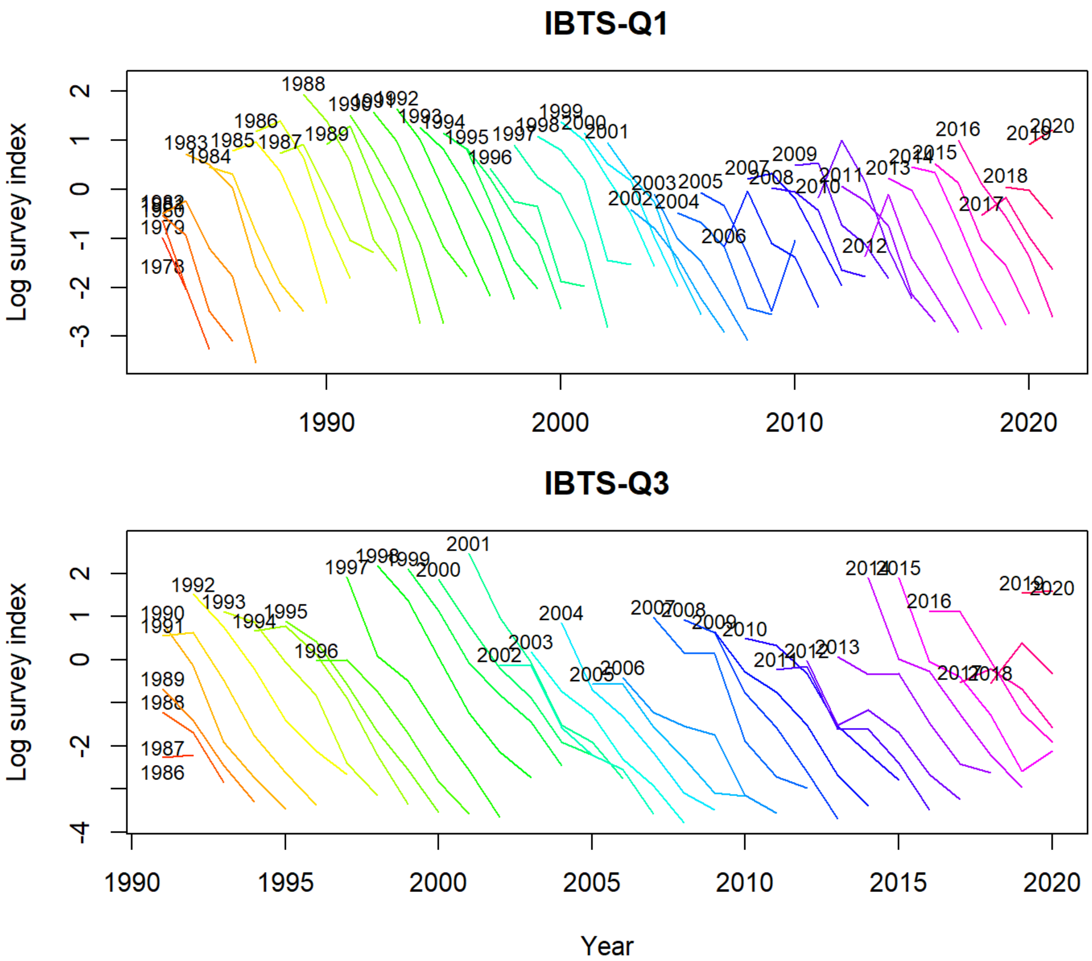


Figure 23.12. Whiting in Subarea 4 and Division 7.d: Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

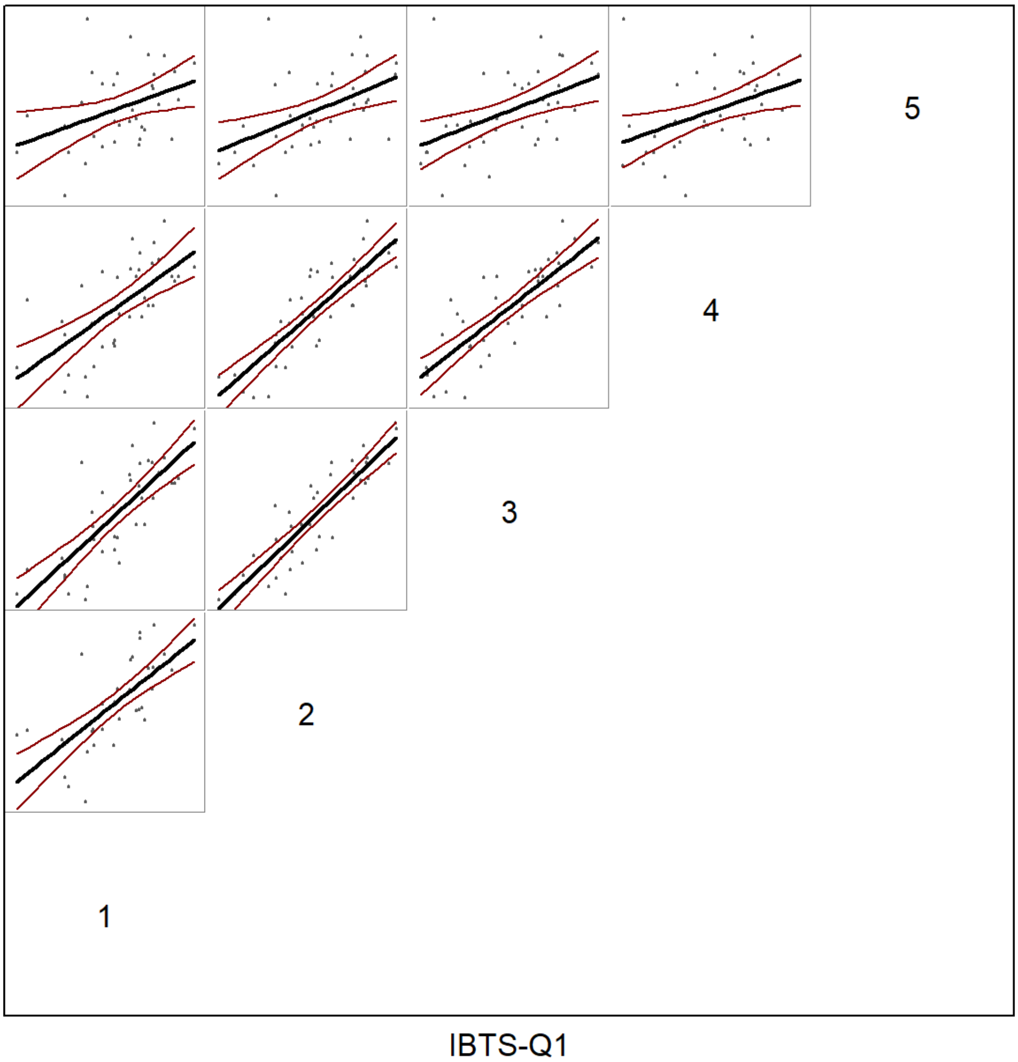


Figure 23.13. Within-survey correlations for the IBTS–Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

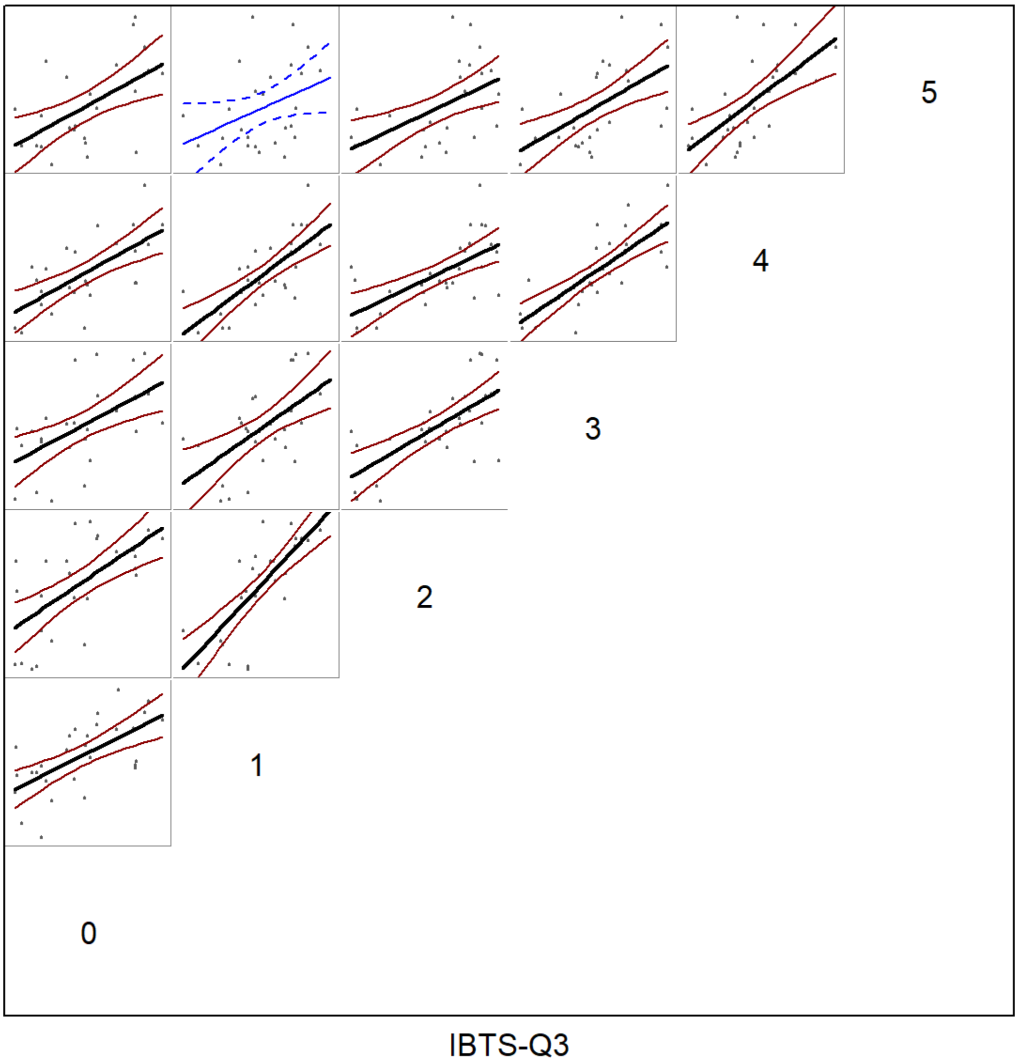


Figure 23.14. Within-survey correlations for the IBTS–Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

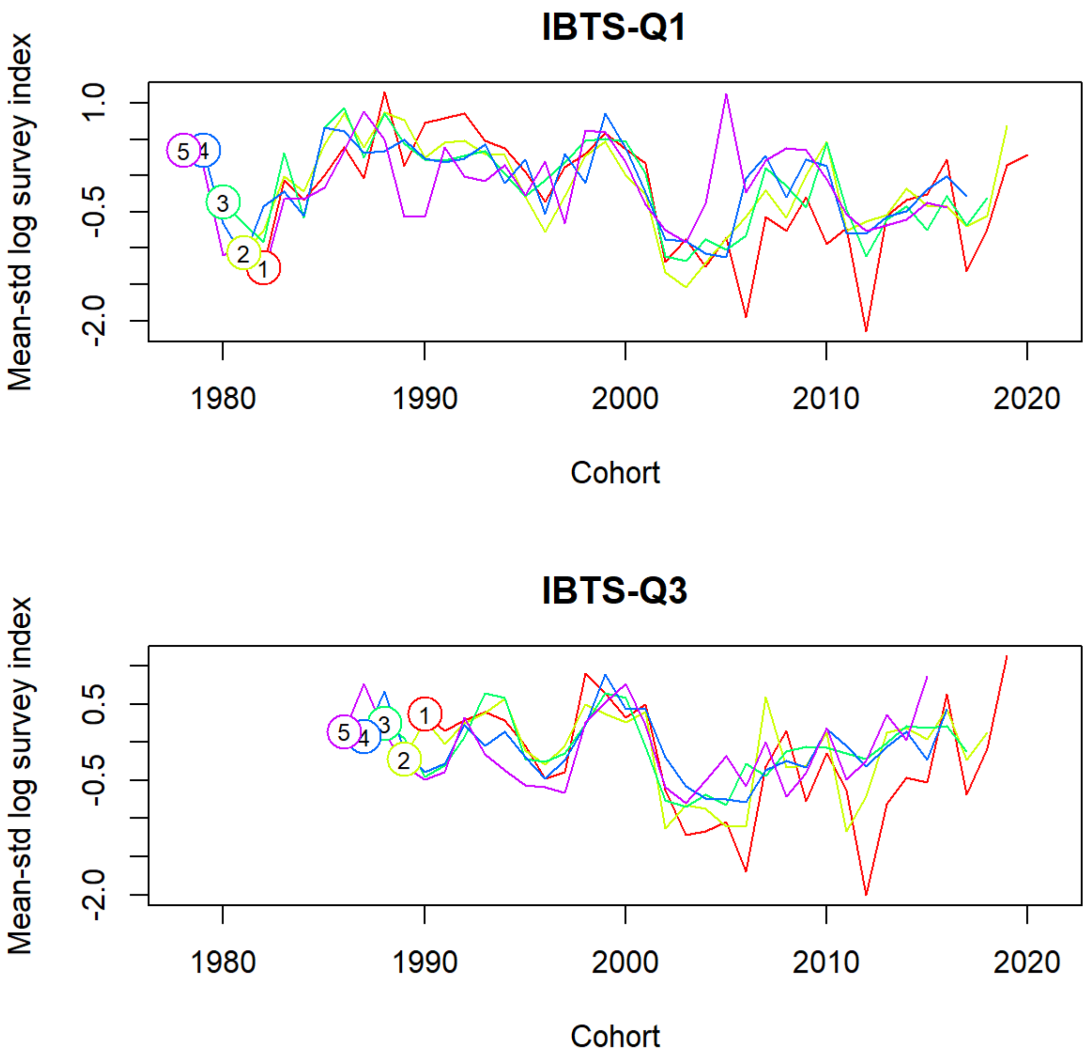


Figure 23.15. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) for the IBTS–Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

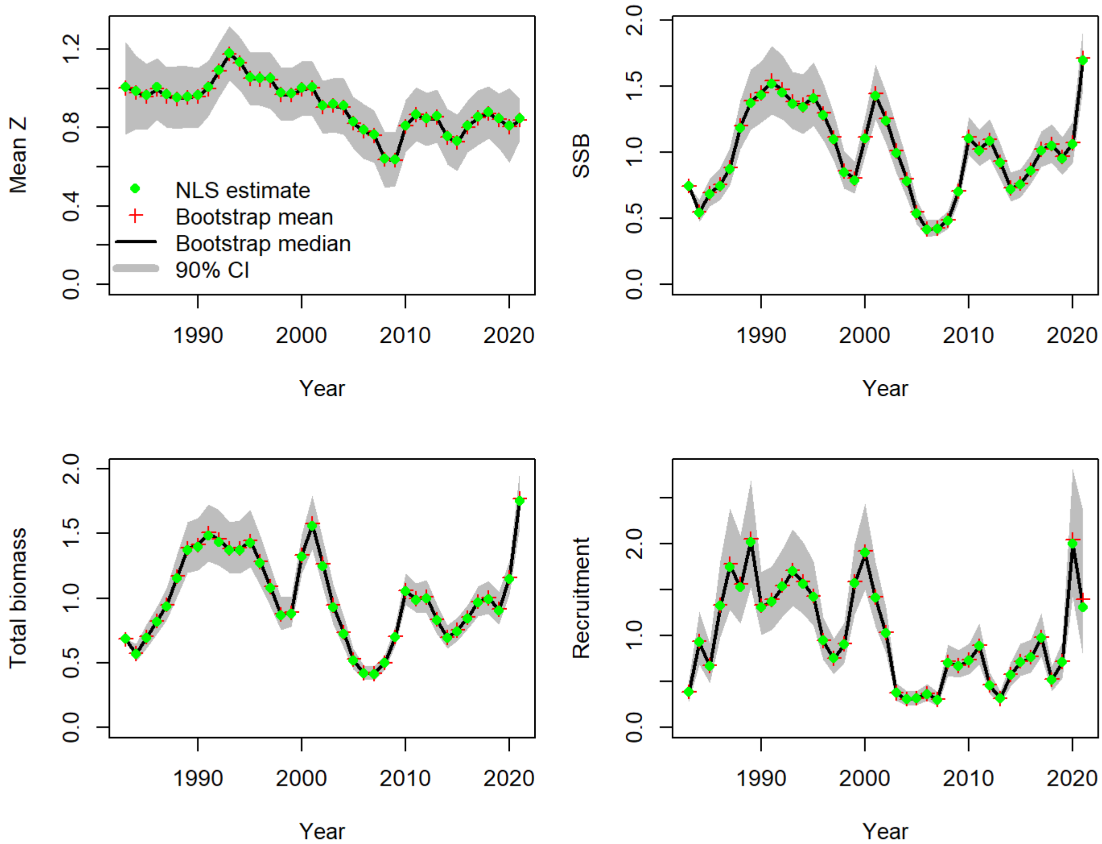
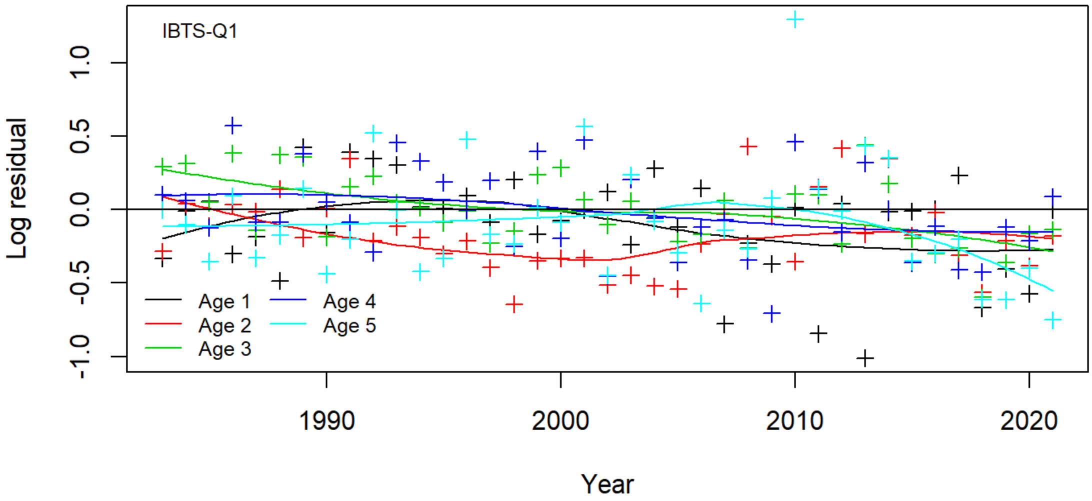


Figure 23.16. Whiting in Subarea 4 and Division 7.d: Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment (age 1). Shaded grey areas 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.



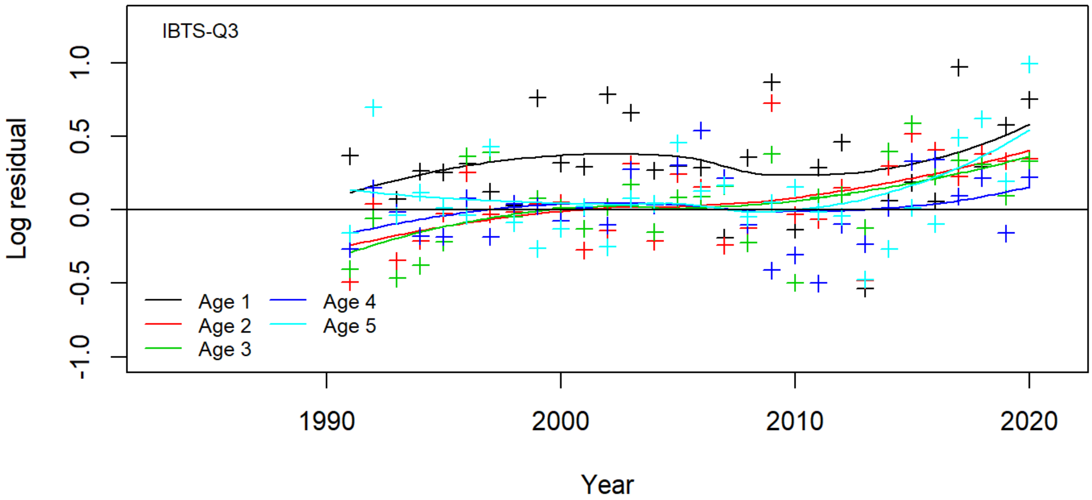


Figure 23.17. Whiting in Subarea 4 and Division 7.d: Log survey residuals from the SURBAR analysis. Ages are color-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

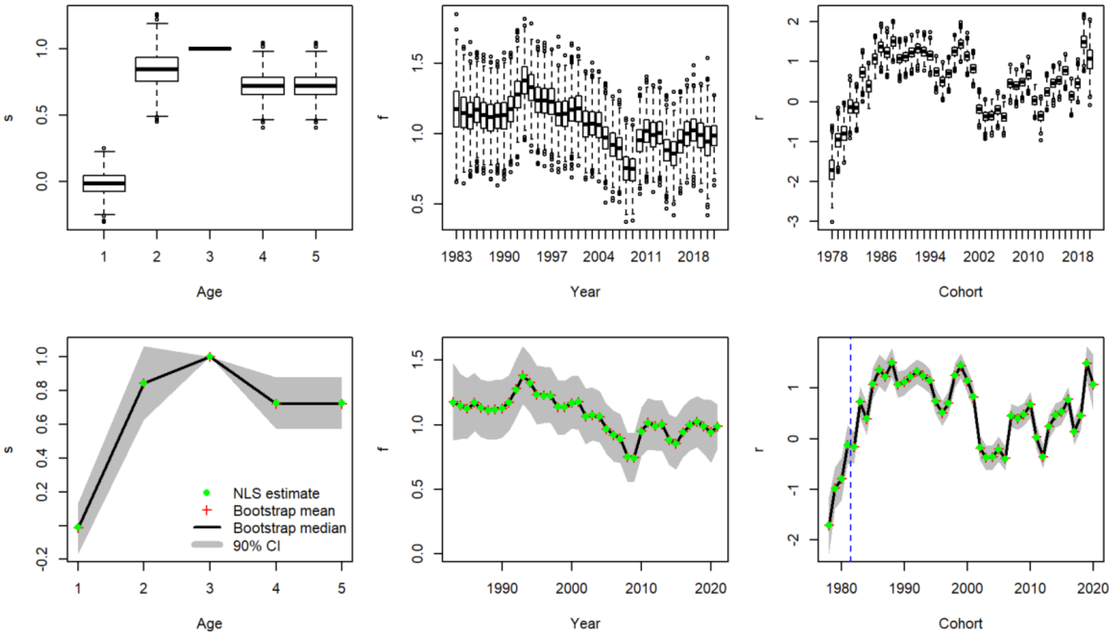


Figure 23.18. Whiting in Subarea 4 and Division 7.d: Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

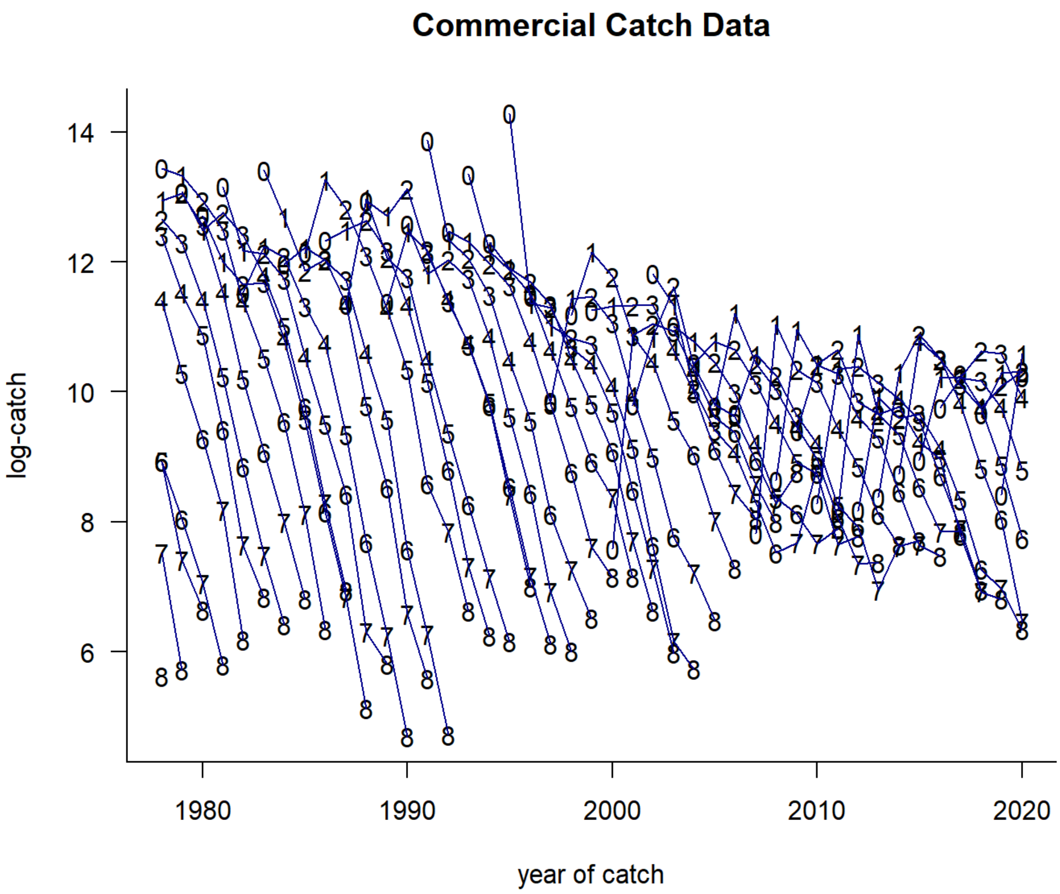


Figure 23.19. Whiting in Subarea 4 and Division 7.d: Log-catch curves by cohort for total catches (ages 0–8+).

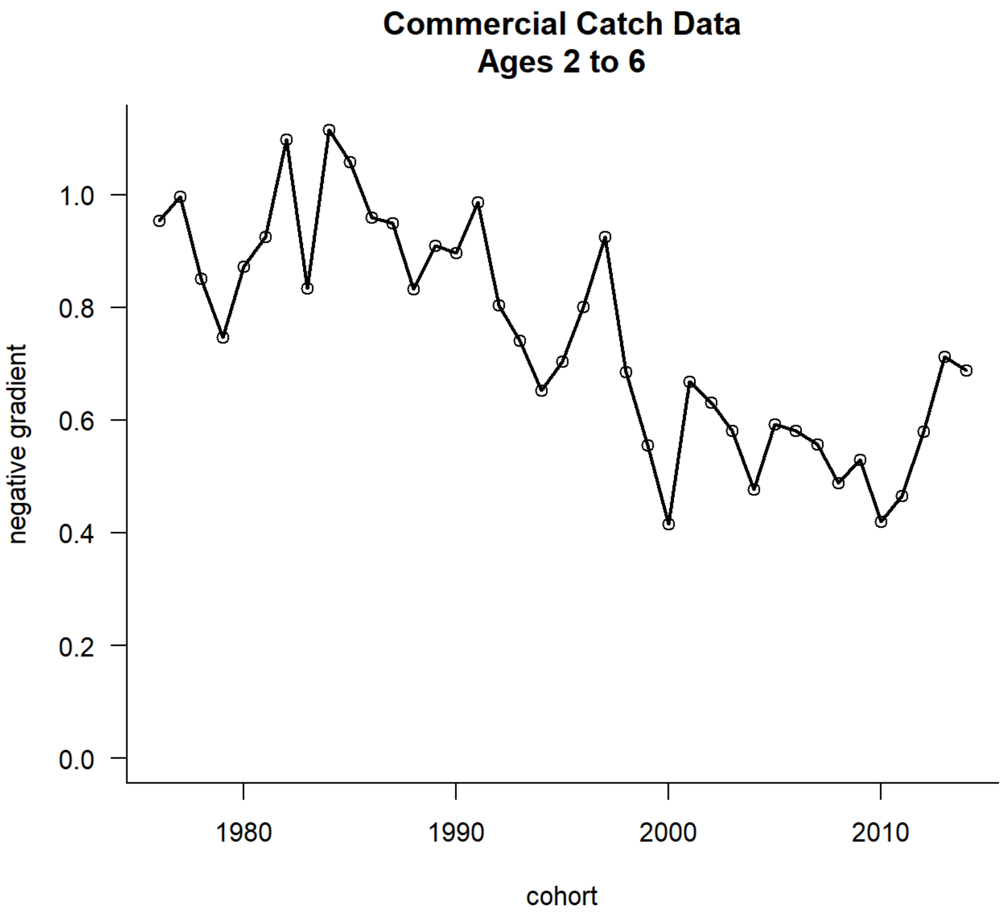


Figure 23.20. Whiting in Subarea 4 and Division 7.d: Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

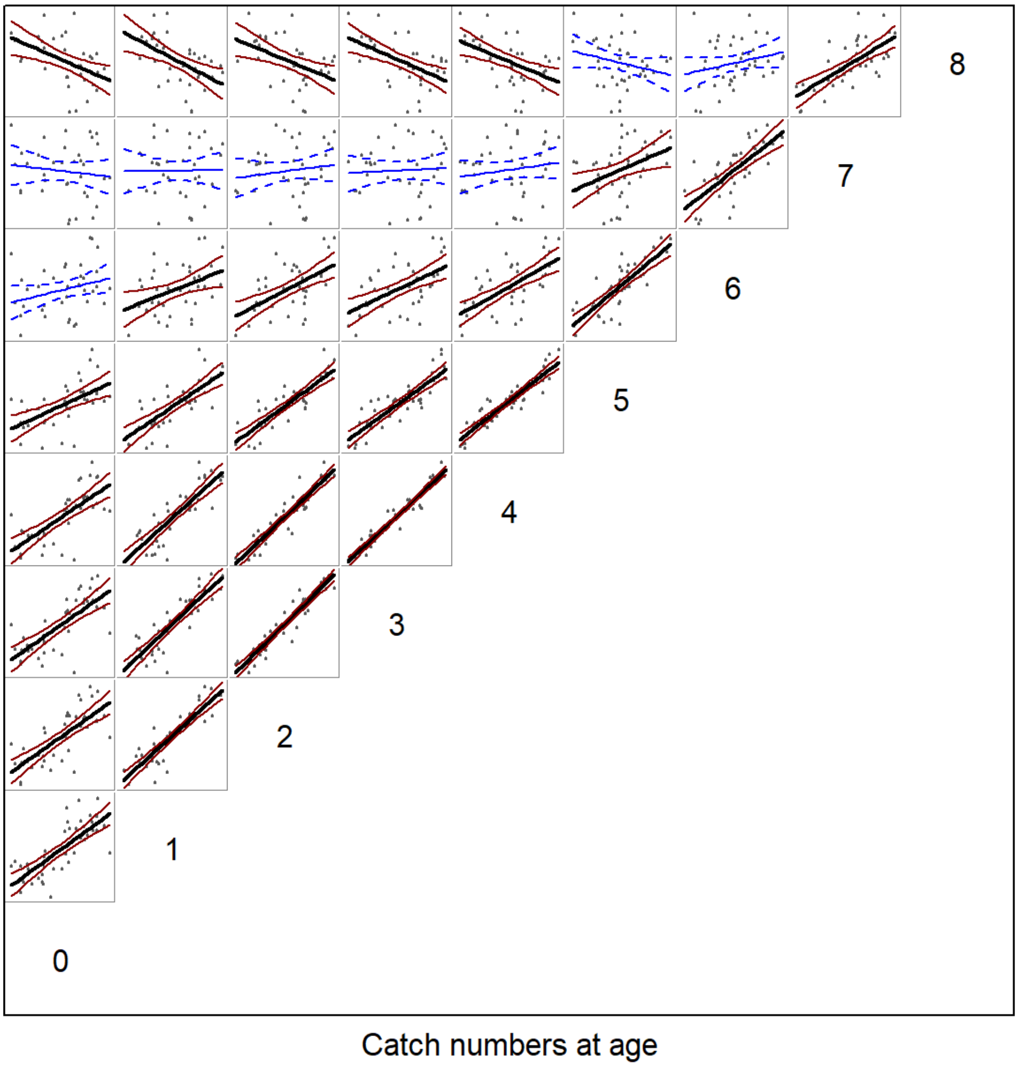
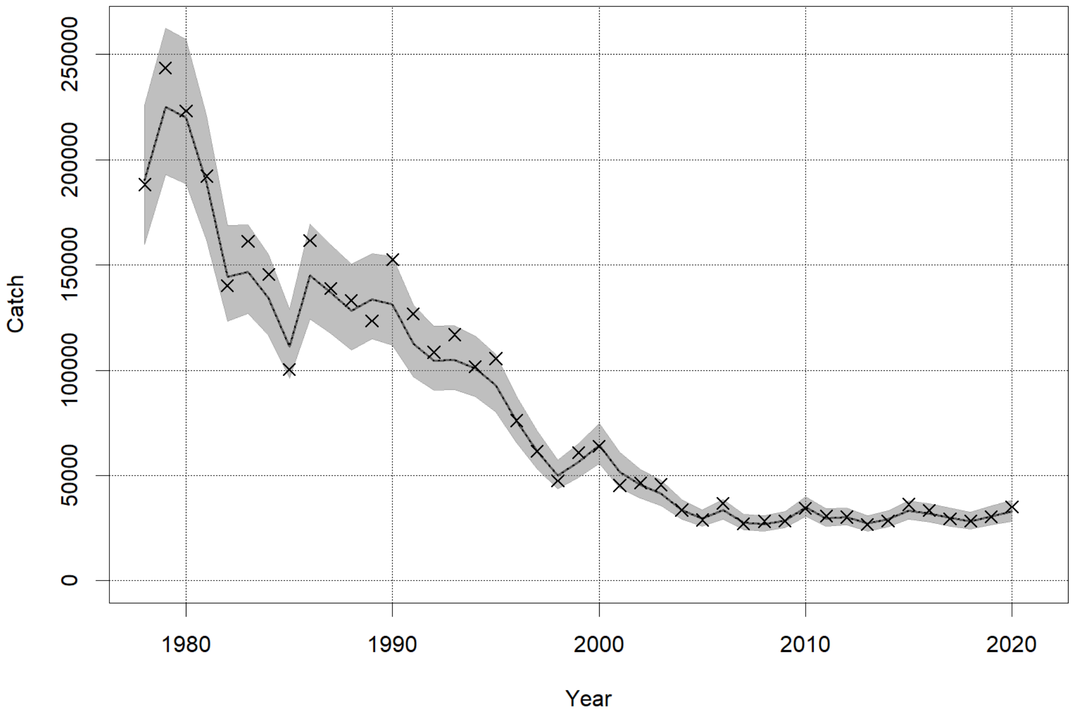
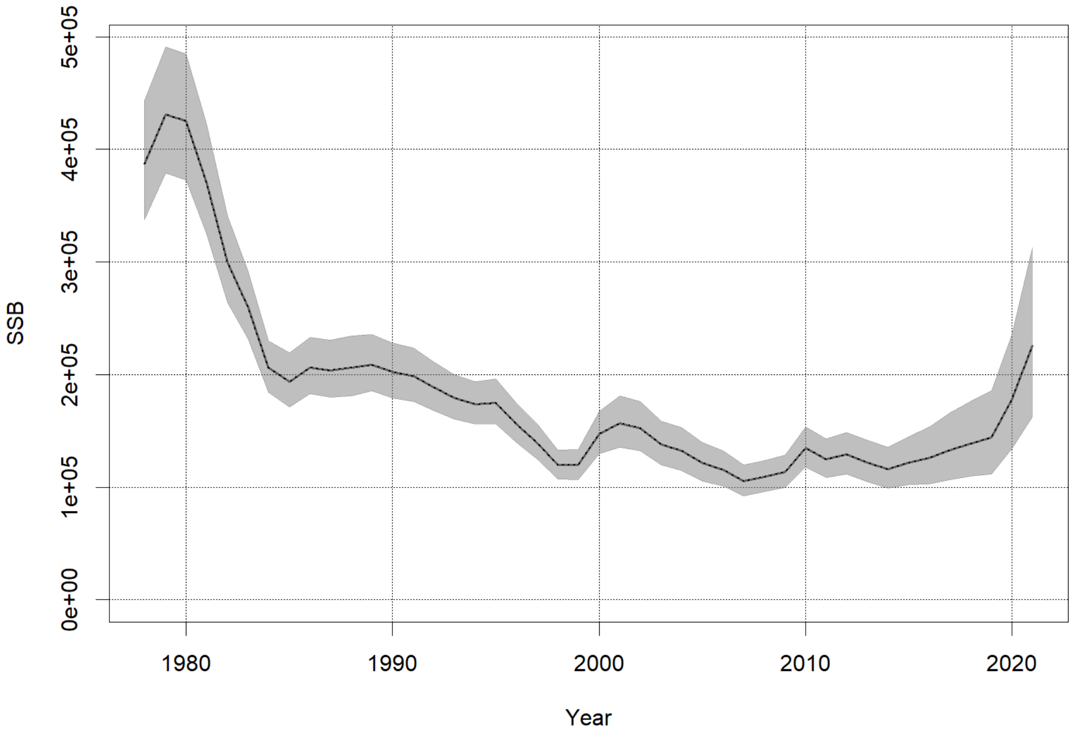
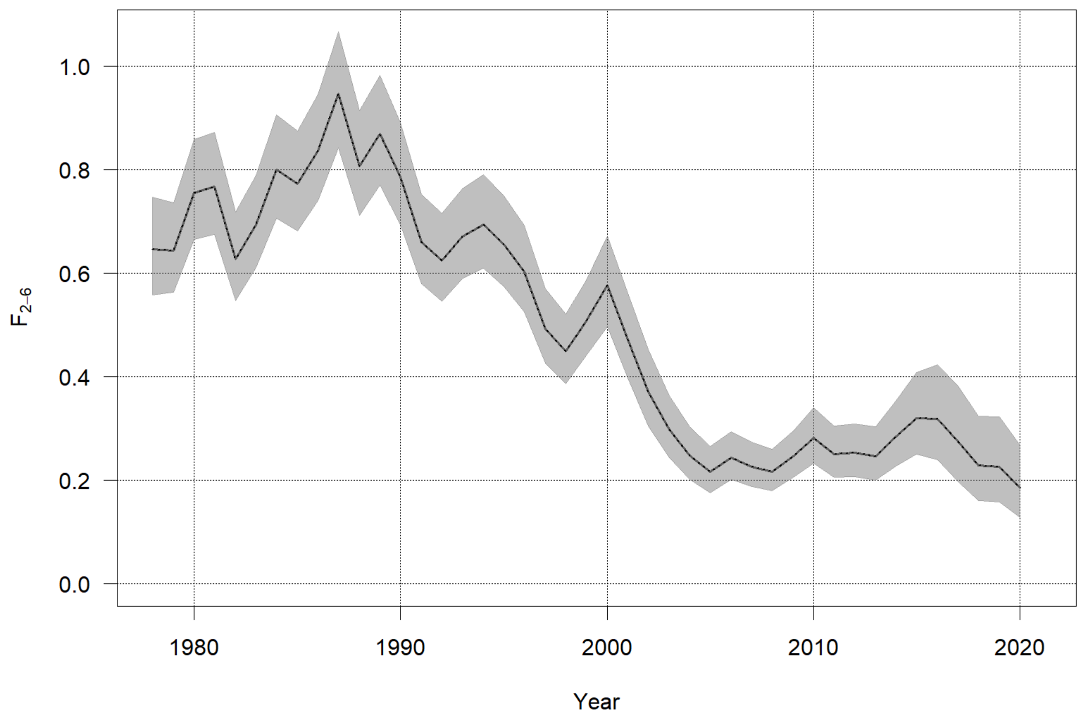


Figure 23.21. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black 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.


Catch
Year
0
50000
100000
150000
200000
250000
1980
1990
2000
2010
2020


SSB
Year
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
1980
1990
2000
2010
2020



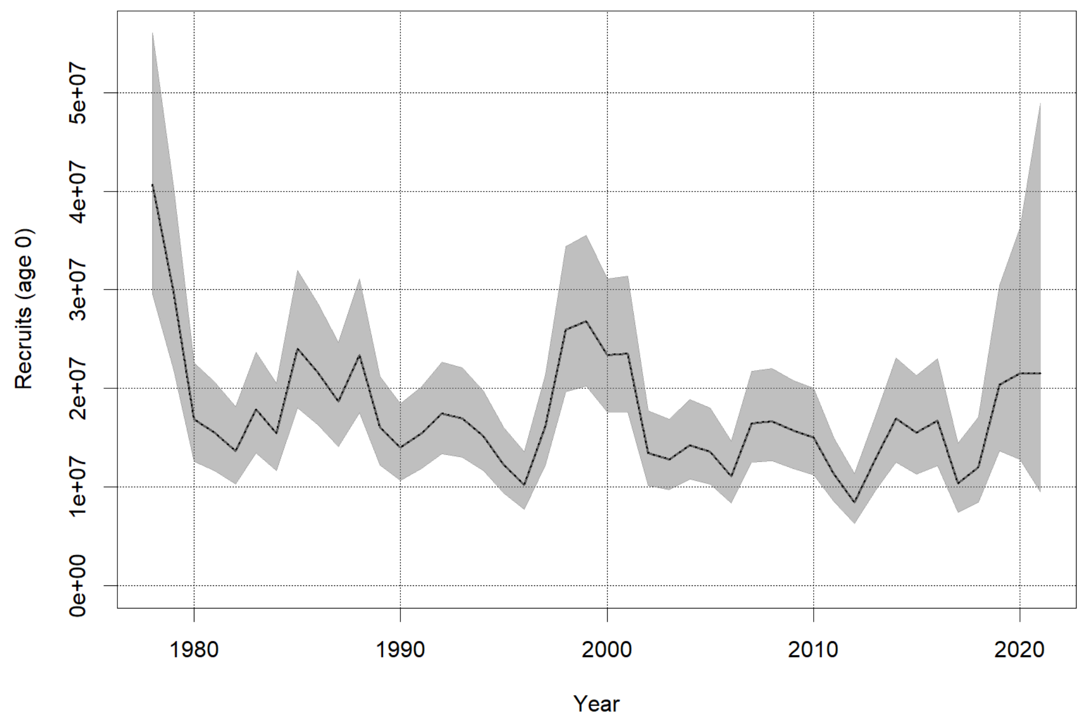


Figure 23.22. Whiting in Subarea 4 and Division 7.d: SAM assessment results using catch data series (1978–2019) with IBTS survey data starting in 1983 (Q1) and 1991 (Q3). Estimates with 95% Confidence intervals for total catch weight, SSB, mean fishing mortality and recruitment (at age 0).

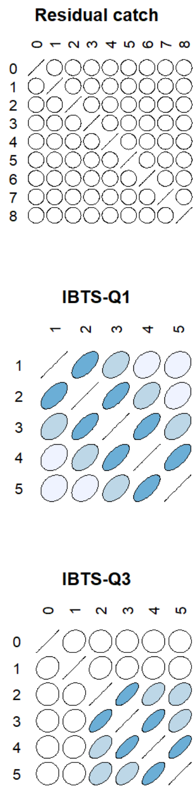


Figure 23.23. Whiting in Subarea 4 and Division 7.d: SAM estimated correlations between age groups for each fleet.

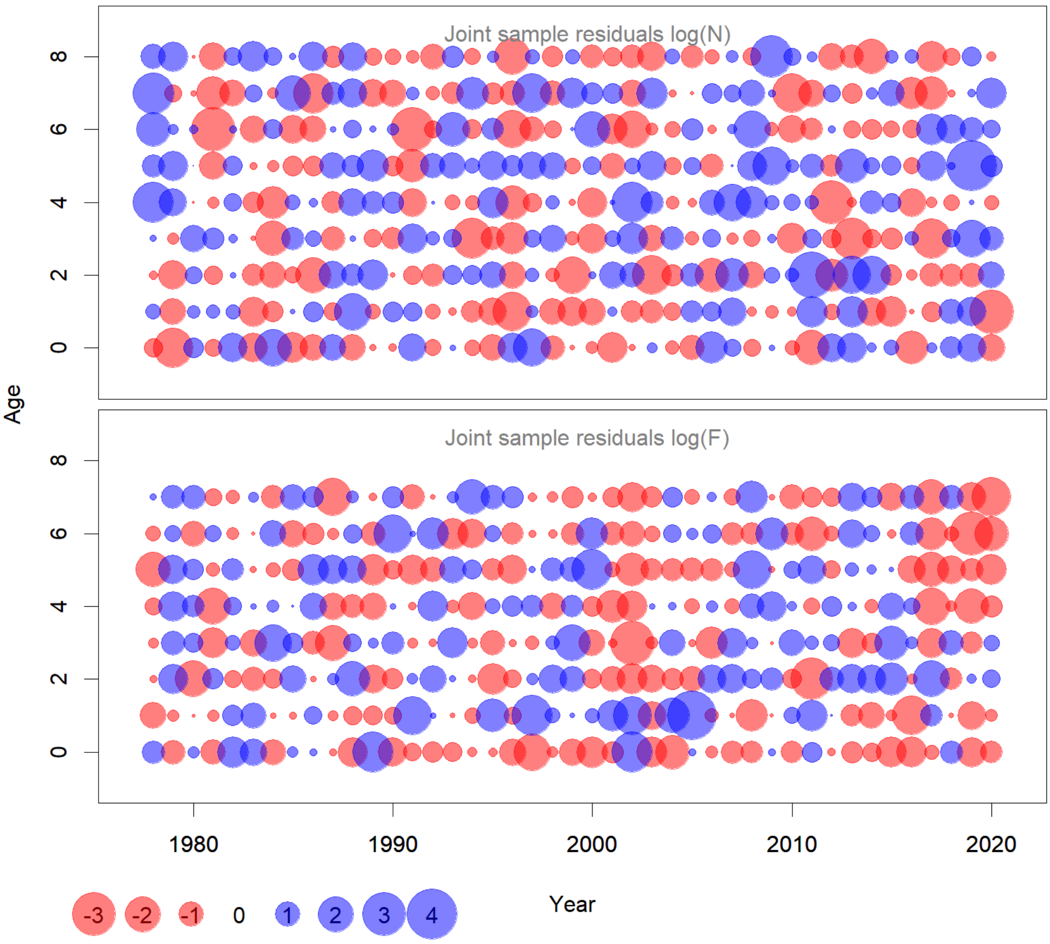


Figure 23.24. Whiting in Subarea 4 and Division 7.d: SAM standardised joint-sample residuals of process increments (for stock size N and fishing mortality F processes).

Figure 23.25. Whiting in Subarea 4 and Division 7.d: SAM standardized one-observation-ahead residuals.

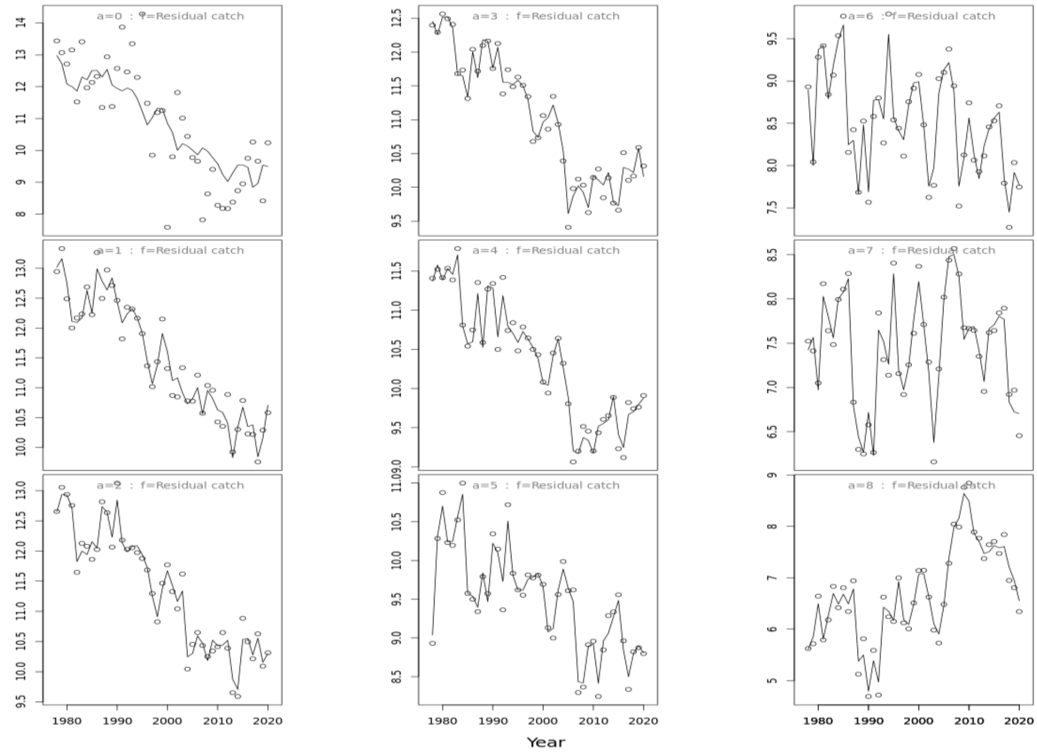


Figure 23.26. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale) for the catch fleet.

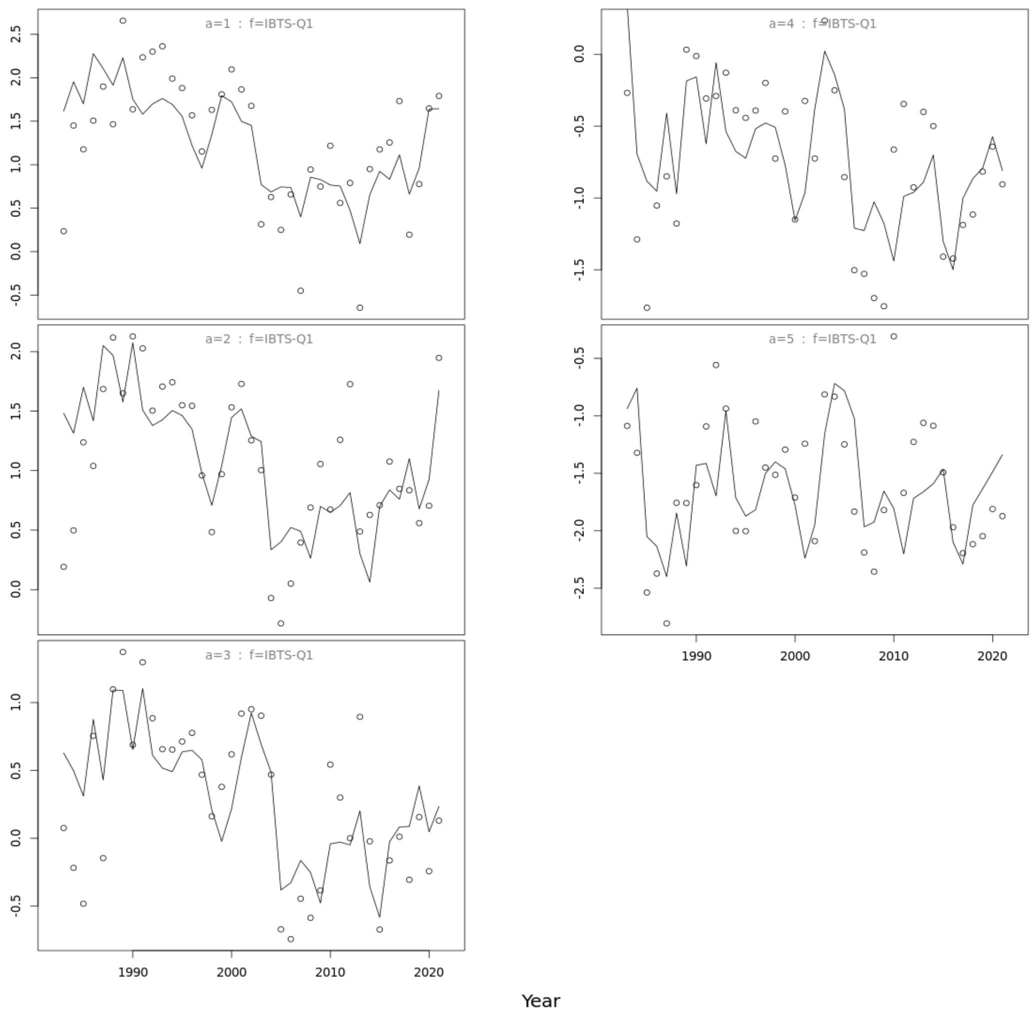


Figure 23.27. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q1.

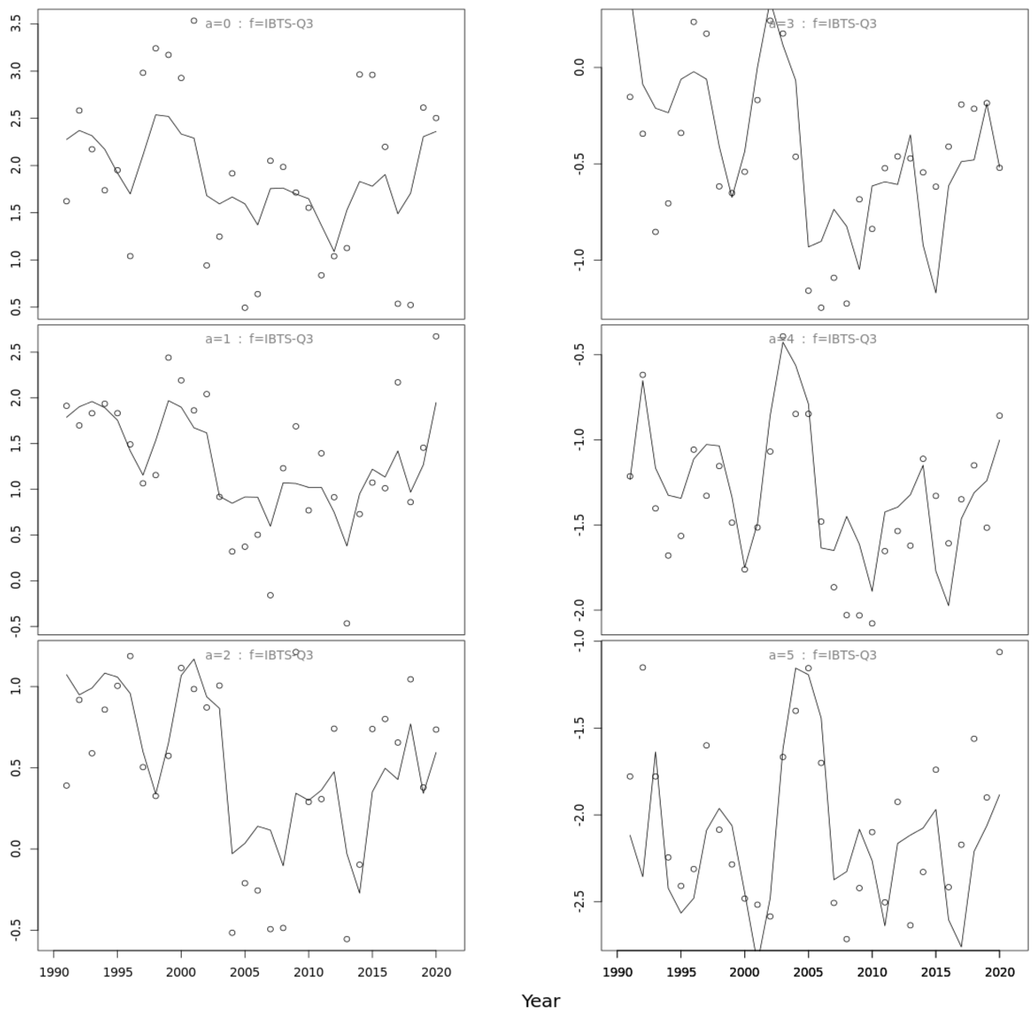
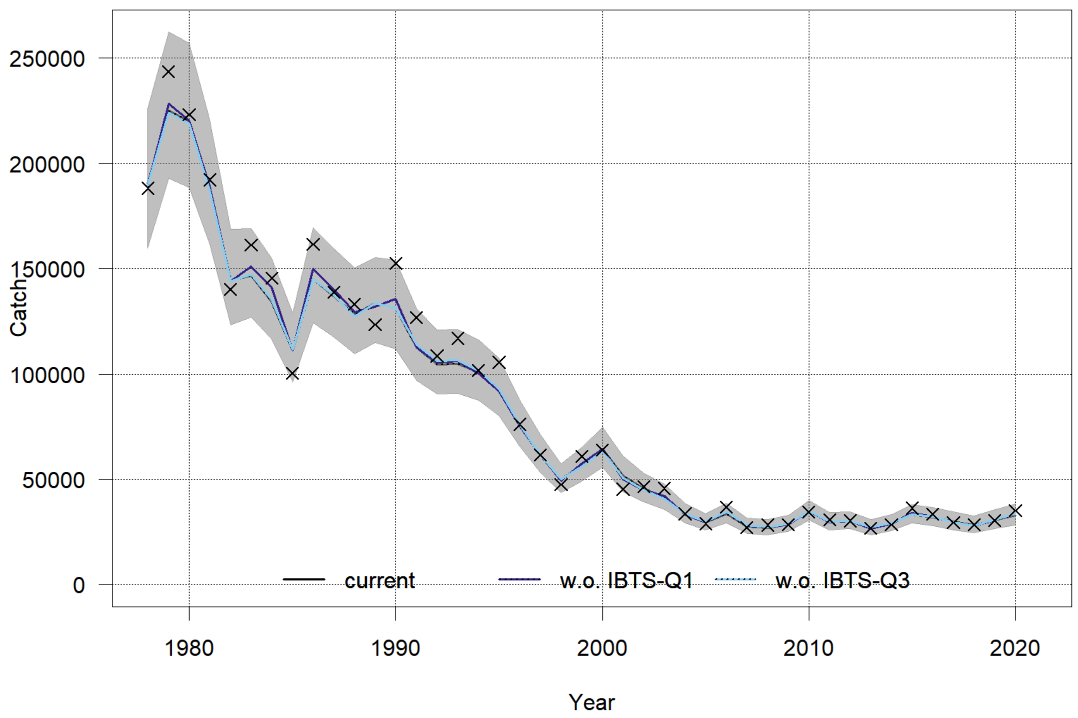
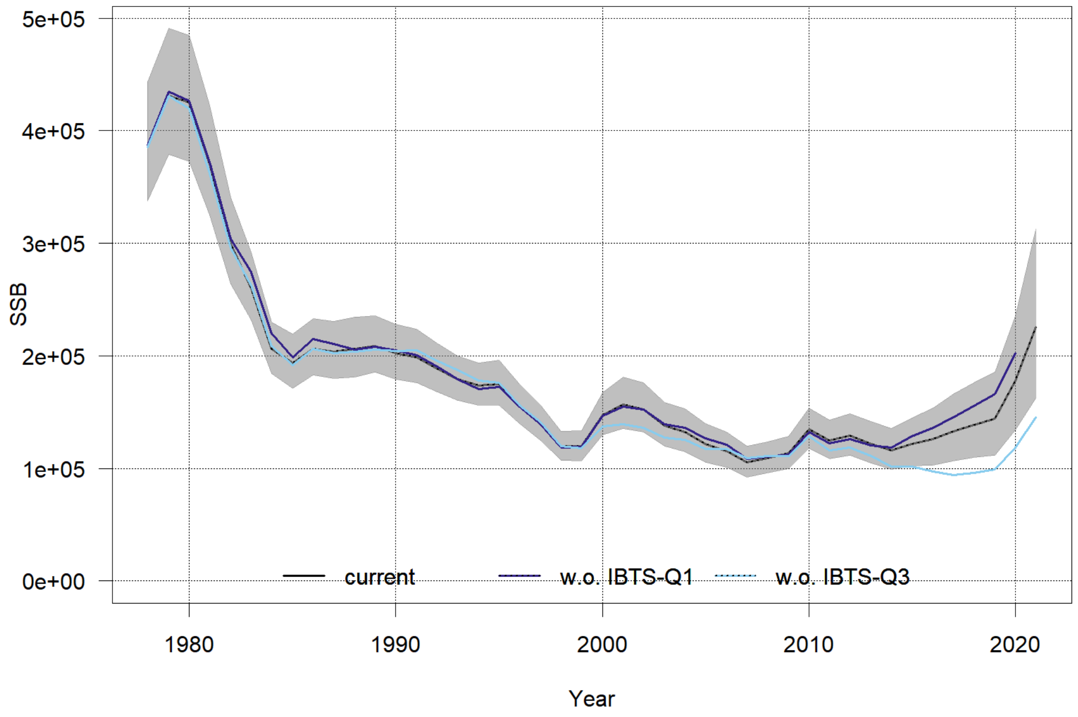


Figure 23.28. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q3.


Catch
250000
200000
150000
100000
50000
0
1980
1990
2000
2010
2020
Year
current
w.o. IBTS-Q1
w.o. IBTS-Q3


SSB
5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
1980
1990
2000
2010
2020
Year
current
w.o. IBTS-Q1
w.o. IBTS-Q3

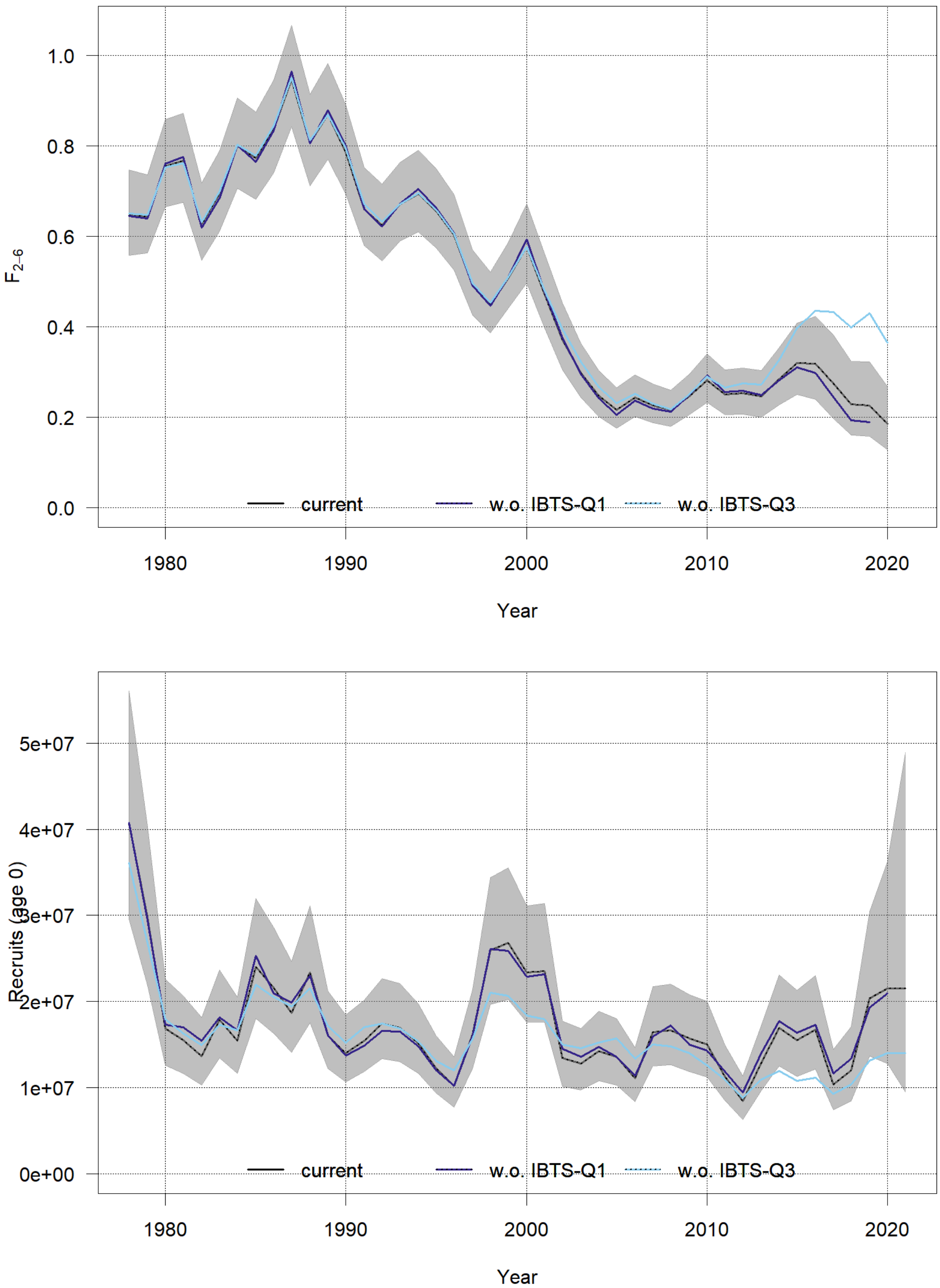
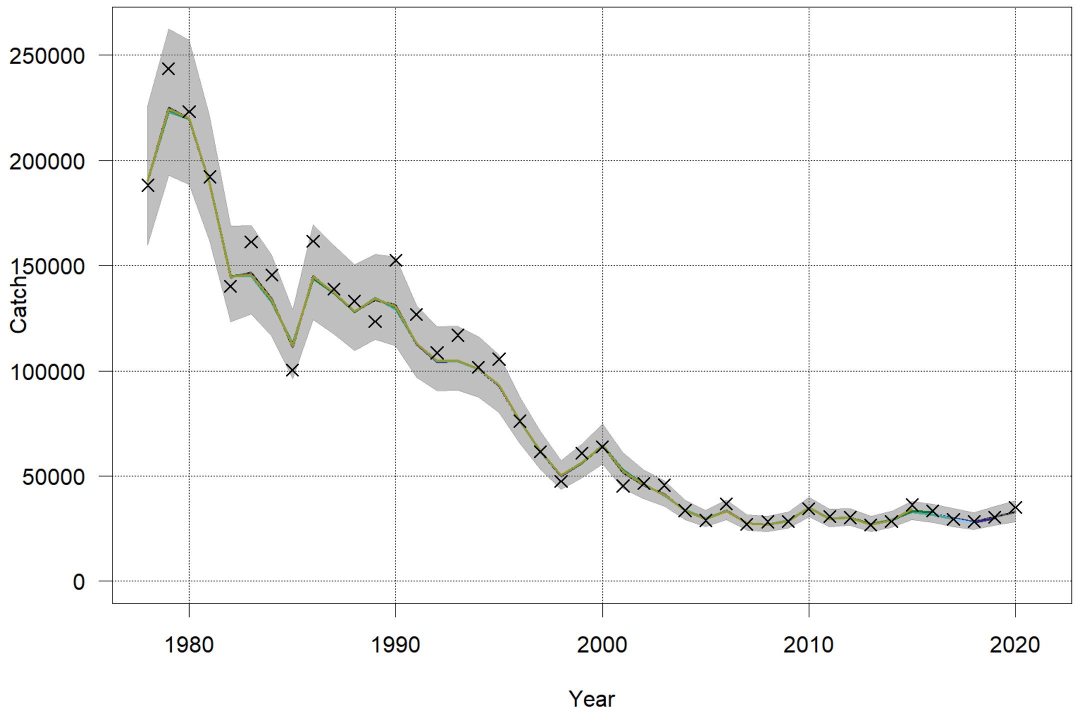
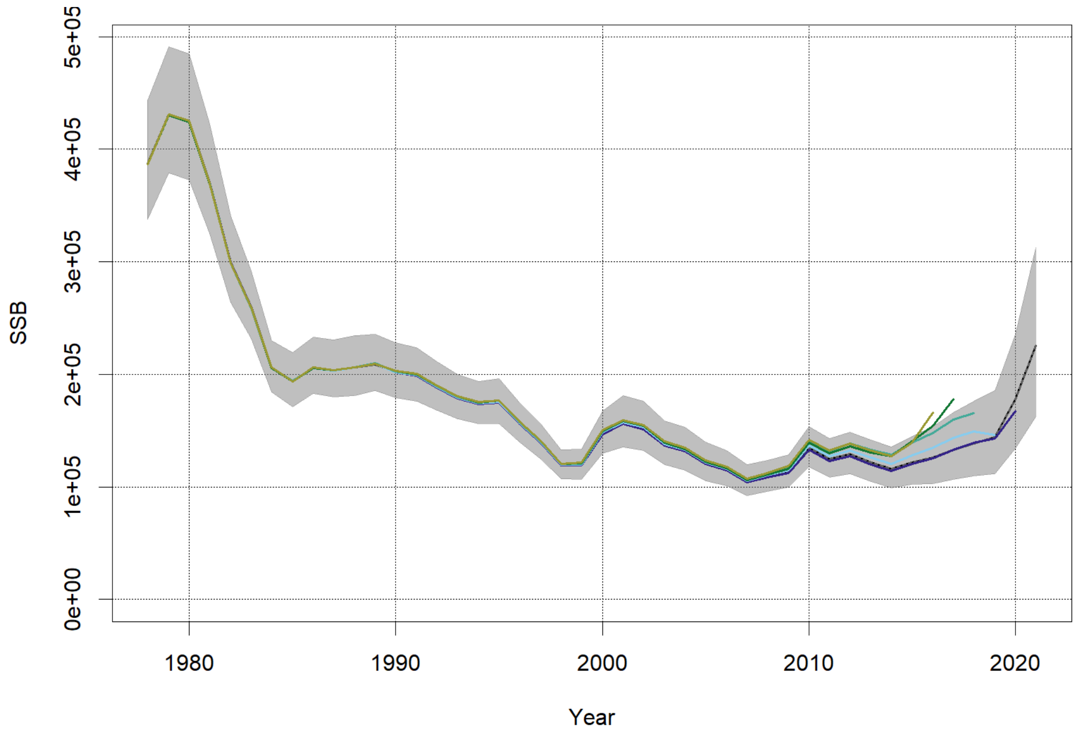
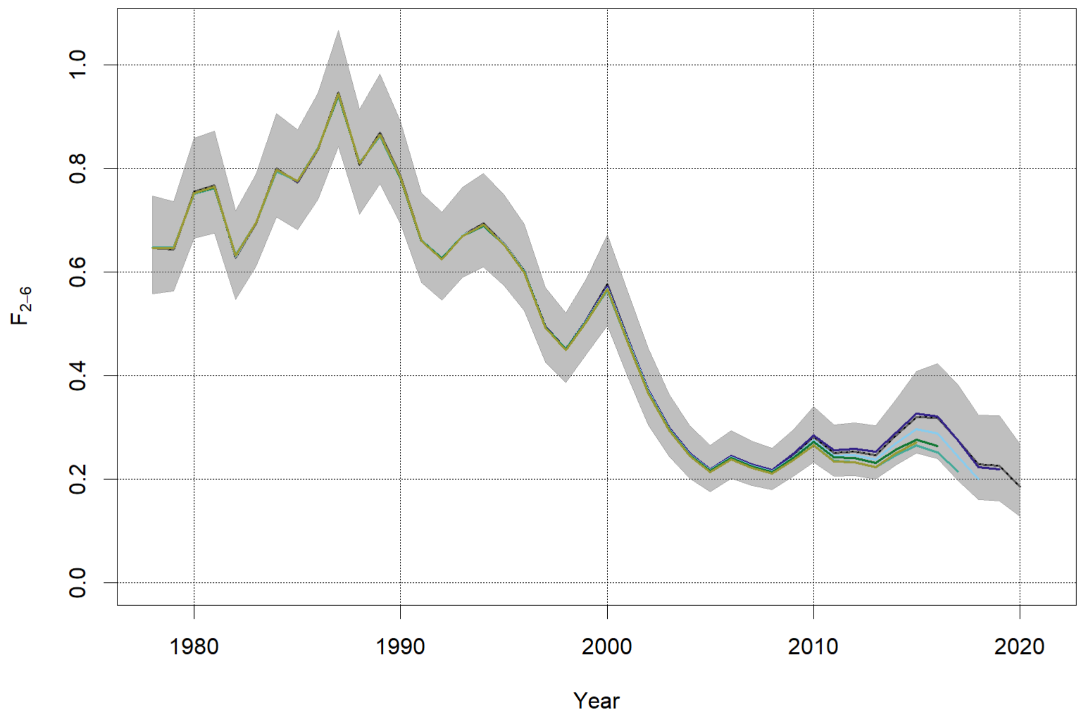


Figure 23.29. Whiting in Subarea 4 and Division 7.d: SAM leave-one-out diagnostics. Final run (black), run without IBTS Q1 (dark blue), run without IBTS Q3 (light blue).


250000
200000
150000
100000
50000
0
Catch
1980
1990
2000
2010
2020
Year


5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
SSB
1980
1990
2000
2010
2020
Year



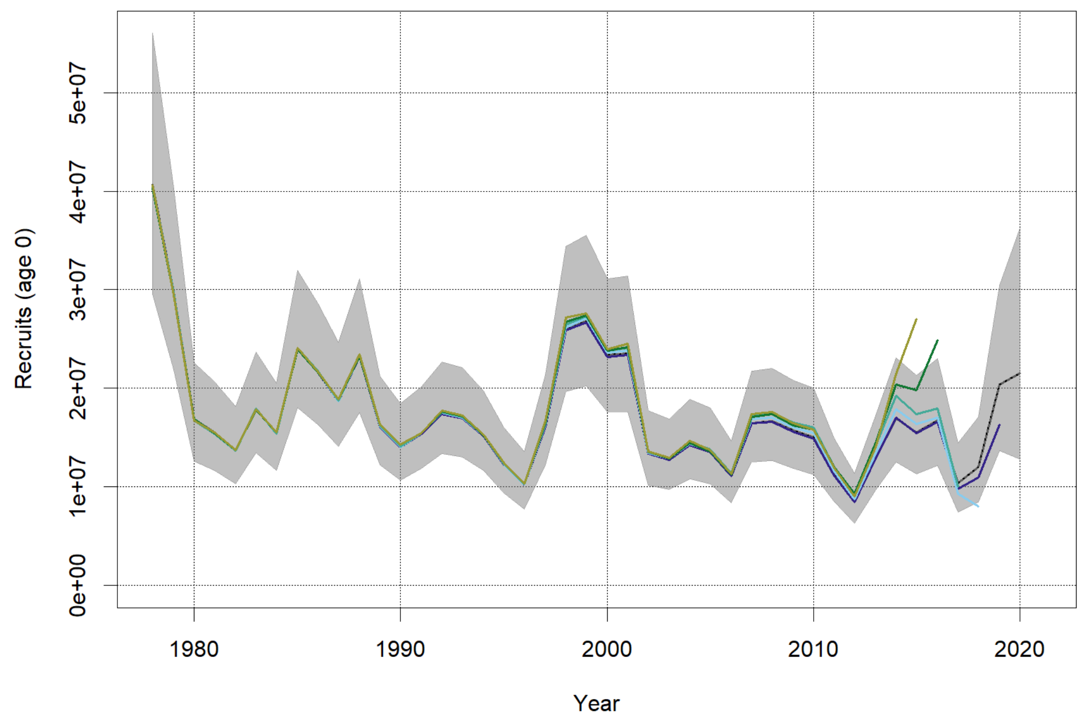


Figure 23.30. Whiting in Subarea 4 and Division 7.d: SAM Retrospective pattern in catch estimates, SSB, fishing mortality and recruitment.

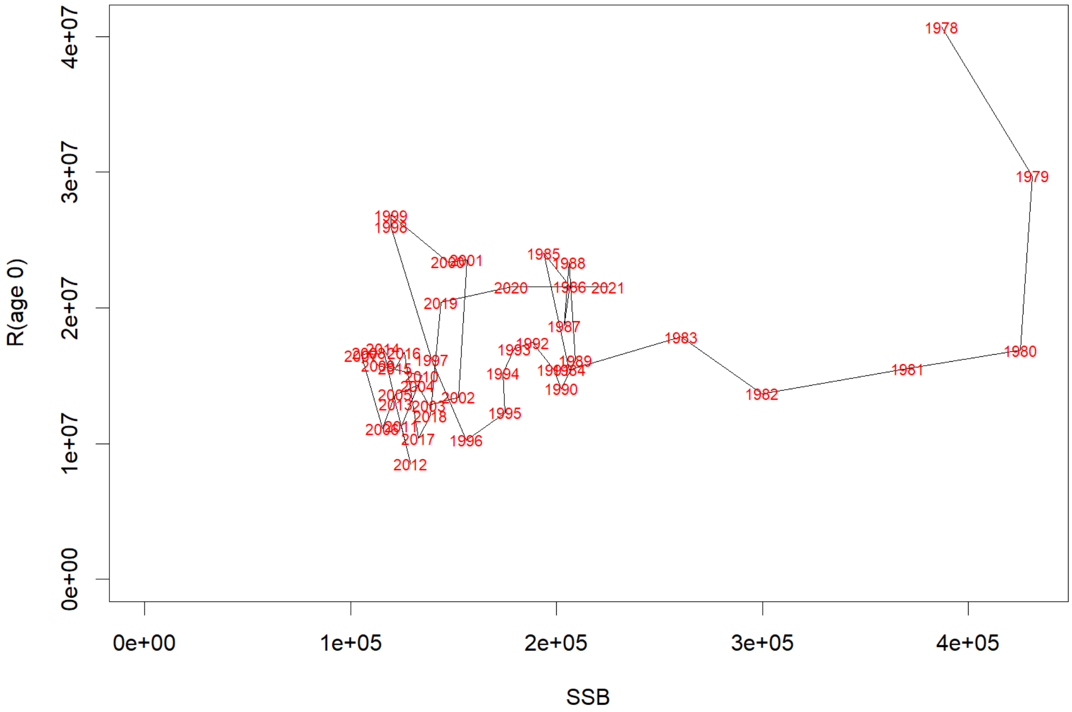


Figure 23.31. Whiting in Subarea 4 and Division 7.d: Stock-recruitment relationship.

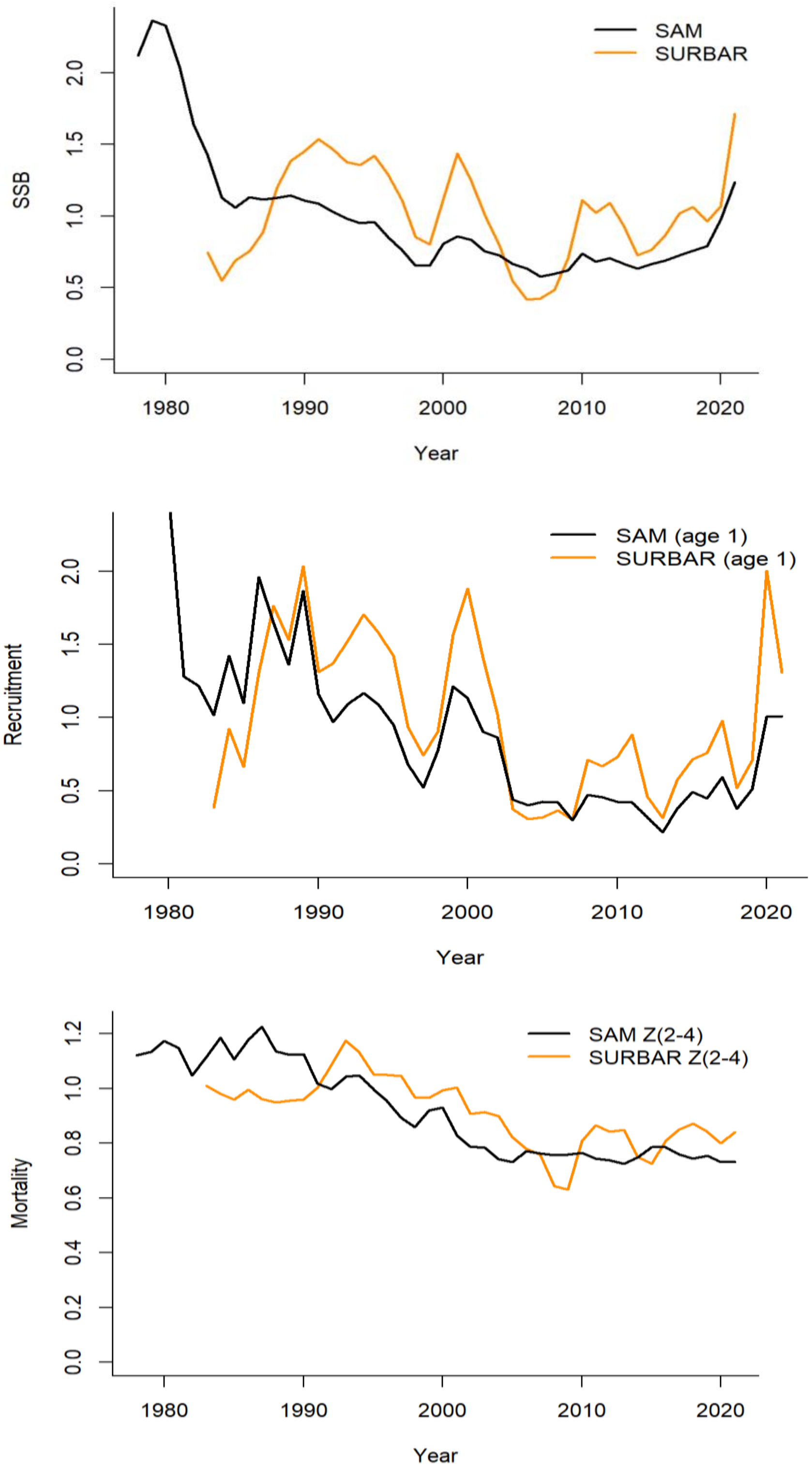


Figure 23.32. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final SAM (black) and SURBAR (orange) models. To facilitate comparison, recruitment and SSB values have been mean-standardised using the year range for which estimates are available from all three models. Mortality is presented as total mortality Z(2–4) for SAM and for SURBAR.

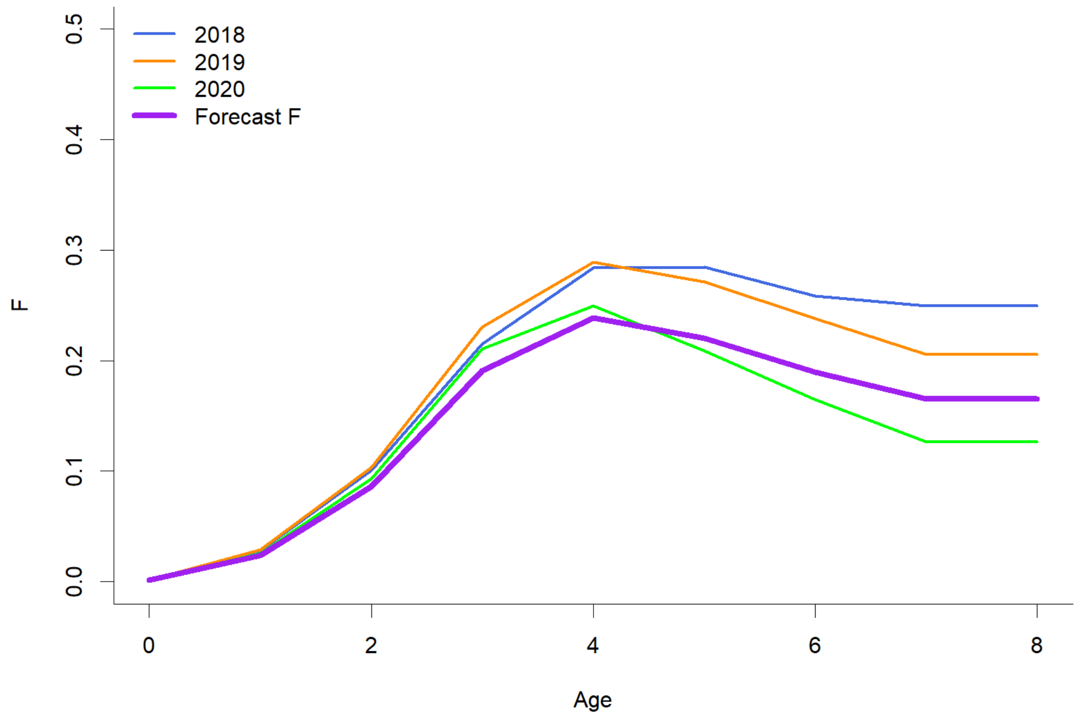


Figure 23.33. Whiting in Subarea 4 and Division 7.d: SAM F at age estimates for 2018–2020, along with scaled mean exploitation used for the forecast.

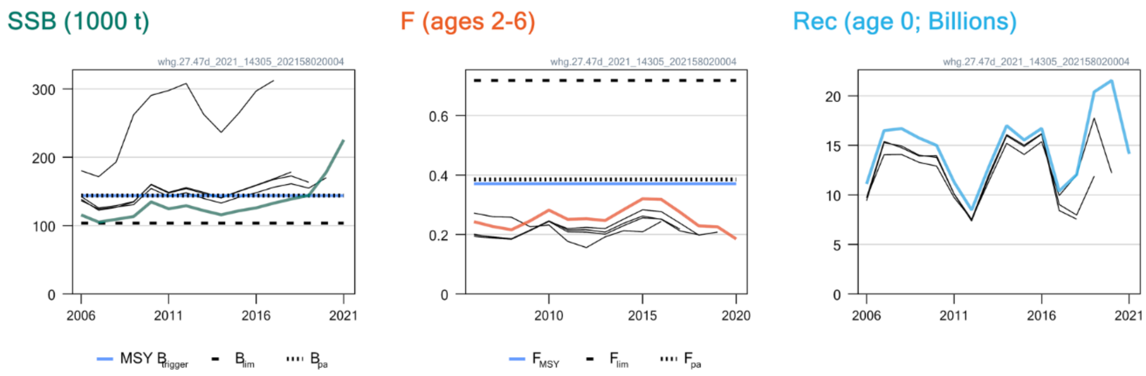


Figure 23.34. Whiting in Subarea 4 and Division 7.d: Historical assessments from Standard graphs.

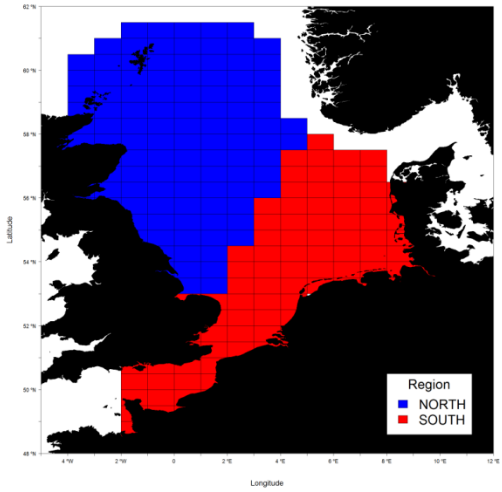


Figure 23.35. Whiting in Subarea 4 and Division 7.d: Components suggested by Holmes *et al*. (2014) to analyse spatial differences in maturation and SURBAR analysis.

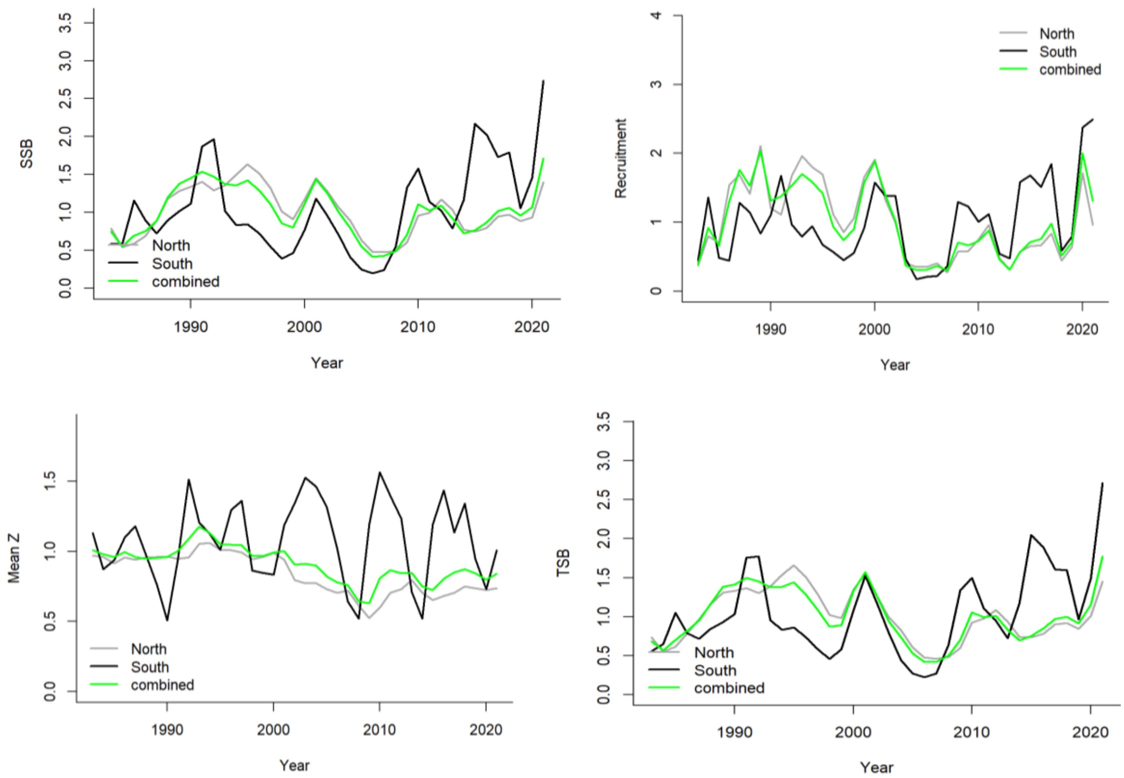


Figure 23.36. Whiting in Subarea 4 and Division 7.d: SURBAR results comparison combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018. Recruitment at age 1, total mortality is mean Z for ages 2–4.

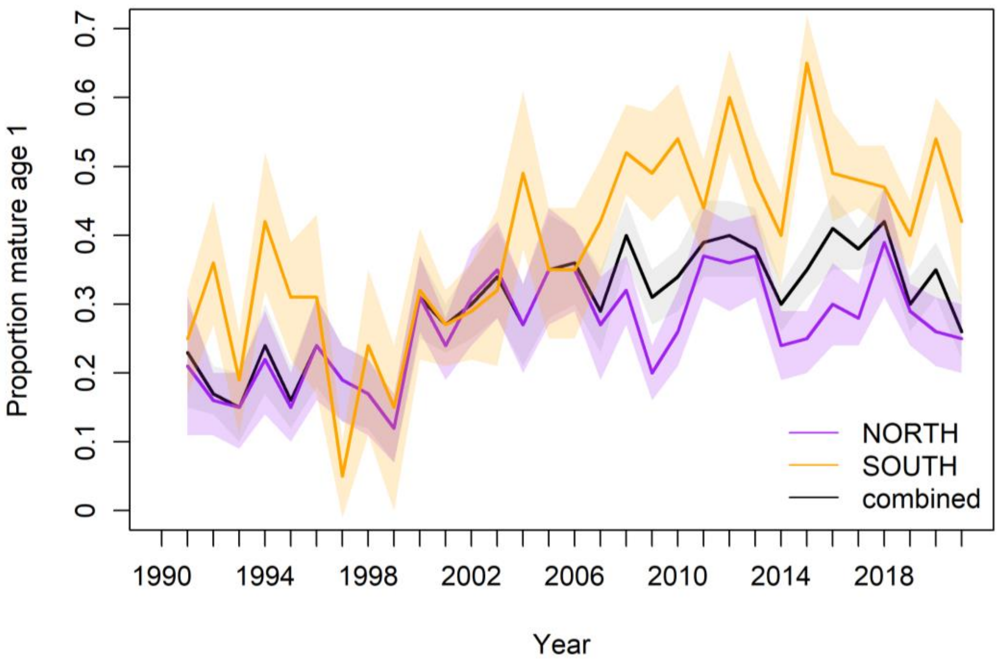


Figure 23.37. Whiting in Subarea 4 and Division 7.d: Trends in proportion mature individuals at age 1 for combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018.

24 Witch in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat) and 7.d (Eastern Channel)

This section was added to the report in October 2021

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 is updated on an annual basis.

In 2021, the stock went through an interbenchmark process (IBP) with main aim to establish a new age-specific survey index (IBPWITCH). That was deemed necessary during the WGNSSK 2021 assessment meeting, as ICES did not provide a survey index. Some issues were identified to the previously used survey index; additionally, the previously used index was never tested by relevant ICES working groups. During the IBP, a new index was established based on a Tweedie-GAM approach and the reference points were updated. Few other decisions of the WKNSEA2018 benchmark were briefly discussed but not changed. Finally, the stock annex was updated to reflect the changes in the survey index calculations and the new reference points.

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, ICES advises 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 (ICES, 2018b).

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 2000s, 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).

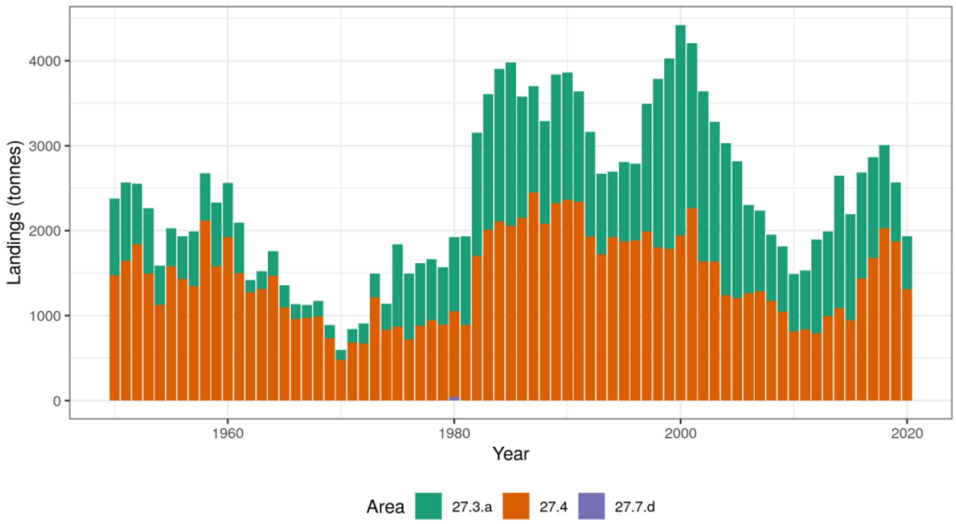


Figure 24.2.1.1. Witch flounder in Subarea 4 and Division 3.a: Total official landings (in tonnes).

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 2021, landings, discards and total catch at age and mean weight at age were updated up to 2020.

The ICES estimated catches for 2020 is 2135 tonnes, split as follows for the separate areas and catch categories:

Area	Landings	Discards	BMS landings
3.a	625.18	90.83	0
4	1311.73	106.64	0
7.d	0.39	0.20	0
Total	**1937.30**	**197.67**	**0**

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).

Total catch numbers-at-age for age groups 0–10+ for the period 2009–2020 are shown in Table 24.4. 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 2020. Data coordinators 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 data required for the assessment.

The proportion of landings with associated discards (same strata) is 78%. The approach used for unmatched discard was to merge all areas (3.a, 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. Very high discard ratios were excluded from the raising of discards. Quarters were merged for fleets with selectivity gears while kept separate for fleets without selectivity gear. A low amount of industrial bycatch is reported in InterCatch (14.1 tonnes in 2020) and is included in the landings.

The landings and discards imported or raised in InterCatch for 2020 are as follows (weights in tonnes; note any differences in landings and discards values to those given above are due to SOP correction):

Catch Category	Raised or Imported	Catch (tonnes)	%
Landings	Imported Data	1937	100
Discards	Imported Data	165	83
Discards	Raised Discards	33	17
BMS landing	Imported Data	0	0
Logbook Registered Discard	Imported Data	0	0

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 2020 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	Catch (tonnes)	%
Landings	Imported Data	Sampled Distribution	1434	74
Landings	Imported Data	Estimated Distribution	504	26
Discards	Imported Data	Sampled Distribution	141	71
Discards	Imported Data	Estimated Distribution	23	12
Discards	Raised Discards	Estimated Distribution	33	17
BMS landing	Imported Data	Estimated Distribution	0	0
Logbook Registered Discard	Imported Data	Estimated Distribution	0	0

In 2020, the largest amount of landings and discards in Subarea 4 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 had the highest landings and discards, both using the OTB_CRU_90-119_0_0_all métier (Figures 24.1 and 24.2, upper plots). The total catch estimated with InterCatch in 2020 was 2135 tonnes, of which 198 tonnes were discards. The unwanted catches were thus 9.3% of the total catch.

Swedish landings in Area 4 for 2019, were not submitted to InterCatch and were made available during the 2020 WGNSSK group meeting. For witch, 2765 tonnes were landed by Sweden in 2019 in Area 4. This corresponds to 0.23 tonnes of discards, assuming the overall discard rate in Area 4 (8.3%). These catches were split to catch at age, assuming the overall catch at age allocation in Area 4 and are included in the assessment.

BMS landing was reported very high in 2018, due to a difference in InterCatch submission compared to different years. Therefore, the decision was made for the 2019 assessment to include BMS landing from Norway to landings. The Norwegian data for 2019 show no BMS landing, indicating that the data was submitted in the way it was done in years prior to 2018.

In general, the discard rate is moderately low in the period 2002–2020 where discard information is available in InterCatch, 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 7.8% in 2019 and a slight increase to 9.3% in 2020. 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 métiers the applied raising procedure might introduce bias to the total discard estimates. 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 and a drop to 2580 tonnes in 2019 and further to 1937 tonnes in 2020.

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 y^{-1} for all ages and years.

24.2.5 Survey data

During the benchmark in 2018, two surveys 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 covers areas 4.b, 4.c and the English Channel (Division 7.d), the IBTS covers area 4.a, the Skagerrak (Division 3.a.20) and Kattegat (Division 3.a.21). 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. Nevertheless, in 2021 ICES DATRAS was not made available for the assessment, as it was not evaluated from a relevant ICES WG and there were issues with the calculations identified. This led to an IBP for the stock with main aim to establish a new age-specific survey index based on a GAM approach. The details of the index calculation are given in the IBPWitch report (ICES, 2021) and in the stock annex.

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.

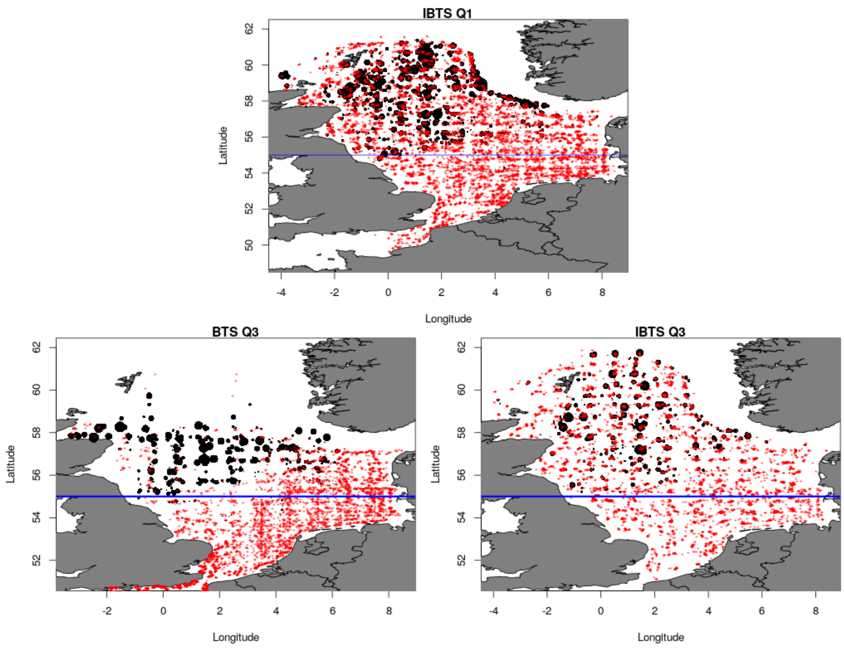


Figure 24.2.5.1. Witch flounder in Subarea 4 and Division 3.a: Aggregated distribution over the period 1983–2017 in the North Sea derived from IBTS–Q1 (upper) and Q3 (lower); data from that period are used to estimate the total biomass indices that are included in the assessment. The sizes of bubbles 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.

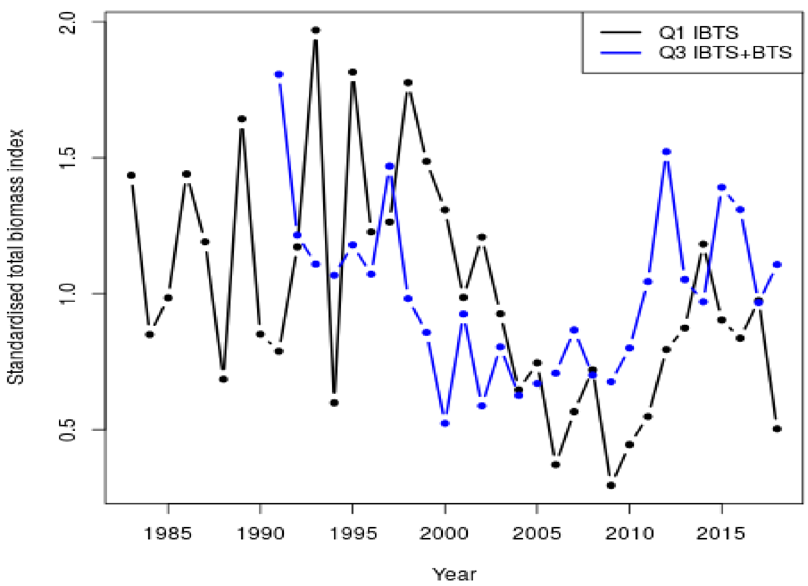


Figure 24.2.5.2. Witch flounder in Subarea 4 and Division 3.a: Q1 and Q3 indices of total biomass (rescaled to mean 1, until 2018). The assessment includes only the time-series up to and including 2008.

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 updated SAM assessment including data up to 2020 is presented in Figures 24.4–24.7. The assessment method was slightly updated during the IBP of the stock, where the index at age includes ages 2–7+ for quarter 1 and 2–6+ for quarter 3. The quarter 3 index includes NS-IBTS and BITS hauls.

24.3.1 Assessment audit

24.3.2 Final assessment

The basic state-space assessment model (SAM) is described in Nielsen and 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 2020. 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 $\boldsymbol{\epsilon}_y^{(s)}$ 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 24.4 and summarized in Table 24.8 that shows the estimated recruitment, SSB, average F (ages 4—8) 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 24.5.

Standardized one-observation-ahead residuals are shown in Figure 24.6 (left) 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 24.6 (right).

The assessment model, input data, results and diagnostics can be found on stockassessment.org with stock name “wit.27.3a47d_2021_IBP_finalIndex_fixedUnits”. The time series that were used as input and the configuration are shown in Table 24.3.2.1.

Table 24.3.2.1. Input time series used in the assessment.

Series	Years	Notes
Catch at age	2009–2020	ages 1–10+
Survey index IBTS Q1, by age	2009–2020	ages 2–7+
Survey index IBTS+BTS Q3, by age	2009–2020	ages 2–6+
Total landings	1950–2008	
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 1 1 0 0 0

$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 (normally first row is not used, as that is covered
by fishing mortality).
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1   0   1   2   3   4   4  -1  -1  -1
  -1   5   6   7   8   8  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
   9  -1  -1  -1  -1  -1  -1  -1  -1  -1
  10  -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 (normally 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
  -1   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
  -1  NA  NA  NA  NA  NA  -1  -1  -1
  -1  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
```

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. The reference points were updated following the same procedure during the last interbenchmark process for witch (ICES, 2021). The procedure is described in the IBPWitch report and the reference points are shown in Table 24.12.

24.5 Short-term forecasts

Short-term forecasts were carried out based on the final SAM assessment. Recruitment in the intermediate year (2021) and the following two years was resampled from the recruitment estimates of the years 2009–2020; median was 36 419 thousand individuals (range: 21361–58489 thousand individuals). The fishing mortality in 2021 is assumed to be equal to the last estimate ($F_{2019} = F_{2020} = 0.28\ y^{-1}$) and the corresponding catch was 2309 tonnes. The spawning stock biomass in the intermediate year was 3562 tonnes.

The weight at age in the forecast is assumed to be the average over the years 2018–2020. 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, 15 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 MSY approach scenario using the reduced F_{MSY} according to the advice rule (F_{MSY} (AR)), on which the advice is based is shown in Figures 24.8.

24.6 Quality of the assessment

There are no signs of problems in the assessment judging from the residuals (One-observation - ahead residuals and process residuals, Figure 24.6) and the retrospective analysis (Figure 24.7). The Mohn's rho values for the recruits, the spawning stock biomass and the fishing pressure are shown in Table 24.6.1.

Table 24.6.1. Mean bias (Mohn's rho) for the recruits (R, age 1), spawning stock biomass (SSB) and fishing pressure (F_{4-8}).

Quantity	Mohn's rho
R(age 1)	-0.2845
SSB	-0.0083
F_{4-8}	0.0484

Age information is only available for the last 12 years of the assessment, i.e. 2009–2020, 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 and repeated during IBPWitch in 2021 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.

24.7 Status of the stock

Witch is being overfished; the fishing mortality in 2020 was equal to 0.28 y^{-1}, above F_{MSY} (0.147 y^{-1}). The biomass of the stock (4124 tonnes) was below the MSY $B_{trigger}$ (4381 tonnes) and the stock was at full reproductive capacity, i.e. the biomass is above B_{lim} (3077 tonnes). The recruitment is variable since 2009 with no apparent trend 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 (ICES, 2018a). 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 time series since 1950, which excludes the initialisation period before the data start (1940–1949). The adequacy of the assessment to estimate SSB and recruitment during that period should be evaluated.

24.10 References

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Table 24.1. Witch flounder in Subarea 4 and Division 3.a. Landings, discards and catches are in tonnes. 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
2004	3029	3059	3428	369	0.12	0.09	0.108
2005	2813	2960	3379	419	0.13	0.09	0.124

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS–Q1 index	IBTS–Q3 index	Discard rate
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
2019	2568	2580*	2797	217	-	-	0.078
2020	1931	1937	2135	198	-	-	0.093

*** 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 2019 and 2020 are preliminary.

Year	3.a	4	Total
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	Total
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	Total
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
2019	698	1869	2567
2020	624	1308	1931

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.

Year	Number of age measurements			Number of age samples		
	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
2019	18573	2307	688	88	45	48
2020	18893	1563	3466	84	23	37

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.

Year	Number of age measurements		Number of age samples	
	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
2019	573	896	110	57
2020	2401	20	56	4

Table 24.4. Witch flounder in Subarea 4 and Division 3.a and 7.d: Catch in numbers at age.

Year/Age	1	2	3	4	5	6	7	8	9	10+
2009	1880573	2342251	1306459	2533154	1750724	1130623	1428139	1136690	440997	249704
2010	2243128	9205743	3114282	621403	1775664	904293	710391	884118	300687	250464
2011	439853	4200087	4860390	2810639	532899	1247980	378356	417048	187914	133150
2012	434615	1866105	4732981	4966594	1795657	373283	865604	226613	112876	134888
2013	659598	1306878	787294	2404872	3344504	926551	452899	496486	156215	299857
2014	473986	874655	1031433	2044359	3602513	2556211	717811	565648	530939	1038283
2015	438688	1583896	1278428	1895083	1999973	2410283	1360073	407315	178735	402182
2016	131888	592166	1138587	2126914	2315582	2411597	2200081	936330	303633	197312
2017	485269	300963	757597	1949013	3174531	1636402	2034440	1476957	687934	740442
2018	133318	597821	350856	1014348	2886430	1883862	2056046	1353651	488024	652598
2019	690854	605544	1599850	701940	1491371	2286068	1601786	1314229	557135	427225
2020	263420	1630164	702115	1163668	912773	1294094	1594476	945132	366735	562454

Table 24.5a. Witch flounder in Subarea 4 and Division 3.a and 7.d: Landings weights at age (kg). In 2018, the landings include the Norwegian BMS.

Year/Age	1	2	3	4	5	6	7	8	9	10+
2009	0.113	0.122	0.149	0.160	0.20	0.26	0.29	0.34	0.35	0.47
2010	0.000	0.000	0.149	0.163	0.23	0.32	0.35	0.30	0.34	0.45
2011	0.000	0.091	0.161	0.189	0.23	0.30	0.39	0.40	0.47	0.52
2012	0.000	0.000	0.167	0.197	0.25	0.29	0.34	0.41	0.47	0.46
2013	0.000	0.000	0.142	0.197	0.24	0.29	0.32	0.40	0.45	0.44
2014	0.000	0.000	0.140	0.194	0.23	0.30	0.31	0.35	0.33	0.35
2015	0.000	0.000	0.161	0.22	0.27	0.33	0.39	0.41	0.47	0.47
2016	0.000	0.000	0.138	0.24	0.26	0.33	0.39	0.42	0.41	0.54
2017	0.000	0.026	0.188	0.199	0.25	0.33	0.36	0.39	0.37	0.42
2018	0.000	0.128	0.146	0.185	0.25	0.31	0.35	0.41	0.40	0.47
2019	0.000	0.000	0.151	0.22	0.25	0.30	0.38	0.40	0.39	0.44
2020	0.000	0.061	0.138	0.182	0.252	0.28	0.33	0.38	0.41	0.41

Table 24.5b. Witch flounder in Subarea 4 and Division 3.a and 7.d: Discards weights at age (kg).

Year/Age	1	2	3	4	5	6	7	8	9	10+
2009	0.0122	0.035	0.094	0.118	0.129	0.185	0.22	0.31	0.28	0.46
2010	0.0141	0.032	0.064	0.095	0.123	0.113	0.000	0.000	0.000	0.000
2011	0.0129	0.048	0.075	0.105	0.106	0.139	0.000	0.146	0.000	0.000
2012	0.0118	0.036	0.094	0.102	0.122	0.140	0.155	0.116	0.000	0.000
2013	0.031	0.077	0.096	0.114	0.146	0.154	0.143	0.180	0.000	0.000
2014	0.0109	0.032	0.090	0.127	0.148	0.162	0.42	0.20	0.000	0.000
2015	0.0098	0.028	0.081	0.130	0.23	0.25	0.30	0.36	0.000	0.000
2016	0.0120	0.033	0.072	0.113	0.143	0.189	0.158	0.152	0.163	0.135
2017	0.0104	0.024	0.078	0.125	0.028	0.153	0.188	0.36	0.000	0.000
2018	0.0158	0.038	0.085	0.129	0.150	0.185	0.253	0.221	0.178	0.000
2019	0.0115	0.046	0.082	0.107	0.123	0.143	0.157	0.098	0.110	0.125
2020	0.0190	0.043	0.085	0.119	0.158	0.170	0.142	0.140	0.200	0.120

Table 24.5c. Witch flounder in Subarea 4 and Division 3.a and 7.d: Catch weights at age (kg).

Year/Age	1	2	3	4	5	6	7	8	9	10+
2009	0.0122	0.035	0.099	0.136	0.197	0.26	0.29	0.34	0.34	0.47
2010	0.0141	0.032	0.071	0.125	0.218	0.32	0.35	0.30	0.34	0.45
2011	0.0129	0.048	0.100	0.171	0.21	0.29	0.39	0.40	0.47	0.52
2012	0.0118	0.036	0.109	0.178	0.24	0.28	0.34	0.40	0.47	0.46
2013	0.031	0.077	0.099	0.188	0.23	0.28	0.32	0.40	0.45	0.44
2014	0.0109	0.032	0.093	0.170	0.21	0.30	0.31	0.35	0.33	0.35
2015	0.0098	0.028	0.084	0.155	0.26	0.33	0.39	0.41	0.47	0.47
2016	0.0120	0.033	0.076	0.158	0.23	0.31	0.39	0.42	0.40	0.53
2017	0.0104	0.024	0.114	0.165	0.090	0.33	0.36	0.39	0.37	0.42
2018	0.0160	0.038	0.093	0.145	0.23	0.29	0.35	0.41	0.39	0.47
2019	0.0115	0.046	0.086	0.182	0.24	0.29	0.37	0.39	0.39	0.43
2020	0.01864	0.04326	0.09023	0.15813	0.24208	0.27124	0.32434	0.37344	0.40981	0.40389

Table 24.6. Witch flounder in Subarea 4 and Division 3.a and 7.d: Stock weights at age (kg); constant for all years (2009–2020).

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, equal to 0.851.**

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), and fishing mortality (Fbar, mean of ages 4–8, y^{-1}). Low and high refer to lower and upper 95% confidence bounds.

Year	R (age 1)			SSB (tonnes)			Fishing pressure			TSB (tonnes)		
	R	Low	High	SSB	Low	High	F(4–8)	Low	High	TSB	Low	High
1950	29065	17851	47324	3881	1794	8397	0.270	0.141	0.519	14737	9459	22960
1951	29811	18612	47749	3778	1728	8258	0.282	0.146	0.547	14241	9070	22360
1952	32116	20363	50654	3609	1610	8092	0.288	0.145	0.570	13585	8484	21753
1953	34617	22191	54000	3443	1485	7983	0.275	0.134	0.563	13008	7956	21266
1954	35344	22441	55666	3372	1424	7984	0.245	0.116	0.517	12806	7780	21079
1955	33673	20878	54310	3388	1427	8044	0.252	0.121	0.527	13134	8103	21288
1956	29653	18006	48833	3435	1468	8042	0.252	0.122	0.520	13453	8487	21323
1957	25612	15352	42730	3504	1540	7977	0.260	0.129	0.521	13677	8825	21199
1958	22818	13862	37561	3498	1574	7772	0.289	0.149	0.561	13564	8872	20736
1959	21057	12954	34230	3374	1531	7435	0.298	0.154	0.576	12810	8365	19616
1960	19398	11729	32081	3154	1410	7053	0.314	0.162	0.612	11782	7602	18260
1961	17572	10454	29535	2889	1253	6664	0.303	0.151	0.606	10556	6685	16669
1962	15838	9451	26542	2679	1133	6333	0.274	0.134	0.561	9523	5950	15241
1963	14422	8554	24317	2501	1043	5999	0.283	0.138	0.577	8812	5499	14120
1964	13149	7576	22822	2281	933	5575	0.307	0.150	0.631	8075	5019	12992
1965	12349	6971	21873	2047	819	5118	0.301	0.143	0.633	7230	4424	11816
1966	12632	7262	21974	1847	722	4725	0.294	0.137	0.632	6531	3913	10902
1967	14375	8617	23981	1668	633	4400	0.303	0.137	0.667	5996	3496	10284
1968	17980	11265	28696	1502	544	4152	0.312	0.136	0.717	5595	3150	9937
1969	21948	13881	34704	1388	479	4016	0.282	0.116	0.685	5413	2963	9889
1970	25069	15656	40142	1374	471	4011	0.240	0.096	0.600	5669	3127	10276
1971	25927	16138	41656	1452	515	4094	0.247	0.102	0.596	6396	3683	11108
1972	26222	16108	42688	1592	601	4217	0.254	0.110	0.585	7276	4378	12093
1973	26270	16100	42863	1764	711	4375	0.282	0.131	0.606	8185	5095	13149
1974	27101	16583	44290	1943	827	4562	0.272	0.129	0.574	8828	5594	13933
1975	29507	18170	47917	2098	922	4770	0.296	0.147	0.598	9425	6027	14739
1976	34091	21413	54277	2206	983	4952	0.286	0.142	0.576	9757	6238	15259
1977	41829	27017	64762	2317	1037	5175	0.283	0.142	0.566	10260	6574	16013
1978	50905	33390	77608	2445	1102	5423	0.276	0.139	0.548	11053	7167	17047
1979	58106	37200	90761	2644	1221	5730	0.263	0.134	0.514	12322	8226	18457
1980	60432	37735	96782	2949	1427	6095	0.262	0.140	0.493	14169	9895	20290
1981	58930	36726	94557	3370	1746	6501	0.262	0.147	0.467	16316	11947	22281
1982	56863	35627	90757	3834	2144	6857	0.296	0.180	0.485	18484	14075	24273
1983	55891	35300	88492	4209	2515	7044	0.318	0.204	0.496	19879	15506	25484
1984	57238	36650	89390	4438	2771	7110	0.332	0.218	0.505	20467	16137	25960
1985	58287	37790	89900	4537	2893	7116	0.334	0.222	0.502	20517	16214	25963
1986	58026	37348	90152	4586	2949	7132	0.324	0.217	0.484	20399	16132	25794

Year	R (age 1)			SSB (tonnes)			Fishing pressure			TSB (tonnes)		
	R	Low	High	SSB	Low	High	F(4–8)	Low	High	TSB	Low	High
1987	54234	34304	85743	4634	2995	7171	0.319	0.214	0.475	20418	16216	25709
1988	49434	30840	79238	4715	3074	7231	0.306	0.208	0.451	20429	16342	25538
1989	45694	28598	73011	4801	3176	7256	0.312	0.216	0.452	20473	16533	25352
1990	44958	28636	70584	4806	3233	7143	0.313	0.220	0.447	20043	16290	24661
1991	46234	30087	71045	4751	3244	6958	0.304	0.215	0.430	19335	15747	23741
1992	49519	32699	74993	4672	3223	6773	0.286	0.202	0.404	18627	15146	22910
1993	52277	34505	79204	4638	3215	6691	0.266	0.187	0.377	18295	14830	22570
1994	54223	35224	83471	4661	3238	6709	0.259	0.183	0.368	18462	14960	22783
1995	54388	35191	84056	4739	3299	6807	0.260	0.183	0.369	18993	15429	23380
1996	53757	35124	82273	4832	3376	6915	0.267	0.189	0.379	19616	16000	24049
1997	51498	33842	78363	4873	3408	6969	0.298	0.211	0.422	20174	16517	24642
1998	48392	31579	74156	4766	3309	6863	0.333	0.233	0.476	20139	16508	24570
1999	44815	28987	69284	4509	3082	6598	0.372	0.258	0.537	19510	16016	23767
2000	42720	27632	66044	4124	2773	6134	0.415	0.287	0.600	18361	15155	22246
2001	43621	29088	65416	3690	2473	5506	0.441	0.309	0.629	16881	14100	20211
2002	43110	29471	63060	3272	2225	4811	0.455	0.325	0.638	15434	13111	18167
2003	38816	27065	55668	2937	2069	4168	0.455	0.335	0.618	14262	12328	16500
2004	29631	21001	41807	2698	1999	3641	0.451	0.344	0.591	13383	11717	15286
2005	25439	18329	35306	2566	2008	3280	0.434	0.344	0.548	12592	11101	14284
2006	27796	21017	36762	2510	2052	3070	0.392	0.320	0.480	11772	10419	13301
2007	24932	17908	34712	2473	2083	2936	0.370	0.307	0.446	11074	9832	12473
2008	38313	30140	48702	2378	2035	2779	0.361	0.299	0.435	10402	9259	11686
2009	58489	46115	74182	2209	1893	2577	0.370	0.305	0.450	10178	9088	11399
2010	51592	40744	65329	2188	1866	2566	0.322	0.262	0.396	10709	9542	12019
2011	34908	27144	44892	2432	2073	2851	0.253	0.202	0.317	12134	10709	13749
2012	32987	25613	42485	2891	2470	3384	0.224	0.178	0.283	13954	12237	15912
2013	36634	28393	47265	3512	2989	4125	0.231	0.185	0.289	15562	13557	17862
2014	32553	25000	42388	3958	3327	4709	0.272	0.217	0.340	16563	14298	19185
2015	24529	18357	32776	4119	3400	4990	0.257	0.204	0.323	16425	14027	19231
2016	21361	15030	30359	4165	3366	5153	0.259	0.203	0.331	16055	13520	19066
2017	32642	22750	46835	4117	3219	5266	0.291	0.221	0.382	15436	12713	18741
2018	36419	23615	56167	3930	2917	5294	0.291	0.210	0.404	14491	11566	18155
2019	48472	29218	80414	3643	2535	5237	0.295	0.202	0.430	13906	10637	18181
2020	42309	22700	78854	3415	2222	5247	0.279	0.180	0.434	14078	10234	19364

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 2009–2020.

Year	1	2	3	4	5	6	7	8	9	10+
1950	0.022	0.088	0.104	0.156	0.227	0.322	0.322	0.322	0.322	0.322
1951	0.023	0.091	0.108	0.163	0.237	0.337	0.337	0.337	0.337	0.337
1952	0.023	0.092	0.110	0.167	0.241	0.344	0.344	0.344	0.344	0.344
1953	0.023	0.091	0.108	0.161	0.231	0.327	0.327	0.327	0.327	0.327
1954	0.022	0.086	0.101	0.148	0.207	0.290	0.290	0.290	0.290	0.290
1955	0.023	0.088	0.103	0.152	0.213	0.299	0.299	0.299	0.299	0.299
1956	0.023	0.088	0.104	0.152	0.212	0.298	0.298	0.298	0.298	0.298
1957	0.023	0.090	0.107	0.157	0.219	0.307	0.307	0.307	0.307	0.307
1958	0.024	0.096	0.116	0.173	0.243	0.344	0.344	0.344	0.344	0.344
1959	0.025	0.099	0.120	0.178	0.251	0.354	0.354	0.354	0.354	0.354
1960	0.026	0.103	0.125	0.187	0.264	0.374	0.374	0.374	0.374	0.374
1961	0.026	0.102	0.123	0.183	0.255	0.359	0.359	0.359	0.359	0.359
1962	0.025	0.098	0.117	0.170	0.232	0.322	0.322	0.322	0.322	0.322
1963	0.025	0.100	0.120	0.176	0.240	0.333	0.333	0.333	0.333	0.333
1964	0.026	0.105	0.128	0.189	0.260	0.363	0.363	0.363	0.363	0.363
1965	0.026	0.105	0.127	0.186	0.255	0.355	0.355	0.355	0.355	0.355
1966	0.026	0.105	0.126	0.184	0.249	0.346	0.346	0.346	0.346	0.346
1967	0.027	0.106	0.129	0.188	0.256	0.356	0.356	0.356	0.356	0.356
1968	0.027	0.108	0.131	0.193	0.263	0.368	0.368	0.368	0.368	0.368
1969	0.026	0.102	0.122	0.177	0.238	0.332	0.332	0.332	0.332	0.332
1970	0.024	0.093	0.109	0.154	0.203	0.280	0.280	0.280	0.280	0.280
1971	0.024	0.094	0.111	0.158	0.209	0.289	0.289	0.289	0.289	0.289
1972	0.025	0.096	0.114	0.162	0.215	0.298	0.298	0.298	0.298	0.298
1973	0.026	0.101	0.123	0.178	0.238	0.332	0.332	0.332	0.332	0.332
1974	0.026	0.100	0.120	0.172	0.229	0.319	0.319	0.319	0.319	0.319
1975	0.027	0.105	0.128	0.186	0.249	0.349	0.349	0.349	0.349	0.349
1976	0.026	0.103	0.125	0.180	0.240	0.336	0.336	0.336	0.336	0.336
1977	0.026	0.102	0.124	0.179	0.237	0.333	0.333	0.333	0.333	0.333
1978	0.026	0.100	0.122	0.175	0.231	0.325	0.325	0.325	0.325	0.325
1979	0.025	0.096	0.117	0.166	0.219	0.309	0.309	0.309	0.309	0.309
1980	0.025	0.096	0.116	0.165	0.218	0.309	0.309	0.309	0.309	0.309
1981	0.025	0.096	0.116	0.165	0.218	0.309	0.309	0.309	0.309	0.309
1982	0.026	0.102	0.126	0.184	0.245	0.350	0.350	0.350	0.350	0.350
1983	0.027	0.107	0.133	0.196	0.263	0.377	0.377	0.377	0.377	0.377
1984	0.028	0.109	0.137	0.203	0.274	0.395	0.395	0.395	0.395	0.395
1985	0.028	0.109	0.138	0.204	0.275	0.397	0.397	0.397	0.397	0.397
1986	0.028	0.108	0.136	0.200	0.267	0.384	0.384	0.384	0.384	0.384
1987	0.027	0.107	0.134	0.197	0.263	0.378	0.378	0.378	0.378	0.378
1988	0.027	0.105	0.131	0.191	0.253	0.362	0.362	0.362	0.362	0.362

Year	1	2	3	4	5	6	7	8	9	10+
1989	0.028	0.108	0.135	0.196	0.259	0.369	0.369	0.369	0.369	0.369
1990	0.028	0.109	0.136	0.198	0.261	0.369	0.369	0.369	0.369	0.369
1991	0.028	0.108	0.135	0.195	0.255	0.357	0.357	0.357	0.357	0.357
1992	0.027	0.105	0.130	0.186	0.241	0.334	0.334	0.334	0.334	0.334
1993	0.026	0.101	0.124	0.175	0.224	0.309	0.309	0.309	0.309	0.309
1994	0.026	0.099	0.121	0.170	0.219	0.303	0.303	0.303	0.303	0.303
1995	0.026	0.099	0.121	0.171	0.219	0.303	0.303	0.303	0.303	0.303
1996	0.026	0.100	0.122	0.174	0.224	0.313	0.313	0.313	0.313	0.313
1997	0.027	0.105	0.131	0.189	0.249	0.351	0.351	0.351	0.351	0.351
1998	0.028	0.110	0.139	0.205	0.275	0.396	0.396	0.396	0.396	0.396
1999	0.030	0.115	0.147	0.221	0.303	0.446	0.446	0.446	0.446	0.446
2000	0.031	0.121	0.157	0.238	0.334	0.501	0.501	0.501	0.501	0.501
2001	0.031	0.125	0.163	0.251	0.355	0.533	0.533	0.533	0.533	0.533
2002	0.032	0.126	0.166	0.256	0.366	0.551	0.551	0.551	0.551	0.551
2003	0.032	0.126	0.165	0.256	0.366	0.551	0.551	0.551	0.551	0.551
2004	0.032	0.125	0.163	0.252	0.361	0.547	0.547	0.547	0.547	0.547
2005	0.031	0.124	0.160	0.244	0.349	0.526	0.526	0.526	0.526	0.526
2006	0.031	0.119	0.151	0.226	0.318	0.472	0.472	0.472	0.472	0.472
2007	0.030	0.117	0.149	0.221	0.305	0.441	0.441	0.441	0.441	0.441
2008	0.030	0.116	0.147	0.218	0.301	0.428	0.428	0.428	0.428	0.428
2009	0.030	0.115	0.147	0.220	0.309	0.441	0.441	0.441	0.441	0.441
2010	0.028	0.109	0.137	0.199	0.273	0.379	0.379	0.379	0.379	0.379
2011	0.023	0.088	0.113	0.169	0.222	0.292	0.292	0.292	0.292	0.292
2012	0.019	0.072	0.095	0.150	0.202	0.256	0.256	0.256	0.256	0.256
2013	0.017	0.058	0.078	0.134	0.202	0.273	0.273	0.273	0.273	0.273
2014	0.015	0.052	0.073	0.136	0.225	0.333	0.333	0.333	0.333	0.333
2015	0.013	0.046	0.065	0.124	0.211	0.316	0.316	0.316	0.316	0.316
2016	0.011	0.038	0.057	0.116	0.209	0.324	0.324	0.324	0.324	0.324
2017	0.010	0.035	0.054	0.116	0.225	0.371	0.371	0.371	0.371	0.371
2018	0.009	0.031	0.048	0.106	0.217	0.377	0.377	0.377	0.377	0.377
2019	0.009	0.032	0.049	0.104	0.215	0.385	0.385	0.385	0.385	0.385
2020	0.009	0.030	0.046	0.096	0.200	0.367	0.367	0.367	0.367	0.367

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 2009–2020.

Year	1	2	3	4	5	6	7	8	9	10+
1950	29065	23965	19445	15483	11348	7558	4547	2713	1609	2342
1951	29811	23219	17936	14350	10856	7418	4489	2700	1610	2346
1952	32116	23808	17323	13156	9976	7018	4338	2625	1578	2313
1953	34617	25688	17742	12673	9093	6405	4070	2517	1523	2258
1954	35344	27754	19212	13017	8805	5888	3769	2397	1483	2226
1955	33673	28377	20894	14232	9199	5864	3609	2310	1469	2273
1956	29653	27036	21340	15459	10013	6085	3559	2191	1402	2271
1957	25612	23751	20327	15792	10897	6634	3700	2163	1332	2233
1958	22818	20466	17778	15003	11093	7196	4005	2231	1304	2150
1959	21057	18208	15197	12968	10351	7128	4182	2327	1296	2006
1960	19398	16817	13484	11027	8887	6609	4103	2406	1338	1900
1961	17572	15489	12427	9729	7468	5578	3720	2311	1355	1824
1962	15838	14027	11463	8996	6619	4722	3181	2123	1320	1814
1963	14422	12645	10416	8360	6225	4300	2803	1888	1260	1860
1964	13149	11512	9360	7562	5751	4022	2529	1648	1109	1835
1965	12349	10474	8482	6739	5120	3628	2289	1440	938	1675
1966	12632	9815	7711	6114	4575	3246	2082	1314	827	1500
1967	14375	10033	7214	5558	4168	2922	1882	1207	762	1349
1968	17980	11419	7355	5173	3765	2644	1676	1080	692	1211
1969	21948	14343	8366	5258	3477	2362	1494	948	611	1076
1970	25069	17556	10619	6038	3591	2232	1382	875	556	987
1971	25927	20110	13130	7811	4240	2400	1381	855	541	955
1972	26222	20734	15041	9639	5474	2818	1471	846	524	917
1973	26270	20953	15440	11036	6740	3632	1716	895	515	877
1974	27101	20936	15506	11180	7567	4344	2131	1008	526	817
1975	29507	21585	15496	11269	7725	4947	2591	1270	600	800
1976	34091	23472	15885	11144	7648	4923	2855	1496	733	808
1977	41829	27129	17304	11455	7610	4923	2880	1670	875	902
1978	50905	33376	20016	12485	7827	4908	2887	1689	980	1042
1979	58106	40719	24737	14478	8562	5073	2898	1706	998	1195
1980	60432	46559	30345	18035	10026	5624	3048	1741	1025	1318
1981	58930	48375	34756	22177	12524	6593	3378	1831	1046	1408
1982	56863	47076	36077	25451	15470	8279	3971	2033	1101	1476
1983	55891	45315	34808	26082	17379	9937	4786	2293	1173	1488
1984	57238	44461	33317	24933	17550	10932	5581	2688	1288	1495
1985	58287	45593	32600	23771	16663	10930	6035	3081	1484	1536
1986	58026	46452	33472	23223	15853	10354	6017	3323	1696	1662
1987	54234	46325	34165	23934	15551	9927	5774	3357	1853	1874
1988	49434	43241	34152	24470	16084	9765	5562	3236	1882	2089

Year	1	2	3	4	5	6	7	8	9	10+
1989	45694	39370	31909	24616	16614	10260	5579	3175	1846	2266
1990	44958	36306	28926	22850	16593	10507	5816	3161	1799	2330
1991	46234	35739	26608	20661	15357	10484	5956	3296	1790	2339
1992	49519	36760	26219	18981	13884	9727	6003	3412	1888	2366
1993	52277	39478	27059	18809	12856	8912	5693	3516	1999	2492
1994	54223	41712	29228	19531	12893	8383	5343	3416	2111	2694
1995	54388	43312	30976	21237	13490	8491	5076	3235	2067	2909
1996	53757	43404	32149	22475	14658	8863	5130	3067	1955	3006
1997	51498	42921	32182	23321	15501	9614	5316	3075	1838	2975
1998	48392	41052	31663	23106	15796	9896	5543	3065	1773	2774
1999	44815	38529	30124	22569	15405	9816	5452	3055	1689	2506
2000	42720	35585	28128	21299	14832	9311	5145	2858	1601	2199
2001	43621	33834	25804	19725	13769	8714	4627	2555	1419	1887
2002	43110	34651	24391	17934	12574	7909	4188	2223	1228	1588
2003	38816	34312	25042	16881	11352	7145	3733	1976	1049	1329
2004	29631	30977	24853	17397	10665	6434	3369	1761	933	1122
2005	25439	23401	22530	17354	11092	6068	3045	1596	834	973
2006	27796	20000	16856	15814	11153	6405	2922	1470	771	873
2007	24932	22238	14413	11818	10411	6687	3282	1488	749	838
2008	38313	19408	16315	10077	7722	6330	3538	1733	781	833
2009	58489	30447	13865	11611	6566	4655	3402	1896	927	856
2010	51592	47278	22236	9531	7735	3899	2454	1797	992	931
2011	34908	41047	35004	15855	6272	4905	2172	1376	1000	1062
2012	32987	27842	30833	25577	10825	4049	3054	1329	839	1255
2013	36634	26469	21250	22835	17849	7076	2552	1957	846	1343
2014	32553	29641	20533	16427	16355	11796	4336	1588	1229	1389
2015	24529	26380	23239	15865	11999	10683	6852	2519	925	1530
2016	21361	19561	20637	17940	11620	8131	6388	4066	1501	1451
2017	32642	17093	15258	16027	13107	7817	4906	3767	2398	1756
2018	36419	26530	13429	11715	11711	8576	4496	2807	2108	2332
2019	48472	29808	21118	10482	8573	7743	4841	2546	1580	2464
2020	42309	39552	23763	16401	7728	5632	4327	2705	1416	2245

Table 24.11. Witch flounder in Subarea 4 and Division 3.a and 7.d: Short-term forecasting scenarios and results.

Basis	Total catch (2022) ^^	Projected landings (2022)	Projected discards * (2022)	F_{total} ages 4–8 (2022 & 2023)	SSB ^ (2022)	SSB ^ (2023)	% SSB change **	% advice change ***
ICES advice basis								
MSY approach: F_{MSY} × SSB(2021)/MSY $B_{trigger}$	1206	1131	75	0.120	4141	5158	25	−30
Other scenarios ^^								
d$F_{MSY\ lower}$× SSB(2021)/MSY $B_{trigger}$	875	822	53	0.085	4213	5412	28	−50
F = 0	0	0	0	0.00	4397	6123	39	−100
F_{pa}	2608	2438	170	0.28	3811	4135	8.5	50
F_{lim}	2925	2729	196	0.32	3727	3914	5.0	69
F_{sq}	2600	2431	169	0.28	3813	4140	8.6	50
SSB (2023) = B_{lim}	4284	3976	308	0.51	3380	3078	-8.9	147
SSB (2023) = B_{pa}	2257	2113	144	0.24	3896	4381	12.4	30
SSB (2023) = MSY $B_{trigger}$	2257	2113	144	0.24	3896	4381	12.4	30
Rollover advice	1733	1627	106	0.177	4019	4838	20	0.00
F_{MSY}	1462	1372	90	0.147	4083	4958	21	−15.6
$F_{MSY\ lower}$	1067	1001	66	0.105	4174	5268	26	−38

*** Including BMS landings, assuming recent discard rate (average of 2018–2020).**
**** SSB in 2023 relative to SSB in 2022.**
***** Advice value for 2022 relative to advice value for 2021 (1733 tonnes).**
^ SSB is estimated at spawning time (1 July).
^^ Other scenarios do not include $F_{MSY\ upper}$ because SSB(2021) < MSY $B_{trigger}$

Table 24.12 Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Reference points estimated using EQSIM during the IBPWitch2021.

Reference Point	Estimate
MSY $B_{trigger}$	4381 tonnes
B_{lim}	3077 tonnes
B_{pa}	4381 tonnes
F_{MSY}	0.147 y^{-1}
$F_{MSY\ upper}$	0.20 y^{-1}
$F_{MSY\ lower}$	0.105 y^{-1}
F_{lim}	0.32 y^{-1}
F_{pa}*	0.28 y^{-1}
$F_{P0.5}$ (with AR)	0.28 y^{-1}
$F_{P0.5}$ (without AR)	0.22 y^{-1}

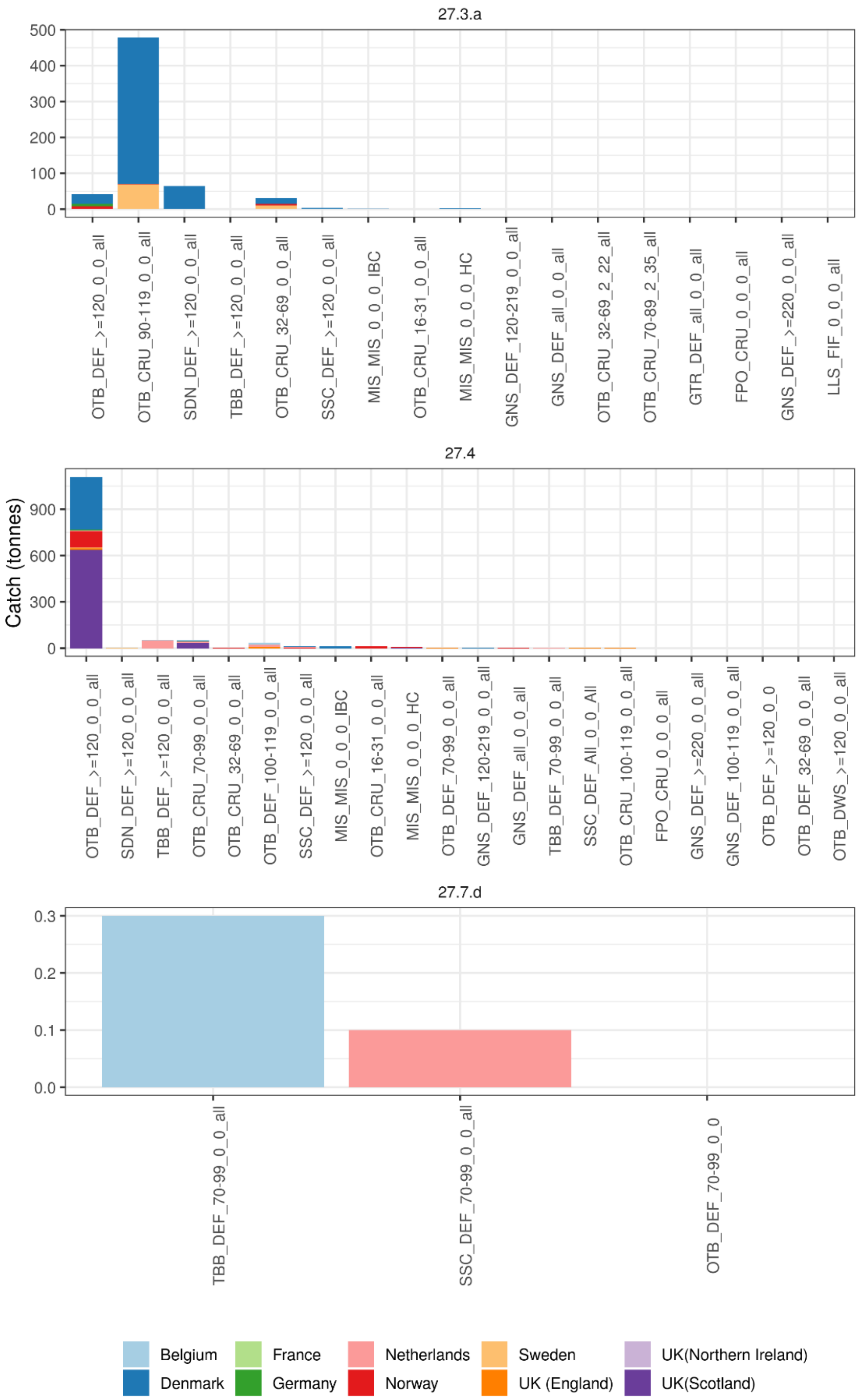

Figure 24.1. Witch flounder Division 3.a (upper plot), in Subarea 4 (middle plot) and Division 7.d (lower plot): Landings in tonnes by métier and country in 2020.

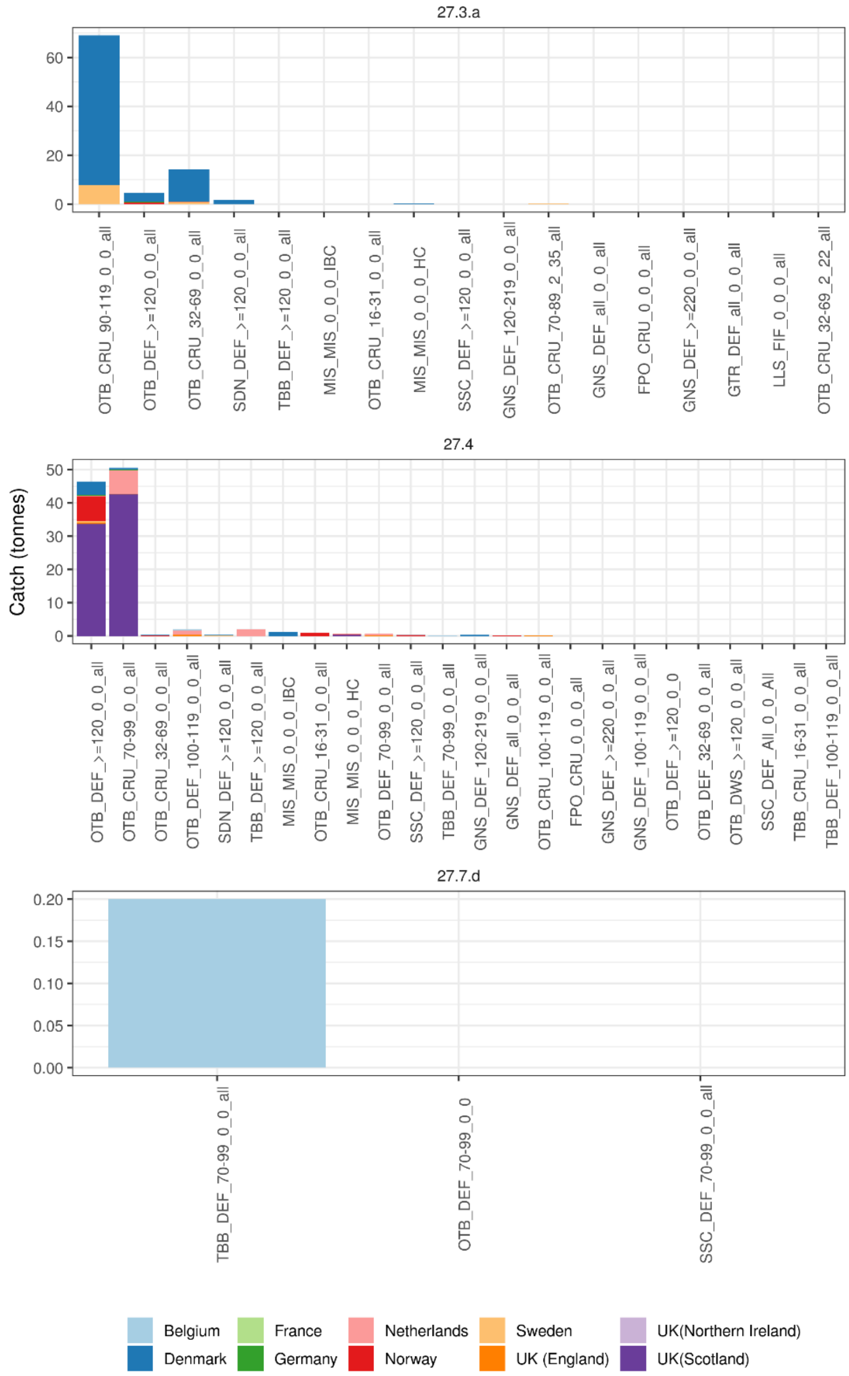

Figure 24.2. Witch flounder in Division 3.a (upper plot), Subarea 4 (middle plot) and Division 7.d (lower plot): Discards by métier and country in 2020.

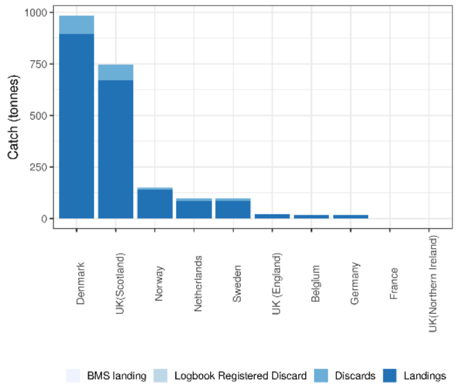

Figure 24.3. Witch flounder in Subarea 4 and Division 3.a: Estimated catch categories by countries in 2020.

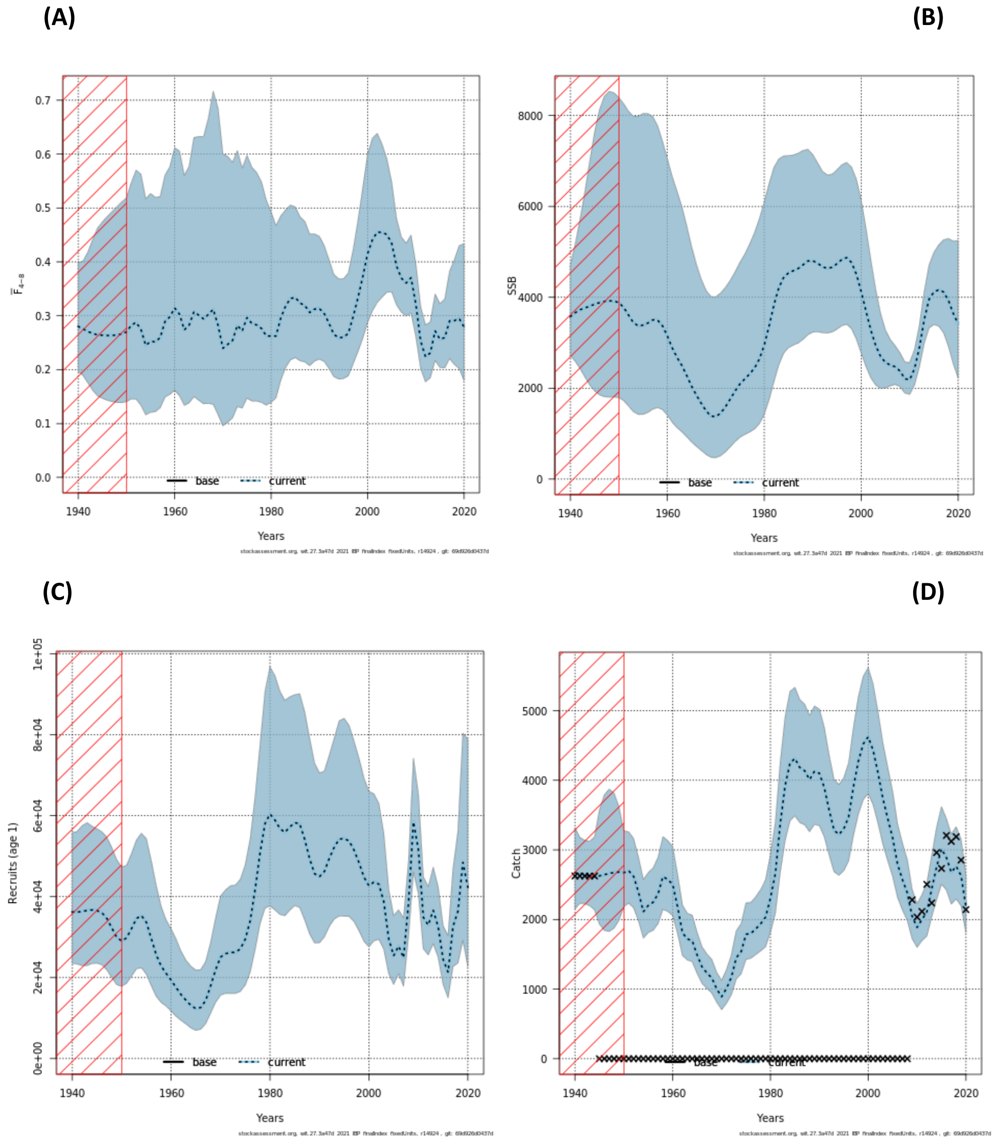

Figure 24.4. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model, fishing mortality (A), SSB (B), Recruits (C) and Catch (D). Median estimates (dashed lines) and point wise 95% confidence intervals (shaded area). The red line shaded area shaded is the period prior to the observations, used for initialization.

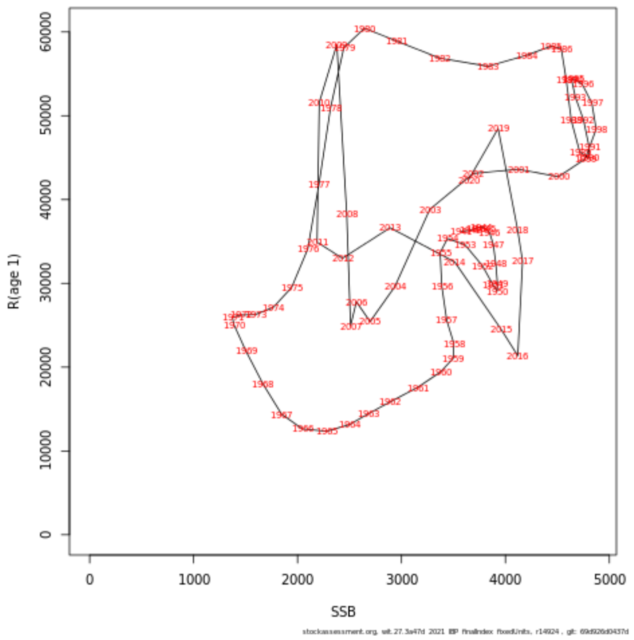

Figure 24.5. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Recruits over spawning stock biomass (SSB).

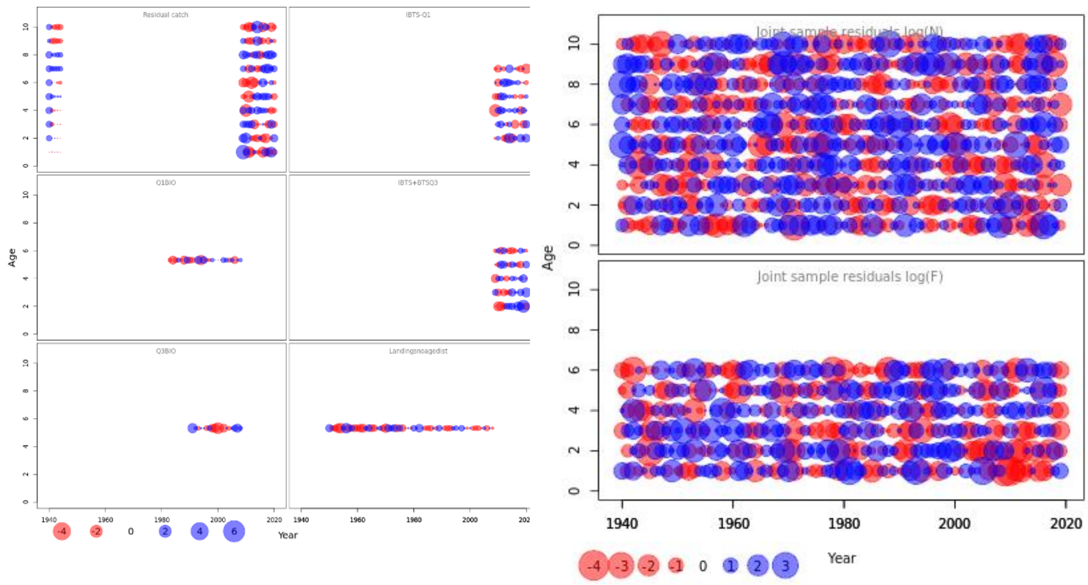

Figure 24.6. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Residual plots, standardized one-observation-ahead residuals (left) and standardized single-joint-sample residuals of process increments (right).

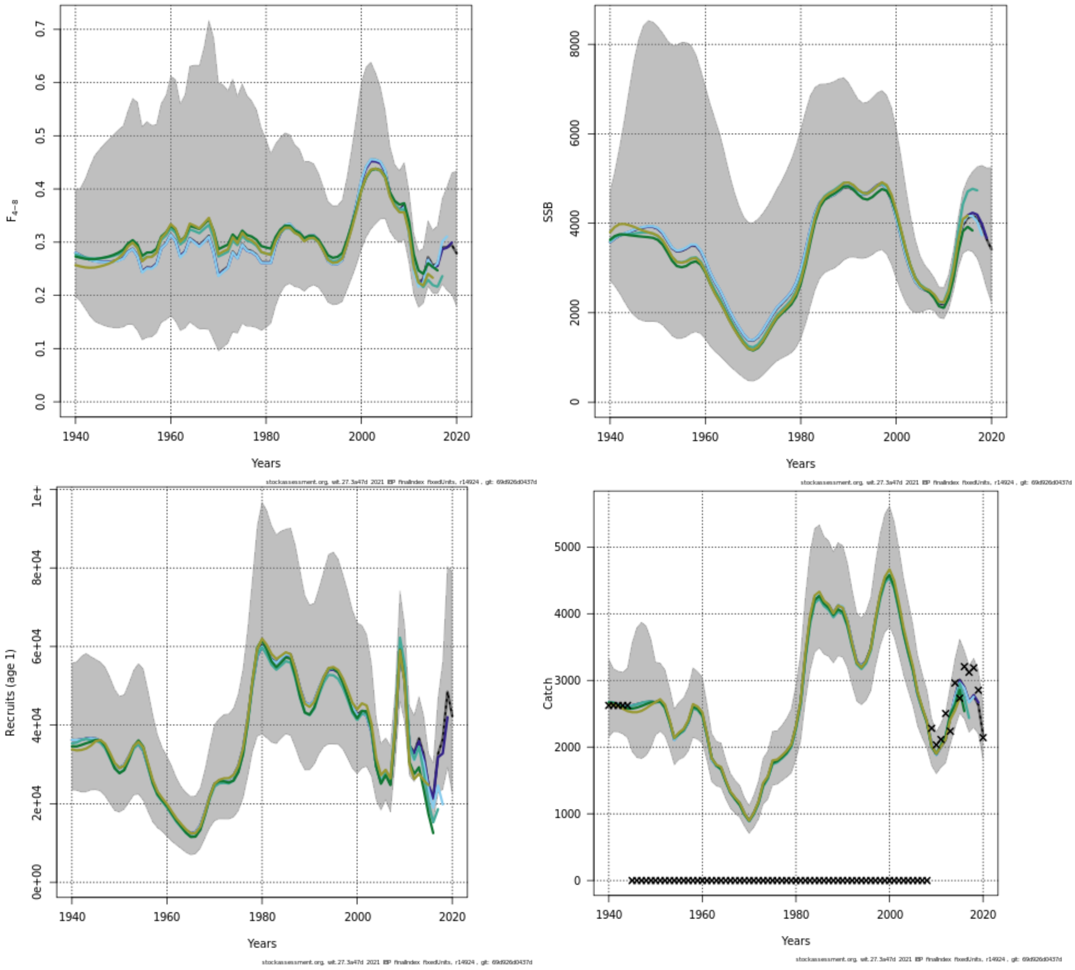

Figure 24.7. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Retrospective analysis, for fishing mortality (top left), spawning stock biomass (SSB, top right), recruits (bottom left) and catch (bottom right).

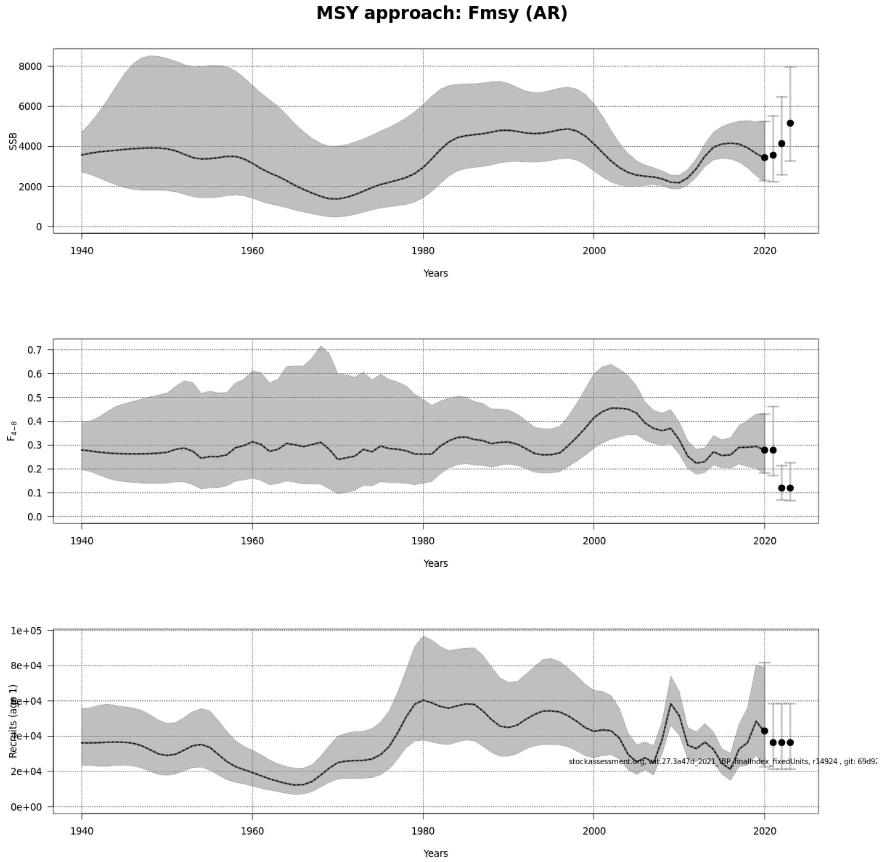

Figure 24.8. Witch flounder in Subarea 4 and Division 3.a: Short-term forecast under the MSY approach scenario (F_{2022} = F_{MSY} × SSB(2021)/MSY $B_{trigger}$ = 0.120 y^{-1}) of the spawning stock biomass (SSB, in tonnes, top), the fishing pressure ($F_{4–8}$, middle) and recruits (bottom).

Annex 1: List of participants

Name	Country
Anja Helene Alvestad	Norway
Jurgen Batsleer	Netherlands
Alan Baudron	United Kingdom
Casper Berg	Denmark
Aaron Brazier	United Kingdom
Katinka Bleeker	Netherlands
Chun Chen	Netherlands
José De Oliveira	United Kingdom
Raphaël Girardin	France
Jette Fredslund	Denmark
Ghassen Halouani	France
Holger Haslob	Germany
Alexander Kempf	Germany
Alexandros Kokkalis	Denmark
Tiago Veiga Malta	Denmark
Carlos Mesquita	United Kingdom
Tanja Miethe	United Kingdom
Sarah Millar	Denmark
Iago Mosqueira	Netherlands
Nikolai Nawri	United Kingdom
Coby Needle	United Kingdom
Anders Nielsen	Denmark
J. Rasmus Nielsen	Denmark
Alessandro Orio	Sweden
Alfonso Perez Rodriguez	Norway
Yves Reecht	Norway
Jon Egil Skjæraasen	Norway

Name	Country
Andreas Sundelöf	Sweden
Klaas Sys	Belgium
Guldborg Søvik	Norway
Marc Taylor	Germany
Sebastian Uhlmann	Netherlands
Mats Ulmestrand	Sweden
Mikael van Deurs	Denmark
Lies Vansteenbrugge	Belgium
Francesca Vitale	Sweden
Nicola Walker	United Kingdom
Fabian Zimmermann	Norway

Annex 2: Resolutions

WGNSSK – Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

2020/2/FRSG19 The **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak** (WGNSSK), chaired by Tanja Miethe, UK, and Raphaël Girardin, France, will meet in ICES HQ, Copenhagen, Denmark, 21–30 April 2021 and by correspondence in September 2021 to:

a) Address generic ToRs for Regional and Species Working Groups.
b) Assess Norway pout assessments by correspondence.
c) Report on reopened advice as appropriate;
d) Add ToR on Benchmark

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 2021 ICES data call.

WGNSSK will report by 14 May 2021, and by 25 September 2021 (Norway pout) for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Generic ToRs for Regional and Species Working Groups

2020/2/FRSG01 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 on the following for the fisheries relevant to the working group:

    i) descriptions of ecosystem impacts on fisheries

    ii) descriptions of developments and recent changes to the fisheries

    iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.

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 2020.

iv) Estimate MSY reference points or proxies for the category 3 and 4 stocks

v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

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

Consistent with ACOM’s 2020 decision, the basis for Fpa should be Fp.05.

1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data 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 associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn’s rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species

Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

   i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention *(restricted access)* and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
   i) update the benchmark issues lists for the individual stocks;
   ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
   iii) determine the prioritization score for benchmarks proposed for 2022–2023;
   iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

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

Annex 3: 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 2021	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)	May 2021	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)	April 2020	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
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

Stock ID	Stock description	Last updated	Link
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 2021	ple.27.420_SA.pdf
ple.27.7d	Plaice (*Pleuronectes platessa*) in Division 7.d (eastern English Channel)	May 2021	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)	May 2021	pok.27.3a46_SA.pdf
pol.27.3a4	Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	May 2021	pol.27.3a4_SA.pdf
sol.27.4	Sole (*Solea solea*) in Subarea 4 (North Sea)	April 2021	sol.27.4_SA.pdf
sol.27.7d	Sole (*Solea solea*) in Division 7.d (eastern English Channel)	May 2021	sol.27.7d_SA.pdf
tur.27.3a	Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)	May 2021	tur.27.3a_SA.pdf
tur.27.4	Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)	May 2021	tur.27.4_SA.pdf
whg.27.3a	Whiting (*Merlangius merlangus*) in Division 3.a (Skagerrak and Kattegat)	April 2020	whg.27.3a_SA.pdf
whg.27.47d	Whiting (*Merlangius merlangus*) in Subarea 4 and Division 7.d (North Sea and eastern English Channel)	May 2021	whg.27.47d_SA.pdf
wit.27.3a47d	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	August 2021	wit.27.3a47d_SA.pdf

Annex 4: Audit reports

This Annex was updated in November 2021

Audits for stocks for which advice sheets were produced were conducted during and immediately following the WGNSSK 2021 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.

Audits for spring 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 an advice using the 2 over 3 rule on the biomass index. This index is driven by a commercial LPUE of the Dutch large beam trawl fleet. A SPiCT model is run to determine the state of the stock in relation to reference points for brill.

For single stock summary sheet advice:

1) **Assessment type:** Cat 3 with annual 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 inform 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. A benchmark to improve this LPUE index is quite urgent considering the changes in the fleet related to technological creep.
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 were correct.

Technical comments

Few inconsistencies were reported to the assessor and have already been fixed in both the advice sheet and report.

The assessment relies solely on a biomass index derived from a the standardized lpue from the Dutch beam-trawl fleet for vessels > 221 kW. Considering the changes in the fleet related to technological creep, a benchmark to improve this index is quite urgent.

The Dutch industry survey seems to be a promising survey that could be used in the future to assess the status of the brill stock.

Conclusions

The assessment has been performed correctly.

cod.27.47d20 (cod)

General

The stock has been benchmarked in 2021 with several changes made to the assessment and reference point calculations. Among other changes, emigration from the North Sea to area 6a is now taken into account via increased natural mortality rates for ages 3 and above. This has to be seen as a quick fix until more sophisticated spatial assessment methods become available and/or the stock definition and assessment area (including at least parts of 6a) is changed. For the reference points the ongoing low productivity of the stock is taken into account by truncating the time series used for reference point determination to the period 1998+. This led to a reduction in Blim, Bpa and MSY Btrigger. Although the stock status is still the same (below Blim and above FMSY), the position of the current SSB and F in relation to the reference points has changed to a larger extent.

For single-stock summary sheet advice

Stock Cod 27.47d20

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update (benchmarked in 2021)
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM assessment accepted by external reviewers during and after the 2021 benchmark - tuning by two scientific surveys (IBTS q1 and IBTS q3) and one additional recruitment index derived from the IBTS q3 survey (age 0)
5) Consistency: 2021 benchmark, therefore not consistent with 2020 assessment.
6) Stock status: $B < B_{lim}$, $F > F_{MSY}$
7) Management plan: EU MAP accepted only by EU. Includes FMSY ranges (also accepted by UK, but not by Norway). Shared stock ➔ Headline advice based on ICES MSY approach

General comments

To have the assessment in TAF is a major improvement. However, data and scripts to derive input data like the Delta Gam indices are not yet in TAF. This could be added in the future.

The report is well written. It mentions the most important changes made in the benchmark and it describes the main issues with the assessment. It gives an overview over the most important results and issues relevant for management.

Technical comments

Information on values used for years prior to the start of the time series is missing for M and maturity in the stock annex

M values for 2020 (values from 2019) were not in accordance with the stock annex (three year average 2017 – 2019). It was a mistake in the stock annex according to the stock assessor and the stock annex will be updated.

Forecast results depend to some extent on the R version used. The routine to generate random seeds changed around R verion 3.6. The assessment and forecast has been carried out with R version R 3.5.1. When running the forecasts with newer R versions (e.g., 4.0.2) slightly different forecast results are produced because of differences in the random seed. The R version used is now specified in the report.

According to the official (and ICES) landings, the TAC in 2020 has been overshot substantially especially in area 4. It is unclear whether this is e.g., a result of banking and borrowing or inter-area flexibilities. This needs to be mentioned and discussed in the report.

The 2020 landings and discards in table 10 (assessment summary) are different to the other tables in the advice sheet (especially the landings). A footnote could be added explaining the difference (likely SOP vs landings and discards uploaded in weight?).

The order of tables does not follow the order how the tables are mentioned in the text. This makes it difficult for the reader to follow. A reorganisation of tables and figures may be envisaged for the next year's report.

Exploitation patterns and maturities are now directly forecasted by SAM. Although this all makes sense, so far the report does not show which exploitation patterns and maturities are forecasted by SAM. Therefore, it is difficult to judge whether the SAM forecast is working as intended. If possible, a figure showing the forecasted exploitation patterns and maturities would be helpful.

For small issues, comments were added directly to the report

Conclusions

The assessment and forecasts have been carried out in accordance with the stock annex (apart from M in 2020 where the description in the stock annex needs to be changed).

fle.27.3a4 (flounder)

For single stock summary sheet advice:

9) **Assessment type:** update
10) **Assessment**: Survey trends-based assessment, length-based indicators
11) **Forecast**: no forecast
12) **Assessment model**: trend-based assessment based on IBTS-Q1
13) **Data issues:** No issues with the data.
14) **Consistency**: consistent with previous advice
15) **Stock status**: Stock status cannot be assessed based on current data availability, exploitation status is currently below the F_{MSY} proxy.
16) **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. Audit was based on powerpoint presentation, stock annex, advice sheet, report, and data files on the ICES sharepoint. Some minor edits necessary, see technical comments below.

Technical comments

Advice Sheet vs Report consistency

- In the advice sheet Table 1, the average discard rate is given as 29%, computed from none-rounded values, although the rounded value is what is reported in the table. Using the values given for discard rate in Table 6.6 in the report I get a value of 30.39%, i.e. rounded value 30%. There thus appears to be some inconsistency here.

  The inconsistency is due to rounded numbers in table 6.6 of the report, while the calculations done for the advice sheet is based on none-rounded numbers.

- The totals given for official landings from subarea 4 in 2017 and 2018 Table 6.5 in the report does not match what is given in Table 7 in the advice sheet.

  Has to be checked.

Stock annex

- In the stock annex under short term forecast it says that "since 2018 no catch advice is given any longer for North Sea flounder". Catch advice is now once again given so this is not correct.

  Stock annex updated accordingly.

- In Table 1 it is said that length at maturity is 21 mm. This should be 21 cm, shouldn't it?

  Yes, 21cm. Corrected accordingly.

Report

- For the last sentence under section 6.1 starting with "This resulted in a catch advice…..", consider adding information about the discard rate in 2018-2020 as well for reader guidance.

  Information about the average discard rate added to the text.

Conclusions
The assessment has been performed correctly

had.27.46a20 (haddock)

Short description of the assessment as follows (examples in grey text):

8) Assessment type: Update
9) Assessment: accepted
10) Forecast: accepted
11) Assessment model: TSA, Age based analytical assessment using IBTS Q1 and Q3 surveys.
12) Consistency: The estimated SSB and F were consistent over last 5 years. Recruitment estimates in recent two years (2019 and 2020) are more uncertain, but it is common due to lack of data.
13) Stock status: Fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim.
14) Management plan: EU multiannual management plan (MAP) plan for the Western Waters (EU, 2019)

General comments

The report was well written. Report and assessments covers a wide range of aspects: Impact of covid 19 in fishing efforts, sampling coverage and data quality was assessed. Changes in discards rate and biological parameters such as mean weight, maturity were well discussed. Exploratory assessments using SURBAR and SAM were conducted and the consistent result to TSA further insure the quality of the current assessment. Issues for coming bechmark were clearly addressed in the report.

Technical comments

The advice sheets are easy to read and clear. Here are few comments:

- Two ICES rounding errors in Table 2 for F (0.964 and 0.916)
- A typo in Table 7
- Overall, it is difficult for me to reproduce ICES landing/discards/catch related numbers, e.g. weights summarized in Table 6 and Table 7. These numbers are different than summarized in Youen's IC summary pdf. Maybe I am missing an extra component? Or the Youen's pdf was an old version?

There are some comments for report:

- Page 243, year typo

Conclusions

Assessment was done consistently, and report was well written

lem.27.3a47d (lemon sole)

General

Audit based on the stock annex, benchmark report, presentations, advice sheet and the report section. Overall, the presented assessment appears sound and conform to the stock annex.

For single-stock summary sheet advice

Stock lem.27.3a47d

Short description of the assessment as follows:

1) **Assessment type:** Updated assessment and advice according to the 2018 WKNSEA benchmark.
2) **Assessment:** accepted. Lemon sole has been defined as a category 3 species according to the ICES guidelines.
3) **Forecast:** No forecast.
4) **Assessment model:** no consistently reliable age structured data is available for commercial catches and the assessment and advice therefore follow a data limited approach:
    - Advice formulated using the data limited "2 over 3" rule, based on SSB index from a SURBAR model (using *ad-hoc* catchability corrections for age 1 and 2). The model uses age-structured GAM indices in Q1 (IBTS) and Q3 (combined IBTS+BTS).
    - Stock exploitation status evaluated using length-based indicators (LBIs), here in relation to the F_{MSY} proxy $L_{mean} = L_{F=M}$ (with assumption M/k = 1.5).
5) **Data:** data limitations such as noisiness of the survey index, partly due to low catchability of younger classes, are well documented and believed to have little influence on the advice. The Q1 index, in particular, shows a poorer internal

consistency and seems to be given a lower weight by the SURBAR model, as suggested by larger residuals.

6) **Consistency:** Consistent with the benchmark. No inconsistency over time revealed; annual advice issued since 2019, every second year before.
7) **Stock status:** relative SSB decreasing in the last two years, as compared to the three previous. $L_{mean} > L_{F=M}$ indicates a stock exploited below $F_{MSY\ proxy}$. No reference point for stock size is defined for this stock. Recruitment exhibited an upward trend over the last three years (but with high uncertainty around the estimate).
8) **Management plan:** none.

General comments

Assessment and advice in line with the stock annex and benchmark decisions (with the well documented exception of the updated L_{mat} estimate for the LBI approach).

Technical comments

The range of possible estimates considered for L_∞, during the benchmark, appears very wide. The choice of the method is therefore expected to have a considerable impact on the estimates for L_{opt} and $L_{F=M}$, and for comparison with $L_{max5\%}$. It is moreover noticed that the option based on survey data (which was disregarded because deemed not representative of the stock size composition):

- did not include a correction for biases induced by length-stratified age sampling (which to the best of my knowledge is standard on IBTS surveys), while fitting the growth function.
- forced the t_0 of the Von Bertalanffy growth function to zero, which, by experience, may have a sizeable impact on the L_∞ estimate.

It may therefore be advisable to reconsider the option based on survey data using an alternative method (such as the one proposed by Perreault *et al.*, 2019) in a future benchmark. Although the method chosen to estimate L_∞ appears sound, it is based on a metanalysis, and therefore need to be considered with caution as it could provide misleading perspective on the exploitation level. A method based on data from the stock itself may provide more accurate estimates, although the issue of the representativeness of course has to be addressed.

Moreover, on Figure 9.6.6 of the report, the left vertical dashed line representing L_{max} (used to estimate L_∞) seems at a suspiciously low value to represent the 99th percentile, if based on the same distribution as represented on the graphic. This may need verification or clarification.

This issue is however not expected to have any influence on this year's advice as the precautionary buffer is not to be considered again until 2023 (for catches in 2024), under current guidelines.

Conclusions

The assessment has been performed correctly and reporting is adequate.

WGNSSK reiterate the advice that management should be implemented at the species level (currently managed under a combined species TAC with witch).

References

Perreault, A. M. J., Zheng, N., and Cadigan, N. G. 2019. Estimation of growth parameters based on length-stratified age samples. Canadian Journal of Fisheries and Aquatic Sciences. http://dx.doi.org/10.1139/cjfas-2019-0129.

ple.27.420 (plaice)

General
The stock is due to be benchmarked in 2021/2022.

For single-stock summary sheet advice

Plaice in 4 and 20

Short description of the assessment as follows (examples in grey text):

15) Assessment type: update
16) Assessment: accepted
17) Forecast: accepted
18) Assessment model: AAP (Aarts and Poos) – tuning with 6 survey indices (combined BTS, IBTS Q1 and IBTS Q3 all derived using delta-GAM and BTS-ISIS and SNS split into two time-series).
19) Consistency: Approach consistent with last years assessment. There has been a large downscaling of the 2019 recruitment.
20) Stock status: $B>B_{trigger}$ & B_{pa}, $F<F_{MSY}$
21) Management plan: Advice is based on the MSY approach. The EU management plan (MAP) is not adopted by Norway and is given only as a catch option.

General comments

Overall, well documented, and consistent with the stock annex. There are a couple places in the report which have not been updated with the latest assessment results and other parts which may now be outdated.

The 2021 assessment is not yet in TAF. This could be added in the future to facilitate the audit process. The audit was based on the presentations to the WG, stock annex, advice sheet, report and assessment and forecast files on SharePoint.

Technical comments

There are several issues with the assessment of this stock, including:

- Conflicting information from surveys due to shifting distributions of younger and older fish.
- Annual upward revisions of ages 5+ in the IBTS Q1 delta-GAM indices that may be contributing to annual revisions of SSB.
- Residual patterns in the catches and surveys.
- An increasing and uncertain plus group.
- A mismatch in perception of the stock between the assessment and industry.
- High sensitivity of assessment results to leave-one-out analyses.

No details of the standard InterCatch raising procedure are provided in the Stock Annex. It is therefore unclear whether the same grouping strategy is used each year.

The report details changes to the May short-term forecast procedure following the ICES WKNSROP workshop in 2020. However, the decision to abandon RCT3 estimates in the May forecast has not been updated in the stock annex. The number of years to use for ‘long-term’ geometric mean of recruitment estimates is not specified in the stock annex but taken as 10 years. The stock annex specifies two assumptions on intermediate year F, although the decision to present only F status quo is well explained and justified in the report section.

The assessment results are highly sensitive to leave-one-out analyses. In particular, the IBTS surveys are the only surveys to sample east of Scotland and there is potential for a ghost stock. This is mentioned only briefly in the 'Issues for future benchmarks'.

F_{pa} was updated to the value of $F_{P.05}$ with advice rule following the new technical basis. This results in a new F_{pa} (0.769) that is much higher than F_{lim} (0.516).

Several minor comments have been added directly to the report section and advice sheet.

Conclusions

The assessment and forecasts have been done correctly and carried out in accordance with the stock annex (although the STF recruitment assumptions need updating in the stock annex following WKNSROP).

ple.27.7d (plaice in the eastern English Channel)

General

Audit was based on the report, PowerPoint presentations, stock annex, advice sheet, scripts and data files on the ICES SharePoint. The assessment was thoroughly discussed in the group given the change in sampling campaign of the FR GFS, historically low recruitment estimate for 2020.

All issues were addressed during the working group and the assessment was accepted and completed largely in line as described in the stock annex.

For single-stock summary sheet advice

Stock: Ple 27.7d

Short description of the assessment as follows (examples in grey text):

22) Assessment type: update
23) Assessment: analytical, presented and accepted
24) Forecast: FLR package, presented during the meeting and accepted
25) Assessment model: Aarts and Poos model, which is an age-based analytical assessment that uses catches in the model and forecast + 2 survey indices UK-BTS and FR-GFS.
26) Consistency: The assessment is largely consistent with last years assessment and forecasts. Some minor deviations are observed in the age allocation for trawlers in InterCatch, changes in the FR GFS (no UK stations) and the recruitment assumption in the Forecast.
27) Stock status: B > $MSYB_{trigger}$, F < F_{msy}, R is uncertain especially in 2020 due to the low sampling for discards given the COVID pandemic.
28) Management plan: MSY approach

General comments

Overall the report is well written and covers all major topics. However, the assessment of this stock encountered some issues due to the COVID-19 pandemic. The issues relate to a lack of discard sampling of the trawler fleet in most quarters of 2020 and the missing UK station in the FR GFS survey. While both issues are mentioned in the report in issues for future benchmarks, I think it would be more appropriate to state the issues in the designated sub-chapters. This will make it more transparent to the reader and provide to opportunity to elaborate by e.g. showing some results of the different runs performed to demonstrate the impact of 1) fully removing the FR GFS, 2) removing the 2020 data point, or 3) the regular assessment. Some elaboration here is needed for future reference.

Technical comments

As mentioned above, the report needs some additional work to cover the main issues discussed during the working group.

1) Elaborate on the missing UK stations in the FR GFS, including a figure comparing as presented during the WG
2) The very low recruitment estimate in 2020 due to the lack of sampling.
3) The change in InterCatch procedure for the trawlers due to the lack of age samples from Q2 onwards.

Furthermore, coding issues with the FR GFS index were mentioned, i.e. some hauls with no catches were dropped from the analysis. It states a new index calculation was done solely for testing purposes and further exploration is needed before a new index can be applied. The report mentions "*issues in the calculation of the FR GFS index were reported...*", but does not state which issues are encountered and still need to be resolved, nor are comparisons in the runs shown. I think the report would benefit by adding a figure showing the effect of the new index.

In the advice, please check the values in the Fmsy scenario. The % advice change are not in line with the STF output provided (Advice_basis_Fmsy_ple.27.7d_WGNSSK.csv). Other values appear to be ok.

Some minor comments and adjustments of the text in the report were made in track changes. Also minor changes in the advice in terms of rounding and removing a row in table 1 of the advice. All is in track changes.

Conclusions

The assessment and forecast of ple.27.7d has been performed in line as described within the Stock Annex. Minor deviations occurred but have been extensively discussed and agreed by the group. As such, I have no major concerns about the assessment and advice for this stock.

pok.27.3a46 (saithe)

General

Overall, a clear assessment presentation that follows the Stock Annex where possible. There were some changes to input data this year to account for previous errors in data submission of collation, but the WG was of the view that these were warranted to ensure an improved and robust assessment this year. The notes regarding benchmark issues are comprehensive and very helpful.

For single-stock summary sheet advice

Saithe in the North Sea (4), Skagerrak (3.a) and West of Scotland (6.a) (pok.27.3a46a)

Short description of the assessment as follows:

29) Assessment type: Update
30) Assessment: Accepted
31) Forecast: Accepted
32) Assessment model: Update SAM assessment on TAF – tuning by one commercial biomass index and one survey index
33) Consistency: mostly consistent with last year, some revisions to commercial tuning index following corrections to French data. Significant impacts on assessment but stock perception very similar, and discussed further in a working document for WGNSSK. Also highlighted a mistake in the 2019 IBP reference point revisions that were corrected by WGNSSK 2021 (Flim and Fpa).
34) Stock status: B > MSY Btrigger (just); F above Fmsy bu below Fpa; recent recruitment the lowest in the time series, continuing a long-term declining trend.
35) Management plan: Previous EU-Norway management plan no longer in force, evaluation continuing on proposed EU-Norway-UK management plan. Baseline advice presented for the ICES MSY approach.

General comments

The text would benefit from a general proof-read – there are some grammar errors in particular that have probably built up over the years. The meaning is clear, but corrections would be a useful exercise at some point.

Technical comments

1) The first line of the last paragraph on page 796 suggests that all Scottish catch of saithe is discarded, whereas actually a proportion is still retained for landing as some quota is available.
2) Page 797, 7th paragraph: change "While Norway has a no landings obligation policy…" to "While Norway has a landings obligation policy…"
3) 1st paragraph of Section 16.3.2: it is noted that sampling is an "issue". Is this a problem that means the assessment is not reliable, or was sampling in 2020 still sufficient?
4) In Section 16.7.2, I'm not sure it's correct to say that the EU-Norway-UK management plan is no longer accepted. The old EU-Norway MP has been discarded because of the reference point issue, but also because of Brexit. The new EU-Norway-UK MP is still under discussion, rather than being no longer accepted.

Conclusions

As always for saithe, this is a complicated assessment but it looks to have been conducted according to the Stock Annex. There were quite a few changes to input data and reference points, but these have been accepted by the WG as necessary to correct previous errors, and are well explained in the report section.

pol.27.3a4 (pollack)

General

Last time advice for Pol.27.3a4 was requested was in 2018. The advice for this year applies to 2022-2024. Unless the stock change category, the next advice update (in 2024) will be 80% of the TAC adviced this year. The stock has never been benchmarked. Apparently, an appropriate survey time-series for this stock has not been identified.

For single-stock summary sheet advice

Pol.27.3a4

Short description of the assessment as follows:

1) Assessment type: Category 5 assessment (i.e. assessment based solely on catches and discards)
2) Assessment: No assessment
3) Forecast: Accepted. Not a real forecast is applied. Instead, average ICES tot. catches for 2018-2020 multiplied by a precautionarity buffer (0.80) was adviced for 2022-2024.
4) Assessment model: Category 5 assessment (i.e. assessment based solely on catches and discards)
5) Consistency: Last time an advice was requested was in 2018
6) Stock status: Not known (information to define reference points are not available)
7) Management plan: There is no management plan available

General comments: none (see conclusion)

Technical comments: There may be a slight inconsistency in the advice sheet. At the the top it is stated that the advice applies to 2022-2024, whereas in table 4 of the advice sheet the adviced TAC is mentioned for 2021-2023. There is also "*" after the official landings for 2019 and 2020 in table 4. Should they still be there.

Conclusions:

No notable issues was raised during the presentation of the assessment, and could not find any potential mistakes when looking through the report and advice sheet, except for those mentioned under technical comments above and a few tiny comments/questions left in the report for the stock assessor to take a look at.

sol.27.4 (sole)

General

- The retrospective pattern should to be investigated. The stock assessment shows 3 of 5 peels outside the envelope and a Mohn's rho > 0.2. According to WKFORBIAS decision tree, the SSB < B_{lim} in 2020 and F_{HCR} << Fp.05, allowing advice based on these results to be provided this year.

For single-stock summary sheet advice

Stock **sol.27.4**

Short description of the assessment as follows (examples in grey text):

36) Assessment type: update of 2020 benchmark assessment
37) Assessment: accepted
38) Forecast: accepted
39) Assessment model: Art and Poos statistical cath-at-age model
40) Consistency: the assessment of 2020 is consistent with last year's assessment. The change in advice (-28%) is mainly due to the downward revision of the large 2018 year class.
41) Stock status: SSB < B_{MSY} since 1999; $F_{MSY} < F < F_{pa}$
42) Management plan: ICES advises that when the MSY approach is applied, catches in 2022 should be no more than 15 330 tonnes.

General comments

The stock is well documented and clearly presented. The audit was based on the report, presentations and the advice sheet on the ICES sharepoint. The assessment was thoroughly discussed during the group due to strong retrospective pattern in estimated SSB (Mohn's rho > 0.20 and 3 peels are outside the bounds) but, no clear explanation has been found. According to the WKFORBIAS decision tree (the stock size estimate in 2020 is below B_{lim} and F_{HCR} is well below Fp.05), the assessment was accepted by the group to provide advice for 2021.

Technical comments

- The excel SAG file of sole.27.4 is missing in the Assessment and Forecast folder.
- The output files of the assessment and the forecast are missing in the Assessment and Forecast folder.
- There are several differences between the values of table 8 in the advice sheet (History of landings) and those of the table 17.2 of the report (Time-series of the official landings) from 2006.
- There is a mismatch in the period of calculation of the geometric mean of recruitment between the report (GM 1957-2019) (section 17.7 Recruitment estimates) and the advice sheet (GM 2008-2019) (the table 1).

Advice sheet:

- Footnote ^^ of table 2 need to be updated/removed since the TAC for 2021 was not yet been set.
- Minor changes in the advice in terms of rounding (Table 2).
- There are some differences between the column landings of the assessment summary (table 9) and ICES estimated landings (table 8) especially for 2012 and 2013.

Conclusions

The assessment has been performed correctly.

sol.27.7d (sole in the eastern English Channel)

General

Audit based on the report section, advice sheet, stock annex, 2021 WKNSEA benchmark report, and data available on the SharePoint. Overall, the presented assessment appears sound.

For single-stock summary sheet advice

Stock: Sole in Division 27.7.d

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM, 3 survey age-structured indices (UK BTS, France YFS and UK YFS), 3 commercial tuning series (FRA-COTB, UK (E&W)-CBT and BE-CBT).
5) Consistency: In 2019 and 2020, category 3 advice was provided for this stock. In 2021 this stock was benchmarked during WKNSEA to address data issues. During WGNSSK 2021, the new assessment performed with SAM was accepted and category 1 advice was provided.
6) 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 between B_{pa} and B_{lim}.
7) Management plan: EU multiannual management plan (MAP) for the Western Waters.

General comments

Overall, the sol.27.7d section of the report is very well written and thoroughly documented. It is easy to follow and interpret. The steps taken for the short-term forecast, for instance, are well explained. The catch advice given in the report section matches with the values given in the advice sheet, and so do the reported landings and stock summary tables. The values in the advice sheet also match with the data available on the SharePoint. The only comment I have is that for some figures, the axis labels and legends are too small to read. I also made some very minor edits throughout the report, mainly formatting.

Technical comments

1. Two sections of the stock annex still need updated (section B.1.2.1 French data and section B.1.2.3 England data).

2. In the advice sheet, the SAG plot for recruitment is missing the 2017 and 2018 time series for comparison with the 2021 assessment and needs updated.

3. As mentioned above, I made a couple of comments in track changes.

Conclusions

The assessment of sol.27.7d has been performed correctly, and all the diagnostics are satisfactory. This stock has recently been through an extensive benchmark and a thorough review of the data input, and the assessment is now performed in SAM. As a result, for 2021 a category 1 stock advice is given for this stock, as opposed to a category 3 advice given last year. I have no concerns about the assessment of this stock.

tur.27.3a (turbot in Skagerrak and Kattegat)

General

Audit based on the report section, advice sheet, stock annex, 2021 WKNSEA benchmark report, and data available on the SharePoint. Overall, the presented assessment appears sound.

For single-stock summary sheet advice

Stock: Sole in Division 27.7.d

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM, 3 survey age-structured indices (UK BTS, France YFS and UK YFS), 3 commercial tuning series (FRA-COTB, UK (E&W)-CBT and BE-CBT).
5) Consistency: In 2019 and 2020, category 3 advice was provided for this stock. In 2021 this stock was benchmarked during WKNSEA to address data issues. During WGNSSK 2021, the new assessment performed with SAM was accepted and category 1 advice was provided.
6) 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 between B_{pa} and B_{lim}.
7) Management plan: EU multiannual management plan (MAP) for the Western Waters.

General comments

Overall, the sol.27.7d section of the report is very well written and thoroughly documented. It is easy to follow and interpret. The steps taken for the short-term forecast, for instance, are well explained. The catch advice given in the report section matches with the values given in the advice sheet, and so do the reported landings and stock summary tables. The values in the advice sheet also match with the data available on the SharePoint. The only comment I have is that for some figures, the axis labels and legends are too small to read. I also made some very minor edits throughout the report, mainly formatting.

Technical comments

1. Two sections of the stock annex still need updated (section B.1.2.1 French data and section B.1.2.3 England data).

2. In the advice sheet, the SAG plot for recruitment is missing the 2017 and 2018 time series for comparison with the 2021 assessment and needs updated.

3. As mentioned above, I made a couple of comments in track changes.

Conclusions

The assessment of sol.27.7d has been performed correctly, and all the diagnostics are satisfactory. This stock has recently been through an extensive benchmark and a thorough review of the data input, and the assessment is now performed in SAM. As a result, for 2021 a category 1 stock advice is given for this stock, as opposed to a category 3 advice given last year. I have no concerns about the assessment of this stock.

tur.27.4 (turbot)

General

Turbot in 27.4 is, since the 2018 interbenhcmark, a category 1 stock assessment. The model applied uses the SAM statistical catch-at-age model. The model uses a combination of scientific surveys (BTS Q3 and SNS), and one LPUE index from the 80mm beam trawl Dutch fleet. There are currently no estimates of discards for the fleet involved in this fishery, so removals in the assessment model account only for landings.

For single-stock summary sheet advice

Stock **turbot in Subarea 4**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: An update of last year's assessment model run.
2) Assessment: The assessment was accepted by the WG.
3) Forecast: The forecast was accepted by the WG.
4) Assessment model: SAM model with commercial landings data, two survey age-based indices (BTS-ISIS and SNS), and a commercial age-aggregated LPUE time series as input.
5) Consistency: The assessment for 2020 is consistent with that for 2019; Mohn's rho is low for this stock for both SSB (-9%) and F (+7%), and higher for recruitment (-15%).
6) Stock status: SSB in 2020 has remained stable and is well above MSYBtrigger. F is still below Fmsy. The 2018 year class was particularly strong and will make its way thorugh ther adult biomass over the next few years.
7) Management plan: TAC is set combined with brill. EU MAP accepted only by EU. Includes FMSY ranges. Headline advice based on ICES MSY approach

General comments

The assessment is well presented and explained. Issues that could affect the quality of results and advice are covered in detail.

Technical comments

Report

- The lack of estimates for the discards of this stock should be reflected upon. If appropriate scenarios on likely discard levels could be generated, some work could be carried out on the impact they could have on the estimated levels of productivity.
- Indices of abundance from both the SNS and BTS surveys do not appear to follow changes in abundance particularly well, given their low correlation along cohorts. This might be partly due to a single ALK being applied over the whole time series. The LPUE series is thus very influential in the model estimates. The report identifies in details these issues and proposes possible solutions to be investigated over the next benchmark.

Advice sheet

- The Quality of the assessment section, 1st paragraph, refers to uncertainty being created by the availability of data from the Dutch fleet. This needs to be explained further. Is that data availability might be biasing the selectivity estimates?

Conclusions

- Following the 2020 decision by ACOM, the value of Fpa is now based on the calculated Fp.05 with advice rule. This leads to an Fpa value of 0.86, well above the set value for Flim (0.61). This discrepancy should lead ACOM to revisit the basis for this decision, or whether it should apply to all stocks.

- The assessment has been according to the benchmark settings, as covered in the stock annex.

whg.27.47d (whiting)

For single-stock summary sheet advice

Whiting in 4 and 7d

Short description of the assessment as follows:

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM, 2 survey tuning indices (IBTS q1 and q3). SURBAR is used for comparison to SAM. SURBAR is used to ensure consistent survey patterns between northern and southern areas, and continued justification for a single stock assessment.
5) Consistency: The assessment was consistent with the agreed procedure defined by the recent IBP in 2020. The main change was a revision in the assumed natural mortality rates, revised by WGSAM.
6) Stock status: Fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim. Revision of assumed natural mortality values following IBPNSWHITING (2021) has shifted several reference points and, consequently, the perception of the stock. Fmsy was revised upwards, resulting in a current exploitation level significantly below Fmsy, whereas the perception of the previous year was that the stock was being fished slightly above Fmsy.
7) Management plan: Part of the EU plan. Shared stock with Norway → Advice based on the MSY approach.

General comments

Overall, well documented and consistent with the IBP.

Technical comments

For future consideration: Smoothing of natural mortality and maturity through time might benefit from a more standardized approach than the currently used GAM (e.g. where number of knots used is dependent on the number of data, or where a moving average with a predefined number of years is specified.

Tables 8a,b need to be revised, as there are possible errors in the catch statistics from the values updated after the advice document was reviewed during WGNSSK. Specifically, landings values for 2018 are anomalously high, resulting in a large mismatch with ICES statistics. Values for 2020 are missing, yet should be available. [**CORRECTED**)

The assessment code has been made available, but is not completely consistent with TAF. This is planned for the next year. Some changes required for TAF consistency include: 1. Documentation of all r packages in SOFTWARE.bib, removal of directory assignments, consistency of script order (e.g. bootstrap called in data.R, subfolder creation should be at the beginning of respective TAF steps: data.R, model.R, output.R, report.R).

Human consumption fishery (HCF) catch includes BMS but not IBC. This is stated in the report, but may be added to the footnote in the advice as further clarification. One instance of % discards in the advice text incorrectly includes IBC.

I recommend that the report description regarding the procedure for IC discard raising etc. not be adjusted from year to year, but rather reflect the preferred, agreed upon, procedure, and add text as needed to reflect deviations done for particular years (e.g. due to a lack of data on segments / quarters etc.).

Conclusions

The assessment has been done correctly. Only minor errors in some reported catch statistics were identified and these have already been partially corrected.

wit.27.3a47d (witch)

General

An assessment for wit.27.3a47d was not possible during the meeting of WGNSSK in 2021 because ICES DATRAS Center was unable to provide the survey indices, probably due to an error in the code.
Thus during the interbenchmark (IBPWITCH, 2021)

- indices were calculated using a GAM approach
- SAM model was updated
- New reference points were calculated

For single-stock summary sheet advice

Stock**: wit 3a47d**

Short description of the assessment as follows (examples in grey text):

43) Assessment type: **Update (Interbenchmark 2021)**
44) Assessment: **accepted**
45) Forecast: **accepted**
46) Assessment model: **SAM – proposed by WGNSSK 2021, accepted by WKNSEA 2018, modified by IBPWitch 2021– tuning by 2 age indices and 2 biomass indices**
47) Consistency: **Interbenchmark 2021 therefore not consistent with 2020 assessment**
48) Stock status: **B < MSY $B_{trigger}$; F_{MSY} < F < F_{lim}**;
49) 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

- The stock annex needs a few updates to bring it into line with what has been done during the interbenchmark (see technical comments).
- All data described in the stock annex were available and used in the assessment.
- The model settings/configuration used are as described in the stock annex
- The output data from the assessment are consistent.
- The forecast settings used are as described in the report.
- The correct basis for advice has been used.
- The stock annex does not list all model setting listed in the report or on stockassessment.org

Technical comments

- Stock annex:
    - Discards rates need to be updated

Conclusions
The assessment has been performed correctly in accordance with the stock annex.

Audits for autumn update assessments (Norway pout and *Nephrops*)

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, updated with 2020 reference points.

For single stock summary sheet advice:

17) **Assessment type:** update assessment
18) **Assessment**: analytical
19) **Forecast**: Stochastic forecast
20) **Assessment model**: Quarterly SESAM model
21) **Data issues:** Q3 English and Scottish survey data available in time for assessment schedule. IBTS data were revised following automation of age allocation procedures, which caused a re-scaling of the assessment (SSB increase, F decrease).
22) **Consistency**: Update assessment, following specifications in the Stock Annex, but with revised reference points following the rescaling in the assessments.
23) **Stock status**: Above B_{lim} and B_{pa}, no F reference points except for F_{cap} (F_{bar}(1-2));
24) **Management Plan**: No management plan, but ICES has evaluated long-term management strategies for Norway Pout following an EU-Norway request

General comments
Given the rapid turnaround for the audit (just a few hours), the auditor only focused on the advice sheet and the relevant inputs from the report to the advice sheet. 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).

Only minor errors detected, and some small improvements needed (rounding) a indicated below.

Technical comments (advice sheet version 7 on the advice sharepoint, as per 28/09/2021)
- Table 2 – rounding rules need to be applied, as indicated by the highlighted numbers. I have indicated what I think they should be, but needs verification by the stock assessor.
- Table 6 – EU TAC value for 2020 is not corrected. I have indicated the source for the correct value (65000 should be 72500). I have also inserted the values for 2021, with the source. An additional footnote may be needed against the EU TAC to explain that it is a combination of the EU and UK.
- Table 8 – the "Bycatch of other species" in the final table section does not add up to the values by division for 2020 and 2021 (fine for other years).

Conclusions

The assessment has been performed correctly.

nep.fu.6

General

For single stock summary sheet advice:

25) **Assessment type:** Category 1 with annual advice (October advice)
26) **Assessment**: UWTV survey
27) **Forecast**: An updated short-term forecast for 2022 was presented. Forecast based on latest UWTV survey (2021), mean weights (2018-2020), discard rate (22.0), discard survival (15%) and MSY harvest rates.
28) **Assessment model**: None
29) **Data issues:** No data issues
30) **Consistency**: This stock has been benchmarked by ICES in 2013 (WKNEPH, 2013) and the stock annex was updated.
31) **Stock status**:
    - The 2021 burrow abundance estimate decreased 11% in relation to 2020 but remains above the Btrigger. The harvest rate decreased in 2020 to 9.1 but remains above Fmsy.
32) **Management Plan**: EU multiannual plan (MAP). There is no agreement with the UK regarding the EU multiannual plan (MAP) and it is not used as the basis of the advice for this stock. 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

Technical comments

The following minor corrections are suggested:

In the report (section short term forecasts) the option for F2020 (9.1%) is missing from the catch option tables.

There is a slight mismatch in the landings and discards reported in Table 6 and Table 8 (see e.g. 2017 and 2018) in the advice sheet.

The headline advice (first sentence) in the advice sheet is slightly different from what was used for other FUs.

Conclusions

The forecast has been performed correctly with no deviations from the standard procedure for this stock.

nep.fu.7

General

For single stock summary sheet advice:

1) **Assessment type:** Category 1 with annual advice (October advice)

2) **Assessment**: UWTV survey

3) **Forecast**: An updated short-term forecast for 2022 was presented. Forecast based on latest UWTV survey (2021), mean weights (2018-2020), discard rate (2018-2020), discard survival (25%) and MSY harvest rates.

4) **Assessment model**: None

5) **Data issues:** No data issues

6) **Consistency**: Discard sampling was impacted by the Covid-19 situation, however sampling in quarters 1 and 4 was considered sufficient (coverage 55% of the landings in 2020) to be used for the discard estimates. This does not present an issue to the time series consistency.

7) **Stock status**: The 2021 burrow abundance estimate increased 38% in relation to 2020 returninf to levels similar to previous years (2017-2019). The harvest rate decreased and is well below Fmsy.

8) **Management Plan**: Since 2021, ICES MSY approach; previously EU multiannual plan (MAP). There is no agreement with the UK regarding the EU MAP and it is not used as the basis of the advice for this stock. 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

Technical comments

As with every other Category 1 functional unit in the NSSK assessment area, advice for FU 7 has been impacted by the ongoing COVID-19 pandemic. However, with the resumption of UWTV surveys in 2021, the assessment could be carried out as normal, and there is no immediate need to reclassify the category of this stock.

The following minor corrections are suggested:

In the report table 11.5.1 starts in the year 1983, while the equivalent table in the advice sheet (table 8) starts at 1981.

Conclusions

The forecast has been performed correctly with no deviations from the standard procedure for this stock.

nep.fu.8

General

For single stock summary sheet advice:

1) **Assessment type:** Category 1
2) **Assessment**: UWTV survey
3) **Forecast**: An updated short-term forecast for 2022 was presented. Forecast based on latest UWTV survey (2021), mean weights (2018-2020), discard rate (2018-2020), discard survival (25%) and MSY harvest rates.
4) **Assessment model**: None
5) **Data issues:** No data issues
6) **Consistency**: In 2020, only commercial catch samples from quarter 1 were available, as a result of the COVID-19 pandemic. As observed discard rates in quarter 1 were lower than average, it was decided to calculate averages for the reference period 2017—2019 and scale to quarter 1 values in 2020. There was no seasonal pattern in discard rate in the past, so the approach was considered appropriate.
7) **Stock status**: The 2021 burrow abundance estimate decreased by 25% in relation to 2020. The harvest rate decreased and is well below Fmsy.
8) **Management Plan**: Since 2021, ICES MSY approach; previously EU multiannual plan (MAP). There is no agreement with the UK regarding the EU MAP and it is not used as the basis of the advice for this stock. 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

Technical comments

As with every other Category 1 functional unit in the NSSK assessment area, advice for FU 8 has been impacted by the ongoing COVID-19 pandemic. However, with the resumption of UWTV surveys in 2021, the assessment could be carried out as normal, and there is no immediate need to reclassify the category of this stock.

Conclusions

The forecast has been performed correctly with no deviations from the standard procedure for this stock.

nep.fu.9

General

FU 9 (Moray Firth) is one of nine Norway Lobster stock units in the North Sea (plus the area outside FUs). ICES advice is given specifically for each individual FU, however EU fishery management uses a combined stock TAC covering FUs 5, 6, 7, 8, 9, 10, 32, 33, 34, as well as regions of Subarea 4 that are outside FUs. FU 9 is a Category 1 (Nephrops) stock: the assessment uses an underwater video survey (UWTV) to estimate absolute abundance.

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Category 1 (UWTV survey) with annual advice
2) Assessment: accepted; absolute abundance from UWTV survey
3) Forecast: not presented; no analytical forecast for any of the Nephrops stocks; advice for this FU is based on the most recent accepted abundance survey (2021), mean weights (2018-2020) and MSY harvest rates.
4) Assessment model: none
5) Consistency: The 2020 UWTV survey was not deemed robust enough for the assessment, because of the reduced number of stations completed due to the COVID-19 disruption on the survey schedule. As such, the stock size for 2020 is unknown. The UWTV survey was resumed in 2021 and carried out as normal. The harvest rate in 2020 was calculated using an interpolated value for abundance (average of 2019 and 2021).
6) Stock status: F is below the F_{MSY} proxy, and stock size is above the MSY $B_{trigger}$ proxy.
7) Management plan: Since 2021, ICES MSY approach; previously EU multi-annual plan

General comments

This Norway Lobster functional unit is generally well documented.

Technical comments

As with every other Category 1 functional unit in the NSSK assessment area, advice for FU 9 has been impacted by the ongoing COVID-19 pandemic. However, with the resumption of UWTV surveys in 2021, the assessment could be carried out as normal, and there is no immediate need to reclassify the category of this stock.

Conclusions

The assessment has been performed correctly in line with the stock annexe.

Annex 5: Benchmarks and prioritisation

This Annex was updated in November 2021

Benchmarks

A.1.1 Executive Summaries of recent benchmarks

Two benchmarks that involved WGNSSK stocks were organised in 2020–2021. The WKNSEA benchmark was convened to evaluate the appropriateness of data and methods to determine stock status for cod in the North Sea, Eastern Channel and Skagerrak (Cod.27.47d20) and sole in the eastern English Channel (Sol.27.7d). Furthermore, two interbenchmark workshops (IBPNSWhiting) were convened in 2021 for North sea whiting (whg.27.47d) to include new natural mortality estimates in the assessment and for witch in the Greater North Sea (wit.27.3a47d) to include new survey indices.

A.1.1.1 Cod in 4, 7.d and 20 (WKNSEA 2021)

The North Sea cod stock was put forward for benchmark in 2021 due to conflicting signals in the underlying data and a developing retrospective bias in the assessment. In addition, the stock ID was put forward as an issue for North Sea cod. To address the latter, a four-day workshop on Stock Identification of North Sea Cod (WKNSCodID) was held in August 2020 to review information on the population structure of cod in the North Sea and adjacent waters. The workshop concluded that North Sea cod includes reproductively isolated Viking and Dogger cod populations, and the Dogger population has some phenotypic structure and extends to 6.a.N. However, the data evaluation workshop found unexplained discrepancies between the spatially-disaggregated data and the data as used in the current assessment, possibly caused by the very short timeframe for data providers to compile the data. Further, the spatially-disaggregated time-series started in 2002 which would truncate the time-series with 40 years. Therefore, the workshop concluded that development of spatial approaches would not be possible in time for a benchmark in 2021, although it was agreed that a spatial-disaggregated cod assessment would be preferable and work to archive this goal should be initiated in the next years. However, after consultation with the ACOM LS it was decided to improve the present combined assessment until a spatially-disaggregated time-series would be available. At this benchmark;

- recreational catches were considered but not included in the analytic assessment due to data quality issues.
- Updates were made to the base calculations for deriving the subarea-weighted maturity ogive. The first 15 years (1963–1977) were removed and the ogive not smoothed. Further, maturity is now modelled as a process.
- Stock weights have changed to IBTS Q1 survey weights for ages 1–2 and as Q1 catch weights for ages 3+.
- A high-resolution delta-GAM survey indices with a fixed spatial term and yearly independent deviances is now used.
- Introduction of a recruitment index based on the IBTS Q3 at age 0 and shifted to the beginning of the following year has been introduced.
- Smoothed M data from the 2020 SMS key run is included with an addition of adjusted Ms from 2011 for ages 3+ to mimic migration out of the stock area into 6aN.

- Several configuration adjustments were made to the model.
- New reference points were calculated based on a truncated time-series (1998–2019) and a type 6 S–R plot.
- Inclusion of both age 0 and age 1 in the protocol on the reopening of the advice.

A.1.1.2 Sole in 7.d (WKNSEA 2021)

Sole in Division 27.7d had data issues with a commercial tuning series, and an inter-benchmark was set up in August 2019. At the end of the inter-benchmark, it was found that some commercial catch data for 2016 and 2017 were aggregated incorrectly for older ages. During the benchmark in February 2020 (WKFLATNSCS 2020), further data issues were discovered. As a result, the benchmark process was postponed to the WKNSEA 2021 benchmark, and in the data call, the commercial catch data time-series was corrected and re-uploaded. Discard data were available from 2004 onwards. Prior to 2004, discards were reconstructed using the ratio between discards and landings in the period 2004–2008. Stock weight-at-age were set to quarter 1 catch weight-at-age (2004–2019) to improve consistency. They were reconstructed prior to 2004 using the ratio between quarter 1 and yearly catch weight-at-age using data from 2004–2019. Six tuning fleets are currently included in the assessment: three survey indices (UK BTS, FRA YFS and UK YFS) and three commercial indices (BEL CBT, UK CBT, FRA COTB). During the benchmark, the commercial indices were changed to biomass indices in the assessment instead of disaggregating them by age to avoid double counting of commercial data. The French commercial otter trawl fleet (FRA COTB) and Belgian commercial beam trawl fleet (BEL CBT) were revised using the adjusted catch data as input and following a model-based approach to derive an lpue index that is considered to reflect the fishable biomass of the stock.

A state–space assessment model (SAM) was chosen for this stock using the three commercial LPUE indices as fishable biomass (FRA COTB, BEL CBT, UK CBT) and three scientific, age-structured survey indices (UK BTS, UK YFS, FRA YFS). Compared to the previous XSA assessment model, the spawning–stock biomass is estimated to be significantly lower, while the fishing mortality is estimated to be higher. Following the changes in the input data and assessment model, the reference points were re-calculated and F_{MSY} is now estimated at 0.193 (similar to previous estimate).

A.1.1.3 Whiting in 4 and 7.d (IBPNSWhiting 2021)

The Inter-Benchmark Protocol of North Sea Whiting (IBPNSWhiting 2021) met to consider the use of updated Natural Mortality estimates from the North Sea multispecies assessment model developed by the Working Group on Multispecies Assessment Methods (WGSAM, 2020) for Whiting in Subarea 4 and Division 7.d (North Sea and eastern English Channel). In this report the estimates of Natural Mortality are compared to previous estimates (WGSAM, 2018), the effects of this change on the assessment model are considered, and reference points recalculated. The estimates of Natural Mortality from the most recent multispecies assessment model were slightly higher than from the previous run, particularly at age 0. Incorporating these revised Natural Mortality estimates into the assessment resulted in only minor changes to the stock size, recruitment and exploitation estimates, and to the quality of the model fit. The updated model showed higher retrospective bias than previously, but was still judged to be acceptable. Following the revision of the assessment model, reference points were re-calculated following the ICES Technical guidance and using the same assumptions as for previous assessments. This resulted in lower biomass reference point (e.g. MSY $B_{trigger}$ decreased from 167 000 t to 144 000 t) and a substantial increase in F_{MSY} (from 0.172 to 0.371).

A.1.1.4 Witch in 3.a, 4 and 7.d (IBPWITCH 2021)

IBPWitch was primarily tasked with establishing a new method to create reproducible survey indices after the method determined in the last full benchmark was no longer available/reproducible. In addition to establishing the new survey indices, the group also considered the assessment model configuration and updated the stock's reference points, to ensure coherence and reproducibility across future assessments. The group selected a Generalised Additive Model modelling approach, which is implemented across many other ICES stocks, to generate indices by age and year across two quarters (Q1 and Q3). The indices' model assumptions and configurations were thoroughly investigated, assessed and documented. The assessment model, a State-space Assessment Model (SAM) that is available on stockassessment.org, was modified so that age1 survey indices were not included in the model. Assumptions of interdependence in fishing pressure between ages that were adopted in the previous benchmark were tested and retained. The short-term forecast methodology was modified, to provide a more consistent estimation of recruitment. The inclusion of different data sources in the calculation of reference points was thoroughly considered and the decision made to utilise the same dataset for the stock-recruitment relationship as in the previous benchmark with just updated recent years. This relationship was modelled according to a "type-two" segmented regression and utilised to estimate B_{lim}. Future work on this stock relies on improved age sampling (spatially and inter-lab calibration) from surveys, investigation of alternate surveys covering deeper waters, and evaluating a shift to a length-based assessment.

A.1.2 Benchmarks for 2022

A.1.2.1 Northern Shelf haddock

Data available/needed

Current assessment issues

Proposed working papers/analyses

Work plan for benchmark

The issue list for Northern shelf haddock (had.27.46a20) 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	SSB is used to indicate both reproductive potential and harvestable biomass, and it may be a poor proxy for both.	Investigate indices of reproductive potential and methods to use them in management advice.	Weight-at-age and fecundity/egg condition data.	Fecundity modelling: Peter Wright (MSS).
	The stock is considered to be homogenous throughout subareas 4 and 6a, but there may be relevant substock structure.	Explore stock ID and structure, using otolith microchemistry, tagging data, and the spatial range of genetic data.	Otolith micro-chemistry, tagging, genetic data.	Stock ID: Peter Wright, Neil Campbell (both MSS)
Tuning series	The survey data used in the assessment cover only the North Sea component.	Explore combining survey indices from the North	Survey data available.	Survey modelling: Andrzej Jaworski (MSS), Casper Berg (DTU-Aqua)

		Sea and West of Scotland.		
Biological parameters	The assessment uses a knife-edge maturity at age 3.	Derive time-varying maturity estimate.	Maturity data from IBTS surveys.	Maturity modelling: Peter Wright (MSS), Casper Berg (DTU-Aqua)
	Mean weights-at-age for total catch are used for stock weights.	Derive estimates of mean weights at age for stock.	Weight data from commercial catch and surveys.	Weight modelling: Peter Wright (MSS), Casper Berg (DTU-Aqua).
Assessment method	TSA support likely unavailable after 2021/22.	Consider alternative models which are compatible with high performance computing (for MSE).	Alternatives likely to use same data as TSA, although a spatio-temporal model such as SS3 would require more extensive spatial data.	SAM: Anders Nielsen (DTU-Aqua). Potentially SS3 expert.
	Plus group does not seem to be well fitted.	Investigate poor fit in plus group in view of increasing relative importance of this age class.	No extra data requirements.	SAM: Anders Nielsen (DTU-Aqua). Potentially SS3 expert.
	Exploratory model SURBAR requires further development.	Develop likelihood profiling for ad hoc parameters, and catchability estimation model based on catch curves.	No extra data requirements.	SURBAR: Coby Needle (MSS).
	Haddock is characterised by occasional large year-classes, which do not conform to the usual distributional assumptions for modelling recruitment.	Exploration of modelling techniques for sporadic recruitment is needed (mixed distributions etc.).	No extra data requirements.	SAM: Anders Nielsen (DTU-Aqua)
Biological Reference Points	Reference points will need to be updated following data, assessment and forecast revisions.	Follow the standard processes where appropriate to generate new reference points.	No extra data requirements.	No external expertise required.
Forecast	Growth model used in forecast needs to evaluated.	Investigate extent of cohort effect on growth rate. Ensure consistency between catch components for weight at age cohort modelling. Develop non-spreadsheet approach to forecasting weights.	No extra data requirements.	Growth modelling: Andrzej Jaworski (MSS), Casper Berg (DTU-Aqua).
	Approach for recruitment estimation in the intermediate year	Investigate intermediate year recruitment assumption.	No extra data required.	Statistical modelling.

	needs to be evaluated.	Forecast value for recruitment would benefit from including information on the probability of large year classes occurring.		
Other	There appear to be SOP issues in InterCatch data.	Ensure consistency in catch data used in assessment and advice sheet.	InterCatch database.	InterCatch experts: Henrik Kjems-Nielsen (ICES)

A.1.2.2 Plaice in 4, 20

Data available/needed

Current assessment issues

Proposed working papers/analyses

Work plan for benchmark

The issue list for plaice in 4, 20 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	Due to a sequence of "low" catch rates in several years, the industry are not in agreement with the ICES estimated stock status.	Dutch commercial LPUE analysis, 1) LPUE by subarea and gear type; 2) LPUE of targeted fisheries	Dutch commercial landing, discards, VMS data	Experts on Dutch fisheries
	Applying smoothed stock/catch/discards at weight, investigate its trend and impact on catch/stock weight	Apply gam		Stock coordinator,
	Update Mortality, maturity, age and length distribution, by subarea (North sea and NW-North sea)	Apply models and evaluating trends Stock ID analysis	BTS, IBTS, commercial catch data	Expert on biological modelling, expert on survey
Tuning series	The delta-gam IBTSQ1 age>=5 indices showed upward revision in last 3 years, this is likely the cause of the	Investigate the data quality and age reading.	IBTS-Q1	Expert in IBTS-Q1 survey, age readers. Stock coordinator, Casper Berg

	upscaling SSB in empirical retro analysis.			
	IBTSQ3 showed strong signals in north west area (around Scotland). Younger ages (>=2) even appear in this area.	Investigate the data quality and age reading, especially around Scotland. Explore gear effect, time-varying spatial random effect. Validate the signals in this area with catches in Scotland	IBTS-Q3 Catches in Scotland	Expert in IBTS-Q3, age readers, Stock coordinator
	Age 0 are moving from coastal area (SNS) to BTS area. This will result in a changed catchability between these 2 surveys.	Explore possibilities of a combined indices; split the time series; include age 0 BTS indices in assessment	BTS, SNS	Casper Berg, Stock coordinator, survey expert in SNS and DFS
	Currently 6 survey indices are included. A clear vision is needed on the contribution of each survey in the assessment.	Sensitivity analysis on survey (LOO), especially when 2 surveys are highly correlated (e.g. BTS and IBTS-Q3) Internal and external correlations within and between surveys (catch as well) SURBAR		Experts on stock assessment, modeling, Coby Needle, Stock coordinator
Assessment method	Residual patterns in both catch survey	Re-define the spline structures in the model; number of knots, age plateau, max (or plus) age		Experts on SAM or AAP
	Confirm the stock status with run on another assessment model	SAM		Experts on SAM
	Large empirical retrospective pattern	Likely caused by the upscaling revision from IBTS-Q1		Stock coordinator
	Currently all discards in assessment are considered dead. A non-zero survival rate could be included in the model.	Include non-zero survival of discards in the model		Expert in survival experiment and stock assessment

Biological Reference Points	Determine MSY reference points	Run EqSim functions	Using the final assessment	Experts in computation of reference points, Stock coordinator
Forecast	Validate the RCT3 method			Experts in RCT3, stock coordinator
	Possibility and quality of including IBTS-Q1 indices in spring forecast.	Validate the prediction performance of IBTS-Q1, ask for possibility of having IBTS-Q1 plaice ready in Spring		Experts in RCT3, IBTS-Q1
	Given large changes in plaice in response to environmental changes (e.g. density dependent growth, differences in age distributions), we need to know the efficacy of ICES advice rule n the long term	MSE		Expert on MSE and stock coordinator

A.1.3 Benchmarks for 2023 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). The stocks being considered for benchmark in 2023 are mur.27.3a47d (red mullet) and pok.27.3a46 (saithe), the former due to the assessment having been rejected in 2021 and being downgraded to category 5, and the latter to improve data input and account for the recent low productivity regime in the forecast. 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)
mur.27.3a47d	Cat 3 No TAC	- Age data from other countries than France need to be provided as everything is actually raised using the French catches in the Eastern Channel and few sample from the North Sea. - Length data is mainly provided by France and a also UK with recently some submission from Netherlands, however the sampling coverage remain to low and further sampling is required. - 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 - CGFS survey data issue in index calculation needs to be fixed. GAM or GLMM methods such as the method developped by Berg et al. or Thorston et al. should be explored to account for missing data UK haul in 2020 and also better account for the change in vessel in 2014.	- Assessment model was rejected by WGNSSK 2021 and a category 5 advice is given for this stock. - With so few age classes exploited the a4a model formulation used needs revision as it is no longer fit to give advice. - Explore other models (SAM, SURBAR, length-based model…) - Explore methods applied to "short lived species" (two stages model)? - SPiCT should be explore again either as basis for advice or to estimate the stock status.	- This stock was downgraded to category 5, 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.	5	4	2	5	3	4.2

stock	Type	Benchmark Issues			Scoring Catego-ries					Total
		data and stock ID	**assessment**	**forecast and reference points**	**1**	**2**	**3**	**4**	**5**	**(weighted)**
		- Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated - Based on the recent WD presented at WGNSSK2020 stock ID should be reinvestigated								
ple.27.420	Cat 1 shared	- The delta-gam IBTSQ1 age>=5 indices showed upward revision in last 3 years, this is likely the cause of the upscaling SSB in empirical retro analysis. Investigate the data quality and ALK. - IBTSQ3 showed strong signals in north west area (around Scotland). Investigate o Quality of samples: gear and age reading. o Why younger ages (age>=2) appear in this area in last 15 years o Indices with/without gear effect, time-invariant and time-varing, including and excluding NWarea o Validate indices with catches in Scotland - WGBEAM indicates an increasing age 0 selectivity in BTS while a decreasing sel in SNS (aim for age0), maybe a combined indices - Investigate the spatial mismatch between survey fishing effort, e.g.	- Solve residual patterns - Investigate the survey leave-one-out results and retro analysis on LOO - “error” in discards due to non-zero survival in assessment (~9%), might lead to overestimate of stock size - explore different assessment models	- RCT3 analysis on recruitment? If not, how to include recuitment survey in assessment, e.g. DYFS - Considering density-dependent growth in reference point calculation?	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)
		LPUE - Explore stock ID trend and difference between NS and NW-NS: maturity/mortality/sex ratio/growth rate/LF/survey_indices								
tur.27.3a	Cat 3 No TAC	- review of knowledge, including genetic findings, and turbot migrations and spawning grounds - Stock definition - dealing with the missing Swedish catches - 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	-advance assessment (SPiCT)	-develop reference points	5	5	2	2	1	4
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

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 3 PA	-explore stock ID	-develop assessment (SPiCT)	-develop reference points -develop advice based on short term forecast	4	4	3	5	1	3.7
pol.27.3a4		- 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 most likely through the use of data limited approaches	-develop an assessment if possible	-develop reference points if possible	4	3	1	5	5	3.6
cod.27.47d20	Cat 1 shared	-develop spatial approaches to better account for stock structure -investigate the significance of spawner age on reproductive potential -investigate perceived catchability problems in IBTS surveys (age reading issues as well as emmigration?) -investigate the possibility of including recreational catches	-develop spatial assessment approaches to better account for stock structure	-explore potential biases in the forecast and how to deal with these	3	4	5	5	1	3.5
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	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.	The effect of the current low productivity regime of the stock (i.e. lower recruitment) on reference pooints should be investigated.	3	4	5	4	3	3.6

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		grounds north of 62°N could improve the assessment. Planned tagging studies may also aid in this. 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. The use of the Norwegian summer accoustic survey (NORACU) - formerly dissmissed during the 2016 benchmark on the ground of (now corrected) inconsistencies - should also be re-evaluated. Catch-per-effort index – The current commercial CPUE index is standardized for area and engine power effects and is not able to account for spatial and temporal effects interactions. The inclusion of alternative explanatory variables (e.g. vessel effect) and spatio-temporal effects should be evaluated.	log-likelihood, AIC). This should be investigated further. CPUE index - issues exist on the calculation method / model. Improved methods exist for deriving yearly indices in the CPUE model. The fix maturity ogive assumption should be re-evaluated, especially in the light of improved sampling during the spawning season (Q1 acoustic survey). Survey Index - time series has been updated using new ALK-matching methodology							

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
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. Ensure consistency in catch data used in assessment and advice sheet (SOP issues in InterCatch 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 shows some bias in prediction errors for Age 0 IBTS Q3 survey. TSA support likely unavailable after 2021/22 so need to consider alternative models. Exploratory assessment model SURBAR – develop likelihood profiling for ad hoc parameters, and catchability estimation model based on catch curves. If TSA is retained, an objective criteria are needed to decide if a year class is significantly large to warrant special treatment in TSA. Alternatively, some exploration of modelling techniques for sporadic recruitment is needed (mixed distributions etc).	Investigate extent of cohort effect on growth rate. Ensure consistency between catch components for weight at age cohort modelling. Investigate intermediate year recruitment assumption. Forecast value for recruitment would benefit from including information on the probability of large year classes occurring.	3	4	5	2	3	3.4
nep.27.4outFU	Cat 4 PA	Data from the Dutch landings and discards length sampling programme from 2015 onwards contain errors due to issues with processing codes and need to be resubmitted to InterCatch. On the basis of the revised sampling data,	No changes to the assessment are anticipated	No reference points have been determined	3	3	3	5	5	3.4

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		raised discards will then be recalculated.								
nep.fu.32	Cat 4 PA	Sampling of trawl catches by the Norwegian coast guard should be improved by sexing individuals and sampling discards and landings components separately to enable discards estimations. An UWTV survey should be carried out to explore and map distribution and density	Assessment methods for data poor stocks should be explored		3	4	3	5	2	3.4
nep.fu.5	Cat 4 PA	Data from the Dutch landings and discards length sampling programme from 2015 onwards contain errors due to issues with processing codes and need to be resubmitted to InterCatch. On the basis of the revised sampling data, raised discards will then be recalculated. Also, the individual mean weights in landings and discards will be recalculated.	The assessment is based on the harvest rate estimate in relation to the MSY proxy of 7.5%. With the revised discard rates and mean weights, the harvest rates from 2015 will be revised, with potential impacts on the next advice due in 2022.	No change to the reference point is anticipated	3	3	3	5	5	3.4
nop.27.3a4	Cat 1 shared	Investigate size-at-age and derived weight-at-age in how it affects model estimation in terms of sampling accuracy and precision achieved under the current design and the most statistically rigorous way to impute values for years where these data are missing or in question.	Investigate retrospective patterns in the assessment among other in relation to the Mohn´s Rho values for recruitment, SSB and F. Introduce procedure in SESAM to make one-out-standard analyses of tuning time series.	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.	3	4	3	2	3	3.2

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		There are currently two recruit indices (age 0 from SGFS and EGFS) being used in model parameter estimation. To avoid duplicative information being introduced into the assessment, a method should be developed that combines the Scottish and the English indices into a single robust index. In general GAMM analyses should be conducted to explore further integration of survey time series. Investigate error variances of the data that concerns sampling mechanics, sampling theoretics and sampling designs for both fishery-independent data, and for those obtained from the fleets.	Develop additional standard diagnostic tools for performance for the new SESAM model: (i) a better format for displaying and interpreting standardized model residuals over time (the bubble plots are horizontally compressed and very difficult to read and interpret); (ii) performance statistics based on prediction skill (e.g., how well does the model predict when a data point is removed?); (iii) likelihood profiles (if there is tension in the model, where does it occur?); (iv) some depictions of any gradient problems that may exist; (v) summary tables with AIC/BIC values for models using the same data (i.e., documentation of all intermediate models tested before arriving at the final choice of parameter coupling); (vi) statistics for model goodness-of-fit.	This has implications for setting of Blim levels. Sensitivity runs on the assumptions of time invariant growth, maturity and natural mortality may need to be considered. For the short term, projections that include different ways to handle mean weight-at-age, including projecting forward with specified uncertainty, should be more fully explored (smoothed historic time series, average over some recent time period, etc.).						
sol.27.4	Cat 1 EU	- Explore data giving rise to larger discards estimates for fish aged 6+	- Investigate retrospective patterns appearing in 2019	-validate RCT3 method	3	3	5	4	1	3.1
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	- exploratory SPiCT model	- investigate the use of rfb, chr HCR	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)
		some nations (e.g. Germany and the UK)								
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.The current survey indices used for North Sea lemon sole are not able to track cohort strength on a consistent basis, and they exhibit generally poor catchability characteristics which limit the reliability of the advice based thereon. It would be very beneficial to be able to include commercial catch data in the assessment in order to improve reliability and reduce variability.	A new method of estimating age-based survey catchability coefficients is needed to help to address the problem of negative Z estimates. Age data are lacking from commercial catch data, so a (spatial) length-based assessment using both catch and survey data should be explored (for example, Stock Synthesis 3).	Reference points are currently based on length-based indicators, and further work could help derive more robust estimates. If a length-based assessment can be developed using commercial and survey data, a full stochastic forecast method should be explored.	3	3	1	5	2	2.9
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) or revise the current biomass index series (cfr. Tur4 assessment); - investigate biological parameters	- Explore whether other assessment methods can be used (Spict/SAM).	-calculate reference points based on any new assessment for the stock	3	3	2	2	3	2.8

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		- Investigate how the biomass index should be corrected for technological creep (Dutch fleet has an increasing amount of pulse trawlers compared to the beginning of the series, who switch back to beam trawl in the most recent year);								
tur.27.4	Cat 1 EU	-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. - A detailed analysis of delta GAM indices with various settings should be carried out once more age information becomes available. -alternatives to smoothing of mean weights-at-age from the fishery to be investigated	- 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 is based on landings instead of catches.	3	3	2	2	2	2.7

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
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) which are able to better reflect the stock status -other stock indicators available? e.g. WFD monitoring from coastal areas	- Investigate available growth darta and use of rfb and chr HCR	3	2	1	5	2	2.6
wit.27.3a47d	Cat 1 MSY	- no issues currently	-The choice of proportion of fishing mortality and natural mortality before spawning (Fprop and Mprop) 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, especially concerning their use in estimating reference points.	2	3	3	2	3	2.5
ple.27.7d	Cat 1 EU	- evaluate FR GFS index, remove potential vessel affect from the data (possibility of splitting the time serie of the index) - there was a lack sampling during CGFS 2020 (stations in UK waters were not sampled)	- test new index produced and evaluate its impact on survey residuals and the assessment - test new maturity ogive and Q1 removal investigate the important decrease of recuitment in 2020	- no issues currently	3	3	5	2	3	3.1

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		- investigate if new maturity data are available and useable - data required to update Q1 migration - lack of information of weight at age for ages 1 and 2 for Q2 - Fix the coding issue of CGFS index (update the calculation of the index)								
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) -DATRAS indices (new French data upload for historical series), exploration of delta GAM method for index calculation	- impact of new 2020 SMS keyrun (WGSAM, 2021) estimates of natural mortality on assessment model: SSB retros just within acceptable limits defined by WKFORBIAS -use of unsmoothed maturity and natural mortality estimates as input (using the new SAM method to estimate missing historical values and forecast)	-further investigate alternative SAM forecast (recruitment assumption, split of catches) -Reference points estimated with EqSim with the new survey indices are slightly different from the ones estimated during the 2018 benchmark.	2	2	4	2	2	2.2
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-	- 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	- investigate HCR from WKLIFE X	3	2	1	1	2	2.2

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
		GAM index with Belgian and German BTS data (prior to 2002).								
sol.27.7d	Cat 1 shared	- further investigation of the perceived subpopulations; - investigate the mechanism of the declining trend in weights-at-age; - investigate natural mortality and maturity	none	none	1	2	5	4	1	2
nep.fu.10	Cat 4 PA									
nep.fu.33	Cat 4 PA	Data from the Dutch landings and discards length sampling programme from 2015 onwards contain errors due to issues with processing codes and need to be resubmitted to InterCatch. On the basis of the revised sampling data, raised discards will then be recalculated. Also, the individual mean weights in landings and discards will be recalculated.	The assessment is based on the harvest rate estimate in relation to the MSY proxy of 7.5%. With the revised discard rates and mean weights, the harvest rates from 2015 will be revised, with potential impacts on the next advice due in 2022.	No change to the reference point is anticipated						0
nep.fu.34	Cat 4 PA									0
nep.fu.3-4	Cat 1 EU									0
nep.fu.6	Cat 1 EU									0
nep.fu.7	Cat 1 EU									0
nep.fu.8	Cat 1 EU									0

stock	Type	Benchmark Issues			Scoring Categories					Total
		data and stock ID	assessment	forecast and reference points	1	2	3	4	5	(weighted)
nep.fu.9	Cat 1 EU									0

Annex 6: Update forecasts and assessments

The Section was added to the report in November 2021

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chairs: Raphaël Girardin, France, and Tanja Miethe, UK) communicated by correspondence at the beginning of October 2021 to evaluate new information from the fisheries independent surveys carried out during 2021 subsequent to the meeting of the group in April/May. For cod in 4, 20 and 7.d, the re-opening protocol was run and concluded that re-opening of advice in autumn was not required.

Scheduled assessment and forecast conducted in autumn 2021 for *Nephrops* (delayed to autumn in 2021), witch (following IBPWITCH) and Norway pout are included in the respective report sections.

A.6.1 Cod in Subarea 4, Division 7.d and Subdivision 20

A.6.1 New fishery information

Absolute landings data for 2021 up to 30 June and up to 30 September were made available for a potential autumn forecast. The data were submitted by nation from official sources and are provided in Table 6.2.1. Nations indicated that the quality of data should be good, although some small amounts of data may be missing for Q3 due to the short time elapsed. Using relationships derived by WKNSROP (ICES-WKNSROP, 2020), the landings data submitted for quarters 1–2 and quarters 1–3 were used to predict landings and catches (assuming the same discard ratio by age for 2020) for the whole year, and subsequently compared to the intermediate year assumptions of the May forecasts. The outcome of this analysis was as follows:

Year	Intermediate year assumptions				Submitted landings		Predicted landings		Predicted catches	
	F	Assumption	Catch	Landings	Q12	Q123	pred Q12	pred Q123	pred Q12	pred Q123
2021	0.37	Lowest F	27153	20790	6444	10478	14881	12781	19363	16614

Reported landings for quarters 1–2 and quarters 1–3 in 2021 (Submitted landings) were lower than all landings values used to fit the regressions (based on InterCatch data from 2002–2019). The predicted landings are therefore extrapolations from the WKNSROP relationships.

A.6.2 New survey information

New survey information, in the form of the IBTS Q3 2021 data, are available, 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 6.2.2.

A.6.3 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA, 2008) and revised by WKNSROP (ICES-WKNSROP, 2020) and WKNSEA (ICES-WKNSEA, 2021), RCT3 analyses were run to provide estimates of the abundances of the incoming 2020 and 2021 year-classes at age 1. The RCT3 input and output files are given in Tables 6.2.3 and 6.2.4–6.2.5, respectively.

A.6.4 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2020–2021 year-classes at age 1	2020 YC	2021 YC
Log WAP from RCT3 (R)	11.96	12.48
Log of recruitment assumed in spring (A)	12.13	12.31
Int SE of log WAP (S)	0.211	0.489
Distance D $\left(D = \frac{R-A}{S}\right)$	**-0.824**	**0.346**

A.6.5 Conclusions from Protocol

As the distances -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea cod should not be reopened**. The autumn indices suggest that the size of the incoming year-classes are not significantly different to what had been assumed in the forecast produced by WGNSSK in May 2021.

A.6.5 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WKNSEA (2021). Benchmark Workshop on North Sea Stocks (WKNSEA). ICES Scientific Reports. 3:25. 756 pp. https://doi.org/10.17895/ices.pub.7922

ICES-WKNSROP (2020). Workshop on the North Sea reopening protocol (WKNSROP). ICES Scientific Reports. 2:108. 74 pp. https://doi.org/10.17895/ices.pub.7576

Table A.6.1. Cod in Subarea 4, Division 7.d and Subdivision 20. Absolute landings data for 2021 up to 30 June and 30 September respectively, in tonnes.

	Landings up to 30 June	Landings up to 30 September
Belgium	99	201
Denmark	1779	2601
France	138	245
Germany	386	633
Netherlands	432	523
Norway	653	1374
Sweden	244	457
UK England	61	112

UK Scotland	2650	4332
Total	6444	10478

Table A.6.2. Cod in Subarea 4, Division 7.d and Subdivision 20. Survey tuning indices for Q3 (NS-IBTS Delta-GAM indices). Data that would be used in the assessment (upon a reopening) are highlighted in bold font. Note that age 0 would be included as a separate index for recruits (see Section 4.2.4 and Table 4.6).

NS cod indices Q3

1992	2021						
1	1	0.5	0.75				
0	5						
1	**5803.864**	**12023.02**	**1593.637**	**441.6012**	**190.1718**	140.526	1992
1	**5387.535**	**2439.537**	**3192.961**	**487.1312**	**143.6823**	153.1586	1993
1	**11540.65**	**14151.29**	**1880.36**	**801.9716**	**145.3561**	103.6606	1994
1	**6050.921**	**6857.126**	**4751.091**	**664.4828**	**240.1699**	81.4452	1995
1	**14838.33**	**3245.861**	**1924.534**	**640.1517**	**170.308**	130.3789	1996
1	**140.8031**	**22922.17**	**2530.816**	**592.5259**	**192.0577**	116.5239	1997
1	**8375.735**	**701.7812**	**6969.819**	**524.4656**	**133.3824**	129.0832	1998
1	**2076.652**	**3068.234**	**453.922**	**1196.326**	**117.4057**	49.4253	1999
1	**1139.583**	**4778.586**	**930.3512**	**88.4127**	**229.2458**	60.6083	2000
1	**8289.472**	**1343.978**	**1643.295**	**283.0903**	**56.9068**	94.6951	2001
1	**305.7283**	**3644.836**	**771.6485**	**588.4548**	**189.737**	64.0558	2002
1	**3771.995**	**550.4667**	**939.2647**	**186.8527**	**164.025**	170.0467	2003
1	**1796.743**	**3054.984**	**592.573**	**369.0233**	**74.4673**	81.4245	2004
1	**2982.532**	**988.354**	**715.5798**	**190.8036**	**92.3108**	65.4966	2005
1	**2256.647**	**3835.547**	**630.2216**	**456.1339**	**84.8357**	37.7303	2006
1	**5099.443**	**1673.984**	**2193.225**	**367.3235**	**144.2785**	121.41	2007
1	**658.9307**	**1916.606**	**835.129**	**846.5508**	**174.8234**	109.7974	2008
1	**930.7701**	**1641.855**	**684.7015**	**222.7547**	**220.426**	85.9741	2009
1	**132.1966**	**1959.454**	**1301.233**	**409.3944**	**135.7178**	100.9053	2010
1	**6320.191**	**854.9964**	**2408.411**	**1049.991**	**293.862**	191.7104	2011
1	**541.3218**	**1677.838**	**791.0738**	**1003.628**	**313.1795**	113.3157	2012
1	**287.4617**	**1579.444**	**850.2284**	**385.7379**	**427.792**	184.7423	2013
1	**414.9033**	**1945.123**	**1207.03**	**529.6413**	**220.5432**	280.7537	2014
1	**24.6971**	**977.163**	**2241.959**	**856.6281**	**350.9956**	252.0677	2015
1	**3225.165**	**700.2286**	**806.3432**	**1091.669**	**597.6461**	260.6544	2016
1	**228.2122**	**3698.326**	**481.8645**	**388.8844**	**376.881**	277.4413	2017
1	**168.4524**	**514.9772**	**1561.238**	**275.9333**	**185.035**	207.3964	2018
1	**2066.085**	**1241.869**	**340.8406**	**446.0782**	**92.6659**	114.4505	2019
1	**758.1143**	**2255.785**	**881.289**	**137.7512**	**168.3398**	99.299	2020
1	**1406.465**	**1088.86**	**1771.954**	**539.9522**	**139.6641**	127.2436	2021

Table A.6.3. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Inputs. Data from the IBTS Q3 2021 survey are highlighted.

yearclass	recruitment	deltaGAMq31	deltaGAMq30
1991	957698	12023.0203	
1992	436538	2439.5372	5803.8644
1993	1078364	14151.2944	5387.535
1994	687763	6857.1256	11540.6546
1995	469770	3245.8612	6050.9214
1996	1542688	22922.1702	14838.3349
1997	144395	701.7812	140.8031
1998	312967	3068.2337	8375.7352
1999	452949	4778.5857	2076.6521
2000	183390	1343.9784	1139.5834
2001	265362	3644.8359	8289.472
2002	120876	550.4667	305.7283
2003	241790	3054.9839	3771.9951
2004	192080	988.354	1796.7434
2005	423208	3835.5474	2982.5315
2006	190907	1673.9835	2256.6472
2007	214364	1916.6059	5099.4426
2008	240060	1641.8548	658.9307
2009	302150	1959.4536	930.7701
2010	143866	854.9964	132.1966
2011	222046	1677.8383	6320.1905
2012	251482	1579.4436	541.3218
2013	313474	1945.1229	287.4617
2014	147284	977.163	414.9033
2015	102928	700.2286	24.6971
2016	313264	3698.3262	3225.165
2017	67402	514.9772	228.2122
2018	145193	1241.869	168.4524
2019	271264	2255.7845	2066.0849
2020		1088.8602	758.1143
2021			1406.4647

Table A.6.4. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Outputs for the 2020 year-class.

```
Analysis by RCT3 ver4.0


Data for 1 surveys over 31 year classes: 1991 - 2021

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.


                  WAP logWAP int.se

yearclass:2020 156672  11.96  0.211
```

Table 6.2.5. Cod in Subarea 4, Division 7.d and Subdivision 20. RCT3 Outputs for the 2021 year-class.

```
Analysis by RCT3 ver4.0


Data for 1 surveys over 31 year classes: 1991 - 2021

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.

                  WAP logWAP int.se

yearclass:2021 263028  12.48 0.4894
```

Annex 7: Data call: Data submission for ICES fisheries advisory work

Fisheries Data Call 2020

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, Below Minimum Size catches (selected working groups), biological, and effort data from 2020, and other supporting information.

The list of stocks included in the data call are provided in DC_Annex_1.xlsx and Table 7.7.1. The data call spreadsheet is an indicative list based on previous catches. All countries that have catch or landings data on these stocks should submit data, **even if they are not listed** on the data call request spreadsheets.

2 Rationale

The requested data will be used by ICES expert groups involved in the development and provision of ICES advice and update stock assessments.

3 Legal framework

Generically, all the governments and intergovernmental commissions requesting and receiving advice from ICES have signed international agreements under UNCLOS 1995[*] 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).
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,.."*

For non-EU states with fisheries operating in the North Atlantic, there is a requirement to make fisheries data available to support fisheries management under OSPAR, HELCOM, and UNCLOS.

ICES is thus mandated to request all fisheries dependent and independent data including VMS and logbook information to be used in order to provide this advice. This mandate is supported by international agreements and the current EU data collection framework (DCF).
In addition, Article 15 of the NASCO Convention, with reference to obligations of Parties to provide to the Council the available catch statistics, other statistics, and any other available scientific information that the Council requires for the purposes of the Convention.

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.

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[*] 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

4 Deadlines

ICES requests that the data are delivered by a date specific to each Expert Group, to provide enough time for additional quality assurance prior to the meeting. Data submission deadlines for each of the Expert Groups are given in Table 4.1. **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/data/data-portals/Pages/DATRAS-deadlines.aspx) or to the ICES acoustic database, as early as possible prior to the Expert Group meeting.

Table 4.1. Data submission deadline for ICES expert groups and respective chair contact.

Working Group (WG)	Chair of the WG	Email Address	Data Submission Deadline
HAWG	Afra Egan & Cecilie Kvamme	afra.egan@marine.ie; cecilie.kvamme@hi.no	**01.03.2021**
WGNAS	Dennis Ensing	dennis.ensing@afbini.gov.uk	**15.03.2021**
WGDEEP	Ivone Figueiredo & Elvar Halldor Hallfredsson	ifigueiredo@ipma.pt elvar.hallfredsson@imr.no	**22.03.2021**
WGBFAS	Mikaela Bergenius	mikaela.bergenius@slu.se	**16.03.2021**
WGBIE	Cristina Silva & Ching Villanueva	csilva@ipma.pt Ching.Villanueva@ifremer.fr	**05.04.2021**
AFWG	Daniel Howell	daniel.howell@imr.no	**24.03.2021**
WGCEPH	Ana Moreno, Daniel Oesterwind & Graham Pierce	amoreno@ipma.pt daniel.oesterwind@thuenen.de g.j.pierce@iim.csic.es	**01.04.2021**
WGNSSK	Raphael Girard & Tanja Miethe	raphael.girardin@ifremer.fr Tanja.Miethe@gov.scot	**31.03.2021**
NWWG	Teunis Jansen	tej@aqua.dtu.dk	**01.04.2021**
WGCSE	Mathieu Lundy & Sofie Nimmegeers	mathieu.lundy@afbini.gov.uk sofie.nimmegeers@ilvo.vlaanderen.be	**14.04.2021**
WGHANSA	Leire Ibaibarriaga	libaibarriaga@azti.es	**01.05.2021 (and see section 7.8)**
WGEF	Jurgen Batsleer & Pascal Lorance	Jurgen.Batsleer@wur.nl pascal.lorance@ifremer.fr	**25.05.2021**
WGWIDE	Andrew Campbell	andrew.campbell@marine.ie	**04.08.2021**
WGScallop	Lynda Blackadder	Lynda.Blackadder@gov.scot	**16.08.2021**
NIPAG	Ole Ritzau Eigaard & Katherine Sosebee	ore@aqua.dtu.dk Katherine.Sosebee@noaa.gov	**18.08.2021**
WGMIXFISH -Advice	Claire Moore	claire.moore@marine.ie	**03.05.2021**

5 Data to report

ICES Member Countries are requested to supply data as specified on the Expert Groups' data request spreadsheets (see attached annexes to this call) 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 2020, and other supporting information;
- for stocks identified in DC_Annex_1.xlsx with '**Y**' under column 'DLS proxy RP'; estimates of length compositions for landings and discards from the latest year (i.e. 2020). If length frequency data have not been reported before for a given stock, 3 years of data (2018, 2019, 2020) should be provided along with supporting information on life-history parameters (see DC_Annex_2_SupportingInformationLifeHistoryParameters.xlsx and Appendix IV).

The list of species and stocks for which data should be submitted is given in DC_Annex_1.xlsx and Table 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 DC_Annex_1.xlsx) 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 4.1) and advice@ices.dk. A full and corrected set of data may need to be uploaded.

Due to the 2020 disruptions caused by the pandemic which affected national data collection programs, ICES would like to give the opportunity for data submitters to provide information/caveats on the data submitted i.e. reductions in sampling size, insufficient spatial coverage, surveys cancelled or shortened, or any other information that is thought to be relevant. This information will be passed directly to expert groups which will make use of this information when running assessments and drafting advice.

Please use this link to provide all the relevant information.

6 Data submission

6.1 Reporting to InterCatch

The InterCatch-formatted national data should be uploaded into InterCatch, which is available on 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://ices.dk/data/data-portals/Pages/InterCatch.aspx An overview of the data fields used in the InterCatch exchange format are detailed in DC_Annex_3_InterCatch Exchange format overview updated.docx. The codes for metiers/fleets and areas are listed in appendices I, II, and III.

For stocks where discard data have been submitted to InterCatch in previous years, they should also be submitted for 2020 (see DC_Annex_1.xlsx).

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[†]. An overview of the fields in the InterCatch commercial catch format is found in the InterCatch Format overview[‡], 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 "InterCatchFileMaker" 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

InterCatch can work with age and length data in parallel. Previously it was important that length data were imported last, though currently the order in which catches with sample data (age/length) are

[†]http://ices.dk/data/Documents/Intercatch/InterCatch%20User%20Manual.pdf

[‡] http://dome.ices.dk/datsu/selRep.aspx?Dataset=76

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 that can be used 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 in InterCatch

When age or length data are imported in InterCatch, 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 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 4.1) 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 Figure 6.2).

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 Figure 6.2).

If it is possible to separate BMS and discards fractions from e.g. at sea observer programme then the BMS estimate should be inserted into the CATON field. If it's not possible to separate discard and BMS fractions then a zero "0" should be entered into the CATON field for BMS. Either way, the value of BMS as reported in the logbook should always be inserted in the OffLandings field (see Figure 6.2).

Logbook Registered Discard, 'R'

This component corresponds to discards which are registered in the logbook.

ICES does not require this fraction to be provided as it is not used for the provision of ICES advice.

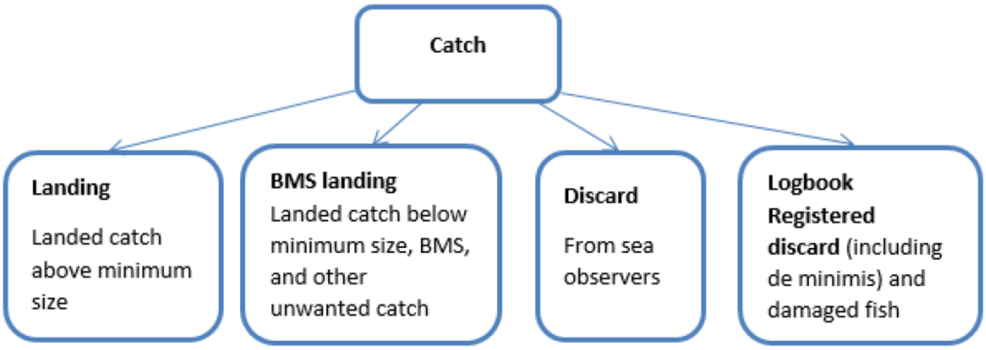

Figure 6.1. Description of the four current catch categories.

BMS landings should be submitted as specified in DC_Annex_1.xlsx for stocks to which landing obligations applies.

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.

Reporting of discard and BMS in the SI record fields CATON and OffLandings

To clarify the values to insert into the CATON and OffLandings fields in the SI record, the following figure gives an overview of the two different discard-BMS scenarios. The overview shows how to fill in data from the at sea observer programs for two different discard-BMS scenarios.

	Scenario 1 **Discard and BMS can be split** Discard | BMS	**Scenario 2** **Discard and BMS cannot be split** Discard + BMS (seen as discard)
SI record with **Catch Category=D** (D for discard)	CATON = Discard weight OffLandings = -9	CATON = Discard + BMS weight OffLandings = -9
SI record with **Catch Category=B** (B for BMS)	CATON = BMS weight OffLandings = declared* BMS	CATON = 0 OffLandings = declared* BMS **If there is no declared BMS** No SI record with 'Catch Category = B' is needed

*Declared BMS from logbooks, sales notes or landing declarations.

Figure 6.2. CATON and OffLandings for two discard and BMS scenarios

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 6.1.

Table 6.1. Units of effort requested/accepted by WGs.

	kW×day	Days at sea
WGBFAS		X
WGCEPH	X	X
WGMIXFISH-Advice	X	X
All others	X	

Please note that the effort value should be the same for all species, for a given strata. The effort in InterCatch supports WGMIXFISH, which needs effort by metier and not by species. 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). If there has been fishing effort but zero landings, the effort should be also imported.

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 expert group, stock, country, and data type references as specified below. The email subject must include expert group, stock, and country references.

"2021 DC [expert group] [stock code/stock codes] [country] [type of data]"

(example: 2021 DC WGBFAS her.27.28 LV landings)

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 Expert Group are listed in DC_Annex_1.xlsx (sheet "IC Metier tags"). If a *metier* needed is not available in InterCatch, please contact the Expert Group chair (see email address in Table 4.1).

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 6.3).

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 6.3. Explanation of the *metier* tag elements; an underscore separates each of the elements.

<u>*Metier* tag elements</u>

1. GEAR TYPE (gear types available under the DCF are shown in 2010/93/EU Appendix IV). Note that WGCSE, WGNSSK, WGBIE and WGMIXFISH allow only specific *metier*s in specific areas (see appendices I-III).

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: units descriptors as specified in InterCatch Exchange Format.

Landings, discards, and recreational catches:

- by number of fish;
- by weight in tonnes (for fish except for wild catches of Atlantic salmon, Norway lobster and Northern prawn) or in Kg (for cephalopods, scallops and wild catches of Atlantic salmon);
- Length distributions; in 1 cm length intervals (for fish and cephalopods) or 1 mm intervals (for Norway lobster and Northern prawn).

Effort (WGNSSK, WGCSE, WGBIE, WGDEEP, WGHANSA, WGEF, WGSCALLOP): 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. "2020".

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; see Table 6.6.1). This is particularly relevant to stocks under WGDEEP, WGWIDE, NWWG and WGEF.

Table 6.6.1. NEAFC area codes and description.

ICES Code	Description
27.1.a	Barents Sea - NEAFC Regulatory Area
27.10.a.1	Azores Grounds - Parts of the NEAFC Regulatory Area

27.12.a.1	Subdivision XIIa1 - NEAFC Regulatory Area
27.12.a.2	Subdivision XIIa2 - NEAFC Regulatory Area
27.14.b.1	Southeast Greenland - Parts of NEAFC Regulatory Area
27.2.a.1	Norwegian Sea - NEAFC Regulatory Area
27.2.b.1	Spitsbergen and Bear Island - NEAFC Regulatory Area
27.5.b.1.a	Faroe Plateau - Part of NEAFC Regulatory Area
27.7.c.1	Porcupine Bank - NEAFC Regulatory Area
27.7.j.1	Southwest of Ireland - East - Parts of the NEAFC Regulatory
27.7.k.1	Southwest of Ireland - West - Part of the NEAFC Regulatory Area
27.8.d.1	Bay of Biscay - Offshore - Parts in NEAFC Regulatory Area
27.8.e.1	West of Bay of Biscay - Parts in NEAFC Regulatory Area
27.9.b.1	Portuguese Waters - West Parts in NEAFC regulatory Area

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 final version of the recreational fisheries data should be submitted separately via email to data.call@ices.dk. The respective Working Group chair (see e-mail addresses in Table 4.1) and ICES Secretariat (advice@ices.dk) should be informed accordingly.

7 Expert group specific uploading information

7.1. HAWG specifications

Herring entries marked with "AC" in DC_Annex_1.xlsx need to be sent by stock in the exchange format specified in the so-called Yellow Sheets (DC_Annex 7.1.1._Yellow sheet).

Sprat entries marked with "AC3" in DC_Annex_1.xlsx need to be sent by stock in the exchange format specified in Annex 7.1.2. (i.e. DC_Annex 7.1.2_ Template_sprat).

For the stock her.27.20-24 entries marked with "AC4" in DC_Annex_1.xlsx need to be sent in the exchange format specified in Annex 7.1.3. (i.e. DC_Annex 7.1.3_ Template_her.27.20-24).

For the stock her.27.3a47d entries marked with "AC12" in DC_Annex_1.xlsx need to be split in 4a West and 4a East (split at 2 degrees East).

7.2 WGDEEP specification

Black scabbardfish (*Aphanopus carbo*) is believed to constitute a unique stock with three migratory components located in the West of the British Islands, Portugal mainland and Canary/Madeira areas. The southernmost component lies under the Fishery Committee for the Eastern Central Atlantic (CECAF) competence and it is believed to be an important spawning area for the species. In order to strengthen the ICES advisory process and allow for a more comprehensive stock assessment of black scabbardfish, access to the southernmost component data (FAO Fishing Area 34, Division 1.2) is requested in this Data Call from all ICES countries with data available from this area.

The data requested, if available, should be provided as follows:

- Landings and discards per month in tonnes.
- Fishing effort per month (kW days).
- Length frequency distribution per month or per quarter.
- Weight length relationship.
- Proportion of mature individuals (by sex) in the last quarter of the year.

Data submitters are also requested to submit catch data for 2020 to InterCatch on Lesser silver smelt/Lesser argentines (ARY) or/and Silver smelt/Argentines (ARG) by ICES Division. This will help to identify the contribution of the different species of argentines in the current assessment.

7.3 WGMIXFISH-ADVICE specification (WGNSSK, WGCSE, WGBFAS and WGBIE)

WGMIXFISH produces fleet-based mixed fisheries forecasts for four ecoregions, the Greater North Sea, Celtic Seas, Baltic Sea, Bay of Biscay and Iberian Coast. WGMIXFISH intends to develop advice for the North Sea, Celtic Sea, and Iberian waters in 2021. This data call is structured to provide biological and economic information at the level of DCF metier level 6 and the vessel length category, disaggregated by ICES divisions and by Subdivision for the Baltic Sea.

Table 7.1 : ICES divisions and species requested by the WGMIXFISH data call

Spatial Dissagregation	Species FAO code
ICES divisions 27.3.a.20, 27.3.a.21, 27.3.a, 27.3.b.23, 27.3.c.22, 27.3.d.24, 27.3.d.25, 27.3.d.26, 27.3.d.27, 27.3.d.28, 27.3.d.28.1, 27.3.d.28.2, 27.3.d.29, 27.3.d.30, 27.3.d.31, 27.3.d.32, 27.4.a, 27.4.b, 27.4.c, 27.6.a, 27.6.b, 27.7.a, 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k,	ANF *(Lophius spp)* ANK (*Lophius budegassa*) BLL (*Scophthalmus rhombus*) CAA (*Anarhichas lupus*) COD (*Gadus morhua*) COE (*Conger conger*) DAB (*Limanda limanda*) FLE (*Platichthys flesus*) GUG (*Eutrigla gurnardus*) GUR (*Aspitrigla cuculus*) HAD (*Melanogrammus aeglefinus*) HAL (*Hippoglossus hippoglossus*)

27.8.a, 27.8.b, 27.8.c, 27.8.d, 27.9.a, Baltic Sea subdivisions: 27.3.d.24, 27.3.d.25, 27.3.d.26, 27.3.d.27, 27.3.d.28, 27.3.d.28.1, 27.3.d.28.2, 27.3.d.29, 27.3.d.30 27.3.d.31, 27.3.d.32	HER (*Clupea harengus*) HKE (*Merluccius merluccius*) HOM (*Trachurus trachurus*) LBD (*Lepidorhombus boscii*) LEM (*Microstomus kitt*) LEZ (*Lepidorhombus* spp.) LIN (*Molva molva*) MAC (*Scombrus scombrus*) MEG (*Lepidorhombus whiffiagonis*) MON (*Lophius piscatorius*) NEP (*Nephrops norvegicus*) *** **Note**: FU must be provided here, i.e. NEP.FU.16 NOP (*Trisopterus esmarkii*) PLE (*Pleuronectes platessa*) POK (*Pollachius virens*) POL (*Pollachius pollachius*) RJU (Raja *undulata*) SKA (aggregated rays and skates: RJC, SKA, RAJ, RJA, RJB, RJC, RJE, RJF, RJH, RJI, RJM, RJN, RJO, RJR, SKA, SKX, SRX) SDV (aggregated dogfish: DGS, DGH, DGX, DGZ, SDV) SOL (*Solea solea*) SPR (*Sprattus sprattus*) TUR (*Scophthalmus maximus*) WHB (*Micromesistius poutassou*) WHG (*Merlangius merlangus*) WIT (*Glyptocephalus cynoglossus*) All remaining catch should be aggregated into an **'OTH'** class.

7.3.1 WGMIXFISH-ADVICE Data Format

This data should be submitted in the following format. Failure to do so will result in file rejection and a request for resubmission.

Files: Two comma separated (.csv) files should be provided, one reporting ‘effort’, and the other reporting ‘catch’.

Format: These two files should adhere to the following format outlined in DC_Annex_1.xlsx for ‘effort’ (sheet “WGMIXFISH-effort”) and ‘catch’ (sheet, “WGMIXFISH-catch”).

Coding: Data entries must be fully consistent with the coding provided in the DC_Annex_1.xlsx and outlined in the table below:

Table: 7.3.1 Fields to be used in the submission spreadsheet with respective descriptor.

Fields	Descriptor
ID	Unique identifier
Country	Two letter short code as per DC_Annex_1.xlsx.
Year	Four digit format e.g. "2020"
Quarter	Abbreviated e.g. Q1
IntercatchMetierTag	Métier should match what has been submitted to InterCatch. A list of accepted metiers can be found in DC_Annex_1.xlsx (sheet "IC Metier tags").
VesselLengthCategory	Vessel length categories are should be specified using one of these exact codes: "<10m", "10<24m", "24<40m", ">=40m".
FDFVessel	Fully Documented Fisheries should be identified here using "FDF". Please leave the field blank for the non-FDF fleet.
Area	ICES divisions should match those in DC_Annex_1.xlsx (sheet "ICES area codes").
Species	Should be consistent with the three letter FAO codes outlined in Table 7.1. Except in the case of *Nephrops*, which the Functional unit must be concatenated to the species name, i.e. a catch of *Nephrops* in FU 16 should be noted as "NEP.FU.16" in the species column. In the case of *Nephrops* caught outside of an FU please provide the subarea, i.e. for *Nephrops* caught outside of an FU in ICES Subarea 27.7 as "NEP.OUT.7".
Landings	Estimated landings in tonnes (live weight). Including landings below minimum conservation reference size.
Value	Estimated total value of the landings in euro.
Discards	Only supply a discards in tonnes if none has been submitted to InterCatch. Or if specific discard information exists for each vessel length category.
KWdays.	Fishing effort in KWdays, i.e. engine power in kW times fishing days
DaysAtSea	Number of days at sea.
NoVessels	Number of vessels executing this activity at this level of aggregation.

Submission: Both files should be submitted to data.call@ices.dk. File name must follow this format "2021 WGMIXFISH-ADVICE" [country] [*metier*_catch/*metier*_effort]" (example: 2021 WGMIXFISH-ADVICE FR_ metier catch).

7.4 WGBFAS specifications

Units for data submission

For landings and discards; numbers (in thousands) and mean weight (in grammes) by age or length (depending on the stock and according to DC_Annex_1.xlsx specifications) per fleet/segment, quarter, year, Subdivision and country.

The unit for commercial effort is **days-at-sea** and should be aggregated at the same level as the sampling data (i.e. effort per fleet/segment, quarter, year, Subdivision and country).

Data specification

- Discard survival rates **should not** be accounted for by countries when uploading the data.
- For **sprat,** fleet segments to be considered are; "Pelagic trawlers" for all trawl gears and "Passive" for all passive gears.

Besides landings and discards InterCatch includes the catch category BMS landings.

It is important when Member Countries are uploading data to InterCatch that the catch categories in CATON are summing up to the total catch. BMS landings can either be calculated as an estimate from the observer trips or from official registrations such as sale slips, logbooks, or landing declarations (see section 6.1.4). Both the landed BMS catch and the discard estimate will be needed for the WGBFAS.

Specifics of data requirements for eastern and western Baltic cod (see also DC_Annex_1.xlsx)

- Denmark and Germany are requested to provide stock (i.e. eastern and western Baltic cod) proportions by gear and subarea (i.e. subareas 1 and 2; see Figure 4 of Western Baltic cod stock annex; link).
- For cod in SubDivisions (SD) 22-23, age distribution data should be uploaded to IC.
- For cod in SD 22-32, length distribution data should be uploaded to IC.
- For cod in SD 24, landings should be submitted by ICES square.

For Recreational catch from Denmark, Germany, and Sweden of western Baltic cod (cod.27.22-24) the following data are requested:

- Catch in weight, separately for SD 22, 23 and 24
- Catch-at-age in numbers, separately for SD 22, 23 and 24 (only age readings originating in SD 22 or 23 should be used. i.e. not age readings from SD 24)
- Mean weight at age in the catch.

The data should be provided as *Excel* spreadsheets and submitted to data.call@ices.dk.

Data from the surveys 1 to 3 below conducted in 2020, should be uploaded to the ICES databases (DATRAS and acoustic-trawl survey) by 1st February 2021. Data from surveys 4 to 6 below should be sent to the WG chair (see contact details in Table 4.1.) by 1st February 2021.

List of surveys conducted in Kattegat-Skagerrak and the Baltic Sea:

1) Baltic Acoustic Spring Survey, BASS;
2) International Bottom Trawl Survey Quarter 3, IBTS Q3;
3) Baltic International Trawl Survey quarter 4, BITS Q4
4) Fishermen-DTU Aqua sole survey, FFS;
5) Cod survey in Kattegat, CODS_Q4;
6) Fehmarn Juvenile Cod Survey, FEJCS.

7.5. WGBIE specifications

For four-spot megrim (*Lepidorhombus boscii*) in divisions 7.b-k, 8.a-b, and 8.d (west and southwest of Ireland, Bay of Biscay) (ldb.27.7b-k8abd) data from Spain (landings, discards, and associated biological information as specified in DC_Annex_1.xlsx) **should be submitted for the years 2003 to 2016 and 2020**.

Reporting of effort should be as reported for megrim (*Lepidorhombus whiffigonus*) in divisions 7.b-k, 8.a-b, and 8.d (west and southwest of Ireland, Bay of Biscay) (meg.27.7b-k8abd).

7.6. WGCEPH specifications

Cephalopod data will be used to describe trends and status of cephalopod fisheries, and to conduct stock assessments.

Data reporting

Data for the species-specific stocks should be reported according to the following list of areas;

27.3.a, 27.4.a, 27.4.b, 27.4.c, 27.5.b, 27.6.a, 27.6.b, 27.7.a, 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k, 27.8.a, 27.8.b, 27.8.c, 27.8.d, 27.9.a.n, 27.9.a.c.n, 27.a.c.s, 27.9.a.s.a, 27.9.a.s.c, 27.10. All catches should be uploaded by ICES Division (e.g. 27.4.c or 27.8.d) except for Division 27.9.a, for which catches should be split into 27.9.a.n., 27.9.a.c.n, 27.9.a.c.s, 27.9.a.s.a, 27.9.a.s.c.

Detailed anonymised data on landings and fishing activities of selected fishing fleets (OTB, TBB and OTM) from countries with significant cephalopod fisheries (i.e. landings exceeding 1000 tonnes per year), as specified in DC_Annex_1.xlsx, should be provided via email to data.call@ices.dk following the format outlined in DC_Annex_7.6.1. WGCEPH Detailed Catch and Effort data.xlsx.

For trawl surveys with accurate identification of cephalopods at species level, the abundance indices (numbers) and cpue (weights) should be provided via email to data.call@ices.dk following the format outlined in DC_Annex_7.6.2. WGCEPH Survey data. **Note** that in the case of surveys with a stratified sampling scheme average computations by strata should be also provided. Survey data should be submitted via data.call@ices.dk unless detail data have already been submitted to the ICES database DATRAS (http://www.ices.dk/data/data-portals/Pages/DATRAS.aspx). Submission of cephalopod survey data to the quality assured and open DATRAS database is encouraged. If the data have been already uploaded to DATRAS, WGCEPH co-chairs should be informed. Additionally, in case of missing data for one of more species, WGCEPH co-chairs should be informed about whether the species are not caught by trawl surveys or whether the species may have been caught but have not been recorded in the DATRAS database.

Data for WGCEPH (see DC_Annex_1.xlsx, 7.6.1 and 7.6.2) should only be submitted using the specific FAO 3-alfa species codes. Please note the code SQU should only be used if there is a genuine doubt as to whether the squid landed were Loliginidae or Ommastrephidae. Additionally, if cephalopod catches are being recorded under any code other than those listed, (a) please indicate this in a note to WGCEPH and (b) include those data also. Finally, if countries are aware of any current issues with coding of cephalopod landings please inform the WGCEPH chairs (see contact details in Table 4.1). This request is prompted by recently reported issues with use of the codes SQZ and SQU. The métier codes to be used are specified in DC_Annex_1.xlsx, in the sheet "IC Metier tags". If other level 6 métiers have catches and are not available in InterCatch, please contact the Expert Group chairs (see email address in Table 4.1).

Effort specifications

The units for fishing effort can be either "KW×fishing days" or "Total Days at sea" but should be consistent with data previously provided to WGCEPH. The fishing 'Effort' in InterCatch concerns all fishing effort of each métier catching cephalopods in the area of the stock. By "all fishing effort" it is meant all the activity of these métiers and not only the trips when cephalopods were caught.

WGCEPH needs all landings data, even if some landings have no associated fishing effort record; in such case enter '−9' in the effort field.

7.7. WGEF specifications

Provide national landings and discards data for 2020 for all elasmobranch in Annex_7.7.1 WGEF.csv. Landings and discards should be provided via InterCatch, by metier level 4 and by ICES Division. Landings and discards should be provided in tonnes with three decimal places.

Submitted data should include national catches for all elasmobranch species in FAO area 27, as well as catches outside ICES areas for selected stocks (see Table 7.1.):

Length composition for all the stocks in Table 7.1 (below) for discards and landings should be submitted via data.call@ices.dk in centimetres (cm). These data should contain the following fields per stock:

- Year,
- Country,
- Catch category (DIS or LAN),
- Sex (M, F),
- Length (cm) and,
- Number of individuals

All countries that have landings or discards data on these stocks should submit data, even if the sampling size is small, this is due to the importance of and scarcity of sampling for these stocks.

File name should follow the following format "2021 WGEF [country]"

(example: 2021 WGEF FR).

Table 7.7.1.: ICES Elasmobranchs stocks *per* FAO area.

FAO Area	Stock code	Description
27 and 34	cyo.27.nea	Portuguese dogfish (*Centroscymnus coelolepis*, *Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)

FAO Area	Stock code	Description
	guq.27.nea	Leafscale gulper shark (*Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
27, 34 and 37	gag.27.nea	Tope (*Galeorhinus galeus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
	por.27.nea	Porbeagle (*Lamna nasus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
	sdv.27.nea	Smooth-hound (*Mustelus spp.*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
21, 27, 31, 34 and 37	bsk.27.nea	Basking shark (*Cetorhinus maximus*) in subareas 1-10, 12 and 14 (Northeast Atlantic and adjacent waters)
	thr.27.nea	Thresher sharks (*Alopias spp.*) in subareas 10, 12, divisions 7.c-k, 8.d-e, and subdivisions 5.b.1, 9.b.1, 14.b.1 (Northeast Atlantic)
27	agn.27.nea	Angel shark (*Squatina squatina*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
	dgs.27.nea	Spurdog (*Squalus acanthias*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
	raj.27.1012	Rays and skates (Rajidae) (mainly thornback ray (*Raja clavata*)) in subareas 10 and 12 (Azores grounds and north of Azores)
	raj.27.3a47d	Rays and skates (Rajidae) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)
	raj.27.67a-ce-h	Rays and skates (Rajidae) in Subarea 6 and divisions 7.a-c and 7.e-h (Rockall and West of Scotland, southern Celtic Seas, western English Channel)
	raj.27.89a	Rays and skates (Rajidae) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)
	rja.27.nea	White skate (*Rostroraja alba*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)
	rjb.27.3a4	Common skate complex (Blue skate (*Dipturus batis*) and flapper skate (*Dipturus intermedius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)
	rjb.27.67a-ce-k	Common skate complex (Blue skate (*Dipturus batis*) and flapper skate (*Dipturus intermedius*) in Subarea 6 and divisions 7.a–c and 7.e–k (Celtic Seas and western English Channel)
	rjb.27.89a	Common skate complex (Blue skate (*Dipturus batis*) and flapper skate (*Dipturus intermedius*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)
	rjc.27.3a47d	Thornback ray (*Raja clavata*) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)
	rjc.27.6	Thornback ray (*Raja clavata*) in Subarea 6 (West of Scotland)
	rjc.27.7afg	Thornback ray (*Raja clavata*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)
	rjc.27.7e	Thornback ray (*Raja clavata*) in Division 7.e (western English Channel)
	rjc.27.8	Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay)
	rjc.27.9a	Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters)
	rje.27.7de	Small-eyed ray (*Raja microocellata*) in divisions 7.d and 7.e (English Channel)

FAO Area	Stock code	Description
	rje.27.7fg	Small-eyed ray (*Raja microocellata*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea North)
	rjf.27.67	Shagreen ray (*Leucoraja fullonica*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)
	rjh.27.4a6	Blonde ray (*Raja brachyura*) in Subarea 6 and Division 4.a (North Sea and West of Scotland)
	rjh.27.4c7d	Blonde ray (*Raja brachyura*) in divisions 4.c and 7.d (southern North Sea and eastern English Channel)
	rjh.27.7afg	Blonde ray (*Raja brachyura*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)
	rjh.27.7e	Blonde ray (*Raja brachyura*) in Division 7.e (western English Channel)
	rjh.27.9a	Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)
	rji.27.67	Sandy ray (*Leucoraja circularis*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)
	rjm.27.3a47d	Spotted ray (*Raja montagui*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)
	rjm.27.67bj	Spotted ray (*Raja montagui*) in Subarea 6 and divisions 7.b and 7.j (West of Scotland, west and southwest of Ireland)
	rjm.27.7ae-h	Spotted ray (*Raja montagui*) in divisions 7.a and 7.e-h (southern Celtic Seas and western English Channel)
	rjm.27.8	Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay)
	rjm.27.9a	Spotted ray (*Raja montagui*) in Division 9.a (Atlantic Iberian waters)
	rjn.27.3a4	Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)
	rjn.27.678abd	Cuckoo ray (*Leucoraja naevus*) in subareas 6-7 and divisions 8.a-b and 8.d (West of Scotland, southern Celtic Seas, and western English Channel, Bay of Biscay)
	rjn.27.8c	Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)
	rjn.27.9a	Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)
	rjr.27.23a4	Starry ray (*Amblyraja radiata*) in subareas 2 and 4, and Division 3.a (Norwegian Sea, North Sea, Skagerrak and Kattegat)
	rju.27.7bj	Undulate ray (*Raja undulata*) in divisions 7.b and 7.j (west and southwest of Ireland)
	rju.27.7de	Undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel)
	rju.27.8ab	Undulate ray (*Raja undulata*) in divisions 8.a-b (northern and central Bay of Biscay)
	rju.27.8c	Undulate ray (*Raja undulata*) in Division 8.c (Cantabrian Sea)
	rju.27.9a	Undulate ray (*Raja undulata*) in Division 9.a (Atlantic Iberian waters)
	sck.27.nea	Kitefin shark (*Dalatias licha*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)

FAO Area	Stock code	Description
	sho.27.67	Black-mouth dogfish (*Galeus melastomus*) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)
	sho.27.89a	Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)
	syc.27.3a47d	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)
	syc.27.67a-ce-j	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and divisions 7.a-c and 7.e-j (West of Scotland, Irish Sea, southern Celtic Seas)
	syc.27.8abd	Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d (Bay of Biscay)
	syc.27.8c9a	Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
	syt.27.67	Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7 (West of Scotland, southern Celtic Sea, and the English Channel)

7.8 WGHANSA specifications

For stocks to be assessed in November 2021 (i.e. ane.27.8, pil.27.7, pil.27.8abd, pil.27.8c9a,) countries are encouraged to submit preliminary catch data from the current year (2021) by the 1st of November of 2021.

7.10 WGCSE specifications

Data submitters are requested to provide additional data for Seabass (*Dicentrarchus labrax*) in Divisions 4.b-c, 7.a, and 7.d-h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea). The data requested is comprised of:

- Monthly landings (kg) by metier (level 5) and vessel (anonymised).
- Monthly length sampling data by metier level 5 for both landings and discards.

The temporal range for the data requested above is from 2010 to 2020

This information should be submitted separately as .csv files via email to data.call@ices.dk. The subject of the email and the file name should be clearly labelled as "2021 WGCSE-bss [country]"

(example: 2021 WGCSE-bss France).

7.11 NWWG specifications

For the stock reb.2127.dp data should be submitted for catches harvested below 500m depth only as specified in DC_Annex_1.xlsx as "AC13".

For the stock reb.2127.sp data should be submitted for catches harvested above 500m depth only as specified in DC_Annex_1.xlsx as "AC14".

7.12 WGNAS specifications

Data on all 2020 Atlantic salmon catches and landings by stock, as specified in DC_Annex_1.xlsx, should be provided via email to data.call@ices.dk following the format outlined in DC_Annex_7.12.1 WGNAS_Template.xlsx. North Atlantic salmon ICES stock definitions align with the NASCO Commission area [§]. Additional data types for Atlantic salmon requested and outlined in DC_Annex_7.12.1 WGNAS_Template.xlsx. include;

- Data on the production of farmed and sea-ranched Atlantic salmon in 2020 (in number of individuals and by weight (tonnes));
- Numbers of fish released back alive from commercial and recreational fisheries;
- Estimates for both reported and unreported catches.

Data should be marked as provisional, where necessary.

When reporting data on salmon caught in rivers, provide the name of the river. This information will be used to develop an accepted list of salmon rivers to be used in future data calls.

Special terminology and codes used in this data call are described in the glossary in Appendix V and DC_Annex_7.12.1 WGNAS_Template.xlsx.

7.13 WGScallop specifications

Data on all 2020 landings by stock, as specified in DC_Annex_1.xlsx, should be provided via email to data.call@ices.dk following the format outlined in DC_Annex_7.13.1 WGSCALLOP Template.xlsx.

Data submitters are requested to contact their national expert to provide further quality assurance prior to the data being submitted.

Table 7.13.1: List of relevant national experts.

[§] For a description of the Commission Areas See Figure in page 3 of the sal.27.neac stock annex; https://www.ices.dk/sites/pub/Publication%20Reports/Stock%20Annexes/2019/sal.27.neac_SA.pdf

Member	Dept/Institute	Email	Country
Lynda Blackadder	Marine Scotland Science	Lynda.Blackadder@gov.scot	United Kingdom-Scotland
Adam DeLargy	Bangor University	Adam.delargy@bangor.ac.uk	United Kingdom-Wales
Carrie McMinn	Agri-food and Biosciences Institute	Carrie.McMinn@afbini.gov.uk	United Kingdom-Northern Ireland
Fabian Zimmermann	Institute Marine Research	fabian.zimmermann@hi.no	Norway
Luis Ridao Cruz	Faroe Marine Research Institute	luisr@hav.fo	Faroe Islands
Andy Lawler	Centre for Environment, Fisheries and Aquaculture Science	andy.lawler@cefas.co.uk	United Kingdom-England
Eric Foucher	Ifremer	eric.foucher@ifremer.fr	France
Isobel Bloor	Bangor University	i.bloor@bangor.ac.uk	United Kingdom-Isle of Man
Jónas Jónasson	Marine and Freshwater Research Institute	jonas.jonasson@hafogvatn.is	Iceland
Oliver Tully	Marine Institute	oliver.tully@marine.ie	Ireland

The species listed in table 7.13.2 are non–exclusive. If a scallop species has been omitted then please submit data using the generic code name (SCX) and notify ICES of any species that should possibly be included in future data calls (link to the SpecASFIS vocabulary).

Table 7.13.2: Species list and respective FAO codes.

Common name	Scientific name	FAO code
Great Atlantic scallop (King scallop)	*Pecten maximus*	SCE
Queen scallop	*Aequipecten opercularis*	QSC
Iceland scallop	*Chlamys islandica*	ISC
American sea scallop	*Placopecten magellanicus*	SCA
Scallops nei	*Pectinidae*	SCX

Data types

Table 7.13.3: Aggregation levels by data type.

Type of data	Temporal aggregation level	Metier level 5	Geographical Reporting Level
Landings Quantity	Monthly	see table 7.13.5	ICES Statistical Rectangle
Effort	Monthly	see table 7.13.5	ICES Statistical Rectangle

The template provided (DC_Annex_7.13.1. WGSCALLOP Template) should be used to reply to this data call. All the fields needed are included in the template.

Please rename the file in order to include; WGSCALLOP and country as specified below. The email subject must include WGSCALLOP and country references.

"2021 DC [expert group] [country]"

example: 2021 DC WGSCALLOP FR

The file should be submitted via e-mail to datacall@ices.dk in as few e-mails as possible.

Table 7.13.4: Reporting format

Variable	Unit	Type	Comments
Country		String	ISO country label
Year		Integer	Year (e.g. "2020")
Month		Integer	Month (1 to 12)
ICES area		String	Up to division level
ICES Statistical rectangle		String	StatRec
Metier level 5		String	Table 7.13.5Metier5_FishingActivity)
Landings	kg	Decimal numeral	
Effort	kWday	Decimal numeral	kW × fishing days

Fishing effort should be calculated following the fecR STECF method which applies the principles of the 2nd Workshop on Transversal Variables and calculates days at sea and fishing days (lb-na-27897-en-n.pdf (europa.eu)). The WG request that effort is reported as **kW fishing days**.

Table 7.13.5: Reporting format

Gear Type	Metier level 5 to be reported
Boat dredge	DRB_MOL
Dive caught or scallops by hand	MDV_MOL
Beam trawl targeting scallops	TBB_MOL
Beam trawl targeting demersal fish	TBB_DEF
Bottom trawl targeting demersal fish	OTB_DEF
Bottom trawl targeting scallops	OTB_MOL
Hand mechanised dredge targeting scallops	HMD_MOL
Miscellaneous gear not included above	MIS_MIS

8. Contact information

For support concerning any data call issues 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 *métier* tag except the MIS_MIS *métier* tags.

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
27.3.a.20 (Skagerrak) and 27.3.a.21 (Kattegat) Area Type = SubDiv	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_90-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_CRU_32-69_2_22_all
		OTB_CRU_70-89_2_35_all
		OTB_CRU_90-119_0_0_all OTB_CRU_90-119_0_0_all_FDF
		OTB_DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all SSC_DEF_>=120_0_0_all_FDF
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all GNS_DEF_120-219_0_0_all_FDF
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all LLS_FIF_0_0_0_all_FDF
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
27.4 – (North Sea) Area type = SubArea & 27.7.d (Eastern Channel) Area Type = Div & 27.6.a (for saithe and haddock only) Area Type = Div	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_70-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_SPF_32-69_0_0_all
		OTB_CRU_70-99_0_0_all OTB_CRU_70-99_0_0_all_FDF
		OTB_ DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF OTB_DEF_70-99_0_0_all
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all

AREA	GEAR TYPE	AVAILABLE METIER TAGS FOR FULLY DOCUMENTED FISHERIES ADD "_FDF" AFTER LENGTH CLASS
		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 II.

Gear coding (as defined under the DCF), allowed for WGCSE and WGMIXFISH-ADVICE in specific areas. Note that the vessel length category (currently '_all') must appear at the end of every *métier* tag except the MIS_MIS *métier* tags.

AREA	GEAR TYPE	AVAILABLE METIER TAGS
West of Scotland (27.6.a) and Rockall (27.6.b)	Pots and traps	FPO_CRU_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
	Longline	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_>=120_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DWS_>=120_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_>=120_0_0_all
		OTB_MOL_100-119_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Irish Sea (27.7.a)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_120-219_0_0_all
		GNS_DEF_90-99_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_MOL_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)	MIS_MIS_0_0_0_IBC
West of Ireland (27.7.b-c) and Celtic Sea slope (27.7.k–j)	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_DWS_100-119_0_0_all
	Otter trawl	OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_100-119_0_0_all
		OTB_CRU_100-119_0_0_all
	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all
		OTM_DEF_100-119_0_0_all
		OTM_LPF_70-99_0_0_all

		OTM_LPF_100-119_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Celtic Sea Shelf (27.7.f–h)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_SPF_10-30_0_0_all
		GTR_DEF_>=220_0_0_all
	Lines	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MCD_70-99_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_100-119_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Western Channel (27.7.e)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_CRU_0_0_0_all
		GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GTR_CRU_0_0_0_all
		GTR_DEF_>=220_0_0_all
		GTR_DEF_120-219_0_0_all
	Lines	LLS_DEF_0_0_0_all
		LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_70-99_0_0_all
	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all

		OTM_DEF_70-99_0_0_all
		OTM_DEF_100-119_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC

* The use of metiers under the MIS_MIS category should be minimized.

Appendix III.

Gear coding (as defined under the DCF), allowed for WGBIE and WGMIXFISH-ADVICE.

GEAR TYPE	AVAILABLE METIER TAGS
Boat dredge, molluscs, no selectivity devise, all vessels	DRB_MOL_0_0_0_all
Pots and Traps, Crustaceans, no selectivity device, all vessels	FPO_CRU_0_0_0_all
Gill nets, demersal fish, mesh size 100-109mm, no selectivity device, all vessels	GN_DEF_100-109_0_0_all
Set gillnet, Demersal fish, mesh size more than 100mm, no selectivity device	GNS_DEF_>=100_0_0
Set gillnet, Demersal fish, mesh size more than 220mm, no selectivity device, all vessels	GNS_DEF_>=220_0_0_all
Set gillnet, Demersal fish, mesh size >=220mm, no selectivity device, all vessels, Fully Documented Fisheries	GNS_DEF_>=220_0_0_all_FDF
Set gillnet, Demersal fish, mesh size 100-119mm, no selectivity device, all vessels	GNS_DEF_100-119_0_0_all
Set gillnet directed to demersal fish (100-219 mm)	GNS_DEF_100-219_0_0
Set gillnet, Demersal fish, mesh size 10-30mm, no selectivity device, all vessels	GNS_DEF_10-30_0_0_all
Set gillnet, Demersal fish, mesh size 120-219mm, no selectivity device, all vessels	GNS_DEF_120-219_0_0_all
Set Gillnet, Demersal Fish, Mesh size 120-219, All Vessels, No grid selectivity, Fully Documented Fisheries	GNS_DEF_120-219_0_0_all_FDF
Set gillnet directed to demersal fish (45-59 mm)	GNS_DEF_45-59_0_0
Set gillnet, Demersal fish, mesh size 60-79 mm, no selectivity device	GNS_DEF_60-79_0_0
Set gillnet directed to demersal fish (80-99 mm)	GNS_DEF_80-99_0_0
Set gillnet, Demersal fish, all mesh sizes, no selectivity device, all vessels	GNS_DEF_all_0_0_all
Trammel nets, Demersal fish, mesh size 60-79mm, no selectivity device	GTR_DEF_60-79_0_0
Trammel nets, Demersal fish, all mesh sizes, no selectivity device, all vessels	GTR_DEF_all_0_0_all
Hand lines directed to demersal fish	LHM_DEF_0_0_0
Set longline directed to demersal fish	LLS_DEF_0_0_0
Set longlines, Demersal fish, mesh size not specified, no selectivity device, all vessels.	LLS_DEF_0_0_0_all
Set longlines, Finfish, no selectivity device, all vessels	LLS_FIF_0_0_0_all
Demersal fisheries, Demersal fish, mesh size any, no selectivity device, all vessels	MIS_DEF_all_0_0_all*
Demersal fisheries - Miscellaneous Industrial bycatch	MIS_MIS_0_0_0_IBC*
Demersal fisheries - Miscellaneous	MIS_MIS_All_0_0_All*
Bottom otter trawl directed to crustaceans (at least 70 mm)	OTB_CRU _>=70_0_0
Otter trawl, Crustaceans, mesh size 100-119, no selectivity device, all vessels	OTB_CRU_100-119_0_0_all
Otter trawl, Crustaceans and Demersal fish, mesh size 32-69, no selectivity device, all vessels	OTB_CRU_32-69_0_0_all
Otter trawl, Crustaceans, mesh size 32-69, selectivity device - grid 22mm, all vessels	OTB_CRU_32-69_2_22_all
Otter trawl, Crustaceans, mesh size 70-89, selectivity device - grid 35mm, all vessels	OTB_CRU_70-89_2_35_all
Bottom otter trawl directed to crustaceans (70-99 mm)	OTB_CRU_70-99_0_0
Otter trawl, Crustaceans and Demersal fish, mesh size 70-99, no selectivity device, all vessels	OTB_CRU_70-99_0_0_all
Otter trawl, Crustaceans and Demersal fish, mesh size 90-119, no selectivity device, all vessels	OTB_CRU_90-119_0_0_all
Bottom otter trawl, Crustaceans, mesh Size 90-119, Selectivity Device - none, All vessel types, Fully Documented Fisheries	OTB_CRU_90-119_0_0_all_FDF
Bottom otter trawl, Crustaceans, all mesh sizes, no selectivity devise, all vessel types	OTB_CRU_All_0_0_All
Bottom otter trawl directed to demersal fish (100-119 mm)	OTB_DEF _100-119_0_0

GEAR TYPE	AVAILABLE METIER TAGS
Otter trawl, Demersal fish and Crustaceans, mesh size more than 120mm, no selectivity device, all vessels	OTB_DEF_>=120_0_0_all
Bottom otter trawl, Demersal fish, Mesh Size 120 or greater, Selectivity Device - none, All vessel types, Fully Documented Fisheries	OTB_DEF_>=120_0_0_all_FDF
Bottom otter trawl directed to demersal fish (at least 55 mm)	OTB_DEF_>=55_0_0
Bottom otter trawler targeting demersal fish with a mesh size > 70 mm	OTB_DEF_>=70_0_0
Bottom otter trawler targeting demersal fish with a mesh size 100-119 mm	OTB_DEF_100-119_0_0_all
Bottom otter trawl directed to demersal fish (70-99 mm)	OTB_DEF_70-99_0_0
Bottom otter trawl directed to demersal fish, all mesh sizes, no selectivity devise	OTB_DEF_All_0_0_All
Otter trawl, Mixed crustaceans and demersal fish, mesh size more than 55mm, no selectivity device.	OTB_MCD_>=55_0_0
Otter trawler targeting cephalopods and fish	OTB_MCF_>=70_0_0
Otter trawl, Molluscs, mesh size 70-99mm, no selectivity device, all vessels	OTB_MOL_70-99_0_0_all
Bottom otter trawl directed to mixed pelagic and demersal fish (at least 70 mm)	OTB_MPD _>=70_0_0
Bottom otter trawl directed to pelagic and demersal fish (at least 55 mm)	OTB_MPD_>=55_0_0
Otter Bottom trawl, Small pelagic fish, 32-69 mm, no selectivity devise, all vessels	OTB_SPF_32-69_0_0_all
Midwater otter trawl, Demersal species, mesh size 100-119mm, no selectivity device, all vessels	OTM_DEF_100-119_0_0_all
Midwater otter trawl, Demersal species, mesh size 32-54mm, no selectivity device, all vessels	OTM_DEF_32-54_0_0_all
Midwater otter trawl, Demersal species, mesh size 55-69mm, no selectivity device, all vessels	OTM_DEF_55-69_0_0_all
Midwater otter trawl, Demersal species, mesh size 70-99mm, no selectivity device, all vessels	OTM_DEF_70-99_0_0_all
Midwater otter trawl, Demersal species, mesh size 80-89mm, no selectivity device, all vessels	OTM_DEF_80-89_0_0_all
Multi-rig otter trawl directed to crustaceans (at least 70 mm)	OTT_CRU _>=70_0_0
Multi-rig otter trawl directed to demersal fish (at least 70 mm)	OTT_DEF _>=70_0_0
Multi-rig otter trawl, demersal fish, mesh size more than 120mm, no selectivity device, all vessels	OTT_DEF_>=120_0_0_all
Multi-rig otter trawl, demersal fish, mesh size 100-119mm, no selectivity device, all vessels	OTT_DEF_100-119_0_0_all
Multi-rig otter trawl, demersal fish, mesh size 16-31mm, no selectivity device, all vessels	OTT_DEF_16-31_0_0_all
Multi-rig otter trawl, demersal fish, mesh size 80-89mm, no selectivity device, all vessels	OTT_DEF_80-89_0_0_all
Multi-rig otter trawl, demersal fish, mesh size 90-99mm, no selectivity device, all vessels	OTT_DEF_90-99_0_0_all
Purse seine, Small pelagic fish, no selectivity device.	PS_SPF_0_0_0
Bottom pair trawl directed to demersal fish (at least 70 mm)	PTB_DEF _>=70_0_0
Pair bottom trawl, demersal fish, mesh size more than 120mm, no selectivity device, all vessels	PTB_DEF_>=120_0_0_all
Pair bottom trawler targeting demersal fish	PTB_DEF_>=70_0_0
Pair bottom trawl, demersal fish, mesh size 80-89mm, no selectivity device, all vessels	PTB_DEF_80-89_0_0_all
Bottom pair trawl directed to mixed pelagic and demersal fish (at least 55 mm)	PTB_MPD_>=55_0_0
Midwater pair trawl, demersal fish, mesh size 90-104 mm, no selectivity device	PTM_DEF_90-104_0_0
Anchored seine, Demersal fish, mesh size more than 120mm, no selectivity device, all vessels	SDN_DEF_>=120_0_0_all

GEAR TYPE	AVAILABLE METIER TAGS
Anchored Seine, Demersal Fish, Mesh Size 120 or above, Selectivity Device - none, All vessels, Fully Documented Fisheries	SDN_DEF_>=120_0_0_all_FDF
Fly shooting seine, Demersal fish, mesh size more than 120mm, no selectivity device, all vessels	SSC_DEF_>=120_0_0_all
Fly shooting seine, Demersal Fish, Mesh Size 120 or greater, Selectivity Device - none, All vessels, Fully Documented Fisheries	SSC_DEF_>=120_0_0_all_FDF
Fly shooting seine, Demersal fish, mesh size 100-119mm, no selectivity device, all vessels.	SSC_DEF_100-119_0_0_all
Fly shooting seine, Demersal fish, mesh size 80-89mm, no selectivity device, all vessels.	SSC_DEF_80-89_0_0_all
Fly shooting seine, , Demersal fish, all mesh sizes, no selectivity, all vessels	SSC_DEF_All_0_0_All
Beam trawl, Crustaceans, mesh size 16-31mm, no selectivity device, all vessels	TBB_CRU_16-31_0_0_all
Beam trawl, Demersal fish, mesh size 16mm or less, no selectivity device, all vessels	TBB_DEF_<16_0_0_all
Beam trawl, Demersal fish, mesh size more than 120, no selectivity device, all vessels	TBB_DEF_>=120_0_0_all
Beam Trawl, mesh size 100-119mm	TBB_DEF_100-119_0_0_all
Beam trawl, Demersal fish, mesh size 70-99, no selectivity device, all vessels	TBB_DEF_70-99_0_0_all
Beam trawl, Demersal fish, mesh size 90-99, no selectivity device, all vessels	TBB_DEF_90-99_0_0_all
Beam trawl, Demersal fish, all mesh sizes, no selectivity, all vessels	TBB_DEF_all_0_0_all

* The use of metiers under the MIS_MIS category should be minimized.

Appendix IV.

The information requested in this Appendix is required for stocks identified in DC_Annex_1.xlsx with "Y" under column "DLS proxy RP" and for which such information has not been reported in previous data calls.

"Supporting life history information" (See DC_Annex_2_SupportingInformationLifeHistoryParameters.xlsx) should include information on life history traits for the last three years (2018, 2019, 2010), 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). Please note that article 17(3) of Regulation (EC) No 2017/1004 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,..*"

^ 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 IV. Supporting life history information.

Appendix V.

WGNAS glossary

1SW (*One-Sea-Winter*). Maiden adult salmon that has spent one winter at sea.

2SW (*Two-Sea-Winter*). Maiden adult salmon that has spent two winters at sea.

MSW (Multi-Sea-Winter). A MSW salmon is an adult salmon that has spent two or more winters at sea and may be a repeat spawner.

Catch-and-release fisheries Catch and release is a practice within recreational fishing intended as a technique of conservation. After capture, the fish are unhooked and returned to the water before experiencing serious exhaustion or injury.

NAC (*North American Commission*). The North American Atlantic Commission of NASCO or the North American Commission area of NASCO.

WGC (*West Greenland Commission*). The West Greenland Commission of NASCO or the West Greenland Commission area of NASCO.

NEAC (*North Eastern Atlantic Commission*). North-East Atlantic Commission of NASCO or the North-East Atlantic Commission area of NASCO.

NEAC – N (*North Eastern Atlantic Commission- northern area*). The northern portion of the North-East Atlantic Commission area of NASCO.

NEAC – S (*North Eastern Atlantic Commission – southern area*). The southern portion of the North-East Atlantic Commission area of NASCO.

NASCO (*North Atlantic Salmon Conservation Organisation*). An international organisation, established by an inter-governmental convention in 1984. The objective of NASCO is to conserve, re-store, enhance and rationally manage Atlantic salmon through international cooperation taking account of the best available scientific information.

Annex 8: Working documents

Working Document 1: Update and correction of the reference points, estimated during the 2019 IBP, for saithe in areas 3a, 4 and 6

Author: Yves Reecht

Date: 23. Apr 2021 (last modified 10/11/2021)

1.1. Background

Following identifications of several issues with the commercial CPUE index used in the pok.27.3a46 assessment and subsequent corrections (see Section 16 of the main report), an attempt was made to evaluate possible impacts of the updated series on the reference point estimates.

1.2. Methods and new issues identified

The reference points (RPs) for pok.27.3a46 were formerly re-estimated during an inter-benchmark protocol (IBP) in early 2019, following detection of an erroneous standardization of F within the assessment model. The IBP report (ICES, 2019) documents the new reference points to be based on corrected runs of the 2018 assessment (with data up to 2017) using the last 5 years of selectivity pattern within the EqSim model, instead of the 10 years used previously. This shortening of the selectivity series used in EqSim was motivated by notable recent changes in the selectivity for ages 3 and 4.

The methodology used here to evaluate the potential effect of the most recent changes (as of 2021 assessment) on the reference points was to (*i*) make sure we could replicate the 2019 IBP results using saved 2018 assessment outputs, (*ii*) replicate the whole process including the 2018 assessment using the data used then (check for consistency in assessment outputs) and (*iii*) compare calculated reference point using the newly corrected CPUE index (calculated on corrected data 2000-2017). In order to account for the stochasticity in the EqSim model outputs, RP estimation was run 150 times (25 SR-fit x 6 EqSim simulations) for each scenario, and RP distributions were compared to each other and to the point estimates from the 2019 IBP.

Step *i* revealed itself more problematic than expected as some reported RPs such as F_{lim} (and derived F_{pa}) or Fp05 (with management rule) were falling far out the newly estimated distributions (Fig. **Error! Reference source not found.**.a). Fortunately, saved R objects of the EqSim runs used to estimate the RPs in 2019 allowed for a detailed investigation of the reasons behind the discrepancies. It appeared that the EqSim runs used to estimate those RPs (no HCR nor F variability, and HCR+F variability) had been using the 2016 stock assessment outputs with the last 10 years of selectivity pattern (Fig. **Error! Reference source not found.**) instead of the 2018 assessment and the last 5 years of selectivity.

F_{MSY}, MSY and the stock status reference points, all based on the run with F variability and no management rule (first case in Fig. **Error! Reference source not found.**), were unaffected by this mistake. Similarly, the stock status RPs not based on

EqSim but relying on the stock-recruitment relationship analysis instead ($B_{\lim} = B_{loss}$ and $B_{trigger} = B_{pa} = B_{\lim} \times e^{1.645 \times 0.2}$ in this case), were exhibiting negligible changes. This is consistent with the overall limited effect of the CPUE index update on the stock assessment outcomes.

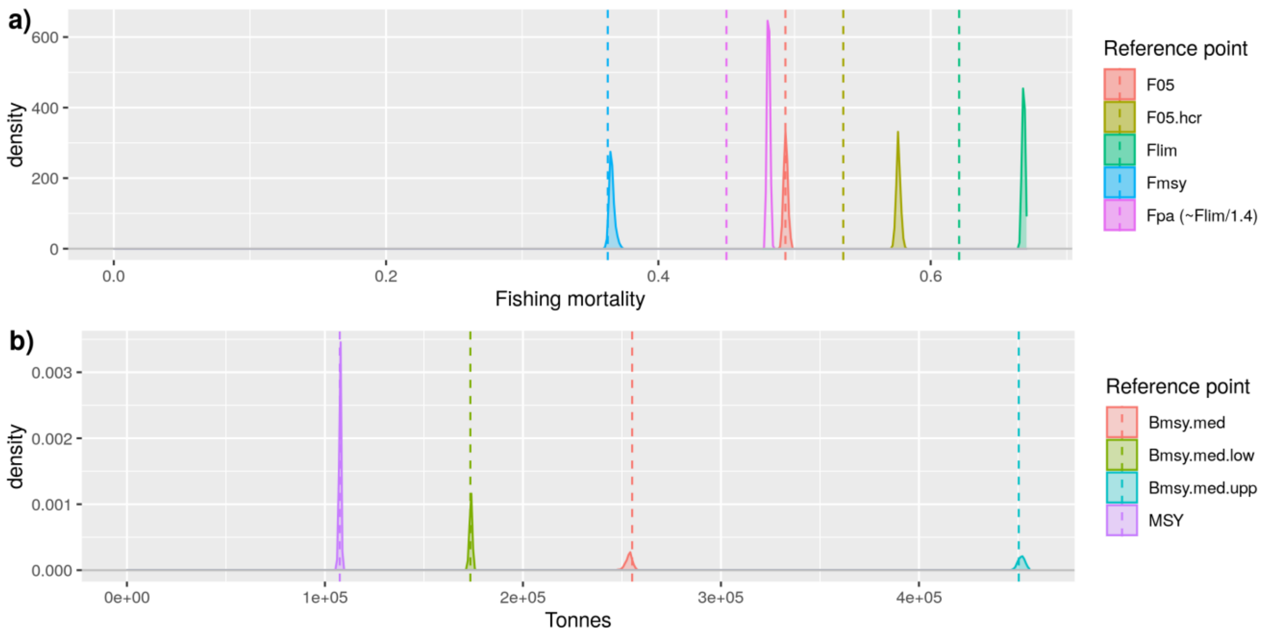

Figure 1. Estimation of reference points using saved 2018 stock assessment outputs (corrected for the 2019 IBP), using settings *documented in the IBP report* (distributions). The vertical dashed lines are the point estimates reported. *With* a) F-based reference points and b) biomass/weight-based reference points.

Run settings (RPs) | **Selectivity patterns 2019 IBP** | **Selectivity patterns 2021**

No HCR, Fcv + Fφ (F_{MSY},...)

Selectivity patterns 2019 IBP:

Age	2013	2014	2015	2016	2017
3	0.28	0.26	0.25	0.23	0.22
4	0.85	0.82	0.82	0.80	0.78
5	1.09	1.09	1.10	1.10	1.09
6	1.09	1.10	1.10	1.10	1.12
7	0.98	0.99	0.98	1.00	1.02
8	0.95	0.97	0.97	1.01	1.02
9	0.87	0.90	0.91	0.96	0.97
10+	0.87	0.90	0.91	0.96	0.97

No HCR, Fcv=Fφ=0 ($F_{\lim}$)

HCR, Fcv + Fφ ($F_{p.05}$,...)

Selectivity patterns 2019 IBP:

Age								2013	2014	2015
3	0.40	0.40	0.37	0.35	0.32	0.34	0.31	0.28	0.26	0.25
4	0.88	0.91	0.90	0.88	0.86	0.89	0.88	0.85	0.82	0.82
5	1.02	1.05	1.07	1.07	1.07	1.09	1.10	1.09	1.09	1.10
6	1.10	1.08	1.08	1.09	1.08	1.06	1.07	1.09	1.10	1.10
7	1.01	0.96	0.96	0.96	0.98	0.96	0.95	0.98	0.99	0.98
8	0.96	0.90	0.90	0.89	0.93	0.91	0.92	0.95	0.97	0.97
9	0.95	0.87	0.86	0.83	0.84	0.83	0.84	0.87	0.90	0.91
10+	0.95	0.87	0.86	0.83	0.84	0.83	0.84	0.87	0.90	0.91

Selectivity patterns 2021:

Age	2013	2014	2015	2016	2017
3	0.28	0.26	0.25	0.23	0.22
4	0.85	0.82	0.82	0.80	0.78
5	1.09	1.09	1.10	1.10	1.09
6	1.09	1.10	1.10	1.10	1.12
7	0.98	0.99	0.98	1.00	1.02
8	0.95	0.97	0.97	1.01	1.02
9	0.87	0.90	0.91	0.96	0.97
10+	0.87	0.90	0.91	0.96	0.97

Figure 2. Comparison of selectivity patterns used for different EqSim runs from the 2019 IBP (extracted from saved EqSim objects) with those documented in the report and replicated in 2021 ("as they should be"). Selectivity years in 2019 (red headings) as guessed after match of selectivities with the 2021 runs.

1.3. Reference points comparisons

The references points calculated using the updated CPUE index were therefore compared to RP based on 2018 saved and re-ran assessments using the last 5 years (2013-2017) of selectivity, as documented in the 2019 IBP report (i.e., as they should have been; ICES, 2019). The distributions based on the saved ("original", as calculated in 2019) stock assessment outputs and the replicated 2018 stock assessment match perfectly, which demonstrate consistency in the model outputs (Fig. **Error! Reference source not found.**). RP distributions estimated based on t he corrected CPUE index overlap mostly the former ones, and the point estimates not wrongly estimated (see previous section) all fall within the newly estimated distributions. This shows that the CPUE update has a negligible impact on the reference point estimates. Following new ICES technical guidelines (ICES, 2021), the F_{pa} reference point should therefore be set to the newly estimated median value of Fp05 using the advice rule (F05.hcr=0.58 in Fig. **Error! Reference source not found.**) instead of the erroneous value (Fp05=0.54) p reviously reported by ICES (2019). F05.hcr also constituted the technical basis for MAP F_{upper}, which should also be updated accordingly: $F_{MSY\ upper}$ (0.564, unchanged) being now more conservative than the corrected value of Fp.05, it becomes the new technical basis for MAP F_{upper}. And finaly, F_{lim}, wrongly estimated during the 2019 IBP, should be raised from 0.62 to 0.69.

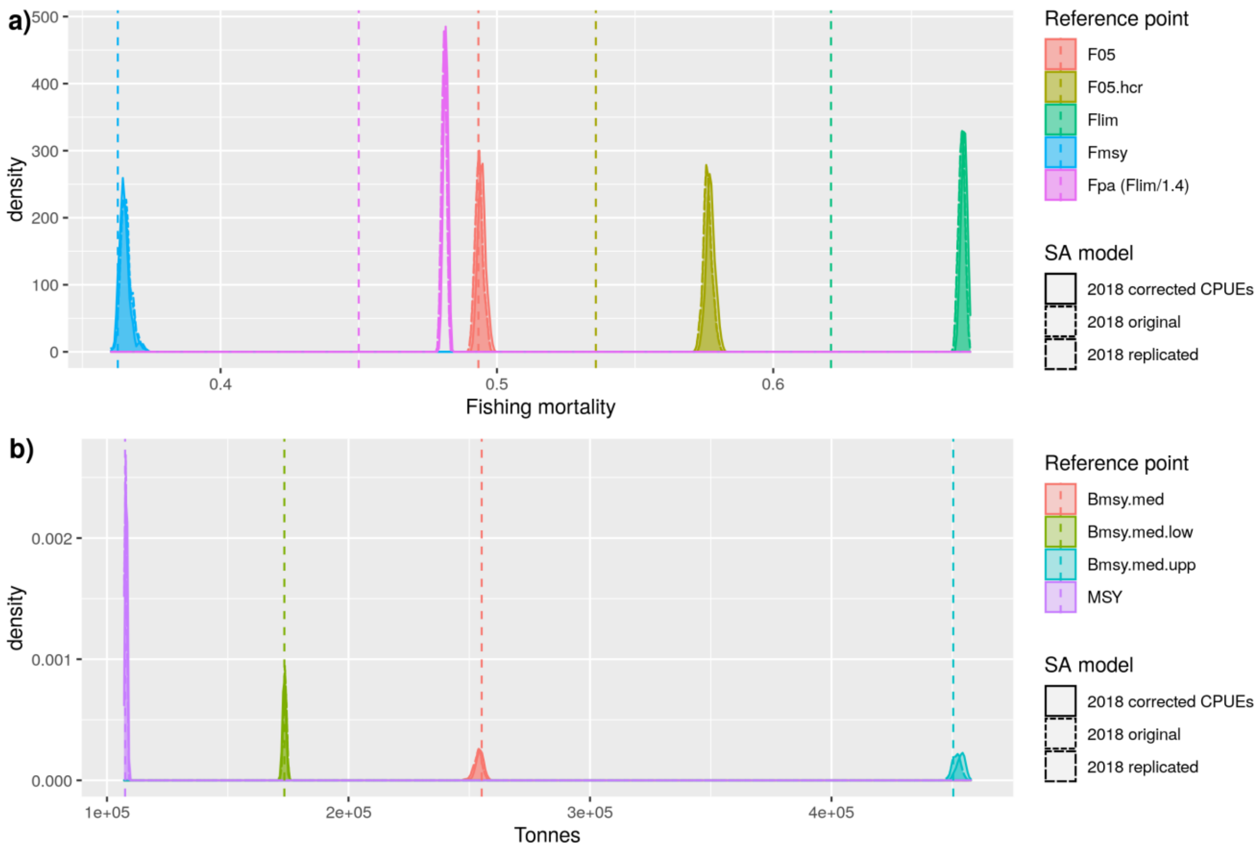

Figure 3. Comparisons of *reference point* estimates (distributions) based on historical 2018 assessment and with corrected CPUE index. Parametrisation of the EqSim simulations as documented in the 2019 IBP report. Vertical dashed lines are the reported point estimates, some (F-based RPs) of which were based on erroneous settings. With a) F-based reference points and b) biomass/weight-based reference points.

1.4. Note on the technical basis for B_{pa}

The 2019 IBP set MSY $B_{trigger}$ = B_{pa} on the basis that the stock had been fished over F_{MSY} for at least one of the last five years (2013-2017) and following ICES (2017). The updated 2018 stock assessment (corrected CPUE index), on the other hand, reveals a possible exploitation below F_{MSY} for just five years, which could prompt a change of technical basis for MSY $B_{trigger}$. More recent stock assessment, including the 2021 one, however do not support the view of stock which has been consistently exploited within or below F_{MSY} over the last years, and a change of technical basis for MSY $B_{trigger}$ is not advisable.

1.5. Acknowledgements

Mistakes happen, especially when dealing with urgent requests. As the newly appointed stock coordinator, I would like to highlight the value of – and warmly thank the then coordinator for – thoroughly documenting and saving the scripts and results from the 2019 IBP. This immensely helped figuring out and solving the issue at hand.

1.6. References

ICES. 2017. Technical Guidelines - ICES fisheries management reference points for category 1 and 2 stocks. http://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=32751 (Accessed 27 April 2021).

ICES. 2019. Report of the Interbenchmark protocol on North Sea saithe (IBPNSsaithe). http://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=35210 (Accessed 23 April 2021).

ICES. 2021. Technical Guidelines - ICES fisheries management reference points for category 1 and 2 stocks (2021). https://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=37356 (Accessed 23 April 2021).

Working Document 2: Exploration of SPiCT forecast for Brill in 27.3a47de

Authors: Lies Vansteenbrugge (ILVO, Belgium), Casper Berg (DTUAqua, Denmark) and Alexandros Kokkalis (DTUAqua, Denmark)

1.1. Introduction

The brill stock in the greater North Sea (27.3a47de) is a category 3 stock, for which the 2 over 3 rule is applied to the Dutch commercial standardised LPUE biomass index (vessels > 221 kW). A SPiCT assessment including landings, the Dutch commercial lpue index and the BTS-ISIS Q3 survey index is run to determine whether the precautionary (PA) buffer should be applied.

WKLIFE X (ICES, 2020) investigated the performance of harvest control rules across life-history types through simulation and management strategy evaluation (MSE) for data-limited stocks such as brill in the greater North Sea. Recommendations include the application of the SPiCT forecast to provide advice.

This working document compares the current way of providing advice (2 over 3 rule) with the recommendations from WKLIFE X.

1.1.1. Current advice: 2 over 3 rule applied to biomass index

For the current brill 27.3a47de advice, the ICES framework for category 3 stocks is applied (ICES, 2021a). The standardised landings per unit effort (lpue) from the Dutch beam-trawl fleet (vessels > 221 kW) was used as biomass index of stock development (Figure 1). The advice is based on the ratio of the mean of the last two index values (index A; Figure 1 red lines) with the mean of the three preceding values (index B) multiplied by the recent advised catch. This results in a 8.3% decrease for the 2022 catch advice compared to the 2021 catch advice (Table 1; ICES, 2021b).

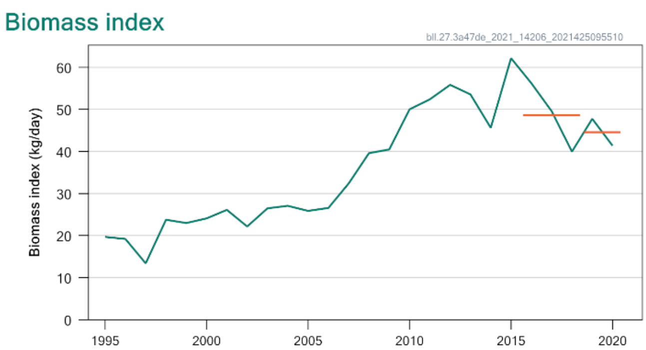

Figure 1: Biomass index as presented in the advice for 2022, showing the standardised landings per unit effort (lpue) from the Dutch beam-trawl fleet (vessels > 221 kW). The red horizontal lines indicate the average of the biomass index for 2019-2020 and for 2016-2018.

Table 1: 2022 Advice for Brill 27.3a47de

Index A (2019–2020)		45 kg d^{-1}
Index B (2016–2018)		49 kg d^{-1}
Index ratio (A/B)		0.92
Uncertainty cap	Not applied	-
Advised catch for 2021		2047 tonnes
Discard rate (2018–2020)		14.3%
Precautionary buffer	Not applied	-

Catch advice *	1878 tonnes
Projected landings corresponding to catch advice **	1610 tonnes
% advice change^	-8.3%

* [Advised catch for 2021] × [Index ratio].
** [Advised catch for 2021] × [Index ratio] × [1 – discard rate].
^ Advice value for 2022 relative to the advice value for 2021.

1.2. SPiCT

To determine whether a precautionary buffer needs to be applied, a SPiCT assessment is run to verify stock status relative to proxy reference points.

The SPiCT assessment was first run during the WGNSSK 2017 and includes 1) landings data truncated from 1987 to the last data year, 2) a BTS-ISI-Q3 survey index (1987 to the last data year) and 3) the standardized lpue index from the Dutch beam-trawl fleet (vessels > 221 kW) from 1995 to the last data year. Settings include priors set to default (ICES, 2017a).

The SPiCT model results are shown in Figure 2. 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.

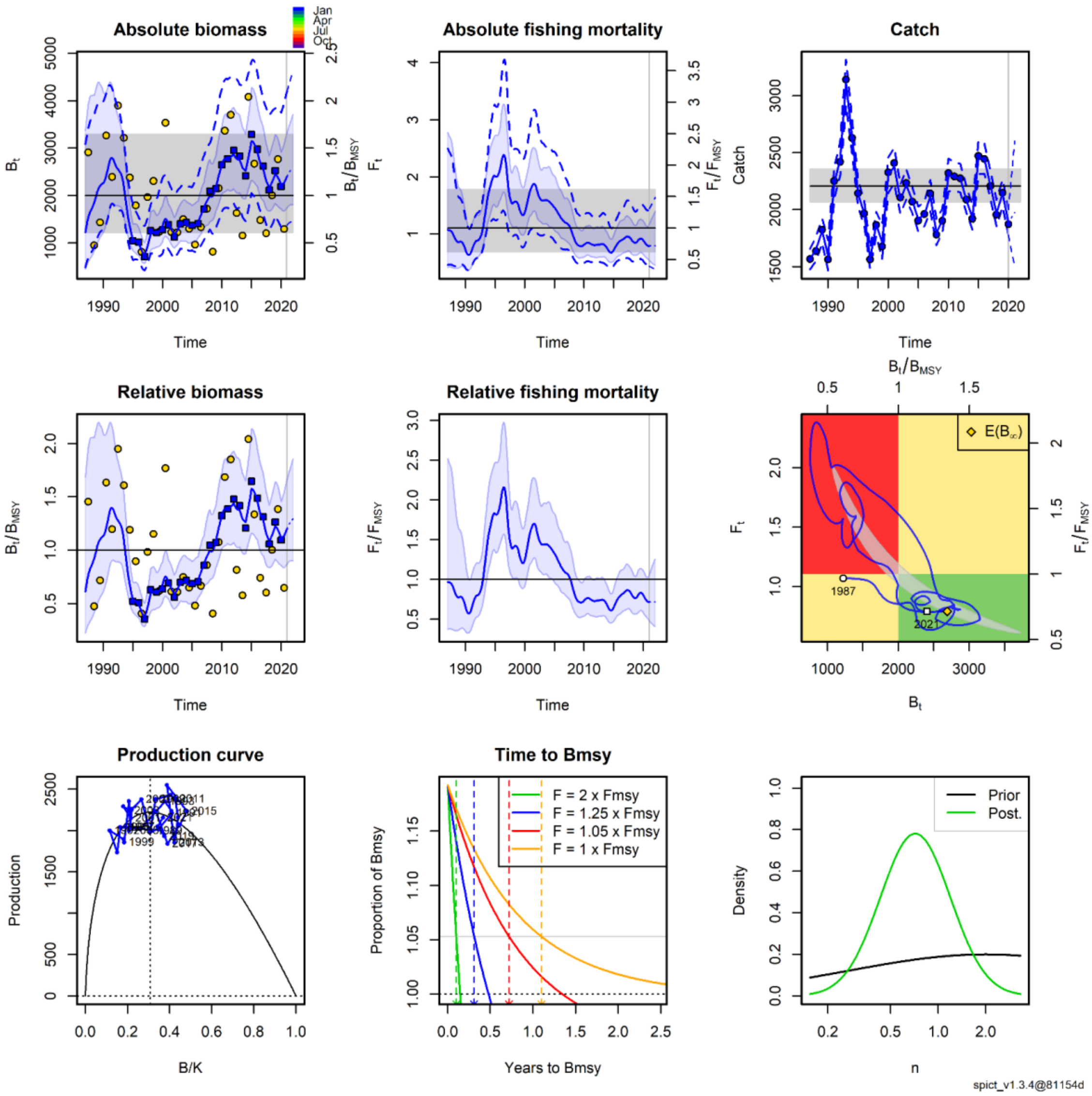

Figure 2: SPiCT model results from WGNSSK 2021. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. Bottom row: 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).

The retrospective analysis shows a stable pattern, with all peels within the confidence bounds (Figure 3). Moreover, the Mohn's Rho values for F/F_{MSY} (0.005) and B/B_{MSY} (-0.023) were low. It was concluded that the model performed well and that the estimated stock status with respect to reference points is consistent.

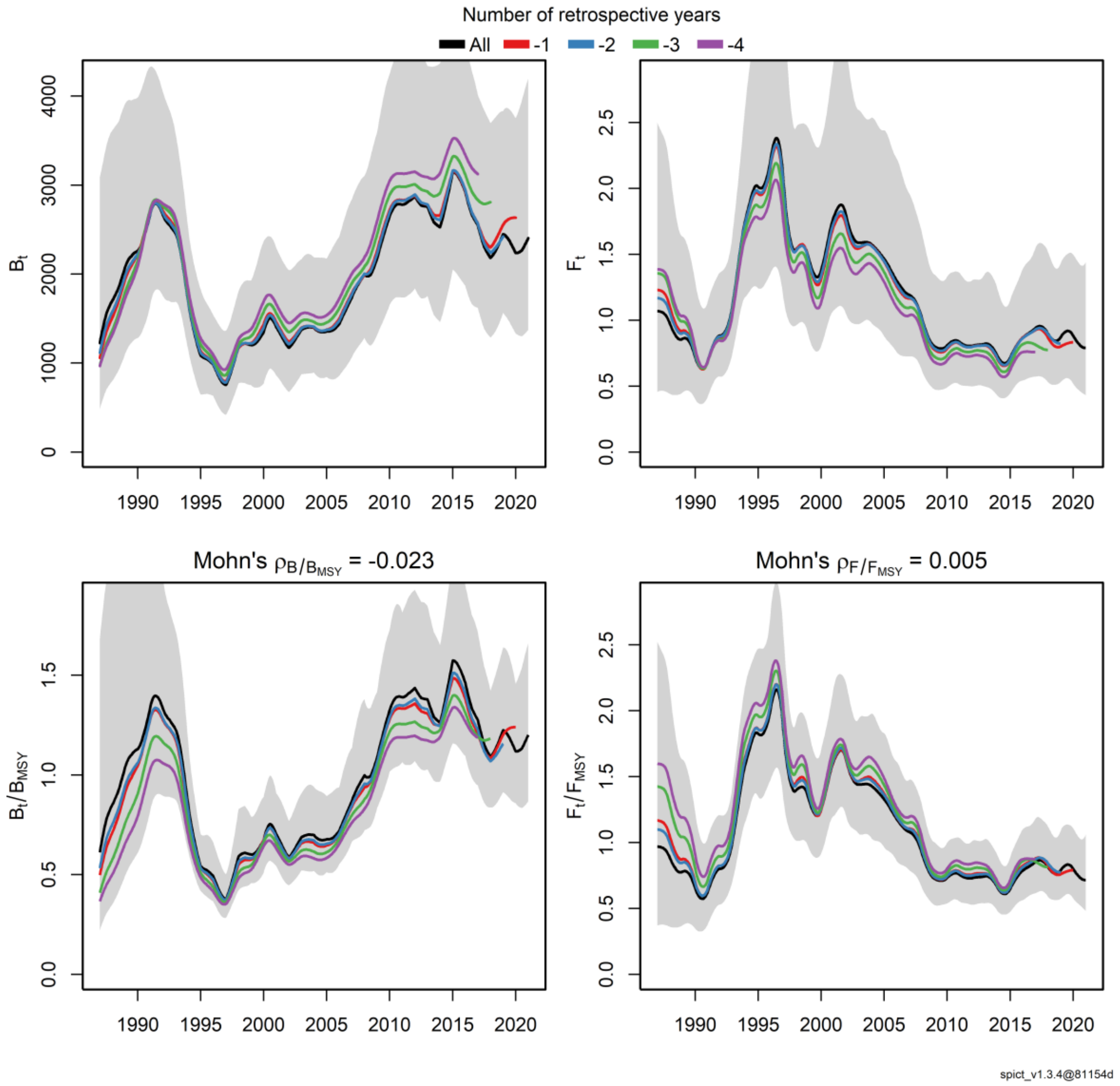

Figure 3: Retrospective analysis of the SPiCT model from WGNSSK 2021. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.

1.3. SPiCT forecast scenarios: median versus fractile rule

For stocks that have an accepted SPiCT assessment, WKLLIFE X recommends to use the fractile rule with 35th percentile of the predicted catch distribution. In theory, with increasing time series and decreasing observation error, the estimated catch should approximate the median rule suggested by WKMSYCat34 while being more precautionary (ICES, 2017b).

Two intermediate year settings were tested for the forecast: 1) F status quo (Fsq), which allows a continuation of the F processes, but does not specify any catch parameters in the intermediate year 2) TAC constraint, which considers the advised landings for 2021 as catch for the intermediate year (TAC for the whole year in 2021 is not available). **Considering that the input data are only landings, the output of the forecasts will also be landings advice.**

1) F status quo:

For the intermediate year settings, a continuation of the F processes was assumed (Fsq). Four catch scenarios were explored for the management period (2022-2023). An overview is given in Table 2 and Figure 4. The Fsq scenario in 2022-2023 gives the landings when assuming a further continuation of the F processes beyond the intermediate year (F2022 = F2021). F_{MSY} in 2022-2023 is defined as F/F_{MSY} equal to 1. The proposed 35% fractile rule suggests a 2444 tonnes landings advice for 2022.

Table 2: SPiCT forecast output showing catch scenarios for the F status quo option in the intermediate year.

F in 2022-2023	Landings advice 2022	B/B_{MSY} (2023)	F/F_{MSY} (2022-2023)
F = 0	0	2.2	0.00
F = Fsq	2069	1.32	0.72
F_{MSY}	2592	1.08	1.00
F_{MSY} 35% fractile	**2444**	1.15	0.91

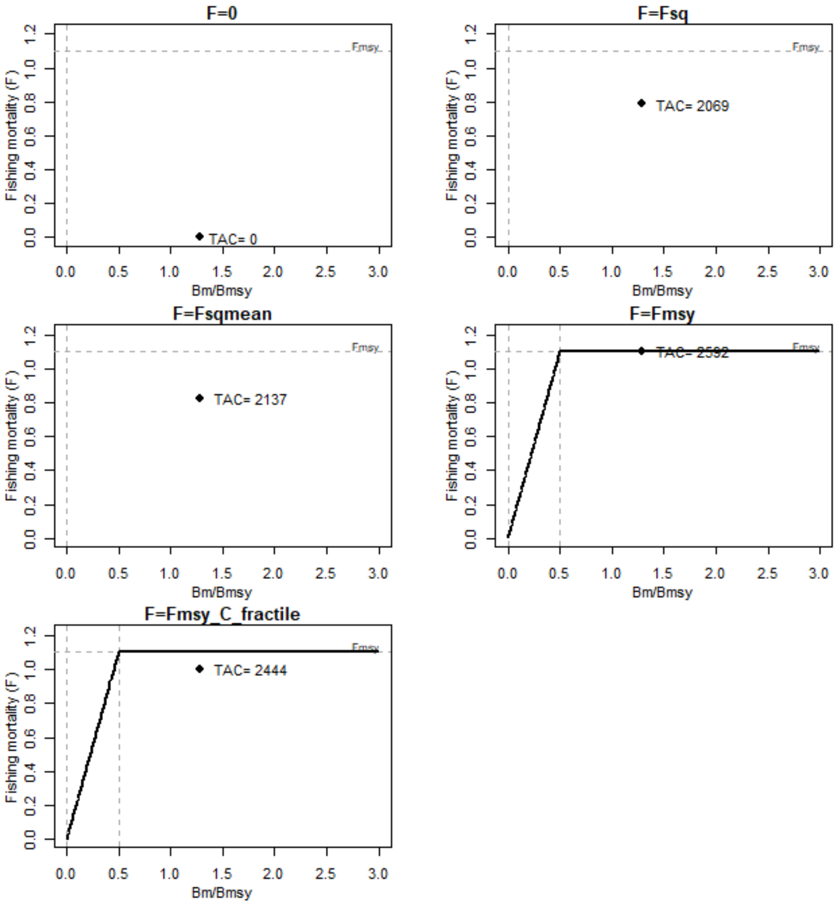

Figure 4: Visualisation of the catch scenarios for the F status quo option in the intermediate year. Vertical dashed lines for B/B_{MSY} indicate B_{lim} (B/B_{MSY} = 0) and $B_{MSY\ proxy}$ (B/B_{MSY} = 0.5). Horizontal dashed line indicates $F_{MSY\ proxy}$.

2) TAC constraint

The landings advice for 2021 (1773 tonnes) was used as intermediate period catch, in absence of the 2021 TAC. Four catch scenarios were explored for the management period (2022-2023). An overview is given in Table 3 and Figure 5. The Fsq scenario in 2022-2023 gives the landings when assuming a further continuation of the F processes from 2020 in 2022-2023 (F2022 = F2021). F_{MSY} in 2022-2023 is defined as F/F_{MSY} equal to 1. The proposed 35% fractile rule suggests a 2530 tonnes landings advice for 2022.

Table 3: SPiCT forecast output showing catch scenarios for the TAC constraint option in the intermediate year.

F in 2022-2023	Landings advice 2022	B/B_{MSY} (2023)	F/F_{MSY} (2022-2023)
F = 0	0	2.2	0.00
F = Fsq	1904	1.43	0.62

F_{MSY}	2657	1.09	1.00
F_{MSY} 35% fractile	**2530**	1.15	0.93

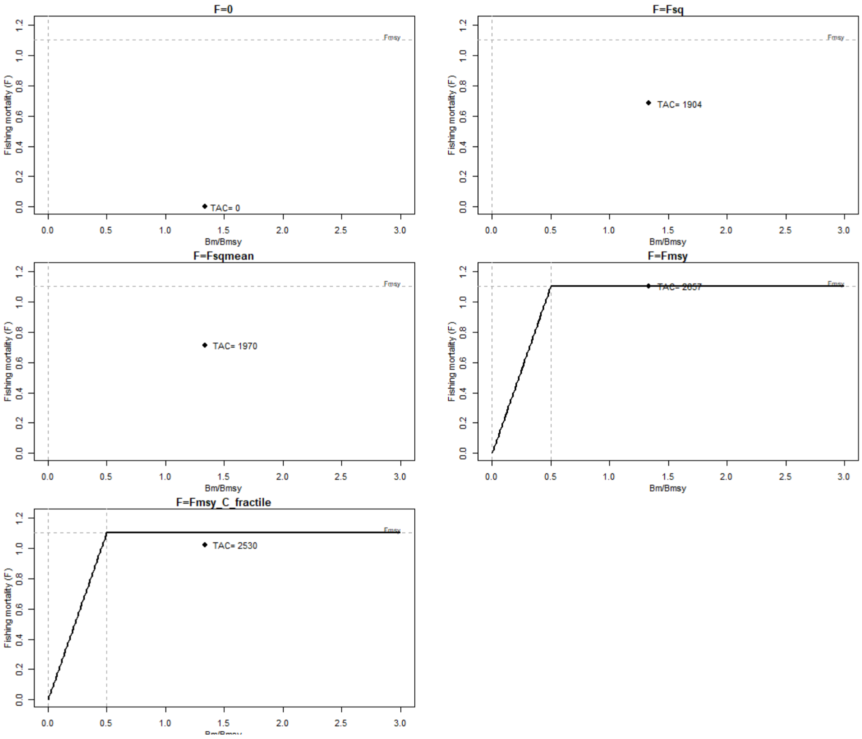

Figure 5: Visualisation of the catch scenarios for the TAC constraint option in the intermediate year. Vertical dashed lines for B/B_{MSY} indicate B_{lim} ($B/B_{MSY} = 0$) and $B_{MSY\ proxy}$ ($B/B_{MSY} = 0.5$). Horizontal dashed line indicates $F_{MSY\ proxy}$.

1.4. Conclusion

Using the 35% fractile approach, landings advice is 2444 tonnes for the F status quo option in the intermediate year. The TAC constraint option gives a landings advice of 2530 tonnes. Comparing this with the current landings advice based on the 2:3 rule (1610 tonnes), there is a difference of 52% for the first option and 57% for the TAC constraint option.

Based on the output of the SPiCT assessment, the brill stock is currently in a good state compared to proxy reference points. Consequently, it is not unusual to expect higher advice using the SPiCT forecast. Furthermore, the Dutch lpue index currently used for advice only covers a part of the stock area (only area 27.4). It is also a raw index (not modelled), which could be improved considering the changes in the Dutch beam trawl fleet (introduction and phasing-out of pulse trawlers).

Applying a precautionary approach to give advice for this stock is necessary. Not only is brill in 27.3a47de a data limited stock, management of brill and turbot also occurs under a combined species TAC (applied to area 27.2a and 27.4). The latter prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. ICES advises that management should be implemented at the species level in the entire stock distribution area (Subarea 4 and divisions 3.a and 7.d–e for brill and 27.4 for turbot) and not applying advice for the whole stock area of brill (27.3a47de) to only area 27.4.

1.5. References

ICES, 2017a. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. https://doi.org/10.17895/ices.pub.5323

ICES, 2017b. Report of the Workshop on the Development of the ICES approach to providing MSY advice for category 3 and 4 stocks (WKMSYCat34), 6–10 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:47. 53 pp.

ICES, 2020. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X). ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

ICES. 2021a. Advice on fishing opportunities. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, section 1.1.1. https://doi.org/10.17895/ices.advice.7720.

ICES. 2021b. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 3:66. https://doi.org/10.17895/ices.pub.8211.

1.6. Annex:

SPiCT forecast output for the option without specific intermediate year assumption:

```
sumspict.manage(fit, include.abs = TRUE)
SPiCT timeline:

      Observations              Intermediate              Management
    1987.00 - 2021.00         2021.00 - 2022.00         2022.00 - 2023.00
 |-----------------------| ----------------------| -------------------
---|

Management evaluation: 2023.00

Predicted catch for management period and states at management evaluat
ion time:

                          C B/Bmsy F/Fmsy      B    F perc.dB perc.dF
1. F=0                  0.0   2.20   0.00 4435.6 0.00    72.0  -100.0
2. F=Fsq             2069.1   1.32   0.72 2650.4 0.79     2.8     0.0
3. F=Fsqmean         2136.8   1.29   0.75 2589.6 0.83     0.4     4.6
4. F=Fmsy            2592.3   1.08   1.00 2173.5 1.10   -15.7    39.8
5. F=Fmsy_C_fractile 2443.9   1.15   0.91 2310.6 1.01   -10.4    27.4
```

SPiCT forecast code for the TAC constraint option, defining the TAC as the landings advice for 2021 (1773 tonnes).

```
sumspict.manage(fit2,include.abs=TRUE)
SPiCT timeline:

      Observations              Intermediate              Management
    1987.00 - 2021.00         2021.00 - 2022.00         2022.00 - 2023.00
 |-----------------------| ----------------------| -------------------
---|

Management evaluation: 2023.00

Predicted catch for management period and states at management evaluat
ion time:
```

	C	B/Bmsy	F/Fmsy	B	F	perc.dB	perc.dF
1. F=0	0.0	2.24	0.00	4498.9	0.00	68.8	-100.0
2. F=Fsq	1904.4	1.43	0.62	2874.9	0.68	7.9	0.0
3. F=Fsqmean	1969.8	1.40	0.65	2817.3	0.71	5.7	4.6
4. F=Fmsy	2656.6	1.09	1.00	2200.1	1.10	-17.4	61.6
5. F=Fmsy_C_fractile	2529.5	1.15	0.93	2316.3	1.02	-13.1	49.7

Annex 9: Approaches to missing data

This section contains reports for stocks on deviations from stock annexes caused by missing information from Covid-19 disruption in 2020/2021.

bll.27.3a47de (brill)

1. Stock: **Bll.27.3a47de**

2. Missing or deteriorated survey data: (Also indicate the reliance of the assessment on this data i.e. which other survey data was available)

All necessary survey data was available.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

The overall discard ratio coverage was 59% in 2020 which is comparable to previous years. The proportion of imported discards was however lower than in 2019 (44% in 2020 versus 68% in 2019). It is unclear whether this is due to Covid-19. Age and length distributions are so far not used in the assessment.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

All necessary commercial lpue data was available.

5. Missing or deteriorated biological data: (e.g. maturity data)

No maturity data is needed for the assessment.

6. Brief description of methods explored to remedy the challenge:

No methods were explored.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

Stock annex was followed.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

Not applicable.

cod.27.47d20 (cod)

1. Stock: cod.27.47d20

2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e. which other survey data was available)

No missing data: both Q1 and Q3 data from the NS-IBTS were used to derive delta-GAM indices as usual.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Lower discard ratio coverage (57% of the landings in comparison to 76% in 2019). Lower proportion of landings sampled for age (75% in 2020 vs 89% in 2019), particularly in Subarea 4 in Q2 (only 36% of landings sampled). A high proportion of discard strata were still sampled although this was lower in Subarea 4 in Q2 (71% compared to >90% for the other quarters).

No deviations from the stock annex with regards to InterCatch raising.

4. Missing or deteriorated commercial LPUE/CPUE data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

N/A

5. Missing or deteriorated biological data: (e.g. maturity data)

Biological sampling of the NS-IBTS-Q1 in the South was extremely low (6 fish), although this is not unique to 2021 and is also a consequence of reduced abundance of cod in that area. Samples from the South were pooled with the Northwest according to the stock annex for low sample size (and has been done in other years). Raw maturities calculated for 2021 were extremely low and could be a consequence of covid or reduced abundance in some subareas. The assessment estimates maturity, rather than taking it as a fixed input, and is therefore able to compensate for this to some extent.

6. Brief description of methods explored to remedy the challenge:

N/A

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

N/A

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

N/A

mur.27.3a47d (red mullet)

1. Stock: **mur.27.3a47d**

2. Missing or deteriorated survey data: (Also indicate the reliance of the assessment on this data i.e. which other survey data was available)

Due to the pandemic, trawling authorization in UK EEZ were not delivered in time, consequently CGFS survey was not allowed to sample station within UK water in 2020. This index is the only one used in the assessment.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Discard are considered negligible. Assessment already suffer from low age and length sampling coverage. Age sampling usually covered around 20-30% of landings and is coming from sampling of French fleets and mostly in 7d. Length samples are uploaded by FR, UK and NL with the same coverage. In 2020, the coverage was down to 8% for age and length data.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

Not applicable.

5. Missing or deteriorated biological data: (e.g. maturity data)

Not applicable.

6. Brief description of methods explored to remedy the challenge:

Due to the lack of sample, all missing strata from Q1, Q2, Q3 and 2020 were allocated using all the data available (1 stratum for Q1 and 4 from Q4). Missing strata from Q4 were allocated with Q4. For length data, Q1 samples were used to allocated Q1 and Q2 missing strata. Q3-Q4 samples were used for Q3 missing strata as only one stratum was available for Q3. Q4 was allocated with Q4. All the strata were used to allocated 2020 strata.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

Stock annex was followed.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

Issues with survey indices at age, lack of age sampling and issue with benchmark model formulation led the group to decide to reject the assessment model. The stock was downgraded to category 5.

ple.27.420 (plaice)

1. Stock: ple27.420
2. Missing or deteriorated survey data: reduced sampled hauls from UK in 2020 in BTS survey. However, we used glm-like method to calculate indices, so the impact on assessment is small. We use BTS, IBTSQ1, IBTSQ3, SNS surveys in assessment.
3. Missing or deteriorated catch data: 72% landing were sampled in area 4 and 58% landing were sampled in 320. The sampling coverage rate was similar to previous year. The largest fleet that under-sampled for both landing and discards is Beamtraler with large mesh size (TBB >120mm).
4. None CPUE data used
5. Biological data were fixed across years
6. No change of process caused by covid19
7. N/A
8. N/A

ple.27.7d (plaice in the eastern English Channel)

1. Stock: **ple.7d**

2. Missing or deteriorated survey data: (Also indicate the reliance of the assessment on this data i.e. which other survey data was available)

Due to the pandemic, trawling authorization in UK EEZ were not delivered in time, consequently CGFS survey was not allowed to sample station within UK water in 2020 which could affect the FR GFS index.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Because of the pandemic, there was a lack of sampling for discards of trawlers during the quarters 2, 3 and 4.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

Not applicable.

5. Missing or deteriorated biological data: (e.g. maturity data)

Not applicable.

6. Brief description of methods explored to remedy the challenge:

Missing strata from Q2, Q3, Q4 of trawl discards were allocated using available samples from Q1.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

The issue related to the FR GFS index have been investigated during the group by i/ testing the impact of removing the index, and ii/ the calculation of a new index without UK sampling stations. Since the results did not show significant impacts on assessment outputs, we kept using the normal procedure.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

We evaluated the lack of sampling by testing different scenarios : i/ testing the impact of removing the index, and ii/ the calculation of a new index without UK sampling stations. The results did not show significant impacts on assessment outputs.

pok.27.3a46 (saithe)

1. Stock: **Pok.27.3a46**

2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e. which other survey data was available)

No missing survey data / negligible impact (IBTS Q3)

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Lower proportion of landings sampled for age (<70% in 2020 vs. >90% in 2019). No impact on raising strategy though.

Still high proportion of discard strata sampled for age (Scotland and Denmark, where most of the discards originate). But based on very few actual samplings, so most unsampled strata not matchable on area and quarter.

4. Missing or deteriorated commercial LPUE/CPUE data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

No deterioration

5. Missing or deteriorated biological data: (e.g. maturity data)

Not relevant (constant ogive).

No foreseeable future impact (benchmark, etc.): IMR spawning saithe survey going on as expected.

6. Brief description of methods explored to remedy the challenge:

Unsampled discards for areas 3a and 6 matched on all available data for raising age structure and weights.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

No change suggested.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

No, but can speculate that likely very low. Mostly affected discard sampling while discards are typically low. Weight-at-age for discards in ranges previously estimated.

sol.27.7d (sole in the eastern English Channel)

1. Stock: **Sol.27.7d**

2. Missing or deteriorated survey data: (Also indicate the reliance of the assessment on this data i.e. which other survey data was available)

All necessary survey data was available.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

The overall discard ratio coverage was 54% in 2020 which was the lowest coverage since 2008. The landings with age distributions were in line with previous years (82%). The discards with age distributions were 52%, which is a little bit lower than the average (66%) of the time series available in InterCatch (2004-2020).

In previous years, approximately 70% of the imported discards (tonnage) originated from France and around 30% from Belgium. However, due to Covid-19, French sampling was hampered. In 2020, the ratio was reversed: 66% of the imported discards (tonnage) came from Belgium, and 34% from France.

Discard (tonnage) for which age distributions were available were also impacted. In previous years both Belgium and France contribute in equal amounts (50%), while in 2020, 99% of the samples were from Belgian sampling.

A high discard rate was observed in 2019 and 2020 as a result of the strong 2018 year class. However, the extent of the perceived discard rate in 2020 might be biased by the lower discard ratio coverage.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

All necessary commercial lpue data was available.

5. Missing or deteriorated biological data: (e.g. maturity data)

All necessary maturity data was available.

6. Brief description of methods explored to remedy the challenge:

The origin of the poorer discard ratio coverage was investigated but no methods were applied to remedy the challenge as it was believed that following the stock annex was still the best approach.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

Stock annex was followed.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

Not applicable.

tur.27.4 (turbot)

1. Stock: **tur.27.4**

2. Missing or deteriorated survey data: (Also indicate the reliance of the assessment on this data i.e. which other survey data was available)

All necessary survey data was available, i.e. BTS-ISIS and SNS as well as Dutch commercial LPUE index.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

The overall discard ratio coverage was 67% in 2020 which was higher compared to last year (62%). The landings with age distributions, 57%, were slightly higher with previous year (52%). There were no discards with age distributions since 2019. In 2018 only 4% of the discards had age distributions coming from Belgium and Denmark. In 2020 Belgium did sample the age of discards, however in too small numbers to be uploaded in InterCatch.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

All necessary commercial lpue data was available.

5. Missing or deteriorated biological data: (e.g. maturity data)

All necessary maturity data was available.

6. Brief description of methods explored to remedy the challenge:

The lack of age data in the discards was discussed. This is not something which can be solved by the working group.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

Stock annex was followed.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

Not applicable.

whg.27.47d (whiting)

1. Stock: WHG.27.47d

2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e. which other survey data was available)

None to report: both Q1 and Q3 data from the NS-IBTS data were used as usual.

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Reduce sampling in 2020 due to COVID-19. In 2020, 50% of landings were sampled across 9 métiers. In comparison, in 2019 68% of landings were sampled across 12 métiers.

4. Missing or deteriorated commercial *LPUE/CPUE* data: (where commercial LPUE/CPUE are used in the assessment indicate the impact of the disruption on these data)

N/A

5. Missing or deteriorated biological data: (e.g. maturity data)

None to report: maturity ogives estimated from survey data vas usual.

6. Brief description of methods explored to remedy the challenge:

For the 2021 assessment, the raising of discards and age allocations in InterCatch were stratified by gear type (i.e., TR1, TR2 and others), but no stratification by quarter or half-year (as usually done) was performed: for some quarter/gear type, too few discard ratios were available, resulting in high mean values and overestimation of catches.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

The deviation from the usual approach in InterCatch raising (i.e., no stratification by quarter or half year) was documented in the report section for the 2021 assessment. As this is expected to be an isolated occurrence, following the stock auditor's feedback the text describing the normal approach (i.e., stratification by gear type, quarter and half year) was left in the report section, but text was added describing the changes applied in 2021.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

No.

nep.fu.3-4

1. Stock: *Nephrops* FU 3 and 4

2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e.

which other survey data was available)

No

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if

appropriate)

No

4. Missing or deteriorated commercial LPUE/CPUE data: (where commercial LPUE/CPUE are used in the

assessment indicate the impact of the disruption on these data)

No

5. Missing or deteriorated biological data: (e.g. maturity data)

On-board sampling of observer trips was interrupted for the Swedish trawl and creel fleets due to covid restrictions. Very few trips were sampled during quarters 2, 3 and 4.

6. Brief description of methods explored to remedy the challenge:

Borrowing data between Denmark/Sweden and between years was investigated with several scenarios. The full procedure is detailed in the WGNSSK report.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

It was decided by the group to use Swedish size composition data pooled by fleet for the years 2018-2020 to be raised to landings.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please

describe)

Several scenarios were simulated. End result differed with less than 1% on the final catch advice.