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

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i Executive summary

The main terms of reference for the The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) were: to update, quality check and report relevant data for the working group, to update and audit the assessment and forecasts of the stocks, to produce a first draft of the advice on the fish stocks and to prepare planning for benchmarks in future years. Ecosystem changes have been analytically considered in the assessments for cod, haddock and whiting in the form of varying natural mortalities estimated by the ICES Working Group on Multi Species Assessment Methods (WGSAM).

Benchmarks and Inter-benchmarks in 2019/2020

Full benchmarks were conducted during 2020 for WGNSSK stocks. These were on 3.a turbot, 3.a whiting, sole in 7.d and sole in 4. However, there were no inter-benchmark protocol (IBP) meetings during 2020.

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, and only the SSBs of cod in 4, 7.d and 20 and sole in 4 are below MSY $B_{trigger}$ at the beginning of 2020. Several North Sea stocks are exploited at or below F_{MSY} levels (haddock in 4, 6.a, plaice in 4 and 20 and sole in 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, whiting in 4 and 7.d, sole in 4, plaice in 7.d, turbot in 4 and witch in 3.a, 4 and 7.d). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids, although there are signs of a strong recruitment for haddock and whiting in 2019. Recruitment in 2019 continues on a high level also for flatfish stocks of plaice, sole and turbot.

All *Nephrops* stocks with agreed biomass reference points (Category 1 stocks, excluding nep.fu.3-4) are currently above MSY $B_{trigger}$, and all *Nephrops* stocks with defined F_{MSY} (Category 1 stocks, including) are being fished above F_{MSY} in 2019, apart from *Nephrops* in FU 7 (nep.fu.7) and FU 3-4 (nep.fu.3-4) which are fished sustainably.

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, sol in 7.d turbot in 3.a, whiting in 3a), along with grey gurnard in 3.a, 4 and 7d 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 and 2019; for 2020, biennial advice was either PA, where catch advice was still needed, or simply reporting stock status where no catch advice was needed. Reopening of advice was triggered for several Category 1 stocks in the autumn, following the availability of Q3 survey results in 2019, namely cod in 4, 7.d and 20, haddock in 4, 6.a and 20, plaice in 4 and 20, sole in 4, and *Nephrops* in FU 6, 7 and 8 (Annex 7).

The summary of stock status is as follows:

1) *Nephrops*:

Category 1:

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

b) FU 6 (nep.fu.6): The stock abundance has increased since 2015, and currently it is above MSY $B_{trigger}$. The harvest rate has shown an increase since 2018, and is above F_{MSY} in 2019.

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 in 2019 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, increased in 2019 and is now above F_{MSY}.

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

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.

No new advice was provided in spring 2020 for *Nephrops* stocks but advice was delayed until autumn 2020:

2) Cod (cod.27.47d20): Fishing pressure has increased since 2016, and is above F_{lim} in 2019. Spawning-stock biomass has decreased since 2015 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, F_{pa} and F_{lim}; the spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.

3) Haddock (had.27.46a20): Fishing pressure has declined since the beginning of the 2000s, but it has been above F_{MSY} for most of the time-series. Only in 2019, fishing pressure is at 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 year-class is estimated to be one of the largest since 2000. Currently, fishing pressure on the stock is at F_{MSY}, but below F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just above it in 2020. Fishing pressure has been above F_{MSY} throughout the time-series, apart from 2005. Recruitment (R) has been fluctuating without trend, but the 2019 year-class is estimated to be the largest since 2002. Currently, fishing pressure on the stock is above F_{MSY}, but below 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 $B_{trigger}$ since 1996. Fishing pressure has decreased and stabilized at or above F_{MSY} since 2014. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. Currently, fishing pressure on the stock is above F_{MSY} and F_{pa}, but below F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

6) Plaice (ple.27.420): The spawning-stock biomass is well above MSY $B_{trigger}$ and has markedly increased since 2008, following a substantial reduction in fishing pressure since 1999. Recruitment in 2019 is estimated to be the second highest in the time-series. Since 2009, fishing pressure has been estimated below F_{MSY}. 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 1999. Fishing pressure has declined since 1999 and is above F_{MSY} in 2019. Recruitment in 2019 is estimated to be the highest since the start of the time series in 1957. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

8) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly above F_{MSY}. Recruitment in 2019 is currently estimated to be highest in the time series since 1980. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

9) Turbot (tur.27.4): Recruitment is variable without a trend. In 2019 recruitment is estimated to be above average of the time series. Fishing pressure has decreased since the mid-1990s, and has been just below F_{MSY} since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY $B_{trigger}$ since 2013. This stock was upgraded to Category 1 from Category 3 following an inter-benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}; spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

10) 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 MSY $B_{trigger}$. Recruitment has declined since 2010 and is currently at a low level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY} and at F_{pa}, but below F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

11) 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 and 2019 was above the long-term average. Currently, spawning stock size is above B_{pa} and B_{lim}; no reference points for fishing pressure or for MSY $B_{trigger}$ have been defined for this stock.

12) Category 3–6 finfish stocks: In 2020, new advice has been produced for bll.27.3a47de, lem.27.3a47d, tur.27.3a, sol.7d (all Category 3 stocks) and whg.27.3a (Category 5). Advice was not provided for gug.27.3a47d, dab.27.3a4, fle.27.3a4, mur.27.3a47d (Category 3) and pol.27.3a4 (Category 5).

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

   b) Grey gurnard (gug.27.3a47d): The time-series of mature biomass index of grey gurnard from the International Bottom Trawl Survey quarter 1 (IBTS-Q1) shows a strong increase from the beginning of 1990s and has since fluctuated at a high level. Fishing pressure is estimated to be below the $F_{MSY\ proxy}$. 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 2018. Recruitment has shown a mostly downwards trend since a peak in 2011, but relatively high recruitment is estimated for 2019. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$. No reference points for stock size have been defined for this stock.

d) 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 without a trend in later 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 above $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger\ proxy}$.

e) Whiting (whg.27.3a): Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid-1990s. The stock size indicator has been fluctuating and is now around the long-term mean. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

f) Sole (sol.27.7d): This stock was downgraded from Category 1 to Category 3 following the Interbenchmark in 2019 and Benchmark in 2020. The XSA assessment is indicative of trends only. The spawning-stock biomass (SSB) has been fluctuating without trend and has been above MSY Btrigger since 2010. Fishing pressure (F) has shown a decreasing trend since 2009 and has been below $F_{MSY\ proxy}$ since 2016. Recruitment has been fluctuating without trend. In 2019, the recruitment is estimated to be the highest of the time series.

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 sole in 4 and cod 4 7d and 20 showed significant retrospective patterns in SSB (Mohn's rho above 0.2). For cod advice is given as usual since only 2 out of recent 5 peels and only 1 out of recent 3 peels fall outside the confidence bounds. A benchmark is planned in 2021 to address the retrospective pattern for cod further. 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, the target F (F_{MSY}) in the forecast for 2021 is well below the F_{05} estimated using EqSim, and advice is given as usual this year.

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	2020
Reporting year in cycle	1/1
Chair	Raphaël Girardin, France, and Tanja Miethe, UK
Meeting venue and dates	22 April – 1 May 2020, via Webex (35 participants)

1 General

1.1 Terms of Reference

2019/2/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 for the fisheries relevant to the working group on:

i) descriptions of ecosystem impacts of fisheries

ii) descriptions of developments and recent changes to the fisheries

iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarising where the item is relevant:

i) Input data and examination of data quality;

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

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

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

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

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

viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

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

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice.

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

Adaptions to expert groups' generic terms of reference for spring 2020.

In light of the challenges caused by the COVID 19 disruption in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. webex) and subgroups to deliver the high priority terms of reference.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant.

Check the list of the stocks to be done in detail and those to roll over.

i) Input data and examination of data quality;

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

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

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

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

viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

[1] These do not apply to WGNAS.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

Medium Priority for spring 2020 advice season

a) Consider and comment on Ecosystem and Fisheries overviews where available;

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

i) descriptions of ecosystem impacts of fisheries

ii) descriptions of developments and recent changes to the fisheries

iii) mixed fisheries considerations, and

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

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Specific ToRs

2019/2/FRSG18 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 Online (Webex), 22 April – 1 May 2020 and by correspondence in September 2020 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;

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 2020 ICES data call. WGNSSK will report by 15 May 2020, and by 25 September 2020 (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, and métier and catch category.

In 2019, the procedure for data submission was similar to previous years, including a requirement for life-history information and length compositions for historic landings and discards for stocks identified as “DLS” (essentially Category 3 stocks) from at least the three most recent consecutive years (only the most recent year for those stock for which length frequency data were already provided in a previous data call). The data call also required reporting to four catch categories, including BMS landings (landings below minimum size for stocks under the landing obligation).

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.

Table 1.2.1.1. Intercatch missing Swedish landings for subarea 4 as reported o WGNSSK during the 2020 meeting.

FAO code	Species	Missing landings (tons) in InterCatch	Stocks
COD	Cod	346.5578	cod.27.47d20
DAB	Dab	0.5202	dab.27.3a4
GUG	Grey gurnard	51.0285	gug.27.3a47d
HAD	Haddock	112.1597	had.27.46a20
HAL	Halibut	6.0661	hal.27.3a47de
LEM	Lemon sole	3.8206	lem.27.3a47d
NOP	Norway pout	15.185	nop.27.3a4
PLE	Plaice	2.9763	ple.27.420
POK	Saithe	937.4609	pok.27.3a46
POL	Pollock	38.2938	pol.27.3a4
TUR	Turbot	1.0133	tur.27.4
WHG	Whiting	3.965	whg.27.47d
WIT	Witch flounder	2.765	wit.27.3a47d

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, the status of InterCatch use was as follows:

Stock	Data Year	Working Group	Extracted	Exported	Status of Data filled in
bll.27.3a47de	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
caa.27.3a47de	2019	WGNSSK	No	No	Notfilled
cod.27.47d20	2019	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
coe.27.3a47de	2019	WGNSSK	No	No	Notfilled
dab.27.3a4	2019	WGNSSK	Extracted	Exported	Notfilled
fle.27.3a4	2019	WGNSSK	Extracted	Exported	Notfilled
gug.27.3a47d	2019	WGNSSK	Extracted	Exported	Notfilled
had.27.46a20	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
hal.27.3a47de	2019	WGNSSK	No	No	Notfilled
lem.27.3a47d	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
mur.27.3a47d	2019	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
mur.27.3a47d	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.27.4outFU	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.10	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.32	2019	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
nep.fu.33	2019	WGNSSK	Extracted	No	Notfilled
nep.fu.34	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.3-4	2019	WGNSSK	Extracted	No	Notfilled
nep.fu.5	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.6	2019	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
nep.fu.7	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.8	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nep.fu.9	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
nop.27.3a4	2019	WGNSSK	No	No	Notfilled
ple.27.420	2019	WGNSSK	Extracted	Exported	DataNOTusedForAssessment
ple.27.7d	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
pok.27.3a46	2019	WGNSSK	Extracted	Exported	Notfilled
pol.27.3a4	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
sol.27.4	2019	WGNSSK	Extracted	Exported	Notfilled

Stock	Data Year	Working Group	Extracted	Exported	Status of Data filled in
sol.27.7d	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
tur.27.3a	2019	WGNSSK	Extracted	Exported	Notfilled
tur.27.4	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment
whg.27.3a	2019	WGNSSK	Extracted	Exported	Notfilled
whg.27.47d	2019	WGNSSK	Extracted	Exported	Notfilled
wit.27.3a47d	2019	WGNSSK	Extracted	Exported	DataUsedForAssessment

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 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 2019 and 2020

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 a 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).

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 2020 could be covered by the internal audit (Table 1.5.1). The audits are given in Annex 5 of the report.

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

Fish Stock	Internal Audit Spring	Internal Audit Autumn
bll.27.3a47de	X	
cod.27.47d20	X	
dab.27.3a4	*No new advice in 2020*	
fle.27.3a4	*No new advice in 2020*	
gug.27.3a47d	X	
had.27.46a20	X	
lem.27.3a47d	X	
mur.27.3a47d	*No new advice in 2020*	
nep.27.4otFU	No advice in spring	X
nep.fu.10	No advice in spring	X
nep.fu.32	No advice in spring	X
nep.fu.33	No advice in spring	X
nep.fu.34	No advice in spring	X
nep.fu.3-4	No advice in spring	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	*No new advice in 2020*	
sol.27.4	X	
sol.27.7d	X	
tur.27.3a	X	
tur.27.4	X	
whg.27.3a	X	

Fish Stock	Internal Audit Spring	Internal Audit Autumn
whg.27.47d	X	
wit.27.3a47d	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. In 2020, most WGNSSK stocks were implemented 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. A WKMIXFISH scoping meeting took place in March 2020. WGMIXFISH meets directly after WGNSSK in June 2020 (WGMIXFISH-METH), and also in late October 2020 (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 2020 report and Fisheries Overview for any further description of the mixed-fisheries context.

However, the group continues to discuss mixed fisheries issues under the landing obligation. There is a potential problem with choke species in the North Sea, where target as well as bycatch species can become choke species for certain fleet segments. One way to deal with this is to use the recently defined ranges for F_{MSY} instead of point estimates (see e.g. ICES WKMSYREF III 2014 and ICES WKMSYREF IV 2016). Ranges can introduce the flexibility needed to minimize the discrepancies in available quotas for species in a mixed fishery, and have been introduced as part of EU MAPs, which are mixed-fishery multiannual plans for demersal stocks in the North Sea (Regulation (EU) 2018/973) and stocks in Western Waters (Regulation (EU) 2019/472). These plans allow fishing within the F_{MSY} range, but with more stringent conditions (related to the need to meet mixed fisheries objectives) for using the part of the range above F_{MSY}, referred to as the upper range. STECF undertook an evaluation of mixed-fishery multiannual plans for the North Sea (STECF EWG-15-02), following a European Commission proposal for such plans, and concluded in relation to the use of the upper range that (STECF PLEN-15-01):

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

and furthermore that:

→ *The use of the F_{MSY} range approach should only be employed when informed by objective mixed fishery advice which demonstrates that attaining F_{MSY} for the key driver species can not be achieved simultaneously and the 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 2020, as follows:

Annual industry survey targeting turbot and brill

Wouter van Broekhoven presented the new annual industry survey targeting turbot and brill, which took place for the first time in Q4 of 2018 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 show poor internal consistency performance for these species. The aim here is to deliver a long-term annual survey using commercial fishing vessels fishing at 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 in 2019. The aim of the programme partners is to carry the current survey design forward so that 2019 will be the first year in the long-term time series.

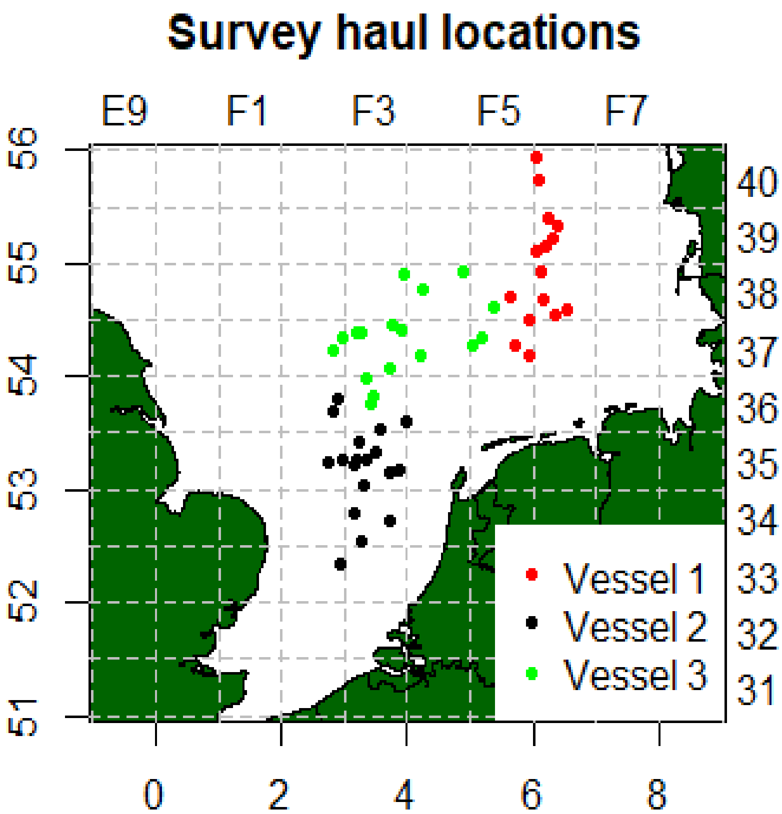
In 2018 one of the three vessels was unable to carry out the survey due to persistent stormy conditions. The issue could have been avoided if the survey would take place earlier in the season than November which due to circumstances was the intended month in 2018. It was decided to plan the survey right at the start of Q4, or depending on circumstances in the later weeks of September to avoid this issue from occurring in future. The main other issues encountered in the 2018 survey which were discussed at WGNSSK and absorbed into the new design based on these discussions were:

- Replacing the pulse trawl vessel with a tickler chain beam trawler in order to avoid a break in the time series when the pulse trawl ban comes fully into force. As of 2019, the survey uses beam trawls only.
- The first survey design made a point of covering ICES rectangles; it was advised that this should not be a focus of the design. As of 2019 this is no longer part of the survey design.
- The first survey design employed a combination of randomly selected predefined haul locations and free-to-choose hauls (by the skipper). This led to concerns around autocorrelation, and the new survey design uses randomly selected predefined haul locations only.
- The Kattegat cod survey was mentioned as an alternative survey design, and the new survey design took significant inspiration from the cod survey.

The new survey design was carried out according to the following main steps. First the survey area was defined based on CPUE data of turbot and brill, with the aim of covering the main catching grounds for these species of the Dutch fleet, covering the main high CPUE areas but also some area 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 5 x 5 km grid was overlayed onto the survey area. A random selection of 60 grid cells was drawn. The cells were divided among the three participating vessels manually to best match their regular fishing grounds, and to reduce distance to be covered by each vessel between survey hauls. 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).

The 2019 survey generally went well, with 50 out of the 60 designated stations achieved. It was felt by the participants that the design is ready to be carried forward into a long-term time series. Smaller modifications currently foreseen for the 2020 survey are to review inaccessible areas within the survey area to make further removals if deemed necessary, and to allow for replacement of designated survey grid cells that are deemed to be unfeasible to fish by the skipper. This is achieved by randomly selecting 75 grid cells rather than 60, then distributing 60 among the participants, and assigning the next – undisclosed – randomly selected grid cell when an unfeasible station is raised. Stations will only be replaced when a convincing case is made for the grounds on which a station is deemed to be unfeasible.

Survey locations visited in 2019:



General statistics for the 2019 survey:

vessel:	1	2	3
# hauls	15	18	17
# brill	324	149	309
# turbot	910	316	515

Over and under the current 27 cm Dutch PO-enforced landing size limit:

vessel:	1	2	3
brill > 27 cm	93.8%	94.0%	98.1%
turbot > 27 cm	74.4%	51.3%	82.3%

CPUE compared to the BTS-ISIS survey:

survey:	Ind.Sur.	BTS-ISIS
# brill h^{-1}	9.3	0.9
# turbot h^{-1}	20.4	2.9

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 dataset. This issue will be investigated further by WMR.

The 2019 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.
- The survey area was discussed in terms of the sufficiency of the total area covered. Ideally a larger area would be covered but budgetary restrictions allow for the current design using a maximum of three vessels, leading to the current survey area which can be covered in practice.
- There was a question from Germany whether a vessel could potentially be added to the survey by Germany, in order to improve coverage in the German Bight. The Dutch delegation welcome this proposal. The programme partners will forward their funding proposal intended to cover the cost of the survey years 2021 – 2023 to the German representative once it is sufficiently ready, so that a discussion can be held to explore options to try and achieve this.
- An issue was raised in relation to the determination of an index intended to identify trends over time, where the question was whether abundance trends can be distinguished from spatial distribution shifts. This issue will be investigated further by WMR.

Development of a Dutch Nephrops catch monitoring programme

Wouter van Broekhoven presented the development of the new 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 these areas are data-poor. Landings are well quantified using standard procedures, but they are not assigned to specific FUs. Discards are estimated from the Dutch discards self-sampling programme, but the coverage and resolution are not sufficient to assign catches of discards to FUs. The aim here is to work towards long-term full catch monitoring on a reference fleet targeting *Nephrops* in order to quantify catches and discards per FU, and allow for the detection of trends over time. The programme is a science-industry collaboration between the Dutch demersal fishing industry and WMR.

Three vessels were recruited to participate in the first stage of the programme which is currently foreseen to run through the summer of 2020. The first stage is a pilot for the monitoring programme in which technological and methodological tests are conducted. The next stage is currently pending a funding decision and is briefly described below. Delays to the start of monitoring activities were incurred in 2019 due to an incident with one of the load cells breaking and falling onto the deck of the vessel in question. Safety modification were made after an extensive review and adapted load cells were fitted to the participating vessels. Subsequently in Q3 of 2019 Brexit-related market conditions resulted in a temporary move away from targeting *Nephrops,* resulting in further delays. Ultimately, 2 of the 3 participating vessels were able to conduct monitoring activities on 6 trips in 2019, with the third vessel to commence monitoring in 2020. Data from 2020 have not yet been reviewed and so were not included in the overview presented at WGNSSK 2020. Out of the 10 planned observer trips intended for validation of the self-sampling monitoring activities, 2 were achieved in 2019. The remaining 8 are due to be planned for 2020, subject to Covid-19 restrictions.

The intended monitoring frequency in the first stage of the programme entails sampling 5 trips per quarter per vessel (20 trips per year per vessel; 60 sampled trips overall). On these trips, 2 hauls will be sampled, measuring carapace length of 50 males and 50 females, and filling 80 kg bags at point of discarding for analysis in the lab. Landings of 9 species will also be recorded per haul. The total discards catch weight of each haul is recorded automatically by a boom-mounted electronic load cell. The total discards weight of a haul is determined by subtracting the landings. The 80 kg sample can be raised to the haul using the resulting total discards weight. Catches can then be raised to the trip using either the proportion of the hauling time of the sampled haul to the total hauling time of all the hauls, or using the proportion of the total discards weight of the sampled haul to the total discards weight of all the hauls.

A power analysis at the start of the programme resulted in the design with three vessels, 5 trips per quarter, and 2 hauls per trip, as the greatest yield in terms of information for the available funding. It was agreed during WGNSSK 2019 that the first data set produced by the programme once data collection commences should be used to refine the analysis in order to determine the required scale of expansion of the programme, noting that the power analysis showed that adding additional vessels was the most potent way of expanding the power of the programme. It was noted that representativeness of the reference fleet's expected catch composition for the entire *Nephrops*-targeting fleet should be given consideration when recruiting additional vessels.

The second stage of the programme is set to take over the monitoring activities around the summer of 2020, while expanding from 3 to 6 participating vessels, and testing alternative ways to raise from the discards sample to the haul and from the haul to the trip. The load cell currently used in the programme works reliably but it cannot be easily transferred to other vessels and thereby hinders the ambitions to scale up the monitoring activities to a broader set of vessels. Alternatives to be explored in the second stage include: 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 sample and 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 second stage is to produce a programme design ready to be implemented and deliver a representative full catch monitoring of the Dutch Nephrops fisheries in FU5, FU33, and out-FU. During WGNSSK 2020 points raised included the following.

- The question of how the data would potentially fit into the assessment in future. In relation to FU33 it was decided to explore options for the collection of additional data during the second stage of the programme, with the aim of raising the assessment category status to a higher level. This could take the form of additional length measurements but is to be investigated in further detail.
- The issue of the reliability of data based on self-sampling was discussed. This is always a concern with any kind of self-sampling, and the programme has the following elements and considerations:
    - The first stage of the programme aims to execute 10 validation trips using observers, in order to validate the samples and measurements taken by the crews. As of the time of the working group only 2 of these trips had been achieved so there are not yet sufficient data to draw conclusions.
    - Regarding the representativeness and reliability of the discards samples to be analysed in the laboratory, the procedure is essentially the same as currently employed by the Dutch DCF discards programme, meaning that the data should at least represent an improvement over the data currently used for the assessment as a result of the increased sampling frequency and coverage.

2 Overview

2.1 Introduction

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

The industrial fisheries which used to dominate the North Sea catch in weight have become much less prominent. Human consumption landings have steadily declined over the last 30 years, with an intermediate high in the early 1980s. The landings of the industrial fisheries show the largest annual variations, resulting from variable recruitment and the short life span of the main target species. The total demersal landings from the Greater North Sea peaked above 1.5 million tonnes in the 1980s, showed a strong decline from the mid to late 1990s, and is now below 500 000 tonnes

(http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/FisheriesOverview_GreaterNorthSea_2019.pdf).

For some stocks, the North Sea assessment area may also cover other regions adjacent to ICES Subarea 4. Thus, combined category 1 assessments are made for cod including Division 7.d and Subdivision 20 (i.e. Skagerrak), haddock including Division 6.a and Subdivision 20, whiting including Division 7.d, saithe including Subarea 6 and Division 3.a, plaice including Subdivision 20, witch including Divisions 3.a and 7.d, and Norway pout including Division 3.a. The state of *Nephrops* stocks are evaluated on the basis of discrete Functional Units (FU) on which estimates of appropriate removals are based. However, quota management for *Nephrops* is still carried out at the Subarea and Division level.

The analysis of biological interactions (predator-prey relationships) among species has been a central theme in ICES over the last 30 years, primarily for the Baltic Sea and the North Sea. The 2011, 2014 and 2017 North Sea key run performed by the multispecies group WGSAM represents the current state of the art in terms of multispecies assessment, with the dynamic estimation of predation mortality. This has led to the publication of the first multispecies advice by ICES in 2013
(http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf).
The single-stock assessments and advice presented in this report are not produced by the multispecies assessment model, but time-varying values of natural mortalities estimated by multispecies assessments for cod, haddock and whiting are incorporated in the assessments of these species. Flatfish are not part of the current multispecies assessment and more work is needed to incorporate information on flatfish in the multispecies advice.

Gear types vary between fisheries. Human consumption fisheries use otter trawls, pair trawls, *Nephrops* trawls, seines, gill nets, or beam trawls, while industrial fisheries use small meshed otter trawls. Trends in reported effort in the major fleets fishing in the North Sea are described annually by the ICES WG on Mixed Fisheries Advice for the North Sea (ICES WGMIXFISH 2019), which meets straight after the WGNSSK. Both WGs share a joint data call issued by ICES for fulfilling the data needs of both groups (Annex 8).

The data distinguish between two basic concepts, the Fleet (or fleet segment), and the Métier. Their definition has evolved with time, but the most recent official definitions are those from the EC's Data Collection Framework (DCF, Reg. (EC) No 949/2008), which we adopt here:

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

Fleets and métiers were defined to match with the available economic data and the former cod long term management plan. In 2013 and 2014, WGMIXFISH included new stocks in its analyses (plaice and sole in the Eastern Channel as full analytical stocks; hake in the North Sea and plaice in Skagerrak as additional "LPUE" stocks as well as turbot, see WGMIXFISH 2013 and 2014 report). Plaice in the Subdivision 20 has been merged with plaice in Subarea 4 in 2015. Mixed-fisheries considerations are based on the single-stock assessments, combined with information on the average catch composition and fishing effort of the demersal fleets and fisheries in the Greater North Sea catching cod (cod.27.47d20), haddock (had.27.46a20), whiting (whg.27.47d), saithe (pok.27.3a46), plaice (ple.27.420 and ple.27.7d), sole (sol.27.4 and sol.27.7d), and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4outFU). In the absence of specific mixed-fisheries management objectives, ICES does not advise on unique mixed-fisheries catch opportunities for the individual stocks but develops scenarios that might show potential discrepancies in the single stock advices in a mixed fisheries context.
In 2017, WGMIXFISH introduced a new scenario, the 'range' scenario taking advantage of the F_{MSY} ranges to reduce the potential inconsistencies in the single species advice. More effort will be put in the future in the inclusion of other stocks without analytical assessment and/or mostly distributed in other areas (i.e. hake) because many of them are important bycatch species and are potential "choke species" once under the landing obligation.

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

Overall nominal effort (kW-days) by EU demersal trawls regulated in the former cod management (TR1, TR2, TR3, GN1, GT1, LL1, BT1, BT2) in the North Sea, Skagerrak, and Eastern Channel has been substantially reduced since the implementation of the two successive effort management plans in 2004 and 2008 (-

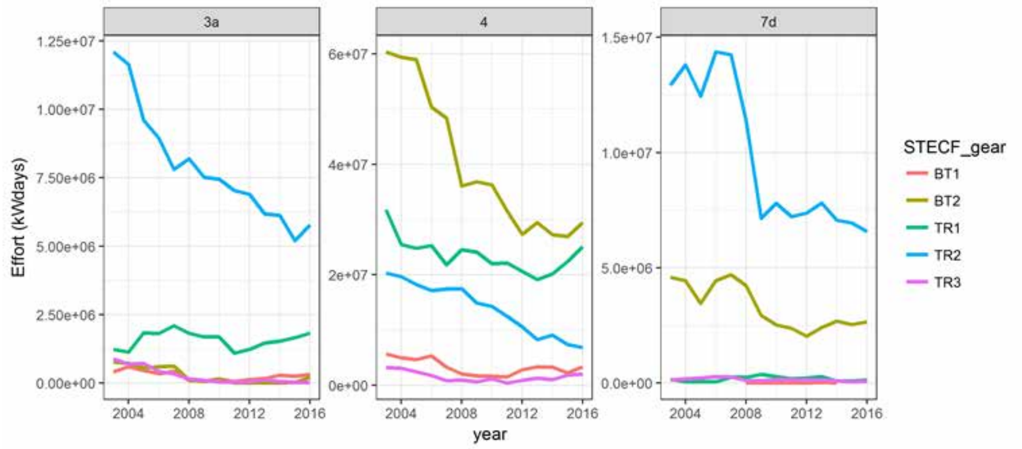


Figure 2.1.1. Trends in fishing effort for different STECF fishing gear groups in ICES Division 3.a, ICES Subarea 4 and ICES Division 7.d for the period 2003– 120 mm. 80 mm and < 120 100 mm. 70 mm and < 100 mm. TR3 are bottom trawl and seines with mesh 16 mm and < 32 mm.

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.

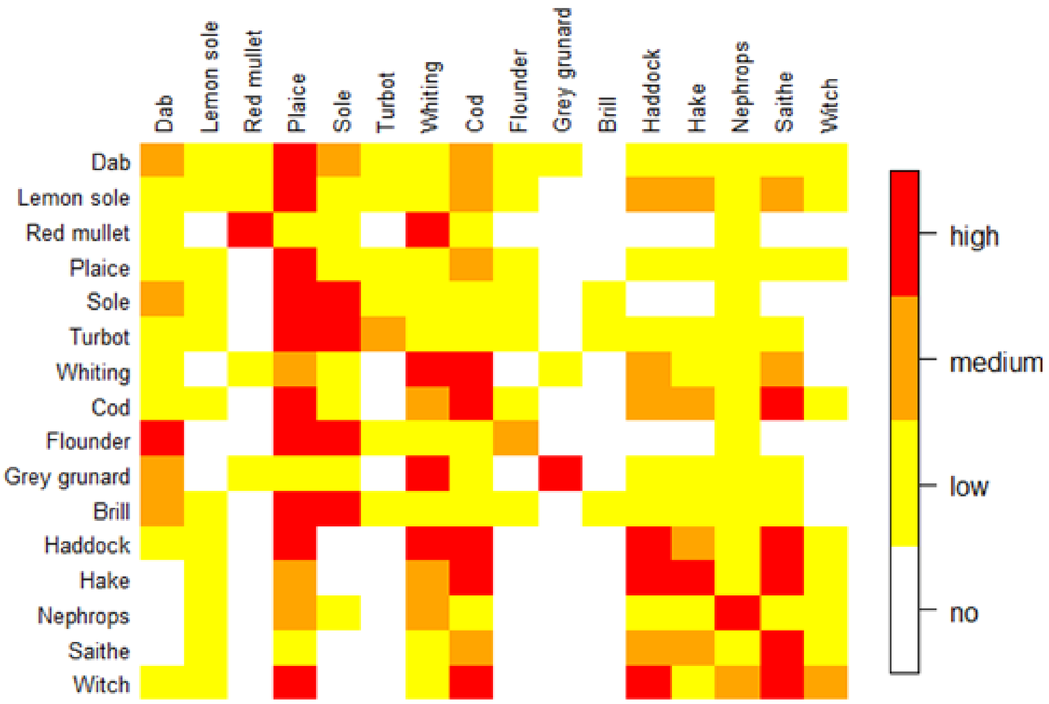


Figure 2.1.2. Technical interactions amongst North Sea demersal stocks (averaged over the years 2014–2015). Horizontal lines of the figure represent the target species of the fishery (species A) for which the interaction with species in each column (species B) was assessed. Red cells indicate that the 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:

2.3 Landing obligation

Fisheries in Norwegian waters have been subject to a landing obligation for cod and haddock from 1987 and for most species since 2009. A landing obligation for EU fisheries on demersal species in the North Sea was implemented from 2016 in a phased approach with all quota stocks subject to the landings obligation from 2019 onwards. Detailed definitions of the landing obligation can be found in Article 15 of regulation 1380/2013. Discard plans have been agreed for 2018 in the North Sea (Subarea 4, Division 3.a and Union waters of Division 2.a; Table 2.2.1.1; Regulation (EU) 2018/45) and in Union and international waters of Subarea 6 and Division 5.b (Table 2.2.1.2; Regulation (EU) 2018/46), and in Division 7.d (Table 2.2.1.3; ; Regulation (EU) 2018/46), defining for which species, gear and mesh size combinations the landing obligation applies. These have been updated for 2019–2021 (Regulation (EU) 2018/2035 and Regulation (EU)

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

2.3.1 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in 2003 and subsequently revised annually. 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, ex- 100 mm), T 70 and < 100 16 and < 32 120 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).

2.3.2 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.

2.3.3 Additional technical measures

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

2.3.3.1 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
	85 mm (25 mm)	105 mm (32 mm)

2.3.4 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:

- **fishing.** It is possible to use a mesh size in range 70–99 mm, provided catches retained on board consist of at least 30% of *Nephrops*. However, the net needs to be equipped with a 80 mm square-mesh panel if a mesh size of 70–99 mm is to be used in the North Sea and if a mesh size of 90 mm is to be used in the Skagerrak and Kattegat the codend has to be square meshed.
- **Saithe fishing.** It is possible to use a mesh size range of 110–119 mm, provided catches consist of at least 70% of saithe and less than 3% of cod. This exception however does not apply to Norwegian waters, where the minimum mesh size for all human consumption fishing is 120 mm. Since January 2002 Norwegian trawlers (human consumption) have had a minimum mesh size of 120 mm in EU-waters. However, since August 2004 they have been allowed to use down to 110 mm mesh size in EU-waters (but minimum mesh size is still 120 mm in Norwegian waters).
- **Fishing for other stocks.** It is possible to use a mesh size range of 100–119 mm, provided the net is equipped with a square-mesh panel of at least 90 mm mesh size and the catch composition retained on board consists of no more than 3% of cod.
- **2002 exemption.** In 2002 only, it was possible to use a mesh size range of 110–119 mm, provided catches retained on board consist of at least 50% of a mixture of haddock, whiting, plaice sole, lemon sole, skates and anglerfish, and no more than 25% of cod.

Beam trawls

- **Northern North Sea.** It is prohibited to use any beam trawl of mesh size range 32 to 119 mm in that part of ICES Subarea 4 to the north of 56° 00' N. However, it is permitted to use any beam trawl of mesh size range 100 to 119 mm within the area enclosed by the east coast of the United Kingdom between 55° 00' N and 56° 00' N and by straight lines sequentially joining the following geographical coordinates: a point on the east coast of the United Kingdom at 55° 00' N, 55° 00' N 05° 00' E, 56° 00' N 05° 00' E, a point on the east coast of the United Kingdom at 56° 00' N, provided that the catches taken within this area with such a fishing gear and retained on board consist of no more than 5% of cod.
- **Southern North Sea.** It is possible to fish for sole south of 56° N with 80–99 mm meshes in the cod end, provided that at least 40% of the catch is sole, and no more than 5% of the catch is composed of cod, haddock and saithe.

Combined nets

It is prohibited to simultaneously carry on board beam trawls of more than two of the mesh size ranges 32 to 99 mm, 100 to 119 mm and equal to or greater than 120 mm.

Fixed gears

The minimum mesh size of fixed gears is of 140 mm when targeting cod, which is when the proportion of cod catches retained exceeds 30% of total catches.

2.3.4.1 Closed areas

Twelve mile zone

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

Plaice box

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

Sandeel box

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, ICES advised in 2000 for a closure of the sandeel fisheries in the Firth of Forth area east of Scotland. All commercial fishing was excluded, except for a maximum of 10 boat days in each of May and June for stock monitoring purposes. The closure was initially designated to last for three years but has been repeatedly extended and remains in force. The level of effort of the monitoring fishery was increased in 2006.

Natura 2000

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

Unilateral management

In addition to the EU-wide statutory regulations, some countries impose additional management schemes on their fleets. One example of this is the Scottish Conservation Credits scheme which encompasses technical regulation and temporary spatial closures in return for derogation from some EU effort controls. This scheme, and others are described in the stock sections to which they pertain.

2.4 Ecosystem Overviews

General observations

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

Discussions revealed that the overview currently does not provide sufficient information on the effects and impacts of observed changes. In general, links are missing between trends in observations and the impact on particular stocks. Such links need to be added either in the ecosystem overviews or as additional information in the single stock advice sheets. An example can be found on page 3: “The seabird population showed an overall increasing trend until 2000, after which it declined. Recent changes in fisheries management policy (e.g. reduction in effort and the landing obligation) will likely affect seabirds as well as other parts of the ecosystem”. The second sentence is very general and does not contain useful information. Indications whether effects of changes are positive or negative or are relevant for certain parts of the ecosystem are missing. Similar examples can be found throughout the document.

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

In the description of the state of the ecosystem, a subsection on crustaceans is missing. Here, the state of stocks of *Nephrops*, the northern shrimp and brown crab should be described. Also European lobster as iconic species could be mentioned. The section on cephalopods could be generalized to molluscs (including scallops and whelks).

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”. Maybe the figure and the text refer to different time scales or focus on different trophic levels. But such an explanation is missing.

Invasive species should be added as a pressure to Figure 3. The overview has a longer section on this topic and the rate of introduction of new species is shown to increase in the area. Also chemical pollution, litter and eutrophication could also be added to Figure 3.

Reports from STECF on the monitoring of the CFP provide useful information on general trends in fishing pressure and biomass of stocks in the greater North Sea. Also, an indicator of developments in recruitment levels is provided. The report provides the full code used for the analyses.

The work is based on ICES assessments and uses the assessment graph database. Therefore, it could be easily used for regular updates of ecosystem overviews.

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

The word “crustaceans” could be replaced with *Nephrops* and *Pandalus borealis* in Figure 5. It is not specified how the ratios in Figure 5 were aggregated across stocks. Particularly for guilds with few stocks, the time series become very wobbly, distracting from the main message (long-term trends for different guilds). This could be resolved with smoothing.

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). If commercial operations are restrained, the stocks are believed to increase. At a constant effort (and limited potential to increase CPUEs) of recreational fishing, this increase in stocks likely leads also to a decrease in mortality rates caused by recreational fishing. Next to this, the sentence on recreational fishing is closely linked to forage and industrial fish. However, recreational fishing is much more problematic for species like seabass and cod.

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

No flatfish are in the figure showing the North Sea food web. This is questionable for a flatfish dominated system. The same holds for crustaceans like *Nephrops* and brown crabs which are found in large areas of the greater North Sea, and northern shrimp which are found in Skagerrak and the Norwegian Deep. Notably shrimp are important food for demersal fish.

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

Figure 12 seems to be from 1989. A similar figure for more recent years should be added.

Ideas for the next version of ecosystem overviews

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

1. Trends in the condition and productivity (e.g., mean weight, recruitment) common for certain stocks (e.g., flatfish, pelagics, gadoids) could add important information for scientists and managers. For example, the current low productivity of many gadoids in the North Sea is not discussed in the document. Overview figures showing trends in condition and productivity (similar to figures for F/FMSY and B/MSY Btrigger) may provide valuable information.

2. So far, no information is available on the distribution of stocks and changes over time. This information could be useful from a scientific but also a management perspective.

3. Density dependent and competition effects may become more important when stocks are recovering. This could have an impact on the appropriateness of current reference points and is therefore relevant for fisheries management.

4. Closed areas, including windfarms, play an increasing role in the greater North Sea. Information on the impact of such closed areas on different species (communities) would be interesting for the assessments (also how much biomass can be expected in areas not covered by surveys?) but also to make conclusions on the effectiveness of spatial management as alternative or addition to TACs.

5. Groups like WGSAM could provide more detailed information on changes in the North Sea food web over time, on descriptions of who eats whom.

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

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

2.5 Fisheries Overviews

ICES has published a Fisheries Overview for the Greater North Sea Ecoregion (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/FisheriesOverview_GreaterNorthSea_2019.pdf). The Executive Summary is as follows:

This fisheries overview contains details of mixed fisheries considerations for North Sea demersal and Nephrops 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 10 *Nephrops* 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) and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4 outFU) taking into account the single-stock advice of those species. For this year the most limiting 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.

2.6 Human consumption fisheries

2.6.1 Data

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

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

For a number of years there had been indications that substantial under-reporting of roundfish and flatfish landings is likely to have occurred. It is suspected to have been particularly strong for cod until 2006, and catches were expected to be larger than the TAC. Since the middle of the 2000s, the WG had used an assessment method for North Sea cod (Section 4) which estimated unallocated removals, potentially due to reporting problems, unrecorded discards, changes in natural mortality, or changes in survey catchability. In 2013, WGNSSK considered that the assumption of unallocated removals after 2006 could not be justified by any known factors (see also ICES WKCOD, 2011), and relaxed that assumption (from 2006 onwards) in the assessment.

Several research vessel survey indices are available for most species, and were used both to calibrate population estimates from catch-at-age analyses, and in exploratory analyses based on survey data only. Commercial CPUE series were available for a number of fleets and stocks, but for various reasons only some of them could be used for assessment purposes (although they are presented and discussed). The use of commercial CPUE indices has been phased out where possible and of the ten category 1 assessments, only saithe and sole in 7.d include a commercial index.

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

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

All *Nephrops* stocks with agreed biomass reference points (Category 1 stocks, excluding nep.fu.3-4) are currently above MSY $B_{trigger}$, and all *Nephrops* stocks with defined F_{MSY} (Category 1 stocks, including) are being fished above F_{MSY} in 2019, apart from *Nephrops* in FU 7 (nep.fu.7) and FU 3-4 (nep.fu.3-4) which are fished sustainably.

WGNSSK is also responsible for the assessment of several data-limited species (Category 3+ stocks) that are mainly by catch in demersal fisheries (brill in 3.a, 4 and 7.d-e, lemon sole in 3.a, 4 and 7.d, dab in 3.a and 4, flounder in 3.a and 4, turbot in 3a, sole in 7.d, whiting in 3a), along with grey gurnard in 3.a, 4 and 7d 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 and 2019; for 2020, biennial advice was either PA, where catch advice was still needed, or simply reporting stock status where no catch advice was needed. Biennial advice is required on a different cycle for pollack in 3.a and 4 and grey gurnard in 3.a, 4 and 7d, and was not provided in 2020; instead, it was only necessary to determine whether the perception of the stocks has changed compared to 2019; because these perceptions have not changed, no reopening was needed for either of these stocks. Triennial advice in now required for dab (provided from 2019 onwards).

Biennial PA advice was provided for data-limited *Nephrops* stocks (Category 4: FU 5, 10, 32, 33, 34) for the first time in 2016, 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).

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

The summary of stock status is as follows:

1) *Nephrops*:

Category 1:

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

b) FU 6 (nep.fu.6): The stock abundance has increased since 2015, and currently it is above MSY $B_{trigger}$. The harvest rate has shown an increase since 2018, and is above F_{MSY} in 2019.

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 in 2019 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, increased in 2019 and is now above F_{MSY}.

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

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.

No new advice was provided in spring 2020 for *Nephrops* stocks but was delayed until autumn 2020.

2) Cod (cod.27.47d20): Fishing pressure has increased since 2016, and is above F_{lim} in 2019. Spawning-stock biomass has decreased since 2015 and is now below B_{lim}. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above F_{MSY}, F_{pa} and F_{lim}; the spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.

3) Haddock (had.27.46a20): Fishing pressure has declined since the beginning of the 2000s, but it has been above F_{MSY} for most of the entire time-series. Only in 2019, fishing pressure is at 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 year-class is estimated to be one of the largest since 2000. Currently, fishing pressure on the stock is at F_{MSY} but below F_{pa} and F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

4) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just above it in 2020. Fishing pressure has been above F_{MSY} throughout the time-series, apart from 2005. Recruitment (R) has been fluctuating without trend, but the 2019 year-classe is estimated to be the largest since 2002. Currently, fishing pressure on the stock is above F_{MSY}, but below 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 $B_{trigger}$ since 1996. Fishing pressure has decreased and stabilized at or above F_{MSY} since 2014. Recruitment has shown an overall decreasing trend over time with lowest levels in the past 10 years. Currently, fishing pressure on the stock is above F_{MSY} and F_{pa}, but below F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

6) Plaice (ple.27.420): The spawning-stock biomass is well above MSY $B_{trigger}$ and has markedly increased since 2008, following a substantial reduction in fishing pressure since 1999. Recruitment in 2019 is estimated to be the second highest in the time-series. Since 2009, fishing pressure has been estimated below F_{MSY}. 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 1999. Fishing pressure has declined since 1999 and is above F_{MSY} in 2019. Recruitment in 2019 is estimated to be the highest since the start of the time series in 1957. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}, and spawning-stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

8) Plaice (ple.27.7d): The spawning-stock biomass has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly above F_{MSY}. Recruitment in 2019 is currently estimated to be 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 above MSY $B_{trigger}$, B_{pa} and B_{lim}.

9) Turbot (tur.27.4): Recruitment is variable without a trend. In 2019 recruitment is estimated to be above average of the time series. Fishing pressure has decreased since the mid-1990s, and has been just below F_{MSY} since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY $B_{trigger}$ since 2013. This stock was upgraded to Category 1 from Category 3 following an inter-benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY}, but below F_{pa} and F_{lim}; spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

10) 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 MSY $B_{trigger}$. Recruitment has declined since 2010 and is currently at a low level. This stock was upgraded to Category 1 from Category 3 following a benchmark during 2018. Currently, fishing pressure on the stock is above F_{MSY} and at F_{pa}, but below F_{lim}, and spawning stock size is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

11) Category 3–6 finfish stocks: In 2020, new advice has been produced for bll.27.3a47de, lem.27.3a47d, tur.27.3a, sol.27.7d (all Category 3 stocks) and whg.27.3a (Category 5). Advice was not provided for gug.27.3a47d, dab.27.3a4, fle.27.3a4, mur.27.3a47d (Category 3) and pol.27.3a4 (Category 5).

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

b) Grey gurnard (gug.27.3a47d): The time-series of mature biomass index of grey gurnard from the International Bottom Trawl Survey quarter 1 (IBTS-Q1) shows a strong increase from the beginning of 1990s and has since fluctuated at a high level. Fishing pressure is estimated to be below the $F_{MSY\ proxy}$. 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 2018. Recruitment has shown a mostly downwards trend since a peak in 2011, but relatively high recruitment is estimated for 2019. Currently, fishing pressure on the stock is below $F_{MSY\ proxy}$. No reference points for stock size have been defined for this stock.

d) 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 without a trend in later 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 above $F_{MSY\ proxy}$ and spawning stock size is above MSY $B_{trigger}$.

e) Whiting (whg.27.3a): Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid-1990s. The stock size indicator has been fluctuating and is now around the long-term mean. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the reference points are undefined.

f) Sole (sol.27.7d): This stock was downgraded from Category 1 to Category 3 following the Interbenchmark in 2019 and Benchmark in 2020. The XSA assessment is indicative of trends only. The spawning-stock biomass (SSB) has been fluctuating without trend and has been above MSY Btrigger since 2010. Fishing pressure (F) has shown a decreasing trend since 2009 and has been below $F_{MSY\ proxy}$ since 2016. Recruitment has been fluctuating without trend. In 2019, the recruitment is estimated to be the highest of the time series.

Industrial fisheries

The Norway Pout (nop.27.3a4) assessment was benchmarked in 2012 through an inter-benchmark protocol (IBPNPOUT), resulting in changes in biological parameters (growth, maturity and natural mortality), and again in 2016 (WKPOUT) during which the assessment model was changed, but the general perception of the stock hasn't changed substantially. Advice for Norway pout was released in the autumn 2019.

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

3 Brill in Subarea 27.4, Divisions 3.a, 27.7.d and 27.7.e (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, 2018a). For this stock, advice is provided based on the LPUE trends of the Dutch beam trawl fleet (vessels > 221 kW). From this year onwards (2020), the European Commission requests annual advice for this stock instead of biennial. Therefore, the new advice replaces the advice given last year.

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 2019 (43%), followed by the UK (16%) and France (13%). Most brill is caught by the TBB fleet (60%), followed by the OTB fleet (28%) and the GTR fleet (8%).

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, 2018b). 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; note here initial quotas are compared regardless of quota exchanges later in the year). In 2016, some of the Member States with a share in the TAC, such as Belgium, Germany and The Netherlands asked for an advance of their quota for 2017, in order to further prevent overshooting (±10%). The TAC in 2017 was 4937 tonnes, but at the end of the year, it was increased to 5924 tonnes (±20%; 10% to compensate for the advance from 2016 and 10% for 2017). There were several reasons to justify this increase: a) after the 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 and 2019, and was undershot by 14%, 39% and 45% respectively (Figure 3.1).

Prior to the landing obligation, no restriction on the minimum length for landing brill was imposed by the EC. Some authorities or producer organizations had however installed Minimum Conservation Reference Sizes (MCRS) for brill. The most frequently applied MCRS was 30 cm (e.g. in Belgium). 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

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

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. Since 1 January 2019, brill is entirely under the landing obligation. Dutch producer organisations still cap weekly landings for turbot and brill (e.g. at 3000 kg), but the MCRS of e.g. 27 cm is no longer valid for brill.

3.1.3.2 ICES advice

3.1.3.2.1 ICES advice for 2019

The ICES advice for 2019 was:

ICES advises that when the precautionary approach is applied, catches should be no more than 3170 tonnes in each of the years 2018 and 2019. If discard rates do not change from the average of the last three years (2014-2016), this implies landings of no more than 2943 tonnes.

The stock status was presented as follows:

	Fishing pressure				Stock size			
		2014	2015	2016		2014	2015	2016
Maximum sustainable yield	F_{MSY} proxy	✔	✔	✔ Below	MSY $B_{trigger}$ proxy	✔	✔	✔ Above
Precautionary approach	F_{pa},F_{lim}	✔	✔	✔ Below possible reference points	B_{pa},B_{lim}	✔	✔	✔ Above possible reference points
Management plan	F_{MGT}	–	–	– Not applicable	B_{MGT}	–	–	– Not applicable
Qualitative evaluation	-	–	–	– -	-	–	–	– -

3.1.3.2.2 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.

3.2 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 call in 2018, 2019 and 2020, 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 can be consulted in Table 3.4 and Figure 3.2. Over the period 1950–1970, total landings stayed quite constant under 1000 tonnes (range from 582 to 947 tonnes), followed by a gradual increase to 2121 tonnes in 1977. From 1978 onwards, total landings remained higher than 1500 tonnes (range: 1517-3141 tonnes). In 1993, a maximum of 3141 tonnes was caught. From 2010-2019, total annual landings fluctuated around an average of 2232 tonnes (range: 1947-2538 tonnes). After a decrease in 2018 (1947 tonnes), 2019 landings are again higher (2172 tonnes).

Subarea 27.4 accounts for the major part of the landings (Figure 3.3), on average generating 68% of the total landings over the time series (range: 50–86%). The English Channel and the Skagerrak-Kattegat area are responsible for average contributions to the international brill landings of 20% and 12% 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 2019, the relative proportion of landings in Subarea 27.4 consisted of 63% of the total landings, for Division 27.3a 6% and for Division 27.7.d, e 30% (Table 3.5).

From 2014 onwards, InterCatch 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 2019. The Netherlands fished the majority of the catches predominantly in Subarea 4, followed by the UK and France. France is responsible for the majority of the landings in Division 27.7e. Belgium and Denmark have the highest landings in Division 27.7d and 27.3a respectively (Table 3.6). The most important gear types are TBB and OTB, followed by GTR and GNS (Table 3.7).

For the WGNSSK data call in 2017, available age and length data were requested through InterCatch for three years back in time (2014–2016). The 2018 and 2019 WGNSSK data call also asked for both age and length. For assessment purposes age/length allocations in InterCatch did not need to be performed. 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 easily 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 2014–2019 are available in InterCatch. The proportion of landings for which discard weights are available in 2019 was 69%. Discards raising was performed on a gear level, regardless of season or country.

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

All discard rates were retained during the raising (none were excluded for example due to being higher than average). Raised discards by country for 2019 are shown in Figure 3.4.

An overview of the overall discards and discard rates from 2014–2019 are shown in Table 3.8 and for 2017-2019 broken down by country and Subarea/Division in Table 3.9 and 3.10 respectively. There is no obvious trend over the period 2014–2019. However, discard rates are overall higher in the most recent years (2018-2019). Discard rates well-above the average are found for e.g. Germany (41% in 2019) and Sweden (40% in 2019). Additionally, higher discard rates seem to be present in the northern part of the stock area (28% 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 41% discard rate 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 and 2036 kg in 2019.

In InterCatch, only 4 kg were reported in 2019 (0 kg prior to 2019). 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 2020.

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) 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.

The numbers at length are shown in Figure 3.7 and the corresponding age–length key is illustrated in Figure 3.8. The main part of the catches in this survey represent brill of ages 1–2 and lengths of 20–30 cm. No obvious shifts in length distributions are apparent over the time series (1987–2019), 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 2020 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 and 2020, 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 < 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. 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. As in Subarea 27.4, no alarming shifts in length distributions (no obvious loss of larger/older individuals from the population) are apparent over the time series (1996–2020). In some years, cohorts are visible, e.g. 2011 and 2019 in Q1 and 2016–2018 in Q4.

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

English Channel (Divisions 27.7.d, e)

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

3.2.5.2 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 2020 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). In 2019, an increase in the LPUE index is observed up to 48 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 and PO Vissersbond, together with Wageningen Marine Research and other partners 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. The haul duration was the same as for commercial hauls, 100-120 minutes.

In every haul, all turbot and brill were counted. Length, weight and sex were registered. Otoliths were collected per 1 cm length class to determine age. Fishing conditions including a description of the gear, a list of all hauls, were recorded.

In 2019, 50 of the 60 hauls could be realised, catching 782 brill (see table below).

vessel:	1 (northern area)	2 (southern area)	3 (central area)
# hauls	15	18	17
# brill	324	149	309
# turbot	910	316	515

The numbers of brill caught during this industry survey were approximately 10 times higher than caught during the BTS-ISI survey (see table below).

survey:	Ind.Sur.	BTS-ISIS
# brill h^{-1}	9.3	0.9
# turbot h^{-1}	20.4	2.9

Length measurements ranged from 17cm to 62cm for turbot and 21cm to 54cm for brill (Figure 3.18). Ageing was done over 1cm-classes for 164 brill and 196 turbot.

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).

3.2.6 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.

3.2.7 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 2019, there was a 19% decrease when applying the 2:3 rule. This year (WGNSSK 2020), this led to a 21% decrease. The index is estimated to have decreased by more than 20% and thus the uncertainty cap was applied.

In order to decide whether the precautionary buffer should be applied, the Surplus Production in Continuous Time (SPiCT) model was run (see §3.3.2).

3.2.8 SPiCT MSY proxy reference points

A Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was applied during the WGNSSK 2020 to estimate the status of the stock against MSY proxy reference points. The procedure and settings of the SPiCT analysis were identical to the agreed method of the WGNSSK 2017 (ICES, 2017).

A fishery independent survey time series (BTS_ISI_Q3 1987-2019; Table 3.11), a standardized LPUE from the Dutch beam-trawl fleet (with vessels > 221 kW; including age 0 and 1; 1995-2019; Table 3.14), and a catch time series (trimmed to 1987-2019; 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, 2017).

The SPiCT run used the settings as defined during WGNSSK 2017 (ICES, 2017) with default priors.

A summary of the SPiCT assessment is given in Figure 3.19 and in Table 3.16. These results suggest that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is well-above the reference B_{MSY}* 0.5 proxy. Therefore, the Precautionary Approach Buffer (PA Buffer) was not applied for the advice for this stock. The retrospective analysis shows a relatively stable pattern (Figure 3.20), from which was concluded that the model performed quite well. The estimated stock status with respect to reference points is consistent.

3.3 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 (2017)
	$F_{MSY_{proxy}}$	$\frac{F}{F_{MSY}} = 1$	Relative value from SPiCT model. F_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2017)
Precautionary approach	B_{lim}	Not defined		
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

3.4 Quality of the assessment

- The advice is based on a commercial biomass index (Dutch beam-trawl fleet, vessels > 221 kW) used as an indicator of stock size. Between 2014 and 2018 the use of pulse trawls in the Dutch fishery operating in the North Sea has increased to 76 vessels (65 of which are > 221 kW) and a handful of vessels operating with traditional beam trawls are now left. The increased use of pulse trawls and other adaptations, like fuel-saving wings, may affect catchability and selectivity of North Sea brill. The effect of these changes on the LPUE as an index has not yet been quantified. As a result of the ban on the use of pulse gear from 2019 onwards, the composition of the Dutch fleet is gradually changing 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. The combined TAC for brill and turbot was no longer restrictive in 2017 and 2018, and was undershot by 23% and 39% respectively.
- The current surveys in this area are not designed for catching brill, especially large brill. A fisheries-independent survey, both with adequate catchability of large flatfish and covering the entire distribution area of the stock, would improve the assessment.

3.5 Management considerations

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

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

3.6 Benchmark issue list

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
New data	Currently a limited amount of brill data is available in InterCatch. Ask all countries involved in the fisheries to provide all available brill data on landings, discards, @age, @length including historical data.	Process data in Inter Catch, use model to bridge gaps in time series (cfr. Turbot assessment)	Data from all countries involved in brill fisheries.	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
	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

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Discards	Discards are not included in the 'assessment' (LPUE biomass index)	Considering that discarding of larger length classes occurs when the TAC is restrictive, it should be verified whether the NL LPUE could be revised to a CPUE index.	Discard data from 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 (2013) 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 Explore whether other assessment methods can be used (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

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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 1950–2019 (Source: ICES Fishstat); *including BMS landings.

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
1950	0	0	234	0	0	85	319
1951	0	0	260	0	4	73	337
1952	0	0	170	0	1	65	236
1953	0	0	175	0	0	71	246
1954	0	0	155	0	1	78	234
1955	0	0	150	0	0	62	212
1956	0	0	163	0	0	50	213
1957	0	0	110	0	0	38	148
1958	0	0	166	0	0	37	203
1959	0	0	175	0	0	58	233
1960	0	0	272	0	0	46	318
1961	0	0	255	0	0	50	305
1962	0	0	207	0	0	0	207
1963	0	0	120	0	0	0	120
1964	0	0	106	0	0	0	106
1965	0	0	155	0	0	0	155
1966	0	0	187	0	0	0	187
1967	0	0	106	0	0	0	106
1968	0	0	100	0	0	0	100
1969	0	0	99	0	0	0	99
1970	0	0	97	0	0	0	97
1971	0	0	104	0	0	0	104
1972	0	0	120	0	0	0	120
1973	0	0	131	0	0	0	131
1974	0	0	200	0	0	0	200
1975	0	0	167	1	0	19	187
1976	1	0	185	26	0	12	224
1977	1	0	276	99	0	12	388
1978	0	0	178	27	0	11	216
1979	0	0	156	17	0	11	184
1980	2	0	69	1	0	10	82
1981	0	0	54	0	0	5	59
1982	1	0	64	1	0	8	74
1983	0	0	73	3	0	7	83
1984	0	0	89	0	0	8	97
1985	0	0	100	0	0	10	110
1986	0	0	94	0	0	13	107
1987	0	0	93	0	0	12	105
1988	0	0	91	0	0	10	101

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
1989	0	0	88	0	0	9	97
1990	1	0	116	0	0	11	128
1991	1	0	81	0	7	10	99
1992	1	0	123	0	7	15	146
1993	2	0	184	0	10	16	212
1994	0	0	191	0	12	19	222
1995	0	0	124	0	13	14	151
1996	0	0	94	0	12	6	112
1997	0	0	83	0	11	12	106
1998	0	0	108	0	10	14	132
1999	0	0	126	0	13	18	157
2000	0	0	112	0	12	17	142
2001	0	0	73	0	13	12	98
2002	0	0	66	0	12	12	89
2003	0	0	99	1	12	16	129
2004	0	0	119	4	15	18	156
2005	0	0	101	3	16	13	133
2006	0	1	105	3	16	14	139
2007	0	1	119	3	15	22	160
2008	0	2	138	1	13	28	182
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	78
2015	0	0	104	11	8	21	145
2016	0	0	125	7	8	28	168
2017	0	0	131	4	8	27*	170
2018	0	0	90	8	9	17*	125
2019	0	2	93*	26*	3	15*	139

Table 3.2: BLL 27.3a47de – Official landings (tonnes) of brill in Subarea 27.4 by country, over the period 1950–2019 (Source: ICES Fishstat); * including BMS landings.

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1950	34	0	39	0	183	108	1	19	384
1951	23	0	53	0	322	93	1	19	511
1952	21	0	65	0	350	117	3	9	565
1953	23	0	49	0	376	130	0	11	589
1954	19	0	53	0	330	106	14	7	529
1955	23	0	51	0	357	137	3	0	571
1956	28	0	47	0	276	156	0	9	516
1957	32	0	27	0	247	154	0	8	468
1958	43	0	42	0	223	162	0	10	480
1959	41	0	30	0	219	125	0	9	424
1960	55	0	37	0	235	150	1	8	486
1961	102	0	40	0	264	166	0	9	581
1962	97	0	42	0	238	214	0	0	591
1963	79	0	59	0	307	175	0	0	620
1964	79	0	46	0	161	279	0	0	565
1965	71	0	56	0	127	281	0	0	535
1966	100	0	63	0	119	264	0	0	546
1967	138	0	29	0	105	137	0	0	409
1968	152	0	43	0	110	274	0	0	579
1969	145	0	47	0	102	364	0	0	658
1970	114	0	42	0	76	386	0	0	618
1971	187	0	72	0	94	720	0	0	1073
1972	213	0	65	0	51	665	0	0	994
1973	185	0	55	0	39	710	0	0	989
1974	135	0	68	0	44	905	0	0	1152
1975	164	0	76	13	44	925	0	0	1222
1976	148	0	65	10	45	940	0	0	1208
1977	166	0	88	17	60	1079	0	0	1410
1978	175	0	123	26	84	967	0	0	1375
1979	188	0	154	10	103	908	0	0	1363
1980	129	0	104	8	45	747	0	0	1033
1981	148	0	66	5	42	957	0	0	1218
1982	182	0	53	11	41	1007	0	0	1294
1983	182	0	62	23	28	1153	0	0	1448
1984	190	0	73	30	29	1200	0	0	1522
1985	187	0	71	35	46	1370	0	0	1709
1986	131	0	76	4	46	950	0	0	1207
1987	140	0	50	17	48	715	0	0	970
1988	102	0	33	18	52	880	0	0	1085

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1989	112	0	43	9	58	1080	0	0	1302
1990	168	0	139	24	82	480	0	0	893
1991	205	38	145	28	147	1111	8	0	1682
1992	203	59	77	34	218	1196	22	1	1810
1993	291	63	118	38	268	1647	14	0	2439
1994	208	90	109	28	235	1235	11	0	1916
1995	194	67	55	24	145	943	6	0	1434
1996	206	47	64	15	175	732	8	0	1247
1997	129	48	38	1	135	590	16	0	957
1998	160	58	58	11	172	808	16	0	1283
1999	161	51	91	0	156	805	16	0	1280
2000	167	77	93	16	141	998	16	0	1508
2001	182	66	67	12	158	1075	13	0	1573
2002	145	58	52	10	120	907	10	0	1302
2003	145	70	57	9	119	934	12	0	1346
2004	140	66	77	7	168	772	19	0	1249
2005	120	62	89	7	138	716	28	0	1160
2006	105	55	75	9	154	765	12	0	1175
2007	110	47	52	12	156	854	9	0	1240
2008	117	42	86	5	93	650	11	0	1004
2009	109	54	96	8	105	786	4	0	1162
2010	104	75	97	12	136	1072	4	0	1500
2011	101	57	122	13	137	1061	6	0	1497
2012	110	71	126	12	122	1084	7	0	1532
2013	101	63	123	10	118	972	4	0	1390
2014	99	69	96	9	117	857	9	0	1256
2015	154	115	122	7	136	1159	1	0	1695
2016	175	90	131	8	156	965	1	0	1526
2017	138	76	121	7	116	1000*	2	0	1460*
2018	99	79	96	6	99	782*	2	0	1163*
2019	116*	132*	90	5	110*	923*	1	0	1378*

Table 3.3: BLL 27.3a47de – Official landings (tonnes) of brill in Subdivisions 27.7.d, e (English Channel) by country, over the period 1950–2019 (Source: ICES Fishstat); * including BMS landings

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

Year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
1989	89	0	213	121	0	0	2	425
1990	99	0	249	187	0	0	8	543
1991	81	0	249	140	0	0	0	470
1992	82	0	223	151	0	0	7	463
1993	78	0	256	152	0	0	4	490
1994	88	0	227	170	0	0	5	490
1995	91	0	248	200	1	0	18	558
1996	105	0	240	253	0	0	10	608
1997	107	0	185	198	1	0	10	501
1998	70	0	196	173	0	2	10	451
1999	97	0	0	127	0	3	13	240
2000	164	0	260	232	1	4	17	678
2001	212	0	256	251	0	2	17	738
2002	204	0	268	227	0	1	16	716
2003	217	0	287	238	1	1	15	759
2004	165	0	259	223	1	3	15	666
2005	138	0	267	183	0	2	21	611
2006	180	0	281	170	0	3	14	647
2007	205	0	325	199	0	1	13	743
2008	155	0	224	199	0	2	13	593
2009	131	0	278	171	0	1	10	591
2010	145	0	340	198	0	1	15	699
2011	141	0	304	202	0	0	18	666
2012	120	0	263	228	0	1	12	625
2013	142	0	238	213	0	1	11	605
2014	166	0	245	219	0	1	13	644
2015	162	0	278	248	0	2	9	698
2016	143	0	286	284	0	1	6	721
2017	135	0	276	246	0	2	3	663
2018	128	0	280	247	1	2	1	659
2019	103	0	284	262*	0	3	2	655

Table 3.4: BLL 27.3a47de – Total official landings (tonnes) of brill in the 27.3a47de (Greater North Sea) over the period 1950–2019, subdivided into Subarea 27.4 and Divisions 27.3.a and 27.7.d, e (Source: ICES Fishstat).

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

Year	3.a	4	7.de	TOTAL
1989	97	1302	425	1824
1990	128	893	543	1564
1991	99	1682	470	2251
1992	146	1810	463	2419
1993	212	2439	490	3141
1994	222	1916	490	2628
1995	151	1434	558	2143
1996	112	1247	608	1967
1997	106	957	501	1564
1998	132	1283	451	1866
1999	157	1280	240	1677
2000	142	1508	678	2328
2001	98	1573	738	2409
2002	89	1302	716	2107
2003	129	1346	759	2234
2004	156	1249	666	2071
2005	133	1160	611	1904
2006	139	1175	647	1961
2007	160	1240	743	2143
2008	182	1004	593	1779
2009	146	1162	591	1899
2010	122	1500	699	2321
2011	131	1497	666	2294
2012	120	1532	625	2277
2013	92	1390	605	2087
2014	78	1256	644	1978
2015	145	1695	698	2538
2016	168	1526	721	2415
2017	170	1460	663	2292
2018	125	1163	659	1947
2019	139	1378	655	2172

Table 3.5: BLL 27.3a47de – Overview of absolute landings per area over the last 10 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	1500	699	**2321**	0.05	0.65	0.30
2011	131	1497	666	**2294**	0.06	0.65	0.29
2012	120	1532	625	**2277**	0.05	0.67	0.27
2013	92	1390	605	**2087**	0.04	0.67	0.29
2014	78	1256	644	**1978**	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	**2292**	0.07	0.64	0.29
2018	125	1163	659	**1947**	0.06	0.60	0.34
2019	139	1378	655	**2172**	0.06	0.63	0.30

Table 3.6: BLL 27.3a47de – Overview of 2019 catches reported to InterCatch (ICES) by country and area.

Country	3a		4		7d		7e		Total		
	Dis	Lan	Dis	Lan	Dis	Lan	Dis	Lan	Dis	Lan	All
Belgium	0	0	14	86	0	133	0	0	15	219	234
Denmark	37	93	8	90	0	0	0	0	45	183	228
France	0	0	1	5	12	44	40	243	53	291	345
Germany	0	1	91	132	0	0	0	0	91	133	224
Ireland	0	0	0	0	0	0	0	0	0	0	0
Netherlands	5	28	171	897	0	2	0	1	177	928	1105
Norway	1	3	0	1	0	0	0	0	1	4	5
Sweden	10	15	0	0	0	0	0	0	10	15	24
UK (England)	0	0	15	80	3	18	6	243	24	342	366
UK(Northern Ireland)	0	0	0	0	0	0	0	0	0	0	0
UK(Scotland)	0	0	2	31	0	0	0	0	2	32	34
Total	53	139	302	1323	16	198	46	487	417	2147	**2564**

Table 3.7: BLL 27.3a47de – Overview of 2019 landings for the most important gear types per area (Source: InterCatch).

Gear type	3a	4	7d	7e	Total
DRB	0	0	6	2	**8**
FPO	0	0	0	0	**0**
GNS	7	35	5	9	**56**
GTR	1	4	9	147	**162**
LLS	0	0	0	0	**0**
MIS	1	3	9	21	**34**
OTB	99	361	21	114	**595**
SDN	2	1	0	0	**4**
SSC	0	3	3	1	**7**
TBB	28	915	145	193	**1281**
Total	**139**	**1323**	**198**	**487**	**2147**

Table 3.8: BLL 27.3a47de – Overall discards and discard rates (all countries and métiers) for brill over the period 2014–2019 (Source: InterCatch).

Year	Discards	Discard rate
2014	231	0.11
2015	230	0.09
2016	267	0.10
2017	208	0.09
2018	349	0.15
2019	417	0.16

Table 3.9: BLL 27.3a47de – Discard rates for brill by country for 2017-2019 (source: InterCatch).

Country	Discard rate 2017	Discard rate 2018	Discard rate 2019
Belgium	0.04	0.09	0.06
Denmark	0.15	0.30	0.20
France	0.09	0.18	0.15
Germany	0.13	0.17	0.41
Ireland			
Netherlands	0.09	0.11	0.16
Norway	0.10	0.19	0.17
Sweden	0.17	0.30	0.40
UK (England)	0.05	0.13	0.06
UK (Northern Ireland)	0.14	0.34	
UK(Scotland)	0.03	0.28	0.07
Overall	**0.09**	**0.15**	**0.16**

Table 3.10: BLL 27.3a47de – Discard rates for brill by area for 2017-2019 (Source: InterCatch).

Subarea/ Division	Discard rate 2017	Discard rate 2018	Discard rate 2019
27.3.a	0.22	0.41	0.28
27.4	0.08	0.12	0.19
27.7.d	0.09	0.19	0.07
27.7.e	0.02	0.09	0.09
Overall	**0.09**	**0.15**	**0.16**

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

Year	N/hr	Year	N/hr
1987	2.104167	2004	0.938272
1988	0.685714	2005	0.695652
1989	1.036585	2006	0.962963
1990	2.361702	2007	1.243902
1991	1.730612	2008	0.588235
1992	2.818557	2009	1.555556
1993	2.325769	2010	2.434842
1994	1.719281	2011	2.676993
1995	1.294353	2012	1.177282
1996	0.585366	2013	0.833333
1997	1.421687	2014	2.949902
1998	1.665552	2015	1.929677
1999	0.893617	2016	1.069767
2000	2.554228	2017	0.870027
2001	0.885714	2018	1.448486
2002	0.881016	2019	2.000000
2003	1.084337		

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

Year	N/hr
1996	1.777778
1997	0.272727
1998	0.500000
1999	0.714286
2000	1.071429
2001	0.642857
2002	1.928571
2003	1.379310
2004	2.000000
2005	1.714286
2006	3.866667
2007	3.214286
2008	2.733333
2009	2.038462
2010	2.896552
2011	3.285714
2012	2.533333
2013	1.571429
2014	2.857143
2015	3.555556
2016	4.857143
2017	7.923077
2018	1.076923
2019	4.272727
2020	3.619048

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

Year	N/hr
1999	2.857143
2000	0.315789
2001	1.800000
2002	2.071429
2003	1.928571
2004	3.310345
2005	2.896552
2006	4.758621
2007	5.117241
2008	4.400000
2009	3.750000
2010	4.838710
2011	5.034483
2012	3.000000
2013	3.830889
2014	6.090370
2015	6.636364
2016	4.666667
2017	3.636364
2018	10.869565
2019	7.093894

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	47.727

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

Year	Landings (tonnes)
1997	1564
1998	1866
1999	1677
2000	2328
2001	2409
2002	2107
2003	2234
2004	2071
2005	1904
2006	1961
2007	2143
2008	1779
2009	1899
2010	2321
2011	2294
2012	2277
2013	2087
2014	1920
2015	2470
2016	2444
2017	2207
2018	1956
2019	2147

Table 3.16: BLL 27.3a47de – SPiCT summary output from the analyses performed during the WGNSSK 2020.

```
> summary(res)
Convergence: 0  MSG: both X-convergence and relative convergence (5)
Objective function at optimum: 6.3713464
Euler time step (years):  1/16 or 0.0625
Nobs C: 33,  Nobs I1: 33,  Nobs I2: 25

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    4.4515734    1.2733417 1.556260e+01  1.4932576
 alpha2    0.7540693    0.0870476 6.532294e+00 -0.2822711
 beta      0.1510594    0.0286956 7.952070e-01 -1.8900821
 r         0.7977419    0.2218522 2.868541e+00 -0.2259702
 rc        2.1049811    1.3303088 3.330764e+00  0.7443065
 rold      3.2958595    0.0385977 2.814339e+02  1.1926670
 m      2249.0754958 2115.3797410 2.391221e+03  7.7182745
 K      6714.8170307 2956.9758296 1.524827e+04  8.8120719
 q1        0.0007191    0.0004622 1.118800e-03 -7.2374937
 q2        0.0184252    0.0120285 2.822350e-02 -3.9940367
 n         0.7579563    0.2711545 2.118710e+00 -0.2771295
 sdb       0.1050662    0.0308465 3.578659e-01 -2.2531646
 sdf       0.2161705    0.1503210 3.108658e-01 -1.5316880
 sdi1      0.4677099    0.3614165 6.052645e-01 -0.7599070
 sdi2      0.0792272    0.0283400 2.214874e-01 -2.5354357
 sdc       0.0326546    0.0066658 1.599681e-01 -3.4217700

Deterministic reference points (Drp)
         estimate        cilow       ciupp   log.est
 Bmsyd 2136.90806 1359.2407712 3359.504912 7.6671152
 Fmsyd    1.05249    0.6651544    1.665382 0.0511593
 MSYd  2249.07550 2115.3797410 2391.221060 7.7182745
Stochastic reference points (Srp)
          estimate        cilow       ciupp   log.est  rel.diff.Drp
 Bmsys 2128.260769 1347.5682725 3361.23519 7.6630604 -0.0040630774
 Fmsys    1.052334    0.6659977    1.66278 0.0510109 -0.0001484611
 MSYs  2239.640481 2111.5680235 2375.48089 7.7140706 -0.0042127362

States w 95% CI (inp$msytype: s)
                   estimate        cilow       ciupp    log.est
 B_2019.50      2623.8390668 1666.4699271 4131.206532  7.8723938
 F_2019.50         0.8233090    0.5147452    1.316841 -0.1944237
 B_2019.50/Bmsy    1.2328560    0.9282254    1.637462  0.2093334
 F_2019.50/Fmsy    0.7823645    0.5641093    1.085063 -0.2454346

Predictions w 95% CI (inp$msytype: s)
                 prediction        cilow       ciupp    log.est
 B_2020.00      2636.1110455 1651.6908406 4207.253121  7.8770600
 F_2020.00         0.8318097    0.5007110    1.381850 -0.1841516
 B_2020.00/Bmsy    1.2386222    0.9210458    1.665699  0.2139996
 F_2020.00/Fmsy    0.7904424    0.5383047    1.160680 -0.2351624
 Catch_2020.00  2192.5218162 1683.5451147 2855.374574  7.6928077
 E(B_inf)       2638.5305159           NA          NA  7.8779774
```

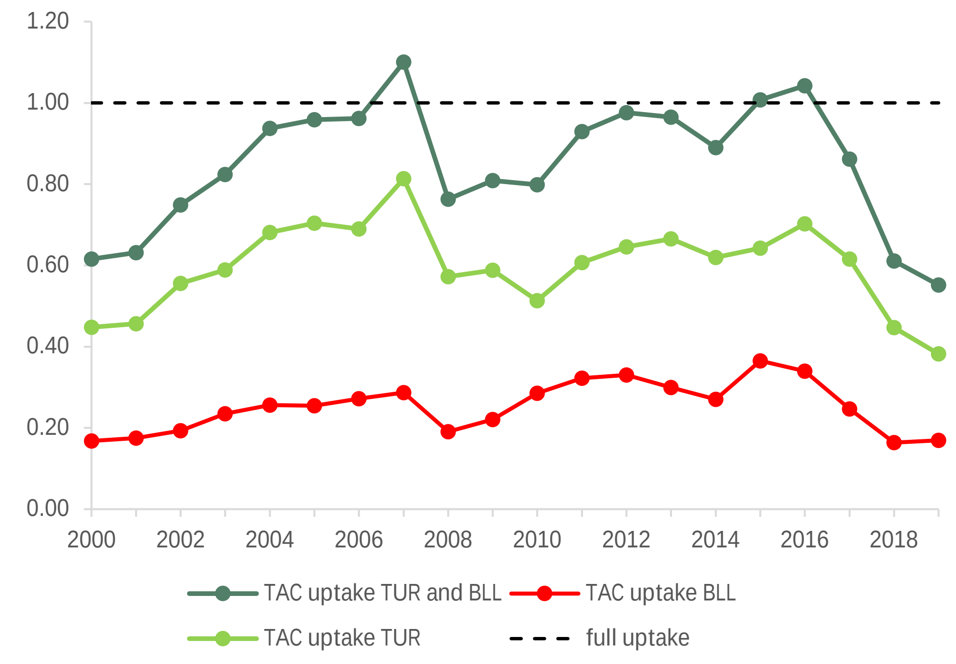

Figure 3.1: BLL 27.3a47de – TAC uptake for both brill and turbot in area 2.a and 4.

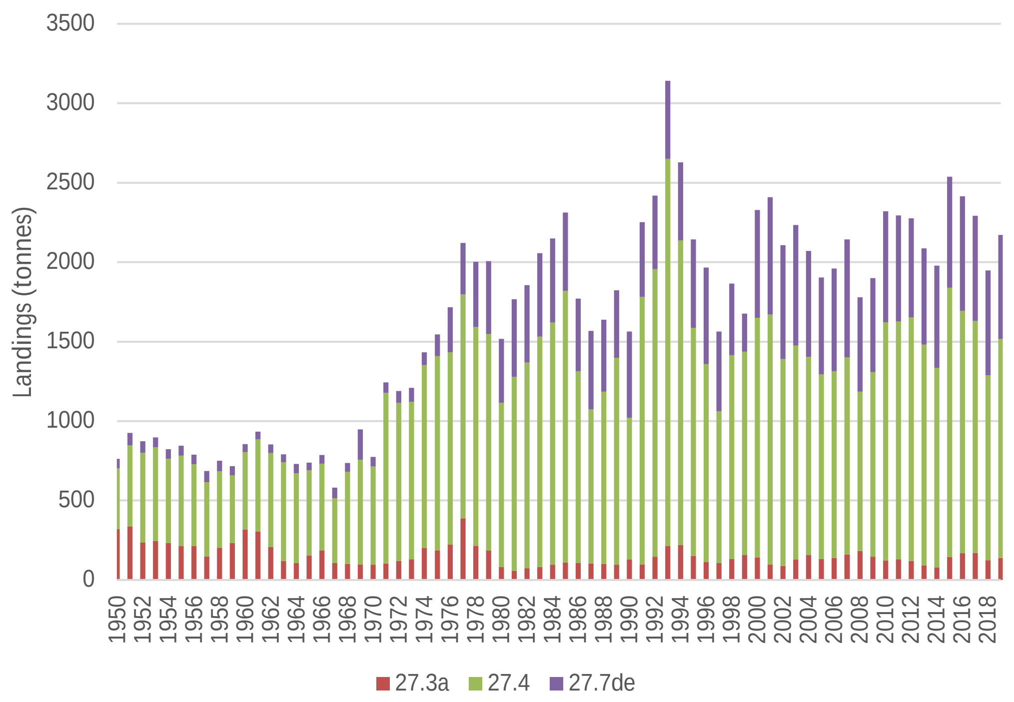

Figure 3.2: BLL 27.3a47de – Official landings (tonnes) over the period 1950–2019, as officially reported (Rec 12; ICES Fishstat).

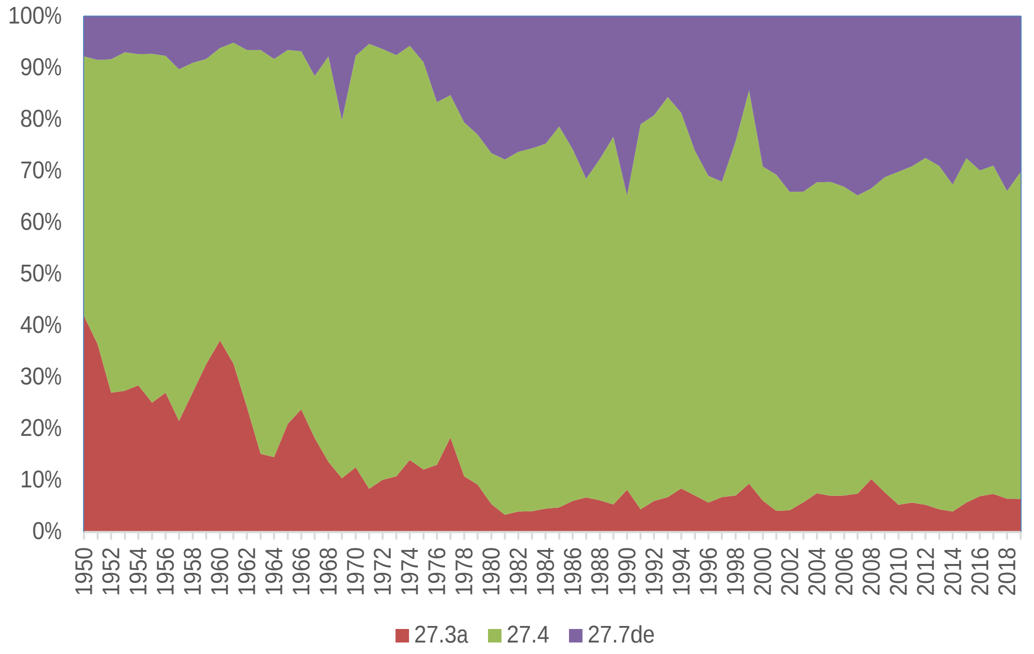

Figure 3.3: BLL 27.3a47de – Relative contribution of the official landings for brill from Subarea 27.4, Division 27.3.a and 27.7.d,e to the total international landings (tonnes) in the Greater North Sea over the period 1950–2019 (Source: ICES Fishstat).

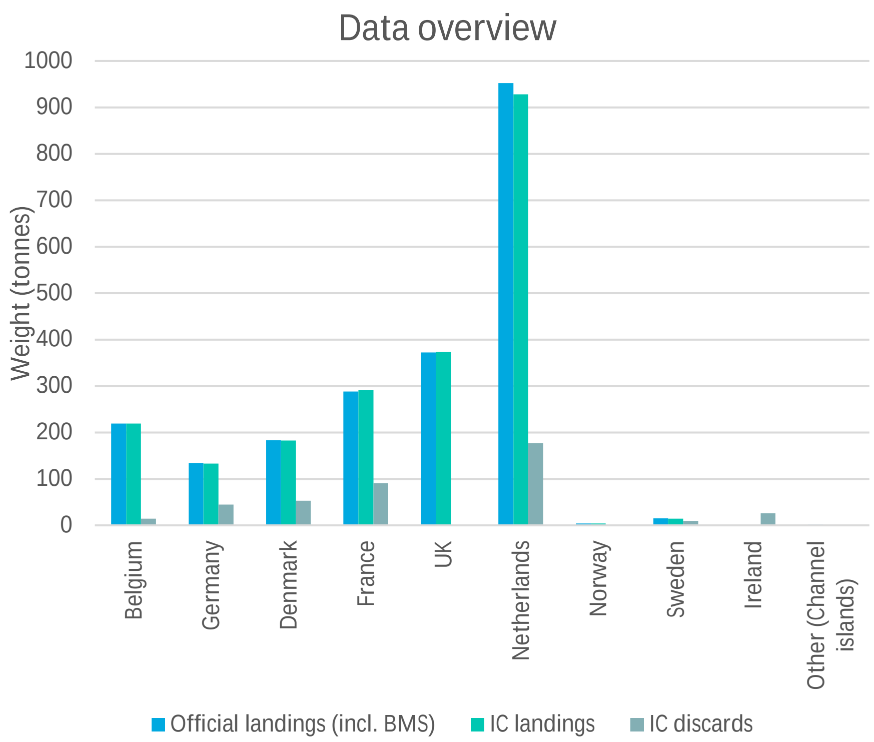

Figure 3.4: BLL 27.3a47de – Comparing ICES catch estimates (InterCatch, IC) to the official catch statistics by country for 2019.

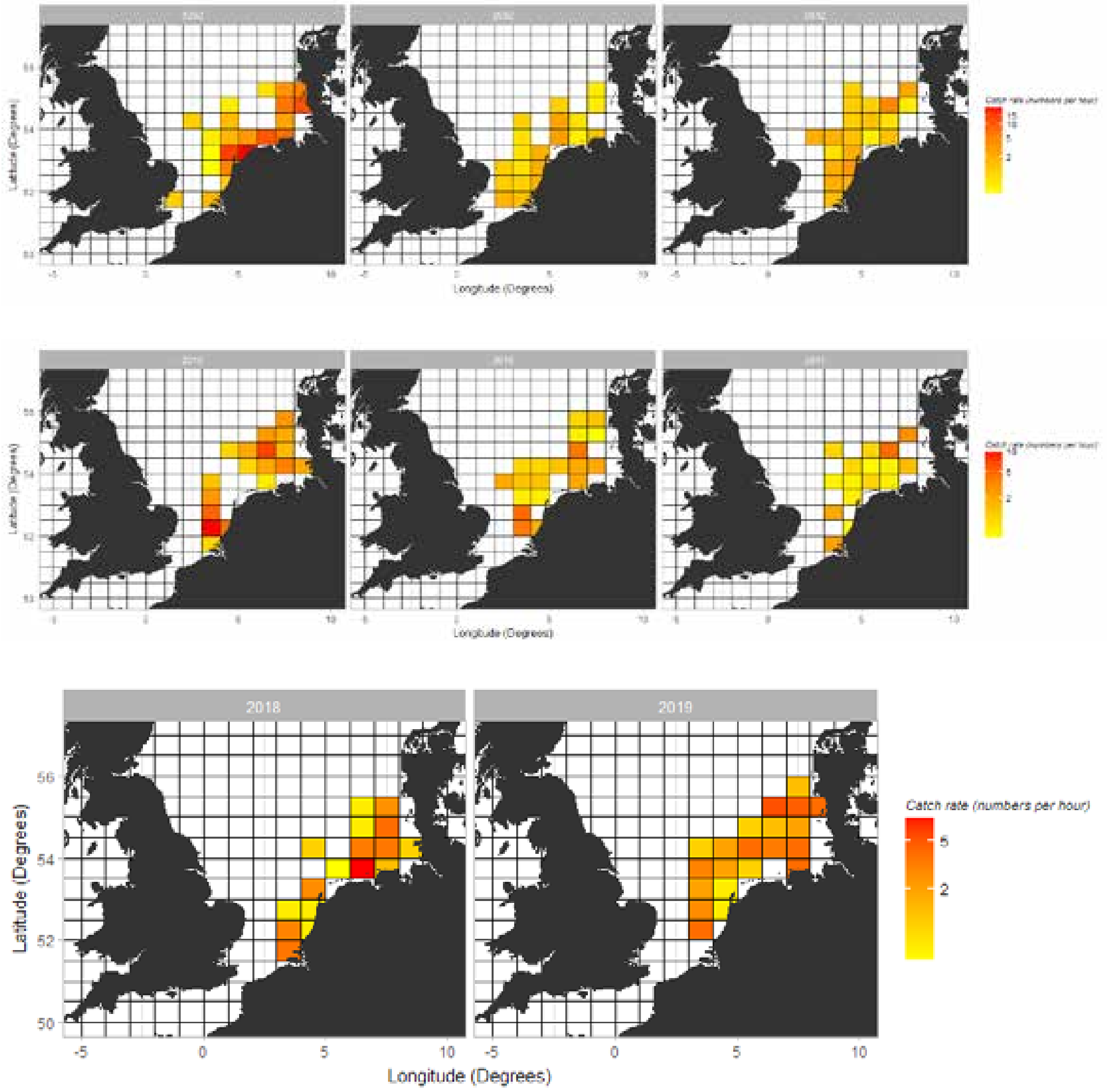

Figure 3.5: BLL 27.3a47de – Average numbers of brill caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (27.4) for 1992, 2002, 2012, 2015, 2016, 2017, 2018 and 2019; note the slightly different scales for the different graphs.

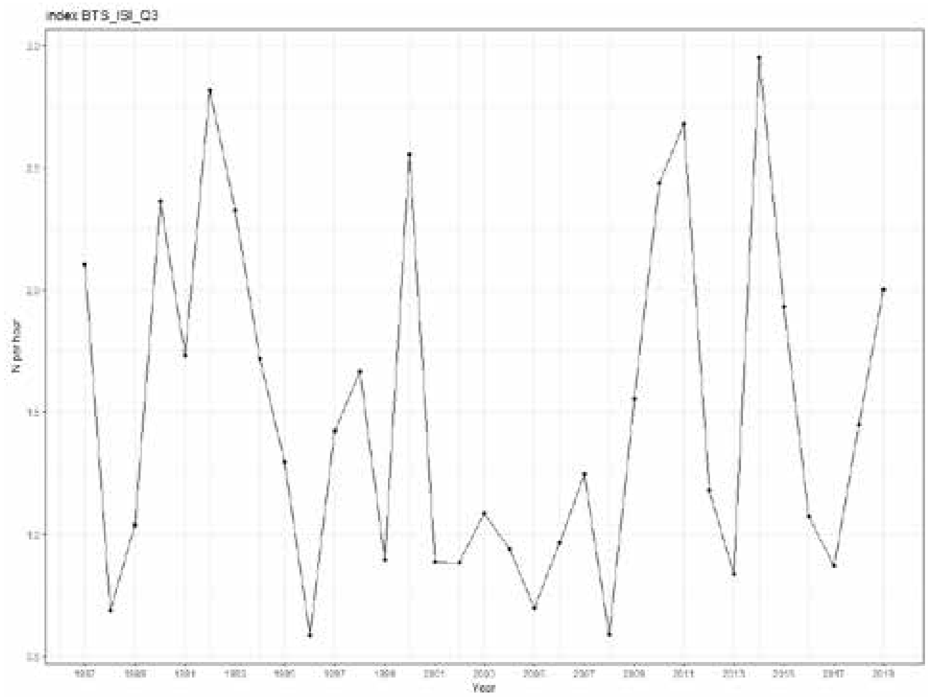

Figure 3.6: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2019.

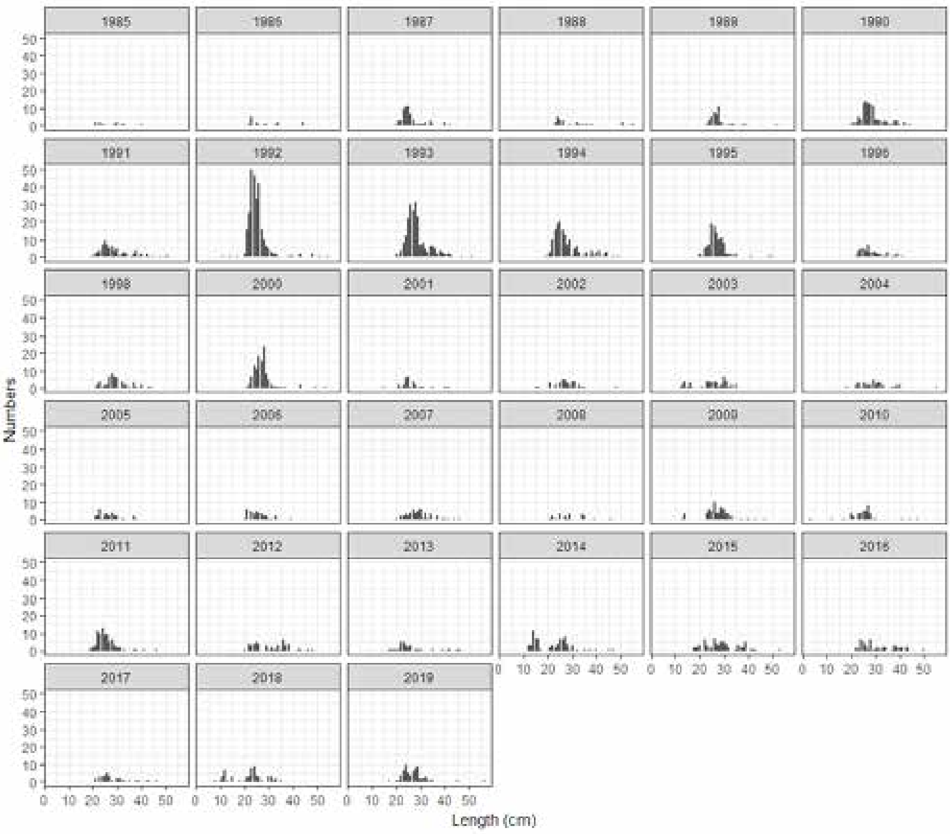

Figure 3.7: BLL 27.3a47de – Length distributions of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1987–2019) (note 1997 and 1999 are missing from this plot).

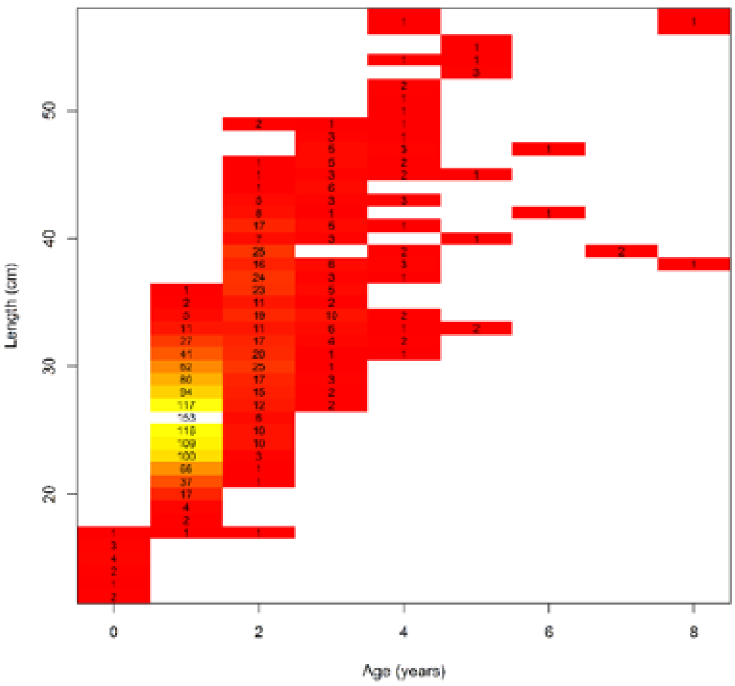

Figure 3.8: BLL 27.3a47de – Age-length key of brill in the North Sea (27.4) as documented by the BTS_ISI_Q3 (1992–2019).

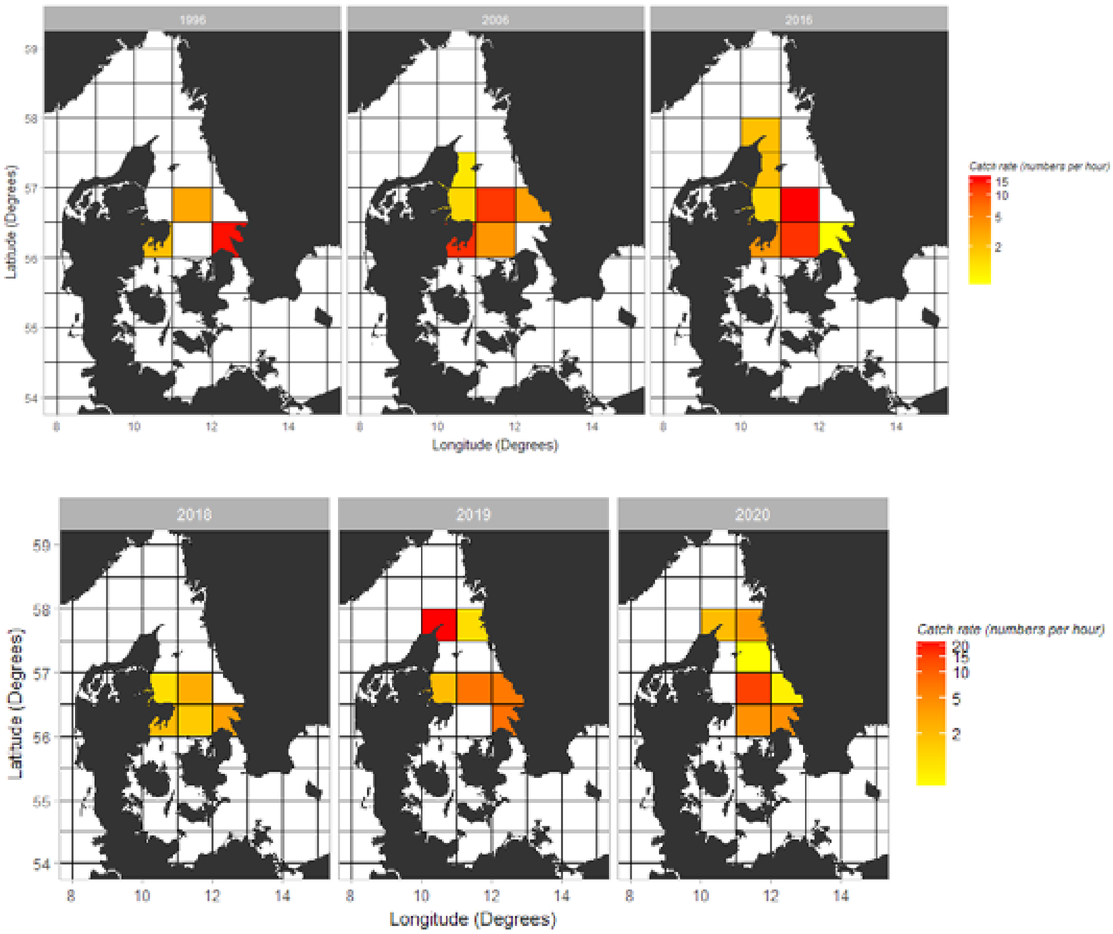

Figure 3.9: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q1 in the Kattegat (27.3.a21) in 1996, 2006, 2016, 2018, 2019 and 2020; note the slightly different scales for the different graphs.

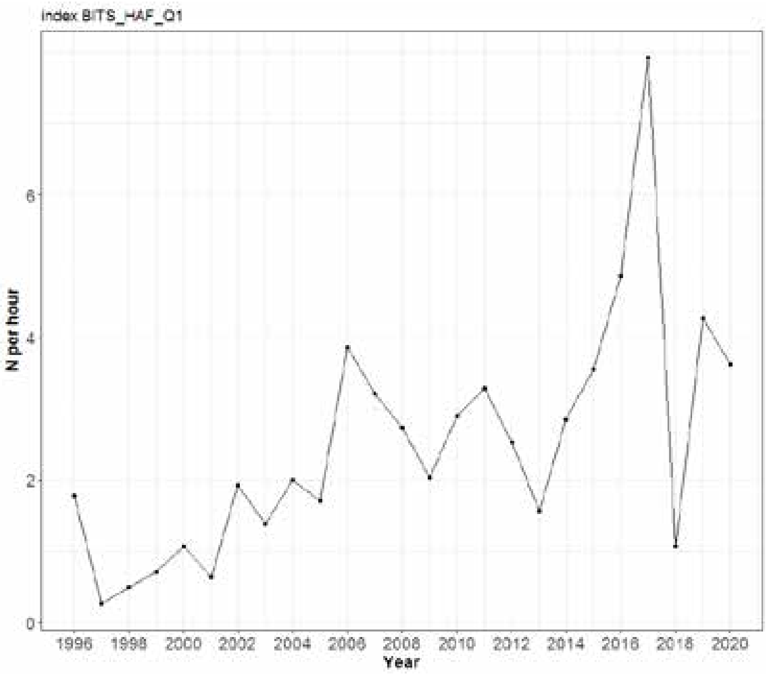

Figure 3.10: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q1) over the period 1996–2020.

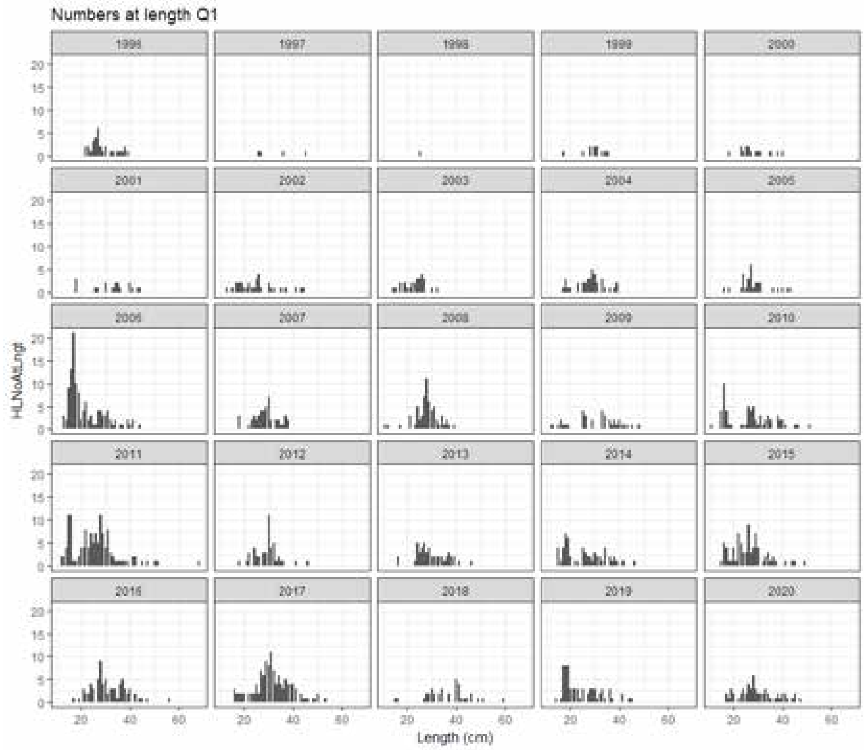

Figure 3.11: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q1 (1996–2020).

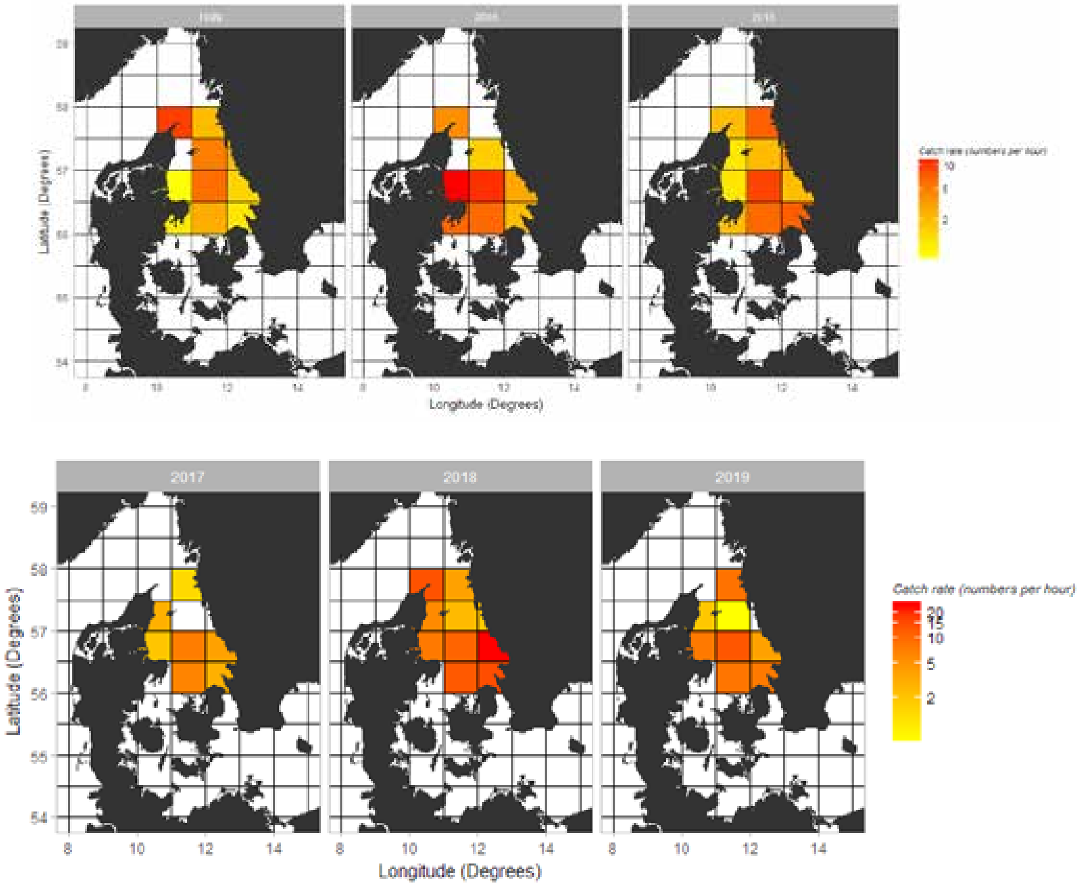

Figure 3.12: BLL 27.3a47de – Numbers of brill caught per hour and rectangle by BITS_HAF_Q4 in the Kattegat (27.3.a21) in 1999, 2006, 2016, 2017, 2018 and 2019; note the slightly different scales for the different graphs.

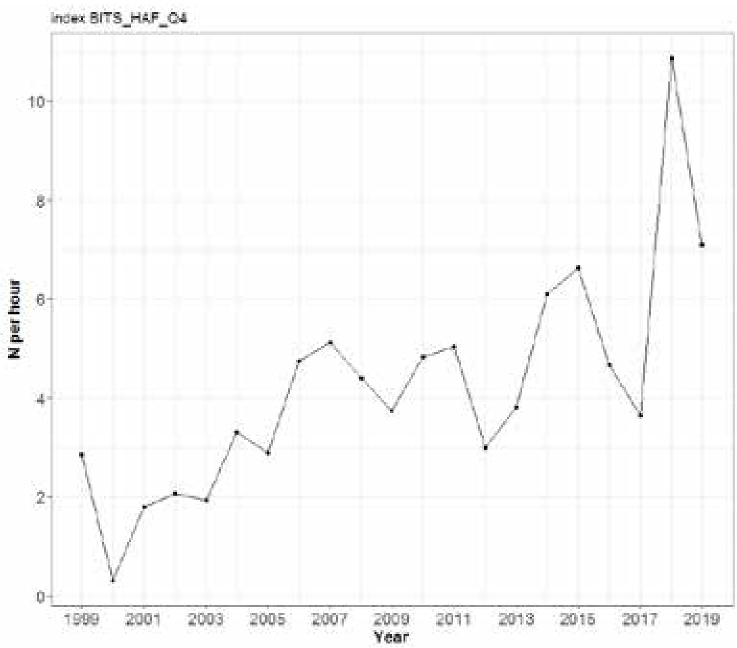

Figure 3.13: BLL 27.3a47de – Abundance index (numbers caught per hour) of brill for the BITS_HAF in the Kattegat (Q4) over the period 1996–2019.

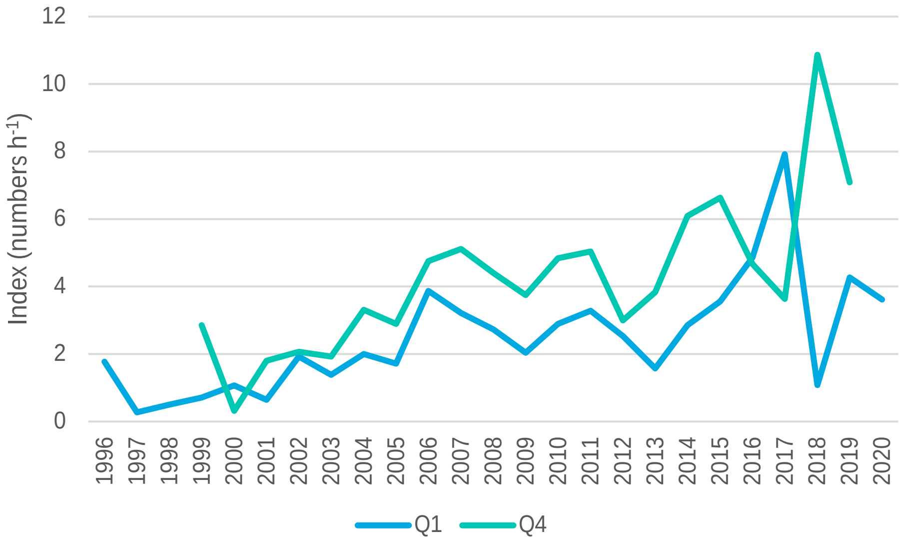

Figure 3.14: BLL 27.3a47de – Abundance indices (numbers caught per hour) of brill for both quarters (Q1 and Q4) of the BITS_HAF in the Kattegat over the period 1996–2020.

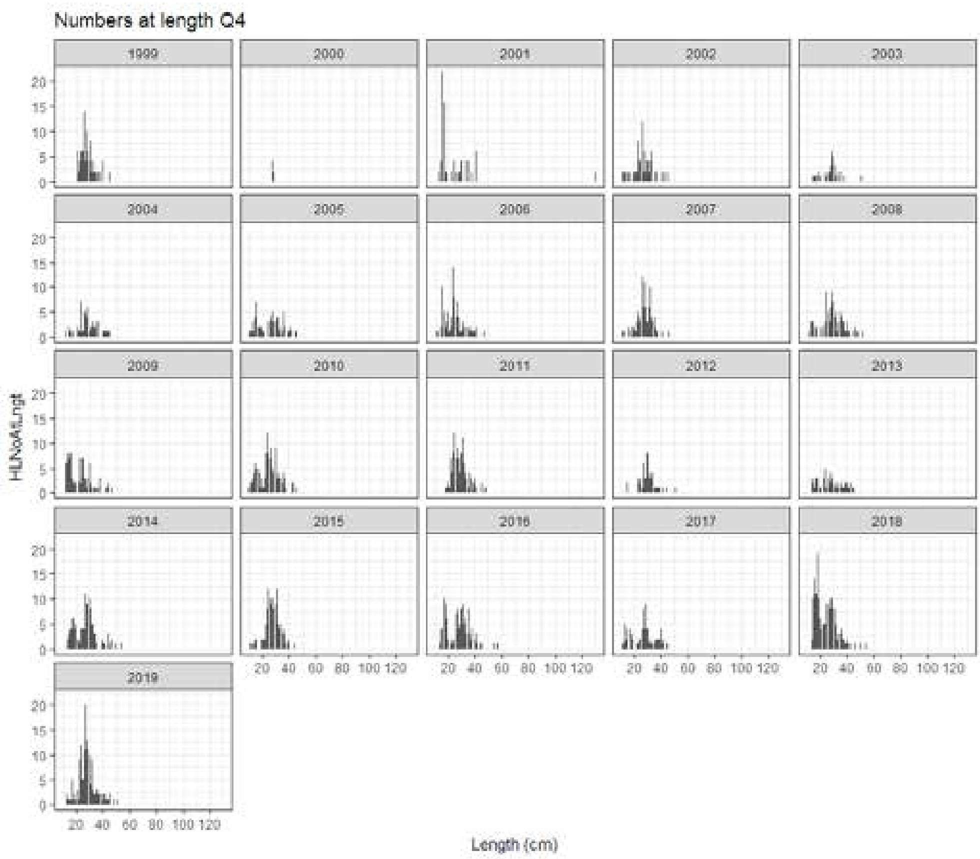

Figure 3.15: BLL 27.3a47de – Length distributions of brill in the Kattegat as documented in the BITS_HAF_Q4 (1996–2019).

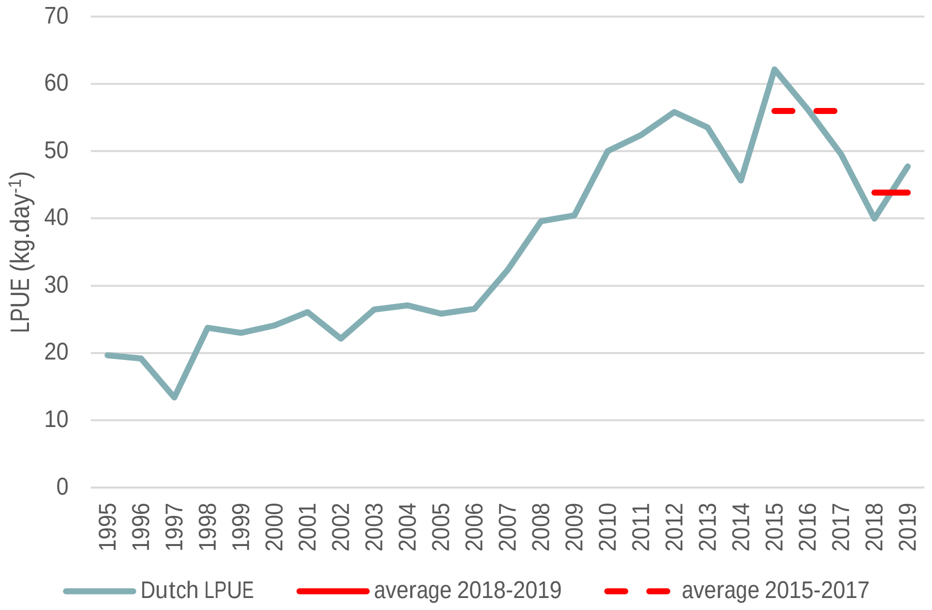

Figure 3.16: BLL 27.3a47de – Commercial LPUE (kg/day) of brill by the Dutch beam trawl fleet > 221 kW (standardized for engine power and corrected for targeting behavior). The red lines are the averages of the last two (2018–2019) and the previous three (2015–2017) years.

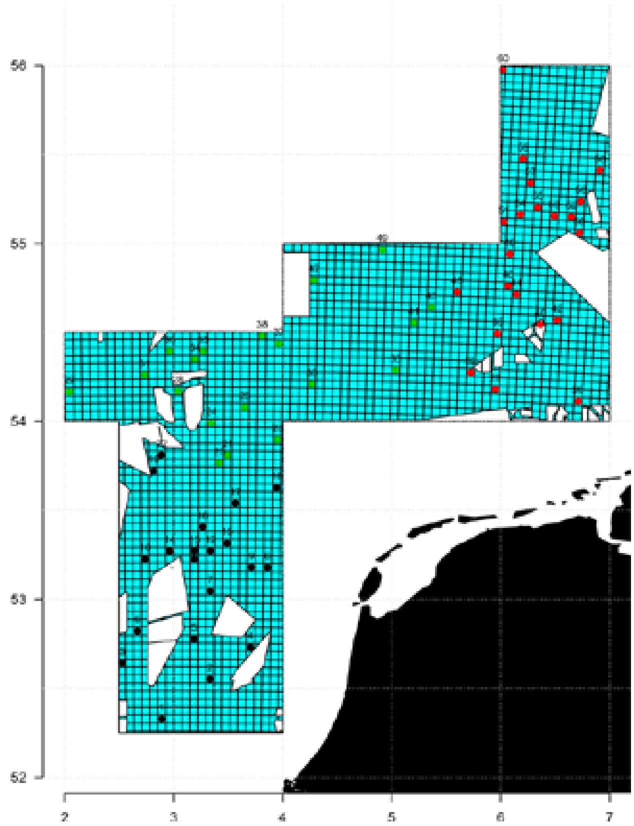

Figure 3.17: BLL 27.3a47de – Map showing the central and southern North Sea subject to monitoring by the Dutch industry survey. The area is divided in grid cells (5 x 5 km) and areas where no fishing is allowed are excluded (white areas). Twenty randomly selected grid cells were allocated to each of three vessels (vessel 1 = red, vessel 2 = black and vessel 3 = green).

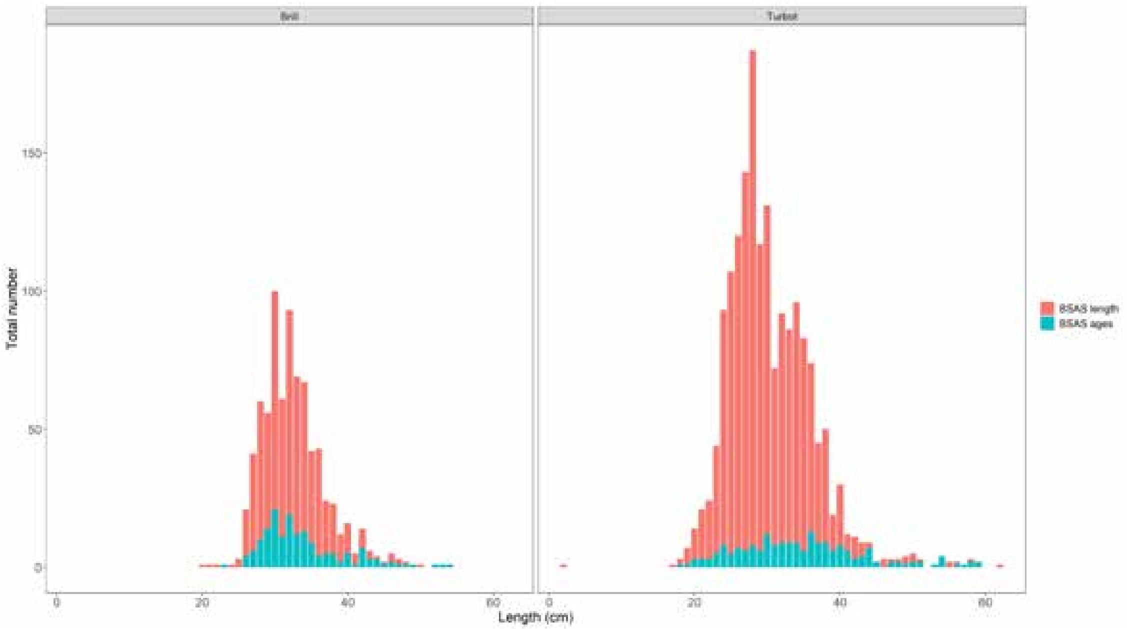

Figure 3.18: BLL 27.3a47de – Length distribution plot showing all brill (left) and turbot (right) sampled during the Dutch industry survey in 2019. The number of individuals sampled for length are shown in red, and those sampled for age and length are shown in blue.

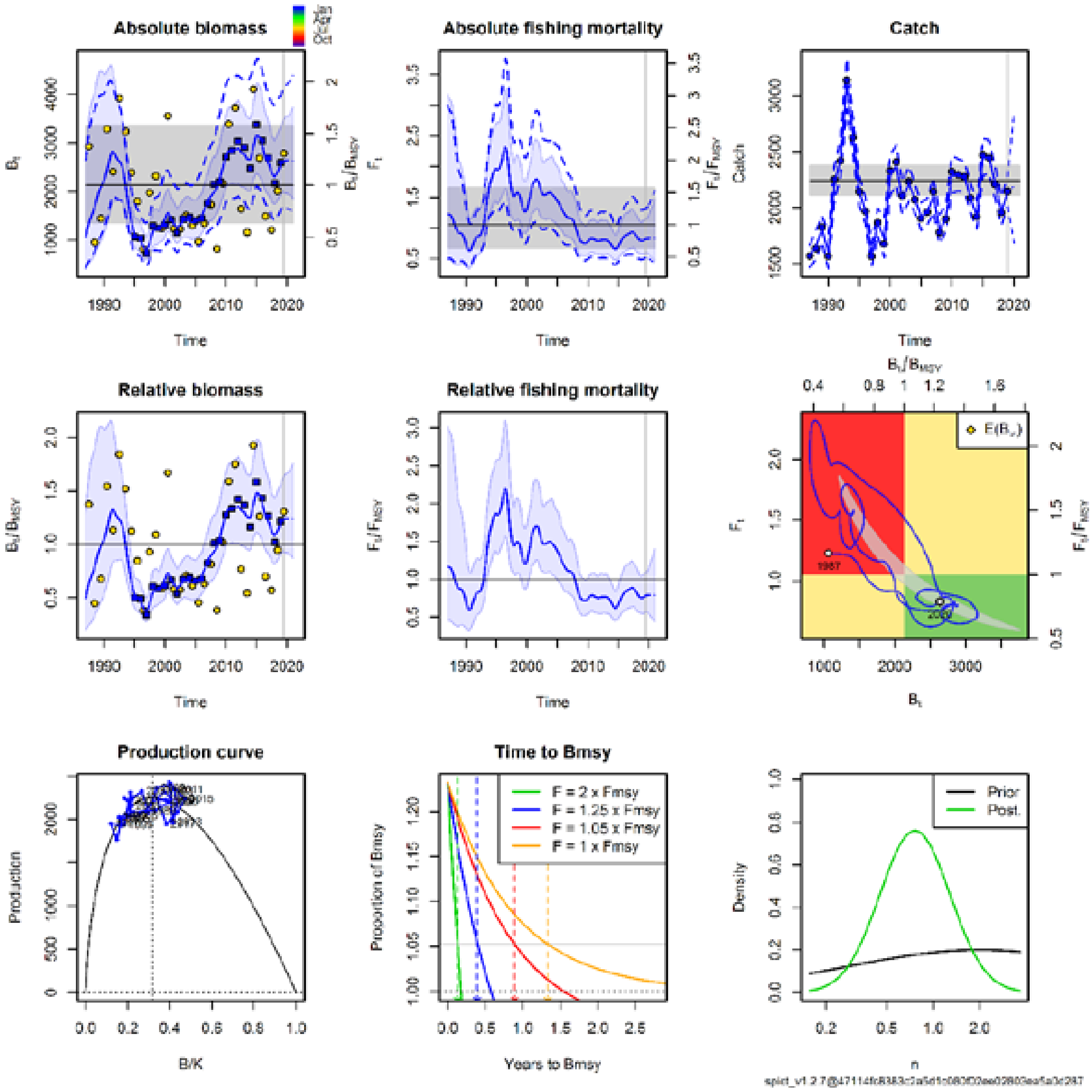

Figure 3.19: BLL 27.3a47de – SPiCT model results from WGNSSK 2020. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. 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).

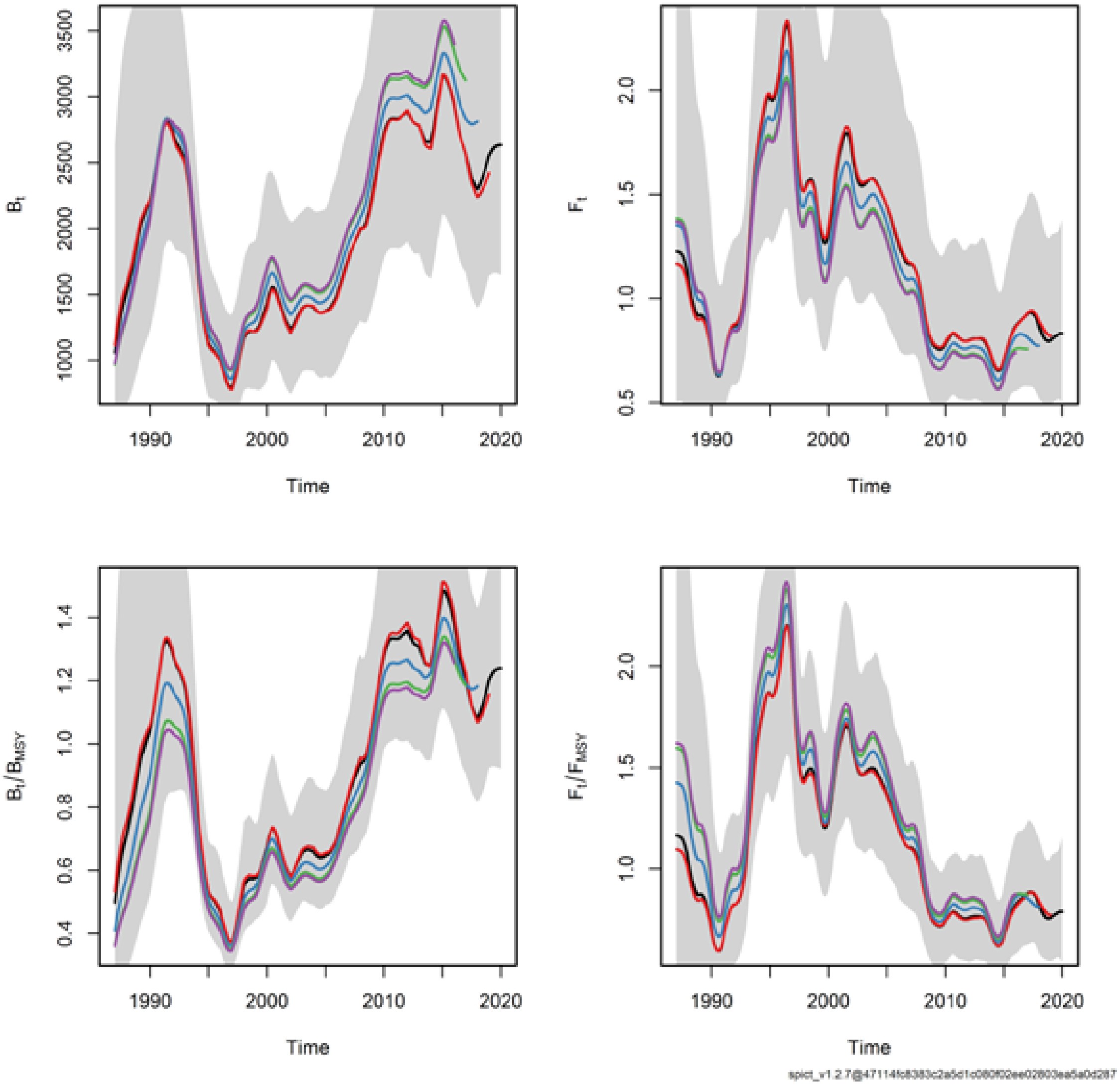

Figure 3.20: BLL 27.3a47de – Retrospective analysis of the SPiCT model from WGNSSK 2020. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.

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

This assessment relates to the cod stock in the North Sea (Subarea 4), the Skagerrak (Subdivision 20) and the eastern Channel (Division 7.d). This assessment is presented as an update from last year.

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

4.1 General

4.1.1 Stock definition

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

4.1.2 Ecosystem aspects

The North Sea is characterised by episodic changes in productivity of key components of the ecosystem. Phytoplankton, zooplankton, demersal and pelagic fish have all exhibited such cycles in variability. Managers should expect long-term change and ensure that management plans have the potential to respond to new circumstances. Examples of these changes include the gadoid outburst in the 1970s. The contracted range of the North Sea cod stock can be linked to reduced abundance as well as environmental factors. A summary of available information on ecosystem aspects is presented in the Stock Annex.

4.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Subarea 4, Subdivision 20 (Skagerrak) and 7.d, including beam trawls, otter trawls, seine nets, gill nets, trammel nets and lines. Most of these gears take a mixture of species. In some of them, cod are considered a bycatch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, in large-meshed otter trawls and some fixed gear fisheries). The main gears landing cod in the EU are primarily TR1 (mainly operated by Scotland and Denmark), but also GN1 (mainly Denmark and Norway), TR2, BT1 and BT2. A summary of historic information on the directed and by-catch cod fisheries and past and current technical measures used for the management of cod is presented in the Stock Annex.

Technical Conservation Measures

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

The expansion of the closed-circuit TV (CCTV) and FDF programmes in 2010–2016 in Scotland, Denmark, Germany, England and the Netherlands is expected to have contributed to 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)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
20(Skagerrak)	3.8	3.8	3.8	4.0	4.2	4.8	5.7	8.0	4.2	2.1
2.a + 4	26.8	26.5	26.5	27.8	29.2	33.7	39.2	43.2	29.4	14.7
7.d	1.6	1.5	1.5	1.6	1.7	2.0	2.1	1.7	1.7	0.9

For 2011–2016, Council Regulations (EC) N°57/2011, 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.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

Cod recovery and management plans

A Cod Recovery Plan which detailed the process of setting TACs for the North Sea cod was in place until 2008. Details of it are given in EC 423/2004 and previous working group reports. ICES considered the recovery plan as not consistent with the precautionary approach because it did not result in a closure of the fisheries for cod at a time of very low stock abundance and until an initial recovery of the cod SSB had been proven.

In April 2008, the European Commission adopted a proposal to amend the cod recovery plan, based on input from stakeholders, and on scientific advice from both ICES and STECF that current measures had been inadequate to reduce fishing pressure on cod to enable stock recovery. The main changes proposed were replacing targets in terms of biomass levels with new targets expressed as optimum fishing rates intended to provide high sustainable yield, and introducing a new system of effort management by setting effort ceilings (kilowatt–days) for groups of vessels or fleet segments to be managed at a national level by Member States. The new system was intended to be simpler, more flexible and more efficient than the previous one, allowing effort reductions to be proportional to targeted reductions in fishing mortality for the segments that contributed the most to cod mortality, while for other segments effort was frozen at the average level for either 2004–2006 or 2005–2007.

In December 2008, the European Commission and Norway agreed on a new cod management plan that aimed to be consistent with the precautionary approach and was intended to achieve sustainable fisheries and high yield, leading to a target fishing mortality of 0.4. In addition to the EU–Norway agreement, the EU implemented effort restrictions, reducing KW-days available to

EU vessels in the main métiers catching cod in direct proportion to reductions in fishing mortality until the long-term phase of the plan was reached, for which the target F was 0.4 if SSB is above B_{pa}. Details of European Commission plan are given in EC 1342/2008.

A joint ICES STECF group met during 2011 to conduct a historical evaluation of the effectiveness of these plans (ICES WKROUNDMP, 2011; Kraak *et al*., 2013), and concluded that for North Sea cod, although there had been a gradual reduction in F and discards, the plans had not controlled F as envisaged, and that following the regime was unlikely to deliver F_{MSY} by 2015. However, there had been positive contributions under Article 13c of the EC plan towards achieving the cod plan targets.

In November 2016, the cod management plan was amended to discontinue the effort regime set out in EC 1342/2008 as it became an obstacle to the implementation of the landings obligation. Details of the amended cod management plan are given in EC 2016/2094.

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

EU-Norway requested an evaluation of multiple management strategies (ICES WKNSMSE, 2019), which are provided as additional options in the forecasts.

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 2019 (uploads in weight) is 35 684 tonnes, split as follows for the separate areas (tonnes):

	TAC	Landings	Discards*	BMS landings**
20–Skagerrak	4205	3478	367	1
4	29437	28558	3245	35
7.d	1715	36	<1	0
Total				

35357):

Catch Category	Raised or Imported	CATON	Percentage
BMS landing	Imported	30	100
Discards	Imported	2751	78
Discards	Raised	792	22
Landings	Imported	31726	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. Although age compositions for discards in 7.d were allocated from métiers in Subarea 4 as there was no discards sampling in 7.d in 2019.

The landings and discards imported in weight or raised, with age distribution sampled or estimated for 2019 are as follows (tonnes; note differences in landings and discards values to those given above are due to Swedish landings in Subarea 4 not being uploaded to InterCatch):

Catch Category	Raised or Imported	Sampled or Estimated	CATON	Percentage
Logbook Registered Discard	Imported	Estimated	0	NA
Landings	Imported	Sampled	28565	90
Landings	Imported	Estimated	3161	10
Discards	Imported	Sampled	2697	76
Discards	Raised	Estimated	792	22
Discards	Imported	Estimated	54	2
BMS landing	Imported	Sampled	30	100
BMS landing	Imported	Estimated	<1	0

The reprocessing of 2018 data by France and subsequent re-raising in InterCatch made little difference to the estimations of landings and discards at age (Figure 4.1c). InterCatch is discussed in Section 1, and all results are available on the WGNSSK SharePoint. Further work is ongoing, analysing the InterCatch data (cf. ICES WGMIXFISH meeting during 2020).

It came to light during the WGNSSK meeting that 347 tonnes of cod landed in Subarea 4 by Sweden were missing from the InterCatch data uploads for 2019. Given that the missing landings represent 1% of total landings, the approach taken was to add the missing landings after InterCatch raising and to estimate the associated discards from the discard ratio in Subarea 4. Ages were then allocated using the age allocations of the overall landings and discards, respectively.

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 2019. Total catch mean weight values were also used as stock mean weights. Long-term trends in mean catch weight at age for ages 1–9 are plotted in Figure 4.2a, which indicates that there have been short-term trends in mean weight at age, currently showing a decline from 2010–2012 for ages 3 and above. Ages 1 and 2 show little absolute variation over the long-term.

4.2.3 Maturity and natural mortality

Until 2015 the maturity values applied to all years were left unchanged from year to year, and were based on NS–IBTS–Q1 data from 1981–1985. However, ICES WKNSEA (2015) noted a change in maturity-at-age in the North Sea cod stock, with fish maturing at a younger age and smaller size. In order to address these changes in the stock, an area-weighted maturity age key is constructed from NS–IBTS–Q1 data. As variation in sampling intensity adds to the interannual variation, a smoother is applied to the maturity age key. This smoothed maturity age key is then applied to the estimation of spawning stock biomass. In 2020, there was insufficient biological sampling to estimate an age-length key for the southern subregion (Figure 4.15c). A range of ALK borrowing options were explored, as well as exclusion of fish from the southern subregion (Figure 4.2b). Given annual maturity ogives from the southern subregion are more similar to those from the northwest subregion and survey-based indices of spawning stock biomass indicated substantial differences to the Viking subregion (see Stock Annex), the northwest ALK was used to assign ages to fish surveyed in the southern subregion. The smoothed time-varying maturity ogive used in the assessment is given in Table 4.5a and illustrated in Figure 4.2b.

Table 4.5b and Figure 4.2c show estimates of M, based on multi species considerations adopted for the assessment. ICES WKROUND (2009) noted that as new stomach data (e.g. on seal predation) become available, a revision of more recent M2 values to reflect the current status of the food web, should be considered. Estimates of natural mortality, derived from multispecies analyses, are updated by the Working Group on Multi Species Stock Assessment Methods (WGSAM) every three years in so called "key runs" to account for improved knowledge of predation on cod by other species (mainly seals, harbour porpoises and gurnards) and cannibalism; the last update occurred in 2017 with the new key run (ICES WGSAM, 2018).

4.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable as it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed. The WG has previously argued that, although they are in general agreement with the survey information, commercial CPUE tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES WGNSSK, 2001), and also changes in gear design and usage, as discussed by ICES WGFTFB (ICES, 2006; 2007). Therefore, although the commercial fleet series are available, only survey and combined commercial landings and discard information are analysed within the assessment presented.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS–Q1): ages 1–6+, covering the period 1976–2020. 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.

Quarter 3 international bottom-trawl survey (IBTS–Q3): ages 0–6+, covering the period 1991–2019. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Maps showing the IBTS distribution of cod are presented in Figures 4.3a–b (ages 1–3+). The recent dominant effect of the size and distribution of the 2005, 2009, 2013 and 2016 year-classes are clearly apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 2000-, 2002- and 2004-year classes, but subsequently increased, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels and has declined over the past three years due to the weak 2017- and 2018-year classes. The 2019 year-class appears a bit stronger than the recent 2017- and 2018- year classes (Figure 4.3a).

The 2011 benchmark of North Sea Cod resulted in the exclusion of the IBTS–Q3 survey index, because divergent trends in recent years were observed when the Q3 index was applied independently of the Q1 index (ICES WKCOD, 2011). At that time, it was decided that until the reasons for the discrepancies were resolved, the Q1 was more likely to reflect the stock, and hence the Q3 index was dropped from the assessment. The indices were calculated using the standard stratified mean methodology (mean by rectangle within year, followed by mean over rectangles by year), applied to an extended area (referred to below as the NS–IBTS extended index; ICES WKROUND, 2009; Figure 4.3c). This simple design-based estimator is unable to account for systematic changes in experimental conditions (e.g. change of survey gear). Given these issues, an alternative methodology that calculates standardized age-based survey indices based on GAMs and Delta-distributions (see also Berg WD3, ICES WKNSEA, 2015) has now been adopted (referred to as the NS–IBTS Delta–GAM index), and has led to both the Q1 and Q3 indices being incorporated into the assessment. The general methodology is described in Berg and Kristensen (2012) and Berg *et al.* (2014) and is implemented in R based on the DATRAS (http://rforge.net/DATRAS/) and surveyIndex packages.

More details of the method used to produce the NS–IBTS Delta–GAM index is provided in the stock annex and can be found in ICES WKNSEA (2015), as well as the above-mentioned publications. In summary the final Delta–GAM models selected for NS–IBTS–Q1 and Q3 comprised a stationary spatial model, and included ship, year and haul-duration effects. In addition, the Q3 model also included a gear effect (Q1 only has a single gear, GOV, so this effect is not an issue). The NS–IBTS Delta–GAM indices used in the assessment are given in Table 4.6. Figure 4.3d compares the Q1 and Q3 NS–IBTS Delta–GAM indices to the corresponding NS–IBTS extended indices and the Delta-GAM indices as used in the assessment last year (October 2019).

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 2020.

4.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 4.4a for the IBTS–Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS–Q3 survey in Figure 4.4b. The log-mean standardised curves indicate that there may be year-effects in recent years, particularly for the IBTS-Q1 which shows a peak for most ages in 2017 followed by a subsequent decline (top-left plots). The log-mean standardised curves track cohort signals well (top right), although there is some loss of signal between the 2012 and 2013 cohorts associated with the apparent positive year effect in 2017 and disappearance of the strong 2013-year class from survey catches at older ages. The log abundance curves for each survey series show 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).

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

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

Biomass: Spawning stock biomass reached the lowest level in the time series in 2005 and subsequently increased again because of the stronger 2005-, 2009- and 2013-year classes and reductions in mortality, reaching a peak in 2016. SSB has since declined rapidly with a slight, but highly uncertain, increase estimated for 2020. This trend can also be seen in the time series for total stock biomass.

Total mortality: the SURBAR analysis indicates an overall gradual decline in total mortality until 2014, followed by a rapid increase peaking in 2017.

Recruitment: the SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, but with stronger 1999, 2005, 2009, 2013 and 2016 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 2017–2019 (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 shows clearly the contribution of the 2005, 2009, 2013 and 2016 year classes to catches in recent years and indicates a relative increase in the number of older fish in the catches. The and 2013- and 2016-year classes feature strongly in the catch in the most recent period.

Catch curve cohort trends

The top panel of Figure 4.8a presents the log catch curve plot for the catch at age data. 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. The lower negative slopes indicate that total mortality rates at the ages comprising the dominant ages within the fishery are declining. Although there are peaks in the negative slopes 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. This is in contrast to equivalent plots for the survey indices, which have shown substantial increases in the negative slopes in recent years.

Comparison with survey indices

Figure 4.8b shows the NS-IBTS-Q1 and Q3 survey indices plotted against the catch at age data. The peak from the strong 2013-year class can be seen clearly from all three sources of observation data until the year-class reaches age 3 in 2016. This peak can be tracked to age 4 in 2017 in the NS-IBTS-Q1 and catch at age data but not the NS-IBTS-Q3 index, where a peak for the 2012-year class presents itself in 2016. There is a clear peak in the NS-IBTS-Q1 index at age 5 in 2017 corresponding to the 2012-year class, while at age 6 a peak occurs in 2018 across all observation data sources and corresponds to the 2012-year class. This indicates that the loss of cohort signal between the 2012- and 2013-year classes is common to both fishery dependent and independent data sources, although there is still a discrepancy between the negative gradients of each.

Assessment model

SAM

SAM (State-space Assessment Model, Nielsen and Berg, 2014, run with R stockassessment package version 0.9.0 in 2020) has been used as the assessment model for North Sea cod since 2011, following acceptance at the 2011 benchmark meeting held for the stock (ICES WKCOD, 2011;

ICES WGNSSK, 2011). More details can be found in Nielsen and Berg (2014) and in the ICES WKCOD 2011 report, but essentially SAM models recruitment from a stock–recruitment relationship, with random variability estimated around it, or as a random walk in log space. Starting from recruitment, each cohort's abundance decreases over time following the usual exponential equation involving natural and fishing mortality. Instead of assuming catches to be known without error and simply subtracting those, SAM assumes that catches include observation noise, and that the survival process along cohorts is a random process. This has the consequence that estimated F-at-age paths display less interannual variability with SAM than with deterministic assessment models, because part of the observed fluctuations in catch-at-age are arising from observation noise instead of from changes in F.

SAM puts random distributions on the fishing mortalities F(y,a), where (y,a) denotes year and age. SAM considers a random walk over time for log [F(y,a)], for each age, allowing for correlation in the increments of the different ages. It has observation equations for both survey indices-at-age and observed catch-at-age, so catch-at-age data are never considered to be known without error. Additionally, in order to deal with the uncertain overall catch levels over the period 1993–2005, SAM estimates annual catch multipliers for this period.

An extension to allow for varying correlation between different ages is achieved by setting the correlation of the log F annual increments to be a simple function of the age difference (AR(1) process over the ages). By doing this, individual log F processes will develop correlated in time, but in such a way that neighbouring age classes have more similar fishing mortalities than more distant ones. This correlation structure does not introduce additional parameters to the model and is referred to as an AR correlation structure (see Nielsen and Berg, 2014, for more details).

SAM is considered more appropriate than VPA approaches such as B–Adapt, because the additional variability/uncertainty considered in various components of SAM seems realistic and gives rise to results that are less reactive to noise in the catch or survey data or to potential changes in survey catchability. The fact that SAM considers random variability of the annual survival process along cohorts separately from fishing mortality produces smoother estimated F paths over time. Because the current management regime for the North Sea cod stock is strongly focused on F estimates in the final assessment year, it is important that these estimates do not change too suddenly in response to some data values which may represent noise. Additionally, SAM utilizes the age structure of the observed catch even in years when the overall catch value is considered biased. SAM was considered by recent benchmarks of North Sea cod (ICES WKCOD, 2011; ICES WKNSEA, 2015) to be the most appropriate modelling approach for the stock assessment.

Figure 4.9 shows the assessment results. Normalised residual plots are shown in Figure 4.10, indicating no serious model misspecification, although residuals for the second to last two years of IBTS-Q1 and IBTS-Q3 data (bar age 1) are all negative. Retrospective plots for SSB, average fishing mortality, recruitment at age 1 and TSB are shown in Figure 4.11. Mohn's rho statistics based on a five-year peel are calculated as 0.286, -0.121, 0.521 and 0.326 for SSB, $F_{2\text{–}4}$, recruitment and TSB respectively, indicating a major retrospective pattern (ICES WKFORBIAS, 2020). A summary of the SAM final assessment run in terms of population trends is provided in Figure 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 4.13.

4.3.4 Final assessment

The SAM update run is accepted as the final assessment. The data used in the assessment are given in Tables 4.2–3 and 4.5–6, and the model configuration in Table 4.7a. Model fitting diagnostics, parameter estimates and associated correlation matrix are given in Table 4.7b, while normalised residual plots and retrospective runs are shown in Figures 4.10 and 4.11 respectively.

Estimates of fishing mortality at age, stock numbers at age and total removals at age are given in Tables 4.8–10 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, total removals and F_{bar} (2–4) are given in Table 4.11a (along with 95% confidence bounds), and estimates of landings, discards, catch, the catch multiplier and total removals (combining all these components) are given in Table 4.11b (and can be compared to the corresponding data in Table 4.4). Table 4.11c provides estimates of the catch multiplier along with 95% confidence bounds. Summary plots of the final assessment in terms of population trends are provided in Figure 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into age is shown in Figure 4.13. A comparison with last year's assessment (updated in October 2019 following the NS-IBTS-Q3 survey) is provided in Figure 4.14a. Differences between the assessments are due to the addition of one year of catch and NS–IBTS Q1 and Q3 survey data, as well as slight revisions to maturity and delta-GAM indices. Addition of the new data results in a downscaling of SSB and an upscaling of F, primarily caused by addition of the catch data for 2019 (Figure 4.14b).

4.4 Historic Stock Trends

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

Recruitment fluctuated at a relatively low level from 1998. The 1996-year class was the last large year class that contributed to the fishery, and subsequent year classes have been the lowest in the time series, with stronger 1999-, 2005-, 2009-, 2013- and 2016-year classes.

Fishing mortality increased until the early 1980s, remained high until 2000 and declined to its lowest level in 2013. This decline in F has subsequently reversed with F increasing rapidly between 2016–2018. F is now above both the precautionary reference points, F_{lim} and F_{pa}, and F_{MSY}.

SSB declined steadily during the 1970s and 1980s. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the mid-1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline to its lowest level in 2006. SSB subsequently increased with a decline in fishing mortality, reaching a peak in 2015, but has since declined rapidly and is now below B_{lim}. TSB estimates follow a similar trend but with a less pronounced peak as SSB in recent years because of continued low recruitment.

Biomass indices by subregion (Figure 4.15a with subregions given in Figure 4.15c) highlight differing rates of change in cod biomass, with a general decline in all areas prior to the mid-2000s, and an increase, peaking between 2015–2017, followed by a sharp decline in all areas thereafter, apart from the southern area where cod has steadily declined over the years. Recruitment indices by subregion (Figure 4.15b with subregions given in Figure 4.15c) show similar trends in all areas, but with indications of increased recruitment in the northern North Sea. Management measures ensuring sustainable exploitation of substocks may be needed in addition to management for the stock as a whole. In particular, the low landings in 7.d in 2019 (36 tonnes) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey in 2020 may indicate a collapse of the stock in this area. Official nominal landings are low in both divisions 4.c (90 tonnes; reported to Subarea in Table 4.1) and 7.d (37 tonnes).

4.5 Recruitment estimates

Recruitment in the intermediate year (2020) 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 1997–2018-year classes, reflecting recent low levels of recruitment, but including the stronger 1999-, 2005-, 2009-, 2013- and 2016-year classes.

4.6 MSY estimation

MSY estimation is performed with the EQSIM software (ICES WGMG, 2013), in accordance with the guidelines provided in ICES WKMSYREF3 (2014). MSY estimation for North Sea cod was last performed during ICES WGNSSK (2017) on the same basis as for ICES WKNSEA (2015) and ICES WGNSSK (2015). Details of the analysis are available in the expert group report (ICES WGNSSK, 2017).

A summary of the biological reference points (not including the advisory HCR in all but FP.05) is provided in the following table.

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

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

4.7 Short-term forecasts

The May forecast

Forecasting takes the form of short-term stochastic projections. A total of 1000 samples are generated from the estimated distribution of survivors. These replicates are then simulated forward according to model and forecast assumptions (see table below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios.

The usual intermediate year assumption is a status quo F relative to the final year of the assessment. Given the 50% reduction in TAC for 2020, this would result in an assumed catch that exceeds the TAC by 16 305 tonnes (i.e. an extra 92% is taken in addition to the TAC) in the intermediate year. Given that ICES estimated catches have been in line with the TAC for the last three years, the WG assumed full TAC utilisation in the intermediate year and not status quo F.

Forecasts are presented in tables 4.12a–b. Forecast assumptions are as follows (note that the values that appear in the catch scenarios in tables 4.12a–b are medians from the distributions that result from the stochastic forecast):

Initial stock size	**Starting populations are simulated from the estimated distribution at the start of the intermediate year (including co-variances).**
Maturity	Maturity for the intermediate year is taken from the smoothed maturity ogive. Maturity for the TAC year onwards is the average of final four years of assessment data
Natural mortality	Average of final three years of assessment data.
F and M before spawning	Both taken as zero.
Weight at age in the catch	Average of final three years of assessment data.
Weight at age in the stock	Assumed to be the same as weight at age in the catch.
Exploitation pattern	Fishing mortalities taken as a three-year average divided by the three-year average fishing mortality for ages 2–4.
Intermediate year assumptions	Median total catch in the intermediate year set equal to the TAC in the intermediate year.
Stock recruitment model used	Recruitment for the intermediate (the year the WG meets) is 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 final year of catch data.
Procedures used for splitting projected catches	The final year landing fractions are used in the forecast period.

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

The October forecast

Since the NS–IBTS Q3 index has been re-introduced into the assessment, there is an opportunity to update the forecast in October following the NS–IBTS Q3 survey. ICES WKNSEA (2015) recommended that the usual procedure be used to establish whether to re-open advice in the autumn (as described in ICES AGCREFA 2008). Once it has been established that advice should be re-opened for North Sea cod, the recommended procedure is to then re-run the assessment and forecast with the new Q3 data included.

The ICES WKNSEA (2015) recommendations on conducting the North Sea cod forecast deviated from the ICES norm in that the October forecast implies re-running the SAM assessment, and was therefore presented to the ICES ACOM leadership who have given it their approval. The forecasting procedure therefore follows the ICES-WKNSEA (2015) recommended approach.

The current May forecast

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

1. MSY framework: F_{bar} (2021) = F_{MSY}×min{1; SSB_{2021}/$B_{trigger}$}
2. EU-MAP: F_{bar} (2021) = $F_{MSY\ lower}$×min{1; SSB_{2021}/$B_{trigger}$}
3. Zero catch: F_{bar} (2021) = 0
4. F_{pa}: F_{bar} (2021) = F_{pa} = F_{lim}/1.4 = 0.39
5. F_{lim}: F_{bar} (2021) = F_{lim} = 0.54
6. SSB (2022) = B_{lim}: F corresponding to SSB (2022) = B_{lim}
7. SSB (2022) = B_{pa}: F corresponding to SSB (2022) = B_{pa}
8. SSB (2022) = $B_{trigger}$: F corresponding to SSB (2022) = $B_{trigger}$
9. Lower TAC constraint: F_{bar} (2021) such that TAC (2021) = 0.8×TAC (2020)
10. Rollover TAC 15%: F_{bar} (2021) such that TAC (2021) = 0.85×TAC (2020)
11. Rollover TAC 10%: F_{bar} (2021) such that TAC (2021) = 0.9×TAC (2020)
12. Rollover TAC 5%: F_{bar} (2021) such that TAC (2021) = 0.95×TAC (2020)
13. Rollover TAC: F_{bar} (2021) such that TAC (2021) = TAC (2020)
14. Rollover TAC + 5%: F_{bar} (2021) such that TAC (2021) = 1.05×TAC (2020)
15. Rollover TAC + 10%: F_{bar} (2021) such that TAC (2021) = 1.1×TAC (2020)
16. Rollover TAC + 15%: F_{bar} (2021) such that TAC (2021) = 1.15×TAC (2020)
17. Upper TAC constraint: F_{bar} (2021) such that TAC (2021) = 1.2×TAC (2020)
18. Status quo – constant F: F_{bar} (2021) = F_{bar} (2020)
19. $F_{MSY\ lower}$: F_{bar} (2021) = $F_{FMY\ lower}$ = 0.198
20. F_{MSY}: F_{bar} (2021) = F_{FMY} = 0.31

These scenarios do not include $F_{MSY\ upper}$ because SSB(2021) < MSY $B_{trigger}$.

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

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

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

Forecasts for the SAM final run are given in Tables 4.12a and b. The working group raised concerns regarding the intermediate year assumption on F given the restrictiveness of the 2020 TAC. Table 4.12c and Figure 4.16 present catch forecasts for the MSY approach (i.e. F=F_{MSY}×SSB_{2021}/$B_{trigger}$ where this brings SSB above B_{lim} in 2022, and the F corresponding to SSB (2022) = B_{lim} otherwise) assuming different multipliers on F(2019) in the intermediate year, and show a wide range of potential total catches in 2021 (161–19 905 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 WGNSSK 2017 following the procedures of ICES WGNSSK 2015 and ICES WGNSSK 2016. Biological reference points and their technical basis are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	150 000 t	The default option of B_{pa} (=1.4×Blim)	
	F_{MSY}	0.31	EQSim analysis based on recruitment period 1988–2016	2017 assessment
Precautionary approach	B_{lim}	107 000 t	SSB associated with the 1996-year class	2017 assessment
	B_{pa}	150 000 t	B_{lim} multiplied by 1.4. This is the current ICES default approach.	
	F_{lim}	0.54	EQSim analysis based on recruitment period 1998–2016	2017 assessment
	F_{pa}	0.39	F_{lim}/1.4	

4.10 Quality of the assessment

The quality of the commercial landings and catch-at-age data for this stock deteriorated in the 1990s following reductions in the TAC without associated control of fishing effort. The WG considers the international landings figures from 1993 onwards to have inaccuracies that lead to retrospective underestimation of fishing mortality and over estimation of spawning stock biomass and other problems with an analytical assessment. The mismatch between reported and actual landings is assumed to be negligible since 2006.

Between 1993–2005, the SAM model estimates the quantity of additional "unaccounted removals" that would be required to be added or removed from the catch-at-age data in order to remove any persistent trends in survey catchability. The unaccounted removals figures given by SAM could potentially include components due to increased natural mortality and discarding as well as misreported landings.

Prior to 2002 estimates of discards for areas 4 and 7.d are taken from the Scottish discard sampling program and the average proportions across gears applied to raise the landings data from other areas. If the gear and fishery characteristics differ, this could introduce bias. This bias is likely to introduce sensitivity to the estimates of the youngest age classes (1 and 2) and will not affect estimates of SSB. InterCatch has been used to raise data for discards ratios and landings and discard age compositions from 2002 onwards. The provision of discard information has vastly improved since 2009.

The estimated CVs for observed catch at age 1, for the NS–IBTS–Q1 and Q3 survey indices at age 1 and for the stock–recruitment relationship are all large: 58%, 48%, 38% and 78%, 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 (0.89) 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.

In recent years (since 2017), assessments have resulted in a downscaling of SSB and upward revision of F. This is thought to be caused by lower catch rates of older fish in the IBTS surveys compared to the commercial catches, although the reason for this discrepancy is not fully understood. The high value of Mohn's rho calculated for SSB (0.286) suggests that the assessment is exhibiting a major retrospective pattern (ICES WKFORBIAS, 2020). Furthermore, estimates of Mohn's rho based on peels of the assessment inputs likely underestimate the true level of retrospective bias in the assessment procedure for North Sea cod given revisions to assessment inputs with new model runs (i.e. the delta-GAM model used to derive indices and the smoother on maturity) (Walker *et al.*, 2020).

Changes to the assessment in 2015 included a reduction of the plus group from 7+ to 6+. This reduces the cohort information for ages 6+; these ages represent 32% of the SSB (by weight) in 2020 (increasing from 19% in 2015), and if the SSB increases, this proportion should also increase as more fish aggregate in the plus group, with an associated increasing loss in cohort signal for ages in the plus group, potentially undermining the assessment. Furthermore, this change introduced increasingly domed selection in the latter half of the time series that was not present in previous assessments; although there are reasons why such increasingly domed selection might occur, such as some evidence that larger cod inhabit less accessible rocky areas or simply move away from areas fishing vessels operate in, these reasons remain largely speculative.

There is general agreement across all models presented (SAM and SURBAR) of a recent decrease in SSB and corresponding increase in fishing mortality (total mortality for SURBAR), and stronger 2005-, 2009-, 2013- and 2016-year classes in recent years. The slight increase in SSB predicted by SURBAR in 2020 is not observed in SAM, which shows 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 appears to have increased and is now above both the precautionary reference points, F_{lim} and F_{pa}, and the level that achieves the long-term objective of maximum yield, F_{MSY}.

Recruitment of 1-year old cod has varied considerably since the 1960s, but since 1998, average recruitment has been lower than any other time. The last larger recruitment observed during this period was the 2016-year class, but the 2019-year class appears stronger than the weak 2017- and 2018-year classes.

4.12 Management considerations

The EU landing obligation was implemented from 1 January 2017 for several gears, including TR1, BT1, and fixed gears. From 2018, cod is fully under the EU landing obligation in Subarea 4 and Subdivision 20. The EU landing obligation did not apply to cod in Division 7.d in 2018–2019. 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 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, in order to allow more fish to reach maturity and increase the probability of good recruitment. Although discards currently contribute only 10% of the total catch by weight, incidence of discarding remain high, with the proportion of discarded fish by number in 2019 being 82% of 1 year old, 47% of 2 year old and 13% of 3 year old cod.

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 recruitment of the relatively more abundant year classes to the fishery may have no beneficial effect on the stock if they are caught and heavily discarded. The last substantial year class to enter the fishery was the 1996-year class. This year class was a prominent feature in all surveys, was heavily exploited and discarded by the fishery at ages 1–5 and disappeared relatively quickly from the fishery.

Cod 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 management plans that do not incorporate such mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, in order to estimate the potential risks of quota over- and under-shooting for the different stocks.

Cod is widely distributed throughout the North Sea, but there are indications of subpopulations inhabiting different regions of the North Sea (e.g. from genetic studies). The inferred limited degree of mixing suggests slow recolonization in areas where subpopulations are depleted. In particular, the low landings in 7.d in 2019 (36 tonnes) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey in 2020 may indicate a collapse of the stock in this area. Official nominal landings are low in both divisions 4.c (90 tonnes; reported to Subarea in Table 4.1) and 7.d (37 tonnes).

There are both retrospective patterns and model / data adjustments, which together have combined to lead to a perception of considerable annual overestimation of SSB and underestimation of F over the last 5 years, which may have led to over-optimistic forecasts in recent years. There are several possible ecological and anthropogenic drivers for this, including a positive survey year-effect in 2017, and discrepancies between catch and survey data under which all models would struggle. If the recent observed retrospective pattern continues, then the current forecast may also be too optimistic.

The catch scenarios presented assume that the TAC is taken in 2020, which implies that management measures in place are sufficient to ensure that catches remain at or below the TAC. This TAC may become restrictive in some areas because it is 50% lower than the TAC in 2019. There are opposing possible outcomes for the fishery in 2020 that could violate this assumption, from an over-catch due to non-compliance to the landing obligation caused by cod becoming a choke species in mixed fisheries to an under-catch because of a severely curtailed fishing season due to the effects of the coronavirus pandemic. In addition to the quality considerations, this could imply the catch scenarios are either too positive or negative.

The forecast procedure uses the assessment estimate of recruitment in 2020. This is slightly larger than the 2018–2019 recruitments and remains to be confirmed by the IBTS-Q3 survey. A reopening of the advice may be triggered in October.

4.13 Issues for future benchmarks

The stock was last benchmarked in 2015 and will next be benchmarked in 2021. 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. The current scoring for this stock is:

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

4.13.1 Data

Stock identity

The last benchmark identified stock ID as an issue for North Sea cod and recommended focusing on the possibility of conducting assessments that allow for multiple stocks. This would require the ability to allocate catch and survey data to stock and account for uncertainty where these data come from areas of overlap or substantial mixing. Trends in substock biomass have been monitored in the meantime and the ICES Workshop on Stock Identification of North Sea cod (WKNSCodID) will meet in August to review information on stock identification and make recommendations on cod stock scenarios to take forward in the forthcoming benchmark.

Maturity

The last benchmark raised concerns that accounting for the increase in maturity may give the impression that the spawning stock is in better condition than it is given the possibility of lower fecundity of younger age groups and the potential for a maternal age effect on survival, and recommended exploration of the significance of spawner age on reproductive potential.

Further attention to consider the base approach for weighting subarea differences in maturity-at-age and the importance of sampling intensity to the interannual variation in maturity estimates was also recommended. Issues related to low sample size encountered in 2016 and 2020 highlight the need to re-evaluate the approach for deriving maturity-at-age.

Survey

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

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

Recreational catches

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

4.13.2 Assessment

Residual patterns

Residuals for the second to last two years of IBTS-Q1 and Q3 data (bar age 1) are all negative and may indicate year effects in the surveys. Model configurations that correlate survey observations should be explored. MSE analyses show that more precautionary advice is needed when year effects in the survey, modelled by correlating the errors between age classes, are present but ignored in the assessment (ICES WKNSMSE, 2019).

Retrospective patterns

Retrospective analyses indicate a tendency to overestimate SSB and recruitment and underestimate fishing mortality. Mohn's rho for SSB indicates that the assessment for North Sea cod exhibits a major retrospective pattern (ICES WKFORBIAS, 2020).

Plus group

The proportion of spawning fish in the plus group has increased since the plus group age was reduced from 7+ to 6+ in 2015, resulting in an increasing loss of cohort information with 32% of spawning stock biomass now estimated to be aggregated within the plus group.

4.13.3 Forecast

Assumptions

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

From 2017, recruitment in the intermediate year has been taken as the SAM estimate of numbers at age 1. This estimate is uncertain and retrospective analyses indicate a strong tendency for the assessment to overestimate recruitment ($\rho_{n=5}$ = 0.52) which may lead to biased catch forecasts.

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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	3,304	2,470	2,616	1,482	1,627	1,722	1,309	1,008	894	946
Denmark	14,000	8,358	9,022	4,676	5,889	6,291	5,105	3,430	3,831	4,402
Faroe Islands	-	9	34	36	37	34	3	-	16	45
France	1,222	717	1,777	620	294	664	354	659	573	950
Germany	1,740	1,810	2,018	2,048	2,213	2,648	2,537	1,899	1,736	2,374
Greenland	.	.	.	.	.	35	23	17	17	11
Netherlands	5,995	3,574	4,707	2,305	1,726	1,660	1,585	1,523	1,896	2,649
Norway	6,410	4,369	5,217	4,417	3,223	2,900	2,749	3,057	4,128	4,234
Poland	18	18	39	35	-	-	-	1	2	3
Sweden	640	661	463	252	240	319	309	386	439	378
UK (E/W/NI)	6,543	4,087	3,112	2,213	1,890	1,270	1,491	1,587	1,546	2,383
UK (Scotland)	21,009	15,640	15,416	7,852	6,650	4,936	6,857	6,511	7,185	9,052
Others	0	0	0	0	0	0	786	-	-	-
Danish industrial by-catch *	.	.	105	22	17	21	11	23	1	72
Norwegian industrial by-catch *	.	.	.	.	.	.	48	101	22	4
Total Nominal Catch	60,881	41,713	44,526	25,958	23,806	22,500	23,119	20,102	22,262	27,497
Unallocated landings	-1,114	-740	-2,333	-1,875	-1,277	356	-2,041	-1,046	-605	136
WG estimate of total landings	**59,767**	**40,973**	**42,193**	**24,083**	**22,529**	**22,855**	**21,078**	**19,056**	**21,657**	**27,634**
Agreed TAC	**81,000**	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**

Division VIId										
Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	110	93	51	54	47	51	80	84	154	73
Denmark	-	-	-	-	-	-	-	-	-	-
France	3,084	1,677	1,361	1,730	810	986	1,124	1,743	1,326	1,779
Netherlands	4	17	6	36	14	9	9	59	30	35
UK (E/W/NI)	385	249	145	121	103	184	267	174	144	133
UK (Scotland)	-	-	-	-	-	-	1	12	7	3
Total Nominal Catch	3,583	2,036	1,563	1,941	974	1,230	1,480	2,073	1,662	2,023
Unallocated landings	-1,258	-463	1,576	190	40	29	-2	74	-33	-135
WG estimate of total landings	**2,325**	**1,573**	**3,139**	**2,131**	**1,014**	**1,259**	**1,479**	**2,147**	**1,629**	**1,887**
Agreed TAC										**1,678**

Division IIIa (Skagerrak)**										
Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Denmark	7,684	5,900	5,525	3,067	3,038	3,019	2,513	2,246	2,553	3,024
Germany	54	32	83	49	99	86	94	67	94	55
Norway	926	762	645	825	856	759	628	681	779	440
Sweden	1,293	1,035	897	510	495	488	372	370	365	459
Others	-	-	-	27	24	21	373	385	13	2
Danish industrial by-catch *	99	687	20	5	4	2	3	2	7	2
Total Nominal Catch	9,957	7,729	7,170	4,483	4,516	4,375	3,983	3,751	3,811	3,982
Unallocated landings	-680	-643	-316	-504	-602	-376	-725	-732	-418	-188
WG estimate of total landings	**9,277**	**7,086**	**6,854**	**3,979**	**3,914**	**3,998**	**3,258**	**3,020**	**3,393**	**3,794**
Agreed TAC	**11,600**	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Nominal Catch	74,421	51,478	53,260	32,382	29,296	28,104	28,582	25,926	27,735	33,502
Unallocated landings	-3,052	-1,846	-1,074	-2,189	-1,839	9	-2,767	-1,703	-1,056	-187
WG estimate of total landings	**71,369**	**49,632**	**52,186**	**30,193**	**27,457**	**28,113**	**25,815**	**24,223**	**26,679**	**33,315**

** 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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Danish industrial by-catch *	99	687	-	-	-	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	.	48	101	22	4
Total	**99**	**687**	.	.	.	.	**48**	**101**	**22**	**4**

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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belgium	666	653	862	1,075	1,258	1,223	1,103	695	818	727
Denmark	5,686	4,863	4,803	4,536	5,457	6,026	6,713	6,119	5,489	4,964
Faroe Islands	32	-	-	-	-	-	-	-	.	0
France	782	619	369	287	637	517	391	401	583	450
Germany	2,844	2,211	2,385	1,921	2,257	2,133	2,083	2,300	1,506	822
Greenland	-	-	-	-	-	-	2	1	.	.
Netherlands	2,657	1,928	1,955	1,344	1,242	1,403	1,365	653	513	716
Norway	4,495	4,898	4,601	4,080	4,600	5,404	5,627	5,521	5,553	4,518
Poland	-	2	-	-	-	-	-	-	.	.
Sweden	362	316	471	332	401	415	373	387	274	344
UK (E/W/NI)	2,553	2,169	1,629	2,129	2,962	.	.	.	.	.
UK (Scotland)	11,567	10,141	10,565	10,619	10,517	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	14,889	16,603	18,523	21,054	15,589
Others	-	-	-	-	-	-	-	0	-	-
Danish industrial by-catch	12	0	0	2	24	0	5	147	0	2
Norwegian indust by-catch *	201	1	.	.	.	.	.	.	.	.
Total Nominal Catch	31,657	27,799	27,640	26,324	29,355	32,011	34,265	34,746	35,789	28,130
Unallocated landings	-677	-1,124	-1,013	-1,009	-805	-767	-1,230	-1,637	-1,345	428
BMS landings	-	-	-	-	-	-	-	1	8	41
WG estimate of total landings	**30,980**	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**	**33,109**	**34,444**	**28,558**
Agreed TAC	**33,552**	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**33,651**	**39,220**	**43,156**	**29,437**

Division VIId

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belgium	57	56	40	53	72	78	39	18	8	3
Denmark	-	-	-	-	-	-	-	.	.	.
France	1,606	1,078	885	768	1,270	1,142	279	92	35	15
Netherlands	45	51	40	38	50	52	40	22	10	3
UK (E/W/NI)	127	125	99	100	156	.	.	.	.	.
UK (Scotland)	1	1	-	-	-	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	162	102	48	39	17
Total Nominal Catch	1,836	1,311	1,064	959	1,548	1,434	459	180	92	37
Unallocated landings	-128	8	56	-43	-112	-36	-38	-10	-8	-1
WG estimate of total landings	**1,708**	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**	**170**	**84**	**36**
Agreed TAC	**1,955**	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**1,961**	**2,059**	**1,733**	**1,715**

Division IIIa (Skagerrak)**

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	3,286	3,118	3,178	3,033	3,430	3,344	3,696	3,665	4,220	2,740
Germany	94	67	94	67	94	67	94	67	86	53
Norway	375	421	615	575	533	500	551	486	288	152
Sweden	458	518	520	529	570	571	641	557	668	354
Others	26	-	-	33	28	26	25	-	58	40
Danish industrial by-catch	10	0	1	1	5	5	0	40	7	1
Total Nominal Catch	4,249	4,124	4,408	4,239	4,660	4,512	5,006	4,815	5,327	3,338
Unallocated landings	-191	-168	-81	-84	27	51	-232	-100	157	140
BMS landings	-	-	-	-	-	-	-	1	4	3
WG estimate of total landings	**4,057**	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**	**4,715**	**5,484**	**3,478**
Agreed TAC	**4,793**	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**4,807**	**5,744**	**7,995**	**4,205**

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Nominal Catch	37,742	33,234	33,112	31,522	35,563	37,958	39,730	39,741	41,208	31,506
Unallocated landings	-996	-1,284	-1,038	-1,136	-890	-752	-1,500	-1,747	-1,196	567
BMS landings	.	.	.	.	.	.	.	2	12	44
WG estimate of total landings	**36,746**	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**	**37,994**	**40,012**	**32,072**

*** 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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Norwegian indust by-catch *	201	1	.	.	.	.	.	.	.	.
Total	**201**	**1**	.	.	.	.	.	.	.	.

Table 4.2a. **Cod in Subarea 4, Division 7.d and Subdivision 20: Landings numbers at age (Thousands). Swedish landings in Subarea 4 for 2019 were added after InterCatch raising.**

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
1	1099	665	683	2240	686	167	351	170	892
2	4540	2230	2688	4207	6384	2035	2240	6004	1860
3	4046	5367	3063	4376	4903	5644	3233	3599	6022
4	1408	1963	2592	1605	1933	3150	3495	2039	1098
5	610	633	865	1286	745	1012	1660	1776	927
6	451	248	190	332	584	277	385	780	496
7	48	139	84	64	144	188	94	282	338
8	27	15	38	38	22	44	78	67	82
9	5	4	5	6	6	9	24	45	61
10	2	4	1	2	1	5	9	15	4
+gp	2	1	1	0	2	2	2	9	6
TOTALNUM	12237	11269	10208	14156	15411	12534	11571	14789	11786
TONSLAND	31950	32074	30386	34673	37205	38230	37994	40012	32072
SOPCOF %	100	100	100	100	100	100	101	100	99

Table 4.2b. **Cod in Subarea 4, Division 7.d and Subdivision 20: Discard numbers at age (including BMS landings from 2016; Thousands). Discards corresponding to Swedish landings in Subarea 4 for 2019 were added after InterCatch raising.**

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
1	3936	11149	6188	7756	3980	3067	9767	2771	4118
2	7851	5190	6055	6504	8935	4942	2814	9039	1618
3	925	1422	856	1434	1965	3110	1271	737	916
4	81	115	397	163	180	257	493	147	16
5	6	5	83	58	55	31	96	8	4
6	4	1	40	5	64	1	9	0	0
7	1	1	16	0	15	0	1	0	0
8	1	0	0	0	5	0	1	0	0
9	0	0	0	0	3	0	0	2	0
10	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0
TOTALNUM	12804	17884	13635	15921	15201	11409	14453	12704	6672
TONSDISC	8745	8689	10324	10666	12562	12315	8731	7824	3612
SOPCOF %	100	101	100	101	100	101	100	101	101

Table 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch numbers at age (Thousands). Swedish catches in Subarea 4 for 2019 were added after InterCatch raising.

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
1	5035	11815	6871	9995	4666	3234	10118	2942	5010
2	12391	7420	8743	10711	15319	6977	5054	15043	3478
3	4970	6789	3919	5810	6869	8754	4504	4337	6938
4	1489	2077	2989	1768	2113	3408	3987	2186	1114
5	616	638	949	1345	800	1044	1756	1784	931
6	455	249	229	337	648	279	395	780	496
7	49	139	100	64	159	188	95	282	338
8	28	15	38	38	27	44	79	67	82
9	5	4	5	6	9	9	24	47	61
10	2	4	2	2	1	5	9	15	4
+gp	2	1	1	0	2	2	2	9	6
TOTALNUM	25041	29153	23844	30076	30612	23942	26024	27493	18458
TONSLAND	40695	40763	40710	45339	49767	50544	46725	47836	35684
SOPCOF %	100	100	100	100	100	100	101	100	99

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 2019. Swedish catches in Subarea 4 were not uploaded to InterCatch and are therefore not included below.**

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	29	60	172	569	53	883
2	169	323	493	821	34	1840
3	976	1710	1763	1412	96	5957
4	208	344	334	189	12	1087
5	222	312	222	151	9	916
6	209	119	101	56	6	491
7	104	94	94	39	4	335
8	35	20	21	4	1	81
9	33	9	17	1	1	61
10	1	1	1	0	0	3
+gp	2	2	2	1	0	7
TOTALNUM	1988	2994	3220	3243	216	11661

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	295	343	676	1668	1090	4072
2	291	416	361	277	256	1601
3	181	385	101	81	158	906
4	2	6	3	1	4	16
5	3	0	0	0	0	3
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	772	1150	1141	2027	1508	6598

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	325	403	848	2237	1143	4956
2	460	739	854	1098	290	3441
3	1157	2095	1864	1492	254	6862
4	210	350	337	190	16	1103
5	225	312	223	152	9	921
6	209	119	101	56	6	491
7	104	94	94	39	4	335
8	35	20	21	4	1	81
9	33	9	17	1	1	61
10	1	1	1	0	0	3
+gp	2	2	2	1	0	7
TOTALNUM	2761	4144	4362	5270	1724	18261

Table 4.2e. Cod in Subarea 4, Division 7.d and Subdivision 20: Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2018, calculated as the weight in each area–season–métier stratum covered by the relevant sampling, then summed over métiers and expressed as a proportion of the total for the area–season (note the country dimension is not used). Also provided is the contribution of landings and discards in each area (by weight) to the total for that catch category (before raising is conducted). BMS landings are included with discards as unwanted catch.

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	79%	74%	73%	81%	100%
27.3.a.20	85%	89%	76%	62%	-
27.7.d	61%	7%	46%	19%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	96%	86%	86%	94%	40%
27.3.a.20	98%	96%	95%	95%	-
27.7.d	37%	-	16%	53%	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	95%	66%	78%	87%	99%
27.3.a.20	100%	100%	95%	98%	-
27.7.d	-	-	-	-	-

Contribution to total (before raising)

Area/Type	Landings	Discards
27.4	89%	71%
27.3.a.20	11%	29%
27.7.d	0%	0%

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

Landings weights at age (kg)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.538	0.496	0.581	0.579	0.590	0.640	0.544	0.626	0.579	0.616	0.559	0.594
2	1.004	0.863	0.965	0.994	1.035	0.973	0.921	0.961	0.941	0.836	0.869	1.039
3	2.657	2.377	2.304	2.442	2.404	2.223	2.133	2.041	2.193	2.086	1.919	2.217
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776	4.156
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488	6.174
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453	8.333
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019	9.889
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810	10.791
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077	12.175
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359	12.425
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886	13.731

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

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

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.640	0.611	0.725	0.626	0.573	0.726	0.747	0.793	0.830	1.067	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
1	0.862	0.938	0.883	0.699	0.596	0.800	0.753	0.607	0.764
2	1.328	1.369	1.240	1.213	1.206	1.315	1.119	1.065	1.119
3	2.525	2.354	2.461	2.390	2.291	2.342	2.379	1.943	2.136
4	4.596	4.175	4.164	4.180	4.112	3.862	3.906	3.838	3.707
5	6.481	6.391	6.187	5.678	5.935	5.744	5.393	5.633	5.504
6	7.843	8.115	8.347	7.435	6.920	7.342	6.897	6.829	7.188
7	9.681	9.092	9.817	9.191	8.775	7.928	8.906	7.683	7.764
8	9.629	11.799	9.486	9.180	9.622	8.717	8.664	8.867	9.667
9	10.845	12.548	11.364	11.469	10.654	10.367	9.586	8.481	6.793
10	14.436	11.436	10.935	16.456	13.838	11.926	17.579	8.972	11.469
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.812

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/YEAR	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/YEAR	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/YEAR	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/YEAR	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/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.277	0.234	0.334	0.311	0.326	0.364	0.231	0.281	0.327
2	0.677	0.556	0.796	0.742	0.759	0.939	0.771	0.607	0.556
3	2.057	1.867	1.493	1.772	1.617	1.767	1.881	1.410	1.381
4	4.099	3.803	3.375	3.128	3.158	3.092	3.002	2.662	2.284
5	5.576	6.456	4.048	3.826	3.983	4.687	3.629	3.560	2.641
6	6.071	8.579	8.419	4.642	5.303	5.439	5.172	0.000	0.000
7	8.264	9.733	7.086	4.423	6.940	0.000	5.313	0.000	0.000
8	6.213	0.000	0.000	0.000	8.390	0.000	4.577	0.000	0.000
9	11.617	0.000	0.000	0.000	4.087	0.000	0.000	9.790	0.000
10	0.000	16.370	16.370	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

Table 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch weights at age (kg), also assumed to represent stock weights-at-age.

Catch weights at age (kg)

AGE/YEAR	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	0.756	0.845	0.834	0.729	0.700	0.901
3	2.647	2.366	2.296	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/YEAR	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	7.046	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	0.437	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	1.965	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/YEAR	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/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.405	0.274	0.388	0.398	0.366	0.387	0.249	0.300	0.405
2	0.915	0.800	0.932	0.927	0.945	1.049	0.925	0.790	0.857
3	2.438	2.252	2.249	2.237	2.098	2.138	2.238	1.853	2.036
4	4.569	4.154	4.060	4.083	4.031	3.803	3.794	3.759	3.687
5	6.472	6.392	5.999	5.598	5.802	5.712	5.296	5.624	5.492
6	7.829	8.117	8.360	7.392	6.761	7.332	6.857	6.829	7.188
7	9.656	9.095	9.385	9.190	8.602	7.928	8.850	7.683	7.764
8	9.461	11.799	9.486	9.180	9.410	8.717	8.618	8.867	9.667
9	10.853	12.548	11.364	11.469	8.663	10.367	9.586	8.546	6.793
10	14.436	11.754	11.680	16.456	13.838	11.926	17.579	8.972	11.469
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.812

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 2019 (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	0.492	0.727	0.833	0.762	0.75	0.764
2	0.838	0.889	1.203	1.219	1.056	1.119
3	1.771	1.812	2.31	2.569	2.035	2.136
4	3.412	3.191	4.191	4.078	4.323	3.707
5	4.727	5.508	6.029	5.867	5.502	5.504
6	6.838	6.865	8.17	7.424	7.086	7.188
7	7.79	7.424	8.343	7.122	7.799	7.764
8	8.805	11.456	9.122	11.428	8.092	9.667
9	6.42	6.483	7.447	10.533	6.733	6.793
10	12.717	10.265	11.574	12.268	16.027	11.469
+gp	21.887	19.091	24.346	21.8	22.393	21.809

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.233	0.275	0.322	0.46	0.169	0.327
2	0.455	0.605	0.552	0.596	0.554	0.556
3	1.173	1.582	1.44	1.187	1.193	1.381
4	2.648	2.416	2.317	2.429	1.913	2.284
5	2.641	2.641	2.641	2.641	2.641	2.641
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	0.256	0.341	0.426	0.537	0.196	0.405
2	0.596	0.729	0.928	1.062	0.613	0.857
3	1.677	1.77	2.263	2.495	1.511	2.036
4	3.406	3.179	4.174	4.071	3.667	3.687
5	4.698	5.506	6.024	5.863	5.489	5.492
6	6.838	6.865	8.17	7.424	7.086	7.188
7	7.79	7.424	8.343	7.122	7.799	7.764
8	8.805	11.456	9.122	11.428	8.092	9.667
9	6.42	6.483	7.447	10.533	6.733	6.793
10	12.717	10.265	11.574	12.268	16.027	11.469
+gp	21.887	19.091	24.346	21.8	22.393	21.809

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.**

Tonnage landed, discarded and caught

year	landings	discards	catch
1963	115893	12199	128092
1964	125393	4656	130049
1965	180120	28973	209092
1966	220197	37862	258059
1967	251687	23285	274972
1968	286948	17468	304417
1969	199746	4757	204503
1970	224993	17663	242656
1971	326492	84007	410498
1972	352161	33603	385764
1973	237874	29966	267840
1974	213215	39533	252748
1975	204249	36841	241089
1976	233007	72397	305404
1977	208318	139027	347345
1978	294640	32434	327074
1979	266019	162278	428297
1980	293753	294208	587962
1981	333616	57076	390691
1982	302365	54008	356372
1983	257634	21430	279065
1984	227070	151004	378074
1985	214354	31298	245651
1986	201279	138604	339883
1987	216041	27706	243747
1988	183202	10504	193706
1989	139578	61656	201233
1990	124835	26747	151582
1991	101442	18199	119641
1992	112740	36193	148932
1993	119947	21412	141358
1994	109915	98208	208123
1995	136397	31707	168104
1996	124721	14030	138751
1997	122434	33184	155618
1998	144637	40102	184740
1999	94108	13642	107749
2000	69567	13360	82927
2001	48440	13519	61960
2002	53152	11901	65053
2003	30426	4007	34433
2004	27748	8721	36469
2005	28165	9932	38097
2006	25665	11923	37589
2007	24215	30422	54637
2008	26814	24984	51798
2009	33177	20846	54023
2010	36762	12341	49103
2011	31979	8711	40689
2012	32124	8638	40762
2013	30474	10289	40763
2014	34651	10538	45190
2015	37373	12537	49910
2016	38104	12203	50307
2017	37668	8702	46371
2018	40153	7744	47898
2019	32362	3559	35921

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

	Age					
	1	2	3	4	5	6+
1963	0.010	0.050	0.230	0.620	0.860	1.000
1964	0.010	0.050	0.230	0.620	0.860	1.000
1965	0.010	0.050	0.230	0.620	0.860	1.000
1966	0.010	0.050	0.230	0.620	0.860	1.000
1967	0.010	0.050	0.230	0.620	0.860	1.000
1968	0.010	0.050	0.230	0.620	0.860	1.000
1969	0.010	0.050	0.230	0.620	0.860	1.000
1970	0.010	0.050	0.230	0.620	0.860	1.000
1971	0.010	0.050	0.230	0.620	0.860	1.000
1972	0.010	0.050	0.230	0.620	0.860	1.000
1973	0.011	0.051	0.236	0.637	0.883	1.000
1974	0.010	0.052	0.229	0.615	0.851	1.000
1975	0.009	0.054	0.223	0.592	0.819	1.000
1976	0.009	0.055	0.218	0.570	0.787	1.000
1977	0.007	0.056	0.213	0.550	0.758	1.000
1978	0.006	0.057	0.209	0.531	0.731	1.000
1979	0.005	0.058	0.207	0.515	0.709	1.000
1980	0.004	0.058	0.205	0.502	0.691	1.000
1981	0.004	0.059	0.205	0.493	0.679	1.000
1982	0.005	0.060	0.208	0.489	0.675	1.000
1983	0.006	0.063	0.214	0.490	0.677	1.000
1984	0.008	0.067	0.223	0.497	0.685	1.000
1985	0.010	0.071	0.239	0.509	0.700	1.000
1986	0.013	0.077	0.259	0.527	0.719	1.000
1987	0.015	0.083	0.286	0.549	0.741	1.000
1988	0.016	0.089	0.318	0.575	0.766	1.000
1989	0.017	0.095	0.352	0.603	0.791	1.000
1990	0.016	0.101	0.387	0.631	0.816	1.000
1991	0.015	0.107	0.420	0.659	0.839	1.000
1992	0.013	0.112	0.447	0.685	0.859	1.000
1993	0.011	0.118	0.468	0.708	0.878	1.000
1994	0.008	0.125	0.482	0.728	0.894	1.000
1995	0.006	0.133	0.488	0.744	0.907	1.000
1996	0.005	0.144	0.491	0.757	0.918	1.000
1997	0.004	0.158	0.492	0.767	0.928	1.000
1998	0.004	0.174	0.495	0.776	0.935	1.000
1999	0.004	0.193	0.504	0.784	0.940	1.000
2000	0.005	0.214	0.522	0.792	0.944	1.000
2001	0.007	0.236	0.549	0.801	0.947	1.000
2002	0.009	0.259	0.584	0.810	0.949	1.000
2003	0.012	0.280	0.626	0.820	0.951	1.000
2004	0.016	0.300	0.669	0.831	0.952	1.000
2005	0.022	0.317	0.709	0.841	0.953	1.000
2006	0.028	0.331	0.742	0.850	0.953	1.000
2007	0.034	0.342	0.764	0.859	0.954	1.000
2008	0.041	0.350	0.773	0.865	0.954	1.000
2009	0.048	0.356	0.768	0.870	0.954	1.000
2010	0.053	0.359	0.751	0.873	0.954	1.000
2011	0.058	0.361	0.725	0.874	0.953	1.000
2012	0.060	0.360	0.694	0.873	0.951	1.000
2013	0.061	0.358	0.663	0.871	0.950	1.000
2014	0.059	0.353	0.635	0.868	0.948	1.000
2015	0.055	0.347	0.615	0.865	0.946	1.000
2016	0.050	0.339	0.602	0.860	0.944	1.000
2017	0.043	0.329	0.598	0.855	0.942	1.000
2018	0.035	0.319	0.600	0.851	0.941	1.000
2019	0.026	0.307	0.608	0.846	0.939	1.000
2020	0.018	0.295	0.617	0.840	0.938	1.000

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

	Age					
y	1	2	3	4	5	6
1963	1.100	0.643	0.213	0.2	0.2	0.2
1964	1.100	0.643	0.213	0.2	0.2	0.2
1965	1.100	0.643	0.213	0.2	0.2	0.2
1966	1.100	0.643	0.213	0.2	0.2	0.2
1967	1.100	0.643	0.213	0.2	0.2	0.2
1968	1.100	0.643	0.213	0.2	0.2	0.2
1969	1.100	0.643	0.213	0.2	0.2	0.2
1970	1.100	0.643	0.213	0.2	0.2	0.2
1971	1.100	0.643	0.213	0.2	0.2	0.2
1972	1.100	0.643	0.213	0.2	0.2	0.2
1973	1.100	0.643	0.213	0.2	0.2	0.2
1974	1.100	0.643	0.213	0.2	0.2	0.2
1975	1.113	0.638	0.216	0.2	0.2	0.2
1976	1.127	0.634	0.218	0.2	0.2	0.2
1977	1.141	0.631	0.221	0.2	0.2	0.2
1978	1.154	0.629	0.223	0.2	0.2	0.2
1979	1.164	0.629	0.225	0.2	0.2	0.2
1980	1.172	0.631	0.228	0.2	0.2	0.2
1981	1.175	0.635	0.230	0.2	0.2	0.2
1982	1.174	0.639	0.232	0.2	0.2	0.2
1983	1.168	0.643	0.234	0.2	0.2	0.2
1984	1.157	0.646	0.236	0.2	0.2	0.2
1985	1.143	0.650	0.238	0.2	0.2	0.2
1986	1.127	0.653	0.240	0.2	0.2	0.2
1987	1.111	0.657	0.242	0.2	0.2	0.2
1988	1.095	0.663	0.244	0.2	0.2	0.2
1989	1.082	0.670	0.246	0.2	0.2	0.2
1990	1.070	0.677	0.247	0.2	0.2	0.2
1991	1.061	0.685	0.249	0.2	0.2	0.2
1992	1.054	0.693	0.251	0.2	0.2	0.2
1993	1.048	0.700	0.255	0.2	0.2	0.2
1994	1.045	0.708	0.259	0.2	0.2	0.2
1995	1.042	0.717	0.265	0.2	0.2	0.2
1996	1.040	0.728	0.274	0.2	0.2	0.2
1997	1.037	0.740	0.284	0.2	0.2	0.2
1998	1.035	0.755	0.295	0.2	0.2	0.2
1999	1.033	0.771	0.308	0.2	0.2	0.2
2000	1.033	0.790	0.322	0.2	0.2	0.2
2001	1.038	0.811	0.335	0.2	0.2	0.2
2002	1.047	0.834	0.348	0.2	0.2	0.2
2003	1.061	0.857	0.359	0.2	0.2	0.2
2004	1.077	0.880	0.366	0.2	0.2	0.2
2005	1.094	0.899	0.369	0.2	0.2	0.2
2006	1.110	0.914	0.368	0.2	0.2	0.2
2007	1.125	0.924	0.363	0.2	0.2	0.2
2008	1.139	0.929	0.356	0.2	0.2	0.2
2009	1.151	0.929	0.348	0.2	0.2	0.2
2010	1.163	0.927	0.340	0.2	0.2	0.2
2011	1.177	0.923	0.333	0.2	0.2	0.2
2012	1.193	0.918	0.327	0.2	0.2	0.2
2013	1.212	0.912	0.324	0.2	0.2	0.2
2014	1.233	0.907	0.321	0.2	0.2	0.2
2015	1.256	0.902	0.320	0.2	0.2	0.2
2016	1.280	0.897	0.320	0.2	0.2	0.2
2017*	1.280	0.897	0.320	0.2	0.2	0.2
2018*	1.280	0.897	0.320	0.2	0.2	0.2
2019*	1.280	0.897	0.320	0.2	0.2	0.2

***A new key run was performed in 2017 with data up to 2016 (ICES WGSAM 2017), so the 2017–2018 M–values are assumed equal to 2016.**

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

IBTS_Q1_gam						
1983	2020					
1	1	0	0.25			
1	5					
1	**3855.89**	**19070.69**	**2293.07**	**1168.56**	**404.16**	350.16
1	**11592.65**	**7327.29**	**3175.23**	**567.04**	**449.34**	162.10
1	**556.04**	**19652.29**	**2810.83**	**1002.39**	**247.72**	241.84
1	**11202.77**	**3164.46**	**4515.89**	**1220.12**	**447.98**	207.57
1	**4733.71**	**18662.18**	**984.53**	**974.97**	**231.36**	178.04
1	**2509.87**	**4587.41**	**4698.45**	**228.01**	**365.13**	188.35
1	**8799.08**	**4440.14**	**3578.16**	**1459.07**	**172.31**	218.74
1	**1937.04**	**9442.29**	**1524.38**	**523.49**	**508.47**	72.42
1	**1582.22**	**2880.92**	**2641.81**	**626.29**	**281.51**	238.69
1	**8570.45**	**3800.21**	**1010.30**	**642.41**	**165.03**	60.14
1	**3038.01**	**10237.46**	**1308.35**	**426.90**	**259.36**	69.75
1	**6462.86**	**2825.80**	**2132.80**	**605.38**	**236.60**	111.96
1	**6396.55**	**12058.61**	**2496.00**	**656.33**	**193.53**	66.94
1	**1691.40**	**5298.98**	**3249.89**	**516.20**	**271.02**	61.25
1	**14156.46**	**3930.39**	**1651.72**	**661.90**	**169.79**	99.50
1	**599.21**	**12631.11**	**1587.81**	**617.97**	**305.49**	91.85
1	**1289.67**	**608.93**	**5717.22**	**656.69**	**296.83**	86.93
1	**3331.99**	**2741.81**	**681.43**	**1179.93**	**179.72**	98.14
1	**795.25**	**5029.34**	**1175.21**	**199.56**	**153.66**	50.01
1	**2681.54**	**1993.55**	**2143.15**	**306.53**	**58.38**	53.37
1	**326.96**	**2592.95**	**984.98**	**589.95**	**162.14**	28.02
1	**2492.37**	**1632.17**	**1533.80**	**235.85**	**192.22**	65.92
1	**997.82**	**1924.51**	**656.38**	**494.02**	**71.02**	99.00
1	**3477.35**	**1134.45**	**1043.85**	**196.73**	**88.66**	51.92
1	**1318.90**	**3377.07**	**940.33**	**286.32**	**89.64**	60.77
1	**2114.27**	**1389.28**	**1587.66**	**363.98**	**205.74**	46.05
1	**1016.59**	**2296.27**	**1116.99**	**486.97**	**128.79**	67.17
1	**2581.44**	**2113.67**	**1575.34**	**411.49**	**210.18**	76.32
1	**700.42**	**3816.86**	**826.41**	**418.30**	**217.59**	120.00
1	**1494.57**	**1994.21**	**2521.57**	**506.81**	**231.99**	71.77
1	**1542.74**	**1906.63**	**1059.06**	**686.74**	**382.12**	92.13
1	**2519.21**	**2269.42**	**1020.43**	**359.57**	**354.51**	100.79
1	**1605.01**	**4703.99**	**1709.55**	**563.98**	**202.40**	137.30
1	**933.80**	**1437.91**	**2613.33**	**766.77**	**370.10**	125.61
1	**7474.77**	**1175.09**	**1673.56**	**1290.58**	**596.18**	123.14
1	**449.41**	**3495.53**	**721.08**	**377.25**	**265.71**	199.09
1	**1245.91**	**679.44**	**1291.02**	**120.57**	**89.71**	68.57
1	**2416.39**	**1517.26**	**442.66**	**374.42**	**67.72**	21.31
IBTS_Q3_gam						
1992	2019					
1	1	0.50	0.75			
1	4					
1	**18743.17**	**1836.32**	**405.97**	**381.77**	124.16	48.15
1	**4981.30**	**4884.41**	**648.54**	**140.30**	97.17	7.59
1	**19250.55**	**2497.42**	**995.15**	**177.34**	45.35	34.27
1	**10161.28**	**7644.33**	**766.42**	**333.27**	35.92	19.61
1	**5402.11**	**3159.47**	**1134.44**	**191.95**	145.04	13.77
1	**30865.99**	**2169.52**	**764.20**	**292.45**	53.36	35.86
1	**917.94**	**9744.78**	**713.43**	**203.80**	123.92	40.79
1	**3612.96**	**516.32**	**2523.23**	**166.55**	44.30	18.05
1	**6659.76**	**1031.05**	**122.33**	**365.96**	41.95	32.02
1	**1475.08**	**2362.20**	**395.39**	**84.33**	67.13	40.16
1	**4149.41**	**977.77**	**784.54**	**207.38**	55.39	24.39
1	**978.08**	**1356.01**	**255.43**	**193.60**	110.42	82.16
1	**3212.60**	**827.92**	**501.59**	**101.54**	77.38	27.62
1	**1100.35**	**802.97**	**297.59**	**126.45**	28.77	50.65
1	**5562.87**	**782.10**	**630.21**	**128.58**	32.22	20.49
1	**1931.09**	**2454.22**	**449.39**	**188.37**	106.57	50.25
1	**2511.52**	**1315.23**	**1161.82**	**244.64**	133.70	35.85
1	**1939.37**	**1041.03**	**303.50**	**251.78**	57.88	27.88
1	**4592.29**	**1707.49**	**552.98**	**193.90**	117.77	23.07
1	**1258.05**	**3073.16**	**947.71**	**412.27**	120.72	113.99
1	**2206.23**	**1094.88**	**1307.78**	**399.98**	111.51	21.03
1	**3181.75**	**1181.70**	**497.63**	**524.11**	148.73	69.20
1	**3467.21**	**1554.24**	**655.82**	**325.48**	211.16	102.41
1	**1896.76**	**3114.26**	**1080.73**	**488.57**	143.74	138.47
1	**1445.04**	**1201.05**	**1686.39**	**881.82**	217.70	139.22
1	**7316.26**	**637.48**	**458.37**	**431.52**	228.88	49.80
1	**1125.44**	**2229.76**	**368.15**	**222.21**	152.76	103.75
1	**2995.7535**	**477.5347**	**601.7485**	**115.2948**	74.9437	46.5554

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

```
# 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
 6

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

$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
   0   1   2   3   4   5
  -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
   0   1   2   3   4  -1
   5   6   7   8  -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

$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row
is used)
   0   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

$keyVarObs
# Coupling of the variance parameters for the observations.
   0   1   2   2   2   2
   3   4   4   4   4  -1
   5   6   6   6  -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"

$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
  NA  NA  NA  NA  NA
  NA  NA  NA  NA  -1
  NA  NA  NA  -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.
 13

$keyScaledYears
# A vector of the years where catch scaling is applied.
 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols
= no ages).
 0    0    0    0    0    0
 1    1    1    1    1    1
 2    2    2    2    2    2
 3    3    3    3    3    3
 4    4    4    4    4    4
 5    5    5    5    5    5
 6    6    6    6    6    6
 7    7    7    7    7    7
 8    8    8    8    8    8
 9    9    9    9    9    9
 10   10   10   10   10   10
 11   11   11   11   11   11
 12   12   12   12   12   12


$fbarRange
# lowest and highest age included in Fbar
 2 4

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB
index).
 -1 -1 -1

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

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
--183.469	34	434.9387

	value	std.dev	logq.Q1_1	logq.Q1_2	logq.Q1_3	logq.Q1_4	logq.Q1_5	logq.Q3_1	logq.Q3_2	logq.Q3_3	logq.Q3_4	logSd.LogF	logSd.LogF	logSd.LogN	logSd.LogN	logSd.LogC	logSd.LogC	logSd.Log3	logSd.logQ	logSd.LodQ	logSd.LogQ	LogSd.Log	itrans_rho	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult1	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2	log.Cmult2
logq Q1_1	-4.72	0.09	1																																	
logq Q1_2	-3.01	0.05	0.22	1																																
logq Q1_3	-2.32	0.05	0.17	0.3	1																															
logq Q1_4	-2.33	0.06	0.19	0.32	0.4	1																														
logq Q1_5	-2.21	0.08	0.2	0.35	0.44	0.58	1																													
logq Q3_1	-3.44	0.08	0.21	0.27	0.22	0.24	0.26	1																												
logq Q3_2	-2.81	0.06	0.21	0.36	0.33	0.36	0.39	0.27	1																											
logq Q3_3	-2.53	0.07	0.19	0.33	0.41	0.46	0.51	0.24	0.37	1																										
logq Q3_4	-2.43	0.09	0.2	0.35	0.44	0.57	0.66	0.26	0.39	0.51	1																									
logSd LogF1	-1.89	0.21	-0.04	-0.03	-0.05	-0.07	-0.09	-0.04	-0.05	-0.06	-0.08	1																								
logSd LogF2+	-2.42	0.14	-0.09	-0.17	-0.2	-0.26	-0.32	-0.12	-0.19	-0.23	-0.3	0.4	1																							
logSd LogN1	-0.25	0.11	-0.03	-0.03	-0.03	-0.04	-0.04	-0.03	-0.03	-0.04	-0.05	0	0.02	1																						
logSd LogN2+	-2.11	0.13	-0.03	-0.05	-0.06	-0.06	-0.04	-0.05	-0.04	-0.08	-0.09	-0.03	0	0.24	1																					
logSd LogC1	-0.54	0.11	0.01	0.01	0.02	0.02	0.02	0	0.02	0.02	0.03	-0.08	0	-0.09	-0.08	1																				
logSd LogC2	-1.47	0.13	0.02	0.03	0.04	0.05	0.05	0.03	0.04	0.05	0.05	0	-0.04	-0.05	-0.08	0.07	1																			
logSd Log3+	-2.81	0.29	-0.02	-0.04	-0.04	-0.08	-0.12	-0.02	-0.04	-0.06	-0.09	-0.02	-0.04	-0.11	-0.58	0.05	0.01	1																		
logSd logQ1_1	-0.73	0.13	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.04	0.01	-0.01	-0.16	-0.16	0.03	0.02	0.07	1																	
logSd LodQ1_2+	-1.34	0.07	0.09	0.15	0.18	0.21	0.25	0.1	0.16	0.21	0.26	-0.03	-0.18	-0.08	-0.14	0.02	0.01	-0.05	0.05	1																
logSd LogQ3_1	-0.98	0.16	0.04	0.06	0.05	0.06	0.05	0.05	0.04	0.06	0.06	0.01	-0.02	-0.18	-0.2	0.04	-0.04	0.09	0.17	0.08	1															
LogSd LogQ3_2+	-1.32	0.09	0.04	0.06	0.09	0.14	0.19	0.05	0.07	0.12	0.17	-0.03	-0.16	-0.07	-0.12	0.01	0	-0.06	0.05	0.13	0.08	1														
itrans_rho	1.41	0.24	-0.01	0	-0.01	-0.01	0	-0.01	0	-0.02	-0.02	0.07	0.27	0.05	0.18	0.1	0.07	0.06	-0.03	-0.08	-0.04	-0.09	1													
log Cmult1993	-0.1	0.09	-0.12	-0.2	-0.23	-0.25	-0.27	-0.14	-0.2	-0.24	-0.26	0.02	0.08	0.03	0.04	-0.02	-0.04	0.05	-0.03	-0.1	-0.06	-0.02	0.02	1												
log Cmult1994	-0.02	0.1	-0.14	-0.24	-0.27	-0.3	-0.31	-0.18	-0.25	-0.28	-0.31	0.04	0.1	0.04	0.06	0	-0.03	0.02	-0.04	-0.13	-0.07	-0.01	0.02	0.43	1											
log Cmult1995	0.11	0.1	-0.16	-0.27	-0.31	-0.35	-0.38	-0.21	-0.29	-0.33	-0.37	0.04	0.17	0.04	0.05	-0.01	-0.01	0.04	-0.04	-0.15	-0.08	-0.05	0.05	0.24	0.47	1										
log Cmult1996	-0.02	0.1	-0.16	-0.27	-0.31	-0.35	-0.38	-0.21	-0.29	-0.34	-0.37	0.02	0.17	0.04	0.07	-0.03	-0.03	0.02	-0.05	-0.14	-0.09	-0.06	0.05	0.16	0.25	0.49	1									
log Cmult1997	-0.18	0.1	-0.14	-0.23	-0.26	-0.28	-0.29	-0.18	-0.25	-0.28	-0.29	0.01	0.08	0.02	0	-0.02	-0.04	0.04	-0.03	-0.06	-0.07	0	-0.04	0.11	0.15	0.23	0.45	1								
log Cmult1998	-0.37	0.1	-0.15	-0.25	-0.29	-0.33	-0.35	-0.19	-0.28	-0.32	-0.35	0.05	0.16	0.03	0.03	-0.02	-0.03	0.03	-0.03	-0.13	-0.07	-0.04	0.01	0.13	0.15	0.19	0.26	0.45	1							
log Cmult1999	-0.21	0.1	-0.15	-0.25	-0.29	-0.32	-0.33	-0.19	-0.28	-0.32	-0.34	0.09	0.26	0.04	0.11	-0.02	-0.04	-0.03	-0.04	-0.22	-0.06	-0.08	0.06	0.13	0.16	0.18	0.19	0.22	0.46	1						
log Cmult2000	-0.17	0.1	-0.15	-0.25	-0.28	-0.31	-0.33	-0.19	-0.27	-0.31	-0.33	0.06	0.21	0.01	0.02	-0.02	-0.03	0.03	-0.01	-0.2	-0.02	0	0.02	0.14	0.16	0.19	0.18	0.15	0.24	0.47	1					
log Cmult2001	0.15	0.1	-0.14	-0.23	-0.27	-0.29	-0.3	-0.18	-0.25	-0.28	-0.3	0	0.07	0.01	0.01	-0.02	0.03	0.02	0	-0.14	-0.02	0.04	-0.04	0.13	0.16	0.18	0.17	0.14	0.16	0.22	0.45	1				
log Cmult2002	-0.23	0.1	-0.13	-0.21	-0.23	-0.24	-0.22	-0.16	-0.23	-0.24	-0.24	0.01	0.05	0.02	0.07	-0.02	-0.03	-0.03	-0.01	-0.12	-0.01	0.03	-0.03	0.11	0.14	0.15	0.15	0.13	0.13	0.14	0.21	0.44	1			
log Cmult2003	0.31	0.1	-0.15	-0.26	-0.29	-0.33	-0.35	-0.2	-0.28	-0.32	-0.35	0.04	0.15	0.01	0.02	-0.02	-0.05	0.07	-0.01	-0.2	0	0	0	0.15	0.18	0.21	0.21	0.16	0.18	0.18	0.19	0.26	0.45	1		
log Cmult2004	0.02	0.1	-0.14	-0.23	-0.26	-0.28	-0.29	-0.17	-0.25	-0.27	-0.29	0.04	0.11	0.01	0.03	-0.01	-0.03	0.03	-0.01	-0.17	0	0.03	0.01	0.13	0.16	0.18	0.18	0.15	0.16	0.16	0.15	0.16	0.22	0.47	1	
log Cmult2005	-0.1	0.09	-0.09	-0.14	-0.15	-0.15	-0.14	-0.11	-0.15	-0.16	-0.15	0	0.03	0.01	0.04	-0.01	-0.07	0	0	-0.09	0.01	0.05	0.01	0.08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.11	0.19	0.41	1

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

Year/Age	1	2	3	4	5	6+	Fbar 2-4
1963	0.091	0.471	0.518	0.473	0.474	0.523	0.487
1964	0.1	0.504	0.565	0.512	0.51	0.559	0.527
1965	0.119	0.557	0.627	0.555	0.542	0.585	0.58
1966	0.124	0.571	0.636	0.551	0.539	0.586	0.586
1967	0.135	0.604	0.674	0.585	0.58	0.627	0.621
1968	0.149	0.642	0.712	0.618	0.611	0.651	0.657
1969	0.14	0.615	0.673	0.585	0.585	0.624	0.624
1970	0.164	0.67	0.714	0.606	0.596	0.624	0.664
1971	0.209	0.772	0.801	0.671	0.65	0.672	0.748
1972	0.248	0.847	0.858	0.716	0.692	0.713	0.807
1973	0.258	0.853	0.838	0.695	0.667	0.681	0.795
1974	0.255	0.832	0.795	0.658	0.64	0.657	0.762
1975	0.291	0.897	0.851	0.701	0.681	0.689	0.816
1976	0.334	0.97	0.908	0.729	0.706	0.707	0.869
1977	0.316	0.93	0.868	0.688	0.683	0.69	0.829
1978	0.353	0.999	0.966	0.77	0.764	0.759	0.912
1979	0.326	0.935	0.918	0.721	0.701	0.695	0.858
1980	0.36	0.997	1.003	0.79	0.748	0.737	0.93
1981	0.357	1.001	1.027	0.811	0.751	0.741	0.946
1982	0.396	1.083	1.147	0.92	0.841	0.823	1.05
1983	0.384	1.07	1.142	0.927	0.838	0.817	1.046
1984	0.348	1.005	1.067	0.884	0.801	0.783	0.985
1985	0.323	0.963	1.023	0.865	0.78	0.763	0.95
1986	0.334	0.994	1.077	0.937	0.84	0.818	1.003
1987	0.312	0.964	1.055	0.931	0.831	0.811	0.983
1988	0.315	0.977	1.086	0.959	0.846	0.82	1.007
1989	0.32	0.989	1.102	0.981	0.868	0.839	1.024
1990	0.291	0.933	1.029	0.915	0.804	0.776	0.959
1991	0.276	0.907	1.018	0.923	0.822	0.79	0.95
1992	0.266	0.892	1.019	0.932	0.826	0.78	0.947
1993	0.256	0.878	1.027	0.938	0.826	0.77	0.948
1994	0.251	0.874	1.052	0.95	0.834	0.767	0.958
1995	0.252	0.892	1.103	0.983	0.861	0.778	0.993
1996	0.234	0.864	1.113	1.009	0.912	0.82	0.995
1997	0.214	0.822	1.1	1.018	0.932	0.824	0.98
1998	0.213	0.821	1.135	1.066	0.975	0.844	1.008
1999	0.214	0.828	1.191	1.139	1.051	0.893	1.053
2000	0.205	0.809	1.182	1.149	1.061	0.879	1.047
2001	0.183	0.752	1.098	1.084	1	0.813	0.978
2002	0.168	0.708	1.043	1.036	0.954	0.766	0.929
2003	0.163	0.692	1.029	1.009	0.92	0.723	0.91
2004	0.155	0.663	0.986	0.937	0.861	0.669	0.862
2005	0.142	0.624	0.926	0.861	0.815	0.629	0.804
2006	0.132	0.592	0.866	0.791	0.771	0.592	0.75
2007	0.119	0.548	0.818	0.746	0.731	0.549	0.704
2008	0.109	0.518	0.791	0.722	0.728	0.545	0.677
2009	0.105	0.505	0.79	0.731	0.741	0.54	0.675
2010	0.088	0.446	0.703	0.654	0.667	0.479	0.601
2011	0.066	0.369	0.583	0.551	0.57	0.411	0.501
2012	0.06	0.342	0.544	0.519	0.533	0.377	0.468
2013	0.057	0.333	0.54	0.516	0.523	0.36	0.463
2014	0.057	0.333	0.55	0.523	0.525	0.354	0.468
2015	0.055	0.326	0.543	0.523	0.534	0.36	0.464
2016	0.054	0.325	0.549	0.526	0.529	0.347	0.466
2017	0.063	0.357	0.617	0.59	0.584	0.374	0.521
2018	0.083	0.433	0.77	0.733	0.724	0.455	0.645
2019	0.08	0.424	0.759	0.731	0.73	0.454	0.638

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	397861	169136	19981	10202	8074	4834	610087
1964	648833	120038	51671	11449	5179	6603	843774
1965	874576	205548	40351	22827	6145	5169	1154617
1966	1061485	252191	67644	16285	9275	5781	1412661
1967	891940	308060	72859	28418	7957	7733	1316968
1968	448109	264046	90089	28690	14211	6649	851793
1969	391264	127074	72201	33933	11282	9507	645261
1970	1319001	118310	38843	32127	15236	7915	1531432
1971	1735275	383556	33619	14922	15970	10049	2193390
1972	431001	479254	90919	12126	5949	12271	1031521
1973	634169	108934	105900	29917	4940	6727	890586
1974	630369	163167	23639	36321	10890	5283	869669
1975	1085628	157334	36828	9673	16331	6787	1312582
1976	754498	272390	34026	13664	3788	9388	1087754
1977	1831202	165785	51095	10763	5093	5813	2069750
1978	1115005	429908	30878	18767	5630	4359	1604546
1979	1396762	256450	80948	8878	7291	3300	1753629
1980	2247728	300326	59297	24517	3957	4415	2640241
1981	874072	479396	59288	17582	8719	3397	1442454
1982	1405138	181734	93768	16989	6556	5319	1709504
1983	778856	301549	33505	21169	5381	4224	1144683
1984	1427094	168957	52221	7949	6698	3603	1666523
1985	351191	318467	33145	14675	2753	3948	724179
1986	1576892	82597	58106	10126	5573	2794	1736087
1987	604506	374644	16620	15346	2975	3154	1017246
1988	415364	147750	71286	5241	4881	2190	646712
1989	725003	103327	30572	17193	1812	2759	880665
1990	290041	175799	20356	7797	5016	1537	500547
1991	331095	73122	30594	5935	2641	2760	446147
1992	755064	87312	14917	8677	1985	1877	869831
1993	383798	191166	17633	4830	2717	1413	601557
1994	914881	103143	35458	5257	1634	1521	1061895
1995	523283	240054	23071	9898	1711	1156	799173
1996	336084	135053	39556	5437	3196	1255	520581
1997	1021714	95432	25825	9169	1775	1493	1155408
1998	108417	287112	20900	6693	2883	1084	427088
1999	218912	31538	52619	5160	1925	1368	311521
2000	404922	63068	8175	9241	1389	913	487708
2001	148931	121308	13654	2062	2114	628	288697
2002	223024	46490	24849	3669	559	817	299407
2003	111362	64256	10562	6820	1010	445	194456
2004	189388	36025	13890	2903	1875	486	244568
2005	152981	53042	8179	3259	951	904	219316
2006	346800	47639	12886	2159	1056	797	411337
2007	166035	100988	10347	4067	933	679	283051
2008	186679	47106	24252	3089	1538	828	263492
2009	179811	53075	11463	7332	1308	938	253926
2010	264120	53437	13063	3750	2958	862	338189
2011	129315	75712	13292	4030	1564	1717	225629
2012	176577	38765	19628	5554	1722	1459	243705
2013	218392	49609	10931	8057	2568	1390	290947
2014	303724	61583	15089	4665	3684	1722	390467
2015	148305	87244	19251	5881	2098	2913	265692
2016	111470	39083	24513	9103	2786	2067	189022
2017	284201	28581	11533	9689	4444	2212	340660
2018	72495	67972	8663	4591	3804	3498	161023
2019	156655	17693	15365	2365	1870	3029	196977
2020	262978	39474	4796	5053	885	2312	315498

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

Year/Age	1	2	3	4	5	6+
1963	21085	48073	7337	3514	2784	1799
1964	37954	36010	20283	4197	1892	2586
1965	60095	66702	17111	8897	2352	2095
1966	76101	83403	28989	6311	3535	2345
1967	69385	106414	32551	11513	3204	3297
1968	38062	95416	41849	12118	5949	2914
1969	31351	44471	32233	13763	4571	4043
1970	122643	44149	18086	13373	6260	3366
1971	202611	158494	16925	6688	6994	4504
1972	58600	211052	47871	5686	2725	5739
1973	89384	48187	54917	13744	2204	3045
1974	88122	71012	11844	16052	4716	2330
1975	169809	72136	19267	4468	7393	3097
1976	132489	131560	18539	6490	1759	4364
1977	304581	78032	27021	4909	2311	2657
1978	203119	212082	17448	9251	2760	2128
1979	236494	121264	44278	4183	3368	1515
1980	413981	147840	34206	12295	1913	2112
1981	159749	236145	34653	8975	4226	1631
1982	280429	93873	58353	9400	3425	2740
1983	151861	154424	20778	11769	2806	2165
1984	256885	83087	31144	4290	3389	1797
1985	59489	152266	19265	7809	1369	1935
1986	277015	40251	34792	5668	2909	1434
1987	100609	178694	9825	8558	1543	1609
1988	70076	70929	42812	2975	2560	1125
1989	124827	49868	18502	9900	967	1440
1990	46069	81484	11835	4300	2544	762
1991	50414	33189	17657	3292	1360	1384
1992	111415	39070	8605	4840	1025	933
1993	54795	84424	10208	2706	1404	696
1994	128663	45266	20779	2967	849	748
1995	74048	106421	13865	5705	908	574
1996	44497	58363	23818	3184	1759	645
1997	124889	39671	15381	5398	990	770
1998	13177	118692	12620	4048	1654	568
1999	26734	13027	32471	3239	1154	743
2000	47539	25461	4997	5831	838	491
2001	15717	46124	7965	1259	1231	321
2002	21702	16782	13992	2182	316	401
2003	10483	22608	5877	3993	559	210
2004	16840	12173	7511	1626	995	217
2005	12466	16999	4246	1730	487	386
2006	26229	14567	6412	1084	521	326
2007	11277	28971	4965	1962	444	263
2008	11658	12901	11415	1457	729	318
2009	10801	14242	5407	3487	628	358
2010	13217	12961	5703	1650	1319	300
2011	4918	15701	5075	1562	622	528
2012	5996	7539	7126	2057	651	418
2013	7055	9449	3953	2968	956	384
2014	9690	11746	5536	1736	1375	468
2015	4529	16365	7006	2190	794	802
2016	3348	7330	8986	3403	1047	552
2017	9792	5821	4618	3951	1799	629
2018	3296	16286	4062	2188	1798	1167
2019	6882	4167	7135	1126	889	1010

Table 4.11a. **Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated stock and management metrics, together with the lower and upper bounds of the pointwise 95% confidence intervals. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), total removals (including catches due to unaccounted mortality) and average fishing mortality for ages 2 to 4 (Fbar 2–4).**

Year	Recruits age 1 ('000)	Low	High	TSB (tonnes)	Low	High	SSB (tonnes)	Low	High	Total removals (tonnes)	Low	High	Fbar 2-4	Low	High
1963	397861	288785	548135	464815	401447	538186	145332	115009	183650	118055	104939	132810	0.487	0.422	0.563
1964	648833	471772	892346	591607	507557	689576	156998	126665	194595	144080	131083	158365	0.527	0.463	0.6
1965	874576	638410	1198107	754709	653155	872053	192122	159523	231384	198223	177382	221511	0.58	0.511	0.658
1966	1061485	775598	1452749	904386	783629	1043753	213317	177928	255745	241058	216246	268716	0.586	0.518	0.663
1967	891940	651352	1221394	959934	840751	1096012	242052	202313	289596	286656	256779	320008	0.621	0.551	0.699
1968	448109	326570	614880	821615	736009	917178	254923	219032	296695	292971	266653	321888	0.657	0.583	0.741
1969	391264	283229	540507	680719	606035	764607	251103	213477	295361	225331	208789	243185	0.624	0.555	0.703
1970	1319001	961192	1810006	1065134	886710	1279460	261273	222836	306341	251642	221578	285786	0.664	0.593	0.743
1971	1735275	1259157	2391427	1203522	1019839	1420288	264824	226257	309965	350638	301595	407656	0.748	0.672	0.834
1972	431001	312283	594849	864632	766909	974807	235810	201592	275837	362786	318194	413626	0.807	0.723	0.9
1973	634169	459742	874773	691200	614969	776880	209602	184592	238000	259812	237012	284805	0.795	0.714	0.886
1974	630369	456309	870823	662430	587137	747379	224993	197494	256321	236305	211382	264166	0.762	0.684	0.849
1975	1085628	778775	1513388	746384	636740	874909	203495	177299	233561	247507	215710	283990	0.816	0.735	0.906
1976	754498	536946	1060195	603230	529856	686766	172037	147979	200007	248057	215452	285596	0.869	0.781	0.967
1977	1831202	1312623	2554656	901575	734881	1106081	145750	125744	168939	264717	217212	322613	0.829	0.746	0.921
1978	1115005	796324	1561220	1020001	853602	1218837	144872	128619	163179	357383	295196	432670	0.912	0.822	1.011
1979	1396762	1000694	1949589	954241	815136	1117086	143234	128040	160231	341262	292292	398438	0.858	0.774	0.951
1980	2247728	1601687	3154351	1143956	950940	1376151	156274	140349	174007	395105	327248	477032	0.93	0.842	1.027
1981	874072	625036	1222332	962960	836042	1109146	164889	149311	182092	397436	339488	465276	0.946	0.859	1.042
1982	1405138	1014950	1945330	1007901	848946	1196617	163862	147848	181610	382353	325163	449602	1.05	0.954	1.155
1983	778856	571939	1060633	798036	688558	924921	135231	121678	150294	319729	273074	374355	1.046	0.952	1.15
1984	1427094	1048957	1941546	810999	681909	964527	117474	105439	130883	277239	235253	326719	0.985	0.897	1.083
1985	351191	255692	482359	551714	487814	623984	116908	104794	130422	241107	208933	278235	0.95	0.864	1.045
1986	1576892	1161952	2140009	729931	599930	888102	109166	98934	120457	228000	190531	272837	1.003	0.914	1.1
1987	604506	447377	816822	690256	593848	802315	111274	100492	123213	257172	217121	304612	0.983	0.896	1.079
1988	415364	306958	562054	512026	449529	583212	110252	101047	120296	205961	182954	231861	1.007	0.918	1.105
1989	725003	533346	985530	511065	432347	604114	102131	93109	112027	178693	153814	207597	1.024	0.933	1.124
1990	290041	215063	391159	350496	308370	398377	89061	80681	98312	138279	120931	158116	0.959	0.87	1.057
1991	331095	246058	445519	319830	278325	367526	87527	78569	97506	117936	104843	132663	0.95	0.859	1.049
1992	755064	560691	1016821	487745	401201	592959	83873	74935	93878	139496	117606	165459	0.947	0.85	1.056
1993	383798	286911	513403	383156	323019	454488	84866	71802	100308	142415	116468	174142	0.948	0.841	1.068
1994	914881	671823	1245876	486912	394702	600664	91184	76499	108688	146512	117593	182543	0.958	0.849	1.082
1995	523283	387969	705792	521253	429513	632587	104979	87800	125519	180109	143557	225966	0.993	0.879	1.121
1996	336084	250674	450594	395554	332155	471053	105387	88246	125859	148245	120642	182163	0.995	0.881	1.125
1997	1021714	747419	1396674	584620	463435	737493	90973	76622	108014	146098	115671	184528	0.98	0.869	1.105
1998	108417	80317	146348	304422	253686	365305	90540	75688	108308	128518	103339	159832	1.008	0.895	1.135
1999	218912	163830	292514	205749	173437	244080	76807	63728	92571	86973	71312	106073	1.053	0.934	1.186
2000	404922	303069	541003	258741	212331	315296	57987	48358	69533	75515	60984	93510	1.047	0.928	1.18
2001	148931	111216	199437	182815	154255	216664	56600	47554	67366	65046	53201	79527	0.978	0.867	1.103
2002	223024	167073	297711	155929	130845	185822	51327	43124	61090	51411	42368	62385	0.929	0.82	1.052
2003	111362	83144	149158	131343	111558	154637	53034	44473	63242	48463	39706	59152	0.91	0.803	1.031
2004	189388	143893	249267	115138	97598	135831	42657	35861	50741	35324	29105	42872	0.862	0.76	0.979
2005	152981	114712	204018	133820	114866	155902	45758	39373	53178	36967	30779	44399	0.804	0.704	0.917
2006	346800	265234	453449	142026	119347	169014	42682	37491	48591	31358	27914	35225	0.75	0.671	0.839
2007	166035	127113	216876	191116	168104	217278	74120	65664	83665	52339	45906	59674	0.704	0.626	0.791
2008	186679	142826	243997	197967	173182	226299	81504	72328	91845	51927	47353	56942	0.677	0.597	0.768
2009	179811	137275	235528	205639	179701	235320	86915	76171	99175	54188	49159	59731	0.675	0.59	0.772
2010	264120	200965	347121	212927	182245	248775	85417	72764	100270	48291	44042	52950	0.601	0.515	0.702
2011	129315	98580	169633	196574	168094	229879	91220	74953	111016	44197	40103	48709	0.501	0.422	0.595
2012	176577	135053	230867	170361	144838	200381	88072	71169	108989	40056	37178	43158	0.468	0.391	0.561
2013	218392	167001	285596	215966	183206	254583	93409	75478	115599	41614	38392	45107	0.463	0.388	0.552
2014	303724	231925	397749	265032	223834	313812	98484	80021	121208	45622	41777	49821	0.468	0.397	0.552
2015	148305	113504	193776	234185	199645	274701	109640	87997	136606	51093	46668	55939	0.464	0.395	0.544
2016	111470	85334	145612	203189	174234	236929	108512	87718	134237	51421	47888	55215	0.466	0.396	0.549
2017	284201	211402	382070	200381	168751	237941	97868	77997	122801	47535	44413	50877	0.521	0.45	0.604
2018	72495	54002	97321	155914	129937	187086	88071	68002	114062	48315	44230	52778	0.645	0.56	0.744
2019	156655	106409	230628	152107	121493	190435	65581	48621	88456	37659	34748	40813	0.638	0.538	0.758
2020	262978	112362	615489				55725	39049	79522						

Table 4.11b. **Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated landings, discards (including BMS landings from 2016), catch (=landings + discards) and total removals in tonnes. Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch (after removing unaccounted mortality), while total removals are the SAM estimates of catch, including a catch multiplier incorporated from 1993 to 2005 only.**

Year	Landings	Discards	Catch	Catch multiplier	Total Removals
1963	107242	10807	118055		118055
1964	134651	9436	144080		144080
1965	181302	16935	198223		198223
1966	214957	26150	241058		241058
1967	260341	26284	286656		286656
1968	276148	16800	292971		292971
1969	215969	9384	225331		225331
1970	231808	19848	251642		251642
1971	292250	58403	350638		350638
1972	328433	34321	362786		362786
1973	234557	25247	259812		259812
1974	209362	26968	236305		236305
1975	209804	37663	247507		247507
1976	202418	45683	248057		248057
1977	183157	81661	264717		264717
1978	308306	49038	357383		357383
1979	277313	63994	341262		341262
1980	291314	103983	395105		395105
1981	343409	53964	397436		397436
1982	320699	61649	382353		382353
1983	283311	36466	319729		319729
1984	209006	68155	277239		277239
1985	213021	28092	241107		241107
1986	168759	59306	228000		228000
1987	224595	32475	257172		257172
1988	191298	14593	205961		205961
1989	138148	40585	178693		178693
1990	115017	23253	138279		138279
1991	102081	15821	117936		117936
1992	107985	31464	139496		139496
1993	129588	28502	158114	0.9	142415
1994	106617	42717	149349	0.98	146512
1995	130305	31424	161684	1.11	180109
1996	130604	20786	151419	0.98	148245
1997	131827	43958	175753	0.83	146098
1998	144536	40888	185492	0.69	128518
1999	94723	13010	107715	0.81	86973
2000	73004	16242	89239	0.85	75515
2001	44560	11446	56027	1.16	65046
2002	53241	11151	64390	0.8	51411
2003	31030	4620	35659	1.36	48463
2004	27266	7457	34723	1.02	35324
2005	29727	11312	41034	0.9	36967
2006	22442	8914	31358		31358
2007	23762	28584	52339		52339
2008	26895	25037	51927		51927
2009	32991	21192	54188		54188
2010	36029	12267	48291		48291
2011	34042	10162	44197		44197
2012	32527	7530	40056		40056
2013	30870	10753	41614		41614
2014	34816	10807	45622		45622
2015	38080	13017	51093		51093
2016	38794	12624	51421		51421
2017	38522	9019	47535		47535
2018	40082	8228	48315		48315
2019	33385	4275	37659		37659

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

	Catch multiplier	Low	High
1993	0.9	0.75	1.08
1994	0.98	0.8	1.2
1995	1.11	0.91	1.37
1996	0.98	0.8	1.2
1997	0.83	0.68	1.01
1998	0.69	0.57	0.85
1999	0.81	0.66	0.99
2000	0.85	0.69	1.04
2001	1.16	0.95	1.42
2002	0.8	0.65	0.97
2003	1.36	1.1	1.67
2004	1.02	0.83	1.24
2005	0.9	0.75	1.08

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

Forecast assumptions

Fbar(2020)	0.294
SSB(2021)	78300
R(2020)	268197
R(2021)	176577
Catch(2020)	17679
Landings(2020)	15132
Discards(2020)	2547

Catch scenarios

Basis	Total catch (2021)	Projected landings (2021)	Projected discards (2021)	F_{total} (2021)	$F_{projected\ landings}$ (2021)	$F_{projected\ discards}$ (2021)	SSB (2022)	% SSB change	% TAC change	% Advice change
MSY approach	14755	12632	2123	0.162	0.136	0.026	112758	44	-16.5	7.8
MAP	9672	8291	1381	0.103	0.087	0.0160	118040	51	-45	-29
F=0	0	0	0	0.00	0.00	0.00	128848	65	-100	-100
Fpa	32411	27556	4855	0.39	0.33	0.063	93679	19.6	83	137
Flim	42307	35860	6447	0.54	0.45	0.088	83289	6.4	139	210
SSB(2022)=Blim	20325	17350	2975	0.23	0.192	0.037	107000	37	15.0	49
SSB(2022)=Bpa	0	0	0	0.00	0.00	0.00	128848	65	-100	-100
SSB(2022)=Btrigger	0	0	0	0.00	0.00	0.00	128848	65	-100	-100
TAC(2020)-20%	14143	12113	2030	0.155	0.130	0.025	113403	45	-20	3.3
TAC(2020)-15%	15027	12862	2165	0.165	0.138	0.027	112489	44	-15.0	9.8
TAC(2020)-10%	15911	13608	2303	0.175	0.147	0.028	111649	43	-10.0	16.3
TAC(2020)-5%	16795	14354	2441	0.186	0.156	0.030	110758	41	-5.0	23
Constant TAC	17679	15102	2577	0.197	0.165	0.032	109876	40	0.00	29
TAC(2020)+5%	18563	15851	2712	0.21	0.174	0.033	108999	39	5.0	36
TAC(2020)+10%	19447	16601	2846	0.22	0.183	0.035	108059	38	10.0	42
TAC(2020)+15%	20330	17355	2975	0.23	0.192	0.037	106995	37	15.0	49
TAC(2020)+20%	21215	18099	3116	0.24	0.20	0.039	106020	35	20	55
F=F2020	25375	21605	3770	0.29	0.25	0.048	101262	29	44	85
Fmsy lower	17794	15199	2595	0.198	0.166	0.032	109762	40	0.65	30
Fmsy	26611	22653	3958	0.31	0.26	0.050	99841	28	51	94

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

Forecast assumptions

Fbar(2020)	0.294
SSB(2021)	78300
R(2020)	268197
R(2021)	176577
Catch(2020)	17679
Landings(2020)	15132
Discards(2020)	2547

Catch scenarios

Basis	Total catch (2021)	Projected landings (2021)	Projected discards (2021)	F_{total} (2021)	$F_{projected\ landings}$ (2021)	$F_{projected\ discards}$ (2021)	SSB (2022)	% SSB change	% TAC change	% Advice change
A	15878	13580	2298	0.175	0.147	0.028	111681	43	-10.2	16.0
B	8920	7648	1272	0.095	0.080	0.0150	118890	52	-50	-35
C	15878	13580	2298	0.175	0.147	0.028	111681	43	-10.2	16.0
A+D	15013	12850	2163	0.165	0.138	0.027	112503	44	-15.1	9.7
B+E	8468	7260	1208	0.090	0.075	0.0150	119417	53	-52	-38
C+E	18072	15431	2641	0.20	0.169	0.032	109489	40	2.2	32
A*	14755	12632	2123	0.162	0.136	0.026	112758	44	-16.5	7.8
A*+D	14755	12632	2123	0.162	0.136	0.026	112758	44	-16.5	7.8

Table 4.12c. Cod in Subarea 4, Division 7.d and Subdivision 20: MSY approach catch scenarios based on the SAM assessment and assuming different multipliers on F(2019) in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

F multiplier	Basis	Total catch (2021)	Projected landings (2021)	Projected discards (2021)	F_{total} (2021)	$F_{projected\ landings}$ (2021)	$F_{projected\ discards}$ (2021)	SSB (2022)	% SSB change	% TAC change	% Advice change
0.1	MSY HCR	19905	17321	2584	0.190	0.159	0.031	125027	36	12.6	45
0.2	MSY HCR	18245	15805	2440	0.181	0.152	0.029	121427	32	3.2	33
0.3	MSY HCR	16783	14476	2307	0.174	0.145	0.029	117760	28	-5.1	23
0.4	MSY HCR	15439	13258	2181	0.166	0.139	0.027	114634	25	-12.7	12.8
0.5	MSY HCR	14267	12166	2101	0.159	0.133	0.026	111459	21	-19.3	4.2
0.6	MSY HCR	13191	11194	1997	0.152	0.128	0.024	108367	17.7	-25	-3.6
0.7	SSB(2022)=Blim	10535	8902	1633	0.125	0.105	0.020	107000	16.2	-40	-23
0.8	SSB(2022)=Blim	7040	5923	1117	0.085	0.072	0.0130	107000	16.2	-60	-49
0.9	SSB(2022)=Blim	3468	2907	561	0.043	0.036	0.0070	107001	16.2	-80	-75
1	SSB(2022)=Blim	161	135	26	0.0020	0.0020	0.00	107000	16.2	-99	-99

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

Forecast assumptions

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

Catch scenarios

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

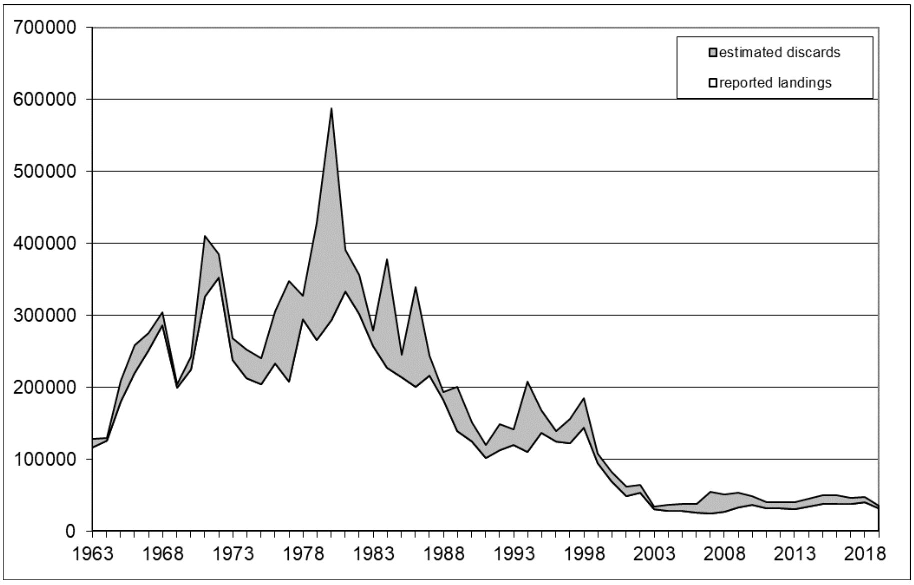


Figure 4.1a. Cod in Subarea 4, Division 7.d and Subdivision 20: stacked area plot of reported landings and estimated discards (including BMS landings; in tonnes).

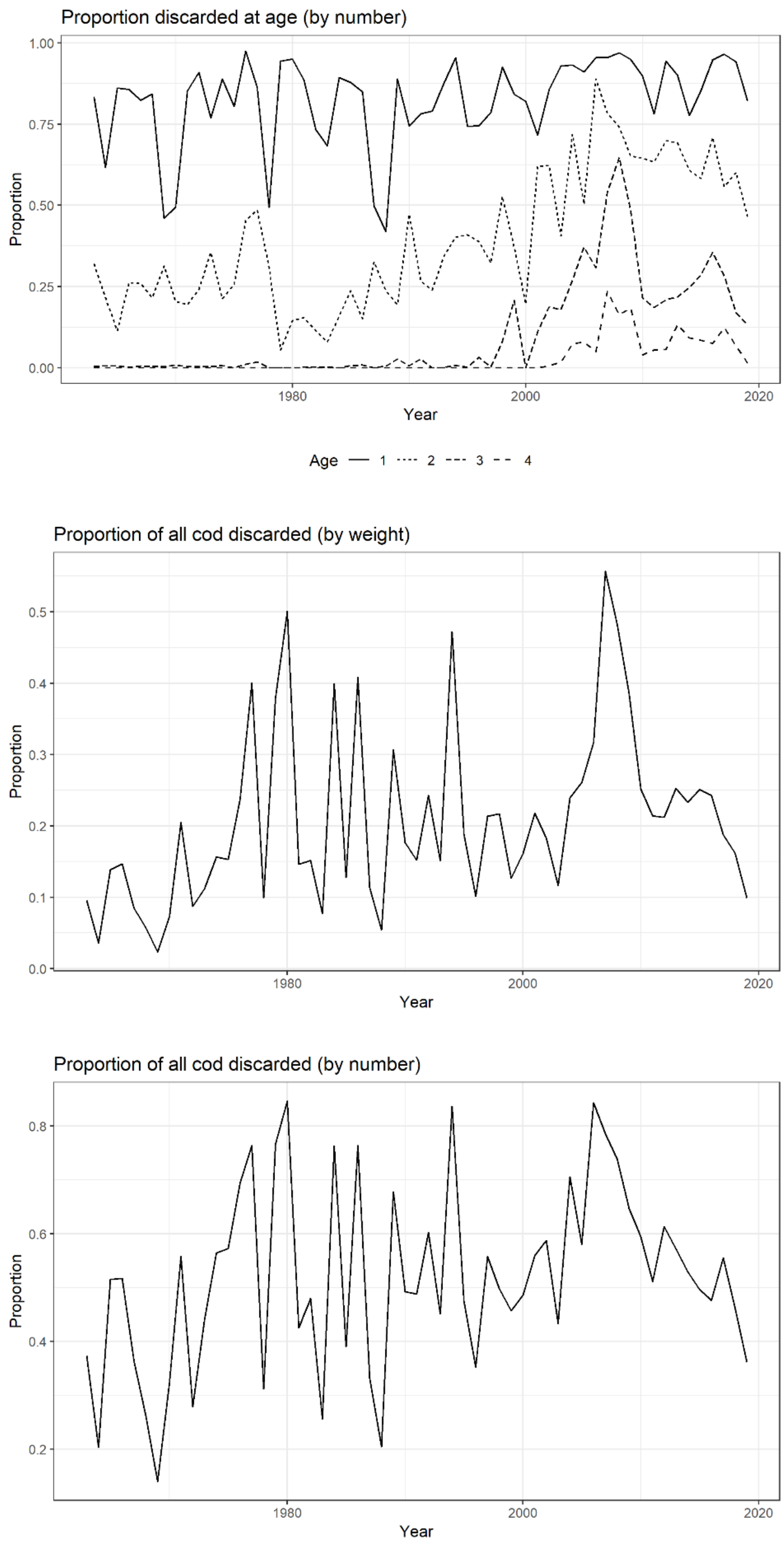


Figure 4.1b. Cod in Subarea 4, Division 7.d and Subdivision 20: (top) proportion of total numbers caught at age that are discarded; (middle) proportion of total weight caught that is discarded; and (bottom) proportion of the total numbers caught that are discarded.

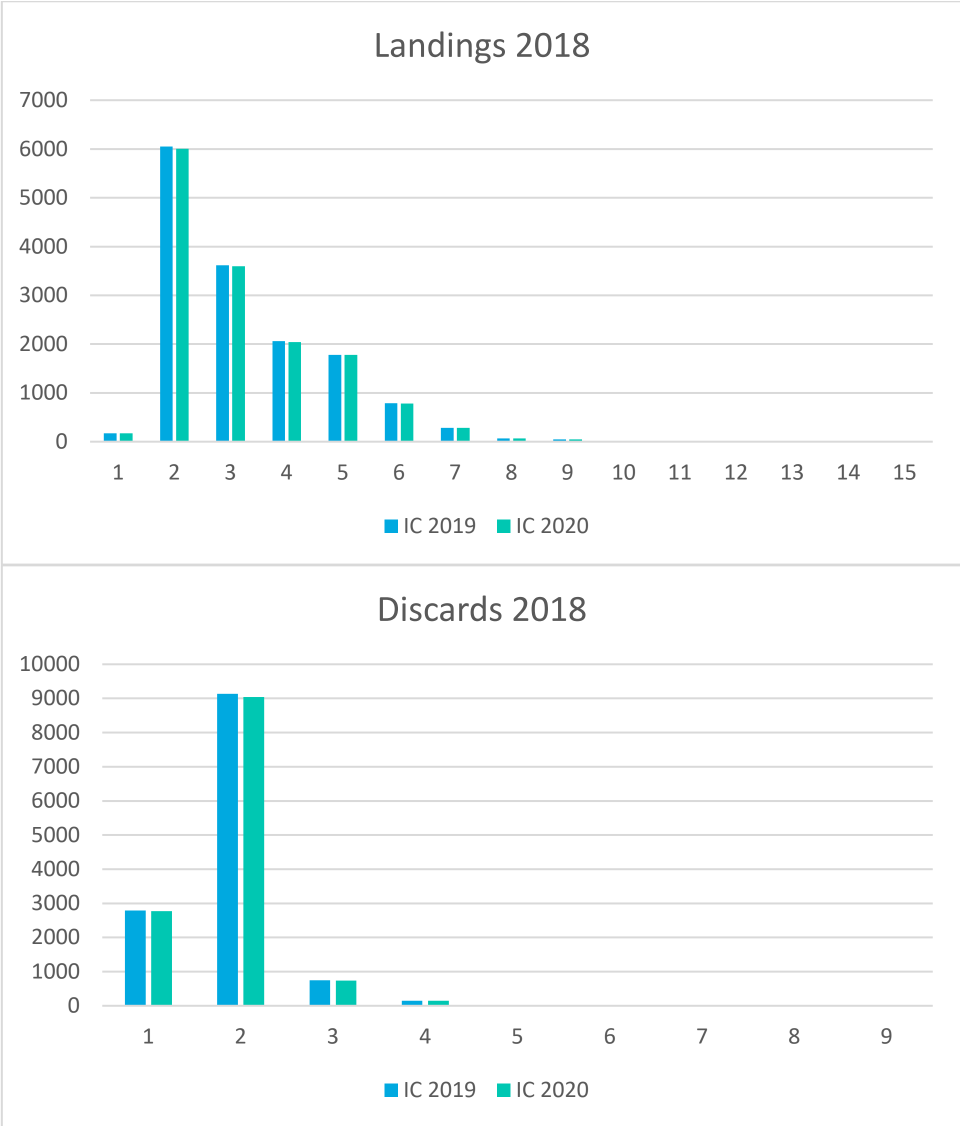


Figure 4.1c. Cod in Subarea 4, Division 7.d and Subdivision 20: (top) landings and (bottom) discards (including BMS landings) numbers at age for 2018 as estimated using InterCatch in 2019 and in 2020 following reprocessing of data by France.

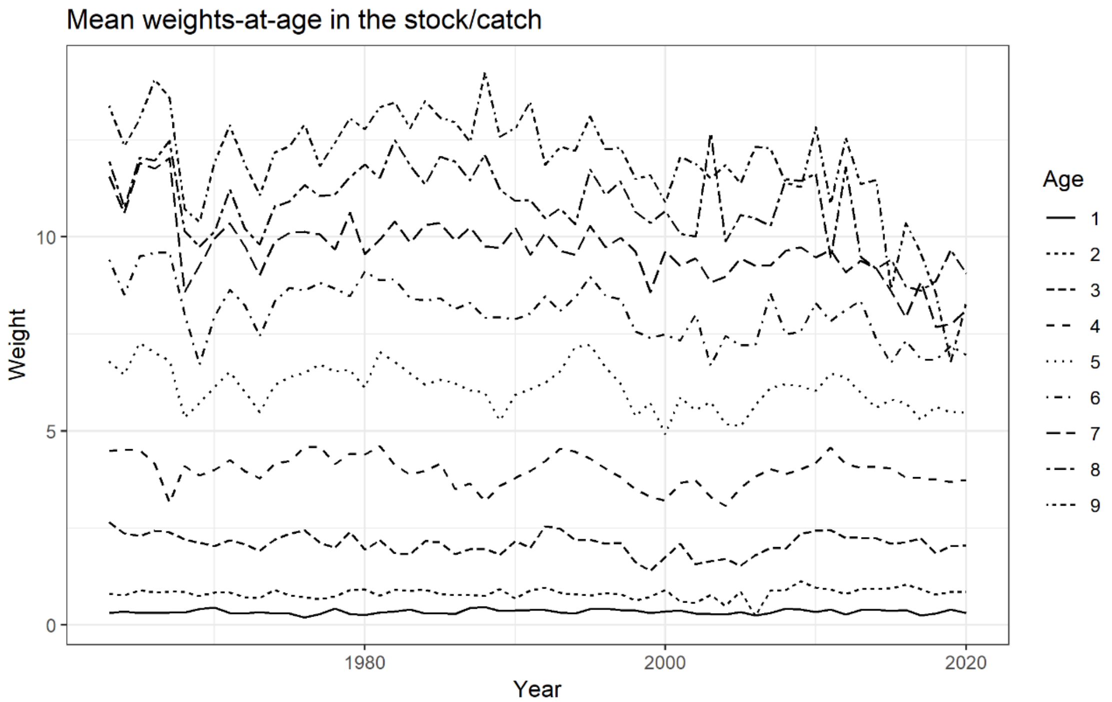


Figure 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weight at age in the catch for ages 1–9.

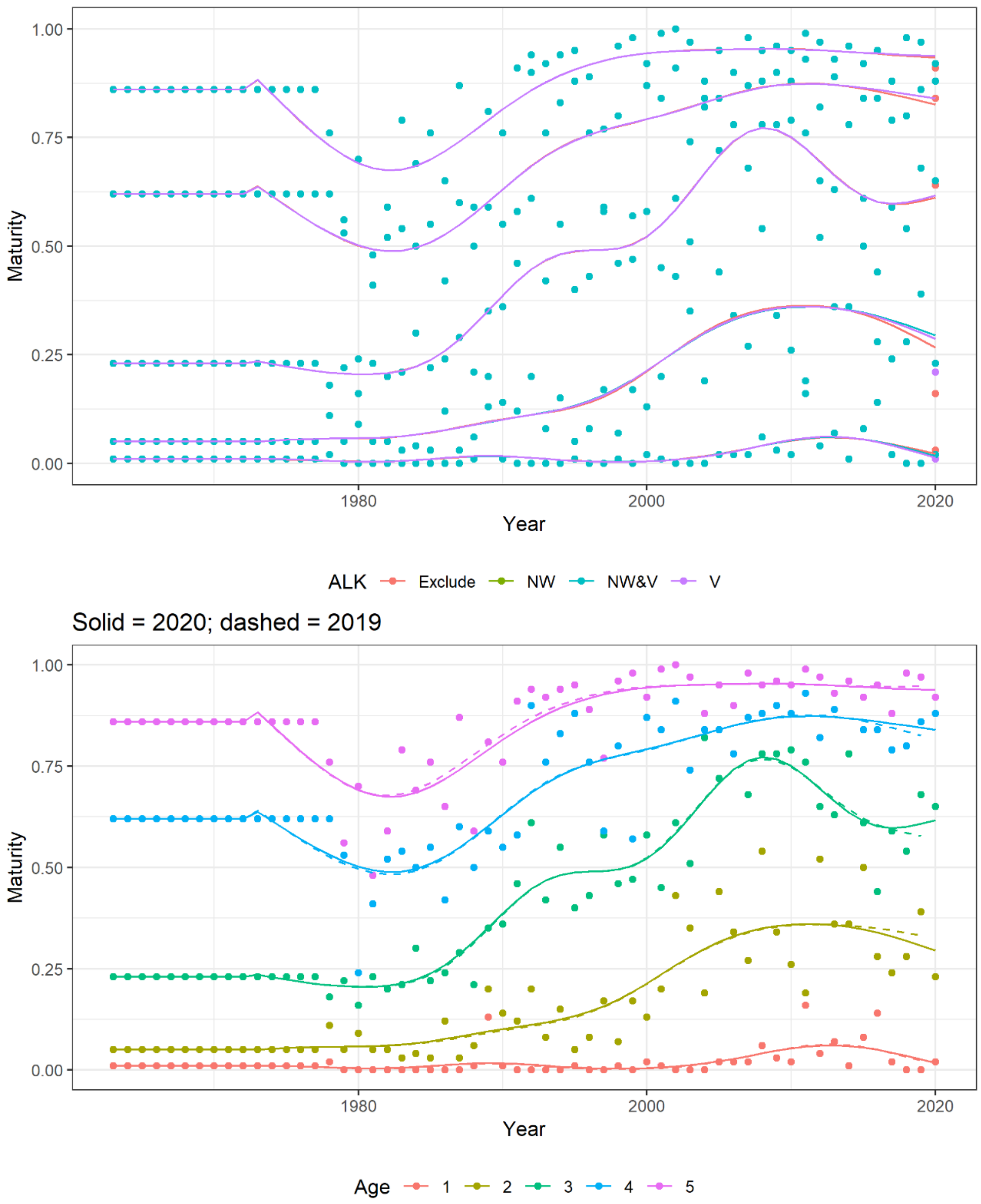


Figure 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Annually varying maturity-at-age (top) comparing ALK borrowing options for the southern subregion and (bottom) as used in the assessment compared to the ogive used in 2019. Values for 1963–1972 are the former constant maturity values used for cod. ALK borrowing options included excluding fish from the southern subregion and assigning ages to those fish using the northwest ALK, a combined northwest and Viking ALK and the Viking ALK.

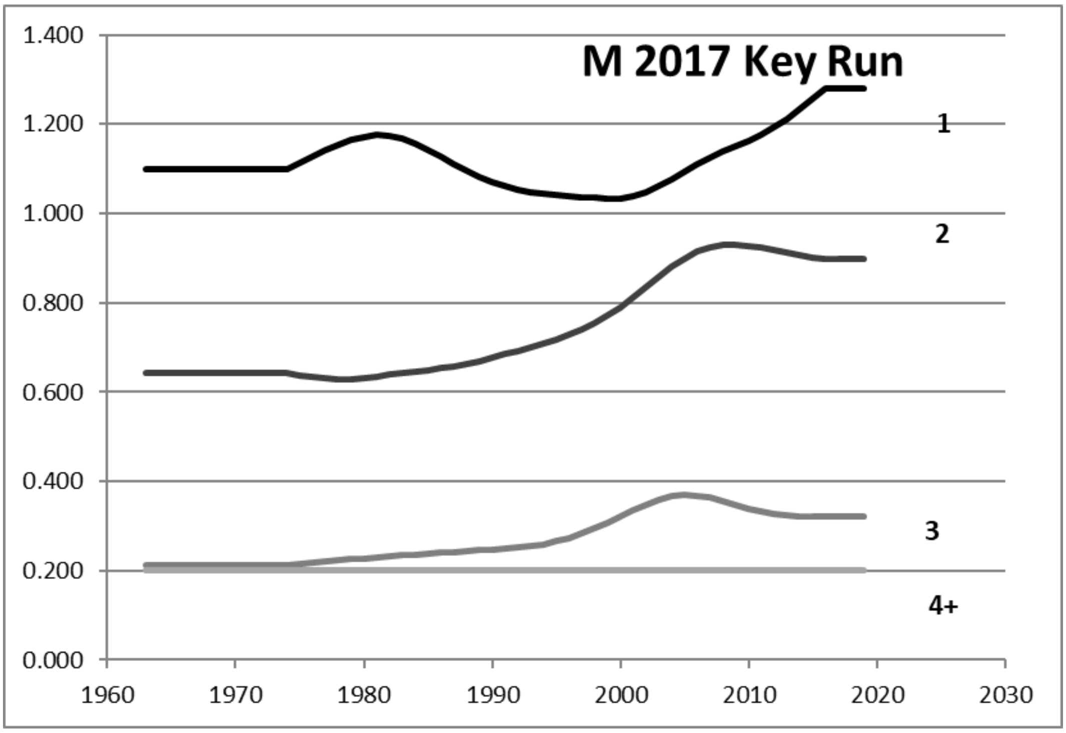


Figure 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2017 key run (ICES WGSAM, 2017). Values for 1963–1972 are set equal to the 1973 value, while values for 2017–2019 are set equal to 2016.

Figure 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2001–2020 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 2001–2020 in the North Sea.

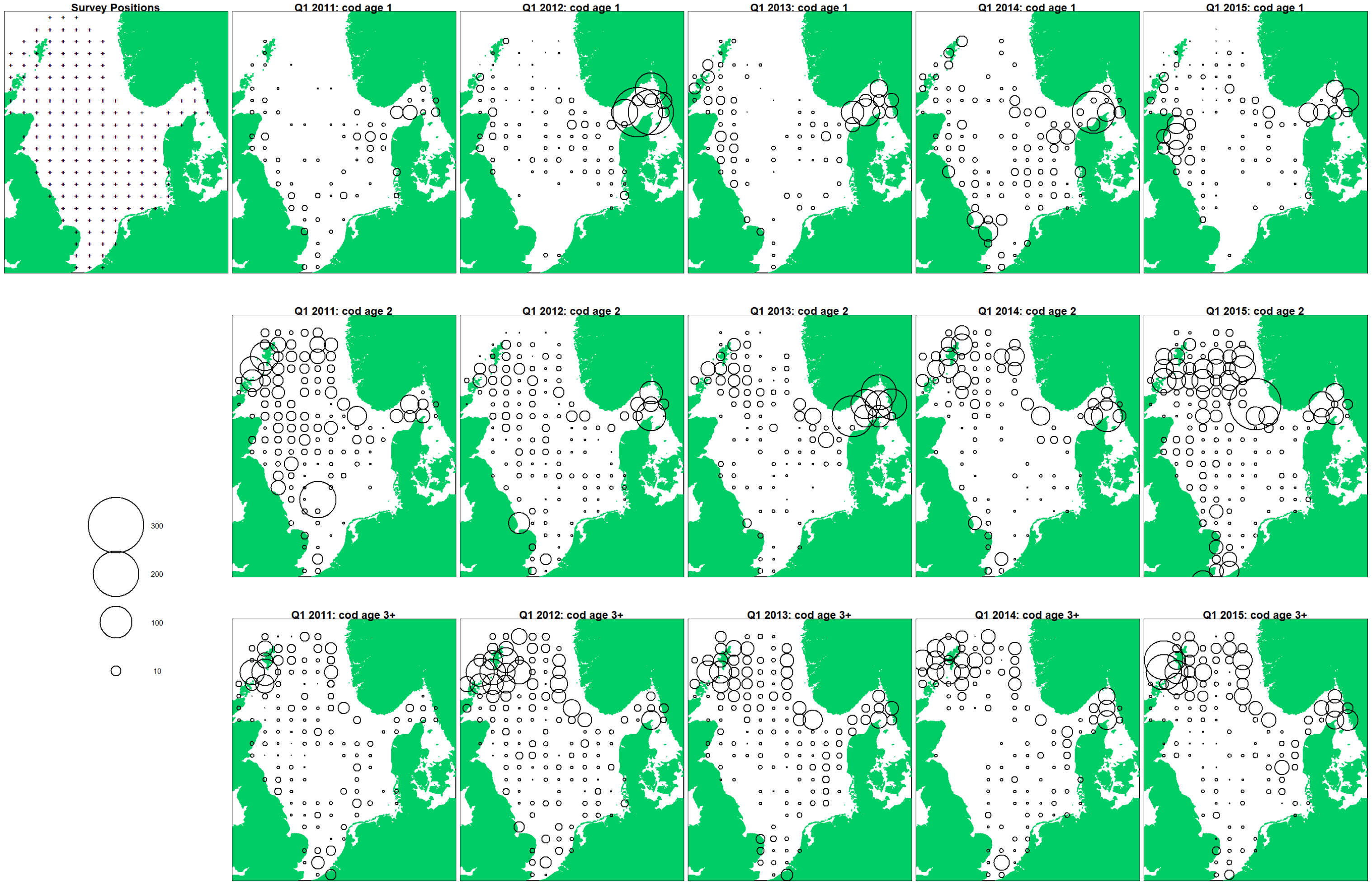


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2001–2020 in the North Sea.

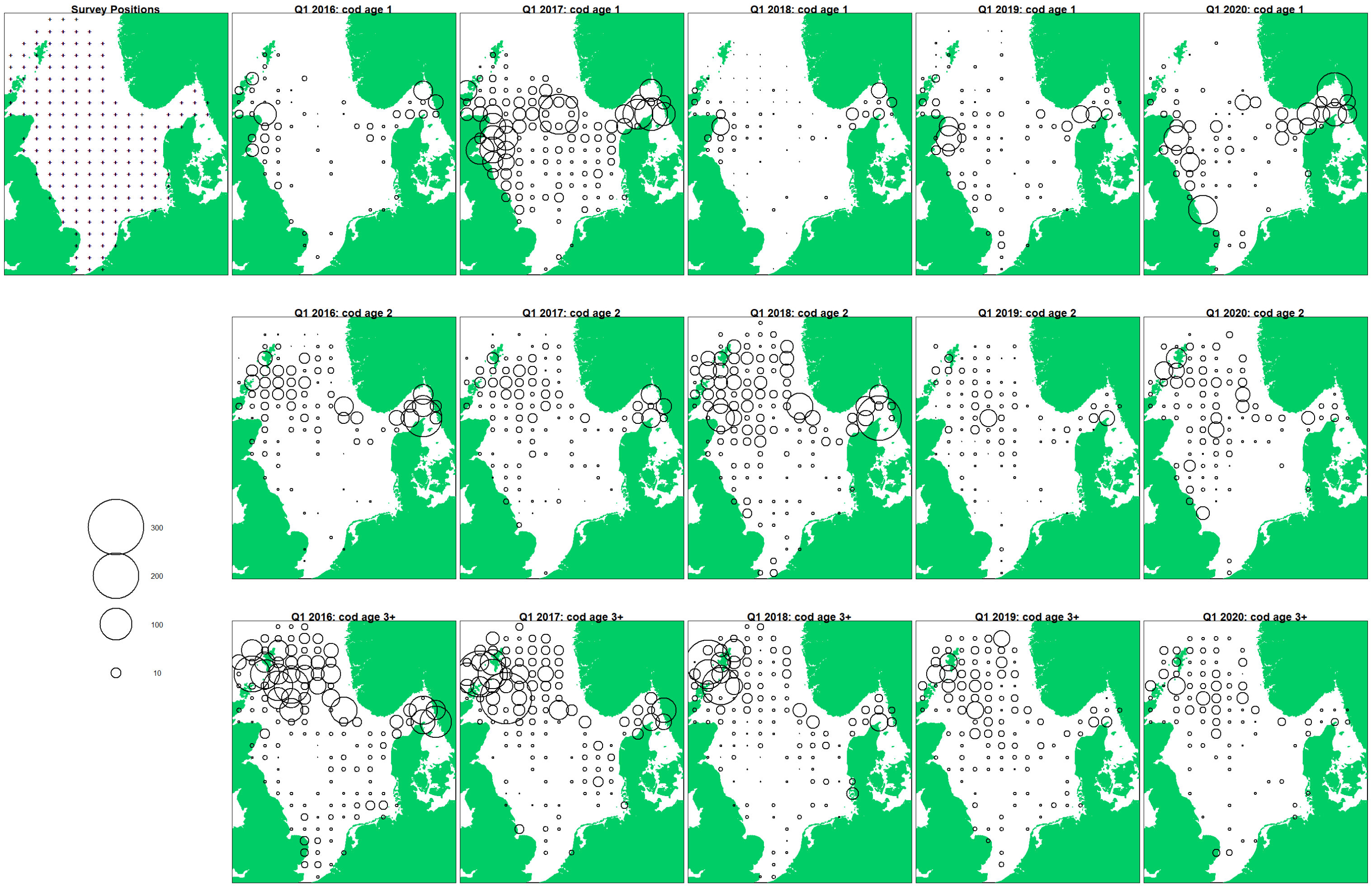


Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2001–2020 in the North Sea.

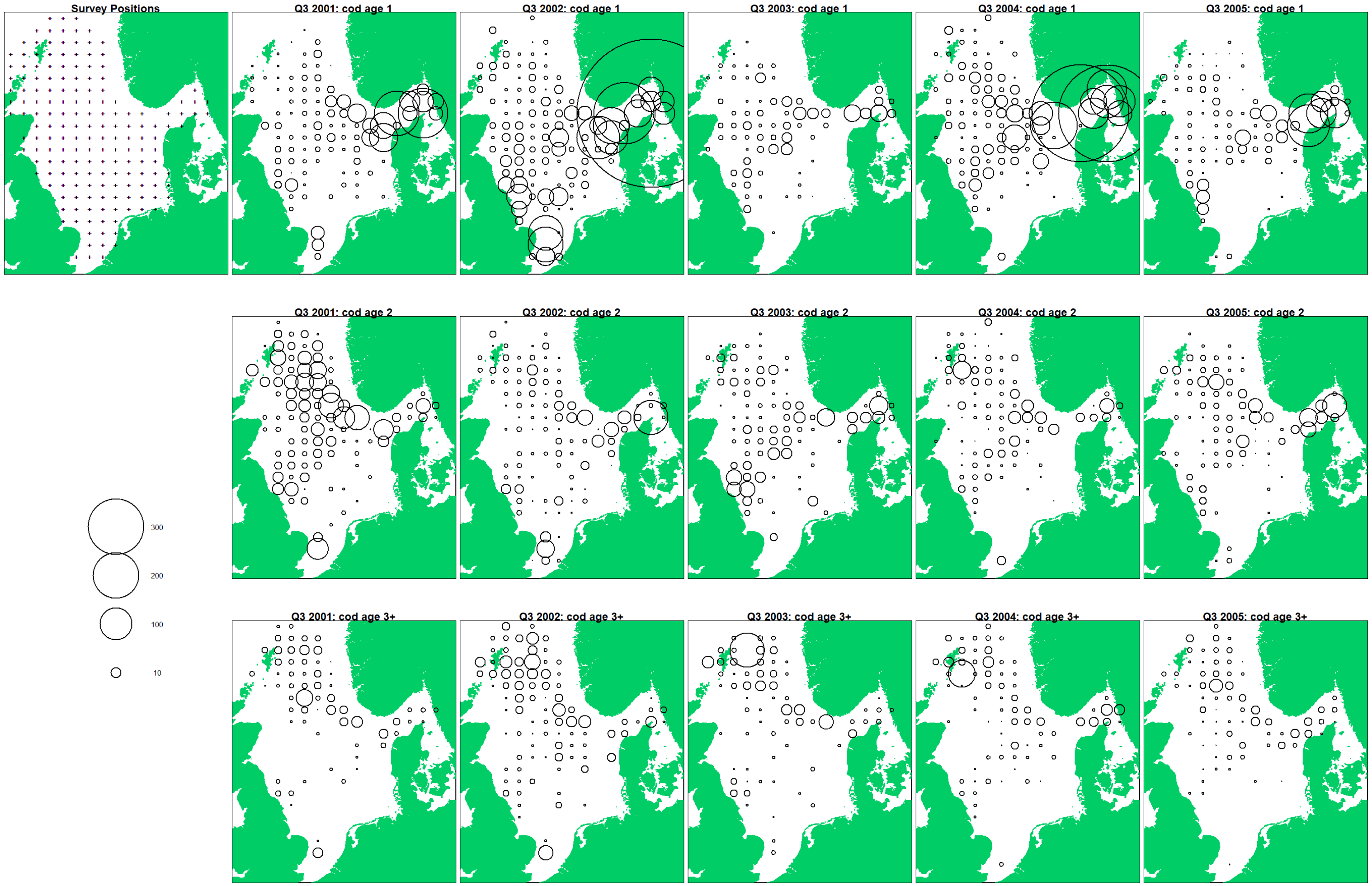


Figure 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2001–2019 in the North Sea.

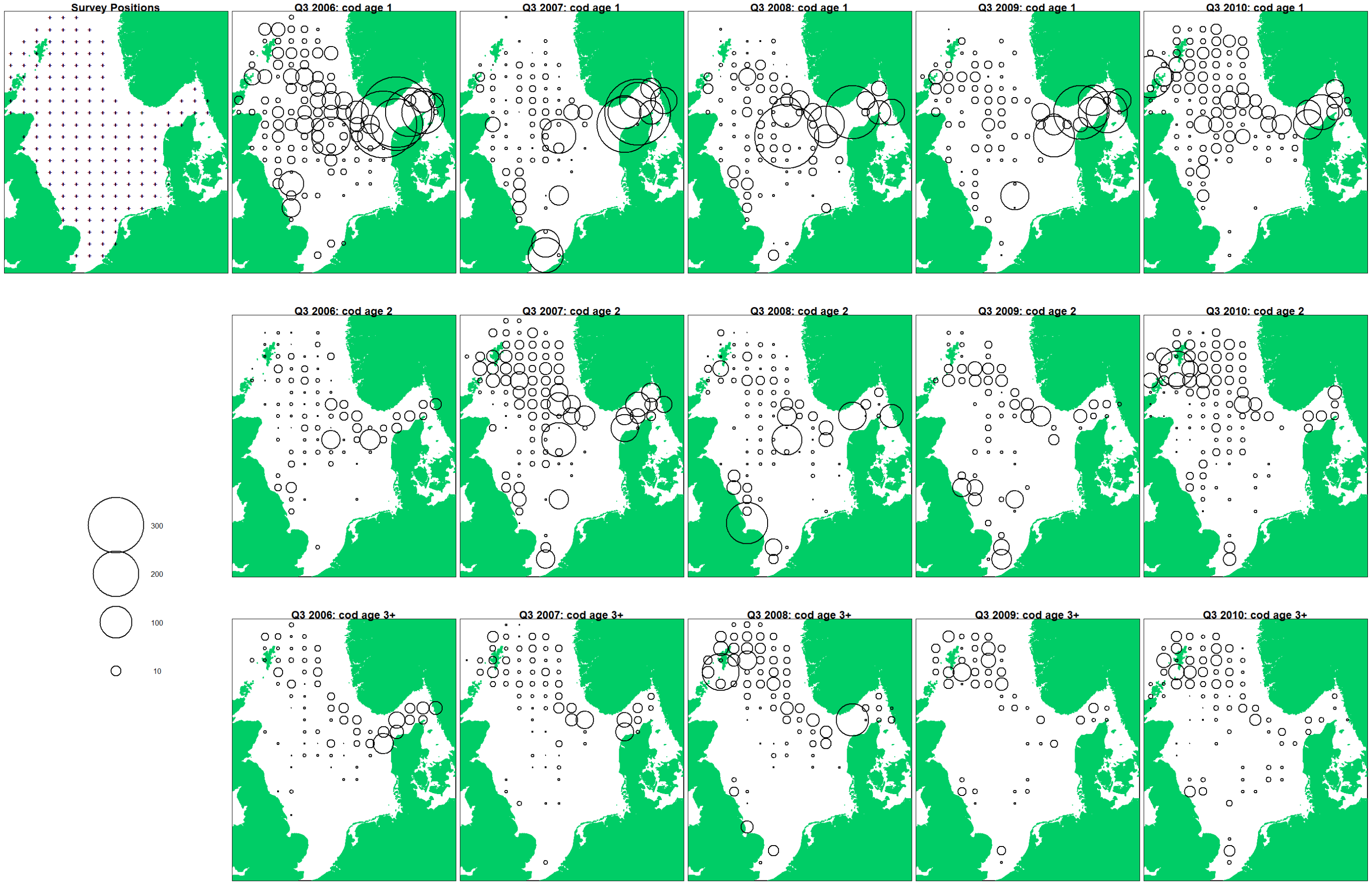


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2001–2019 in the North Sea.

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 2001–2019 in the North Sea.

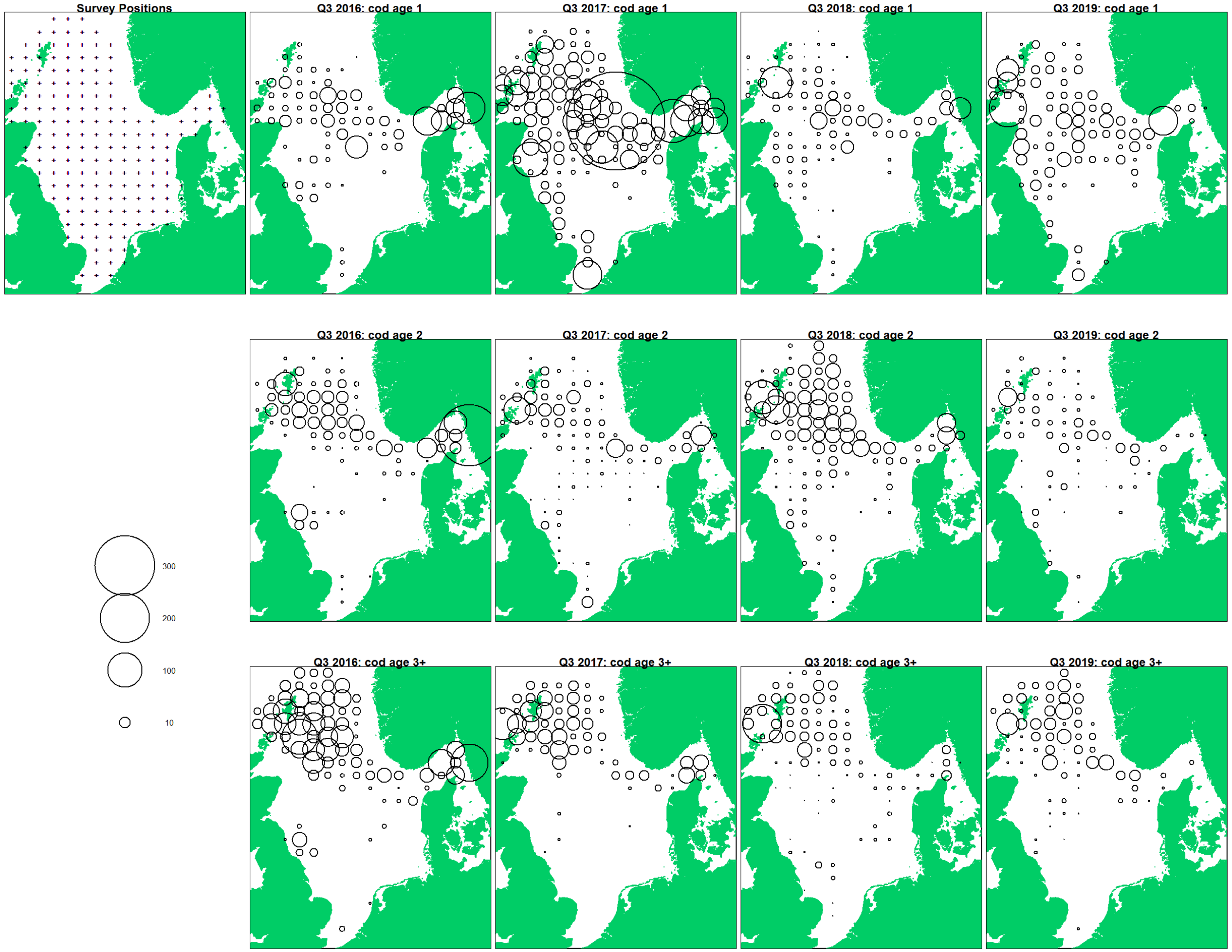


Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2001–2019 in the North Sea.

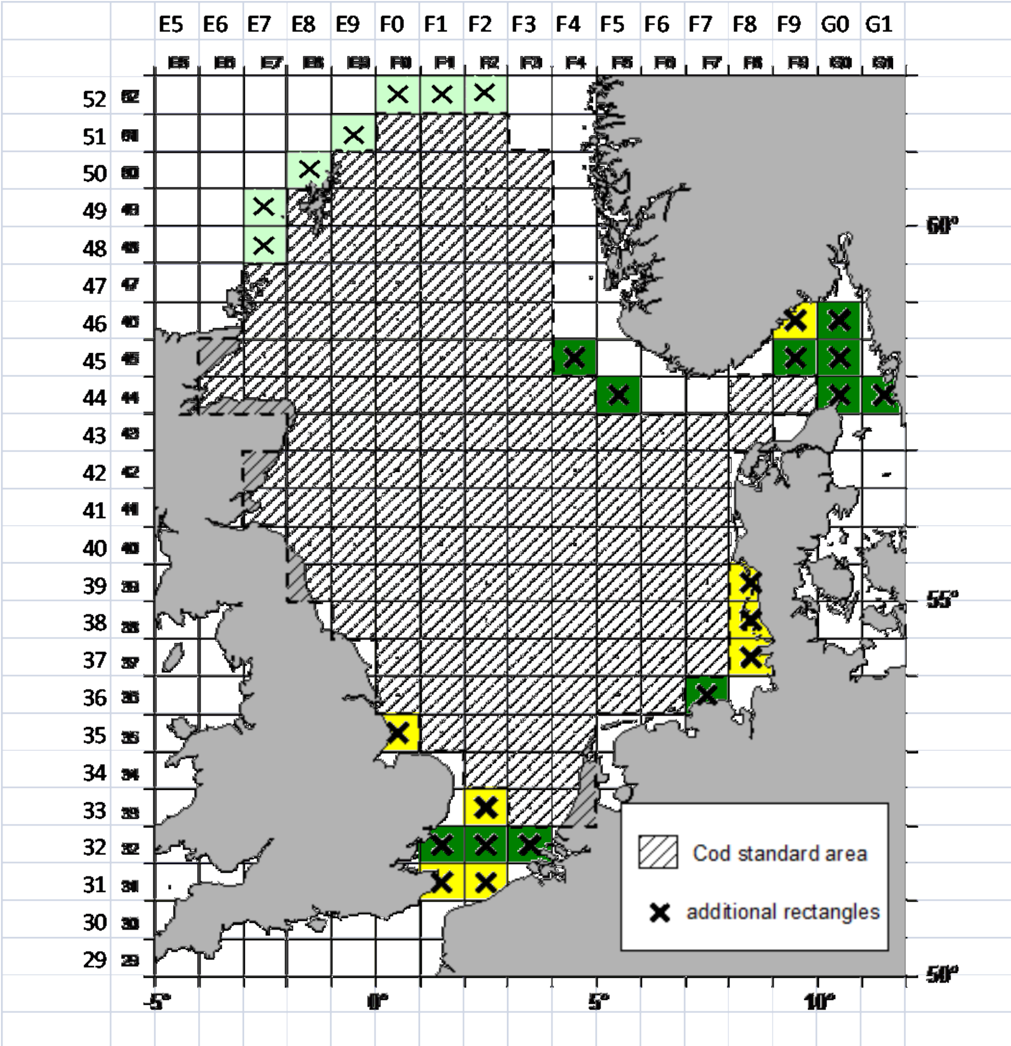


Figure 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND, 2009; ICES WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is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

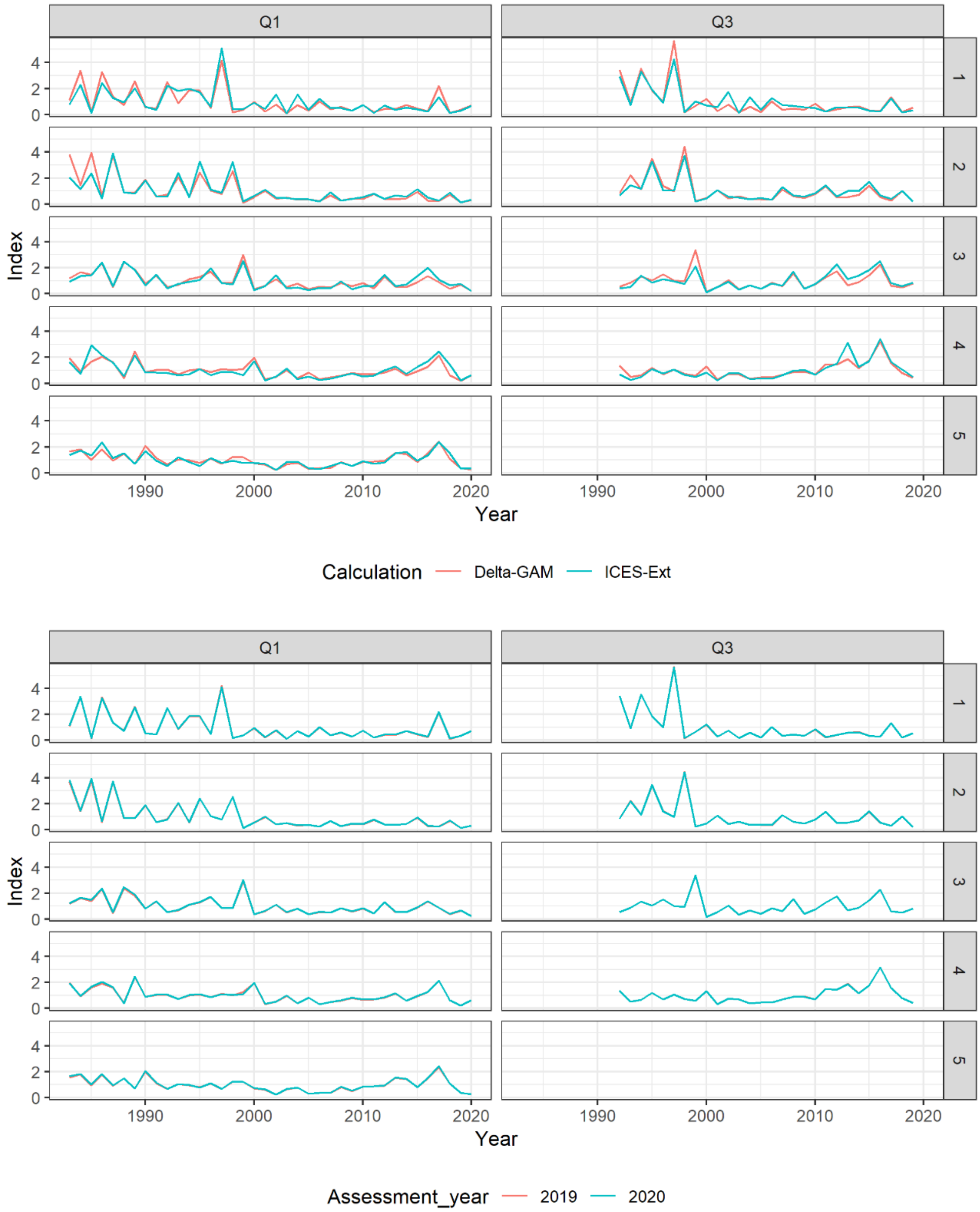


Figure 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS Delta–GAM indices used in the assessment to the corresponding (top) NS–IBTS extended indices (ICES-Ext) and (bottom) the Delta-GAM indices used in the 2019 assessment (October update). The indices are mean-standardised.

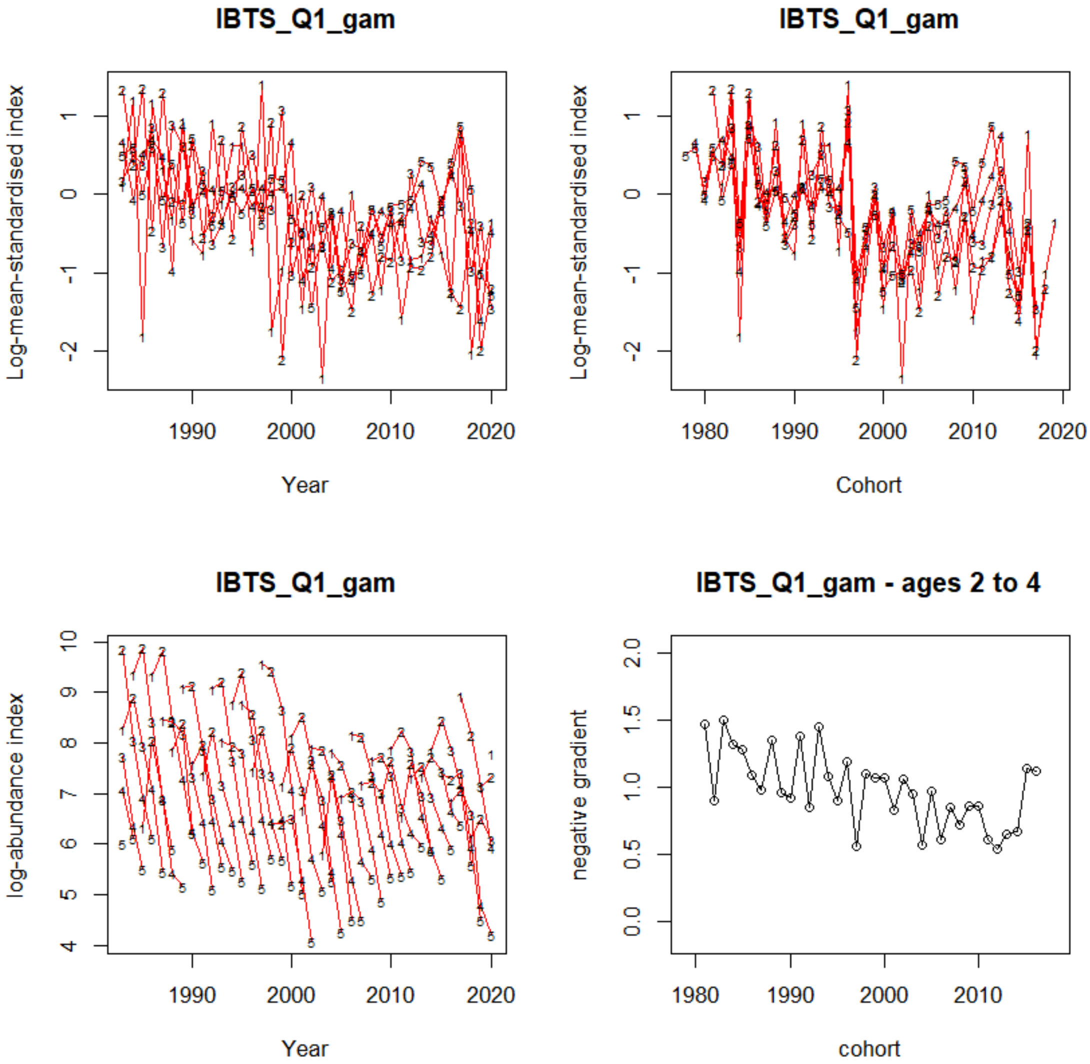


Figure 4.4a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

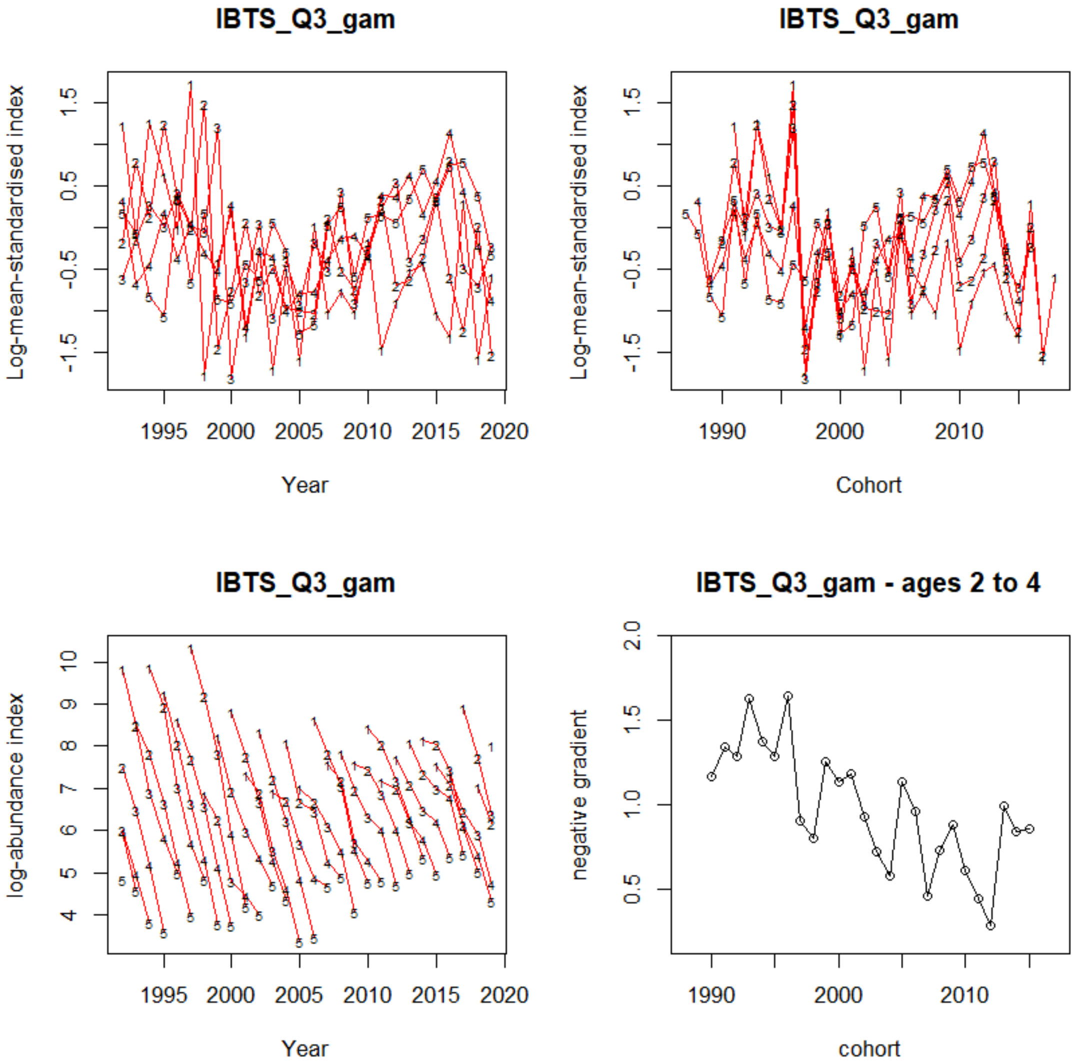


Figure 4.4b. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the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

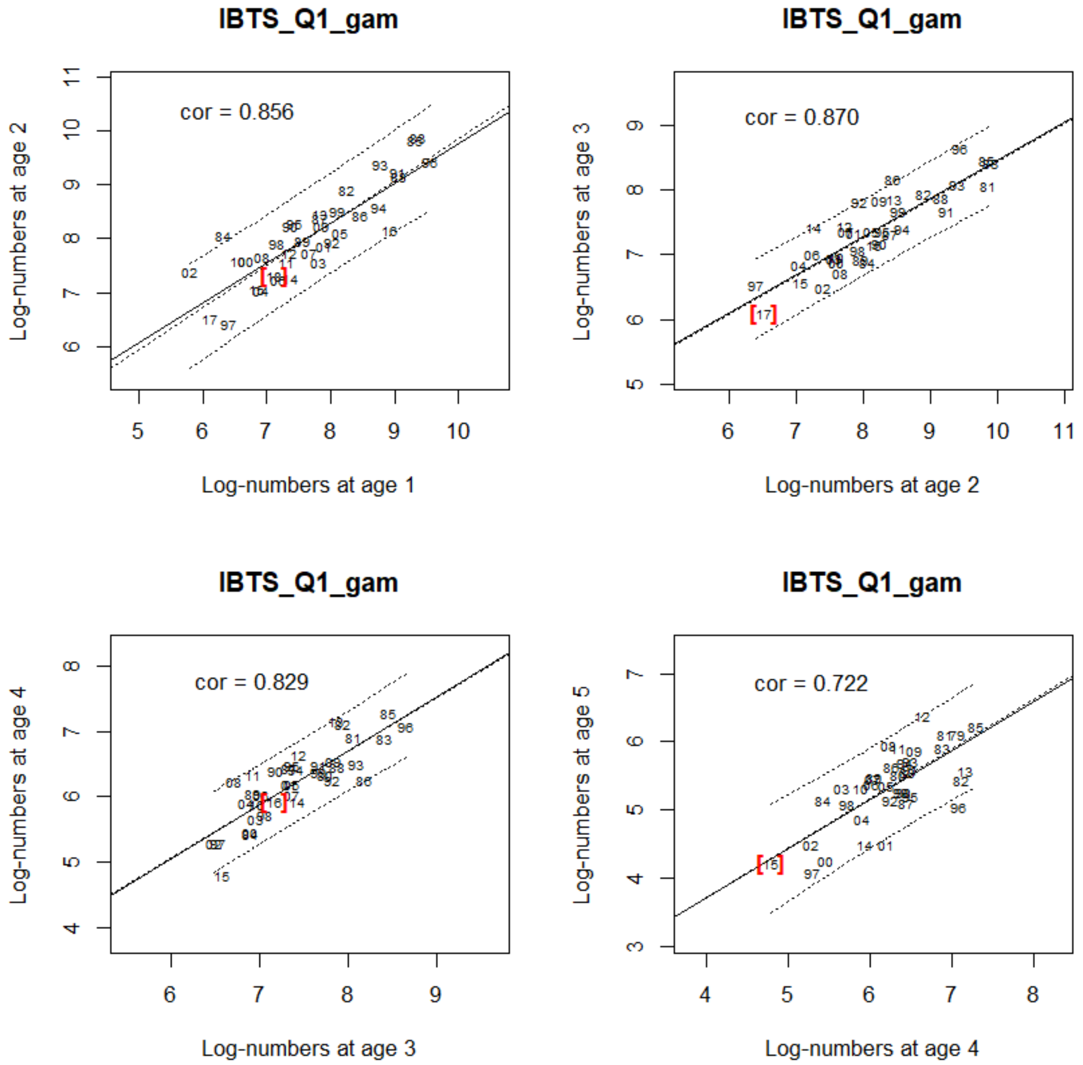


Figure 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2020. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear 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.

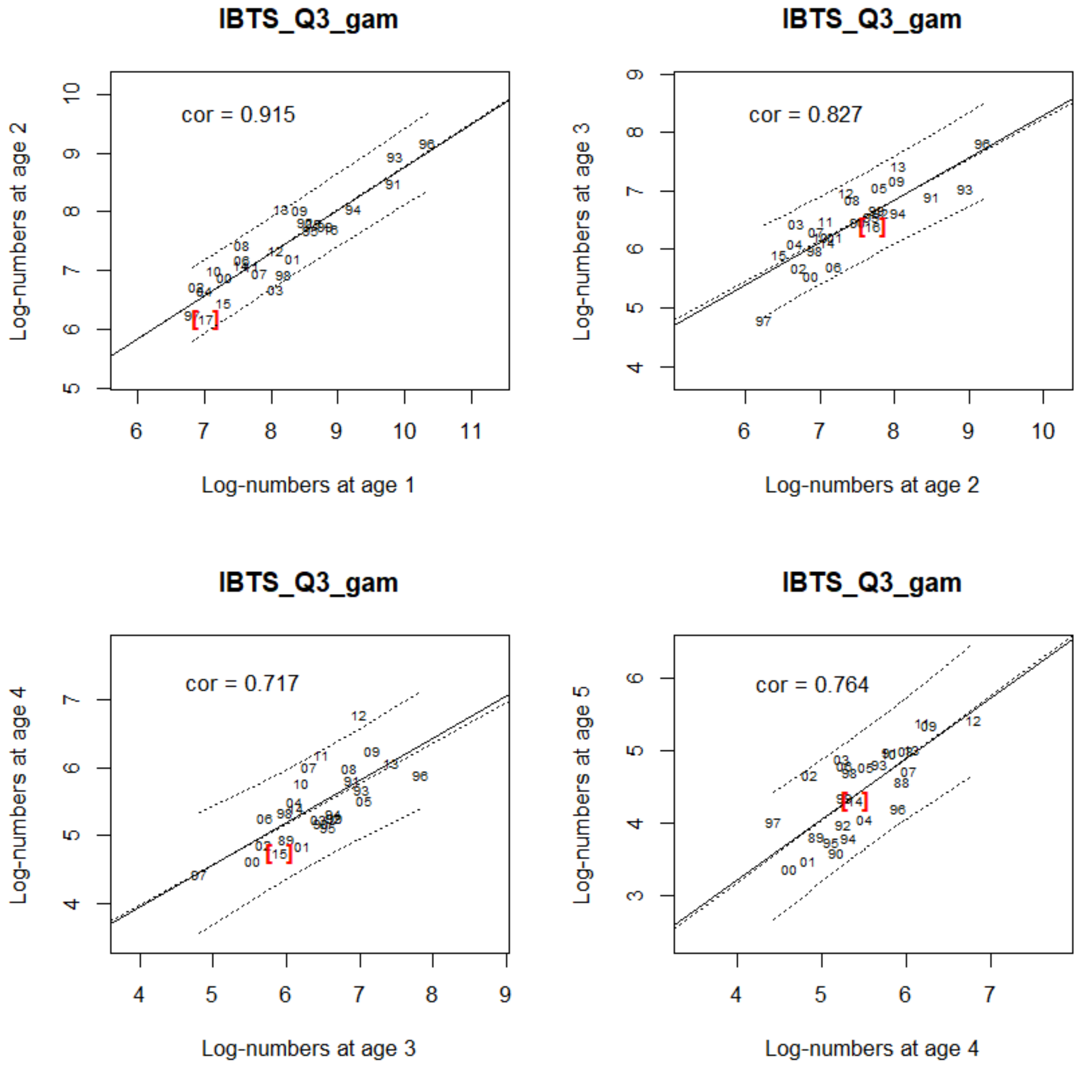


Figure 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2019. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

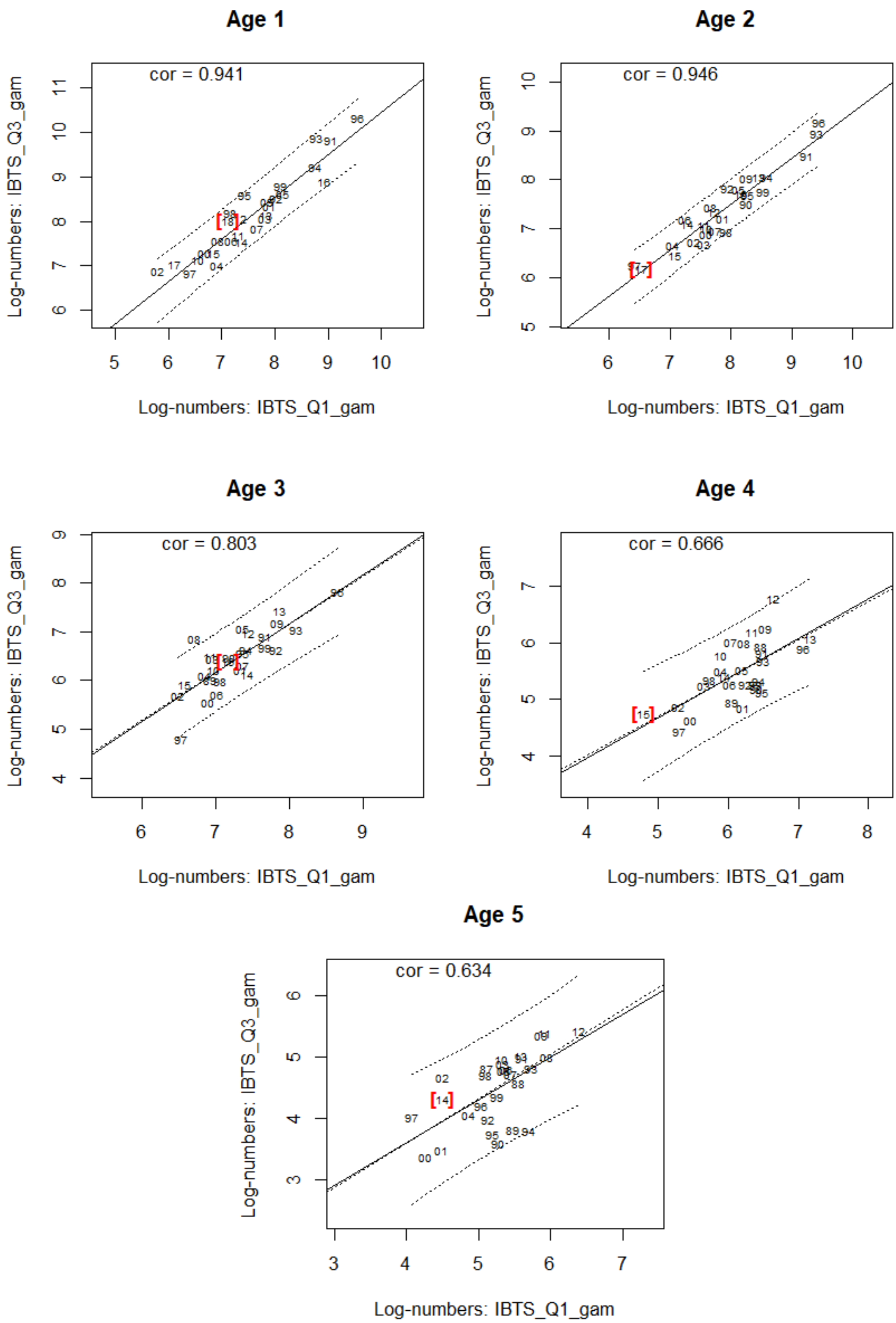


Figure 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2019. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest 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.

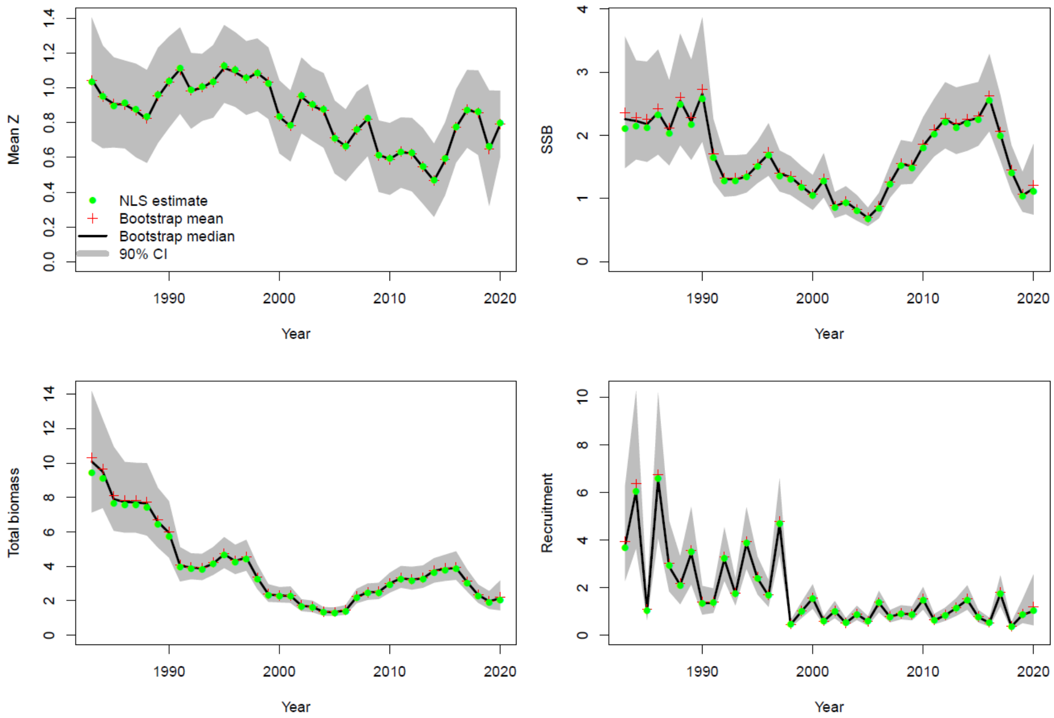


Figure 4.6a. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to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

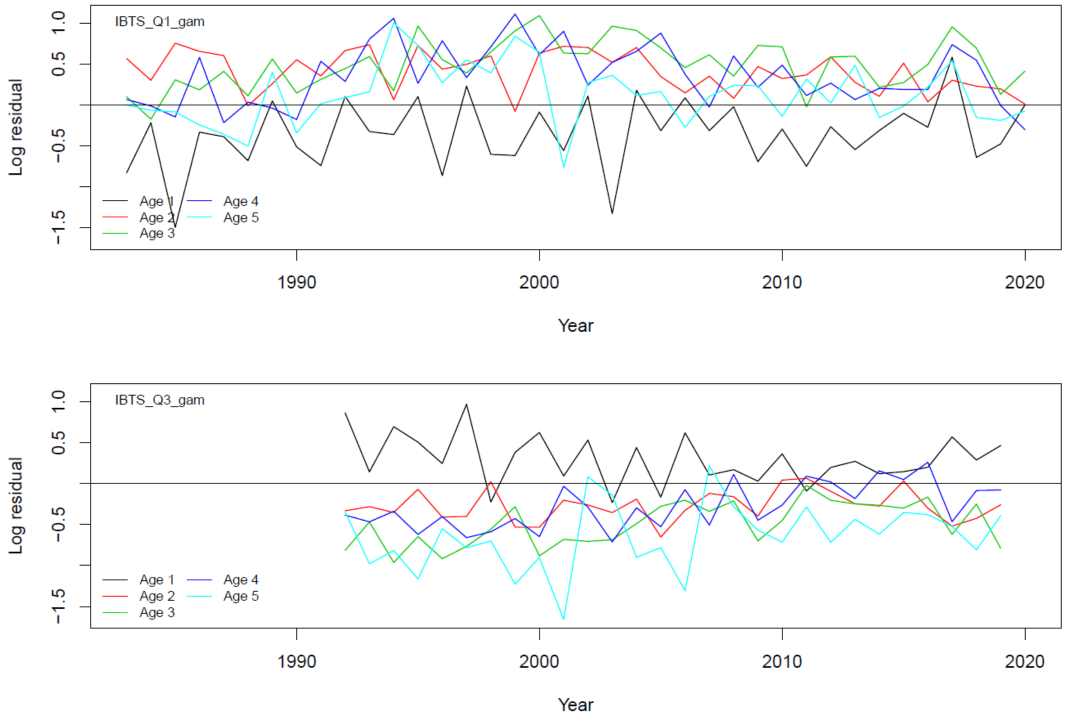


Figure 4.6b. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR residual plots for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3.

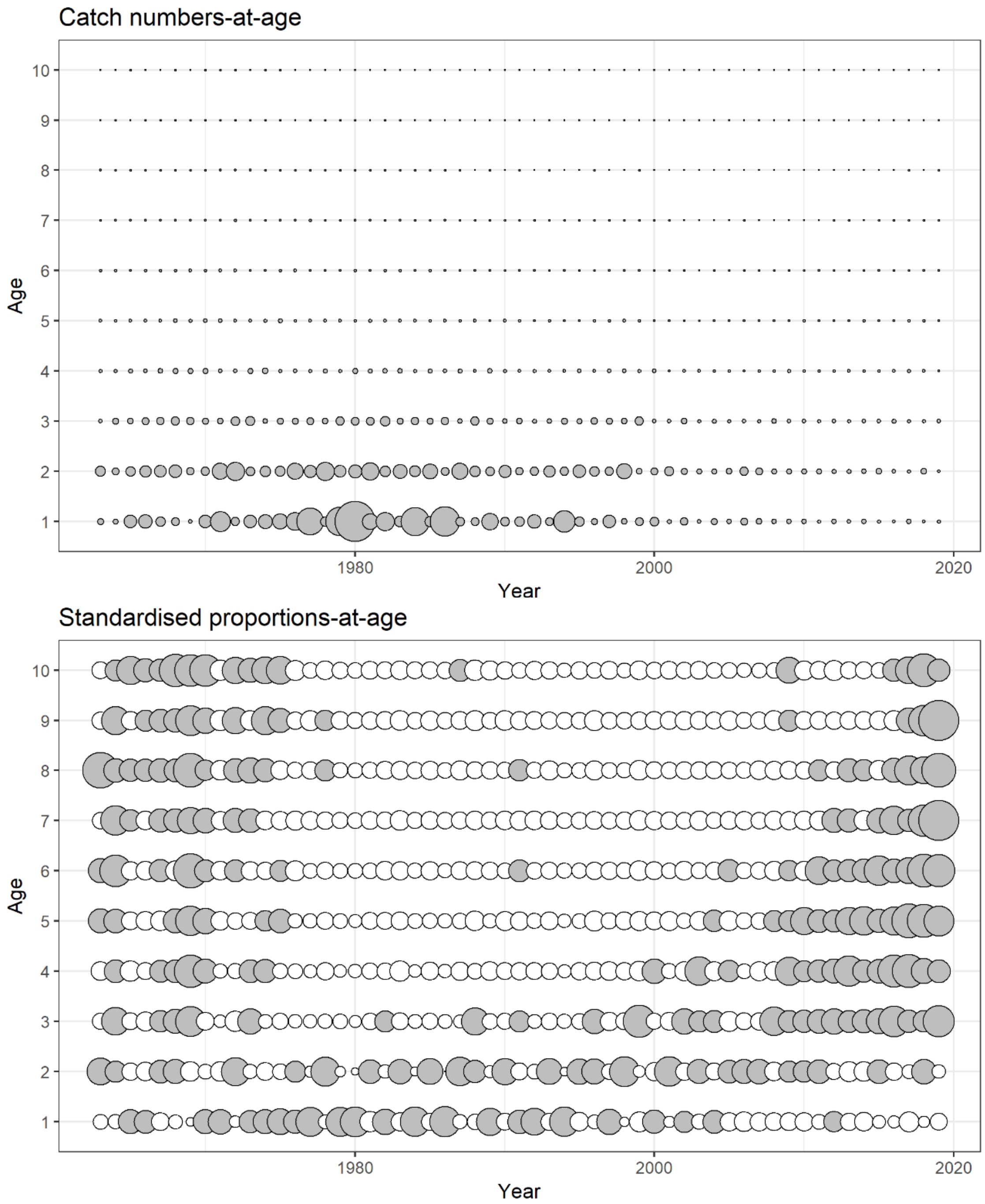


Figure 4.7. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catch-at-age matrix expressed as (top) numbers-at-age and (bottom) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing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

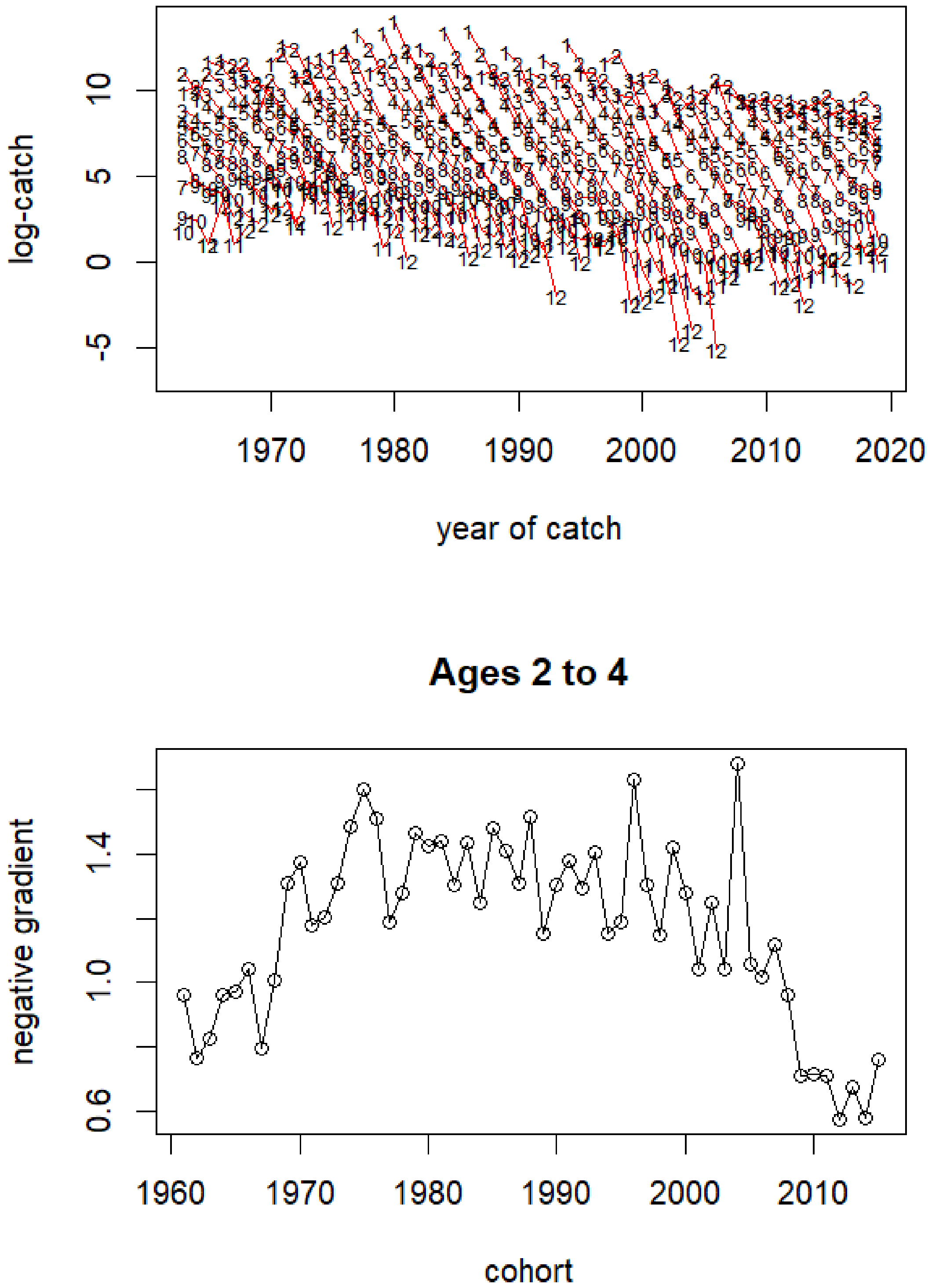


Figure 4.8a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

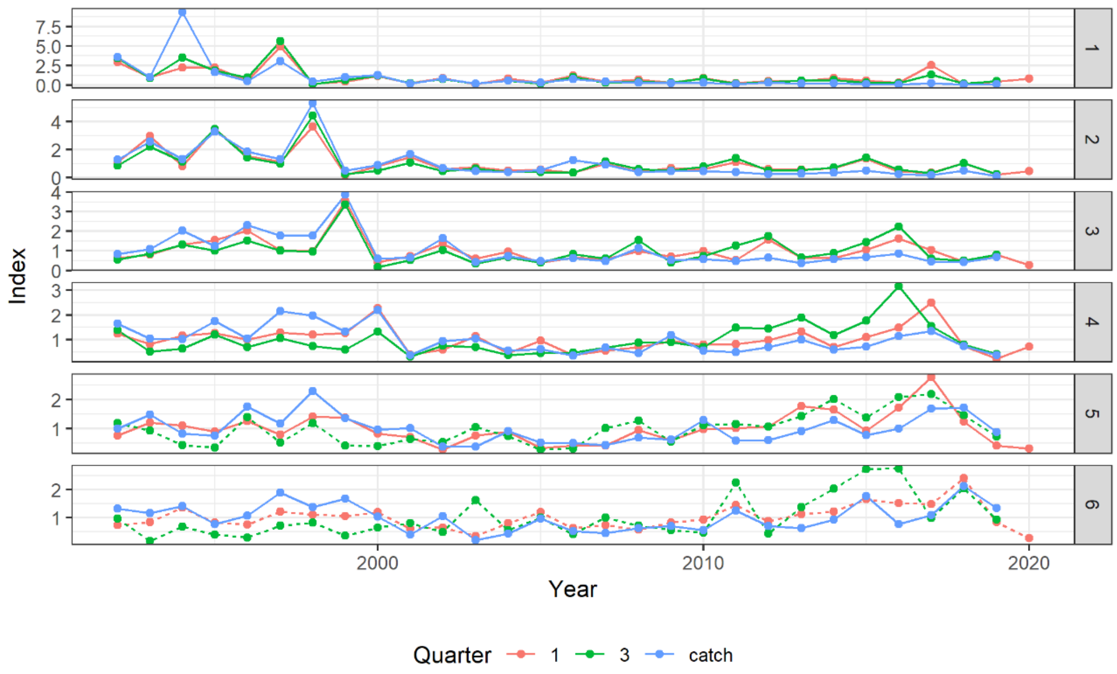


Figure 4.8b. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS indices with catch-at-age data. The survey indices and catch data are mean standardised from 1992. Data used in the assessment are plotted with solid lines.

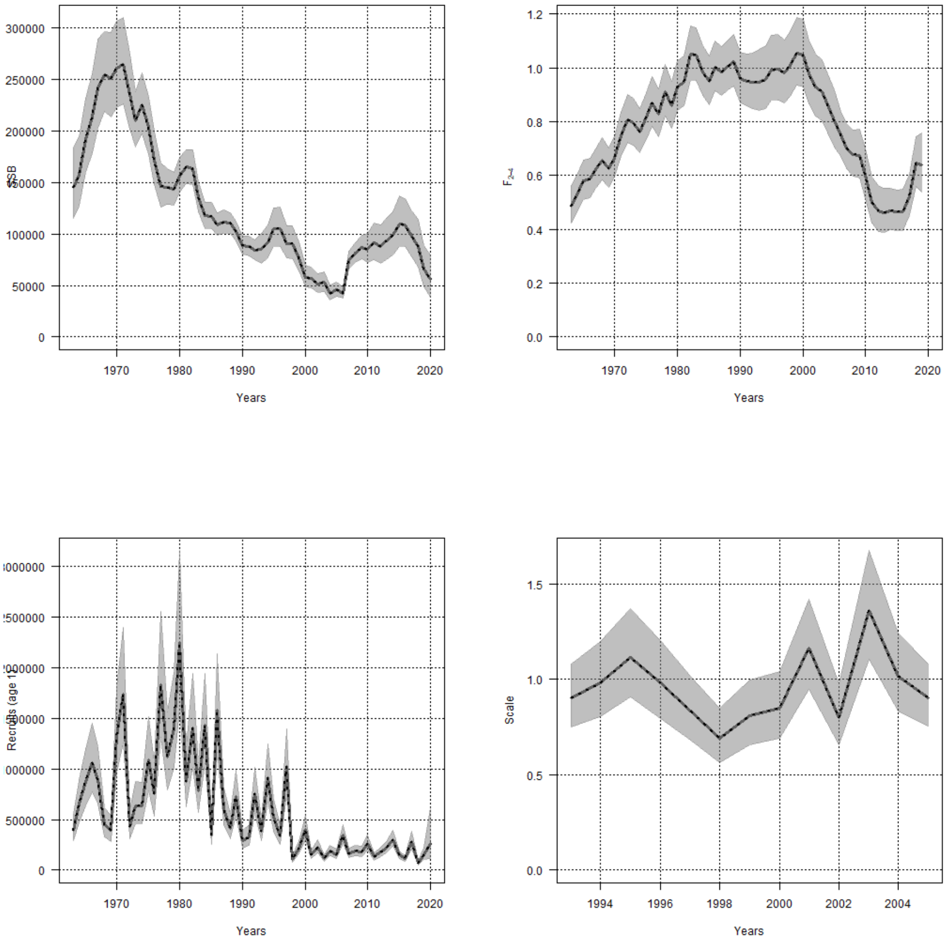
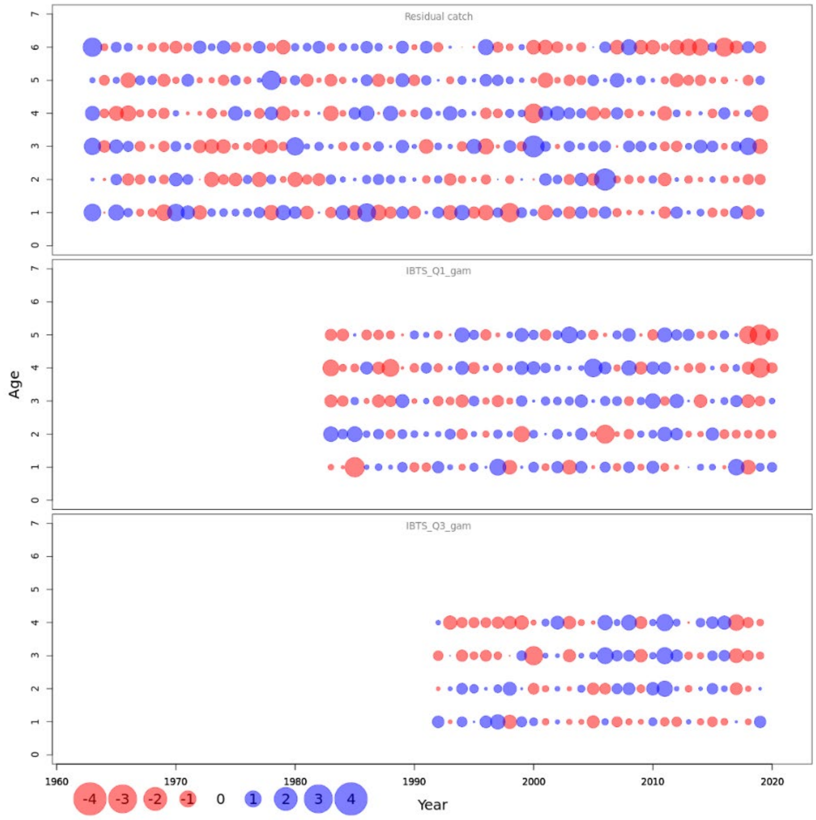


Figure 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and the catch multiplier from the SAM assessment (black lines = estimate and shaded area = corresponding pointwise 95% confidence intervals).



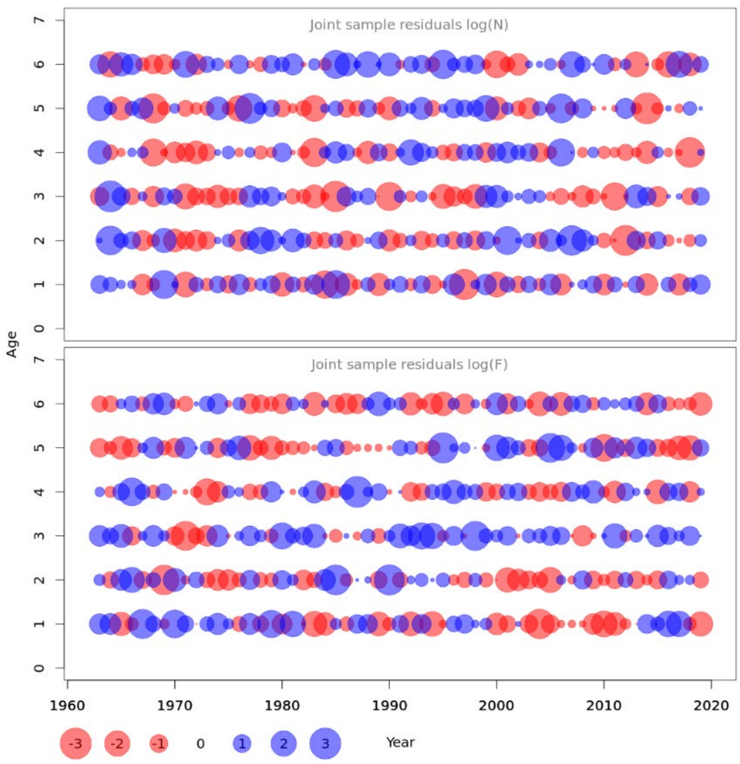


Figure 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: Normalized residuals for the SAM assessment for (top) total catch, IBTS–Q1, IBTS–Q3 and (bottom) the process increments. Blue circles indicate a positive residual and red circles a negative residual.

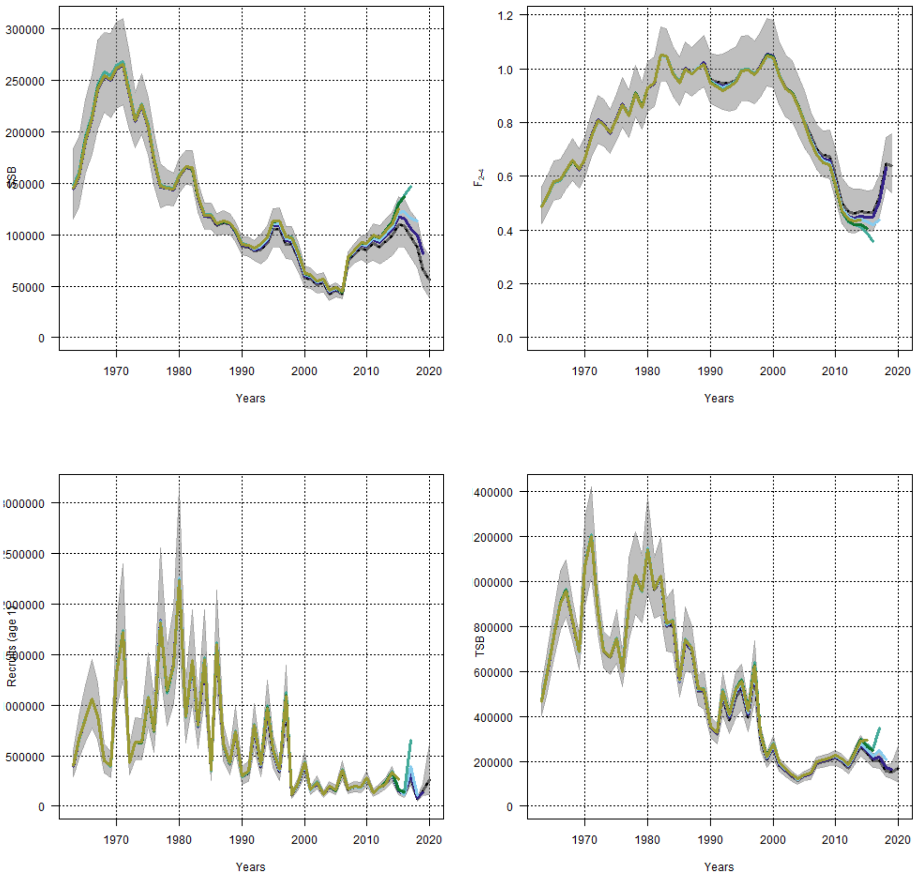


Figure 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: Retrospective estimates (5 years) from the SAM assessment. Estimated yearly SSB (top left), average fishing mortality (top right), recruitment age 1 (bottom left) and TSB (bottom right), together with corresponding pointwise 95% confidence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

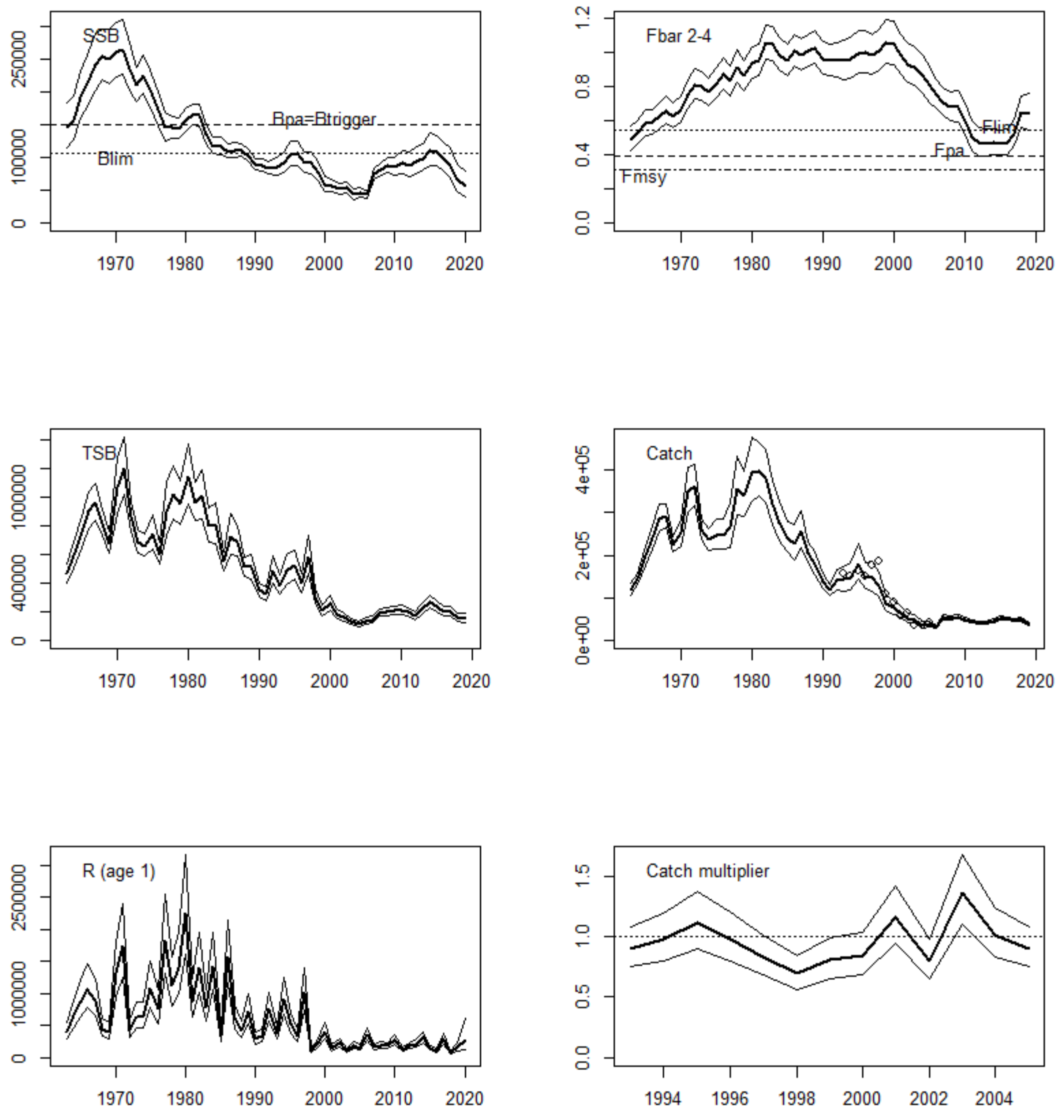


Figure 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Anticlockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2–4 (F(2–4)), from the SAM final run (catch multiplier estimated for 1993–2005 only). The heavy lines represent the point-wise estimate, and the light lines point-wise 95% confidence intervals. The open circles given in the catch plot represent model estimates of the total catch excluding unaccounted mortality, while the solid lines represent the total catch including unaccounted mortality for 1993–2005. The horizontal broken lines in the SSB plot indicate B_{lim} = 107 000 t and B_{pa} = 150 000 t, and in the F_{bar} plot F_{lim} = 0.54, F_{pa} = 0.39 and F_{MSY} = 0.31. The horizontal broken line in the catch multiplier plot indicates a multiplier of 1. Catch, SSB and TSB are in tonnes, and R in thousands.

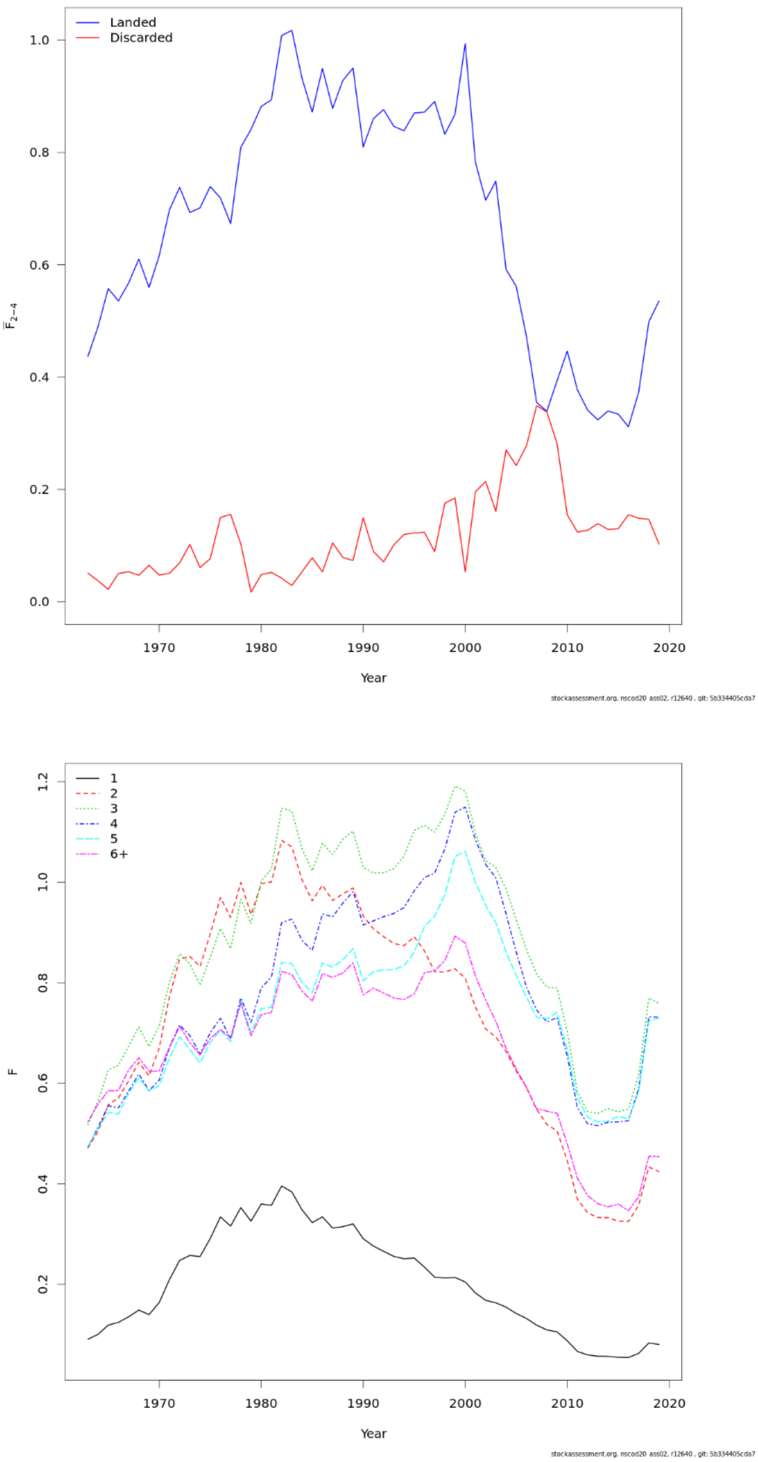


Figure 4.13. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age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

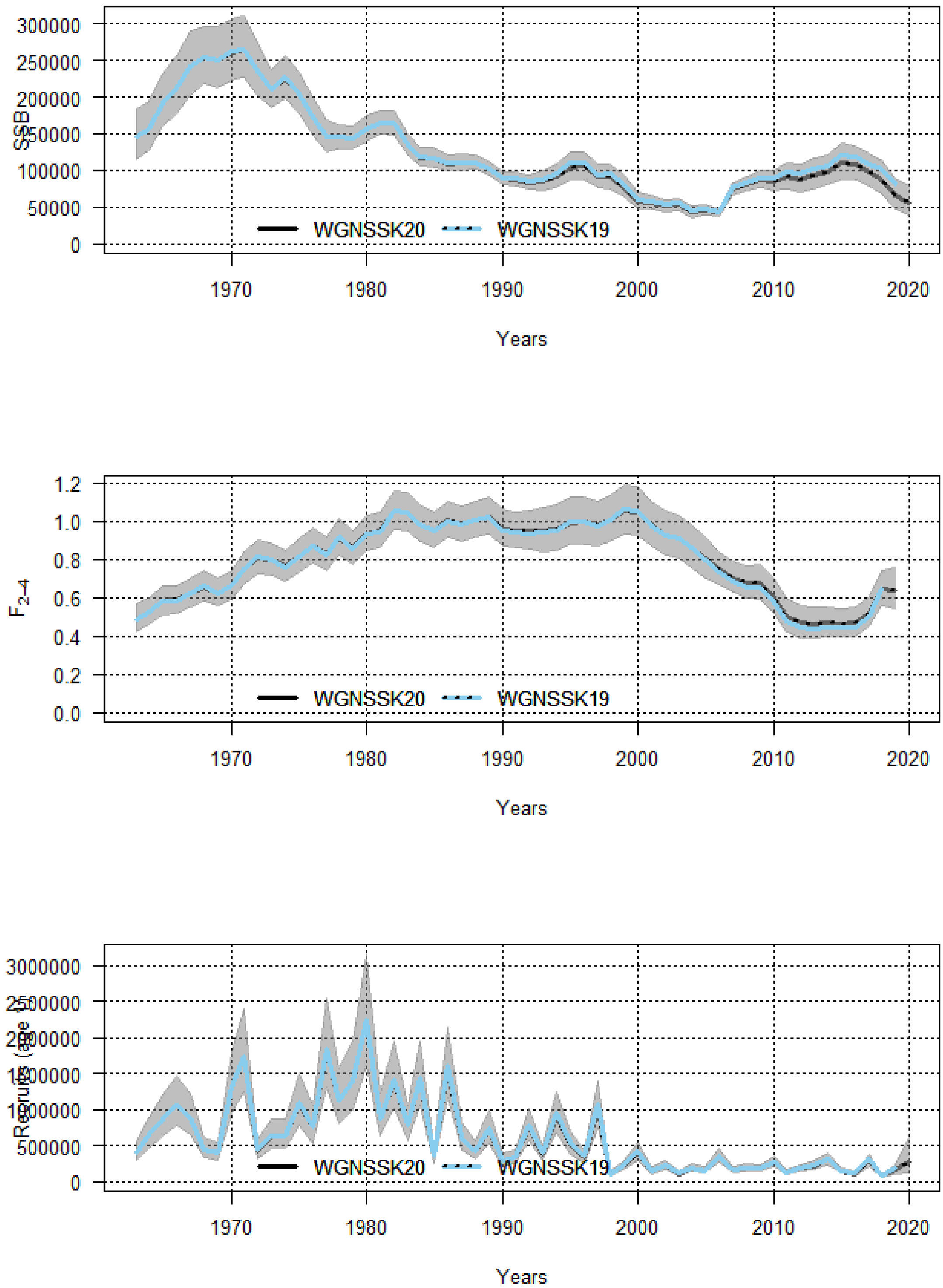


Figure 4.14a. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the final SAM assessment for 2020 with the final SAM assessment for 2019 (updated in October 2019). Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding pointwise 95% confidence intervals.

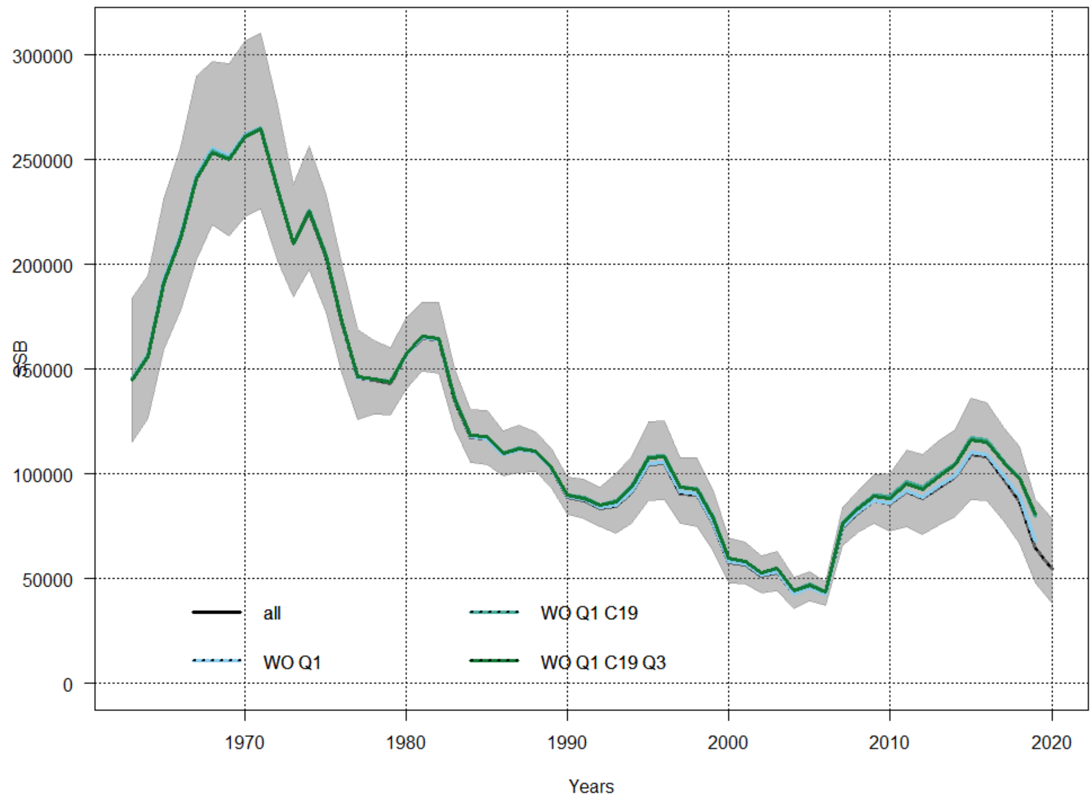


Figure 4.14b. Cod in Subarea 4, Division 7.d and Subdivision 20: Contribution of new data to the downscaling of SSB in the final SAM assessment for 2020, showing assessment runs without NS-IBTS Q1 data for 2020 (Q1), 2019 catch data (C19) and NS-IBTS Q3 data for 2019 (Q3).

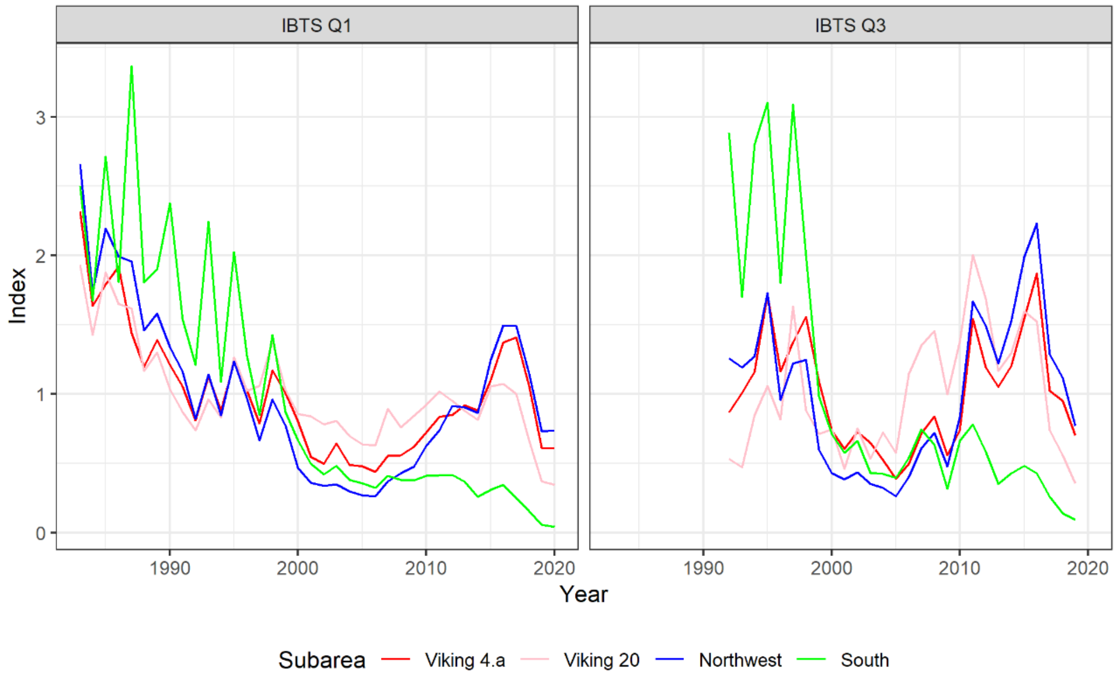


Figure 4.15a. Cod in Subarea 4, Division 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.15c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model (including ship effects) to numbers-at-age for the entire dataset and integrating the fitted abundance surface over each of the 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.

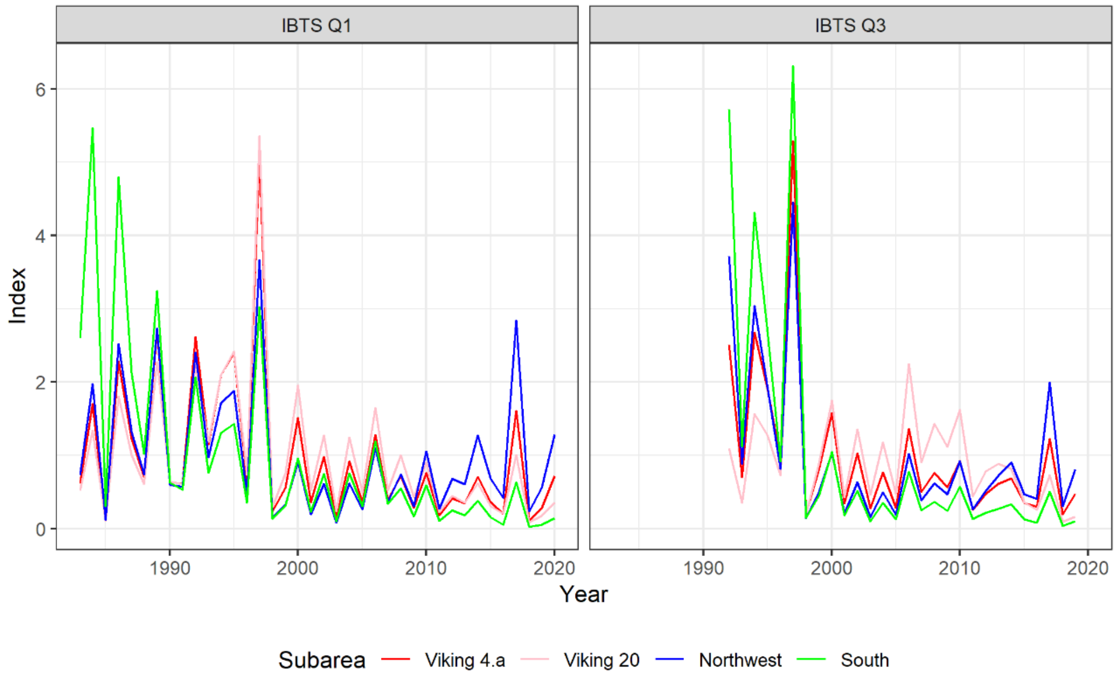


Figure 4.15b. Cod in Subarea 4, Division 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.15c), based on NS–IBTS–Q1 and Q3 data.

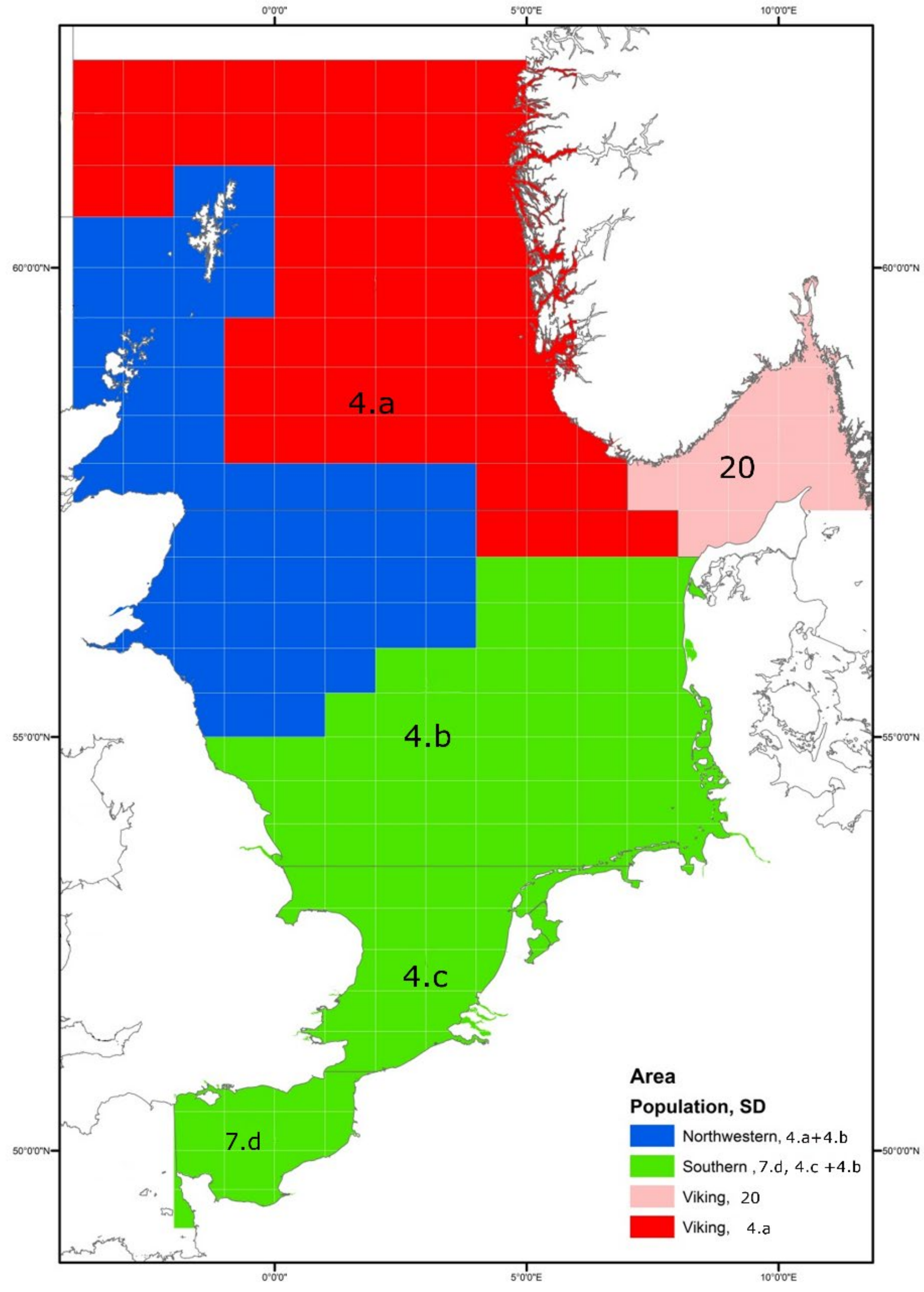


Figure 4.15c. Cod in Subarea 4, Division 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

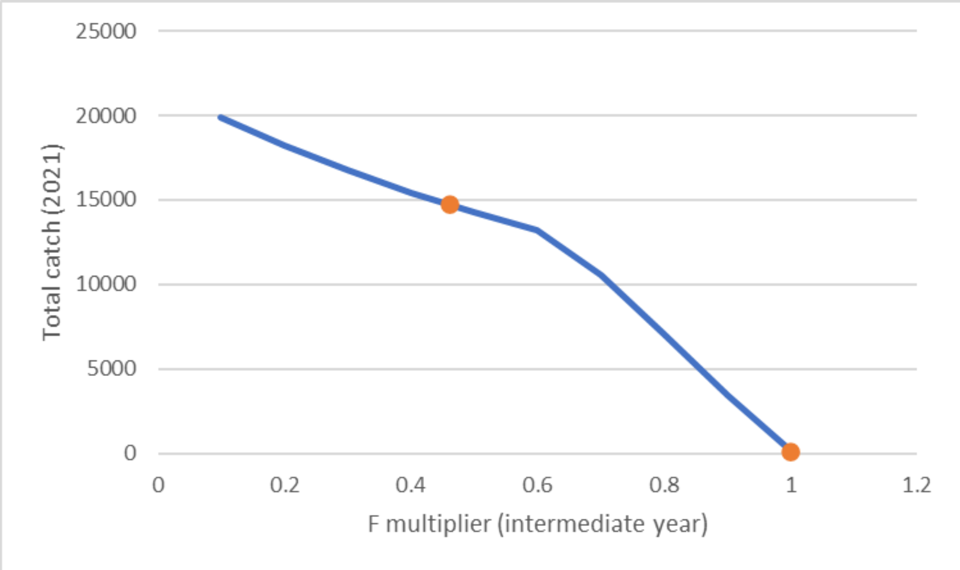


Figure 4.16. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catches in 2021 corresponding to the MSY approach (i.e. $F=F_{MSY}\times SSB_{2021}/B_{trigger}$ where this brings SSB above B_{lim} in 2022, and the F corresponding to SSB (2022) = B_{lim} otherwise) assuming different multipliers on F(2019) in the intermediate year. The orange dots correspond to full TAC utilisation (F multiplier of 0.46) and F status quo (F multiplier of 1).

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

5.1 General

Dab (*Limanda limanda*) was assessed for the first time by the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) in 2014. Until 2013 dab was assessed by the Working Group on Assessment of New MoU Species (ICES, 2013a). This group was dissolved in 2014. Because only official landings and survey data were available at that time, dab was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Since 2015 dab was included in the official data call for the WGNSSK and discard estimates could be included into the dab assessment since then. In 2016 a benchmark assessment of dab was conducted by ICES. For this benchmark assessment, catch data from 2002 were requested and uploaded into the InterCatch data portal by all relevant countries (ICES, 2016). The benchmark agreed on the use of a survey based assessment model (SURBAR; Needle, 2015) to inform stock status of North Sea dab (ICES, 2016). This model provides relative estimates of the spawning stock, recruitment, and total mortality. During the WGNSSK 2017 MSY proxy reference points were determined applying the Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) and catch advice for dab was provided for 2017 and 2018. In 2017 the combined TAC for dab and flounder was removed (EU COM, 2017/595). North Sea dab has become a non-target species with no TAC since then and ICES has not been requested to provide advice on fishing opportunities for this stock since then. However, catch data, indices and the SURBAR assessment were updated and also an updated SPiCT assessment was performed. In 2019, catches decreased to 40 725 tonnes (compared to 44 792 tonnes in 2018). The SSB value was nearly the same as for 2018, and is still on a comparable high level. Recruitment showed a decreasing trend from 2015 to 2018 but again increased in 2019. The updated results of the SPiCT assessment for dab in Subarea 4 and Division 3.a showed that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is above the reference B_{MSY} proxy.

5.1.1 Biology and ecosystem aspects

Dab is a widespread demersal species on the Northeast Atlantic shelf and distributed from the Bay of Biscay to Iceland and Norway, including the Barents Sea and the Baltic. In the North Sea it is one of the most abundant species distributed over the whole area in depths down to 100 m, but it was also found occasionally down to depths of 150 m. The main concentration of dab can be found in the south eastern North Sea especially that of the younger age groups 1–2. Older age groups are more distributed in the central and more Northern parts of the North Sea (Figure 5.14). Generally, dab abundance decreases towards the northern parts of the North Sea. Dab feeds on a variety of small invertebrates, mainly polychaete worms, shellfish and crustaceans. Early sexual maturation was reported for dab, maturing at ages of 2 to 3 years corresponding to approximately 11 cm to 14 cm total length. Peak spawning in the south eastern North Sea occurs from February to April.

5.1.2 Stock ID and possible assessment areas

The several spawning grounds and the wide distribution of dab indicate the presence of more than one stock. Meristic data (Lozán, 1988) corroborate the hypothesis of several stocks for dab, distinguishing significantly between populations from western British waters, the North Sea and the Baltic Sea.

5.1.3 Management regulations

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

5.2 Fisheries data

5.2.1 Historical landings

Dab is a bycatch species mainly in the fisheries for plaice and sole but also in fisheries targeting demersal round fish. According to ICES catch statistics, annual landings of dab in ICES Subarea 4 and Division 3.a has been well above 10 000 tonnes since 1973 (Figure 5.1–5.3, Table 5.13). The apparent decrease in official landings in the 1980s and 1990s are due to unreported landings by the Netherlands and Norway. However, since 1999 total landings for both areas (Subarea 4 and Division 3.a) steadily decreased. This trend continued until 2015 with total official landings of 4512 tonnes. In 2016, official landings for both areas increased slightly and resulted in total landings of 4953 tonnes. In 2017, a strong decrease in official landings to 3529 tonnes was observed. This was the lowest record of official landings for the whole time series (1950–2019). In 2019 the official landings increased to 5053 tonnes.

The main fishing gear in the North Sea is the beam trawl with mesh sizes between 80 and 100 mm. Large effort reductions took place in this fishery over the last decade. The largest part of the landings in Subarea 4 is taken by the Netherlands, followed by Denmark, 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).

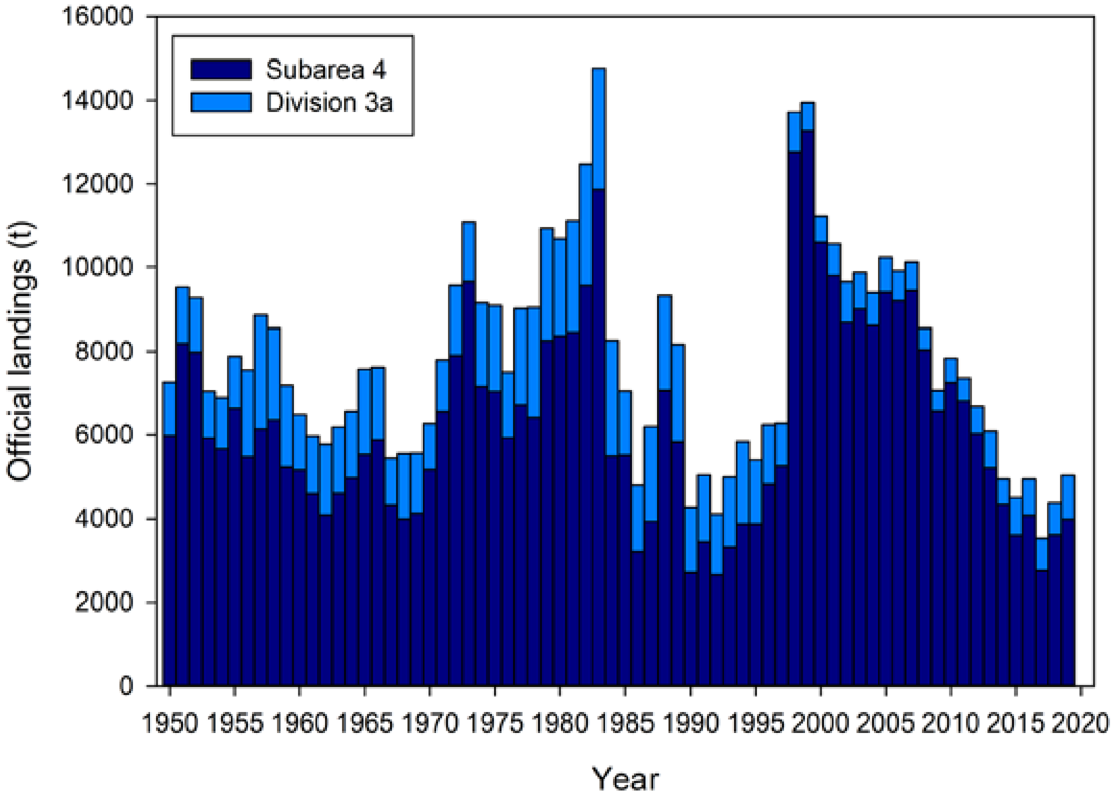


Figure 5.1. Dab in Subarea 4 and Division 3.a: Total official landings of dab in Subarea 4 and Division 3.a in 1950–2019.

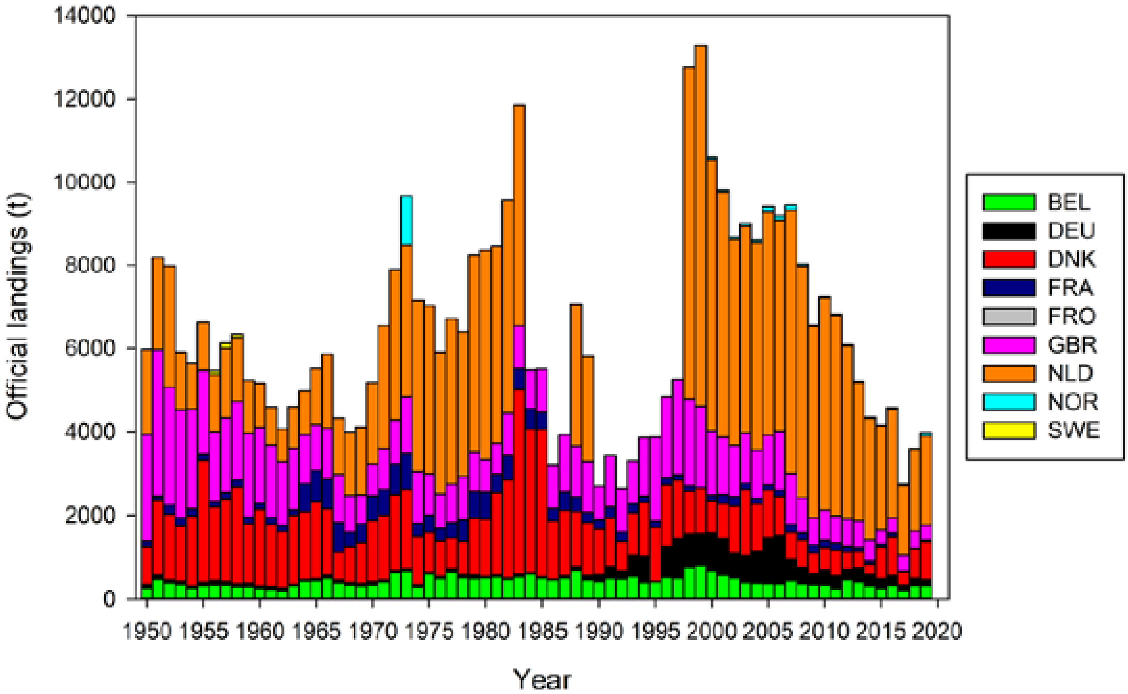


Figure 5.2. Dab in Subarea 4 and Division 3.a: Official landings of dab in Subarea 4 by country 1950 to 2019.

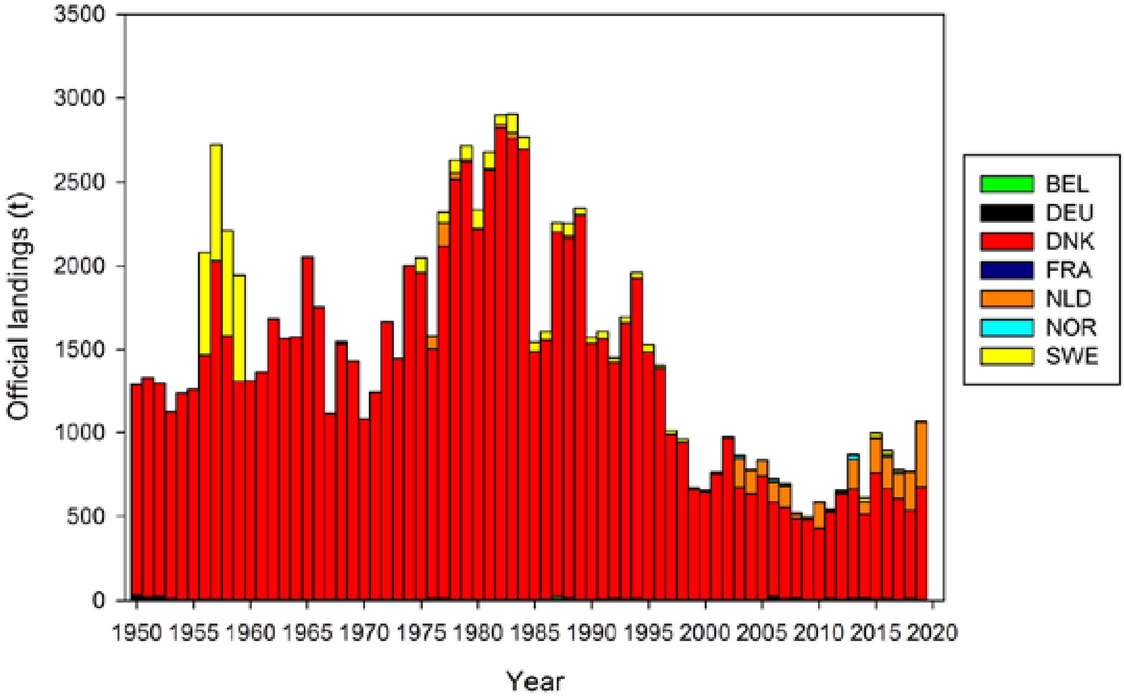


Figure 5.3. Dab in Subarea 4 and Division 3.a: Official landings of dab in Division 3.a by country 1950–2019.

5.2.2 InterCatch

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

In 2019 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 2019 was taken by The Netherlands (21 335 tonnes in total) followed by Germany with 7131 tonnes. All other countries did catch less than 5000 tonnes (Figure 5.7). The total dab catch estimated with InterCatch for 2019 was 40 725 tonnes (- 4 067 tonnes compared to 2018) from which 5024 tonnes were landings and 35 702 tonnes discards (88% 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 2019 data discard raising:

Group 1: MIS_MIS_HC all area (3.a and area 4) -> raised with all other métiers because no specific MIS_MIS_HC all data were available in 2019 data.

Group 2: passive gears area 3.a -> raised with all available passive gears (FPO excluded because of exceptional high discard ratio)

Group 3: passive gears area 4 -> raised with all available passive gears (FPO excluded because of exceptional high discard ratio)

Group 4: OTB_CRU_70-99__0_0_all and OTB_CRU_70-89_2_35 -> raised with OTB_CRU_70-99_0_0_all métiers (two Dutch métiers excluded because of exceptional high discard ratios).

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

Group 6: OTB_DEF_>120__0_0_all area 4 -> raised with all available OTB_DEF_>120__0_0_all métiers in area 4.

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

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

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

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

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

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

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

The following 48 métiers were not raised because they were negligible or no suitable data were available:

- TBB_CRU_16-31_0_0_all (10 métiers)
- OTB_CRU_16-31_0_0_all (7 métiers)
- OTB_CRU_32-69_0_0_all (NOR, 5 métiers)
- OTB_SPF_70-99_0_0_all (FRA, 3 métiers)
- OTM_SPF_70-99_0_0_all (FRA, 3 métiers)
- MIS_MIS_0_0_0_IBC (16 métiers)
- OTB_SPF_32-69_0_0_all (3 métiers)
- OTB_DEF_32-69_0_0_all (BEL, 1 métier)

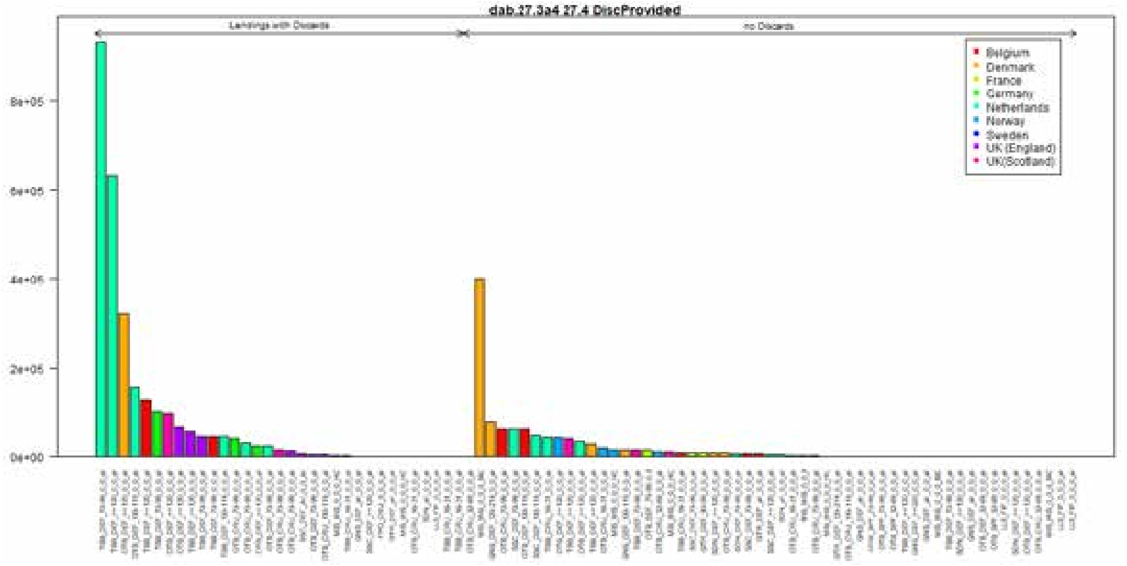


Figure 5.4. Dab in Subarea 4 and Division 3.a: Dab landings and discards (kg) provision for Subarea 4 and Division 3.a by métier and country in 2019 as uploaded into InterCatch.

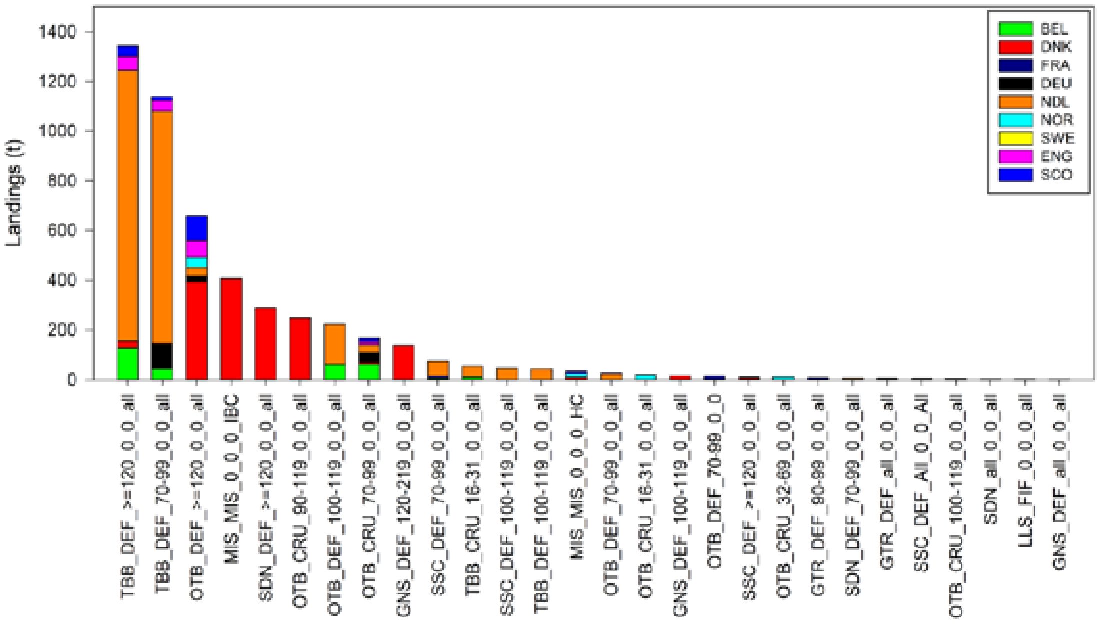


Figure 5.5. Dab in Subarea 4 and Division 3.a: Dab landings (tonnes) for Subarea 4 and Division 3.a by métier and country in 2019 as uploaded to InterCatch.

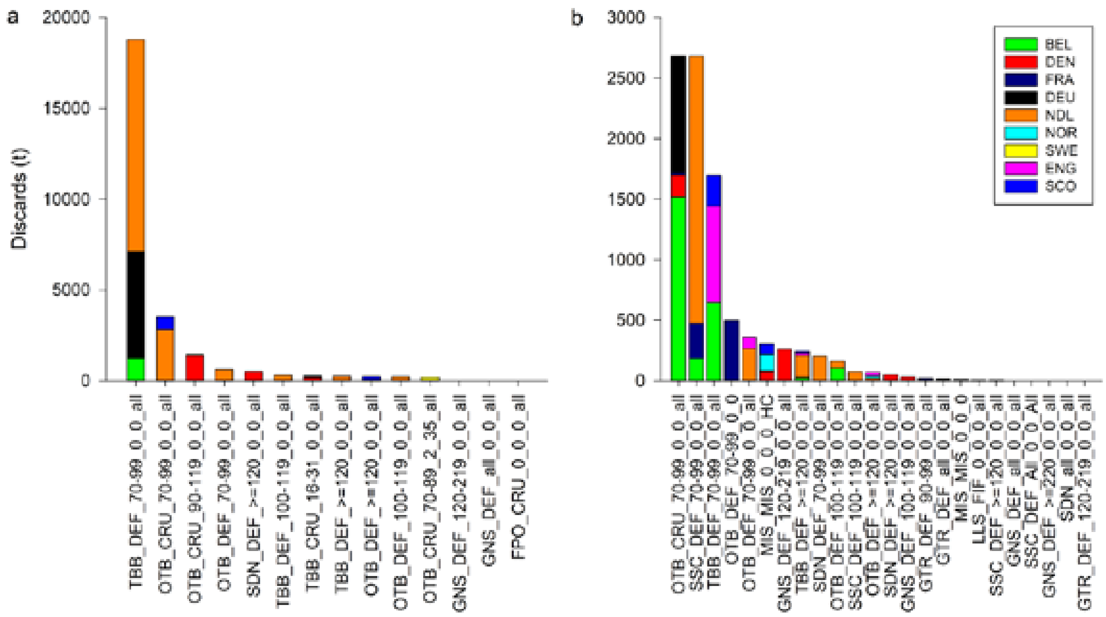


Figure 5.6. Dab in Subarea 4 and Division 3.a: Dab discards for Subarea 4 and Division 3.a by métier and country in 2019. Reported discards (a), raised discards (b).

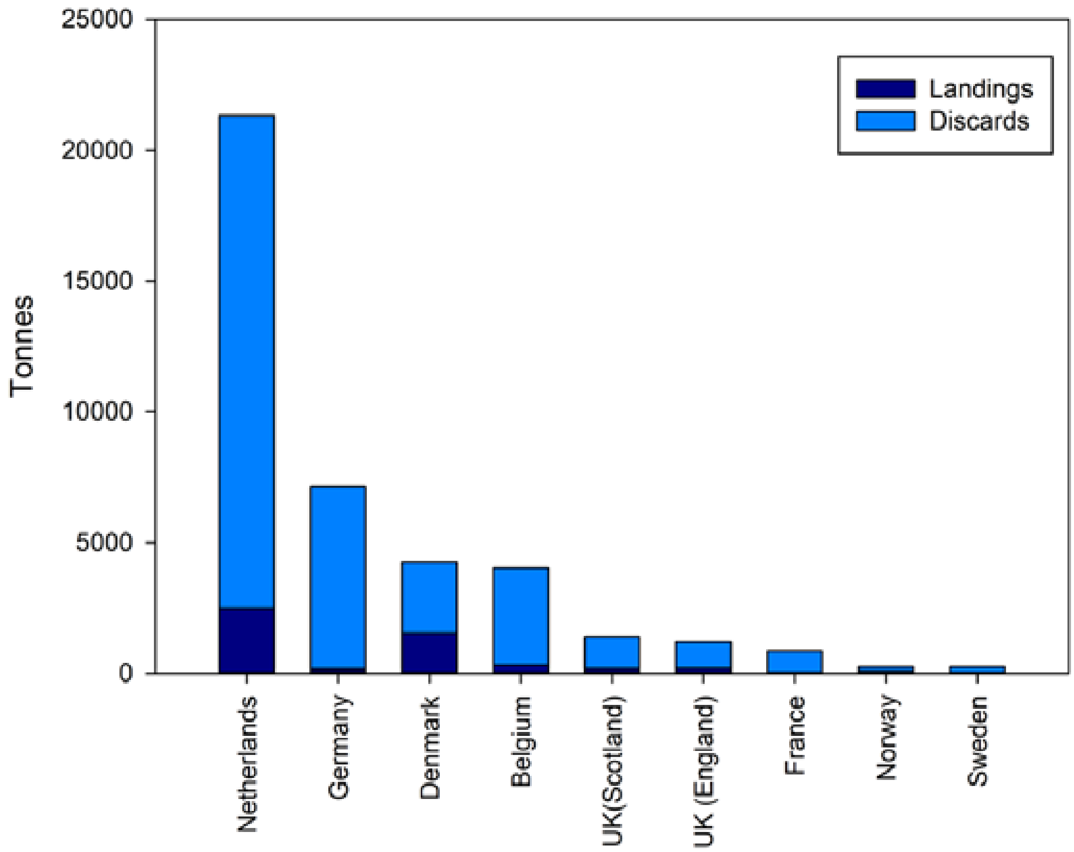


Figure 5.7. Dab in Subarea 4 and Division 3.a: Dab landings and estimated discards for Subarea 4 and Division 3.a by countries in 2019.

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).

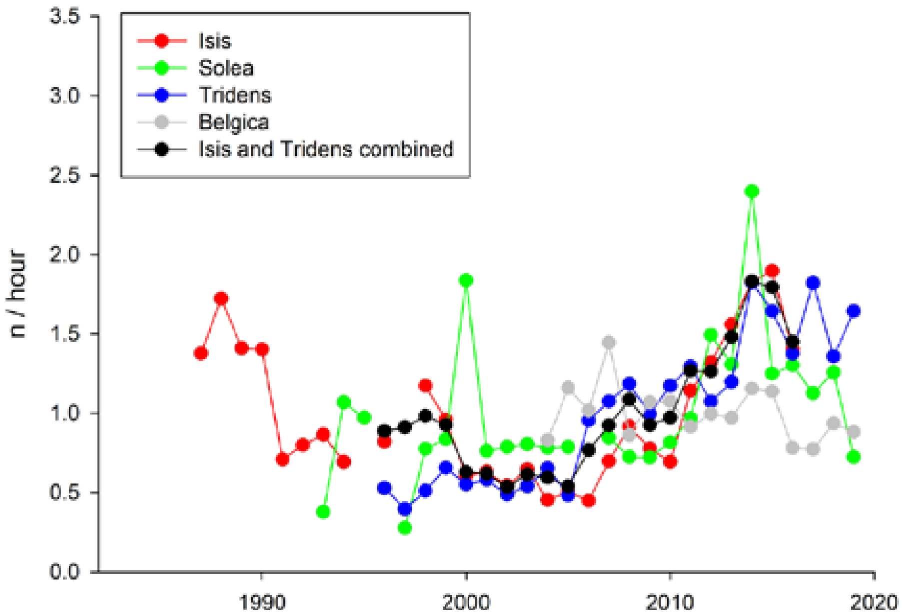


Figure 5.8. Dab in Subarea 4 and Division 3.a: Standardized dab beam trawl survey indices (n/hour) in Subarea 4.

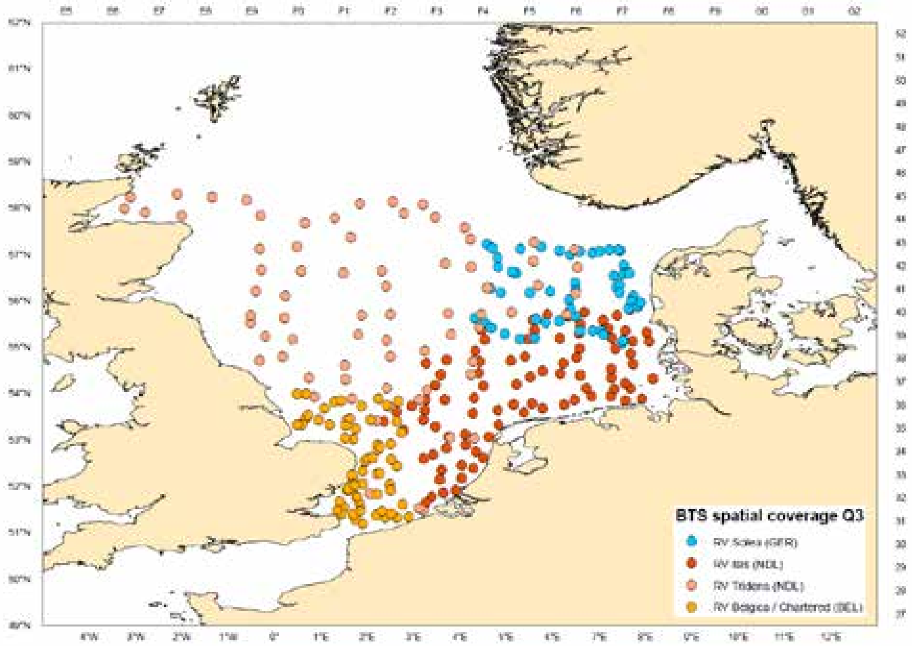


Figure 5.9. Dab in Subarea 4 and Division 3.a: Spatial coverage of the different beam trawl surveys in the North Sea. Since 2017, the survey area from RV Isis is also covered by RV Tridens.

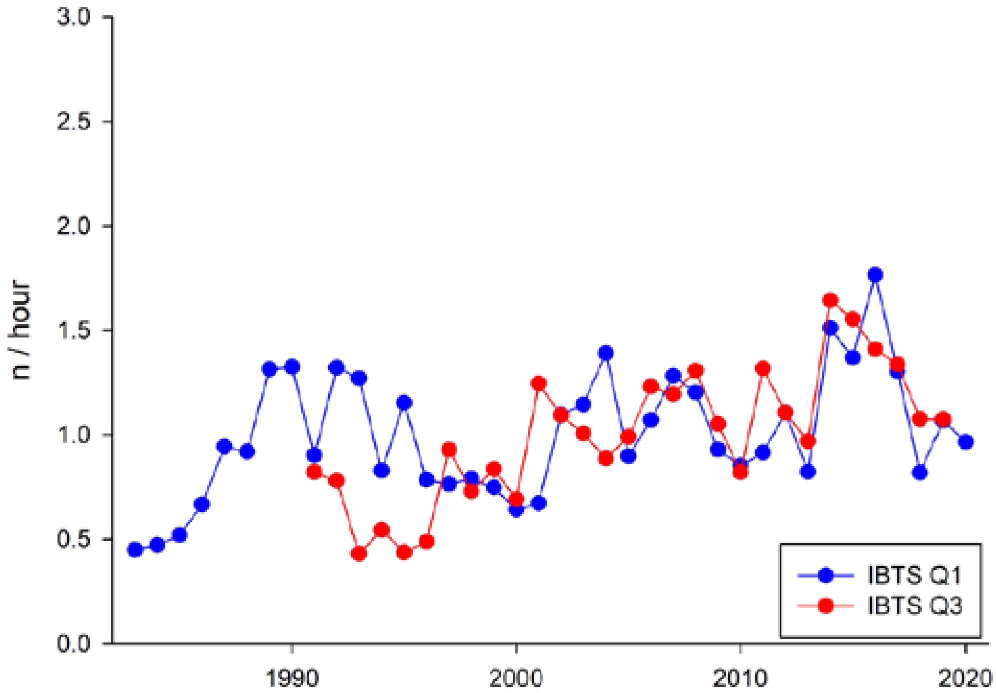


Figure 5.10. Dab in Subarea 4 and Division 3.a: Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

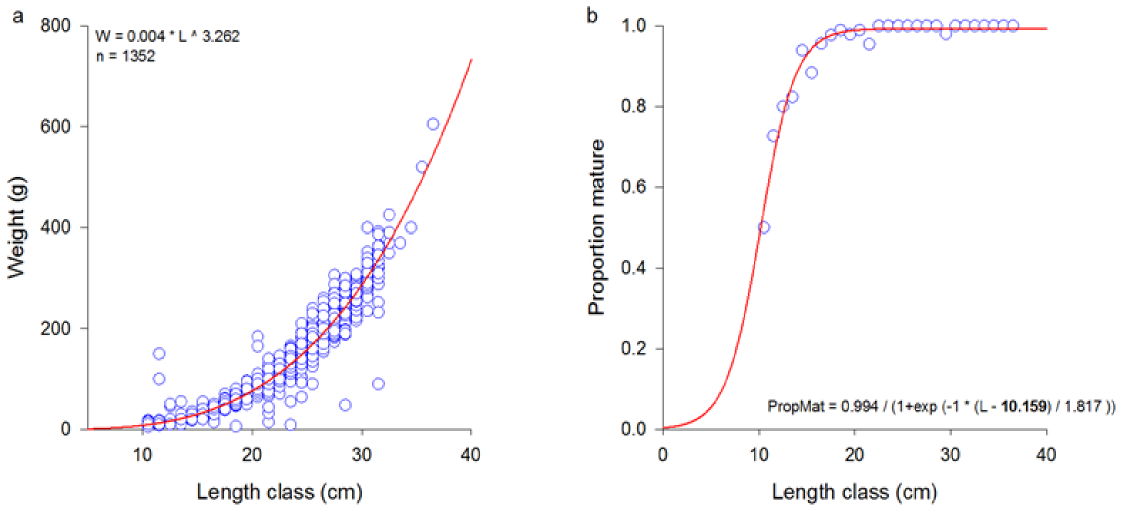


Figure 5.11. Dab in Subarea 4 and Division 3.a: Length weight relation (a) and length based maturity ogive (b) obtained from survey data (IBTS–Q1).

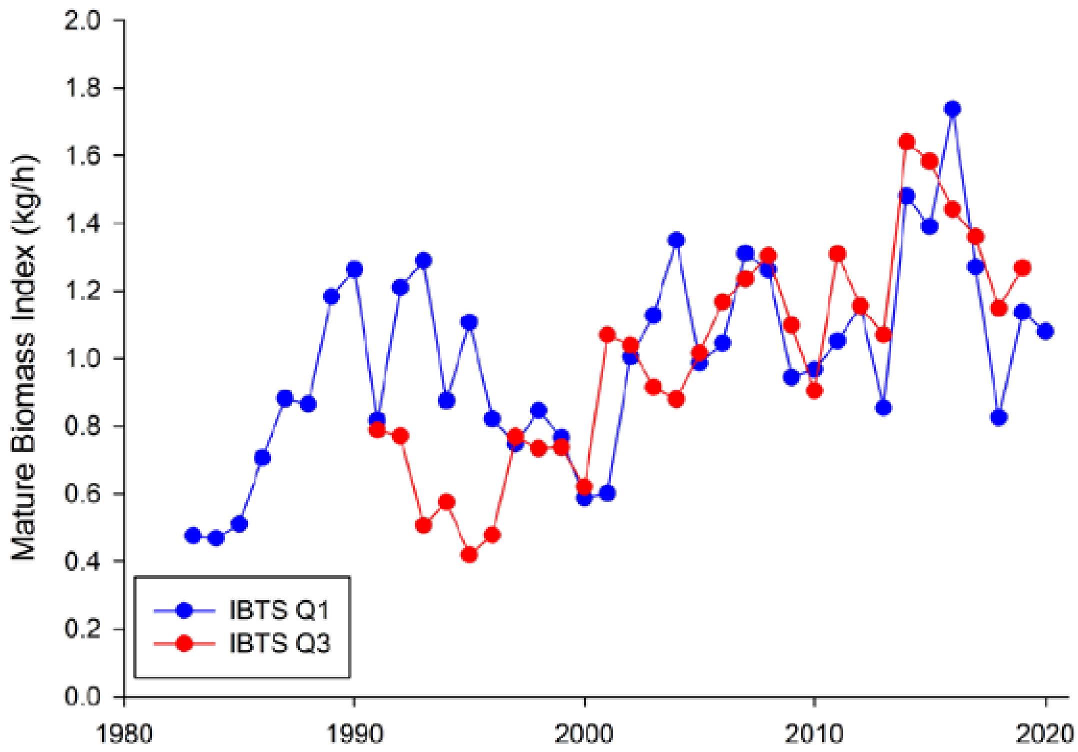


Figure 5.12. Dab in Subarea 4 and Division 3.a: Mature biomass index IBTSQ1 and IBTSQ3.

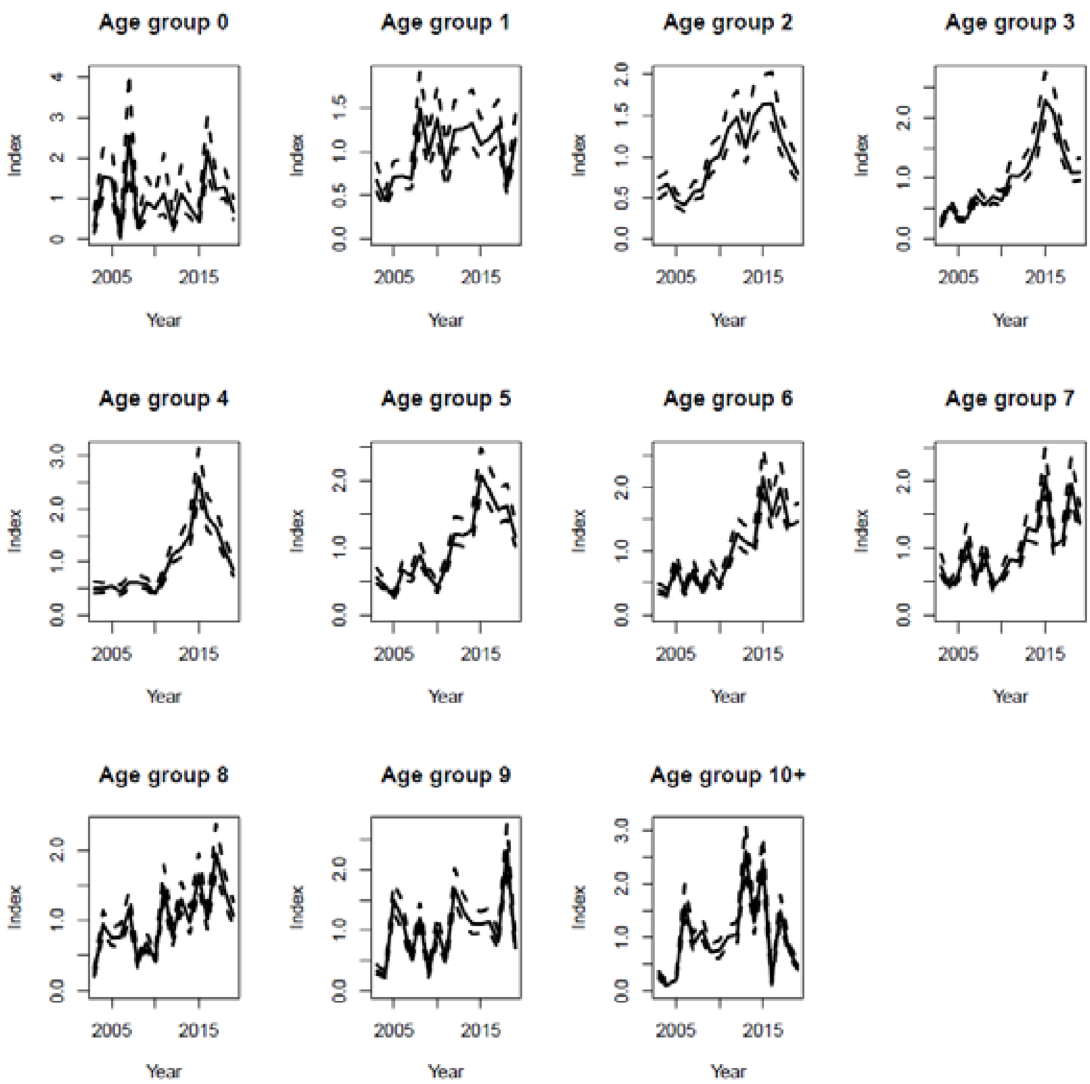


Figure 5.13. Dab in Subarea 4 and Division 3.a: Combined beam trawl index by age groups (2003–2019). Age group = age group -1.

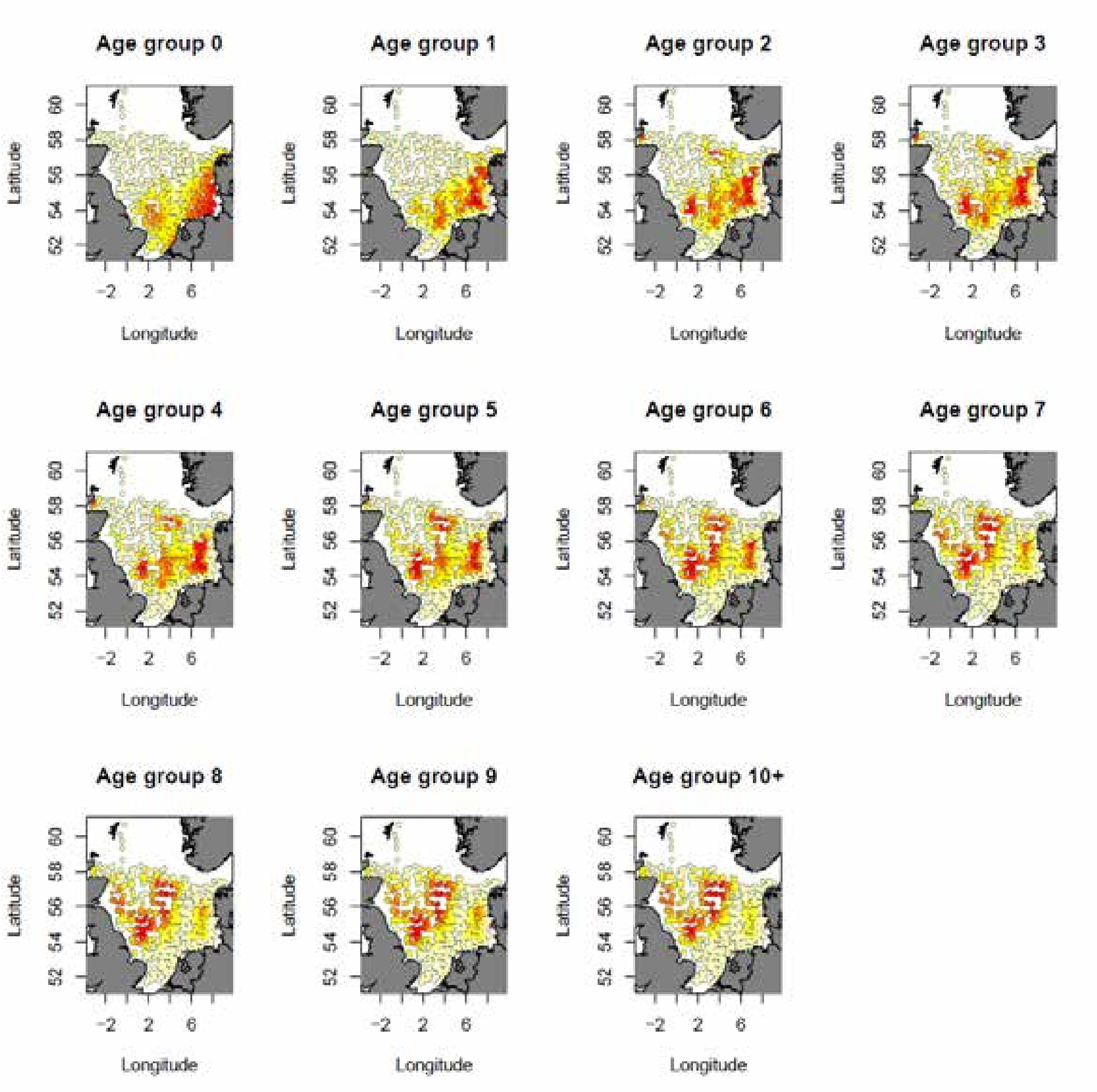


Figure 5.14. Dab in Subarea 4 and Division 3.a: Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys.

Figure. 5.15 Dab in Subarea 4 and Division 3.a: Weight at age derived from beam trawl survey data 2003–2019).

5.4 Survey Based Assessment (SURBAR)

In 2016, a benchmark assessment was carried out for dab (ICES, 2016). During this benchmark it was agreed to make use of the available data from the beam trawl surveys and to run a survey based assessment model (SURBAR; Needle, 2015) taking the age structure of dab into account. The SURBAR results of the update assessment showed an overall decreasing trend in total mortality for the years 2003–2014 (Figure 5.16, upper left panel) while the spawning stock biomass (relative biomass) continued to increase for the years 2003–2016 (Figure 5.16, upper right panel). Total mortality increased for the years 2015–2017, but stabelized in 2018 and 2019. The spawning stock biomass also decreases since 2017, but is still on a comparable high level in 2019. The recruitment increased by a factor of 2.6 from 2003 to 2014 but decreased since 2015 (Figure 5.16, lower right panel). In 2018 a sharp decrease of recruitment was observed, but it increased again in 2019. However, there was quite a strong retrospective pattern in recruitment with an underestimation of recruitment for some years (Figure 5.21). This might indicate a lower catchability of the survey for the youngest age group and a lower capability of the SURBAR model to track the young age groups. No pattern was detected in the log residual pattern of the age based survey indices (Figure 5.17).

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

Setting/Data	Values/source
Survey index	Combined beam trawl survey index 2003–current assessment year (BTS-Isis, BTS-Tridens, German BTS) . Delta GAM Method by Berg *et al.* (2014).
Ages	1–6
Lambda	3
zbar	1–6
Spawning time	0.4
Maturity ogive	Fixed ogive, age 1 = 60%, age 2 = 80%, age 3 and older 100%
Weight at age	Data from Dutch Beam Trawl Surveys (2003–current assessment year)

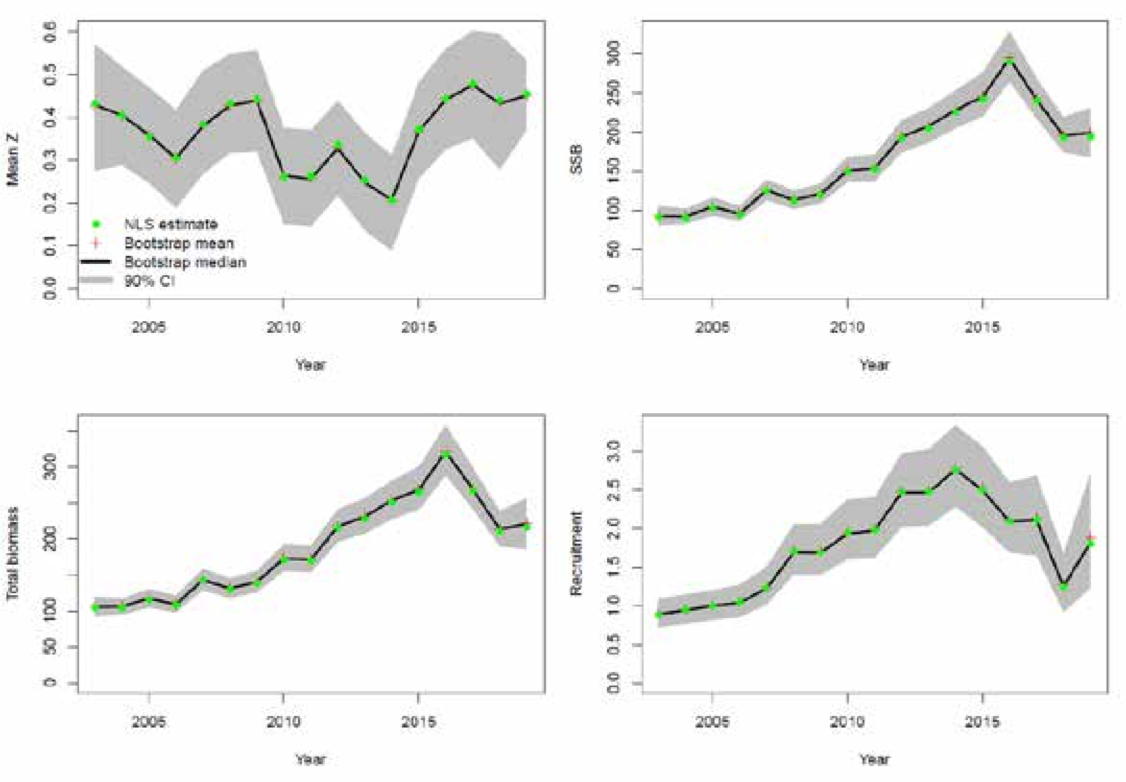


Figure 5.16. Dab in Subarea 4 and Division 3.a: SURBAR model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

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

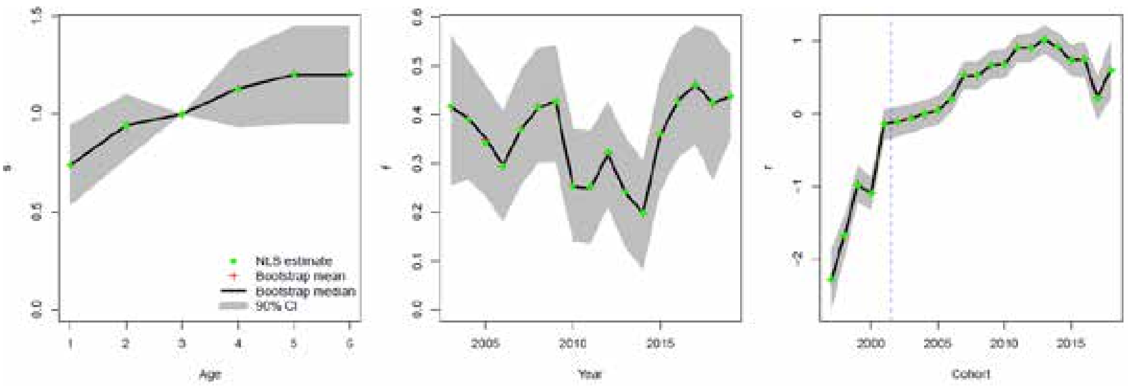


Figure 5.18. Dab in Subarea 4 and Division 3.a: SURBAR model results displaying the age, year and cohort effects.

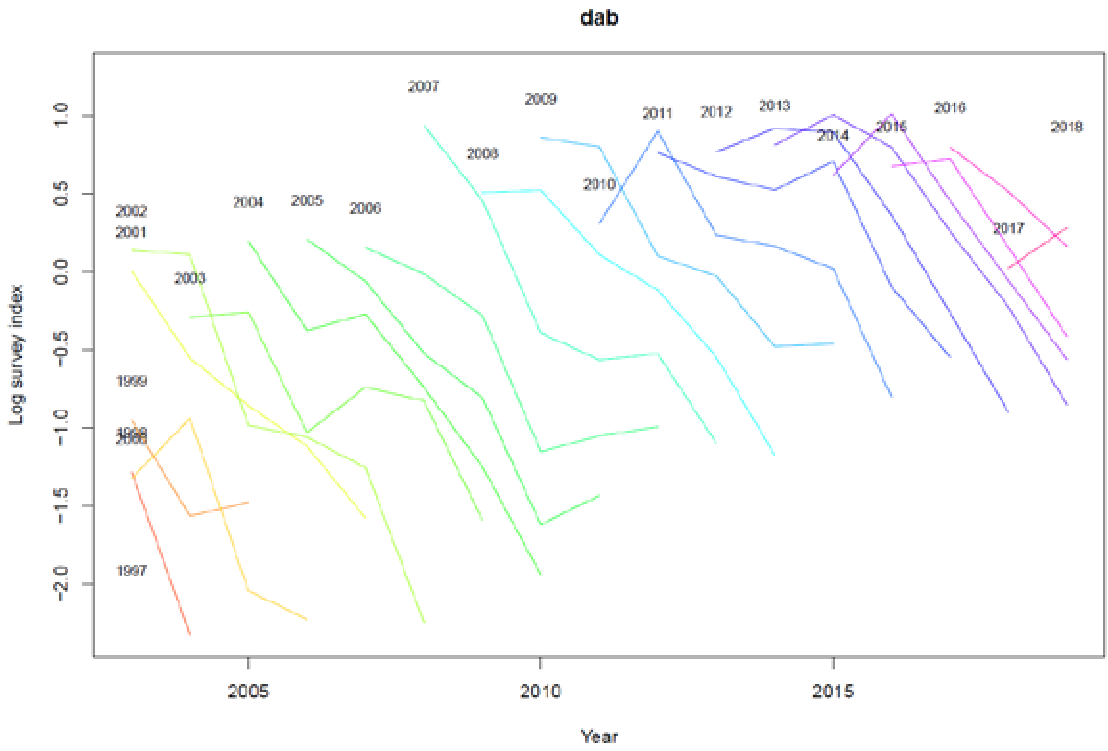


Figure 5.19. Dab in Subarea 4 and Division 3.a: SURBAR model results: catch curves.

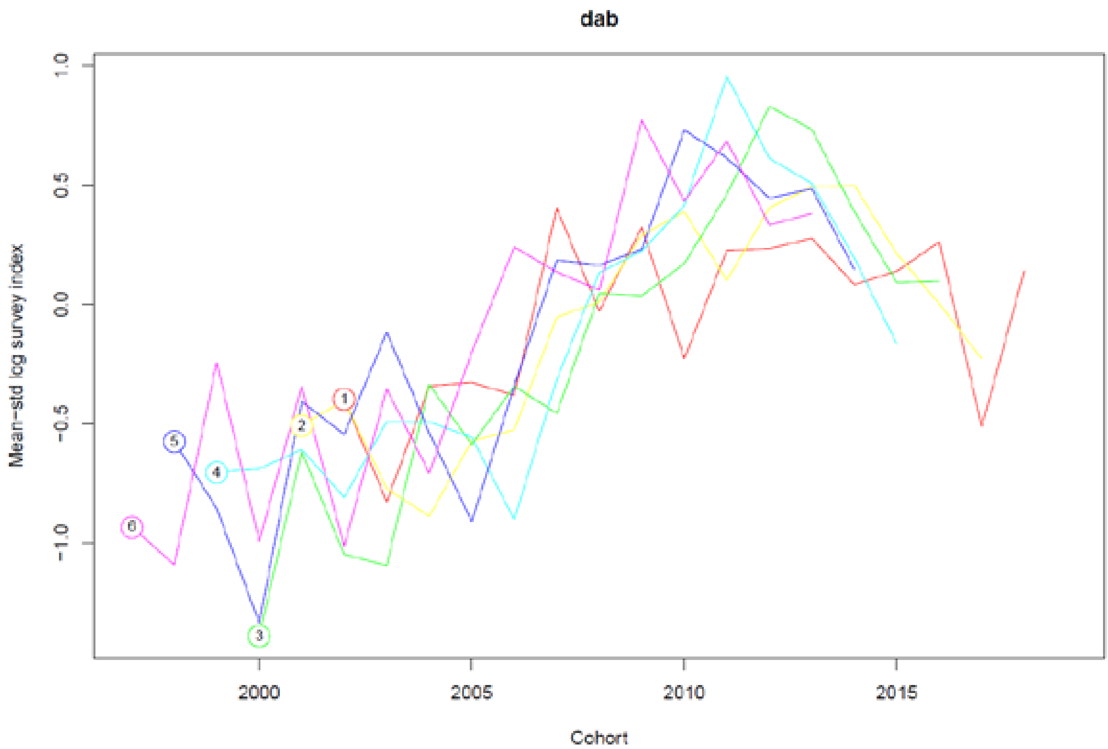


Figure 5.20. Dab in Subarea 4 and Division 3.a: SURBAR mean-standardized log survey index.

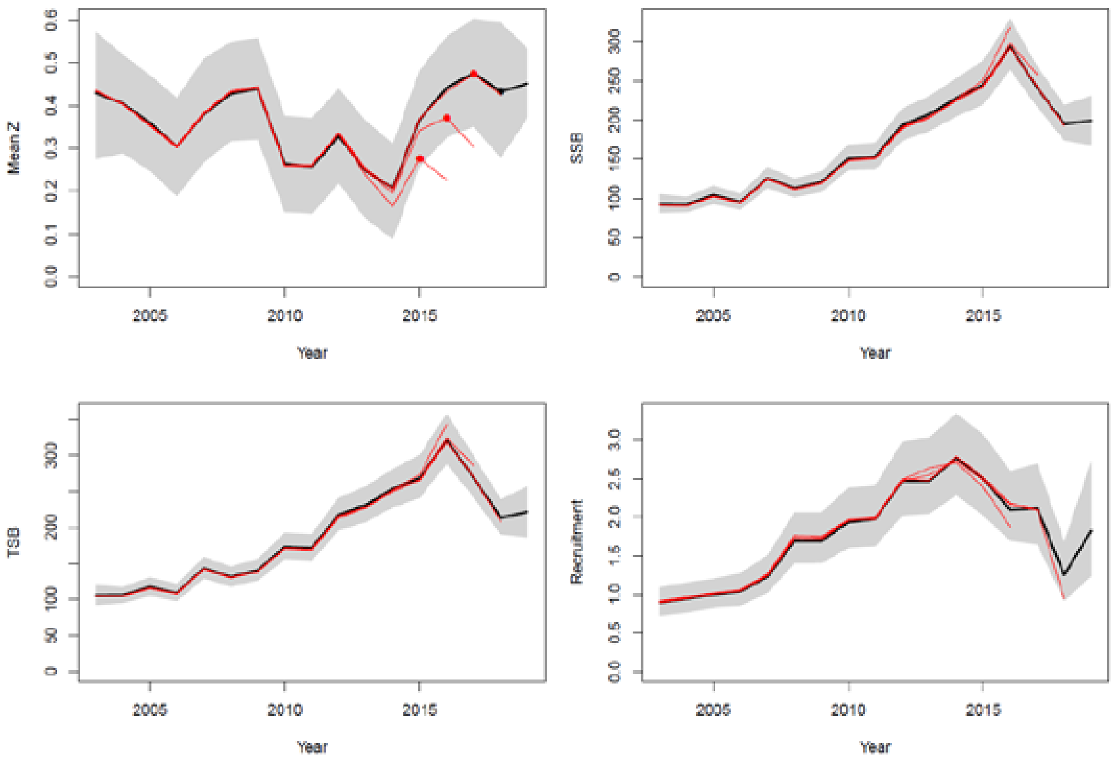


Figure 5.21. Dab in Subarea 4 and Division 3.a: SURBAR Retrospective runs.

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

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

In order to estimate MSY proxy reference points for dab a Surplus Production Model in Continuous Time (SPiCT; Pedersen and Berg, 2017) was applied. Three fishery independent survey time series and a catch time series (2002–2019) 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 2002–2019
BTS Isis	1987–2002, >12 cm
BTS Tridens	1996–2002, >12 cm
Combined BTS (Isis, Tridens, Solea)	2003–2019, Age > 1 yr
SPiCT settings	Default from stockassessment.org, no priors

The results of the SPiCT assessment for dab in Subarea 4 and Division 3.a showed that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is above the reference B_{MSY} * 0.5 proxy. Also the estimated uncertainty boundaries around the relative F values show that these are below the reference F_{MSY} proxy for recent years, and those estimated for the relative biomass are above the reference B_{MSY}* 0.5 for recent years. However, it has to be noted here that the absolute F and biomass estimates are highly uncertain and must not be used for any further analyses or conclusions. All results of the SPiCT assessment are given in figures 5.22–5.28.

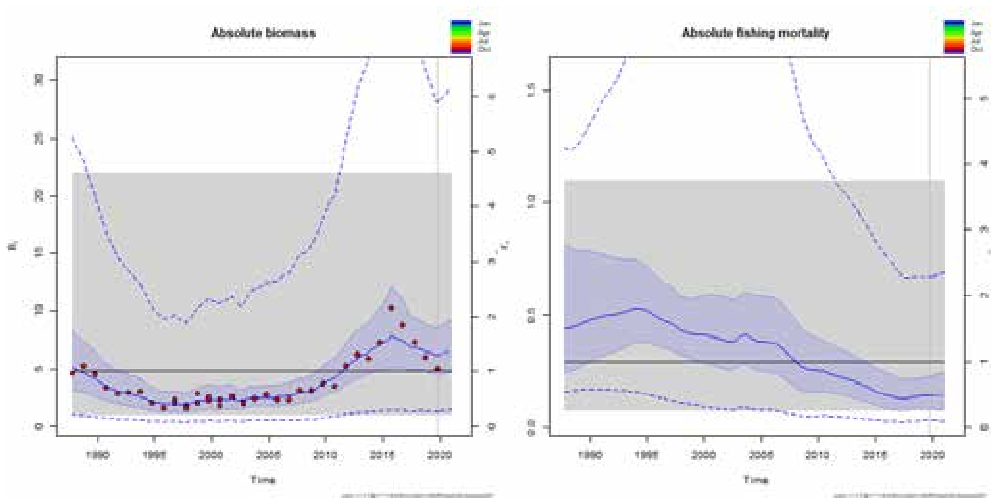


Figure 5.22. Dab in Subarea 4 and Division 3.a: SPiCT results. Absolute biomass (left panel) and absolute fishing mortality (right panel).

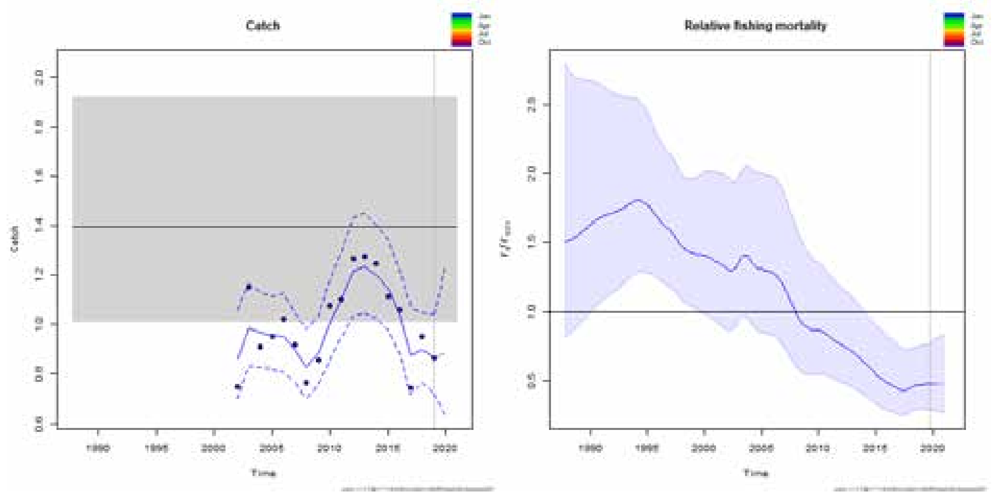


Figure 5.23. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch time series (left panel) and relative fishing mortality (right panel).

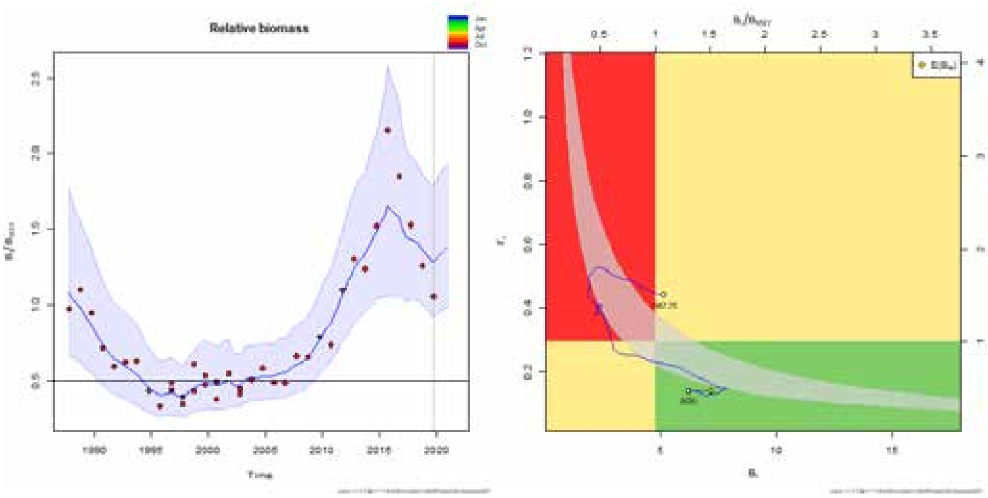


Figure 5.24. Dab in Subarea 4 and Division 3.a: SPiCT results. Relative biomass (left panel) and Kobe plot of relative fishing mortality over biomass estimate (right panel).

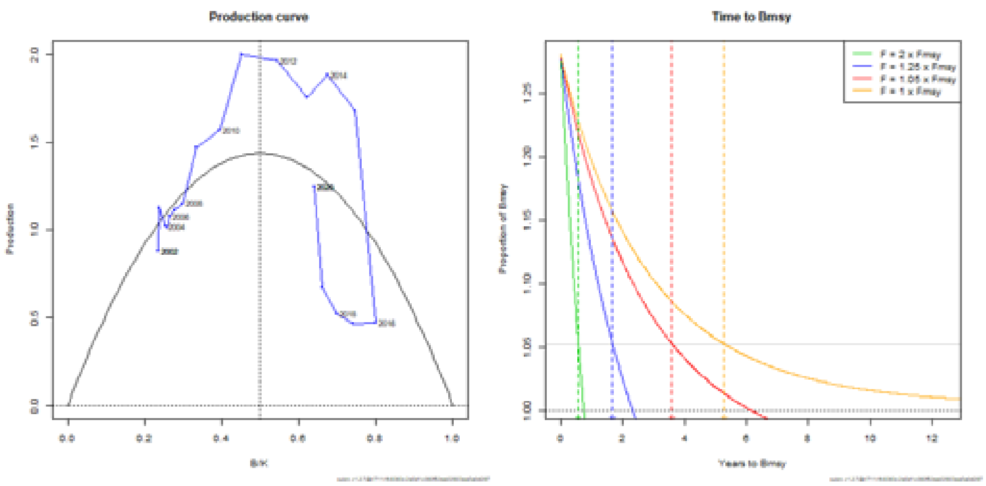


Figure 5.25. Dab in Subarea 4 and Division 3.a: SPiCT results. Production curve (left panel) and estimated time to B_{MSY} (right panel).

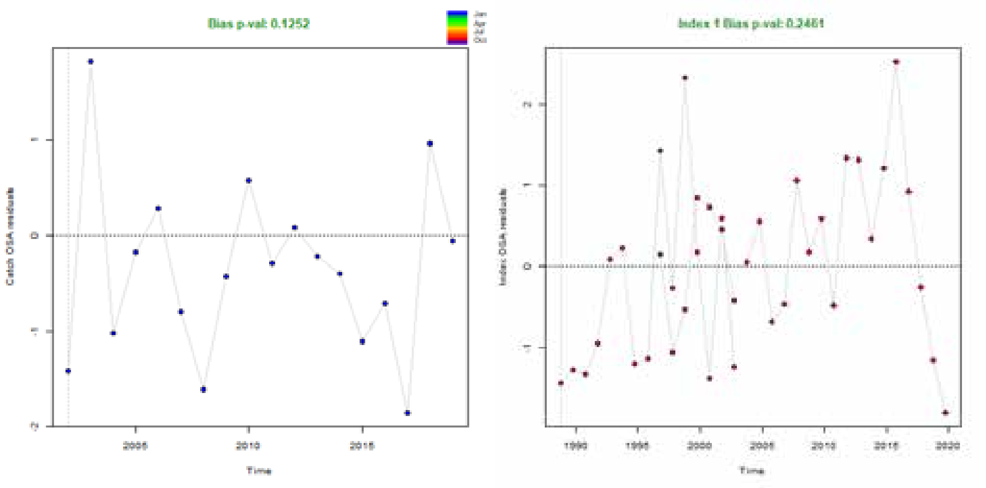


Figure 5.26. Dab in Subarea 4 and Division 3.a: SPiCT results. Catch residuals (left panel) and survey residuals (right panel).

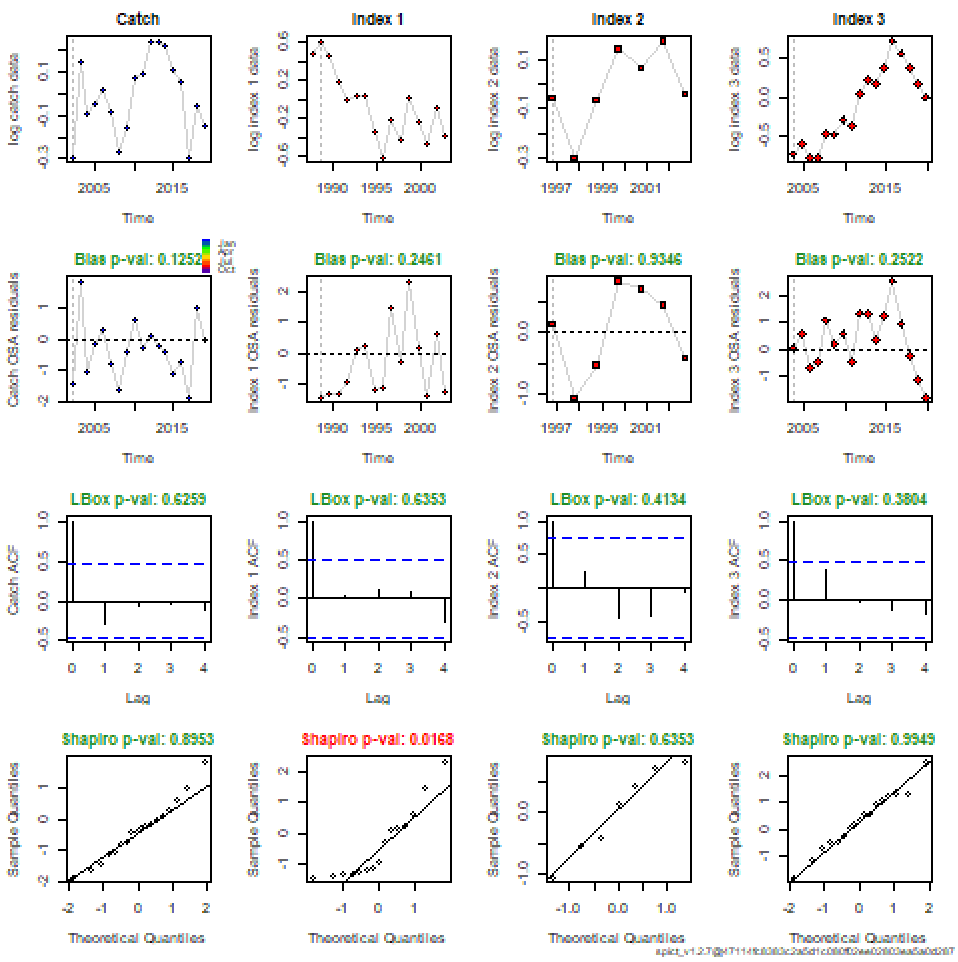


Figure 5.27. Dab in Subarea 4 and Division 3.a: SPiCT diagnostics.

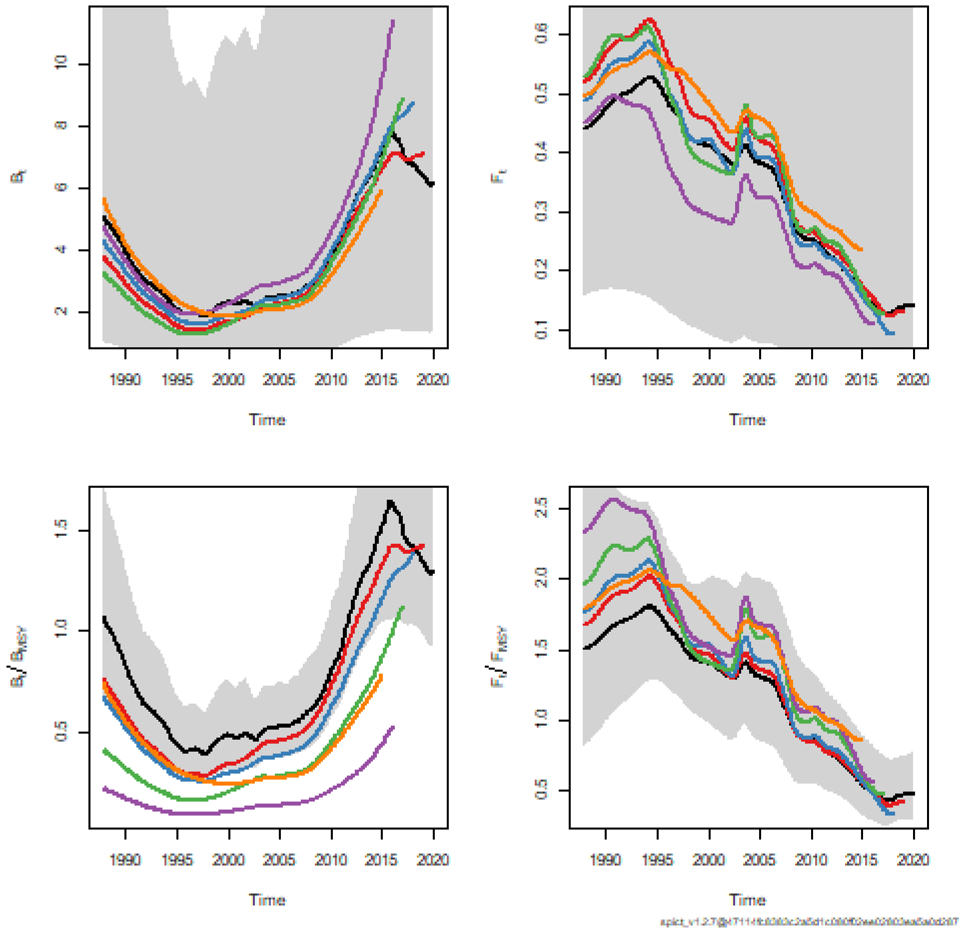


Figure 5.28. Dab in Subarea 4 and Division 3.a: SPiCT retrospective plots.

5.6 Issues list

- Métiers with zero landings but no discards reported. No raising possible for these cases. What is the possible impact on catch estimation? Are there other ways to estimate 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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5.8 Tables

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

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

Year	Subarea 4	Division 3.a	Total
1988	7067	2254	9321
1989	5816	2346	8162
1990	2701	1574	4275
1991	3448	1609	5057
1992	2647	1454	4101
1993	3309	1695	5004
1994	3861	1961	5822
1995	3865	1530	5395
1996	4834	1405	6239
1997	5259	1012	6271
1998	12759	961	13720
1999	13276	673	13949
2000	10595	654	11249
2001	9799	765	10564
2002	8678	977	9655
2003	9008	865	9873
2004	8608	779	9387
2005	9402	836	10238
2006	9190	725	9915
2007	9434	694	10128
2008	8029	522	8551
2009	6561	498	7059
2010	7240	589	7829
2011	6824	545	7369
2012	6095	653	6748
2013	5214	871	6085
2014	4344	611	4955
2015	3595	917	4512
2016	4070	883	4953
2017	2751	778	3529
2018	3607	770	4377
2019*	3987	1066	5053

*** 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

*** preliminary catch statistics**

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

Year	Bel	Deu	Dnk	Fra	Nld	Nor	Swe	Division 3.a
1950	0	34	1253	0	0	0	0	1287
1951	0	17	1315	0	0	0	0	1332
1952	0	21	1273	0	0	0	0	1294
1953	0	9	1114	0	0	0	0	1123
1954	0	4	1233	0	0	0	0	1237
1955	0	3	1254	0	0	0	0	1257
1956	0	5	1462	0	0	0	614	2081
1957	0	5	2025	0	0	0	694	2724
1958	0	4	1578	0	0	0	628	2210
1959	0	2	1307	0	0	0	634	1943
1960	0	1	1313	0	0	0	0	1314
1961	0	0	1367	0	0	0	0	1367
1962	0	2	1681	0	0	0	0	1683
1963	0	0	1565	0	0	0	0	1565
1964	0	1	1574	0	0	0	0	1575
1965	0	1	2051	0	0	0	0	2052
1966	0	0	1755	0	0	0	0	1755
1967	0	0	1115	0	0	0	0	1115
1968	0	0	1535	13	0	0	0	1548
1969	0	0	1430	0	0	0	0	1430
1970	0	0	1079	0	0	0	0	1079
1971	0	0	1242	0	0	0	0	1242
1972	0	0	1669	0	0	0	0	1669
1973	0	0	1449	0	0	0	0	1449
1974	0	0	2003	0	0	0	0	2003
1975	0	0	1959	0	2	0	88	2049
1976	10	0	1493	0	80	0	0	1583
1977	11	0	2105	0	142	0	60	2318
1978	2	0	2515	0	39	0	74	2630
1979	3	0	2616	0	15	0	82	2716
1980	3	0	2218	0	3	0	109	2333
1981	0	0	2574	0	5	0	100	2679
1982	1	0	2823	0	22	0	56	2902
1983	1	0	2759	0	34	0	112	2906
1984	0	0	2695	0	0	0	74	2769
1985	1	0	1486	0	0	0	58	1545
1986	5	0	1551	0	0	0	52	1608
1987	19	0	2182	0	0	0	57	2258
1988	13	0	2150	0	15	0	76	2254

Year	Bel	Deu	Dnk	Fra	Nld	Nor	Swe	Division 3.a
1989	4	0	2302	0	0	0	40	2346
1990	3	0	1535	0	0	0	36	1574
1991	5	1	1556	0	0	0	47	1609
1992	10	0	1412	0	0	0	32	1454
1993	7	0	1656	0	0	0	32	1695
1994	9	0	1917	0	0	0	35	1961
1995	3	0	1482	0	0	0	45	1530
1996	0	0	1387	0	0	0	18	1405
1997	0	0	990	0	0	0	22	1012
1998	0	0	942	0	0	0	19	961
1999	0	0	661	0	0	0	12	673
2000	0	0	647	0	0	1	6	654
2001	0	0	751	0	0	7	7	765
2002	0	0	968	0	0	3	6	977
2003	0	0	674	0	173	14	4	865
2004	0	0	637	0	138	1	3	779
2005	0	0	738	0	95	0	3	836
2006	0	20	566	0	117	18	4	725
2007	0	9	547	0	126	3	9	694
2008	0	12	475	0	26	2	7	522
2009	0	4	478	0	3	1	12	498
2010	0	4	426	0	151	0	8	589
2011	0	10	517	0	0	11	7	545
2012	0	5	632	0	0	10	6	653
2013	0	11	654	0	174	26	6	871
2014	0	12	501	0	75	2	21	611
2015	0	8	752	0	203	8	24	995
2016	0	9	657	0	189	14	26	895
2017	0	5	601	0	146	14	12	778
2018*	0	10	528	n.a.	229	2	1	770
2019	0	1	675	0	387	1	2	1066

*** preliminary catch statistics**

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

Year	Landings	Imported discards	Raised discards	Total discards	Total catch	% discards
2002	8588	14448	12183	26631	35219	76%
2003	9433	22152	22778	44930	54363	83%
2004	8647	18559	15714	34273	42920	80%
2005	9537	21295	13996	35291	44828	79%
2006	10236	16106	21871	37977	48214	79%
2007	9881	8936	24392	33328	43208	77%
2008	8645	14781	12598	27379	36024	76%
2009	7040	20652	12769	33421	40461	83%
2010	8279	23688	18798	42486	50765	84%
2011	7422	28227	16234	44460	51882	86%
2012	7047	33220	19412	52632	59679	88%
2013	6611	36855	16621	53476	60087	89%
2014	5047	35383	18350	53733	58780	91%
2015	5082	26468	20904	47372	52454	90%
2016	5085	29023	15788	44811	49896	90%
2017	3598	22241	9274	31515	35113	90%
2018	4233	28630	11915	40545	44792	91%
2019	5024	26330	9372	35702	40725	88%

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 2017 and 2018 during the WGNSSK 2017 (ICES, 2017a). However, in 2017 the combined TAC for dab and flounder was removed (EU COM, 2017/595), and North Sea flounder has become a non-target species with no TAC since then. ICES has not been requested to provide advice on fishing opportunities for flounder since then. 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 with 2017 and 2018 data increased the uncertainties to unacceptable levels. Therefore, the LBI method was used instead, as it was done for the previous advice (ICES, 2017b). Catch data, survey indices, the SPiCT assessment and the LBI method were updated and presented during the WGNSSK2020 meeting.

(i) 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.

(ii) 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).

(iii) 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

(iv) Historical landings

In the North Sea and in the Skagerrak and Kattegat flounder is mainly a bycatch in the fishery for commercially more important flatfish such as sole and plaice and in the mixed demersal fisheries. The largest part of official landings is reported for Subarea 4, especially for the last decade (Figure 6.1; Table 6.5). Landings in ICES Subarea 4 and Division 3.a by country are shown in Figures 6.2 and 6.3 and in Tables 6.3 and 6.4. The apparent decrease in official landings between 1984 and 1997 is due to unreported landings by the Netherlands. Further, there seem to be an issue with Danish and German official landings in Subarea 4 which drastically dropped after 1997 (Figure 6.3, red and black bars). At least the drastic decline in Danish landings could be explained by a combined TAC for dab and flounder which was established in 1998, i.e. that before 1998 partly combined dab and flounder landings may have been reported by the Danish fishery. Another reason maybe misreporting to flounder from other quota species from the fishery in area 4 before the TAC came in force in 1998.

Since 1950, annual landings from the North Sea have fluctuated, without any clear pattern (Figure 6.1). During the last decade, landings declined considerably. This decline goes hand in hand with a reduction in fishing effort of bottom trawl fleets in the North Sea. For 2018, total official landings were reported with 1582 tonnes, compared to 1262 tonnes in 2017. This is a slight increase but still the second lowest value observed in the whole time series. In Area 3.a, annual landings in general have decreased sharply from mid of the 1980s until 2015. Official landings increased slightly in 2018 (192 tonnes), but they are still on low levels compared with earlier years (Figure 6.2).

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

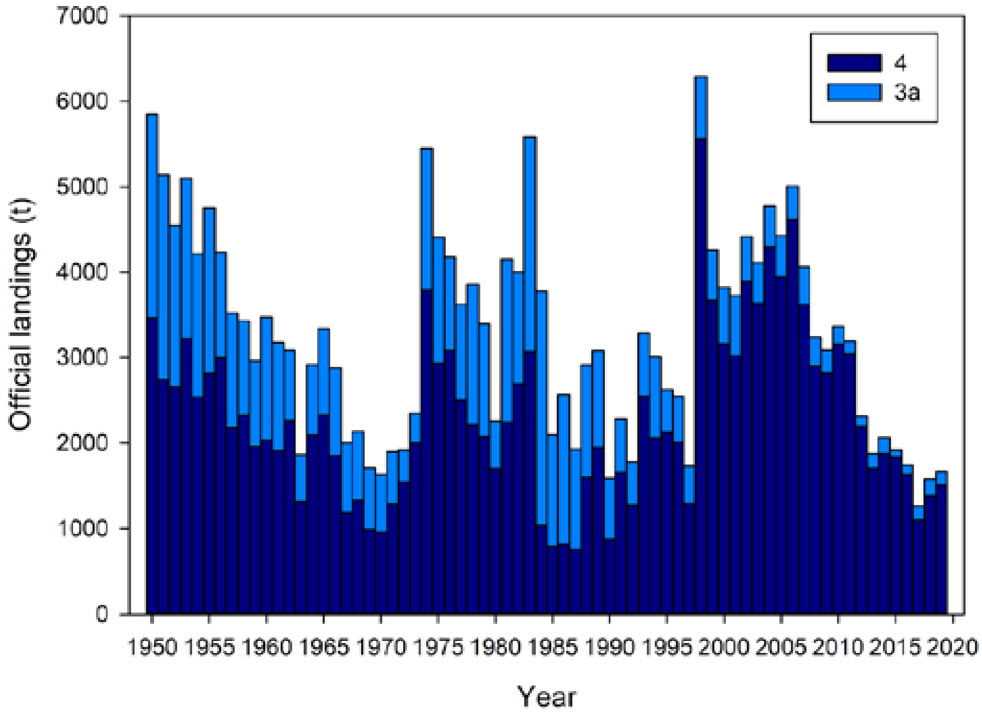

Figure. 6.1. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder by area 1950–2019.

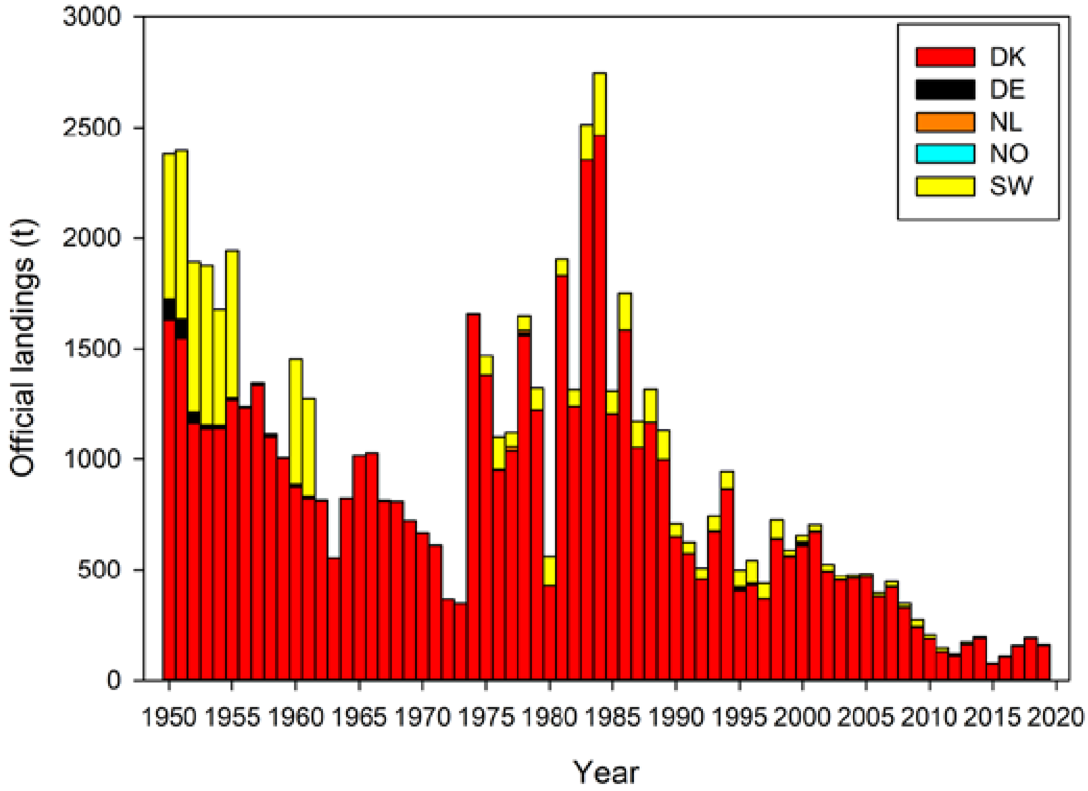

Figure 6.2. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder in ICES Division 3.a by country 1950–2019.

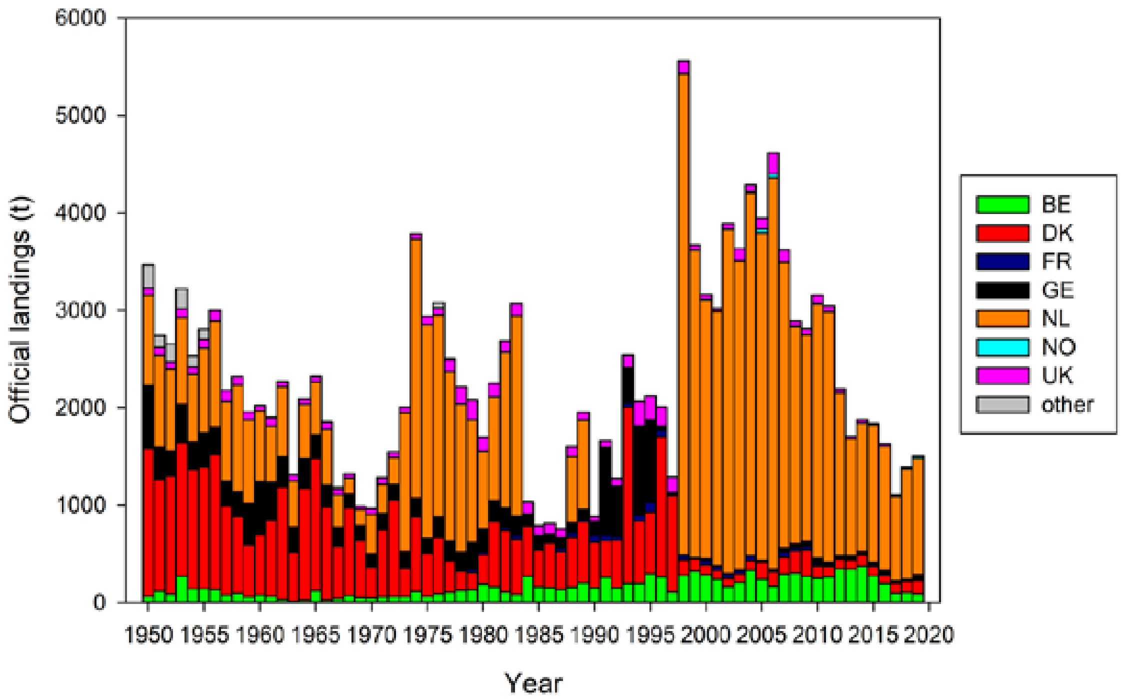

Figure 6.3. Flounder in Subarea 4 and Division 3.a: Official landings of flounder in ICES Subarea 4 by country 1950–2019.

(v) InterCatch

Flounder landings and discards data from 2002–2019 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 87% of all métiers in 2019 (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 2019, by far the largest proportion of landings (1339 tonnes, ~56% of total landings) was reported by Dutch beam trawlers (TBB_DEF_70_99_0_0_all), followed by the Belgium OTB_CRU_70-99_0_0_all metier (157 tonnes) and the Danish OTB_CRU_90-119_0_0_all (192 tonnes) and the GNS_DEF_120_219_0_0_all métiers (101 tonnes). Other métiers landing flounder in considerable amounts did in general not land more than 50 tonnes each (Figure 6.5). The highest amount of discards in 2019 was reported for the Dutch TBB_DEF_70_99_0_0_all metier (220 tonnes) and the Danish OTB_CRU_90-119_0_0_all (105 tonnes; Figure 6.6).

The largest total catch estimated in 2019 was taken by the Netherlands (1421 tonnes), followed by Denmark (437 tonnes), Belgium (288 tonnes) and Germany (91 tonnes). All other countries catch less than 60 tonnes (Figure 6.7). The total catch estimated with InterCatch was 2380 tonnes from which 1653 tonnes were landings (compared to 1668 tonnes reported official landings) and 727 tonnes discards (31% of the total catch). However, it should be noted that not all métiers were sampled in every quarter and that the raising procedure may not be adequate for all cases.

In general it was attempted to use the same groupings for discard raising as for the previous data years. However, this was not possible for all cases and compared to the previous year slight changes had to be made. The grouping is based on gear type and mesh size over areas and season. For the sample allocation scheme only one landing and one discard group was set up, because data availability did not allow for a higher resolution. Danish sample data were not used for the allocation scheme because only dummy values were uploaded for mean weights. The following groupings were used for the 2019 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: OTB_DEF_70-99_0_0_all, SSC_DEF_70-99_0_0_all, SDN_DEF_70-99_0_0_all, SDN_all_0_0_all raised with OTB_DEF_70-99_0_0_all (1 ENG métier)

Group 4: OTB_CRU_70-99_0_0_all raised with all other OTB_CRU_70-99_0_0_all (1 SCO métier)

Group 5: All passive gears raised with all passive gears

Group 6: OTB_SSC_SDN_DEF and OTB_CRU 90-119 raised with OTB_CRU_90-119_0_0_all

Group 7: OTB_DEF>=120 (including OTB_DEF NOR métier) with all OTB_DEF_>=120

Group 8: SDN_SSC_DEF_>=120 with all other SDN_SSC_DEF_>120

Group 9: TBB_DEF_>=120_0_0_0_all raised with TBB_DEF_70-99_0_0_all

Not taken into account for raising (21 métiers):

- MIS_MIS_0_0_0_IBC (negligible, no data available)
- TBB_CRU_16-32_0_0_0_all (no suitable data available)
- OTB_CRU_16-31_0_0_all (no suitable data available)
- OTB_CRU_32-69_0_0_all
- OTB_CRU_70-89_2_35_all (no suitable data available)

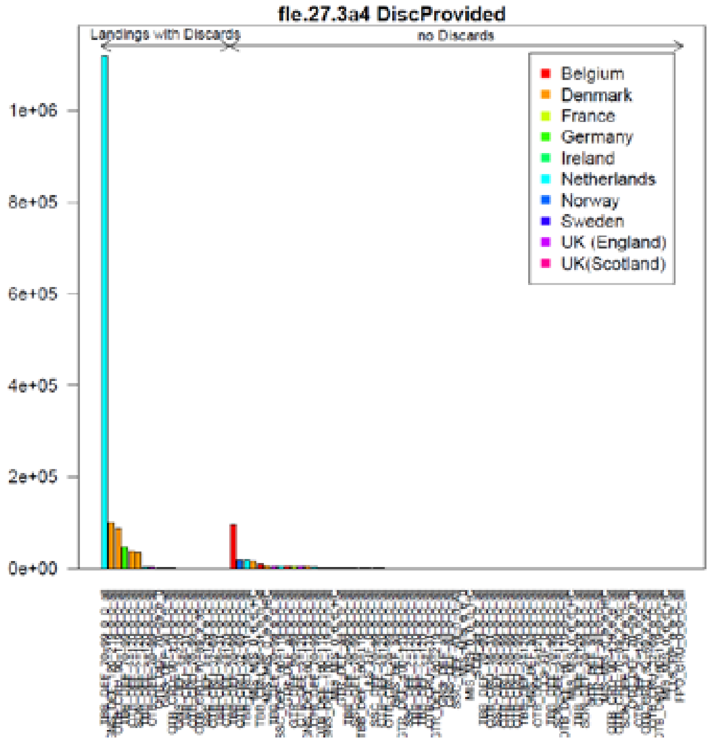

Figure 6.4. Flounder in Subarea 4 and Division 3.a: Provision of discards information by country and fleets imported to InterCatch for 2019 data.

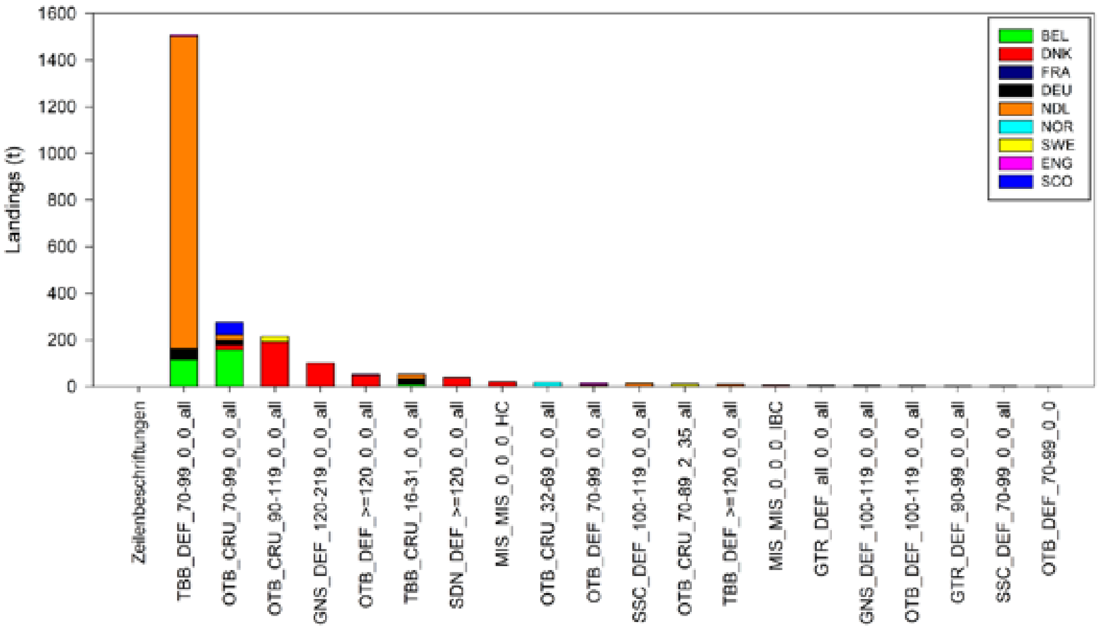

Figure 6.5. Flounder in Subarea 4 and Division 3.a: Flounder landings by métier and country in 2019 as uploaded to InterCatch.

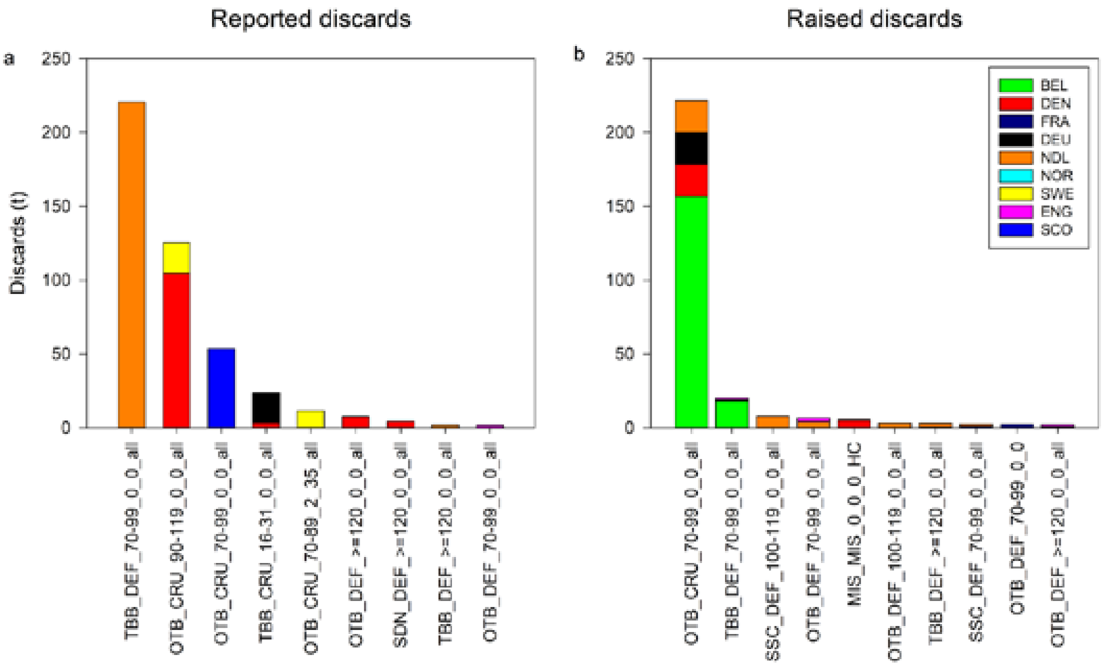

Figure 6.6. Flounder in Subarea 4 and Division 3.a: Flounder discards by métier and country in 2019. Reported discards panel (a), raised discards panel (b).

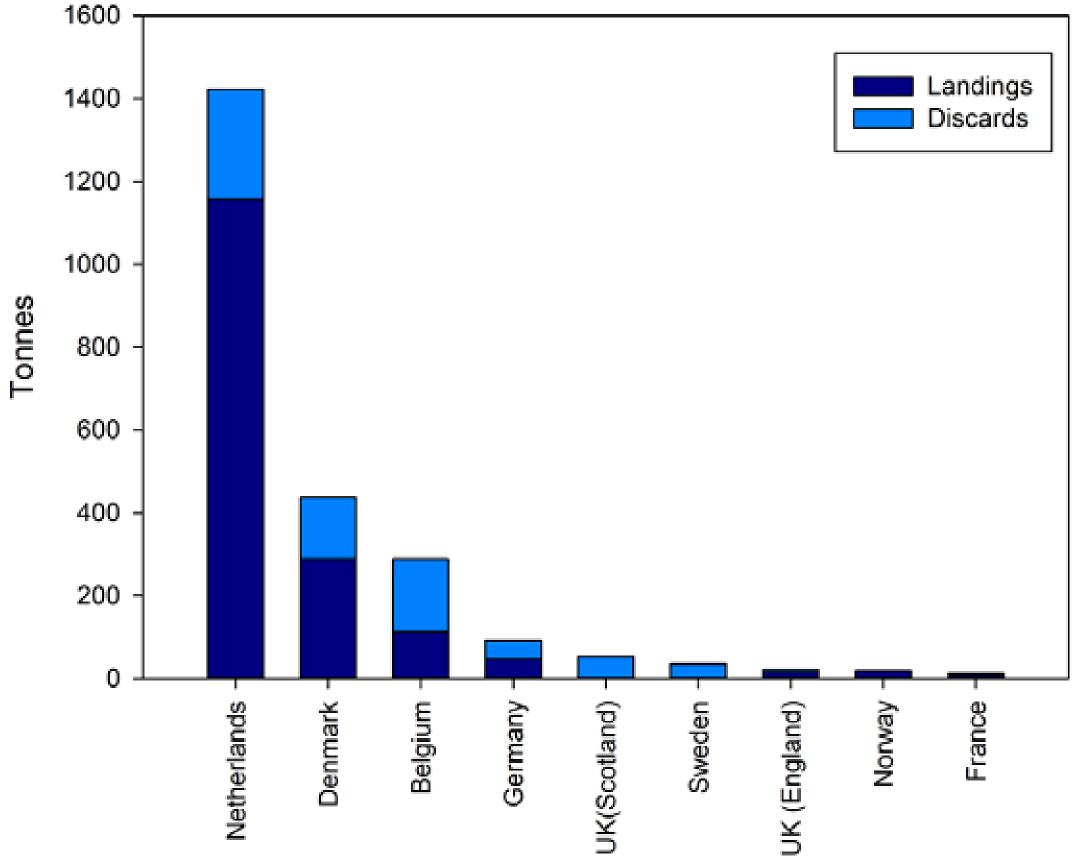

Figure 6.7. Flounder in Subarea 4 and Division 3.a: Flounder landings and discards by country in 2019 estimated with InterCatch.

6.3 Survey data/recruit series

Several surveys in the North Sea, Skagerrak and Kattegat provide information on distribution, abundance and length composition of flounder. The most relevant survey for flounder is probably the International Bottom Trawl Survey IBTS in quarter 1 because it covers the whole distribution area of the stock and shows even a higher catchability compared to the beam trawl surveys conducted in quarter 3. However, the IBTSQ1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. Further, it should be noted here that the IBTS was not fully standardized before 1983. Therefore, index data before this year should be interpreted with caution and are not presented in this report. The beam trawl surveys (BTS) use a beam trawl and are designed for catching flatfish. However, they are carried out in quarter 3, in a time of year in which flounder still maybe distributed in more coastal, shallow and brackish waters.

The mature biomass index (kg/hour) was based on the IBTSQ1 survey which covers most of the distribution area of flounder in Subarea 4 and Division 3.a. Roundfish areas 1 and 2 were excluded from the analyses because flounder does only occur very occasionally in these areas (Figure 6.8). To estimate a mature biomass index (kg/hour) a length weight relationship derived from available IBTSQ1 data was applied (Figure 6.9). The same data set shows that above 20 cm probably most flounder are mature (Figure 6.10). Therefore, only data > 20 cm were taken into account to calculate the index.

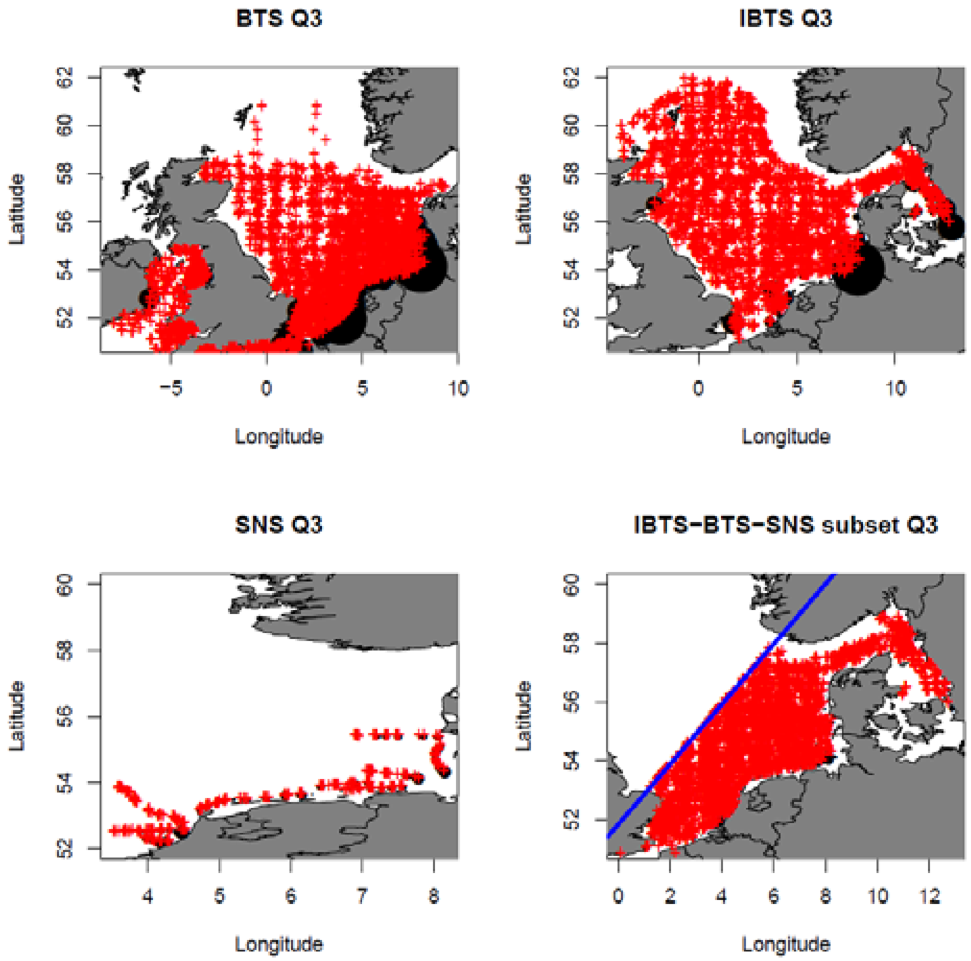

Figure 6.8. Flounder in Subarea 4 and Division 3.a: Distribution of flounder derived from different bottom trawl surveys in Subarea 4 and Division 3.a and the defined index area (lower right panel).

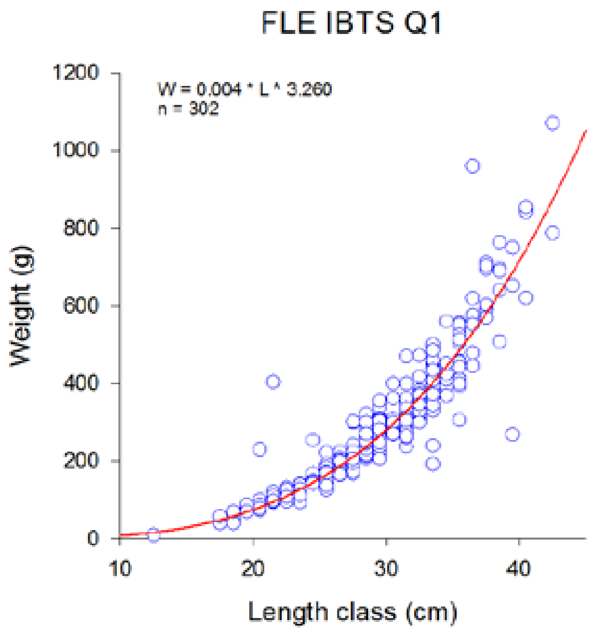

Figure 6.9. Flounder in Subarea 4 and Division 3.a: Length weight relationship of flounder derived from IBTS–Q1 data.

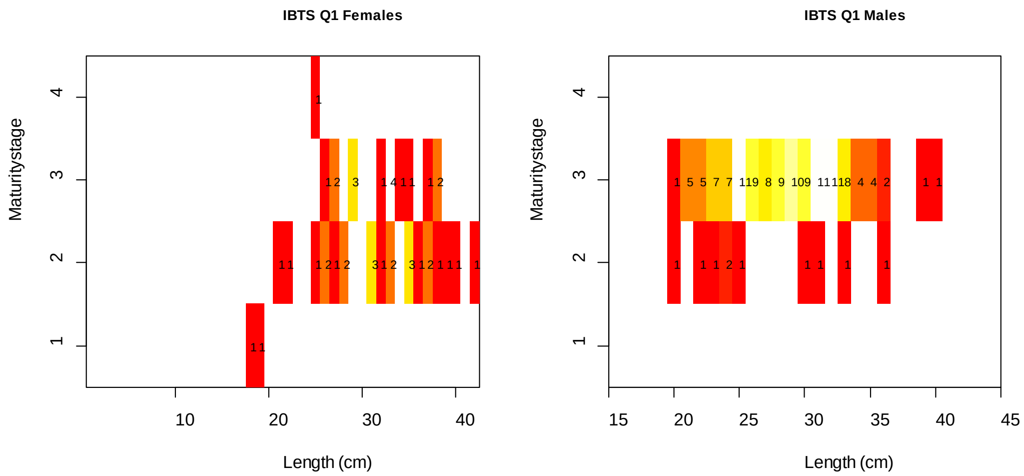

Figure 6.10. Flounder in Subarea 4 and Division 3.a: Maturity at length of female and male flounder derived from IBTS–Q1 data.

The biomass index shows a rather stable trend from 1983 onwards with two major peaks between 1985 and 1995 (Figure 6.11). From 1997 to 2002 the index declined, followed by an increase until 2005. Since then it fluctuated without a clear trend up to 2010. A declining trend can be observed from 2010 to 2014, while the values from 2015 to 2017 are again somewhat higher. In 2018 again a decrease was observed. In 2019 the index only slightly increase and stayed on the same level as in the previous year.

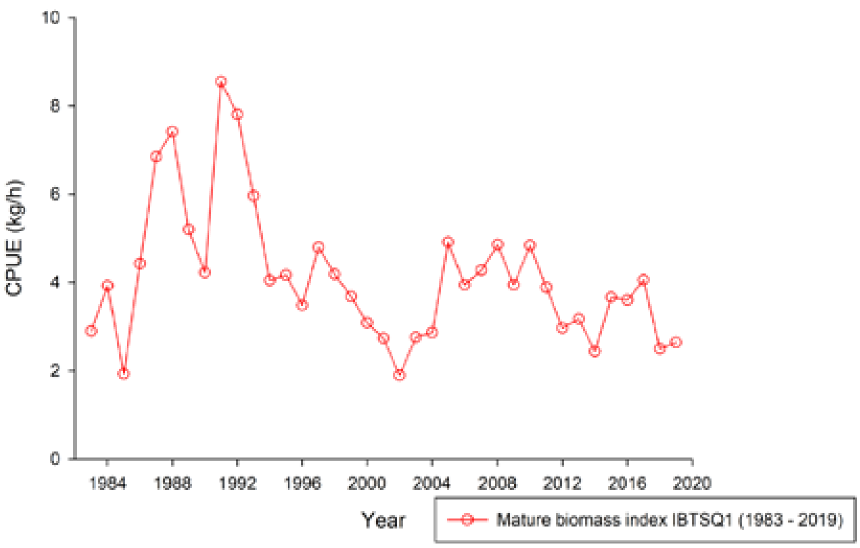

Figure 6.11. Flounder in Subarea 4 and Division 3.a: Mature biomass index of flounder in Subarea 4 and Division 3.a derived from IBTS–Q1 data 1983–2019.

New survey indices

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

Quarter 1

$$g(\mu_i) = Year(i) + f_1(lon_i + lat_i) + f_2(dept$$

Flounder length samples (sex combined) from commercial catches were provided in InterCatch format for the years 2014–2019. These data were used for the analyses of MSY proxies applying the Length Based Indicator method (LBI; ICES 2017). The commercial length data show incoming recruitment peaks for some of the years (Figure 6.17). Since the LBI method assumes constant recruitment, the data sets were reduced by length classes below 16 cm (corresponding to ages below 2 years) for the analyses. Further, the length distributions were binned to 30 mm length classes. The method also requires growth parameters, which were taken from literature (Froese and Sampang, 2013; Table 6.1).

The results of the LBI method showed that most of the indicators are above the reference points (Table 6.2). Only the P_{mega} indicator decreased since 2014 and dropped below the 30% reference point for 2018 and 2019. The L_C / L_{mat} ratio fluctuated around 1 but was above in 2019. 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
	41
von Bertalanffy k (yr^{-1})	0.36
Length-weight a	0.00867
Length weight b	3.06
Natural mortality M (yr^{-1})	0.2
Length-at-maturity (mm)	21
Natural mortality M	0.2

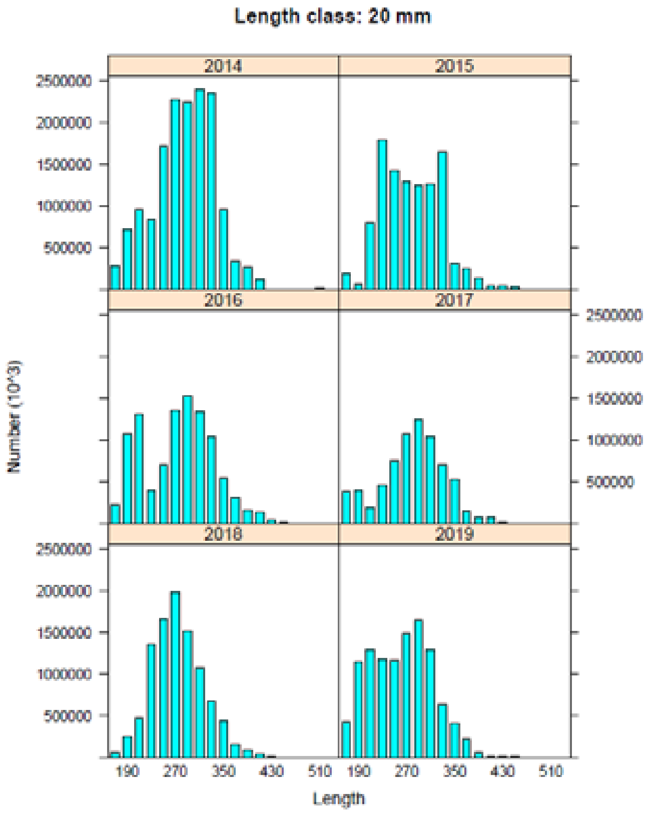

Figure 6.17. Flounder in Subarea 4 and Division 3.a. Left panel: Length distribution (20 mm length classes) from InterCatch 2014–2019. Right panel: Binned to 30 mm and reduced by incoming recruits (>150 mm, right panel) as used in the analyses.

Table 6.2. Flounder in Subarea 4 and Division 3.a. Length Based Indicator table displaying the reference points and indicators based in InterCatch length sample data 2014–2019.

	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)**	
2014	0.90	1.21	0.94	0.42	1.06	1.18
2015	1.10	1.12	0.95	0.36	1.06	1.06
2016	0.90	1.02	0.97	0.35	1.02	1.14
2017	0.81	1.17	0.93	0.37	1.03	1.22
2018	1.10	1.17	0.91	0.26	1.04	1.04
2019	0.90	1.02	0.90	0.24	0.99	1.10

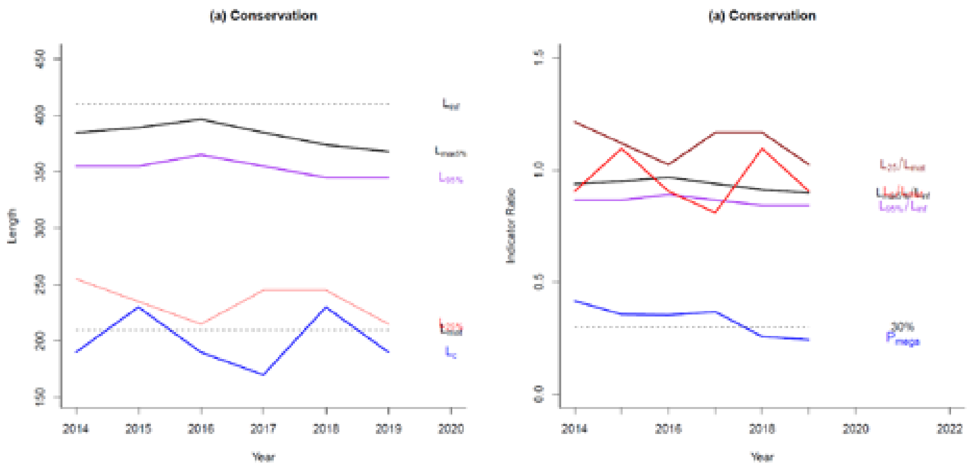

Figure 6.18. Flounder in Subarea 4 and Division 3.a. Conservation indicators (left panel) and indicator ratios (right panel).

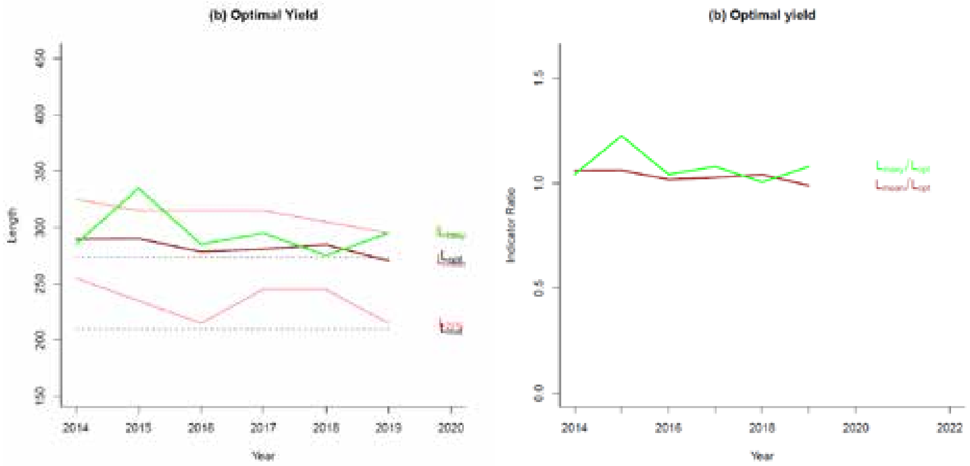

Figure 6.19. Flounder in Subarea 4 and Division 3.a. Optimum yield indicators (left panel) and indicator ratios (right panel).

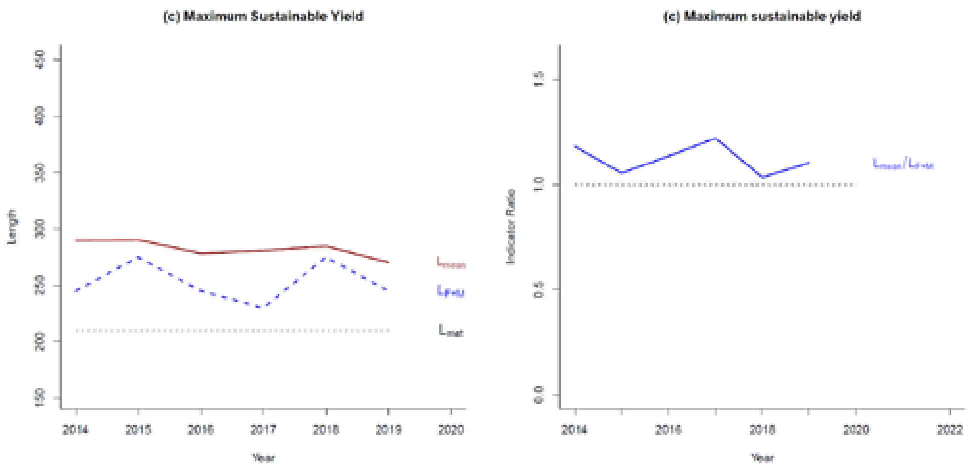

Figure 6.20. Flounder in Subarea 4 and Division 3.a. Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

6.4 Issues List

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

6.5 References

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3. Tables

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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1950	67	1514	0	641	937	0	67	241	3467
1951	119	1143	0	329	949	0	81	127	2748
1952	91	1210	0	257	841	0	71	186	2656
1953	270	1372	0	397	886	0	92	203	3220
1954	142	1225	0	281	696	0	71	121	2536
1955	145	1244	0	353	871	0	88	109	2810
1956	132	1389	0	277	1097	0	102	2	2999
1957	81	910	0	250	825	0	112	0	2178
1958	99	784	0	257	1088	0	94	0	2322
1959	62	533	0	424	857	0	79	1	1956
1960	82	614	0	540	733	0	49	8	2026
1961	68	776	0	390	579	0	81	13	1907
1962	37	1146	0	313	717	0	53	2	2268
1963	16	501	0	263	467	0	65	0	1312
1964	30	1141	0	305	563	0	48	6	2093
1965	121	1349	0	248	549	0	54	3	2324
1966	32	946	0	229	573	0	71	2	1853
1967	43	540	0	193	331	0	57	25	1189
1968	75	894	0	152	160	0	43	1	1325
1969	54	582	0	158	161	0	33	0	988
1970	50	316	0	135	405	0	57	0	963
1971	60	685	0	173	297	0	70	0	1285
1972	63	991	0	159	275	0	60	0	1548
1973	63	290	0	172	1424	0	53	0	2002
1974	115	766	0	190	2661	0	58	0	3790
1975	68	437	0	155	2191	0	87	1	2939
1976	94	575	0	209	2077	0	70	54	3079
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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1981	164	669	14	200	1068	0	133	0	2248
1982	110	630	31	200	1597	0	121	0	2689
1983	88	564	36	197	2059	0	125	0	3069
1984	272	518	15	103	0	0	122	0	1030
1985	163	379	14	128	0	0	109	0	793
1986	155	456	1	91	0	0	111	0	814
1987	132	394	32	106	0	0	90	0	754
1988	160	509	44	105	682	0	98	0	1598
1989	200	632	28	95	916	0	80	0	1951
1990	153	467	69	147	0	0	45	0	881
1991	260	377	51	902	0	0	69	0	1659
1992	152	492	35	521	0	0	76	0	1276
1993	194	1812	47	356	0	0	136	0	2545
1994	196	642	57	921	0	0	247	0	2063
1995	301	628	103	843	0	0	250	0	2125
1996	262	1439	68	43	0	0	193	0	2005
1997	110	988	10	25	0	0	157	0	1290
1998	283	154	40	13	4938	0	132	0	5560
1999	326	123	0	11	3158	0	54	0	3672
2000	289	100	46	17	2656	5	52	0	3165
2001	241	92	42	4	2608	3	32	0	3022
2002	165	83	51	2	3531	3	55	0	3890
2003	206	94	33	3	3172	9	120	0	3637
2004	335	96	46	5	3720	18	74	0	4294
2005	241	171	17	5	3363	38	111	0	3946
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

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
2015	277	97	19	19	1409	0	15	0	1836
2016	194	87	20	27	1277	0	25	0	1630
2017	97	101	0	28	944	1	14	0	1185
2018	104	114	n.a.	23	1130	1	18	0	1390
2019	94	136	9	48	1186	19	15	0	1507

***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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
1982	1236	0	0	0	75	1311
1983	2352	0	0	0	160	2512
1984	2463	0	0	0	283	2746
1985	1203	0	0	0	102	1305
1986	1585	0	0	0	166	1751
1987	1050	0	0	0	119	1169
1988	1164	0	0	0	149	1313
1989	996	0	0	0	133	1129
1990	650	1	0	0	57	708
1991	574	0	0	0	50	624
1992	455	0	0	0	52	507
1993	673	3	0	0	67	743
1994	865	1	0	0	77	943
1995	403	19	0	0	76	498
1996	429	9	0	0	104	542
1997	367	2	0	0	68	437
1998	637	5	0	0	83	725
1999	558	6	0	0	24	588
2000	609	17	0	0	30	656
2001	672	2	0	1	30	705
2002	493	0	0	1	30	524
2003	452	3	0	0	18	473
2004	462	2	0	0	14	478
2005	467	0	0	0	15	482
2006	380	0	0	0	13	393
2007	419	3	1	0	22	445
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

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
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

*** 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

Year	Division 3.a	Subarea 4	Total
1982	1311	2689	4000
1983	2512	3069	5581
1984	2746	1030	3776
1985	1305	793	2098
1986	1751	814	2565
1987	1169	754	1923
1988	1313	1598	2911
1989	1129	1951	3080
1990	708	881	1589
1991	624	1659	2283
1992	507	1276	1783
1993	743	2545	3288
1994	943	2063	3006
1995	498	2125	2623
1996	542	2005	2547
1997	437	1290	1727
1998	725	5560	6285
1999	588	3672	4260
2000	656	3165	3821
2001	705	3022	3727
2002	524	3890	4414
2003	473	3637	4110
2004	478	4294	4772
2005	482	3946	4428
2006	393	4616	5009
2007	445	3620	4065
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

Year	Division 3.a	Subarea 4	Total
2016	109	1630	1739
2017	159	1103	1262
2018	192	1390	1582
2019*	161	1507	1668

*** 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%

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 2018 the official landings in 2019 with 1621 tonnes were on a rather constant level (1600 tonnes in 2018; Table 7.8). The average official landings for the last ten years (2010–2019) was 1280 tonnes. Official landings data from 1950 to 2005 were taken from the “ICES catch statistics 1950 to 2010” (http://www.ices.dk/marine-data/Documents/CatchStats/HistoricalLandings1950-2010.zip). Data from 2006 to 2017 were taken from the “ICES catch statistics 2006 to 2017” (http://www.ices.dk/marine-data/Documents/CatchStats/OfficialNominalCatches.zip). Data for 2018 and 2019 were taken from the preliminary catch statistics provided by ICES (http://data.ices.dk/rec12/login.aspx).

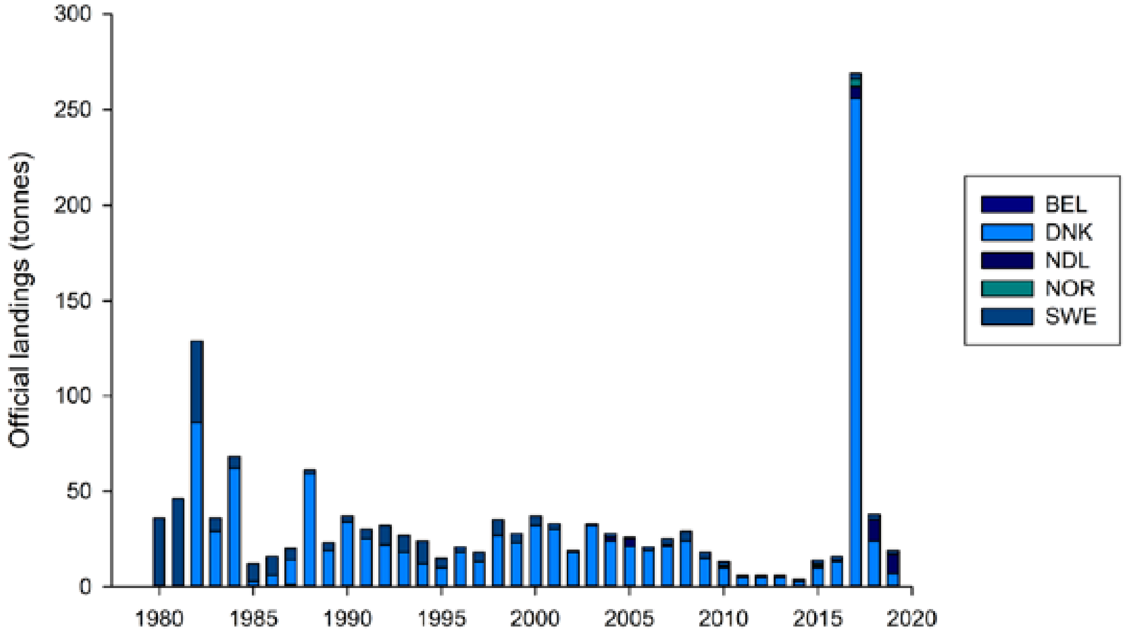

Figure 7.1. Grey gurnard in Subarea 4, Division 3.a and Division 7.d: Official landings of grey gurnard in Division 3.a 1980–2019.

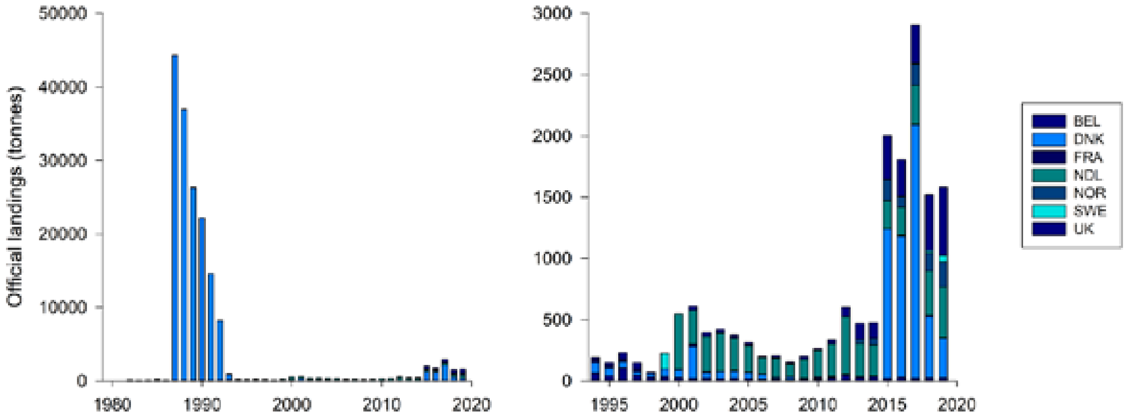

Figure 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Subarea 4 by country for the years 1980 - 2019 (a), and official landings of grey gurnard by country in Subarea 4 for the years 1994 - 2019 (b).

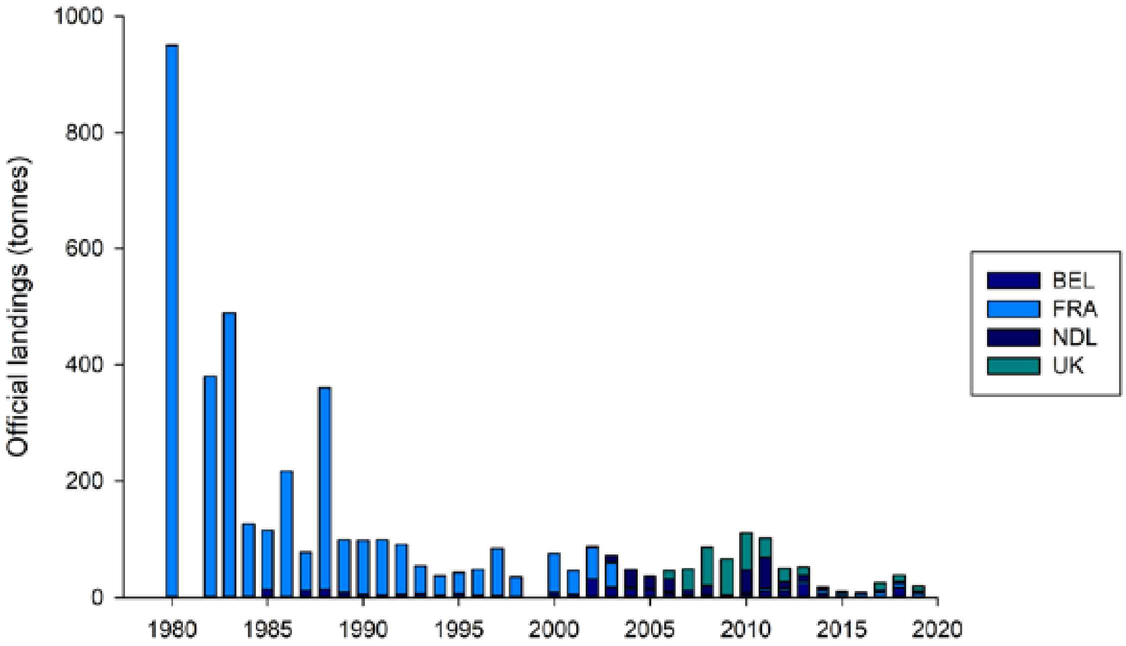

Figure 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings by country of grey gurnard in Division 7.d for the years 1980–2019.

7.2.2 InterCatch data

InterCatch contains now data for the years 2012–2019. The largest amount of landings in 2019 was reported by Scotland for the OTB_DEF_>=120_0_0_all métier (434 tonnes). Considerable amounts of landings were also reported by The Netherlands (148 tonnes, TBB_DEF_70-99_0_0_all; 104 tonnes, TBB_DEF_>=120_0_0_all), Germany (82 tonnes, TBB_DEF_70-99_0_0_all), Denmark (301 tonnes, MIS_MIS_0_0_0_IBC), and Norway (116 tonnes, MIS_MIS_0_0_0_HC). For all other métiers the landings were below 80 tonnes (Figure 7.4). In the subsequent InterCatch raising procedure the industrial bycatch métiers (IBC) were grouped with landings. No further raisings were applied for the IBC métiers. For all countries 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 (1023 tonnes), the Dutch TBB_DEF_70-99_0_0_all métier (736 tonnes), and the Dutch OTB_CRU_70-99_0_0_all métier (490 tonnes).

The largest amount of discards was estimated for the Dutch SSC_DEF_>=120_0_0_all métier (976 tonnes) and the Dutch SSC_DEF_70-99_0_0_all métier (841 tonnes). The total catch estimated with InterCatch for the year 2019 was 9 295 tonnes from which 1 709 tonnes were landings (18%) and 7 586 tonnes estimated discards (82% of total catch). In total The Netherlands took the largest proportion of the total catch in 2019 with a high amount of discards, followed by UK Scotland, and UK England. It has to be noted here, that Swedish landings data were incomplete in InterCatch for the working group and will be uploaded with the 2020 data next year. However, the relatively small amount of missing Swedish landings in InterCatch (50 tonnes) will not result in a substantial change in the total catch. Missing Swedish landings were added manually to the total landings. These data will be updated during WGNSSK 2021.

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 2019 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)

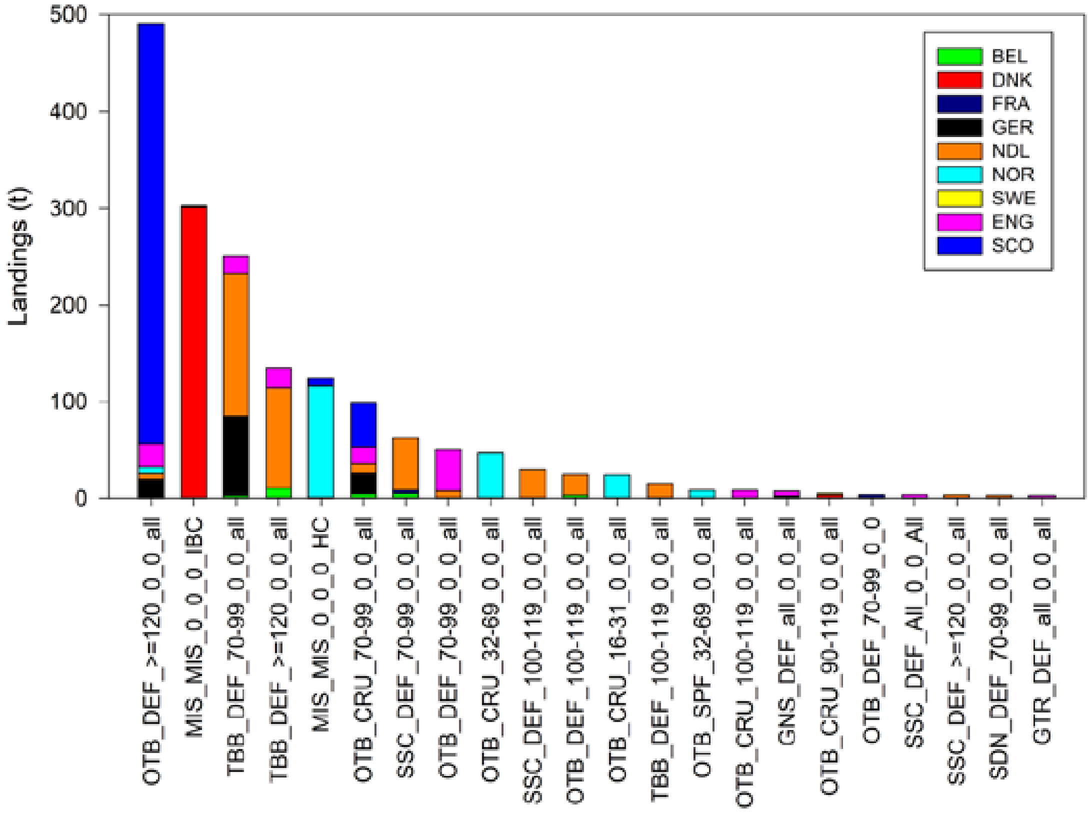

Figure 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard landings in 2019 by métier and country as uploaded into InterCatch.

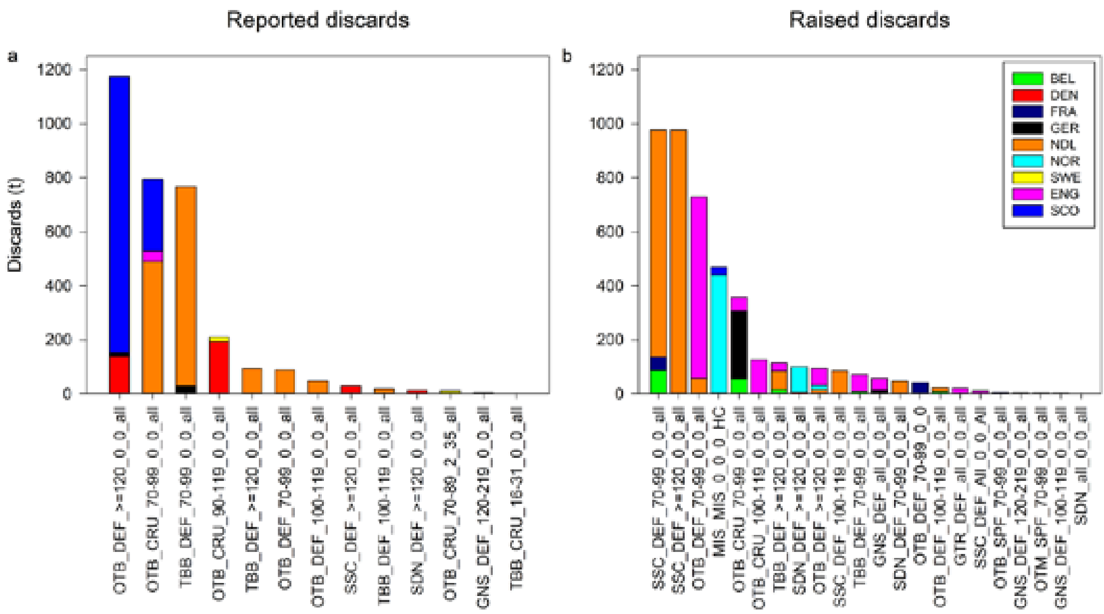

Figure 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Grey gurnard discards in 2019 by métier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

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).

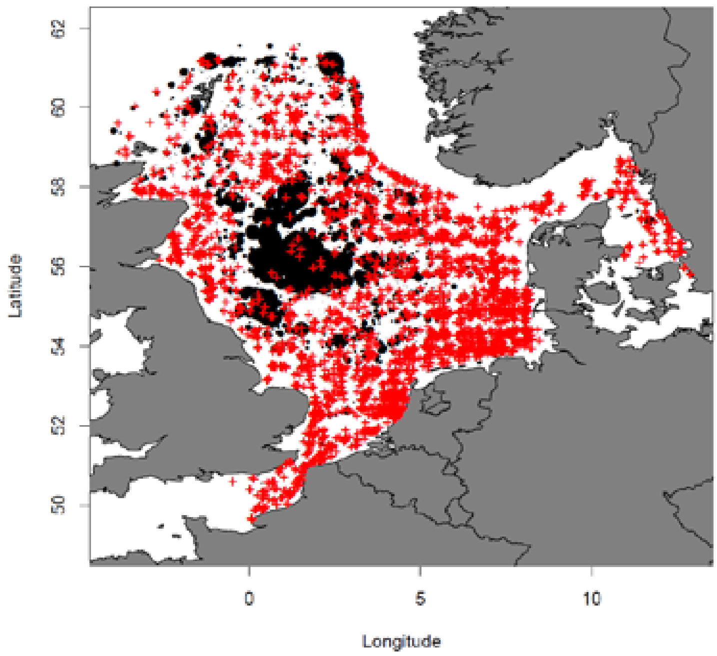

Figure 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d. Spatial distribution of grey gurnard from IBTS–Q1 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

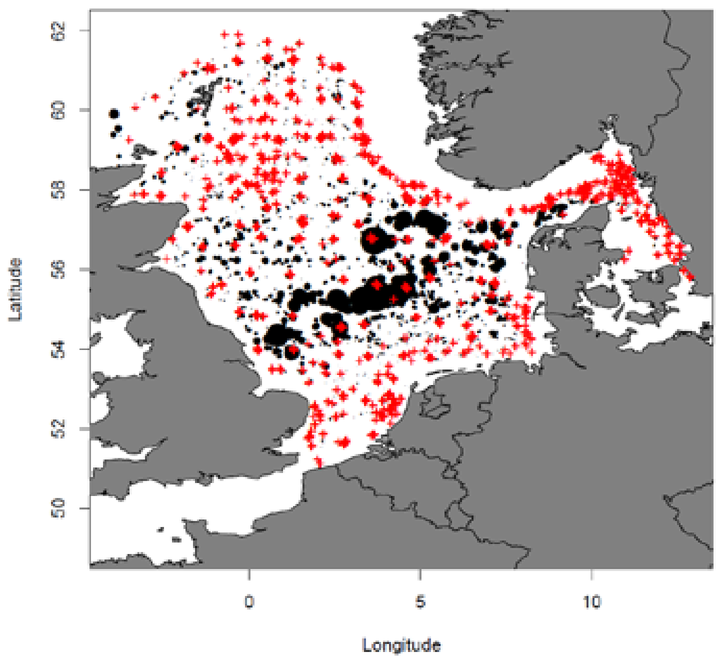

Figure 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q3 survey (all years) in Subarea 4 and Division 3.a. Red crosses display zero hauls.

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.

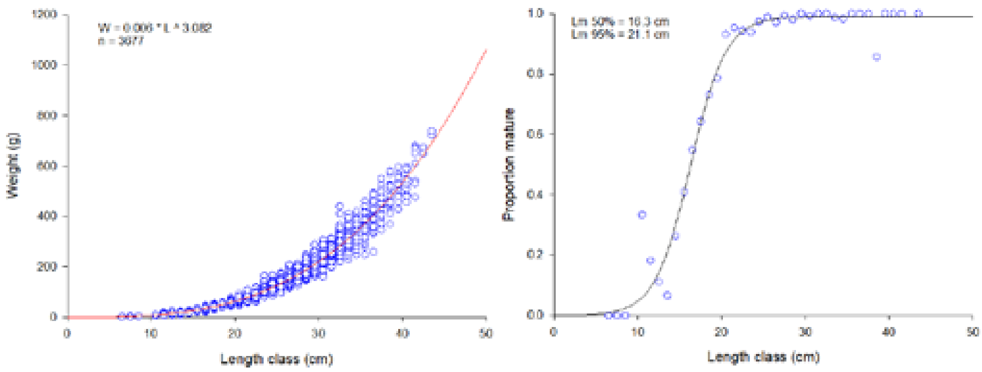

Figure 7.8 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length-weight relationship from IBTS Q1 and IBTS Q3 CA data (left panel); maturity ogive obtained from IBTS Q1 CA data (right panel).

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. 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. In general, lower biomass and abundance values were observed for the IBTS–Q3 survey time series. Compared to the North Sea/Skagerrak (Subarea 4/Division 3.a) the mature biomass values recorded by the Channel Ground Fish Survey (CGFS) in the Eastern Channel (Division 7.d) were extremely low (not shown in this report). No trend could be detected in the CGFS index. Therefore, the advice for grey gurnard in area 4, 3.a and 7.d should be based on the IBTS survey, which covers by far the largest part of the stock distribution area.

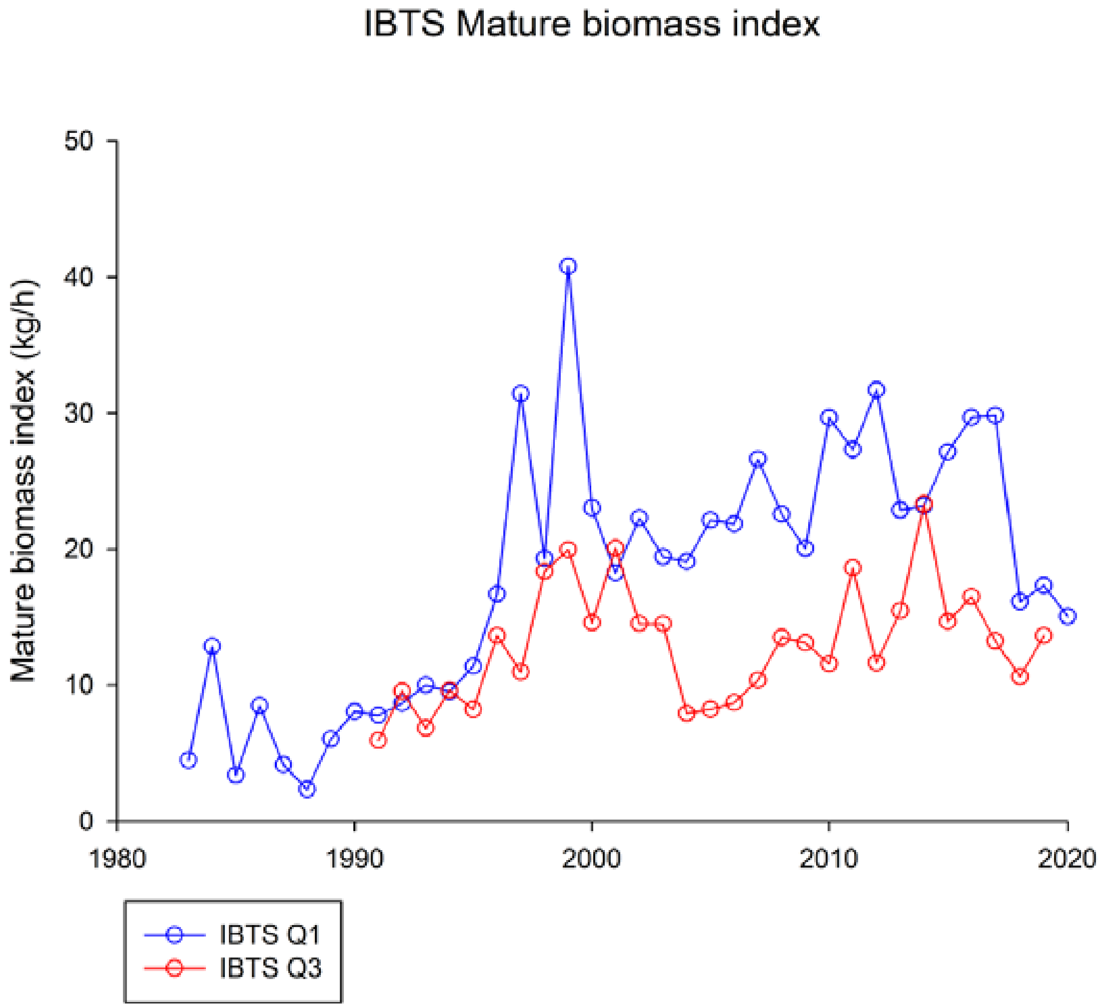

Figure 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: IBTS–Q1 and IBTS–Q3 grey gurnard mature biomass index.

7.6 MSY Proxies

7.6.1 Length Based Indicators (LBI) - update

Results of the length based indicator method are sensitive to the assumed values of L_{inf} (37.2 cm) and L_{mat} (16.3 cm). How these values were estimated is described in detail in the 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 results show that with respect to conservation the indicators are above the reference points for LC / L_{mat} and $L_{25\%}$ / L_{mat} for the recent five years (Figure 7.11 and Table 7.2 and Table 7.3). For the $L_{max5\%}$ / L_{inf} reference point the indicator is only above the reference point for the last two years. The P_{mega} was for the years 2015–2017 below the reference of 30%, above it in 2018 but below again for the last data year. With respect to MSY the indicator is above the reference points for the last three data years (Figure 7.13). It was concluded, that the exploitation for this stock was below F_{MSY} in the year 2019.

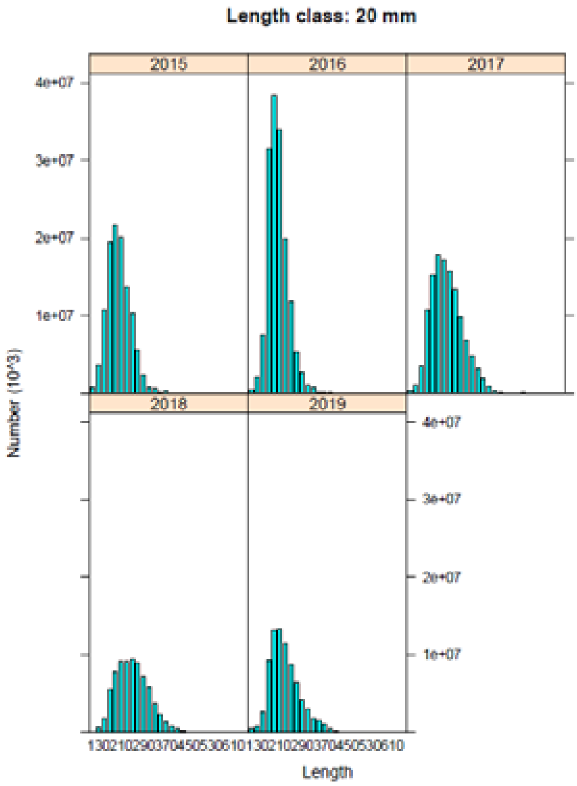

Figure 7.10 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Obtained length frequency distributions binned into 20 mm size classes.

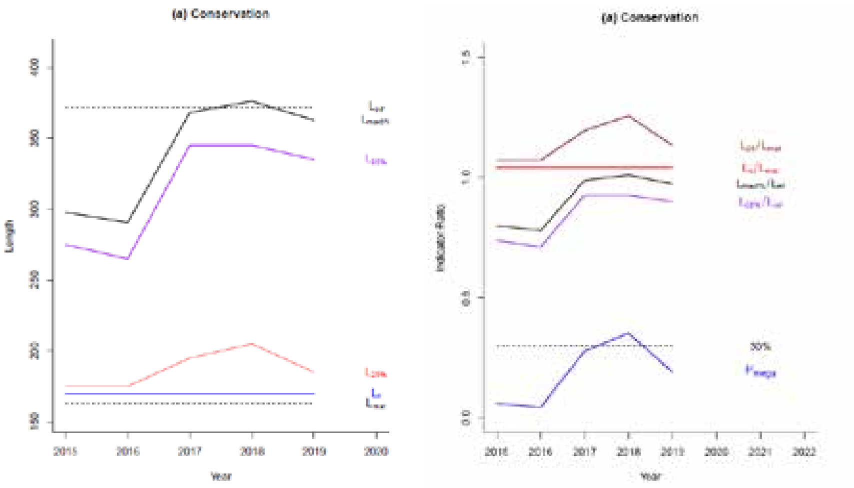

Figure 7.11 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Conservation indicators (left panel) and indicator ratios (right panel).

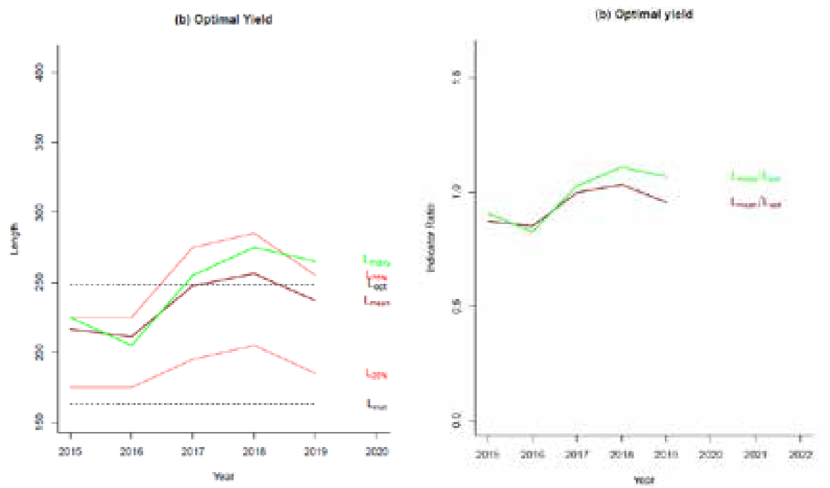

Figure 7.12 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Optimum yield indicators (left panel) and indicator ratios (right panel).

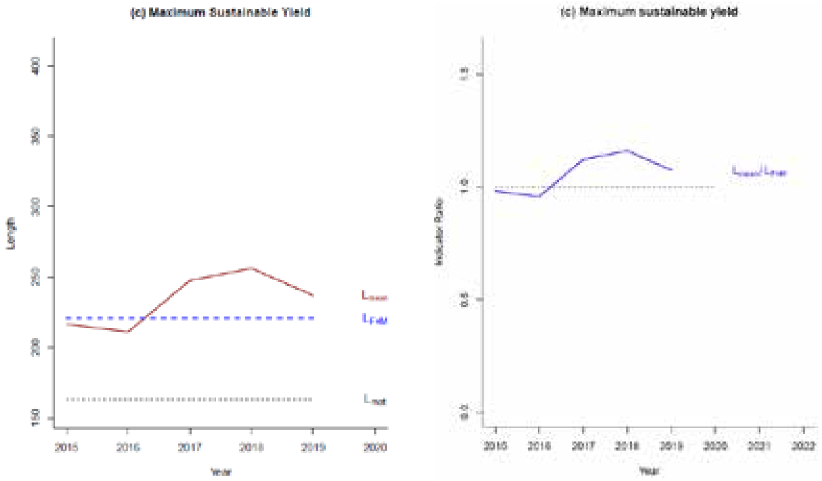

Figure 7.13 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Maximum sustainable yield indicator (left panel) and indicator ratio (right panel).

Table 7.2 Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Length-based reference points.

Year	L75	L25	Lmed	L90	L95	Lmean	Lc	LFeM	Lmaxy	Lmat	Lopt	Linf	Lmax5
2015	225	175	195	255	275	216.53	170	220.5	225	163	248	372	297.77
2016	225	175	195	245	265	211.17	170	220.5	205	163	248	372	290.57
2017	275	195	235	315	345	247.62	170	220.5	255	163	248	372	368.15
2018	285	205	245	325	345	256.17	170	220.5	275	163	248	372	376.01
2019	255	185	215	305	335	236.92	170	220.5	265	163	248	372	362.76

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.

					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)**	

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.

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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

Year	BE	DK	NL	NO	SE	Total
2007	0	21	1	0	3	25
2008	0	24	0	0	5	29
2009	0	15	0	0	3	18
2010	0	10	1	0	2	13
2011	0	5	0	0	1	6
2012	0	5	0	0	1	6
2013	0	5	0	0	1	6
2014	0	3	0	0	1	4
2015	0	10	0	1	2	14
2016	0	13	1	0	2	16
2017	0	256	6	4	3	269
2018	0	24	11	0	3	38
2019	0	7	10	0	2	19

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

Year	BE	DK	FR	NL	NO	SE	UK	Total
1993	106	822	27	0	0	0	24	979
1994	63	87	21	0	0	0	22	193
1995	43	63	26	0	0	0	21	153
1996	108	52	18	0	0	0	54	232
1997	49	23	22	0	0	0	57	151
1998	33	29	13	0	0	0	0	75
1999	35	63	0	0	0	127	0	225
2000	28	63	5	452	0	0	0	548
2001	22	258	20	277	0	1	33	611
2002	23	45	10	285	0	1	29	393
2003	16	60	5	307	0	6	26	420
2004	21	59	6	264	0	3	23	376
2005	16	52	5	213	0	8	22	316
2006	10	46	2	133	2	0	7	200
2007	11	16	3	155	5	0	14	204
2008	8	24	2	104	5	3	12	158
2009	15	6	2	154	1	1	22	201
2010	14	8	10	218	1	0	14	266
2011	26	6	7	263	1	0	31	334
2012	49	3	4	467	2	0	77	602
2013	30	4	2	268	33	1	131	470
2014	35	4	3	252	56	0	128	478
2015	20	1220	2	229	172	5	354	2004
2016	31	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

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

Year	BE	FR	NL	UK	Total
2009	1	1	3	61	66
2010	6	2	39	64	111
2011	11	5	53	33	102
2012	11	5	11	23	50
2013	23	4	11	14	52
2014	7	5	4	2	18
2015	2	6	2	0	10
2016	1	6	2	0	9
2017	1	8	4	12	25
2018	17	6	4	11	38
2019	1	7	3	8	19

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

Year	IBTS–Q1	IBTS–Q3
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
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	

Table 7.8. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Summary of the assessment done during the WGNSSK 2020 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					
2005	378					
2006	267					
2007	279					
2008	273					
2009	285					
2010	390					

Year	Official landings	Official BMS landings	ICES Landings	ICES catches	ICES discards	Discard rate
2011	442					
2012	658		689	8345	7656	0.92
2013	528		1180	10230	9050	0.88
2014	500		1892	8596	6704	0.78
2015	2028		2141	8451	6310	0.75
2016	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

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

Until 2014, haddock in Subarea 4, Division 6.a and Subdivision 20 (referred to hereafter as Northern Shelf haddock) were assessed as two separate stocks: Subarea 4 and Subdivision 20 by WGNSSK, and Division 6.a by WGCSE. The 2014 Benchmark Workshop for Northern Haddock Stocks (ICES, 2014) concluded that the two notional haddock stocks should be assessed as one stock.

8.1 General

8.1.1 Ecosystem aspects

Ecosystem aspects are summarised in the Stock Annex.

8.1.2 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex. Most of the information presented below and in the Stock Annex pertains to the Scottish fleet, which takes the largest proportion of the haddock stock. This fleet is not just confined to the Northern Shelf area, as vessels will sometimes operate in Divisions 6.b (Rockall) and 5.b (Faroes).

8.1.2.1 Changes in fleet dynamics

There have been no decommissioning schemes affecting haddock fisheries since the major rounds in 2002 and 2004. A number of Scottish vessels have been taking up opportunities for oil and gas, and renewables sector support work during recent years with a view to saving quota and days at sea.

With the relatively limited cod and whiting quotas in recent years, many vessels have tended to concentrate more on the haddock fishery, with others taking the opportunity to move between the *Nephrops* and demersal fisheries (particularly during 2006 and 2007 – there may have been fewer boats changing focus in this way from 2008 to 2015). Accompanying the change in emphasis towards the haddock fishery, there has also been a tendency to target smaller fish in response to market demand. Some trawlers operating in the east of the North Sea have used 130 mm mesh and this is likely to have improved selectivity for haddock. Fish from the 2014, 2016 and 2018 year-class form the bulk of haddock catches in 2019. The entry of the 2018 year class into the fishery has led to a slight increase in the discarding rate for 2019. Previous changes in discarding rates may also have been due to other measures related to the Scottish Conservation Credits scheme (CCS; see Section 8.1.4).

Specific information on changes in the Scottish fleet during 2011–2019 was not provided to WGNSSK in 2020. It is difficult to reach a firm conclusion on the likely effect of recent fishery changes on haddock mortality. Changes in gear that were required to qualify for the Scottish CCS are likely to have reduced bycatch (and therefore discards) of haddock in the *Nephrops* fishery in particular. The inclusion of Scottish vessels in the CCS has been mandatory since the beginning of 2009, and compliance has been close to 100%. Cod avoidance under the real-time closures scheme (which is a component of the CCS) could also have moved vessels away from haddock concentrations, but the extent of this depends on how closely cod and haddock distributions are linked, and on how successful the avoidance strategies have been. On the other hand, vessels catching fewer cod may have increased their exploitation of haddock in order to maintain economic viability. It is unclear what changes in fleet dynamics and fishing behaviour have been caused by the EU landings obligation which was implemented for the majority of fleets catching Northern Shelf haddock in January 2016.

Following trials during 2010–2013, 26 Scottish demersal whitefish vessels participated in the 2014 Fully Documented Fishery (FDF) scheme (although 3 vessels left the scheme during the year). Similar trials have been conducted during various periods by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on haddock fisheries of an enforceable discard ban for cod, and in data collation for the haddock assessment it was assumed that FDF vessels would have similar haddock discard patterns as other vessels, but this remains to be verified. It should be noted that the Scottish FDF schemes implemented to date have all been restricted to the North Sea: cod discarding from CCTV vessels has remained legal in Division 6.a, and indeed has been mandatory for over-quota cod. The Scottish FDF scheme for 2015 continued without a break from the end of 2014, and included 24 vessels (although 6 left during the year). In 2016, 14 vessels participated in the scheme: the uptake of the scheme declined due to concerns about monitoring of discards under the EU Landing Obligation. The cod-specific FDF scheme terminated at the end of 2016, due to the suspension of most aspects of the EU Cod Recovery plan which removed the opportunity for countries to provide additional quota for participants. However, a new Scottish FDF scheme has commenced, which is being run along similar lines and which is intended to monitor discarding of saithe and monkfish: three vessels participating in this new scheme in 2017.

8.1.2.2 Additional information provided by the fishing industry

Haddock are still the mainstay of the Scottish whitefish fleet, and have become increasingly so following cod-avoidance initiatives under the Scottish Conservation Credits scheme.

8.1.3 ICES advice

8.1.3.1 ICES advice for 2019

Subarea 4, Division 6.a and Subdivision 20

The advice for 2019 was updated in November 2018:

ICES advises that when the MSY approach is applied, total catches in 2019 should be no more than 33 956 tonnes.

8.1.3.2 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.

8.1.4 Management

Until 2014, North Sea haddock (Subarea 4 and Subdivision 20) were jointly managed by the EU and Norway under an agreed management plan, the details of which are given in the Stock Annex. However, the validity and sustainability of the management plan when applied to the wider Northern Shelf area had not been evaluated by ICES, and advice could not be provided on the basis of the plan as a consequence. A separate management plan for Division 6.a was evaluated by ICES in 2008 to be precautionary, but similarly cannot be used to provide advice for the full stock area. A management plan for Northern Shelf haddock was to have been developed during 2015, but this did not occurred as the basis for management of shared EU-Norway stocks was not agreed. More recently, in 2018, EU-Norway requested an evaluation of multiple management strategies (ICES, 2019a), which are currently under consideration. In the meantime the stock is managed according to advice based on the ICES MSY approach.

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010, there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), 166 (2013), 94 (2014), and 97 (2015). 114 closures were implanted during 2016, although the scheme was suspended on 20 November and there are no plans for its reintroduction. The CCS had two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts were also being made to reduce discards generally. Although the scheme was intended to reduce mortality on cod, it undoubtedly had an effect on the mortality of associated species such as haddock.

Studies tracking Scottish vessels during 2009–2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the haddock stock is still under investigation.

In early 2008, a one-net rule was introduced in Scotland as part of the CCS. This is likely to have improved the accuracy of reporting of landings to the correct mesh size range. The remaining technical conservation measures in place for the haddock fisheries in Subarea 4, Division 6.a and Subdivision 20 are summarised in the Stock Annex.

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

Annual management of the fishery operates through TACs for three discrete areas. The first is Subarea 4 (and EU Waters of 2.a). The 2019 and 2020 TACs for haddock in this area were 28 950 tonnes and 35 653 tonnes respectively. The second is Division 3.a (EU waters), for which the TACs for 2019 and 2020 were 1780 tonnes and 2193 tonnes respectively. The third is Division 6.a, for which the TACs in 2019 and 2020 were 3226 tonnes and 3973 tonnes respectively.

8.2 Data available

8.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 8.2.1, together with the corresponding WG estimates and the agreed international quota (listed as "total allowable catch" or TAC). Since 2012, international data on landings and discards have been collated through the InterCatch system (see Section 1.2). International data for below minimum size (BMS) landings and logbook registered discards (LRD) for Northern Shelf haddock have been collated through the InterCatch system from 2016. Figure 8.2.1 and Tables 8.2.2 to 8.2.4 summarise the proportion of landings in the combined Northern Shelf area, for which samples have been provided. While there are a large number of fleets for which landings have not been sampled, the overall contribution of these fleets to total landings is small and 93% of landings by weight have been sampled appropriately. Age compositions for the remaining landings have therefore been determined by averaging across the available sampling (as for last year), without consideration of quarter, country or gear type. Similarly, discard observations are available for the fleets landing the vast majority of haddock (see Figure 8.2.2), so discard rates for the remaining fleets have also been inferred using simple averaging weighted by landing weight.

The collation of BMS landings and logbook registered discards in InterCatch was introduced in 2016 in accordance with the implementation of the EU landing obligation. However, BMS data from Scotland were not submitted in 2017 resulting in no sampled of the BMS landings by weight. In 2018, BMS landings were only partially sampled in Scotland (2 out of 4 quarters) resulting in just 28% of the total BMS landings being sampled (see Figure 8.2.3). However, in 2019 91% of the total BMS landings were sampled. Age compositions for the BMS landings were determined in a similar way to the landings without consideration of quarter, country or gear. Logbook registered discard observations have not been submitted by any country for haddock since 2016.

The full time series of landings, discards, BMS landings and industrial by-catch (IBC) is presented in Table 8.2.5. These data are illustrated further in Figure 8.2.4. The total landed yield of the international fishery has been relatively stable since 2007. The WG estimates (Table 8.2.5) suggest that haddock discarding (as a proportion of the total catch) decreased significantly during 2013, and the discard rate for that year was the lowest in the time series at 7.2% by weight. This may have been due in part to fleet behaviour changes related to cod avoidance measures, but also to the weak year-classes since 2009 (implying that the bulk of the catch was large, mature fish that are less likely to be discarded). The discard rate increased year on year to 18% in 2016; dropping slightly in 2017 (17%) and 2018 (13%). In 2019, the discard rate has increased again to 15%. Total catches in 2019 are slightly higher than 2018 suggesting that the rise in discarding is due to more fish being caught and subsequently discarded; possibly a result of the entry of the 2018 year class into the fishery. The recent changes in discarding are not consistent across ages (Figure 8.2.5).

It would be expected that under the EU Landing Obligation fish caught under the MCRS would be landed and recorded as BMS landings in log books rather than discarded as happened before the Landing Obligation. The log book records of BMS landings would then be reported to ICES. However, low BMS values may be seen if the fish caught below MCRS are either not landed, not recorded in log books, not reported to ICES or a mixture of the three. BMS landings reported to ICES in 2019 are 0.49% of the total catch which is significantly lower than the discard estimate of 14.6% 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.

Estimated discard rates can be calculated using video data from Scottish vessels carrying cameras (as part of the FDF scheme described in Section 8.1.2). Neither fish ages nor weights can be measured directly using video, but a method has been developed in Scotland for estimating discard rates by measuring numbers and lengths of discarded fish and applying existing weight-length relationships to obtain a discarded weight, which can then be compared with the total landed weight (see Needle *et al.*, 2015). The lack of age information currently impedes the use of these estimates in the ICES assessment process, but work is underway in Scotland and elsewhere to address this.

In 2020, new catch data for 2018 were submitted to InterCatch by France due to modifications made to their data processing procedure covering the gap filling method in age-length keys and the effort aggregates used in the discard raising procedure (see WD for more details). Thus, the 2018 catch data needed to be re-processed within InterCatch in light of this new data submission. Catches by French vessels account for a very small portion of the total catch and so the overall effect of these new data was a reduction in total catch, landings and discard numbers of less than 0.5% and slight changes (less than a tenth of a gram) in the mean weights for total catch and landings.

Further to this, it was revealed during the WGNSSK meeting that all stocks were missing some landings data from Sweden for Subarea 27.4. For Northern Shelf haddock this amounted to 0.32% of the total catch. It was agreed by the expert members of the group that the data extracted from InterCatch would be raised manually to reflect the missing landings and the missing Swedish landings would be submitted to InterCatch next year. All catch numbers in this report include this manual raising and are the data used in the assessment.

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 discard in 2019 is due to the entry of the 2018 year class to the fishery. In the past, vessels have very seldom exhausted their quota in this fishery, and previous discarding behaviour is thought to be driven by a complicated mix of economic and other market-driven factors.

8.2.3 Weight at age

Weight-at-age for the total catch in the North Sea is given in Table 8.2.11. Weight-at-age in the total catch is a number-weighted average of weight-at-age in the human consumption landings, discards, BMS landings and industrial bycatch components. Weight-at-age in the stock is assumed to be the same as weight-at-age in the total catch. The mean weights-at-age for the separate catch components are given in Tables 8.2.12 to 8.2.15 and are illustrated in Figure 8.2.6: this shows the declining trend in weights-at–age for older ages in total catch and landings however in recent years there has been a slight increase in mean weight at age. There is some evidence for reduced growth rates for large year classes. Jaworski (2011) concluded that linear cohort-based growth models are the most appropriate method for characterising haddock growth, and these are used in the short-term forecast (Section 8.6).

8.2.4 Maturity and natural mortality

Maturity is assumed to be fixed over time and knife-edged at age 3 (that is, all fish aged 0–2 are assumed to be immature, all fish aged 3 and older are assumed to be fully mature). Natural mortality varies with age and year as shown in Figure 8.2.7 and Table 8.2.16. The general basis for these estimates is described in the Stock Annex, and these values shown here are derived from the WGSAM 2014 key run (as revised in 2017).

8.2.5 Catch, effort and research vessel data

The survey data available are summarised in the following table: data used in the final assessment are highlighted in bold.

Area	Country	Quarter	Code	Year range	Age range
Subarea 4	Scotland	Q3	ScoGFS Aberdeen Q3	1982-1997	0-8
Subarea 4	Scotland	Q3	ScoGFS Q3 GOV	1998-present	0-8
Subarea 4	England	Q3	EngGFS Q3 GRT	1977-1991	0-9
Subarea 4	England	Q3	EngGFS Q3 GOV	1992-present	0-9
Subarea 4 and Division 3.a	**International**	**Q1**	**IBTS Q1**	**1983-present**	**1-5**
Subarea 4 and Division 3.a	**International**	**Q3**	**IBTS Q3**	**1991-present**	**0-5**
Subarea 6.a	Scotland	Q1	ScoGFS-WIBTS Q1	1985-2010	1-8
Subarea 6.a	Scotland	Q1	New ScoGFS-WIBTS Q1	2011-present	1-8
Subarea 6.a	Scotland	Q4	ScoGFS-WIBTS Q4	1996-2009	0-7
Subarea 6.a	Scotland	Q4	New ScoGFS-WIBTS Q4	2011-present	0-7
Subarea 6.a	Ireland	Q4	IGFS-WIBTS-Q4	1993-2002	0-8
Subarea 6.a	Ireland	Q4	New IGFS-WIBTS-Q4	2003-present	0-8

The 2014 benchmark meeting (ICES, 2014) concluded that only the North Sea IBTS Q1 and Q3 survey indices should be used to tune the Northern Shelf assessment. The West of Scotland surveys conducted by Scotland and Ireland covered too small a proportion of the overall stock area to be considered reliable indicators of overall stock dynamics, and the separate English and Scottish North Sea indices were only used previously because of the historical timing of the working group (WGNSSK met in early October when IBTS Q3 was not yet available). ICES WKHAD (2014) recommended that the IBTS working group consider whether the North Sea IBTS Q1 and West of Scotland ScoGFS Q1 indices could be combined, but this is for future consideration.

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.

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. A large incoming 2019 year-class can be seen in both the North Sea surveys though it is not apparent in the West of Scotland surveys. Both North Sea surveys show a concentration of this year-class further to the south than usually seen and this change in geographical extent possibly accounts for the lack of synchrony between the North Sea and West of Scotland surveys for this year-class. Abundance trends in survey indices are shown in Figure 8.2.11. These indicate reasonably good consistency in stock signals from the two North Sea surveys, and support the perception of a large 2019 year-class.

8.3 Data analyses

The assessment has been carried out using TSA (Fryer, 2002) as the main assessment method. The results of SURBAR and SAM analyses are also shown, to corroborate (or otherwise) the main assessment.

8.3.1 Exploratory catch-at-age-based analyses

The catch-at-age data, in the form of log-catch curves linked by cohort (Figure 8.3.1), indicates partial recruitment to the fishery for most cohorts up to age 2. Gradients between consecutive values within a cohort have reduced considerably for some recent cohorts, reflecting a reduction in fishing mortality, although catch curves are considerably more variable in recent years suggesting less consistent catch data (which may reflect the lower sample size available from reduced landings). Figure 8.3.2 plots the negative gradient of straight lines fitted to each cohort over the age range 2–4, which can be viewed as a rough proxy for average total mortality for ages 2–4 in the cohort. These negative gradients are also lower in most recent cohorts, and the negative gradient measure for the 2010 cohort is the lowest in the time-series: it is itself negative, which in the absence of other information would indicate that the 2010 was increasing in size over time. As this cannot be the case, it suggests potential problems with recent catch data. It can also be seen that the negative gradient for the 2010 cohort (from ages 2–4) rises sharply, which suggests that fishing mortality may have increased in the most recent time-period.

Cohort correlations in the catch-at-age matrix (plotted as log-numbers) are shown in Figure 8.3.3. These correlations show good consistency within cohorts up to the plus-group, verifying the ability of the catch-at-age data over the full time-series to track relative cohort strengths (although data for ages 0 and 1 are slightly more variable, and recent years may be problematic as discussed above).

An exploratory SAM assessment was conducted, using the run settings stipulated in ICES WKHAD (2014). The stock summary and residual plots from this run are given in Figure 8.3.4. The SAM assessment follows similar trends to the final TSA assessment (see also Figure 8.3.10). There is evidence of some retrospective underestimation of mean F in the SAM runs, with a corresponding retrospective overestimation of SSB.

8.3.2 Exploratory survey-based analyses

A SURBAR run (ICES, 2010; Needle, 2015) was carried out using the same combination of tuning indices as the TSA and SAM assessments. The summary plot from this run is given is Figure 8.3.5, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The SURBAR residual plot in Figure 8.3.6 shows that the surveys agree more closely in recent years than was the case at the 2014 WGNSSK meeting, although there remains an indication of some conflict (mostly negative residuals for Q1 and a more even spread for Q3. The plot of survey catch curves also shows reasonable consistency (Figure 8.3.7). The plots of mean-standardised log survey indices by age and cohort (Figure 8.3.8) and the pairwise within-survey correlations (Figure 8.3.9) show that both surveys track year-class strength well through the population overall. The results are discussed further in Section 8.3.4 below.

8.3.3 Conclusions drawn from exploratory analyses

Mean-standardising SSB and recruitment estimates (using a common year-range for the mean) and generating TSA and SAM estimates of Z by adding F and M enables the comparison between TSA, SAM and SURBAR shown in Figure 8.3.10. SSB and recruitment estimates are very similar from the three models, although it is noticeable that the SURBAR estimates for large year-classes in particular tend to be higher, and the swings between high and low SURBAR SSB estimates are more pronounced than for TSA and SAM. The mean Z time-series from SAM and SURBAR are consistent with that from TSA though while the SURBAR mean Z estimates tend to be smoother, but the overall trajectory are not different. Overall, the SAM and SURBAR assessments concur with and support the final TSA assessment, with some relatively minor variations.

8.3.4 Final assessment

Table 8.3.1 gives the final TSA assessment settings, while Table 8.3.2 gives the corresponding parameter estimates from the completed run. A full description of the TSA method and the purposes of each parameter are given in the Stock Annex, and the ICES WKHAD (2014) report. Note that, for assessment purposes, total catch is divided into human consumption landings (referred to as “landings”) and a composite of discards, BMS landings and industrial bycatch (referred to as “discards” or “discards+bycatch+BMS”), as the selectivity characteristics of these latter components are similar.

In 2020, there was some discussion as to whether there was enough evidence to class the 2019 year-class as a large year-class which would involve some changes to the TSA settings. So far, this year class has been seen in the IBTS Q1 and Q3 surveys and the data suggest that this year class is significantly larger than those seen recently and may be the largest year-class seen since 1999. However, this year-class is yet to be detected in the catch data. 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 year class 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 low in general. Furthermore, the size of sporadic, larger year classes has diminished since the large 1999 year-class though the 2019 year class may prove to oppose this trend. Figure 8.3.14 summarizes the observed and fitted discards (discard+bycatch+BMS) proportions by age, from which the decline in discard (discard+bycatch+BMS) rates across ages 2 to 4 in recent years can be seen.

Standardized prediction errors are given in Figures 8.3.15 (landings), 8.3.16 (discard+bycatch+BMS), 8.3.17 (the IBTS Q1 survey) and 8.3.18 (the IBTS Q3 survey). These are the principal diagnostic tools for fitting time-series Kalman filter models like TSA, and indicate the discrepancy between the model prediction and observation as the model steps through the data from the start to the end. They are a useful guide to suggest observations which might need to be down-weighted to improve the model fit, but as TSA also includes a backwards smoothing step they cannot be considered to be residuals in the usual sense.

The time-series of observed and fitted values for total catch (Figure 8.3.19), the IBTS Q1 survey (Figure 8.3.20) and the IBTS Q3 survey (Figure 8.3.21) are more interpretable in that context. The estimate of total catch at age-0 prior to 1991 is based on quite noisy discard+bycatch+BMS data where they are available, or on model inference where they are not (1973–1977), so for the earlier period model fits are not necessarily very close to observations. The other notable feature is that total catch tends to be overestimated for the larger 1999 year-classes, whereas survey indices tend to be slightly underestimated for this year class: the TSA model fit is a compromise between the two.

Figure 8.3.22 summarizes the results of TSA retrospective analyses for Northern Shelf haddock. There is very little retrospective noise or bias: only one retrospective run falls outside an approximate pointwise 95% confidence intervals of the full time-series assessment, specifically in the mean *F* estimates. It may be hypothesized that the strong population signals from occasional large year-classes provide sufficient data contrast to obviate against retrospective noise.

Mohn’s rho values (average relative bias of retrospective estimates) were calculated for SSB, F and recruitment estimates from TSA and were 0.0142, 0.1191 and 0.8034 respectively. The Mohn’s rho value for recruitment is significantly high. This results from the tendency of TSA to overestimate the recruitment forecast for the terminal year (last year of data + 1). The TSA forecast of recruitment is used in the Mohn’s rho calculation since this value is used in the short term forecast. The tendency of TSA to overestimate the forecasted recruitment has implications for the validity of short term forecasts.

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

8.4 Historical Stock Trends

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

Landings yields have stabilised since 2000, partly due (until 2014) to the limitation of inter-annual TAC variation to ±15% in the EU-Norway management plan for the North Sea. Discards have fluctuated in the same period due to the appearance and subsequent growth of the 1999, 2005, 2009 and 2014 year-classes, while industrial bycatch (IBC) is now at a very low level for haddock (see also Figure 8.2.3).

Estimated fishing mortality for 2008 to 2019 appears to fluctuate between 0.2 and 0.4 and is now below the F_{MSY} value of 0.194 in 2019 (see Section 8.7). Fluctuations around the previous target-F rate (0.3) of the management plan are an expected consequence of the lag between data collection and management action, and should not be taken to indicate that the plan did not work. The 2006–2008 and 2010–2013 year-classes are estimated to have been very weak, and the fishery has been sustained in recent years by the 2005 and 2009 year-classes. The 2014 year-class is modest in size compared to the previous sporadic larger year classes and is below the long-term average for recruitment. Therefore, it is expected to make a smaller contribution to the stock compared to other recent “large” year classes over the next few years.

8.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2020) and in the quota year (IY + 1 = 2021) 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 is updated with a recruitment estimate resulting from an RCT3 analysis.

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

Year class	Age in 2020	TSA estimate (millions)	TSA forecast (millions)
2018	2	225	
2019	1	4728	
2020	0		5406
2021	Age 0 in 2021		5406
2022	Age 0 in 2022		5406

8.6 Short-term forecasts

Weights-at-age

Mean weights-at-age are forecast using the method proposed by Jaworski (2011) and discussed by ICES WKHAD (2014). The method is also summarized in the Stock Annex, and involves fitting straight lines to cohort-based weight estimates and extrapolating forward in time.

The outcomes for the total catch and the landings (also referred to as wanted catch) are summarized in Figures 8.6.1 and 8.6.2 respectively. The weights-at-age for discards and BMS were combined into an unwanted catch category using the relative contribution of each component (in 2019) 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 (2017–2019) means by age are used for all forecast years.

Fishing mortality

ICES WKHAD (2014) concluded that fishing mortality estimates for the intermediate year should be taken to be the same as the final year, considering that F is smoothed within the TSA model. When this approach results in landings that overshoot the TAC, a TAC constraint should be considered. A TAC constraint was needed for the intermediate year to avoid a TAC overshoot of 1544 t. The combined-area TAC for 2020 was 41 819 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 2017–2019) of each component to the total catch.

Splitting catch forecasts between management units

The haddock assessment presented in this section is for the combined Northern Shelf stock, following the conclusion from ICES WKHAD (2014) that this was biologically appropriate. However, catch advice is still required for the extant management units. ICES WKHAD (2014) proposed a survey-based method for splitting forecast catch into sub-units on the basis of a time-smoothed survey-based estimate of the proportion of the fishable stock in each area in each year. This is summarised in the Stock Annex.

However, the survey-based proportions were not accepted by ACOM (in June 2014) as the basis for advice, due to concerns over the comparability of survey catchability between the three management areas covered by the assessment area. As a consequence, the catch forecasts provided in Table 8.6.2 are provided for the full stock area only (Subarea 4, Division 6.a and Subdivision 20).

Forecast results

The inputs to the short-term forecast (conducted using the MFDP program) are presented in Table 8.6.1. Results for the short-term forecasts are presented in Table 8.6.2. Assuming an F of 0.197 in 2020, SSB is expected to be 210 875 tonnes in 2020, before decreasing in 2021 to 206 064 tonnes. In this case, projected wanted catch (human consumption yield) in 2020 would be 28 796 tonnes with associated projected unwanted catch (discards + BMS) of 13 023 t.

Several alternative options for 2021 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}, $F_{MSY\text{-}upper}$, $F_{MSY\text{-}lower}$. Under the assumption of F_{MSY}, the 2021 total catch is forecast to be 69 280 tonnes, which corresponds (if 2020 discard+BMS rates remain unchanged) to a wanted-catch yield of 49 061 tonnes and unwanted catch of 20 110 tonnes. This advised catch is a 65% increase on the 2020 TAC. This exploitation is forecast to lead in turn to a SSB in 2022 of 471 256 tonnes, an increase of 129% on the value forecast above for 2020.

8.7 Medium-term forecasts

No specific medium-term forecasts have been carried out for this stock. Management simulations over the medium-term period were performed for North Sea haddock (Needle, 2008a, b) and West of Scotland haddock (Needle, 2010), as discussed briefly in Section 8.1.4 above.

8.8 Biological reference points

Following the estimation of revised F_{MSY} reference points at the 2014 WKMSYREF3 meeting, WGNSSK 2016 conducted further analysis using the EqSim software to check that the estimated points remained valid following the update assessment. These analyses were repeated by the IBP following the modifications made to the assessment (ICES IBPHaddock, 2016). Figure 8.8.1 summarises the output from this analysis, which indicates that an appropriate value of F_{MSY} for Northern Shelf haddock is now 0.194. This is a reduction from the value set at WKMSYREF3 (0.37): the key difference in the estimates is that the calculation is based on the recruitment time-series from 2000–2015, rather than the full 1972–2015 time series. WGNSSK proposes that the former period is more appropriate, as recruitment does appear to be declining (see Figure 8.3.11) and it would be unwise to assume that a very large recruitment is likely in the near future. However, the size of the 2019 year class may lead to this assumption being reassessed.

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

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

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

8.9 Quality of the assessment

Survey data are consistent both within and between surveys, and the catch data are internally consistent. Trends in mortality from catch data and survey indices are similar. Retrospective bias in the TSA model has been significantly reduced in the current implementation, and a previous coding error has been identified and removed (ICES, 2016).

8.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2019 and is now fluctuating around the historical minimum, although this remains above the estimate of F_{MSY} (0.194). Discard rates have increased slightly above the historical minimum observed in 2013, but remain low. The 2010–2013 year-classes were estimated to be weak, following the relatively strong 2009 year-class, but the 2014 year-class is slightly larger than the recent average and the incoming 2019 year class appears to be the largest since 1999. Recruitment since the very large 1999 year-class has generally been low, compared with the historical time series. Spawning stock biomass is currently well above B_{pa} (132 kt) and is predicted to increase over the next few years as the 2019 year-class matures.

8.11 Management Considerations

The previous EU-Norway management plan for North Sea haddock, and the EU management plan for Division 6.a haddock, are not appropriate for the Northern Shelf stock, as they relate to only a part of the full stock area. Discussions have been ongoing between the EU and Norway which may establish a new management strategy on the basis of the Northern Shelf stock. In 2018 EU-Norway requested an evaluation of multiple management strategies (ICES, 2019a), which are currently under consideration. However, in the meantime the principal basis for management of this haddock stock is the MSY approach. The survey-based proposal for splitting catch advice into management subunits, which was proposed by WGNSSK in 2014, has not been agreed by ACOM, and the split of quota into management units remains based on historical landings. It is unlikely, therefore, to follow any future changes in stock distribution across the Northern Shelf.

Considering the Northern Shelf as a whole, fishing mortality declined significantly in the early 2000s and has fluctuated around a relatively low level since. However, the current estimate remains above F_{MSY}. Spawning stock biomass is estimated to have reached a historical peak in 2002 with the growth of the large 1999 year-class, but declined again rapidly and is now driven strongly by occasional moderate year-classes. The most recent of these occurred in 2005, 2009 and 2014 with a seemingly substantial year class occurring in 2019. Other recent cohorts have been very weak. SSB is expected to increase over the next few years as the 2019 year-class matures and its impact on SSB is expected to be the most significant for the last 20 years.

Keeping fishing mortality close to the target MSY level would be preferable to encourage the sustainable exploitation of the more recent larger year-classes. Estimated discard rates are now low, which may be due partly to the lack of small fish in the population, and partly due to an increased awareness of discard problems following public campaigns and (particularly) the installation of CCTV monitoring cameras on a number of vessels. However, discard rates do remain high in certain small-mesh fisheries (such as the TR2 *Nephrops* fleets in Division 6.a). Further improvements to gear selectivity measures, allowing for the release of small fish, would be highly beneficial not only for the haddock stock, but also for the survival of juveniles of other species that occur in mixed fisheries along with haddock. Similar considerations also apply to spatial management approaches (such as real-time closures), and other measures intended to reduce unwanted bycatch and discarding of various species (such as the Scottish Conservation Credits scheme; see Section 8.1.4). Haddock is included in the EU Landings Obligation regulation from 2016, though the impacts on fishing and on the stock are as yet unknown.

Haddock is a specific target for some fleets, but is also caught as part of a mixed fishery catching cod, whiting and *Nephrops*. It is important to consider both the species-specific assessments of these species for effective management, as well as the latest developments in the mixed fisheries approach. This is not straightforward when stocks are managed via a series of single-species, single-area management plans that do not incorporate mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another and the implications of any change need to be considered carefully.

8.12 Assessment frequency

Regarding the Northern Shelf haddock assessment, the following summarises the WGNSSK responses to each of the criteria:-

- Stocks are considered candidates for biennial assessment if the advice for the stock has been 0-catch or equivalent for the latest three advice years.

   - This **does not apply** for haddock.

Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously.

- Life span (i.e. maximum normal age) of the species is larger than 5 years.
   - This **applies** to haddock.
- The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x F_{MSY} OR if F_{MSY} range has been defined: F(latest assessment year) is <= F_{upper} (upper bound in F range) AND SSB(start of intermediate year) >= MSY $B_{trigger}$
   - This **applies** to haddock.
- The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.
   - The first age in the assessment of haddock is zero. Applying the method given here, 3% of the catch is at age zero. Using age-1 instead (which would be the recruiting age for most comparable stocks) gives 3%. So the criterion **applies** to haddock as given.
- The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by more than 20%. The formula to be used in the calculations is: $\rho = \frac{1}{7}$

large incoming year-classes. It is hard to be certain what the outcome would be, however, without more comprehensive risk analyses.

This leads to the more general point. One further opinion expressed during the WGNSSK discussion on this issue was that relatively simple tests would generally be insufficient to determine the risk of unwanted outcomes, should the frequency of assessments for a particular stock be reduced. Such an exercise would require a simulation analysis of the type used to evaluate management plans and strategies. An approach of this kind would take considerable time that would not be available during the WG meeting itself, and would thus require the implementation of a directed Expert Group or coordinated intersessional work. Several members of WGNSSK have tried to set up such a Group within ICES in recent years to no avail, and the difficulty of instigating this work should not be underestimated. There remains a real concern that the simple application of the criteria could lead rapidly to very undesirable outcomes which cannot be predicted without a more robust risk analysis.

8.13 "Living issues" benchmark list

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

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

8.13.1 Data and stock ID

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

8.13.2 Assessment

- The TSA model fit to catch data for the plus group (age 8+) is poor relative to other age classes. The impact of this on the perception of the stock biomass needs assessing since the contribution of the plus group to the SSB seems to be increasing over time
- TSA shows some bias in prediction errors for Age 0 IBTS Q3 survey
- Assessment model (TSA) is not compatible with analyses involving large numbers of simulation runs (i.e. management strategy evaluations).

- Technical support for the assessment model (TSA) will likely be unavailable in the next few years following the retirement of model developer.
- Exploratory assessment model SURBAR – some age classes show bias and trends in residuals
- 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).

8.13.3 Forecast

- Weights at age – linear extrapolation of mean weights at age for individual cohorts are not always consistent across catch components
- Determine extent of growth rate dependent on cohort size (not clear from last benchmark).
- Investigate alternative intermediate year recruitment assumptions. Forecast value for recruitment would benefit from including information on the probability of large year classes occurring.

8.14 References

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

Subdivision 20										
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
DE	65	102	120	90	114	103	125	56	31	30
DK	1139	1661	1916	1456	1763	1059	908	852	542	458
NL	1	0	0	6	6	4	0	20	4	4
NO	81	125	303	223	86	63	70	65	36	27
SE	126	198	210	217	219	202	129	104	140	93
UK	0	0	0	3	0	0	0	0	0	0
Subarea 4										
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
BE	78	106	78	78	98	47	53	30	29	29
DE	634	575	548	677	677	599	554	609	347	311
DK	725	697	947	1283	1079	1442	1244	1185	1117	1203
FO	5	0	0	0	0	0	0	0	0	1
FR	276	320	175	177	209	100	121	140	201	189
NL	41	71	191	172	99	44	146	75	89	162
NO	1126	1195	1006	1662	2743	2003	1499	2164	1431	1517
SE	90	128	103	113	154	136	118	181	99	111
UK	24983	23343	27378	33013	29851	25905	26427	25667	25880	21930
Division 6.a										
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
DE	1	0	0	0	0	0	0	0	0	0
DK	0	0	0	0	0	0	2	2	1	9
ES	28	36	15	14	19	9	33	28	28	64
FO	0	0	0	0	0	0	0	<1	0	0
FR	89	73	32	51	67	41	62	68	66	57
IE	396	290	845	746	667	768	1034	641	758	562
NL	0	0	0	0	0	11	28	31	15	54
NO	9	4	0	6	2	7	5	1	7	10
UK	2415	1364	4123	3878	3261	3051	3101	2480	3295	2789
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Official landings	32308	30288	37990	43851	41114	35594	35659	34399	34116	29610
ICES landings	31940	36570	38162	43734	41143	35295	35058	32827	34404	30743
ICES discards	13071	13067	5032	3305	5090	6255	7749	6936	4871	5345
ICES IBC	431	24	1	54	65	21	37	19	5	186
ICES BMS							201	93	155	179

ICES total catch	45442	49661	43195	47092	46295	41571	43133	40801	39492	36602
TAC 4	35794	34057	39000	45041	38284	40711	61933	33643	41767	28950
TAC 3.a	2201	2100	2095	2770	2355	2504	3926	2069	2569	1780
TAC 6.a	2670	2005	6015	4211	3988	4536	6462	3697	4654	3226
Total TAC	40665	38162	47110	52022	44627	47751	72321	39409	48990	33956
ICES quota uptake	79%	96%	81%	84%	92%	74%	48%	82%	80%	108%

Table 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of sampling strata for discards imported into InterCatch and proportion of discards raised from averaged discard rates.

Catch category	Raised or imported	Weight (tonnes)	Proportion
BMS landings	Imported	168	100
Discards	Imported	4829	91
Discards	Raised	494	9
Landings	Imported	29873	100

Table 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of age distributions for landings, BMS landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Weight (tonnes)	Proportion
Landings	Imported	Sampled	27806	93
Landings	Imported	Estimated	2066	7
Discards	Imported	Sampled	4804	90
Discards	Raised	Estimated	494	9
Discards	Imported	Estimated	25	0
BMS landings	Imported	Estimated	153	91
BMS landings	Imported	Sampled	15	9

Table 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion by area of distributions for landings, BMS landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Area	Weight (tonnes)	Proportion
Landings	Imported	Sampled	27.6.a	3220	90
Landings	Imported	Estimated	27.6.a	355.2	10
Discards	Imported	Sampled	27.6.a	1783	97
Discards	Imported	Estimated	27.6.a	<1	0
Discards	Raised	Estimated	27.6.a	62	3
BMS landings	Imported	Sampled	27.6.a	0	0
BMS landings	Imported	Estimated	27.6.a	15	100
Landings	Imported	Sampled	27.4	24089	94
Landings	Imported	Estimated	27.4	1593	6
Discards	Imported	Sampled	27.4	2965	87
Discards	Raised	Estimated	27.4	414.7	12
Discards	Imported	Estimated	27.4	22.03	1
BMS landings	Imported	Estimated	27.4	1	0
BMS landings	Imported	Sampled	27.4	153	100
Landings	Imported	Sampled	27.3.a.20	498	81
Landings	Imported	Estimated	27.3.a.20	119	19
Discards	Raised	Estimated	27.3.a.20	17	23
Discards	Imported	Sampled	27.3.a.20	56	74
Discards	Imported	Estimated	27.3.a.20	3	3
BMS landings	Imported	Estimated	27.3.a.20	0	0

Table 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Working Group estimates of catch components by weight (000 tonnes). *Note that Subarea 4 and Subdivision 20 data are collated together in 2013, and are listed here only in the Subarea 4 section.

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
1965	161.7	62.3		74.6	298.6	0.7			0.7	32.5	3.4		35.9	194.9	65.7		74.6	335.2
1966	225.6	73.5		46.7	345.8	0.6			0.6	29.9	0.7		30.6	256.1	74.2		46.7	377.0
1967	147.4	78.2		20.7	246.3	0.4			0.4	20.3	7.4		27.7	168.1	85.6		20.7	274.4
1968	105.4	161.8		34.2	301.4	0.4			0.4	20.5	25.3		45.8	126.3	187.1		34.2	347.6
1969	331.1	260.1		338.4	929.5	0.5			0.5	26.3	25.2		51.5	357.9	285.3		338.4	981.6
1970	524.1	101.3		179.7	805.1	0.7			0.7	34.1	6.2		40.3	558.9	107.5		179.7	846.1
1971	235.5	177.8		31.5	444.8	2			2	46.3	12.2		58.5	283.8	190.0		31.5	505.3
1972	193	128		29.6	350.5	2.6			2.6	41.1	16.4		57.5	236.7	144.4		29.6	410.7
1973	178.7	114.7		11.3	304.7	2.9			2.9	28.8	11.4		40.2	210.4	126.1		11.3	347.8
1974	149.6	166.4		47.5	363.5	3.5			3.5	18.0	15.4		33.3	171.1	181.8		47.5	400.3
1975	146.6	260.4		41.5	448.4	4.8			4.8	13.7	33.0		46.6	165.1	293.4		41.5	499.9
1976	165.7	154.5		48.2	368.3	7			7	18.8	15.3		34.1	191.5	169.8		48.2	409.5
1977	137.3	44.4		35	216.7	7.8			7.8	19.3	4.4		23.7	164.4	48.8		35	248.2
1978	85.8	76.8		10.9	173.5	5.9			5.9	17.2	1.1		18.3	108.9	77.9		10.9	197.7
1979	83.1	41.7		16.2	141	4			4	14.8	6.5		21.3	101.9	48.2		16.2	166.3
1980	98.6	94.6		22.5	215.7	6.4			6.4	12.8	4.8		17.5	117.8	99.4		22.5	239.6
1981	129.6	60.1		17	206.7	6.6			6.6	18.2	7.1		25.3	154.4	67.2		17	238.6
1982	165.8	40.6		19.4	225.8	7.5			7.5	29.6	7.7		37.3	202.9	48.3		19.4	270.6
1983	159.3	66		12.9	238.2	6			6	29.4	3.4		32.8	194.7	69.4		12.9	277.0
1984	128.2	75.3		10.1	213.6	5.4			5.4	30.0	8.1		38.1	163.6	83.4		10.1	257.1
1985	158.6	85.2		6	249.8	5.6			5.6	24.4	10.7		35.1	188.6	95.9		6	290.5

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
1986	165.6	52.2		2.6	220.4	2.7			2.7	19.6	5.2		24.7	187.9	57.4		2.6	247.8
1987	108	59.1		4.4	171.6	2.3			2.3	27.0	11.1		38.1	137.3	70.2		4.4	211.9
1988	105.1	62.1		4	171.2	1.9			1.9	21.1	5.0		26.1	128.1	67.1		4	199.2
1989	76.2	25.7		2.4	104.2	2.3			2.3	16.7	2.5		19.2	95.2	28.2		2.4	125.8
1990	51.5	32.6		2.6	86.6	2.3			2.3	10.1	0.8		11.0	63.9	33.4		2.6	100.0
1991	44.7	40.2		5.4	90.2	3.1			3.1	10.6	4.8		15.3	58.4	45.0		5.4	108.7
1992	70.2	47.9		10.9	129.1	2.6			2.6	11.3	3.5		14.9	84.1	51.4		10.9	146.5
1993	79.6	79.6		10.8	169.9	2.6			2.6	19.1	7.0		26.1	101.3	86.6		10.8	198.7
1994	80.9	65.4		3.6	149.8	1.2			1.2	14.2	5.0		19.2	96.3	70.4		3.6	170.3
1995	75.3	57.4		7.7	140.4	2.2			2.2	12.4	7.7		20.0	89.9	65.1		7.7	162.6
1996	76	72.5		5	153.5	3.1			3.1	13.5	7.8		21.3	92.6	80.3		5	177.9
1997	79.1	52.1		6.7	137.9	3.4			3.4	12.9	7.5		20.4	95.4	59.6		6.7	161.7
1998	77.3	45.2		5.1	127.6	3.8			3.8	14.4	7.0		21.4	95.5	52.2		5.1	152.8
1999	64.2	42.6		3.8	110.7	1.4			1.4	10.4	3.9		14.3	76.0	46.5		3.8	126.3
2000	46.1	48.8		8.1	103	1.5			1.5	7.0	6.3		13.2	54.6	55.1		8.1	117.7
2001	39	118.3		7.9	165.2	1.9			1.9	6.7	8.5		15.2	47.6	126.8		7.9	182.3
2002	54.2	45.9		3.7	103.8	4.1			4.1	7.1	9.4		16.5	65.4	55.3		3.7	124.4
2003	40.1	23.5		1.1	64.8	1.8	0.2		2	5.3	4.5		9.8	47.2	28.2		1.1	76.5
2004	47.3	15.4		0.6	63.2	1.4	0.1		1.6	3.2	4.5		7.7	51.9	20.0		0.6	72.5
2005	47.6	8.4		0.2	56.2	0.8	0.2		1	3.1	3.8		6.9	51.5	12.4		0.2	64.1
2006	36.1	16.9		0.5	53.6	1.5	1		2.5	5.7	5.2		10.9	43.3	23.1		0.5	66.9
2007	29.4	27.8		0	57.3	1.5	0.8		2.3	3.7	4.0		7.8	34.6	32.6		0	67.3
2008	28.9	12.5		0.2	41.6	1.4	0.6		2	2.8	1.3		4.1	33.1	14.4		0.2	47.7

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
2009	31.3	10		0.1	41.3	1.5	0.6		2.1	2.8	1.8		4.6	35.6	12.4		0.1	48.1
2010	27.8	9.5		0.4	37.7	1.3	0.6		1.9	2.9	2.9		5.8	32.0	13.0		0.4	45.4
2011	26.3	10.2		0	36.5	9.9	1.7		11.6	1.7	1.5		3.3	37.9	13.4		0	51.4
2012	30.3	3.7		1.2	35.0	2.6	0.7		3.4	5.1	0.5		5.6	38.0	4.9		1.2	44.1
2013*	38.9	2.0		0.1	41.0					4.7	1.1		5.8	43.7	3.0		0.1	46.8
2014	34.9	4.1		0.1	39.1	2.3	0.1		2.4	4.0	0.8		4.8	41.1	5.1		0.1	46.3
2015	30.2	4.2		0.0	34.3	1.4	0.1		1.5	3.9	1.3		5.2	35.3	6.3		0.0	41.6
2016	29.8	5.5	0.2	0.0	35.5	1.2	0.0	0.0	1.2	4.2	1.5	0.0	5.8	35.2	7.1	0.2	0.0	42.6
2017	29.2	5.2	0.1	0.0	34.5	1.1	0.1	0.0	1.2	3.3	1.5	0.0	4.8	33.5	6.9	0.1	0.0	40.6
2018	29.3	3.3	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

Table 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers at age data (thousands) for total catch. Ages 0–7 and 8+ and years 1972–2018 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	650218	368560	16491	721514	36301	4954	2245	626	118	97	47	0	0	0	0	0	262
1966	1672925	1007517	26186	7536	459941	11903	1109	633	222	90	23	2	0	0	0	0	337
1967	345371	856339	108401	5814	3850	202830	2843	223	231	61	34	0	0	0	0	0	326
1968	11133	1226448	477603	22671	2303	3210	60034	1052	84	22	5	0	0	0	0	0	111
1969	75301	20554	3736629	313593	9029	2678	2894	23704	392	32	7	0	0	0	0	0	431
1970	941790	272467	218881	2003201	60200	1350	1285	401	6539	81	13	19	0	0	0	0	6652
1971	337277	1881729	74866	50845	480381	10916	589	201	167	1767	176	3	5	0	0	0	2119
1972	255110	696714	671965	43309	23547	211817	4067	241	53	27	475	11	0	0	0	0	566
1973	79461	412305	587335	260080	6450	5689	72652	1406	140	34	234	49	5	0	0	0	462
1974	665110	1283252	187149	342628	60523	1956	1795	22380	345	57	63	4	7	4	0	0	480
1975	51796	2276937	673960	62175	112242	17691	1078	718	6168	339	70	11	0	8	0	0	6596
1976	171400	192030	1127520	225532	11538	32677	5864	228	84	1863	64	3	5	0	0	0	2019
1977	119506	263702	109480	426291	45756	4984	6757	1608	163	40	460	8	0	1	0	0	672
1978	281785	223294	130963	31141	144703	11791	1582	2322	740	122	33	275	16	2	0	0	1188
1979	844410	261156	220200	45487	7978	38097	3069	377	629	181	57	13	52	3	0	0	935
1980	374573	439674	374310	80225	11364	2040	11143	827	143	168	96	34	9	7	1	0	457
1981	645352	116229	430149	180553	17044	2225	497	3320	164	78	26	32	5	1	4	0	311
1982	275508	217834	89989	390347	49835	4275	820	551	1072	60	28	8	2	2	0	0	1172
1983	513034	148158	222772	83199	166812	20055	2365	338	255	385	93	21	4	4	0	0	763
1984	95862	483045	139887	143821	29321	56077	6238	967	127	84	185	19	5	1	1	0	423
1985	127003	161400	441785	80605	41508	7082	18393	1929	296	56	29	144	9	0	0	1	535
1986	45703	137091	144075	328016	29497	10595	1686	4421	581	156	56	47	37	16	4	1	898
1987	10249	253236	259369	56407	92705	6214	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	16679	33092	424014	96795	17161	27728	2030	874	368	1076	95	21	12	13	17	1	1603
1989	19587	51743	43162	216359	21015	4189	7671	763	285	170	469	69	8	3	2	1	1007

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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2016	1845	10258	61899	8780	5537	646	507	10150	262	151	9	146	8	0	0	1	57
2017	2593	12665	23033	55077	3214	1517	142	373	1482	509	5	20	5	1	0	1	2023
2018	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

Table 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers at age data (thousands) for landings. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	0	2670	3908	396363	30232	4358	2126	620	118	97	47	0	0	0	0	0	262
1966	0	13034	6899	5332	419437	11113	1082	631	222	90	23	2	0	0	0	0	337
1967	0	55548	40030	4627	3607	198991	2821	223	231	61	34	0	0	0	0	0	326
1968	0	22108	151474	17130	2160	3176	59110	1051	84	22	5	0	0	0	0	0	111
1969	0	143	759680	175763	7965	2282	2760	23452	392	32	7	0	0	0	0	0	431
1970	0	2428	52031	1211535	53570	1184	1220	398	6539	81	13	19	0	0	0	0	6652
1971	0	35945	27011	37832	448352	10551	582	201	167	1767	176	3	5	0	0	0	2119
1972	0	13354	233966	35440	22165	210167	4054	241	53	27	475	11	0	0	0	0	566
1973	0	7277	211018	209961	6085	5459	72528	1406	140	34	234	49	5	0	0	0	462
1974	0	25699	55734	236624	53054	1868	1679	22156	345	57	63	4	7	4	0	0	480
1975	0	28773	211495	41030	93617	17406	1073	718	6163	339	70	11	0	8	0	0	6591
1976	0	3045	246027	155162	11292	29594	5846	228	84	1863	64	3	5	0	0	0	2019
1977	0	8934	33058	278741	42737	4737	6516	1608	163	40	460	8	0	1	0	0	672
1978	0	13913	55636	26119	123655	11479	1496	2317	740	122	33	275	16	2	0	0	1187
1979	0	16077	120456	38247	7752	37353	3052	377	629	181	57	13	52	3	0	0	935
1980	0	11487	154765	67241	9978	1985	11057	820	143	166	96	34	9	7	1	0	456
1981	0	1959	174018	128102	16447	2219	494	3320	164	78	26	32	5	1	4	0	311

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1982	0	7623	40161	282492	45732	3811	820	551	1072	60	28	8	2	2	0	0	1172
1983	0	7669	114118	57151	152477	19147	2201	338	255	385	93	21	4	4	0	0	763
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706
1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381
2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
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	0.000	282	5074	21822	6964	20335	421	366	19	46	137	5	1	4	1	10	222

Table 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers-at-age data (thousands) for discards. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	5757	111654	4897	141863	3704	4	1	0	0	0	0	0	0	0	0	0	0
1966	13832	445648	12742	1197	24643	35	2	0	0	0	0	0	0	0	0	0	0
1967	46372	408281	62831	1032	219	1576	9	0	0	0	0	0	0	0	0	0	0
1968	67	741402	244976	3512	97	15	186	0	0	0	0	0	0	0	0	0	0
1969	4475	5234	1273332	39179	432	16	8	0	0	0	0	0	0	0	0	0	0
1970	68905	99125	78340	306391	2663	13	4	0	0	0	0	0	0	0	0	0	0
1971	14189	1275394	37883	9623	25648	66	2	0	0	0	0	0	0	0	0	0	0
1972	18446	444794	380988	6846	1236	1212	13	0	0	0	0	0	0	0	0	0	0
1973	38129	287558	363916	50108	354	33	123	0	0	0	0	0	0	0	0	0	0
1974	88456	982287	99148	59143	2869	6	4	0	0	0	0	0	0	0	0	0	0

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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0
2004	3758	24613	21221	3967	14548	19811	5	4	0	0	0	0	0	0	0	0	0
2005	8779	16730	18722	6181	1258	4826	4496	1	1	0	0	0	0	0	0	0	1
2006	3229	118636	19862	8636	2634	823	1596	2520	6	1	1	0	0	0	0	0	8
2007	2045	19393	142509	5585	826	97	38	103	71	0	0	0	0	0	0	0	71
2008	3768	14623	25111	24195	243	46	134	2	30	4	0	0	0	0	0	0	34
2009	10468	10521	10601	11050	16522	79	50	46	0	1	4	0	0	0	0	0	5
2010	2930	102881	11872	5201	1125	2415	25	0	14	0	0	1	0	0	0	0	15
2011	3002	5858	49830	1817	806	105	224	0	0	0	1	1	0	0	0	0	2
2012	1319	3128	1973	14017	503	11	7	15	0	0	0	0	0	0	0	0	0
2013	1285	11014	1898	494	2695	26	11	12	24	0	1	0	0	0	0	0	25
2014	3537	7272	7187	980	161	4185	2	14	7	1	0	0	0	0	0	0	8
2015	3820	26920	5225	1545	94	31	989	0	0	0	2	0	0	0	0	0	2
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

Table 8.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers-at-age data (thousands) for BMS landings Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
2016	0	189	725	2	1	0	0	0	0	0	0	0	0	0	0	0	0
2017	34	166	158	95	1	0	0	0	0	0	0	0	0	0	0	0	0

2018	0	8	547	13	74	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	194	285	218	0	2	0	0	0	0	0	0	0	0	0	0	0

Table 8.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Numbers-at-age data (thousands) for IBC. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	644461	254237	7686	183288	2365	592	118	6	0	0	0	0	0	0	0	0	0
1966	1659093	548835	6546	1007	15861	755	25	2	0	0	0	0	0	0	0	0	0
1967	298999	392510	5539	155	24	2264	12	0	0	0	0	0	0	0	0	0	0
1968	11066	462938	81153	2029	46	19	738	1	0	0	0	0	0	0	0	0	0
1969	70826	15178	1703617	98650	632	380	126	252	0	0	0	0	0	0	0	0	0
1970	872884	170914	88509	485275	3967	153	61	2	0	0	0	0	0	0	0	0	0
1971	323088	570391	9972	3390	6381	299	6	0	0	0	0	0	0	0	0	0	0
1972	236664	238566	57010	1023	146	439	0	0	0	0	0	0	0	0	0	0	0
1973	41332	117470	12402	11	11	196	0	0	0	0	0	0	0	0	0	0	0
1974	576654	275266	32267	46862	4600	82	112	224	0	0	0	0	0	0	0	0	0
1975	44317	594854	84620	4761	5203	141	5	0	5	0	0	0	0	0	0	0	5
1976	164982	66973	183064	29188	46	2946	17	0	0	0	0	0	0	0	0	0	0
1977	103142	147019	29352	67628	2355	238	240	0	0	0	0	0	0	0	0	0	0
1978	280592	125698	11330	809	1480	64	6	5	0	0	0	0	0	0	0	0	0
1979	839615	125834	17671	1507	84	379	16	0	0	0	0	0	0	0	0	0	0
1980	374315	281436	21820	8258	1291	54	86	7	0	1	0	0	0	0	0	0	1
1981	644910	99247	30358	4613	440	6	2	0	0	0	0	0	0	0	0	0	0
1982	275003	174147	14740	13540	1810	464	0	0	0	0	0	0	0	0	0	0	0
1983	488707	63818	14331	5134	2242	3	0	0	0	0	0	0	0	0	0	0	0
1984	92587	98257	10644	4702	368	535	0	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1985	122079	11672	17826	1739	547	223	17	0	0	0	0	0	0	0	0	0	0
1986	32696	40023	1831	802	103	7	0	0	0	0	0	0	0	0	0	0	0
1987	8253	82226	3797	295	138	0	0	0	0	0	0	0	0	0	0	0	0
1988	9280	3309	12819	2462	620	202	0	0	0	0	0	0	0	0	0	0	0
1989	8914	2541	1751	2789	460	37	86	10	0	0	0	0	0	0	0	0	0
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0
1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198033	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0
2004	0	590	265	84	258	753	8	4	0	0	0	0	0	0	0	0	0
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	0	1
2007	1	27	218	6	1	0	0	0	0	0	0	0	0	0	0	0	0
2008	12	82	280	180	52	18	4	1	0	0	0	0	0	0	0	0	0
2009	15	36	97	48	19	6	2	0	0	0	0	0	0	0	0	0	0
2010	0	4169	355	36	0	0	0	0	0	0	0	0	0	0	0	0	0

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

Table 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for total catch. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.010	0.070	0.227	0.370	0.655	0.846	1.170	1.190	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.088	0.247	0.394	0.536	0.962	1.254	1.512	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.014	0.116	0.278	0.478	0.591	0.641	1.072	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.129	0.254	0.516	0.743	0.827	0.829	1.483	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.012	0.064	0.217	0.410	0.817	0.905	1.029	1.074	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.013	0.075	0.222	0.353	0.738	0.925	1.195	1.246	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000
1971	0.012	0.109	0.246	0.359	0.509	0.888	1.269	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.025	0.117	0.242	0.383	0.503	0.585	0.987	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.043	0.118	0.239	0.369	0.578	0.611	0.648	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.025	0.129	0.226	0.339	0.536	0.867	0.828	0.863	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.023	0.105	0.240	0.353	0.442	0.678	1.190	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.014	0.129	0.225	0.394	0.505	0.578	0.916	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.020	0.111	0.238	0.339	0.586	0.612	0.787	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.011	0.104	0.254	0.396	0.424	0.707	0.784	0.921	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.009	0.093	0.287	0.417	0.611	0.669	0.931	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.012	0.081	0.276	0.464	0.693	0.985	0.908	1.264	1.511	1.501	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.009	0.060	0.264	0.445	0.726	1.055	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.010	0.074	0.286	0.423	0.759	1.109	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.011	0.132	0.303	0.431	0.612	0.904	1.211	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.010	0.142	0.303	0.461	0.645	0.736	1.077	1.205	1.821	2.030	1.732	1.950	2.422	2.822	4.995	0.000
1985	0.010	0.148	0.296	0.466	0.649	0.835	0.934	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.023	0.123	0.261	0.406	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.010	0.125	0.264	0.405	0.594	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.042	0.163	0.232	0.411	0.581	0.731	1.203	1.363	1.281	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.036	0.200	0.282	0.367	0.590	0.770	0.935	1.259	1.586	1.507	1.034	1.534	2.431	2.559	2.307	0.980
1990	0.040	0.187	0.313	0.422	0.506	0.795	0.995	1.179	1.495	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.030	0.175	0.308	0.454	0.574	0.644	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.019	0.102	0.306	0.466	0.717	0.923	0.903	1.382	1.514	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.010	0.110	0.282	0.454	0.660	0.877	1.053	1.062	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.018	0.121	0.247	0.435	0.599	0.846	1.240	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.012	0.107	0.290	0.369	0.581	0.774	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.022	0.126	0.241	0.382	0.484	0.746	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.029	0.138	0.280	0.360	0.585	0.634	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.027	0.153	0.255	0.396	0.444	0.665	0.777	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.025	0.166	0.250	0.356	0.477	0.510	0.735	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.052	0.121	0.256	0.355	0.480	0.605	0.656	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.029	0.111	0.219	0.321	0.466	0.658	0.735	0.945	1.690	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.017	0.109	0.255	0.311	0.527	0.703	0.829	0.818	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.024	0.082	0.221	0.327	0.400	0.681	0.758	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2004	0.039	0.139	0.238	0.378	0.395	0.440	0.686	0.926	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.054	0.160	0.271	0.364	0.495	0.479	0.522	0.925	1.054	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.042	0.126	0.283	0.352	0.442	0.507	0.538	0.550	1.048	1.395	2.031	2.525	1.834	3.532	5.274	2.580
2007	0.042	0.159	0.227	0.407	0.478	0.538	0.657	0.700	0.745	0.902	2.272	0.971	1.712	2.348	4.244	0.000
2008	0.030	0.170	0.256	0.366	0.593	0.662	0.714	0.928	0.924	0.878	1.689	1.970	0.988	0.224	3.792	3.024
2009	0.048	0.175	0.305	0.323	0.388	0.677	0.799	0.839	1.308	1.318	1.025	1.045	1.150	3.091	2.115	0.000
2010	0.016	0.078	0.288	0.411	0.454	0.466	0.710	0.899	1.269	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.017	0.140	0.260	0.399	0.434	0.466	0.534	0.661	0.864	0.558	1.484	1.787	1.593	0.000	0.000	0.000
2012	0.035	0.160	0.439	0.408	0.576	0.706	0.711	0.654	1.278	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.034	0.172	0.425	0.599	0.487	0.727	0.854	0.796	0.758	1.085	1.842	2.191	2.607	1.810	2.512	0.000
2014	0.042	0.139	0.433	0.589	0.656	0.537	0.780	0.831	0.923	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.031	0.145	0.417	0.561	0.752	0.698	0.631	0.685	0.970	0.725	0.715	0.719	1.448	2.954	0.000	0.000
2016	0.048	0.154	0.362	0.642	0.776	0.886	0.989	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.836
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.803	2.670	0.678	0.890	1.514	0.909	0.000
2018	0.043	0.139	0.356	0.504	0.533	1.024	1.031	1.135	1.437	0.895	1.255	2.921	2.408	3.356	2.198	4.661
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

Table 8.2.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for landings. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.000	0.308	0.348	0.413	0.680	0.904	1.211	1.197	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.000	0.300	0.382	0.445	0.554	1.001	1.275	1.515	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.000	0.260	0.399	0.530	0.610	0.646	1.077	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.000	0.256	0.360	0.595	0.769	0.832	0.835	1.484	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.000	0.178	0.302	0.508	0.878	0.989	1.058	1.081	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.000	0.249	0.309	0.402	0.787	0.997	1.235	1.250	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1971	0.000	0.256	0.332	0.393	0.525	0.905	1.280	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.000	0.243	0.325	0.415	0.518	0.587	0.989	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.000	0.228	0.310	0.400	0.596	0.621	0.649	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.000	0.268	0.314	0.381	0.567	0.882	0.866	0.867	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.000	0.254	0.336	0.400	0.476	0.683	1.193	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.000	0.243	0.331	0.452	0.509	0.601	0.917	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.000	0.272	0.344	0.381	0.595	0.625	0.800	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000
1978	0.000	0.257	0.333	0.427	0.456	0.717	0.812	0.922	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.000	0.262	0.348	0.447	0.620	0.675	0.932	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.000	0.274	0.347	0.501	0.706	0.992	0.907	1.261	1.511	1.499	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.000	0.334	0.364	0.503	0.734	1.056	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.000	0.299	0.349	0.478	0.788	1.153	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.000	0.320	0.375	0.464	0.624	0.914	1.242	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.000	0.280	0.350	0.493	0.666	0.764	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000
1985	0.000	0.279	0.348	0.478	0.651	0.844	0.935	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.000	0.277	0.348	0.428	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.000	0.265	0.335	0.440	0.603	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.000	0.236	0.322	0.437	0.594	0.732	1.203	1.363	1.370	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.000	0.319	0.356	0.413	0.602	0.769	0.934	1.256	1.579	1.507	1.025	1.534	2.431	2.559	2.307	0.980
1990	0.000	0.260	0.372	0.439	0.525	0.796	1.015	1.196	1.504	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.000	0.269	0.363	0.462	0.576	0.645	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.000	0.287	0.367	0.486	0.723	0.924	0.904	1.382	1.515	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.000	0.293	0.372	0.484	0.666	0.878	1.053	1.067	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.000	0.269	0.378	0.473	0.617	0.851	1.241	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.000	0.316	0.400	0.424	0.600	0.782	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.000	0.326	0.364	0.471	0.519	0.747	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1997	0.000	0.344	0.410	0.418	0.615	0.641	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.000	0.271	0.370	0.441	0.470	0.670	0.778	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.000	0.297	0.349	0.422	0.490	0.523	0.746	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.000	0.334	0.368	0.421	0.515	0.617	0.663	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.000	0.379	0.352	0.448	0.483	0.675	0.735	0.946	1.695	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.000	0.427	0.446	0.397	0.569	0.713	0.829	0.901	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.000	0.283	0.377	0.464	0.441	0.684	0.759	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.000	0.366	0.383	0.474	0.454	0.468	0.688	0.932	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.000	0.399	0.399	0.428	0.548	0.516	0.536	0.926	1.056	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.000	0.392	0.386	0.418	0.493	0.546	0.574	0.583	1.093	1.431	2.109	2.643	1.926	3.592	5.292	2.709
2007	0.000	0.379	0.385	0.466	0.497	0.542	0.662	0.705	0.748	0.902	2.272	0.971	1.712	2.348	4.244	0.000
2008	0.000	0.357	0.408	0.414	0.607	0.668	0.754	0.931	0.935	0.879	1.703	1.970	0.988	0.224	3.792	3.024
2009	0.000	0.443	0.434	0.410	0.416	0.691	0.830	0.882	1.309	1.321	1.029	1.045	1.150	3.091	2.115	0.000
2010	0.000	0.278	0.473	0.457	0.471	0.476	0.721	0.899	1.364	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.016	0.266	0.358	0.411	0.442	0.468	0.535	0.661	0.864	0.559	1.456	1.698	1.593	0.000	0.000	0.000
2012	0.000	0.358	0.525	0.445	0.606	0.707	0.712	0.654	1.279	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.000	0.437	0.564	0.625	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000
2016	0.356	0.383	0.445	0.649	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.835
2017	0.000	0.249	0.448	0.469	0.783	0.963	1.295	1.034	1.022	0.647	2.744	0.910	2.824	2.333	4.673	5.558
2018	0.000	0.418	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
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

Table 8.2.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for discards. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.062	0.131	0.203	0.335	0.607	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.053	0.141	0.208	0.245	0.309	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.043	0.170	0.210	0.273	0.306	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.054	0.181	0.212	0.257	0.317	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.049	0.129	0.216	0.238	0.300	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.057	0.131	0.210	0.239	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.052	0.135	0.202	0.244	0.264	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.045	0.140	0.207	0.239	0.261	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.051	0.135	0.201	0.237	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.046	0.146	0.201	0.234	0.259	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.041	0.126	0.201	0.257	0.275	0.348	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.053	0.172	0.198	0.239	0.291	0.337	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.062	0.191	0.198	0.220	0.306	0.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.042	0.175	0.199	0.222	0.225	0.265	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.037	0.128	0.221	0.245	0.259	0.314	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.051	0.147	0.232	0.276	0.325	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.074	0.160	0.199	0.296	0.621	0.727	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.055	0.194	0.247	0.265	0.289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.066	0.184	0.237	0.343	0.458	0.711	0.792	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.047	0.160	0.245	0.315	0.309	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.040	0.154	0.221	0.271	0.356	0.423	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.057	0.140	0.185	0.246	0.337	0.329	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.026	0.160	0.201	0.227	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.072	0.167	0.172	0.239	0.256	0.352	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.054	0.188	0.229	0.266	0.336	0.708	0.844	0.000	2.572	0.000	3.048	0.000	0.000	0.000	0.000	0.000

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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2016	0.048	0.149	0.245	0.357	0.361	0.876	0.457	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.803	2.670	0.678	0.890	1.514	0.909	0.000
2018	0.043	0.133	0.243	0.342	0.352	0.478	0.000	0.561	0.000	0.905	0.000	0.000	0.000	0.000	0.000	0.000
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

Table 8.2.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for BMS landings. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2016	0.068	0.239	0.213	0.386	0.000	0.000	0.481	0.000	0.991	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.039	0.148	0.235	0.306	0.516	0.439	0.904	0.564	0.603	0.000	2.67	0.000	0.000	1.514	0.000	0.000
2018	0.000	0.286	0.233	0.299	0.291	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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

Table 8.2.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weight at age data (kg) for IBC. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.023	0.067	0.136	0.255	0.288	0.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.035	0.068	0.141	0.246	0.327	0.396	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.022	0.058	0.150	0.260	0.359	0.579	0.277	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	0.020	0.039	0.173	0.275	0.267	0.413	0.585	0.000	0.585	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.012	0.046	0.181	0.304	0.473	0.360	0.725	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.013	0.042	0.184	0.307	0.490	0.352	0.442	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.011	0.040	0.174	0.286	0.372	0.473	0.411	0.456	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1979	0.009	0.039	0.177	0.285	0.384	0.461	0.735	1.234	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1980	0.012	0.039	0.176	0.268	0.623	0.722	1.102	1.591	0.000	1.796	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.009	0.040	0.176	0.371	0.467	0.858	1.200	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1982	0.010	0.040	0.206	0.379	0.636	0.751	1.225	1.233	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.008	0.047	0.173	0.428	0.584	1.006	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.009	0.045	0.211	0.414	0.626	0.751	1.225	1.234	1.315	1.319	1.400	1.400	0.000	0.000	0.000	0.000
1985	0.009	0.043	0.186	0.371	0.550	0.563	0.565	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1986	0.010	0.040	0.186	0.375	0.626	1.259	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1987	0.006	0.038	0.258	0.442	0.908	1.171	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.018	0.077	0.196	0.274	0.455	0.549	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1989	0.015	0.165	0.251	0.347	0.670	0.923	1.065	1.492	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1990	0.005	0.104	0.229	0.506	0.609	0.842	0.829	0.796	0.956	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.027	0.058	0.206	0.357	0.472	0.477	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.015	0.059	0.217	0.422	0.552	0.615	0.548	1.234	0.621	0.820	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.008	0.053	0.206	0.399	0.521	0.578	1.225	0.582	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.011	0.055	0.155	0.435	0.595	0.698	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.012	0.045	0.193	0.285	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.018	0.077	0.136	0.162	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.007	0.076	0.149	0.309	0.419	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.020	0.075	0.166	0.291	0.351	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.018	0.064	0.177	0.304	0.416	0.309	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.058	0.070	0.113	0.176	0.370	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2001	0.014	0.086	0.133	0.110	0.353	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.016	0.064	0.178	0.283	0.374	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.031	0.056	0.231	0.326	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.116	0.183	0.255	0.276	0.446	0.539	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.107	0.187	0.239	0.268	0.287	0.598	0.619	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.127	0.232	0.273	0.273	0.280	0.283	0.286	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.035	0.141	0.192	0.290	0.315	0.370	0.427	0.342	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.042	0.146	0.291	0.388	0.454	0.526	0.414	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.047	0.180	0.252	0.247	0.279	0.410	0.417	0.413	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.080	0.244	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000
2012	0.451	0.762	1.045	1.498	1.854	2.098	2.188	2.317	2.541	2.173	2.324	2.121	2.452	2.368	0.000	0.000
2013	0.000	0.437	0.564	0.626	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.830
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000
2016	0.356	0.383	0.445	0.49	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	3.766
2017	0.000	0.249	0.448	0.469	0.783	0.963	1.295	1.034	1.022	0.647	2.744	0.910	2.824	2.333	4.673	5.558
2018	0.000	0.417	0.470	0.524	0.542	1.025	1.031	1.145	1.437	0.895	1.255	2.921	2.408	3.356	2.198	0.000
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

Table 8.2.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimates of natural mortality from the most recent key run of SMS (ICES WGSAM, 2017).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1966	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1967	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1968	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1969	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1970	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1971	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1972	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1973	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1974	1.271	1.493	0.773	0.520	0.416	0.284	0.251	0.235	0.218	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1975	1.316	1.514	0.748	0.505	0.401	0.280	0.248	0.232	0.216	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1976	1.357	1.536	0.722	0.490	0.385	0.275	0.245	0.228	0.214	0.205	0.201	0.233	0.233	0.233	0.233	0.233
1977	1.394	1.555	0.696	0.476	0.369	0.270	0.242	0.225	0.212	0.205	0.201	0.233	0.233	0.233	0.233	0.233
1978	1.424	1.569	0.669	0.461	0.354	0.264	0.238	0.222	0.210	0.205	0.201	0.232	0.232	0.232	0.232	0.232
1979	1.449	1.574	0.642	0.446	0.339	0.259	0.235	0.219	0.208	0.205	0.201	0.231	0.231	0.231	0.231	0.231
1980	1.467	1.569	0.615	0.432	0.325	0.254	0.231	0.217	0.207	0.204	0.201	0.230	0.230	0.230	0.230	0.230
1981	1.478	1.550	0.588	0.417	0.313	0.249	0.227	0.215	0.206	0.204	0.202	0.228	0.228	0.228	0.228	0.228
1982	1.484	1.515	0.561	0.404	0.303	0.246	0.224	0.213	0.205	0.204	0.202	0.226	0.226	0.226	0.226	0.226
1983	1.485	1.464	0.534	0.390	0.295	0.243	0.221	0.212	0.204	0.204	0.202	0.224	0.224	0.224	0.224	0.224
1984	1.483	1.402	0.510	0.377	0.289	0.241	0.219	0.210	0.204	0.204	0.202	0.222	0.222	0.222	0.222	0.222
1985	1.479	1.337	0.487	0.365	0.284	0.239	0.218	0.209	0.204	0.204	0.202	0.219	0.219	0.219	0.219	0.219
1986	1.470	1.275	0.467	0.355	0.280	0.238	0.216	0.209	0.204	0.204	0.203	0.217	0.217	0.217	0.217	0.217
1987	1.455	1.222	0.451	0.345	0.277	0.237	0.215	0.208	0.203	0.204	0.203	0.215	0.215	0.215	0.215	0.215
1988	1.433	1.179	0.437	0.337	0.274	0.236	0.214	0.207	0.203	0.204	0.203	0.213	0.213	0.213	0.213	0.213
1989	1.404	1.146	0.426	0.329	0.272	0.235	0.214	0.207	0.203	0.204	0.203	0.211	0.211	0.211	0.211	0.211

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1990	1.370	1.125	0.417	0.322	0.270	0.234	0.214	0.207	0.203	0.203	0.203	0.210	0.210	0.210	0.210	0.210
1991	1.334	1.113	0.409	0.316	0.268	0.234	0.213	0.207	0.203	0.203	0.202	0.208	0.208	0.208	0.208	0.208
1992	1.302	1.110	0.402	0.311	0.267	0.234	0.213	0.207	0.203	0.202	0.202	0.207	0.207	0.207	0.207	0.207
1993	1.278	1.112	0.397	0.308	0.266	0.235	0.213	0.207	0.203	0.202	0.201	0.207	0.207	0.207	0.207	0.207
1994	1.263	1.117	0.392	0.306	0.266	0.236	0.214	0.207	0.203	0.201	0.201	0.206	0.206	0.206	0.206	0.206
1995	1.257	1.125	0.388	0.305	0.267	0.238	0.215	0.208	0.203	0.201	0.201	0.205	0.205	0.205	0.205	0.205
1996	1.257	1.132	0.385	0.306	0.268	0.242	0.217	0.208	0.204	0.201	0.200	0.204	0.204	0.204	0.204	0.204
1997	1.263	1.138	0.382	0.309	0.270	0.246	0.220	0.209	0.204	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1998	1.272	1.144	0.381	0.313	0.273	0.250	0.224	0.209	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
1999	1.284	1.153	0.381	0.318	0.276	0.255	0.228	0.210	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2000	1.296	1.166	0.384	0.323	0.280	0.261	0.232	0.211	0.204	0.200	0.200	0.203	0.203	0.203	0.203	0.203
2001	1.306	1.185	0.390	0.330	0.284	0.266	0.237	0.212	0.204	0.200	0.199	0.203	0.203	0.203	0.203	0.203
2002	1.308	1.208	0.398	0.336	0.289	0.272	0.242	0.214	0.204	0.201	0.199	0.204	0.204	0.204	0.204	0.204
2003	1.300	1.232	0.407	0.340	0.293	0.277	0.248	0.216	0.205	0.201	0.199	0.205	0.205	0.205	0.205	0.205
2004	1.280	1.252	0.417	0.343	0.297	0.281	0.253	0.219	0.205	0.203	0.199	0.206	0.206	0.206	0.206	0.206
2005	1.251	1.263	0.427	0.344	0.299	0.283	0.257	0.222	0.206	0.204	0.199	0.208	0.208	0.208	0.208	0.208
2006	1.216	1.266	0.437	0.342	0.300	0.284	0.259	0.225	0.207	0.207	0.199	0.209	0.209	0.209	0.209	0.209
2007	1.181	1.261	0.448	0.338	0.299	0.283	0.261	0.228	0.208	0.209	0.200	0.212	0.212	0.212	0.212	0.212
2008	1.147	1.250	0.458	0.333	0.297	0.282	0.261	0.231	0.209	0.212	0.201	0.214	0.214	0.214	0.214	0.214
2009	1.118	1.238	0.470	0.327	0.295	0.280	0.261	0.235	0.210	0.216	0.202	0.216	0.216	0.216	0.216	0.216
2010	1.094	1.227	0.482	0.320	0.292	0.278	0.260	0.239	0.211	0.220	0.203	0.219	0.219	0.219	0.219	0.219
2011	1.074	1.221	0.496	0.314	0.288	0.276	0.258	0.243	0.213	0.223	0.205	0.219	0.219	0.219	0.219	0.219
2012	1.054	1.221	0.510	0.307	0.284	0.273	0.255	0.248	0.215	0.226	0.208	0.219	0.219	0.219	0.219	0.219
2013	1.035	1.225	0.526	0.302	0.279	0.269	0.252	0.252	0.217	0.229	0.211	0.219	0.219	0.219	0.219	0.219
2014	1.017	1.234	0.542	0.297	0.274	0.265	0.248	0.257	0.220	0.231	0.214	0.219	0.219	0.219	0.219	0.219
2015	0.999	1.245	0.560	0.292	0.268	0.260	0.244	0.262	0.223	0.233	0.217	0.219	0.219	0.219	0.219	0.219

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2016	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
2017	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
2018	0.981	1.258	0.577	0.288	0.263	0.255	0.240	0.267	0.226	0.235	0.221	0.219	0.219	0.219	0.219	0.219
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

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	2020				
1	1	0.00	0.25		
1	5				
100	302.278	403.079	89.463	116.447	13.182
100	1072.285	221.275	127.77	20.41	20.9
100	230.968	833.257	107.598	32.317	3.575
100	573.023	266.912	303.546	17.888	6.49
100	912.559	328.062	45.201	58.262	4.345
100	101.691	677.641	97.149	12.684	13.965
100	219.06	97.372	273.008	16.604	2.114
100	217.448	139.114	32.997	50.367	3.163
100	680.231	134.076	25.032	4.26	8.476
100	1141.396	331.044	17.035	3.026	0.664
100	1242.121	519.521	152.384	8.848	1.076
100	227.919	491.051	97.656	23.308	1.566
100	1355.485	201.069	176.165	24.354	5.286
100	267.411	813.268	65.869	46.691	7.734
100	848.966	354.766	466.823	24.987	15.238
100	357.597	420.926	103.531	112.632	8.758
100	211.139	222.907	127.063	48.217	36.649
100	3734.2	107.125	48.605	24.504	15.594
100	893.46	2220.593	76.321	14.493	6.385
100	57.309	473.459	1309.38	9.18	6.886
100	89.981	39.261	241.523	532.045	5.355
100	71.745	79.256	36.962	176.352	324.91
100	70.189	51.885	38.458	14.057	54.576
100	1158.194	46.081	28.477	9.896	4.837
100	109.44	963.393	35.962	14.956	3.019
100	61.357	107.39	241.221	14.886	1.592
100	75.068	141.444	102.986	135.595	2.528
100	674.962	71.132	68.015	51.48	90.942
100	46.068	781.507	101.666	35.942	47.87
100	14.103	66.523	391.036	21.248	15.153
100	58.249	24.585	32.557	93.814	6.488
100	24.067	104.034	18.351	49.981	126.068
100	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	3.07
100	47.048	155.733	54.928	67.8	1.016

100	153.07	126.234	150.811	22.464	77.331
100	2355.81	162.481	61.292	55.104	8.536

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	2019					
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

Table 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA final assessment:

in the overall assessment.

Landings	Ages	0–8+
	Years	1972–2019
Discards	Ages	0–8+
	Years	1972, 1978–2019
Industrial bycatch	Ages	0–8+
	Years	1972, 1978–2019
BMS landings	Ages	0–8+
	Years	2016–2019
Survey: NS IBTS Q1	Ages	1–5
	Years	1983–2020
Survey: NS IBTS Q3	Ages	0–5
	Years	1991–2019
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	0.0423	0.005	0.1	TRUE	FALSE
F age 1	0.0911	0.05	0.3	TRUE	FALSE
F age 2	0.862	0.6	1.5	TRUE	FALSE
F age 7	1.3242	1	1.4	TRUE	FALSE
sd F	0.1774	0.01	0.2	TRUE	FALSE
sd U	0.0692	0.01	0.15	TRUE	FALSE
sd V	0.1442	0.01	0.2	TRUE	FALSE
sd Y	0.1503	0.01	0.25	TRUE	FALSE
cv landings	0.1413	0.05	0.3	TRUE	FALSE
cv discards+bycatch+bms	0.2806	0.1	0.4	TRUE	FALSE
log mean recruitment at start	7.0066	7	9	TRUE	FALSE
sd of random walk	0.0475	0	0.25	TRUE	FALSE
recruitment cv	0.5641	0.3	0.6	TRUE	FALSE
discards sd transitory	0	0	0.35	TRUE	FALSE
discards sd persistent	0.3318	0.125	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2867	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.702	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.737	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5285	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4553	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.3465	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.1182	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.0877	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2577	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3965	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5812	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.4929	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3727	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.3242	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.2542	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.0881	0	0.3	TRUE	FALSE
NSQ3 omega	0.0741	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 2020 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
1972	0.04	0.083	0.603	1.025	0.966	0.914	1.006	1.039	0.963	0.865
1973	0.035	0.099	0.581	0.904	0.859	0.899	0.996	1.035	1.121	0.782
1974	0.033	0.093	0.635	0.708	0.865	0.754	0.894	0.967	0.975	0.736
1975	0.036	0.091	0.704	0.891	0.98	0.933	1.106	1.083	1.065	0.858
1976	0.034	0.093	0.551	0.982	0.861	1.068	0.966	0.993	0.998	0.798
1977	0.033	0.103	0.622	0.73	1.09	0.981	0.974	0.93	0.965	0.814
1978	0.027	0.125	0.669	0.948	1.094	1.091	1.074	1.075	1.122	0.904
1979	0.032	0.102	0.72	1.051	0.992	1.021	1.032	1.037	1.045	0.921
1980	0.037	0.084	0.508	1.055	1.12	0.794	0.923	0.967	0.968	0.894
1981	0.032	0.075	0.319	0.792	0.912	0.754	0.44	0.736	0.697	0.674
1982	0.023	0.077	0.389	0.571	0.697	0.584	0.605	0.722	0.626	0.553
1983	0.021	0.088	0.463	0.839	0.858	0.916	0.757	0.749	0.768	0.72
1984	0.024	0.122	0.506	0.939	1.093	0.822	0.837	0.805	0.806	0.846
1985	0.024	0.124	0.457	0.911	1.028	0.878	0.832	0.775	0.783	0.799
1986	0.018	0.13	0.67	0.93	1.125	0.828	0.662	0.673	0.727	0.908
1987	0.025	0.1	0.762	1.001	0.955	0.883	0.891	0.828	0.795	0.906
1988	0.024	0.121	0.601	1.16	1.102	0.95	0.854	0.781	0.829	0.954
1989	0.022	0.125	0.65	0.94	1.119	0.876	0.847	0.788	0.795	0.903
1990	0.017	0.12	0.743	0.969	0.987	0.864	0.714	0.678	0.7	0.9
1991	0.019	0.17	0.707	1.015	0.928	0.788	0.77	0.741	0.697	0.883
1992	0.022	0.125	0.646	0.983	0.998	0.649	0.86	0.7	0.728	0.876
1993	0.024	0.165	0.804	0.991	1.016	0.969	0.814	0.824	0.847	0.937
1994	0.016	0.127	0.719	1.015	0.98	1.026	0.968	0.924	0.833	0.904
1995	0.022	0.099	0.584	0.897	0.938	0.813	0.908	0.711	0.706	0.807
1996	0.02	0.097	0.514	0.861	1.004	0.973	0.962	0.706	0.699	0.793
1997	0.015	0.118	0.481	0.62	0.737	0.897	0.781	0.609	0.592	0.613
1998	0.014	0.152	0.622	0.675	0.868	0.806	0.786	0.611	0.594	0.721
1999	0.012	0.126	0.669	0.905	0.84	1.075	0.853	0.667	0.632	0.805
2000	0.012	0.098	0.736	0.945	0.952	0.793	0.84	0.595	0.569	0.878
2001	0.011	0.08	0.4	0.677	0.693	0.645	0.575	0.42	0.404	0.59
2002	0.007	0.112	0.266	0.35	0.475	0.453	0.409	0.283	0.281	0.364
2003	0.005	0.047	0.208	0.213	0.259	0.322	0.271	0.181	0.176	0.227
2004	0.004	0.052	0.206	0.233	0.242	0.301	0.236	0.153	0.149	0.227
2005	0.003	0.06	0.279	0.343	0.266	0.32	0.305	0.165	0.159	0.296
2006	0.005	0.052	0.425	0.52	0.547	0.522	0.38	0.263	0.212	0.497
2007	0.005	0.057	0.231	0.509	0.513	0.487	0.379	0.22	0.213	0.418
2008	0.004	0.038	0.179	0.221	0.331	0.305	0.257	0.144	0.142	0.244
2009	0.002	0.033	0.128	0.19	0.267	0.243	0.18	0.115	0.105	0.195

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
2010	0.003	0.034	0.169	0.242	0.227	0.267	0.175	0.111	0.103	0.213
2011	0.004	0.041	0.13	0.413	0.402	0.376	0.269	0.148	0.124	0.315
2012	0.002	0.037	0.136	0.176	0.253	0.229	0.156	0.101	0.087	0.188
2013	0.002	0.044	0.179	0.177	0.261	0.22	0.145	0.089	0.091	0.206
2014	0.002	0.038	0.318	0.341	0.345	0.363	0.166	0.118	0.11	0.335
2015	0.004	0.038	0.441	0.543	0.366	0.483	0.288	0.164	0.142	0.45
2016	0.003	0.034	0.178	0.437	0.356	0.296	0.16	0.131	0.104	0.324
2017	0.002	0.026	0.174	0.245	0.302	0.24	0.12	0.088	0.084	0.24
2018	0.002	0.024	0.125	0.268	0.248	0.211	0.111	0.086	0.073	0.214
2019	0.001	0.027	0.114	0.208	0.209	0.227	0.104	0.07	0.062	0.177
2020*	0.002	0.026	0.137	0.24	0.238	0.227	0.116	0.076	0.076	0.205

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	8941710	13180460	2098160	78660	44970	397300	7160	440	1170
1973	32856990	1988910	2705160	485810	17090	11190	119000	2080	470
1974	50756000	7295220	400940	642470	117920	4770	3420	34680	720
1975	2869170	13877200	1482380	106670	185570	33300	1660	1090	10590
1976	5251130	906510	2854490	348990	27640	48270	10280	450	3390
1977	11858340	1523760	212930	816790	83430	8400	13330	3280	1230
1978	24668250	2943300	283370	64310	256730	20900	2660	4490	1560
1979	48898240	5771040	542140	77480	16230	63420	5330	760	1750
1980	9044090	11290030	1078230	141310	18020	4680	18910	1660	790
1981	15377060	2020670	2165030	343900	33680	4650	1650	6260	810
1982	9306640	3439220	401230	796420	100740	10620	1760	660	2610
1983	30219070	2081850	697980	161960	299520	37640	4720	790	1410
1984	5826760	6679860	441770	261080	48600	94650	12100	1820	840
1985	9625300	1459760	1446560	160700	71970	12610	30900	4300	920
1986	17987670	2224450	339220	556140	45810	20010	4220	10910	1940
1987	79390	3869390	545170	110220	152630	11610	6820	1650	4860
1988	1014140	331210	1032000	161500	29450	44140	3860	2320	2390
1989	1827160	531540	102000	366170	35900	7640	13600	1360	1760
1990	8502450	737490	147460	35000	105090	9140	2590	4860	1200
1991	9801330	2220040	211780	42160	9690	30920	3170	1050	2570
1992	16230720	2528410	611620	69740	11460	2770	9940	1180	1380
1993	4268960	4320710	730500	214900	18150	3200	1100	3440	1040
1994	16903440	1163160	1190250	218450	59090	5040	980	400	1660
1995	4763320	4704070	336040	389380	59000	17000	1440	310	760

	0	1	2	3	4	5	6	7	8+
1996	6836620	1329480	1383430	127580	117850	17770	6000	490	450
1997	4157570	1909510	389760	562790	39960	33340	5350	1900	390
1998	3059710	1154490	542590	164990	222620	14680	10650	2010	1040
1999	45622980	871080	315280	196740	61700	71670	5130	3880	1390
2000	9041730	12478310	242690	108170	56120	20120	18780	1750	2270
2001	903940	2445910	3525700	79640	29820	15980	6970	6390	1900
2002	1162430	343740	691470	1606560	28610	11160	6390	3120	4530
2003	1315780	390880	92060	356450	810730	13200	5410	3360	4770
2004	1220530	415960	108860	49870	205310	466270	7220	3220	5580
2005	13065430	420360	112890	58390	28020	119550	258030	4400	6150
2006	2720420	3727650	112080	55790	29410	15940	65220	144940	7250
2007	1786130	809800	997280	47480	23670	12680	7170	34460	92790
2008	1215990	573930	216770	505820	20440	10550	5900	3810	82720
2009	9530770	454690	157970	114650	289600	10940	5890	3530	60900
2010	787910	3108380	127620	86990	68450	165190	6500	3800	47140
2011	56300	314250	880870	66650	49670	40810	96050	4220	37170
2012	1093370	115110	89020	470920	31800	24900	21310	56910	29490
2013	490180	422990	32750	46650	290140	18480	15090	14180	62070
2014	6082750	261030	118960	15850	28910	169020	11340	10160	55740
2015	1594470	2194770	73280	50000	8060	15570	90490	7500	47140
2016	2879410	601850	608540	26970	21190	4230	7410	53360	37720
2017	1273840	1076730	165440	285970	13020	11310	2450	4980	63060
2018	2150930	495750	298270	78160	168140	7390	6920	1710	49810
2019	12622690	812370	137470	147440	44890	100900	4650	4880	38160
2020	5406360	4728130	224700	68970	90010	28070	62400	3300	32110

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	384987	40441	234140	229156	23853	173903	155832	28935	0.865	0.063	294819	28192	2568230	236261	8941713	1934117
1973	344581	374778	48231	207383	214553	19292	137198	160225	38554	0.782	0.068	276036	18019	2570112	219908	32856987	3834023
1974	397158	247916	28189	167655	155919	12633	229503	91997	22628	0.736	0.069	318979	20238	2619576	259742	50756003	8005069
1975	494390	295197	39870	160380	161612	13239	334009	133585	34464	0.858	0.079	156812	9857	2035681	248486	2869166	1561646
1976	401969	331418	47972	184244	205935	21750	217725	125483	36662	0.798	0.078	194021	14767	1026738	114902	5251127	1509629
1977	240259	196371	20274	156534	159857	16826	83726	36513	8764	0.814	0.083	347174	27367	804155	62976	11858343	1739697
1978	146700	139109	12920	102940	102732	9493	43760	36377	7193	0.904	0.085	157566	12753	806995	51677	24668248	1857577
1979	149260	143940	15549	97884	87329	8863	51376	56611	10235	0.921	0.087	93041	10312	1225426	68850	48898245	4728008
1980	202640	188919	18713	111375	106190	9939	91265	82728	14013	0.894	0.081	103242	10292	1423855	85048	9044090	987378
1981	226585	219058	19767	147920	148244	13964	78665	70814	11371	0.674	0.063	193204	12347	1024405	52156	15377061	1581773
1982	256302	207839	14882	195572	166126	12656	60730	41713	6731	0.553	0.045	432638	19452	894958	36253	9306638	809155
1983	253185	228272	16167	188735	180223	12414	64451	48049	7589	0.720	0.052	295992	14476	1114694	43998	30219066	2104039
1984	247238	229155	22718	158181	150893	10775	89057	78261	17367	0.846	0.059	238145	14449	1378810	71715	5826765	1655937
1985	247430	227240	17778	183055	166626	13319	64375	60614	9716	0.799	0.055	168465	8210	908944	38397	9625296	1323467
1986	223854	209678	14726	185119	166527	12107	38735	43151	6937	0.908	0.059	290467	15875	1066326	56320	17987671	1949224
1987	195046	179389	14341	135000	126098	9121	60046	53291	9190	0.906	0.061	163595	8448	791987	40117	79389	1509434
1988	179911	168629	13552	126181	122380	10439	53729	46249	7316	0.954	0.066	126323	8242	462328	89008	1014139	1955670
1989	127679	118505	9642	92801	93678	8325	34878	24827	4390	0.903	0.066	178201	10946	379049	61920	1827160	1607263
1990	86743	78923	7362	61584	57581	4990	25159	21342	4139	0.900	0.065	85636	5599	609802	67962	8502452	1611958
1991	97205	93480	12863	55211	45982	4424	41993	47498	10609	0.883	0.065	52493	3811	800269	40507	9801333	767317
1992	134993	126544	11839	81572	72078	6957	53421	54466	8357	0.876	0.052	56284	2687	809720	36350	16230725	1265811

Year	Catch	Catch.est	Catch.se	Landings	Landings.est	Landings.se	Discards**	Discards.est **	Discards.se **	Meanf.est	Meanf.se	Ssb.est	Ssb.se	Tsb.est	Tsb.se	Recruit.est	Recruit.se
1993	180206	210015	21108	98697	110251	10236	81509	99764	16415	0.937	0.056	118876	7219	842844	43501	4268959	374612
1994	169472	224466	21470	95175	127058	12651	74297	97408	14613	0.904	0.059	138804	9414	877800	38014	16903435	1135137
1995	168893	170427	16382	89858	101283	10077	79035	69144	11285	0.807	0.057	194125	13384	852072	39632	4763322	376243
1996	204687	196535	17950	92632	97499	8396	112055	99036	14110	0.793	0.054	125241	6901	776567	32915	6836616	567769
1997	170051	161991	14217	95448	94020	8382	74603	67971	10131	0.613	0.048	254546	14455	747760	33829	4157570	479765
1998	161971	159199	13330	95513	92693	7370	66457	66506	9386	0.721	0.055	185567	9427	583177	25037	3059710	334554
1999	123421	127334	10674	75974	73730	5865	47446	53605	7441	0.805	0.060	144157	8558	1508153	86605	45622975	3283007
2000	126870	164568	29321	54476	55786	4873	72395	108782	27066	0.878	0.064	94108	6241	2136282	118798	9041729	607723
2001	173526	266792	36710	47549	97616	13787	125978	169176	29677	0.590	0.051	64113	4389	1133952	65497	903938	814662
2002	155145	182074	20915	65399	97011	11419	89745	85062	15288	0.364	0.036	537246	35907	770799	40300	1162427	495397
2003	74415	96654	10773	47266	74632	8943	27149	22022	4189	0.227	0.024	464994	27507	548971	29952	1315777	421004
2004	72511	76080	8996	51925	64935	8170	20586	11145	1933	0.227	0.024	321439	21983	452768	27104	1220531	353999
2005	64116	64883	7437	51542	55268	6791	12573	9616	1505	0.296	0.029	238917	19275	1042300	45028	13065429	708589
2006	66955	66099	7926	43333	45569	5292	23622	20530	4441	0.497	0.042	164779	15547	780440	34794	2720422	326715
2007	67430	75139	7837	34680	45100	4996	32751	30039	4660	0.418	0.037	135822	15417	565980	31616	1786130	510794
2008	47733	55365	5599	33037	40774	4234	14697	14591	2514	0.244	0.025	286240	18629	475782	24817	1215987	433473
2009	47943	44879	4380	35569	36722	3728	12374	8157	1259	0.195	0.020	235235	17621	820463	32020	9530774	493226
2010	45412	44201	4530	31937	35303	3542	13474	8898	1740	0.213	0.022	217642	17034	509456	26114	787912	809151
2011	49658	56974	5281	36572	40467	3565	13086	16507	2828	0.315	0.031	155802	11247	429779	21387	56297	685464
2012	43196	45787	4459	38164	40396	3931	5032	5392	1097	0.188	0.020	321728	17599	417494	23216	1093372	394004
2013	47066	43997	4469	43712	40614	4150	3354	3384	690	0.206	0.021	254516	13566	357854	20029	490182	384463
2014	46317	50472	4871	41165	45603	4491	5152	4868	853	0.335	0.031	182682	11444	525948	19909	6082750	346063
2015	41594	48461	4786	35306	38976	3571	6287	9486	2252	0.450	0.038	144035	10266	542261	23764	1594467	285534

Year	Catch	Catch.est	Catch.se	Landings	Landings.est	Landings.se	Discards**	Discards.est **	Discards.se **	Meanf.est	Meanf.se	Ssb.est	Ssb.se	Tsb.est	Tsb.se	Recruit.est	Recruit.se
2016	43053	48202	4957	35060	37933	4033	7994	10269	1825	0.324	0.031	122029	10253	573217	22333	2879410	224001
2017	39898	43017	4146	32843	36446	3598	7055	6571	1176	0.240	0.024	215992	12469	482023	21245	1273838	184220
2018	39435	40932	3737	34404	35570	3311	5031	5363	897	0.214	0.023	193999	11311	461739	22430	2150928	295104
2019	36453	36676	3544	30743	32030	3076	5710	4646	912	0.177	0.022	238515	15122	953411	47037	12622694	903656
2020*		48381	12292		34877	8440		13503	5208	0.205	0.057	228239	15251	1219761	155512	5406363	3455934

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

MFDP version 1a							
Run: TACcontRun_Run1							
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							
2020							
Age		N	M	Mat	PF	PM	SWt
	0	5406360	0.981	0	0	0	0.042
	1	4728130	1.258	0	0	0	0.146
	2	224700	0.577	0	0	0	0.335
	3	68970	0.288	1	0	0	0.433
	4	90010	0.263	1	0	0	0.616
	5	28070	0.255	1	0	0	0.795
	6	62400	0.24	1	0	0	0.745
	7	3300	0.267	1	0	0	1.301
	8	32110	0.376	1	0	0	1.634
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.002	0.042		
	1	0	0.481	0.026	0.14		
	2	0.064	0.451	0.073	0.23		
	3	0.208	0.495	0.031	0.304		
	4	0.229	0.549	0.008	0.446		
	5	0.223	0.708	0.004	0.431		
	6	0.113	0.661	0.002	0.467		
	7	0.075	1.237	0.001	0.699		
	8	0.076	1.571	0	0.78		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.4806				
	2	0.0001	0.4513				
	3	0.0005	0.4949				
	4	0.0005	0.6542				
	5	0.0005	0.8583				
	6	0.0003	1.1131				
	7	0.0002	1.0538				
	8	0.0002	1.0801				

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

2021							
Age		N	M	Mat	PF	PM	SWt
	0	5406360	0.981	0	0	0	0.042
	1	.	1.258	0	0	0	0.146
	2	.	0.577	0	0	0	0.335
	3	.	0.288	1	0	0	0.471
	4	.	0.263	1	0	0	0.568
	5	.	0.255	1	0	0	0.762
	6	.	0.24	1	0	0	0.95
	7	.	0.267	1	0	0	0.857
	8	.	0.376	1	0	0	1.508
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.002	0.042		
	1	0	0.481	0.026	0.14		
	2	0.064	0.451	0.073	0.23		
	3	0.208	0.495	0.031	0.314		
	4	0.229	0.654	0.008	0.391		
	5	0.223	0.612	0.004	0.545		
	6	0.113	0.791	0.002	0.504		
	7	0.075	0.724	0.001	0.531		
	8	0.076	1.39	0	0.79		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.4806				
	2	0.0001	0.4513				
	3	0.0005	0.4949				
	4	0.0005	0.6542				
	5	0.0005	0.8583				
	6	0.0003	1.1131				
	7	0.0002	1.0538				
	8	0.0002	1.0801				

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	5406360	0.981	0	0	0	0.042
	1	.	1.258	0	0	0	0.146
	2	.	0.577	0	0	0	0.335
	3	.	0.288	1	0	0	0.471
	4	.	0.263	1	0	0	0.646
	5	.	0.255	1	0	0	0.704
	6	.	0.24	1	0	0	0.907
	7	.	0.267	1	0	0	1.105
	8	.	0.376	1	0	0	1.336
Catch							
Age		Sel	CWt	DSel	DCWt		
	0	0	0	0.002	0.042		
	1	0	0.481	0.026	0.14		
	2	0.064	0.451	0.073	0.23		
	3	0.208	0.495	0.031	0.314		
	4	0.229	0.654	0.008	0.389		
	5	0.223	0.858	0.004	0.478		
	6	0.113	0.674	0.002	0.645		
	7	0.075	0.875	0.001	0.577		
	8	0.076	1.184	0	0.66		
IBC							
Age		Sel	CWt				
	0	0	0				
	1	0	0.4806				
	2	0.0001	0.4513				
	3	0.0005	0.4949				
	4	0.0005	0.6542				
	5	0.0005	0.8583				
	6	0.0003	1.1131				
	7	0.0002	1.0538				
	8	0.0002	1.0801				
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 (2021)	Projected landings * (2021)	Projected discards ** (2021)	IBC *** *(2021)	HC catch (2021)	F_{total} (ages 2-4) (2021)	$F_{projected\ landings}$ (ages 2-4) (2021)	$F_{projected\ discards}$ (ages 2-4) (2021)	F_{IBC} (ages 2-4) (2021)	SSB (2022)	% SSB change ^	% TAC change ^^	% Advice change ^^^
ICES advice basis													
MSY approach: F_{MSY}	69280	49061	20110	110	69170	0.194	0.158	0.035	0.00040	471256	129%	65%	66%
Other scenarios													
F = MAP# $F_{MSY\ lower}$	60139	42609	17419	111	60028	0.167	0.136	0.030	0.00040	480443	133%	44%	44%
F = MAP $F_{MSY\ upper}$##	69280	49061	20110	110	69170	0.194	0.158	0.035	0.00040	471256	129%	65%	66%
F = 0##	119	0	0	119	0	0	0	0	0.00040	542133	163%	-100%	-100%
F_{pa}	95457	67474	27876	107	95350	0.274	0.224	0.050	0.00040	445065	116%	128%	128%
F_{lim}	129323	91152	38069	102	129220	0.384	0.314	0.070	0.00040	411465	100%	209%	209%
SSB (2022) = B_{lim}	493824	327191	166580	52	493771	2.66	2.17	0.49	0.00040	94000	-54%	1081%	1081%
SSB (2022) = B_{pa} = MSY $B_{trigger}$	436337	293347	142930	61	436276	2.06	1.68	0.38	0.00040	132000	-36%	943%	943%
F_{2020}	70253	49746	20397	110	70143	0.197	0.161	0.036	0.00040	470279	128%	68%	68%
Rollover TAC	41818	29647	12057	114	41704	0.114	0.093	0.021	0.00040	498918	142%	0%	0%
MSE HCR A	97366	68814	28446	106	97260	0.280	0.23	0.051	0.00040	443161	115%	133%	133%
MSE HCR B	100533	71034	29393	106	100427	0.290	0.24	0.053	0.00040	440007	114%	140%	140%
MSE HCR C	97366	68814	28446	106	97260	0.280	0.23	0.051	0.00040	443161	115%	133%	133%
MSE HCR AD	97366	68814	28446	106	97260	0.280	0.23	0.051	0.00040	443161	115%	133%	133%
MSE HCR BE	94180	66578	27495	107	94073	0.270	0.22	0.049	0.00040	446338	117%	125%	125%
MSE HCR CE	90972	64326	26539	107	90865	0.260	0.21	0.047	0.00040	449539	118%	117%	118%
MSE A*+D	69280	49061	20110	110	69170	0.194	0.158	0.035	0.00040	471256	129%	65%	66%

* Marketable landings.

** Including BMS landings (EU stocks), assuming recent discard rate.
*** IBC = Industrial bycatch, HCF = Human Consumption fishery.
^ SSB 2022 relative to SSB 2021.
^^ Human Consumption fishery (HCF) catch in 2021 relative to TAC in 2020: Subdivision 20 (2 193 t) + Subarea 4 (35 653 t) + Division 6.a (3 973 t) = 41 819 t.
^^^ Total catch 2021 relative to advice value 2020 (41 818 t).
[#] EU multiannual plan (MAP) for the North Sea (EU, 2018).
[##] For this stock, $F_{MSY\ upper} = F_{MSY}$.

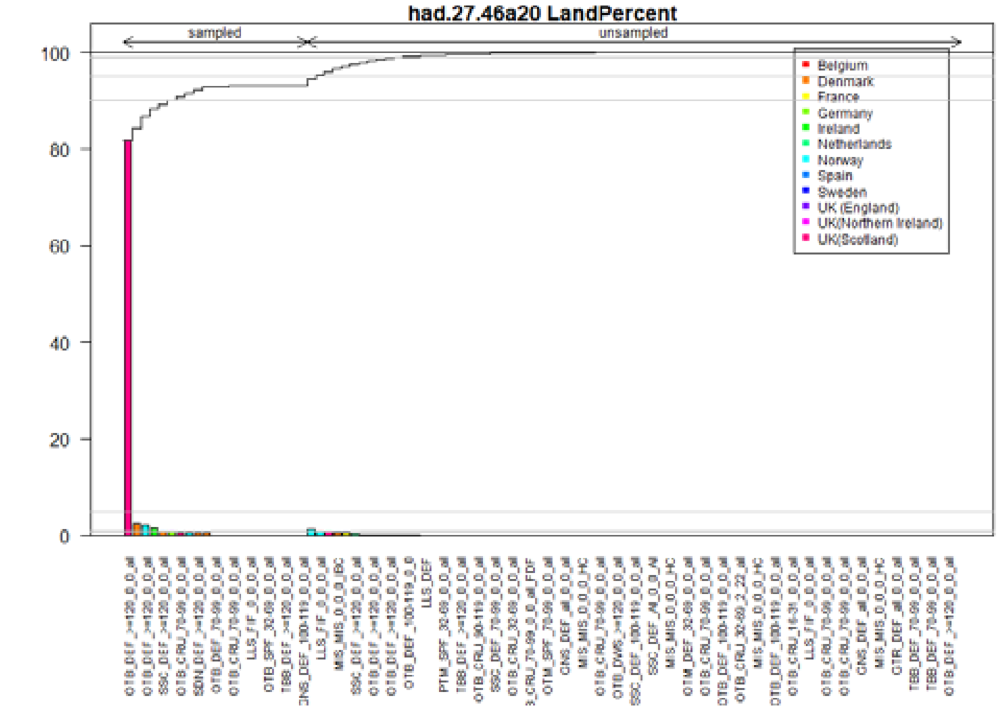

Figure 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

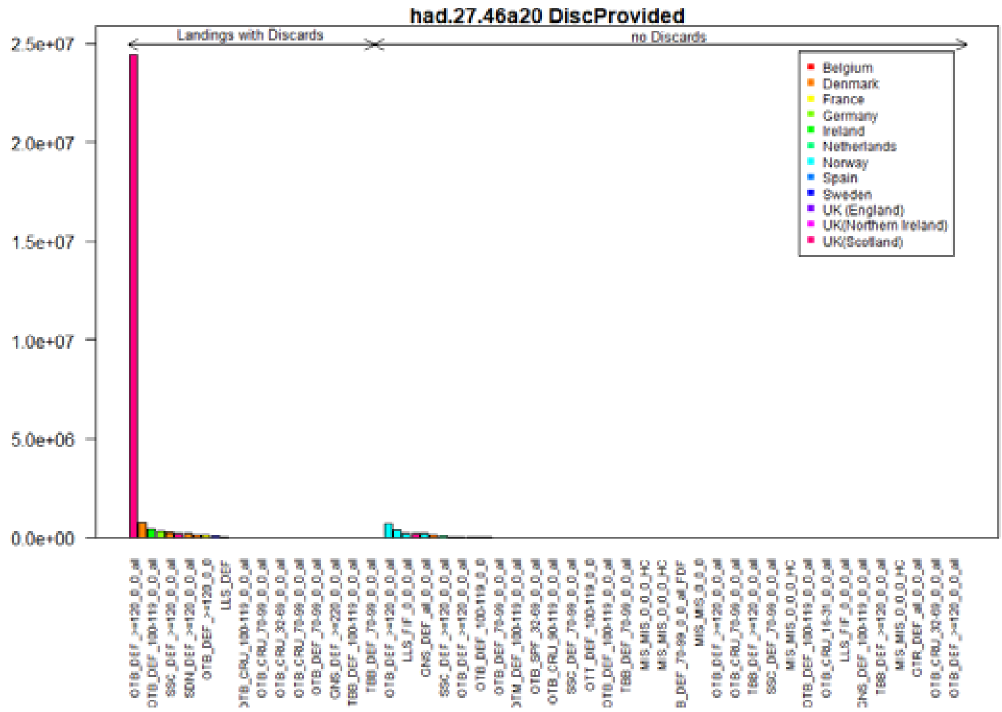

Figure 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary of landings for fleets with and without discard estimates.

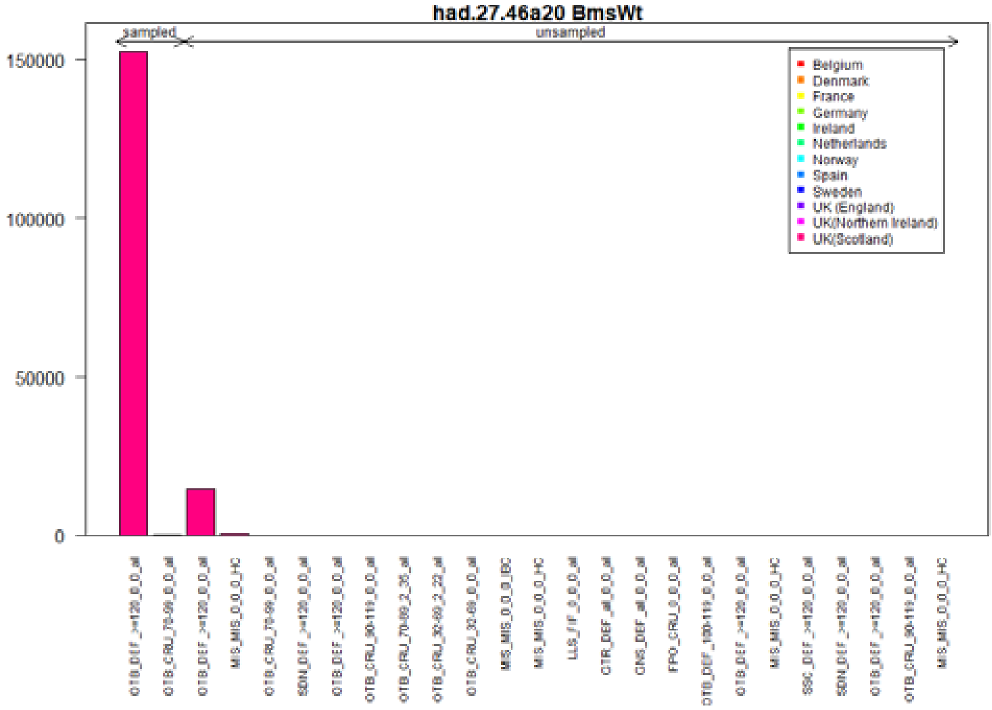

Figure 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Reported BMS landings for each sampled and unsampled fleet in the full stock area, in descending order of yield.

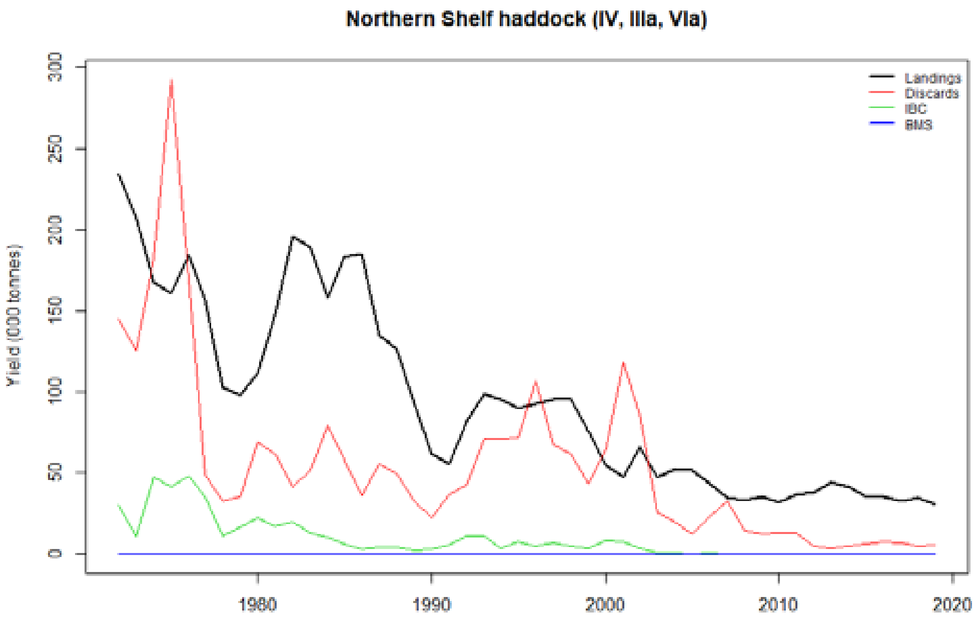

Figure 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Yield by catch component.

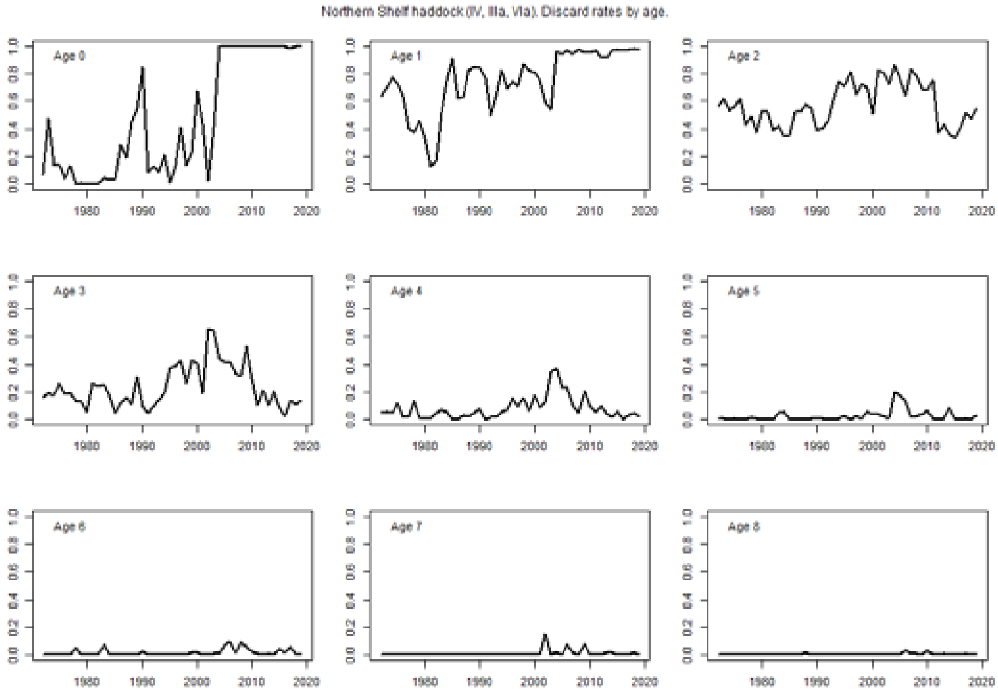

Figure 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Proportion of total catch discarded, by age and year.

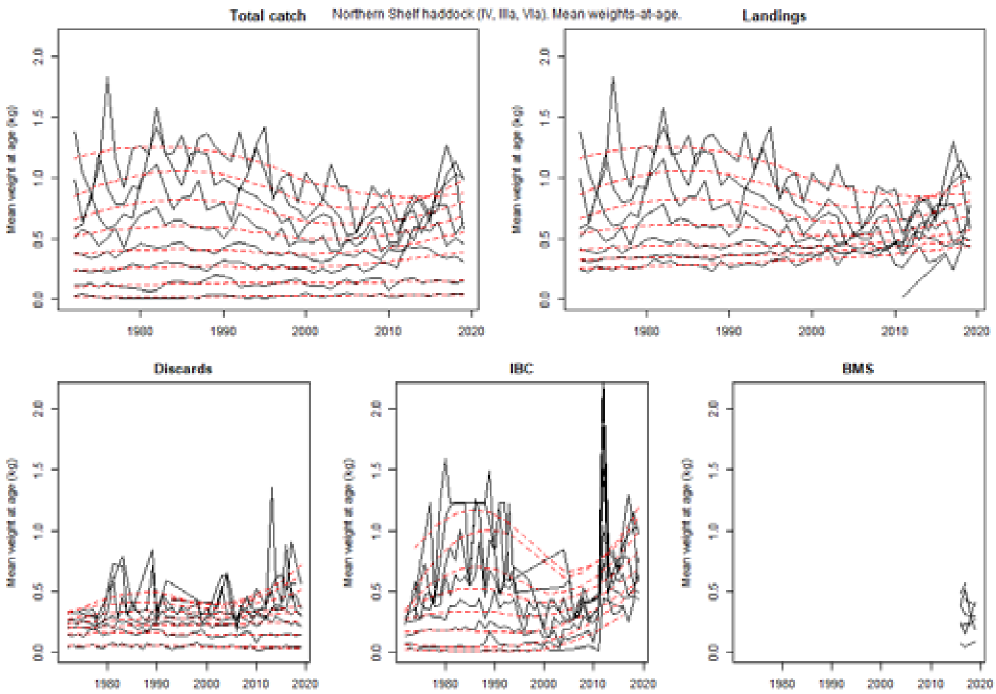

Figure 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

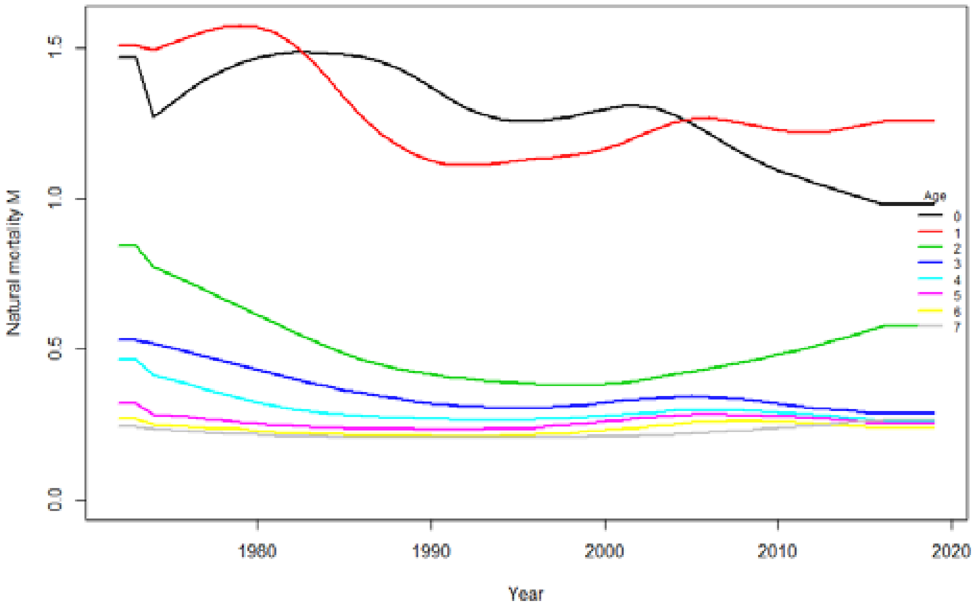

Figure 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time series of estimated natural mortality at age, from ICES WGSAM (2014).

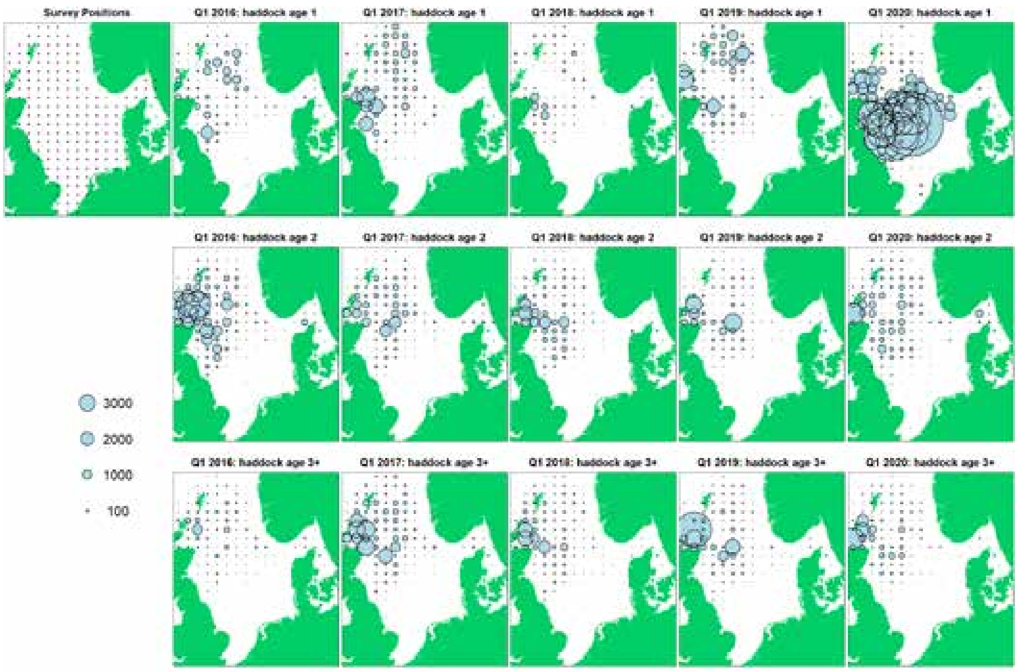

Figure 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey distributions by age for the international IBTS Q1 survey (North Sea).

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

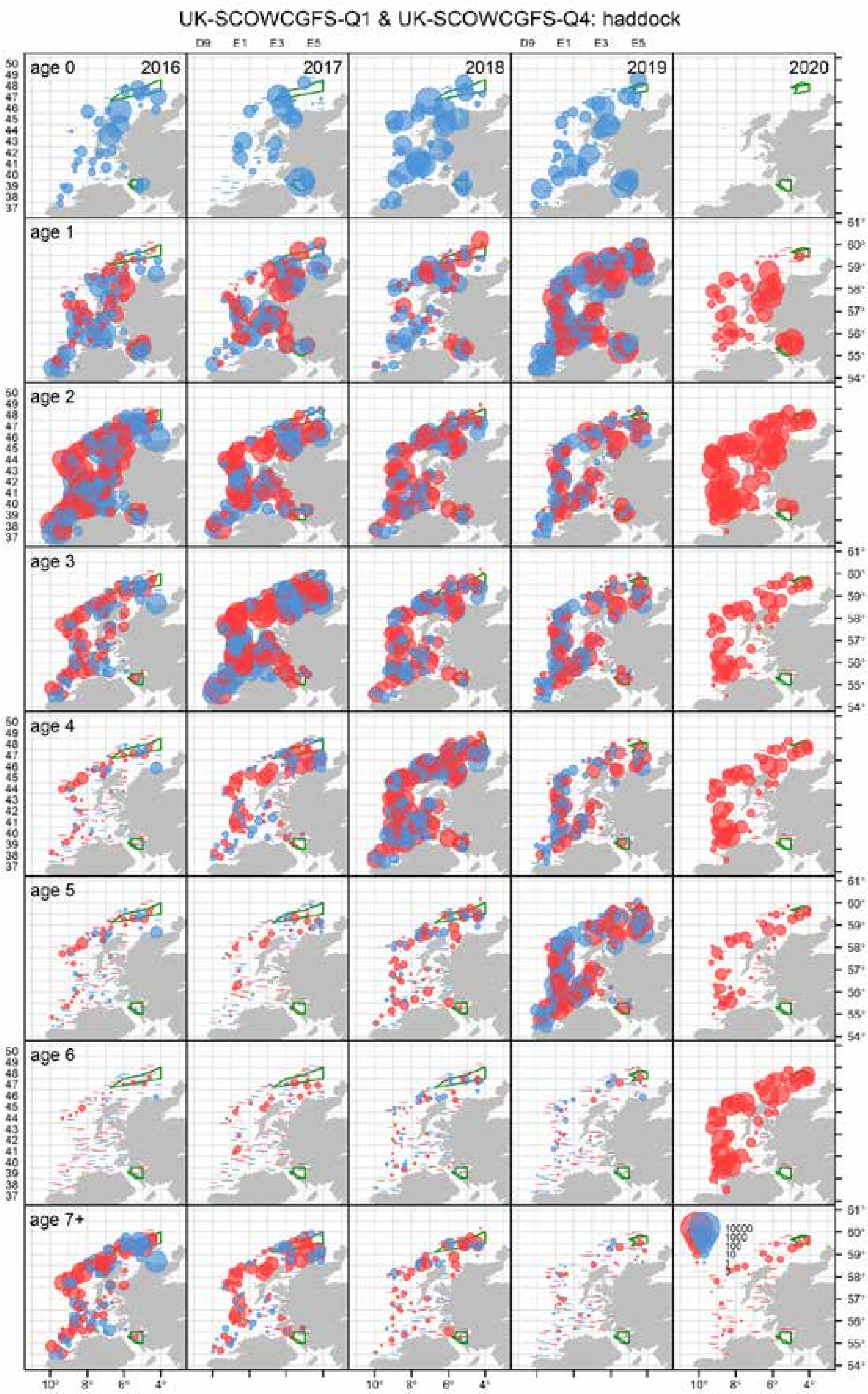
UK-SCOWCGFS-Q1 & UK-SCOWCGFS-Q4: haddock
age 0
age 1
age 2
age 3
age 4
age 5
age 6
age 7+
2016
2017
2018
2019
2020
10000
1000
100
10
1

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). Rows show years 2016–2020 (from top to bottom).

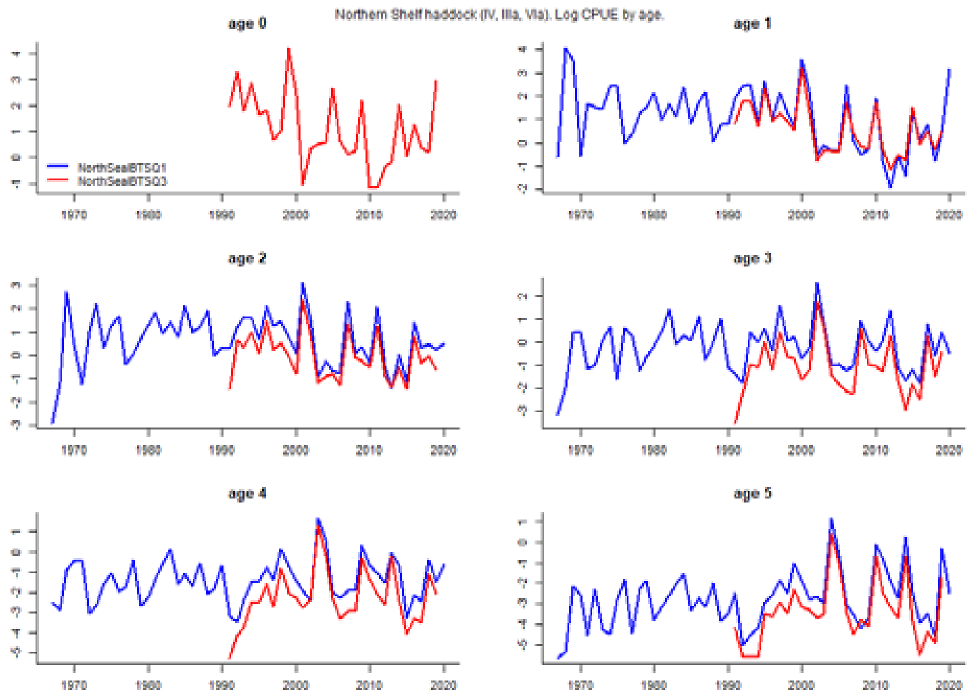

Figure 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey log CPUE (catch per unit effort) at age.

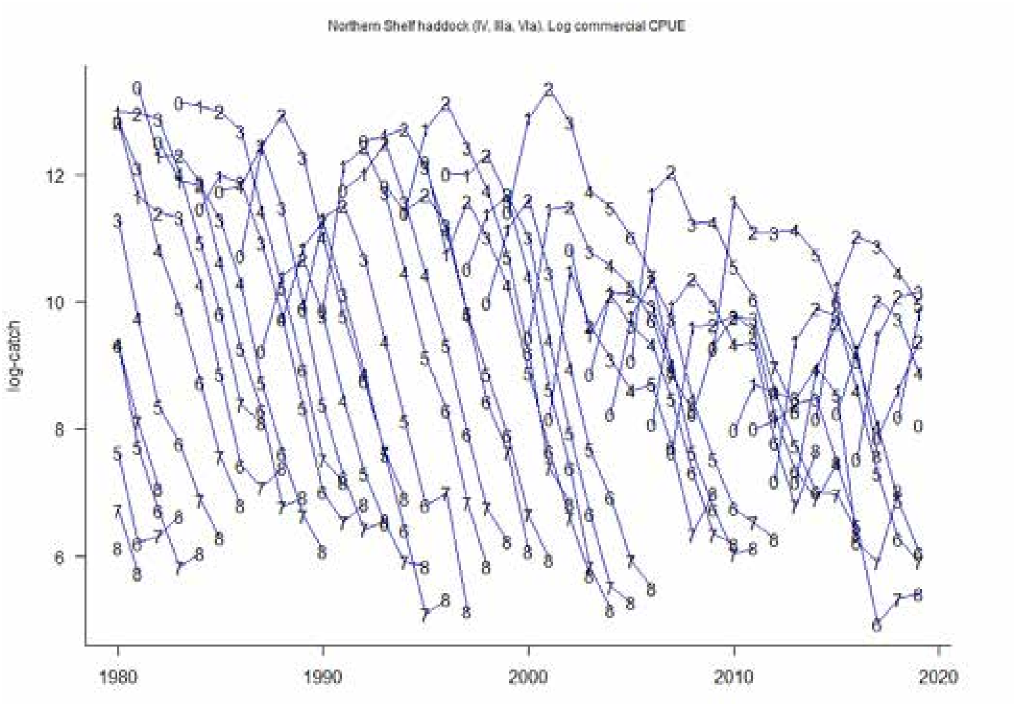

Figure 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log catch curves by cohort for total catches.

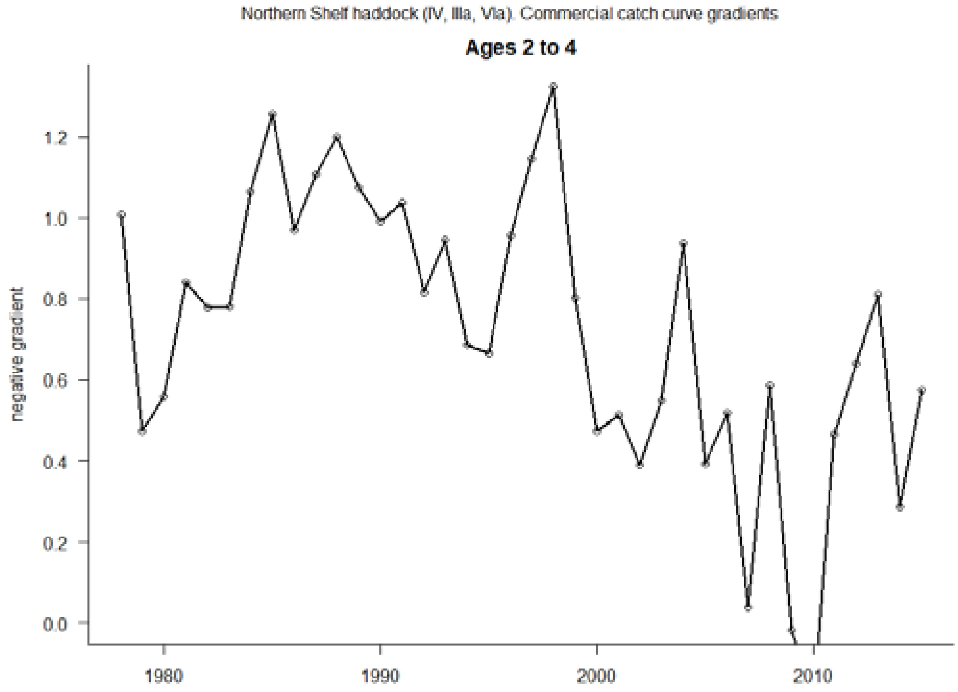

Figure 8.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Negative gradients of log catches per cohort, averaged over ages 2–4. The x-axis represents the spawning year of each cohort.

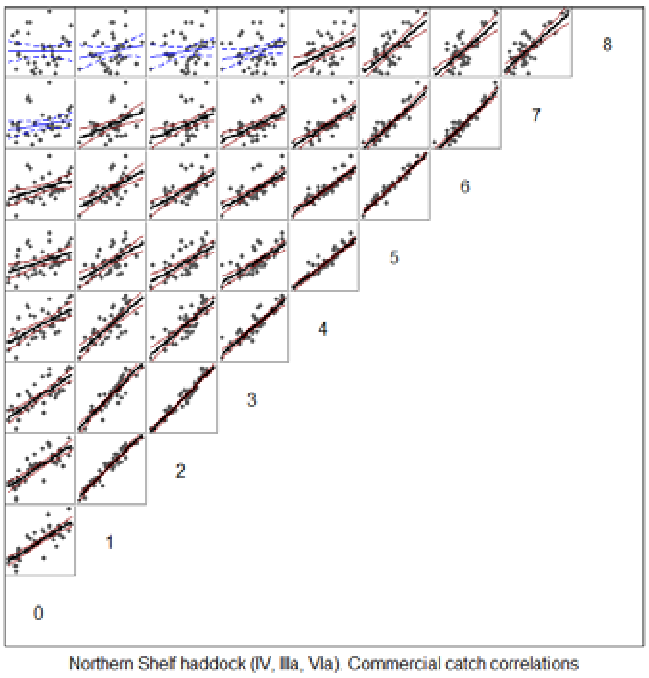

Figure 8.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

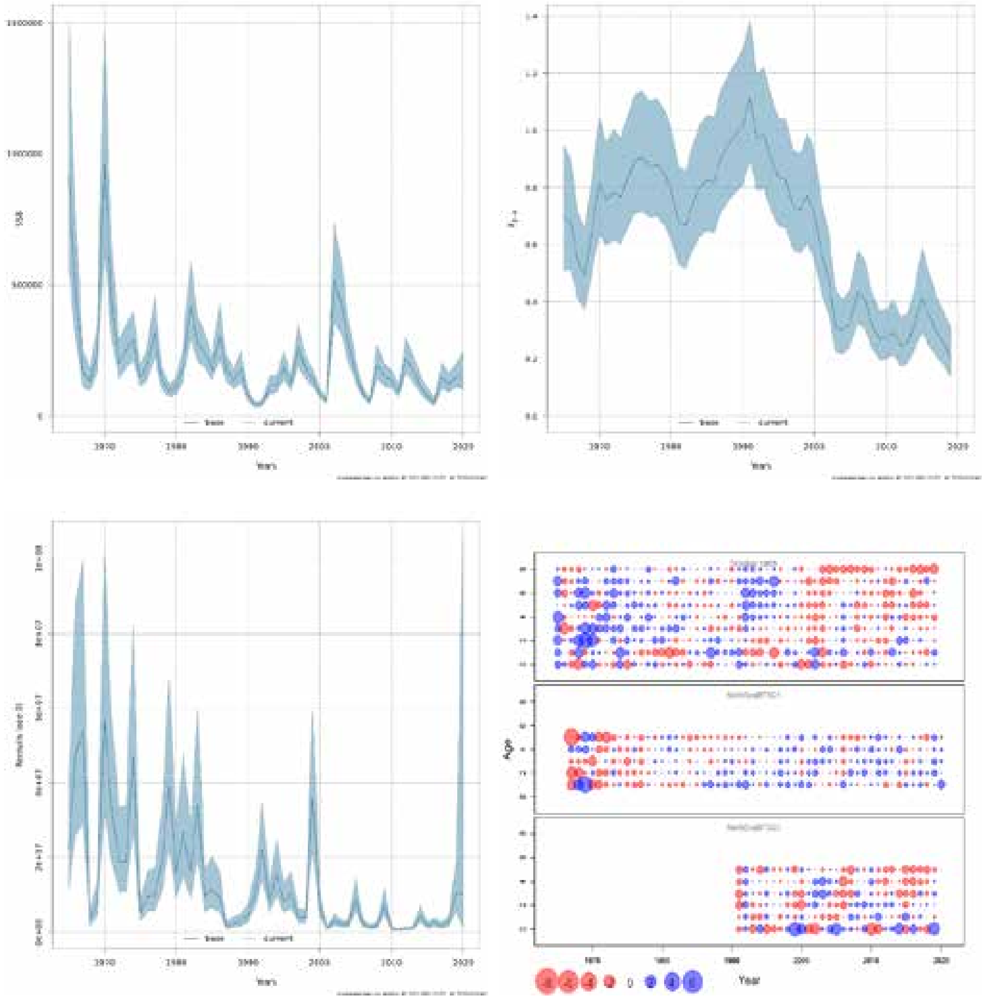

Figure 8.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SAM assessment. Time-series of estimated mean F (2–4) (top left), SSB F(2–4) (top right) and recruitment (bottom left) are shown with approximate pointwise 95% confidence intervals. Retrospective runs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

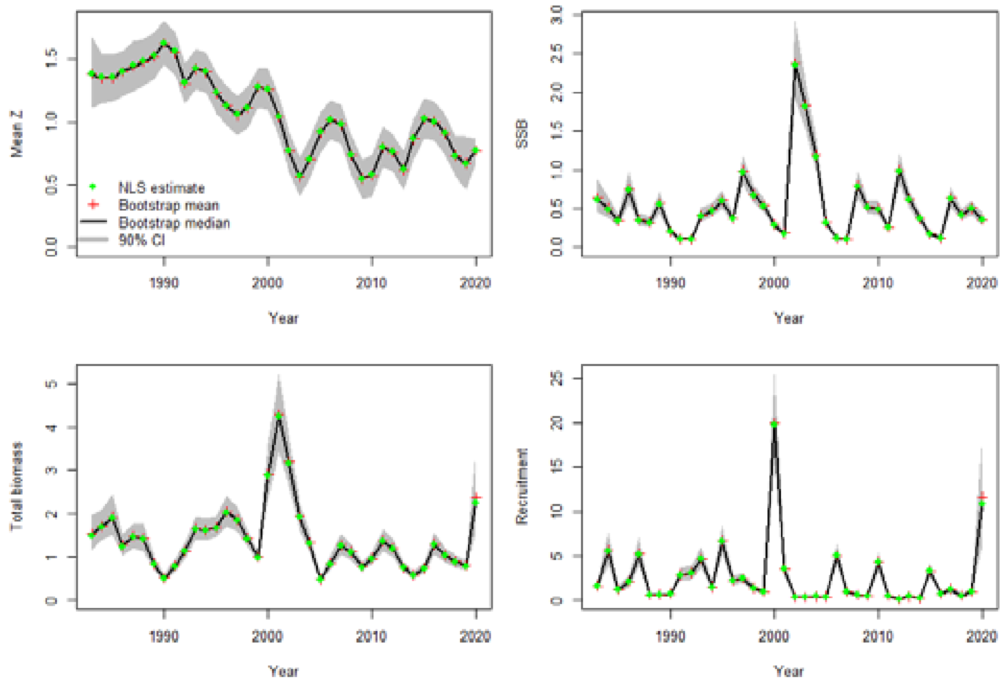

Figure 8.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

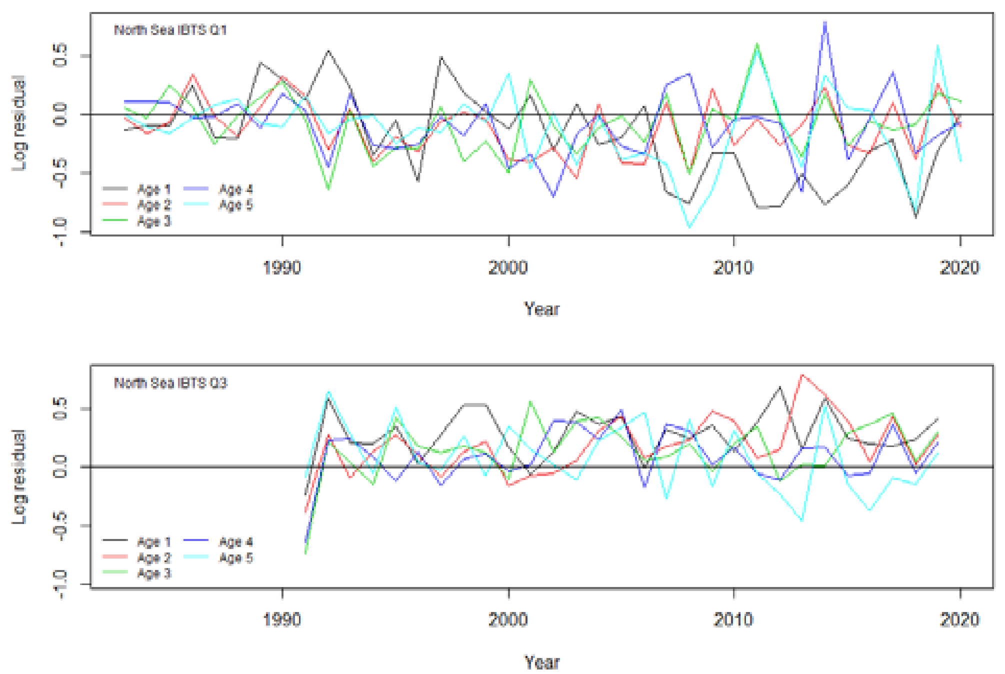

Figure 8.3.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).

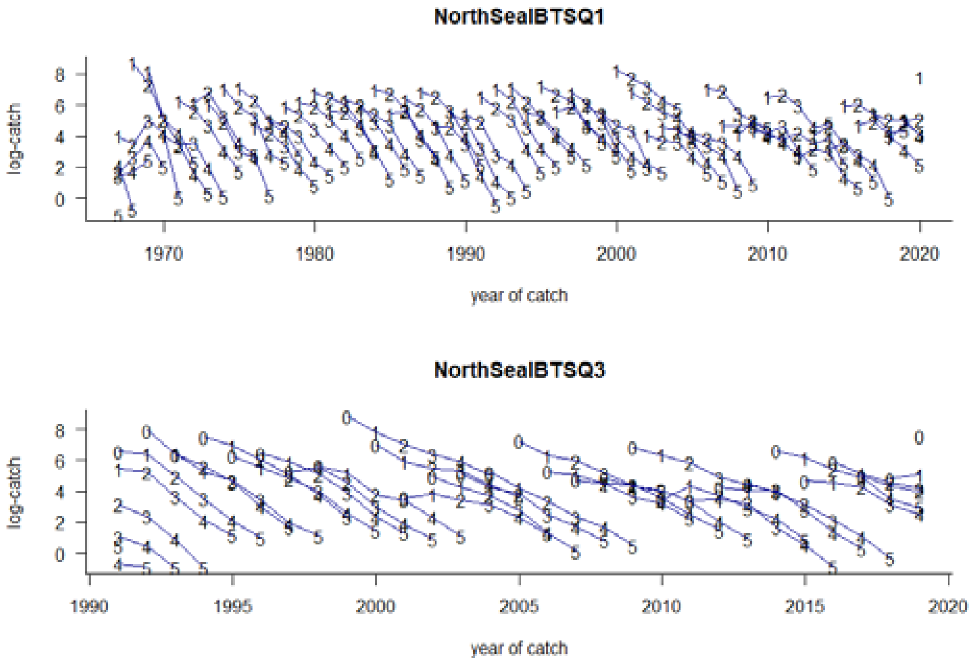

Figure 8.3.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

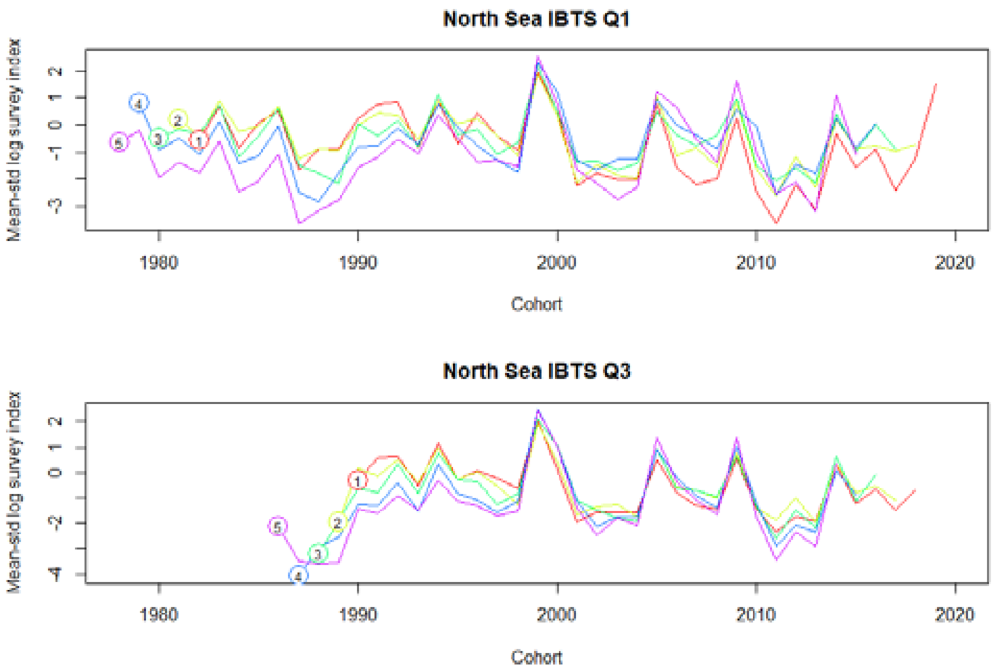

Figure 8.3.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.

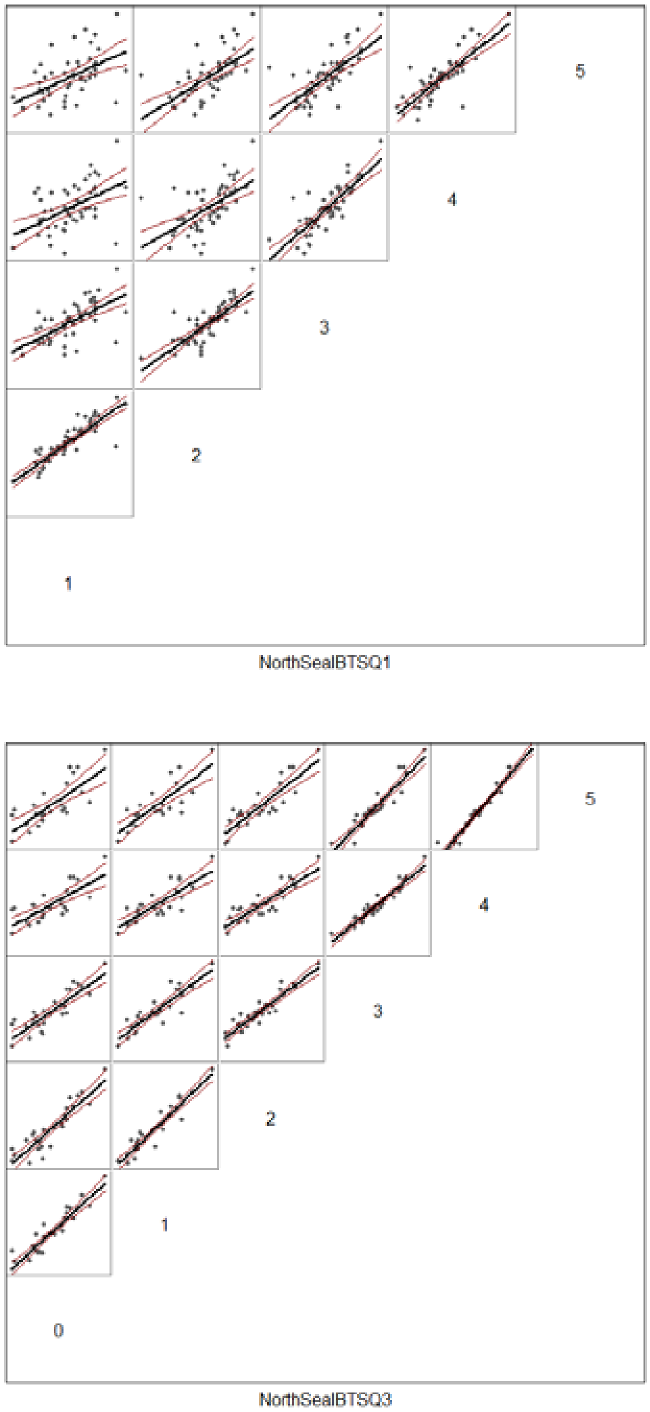

Figure 8.3.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

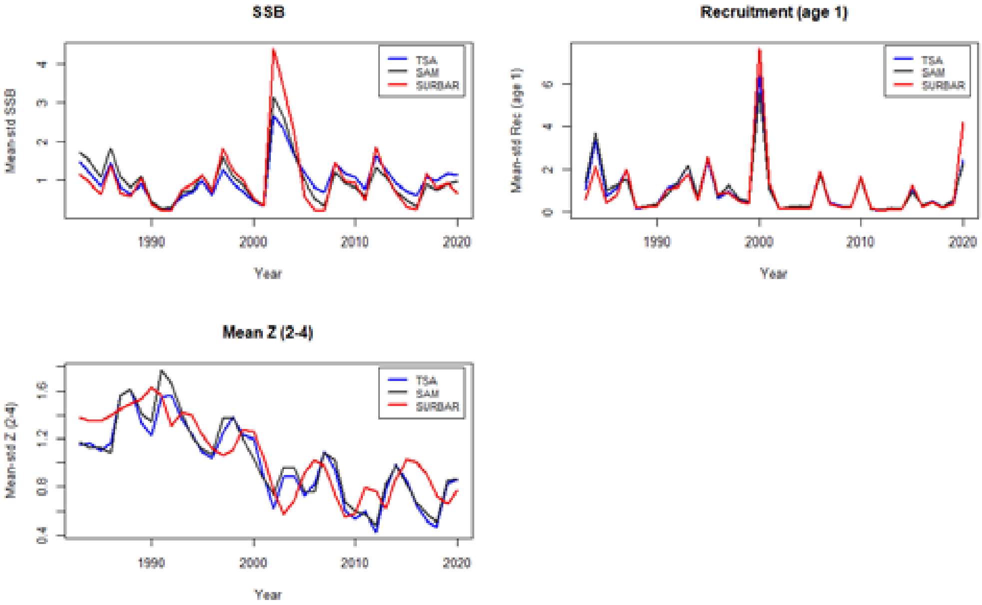

Figure 8.3.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Comparisons of stock summary estimates from TSA (blue), SAM (grey) and SURBAR (red) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models,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

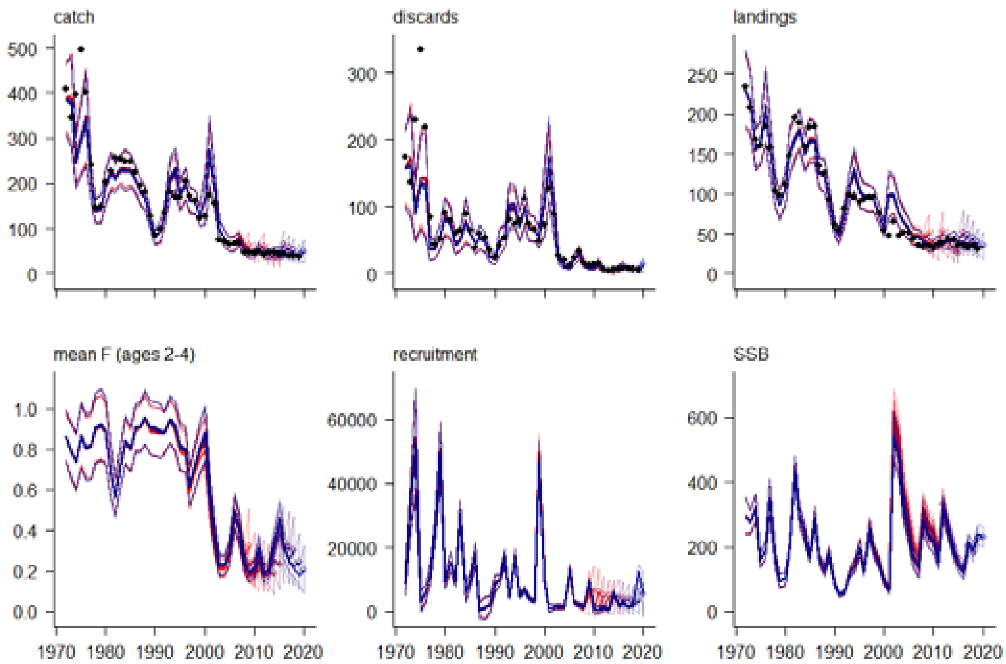

Figure 8.3.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary from final TSA assessment (including forecasts for 2020). Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for discards (discards+IBC+BMS), and landings).

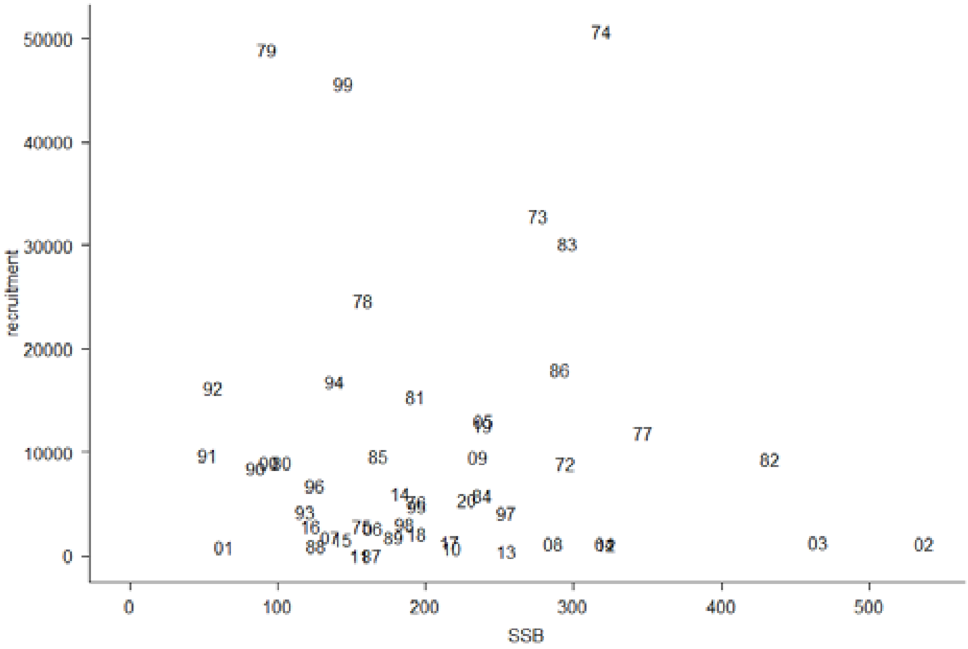

Figure 8.3.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

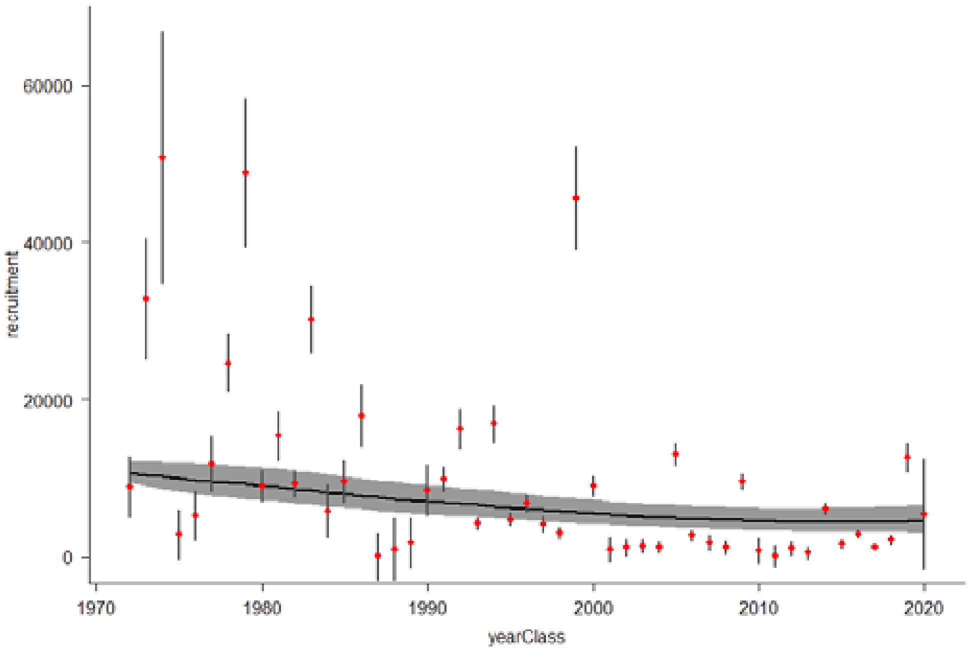

Figure 8.3.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk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

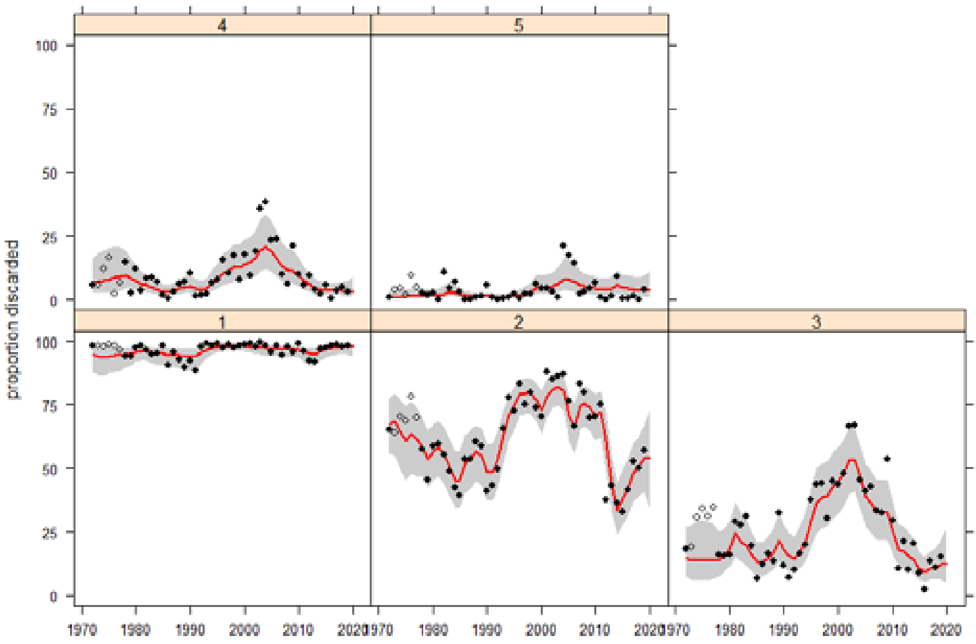

Figure 8.3.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch + BMS. The open points for the years 1973–1977 indicate that these values are treated as missing in the TSA estimation. All haddock of age 0 are assumed to be either discarded or caught as industrial bycatch or BMS.

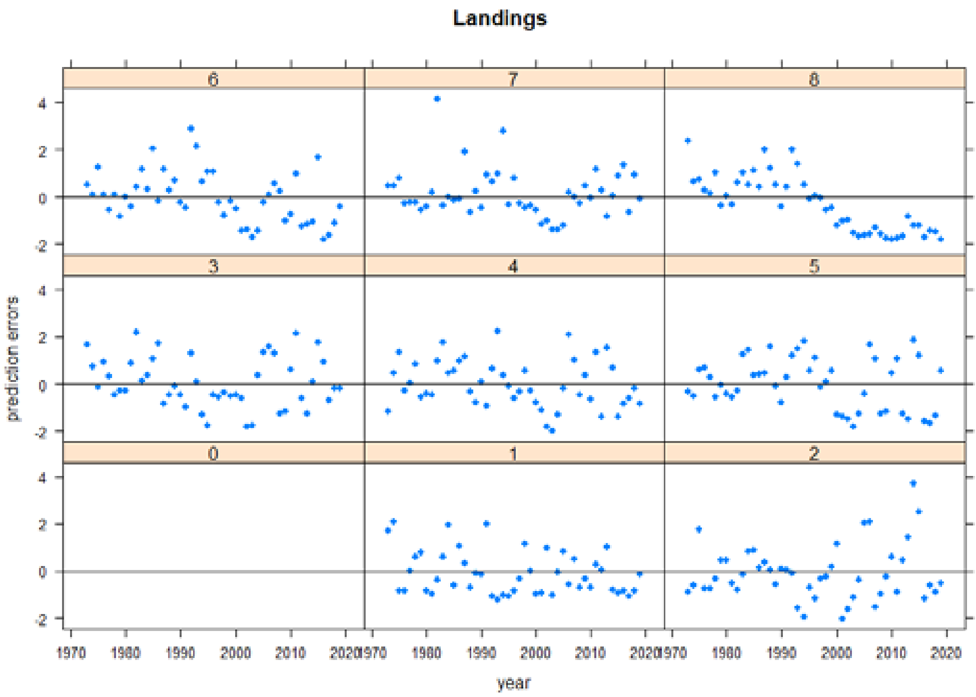

Figure 8.3.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA landings prediction errors by age.

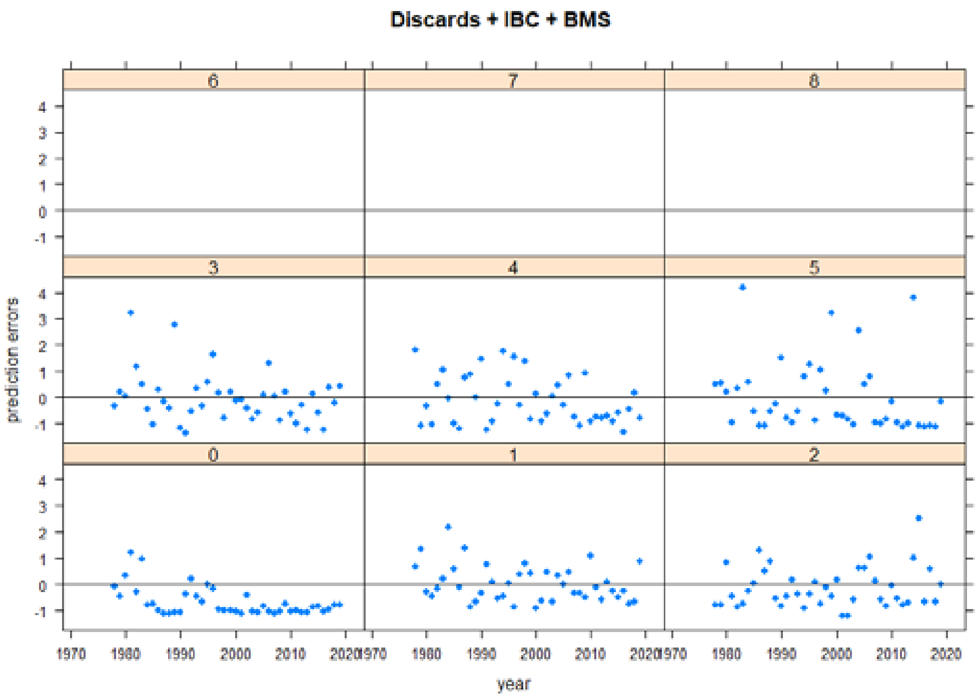

Figure 8.3.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA discards + IBC + BMS prediction errors by age.

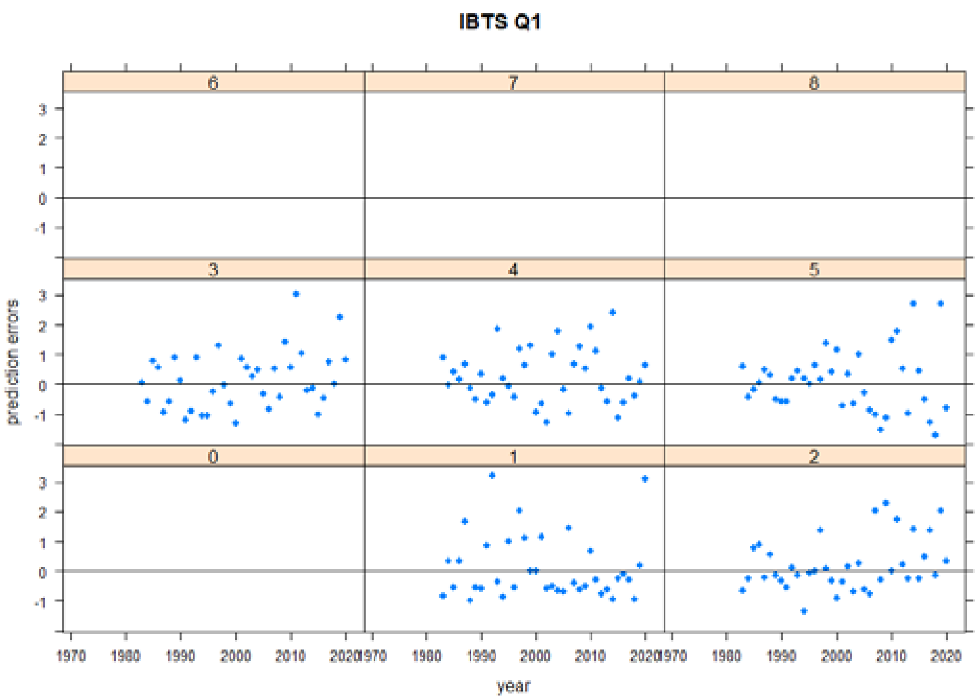

Figure 8.3.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q1 survey index.

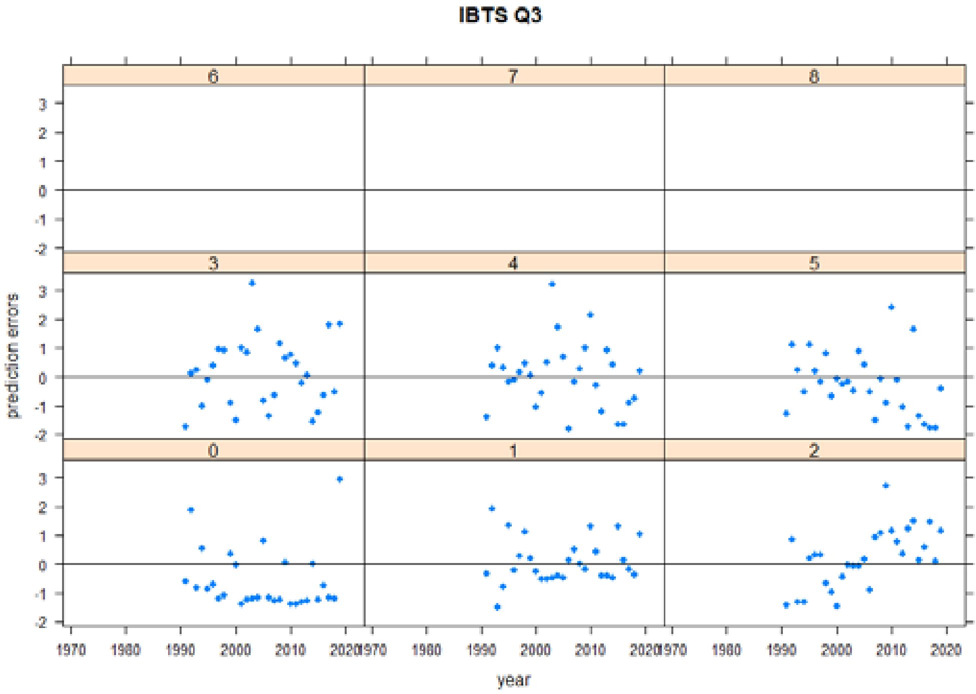

Figure 8.3.18. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS Q3 survey index.

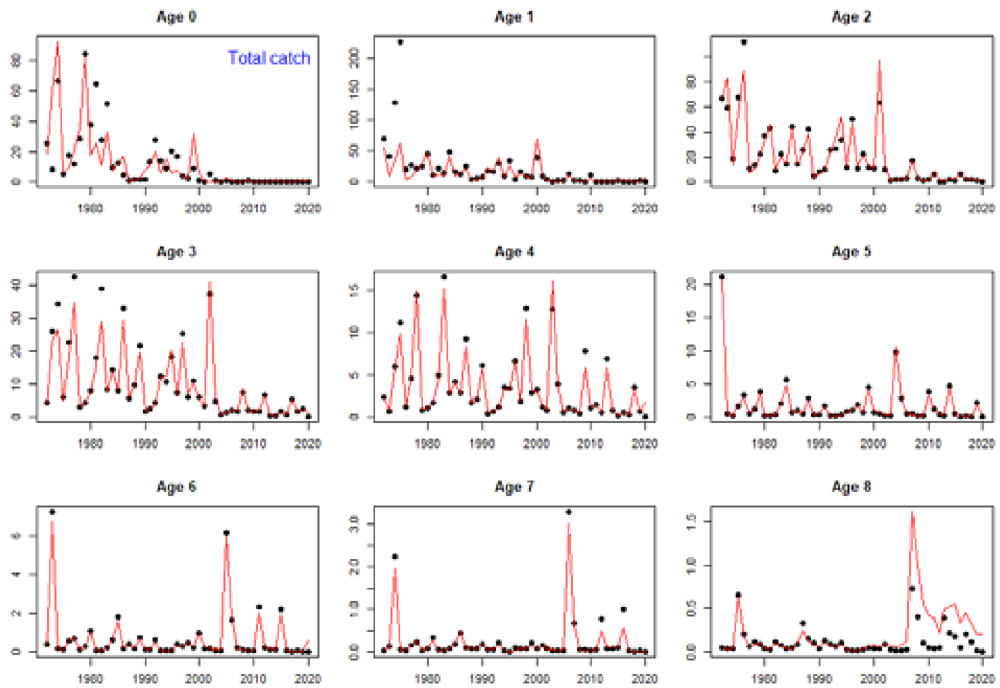

Figure 8.3.19. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for total catch, by age.

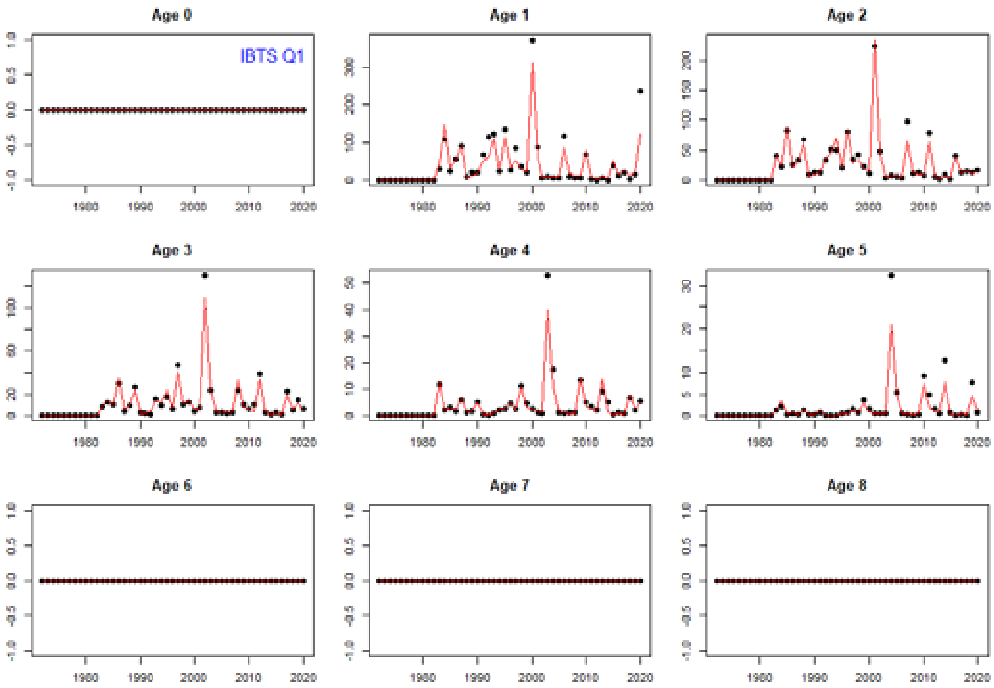

Figure 8.3.20. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

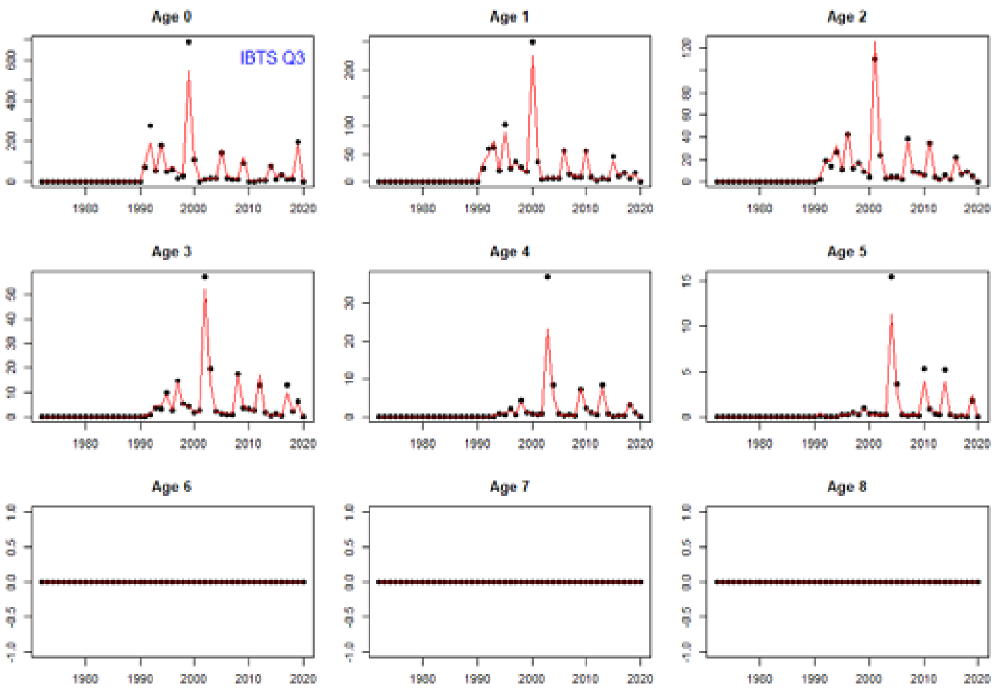

Figure 8.3.21. Haddock in Subarea 4, Division 6.a and Subdivision 20 Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.

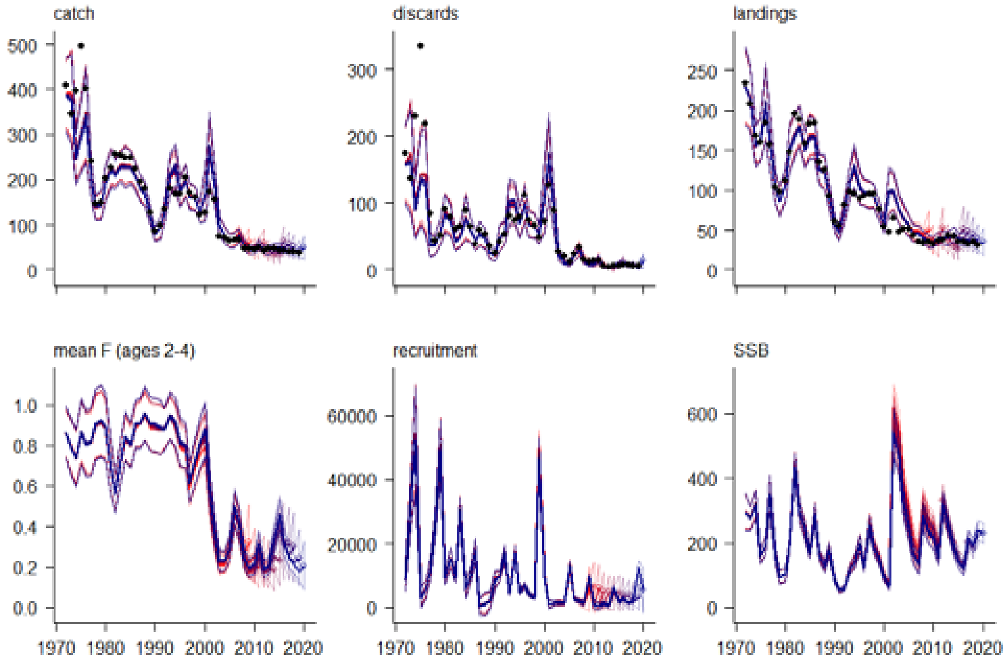

Figure 8.3.22. Haddock in Subarea 4, Division 6.a and Subdivision 20. Retrospective plots for the TSA assessment. The best estimates for each retrospective run end in an open circle, and each run is shown with the approximate pointwise 95% confidence interval. Estimates and CIs are colour-coded, with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

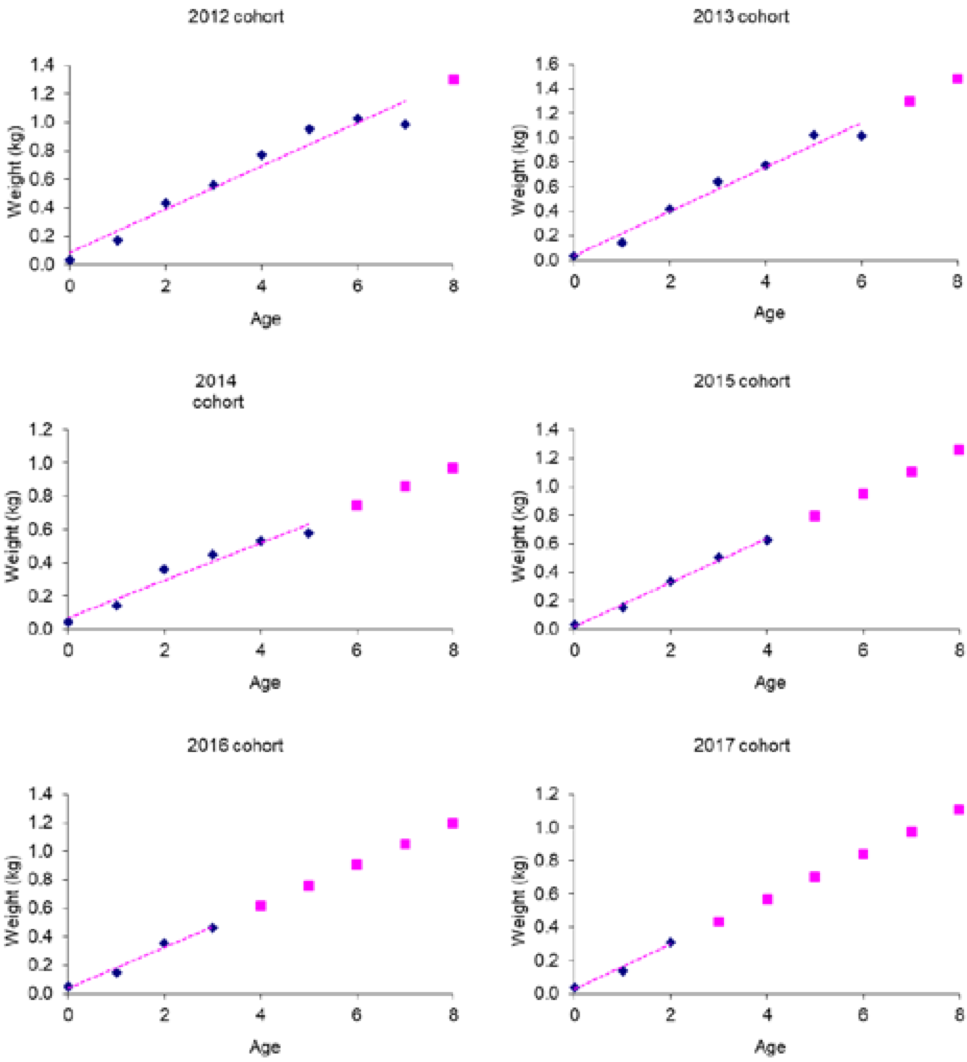

Figure 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski, 2011). Cohorts 2012–2017 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

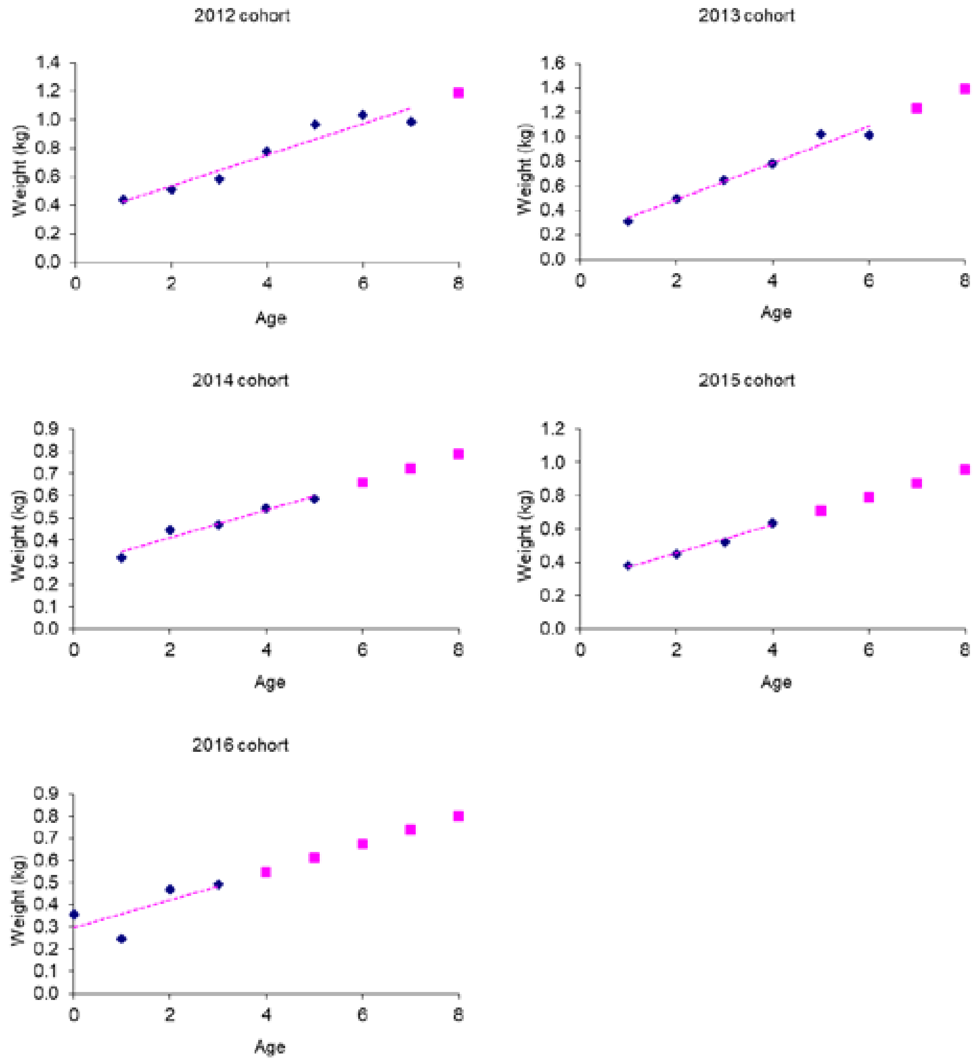

Figure 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for wanted catch (landings) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2012–2016 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

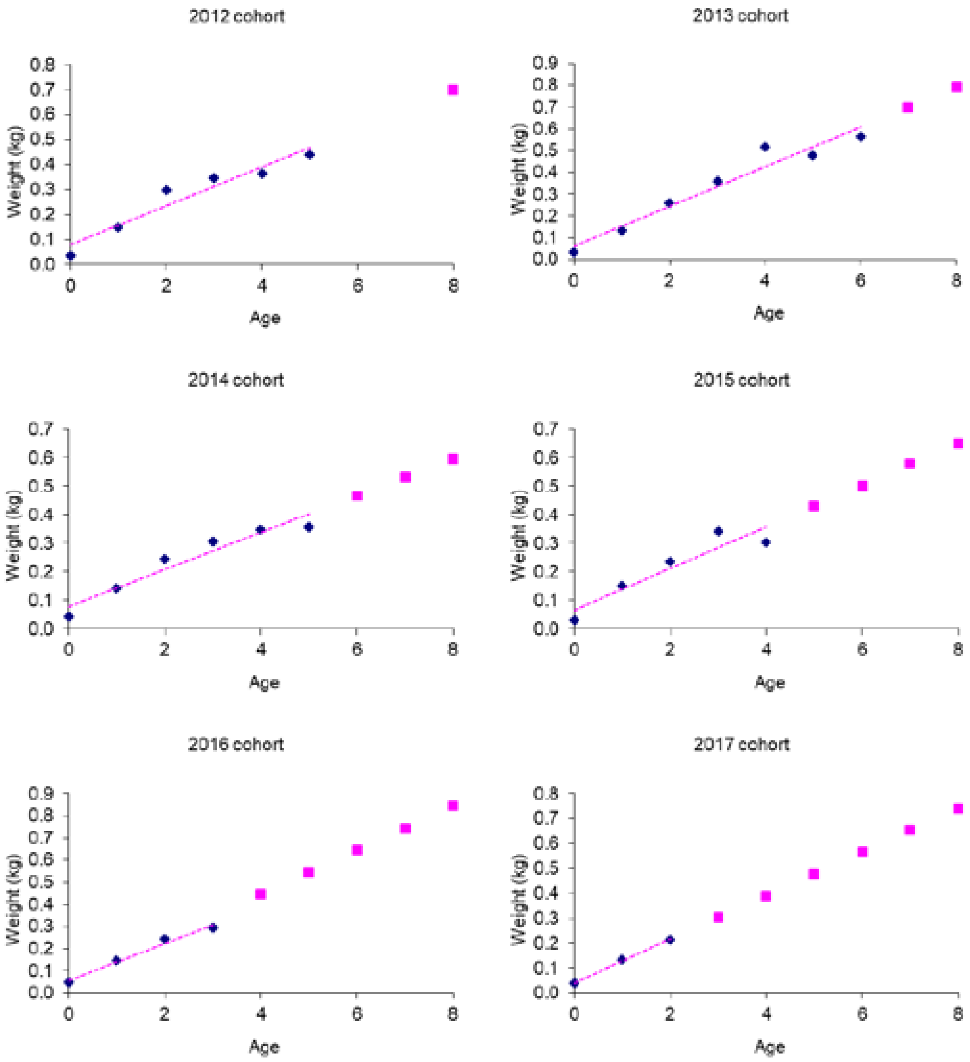

Figure 8.6.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for unwanted catch (discards + BMS) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2012–2017 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

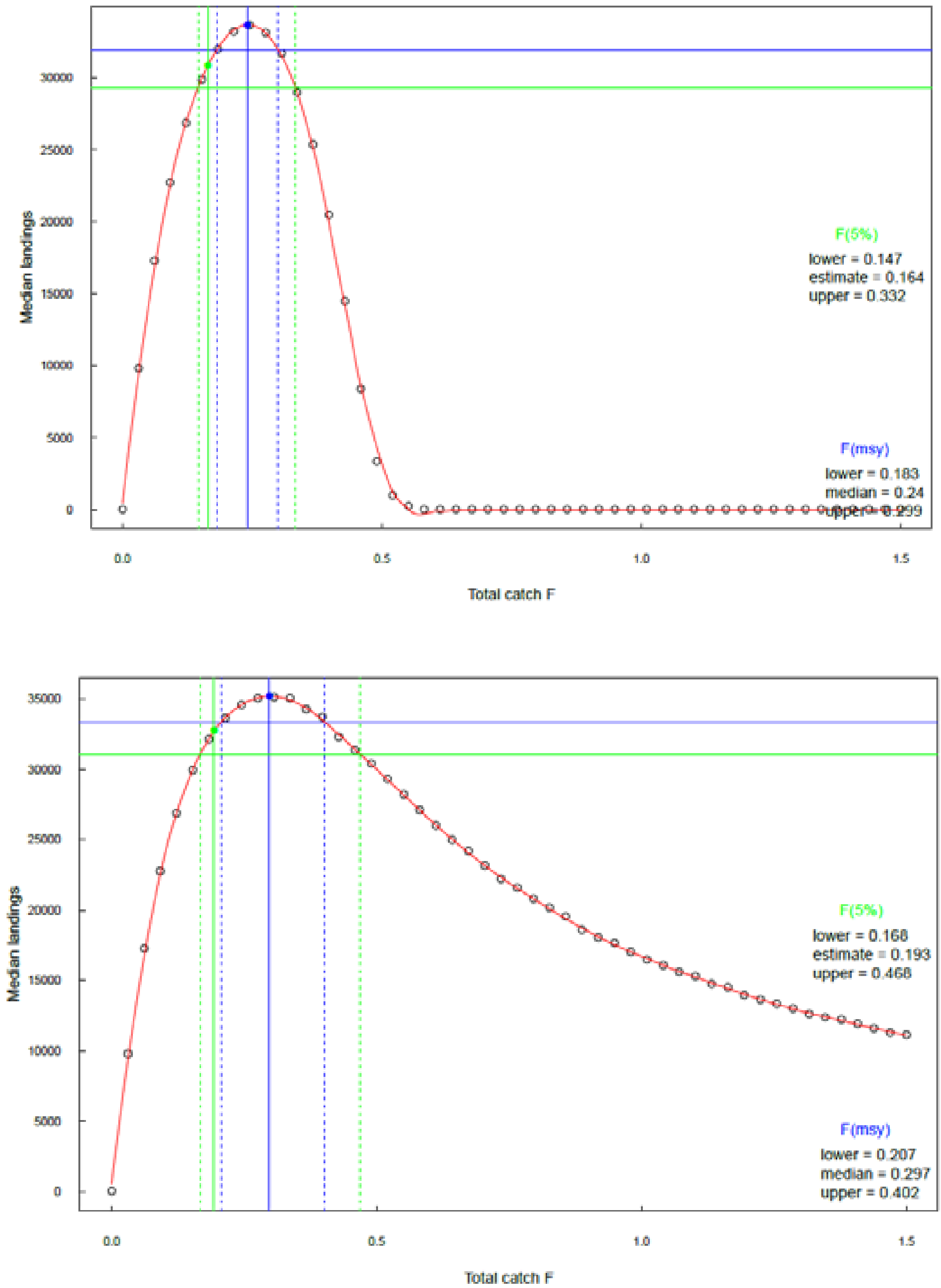

Figure 8.8.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSim estimation from IBPhaddock 2016 of F($_{MSY}$) with the advice error but no rule (top) and of Fp05 with both advice error and rule (bottom).

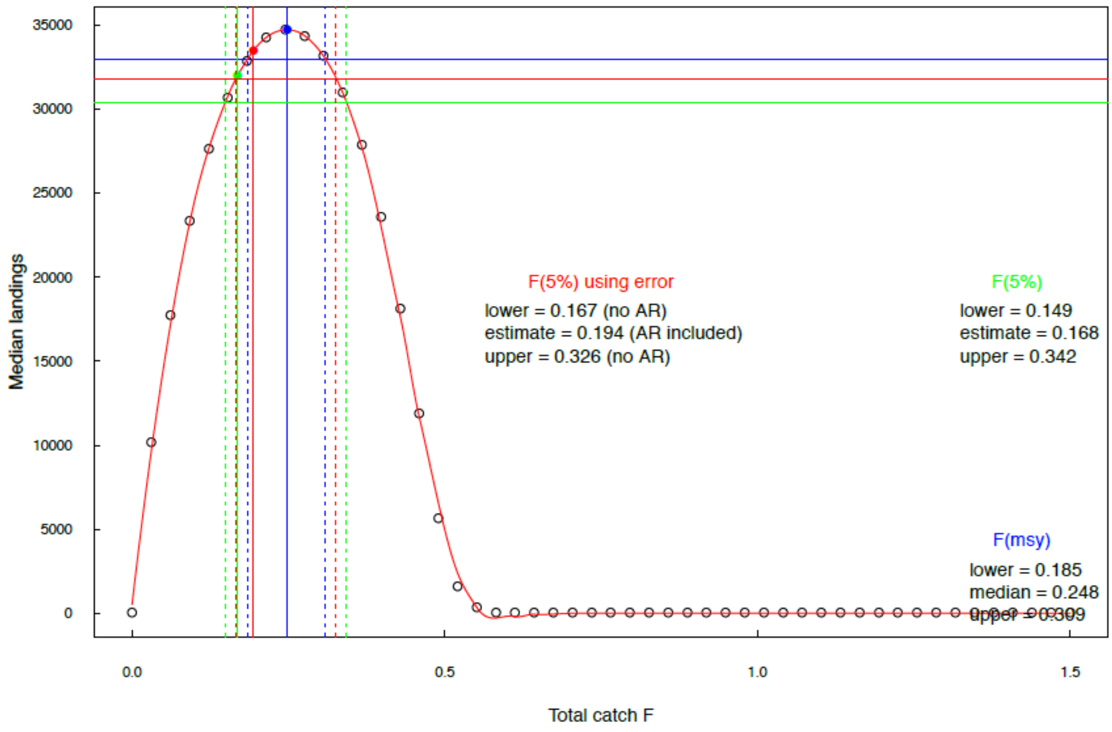

Figure 8.8.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSim estimation run for ADGNS 2017 following updated guidance (WKMSYREF4).

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, so the outcome of the current assessment will be used to provide new catch advice for 2021.

9.1.1 Biology and ecosystem aspects

Lemon sole is a commercially important flatfish that is found in the shelf waters of the North Atlantic from the White Sea and Iceland southwards to the Bay of Biscay. Lemon sole spawn for a lengthy period in the North Sea, starting as early as April in the north and ending as late as November in the south (Rae 1965). In the western English Channel, lemon sole spawn in April and May (Jennings *et al.* 1993). In the English Channel, investigations of habitat association for plaice, sole and lemon sole indicated that distribution is restricted to a few sites and that lemon soles appear to prefer sandy and gravely strata, living deeper, at higher salinitiesand 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. In the event, for 2019 there were no submissions for logbook-recorded discards (0 tonnes), and only Scotland provided submissions for BMS landings (a total of 0.224 tonnes for area 4).

Revised French data for 2018 were provided in 2020. The InterCatch estimation for 2018 was recalculated including these new data, which led to very minor changes in change (0.03%). The updated 2018 data were used for subsequent analysis.

During the WG meeting, it became clear that Sweden had uploaded catch data incorrectly to InterCatch. The consequence for the lemon sole assessment was that 3.820 tonnes of Swedish landings were missing from the InterCatch collation, along with an unknown quantity of discards. When this omission was discovered it was too late to rerun the InterCatch estimation, so the missing landings were added manually to the extant total. The overall estimated discard rate for the stock (15.49%) was then used to generate implied Swedish discards (0.592 tonnes), which were also added manually to the total catch.

InterCatch summary plots are given in Figures 9.2.5 to 9.2.8. The resultant estimates for landings and discards for 2002-2019, along with official landings for 1968-2019, 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 (2020) and IBTS Q3 data (2019: 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 2020 are included here: these are not currently used in the stock assessment which concludes in 2019, 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 2020.

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-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 2019 should be considered to be uncertain.

Finally, the run presented here assumes a lambda smoother of 3.0. Sensitivity runs to this setting were carried out by WGNSSK, and the results are summarised in Figure 9.4.5. 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 July 2019:

> *ICES advises that when the precautionary approach is applied, catches should be no more than 4279 tonnes in each of the years 2020 and 2021.*

ICES advises that if lemon sole continues to be managed using a total allowable catch (TAC), then it should be a single-species TAC covering an area appropriate to the relevant stock distribution (ICES Subarea 4 and divisions 3.a and 7.d).

Since this advice was released, ICES has been requested to issue annual advice for North Sea lemon sole. It is therefore necessary to provide new advice which supercedes the above advice for 2021.

The application of the DLS 3.2 rule, based on the most recent advised catch (for 2020), is given in Figure 9.5.1. The change ratio of the abundance index was -13%, which implies that catches for 2021 should be . 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, as a precautionary buffer was applied to the previous advice for this stock (given in 2019), no precautionary buffer is required for the advice for 2021.

9.6 Length–based F_{msy} proxy estimation

Length-based indicators (LBIs) for F_{msy}Fmsy proxies were estimated for North Sea lemon sole, following the standard approach outlined by WKLIFE (ICES-WKLIFEVI 2017) and WKPROXY (ICES-WKPROXY 2017), and stipulated in the relevant Stock Annex by the 2018 benchmark meeting (ICES-WKNSEA 2018). Data were taken from the length samples submitted to InterCatch for 2002-2019.

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 slightly higher than the equivalent estimate produced by WGNSSK in 2019 (128 mm).

Figure 9.6.5 shows an estimated L_{∞} value of 283 mm, derived from all available survey data (the corresponding value from WGNSSK 2019 was 284 mm). WGNSSK was concerned that the survey-derived value of 283 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	$\boldsymbol{L_{max}}$	$\boldsymbol{L_{\infty}}$
Trimmed L_{max}	385 mm	375 mm
Observed L_{max}	685 mm	642 mm
Survey data	-	283 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 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 2021. The estimate also suggests that the 2019 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 2017-2019.

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 2021 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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Official landings									
Year	3.a	4	7.d	Total	Year	3.a	4	7.d	Total
1950	307	3754	208	4269	1985	793	6435	347	7575
1951	248	4710	314	5272	1986	639	5047	251	5937
1952	243	4922	298	5463	1987	669	5516	310	6495
1953	132	5440	386	5958	1988	642	5898	258	6798
1954	128	3972	534	4634	1989	693	5967	364	7024
1955	102	3836	141	4079	1990	872	6190	423	7485
1956	96	3395	103	3594	1991	734	6618	428	7780
1957	78	3419	102	3599	1992	952	6126	364	7442
1958	94	3104	82	3280	1993	1156	5839	422	7417
1959	130	3647	82	3859	1994	803	5262	695	6760
1960	153	4035	66	4254	1995	714	4712	877	6303
1961	161	4900	108	5169	1996	635	4737	1151	6523
1962	93	4630	101	4824	1997	768	4727	563	6058
1963	99	3791	66	3956	1998	868	6466	346	7680
1964	134	4121	77	4332	1999	844	6316	140	7300
1965	164	4949	105	5218	2000	803	5980	388	7171
1966	159	5415	201	5775	2001	584	5389	483	6456
1967	191	6188	331	6710	2002	522	3827	474	4823
1968	185	6270	337	6792	2003	543	3688	491	4722
1969	215	4470	315	5000	2004	607	3543	424	4574
1970	169	3434	256	3859	2005	674	3444	350	4468
1971	173	3967	357	4497	2006	417	3627	246	4290
1972	168	3672	475	4315	2007	432	3892	164	4488
1973	214	4568	451	5233	2008	276	3466	234	3976
1974	183	4227	351	4761	2009	262	2693	442	3397
1975	317	5029	33	5379	2010	350	2625	223	3198
1976	361	4830	42	5233	2011	251	3365	403	4019

1977	627	5661	37	6325	2012	482	2119	358	2959
1978	705	6108	141	6954	2013	289	2981	491	3761
1979	833	6428	260	7521	2014	315	3017	356	3688
1980	722	6424	152	7298	2015	269	2871	253	3393
1981	793	5933	290	7016	2016	299	3266	240	3805
1982	735	7168	584	8487	2017	343	2822	158	3323
1983	759	8257	491	9507	2018	280	2635	99	3014
1984	595	6930	586	8111	2019	329	2805	104	3238

Year	BEL	DNK	FRA	NED	UK	Other	Total	Year	BEL	DNK	FRA	NED	UK	Other	Total
1950	10	0	174	0	24	0	208	1985	117	0	164	0	66	0	347
1951	5	0	262	0	47	0	314	1986	77	0	133	0	41	0	251
1952	10	0	188	0	100	0	298	1987	81	0	185	0	44	0	310
1953	7	0	196	0	183	0	386	1988	74	0	155	0	29	0	258
1954	9	0	361	0	164	0	534	1989	68	0	252	0	44	0	364
1955	9	0	0	0	132	0	141	1990	68	0	272	0	83	0	423
1956	4	0	0	0	99	0	103	1991	83	0	272	0	73	0	428
1957	7	0	0	0	95	0	102	1992	66	0	176	0	122	0	364
1958	1	0	0	0	81	0	82	1993	36	0	311	0	75	0	422
1959	2	0	0	0	80	0	82	1994	97	0	505	0	93	0	695
1960	4	0	0	0	62	0	66	1995	138	0	584	0	155	0	877
1961	1	0	0	0	106	1	108	1996	213	0	720	0	218	0	1151
1962	2	0	0	0	99	0	101	1997	143	0	305	0	115	0	563
1963	3	0	0	0	63	0	66	1998	53	0	198	0	95	0	346
1964	5	0	0	0	72	0	77	1999	50	0	0	0	90	0	140
1965	16	0	0	0	89	0	105	2000	62	0	200	0	126	0	388
1966	7	0	0	0	194	0	201	2001	104	0	191	0	188	0	483
1967	6	0	0	0	325	0	331	2002	101	0	256	0	117	0	474
1968	8	0	0	0	329	0	337	2003	128	0	251	0	112	0	491
1969	12	0	0	0	303	0	315	2004	120	0	198	1	105	0	424
1970	16	0	0	0	240	0	256	2005	90	0	187	2	71	0	350
1971	22	0	0	0	335	0	357	2006	98	0	100	0	48	0	246
1972	18	0	0	0	457	0	475	2007	70	0	72	1	21	0	164
1973	25	0	0	0	426	0	451	2008	140	0	46	3	45	0	234
1974	16	0	0	1	334	0	351	2009	149	0	176	9	108	0	442
1975	19	0	0	0	14	0	33	2010	101	0	85	5	32	0	223

1976	**24**	**0**	**0**	**0**	**18**	**0**	**42**	**2011**	**153**	**0**	**178**	**15**	**57**	**0**	**403**
1977	**21**	**1**	**0**	**0**	**15**	**0**	**37**	**2012**	**171**	**0**	**167**	**20**	**0**	**0**	**358**
1978	**45**	**2**	**63**	**0**	**31**	**0**	**141**	**2013**	**176**	**0**	**179**	**26**	**110**	**0**	**491**
1979	**60**	**0**	**165**	**0**	**35**	**0**	**260**	**2014**	**162**	**0**	**108**	**14**	**72**	**0**	**356**
1980	**33**	**0**	**109**	**0**	**10**	**0**	**152**	**2015**	**123**	**0**	**84**	**5**	**41**	**0**	**253**
1981	**66**	**0**	**212**	**0**	**12**	**0**	**290**	**2016**	**115**	**0**	**69**	**9**	**47**	**0**	**240**
1982	**96**	**0**	**406**	**1**	**81**	**0**	**584**	**2017**	**87**	**0**	**34**	**8**	**29**	**0**	**158**
1983	**108**	**0**	**298**	**0**	**85**	**0**	**491**	**2018**	**57**	**0**	**21**	**5**	**15**	**0**	**99**
1984	**110**	**0**	**367**	**0**	**109**	**0**	**586**	2019	49	0	27	6	23	0	104

Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total	Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total
1950	112	435	139	31	156	0	2855	26	3754	1985	989	555	157	26	0	0	4703	5	6435
1951	115	845	90	21	167	0	3430	42	4710	1986	511	577	103	16	0	0	3839	1	5047
1952	98	391	227	26	168	0	3953	59	4922	1987	448	742	174	14	0	0	4137	1	5516
1953	73	409	189	18	132	0	4590	29	5440	1988	539	639	184	14	301	0	4220	1	5898
1954	2	272	177	24	112	0	3368	17	3972	1989	441	828	176	40	397	0	4083	2	5967
1955	49	311	0	15	78	0	3374	9	3836	1990	491	1007	208	49	0	0	4431	4	6190
1956	48	222	0	19	58	0	3034	14	3395	1991	544	1099	250	41	0	12	4666	6	6618
1957	39	249	0	24	64	0	3032	11	3419	1992	577	1149	177	30	0	13	4175	5	6126
1958	30	171	0	13	43	0	2835	12	3104	1993	525	966	240	37	0	9	4059	3	5839
1959	85	242	0	40	43	0	3226	11	3647	1994	436	597	436	27	0	11	3754	1	5262
1960	155	577	0	46	67	0	3178	12	4035	1995	588	585	412	70	0	9	3046	2	4712
1961	286	488	0	79	102	0	3934	11	4900	1996	592	547	534	67	0	18	2976	3	4737
1962	175	501	0	54	106	0	3794	0	4630	1997	504	499	224	76	0	29	3391	4	4727
1963	365	222	0	36	71	0	3097	0	3791	1998	815	796	197	149	838	23	3643	5	6466
1964	484	358	0	62	75	0	3142	0	4121	1999	662	1015	0	62	681	24	3866	6	6316
1965	562	385	0	91	93	0	3818	0	4949	2000	711	1277	184	72	492	17	3222	5	5980
1966	594	548	0	98	65	0	4110	0	5415	2001	694	1281	191	77	451	22	2666	7	5389
1967	601	791	0	136	61	0	4599	0	6188	2002	604	971	190	116	402	17	1521	6	3827
1968	422	775	0	96	34	0	4943	0	6270	2003	517	1008	239	136	369	16	1399	4	3688

1969	292	639	0	80	36	0	3423	0	4470	2004	667	1113	120	81	355	12	1192	3	3543
1970	241	307	0	52	58	0	2776	0	3434	2005	595	1057	102	85	402	13	1188	2	3444
1971	348	514	0	54	122	0	2929	0	3967	2006	552	968	57	183	412	13	1440	2	3627
1972	423	530	0	59	130	0	2530	0	3672	2007	542	1136	65	143	367	23	1610	6	3892
1973	566	478	0	73	217	16	3218	0	4568	2008	527	925	47	120	434	26	1383	4	3466
1974	486	447	0	59	269	0	2966	0	4227	2009	389	898	88	64	294	31	927	2	2693
1975	748	521	0	83	299	0	3367	11	5029	2010	375	821	32	102	323	35	935	2	2625
1976	493	506	0	68	308	0	3443	12	4830	2011	387	999	56	96	641	27	1157	2	3365
1977	618	321	0	71	262	0	4387	2	5661	2012	406	999	34	61	587	30	0	2	2119
1978	760	517	28	54	231	0	4518	0	6108	2013	527	649	27	67	479	16	1214	2	2981
1979	674	876	136	41	390	0	4308	3	6428	2014	648	626	27	63	425	23	1202	3	3017
1980	484	599	102	49	303	0	4885	2	6424	2015	425	794	16	82	423	12	1116	3	2871
1981	555	605	237	39	412	0	4084	1	5933	2016	448	1054	15	82	443	23	1196	5	3266
1982	879	670	419	52	759	0	4386	3	7168	2017	345	1032	0	42	356	14	1028	4	2822
1983	1122	735	402	28	1009	0	4957	4	8257	2018	370	815	9	52	347	14	1025	3	2635
1984	1144	567	344	22	0	0	4850	3	6930	2019	467	671	8	46	473	13	1122	4	2805

Year	BEL	DNK	GER	NED	SWE	Other	Total	Year	BEL	DNK	GER	NED	SWE	Other	Total
1950	0	100	1	0	206	0	307	1985	0	729	0	0	64	0	793
1951	0	74	1	0	173	0	248	1986	7	576	0	0	56	0	639
1952	0	64	0	0	179	0	243	1987	24	577	0	0	68	0	669
1953	0	35	0	0	97	0	132	1988	11	569	0	6	56	0	642
1954	0	33	0	0	95	0	128	1989	8	610	0	0	75	0	693
1955	0	29	0	0	73	0	102	1990	16	782	0	0	74	0	872
1956	0	33	0	0	63	0	96	1991	11	640	0	0	83	0	734
1957	0	27	0	0	51	0	78	1992	22	793	0	0	120	17	952
1958	0	38	0	0	56	0	94	1993	14	980	4	0	141	17	1156
1959	0	71	0	0	59	0	130	1994	10	648	2	0	127	16	803
1960	0	95	1	0	57	0	153	1995	27	576	2	0	91	18	714
1961	0	90	0	0	71	0	161	1996	0	513	1	0	97	24	635
1962	0	92	1	0	0	0	93	1997	0	628	2	0	115	23	768
1963	0	99	0	0	0	0	99	1998	0	743	3	0	100	22	868
1964	0	133	1	0	0	0	134	1999	0	731	3	0	88	22	844
1965	0	163	1	0	0	0	164	2000	0	722	1	0	65	15	803
1966	0	159	0	0	0	0	159	2001	0	511	1	0	53	19	584
1967	0	189	1	0	0	1	191	2002	0	457	4	0	41	20	522
1968	0	184	0	0	0	1	185	2003	0	451	6	30	35	21	543
1969	0	215	0	0	0	0	215	2004	0	472	5	82	29	19	607
1970	0	169	0	0	0	0	169	2005	0	468	5	147	38	16	674
1971	0	173	0	0	0	0	173	2006	0	321	8	40	32	16	417
1972	0	168	0	0	0	0	168	2007	0	374	5	16	18	19	432
1973	0	214	0	0	0	0	214	2008	0	239	7	3	15	12	276
1974	0	183	0	0	0	0	183	2009	0	233	4	1	15	9	262
1975	0	263	1	1	52	0	317	2010	0	286	3	35	19	7	350
1976	10	294	1	19	37	0	361	2011	0	223	0	0	12	16	251

1977	9	528	2	37	51	0	627	2012	0	446	3	0	15	18	482
1978	4	628	2	12	59	0	705	2013	0	259	3	5	10	12	289
1979	7	704	1	10	111	0	833	2014	0	276	7	12	14	6	315
1980	12	622	0	0	87	1	722	2015	0	250	4	0	9	6	269
1981	1	710	0	3	75	4	793	2016	0	265	5	16	7	6	299
1982	2	647	0	9	77	0	735	2017	0	314	5	11	6	7	343
1983	3	636	0	10	110	0	759	2018	0	252	5	14	6	2	280
1984	6	525	0	0	64	0	595	2019	0	293	1	29	5	1	329

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%
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	600	3873	15.50%

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
2005	0.0896	0.0757	0.1163	0.2227	0.3000	0.3476	0.3796	0.2237	0.2669
2006	0.0794	0.0763	0.1208	0.2264	0.3031	0.3391	0.3691	0.2383	0.2614
2007	0.0699	0.0762	0.1240	0.2281	0.3042	0.3322	0.3609	0.2533	0.2600
2008	0.0611	0.0753	0.1258	0.2278	0.3032	0.3268	0.3548	0.2680	0.2618
2009	0.0531	0.0739	0.1265	0.2256	0.3005	0.3222	0.3499	0.2822	0.2673
2010	0.0455	0.0717	0.1258	0.2212	0.2955	0.3183	0.3463	0.2961	0.2762
2011	0.0383	0.0692	0.1241	0.2153	0.2887	0.3152	0.3449	0.3097	0.2903
2012	0.0320	0.0655	0.1201	0.2063	0.2772	0.3129	0.3458	0.3218	0.3045
2013	0.0282	0.0619	0.1158	0.1969	0.2665	0.3117	0.3471	0.3334	0.3255
2014	0.0252	0.0586	0.1114	0.1871	0.2575	0.3089	0.3496	0.3451	0.3461
2015	0.0222	0.0556	0.1070	0.1775	0.2490	0.3112	0.3548	0.3562	0.3531
2016	0.0200	0.0528	0.1024	0.1676	0.2411	0.3178	0.3630	0.3687	0.3516
2017	0.0180	0.0504	0.0978	0.1577	0.2334	0.3281	0.3734	0.3817	0.3435
2018	0.0165	0.0484	0.0930	0.1477	0.2258	0.3420	0.3865	0.3953	0.3291
2019	0.0154	0.0466	0.0882	0.1377	0.2187	0.3600	0.4029	0.4106	0.3081
2020	0.0148	0.0451	0.0835	0.1279	0.2123	0.3831	0.4238	0.4282	0.2795

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.

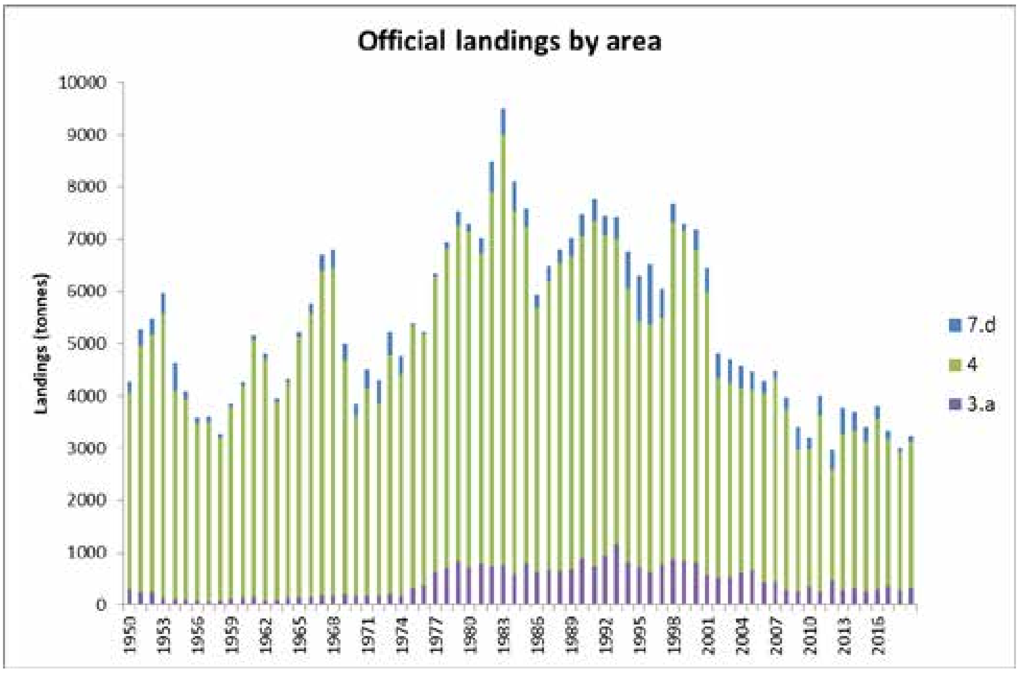
NS Lemon Sole Q1 IBTS ; Last age is NOT plus group, calculated 2020-04-17 12:59:09					
2007	2020				
1	1	0.09227893	0.09227893		
1	5				
1	81.9102				
1	NA				
1	65.4706				
1	101.9016				
1	12.6038				
1	63.4222				
1	43.4031				
1	70.9634				

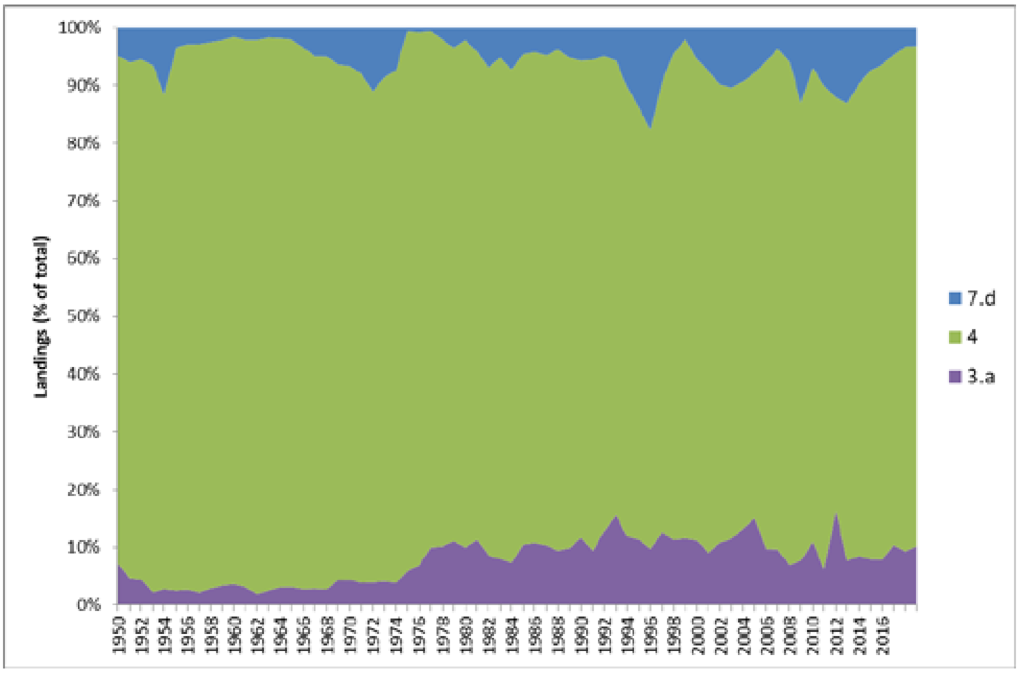
1	10.9446				
1	18.4963				
1	13.0315				
1	67.3802				
1	2.3749				
1	3.6184	690.9862	1259.1854	672.2442	267.4706

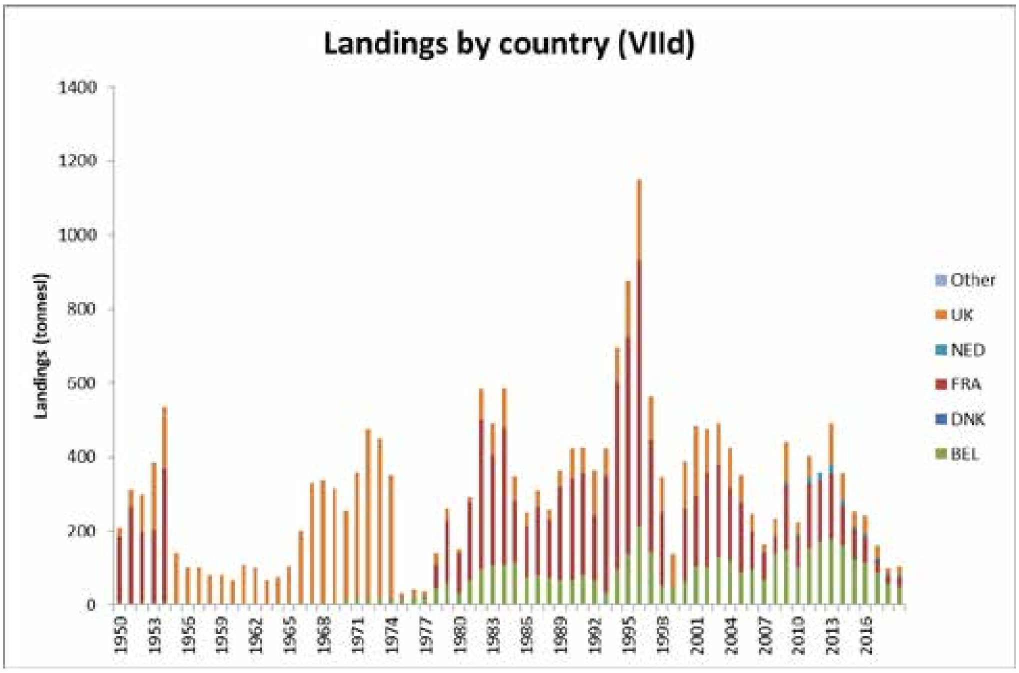
NS Lemon Sole Q3 IBTS+BTS ; Last age is plus group, calculated 2020-04-15 15:28:36										
2005	2019									
1	1	0.6220286	0.6220286							
1	10									
1										511.7196
1										924.751
1										751.6691
1										674.3164
1										753.9123
1										609.7257
1										1295.3958
1										1194.6714
1										1784.6164
1										1389.1765
1										1045.6751
1										1261.6123
1										820.5262
1										755.7691
1										1223.0716

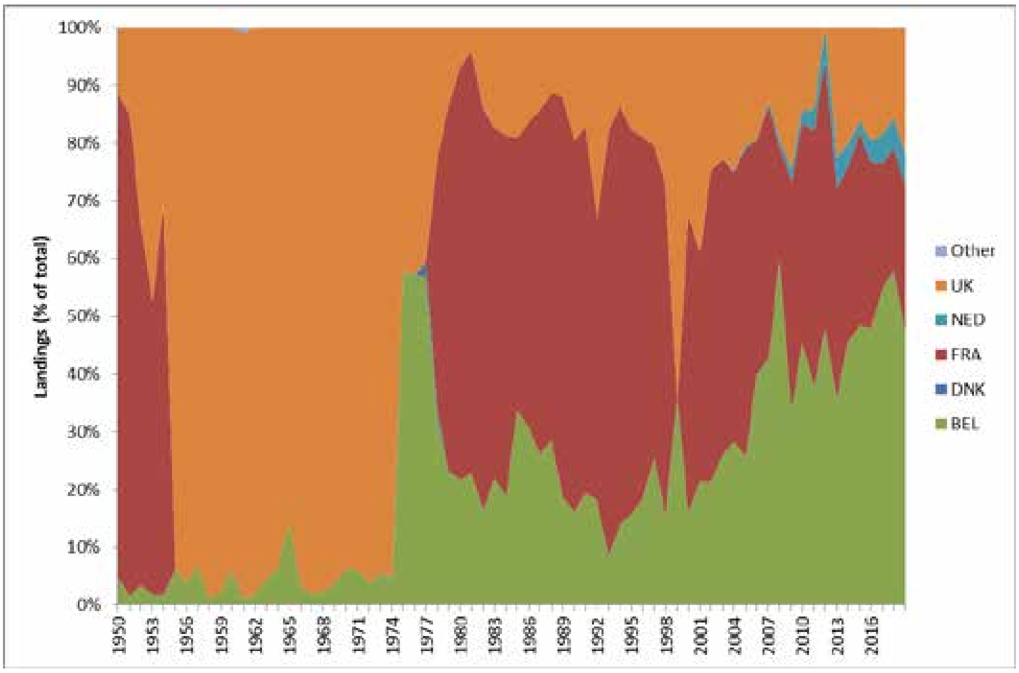
	z.low	z	z.high	ssb.low	ssb	ssb.high	rec.low	rec	rec.high
2005	-0.129	0.177	0.460	0.661	0.848	1.194	0.535	0.745	1.064
2006	-0.066	0.190	0.451	0.728	0.896	1.203	0.570	0.782	1.103
2007	0.168	0.410	0.660	0.755	0.921	1.214	0.751	1.066	1.588
2008	0.149	0.385	0.614	0.646	0.760	0.985	0.628	0.845	1.209
2009	-0.261	-0.036	0.176	0.537	0.633	0.821	0.725	0.970	1.283
2010	-0.230	-0.003	0.230	0.732	0.872	1.113	0.954	1.270	1.697
2011	-0.089	0.142	0.379	0.896	1.093	1.410	0.994	1.293	1.766
2012	0.000	0.252	0.486	0.978	1.182	1.501	0.870	1.187	1.673
2013	0.003	0.242	0.446	0.925	1.118	1.425	0.661	0.907	1.241
2014	-0.085	0.158	0.408	0.907	1.073	1.388	0.858	1.187	1.624
2015	-0.177	0.069	0.296	0.926	1.118	1.471	0.536	0.739	1.024
2016	-0.057	0.179	0.397	1.028	1.231	1.647	0.704	1.005	1.441
2017	-0.003	0.237	0.450	0.996	1.191	1.558	0.548	0.831	1.268
2018	-0.127	0.167	0.423	0.865	1.055	1.421	0.525	0.893	1.573
2019	0.072	0.194	0.299	0.797	1.009	1.421	0.552	1.280	3.143

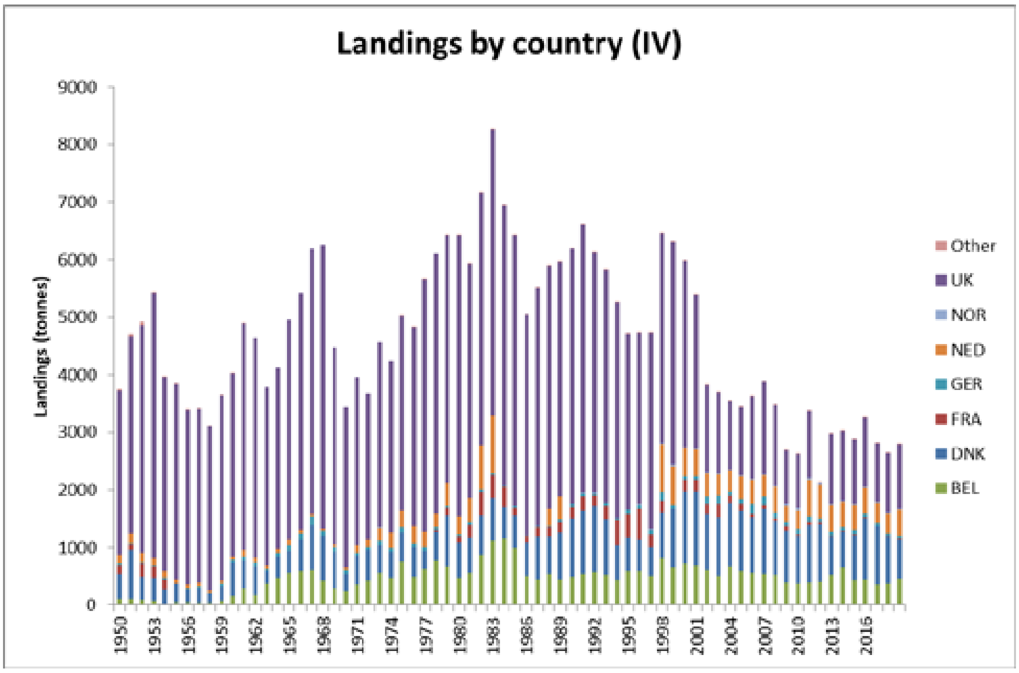
	Conservation				Optimising yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/L(F=M)
Year	>1	>1	>0.8	>30%	~1(>0.9)	>=1
2002	0.692	1.808	1.001	0.588	1.107	1.716
2003	1.154	1.731	0.997	0.481	1.074	1.302
2004	1.769	1.885	1.001	0.609	1.202	1.128
2005	1.923	1.885	0.910	0.383	1.126	1.001
2006	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	0.538	1.346	0.959	0.285	0.919	1.571
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	1.462	1.577	0.995	0.284	1.036	1.096
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	0.434	1.033	1.766

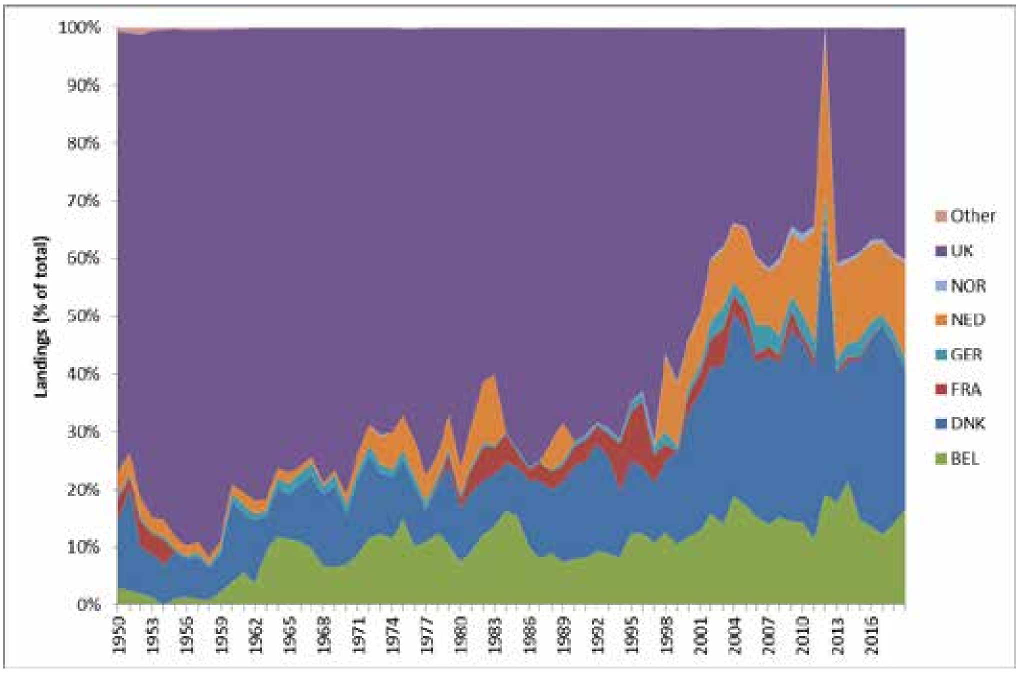

Official landings by area
Landings (tonnes)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
7.d
4
3.a

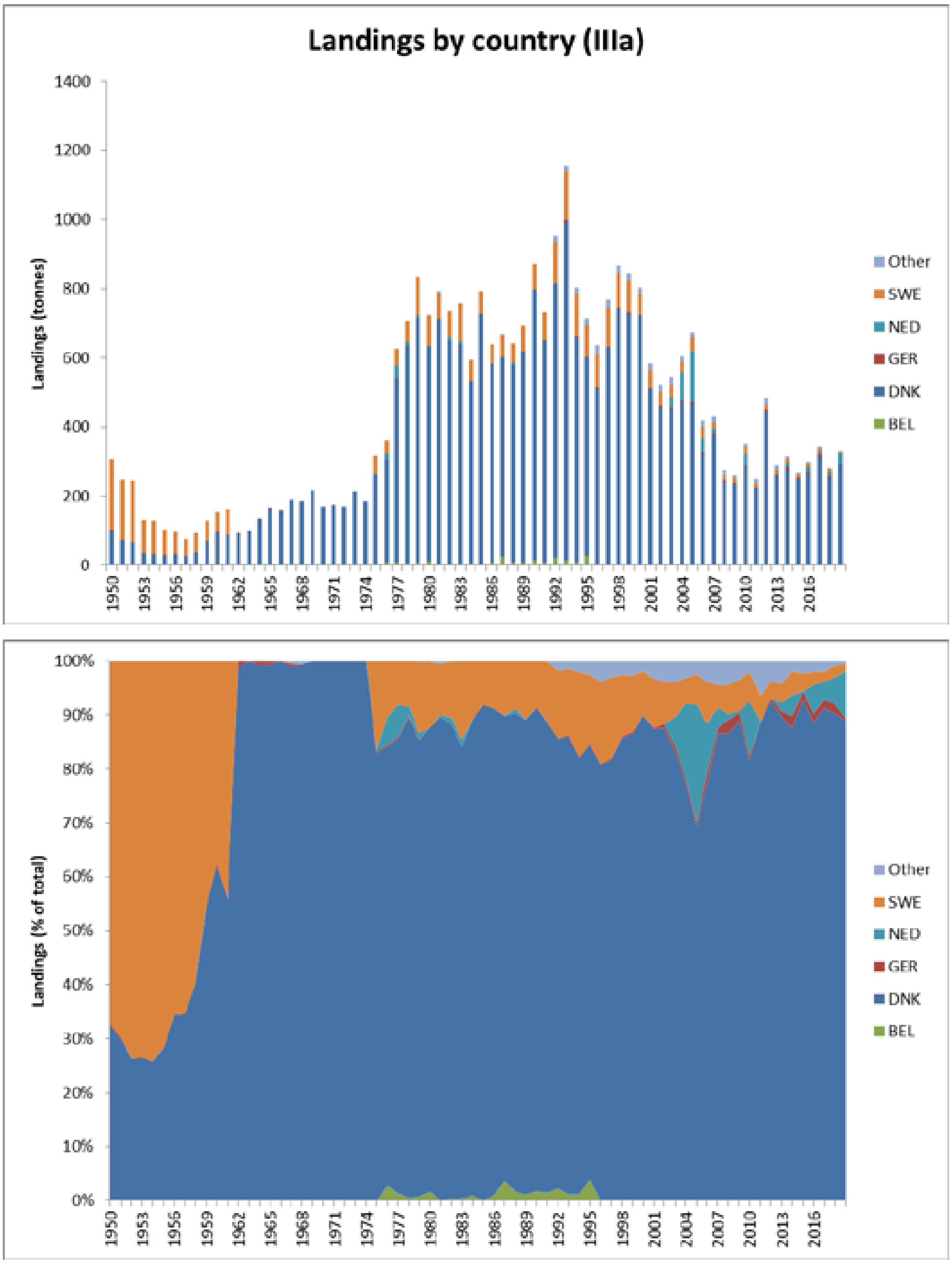

Landings (% of total)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
7.d
4
3.a

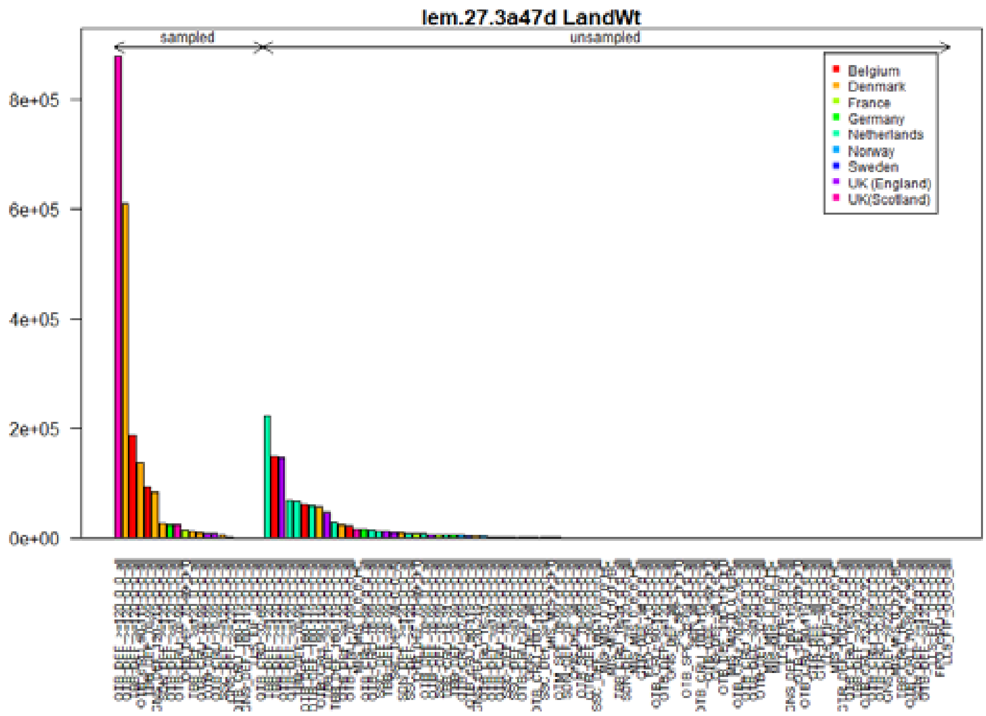

Landings by country (VIId)
Landings (tonnes)
Other
UK
NED
FRA
DNK
BEL

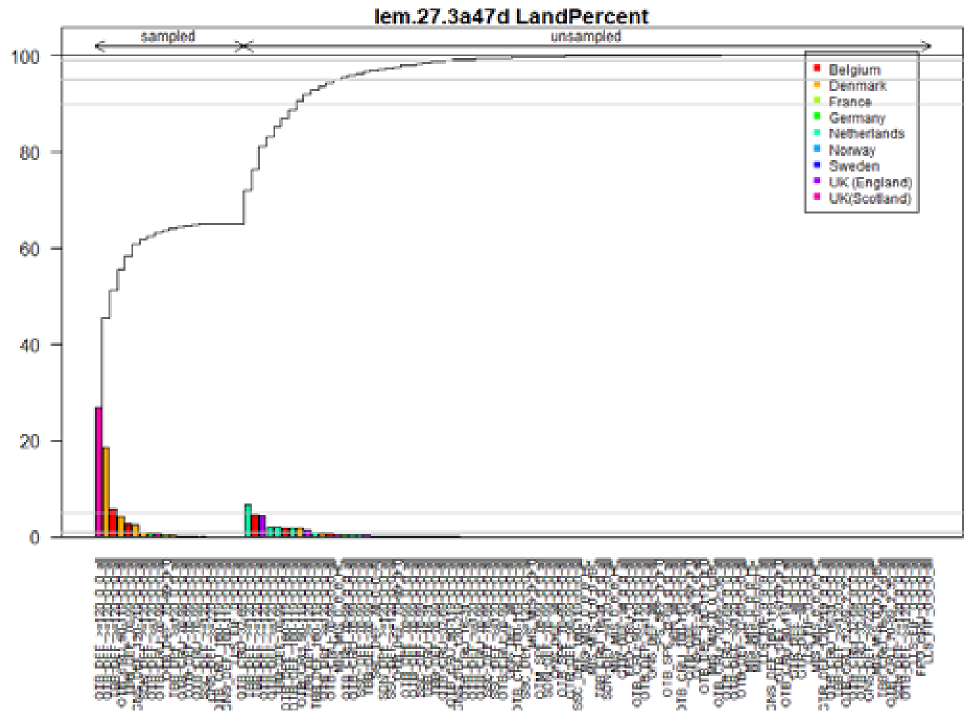

Landings (% of total)
Other
UK
NED
FRA
DNK
BEL

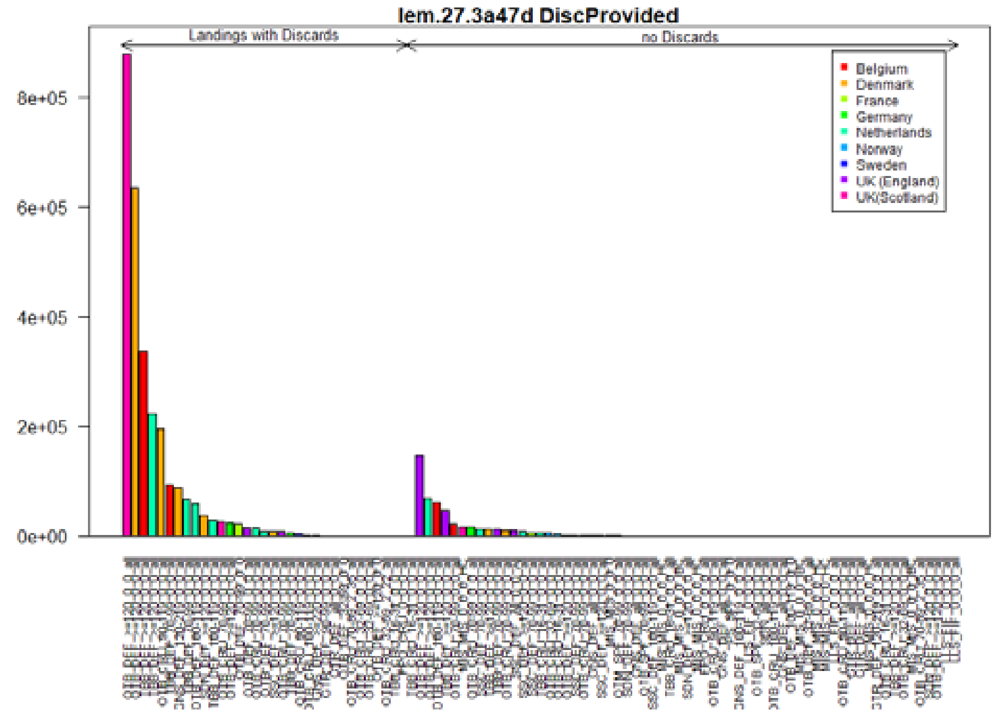

Landings by country (IV)
Landings (tonnes)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
Other
UK
NOR
NED
GER
FRA
DNK
BEL

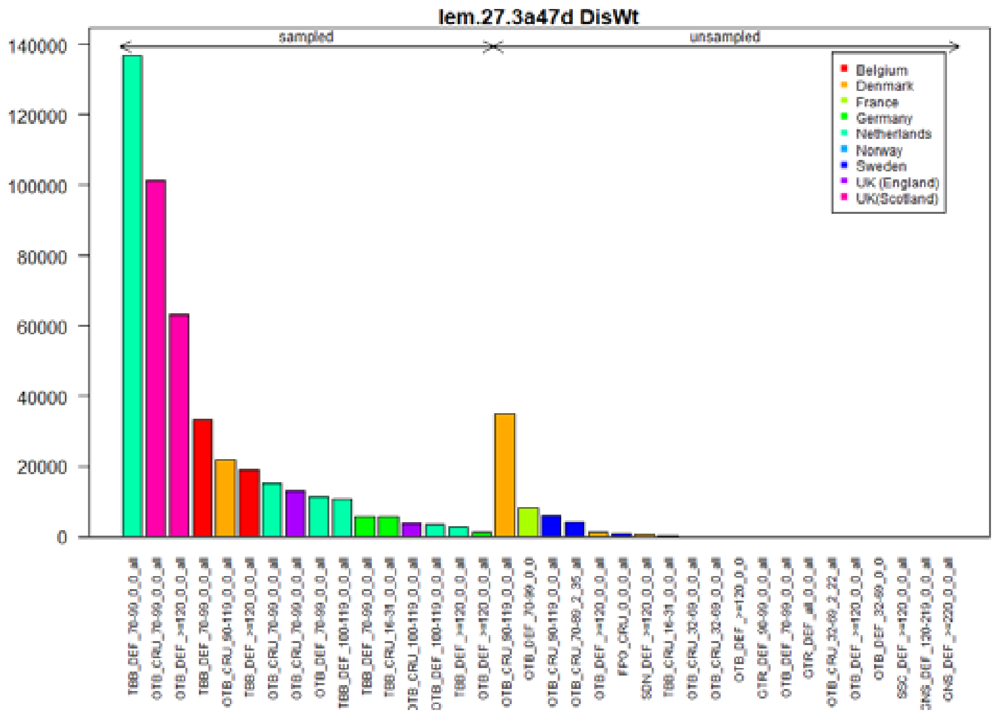

Landings (% of total)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
Other
UK
NOR
NED
GER
FRA
DNK
BEL

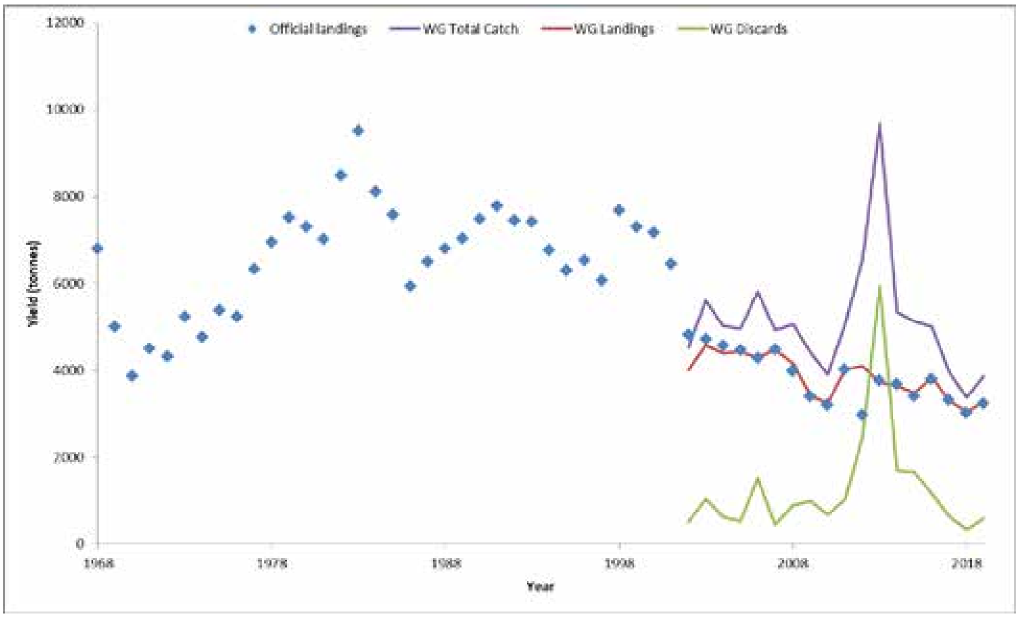

Landings by country (IIIa)
Landings (tonnes)
Other
SWE
NED
GER
DNK
BEL
Landings (% of total)


lem.27.3a47d LandWt
sampled
unsampled
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)
8e+05
6e+05
4e+05
2e+05
0e+00

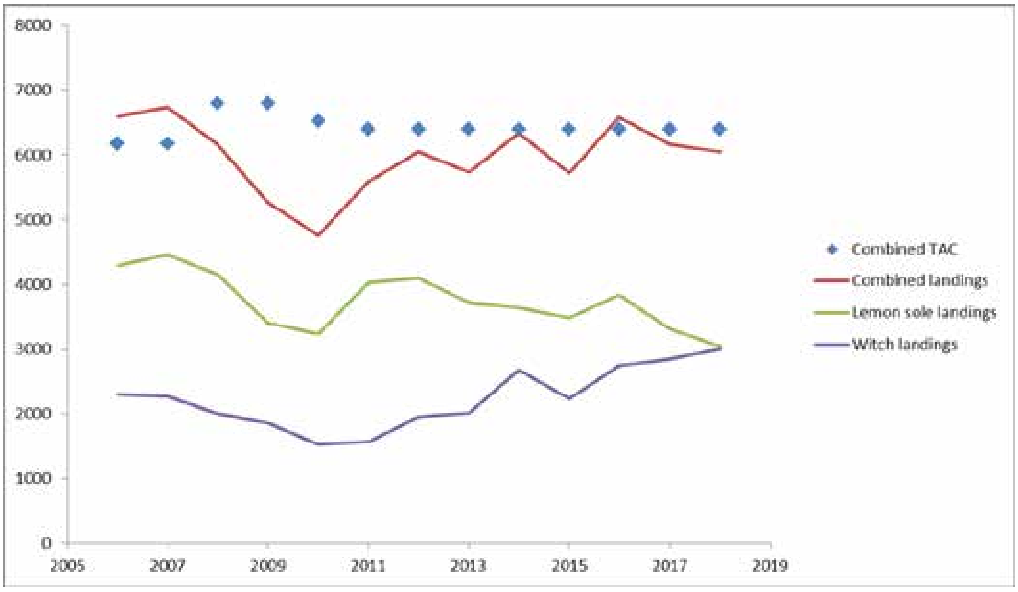

lem.27.3a47d LandPercent
sampled
unsampled
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)
100
80
60
40
20
0


lem.27.3a47d DiscProvided
Landings with Discards
no Discards
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)
8e+05
6e+05
4e+05
2e+05
0e+00


lem.27.3a47d DisWt
sampled
unsampled
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)
140000
120000
100000
80000
60000
40000
20000
0

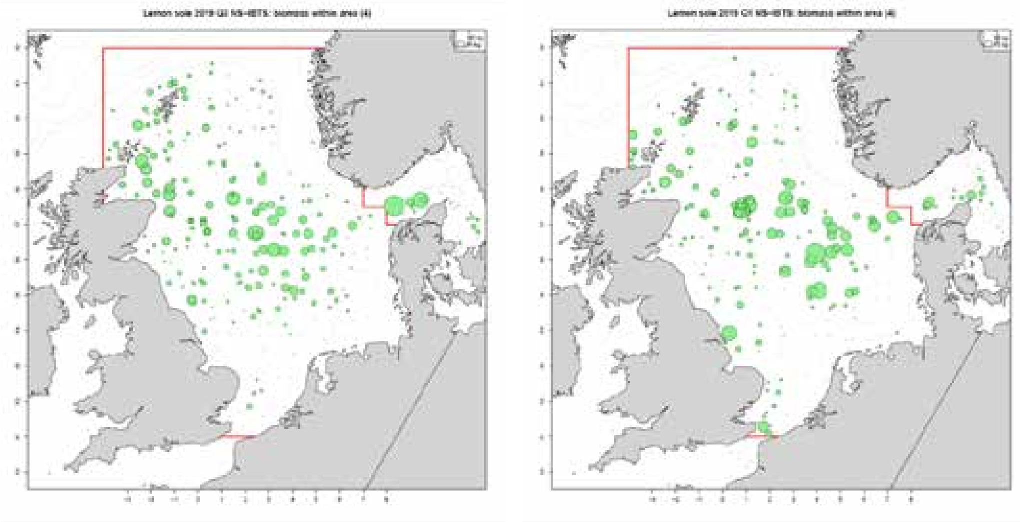


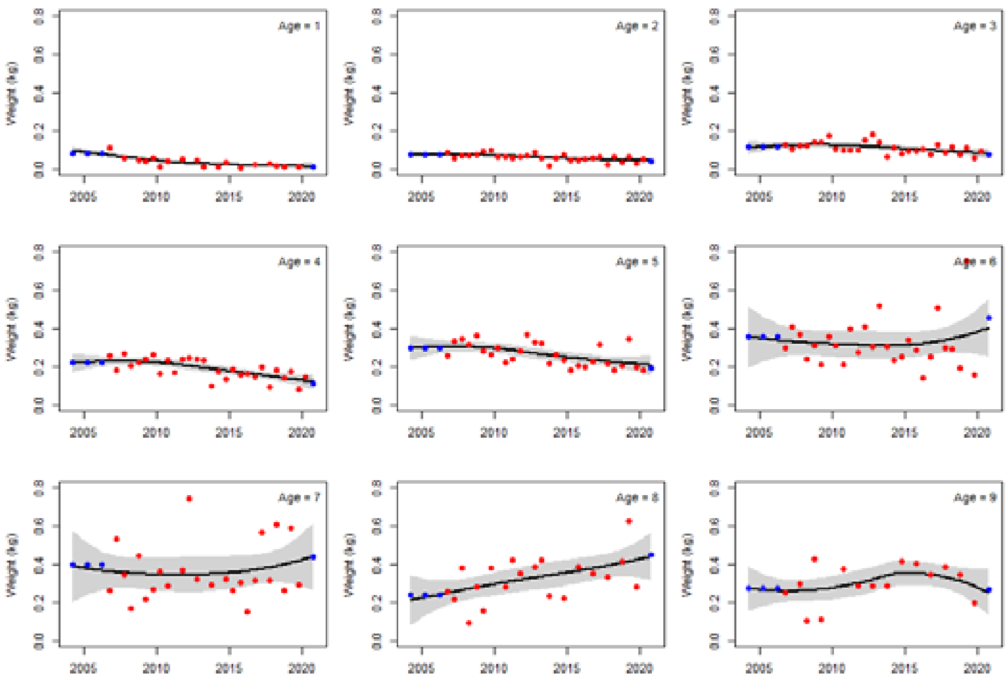
Official landings
WG Total Catch
WG Landings
WG Discards
Yield (tonnes)
Year

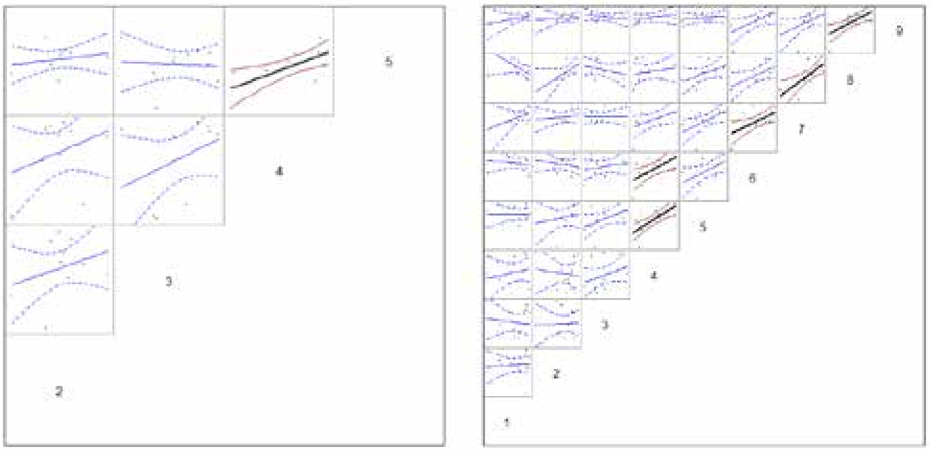


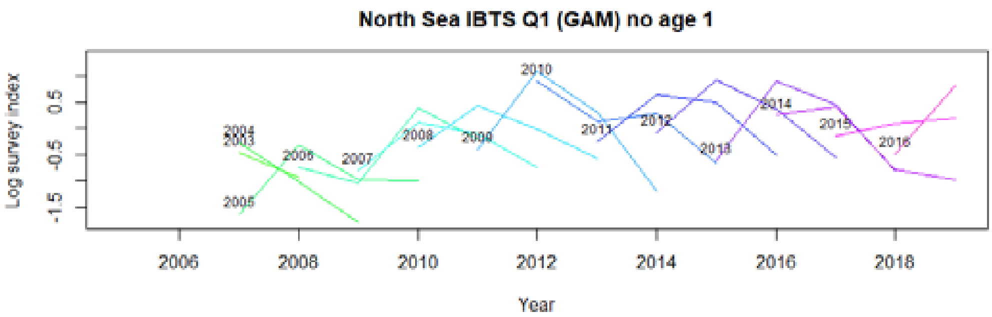
Combined TAC
Combined landings
Lemon sole landings
Witch landings

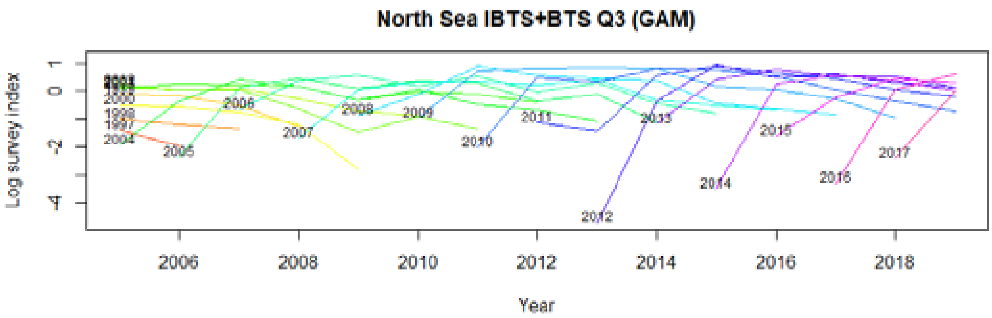
Figure 9.2.10. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of ICES WG estimates of landings for lemon sole (green line), witch (purple line) and combined (red line), along with the joint lemon sole-witch TAC (dots).

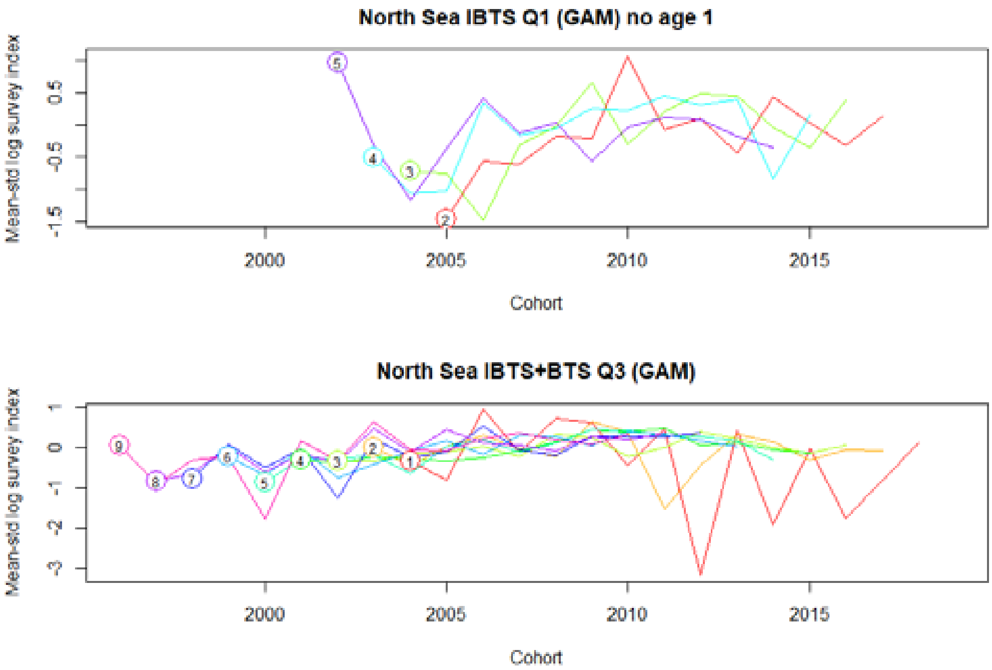




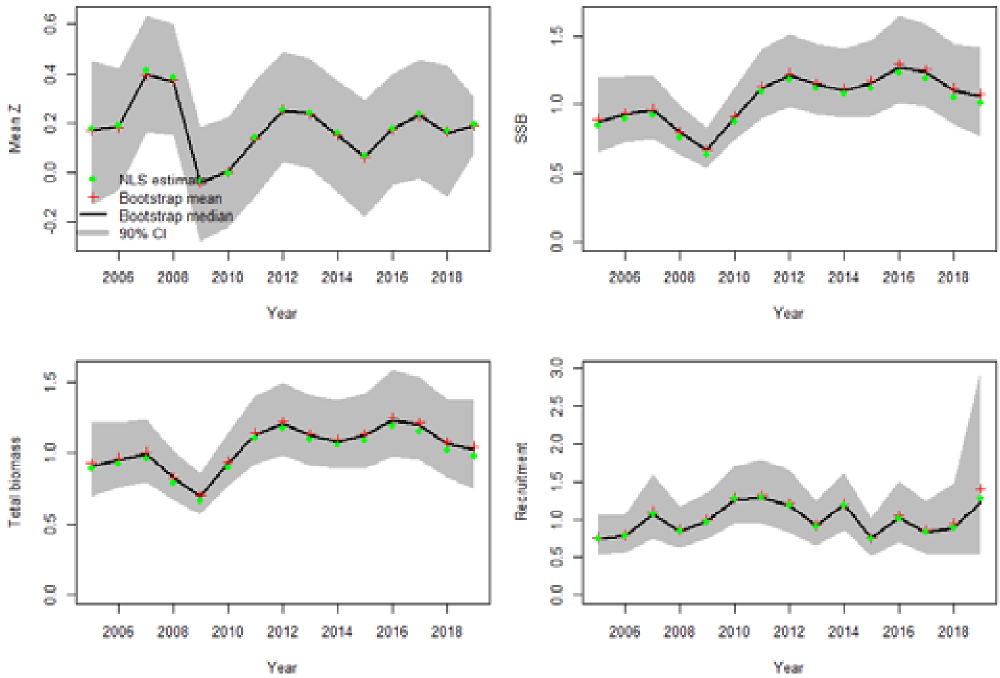


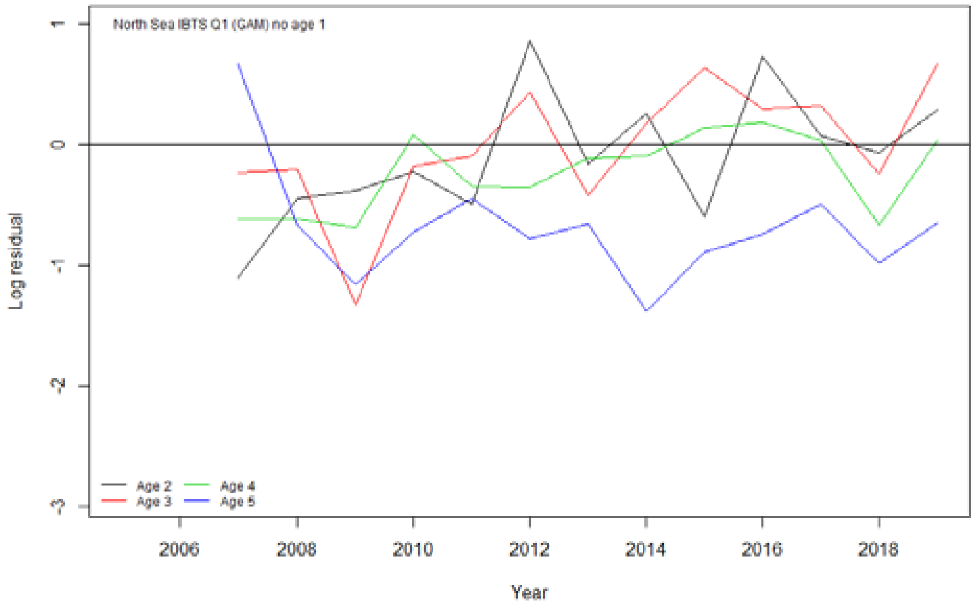

North Sea IBTS Q1 (GAM) no age 1
Log survey index
Year

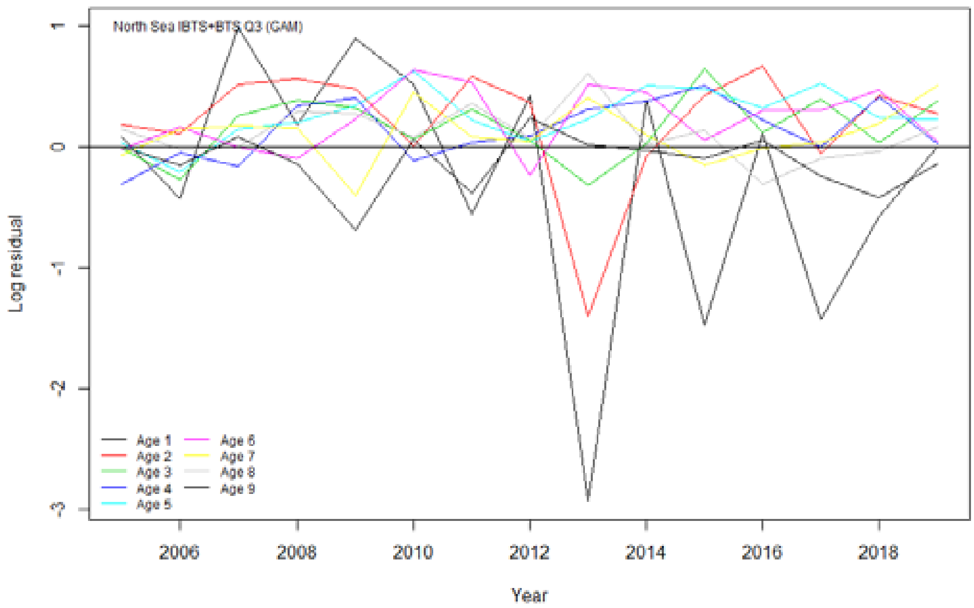

North Sea IBTS+BTS Q3 (GAM)
Log survey index
Year

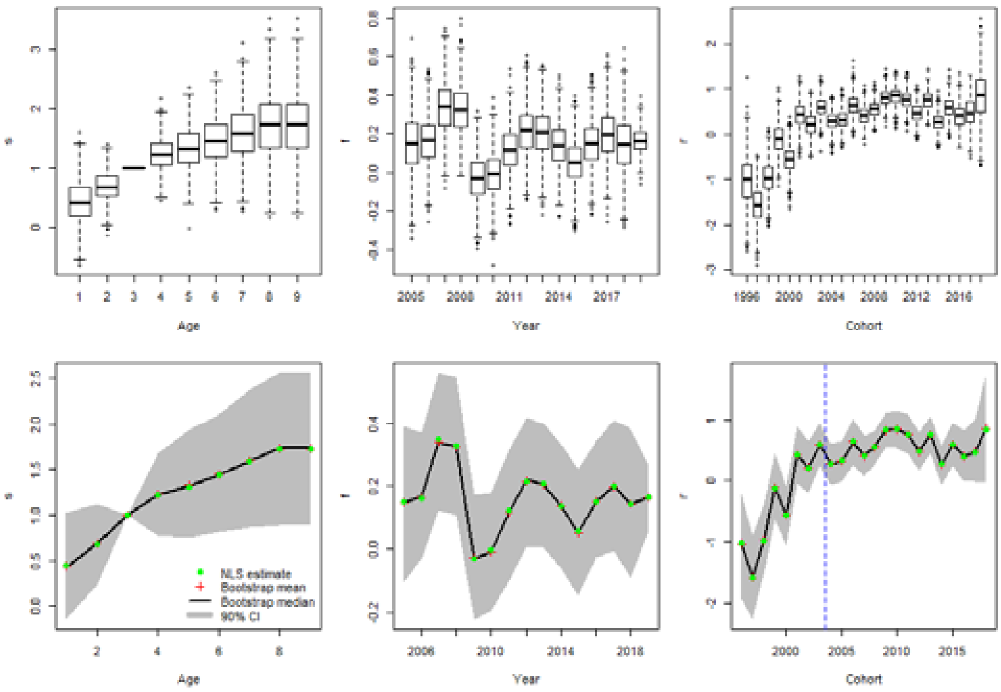

North Sea IBTS Q1 (GAM) no age 1
Mean-std log survey index
Cohort
North Sea IBTS+BTS Q3 (GAM)
Mean-std log survey index
Cohort

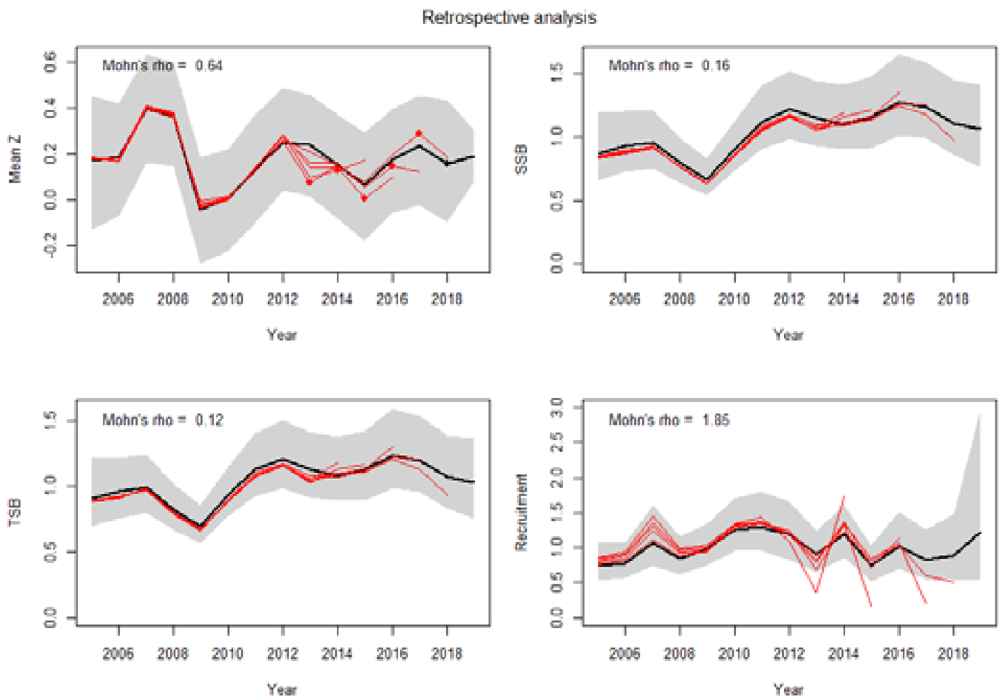

Age 1
Age 2
Age 3
Age 4
Age 5
Age 6
Age 7
Age 8
Age 9

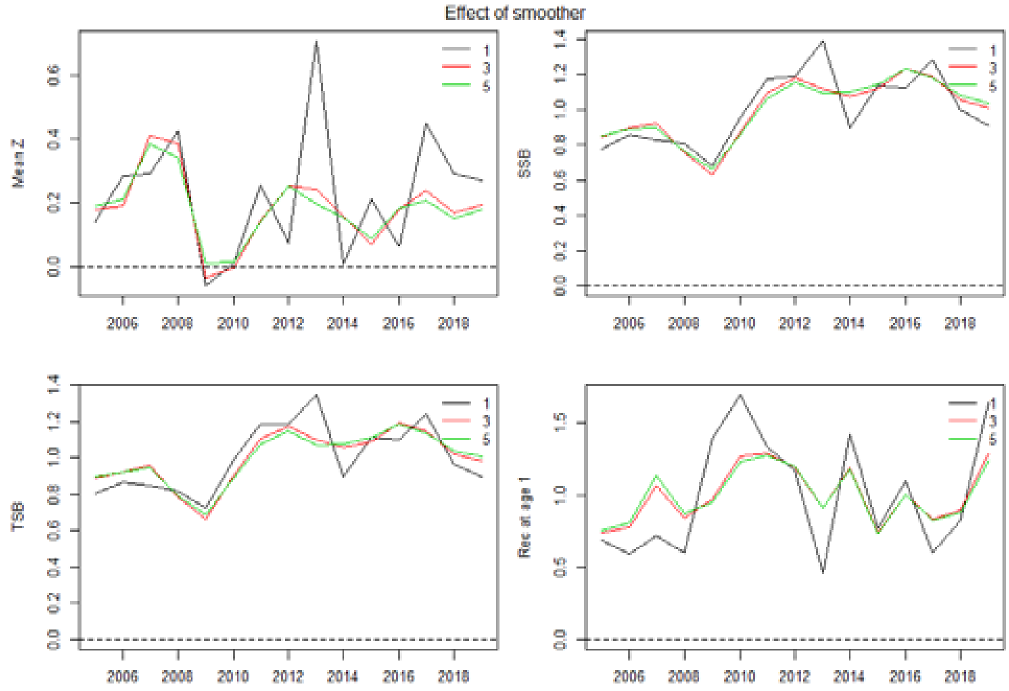

Mean Z
NLS estimate
Bootstrap mean
Bootstrap median
90% CI
Year
SSB
Year
Total biomass
Year
Recruitment
Year

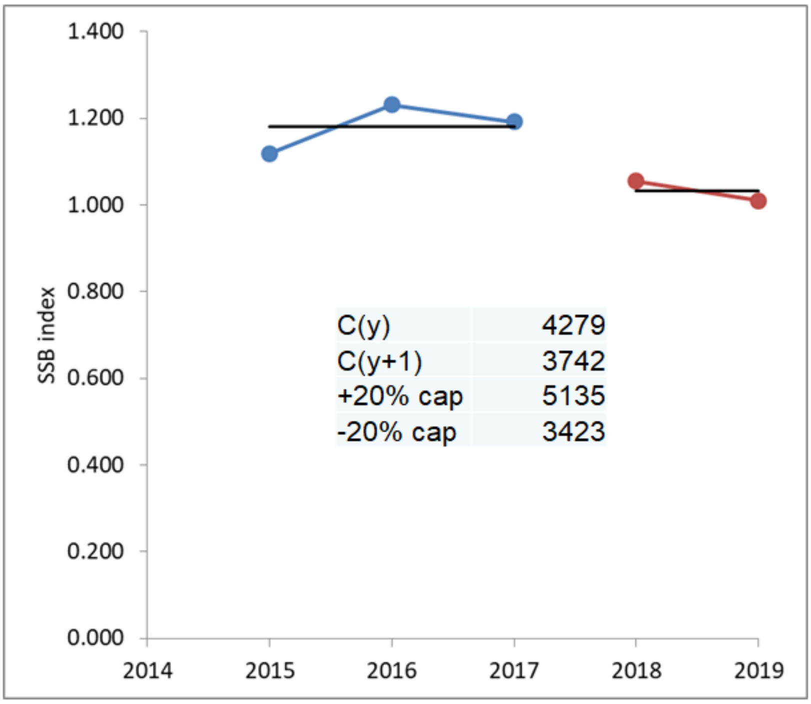

North Sea IBTS Q1 (GAM) no age 1
Log residual
1
0
-1
-2
-3
Age 2
Age 3
Age 4
Age 5
2006
2008
2010
2012
2014
2016
2018
Year

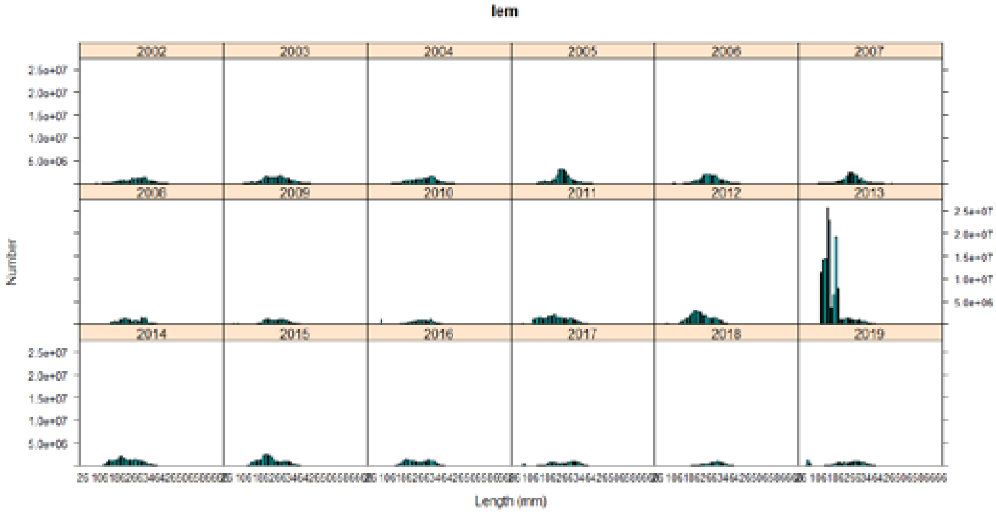

North Sea IBTS+BTS Q3 (GAM)
Log residual
1
0
-1
-2
-3
Age 1
Age 2
Age 3
Age 4
Age 5
Age 6
Age 7
Age 8
Age 9
2006
2008
2010
2012
2014
2016
2018
Year

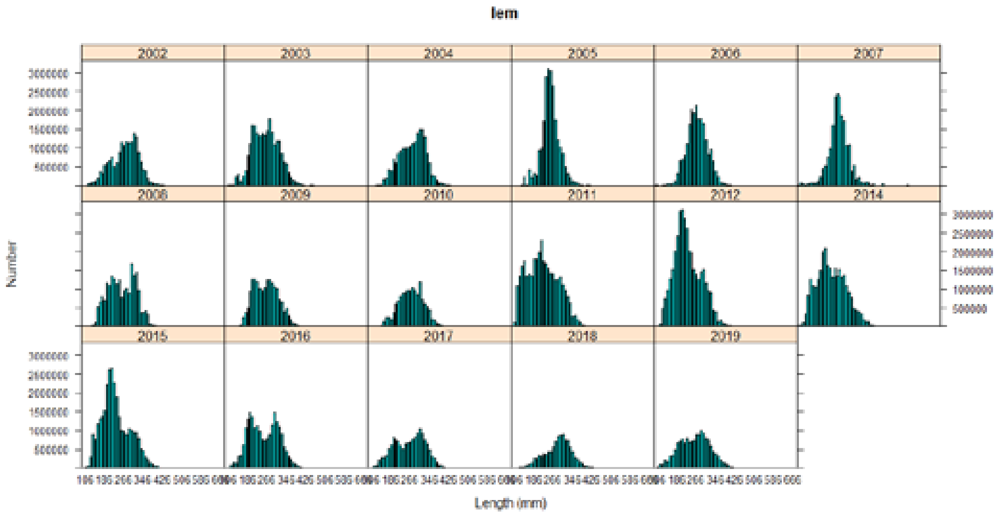

Age
Year
Cohort
NLS estimate
Bootstrap mean
Bootstrap median
90% CI

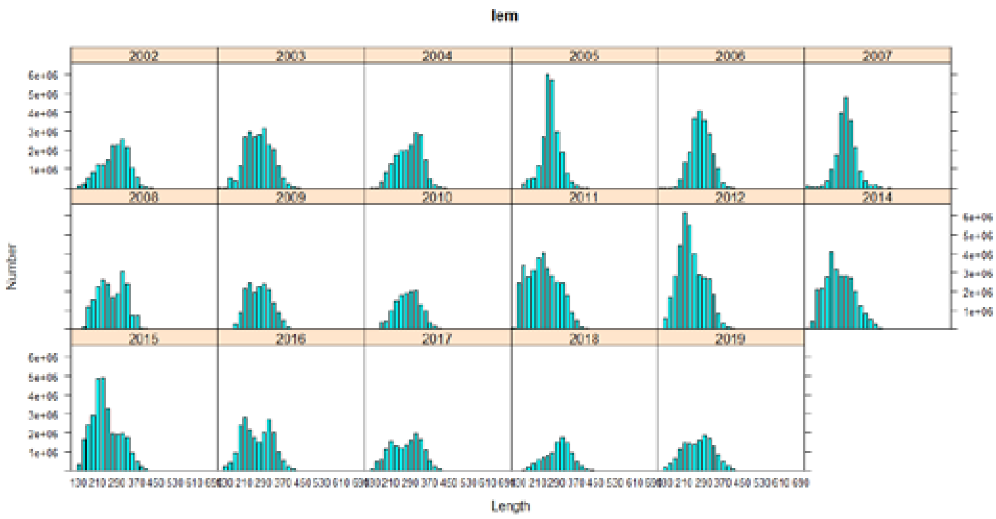

Retrospective analysis
Mohn's rho = 0.64
Mean Z
Mohn's rho = 0.16
SSB
Mohn's rho = 0.12
TSB
Mohn's rho = 1.85
Recruitment
Year

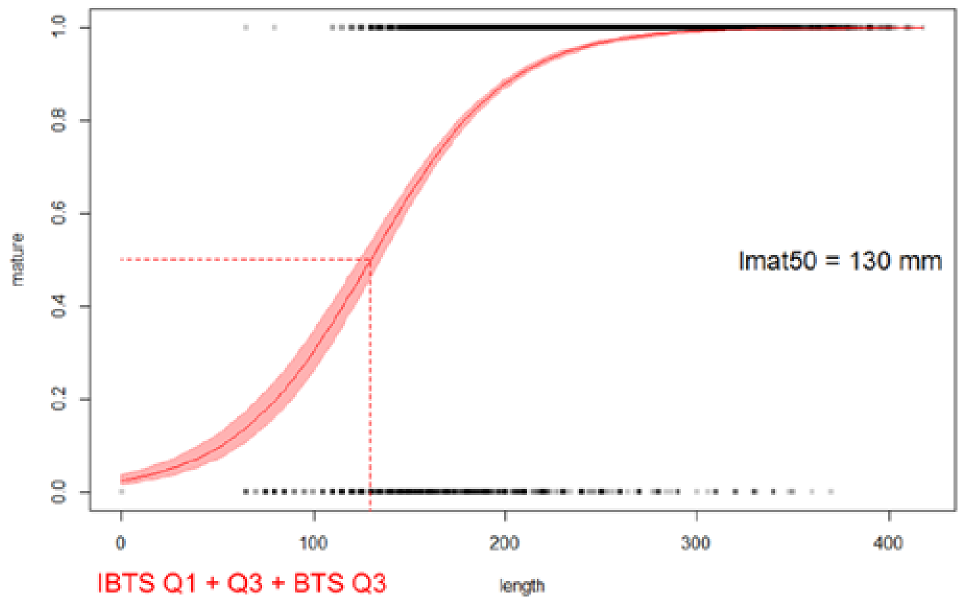

Effect of smoother
Mean Z
SSB
TSB
Rec at age 1
1
3
5
2006
2008
2010
2012
2014
2016
2018

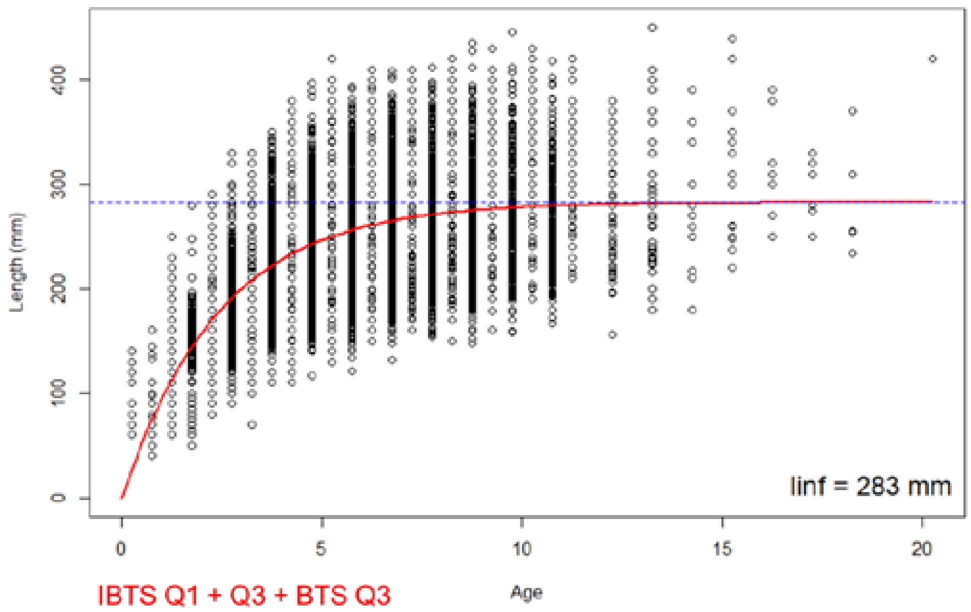

SSB index
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
2014
2015
2016
2017
2018
2019
C(y) 4279
C(y+1) 3742
+20% cap 5135
-20% cap 3423

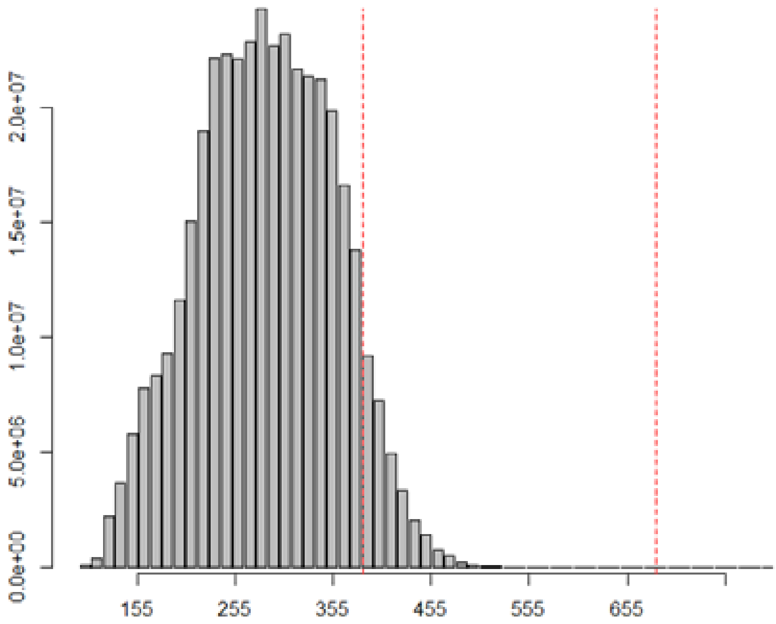

lem
Number
Length (mm)

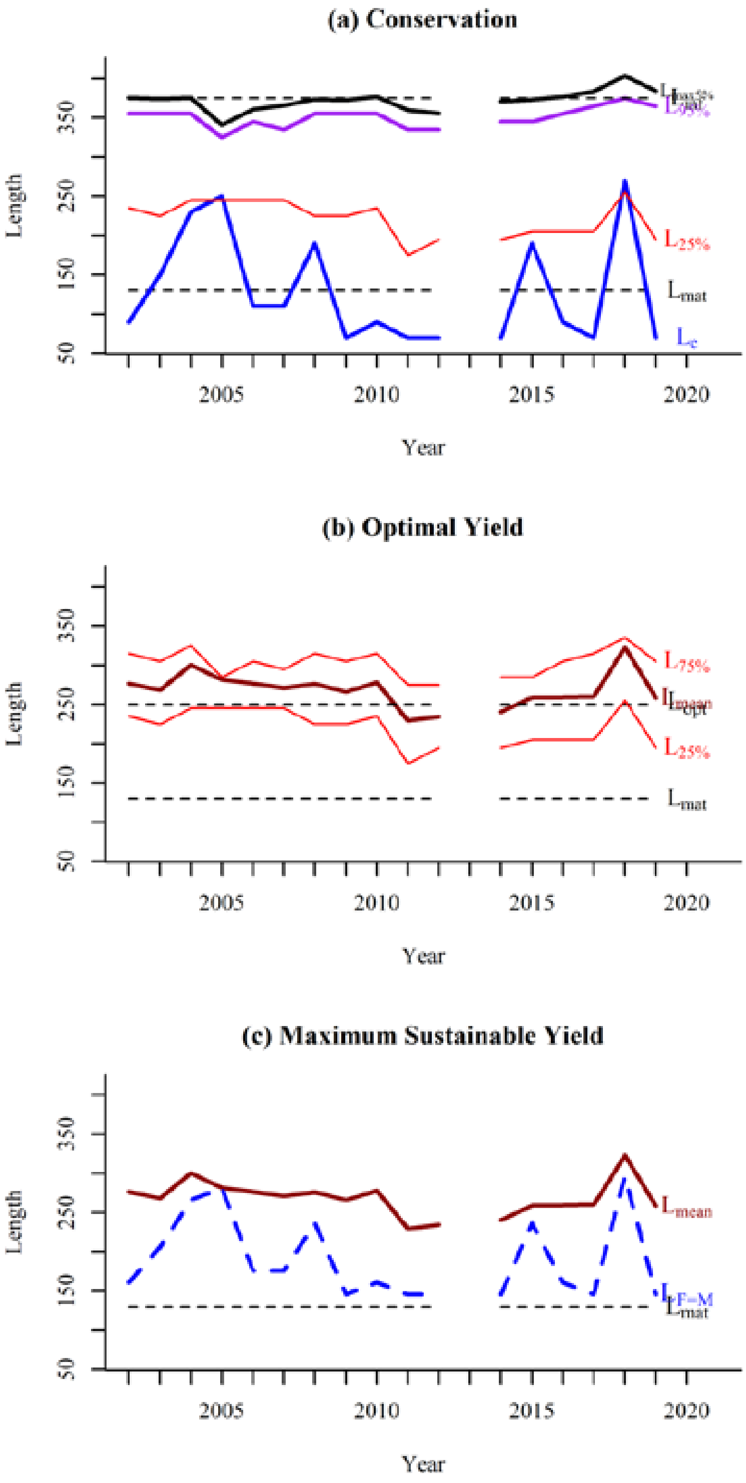

lem
Number
Length (mm)

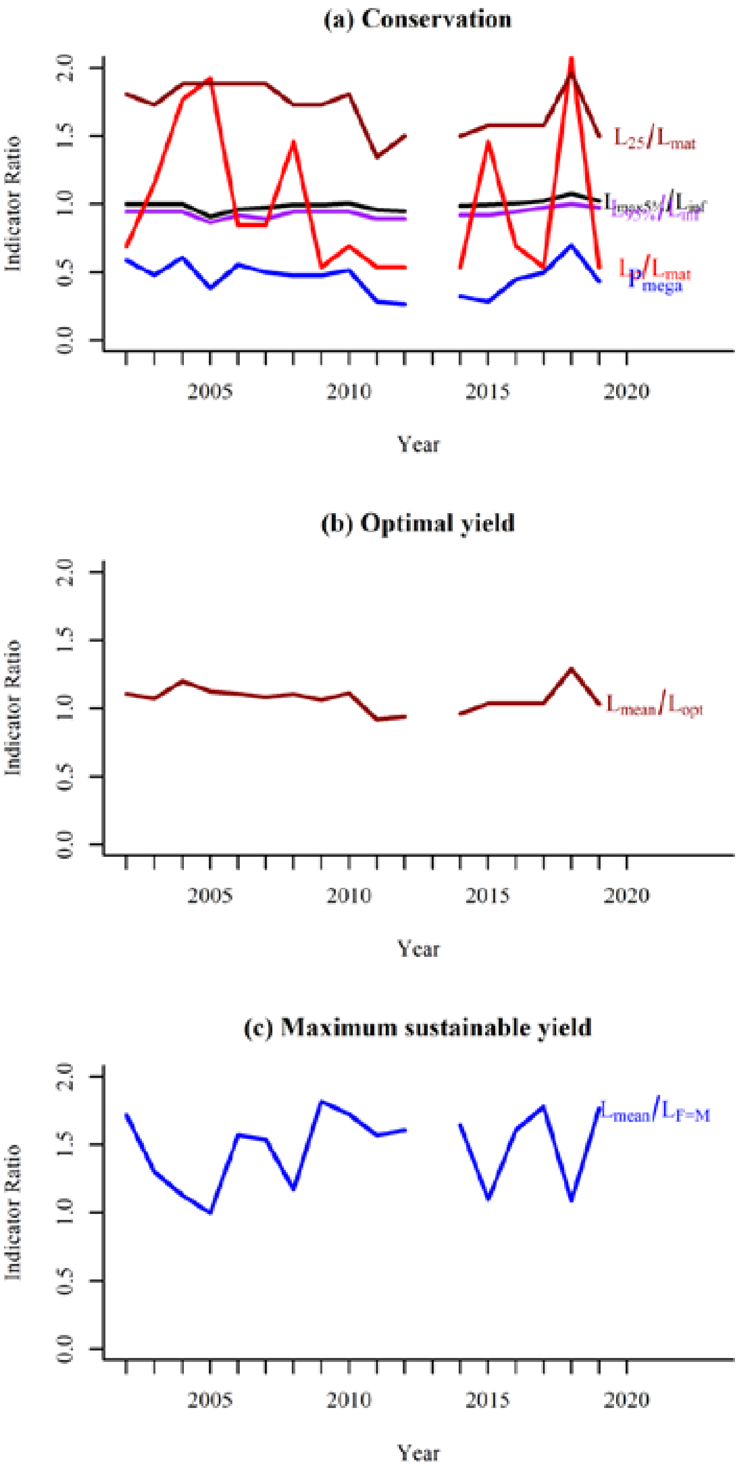

lem
Number
Length


mature
0.0
0.2
0.4
0.6
0.8
1.0
0
100
200
300
400
length
lmat50 = 130 mm
IBTS Q1 + Q3 + BTS Q3


Length (mm)
0
100
200
300
400
0
5
10
15
20
Age
linf = 283 mm
IBTS Q1 + Q3 + BTS Q3


0.0e+00
5.0e+06
1.0e+07
1.5e+07
2.0e+07
155
255
355
455
555
655


(a) Conservation
Length
Year
L25%
Lmat
Lc
(b) Optimal Yield
Length
Year
L75%
L25%
Lmat
(c) Maximum Sustainable Yield
Length
Year
Lmean
50
150
250
350
2005
2010
2015
2020


(a) Conservation
Indicator Ratio
0.0 0.5 1.0 1.5 2.0
2005 2010 2015 2020
Year
L25/Lmat
Pmega
(b) Optimal yield
Indicator Ratio
0.0 0.5 1.0 1.5 2.0
2005 2010 2015 2020
Year
Lmean/Lopt
(c) Maximum sustainable yield
Indicator Ratio
0.0 0.5 1.0 1.5 2.0
2005 2010 2015 2020
Year
Lmean/LF=M

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

10.1 General

At present, there are two functional units in Division 3.a: Skagerrak (3.a.20) and Kattegat (3.a.21). This separation was based on observed differences between Skagerrak and Kattegat regarding *Nephrops* size composition in catches in the 1980s and 1990s. However, the distribution of *Nephrops* is almost continuous from southern Kattegat into Skagerrak, and the exchange of pelagic larvae between the southern and northern areas is very likely. With the longer data series now available, it seems the differences in size composition between the two areas are more likely to be random or caused by factors from fishing operations. The assessment is therefore conducted on *Nephrops* in 3.a as one stock.

Ecosystem aspects

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

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of 3.a in late summer, where unusually high catch rates of *Nephrops* were observed. The increasing amount of dead specimens in the catches led to the conclusion of severe oxygen deficiency in especially the Kattegat (3.a.21) in late 1988 (Bagge *et al*., 1990).

No information is available on the extent to which larval mixing occurs between *Nephrops* stocks, but the similarity in stock indicator trends between 3.a.20 and 3.a.21 for both Denmark and Sweden indicates that recruitment has been similar in both areas. These observations suggest they may be related to environmental influences.

ICES Advice

The most recent advice for *Nephrops* in 3.a was given in 2018. ICES concluded that:

´The stock size is considered to be stable. The estimated harvest rate for this stock is currently below F_{MSY}.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area 3.a was increased from 5318 tonnes in 2015 to 11 001 tonnes in 2016, 12 715 tonnes in 2017, 11 738 tonnes in 2018 and 13 733 tonnes in 2019. The large increase in quota 2015 to 2016 was due to the fact that the EU shifted from providing landings advice to providing catch advice. The minimum conservation reference size (previously referred to as minimum landings size) for *Nephrops* in area 3.a was reduced in 2016 from 40 to 32 mm carapace length. The historically large MLS led to a high discard ratios (discards/(discards + landings)) around 50%, and the discard proportion 2016 was decreased to 12% of the catch (in numbers) in 3.a consisted of undersized individuals. In 2017 and 2018, the discard proportion increased to 32 and 46%, respectively, probably as a result of increased recruitment (Figure 10.2.1.1). The reduction in MLS has reduced the proportion of the catch discarded considerably. Furthermore, it is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. A discard ban was implemented in EU waters from 1 January 2015. The discard ban became applicable to *Nephrops* from 1 January 2016, however an exemption for high survivability was introduced. New technical measures have also been agreed upon and have been implemented since 1 February 2013.

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

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

10.2.1 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 71 % and 26 % by weight of the landings in 2019, 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 2 670 tonnes. Since then they have been fluctuating around a mean of 2500 tonnes (Figure 10.2.2.1). In recent increase landings have increased to 4625 tonnes in 2019 (Table 10.2.1.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2019, Denmark accounted for about 77 % of total landings in FU4, while Sweden took 23 % (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 til 2015, landings show a decreasing trend. Landings have increased since 2015 reaching 3128 tonnes in 2019, the maximum observed in the time series.

10.2.2 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 til 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 1992–2019. 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.

10.2.3 Natural mortality, maturity at age and other biological parameters

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

Growth parameters are as follows:

Males:

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).

10.2.5 Catch and effort data–FU4

Swedish total effort has been relatively stable over the period 1978–90. Effort increased from 1990 to 1993, followed by a decrease to 1996. During the last 20 years effort has remained relatively stable, except for 2007 and 2008 where effort increased (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.

10.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

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

10.3.1 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 2019. A similar survey design has been applied for both national surveys: a fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in 3.a. VMS data from the Swedish and Danish fishery from 2010 were used (Figure 10.2.3.3) and are described in more detail in ICES (2011). The area estimates for each Subarea are defined in Table 10.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS (ICES 2013).

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in 3.a divided into sub-areas Figure 10.2.3.2 is shown in Table 10.2.3.1 and Figure 10.2.3.4.

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

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

10.3.2 Assessment

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2019. Additional used information was trends in total combined (Denmark and Sweden) lpue, and discards (numbers) as a proxy for recruitment during the period 1990–2018.

Combined relative effort declined slightly over the period 1990 to 2019 (Figure 10.2.4.1) while combined relative lpue shows an increasing trend and is at a high level in 2019 (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.

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

The absolute burrow density in Division 3.a is medium (0.3–0.8/m^2), the observed harvest rate is below $F_{0.1}$ and historically the fishery is stable both spatially and temporally. This means that $F_{0.1}$ may be selected as a proxy for F_{MSY}. As the MLS has been decreased in 2016 it is recommended to use F_{max} as a proxy for F_{MSY} as in last years. For 2019 this corresponds to a TAC of 13 733 tonnes if a landing obligation is applied. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with F_{MSY} as total catches would be subjected to 100% mortality (current discard survival is estimated to be 25 %).

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

	Male	Female	Combined
Fmax	6.8 %	10.0 %	7.9 %
F0.1	4.9 %	7.6 %	5.6 %
F35%SpR	8.1 %	12.9 %	10.5 %

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

Norway lobster in Division 3.a. The catch scenarios (weight in tonnes):

Basis	Total catch	Dead removals	Wanted catch	Dead unwanted catch	Surviving unwanted catch	Harvest rate*	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
EU MAP^: F_{MSY}	19 904	19 313	17 540	1 773	591	7.9	-8.02%
F= MAP $F_{MSY\ lower}$	14 109	13 690	12 433	1 257	419	5.6	-34.80%
F = MAP $F_{MSY\ upper}$***	19 904	19 313	17 540	1 773	591	7.9	-8.02%
Other scenarios							
F_{2018}	9 019	8 751	7 948	803	268	3.6	-58.32%

Basis	Total catch	Wanted catch	Unwanted catch	Harvest rate *	% advice change **
	WC+UC	WC	UC	for WC+UC	
EU MAP^: F_{MSY}	18 643	16 429	2 214	7.9	-13.85%
F= MAP $F_{MSY\ lower}$	13 215	11 646	1 569	5.6	-38.93%
F = MAP $F_{MSY\ upper}$***	18 643	16 429	2 214	7.9	-13.85%
Other scenarios					
F_{2018}	8 448	7 445	1 003	3.58	-60.96%

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

* Calculated in numbers for dead removals.

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

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

A summary of the results from the TV survey 2019 is presented in Table 10.2.3.1. The estimated abundance index was 0.354 resulting in a total abundance of 4502 million individuals. Total removals (landings + dead discards) were estimated to 198 million individuals resulting in a harvest rate of 3.7%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased by 50 % since 2002 and is currently at a low level while lpue shows an increasing trend and is at a long term high level in recent years (Figures 10.2.4.1 and 10.2.4.2). Mean sizes are fluctuating without trend. There are no signs of overexploitation in 3.a.

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

10.4 Biological reference points

No biological reference points are used for this stock.

10.5 Quality of the assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling in this fishery has been conducted on a quarterly basis for Danish and Swedish *Nephrops* trawlers since 1990, and is considered to represent the fishery adequately.

The UWTV survey 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.

10.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the nineth year (2011–2019; new Subarea 7 only in 2014–2019 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 2016–2019 harvest rate was estimated to be relatively low (3,1 % from UWTV surveys) implying the stock appears to be exploited sustainably.

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

10.7 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.

10.7.1 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 2019.

Table 10.1.1. Definition of Functional Units in 3.a and IV in terms of ICES statistical rectangles.

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

Table 10.2.1.1. Division 3.a: Total landings (tonnes) by Functional Unit, 1981–2019.

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
2018	4222	2878	7100
2019	4625	3128	7753

Table 10.2.1.2. Division 3.a: Total landings (tonnes) by country, 1991–2019.

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

Table 10.2.2.1. in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2019.

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

Table 10.2.2.2. Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish trawlers, 1991–2019. (*Include only trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	cpue	lpue
1991	676	401	71.4	9.5	5.6
1992	360	231	73.7	4.9	3.1
1993	614	279	72.6	8.4	3.8
1994	441	246	60.1	7.3	4.1
1995	501	336	60.8	7.8	5.2
1996	754	488	51.1	14.8	9.6
1997	643	437	44.4	14.4	9.8
1998	794	557	49.7	16.0	11.2
1999	605	386	34.5	17.5	9.3
2000	486	329	32.7	14.9	10.9
2001	446	236	26.2	17.0	10.4
2002	503	301	29.4	17.1	8.8
2003	310	254	21.5	13.9	11.4
2004*	474	257	20.1	23.6	13.4
2005*	760	339	29.7	25.6	12.7
2006*	839	401	37.5	22.4	12.2
2007*	894	314	24.1	37.0	13.0
2008*	605	264	20.0	30.3	13.2
2009*	482	285	19.6	24.5	14.5
2010*	476	286	20.7	23.0	13.8
2011*	334	198	16.8	19.9	11.8
2012*	542	238	16.0	33.8	14.9
2013*	251	137	11.3	22.2	12.1
2014*	240	157	11.0	21.7	14.2
2015*	187	133	9.5	19.6	14.0
2016*	216	188	14.9	14.4	12.6

2017*	362	232	16.9	21.4	13.7
2018*	369	265	13,5	27,3	19,6
2019*	287	224	12.7	22.5	17.6

Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4

Twin trawl (continued)					
Year	Catches	Landings	Effort	CPUE	LPUE
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1
2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3
2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6

2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8
2014*	484	316	16.0	30.3	19.8
2015*	328	234	11.3	28.9	20.6
2016*	471	410	20.1	23.4	20.4
2017*	667	427	17.5	38.2	24.5
2018*	851	610	21,1	40,4	29,0
2019*	847	662	23.7	35.8	28.0

Table 10.2.2.3. Skagerrak (FU 3): Logbook recorded effort (kW days, Days at sea, and fishing days) and lpue (kg/day) for bottom trawlers catching with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2019.

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

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female in catches of Danish and Swedish combined, 1991–2019.

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

Table 10.2.2.5. Kattegat (FU 4): Landings (tonnes) by country, 1991–2019.

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

Table 10.2.2.6. Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish trawlers, 1991–2019 (*Include only trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	66	39	10.3	6.4	3.7
1992	44	28	11.6	3.8	2.4
1993	128	58	14.9	8.6	3.9
1994	95	53	16.2	5.7	3.2
1995	79	53	9.6	7.8	5.5
1996	207	134	13.7	15.1	9.8
1997	269	183	18.0	15.0	10.2
1998	181	127	13.1	13.8	9.7
1999	146	93	8.1	17.9	11.4
2000	114	77	8.5	13.4	9.1
2001	117	62	7.6	15.4	8.2
2002	42	25	3.7	11.2	6.7
2003	49	40	4.6	10.7	8.7
2004	70	44	4.3	16.2	10.1
2005	147	100	12.3	11.9	8.1
2006	234	154	15.1	15.5	10.2
2007*	107	51	4.1	25.7	12.3
2008*	121	57	4.4	27.6	13.0
2009*	157	81	5.1	30.9	16.1
2010*	181	102	7.6	23.8	13.4
2011*	75	45	3.8	20.0	12.0
2012*	80	45	3.4	23.5	13.3
2013*	44	26	2.3	19.5	11.6
2014*	35	25	2.2	15.8	11.6
2015	43	29	2.6	16.6	11.0
2016*	50	47	5.4	9.4	8.7

2017*	65	45	4.0	16.2	11.2
2018*	84	63	4.1	20.4	15.4
2019*	92	71	4.6	20.0	15.5

Twin trawl					
Year	Catches	Landings	Effort	cpue	lpue
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4

Twin trawl (continued)					
Year	Catches	Landings	Effort	cpue	lpue
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	8.9	7.3
2004	253	158	16.5	15.4	9.6
2005	198	135	15.3	12.9	8.8
2006	183	121	12.7	14.4	9.5
2007*	112	54	3.6	30.9	14.8
2008*	164	78	4.8	34.1	16.1
2009*	309	161	11.0	28.2	14.6
2010*	297	167	9.2	32.2	18.1
2011*	266	159	9.7	27.3	16.3

2012*	406	231	12.4	32.8	18.6
2013*	354	210	15.0	23.7	14.0
2014*	282	206	14.4	19.6	14.4
2015	262	173	11.3	23.2	15.4
2016*	404	378	19.4	20.9	19.5
2017*	603	418	17.5	34.4	23.8
2018*	774	586	18,7	41,4	31,3
2019*	760	589	20.0	38.0	29.4

Table 10.2.2.7. Kattegat (FU 4): Logbook recorded effort (kW days, Days at sea, and fishing days) and lpue (kg/day) for bottom trawlers catching with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2019.

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

Table 10.2.2.8. Kattegat (FU 4): Mean sizes (mm CL) of male and female in discards, landings and catches, 1991–2019. 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

Table 10.2.3.1. Summary output of the TV-survey in 3.a from 2019.

Subarea	Area (km^2)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)
1	2575	32	0,282	0,124	725,757
2	1958	38	0,362	0,178	708,355
3	2613	36	0,415	0,143	1085,293
4	962	9	0,541	0,149	520,705
5	996	18	0,327	0,237	325,405
6	1719	26	0,482	0,143	828,294
7	1295	14	0,131	0,109	169,209
9	385	0	0, 362***	0,178***	139,283
Total	12503	178	0.354		4502,303
				Harvest rate	0.0371
Removals 2019 (landings + dead discards**)				198*	

*** In millions**

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

*****No stations in subarea 9, therefore values borrowed from nearest subarea (subarea 2)**

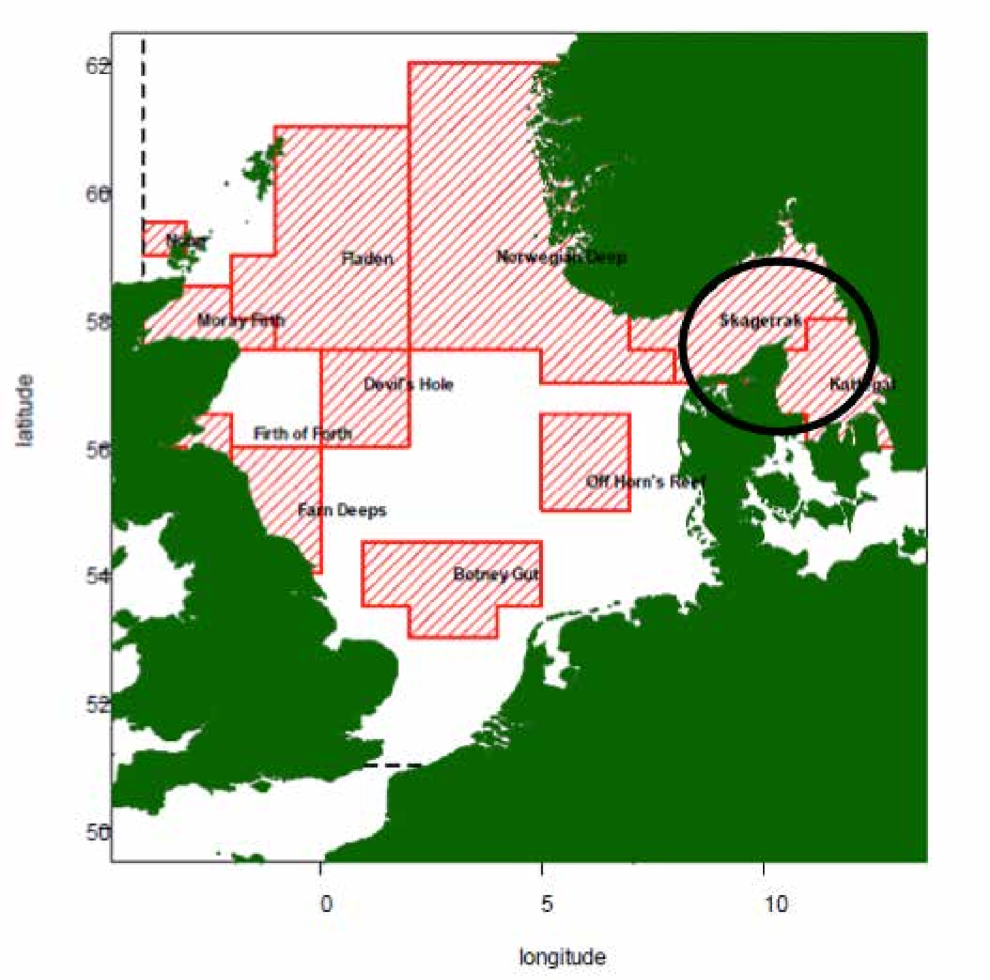


Figure 10.1.1. **Functional Units in the North Sea and Skagerrak/Kattegat region.**

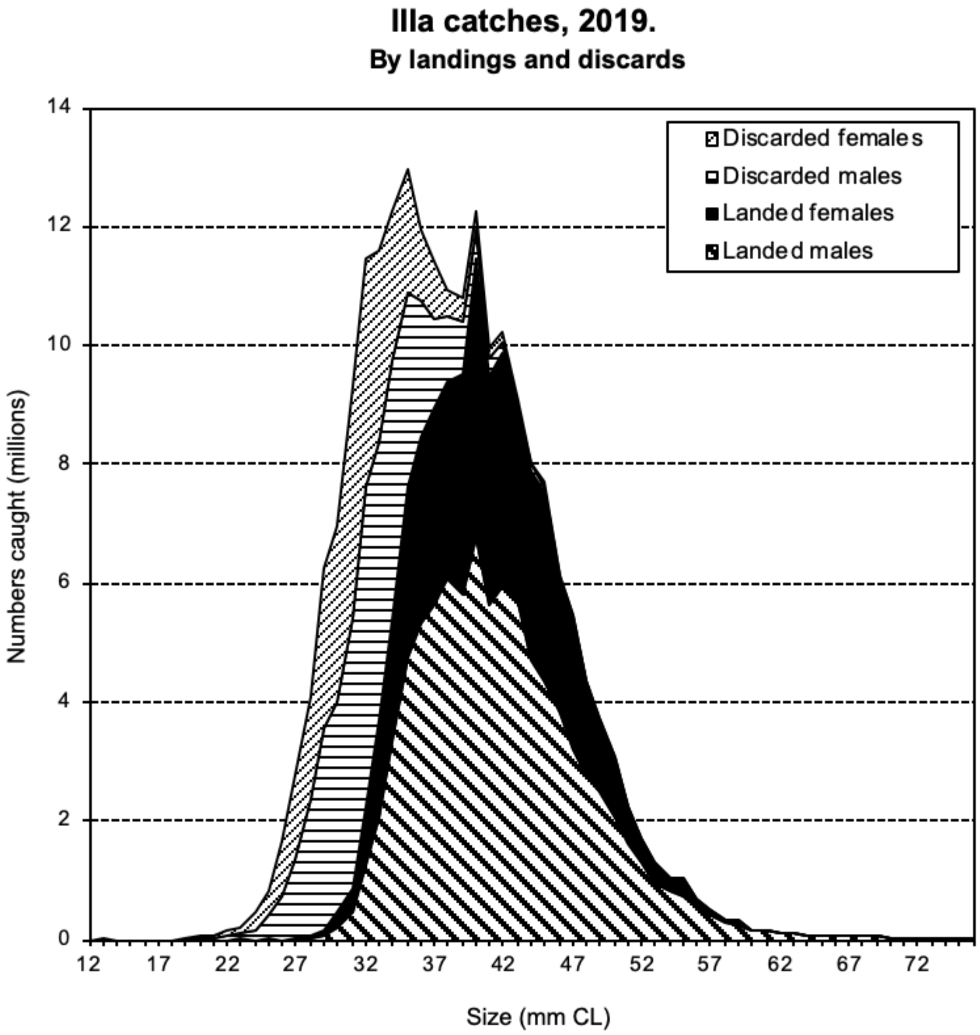


Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2019.

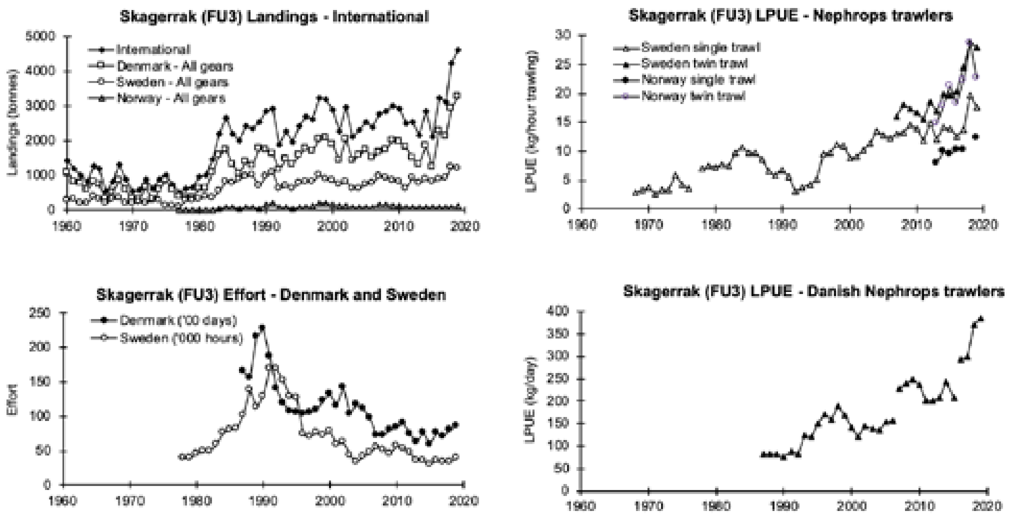


Figure 10.2.2.1. Skagerrak (FU 3): Long-term trends in landings, effort, and lpues.

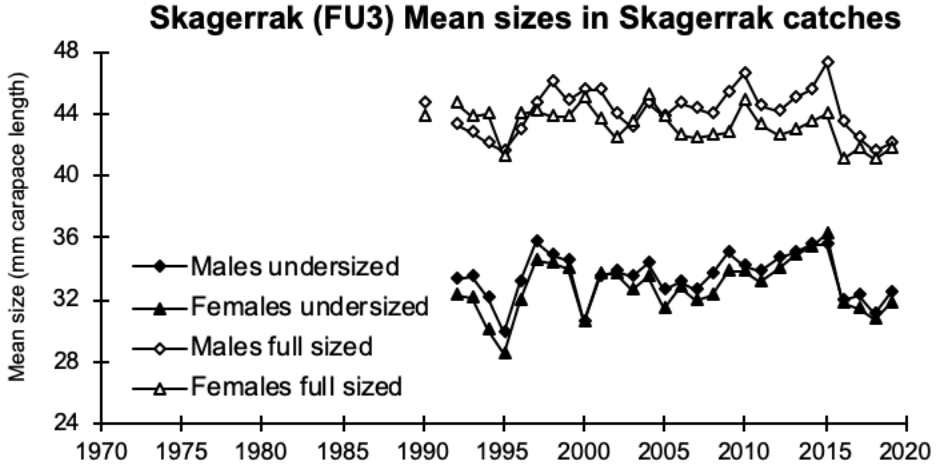


Figure 10.2.2.2. **in FU 3. Mean sizes in the catches.**

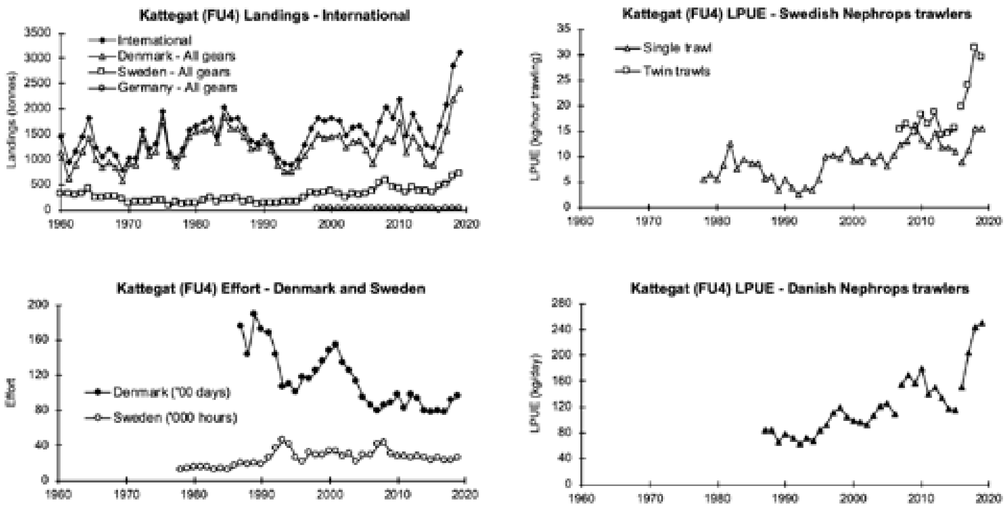


Figure 10.2.2.3. **Kattegat (FU 4): Long-term trends in landings, effort and lpues.**

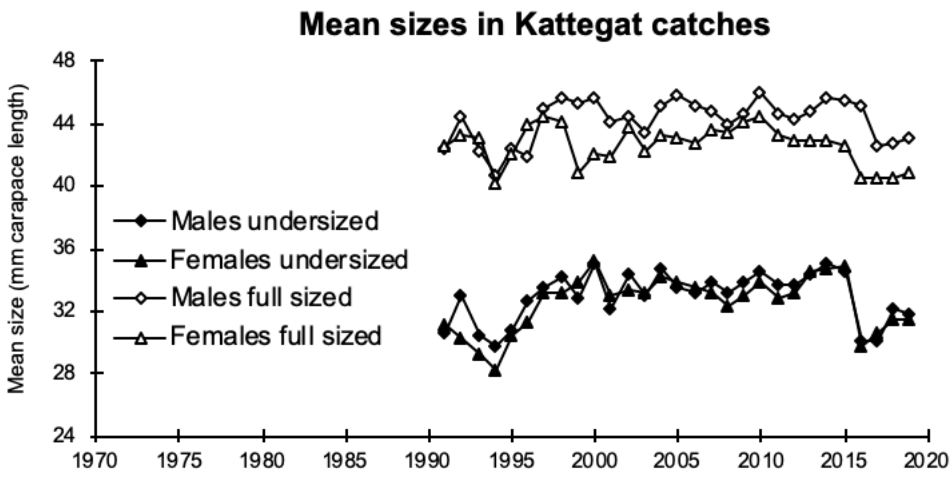


Figure 10.2.2.4. in FU 4: Mean sizes in the catches.

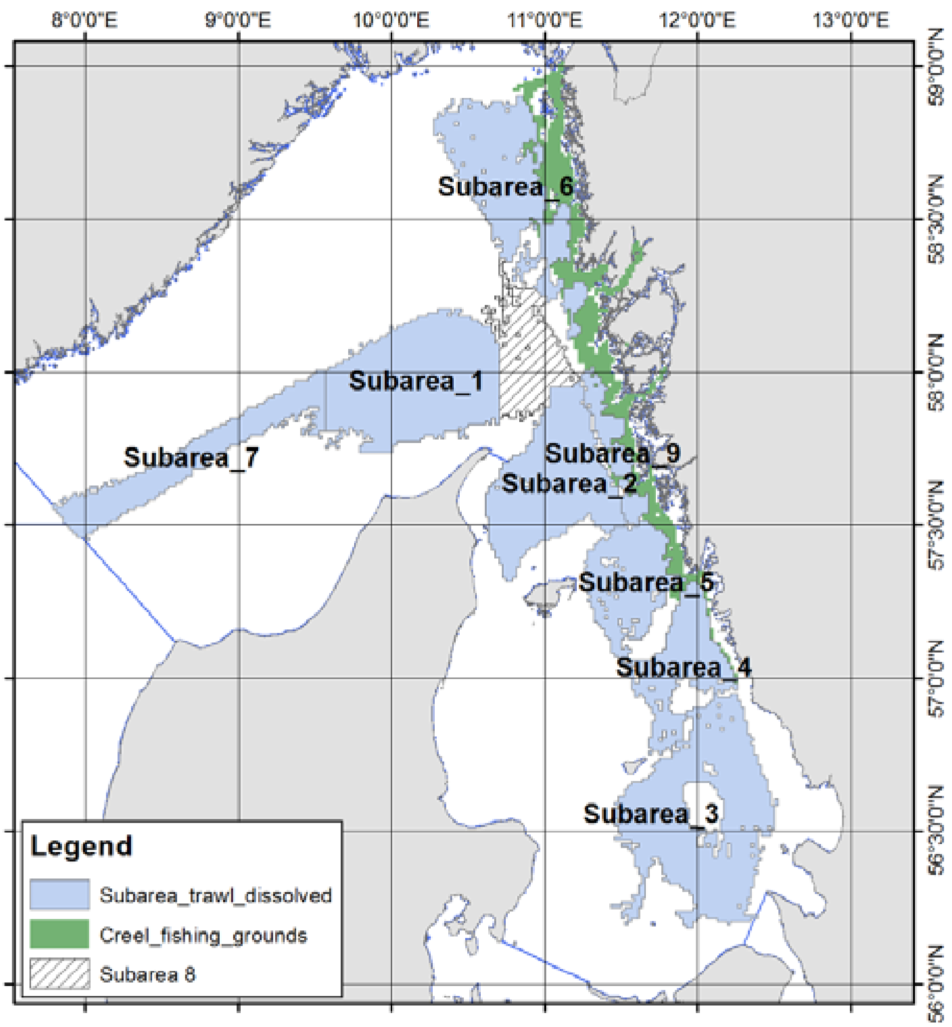


Figure 10.2.3.2. The defined sub areas of the stock in 3.a.

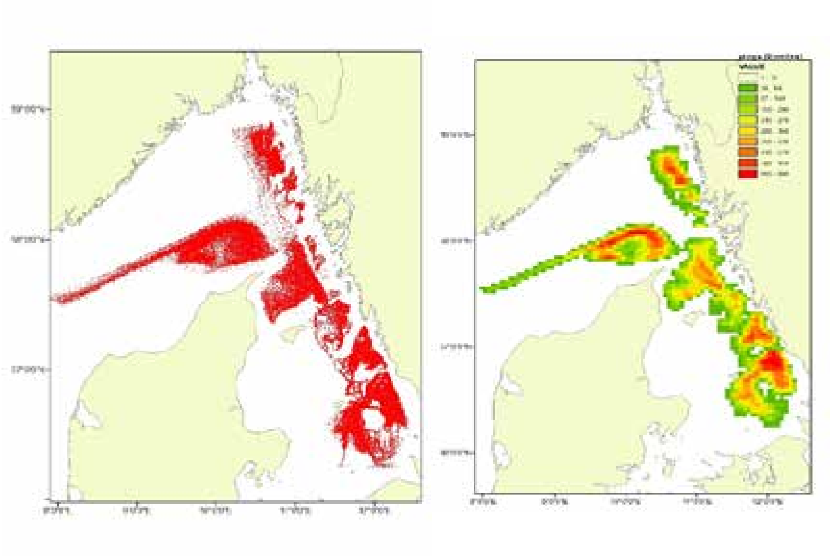


Figure 10.2.3.3. The spatial distribution of the Danish and Swedish fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

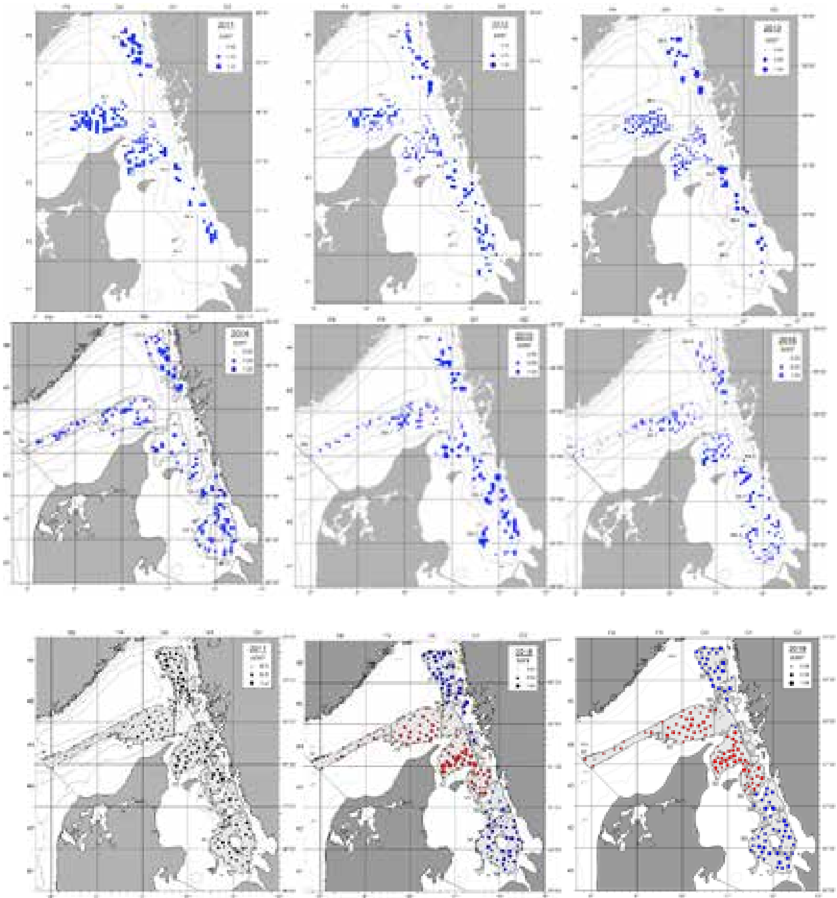


Figure 10.2.3.4. Sampling locations and burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations), 2016 (176 stations), in 2017 (171 stations), 2018 (177 stations) and 2019 (178).

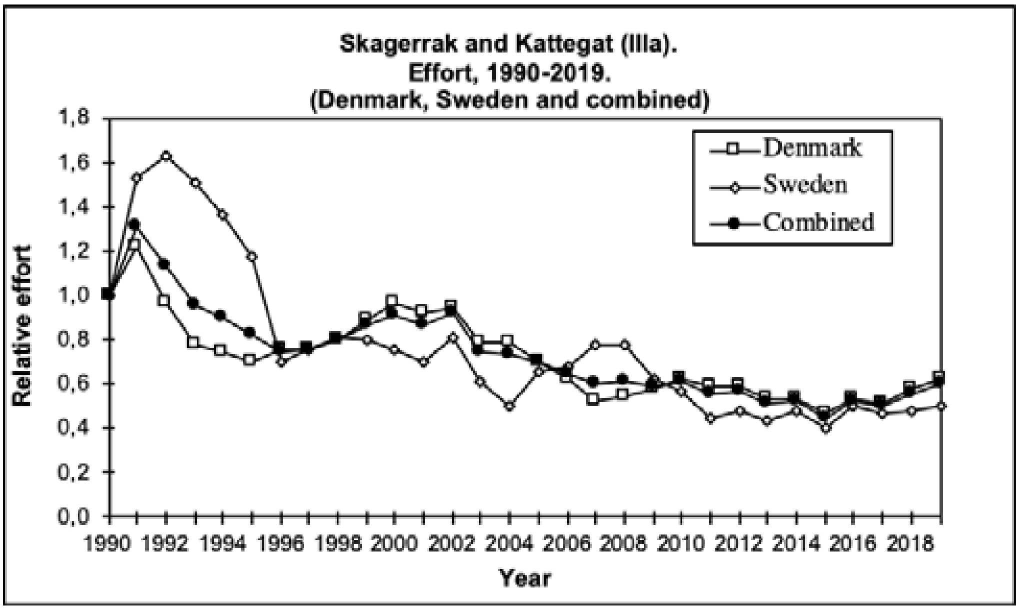


Figure 10.2.4.1 in Area 3.a: Combined Effort for FU 3&4.

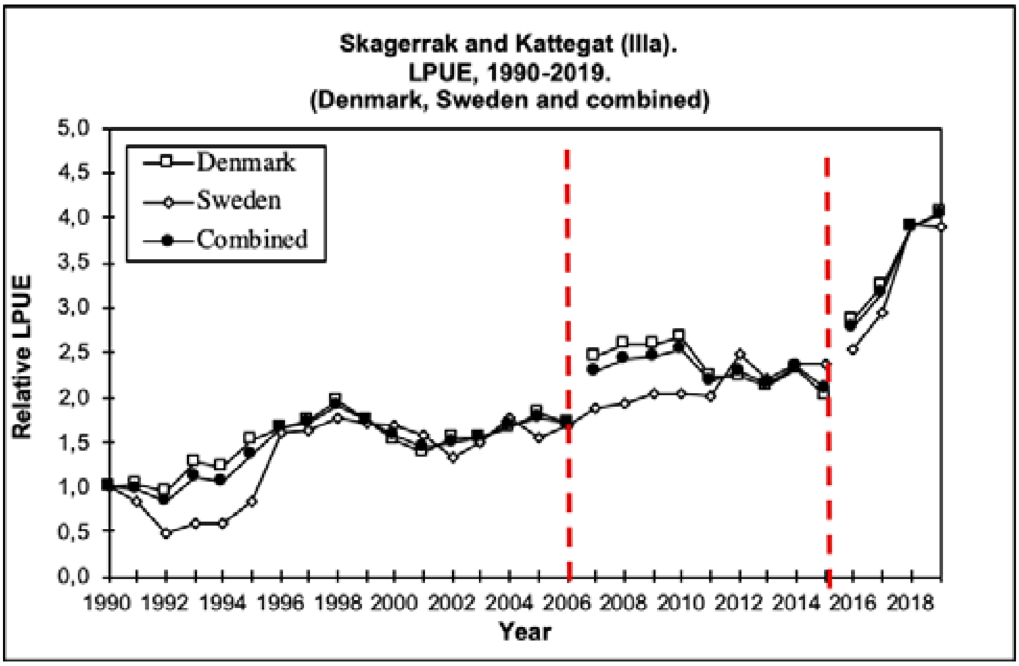


Figure 10.2.4.2 in Area 3.a: Combined lpue for FU 3&4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.

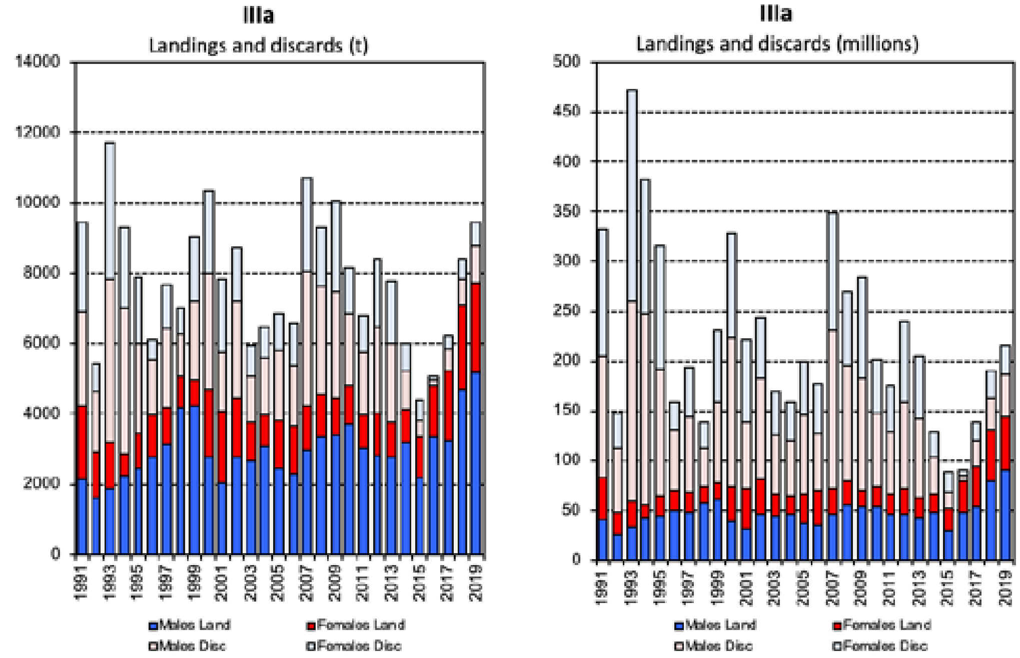


Figure 10.2.4.3. in 3.a: Catch by sex and size category in biomass and numbers.

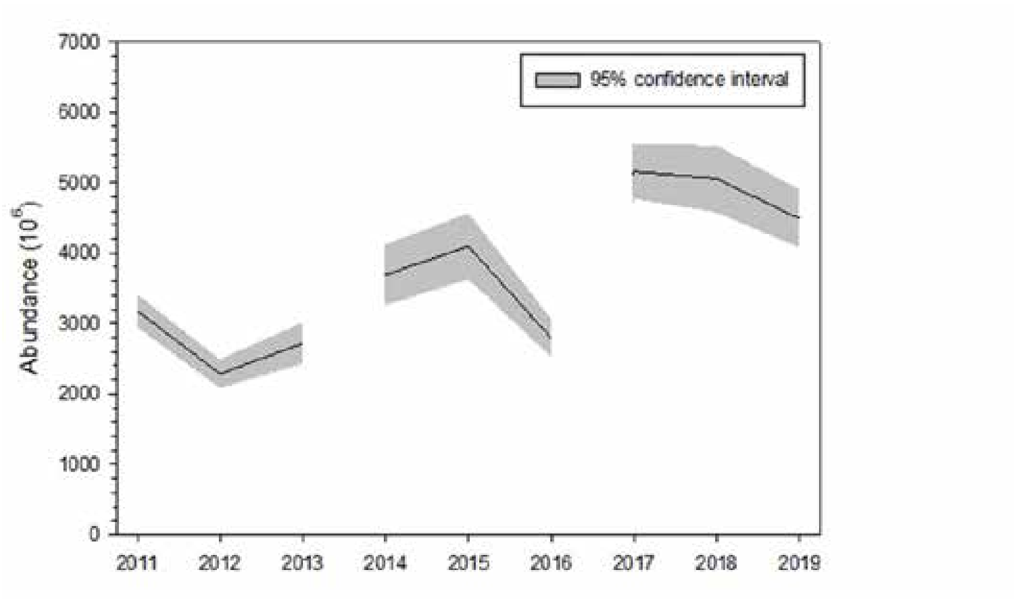


Figure 10.2.4.4. Mean abundance in 3.a by year: Error bars indicate the 95 % confidence intervals. Broken lines indicate change in area definition of grounds.

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

11.1 General comments relating to all Nephrops stocks

See Section 10.1

11.2 Nephrops in Subarea 4

Subarea 4 contains nine FUs 5, 6, 7, 8, 9, 10, 32, 33 and 34. Management is applied at the scale of ICES Subarea through the use of a TAC and an effort regime. FU 34 (The Devil's Hole) is a relatively new functional unit having been designated in 2010 (SGNepS, 2010).

Management at ICES Subarea Level

The 2018 EC TAC for *Nephrops* in ICES Subarea 2.a and 4 was 24 518 tonnes in EC waters (plus 800 tonnes in Norwegian waters). For 2019, this was decreased to 22 103 tonnes in EC waters and 600 tonnes in Norwegian waters.

A major change in the management of *Nephrops* fisheries in ICES Subarea 4 since 2016 has been the introduction of the landing obligation for *Nephrops* fisheries in the 80–99 mm trawl fisheries. A *de minimis* exemption for catches below the Minimum Conservation Reference Size (MCRS) of up to 6% was permitted for the fishery in Subarea 4. The application of this exemption was not clear (i.e. whether the 6% applied at a trip level or to the total annual catch). Because there was no evidence presented to the Working Group that the introduction of the landing obligation had caused any change to discarding practices for the 2017 and 2018 fishery, the catch options have been estimated assuming discarding continues according to historic patterns.

The minimum landings size (MLS) for *Nephrops* in Subarea 4 (EC) is 25 mm carapace length. Denmark, Sweden and Norway applied a national MLS of 40 mm up to 2015 but this was changed to 32 mm from 1 January 2016.

Days-at-sea regulations and recently introduced effort allocation schemes (kW*day) have reduced opportunities for directed whitefish fishing. STECF 2010 stated that the overall effort (kW*days) by demersal trawls, seines and beam trawls shows a substantial reduction since 2002. However, there have also been substantial changes in the usage of the different mesh size categories by the demersal trawls. In particular there has been a sharp reduction in usage of gears with a mesh size of between 100 mm and 119 mm (targeting whitefish), but only a gradual decline in the effort of *Nephrops* vessels (TR2).

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops*, the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70–99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double. The UK introduced emergency technical measures for UK vessels targeting *Nephrops* in the Farn Deeps in 2016 (see Section 11.4).

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90 mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller than 100 mm in the North Sea south of 57°30’N.

Official catch statistics for Subarea 4 are presented in Table 11.2.1. The preliminary officially reported landings in 2018 are 13 164 tonnes, 18% lower than in 2017 (16 049 tonnes), and 54% lower than the peak observed in 2009 (24 597 tonnes). All countries except Norway decreased their landings in 2018 compared to 2017. UK is the main producer country (reporting 83.3% of the total landings in 2018), followed by Netherlands (6.1%), Belgium (4.8%) and Germany (4.2%).

Table 11.2.2 shows landings by FU as reported to the WG. The most productive functional units are 7 (34% of the total landings), followed by 8 (20%), 6 (14%) and 9 (11%). A small but significant proportion of the landings from Subarea 4 come from outside the defined *Nephrops* FUs. This value increased to nearly 10% of the total in 2009 and as a response, a new Functional Unit at the Devil’s Hole (FU 34) was designated in 2011. Landings from outside the Functional Units exceeded 1000 tonnes in 2017 and decreased to 612 tonnes in 2018. However, they still overtook the landings from FU 34.

11.3 Botney Cut (FU 5)

11.3.1 The fishery in 2018 and 2019

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 2110 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.

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 were at more long-term representative values of 1004 and 1172 tonnes, respectively.

Between 1991 and 1995, the Belgian fleet took more than 75% of the international *Nephrops* landings from this functional unit, but since then, the 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. In 2017 and 2018, the UK reduced their participation in the fishery, catching only 14% of the total landings in 2018, and 12% in 2019.

Length composition

The length composition of landings by sex has been provided by Netherlands since 2004. Data were not available for 2013 as the sample rate was considered insufficient to raise the distributions. Since 2015, Netherlands has also provided the unsexed length composition of their discards.

The 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, while 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 last year's 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:

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 (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. In 2018 and 2019, only 1 and 4 UK vessels targeted *Nephrops*, respectively.

Although an LPUE (tonnes per days fishing) estimate has been calculated for previous years, it was decided during WGNSSK 2020 that neither the UK landings component nor the number of UK *Nephrops* trawlers during the past two years was high enough to be able to calculate an LPUE measure that is representative of the entire fleet targeting this functional unit.

UWTV survey

There were no new surveys in FU 5 since the last assessment in 2013. 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, and only four vessels fished in this functional unit in 2019. 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. Assuming the density has been constant since 2012, the harvest rate in 2017, corresponding to the total landings of 2110 tonnes, was 9.7%, and therefore above the proxy MSY rate of 7.5%. Since then, the landings have gone down to 1004 tonnes in 2018, and 1172 tonnes in 2019, with corresponding harvest rates of 4.6% and 5.4%.

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 advice is based upon the 10 year average (2010–2019) landings and the application of the 20% uncertainty cap in advice change on wanted catch (in accordance with the ICES data limited approach method 4.1.4), with an allowance for discarding (assuming recent patterns are continued) to derive catch advice. Applying this approach, catches in 2021 and 2022 should be no more than 1963 tones. This implies that landings should be no more than 1289 tonnes.

***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	Wanted Catch	Unwanted Catch	Range of potential densities (*Nephrops* m^{-2})								
				0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.5 x average landings (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	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	92.2%	46.1%	23.1%	15.4%	11.5%	9.2%	7.7%	6.6%	5.8%
Average landings (2010–2019) +20%	2568	1686	882		54.4%	27.2%	18.1%	13.6%	10.9%	9.1%	7.8%	6.8%
F_{MSY}	2688	1765	923		57.0%	28.5%	19.0%	14.2%	11.4%	9.5%	8.1%	7.1%
Maximum landings	3861	2535	1326		81.8%	40.9%	27.3%	20.5%	16.4%	13.6%	11.7%	10.2%

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 2018 and 2019

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-
98%) from the Farn Deeps (Table 11.4.1). The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March. The 2019 data therefore comprise the end of the 2018–2019 fishery and the start of the 2019–2020 fishery.

The landings in 2018 and 2019 were 1807 and 4359 tonnes, respectively. This is an increase by a factor of 2.41 (141%). The landings in 2019 were also above the 10-year average (2009–2018) of 2117 tonnes, by a factor of 2.06 (106%) (Figure 11.4.1). While the combined relative contribution from English, Welsh, and Northern Irish vessels has decreased from 86% to 79%, the contribution from Scottish vessels has increased from 13% to 20%.

The discard rate in both 2018 and 2019 was 9.5% (estimated as percentage of biomass), lower than the average rate for the last 10 years (2010—2019) of 10.9%.

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 2019

“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 MAP are between 2055 tonnes and 2384 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

In order to ensure the stock in Functional Unit (FU) 6 is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to FU 6 could rapidly lead to over-exploitation.”

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

11.4.2 Assessment

Review of the 2019 assessment

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

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 or, alternatively, a decrease in recruitment levels. There is a decrease in the overall abundance (as established by UWTV survey) around the same time, indicating that this change in length distribution may at least partly reflect a reduction in the level of recruitment (Figure 11.4.4).

A bi-modal length frequency distribution for landed females was observed between 2009–2014, becoming more pronounced throughout that period. This could be the result of a large year class, but a similar phenomenon is not observed in the male part of the population; in fact the mean size in the males decreased in 2012 and 2013 (Table 11.4.2). 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 higher 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 length of large animals 35 mm) in the landings have gradually increased over the period 2008–2019, especially for females (Figure 11.4.1). The mean size of small animals (< 35 mm) in the landings does not have any clear temporal pattern, and therefore, the mean size and mean weight of the landings have progressively increased over time.

Effort and LPUE

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

Historically the fishery has been prosecuted by a combination of local English boats (smaller vessels undertaking day–trips) and larger vessels from Scotland with occasional influxes of 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 11.4.5), but overall the fleet size had been declining until 2018, with an increase in 2019. The majority of the dynamic in fleet size is due to changes in the above 15 m fleet, which experienced an influx of vessels from Scotland for the periods between 2012–2014, and again in 2019. In contrast, the size fleet for the 12–15 m sector has remained fairly constant since 2006, and it has declined for the under-12 m sector.

Directed effort is calculated taking into account only TR2 gear, with a *Nephrops* catch component d 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.

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 increase again from 2018 to 2019 – were driven primarily by fluctuations in the fishing effort of the >15 m fleet (Figure 11.4.1, Table 11.4.3). The relative strength of effort within a season (i.e. the fourth quarter compared to the first quarter) fluctuates without trend. Effort in the summer of 2016 was unusually high, with a clear spike in the catch rate of females (Figure 11.4.6).

The use of LPUE (landings per unit effort) as an index of stock abundance for *Nephrops* is confounded by changes in availability of *Nephrops* to fishing gears, depending upon environmental factors such as tide and light levels, plus changes to emergence behaviour induced by mating and predator avoidance. Therefore, the temporal trend of LPUE 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 sharply declined from 2006 to 2008, and has fluctuated between 0.7—1.4 kg/kWd, without significant trends, since then (Figure 11.4.1, Table 11.4.3).

Traditionally, males tend to predominate the landings, averaging about 70% (range 64%–79%) by biomass in the period 1992–2005. Towards the end of the fishing season (February–March) there is usually an increase in female availability as mature females emerge from their burrows having released their eggs. There has been a marked change in the seasonal pattern of sex-ratio (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 11.4.7). The sex ratio since 2015 returned to a generally male dominated fishery and can be explained by the lack of large females in the catches during the winter months (Figure 11.4.3). However, in 2019, for the first time since 2013, a larger number of females was caught in the fourth quarter. It remains be seen, if this is the beginning of another extended period of overall high female catches.

UWTV

Underwater TV surveys of the Farn Deeps grounds have been conducted at least once in each year from 1996 onwards.

A time series of indices is given in Figure 11.4.4 and Table 11.4.4. The procedure used to work up the 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, a 3D 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 2007 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. Since 2015, 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). The spatial pattern of burrow density is similar through time with the highest density ground running along the eastern edge of the mud-patch (Figure 11.4.8).

11.4.4 InterCatch

In 2019, 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.

Unreported discards for the reported landings were calculated in InterCatch, based on the UK discard ratios. In all, 83 tonnes of discards (18% of the reported plus calculated total) were raised using this procedure.

The length distributions imported by England and Scotland represented 86% of the landings and 82% of the discards. Consequently, length frequencies for the remaining metiers were generated from the pooled data (i.e. irrespective of metier or quarter) for both landing and discard components.

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 not undertaken until June. 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 2019 was 1163 million individuals (± 26 million 95% CI), above the 2007 estimate of 858 million used as MSY $B_{trigger}$. The estimated harvest rate for 2019 was 16.6% (Table 11.4.5), more than twice above the MSY proxy level of 8.1%.

11.4.7 Historical stock trends

The time series of UWTV surveys is 19 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 ratio (the proportion of the stock which is removed) range from 6.2% to 25.5% (Table 11.4.5, Figure 11.4.10). The harvest ratio jumped from around 12% in 2004–

2005 to 25.5% in 2006, when the new reporting legislation came in. The harvest rate has only been below the MSY level once in the last 12 years (at 6.2% in 2008).

11.4.8 MSY considerations

Considerations for setting harvest ratios associated with proxies for F_{MSY} for *Nephrops* are described in ICES, WGNSSK, 2010, Section 10.1.

- Average density in the stock is at a medium level, above the level of 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 (6–26%). The observed harvest rate is, of course, confounded by the change in reporting levels considered to have occurred around 2006. The average harvest rate of 2007—2019 is 13.8%, which is above the most recent estimate of F_{max} for males.

The following table shows the mean F, implied harvest rate and resulting spawner per recruit values (expressed as 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	
		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 2021 are given in the table below. This assumes that the absolute abundance estimate made in June 2019 is relevant to the stock status for 2021.

In November 2016, ICES advised on fishing opportunities assuming that discarding would only occur below the MCS. Observations from the fishery in 2016, 2017 and 2018 indicate that discarding above the MCS continues, and practices have not changed markedly (Figure 11.4.3). Consequently, ICES has provided advice for 2018–2021 assuming average discard rates observed over the last three years, which is considered to be a more realistic assumption. A table with the catch and landing predictions assuming zero discards is also presented for comparison.

The ICES MSY approach dictates that where the stock status is above the trigger point, the maximum advised fishing rate should be the MSY rate. Applying this approach, catches in 2021 that correspond to the F ranges in the EU multi-annual plan (MAP) for the North Sea are between 2105 tonnes and 2406 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	1163 million individuals	UWTV 2019
Mean weight in wanted catch	28.76 g	Average 2017–2019
Mean weight in unwanted catch	11.02 g	Average 2017–2019
Unwanted catch proportion	21%	Average 2017–2019 (proportion by number)
Unwanted catch survival rate	15%	Only applies in scenarios where discarding is allowed.
Dead unwanted catch proportion	19%	Average 2017–2019 (proportion by number), only applies in scenarios where discarding is allowed

Nephrops FU 6. Catch options assuming discarding continues at recent average. All weights are in tonnes.

Catch options assuming recent discard rates

Basis	Total catch L+DD+SD	Dead removals L+DD	Landings L	Dead discards DD	Surviving discards SD	Harvest rate* for L+DD
FmsyLower	2101	2072	1904	168	30	7.0%
F0.1Male	2134	2104	1934	170	30	7.1%
FmsyUpper	2437	2403	2209	194	34	8.1%
F35%Male	2437	2403	2209	194	34	8.1%
FMSY ApproachComb	2437	2403	2209	194	34	8.1%
F0.1Comb	2605	2569	2361	208	37	8.7%
F35%Comb	3344	3297	3030	267	47	11.1%
FmaxMale	3482	3433	3155	278	49	11.6%
F0.1Female	4208	4149	3813	336	59	14.0%
F35%Female	4560	4495	4132	364	64	15.2%
FmaxComb	4593	4528	4162	366	65	15.3%
Fcurrent	5133	5061	4651	409	72	17.1%
FmaxFemale	6484	6392	5875	517	91	21.6%

Catch options assuming zero discard rates

Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
FmsyLower	2034	1843	191	7.0%
F0.1Male	2066	1872	194	7.1%
FmsyUpper	2360	2138	221	8.1%
F35%Male	2360	2138	221	8.1%
FMSY ApproachComb	2360	2138	221	8.1%
F0.1Comb	2522	2286	237	8.7%
F35%Comb	3237	2933	304	11.1%
FmaxMale	3371	3055	316	11.6%
F0.1Female	4074	3692	382	14.0%
F35%Female	4414	4000	414	15.2%
FmaxComb	4446	4029	417	15.3%
Fcurrent	4969	4503	466	17.1%
FmaxFemale	6277	5688	589	21.6%

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 t compared with the value submitted in 2017. It also caused an increase of the estimated discard and harvest rate, and a decrease of the mean weight and size of the catch for that year. The fishing effort and LPUE for English vessels were also updated.

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

The 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 2019 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 the size of the stock has increased and it is above the MSY $B_{trigger}$. The harvest rate, estimated as the proportion of the stock that has been fished, has significantly increased from 2018 and is about twice the $F_{MSY\ trigger}$.

The temporal trend of abundance indicates that the status of the stock has improved compared to 2018. This improvement is probably due to a year with a strong recruitment that has increased the stock abundance. However, since recruitment is affected by many environmental factors in addition to fishing, annual recruitment is highly variable, and it could decrease again in the coming years.

11.4.13 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. In 2016–2019, no Norway lobster were recorded as below MCS (BMS category) in FU 6, despite catches having been observed below the MCS.

11.5 Fladen Ground (FU 7)

11.5.1 Ecosystem aspects

The Fladen Ground (Functional Unit 7) is located towards the centre of the Northern North Sea off the east coast of Scotland (Figure 10.1.1). This region is characterised by an extensive area of mud and muddy sand, and hydrographic conditions include a large scale seasonal gyre which develops in the late spring over a dome of colder water.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the Fladen Ground FU these substrates are distributed more or less continuously over a very large area (approx. 30 000 km^2). Figure 11.5.5 shows the distribution of sediment in the area. Sandy mud and muddy sand are the dominant sediment types, with patches of mud in the south west area of the FU. Numerous fish species occur in in the same area as *Nephrops* with demersal fish more prevalent in the northern area. In the softest areas of mud, *Pandalus borealis* is also found.

11.5.2 The Fishery in 2019

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (9032 tonnes in 2019), with Denmark taking 7 tonnes, and other countries (England, Netherlands and Norway) 19 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. Fishing in 2019 was generally better than in previous years. Information on the fishery suggests that some vessels moved through the west of Scotland to the South of England, fishing off the Scilly Islands (FU 20–21) between April and July. Additionally, some vessels also spent time fishing in the Farne Deeps (FU 6) and Devil's Hole (FU 34). The fishery in Fladen continued to perform well in the second half of 2019 with vessels being asked to reduce landings towards the end of the year due to shellfish processor stores being full. Despite this prices were reported to have remained stable throughout the year. 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 2019

The ICES conclusions in 2019 in relation to state of the stock were as follows:

"*The stock size has been above MSY Btrigger for most of the time-series. The harvest rate has declined since 2010, and remains well below FMSY.*"

The ICES advice in 2019 (for 2020) (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 12 552 tonnes and 14 263 tonnes. 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 2020

The assessment of *Nephrops* in 2020 is based on examining trends in the UWTV survey data (1992–2019) 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 2020 followed the process of 2019, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

11.5.6 Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with small contributions from Denmark and England, and are presented in Table 11.5.1 and Figure 11.5.1. Total international landings (as reported to the WG) in 2019 were 9032 tonnes (104% increase in comparison with the 2018 total), consisting mostly of Scottish landings with 26 tonnes landed by other countries (England, Denmark, Netherlands and Norway). *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 7 in 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, 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 2019 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 was analysed at the time of the WG meeting). In 2017–2019, a slight increase in effort was recorded for Scottish trawlers. LPUE has gradually increased since 2000 to a peak of over 620 kg/day in 2009. It has fallen since then until 2015 to values similar to those observed in the early 2000s (~200 kg/day). In 2019 the Scottish LPUE increased markedly and is currently at the same level observed in the late 2010's. Danish LPUE data (1991–2019) 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 2019 the Danish LPUE showed a clear increase (3.5 times the value recorded in 2017-18). 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. The discarding rate average from 2000 is approximately 7% 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 (both landings and discards) increased in FU 7 and the discard rate in 2019 was estimated to be 2.2%.

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 2019 data (official landings and sampled data for landings and discards) were successfully uploaded into Intercatch. National data co-ordinators for other countries (England, Denmark, Netherlands and Norway) also uploaded landings data to Intercatch ahead of the 2020 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2019.

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 2019. Catch (removals) length compositions are shown for each sex with the mean catch and landings lengths shown in relation to MLS (25 mm) and 35 mm. In both sexes, the mean sizes have been generally stable over time except until 2011 when a noticeable shift in the length distribution and an increase in the mean size has been observed for males and to a lesser extent, females. In 2017, length distributions in both sexes showed a marked decrease in the mean size in catches to similar values as those observed prior to 2011. In 2019 length distributions were generally similar to 2017-2018 for both males and females. In 2018, a second peak (mode) was detected in the length distribution of females, implying possibly a large cohort moving through the population – the peak is not evident in the most recent data although some large individuals were recorded in the right tale of the 2019 female length distribution. 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 a small increase in 2018-19 and is now around 29 mm CL for females and 31 mm CL for males. The discard rate in 2019 was estimated to have decreased slightly from the 2017 high value (4.4%) and is now 2.2% 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 (1990–2019) 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 2019, the mean weight in landings decreased from 30.6g to 28.3g and is now similar to the values observed prior to 2010 when the stock declined markedly.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 11.5.6. On average, approximately 65 stations have been considered valid each year (70 stations in 2019). 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 (2014–2019) with the size of the symbol reflecting the *Nephrops* burrow density. The abundance in 2019 increased 8% from 2018. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground. Table 11.5.6 and Figure 11.5.6 show the time series estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. Following the low UWTV estimated densities in the period 2011–2015 and the apparent *Nephrops* fleet preference for the fishing grounds located to the south of Fladen (Figure 11.5.8), the WG looked closely at the spatial distribution of the UWTV survey in the last eleven years. It was suggested (as a hypothesis) that the north of the ground has been more affected by the recent decline (from 2009) in abundance than the areas in the south where most fishing took place in recent years. To test this, the TV surveys from 2009–2019 were re-worked by sediment type, splitting the ground in two areas, north and south of the 58.75 N latitude line. Results seem to support that the areas mostly affected by the reduction in the mean *Nephrops* burrow density from 2009 were in fact located in the south, especially those made of finer sediments located in the central south region (Figure 11.5.9). In the north of Fladen, where coarser sediments (<40% silt and clay) dominate, a decrease in density was also observed but to a lesser extent when compared with those in the south. This analysis also shows that even during the period of lowest abundance in FU 7 the mean densities in the south remain in average higher than those in the north. The density increase 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 mis–identification and burrow occupancy. The cumulative bias correction factor estimated for FU 7 was 1.35 meaning that the raw UWTV survey is likely to overestimate *Nephrops* abundance by 35%. In order to convert the raw UWTV survey abundance to an absolute abundance the raw data are divided by 1.35.

Final assessment

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

The latest UWTV survey data shows that the abundance has increased 8% in 2019. The stock is above the average abundance over the time series and is well above the biomass trigger. The harvest ratio in 2019 (5.6%, 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 2009-2011. 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 the observed recruitment pulse seems to be moving up in the length distributions as suggested by a slight decrease in the discard rate and a small increase in the mean sizes of catches below 35 mm CL from 2017 to 2018-2019.

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 2019, the abundance remains at a high level estimated to be 6129 million (Table 11.5.8).

Table 11.5.8 also shows the estimated harvest ratios from 1992–2019. 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 2019, due to the recent increase in landings and the abundance remaining at a similar level compared to the previous year, the harvest ratio has increased and is now estimated to be at 5.6%, closer to 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 2.2% by number in 2019.

11.5.8 Recruitment estimates

Recruitment estimates from surveys are not available for this FU. However, the increase in mean size of small animals <35 mm (i.e. a lower proportion of small animals in this component of the catch) observed in recent years may be indicative of lower recruitments in the period 2010–2015. The recent increase in abundance suggests a good recruitment in 2016–2017.

11.5.9 MSY considerations

F_{MSY} proxies for *Nephrops* are obtained from the per-recruit analysis as documented in the WGNSSK 2015 report. The most recent analysis used 2012–14 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. Length frequency data in Fladen have shifted towards larger animals since 2010 (see Section 11.5.5 and Figure 11.5.3) suggesting a different selection pattern in the fishery. In addition, the discard rate has shown generally a declining trend over the last 10 years due to a combination of low recruitments, a shift to larger meshes (TR1) and the increase in the use of the use of Highly Selective Gears for reducing fish bycatch. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit F_{MSY} proxies is given in the table below and the basis for choosing an appropriate F_{MSY} proxy remains the same and is described in WGNSSK 2010 report.

WGNSSK 2015		F_{bar}(20–40 mm)		HR (%)	SPR (%)		
		M	F		M	F	T
$F_{0.1}$	M	0.07	0.07	6.4	47.4	58.3	51.9
	F	0.14	0.15	10.6	33.3	40.8	36.4
	T	0.08	0.09	7.5	43.0	53.1	47.2
F_{max}	M	0.21	0.22	13.8	26.6	31.6	28.7
	F	0.44	0.46	21.2	17.5	18.7	18.0
	T	0.27	0.29	16.4	22.8	26.1	24.2
$F_{35\%SpR}$	M	0.13	0.13	10.0	34.8	42.9	38.1
	F	0.18	0.19	12.6	29.0	34.9	31.4
	T	0.15	0.16	11.2	31.9	39.0	34.8

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

Due to the Covid-19 outbreak it was decided by ICES prior to the 2020 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. Therefore *Nephrops* catch forecasts for 2021 in FU 7 are not presented as usual as they will be calculated in October.

Biological Reference points

Biological reference points have not been defined for this stock.

11.5.11 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately. The proportion of landings with discards associated (same strata) is 92% in 2019 (91% of the discards were imported and 9% were raised discards).

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

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

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

The Fishers’ North Sea stock survey suggests that moderate or high amounts of recruits were apparent in Area 1 (which Fladen FU lies largely within) in 2011 compared to 2009. The time series of perceived abundance in Area 1 increases up to 2011. Opinion on discards appears to be split fairly evenly between lower, higher and no change. There are no Fishers’ North Sea survey data available for 2013–2019.

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 2019 (9032 tonnes) were lower than the 2018 total catch advice (for 2019) of 13 178 tonnes. The harvest rate doubled in 2019 (in relation to the previous year) to 5.6% but 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. From 2017, length distributions in catches showed a decrease in the mean size and the discard rates (previously estimated to be zero) increased.

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 survivability exemption in place for *Nephrops* in the North Sea. *Nephrops* below MCRS caught with pots (all year) or in winter months (October to March) with certain TR2 gears could be discarded without restrictions due to high survival rates. In 2019, 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.

11.6 Firth of Forth (FU 8)

11.6.1 Ecosystem aspects

The Firth of Forth Functional Unit 8 is located in the south-west of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 10.1.1.). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to seaward, narrowing towards the coast with river basins draining into the area. Sandy mud and muddy sand deposits are widespread throughout the area covering an area of 915 km^2, the coarsest muds being found offshore beyond the Isle of May.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 11.6.4 shows the distribution of sediment in the area. There is some evidence of *Nephrops* larval drift from grounds to the south of the area but most larvae appear to be produced locally and the population is characterised by high density and generally small size. Although this area was historically important for fish catches, this area has now declined and *Nephrops* is the main commercial species. The recruits of numerous demersal fish species occasionally aggregate in the area and small pelagics (sprat and juvenile herring) are seasonally abundant. Important seabird colonies occur in the area and the ‘Wee Bankie’ gravel area, important for sandeels is located further offshore to the north and east of the Firth.

11.6.2 The fishery in 2019

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 11.6.1). In recent years, around 40 vessels worked regularly in the Firth of Forth. Most vessels are under 12m in length with about 10 in 12–15 m category and a few above 15 m. Engine power ranges from just under 100 kw to around the 300 kw. The trip length for most of the fleet is one day. In the winter, most vessels fish from around dawn till 16:00–19:00. In spring/summer, vessels switch to nights, working from around 19:00 to 07:00–10:00. The few larger vessels (over 15 m) fishing in FU 8, undertake trips of around 2–3 days. The overall number of boats operating varies seasonally as vessels move around the UK in response to varying catch rates. In recent years some large Fraserburgh boats, which usually operate in FU 7, moved into the area, fishing mostly to the east grounds of the Firth. Visitor boats come generally from the Northeast of Scotland (FU 7 and FU 9) in periods of poor fishing in those grounds but tend to land to harbours in the northeast of Scotland. A few English vessels also visited FU 8 with landings from the rest of UK estimated at 39 tonnes in 2019. Catches were generally reported as good although market demand and *Nephrops* prices (particularly for tails) dropped towards the end of the year due to oversupply of the market. 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. Landings by creel vessels in this area were lower than in previous years (less than 1% of the total) – typically, the main target species of these vessels are crabs and lobsters.

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

11.6.3 Advice in 2019

The ICES conclusions in 2019 in relation to State of the Stock were as follows:

"*The stock size has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate is varying, and is now below F_{MSY}.* "

The ICES advice in 2019 (for 2020) (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 2045 tonnes and 3143 tonnes. The entire range is considered precautionary when applying the ICES advice rule.*

To ensure that the stock in Functional Unit 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 2019

The assessment in 2020 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 2020 followed the process of 2019, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involving collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.6.1 and Figure 11.6.1. Most of the landings are made by trawlers with creels accounting for less than 1% of the total. Reported landings rose from 1100 to over 2650 tonnes between 2003 and 2009 and have fluctuated since then around 2000 tonnes. The value for 2019 of 2684 tonnes was the second highest in the available time series and is above the ten year average (2155 tonnes). *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 8 in 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 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 2000’s with greatest effort in the 3rd quarter when females are likely to be more available to the fishery (compared with a more evenly distributed seasonal effort pattern in 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. Historically, discard rates have been higher in this stock than the more northerly North Sea FUs for which Scottish discard estimates are also available. This could arise from the fact that the use of larger meshed nets is not so prevalent in this fishery (80–95 mm is more common) and in addition, the population appears to consist of smaller individuals due to slower growth. Discarding rates in this FU have varied between 16% and 55% of the catch by number (2010–2019 average 23%). In 2019 the discard rate was recorded at 24.9%. 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 2019 data (official landings and sampled data for landings and discards) were successfully uploaded into InterCatch. National data co-ordinators for other countries (England) also uploaded landings data to InterCatch ahead of the 2019 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2019.

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 2019. Size information on catches (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35 mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35 mm shows no evidence of reductions in relative numbers of larger animals.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35 mm) in the landings shown in Figure 11.6.1 and Table 11.6.3. This parameter might be expected to reduce in size if overexploitation were taking place but over the last 20 years has in fact been quite stable. The mean size in the catch in the <35 mm category (Figure 11.6.1) also shows no particular trend. The increase in the lower tail of discarded length frequencies (Figure 11.6.3), the slight decrease in the mean size of animals below 35 mm (Figure 11.6.1) and an increase in the discard rate suggest possible a larger recruitment in 2019.

Mean weight in the landings is shown in Figure 11.5.4 and Table 11.5.5 and this shows no systematic changes over the time series.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

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

The numbers of valid stations used in the final analysis in each year are shown in Table 11.6.4. On average, about 45 stations have been considered valid each year. In 2019, there were 50 valid stations. Abundance data are raised to a stock area of 915 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

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

Data analyses

Exploratory analyses of survey data

Table 11.6.5 shows the basic analysis for the three most recent TV surveys conducted in FU 8. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand. Depending on the year, high variance in the survey is associated with different strata and there is no clear distributional or sedimentary pattern in this area. Densities observed in this FU are typically higher than those of the more northerly FUs in the North Sea.

Figure 11.6.4 shows the distribution of stations in TV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is currently higher towards the eastern parts of the ground and around the Isle of May. Table 11.6.4 and Figure 11.6.5 show the time series of estimated abundance for the TV surveys, with 95% confidence intervals on annual estimates. The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009). A number of potential issues were highlighted including those arising from edge effects, species burrow mis-identification and burrow occupancy. To take account of these effects, a cumulative correction factor of 1.18 was estimated for FU 8 and this is applied to raw counts in order to derive the absolute abundance.

Final assessment

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

The UWTV abundance was relatively high in the period 2003 to 2008 but has shown a decreasing trend in 2008–2014. The stock has increased again in recent years and in 2019 it is close to the highest point of the time series (1025 million in 2018). 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) increased and is now above F_{MSY} (previously below F_{MSY}). This is mostly the result of a 16% decrease in stock abundance with the landings in 2019 remaining at the same level as that recorded in 2018. 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 although in 2019 this indicator has decreased, potentially indicating a larger recruitment. Larger square mesh panels and new, more selective TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme may have improved the exploitation pattern. The effect of these changes are not however, as evident as those observed in FU 7 and length frequencies in recent years remain relatively stable in the Firth of Forth.

11.6.6 Historical stock trends

The TV survey estimate of abundance for *Nephrops* in the Firth of Forth suggests that the population decreased between 1993 and 1998 and then began a steady increase up to 2008. Abundance is estimated to have fluctuated in the years since then. The abundance estimates from 1993–2019 are shown in Table 11.6.6. The stock is currently estimated to consist of 865 million individuals.

Table 11.6.6 also shows the estimated harvest ratios over this period. From 2003 (the period over which the survey estimates have been revised) these range from 12–29% with the upper range being the value for 2014 (estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation). The estimated harvest rate in 2019 is 18.3% which is above the estimated value at F_{MSY} (16.3%).

In addition to the discard rate, Table 11.6.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

11.6.7 Recruitment estimates

Survey recruitment estimates are not available for this stock.

11.6.8 MSY considerations

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

WGNSSK 2011		**F_{bar}(20–40 mm)**		**HR (%)**	**SPR (%)**		
		M	**F**		**M**	**F**	**T**
F0.1	M	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29
	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

Due to the Covid-19 outbreak it was decided by ICES prior to the 2020 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. Therefore *Nephrops* catch forecasts for 2021 and 2022 in FU 8 are not presented as usual as they will be calculated in October.

Biological Reference points

Biological reference points have not been defined for this stock.

11.6.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. The proportion of landings with discards associated (same strata) is 98% in 2019 (98% of the discards were imported and 2% 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 2013–2019.

11.6.11 Status of the stock

The stock has shown an increasing trend in the last 5 years and is above the average abundance and well above the MSY $B_{trigger}$ level. The abundance value calculated for 2019 is 865 million. Landings taken from this FU in 2019 (2684 tonnes) were lower than the 2018 total catch advice (for 2019) of 3569 tonnes. Despite this, the harvest rate increased in 2019 to 18.3% (due to the 16% abundance decrease in 2019) and is now above F_{MSY}. Length frequencies in the catches have been 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 do not appear to have adversely affected the stock, they are estimated to be equivalent to fishing at a rate greater than F_{MSY} and therefore it would be unwise to allow effort to increase in this FU.

This stock is under the landings obligation although there is a survivability exemption in place for *Nephrops* in the North Sea. *Nephrops* below MCRS caught with pots (all year) or in winter months (October to March) with certain TR2 gears could be discarded without restrictions due to high survival rates. In 2019, 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.

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 2019

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 11.7.1). Vessels targeting this fishery typically conduct day trips from the nearby ports along the Moray Firth coast. Around 20–25 local vessels (all single riggers) regularly fish in Moray Firth area, mostly out of Burghead. The majority of the Moray Firth fleet is under 10 m. Most vessels over 10 m are using 250 mm square mesh panels and reporting better catches than when they used HSGs. Square mesh panels of 160 mm and 200 mm were introduced for under 10 m vessels in the end of 2017. The fleet have been consistent in their grounds throughout the years, with smaller vessels fishing locally from Burghead and larger and more powerful vessels venturing further out. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. These larger twin riggers (typically over 15 m) fished in the outer areas of the Firth during the winter months and unlike the smaller local vessels, they can continue to operate in periods of poor weather. In 2012, a new voluntary code of conduct for *Nephrops* trawlers (Moray Firth Prawn Agreement) has been agreed amongst fishermen for the Inner Moray Firth so as to protect the viability of smaller vessels based in the area. The agreement proposes that an area in the most westerly part of the Moray Firth be reserved for vessels under 300 HP with a further small area reserved for vessels under 400 HP. Prices of *Nephrops* and fuel costs have been reported as similar to previous years. 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 13 tonnes landed in 2019) as grounds are in open water and gear conflicts with trawl vessels are likely to happen. A squid fishery usually takes place in the Moray Firth in the late summer, starting in the Southern Trench when squid moves inshore. The majority of the local fleet participated in the squid fishery between September and October, returning to *Nephrops* fishing in November. In 2019, 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 2019

The ICES conclusions in 2019 in relation to State of the Stock were as follows:

The stock has been above MSY $B_{trigger}$ *for the entire time-series. The harvest rate has fluctuated around* F_{MSY} *in recent years and is now just below* F_{MSY}.

The ICES advice in 2019 (for 2020) (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 2020 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 2020 followed the process of 2019, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{MSY} for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.7.1. Total landings (as reported to the WG) in 2019 for Scotland were 1395 tonnes (a decrease of 4 tonnes in relation to 2018) and England landed only 2 tonnes. Landings in recent years (post 2006) are more reliable due to the introduction of ‘buyers and sellers’ legislation. The long term landings trends are shown in Figure 11.7.1. *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 9 in 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. 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 2016–2019, males dominate again. The high contribution of females previously recorded appears to be due to a much higher proportion of the fishery taking place in the second and third quarter when females are more available. This observation has been made a number of times before in the Moray Firth (particularly for example in 1994 when female catches exceeded those of males). Figure 11.7.6 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is evident with males dominating catches during winter time. In quarters 2 and 3, females become more active and are more available to the fishery. These data suggest a fairly stable sex ratio in quarterly catches throughout the time series. Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This is not the case here.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates in this FU appear to be highly variable with rates over the time series of 1% to 54% of the catch by number. In 2019 the observed rate by number was at a low level, approximately 2% by number, suggesting poor recruitment to the fishery. Discards rates were generally higher in the past and in recent years appear to be lower but with occasional high annual levels which may be associated with sporadic high recruitments (e.g. 2002, 2004, 2010 and 2014-2016). It is likely that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed in order to calculate dead removals (landings + dead discards) from the population.

InterCatch

Scottish 2019 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 2020 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2019.

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 2019. 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 three 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, 55 stations were sampled in 2019. Abundance data are raised to a stock area of 2195 km². General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 11.7.5 shows the basic analysis for the three most recent UWTV surveys conducted in FU 9. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand and typically, the variance in the survey is higher in the muddy sand (west) strata and seems to be evenly split among the other different strata in recent years. The densities typically observed in this FU are lower than those observed in FU 8.

Figure 11.7.4 shows the distribution of stations in UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In recent years the abundance appears to be highest at the western inshore and to the southeast of the FU, with lower densities in the central north and eastern areas. Table 11.7.4 and Figure 11.7.5 show the time series of estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

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

Final assessment

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

The abundance in the Moray Firth has gradually declined since 2007 having increased in 2013 followed by a further decrease in 2014 and remained stable in the last 5 years. The abundance in 2019 was 376 million, a decrease of 10% compared with the previous year. The stock is currently below the average abundance over the time series but remains above the biomass trigger. The calculated harvest ratio in 2019 (dead removals/TV abundance) is now just above F_{MSY} (previously at 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 3 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. The abundance estimates from 1993–2019 are shown in Table 11.7.6 and Table 11.7.6 shows the estimated harvest ratios. These range from 6–33% over this period. Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The harvest ratio has increased in 2019 to 14.8% and is now just above the F_{MSY} proxy value of 11.8%.

In addition to the discard rate, Table 11.7.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

11.7.7 Recruitment estimates

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

11.7.8 MSY considerations

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

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

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

Moderate absolute densities are generally observed on the UWTV survey of this FU (average of ~ 0.2 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) appear to have been above $F_{35\%SPR}$ and in addition there is a long time series of relatively stable landings (average reported landings ~ 1300 tonnes, above those predicted by currently fishing at $F_{35\%SPR}$). For these reasons, it is suggested that $F_{35\%SPR(T)}$ is used as the F_{MSY} proxy.

The F_{MSY} proxy harvest ratio is 11.8%.

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

11.7.9 Short-term forecasts

Due to the Covid-19 outbreak it was decided by ICES prior to the 2020 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. Therefore *Nephrops* catch forecasts for 2021 and 2022 in FU 9 are not presented as usual as they will be calculated in October.

Biological Reference points

Biological reference points have not been defined for this stock.

11.7.10 Quality of assessment

The length and sex composition of the landings data is considered to be relatively well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. The proportion of landings with discards associated (same strata) is 78% in 2019 (82% of the discards were imported and 18% 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 since 1993, with a continual annual series available since 1996. The number of valid stations in the survey has remained relatively stable throughout the time period.

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. Area 3 covers the Moray Firth, Firth of Forth and areas of the Devil's Hole and there appears to be some inconsistencies between the report in 2011 and 2012. In 2011 the report documented a perceived increase in the *Nephrops* abundance in this area since 2008; however the 2012 report appears to show a perceived decrease since 2008. There are no Fishers' North Sea survey data available for 2013–2019.

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 decreased 10% in 2019 (to 376 million) remaining approximately at the same level as in the late 2000s. The stock size is above the MSY $B_{trigger}$ level. Landings taken from this FU in 2019 (1395 tonnes) were higher than the 2018 total catch advice (for 2019) of 1274 tonnes (wanted catch). The harvest rate increased in 2019 to 14.3% and is just above 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 survivability exemption in place for *Nephrops* in the North Sea. *Nephrops* below MCRS caught with pots (all year) or in winter months (October to March) with certain TR2 gears could be discarded without restrictions due to high survival rates. In 2019, no *Nephrops* were recorded as below the minimum size (BMS) in FU 9 despite catches having been observed below the MCRS and this being a Functional unit that historically have shown occasional high discard rates.

11.8 Noup (FU 10)

11.8.1 Ecosystem aspects

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

11.8.2 The fishery in 2018 and 2019

The Noup currently supports a relatively small fishery. Few vessels target *Nephrops* regularly in this area. In Orkney there is currently only two part-time (summer) vessels fishing for *Nephrops* as most of the local fleet targets crabs and lobsters. *Nephrops* boats from Orkney spend most of the year fishing in the Moray Firth (FU 9). In recent years, vessels from Scrabster landing *Nephrops* use 120 mm mesh twin rigs (targeting whitefish). Landings from Noup have decreased steadily since 2002 and in 2019 only 21 tonnes of *Nephrops* were landed (Table 11.8.1). Further general information on the fishery can be found in the Stock Annex.

11.8.3 Advice in 2018

The advice provided in 2018 was biennial and valid for 2019 and 2020.

"*ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should not exceed 48 tonnes.*

To ensure the stock in Functional Unit (FU) 10 is exploited sustainably, management should be implemented at the functional unit level."

Data available

Commercial catch and effort data

Landings from this fishery are reported only from Scotland and are presented in Table 11.8.1 and Figure 11.8.1. Total landings (as reported to the WG) in 2019 were 21 tonnes, an increase of 4 tonnes from 2018. *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 five years effort has been relatively stable but the LPUE has increased slightly in 2019.

Length compositions

Levels of market sampling are low and discard sampling is not available. Mean sizes in the landings in previous years are shown in Figure 11.8.1 and Table 11.8.3. There were no sampling data available for 2015 and 2018, two sampling trips in 2016, 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 2019 were successfully uploaded into InterCatch prior to the 2020 WG meeting according with the deadline proposed. Data for this stock in previous years has been limited to official landings (classified as “Landing only” in InterCatch with no sampling data). The 2019 data provided by Scotland was raised based on length frequencies collected in quarter 2. Careful must be taken however when interpreting this information due to the low levels of sampling.

Natural mortality, maturity at age and other biological parameters

No data available.

Research vessel data

An underwater TV (UWTV) survey of this FU has been conducted sporadically (1994, 1999, 2006, 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.

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, 4 tonnes in 2018 and 21 tonnes in 2019.

11.8.5 Recruitment estimates

There are no recruitment estimates for this FU.

11.8.6 Short-term Forecasts

Due to the Covid-19 outbreak it was decided by ICES prior to the 2020 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. Therefore *Nephrops* catch forecasts for 2021 and 2022 in FU 10 are not presented as usual as they will be calculated in October.

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 in the Union waters of the North Sea (ICES divisions 2.a, 3.a and Subarea 4) with certain gears (Regulation (EU) 2018/2035) for the period 2019–2021 (Regulation (EU) 2018/2035).

11.9 Norwegian Deep (FU 32)

11.9.1 Ecosystem aspects.

See stock annex (Section A.3).

11.9.2 The fishery in 2018 and 2019

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 2018

Advice for *Nephrops* in FU 32 is biannual and was last updated in 2018. This advice applied for 2019 and 2020. 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.

The ICES advice in 2018 (for 2019 and 2020) (single-stock exploitation boundaries) was as follows:

ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should be no more than 397 tonnes. If this stock is not under the Norwegian discard ban in 2019 and 2020 and discard rates do not change from the average of the period 2014–2016, this implies landings of no more than 389 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 600 tonnes in 2020 (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 2019 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, total landings increased again, to 191 tonnes. 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, due to Danish landings more than doubling from the previous year, Denmark landed 48% of the total landings. Norwegian landings decreased from 2008 to 2014, but have increased since, to 103 and 100 tonnes in 2018 and 2019 respectively. 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, resulting in 78% 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 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 2014–2019 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 six years may indicate low recruitment to the stock. Discards were low also in FUs 3–4 in 2014–2016, but increased in 2017 and 2018. There are no Norwegian discard data, and Norwegian discards are assumed to be zero (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 five years (Table 11.9.1).

Length composition

The average size of *Nephrops* 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, and has thereafter fluctuated around this level. The average size of landed females, on the other hand, has remained at the low 2013-level. The mean size of discards (< 40 mm) has fluctuated without trend since 2002. In the 2014-report it was suggested that a possible explanation for the decreased mean size of *Nephrops* 40 mm could be that the Danish fishery in 2013 contracted into an area with small *Nephrops*. 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.

Mean size of the Danish catches from the years 2007, 2010, 2012, 2014, 2016, 2017, and especially 2018 and 2019, 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. 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 1989–2019 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 (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 has had reasonably good catch rates since 2013. Environmental changes resulting in lower *Nephrops* densities in the whole functional unit cannot be ruled out. The likely low recruitment to the stock in 2014–2019 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 elec- 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 2016 benchmark concluded that an LPUE index based on the electronic logbooks is not representative of the present Norwegian *Nephrops* fishery in FU 32. The 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 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 bottom trawl shrimp 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 is 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 has fluctuated without trend around this lower level, reaching its minimum value in 2020 (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 bi-annual 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 trawl survey.

11.9.6 Historic stock trends

The increase in mean size in landings from 2006 to 2012 in females and from 2005 to 2018 in males could reflect the lower exploitation pressure 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 declined from 2007 to 2008 and has thereafter fluctuated without trend.

11.9.7 Recruitment estimates

There are no recruitment estimates for this stock. Fluctuations in catches of small *Nephrops* are used as a proxy for recruitment. Discards of small *Nephrops* were very low in 2014–2019, indicating low recruitment these years.

11.9.8 Forecasts

There were no forecasts for this stock.

11.9.9 Biological reference points

No reference points are defined for this stock.

11.9.10 Quality of assessment

The data available for this stock remain limited.

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 fishery patterns, 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 2013–2019 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 six 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 235 tonnes (2010–2019), while the short-term average landings are 169 tonnes (2015–2019).

11.9.12 Living issues list

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 to 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 six 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 discard 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 below) was calculated. The biomass estimates imply low harvest rates in FU 32, even in former years with high landings (1000–1200 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 wanted catches	75 g	Average of 2016, 2018 and 2019
Mean weight in unwanted catches	43 g	Average of 2016, 2018 and 2019
Unwanted catches rate (total)	0.8%	Average of 2016, 2018 and 2019 (proportion by numbers)
Discard survival rate	25%	Discard survival is assumed to be 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

					Range of potential densities (*Nephrops* m ^{2})								
Basis	**Live discards**	**Dead discards**	**Landings**	**Dead removals**	**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)	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)	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%	0	1	311	312	2.3%	1.2%	0.6%	0.4%	0.3%	0.2%	0.2%	0.2%	0.1%
2018 advice	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%	1	2	467	469	3.5%	1.7%	0.9%	0.6%	0.4%	0.3%	0.3%	0.2%	0.2%
Maximum landings	1	4	1190	1194	8.8%	4.4%	2.2%	1.5%	1.1%	0.9%	0.7%	0.6%	0.6%
FMSY	2	7	2020	2027	15.0%	7.5%	3.8%	2.5%	1.9%	1.5%	1.3%	1.1%	0.9%

11.9.15 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 to 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 to 2005 and 2009 to 2016 are shown in Figure 11.10.2. Notice, that except for 2005 and 2011 they are rather similar. No discards were observed in the Danish at-sea observer data in 2016, hence the large increase in mean length. Figure 11.10.1 shows the development of the mean size of *Nephrops* in catches. The drop in the mean CL in the catches in 2005 and 2011 reflects an increase in numbers at around 30 mm CL and could indicate a large recruitment in these years, see also Figure 11.10.1.

In the period 2001–2005, and in 2009–2016 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples do not cover all quarters. In 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 station 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

Forecasts were not performed.

Biological reference points

There are no reference points defined for this stock.

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

11.10.2 Quality of the assessment

Catch sampling needs to be improved. Discard data exist but are not considered representative and are not used to formulate advice. It is currently not possible to update mean weight estimates for landings because current sampling levels are too low. Samples are needed from the main fleets fishing in this FU.

The advice is based on a calculation of potential landing options and harvest rates, given the known surface area of Norway lobster habitat and observed densities of the functional unit.

11.10.3 Management considerations for FU 33

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

11.10.4 Status of the stock

Previously, the state of this stock has been unknown, where an assumed low density (based on the lowest observed density in FU 7 (Fladen Ground) has been used to estimate harvest rates. In 2017, Denmark began conducting an UWTV survey of this functional unit. The observed density in 2017 (0.13 *Nephrops* m ^{2}) conformed well to those previous adopted from FU 7 (0.1 *Nephrops* m ^{2}). In 2018 and 2019, the observed densities were lower than what was observed in 2017 at 0.07 *Nephrops* m ^{2}. Harvest rates are considered low for this stock.

The mean individual weight in landings and discards in 2015 are 40.57 and 17.19 g respectively and the survival rate of discards is 25%. Discards are known to take place for the entire fishery, however only length measured discard data exist for the Dutch fishery. These data are not believed to be representative for the entire fishery as considerable 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.

11.11 Devil’s Hole (FU 34)

The Devil’s Hole was designated as a functional unit in 2010, after recommendation from SGNEPS because of increasing landings in the area. The latest advice for this functional unit was provided in 2018 using the ICES data limited approach for *Nephrops*.

11.11.1 Ecosystem aspects

The area consists of a number of narrow trenches (up to 2 km wide) running in a north-south direction, with an average length of 20–30 km. These trenches fall across six ICES statistical rectangles: 41–43F0 and 41–43F1, which are used to define this functional unit. The British Geological Survey (BGS) sediment map (showing sediments suitable for *Nephrops*) of the area is shown in Figure 11.11.5 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 2018 and 2019

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 2018

Advice provided in 2018 was biennial for 2019 and 2020.

"*ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should not exceed 590 tonnes.*

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

11.11.3 Management

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

11.11.4 Assessment

Data are presented which in future may form the basis for an assessment. A benchmark was carried out for this functional unit in 2013 (WKNEPH, 2013) which advised to continue with the data limited approach at present with the aim of moving to a full underwater TV (UWTV) assessment (Category 1) in the near future.

Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2019 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 have fluctuated around 500 tonnes but in 2019 a marked increase was recorded with landings rising to 1186 tonnes (a 272% increase in relation to 2018).

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

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 2010's 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 2015–2019, 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 2019 were successfully uploaded into InterCatch prior the 2020 WG meeting according with the deadline proposed. Both landings and discard sampling have been very limited in recent years and Intercatch has been used mainly to record official landings data from counties who submitted data into FU 34 (Scotland and England).

Length Base Indicators (LBI)

The terms of Reference for the 2018 WGNSSK meeting requested the WG to propose appropriate MSY proxies for a number of Category 3 and 4 stocks including (*Nephrops* FU 34) by using methods provided in the ICES Technical Guidelines (ICES, 2017) along with available data and expert judgement. For FU 34, only limited length frequency information is available with few landings and discard samples collected per year. An attempt was made to run the Length Base Indicators (LBI) screening method using data from 2014 to 2017 (Figure 11.11.7). 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)	
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)	
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 and 2016 but the survey has continued in 2014, 2015 and 2017–2019. The most recent survey, conducted in the Summer of 2019 (20 TV stations completed) gives an estimate of density of 0.29 burrows/m^2, a significant increase in relation to the 2018 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

Due to the Covid-19 outbreak it was decided by ICES prior to the 2020 WG meeting that the advice for North Sea *Nephrops* stocks would be delayed until autumn after the summer surveys. Therefore *Nephrops* catch forecasts for 2021 and 2022 in FU 34 are not presented as usual as they will be calculated in October.

11.11.9 Quality of the assessment

The time-series of underwater TV (UWTV) survey data is incomplete. Surveys were conducted in 2003 and 2005 and during the periods 2009–2012, 2014–2015, and 2017–2019.

The catch options are based on a calculation of potential landing options and harvest rates, given the known surface area of Norway lobster habitat and observed densities of the functional unit. The surface area is based on an estimate of area derived from Scottish vessel monitoring system (VMS) data from Scottish Norway lobster vessels from 2006 to 2009. The area of ground shown in geological charts is significantly larger than this and landings have been made from these areas. Therefore, the area should be regarded as a minimum estimate and the harvest rate could well be lower than implied by the analysis.

In recent years, only limited sampling data of catches have been available for this stock. Therefore, mean weights in discards are borrowed from the adjacent FU 7 and are used in addition to historical data.

11.11.10 Status of the stock

The current state of the stock is unknown.

11.11.11 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource. In 2016–2017, catches increased substantially to levels well above ICES advice in 2016 and 2017, highlighting the issue that current management arrangements are not sufficient to contain the fishery within the sustainable limits determined by ICES.

There is a by-catch of other species in the Devil's Hole area. It is important that efforts are made to ensure that unwanted by-catch is kept to a minimum in this fishery.

This stock is under the landings obligation although there is a survivability exemption in place for *Nephrops* in in the Union waters of the North Sea (ICES divisions 2.a, 3.a and Subarea 4) with certain gears (Regulation (EU) 2018/2035) for the period 2019-2021 (Regulation (EU) 2018/2035).

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). *Nephrops* are landed throughout the year although the main fishing season is the summer, and the predominant gears are bottom otter trawl (OTB) and beam trawls (TBB) with 70–99 mm of mesh size. Landings by creel vessels are typically lower than 1.5%.

The *Nephrops* fishery outside of the functional units has fluctuated over time. Landings exceeded 1000 tonnes in 2011, the first year with data. Then they dropped during the period 2012–2015, reaching a minimum of 393 tonnes in 2014. In 2016 and 2017 landings increased up to the original values, but they were reduced by half in 2018 (Table 11.12.1). Except Scotland and Sweden, all countries decreased their landings in 2018 by 50% or 60% in comparison to 2017. 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 and 2017. The discards reported in 2019 were 567 tonnes, 3.4 times higher than in 2018 and the highest on record (Table 11.12.2).

Advice in 2017

The Subarea 4 outside the functional units is assessed every three years. The last assessment was conducted in 2017, and the outcome was 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.

Table 11.2.1. Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2018, as officially reported to ICES.

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

Table 11.2.1 (continued). Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2017, as officially reported to ICES.

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

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Table 11.2.1 (continued). Nominal landings (tonnes) of *Nephrops* in Subarea 4, 1984–2017, as officially reported to ICES.

	2013	2014	2015	2016	2017	2018
Belgium	303	494	349	880	1109	635
Denmark	387	624	515	755	594	100
Faeroe Islands	0	0	0	0	0	0
France	0	0	0	0	0	0
Germany	425	418	435	862	923	557
Ireland	0	1	0	0	0	0
Netherlands	910	1154	1113	1464	1418	803
Norway	63	63	81	98	94	103
Sweden	0		0	1	0	0
UK (Eng + Wales + NI)	-					
UK (Scotland)	-					
UK	8625	11211	6825	9337	11911	10966
Total	10713	13965	9318	13397	16049	13164

Table 11.2.2. Summary of *Nephrops* landings from the ICES area, by Functional Unit, 1981–2018.

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981		1073	373	1006	1416	36				76	3980
1982		2524	422	1195	1120	19				157	5437
1983		2078	693	1724	940	15				101	5551
1984		1479	646	2134	1170	111				88	5628
1985		2027	1148	1969	2081	22				139	7386
1986		2015	1543	2263	2143	68				204	8236
1987		2191	1696	1674	1991	44				195	7791
1988		2495	1573	2528	1959	76				364	8995
1989		3098	2299	1886	2576	84				233	10176
1990		2498	2537	1930	2038	217				222	9442
1991	862	2063	4223	1404	1519	196				560	10827
1992	612	1473	3363	1757	1591	188				401	9385
1993	721	3030	3493	2369	1808	376	339	160		434	12730
1994	503	3683	4569	1850	1538	495	755	137		703	14233
1995	869	2569	6440	1763	1297	280	489	164		844	14715
1996	679	2483	5217	1688	1451	344	952	77		808	13699
1997	1149	2189	6171	2194	1446	316	760	276		662	15163
1998	1111	2177	5136	2145	1032	254	836	350		694	13735
1999	1244	2391	6521	2205	1008	279	1119	724		988	16479
2000	1121	2178	5569	1785	1541	275	1084	597		900	15050
2001	1443	2574	5541	1528	1403	177	1190	791		1268	15915
2002	1231	1954	7247	1340	1118	401	1170	861		1383	16705
2003	1144	2245	6294	1126	1079	337	1089	929		1390	15633
2004	1070	2153	8729	1658	1335	228	922	1268		1224	18587
2005	1099	3094	10685	1990	1605	165	1089	1050		1120	21897
2006	974	4903	10791	2458	1803	133	11033	1288		1249	24627
2007	1294	2966	11910	2652	1842	155	755	1467		1637	24678
2008	963	1218	12240	2450	1514	173	675	1444		1673	22350

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
2009	728	2703	13327	2662	1067	89	477	1163		2367	24583
2010	959	1443	12825	1871	1032	38	407	806	757	709****	20847
2011	1053	2070	7558	1888	1391	69	395	1191	433	1166*****	17214
2012	1240	2460	4369	2091	860	13	310	1084	597	608****	13632
2013	1050	2982	2951	1503	623	16	191	946	120	409	10791
2014	1416	2503	4147	2370	1252	15	205	1146	320	393	13766
2015	1516	1371	1784	1897	816	15	192	1003	440	610	9656
2016	2535	1854	2399	1937	1146	23	178	1636	780	966	13454
2017	2110	1963	5147	2493	1119	9	147	1472	550	1191	16050
2018*	1004	1807	4418	2690	1399	4	137	776	318	612	13165

Table 11.3.1. *Nephrops* in FU 5: Nominal Landings (tonnes) of *Nephrops*, 1991–2019, as reported to the WG.

	Belgium	Denmark	Netherlands	Germany	UK	Total**	Catch***
1991	682	176	na		4	862	
1992	571	22	na		19	612	
1993	694	20	na		7	721	
1994	494	0	na		9	503	
1995	641	77	148		3	869	
1996	266	41	317		55	679	
1997	486	67	540		56	1149	
1998	372	88	584	39	28	1111	
1999	436	53	538	59	158	1244	
2000	366	83	402	52	218	1121	
2001	353	145	553	114	278	1443	
2002	281	94	617	88	151	1231	
2003	265	36	661	24	158	1144	
2004	171	39	646	16	198	1070	
2005	109	87	654	51	198	1099	
2006	77	24	444	99	330	974	
2007	75	3	464	201	551	1294	
2008	49	29	268	108	509	963	
2009	52	3	288	98	287	728	
2010	48	5	354	140	411	959	
2011	60	18	480	145	350	1053	
2012	129	0	497	121	493	1240	
2013	142	1	447	168	292	1050	
2014	131	41	645	139	460	1416	
2015	146	0	681	184	505	1516	3562
2016	233	0	801	442	1059	2535	3243
2017	416	0	745	374	575	2110	2995
2018	234	1	429	204	136	1004	1709
2019	194	0	551	284	143	1172	2154

Table 11.4.1. *Nephrops* in FU 6: Nominal Landings (tonnes) of *Nephrops*, 1981–2019, as reported to the WG.

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
1981	1006	67	1073	0	1073
1982	2443	81	2524	0	2524
1983	2073	5	2078	0	2078
1984	1471	8	1479	0	1479
1985	2009	18	2027	0	2027
1986	1987	28	2015	0	2015
1987	2158	33	2191	0	2191
1988	2390	105	2495	0	2495
1989	2930	168	3098	0	3098
1990	2306	192	2498	0	2498
1991	1884	179	2063	0	2063
1992	1403	60	1463	10	1473
1993	2941	89	3030	0	3030
1994	3530	153	3683	0	3683
1995	2478	90	2568	1	2569
1996	2386	96	2482	1	2483
1997	2109	80	2189	0	2189
1998	2029	147	2176	1	2177
1999	2197	194	2391	0	2391
2000	1947	231	2178	0	2178
2001	2319	255	2574	0	2574
2002	1739	215	1954	0	1954
2003	2031	214	2245	0	2245
2004	1952	201	2153	0	2153
2005	2936	158	3094	0	3094
2006	4430	434	4864	39	4903
2007	2525	437	2962	4	2966

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
2008	976	244	1220	0	1220
2009	2299	414	2713	0	2713
2010	1258	185	1443	0	1443
2011	1806	250	2056	14	2070
2012	2177	256	2433	27	2460
2013	2666	305	2971	11	2982
2014	2104	345	2449	54	2503
2015	1186	174	1360	11	1371
2016	1726	125	1851	3	1854
2017	1685	260	1945	18	1963
2018	1557	229	1786	21	1807
2019	3451	853	4304	55	4359

Table 11.4.2. *Nephrops* in FU 6: Mean sizes in catches and landings by sex.

Year	Catches		Landings	
	Males	Females	Males	Females
1985	30.1	28.5	35.4	33.8
1986	31.7	30.2	35.3	33.7
1987	28.6	27	35.3	33.3
1988	28.7	27.3	35	33.9
1989	29	28.2	32.4	31.9
1990	27.1	27.4	31.8	31.3
1991	28.9	27.1	33.5	33.1
1992	30.8	29	33	31.9
1993	32.1	28.7	33.4	30.1
1994	30.5	27.7	33.8	30.5
1995	28.4	27.4	33.8	31.6
1996	29.8	28.2	34.5	32.1
1997	29.9	29.6	33.5	32.1
1998	30	28.9	34.9	33.7
1999	29.6	27.5	35.1	33.6
2000	27.2	26.8	31.1	31.3
2001	26.2	26.3	30.6	31.3
2002	28.0	26.9	30.9	30.0
2003	29.0	27.1	31.7	30.6
2004	29.2	27.0	32.3	30.6
2005	29.7	29.4	32.1	32.2
2006	29.0	30.3	31.4	32.4
2007	31.3	30.7	33.3	32.6
2008	31.5	31.1	33.5	33.3
2009	30.0	31.0	32.1	33.3
2010	31.2	31.4	32.8	33.2
2011	32.0	31.6	33.7	33.6
2012	30.8	32.0	33.2	34.5
2013	29.6	32.4	32.0	35.3
2014	31.8	35.4	32.9	36.6
2015	31.5	31.7	33.9	34.9
2016	31.2	31.3	33.3	34.3
2017	32.5	31.8	34.2	34.3
2018	32.5	32.3	34.0	34.6
2019	32.0	33.0	33.4	34.8

Table 11.4.3. *Nephrops* in FU 6: Landings and effort by UK vessels targeting *Nephrops*

Year	< 12 m			12–15 m			> 15 m		
	Landings [t]	Effort [kWd]	LPUE [kg/kWd]	Landings [t]	Effort [kWd]	LPUE [kg/kWd]	Landings [t]	Effort [kWd]	LPUE [kg/kWd]
2006	837	587489	1.42	335	198113	1.69	602	515764	1.17
2007	581	519723	1.12	205	149286	1.37	289	307798	0.94
2008	327	378205	0.87	138	147808	0.93	130	175588	0.74
2009	541	438661	1.23	301	244381	1.23	455	439956	1.03
2010	377	303615	1.24	163	131465	1.24	269	324728	0.83
2011	512	391844	1.31	190	132333	1.43	385	385763	1.00
2012	521	401542	1.30	266	208761	1.27	341	340420	1.00
2013	608	414242	1.47	333	230972	1.44	392	331996	1.18
2014	501	363987	1.38	225	157632	1.43	392	368393	1.07
2015	224	246933	0.91	112	114718	0.98	212	281224	0.75
2016	549	450947	1.22	173	168254	1.03	378	471716	0.80
2017	577	470314	1.23	161	152197	1.06	313	351517	0.89
2018	481	467120	1.03	157	179290	0.87	194	234121	0.83
2019	720	613204	1.17	273	206253	1.32	500	488101	1.02

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

Table 11.4.5. *Nephrops* in FU 6: Historical harvest rate determination.

Year	TV abundance index	Landings (t)	Discard rate	Mean Weight Landings (g)	Mean Weight Discards (g)	N removed	Observed Harvest Rate
2001	1685	2574	66.60%	20.67	9.62	373	22.1%
2002	1048	1953	46.10%	20.00	9.50	181	17.3%
2003	1085	2245	42.10%	21.89	9.56	177	16.3%
2004	1377	2152	41.70%	23.14	9.22	160	11.6%
2005	1657	3094	34.50%	23.58	10.32	200	12.1%
2006	1244	4858	31.30%	22.53	10.58	314	25.2%
2007	858	2966	25.00%	24.95	10.89	159	18.5%
2008	987	1213	24.90%	26.63	10.97	61	6.1%
2009	682	2711	29.30%	24.45	10.54	157	23.0%
2010	785	1443	23.00%	25.18	11.74	74	9.5%
2011	878	2072	22.60%	27.05	11.02	99	11.3%
2012	758	2457	27.42%	27.30	10.16	124	16.4%
2013	706	2982	29.80%	27.60	9.80	154	21.8%
2014	755	2503	14.90%	29.90	13.50	98	13.0%
2015	565	1371	28.97%	29.39	9.99	66	11.6%
2016	697	1854	28.65%	27.97	10.23	93	13.3%
2017	902	1963	22.25%	29.18	10.29	87	9.6%
2018	950	1807	21.34%	28.97	11.22	79	8.3%
2019	1163	4359	20.39%	28.76	11.55	193	16.6%

Table 11.4.6. Nephrops in FU 6: Summary of the imported and sampled data submitted in InterCatch

Catch category	Raised Or Imported	Sampled Or Estimated	Tonnes	Percent
Landings	Imported_Data	Sampled_Distribution	1439	80
Landings	Imported_Data	Estimated_Distribution	368.1	20
Discards	Imported_Data	Sampled_Distribution	139.3	73
Discards	Raised_Discards	Estimated_Distribution	50.56	27

Table 11.5.1. *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981–2019, as reported to the WG

Year	UK Scotland				Denmark	Other countries **	Total
	Nephrops trawl	Other trawl	Creel	Sub-total			
1981	304	68	0	372	0	0	372
1982	381	40	0	421	0	0	421
1983	588	105	0	693	0	0	693
1984	552	94	0	646	0	0	646
1985	1020	120	0	1140	7	0	1147
1986	1401	92	0	1493	50	0	1543
1987	1023	349	0	1372	323	0	1695
1988	1309	185	0	1494	81	0	1575
1989	1724	410	0	2134	165	0	2299
1990	1703	598	0	2301	236	3	2540
1991	3021	772	0	3793	424	6	4223
1992	1809	1164	0	2973	359	31	3363
1993	2031	1234	0	3265	224	3	3492
1994	1816	2356	0	4172	390	6	4568
1995	3568	2389	19	5976	439	4	6419
1996	2338	2578	7	4923	286	1	5210
1997	2712	3221	0	5933	235	2	6170
1998	2290	2673	0	4963	173	0	5136
1999	2860	3546	0	6406	96	16	6518
2000	2916	2546	0	5462	103	5	5570
2001	3540	1936	0	5476	64	2	5542
2002	4511	2546	0	7057	173	15	7245
2003	4175	2033	0	6208	82	4	6294
2004	7274	1319	1	8594	136	0	8730
2005	8849	1508	5	10362	321	1	10684
2006	9470	1026	1	10497	283	11	10791
2007	11055	734	0	11789	119	3	11911
2008	11432	666	0	12098	133	8	12239
2009	12688	499	0	13187	130	10	13327
2010	12544	288	0	12832	124	12	12968
2011	7367	128	0	7495	64	<0.5	7559
2012	4257	81	0	4338	75	2	4415
2013	2275	663	0	2938	5	8	2951
2014	3928	206	0	4134	10	3	4147
2015	1465	307	0	1772	8	4	1784
2016	2021	374	0	2395	2	2	2399
2017	2853	2291	0	5144	1	2	5147
2018	2283	2130	0	4413	1	4	4418
2019*	6773	2233	0	9006	7	19	9032

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, 2000–2019.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	5462	35367	154.4
2001	5476	28558	191.8
2002	7057	28586	246.9
2003	6208	21960	282.7
2004	8593	21562	398.5
2005	10357	23555	439.7
2006	10496	22836	459.6
2007	11789	21603	545.7
2008	12098	22856	529.3
2009	13187	21153	623.4
2010	12832	20968	612.0
2011	7495	15273	490.7
2012	4338	11994	361.7
2013	2938	11933	246.2
2014	4134	12629	327.3
2015	1772	10562	167.8
2016	2395	12297	194.8
2017	5144	15205	338.3
2018	4413	14431	305.8
2019*	9006	15244	590.8

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, 1991–2019.

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

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, 1993–2019.

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

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
Mean (17–19)	31.48*	23.06	26.78	31.76**	-

Table 11.5.6. *Nephrops*, Fladen (FU 7): Results of the 1992–2019 TV surveys

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

Table 11.5.7. *Nephrops*, Fladen Ground (FU 7): Summary of TV results for most recent 3 years (2017–2019) 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
2017 TV survey							
>80	3248	10	0.479	0.026	1557	27941	0.119
55<80	4967	15	0.392	0.043	1947	71354	0.305
40<55	4304	10	0.258	0.008	1109	15396	0.066
<40	15634	36	0.155	0.018	2422	119582	0.51
Total	28153	71			7036	234273	1
2018 TV survey							
>80	3248	9	0.364	0.007	1182	8658	0.073
55<80	4967	16	0.290	0.012	1437	18334	0.154
40<55	4304	11	0.245	0.013	1055	21311	0.179
<40	15634	35	0.127	0.010	1982	70523	0.593
Total	28153	71			5656	118826	1
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

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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 1992–2019.**

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
1992	3661	376	3.1	114	NA	NA	3363	NA	0	NA	29.61	NA	NA
1993	4450	569	3.1	138	NA	NA	3492	NA	0	NA	25.38	NA	NA
1994	6170	814	3.1	193	NA	NA	4568	NA	0	NA	23.72	NA	NA
1995	4987	896	4.7	233	NA	NA	6419	NA	0	NA	27.51	NA	NA
1996	NA	NA	NA	175	NA	NA	5210	NA	0	NA	29.82	NA	NA
1997	2767	510	7	192	NA	NA	6170	NA	0	NA	32.08	NA	NA
1998	3838	717	4.3	164	NA	NA	5136	NA	0	NA	31.37	NA	NA
1999	4146	649	5.1	213	NA	NA	6518	NA	0	NA	30.55	NA	NA
2000	3628	491	4.7	153	21	169	5570	340	255	12	36.35	16.24	9.3
2001	4981	970	5.1	221	43	253	5542	687	515	16.3	25.1	15.94	12.8
2002	6087	757	4.9	259	55	301	7245	820	615	17.4	27.93	14.97	13.7
2003	5547	1076	4.1	209	24	226	6294	349	262	10.1	30.15	14.83	7.8
2004	5725	1030	5.4	282	34	307	8730	506	379	10.6	30.98	15.06	8.2
2005	4325	662	9.3	368	46	403	10684	823	617	11.2	29.05	17.74	8.6
2006	4862	619	8.4	369	54	409	10791	798	599	12.7	29.25	14.87	9.8
2007	7017	730	7	447	55	488	11911	747	560	10.9	26.63	13.67	8.4
2008	7360	1019	6.1	434	18	448	12239	257	192	3.9	28.18	14.54	3.0
2009	5457	772	9.4	473	51	511	13327	707	530	9.7	28.20	13.85	7.5
2010	5224	711	9.9	492	34	517	12968	560	420	6.5	26.38	16.44	4.9
2011	3382	435	6.2	209	0	209	7559	0	0	0	36.17	NA	0
2012	2748	392	4.7	128	0	128	4415	0	0	0	36.91	NA	0
2013	2902	335	3.1	89	0	89	2951	0	0	0	34.90	NA	0

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
2014	2990	412	3.5	102	3	104	4147	37	28	2.5	43.11	13.9	1.9
2015	2569	320	2	51	0	51	1784	0	0	0	36.7	NA	0
2016	4449	662	1.4	63	0	63	2399	0	0	0	39.43	NA	0
2017	7036	968	3.1	212	10	219	5147	115	86	4.4	25.37	11.66	3.4
2018	5656	689	2.8	155	5	159	4418	68	51	2.9	30.58	14.42	2.2
2019	6129	802	5.6	338	8	344	9032	100	75	2.2	28.31	13.32	1.6

Table 11.6.1 *Nephrops*. Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981–2019, as reported to the WG.

Year	UK Scotland					UK	Total **
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	
1981	947	60	0	0	1007	0	1007
1982	1138	57	0	0	1195	0	1195
1983	1681	43	0	0	1724	0	1724
1984	2078	56	0	0	2134	0	2134
1985	1907	61	0	0	1968	0	1968
1986	2204	59	0	0	2263	0	2263
1987	1583	90	2	0	1675	0	1675
1988	2455	74	0	0	2529	0	2529
1989	1834	53	0	0	1887	1	1888
1990	1900	30	0	0	1930	1	1931
1991	1362	43	0	0	1405	0	1405
1992	1715	41	0	0	1756	0	1756
1993	2349	17	0	0	2366	2	2368
1994	1827	17	0	0	1844	6	1850
1995	1707	53	0	0	1760	2	1762
1996	1621	66	0	0	1687	0	1687
1997	2136	55	0	0	2191	2	2193
1998	2105	37	0	0	2142	2	2144
1999	2193	10	1	0	2204	3	2207
2000	1775	9	0	0	1784	1	1785
2001	1484	34	0	0	1518	9	1527
2002	1302	31	1	0	1334	6	1340
2003	1116	8	0	0	1124	3	1127
2004	1650	4	0	0	1654	3	1657
2005	1974	0	4	0	1978	11	1989
2006	2438	3	12	0	2453	5	2458
2007	2627	10	7	0	2644	7	2651

Year	UK Scotland					UK	Total **
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	
2008	2435	2	8	0	2445	5	2450
2009	2620	8	26	0	2654	9	2663
2010	1923	5	13	0	1941	9	1950
2011	1789	6	89	0	1884	5	1889
2012	1944	17	126	0	2087	42	2129
2013	1409	24	58	0	1491	12	1503
2014	2344	4	14	0	2362	22	2384
2015	1784	2	43	0	1829	68	1897
2016	1786	1	116	1.5	1905	32	1937
2017	2406	16	10	0	2432	61	2493
2018	2638	7	4	0	2649	41	2690
2019*	2625	16	4	0	2645	39	2684

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, 2000–2019.

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

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2011	1795	4614	389.0
2012	1961	5058	387.7
2013	1433	4029	355.7
2014	2348	6812	344.7
2015	1786	6024	296.5
2016	1787	5224	342.1
2017	2422	5261	460.4
2018	2645	4886	541.3
2019	2641	5116	516.2

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, 1981–2019.

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

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011	28.6	27.5	30.0	28.3	38.8	38.2
2012	28.4	28.0	30.4	29.3	39.0	38.1
2013	28.3	27.4	29.6	28.8	38.8	37.9
2014	29.6	29.1	31.1	30.3	38.6	38.1
2015	27.9	28.3	29.5	29.3	39.6	38.5
2016	29.3	28.6	30.5	29.7	39.4	38.5
2017	29.6	28.1	30.9	29.3	38.5	38.9
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

Table 11.6.4. *Nephrops*, Firth of Forth (FU 8): Results of the 1993–2019 TV surveys.

Year	Stations	Mean Density burrows/m²	Abundance millions	95% conf interval millions
1993	37	0.61	555	142
1994	30	0.49	448	78
1995	no survey			
1996	27	0.41	375	88
1997	no survey			
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125
2014	51	0.47	428	80
2015	51	0.73	664	127
2016	50	0.87	797	146
2017	52	0.73	670	133
2018	50	1.12	1025	190
2019	50	0.95	865	135

Table 11.6.5. *Nephrops*, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2017–2019) 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
2017 TV survey							
M & SM	170	10	0.505	0.263	86	765	0.172
MS(west)	139	9	0.597	0.350	83	751	0.169
MS(mid)	211	11	0.921	0.366	194	1478	0.333
MS(east)	395	22	0.777	0.204	307	1445	0.325
Total	915	52			670	4439	1
2018 TV survey							
M & SM	170	9	0.694	0.855	118	2760	0.306
MS(west)	139	8	0.790	0.954	110	2302	0.255
MS(mid)	211	11	1.714	0.432	361	1744	0.193
MS(east)	395	22	1.103	0.313	436	2220	0.246
Total	915	50			1025	9026	1
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

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 1993–2019.**

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
1993	555	142	24.1	97	49	134	2368	426	426	33.3	24.3	11.64	27.3
1994	448	78	51.3	95	180	230	1850	1188	1188	65.5	19.51	8.79	58.8
1995	NA	NA	NA	90	59	134	1762	465	465	39.5	19.55	10.54	32.9
1996	375	88	37.3	81	78	140	1687	697	697	49.2	20.81	11.85	42.1
1997	NA	NA	NA	116	56	158	2193	371	371	32.6	18.87	8.79	26.6
1998	292	81	55.7	118	60	163	2144	434	434	33.9	18.23	9.6	27.8
1999	463	78	39.6	110	97	183	2207	704	704	47	20.05	9.63	39.9
2000	443	70	33.7	82	90	150	1785	774	774	52.5	21.83	11.42	45.3
2001	419	79	25.3	72	45	106	1527	327	327	38.7	21.22	9.59	32.1
2002	508	119	21.1	68	52	107	1340	316	316	43.1	19.62	8.16	36.2
2003	767	138	12.4	51	59	95	1127	546	410	53.9	22.31	9.25	46.7
2004	630	140	16.4	74	40	103	1657	406	304	34.9	22.45	10.25	28.7
2005	710	143	19.4	89	65	138	1989	602	452	42.1	22.33	9.28	35.3
2006	827	126	26.7	115	142	221	2458	1510	1133	55.2	21.43	10.67	48.1
2007	692	132	22.9	126	43	159	2651	614	461	25.3	20.97	14.34	20.3
2008	881	297	21.1	142	58	186	2450	796	597	29.1	17.23	13.65	23.5

Year	Adjusted abun-dance (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 dis-card rate
2009	732	142	26	137	71	190	2663	573	430	34.1	19.41	8.09	27.9
2010	682	147	19.2	99	43	131	1950	407	305	30.2	19.76	9.55	24.5
2011	533	87	22.1	100	24	118	1889	231	173	19.5	19.75	9.56	15.3
2012	522	64	24.6	100	38	129	2129	379	284	27.2	21.66	10.10	21.9
2013	668	126	15.6	81	31	104	1503	301	226	27.4	19.30	9.82	22.0
2014	428	80	29.1	102	30	124	2384	353	265	22.9	24.30	11.66	18.3
2015	664	127	16.8	90	29	112	1897	311	234	24.4	21.84	10.74	19.5
2016	797	146	12.3	85	17	98	1937	165	123	16.4	23.62	9.86	12.8
2017	670	133	19.7	111	28	132	2493	280	210	20	23.07	10.07	15.8
2018	1025	190	12.9	114	24	132	2690	275	206	17.4	24.29	11.42	13.6
2019	865	135	18.3	127	42	158	2684	411	308	24.9	21.81	9.76	19.9

Table 11.7.1. *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981–2019, as reported to the WG.

Year	UK Scotland				UK *	Total **
	Nephrops trawl	Other trawl	Creel	Sub-total	England	
1981	1299	117	0	1416	0	1416
1982	1033	86	0	1119	0	1119
1983	850	91	0	941	0	941
1984	960	209	0	1169	0	1169
1985	1908	173	0	2081	0	2081
1986	1932	211	0	2143	0	2143
1987	1724	268	0	1992	0	1992
1988	1637	322	0	1959	0	1959
1989	2102	474	0	2576	0	2576
1990	1698	339	0	2037	0	2037
1991	1285	235	0	1520	0	1520
1992	1285	306	0	1591	0	1591
1993	1505	304	0	1809	0	1809
1994	1179	358	0	1537	0	1537
1995	967	312	0	1279	0	1279
1996	1084	364	1	1449	2	1451
1997	1103	343	0	1446	1	1447
1998	739	289	4	1032	0	1032
1999	813	194	2	1009	0	1009
2000	1341	196	2	1539	0	1539
2001	1186	213	2	1401	0	1401
2002	883	247	2	1132	0	1132
2003	873	196	11	1080	0	1080
2004	1222	103	8	1333	0	1333
2005	1526	64	12	1602	3	1605
2006	1751	42	11	1804	1	1805
2007	1818	17	6	1841	2	1843
2008	1444	68	3	1515	0	1515
2009	1033	31	2	1066	1	1067
2010	1026	28	9	1063	0	1063
2011	1358	23	9	1390	1	1391
2012	834	24	8	866	0	866
2013	497	116	7	620	3	623
2014	1183	56	2	1241	12	1253
2015	774	40	0	814	2	816
2016	1105	37	4	1146	<0.5	1146
2017	931	183	4	1118	1	1119
2018	1204	184	9	1397	2	1399
2019*	1181	199	13	1393	2	1395

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, 2000–2019

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	1537	7943	193.5
2001	1399	7219	193.8
2002	1130	7495	150.8
2003	1069	5934	180.1
2004	1325	6200	213.7
2005	1590	4805	330.9
2006	1793	4588	390.8
2007	1835	4758	385.7
2008	1512	4328	349.4
2009	1064	3546	300.1
2010	1054	3589	293.7
2011	1381	3880	355.9
2012	858	3079	278.7
2013	613	2954	207.5
2014	1239	4099	302.3
2015	814	3755	216.8
2016	1142	3577	319.3
2017	1114	5044	220.9
2018	1388	4579	303.1
2019*	1380	4343	317.8

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, 1981–2019.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	30.5	28.2	39.1	37.7
1982	na	na	30.2	29.0	40.0	37.9
1983	na	na	29.9	29.1	40.6	38.3
1984	na	na	29.7	29.3	39.4	38.1
1985	na	na	28.9	28.7	38.7	37.8
1986	na	na	28.7	27.8	39.1	38.4
1987	na	na	29.0	28.3	39.4	38.6
1988	na	na	29.1	28.7	38.9	38.4
1989	na	na	29.8	28.8	40.1	39.4
1990	28.8	28.1	30.3	29.1	38.4	38.7
1991	28.3	27.4	30.1	28.6	38.2	38.2
1992	29.4	28.6	31.0	30.5	38.3	38.0
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31.0	39.4	37.5
1995	25.8	25.0	29.9	29.3	39.1	38.0
1996	29.3	28.4	30.6	29.7	38.5	38.0
1997	28.5	27.9	29.5	28.9	38.8	38.2
1998	28.7	28.2	30.1	29.3	38.8	38.2
1999	29.5	28.8	30.4	29.7	38.9	37.6
2000	29.8	29.1	31.5	30.6	39.2	38.3
2001	30.0	29.2	30.9	30.2	39.5	37.9
2002	27.2	27.0	31.2	30.9	41.0	38.7
2003	29.3	29.2	30.3	30.1	39.8	38.0
2004	29.3	28.4	31.3	30.8	39.0	39.2
2005	30.0	28.7	31.0	29.6	39.2	38.5
2006	29.7	28.9	30.6	29.6	39.3	38.6
2007	30.1	28.8	30.3	29.0	39.4	38.6
2008	29.3	27.7	30.2	28.2	39.8	40.2
2009	29.7	28.9	30.7	29.3	39.6	38.5
2010	29.7	29.1	31.1	30.5	40.0	38.9
2011	28.6	28.4	29.4	29.0	39.5	38.4
2012	29.5	29.1	30.5	29.9	39.2	38.5
2013	30.7	29.3	30.9	29.5	39.6	38.4
2014	30.2	29.8	31.6	30.8	40.3	39.0
2015	29.8	29.4	31.5	30.6	40.6	39.1
2016	29.3	28.6	30.7	29.8	40.1	38.5
2017	30.6	29.6	30.7	29.8	40.0	39.7
2018	31.5	30.7	31.6	30.8	39.7	38.8
2019	30.1	29.6	30.3	29.7	40.3	38.5

Table 11.7.4. *Nephrops*, Moray Firth (FU 9): Results of the 1993–2019 TV surveys

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995	no survey			
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84
2016	53	0.18	388	87
2017	55	0.19	412	106
2018	55	0.19	417	126
2019	55	0.17	376	146

Table 11.7.5. *Nephrops*, Moray Firth (FU 9): Summary of TV results for most recent 3 years (2017–2019) 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
2017 TV survey							
M & SM	169	2	0.38	0.03	64	356	0.126
MS(west)	682	19	0.19	0.06	128	1393	0.495
MS(mid)	698	17	0.16	0.01	111	364	0.129
MS(east)	646	17	0.17	0.03	109	701	0.249
Total	2195	55			412	2813	1
2018 TV survey							
M & SM	169	3	0.30	0.02	51	199	0.05
MS(west)	682	18	0.19	0.08	127	2135	0.539
MS(mid)	698	18	0.20	0.02	141	492	0.124
MS(east)	646	16	0.15	0.04	98	1134	0.286
Total	2195	55			417	3960	1
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

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 1993–2019.

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
1993	345	78	26.5	77	19	91	1809	214	161	19.8	23.42	11.26	15.6
1994	702	176	11.4	69	15	80	1537	153	115	17.8	22.25	10.21	14
1995	NA	NA	NA	62	72	116	1279	502	376	53.8	20.59	6.93	46.6
1996	465	90	21.1	68	41	98	1451	492	369	37.5	21.4	12.11	31
1997	262	55	33.3	71	22	87	1447	230	172	23.8	20.43	10.42	18.9
1998	323	95	18.1	50	11	58	1032	89	67	17.6	20.47	8.29	13.8
1999	400	87	12.8	46	6	51	1009	55	41	12	21.79	8.63	9.3
2000	386	98	20.1	61	23	78	1539	269	201	27.5	25.44	11.73	22.1
2001	345	112	19.3	58	11	66	1401	125	94	16.3	24.18	11.04	12.8
2002	521	121	11.7	41	27	61	1132	220	165	39.7	27.68	8.18	33.1
2003	730	314	7.1	46	7	52	1080	70	52	13.7	23.32	9.51	10.6
2004	626	186	10.5	48	23	66	1333	272	204	32.6	27.57	11.62	26.6
2005	869	198	8.8	67	12	76	1605	122	92	15.0	23.84	10.31	11.7
2006	445	124	20.1	81	12	90	1805	117	87	12.8	22.34	9.86	9.9
2007	531	156	16	80	7	85	1843	95	72	7.9	23.04	13.95	6.0
2008	481	151	13.7	60	8	66	1515	74	55	11.4	25.29	9.60	8.8
2009	415	140	11.6	45	4	48	1067	33	25	7.6	23.46	8.72	5.8
2010	406	115	11.5	39	10	47	1063	104	78	19.8	26.94	10.63	15.7
2011	372	161	18.9	63	10	70	1391	102	77	13.9	21.63	10.12	10.8
2012	299	90	13.7	37	6	41	866	54	41	13.2	23.16	9.72	10.3
2013	469	106	5.8	26	1	27	623	10	8	3.3	24.95	11.21	2.5

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
2014	331	90	14.7	43	7	49	1253	87	65	14.6	28.94	11.79	11.3
2015	347	84	9.1	28	5	32	816	56	42	15.1	29.1	11.35	11.8
2016	388	87	12.7	42	9	49	1146	95	71	18.0	26.83	10.16	14.2
2017	412	106	10.5	42	1	43	1119	12	9	2.6	26.34	10.74	2.0
2018	417	126	11.7	48	0	49	1399	4	3	0.9	28.86	9.58	0.7
2019	376	146	14.8	55	1	56	1395	10	8	1.9	25.13	9.84	1.4

Table 11.8.1. *Nephrops*, Noup (FU 10): Nominal landings (tonnes) of *Nephrops*, 1981–2019, as reported to the WG.

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

2009	24	63	0	87	0	87
2010	4	35	0	39	0	39
2011	27	41	0	68	0	68
2012	2	11	0	13	0	13
2013	4	12	0	16	0	16
2014	3	11	1	15	0	15
2015	1	14	0	15	0	15
2016	9	14	0	23	0	23
2017	0	9	0	9	0	9
2018	0	4	0	4	0	4
2019*	0	21	0	21	0	21

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, 2000–2019.

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

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 and 2018.**

	Landings			
Year	< 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

Table 11.8.4. *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006, 2007, 2014 & 2019 TV surveys (absolute conversion factor = 1.35, from Fladen).

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

Table 11.9.1. *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993–2019, estimated Danish discards (2003–2019), and TAC (EU).

Year	Denmark	Danish discards		Norway			Sweden	UK	Netherlands	Total	TAC
		dead	live	Trawl	Creel	Sub-total					
1993	220			102	1	103		16		339	
1994	584			161	0	161		10		755	
1995	418			68	1	69		2		489	
1996	868			73	1	74		10		952	
1997	689			56	8	64		7		760	
1998	743			88	1	89		4		836	
1999	972			119	15	134		13		1119	
2000	871			143	0	143	37	34		1085	
2001	1026			72	13	85	26	53		1190	
2002	1043			42	21	63	13	52		1171	
2003	996	145	48	68	11	79	1	14		1090	
2004	835	200	67	72	8	80	1	6		922	1000
2005	979	194	65	89	13	102	2	6		1089	1000
2006	939	126	42	62	19	81	1	7	5	1033	1300
2007	652	64	21	77	20	97	5	1		755	1300
2008	505			112	30	142	24	4		675	1300
2009	331	29	10	107	31	138	2	6		477	1200
2010	282	36	12	82	41	123	1	1		407	1200
2011	322			29	40	69	1	3		395	1200
2012	234	35	12	25	50	75	1	0		310	1200
2013	128	51	17	18	45	63	0	0		191	1000
2014	143	4	1	15	47	62	0	0		205	1000
2015	110	5	2	8	74	82	0	0		192	1000
2016	80	1	0	7	90	97	0	0	1	178	1000
2017	53	1	0	9	85	94	0	0	0	147	1000
2018	34	0	0	10	93#	103	0	0		137	800
2019*	91	1	0	22	78#	100	0	0	0	191	600
2020											600

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*, 1993–2019.

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

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 2006-2020.

Year	mean	SD	25th percentile	median	75th percentile
2006	1414	735	910	1250	1730
2007	964	320	735	920	1128
2008	304	119	220	283	362
2009	292	105	217	277	348
2010	589	180	463	562	688
2011	413	129	323	393	480
2012	710	297	496	651	863
2013	435	142	332	415	512
2014	370	321	170	282	470
2015	641	301	429	583	788
2016	296	121	212	273	355
2017	429	128	338	409	500
2018	298	97	229	284	353
2019	171	59	130	162	203
2020	1414	735	910	1250	1730

Table 11.10.1 *Nephrops* in FU 33: (Off Horns Reef) Landings (tonnes) by country, 1993–2019.

	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

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 burrows/m²	Abundance millions	95% confidence interval 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* 1986–2019 as reported to the WG. Scottish data only from 1986 to 2009.

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

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-total				
2013	65	41	0	106	11	3		120
2014	293	14	0	307	13			320
2015	383	18	0	401	39	<0.5		440
2016	738	6	0	744	36			780
2017	400	122	0	522	28			550
2018	218	86	0	304	14			318
2019	1038	111	0	1149	37			1186

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, 2000–2019.

Year	Landings (tonnes)	Effort (days)	LPUE (kg/day)
2000	184	3391	54.3
2001	271	3142	86.3
2002	343	2022	169.6
2003	675	2614	258.2
2004	488	1551	314.6
2005	378	1545	244.7
2006	448	1440	311.1
2007	717	1824	393.1
2008	937	1673	560.1
2009	1305	1921	679.3
2010	838	1465	572.0
2011	422	1041	405.4
2012	550	1255	438.2
2013	106	438	242.0
2014	307	758	405.0
2015	401	1222	328.2
2016	744	1640	453.7
2017	522	1088	479.8
2018	304	620	490.3
2019*	1149	1291	890.0

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, 2006–2019. 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

Table 11.11.4. ***Nephrops*****, Devil's Hole (FU 34): Results of the 2003, 2005, 2009–12, 2014–2015 and 2017–2019 surveys.**

Year	Stations	Mean density burrows/m²	95% confidence interval burrows/m²
2003	20	0.09	0.02
2004		no survey	
2005	29	0.09	0.04
2006		no survey	
2007		no survey	
2008		no survey	
2009	12	0.28	0.13
2010	19	0.24	0.08
2011	14	0.16	0.09
2012	15	0.14	0.06
2013		no survey	
2014	13	0.13	0.04
2015	17	0.16	0.06
2016		no survey	
2017	16	0.09	0.04
2018	15	0.21	0.09
2019	20	0.29	0.09

Table 11.12.1. ***Nephrops*** **landings from Subarea 27.4 outside FUs.**

Year	Belgium	Denmark	France	Germany	Netherlands	Sweden	UK (England)	UK (Scotland)	Total
2012	57.1	27.1	-	131.7	128.0	0.1	43.5	202.0	532.5
2013	30.6	7.8	-	83.8	151.5	0.1	56.8	78.3	409.4
2014	50.6	30.9	-	115.1	69.2	0.1	28.4	98.2	392.5
2015	173.0	24.6	-	104.9	154.5	0.1	36.0	117.4	610.4
2016	217.0	22.9	-	218.6	289.7	0.1	53.3	164.0	965.6
2017	269.8	29.3	-	352.0	319.3	0.1	62.4	158.3	1,191.1

2018	121.2	16.3	-	143.4	117.8	0.1	32.9	180.7	612.4
2019	95.7	25.4	-	190.5	183.9	0.1	34.0	194.1	723.8

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	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-
2014	-	0.5	-	-	-	-	-	-	0.5
2015	-	1.4	-	-	-	-	-	-	1.4
2016	-	0.1	-	-	550.6	-	-	1.8	552.5
2017	-	0.01	-	-	133.2	-	-	8.2	141.5
2018	-	0.01	-	-	176	-	-	-	176
2019	-	0.3	-	-	566.0	-	-	0.7	567.1

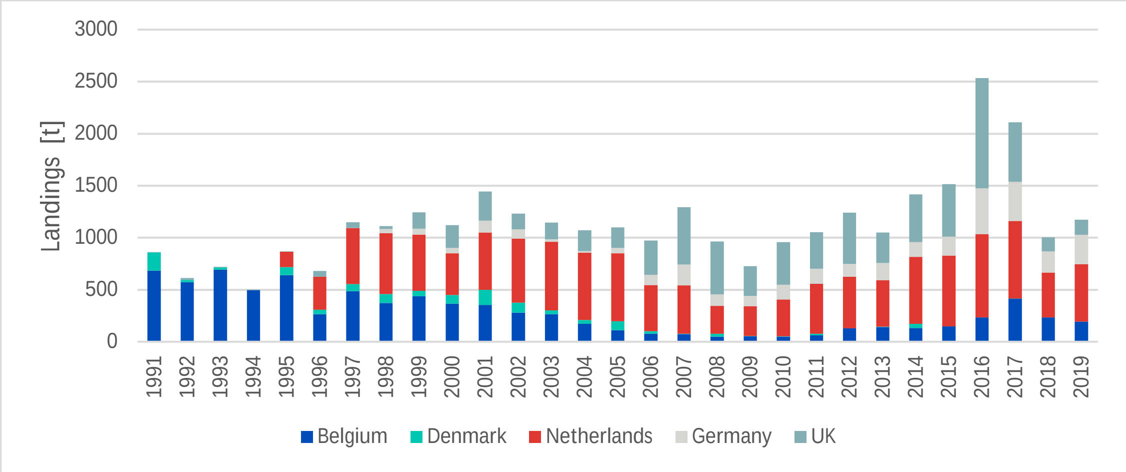


Figure 11.3.1. FU 5 Botney Cut/Silver Pit: Annual landings by country

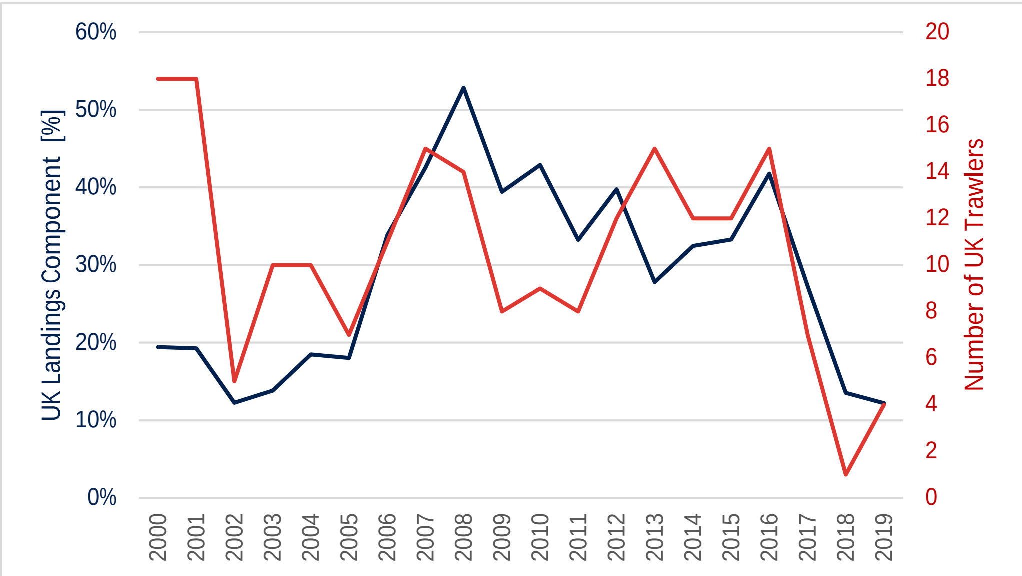


Figure 11.3.2. FU 5 Botney Cut/Silver Pit: Annual UK landings as percent of total international landings (blue), and number of UK *Nephrops* directed trawlers (red).

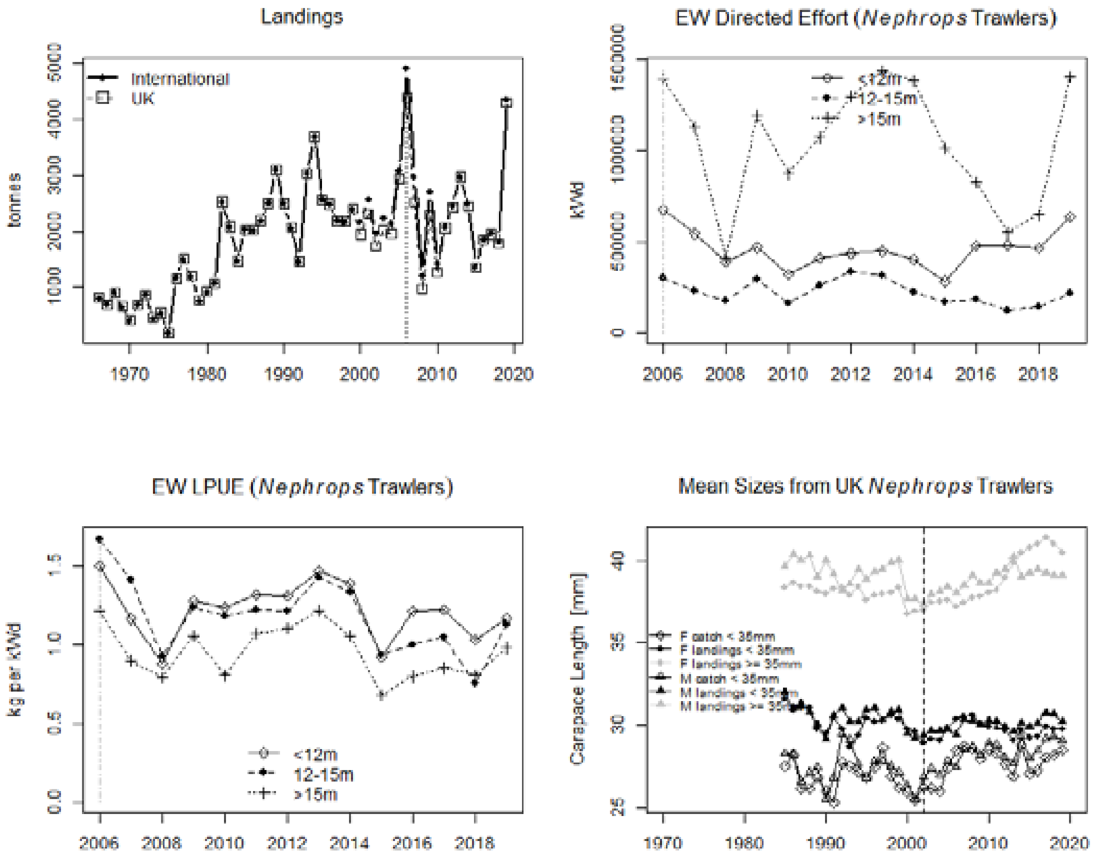


Figure 11.4.1. *Nephrops* in FU 6: Landings, directed effort, directed LPUE and mean sizes of different catch components.

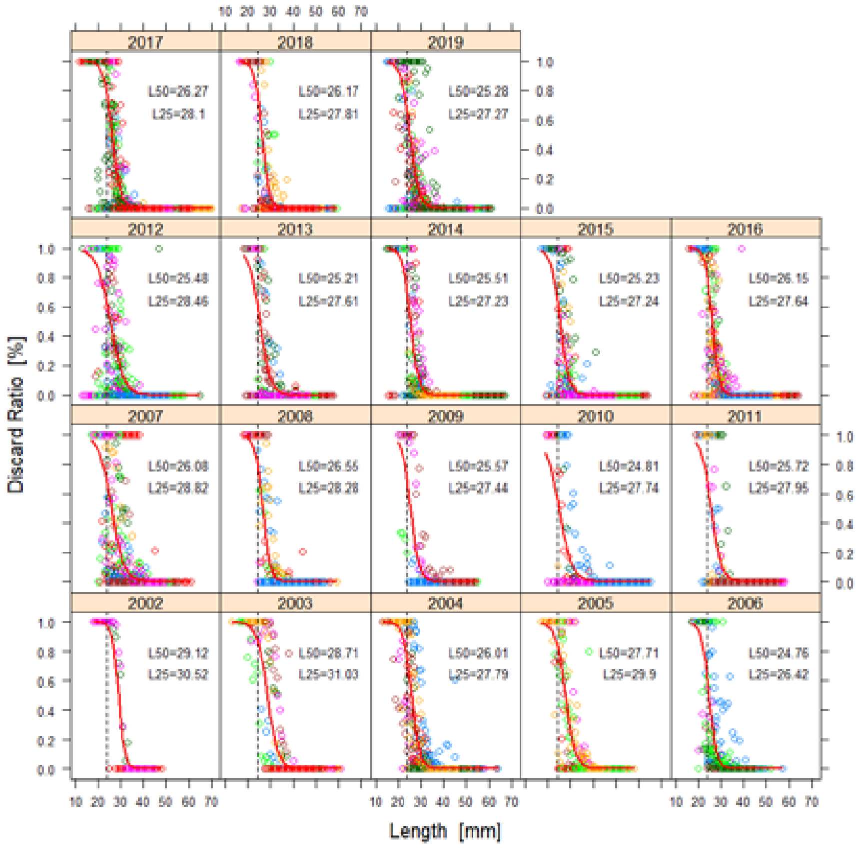


Figure 11.4.2. *Nephrops* in FU 6, annual discard ogives: The different point shapes represent different sampling trips within any year.

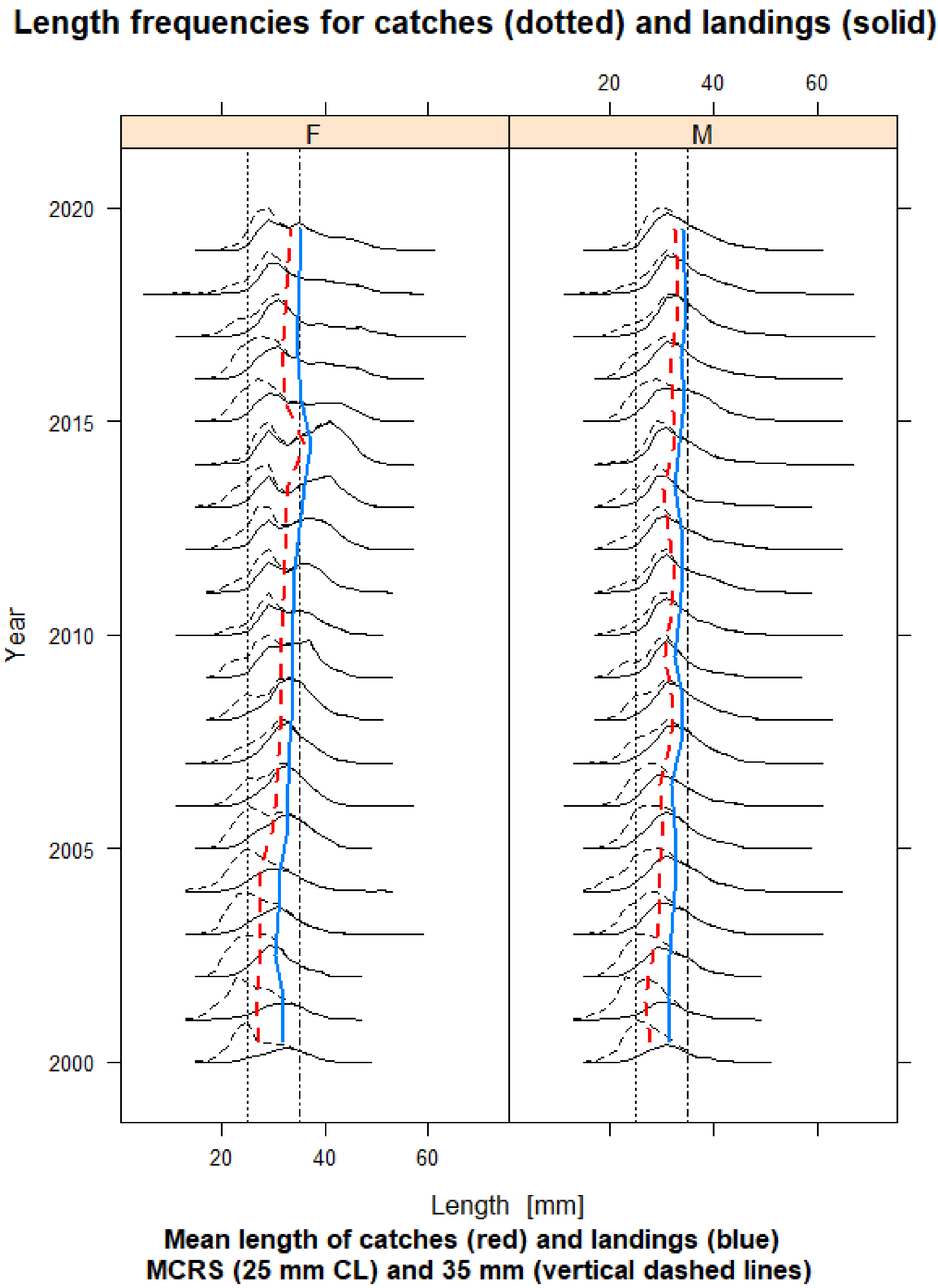


Figure 11.4.3. ***Nephrops*** **in FU 6: Annual length frequencies for landings and catch by sex, together with mean size of the landings (blue line) and catch (red line).**

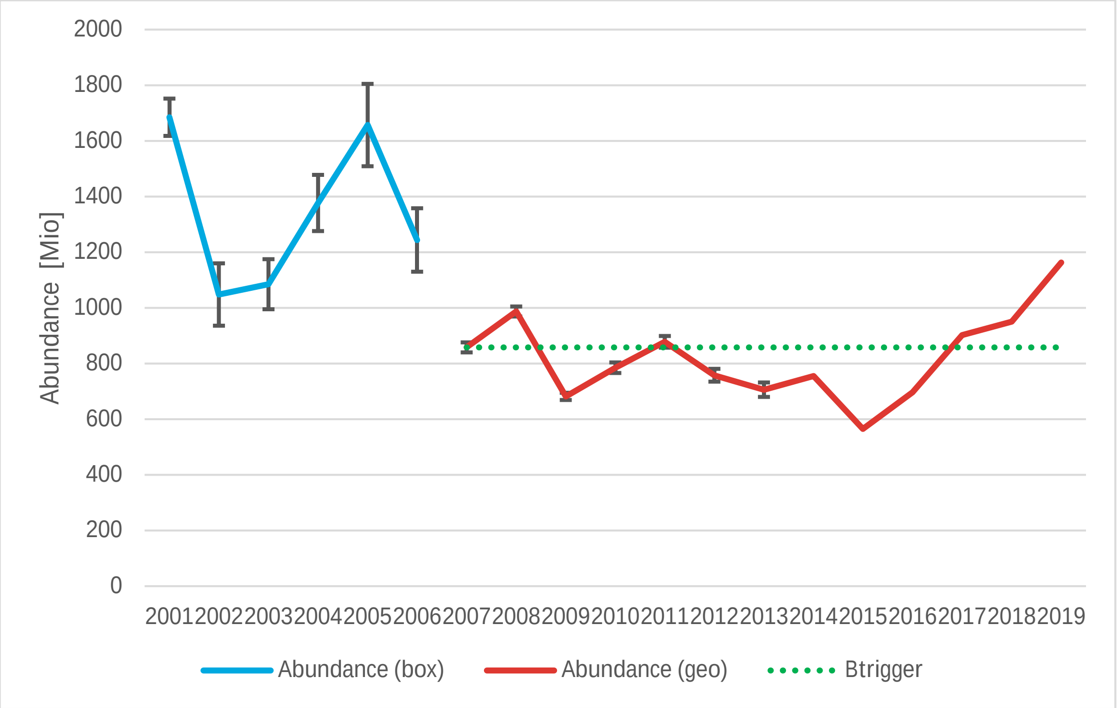


Figure 11.4.4. *Nephrops* in FU 6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the geostatistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground. Due to the spatial distribution of stations, this estimate was biased. Error bars indicate the 95% confidence interval.

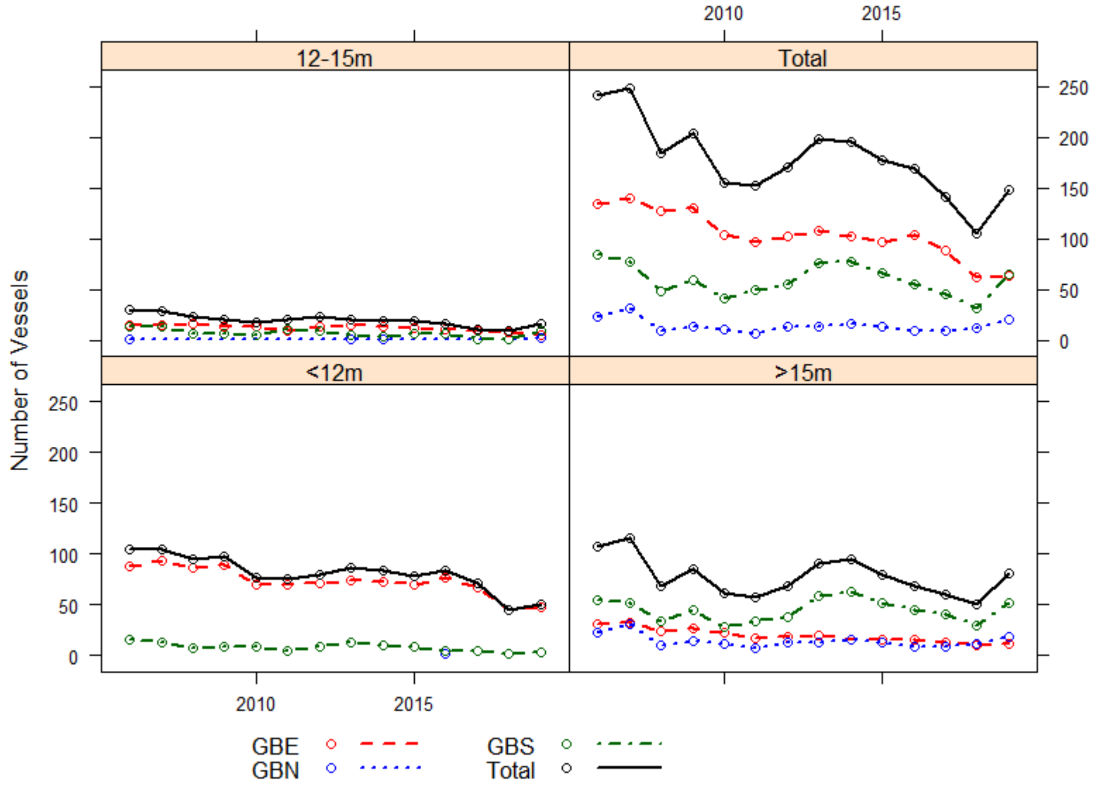


Figure 11.4.5. *Nephrops* in FU 6: Number of participating UK vessels by length class.

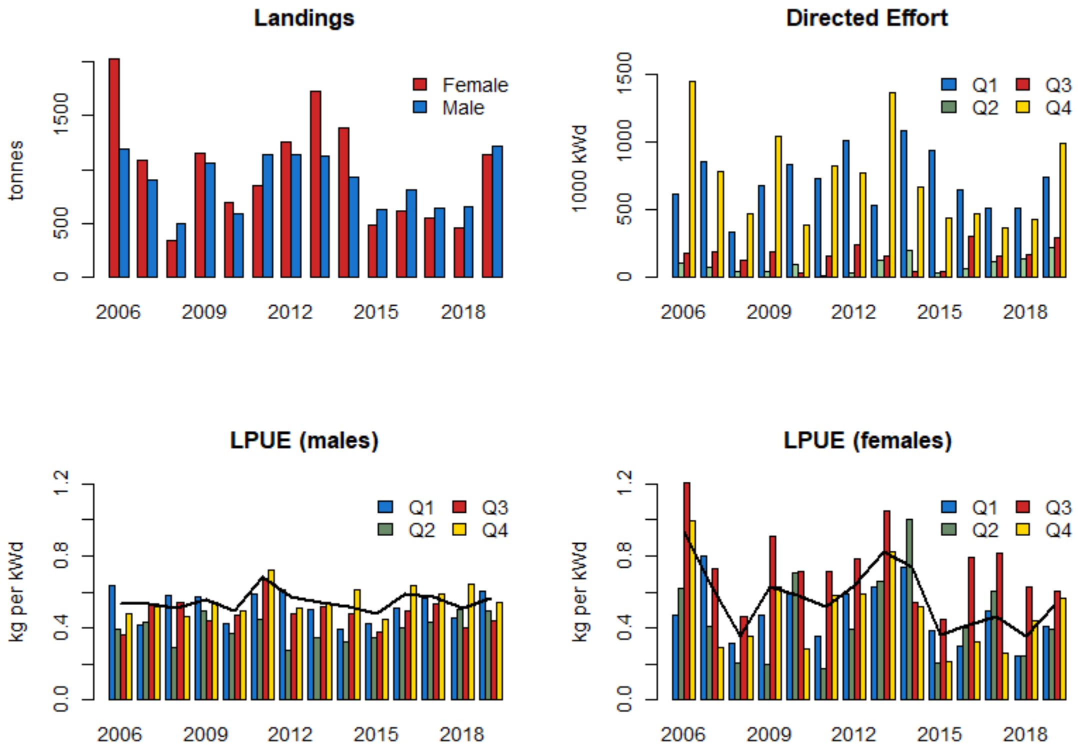


Figure 11.4.6. *Nephrops* in FU 6: Landings, effort, and LPUE by sex and quarter.

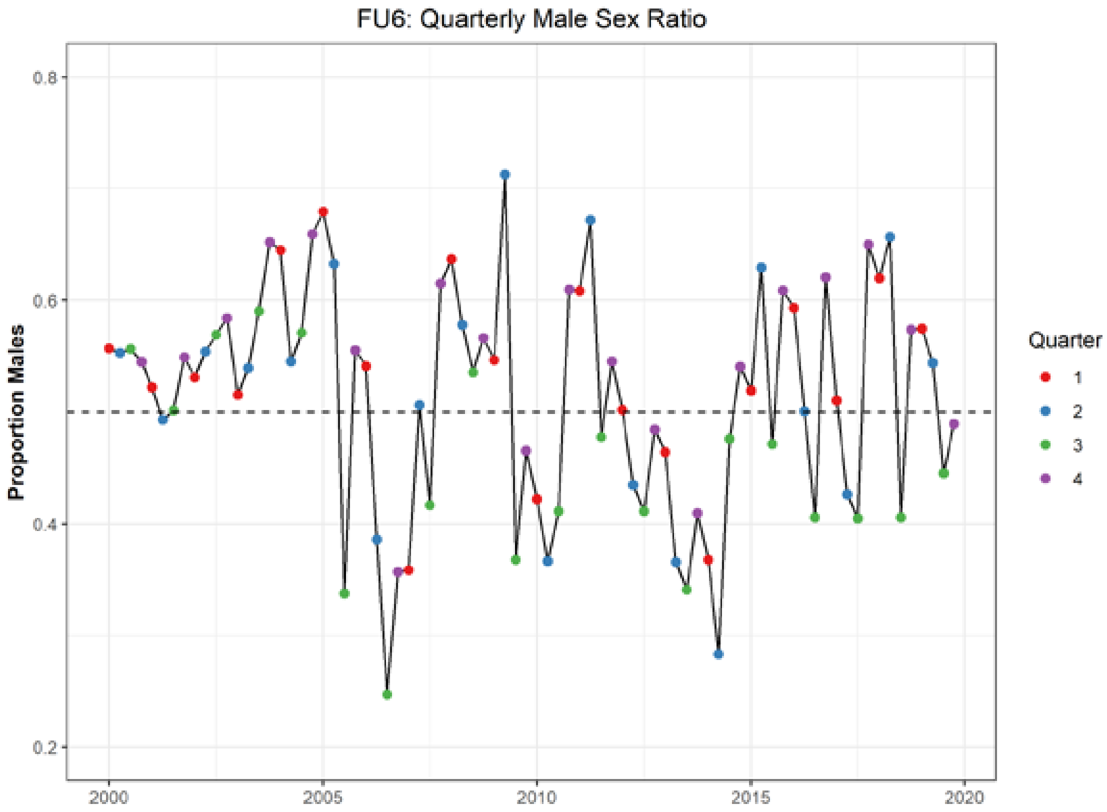


Figure 11.4.7. *Nephrops* in FU 6: Quarterly sex ratio in the catches.

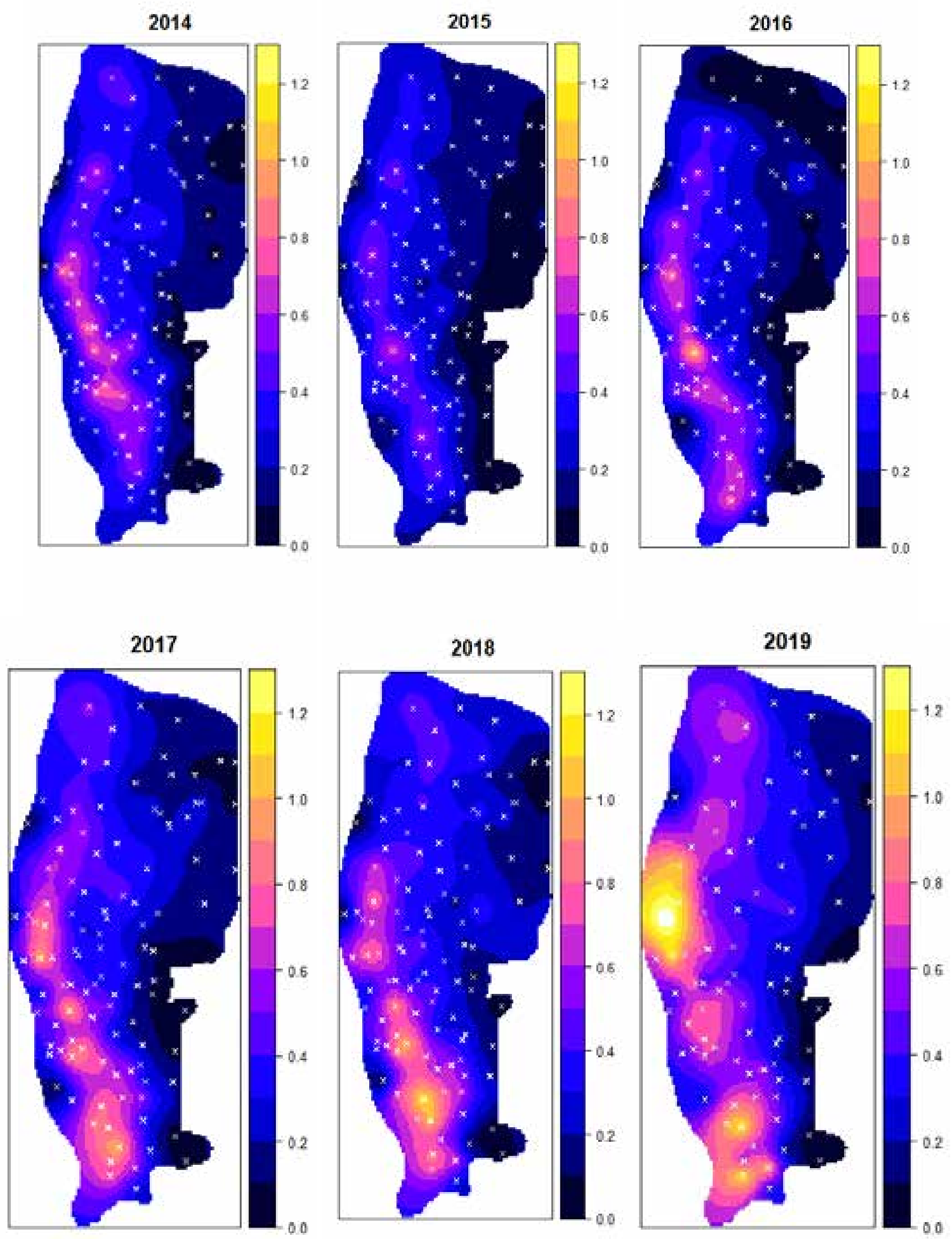


Figure 11.4.8. ***Nephrops*** **in FU 6: Density (individuals per m²) from the UWTV survey.**

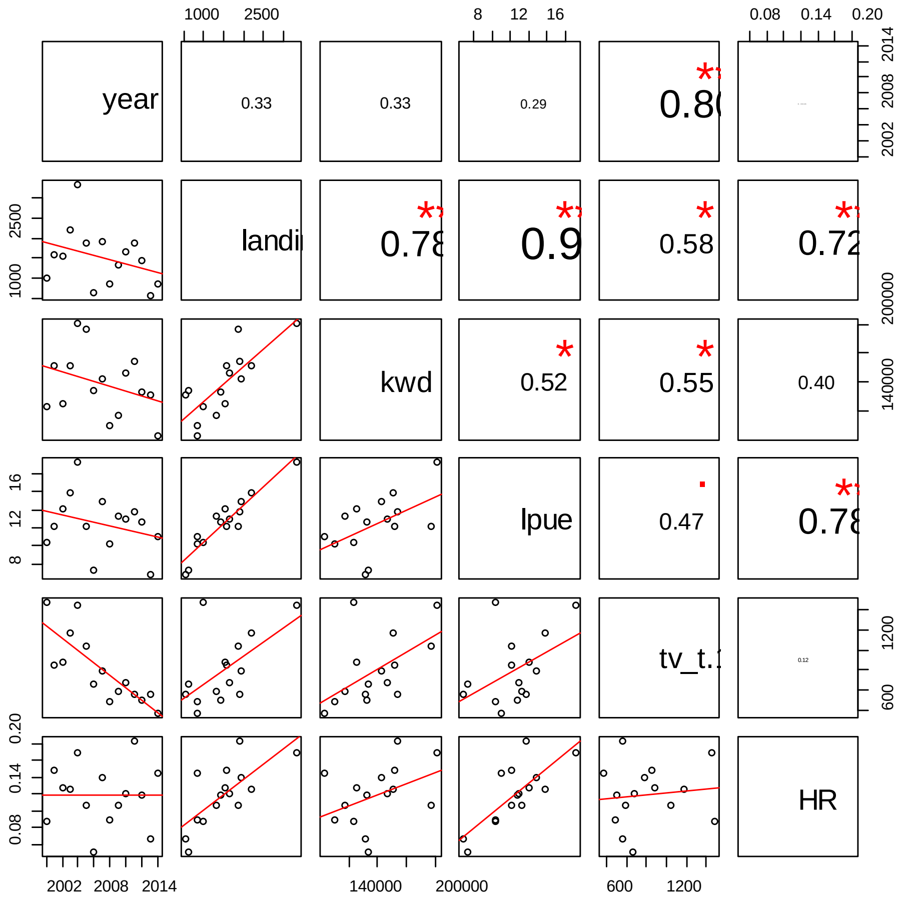


Figure 11.4.9. ***Nephrops*** **in FU 6. Scatterplot matrices of** ***Nephrops*** **metrics, where the UWTV survey lagged by 1 year (i.e., UWTV survey in the year preceding the fishery statistics).**

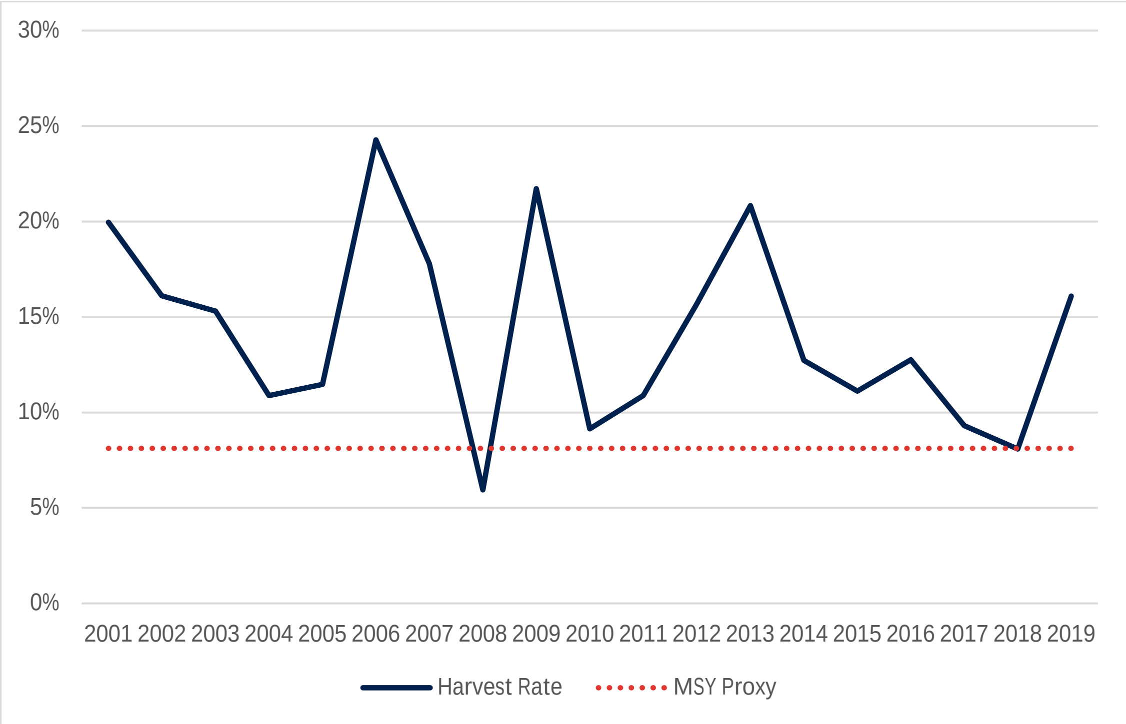


Figure 11.4.10. *Nephrops* in FU 6: Observed harvest ratio (removals divided by abundance estimate).

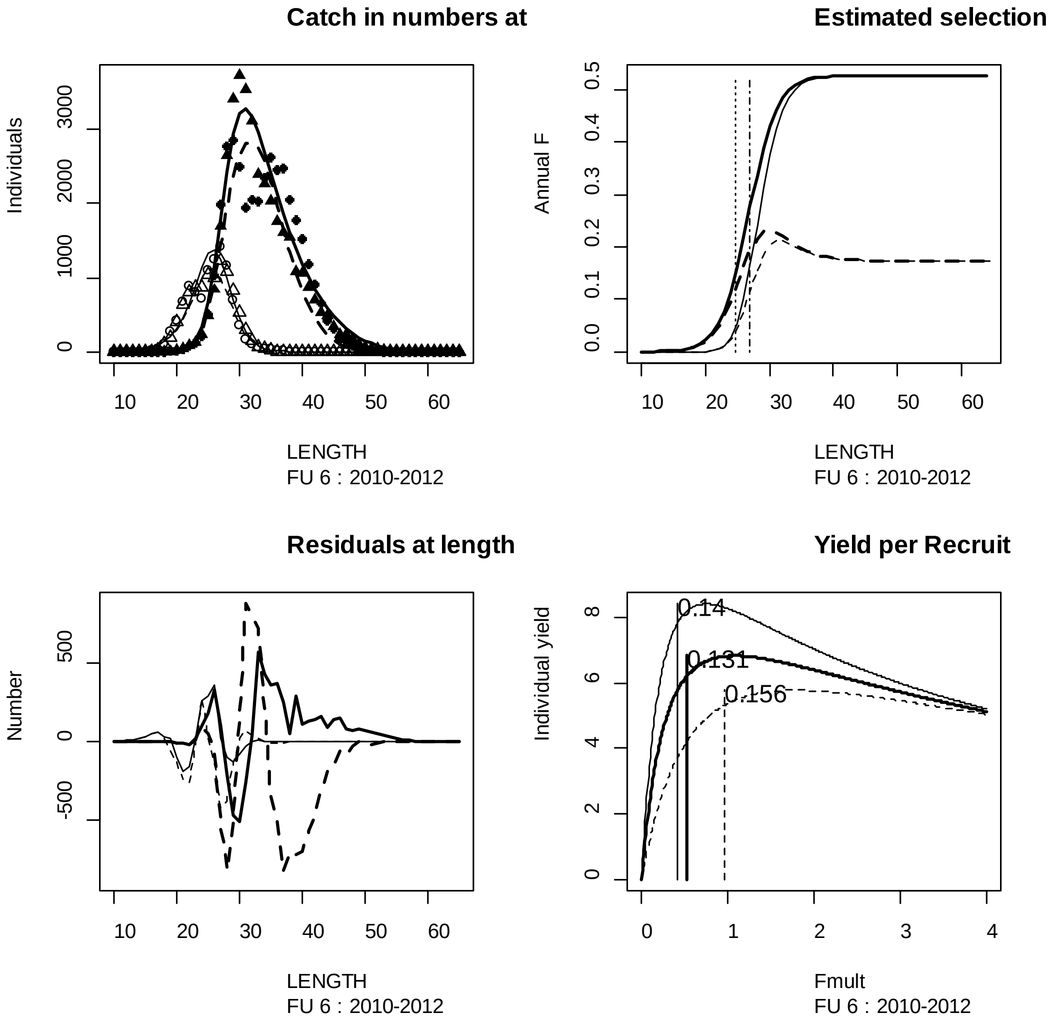


Figure 11.4.11. *Nephrops* in FU 6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards 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.

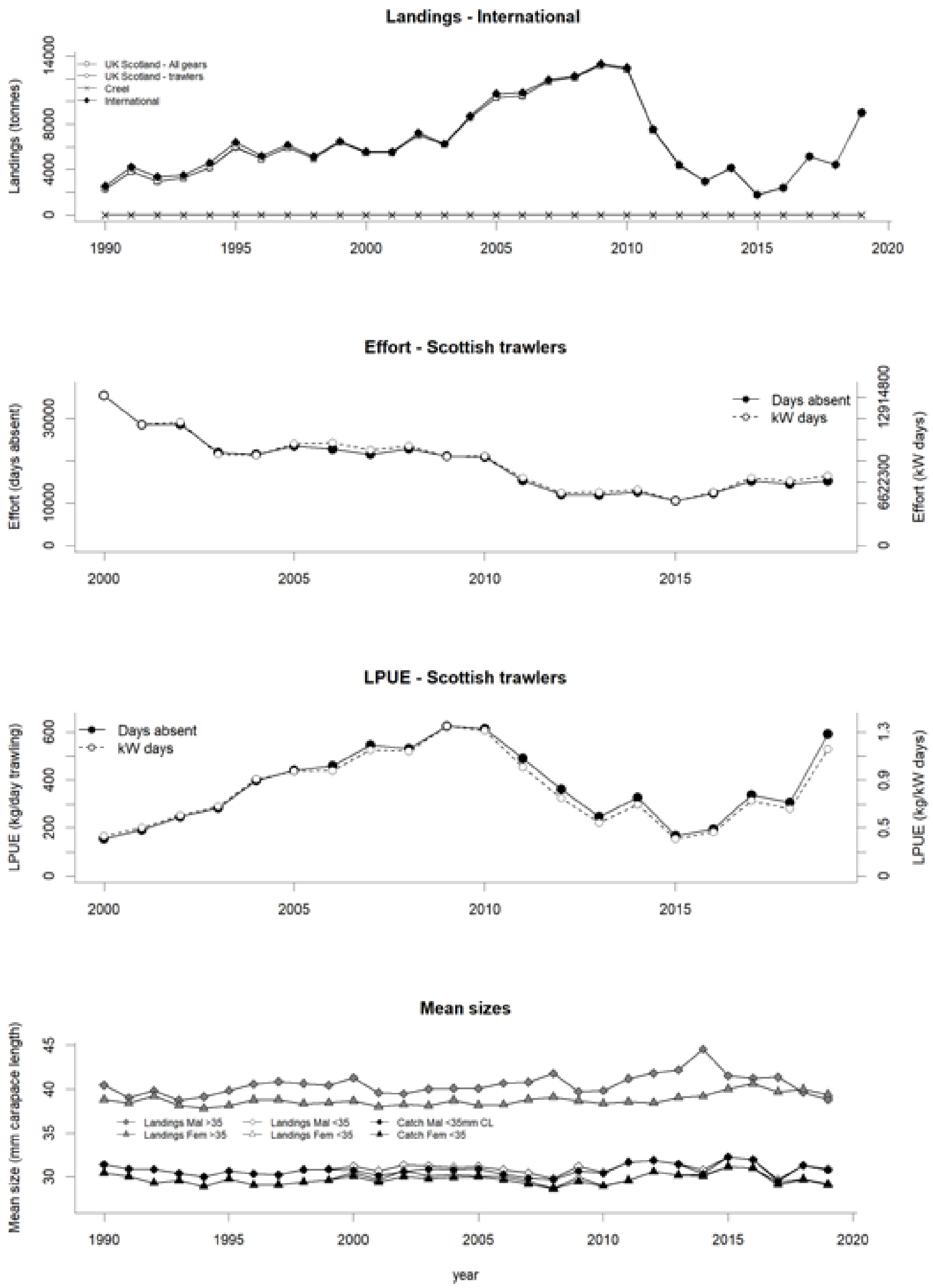


Figure 11.5.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2019.**

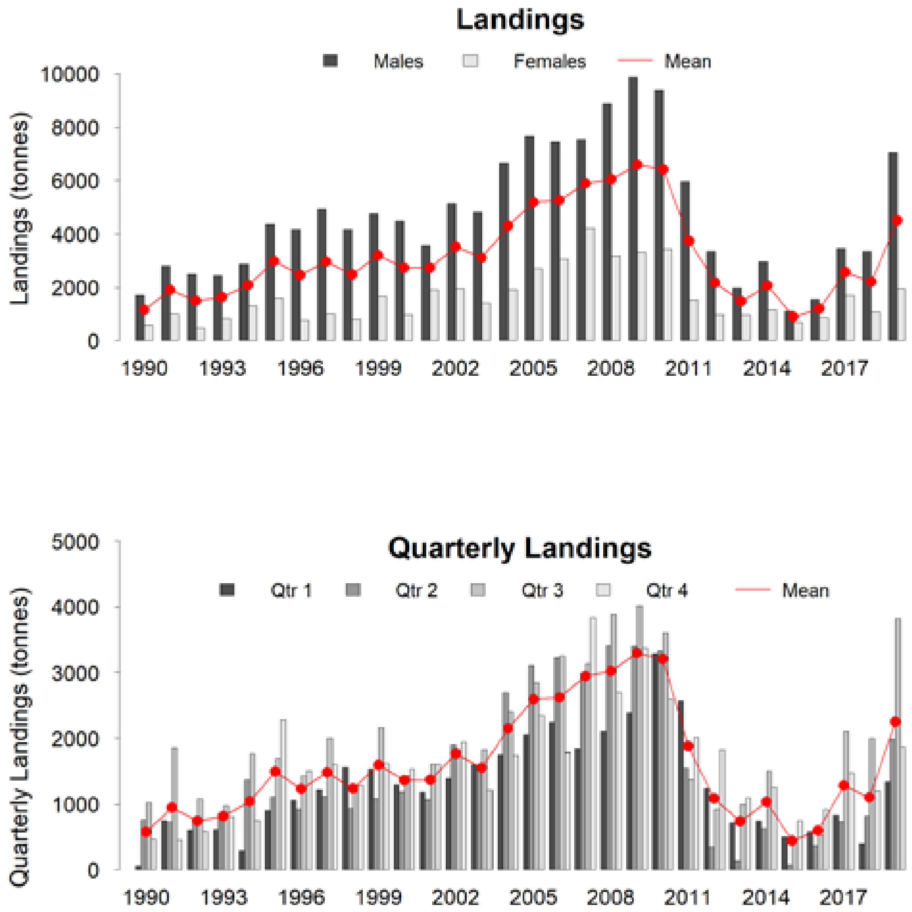


Figure 11.5.2 *Nephrops*, Fladen (FU 7), Landings by quarter and sex from Scottish *Nephrops* trawlers.

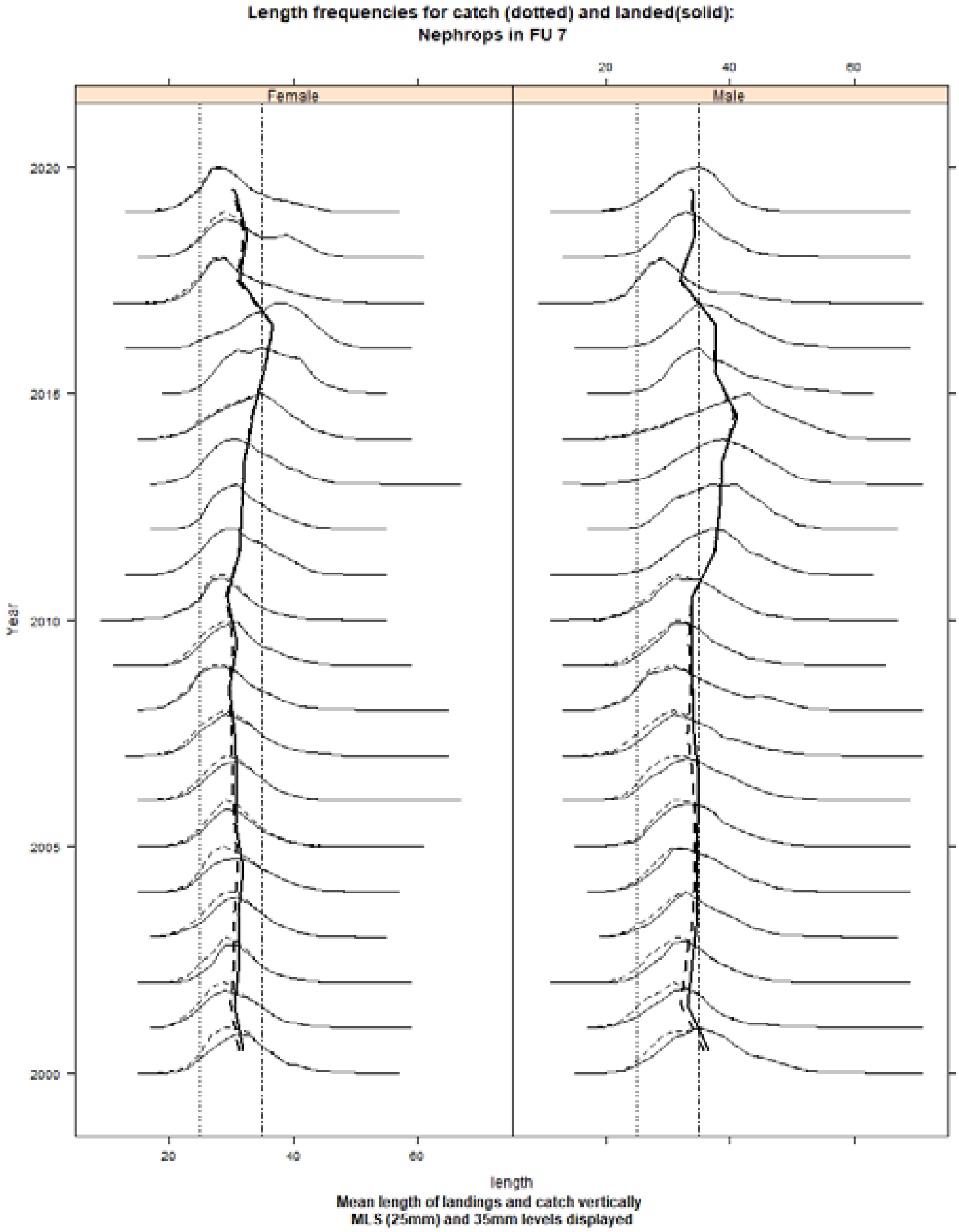
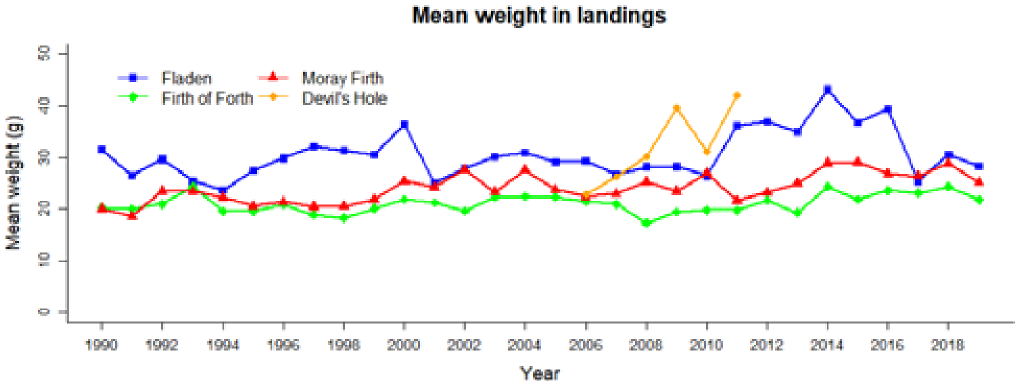


Figure11.5.3 *Nephrops* Fladen Ground (FU 7) Length composition of catch of males (right) and females left from 2000 (bottom) to 2019 (top). Mean sizes of catch and landings are displayed vertically.



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 1990–2019 (Scottish market sampling data). FU 34 data only shown for 2006–2011.

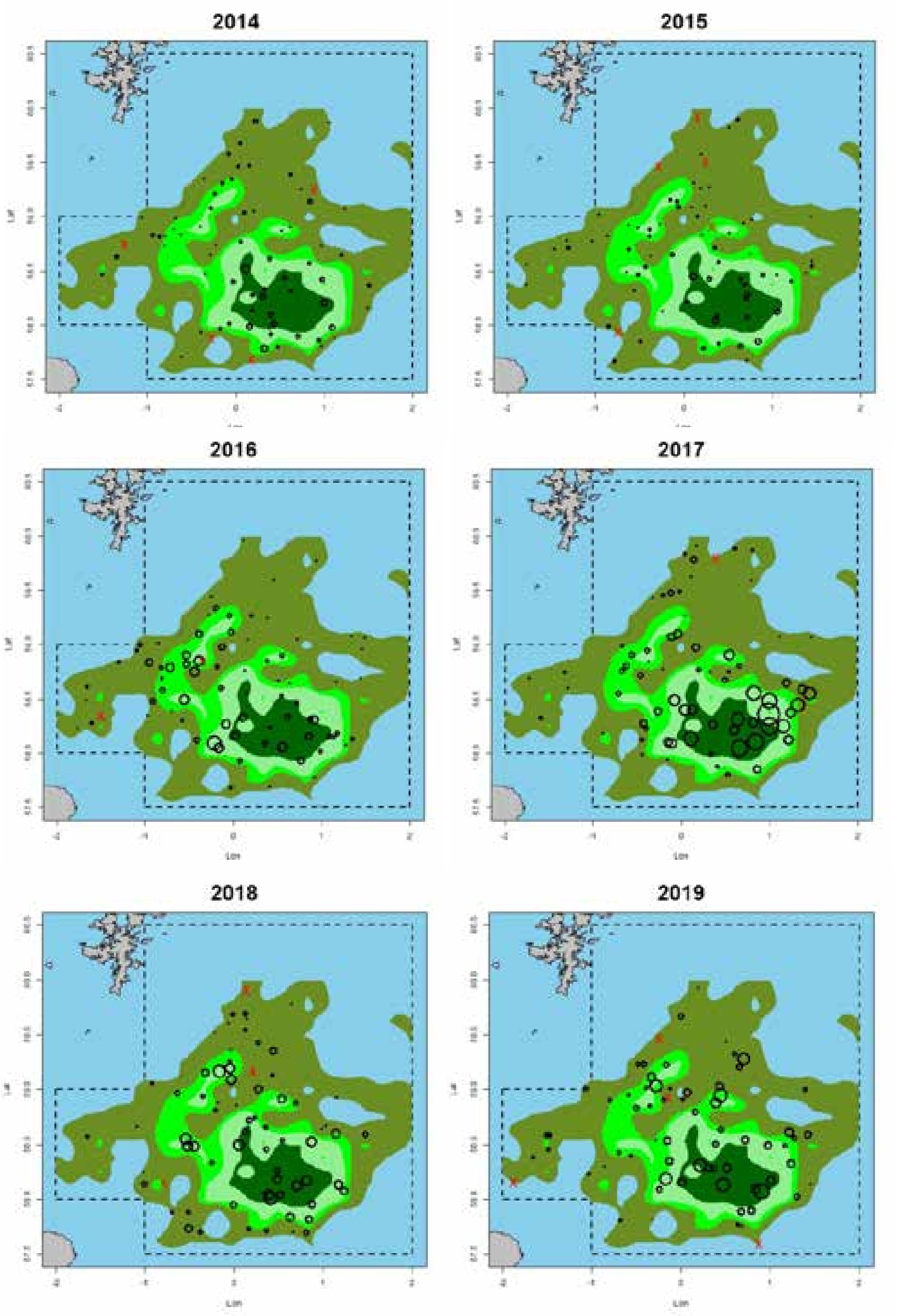


Figure 11.5.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2014–2019). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

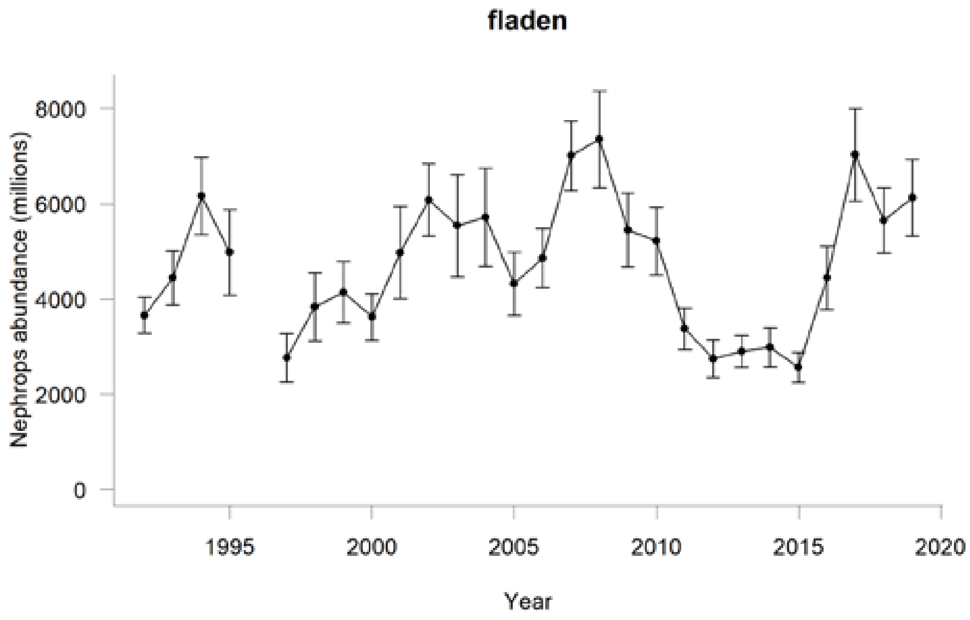


Figure 11.5.6 *Nephrops*, Fladen (FU 7), Time series of TV survey abundance estimates with 95% confidence intervals, 1992–2019.

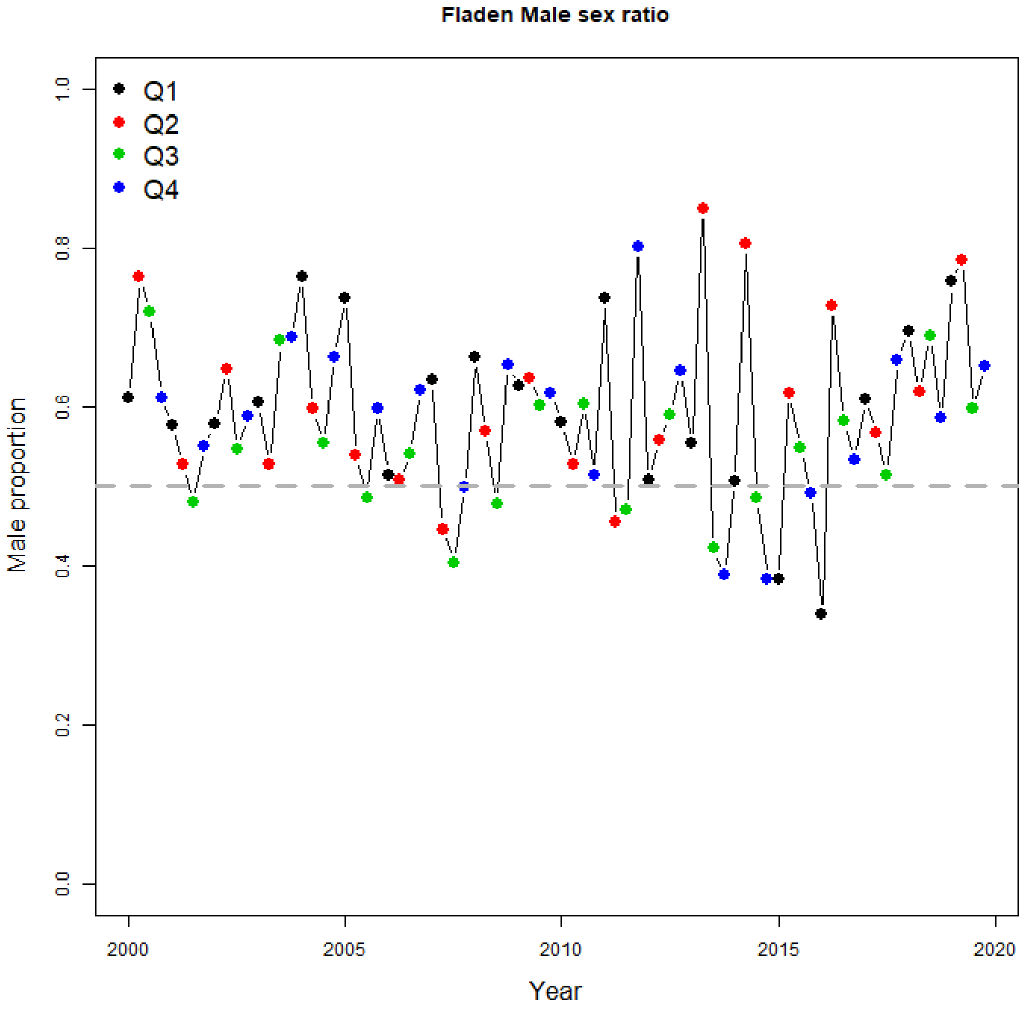


Figure 11.5.7 ***Nephrops*****, Fladen (FU 7), Quarterly sex ratio (by number) in catches.**

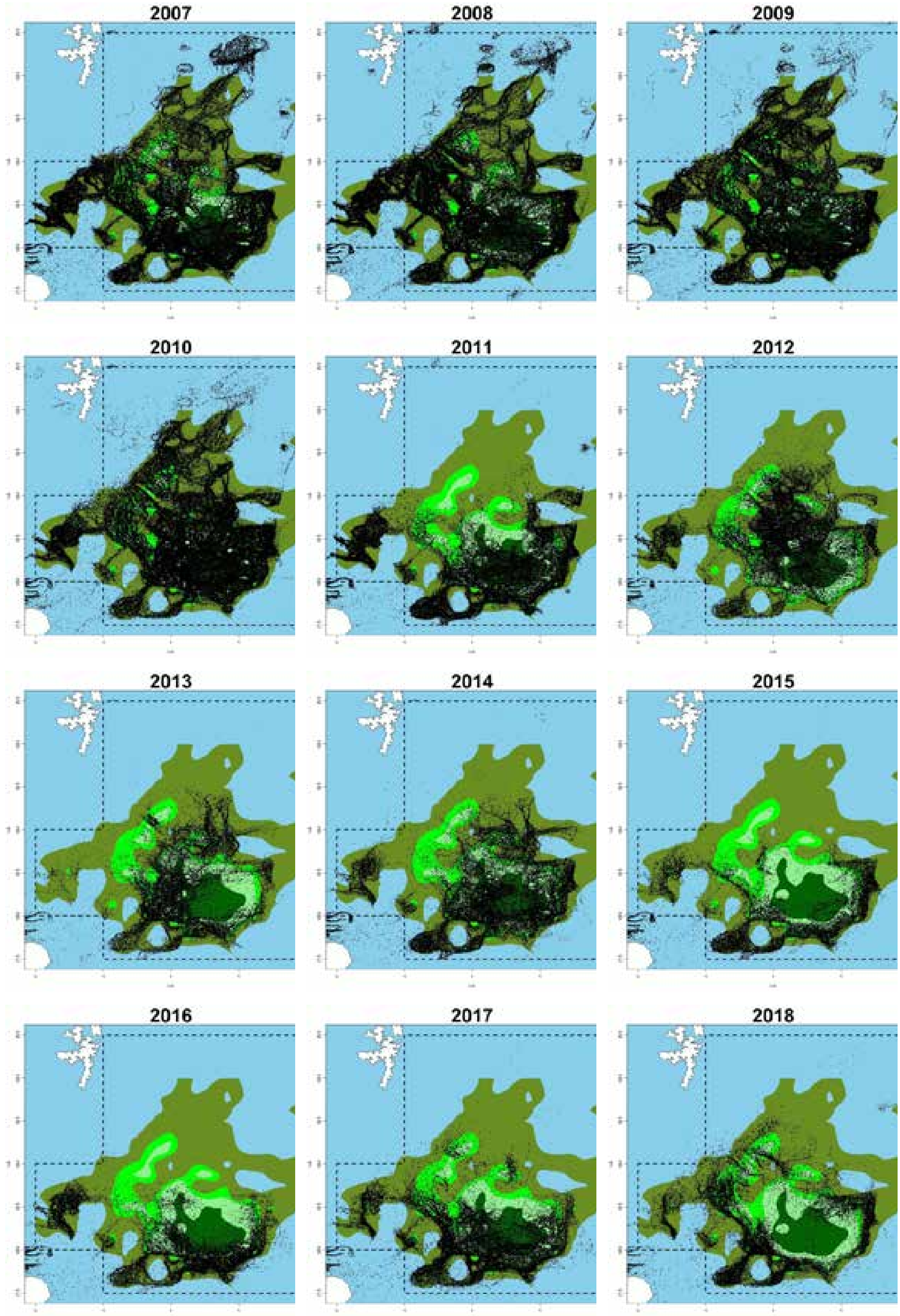


Figure 11.5.8 *Nephrops*, Fladen (FU 7), VMS distribution of vessels in Fladen (2007–2018). Points in figure correspond to fishing pings (speed < 5 kn) associated with trips made by otter trawlers landing more than 25% of *Nephrops* by weight.

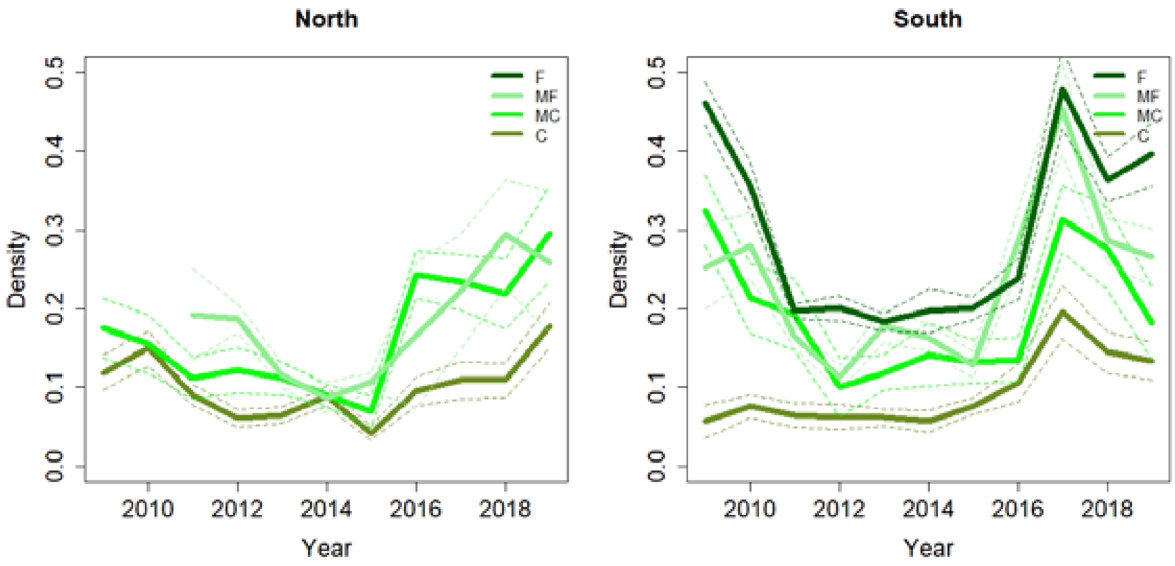


Figure 11.5.9 ***Nephrops*****, Fladen (FU 7), UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt & clay > 80%); MF: medium fine sediment (55% < silt and clay < 80); MC: medium coarse sediment (40% < silt and clay < 55); C: coarse sediment (silt and clay < 40%).**

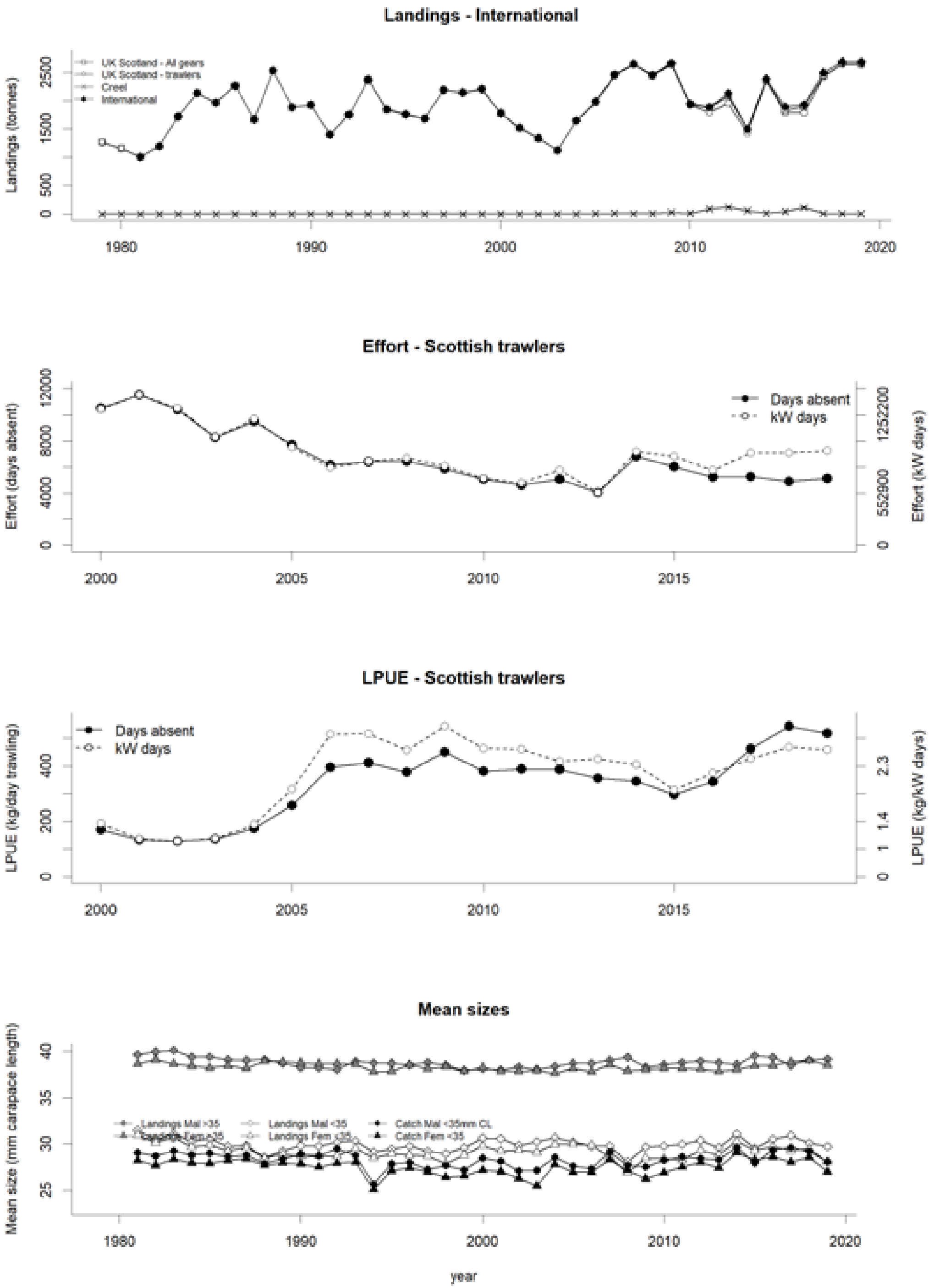
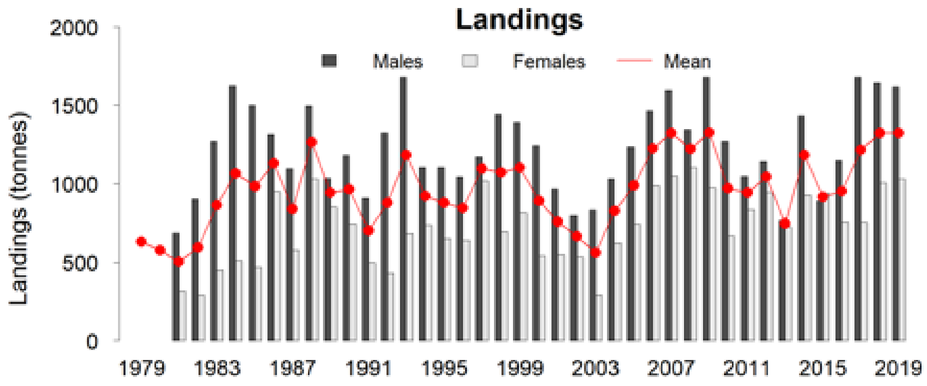


Figure 11.6.1 ***Nephrops*****, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2019.**



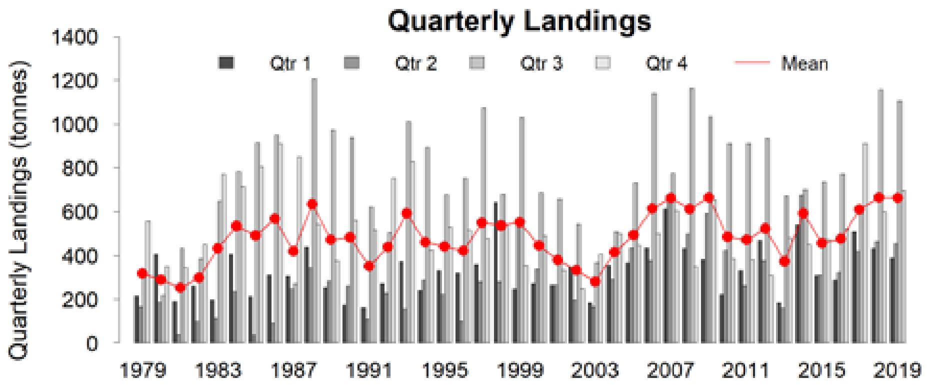


Figure 11.6.2 *Nephrops*, Firth of Forth (FU 8), Landings by quarter and sex from Scottish *Nephrops* trawlers.

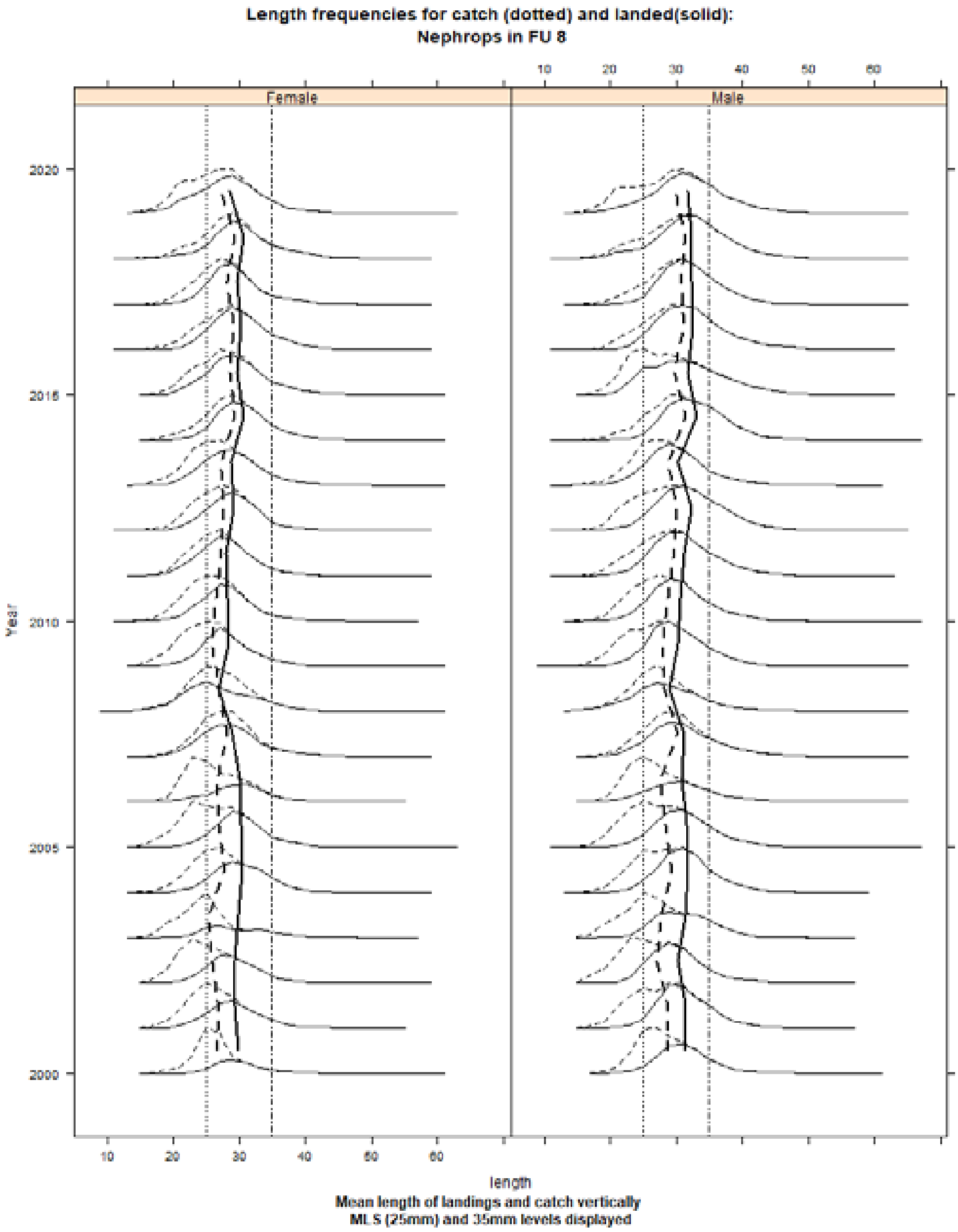


Figure 11.6.3 ***Nephrops*** **Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2019 (top). Mean sizes of catch and landings are displayed vertically.**

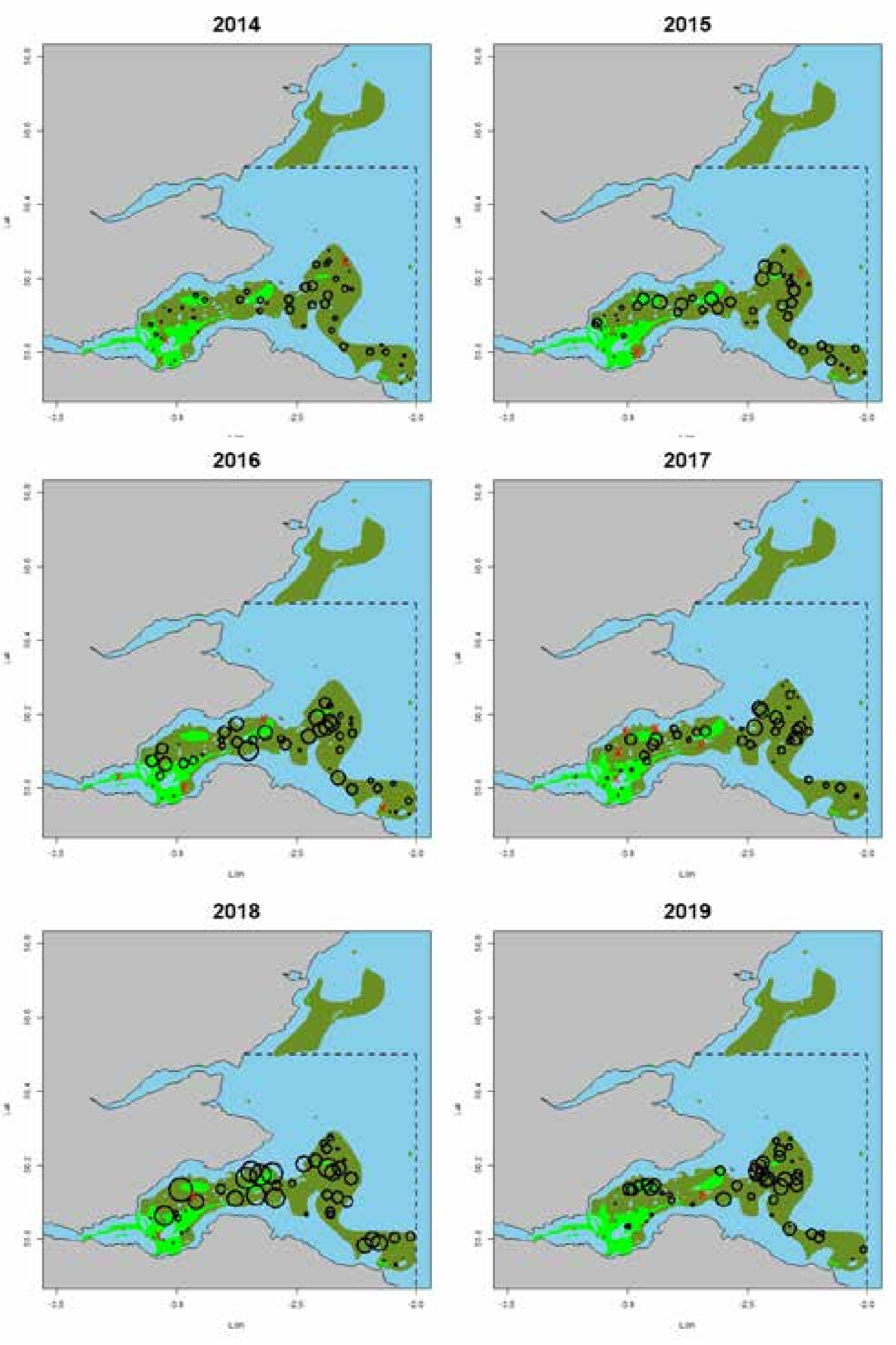


Figure 11.6.4 *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density (2014–2019). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

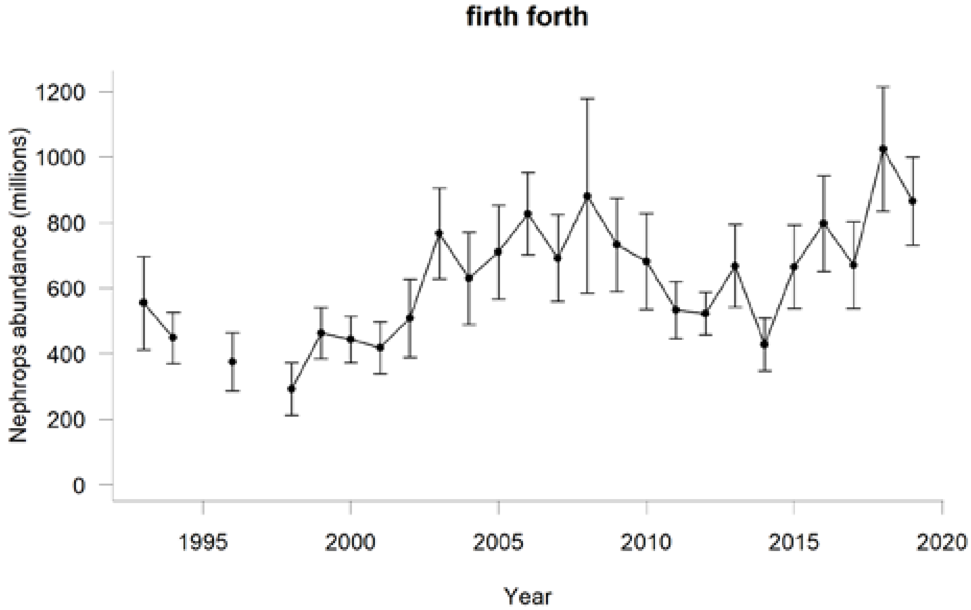


Figure 11.6.5 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2019.**

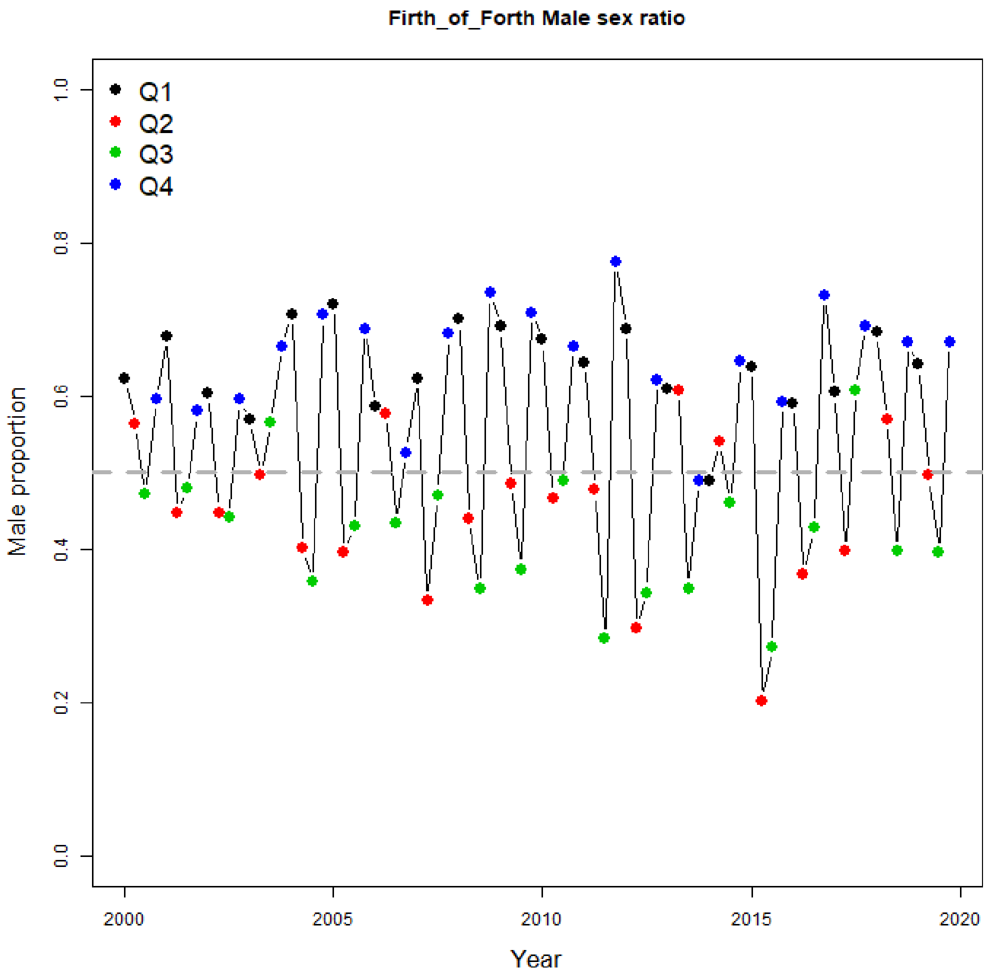


Figure 11.6.6 *Nephrops*, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.

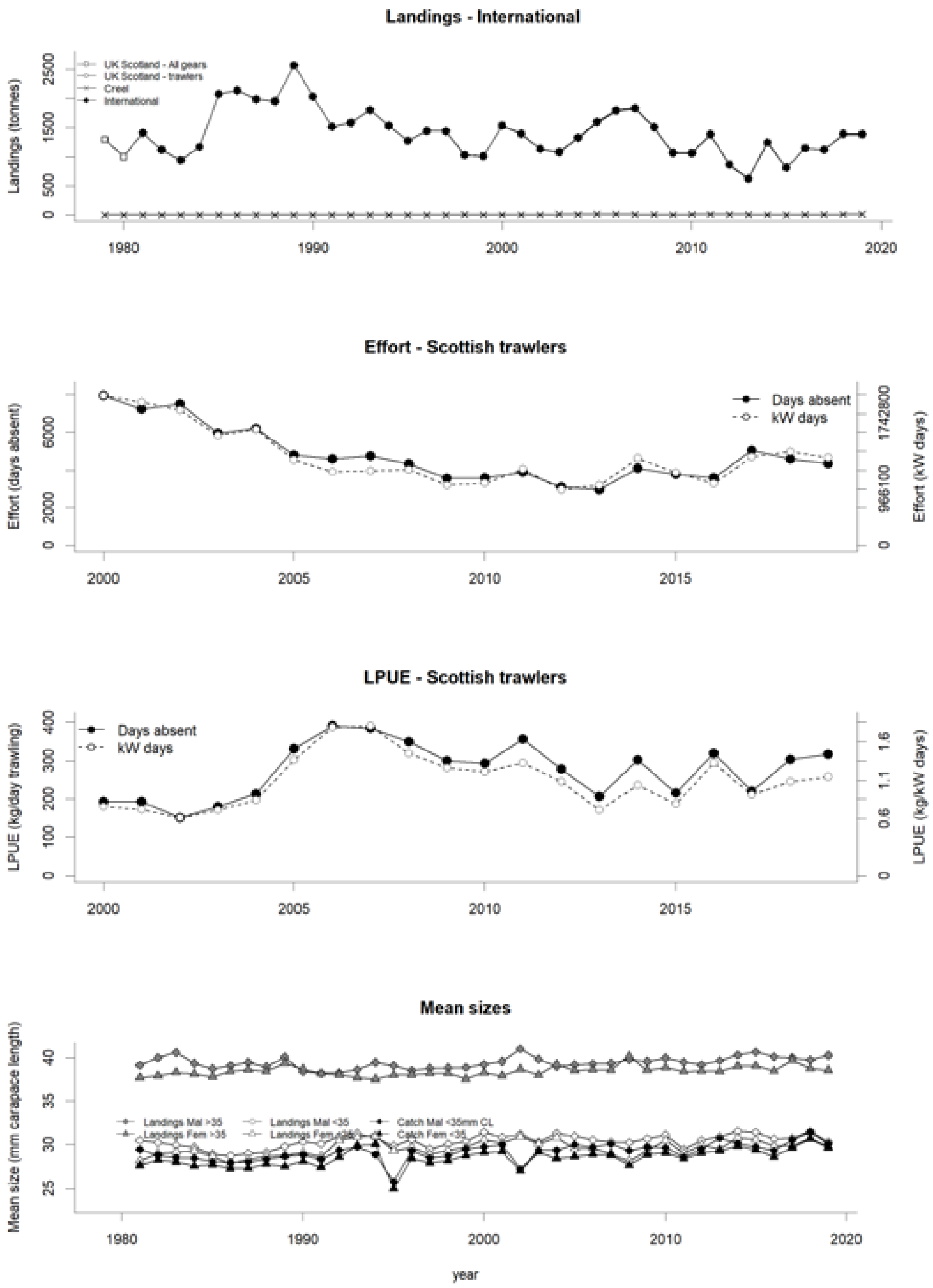
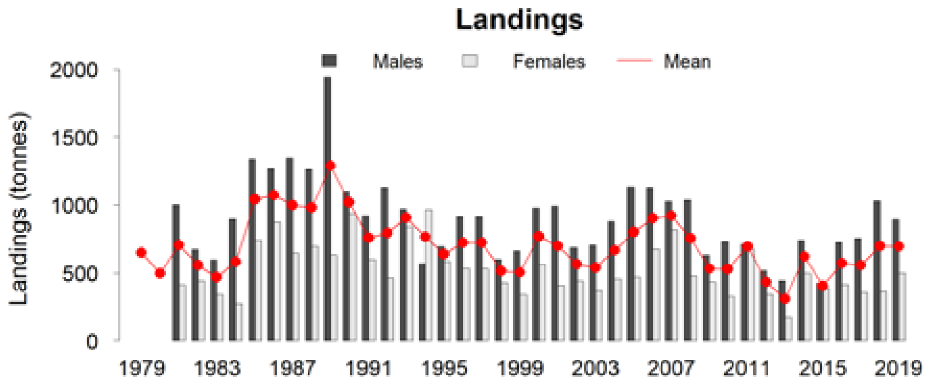


Figure 11.7.1 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2019.**



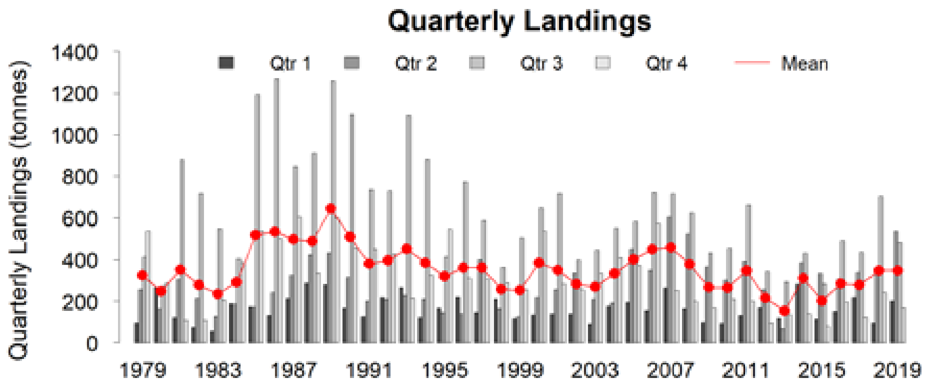


Figure 11.7.2 *Nephrops*, Moray Firth (FU 9), Landings by quarter and sex from Scottish *Nephrops* trawlers.

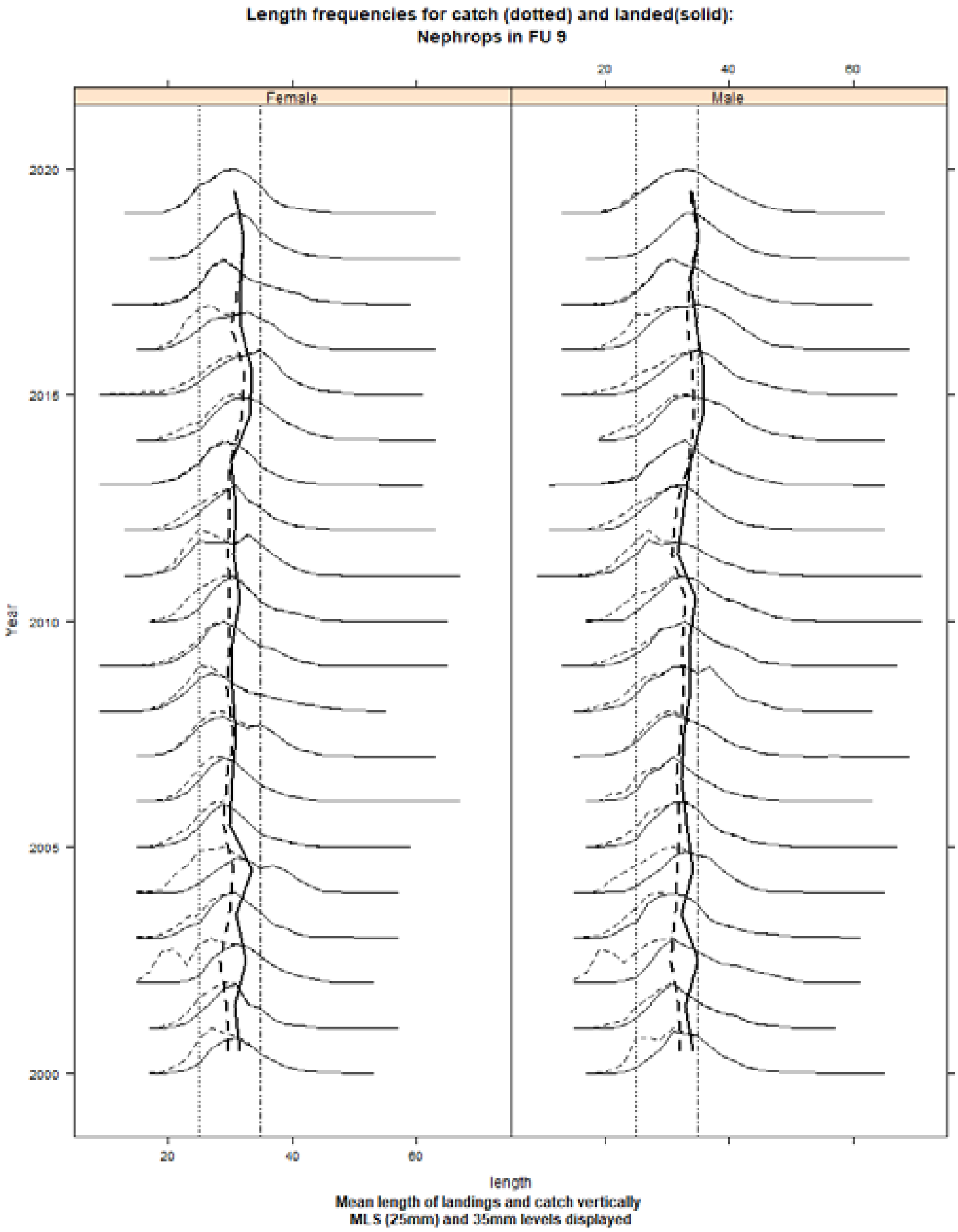


Figure 11.7.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2019 (top). Mean sizes of catch and landings are displayed vertically.**

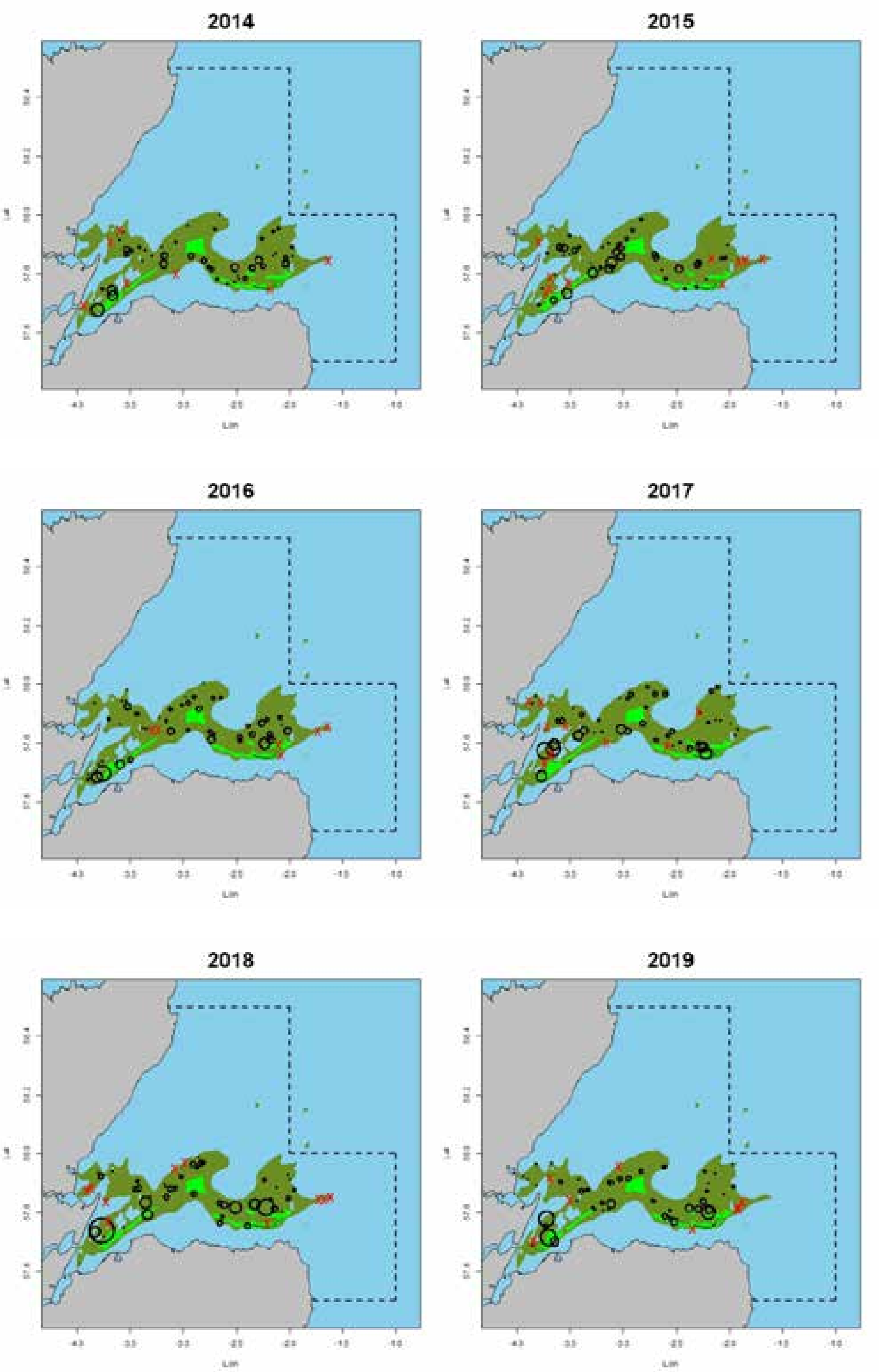


Figure 11.7.4 *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2014–2019). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

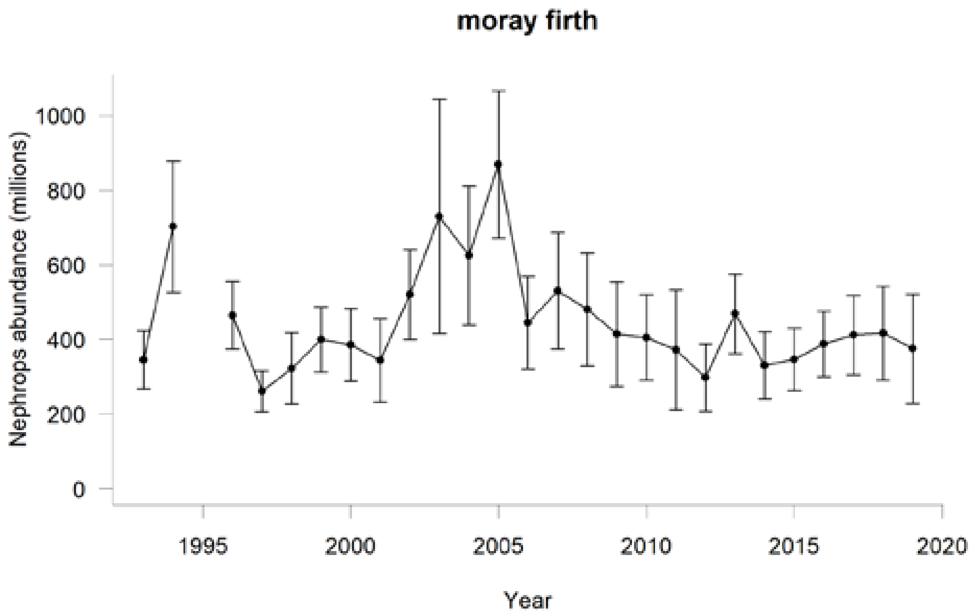


Figure 11.7.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2019.

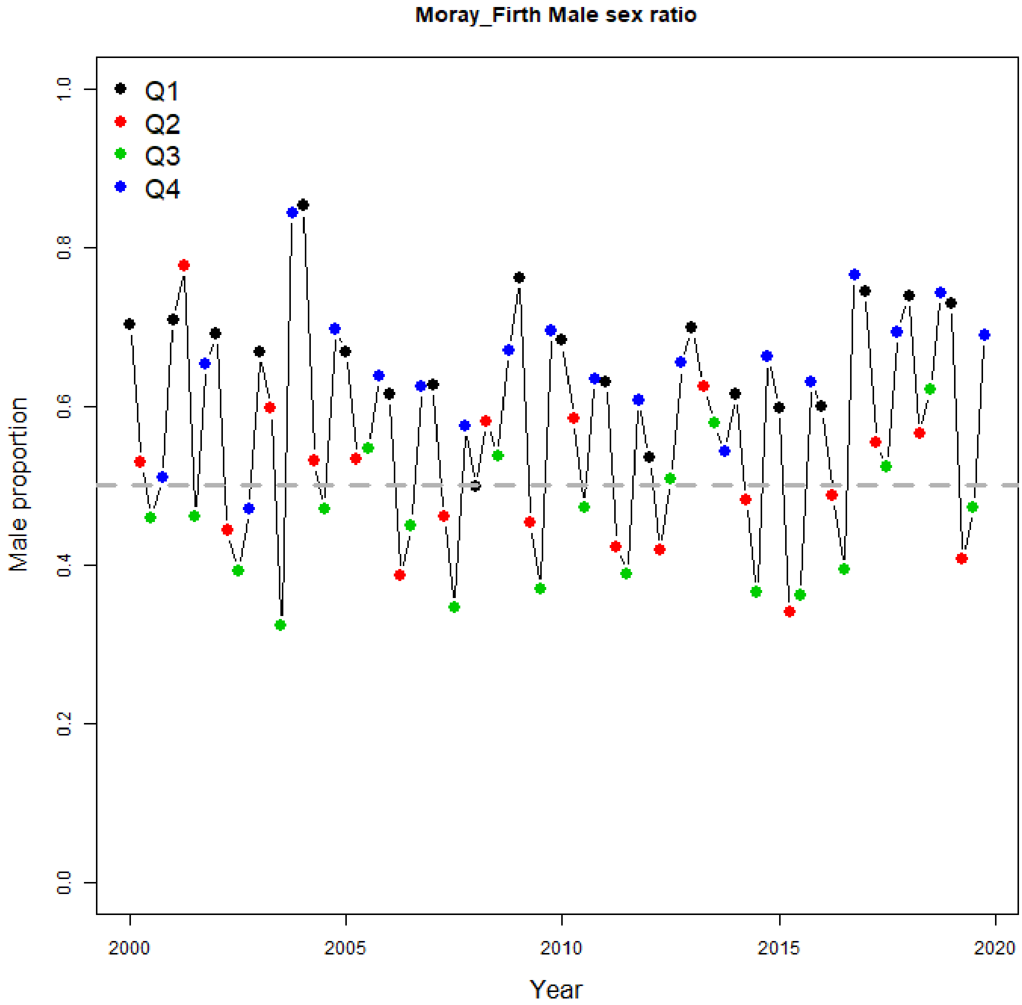


Figure 11.7.6 ***Nephrops*****, Moray Firth (FU 9), Quarterly sex ratio (by number) in catches.**

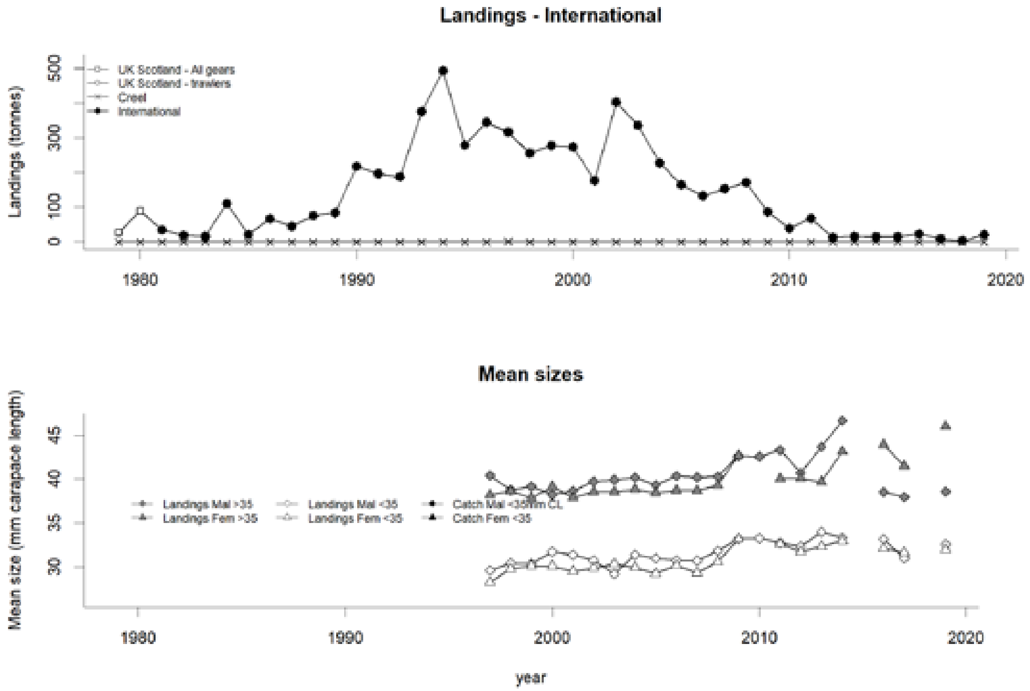


Figure 11.8.1 ***Nephrops*, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010 and no samples in 2015 and 2018).**

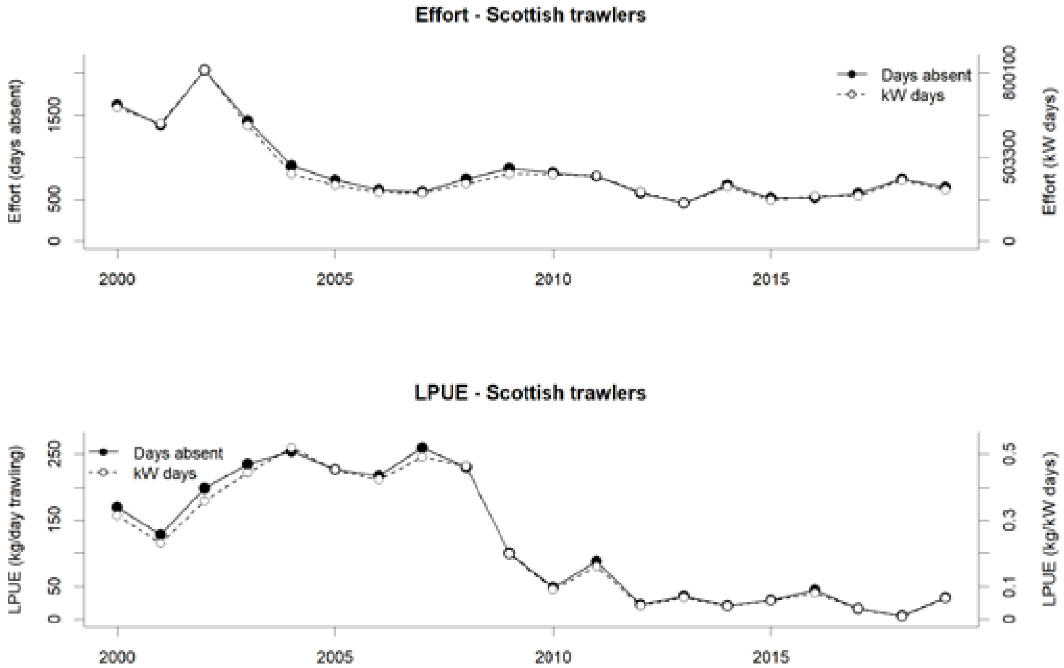


Figure 11.8.2 ***Nephrops*, Noup (FU 10), Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

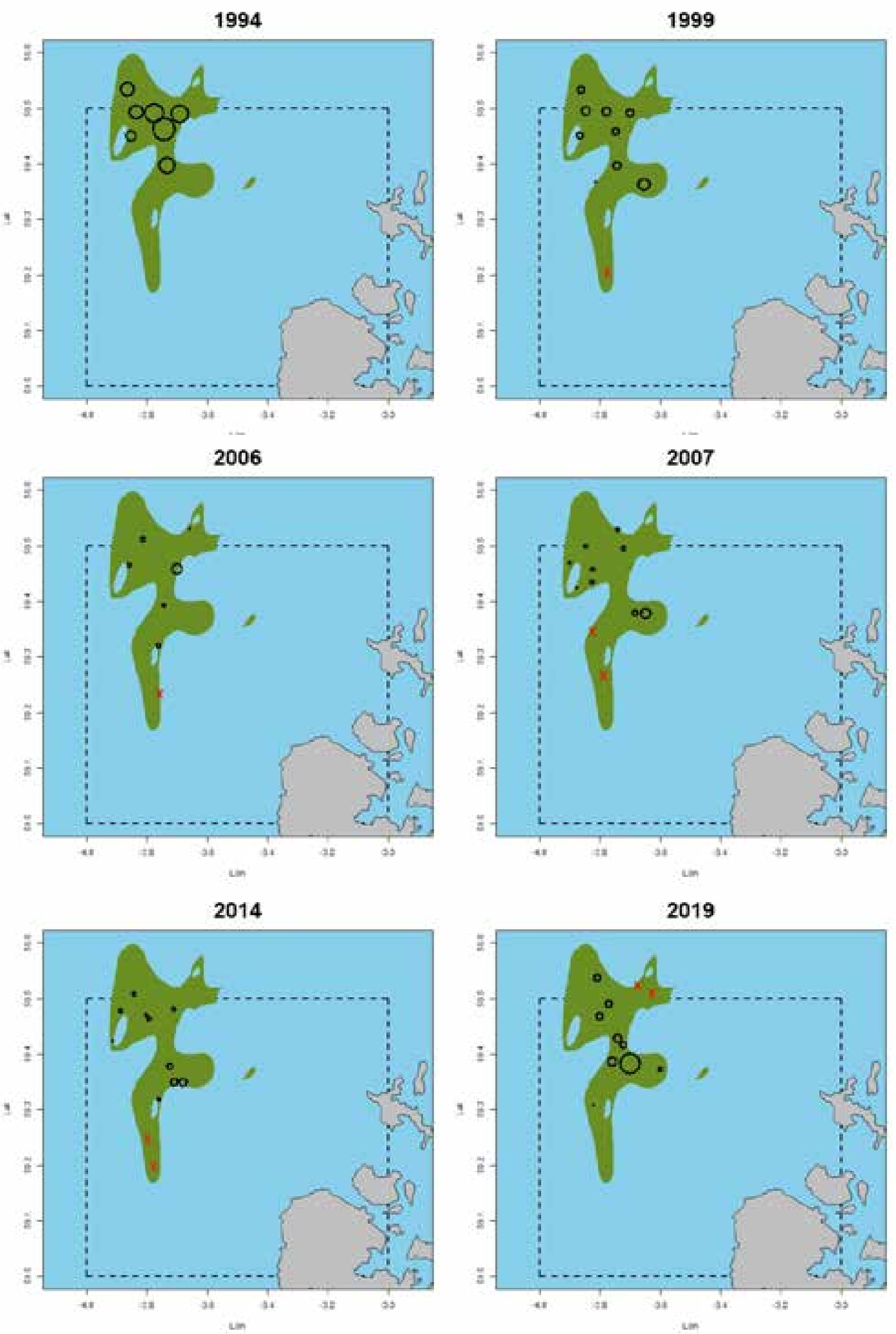


Figure 11.8.3 ***Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007, 2014 & 2019). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

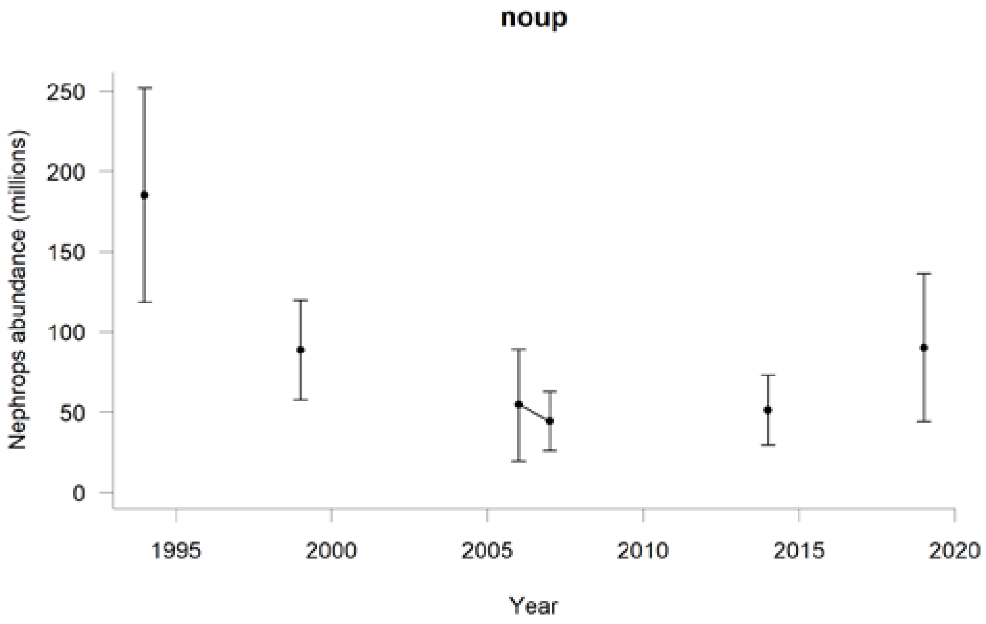


Figure 11.8.4 *Nephrops*, Noup (FU 10), Time series of TV survey abundance estimates (absolute conversion factor = 1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007, 2014 & 2019.

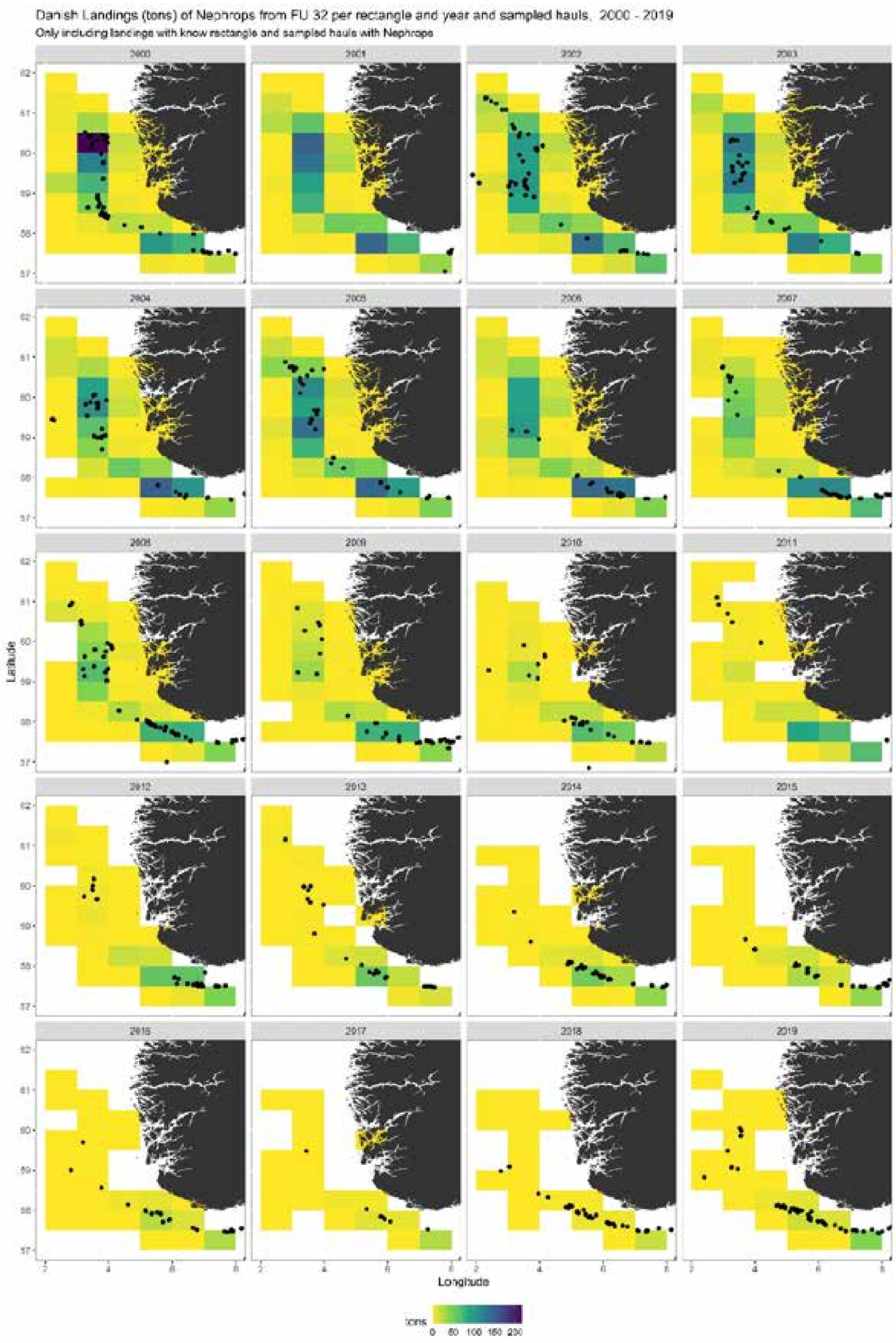

Danish Landings (tons) of Nephrops from FU 32 per rectangle and year and sampled hauls, 2000 - 2019
Only including landings with know rectangle and sampled hauls with Nephrops
Latitude
Longitude
tons

Figure 11.9.1. *Nephrops* Norwegian Deep (FU 32). Danish landings of *Nephrops* by ICES statistical square, 2000–2019. Dots represent hauls with *Nephrops* from the Danish at-sea-sampling program.

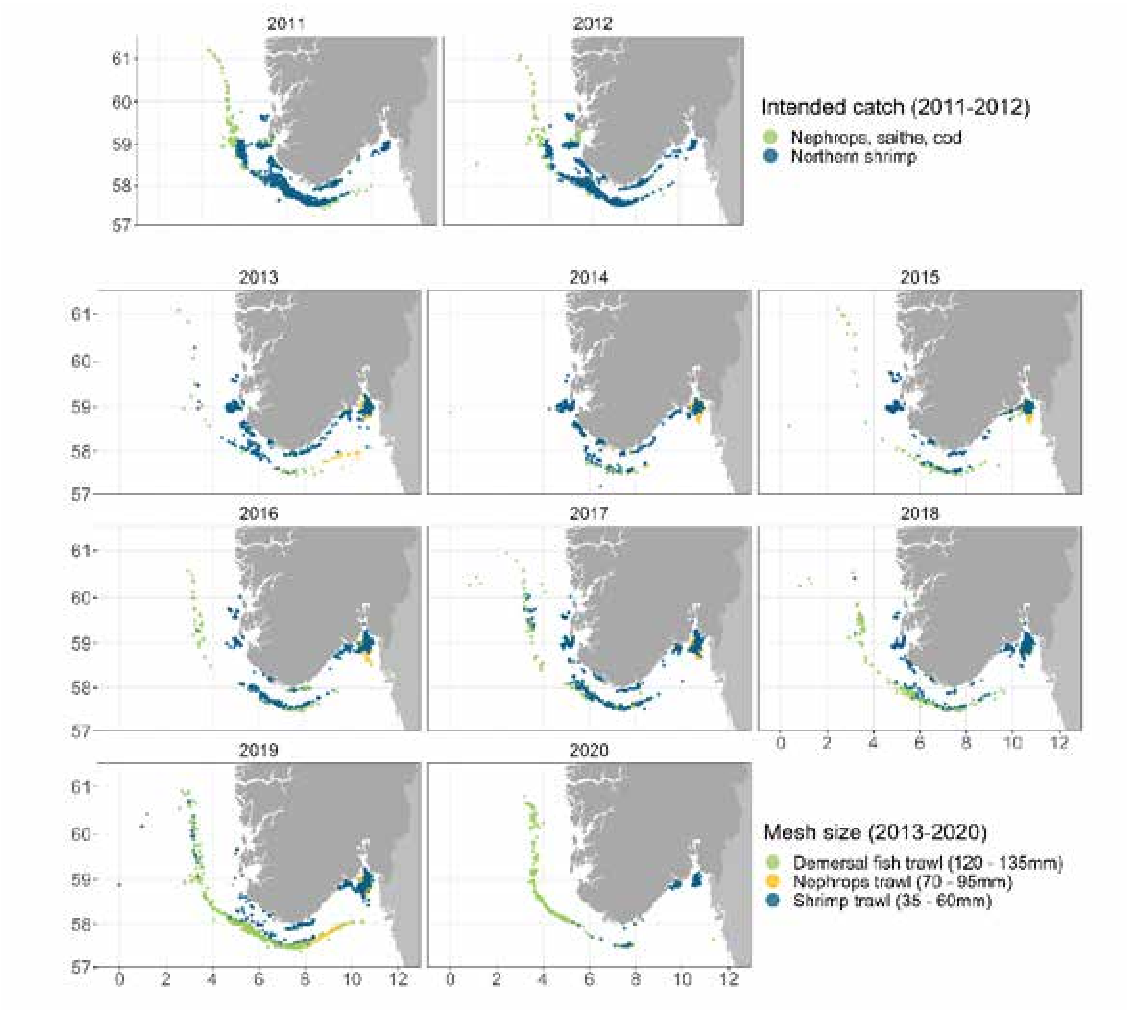


Figure 11.9.2. *Nephrops* Norwegian Deep (FU 32): Positions of trawl hauls with *Nephrops* in the catch from Norwegian bott 15 m (large mesh and small mesh shrimp trawlers), 2011–2020. Information on mesh size was not available in 2011-2012, and type of trawl was determined from information on intended catch. Data from 2020 are from January-March.

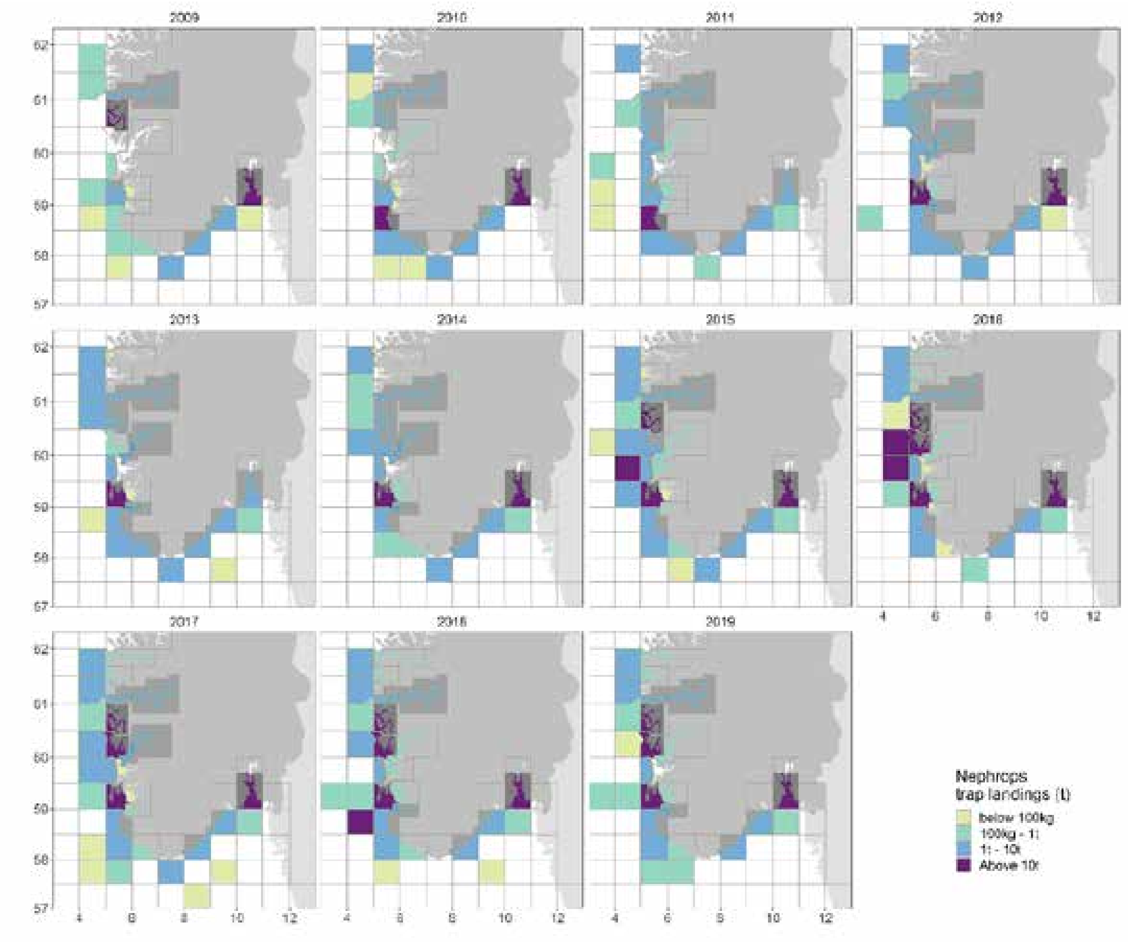


Figure 11.9.3. ***Nephrops*** **Norwegian Deep (FU 32): Norwegian creel landings by ICES statistical square, 2009–2019.**

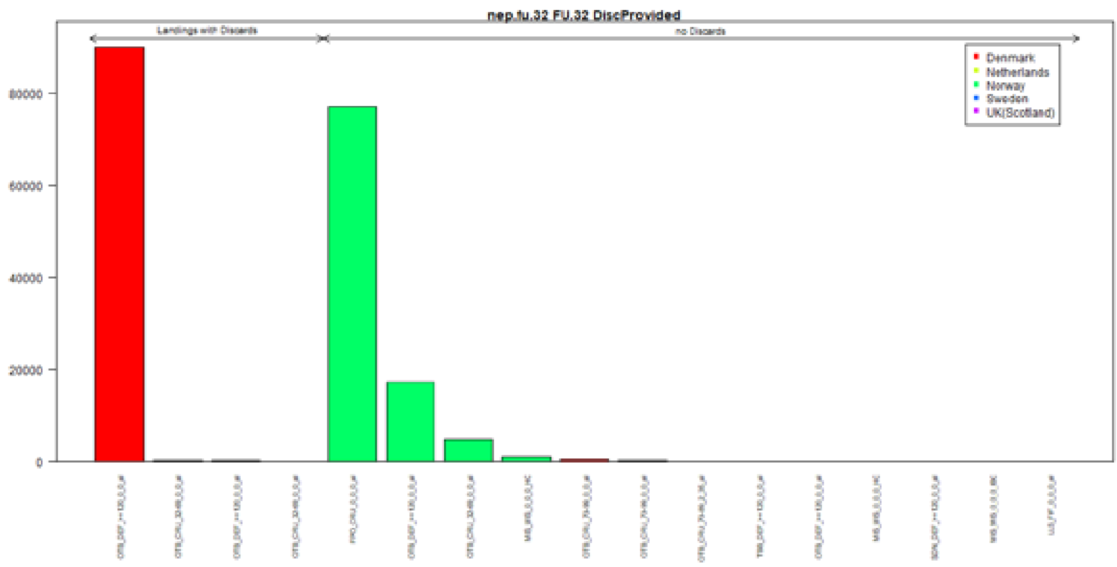


Figure 11.9.4. ***Nephrops*** **Norwegian Deep (FU 32): Landings (kg) by country and métier in 2019 associated with discards as uploaded into InterCatch.**

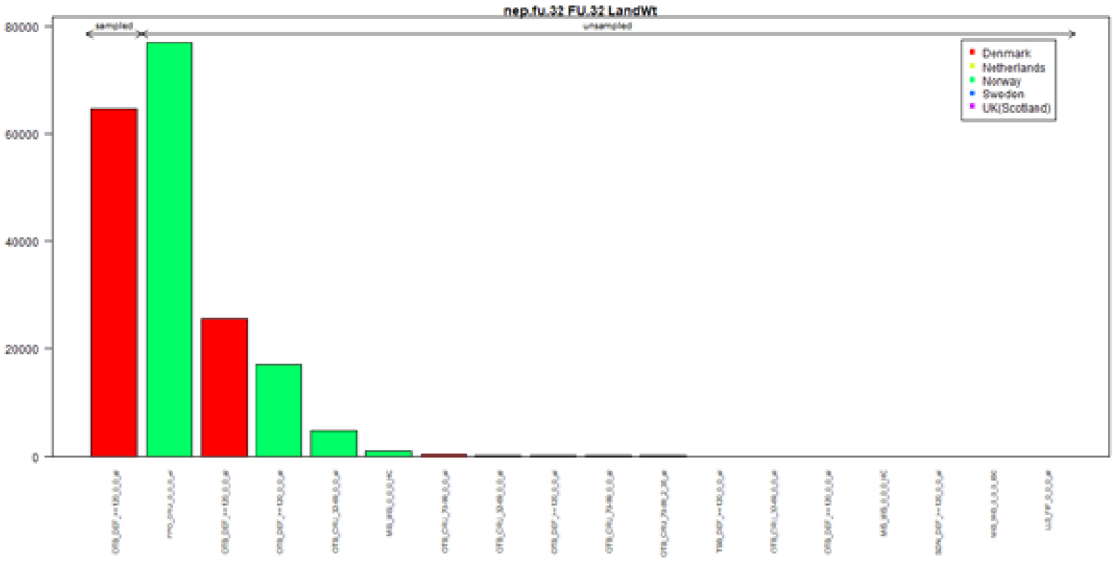


Figure 11.9.5. ***Nephrops*** **Norwegian Deep (FU 32): Landings (kg) by country and métier in 2019 with length samples as uploaded into InterCatch.**

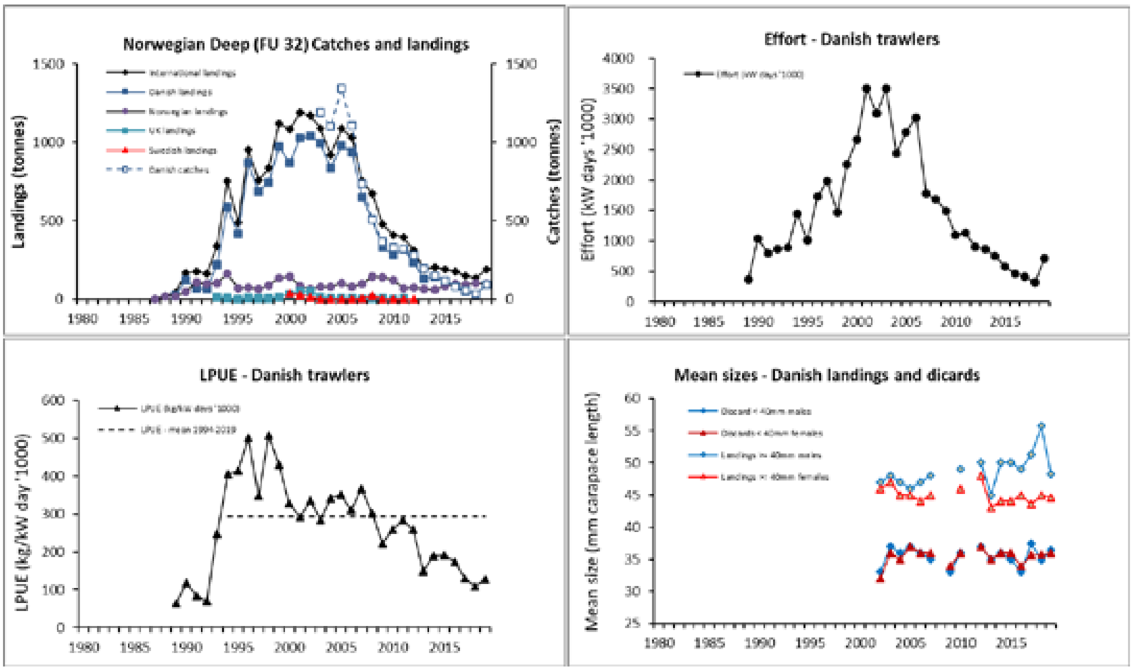


Figure 11.9.6. ***Nephrops*** **Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards (< 40 40 mm).**

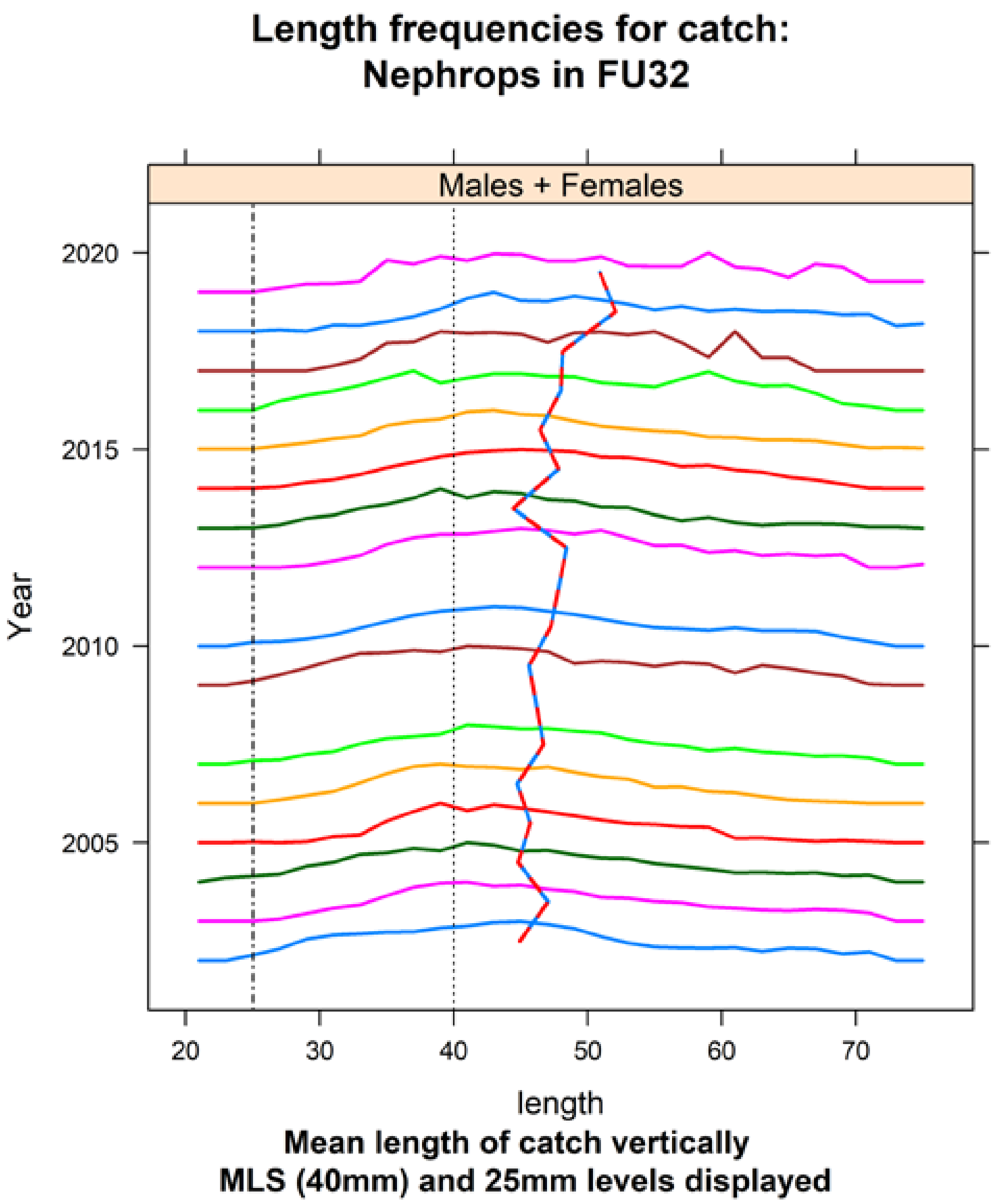


Figure 11.9.7. *Nephrops* Norwegian Deep (FU 32): Size distribution in Danish catches, 2002-2019.

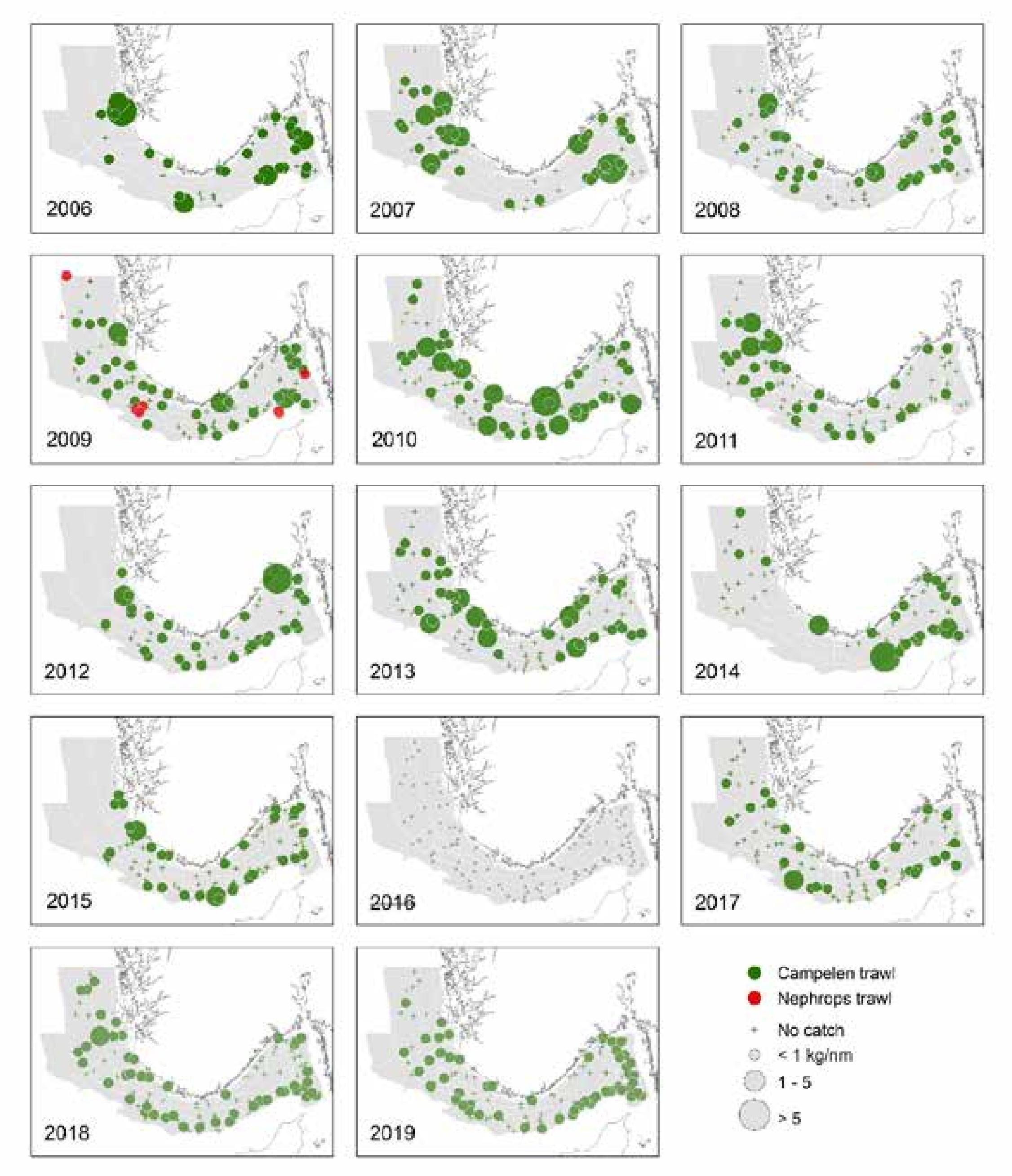


Figure 11.9.8. ***Nephrops*** **Norwegian Deep (FU 32): Distribution of** ***Nephrops*** **in Norwegian bottom trawl shrimp survey, 2006–2019. The 2016-data are omitted from the time series due to technical problems with the trawl gear in this year's survey.**

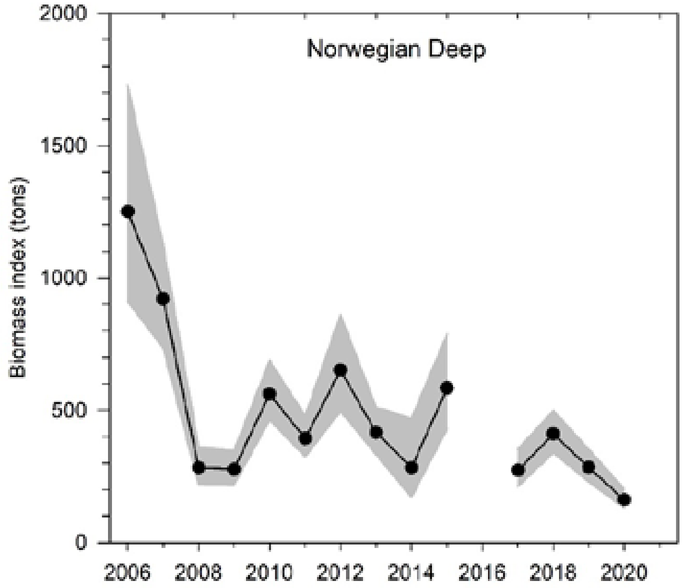


Figure 11.9.9. ***Nephrops*** **Norwegian Deep (FU 32): Biomass index (tonnes) (2006–2020) from the Norwegian bottom trawl shrimp survey. The 2016–data are omitted from the time series due to technical problems with the trawl gear at this year's survey.**

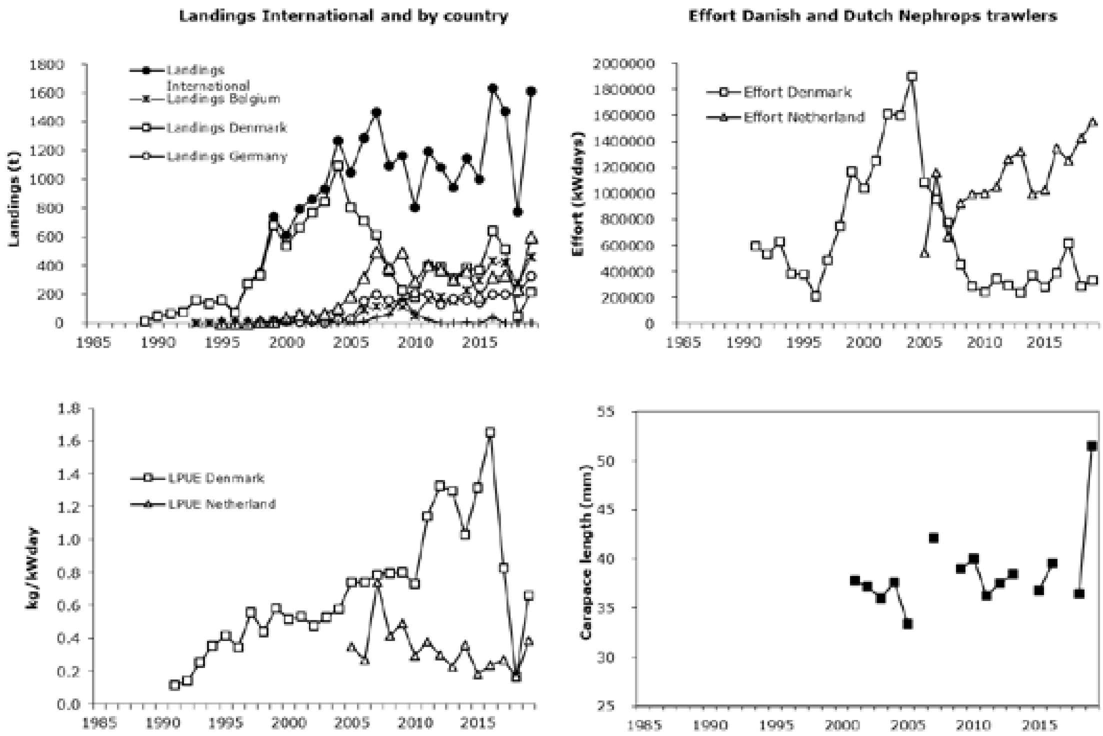


Figure 11.10.1. ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort, LPUE and mean size.**

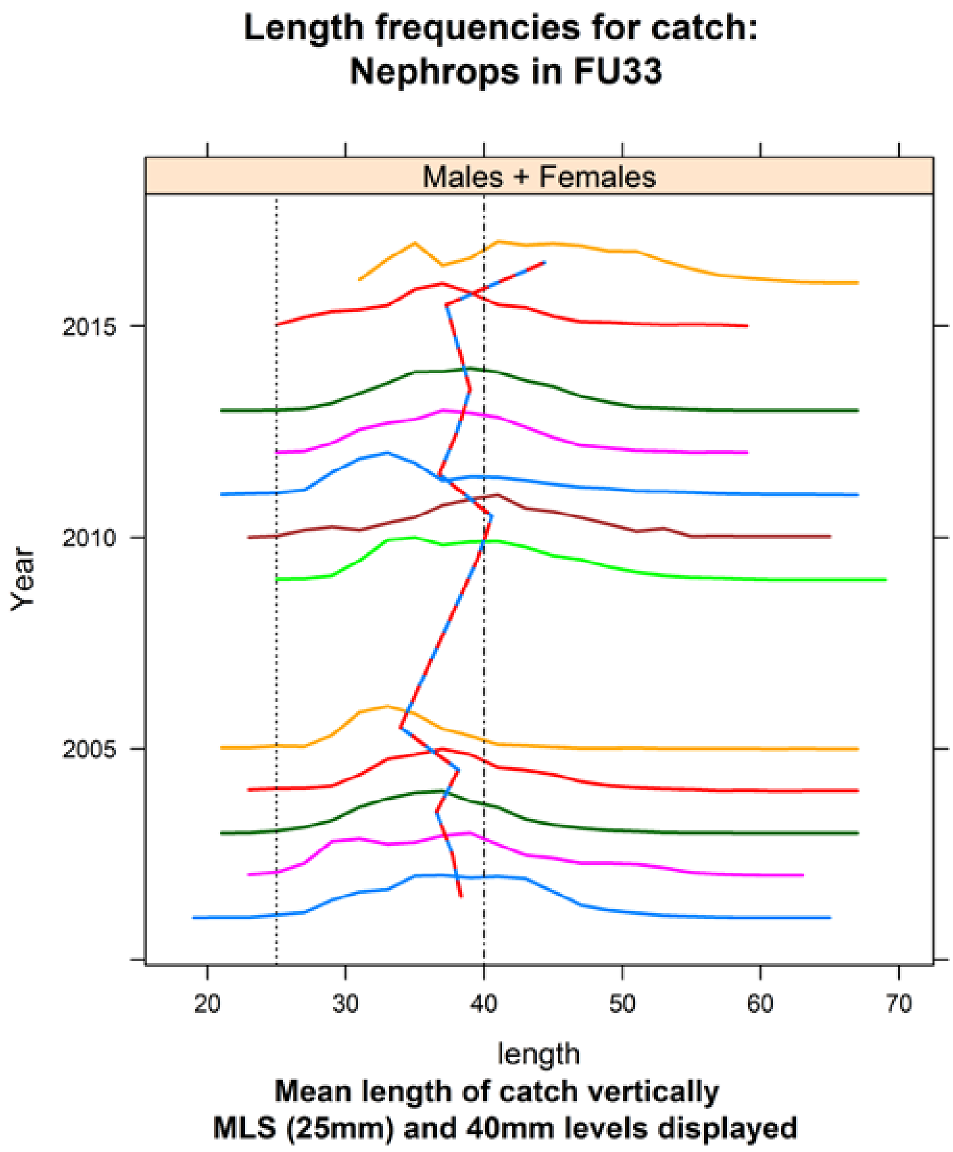


Figure 11.10.2. ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

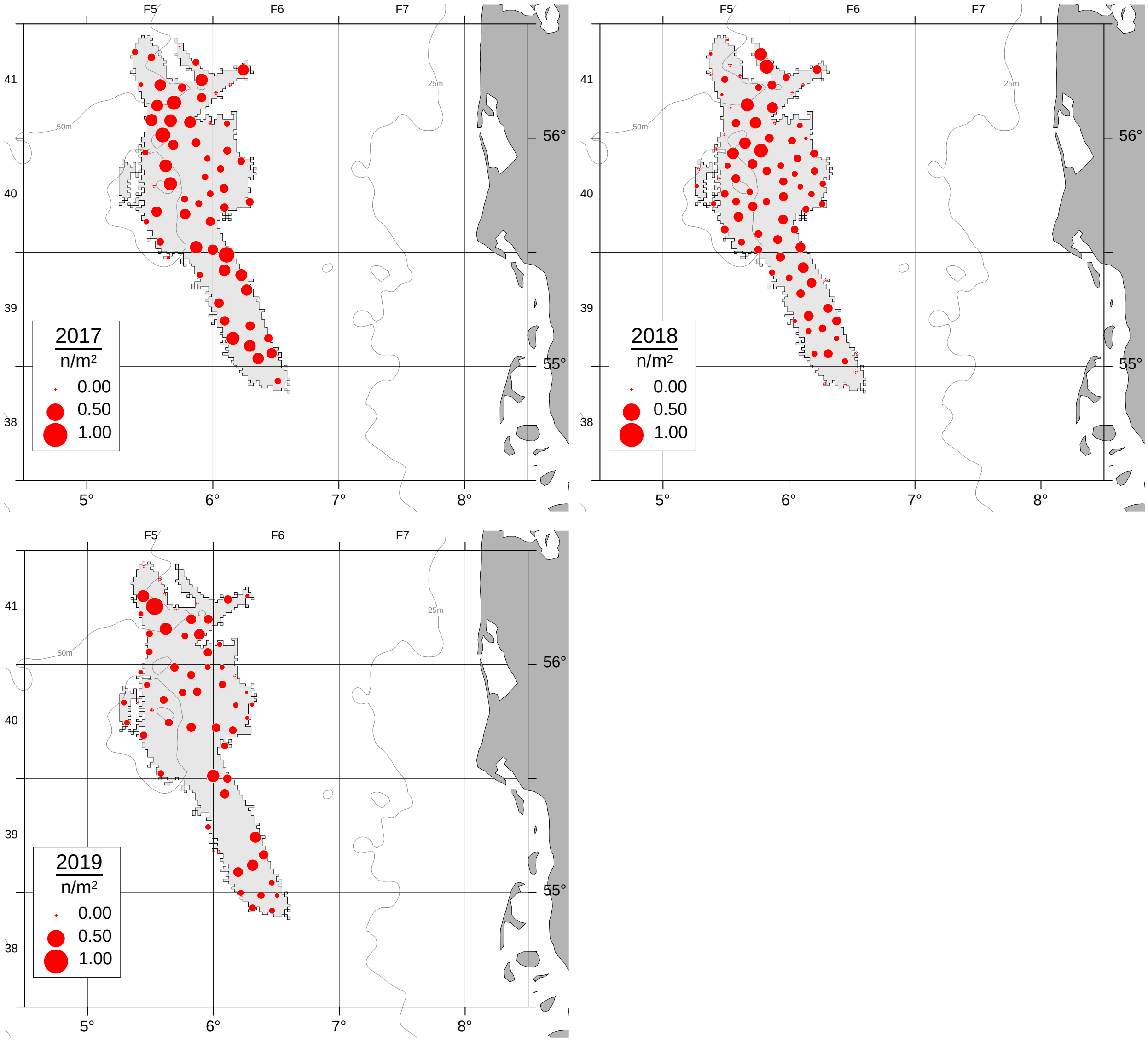


Figure 11.10.3. FU 33 (Off Horn's Reef) *Nephrops* burrow density by station for each year.

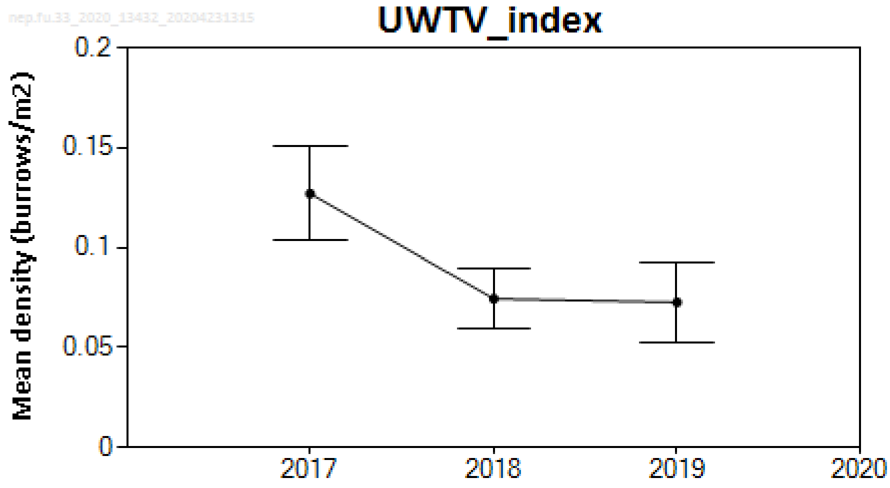


Figure 11.10.4. *Nephrops*, Off Horn's Reef (FU 33), Time series of TV survey abundance estimates (absolute conversion factor = 1.1, from FU 3 & 4), with 95% confidence intervals, from 2017 to 2019.

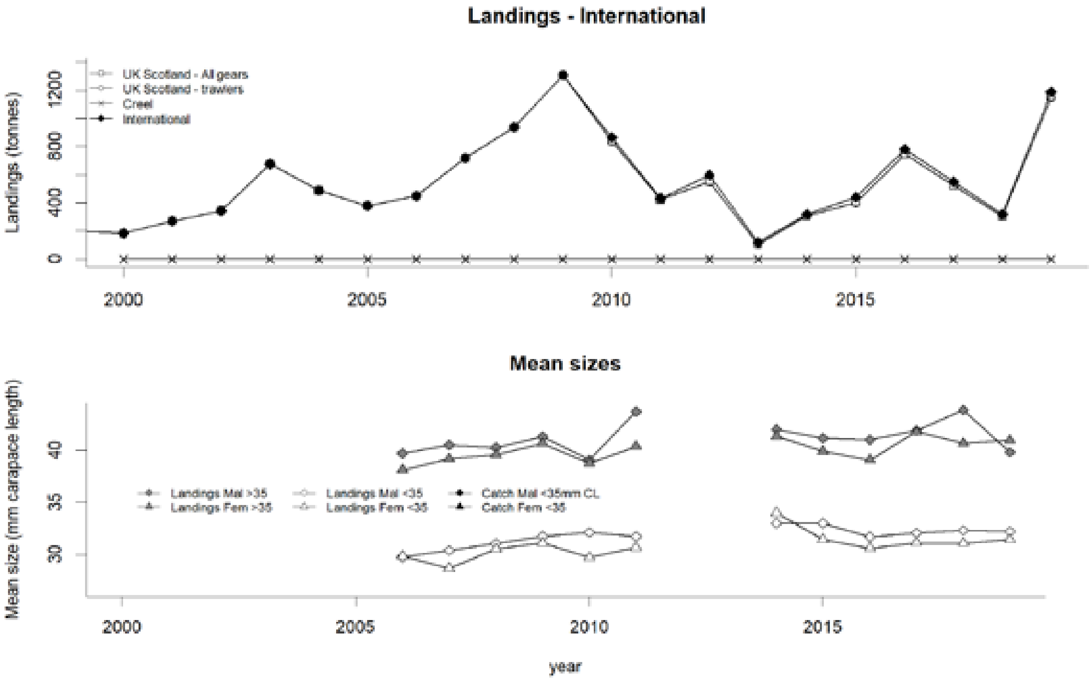


Figure 11.11.1. ***Nephrops*****, Devil's Hole (FU 34). Long term landings and mean sizes, data from year 2000.**

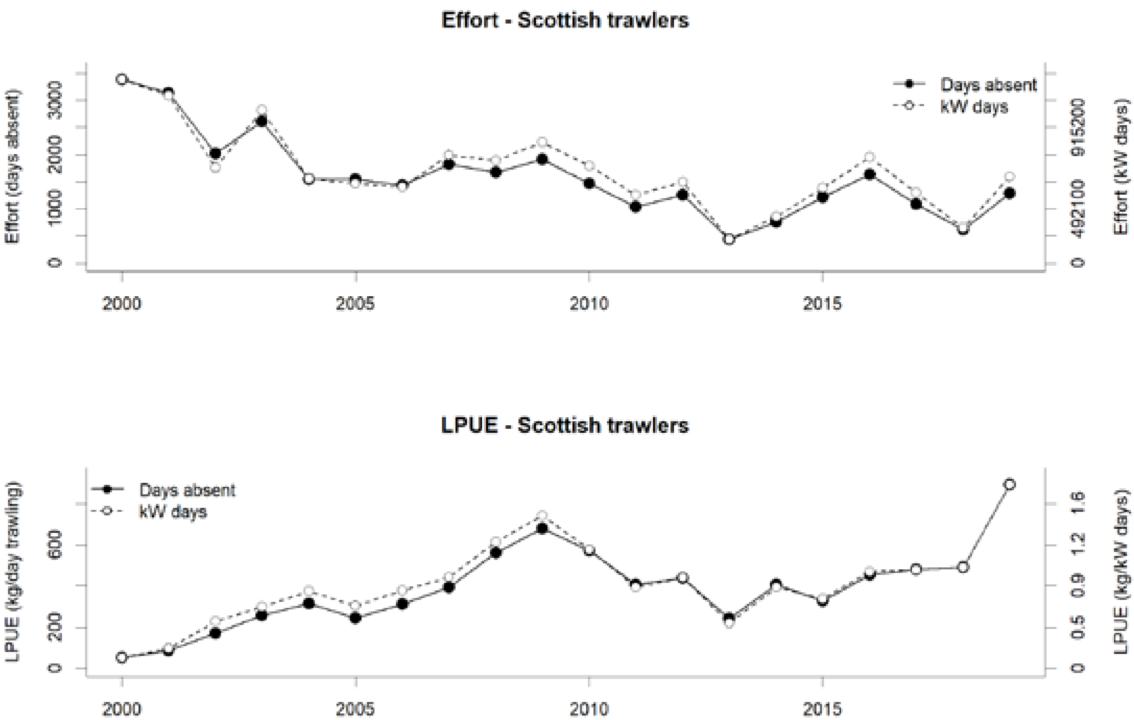


Figure 11.11.2. ***Nephrops*****, Devil's Hole (FU 34). Effort (days, kWday) and LPUE (kg/day, kg/kWdays), data from year 2000.**

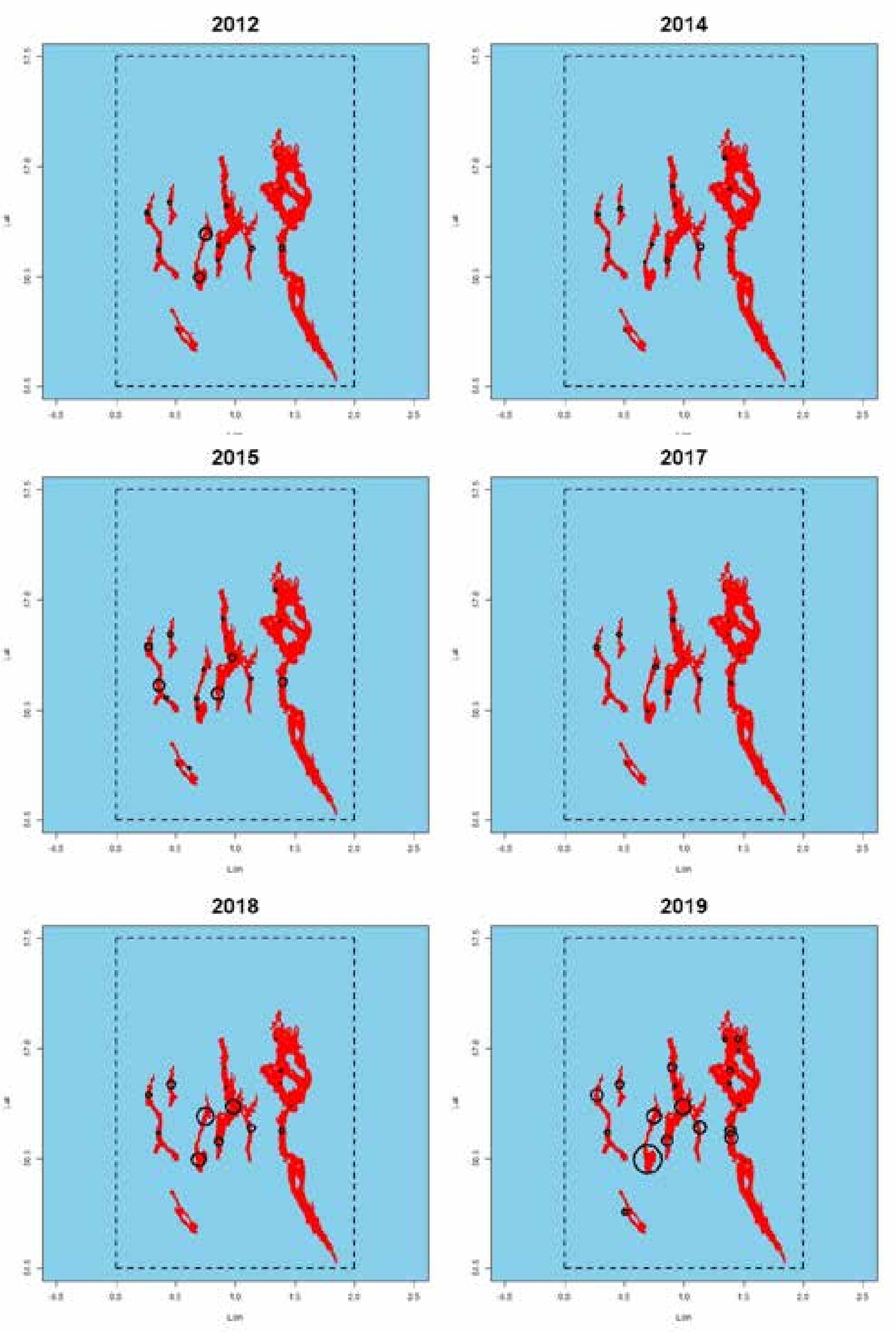


Figure 11.11.3. ***Nephrops*****, Devil's Hole (FU 34). UWTV survey distribution and relative density (2012–2019). Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

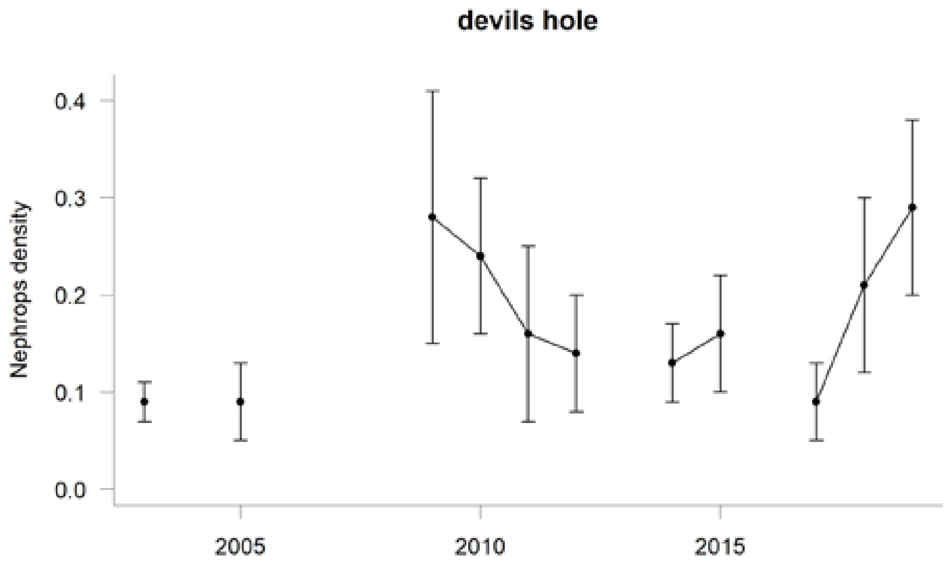


Figure 11.11.4. ***Nephrops*****, Devil's Hole (FU 34). Time series of UWTV survey density estimates with 95 % confidence intervals, 2003, 2005, 2009–2019.**

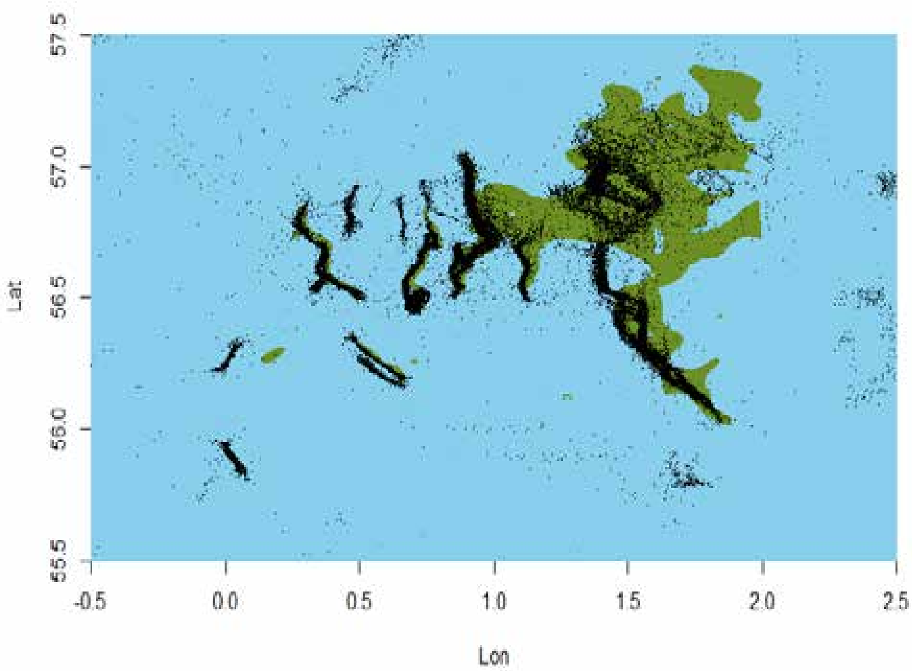


Figure 11.11.5. ***Nephrops*****, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for** ***Nephrops*** **landings > 30% of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

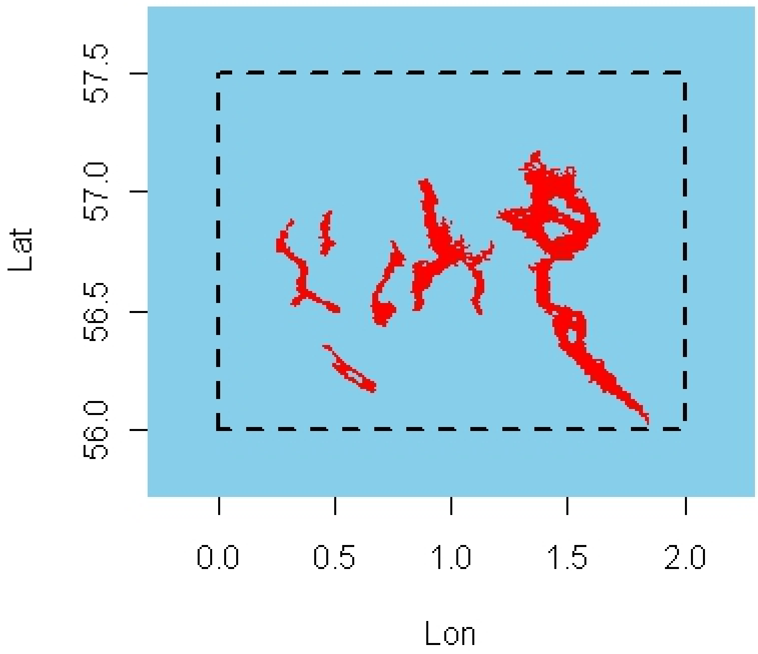


Figure 11.11.6. ***Nephrops*****, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for** ***Nephrops*** **landings > 30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

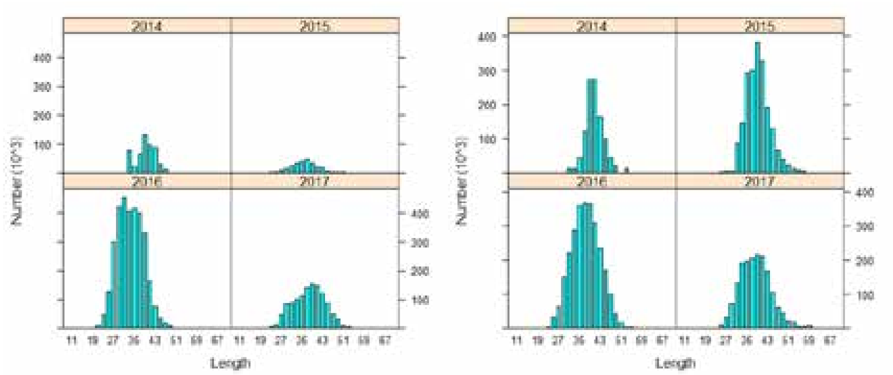


Figure 11.11.7. ***Nephrops*****, Devil's Hole (FU 34). Landings length distributions for females (left) and males (right) obtained from Intercatch and used to run the LBI screening methods (2014–2017).**

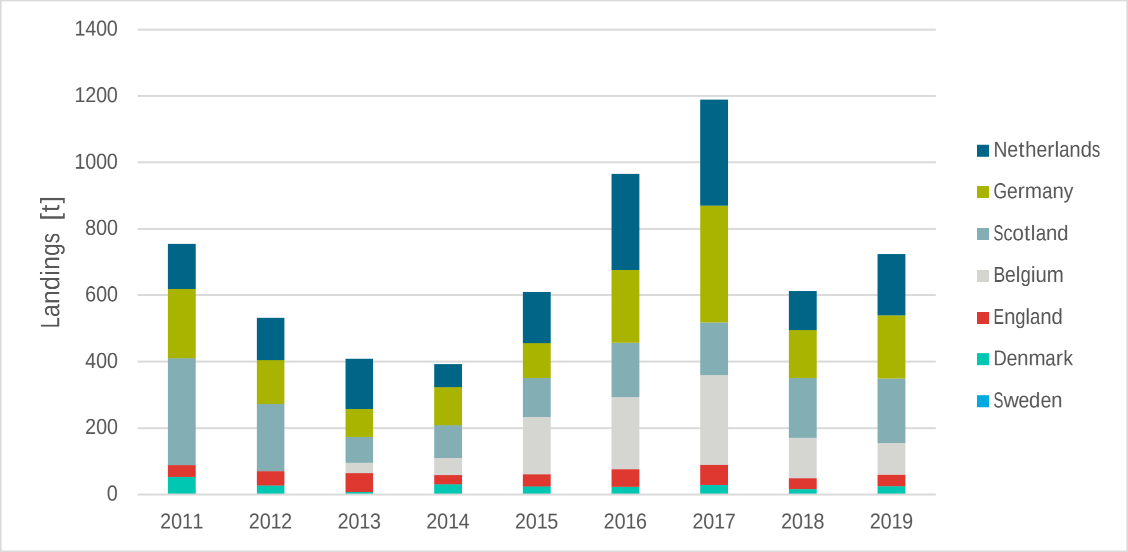


Figure 11.12.1. ***Nephrops*, Subarea 27.4 outside FUs. Annual landings by country.**

12 Norway pout in ICES Subarea 4 and Division 3.a

The Section was added to the report in October 2020

Introduction: Benchmark assessment

The September 2020 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 2020, and includes new information from 2nd half year 2019 and for the quarters 1, 2 and 3 in 2020. The assessment includes the new 3rd quarter 2020 survey information also covering the 0-group 2020 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 2020 and 1 November 2021 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.

Landings have been relatively low since 2001 except for 2010 and 2019, and the 2003–2004 landings were the lowest on record (tables 12.2.1–2). The directed fishery for Norway pout was closed in 2005, in the first half of 2006, and in 2007 as well as in the first half of 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery around 5 kt, as well as in a small experimental fishery in 2007 (1 kt). In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low. Catches were above 100 kt in 2010, but have in the period 2012–2018 been well below 100 kt, and around 100 kt in 2019. The quota has not been taken in those years. The landings in 2018 and 2019 were 36.2 kt and 97.7 kt, respectively. The fishery has in these periods mainly been based on the 2008, 2009, 2012, 2014, 2016, 2018 and 2019 year classes being above the long term average level. The TAC was not taken in 2008–2010 and 2012–2020, 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 low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from Table 12.2.1. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012; see also review in Nielsen *et al*., 2016a; Johnsen *et al*., 2016). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found in Nielsen *et al.*, (2016a) and in the Stock Annex.

The quality of the landings statistics in Norway and Denmark is described in the ICES WKPOUT (2016) and associated Annexes (Nielsen *et al.*, 2016a; Johnsen *et al.*, 2016). The quality seems to be relatively constant during the last 20 years and of a higher quality than in the years before. The discard level of Norway pout in the North Sea fisheries is considered to be low (Nielsen *et al.*, 2016a).

12.1.3ICES advice

In September 2019, the advice on North Sea Norway pout was updated. Based on the estimates of SSB in September 2019, 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). Consequently, the B_{lim} was adjusted in the benchmark assessment in 2016. The B_{lim} estimate in the 4th quarter is lower than the previous value of B_{lim} for the 1st quarter because the 0-group and many of the 1-group fish are not yet included in the estimate of SSB. The catch forecast is for the period 1 October to 30 September. ICES considered that this forecast could be used directly for management purposes for the period 1 November 2016 to 31 October 2020. In recent years the escapement strategy has been practiced in reality in management.

The ICES advice in September 2019 was that with catches up to 167 kt in the directed Norway pout fishery in the period 1 November 2019 to 31 October 2020 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} (39 450 t). The SSB was expected to remain high during 2019 and 2020 due to the high 2018 and 2019 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 and 2019, as well as a just below average recruitment in 2015 and 2017, the fishery has remained open for all of 2013–2020. The quota uptake has been less than 30% in recent years (Nielsen *et al*. 2016a). The quota uptake in 2019 was below 75%.

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 (0.34) as estimated from the assessment in September 2020.

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 2021 (up to 31 October) is provided for the stock in autumn 2020 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.

12.1.4Management up to 2019

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 2020 up to now has been 135.5 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.

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.

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

12.2.2Landings / 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) and 2019 (98 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 2020 include Danish and Norwegian catches up to 20 September 2020. Catches in the last 10 days of 3rd quarter 2020 are assumed to be relatively low and no guesses on that have been included in the assessment.

12.2.3Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 2007 and 2008). Catch at age by quarter of year is shown in Table 12.2.4. Only very few biological samples were taken from the low Norway pout catches in 2005 and 2011, as well as in first half year 2006, 2007, and 2012. The data are in the InterCatch database.

As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches, the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery for those years. As no age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches the catch at age numbers from Danish fishery is calculated from Danish total catch weight divided by mean weight at age from the Norwegian fishery in 2010.

A full scale age Norway pout 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.

12.2.4Weight 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 as well as for quarter 1 to quarter 3 2020. 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.

12.2.5 Maturity and natural mortality

The Inter-benchmark assessment in spring 2012 (ICES IBPNorwayPout, 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM, 2011; ICES WGSAM, 2014). In Nielsen (2016) and in the Stock Annex a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment where maturity and natural mortality used in the assessment is described. Proportion mature and natural mortality by age and quarter used in the assessment is given in Table 12.2.6.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a paper by Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, then variable natural mortality between ages have been introduced in the 2012 ICES IBPNorwayPout inter-benchmark assessment (ICES, 2012c) and the present assessment. The revision of the natural mortality 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.

12.2.6 Summary of Inter-benchmark assessment on population dynamic parameters

A summary of the ICES Spring 2012 inter-benchmark assessment with revised weight, maturity and natural mortality parameters at age included in the assessment is given in Nielsen (2016) and in the Stock Annex as well as in the ICES IBPNorwayPout inter-benchmark assessment report (ICES, 2012c)

12.2.7Catch, 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).

12.1.1.1 Commercial fishery data

Catch information for 1984–2020 is included in this assessment as presented in tables 12.2.1–12.2.5 and Figure 12.2.1. Catches in all of 2005, 1st quarter 2009, first half year 2011 and 2012, and first quarter 2013 were nearly 0 and only very limited information exists about this catch. Consequently, there has been assumed and used low catches of 0.1 million individuals per age (for age groups 1–3) per quarter in the assessment for 2005 and 2011. The fishing effort and catch efficiency (catch per unit of effort) and of the Danish and Norwegian commercial fishery according to year and quarter of year are shown in tables 12.2.7 and 12.2.8, respectively, and according to year and fishing vessel engine horse power category in Tables 12.2.9 and 12.2.10, respectively. Furthermore, trends herein are shown in Nielsen *et al.* (2016a) and in Johnsen *et al.* (2016).

No commercial fishery tuning fleet is included in the assessment from 2006 onwards based on the decisions made in the Norway pout benchmark assessment in September 2016 (ICES WKPOUT, 2016).

12.1.1.2 Research vessel data

Fishery independent survey data used as tuning fleets in the present assessment is given in Table 12.2.11 and Figure 12.2.2 (see also Table 12.3.1).

Survey indices series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (International Bottom Trawl Survey 1st and 3rd quarter) and the EGFS (English Ground Fish Survey, 3rd quarter) and SGFS (Scottish Ground Fish Survey, 3rd quarter), Table 12.2.11. The new survey data from the 1st quarter 2020 IBTS and the 3rd quarter 2019 IBTS research surveys have been included in this September 2020 assessment as well as the 3rd quarter 2020 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 2017–2020 and, accordingly, no new 15 min hauls have been conducted and included in the Q3 2017–2020 SGFS and EGFS survey indices (and consequently in the combined Q3 IBTS survey index). Analyses of this are still on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices. Preliminary analyses indicate no significant differences in catch rates of Norway pout between the 15 min hauls and the 30 min hauls in the SGFS, however, the variability is very high and there are only very few observations available. Long time series and many observations are necessary to make statistical robust evaluation of potential differences.

In September 2015, the EGFS survey indices were revised as to incorporate the relevant primes within the Norway pout area following the IBTS Manual (2015), i.e. in the selection of the prime stations to be included in the Norway pout index calculation. The revision is described in detail in an ICES working document to ICES WGNSSK 2015 (Silva, 2015). 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 2017–2020, 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 2017–2020 indices used in the assessment. By comparison it appears that the survey trends seem similar with or without prime 77 in the EGFS for 2017–2020. In the 2020 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.

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 12.7 below.

The survey data time series including the new information are presented in Table 12.2.11.

12.2.7.1 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 1984–2020, 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

12.3.2Review of assessment

The September 2019 assessment was accepted and no overall or specific recommendations and comments were given here. Potential retrospective patterns in SSB and R were discussed at the ICES WGNSSK meeting in May 2018, but no major issues and problems were pointed at, and it was concluded that the assessment has been performed correctly and performs 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.

12.3.3Final Assessment

A seasonal extension to the State-space Assessment Model (SAM) was used during this September 2020 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 2020 assessment under "NP_Sep20_1" at the same website.

In brief, the model is the same as the SAM model, except that the time step used is one quarter of a year rather than a full year. Recruitment is assumed to occur in quarter 3 only. The logarithm of the fishing mortality at age and quarter is assumed to follow a multivariate random walk with lag 4 and correlated increments, i.e. the log F-at-age in a given quarter is given by the log F-vector in the same quarter one year earlier plus a correlated noise term with mean zero.

The observation equations in SESAM are also extended to deal with zero observations (both surveys and catches), which are usually treated as missing values in SAM. This is done by introducing a detection limit for each fleet, and defining the likelihood of a zero observation to be the probability of obtaining a value less than the detection limit. The detection limit is set to 0.5 times the smallest positive observation by fleet.

A special option was included to down-weight the influence of large jumps in log F on the estimated random walk variance due to periods where the fishery was closed. This option reduced the estimated log F process variance considerably.

In the ICES WKPOUT (2016) benchmark, a number of variants of the SESAM model were investigated and compared to the previous assessment model, SXSA. These variants included the use (or not) of commercial CPUE data, omission of the earliest years of data from the assessment, alternative settings for the detection threshold used to handle zero-valued data, and omitting the years of fishery closure when estimating the random walk variance on fishing mortality.

The final SESAM model also used in this September 2020 assessment excludes commercial CPUE data, omits 1983 data from the assessment, use age 3+-group, and omits the years of fishery closure from the random walk variance calculation. In relation to evaluation of stock sustainability and forecast, B_{lim} is set equal to B_{loss} based on quarter 4 SSB values to align with the new fishing season (1 November to 31 October). The short-term forecast is stochastic, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season.

Stock indices and assessment settings used in the assessment are presented in tables 12.3.1–12.3.2.

Results of the SESAM analysis are presented in tables 12.3.1–12.3.2 (assessment model parameters, settings, and options), Table 12.3.3 (population numbers at age (recruitment)), Table 12.3.4 (fishing mortalities by year and quarter), Table 12.3.5 (diagnostics), and Table 12.3.6 (stock summary). The summary of the results of the assessment are shown in Table 12.3.6 and Figures 12.3.1 (spawning stock biomass, SSB), 12.3.2 (total stock biomass, TSB), 12.3.3 (fishing mortality, F_{bar}), 12.3.4 (recruitment), 12.3.5 (yield, catches on yearly and quarterly basis), and 12.3.6–12.3.7 (stock-recruitment plots for quarter 1 and quarter 3, respectively). The retrospective patterns and the residuals from the SESAM September 2019 assessment are given in Figure 12.3.8 and Figures 12.3.9–12.3.11, respectively.

Fishing mortality has generally been lower than natural mortality and has decreased in the recent 20 years below the long term yearly average (0.34, 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 2013–2019, 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%. 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 and 2019 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 and 2020 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 and 2019 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 was slightly below long term average (48 billion), but because of the strong 2012, 2014, 2016 and 2018 year classes the SSB has been well above B_{pa} (= MSY $B_{escapement}$) by 1 January 2014, 2015, 2016, 2017, 2018 and 2019 even with a high yearly TAC in 2014–2019 considering growth, high natural mortality, and 20% maturation at age 1. Because of the strong 2016, 2018, 2019 and 2020 recruitment the stock is expected to remain above B_{pa} by the end of 2020.

12.3.4Comparison with 2015-2019 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 2020 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 2020 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. No strong retrospective patterns are observed, however, the Mohns rho values are relatively high for SSB (38%). It should be noted that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments.

12.4 Historical stock trends

The assessment and historical stock performance is consistent with previous years assessments, i.e. the perception of stock dynamics of the SSB and recruitment over time are consistent, while there is some variability between models in the estimates of the average fishing mortality of ages 1 and 2 over time especially in the middle of the assessment period. However, the SXSA estimates of fishing mortality is within the confidence limits of the SESAM estimates of fishing mortality. Based on the Inter-Benchmark in spring 2012 with revised estimates of natural mortality, maturity at age and mean weight at age for the stock in the assessment there is a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10 % in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter. This is shown in the ICES IBPNorwayPout Report (ICES, 2012c) and the Stock Annex.

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 48 billion (arithmetic mean) for the period 1984–2020 (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 has been below long term average (48 billion).

12.5 Short-term prognoses

The short-term forecast is stochastic based on the SESAM September 2020 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 $\log F_t = \log F_{t-4} + \log G_t$, 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.
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 2020 recruitment (Q3 2020) in the SSB estimate by 4th quarter 2020 The recruits in 2021 do not become a part of SSB by 4th quarter (1 October) 2021 because they have not reached maturity yet by 4th quarter 2021, but will do that by 1 January 2022 (20% mature as 1-group here). However, the forecast is just run up to 4th quarter 2021, and the recruits in 2021 is accordingly not used (and shall not be that) in the forecast SSB estimate in Q4 2021.

5. 5. Find G_t 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 μa,q is a mean for each combination of quarter and age, s( ) is tensor product smoothing spline, and U_t are normal distributed random effects. The square root transform is used to achieve variance homogeneity in the residuals. See Figure 1 in ICES WKPOUT (2016, WD6, Nielsen and Berg, 2016).

The projected mean weight at ages in the catch used in the forecast are shown in Table 12.6.1.

Forecasts

The first forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1 October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1 October as explained below in Section 12.7. The purpose of the first forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 with F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2021) 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 349 kt (349 090 t) in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 1.093 and a SSB at 166 kt (166 810 t) by 1 October 2020.

The purpose of the second forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.00 and a SSB at 368 kt (368 180 t) by 1 October 2021.

The purpose of the third forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 with F scaled to F status quo for previous year up to 1 October 2020. The results of the forecast are presented in Table 12.6.4 and Figure 12.6.3 where catches up to 101 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.243 and a SSB at 299 kt (299 940 t) by 1 October 2021.

The purpose of the fourth forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 with F scaled such that the median of the SSB distribution one year a head (1 October 2021) equals B_{lim}. The results of the forecast are presented in Table 12.6.5 and Figure 12.6.4 where catches up to 704 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 4.065 and a SSB of 42 kt (42 573 t) by 1 October 2021.

The purpose of the fifth forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 with F scaled such that SSB one year a head (1 October 2021) equals B_{pa}. The results of the forecast are presented in Table 12.6.6 and Figure 12.6.5 where catches up to 606 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 2.798 and a SSB of 70 kt (70 000 t = B_{pa}) by 1 October 2021.

The purpose of the sixth forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 125 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.305 and a SSB of 125 kt (125 191 t) by 1 October 2021.

The purpose of the seventh forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 160 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.405 and a SSB of 262 kt (262 700 t) by 1 October 2021.

The purpose of the eight forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 193 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.505 and a SSB of 243 kt (243 520 t) by 1 October 2021.

The purpose of the ninth forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 225 kt can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.608 and a SSB of 226 kt (226 610 t) by 1 October 2021.

The purpose of the tenth forecast is to calculate the catch of Norway pout from 1 October 2020 to 31 October 2021 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 254 kt (254 038 t) can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.708 and a SSB of 211 kt (211 550 t) by 1 October 2021.

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 12.7 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).

The B_{lim} SSB estimate in Q4 is low because of the 0-group and many of the 1-group fish are not in the SSB yet at that time. However, in the forecast there is a change in maturity and a age class shift by 1 January, i.e. the 0-group becomes 1-group and 20% of those become mature, and the 1-group becomes 2-group and 100% of those become mature. This is in the forecast calculated into the SSB available for spawning in 1 quarter of the forecast year.

The fishing pattern has not changed in the most recent years. Accordingly, the use of B_{lim} by Q4 should be sustainable.

It should be noted that there is a tendency towards the retrospective analyses do not fully converge even though being at the same level. It should also be noted that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments.

	Type	Value	Technical basis
MSY Approach	MSY	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	B_{pa}	65 000 t, quarter 4	$= B_{lim}\, e^{0.3*1.645}$
	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

No F-based reference points are advised for this stock except for an F_{cap} (see 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.

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} (39 450 and 65 000 t) is 0.6.

It is obvious that the Norway pout, being a short-lived species, has no well-defined break point (inflection) in the SSB-R relationship (ICES IBPNorwayPout 2012c; ICES WKPOUT, 2016) and therefore there is not clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high recruitment observed at B_{loss} as well as more observations above than below the inflection point).

The B_{lim} = Bloss = 39 450 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.

	Type	Value	Technical basis
MSY Approach	MSY	42 573 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	42 573 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
	B_{pa}	70 000 t, quarter 4	$= B_{lim}\ e^{0.3*1.645}$
	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

The relationship between the B_{lim} and B_{pa} (42 573 and 70 000 t) is 0.6.

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 (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 2020, with terminal assessment year ranging from 2005–2020, is 38% for SSB, -20% for F_{bar}, and 77% for R shown in Figure 12.3.8. Despite these tendencies of overestimating spawning stock biomass, underestimating fishing mortality, and overestimating recruitment, then the terminal year estimates lie within the confidence limits of the model estimates which appear from Figure 12.3.8.

The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the assessment taking into account the seasonality in fishery, use of seasonal based fishery independent information, and using most recent information about recruitment. The assessment provides stock status and year class strengths of all year classes in the stock up to the end of third quarter of the assessment year. The assessment method gives a good indication of the stock status the 1 October the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

12.9 Status of the stock

Based on the estimates of SSB in September 2020, ICES classifies the stock at full reproductive capacity.

With F scaled to 0.7, i.e. with a F_{cap} = 0.7 catches up to 167 kt (167 105 t) can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to a $F_{bar(1–2)}$ of 0.708 and a SSB of 139 kt (139 130 t) by 1 October 2020. This is due to the strong 2016, 2018 and 2019 recruitment being above the long term average recruitment (48 billion), growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.43). Targeted fishery for Norway pout was closed in 2005, first half year 2006, in all of 2007, as well as in first half of 2011 and 2012 and fishing mortality and effort has accordingly reached historical minima in these periods (Table 12.3.6). The fishery was open for the second half 2006, 2011 and 2012 as well as in all of the years 2008–2010 and 2013–2018. Here, the fishing mortality was low in 2008 and 2011, moderate in 2009 and 2010, and on a higher level in 2013–2018, but still well below the long term average. The TACs have not been fished up in any of these recent years.

The recruitment reached historical minima in 2003–2004, and the 1987, 2002, 2006, and 2010 year classes were weak. The recruitment in 2008, 2009, 2012, 2014, 2016, 2018, 2019 and 2020 was high well above the long term average (48 billion). Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 has been below the long term average (Table 12.3.6).

12.10 Management considerations

There are no management objectives for this stock.

From the results of the forecast presented here with a F scaled to 0.7, i.e. with a F_{cap} = 0.7 catches up to 254 kt (254 038 t) can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $F_{bar(1–2)}$ of 0.708 and a SSB of 211 kt (211 550 t) by 1 October 2021. This is due to the strong 2018, 2019 and 2020 recruitment being above the long term average recruitment (48 billion), 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 low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from Table 12.2.1. Sorting grids in combination with square mesh panels have been shown to reduce by-catches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen, 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. ICES suggests, that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. The implementation of these technical measures shall be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing by-catch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the Stock Annex.

12.10.2 Long term management strategies

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F = 0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES does not recommend any particular one of the strategies.

The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The variable TAC escapement strategy as evaluated in 2007 has higher long term yield compared to the fixed fishing mortality strategy (and the fixed TAC strategy), but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better.

There should be no shift in management strategies between years. In recent years the escapement strategy has been practiced.

A detailed description of these long term management strategies and management plan evaluations can be found in the Stock Annex and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30, Section 5.3) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports as well as in Vinther and Nielsen (2012, 2013).

ICES has again in September–October 2012 and April–May 2013 (Vinther and Nielsen, 2012; 2013) evaluated and commented on long term management strategies for the stock using updated stock information. In September 2012, ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100–250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the result that an initial TAC between 25–50 kt and a fixed F = 0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year 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.

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.

12.12 References

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Table 12.2.1 Norway pout in 4 and 3.a. Nominal landings (tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas4 and 3.a in the period 2009–2019, 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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	-	51	2	118	6.945	538	2.220	918	110	159	1.125 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Norway	209	711	-	-	147	9	41	82	72	6	6 *
Sweden	-	10	-	-	1	1	1	1	4	1	18 *
Germany	-	-	-	-	-	-	-	-	2	-	-
Total	209	772	2	118	7.093	548	2.262	1.001	188	166	1.149

*Preliminary.

Norway pout ICES area IVa

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	19.226	71.032	4.038	25.431	31.375	27.894	10.760	21.125	12.312	10.367	35.647 *
Faroe Islands	-	-	-	-	-	-	5.270	3.156	-	-	3034 *
Netherlands	22	18	-	-	-	-	17	8	1	2	- *
Germany	-	-	-	-	-	-	22	27	1	-	- *
Norway	36.961	64.303	3.189	4.528	45.839	18.647	43.742	35.959	21.275	25.498	59.546 *
Sweden	-	+	1	3	4	1	12	-	-	4	32 *
UK(Scotland)	-	29	-	-	-	8	3	12	-	-	- *
Total	56.209	135.353	7.228	29.962	77.218	46.542	59.823	60.275	33.589	35.871	98.259

*Preliminary.

Norway pout ICES area IVb

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	595	229	32	9	43	16	53	1463	45	20	573 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Germany	75	-	-	-	-	-	-	-	13	3	- *
Netherlands	-	-	-	-	-	-	1	-	-	-	1 *
Norway	82	620	21	59	615	8	577	11	10	-	109 *
Sweden	-	-	-	-	0	0	714	1	2	-	3 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	6	-	18	-	-	- *
Total	752	849	53	68	658	30	1.345	1.493	70	23	686

*Preliminary.

Norway pout ICES area IVc

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	-	-	-	-	-	-	-	1	-	-	-
France	-	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	1	0	0	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Denmark	19.821	71.312	4.072	25.558	38.363	28.448	13.033	23.507	12.467	10.546	37.345
Faroe Islands	0	0	0	0	0	0	5.270	3.156	0	0	3.034
Norway	37.252	65.634	3.210	4.587	46.601	18.664	44.360	36.052	21.357	25.504	59.661
Sweden	0	10	1	3	5	2	727	2	6	5	53
Netherlands	22	18	0	0	0	0	18	8	1	2	1
Germany	75	0	0	0	0	0	22	27	16	3	0
UK	0	0	0	0	0	6	0	18	0	0	0
Total nominal landings	57.170	136.974	7.283	30.148	84.969	47.120	63.430	62.770	33.847	36.060	100.094
By-catch of other species and other	-2.670	-11.019	-759	-3.075	-2.869	-2.950	-30	630	86	87	-2.440
ICES estimate of total landings (IV+IIIaN)	54.500	125.955	6.524	27.073	82.100	44.170	63.400	63.400	33.933	36.147	97.654
Agreed TAC (EU)	116.279 x	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
TAC (Norway)	128.000	86.000	3.000	25.000	157.000	108.000	178.000	210.000	204.235	90.978	82.230

* 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 in 4 and 3.a. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, 3.aS) by country, for 1961–2019 (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

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.
** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 12.2.3 Norway pout in 4 and 3.a. National landings (tonnes) by quarter of year 2003–2020 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
2003	1	-	1	1	615	581	22	-	1.218	1.218	1976,86	1976,86	3.195
	2	246	160	406	76	-	22	-	98	344	2773,5	2773,499	3.117
	3	2.984	1.005	3.989	172	1.613	89	-	1.874	4.858	5989,37	5989,366	10.847
	4	188	547	735	-	6.270	457	-	6.727	6.915	643,592	643,592	7.559
	Total	3.418	1.713	5.131	863	8.464	590	-	9.917	13.335	11.383	11383,32	24.718
2004	1	316	-	316	87	650	-	-	737	1.053	989	989	2.042
	2	-	-	-	-	-	7	-	7	7	660	660	667
	3	14	-	14	289	1.195	9	-	1.493	1.507	2484	2484	3.991
	4	13	-	13	93	5683	107	-	5.883	5.896	865	865	6.761
	Total	343	-	343	469	7.528	123	-	8.120	8.463	4.998	4.998	13.461
2005	1	-	-	-	9	0	-	-	9	9	12	12	21
	2	-	-	-	151	-	0	-	151	151	352	352	503
	3	-	-	-	781	0	0	-	781	781	387	387	1.168
	4	0	-	-	0	0	0	-	-	-	211	211	211
	Total	-	-	-	941	-	-	-	941	941	962	962	1.903
2006	1	-	-	-	75	83	-	-	158	158	2.205	2205	2.363
	2	-	-	-	-	-	15	-	15	15	2.846	2846	2.861
	3	114	-	114	-	649	20	-	669	783	5.749	5749	6.532
	4	3	-	3	-	34.262	-	-	34.262	34.265	605	605	34.870
	Total	117	-	117	75	34.994	35	-	35.104	35.221		11.405	46.626
2007	1	-	-	-	561	789	-	-	1.350	1.350	74	74	1.424
	2	-	-	-	4	-	-	-	4	4	1.097	1097	1.101
	3	1	2	3	-	-	-	-	-	1	2.429	2429	2.430
	4	-	-	-	-	682	-	-	682	682	155	155	837
	Total	1	2	3	565	1.471	-	-	2.036	2.037		3.755	5.792
2008	1	125	-	125	19	86	123	-	228	353	7	7	360
	2	-	-	-	-	-	30	-	30	30	1.803	1803	1.833
	3	-	-	-	-	6.102	-	-	6.102	6.102	3.582	3582	9.684
	4	-	-	-	-	22.686	1.239	-	23.925	23.925	336	336	24.261
	Total	125	-	125	19	28.874	1.392	-	30.285	30.410		5.728	36.138
2009	1	1	-	1	22	515	-	-	537	538	2	2	540
	2	-	-	-	-	-	-	-	-	-	4.026	4026	4.026
	3	2	-	2	-	11.567	-	-	11.567	11.569	31.251	31251	42.820
	4	-	-	-	-	5.399	4	-	5.403	5.403	1.736	1736	7.139
	Total	3	-	3	22	17.481	4	-	17.507	17.510	37.015	37.015	54.525
2010	1	-	-	-	-	194	-	-	194	194	104	104	298
	2	157	-	157	-	478	59	-	537	694	17.906	17906	18.600
	3	37	-	37	-	33.618	213	-	33.831	33.868	41.883	41883	75.751
	4	8	-	8	-	30.276	38	-	30.314	30.322	984	984	31.306
	Total	202	-	202	-	64.566	310	-	64.876	65.078	60.877	60.877	125.955
2011	1	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	-	-	-	-	188	188	188
	3	-	-	-	-	456	5	-	461	461	3.004	3004	3.465
	4	-	-	-	-	2.853	-	-	2.853	2.853	18	18	2.871
	Total	-	-	-	-	3.309	5	-	3.314	3.314	3.210	3.210	6.524
2012	1	-	-	-	-	15	-	-	15	15	12	12	27
	2	-	-	-	-	-	-	-	-	-	280	280	280
	3	2	-	2	-	62	8	-	70	72	395	395	467
	4	125	-	125	-	22.204	-	-	22.204	22.329	3.900	3.900	26.229
	Total	127	-	127	-	22.281	8	-	22.289	22.416	4.587	4.587	27.003
2013	1	-	-	-	-	59	-	-	59	59	18	18	77
	2	6	-	6	-	409	-	-	409	415	10.045	10.045	10.460
	3	4.791	-	4.791	5	3.260	43	-	3.308	8.099	16.350	16.350	24.449
	4	1.366	-	1.366	-	25.211	-	-	25.211	26.577	20.537	20.537	47.114
	Total	6.163	-	6.163	5	28.939	43	-	28.987	35.150	46.950	46.950	82.100
2014	1	-	-	-	-	1.318	-	-	1.318	1.318	6	6	1.324
	2	62	-	62	-	-	2	-	2	64	3.146	3.146	3.210
	3	492	-	492	-	5.606	20	-	5.626	6.118	7.252	7.252	13.370
	4	-	-	-	-	18.006	-	-	18.006	18.006	8.260	8.260	26.266
	Total	554	-	554	-	24.930	22	-	24.952	25.506	18.664	18.664	44.170
2015	1	-	-	-	21	305	-	-	326	326	268	268	594
	2	2	-	2	-	549	-	-	549	551	6.812	6.812	7.363
	3	2.217	1	2.218	10	3.221	19	-	3.250	5.467	21.335	21.335	26.802
	4	-	-	-	-	6.689	-	-	6.689	6.689	15.945	15.945	22.634
	Total	2.219	1	2.220	31	10.764	19	-	10.814	13.033	44.360	44.360	57.393
2016	1	-	-	-	-	514	-	-	514	514	575	575	1.089
	2	244	1	245	-	267	-	-	267	511	8.296	8.296	8.807
	3	673	1	674	5	2.222	51	-	2.278	2.951	20.897	20.897	23.848
	4	-	-	-	3	20.135	-	-	20.138	20.138	6.286	6.286	26.424
	Total	917	2	919	8	23.138	51	-	23.197	24.114	36.054	36.054	60.168
2017	1	-	-	-	-	703	-	-	703	703	30	30	733
	2	5	-	5	-	-	-	-	-	5	3.470	3.470	3.475
	3	104	-	104	6	1.969	-	-	1.975	2.079	11.546	11.546	13.625
	4	-	-	-	68	9.597	2	-	9.667	9.667	6.433	6.433	16.100
	Total	109	-	109	74	12.269	3	-	12.345	12.454	21.479	21.479	33.933
2018	1	-	-	-	-	371	-	-	371	371	9	9	380
	2	2	-	2	-	3	-	-	3	5	4.138	4.138	4.143
	3	157	-	157	-	190	1	-	191	348	8.969	8.969	9.317
	4	-	-	-	-	9.921	-	-	9.921	9.921	12.386	12.386	22.307
	Total	159	-	159	-	10.485	1	-	10.486	10.645	25.502	25.502	36.147
2019	1	-	-	-	-	483	-	-	483	483	13	13	496
	2	178	-	178	-	2.166	-	-	2.166	2.344	8.832	8.832	11.176
	3	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	2.872	-	2.872	-	982	1	-	983	3.855	43.569	43.569	47.424

Table 12.2.3a Norway pout in 4 and 3.a.N (Skagerrak). Observed and SESAM model predicted total catches in tonnes by quarter (millions).

	year	observed	predicted
1	1984.00	56790	65901
2	1984.25	56532	27182
3	1984.50	152291	100147
4	1984.75	110942	93903
5	1985.00	57467	42618
6	1985.25	15509	15573
7	1985.50	62489	57149
8	1985.75	92017	59782
9	1986.00	37773	25132
10	1986.25	7657	10334
11	1986.50	45085	37670
12	1986.75	89993	42849
13	1987.00	33883	26834
14	1987.25	15435	9689
15	1987.50	38729	36858
16	1987.75	60847	56098
17	1988.00	22181	23210
18	1988.25	3559	7688
19	1988.50	21793	20253
20	1988.75	61762	31357
21	1989.00	15379	14517
22	1989.25	13234	10462
23	1989.50	55066	35808
24	1989.75	82880	45317
25	1990.00	27984	24655
26	1990.25	39713	17022
27	1990.50	26156	32281
28	1990.75	45242	49383
29	1991.00	42722	28072
30	1991.25	20786	19299
31	1991.50	62518	59603
32	1991.75	64380	64137
33	1992.00	64218	47233
34	1992.25	27973	27235
35	1992.50	114122	87444
36	1992.75	96177	84272
37	1993.00	36214	45010
38	1993.25	29291	25207
39	1993.50	62290	54307

	year	observed	predicted
40	1993.75	53470	44514
41	1994.00	34575	23138
42	1994.25	15373	13992
43	1994.50	53799	41555
44	1994.75	79838	43087
45	1995.00	36942	27150
46	1995.25	28019	18530
47	1995.50	69763	75650
48	1995.75	97048	64641
49	1996.00	21888	27545
50	1996.25	13366	16320
51	1996.50	74631	61599
52	1996.75	46194	44412
53	1997.00	15320	17850
54	1997.25	8708	12592
55	1997.50	78809	58325
56	1997.75	54100	52531
57	1998.00	19502	19243
58	1998.25	11836	12196
59	1998.50	20866	31280
60	1998.75	22830	26532
61	1999.00	7827	7889
62	1999.25	12533	6612
63	1999.50	41445	22561
64	1999.75	30497	31795
65	2000.00	10207	12362
66	2000.25	11589	12930
67	2000.50	44173	45594
68	2000.75	119001	62595
69	2001.00	21400	14305
70	2001.25	11778	8729
71	2001.50	4630	21740
72	2001.75	26565	32522
73	2002.00	8553	5792
74	2002.25	6686	4062
75	2002.50	32922	15505
76	2002.75	28947	19995
77	2003.00	3190	3637
78	2003.25	3106	2044
79	2003.50	10833	10602

	year	observed	predicted
80	2003.75	7518	8375
81	2004.00	2040	2110
82	2004.25	667	931
83	2004.50	4018	5917
84	2004.75	6762	8030
85	2005.00	8	5
86	2005.25	8	5
87	2005.50	13	10
88	2005.75	13	12
89	2006.00	2205	1836
90	2006.25	2848	2479
91	2006.50	6551	8232
92	2006.75	34949	25557
93	2007.00	1428	357
94	2007.25	1100	1200
95	2007.50	2430	5573
96	2007.75	838	3237
97	2008.00	361	258
98	2008.25	1840	1534
99	2008.50	8532	5777
100	2008.75	24111	4650
101	2009.00	538	233
102	2009.25	2105	2883
103	2009.50	36661	13130
104	2009.75	6509	9752
105	2010.00	198	441
106	2010.25	40322	5115
107	2010.50	57487	21497
108	2010.75	33071	17706
109	2011.00	0	0
110	2011.25	222	2334
111	2011.50	3749	8226
112	2011.75	2872	7723
113	2012.00	29	75
114	2012.25	281	881
115	2012.50	469	2656
116	2012.75	26168	9630
117	2013.00	79	156
118	2013.25	10460	2514
119	2013.50	24444	11826

	year	observed	predicted
120	2013.75	47126	30702
121	2014.00	1324	321
122	2014.25	3212	3925
123	2014.50	13384	13818
124	2014.75	26244	19034
125	2015.00	594	363
126	2015.25	7364	6170
127	2015.50	26804	22831
128	2015.75	22655	31850
129	2016.00	1089	545
130	2016.25	8846	6093
131	2016.50	23849	23571
132	2016.75	26457	23845
133	2017.00	735	457
134	2017.25	3475	5362
135	2017.50	13623	18827
136	2017.75	16107	23543
137	2018.00	379	209
138	2018.25	4143	4612
139	2018.50	9316	14382
140	2018.75	22292	14240
141	2019.00	495	200
142	2019.25	11179	6682
143	2019.50	38621	25176
144	2019.75	47373	34309
145	2020.00	2121	298
146	2020.25	10961	12449
147	2020.50	47420	34278

Table 12.2.4 Norway pout in 4 and 3.a.N (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											
	Quarter	1	2	3									
0		0	0	0									
1		1	378	1504									
2		272	279	603									
3		2	16	29									
4+		0	0	0									
SOP		3808	10960	47422									

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.a.N (Skagerrak). Mean weights (grams) at age in catch, by quarter 1984–2020, 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											
Quarter of year	1	2	3									
Age 0												
1	5,82	13,82	19,51									
2	7,61	18,87	28,35									
3	20,10	28,87	33,91									
4												

Mean weights at age from Danish and Norwegian landings from 2005-2008 uncertain because of few observations and use of values from 2004 and from adjacent quarters in the same year where observations have been missing. No mean weight at age data delivered by Norway in 2007-2008.
In general, mean weights at age are uncertain for quarters and countries where only very few fish have been caught. This problem is met by always calculating and using weighted mean weights at age, i.e. weighted by the catch number by country (Denmark and Norway) and quarter of year.

Table 12.2.6 Norway pout 4 and 3.aN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment. (Inter-Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0,29
1	9	14	28	28	0,2	0,29
2	26	25	38	40	1	0,39
3	43	38	51	58	1	0,44

Table 12.2.7 Norway pout 4 and 3.aN (Skagerrak). Danish fishing effort (number of fishing days) and catch per unit of effort (CPUE in tonnes / fishing day) per year and quarter of year (1987–2020) 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	5		112	50	30	38		47

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 (2011–2019) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	Q1	Q2	Q3	Q4	Yearly	Q1	Q2	Q3	Q4	Yearly
2011	OTB_DEF_16-31_0_0	0	1	23	0	24		10,0	24,1		23,5
2011	OTB_DEF_16-31_2_40	0	5	75	0	80		20,2	29,2		28,6
2012	OTB_DEF_16-31_0_0	0	0	3	24	27			15,7	35,4	33,2
2012	OTB_DEF_16-31_2_40	0	0	0	74	74				38,9	38,9
2013	OTB_DEF_16-31_0_0	0	101	163	99	363		31,3	29,9	47,2	35,0
2013	OTB_DEF_16-31_2_40	0	224	341	227	792		30,7	31,1	60,8	39,5
2014	OTB_DEF_16-31_0_0	0	62	64	57	183		18,2	35,1	33,9	29,0
2014	OTB_DEF_16-31_2_40	0	41	123	143	307		26,0	34,7	38,2	35,2
2015	OTB_DEF_16-31_0_0	0	130	308	71	509		38,3	37,8	38,7	38,0
2015	OTB_DEF_16-31_2_40	5	38	235	192	470	28,7	41,0	42,5	55,6	47,6
2016	OTB_DEF_16-31_0_0	0	269	269	51	589		24,1	23,0	22,6	23,4
2016	OTB_DEF_16-31_2_40	23	37	357	80	497	24,9	23,5	38,6	45,8	38,0
2017	OTB_DEF_16-31_0_0	0	125	198	15	338		28,7	22,5	25,6	24,9
2017	OTB_DEF_16-31_2_40	0	1	105	87	193		8,8	37,8	51,2	43,7
2018	OTB_DEF_16-31_0_0	0	128	163	43	334		23,5	22,4		22,4
2018	OTB_DEF_16-31_2_40	0	17	112	233	362		27,8	35,3		41,2
2019	OTB_DEF_16-31_0_0	0	243	526	112	881		31,6	37,9	34,1	35,7
2019	OTB_DEF_16-31_2_40	0	44	272	220	536		36,1	40,5	54,0	45,7
2020	OTB_DEF_16-31_0_0	2	172	373	0	547	25,0	38,5	40,8		40,0
2020	OTB_DEF_16-31_2_40	6	24	388	0	418	24,3	40,5	36,5		36,6

Table 12.2.9 Norway pout 4 and 3.a.N (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton per fishing day) per year and vessel horse power (HP) class (1987–2020) 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		34	53	13	12	112	36	22	79	75	47

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 (2011–2020) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	500-1000	1000-1500	1500-2000	> 2000	Yearly	500-1000	1000-1500	1500-2000	> 2000	Yearly
2011	OTB_DEF_16-31_0_0	0	24	0	0	24		23,5			23,5
2011	OTB_DEF_16-31_2_40	0	20	0	60	80		18,3		32,1	28,6
2012	OTB_DEF_16-31_0_0	0	17	4	6	27		34,8	13,8	41,7	33,2
2012	OTB_DEF_16-31_2_40	19	28	0	27	74	21,2	26,9		63,8	38,9
2013	OTB_DEF_16-31_0_0	0	273	75	15	363		34,4	30,9	65,3	35,0
2013	OTB_DEF_16-31_2_40	0	162	130	500	792		23,2	34,1	46,2	39,5
2014	OTB_DEF_16-31_0_0	0	142	16	25	183		25,5	16,6	56,4	29,0
2014	OTB_DEF_16-31_2_40	80	58	67	102	307	42,9	14,6	36,6	39,8	35,2
2015	OTB_DEF_16-31_0_0	0	228	106	175	509		33,7	42,7	40,8	38,0
2015	OTB_DEF_16-31_2_40	0	0	103	367	470			49,7	47,0	47,6
2016	OTB_DEF_16-31_0_0	0	207	136	246	589		25,5	21,0	23,0	23,4
2016	OTB_DEF_16-31_2_40	0	18	72	407	497		28,3	42,8	37,6	38,0
2017	OTB_DEF_16-31_0_0	0	123	107	108	338		24,7	21,4	28,6	24,9
2017	OTB_DEF_16-31_2_40	0	9	86	98	193		51,9	41,1	45,2	43,7
2018	OTB_DEF_16-31_0_0	40	121	107	66	334	20,9	20,2	22,1	27,8	22,4
2018	OTB_DEF_16-31_2_40	14	26	63	259	362	36,2	46,6	34,4	42,5	41,2
2019	OTB_DEF_16-31_0_0	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	107	94	93	253	547	29,2	34,7	34,4	48,6	40,0
2020	OTB_DEF_16-31_2_40			64	354	418			35,4	36,8	36,6

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	7,522	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				

[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 2016–2020 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	2016-2020 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2020)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2020)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	3+ (SESAM) (1984-2020)
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	1984-2020
	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	1992-2020
	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	1998-2020
	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	1991-2019
	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 2020

Run: September 2020 (NP_Sep2020_1, www.stockassessment.org)

The following parameters were used:

Year range:	1984 - 2020
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	44559	9529	576
1984.25	0	30368	5222	328
1984.5	39078	21113	3115	193
1984.75	0	12198	1383	112
1985	0	21255	6062	596
1985.25	0	14481	2906	330
1985.5	28734	10247	1647	194
1985.75	0	6171	701	112
1986	0	15239	3136	319
1986.25	0	10402	1624	182
1986.5	46842	7516	984	111
1986.75	0	4765	486	67
1987	0	27067	2599	260
1987.25	0	19583	1366	147
1987.5	9979	14516	827	90
1987.75	0	9726	426	56
1988	0	5069	5573	210
1988.25	0	3849	3283	119
1988.5	44179	3025	2198	71
1988.75	0	2227	1318	44
1989	0	24421	1437	716
1989.25	0	17735	924	444
1989.5	46839	13010	613	282
1989.75	0	8771	354	181
1990	0	25209	5366	312
1990.25	0	18553	3155	191
1990.5	58997	13436	1896	118
1990.75	0	9230	1070	74
1991	0	32203	5928	622
1991.25	0	23389	3503	362
1991.5	101374	17391	2165	215
1991.75	0	12155	1216	135
1992	0	56417	8134	741
1992.25	0	40748	5107	489
1992.5	53833	29753	3410	329
1992.75	0	19761	2043	207
1993	0	28963	12484	1344
1993.25	0	20234	7136	842
1993.5	47242	14183	4265	534

Time\Age	0	1	2	3
1993.75	0	8972	2217	328
1994	0	24693	5472	1300
1994.25	0	17271	3316	772
1994.5	131071	12301	2075	465
1994.75	0	8427	1213	287
1995	0	73304	5615	916
1995.25	0	54066	3561	615
1995.5	51703	39608	2292	416
1995.75	0	26986	1372	265
1996	0	26122	17782	1029
1996.25	0	19366	11037	655
1996.5	109888	14221	7156	418
1996.75	0	10095	4365	262
1997	0	61990	7133	2910
1997.25	0	45337	4564	1854
1997.5	21391	35215	2984	1182
1997.75	0	25215	1774	752
1998	0	11905	17774	1548
1998.25	0	8904	11136	952
1998.5	38807	6582	7086	584
1998.75	0	4915	4320	373
1999	0	22872	3539	2909
1999.25	0	17557	2403	1851
1999.5	90384	13394	1587	1171
1999.75	0	9985	949	734
2000	0	54014	7255	994
2000.25	0	41795	4956	619
2000.5	25494	33000	3369	383
2000.75	0	23647	2141	245
2001	0	13682	15625	1443
2001.25	0	9844	9728	925
2001.5	24025	7070	6132	590
2001.75	0	5097	4002	376
2002	0	14140	3495	2674
2002.25	0	10609	2212	1648
2002.5	21016	7708	1449	1024
2002.75	0	5275	905	646
2003	0	10682	3397	907
2003.25	0	7348	2148	547
2003.5	8526	5055	1363	330

Time\Age	0	1	2	3
2003.75	0	3402	803	208
2004	0	4653	2289	555
2004.25	0	3323	1496	352
2004.5	7799	2507	996	224
2004.75	0	1731	614	142
2005	0	4381	1143	443
2005.25	0	3225	786	296
2005.5	31283	2397	538	196
2005.75	0	1815	364	128
2006	0	17732	1407	325
2006.25	0	12997	1005	215
2006.5	21612	9682	698	140
2006.75	0	7155	444	89
2007	0	12171	4713	309
2007.25	0	8958	3053	213
2007.5	32725	6530	1968	147
2007.75	0	4773	1267	95
2008	0	18727	3645	918
2008.25	0	14208	2543	599
2008.5	45856	10746	1731	391
2008.75	0	8268	1122	247
2009	0	29296	6107	889
2009.25	0	22419	4131	558
2009.5	68801	17545	2755	348
2009.75	0	13443	1687	222
2010	0	41227	10410	1214
2010.25	0	32931	7880	786
2010.5	6395	24879	5497	503
2010.75	0	17539	3559	320
2011	0	3643	12082	2471
2011.25	0	2691	7658	1552
2011.5	11005	2087	5164	983
2011.75	0	1565	3400	626
2012	0	6337	1176	2719
2012.25	0	4810	813	1815
2012.5	56541	3757	575	1212
2012.75	0	2958	395	797
2013	0	32451	2148	773
2013.25	0	24634	1530	496
2013.5	16834	17719	1053	316

Time\Age	0	1	2	3
2013.75	0	12223	662	202
2014	0	9247	7808	497
2014.25	0	6746	4860	312
2014.5	101164	4918	2993	195
2014.75	0	3639	1765	121
2015	0	54345	2497	1079
2015.25	0	38065	1618	691
2015.5	38177	26235	1036	439
2015.75	0	16740	585	273
2016	0	20122	10262	487
2016.25	0	13845	6428	309
2016.5	64708	9228	3916	193
2016.75	0	5736	2251	119
2017	0	34129	3399	1318
2017.25	0	23102	2173	831
2017.5	23076	15623	1381	519
2017.75	0	10088	809	326
2018	0	11532	6265	661
2018.25	0	8169	3837	398
2018.5	86116	5682	2290	236
2018.75	0	4079	1302	145
2019	0	46848	2793	774
2019.25	0	34362	1933	489
2019.5	81670	24768	1229	301
2019.75	0	18200	733	187
2020	0	43256	12697	557
2020.25	0	33041	8572	362
2020.5	103267	24996	5564	230
2020.75	0	17891	3316	144

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 2020 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	0.000	0.362	0.993	0.435
1984.25	0.000	0.233	0.571	0.280
1984.5	0.009	0.936	1.677	0.306
1984.75	0.182	1.536	2.250	0.056
1985	0.001	0.387	1.063	0.465
1985.25	0.000	0.189	0.464	0.228
1985.5	0.008	0.860	1.541	0.281
1985.75	0.174	1.469	2.152	0.054
1986	0.000	0.349	0.959	0.420
1986.25	0.000	0.151	0.370	0.182
1986.5	0.006	0.653	1.169	0.213
1986.75	0.141	1.193	1.748	0.043
1987	0.000	0.308	0.846	0.370
1987.25	0.000	0.131	0.322	0.158
1987.5	0.005	0.532	0.953	0.174
1987.75	0.137	1.156	1.694	0.042
1988	0.000	0.253	0.696	0.305
1988.25	0.000	0.122	0.299	0.147
1988.5	0.004	0.429	0.769	0.140
1988.75	0.106	0.900	1.318	0.033
1989	0.000	0.212	0.583	0.255
1989.25	0.000	0.153	0.374	0.184
1989.5	0.004	0.452	0.810	0.148
1989.75	0.097	0.816	1.195	0.030
1990	0.000	0.225	0.617	0.270
1990.25	0.000	0.180	0.441	0.217
1990.5	0.004	0.410	0.734	0.134
1990.75	0.081	0.688	1.008	0.025
1991	0.000	0.228	0.627	0.274
1991.25	0.000	0.164	0.402	0.198
1991.5	0.004	0.408	0.730	0.133
1991.75	0.074	0.627	0.919	0.023
1992	0.000	0.211	0.581	0.254
1992.25	0.000	0.147	0.360	0.177
1992.5	0.004	0.408	0.731	0.133
1992.75	0.070	0.588	0.862	0.021
1993	0.000	0.188	0.518	0.227
1993.25	0.000	0.140	0.343	0.169

Year\Age	0	1	2	3+
1993.5	0.004	0.429	0.769	0.140
1993.75	0.068	0.574	0.842	0.021
1994	0.000	0.172	0.473	0.207
1994.25	0.000	0.125	0.305	0.150
1994.5	0.004	0.395	0.707	0.129
1994.75	0.055	0.463	0.679	0.017
1995	0.000	0.131	0.360	0.157
1995.25	0.000	0.107	0.262	0.129
1995.5	0.003	0.317	0.568	0.104
1995.75	0.048	0.404	0.592	0.015
1996	0.000	0.102	0.281	0.123
1996.25	0.000	0.083	0.203	0.100
1996.5	0.003	0.331	0.593	0.108
1996.75	0.044	0.371	0.543	0.014
1997	0.000	0.084	0.231	0.101
1997.25	0.000	0.066	0.163	0.080
1997.5	0.003	0.317	0.568	0.104
1997.75	0.046	0.385	0.564	0.014
1998	0.000	0.076	0.208	0.091
1998.25	0.000	0.071	0.174	0.086
1998.5	0.003	0.275	0.492	0.090
1998.75	0.045	0.384	0.563	0.014
1999	0.000	0.065	0.179	0.078
1999.25	0.000	0.072	0.177	0.087
1999.5	0.003	0.267	0.478	0.087
1999.75	0.049	0.417	0.611	0.015
2000	0.000	0.061	0.168	0.073
2000.25	0.000	0.062	0.151	0.074
2000.5	0.002	0.213	0.382	0.070
2000.75	0.053	0.449	0.658	0.016
2001	0.000	0.063	0.174	0.076
2001.25	0.000	0.055	0.135	0.066
2001.5	0.002	0.167	0.300	0.055
2001.75	0.051	0.431	0.632	0.016
2002	0.000	0.059	0.163	0.071
2002.25	0.000	0.047	0.114	0.056
2002.5	0.002	0.220	0.394	0.072
2002.75	0.056	0.474	0.695	0.017
2003	0.000	0.047	0.128	0.056
2003.25	0.000	0.038	0.092	0.045

Year\Age	0	1	2	3+
2003.5	0.002	0.213	0.381	0.070
2003.75	0.049	0.416	0.610	0.015
2004	0.000	0.040	0.111	0.048
2004.25	0.000	0.028	0.069	0.034
2004.5	0.002	0.191	0.342	0.062
2004.75	0.049	0.414	0.606	0.015
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	0.081	0.030
2006.25	0.000	0.041	0.126	0.061
2006.5	0.001	0.113	0.309	0.063
2006.75	0.037	0.535	0.858	0.016
2007	0.000	0.003	0.010	0.003
2007.25	0.000	0.018	0.048	0.021
2007.5	0.000	0.043	0.123	0.024
2007.75	0.002	0.044	0.073	0.001
2008	0.000	0.002	0.007	0.002
2008.25	0.000	0.018	0.050	0.022
2008.5	0.000	0.057	0.165	0.033
2008.75	0.003	0.068	0.112	0.002
2009	0.000	0.001	0.005	0.001
2009.25	0.000	0.018	0.050	0.022
2009.5	0.000	0.084	0.242	0.048
2009.75	0.004	0.083	0.137	0.002
2010	0.000	0.001	0.003	0.001
2010.25	0.000	0.020	0.056	0.024
2010.5	0.000	0.082	0.237	0.047
2010.75	0.006	0.117	0.193	0.003
2011	0.000	0.001	0.003	0.001
2011.25	0.000	0.012	0.033	0.014
2011.5	0.000	0.064	0.184	0.036
2011.75	0.008	0.150	0.248	0.004
2012	0.000	0.001	0.003	0.001
2012.25	0.000	0.014	0.038	0.017
2012.5	0.000	0.061	0.174	0.035
2012.75	0.015	0.286	0.474	0.007
2013	0.000	0.001	0.004	0.001
2013.25	0.000	0.023	0.064	0.028

Year\Age	0	1	2	3+
2013.5	0.000	0.105	0.302	0.060
2013.75	0.019	0.377	0.625	0.009
2014	0.000	0.002	0.007	0.002
2014.25	0.000	0.027	0.075	0.033
2014.5	0.000	0.138	0.397	0.079
2014.75	0.019	0.366	0.606	0.009
2015	0.000	0.002	0.009	0.003
2015.25	0.000	0.033	0.092	0.040
2015.5	0.001	0.169	0.485	0.096
2015.75	0.019	0.366	0.606	0.009
2016	0.000	0.002	0.009	0.003
2016.25	0.000	0.041	0.114	0.050
2016.5	0.001	0.180	0.517	0.103
2016.75	0.020	0.385	0.637	0.009
2017	0.000	0.002	0.008	0.002
2017.25	0.000	0.044	0.121	0.053
2017.5	0.001	0.175	0.501	0.100
2017.75	0.020	0.383	0.635	0.009
2018	0.000	0.002	0.008	0.003
2018.25	0.000	0.055	0.150	0.066
2018.5	0.001	0.173	0.496	0.098
2018.75	0.020	0.387	0.642	0.010
2019	0.000	0.002	0.009	0.003
2019.25	0.000	0.067	0.185	0.081
2019.5	0.001	0.182	0.524	0.104
2019.75	0.019	0.359	0.595	0.009
2020	0.000	0.002	0.009	0.003
2020.25	0.000	0.065	0.179	0.079
2020.5	0.001	0.178	0.510	0.101
2020.75	0.019	0.359	0.595	0.009

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	0.12366	0.07303	0.20940
2	2	2	0.18923	0.10074	0.35547
3	2	3	0.19750	0.07732	0.50448
4	3	0	0.06625	0.03677	0.11937
5	3	1	0.18861	0.10232	0.34767
6	4	0	0.16283	0.08838	0.29999
7	4	1	0.19365	0.10267	0.36524
8	5	2	0.21240	0.09767	0.46189
9	5	3	0.11057	0.04104	0.29786

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	1244.55	19
Current	1244.55	19

Table 12.3.6 Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2020. Estimated yearly and quarterly recruitment (millions), spawning stock biomass SSB (t), total stock biomass TSB (t) and fishing mortality for ages 1–2 (F12).

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1984				341453	147870	535036	662281	320260	1004302	1.070	0.569	2.010
1984.25				219844	91637	348052	511374	230259	792489			
1984.5	39078	20127	75871	241725	101396	382053	663988	290677	1037300			
1984.75				122843	41643	204044	366810	143173	590446			
1985				213631	80233	347028	366668	168672	564664	1.016	0.535	1.927
1985.25				123887	42906	204868	262906	113638	412175			
1985.5	28734	14820	55712	128745	48700	208790	333692	145317	522066			
1985.75				65391	19349	111433	188807	72062	305552			
1986				118605	43573	193636	228328	99738	356918	0.824	0.447	1.517
1986.25				74687	24745	124628	174543	70723	278362			
1986.5	46842	23780	92267	83581	30061	137100	233902	95147	372656			
1986.75				47120	13918	80321	142419	52074	232764			
1987				124081	50474	197688	318960	134434	503486	0.743	0.401	1.375
1987.25				88512	33773	143251	276511	108385	444637			
1987.5	9979	4925	20219	111089	43873	178304	401418	156637	646199			
1987.75				68889	24339	113438	263406	95899	430913			
1988				156859	49535	264182	193358	73841	312874	0.598	0.334	1.072
1988.25				97236	25734	168739	134188	48398	219977			
1988.5	44179	22422	87049	107329	27028	187630	167835	62293	273377			
1988.75				66405	11593	121217	110944	35762	186126			
1989				108492	39383	177601	284320	113557	455083	0.574	0.320	1.030
1989.25				87869	29304	146434	258121	98581	417661			
1989.5	46839	23680	92648	106495	37957	175033	366693	139309	594078			
1989.75				68506	21794	115218	243933	87283	400583			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1990				192008	75069	308947	373512	162896	584127	0.538	0.296	0.977
1990.25				132928	48716	217140	311040	127117	494964			
1990.5	58997	29706	117169	150073	54836	245310	418793	165528	672059			
1990.75				93249	29755	156742	277860	101940	453779			
1991				231074	90236	371912	462936	197238	728633	0.513	0.278	0.946
1991.25				161819	58885	264753	386355	153966	618745			
1991.5	101374	50828	202188	186438	68193	304684	534266	206862	861669			
1991.75				117278	37429	197128	360391	129353	591428			
1992				334523	131352	537694	740727	304858	1176596	0.486	0.259	0.913
1992.25				249930	89691	410170	641108	245948	1036269			
1992.5	53833	27370	105883	304927	106556	503298	899984	336416	1463552			
1992.75				192549	55862	329235	587778	198981	976575			
1993				418005	134787	701223	626536	241028	1012043	0.475	0.239	0.947
1993.25				269095	76852	461339	463340	168425	758255			
1993.5	47242	23791	93809	273577	78200	468954	557234	204359	910108			
1993.75				152576	32965	272187	332020	106109	557930			
1994				233260	73062	393457	411051	153980	668123	0.415	0.209	0.825
1994.25				162969	45127	280811	328768	115329	542206			
1994.5	131071	65245	263309	172393	49794	294993	418423	147498	689348			
1994.75				107293	24172	190413	275844	84309	467379			
1995				308962	109491	508432	836752	302303	1371201	0.343	0.170	0.689
1995.25				249544	82026	417063	768575	261377	1275772			
1995.5	51703	25577	104516	314651	102883	526418	1106806	369688	1843924			
1995.75				205148	57731	352565	744870	223693	1266047			
1996				532709	153745	911674	720785	249939	1191631	0.313	0.154	0.639
1996.25				355173	92126	618221	541085	179632	902539			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1996.5	109888	53585	225351	382429	94662	670197	666846	219919	1113774			
1996.75				240310	39683	440936	442216	119247	765185			
1997				406310	114450	698169	852637	282314	1422960	0.297	0.144	0.615
1997.25				315613	82413	548813	750846	238432	1263261			
1997.5	21391	10393	44026	366333	103413	629252	1070637	338684	1802590			
1997.75				240662	55623	425700	744961	203574	1286347			
1998				527709	126900	928518	613426	172578	1054275	0.281	0.135	0.584
1998.25				347367	75350	619385	432843	118250	747437			
1998.5	38807	19365	77767	351415	72211	630619	483052	135303	830801			
1998.75				218997	28726	409267	317304	71047	563560			
1999				246029	51422	440636	410705	121541	699869	0.283	0.135	0.597
1999.25				194753	36405	353101	363304	104926	621682			
1999.5	90384	44749	182557	200711	44230	357191	468586	144603	792569			
1999.75				130471	24033	236909	330175	89314	571035			
2000				318384	95195	541573	707286	238832	1175739	0.268	0.124	0.577
2000.25				255172	73206	437137	656401	212013	1100788			
2000.5	25494	12619	51506	322752	93078	552426	982764	308032	1657496			
2000.75				218113	53152	383073	691057	191051	1191064			
2001				472983	110352	835614	571494	158386	984602	0.245	0.110	0.544
2001.25				313083	65022	561143	407586	108959	706212			
2001.5	24025	11839	48753	316037	62856	569219	457450	125956	788945			
2001.75				207372	29002	385743	309320	71385	547256			
2002				219762	38950	400573	321571	82131	561011	0.271	0.118	0.622
2002.25				163127	24955	301298	264971	65936	464005			
2002.5	21016	10093	43758	157915	29321	286510	312069	87502	536636			
2002.75				100035	14441	185629	205546	50865	360228			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2003				140414	32278	248550	217327	63484	371169	0.241	0.100	0.578
2003.25				98702	21150	176255	169245	48932	289557			
2003.5	8526	4109	17694	99574	23127	176022	200673	61610	339737			
2003.75				61168	11148	111188	129223	34457	223990			
2004				87795	19857	155732	121294	33858	208731	0.225	0.089	0.571
2004.25				62972	12732	113212	94872	25453	164291			
2004.5	7799	3776	16108	65775	13863	117687	115910	32564	199257			
2004.75				41456	6505	76407	76074	18082	134065			
2005				54178	10867	97488	85720	23051	148389	0.001	0.000	0.001
2005.25				42164	7829	76499	73126	19340	126913			
2005.5	31283	15128	64690	45285	9264	81305	93223	26148	160298			
2005.75				31075	6122	56028	67375	18278	116472			
2006				80088	26636	133541	207759	67688	347830	0.260	0.091	0.749
2006.25				67045	21170	112920	191816	60212	323419			
2006.5	21612	10378	45009	84704	26033	143375	278343	85210	471476			
2006.75				58704	15809	101600	201812	54807	348818			
2007				152079	33534	270623	239708	67627	411789	0.045	0.017	0.116
2007.25				108445	23338	193551	194445	54167	334723			
2007.5	32725	15696	68229	120168	25562	214774	250779	69092	432466			
2007.75				80076	14392	145759	175540	43193	307887			
2008				161561	42958	280164	296394	90287	502500	0.060	0.025	0.143
2008.25				127618	31835	223401	264012	76380	451645			
2008.5	45856	21756	96652	146460	35966	256953	361382	101108	621656			
2008.75				100525	21220	179830	265895	64508	467283			
2009				240958	63685	418231	451891	136413	767370	0.078	0.033	0.182
2009.25				185007	47918	322097	400225	117511	682940			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2009.5	68801	33024	143337	218832	56546	381118	569741	162757	976724			
2009.75				147561	32818	262304	416431	103816	729045			
2010				383026	100900	665152	679864	207611	1152117	0.089	0.038	0.206
2010.25				315304	75474	555134	631440	178323	1084556			
2010.5	6395	3022	13535	374449	85365	663533	872029	236614	1507444			
2010.75				248598	45785	451412	599385	143505	1055265			
2011				407447	87404	727489	433679	99646	767713	0.087	0.036	0.211
2011.25				275510	54112	496908	301345	65894	536797			
2011.5	11005	5285	22918	275964	49527	502401	317706	67995	567417			
2011.75				180157	23295	337020	211460	36447	386472			
2012				149545	20781	278309	195171	40385	349956	0.131	0.053	0.324
2012.25				122610	13476	231744	168785	33092	304478			
2012.5	56541	27233	117387	114505	14488	214521	189646	43408	335885			
2012.75				76778	8005	145551	135946	28686	243206			
2013				143056	38839	247273	376705	111277	642132	0.188	0.073	0.485
2013.25				122185	32505	211864	358675	102320	615030			
2013.5	16834	8156	34745	149664	41864	257464	504052	147575	860528			
2013.75				99316	25198	173434	343775	93953	593597			
2014				231718	55469	407968	298293	85647	510940	0.202	0.078	0.523
2014.25				153286	36702	269871	218045	64788	371302			
2014.5	101164	47247	216608	155992	37237	274747	254351	77667	431035			
2014.75				95785	16857	174713	168572	43593	293552			
2015				203389	56026	350751	594670	168315	1021024	0.220	0.083	0.585
2015.25				166351	46364	286337	531778	153075	910481			
2015.5	38177	17698	82355	198987	58456	339518	723697	215913	1231481			
2015.75				122949	31952	213946	457748	126552	788943			

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2016				312243	79002	545483	457124	137664	776584	0.236	0.088	0.633
2016.25				209386	53164	365609	342300	105615	578984			
2016.5	64708	30076	139221	214339	53696	374982	398909	124899	672919			
2016.75				125615	20756	230473	240333	61815	418850			
2017				199143	49961	348325	444875	129571	760179	0.234	0.088	0.618
2017.25				151332	38060	264605	373114	111185	635044			
2017.5	23076	10984	48482	164501	44728	284274	476966	146791	807141			
2017.75				101709	22339	181080	303481	83161	523801			
2018				203814	48993	358634	286847	85240	488454	0.239	0.092	0.622
2018.25				135453	32783	238124	213874	65816	361932			
2018.5	86116	41793	177443	134196	32153	236238	247844	77453	418234			
2018.75				80880	13803	147958	162458	42827	282088			
2019				185136	54708	315563	522440	163972	880909	0.241	0.094	0.615
2019.25				155225	46044	264407	485103	149703	820503			
2019.5	81670	38861	171635	191068	56863	325274	686427	206748	1166105			
2019.75				131157	32031	230283	495163	124760	865567			
2020				417568	100461	734676	729008	223229	1234788			
2020.25				311700	72753	550647	628898	185933	1071862			
2020.5	103267	38014	280529	361322	76915	645729	861250	231972	1490528			
2020.75				230750	29609	431890	588575	112179	1064970			

Table 12.3.6 (cont). Norway pout 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2020. Long term arithmetic means of yearly recruitment (millions), quarterly spawning stock biomass SSB (t), quarterly total stock biomass TSB (t) and yearly fishing mortality for ages 1–2 (F_{bar}=F12) for the period 1984–2020. (Numbers are given for start of the season).

	value
Avg. recruitment	48552.18
Avg SSB Q 1	250216.07
Avg SSB Q 2	180348.80
Avg SSB Q 3	199848.60
Avg SSB Q 4	126417.95
Avg TSB Q 1	441678.41
Avg TSB Q 2	366890.85
Avg TSB Q 3	485063.98
Avg TSB Q 4	323646.04
Avg. FBAR	0.34

Table 12.6.1 Norway pout4 and 3.aN (Skagerrak). Projected mean weight at age used in the forecast by quarter of year.

Age/Quarter	1	2	3	4
0	4.796	6.342	4.545	6.113
1	6.257	9.956	19.684	22.486
2	17.119	19.945	27.602	31.700
3	27.424	27.666	34.245	38.477

Table 12.6.2 Norway pout4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2021) equals Blim.

Basis:
F (2020 up to Q4) = estimated from in year assessment 1 October 2020, F(age,quarter1,2,3 2020), Table 12.3.4.
SSB (2020 up to Q4) = estimated from in year assessment 1 October 2020 (start Q4) = 230 750 tonnes;
R(2020) = estimated / observed from in year assessment 1 July 2020 (age 0 in start of Q3) = 103 267 million;
Biological parameters (2020–2021): 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 2020 - Q4 2021): (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
2020.75	2.19	235.52	118.33	173010.79
2021	0.03	384.90	137.98	2150.34
2021.25	0.57	308.25	111.05	47433.26
2021.5	1.58	329.99	106.07	126495.81
2021.75		166.81	42.57	
Sum				349090.20

Table 12.6.3 Norway pout4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1 October 2020 to 1 October 2021.

Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2020.75	0.00	235.52	118.33	0.00
2021	0.00	561.18	277.12	0.00
2021.25	0.00	440.66	207.78	0.00
2021.5	0.00	517.53	224.86	0.00
2021.75		368.18	149.05	
Sum				0.00

Table 12.6.4 Norway pout4 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 1 October 2020.

Basis: Same as above

	F12	SSB	SSB 5th quantile	median catch
2020.75	0.48	235.52	118.33	45619.81
2021	0.01	510.82	233.75	615.40
2021.25	0.13	403.23	177.70	13721.52
2021.5	0.35	463.67	191.97	41494.17
2021.75		299.94	108.55	
Sum				101450.90

Table 12.6.5 Norway pout4 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 (1 October 2021) equals B_{lim}.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	8.17	235.52	118.33	392731.07
2021	0.09	189.04	53.70	4506.27
2021.25	2.12	164.98	46.54	102260.94
2021.5	5.88	149.37	35.38	205486.01
2021.75		42.57	5.75	
Sum				704984.29

Table 12.6.6 Norway pout4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that SSB one year a head (1 October 2021) equals Bpa.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	5.62	235.52	118.33	325311.02
2021	0.06	244.85	69.22	3777.26
2021.25	1.46	205.75	59.00	85317.21
2021.5	4.05	197.95	51.42	191611.08
2021.75		70.00	12.22	
Sum				606016.57

Table 12.6.7 Norway pout4 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 1 October 2020 to 1 October 2021.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	0.61	235.52	118.33	56914.89
2021	0.01	498.66	224.31	760.02
2021.25	0.16	393.85	171.41	16964.99
2021.5	0.44	450.62	183.54	50550.94
2021.75		284.92	100.58	
Sum				125190.84

Table 12.6.8 Norway pout4 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 1 October 2020 to 1 October 2021.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	0.81	235.52	118.33	74036.86
2021	0.01	480.33	209.98	975.89
2021.25	0.21	380.13	162.42	21822.39
2021.5	0.59	431.04	171.06	63917.04
2021.75		262.70	88.36	
Sum				160752.19

Table 12.6.9 Norway pout4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (Fcap = 0.5) for the period 1 October 2020 to 1 October 2021.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	1.02	235.52	118.33	90285.76
2021	0.01	462.37	196.36	1182.89
2021.25	0.26	367.84	153.45	26272.20
2021.5	0.73	412.53	157.73	76232.50
2021.75		243.52	78.17	
Sum				193973.36

Table 12.6.10 Norway pout4 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 1 October 2020 to 1 October 2021.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	1.22	235.52	118.33	106310.21
2021	0.01	448.30	184.70	1375.10
2021.25	0.32	356.89	145.28	30501.65
2021.5	0.88	396.19	147.03	86929.60
2021.75		226.61	69.42	
Sum				225116.56

Table 12.6.11 Norway pout4 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 1 October 2020 to 1 October 2021.

Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2020.75	1.42	235.52	118.33	121300.33
2021	0.02	434.38	172.52	1554.73
2021.25	0.37	345.52	137.02	34561.47
2021.5	1.02	381.03	136.41	96621.79
2021.75		211.55	62.19	
Sum				254038.32

Table 12.6.12 Norway pout4 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 B_{lim} according to the ICES WKPOUT 2016 benchmark assessment which by 1 October is B_{lim}=39 450 t.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

Table 12.6.13 Norway pout4 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.stock-assessment.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 B_{lim} according to the assessment run above which by 1 October is B_{lim}=42 573 t.

SSB	Quarter	Year
77586	1	2005
59514	2	2005
62543	3	2005
42573	4	2005

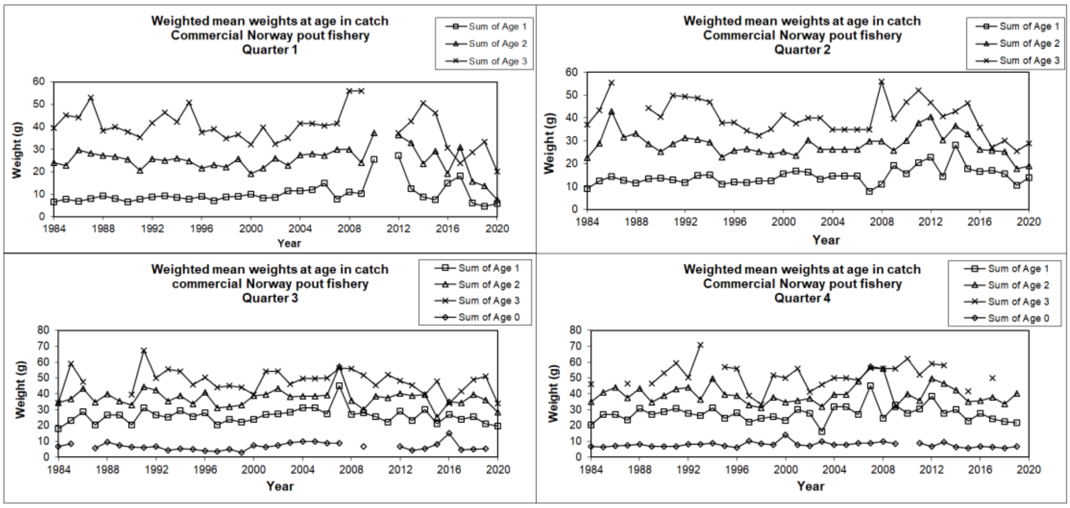

Figure 12.2.1. Norway pout 4 and 3.aN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1984–2020.

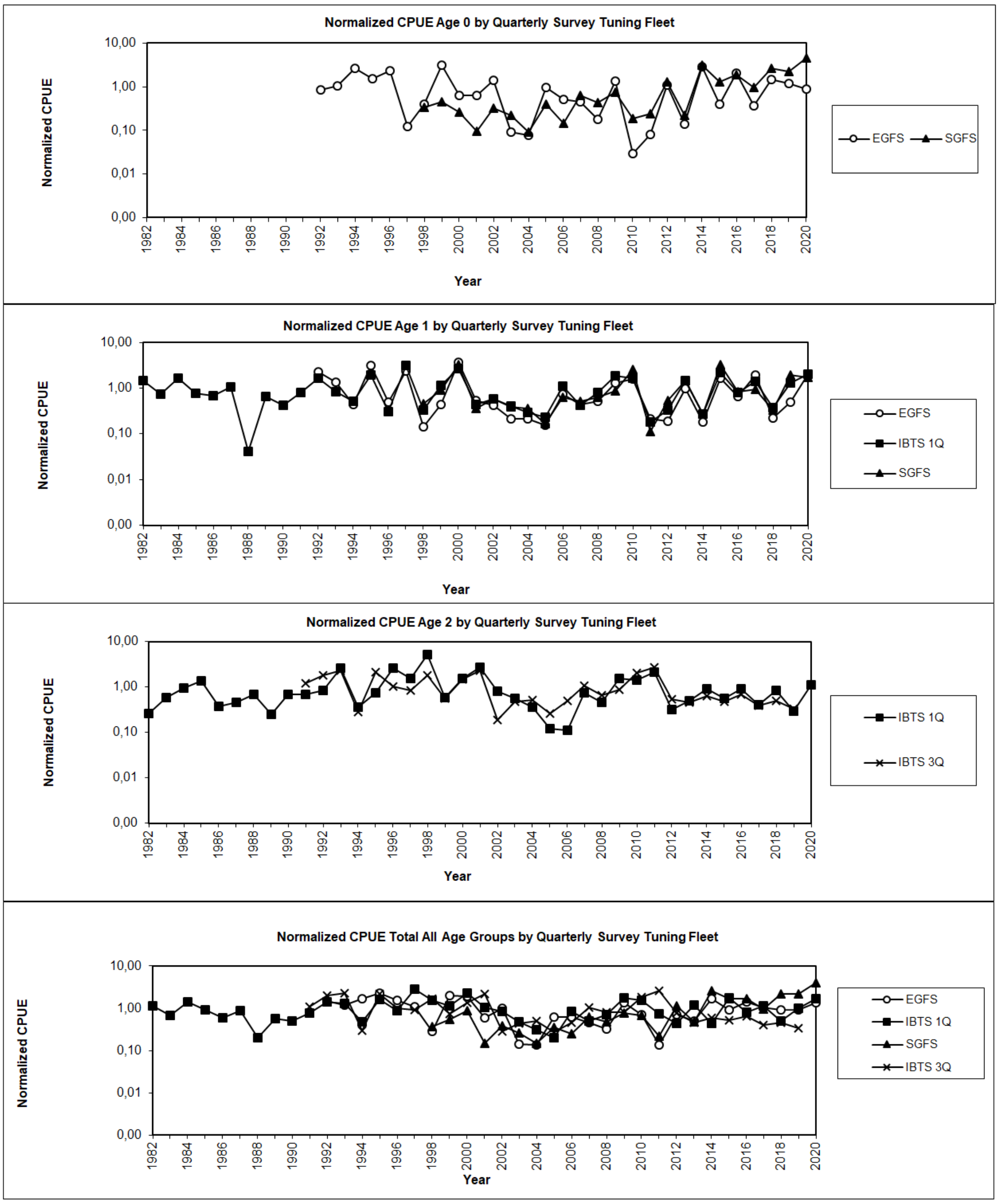

Figure 12.2.2. Norway pout 4 and 3.aN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly survey tuning fleet used in the Norway pout assessment for each age group and all age groups together.

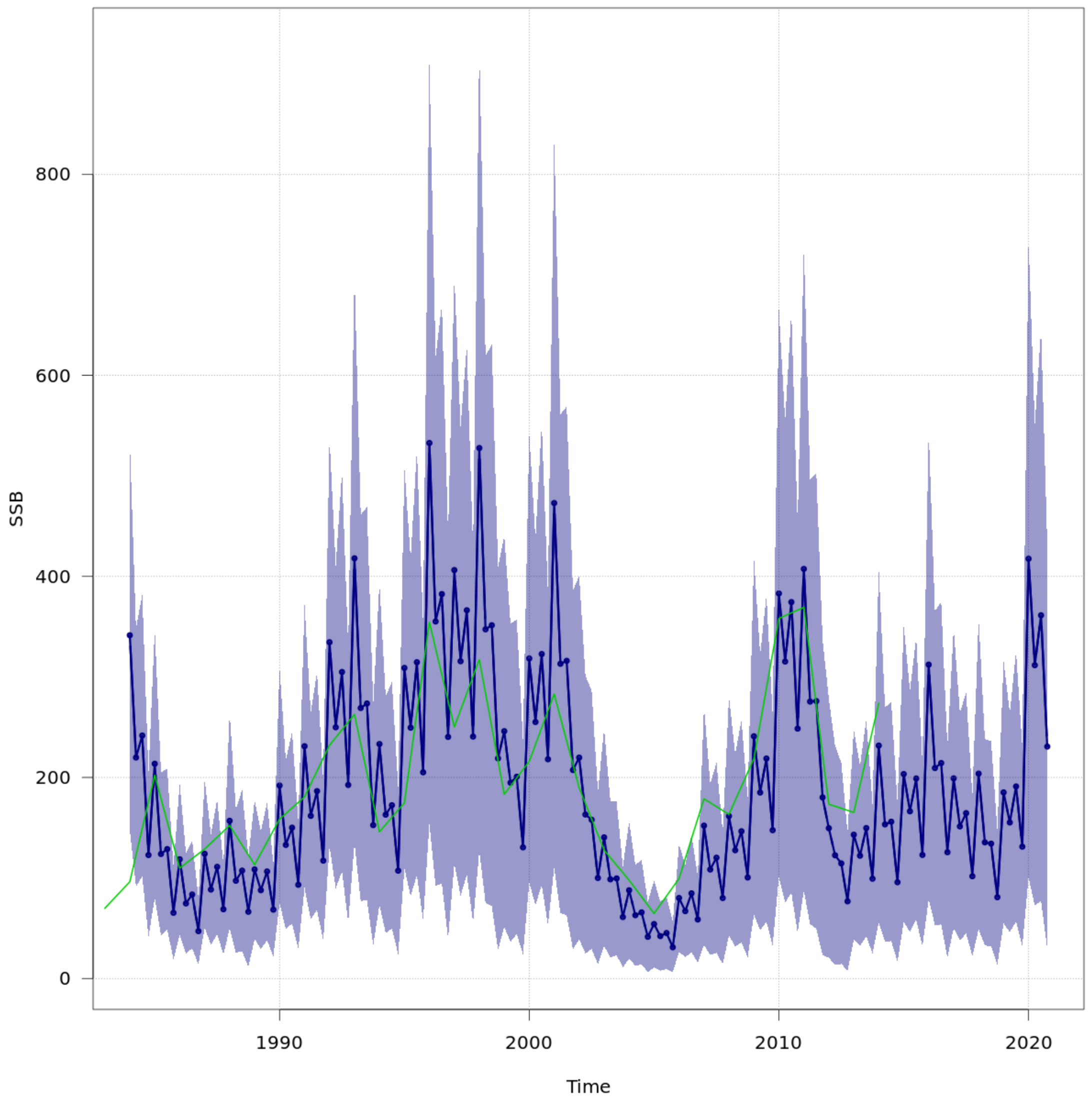

Figure 12.3.1. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: SSB (t), quarterly. SESAM baseline run September 2020. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only – connecting lines are interpolations).

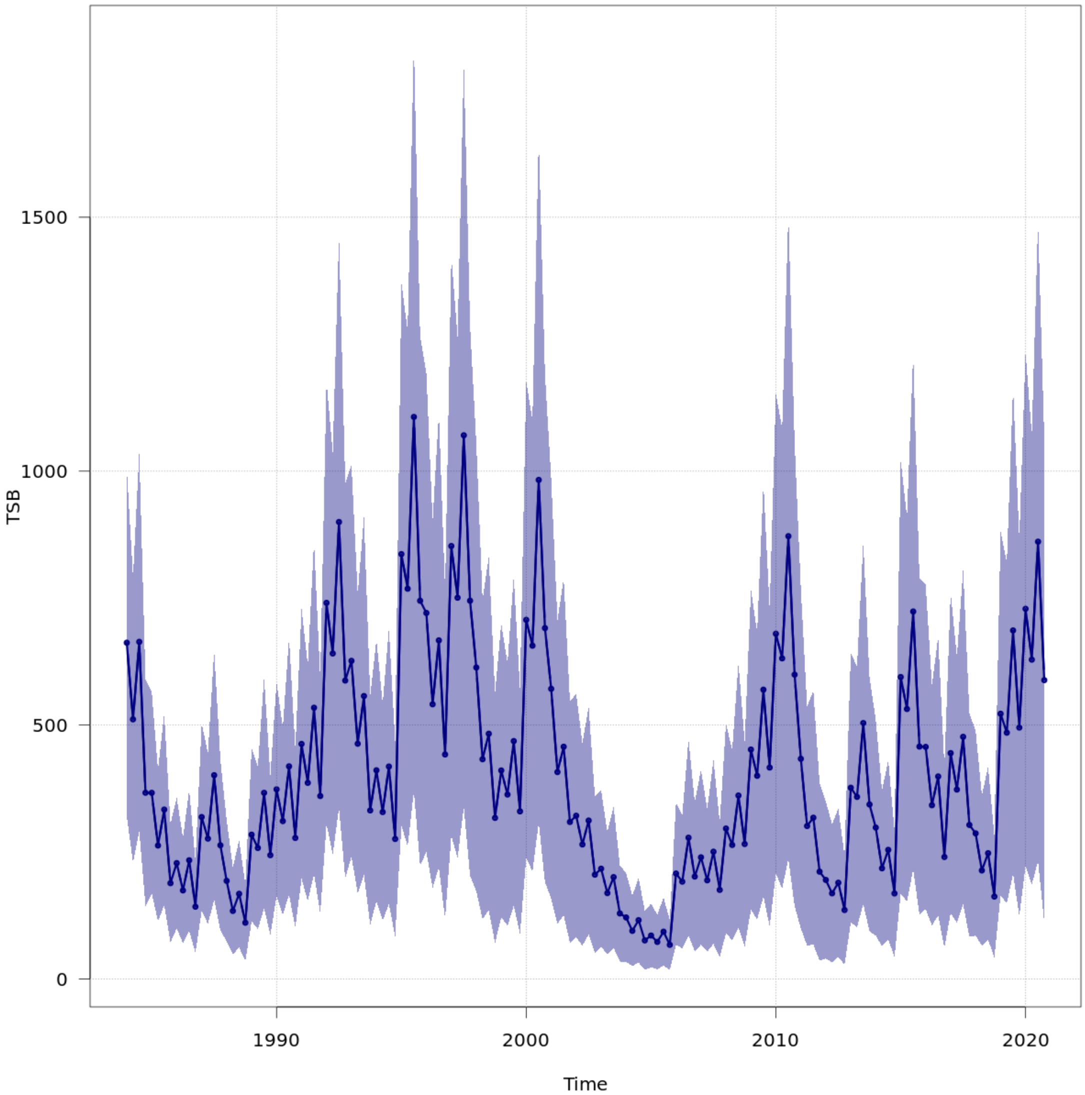

Figure 12.3.2. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: TSB (t), quarterly. SESAM baseline run September 2020.

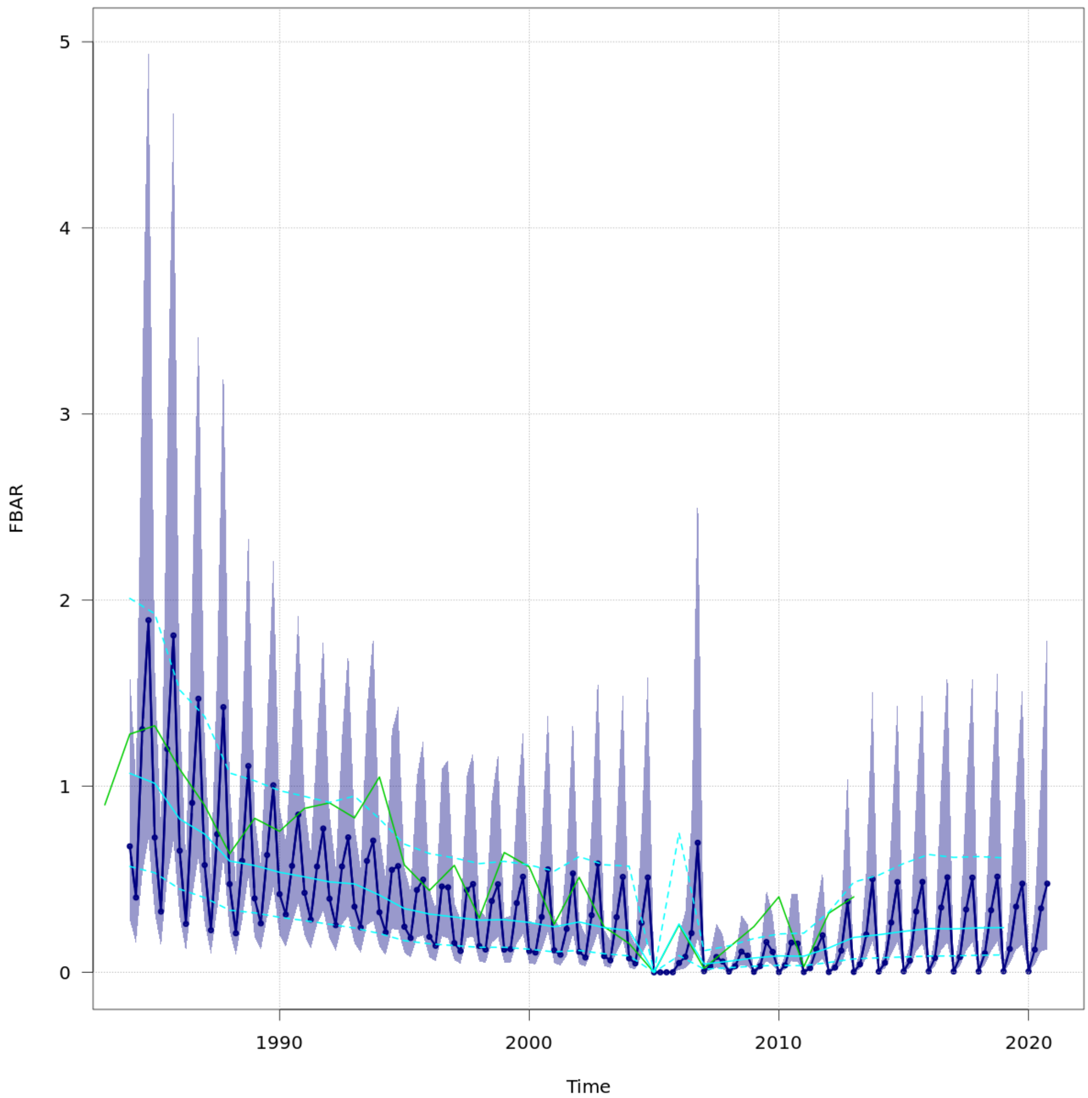

Figure 12.3.3. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: $F_{1-2}=F_{bar}$, quarterly. SESAM baseline run September 2020. Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

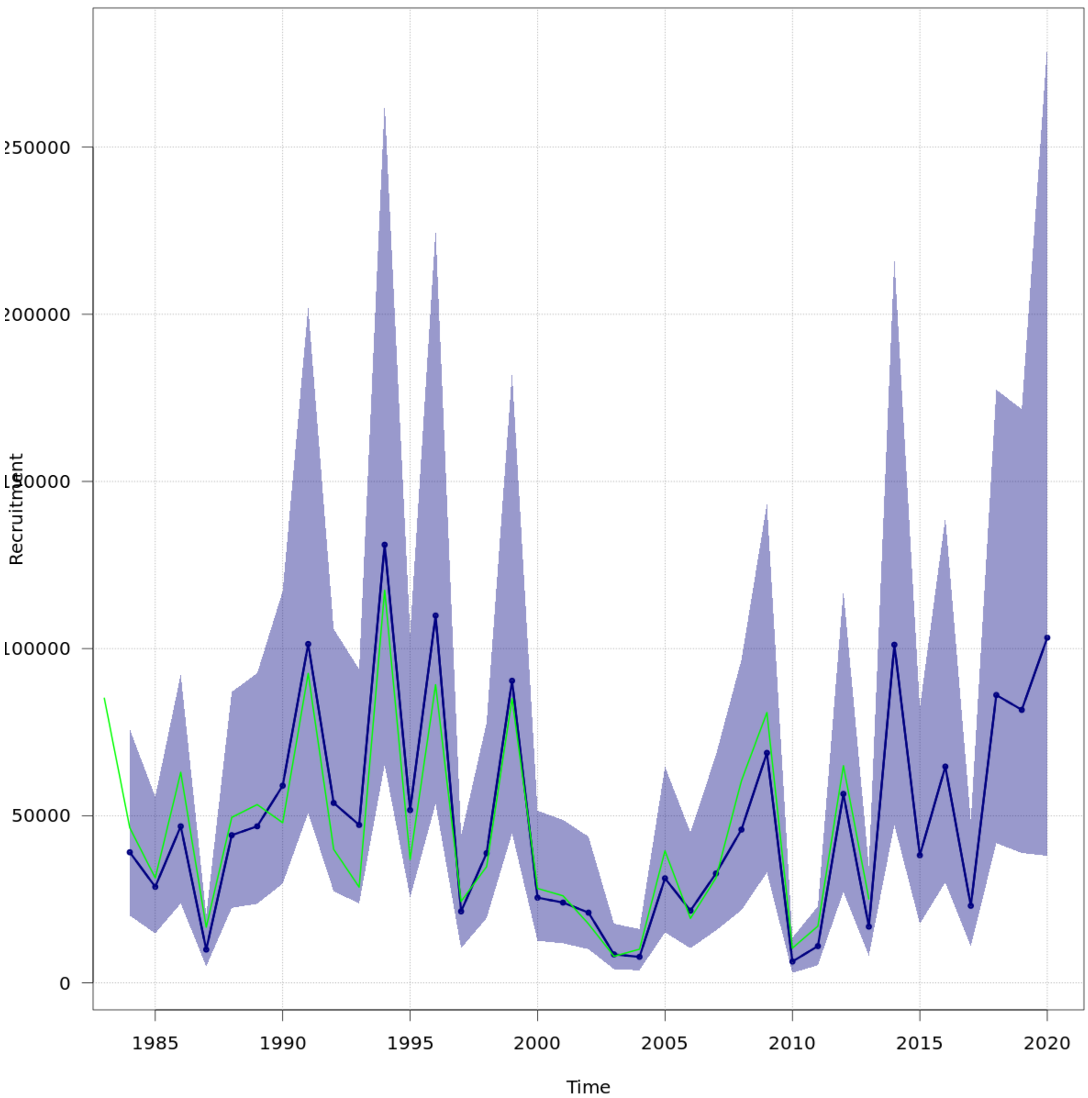

Figure 12.3.4. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Recruitment (millions), yearly. SESAM baseline run September 2020. Blue is SESAM, green is SXSA.

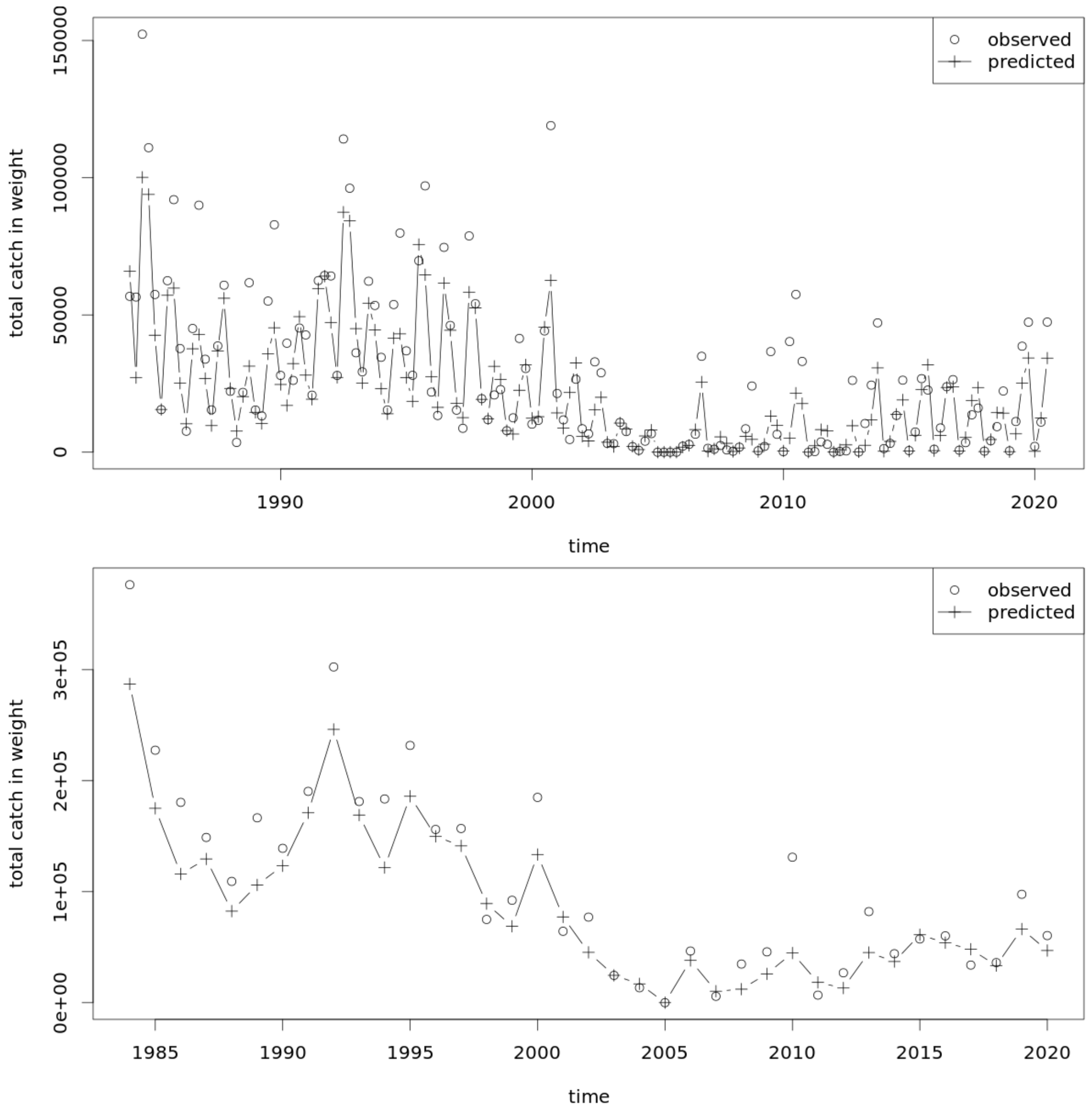

Figure 12.3.5. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Yield = Total Catch (t), quarterly and yearly. SESAM baseline run September 2020.

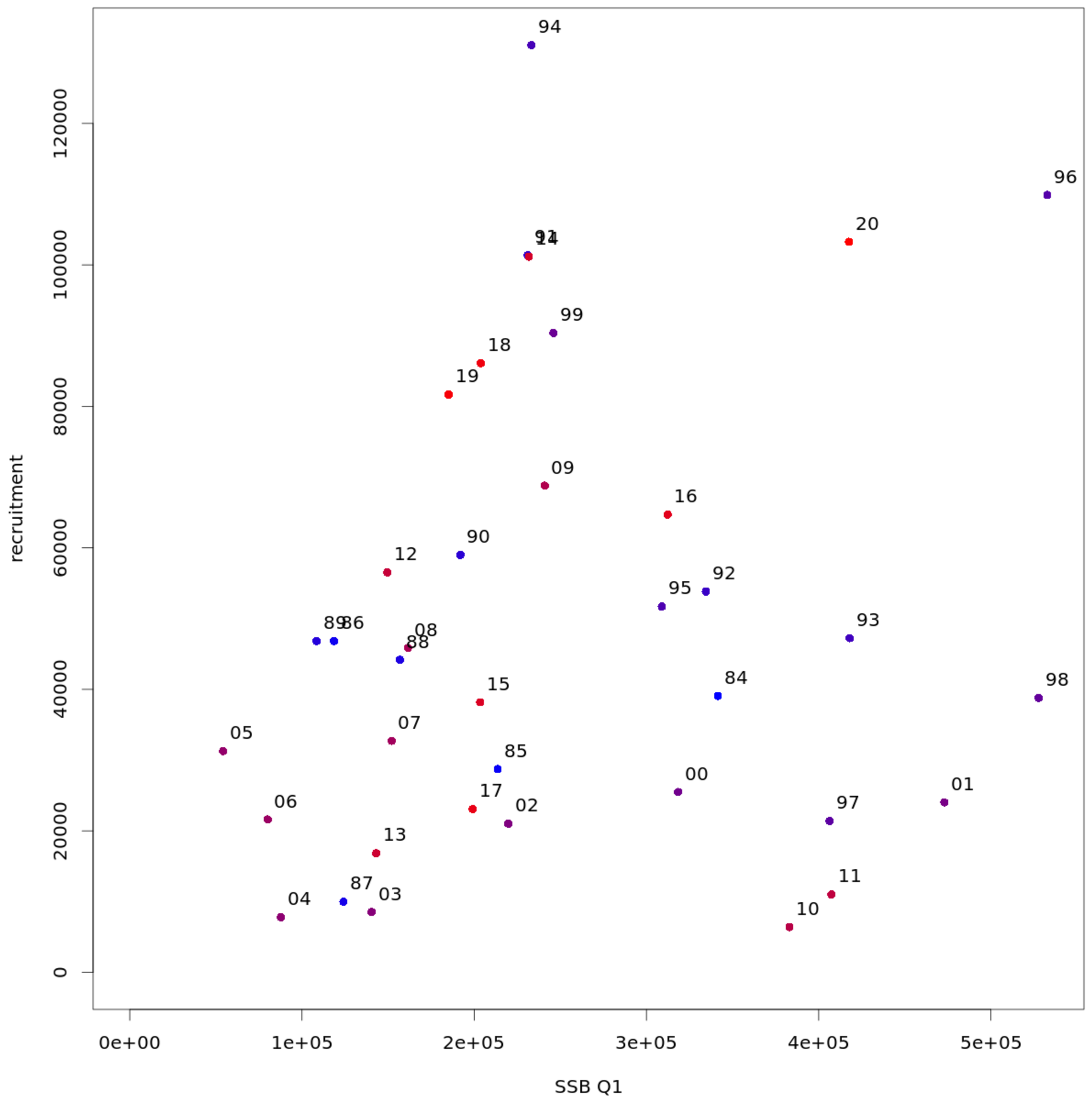

Figure 12.3.6. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 1. SESAM baseline run September 2020.

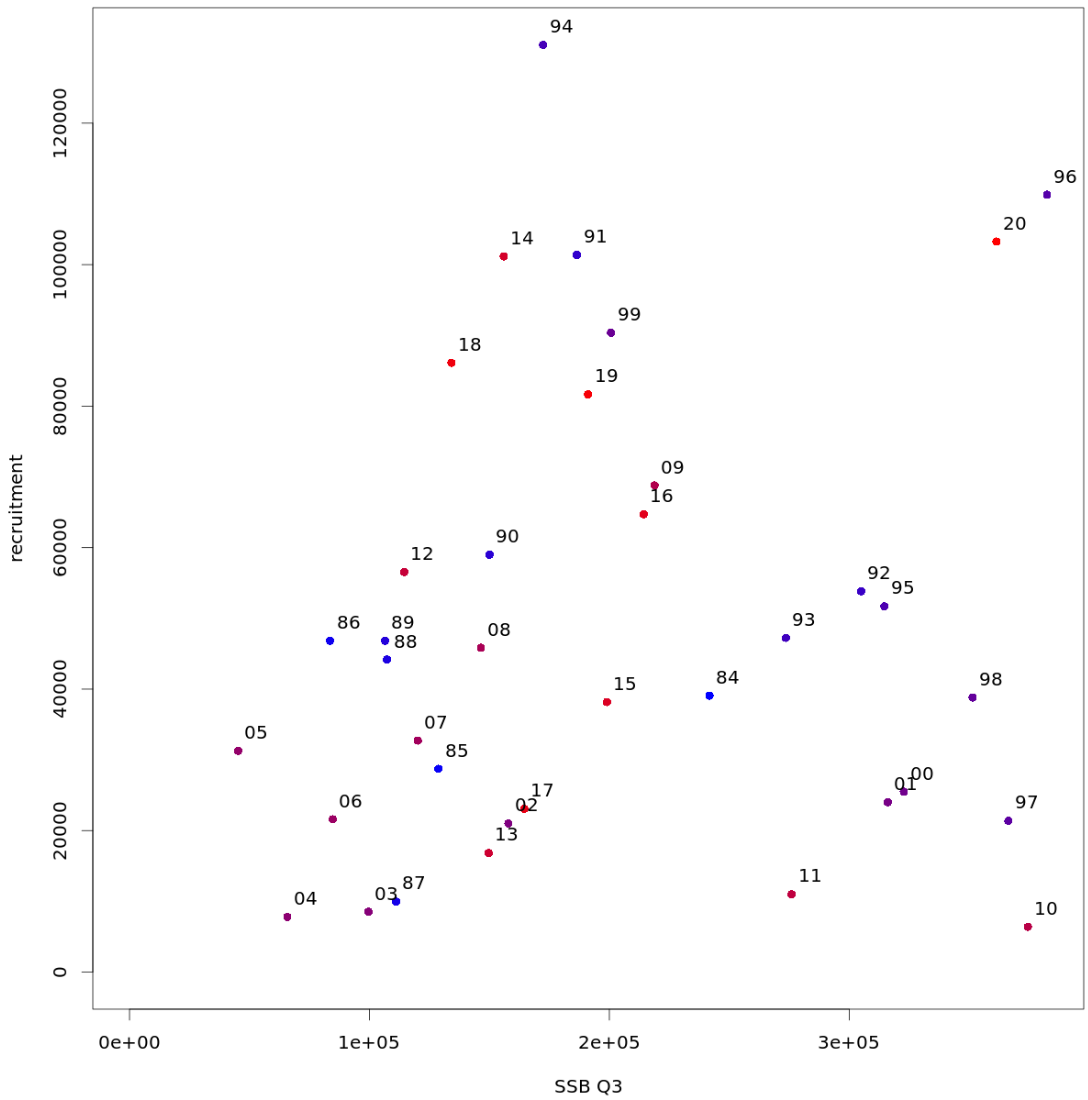

Figure 12.3.7. Norway pout 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 3. SESAM baseline run September 2020.

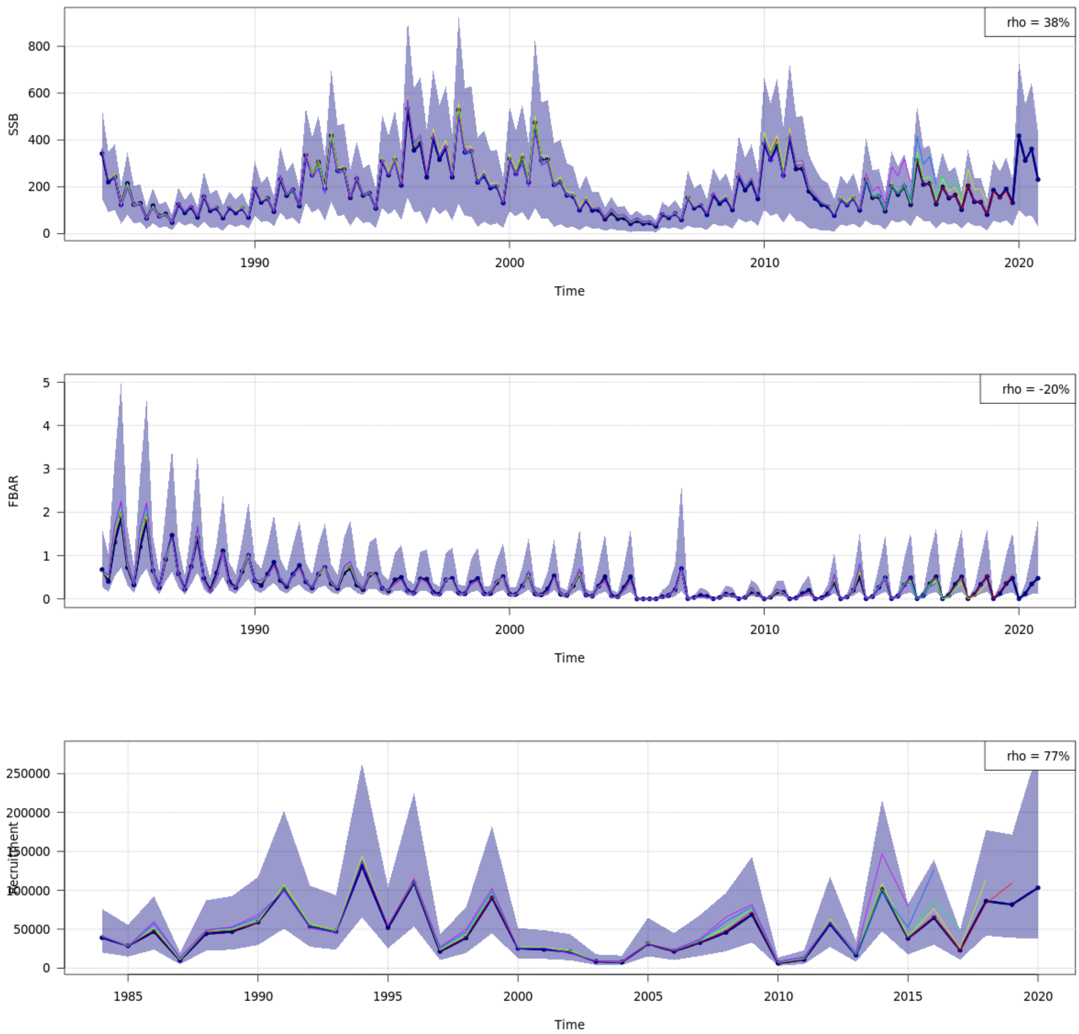

Figure 12.3.8 Norway pout 4 and 3.aN (Skagerrak). Retrospective plots of baseline SESAM assessment September 2020, with terminal assessment year ranging from 2005–2020.

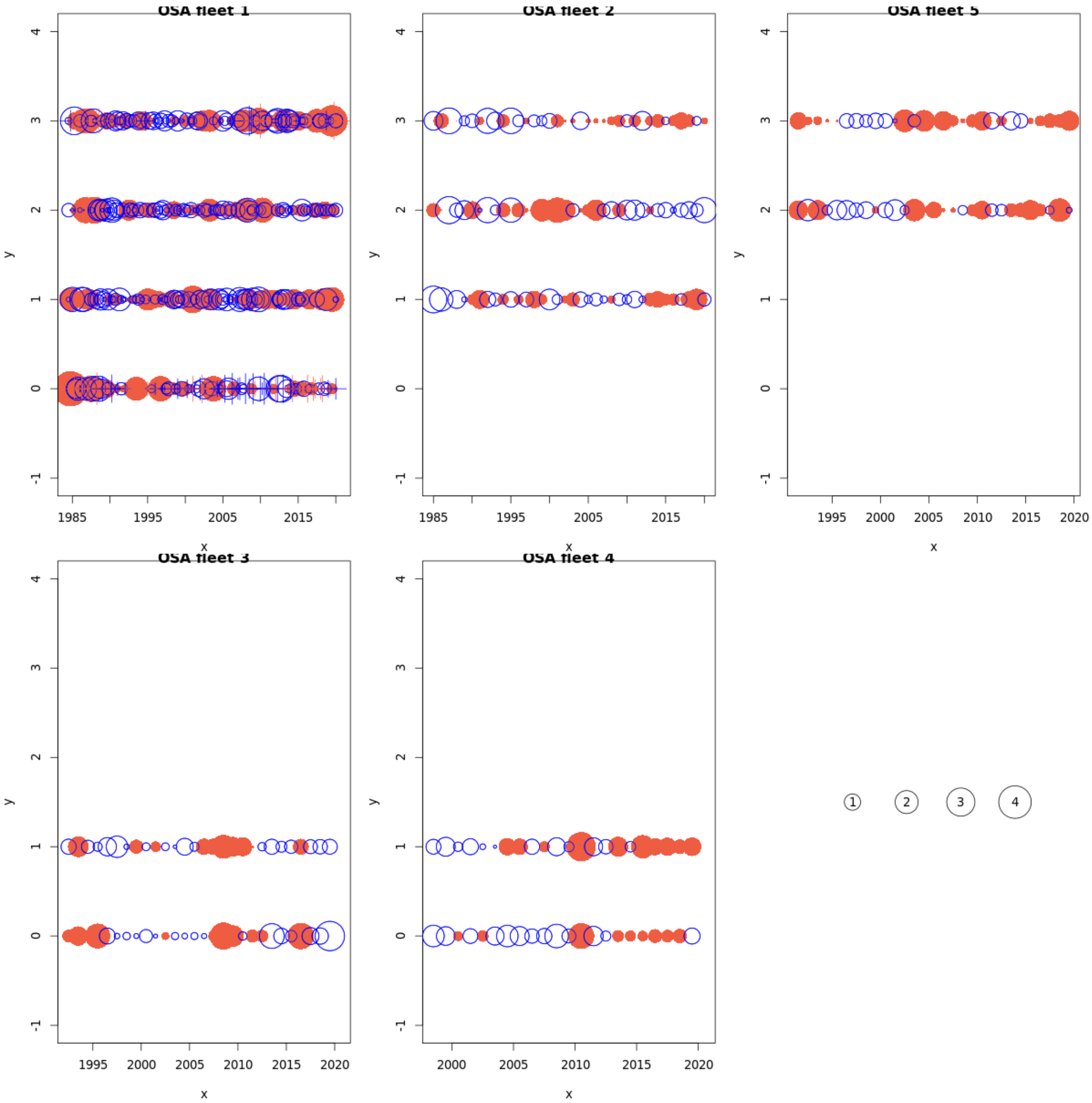

Figure 12.3.9. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet: One step ahead residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2020.

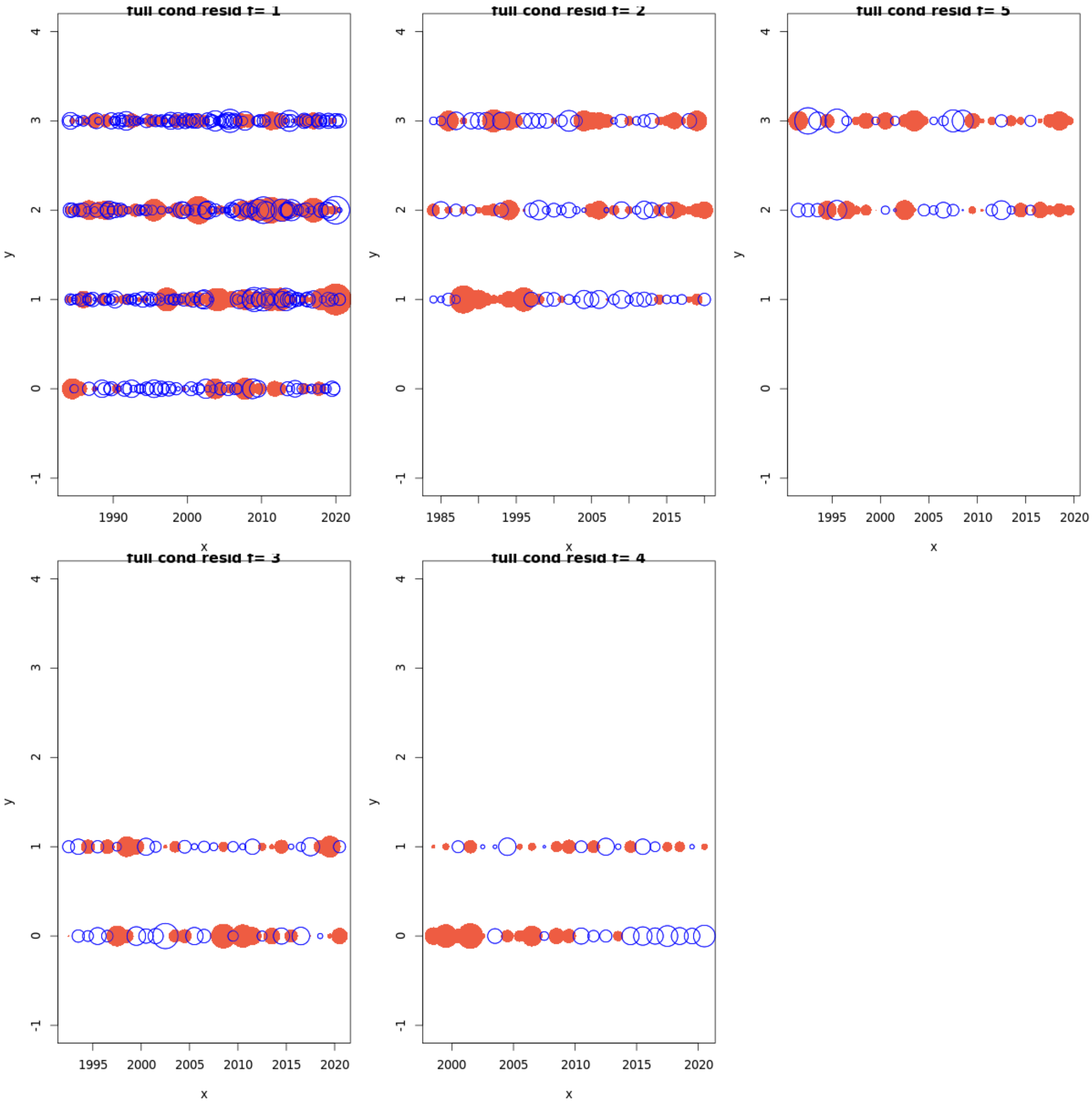

Figure 12.3.10. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots: Full conditional residuals or auxiliary residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2020.

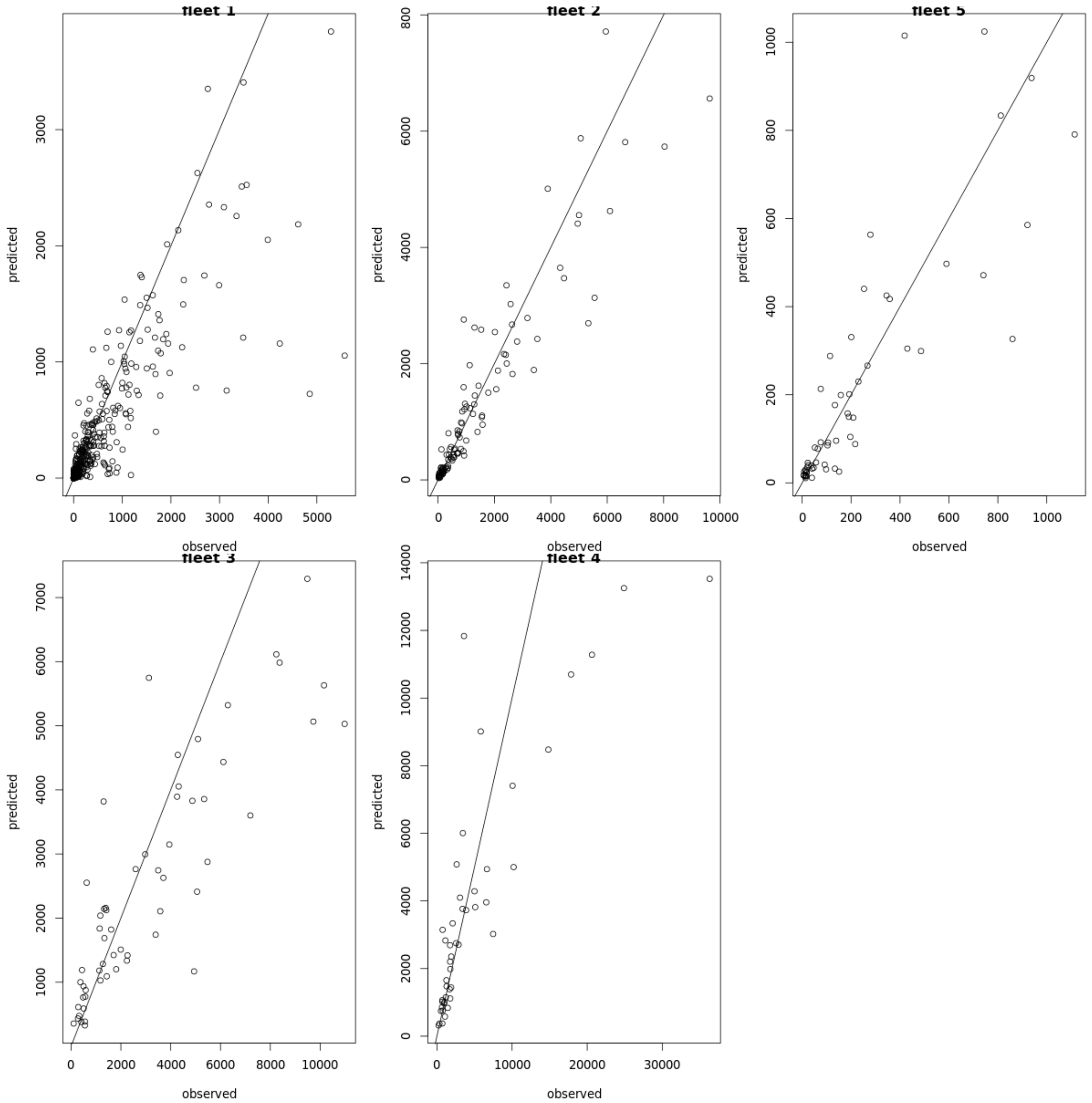

Figure 12.3.11. Norway pout 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet. SESAM baseline run September 2020.

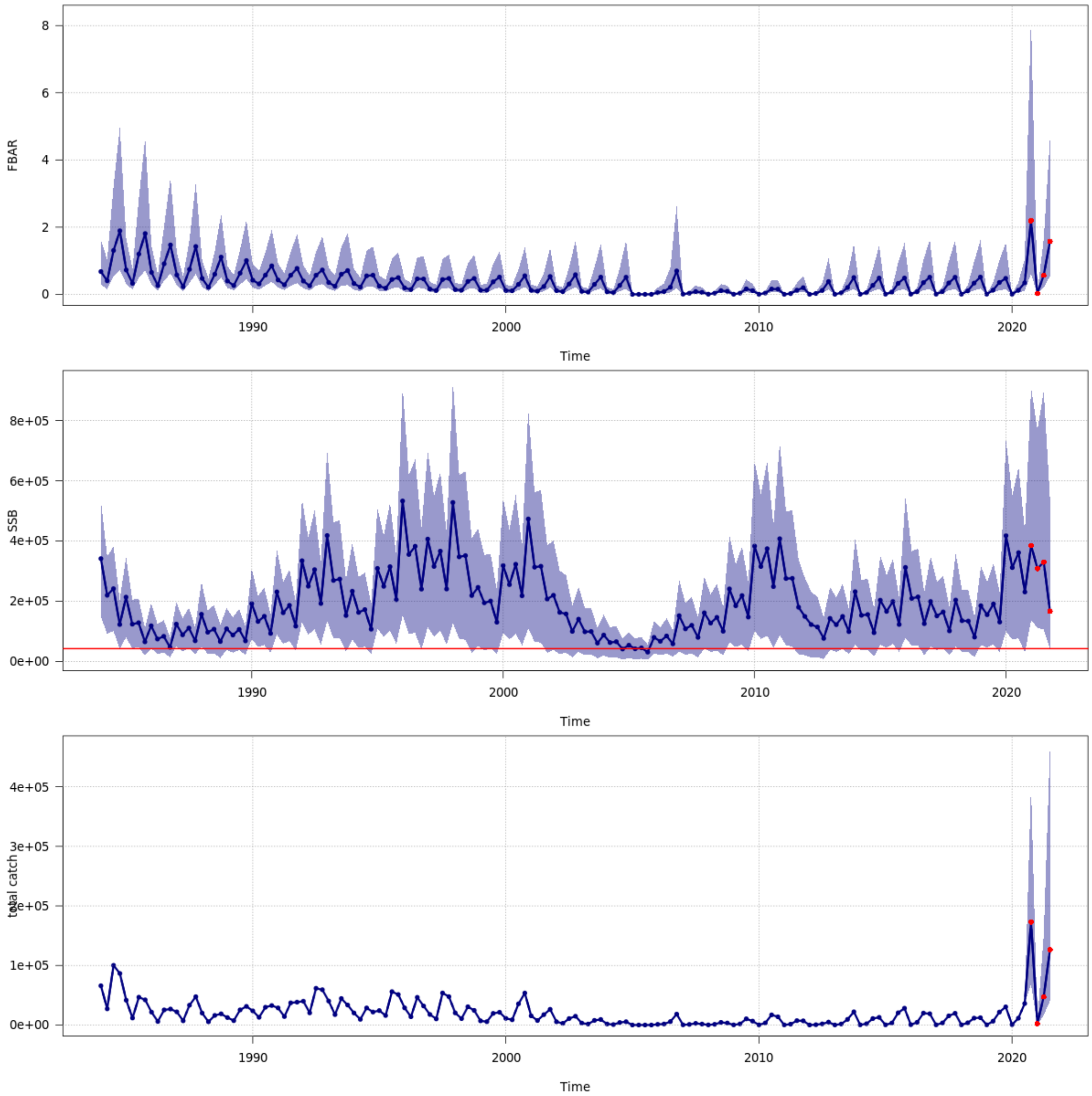

Figure 12.6.1 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year a head (1 October 2021) equals B_{lim}.

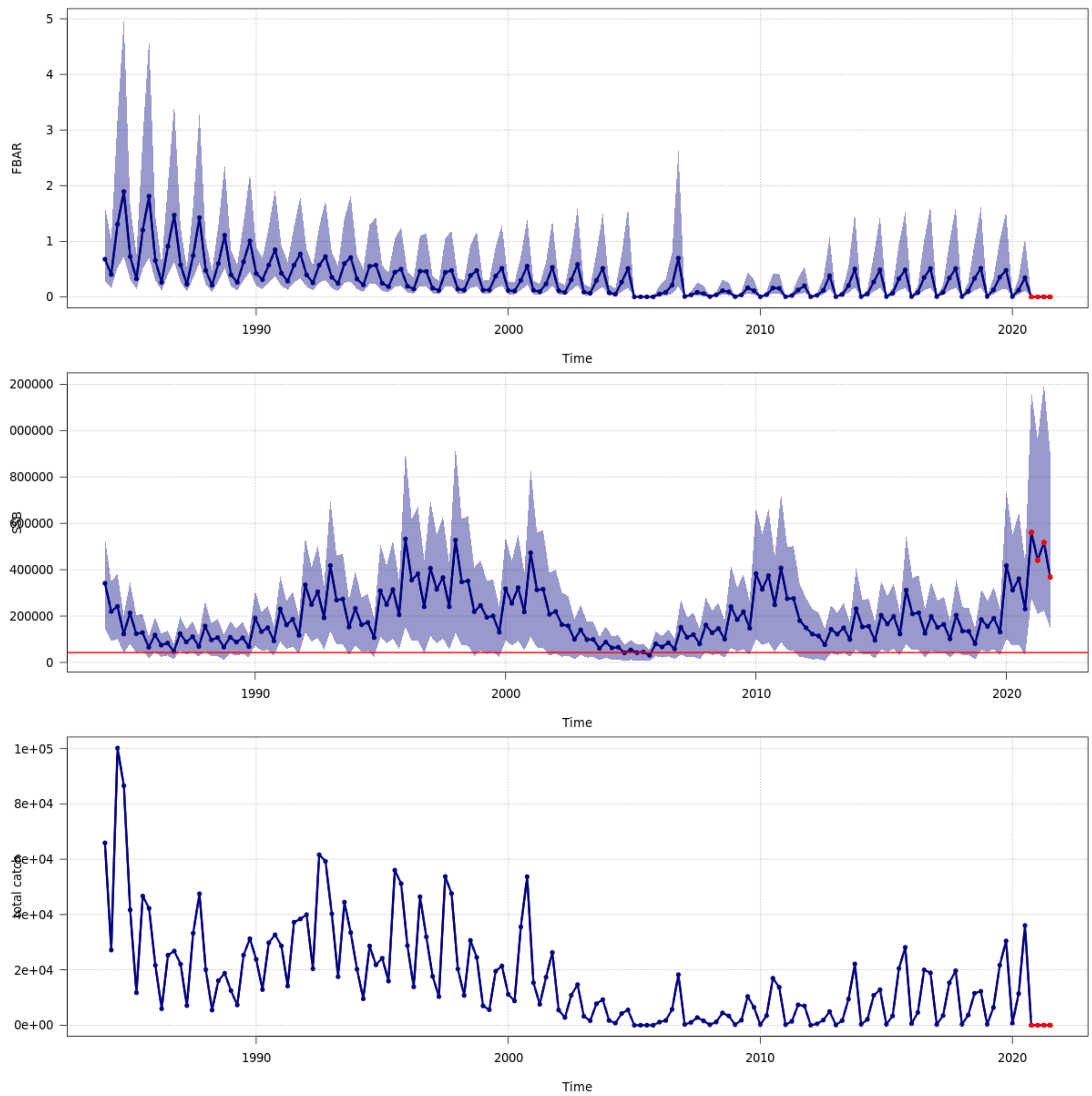

Figure 12.6.2 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1 October 2020 to 1 October 2021.

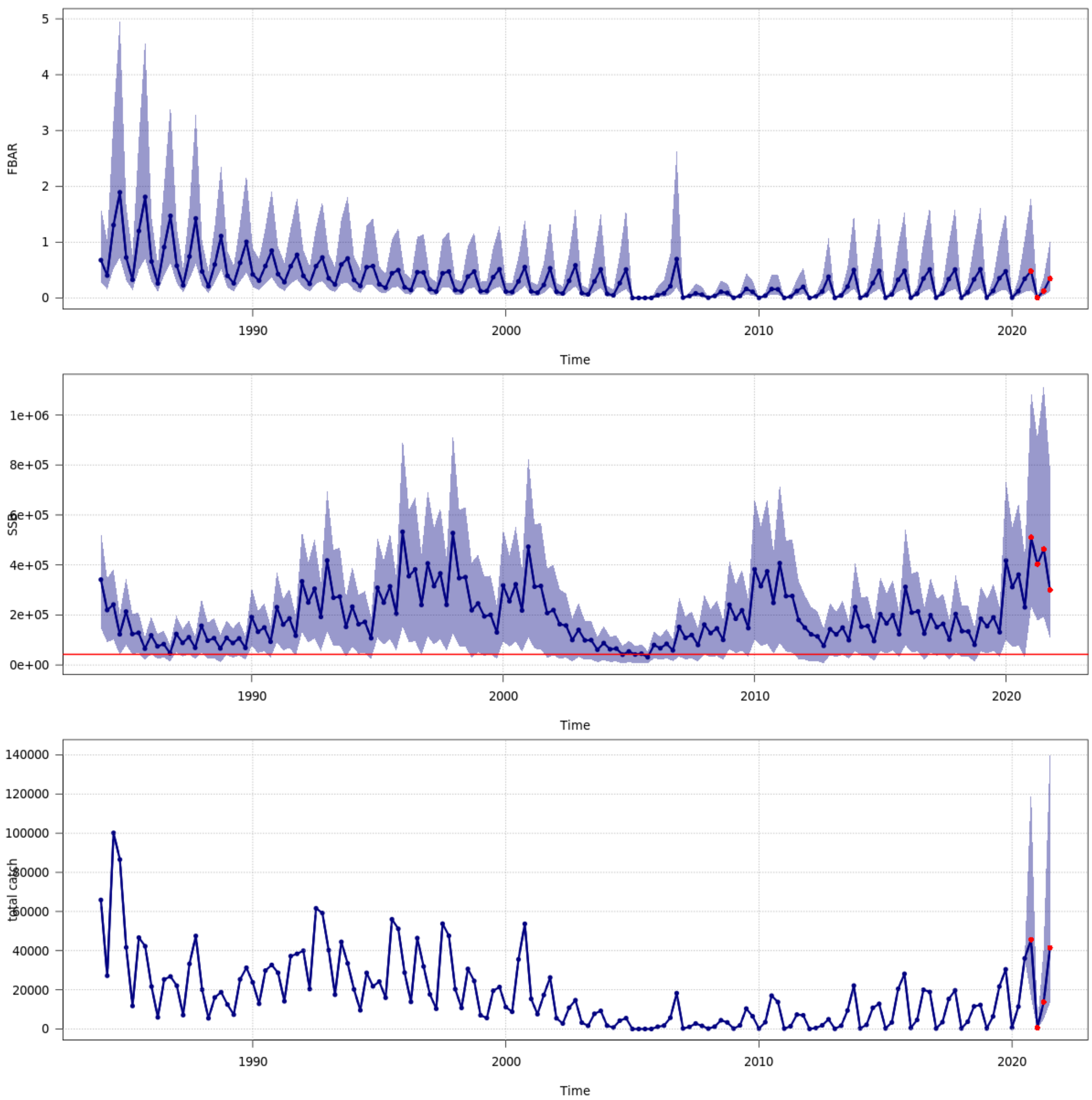

Figure 12.6.3 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year to 1 October 2020.

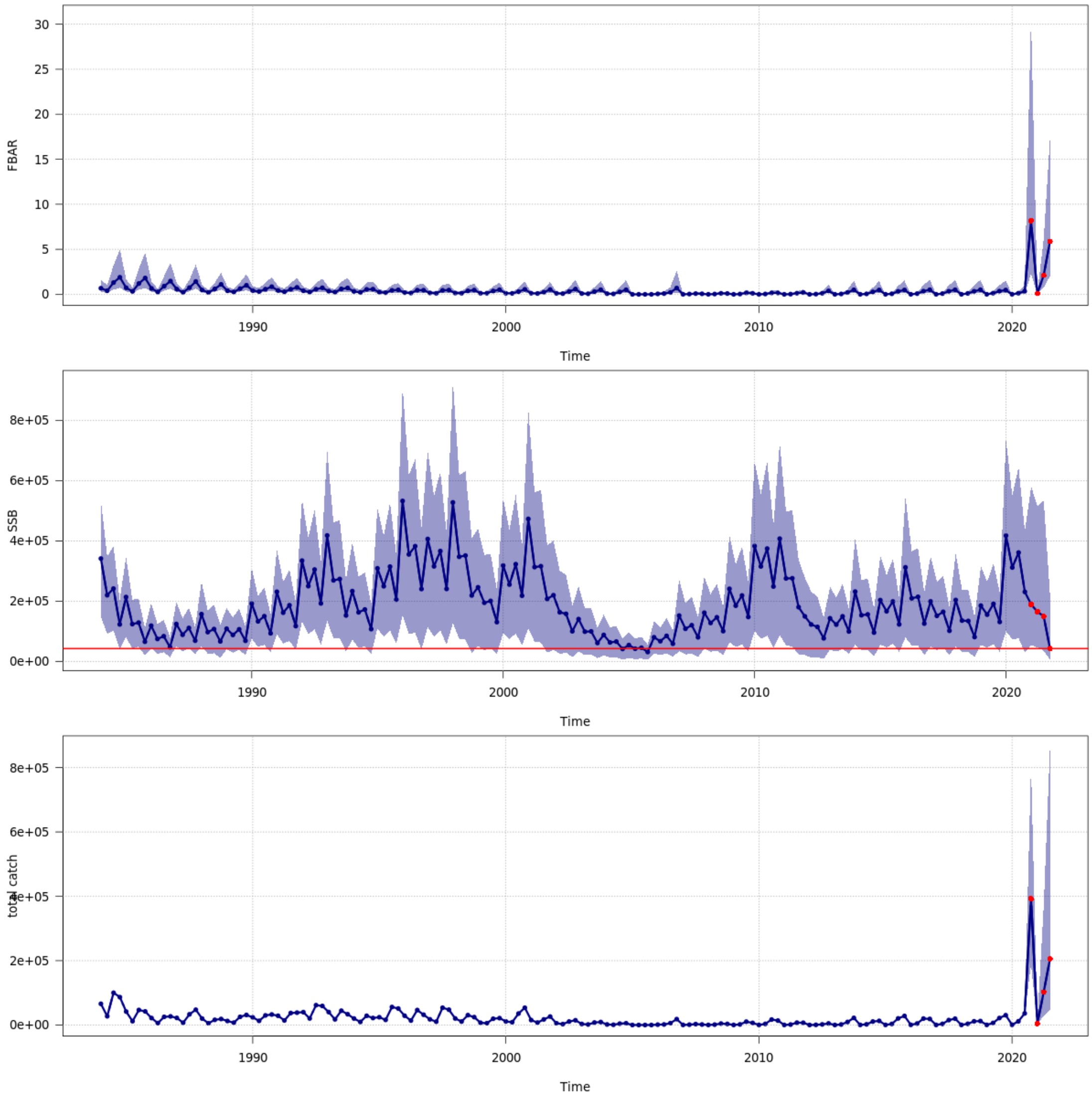

Figure 12.6.4 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year a head (1 October 2021) equals B_{lim}.

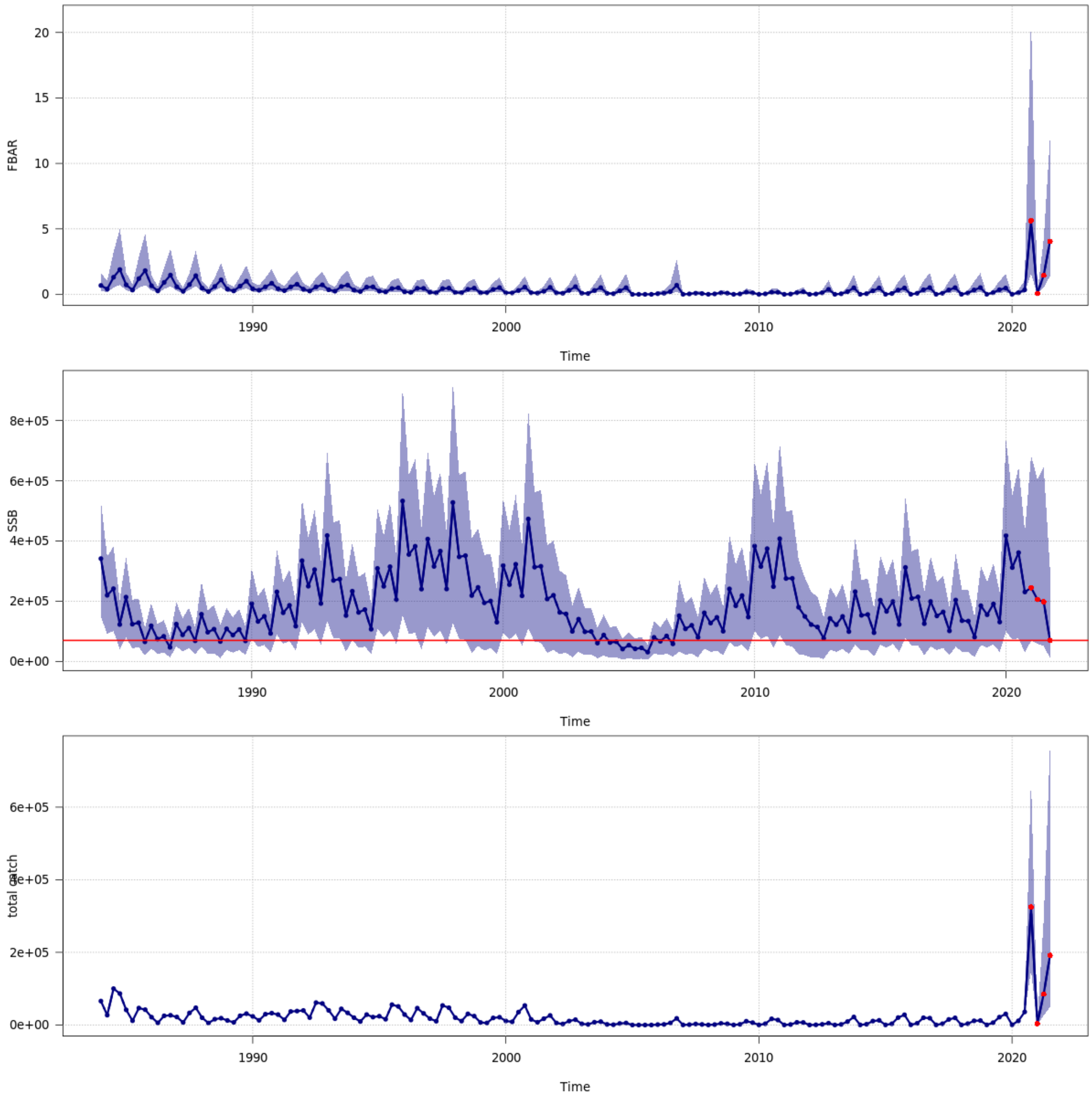

Figure 12.6.5 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the SSB distribution one year a head (1 October 2021) equals B_{pa}.

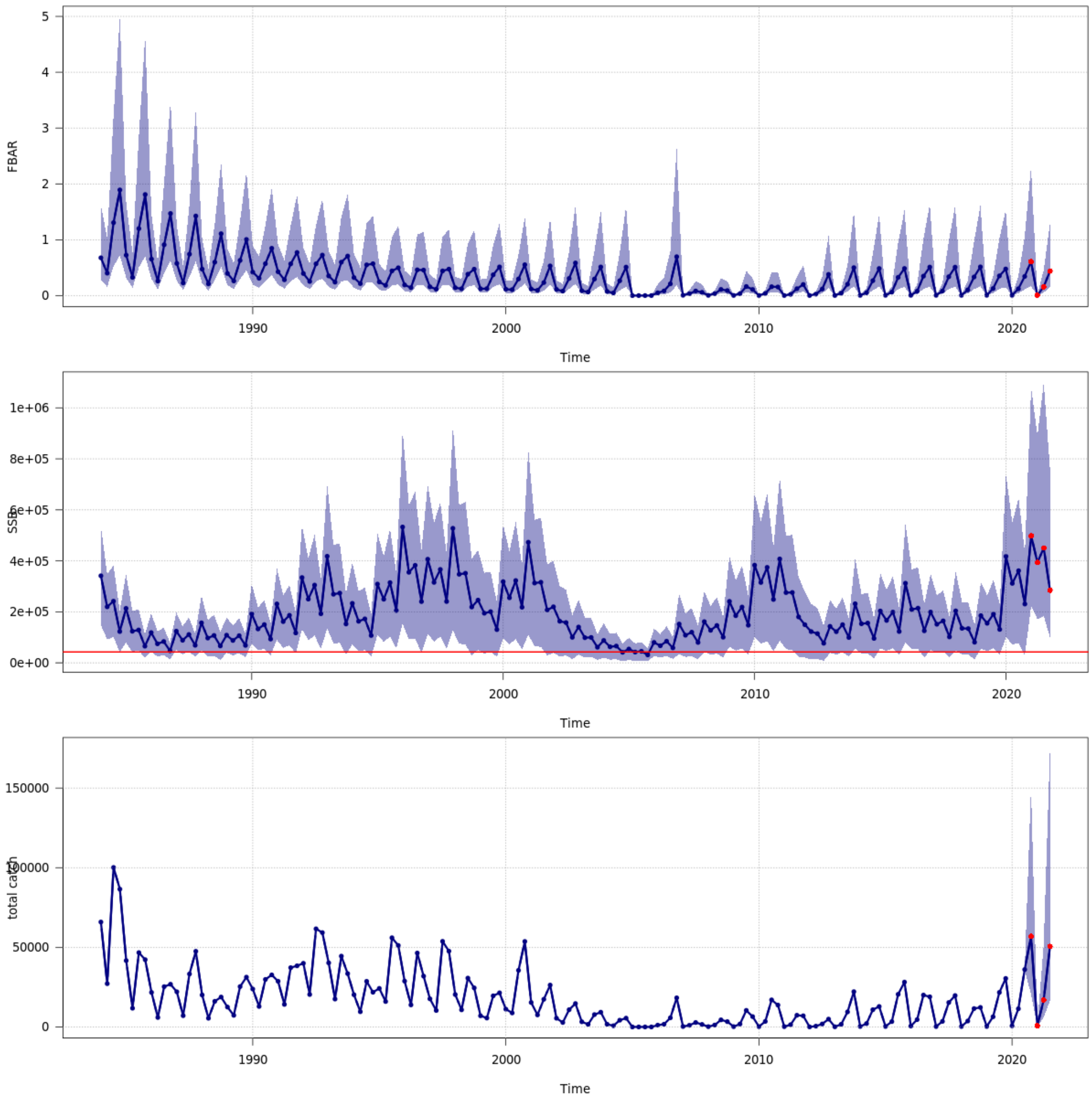

Figure 12.6.6 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.3 (F_{cap} = 0.3) for the period 1 October 2020 to 1 October 2021.

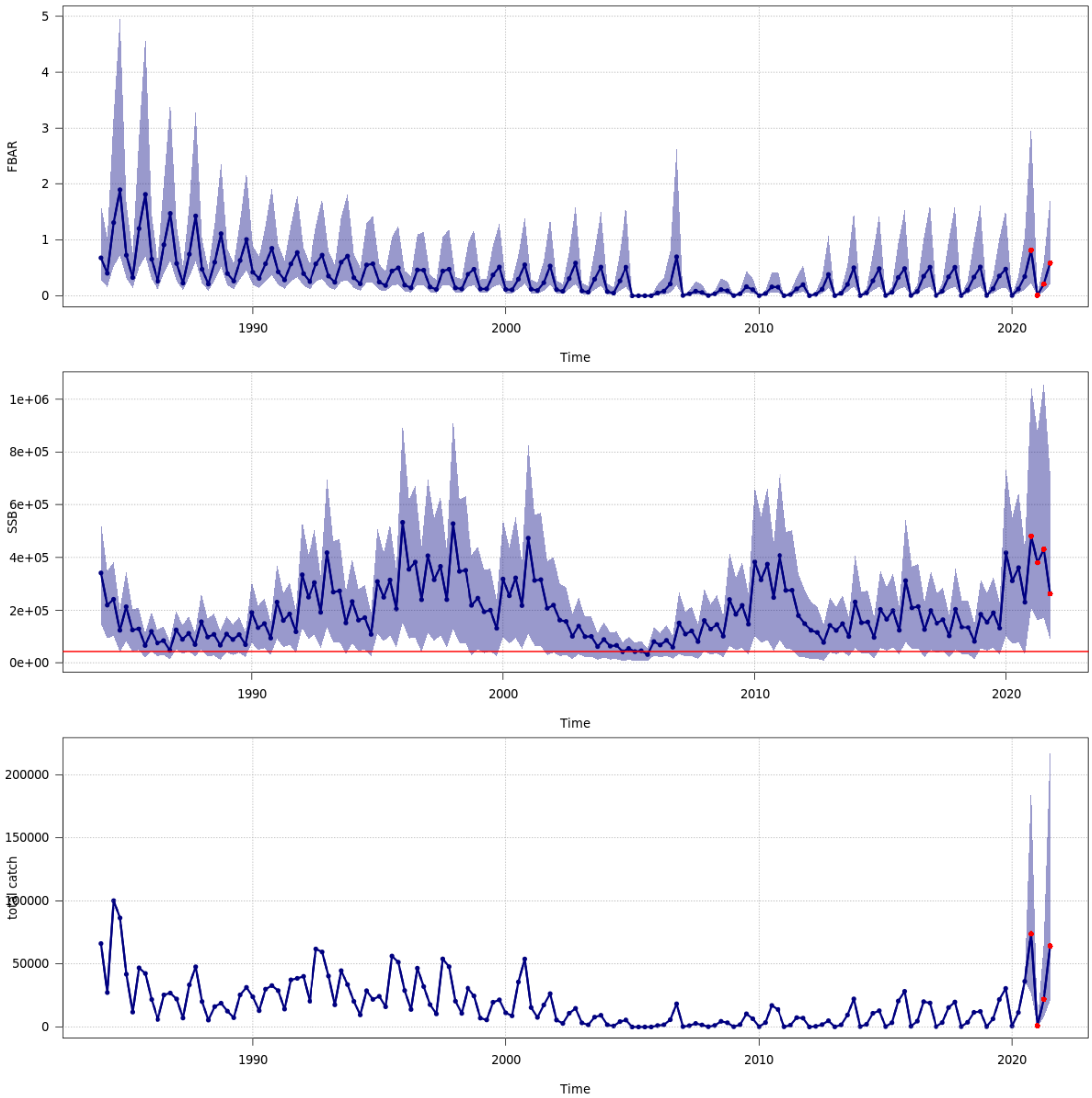

Figure 12.6.7 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.4 (F_{cap} = 0.4) for the period 1 October 2020 to 1 October 2021.

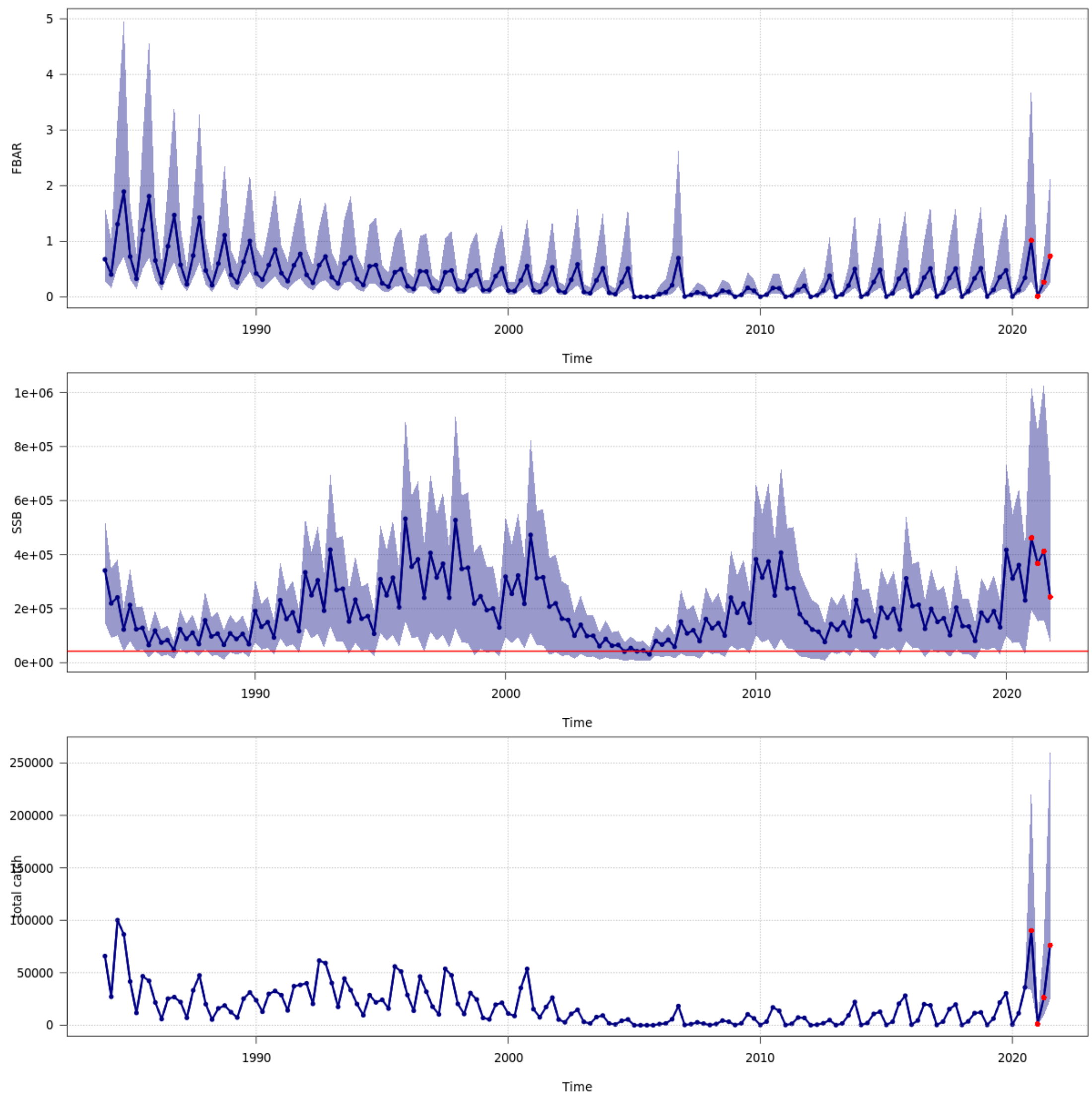

Figure 12.6.8 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.5 (F_{cap} = 0.5) for the period 1 October 2020 to 1 October 2021.

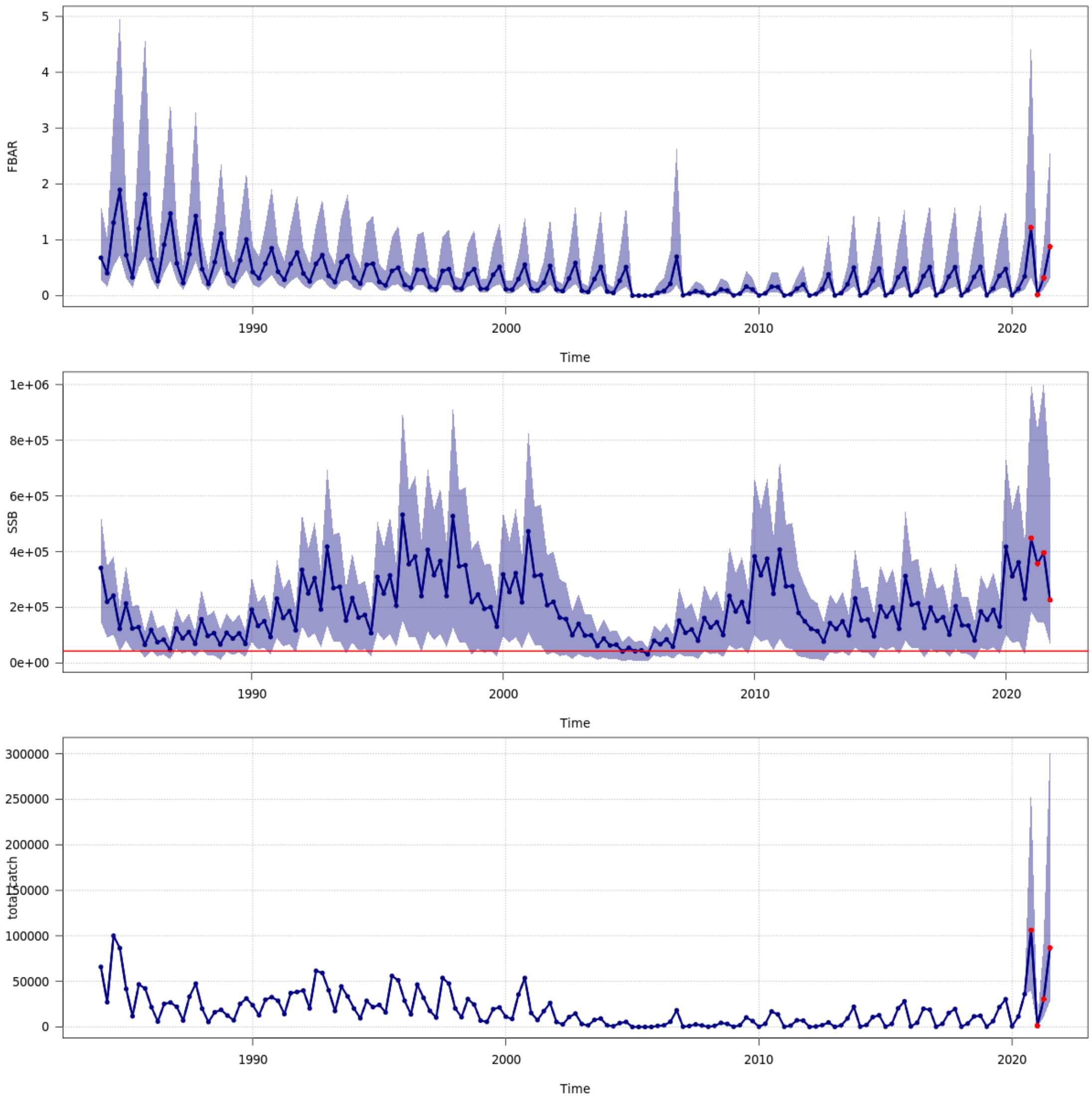

Figure 12.6.9 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.6 (F_{cap} = 0.6) for the period 1 October 2020 to 1 October 2021.

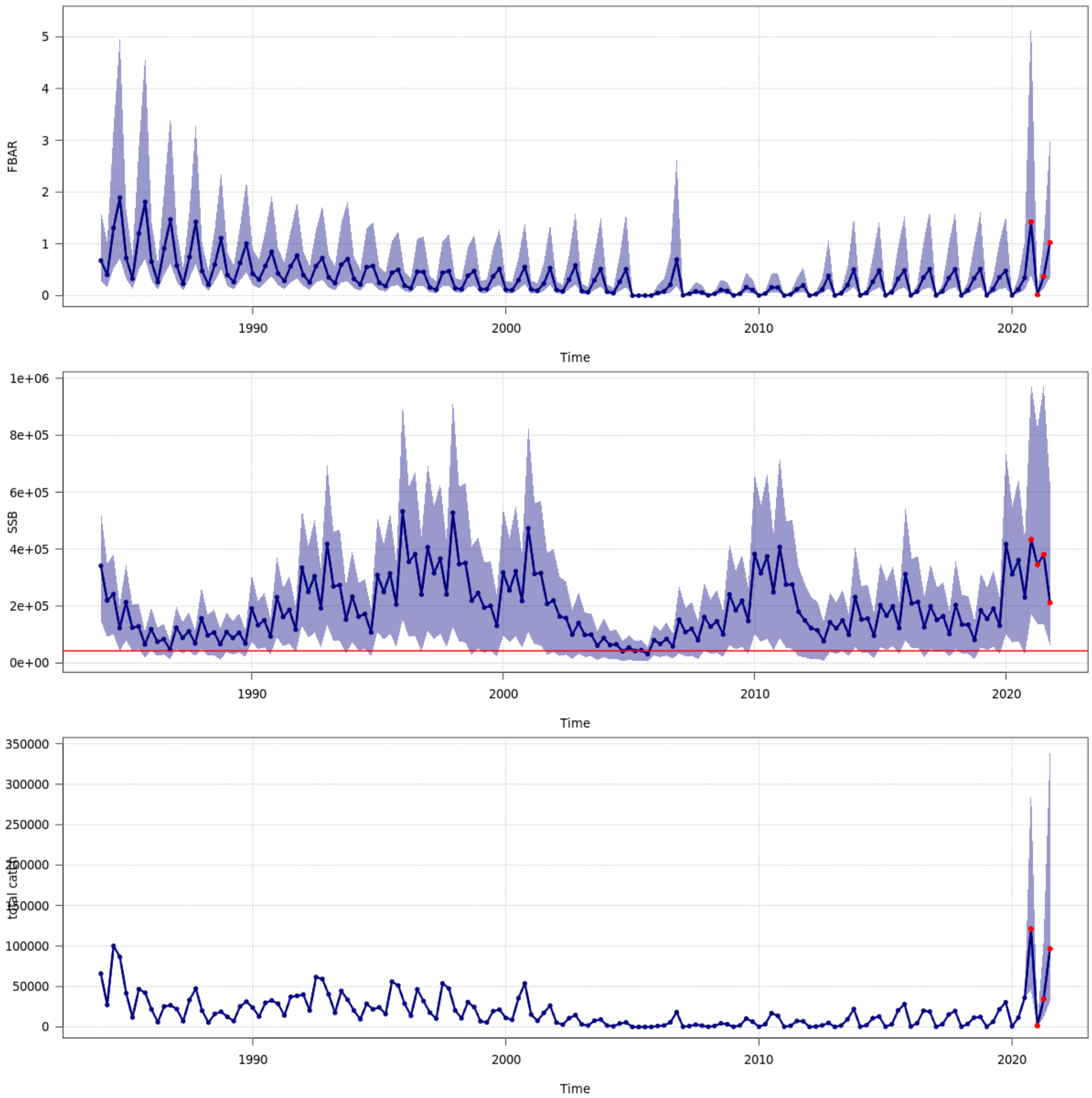

Figure 12.6.10 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to 0.7 (F_{cap} = 0.7) for the period 1 October 2020 to 1 October 2021.

13 Plaice in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)

In 2017, the Stock Annex was updated. Therefore only a comprehensive description of the stock assessment results and deviations from the stock annex are presented within this Section of the report. In 2017 the stock had a benchmark assessment. Decisions from the benchmark in 2017 are also included in the report.

13.1 General

13.1.1 Stock structure

Plaice in the Skagerrak (Subdivision 20) is considered to have two components: an Eastern and Western. The latter occurs in a mix with plaice migrating in from the North Sea (Ulrich *et al.*, 2013) and the predominance of catches occurs on summer feeding aggregations in the Western Skagerrak. In a benchmark (WKPLE, 2015; ICES, 2015) it was decided that plaice in the Skagerrak would be assessed together with the North Sea stock.

In addition, as in previous years, 50% of the mature animals from 7.d in quarter 1 are included in the North Sea plaice assessment, since North Sea plaice migrates into the area in that season (ICES, 2010).

13.1.2 Ecosystem considerations

Available information on ecosystem aspects can be found in the Stock Annex. In addition, the ICES Working Group on the Ecosystem Effects of Fishing Activities (WGECO, ICES, 2014b) met in April 2014 and addressed a specific question in relation to North Sea plaice, in response to a request from WGNSSK in 2013:

“According to WGNSSK estimates, the North Sea is currently ongoing a plaice outburst without precedent. However, plaice is not included in multispecies models, so the consequences of this outburst on the North Sea ecosystem are unclear and would potentially require additional focus”.

WGECO addressed the trends shown in the stock assessment of plaice, which show how increasing fishing pressure on the stock has progressively moved SSB away from the desired state (in the 1980s and 1990s), and then how management has rectified this situation in recent years, which has brought the North Sea plaice stock in a situation unlike any other over the whole 58 year period for which data is available. The group investigated a possible relationship of these trends with abundance of benthic biomass, which is a predominant food source for plaice. Q1 IBTS data showed a two-fold increase in demersal benthivore biomass over the last 29 year period of the survey, and that species composition of the demersal benthivore guild has changed as well. The data showed that predation loading by plaice on benthic invertebrates increased by a factor of 13.8 in just eleven years (2000–2011).

The increase in the consumption of benthic invertebrate prey by the whole demersal benthivore guild, and particularly by plaice, raises the question as to whether the abundance of benthic invertebrate prey might be becoming limiting. If the biomass of demersal benthivorous fish is approaching its carrying capacity, then growth rates in the dominant species in the guild might start to decline (which is in this case plaice growth rates). Computed growth coefficients for the

1956 to 2002 cohorts showed a strong declining linear trend over the whole period (albeit with clear systematic variation in the residuals), and this has been related to increasing water temperature in the North Sea. However, fitting a 4th order polynomial function to the data suggested a marked decline in cohort growth towards the end of the time-series. This is perhaps indicative of plaice becoming food limited, possibly suggesting that B_{MSY} targets for the stock might be marginally too high to be supported by available benthic invertebrate food supplies. However, this evidence is by no means conclusive as polynomial functions are known to show a tendency for marked swings at the extremes of the data range.

More in-depth analysis in WGECO 2018 using the recent years' data showed that the co-occurrence of reduced size at age and increasing stock abundance has led to a negative relationship in period 2006–2016. This correlative indication of density-dependent growth reduction, is further strengthened by a coinciding reduction in physical condition across a range of sizes, hinting that food scarcity may indeed be the mechanism behind the patterns (ICES, 2018b).

13.1.3 Fisheries

A basic description of the fisheries is available in the Stock Annex. In recent years, pulse trawling, aiming at reduction of fuel consumption and reduction of bottom disturbance, has been adopted in fisheries. In 2011, approximately 30 derogation licenses for pulse trawls were taken into operation, which increased to 42 in 2012. An additional 42 derogation licenses have been extended in spring 2014. In 2016 and 2018, ICES published advices on ecological and environmental effects of pulse trawling, compared to traditional beam trawls (ICES, 2016; ICES, 2018a). It was concluded that pulse trawling has fewer environmental and ecological effects than beam trawls. Pulse trawls have been increasingly used in the North Sea flatfish fisheries since 2009. Over this period, the fishing mortality has reduced and stock biomass has increased, mostly due to an overall decrease in effort. The shift in fishing method has resulted in a change in distribution of the fishery. Pulse trawling has increased in areas such as off the Thames estuary and the Belgian coast but decreased in others. This change is related to lighter gear, which can be used on softer grounds than the beam trawls (ICES, 2018a).

In 2019 the European Parliament decided to ban pulse fisheries in European waters. This ban on pulse fishing implies that ultimately only 5% of the fleet of each member state can continue its fishing activities with the pulse trawl until the first of July 2021, after which a total ban will apply. In this context, research into the effects of the pulse trawl on commercial stocks and wider ecosystem effects will continue.

13.1.4 ICES Advice

The information in this Section is taken from the ICES advice sheet 2020:

ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 162 607 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.

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 53% and 66% of the landings in weight were sampled in Subarea 4 and Subdivision 20 respectively, to obtain information on age-composition (Note that the UK vessels of the TBB_DEF_70–99_mm métier are exclusively Dutch owned flag vessels and de facto are thus sampled in the Dutch market sampling programme). Of the metiers for which discards are monitored in sampling programmes, the largest part of these discards is covered in the TBB_DEF_70–99_mm fleet. In most discards monitoring programmes, age composition information is also collected. To raise the amount of discards for landings that had no discards and to raise the landings and discards for which no age distribution was known, the same grouping strategy was used (see table below). The TBB and OTB fleets that covered most of the catches each had their own group (TBB<100, TBB >=100, OTB/OTM<100, and OTB/OTM>=100). Other major groups include Seines, shrimper, gillnets. All discards raising and age allocations were done per quarter. If discards/age structures were present for data for the whole year only, these were added to all quarters. If there were no discards/age structures in a specific quarter, all other quarters were used. Allocations to calculate the age compositions were done separately for discards and landings.

For Subarea 4, 76% of the total discards in 2019 were imported with landing, and 74% of the total discards in Subarea 4 were obtained from sampling. For Subdivision 20, 65% of the total discards are imported with landing, and 65% of the total discards were obtained from sampling. BMS landings, where reported, were included with discards as unwanted catch in the assessment since 2016.

Summary of the imported/Raised/SampledOrEstimated data by area.

CatchCategory	RaisedOrImported	SampledOrEstimated	Area	CATON	perc
Landings	Imported_Data	Sampled_Distribution	27.4	21212	53
Landings	Imported_Data	Estimated_Distribution	27.4	18759	47
Discards	Imported_Data	Sampled_Distribution	27.4	24743	74

Discards	Raised_Discards	Estimated_Distribution	27.4	7913	24
Discards	Imported_Data	Estimated_Distribution	27.4	683	2
BMS landing	Imported_Data	Estimated_Distribution	27.4	58	100
Landings	Imported_Data	Sampled_Distribution	27.3.a.20	5346	66
Landings	Imported_Data	Estimated_Distribution	27.3.a.20	2745	34
Discards	Imported_Data	Sampled_Distribution	27.3.a.20	2142	65
Discards	Raised_Discards	Estimated_Distribution	27.3.a.20	1173	35
Discards	Imported_Data	Estimated_Distribution	27.3.a.20	1	0
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, larger 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<100, because several countries have extremely high discards rate and their fisheries might have a different regulations.**

13.2.2 Landings

Since 2016, large mesh trawlers (TR1 and BT1) with low discard rates were required to report BMS under landing obligation in Subarea 4. According to ICES data, in 2019, BMS landings were 58.3 tonnes and UK was the only country to report to ICES. Meanwhile the official reported BMS landings were 220.2 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 2019 was 48 745 tonnes. Of these 39 973 tonnes came from the Subarea 4, 8091 tonnes came from Subdivision 20, and 681 tonnes came from 7.d. The landings in Subarea 4 decreased 21% (of 2018). The landings in Subdivision 20 increased 30% (of 2018). Total landings (in tonnes) are presented in Table 13.2.1 and landings in numbers at age in Table 13.2.2 and Figure 13.2.4. Since 2010, the majority of landings were age 3–6.

13.2.3 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2019, as described in the stock annex. From Belgium, discards data have been available as well but were only used in the assessment since 2012 when it became available in InterCatch. See Section 13.2.7 for more information on the use of InterCatch for raising discards rates across metiers and countries. The Dutch discards data for 2009 and 2010 were derived from a combination of the observer programme that has been running since 2000, and a new self-sampling programme. The estimates from both programmes were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet. Since 2011, estimates were derived exclusively from the self-sampling data. There is an on-going project within WMR to validate these estimates by examining matched (same vessel and haul) trips where both observer estimates and self-sampling estimates are derived.

To reconstruct the number of plaice discards at age before 2000, catch numbers at age data was reconstructed in 2005 based on a model-based analysis of growth, selectivity of the 80-mm beam trawl gear, and the availability of undersized plaice on the fishing grounds. Discards numbers at age are presented in Table 13.2.3. Figure 13.2.3 presents a time series of landings, catches and discards from these different sources. Age distributions of discards are presented in Figure 13.2.4 and Table 13.2.3. The total discards weight has been gradually decreasing since our first year of observed discards 2000. The discards ratio are illustrated in Figure 13.2.6. Since 2010, the majority of discards were age 1–3.

13.2.4 Catch

The catches of 2019 in Subarea 4 reached 58% of the 125 435 tonnes catch TAC for 2019. The catches of 2019 in Subdivision 20 reached 69% of the 16 782 tonnes catch TAC for 2019. 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); (1996–2019); 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); (2000–2019); Age 1–6
- IBTS–Q1 plaice index; 2007–2019; Age 1–7;
- IBTS–Q3 plaice index; 1997–2019; 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 2019 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 13.3.8 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 center of North Sea and Scotland coastal area. On the other hand, the IBTS-Q1 survey does not show strong difference in age distributions. This is likely due to the spawning and nursery season in Q1.

Table 13.2.10 and Figure 13.2.10 show the survey index values. Overall, BTS-Q3 and IBTS-Q3 give consistent indices. Two moderately strong year class 2013 and 2016 were 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.

Besides stock assessment, additional survey indices are used for recruitment estimates in the RCT3 analysis (Table 13.4.1):

- 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 13.6.

13.3 Data analysis

The assessment of North Sea plaice by AAP was carried out using the FLR (FLCore v. 2.3 and FLXSA v.2.0), splines and mgcv packages in R version 3.5.1.

Since 2013, ICES does not operate with external review groups anymore. Audits were done by internal reviewers (members of the WGNSSK group) and potential issues were directly discussed between the auditors and the stock assessor. Therefore there is no written review to be presented here.

13.4 Assessment

13.4.1 Model parameters and diagnostics

The table below gives an overview of data and parameters used in the AAP assessment model:

Stock	PLE.27.420
Assessment year	2020
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 1996–2019; 1–9 SNS1 1970–1999; 1–6 SNS2 2000-2019 (excl. 2003); 1–6 IBTS-Q1 2007–2019; 1–7 IBTS-Q3 1997–2019; 1–9
Plus group	10
Last data year	2019
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 needs to be conducted. The retrospective plots do not exhibit negative or positive pattern.

13.4.2 Assessment results

Figure 13.2.1 illustrates the trends in observed catch, landing and discards. Reported landings gradually increased up to the late 1980s and then rapidly declined until 1995, in line with the decrease in TAC. The landings show a general decline from 1987 onwards, increasing slowly but steadily in recent years. Discards were particularly high in 1997 and 1998 (reconstructed), and in 2001 and 2003 (observed), resulting from strong year classes.

Figure 13.3.1 and Table 13.3.4 present the model estimated F(2–6), SSB, and recruitment. The estimated SSB in 2019 is 1052 312 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 2019 is 0.166 $year^{-1}$, and it has been around F_{MSY} since 2009. The estimated recruitment in 2019 is 2865 930 thousand, and it's the highest recruitment since 1990.

The estimated model parameters are presented in Table 13.3.1. The estimated fishing mortality and stock numbers are shown in Tables 13.3.2 and Figure 13.3.5, respectively.

The stock dynamics are partly affected by the occurrence of strong year-classes. However, catch and survey indices do not exhibit strong year-class in recent years. The increased stock size in recent years is therefore partly the direct consequence of reduced fishing mortality. Additionally, The age composition in SSB (Figure 13.3.6) implies that older aged plaices (age >= 5) have been increasing since 2010. In 2019, they contribute to as high as 86% of SSB. Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies that older fishes are likely migrating to the north western part of the North Sea (ICES 2019a), where the targeted fishing effort is low (Figure 13.2.12).

The predominant age in the landings is currently age–4 (in 2017 as well as in the past decade, see Figure 13.2.4). Notably, during the time series, this was only also observed in the 1960s. In contrast, the predominant age in the landings in the 1970s, 1980s and 1990s, was age–3. The age distribution in the landings in recent years furthermore shows more similarity with the 1960s in that age–5 and age–6 fish are relatively abundant in the landings in comparison to the rest of the time series and age-2 fish are notably underrepresented in the landings. These shifts in age distribution may be explained by the still relatively low exploitation level in the 1960s, which subsequently substantially increased over the next three decades and since the early 2000s has shown a dramatic decline. Changes in spatial distribution of fishing effort and shifts in spatial distribution of the fish may also have affected these changes. The 'lack' of age-2 fish in the landings in the 1960s as well as in recent years may be for a number of reasons. When considering the age distribution in the catches age–2 fish were also lacking in the catches in the 1960s, while this is not the case in recent years. One possible explanation may be the occurrence of high grading (discarding of smaller fish in order to allow for landing higher numbers of large fish for which a higher price may be received or to avoid exhaustion of quota). The latter seems unlikely since the TAC has not been fully utilised in recent years. Another explanation may be that plaice have become mature at younger ages than in the past since this shift in maturation also leads to mature fish being of a smaller size at age, because growth rate diminishes after maturation. Grift *et al.* (2003) observed that this may occur due to fisheries-induced genetic change: those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This could cause age–2 fish to be discarded more abundantly in recent years because a larger fraction of them being under the minimum size in comparison to the past.

13.5 Recruitment estimates for short-term forecast

In the short term forecasts, assumptions are made on a number of things (see also Section 13.5). One of the more difficult things to predict is the strength of incoming year classes (abundance of ages 0–2) in the assessment year. A number of options are considered as follows:

Age–0: More specifically, the abundance estimate of age–1 fish in the year after the assessment year, i.e. in the TAC–year, needs to be assumed and no data is available from surveys or otherwise. Therefore, the geometric mean of the time series is used.

Age–1: The RCT3 analysis is run which combines DFS and SNS survey data and the assessment results to predict the abundance of age–1. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise, the geometric mean is used.

Age–2: The RCT3 analysis is run which combines DFS, BTS and SNS survey data and the assessment results to predict the abundance of age–2. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise the AAP survivors estimate is used.

Input to the RCT3 analysis is presented in Table 13.4.1. The results for age–1 and age–2 abundance estimates are presented in Table 13.4.2, and in Table 13.4.3 respectively. According to SNS, the 2019 year class returned to around last 10 year average, after an extremely strong 2018 year class (Figure 13.3.7). It was considered since 2019 WG that the age0 survey signals are too uncertain about the recruitment in the intermediate year, and an update of the survey age 1 signal in autumn will give more reliable information on recruitment. Therefore, the geometric mean of 2007–2016 (last 10 years excluding recent 3 years) was chosen for age 1 in 2020 in Spring. For age 2 in 2020, 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 2020	AAP survivors	RCT3	GM 2007–2016	Accepted estimate
2018	2	<u>2442455</u>	1963968	1072476	AAP survivors
2019	1		1012237	<u>1363360</u>	GM 2007–2016*
2020	0			<u>1363360</u>	GM 2007–2016

*** 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 2019 (the last data year) into 2020 (the intermediate year in which the assessment is done); into 2021 (the TAC year) and finally into 2022 (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 a increasing trend of Fbar since

2017, F_{sq} was further re-scaled to have equal Fbar as Fbar_2019. 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 2020 and 2021 were taken from the geometric mean (2007–2016). 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	$F_{(2–6)}$ 2020	SSB 2021	Recruitment 2020	Landings 2020	Discards 2020
F2020 = Fsq-re-scaled	0.166	1302883 t	1363360 thousand	57634 t	54325 t

A series of F options were assumed for the TAC year. Resulting management options for 2021 are given in Table 13.5.2.

13.7 Biological reference points

13.7.1 Precautionary approach reference points

The current precautionary approach reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks (Figure 13.4.2). Therefore, ICES considered that B_{lim} can be set at B_{loss} = 160 000 tonnes and that B_{pa} can then be set at 230 000 tonnes using A multiplier of 1.44. F_{lim} was set at F_{loss} (0.74). F_{pa} was proposed to be set at 0.6 which is the 5th percentile of F_{loss} and gave a 50% probability that SSB is around B_{pa} in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 tonnes.

13.7.2 FMSY reference points

In 2010, ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 2014, the joint ICES MYFISH Workshop (WKMSYREF3, ICES, 2014) held place to consider the basis for F_{MSY} ranges. The workshop was convened in response to a request from the European Commission for advice on potential intervals above and below F_{MSY}. This resulted in an F_{MSY} range for North Sea plaice of 0.13–0.27. The point value of F_{MSY} was set at 0.19.

This values differs from the previous value of F_{MSY} = 0.25 (range 0.2–0.3, Miller and Poos, 2010).

13.7.3 Update of Flim and Fpa 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}

the final assessment year. In case of
$F_{pa} = F_{lim}$ /1.4. The last 10 years of the 2014 stock assessment object (data year 2004–2013) was retrieved and the distribution of recruitment at SSB was simulated using EqSIM, setting B_{lim} = 160 000. The estimated 10 years plaice SSB are all far higher than B_{lim}. The estimated F_{lim} is 0.63 and the corresponding F_{pa} = 0.45 using the default ratio of 1.4. The updated values of both F_{lim} and F_{pa} deviate from their original values, most likely due to the inclusion of Skagerrak (Subdivision 20) data in the recent years where the original reference point was not derived from.

13.7.4 Update of reference point in 2017 benchmark

A full update of the precautionary and MSY based reference points was conducted during 2017 benchmark, using the same method as described in Section 13.6.3.

The reference points used prior to 2017 benchmark are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	230000 t	Default to value of B_{pa}	
	F_{MSY}	0.19	Combined stock	ICES (2014)
Precautionary approach	B_{lim}	160000 t	B_{loss} = 160000 t, the lowest observed biomass in 1997 as assessed in 2004	ICES (2004)
	B_{pa}	230000 t	1.44 × B_{lim}	ICES (2004)
	F_{lim}	0.63	The F that in equilibrium will maintain the stock above B_{lim} with a 50% probability	ICES (2016a)
	F_{pa}	0.45	$F_{pa} = F_{lim}$ F 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	$B_{pa} = B_{lim} \times \exp(1.645 \times$ $\times B_{lim}$	WKNSEA 2017; WKMSYREF4
	F_{lim}	0.516	Estimated by application of EqSIM evaluation	WKNSEA 2017; WKMSYREF4
	F_{pa}	0.369	$F_{pa} = F_{lim} \times \exp(-1.645 \times$ $F_{lim} / 1.4$	WKNSEA 2017; WKMSYREF4

And the proposed MSY reference points:

Reference point	Value
F_{MSY} without $B_{trigger}$	0.21
$F_{MSY\ lower}$ without $B_{trigger}$	0.146
$F_{MSY\ upper}$ without $B_{trigger}$	0.3
FP.05 (5% risk to B_{lim} without $B_{trigger}$)	0.43
F_{MSY} with $B_{trigger}$	0.21
$F_{MSY\ lower}$ with $B_{trigger}$	0.15
$F_{MSY\ upper}$ with $B_{trigger}$	0.3
FP.05 (5% risk to B_{lim} with $B_{trigger}$)	0.77
MSY	104113 t
Median SSB at F_{MSY}	1104120 t
Median SSB lower precautionary (median at $F_{MSY\ upper}$ precautionary)	690328 t
Median SSB upper (median at $F_{MSY\ lower}$)	1616173 t

13.8 Quality of the assessment

The assessment does not provide robust estimates for ages 1–3 because of conflicting information between different data sources. Information from BTS, SNS and DFS surveys suggest that in recent years the nursery area of plaice (or age 0–1) are shifting from coastal area (covered by DFS and SNS) towards off-shore (covered by BTS and IBTS) (ICES, 2019a). Older ages also show a northward expansion in distribution that may affect estimates for these ages.

The deterioration of recruitment signal of age 0 in SNS and DFS has led to less consistent recruitment estimate for the intermediate year in Spring (using RCT3), as compared to the Autumn estimation where BTS-age1 data are added. However, there are indications that the 2018 year class may be stronger than the recruitment assumed in the forecast. If this is confirmed by the summer surveys in 2019 to be significantly different to the current recruitment assumption in the forecast, the forecast will be updated in the autumn.

Information from surveys (BTS, IBTS-Q3, SNS and DFS) implies 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 13.3.11). The leave-one-out results show significantly reduced SSB estimates after leaving out IBTS-Q3. This surprising results was 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 46% and 29% of the total catch in 2019 was discarded in Subarea 4 and Subdivision 20, respectively. The reported BMS landings for fleets that are under the landing obligation in Subarea 4 are currently much lower than the estimates of unwanted catch from catch monitoring programmes. ICES understands that this is not in accordance with the current EU regulation.

13.9 Status of the stock

SSB in 2019 is estimated around 1052 312 tonnes which is well above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Fishing mortality in 2019 is estimated to be at a value of 0.166 (below F_{pa} of 0.369, below the long-term management target F of 0.30 and below F_{MSY} of 0.210).

13.10 Management considerations

Plaice is mainly taken by beam trawlers in a mixed fishery with sole in the southern and central part of the North Sea. There are a number of EC regulations that affect the fisheries on plaice and sole in the North Sea, e.g. as a basis for setting the TAC, limiting effort, minimum landing size and minimum mesh size.

13.10.1 Multiannual plan North Sea

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007). This plan is written for the North Sea stock and does not take the merging with the Skagerrak into account. The plan describes two stages: to be deemed a recovery plan during its first stage and a management plan during its second stage. ICES has evaluated this management plan in 2010 and considers it to be precautionary (ICES, 2010a). Objectives are defined for these two stages; to rebuild the stocks to within safe biological limits and to exploit the stocks at MSY respectively. In 2015 WKMSYREF3 estimated F_{MSY} to be between 0.13 and 0.27. ICES identified the point estimate for the North Sea stock to be 0.19 (ADGMSYREF3).

Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years. The plaice stock has been within safe biological limits (F = 0.6) as defined by the plan since 2005. The sole stock has been within safe biological limits in terms of fishing mortality and SSB has been above the biomass limit (B_{pa} = 35 kt) in the latest years. According to the management plan (Article 3.2), this signals the end of stage one. Consequently, utilisation of the plan as a basis for advice is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). In 2012, ICES evaluated a proposal by the Netherlands for an amended management plan, which could serve as the ‘stage 2’ plan (Coers *et al.*, 2012). ICES concluded that the plan, subject to those amendments, is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY). However, implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Since the management plan is now in stage 2, the EU regulation stipulates that the stocks should be managed on the basis of MSY. For plaice, the ICES F_{MSY} estimate is 0.21, which is below the target F (0.3) defined in the plan. Considering that the plan specifies that fishing mortality in stage 2 should not be below the target of 0.3 (which coincides with the upper bound of a range of F_{MSY} values suggested by ICES), the current advice for plaice is still on the basis of moving towards the target of 0.3, rather than on the basis of F_{MSY} point estimate of 0.21 (albeit that the TAC change is restricted to a maximum 15% change). This apparent conflict in the basis for TAC setting in the management plan should be addressed.

This management plan is written for the North Sea stock. No specific management plan exists for the Skagerrak. The North Sea management plan should be updated including the Skagerrak. The forecast and advice are given for both areas with a combined TAC.

13.10.2 Effort regulations (North Sea)

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In 2009, the effort management programme switched from a days-at-sea to a kW–day system (EC regulation 43/2009), in which different amounts of kW–days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. A minor part of the fleets exploiting sole, i.e. otter trawls (OTB) with a mesh size equal to or larger than 100 mm included in Figure 13.2.1, have since 2009 been affected by the regulation. The beam trawl fleet (BT2) was affected by this regulation only once in 2009 but not afterwards.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, likely due to a number of reasons, including the above-mentioned effort limitations for the recovery of the cod stock. 25 vessels were decommissioned in 2014. In addition, the current sole and plaice long-term management plan specifically reduces effort as a management measure. However, the evaluation of amendments to the plan in 2012 showed that the plan is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY) also without reductions of effort (Coers *et al.*, 2012).

Fishing effort of the beam trawl fleet has shifted towards the southern North Sea to target sole over the past decade. Juvenile plaice tend to be relatively abundant there, leading to relatively high discarding rates of small plaice. This shift was amongst others driven by a number of economic factors, such as the prices for sole and plaice respectively and fuel costs, which meant that the sole fishery was the most profitable fishery. With the recent substantial increases in biomass of the plaice stock, and thus to be expected increased catch rates, targeting plaice further North may become more economically favourable again. With the relatively low fishing mortality levels in recent years, it is also to be expected that a larger proportion of the population will be made up of older fish, of which the fishery could potentially benefit, since larger plaice receive higher prices on the market than small plaice. However, this benefit may be reduced if weight at age are decreasing, which seems to be the case in the plaice stock. At present, the beam trawl fleet is limited in its ability to move northwards (where larger plaice are more abundant) by effort restrictions for the BT1 fleet, which are imposed on the basis of the North Sea cod management plan. This trade-off between objectives in the cod and flatfish plans deserves some attention. Ongoing work in the Netherlands on the levels of cod catch rates (which are considered to be low) in the beam trawl fisheries should help quantification of this trade-off. The introduction of the landing obligation will likely provide an additional strong driver for at least part of the beam trawl fleet to focus on a more northerly plaice fishery, to avoid the complications of the high unwanted bycatches of undersized plaice in the South. For effort regulations in the Skagerrak see Section 07.

13.10.3 Technical measures

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea where sole has become relatively more abundant, affect both sole and plaice. The minimum mesh size of 80 mm selects sole at the minimum landing size. However, this mesh size generates high discards of plaice with a larger minimum landing size than sole. For the overall fleet the discards ratio has been slightly decreasing since 2003 and at present is approximately 40% by weight. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. Furthermore, the size selectivity of the fleet may lead to a shift in the age and size at maturation. For example, in recent years plaice and sole have become mature at younger ages and at smaller sizes than in the past (Grift *et al.*, 2003). The introduction of the Omega (mesh size) meter in 2010 has led to a slight increase in the effective mesh size in the fishery.

Technical management measures have caused a shift towards two categories of vessels: 2000 HP (the maximum engine power allowed) and 300 HP. The 300 HP vessels are allowed to fish within the 12–nautical mile coastal zone and in the Plaice Box. The Plaice Box is a partially closed area along the continental coast that was implemented in phases, starting in 1989. The area has been closed to most categories of vessels >300 HP all year round since 1995. The most recent EU-funded evaluation by Beare *et al.* (2010) reported the Plaice Box as having very little impact on the plaice stock.

Large scale adoption of innovative gears, for instance if EU regulations would permanently legalize the use of pulse gears could cause changes in fishing patterns in the near future (see Section 13.1.3).

13.10.4 Frequency of assessment

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment.

The North Sea Plaice assessment succeeded in all four criteria when evaluated in 2015 (ICES WGNSSK, 2015). Therefore the North Sea Plaice stock is a candidate for less frequent assessments. The perception of the stock and the retrospective pattern in the stock did not change since last year.

13.11 Issues for future benchmarks

13.11.1 Data

- The delta-gam IBTS-
  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 close 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 indices, 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 Preliminary run in SURBAR

Due to the residual pattern issues in the current AAP assessment, a preliminary run in SURBAR was conducted using surveys since 1996. SURBAR is a survey-based fisheries stock assessment model that is used to indicate relative stock dynamics and provide advice for both data-rich and data-poor fisheries (Needle, Coby, 2015). The goal of the SURBAR run was to 1) test whether survey based assessment gives similar perception of the stock trends as compared to the current AAP assessment, and 2) checking the consistencies among surveys.

SURBAR showed similar SSB trend as AAP assessment (Figure 13.3.9). The residual patterns (Figure 13.3.10) in IBTS and SNS imply inconsistencies among surveys: likely higher abundances indicated by IBTS. The results of SURBAR suggests further investigations on survey internal consistency, between survey consistency and survey-catch consistency.

13.13 Added reference

EU. 2018. Regulation (EU) 2018/973 of the European Parliament and of the council of 4 July 2018 establishing a multiannual plan for demersal stocks in the North Sea and the fisheries exploiting those stocks, specifying details of the implementation of the landing obligation in the North Sea and repealing Council Regulations (EC) No 676/2007 and (EC) No 1342/2008. Official Journal of the European Union, L 179: 1–13. http://data.europa.eu/eli/reg/2018/973/oj

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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

					North Sea									Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
1996	5765	11776	379	4780	35419	917	5	20992		80033	1640	81673	81000	10517	11200
1997	5223	13940	254	4159	34143	1620	10	22134		81483	1565	83048	91000	10292	11200
1998	5592	10087	489	2773	30541	965	2	19915	1	70365	1169	71534	87000	8431	11200
1999	6160	13468	624	3144	37513	643	4	17061		78617	2045	80662	102000	8719	11200
2000	7260	13408	547	4310	35030	883	3	20710		82151	-1001	81150	97000	8826	11200
2001	6369	13797	429	4739	33290	1926	3	19147		79700	2147	81847	78000	11653	9400
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000	8789	6400
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250	9110	1400
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000	9090	9500
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000	6764	7600
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441	9565	7600
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261	8747	8500
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000	8657	9300
2009	3474	NA*	NA*	2931	29142	1116	1	13143	-	NA*	-	54973	55500	6748	9300
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825	9057	9300
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400	8251	7900

	North Sea													Skagerrak	
YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410	7611	7900
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070	6911	9142
2014	7105	12003	276	4203	29306	577	5	17370	-	69179	1668	70847	111631	9004	10056
2015	5522	14401	223	5171	32074	169	7	17240	-	74807	156	74963	128376	10171	10056
2016	6659	16398	169	4371	32227	94	9	18731	-	78659	2400	81059	131714	10883	11766
2017	5317	12518	151	2526	28775	67	5	14993	0	64352	1090	65442	129917	8467	17639
2018	4894	9666	112	2580	22586	69	3	9603	0	49513	1270	50783	112643	5958	15343
2019	3912	6583	61	2059	19289	57	3	7410	0	39374	596	39970	125435	4614	16782
2020													146852		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.

	age									
year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1957	0	4792	66428	49659	35282	9867	12248	10026	5522	12059
1958	0	7581	23612	65979	36274	20836	8696	8507	6497	13981
1959	0	16914	31085	26040	41988	23432	14173	6547	6739	16530
1960	0	5998	62285	51359	21462	27510	14280	9073	5121	15253
1961	0	2299	33913	68965	33209	12958	14909	9900	6089	14889
1962	0	2075	34677	64548	48387	19939	8757	8733	5081	12373
1963	0	4424	21886	78412	55414	32413	13096	6965	7183	16912
1964	0	14818	40789	65219	57837	37368	15937	6644	4010	17012
1965	0	9913	42438	53486	43919	30320	18464	8602	4237	17686
1966	0	4220	66196	52428	37336	27870	16801	10981	6585	15201
1967	0	6101	30905	115157	42204	22490	16496	8163	6861	11397
1968	0	9750	41883	39251	127220	17638	10642	10396	4039	13754
1969	3	15892	47819	38185	37657	107955	11016	6440	8669	17029
1970	74	16850	49861	54712	39642	34174	76862	6149	4078	14459
1971	20	30568	49876	34580	26919	23659	17471	30711	6626	17468
1972	2296	37561	63958	54402	23695	17479	14787	11211	19111	16094
1973	1332	33342	62095	76769	44397	14517	9335	10347	6392	25194
1974	2305	23972	57595	43677	42588	20391	8300	6554	5773	22790
1975	1042	29877	65465	33211	27004	22509	12613	6292	4362	20923
1976	2892	34497	79621	98846	14129	10156	9352	6553	3022	12871
1977	3225	57061	43359	66120	83841	9157	5922	5030	4068	9206
1978	1102	58412	60114	52398	48310	34240	5728	3232	2333	7201
1979	1316	57933	118662	48879	47805	39864	24187	4154	2802	9272
1980	996	66095	136274	79035	25548	18321	14018	8621	1898	5497
1981	259	103354	125928	59565	36670	12750	9805	8295	5005	6091
1982	3373	48354	212188	71167	29191	16975	7704	5551	4539	8775

	age									
year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1983	1214	119696	115332	100473	29591	12960	8238	4224	3013	8308
1984	108	63507	280481	62835	41492	15417	6842	5593	2729	6551
1985	120	72806	146839	201629	37939	17106	7441	3780	2813	5830
1986	1669	66935	165986	106461	101684	27971	9839	4704	2834	7083
1987	1	85153	118416	120782	81304	44590	13539	4669	2346	5610
1988	1	15200	253815	85347	59950	31492	19347	6198	3434	6402
1989	1254	46810	108272	238243	58767	21667	11605	8025	2321	5806
1990	1546	33766	104796	119829	169465	29946	9053	4689	3803	4206
1991	1425	43064	87196	122233	76075	78728	15410	5390	3215	5634
1992	3386	43769	86358	81470	88534	37542	30444	7229	3295	6976
1993	3416	53555	99805	80856	63275	35042	14745	11500	3704	5883
1994	1375	44554	105863	86992	47577	27680	17279	6661	5449	5458
1995	7779	36761	82649	84778	47911	24572	14746	5285	2495	3896
1996	1103	43346	68155	52961	37285	19160	12400	5881	2799	4989
1997	897	43122	88687	49362	31750	18673	9518	5037	3054	4400
1998	197	30594	74441	62339	22793	9151	5703	2870	1983	3360
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

year	age 1	2	3	4	5	6	7	8	9	10
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										

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

year	age 1	2	3	4	5	6	7	8
1971	69337	96968	42354	2675	426	81	0	0
1972	70002	55470	33899	5714	567	73	0	0
1973	132352	49815	4008	673	1289	67	0	0
1974	211139	308411	3652	285	611	109	0	0
1975	244969	280130	190536	4807	253	123	0	0
1976	183879	140921	71054	18013	174	41	0	0
1977	256628	103696	79317	33552	9317	129	0	0
1978	226872	154113	27257	10775	1244	570	0	0
1979	293166	215084	57578	18382	589	310	0	0
1980	226371	122561	932	687	193	86	0	0
1981	134142	193241	1850	373	431	55	0	0
1982	411307	204572	4624	1109	216	98	0	0
1983	261400	436331	30716	2235	804	72	0	0
1984	310675	313490	52651	24529	1492	69	0	0
1985	405385	229208	35566	2221	200	78	0	0
1986	1117345	490965	48510	26470	1451	146	0	0
1987	361519	1374202	180969	1427	1348	248	0	0
1988	348597	608109	459385	61167	882	177	0	0
1989	213291	485845	193176	85758	7224	115	0	0
1990	145314	279298	168674	28102	5011	177	0	0
1991	183126	301575	141567	40739	5528	939	0	0
1992	138755	219619	94581	34348	4307	880	0	0
1993	96371	154083	48088	11966	1635	216	0	0
1994	62122	95703	35703	1038	822	144	0	0
1995	118863	82676	15753	860	663	120	0	0
1996	111250	331065	27606	3930	451	116	0	0
1997	128653	510918	193828	588	271	108	0	0
1998	104538	646250	191631	53354	297	33	0	0

year	age 1	2	3	4	5	6	7	8
1999	127321	208401	231769	54869	278	58	0	0
2000	103468	171213	51092	64971	1230	241	263	167
2001	30346	352452	186900	74744	54276	152	45	1
2002	310442	178402	78296	13940	2834	718	109	1
2003	67798	523336	56580	20184	4358	419	5756	1
2004	233682	183508	127876	10650	1975	450	41	1
2005	93936	332157	46454	23763	4494	6007	287	6
2006	220982	226944	117342	9785	2369	251	736	195
2007	77687	210407	73043	13942	1594	7028	190	1644
2008	135504	255948	37983	5356	1785	336	8852	885
2009	148666	193174	68975	9471	2007	1108	138	3220
2010	167387	180364	59943	22776	2699	1736	2074	283
2011	117902	153773	62696	37050	12949	2924	143	2273
2012	91961	313013	123821	32986	9439	1547	226	7
2013	128227	156837	125878	24797	4679	1033	219	15
2014	293515	192537	116178	55315	19141	2610	478	67
2015	83433	288990	130826	38858	12591	2367	521	209
2016	79202	144049	133284	48501	21078	7479	2068	1857
2017	129559	144559	77236	59006	16045	3812	1268	268
2018	64618	266462	101461	39258	21422	4803	1480	243
2019	134628	115294	119574	29706	11845	8536	3134	1412

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

year	age 1	2	3	4	5	6	7	8	9	10
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

year	age 1	2	3	4	5	6	7	8	9	10
1988	348598	623309	713200	146514	60832	31669	19347	6198	3434	6402
1989	214545	532655	301448	324001	65991	21782	11605	8025	2321	5806
1990	146860	313064	273470	147931	174476	30123	9053	4689	3803	4206
1991	184551	344639	228763	162972	81603	79667	15410	5390	3215	5634
1992	142141	263388	180939	115818	92841	38422	30444	7229	3295	6976
1993	99787	207638	147893	92822	64910	35258	14745	11500	3704	5883
1994	63497	140257	141566	88030	48399	27824	17279	6661	5449	5458
1995	126642	119437	98402	85638	48574	24692	14746	5285	2495	3896
1996	112353	374411	95761	56891	37736	19276	12400	5881	2799	4989
1997	129550	554040	282515	49950	32021	18781	9518	5037	3054	4400
1998	104735	676844	266072	115693	23090	9184	5703	2870	1983	3360
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

year	age 1	2	3	4	5	6	7	8	9	10
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

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

year	age 1	2	3	4	5	6	7	8	9	10
1977	0.064	0.184	0.265	0.311	0.405	0.551	0.627	0.690	0.667	0.759
1978	0.064	0.151	0.319	0.373	0.411	0.467	0.547	0.630	0.704	0.773
1979	0.062	0.179	0.258	0.365	0.414	0.459	0.543	0.667	0.764	0.826
1980	0.049	0.163	0.289	0.428	0.444	0.524	0.582	0.651	0.778	1.025
1981	0.041	0.140	0.239	0.421	0.473	0.536	0.570	0.624	0.707	0.849
1982	0.048	0.128	0.250	0.351	0.490	0.589	0.631	0.679	0.726	0.828
1983	0.045	0.128	0.242	0.381	0.494	0.559	0.624	0.712	0.754	0.791
1984	0.048	0.129	0.216	0.413	0.464	0.571	0.649	0.692	0.787	0.898
1985	0.048	0.146	0.232	0.320	0.452	0.536	0.635	0.656	0.764	0.869
1986	0.043	0.126	0.245	0.311	0.440	0.533	0.692	0.779	0.888	0.971
1987	0.036	0.105	0.200	0.383	0.401	0.503	0.573	0.711	0.747	0.817
1988	0.036	0.097	0.172	0.264	0.426	0.467	0.547	0.644	0.706	0.897
1989	0.039	0.101	0.192	0.247	0.362	0.484	0.553	0.616	0.759	0.837
1990	0.043	0.108	0.176	0.261	0.343	0.422	0.555	0.647	0.701	0.760
1991	0.048	0.131	0.184	0.260	0.342	0.401	0.463	0.633	0.652	0.744
1992	0.043	0.121	0.199	0.270	0.318	0.403	0.500	0.573	0.683	0.730
1993	0.050	0.119	0.208	0.315	0.330	0.391	0.490	0.587	0.633	0.723
1994	0.053	0.141	0.214	0.290	0.360	0.404	0.462	0.533	0.653	0.702
1995	0.050	0.142	0.254	0.336	0.399	0.448	0.509	0.584	0.678	0.789
1996	0.044	0.117	0.229	0.368	0.390	0.462	0.488	0.554	0.660	0.791
1997	0.035	0.115	0.233	0.359	0.439	0.492	0.521	0.543	0.627	0.734
1998	0.038	0.081	0.207	0.333	0.474	0.577	0.581	0.648	0.656	0.642
1999	0.044	0.091	0.150	0.319	0.437	0.524	0.586	0.644	0.664	0.620
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

year	age 1	2	3	4	5	6	7	8	9	10
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

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

year	age 1	2	3	4	5	6	7	8	9	10
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

year	age 1	2	3	4	5	6	7	8	9	10
1994	0.229	0.263	0.284	0.333	0.375	0.417	0.491	0.610	0.731	0.906
1995	0.272	0.277	0.301	0.335	0.375	0.420	0.474	0.593	0.734	0.906
1996	0.240	0.279	0.304	0.346	0.415	0.465	0.490	0.553	0.712	0.858
1997	0.208	0.271	0.313	0.355	0.410	0.474	0.541	0.574	0.616	0.912
1998	0.151	0.260	0.306	0.384	0.452	0.546	0.613	0.673	0.687	0.899
1999	0.245	0.253	0.280	0.347	0.415	0.416	0.538	0.637	0.748	0.804
2000	0.228	0.267	0.283	0.312	0.378	0.461	0.597	0.689	0.752	0.888
2001	0.238	0.267	0.291	0.307	0.360	0.412	0.582	0.701	0.796	0.799
2002	0.237	0.264	0.289	0.311	0.336	0.430	0.477	0.644	0.760	0.904
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

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

year	age 1	2	3	4	5	6	7	8	9	10
1985	0.054	0.139	0.177	0.197	0.231	0.244	0.000	0.000	0.000	0.000
1986	0.049	0.124	0.181	0.196	0.220	0.244	0.244	0.000	0.000	0.000
1987	0.043	0.105	0.166	0.205	0.220	0.231	0.000	0.000	0.000	0.000
1988	0.043	0.098	0.153	0.185	0.220	0.244	0.000	0.000	0.000	0.000
1989	0.046	0.102	0.163	0.181	0.196	0.000	0.000	0.000	0.000	0.000
1990	0.051	0.111	0.157	0.186	0.212	0.231	0.000	0.000	0.000	0.000
1991	0.055	0.130	0.161	0.185	0.203	0.221	0.231	0.231	0.000	0.000
1992	0.050	0.122	0.167	0.188	0.204	0.212	0.231	0.244	0.000	0.000
1993	0.056	0.121	0.171	0.197	0.211	0.231	0.244	0.000	0.000	0.000
1994	0.060	0.140	0.175	0.194	0.213	0.244	0.244	0.221	0.000	0.000
1995	0.058	0.141	0.186	0.201	0.220	0.232	0.232	0.244	0.000	0.000
1996	0.052	0.122	0.179	0.205	0.221	0.232	0.000	0.000	0.000	0.000
1997	0.044	0.117	0.178	0.203	0.221	0.244	0.000	0.000	0.000	0.000
1998	0.047	0.086	0.170	0.199	0.220	0.000	0.244	0.000	0.000	0.000
1999	0.053	0.097	0.143	0.197	0.220	0.000	0.000	0.000	0.000	0.000
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

year	age 1	2	3	4	5	6	7	8	9	10
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

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

year	age									
	1	2	3	4	5	6	7	8	9	10
1974	0.056	0.121	0.343	0.404	0.472	0.552	0.609	0.693	0.707	0.926
1975	0.069	0.152	0.205	0.393	0.492	0.585	0.636	0.703	0.783	1.019
1976	0.088	0.181	0.262	0.347	0.509	0.592	0.641	0.705	0.741	0.980
1977	0.071	0.218	0.245	0.318	0.396	0.551	0.647	0.721	0.715	0.978
1978	0.070	0.190	0.315	0.364	0.432	0.486	0.609	0.687	0.776	0.950
1979	0.067	0.190	0.295	0.338	0.426	0.472	0.550	0.675	0.796	0.960
1980	0.056	0.197	0.343	0.399	0.471	0.542	0.588	0.662	0.772	1.013
1981	0.048	0.183	0.327	0.415	0.502	0.556	0.604	0.642	0.725	1.007
1982	0.056	0.152	0.308	0.421	0.512	0.606	0.664	0.712	0.738	0.984
1983	0.052	0.153	0.275	0.379	0.507	0.602	0.677	0.771	0.815	0.984
1984	0.053	0.150	0.265	0.321	0.470	0.588	0.677	0.726	0.839	1.036
1985	0.054	0.169	0.268	0.333	0.444	0.562	0.667	0.730	0.807	1.021
1986	0.049	0.141	0.275	0.311	0.402	0.472	0.668	0.750	0.856	1.014
1987	0.043	0.113	0.219	0.343	0.375	0.471	0.574	0.728	0.835	0.993
1988	0.043	0.102	0.197	0.276	0.415	0.477	0.590	0.680	0.808	1.017
1989	0.047	0.118	0.215	0.291	0.364	0.512	0.591	0.668	0.785	0.940
1990	0.053	0.130	0.211	0.290	0.360	0.440	0.586	0.690	0.761	1.010
1991	0.056	0.149	0.211	0.273	0.349	0.449	0.526	0.666	0.743	0.924
1992	0.055	0.145	0.226	0.275	0.324	0.410	0.530	0.607	0.719	0.891
1993	0.063	0.160	0.250	0.303	0.340	0.407	0.512	0.630	0.720	0.856
1994	0.064	0.179	0.257	0.331	0.372	0.416	0.491	0.610	0.731	0.906
1995	0.071	0.183	0.283	0.334	0.373	0.419	0.474	0.593	0.734	0.906
1996	0.054	0.140	0.268	0.336	0.413	0.464	0.490	0.553	0.712	0.858
1997	0.045	0.129	0.220	0.353	0.408	0.473	0.541	0.574	0.616	0.912
1998	0.047	0.094	0.208	0.299	0.449	0.544	0.613	0.673	0.687	0.899
1999	0.054	0.103	0.199	0.267	0.413	0.414	0.538	0.637	0.748	0.804
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

year	age 1	2	3	4	5	6	7	8	9	10
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

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

BTS–Isis	age								
year	1	2	3	4	5	6	7	8	9
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	23091.8	23553.8	5082.2	1843.9	1408.3	580.9	243.7	136.7	62.1
1997	20419.4	9728.2	3985.2	1332.8	474.4	312.4	71.0	174.4	26.0
1998	33558.9	87255.1	9738.2	2724.3	655.6	379.0	223.2	188.7	72.4
1999	36213.7	8495.5	12448.0	2325.8	848.9	319.8	103.4	95.8	48.1
2000	39524.2	22614.8	9249.8	10118.8	632.3	218.8	108.2	95.3	17.0
2001	28685.2	20774.4	7088.8	3585.8	3593.0	284.7	92.7	74.0	58.0
2002	120675.0	16881.6	7257.8	3995.1	2232.6	1632.2	284.3	139.2	47.0
2003	29807.2	46913.3	7067.1	3590.3	1695.8	975.3	958.2	76.5	56.2
2004	41466.1	15120.3	17968.1	3129.4	1614.7	931.9	531.9	825.2	49.6
2005	39068.8	29087.9	4915.8	7303.8	1047.1	1106.9	381.9	89.5	886.7
2006	44088.6	19019.6	9326.7	2457.5	3939.3	641.3	764.9	110.5	148.5
2007	66955.6	22749.1	11059.4	7956.2	1748.4	2635.1	307.9	633.7	77.7
2008	67826.8	43424.2	12161.5	6384.3	4438.3	963.8	1559.2	295.0	468.6
2009	59008.7	25442.7	19830.7	5376.9	3287.9	2521.6	655.8	1456.4	284.8
2010	70879.2	28173.4	14169.8	10387.3	3154.9	1748.3	1765.3	608.0	1007.5
2011	113837.9	41772.6	18603.9	9393.2	6203.6	1994.2	902.6	1577.7	232.9
2012	51593.9	61728.0	38602.6	14123.7	6915.8	4489.2	1401.1	1101.4	1542.9
2013	76878.2	52494.5	39866.6	19959.4	7362.3	4378.2	3188.3	1273.5	790.3
2014	125983.4	60773.0	27631.6	21128.2	8739.1	3719.0	2214.4	1737.7	993.7
2015	46705.2	67615.6	35379.9	17480.2	13184.7	6823.6	2296.1	1655.6	1545.1
2016	74804.8	31826.3	33426.3	18531.7	9621.7	6610.7	3674.7	1680.5	1095.2
2017	122293.9	50536.6	18302.8	20148.0	10498.9	5087.7	3084.2	1940.7	672.0
2018	74604.2	70950.2	22422.5	11686.1	11375.8	5516.1	3356.9	1909.4	1604.1
2019	291687.7	58670.4	31581.3	9933.6	6885.2	4932.7	2916.3	2216.3	1223.5

	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							
1991	57221	11247	1518	1077	128	74.4							
1992	46798	13842	2268	613	176	52.0							
1993	22098	9686	1006	98	60	58.8							
1994	19188	4977	856	76	23	2.7							
1995	24767	2796	381	97	38	0.0							
1996	23015	10268	1185	45	47	0.0							

	SNS1							SNS2					
	age							age					
year	1	2	3	4	5	6	year	1	2	3	4	5	6
1997	95901	4473	497	32	0	13.3							
1998	33666	30242	5014	50	10	0.0							
1999	32951	10272	13783	1058	17	0.0							

IBTS–Q3	1	2	3	4	5	6	7	8	9
1997	3421.0	3405.4	1952.7	519.5	214.5	161.8	77.7	54.9	51.6
1998	1057.5	5074.3	1699.7	833.6	316.6	137.7	86.0	92.7	42.7
1999	927.7	2288.5	4306.6	706.6	277.5	133.2	46.8	45.3	31.1
2000	947.0	1758.5	1940.9	2137.4	225.1	124.9	54.4	41.6	12.7
2001	1172.0	3259.8	2085.7	1125.8	1155.8	174.0	79.0	63.6	51.0
2002	6104.2	2848.9	2336.5	1265.5	673.7	434.2	101.9	91.7	43.5
2003	1381.9	4931.1	1669.0	1022.9	462.3	270.6	274.2	50.4	54.0
2004	2517.2	2544.3	4009.6	929.0	608.9	304.6	185.8	228.9	42.7
2005	1966.7	4701.2	1591.0	2293.6	404.9	492.0	231.9	79.4	228.6
2006	2215.1	3053.8	3744.9	1095.5	1228.2	391.5	398.2	153.9	83.7
2007	5646.0	4649.8	3680.6	3189.6	819.3	1295.6	326.2	446.7	115.4
2008	6096.8	10636.9	5013.6	3367.5	2167.3	724.3	728.0	306.9	269.6
2009	2768.3	4979.4	7593.2	2755.3	1696.4	1184.2	448.7	725.4	190.6
2010	3209.1	4914.5	5339.7	4820.8	1610.0	1135.7	1068.8	470.2	649.4
2011	6569.7	8955.2	7309.7	4767.1	3381.8	1261.8	842.2	1043.6	265.0
2012	2428.2	10861.5	11295.9	6269.6	3510.2	2438.9	1095.4	880.9	909.1
2013	2691.8	6778.6	9570.8	6334.5	3314.8	2043.9	1535.0	719.2	474.9
2014	5218.5	8912.2	7676.7	6370.3	3206.3	1484.5	1047.0	753.1	473.8
2015	1696.9	7367.3	8248.9	5977.3	4572.1	2543.2	1280.9	940.0	780.2
2016	3151.0	4915.9	7315.1	5539.4	3060.4	2323.4	1529.7	967.0	754.4
2017	4029.3	4850.1	3488.6	4431.1	2883.9	1750.9	1136.5	872.7	510.7
2018	2182.0	6071.4	3933.4	2476.7	2433.9	1592.6	1222.3	751.1	632.7

2019	5956.2	5398.9	4184.8	2059.1	1333.5	1051.1	738.8	627.5	342.9

IBTS–Q1	1	2	3	4	5	6	7
2007	2347.0	5070.9	5616.9	5904.0	2068.8	1056.3	551.1
2008	2487.4	10800.4	7435.0	3425.7	2608.3	705.7	650.2
2009	2869.2	7310.5	12796.3	4152.5	2153.8	888.3	453.0
2010	1428.6	5715.7	9189.4	7834.7	3472.3	1375.2	929.1
2011	1176.6	5836.8	6387.9	6307.7	5085.1	1722.1	905.0
2012	1924.6	13685.6	15249.0	6918.4	4913.6	3242.9	1296.0
2013	1385.7	5075.4	10114.4	6546.9	3246.3	1831.9	932.1
2014	2726.2	7220.5	8901.0	8523.3	4879.7	1770.8	1023.5
2015	868.3	9633.1	10762.8	8509.6	6067.6	2760.7	1186.7
2016	2122.4	5288.9	9433.4	7272.5	5122.4	2394.1	1366.8
2017	1978.1	6622.6	4212.8	6846.7	4546.2	2864.0	1403.4
2018	673.7	5952.3	6103.7	2191.5	3100.0	1817.6	1258.2
2019	4274.0	4258.8	6566.2	3165.9	1715.8	1428.0	1264.3

Table 13.3.1. Plaice in Subarea 4 and Subdivision 20: Estimated parameters from AAP model in final run.

Number of parameters = 285 Objective function value = 352.406 Maximum gradient component = 0.000381751
logsigmaC:
-0.447492 -0.639882 0.0585298

logsigmaU:
-0.420651 -0.261830 0.0335281
-0.360839 -0.420609 0.0457754
-1.30235 0.410410 -0.0206114
-1.32790 0.271006 0.00605274
-0.638444 -0.431894 0.0483787
-0.691592 -0.477648 0.0631315

log_sel_coff1:
-1.30440 -0.649506 -0.721507 -1.29145 -0.962371 -0.230279 -0.310094 0.0252758 0.373288 0.151231 -0.117092 0.188729 0.180333 -0.203052 0.00429395 -0.405724 -0.671373 -0.480066 -0.480950 -0.153045 -0.573577 -0.452209 -1.13938 -0.556370 -0.734712 -1.47342 -0.116605 0.291551 0.310697 0.577986 0.291939 0.472560 0.418019 0.657095 0.539799 0.852053 0.868759 0.668508 0.900962 0.796708 0.873117 0.627763 1.21414 0.588982 0.880920 0.613626 0.367561 -0.215860 -0.214395 -0.204196 0.105768 -0.0863723 0.154909 0.334953 0.333237 0.479614 0.404119 0.318181 0.532812 0.772272 0.620525 0.786514 0.902632 0.860200 0.957896 0.922678 0.847554 0.936958 0.942221 1.05153 0.723380 0.368225 -0.106030 -0.420303 -0.318141 -0.347321 -0.0780339 -0.358650 -0.184513 0.220894 0.341290 0.471969 0.424122 0.434982 0.433034 0.633833 0.534957 0.736088 0.555850 0.659181 1.05626 0.925191 1.15180 0.856235 1.02176 0.759870 0.740134 0.134512 -0.450962 -1.02574 -0.851174 -0.942484 -0.653576 -1.01319 -0.106315 -0.133128 0.0645415 0.162156 0.0466545 0.319732 0.270147 0.425573 0.339306 0.534860 0.434226 0.365805 0.762655 0.644161 0.761296 0.889738 0.691959 0.165957 0.0951252 -0.336087 -1.02882 -1.34639 -1.77214 -1.70168 -1.61004 -1.72304 -0.249898 -0.0335808 -0.315921 0.0827175 -0.213872 0.0160152 0.224451 0.414903 0.207121 0.191218 0.304165 0.226923 0.452833 0.467246 0.660335 0.440129 0.486936 -0.232691 -0.798872 -1.59878 -1.97674 -2.78839 -2.41852 -2.72497 -2.70773 -3.15174

log_sel_cofU:
-8.11670 -7.75686 -8.73858 -9.96088 -10.7898 -10.6642
-2.83326 -2.79987 -3.42758 -3.58874 -4.06546 -4.41682
-3.33994 -3.38940 -4.52213 -7.05169 -8.28306 -8.68730
-4.29134 -5.34482 -6.49327 -7.68371 -8.68313 -8.98988
-5.97108 -5.13888 -4.62364 -4.70387 -5.06192 -5.13171
-6.50744 -5.27416 -4.20718 -4.56840 -4.46453 -5.00611

log_initpop:
12.4899 12.8006 12.3179 11.9176 11.0087 11.0507 10.8100 10.3550 11.1293 13.0771 13.4739 13.6821 13.6039 13.6680 13.3275 13.3176 14.7164 13.4063 13.2678 12.9699 12.9465 13.4174 13.4229 12.9604 12.7996 14.1722 13.9044 13.5782 13.4083 13.8457 13.6832 13.7327 13.9091 13.8152 14.4656 14.1174 14.0834 14.4331 15.3018 14.4420 14.3664 14.0629 13.9426 13.8027 13.6066 13.1949 13.3363 13.8395 13.6927 14.6187 13.6171 13.5676 13.7391 13.3448 14.3947 13.3738 14.1840 13.7631 13.7529 14.2477 14.1129 14.0398 14.2682 14.3389 14.1538 14.2401 14.2951 13.7378 13.8203 14.1573 13.7785 14.8684

Table 13.3.2. Plaice in Subarea 4 and Subdivision 20: Harvest (F) at age.

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.101	0.175	0.263	0.305	0.255	0.212	0.225	0.228	0.204	0.204
1958	0.114	0.211	0.308	0.329	0.292	0.247	0.222	0.220	0.234	0.234
1959	0.127	0.244	0.346	0.347	0.325	0.282	0.225	0.215	0.249	0.249
1960	0.137	0.261	0.358	0.352	0.343	0.310	0.239	0.214	0.231	0.231
1961	0.138	0.259	0.354	0.349	0.348	0.330	0.264	0.219	0.197	0.197
1962	0.123	0.258	0.368	0.355	0.354	0.348	0.292	0.233	0.187	0.187
1963	0.096	0.268	0.423	0.381	0.370	0.371	0.313	0.257	0.219	0.219
1964	0.075	0.275	0.484	0.412	0.390	0.389	0.320	0.275	0.266	0.266
1965	0.068	0.261	0.478	0.420	0.401	0.391	0.308	0.266	0.271	0.271
1966	0.077	0.238	0.415	0.401	0.398	0.379	0.291	0.241	0.233	0.233
1967	0.100	0.237	0.369	0.375	0.386	0.372	0.290	0.233	0.205	0.205
1968	0.142	0.275	0.371	0.355	0.369	0.379	0.319	0.257	0.214	0.214
1969	0.190	0.327	0.395	0.349	0.358	0.389	0.354	0.298	0.246	0.246
1970	0.209	0.341	0.404	0.359	0.361	0.384	0.362	0.319	0.276	0.276
1971	0.196	0.317	0.399	0.388	0.380	0.374	0.344	0.317	0.298	0.298
1972	0.187	0.307	0.413	0.435	0.417	0.380	0.338	0.319	0.323	0.323
1973	0.204	0.338	0.462	0.497	0.470	0.416	0.361	0.344	0.358	0.358
1974	0.244	0.386	0.511	0.541	0.512	0.453	0.391	0.370	0.385	0.385
1975	0.297	0.409	0.503	0.531	0.507	0.452	0.391	0.367	0.376	0.376
1976	0.347	0.404	0.457	0.487	0.473	0.424	0.370	0.344	0.341	0.341
1977	0.372	0.408	0.442	0.464	0.458	0.420	0.368	0.331	0.310	0.310
1978	0.355	0.440	0.490	0.488	0.484	0.462	0.403	0.345	0.299	0.299
1979	0.312	0.480	0.576	0.541	0.524	0.509	0.447	0.371	0.305	0.305
1980	0.266	0.493	0.649	0.596	0.540	0.506	0.454	0.388	0.322	0.322
1981	0.234	0.474	0.673	0.632	0.529	0.459	0.423	0.386	0.341	0.341
1982	0.229	0.442	0.641	0.637	0.515	0.418	0.384	0.366	0.345	0.345
1983	0.255	0.415	0.574	0.613	0.518	0.411	0.361	0.339	0.329	0.329
1984	0.297	0.411	0.529	0.592	0.544	0.446	0.370	0.332	0.319	0.319

year	age 1	2	3	4	5	6	7	8	9	10
1985	0.329	0.443	0.547	0.600	0.600	0.535	0.432	0.367	0.337	0.337
1986	0.329	0.491	0.608	0.629	0.667	0.653	0.531	0.433	0.377	0.377
1987	0.294	0.501	0.651	0.654	0.699	0.712	0.591	0.478	0.405	0.405
1988	0.242	0.455	0.636	0.655	0.676	0.665	0.562	0.467	0.404	0.404
1989	0.210	0.418	0.609	0.637	0.646	0.617	0.516	0.441	0.403	0.403
1990	0.217	0.437	0.613	0.608	0.653	0.657	0.518	0.440	0.435	0.435
1991	0.246	0.481	0.627	0.585	0.684	0.751	0.562	0.465	0.482	0.482
1992	0.254	0.466	0.602	0.581	0.691	0.773	0.605	0.499	0.489	0.489
1993	0.221	0.385	0.540	0.602	0.656	0.679	0.618	0.527	0.440	0.440
1994	0.178	0.337	0.529	0.631	0.619	0.597	0.616	0.542	0.399	0.399
1995	0.147	0.384	0.641	0.650	0.611	0.610	0.616	0.537	0.408	0.408
1996	0.132	0.489	0.830	0.662	0.629	0.673	0.594	0.499	0.430	0.430
1997	0.132	0.512	0.875	0.683	0.655	0.674	0.519	0.419	0.394	0.394
1998	0.145	0.407	0.701	0.709	0.675	0.583	0.415	0.324	0.296	0.296
1999	0.157	0.321	0.551	0.710	0.673	0.504	0.344	0.256	0.212	0.212
2000	0.156	0.325	0.540	0.660	0.639	0.497	0.329	0.224	0.165	0.165
2001	0.153	0.387	0.606	0.582	0.576	0.517	0.339	0.209	0.135	0.135
2002	0.166	0.438	0.628	0.506	0.492	0.483	0.330	0.188	0.103	0.103
2003	0.199	0.429	0.556	0.444	0.404	0.384	0.283	0.157	0.072	0.072
2004	0.220	0.389	0.471	0.386	0.325	0.287	0.221	0.123	0.053	0.053
2005	0.193	0.354	0.423	0.327	0.263	0.223	0.165	0.095	0.045	0.045
2006	0.155	0.319	0.384	0.272	0.212	0.177	0.124	0.074	0.040	0.040
2007	0.145	0.276	0.321	0.225	0.168	0.136	0.099	0.060	0.031	0.031
2008	0.161	0.230	0.248	0.192	0.135	0.104	0.086	0.050	0.021	0.021
2009	0.164	0.192	0.203	0.175	0.119	0.087	0.076	0.043	0.016	0.016
2010	0.125	0.169	0.196	0.177	0.125	0.087	0.065	0.038	0.017	0.017
2011	0.089	0.158	0.208	0.187	0.141	0.094	0.056	0.034	0.021	0.021
2012	0.084	0.158	0.213	0.190	0.147	0.096	0.052	0.031	0.023	0.023

year	age 1	2	3	4	5	6	7	8	9	10
2013	0.109	0.168	0.205	0.184	0.139	0.091	0.053	0.031	0.020	0.020
2014	0.145	0.185	0.206	0.185	0.136	0.089	0.056	0.032	0.017	0.017
2015	0.156	0.206	0.232	0.206	0.151	0.099	0.060	0.033	0.016	0.016
2016	0.137	0.221	0.270	0.234	0.173	0.113	0.063	0.033	0.017	0.017
2017	0.108	0.216	0.290	0.243	0.178	0.116	0.064	0.033	0.016	0.016
2018	0.081	0.193	0.278	0.225	0.157	0.104	0.061	0.031	0.014	0.014
2019	0.060	0.165	0.252	0.196	0.129	0.087	0.058	0.029	0.011	0.011

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	477885	265631	362453	223660	149879	60400	62987	49514	31414	68142
1958	710645	390744	201859	252091	149129	105106	44223	45517	35656	73490
1959	875113	573545	286303	134241	164180	100810	74297	32036	33039	78173
1960	809279	697325	406444	183334	85856	107360	68788	53662	23383	78422
1961	862838	638528	486256	256978	116667	55103	71227	48994	39221	73123
1962	613837	680025	445747	308766	164039	74517	35851	49482	35628	83449
1963	607810	490967	475366	279249	195905	104228	47605	24219	35469	89382
1964	2461850	499483	339957	281707	172549	122450	65090	31498	16948	90789
1965	664199	2066530	343447	189655	168817	105699	75062	42785	21646	74690
1966	578267	561221	1440730	192741	112754	102281	64690	49911	29665	66457
1967	429294	484643	400307	860780	116754	68510	63334	43760	35480	68925
1968	419357	351455	346111	250470	535422	71836	42732	42863	31379	76937
1969	671593	329318	241662	216081	158858	334810	44488	28112	29984	79096
1970	675267	502718	214972	147338	137984	100446	205405	28241	18891	77199
1971	425222	495869	323546	129862	93131	87056	61877	129417	18575	65948
1972	362072	316164	326650	196380	79741	57643	54201	39677	85299	56753
1973	1428550	271639	210415	195626	114961	47529	35657	34986	26085	93044

year	age 1	2	3	4	5	6	7	8	9	10
1974	1092920	1053810	175318	119919	107738	64981	28373	22481	22447	75330
1975	788766	775070	648285	95144	63172	58409	37376	17367	14053	60212
1976	665497	530542	466017	354815	50635	34411	33646	22875	10883	46140
1977	1030690	425489	320434	266915	197289	28548	20366	21021	14676	36686
1978	876090	643011	256060	186362	151901	112973	16967	12754	13657	34074
1979	920549	556059	374590	141875	103527	84731	64432	10259	8169	32017
1980	1098120	609560	311377	190462	74712	55450	46072	37299	6402	26814
1981	999711	761506	337009	147195	94938	39382	30262	26480	22894	21782
1982	1915720	715890	428986	155531	70790	50612	22524	17941	16294	28745
1983	1352420	1378970	416319	204543	74446	38262	30149	13883	11264	28871
1984	1307240	948264	823629	212186	100220	40142	22947	19023	8949	26137
1985	1854500	878772	568981	438903	106210	52659	23257	14344	12350	23085
1986	4420730	1208140	510622	297845	218042	52764	27910	13659	8991	22886
1987	1871050	2877730	669115	251454	143638	101286	24846	14855	8019	19787
1988	1734770	1261380	1578210	315826	118278	64612	44989	12455	8335	16779
1989	1280620	1231690	724054	755879	148403	54453	30070	23211	7062	15174
1990	1135470	938815	733898	356365	361757	70405	26577	16245	13514	13443
1991	987306	826829	548825	359871	175474	170312	33009	14321	9470	15785
1992	811477	698780	462617	265203	181458	80132	72748	17022	8143	14112
1993	537594	569623	396716	229378	134173	82298	33478	35938	9355	12355
1994	619267	390091	350838	209091	113628	62986	37752	16322	19202	12650
1995	1024310	469170	251921	187051	100616	55386	31365	18442	8589	19339
1996	884461	800092	289113	120032	88327	49441	27227	15335	9751	16810
1997	2232740	701278	444012	114074	55996	42629	22831	13606	8425	15629
1998	820045	1770060	380116	167559	52160	26310	19664	12293	8095	14682
1999	780402	642106	1066330	170711	74620	24040	13290	11750	8042	15326
2000	926395	603513	421414	555881	75918	34458	13138	8528	8233	17104
2001	624547	716907	394682	222106	259855	36261	18960	8557	6168	19430

year	age 1	2	3	4	5	6	7	8	9	10
2002	1784620	485094	440538	194908	112353	132228	19558	12217	6283	20240
2003	642943	1368430	283136	212793	106287	62146	73810	12718	9157	21658
2004	1445570	476878	806600	146918	123467	64234	38309	50309	9839	25945
2005	948934	1050010	292360	455631	90350	80691	43608	27778	40236	30707
2006	939320	708215	667159	173336	297235	62832	58431	33463	22856	61345
2007	1540570	728233	465813	411213	119487	217511	47649	46725	28125	73177
2008	1346380	1206360	499854	305810	296983	91399	171769	39047	39836	88868
2009	1251490	1037020	867316	352963	228445	234897	74550	142653	33600	114066
2010	1572540	960935	774041	640632	268073	183426	194849	62550	123594	131517
2011	1687760	1255350	734164	575679	485561	213967	152216	165275	54503	226966
2012	1402570	1396810	969560	539651	431958	381529	176304	130254	144610	249379
2013	1528950	1167250	1078650	709214	403772	337379	313646	151469	114207	348491
2014	1615450	1241050	892559	794849	533764	317814	278718	269266	132844	410473
2015	925208	1263850	932885	657108	597485	421426	262967	238465	235992	483410
2016	1004770	716300	930542	669523	483977	464765	345421	224054	208818	640353
2017	1407470	793084	519783	642933	479578	368276	375728	293364	196120	755424
2018	963668	1143530	578029	351950	456205	363293	296733	318942	256946	847067
2019	2865930	803982	852812	395885	254260	352764	296201	252483	279794	985141

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	477885	342253.4	78800.26	71266.45	7534	0.242	0.201	0.095	0.21
1958	710645	355200.4	88427.46	73894.62	14533	0.277	0.202	0.173	0.21
1959	875113	362388.6	104338.66	77625.42	26713	0.309	0.196	0.211	0.21
1960	809279	381206.3	118104.42	88857.48	29247	0.325	0.239	0.201	0.23
1961	862838	393096.1	120603.21	85755.04	34848	0.328	0.221	0.256	0.22
1962	613837	483299.4	126530.31	90371.51	36159	0.336	0.213	0.259	0.19
1963	607810	441514.2	139789.07	102880.54	36909	0.363	0.227	0.311	0.23
1964	2461850	431491.1	147147.61	111087.10	36061	0.390	0.248	0.273	0.26
1965	664199	384933.1	152837.48	106357.15	46480	0.390	0.276	0.267	0.28
1966	578267	404360.9	163119.85	98472.48	64647	0.366	0.230	0.290	0.24
1967	429294	473119.4	152295.50	102455.05	49840	0.348	0.203	0.249	0.22
1968	419357	460228.7	148823.45	120387.21	28436	0.350	0.223	0.218	0.26
1969	671593	404611.5	147488.63	123845.90	23643	0.363	0.264	0.183	0.31
1970	675267	371825.8	140306.02	114711.02	25595	0.370	0.269	0.226	0.31
1971	425222	360019.8	141384.67	117293.31	24091	0.372	0.280	0.212	0.33
1972	362072	363380.7	144951.09	126681.35	18270	0.391	0.315	0.163	0.35
1973	1428550	302825.2	148928.06	131191.32	17737	0.437	0.387	0.115	0.43
1974	1092920	302290.8	162010.89	117382.77	44628	0.481	0.400	0.194	0.39
1975	788766	304635.2	172127.90	97971.25	74157	0.480	0.317	0.372	0.32
1976	665497	327045.4	176510.89	122676.67	53834	0.449	0.325	0.270	0.38
1977	1030690	325152.3	160618.45	104967.02	55651	0.438	0.287	0.274	0.32
1978	876090	327361.3	173794.81	125303.19	48492	0.473	0.358	0.236	0.38
1979	920549	306141.8	175835.40	122344.57	53491	0.526	0.381	0.283	0.40
1980	1098120	321980.2	190653.20	154939.59	35714	0.557	0.490	0.162	0.48
1981	999711	290014.1	187211.56	152943.20	34268	0.553	0.487	0.159	0.53
1982	1915720	280553.9	190756.39	144813.00	45943	0.531	0.453	0.186	0.52
1983	1352420	334751.6	206000.60	139848.85	66152	0.506	0.411	0.223	0.42
1984	1307240	365740.9	222069.96	158418.05	63652	0.504	0.382	0.213	0.43
1985	1854500	400506.7	251611.34	184780.46	66831	0.545	0.454	0.221	0.46

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1986	4420730	415515.6	296548.54	175124.61	121424	0.610	0.468	0.285	0.42
1987	1871050	469799.7	316583.16	158602.66	157980	0.643	0.466	0.432	0.34
1988	1734770	414406.5	299445.29	160539.90	138905	0.617	0.389	0.427	0.39
1989	1280620	447476.1	280613.45	181891.69	98722	0.585	0.383	0.386	0.41
1990	1135470	407034.8	257131.49	177359.27	79772	0.594	0.413	0.384	0.44
1991	987306	368789.8	235939.77	157665.70	78274	0.625	0.423	0.404	0.43
1992	811477	311899.9	194037.56	135556.46	58481	0.622	0.437	0.352	0.43
1993	537594	276214.8	162946.81	130157.15	32790	0.573	0.461	0.231	0.47
1994	619267	239590.4	141642.65	119315.77	22327	0.543	0.466	0.182	0.50
1995	1024310	240929.7	141444.72	116505.31	24939	0.579	0.502	0.184	0.48
1996	884461	222884.5	150659.59	104416.50	46243	0.657	0.511	0.336	0.47
1997	2232740	214596.1	153642.97	82636.74	71006	0.680	0.462	0.536	0.39
1998	820045	240858.2	148162.85	66864.81	81298	0.615	0.369	0.446	0.28
1999	780402	239049.7	156284.72	89327.27	66957	0.552	0.347	0.318	0.37
2000	926395	268137.2	158134.53	107870.50	50264	0.532	0.369	0.299	0.40
2001	624547	274626.0	138274.92	70303.81	67971	0.533	0.264	0.405	0.26
2002	1784620	259644.7	141026.10	86402.21	54624	0.510	0.330	0.379	0.33
2003	642943	295395.3	139238.64	68842.88	70396	0.443	0.271	0.344	0.23
2004	1445570	303916.8	137290.62	79598.96	57692	0.372	0.227	0.305	0.26
2005	948934	346991.3	121119.02	64631.90	56487	0.318	0.160	0.296	0.19
2006	939320	394164.0	118025.98	66427.39	51599	0.273	0.153	0.261	0.17
2007	1540570	405765.7	103322.42	59405.66	43917	0.225	0.116	0.227	0.15
2008	1346380	517522.3	107425.85	60403.87	47022	0.182	0.111	0.161	0.12
2009	1251490	643553.2	110889.53	65041.34	45848	0.155	0.089	0.144	0.10
2010	1572540	792570.2	117884.98	74668.25	43217	0.151	0.086	0.130	0.09
2011	1687760	824392.3	122416.29	77620.22	44796	0.158	0.082	0.133	0.09
2012	1402570	874477.7	130781.53	82429.97	48352	0.161	0.082	0.149	0.09
2013	1528950	990615.7	133071.38	90991.58	42080	0.158	0.086	0.147	0.09
2014	1615450	1148875.3	131192.29	80635.56	50557	0.161	0.069	0.167	0.07

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
2015	925208	1069939.9	138913.03	92179.11	46734	0.179	0.081	0.189	0.09
2016	1004770	1147046.5	141742.46	93385.48	48357	0.202	0.088	0.211	0.08
2017	1407470	1213531.3	131457.14	88616.71	42840	0.209	0.088	0.214	0.07
2018	963668	1152049.4	101136.65	59275.28	41861	0.192	0.072	0.206	0.05
2019	2865930	1052312.4	93839.02	53967.45	39872	0.166	0.063	0.170	0.05

Table 13.4.1. Plaice in Subarea 4 and Subdivision 20: Input table for RCT3 analysis.

Year–class	age 1 AAP	age 2 AAP	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1978	920549	605875	NA	NA	12882.300	NA	NA	NA
1979	1098120	756982	NA	NA	18785.300	NA	NA	NA
1980	999711	722164	NA	NA	8642.000	NA	NA	NA
1981	1915720	1385660	NA	NA	13908.600	NA	NA	NA
1982	1352420	951873	NA	NA	10412.800	NA	NA	NA
1983	1307240	874272	NA	NA	13847.800	NA	NA	NA
1984	1854500	1181680	NA	NA	7580.400	NA	NA	NA
1985	4420730	2827550	NA	NA	32991.100	NA	NA	NA
1986	1871050	1274770	NA	NA	14421.100	NA	NA	NA
1987	1734770	1255600	NA	NA	17810.200	NA	NA	NA
1988	1280620	926940	NA	NA	7496.000	NA	NA	NA
1989	1135470	800409	NA	NA	11247.200	NA	NA	NA
1990	987306	688318	NA	NA	13841.800	NA	NA	439.6000
1991	811477	586968	NA	NA	9685.600	NA	NA	332.4000
1992	537594	408199	NA	NA	4976.600	NA	NA	180.3000
1993	619267	457421	NA	NA	2796.400	NA	NA	217.0000
1994	1024310	722667	NA	NA	10268.200	NA	23553.786	283.4000
1995	884461	651071	NA	NA	4472.700	23091.77	9728.237	146.1000
1996	2232740	1874820	NA	NA	30242.200	20419.38	87255.143	619.6000
1997	820045	651341	NA	NA	10272.100	33558.90	8495.522	229.2000
1998	780402	564782	NA	NA	2493.400	36213.65	22614.769	NA
1999	926395	646646	NA	22855.000	2898.500	39524.21	20774.421	NA
2000	624547	463267	24213.50	11510.524	1102.700	28685.17	16881.559	124.9000
2001	1784620	1389210	99628.05	30809.227	NA	120675.03	46913.306	313.2000
2002	642943	450941	31202.02	NA	1349.700	29807.17	15120.298	122.9000
2003	1445570	933906	NA	18201.602	1818.900	41466.14	29087.867	238.6000
2004	948934	618243	13537.18	10118.405	1571.000	39068.83	19019.617	126.7000
2005	939320	660013	27390.56	12164.222	2133.900	44088.64	22749.143	85.9000
2006	1540570	1125810	51124.24	14174.543	2700.400	66955.63	43424.241	168.0000

Year–class	age 1 AAP	age 2 AAP	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
2007	1346380	933240	40580.90	14705.767	2018.700	67826.82	25442.669	98.3000
2008	1251490	857361	50179.33	14860.033	1811.500	59008.66	28173.439	129.7000
2009	1572540	1139010	53258.82	11946.907	1142.500	70879.18	41772.623	141.9000
2010	1687760	1321860	49347.24	18348.596	2928.600	113837.89	61727.971	179.6000
2011	1402570	1113120	52643.00	5893.440	3021.300	51593.89	52494.484	93.0000
2012	1528950	1231720	45027.08	15394.879	2258.300	76878.20	60773.047	181.1000
2013	1615450	1287570	44327.52	17312.697	5040.400	125983.44	67615.550	168.5000
2014	925208	711007	11722.34	16726.486	2434.300	46705.17	31826.301	108.0000
2015	1004770	NA	30494.46	10384.821	1715.500	74804.78	50536.638	100.2000
2016	NA	NA	44110.99	15935.908	5250.000	122293.93	70950.156	78.0500
2017	NA	NA	27396.53	9464.911	1885.619	74604.22	58670.426	127.2000
2018	NA	NA	190207.50	28308.590	NA	291687.68	NA	219.3400
2019	NA	NA	24808.88	NA	NA	NA	NA	200.1965

Table 13.4.2. Plaice in Subarea 4 and Subdivision 20. RCT3 results for age 1 in 2019 (year class 2018).

```
Analysis by RCT3 ver4.0

Data for 6 surveys over 42 years : 1977 - 2018
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2018
   index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
    SNS0 0.8799    4.6976 0.3587 0.52844 14  12.156      15.39  0.5056     0.39561
    DFS0 2.6935   -0.1081 1.3329 0.08436 23   5.391      14.41  1.4298     0.04948
 VPA Mean     NA        NA     NA      NA 38      NA      13.96  0.4269     0.55491

                WAP logWAP int.se
yearclass:2018 2084830  14.55  0.318
```

Table 13.4.3. Plaice in Subarea 4 and Subdivision 20: RCT3 results for age 2 in 2019 (year class 2017).

```
Data for 6 surveys over 42 years : 1978 - 2019
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.
 yearclass:2019
 index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
  SNS0 0.8666     4.886 0.3484 0.50742 15  10.119      13.65  0.3929     0.51561
  SNS1 2.7623   -12.419 1.0276 0.08223 16      NA         NA      NA          NA
  SNS2 1.0053     5.395 0.8970 0.18167 37      NA         NA      NA          NA
  BTSC1 1.2909    -0.018 0.5833 0.28014 21      NA         NA      NA          NA
  BTSC2 0.6857     6.890 0.2528 0.66446 22      NA         NA      NA          NA
  DFS0 3.2791    -3.033 1.6584 0.05300 24   5.299      14.34  1.7704     0.02539
  VPA Mean     NA        NA     NA      NA 38      NA      13.99  0.4164     0.45899

                 WAP logWAP int.se
yearclass:2019 1012237  13.83 0.2821
```

Table 13.5.1. Plaice in Subarea 4 and Subdivision 20: Input to the short term forecast (F values presented are for Fsq).

2020_ssb	2020_f2–6	2020_f_dis2–3	2020_f_hc2–6	2020_recruits	2020_landings	2020_discards	2020_catch	2020_TAC	2021_ssb		
1253492	0.166	0.173	0.065	1363360	57634	54325	111959	166499	1302883		
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**

2020_ssb	2020_f2–6	2020_f_dis2–3	2020_f_hc2–6	2020_recruits	2020_landings	2020_discards	2020_catch	2020_TAC	2021_ssb		
1253492	0.166	0.173	0.065	1363360	57634	54325	111959	166499	1302883		
age	**year**	**f**	**f.disc**	**f.land**	**stock.n**	**catch.wt**	**landings.wt**	**discards.wt**	**stock.wt**	**mat**	**M**

Table 13.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short term forecast assuming $F_{2019} = F_{\text{-status quo}}$ (rescaled).

Basis	Total catch (2021)	Projected landings * (2021)	Projected discards ** (2021)	F_{total} ages 2–6 (2021) ^^^	$F_{projected\ landings}$ ages 2–6 (2021)	$F_{projected\ discards}$ ages 2–3 (2021)	SSB (2022)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis										
MSY approach: F_{MSY}	162607	87576	75031	0.21	0.083	0.22	1374316	5.5	-2.3	-2.3
Other scenarios										
F = MAP F_{MSY} upper	222956	120730	102226	0.30	0.118	0.31	1316942	1.08	34	34
F = MAP F_{MSY} lower	116260	62400	53860	0.146	0.057	0.152	1418596	8.9	-30	-30
F = 0	0	0	0	0	0	0	1531915	17.6	-100	-100
F_{pa}	265735	144515	121220	0.369	0.145	0.38	1276485	-2	60	60
F_{lim}	347946	190981	156965	0.516	0.20	0.54	1199290	-8	109	109
SSB (2022) = B_{lim}	1524539	1136496	388043	16.9	6.6	10.2	207288	-84	816	816
SSB (2022) = B_{pa}	1434040	1041759	392281	12.5	4.9	13.0	290203	-78	760	760
SSB (2022) = MSY $B_{trigger}$	1082564	707087	375477	4.7	1.84	4.9	564599	-57	550	550
Rollover TAC	166499	89699	76800	0.22	0.085	0.22	1370609	5.2	0	0
$F_{2021} = F_{2020}$	131067	70418	60649	0.166	0.065	0.173	1404430	7.8	-21	-21

* “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 2017–2019. 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 2021. The subtracted value (633 t of projected landing and 920 t of projected discards) is estimated based on the plaice catch advice for Division 7.d for 2021.

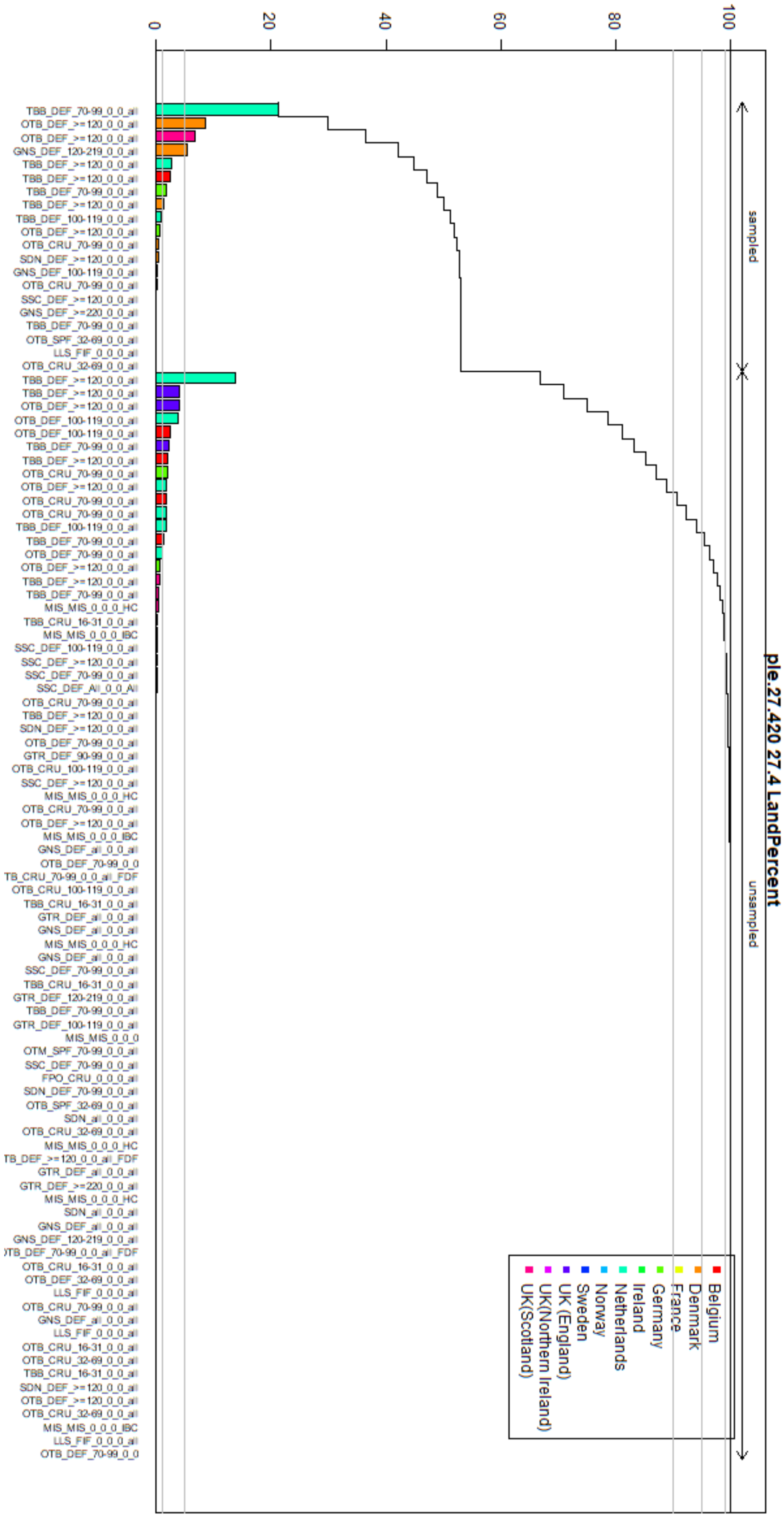
* Marketable landings.

Table 13.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming $F_{2019} = F_{-status\ quo}$, 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	2020	0.073	0.073	0.000	1363360	0.051	0.126	0.051	0.030	0	0.1	91244	15	91229
2	2020	0.168	0.162	0.007	2442455	0.089	0.246	0.082	0.065	0.5	0.1	360571	14115	346457
3	2020	0.240	0.184	0.057	616924	0.154	0.264	0.120	0.122	0.5	0.1	125745	29600	96145
4	2020	0.195	0.099	0.096	599535	0.214	0.294	0.137	0.173	1	0.1	101106	49911	51194
5	2020	0.136	0.042	0.094	294361	0.280	0.337	0.152	0.242	1	0.1	35613	24525	11089
6	2020	0.090	0.017	0.073	202284	0.342	0.385	0.165	0.290	1	0.1	16588	13469	3119
7	2020	0.054	0.007	0.047	292553	0.397	0.429	0.175	0.346	1	0.1	14554	12761	1793
8	2020	0.027	0.002	0.025	252953	0.469	0.493	0.186	0.405	1	0.1	6436	5944	492
9	2020	0.012	0.000	0.012	221933	0.528	0.528	0.297	0.434	1	0.1	2547	2547	0
10	2020	0.012	0.000	0.012	1131835	0.652	0.653	0.000	0.532	1	0.1	12990	12989	2
1	2021	0.073	0.073	0.000	1363360	0.051	0.126	0.051	0.030	0	0.1	91244	15	91229
2	2021	0.168	0.162	0.007	1146914	0.089	0.246	0.082	0.065	0.5	0.1	169315	6628	162687
3	2021	0.240	0.184	0.057	1867662	0.154	0.264	0.120	0.122	0.5	0.1	380677	89610	291067
4	2021	0.195	0.099	0.096	438893	0.214	0.294	0.137	0.173	1	0.1	74015	36538	37477
5	2021	0.136	0.042	0.094	446503	0.280	0.337	0.152	0.242	1	0.1	54020	37200	16820
6	2021	0.090	0.017	0.073	232525	0.342	0.385	0.165	0.290	1	0.1	19068	15483	3586

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
7	2021	0.054	0.007	0.047	167273	0.397	0.429	0.175	0.346	1	0.1	8322	7296	1025
8	2021	0.027	0.002	0.025	250881	0.469	0.493	0.186	0.405	1	0.1	6383	5895	488
9	2021	0.012	0.000	0.012	222763	0.528	0.528	0.297	0.434	1	0.1	2557	2556	0
10	2021	0.012	0.000	0.012	1210167	0.652	0.653	0.000	0.532	1	0.1	13889	13887	2
1	2022	0.073	0.073	0.000	1363360	0.051	0.126	0.051	0.030	0	0.1	91244	15	91229
2	2022	0.168	0.162	0.007	1146914	0.089	0.246	0.082	0.065	0.5	0.1	169315	6628	162687
3	2022	0.240	0.184	0.057	877006	0.154	0.264	0.120	0.122	0.5	0.1	178756	42078	136678
4	2022	0.195	0.099	0.096	1328693	0.214	0.294	0.137	0.173	1	0.1	224071	110614	113457
5	2022	0.136	0.042	0.094	326865	0.280	0.337	0.152	0.242	1	0.1	39546	27233	12313
6	2022	0.090	0.017	0.073	352706	0.342	0.385	0.165	0.290	1	0.1	28924	23485	5439
7	2022	0.054	0.007	0.047	192280	0.397	0.429	0.175	0.346	1	0.1	9566	8387	1179
8	2022	0.027	0.002	0.025	143446	0.469	0.493	0.186	0.405	1	0.1	3650	3371	279
9	2022	0.012	0.000	0.012	220938	0.528	0.528	0.297	0.434	1	0.1	2536	2535	0
10	2022	0.012	0.000	0.012	1280933	0.652	0.653	0.000	0.532	1	0.1	14702	14700	2

(a)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unsampled
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France
Germany
Ireland
Netherlands
Norway
Sweden
UK (England)
UK(Northern Ireland)
UK(Scotland)

(b)

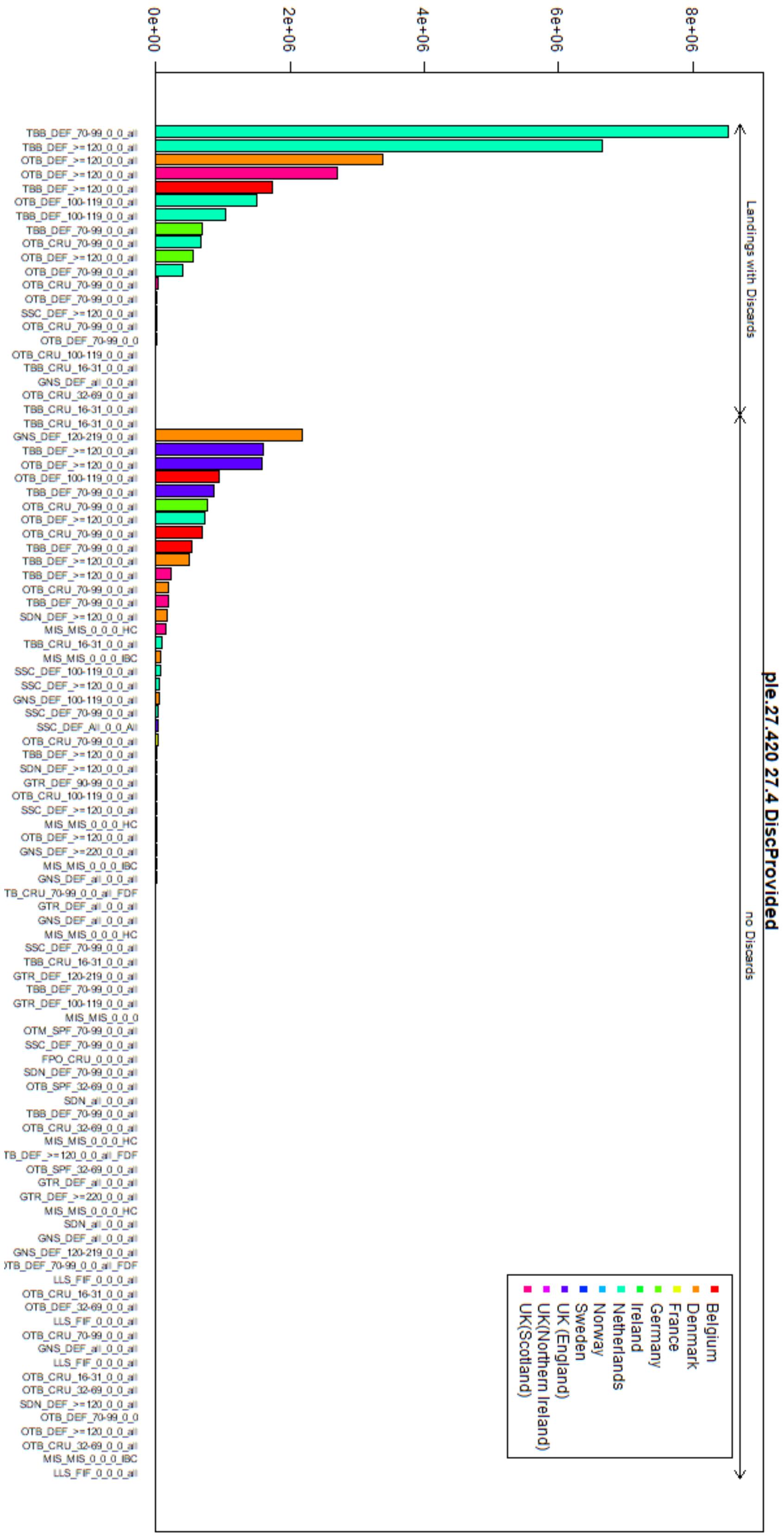
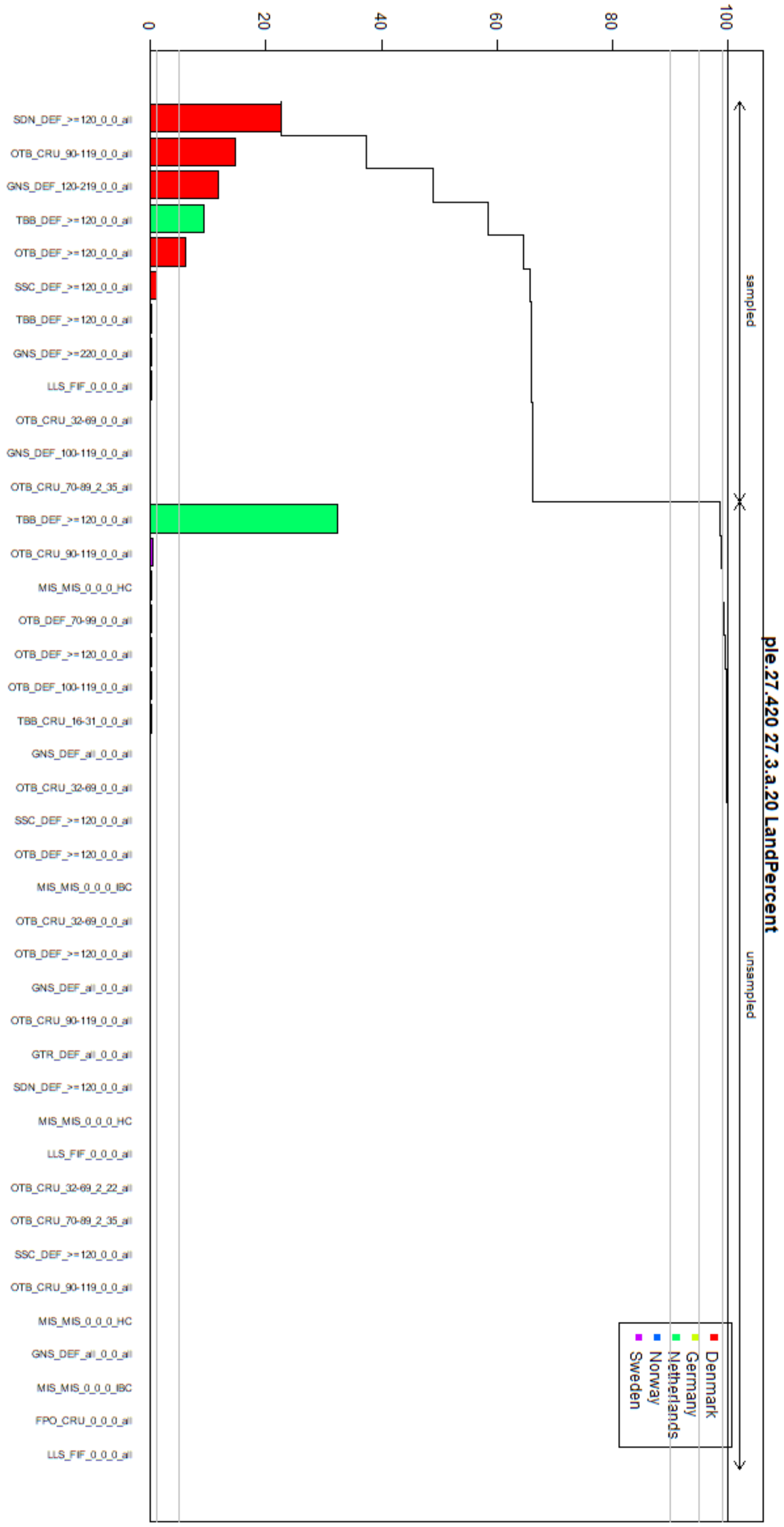


Figure 13.2.1. Summary of data upload in Intercatch for Subarea 4: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

(a)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OTB_DEF_>=120_0_0_all
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GTR_DEF_all_0_0_all
SDN_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
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Germany
Netherlands
Norway
Sweden

(b)

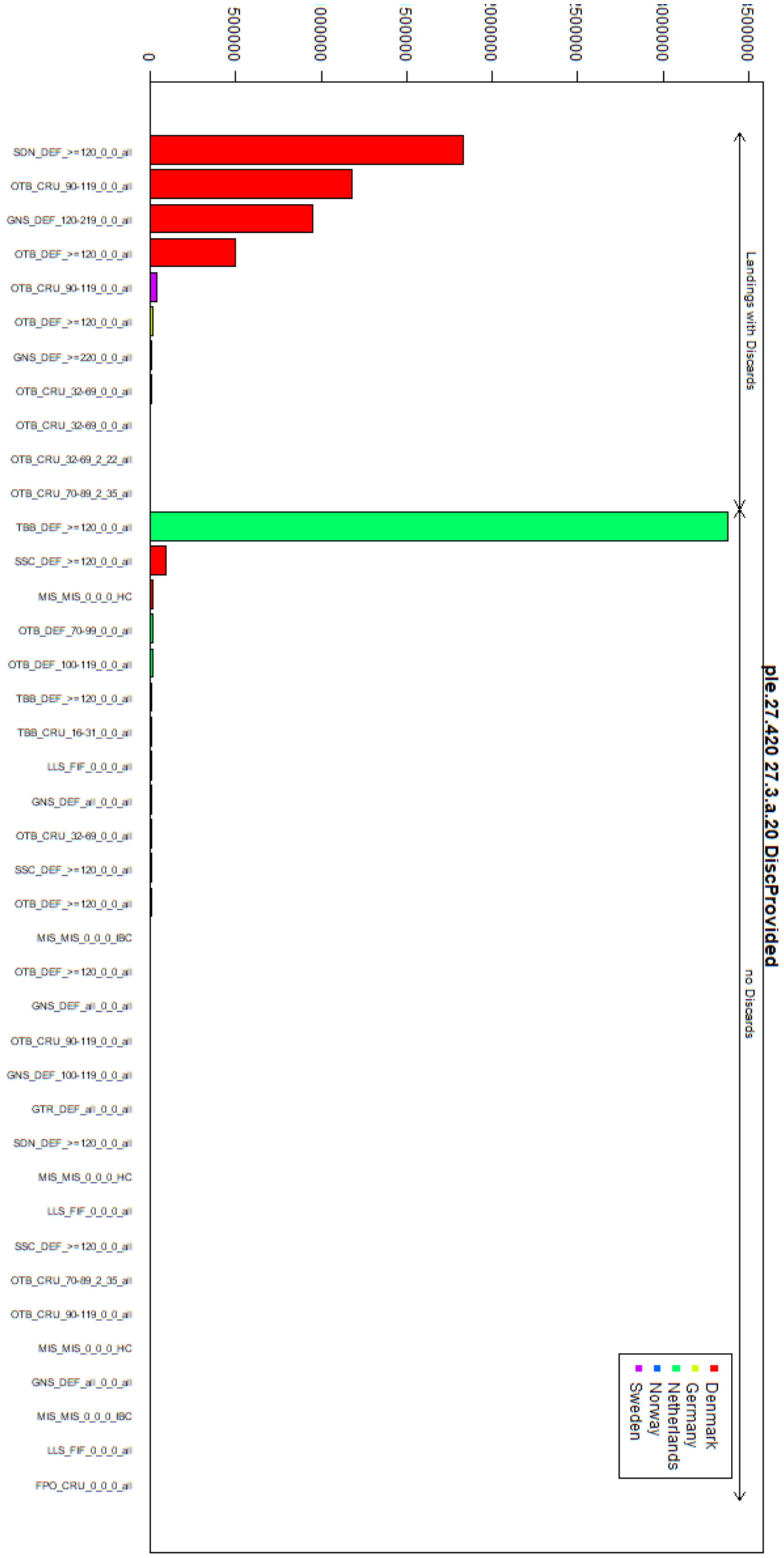


Figure 13.2.2. Summary of data upload in Intercatch for Subdivision 20: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

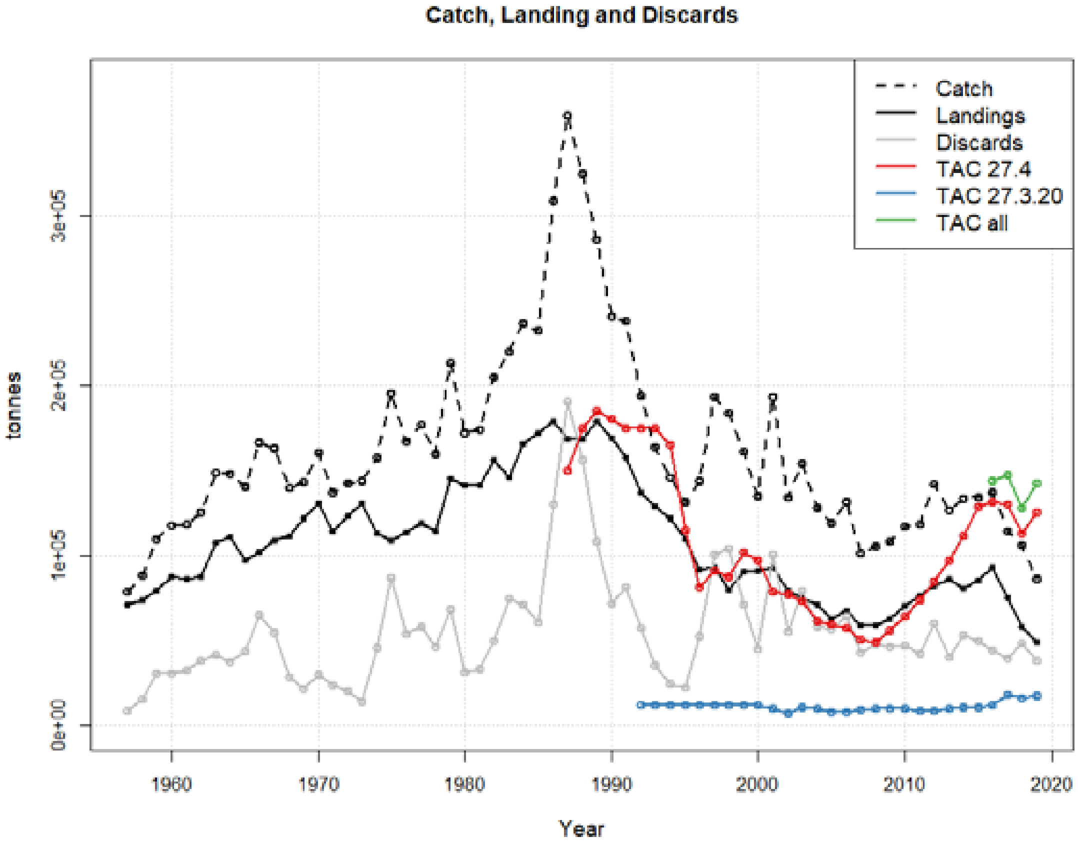


Figure 13.2.3. Plaice in Subarea 4 (including Subdivision 20 and 7.d Q1): Time series of catch (dashed line), landings (solid black line) and discards (gray line) estimates. Landings TAC for Subarea 4 (red) and Subdivision 20 (blue) are also plotted. Discards before 2000 were reconstructed using a model based method. TAC since 2019 refers to catch TAC.

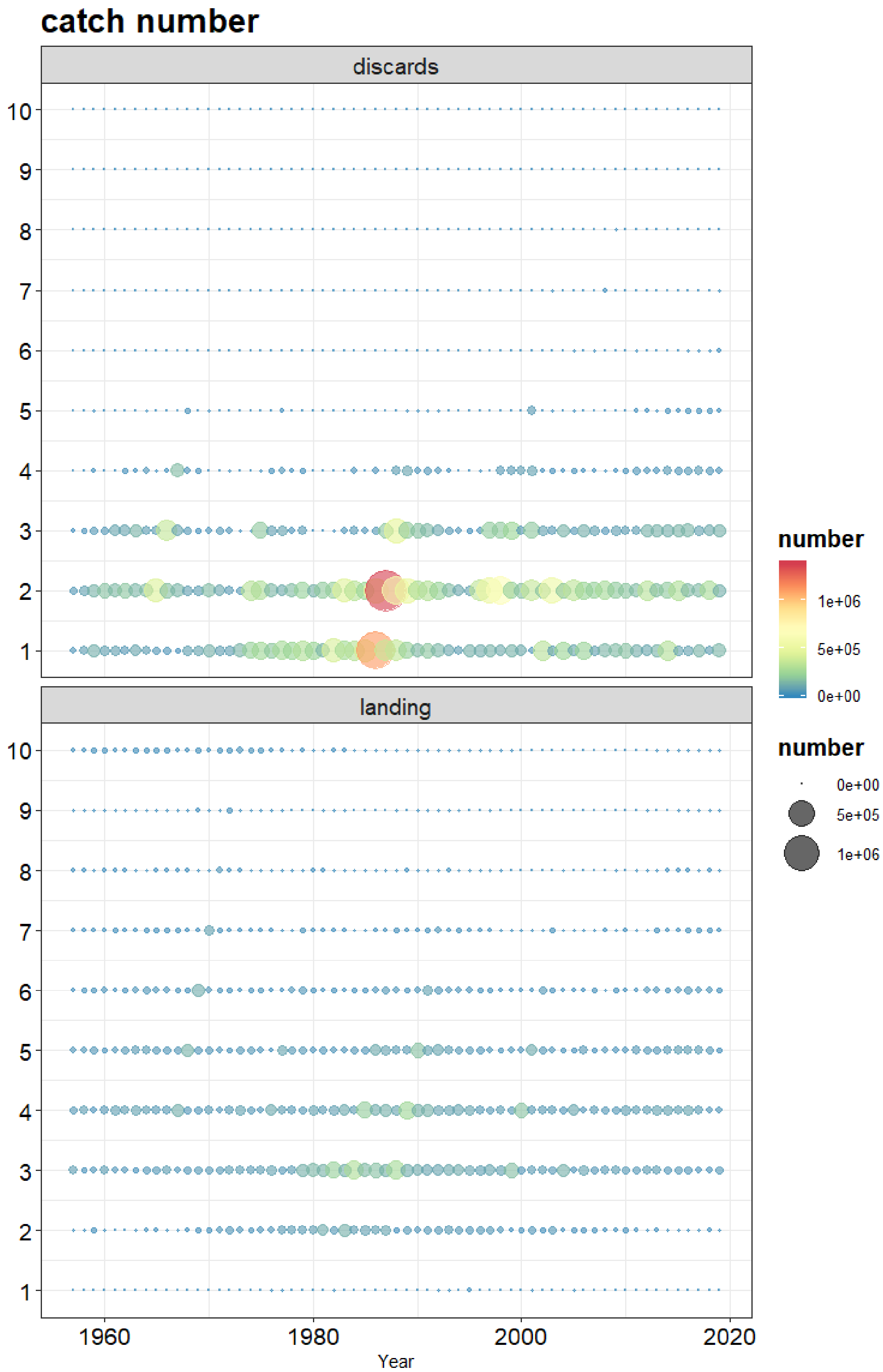


Figure 13.2.4. Plaice in Subarea 4 and Subdivision 20: Discards numbers-at-age (top) and landings numbers-at-age (down). Discards before 2000 were reconstructed using a model based method.

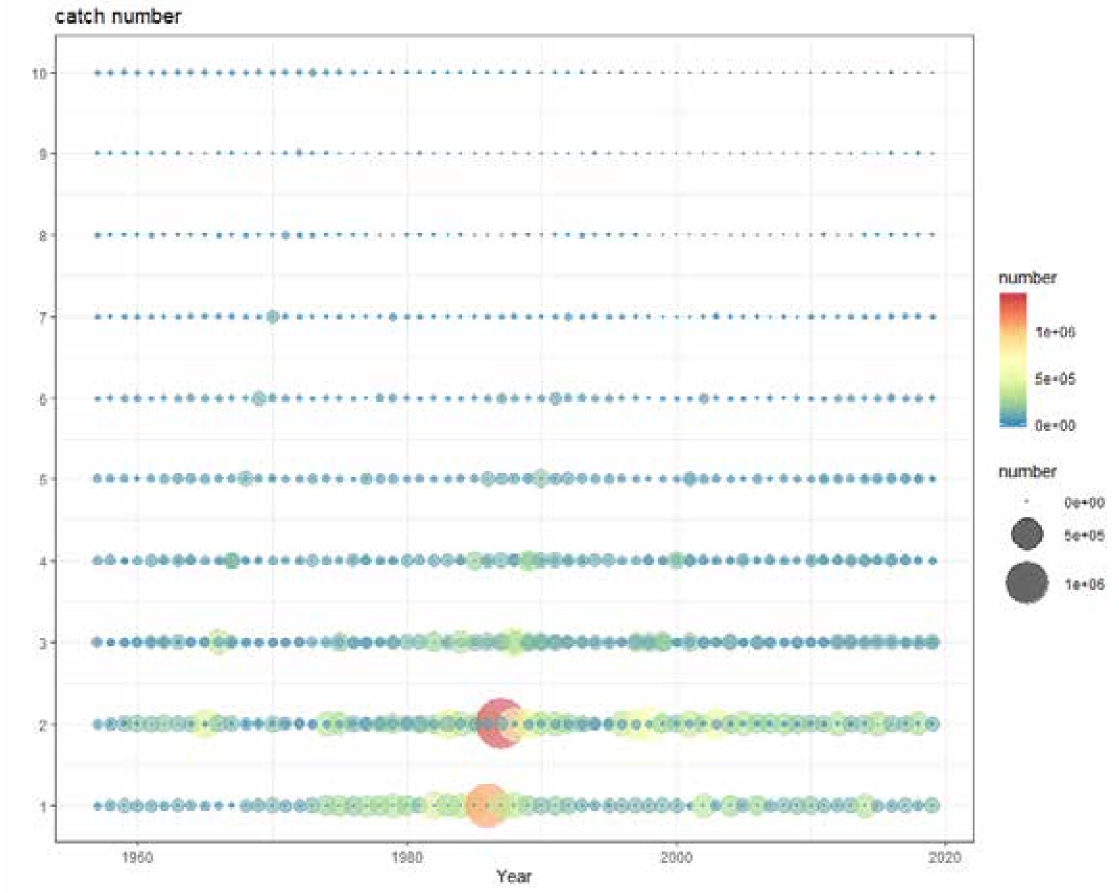
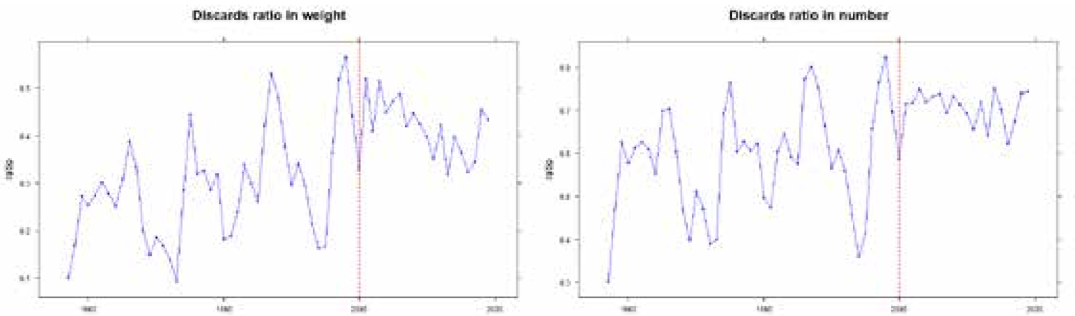
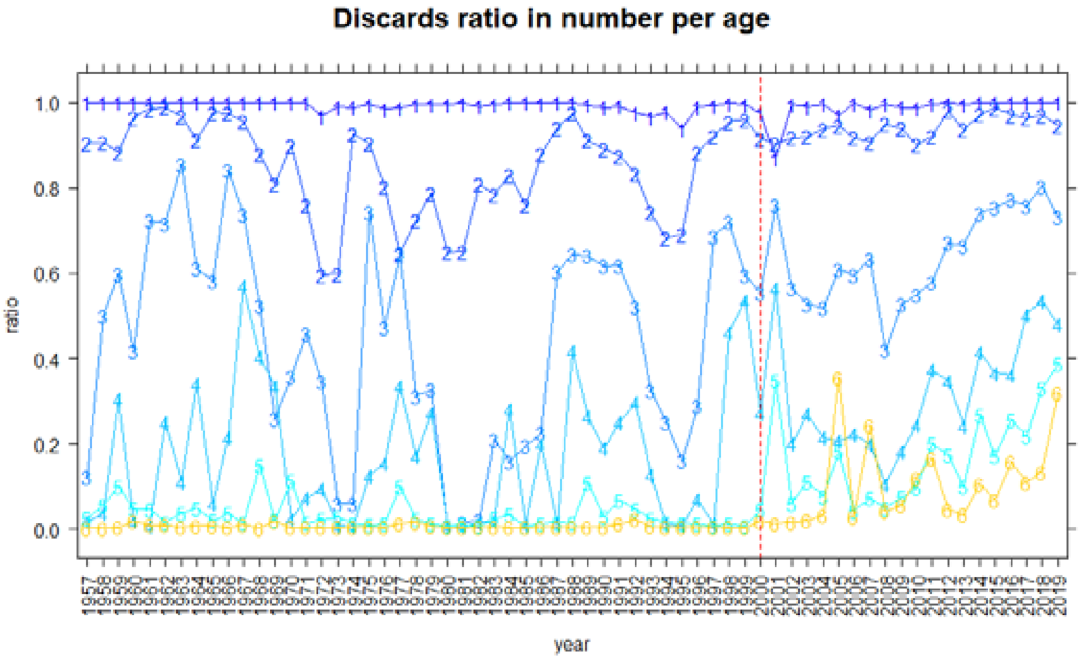


Figure 13.2.5. Plaice in Subarea 4 and Subdivision 20. Catch numbers-at-age: Discards before 2000 were reconstructed using a model based method.

Figure 13.2.6. Discards ratio. Discards before 2000 were reconstructed using a model based method.




Discards ratio in number per age
ratio
year

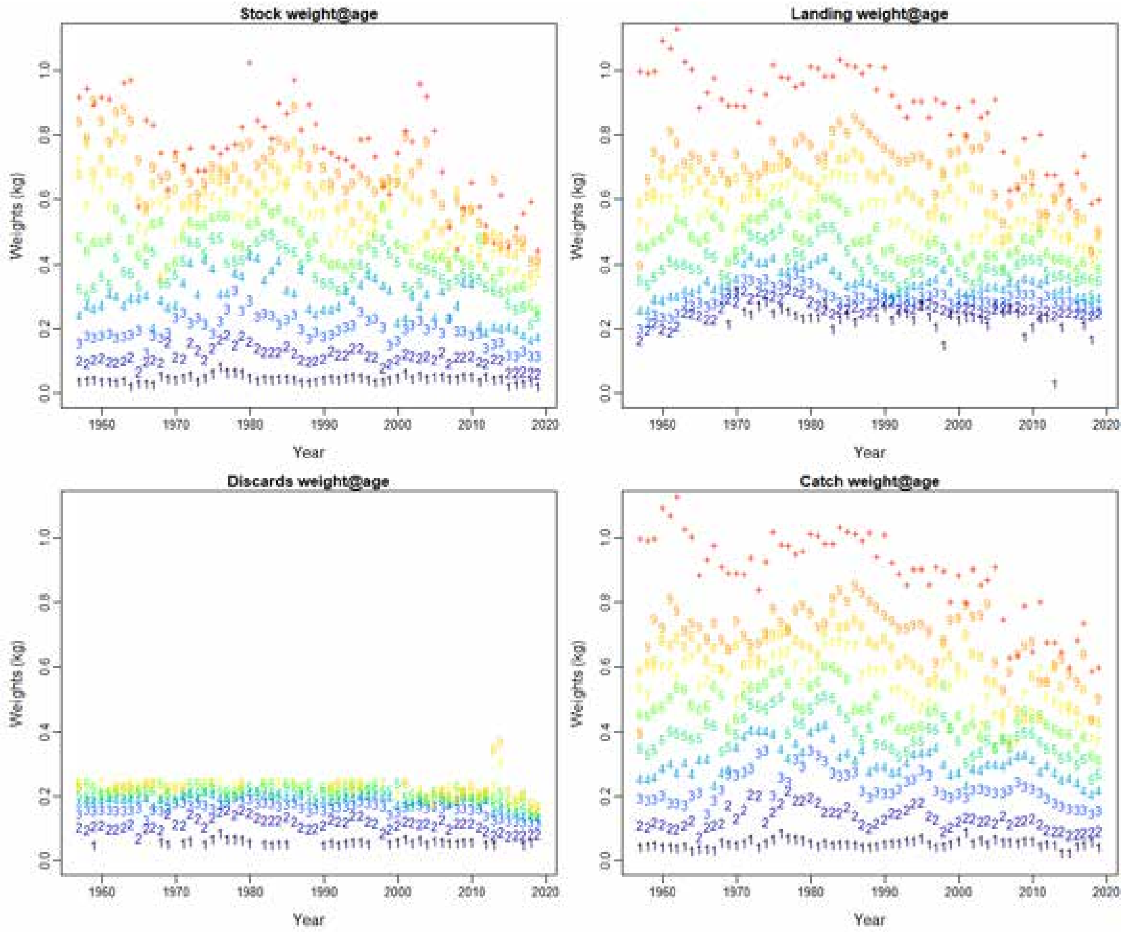
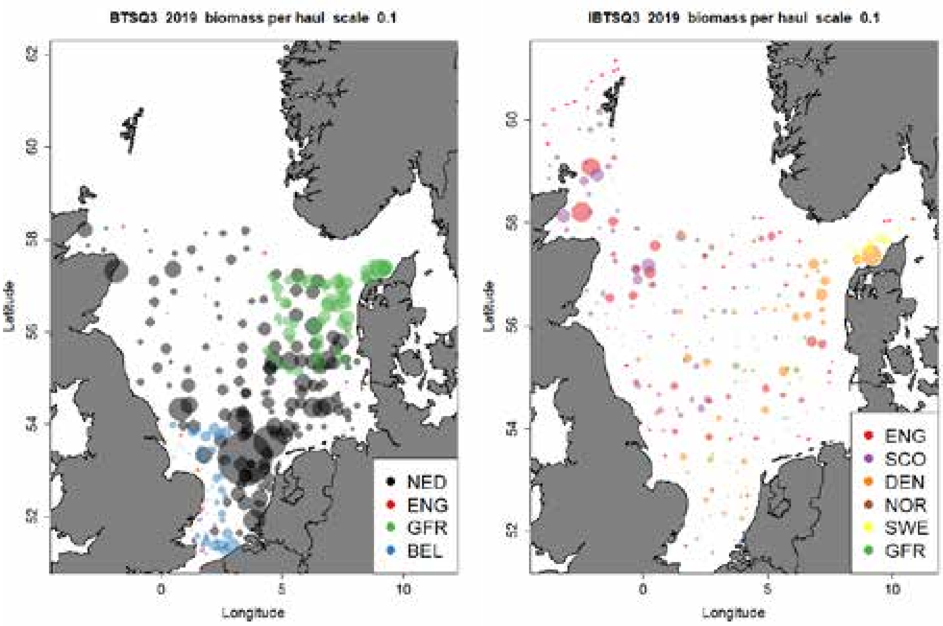


Figure 13.2.7. Plaice in Subarea 4 and Subdivision 20: Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).



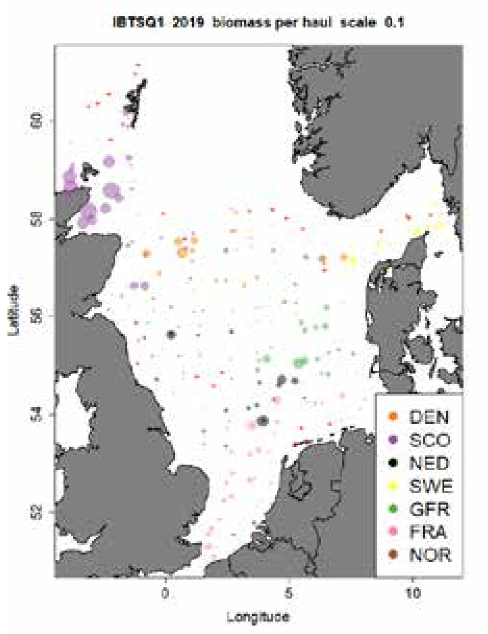
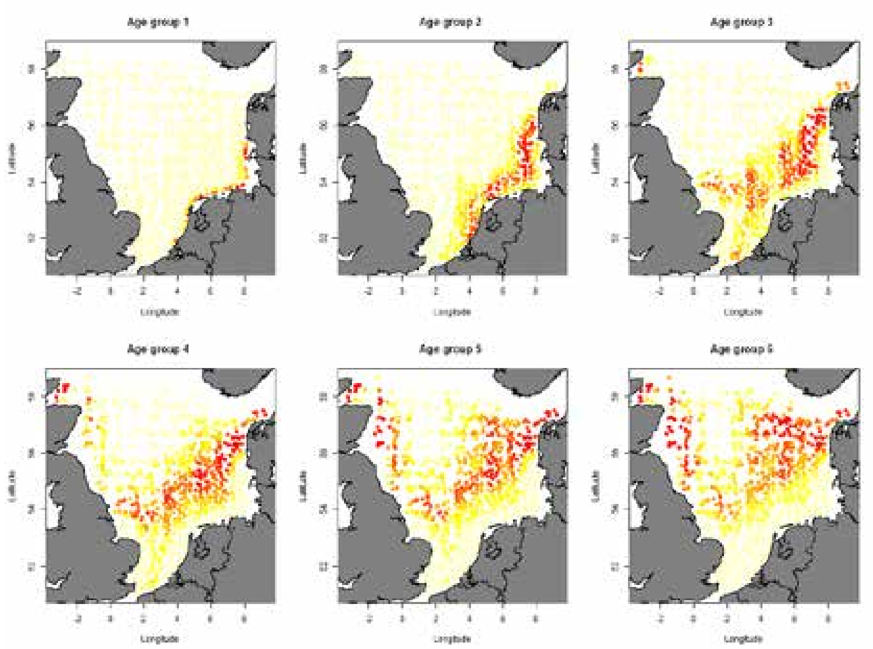
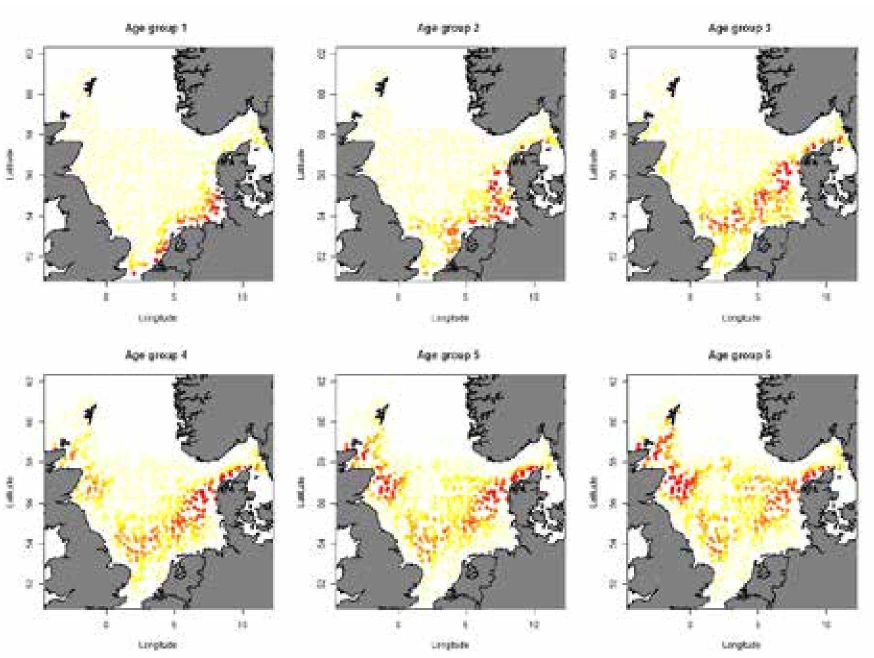


Figure 13.2.8. Spatial distribution of biomass per haul for BTS-Q3, IBTS-Q3 and IBTS-Q1 surveys in 2019. Indices for these 3 surveys were extracted using the delta-GAM method. Samples in gray area were excluded due to low coverage.

(a) BTS-Q3



(b) IBTS-Q3



(c) IBTS-Q1

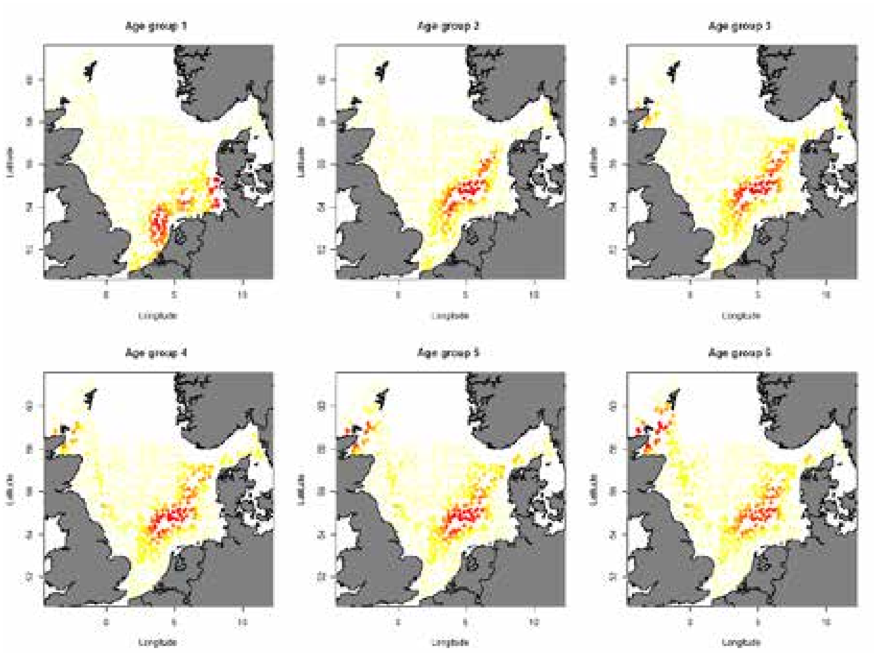


Figure 13.2.9. The estimated spatial age distribution for (a) BTS-Q3, (b) IBTS-Q3 and (c) IBTS-Q1, estimated using delta-GAM method. Age group 1–6 refers to age 0–5. Abundance decreasing from red to white color.

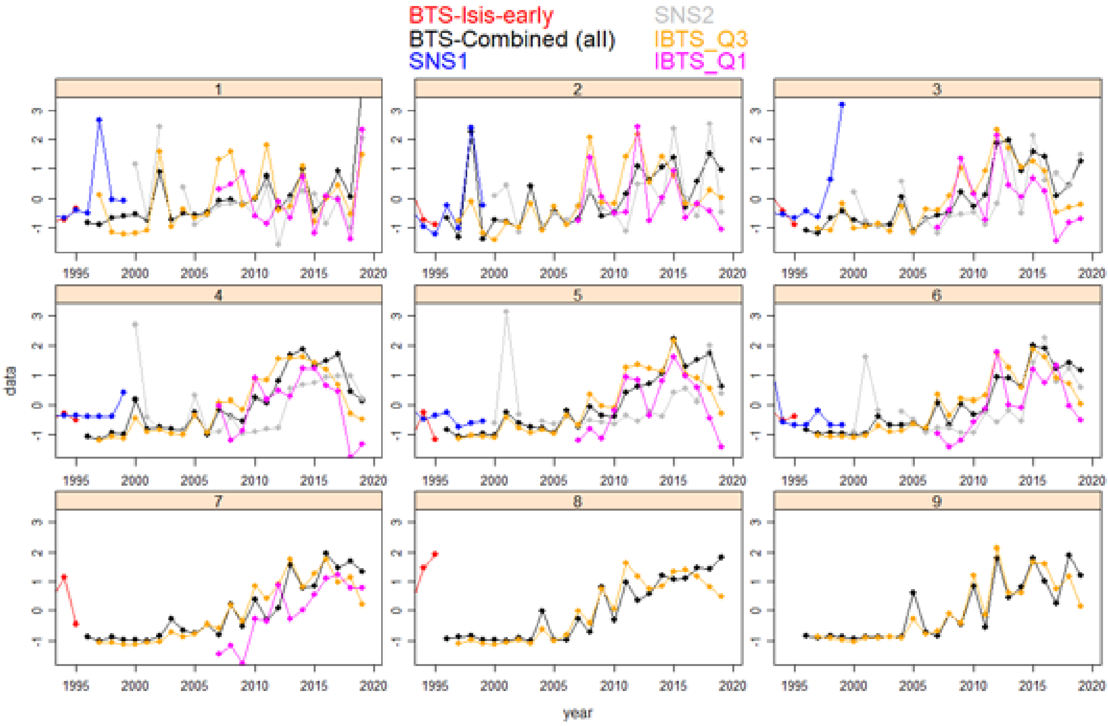


Figure 13.2.10. Plaice in Subarea 4 and Subdivision 20. Standardized survey tuning indices used for tuning stock assessment model: BTS–combined (1996–2019, black), BTS–Isis-early (1985–1995, red) SNS–1 (1970–1999, blue), SNS–2 (2000–2019, grey), IBTS–Q3 (1997–2019, yellow) and IBTS–Q1 (2007-2019, pink). Note: only ages used in the assessment are presented. The BTS–combined index combines BTS–Tridens and BTS–Isis indices.

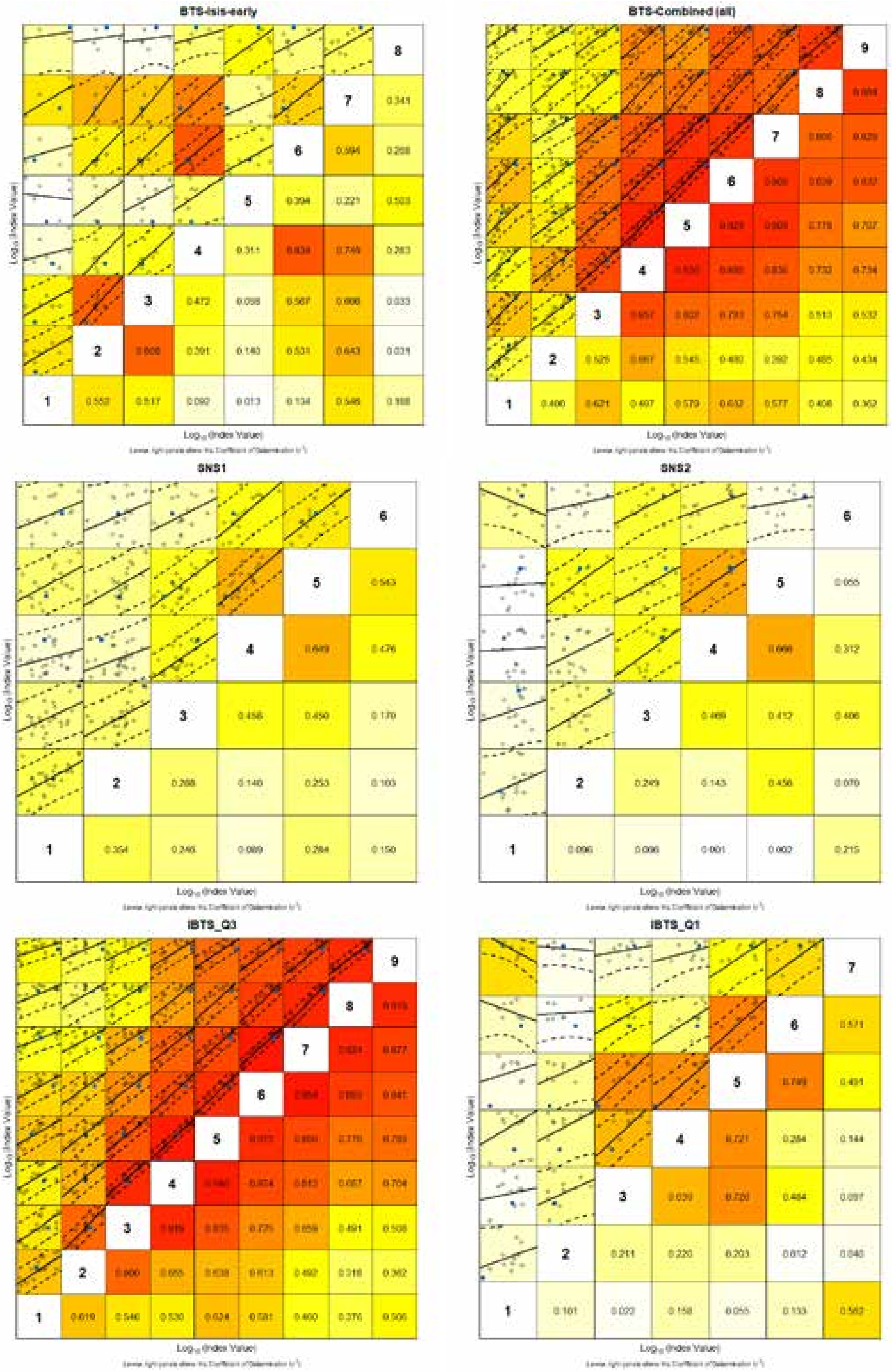


Figure 13.2.11. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for surveys.

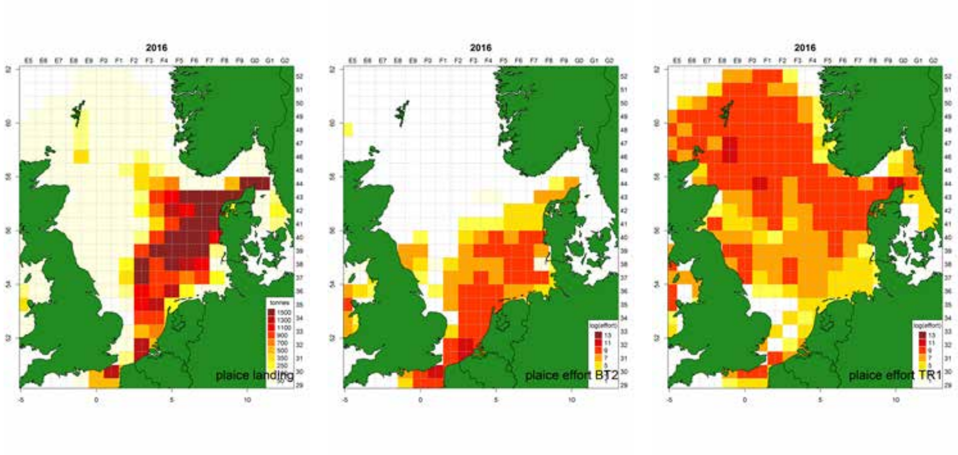


Figure 13.2.12. (a) Spatial distribution (by ICES rectangle) of landed plaice in 2016; (b) Spatial distribution of log-transformed TB2 fishing effort in 2016; (c) Spatial distribution of log-transformed TR1 fishing effort in 2016. Data were extracted from STECF FDI dataset. TB2 and TR1 are the two major gears in catching plaice in North Sea.

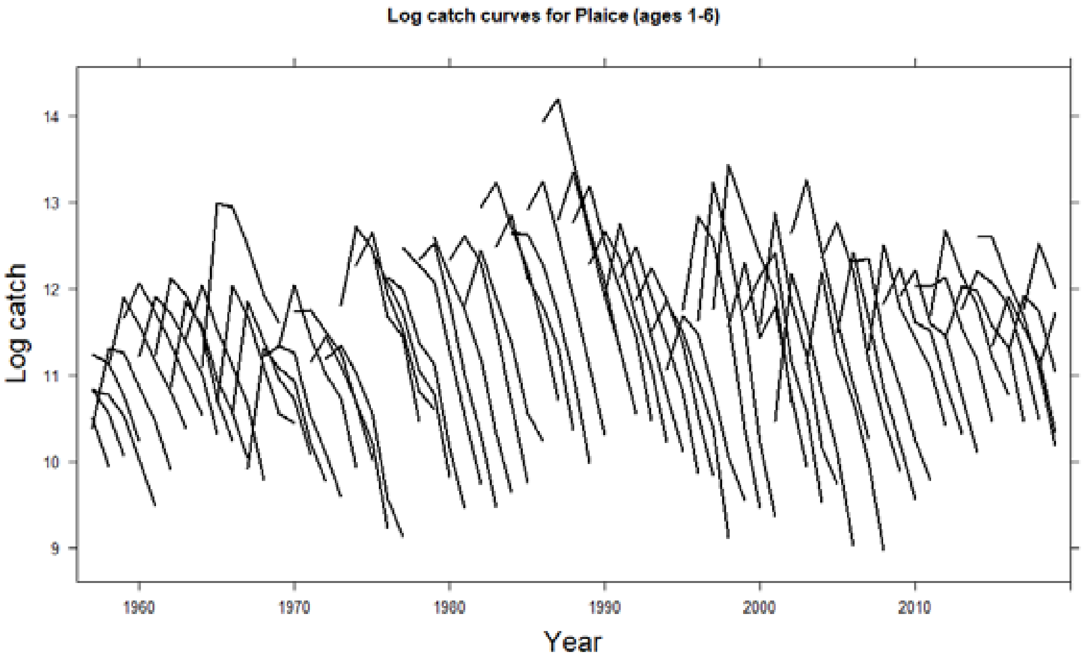


Figure 13.2.13. Catch curves for catches in age 1–6.

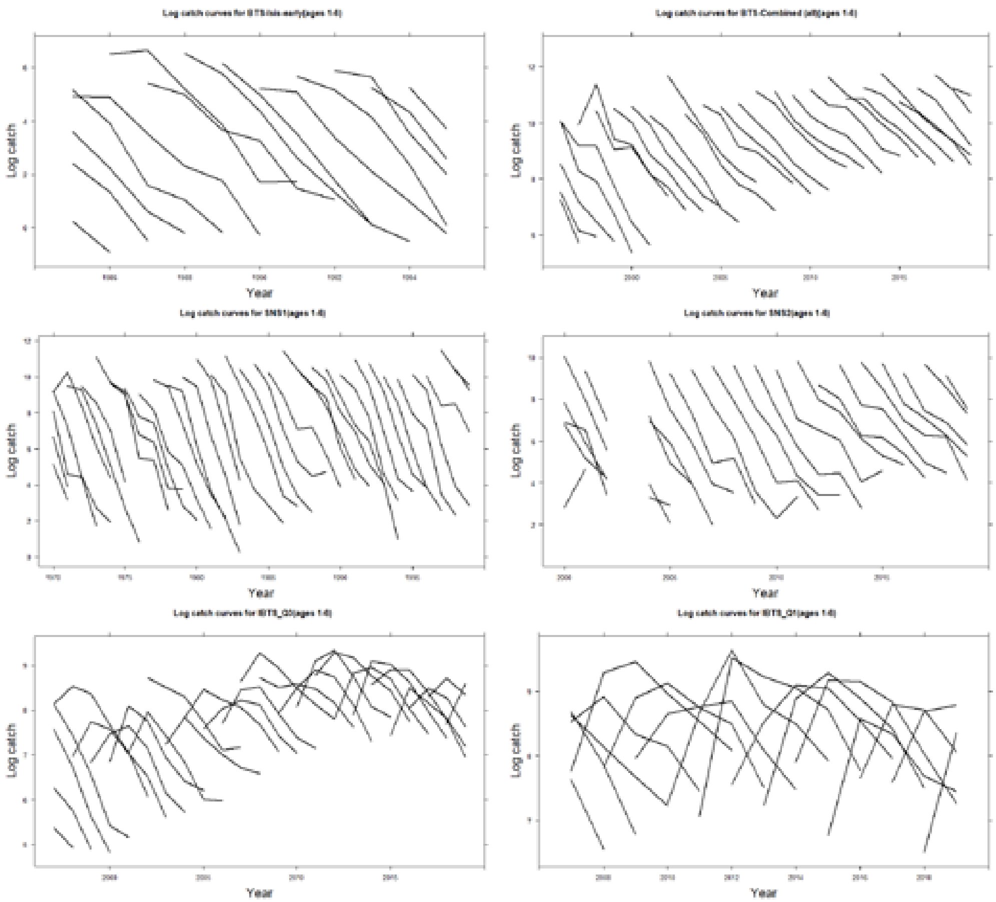
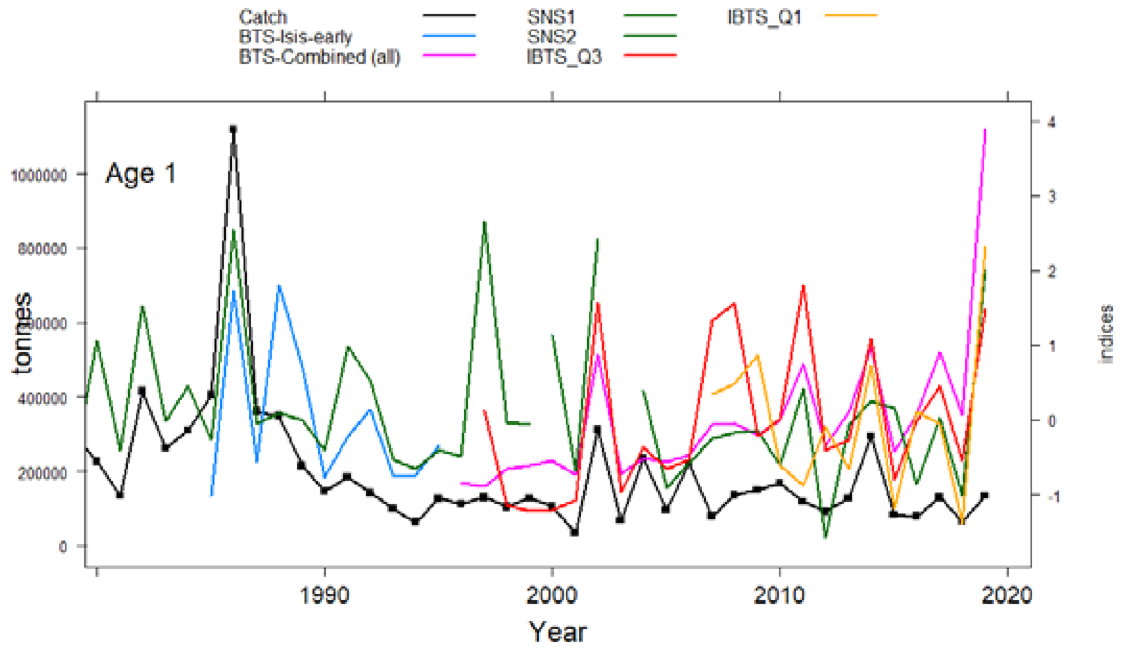
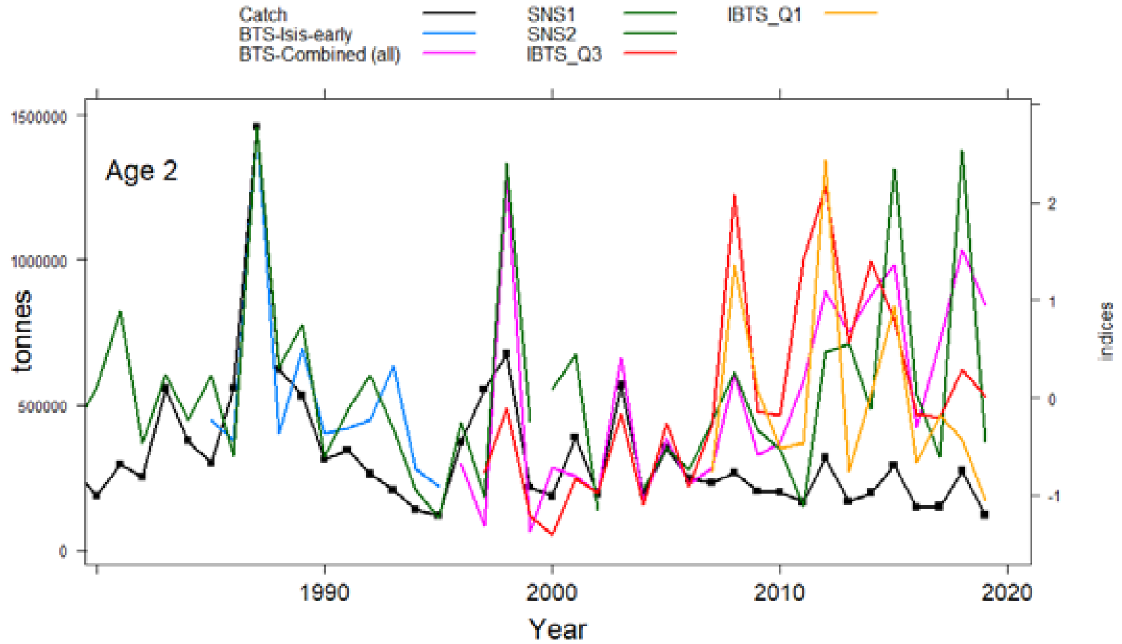
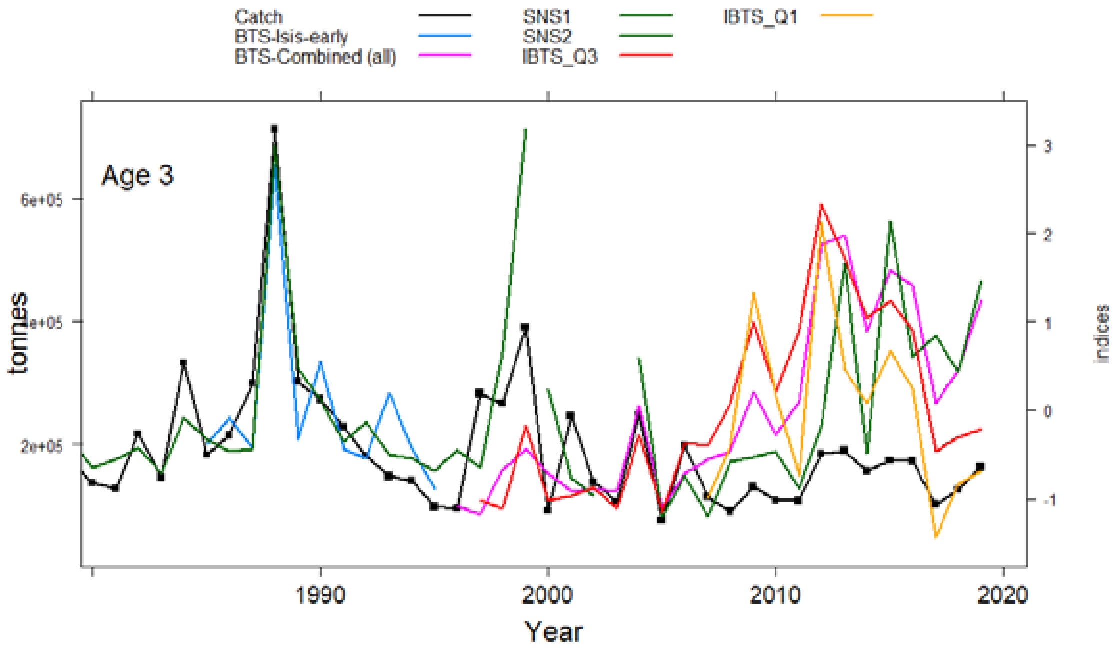


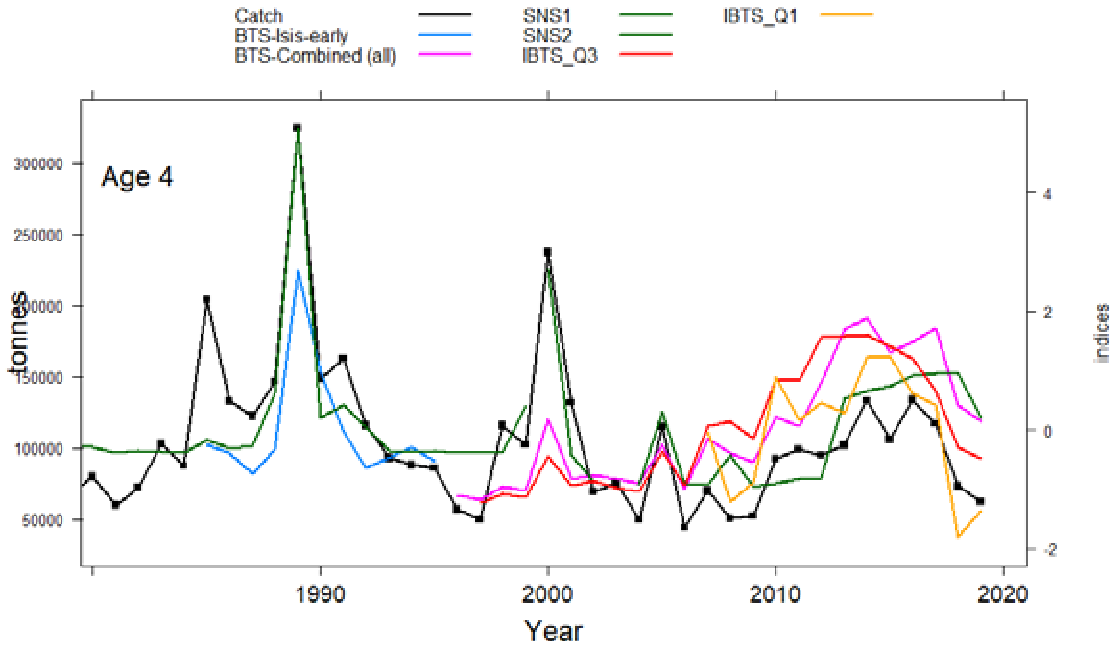
Figure 13.2.14. Catch curves for Surveys in age 1–6.


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 1
tonnes
indices
Year
1990
2000
2010
2020


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 2
tonnes
indices
Year
1990
2000
2010
2020



Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 3
tonnes
indices
Year



Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 4
tonnes
indices
Year

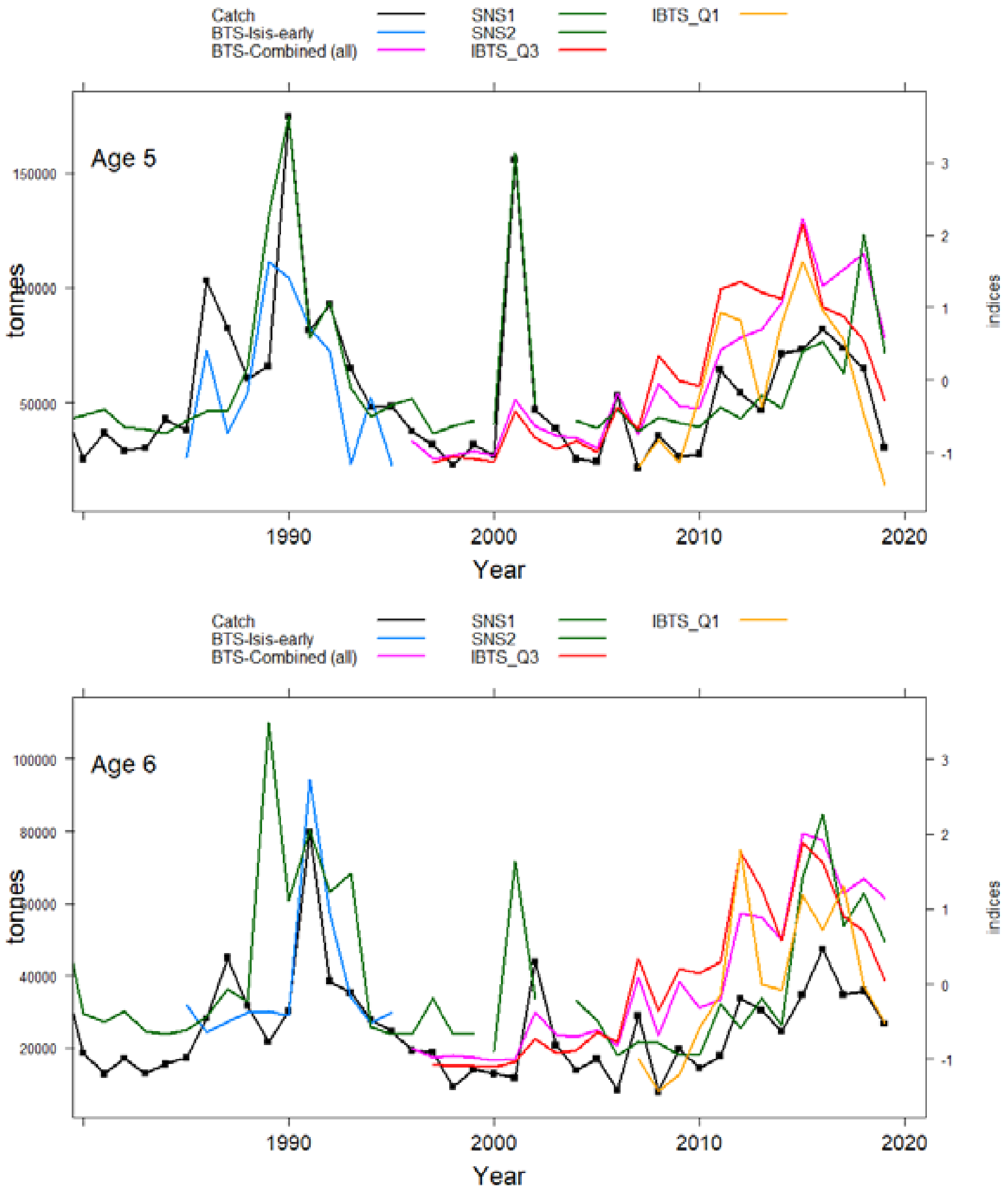


Figure 13.2.15: Catches vs. standardized survey indices by age (1–6).

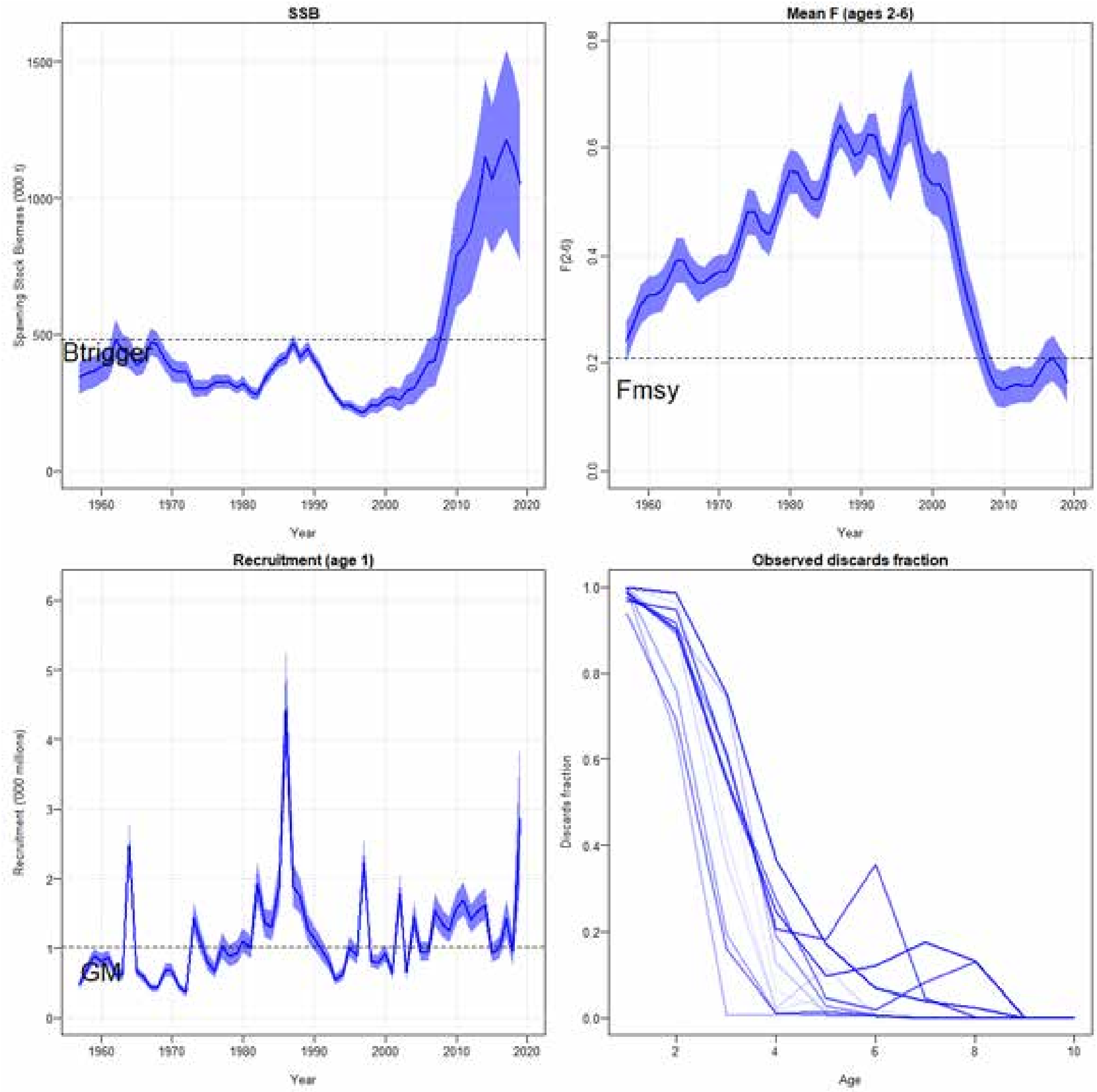


Figure 13.3.1. Stock assessment output for ple.27.420. SSB (top left), fishing mortality (top right), recruitment (bottom left) estimates of the assessment and the observed discards fraction (bottom right).

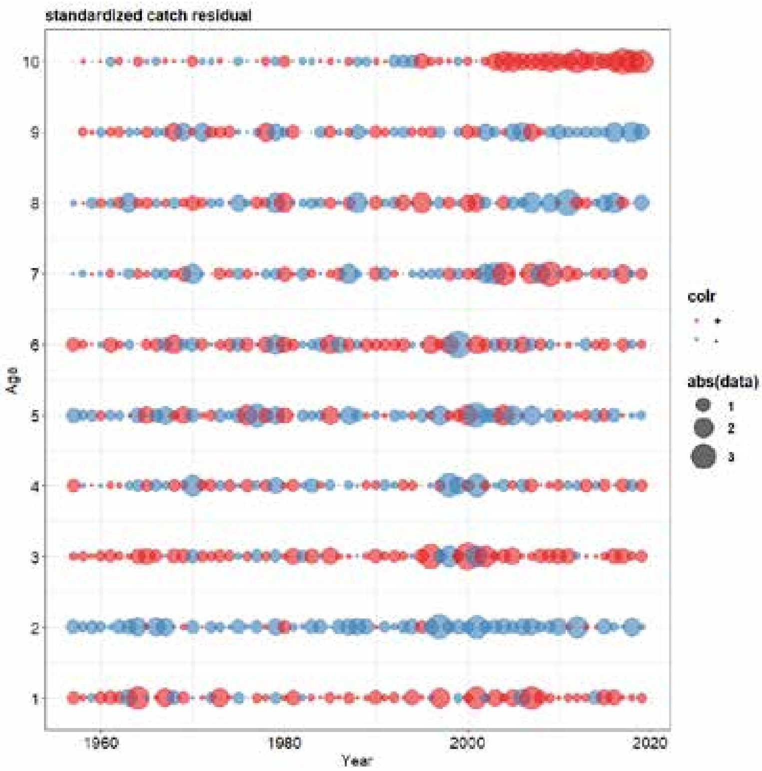


Figure 13.3.2. Log-catch residuals (observed minus estimated), standardized by the standard error of catch. Positive values are in red and negative values are in blue.

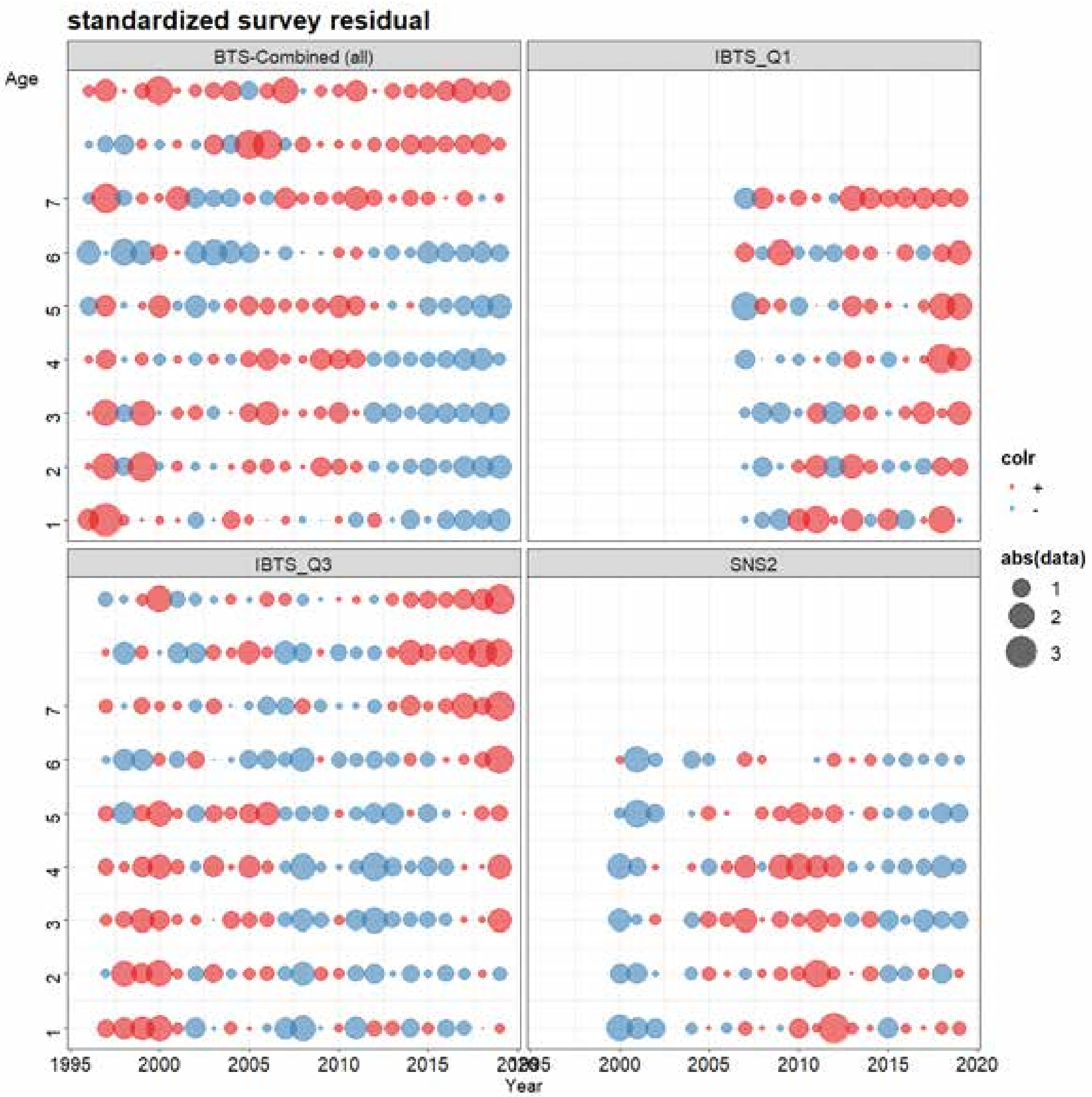


Figure 13.3.3. Log-survey indices residuals (observed minus estimated), standardized by the standard error of indices. Positive values are in red and negative values are in blue.

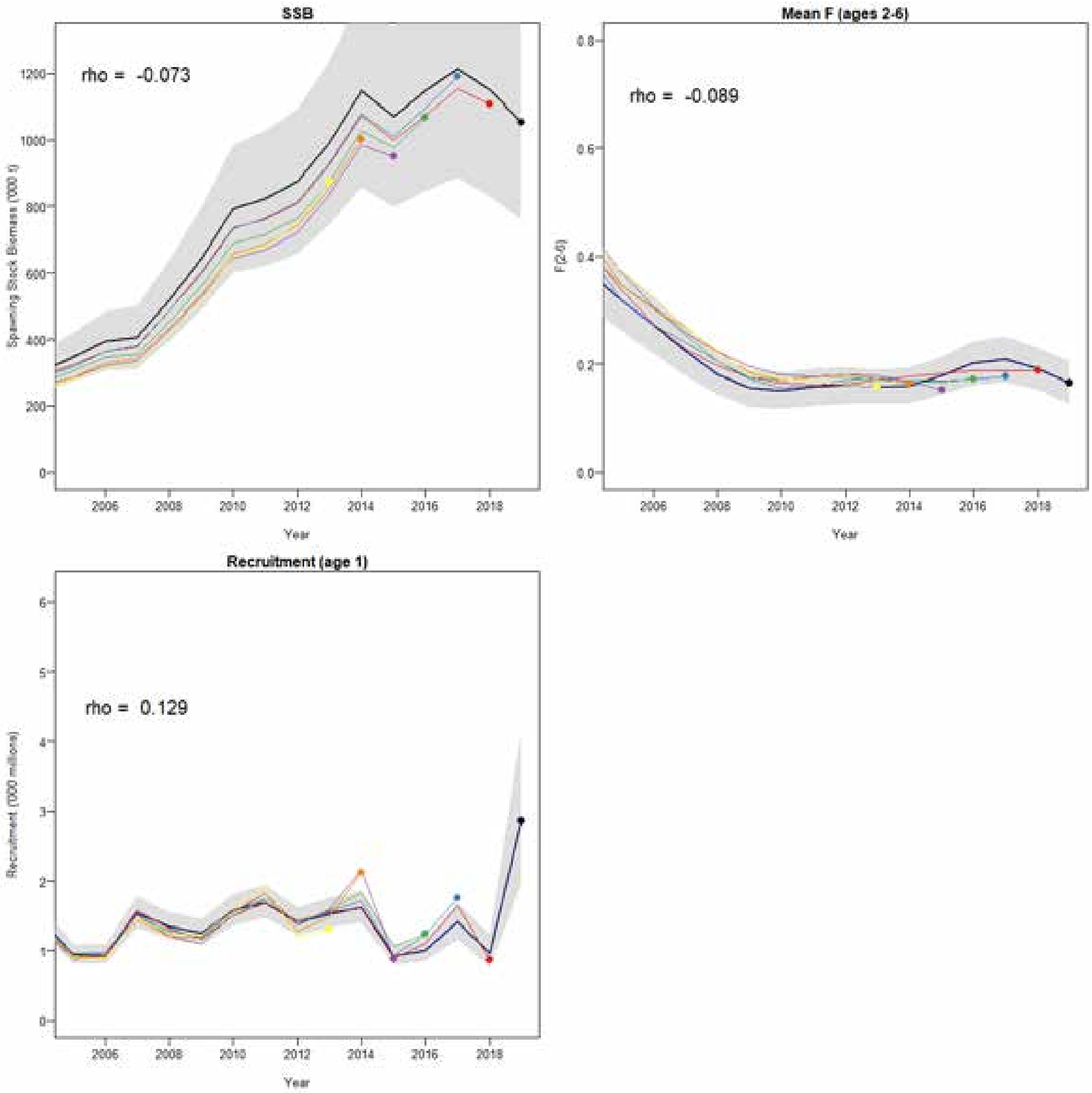


Figure 13.3.4. Retrospective pattern of the final AAP run with respect to SSB, recruitment and F.

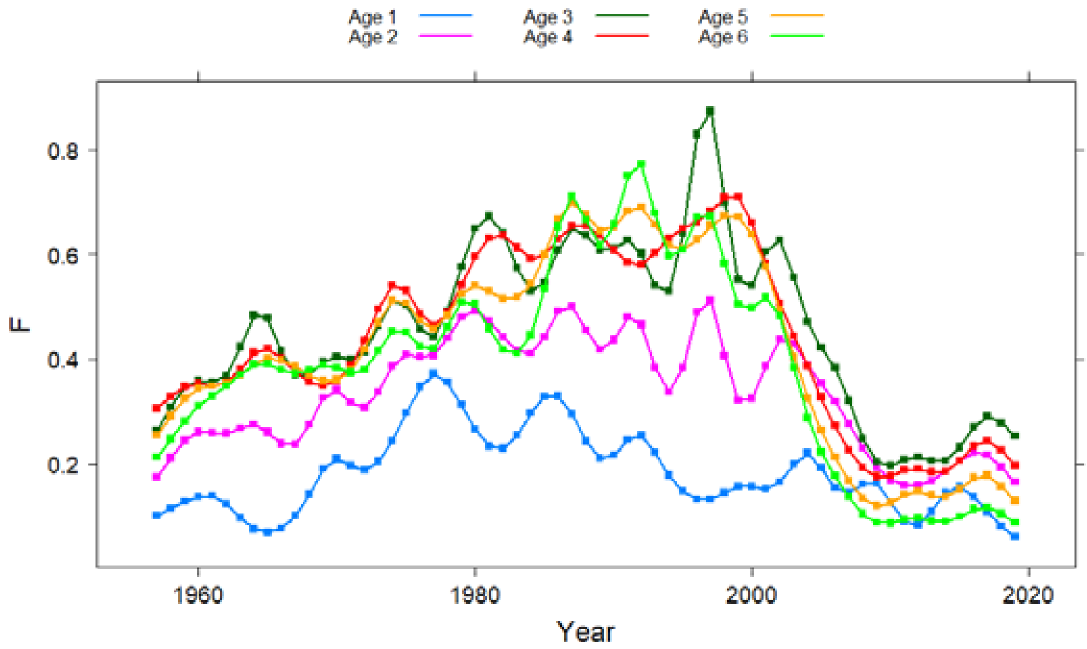


Figure 13.3.5. Estimated fishing mortality by age.

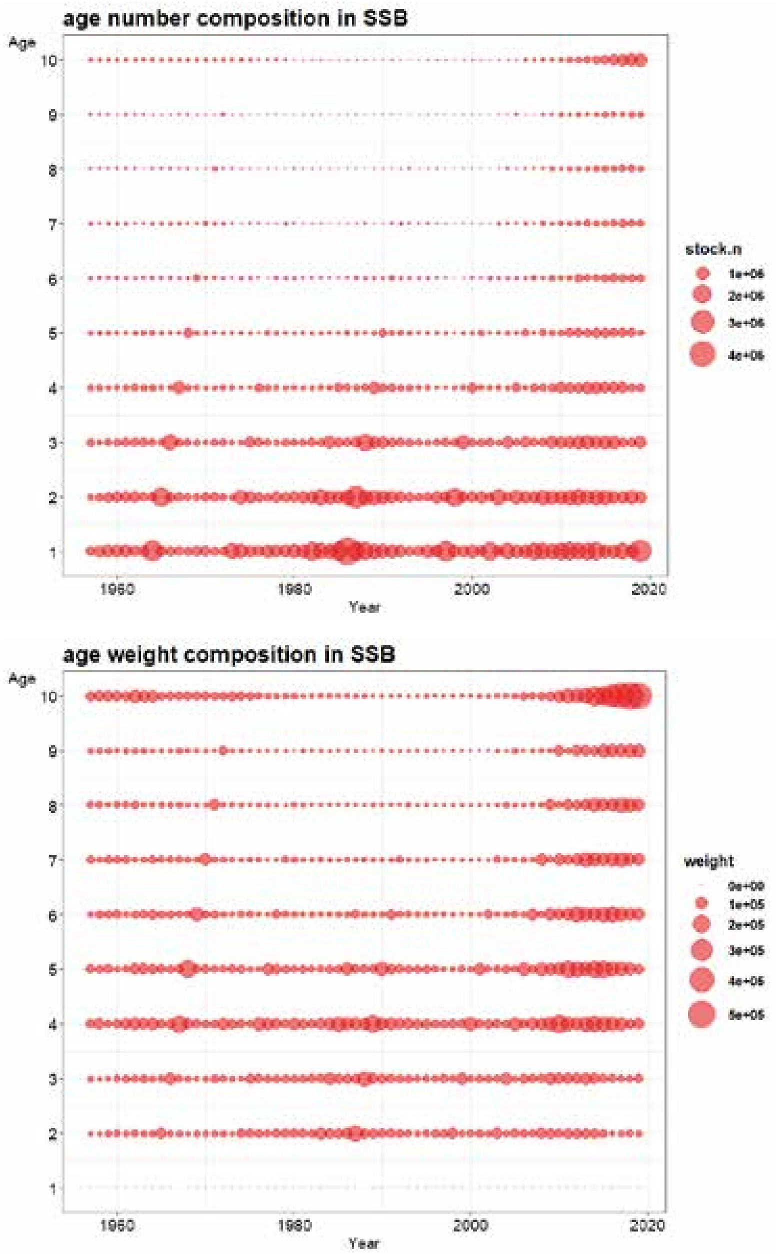


Figure 13.3.6. Age compositions in the estimated SSB.

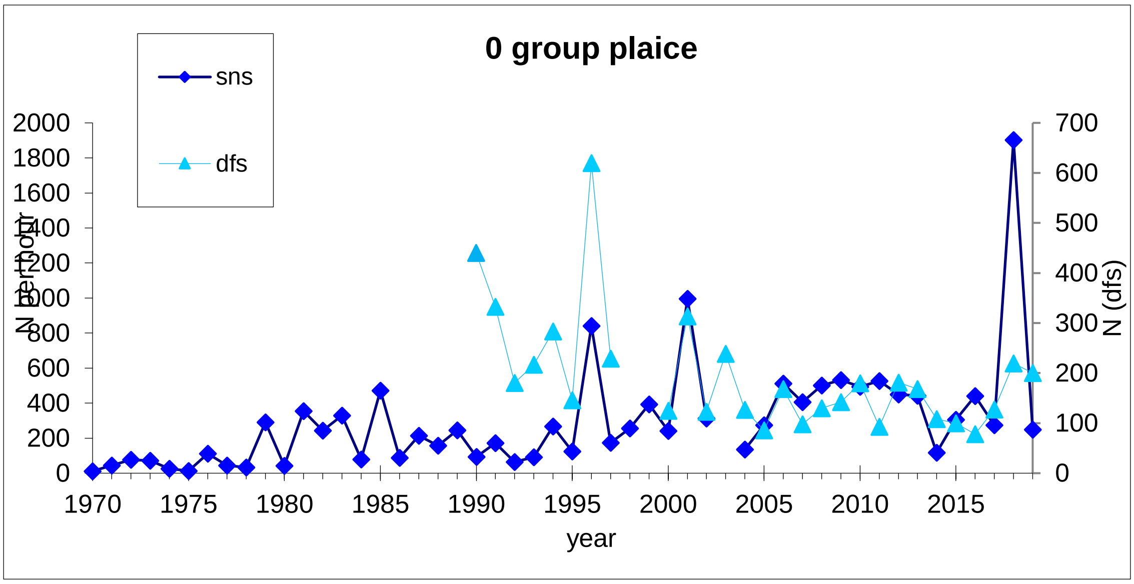
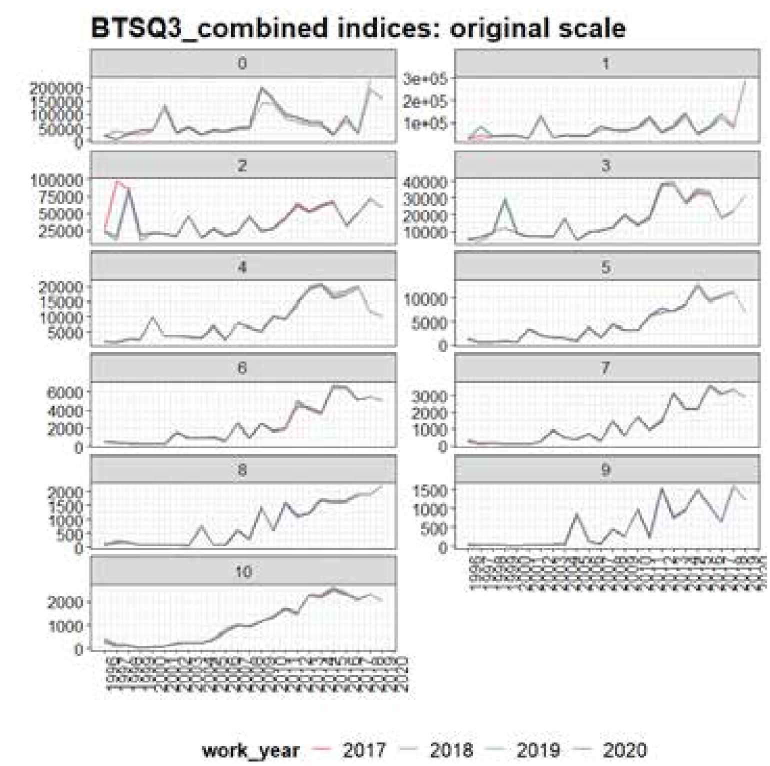
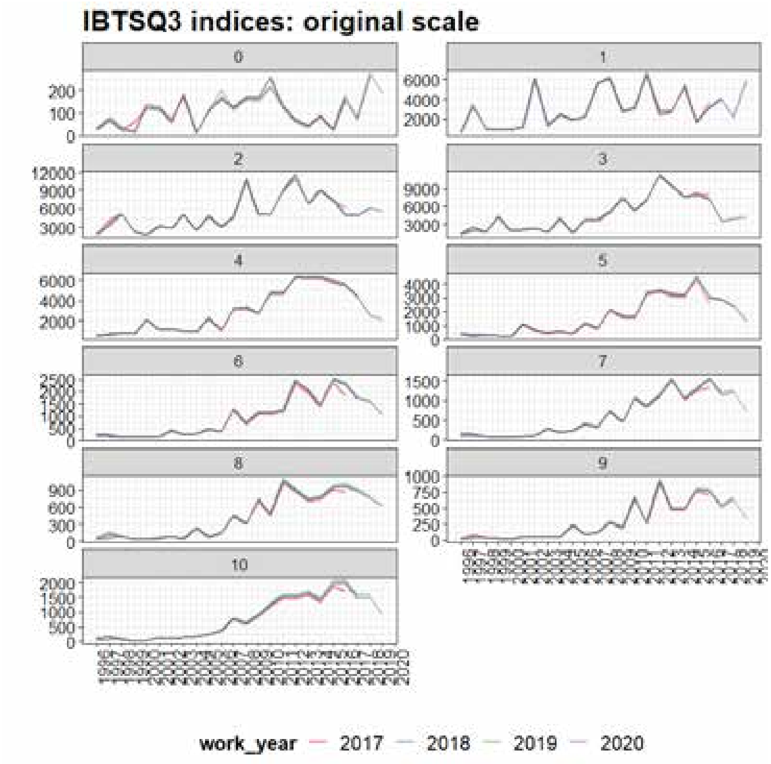


Figure 13.3.7. Indices of age 0 in SNS and DFS surveys.




IBTSQ3 indices: original scale
0
1
2
3
4
5
6
7
8
9
10
work_year 2017 2018 2019 2020

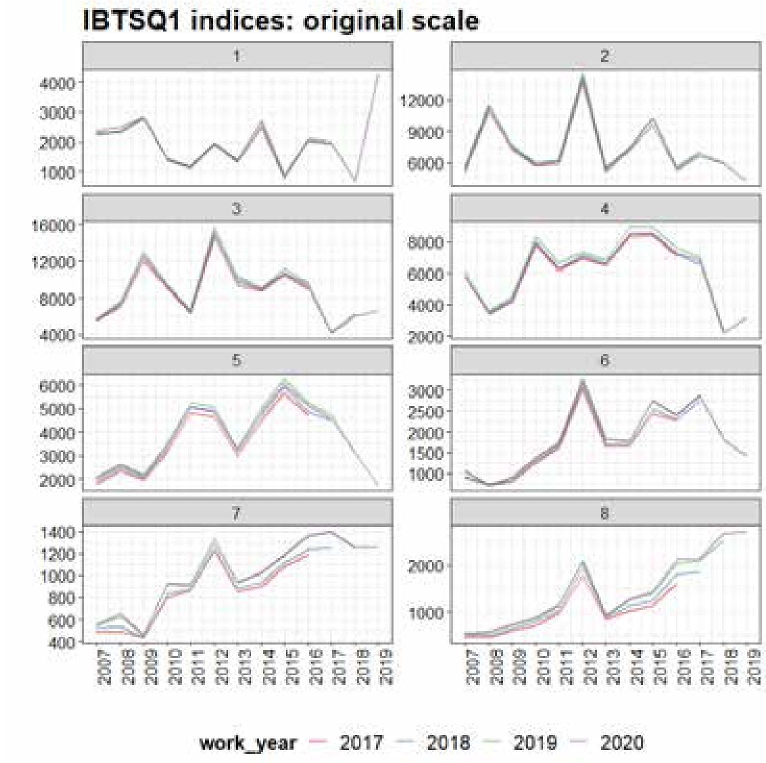

IBTSQ1 indices: original scale
1
2
3
4
5
6
7
8
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
work_year 2017 2018 2019 2020

Figure 13.3.8. Yearly estimated delta-GAM indices for BTS, IBTS-Q3 and IBTS-Q1 since 2017.

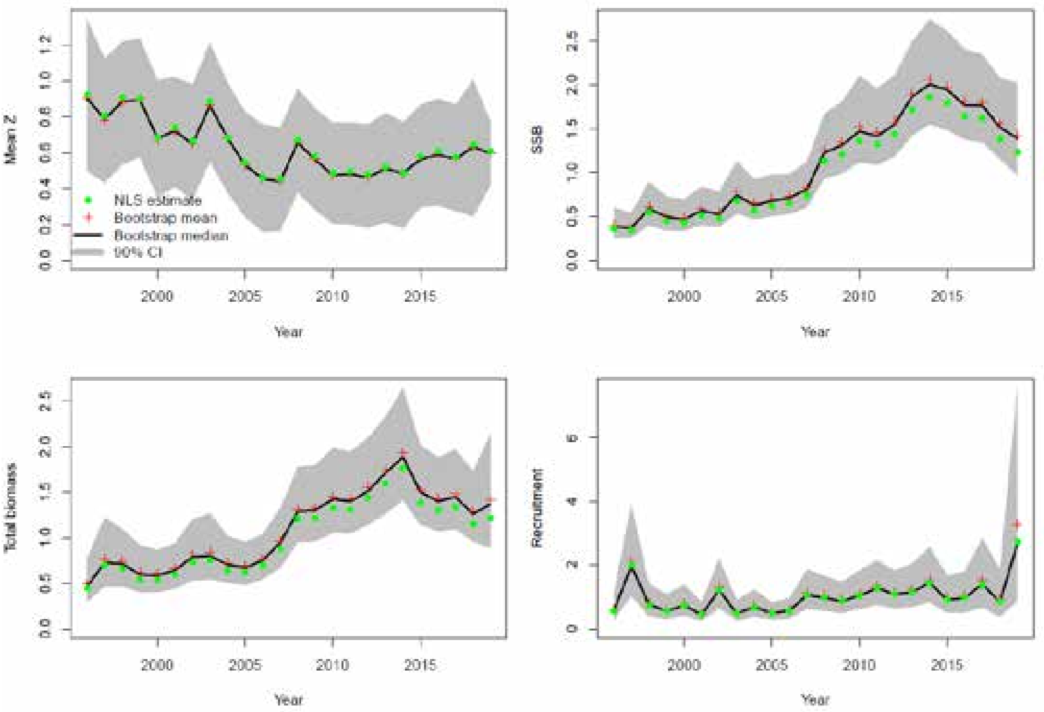


Figure 13.3.9. Results of the preliminary SURBAR run using surveys since 1996. The lambda smoother is set as 5. q (catch-ability parameter) for both the IBTS surveys was adjusted with q(1) = 0.1 and q(2) = 0.5. this is to try and deal with the significant hooks in the catch curves at younger ages.

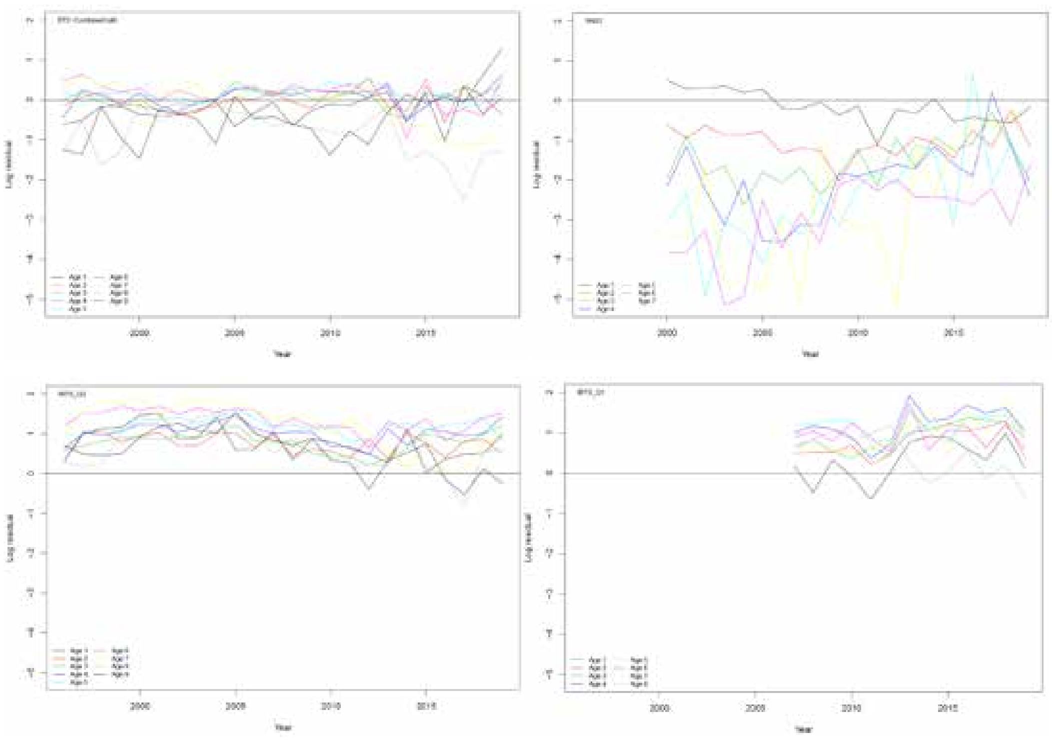
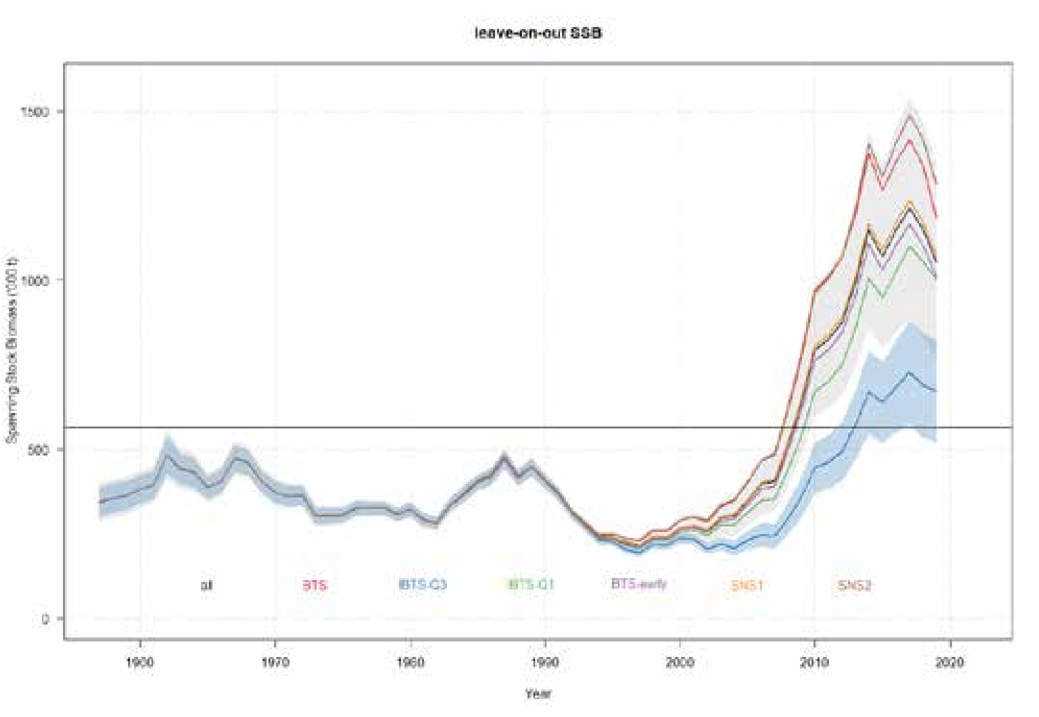
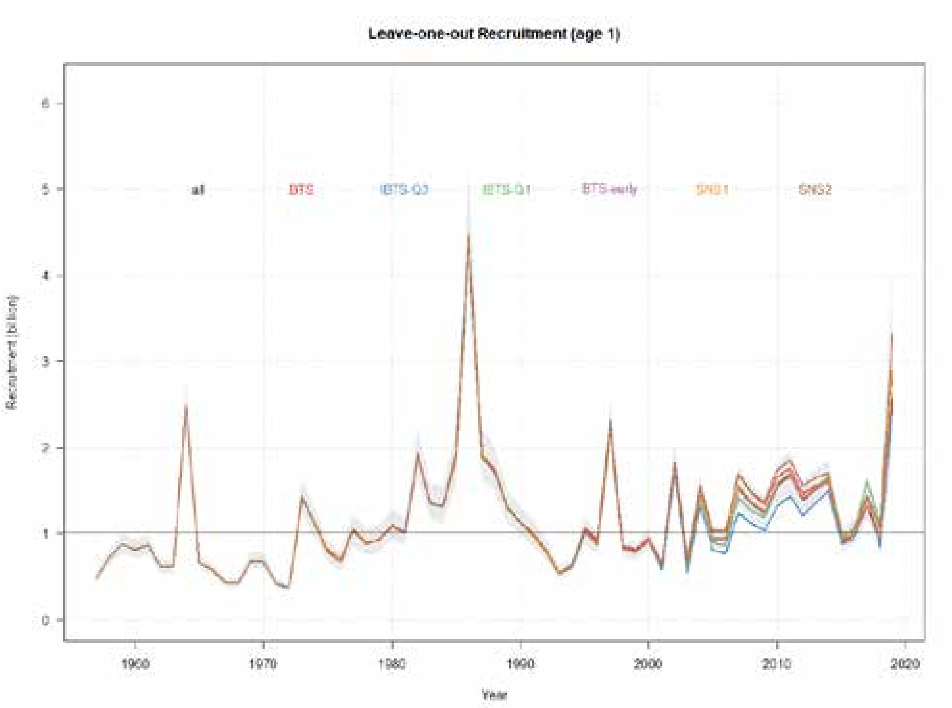


Figure 13.3.10. Residuals of the preliminary SURBAR run using surveys since 1996.


leave-on-out SSB
Spawning Stock Biomass ('000 t)
all
BTS
IBTS-Q3
IBTS-Q1
BTS-early
SNS1
SNS2
Year


Leave-one-out Recruitment (age 1)
Recruitment (billion)
all
BTS
IBTS-Q3
IBTS-Q1
BTS-early
SNS1
SNS2
Year

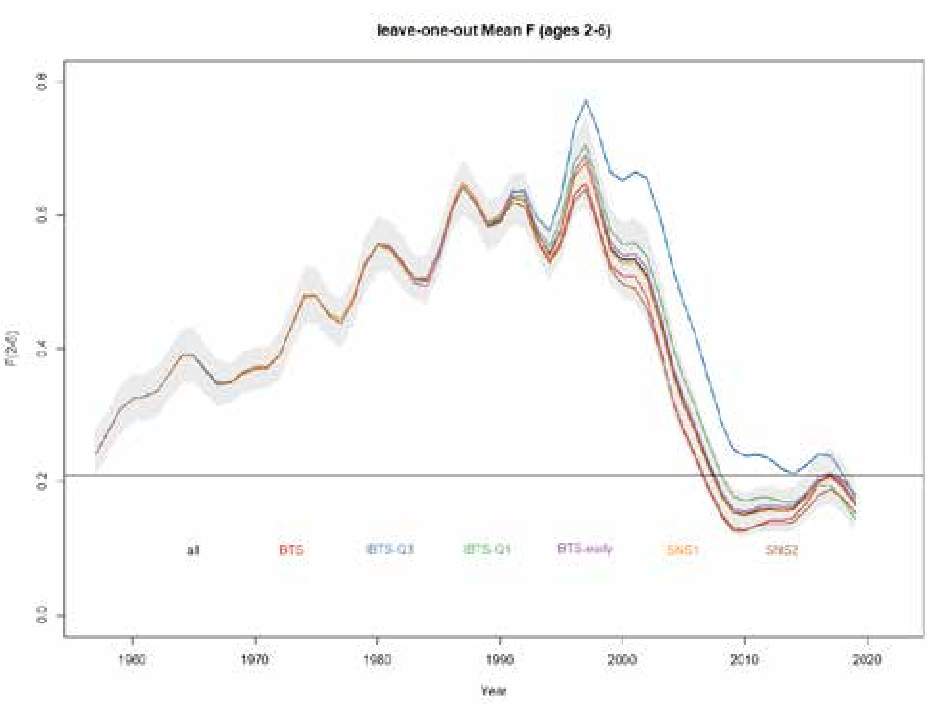


Figure 13.3.11. Sensitivity analysis by leave one out of each survey used in the assessment. The black curve (and 95% CI in gray) is the base run with all surveys included, the red curve is the run without BTS and the blue curve(and 95% CI in blue) is the run without IBTS-Q3.

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

2018 advice: ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 7864 tonnes. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2017, this will correspond to catches of plaice in Division 7.d in 2019 of no more than 9225 tonnes.

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.

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 2019 landings of 3681 tonnes are within 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 2019, with Belgium contributing for 35% and UK for 17%.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.

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 74% 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 2019, 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 2019, 80% 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 21% of the total discards.

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 72% of the total discards (imported + raised).

The method used to process French fisheries data was modified to solve some issues that went undetected until data submission of sol.27.7d full time series for WKFlatNSCS benchmark. The new procedure was used to submit 2018 and 2019 datasets into InterCatch for all stocks. The main changes in the method consist in 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.

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2017 in Figure 14.2.3.3.

Figure 14.2.3.4 presents the discards at age ratios (i.e. discards numbers / landings numbers) per age over the sampled period 2006–2019. From 2013, the ratio is higher for the ages 4 and 5. The ratio for ages 1 to 3 remains stable between 2017 and 2019.

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 used to be the Q2 landings weights. However, in 2020 this information was missing for ages 1 and 2 in InterCatch data, Therefore, Q3 and Q4 landings weights were used instead since they had the most similar distribution to Q2. These weights at age do not show specific trends, apart from a general decrease in landing weights in 2013–2019 for ages 5, 6 and 7.

14.2.5 Maturity and natural mortality

The maturity ogive used in the assessment is given in the table below.

Age	1	2	3	4	5	6	7
Proportion of mature	0	0.15	0.53	0.96	1	1	1

New age-specific natural mortality rates have been estimated from Peterson and Wroblewski's relationship during the 2015 WKPLE benchmark, as detailed in the Stock Annex.

Age	1	2	3	4	5	6	7

Natural mortality	0.3531	0.3132	0.292	0.2749	0.2594	0.2474	0.2329

14.2.6 Surveys

The survey series used in the assessment are the French Ground Fish Survey (FR GFS), 1993 – present and the UK beam trawl survey (UK BTS), 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).

The consistencies between ages are good for the UK-BTS survey, and correct for ages 2 to 6 (Figure 14.2.6.2).

14.3 Assessment

The model used is the Aart and Poos model (AAP, Aarts and Poos, 2009, for more details please refer to the Stock Annex).

Year of assessment:		**2020**
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
UK Beam Trawl Survey	Age range	1–
	Year range	

14.3.1 Results

The landings and discards estimated by the model are presented in Figure 14.3.1.1 and the residuals in tables 14.3.1.1 and 14.3.1.2. Given the observed trend in the discard at age ratio (see Section 14.2.3), the average discard at age ratio over 2006–2011 is used to estimate the discards prior to 2006; while the actual discard at age ratios are used in the assessment to estimate the discards for the last 8 years (2012 to 2019).

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.

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 2020 are AAP survivors estimates.

14.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated. For 2019 and the previsions (2020, 2021 and 2022), the recruitment was calculated as the geometric mean recruitment over the period y–5 to y–2 (i.e. 2014–2017 this year, blue line in Figure 14.5.1.2) as recommended in the stock annex. In 2018, the geometric mean over the entire time series (i.e. 1980–2018 red line in Figure 14.5.1.2) was used given the drop in the recruitment in 2016-2017. With the increase of recruitment in 2018 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 2019 (status quo). Plaice in 7.d are under landing obligation since the 1 January 2019. To assess if the TAC in 2020 will be fully taken, we compared ICES catches of resident plaice in 7.d in 2019 to the proportion of the 2020 TAC corresponding to resident plaice in 7.d (5840 tonnes, dark green dot in Figure 14.5.2.1). Using first the average official landing proportion between 7.e and 7.d, e over the period 2003–2019 (Figure 14.5.2.2) we obtain the TAC in 7.d. Then we applied the Q1 removal ratio over the same period to account for migration of mature plaice from the 7.e and 4.c during Q1 (Figure 14.5.2.3). If we compare ICES catches to 2020 TAC corresponding to resident plaice in 7.d (dark green line and dot, Figure 14.5.2.1), TAC will be fully used in 2019. However if we account for survivability exemption applied to OTB, OTT, OTM, GTR and SDN fleets (green dot, Figure 14.5.2.1) (EU, 2018), landings under landing obligation are significantly lower than the TAC (dark green dot, Figure 14.5.2.1), leading to the decision that the usual fully taken TAC assumption was inappropriate[1].

14.5.3 Management options tested

14.5.3.1 Calculation of STF

Potential TACs for 2021 were calculated using $F_{MSY\ lower}$, $F_{MSY\ upper}$ and F_{MSY} as prescribed by the EU multiannual plan (MAP) for the Western Waters (EU, 2019). Alternative options were also tested. Results are presented in Table 14.5.3.1.1 for the resident stock.

Following the MAP would lead to catches from the stock in 2021 that correspond to the fishing mortality (F) ranges, between 6066 tonnes and 11 130 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (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.

These options are then calculated for the total 7.d stock (including the migratory components from 4 and 7.e) using the long term average of the migratory landings over the total annual landings (Figure 14.5.2.3).

Following the MAP would lead to catches in 2021 for the plaice in 7.d between 7190 tonnes and 13 192 tonnes. Again, catches higher than those corresponding to F_{MSY} (9959 tonnes) can only be taken under conditions specified in the MAP.

14.6 Quality of the assessment

The sampling for plaice in 7.d are considered to be at a reasonable level.

The quality of the assessment is considered to have improved in 2015 following the change of assessment model and the inclusion of discards.

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.

[1] Note: Didn't account for TBB, because it is not possible to estimates with InterCatch data (regulation based on engine power kW, vessel length and fishing area).

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 above F_{MSY}; and spawning stock size is above MSY $B_{trigger}$ (Figure 14.3.1.3).

	Fishing pressure					Stock size				
		2017	2018	2019			2018	2019	2020	
Maximum sustainable yield	F_{MSY}	✓	✓	✗	Above	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within range	B_{MGT}	✓	✓	✓	Above trigger

14.8 Management considerations

The stock identity of plaice in the Channel is unclear and may raise some issues.

The TAC is combined for divisions 7.d and 7.e. Plaice in 7.e is considered at risk of being harvested unsustainably (F above F_{MSY}).

The plaice stock in 7.d is mostly harvested in a mixed fishery with sole in 7.d.

Due to the minimum mesh size (80 mm) in the mixed beam and otter trawl fisheries, a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

14.9 Issue for future benchmarks

14.9.1 Data

The vessel used for FR GFS survey was changed in 2014, moving from the R/V Gwen Drez to the R/V Thalassa. Even if the inter-calibration between the two vessels realised in 2015 showed no significant effect on plaice catches (Auber *et al.*, 2015) and no correction coefficients were applied to calculate plaice survey indices (Travers-Trolet *et al.*, 2016). Further 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.

14.9.2 Assessment

Residual patterns in the FR GFS residuals and the year effect (2018) 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, 1976–2019.

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

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)
1993	877	2792	1102		4771	560	5331		1614	8500
1994	1418	3199	1007	9	5633	488	6121		1404	9100
1995	1157	2598	814		4569	561	5130		1247	8000
1996	1112	2630	856		4598	795	5393		1266	7530
1997	1161	3077	1078		5316	991	6307		1583	7090
1998	854	3276	700		4830	932	5762		1346	5700
1999	1306	3388	743		5437	889	6326		1543	7400
2000	1298	3183	754		5235	779	6014		1625	6500
2001	1346	2962	660		4968	298	5266		1310	6000
2002	1204	3450	841	1	5496	281	5777		1472	6700
2003	998	2893	756	3	4650	-564	4086		1387	5970
2004	954	2766	582	10	4312	438	4750		1337	6060
2005	832	2432	421	21	3706	285	3991		1319	5150
2006	1024	1935	550	16	3525	121	3646	749	1411	5151
2007	1355	2017	463	10	3845	156	4001	1252	1146	5050
2008	1386	1740	471	12	3609	255	3864	936	1112	5050
2009	1002	1892	612	16	3522	38	3560	1528	1024	4646
2010	1123	2190	517	62	3892	519	4411	2511	1208	4274

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7.d (1)	Estim.discards 7.d (2)	Tot. land. rep. in 7.e (3)	Agreed TAC (4)
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

(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
2018	4999	1024	3975	6215	1255	4960
2019	3721	885	2836	7064	854	6210

(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

	age						
year	1	2	3	4	5	6	7+
1993	740	7473	3295	863	359	313	581
1994	1242	3570	6015	2131	563	280	781
1995	2592	4264	2532	2006	611	152	591
1996	1119	4762	3113	1060	951	326	585
1997	550	4168	6184	2382	724	506	722
1998	464	4323	7467	2335	360	94	289
1999	741	1737	10493	4583	696	121	223
2000	1383	6177	3432	3992	752	150	142
2001	2682	4070	3589	1385	1253	203	145
2002	902	6876	4553	1390	1144	603	288
2003	0	3597	2103	1380	350	356	758
2004	922	2718	4573	760	400	219	527
2005	86	2602	2153	1975	449	245	508
2006	191	2801	3081	1626	987	166	379
2007	529	2986	2379	1237	534	395	274
2008	293	3844	2512	1125	584	218	258
2009	491	2975	3112	848	402	242	240
2010	530	4238	3367	1465	392	278	287
2011	93	4436	3557	964	316	59	119
2012	18	1266	3780	1845	524	195	171
2013	9	756	3666	3294	1158	247	156
2014	76	759	2015	3731	1848	468	202
2015	3	600	1523	1483	1933	940	642
2016	12	233	2115	2220	1431	1719	1028
2017	3	120	1370	2772	1753	987	1645
2018	18	217	1045	2852	2482	1316	2410
2019	41	233	1506	1256	1681	1462	1424

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

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

	1	2	3	4	5	6	7
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
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

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

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

year	1	2	3	4	5	6	7
1992	0.088	0.241	0.336	0.421	0.477	0.521	0.725
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.727
1994	0.165	0.198	0.276	0.331	0.383	0.493	0.866
1995	0.124	0.257	0.286	0.354	0.442	0.707	0.855
1996	0.178	0.229	0.263	0.347	0.354	0.474	0.934
1997	0.059	0.202	0.256	0.266	0.417	0.530	0.902
1998	0.072	0.203	0.273	0.361	0.530	0.670	0.873
1999	0.072	0.172	0.213	0.351	0.429	0.644	0.904
2000	0.068	0.184	0.204	0.246	0.355	0.554	0.928
2001	0.093	0.206	0.274	0.338	0.404	0.624	1.104
2002	0.102	0.206	0.281	0.379	0.467	0.558	0.809
2003	NA	0.306	0.403	0.528	0.673	0.592	0.961
2004	0.280	0.366	0.508	0.571	0.701	0.788	0.861
2005	0.174	0.299	0.377	0.489	0.672	0.683	1.010
2006	0.220	0.270	0.343	0.419	0.506	0.637	0.938
2007	0.063	0.247	0.391	0.543	0.579	0.656	0.825
2008	0.121	0.245	0.301	0.368	0.448	0.462	1.005
2009	NA	0.268	0.358	0.487	0.476	0.719	1.036
2010	NA	0.280	0.354	0.415	0.455	0.561	0.719
2011	0.189	0.238	0.402	0.535	0.737	0.791	0.908
2012	NA	0.253	0.298	0.424	0.517	0.629	0.938
2013	0.174	0.252	0.277	0.479	0.454	0.886	0.995
2014	0.157	0.256	0.243	0.381	0.518	0.756	1.042
2015	0.154	0.253	0.256	0.287	0.363	0.436	0.782
2016	0.258	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

Table 14.2.6.1. Plaice in 7.d: Tuning fleets.

UK BTS						
1989 2019						
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

Table 14.2.6.1. (cont.) Plaice in 7.d: Tuning fleets.

FR GFS						
1993 2019						
1 1 0.75 1						
1 6						
1	232.04	867.4	345	125.8	32	8.66
1	468.69	347.5	148	67.6	26.2	11.65
1	30.31	336.5	364	142.1	101.1	27.19
1	772.65	243.8	181	26.6	12.9	15.07
1	537.67	800.7	267	245.8	20.8	8.55
1	551.31	415.3	406	93.7	29.3	0
1	66.49	529.1	254	392	76.1	12.41
1	2347.63	653.6	655	201.1	192.6	50.45
1	62.33	290.8	187	81.6	75.1	35.37
1	36.13	584.9	303	189.7	69.8	51.4
1	698.12	304	460	81.8	16.8	17.21
1	67.8	388.3	281	137	40	4.34
1	105.13	405.9	746	360	114.2	32.07
1	2163.19	684.3	447	152	61.4	32.69
1	46.64	446	395	237.2	105.1	33.52
1	120.29	235	642	140.1	46.8	12.23
1	48.65	293.8	223	94.6	27.8	6.82
1	36.36	745.5	467	109.5	29	7.46
1	729.93	1973.9	2370	734.3	116.8	12.96
1	224.96	557.3	1504	1282	257.9	97.02
1	304.35	716.4	567	1148.2	288.4	88.07
1	75.67	556.2	470	542.7	708.6	172.21
1	4.18	96.8	683	556.5	152.8	173.23
1	10.39	44.9	243.12	367.0	136.91	93.37
1	8.31	53.59	108.57	147.1	142.44	44.55
1	42.64	83.82	241.83	119.56	170.23	52.43
1	16.48445649	616.7568248	407.318741	315.5103249	127.8535144	187.8723828

Table 14.3.1.1. Plaice in 7.d: Landings Residuals.

age	1	2	3	4	5	6	7
1980	-0.531	0.859	-0.448	-0.314	0.207	-0.034	-0.127
1981	-1.486	0.138	0.378	0.345	-0.091	-0.178	0.302
1982	0.280	0.081	-0.112	-0.040	0.079	0.361	-0.283
1983	-0.716	0.107	-0.269	0.114	-0.318	-0.241	-0.045
1984	0.821	-0.278	-0.150	0.146	0.108	0.116	0.267
1985	-0.035	0.817	-0.230	0.196	-0.536	-0.044	-0.009
1986	0.923	0.402	-0.131	0.139	0.187	0.597	-0.536
1987	-2.140	0.255	-0.269	0.037	0.117	-0.371	0.229
1988	-2.686	0.203	0.052	-0.013	-0.182	-0.082	0.048
1989	1.044	0.237	-0.310	-0.153	0.265	-0.055	-0.063
1990	1.198	0.190	0.355	-0.063	-0.145	0.003	0.240
1991	0.214	0.745	0.356	0.282	0.092	0.057	-0.031
1992	-0.301	0.092	0.184	0.010	0.000	0.102	0.024
1993	-0.716	-0.010	-0.376	-0.151	-0.187	-0.216	-0.271
1994	-0.168	0.034	0.119	0.301	0.314	0.218	0.071
1995	0.314	0.563	0.047	-0.037	-0.122	-0.299	-0.080
1996	0.040	0.424	0.368	-0.100	0.049	0.053	0.033
1997	-0.480	0.343	0.362	0.648	0.456	0.414	0.324
1998	0.250	-0.164	0.198	-0.121	-0.117	-0.329	-0.364
1999	0.171	-0.674	-0.111	0.316	-0.006	0.257	0.021
2000	-0.399	0.430	-0.454	-0.231	-0.095	-0.096	0.131
2001	0.086	-0.231	0.003	-0.290	-0.076	-0.202	0.029
2002	-0.371	0.758	0.285	0.201	0.632	0.008	0.105
2003	-4.971	0.132	-0.438	0.174	-0.201	0.019	0.160
2004	2.765	0.819	-0.328	-0.464	-0.105	-0.178	-0.253
2005	0.512	0.525	-0.592	-0.192	0.054	0.005	-0.001
2006	0.622	0.487	-0.460	0.170	0.223	-0.250	0.068
2007	0.669	0.399	-0.500	-0.235	0.185	0.025	0.039
2008	-0.152	0.352	-0.279	-0.038	0.138	-0.017	-0.219

age	1	2	3	4	5	6	7
2009	0.275	0.029	-0.305	-0.113	0.069	-0.050	-0.150
2010	0.338	0.083	-0.402	0.185	0.274	0.459	0.054
2011	-1.483	-0.105	-0.749	-0.491	-0.179	-0.722	-0.622
2012	-0.159	-0.079	-0.152	-0.024	0.086	0.324	-0.075
2013	-0.136	0.095	-0.043	-0.011	0.155	0.269	-0.262
2014	0.114	0.188	0.519	0.101	0.124	0.146	-0.407
2015	0.151	-0.038	-0.077	-0.172	-0.135	0.065	-0.034
2016	-0.202	-0.267	-0.222	-0.083	0.060	-0.011	-0.412
2017	-0.252	0.170	-0.175	-0.103	-0.019	0.085	-0.441
2018	0.115	0.284	0.272	0.185	0.110	0.365	0.078
2019	-0.016	-0.208	0.140	-0.080	-0.082	-0.007	-0.395

Table 14.3.1.2. Plaice in 7.d: Discards Residuals.

age	1	2	3	4	5	6	7
2006	-0.053	-0.030	-0.087	-0.754	-0.746	0.068	0.418
2007	-0.226	0.595	0.105	0.488	-2.563	0.078	0.583
2008	0.200	-0.352	-0.763	0.250	0.951	1.679	0.981
2009	-0.043	0.255	0.143	0.102	0.512	2.616	1.896
2010	-0.059	0.686	0.456	0.928	1.187	1.117	1.787
2011	0.050	0.168	-0.678	-0.099	0.311	3.005	1.387
2012	-0.139	-0.079	-0.152	-0.023	0.105	1.456	3.941
2013	-0.100	0.096	-0.043	-0.011	0.167	0.371	0.509
2014	0.120	0.189	0.519	0.101	0.126	0.160	-0.306
2015	0.247	-0.037	-0.077	-0.171	-0.133	0.069	-0.009
2016	-0.172	-0.265	-0.222	-0.082	0.062	-0.006	-0.375
2017	-0.168	0.173	-0.175	-0.103	-0.017	0.089	-0.426
2018	0.135	0.286	0.273	0.185	0.111	0.367	0.081
2019	-0.007	-0.206	0.141	-0.079	-0.082	-0.006	-0.391

Table 14.3.1.3. Plaice in 7.d: Survey residuals.

UK BTS age	1	2	3	4	5	6
1989	-1.251	-0.628	-0.087	0.337	-0.103	0.110
1990	-0.381	-0.597	-0.514	-0.199	0.177	-0.356
1991	-0.305	-0.086	0.131	0.006	0.200	-0.199
1992	-0.246	-0.124	-0.250	0.366	0.478	0.311
1993	-1.075	-0.329	-0.417	-0.276	0.208	-0.038
1994	-0.210	-0.423	-0.318	0.144	0.087	-0.632
1995	-0.319	-0.620	-0.539	0.017	-0.052	-0.182
1996	-0.108	-0.285	-1.244	-0.818	-0.139	0.109
1997	0.087	-0.108	-0.198	-0.560	0.512	-0.607
1998	0.362	-0.441	-0.468	-0.002	-0.188	0.430
1999	-0.279	-0.919	-0.214	-0.506	-0.186	-0.014
2000	-0.015	0.478	0.195	0.284	0.345	0.211
2001	0.492	0.071	0.363	0.356	0.653	0.319
2002	0.384	0.393	0.269	0.228	-0.276	0.171
2003	-0.283	0.189	0.025	0.056	0.052	-0.483
2004	1.082	0.121	0.043	0.119	-0.530	-1.172
2005	0.028	0.356	0.021	0.107	0.418	0.017
2006	0.764	0.324	0.048	0.014	-0.079	0.162
2007	1.034	0.454	-0.061	-0.212	0.020	0.088
2008	0.501	0.504	-0.059	-0.381	-0.095	-0.008
2009	0.634	0.209	0.317	0.058	-0.091	-0.118
2010	-0.007	0.122	-0.171	0.167	-0.006	-0.226
2011	0.392	0.196	-0.024	-0.078	0.439	0.351
2012	-0.470	-0.326	-0.215	-0.182	-0.423	0.137
2013	-0.323	0.055	0.001	0.120	-0.259	-0.206
2014	0.691	0.872	0.092	0.180	0.118	0.041
2015	-0.521	0.517	0.185	0.098	0.088	0.040
2016	-1.120	0.082	0.195	0.208	0.294	0.204
2017	0.240	0.608	0.144	0.147	-0.050	-0.121
2018	-0.717	0.560	1.017	0.293	0.129	-0.096
2019	0.308	0.137	0.403	0.604	-0.126	-0.272

Table 14.3.1.3. (cont.) Plaice in 7.d: Survey Residuals.

FR GFS age	1	2	3	4	5	6
1993	1.663	0.190	0.171	0.101	-0.483	-0.421
1994	0.930	0.105	-0.567	-0.384	0.002	0.952
1995	0.336	1.080	0.882	0.845	0.528	2.136
1996	-0.229	-0.323	-0.692	-0.273	0.034	0.973
1997	0.356	-0.283	0.712	0.249	0.453	1.813
1998	0.427	-0.487	-0.602	-0.190	-1.037	1.365
1999	0.905	-0.148	0.207	0.264	0.007	1.738
2000	1.009	1.207	0.387	0.468	0.713	1.125
2001	0.383	-0.019	-0.046	0.325	-0.405	-0.226
2002	0.603	0.491	0.807	0.699	0.717	-0.063
2003	0.517	0.227	-0.030	-0.598	0.165	0.329
2004	0.524	0.213	-0.254	0.198	-0.867	1.234
2005	0.728	0.947	1.154	0.462	0.779	1.110
2006	1.337	0.644	0.056	0.270	0.012	0.755
2007	0.618	0.666	0.704	0.515	0.412	-0.564
2008	-0.259	0.860	0.329	-0.084	-0.801	0.338
2009	-0.580	-0.471	-0.369	-0.447	-1.105	-0.168
2010	-0.107	-0.329	-0.566	-0.739	-0.922	0.091
2011	0.682	0.807	0.649	0.236	-0.814	1.692
2012	0.093	0.149	0.647	0.319	0.693	0.376
2013	0.225	-0.162	0.287	-0.149	-0.103	-0.421
2014	-0.515	-0.474	0.178	0.484	-0.017	-0.632
2015	-2.118	-0.590	0.075	-0.400	-0.259	-0.570
2016	-2.355	-1.484	-0.812	-0.622	-0.206	-0.796
2017	-2.205	-1.756	-1.544	-1.025	-1.012	-1.096
2018	-2.059	-0.953	-1.155	-0.624	-1.268	-1.121
2019	-0.578	-0.673	-0.074	-0.238	0.239	-0.015

Table 14.3.1.4. Plaice in 7.d: Fishing mortality (F) at age.

	1	2	3	4	5	6	7
1980	0.011	0.116	0.392	0.320	0.177	0.102	0.102
1981	0.017	0.144	0.438	0.385	0.232	0.140	0.140
1982	0.025	0.173	0.490	0.447	0.287	0.183	0.183
1983	0.027	0.196	0.553	0.485	0.314	0.213	0.213
1984	0.021	0.204	0.625	0.482	0.296	0.215	0.215
1985	0.015	0.202	0.678	0.457	0.264	0.204	0.204
1986	0.014	0.195	0.672	0.439	0.254	0.206	0.206
1987	0.018	0.192	0.593	0.444	0.286	0.236	0.236
1988	0.033	0.199	0.505	0.455	0.338	0.280	0.280
1989	0.063	0.229	0.459	0.448	0.363	0.304	0.304
1990	0.106	0.296	0.479	0.409	0.320	0.275	0.275
1991	0.159	0.403	0.544	0.365	0.256	0.227	0.227
1992	0.227	0.526	0.613	0.343	0.219	0.192	0.192
1993	0.313	0.605	0.642	0.357	0.224	0.185	0.185
1994	0.356	0.592	0.630	0.407	0.266	0.201	0.201
1995	0.271	0.477	0.597	0.487	0.343	0.239	0.239
1996	0.128	0.322	0.561	0.587	0.447	0.296	0.296
1997	0.060	0.225	0.536	0.667	0.533	0.344	0.344
1998	0.051	0.210	0.531	0.664	0.526	0.335	0.335
1999	0.108	0.302	0.550	0.559	0.406	0.256	0.256
2000	0.296	0.495	0.581	0.438	0.284	0.182	0.182
2001	0.404	0.610	0.600	0.363	0.218	0.149	0.149
2002	0.149	0.430	0.591	0.350	0.212	0.163	0.163
2003	0.030	0.232	0.563	0.368	0.236	0.210	0.210
2004	0.010	0.147	0.536	0.381	0.257	0.256	0.256
2005	0.010	0.149	0.520	0.358	0.244	0.254	0.254
2006	0.022	0.200	0.512	0.316	0.209	0.215	0.215
2007	0.043	0.263	0.508	0.277	0.174	0.173	0.173
2008	0.042	0.265	0.499	0.252	0.149	0.142	0.142
2009	0.027	0.219	0.470	0.235	0.131	0.119	0.119
2010	0.018	0.167	0.410	0.218	0.117	0.096	0.096
2011	0.016	0.132	0.325	0.197	0.106	0.074	0.074
2012	0.019	0.109	0.248	0.178	0.099	0.060	0.060
2013	0.023	0.095	0.196	0.165	0.099	0.057	0.057
2014	0.024	0.087	0.173	0.159	0.108	0.068	0.068
2015	0.024	0.086	0.170	0.164	0.124	0.094	0.094
2016	0.025	0.093	0.188	0.180	0.147	0.128	0.128
2017	0.028	0.113	0.233	0.213	0.173	0.157	0.157
2018	0.034	0.149	0.310	0.266	0.202	0.175	0.175
2019	0.043	0.205	0.430	0.340	0.234	0.185	0.185

Table 14.3.1.5. Plaice in 7.d: Stock number from the assessment.

	1	2	3	4	5	6	7
1980	67073	29931	9998	2423	1982	654	1863
1981	34321	46608	18721	4747	1237	1167	1597
1982	65423	23693	28355	8491	2270	689	1687
1983	57174	44842	14002	12200	3814	1197	1390
1984	58725	39107	25906	5657	5275	1957	1469
1985	77898	40396	22398	9744	2454	2757	1942
1986	159417	53900	23194	7989	4332	1324	2690
1987	96029	110489	31153	8324	3617	2361	2295
1988	60346	66231	64082	12094	3752	1910	2584
1989	37479	41007	38123	27179	5390	1879	2385
1990	38599	24712	22916	16924	12202	2633	2210
1991	66789	24382	12911	9967	7899	6225	2583
1992	87305	40018	11447	5265	4861	4294	4934
1993	44266	48891	16620	4355	2626	2744	5351
1994	38471	22735	18749	6146	2140	1475	4727
1995	62648	18923	8839	7017	2875	1152	3563
1996	70617	33555	8254	3420	3030	1433	2608
1997	120978	43639	17080	3308	1336	1361	2111
1998	58129	80042	24477	7020	1193	551	1728
1999	48209	38824	45580	10114	2538	496	1145
2000	63224	30396	20165	18465	4063	1188	892
2001	58069	33036	13021	7923	8375	2149	1219
2002	74706	27248	12612	5018	3871	4730	2039
2003	38267	45229	12447	4908	2484	2200	4038
2004	47625	26081	25189	4979	2385	1378	3552
2005	40564	33133	15814	10357	2390	1296	2681
2006	37510	28205	20052	6606	5085	1315	2167
2007	51190	25779	16216	8439	3382	2898	1973
2008	65061	34453	13926	6854	4492	1997	2879
2009	110550	43806	18561	5939	3742	2720	2970
2010	172484	75582	24732	8147	3299	2307	3551
2011	206930	119066	44932	11531	4604	2062	3739
2012	105755	143057	73325	22813	6649	2910	3786
2013	119502	72912	90096	40212	13408	4230	4431
2014	194829	82061	46573	52010	23958	8531	5750
2015	171519	133572	52841	27534	31153	15110	9374
2016	103466	117614	86135	31313	16422	19324	15665
2017	105763	70922	75298	50122	18374	9958	21620
2018	141687	72279	44510	41920	28455	10857	18958
2019	233770	96246	43756	22929	22578	16339	17588

Table 14.3.1.6 Plaice in 7.d: Summary table (Outputs from the model).

Year	Recruitment			SSB (tonnes)			Landings	Discards	F		
	Age 1	High	Low		High	Low	tonnes	tonnes	Ages 3–6	High	Low
1980	67073	86725	51922	8171	10365	5976	2223		0.25	0.33	0.16
1981	34321	45362	25992	10892	13234	8550	4009		0.30	0.38	0.22
1982	65423	85761	49945	13275	15982	10568	4040		0.35	0.44	0.26
1983	57174	75261	43446	13288	15978	10598	4093		0.39	0.49	0.29
1984	58725	77103	44761	13161	15814	10508	4249		0.40	0.50	0.31
1985	77898	100067	60621	13096	15685	10507	5000		0.40	0.49	0.32
1986	159417	201004	126364	13152	15545	10759	5673		0.39	0.48	0.31
1987	96029	121130	76068	15945	18462	13428	7006		0.39	0.47	0.31
1988	60346	76686	47502	20748	24014	17482	8785		0.39	0.47	0.32
1989	37479	48354	29077	21788	25135	18441	7093		0.39	0.47	0.32
1990	38599	51266	29063	18534	21533	15535	7349		0.37	0.44	0.30
1991	66789	92452	48221	14631	17291	11971	6362		0.35	0.41	0.28
1992	87305	126230	60364	12200	14537	9863	5219		0.34	0.41	0.27
1993	44266	65367	29978	11368	13455	9281	4479		0.35	0.41	0.29
1994	38471	58734	25216	10350	12202	8498	5047		0.38	0.44	0.32
1995	62648	89883	43640	8590	10127	7052	4196		0.42	0.49	0.35
1996	70617	91440	54533	7370	8671	6069	4430		0.47	0.55	0.40
1997	120978	151943	96253	7983	9364	6602	5180		0.52	0.61	0.43
1998	58129	73876	45700	11082	12875	9289	4831		0.51	0.61	0.42
1999	48209	64800	35844	14840	17235	12445	5268		0.44	0.53	0.36
2000	63224	96961	41190	14914	17454	12374	4521		0.37	0.44	0.30
2001	58069	95305	35354	12862	15242	10482	4380		0.33	0.41	0.26
2002	74706	97653	57115	11451	13718	9184	4846		0.33	0.40	0.26
2003	38267	47508	30802	11310	13573	9047	3610		0.34	0.42	0.27
2004	47625	58364	38853	12221	14634	9808	4206		0.36	0.44	0.27
2005	40564	49165	33492	12583	15120	10046	3485		0.34	0.43	0.26
2006	37510	45343	31008	12832	15491	10173	3225	727	0.31	0.39	0.24

Year	Recruitment			SSB (tonnes)			Land-ings	Dis-cards	F		
	Age 1	High	Low		High	Low	tonnes	tonnes	Ages 3–6	High	Low
2007	51190	61547	42550	12879	15665	10093	3381	1220	0.28	0.35	0.21
2008	65061	79160	53464	12824	15696	9952	3278	888	0.26	0.33	0.20
2009	110550	132555	92157	13727	16769	10685	3124	1473	0.24	0.30	0.18
2010	172484	208192	142883	16792	20335	13249	3910	2412	0.21	0.27	0.15
2011	206930	250643	170794	23941	28730	19152	3291	1926	0.18	0.22	0.13
2012	105755	129118	86640	35749	42858	28640	3178	3043	0.15	0.18	0.11
2013	119502	146219	97650	47129	56805	37453	3604	2696	0.13	0.16	0.10
2014	194829	238241	159366	51788	62928	40648	3675	3325	0.13	0.16	0.10
2015	171519	213028	137974	52246	63635	40857	2957	2368	0.14	0.17	0.10
2016	103466	134740	79451	54534	66367	42701	3617	3090	0.16	0.20	0.12
2017	105763	141274	79185	53908	66085	41731	3689	4075	0.19	0.24	0.14
2018	141687	214589	93482	46309	57825	34793	3975	4959	0.24	0.30	0.17
2019	233770	470655	116090	36963	47351	26575	2836	6211	0.30	0.40	0.20

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 (2020)	0.30	AAP	Correspond to F_{2019} (status quo assumption)
SSB (2021)	38191	AAP	Short term forecast (STF), tonnes
Rage1 (2020-2021)	138285	GM 2014–2017	Thousands individuals
Catch (2020)	9836	AAP	STF, in tonnes (resident stock)
Landings (2020)	4129	AAP	STF, in tonnes; projection based on the average landing ratio (2017–2019) by age
Discards (2020)	5707	AAP	STF, in tonnes; projection based on the average landing ratio (2017–2019) 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 (2021)	Projected landings* (2021)	Projected discards** (2021)	F_{total} (ages 3 – 6 2021)	SSB (2021)	% SSB change	% change in projected landings
EU MAP ***: F_{MSY}	8402	3424	4978	0.25	39205	2.7	21
EU MAP ***: F = $F_{MSY\ lower}$	6066	2470	3596	0.175	41913	9.7	-12.9
EU MAP ***: F = $F_{MSY\ upper}$	11130	4540	6589	0.344	36088	-5.5	60
F = 0	0	0	0	0	49099	29	-100
F_{pa}	11573	4722	6851	0.36	35586	-6.8	66
F_{lim}	15216	6214	9002	0.50	31521	-17.5	119
SSB (2022) = B_{lim}	27772	11341	16430	1.15	18447	-52	300
SSB (2022) = B_{pa}	20495	8377	12118	0.736	25826	-32	195
SSB (2022) = MSY $B_{trigger}$	20495	8377	12118	0.736	25826	-32	195
F = F_{2020}	9803	3997	5806	0.297	37597	-1.55	41

*** Marketable landings**

**** Including BMS landings (EU stocks), assuming recent discard rate**

***** EU multiannual plan (MAP) for the Western Waters (EU, 20196).**

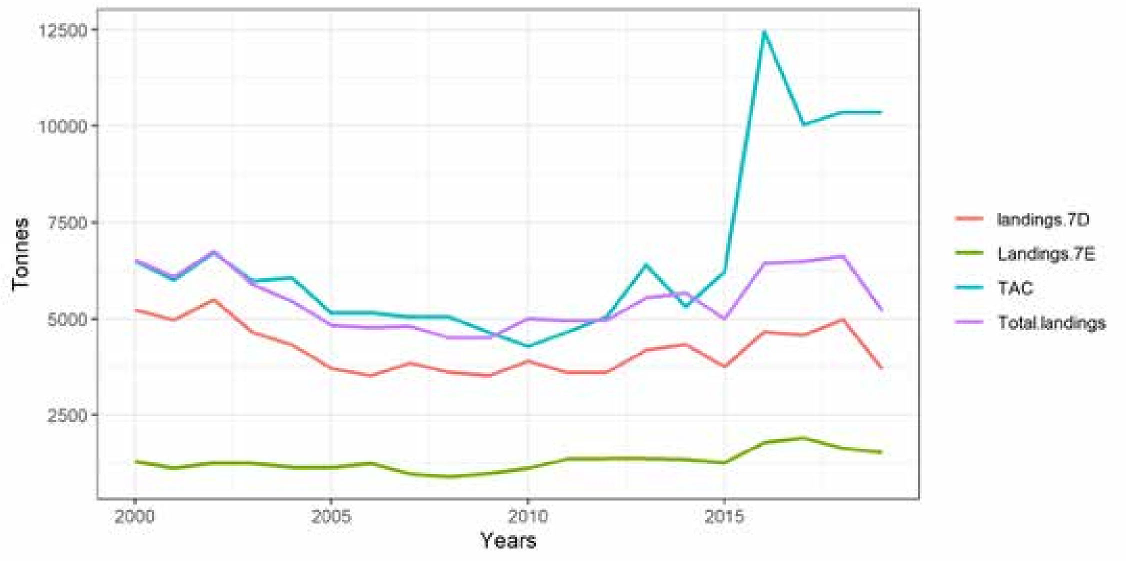


Figure 14.2.1.1. Plaice in 7.d. Official landings in 7.d and 7.e compared to the TAC: in 2019, the advice was given on catch rather than landings.

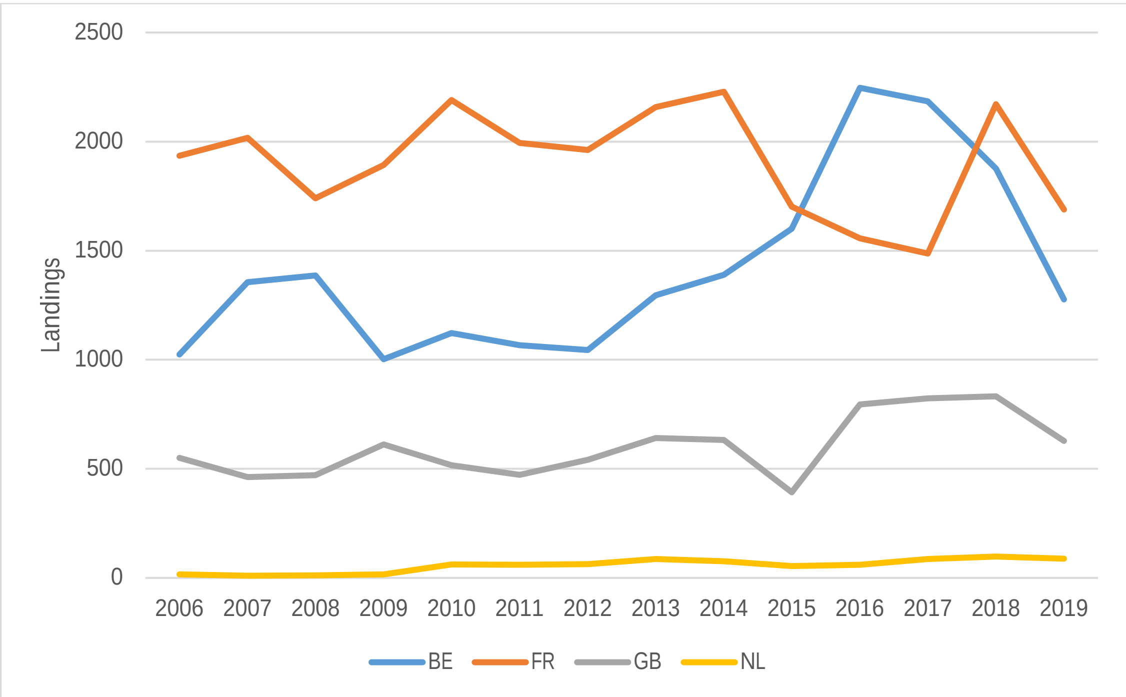


Figure 14.2.1.2. Plaice in 7.d: Official landings.

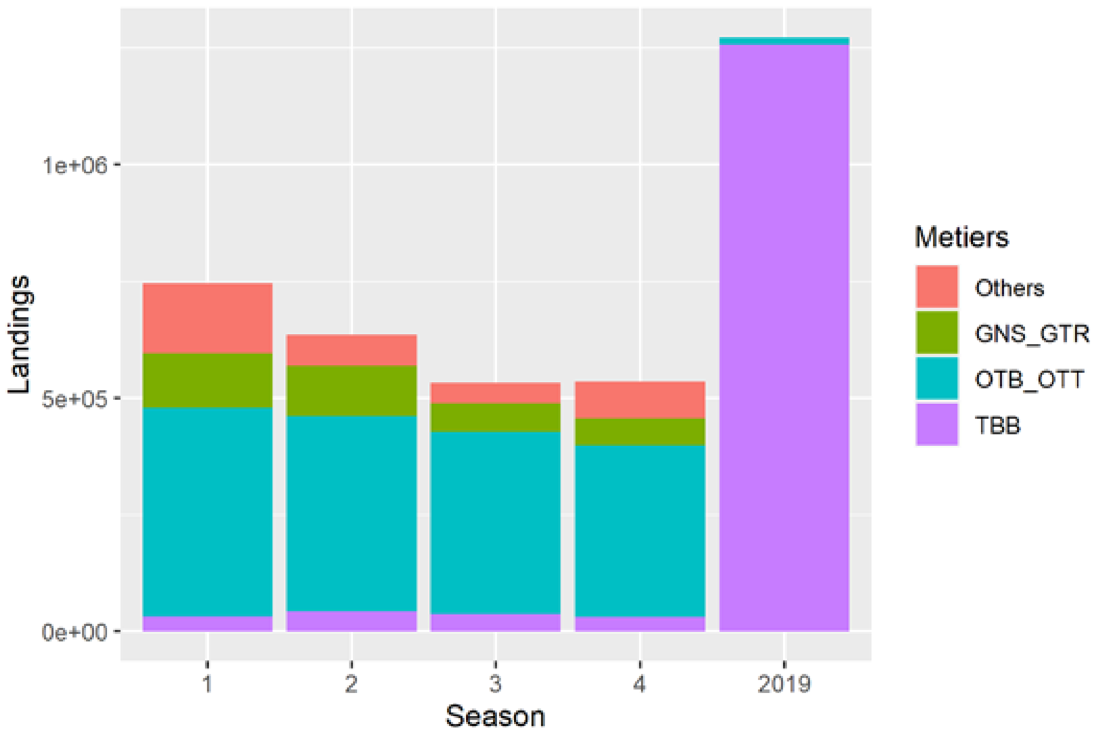


Figure 14.2.1.3. Plaice in 7.d: Landings per quarter.

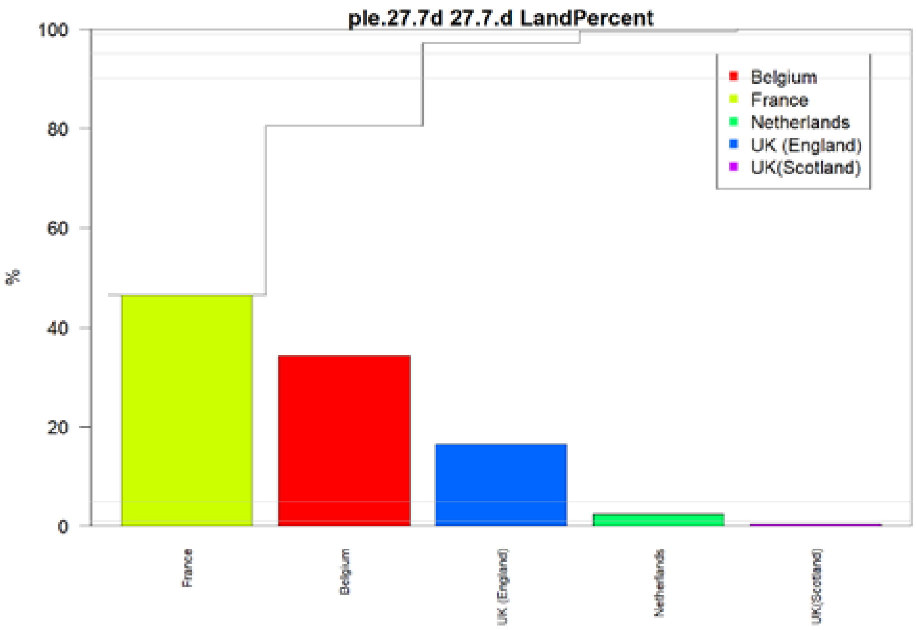


Figure 14.2.2.1. Proportions of total landings per country with and without age distribution provided.

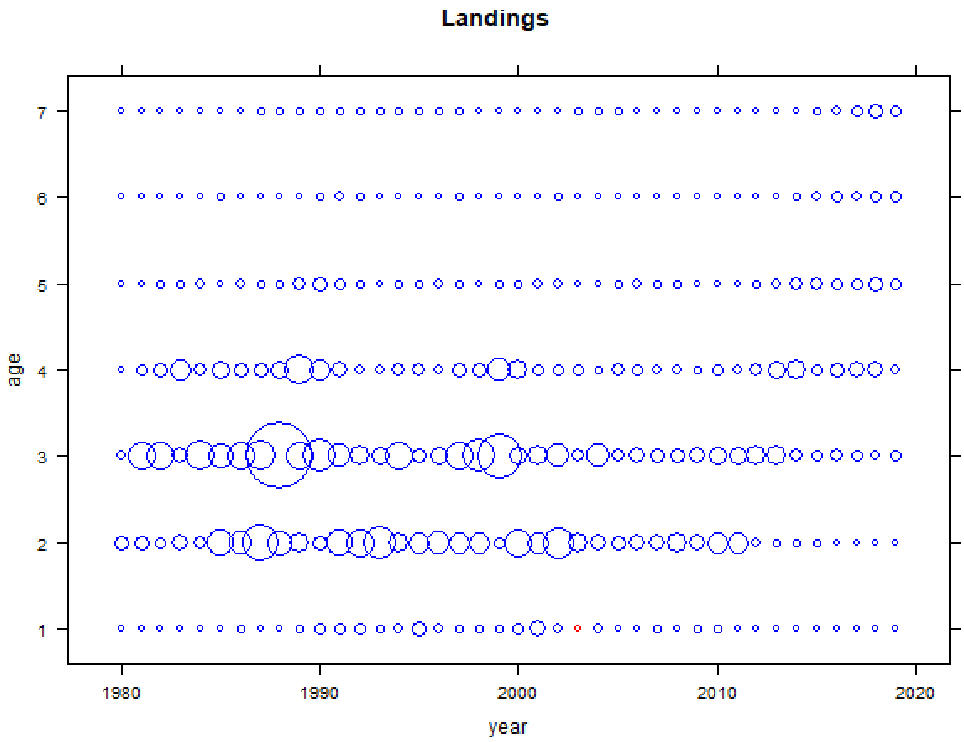


Figure 14.2.3.1. Plaice in 7.d: Age composition of the landings, missing data are presented in red.

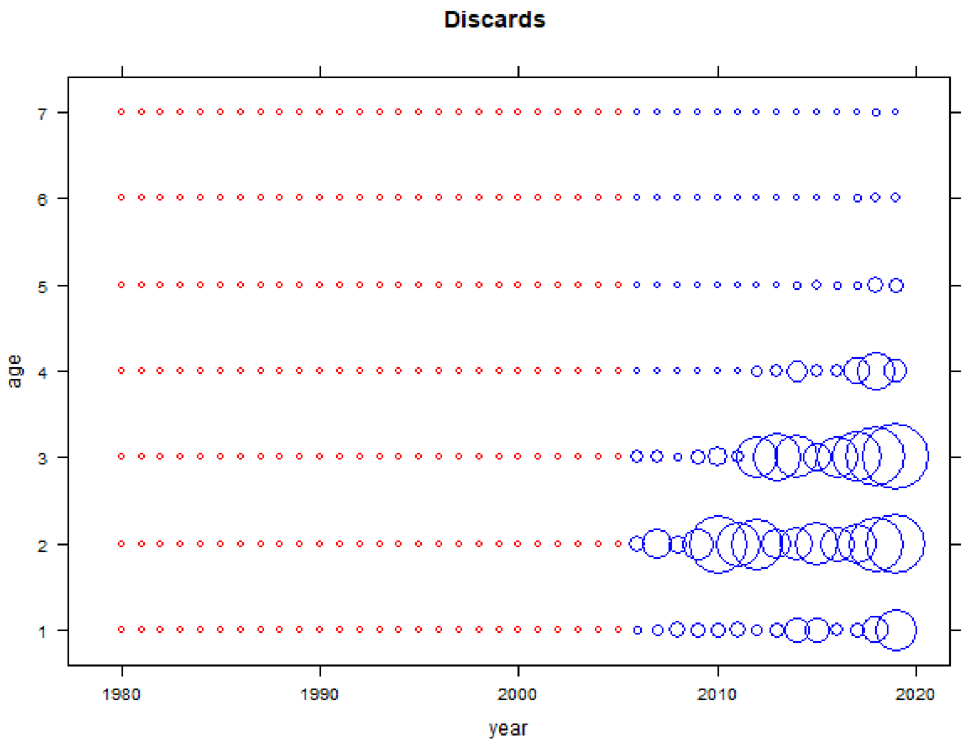
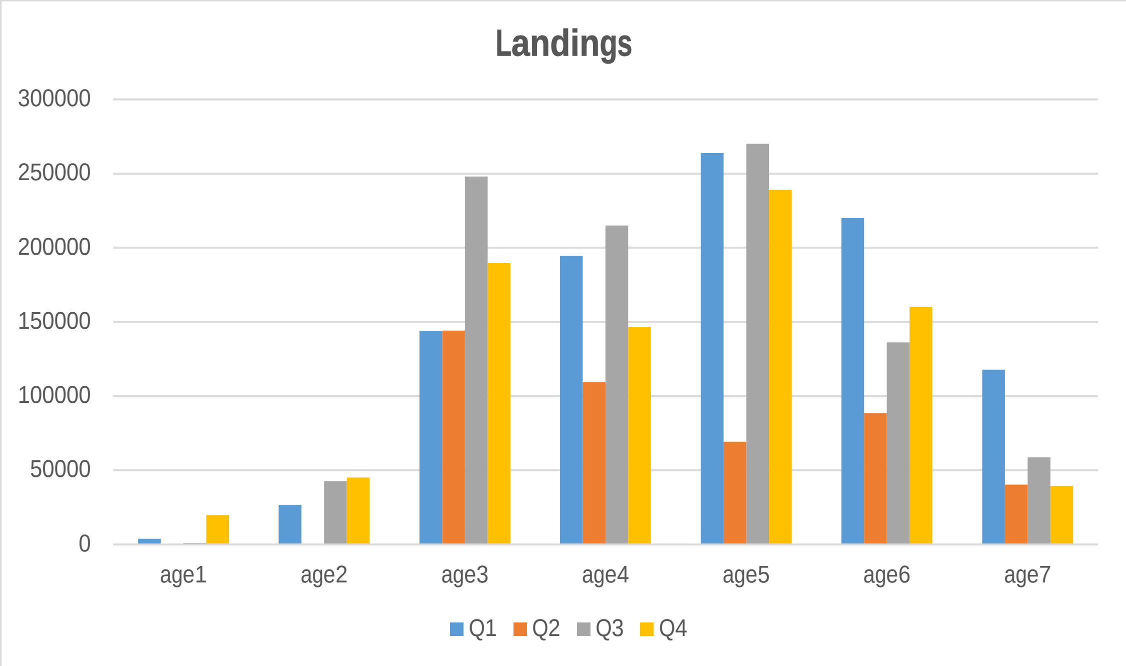


Figure 14.2.3.2. Plaice in 7.d: Age composition of the discards (data available from 2006 onward).



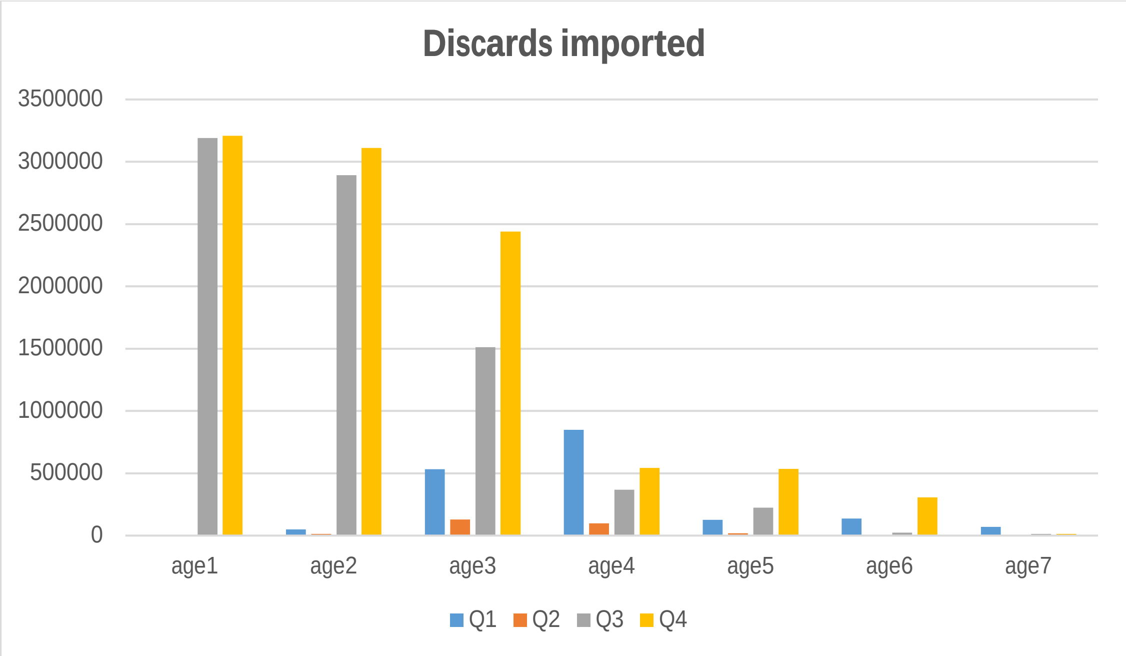
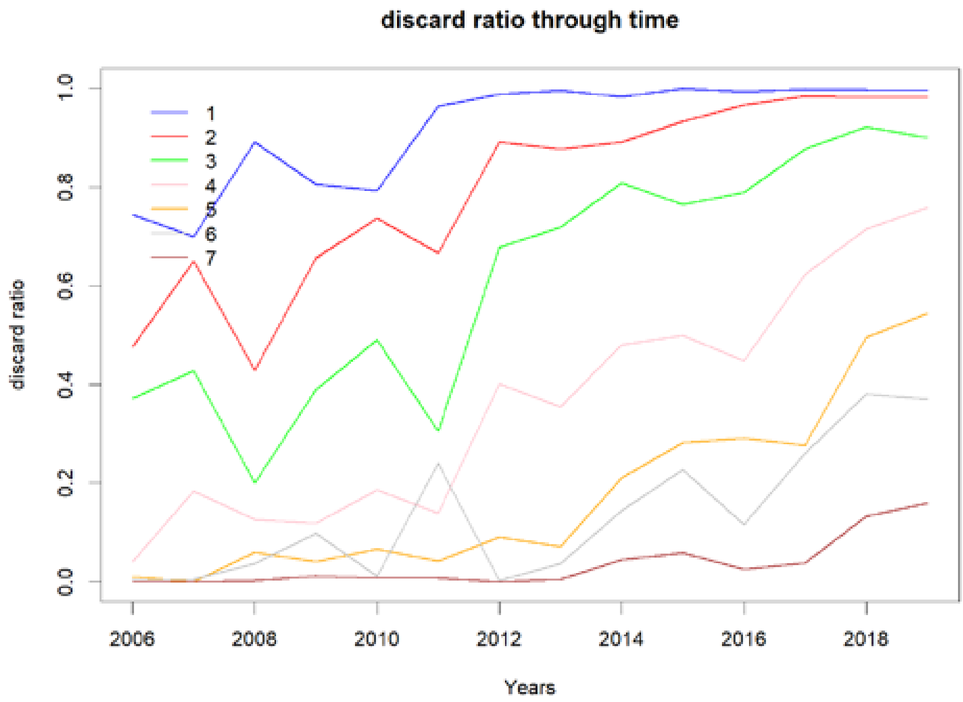


Figure 14.2.3.3. Plaice in 7.d: 2019 Age distribution in the sampled landings and discards per quarter.



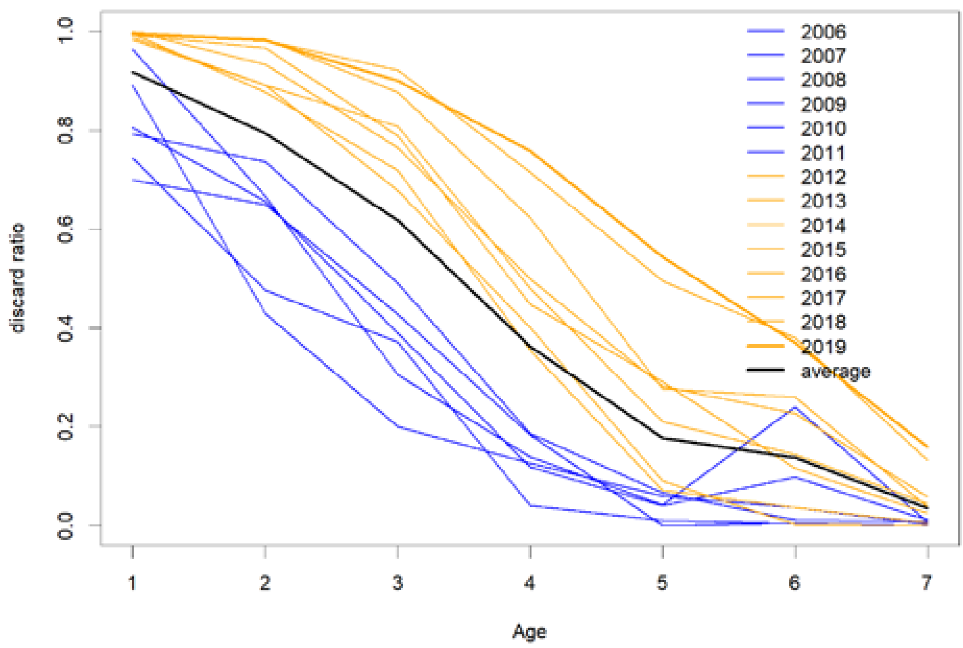


Figure 14.2.3.4. Plaice in 7.d: Discards at age ratio (discards numbers/landings numbers) per age and through time.

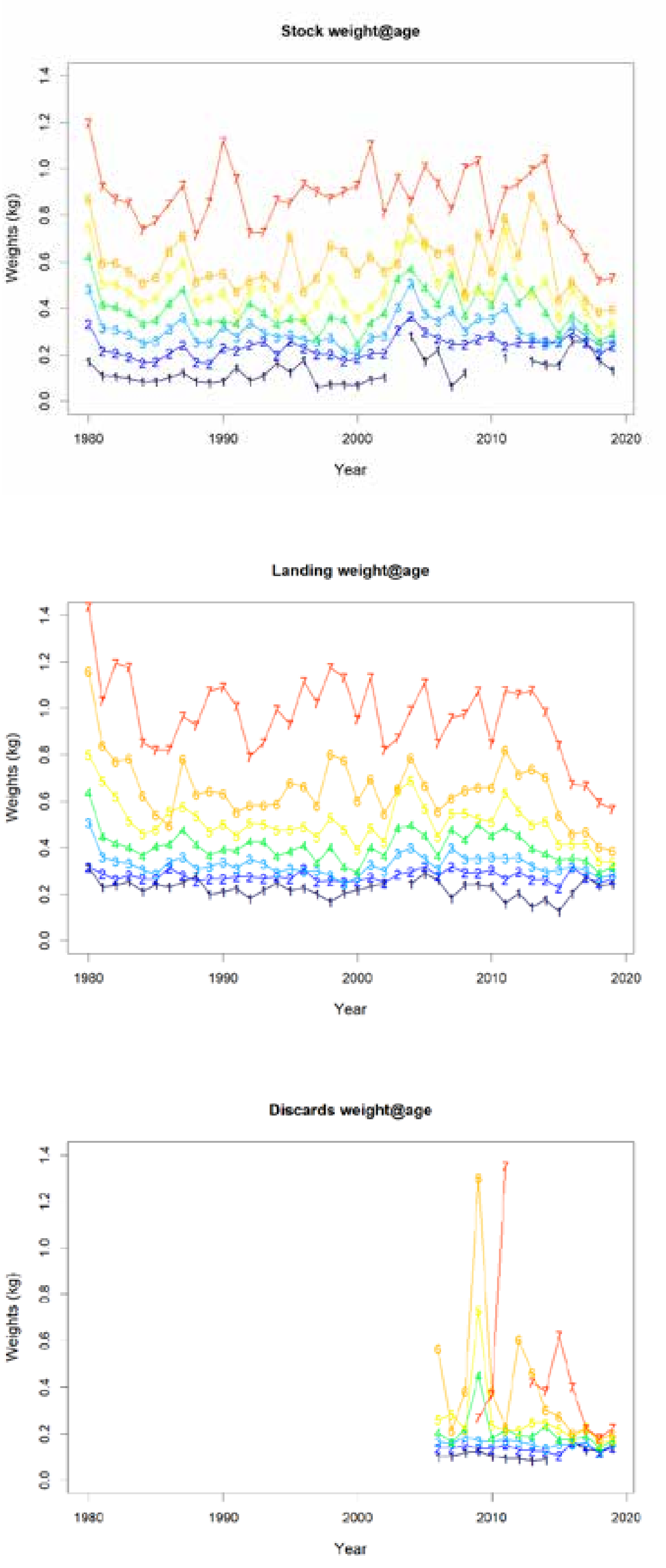


Figure 14.2.4.1. Plaice in 7.d: Stock, Landing and discard weights.

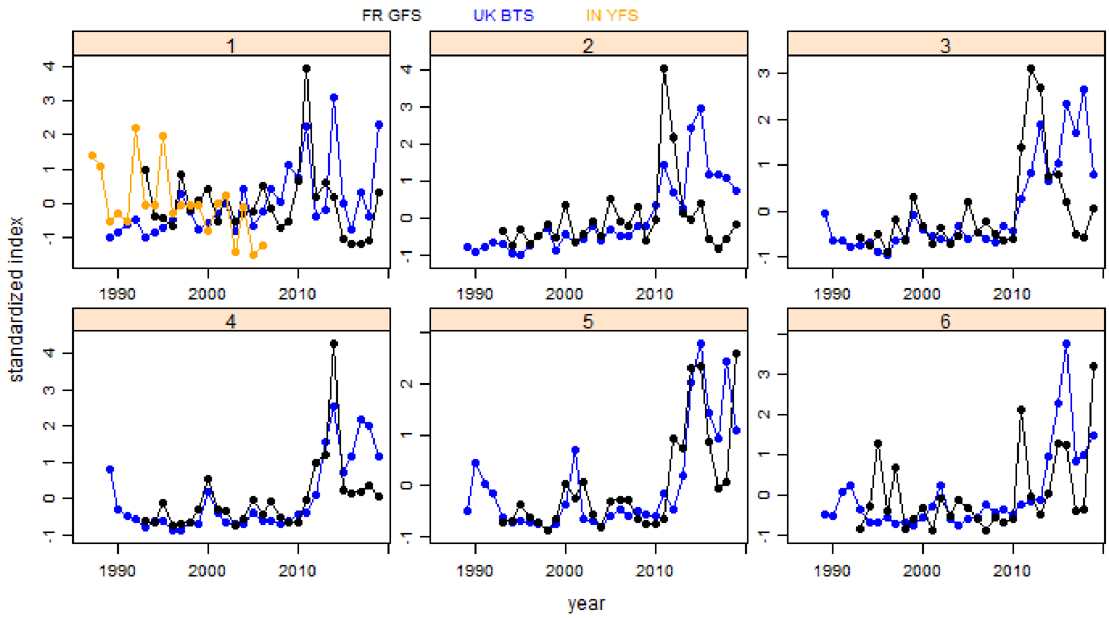
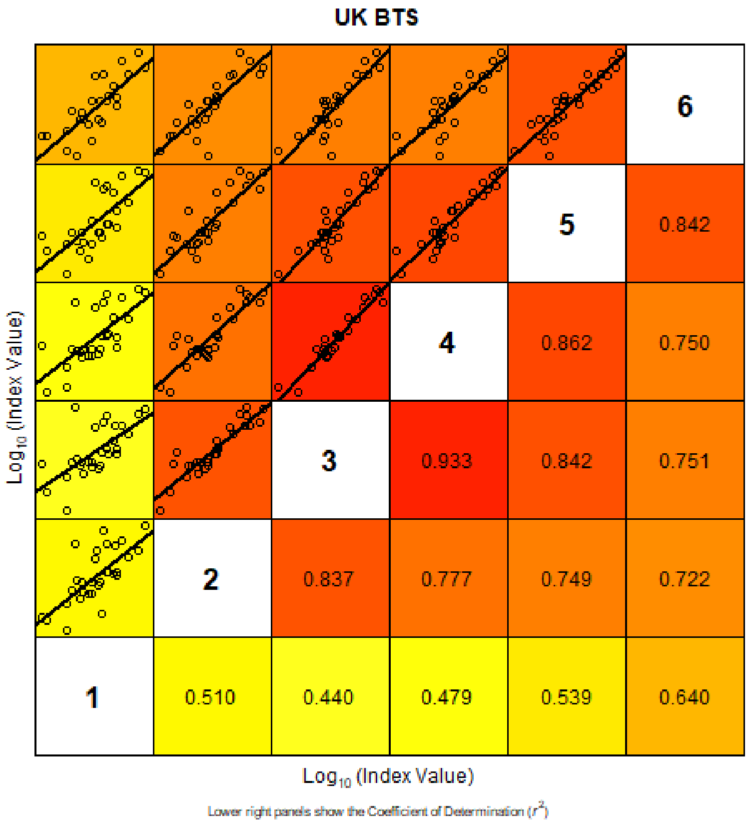


Figure 14.2.6.1. Plaice in 7.d: Survey Consistency: mean standardized indices by surveys for each age.



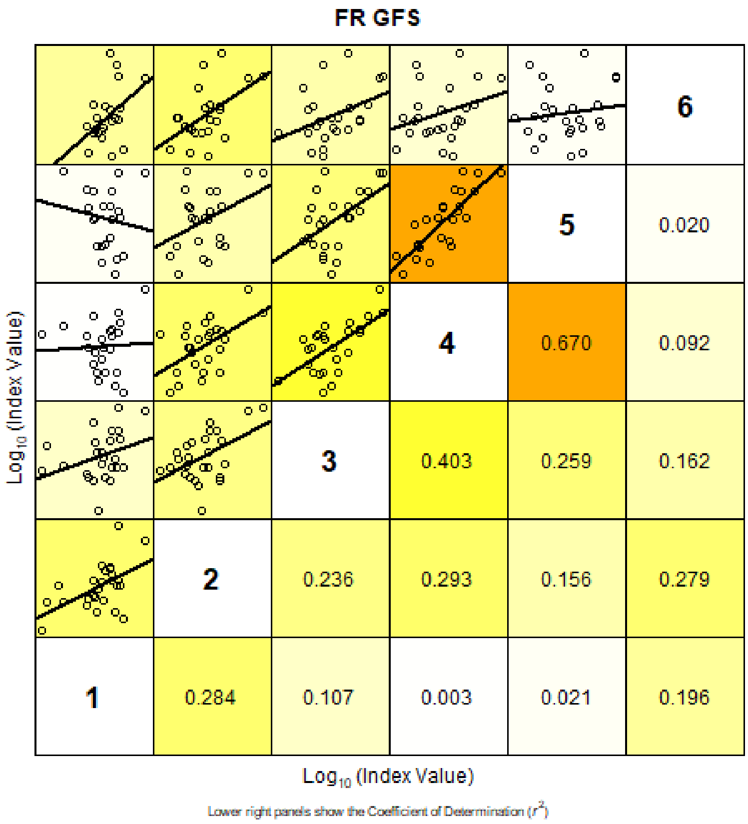


Figure 14.2.6.2. UK BTS and FR GFS indices consistencies.

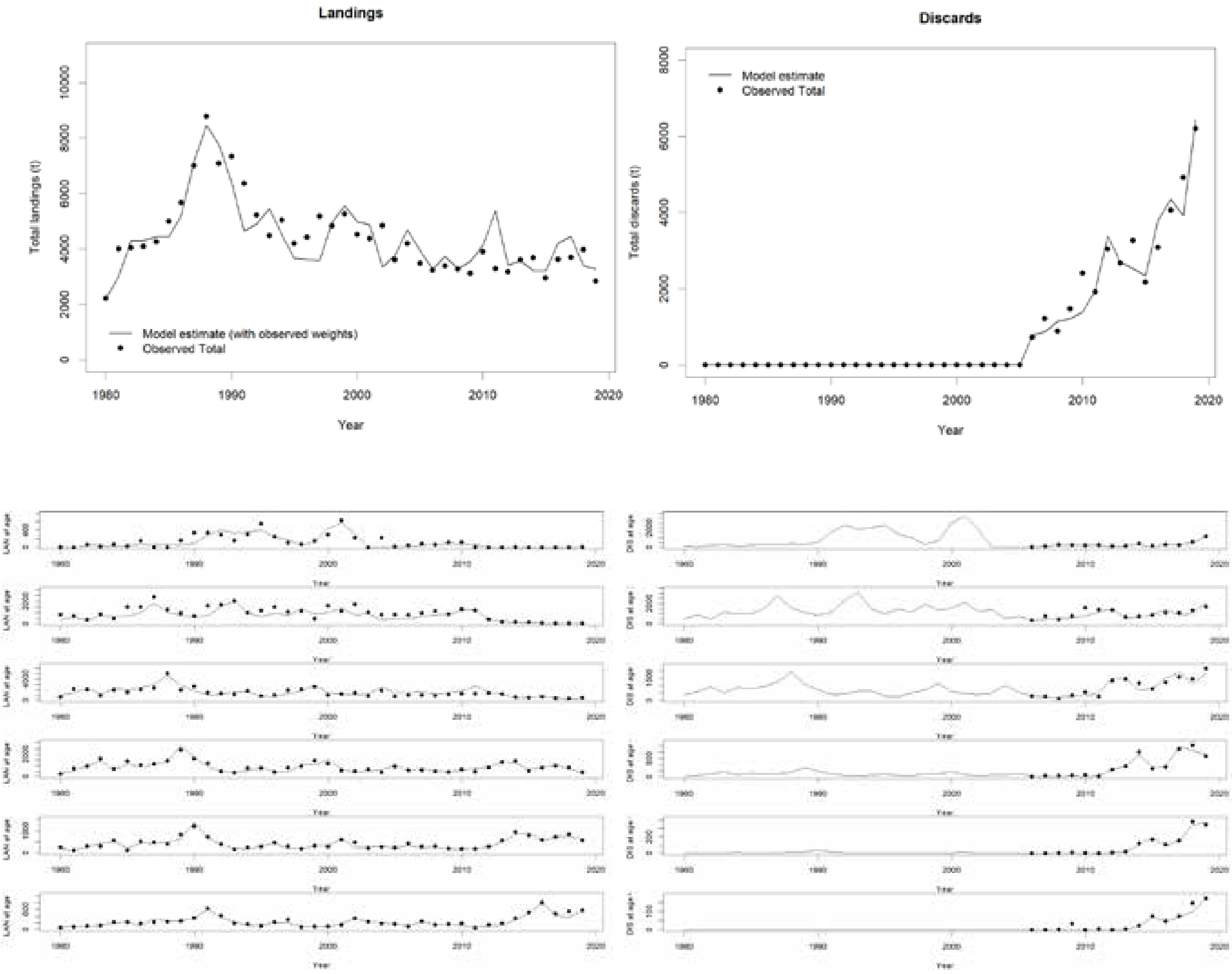


Figure 14.3.1.1. Plaice in 7.d: Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).

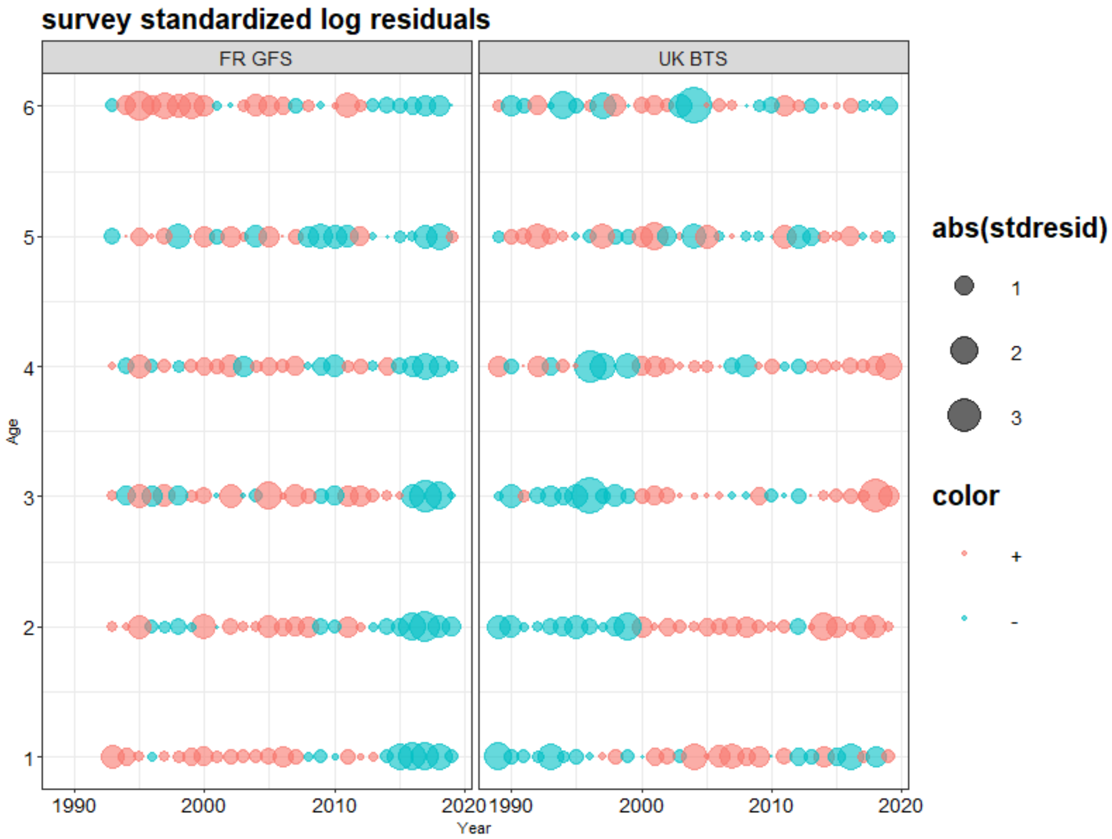
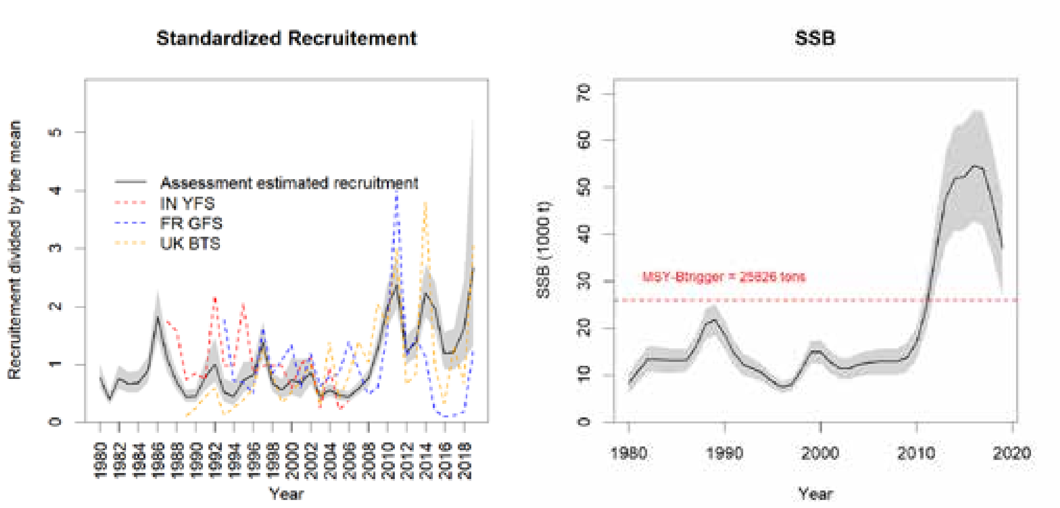


Figure 14.3.1.2. Plaice in 7.d: Survey residuals from the AAP assessment.



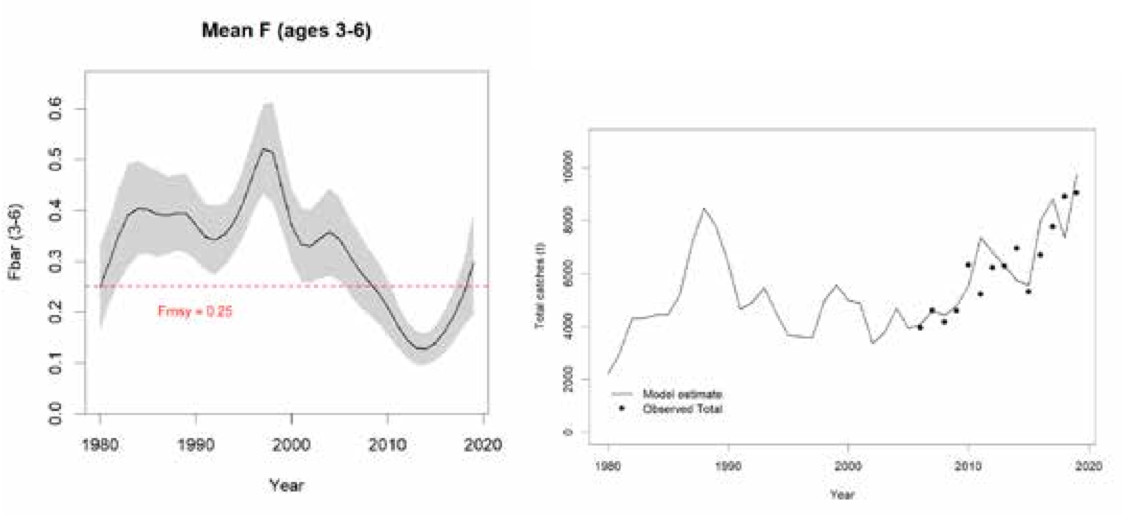
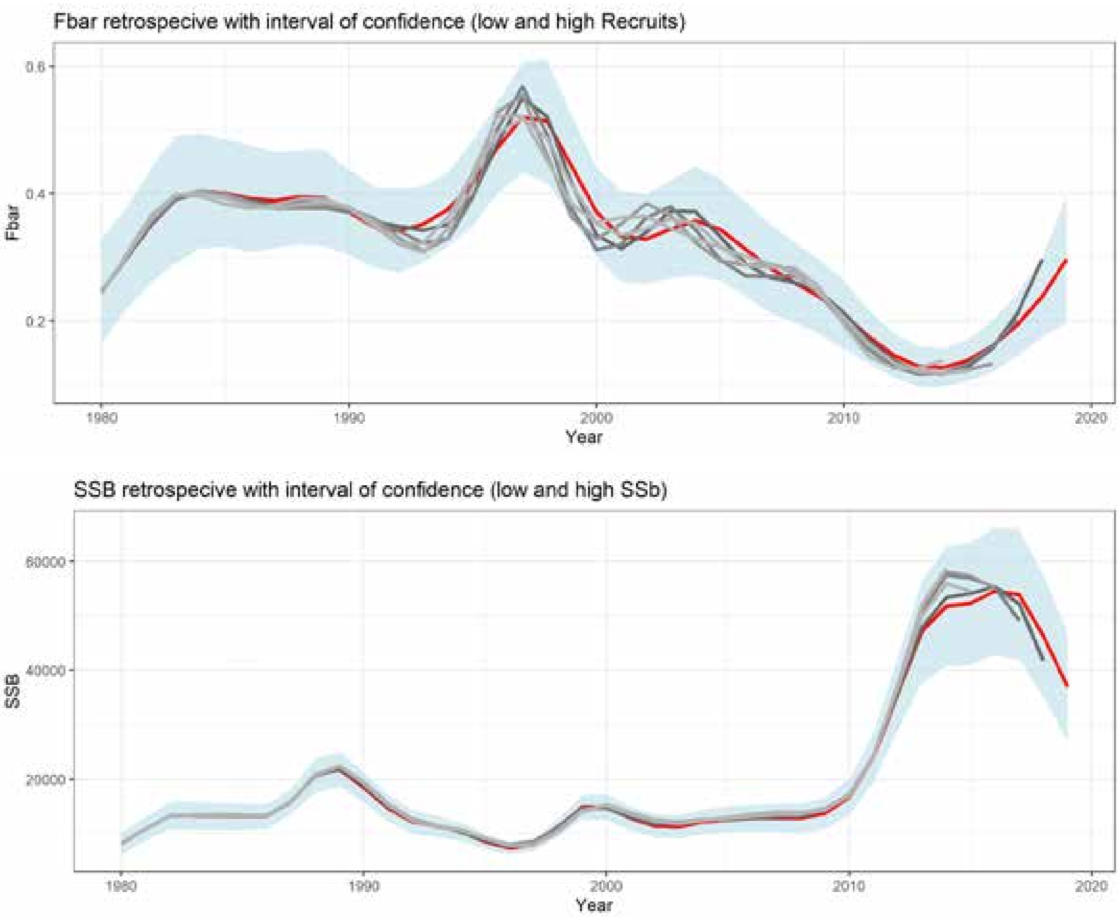


Figure 14.3.1.3. Plaice in 7.d: Summary of assessment results.



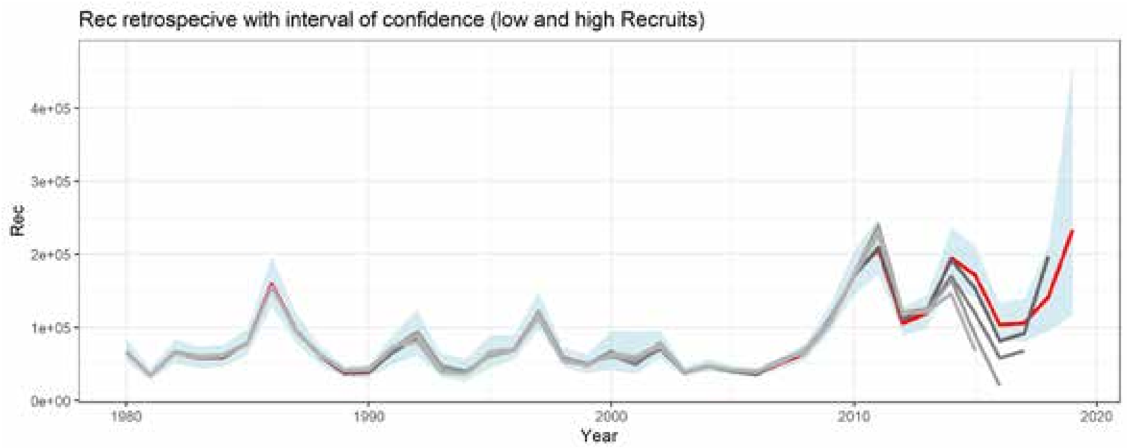


Figure 14.3.1.4: Plaice in 7.d. Retrospective patterns (MohnRho Fbar = 0.0166, MohnRho SSB = -0.0003, MohnRho Rec = -0.3240).

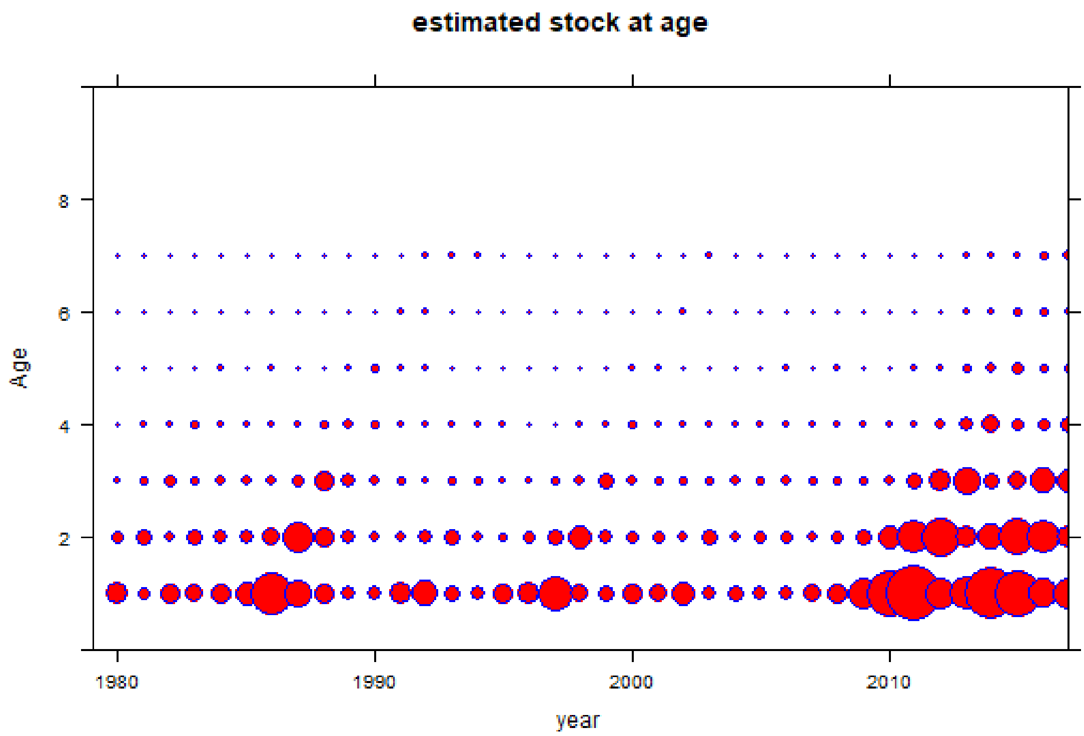


Figure 14.3.1.5: Plaice in 7.d. Estimated stock numbers.

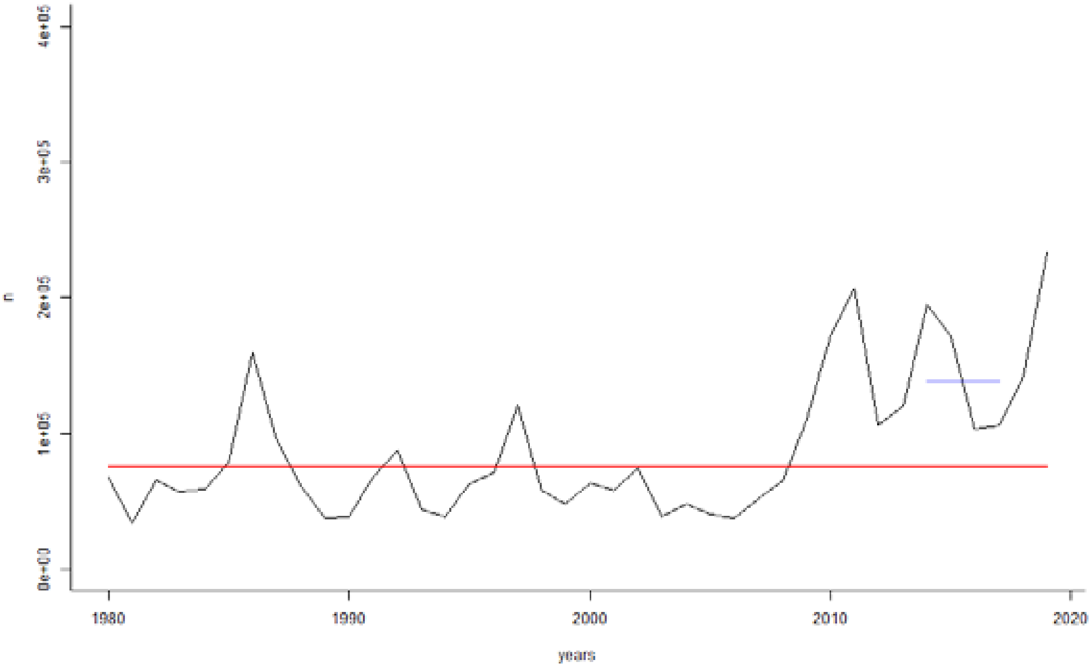


Figure 14.5.1.2. Plaice in 7.d: Number of individuals of age 1 as estimated by the assessment model (black), with the geometric mean over the whole time series (red), and the geometric mean over 2014–2017 (blue).

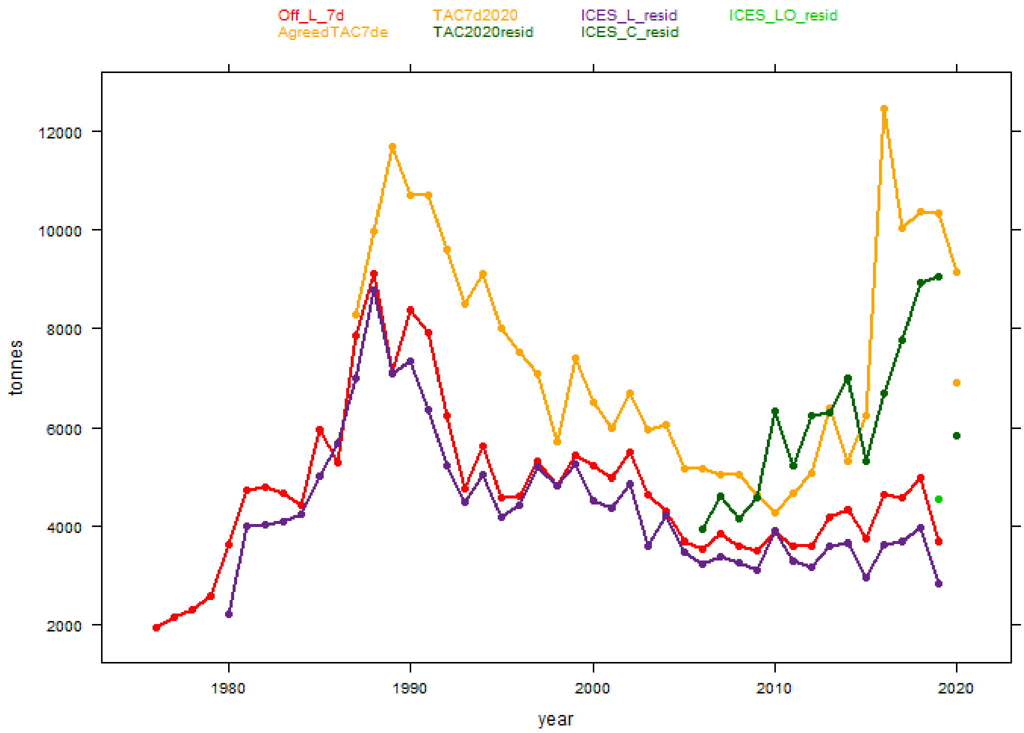


Figure 14.5.2.1. Plaice in 7.d. Official landings in 7.d (red line), ICES landings of resident plaice in 7d (purple line), ICES catches of resident plaice in 7d (dark green line) and agreed TAC for 7d,e plaice (orange line). The orange dot correspond to 7d proportion of 2019 TAC, the dark green dot is the resident plaice in 7d proportion of 2019 TAC, and the green dot is the landings of resident plaice in 7d in 2018 if plaice was under landing obligation in 2019 (ICES catches 2019 minus discards from exempted fleets).

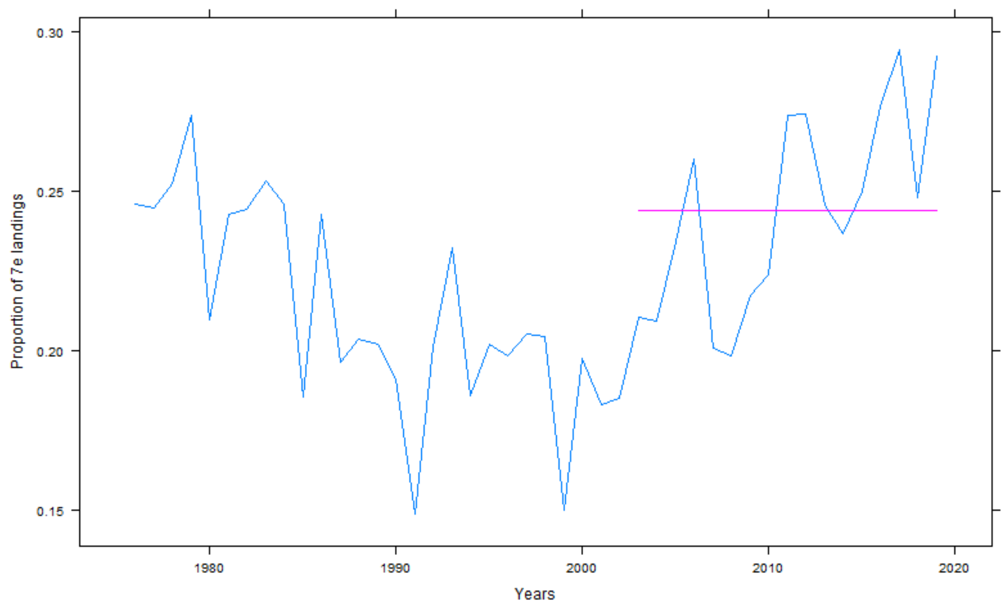


Figure 14.5.2.2. Plaice in 7.d: Time series of the proportion of the official landings in 7.e over the 7.d,e official landings, and the average used.

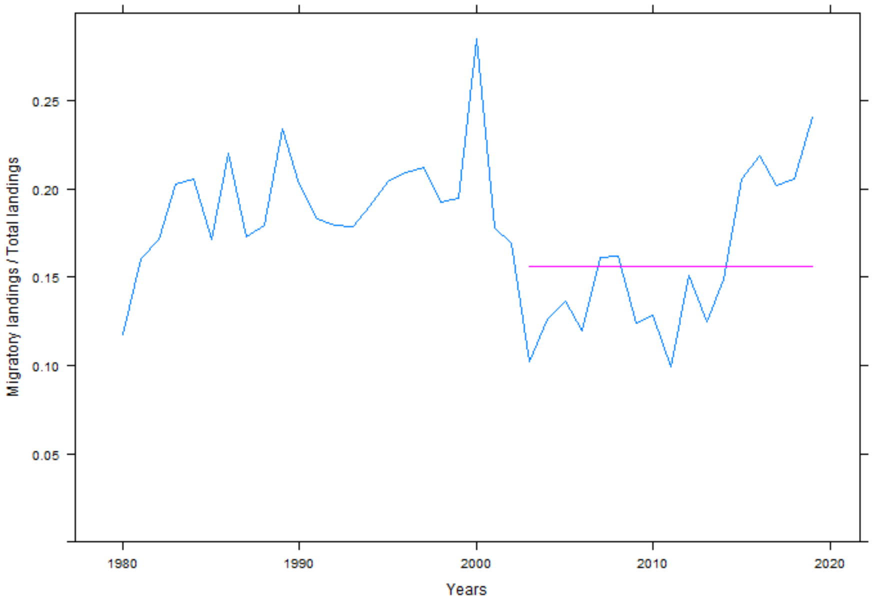


Figure 14.5.2.3. Plaice in 7.d: Time series of the proportion of the catch of fish coming from 7.e and 4 over the 7.d catch, and the average used.

15 Pollack (Pollachius pollachius) in Subarea 4 and Division 3.a (North Sea and Skagerrak)

15.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >35 cm, at 3–4 years of age and growth after age 3 is about 7 cm per year (Heino *et al.*, 2012). Pollack feeds mainly on fish, and incidentally on crustaceans and cephalopods.

15.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including 7.d and 3.a). In the ICES advice, it was, however, decided to include 7.d Pollack in the Celtic Seas Ecoregion.

15.3 Management

For 4 and 3.a there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

15.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977, the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2017 in Division 3.a (Skagerrak/Kattegat) and Subarea 4 (North Sea) are shown in Table 15.1. Figure 15.1 shows total landings in Subarea 4 and Division 3.a from 1977–2017. Two periods with high landings can be seen, and over the entire period total landings for both areas have declined. In Division 3.a, landings have been low but stable since 2000, while in Subarea 4 landings have fluctuated over the same period and stabilised the last five years. Swedish fishers targeted pollack from the 1940s until mid-1980s when landings sometimes amounted to over 1000 tonnes. From the 1980s, pollack started to decline severely and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast.

Nowadays, no fishery is targeting pollack, and it is mainly, possibly exclusively, a bycatch in various commercial fisheries. Norwegian catches peak in the months of March and April, and this may be associated with spawning aggregations. In 2019, 45% of the total landings were caught with gillnet and 36% with otter trawls in Division 3.a. In Subarea 4, 21% of the total landings were made with gillnets and 69% with otter trawls. The geographical distribution of Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower. Discards are now considered by ICES to be known to take place, although at a seemingly small rate, and raised discards were estimated at 25.1 tonnes in total between division 3a and subarea 4 in 2018 (see Table 15.2 for total catches and Table 15.3 for estimated discards). Discard numbers were raised for all nations. Virtually all discards (>99 %) were reported by bottom trawl fleets with France the country reporting the largest number of discards (89 % of total). In 2018, below minimum size (BMS) landings and logbook reported discards were also reported to ICES for pollack. No BMS landings or logbook reported discards were reported and no BMS landings were recorded in the preliminary landings.

Pollack is also frequently caught in recreational fisheries. Regularly collected data about these catches are not available to the working group. Norwegian recreational fishing data collected in 2009 suggests that catches of pollack south of 62° north in the tourist fishery may range between 13–30 tonnes (Vølstad *et al.*, 2011).

15.5 Survey data / recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the CPUE was much higher in the 1970s. They are distributed mainly over the northern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat. Time series of abundance (average number per hour) in the IBTS are shown for Subarea 4 and Division 3.a separately, for quarter 1 (from 1983 onwards) and quarter 3 (from 1996 onwards) (Figure 15.2). The catches are small, and rather irregular, and no clear patterns emerge in 3 and 4.

15.5.1 Biological sampling

There has been some collection of length data in Subarea 4 and Division 3.a by Norway in the most recent years. Preliminary analysis of this data indicates that length ranges of pollack caught in gill net fisheries differ with mesh size and location. The majority of fish caught in western Norwegian fjords had a size range of 60–80 cm (Figure 15.3) compared to 50–70 cm in the Skagerrak (Figure 15.4).

15.5.2 Analysis of stock trends

In previous years the study by Cardinale *et al.* (2012), which analysed the spatial distribution and stock trends for the period 1906–2007, based on IBTS Q1 and commercial catches, was used to assess the stock for Division 3.a (Skagerrak and Kattegat) and it was found that there had a been large decline in stock size from approximately 1960 to 2000. However, during routine IBTS surveys in Subarea 4 and Subarea 3, pollack catches seem rather irregular and with no clear pattern. A spatial analysis of Norwegian fisheries data from 2013, showing total Pollack catches by ICES rectangle, indicates that the surveys do not cover the geographic distribution of the species adequately in both Subarea 4 and Division 3.a (Figures 15.5 and 15.6). The surveys may therefore not be very well suited for monitoring this species as trends in standardised CPUE likely are not a reliable indicator for the status of the stock. However, if the stock increases, it is arguably expected that present trawl surveys (e.g. IBTS) would be able to detect such a stock trend in a consistent manner (Cardinale *et al.*, 2012).

15.6 Living Issues List

15.6.1 Data

In order to get a better understanding of growth and maturity, WGNEW recommended that the collection of otoliths and maturity should be continued during the IBTS surveys for a few years. WGNSSK recommends also that the Norwegian biological data from commercial catches should be processed. An effort should also be made to see if biological information is available from other countries, 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.

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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Table 15.1. Pollack in Subarea 4 and Division 3.a. Landings (tonnes) by country as officially reported to ICES 1977–2019.

	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*

*** Preliminary**

ICES Subarea 4											
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
1977	121	275		75	142	38	419	9	0	442	1521
1978	102	249		98	154	21	492	2	0	471	1589
1979	62	333		72	64	8	563	11	31	429	1573
1980	82	407		66	58	2	1095		38	355	2103
1981	59	500		173	21	2	1261		12	362	2390
1982	46	431		59	40	1	1169	33	23	270	2072
1983	58	481		79	44	1	1081		57	300	2101
1984	52	402		108	37	0	880	2	106	315	1902
1985	14	308		69	23	0	686		51	363	1514
1986	44	550		45	21	0	602		67	362	1691
1987	21	427		988	21	0	471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273		0	21	4	568		37	269	1203
1990	44	924		0	34	3	651		126	366	2148
1991	31	1464		0	48	4	887		153	684	3271
1992	49	794		18	59	7	1051		141	1310	3429
1993	46	1161		8	161	19	1429		217	1561	4602
1994	42	635		12	55	14	845		113	872	2588
1995	56	532	1	7	84	18	1203		175	1525	3601
1996	13	366		4	99	13	909		82	945	2431
1997	20	272	1	1	115	11	733		82	1185	2420
1998	21	265		7	44	5	567		75	780	1764
1999	21	288		0	62	5	768		72	636	1852
2000	45	291		24	38	5	880		91	877	2251
2001	36	156		6	40	1	860		63	809	1971
2002	27	234		6	112	0	879		68	711	2037
2003	13	191		9	82	1	971		36	837	2140
2004	28	162		5	57	0	517		16	612	1397
2005	26	173		3	128	3	511		46	477	1367
2006	18	152		4	80	1	545		12	587	1399

ICES Subarea 4											
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
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	484	1586*
2019	20	184		24	159	6	894		38	557	1881*

*** 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**
Denmark	214	192	192	152	187	229	196
Germany	11	6	35	7	11	13	5
Netherlands	<0.5	0	0	1	5	2	1
Norway	174	156	138	135	117	108	81
Sweden	36	30	46	47	43	64	30
ICES Total	435	384	413	343	363	415	307
Official Total	420	383	389	338	357	406*	314*
Diff ICES-Off	15	1	24	5	6	9	-6

*** Preliminary**

ICES Subarea 4							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium	17	24	20	21	18	14	20
Denmark	150	122	183	127	187	139	184
France	2	32	2	2	8	46	24
Germany	59	145	216	107	267	151	159
Netherland.	3	1	2	2	2	2	4
Norway	379	481	466	440	508	738	901
Sweden	29	41	50	36	44	30	38
UK	456	377	626	423	508	488	569
Ices Total	1103	1227	1567	1159	1543	1608	1899**
Official Total	1080	1215	1594	1174	1551	1586*	1881*
Diff ICES-Off	23	12	-27	-15	-8	22	18

*** 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

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

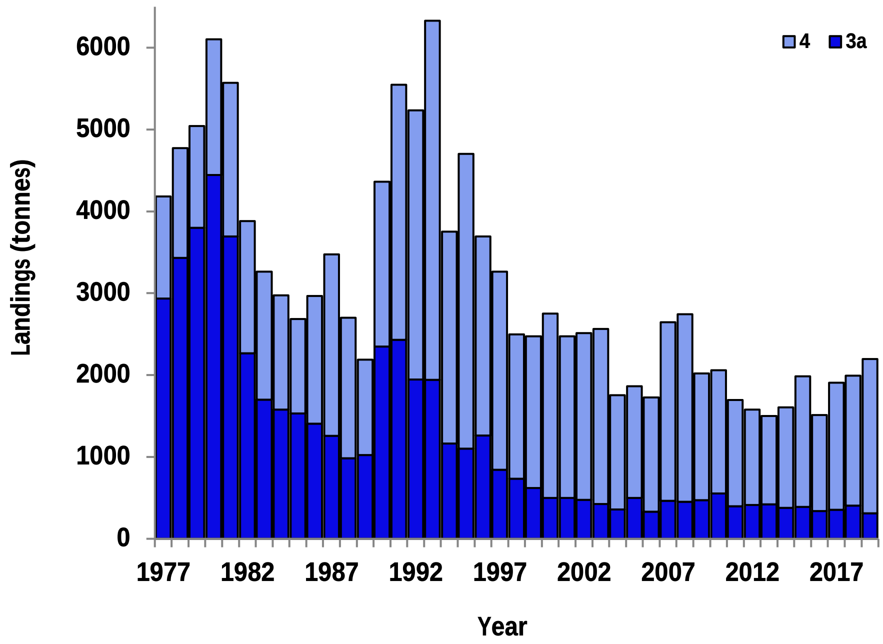
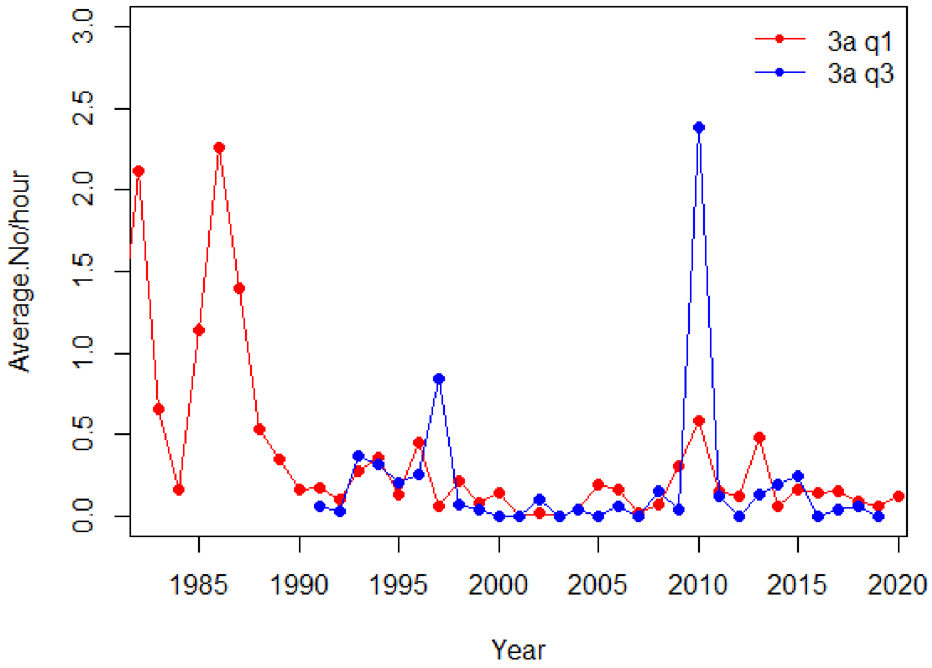


Figure 15.1. Pollack. Total landings of pollack from 2007–2019 in Division 3.a and Subarea 4 as officially reported to ICES.



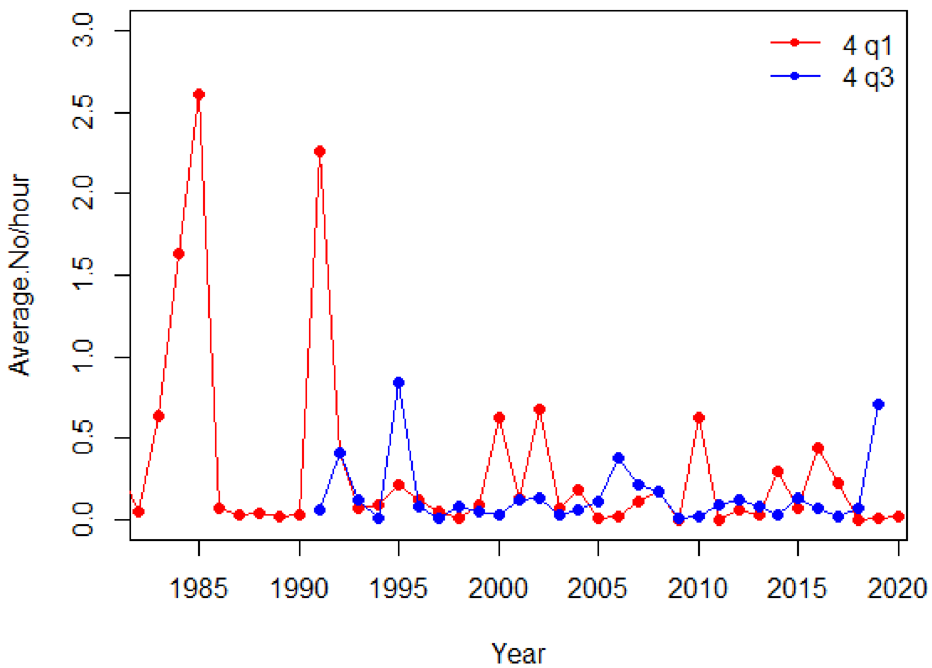


Figure 15.2. Time series of catches of pollack from 1983–2018 in ICES Division 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV-trawl. Data from Datras.

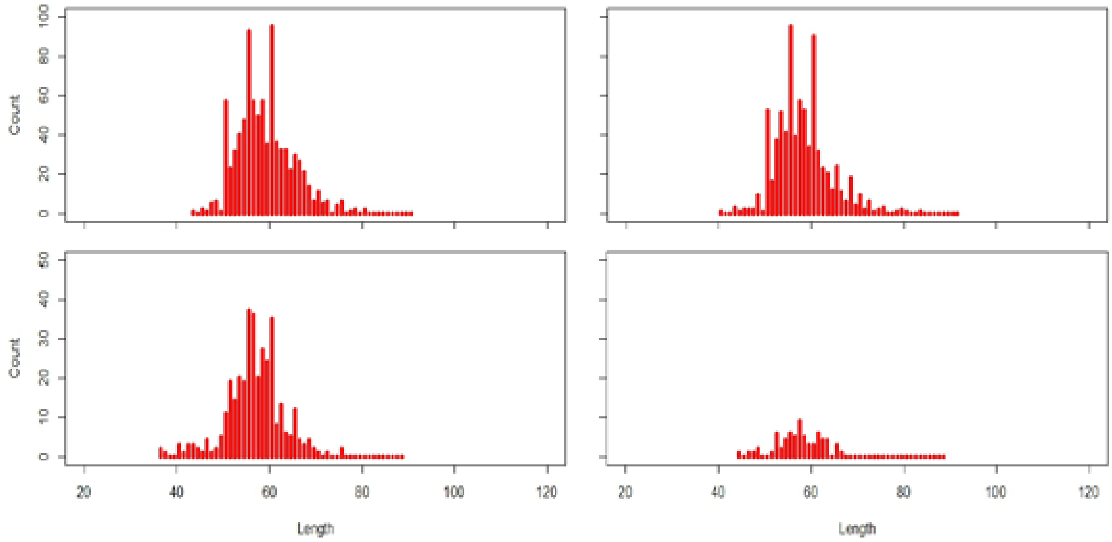


Figure 15.3 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a. The data is aggregated for gillnets with a 63 mm mesh size.

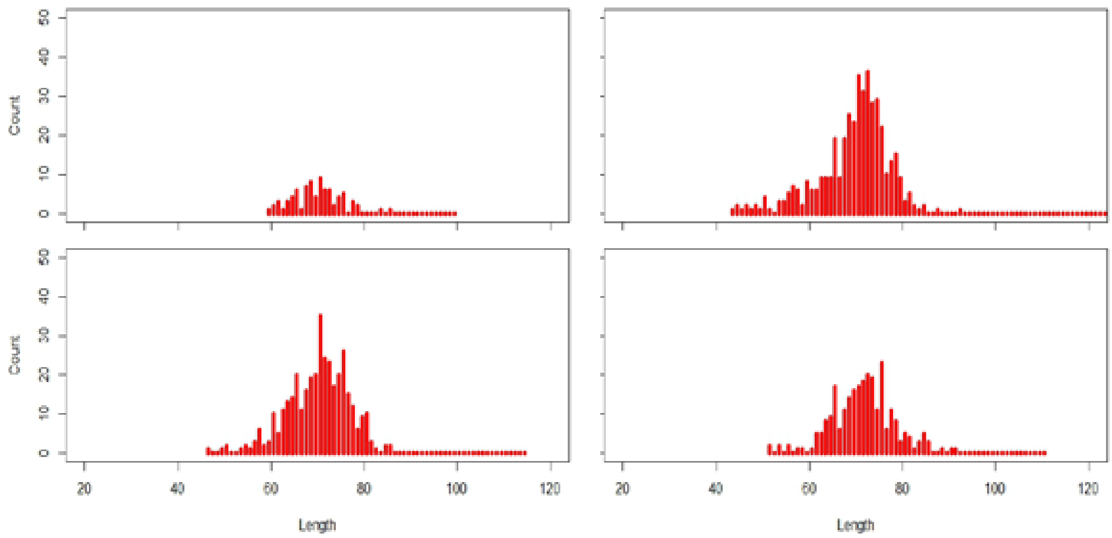


Figure 15.4 Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70 mm mesh size.

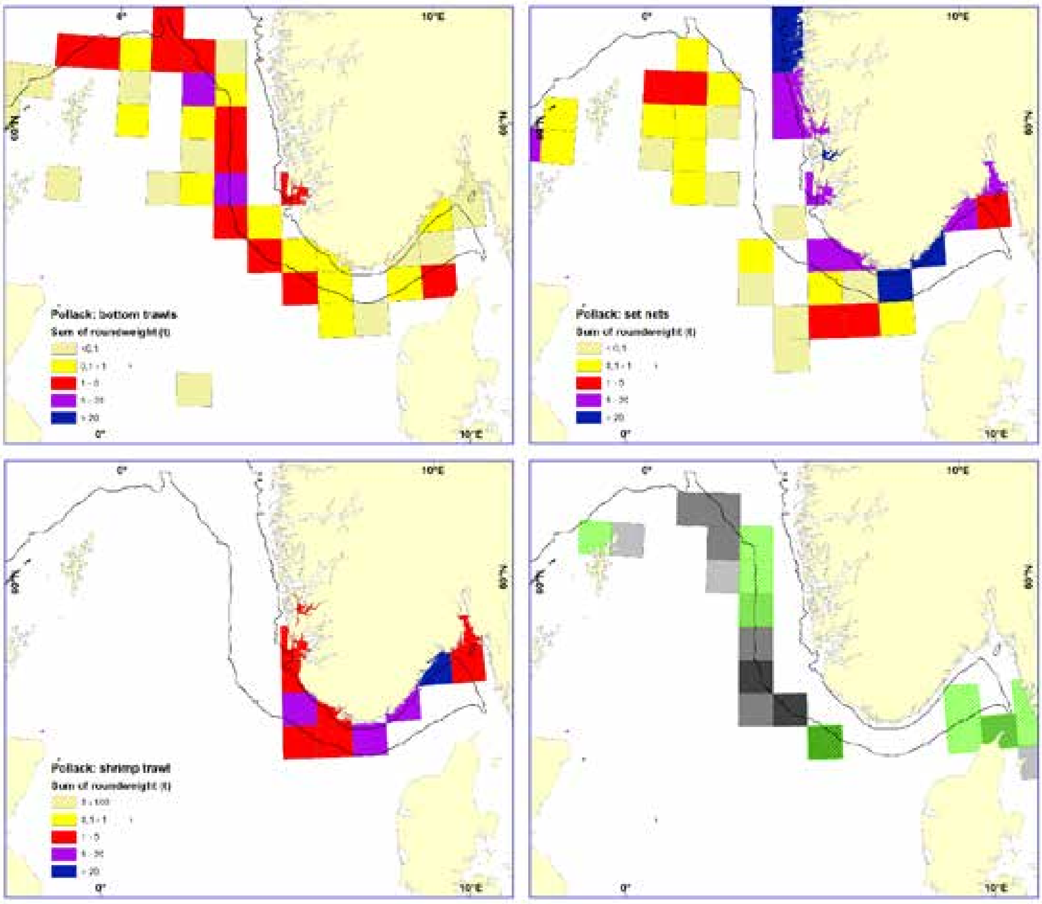


Figure 15.5 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

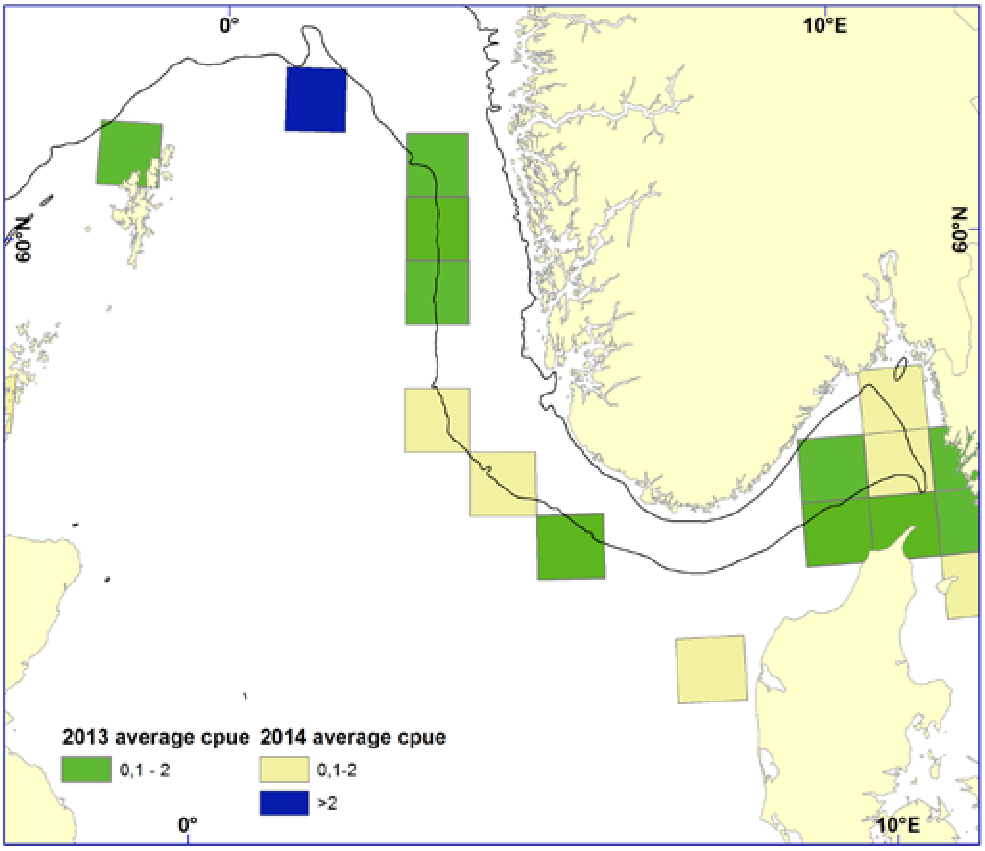


Figure 15.6 Pollack catches from IBTS surveys in 2013 (green) and 2014.

16 Saithe (*Pollachius virens*) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat)

The assessment of saithe in Division 3.a and subareas 4 and 6 follows the protocol defined during the inter-benchmark in January 2019, which revised errors in the assessment code that existed from 2016–2018 and triggered a revised advice for 2018 (published 22 February 2019). With the code error corrected, the model produced lower biomass estimates in recent years, slightly different reference points, and a lower recommended TAC, which explain part of the retrospective pattern observed in the advice 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 2020. 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 an 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, which is then discarded due to lack of quota. Discarding continued in 2019 in areas 4 and 3a despite a full landing obligation in place. In area 6 fisheries targeting saithe were under the landing obligation. Discards can also be high in a few Danish and Swedish fisheries in the Skagerrak because these fleets do not have sufficient quota allocations.

16.1.4 ICES Advice

The information in this section is taken from the 2019 Advice sheet.

Advice for 2019

"ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 88 093 tonnes."

The agreed TAC 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 imply a need to re-evaluate the EU-Norway management strategy to ascertain if it can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice will be given according to the ICES MSY approach. EU-Norway initiated consultations for new management strategies. ICES evaluated these management strategies and they are provided as additional options in forecasts and in the catch option table in the advice (See Section 16.7).

16.3 Data available

16.3.1 Catch

Official landings for each country participating in the fishery, together with the corresponding WG estimates and the agreed international quota ("total allowable catch" or TAC) and ICES estimated discards and BMS landings are presented in Table 16.3.1. In 2019, the method for raising discards and allocating landings and discards at age for French data was reviewed and updated. The changes were applied to 2018 data in Intercatch (update) and we hence present updated 2018 Intercatch extraction along with 2019 new data.

ICES estimates of landings were in 2018 lower than the official figures in Subarea 6, and slightly higher in Subarea 4 and 3a. In 2019, official landings and ICES estimates were very close in both 3a-4 and 6. ICES estimates correspond to the sum of products (SOP) uploaded to Intercatch and present a good match for overall catch in both years (100.2% in 2018 and 99.9% in 2019).

In 2019, 94% of discards were imported to Intercatch while 6% were raised (Table 16.3.2). After update of 2018 data, the percent of imported discards for this year raised from 85% to 92%. Discard observations were not available for some of the fleets landing larger amounts of saithe (Figure 16.3.1 and 16.3.2). This is mainly the case for the Norwegian fleets. While Norway has a no landings obligation policy for all métiers and in all areas, discarding is not monitored and discard information is not collected; therefore, discards for the Norwegian, French, and German trawler fleets (TR1) were raised using provided discard information from the French and German trawler fleets (i.e., targeted saithe fisheries; quarterly stratification). Trawler fleets (TR1) from other countries were raised with trawler fleets from these countries (by quarter and area). Discards for other fleets (all countries), were raised using a stratification by quarter and area (4/6 and 3.a were distinguished). Information on discarding from Scottish métiers were not included when raising discards for active gears because rates were typically high (see Section 16.1.3).

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 16.3.3. 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 2018 and 2019 (Table 16.3.2).

16.3.2 Age compositions

International catch data was collated and catch-at-age was generated using InterCatch. Age composition in the landings was based on samples, provided by Denmark, France, Scotland, Germany, Ireland, and Norway, which accounted for 90% of the total landings in 2019 and 91% (unchanged) in 2018 (Table 16.3.4; Figure 16.3.4 and 16.3.5). A large number of fleets do not provide samples for the landings, but these do not contribute to a large proportion of the catch. However, the number of samples taken, especially in the targeted trawl fisheries, is an issue (see ICES, 2016b). Stratification for age compositions was by quarter and area (Division 3.a or combined subareas 4/6) for the unsampled landings, as described in ICES (2016b). This is because the fleets, particularly the target trawl fishery, are targeting the spawning fish in the first two quarters, while a wider range of age classes are captured in the latter part of the year. Smaller and younger fish are generally found in Division 3.a.

93 percent of the discards were sampled for age distributions in 2019 and 91% (up from 84%) in 2018 (Table 16.3.4). Two countries provided mainly the age information for discards, Denmark and Scotland, although in 2019, Denmark declared less discards than in 2018 (Figure 16.3.6 and 16.3.7). These countries have also by far the largest amounts of discards. While the proportion of discards sampled for age distribution was high (Table 16.3.4), the number of age samples per metier is often low (ICES, 2016b). A stratification by quarter and area was used when estimating the age disaggregation for discards. Catch-at-age for the BMS landings was generated from the discards age information.

Total catch-at-age data are given in Table 16.3.5, while catch-at-age data for each catch component are given in Tables 16.3.6 and 16.3.7. Age 3 fish make up a smaller portion of the landings in recent years (Figure 16.3.8). The last strong year class in the catch appears to be the 2009 year class as seen in the discards in 2012 at age 3 and landings in 2013 at age 4. 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 and 2019 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

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").

The CPUE index exhibited, in 2019, a substantial decline (Figure 16.3.10), which seemed accentuated by French data, as shown by fitting of the model with sequentially on Country out (Figure 16.3.11). Although the model was still performing decently, it showed signs of strains on assumptions, such as the absence of Year:Nation or Year:Area interactions. This was further highlighted by investigating effects in the raw data, which suggest a more pronounced drop of CPUEs in area 6a (only fished by French vessels among the three countries considered here) in 2019 (Figures 16.3.12). This seemed not to be driven solely by changes in the distribution of other factors influencing the CPUEs (as illustrated in Figure 16.3.13).

Inspection of the commercial CPUE model assumptions and consideration of alternative modelling approaches have consequently been added to the list of issues for the next benchmark.

16.4 Data analyses

16.4.1 Exploratory survey-based analyses

Numbers-at-age for saithe ages 3 to 8 (IBTS–Q3) on the log–scale, linked by cohort, showed year effects (for example, low values around 2010) (Figure 16.4.1, top-left panel). The ability to track cohorts has been diminished in later years of the survey (post-2000) (Figure 16.4.1, top right panel). The survey catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages (Figures 16.4.1, top-right panel, and 16.4.2). This is likely because age 3 fish are not fully represented in the survey; fish begin migrating out of the inshore nursery areas at age 3, but do not fully recruit to the more ocean population (and fishery) until after age 5.

A high degree of uncertainty in the IBTS–Q3 index has been commented on previously (ICES 2016b), especially in terms of the influence of single samples that may influence the overall index, or lack of sampling of un-trawlable areas on the northern part of the shelf where dense aggregations are common. Despite this, the index is still currently used in the assessment, although it is clear that the assessment places more weight on the CPUE index, as observed in the leave-one-out analysis (see Section 16.4.4). IBTS–Q3 indices used in the final assessment are in Table 16.4.1.

16.4.2 Exploratory catch-at-age-based analyses

The outcome of WKNSEA 2016 was to remove the 3 CPUE series for the targeted trawl fisheries, partially due to concerns over using information in the catch-at-age matrix in both the CPUE and in the catch-at-age and because more weight was given to 3 indices within the former assessment model (artificially giving higher weighting to the CPUE indices). A standardized combined CPUE index was created for the French, German, and Norwegian trawl fleet targeting saithe, which was then tuned to the exploitable biomass, removing the need to use the information in the catch-at-age matrix twice (see ICES (2016b) for details).

The partial year effects for each of the main fleets show that CPUE declined in 2016 for all fleets, but the decline was most pronounced for the German fleet (ICES, 2017). Fleet restructuring has been occurring for several years within the German fleet and 2016 saw two vessels change to paired trawls (they are not included in the otter trawl CPUE index of 2016). In 2017 and 2018, these vessels returned to otter trawling. The fit of the CPUE to the exploitable biomass shows a decline in 2016 when all fleet information is included, but the index increased again in 2017 and only slightly decreased in 2018 (Figure 16.4.3). The more substantial decline in 2019, although observed with all combinations of fleets, is accentuated by low CPUEs of the French fleet (Figure 16.3.11). Reasons are still unclear but may include changes in the spatial distribution of the effort and/or resource, as well as a possible drift in fishing strategy and experience within the French fleet operating in 6a.

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. Also age 4 shows a declining trend in 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 three years has however increased again for age classes 4+, but recruitment was also very low in 2018 and 2019. Estimated population numbers-at-age are in Table 16.4.4.

The residuals are shown in Figure 16.4.5. After accounting for the correlation between ages within years, the IBTS–Q3 residuals show less of a pattern. Even after accounting for the correlation, the series is still largely positive at the end of the series, especially for age 6 and 7. The strength of the correlation between ages is strong between subsequent ages for all ages (Figure 16.4.6).

The retrospective analysis shows a retrospective pattern for SSB and F while recruitment is well estimated for the last 5 years (Figure 16.4.7). Although SSB tends to be overestimated and F to be underestimated, the peels all fall within the confidence intervals of the most recent assessment. Mohn’s rho, estimated using the last 5 years, is 0.055 for SSB, -0.083 for F, and -0.009 for recruitment, all well within acceptable limits.

The final assessment and leave-one out results are in Figure 16.4.8. Removing the IBTS Q3 indices leads to a slightly lower SSB and recruitment, especially in the last 3 years. Conversely, using only the IBTS Q3 indices gives an extremely optimistic view of the stock; the estimated SSB is outside of the 95% confidence interval of the final assessment after 2015.

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 and 2019 were the two lowest estimates for the time series. SSB, has fluctuated around 195 000 tonnes in the 2010's, which is below the average of the 2000's (around 235 000 tonnes). Short term variations show a slight decline since 2017. The final year estimate of SSB is just above B_{pa} and MSY $B_{trigger}$. Fishing mortality has generally declined since the mid–1980s but exhibits a distinct raise over the last three years. It is currently estimated to be above F_{MSY} and even slightly above F_{pa}.

16.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The resampling among 2010–2019 values (with a geometric mean about 78 102 000) used in the short-term forecast is a conservative assumption taking into account recent low recruitment although is still considerably higher than the estimated recruitments for 2018 and 2019 (respectively 39 247 000 and 51 955 000).

16.7 Short-term forecasts

A short-term forecast was carried out based on the final assessment.

Weight-at-age in the stock and catch were the mean values for the last 3 years. The exploitation pattern (selectivity pattern) was chosen as the mean exploitation pattern over the last three years scaled to F_{4-7} in 2019. The fishing mortality in the intermediate year was F status quo, as TAC has usually not been constraining in the recent past (with the exception of 2015). Population numbers-at-age for ages 4 and older in 2015 were survivor estimates, while numbers at age 3 were resampled from the past 10 years (2010–2019). 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_{2020} of 0.46 and a SSB in 2021 of 151 404 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, the management plan is no longer valid and it is a shared stock between EU and Norway; therefore, the MSY approach is used as the basis for advice 16.7.3a. The advised total catch in 2021 is advised to be no more than 65 687 tonnes, where wanted catch is 61 056 tonnes; this is a 25% decrease when compared to the advised total catch in 2020. More catch options can be found in Table 16.7.3

The contribution of the 2011–2018 year classes to landings in 2021 are shown in Table 16.7.4. The 2017, 2016, 2014 and 2013 year classes contribute the most to the forecasts. The weaker 2015 year class is expected to contribute slightly less. Recruitment at age 3 is not expected to contribute greatly to the catches in 2021; rather, ages 4–8 are the main contributors (77% of projected landings for 2021). This is clearly seen in the catch-at-age (Figure 16.3.8) and F at age (Figure 16.4.4).

16.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

16.9 Quality and benchmark planning

16.9.1 Quality of the assessment and forecast

Many of the issues noted after the benchmark and last year's assessment still exist.

The commercial CPUE indices may introduce biases into the assessment if changes in fishing patterns occur. Factors, such as vessel experience and fishing behaviour, likely contribute to the variability in CPUE for all fleets, but these factors are not captured in the CPUE model.

The scientific survey used in the assessment does not cover the whole stock distribution; however, it is considered generally representative. The number of observations (trawl stations) where saithe is caught is low, and can be influenced by occasional large catches. The resulting survey index is uncertain.

Conflicting signals between the survey and fishable biomass index contributes to the assessment uncertainty 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 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.

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, this year, 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

ICES assesses that fishing pressure on the stock is above F_{MSY} and F_{pa}, and below F_{lim}; spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.

16.11 Management considerations

The assessment is sensitive to relatively small changes in the input data. Because this stock suffers from ‘poor data’, the assessment is relatively uncertain. Recruitment is currently at a low level and it appears that strong recruitment pulses are more sporadic than in the past.

The reported landings have been relatively stable since the early 1990s. Landings have been lower than the TAC in most years since 2002, despite the reductions in the TAC between 2013 and 2016.

Information from fishers’ survey (Napier, 2014) has been moved to the Stock Annex.

Bycatch of other demersal fish species does occur in the target trawl fishery for saithe. Saithe is also taken as unintentional bycatch in other fisheries, and discards do occur.

16.11.1 Evaluation of the management plan

Because reference points were re-estimated after the inter-benchmark, the management plan is no longer valid. New EU/Norway management strategies have been proposed and evaluated (ICES, 2019).

16.12 References

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Table 16.3.1. Saithe in subareas 4 and 6 and Division 3.a. Official nominal landings (tonnes) of saithe by nation, 2004–2018. ICES estimates are landings reported to ICES and the Working Group.

	Subarea 4 and Division 3.a														
Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018***	**2019***
Belgium	28	15	18	7	27	15	2	2	3	5	6	16	15	14	7
Denmark	7498	7471	5443	8068	8802	8018	6331	5171	5695	4913	4512	4084	5690	7016	5275
Faroe Isl.	463	60	15	108	841	146	2	8	3	1	0	18	16	4	5
France	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7910	11574	10794	10334	12598	11366
Germany	12401	14397	12791	14140	13410	11193	10234	8052	9690	8602	7954	6279	7943	7944	7048
Greenland	1042	924	564	888	927	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	0
Lithuania	149	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	40	28	5	3	16	3	24	34	168	43	75	112	191	264	178
Norway	68122	61318	45396	61464	57708	52712	46809	33288	35701	37519	35631	31596	49580	39133	50311
Poland	1100	1084	1384	1407	988	654	584	0	0	0	0	0	0	0	0
Portugal		228	68												
Russia	35	2	5	5	13	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
UK (E/W/NI)	960	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	687	8888**	8561**	8640**	12415**	11875**
UK (Scotland)	6170									7686					
Total reported	111970	113354	91778	115414	103883	90755	89427	69241	71516	68695	69796	62658	83594	80704	87473
Unallocated	1418	1509	824	57	2090	6012	2101	1623	110	677	393	-154	-2024	1162	176
BMS landings													< 1	11	20
ICES estimate	113388	111845	92602	115471	105973	96767	91528	70864	71406	69372	69403	62504[#]	81570[#]	81866[#]	87649[#]
TAC	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696	100287	105793	93614

	Subarea 6														
Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*	2019*
Denmark	0	0	0	0	0	0	0	0	0	20	0	0	5	1	7
Faroe Islands	25	76	32	23	60	24	5	6	25	29	3	7	13	21	7
France	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2299	3968	3626	1335
Germany	373	532	580	148	298	257	0	9	0	0	0	9	< 1	<1	<1
Ireland	168	267	322	288	407	520	359	364	313	128	105	185	171	231	109
Netherlands	0	3	36	1	0	0	0	0	0	0	6	12	3	70	4
Norway	20	28	377	78	68	121	240	5	715	442	677	555	633	955	478
Russia	25	7	2	50	4	2	0	0	0	9	1	0	2	0	2
Spain	3	6	3	4	8	18	31	13	21	9	15	15	4	7	24
Sweden	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**	2684**	2822**
UK (Scotland)	2922									3191					
Total reported	7623	9759	7103	7717	6438	6118	7492	7558	8534	6829	7577	5852	7453	7595	4787
Unallocated	1167	1191	501	1005	144	145	575	9	119	191	43	279	-337	-954	88
BMS landings													0	31	0
ICES estimate	6456	8568	6602	6712	6294	6263	6917	7549	8653	7020	7534		7116	6641	4875
TAC	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816			9713

	Subareas 4 and 6 and Division 3.a														
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ICES estimate	119844	121320	99204	122184	112267	103030	98446	78414	80059	76392	76936	68709 #	88686 #	88507 #	92524 #
TAC	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512			103327

Table 16.3.2. Saithe in subareas 4 and 6 and Division 3.a. Catch data (2018 update and 2019; 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.

		2018 (update)		2019	
Catch Category	Raised or Imported	Weight (tonnes)	Proportion	Weight (tonnes)	Proportion
BMS landing	Imported data	90.62	100	10.3	100
Discards	Imported data	6755	92	4254	94
Discards	Raised discards	578	8	272	6
Landings	Imported data	88263	100	91724	100
Logbook registered discard	Imported data	0	0	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

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
1991	130973	108071		22902	17
1992	115537	99745		15792	14
1993	132618	111499		21119	16
1994	126759	109621		17138	14
1995	141190	121795		19395	14
1996	128896	114968		13928	11
1997	120103	107348		12755	11
1998	117222	106126		11096	9
1999	119467	110531		8936	7
2000	93795	85781		8014	9
2001	102859	91741		11118	11
2002	129847	110911		18936	15
2003	121656	110282		11374	9
2004	113792	107356		6436	6
2005	121217	118625		2592	2
2006	128711	120414		8297	6
2007	106333	94958		11375	11
2008	129887	121618		8269	6
2009	114520	110972		3548	3
2010	104723	102128		2595	2
2011	102006	98034		3972	4
2012	87049	78144		8905	10
2013	87271	79859		7412	8
2014	82172	76057		6115	7
2015	81445	76748		4697	6
2016	77672	67620#	0	10052##	13
2017	94581.5	88010#	0.5	6571##	7
2018	95447	88328#	42	7076##	7
2019^	96634	92390#	19.85	4224##	4

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 (2018 update and 2019) 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+).

			2018 (update)		2019	
Catch Category	Raised Or Imported	Sampled Or Estimated	Weight	Proportion	Weight	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	0	0	0
Landings	Imported_Data	Sampled_Distribution	80449	91	82395	90
Landings	Imported_Data	Estimated_Distribution	7814	9	9329	10
Discards	Imported_Data	Sampled_Distribution	6705	91	4226	93
Discards	Raised_Discards	Estimated_Distribution	578.1	8	272	6
Discards	Imported_Data	Estimated_Distribution	50.84	1	27.75	1
BMS landing	Imported_Data	Estimated_Distribution	90.62	100	10.26	99.6
BMS landing	Imported_Data	Estimated_Distribution	0	0	0.042	0.4

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

Year/Age	3	4	5	6	7	8	9	10+
1988	50657	31577	37919	3918	1927	1130	796	687
1989	34408	36772	14156	11211	1572	757	430	493
1990	63454	23416	12154	4826	2803	762	288	368
1991	71710	35719	8016	3669	1733	976	376	463
1992	28617	40193	13691	3269	1539	712	531	426
1993	58813	24905	12715	3199	1583	1547	835	1037
1994	31034	48062	13992	4399	957	354	438	803
1995	41461	31130	15884	3864	3529	690	566	809
1996	17208	46468	12653	7915	3194	827	215	496
1997	23380	23077	32395	3763	2666	1036	299	292
1998	16113	37088	17570	16459	2253	1234	581	280
1999	14661	16588	28645	8588	10169	2401	914	665
2000	10985	20680	9597	12632	3190	3302	657	446
2001	24961	21100	24068	3429	3621	1814	1655	248
2002	17570	37489	14736	13731	2309	2544	1321	1575
2003	28296	31752	20631	6836	6855	1535	2000	2042
2004	13642	24479	15649	15220	2037	2164	1300	1066
2005	12690	15473	19060	20042	7956	1628	1188	1151
2006	17313	31972	10381	11286	8395	3824	1008	1281
2007	24614	13314	20919	7175	5564	3610	1218	930
2008	7620	30911	12540	14941	5088	3285	3551	3118
2009	7438	15507	14222	5847	8512	2994	1519	2945
2010	8766	9249	9440	6511	2671	4773	1679	2707
2011	12786	24269	8980	3674	2867	1208	1564	3877
2012	14334	13053	16948	4075	1977	1268	541	2611
2013	7267	30318	5312	7869	1890	1241	616	1658
2014	4055	14322	15195	3957	4124	1040	429	1389
2015	8369	8323	14259	8254	1862	1623	715	977
2016	7382	14241	9661	5729	2758	1430	853	1317
2017	4977	18989	9773	6247	5364	1876	820	1113
2018	2603	16250	18858	7376	2142	2027	978	1178
2019	6240	8570	14841	10394	2881	1127	1027	1236

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

Table 16.3.7. Saithe in subareas 4 and 6 and Division 3.a. Discards numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	9617	3175	1141	55	16	7	5	2
1968	12888	4156	969	143	4	6	3	2
1969	16779	3461	813	181	57	19	16	2
1970	20671	15007	1102	288	38	42	8	3
1971	38741	11313	2406	112	42	67	48	9
1972	26680	12938	1861	504	36	69	42	18
1973	30152	7380	1973	381	83	47	35	26
1974	37148	6605	1038	491	144	122	38	22
1975	31626	5063	758	180	135	220	89	30
1976	115333	10387	860	148	39	126	92	38
1977	15240	10760	1084	130	37	81	97	52
1978	19456	5338	1327	79	11	24	20	38
1979	9063	2783	822	207	28	17	14	23
1980	9709	2416	662	160	56	27	13	25
1981	14527	1632	495	87	33	80	17	28
1982	17700	7945	674	142	21	34	25	14
1983	15673	4033	1912	135	48	35	26	15
1984	44915	6298	952	309	16	29	9	7
1985	74378	10885	976	113	30	16	10	8
1986	30764	17857	1116	128	26	34	11	10
1987	17326	19080	1028	75	18	29	23	8
1988	18079	5169	2596	91	19	26	20	7

Year/Age	3	4	5	6	7	8	9	10+
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

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

Table 16.3.9. Saithe in subareas 4 and 6 and Division 3.a. Landings weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.931	1.362	2.104	3.186	3.754	5.316	5.891	7.719
1968	1.278	1.652	1.989	3.009	4.040	4.428	6.136	7.406
1969	0.966	1.557	2.261	2.713	3.559	4.406	5.220	6.768
1970	0.941	1.441	2.059	2.718	3.600	4.463	5.687	6.845
1971	0.840	1.348	2.178	2.936	3.766	4.634	5.173	6.163
1972	0.808	1.196	1.961	2.369	3.794	4.228	4.630	6.326
1973	0.821	1.406	1.641	2.571	3.357	4.684	4.814	6.445
1974	0.861	1.561	2.383	2.753	3.429	4.498	5.713	7.857
1975	0.893	1.498	2.490	3.300	3.765	4.296	5.540	7.562
1976	0.702	1.309	2.260	3.071	4.035	4.383	5.112	7.147
1977	0.760	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.340	4.522	4.901	5.449	7.400
1979	1.107	1.623	2.238	3.095	4.050	5.274	6.308	7.955
1980	0.955	1.821	2.391	3.030	4.090	5.126	5.939	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.980	8.724
1982	1.086	1.575	2.529	3.220	4.207	5.125	5.905	8.823
1983	1.028	1.718	2.149	3.138	3.691	4.632	5.505	8.453
1984	0.795	1.614	2.297	2.690	3.896	4.665	6.183	8.474
1985	0.663	1.265	1.951	2.772	3.407	4.950	5.865	8.854
1986	0.694	1.035	1.794	2.432	3.572	4.209	5.651	8.218
1987	0.674	0.876	1.824	3.075	4.210	5.330	6.128	8.603
1988	0.779	0.981	1.386	2.791	4.024	5.254	6.322	8.649
1989	0.895	1.036	1.420	1.998	3.914	5.018	6.430	8.431

Year/Age	3	4	5	6	7	8	9	10+
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

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

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	2.185
2001	21.475	6.169	3.936	0.356	0.444	0.113	2.437
2002	10.748	18.974	1.327	1.090	0.162	0.264	1.991
2003	19.272	23.802	13.402	0.393	0.439	0.168	1.852
2004	4.930	6.727	3.237	0.921	0.064	0.085	2.345
2005	8.916	7.512	4.428	1.914	1.082	0.104	2.563
2006	10.553	29.579	2.835	1.177	0.445	0.242	2.660
2007	34.006	5.578	11.700	1.016	0.743	0.358	2.210
2008	3.312	5.584	0.907	1.997	0.254	0.254	2.633
2009	1.346	1.703	0.568	0.101	0.229	0.200	2.067
2010	1.361	0.964	0.471	0.205	0.045	0.166	1.931
2011	4.520	8.451	1.059	1.114	0.426	0.080	1.911
2012	11.134	2.497	2.968	0.503	0.483	0.344	1.680

Year	IBTS–Q3 (DATRAS standard index)						CPUE
	3	4	5	6	7	8	
2013	14.701	16.279	1.830	1.858	0.308	0.146	1.836
2014	1.649	3.923	2.822	0.481	0.520	0.114	1.779
2015	11.001	5.613	4.611	1.581	0.289	0.285	2.020
2016	37.901	17.439	3.255	2.681	0.945	0.195	1.757
2017	11.447	13.102	3.068	1.267	0.942	0.473	1.992
2018	1.877	6.885	6.027	1.450	0.322	0.183	1.927
2019	2.143	3.189	3.071	0.999	0.194	0.077	1.542

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	0.262	0.382	0.357	0.356	0.315	0.283	0.319
1968	0.236	0.345	0.304	0.287	0.245	0.221	0.252
1969	0.251	0.369	0.324	0.314	0.277	0.253	0.279
1970	0.301	0.418	0.353	0.328	0.283	0.252	0.268
1971	0.369	0.467	0.375	0.344	0.307	0.283	0.298
1972	0.449	0.520	0.401	0.365	0.329	0.305	0.311
1973	0.531	0.573	0.424	0.376	0.342	0.317	0.317
1974	0.649	0.663	0.491	0.432	0.395	0.362	0.348
1975	0.665	0.694	0.530	0.471	0.440	0.408	0.383
1976	0.763	0.777	0.606	0.528	0.483	0.442	0.405
1977	0.634	0.709	0.596	0.541	0.511	0.475	0.428
1978	0.508	0.586	0.491	0.439	0.417	0.389	0.353
1979	0.421	0.520	0.458	0.423	0.411	0.383	0.346
1980	0.404	0.517	0.477	0.455	0.452	0.429	0.389
1981	0.359	0.491	0.468	0.460	0.471	0.461	0.423
1982	0.429	0.580	0.551	0.523	0.514	0.487	0.439
1983	0.509	0.697	0.672	0.630	0.604	0.562	0.496
1984	0.592	0.795	0.727	0.630	0.562	0.504	0.441
1985	0.637	0.881	0.776	0.622	0.537	0.479	0.433
1986	0.587	0.906	0.826	0.651	0.561	0.509	0.478
1987	0.533	0.850	0.798	0.628	0.548	0.509	0.494
1988	0.522	0.833	0.806	0.643	0.564	0.521	0.509
1989	0.516	0.816	0.786	0.627	0.535	0.481	0.466
1990	0.507	0.792	0.754	0.589	0.497	0.434	0.421
1991	0.471	0.754	0.725	0.562	0.475	0.412	0.408
1992	0.415	0.702	0.703	0.560	0.480	0.414	0.415
1993	0.391	0.685	0.714	0.604	0.564	0.502	0.511
1994	0.321	0.603	0.635	0.541	0.519	0.470	0.489
1995	0.273	0.556	0.622	0.562	0.577	0.545	0.569
1996	0.216	0.467	0.551	0.513	0.522	0.500	0.519
1997	0.182	0.404	0.479	0.448	0.445	0.434	0.453
1998	0.183	0.402	0.486	0.461	0.446	0.438	0.455
1999	0.176	0.401	0.506	0.502	0.486	0.489	0.508
2000	0.149	0.349	0.439	0.435	0.402	0.398	0.415
2001	0.146	0.339	0.416	0.406	0.362	0.350	0.363
2002	0.152	0.350	0.442	0.461	0.415	0.404	0.427
2003	0.160	0.354	0.438	0.485	0.447	0.435	0.464
2004	0.134	0.309	0.373	0.416	0.386	0.379	0.399
2005	0.132	0.311	0.376	0.417	0.382	0.368	0.373

Year/Age	3	4	5	6	7	8	9+
2006	0.152	0.339	0.397	0.425	0.386	0.366	0.360
2007	0.145	0.338	0.390	0.403	0.359	0.335	0.319
2008	0.154	0.378	0.453	0.461	0.412	0.387	0.364
2009	0.153	0.387	0.476	0.484	0.431	0.403	0.368
2010	0.139	0.370	0.465	0.473	0.428	0.407	0.367
2011	0.146	0.385	0.478	0.471	0.419	0.402	0.363
2012	0.127	0.358	0.450	0.447	0.393	0.378	0.341
2013	0.105	0.320	0.412	0.417	0.368	0.356	0.321
2014	0.092	0.293	0.393	0.404	0.354	0.341	0.308
2015	0.089	0.290	0.397	0.408	0.351	0.337	0.306
2016	0.082	0.281	0.396	0.412	0.358	0.346	0.316
2017	0.084	0.294	0.425	0.456	0.395	0.373	0.337
2018	0.093	0.316	0.458	0.488	0.415	0.387	0.346
2019	0.111	0.354	0.506	0.533	0.448	0.412	0.365

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	141749	81682	57151	7136	4892	1145	743	680
1968	160573	92357	50363	31727	3724	2531	656	773
1969	287062	90678	54479	30975	20410	2825	1948	818
1970	294929	216993	49224	35290	18630	11694	1794	1623
1971	356355	192242	119360	24728	19409	11907	7808	2491
1972	223448	210068	103402	67485	14556	11375	7295	6469
1973	200427	111089	105681	63553	35899	8712	6351	8581
1974	198604	90150	48375	62911	42055	20619	5416	8551
1975	234351	76052	35410	24300	36232	25129	12021	8511
1976	407390	102068	29561	17414	12913	19135	13281	11619
1977	149340	148020	35519	12414	8668	7190	10745	14016
1978	120146	72171	58100	14229	5116	4005	3392	13162
1979	87394	53725	34683	29233	7770	2806	2206	9553
1980	85398	47055	25667	18655	16003	4010	1657	7664
1981	164062	41959	24949	12279	9580	8208	2117	5849
1982	140997	108860	23048	15060	6262	4783	3728	4039
1983	148474	69804	55047	11354	8239	3118	2499	3794
1984	255333	76349	30153	23877	4729	3463	1326	2782
1985	356047	108138	29492	12808	9471	2222	1591	2300
1986	291152	141472	32133	11761	6369	4485	1193	2259
1987	149047	164118	36244	10178	5140	3287	2286	1795
1988	138414	71678	61327	11414	4550	2592	1736	1923

Year/Age	3	4	5	6	7	8	9	10+
1989	102008	69697	27720	21730	4715	2093	1241	1642
1990	150308	47874	25776	11117	8382	2313	1028	1403
1991	175002	70826	17270	10299	5260	3807	1239	1386
1992	103513	88962	25586	6728	5234	2855	2062	1473
1993	176271	58355	34086	9078	2860	3173	1791	2229
1994	118068	96488	28197	13374	3387	1398	1469	2102
1995	213835	65812	42118	12873	6295	1563	898	1866
1996	118651	148029	29476	19441	6929	2423	677	1275
1997	150312	78950	90122	13053	9058	3386	1069	909
1998	87577	120289	45371	49022	7112	4512	1808	971
1999	117064	55133	72753	22620	26718	4153	2282	1499
2000	100942	97372	28997	36828	11082	12710	1930	1602
2001	207271	68817	65279	14224	17772	6280	6805	1496
2002	152571	142996	35172	34261	8304	9516	3788	4780
2003	158002	115392	82853	16402	16861	5331	5133	4749
2004	115544	103954	70944	47401	7855	8117	3232	4464
2005	146607	75017	64490	47856	27497	4879	4420	4177
2006	100552	126843	41920	36298	26648	14186	3022	4756
2007	156429	54967	79992	24350	19609	15130	7308	4359
2008	74067	99644	31440	49749	15322	11131	10251	8352
2009	57208	52124	44971	14927	25822	9463	5999	10788
2010	90078	37412	27935	20582	7255	13485	5625	10147
2011	80065	78816	21958	14034	10154	3711	6779	10507
2012	129691	46054	47392	11685	7298	4969	2035	9772
2013	90971	96927	22531	25565	6654	3953	2674	6785
2014	56389	67685	51452	12544	13869	3981	2080	5571
2015	93144	42128	44872	26676	7269	7192	2558	4572
2016	114203	63548	26986	23899	12905	4609	3862	4504
2017	78090	88048	35688	15522	14019	7124	2814	4727
2018	39247	62899	54661	19319	7614	7205	3857	4369
2019	51955	30151	37988	26696	9039	3971	3855	4573

Table 16.5.1. Saithe in subareas 4 and 6 and Division 3.a. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 7 (F4–7), 1967–2019. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4\text{-}7)}$	Low	High	TSB	Low	High
1967	141749	101589	197785	152252	121198	191262	0.352	0.276	0.450	413079	340284	501447
1968	160573	116806	220739	210476	170005	260580	0.295	0.232	0.375	579164	480146	698602
1969	287062	208743	394767	276585	226175	338230	0.321	0.259	0.398	713804	594945	856409
1970	294929	215707	403247	346060	287456	416611	0.345	0.282	0.424	912458	767947	1084162
1971	356355	263120	482628	461829	384613	554547	0.373	0.307	0.454	1058789	900441	1244982
1972	223448	166099	300599	491096	411499	586090	0.404	0.334	0.488	960745	825039	1118772
1973	200427	149121	269386	523606	438789	624818	0.429	0.357	0.515	895409	774713	1034909
1974	198604	147558	267309	578302	486871	686903	0.495	0.416	0.589	926090	805843	1064281
1975	234351	174954	313915	517934	435093	616548	0.534	0.450	0.633	857038	745942	984679
1976	407390	299348	554427	399712	333828	478599	0.599	0.504	0.711	814310	700441	946689
1977	149340	110720	201431	325413	271390	390189	0.589	0.491	0.708	612297	528297	709653
1978	120146	89343	161571	297647	247309	358230	0.483	0.404	0.578	520081	448379	603249
1979	87394	64754	117949	278532	234019	331512	0.453	0.378	0.543	482917	418313	557499
1980	85398	63278	115251	260299	220376	307454	0.475	0.399	0.565	438728	381869	504054
1981	164062	120679	223041	248762	211641	292392	0.472	0.396	0.563	492923	426610	569544
1982	140997	104881	189550	219830	189472	255052	0.542	0.461	0.637	531196	458572	615323
1983	148474	110364	199744	219780	188883	255730	0.651	0.554	0.764	509131	441572	587026
1984	255333	189343	344321	188722	162866	218683	0.678	0.581	0.792	516409	444405	600079
1985	356047	261427	484913	165894	143863	191299	0.704	0.604	0.821	528039	447187	623510
1986	291152	216022	392410	156348	135833	179960	0.736	0.626	0.866	491949	420053	576150
1987	149047	110690	200695	165251	143555	190225	0.706	0.605	0.825	403940	349439	466942
1988	138414	103152	185730	154533	132863	179738	0.712	0.609	0.831	349090	303498	401532
1989	102008	75937	137028	126333	108997	146426	0.691	0.591	0.808	292473	254257	336434

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1990	150308	111684	202288	114507	98582	133004	0.658	0.562	0.770	300979	258775	350066
1991	175002	130539	234610	107232	92832	123866	0.629	0.537	0.737	320292	273645	374890
1992	103513	77622	138041	112573	98045	129254	0.611	0.520	0.719	309381	266322	359403
1993	176271	131824	235705	119161	103065	137771	0.642	0.544	0.757	354914	303247	415383
1994	118068	88535	157452	123438	106913	142517	0.574	0.488	0.677	337164	289626	392505
1995	213835	158307	288839	142510	122764	165432	0.579	0.489	0.687	448859	379262	531228
1996	118651	87968	160036	153695	132717	177989	0.513	0.432	0.610	429124	365001	504511
1997	150312	110720	204061	191980	162923	226219	0.444	0.372	0.530	446239	381679	521719
1998	87577	64730	118488	189382	161714	221784	0.449	0.378	0.533	392421	338881	454420
1999	117064	86247	158892	198039	169005	232060	0.474	0.397	0.566	382435	332117	440377
2000	100942	74652	136492	190738	164429	221257	0.406	0.339	0.487	403403	351034	463585
2001	207271	153671	279565	198099	170468	230209	0.381	0.316	0.458	452556	391278	523430
2002	152571	112778	206405	219417	189662	253839	0.417	0.348	0.500	482709	416714	559156
2003	158002	116775	213785	207366	178076	241472	0.431	0.359	0.518	429678	372121	496136
2004	115544	85928	155366	259445	222342	302741	0.371	0.307	0.448	484872	422509	556440
2005	146607	108213	198625	253086	217814	294070	0.371	0.309	0.446	472032	412556	540083
2006	100552	73133	138251	270709	232657	314984	0.387	0.323	0.464	499152	437282	569776
2007	156429	114092	214477	252682	216215	295300	0.373	0.311	0.447	466911	407261	535298
2008	74067	54998	99746	257281	219940	300962	0.426	0.357	0.508	440889	385263	504548
2009	57208	42543	76928	254800	216849	299393	0.445	0.372	0.532	402534	351902	460451
2010	90078	66823	121424	237453	200294	281506	0.434	0.363	0.518	404096	351538	464512
2011	80065	58930	108780	187777	158153	222950	0.438	0.367	0.523	359891	312624	414305
2012	129691	96572	174169	168706	142511	199716	0.412	0.344	0.493	361864	312603	418888
2013	90971	67581	122458	172703	146181	204038	0.379	0.316	0.456	361489	313445	416897
2014	56389	41553	76522	193901	164851	228069	0.361	0.300	0.435	357947	311430	411411
2015	93144	68544	126573	199500	169764	234444	0.362	0.300	0.436	365762	318143	420510

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
2016	114203	83680	155859	185528	157493	218552	0.362	0.299	0.437	380424	329113	439736
2017	78090	56164	108575	206143	175503	242131	0.393	0.322	0.479	396364	343934	456787
2018	39247	26511	58104	204242	173213	240829	0.419	0.335	0.524	346805	298589	402807
2019	51955	30029	89889	196167	161126	238829	0.461	0.347	0.611	324614	263929	399254

Table 16.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2020)	0.46	Average exploitation pattern (2017-2019) scaled to F_{4-7} in 2019
SSB (2021)	151 404	SSB at the beginning of the TAC year, in tonnes
$R_{age\ 3}$ (2020)	78 287	Geometric mean recruitment re-sampled from the years 2010-2019, in thousands
$R_{age\ 3}$ (2021)	77 918	Geometric mean recruitment re-sampled from the years 2010-2019, in thousands
Total catch (2020)	80 363	Short-term forecast, in tonnes
Wanted catch (2020)	81 897	Assuming 2017-2019 ave. landing fraction by age from numbers, in tonnes
Unwanted catch (2020)	6 812	Assuming 2017-2019 ave. 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} $_{lim}$	ICES (2019a)
	F_{lim}	0.620	EQsim analysis based on the recruitment period 1998–2017.	ICES (2019a)
	F_{pa}	0.446	F_{lim} $_{lim}$ / 1.4	ICES (2019a)
Management plan*	MAP MSY $B_{trigger}$	149 098 t	MSY $B_{trigger}$	ICES (2019a)
	MAP B_{lim}	107 297 t	B_{lim}	ICES (2019a)
	MAP F_{MSY}	0.363	F_{MSY}	ICES (2019a)
	MAP range F_{lower}	0.210	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019a)
	MAP range F_{upper}	0.536	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019a)

Table 16.7.3. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2020)	Wanted catch* (2020)	Unwanted catch* (2020)	Wanted catch*# 3a4	Wanted catch*# 6	F_{total} (ages 4-7) (2020)	F_{wanted} (ages 4-7) (2020)	$F_{unwanted}$ (ages 4-7) (2020)	SSB (2021)	% SSB change **	% TAC change ***	% advice change ^
ICES advice basis												
MSY approach: F_{MSY}	65687	61056	4631	55317	5739	0.36	0.34	0.024	164624	8.7	-25	-25
Other scenarios												
F = MAP^^ $F_{MSY\ lower}$	40391	37551	2840	34021	3530	0.21	0.196	0.0140	187780	24	-54	-54
F = MAP^^ $F_{MSY\ upper}$	90731	84297	6434	76373	7924	0.54	0.50	0.035	142255	-6.0	3.0	3.0
F = 0	0	0	0	0	0	0.00	0.00	0.00	225332	49	-100	-100
F_{pa}	78122	72613	5509	65787	6826	0.45	0.42	0.030	153407	1.32	-11.3	-11.3
F_{lim}	101721	94499	7222	85616	8883	0.620	0.58	0.041	132683	-12.4	15.5	15.5
$SSB_{2022} = B_{lim}$	131384	121862	9522	110407	11455	0.88	0.82	0.058	107297	-29	49	49
$SSB_{2022} = B_{pa}$	83429	77541	5888	70252	7289	0.48	0.45	0.031	149098	-1.52	-5.3	-5.3
SSB_{2022} = MSY $B_{trigger}$	83429	77541	5888	70252	7289	0.48	0.45	0.031	149098	-1.52	-5.3	-5.3
$F = F_{2020}$	80210	74548	5662	67540	7008	0.46	0.43	0.031	151564	0.106	-8.9	-8.9
TAC_{2020}	88093	81868	6225	74172	7696	0.52	0.48	0.034	144600	-4.5	0.00	0.00
TAC_{2020} -15%	74879	69603	5276	63060	6543	0.42	0.40	0.028	156285	3.2	-15.0	-15.0
TAC_{2020} +15%	101308	94102	7206	85256	8846	0.62	0.58	0.041	133033	-12.1	15.0	15.0
TAC_{2020} -20%	70476	65513	4963	59355	6158	0.39	0.37	0.026	160238	5.8	-20.0	-20.0
TAC_{2020} +25%	110117	102228	7889	92619	9609	0.69	0.64	0.045	125433	-17.2	25	25

Table 16.7.4. Saithe in subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2021.

Year class	Contribution to landings (%)
2018	8.4
2017	25.6
2016	17.4
2015	10.1
2014	12.5
2013	11.4
2012	4.5

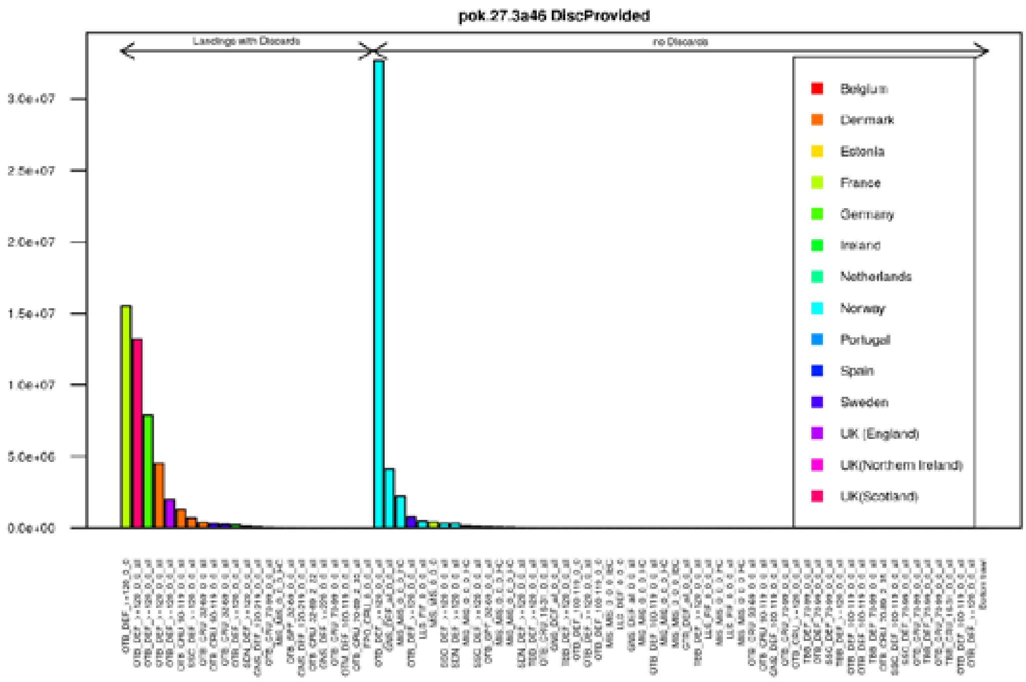

Figure 16.3.1. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier for 2018 (updated).

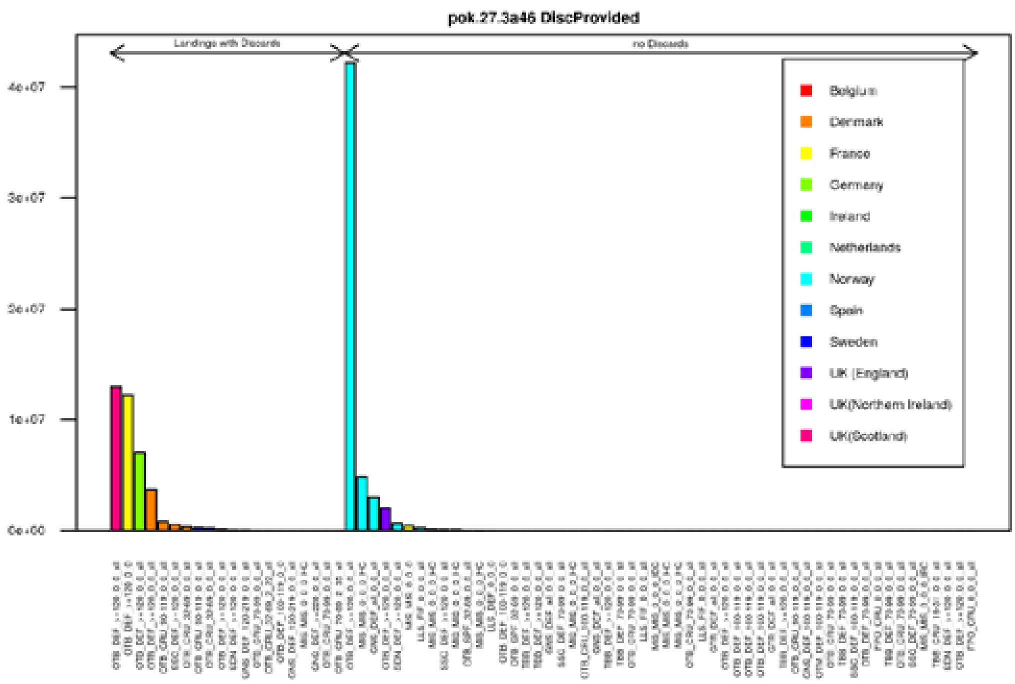

Figure 16.3.2. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier for 2019

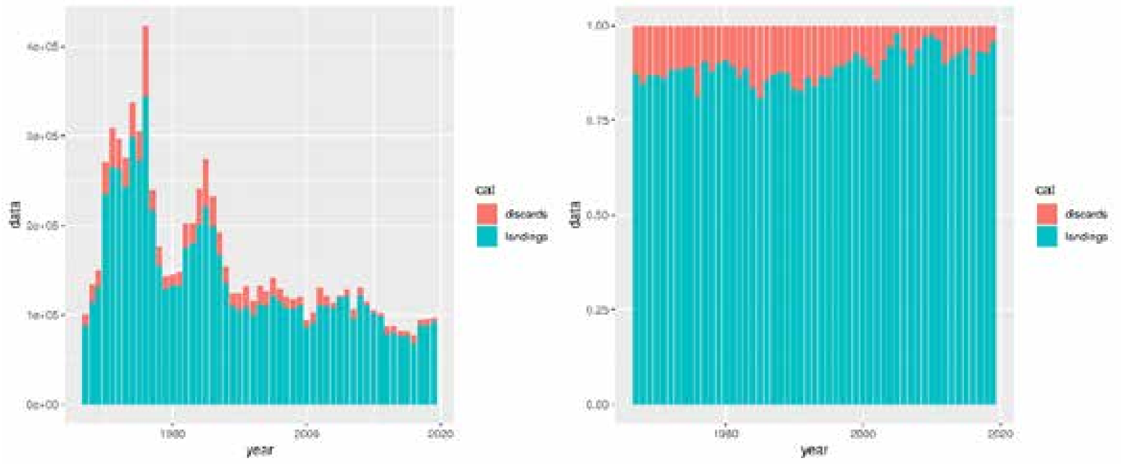

Figure 16.3.3. Saithe in subareas 4 and 6 and Division 3.a: Yield as stacked plot for landings and discards in tonnes (left panel) and as percent (right panel). Landings include BMS landings from Norway since 2016. Discards correspond to unwanted catch (discards + EU BMS) since 2016.

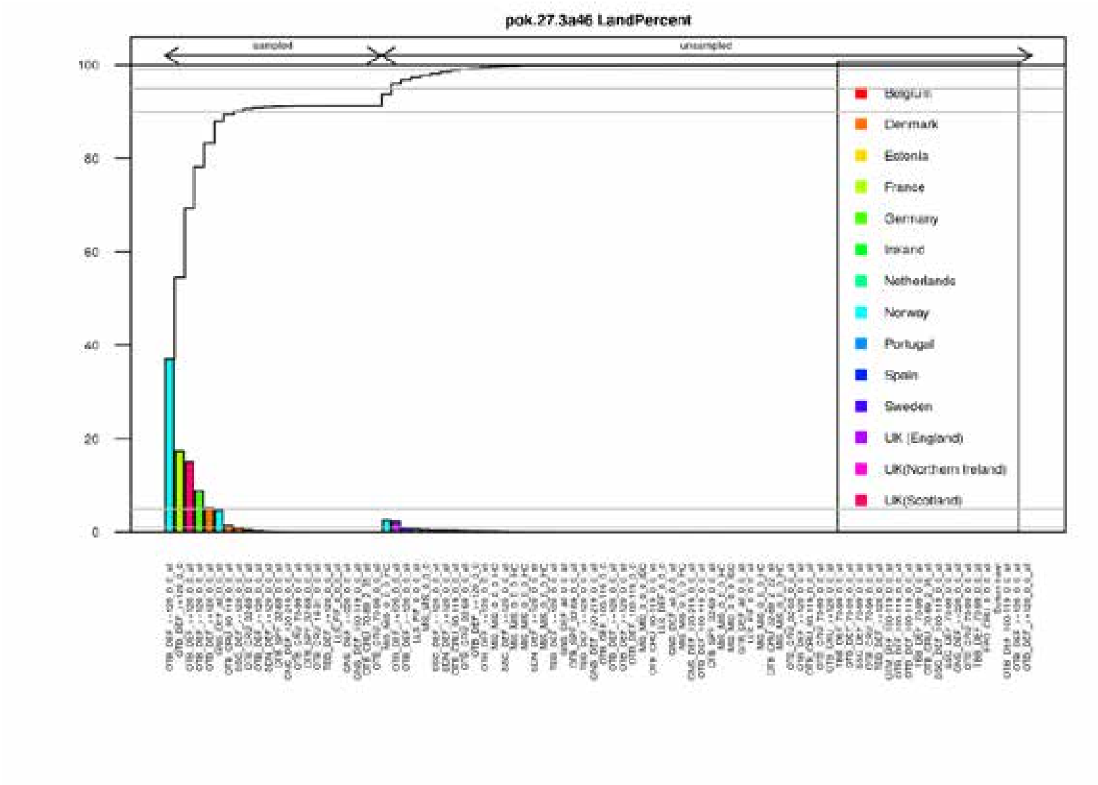

Figure 16.3.4. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier for 2018 (updated).

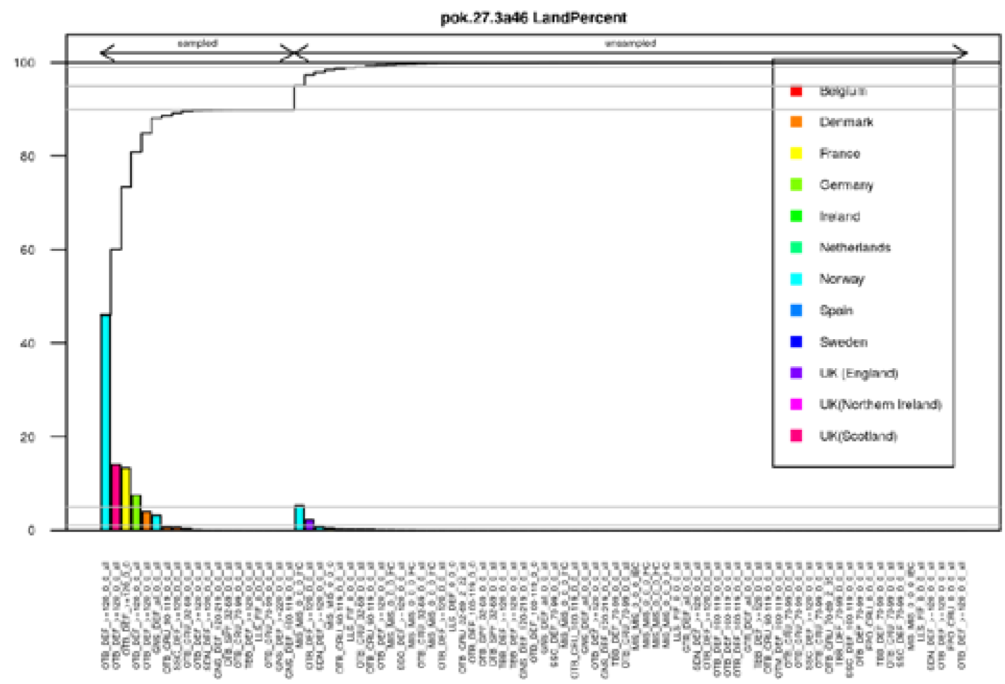

Figure 16.3.5. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier for 2019.

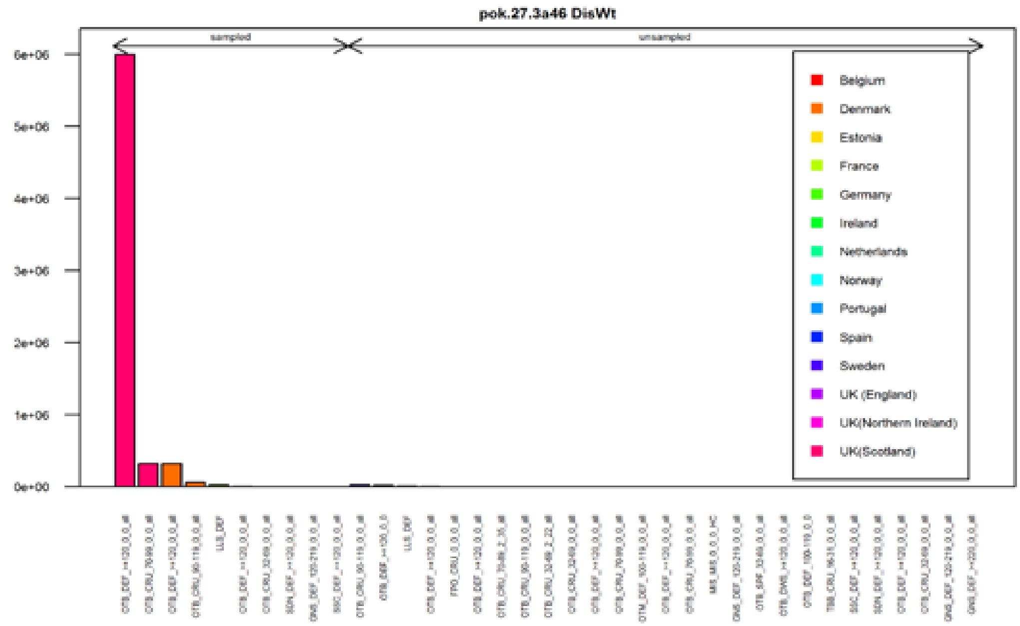

Figure 16.3.6. Saithe in subareas 4 and 6 and Division 3.a: Overview of age sampled and unsampled imported discards by country and métier for 2018 (updated).

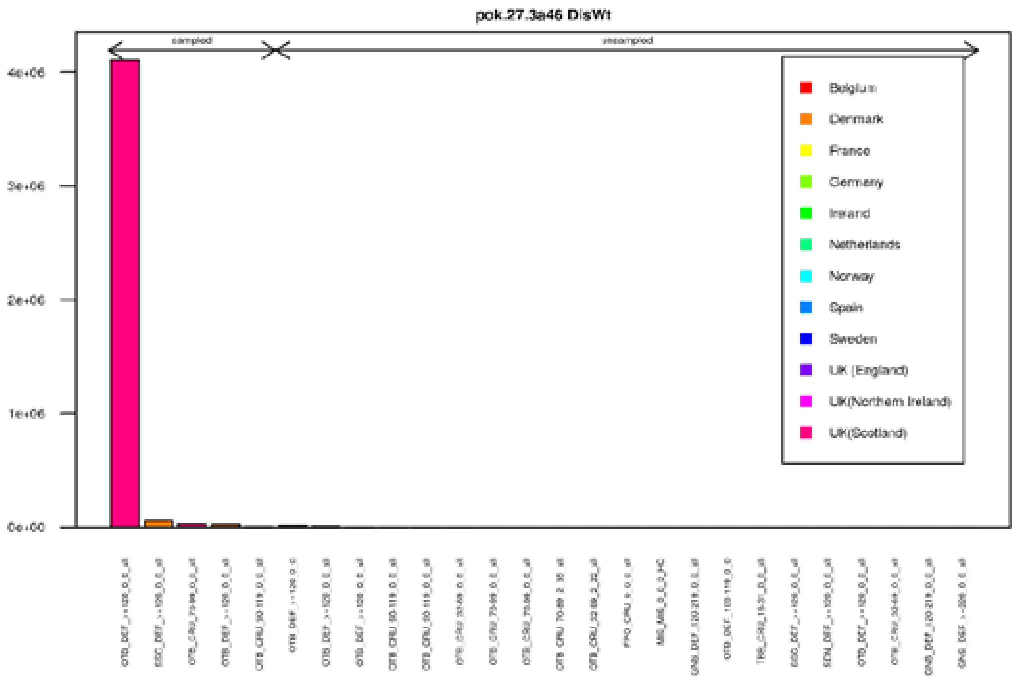

Figure 16.3.7. Saithe in subareas 4 and 6 and Division 3.a: Overview of age sampled and unsampled imported discards by country and métier for 2019.

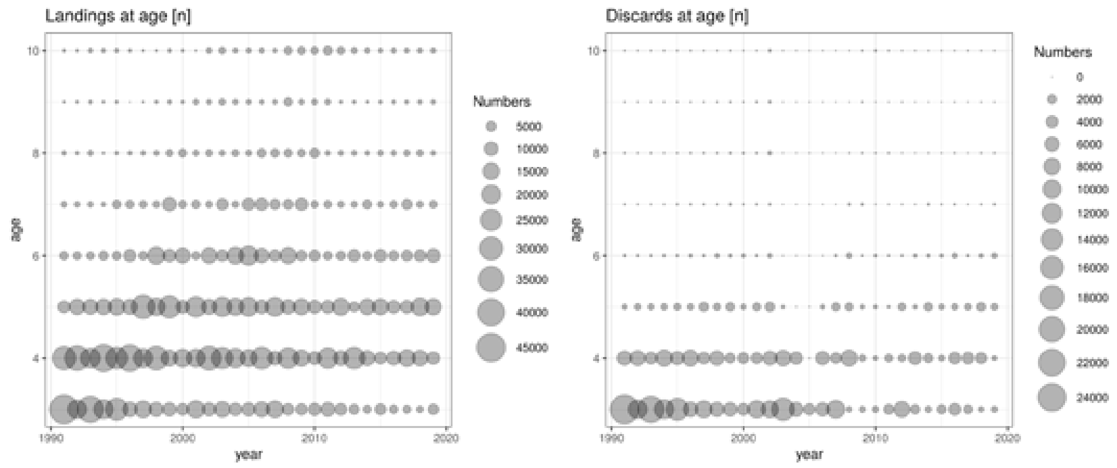

Figure 16.3.8. Saithe in subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2019. (Right) Discard numbers at age for saithe ages 3–10+, 1990–2019.

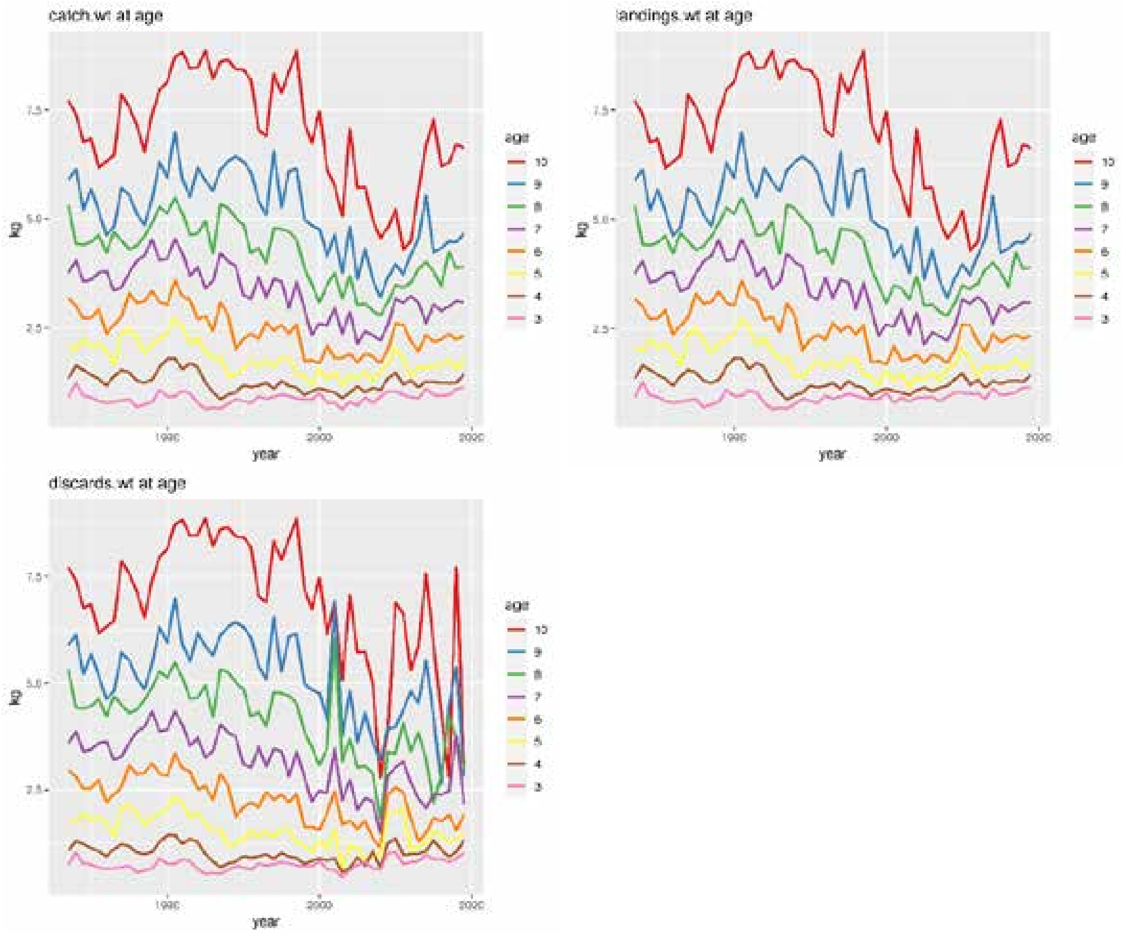

Figure 16.3.9. Saithe in subareas 4 and 6 and Division 3.a. Catch weight-at-age (top left pane), landing weight-at-age (bottom left panel) and discard weights-at-age (bottom right panel), in kilograms, for saithe ages 3–10+, 1967–2019.

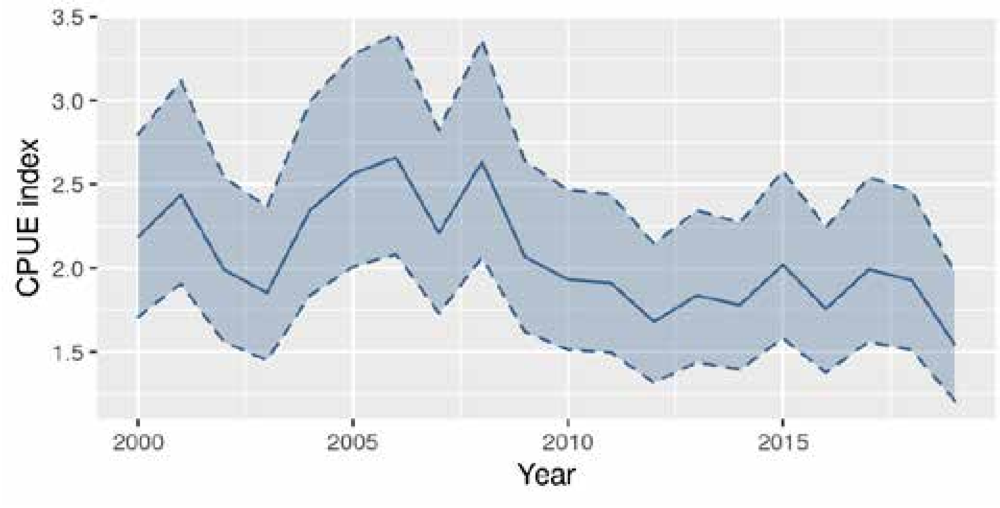

Figure 16.3.10. Saithe in subareas 4 and 6 and Division 3.a: Standardised commercial CPUE index time series and 95% confidence interval. Based on logbook data from France, Germany and Norway.

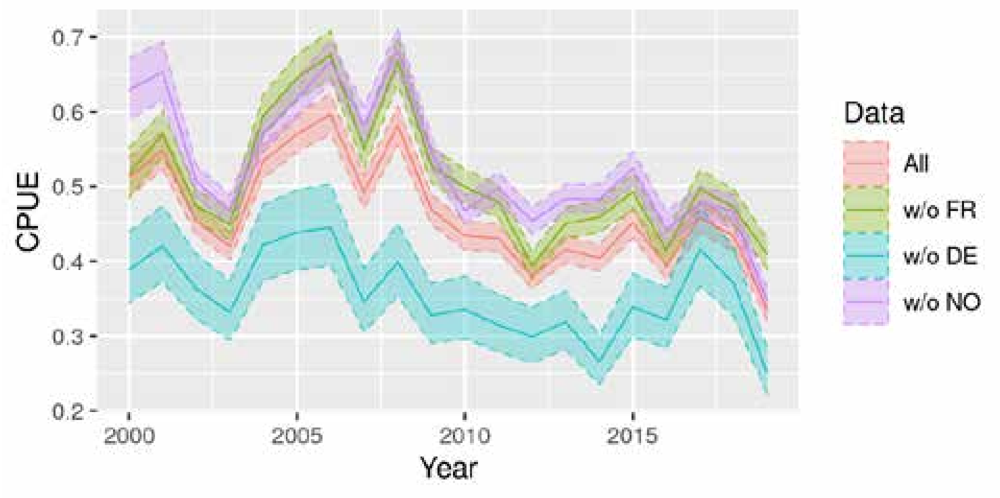

Figure 16.3.11. Saithe in subareas 4 and 6 and Division 3.a: Commercial CPUE index fitted with data from one sequentially taken out, compared to all data. The power category used as reference is different to the one in Figure 16.3.10, which explains the differences in scale.

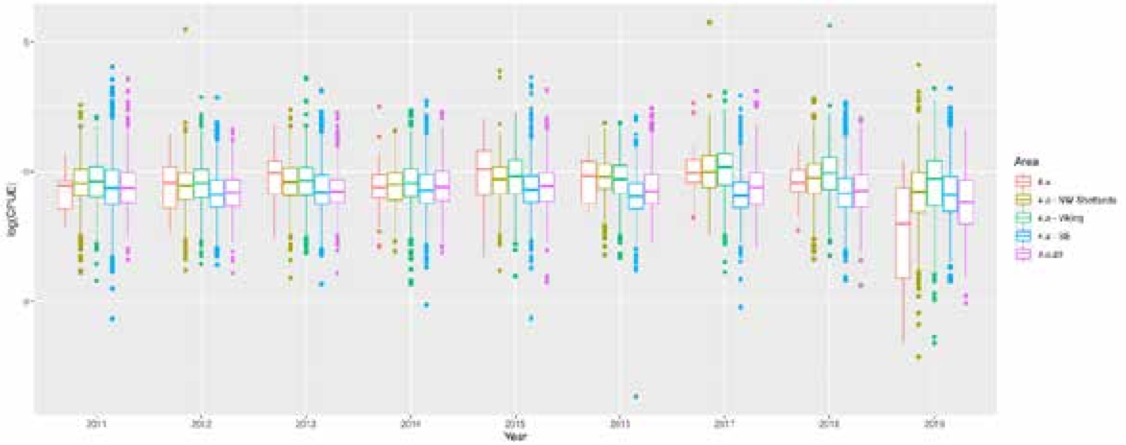

Figure 16.3.12. Saithe in subareas 4 and 6 and Division 3.a: Illustration of the marked decrease of CPUEs in area 6a in 2019. Unlike in Figure 16.3.13, all factor expected to influence CPUEs are not controlled for, and variations of CPUEs (or the lack thereof) may integrate within area changes in Quarter, vessel power and nation allocations.

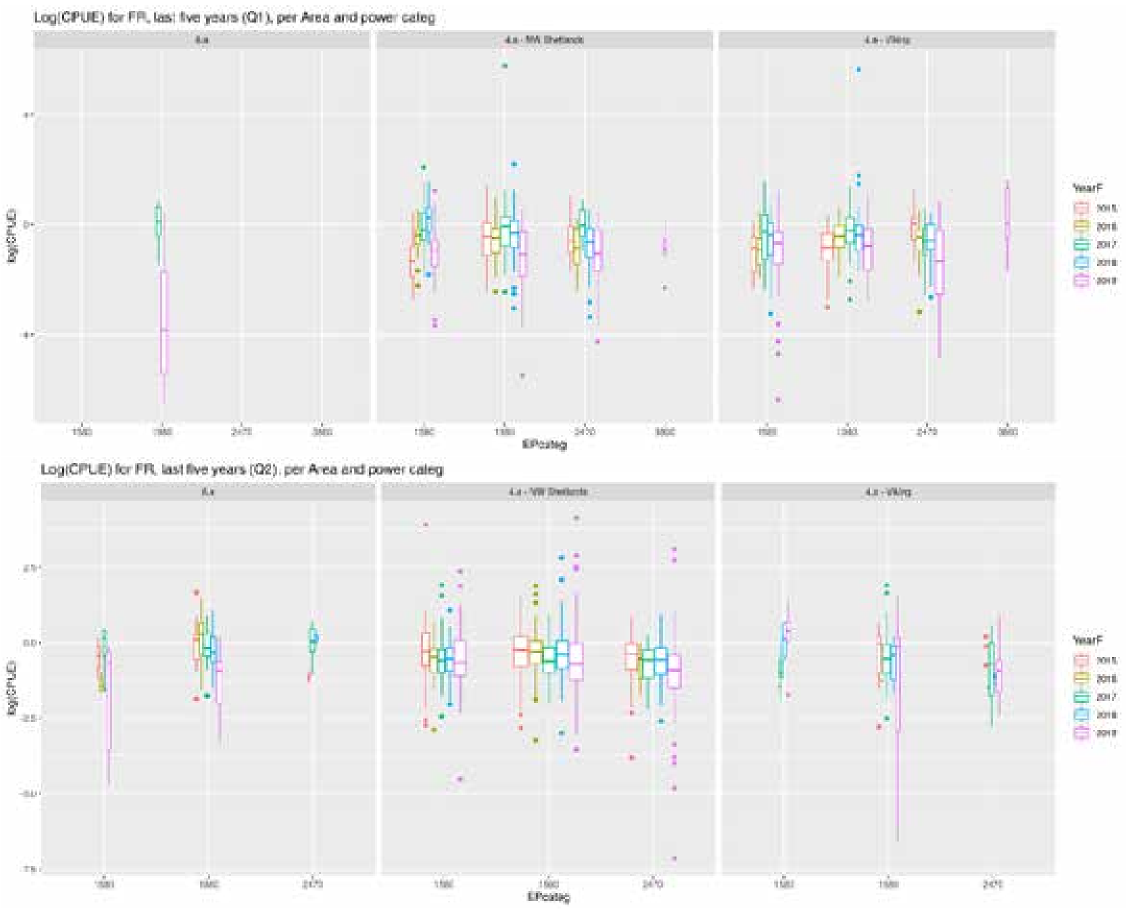

Figure 16.3.13. Saithe in subareas 4 and 6 and Division 3.a: Illustration of the sharp decrease in CPUEs distributions in area 6.a (French vessels only, mostly Q1-2 (respectively upper and lower panels) in 2019. As all the factors of the model are controlled for, the comparatively milder decrease in area 4a questions the absence of Year:Area interactions. It is however based on too few data to be fully conclusive.

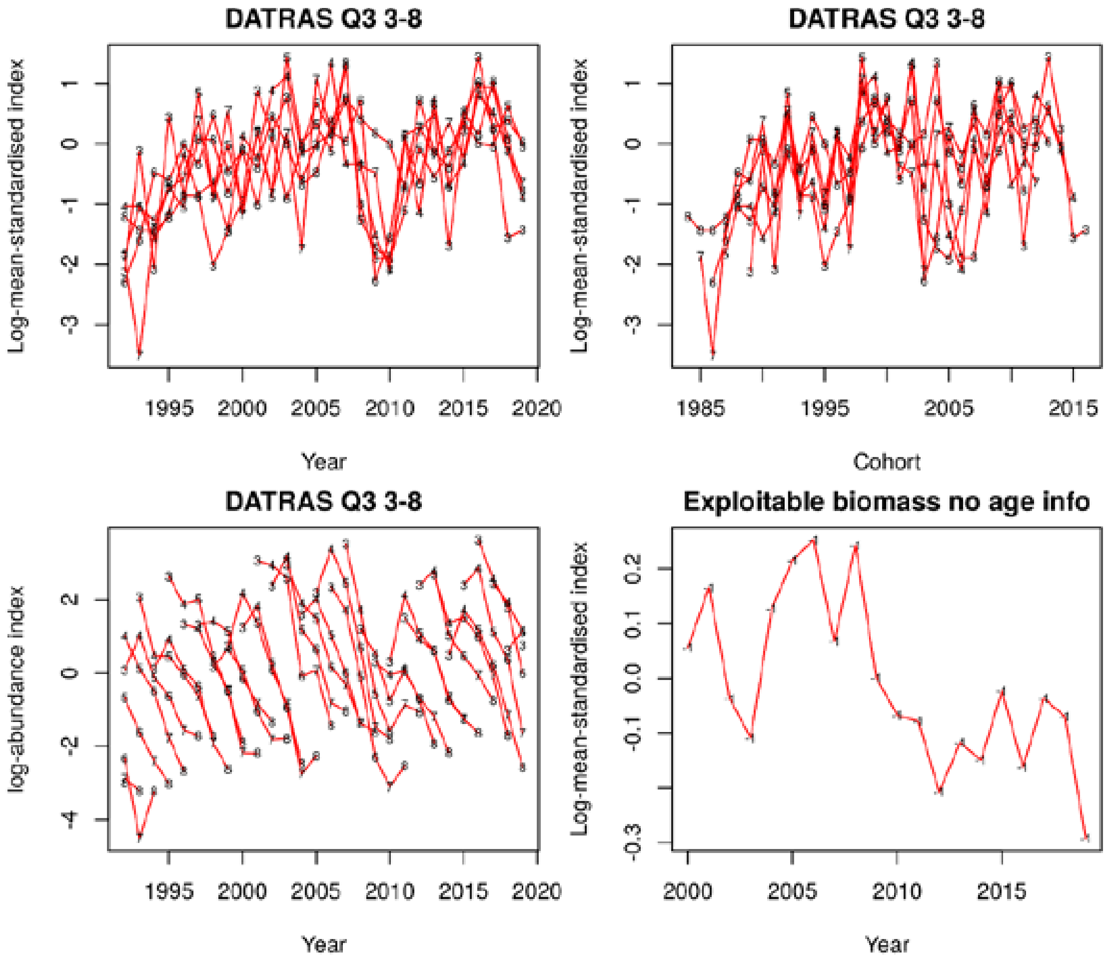

Figure 16.4.1. Saithe in subareas 4 and 6 and Division 3.a: Research survey index, IBTS–Q3, for ages 3 to 8, 1992–2019 is shown in terms of indices by age and year (top-left panel), indices by age and cohort (top-right panel), and log-catch curves by cohort (bottom-left panel). Commercial catch-per-unit-effort (CPUE) is shown in the bottom-right panel.

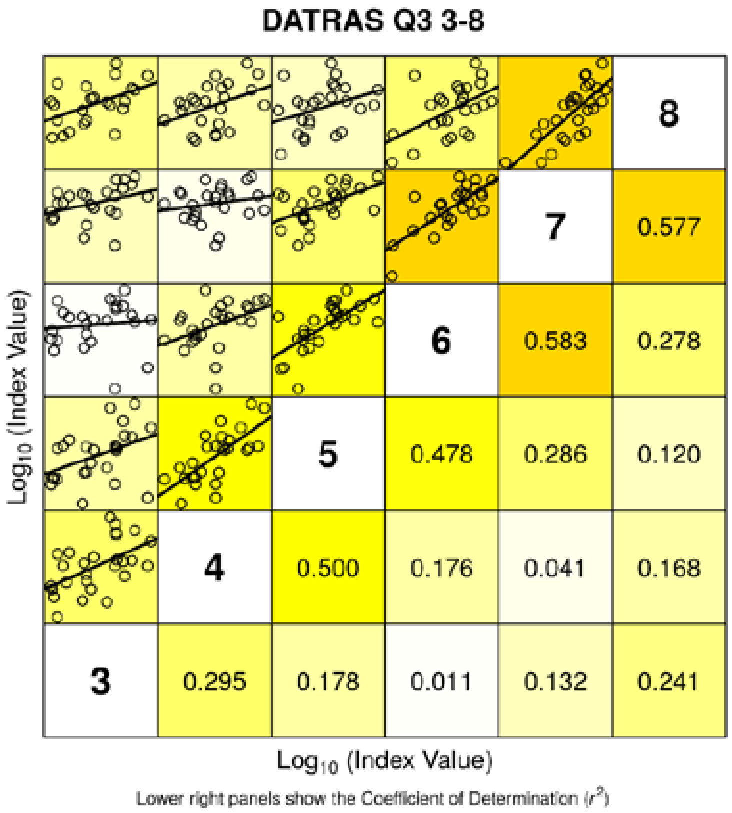

Figure 16.4.2. Saithe in subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2019 ages 3 to 8.

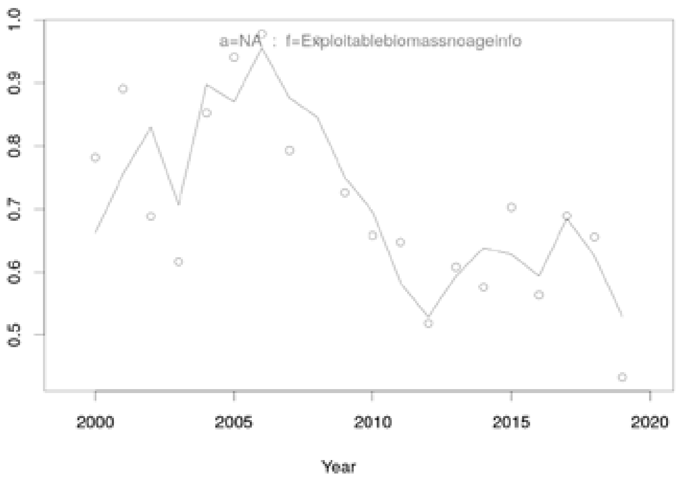

Figure 16.4.3. Saithe in subareas 4 and 6 and Division 3.a. Standardized combined CPUE index (year effects, open circles) and fit of model after tuning to the exploitable biomass, 2000–2019.

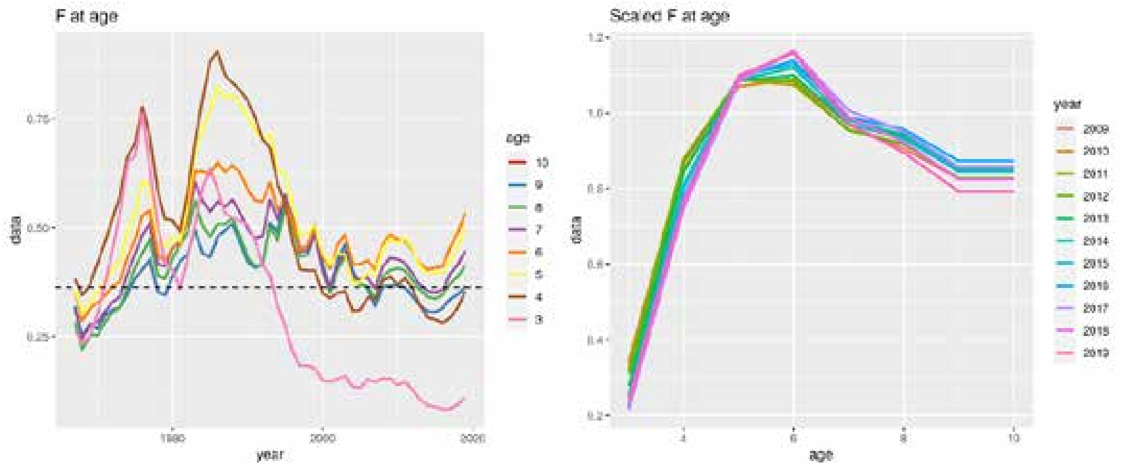

Figure 16.4.4. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortality at age for the final assessment model. Time series (left panel) and scaled at F_{4-7} for the last 11 years (right panel).

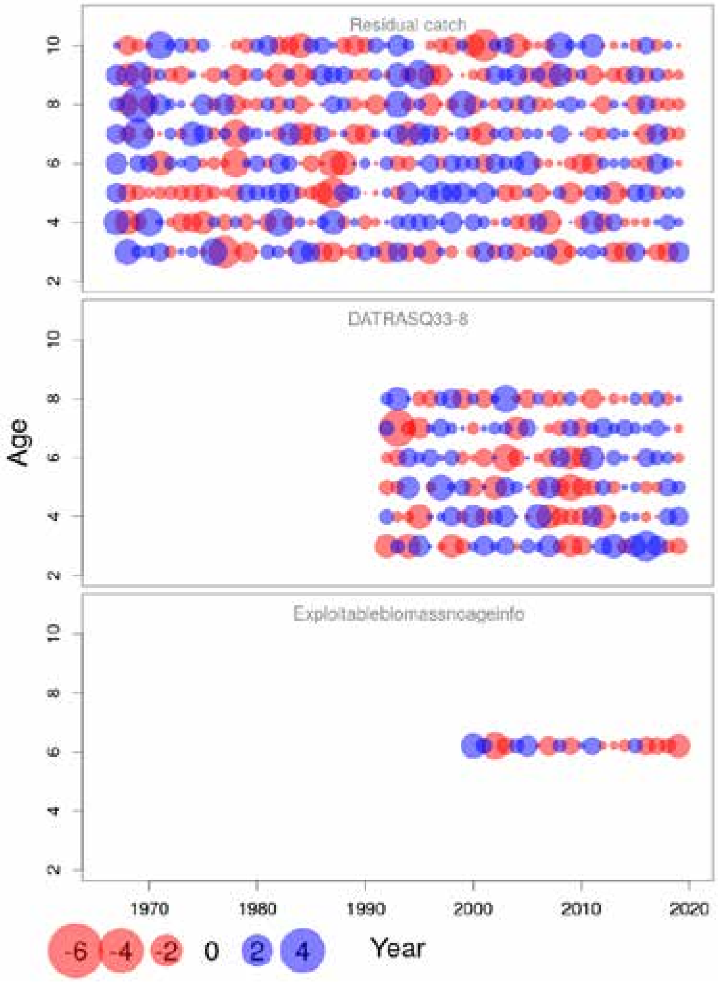

Figure 16.4.5. Saithe in subareas 4 and 6 and Division 3.a. Residual patterns for the final SAM model.

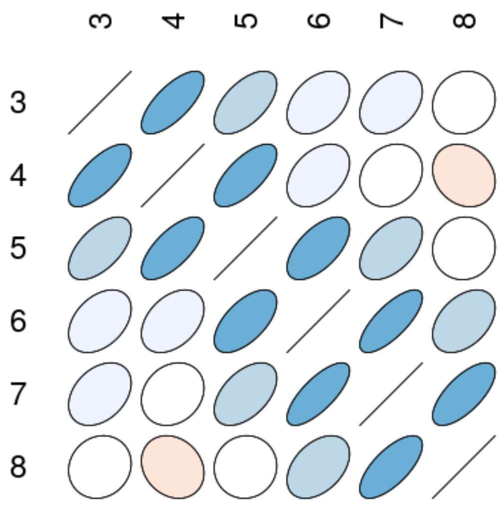

Figure 16.4.6. Saithe in subareas 4 and 6 and Division 3.a. Correlation between age classes within years for IBTS Q3 (ages 3–8). The darker the blue colour, the stronger the correlation.

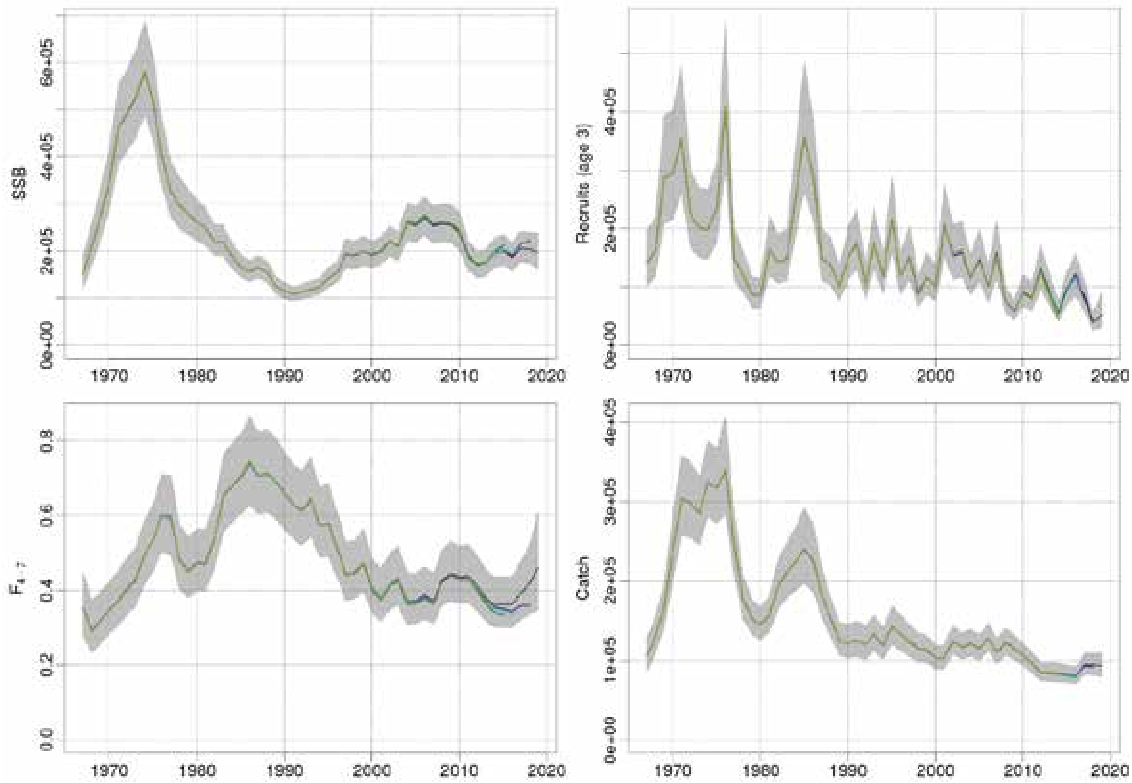

Figure 16.4.7. Saithe in subareas 4 and 6 and Division 3.a. Five year retrospective pattern in SSB, F_{4-7}, recruitment, and catches for the final assessment.

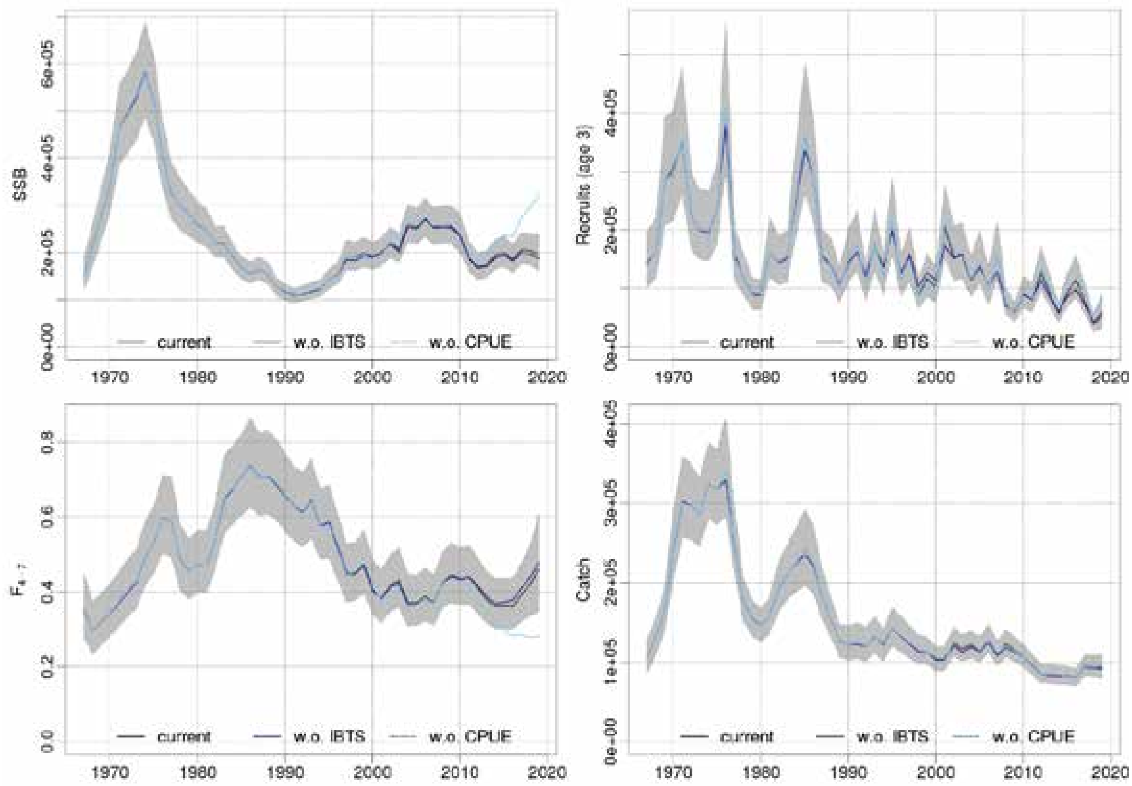

Figure 16.4.8. Saithe in subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, recruitment, and catches for the final assessment model. Black lines and grey-shaded confidence interval indicates the final assessment model, including the IBTS Q3 indices for ages 3–8 and the CPUE index. The cyan line is the assessment with only the IBTS Q3 tuning series, while the blue line is the assessment with only the CPUE index.

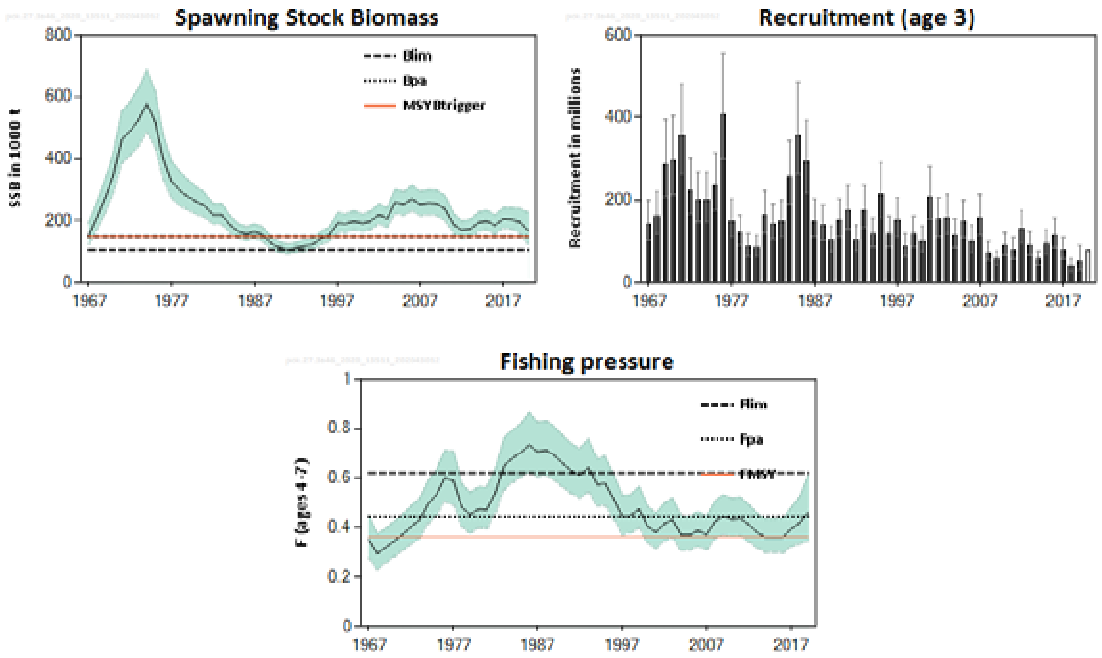

Figure 16.5.1. Saithe in subareas 4 and 6 and Division 3.a. Summary of stock assessment in relation to reference points for SSB and F. Predicted recruitment values are not shaded. Shaded areas (F, SSB) and error bars (R) indicate point-wise 95% confidence intervals.

17 Sole (*Solea solea*) in Subarea 27.4 (North Sea)

17.1 General

The assessment of sole in Subarea 27.4 is the result of applying the methodology agreed at the recent 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 main difference with previous assessment lies on the use of a new index of abundance based on the BTS Q3 survey. Survey data from The Netherlands, Belgium and Germany have been combined so as to better cover 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 relevant 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 2021.

17.1.1 Stock structure and definition

North Sea sole is assumed to consist of a single stock unit.

17.1.2 Fisheries

Many vessels in the beam trawl fleet, targeting sole in the North Sea, have transitioned to using electrical pulse gears. In 2011, approximately 30 derogation licenses for Pulse trawls were taken into operation, which increased to 42 in 2012.

The catch composition of these gears was 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 has recommended that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls are 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 the Division 4.c. As a consequence of this, 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 will continue.

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.

17.1.3 Management regulations

Sole in Subarea 27.4 falls under the EU MAP for the North Sea. ICES is requested to provide advice based on the EU MAP. ICES advises that when the proposed EU multiannual plan (MAP) for the North Sea is applied, catch in 2021 that correspond to the F ranges in the MAP are between 13 237 tonnes and 32 920 tonnes. According to the MAP, catch higher than those corresponding to FMSY (21 361 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

17.2 Fisheries data

17.2.1 Official catches

For 2019, the official landings are presented next to the landings and discards data submitted to Intercatch in Figure 17.2.1. A time-series of the official landings by country, overall total landings, the officially reported BMS landings, the landings reported to ICES and the agreed TAC are presented in Table 17.2.1.

17.2.2 Intercatch processing

Data submitted on landings and discards at age by métier and quarter has been extracted from Intercatch. Figures 17.2.2, 17.2.3 and 17.2.4 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 17.2.5 presents the time series of total catches, landings and discards over the 1957-2019 period. Landings, in numbers by age, as used as input for the assessment, are presented in Table 17.2.2 and Figure 17.2.6. Total landings reported to ICES for sole in Subarea 27.4 in 2019 amounted to 8658 tonnes, a decrease of around 23% compared to 2018.

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 2019 were 48 tonnes. For the assessment, BMS landings are considered to be below minimum landings size and thus treated as discards.

Discards, in numbers by age, as used as input for the assessment, are presented in Table 17.2.3 and Figure 17.2.7. The proportions of caught fish at age that are discarded Figure over the 2002-2019 period, over which data on discards is available, is presented in Figure 17.2.8.

In 2019, official catches amounted to 66.4% of the TAC, while landings reported to ICES were 69% of the TAC. If both landings and discards estimates are used, total catch in 2019 was 84.5% 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 17.3.1 and Figure 17.3.1. These are measured weights from the various national catch and market sampling programmes. Discard weights at age (Table 17.3.2) are derived from the various national catch and discard programmes (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 17.3.3) are the average weights from the 2nd quarter landings and discards as constructed by Intercatch. The mean stock weights-at-age are still showing a downward trend, returning to values similar to those observed at the start of the time series (Figure 17.3.2).

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 17.4.1). No new data was presented at the working group in 2019. Natural mortality at age is assumed to be constant at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter of 1962-1963. The estimate of 0.9 was based on an analysis of the CPUE in the fisheries targeting sole before and after the severe winter (ICES FWG, 1979).

17.5 Survey data

Two survey series are available for use in the assessment of North Sea sole:

- Quarter 3 Beam Trawl Survey (BTS), covering the 1982-2019 period and containing samples for ages 1 to 10+.
- Quarter 3 Sole Net Survey (SNS), extending from 1970 to 2019, with the exception of 2003, and with samples including ages 0 to 6.

An index of abundance has been assembled based on the BTS Q3 samples collected by The Netherlands, Belgium and Germany (Figure 17.5.1), 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, (Figure 17.5.2).

The SNS index is calculated by The Netherlands based on the mean densities across all sampled stations (Figure 17.5.3).

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1 Input data, source code and output of the index standardization will be available at the https://github.com/ices-taf/2020_sol.27.4_survey/ TAF repository.

A standardized comparison of the two indices over the available time-series is presented in Figure 17.5.4. The internal consistency plots of the year class cohorts of the two indices are presented in Figures 17.5.5 and 17.5.6, while the mean standardized indices per cohort and by year are shown on Figures 17.5.7 and 17.5.8. The two survey indices used in the assessment are presented in Tables 17.5.1 and 17.5.2.

17.6 Assessment

The model applied to North Sea sole is the Art 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).

Settings of the 2020 AAP stock assessment 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 17.6.1. The estimates of spawning biomass and corresponding recruitment at age 1, over the whole time series, are shown in Figure 17.6.2. The proportion of spawning biomass estimated to be accounted for by age and year is presented in Figure 17.6.3. 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 17.6.4.

The retrospective patterns for recruitment, spawning biomass and fishing mortality are summarized in Figure 17.6.5. A leave-one-out analysis of model fit over the two indices of abundance can be found in Figure 17.6.6. The estimated standard deviations of the lognormal likelihood for each age and data source is presented in Figure 17.6.7.

Yearly estimates of abundances and fishing mortality-at-age obtained by the model run are presented in Tables 17.6.1 and 17.6.2 respectively. Table 17.6.3 contains the estimates of SSB and fishing mortality, including confidence intervals, computed as 2 times the standard deviation.

17.7 Recruitment estimates

The short term forecast for the stock requires an assumption about recruitment in the intermediate year, 2020. This has been set to the geometric mean of the 1957-2016 time series of recruitment estimates, 111.481 million fish.

17.8 Short-term forecasts

Short-term forecasts were carried out from the abundances estimated by the assesment model in 2019, with the following settings

- Natural mortality, maturity and weights-at-age in landings, discards and stock for 2020-2022 set as the average of the 2015-2019 period.
- Selectivity-at-age for 2020-2022 set as the average of the last five years (2015-2019).
- Ratio of discards to landings at age as the average over the last three years (2017-2019).
- Recruitment in 2020 and 2021 set as 111.481 million fish.
- Population numbers in the intermediate year for ages 2 and older are taken from the AAP survivor estimates.

Fishing mortality in the intermediate year, 2020, was set as that that would result in catches equal to the 2020 TAC, 17 545 t. Projecting the stock in 2020 under the same fishing mortality as that estimated for 2019, 0.272, would lead to catches that are larger than the agreed TAC. Consequently, fishing mortality in the intermediate year was set at 0.256.

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:

1. F_{MSY}: F_{bar} (2021) = 0.207
2. F_{MSY} lower: F_{bar} (2021) = 0.123
3. F_{MSY} upper: F_{bar} (2021) = 0.123
4. Zero catch: F_{bar} (2021) = 0
5. F_{pa}: F_{bar} (2021) = 0.302
6. F_{lim}: F_{bar} (2021) = 0.42
7. B_{pa}: SSB (2022) = 42 838
8. F_{lim}: SSB (2022) = 30 828
9. MSY $B_{trigger}$: SSB (2022) = 42 838
10. F_{2020}: F_{bar} (2021) = 0.256

2 https://flr-project.org

3 https://flr-project.org/FLasher

4 https://github.com/ices-taf/2020_sol.27.4_forecast/

11. F_{mp}: F_{bar} (2021) = 0.20
12. 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; Mosqueira, 2020), following the procedures of ICES WKMSYREF3 (2014). All values are derived from a run of the accepted AAP model including data up to 2018. The reference points in use for the stock are as follows:

Reference point	Value	Technical basis
MSY $B_{trigger}$	42 838 t	B_{pa}
F_{MSY}	0.207	EQsim analysis based on the recruitment period 1958-2015
B_{lim}	30 828 t	Break-point of hockey stick stock-recruit relationship, based on the recruitment period 1958-2018
B_{pa}	42 838 t	B_{lim}

17.11 Status of the stock

The status of the stock inferred from the 2020 stock assessment is more pessimistic than previously. Biomass appears to have been oscillating around the B_{lim} level since the early 2000s, although fishing mortality has markedly been reduced over the same period. The stronger year classes in the last two decades were not particularly large, especially when compared with past recruitment events.

The estimated spawning biomass in 2019, 28 244 t, is lower than B_{lim}, although it is expected to have moved already above that limit at the start of 2020, up to 34 569 t, given the 2019 catch levels.

Recruitment in 2019 is currently estimated to be the largest in the time series, 616 million fish, and despite the uncertainty in model estimates in the final year, all surveys seem to agree on the 2018 year class, which is assumed to enter the spawning stock in 2021, being particularly strong.

17.12 Management considerations

The expected increase in stock biomass as a consequence of the 2018 year-class is leading to the corresponding increase in TAC that are now much higher than the recent catches. TAC for 2020, 17 545 t, set during the autumn update and already accounting for the 2019 recruitment effect on the 2021 SSB, is substantially higher than the 2019 estimated catches, 10 607 t. The TAC proposal for 2021 that would bring the stock to F_{MSY} levels in 2022, 21 361 t, expects catches to be even higher.

17.13 Issues for future benchmarks

The stock has gone through a benchmark process in 2020 (ICES WKFLATNSCS, 2020) that concentrated on the two main items on the ICES WGNSSK (2019) issue list: for the BTS Q3 index of abundance to include samples from multiple surveys, and improvements on the residual patterns of the model fit.

Limitations on time 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.

17.14 References

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Table 17.2.1. Time-series of the official landings by country and overall total, the official BMS landings, the landings reported to ICES and the total TAC (figures rounded to the nearest tonne).

Year	BE	DK	FR	DE	NL	UK	Other	Official	BMS	ICES	TAC
1982	1900	524	686	266	17686	403	2	21467	NA	21579	21000
1983	1740	730	332	619	16101	435	0	19957	NA	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	NA	26839	20000
1985	2390	692	875	303	14897	774	3	19934	NA	24248	22000
1986	1833	443	296	155	9558	647	2	12934	NA	18201	20000
1987	1644	342	318	210	10635	676	4	13829	NA	17368	14000
1988	1199	616	487	452	9841	740	28	13363	NA	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	NA	21805	14000
1990	2389	1427	352	2296	18202	1614	263	26543	NA	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	NA	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	NA	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	NA	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	NA	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	NA	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	NA	22651	23000
1997	1519	689	99	510	10241	479	204	13741	NA	14901	18000
1998	1844	520	510	782	15198	549	339	19742	NA	20868	19100
1999	1919	828	NA	1458	16283	645	501	21634	NA	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	NA	22641	22000
2001	1874	772	411	958	13345	597	394	18351	NA	19944	19000
2002	1437	644	266	759	12120	451	292	15969	NA	16945	16000
2003	1605	703	728	749	12469	521	363	17138	NA	17920	15900
2004	1477	808	655	949	12860	535	544	17828	NA	18757	17000
2005	1374	831	676	756	10917	667	357	15579	NA	16355	18600
2006	980	585	648	475	8299	910	0	11933	NA	12594	17700
2007	955	413	401	458	10365	1203	5	13800	NA	14635	15000
2008	1379	507	714	513	9456	851	15	13435	NA	14071	12800
2009	1353	476	NA	555	12038	951	1	14898	NA	13952	14000

Year	BE	DK	FR	DE	NL	UK	Other	Official	BMS	ICES	TAC
2010	1268	406	621	537	8770	526	1	12129	NA	12603	14100
2011	857	346	539	327	8133	786	2	10990	NA	11485	14100
2012	593	418	633	416	9089	599	3	11752	NA	11602	16200
2013	697	497	680	561	9987	867	0	13291	NA	13137	14000
2014	920	314	675	642	9569	840	0	12547	NA	13060	11900
2015	933	271	532	765	8899	804	0	12203	NA	12867	11900
2016	767	355	362	861	9600	705	0	12651	NA	14127	13262
2017	556	432	393	731	9155	513	0	11781	30	12370	16123
2018	408	368	432	717	8412	431	2	10771	57	11199	15694
2019	259	116	110	616	7212	334	1	8339	48	8658	12555
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17545

Table 17.2.2. 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	1472	10556	13150	3913	3041	6780	1803.0	529	6541
1958	0	1863	8482	14240	9547	3501	3023	4461.0	2264	6590
1959	0	3694	12139	10499	9060	5823	1217	2044.0	2598	5668
1960	0	11965	14043	16691	9248	8313	4815	1583.0	1049	7851
1961	0	972	50470	19403	12574	4760	3998	4338.0	847	7355
1962	0	1584	6173	58836	15254	10478	4797	4087.0	2074	7450
1963	0	670	8271	8485	45823	8420	6603	2403.0	3365	8316
1964	53	150	2041	5518	3680	16749	3020	1749.0	790	2913
1965	0	45180	1045	1534	4798	2381	11990	1494.0	1463	3077
1966	0	12145	132170	979	1168	3649	736	6255.0	694	2424
1967	0	3769	26260	87039	1998	548	1962	777.0	5160	2978
1968	1034	17093	13852	24894	48417	461	244	1639.0	323	6502
1969	404	24404	21884	5433	12638	25646	338	249.0	1214	5379
1970	1299	6141	25996	8236	1784	3231	11961	246.0	140	5234
1971	425	33765	14596	12909	4538	1459	2355	7300.0	194	4649
1972	354	7511	36356	6997	4911	1548	517	1218.0	4654	2772

Year	1	2	3	4	5	6	7	8	9	10
1973	716	12459	13025	16493	4101	2368	1013	779.0	1241	5899
1974	100	15171	21248	5412	6965	1896	1563	649.0	396	4750
1975	267	23193	28833	11839	2110	3870	798	916.0	513	3481
1976	1064	3619	28571	14316	4923	987	1950	562.0	434	2721
1977	1780	22747	12299	15593	7580	1812	325	1133.0	261	2155
1978	27	24921	29163	6102	6610	4231	1730	608.0	643	1595
1979	9	8280	41681	16259	3033	3262	1769	826.0	244	1546
1980	650	1233	12762	18138	7444	1479	2241	1437.0	374	1227
1981	434	29983	3344	7046	8439	3757	973	909.0	786	932
1982	2697	26799	46375	1868	3584	4855	1701	623.0	613	1295
1983	391	34545	41551	21273	626	1383	1958	982.0	388	1181
1984	192	30839	44081	22631	8821	744	857	1047.0	526	897
1985	163	16449	42773	20079	9307	3520	207	375.0	631	965
1986	372	9304	18381	17591	7698	5480	2256	109.0	281	1671
1987	93	28896	21927	8851	6477	3102	1559	898.0	81	690
1988	10	13206	47135	15217	4377	3878	1549	890.0	523	317
1989	115	45652	17973	22295	4551	1627	1414	637.0	451	459
1990	854	11816	103380	9667	9099	3315	1032	1186.0	548	837
1991	118	12938	24985	76580	6609	3612	1706	707.0	718	1072
1992	965	6730	43713	15961	37745	2440	2995	730.0	393	1163
1993	53	49870	16575	31047	13709	23758	1472	1170.0	456	833
1994	709	7710	86349	13387	18513	5642	11174	458.0	905	897
1995	4766	12674	16700	68073	6262	7254	1981	5971	293	665
1996	170	18609	16005	16770	26946	3814	4725	932	3267	976
1997	1574	5987	23418	7253	5058	12667	1189	2303	330	1672
1998	242	56162	15011	14806	3466	1924	4727	787	1022	838
1999	284	15601	71730	8103	6049	1200	657	1964	328	804
2000	2329	14929	32425	42394	3257	2453	796	431	922	708
2001	857	25045	20925	19260	16211	1383	808	266	163	701

Year	1	2	3	4	5	6	7	8	9	10
2002	1046	10958	32570	12185	8145	6393	667	592	88	362
2003	1047	32295	17479	16072	5814	3902	2427	400	128	451
2004	516	14960	48003	9531	7462	2167	902	962	389	389
2005	1131	7254	22633	28875	4168	3861	1491	602	768	392
2006	7008	9966	10397	9606	10943	1617	1577	724	373	553
2007	315	39643	10820	6407	5706	5479	819	725	498	541
2008	1959	6325	37427	5996	2928	2393	2613	448	491	459
2009	1630	10417	10771	26548	3278	1652	1591	1532	312	864
2010	371	11659	13354	8530	13623	1817	907	809	1196	690
2011	44	11992	19788	8379	5070	6436	983	431	283	765
2012	1	6439	28605	11069	4285	2146	4072	587	286	1028
2013	0	2741	28189	21500	5643	2042	1532	2246	242	471
2014	371	8111	6916	22942	11440	2591	1808	620	840	459
2015	201	10512	16589	4738	14756	6157	1470	562	393	545
2016	119	6151	24249	11489	4475	8994	4495	774	278	854
2017	416	4928	17641	16818	5909	2118	3745	2005	443	498
2018	331	11141	9184	11994	10095	3918	1096	1942	804	436
2019	488	6238	15757	6237	5383	4784	1485	696	1623	473

Table 17.2.3. 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
2003	1156	7152	5059	1212	381	0	0	0	0	0
2004	293	12832	7449	1719	518	12	0	0	0	0
2005	2256	5622	4796	1258	375	63	22	0	0	0
2006	2390	5727	2705	654	197	28	18	7	0	0
2007	818	4923	3010	619	226	57	4	0	0	0
2008	1230	2704	1764	371	106	0	8	0	0	0
2009	2695	6480	3652	999	266	5	9	0	0	0
2010	5687	12164	6670	1544	493	31	10	2	2	0

Year	1	2	3	4	5	6	7	8	9	10
2011	3457	10298	5482	1273	354	33	0	0	0	0
2012	1132	19556	9444	984	230	232	36	4	7	1
2013	4653	5733	12558	3649	340	125	19	3	0	0
2014	7162	5836	2371	3488	1366	238	198	6	0	0
2015	9454	9166	3913	1991	1528	415	15	50	8	1
2016	5145	5338	5048	1393	291	536	226	4	1	1
2017	6083	4171	3633	2712	469	89	342	138	0	0
2018	2928	7760	1704	1448	1186	98	15	125	36	0
2019	12596	8610	5486	1640	788.6	793.9	233.1	18.53	79.48	0.812

Table 17.3.1. 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	0.155	0.1540	0.1770	0.2040	0.2480	0.2790	0.290	0.3350	0.4360	0.4081
1958	0.155	0.1450	0.1780	0.2200	0.2540	0.2730	0.314	0.3230	0.3880	0.4134
1959	0.155	0.1620	0.1880	0.2280	0.2610	0.3010	0.328	0.3210	0.3730	0.4262
1960	0.155	0.1530	0.1850	0.2350	0.2540	0.2770	0.301	0.3090	0.3810	0.4177
1961	0.155	0.1460	0.1740	0.2110	0.2550	0.2880	0.319	0.3040	0.3460	0.4193
1962	0.155	0.1550	0.1650	0.2080	0.2410	0.2950	0.320	0.3210	0.3340	0.4119
1963	0.155	0.1630	0.1710	0.2190	0.2580	0.3090	0.323	0.3870	0.3760	0.4846
1964	0.153	0.1750	0.2130	0.2520	0.2740	0.3090	0.327	0.3460	0.3880	0.4805
1965	0.155	0.1690	0.2090	0.2460	0.2860	0.2820	0.345	0.3780	0.4040	0.4797
1966	0.155	0.1770	0.1900	0.1800	0.3010	0.3320	0.429	0.3990	0.4490	0.5015
1967	0.155	0.1920	0.2010	0.2520	0.2770	0.3890	0.419	0.3390	0.4240	0.4912
1968	0.157	0.1890	0.2070	0.2670	0.3270	0.3420	0.354	0.4550	0.4650	0.5075
1969	0.152	0.1910	0.1960	0.2550	0.3110	0.3730	0.553	0.3980	0.4680	0.5227
1970	0.154	0.2120	0.2180	0.2850	0.3500	0.4040	0.441	0.4630	0.4430	0.5326
1971	0.145	0.1930	0.2370	0.3220	0.3580	0.4250	0.420	0.4900	0.5340	0.5471
1972	0.169	0.2040	0.2520	0.3340	0.4340	0.4250	0.532	0.4850	0.5580	0.6291
1973	0.146	0.2080	0.2380	0.3460	0.4040	0.4480	0.552	0.5670	0.5090	0.5858
1974	0.164	0.1920	0.2330	0.3380	0.4180	0.4480	0.520	0.5590	0.6090	0.6533

Year	1	2	3	4	5	6	7	8	9	10
1975	0.129	0.1820	0.2250	0.3200	0.4060	0.4560	0.529	0.5950	0.6290	0.6693
1976	0.143	0.1900	0.2220	0.3060	0.3890	0.4410	0.512	0.5620	0.6670	0.6647
1977	0.147	0.1880	0.2360	0.3070	0.3690	0.4240	0.430	0.5200	0.5620	0.6194
1978	0.152	0.1960	0.2310	0.3140	0.3700	0.4260	0.466	0.4170	0.5720	0.6664
1979	0.137	0.2080	0.2460	0.3230	0.3910	0.4480	0.534	0.5440	0.6090	0.7630
1980	0.141	0.1990	0.2440	0.3310	0.3710	0.4180	0.499	0.5500	0.5980	0.6841
1981	0.143	0.1870	0.2260	0.3240	0.3780	0.4240	0.442	0.5160	0.5420	0.6302
1982	0.141	0.1880	0.2160	0.3070	0.3710	0.4090	0.437	0.4910	0.5800	0.6557
1983	0.134	0.1820	0.2170	0.3010	0.3890	0.4160	0.467	0.4890	0.5050	0.6423
1984	0.153	0.1710	0.2210	0.2860	0.3610	0.3860	0.465	0.5550	0.5750	0.6338
1985	0.122	0.1870	0.2160	0.2880	0.3570	0.4270	0.447	0.5440	0.6120	0.6448
1986	0.135	0.1790	0.2130	0.2990	0.3570	0.4070	0.485	0.5430	0.5680	0.6095
1987	0.139	0.1850	0.2050	0.2770	0.3560	0.3780	0.428	0.4810	0.3930	0.6570
1988	0.127	0.1750	0.2170	0.2700	0.3540	0.4280	0.484	0.5210	0.5590	0.7124
1989	0.118	0.1730	0.2160	0.2880	0.3360	0.3750	0.456	0.4920	0.4700	0.6111
1990	0.124	0.1830	0.2270	0.2920	0.3710	0.4130	0.415	0.5140	0.4760	0.6197
1991	0.127	0.1860	0.2100	0.2630	0.3150	0.4360	0.443	0.4670	0.5070	0.5581
1992	0.146	0.1780	0.2130	0.2580	0.2980	0.3800	0.409	0.4600	0.4870	0.5557
1993	0.097	0.1670	0.1960	0.2390	0.2640	0.3000	0.338	0.4410	0.4960	0.6031
1994	0.143	0.1800	0.2020	0.2280	0.2570	0.3000	0.317	0.4320	0.4090	0.5101
1995	0.151	0.1860	0.1960	0.2470	0.2650	0.3190	0.344	0.3560	0.4440	0.5916
1996	0.163	0.1770	0.2020	0.2340	0.2740	0.2850	0.318	0.3700	0.3900	0.5943
1997	0.151	0.1800	0.2060	0.2360	0.2670	0.2960	0.323	0.3060	0.3840	0.4396
1998	0.128	0.1820	0.1890	0.2520	0.2620	0.2890	0.336	0.2920	0.3350	0.5037
1999	0.163	0.1790	0.2120	0.2290	0.2870	0.3240	0.354	0.3720	0.3720	0.4527
2000	0.145	0.1700	0.2000	0.2480	0.2900	0.2990	0.323	0.3680	0.4020	0.4276
2001	0.143	0.1850	0.2020	0.2700	0.2750	0.3330	0.391	0.4140	0.4330	0.4934
2002	0.140	0.1830	0.2110	0.2430	0.2810	0.3120	0.366	0.3190	0.5710	0.5364
2003	0.136	0.1820	0.2140	0.2560	0.2730	0.3170	0.340	0.3440	0.5030	0.4305

Year	1	2	3	4	5	6	7	8	9	10
2004	0.127	0.1800	0.2090	0.2520	0.2630	0.2840	0.378	0.3670	0.3270	0.4246
2005	0.172	0.1850	0.2070	0.2430	0.2410	0.2820	0.265	0.3770	0.3180	0.4006
2006	0.156	0.1900	0.2200	0.2630	0.2910	0.3220	0.293	0.3580	0.3970	0.3962
2007	0.154	0.1800	0.2050	0.2370	0.2530	0.2730	0.295	0.2990	0.2810	0.3264
2008	0.150	0.1810	0.2230	0.2400	0.2650	0.3240	0.314	0.2970	0.3070	0.4175
2009	0.138	0.1850	0.2020	0.2560	0.2750	0.2780	0.325	0.3340	0.3030	0.3979
2010	0.163	0.1810	0.2200	0.2360	0.2730	0.3080	0.283	0.3110	0.3610	0.3807
2011	0.152	0.1620	0.1940	0.2330	0.2420	0.2740	0.272	0.2930	0.3350	0.3470
2012	0.095	0.1690	0.1850	0.2330	0.2560	0.2340	0.270	0.2600	0.2830	0.2690
2013	0.125	0.1690	0.1850	0.2240	0.2530	0.2660	0.297	0.2780	0.3090	0.4660
2014	0.155	0.1910	0.2120	0.2280	0.2630	0.2730	0.249	0.2790	0.3190	0.3510
2015	0.145	0.1690	0.2050	0.2400	0.2630	0.2740	0.304	0.2930	0.3300	0.3193
2016	0.143	0.1750	0.2000	0.2360	0.2650	0.2750	0.273	0.2940	0.3250	0.3039
2017	0.109	0.1680	0.1900	0.2260	0.2760	0.2740	0.313	0.3090	0.2800	0.3500
2018	0.123	0.1650	0.1980	0.2330	0.2560	0.2630	0.242	0.2580	0.2680	0.2757
2019	0.143	0.1618	0.1838	0.2198	0.2303	0.2228	0.245	0.2274	0.2067	0.3142

Table 17.3.2. 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	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1958	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1959	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1960	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1961	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1962	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1963	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1964	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1965	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1966	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1967	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370

Year	1	2	3	4	5	6	7	8	9	10
1968	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1969	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1970	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1971	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1972	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1973	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1974	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1975	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1976	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1977	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1978	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1979	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1980	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1981	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1982	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1983	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1984	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1985	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1986	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1987	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1988	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1989	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1990	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1991	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1992	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1993	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1994	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1995	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1996	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370

Year	1	2	3	4	5	6	7	8	9	10
1997	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1998	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
1999	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
2000	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
2001	0.05900	0.08200	0.09600	0.10400	0.11200	0.106	0.1200	0.13100	0.1370	0.1370
2002	0.04600	0.06800	0.08400	0.09100	0.09600	0.110	0.1240	0.13700	0.1370	0.1370
2003	0.05400	0.08700	0.10000	0.10700	0.11400	0.110	0.1240	0.13700	0.1370	0.1370
2004	0.06500	0.08900	0.10300	0.11100	0.11800	0.095	0.1240	0.13700	0.1370	0.1370
2005	0.06800	0.08900	0.10400	0.10900	0.11400	0.103	0.1070	0.13700	0.1370	0.1370
2006	0.06600	0.08200	0.09900	0.10900	0.10800	0.115	0.1130	0.12100	0.1370	0.1370
2007	0.06600	0.08700	0.09800	0.10200	0.10700	0.104	0.1210	0.13600	0.1360	0.1360
2008	0.06400	0.08600	0.10100	0.11200	0.12400	0.110	0.1110	0.13700	0.1370	0.1370
2009	0.06600	0.08900	0.10100	0.10600	0.11400	0.126	0.1040	0.13700	0.1370	0.1370
2010	0.06600	0.08300	0.09600	0.10500	0.10900	0.111	0.1130	0.12100	0.1210	0.1210
2011	0.05300	0.08100	0.09300	0.10400	0.11300	0.104	0.1100	0.12200	0.1260	0.1260
2012	0.05900	0.07500	0.09000	0.09600	0.11100	0.080	0.1150	0.12200	0.1210	0.1210
2013	0.04100	0.07500	0.08600	0.10000	0.11700	0.090	0.1120	0.11700	0.1210	0.1210
2014	0.05100	0.07900	0.08900	0.09700	0.10600	0.100	0.1170	0.09900	0.1470	0.1470
2015	0.03200	0.07600	0.09500	0.08700	0.10500	0.117	0.1320	0.12400	0.1590	0.1590
2016	0.02400	0.07300	0.08700	0.09500	0.11400	0.108	0.1240	0.22100	0.2140	0.2140
2017	0.04700	0.07300	0.08600	0.08600	0.09700	0.124	0.1110	0.11300	0.2870	0.2870
2018	0.03500	0.06900	0.08600	0.09100	0.09700	0.103	0.1020	0.10500	0.0127	0.0127
2019	0.04269	0.07026	0.08313	0.09408	0.09603	0.106	0.1053	0.09781	0.1177	0.1297

Table 17.3.3. 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	0.02500	0.07000	0.1470	0.1870	0.208	0.2530	0.2620	0.3550	0.3900	0.3652
1958	0.02500	0.07000	0.1640	0.2050	0.226	0.2280	0.2970	0.3180	0.3930	0.4215
1959	0.02500	0.07000	0.1590	0.1980	0.239	0.2710	0.2920	0.2760	0.3030	0.4258
1960	0.02500	0.07000	0.1630	0.2070	0.234	0.2400	0.2680	0.2420	0.3600	0.4313
1961	0.02500	0.07000	0.1480	0.2060	0.235	0.2320	0.2590	0.2740	0.2810	0.3964
1962	0.02500	0.07000	0.1480	0.1920	0.240	0.3010	0.2930	0.2820	0.2730	0.4414
1963	0.02500	0.07000	0.1480	0.1930	0.243	0.2750	0.3110	0.3630	0.3290	0.4654
1964	0.02500	0.07000	0.1590	0.2140	0.240	0.2910	0.3050	0.3060	0.3650	0.4739
1965	0.02500	0.14000	0.1980	0.2230	0.251	0.2970	0.3370	0.3580	0.5260	0.4604
1966	0.02500	0.07000	0.1600	0.1490	0.389	0.3100	0.4060	0.3770	0.3850	0.5045
1967	0.02500	0.17700	0.1640	0.2350	0.242	0.3990	0.3620	0.2830	0.3810	0.4591
1968	0.02500	0.12200	0.1710	0.2480	0.312	0.2800	0.6290	0.4160	0.4100	0.4856
1969	0.02500	0.13700	0.1740	0.2520	0.324	0.3640	0.5790	0.4150	0.4690	0.5211
1970	0.02500	0.13700	0.2010	0.2750	0.341	0.3670	0.4230	0.4580	0.3900	0.5544
1971	0.03400	0.14800	0.2130	0.3130	0.361	0.4100	0.4320	0.4740	0.4830	0.5325
1972	0.03800	0.15500	0.2180	0.3130	0.419	0.4430	0.4430	0.4430	0.5080	0.6018
1973	0.03900	0.14900	0.2260	0.3220	0.371	0.4330	0.4520	0.4720	0.4460	0.5355
1974	0.03500	0.14600	0.2180	0.3290	0.408	0.4290	0.4990	0.5650	0.5420	0.6180
1975	0.03500	0.14800	0.2060	0.3110	0.403	0.4460	0.5080	0.5820	0.5800	0.6501
1976	0.03500	0.14200	0.2010	0.3010	0.379	0.4580	0.5080	0.5170	0.6440	0.6648
1977	0.03500	0.14700	0.2020	0.2910	0.365	0.4090	0.4780	0.4870	0.5310	0.6443
1978	0.03500	0.13900	0.2110	0.2900	0.365	0.4290	0.4270	0.3850	0.5420	0.6444
1979	0.04500	0.14800	0.2110	0.3000	0.352	0.4290	0.5210	0.5620	0.5670	0.7434
1980	0.03900	0.15700	0.2000	0.3040	0.345	0.3940	0.4890	0.5370	0.5790	0.6451
1981	0.05000	0.13700	0.2000	0.3050	0.364	0.4020	0.4540	0.5220	0.5610	0.6223
1982	0.05000	0.13000	0.1930	0.2700	0.359	0.4110	0.4290	0.4760	0.5830	0.6422
1983	0.05000	0.14000	0.2000	0.2850	0.329	0.4350	0.4640	0.4830	0.5100	0.6362
1984	0.05000	0.13300	0.2030	0.2680	0.348	0.3860	0.4880	0.5910	0.5670	0.6635
1985	0.05000	0.12700	0.1850	0.2670	0.324	0.3810	0.3800	0.6260	0.5540	0.6423

Year	1	2	3	4	5	6	7	8	9	10
1986	0.05000	0.13300	0.1910	0.2780	0.345	0.4230	0.4950	0.4870	0.5870	0.6863
1987	0.05000	0.15400	0.1910	0.2620	0.357	0.3810	0.4060	0.4540	0.3320	0.6197
1988	0.05000	0.13300	0.1930	0.2600	0.335	0.4090	0.4170	0.4740	0.4860	0.6543
1989	0.05000	0.13300	0.1950	0.2900	0.350	0.3400	0.4110	0.4750	0.4190	0.5944
1990	0.05000	0.14800	0.2030	0.2940	0.357	0.4470	0.3990	0.4940	0.4810	0.6528
1991	0.05000	0.13900	0.1840	0.2540	0.301	0.4130	0.4470	0.5220	0.5480	0.5734
1992	0.05000	0.15600	0.1940	0.2570	0.307	0.3980	0.4060	0.4720	0.5000	0.5401
1993	0.05000	0.12800	0.1840	0.2290	0.265	0.2930	0.3440	0.4820	0.4370	0.5833
1994	0.05000	0.14300	0.1740	0.2090	0.257	0.3260	0.3490	0.4020	0.4940	0.4589
1995	0.05000	0.15100	0.1790	0.2400	0.253	0.3210	0.3650	0.3570	0.5450	0.5453
1996	0.05000	0.14700	0.1780	0.2080	0.274	0.2680	0.3210	0.3750	0.4020	0.5464
1997	0.05000	0.15000	0.1900	0.2250	0.252	0.3030	0.3190	0.3250	0.3600	0.4240
1998	0.05000	0.14000	0.1730	0.2340	0.267	0.2810	0.3280	0.2730	0.3360	0.4546
1999	0.05000	0.13100	0.1870	0.2160	0.259	0.2960	0.3400	0.3220	0.3690	0.4639
2000	0.05000	0.13900	0.1850	0.2260	0.264	0.2750	0.2870	0.3370	0.3910	0.3763
2001	0.05000	0.14400	0.1850	0.2230	0.263	0.3190	0.3270	0.4210	0.4100	0.5302
2002	0.05000	0.14500	0.1970	0.2450	0.267	0.2670	0.2990	0.3080	0.4350	0.4354
2003	0.05000	0.14600	0.1940	0.2400	0.256	0.2880	0.3300	0.3120	0.5090	0.4697
2004	0.05000	0.13700	0.1950	0.2400	0.245	0.3050	0.3160	0.4480	0.3560	0.6014
2005	0.05000	0.15000	0.1890	0.2340	0.237	0.2580	0.2760	0.3960	0.3690	0.4286
2006	0.05000	0.14800	0.1970	0.2500	0.270	0.3190	0.2860	0.3410	0.4090	0.4552
2007	0.05000	0.15200	0.1790	0.2160	0.242	0.2450	0.2750	0.2520	0.2570	0.3640
2008	0.05000	0.15400	0.1980	0.2120	0.239	0.3020	0.2820	0.2310	0.2740	0.4004
2009	0.05000	0.14200	0.1850	0.2320	0.255	0.2790	0.2830	0.3330	0.3020	0.3902
2010	0.05000	0.14900	0.2000	0.2300	0.272	0.3070	0.3360	0.3360	0.3610	0.4100
2011	0.05000	0.14100	0.1790	0.2230	0.261	0.2760	0.3200	0.3600	0.4440	0.3908
2012	0.02500	0.05800	0.1440	0.2050	0.230	0.2090	0.2510	0.2350	0.3340	0.2230
2013	0.03400	0.06800	0.1170	0.1860	0.254	0.2580	0.3090	0.2410	0.3250	0.5620
2014	0.02200	0.07900	0.1360	0.1880	0.212	0.2270	0.2280	0.2900	0.3430	0.6030

Year	1	2	3	4	5	6	7	8	9	10
2015	0.07000	0.07500	0.1420	0.1480	0.227	0.2440	0.2630	0.2880	0.3700	0.3893
2016	0.01000	0.06700	0.1510	0.1860	0.232	0.2480	0.2360	0.2610	0.2210	0.2808
2017	0.02100	0.07400	0.1310	0.1740	0.231	0.2420	0.2490	0.2170	0.2330	0.3674
2018	0.02600	0.08400	0.1460	0.1800	0.205	0.2370	0.2280	0.2190	0.2600	0.4249
2019	0.02733	0.07248	0.1328	0.1525	0.191	0.1684	0.1768	0.2236	0.1942	0.2481

Table 17.4.1. Assumed values of maturity and natural mortality-at-age in the stock of sole in Subarea 27.4.

Age	Maturity	M
1	0	0.1
2	0	0.1
3	1	0.1
4	1	0.1
5	1	0.1
6	1	0.1
7	1	0.1
8	1	0.1
9	1	0.1
10	1	0.1

Table 17.5.1. 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	876.6	811.5	777.5	425.54	196.77	85.93	0.00	0.000	20.685	47.315
1986	3478.1	1732.2	646.2	406.38	276.40	103.53	60.11	0.000	27.282	71.796
1987	698.7	2173.2	491.9	178.11	162.77	119.39	97.41	88.446	5.604	6.112
1988	7146.8	835.6	766.0	227.01	86.20	81.15	70.22	41.703	15.414	26.859
1989	2160.9	6189.9	653.1	554.73	106.88	61.33	53.76	1.850	45.410	35.233
1990	2878.8	2580.1	4901.1	379.36	236.70	138.39	38.62	30.129	15.662	25.722
1991	1251.8	3401.8	1395.1	1915.29	108.93	56.21	30.49	27.813	21.047	53.450
1992	17407.1	3284.4	3673.8	721.10	1109.16	17.04	58.57	12.166	7.251	15.418
1993	5203.9	11170.8	591.2	1894.71	731.05	1322.81	50.35	72.126	21.735	100.877

Year	1	2	3	4	5	6	7	8	9	10
1994	3770.0	2731.0	6509.0	79.87	368.17	61.78	347.12	53.472	12.023	100.954
1995	7318.7	2405.7	1808.0	1931.28	200.70	270.66	84.95	153.610	24.134	48.792
1996	1592.0	2327.6	489.5	485.30	724.40	93.04	108.39	31.878	66.028	30.356
1997	16121.7	1059.3	819.8	195.93	219.84	158.89	26.89	15.499	15.083	20.569
1998	2802.9	5073.4	190.5	262.47	62.22	58.62	105.68	6.560	15.561	30.689
1999	2620.3	1604.7	2006.2	50.68	124.53	21.30	14.82	59.541	9.011	40.596
2000	2848.4	878.0	690.8	367.19	73.67	24.28	15.22	2.563	29.416	18.569
2001	2083.6	1359.1	460.0	469.71	235.72	31.48	3.96	12.488	10.659	42.073
2002	3241.4	650.4	587.0	210.09	98.42	114.47	20.39	17.341	7.267	24.749
2003	2874.7	1453.8	393.8	259.71	77.53	57.29	62.98	5.073	4.367	10.340
2004	994.4	1123.9	862.3	167.44	131.54	37.12	21.29	10.706	1.143	15.934
2005	1625.0	881.2	532.1	371.85	85.27	75.56	32.35	10.749	8.844	15.072
2006	4255.4	737.5	241.4	381.43	203.04	50.62	59.22	20.515	20.469	8.914
2007	2100.1	3026.1	386.3	116.10	154.37	142.66	28.91	26.804	13.552	14.137
2008	2922.0	1456.0	1396.2	211.94	67.32	72.34	92.80	11.398	24.667	14.866
2009	3193.4	1261.1	692.7	804.04	117.26	40.29	85.70	61.248	14.233	25.748
2010	3580.4	1514.3	481.9	266.36	250.33	79.14	20.81	19.355	18.993	26.605
2011	2967.4	2711.3	686.2	233.20	191.13	185.60	28.11	14.700	20.359	27.124
2012	1360.9	3901.5	1470.3	344.35	164.38	99.35	57.97	20.317	6.474	22.339
2013	1715.0	880.8	2045.9	593.77	191.46	50.88	53.23	46.854	10.702	39.327
2014	4037.2	2114.6	445.6	826.93	351.92	79.35	24.18	27.288	16.328	5.695
2015	3171.7	2600.5	1389.5	375.38	691.84	224.66	101.93	24.983	20.247	31.275
2016	1671.4	2065.2	1383.7	691.09	205.42	356.57	102.99	22.529	2.597	33.483
2017	6521.2	1391.7	1257.0	627.68	268.33	88.82	121.43	58.816	2.376	17.269
2018	3516.6	2174.6	613.0	599.41	197.99	133.93	45.50	69.661	7.142	5.288
2019	15323.3	1908.6	1259.1	337.57	237.44	82.08	67.59	16.236	22.790	9.221

Table 17.5.2. Index of abundance, based on the SNS survey, used in the assessment of sole in Subarea 27.4.

Year	0	1	2	3	4	5	6
1970	623.1	5410.3	734.4	237.7	35.4	4.0	0.0
1971	10685.1	902.7	1831.1	113.4	2.9	28.9	0.0
1972	16.0	1454.7	272.3	148.6	0.0	28.3	0.0
1973	895.7	5587.2	935.3	83.8	37.3	13.0	0.0
1974	174.4	2347.9	361.4	65.2	0.0	0.0	4.4
1975	577.5	525.4	864.5	177.0	17.5	0.0	17.1
1976	464.6	1399.4	73.6	229.1	26.7	5.7	0.0
1977	1585.0	3742.9	776.1	103.8	43.1	31.7	3.9
1978	10370.5	1547.7	1354.7	294.1	28.0	99.4	13.3
1979	3922.7	93.8	408.3	300.8	76.9	0.0	16.7
1980	5145.8	4312.9	88.9	109.3	61.3	3.3	0.0
1981	3240.7	3737.2	1413.1	50.0	20.0	0.0	0.0
1982	2147.0	5856.5	1146.2	227.8	6.7	10.0	0.0
1983	769.1	2621.1	1123.3	120.6	39.9	0.0	19.7
1984	3334.0	2493.1	1099.9	318.3	74.4	8.0	0.0
1985	2713.4	3619.4	715.6	167.1	49.3	4.4	0.0
1986	742.0	3705.1	457.6	69.2	31.4	16.7	0.0
1987	13610.1	1947.9	943.7	64.8	21.3	0.0	0.0
1988	522.7	11226.7	593.8	281.6	81.5	10.2	15.5
1989	1743.4	2830.7	5005.0	207.6	53.1	18.2	18.6
1990	50.8	2856.2	1119.5	914.3	100.4	49.6	12.5
1991	3639.7	1253.6	2529.1	513.8	623.9	27.2	35.8
1992	302.9	11114.0	144.4	360.4	194.9	284.8	20.0
1993	231.3	1290.8	3419.6	153.8	212.8	0.0	191.7
1994	4692.7	651.8	498.3	934.1	10.2	59.3	0.0
1995	1374.9	1362.1	223.7	142.8	411.1	7.1	31.1
1996	2322.3	218.4	349.1	29.6	35.5	90.0	10.0
1997	803.0	10279.3	153.6	189.8	26.5	58.1	230.0
1998	327.9	4094.6	3126.4	141.7	98.7	0.0	10.0

Year	0	1	2	3	4	5	6
1999	2187.9	1648.9	971.8	455.6	10.0	20.7	0.0
2000	70.0	1639.2	125.9	166.3	118.0	0.0	2.0
2001	8340.0	970.3	655.4	106.7	35.5	56.2	0.0
2002	1127.7	7547.5	379.0	195.3	0.0	30.8	19.2
2003	NA	NA	NA	NA	NA	NA	NA
2004	162.0	1369.5	624.4	393.0	68.9	53.1	7.5
2005	305.0	568.1	162.9	124.0	0.0	21.3	6.7
2006	16.0	2726.4	117.1	25.0	30.0	0.0	0.0
2007	466.9	848.6	911.0	33.3	39.5	14.4	0.0
2008	754.7	1259.1	258.5	325.3	0.0	10.0	0.0
2009	2291.0	1931.6	344.4	61.7	102.7	0.0	0.0
2010	333.9	2636.9	237.1	67.1	42.2	23.2	0.0
2011	136.3	1248.0	883.9	211.3	111.8	0.0	38.0
2012	144.7	226.6	159.5	54.0	18.0	0.0	0.0
2013	237.3	967.4	426.6	490.5	179.3	50.8	7.6
2014	126.0	2849.0	448.2	44.8	60.0	33.6	0.0
2015	109.7	3192.0	2333.9	137.8	159.9	162.4	150.6
2016	373.2	733.8	623.3	494.6	109.8	16.7	42.9
2017	205.9	956.7	204.3	209.6	209.7	41.6	5.2
2018	6574.9	1002.3	482.4	163.1	94.1	82.4	5.7
2019	78.4	7896.7	476.3	375.2	60.7	6.7	50.9

Table 17.6.1 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	137911	75380	86824	62785	17357	18093	35136	17339	3038	45102
1958	121838	124786	65842	64508	41740	11626	12923	24773	13876	35537
1959	443013	110243	109380	47514	45231	28308	8150	9296	18666	37704
1960	40092	400848	96634	76440	33825	30331	19396	5873	6459	43266
1961	67021	36276	349031	65341	52011	21361	20164	13529	3726	36618
1962	10554	60640	31186	230330	40494	30053	13710	13208	8094	27277

Year	1	2	3	4	5	6	7	8	9	10
1963	12372	9548	51590	20563	134757	22771	18695	8458	8162	22519
1964	583561	11192	8097	34563	12476	80256	13950	11380	5739	20135
1965	146876	527948	9432	5432	22468	7782	49826	8949	8299	18356
1966	59219	132895	435471	6099	3699	13804	5021	34884	6707	20276
1967	96575	53583	104434	259404	4117	2141	9195	3714	25904	21188
1968	131700	87376	38297	54440	157488	2206	1429	6793	2629	36439
1969	85878	118729	54824	17159	27308	80486	1448	1017	4523	28785
1970	197968	75052	69884	22824	7775	14501	52326	1000	675	23436
1971	58013	172233	45852	29622	11024	4474	9435	36002	696	16661
1972	118261	51563	109067	19490	15207	6514	2898	6533	25511	11846
1973	153656	106059	32415	43596	9773	8483	4135	2006	4442	24901
1974	120919	138043	67240	12491	20639	5049	5207	2810	1293	19229
1975	61016	108217	93397	27916	5757	10596	2977	3386	1812	13563
1976	145354	54166	77447	42839	13168	3080	6107	1858	2216	10327
1977	182236	129066	38676	36569	21555	7248	1813	3854	1168	8418
1978	62372	163160	88111	17671	19462	11879	4454	1189	2215	6323
1979	17166	56127	109176	39032	9295	10576	7441	2922	657	5545
1980	187117	15472	38813	48428	18806	4953	6490	4612	1717	4009
1981	239299	168528	10919	17186	21718	9851	2902	3798	2894	3687
1982	215666	214486	115156	4662	7983	11276	5454	1707	2417	4190
1983	200709	191353	138283	46020	2284	4117	5904	3260	1066	4176
1984	90233	177535	120310	51098	21958	1164	2067	3382	1983	3340
1985	106378	80484	113984	42381	22537	10996	573	1092	2011	3376
1986	166588	95627	53657	41755	18289	11113	5480	296	642	3192
1987	79837	150294	66314	21824	19177	8980	5738	3033	176	2013
1988	589903	72110	108650	29327	10620	9597	4857	3440	1890	1152
1989	114202	532820	54213	49854	14392	5525	5426	3049	2283	1909
1990	220001	103093	410703	26280	24261	7656	3215	3417	2063	2931
1991	92487	198430	79828	222461	12920	12616	4469	1927	2160	3387

Year	1	2	3	4	5	6	7	8	9	10
1992	511966	83342	151273	47360	111946	6383	7152	2462	1090	3329
1993	123568	461000	61149	90398	24210	53084	3366	3671	1402	2477
1994	86784	111098	320049	33720	45424	11246	25322	1672	2290	2270
1995	123913	77474	74006	153491	15504	20584	5040	12327	1042	2734
1996	78075	107754	51550	30465	59578	6736	9345	2400	6495	2139
1997	307085	67070	72913	19145	10604	24818	3118	4437	1016	4465
1998	146503	273882	45757	27226	7383	4321	11151	1526	1928	2691
1999	117612	132011	184335	18391	11979	2999	1886	5626	761	2290
2000	141741	105445	84778	79959	7985	4903	1371	946	2902	1603
2001	78486	119410	64569	38801	31258	3323	2418	673	462	2558
2002	207098	60838	75641	30357	15389	13393	1654	1216	324	1842
2003	101725	178799	42063	35658	14166	6856	6252	891	628	1375
2004	53242	90774	127195	19616	18411	6569	3128	3551	494	1241
2005	52919	47382	60240	58868	9774	8848	3302	1789	2033	956
2006	168662	46337	29264	28763	27113	4853	4938	1885	1051	1457
2007	68487	147643	31382	15268	13394	13887	2792	2895	1165	1286
2008	78240	60651	111290	17757	7681	7035	7801	1682	1867	1439
2009	100181	69284	45873	63580	9392	4089	3818	4603	1079	2070
2010	177721	87416	47580	24770	33478	4996	2185	2099	2778	1939
2011	165023	153170	55787	24472	12440	17556	2704	1135	1162	2753
2012	48820	144000	106863	29452	11496	6384	9811	1414	587	2172
2013	97206	42941	108867	61129	13663	5858	3622	5162	717	1512
2014	158225	84319	32412	68185	31170	7145	3229	1798	2714	1272
2015	116715	131655	61179	21401	38444	16926	3741	1466	970	2344
2016	73331	94200	95614	39802	12302	21351	8634	1652	747	1850
2017	143480	60370	71475	58349	22082	6933	11183	4115	754	1260
2018	108700	121825	47049	42202	32637	12884	3909	6140	1883	854
2019	616179	94260	94397	29247	25872	20229	8003	2494	3342	1130

Table 17.6.2 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	1.259e-05	0.03530	0.1971	0.3083	0.3008	0.2365	0.2495	0.1228	0.2035	0.2035
1958	1.298e-05	0.03177	0.2262	0.2550	0.2883	0.2552	0.2294	0.1831	0.1705	0.1705
1959	1.552e-05	0.03175	0.2583	0.2398	0.2996	0.2780	0.2277	0.2640	0.1646	0.1646
1960	2.461e-05	0.03842	0.2913	0.2851	0.3596	0.3083	0.2602	0.3551	0.2060	0.2060
1961	5.137e-05	0.05118	0.3156	0.3785	0.4485	0.3434	0.3231	0.4137	0.2914	0.2914
1962	1.276e-04	0.06163	0.3165	0.4360	0.4757	0.3747	0.3831	0.3813	0.3515	0.3515
1963	2.438e-04	0.06485	0.3005	0.3997	0.4182	0.3900	0.3964	0.2877	0.3212	0.3212
1964	1.516e-04	0.07100	0.2992	0.3307	0.3721	0.3767	0.3439	0.2157	0.2433	0.2433
1965	2.747e-05	0.09257	0.3361	0.2844	0.3871	0.3380	0.2565	0.1884	0.1736	0.1736
1966	1.217e-05	0.14100	0.4180	0.2928	0.4469	0.3062	0.2016	0.1976	0.1418	0.1418
1967	1.008e-04	0.23587	0.5515	0.3990	0.5241	0.3041	0.2028	0.2456	0.1565	0.1565
1968	3.686e-03	0.36608	0.7028	0.5899	0.5713	0.3203	0.2393	0.3066	0.2055	0.2055
1969	3.475e-02	0.43000	0.7763	0.6917	0.5330	0.3306	0.2702	0.3095	0.2515	0.2515
1970	3.926e-02	0.39277	0.7583	0.6277	0.4525	0.3298	0.2739	0.2618	0.2696	0.2696
1971	1.787e-02	0.35689	0.7555	0.5668	0.4261	0.3341	0.2675	0.2445	0.2821	0.2821
1972	8.900e-03	0.36417	0.8170	0.5903	0.4837	0.3543	0.2681	0.2858	0.3056	0.3056
1973	7.148e-03	0.35573	0.8536	0.6478	0.5605	0.3881	0.2864	0.3393	0.3226	0.3226
1974	1.098e-02	0.29071	0.7791	0.6747	0.5667	0.4280	0.3303	0.3388	0.3141	0.3141
1975	1.909e-02	0.23455	0.6794	0.6514	0.5253	0.4509	0.3715	0.3236	0.2980	0.2980

Year	1	2	3	4	5	6	7	8	9	10
1976	1.885e-02	0.23682	0.6504	0.5869	0.4971	0.4297	0.3603	0.3637	0.2988	0.2988
1977	1.057e-02	0.28172	0.6833	0.5308	0.4959	0.3868	0.3215	0.4540	0.3161	0.3161
1978	5.501e-03	0.30177	0.7142	0.5425	0.5099	0.3677	0.3215	0.4931	0.3317	0.3317
1979	3.904e-03	0.26885	0.7129	0.6302	0.5295	0.3882	0.3783	0.4313	0.3364	0.3364
1980	4.631e-03	0.24854	0.7147	0.7019	0.5466	0.4345	0.4357	0.3659	0.3404	0.3404
1981	9.471e-03	0.28082	0.7511	0.6668	0.5555	0.4912	0.4303	0.3518	0.3515	0.3515
1982	1.961e-02	0.33894	0.8172	0.6134	0.5621	0.5470	0.4145	0.3704	0.3588	0.3588
1983	2.269e-02	0.36405	0.8956	0.6400	0.5745	0.5890	0.4571	0.3973	0.3509	0.3509
1984	1.434e-02	0.34311	0.9434	0.7186	0.5916	0.6072	0.5379	0.4197	0.3553	0.3553
1985	6.551e-03	0.30545	0.9042	0.7404	0.6071	0.5963	0.5595	0.4310	0.4232	0.4232
1986	2.933e-03	0.26605	0.7996	0.6781	0.6113	0.5609	0.4916	0.4197	0.5444	0.5444
1987	1.787e-03	0.22446	0.7159	0.6203	0.5922	0.5145	0.4115	0.3730	0.5416	0.5416
1988	1.774e-03	0.18527	0.6790	0.6119	0.5535	0.4702	0.3654	0.3100	0.3659	0.3659
1989	2.336e-03	0.16031	0.6241	0.6202	0.5311	0.4414	0.3623	0.2906	0.2580	0.2580
1990	3.193e-03	0.15576	0.5131	0.6100	0.5539	0.4382	0.4117	0.3588	0.2883	0.2883
1991	4.114e-03	0.17135	0.4221	0.5867	0.6051	0.4676	0.4961	0.4692	0.4105	0.4105
1992	4.862e-03	0.20964	0.4149	0.5710	0.6461	0.5399	0.5668	0.4633	0.4792	0.4792
1993	6.374e-03	0.26492	0.4952	0.5882	0.6668	0.6402	0.5997	0.3719	0.4358	0.4358
1994	1.348e-02	0.30627	0.6348	0.6770	0.6915	0.7025	0.6199	0.3726	0.4116	0.4116
1995	3.973e-02	0.30739	0.7876	0.8464	0.7336	0.6896	0.6418	0.5408	0.4680	0.4680

Year	1	2	3	4	5	6	7	8	9	10
1996	5.193e-02	0.29058	0.8905	0.9553	0.7757	0.6703	0.6447	0.7598	0.5595	0.5595
1997	1.442e-02	0.28238	0.8851	0.8529	0.7977	0.7000	0.6143	0.7336	0.6114	0.6114
1998	4.164e-03	0.29594	0.8115	0.7211	0.8008	0.7291	0.5841	0.5953	0.6014	0.6014
1999	9.206e-03	0.34285	0.7352	0.7342	0.7934	0.6825	0.5900	0.5619	0.5435	0.5435
2000	7.144e-02	0.39046	0.6816	0.8392	0.7767	0.6066	0.6108	0.6147	0.4661	0.4661
2001	1.547e-01	0.35656	0.6547	0.8248	0.7476	0.5975	0.5874	0.6297	0.3948	0.3948
2002	4.693e-02	0.26904	0.6520	0.6622	0.7086	0.6617	0.5180	0.5603	0.3547	0.3547
2003	1.390e-02	0.24054	0.6628	0.5611	0.6684	0.6845	0.4658	0.4889	0.3789	0.3789
2004	1.661e-02	0.31004	0.6704	0.5966	0.6327	0.5876	0.4587	0.4575	0.4959	0.4959
2005	3.282e-02	0.38190	0.6393	0.6753	0.6001	0.4832	0.4604	0.4317	0.6187	0.6187
2006	3.310e-02	0.28972	0.5506	0.6643	0.5691	0.4526	0.4338	0.3816	0.5677	0.5677
2007	2.150e-02	0.18266	0.4694	0.5870	0.5438	0.4767	0.4066	0.3385	0.4327	0.4327
2008	2.156e-02	0.17926	0.4598	0.5370	0.5304	0.5111	0.4274	0.3439	0.3684	0.3684
2009	3.630e-02	0.27580	0.5163	0.5414	0.5312	0.5265	0.4982	0.4049	0.3849	0.3849
2010	4.867e-02	0.34913	0.5649	0.5887	0.5455	0.5139	0.5547	0.4913	0.4385	0.4385
2011	3.628e-02	0.26000	0.5388	0.6556	0.5672	0.4819	0.5483	0.5589	0.4890	0.4890
2012	2.831e-02	0.17968	0.4586	0.6681	0.5741	0.4666	0.5421	0.5780	0.5018	0.5018
2013	4.223e-02	0.18130	0.3679	0.5735	0.5483	0.4955	0.6001	0.5427	0.4613	0.4613
2014	8.383e-02	0.22080	0.3151	0.4730	0.5106	0.5469	0.6894	0.5172	0.4309	0.4309
2015	1.143e-01	0.21986	0.3299	0.4537	0.4881	0.5731	0.7170	0.5739	0.4827	0.4827

Year	1	2	3	4	5	6	7	8	9	10
2016	9.449e-02	0.17607	0.3939	0.4891	0.4735	0.5466	0.6410	0.6839	0.6232	0.6232
2017	6.361e-02	0.14931	0.4269	0.4810	0.4388	0.4729	0.4996	0.6817	0.7583	0.7583
2018	4.254e-02	0.15507	0.3754	0.3893	0.3784	0.3760	0.3495	0.5083	0.7848	0.7848
2019	2.860e-02	0.18030	0.2944	0.2832	0.3137	0.2863	0.2314	0.3238	0.7427	0.7427

Table 17.6.3. 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	65708	58319	73097	0.2156	0.1748	0.2563
1958	68255	60703	75807	0.2113	0.1849	0.2377
1959	71937	64476	79398	0.2215	0.1890	0.2540
1960	74376	66758	81994	0.2565	0.2236	0.2894
1961	106790	95894	117686	0.3074	0.2672	0.3476
1962	89594	81127	98061	0.3329	0.2900	0.3758
1963	72662	65729	79595	0.3147	0.2774	0.3519
1964	54407	48353	60461	0.2899	0.2473	0.3326
1965	43843	37827	49859	0.2876	0.2491	0.3261
1966	104300	90071	118529	0.3210	0.2706	0.3714
1967	103920	93241	114599	0.4029	0.3488	0.4571
1968	92302	83689	100915	0.5101	0.4394	0.5807
1969	70390	63939	76841	0.5523	0.4730	0.6316
1970	64146	57808	70484	0.5122	0.4437	0.5807
1971	55203	49761	60645	0.4879	0.4129	0.5628
1972	63402	56255	70549	0.5219	0.4597	0.5841
1973	46796	41999	51593	0.5611	0.4835	0.6387
1974	46126	41347	50905	0.5478	0.4887	0.6070
1975	48319	42707	53931	0.5083	0.4455	0.5711
1976	47220	42630	51810	0.4802	0.4242	0.5361
1977	38075	34743	41407	0.4757	0.4182	0.5332

Year	SSB	SSB lower	SSB upper	F	F lower	F upper
1978	43552	38786	48318	0.4872	0.4209	0.5535
1979	52569	46478	58660	0.5059	0.4522	0.5597
1980	40157	36422	43892	0.5292	0.4640	0.5945
1981	26510	24535	28485	0.5491	0.4947	0.6035
1982	38237	32551	43923	0.5757	0.5035	0.6480
1983	50830	43508	58152	0.6126	0.5455	0.6797
1984	52556	45276	59836	0.6408	0.5708	0.7108
1985	48079	42254	53904	0.6307	0.5614	0.7000
1986	38292	34916	41668	0.5832	0.5281	0.6383
1987	33664	30543	36785	0.5335	0.4736	0.5933
1988	41407	36891	45923	0.5000	0.4541	0.5458
1989	37715	34213	41217	0.4754	0.4214	0.5295
1990	109060	94319	123801	0.4542	0.4118	0.4966
1991	86423	77068	95778	0.4506	0.4032	0.4980
1992	84836	77982	91690	0.4763	0.4287	0.5239
1993	58907	54235	63579	0.5311	0.4808	0.5814
1994	89759	77769	101749	0.6024	0.5350	0.6699
1995	68914	61322	76506	0.6729	0.6156	0.7302
1996	41323	37717	44929	0.7165	0.6417	0.7913
1997	33050	29593	36507	0.7036	0.6461	0.7611
1998	23418	21102	25734	0.6717	0.6033	0.7400
1999	46230	39021	53439	0.6576	0.5953	0.7199
2000	39662	34524	44800	0.6589	0.5995	0.7183
2001	32500	29436	35564	0.6362	0.5744	0.6980
2002	31836	28580	35092	0.5907	0.5458	0.6356
2003	25627	23343	27911	0.5635	0.5087	0.6183
2004	39527	34659	44395	0.5595	0.5157	0.6032
2005	32541	29106	35976	0.5560	0.4994	0.6125
2006	24973	23133	26813	0.5053	0.4620	0.5485

Year	SSB	SSB lower	SSB upper	F	F lower	F upper
2007	17824	16464	19184	0.4519	0.4089	0.4950
2008	33437	29610	37264	0.4435	0.4011	0.4860
2009	30520	27709	33331	0.4782	0.4365	0.5200
2010	29091	26741	31441	0.5124	0.4578	0.5670
2011	26402	24111	28693	0.5007	0.4607	0.5407
2012	28880	25885	31875	0.4694	0.4225	0.5163
2013	32536	29773	35299	0.4333	0.3981	0.4685
2014	28413	26104	30722	0.4133	0.3726	0.4540
2015	27390	25255	29525	0.4129	0.3690	0.4568
2016	33144	29535	36753	0.4158	0.3583	0.4733
2017	30612	26648	34576	0.3938	0.3180	0.4696
2018	27298	22578	32018	0.3348	0.2583	0.4114
2019	28244	21939	34549	0.2716	0.1820	0.3611

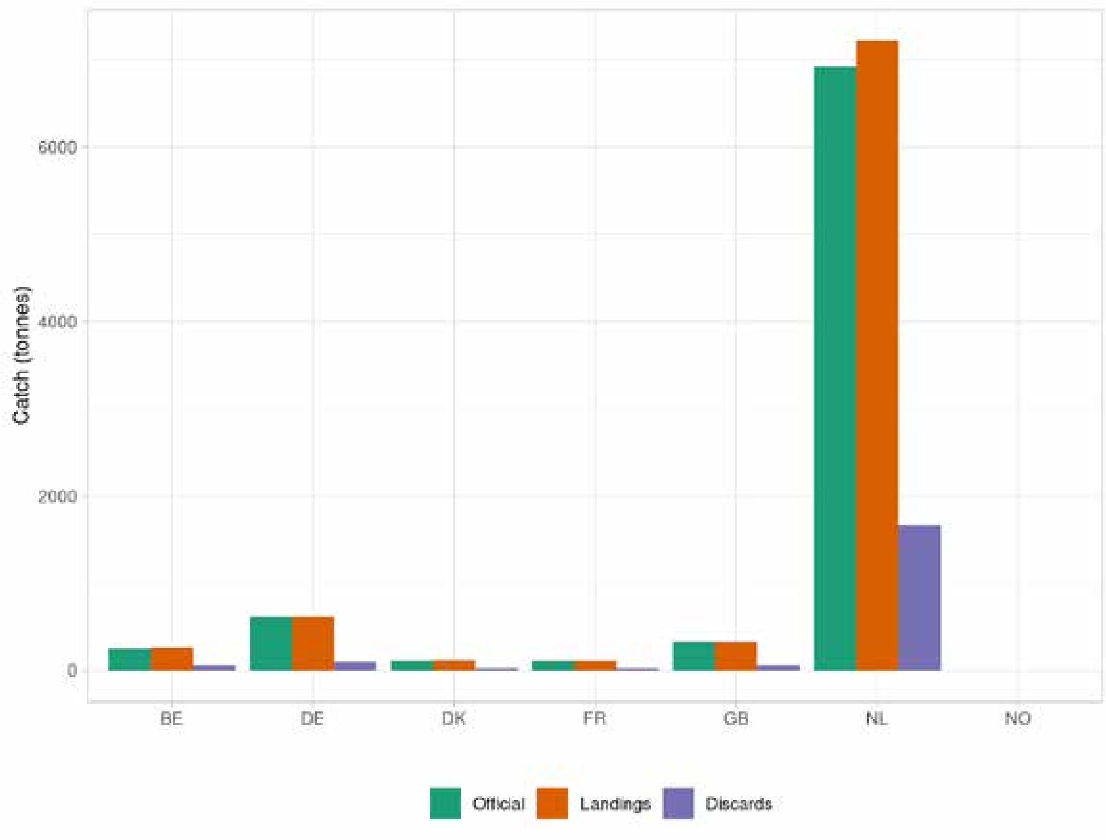


Figure 17.2.1. Sole in 27.4. Official landings, and landings and discards reported to ICES by country in 2019.

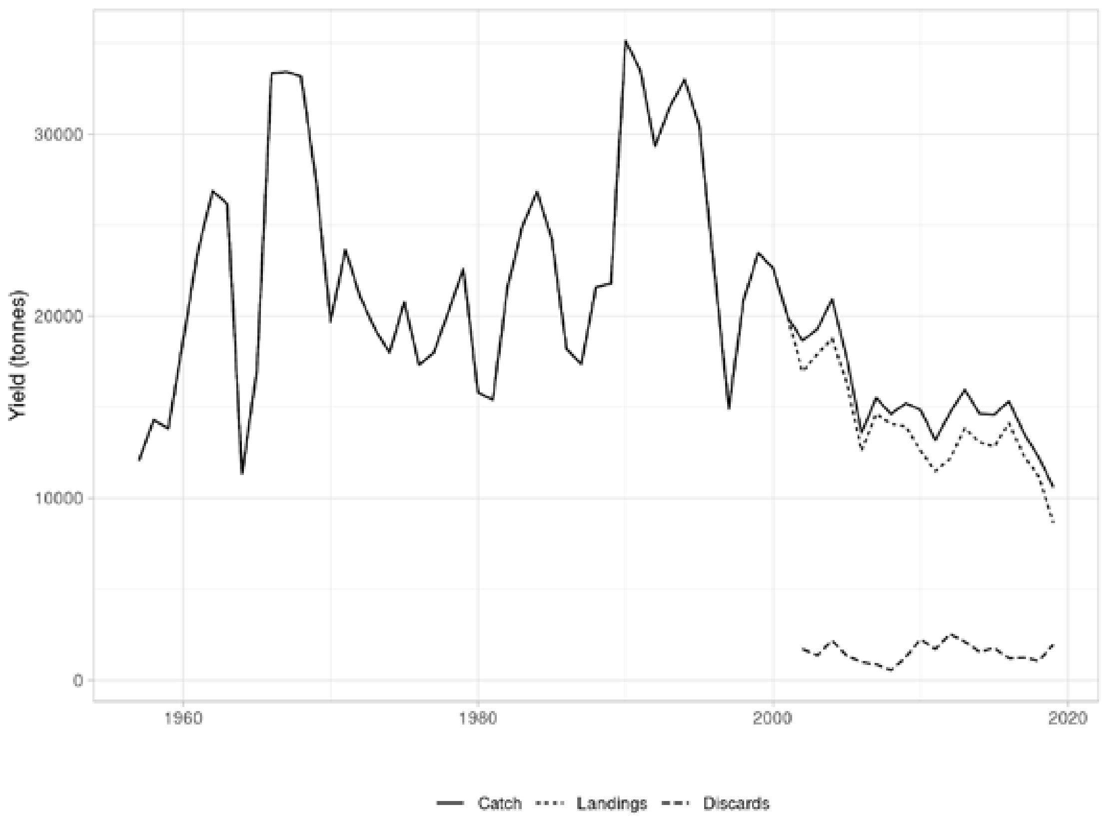


Figure 17.2.5. Sole in 27.4. Time series of catches, landings and discards (in tonnes) reported to ICES Intercatch.

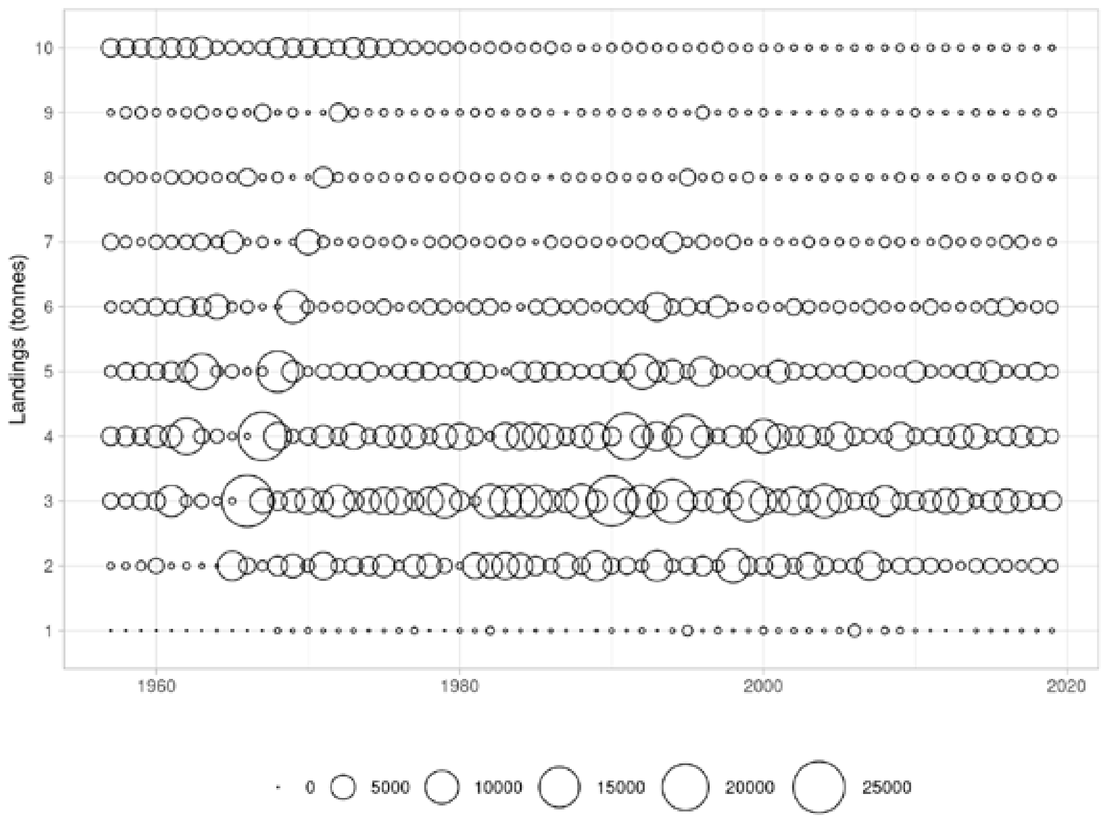


Figure 17.2.6. Sole in 27.4. Time series of landings at age (in thousands).

Figure 17.2.7. Sole in 27.4. Time series of discards at age (in thousands).

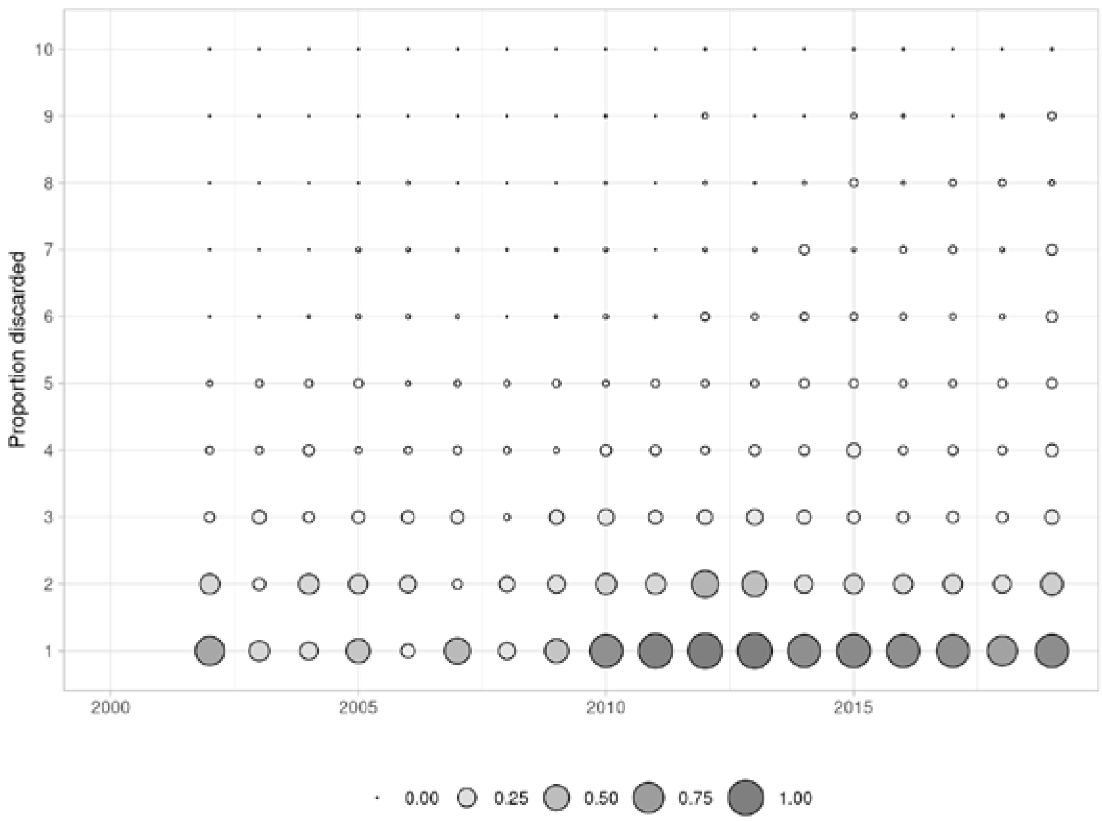


Figure 17.2.8 Sole in 27.4. Proportions of fish discarded by age over the 2002-2019 period.

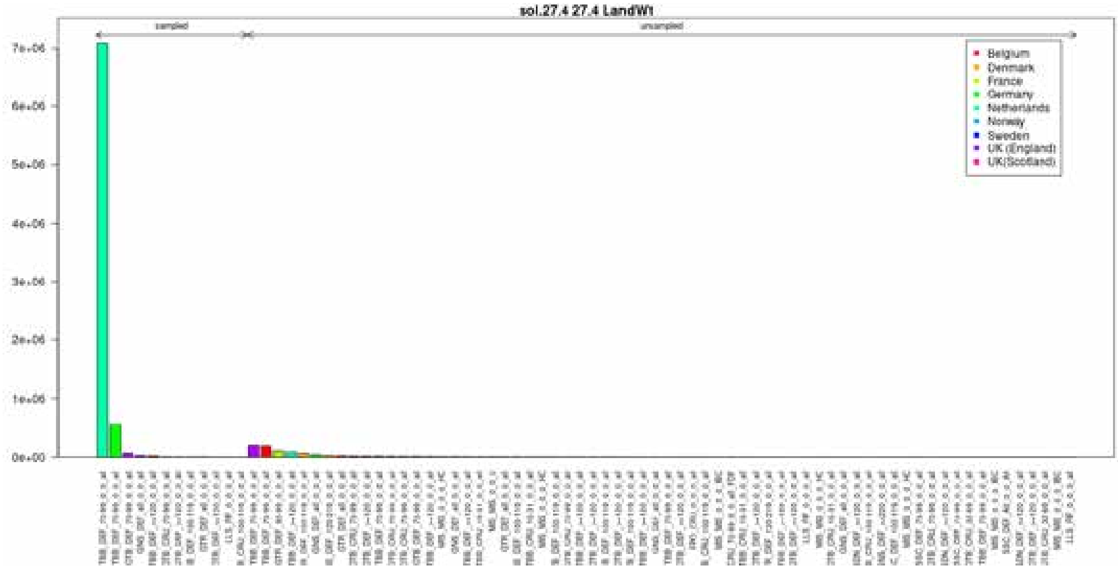


Figure 17.2.2. Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (tonnes).

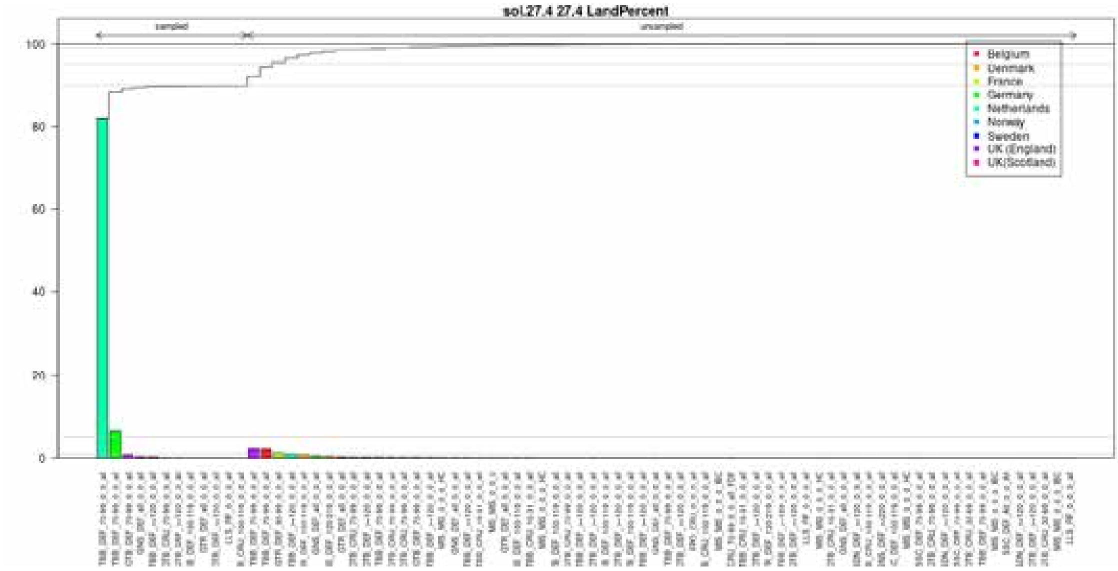


Figure 17.2.2. Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for landings yield estimation (cumulative percentage)

Figure 17.2.3. Sole in 27.4. InterCatch summary plots. Sampled and unsampled fleets for discards yield estimation

(tonnes).

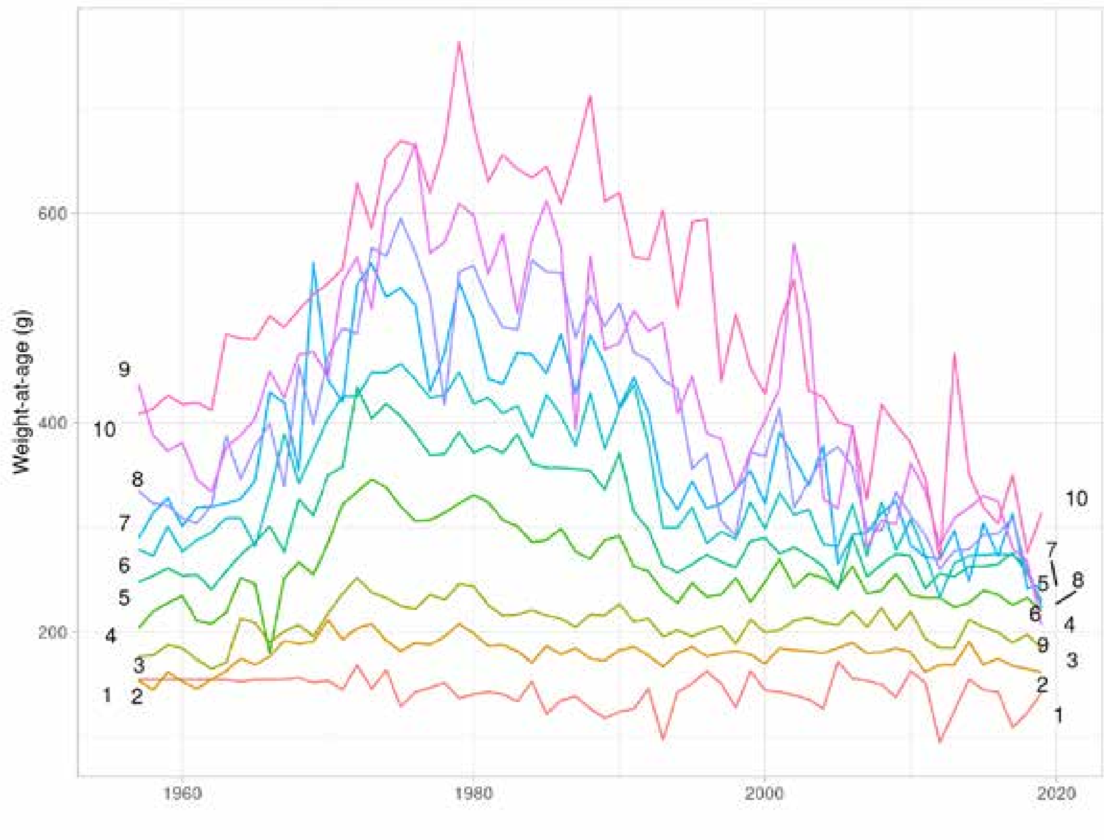


Figure 17.3.1. Sole in 27.4. Time series of mean weight-at-age in the landings (in grams).

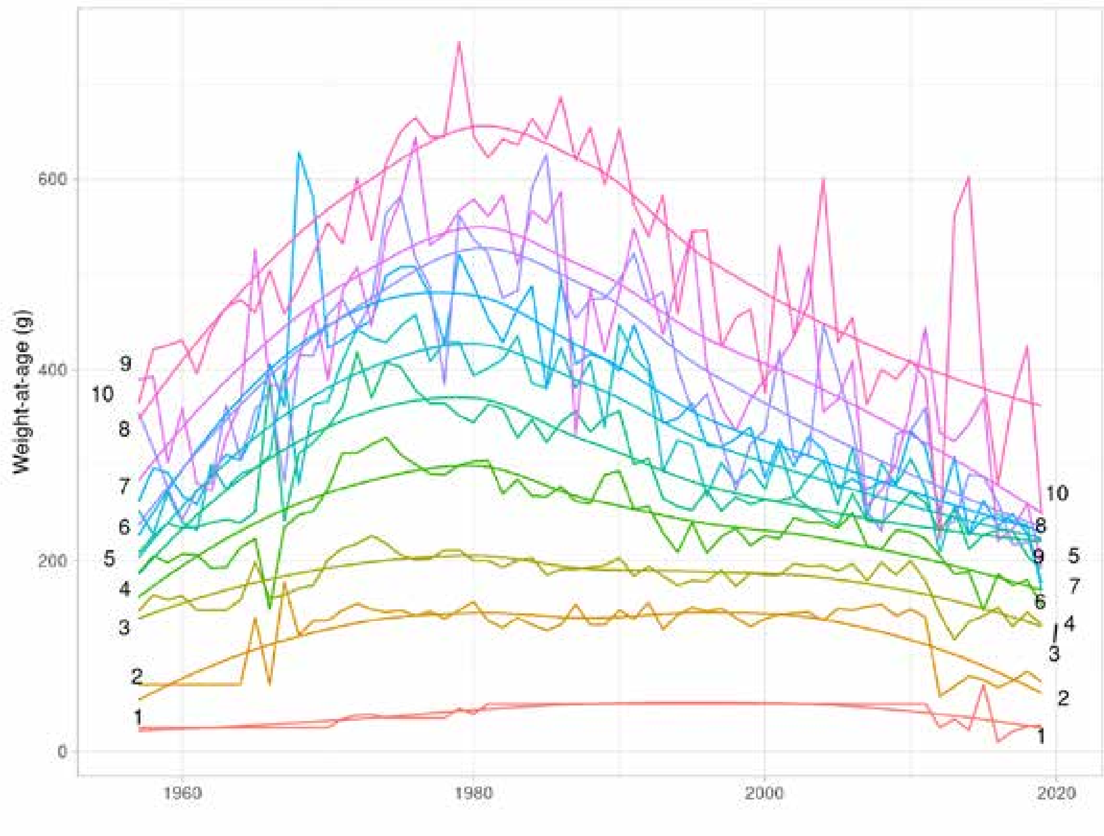


Figure 17.3.2 Sole in 27.4. Time series of mean weight-at-age in the stock (in grams).

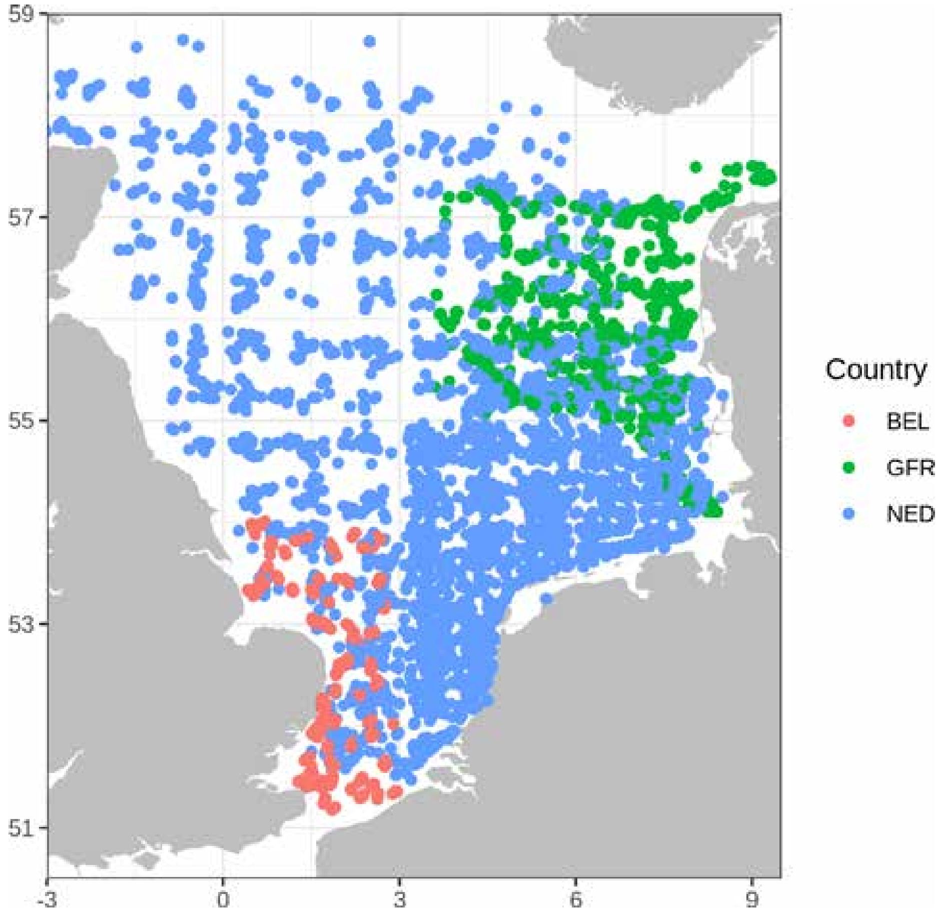


Figure 17.5.1. Sole in 27.4. Location of stations sampled during the BTS Q3 survey and included in the BTS index of abundance.

Figure 17.5.4 Sole in 27.4. Comparison of the time series of relative abundance at age from the BTS Q3 delta-lognormal GAM standardized (1985-2019) and SNS (1970-2019) indices of abundance.

Figure 17.5.2 Sole in 27.4. Time series of relative abundance at age from the BTS Q3 delta-lognormal GAM standardized index of abundance (1985-2019).

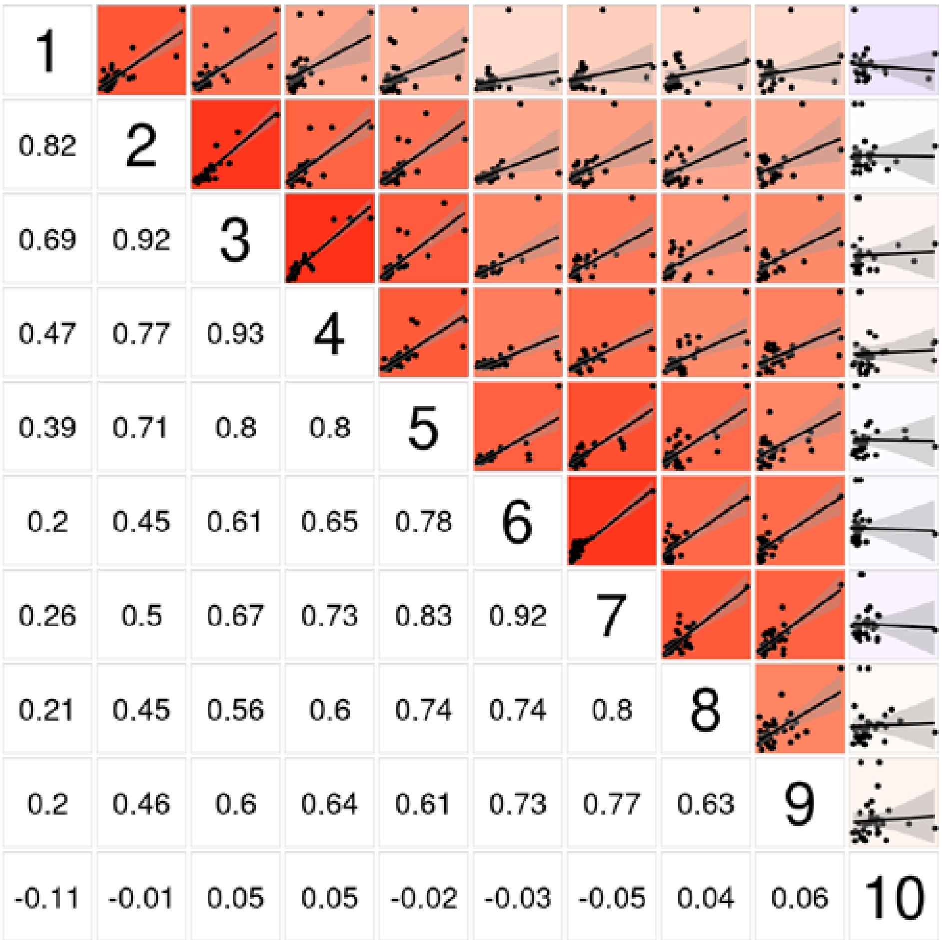


Figure 17.5.5. Sole in 27.4. Bivariate cross-correlation plots showing the internal consistency in signals by cohort for the BTS Q3 delta-lognormal GAM standardized index of abundance (1985-2019).

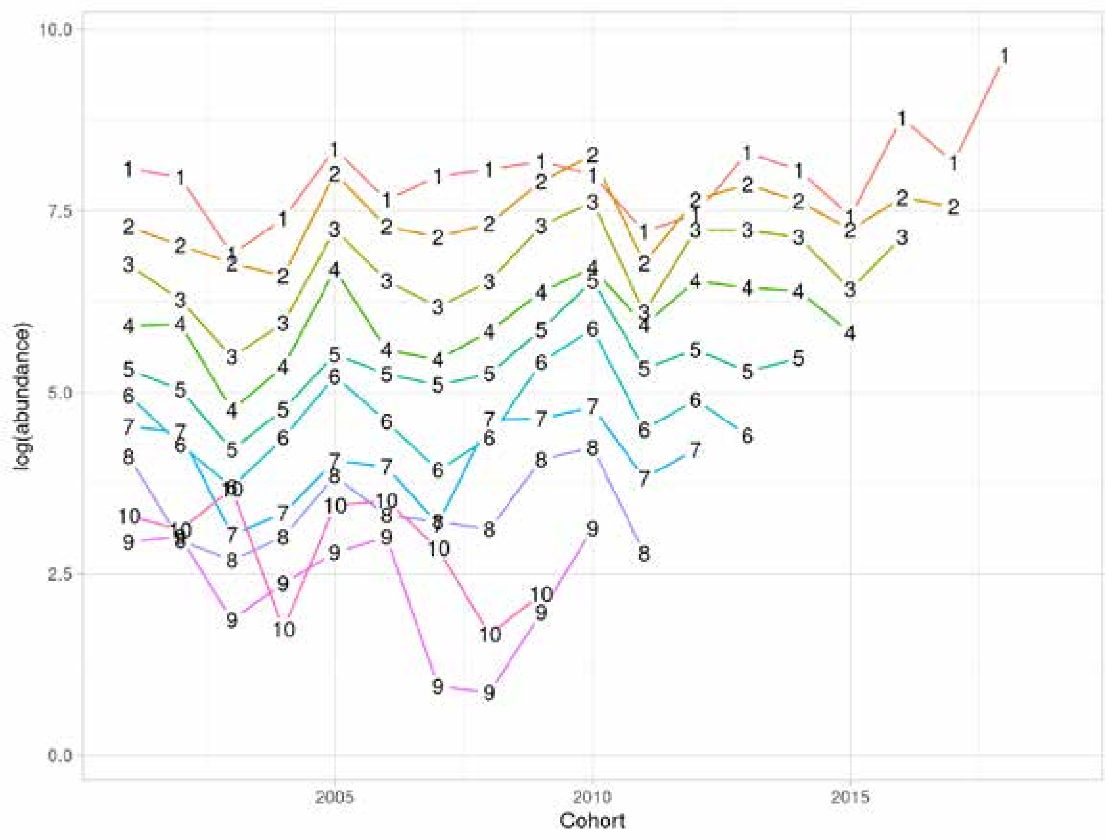


Figure 17.5.7. Sole in 27.4. Abundance in log scale by cohort (in the x axis) and age (coloured lines) for the BTS Q3 delta-lognormal GAM standardized index of abundance (2001-2019).

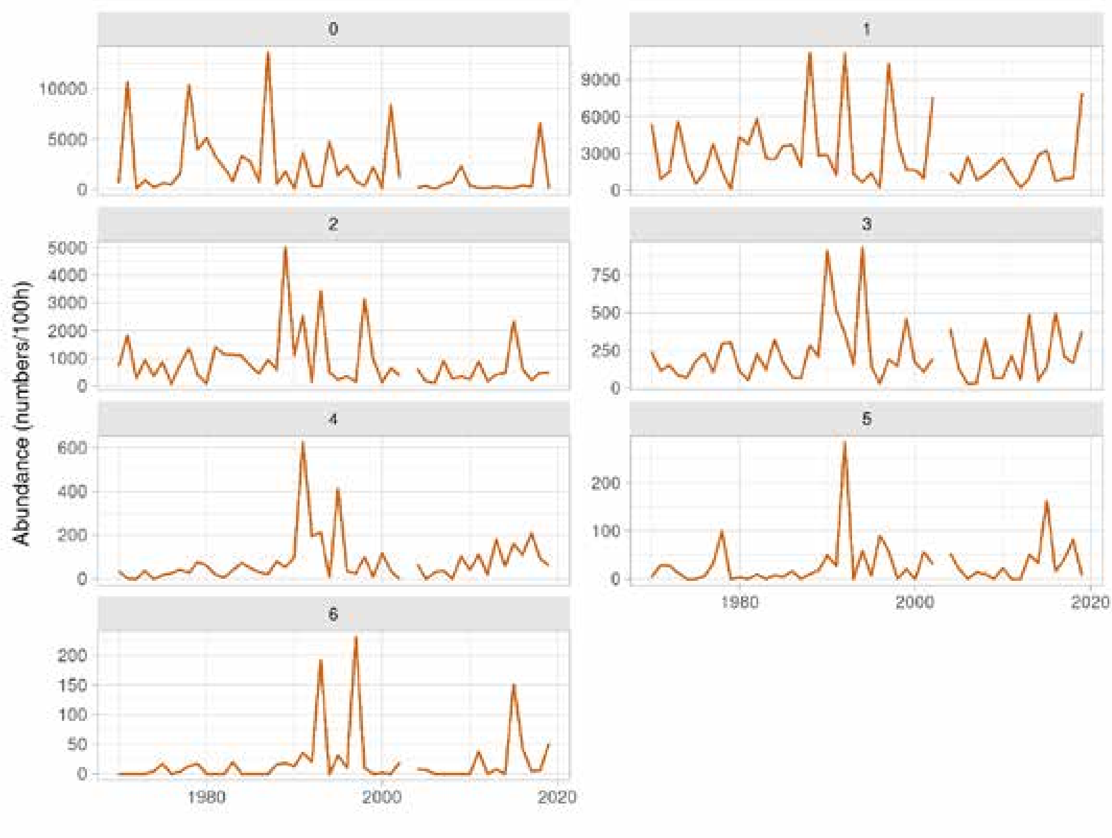


Figure 17.5.3. Sole in 27.4. Time series of relative abundance at age from the BTS Q3 delta-lognormal GAM standardized index of abundance (1985-2019).

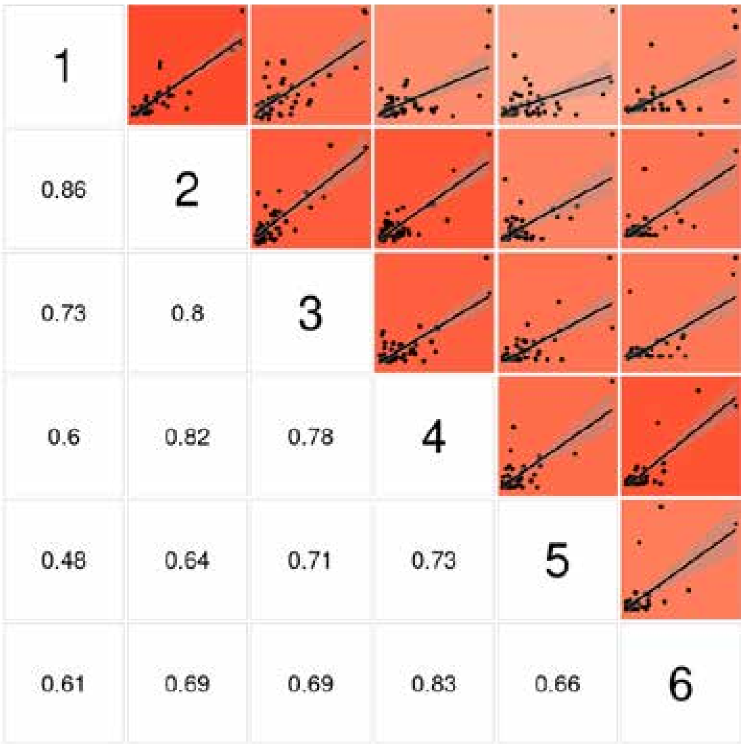


Figure 17.5.6. Sole in 27.4. Bivariate cross-correlation plots showing the internal consistency in signals by cohort for the SNS index of abundance (1970-2019).

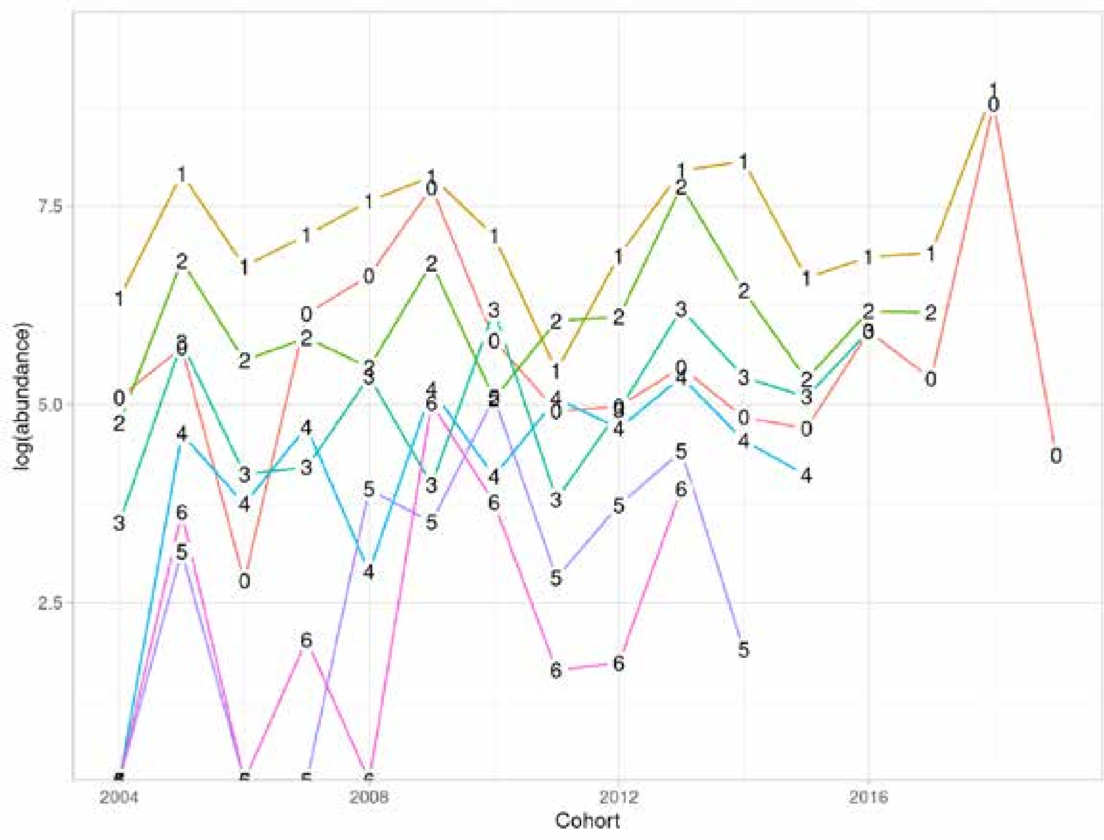


Figure 17.5.8. Sole in 27.4. Abundance in log scale by cohort (in the x axis) and age (coloured lines) for the SNS index of abundance (2004-2019).

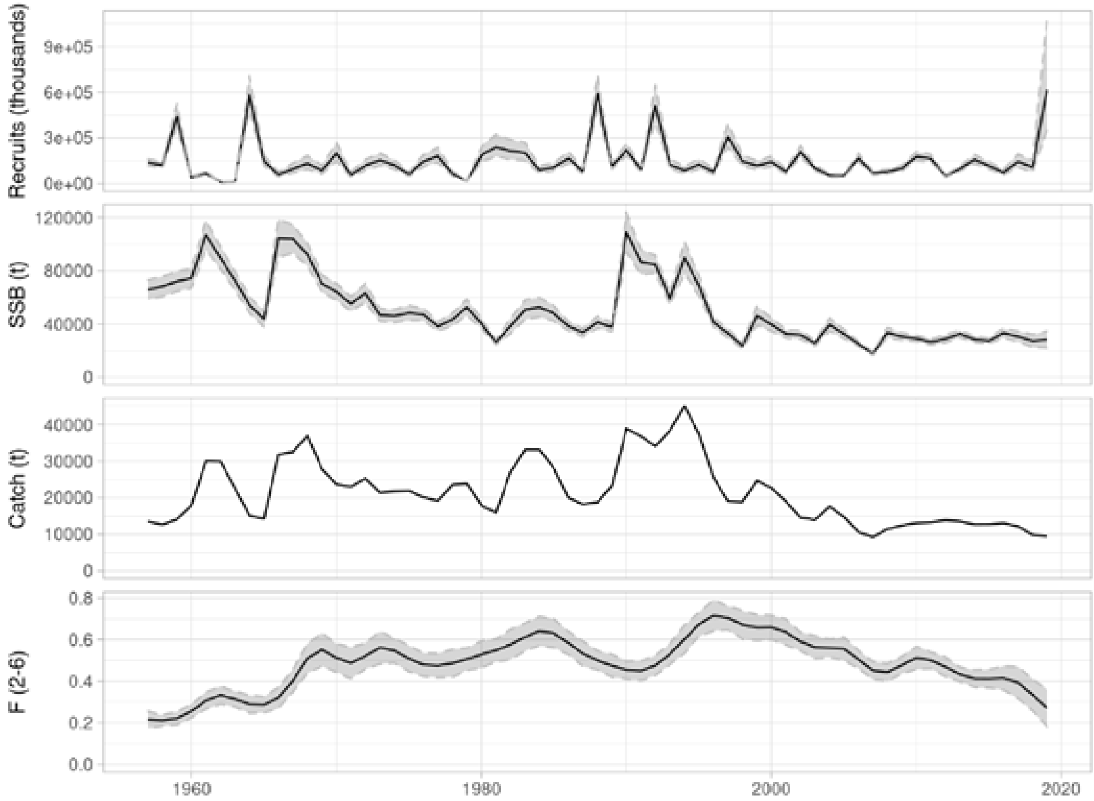


Figure 17.6.1. Sole in 27.4. Estimates time series of recruitment at age 1 (in thousands), spawning biomass (in tonnes) and fishing mortality (as average of ages 2 to 6), together with total catch (in tonnes). Grey bands show the 95% uncertainty estimate, computed as two times the standard deviation.

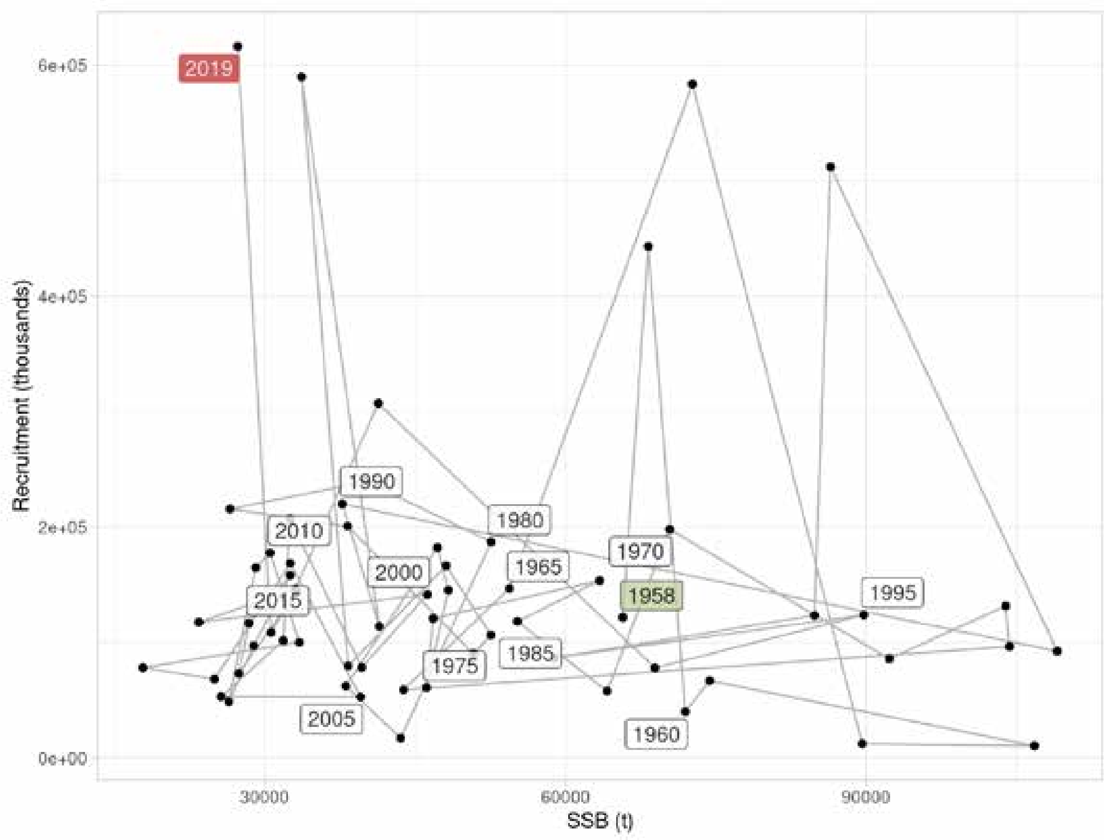


Figure 17.6.2. Sole in 27.4. Estimates of recruitment at age 1 (in thousands) and spawning biomass (in tonnes), connected in time. Labels refer to the year in which recruitment was observed.

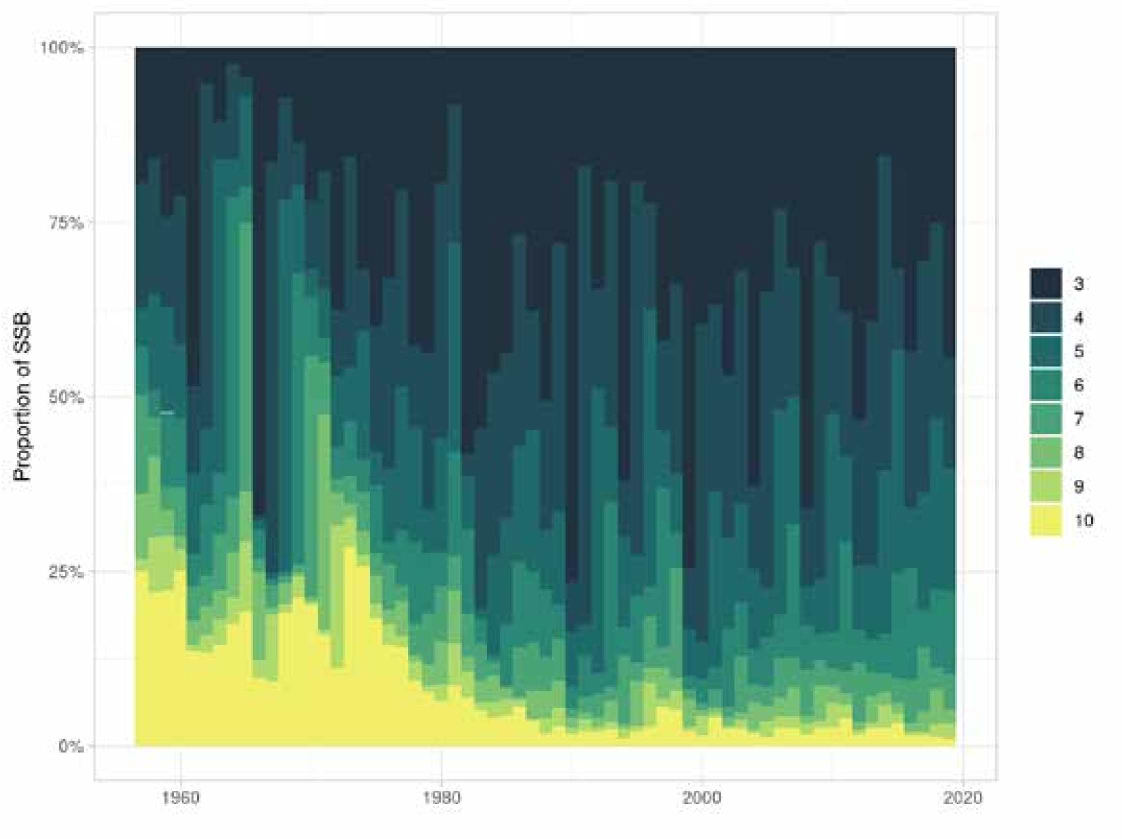


Figure 17.6.3. Sole in 27.4. Estimated proportions of spawning biomass by age and year.

Figure 17.6.4. 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.

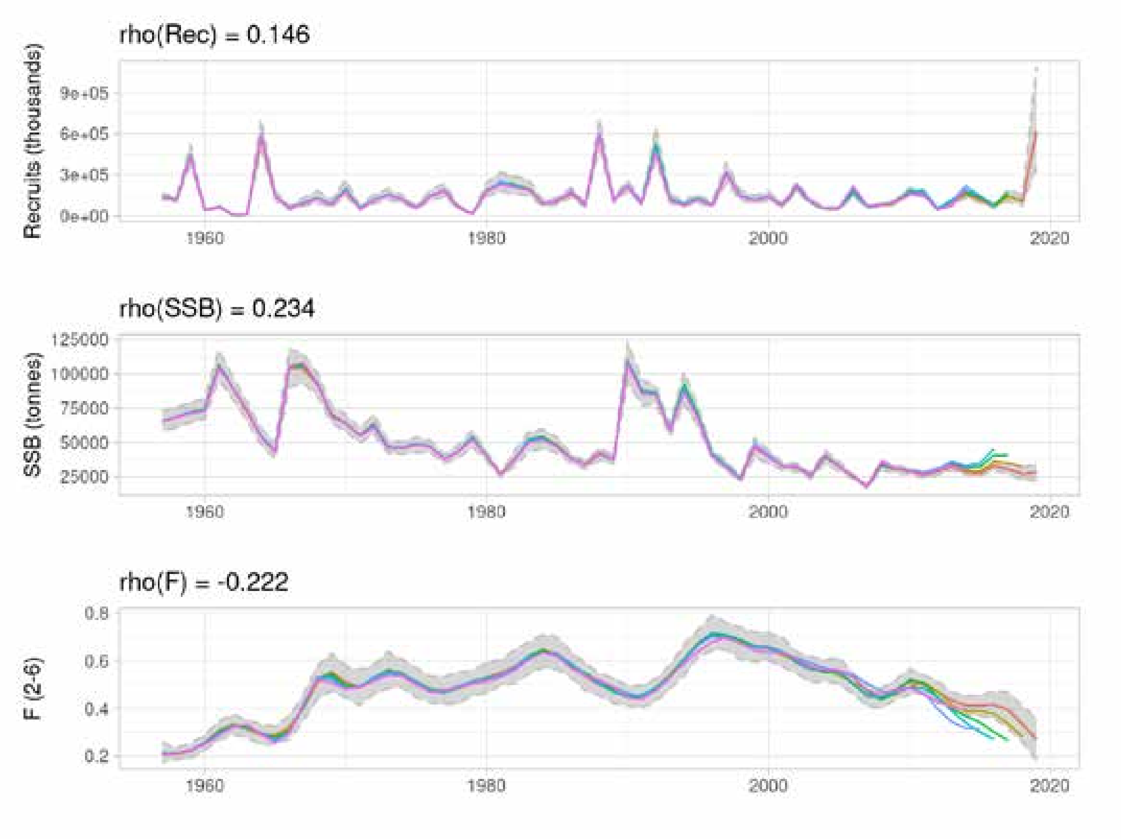


Figure 17.6.5. Sole in 27.4. Retrospective patterns in estimated age 1 recruitment, spawning biomass and mean fishing mortality, computed over five one-year steps.

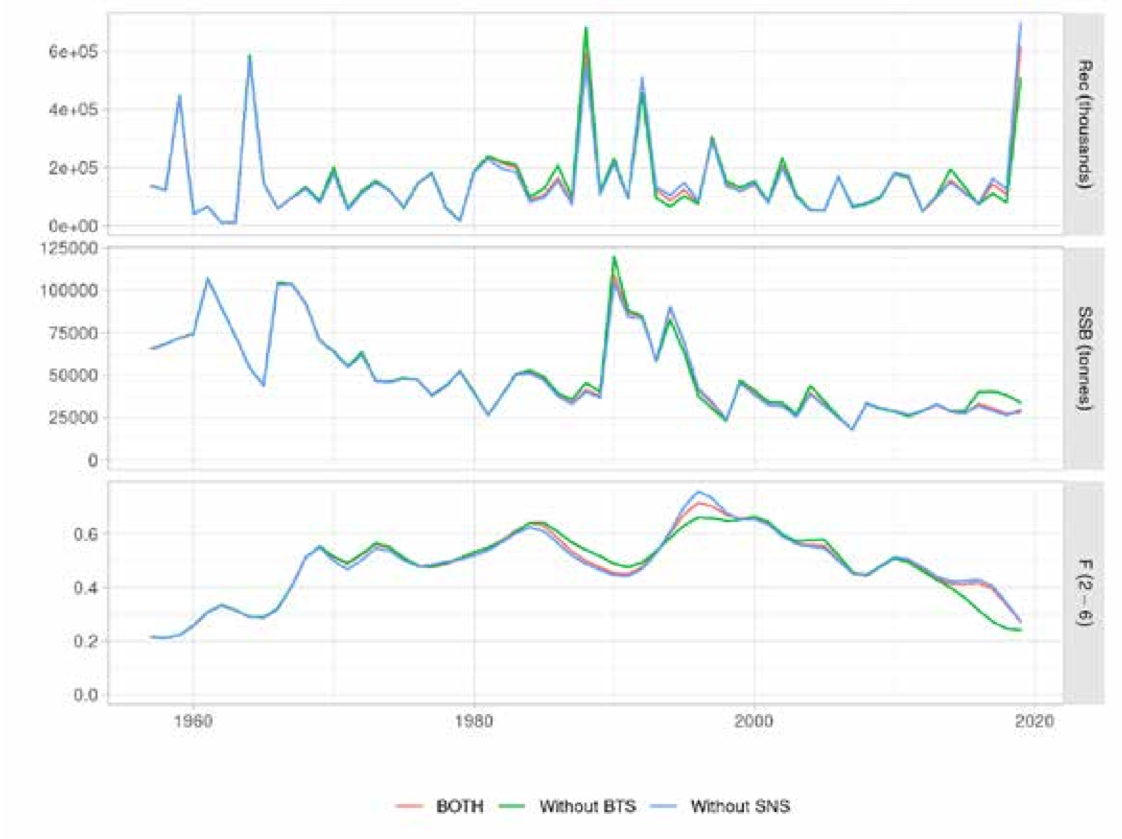


Figure 17.6.6. Leave-one-out analysis of the AAP model run.

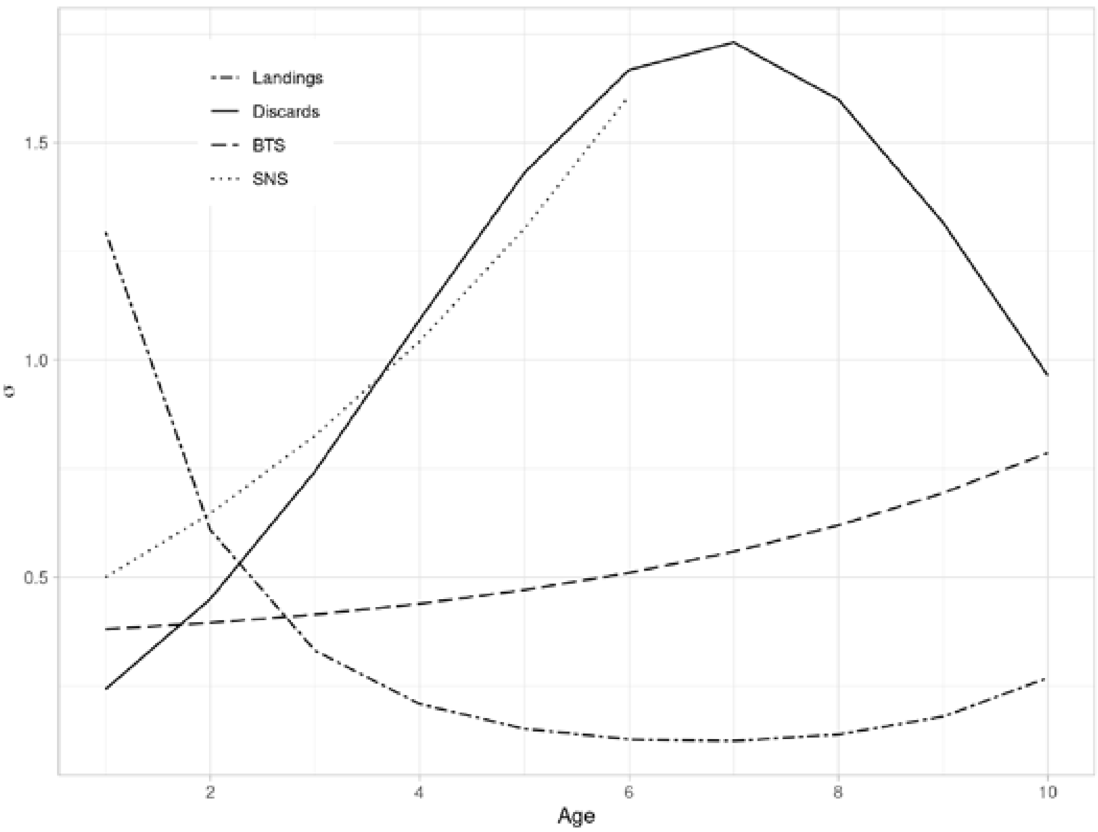


Figure 17.6.7. Sole in 27.4. Estimated standard deviations of the partial model likelihood by age and per each component.

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 2020 assessment of sole in Division 27.7.d. Additional background information can be found in the Stock Annex which was updated after the inter-benchmark in August 2019.

This stock has encountered a few issues over the past year. A short description is given in the following paragraphs.

The assessment and forecast of sole in Division 27.7.d presented at WGNSKK 2019 in Bergen (Norway) were not accepted (ICES, 2019a). The main reason was that 2018 data were missing for one of the tuning fleets (the UK commercial beam trawl tuning fleet). Furthermore, the 2017 data had to be removed from this tuning fleet due to doubts on the accuracy of the data. In August 2019, an inter-benchmark was organised to build a new UK CBT tuning fleet and integrate it in the assessment (ICES, 2019b). Besides the new UK CBT, also a new Belgian CBT was constructed and integrated in the assessment. This resulted in an upward revision in SSB and downward revision in F, especially in more recent years. The primary cause of this upward revision in SSB was the result of treating the Belgian commercial index as a CPUE index instead of LPUE, and

However, subsequent investigation highlighted the hanging plus-group in XSA, based on the catch numbers in the plus-group, as a primary cause of a large increase in the TAC advice, when the assessment was treated as a Category 1 assessment. It was also found that French catch data was aggregated incorrectly for older ages for 2016 and 2017, which meant that the catch data was not reliable for these years. For this reason, the XSA assessment was not considered reliable in absolute terms, and the assessment was downgraded to Category 3 (indicative of trends only). This issue would be investigated during the benchmark in 2020 (WKFlatNSCS 2020; ICES, 2020).

A re-upload of French data for the period 2016-2018 was requested in the data call for the benchmark 2020 to be able to fix this issue. However, the new upload revealed two problems with the French data 1) the effort used to do the national raising was calculated in a different way to comply with EU STECF FDI standards, 2) the method to construct the Age-Length Key changed from multinomial regression to Von Bertalanffy growth curves, which caused the pres-ence of one very old fish in the data to have a large effect on the overall age distributions (num-bers at age). France was unable to fix these issues during the benchmark. Therefore, the bench-mark was inconclusive for sole in Division 27.7.d and postponed to 2021.

During the WGNSSK 2020 (meeting via webex) the group agreed to give advice in the same way as was done in autumn 2019 as a Category 3 stock indicative of trends only using the XSA as-sessment output.

18.1 General

18.1.1 Stock definition

During the WKNSEA 2017 benchmark, the available information on stock identity was investi-gated, including genetic, tagging and otolith information. Sole in the eastern English Channel (7.d) is still considered to be a stock separated from the larger North Sea stock (27.4) to the east and the smaller geographically-separated stock to the west in 27.7.e (western English Channel).

Considering the sub-stock structure, three regions with low connectivity were identified within Division 7.d for both larvae and juveniles, and adults. More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES, 2017).

18.1.2 Ecosystem aspects

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

18.1.3 Fisheries

A general description of the fishery is presented in the Stock Annex.

18.1.3.1 Management regulations

Management of sole in 7.d is by TAC and technical measures.

From 2018 onwards, this stock is fully under the landing obligation (partially since 2016) (EU, 2018/2034). There are two exemptions in place which allow for discarding of undersized sole in Division 7.d: 1) a survival exemption for coastal otter trawlers outside nursery areas with cod end mesh size of 80–99 mm and 2) a *de minimis* exemption for vessels using trammel and gill nets (max. 3% of annual catches) and using TBB gear with a mesh size of 80–119 mm equipped with the Flemish panel (max. 3% of annual catches). The minimum landing size for sole is 24 cm.

A historical overview of the TAC for sole 7.d since 2000 is presented in the table below.

Historical overview of the TACs for sole in Division 27.7.d (2000–2019); Note: TAC represents catch from 2016 onwards (landing obligation)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	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	

Except for 2009 and 2010, the TAC has not been restrictive since 2003. In 2014, it became restrictive for Belgium, and in 2015 this was the case for Belgium and France (see 18.2.1 Landings). Note that initial quota are compared regardless of quota exchanges among countries.

In response to a drop in SSB and the poor recruitment in 2012, the two main countries participating in the fishery (France and Belgium) implemented additional conservation measures. For Belgian beam trawlers in 7.d (and 27.7.fg, 27.7.a) it is mandatory since 1 April 2015 to incorporate a 3 m long section (tunnel) with a 120 mm mesh size before the cod-end (Flemish panel), in order to reduce the catches of small sole (reduction of undersized sole with 40% and marketable sole with 16%). France engaged in 2016 to i) strengthen the protection of the nursery areas, ii) increase the area closed to fishing within the nursery areas, and iii) increase the minimum conservation reference size to 25 cm for French vessels in accordance with EU legislation, where appropriate. From 11 March until 31 December 2017, the minimum conservation reference size for Belgian vessels also increased to 25 cm. This MCRS is still used up until now (dd. May 2020). 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 2019

The ICES advice for 2019 was:

ICES advises that when the MSY approach is applied, catches in 2019 should be no more than 2571 tonnes.

In 2018, the stock status was presented as follows:

		Fishing pressure				Stock size			
		2015	2016	2017			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below	MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	○	✓	✓	Harvested sustainably	B_{pa},B_{lim}	○	✗	○	Increased risk
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

18.1.4.2 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

18.2 Data

As a result of the data call for the 2017 WKNSEA benchmark, new landings and discard data were uploaded in InterCatch from 2003–2015. For the purpose of the 2020 WKFlatNSCS benchmark, new landings and discard data were uploaded in InterCatch:

- For 2016-2018 by UK (E&W)
- For 2002-2018 by France
- For 2002-2008 by UK (Scotland) minor change in metier code

For the WGNSSK 2020 assessment the same input data were used as provided for the IBP 2019 with the exception of the 2018 data which were modified by France (cfr. data issues) and by Belgium (minor change to the total landings) and the addition of 2019 data.

18.2.1 Landings

Table 18.1 and Figure 18.1 summarise the official sole landings by country for Division 7.d. The landings have steadily increased over the 1970s and 1990s, fluctuated around an average of 4839 t in 2000–2014 (range: 3832 t–6247 t), and dropped to 3411 tonnes in 2015 and even further to 2218 tonnes in 2017. In 2018, a small increase up to 2307 tonnes was observed. However, in 2019, landings decreased further to 1762 tonnes. Over the last *ca.* 30 years, the contribution to the landings of the three main countries involved in this fishery has remained rather stable over time (~30% Belgium, ~20% UK, and ~50% France) (Figure 18.2).

Since 2010, full uptake of the sole 27.7.d TAC has not been realized. However, in 2014, the 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 89% was realized in 2017, 76% in 2018 and 87% in 2019 (Figure 18.3). Figure 18.4 presents a historic overview of TAC levels compared to official landings and ICES estimates (both landings and discards).

ICES estimates were uploaded to InterCatch from 2003 onwards as a result of the WKNSEA 2017 benchmark data call. Figure 18.5 summarises the proportion of landings for which samples (age) have been provided in InterCatch by country (80%; see also Table 18.2). Figure 18.6 provides this overview by fleet and country. Age compositions for the remaining landings were allocated using the ‘mean weight weighted by numbers at age’ weighting factor and according to the following scenarios.

- By for métiers representing 75% of the total landings
- By when the proportion of landings covered by age was ≥75%. The following gear groups were distinguished: TBB, OTB/OTT/SSC/SDN and GTR/GNS. GNS/GTR, TBB and OTB/OTT/SSC/SDN contribute respectively 30%, 38% and 27% to the landings of sole in 27.7.d (Table 18.3).
- : When the proportion of landings covered by age was < 75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data. For the 2019 data, the OTB/OTT/SSC/SDN group did not meet the 75% threshold and was therefore added to the ‘overall’ group.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES, 2017).

18.2.2 Discards

For the benchmark (ICES, 2017), a data call for all countries involved in this fishery was launched to acquire discard data from 2003 onwards. From the 2017 assessment onwards, discards are included.

Figure 18.7 shows that for the major part of the landings, discard weights are available (73%; shown by fleet and country). When discards were not available, these were raised in InterCatch. Discards on a country-quarter-métier basis were automatically matched by InterCatch to the corresponding landings. The matched discards-landings provided a landing-discard ratio estimate, which was then used for further raising (creating discard amounts) of the unmatched discards (discard ratios larger than 0.5 were excluded as they were not assumed to be representative for the available strata). The weighting factor for raising the discards was 'Landings CATON'. Discard raising was performed on a gear level regardless of season or country.

- The following groups were distinguished based on the gear:
  - TBB
  - OTB, OTT, SSC and SDN
  - GTR and GNS
- The remaining gears were combined in a REST group (including for example MIS, FPO, LLS and DRB)
- Raising within a gear group was performed when the proportion of landings for which discard weights are available, was equal or larger than 75% compared to the total landings of that group. For 2019, this was the case for the TBB and OTB/OTT/SSC/SDN groups. The GTR/GNS group was added to the REST group.

More information on how discard raising was performed is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES, 2017).

The proportion of discards that was sampled for age was 44% (Table 18.2). This is lower than the discard age coverage in 2018 (70%). For the French GTR_DEF_90-99 fleet, discards were sampled less in 2019 compared to 2018. The difference between both years could be related to the change in the construction of the ALK. Age compositions for the remaining discards were allocated using the 'mean weight weighted by numbers at age' weighting factor and according to the following scenarios.

- By when the proportion of discards covered by age was ≥75%. For the 2019 data, only the TBB group met this requirement. The OTB/OTT/SSC/SDN and the GTR/GNS group were added to the 'overall' group.
- : When the proportion of landings covered by age was < 75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES, 2017).

Belgian 2017 discard age distribution data were re-uploaded in 2019 as Belgium noticed during the raising process that the multinomial logistic regression model did not make a good estimate of the age distribution for large discards (*i.e.* larger than the minimum landing size). This resulted in only minor changes to the discard numbers at age and discard mean weight at age.

18.2.3 BMS landings

Sole in Division 27.7d is fully under the landing obligation since 2018 with some exemptions (see §18.8).

The official catch statistics have reported BMS landings in 2017 (144 kg) and in 2019 (2.8 kg). No BMS landings were reported in 2018.

BMS landings have not been reported through InterCatch so far.

18.2.4 Logbook registered discards

No logbook registered discards were uploaded to InterCatch.

18.2.5 Weight-at-age

Weights-at-age for discards and landings are shown in Figure 18.8 and 18.9 respectively and weights-at-age in the catch are given in Table 18.4.

During the benchmark, the landings mean weight- and number-at-age data for the years 2003–2010 and discard mean weight- and number-at-age data for the years 2003–2015 were processed through InterCatch for the first time. Because in 2003 the percentage of landings with associated discards is only 4%, it was decided to exclude the estimated discard mean weight- and number-at-age for that year. To estimate discards mean weights- and numbers-at-age prior to 2004, a constant ratio of discards to landings by age was applied using data from 2004–2008 (Figure 18.10). Only data from 2004–2008 were used as a notably larger proportion of age 2 and age 3 sole are discarded in more recent years (2009–2019).

Stock weights-at-age were calculated from the quarter 2 mean catch weights (Figure 18.11; Table 18.5). Note that for the current assessment, Belgium was not able to provide quarterly data for the TBB_DEF_70-99 métier. Therefore, the Belgian data were not taken into account for the calculation of the quarter 2 catch weights in InterCatch. For the years 2006–2007, 2012–2015 and 2018, weights from this Belgian stratum were available and included.

18.2.6 Maturity and natural mortality

During the benchmark, the knife-edged maturity ogive with full maturation from age 3 onwards was investigated. Using data from the French IBTS survey and commercial data from Belgium, France and the UK (15 191 records), a new maturity ogive was constructed (see table below). More information on how this was achieved is provided in the WKNSEA 2017 report and the associated working document (ICES, 2017).

Age	0	1	2	3	4	5	6	7	8	9	10	11(+)
Maturity	0.00	0.00	0.53	0.92	0.96	0.97	1.00	1.00	1.00	1.00	1.00	1.00

Natural mortality is assumed to be a fixed value (0.1) for all ages across all years. This biological parameter was not further investigated during the benchmark.

18.2.7 Tuning series

The assessment of sole in the Eastern English Channel is tuned with three survey (UK(E&W)-BTS-Q3, UK-YFS and FRA-YFS) and three commercial tuning series (FRA-COTB, UK(E&W)-CBT and BE-CBT). During the inter-benchmark (August 2019), 2 tuning series used for the calibration of the assessment of sole in Division 27.7.d were modified.

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 1986-2019 disaggregated by age.

The Belgian commercial index as calculated during the benchmark in 2017 focussed on the large fleet segment (>221 kW) and was an LPUE index. During the inter-benchmark (ICES, 2019b), a CPUE index was constructed including
covering most of Division 7.d. The model accounted for potential misreporting of horse power by including a random vessel effect. There were two reasons to modify the index from a LPUE

to a CPUE: 1) there is a pattern of increased discarding in the most recent years, and 2) having a second tuning fleet to tune age 2 in the assessment could put the UK-BTS-Q3, with spatial coverage restricted to inshore waters, into perspective. However, as the pattern when including age 2 in this commercial index did not change substantially, it was decided during the IBP to include the Belgian commercial CPUE index from age 3-8.

The French commercial otter trawl series (from 2002 onwards) and the survey indices (FRA YFS from 1987 funded by EDF (Noursom), UK YFS from 1987–2006 and the UK BTS from 1989) were left unchanged during the IBP. The series are presented in Tables 18.6–18.11.

The time series of the standardized indices for ages 1 to 8 from the six tuning fleets (BE-CBT, UK(E&W)-CBT, FRA-COT, UK(E&W)-BTS, UK(E&W)-YFS and FRA-YFS) are plotted in Figure 18.12. All tuning fleets appear to track the year classes reasonably well. In general, the UK BTS gives the most optimistic estimates at age compared to the other tuning fleets. It shows three clear year classes entering the population: the 2014, 2016 and 2018 year class. Whilst the 2016 year class was not confirmed by the FRA YFS, the 2018 year class is. Note that the spatial coverage of both tuning fleets is quite different. The UK BTS covers most of the coastal areas 7.d area, while the FRA YFS is confined in the Somme estuary (see stock annex). The new Belgian CBT tuning fleet is the only fleet confirming the strong year class of 2014 (*i.e.* age 3 in 2017). All commercial tuning fleets seem to confirm the 2016 year class, meaning that this year class is found in the commercial catches.

Internal consistency plots for the 3 commercial fleets and the UK beam trawl survey are presented in figures 18.13–18.16. The internal consistency of these four fleets is reasonable for the entire age-range.

18.3 Analyses of stock trends/Assessment

18.3.1 Review of last year’s assessment

Last year, there were no major comments to the assessment and forecast. The few edits were directly provided to the stock coordinator and taken into account before the ADG.

18.3.2 Exploratory catch at age analysis

Catch, discard and landings numbers-at-age are shown in Figure 18.17, 18.18 and 18.19 respectively. Catch numbers have decreased over the time series and low numbers are caught since 2015. In 2008–2009, a strong year class entered the stock and was found in the landings. Since 2013, several bigger year classes have been observed in the discards, but these were not obvious in the landings. The strong 2018 year class as predicted from the surveys is proportionally larger than the year classes entering in the period 2013-2017 (Figure 18.12). In two years’ time this year class could be observed in the catches.

Catch proportions at age relative to the average proportion at age are shown in Figure 18.20. Last year, proportionally much older fish (especially in the plusgroup 11+) were observed which is related to the change from multinomial regression to Von Bertalanffy growth curves to construct the ALK in the French data. This year, it is clear that this issue is fixed for 2018 and 2019. Nevertheless, Figure 18.20 shows that fish from the strong 2008 year class are still caught corresponding to age 10-11 in 2019.

The catchability residuals of the tuning series for the proposed final XSA (see below) are shown in Figure 18.21. Some concern rises considering the UK(E&W)-BTS-Q3, which shows an age effect for age 1 and a year effect for age 1-3 in the most recent years. The residuals of the new

Belgian CBT series and the new UK CBT series are small, although the latter also shows a year effect for the most recent years.

Figure 18.22 presents the standardised mean log catchabilities for each tuning fleet included in the 2020 assessment.

18.3.3 Survivors estimates

In this year's assessment, the estimates for the year class 2018 (recruits (age 1) in 2019) were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of 46% and 43% respectively in the final year survivor estimates (Table 18.12). Both surveys give a high estimate of the age 1 in 2019, which results in a survivor estimate of 89172 thousand individuals being the largest of the time series. Shrinkage takes 12% of the weighting. However, it should be noted that the internal standard errors of both surveys are around 1.0, indicating a high variability and therefore an uncertain estimate for this year class.

The 2017 year class (age 2 in 2019) is also estimated by the UK beam trawl survey and the French component of the Young Fish Survey, with a weighting of 83% and 13% respectively (Table 18.12). The UK BTS gives a positive signal for this year class (Figure 18.12). Considering the large weighting percentage by this tuning fleet, the survivor estimates were set at 27554. Shrinkage takes 4% of the weighting.

The 2016 year class (age 3 in 2019) is estimated by 5 tuning fleets and the F shrinkage (Table 18.12). All commercial tuning fleets and the UK BTS index show a positive trend (Figure 18.12). Especially the UK BTS (30%), FRA COTB (29%) and BEL CBT (27%) have the largest weighting percentages for this estimate, resulting in 22834 thousand survivors.

The 2015 year class (age 4 in 2019) is also tuned by 5 tuning fleets and the F shrinkage. All relevant tuning fleets show a negative trend for this year class (Figure 18.12). The BEL CBT (33%), the UK BTS (27%) and the FRA COTB (24%) contribute most and result of a survivor estimate of 6669 thousand individuals.

18.3.4 Final assessment

Considering the inconclusive benchmark (WKFlatNSCS; ICES, 2020) and the remaining issues with the French data for 2016-2017, three different methods to provide advice were explored during WGNSSK 2020:

- The XSA assessment to provide category 3 advice using the 2 over 3 rule applied to the SSB estimates
- The different tuning fleets to provide category 3 advice using the 2 over 3 rule applied to the tuning fleets as biomass indices (not age-structured)
- The landings to provide category 3 advice using the average landings of the last 3 years

<u>XSA assessment:</u>

The final settings are specified in the Stock Annex and detailed below.

	2019 ASSESSMENT		
Fleets	Years	Ages	a-b
new BE_CBT commercial	04–19	3–8	0–1
FR_COT commercial	02–19	3–8	0–1
new UK(E&W)_CBT commercial	86–19	3–8	0–1

UK(E&W)_BTS survey	89–19	1–6	0.5–0.75
UK_YFS survey	87–06	1–1	0.5–0.75
FR_YFS survey	87–19	1–1	0.5–0.75

-First data year	1982
-Last data year	2019
-First age -Last age	1 11+
Time series weights	None
-Model	No Power model
-Q plateau set at age	7
-Survivors estimates shrunk towards mean F	5 years / 5 ages
-s.e. of the means	2.0
-Min s.e. for pop. Estimates	0.3
-Prior weighting	None

The diagnostics of this run (including fishing mortalities and stock numbers by age and year) are presented in Table 18.12. A summary of the XSA results is given in Table 18.13 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 18.23 (red dashed line). Figure 18.23 also shows the WGNSSK 2019 run and the final inter-benchmark run. The WGNSSK 2019 run (black) shows the outcome of the assessment before the inter-benchmark, which includes the old UK CBT series with data up to 2016 and the old BE CBT series. The inter-benchmark run includes the new UK CBT and new BEL CBT tuning fleets. Note that the 2018 data between the WGNSSK 2019 and IBP run are different from the WGNSSK 2020 run as a result of the new upload from France. Differences between the runs in Figure 18.23 are minimal except for the recent recruitment estimates.

Retrospective patterns for the final run are shown in Figure 18.24. There appears to be no apparent retrospective bias. Recruitment estimates are uncertain. Mohn's Rho calculations for SSB, Mean F and Recruits were 0.083, -0.082 and -0.048 respectively, which are all within acceptable limits.

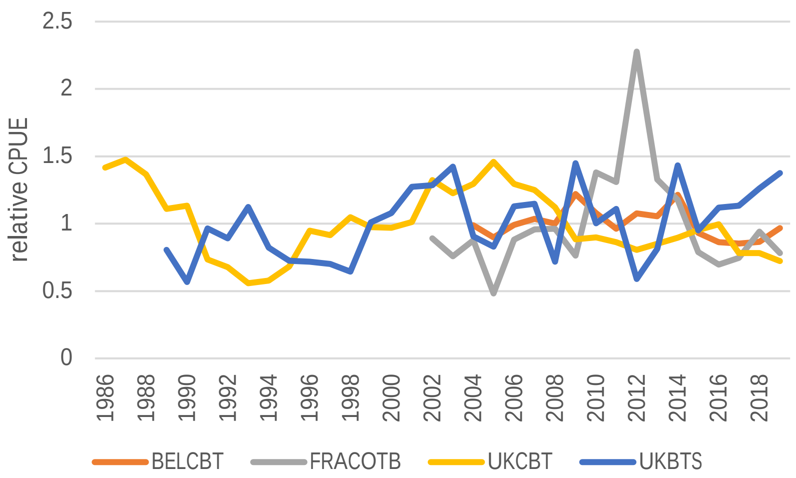
A summary of the assessment in relative terms is given in Table 18.14.

<u>Tuning fleets as biomass indices:</u>

Four tuning fleets were considered to provide category 3 advice. The indices, not structured for age, are presented in the Table (absolute values) and Figure (relative values) below.

Year	BELCBT Kg/h	FRACOTB Kg/kWh	UKCBT Kg/activity day	UKBTS Kg/h
1986			137	
1987			142	
1988			132	

1989			107	5.7
1990			109	4.0
1991			71	6.8
1992			65	6.3
1993			54	7.9
1994			56	5.8
1995			66	5.1
1996			91	5.1
1997			88	5.0
1998			101	4.5
1999			94	7.1
2000			93	7.6
2001			98	9.0
2002		7.6	127	9.1
2003		6.5	118	10.1
2004	29	7.5	125	6.4
2005	26	4.1	141	5.9
2006	29	7.6	125	8.0
2007	30	8.2	121	8.1
2008	29	8.3	108	5.1
2009	35	6.5	85	10.2
2010	31	11.8	87	7.1
2011	28	11.2	83	7.8
2012	31	19.5	78	4.2
2013	31	11.4	82	5.7
2014	35	10.1	86	10.1
2015	27	6.8	92	6.7
2016	25	6.0	96	7.9
2017	25	6.4	75	8.0
2018	25	8.1	75	8.9
2019	28	6.7	70	9.7



When applying the 2 over 3 rule for each of these indices the following index ratios are obtained.

→ BEL CBT CPUE (kg/h):

2:3 rule		
av(2018-19)	26.53352	
av(2015-17)	25.56876	
	1.037732	3.77%

→ FRA COTB (kg/kWh):

2:3 rule		
av(2018-19)	7.38967914	
av(2015-17)	6.38520063	
	1.15731354	15.73%

→ UK CBT (kg/activity day):

2:3 rule		
av(2018-19)	72.54393	
av(2015-17)	87.74214	
	0.826786	-17.32%

→ UK BTS (av. kg/h):

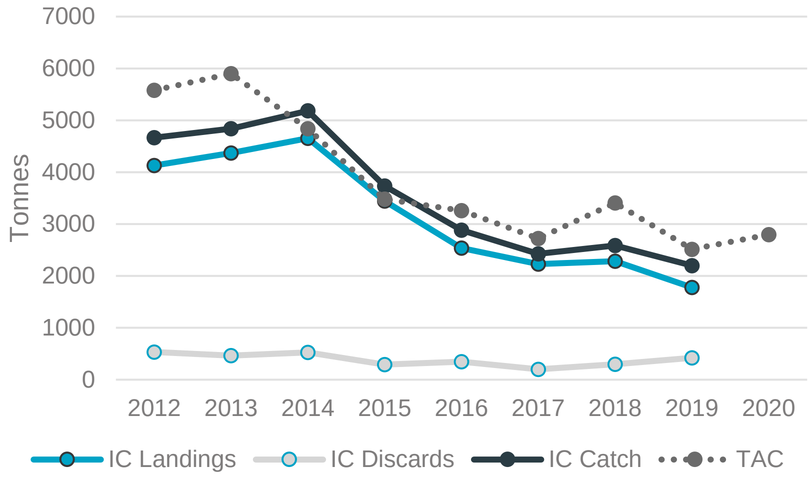
2:3 rule		
av(2018-19)	9.316142	
av(2015-17)	7.541216	
	1.235363	23.54%

All tuning fleets show a positive increase except for the UK CBT fleet. The UK CBT index is calculated for a fleet that has faced large effort reductions over the past 20 years. UK vessels fishing in Division 27.7d are concentrated in 3 ICES statistical rectangles, which is not that representative for the entire stock area. The most positive index is the UK BTS, which is spatially confined to the coastal areas of Division 27.7d and has recently observed a strong year class. Also the French COTB fleet shows a positive index. This part of the French fleet is however not the major contributor to sole landings in Division 27.7d (the GTR fleet has the most landings). The Belgian CBT gives a slight positive index. This fleet is well distributed over the entire Division

culation of the index. The former being allowed to fish within the 12 nautical mile zone of both France and England. One could argue that this fleet gives the most representative image of the stock. However, the WKFlatNSCS 2020 investigated non-compliance in the Belgian fleet and found over-reporting over the entire time series (ICES, 2020).

<u>Landings only:</u>

Finally, an overview of the recent catches was made (see Figure and Table below).



Year	IC Landings	IC Discards	IC Catch	TAC	TAC uptake	DR
2012	4131	533	4664	5580	84%	0.11
2013	4372	466	4838	5900	82%	0.10
2014	4655	528	5183	4838	107%	0.10
2015	3443	294	3737	3483	107%	0.08
2016	2538	344	2882	3258	88%	0.12
2017	2228	200	*2428*	2724	89%	0.08
2018	2287	297	*2584*	3405	76%	0.11
2019	1778	421		2515	87%	0.19
2020				2797		
Average 2017-2019			2404			

An average catch of 2404 tonnes was calculated for the period 2017-2019.

18.3.5 Historical stock trends

Trends in catch, SSB, Fbar and recruitment are presented in Table 18.14 and Figure 18.25.

Catches have been stable around 4000 tonnes up to 2003. Higher catches from 2003 onwards are a result of the benchmark data call (ICES, 2017) and fluctuate around 5000 tonnes (including discard information). In more recent years, catches have decreased to approximately 2500 tonnes (2428 tonnes in 2017, 2584 tonnes in 2018). In 2019, the lowest catches of the time series were noted: 2200 tonnes.

For most of the time series, the *spawning-stock biomass* (SSB) has been fluctuating without trend since the 1980s around MSY $B_{trigger}$. From 2011 onwards, SSB exceeded MSY $B_{trigger}$, probably as a result of the decreased F. However, the weak recruitment of 2012, 2013 and 2014 probably contributed to reverse the increasing trend in SSB from 2013 onwards. In 2016, SSB was just above MSY $B_{trigger}$. In 2017, SSB increased again, probably as a result of the stronger recruitment in 2015 and 2017 and a further reduction in the fishing mortality. In 2018-2019, SSB continued to increase as recruitment remained at high levels and fishing mortality at low levels.

Fishing mortality (F) has been fluctuating between 0.72 and 1.48 prior to 2007, staying above F_{MSY} and occasionally exceeding F_{lim}. From 2007 onwards, fishing mortality has been decreasing and is below F_{MSY} since 2017. In 2019, F is at its lowest point of the entire time series (relative value = 0.37).

Recruitment has been fluctuating without trend with occasional strong year classes. After a period of lower recruitment (2012-2016), strong year classes were observed in the 3 most recent years (2017-2019), with 2019 representing the highest recruitment of the time series.

18.4 Recruitment estimates and short-term forecast

18.4.1 Recruitment estimates

From the retrospective analysis it is clear that recruitment is highly variable in the most recent years. Age 1 is tuned by the French YFS and UK-BTS. Age 2 is only tuned by the UK-BTS. From age 3 onwards, the commercial tuning series give information. From one year to the next, recruitment can be revised markedly, creating instability in the deterministic forecast from one year to the next.

The IBP decided to change the settings of the forecast and more specifically the estimation of age 1, 2 and 3 in 2019 (ICES, 2019b). Up until now, only age 1 was altered and estimated by an RCT3 estimate or the geometric mean minus the last 3 data years. By altering age 1, 2 and 3, we affect approximately 40% of the estimation of the catch in 2021 (Figure 18.26) and approximately 45% of the estimation of the SSB in 2021 (Figure 18.27). The IBP decided to use a *short* geometric mean for age 1, 2 and 3. The short geometric mean was calculated using the final data year -5 to the final data year -2 (in this case 2014-2017).

For age 1, the geometric mean from 2014-2017 corresponded to 24858 thousand individuals ( ).

To obtain the stock numbers for age 2, this value was multiplied by the mortality (fishing mortality and natural mortality = Z) of age 1 in 2019 as follows: * (e^{-Z} @age1 in 2019), giving 22359 thousand individuals.

To obtain the stock numbers for age 3, the GM 2014-2017@age1 was multiplied by the mortality (Z) of age 1 in 2018 and by the mortality (Z) of age 2 in 2019 as follows: * (e^{-Z} @age1 in 2018)* (e^{-Z} @age2 in 2019), giving 18218 thousand individuals.

The estimates of year-class strength used for prediction can be summarised as follows (in thousands individuals):

Year class	@ age in 2020	GM	Settings

Weights-at-age in the catch and in the stock are averages for the years 2017–2019.

18.4.2 Short-term forecast

For sole in Division 27.7d a deterministic forecast is run. There are two options to set the fishing mortality of the intermediate year: 1) F status quo (Fsq) set as the mean over the last three years scaled or not scaled to the last data year or 2) F set to constrain the TAC in the intermediate year. If the TAC is not fished (e.g. for sol 7d in 2019), the TAC constraint option should not be considered. However, both options are explored to identify potential issues with the data (e.g. plusgroup issue).

1) Fsq:

   If the F shows an increasing or decreasing trend in the last three years, the Fsq should be scaled to the last data year (*i.e.* 2019). According to Figure 18.23 and Table 18.14, there is no decreasing trend in F over these three years (relative F2017 = 0.51, F2018 = 0.52, F2019 = 0.37). Therefore, F is set to 0.158. However, this resulted in an estimated catch in 2020 of 3119 tonnes. This means overshooting the current TAC in 2020 (2797 t) with 11.5%. The predicted catch for 2021 is 3749 tonnes when fishing at F_{MSY}. This results in an SSB of 21628 tonnes in 2021 and 21262 tonnes in 2022. This means a 34% increase compared to the TAC of 2020 and a 32% increase compared to the advice for 2020 (2846 tonnes).

SSB 2020	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
21132	0.158	0.035	0.141	24858
landings	**discards**	**catch**	**TAC**	
2846	273	3119	2797	

2) F TAC constraint:

   If we assume the TAC will be fished in 2020, the F in the intermediate year (2020) should be 0.140. The predicted catch for 2021 is 3806 tonnes when fishing at Fmsy. This results in an SSB of 21960 tonnes in 2021 and 21539 tonnes in 2022. This means a 36% increase compared to the TAC of 2020 and a 34% increase compared to the advice for 2020 (2846 tonnes).

SSB 2020	F3–7	Fdis1–3	Fhc3–7	recruits (age 1)
21132	0.140	0.032	0.126	24858
landings	**discards**	**catch**	**TAC**	
2553	244	2797	2797	

The output of the forecast, for the Fsq option (mean of the last three years), is shown in the table below.

basis	catch	landings	discards	f3–7	f_hc3–7	f_dis1–3	SSB 2020	SSB 2021	SSB change	TAC change	Advice change
F_{MSY}	3749	3429	320	0.192	0.172	0.055	21628	21262	-2.0%	34%	32%
F_{MSY}_lower	2344	2146	198	0.116	0.104	0.033	21628	22688	5.0%	-16.0%	-18%

F_{MSY}_upper	5888	5378	510	0.32	0.29	0.092	21628	19093	-12.0%	111%	107%
F_{pa}	5583	5101	482	0.30	0.27	0.087	21628	19402	-10.0%	100%	96%
F_{lim}	7434	6783	651	0.42	0.38	0.121	21628	17528	-19.0%	166%	161%
SSB>B_{pa}	9867	8984	883	0.60	0.54	0.174	21628	15072	-30%	253%	247%
SSB>B_{lim}	14155	12828	1327	1.02	0.92	0.30	21628	10766	-50%	406%	397%
TACsq	2797	2560	237	0.140	0.125	0.040	21628	22227	3.0%	0%	-1.72%

The output of the forecast, for the F TAC constraint option, is shown in the table below.

basis	catch	landings	discards	f3–7	f_hc3–7	f_dis1–3	SSB 2020	SSB 2021	SSB change	TAC change	Advice change
F_{MSY}	3806	3484	322	0.192	0.172	0.055	21960	21539	-2.0%	36%	34%
F_{MSY}_lower	2379	2180	199	0.116	0.104	0.033	21960	22987	5.0%	-15.0%	-16.4%
F_{MSY}_upper	5977	5464	513	0.32	0.29	0.092	21960	19339	-12.0%	114%	110%
F_{pa}	5668	5182	486	0.30	0.27	0.087	21960	19652	-11.0%	103%	99%
F_{lim}	7546	6891	655	0.42	0.38	0.121	21960	17751	-19.0%	170%	165%
SSB>B_{pa}	10201	9294	907	0.62	0.55	0.178	21960	15072	-31%	265%	258%
SSB>B_{lim}	14492	13142	1350	1.04	0.93	0.30	21960	10766	-51%	418%	409%
TACsq	2797	2562	235	0.138	0.123	0.040	21960	22563	3.0%	0%	-1.7%

Both options assume unlikely intermediate year settings. The Fsq scenario overshoots the TAC 37% and the TAC constraint option assumes that the TAC will be fished. The TAC was not restrictive the past 5 years and provisional official numbers indicate that this will most likely not be the case in 2020 either.

The advice is based on the ratio between the average of the two latest index values (index A: 2018-2019) and the average of the three preceding values (index B: 2015-2017), multiplied by the recent advised catch (for 2020).

The index is estimated to have increased by less than 20% and, thus, the uncertainty cap is not applied. The stock size is above and fishing mortality is below proxies for the MSY reference points (Figure 18.25), therefore the precautionary buffer is not applied.

Index A (2018–2019)		1.12
Index B (2015–2017)		0.98
Index ratio (A/B)		1.14
Uncertainty cap	Not Applied	-
Advised catch for 2020		2846 tonnes
Discard rate (2017-2019)		12.7%
Precautionary buffer	Not Applied	-
Catch advice**		3248 tonnes
Projected landings corresponding to the advice ***		2834 tonnes
% Advice change^		14%

** Advised catch for 2020 × index ratio
*** Advised catch for 2020 x index ratio x (1-discard rate)
^ Advice value for 2021 relative to advice value for 2020 [2846 tonnes].

18.5 Biological reference points

The table below summarizes all known reference points for sole in Division 27.7.d and their technical basis. Reference points have been redefined as a result of the inter-benchmark (more information is provided in the IBPsol7d report (ICES, 2019b)). The management plan defined in the table is the EU multiannual plan (MAP) for the Western Waters (EU, 2019).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	15072 t	B_{pa}	ICES (2016, 2019b)
	F_{MSY}	0.192	EQsim analysis based on the recruitment period 1982–2016	ICES (2016, 2019b)
Precautionary approach	B_{lim}	10766 t	B_{loss}	ICES (2016, 2019b)
	B_{pa}	15072 t	B_{lim} × exp(1.645 × 1.4 × B_{lim}	ICES (2016, 2019b)
	F_{lim}	0.421	EQsim analysis, based on the recruitment period 1982–2016	ICES (2016, 2019b)
	F_{pa}	0.300	F_{lim} × × F_{lim} / 1.4	ICES (2016, 2019b)
Management plan	MAP MSY $B_{trigger}$	15072 t	MSY $B_{trigger}$	ICES (2019b)
	MAP B_{lim}	10766 t	B_{lim}	ICES (2019b)
	MAP F_{MSY}	0.192	F_{MSY}	ICES (2019b)
	MAP range F_{lower}	0.116–0.192	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019b)
	MAP range F_{upper}	0.192–0.319	Consistent with ranges provided by ICES (2019b), resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019b)

The relative reference points as used for the category 3 advice are shown below. All values are relative to the average of the time-series in the stock assessment (see Table 18.14).

Framework	Reference point	Relative value**	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.92	B_{pa}	ICES (2019b)
	F_{MSY}	0.57	EQsim analysis based on the recruitment period 1982–2016	ICES (2019b)
Precautionary approach	B_{lim}	0.66	B_{loss}	ICES (2019b)
	B_{pa}	0.92	B_{lim} × exp(1.645 × 1.4 × B_{lim}	ICES (2019b)
	F_{lim}	1.25	EQsim analysis, based on the recruitment period 1982–2016	ICES (2019b)
	F_{pa}	0.89	F_{lim} × × F_{lim} / 1.4	ICES (2019b)

Management plan	MAP MSY $B_{trigger\ proxy}$	0.92	MSY $B_{trigger\ proxy}$	ICES (2019b)
	MAP $F_{MSY\ proxy}$	0.57	$F_{MSY\ proxy}$	ICES (2019b)

18.6 Quality of the assessment

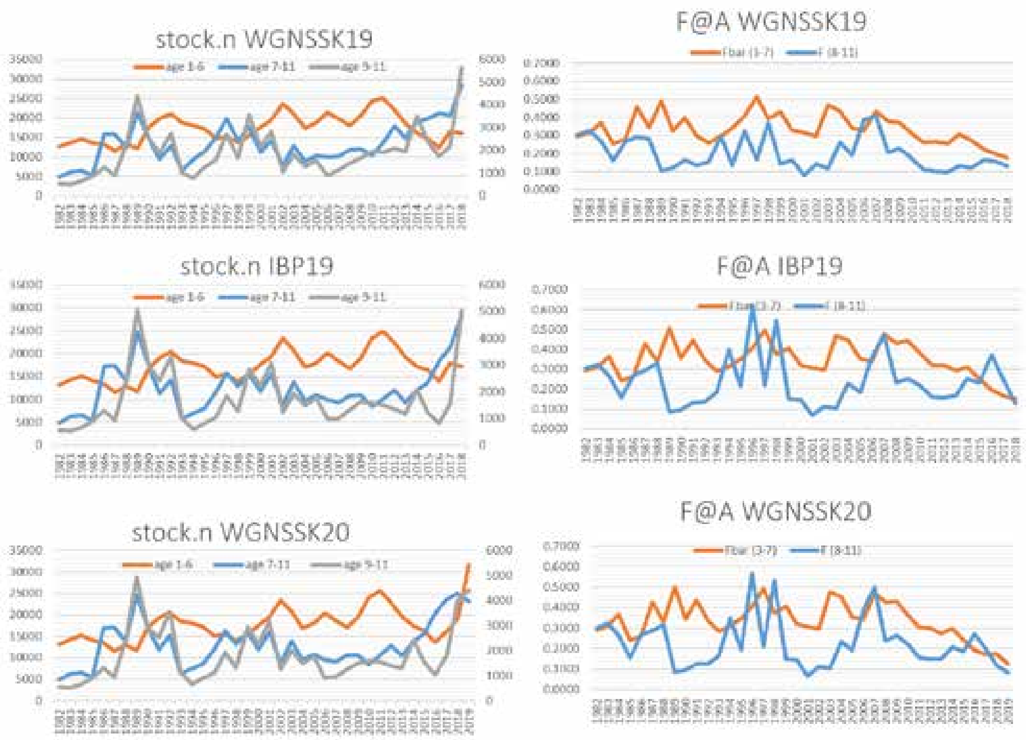
For the second year in a row and due to the inconclusive benchmark (WKFlatNSCS, ICES 2020), the XSA assessment was not considered reliable in absolute terms, and the assessment was downgraded to Category 3 (indicative of trends only). Fixing the French catch data by aggregating them correctly (multinomial regression for ALK) for 2016 and 2017 is the priority for the next benchmark in 2021.

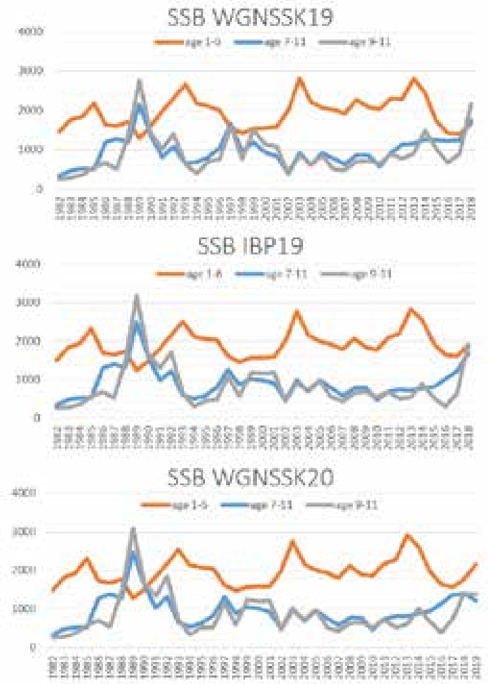
18.7 Benchmark issue list

18.7.1 Data issues

There are several issues with the data:

- A revision of the entire French time series (2002-2017) is needed (2018 and 2019 were updated for WGNSSK 2020), including raising by landings and using the multinomial regression instead of Von Bertalanffy growth curves for modelling ALKs. Data should be uploaded to InterCatch.
- Investigate the strange behaviour of older ages in stock numbers and fishing mortality at age and determine the cause of this problem (see Table 18.15-18.17 and figure below for stock numbers, fishing mortality (F) and spawning stock biomass (SSB) for the respective XSA stock objects from WGNSSK 2019 (upper row), inter-benchmark (IBP, middle row) and WGNSSK 2020 (lower row)).





An overview of the input data for these different runs is given in the Table below (with * = new data from France for 2018 and ! = mistake corrected in filtering of input dataset).

Data input		WGNSSK 2019	IBP 2019	WGNSSK 2020
Catch series 1982-2018		X	X	
Catch series 1982-2019*				X
BEL CBT LPUE (2004-2018)	age 3-8	X		
BEL CBT CPUE (2004-%)	age 3-8		X (% = 2018)	X (% = 2019) !
UK CBT (1986-2016)	age 3-8	X		
UK CBT new (1986-#)	age 3-8		X (# = 2018)	X (# = 2019)
FRA COTB (2002-§)	age 3-8	X (§ = 2018)	X (§ = 2018)	X (*;§ = 2019)
Surveys (UK BTS (1-6), FRA YFS(1), UK YFS (1))		X	X	X
Maturity & Nat. mortality (WKNSEA 2017)		X	X	X
Stock weight		X	X	X*

- A revision of the French commercial otter trawl tuning fleet considering the revised French time series and model LPUE is needed.
- Investigate trends in stock weights, decipher the origin of stock weights over the time series and potentially model stock weights.
- Consider the output of the French SMAC project on sol in Division 27.7d which investigated the presence of subpopulations in this stock.
- Currently, six tuning fleets are used in the assessment. Most of them are only covering a small part of Division 27.7d. It should be investigated if all tuning fleets should be retained in the assessment and leave-one-out runs should be explored.

18.7.2 Assessment issues

Currently, XSA is used as the assessment model for this stock. This VPA-based model calculates the population abundance at age directly from catch-at-age (treated as known and without error in every time step) and natural mortality, starting from the latest year and oldest true age for each cohort (excluding the plus group) (ICES, 2012). One of its limitations compared to statistical catch-at-age models, such as SAM, is that highly structured fishing mortality calculations allow less flexibility in distributing the goodness of fit. Moreover, issues with the plugroup in the raw catch data have shown to be problematic to produce an assessment of good quality (category 1) using XSA (§ 18.6). Other models should be further explored that are better equipped to appropriately handle the plusgroup.

18.7.3 Short-term forecast issues

From one year to the next, recruitment can be revised markedly, creating instability in the forecast from one year to the next. The inter-benchmark aimed to solve this problem by setting 2019 estimates for age 1, 2 and 3. However, when moving towards a statistical catch-at-age model, a stochastic forecast should be considered instead of a deterministic forecast.

18.8 Management considerations

- Since 1 January 2016, sole fisheries in 27.7.d fall largely under the landing obligation (EU regulation nr. 2015/2438 (12/10/2015)). However, some fleets where the total landings were less than 5% of sole were exempted from the landing obligation (STECF-15-10). From 2018 onwards, all fleets active in Division 7.d fall under the sole landing obligation (STECF-17-13). However, the Commission delegated regulation (EU) 2018/2034 (EU, 2018) also describes two exemptions which allow for discarding of undersized sole in division 7.d: 1) a survival exemption for coastal otter trawlers outside nursery areas with cod end mesh size of 80–99 mm and 2) a *de minimis* exemption for vessels using trammel and gill nets (max. 3% of annual catches) and using TBB gear with a mesh size of 80–119 mm equipped with the Flemish panel (max. 3% of annual catches).
- The sole stock in Division 27.7.d is harvested in a mixed fishery with plaice in 27.7.d. Due to the minimum mesh size in the mixed beam and otter trawl fisheries (80 mm), a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

18.9 References

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Table 18.1: Sole 27.7.d - Official landings (tonnes) by country over the period 1974–2019; ICES estimates (as reported in InterCatch) for both landings and discards (tonnes) used by the working group. TAC (tonnes) represents landings until 2015. From 2016 onwards TAC represents catch.

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
1974	159	383	309	3	854	884		
1975	132	464	244	1	841	882		
1976	203	599	404		1206	1305		
1977	225	737	315		1277	1335		
1978	241	782	366		1389	1589		
1979	311	1129	402		1842	2215		
1980	302	1075	159		1536	1923		
1981	464	1513	160		2137	2477		
1982	525	1828	317	4	2674	3190	183	
1983	502	1120	419		2041	3458	100	
1984	592	1309	505		2406	3575	131	
1985	568	2545	520		3633	3837	219	
1986	858	1528	551		2937	3932	139	
1987	1100	2086	655		3841	4791	179	3850
1988	667	2057	578		3302	3853	188	3850
1989	646	1610	689		2945	3805	171	3850
1990	996	1255	785		3036	3647	300	3850
1991	904	2054	826		3784	4351	317	3850
1992	891	2187	706	10	3794	4072	251	3500
1993	917	2322	610	13	3862	4299	247	3200
1994	940	2382	701	15	4038	4383	123	3800
1995	817	2248	669	9	3743	4420	249	3800
1996	899	2322	877		4098	4797	166	3500
1997	1306	1702	933		3941	4764	143	5230
1998	541	1703	803		3047	3363	120	5230
1999	880	2251	769		3900	4135	227	4700
2000	1021	2190	621		3832	3476	180	4100
2001	1313	2482	822		4617	4025	280	4600
2002	1643	2780	976		5399	4733	390	5200
2003	1657	3475	1114	1	6247	6977.23	473	5400
2004	1485	3070	1112		5667	6283	308	5900
2005	1221	2832	567		4620	5056	319	5700
2006	1547	2627	678	0.000	4852	5040	229	5720
2007	1530	2981	801	1.000	5313	5588	379	6220
2008	1368	2880	724	0.000	4972	5256	256	6593
2009	1475	3047	760	0.000	5282	5251	360	5274
2010	1294	2476	679	0.000	4449	4269	438	4219

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
2011	1222	2281	700	0.000	4203	4225	477	4852
2012	941	2475	627	0.250	4043	4131	533	5580
2013	952	2884	605	0.000	4441	4372	466	5900
2014	1496	2507	648	0.100	4651	4655	528	4838
2015	1048	1895	468	0.000	3411	3443	294	3483
2016	799	1337	391	0.044	2527	2538	344	3258
2017	696	1178	344	0.154	2218	2228	200	2724
2018	651	1265	391	0.180	2307	2287	297	3405
2019	603	914	245	0.043	1762	1778	421	2515
2020								2797

Table 18.2: Sole 27.7.d - Summary of the InterCatch data in 2019 (imported vs. raised data; sampled vs. estimated data)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Logbook Registered Discard	Imorted_Data	Estimated_Distribution	0	NA
Landings	Imported_Data	Sampled_Distribution	1351	80
Landings	Imported_Data	Estimated_Distribution	344.2	20
Discards	Imported_Data	Sampled_Distribution	183	44
Discards	Imported_Data	Estimated_Distribution	172.2	41
Discards	Raised_Discards	Estimated_Distribution	63.45	15
BMS landing	Imported_Data	Estimated_Distribution	0	NA

Table 18.3: Sole 27.7.d - Landings percentages by gear type for 2015–2019 (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
GNS/GTR	46%	43%	43%	40%	30%
TBB	34%	40%	39%	32%	38%
OTB/OTT/SSC/SDN	15%	16%	17%	23%	27%
Other	5%	1%	1%	4%	4.1%

Table 18.4: Sole 27.7.d - Catch weights at age

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.078	NA	0.076	0.069	0.103	0.072	0.078	0.081	0.091	0.087	0.078	0.065	0.075
2	0.155	0.157	0.162	0.166	0.164	0.159	0.139	0.140	0.162	0.147	0.139	0.134	0.137
3	0.213	0.218	0.222	0.218	0.201	0.224	0.215	0.182	0.226	0.198	0.193	0.187	0.177
4	0.309	0.299	0.311	0.278	0.303	0.292	0.275	0.268	0.286	0.263	0.264	0.244	0.233
5	0.385	0.403	0.379	0.367	0.362	0.352	0.359	0.292	0.348	0.353	0.289	0.334	0.287
6	0.426	0.434	0.434	0.392	0.385	0.405	0.407	0.357	0.338	0.392	0.401	0.382	0.353
7	0.439	0.434	0.417	0.516	0.436	0.411	0.459	0.388	0.470	0.420	0.391	0.537	0.381
8	0.509	0.523	0.537	0.543	0.520	0.482	0.514	0.472	0.464	0.430	0.462	0.553	0.505
9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459	0.515	0.484
10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463	0.766	0.496
11	0.673	0.628	0.714	0.800	0.602	0.618	0.665	0.701	0.562	0.566	0.566	0.667	0.616

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.098	0.108	0.106	0.101	0.099	0.111	0.082	0.091	0.102	0.131	0.120	0.157	0.079
2	0.160	0.150	0.139	0.145	0.138	0.129	0.139	0.148	0.149	0.178	0.156	0.158	0.154
3	0.170	0.169	0.179	0.163	0.179	0.167	0.200	0.194	0.217	0.194	0.202	0.198	0.188
4	0.228	0.227	0.231	0.233	0.213	0.221	0.280	0.250	0.286	0.262	0.268	0.260	0.215
5	0.254	0.268	0.291	0.285	0.259	0.331	0.287	0.315	0.365	0.306	0.330	0.299	0.272
6	0.332	0.323	0.342	0.342	0.279	0.375	0.333	0.373	0.406	0.341	0.384	0.344	0.291
7	0.357	0.361	0.390	0.383	0.290	0.423	0.366	0.375	0.165	0.380	0.448	0.386	0.389
8	0.385	0.404	0.404	0.417	0.341	0.427	0.374	0.393	0.474	0.434	0.462	0.416	0.400
9	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.424	0.483	0.554	0.503	0.466
10	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.504	0.442	0.544	0.530	0.406
11	0.654	0.585	0.651	0.616	0.535	0.680	0.544	0.531	0.565	0.635	0.557	0.560	0.550

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.115	0.149	0.081	0.081	0.039	0.039	0.048	0.067	0.110	0.096	0.079	0.063
2	0.151	0.130	0.142	0.120	0.097	0.105	0.128	0.122	0.135	0.130	0.129	0.116
3	0.207	0.206	0.192	0.199	0.179	0.180	0.174	0.174	0.184	0.173	0.180	0.172
4	0.243	0.257	0.235	0.245	0.231	0.237	0.224	0.227	0.238	0.210	0.216	0.220
5	0.159	0.301	0.275	0.295	0.259	0.295	0.262	0.268	0.262	0.253	0.271	0.241
6	0.299	0.313	0.316	0.329	0.299	0.305	0.322	0.282	0.276	0.306	0.286	0.246
7	0.377	0.354	0.337	0.334	0.342	0.378	0.335	0.321	0.324	0.309	0.296	0.298
8	0.392	0.388	0.354	0.382	0.322	0.432	0.393	0.340	0.376	0.344	0.274	0.324
9	0.420	0.385	0.417	0.378	0.381	0.392	0.408	0.405	0.351	0.422	0.325	0.271
10	0.449	0.384	0.462	0.430	0.443	0.462	0.475	0.355	0.407	0.415	0.374	0.339
11	0.492	0.376	0.433	0.470	0.373	0.481	0.450	0.461	0.546	0.573	0.430	0.408

Table 18.5: Sole 27.7.d - Stock weights at age

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.059	0.070	0.067	0.065	0.070	0.072	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.114	0.135	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138	0.144	0.130	0.116	0.126	0.155
3	0.167	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225	0.199	0.189	0.161	0.129	0.176
4	0.217	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279	0.277	0.246	0.215	0.220	0.258
5	0.263	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.400	0.380	0.305	0.366	0.273	0.234	0.286
6	0.306	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384	0.454	0.377	0.316	0.333	0.308
7	0.347	0.406	0.403	0.436	0.403	0.417	0.477	0.480	0.476	0.410	0.405	0.545	0.368	0.357	0.366
8	0.384	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449	0.459	0.560	0.530	0.330	0.391
9	0.418	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474	0.430	0.559	0.461	0.614	0.438
10	0.450	0.522	0.529	0.611	0.512	0.536	0.636	0.536	0.507	0.451	0.528	0.813	0.470	0.382	0.466
11	0.530	0.601	0.627	0.780	0.576	0.616	0.750	0.714	0.577	0.620	0.527	0.566	0.612	0.629	0.630

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.050	0.050	0.050	0.050	0.050	0.050	0.118	0.092	0.102	0.101	0.071	0.107	0.130	0.081	0.081
2	0.139	0.140	0.128	0.122	0.127	0.136	0.155	0.110	0.132	0.128	0.119	0.146	0.111	0.124	0.081
3	0.165	0.158	0.180	0.148	0.157	0.179	0.212	0.171	0.186	0.169	0.157	0.190	0.180	0.175	0.186
4	0.220	0.233	0.205	0.208	0.216	0.209	0.280	0.241	0.249	0.268	0.181	0.239	0.244	0.212	0.232
5	0.264	0.299	0.253	0.402	0.226	0.258	0.345	0.271	0.292	0.297	0.240	0.266	0.290	0.251	0.267
6	0.317	0.374	0.277	0.440	0.223	0.254	0.432	0.318	0.318	0.363	0.251	0.329	0.321	0.263	0.309
7	0.376	0.363	0.298	0.395	0.231	0.301	0.298	0.303	0.487	0.393	0.302	0.370	0.416	0.292	0.339
8	0.404	0.357	0.324	0.554	0.253	0.234	0.531	0.371	0.498	0.444	0.341	0.406	0.412	0.312	0.329
9	0.563	0.450	0.336	0.443	0.256	0.326	0.332	0.475	0.584	0.507	0.388	0.445	0.372	0.289	0.458
10	0.494	0.372	0.323	0.420	0.301	0.404	0.529	0.312	0.586	0.585	0.377	0.516	0.439	0.405	0.505
11	0.654	0.577	0.512	0.682	0.420	0.417	0.507	0.602	0.525	0.609	0.535	0.530	0.447	0.362	0.441

age	2012	2013	2014	2015	2016	2017	2018	2019
1	0.044	0.044	0.052	0.068	0.127	0.093	0.080	0.041
2	0.057	0.082	0.117	0.070	0.120	0.122	0.116	0.113
3	0.151	0.160	0.160	0.164	0.156	0.168	0.165	0.173
4	0.223	0.239	0.210	0.213	0.222	0.208	0.205	0.226
5	0.240	0.301	0.259	0.254	0.259	0.236	0.265	0.233
6	0.275	0.315	0.310	0.279	0.259	0.287	0.273	0.242
7	0.381	0.393	0.288	0.301	0.303	0.289	0.283	0.316
8	0.342	0.472	0.360	0.341	0.348	0.336	0.301	0.285
9	0.381	0.433	0.336	0.460	0.295	0.381	0.314	0.289
10	0.519	0.456	0.425	0.384	0.384	0.415	0.343	0.311
11	0.345	0.526	0.487	0.472	0.502	0.565	0.443	0.347

Table 18.6: Sole 27.7.d - Tuning series 1: new Belgian commercial beam trawl CPUE (2004–2019)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2004	1	0.894	0.338	0.497	0.178	0.040	0.038
2005	1	0.516	0.474	0.125	0.090	0.067	0.034
2006	1	0.471	0.402	0.374	0.156	0.150	0.076
2007	1	0.747	0.348	0.144	0.277	0.110	0.137
2008	1	0.923	0.864	0.199	0.137	0.117	0.064
2009	1	0.695	0.684	0.449	0.111	0.064	0.068
2010	1	0.697	0.222	0.362	0.184	0.064	0.036
2011	1	1.005	0.313	0.176	0.131	0.091	0.028
2012	1	1.584	0.997	0.272	0.084	0.100	0.098
2013	1	0.473	0.918	0.714	0.213	0.102	0.121
2014	1	0.569	0.724	0.879	0.511	0.134	0.065
2015	1	0.591	0.564	0.630	0.770	0.536	0.185
2016	1	0.565	0.355	0.439	0.413	0.424	0.321
2017	1	0.802	0.497	0.255	0.290	0.261	0.358
2018	1	0.629	0.913	0.368	0.289	0.230	0.205
2019	1	1.362	0.498	0.854	0.197	0.146	0.071

Table 18.7: Sole 27.7.d - Tuning series 2: new UK (E&W) commercial beam trawl (1986–2019)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
1986	1	162.44	112.77	31.47	32.33	44.26	1.34
1987	1	78.60	106.47	73.61	13.82	10.83	27.91
1988	1	225.13	45.09	50.32	31.68	7.17	9.20
1989	1	61.47	113.52	14.34	24.98	18.22	3.99
1990	1	197.36	28.74	39.85	8.52	9.12	9.12
1991	1	57.20	80.19	3.44	12.62	2.08	3.04
1992	1	138.66	21.81	44.95	2.99	5.44	1.73
1993	1	67.48	66.39	10.49	15.97	1.59	3.25
1994	1	85.69	47.31	37.21	9.03	14.93	1.46
1995	1	34.65	71.43	34.87	30.66	5.95	12.15
1996	1	90.22	28.52	60.65	30.36	24.18	6.29
1997	1	109.13	52.24	13.98	41.26	16.75	16.05
1998	1	93.30	53.69	35.91	12.20	28.49	15.87
1999	1	181.49	63.89	26.36	19.24	7.43	15.89
2000	1	104.70	100.41	32.05	15.14	10.64	4.05
2001	1	120.75	45.49	50.43	19.82	8.54	8.82
2002	1	211.47	104.63	33.78	25.88	10.77	8.74
2003	1	118.43	80.17	34.77	14.58	17.19	8.05
2004	1	282.90	66.29	39.98	20.95	6.17	11.68
2005	1	89.39	188.76	34.80	36.23	17.73	8.73

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2006	1	163.34	52.87	88.06	14.78	13.10	6.32
2007	1	195.95	74.11	22.34	66.31	15.48	15.20
2008	1	270.29	81.46	17.93	10.87	15.08	5.54
2009	1	46.24	111.19	40.27	6.24	5.08	10.81
2010	1	103.83	34.78	69.08	23.20	8.14	5.34
2011	1	99.27	48.73	13.52	30.40	8.83	2.05
2012	1	241.22	44.42	25.58	4.38	11.91	6.36
2013	1	90.10	164.95	30.00	17.55	5.54	7.43
2014	1	61.86	139.85	81.08	12.10	7.26	0.87
2015	1	83.98	44.78	86.01	64.58	9.00	5.78
2016	1	123.84	73.89	25.59	50.21	35.62	10.40
2017	1	103.74	49.10	30.84	13.11	30.97	27.45
2018	1	58.32	117.89	25.02	16.19	6.69	15.78
2019	1	99.86	26.44	75.78	11.51	9.05	5.67

Table 18.8: Sole 27.7.d - Tuning series 3: French commercial otter trawl (2002–2019)

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2002	1	2.42	1.09	0.47	0.38	0.14	0.04
2003	1	2.04	0.73	0.59	0.18	0.23	0.08
2004	1	3.42	1.00	0.69	0.42	0.24	0.17
2005	1	1.13	1.24	0.54	0.41	0.16	0.15
2006	1	0.92	0.96	1.18	0.39	0.27	0.18
2007	1	3.15	1.28	0.67	0.86	0.23	0.11
2008	1	3.44	2.01	0.49	0.47	0.61	0.32
2009	1	2.23	2.54	0.58	0.30	0.18	0.22
2010	1	1.57	2.13	1.71	0.61	0.16	0.32
2011	1	3.98	1.18	0.94	1.00	0.44	0.10
2012	1	7.82	5.60	1.36	1.30	0.77	0.29
2013	1	5.03	4.04	1.69	0.76	0.73	0.73
2014	1	2.42	4.86	2.81	1.37	0.51	0.36
2015	1	1.02	1.54	2.03	1.41	0.74	0.33
2016	1	1.96	1.09	1.20	1.18	0.76	0.49
2017	1	1.73	1.23	0.76	0.85	0.74	0.65
2018	1	1.42	1.62	0.87	0.84	0.57	0.57
2019	1	2.63	0.99	0.72	0.37	0.31	0.34

Table 18.9: Sole 27.7.d - Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2019)

	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

Table 18.10: Sole 27.7.d - Tuning series 5: UK (E&W) young fish survey (1987–2006)

	Effort	Age1
1987	1	1.38
1988	1	1.87
1989	1	0.62
1990	1	1.9
1991	1	3.69
1992	1	1.5
1993	1	1.33
1994	1	2.68
1995	1	2.91
1996	1	0.57
1997	1	1.12
1998	1	1.12
1999	1	1.47
2000	1	2.47
2001	1	0.38
2002	1	4.15
2003	1	1.44
2004	1	2.72
2005	1	4.07
2006	1	2.21

Table 18.11: Sole 27.7.d - Tuning series 6: French young fish survey (1987–2019) funded by EDF (noursom)

	Effort	Age1
1987	1	0.07
1988	1	0.17
1989	1	0.14
1990	1	0.54
1991	1	0.38
1992	1	0.22
1993	1	0.03
1994	1	0.7
1995	1	0.28
1996	1	0.15
1997	1	0.03
1998	1	0.1
1999	1	0.35
2000	1	0.31
2001	1	1.21
2002	1	0.11

	Effort	Age1
2003	1	0.32
2004	1	0.15
2005	1	0.82
2006	1	0.83
2007	1	0.08
2008	1	0.06
2009	1	2.78
2010	1	0.1
2011	1	0.32
2012	1	0.35
2013	1	0.052
2014	1	0.04
2015	1	0.09
2016	1	0.04
2017	1	0.05
2018	1	0.03
2019	1	0.45

Table 18.12: Sole 27.7.d - XSA diagnostics of the 2020 assessment

FLR XSA Diagnostics 2020-04-25 15:47:05
CPUE data from indices
Catch data for 38 years. 1982 to 2019. Ages 1 to 11.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE-CBT-CPUE	3	8	2004	2019	0	1
2	UK(E&W)-CBT-new	3	8	1986	2019	0	1
3	FR-COTB	3	8	2002	2019	0	1
4	UK(E&W)-BTS-Q3	1	6	1989	2019	0.5	0.75
5	UK(E&W)-YFS	1	1	1987	2006	0.5	0.75
6	FR-YFS	1	1	1987	2019	0.5	0.75

Time series weights :
Tapered time weighting not applied
Catchability analysis :
Catchability independent of size for all ages
Catchability independent of age for ages > 7
Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.
S.E. of the mean to which the estimates are shrunk = 2
Minimum standard error for population
estimates derived from each fleet = 0.3
prior weighting not applied
Regression weights

age \ year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.019	0.005	0.014	0.018	0.051	0.015	0.043	0.017	0.027	0.006
2	0.225	0.189	0.132	0.180	0.139	0.176	0.073	0.086	0.078	0.084
3	0.353	0.308	0.271	0.244	0.334	0.215	0.213	0.112	0.172	0.135
4	0.446	0.344	0.341	0.289	0.411	0.270	0.188	0.206	0.168	0.157
5	0.376	0.383	0.278	0.233	0.266	0.293	0.230	0.187	0.163	0.130
6	0.366	0.301	0.434	0.213	0.236	0.225	0.194	0.217	0.183	0.117
7	0.279	0.178	0.176	0.388	0.238	0.223	0.133	0.128	0.197	0.091
8	0.334	0.234	0.195	0.173	0.471	0.236	0.167	0.121	0.145	0.089
9	0.191	0.231	0.191	0.124	0.166	0.220	0.328	0.127	0.082	0.101
10	0.177	0.078	0.103	0.149	0.100	0.142	0.297	0.279	0.122	0.069
11	0.177	0.078	0.103	0.149	0.100	0.142	0.297	0.279	0.122	0.069

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10	11
2010	61953	40879	16511	9012	10049	5697	1393	1082	1950	534	2214
2011	46783	54981	29541	10492	5222	6240	3577	953	701	1457	2475
2012	23808	42134	41194	19647	6731	3222	4181	2708	682	503	2956
2013	17334	21240	33417	28415	12646	4613	1888	3171	2016	510	1378
2014	20786	15411	16045	23688	19254	9062	3372	1159	2413	1612	3231
2015	30112	17870	12134	10391	14205	13350	6478	2405	655	1849	2050

2016 15734 26847 13561 8855 7180 9589 9642 4690 1720 476 927
2017 38772 13632 22590 9913 6640 5163 7147 7637 3590 1121 661
2018 37595 34499 11320 18267 7297 4985 3760 5691 6125 2862 2963
2019 99135 33108 28870 8624 13979 5608 3755 2795 4456 5105 3677

Estimated population abundance at 1st Jan 2020

	age										
year	1	2	3	4	5	6	7	8	9	10	11
2020	0	89172	27554	22834	6669	11111	4513	3104	2315	3647	4313

Fleet: BE-CBT-CPUE
Log catchability residuals.

	year															
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3	-0.161	-0.038	0.062	-0.156	-0.125	0.286	0.192	-0.045	0.060	-0.952	0.009	0.270	0.113	-0.095	0.381	0.200
4	-0.198	-0.417	0.127	0.168	0.440	0.003	-0.431	-0.286	0.243	-0.232	-0.231	0.278	-0.064	0.168	0.147	0.286
5	0.248	-0.752	-0.201	-0.437	0.189	0.259	-0.113	-0.177	-0.044	0.269	0.072	0.056	0.347	-0.138	0.123	0.299
6	0.051	-0.776	-0.004	0.100	0.117	0.240	-0.154	-0.615	-0.336	0.132	0.343	0.360	0.053	0.330	0.346	-0.187
7	-0.501	-0.480	0.171	0.186	-0.221	-0.032	0.203	-0.436	-0.498	0.415	0.038	0.765	0.090	-0.099	0.450	-0.054
8	-0.513	-0.148	-0.001	0.526	0.173	-0.422	-0.094	-0.265	-0.075	-0.033	0.491	0.698	0.548	0.148	-0.104	-0.480

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-10.0463	-9.9199	-9.8892	-9.9627	-10.0074	-10.0074
S.E_Logq	0.3203	0.3203	0.3203	0.3203	0.3203	0.3203

Fleet: UK(E&W)-CBT-new
Log catchability residuals.

	year																	
age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
3	0.601	0.402	0.762	0.521	0.493	-0.085	-0.315	-0.863	-0.603	-0.822	-0.298	0.278	0.053	0.257	0.404	0.038	0.304	0.027
4	0.323	0.774	0.460	0.770	0.483	0.097	-0.466	-0.587	-0.730	-0.344	-0.431	-0.184	0.214	0.298	0.227	0.118	0.423	-0.211
5	0.331	0.484	0.731	0.167	0.547	-0.870	0.204	-0.516	-0.528	-0.316	0.159	-0.241	0.227	0.232	0.323	0.237	0.470	0.023
6	0.377	0.082	0.107	0.577	0.406	0.053	-0.365	-0.349	-0.090	-0.169	0.162	0.361	0.439	0.163	0.228	0.368	0.085	0.228
7	0.157	-0.166	0.050	-0.016	0.114	-0.410	-0.159	-0.391	0.015	0.075	0.151	0.177	0.499	0.613	0.065	0.133	0.260	0.377
8	-0.309	-0.091	0.017	-0.231	-0.506	-0.698	-0.182	-0.367	-0.087	0.042	0.527	0.083	0.455	0.189	0.410	0.079	0.385	0.219

	year															
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3	0.474	-0.005	0.789	0.291	0.433	-0.639	0.073	-0.575	-0.036	-0.825	-0.425	0.104	0.381	-0.355	-0.211	-0.628
4	0.089	0.578	0.014	0.537	-0.006	0.102	-0.369	-0.230	-0.952	-0.033	0.041	-0.340	0.282	-0.230	0.016	-0.734
5	-0.118	0.123	0.506	-0.147	-0.064	0.002	0.384	-0.589	-0.254	-0.747	-0.157	0.218	-0.341	-0.097	-0.412	0.030
6	0.143	0.546	-0.128	0.902	-0.185	-0.406	0.007	0.156	-1.058	-0.132	-1.168	0.114	0.178	-0.534	-0.304	-0.795
7	0.005	0.566	0.108	0.600	0.105	-0.190	0.516	-0.394	-0.251	-0.123	-0.502	-0.947	-0.012	0.145	-0.712	-0.460
8	0.682	0.867	-0.113	0.702	0.101	0.114	0.373	-0.505	-0.435	-0.448	-1.448	-0.393	-0.506	-0.046	-0.293	-0.633

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-4.9241	-4.9279	-5.1352	-5.2870	-5.4746	-5.4746
S.E_Logq	0.4272	0.4272	0.4272	0.4272	0.4272	0.4272

Fleet: FR-COTB
Log catchability residuals.
year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
3	-0.176	-0.045	0.048	-0.387	-0.401	0.151	0.058	0.319	-0.129	0.198	0.524	0.279	0.324	-0.317	0.224	-0.459	0.063
4	-0.277	-1.046	-0.241	-0.583	-0.130	0.342	0.156	0.187	0.702	-0.087	0.841	0.122	0.545	0.154	-0.070	-0.053	-0.408
5	-0.057	-0.305	-0.430	-0.294	-0.058	0.094	0.085	-0.490	0.434	0.493	0.560	0.125	0.229	0.220	0.347	-0.052	-0.022
6	-0.591	-0.621	-0.222	-0.391	-0.218	0.102	0.219	0.103	-0.086	0.287	1.272	0.273	0.198	-0.166	-0.028	0.274	0.282
7	-0.615	-0.469	0.226	-0.674	-0.306	-0.141	0.366	-0.063	0.055	0.075	0.478	1.319	0.310	0.022	-0.391	-0.121	0.293
8	-1.534	-0.924	-0.080	0.271	-0.204	-0.759	0.718	-0.312	1.026	-0.057	-0.055	0.700	1.138	0.212	-0.093	-0.321	-0.146

year

age	2019
3	-0.275
4	-0.155
5	-0.878
6	-0.688
7	-0.366
8	0.021

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-8.9137	-8.7920	-8.8835	-8.8318	-8.9426	-8.9426
S.E_Logq	0.4554	0.4554	0.4554	0.4554	0.4554	0.4554

Fleet: UK(E&W)-BTS-Q3
Log catchability residuals.

year

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	-0.647	0.110	-0.005	-2.228	-1.935	-0.170	-0.180	-0.258	0.875	-0.688	1.331	0.133	-0.156	1.143	0.338	0.659	1.195
2	0.232	-0.592	0.102	-0.389	0.025	-0.976	-0.145	-0.188	-0.204	0.160	-0.328	0.456	0.179	-0.223	0.498	-0.172	-0.472
3	0.684	-0.388	-0.254	0.043	0.043	0.032	-0.868	-0.299	-0.200	-0.469	0.193	0.183	0.391	-0.205	-0.236	-0.082	-0.537
4	0.101	0.482	-0.118	-0.352	0.635	0.086	-0.237	-0.566	-0.316	-0.245	-0.247	0.326	-0.075	0.534	-0.320	-0.249	0.112
5	0.072	-0.036	0.262	-0.043	0.351	0.396	-0.265	-0.236	-1.078	-0.455	-0.264	0.323	0.253	-0.754	0.283	0.044	0.306
6	-0.755	0.086	0.073	0.403	0.208	-0.628	0.091	-0.166	-0.623	-0.773	0.157	0.047	0.024	-0.218	-0.385	0.340	0.028

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	-0.282	-1.033	-0.790	1.279	-0.130	-0.053	-1.426	-1.995	1.407	1.008	0.766	0.855	0.264	0.617
2	0.635	0.108	-0.585	0.293	0.202	-0.190	-1.038	-0.410	0.492	0.634	0.602	0.507	0.451	0.335
3	-0.116	0.449	-0.260	0.190	-0.247	0.194	-0.833	0.057	0.649	0.136	0.639	0.441	0.277	0.393
4	0.157	-0.231	0.506	0.297	-0.275	-0.491	-0.366	0.246	0.708	-0.206	0.225	-0.044	0.672	-0.752
5	0.068	-0.118	-0.759	0.991	0.233	-0.718	-0.504	0.093	0.148	0.348	0.639	0.292	-0.019	0.145
6	-0.480	0.123	0.004	-0.100	0.813	0.640	-0.520	0.038	0.268	-0.398	0.286	0.233	0.585	0.598

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	1	2	3	4	5	6
Mean_Logq	-8.0204	-7.1913	-7.5452	-7.9839	-8.1580	-8.1659
S.E_Logq	0.5527	0.5527	0.5527	0.5527	0.5527	0.5527

Fleet: UK(E&W)-YFS
Log catchability residuals.

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.711	0.094	-0.506	-0.415	0.526	-0.386	0.27	0.418	0.837	-0.766	-0.499	-0.038	-0.146	0.052	-1.724	0.306	0.023	0.842	0.552

year

age	2006
1	-0.151

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	1
Mean_Logq	-9.7419
S.E_Logq	0.6190

Fleet: FR-YFS
Log catchability residuals.

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.021	-0.013	0.297	0.618	0.543	-0.015	-1.231	1.366	0.786	0.19	-1.828	-0.163	0.71	0.268	1.725	-1.033	0.81	0.235	1.241

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	1.161	-0.49	-0.918	2.377	-1.229	0.205	0.977	-0.611	-1.034	-0.616	-0.76	-1.455	-1.929	-0.204

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	1
Mean_Logq	-12.0328
S.E_Logq	1.0294

Terminal year survivor and F summaries:

Age 1 Year class =2018

source

	scaledWts	survivors	yrcls
UK(E&W)-BTS-Q3	0.455	165311	2018
FR-YFS	0.428	72732	2018
fshk	0.117	17108	2018

Age 2 Year class =2017

source

	scaledWts	survivors	yrcls
UK(E&W)-BTS-Q3	0.944	38518	2017
fshk	0.056	20595	2017

Age 3 Year class =2016

source

	scaledWts	survivors	yrcls
BE-CBT-CPUE	0.320	27880	2016
UK(E&W)-CBT-new	0.135	12189	2016
FR-COTB	0.347	17345	2016
UK(E&W)-BTS-Q3	0.190	33827	2016
fshk	0.009	14088	2016

Age 4 Year class =2015

source

	scaledWts	survivors	yrcls
BE-CBT-CPUE	0.402	8878	2015
UK(E&W)-CBT-new	0.189	3202	2015
FR-COTB	0.166	5714	2015
UK(E&W)-BTS-Q3	0.233	3143	2015
fshk	0.011	4011	2015

Age 5 Year class =2014

source

	scaledWts	survivors	yrcls
BE-CBT-CPUE	0.366	14978	2014
UK(E&W)-CBT-new	0.221	11453	2014

```
FR-COTB          0.234    4619  2014
UK(E&W)-BTS-Q3    0.170    12843  2014
fshk             0.010    6000  2014
 Age 6 Year class =2013
source
          scaledWts survivors yrcls
BE-CBT-CPUE       0.347    3743  2013
UK(E&W)-CBT-new    0.210    2038  2013
FR-COTB          0.194    2269  2013
UK(E&W)-BTS-Q3    0.237    8205  2013
fshk             0.012    2383  2013
 Age 7 Year class =2012
source
          scaledWts survivors yrcls
BE-CBT-CPUE       0.370    2941  2012
UK(E&W)-CBT-new    0.388    1960  2012
FR-COTB          0.228    2153  2012
fshk             0.015    1456  2012
 Age 8 Year class =2011
source
          scaledWts survivors yrcls
BE-CBT-CPUE       0.496    1432  2011
UK(E&W)-CBT-new    0.322    1229  2011
FR-COTB          0.161    2364  2011
fshk             0.021     837  2011
 Age 9 Year class =2010
source
    scaledWts survivors yrcls
fshk       1    1901  2010
 Age 10 Year class =2009
source
    scaledWts survivors yrcls
fshk       1    2763  2009

Survivors
Age =  1 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2018
Fleet =  FR-YFS
              1
Survivors   72732.000
Raw weights    0.911
Fleet =  fshk
              1
Survivors   17108.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               1
Survivors   165311.000
Raw weights     0.969
    Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "FR-YFS"        "72732"     "1.045"   "Inf"     "Inf"     "1" "0.428"     "0.007"
[2,] "fshk"          "17108"     "1.994"   "Inf"     "Inf"     "1" "0.117"     "0.031"
[3,] "UK(E&W)-BTS-Q3" "165311"     "1.013"   "Inf"     "Inf"     "1" "0.455"     "0.003"
```

```
Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "89172"  ""       ""       ""       "0.006"

Age =  2 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2017
Fleet =  FR-YFS
              1
Survivors   4003.00
Raw weights    0.82
Fleet =  fshk
               2
Survivors   20595.00
Raw weights     0.25
Fleet =  UK(E&W)-BTS-Q3
                2        1
Survivors   38518.000 35870.000
Raw weights     4.251     0.873
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "FR-YFS"         "4003"       "1.045"   "Inf"     "Inf"     "1" "0.132"     "0.471"
[2,] "fshk"           "20595"      "1.918"   "Inf"     "Inf"     "1" "0.04"      "0.11"
[3,] "UK(E&W)-BTS-Q3" "38054"      "0.423"   "0.027"   "0.064"   "2" "0.827"     "0.061"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "27554"  ""       ""       ""       "0.084"

Age =  3 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2016
Fleet =  BE-CBT-CPUE
                3
Survivors   27880.000
Raw weights     8.931
Fleet =  FR-COTB
                3
Survivors   17345.000
Raw weights     9.712
Fleet =  FR-YFS
               1
Survivors   5327.000
Raw weights    0.728
Fleet =  fshk
               3
Survivors   14088.00
Raw weights     0.25
Fleet =  UK(E&W)-BTS-Q3
                3        2        1
Survivors   33827.000 35841.000 53673.000
Raw weights     5.298     3.737     0.775
Fleet =  UK(E&W)-CBT-new
                3
Survivors   12189.000
Raw weights     3.763
```

```
   Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "27880"      "0.313"   "Inf"     "Inf"     "1" "0.269"     "0.112"
[2,] "FR-COTB"         "17345"      "0.3"     "Inf"     "Inf"     "1" "0.293"     "0.174"
[3,] "FR-YFS"          "5327"       "1.045"   "Inf"     "Inf"     "1" "0.022"     "0.481"
[4,] "fshk"            "14088"      "1.87"    "Inf"     "Inf"     "1" "0.008"     "0.21"
[5,] "UK(E&W)-BTS-Q3"  "35865"      "0.293"   "0.086"   "0.294"   "3" "0.296"     "0.088"
[6,] "UK(E&W)-CBT-new" "12189"      "0.482"   "Inf"     "Inf"     "1" "0.113"     "0.239"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "22834"  ""      ""      ""       "0.135"

Age =  4 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2015
Fleet =  BE-CBT-CPUE
               4       3
Survivors   8878.000 9764.000
Raw weights    9.495    7.352
Fleet =  FR-COTB
               4       3
Survivors   5714.000 7102.000
Raw weights    3.929    7.994
Fleet =  FR-YFS
               1
Survivors   3118.000
Raw weights    0.579
Fleet =  fshk
              4
Survivors   4011.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               4       3        2        1
Survivors   3143.000 8795.000 11073.000 14342.000
Raw weights    5.506    4.361     3.052     0.617
Fleet =  UK(E&W)-CBT-new
               4       3
Survivors   3202.000 5398.000
Raw weights    4.467    3.097
    Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "9254"       "0.217"   "0.047"   "0.217"   "2" "0.332"     "0.116"
[2,] "FR-COTB"         "6611"       "0.253"   "0.102"   "0.403"   "2" "0.235"     "0.158"
[3,] "FR-YFS"          "3118"       "1.045"   "Inf"     "Inf"     "1" "0.011"     "0.31"
[4,] "fshk"            "4011"       "1.849"   "Inf"     "Inf"     "1" "0.005"     "0.249"
[5,] "UK(E&W)-BTS-Q3"  "6232"       "0.236"   "0.334"   "1.415"   "4" "0.267"     "0.167"
[6,] "UK(E&W)-CBT-new" "3965"       "0.325"   "0.257"   "0.791"   "2" "0.149"     "0.252"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "6669"   ""      ""      ""       "0.157"

Age =  5 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2014
Fleet =  BE-CBT-CPUE
                5        4        3
Survivors   14978.000 12866.000 10100.000
```

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Raw weights    9.304    8.254    6.784
Fleet =  FR-COTB
             5       4       3
Survivors   4619.000 7391.000 7020.000
Raw weights    5.939    3.415    7.376
Fleet =  FR-YFS
             1
Survivors   6000.000
Raw weights    0.557
Fleet =  fshk
            5
Survivors   6000.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
              5        4        3        2        1
Survivors   12843.000 21759.000 17273.000 20283.000 30438.000
Raw weights    4.326    4.786    4.024    2.854    0.593
Fleet =  UK(E&W)-CBT-new
              5        4       3
Survivors   11453.000 11285.000 7791.000
Raw weights    5.613    3.883    2.858
    Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "12746"      "0.178"   "0.112"   "0.629"   "3" "0.344"     "0.114"
[2,] "FR-COTB"        "6114"      "0.213"   "0.148"   "0.695"   "3" "0.236"     "0.224"
[3,] "FR-YFS"         "6000"      "1.045"   "Inf"     "Inf"     "1" "0.008"     "0.228"
[4,] "fshk"           "6000"      "1.874"   "Inf"     "Inf"     "1" "0.004"     "0.228"
[5,] "UK(E&W)-BTS-Q3"  "17928"      "0.21"    "0.115"   "0.548"   "5" "0.234"     "0.082"
[6,] "UK(E&W)-CBT-new" "10428"      "0.252"   "0.113"   "0.448"   "3" "0.174"     "0.138"
 Weighted prediction:
   Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "11111"  ""      ""      ""       "0.13"

Age =  6 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2013
Fleet =  BE-CBT-CPUE
             6       5       4       3
Survivors   3743.000 5104.000 5340.000 5053.000
Raw weights    7.248    8.001    6.828    5.073
Fleet =  FR-COTB
             6       5       4       3
Survivors   2269.000 4414.000 4279.000 5647.000
Raw weights    4.057    5.108    2.825    5.516
Fleet =  FR-YFS
             1
Survivors   1605.000
Raw weights    0.362
Fleet =  fshk
            6
Survivors   2383.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
             6       5      4       3       2       1
Survivors   8205.000 4428.000 4317.00 8550.000 8509.000 18431.000
```

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Raw weights    4.963    3.721    3.96    3.009    1.925    0.386
Fleet =  UK(E&W)-CBT-new
               6       5       4       3
Survivors   2038.000 2990.000 3584.000 6604.000
Raw weights    4.382    4.827    3.212    2.137
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "4743"      "0.161"   "0.083"   "0.516"   "4" "0.349"     "0.112"
[2,] "FR-COTB"        "4068"      "0.197"   "0.196"   "0.995"   "4" "0.225"     "0.129"
[3,] "FR-YFS"         "1605"      "1.045"   "Inf"     "Inf"     "1" "0.005"     "0.3"
[4,] "fshk"           "2383"      "1.886"   "Inf"     "Inf"     "1" "0.003"     "0.212"
[5,] "UK(E&W)-BTS-Q3"  "6447"      "0.194"   "0.159"   "0.82"    "6" "0.231"     "0.083"
[6,] "UK(E&W)-CBT-new" "3115"      "0.223"   "0.218"   "0.978"   "4" "0.187"     "0.166"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "4513"   ""      ""      ""       "0.117"

Age =  7 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2012
Fleet =  BE-CBT-CPUE
               7       6       5       4       3
Survivors   2941.000 4385.000 2703.000 2911.000 4065.000
Raw weights    6.271    6.197    6.682    5.809    4.309
Fleet =  FR-COTB
               7       6       5       4       3
Survivors   2153.000 4113.000 2946.000 2893.000 2260.000
Raw weights    3.856    3.469    4.266    2.403    4.685
Fleet =  FR-YFS
              1
Survivors   1685.00
Raw weights    0.33
Fleet =  fshk
              7
Survivors   1456.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               6       5       4       3       2       1
Survivors   5569.000 4157.000 3888.000 3557.000 5075.000 422.000
Raw weights    4.243    3.107    3.369    2.556    1.696   0.352
Fleet =  UK(E&W)-CBT-new
               7       6       5       4       3
Survivors   1960.000 2289.000 2816.000 4115.000 3444.000
Raw weights    6.567    3.747    4.031    2.733    1.815
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "3286"      "0.151"   "0.098"   "0.649"   "5" "0.354"     "0.086"
[2,] "FR-COTB"        "2743"      "0.186"   "0.116"   "0.624"   "5" "0.226"     "0.102"
[3,] "FR-YFS"         "1685"      "1.045"   "Inf"     "Inf"     "1" "0.004"     "0.161"
[4,] "fshk"           "1456"      "1.911"   "Inf"     "Inf"     "1" "0.003"     "0.184"
[5,] "UK(E&W)-BTS-Q3"  "4198"      "0.193"   "0.175"   "0.907"   "6" "0.185"     "0.068"
[6,] "UK(E&W)-CBT-new" "2566"      "0.195"   "0.133"   "0.682"   "5" "0.228"     "0.108"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "3104"   ""      ""      ""       "0.091"
```

Age = 8 . Catchability constand w.r.t. time and dependant on age
Year class = 2011
Fleet = BE-CBT-CPUE

	8	7	6	5	4	3
Survivors	1432.000	3630.000	3219.000	3275.000	3055.00	2334.000
Raw weights	6.017	5.162	4.931	5.093	4.08	2.686

Fleet = FR-COTB

	8	7	6	5	4	3
Survivors	2364.000	3102.000	3045.00	3275.000	2700.000	3199.00
Raw weights	1.955	3.174	2.76	3.251	1.688	2.92

Fleet = FR-YFS

	1
Survivors	6145.000
Raw weights	0.198

Fleet = fshk

	8
Survivors	837.00
Raw weights	0.25

Fleet = UK(E&W)-BTS-Q3

	6	5	4	3	2	1
Survivors	2922.000	4382.000	1884.000	4429.000	1536.000	556.000
Raw weights	3.376	2.368	2.366	1.593	1.014	0.211

Fleet = UK(E&W)-CBT-new

	8	7	6	5	4	3
Survivors	1229.000	1135.000	1356.000	1645.000	1647.000	1513.000
Raw weights	3.911	5.405	2.981	3.073	1.919	1.131

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-CPUE"	"2669"	"0.148"	"0.154"	"1.041"	"6"	"0.38"	"0.077"
[2,]	"FR-COTB"	"2995"	"0.188"	"0.047"	"0.25"	"6"	"0.214"	"0.069"
[3,]	"FR-YFS"	"6145"	"1.045"	"Inf"	"Inf"	"1"	"0.003"	"0.034"
[4,]	"fshk"	"837"	"1.913"	"Inf"	"Inf"	"1"	"0.003"	"0.228"
[5,]	"UK(E&W)-BTS-Q3"	"2812"	"0.199"	"0.196"	"0.985"	"6"	"0.149"	"0.074"
[6,]	"UK(E&W)-CBT-new"	"1337"	"0.187"	"0.066"	"0.353"	"6"	"0.251"	"0.149"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"2315"	""	""	""	"0.089"

Age = 9 . Catchability constand w.r.t. time and dependant on age
Year class = 2010
Fleet = BE-CBT-CPUE

	8	7	6	5	4	3
Survivors	3285.000	3304.000	3846.000	3855.000	2894.000	1407.000
Raw weights	5.145	4.728	4.622	4.482	3.116	2.245

Fleet = FR-COTB

	8	7	6	5	4	3
Survivors	3150.000	3230.000	3546.000	4544.000	6288.000	4821.000
Raw weights	1.672	2.907	2.587	2.861	1.289	2.441

Fleet = FR-YFS

	1
Survivors	4477.000
Raw weights	0.176

Fleet = fshk

	9

```
Survivors   1901.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               6       5       4       3       2       1
Survivors   4854.000 5164.000 7403.000 3860.000 1291.00 3457.000
Raw weights    3.165    2.084    1.807    1.332    0.89    0.187
Fleet =  UK(E&W)-CBT-new
               8       7       6       5       4       3
Survivors   2719.000 4214.000 4357.000 4535.000 3797.000 1598.000
Raw weights    3.344    4.951    2.795    2.704    1.466    0.946
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "3175"      "0.149"   "0.124"   "0.832"   "6" "0.379"     "0.115"
[2,] "FR-COTB"         "4021"      "0.191"   "0.098"   "0.513"   "6" "0.214"     "0.092"
[3,] "FR-YFS"          "4477"      "1.045"   "Inf"     "Inf"     "1" "0.003"     "0.083"
[4,] "fshk"            "1901"      "1.902"   "Inf"     "Inf"     "1" "0.004"     "0.185"
[5,] "UK(E&W)-BTS-Q3"  "4529"      "0.203"   "0.202"   "0.995"   "6" "0.147"     "0.082"
[6,] "UK(E&W)-CBT-new" "3669"      "0.189"   "0.124"   "0.656"   "6" "0.252"     "0.1"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "3647"   ""      ""      ""       "0.101"

Age =  10 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2009
Fleet =  BE-CBT-CPUE
               8      7      6       5       4      3
Survivors   4998.000 4717.00 6183.00 4635.000 3419.000 4579.00
Raw weights    5.011    4.58    4.34    4.322    3.395    2.38
Fleet =  FR-COTB
               8       7       6       5       4       3
Survivors   3129.000 2915.000 3654.000 5420.000 4870.000 7283.000
Raw weights    1.628    2.816    2.429    2.759    1.405    2.588
Fleet =  FR-YFS
               1
Survivors   1261.000
Raw weights    0.173
Fleet =  fshk
              10
Survivors   2763.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               6      5       4       3       2       1
Survivors   2896.000 5001.00 5516.000 1875.000 3566.000 3785.000
Raw weights    2.971    2.01    1.969    1.412    0.892    0.184
Fleet =  UK(E&W)-CBT-new
               8       7       6       5       4       3
Survivors   4120.000 4260.000 4832.000 3684.000 4173.000 4158.000
Raw weights    3.257    4.796    2.624    2.608    1.597    1.003
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-CPUE"     "4761"      "0.147"   "0.076"   "0.517"   "6" "0.379"     "0.063"
[2,] "FR-COTB"         "4354"      "0.188"   "0.15"    "0.798"   "6" "0.215"     "0.068"
[3,] "FR-YFS"          "1261"      "1.045"   "Inf"     "Inf"     "1" "0.003"     "0.218"
[4,] "fshk"            "2763"      "1.932"   "Inf"     "Inf"     "1" "0.004"     "0.105"
[5,] "UK(E&W)-BTS-Q3"  "3575"      "0.199"   "0.167"   "0.839"   "6" "0.149"     "0.082"
```

[6,] "UK(E&W)-CBT-new" "4203" "0.187" "0.035" "0.187" "6" "0.251" "0.071"
Weighted prediction:
Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "4313" "" "" "" "0.069"

Table 18.13: Sole 27.7.d - XSA summary

Year	Recruitment Age 1 thousands	SSB tonnes	Landings tonnes	Discards tonnes	F Ages 3–7 Year^{-1}
1982	15289	10715	3190	183	0.29
1983	28857	13415	3458	100	0.31
1984	25417	14256	3575	131	0.37
1985	14201	16518	3837	219	0.24
1986	28947	16751	3932	139	0.26
1987	12291	17004	4791	179	0.43
1988	30974	17168	3853	188	0.33
1989	18868	19960	3805	171	0.50
1990	53992	17154	3647	300	0.34
1991	40087	16256	4351	317	0.44
1992	40133	19607	4072	251	0.34
1993	18521	18478	4299	247	0.29
1994	32018	15518	4383	123	0.31
1995	24111	15558	4420	249	0.35
1996	22231	16463	4797	166	0.41
1997	33453	16315	4764	143	0.49
1998	21127	13326	3363	120	0.37
1999	31061	14702	4135	227	0.41
2000	42668	14519	3476	180	0.32
2001	38840	14214	4025	280	0.31
2002	56397	14318	4733	390	0.30
2003	25514	21639	6977	473	0.48
2004	21828	16398	6283	308	0.45
2005	42825	16876	5056	319	0.35
2006	46940	15408	5040	229	0.34
2007	23625	13739	5588	379	0.47
2008	27726	16615	5256	256	0.43
2009	47970	15262	5251	360	0.43
2010	61953	13450	4269	438	0.36
2011	46783	16706	4225	477	0.30
2012	23808	17715	4131	533	0.30
2013	17334	21576	4372	466	0.27
2014	20786	20197	4655	528	0.30
2015	30112	16592	3443	294	0.25
2016	15734	15537	2538	344	0.19
2017	38772	16193	2228	200	0.17
2018	37595	17664	2287	297	0.18
2019	99135	19098	1778	421	0.13

Table 18.14: Sole 27.7.d - XSA summary in relative terms. Recruitment, SSB and F are relative to the mean of the time-series.

Year	Relative recruitment Age 1	Relative SSB	Relative F Ages 3-7	Landings tonnes	Discards tonnes
1982	0.46	0.65	0.87	3190	183
1983	0.87	0.82	0.92	3458	100
1984	0.77	0.87	1.09	3575	131
1985	0.43	1.01	0.72	3837	219
1986	0.87	1.02	0.78	3932	139
1987	0.37	1.04	1.26	4791	179
1988	0.94	1.05	0.98	3853	188
1989	0.57	1.22	1.48	3805	171
1990	1.63	1.05	1.02	3647	300
1991	1.21	0.99	1.29	4351	317
1992	1.21	1.20	1.01	4072	251
1993	0.56	1.13	0.85	4299	247
1994	0.97	0.95	0.92	4383	123
1995	0.73	0.95	1.03	4420	249
1996	0.67	1.00	1.21	4797	166
1997	1.01	1.00	1.47	4764	143
1998	0.64	0.81	1.10	3363	120
1999	0.94	0.90	1.20	4135	227
2000	1.29	0.89	0.95	3476	180
2001	1.17	0.87	0.91	4025	280
2002	1.70	0.87	0.89	4733	390
2003	0.77	1.32	1.41	6977	473
2004	0.66	1.00	1.35	6283	308
2005	1.29	1.03	1.05	5056	319
2006	1.42	0.94	1.02	5040	229
2007	0.71	0.84	1.41	5588	379
2008	0.84	1.01	1.26	5256	256
2009	1.45	0.93	1.27	5251	360
2010	1.87	0.82	1.08	4269	438
2011	1.41	1.02	0.90	4225	477
2012	0.72	1.08	0.89	4131	533
2013	0.52	1.32	0.81	4372	466
2014	0.63	1.23	0.88	4655	528
2015	0.91	1.01	0.73	3443	294
2016	0.48	0.95	0.57	2538	344
2017	1.17	0.99	0.51	2228	200
2018	1.14	1.08	0.52	2287	297
2019	2.99	1.17	0.37	1778	421

Table 18.15: Sole 27.7.d – Stock numbers for the respective XSA stock objects from WGNSSK 2019, inter-benchmark (IBP 2019) and WGNSSK 2020.

Stock numbers WGNSSK 2019

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
14730	27237	25073	14265	29628	12573	33098	19205	55646	39976	39586	18268	31683	23713	21814	33333	21357	31399	42915	39194	57137	26162	22533	44682	49309	24836	28995	48744	58823	43013	23646	15619	19261	27299	15208	46902	16472
19871	12996	24645	22635	12801	26702	11356	29742	17022	47644	35338	35590	16345	28600	19634	19719	30109	19253	28046	38530	35099	50161	23625	19537	39861	44061	22123	25043	41581	52149	38723	21094	13859	16490	24301	13156	41855
29536	14817	10717	19885	15933	10039	20315	7609	22618	11888	34272	26987	26000	13933	22208	15514	16007	25546	13396	20953	27410	23116	31436	16917	13224	27455	32647	16697	17550	30175	38632	30331	15913	10730	12312	20287	10889
4858	21243	9741	6352	12422	8744	5087	10700	3439	14494	6361	21601	17519	16885	7924	11782	7542	8473	14016	6922	12324	16760	10745	19189	9540	8632	16661	20309	9909	11432	20222	26097	20896	10272	7585	8782	16183
3530	2761	15428	6301	4148	8128	4726	3043	5401	1992	9064	3916	14244	10105	10640	4215	5785	4188	4450	8399	4709	7485	11286	6804	11722	6046	4738	9349	11637	6034	7581	13165	17156	11678	7071	5491	6274
3605	2664	1648	12163	4721	2888	5389	3167	1383	3457	1225	6295	2579	9632	6305	6561	1822	3667	2537	2996	5216	2909	4713	5134	4298	7565	3764	2832	6824	7677	3956	5382	9532	11452	7303	5065	3944
1730	2652	1711	787	9222	3533	1612	4054	2059	962	2171	831	5154	1772	6814	3954	4332	1063	2484	1810	2011	4090	2004	2993	3549	2858	4259	2287	1780	4596	5481	2552	4068	6903	7924	5078	3671
839	1057	1807	1118	575	7336	2157	1089	3124	1492	625	1614	598	4123	1246	4942	2705	3387	628	1943	1361	1536	1738	1231	2205	2396	1675	3058	1403	1303	3631	4347	1760	3035	5075	6083	3819
483	537	641	1336	861	373	5890	1709	794	2579	1115	437	1281	437	3466	869	3734	2026	2425	427	1636	1108	1172	1026	774	1535	1503	1093	2282	992	999	2850	3478	1199	2290	3939	4719
341	325	384	453	1060	599	232	5086	1388	596	2088	846	285	1019	312	2832	559	3041	1500	1882	333	1388	933	917	763	497	976	1204	678	1758	766	797	2367	2812	968	1637	3177
828	702	921	838	1856	1680	765	6398	5382	2469	5072	1758	788	2315	955	4471	700	5681	2476	6153	1149	2952	1697	2667	1147	1335	1796	2715	2812	2986	4504	2154	4747	3120	1889	965	8978

Stock numbers IBP 2019

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
15248	28446	25146	14134	28716	12260	30665	18852	53750	40044	39988	18525	31843	24092	22190	33687	21170	31109	42905	38902	56244	25507	21726	42350	46040	23280	27205	47041	60780	45802	24117	17456	21196	31164	16088	47967	17041
20426	13465	25739	22701	12682	25876	11073	27541	16703	45927	35400	35954	16578	28746	19977	20059	30429	19084	27784	38521	34835	49353	23033	18807	37750	41104	20715	23423	40040	53919	41246	21520	15522	18241	27799	13953	42819
31107	15319	11142	20875	15993	9932	19568	7353	20626	11599	32719	27044	26329	14144	22340	15825	16315	25836	13243	20715	27402	22877	30704	16381	12563	25545	29971	15423	16084	28781	40234	32614	16299	12234	13896	23452	11610
4795	22665	10196	6737	13318	8799	4990	10024	3207	12691	6099	20196	17570	17182	8114	11901	7823	8752	14278	6783	12109	16753	10529	18528	9055	8034	14932	17888	8756	10106	18960	27546	22961	10620	8946	10216	19047
3579	2704	16715	6713	4496	8938	4775	2955	4790	1782	7433	3680	12972	10152	10909	4387	5892	4442	4702	8636	4583	7291	11279	6609	11123	5607	4196	7785	9447	4991	6381	12024	18467	13548	7387	6722	7571
3643	2709	1596	13328	5093	3203	6123	3211	1303	2904	1035	4819	2365	8482	6347	6805	1978	3765	2767	3224	5430	2795	4537	5128	4122	7023	3367	2343	5409	5695	3012	4296	8499	12639	8994	5351	5059
1745	2686	1751	740	10276	3870	1897	4717	2100	890	1670	660	3819	1579	5773	3992	4553	1204	2572	2018	2218	4284	1901	2834	3543	2698	3769	1928	1337	3316	3687	1699	3086	5969	8998	6608	3929
839	1070	1838	1154	533	8290	2461	1346	3725	1528	560	1160	443	2915	1071	4000	2739	3587	756	2023	1549	1722	1914	1138	2060	2391	1530	2614	1078	902	2473	2724	987	2146	4230	7055	5203
484	537	654	1364	894	335	6753	1985	1027	3122	1148	378	871	297	2372	710	2881	2057	2606	543	1708	1279	1341	1185	690	1404	1499	962	1881	698	636	1802	2009	500	1485	3173	5598
343	326	384	464	1086	628	197	5867	1638	807	2579	876	232	648	185	1843	415	2270	1528	2046	438	1454	1087	1070	907	420	858	1200	560	1395	500	468	1419	1484	335	909	2485
833	704	921	858	1901	1764	650	7380	6350	3345	6267	1820	640	1471	563	2909	519	4239	2523	6687	1511	3091	1979	3112	1364	1129	1579	2706	2320	2369	2939	1266	2844	1645	653	535	7019

Stock numbers WGNSSK 2020

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
15289	28857	25417	14201	28947	12291	30974	18868	53992	40087	40133	18521	32018	24111	22231	33453	21127	31061	42668
20316	13502	26111	22947	12743	26086	11101	27820	16718	46146	35439	36086	16574	28904	19994	20095	30217	19045	27740
30758	15220	11175	21212	16215	9987	19757	7379	20879	11612	32917	27078	26448	14140	22483	15840	16348	25645	13208
4809	22349	10106	6767	13623	8999	5040	10196	3230	12920	6111	20375	17602	17290	8111	12030	7837	8781	14105
3588	2717	16429	6631	4523	9214	4957	3000	4945	1803	7640	3691	13135	10180	11007	4384	6010	4455	4729
3650	2717	1608	13069	5020	3228	6372	3376	1344	3044	1054	5006	2375	8628	6373	6893	1975	3871	2778
1744	2693	1759	751	10042	3803	1919	4943	2248	927	1798	677	3988	1587	5905	4015	4632	1201	2668
840	1070	1844	1161	542	8078	2401	1367	3929	1663	593	1275	458	3069	1079	4120	2760	3659	753
485	539	653	1369	900	343	6561	1930	1046	3307	1270	408	975	311	2511	717	2990	2076	2671
344	326	386	463	1091	634	205	5693	1589	823	2747	986	259	743	198	1969	422	2368	1545
834	706	924	858	1910	1780	676	7162	6158	3414	6674	2050	716	1685	603	3107	527	4423	2551

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
38840	56397	25514	21828	42825	46940	23625	27726	47970	61953	46783	23808	17334	20786	30112	15734	38772	37595	99135
38307	34778	49492	23039	18899	38180	41917	21028	23895	40879	54981	42134	21240	15411	17870	26847	13632	34499	33108
20676	27208	22826	30830	16386	12647	25933	30707	15706	16511	29541	41194	33417	16045	12134	13561	22590	11320	28870
6751	12073	16578	10483	18642	9060	8110	15284	18554	9012	10492	19647	28415	23688	10391	8855	9913	18267	8624
8479	4554	7258	11121	6567	11226	5612	4265	8103	10049	5222	6731	12646	19254	14205	7180	6640	7297	13979
3248	5288	2769	4508	4984	4084	7117	3372	2405	5697	6240	3222	4613	9062	13350	9589	5163	4985	5608
2028	2240	4156	1877	2807	3414	2664	3853	1932	1393	3577	4181	1888	3372	6478	9642	7147	3760	3755
2109	1558	1742	1798	1117	2037	2274	1499	2691	1082	953	2708	3171	1159	2405	4690	7637	5691	2795
541	1787	1287	1359	1080	671	1383	1392	934	1950	701	682	2016	2413	655	1720	3590	6125	4456
2105	436	1525	1095	1086	812	403	839	1104	534	1457	503	510	1612	1849	476	1121	2862	5105
6880	1504	3242	1992	3160	1220	1081	1543	2489	2214	2475	2956	1378	3231	2050	927	661	2963	3677

Table 18.16: Sole 27.7.d – Fishing mortality (F) at age for the respective XSA stock objects from WGNSSK 2019, inter-benchmark (IBP 2019) and WGNSSK 2020.

F WGNSSK 2019

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	0.03	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.06	0.02	0.01	0.01	0.00	0.09	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.00	0.04	0.01	0.01	0.02	0.05	0.06	0.02	0.01	0.01	0.02	0.06	0.02	0.04	0.01	0.04
	0.19	0.09	0.11	0.25	0.14	0.17	0.30	0.17	0.26	0.23	0.17	0.21	0.06	0.15	0.14	0.11	0.06	0.26	0.19	0.24	0.32	0.37	0.23	0.29	0.27	0.20	0.18	0.26	0.22	0.20	0.14	0.18	0.16	0.19	0.08	0.09	0.07
	0.23	0.32	0.42	0.37	0.50	0.58	0.54	0.69	0.35	0.53	0.36	0.33	0.33	0.46	0.53	0.62	0.54	0.50	0.56	0.43	0.39	0.67	0.39	0.47	0.33	0.40	0.37	0.42	0.33	0.30	0.29	0.27	0.34	0.25	0.24	0.13	0.16
	0.46	0.22	0.34	0.33	0.32	0.52	0.41	0.58	0.45	0.37	0.38	0.32	0.45	0.36	0.53	0.61	0.49	0.54	0.41	0.29	0.40	0.30	0.36	0.39	0.36	0.50	0.48	0.46	0.40	0.31	0.33	0.32	0.48	0.27	0.22	0.24	0.17
	0.18	0.42	0.14	0.19	0.26	0.31	0.30	0.69	0.35	0.39	0.26	0.32	0.29	0.37	0.38	0.74	0.36	0.40	0.30	0.38	0.38	0.36	0.69	0.36	0.34	0.37	0.41	0.21	0.32	0.32	0.24	0.22	0.30	0.37	0.23	0.23	0.17
	0.21	0.34	0.64	0.18	0.19	0.48	0.18	0.33	0.26	0.37	0.29	0.10	0.28	0.25	0.37	0.32	0.44	0.29	0.24	0.30	0.14	0.27	0.35	0.27	0.31	0.47	0.40	0.36	0.30	0.24	0.34	0.18	0.22	0.27	0.26	0.22	0.20
	0.39	0.28	0.33	0.21	0.13	0.39	0.29	0.16	0.22	0.33	0.20	0.23	0.12	0.25	0.22	0.28	0.15	0.43	0.15	0.19	0.17	0.76	0.39	0.21	0.29	0.43	0.23	0.39	0.21	0.14	0.13	0.27	0.19	0.21	0.16	0.18	0.18
	0.35	0.40	0.20	0.16	0.33	0.12	0.13	0.22	0.09	0.19	0.26	0.13	0.21	0.07	0.26	0.18	0.19	0.23	0.29	0.07	0.10	0.17	0.43	0.36	0.26	0.37	0.33	0.19	0.25	0.17	0.14	0.12	0.28	0.18	0.15	0.15	0.18
	0.30	0.24	0.25	0.13	0.26	0.38	0.05	0.11	0.19	0.11	0.18	0.33	0.13	0.24	0.10	0.34	0.11	0.20	0.15	0.15	0.06	0.07	0.15	0.20	0.34	0.35	0.12	0.38	0.16	0.16	0.13	0.09	0.11	0.11	0.24	0.11	0.10
	0.29	0.34	0.31	0.17	0.24	0.34	0.47	0.05	0.10	0.18	0.05	0.08	0.42	0.12	0.47	0.06	0.60	0.07	0.11	0.05	0.20	0.11	0.24	0.10	0.47	0.46	0.19	0.17	0.14	0.06	0.07	0.09	0.07	0.09	0.14	0.18	0.12
	0.29	0.34	0.31	0.17	0.24	0.34	0.47	0.05	0.10	0.18	0.05	0.08	0.42	0.12	0.47	0.06	0.60	0.07	0.11	0.05	0.20	0.11	0.24	0.10	0.47	0.46	0.19	0.17	0.14	0.06	0.07	0.09	0.07	0.09	0.14	0.18	0.12

F IBP 2019

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.06	0.02	0.01	0.01	0.00	0.09	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.00	0.04	0.01	0.01	0.02	0.05	0.06	0.02	0.00	0.01	0.02	0.05	0.01	0.04	0.01	0.04
	0.19	0.09	0.11	0.25	0.14	0.18	0.31	0.19	0.26	0.24	0.17	0.21	0.06	0.15	0.13	0.11	0.06	0.27	0.19	0.24	0.32	0.37	0.24	0.30	0.29	0.22	0.19	0.28	0.23	0.19	0.13	0.18	0.14	0.17	0.07	0.08	0.07
	0.22	0.31	0.40	0.35	0.50	0.59	0.57	0.73	0.39	0.54	0.38	0.33	0.33	0.46	0.53	0.60	0.52	0.49	0.57	0.44	0.39	0.68	0.41	0.49	0.35	0.44	0.42	0.47	0.36	0.32	0.28	0.25	0.33	0.21	0.21	0.11	0.15
	0.47	0.20	0.32	0.30	0.30	0.51	0.42	0.64	0.49	0.44	0.41	0.34	0.45	0.35	0.51	0.60	0.47	0.52	0.40	0.29	0.41	0.30	0.37	0.41	0.38	0.55	0.55	0.54	0.46	0.36	0.36	0.30	0.43	0.26	0.19	0.20	0.14
	0.18	0.43	0.13	0.18	0.24	0.28	0.30	0.72	0.40	0.44	0.33	0.34	0.32	0.37	0.37	0.70	0.35	0.37	0.28	0.36	0.39	0.37	0.69	0.37	0.36	0.41	0.48	0.26	0.41	0.40	0.30	0.25	0.28	0.31	0.22	0.18	0.14
	0.20	0.34	0.67	0.16	0.17	0.42	0.16	0.32	0.28	0.45	0.35	0.13	0.30	0.28	0.36	0.30	0.40	0.28	0.22	0.27	0.14	0.29	0.37	0.27	0.32	0.52	0.46	0.46	0.39	0.33	0.47	0.23	0.25	0.24	0.21	0.21	0.15
	0.39	0.28	0.32	0.23	0.11	0.35	0.24	0.14	0.22	0.36	0.26	0.30	0.17	0.29	0.27	0.28	0.14	0.37	0.14	0.16	0.15	0.71	0.41	0.22	0.29	0.47	0.27	0.48	0.29	0.19	0.20	0.44	0.26	0.24	0.14	0.14	0.17
	0.35	0.39	0.20	0.16	0.37	0.11	0.12	0.17	0.08	0.19	0.29	0.19	0.30	0.11	0.31	0.23	0.19	0.22	0.23	0.07	0.09	0.15	0.38	0.40	0.28	0.37	0.36	0.23	0.34	0.25	0.22	0.20	0.58	0.27	0.19	0.13	0.13
	0.30	0.24	0.24	0.13	0.25	0.43	0.04	0.09	0.14	0.09	0.17	0.39	0.20	0.37	0.15	0.44	0.14	0.20	0.14	0.11	0.06	0.06	0.13	0.17	0.40	0.39	0.12	0.44	0.20	0.23	0.21	0.14	0.20	0.30	0.39	0.14	0.09
	0.28	0.34	0.31	0.17	0.23	0.32	0.58	0.04	0.08	0.13	0.04	0.08	0.55	0.19	1.01	0.10	0.93	0.09	0.11	0.04	0.15	0.10	0.20	0.08	0.38	0.57	0.22	0.17	0.17	0.08	0.10	0.16	0.11	0.18	0.45	0.36	0.15
	0.28	0.34	0.31	0.17	0.23	0.32	0.58	0.04	0.08	0.13	0.04	0.08	0.55	0.19	1.01	0.10	0.93	0.09	0.11	0.04	0.15	0.10	0.20	0.08	0.38	0.57	0.22	0.17	0.17	0.08	0.10	0.16	0.11	0.18	0.45	0.36	0.15

F WGNSSK 2020

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.06	0.02	0.01	0.01	0.00	0.09	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.00	0.04	0.01	0.01	0.02	0.05	0.06	0.02	0.00	0.01	0.02	0.05	0.01	0.04	0.02	0.03	0.01
	0.19	0.09	0.11	0.25	0.14	0.18	0.31	0.19	0.26	0.24	0.17	0.21	0.06	0.15	0.13	0.11	0.06	0.27	0.19	0.24	0.32	0.37	0.24	0.30	0.29	0.21	0.19	0.27	0.22	0.19	0.13	0.18	0.14	0.18	0.07	0.09	0.08	0.08
	0.22	0.31	0.40	0.34	0.49	0.58	0.56	0.73	0.38	0.54	0.38	0.33	0.33	0.46	0.53	0.60	0.52	0.50	0.57	0.44	0.40	0.68	0.40	0.49	0.34	0.43	0.40	0.46	0.35	0.31	0.27	0.24	0.33	0.22	0.21	0.11	0.17	0.13
	0.47	0.21	0.32	0.30	0.29	0.50	0.42	0.62	0.48	0.43	0.40	0.34	0.45	0.35	0.52	0.59	0.46	0.52	0.41	0.29	0.41	0.30	0.37	0.41	0.38	0.54	0.53	0.51	0.45	0.34	0.34	0.29	0.41	0.27	0.19	0.21	0.17	0.16
	0.18	0.42	0.13	0.18	0.24	0.27	0.28	0.70	0.39	0.44	0.32	0.34	0.32	0.37	0.37	0.70	0.34	0.37	0.28	0.37	0.40	0.38	0.70	0.38	0.36	0.41	0.47	0.25	0.38	0.38	0.28	0.23	0.27	0.29	0.23	0.19	0.16	0.13
	0.20	0.33	0.66	0.16	0.18	0.42	0.15	0.31	0.27	0.43	0.34	0.13	0.30	0.28	0.36	0.30	0.40	0.27	0.21	0.27	0.14	0.29	0.37	0.28	0.33	0.51	0.46	0.45	0.37	0.30	0.43	0.21	0.24	0.23	0.19	0.22	0.18	0.12
	0.39	0.28	0.32	0.22	0.12	0.36	0.24	0.13	0.20	0.35	0.24	0.29	0.16	0.29	0.26	0.27	0.14	0.37	0.13	0.16	0.15	0.74	0.42	0.22	0.31	0.48	0.26	0.48	0.28	0.18	0.18	0.39	0.24	0.22	0.13	0.13	0.20	0.09
	0.34	0.39	0.20	0.15	0.36	0.11	0.12	0.17	0.07	0.17	0.27	0.17	0.29	0.10	0.31	0.22	0.18	0.21	0.23	0.07	0.09	0.15	0.41	0.41	0.29	0.39	0.37	0.22	0.33	0.23	0.20	0.17	0.47	0.24	0.17	0.12	0.14	0.09
	0.30	0.23	0.24	0.13	0.25	0.42	0.04	0.09	0.14	0.09	0.15	0.35	0.17	0.35	0.14	0.43	0.13	0.20	0.14	0.12	0.06	0.06	0.12	0.19	0.41	0.40	0.13	0.46	0.19	0.23	0.19	0.12	0.17	0.22	0.33	0.13	0.08	0.10
	0.28	0.33	0.31	0.17	0.23	0.32	0.55	0.04	0.09	0.12	0.04	0.07	0.47	0.16	0.90	0.09	0.91	0.09	0.11	0.04	0.15	0.10	0.20	0.08	0.44	0.60	0.23	0.19	0.18	0.08	0.10	0.15	0.10	0.14	0.30	0.28	0.12	0.07
	0.28	0.33	0.31	0.17	0.23	0.32	0.55	0.04	0.09	0.12	0.04	0.07	0.47	0.16	0.90	0.09	0.91	0.09	0.11	0.04	0.15	0.10	0.20	0.08	0.44	0.60	0.23	0.19	0.18	0.08	0.10	0.15	0.10	0.14	0.30	0.28	0.12	0.07

Table 18.17: Sole 27.7.d – Spawning stock biomass (SSB) at age for the respective XSA stock objects from WGNSSK 2019, inter-benchmark (IBP 2019) and WGNSSK 2020.

SSB WGNSSK 2019

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	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	0	0	0	0	0	0	0	0
	1201	930	1711	1548	923	1967	873	1781	1245	3485	2697	2452	1005	1910	1613	1453	2234	1306	1813	2593	2530	4121	1377	1367	2704	2779	1712	1473	2733	2239	1170	917	859	612	1546	851	2551
	4538	2685	1893	3513	2902	1875	4168	1274	4828	2461	6274	4693	3851	1654	3596	2355	2327	4230	1824	3026	4514	4509	4945	2895	2056	3966	5707	2765	2826	5164	5367	4465	2342	1619	1767	3136	1653
	1012	5200	2328	1549	3053	2199	1309	2763	1007	3882	1691	5101	3616	3566	1963	2488	1687	1667	2799	1435	2473	4505	2486	4587	2454	1500	3823	4757	2017	2546	4329	5988	4213	2100	1616	1754	3123
	900	828	4550	1925	1243	2507	1673	953	2096	734	2681	1390	3772	2294	2952	1079	1678	1028	1735	1841	1178	2505	2967	1927	3377	1407	1222	2630	2833	1563	1765	3844	4310	2877	1777	1257	1637
	1103	956	585	4573	1690	1069	2290	1061	499	1328	556	2373	815	3207	1942	2080	681	1016	1116	668	1325	1257	1499	1633	1560	1899	1238	909	1795	2372	1088	1695	2955	3195	1891	1454	1108
	600	1077	690	343	3716	1473	769	1946	980	394	879	453	1897	633	2494	1487	1572	317	981	418	605	1219	607	1458	1395	863	1576	952	520	1558	2088	1003	1172	2078	2401	1467	1054
	322	473	809	553	255	3382	1074	549	1671	670	287	904	317	1361	487	1997	966	1097	348	492	318	815	645	613	979	817	680	1260	438	429	1242	2052	634	1035	1766	2044	1180
	202	262	314	740	413	187	3369	1001	453	1222	479	244	591	269	1518	489	1680	681	1074	109	533	368	557	599	393	595	669	407	660	454	381	1234	1168	552	676	1501	1552
	154	169	203	277	543	321	148	2726	704	269	1102	688	134	389	145	1399	208	982	630	567	135	734	291	537	446	187	504	529	275	888	398	363	1006	1080	372	679	1166
	439	422	577	653	1069	1034	574	4565	3103	1532	2672	996	482	1456	602	2922	404	2907	1689	2586	479	1495	1022	1399	698	715	952	1214	1018	1315	1555	1134	2312	1473	948	546	3795

SSB IBP 2019

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	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	0	0	0	0	0	0	0	0
	1234	963	1787	1552	914	1906	851	1649	1222	3359	2702	2477	1019	1920	1641	1478	2258	1295	1796	2593	2511	4054	1343	1316	2561	2592	1603	1378	2631	2315	1246	935	963	677	1768	902	2610
	4779	2776	1968	3687	2913	1855	4015	1231	4402	2401	5990	4702	3900	1679	3617	2402	2371	4278	1803	2992	4513	4462	4830	2803	1953	3690	5239	2554	2590	4925	5589	4801	2399	1846	1994	3625	1762
	999	5548	2437	1643	3273	2213	1284	2589	939	3399	1622	4769	3626	3629	2010	2513	1750	1722	2851	1406	2430	4503	2436	4429	2330	1396	3426	4190	1782	2251	4059	6320	4629	2172	1906	2040	3675
	913	810	4929	2051	1348	2757	1691	926	1858	657	2199	1306	3435	2304	3026	1123	1709	1090	1833	1893	1147	2440	2965	1872	3205	1305	1083	2190	2300	1293	1486	3511	4640	3338	1856	1539	1976
	1115	972	567	5011	1823	1185	2602	1076	470	1115	470	1817	747	2824	1955	2157	740	1043	1217	719	1379	1207	1443	1631	1496	1763	1108	752	1423	1760	828	1353	2635	3526	2329	1536	1421
	605	1091	706	323	4141	1614	905	2264	999	365	677	360	1405	564	2113	1501	1653	359	1016	466	668	1277	576	1380	1393	815	1395	802	390	1124	1405	668	889	1797	2726	1910	1128
	322	480	823	571	236	3822	1226	679	1993	686	257	650	235	962	419	1616	978	1162	419	512	362	915	710	567	915	815	621	1077	336	297	846	1286	355	732	1472	2370	1608
	203	262	320	756	429	167	3863	1163	586	1480	494	211	402	182	1039	400	1297	691	1154	139	557	425	637	692	350	545	667	358	544	319	242	780	675	230	438	1209	1842
	154	170	203	283	556	337	125	3145	830	364	1362	712	109	248	86	911	155	733	642	616	177	769	339	627	531	158	443	527	227	704	260	214	603	570	129	377	912
	441	423	577	669	1095	1086	487	5266	3661	2075	3302	1031	392	926	355	1901	299	2169	1721	2811	630	1566	1191	1633	830	604	836	1210	840	1044	1015	666	1385	776	328	303	2967

SSB WGNSSK 2020

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1228	966	1813	1569	919	1922	853	1666	1223	3375	2705	2486	1019	1930	1642	1480	2242	1292	1794
	4726	2758	1974	3747	2954	1865	4053	1236	4456	2404	6026	4708	3917	1678	3640	2405	2376	4247	1798
	1002	5471	2416	1650	3348	2264	1297	2633	946	3460	1625	4812	3633	3652	2009	2541	1753	1728	2816
	915	814	4845	2026	1356	2842	1755	940	1919	665	2260	1310	3478	2311	3053	1123	1743	1093	1844
	1117	975	571	4914	1797	1194	2708	1131	485	1169	479	1887	750	2873	1963	2185	739	1072	1222
	605	1093	709	327	4047	1586	916	2373	1070	380	728	369	1468	567	2161	1510	1681	358	1054
	323	479	826	575	240	3724	1196	689	2102	747	272	714	243	1013	422	1665	985	1185	417
	203	262	320	759	432	172	3753	1131	597	1567	546	228	450	191	1100	404	1346	698	1183
	155	170	204	283	558	340	130	3052	805	371	1450	802	122	284	92	973	157	765	649
	442	424	579	669	1100	1096	507	5110	3550	2118	3516	1161	438	1060	380	2031	304	2264	1741

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2578	2507	4066	1343	1322	2590	2644	1627	1406	2687	2360	1273	923	956	663	1707	881	2121	1983
	2986	4481	4452	4850	2804	1966	3746	5368	2601	2658	5055	5723	4919	2362	1831	1946	3492	1718	4595
	1400	2422	4456	2425	4456	2331	1409	3507	4346	1834	2337	4206	6520	4776	2125	1887	1979	3595	1871
	1859	1140	2429	2923	1860	3234	1306	1100	2279	2447	1352	1567	3692	4837	3500	1804	1520	1876	3159
	724	1343	1196	1434	1585	1482	1786	1109	772	1498	1928	886	1453	2809	3725	2484	1482	1361	1357
	469	674	1238	569	1367	1342	804	1426	804	407	1212	1593	742	971	1950	2921	2065	1064	1186
	534	365	925	667	556	904	775	609	1109	338	314	926	1497	417	820	1632	2566	1713	796
	138	583	427	646	631	340	537	620	348	564	321	260	873	811	301	507	1368	1923	1288
	633	176	807	342	636	475	152	433	485	216	736	261	233	685	710	183	465	982	1588
	2892	627	1642	1199	1658	743	579	817	1113	802	1090	1020	726	1574	968	465	373	1311	1274

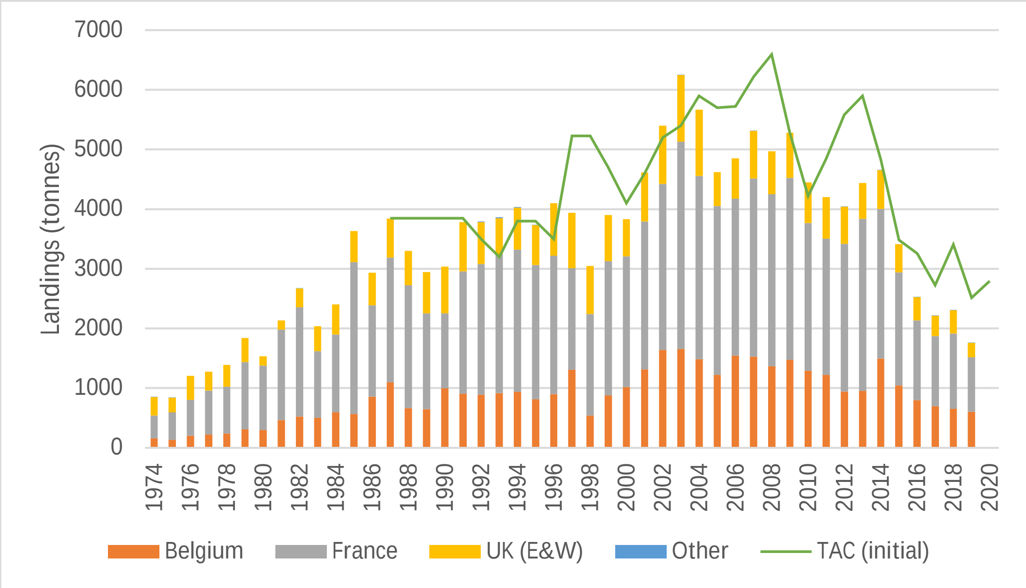

Figure 18.1: Sole 27.7.d - Official landings (tonnes) for sole in Division 27.7.d by country over the period 1974–2019, as officially reported (Rec 12) (stacked barplot; other represents landings from UK Scotland or The Netherlands); green line represents the official TAC (landings; Note that from 2016 onwards the TAC represents catch).

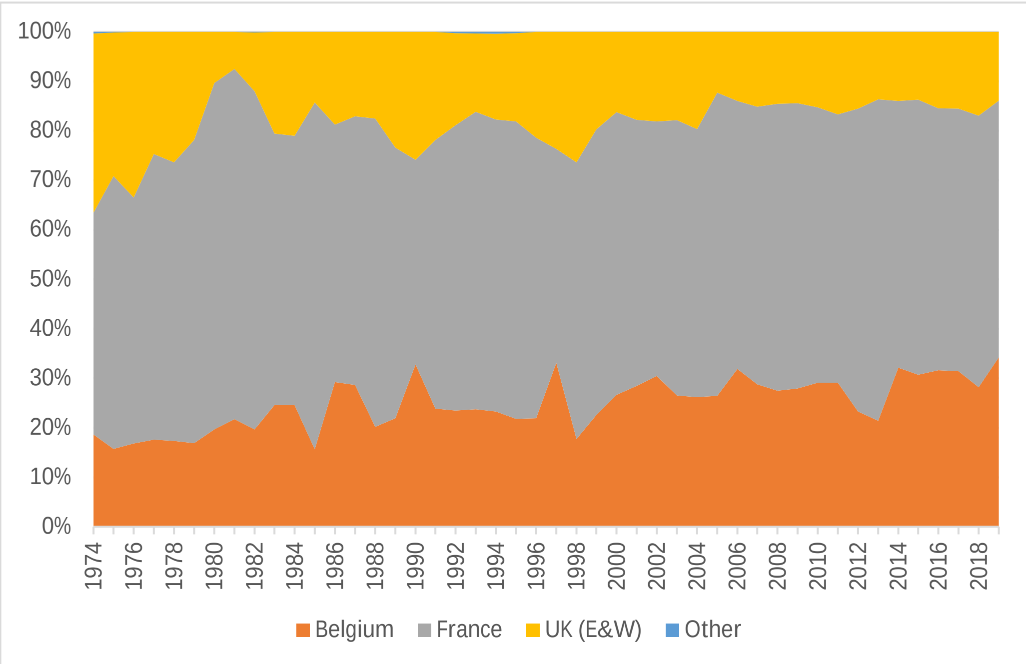

Figure 18.2: Sole 27.7.d - Relative contribution to the official landings of sole in Division 27.7.d for the main countries involved over the period 1974–2019.

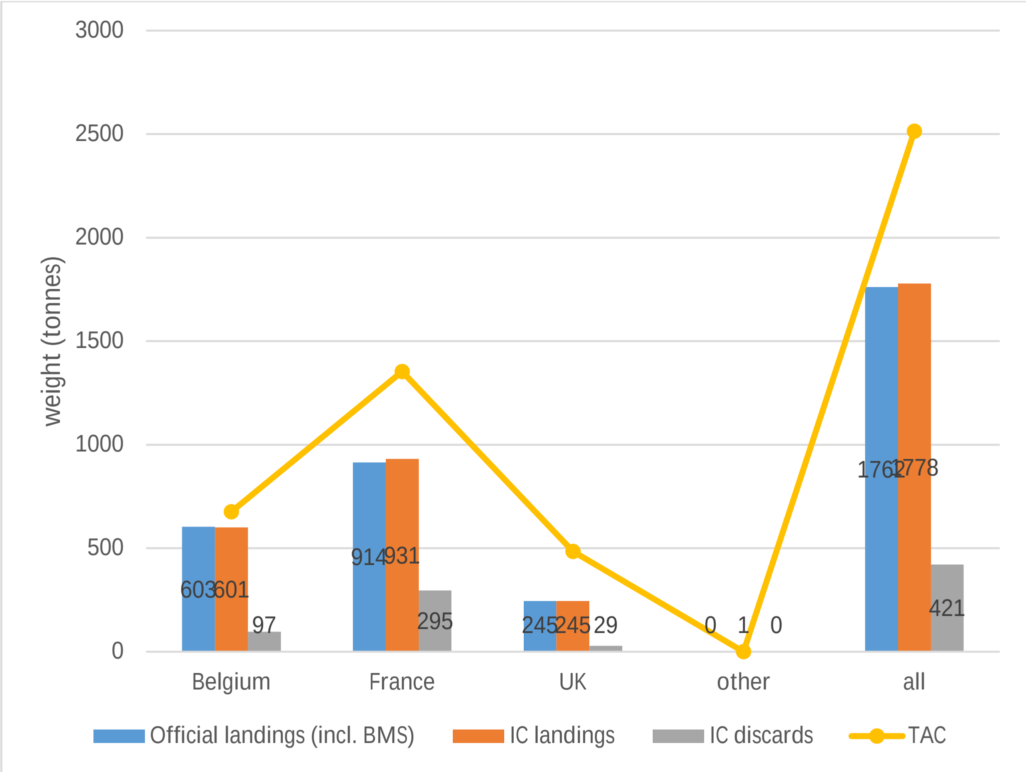

Figure 18.3: Sole 27.7.d - Uptake of the national quota and the total TAC of sole in 27.7.d in 2019.

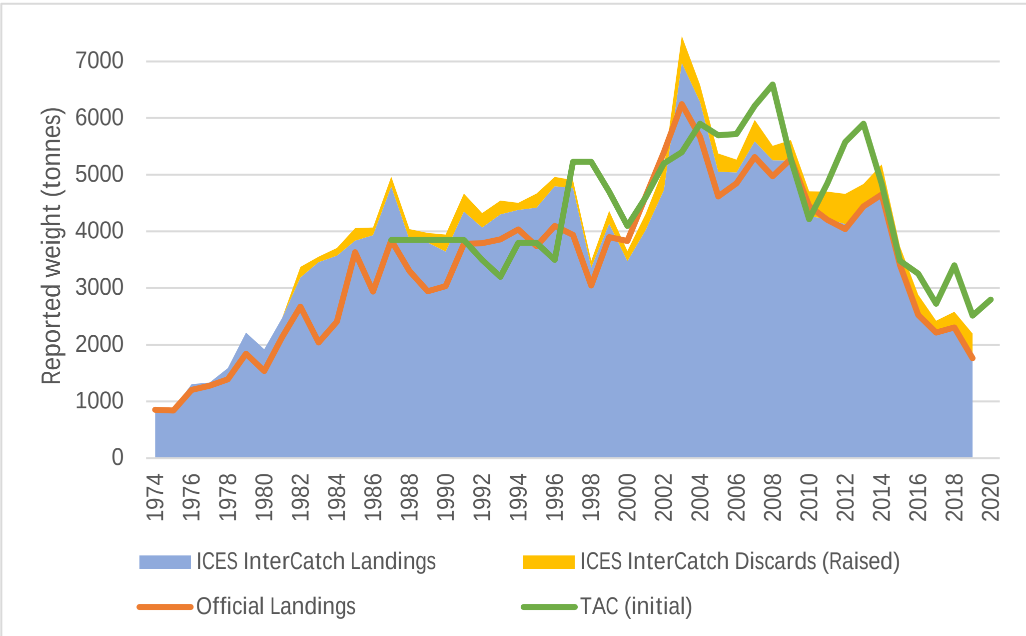

Figure 18.4: Sole 27.7.d - Historic overview (1974–2019) of the official landings, TAC and ICES estimates (InterCatch; including actual discards from 2004 onwards and extrapolated to years prior to 2004); Note that the TAC value represents catch from 2016 onwards.

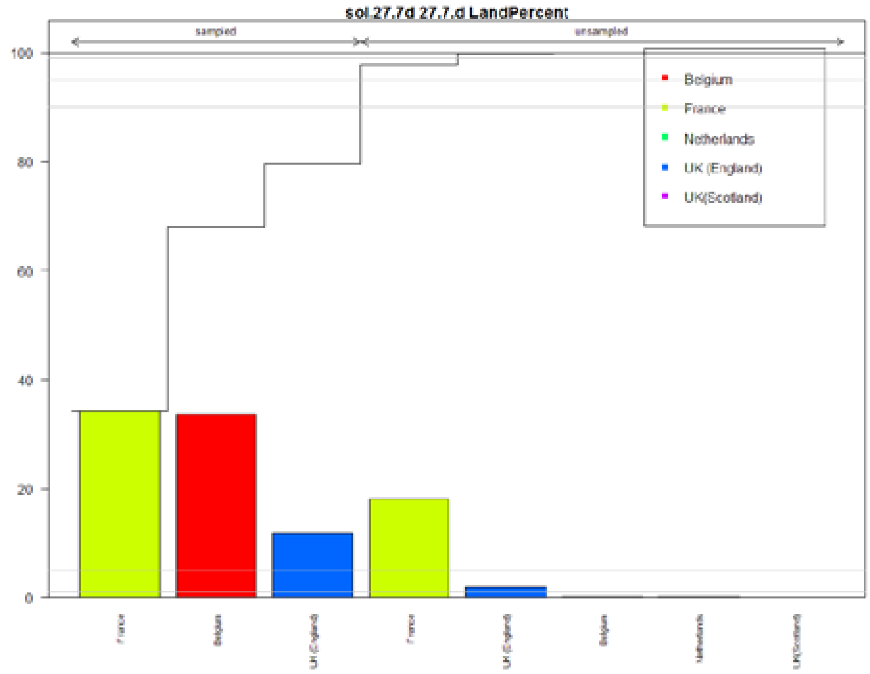

Figure 18.5: Sole 27.7.d - Overview of the proportion of 2019 landings of sole in Division 27.7.d for which samples (age) have been provided in InterCatch by country.

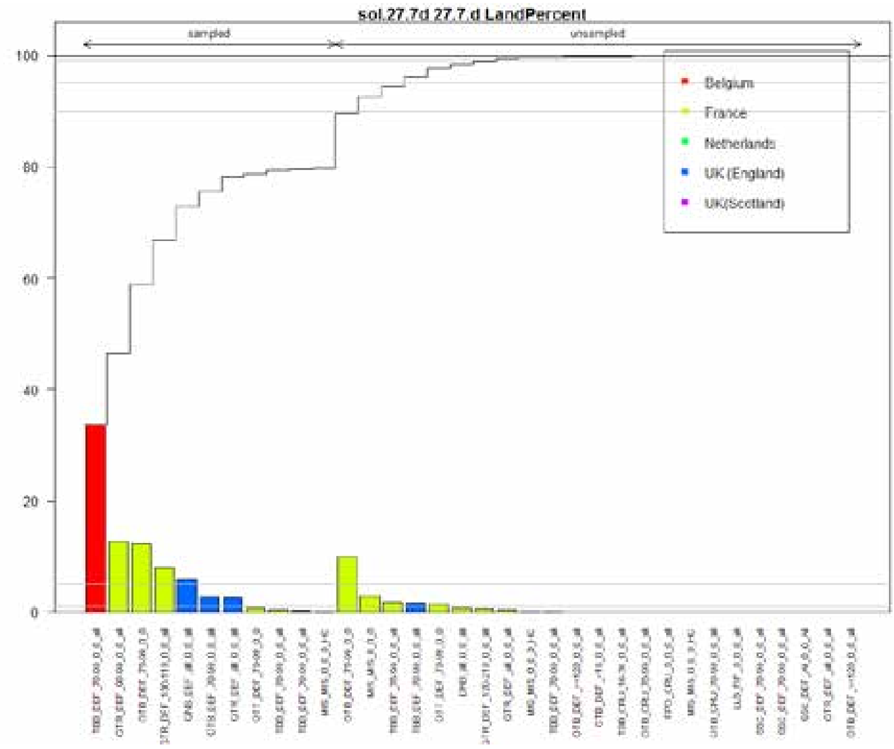

Figure 18.6: Sole 27.7.d - Overview of the proportion of 2019 landings of sole in Division 27.7.d for which samples have been provided in InterCatch by fleet and country.

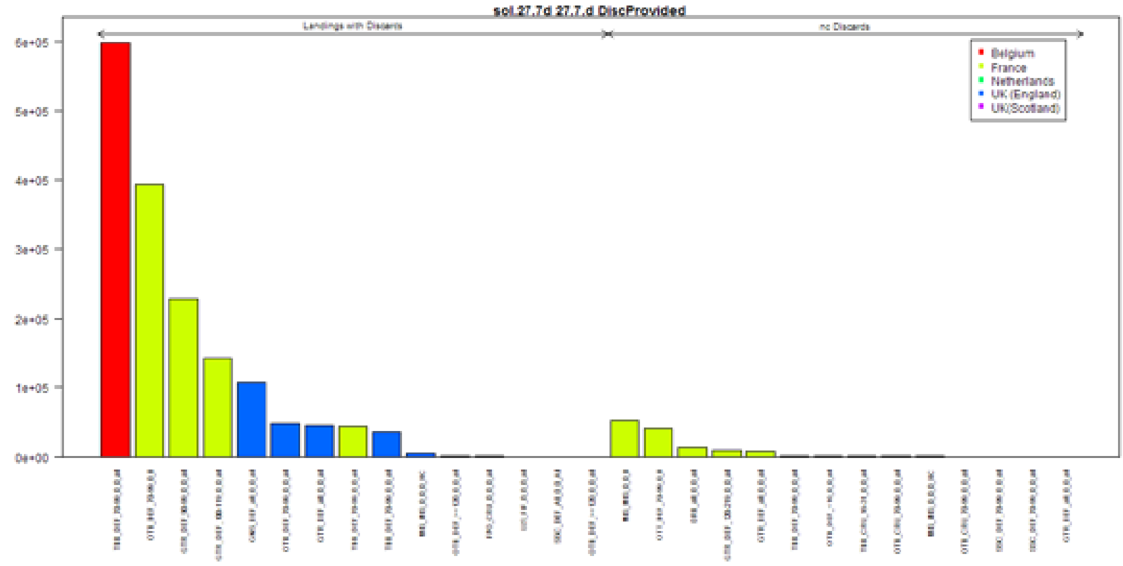

Figure 18.7: Sole 27.7.d - Overview of the 2019 landings with and without discards by fleet and country.

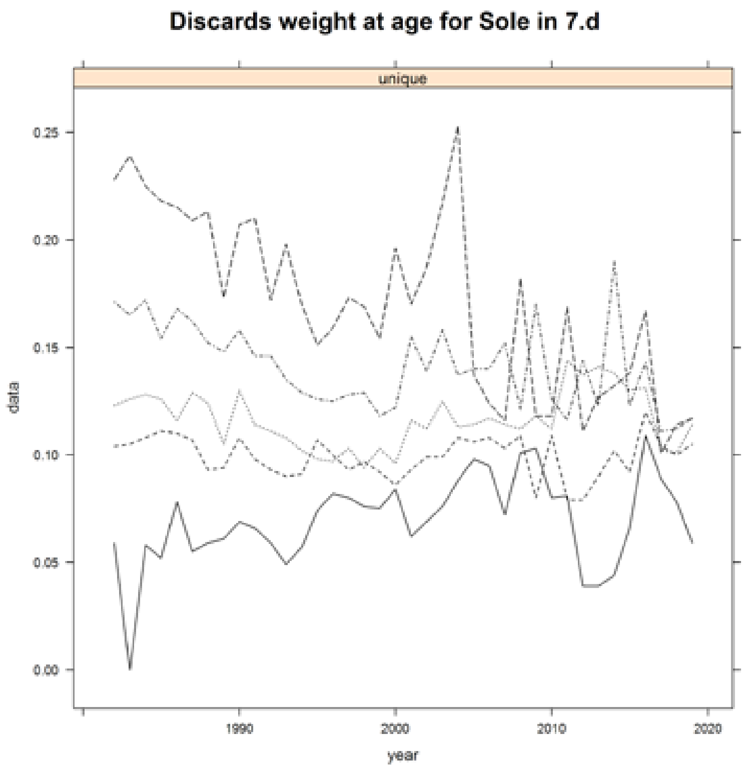

Figure 18.8: Sole 27.7.d - Discard weights-at-age (ages 1–5 are shown).

Figure 18.9: Sole 27.7.d - Landings weights-at-age (ages 1–8 are shown).

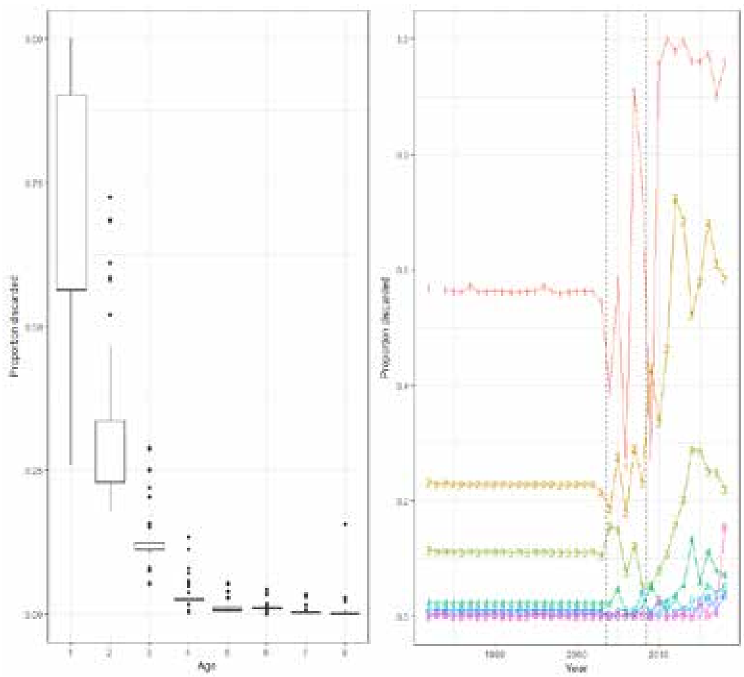

Figure 18.10: Sole 27.7.d - Proportion discarded (discard numbers/catch numbers) (data before 2004 are estimated based on an average ratio from 2004–2008 (indicated by dotted lines)) at age.

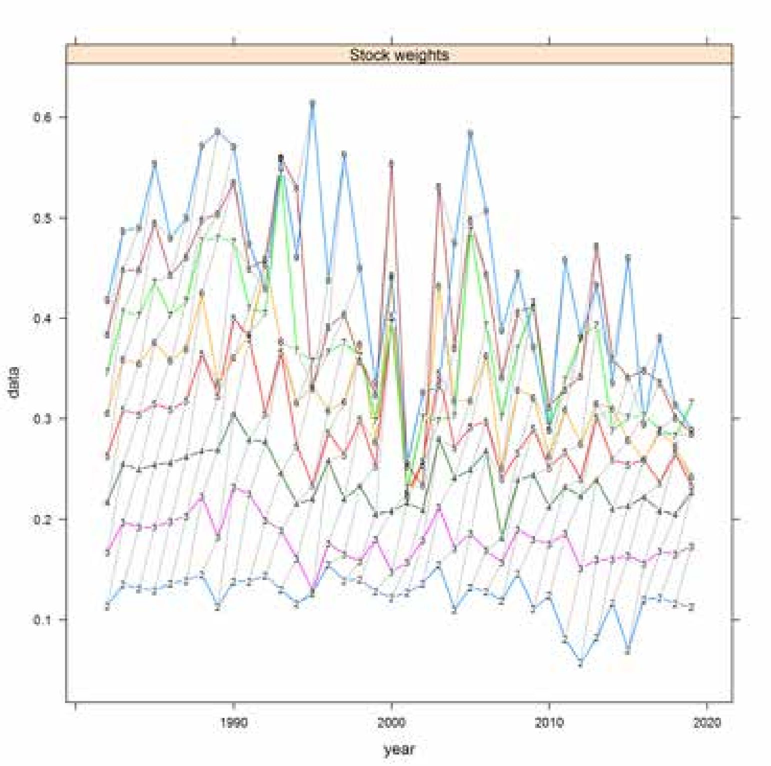

Figure 18.11: Sole 27.7.d - Stock weights (kg) at age (Q2) with indication of year classes (grey lines).

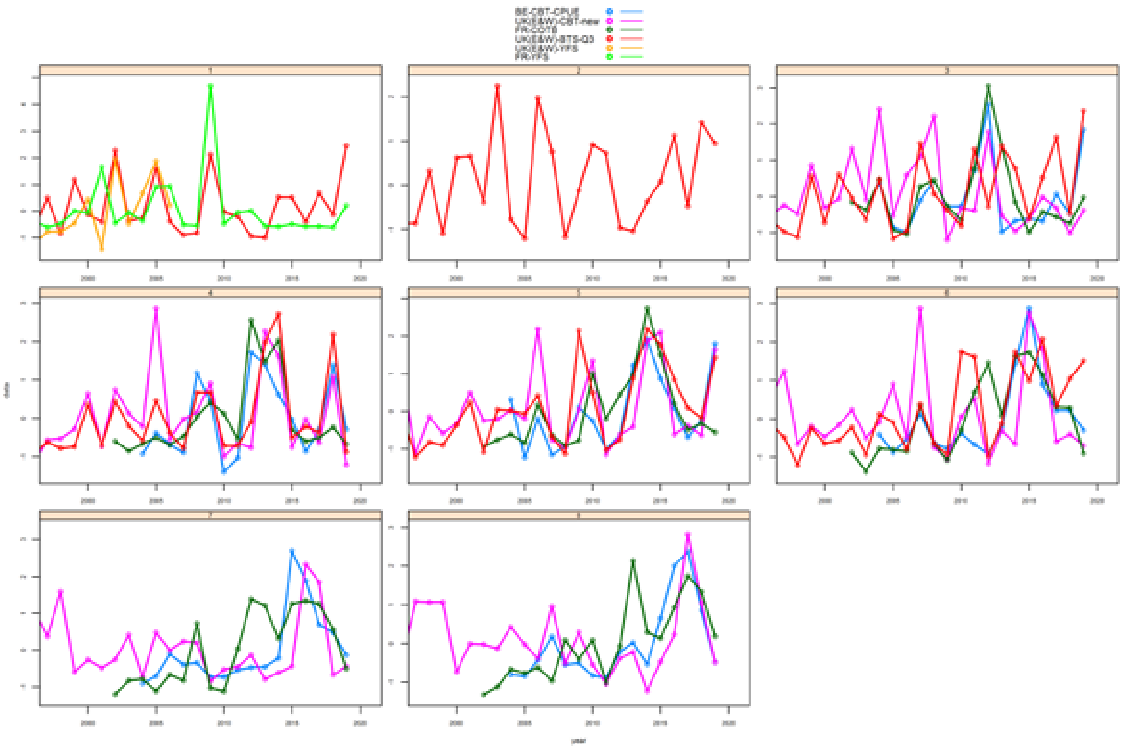

Figure 18.12: Sole 27.7.d - Standardized tuning indices at age.

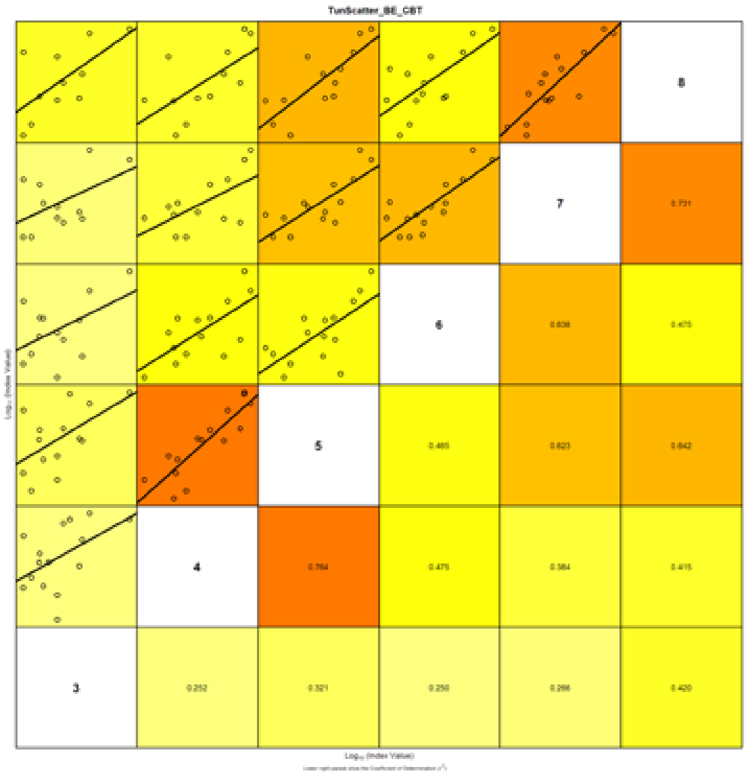

Figure 18.13: Sole 27.7.d - Internal consistency plot of the new BEL-CBT CPUE tuning series.

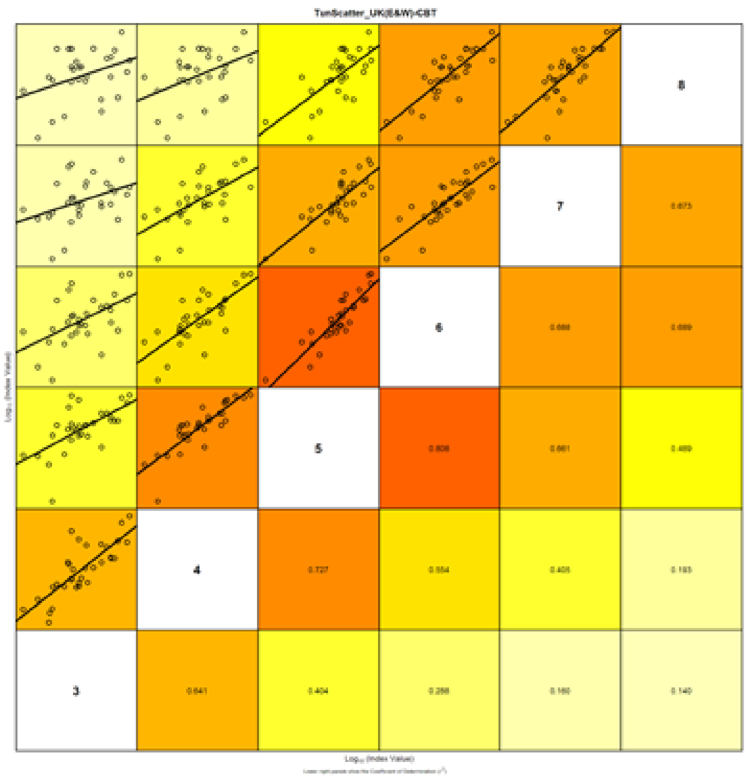

Figure 18.14: Sole 27.7.d - Internal consistency plot of the UK-CBT tuning series.

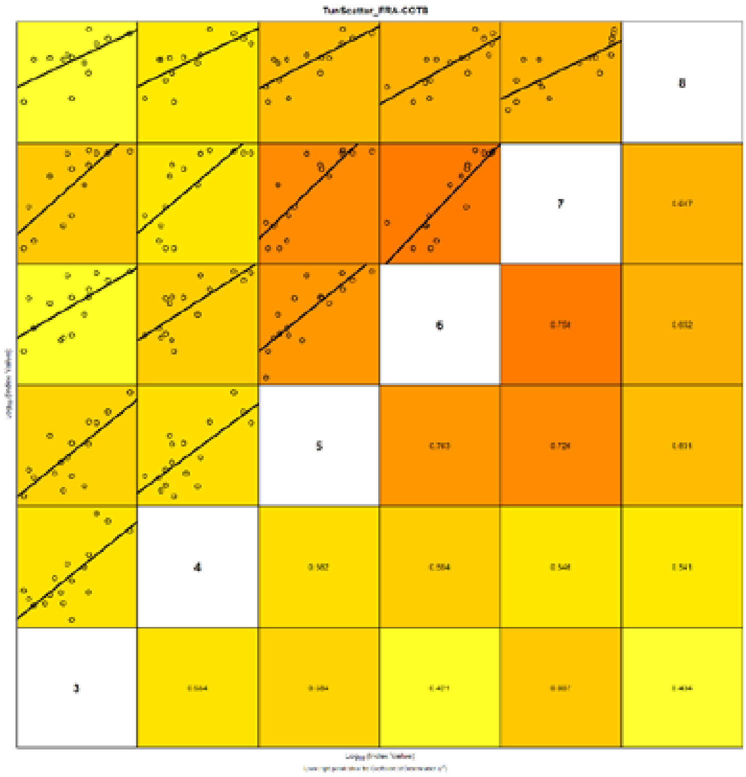

Figure 18.15: Sole 27.7.d - Internal consistency plot of the FRA-COT tuning series.

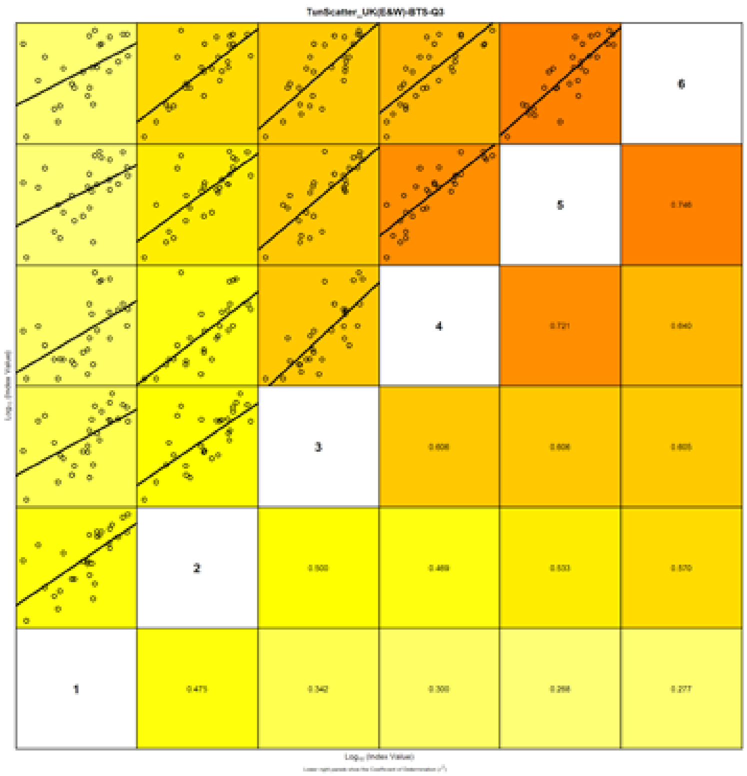

Figure 18.16: Sole 27.7.d - Internal consistency plot of the UK-BTS tuning series.

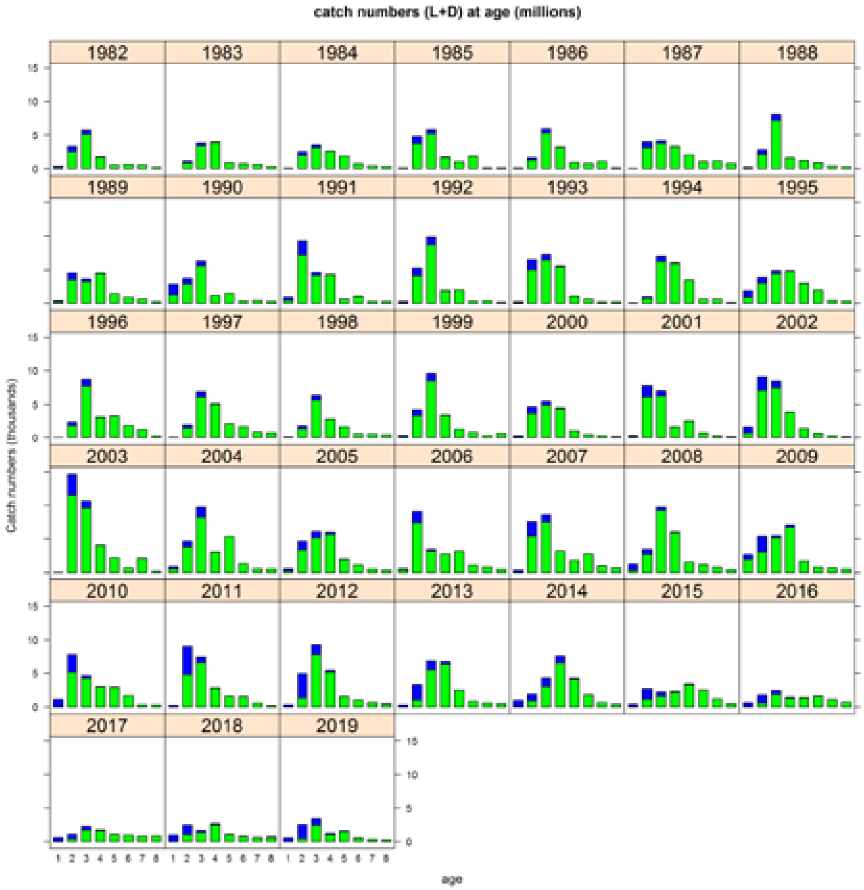

Figure 18.17: Sole 27.7.d - Catch numbers at age.

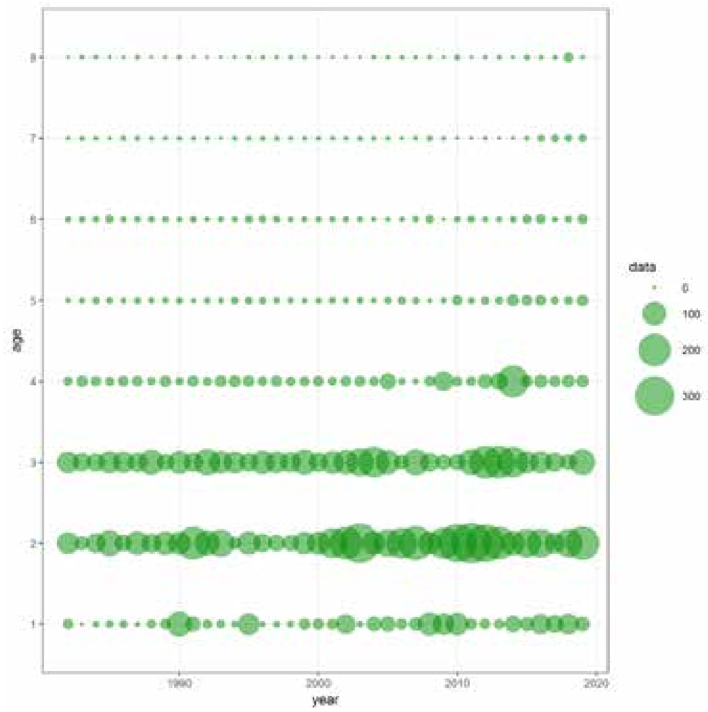

Figure 18.18: Sole 27.7.d – Discard numbers at age.

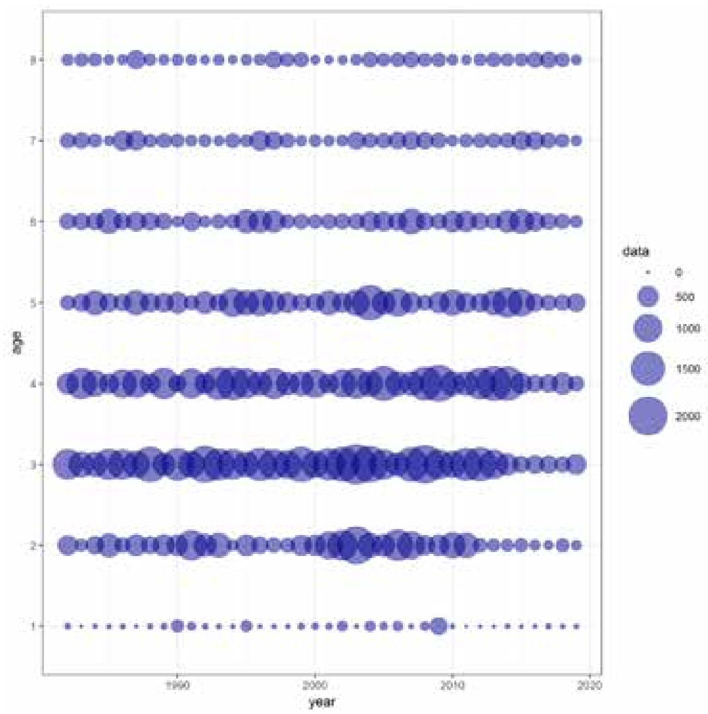

Figure 18.19: Sole 27.7.d – Landings numbers at age.

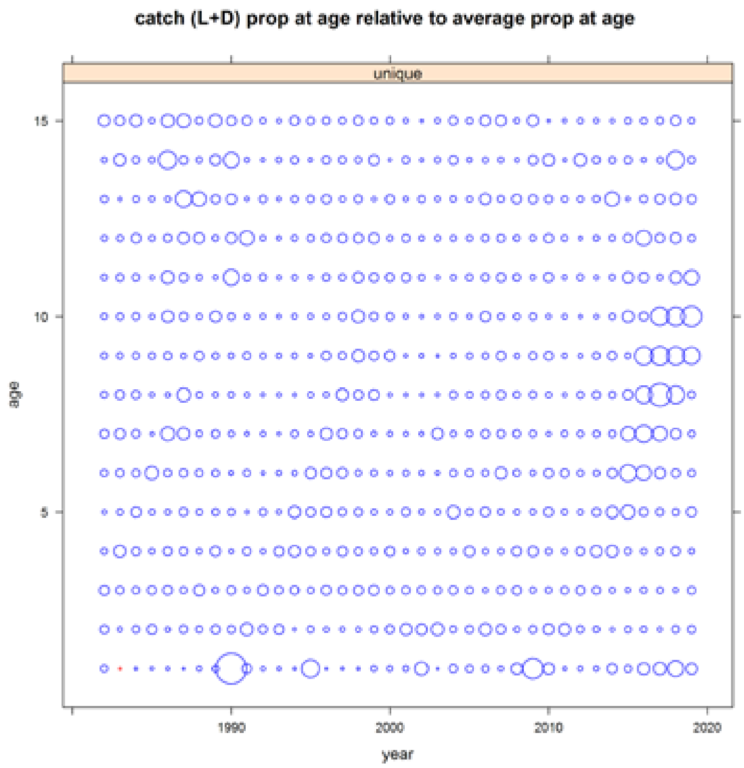

Figure 18.20: Sole 27.7.d - Catch proportion at age.

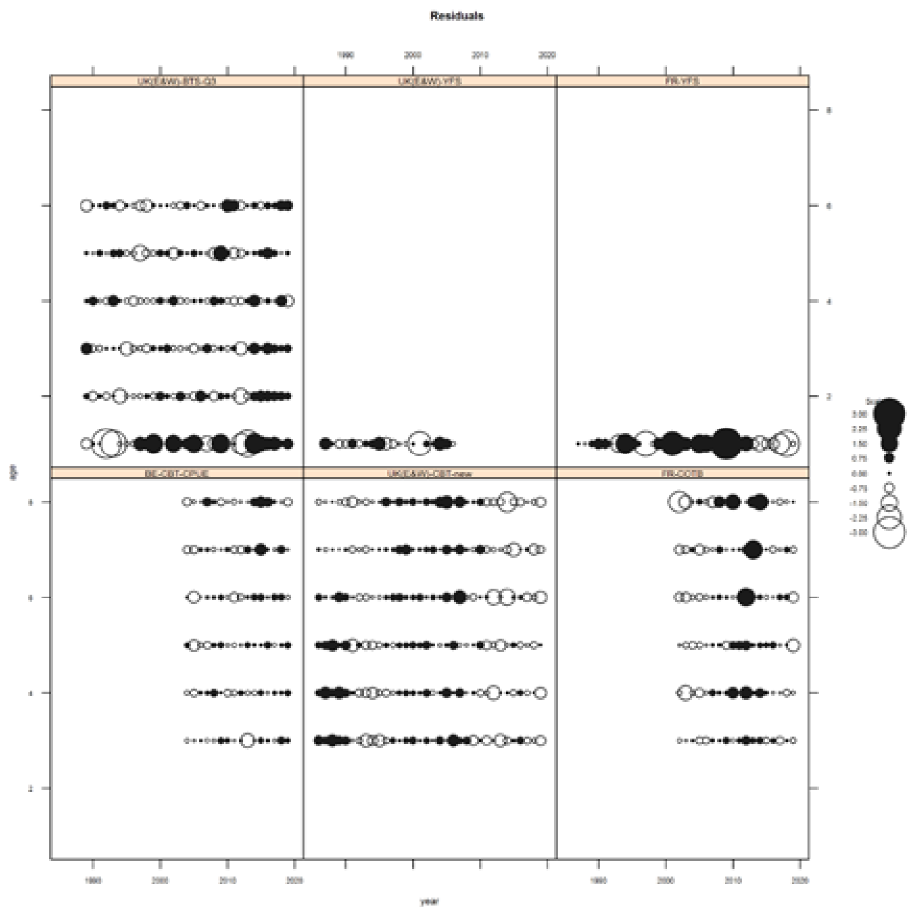

Figure 18.21: Sole 27.7.d - Catchability residuals for all tuning fleets used in the 2020 assessment.

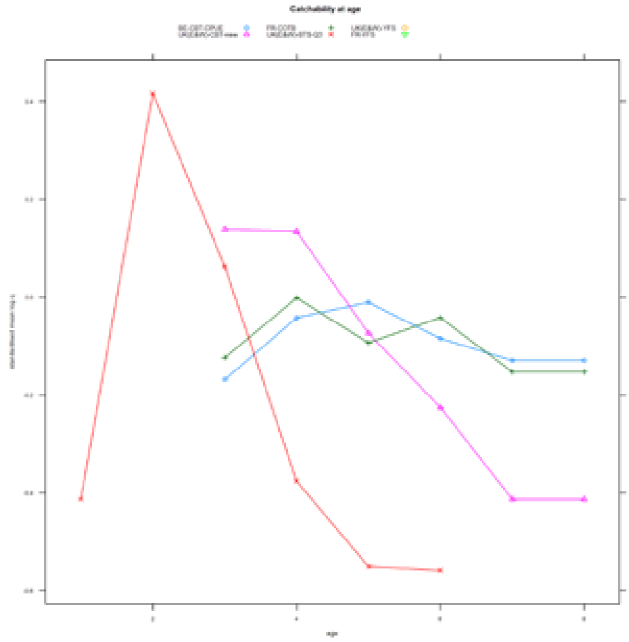

Figure 18.22: Sole 27.7.d – The standardized mean log catchability for all tuning fleets (note the YFS surveys only contain one age class).

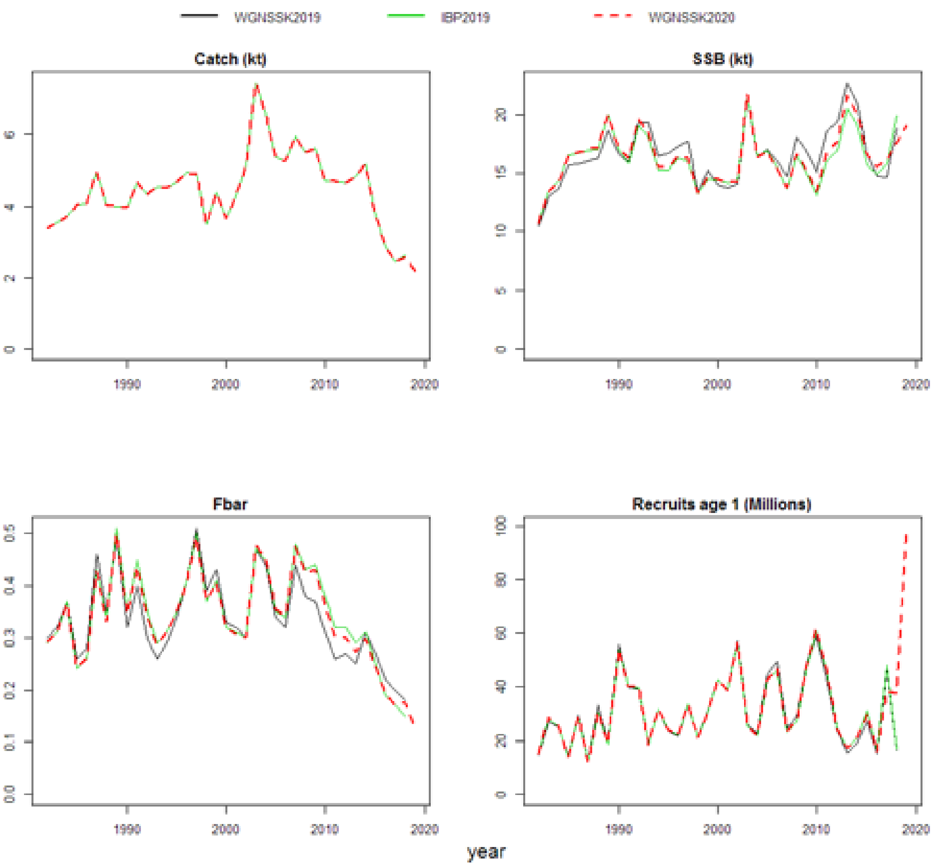

Figure 18.23: Sole 27.7.d - XSA summary: trends in catch, spawning stock biomass (SSB), Fbar and recruitment with indication of the 2019 WGNSSK run with the old UK CBT series up to 2016 and the old French data for 2018 (black line), the IBP run including the new UK CBT and the new BE CBT (green line) and the 2020 assessment (WGNSSK 2020) including new French data for 2018 (red dashed line).

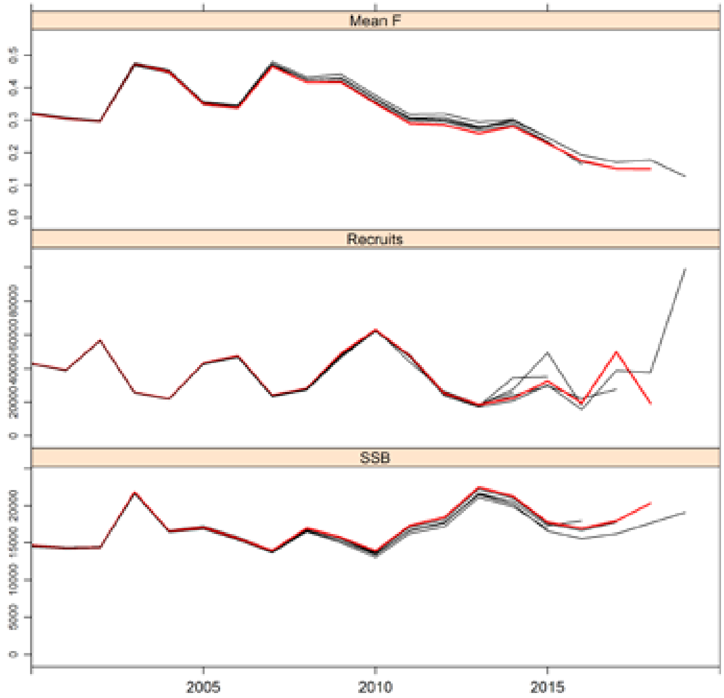

Figure 18.24: Sole 27.7.d - Retrospective pattern in F, recruitment and SSB.

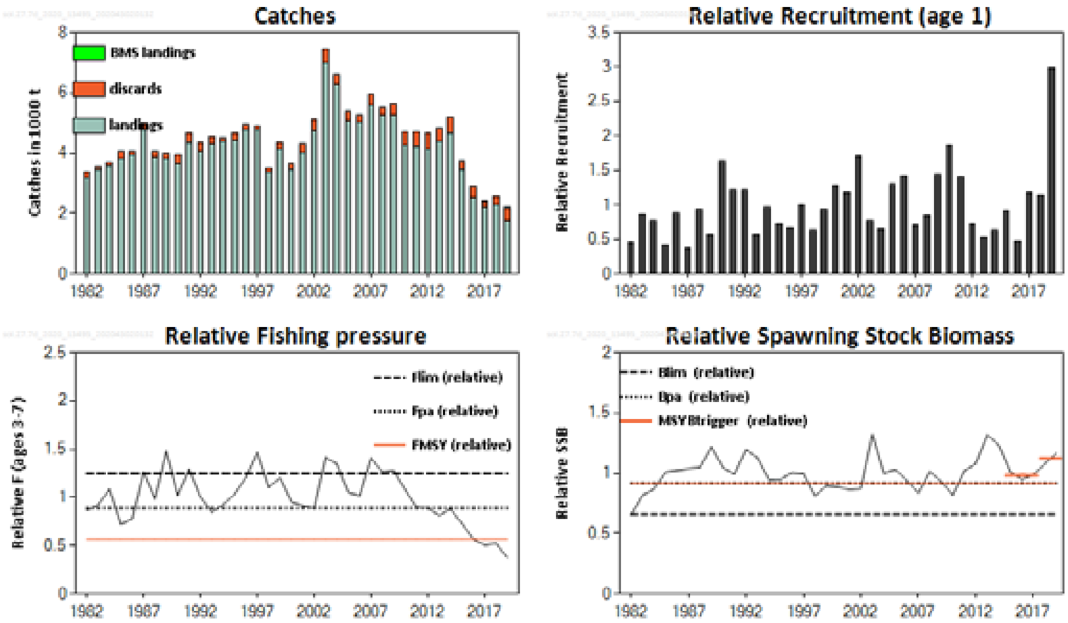

Figure 18.25: Sole 27.7.d – Summary of the 2020 assessment, Recruitment, F and SSB values are relative to the average of the time-series. The short orange lines in the relative SSB plot indicate the average values of the respective years (2015-2017 and 2018-2019). Reference points shown in the graphs are relative to the average of the time-series.

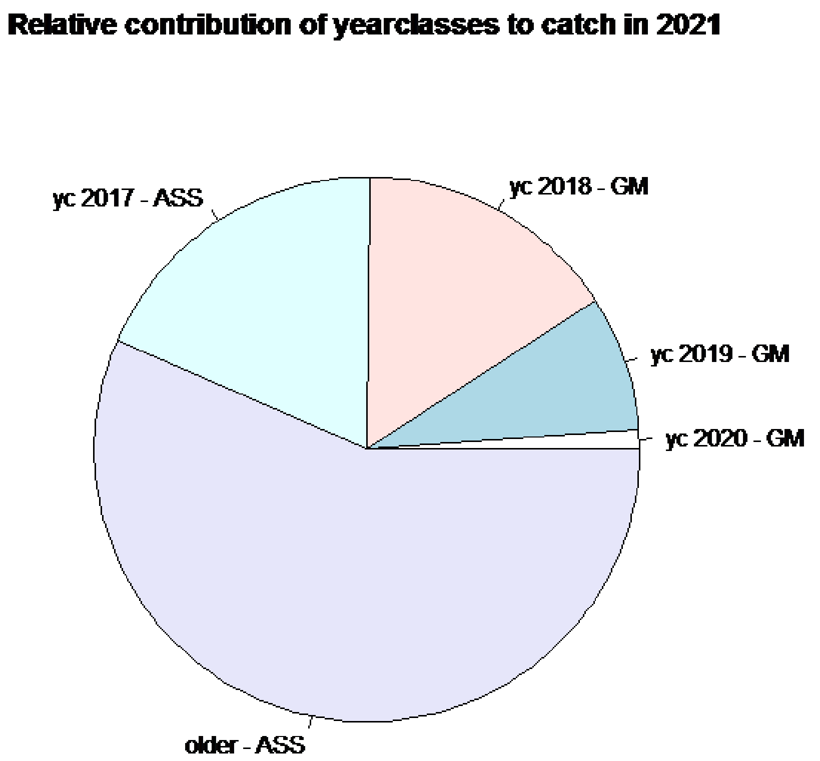

Figure 18.26: Sole 27.7.d - Relative contribution of year classes to catch in 2021 for TAC constraint option.

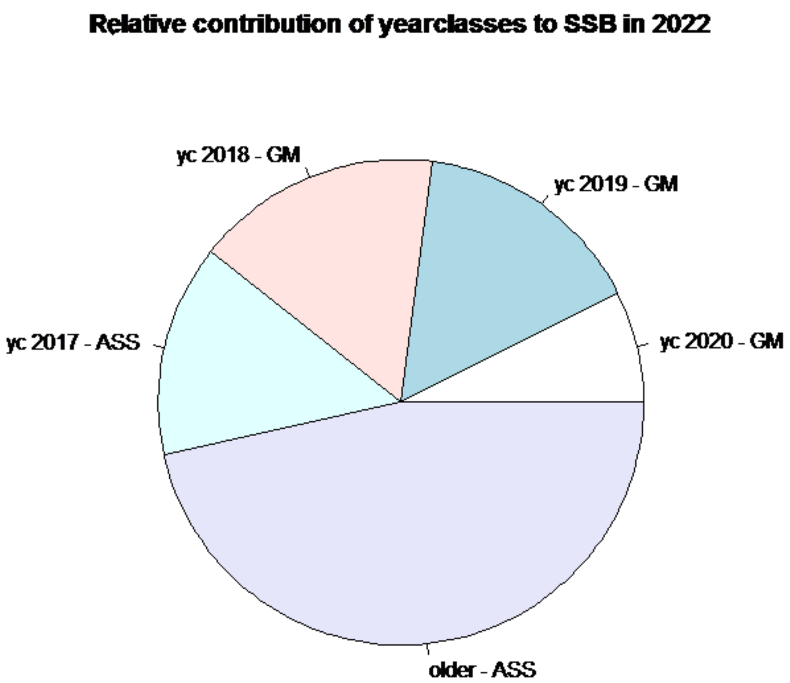

Figure 18.27: Sole 27.7.d - Relative contribution of year classes to SSB in 2022 for TAC constraint option.

19 Striped red mullet in Subarea 4 (North Sea), divisions 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

This stock is under a biennial advice. No TAC is set for this stock. The last advice issued in 2017 was based on the 4:1 rule applied to the SSB estimated by the age-based model.

The general perception is that the landings 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. This decrease in landings up to 2018 follows the perception biomass estimated by the group. The age-based model was run indicating an increase in fishing mortality and a decrease in Spawning Stock Biomass up to 2018. A better recruitment observed in 2018 compared to the last 4 years explains the increase of SSB in 2019. 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 subpopulation 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

ICES has not been requested to provide advice on fishing opportunities for this stock.

Advice for 2018 and 2019.

ICES advices that the fishery for striped red mullet should be managed through technical measures that would reduce the catches of small fish and would contribute to more stable yields.

Fishing mortality is above proxies of the MSY reference points (as indicated by a length-based analysis). The stock size relative to reference points is unknown. For these reasons, the precautionary buffer, which was last applied in 2013, was applied again in this assessment.

ICES advises that when the precautionary approach is applied, catches should be no more than 465 tonnes in each of the years 2018 and 2019. All catches are assumed to be landed.

19.4 Management

No specific management objectives are known to ICES. There is no TAC for this species.

There is no minimum landing size for this species.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

19.5 Data available

19.5.1 Catch

Official landings data are shown by country in Table 19.5.1.1 and by area in Table 19.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 19.5.1.3 presents total official landings and ICES estimates over the period 2006–2019 as well as the predicted catch corresponding to advice. In 2019, 68% of the catches were made using demersal seines and 26% using demersal trawls.

Total landings were provided under the ICES InterCatch format for the period 2003–2013 during the benchmark. However, only France provided age composition for the period 2006–2013. 2014 to 2019 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 in 2019 16% of the total landings in 7d) were provided in 2014 to 2019 with an age structure, some landings made in area 4 were also provided from France with an age structure but only representing around 4% 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 structures and only for the area 27.7.d, all landings are then raised using French structures for that area. In 2020, France had updated 2018 data in InterCatch, 2018 data were raised again and included in the assessment.

19.5.2 Weight-at-age

Mean weight at age were computed as described in the Stock Annex and are presented in Figures 19.5.2.1 and 19.5.2.2 and Table 19.5.2.1.

Weights at age in the landings show a slight decrease for the oldest ages. However sampling intensity for these ages is very low due to the low number of fishes in the catches. Stock weight do not show this slight decrease of age 3 and 4+ but as for landings weight, the sampling is very low due to the low number of fishes in the landings.

19.5.3 Maturity and natural mortality

Information about maturity per age class is given with the table included in this section. At an age of one year more than 50 percent of the striped red mullet are mature.

Age	0	1	2	3	4	5	6
Maturity	0	0.54	0.65	1	1	1	1

As defined during WKNSEA (ICES, 2015), natural mortality was derived from Gislason first estimator (Gislason *et al.*, 2010) leading, as expected for this species, to high natural mortality for the youngest ages (see table below).

age	M_Gislason

0	1.426
1	0.6641
2	0.4888
3	0.4164
4	0.3616
5	0.3275
6	0.3421

19.5.4 Survey data

The Channel Ground Fish Survey (CGFS) and the IBTS–Q3 surveys were estimated to be good indicators of the population trends as they cover the spatial distribution of this stock. However, none of them have an exhaustive coverage of the spatial distribution.

In 2015, a change in the research vessel used for the CGFS was realised. The consequences of these changes were assessed via an inter-calibration in 2014 and some analysis of the catch data (ICES, 2017, Section "CGFS: Change of vessel from 2015 onwards and consequences on survey design and stock indices"). It appeared that for red mullet indices seem to be used without correcting factor.

Only CGFS survey allowed deriving age structured indices. Internal consistencies of the survey (Figure 19.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 19.5.4.2. The age composition is still truncated with catches hardly only composed by age 0 and 1 individual. The Abundance index shows an increase of the age 0 compared to 2015, 2016 and 2017 and is in 2018 the second highest observed.

19.6 Trend based assessment

19.6.1 Assessment model agree 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. Fbar (age 1-2) estimates for 2019 remain in absolute value above 3 in all the scenarios (Figure 19.6.1.1). Scenario with 6 knots was disregarded as F for age 3 was unrealistic (Figure 19.6.1.2). 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 and SURBAR

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 spline to characterise selectivity seems to allow a more realistic representation of the fishing pressure. However Fbar estimated by the alternative model remains high and the uncertainty around Fbar and SSB is still relatively important.

A preliminary SURBAR (Needle 2015) run using the default setting was tested on 2004-2019 CGFS survey indices using ages 0-4 and a mean Z estimated other age 1-2. Results from SURBAR are presented in Figure 19.6.2.5 and the residuals in Figure 19.6.2.6. Towards the end of the time series SSB and recruitment estimates are uncertain but no spike in mean Z is observed contrary to the assessment run from the model agreed on during the benchmark. However, we still observe an upward trend in mean Z and mean Z remains high (around 2 at the end of the time series).

If we compare the three different models, there is an upward trend in fishing/total mortality and the mortality on the stock is high (mostly due to high fishing pressure). It seems that toward the end of the time series the SSB is increasing, however this estimate remain uncertain. The two alternative model tested disagree with the unlikely large increase of Fbar observed in the model agreed on during the last benchmark. 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).

19.7 Length-based indicators screening

The ICES LBI were computed for five years of data (2014–2016 and 2018-2019), using the length distributions from InterCatch (Tables 19.7.1).

Most of the indicators appear outside the established references in 2019:

- Length at first catch Lc and Length of 25% of catches are above Lmaturity (16 cm) in 2015, 2016 and 2019. 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) no good recruitment was observed and Lc and L25 increased to be above Lmat.
- ratio of the 5% largest catches to Linf (40 cm) around 0.6/0.7 clearly show the lack of big/old fish in the population
- Lmean/Lopt around 0.8 give the same picture as Lmax5
- Lmean/$L_{F=M}$ below 1 tend to show that this stock is not exploited optimally except for 2018 where the ratio is just above 1.

This indicates that the stock may be considered not to be exploited sustainably. The main concerns are for the big/old fish that are missing from the population. Length-based indicators based on samples from commercial catches (2014–2016 and 2019) show that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized it’s growth potential (Table 19.7.2).

Conclusions drawn from analyses:

The very good recruitment observed in 2014 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 appear to be still truncated.

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016 and 2018-2019) show in 2020 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.
- No survey is available in the North Sea; IBTS/UK BTS should be investigated again. So work was done to assess the representativeness of the Eastern Channel data compared to the stock, but these should be investigated further
- Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated
- Based on the recent WD presented at WGNSSK2020 stock ID should be reinvestigated

Assessment:

- With so few age classes exploited the a4a model used might not be the best model (explore SAM, SURBAR).
- 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

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	77	0.044	593	826	154	1650
2019	232	0.037	1401	1821	589	4043

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
2003	1618	0	2469	4087

Year	4	3.a	7.d	Total [2]
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	385	0.018	1266	1651
2019	1282	0.022	2761	4043

[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
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	1651	1640
2019	Precautionary approach	<465	4044	4048
2020	No Advice	-		
2021	No Advice			

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

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
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

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 2018-2019	Length data from IC
Length-weight relationship parameters for landings	2014-2016 2018-2019	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)**	

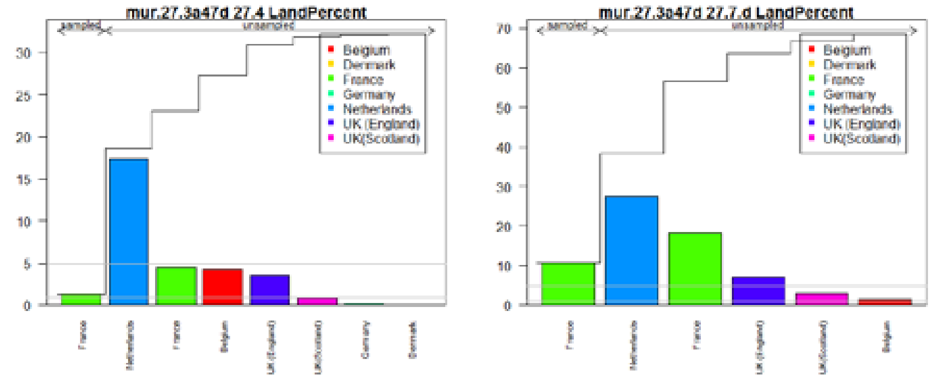


Figure 19.5.1.1. Striped red mullet in Subarea 4 and Division 7.d ICES landings by country (percentage over the total area).

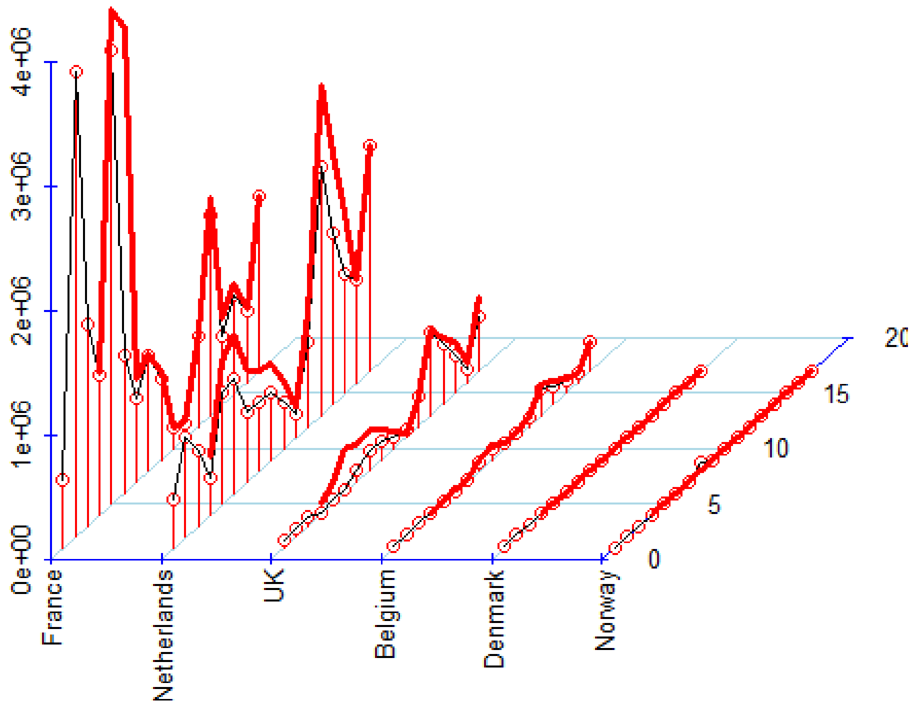


Figure 19.5.1.2. Striped red mullet in Subarea 7d and 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

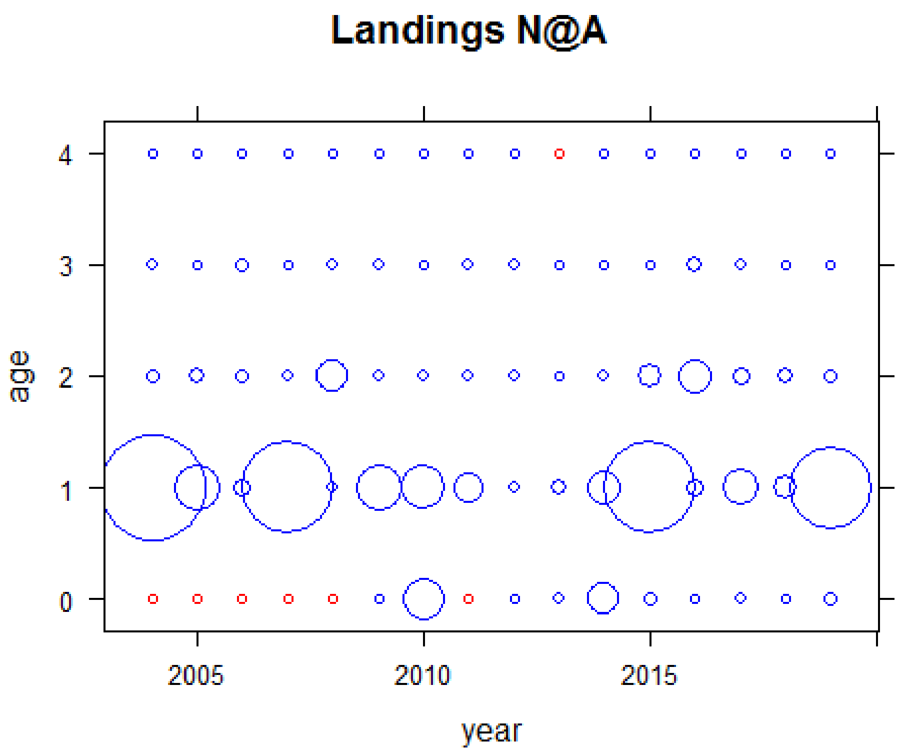


Figure 19.5.1.3. Striped red mullet age structure (in numbers) as provided in the landings.

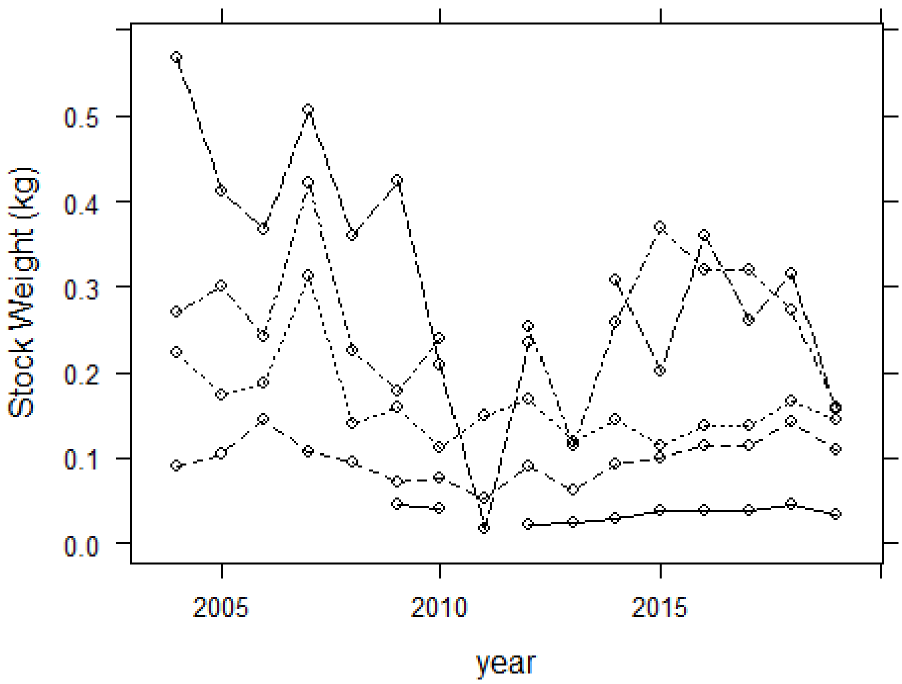


Figure 19.5.2.1. Weight at age in the stock.

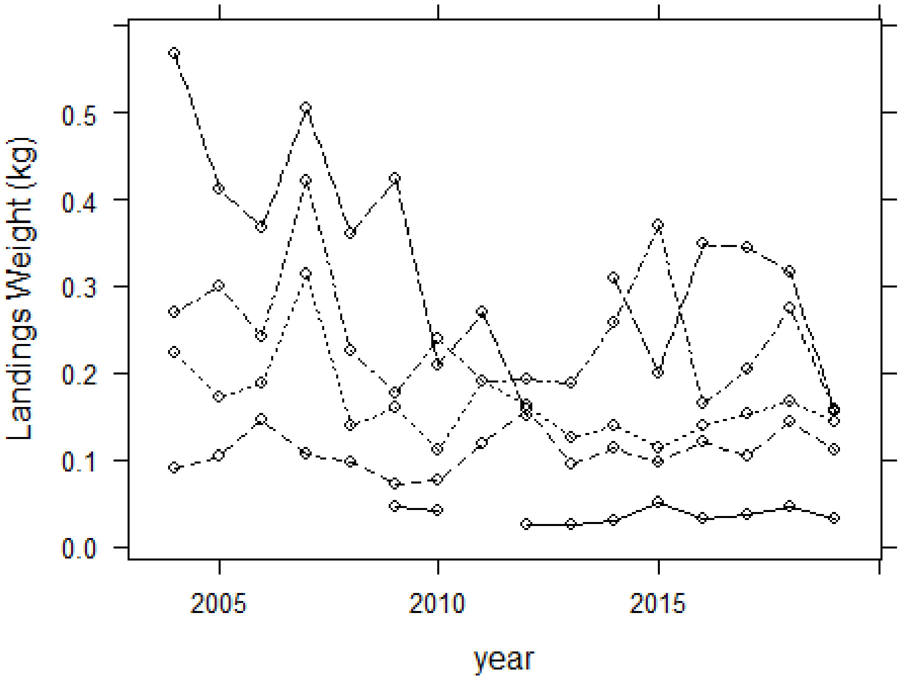


Figure 19.5.2.2. Weight at age in the landings.

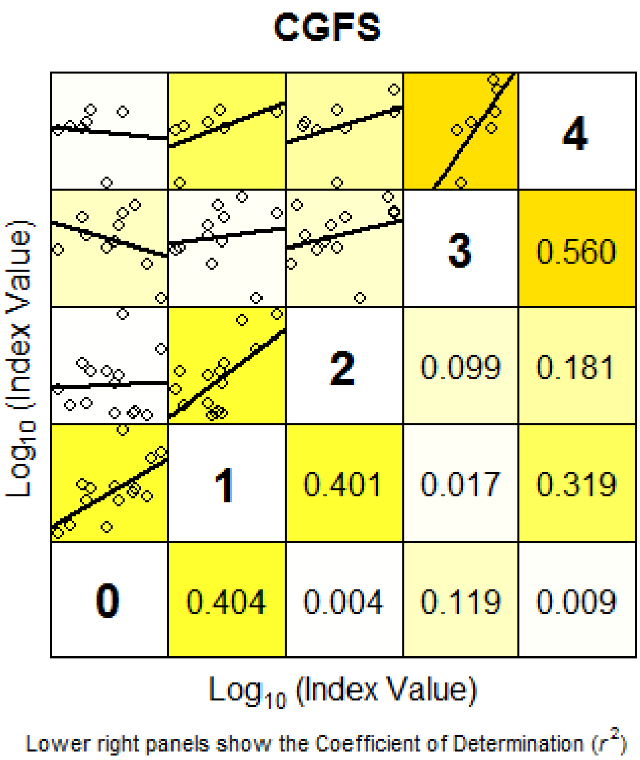


Figure 19.5.4.1. CGFS internal consistencies.

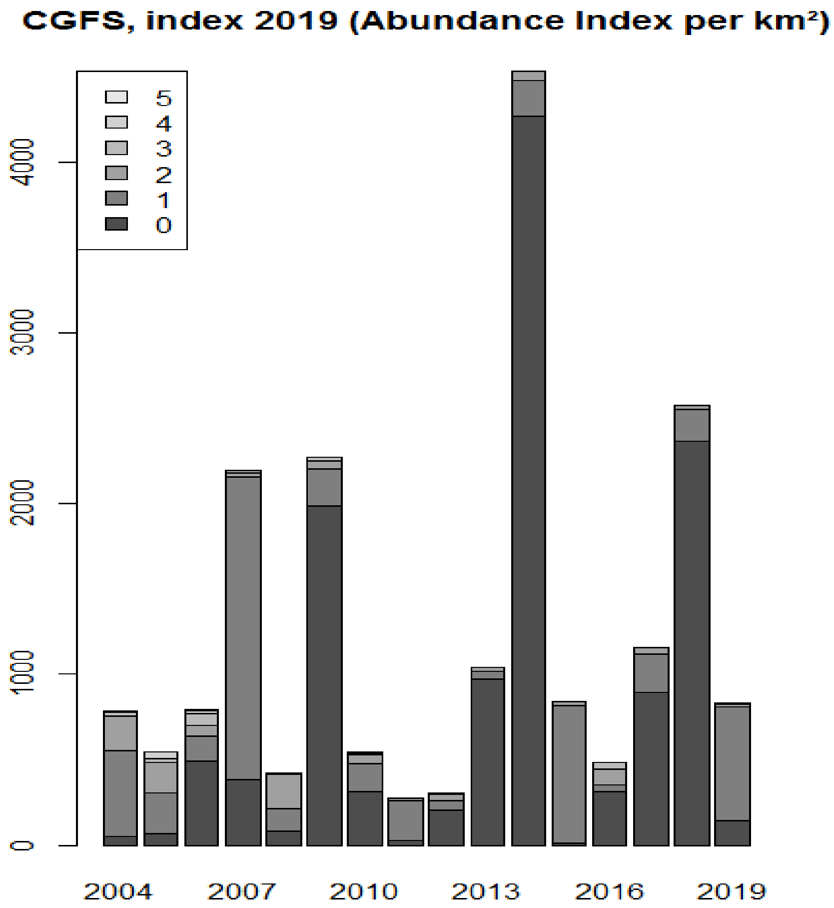


Figure 19.5.4.2. CGFS catch age composition.

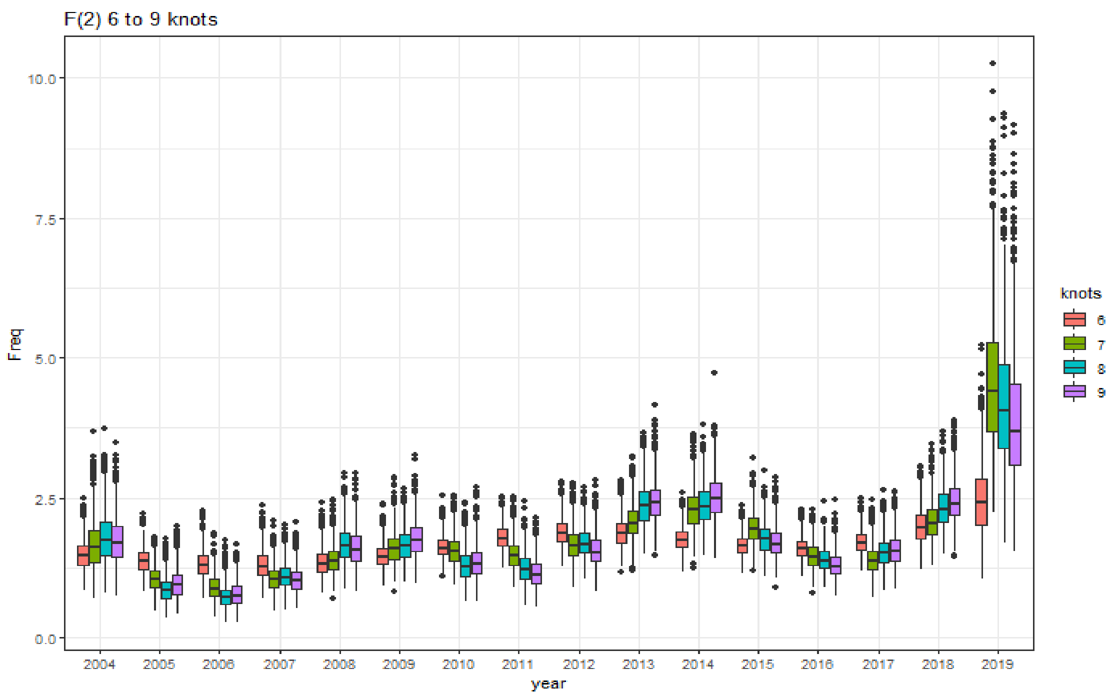


Figure 19.6.1.1. Fbar ages 1 to 2 outputs from assessment sensitivity runs using an increasing number of knots (6 to 9) to fit the fishing mortality spline in a4a.

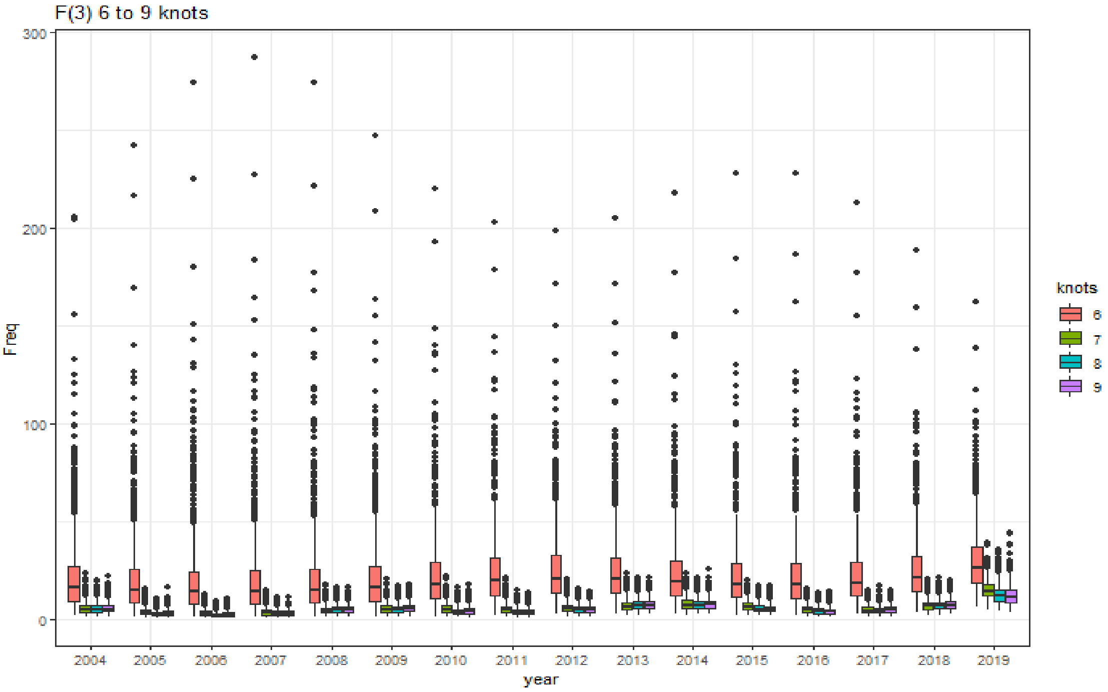


Figure 19.6.1.2. F at age 3 outputs from assessment sensitivity runs using an increasing number of knots (6 to 9) to fit the fishing mortality spline in a4a.

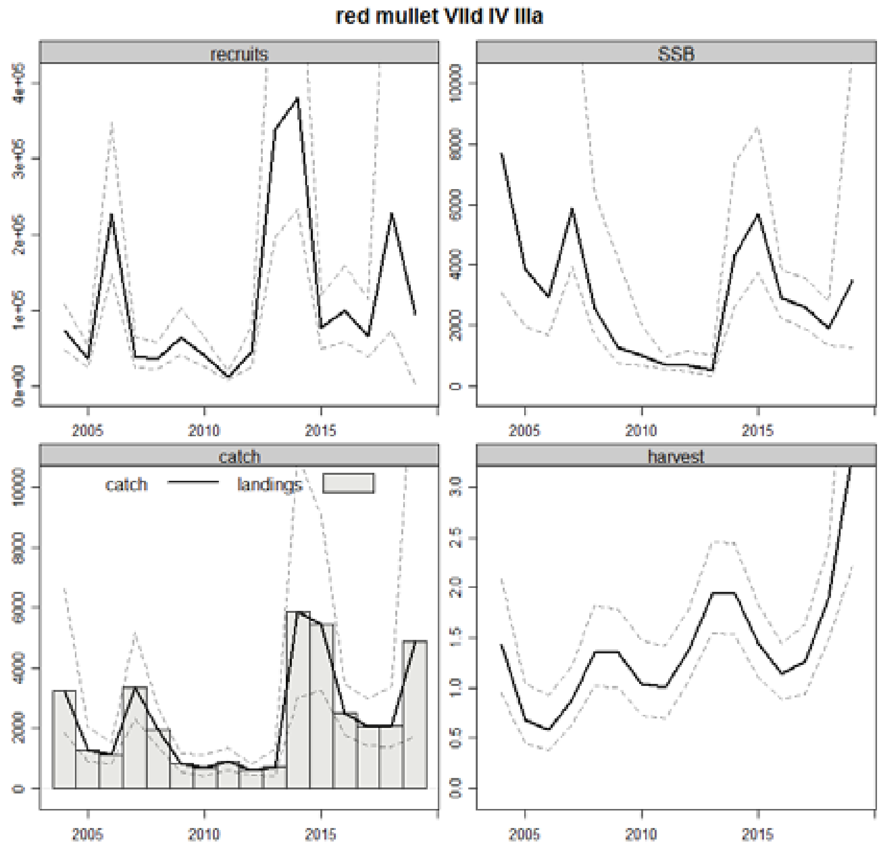


Figure 19.6.1.3. Absolute value of recruitment, SSB, catch and Fbar(1-2) estimate using a4a model formulation approved during the last benchmark.

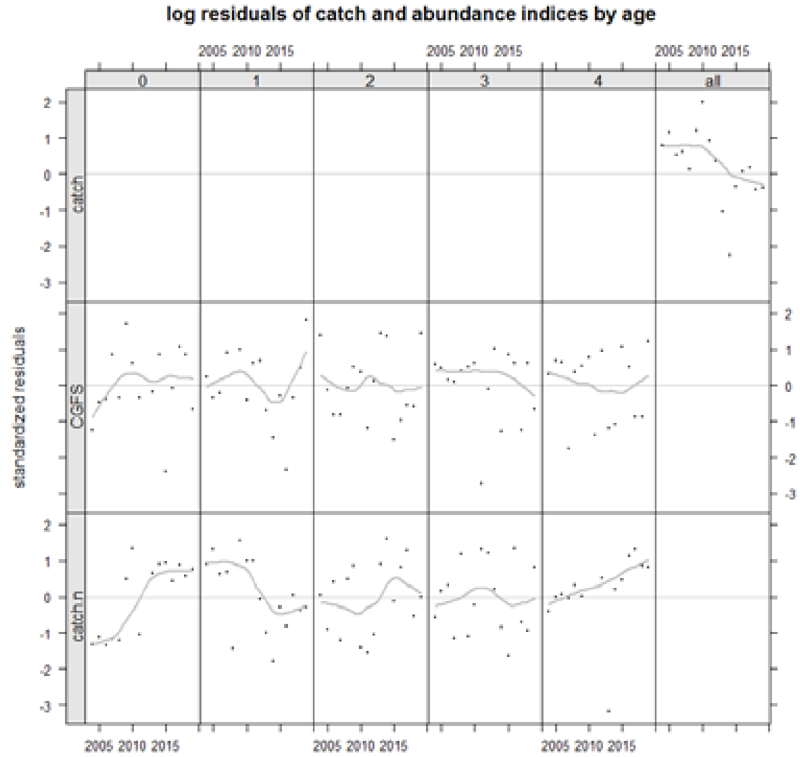


Figure 19.6.1.4. Log residuals of the assessment.

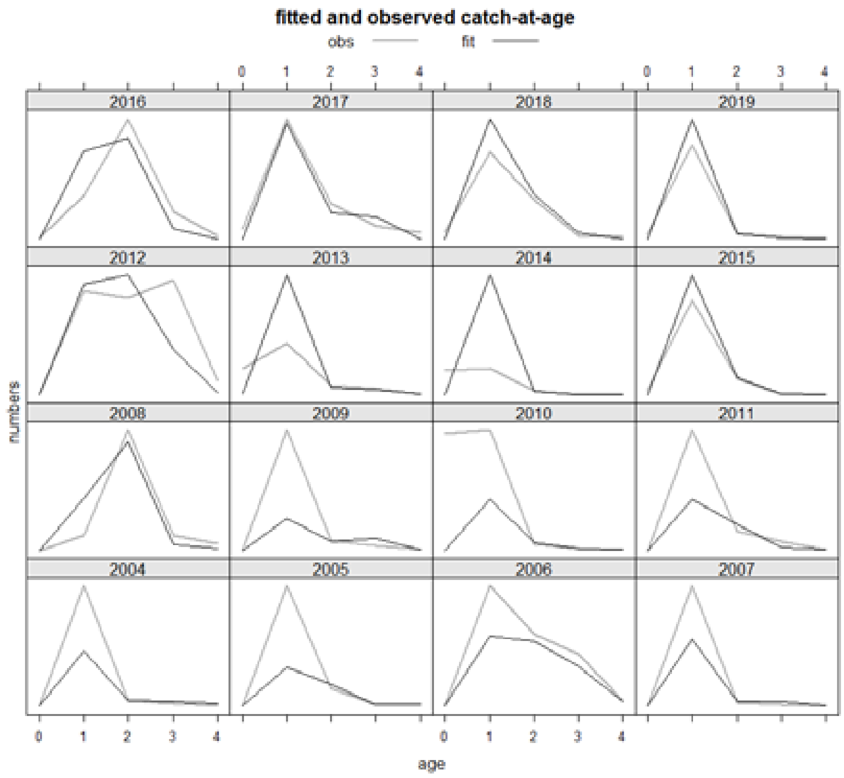


Figure 19.6.1.5. Observed (grey) and estimated (black) catch number-at-age.

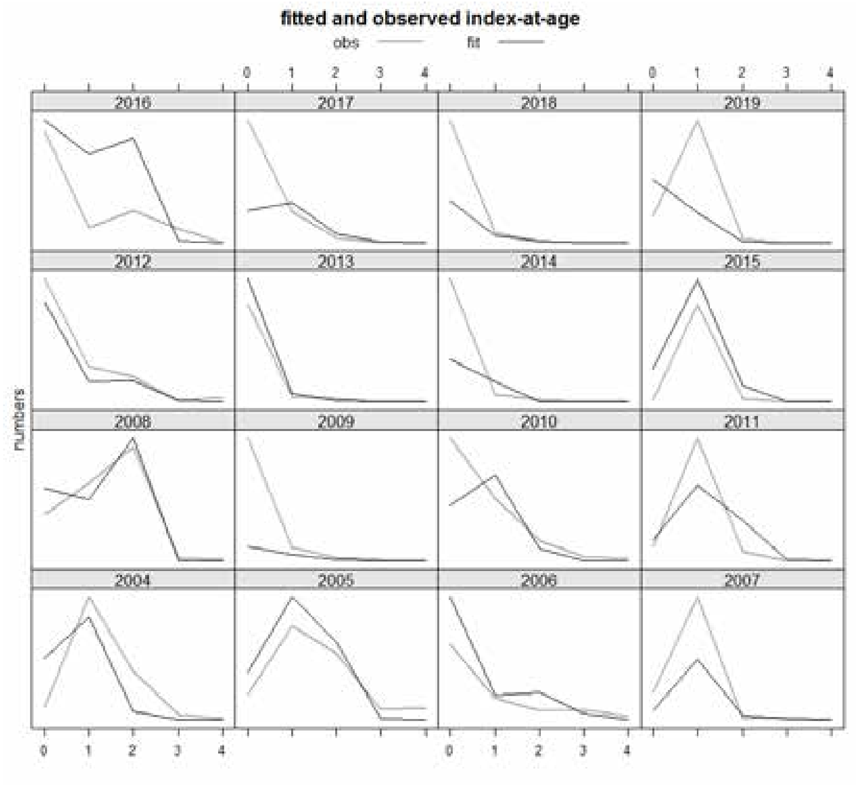


Figure 19.6.1.6. Observed (grey) and estimated (black) indices at age.

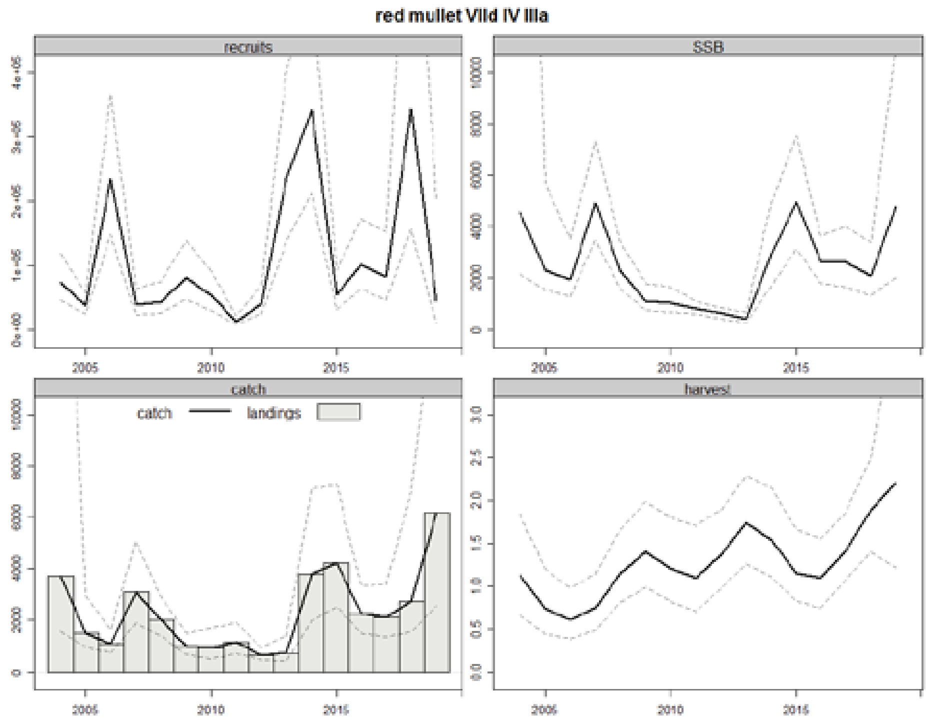


Figure 19.6.2.1. Absolute value of recruitment, SSB, catch and Fbar(1-2) estimate using alternative formulation of a4a to constrain selectivity at age and consider variance at age.

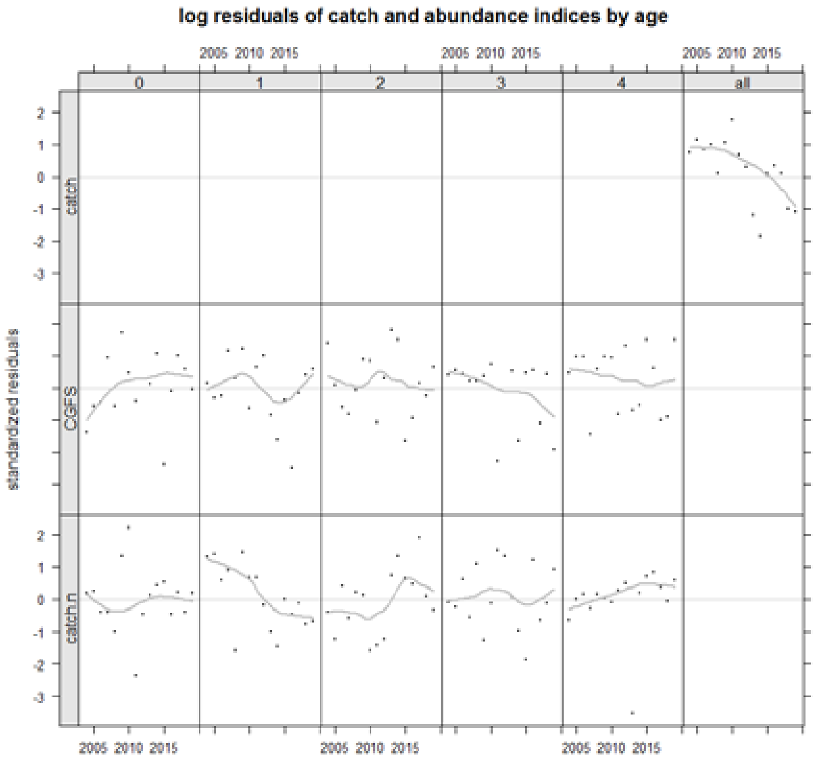


Figure 19.6.2.2. Log residuals of the alternative a4a model.

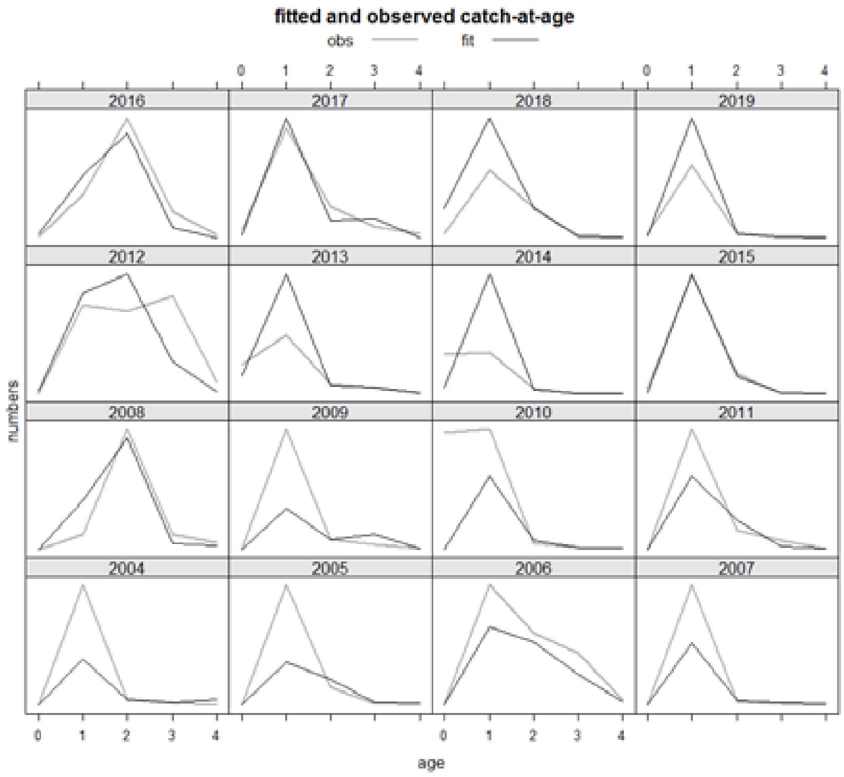


Figure 19.6.2.3. Observed (grey) and estimated by the alternative a4a model (black) catch number-at-age.

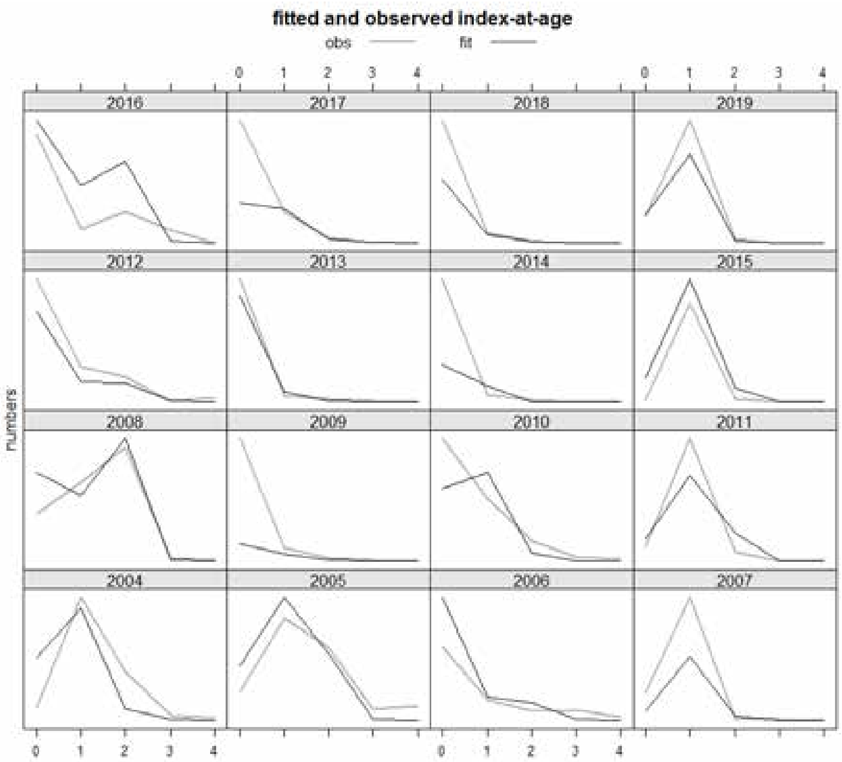


Figure 19.6.2.4. Observed (grey) and by the alternative a4a model (black) indices at age.

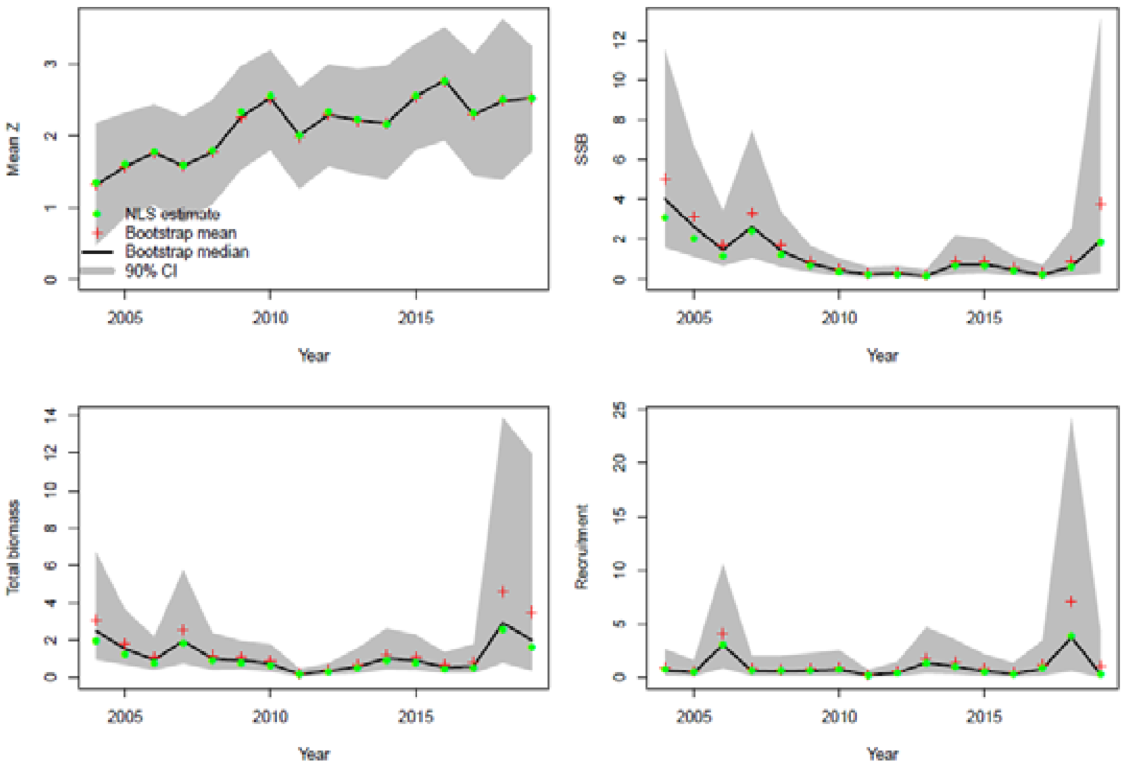


Figure 19.6.2.5. SURBAR stock summary (clockwise from upper left: mean Z(1-2), relative SSB, relative recruitment at age 0, relative total biomass). In each plot, the green dots give the nonlinear least-squares estimates, the red crosses give the uncertainty-estimation bootstrap mean, the black line gives the bootstrap median, and the grey band gives a 90% confidence interval about the median.

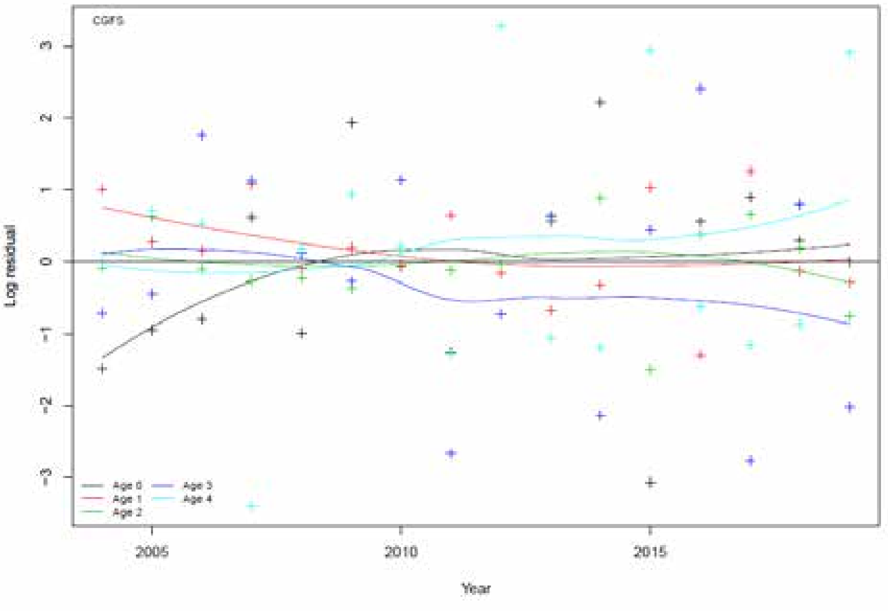


Figure 19.6.2.6. SURBAR Log residuals at age for CGFS.

20 Turbot in 3.a (Kattegat, Skagerrak)

The last advice issued in 2019 was based on the 3:2 rule for category 3 stock, applied to the IBTS Q1 and Q3 biomass indices. In 2019, 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. The same applies to 2020.

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.

20.1 Management regulations

There no TAC in place for turbot in area 3.a.

There is no official EC minimum landing size, but Denmark has a minimum size at 30 cm. In the Netherlands, various restrictions and MLS for North Sea turbot have been applied by Dutch POs over time, which may also affect the Dutch discarding of turbot caught in Skagerrak.

20.2 Fisheries data

Turbot is now only caught as by-catch in the trawl and gillnet fisheries. Table 20.1 and Figure 20.1 summarize turbot landings in ICES area 3.a. Over the period 1975–2019, total landings (3.a) ranged from 95 t to 736 t per year, with the lowest landings in 2010-2011 and the highest peaks in the late 1970s and in the early 1990s. The peak 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 2019, the total landings were 204 tonnes.

The stock was benchmarked in early 2020, which included a data call for turbot in Division 3.a with data 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 (10.9%) was used for earlier years. Details of the benchmark are provided in the associated report (ICES, 2020).

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) and two Danish national surveys (TN and TOR), all covering parts of Division 3.a. (ICES, 2020). The new exploitable biomass index provided a major improvement that was used for applying a SPiCT model during the benchmark. The SPiCT model combined the new exploitable biomass index and updated fisheries data and was approved during the benchmark (ICES, 2020).

20.4 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 addressed.
- 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.

20.5 Summary

The turbot stock in Division 3.a was benchmarked in early 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 proxy reference point of 0.5. By the end of 2019, fishing pressure (F/F_{MSY}) went above the proxy reference point of 1.

Table 20.1. Turbot in 27.3a. History of commercial landings 1975-2019; 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

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
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

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
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
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

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%

Year	Discards	Landings	Total	discard ratio
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%
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%

Year	Discards	Landings	Total	discard ratio
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%
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%

Table 20.3: Turbot in 27.3a. Summary of the imported/Raised data for 2019. Stock exported without length allocation.

Discards	**41903**	
Imported Data	22790	54%
Raised Discards	19112	46%
Landings	**204356**	
Imported Data	204356	
Grand Total	**246259**	

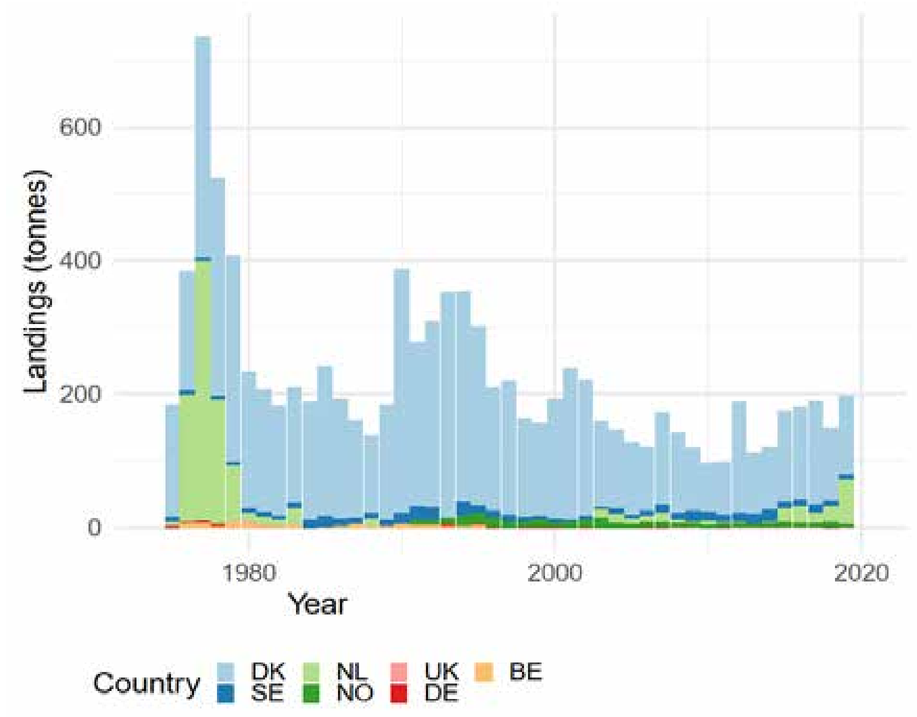


Figure 20.1. Turbot in 27.3a: Official landings by country from 1975 to 2019.

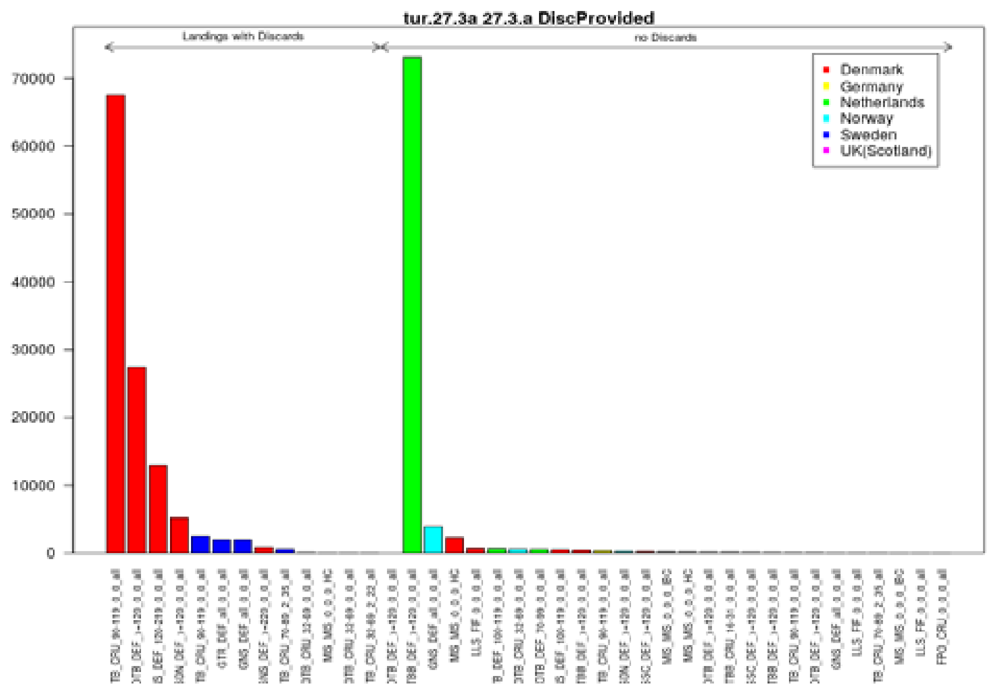


Figure 20.2. Turbot in 27.3a. Summary of the information provided to InterCatch for 2019. Landings by metier and country, distinguishing between strata with and without corresponding discard information provided.

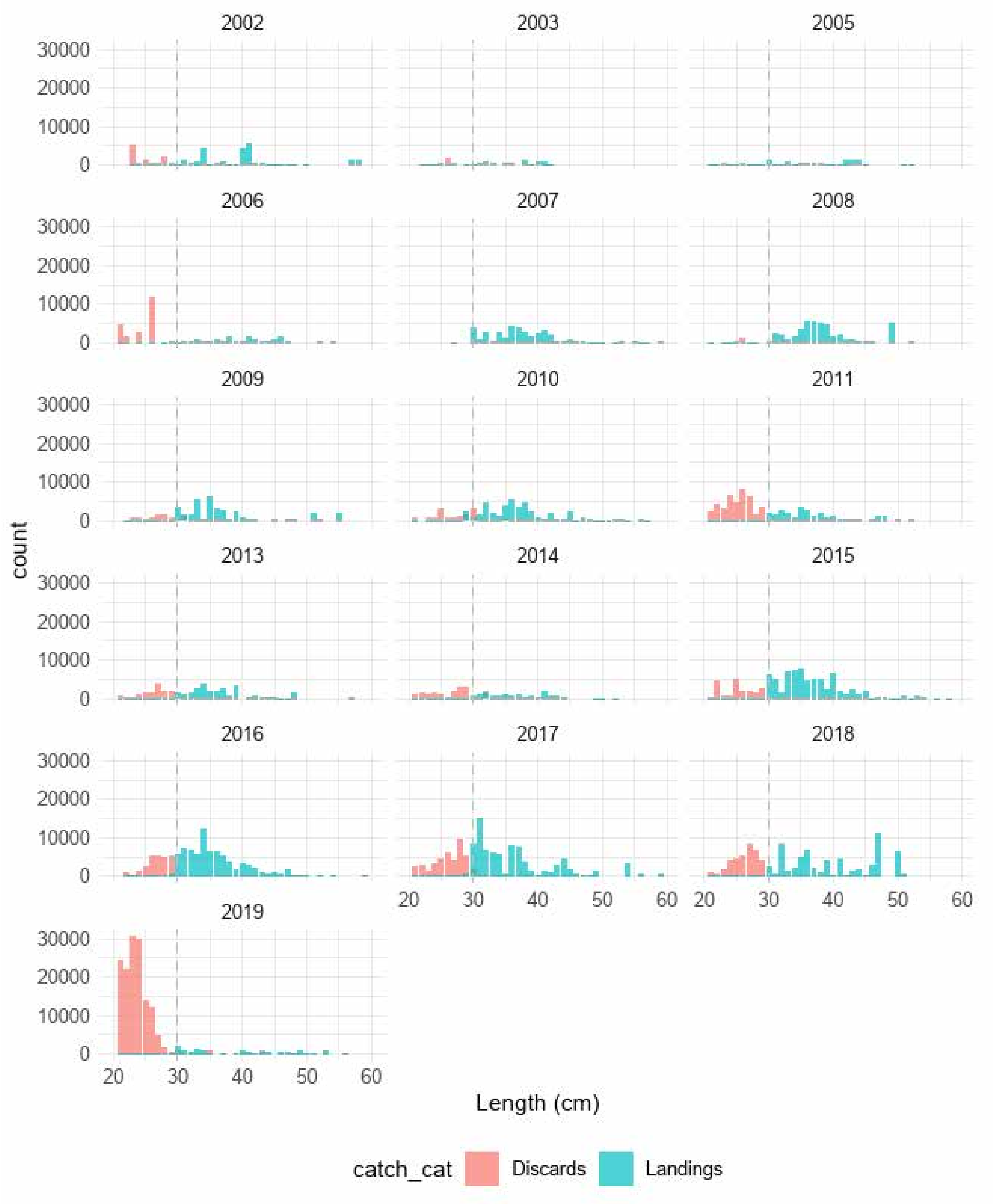
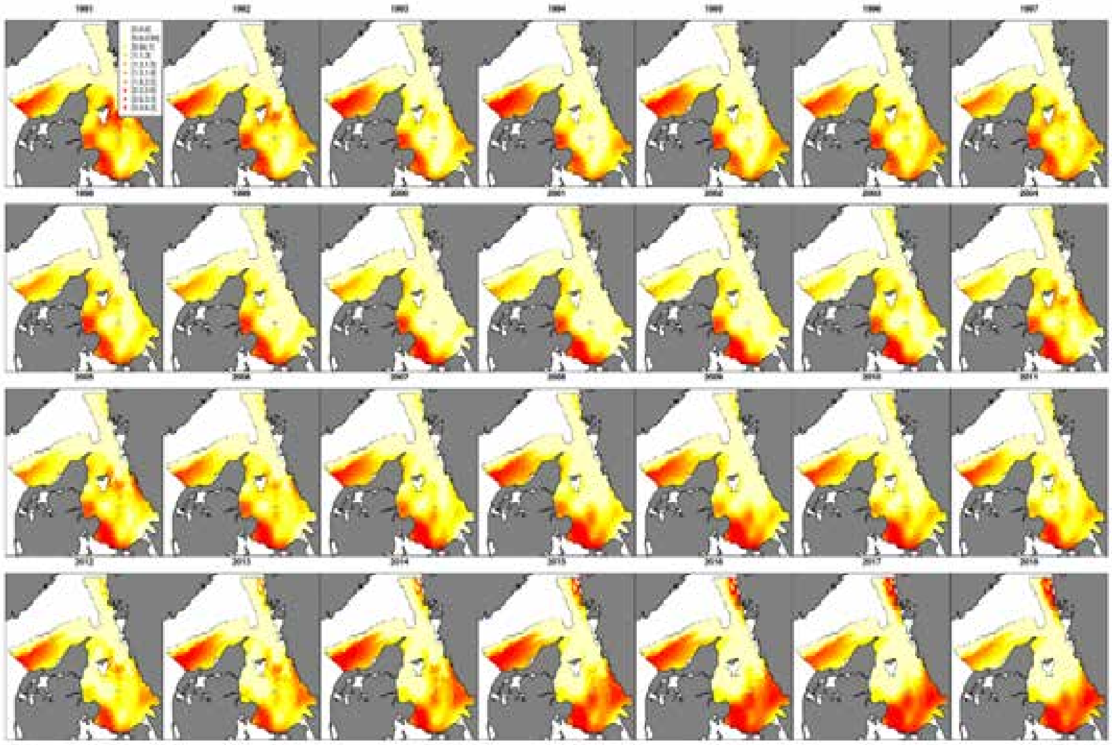
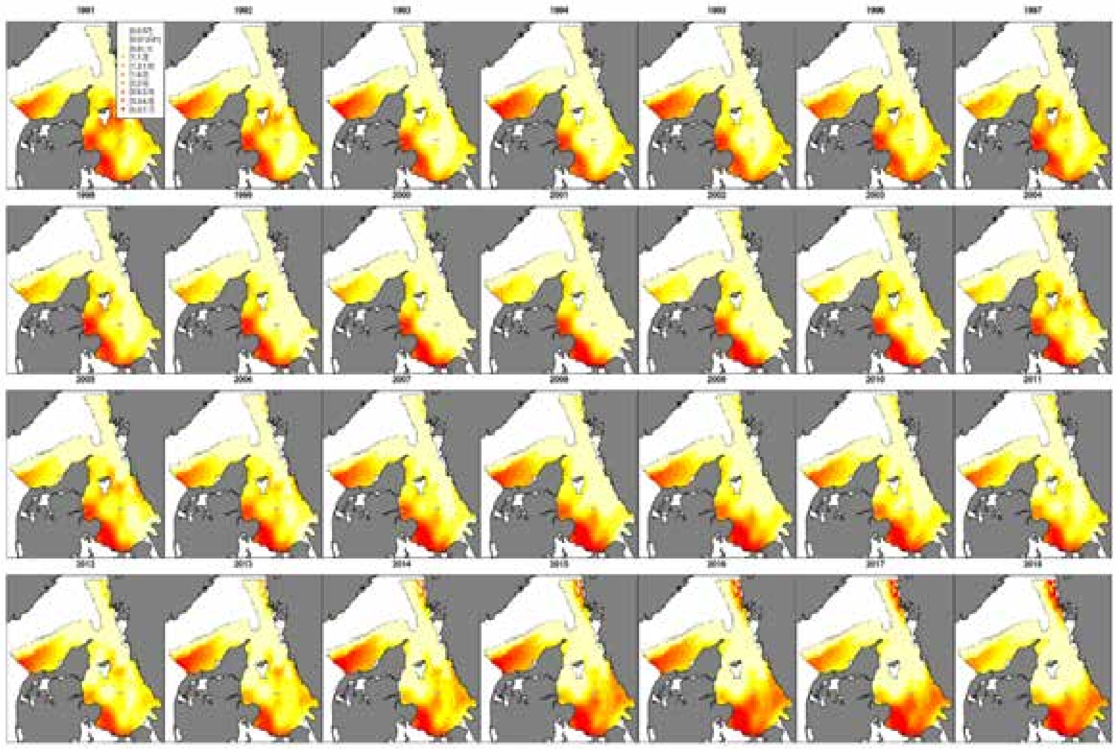


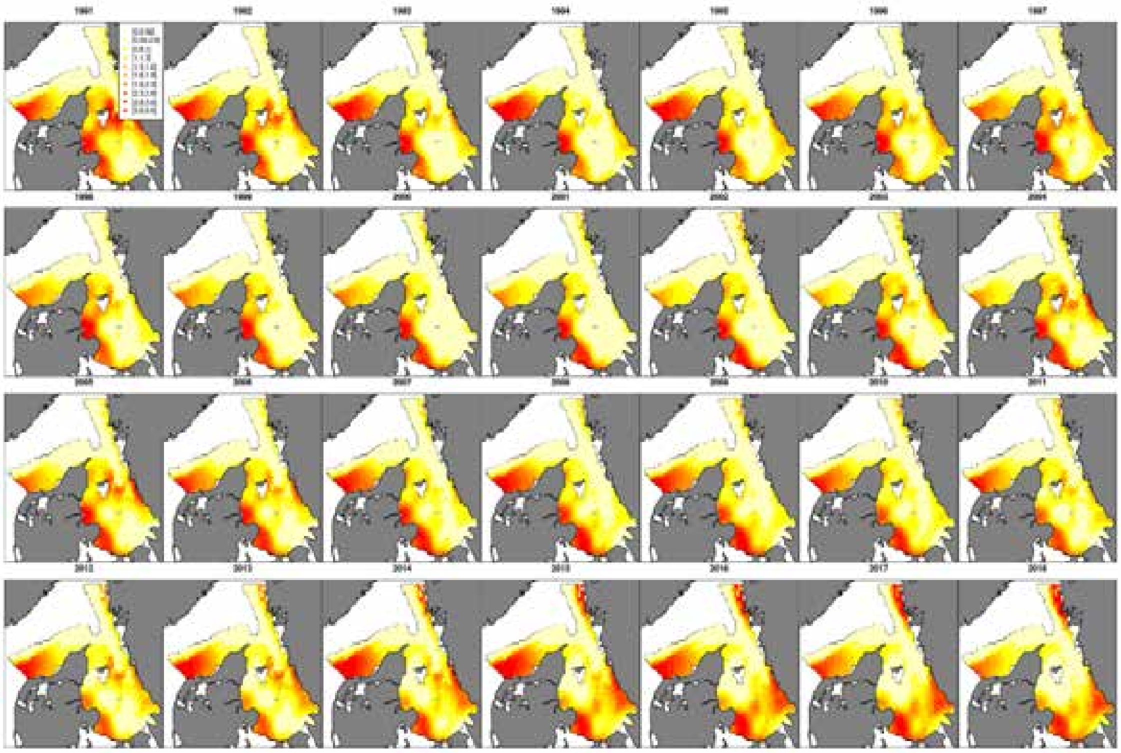
Figure 20.3. Turbot in 27.3a: Length distribution in landings and discards across 2002-2019. Most individuals below 30 cm are discarded (vertical dashed line).



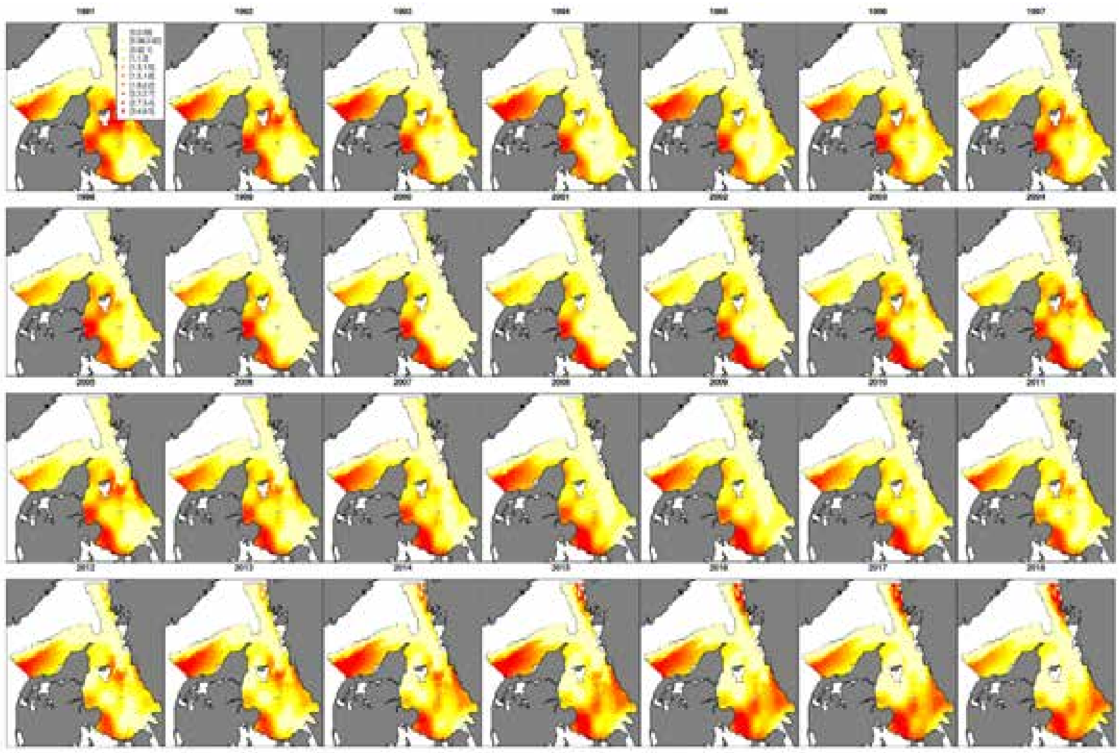
A: Exploitable biomass index in Q1 in 27.3.a.



B: Exploitable biomass index in Q2 in 27.3.a.



C: Exploitable biomass index in Q3 in 27.3.a.



D: Exploitable biomass index in Q4 in 27.3.a.

Figure 20.4 (A – D). Turbot in 27.3a. Exploitable biomass survey indices by quarter (Q1 – Q4)

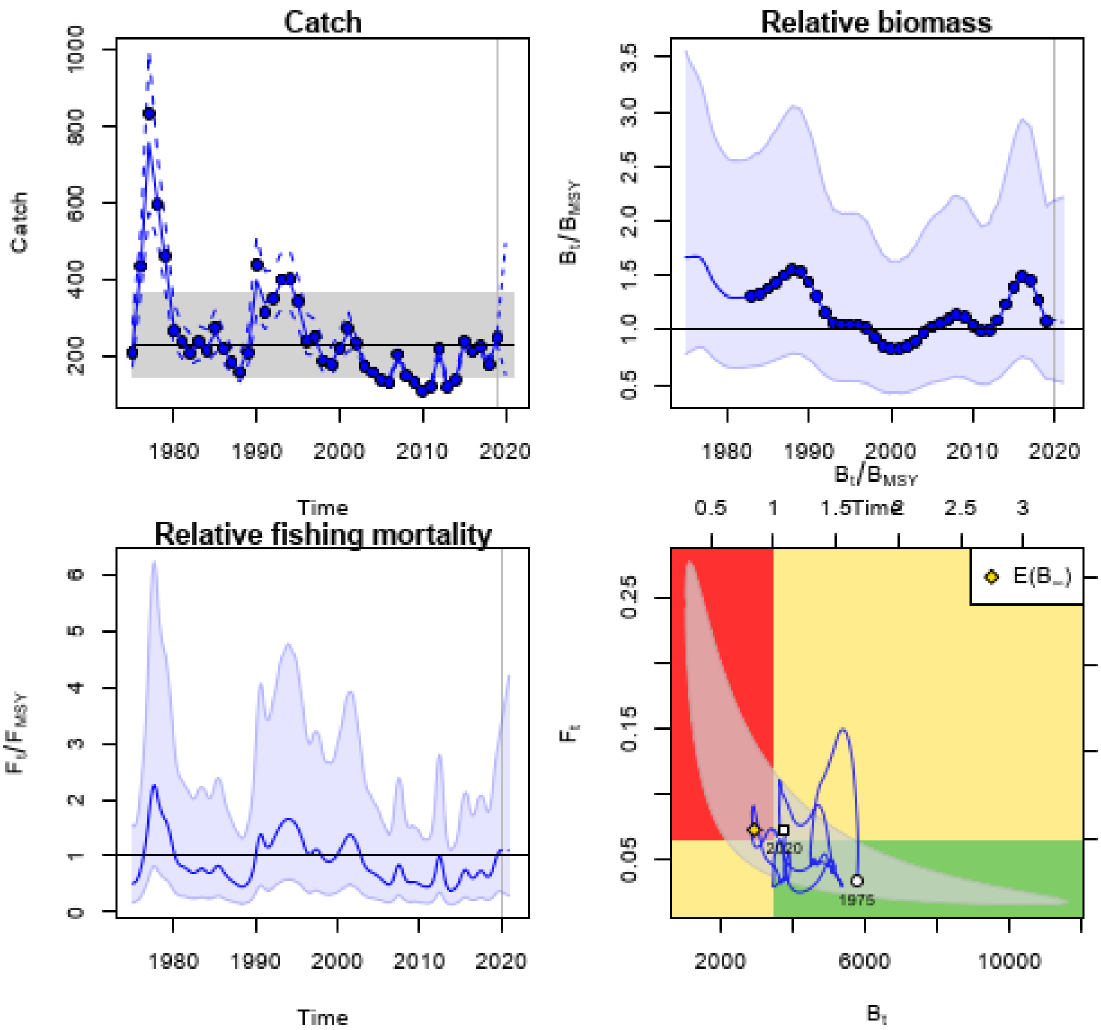


Figure 20.5. Turbot in 27.3a. SPiCT assessment running to the end of 2019 using settings developed during the benchmark in early 2020 (ICES, 2020).

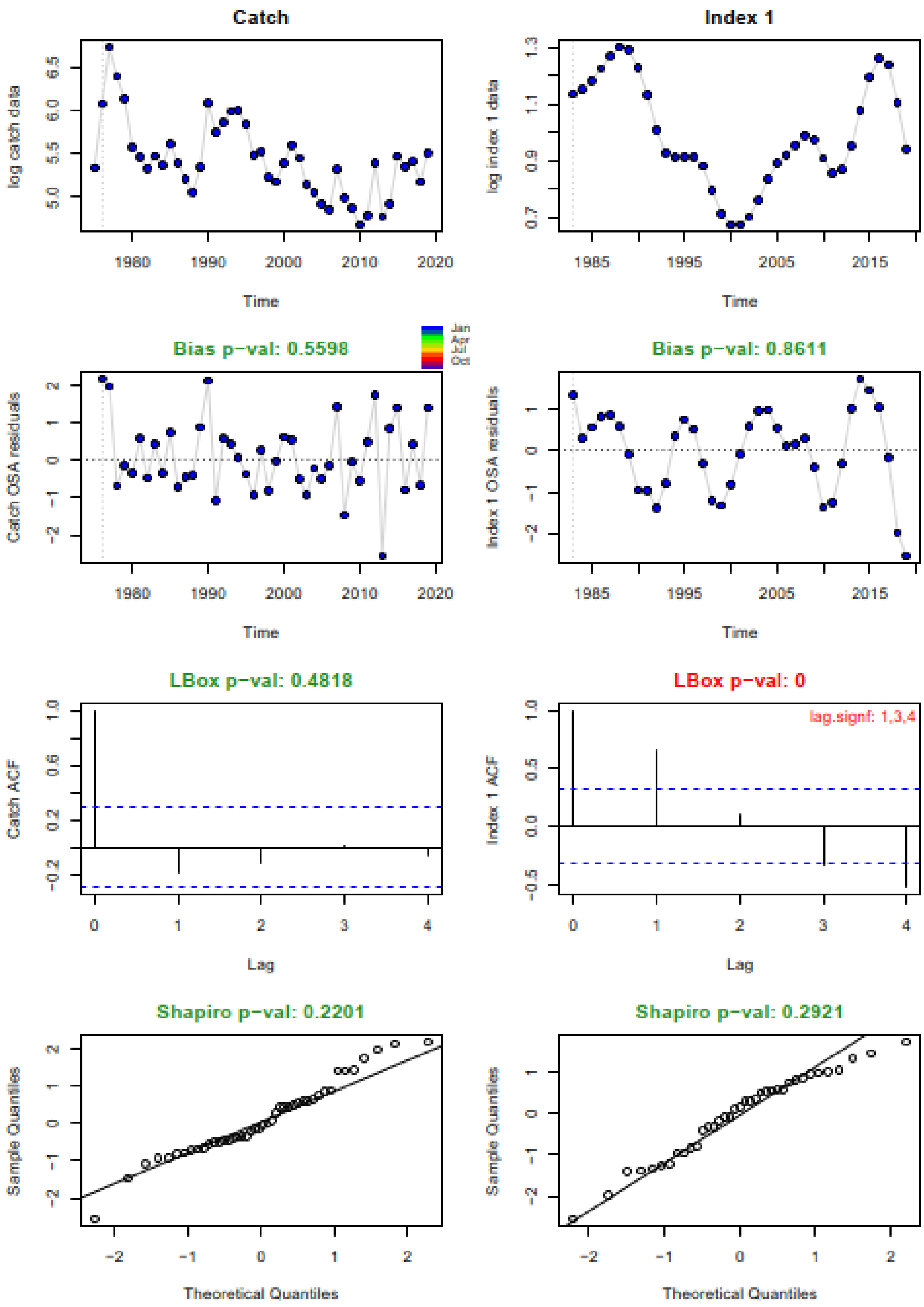


Figure 20.6. Turbot in 27.3a. Evaluation of SPiCT assessment running to the end of 2019. The application of the new exploitable biomass index via SPiCT indicated residual autocorrelation issues.

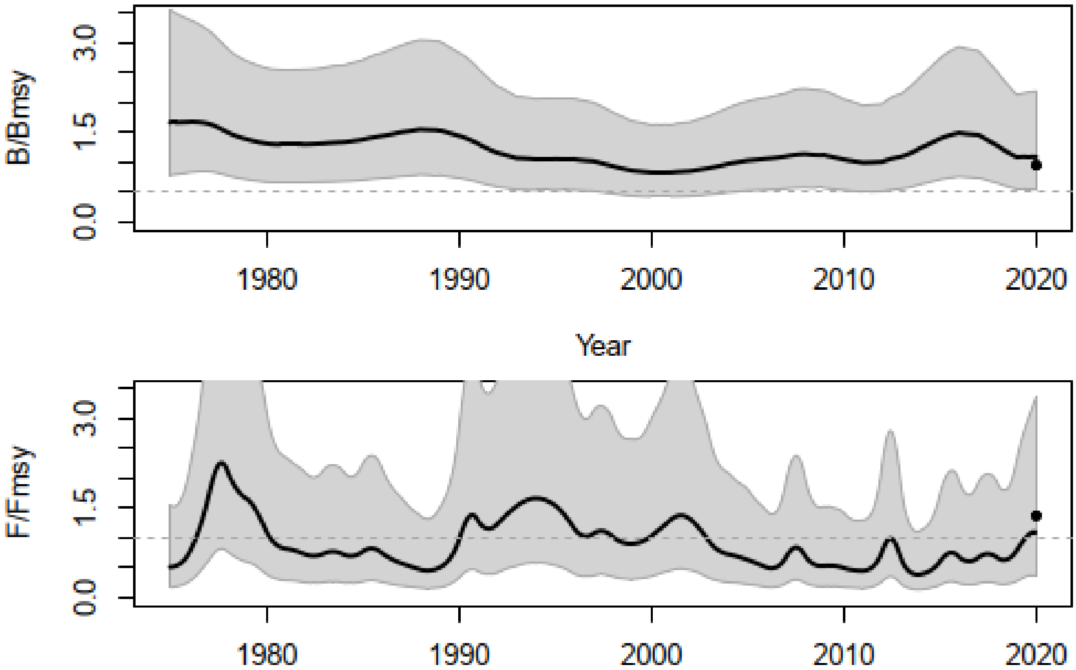


Figure 20.7. Turbot in 27.3a. B/Bmsy and F/Fmsy from 1975 to the end of 2019. The B/B$_{MSY}$ 35th percentile is above the proxy reference point of 0.5 (see single datum; 0.95). The F/F$_{MSY}$ 65th percentile is above the proxy reference point of 1 (see single datum; 1.38).

21 Turbot in Subarea 4

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2020. 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. Despite its role as a top predator in the North Sea ecosystem, at present turbot is not included as a species in the WGSAM multispecies assessment (ICES, 2014a).

21.1.2 Fisheries

In the 1950s, the UK was the biggest contributor to the landings (~50% of the landings). In recent years, most of the landings stem from the Netherlands (~50–60%). In most countries, turbot is caught in 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).

See the Stock Annex for more details.

21.1.3 Management

A combined EU TAC for turbot and brill is set for EU waters in areas 2.a and 4. This TAC only applies to the EU fisheries. This management area (particularly the inclusion of Area 2.a) does not correspond to either of the stock areas defined by ICES for turbot and brill.

No specific management objectives or plans are known to ICES.

As a primarily bycatch species, regulations relating to effort restrictions for the primary métiers catching turbot (e.g. beam trawlers) are likely to impact on the stock. Fishing effort has been restricted in the past for demersal fleets in a number of EC regulations (e.g. EC Council Regulation Nos. 2056/2001, 51/2006, 41/2007, and 40/2008).

The Dutch Producer Organisations have introduced a minimum landings size of 27 cm in 2013. In 2016, this size was increased to 30 cm first, and then to 32 cm. In the summer of 2016, the POs decided to prohibit landing the smallest market category and in October and November the weekly landings were capped to respectively 375 kg and 600 kg wk^{-1}. These measures were taken to keep the landings in line with the national quota. In 2018, the TAC for turbot and brill was substantially increased; however, Dutch PO measures were still in place with a minimum landing size of 30 cm and 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.

Measures taken by the Dutch Producer Organisations from 2016 up to present.

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

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.

21.1.4 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. In 2018, official landings in Subarea 4 decreased to 3168 tonnes, decreasing slightly further to 3095 tonnes in 2019. In the last 3 years, the combined TAC for turbot and brill has not been fully utilized. In 2019, only 55% of the combined TAC (8122 tonnes) was taken of which turbot had the largest share (38%).

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. However, in the last 5 years, an increase is observed in the proportion of age 5+ fish in the landings compared to the five years prior to that; 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 2019, there is a decrease in landings of age 4. This decrease may result from the weak 2016 year class. In 2019 more age 2 and 3 as well as 5+ fish are observed in the landings.

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).

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[1] see Stock Annex for turbot 27.4 for full details

21.1.5 Discards

The assessment of this stock does not include discards as there is very limited age sampling of the discards. Very few fish were sampled in the discards of some Danish métiers (<10 per métier) which is not enough to be used in the raising of international landings.. 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: 230 172 / (discards + landings: 3 044 778) was 7% in 2019. This is lower compared to the previous three years (i.e. an average of 14% over 2016-2018). The discard rate in 2019 is more in line with the discard rate observed in the period 2013–2015, when discard ratios were approximately 5%. No useable age structure information was submitted for the discard estimates.

21.1.6 BMS landings

In 2019, BMS landings were reported by the UK (England); however, the submitted values were very low (57kg) and were therefore not raised in InterCatch.

21.1.7 Logbook registered discards

In 2019, 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.

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 (4186) almost doubled compared to 2018 (2267) and is mainly due to an increase in sampling of landings in different Danish métiers. The Dutch 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 2019. Approximately 52% 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. If by quarter was not possible, available quarters were grouped. Also note, that in 2019, no age samples of discards were available. The allocation for discards were done separately, but made 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, all quarter
OTB < 100 mm	Within metier, by quarter
OTB > 100 mm	Within metier, by quarter
SSC/SDN > 70 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 discards or age structure is known.**

**** Sampled fleet are those fleets for which age structure is known.**

In 2019, most countries provided estimates of discards to InterCatch. Although 4% of discards in weight were sampled in 2018, no discard age samples were available in 2019. 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.

Out of the 230 tonnes of estimated discards, 188 tonnes (82%) was reported data and 42 tonnes are raised in InterCatch. The proportion of landings with discards associated (same strata) is 63%.

21.1.9 Survey data and commercial LPUE

Two survey abundance indices, the Sole Net Survey (SNS) and the Beam Trawl Survey (BTS ISIS), and one standardised commercial LPUE abundance index based on the Dutch 80 mm beam trawl fleet (BT2), are used to tune the assessment (Table 21.3.1–3 and Figure 21.2.4).

All abundance indices indicate an increase in the number of fish aged 4 and older in late 2000s compared to the past. An increase in the amount of older fish would indicate either strong recruitment or a decrease in mortality (e.g. fishing pressure) exerted on the stock. After a decrease in some of the older ages and no clear indications of strong year classes since 2010, year class 2015 (ages 4 in 2018 and 5 in 2019) appear strong. In 2019 a higher recruitment (age 1) compared to 2018 is observed. The Dutch BT2 LPUE index shows a continuous gradual increase since 2000. After two years of decline, the LPUE increases slightly in 2019. 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.

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) 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	2.1.0
FLCORE version	2.6.14
R version	3.6.1 (2019-07-05)
Platform	x86_64-w64-mingw32
Run date	2020-04-24 14:00:21

Model	SAM
First tuning year	1981
Last data year	2019
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–

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 (Fmsy) since 2012. However, in 2018 and 2019 fishing mortality is estimated at 0.368 and 0.367, respectively. As such fishing mortality has been just above Fmsy, but well below the long term geometric mean (0.51). The SSB in 2019 was estimated to be 8211 tonnes, a decrease (8%) from 2018 which was estimated at 8939 tonnes (Table 21.4.1b). SSB has been above MSY $B_{trigger}$ (6353 tonnes) since 2013. The estimated recruitment (age 1) for 2019 (8095) is the second highest recruitment in the time-series. The estimated recruitment is well above the geometric mean of the time series (4563) (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 0.84, 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 0.38 in 2008. Between 2012 and 2017, F has fluctuated around 0.34. In the last two years F has slightly increased to Fmsy 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 –11.3% on SSB, 7.6% on F and -5.0% 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 (Fpar), 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 2019 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 2019 the North Sea Working Group decided to replace F_{pa} with $F_{P.05}$. $F_{P.05}$ is the value of F, including modification with biomass criteria that, if applied as target in the advice rule would $_{lim}$ with a 95% probability. $F_{P.05}$ provides an upper F limit that is considered precautionary for management plans and MSY rules.

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. $F_{pa} = F_{P.05}$	0.47
5. F_{lim}	0.61
7. F_{MSY}	0.36
8. $F_{MSY\ lower}$	0.25
9. $F_{MSY\ upper}$	0.48

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 recent years, the TAC has not been exhausted, and therefore using a % TAC was deemed inappropriate. Hence, the assumption for the intermediate year was made to not use a catch constraint but a status-quo F instead. This was also supported by the recent years in which F has been very 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
$F_{ages\ 2–6}$ (2020)	0.36	$F_{sq} = F_{average}$ of F (2017–2019)
SSB (2021)	9161	Short-term forecast
R_{age1} (2020, 2021)	4563	Geometric mean (GM, 1981–2019)
Projected landings (2020)	3402	Short-term forecast (STF), assuming an F status quo

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 * (2021)	Projected landings ** (2021)	Projected discards *** (2021)	F (2-6) (2021)	SSB (2022)	% SSB change ^	% advice change ^^
MSY approach: FMSY	3948	3514	435	0.36	9449	3	-13
FMSY upper = 0.48	4984	4435	549	0.48	8449	-8	10
FMSY lower = 0.25	2887	2569	318	0.25	10484	14	-36
F = 0	0	0	0	0.00	13337	46	-100
Fpa	4902	4363	540	0.47	8528	-7	8
Flim	5980	5322	658	0.61	7498	-18	32
Fsq	3985	3547	439	0.36	9414	3	-12
SSB (2021) = Blim	10948	9742	1205	1.69	2974	-68	141
SSB (2021) = Bpa	9587	8531	1055	1.28	4163	-55	111
SSB (2021) = MSY Btrigger	7194	6402	792	0.79	6353	-31	59
Rollover advise	4537	4038	499	0.43	8879	-3	0
Multi-options table							
F = 0	0	0	0	0	13303	46	-100
F= 0.05	635	565	70	0.05	12671	39	-86
F = 0.10	1238	1102	136	0.10	12073	32	-73
F = 0.15	1813	1613	200	0.15	11506	26	-60
F = 0.20	2359	2099	260	0.20	10968	20	-48
F = 0.25	2879	2562	317	0.25	10458	14.5	-37
F = 0.30	3375	3003	371	0.30	9974	9.2	-26
F = 0.35	3846	3423	423	0.35	9515	4.2	-15.2
F = 0.40	4296	3823	473	0.40	9079	-0.6	-5.3
F = 0.45	4724	4204	520	0.45	8666	-5.1	4.1
F = 0.50	5132	4567	565	0.50	8274	-9.4	13.1

*** (projected landings) / (1 – average discard rate); average discard rate 2017–2019 = 11.0%**

**** Marketable landings**

***** Including BMS landings (EU stocks), assuming recent discard rate.**

^ SSB 2022 relative to SSB 2021.

^^ Total catch in 2021 relative to advice value for 2020 (4538 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. In 2019 turbot fell 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.

In 2019, the survey took place in quarter 3 and 3 traditional beam trawl vessels were selected. The area definition is based on CPUE data and unfishable areas such as N2000 areas or wind parks are removed (Figure 21.9.1). Furthermore the area is divided in 5x5 grid cells of which 60 are randomly chosen each year. The 60 cells are manually divided over the three vessels based on their knowledge of the fishing grounds. The skippers are instructed to start fishing anywhere in the prescribed cell, but can fish any route as if they complete a regular commercial haul; as such fishing activities may exit the cells, but not allowed to exit the survey area.

Data collection of the turbot and brill caught in the haul consisted of:

- Fishing conditions (haul list, gear description)
- Count all turbot and brill per survey haul
- Length, weight and sex of all turbot and brill
- Age by otolith per length class

In total, 50 hauls were sampled in the 2019 survey, catching 782 brill and 1741 turbot. The numbers of turbot caught during this industry survey were approximately 9 times higher than caught during the BTS-ISIS survey. Length measurements ranged from 17cm to 62cm for turbot and 21cm to 54cm for brill (Figure 21.9.2). Ageing was done over 1cm-classes for 164 brill and 196 turbot, showing that most of the fish caught are within ages 1 to 3 (Figure 21.9.3.). 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. However, there are some practical drawbacks which need to be sorted out to verify if this rather costly survey could be continued.

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	282.247	712.696	502.191	432.338	165.195	63.246	101.005
1982	0	149.515	925.398	236.215	147.745	258.333	86.701	137.129
1983	0	357.366	598.277	425.817	97.787	100.454	160.015	180.461
1984	0	1188.916	1121.948	285.303	144.028	55.042	52.290	178.888
1985	0	618.991	1880.33	509.207	139.37	84.868	20.244	124.577
1986	0	320.687	1270.648	602.477	158.183	57.914	25.067	107.184
1987	12.614	628.776	529.802	655.945	153.313	50.457	18.436	67.923
1988	32.221	970.218	802.846	159.316	157.526	80.553	25.061	68.918
1989	0	667.517	1165.346	353.986	156.204	82.035	31.465	68.550
1990	44.398	988.110	1065.548	314.915	165.201	75.373	101.186	113.576
1991 – 1997	NO DATA							
1998	0	402.412	862.949	354.718	72.285	29.287	8.421	14.166
1999 – 2002	NO DATA							
2003	210.208	1912.342	461.356	297.598	70.857	32.988	20.706	20.548
2004	436.556	1987.094	795.193	138.759	82.721	9.695	7.561	6.093
2005	345.361	1990.781	724.891	231.348	24.914	21.948	2.61	19.279
2006	893.27	1660.72	815.171	120.25	35.442	7.974	16.329	18.303
2007	79.773	2824.495	626.002	289.538	40.935	29.553	8.387	16.164
2008	180.397	1372.774	835.006	223.907	198.485	47.910	13.102	10.394
2009	122.148	1124.302	1050.115	453.483	96.13	27.063	11.912	20.020
2010	280.461	1412.965	388.476	311.492	172.919	88.710	30.794	19.684
2011	214.893	1978.27	613.98	112.792	140.254	78.464	32.857	24.039
2012	0	1928.838	785.002	269.484	42.894	64.563	73.766	24.974
2013	174.239	1595.558	1091.829	328.498	91.840	26.231	42.407	26.134
2014	65.449	372.195	618.004	649.635	130.675	115.835	36.126	99.856
2015	39.196	1211.195	463.216	325.260	315.262	109.37	43.032	79.464
2016	0	1027.671	982.364	329.608	354.081	185.173	44.609	69.780
2017	6.782	324.008	1631.371	589.01	136.285	61.520	96.339	59.606

Year	Age							
	1	2	3	4	5	6	7	8
2018	176.532	691.014	466.277	894.467	248.406	67.067	44.591	70.386
2019	168.586	1039.691	863.145	257.190	351.274	119.634	22.405	62.557

Table 21.2.1b. ICES estimated landings (tonnes) SOP corrected and discards of turbot in Area 4.

Year	Landings	Landing SOP	Discards
1981	4755	1	
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	

Year	Landings	Landing SOP	Discards
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							

Year	Age							
	1	2	3	4	5	6	7	8
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

Table 21.2.2b. Turbot in Area 4. Modelled weights at age in the catch (units: kg).

	Age							
Year	1	2	3	4	5	6	7	8
1981	0.351	0.752	1.299	1.962	2.712	3.515	4.347	5.974
1982	0.363	0.78	1.346	2.034	2.81	3.643	4.504	6.299
1983	0.376	0.806	1.392	2.103	2.905	3.767	4.657	6.38
1984	0.387	0.832	1.436	2.169	2.997	3.885	4.804	6.608
1985	0.399	0.856	1.477	2.232	3.084	3.998	4.943	7.026
1986	0.409	0.878	1.516	2.290	3.164	4.103	5.073	7.559

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1987	0.419	0.899	1.551	2.344	3.238	4.198	5.191	7.916
1988	0.427	0.917	1.582	2.391	3.304	4.283	5.296	7.085
1989	0.434	0.932	1.609	2.431	3.36	4.356	5.386	7.542
1990	0.44	0.945	1.631	2.464	3.405	4.415	5.459	7.351
1991	0.445	0.954	1.647	2.489	3.439	4.459	5.514	7.606
1992	0.447	0.96	1.658	2.505	3.461	4.487	5.548	7.654
1993	0.449	0.963	1.662	2.511	3.469	4.498	5.562	7.672
1994	0.448	0.961	1.659	2.507	3.464	4.491	5.553	7.66
1995	0.445	0.956	1.65	2.492	3.444	4.465	5.521	7.616
1996	0.441	0.946	1.633	2.467	3.409	4.42	5.465	7.539
1997	0.434	0.932	1.609	2.432	3.36	4.356	5.386	7.43
1998	0.426	0.915	1.579	2.385	3.296	4.273	5.283	7.175
1999	0.416	0.893	1.542	2.33	3.22	4.174	5.162	7.12
2000	0.405	0.87	1.501	2.268	3.134	4.063	5.024	6.931
2001	0.393	0.844	1.457	2.201	3.041	3.943	4.875	6.726
2002	0.381	0.817	1.41	2.13	2.944	3.816	4.719	6.51
2003	0.368	0.789	1.362	2.058	2.843	3.687	4.558	6.302
2004	0.355	0.761	1.314	1.985	2.743	3.556	4.397	5.78
2005	0.342	0.733	1.266	1.913	2.643	3.426	4.237	5.434
2006	0.329	0.706	1.219	1.842	2.546	3.3	4.081	6.023
2007	0.317	0.68	1.175	1.775	2.452	3.179	3.931	5.276
2008	0.306	0.656	1.132	1.711	2.364	3.065	3.789	5.325
2009	0.295	0.633	1.093	1.651	2.281	2.957	3.657	5.11
2010	0.285	0.612	1.056	1.596	2.205	2.859	3.535	4.882
2011	0.276	0.593	1.023	1.546	2.137	2.77	3.425	4.425
2012	0.268	0.576	0.994	1.502	2.076	2.691	3.328	4.371
2013	0.262	0.562	0.969	1.465	2.024	2.624	3.244	4.164
2014	0.256	0.549	0.949	1.433	1.98	2.567	3.174	4.253

Year	Age 1	2	3	4	5	6	7	8
2015	0.252	0.54	0.932	1.409	1.946	2.523	3.12	4.333
2016	0.249	0.533	0.921	1.391	1.922	2.492	3.081	4.331
2017	0.247	0.53	0.914	1.381	1.909	2.475	3.06	4.28
2018	0.247	0.529	0.913	1.38	1.907	2.472	3.057	4.185
2019	0.248	0.532	0.919	1.388	1.918	2.486	3.074	4.179

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

Year	Age							
	1	2	3	4	5	6	7	8
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

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	0.336	0.722	1.246	1.883	2.601	3.373	4.170	5.732
1982	0.349	0.748	1.291	1.951	2.696	3.495	4.321	6.044
1983	0.360	0.773	1.335	2.017	2.787	3.614	4.468	6.120
1984	0.372	0.798	1.377	2.081	2.875	3.728	4.609	6.340
1985	0.382	0.821	1.417	2.141	2.958	3.836	4.743	6.741
1986	0.393	0.842	1.454	2.197	3.036	3.936	4.867	7.252
1987	0.402	0.862	1.488	2.248	3.107	4.028	4.980	7.595
1988	0.410	0.880	1.518	2.294	3.169	4.109	5.081	6.797
1989	0.417	0.894	1.544	2.333	3.223	4.179	5.167	7.236
1990	0.422	0.907	1.565	2.364	3.267	4.236	5.237	7.053
1991	0.427	0.916	1.581	2.388	3.300	4.278	5.290	7.297
1992	0.429	0.921	1.590	2.403	3.320	4.305	5.323	7.343
1993	0.430	0.924	1.594	2.409	3.328	4.315	5.336	7.361
1994	0.430	0.922	1.592	2.405	3.323	4.308	5.327	7.349
1995	0.427	0.917	1.583	2.391	3.304	4.284	5.297	7.307
1996	0.423	0.908	1.567	2.367	3.271	4.241	5.243	7.233

Year	Age							
	1	2	3	4	5	6	7	8
1997	0.417	0.894	1.544	2.333	3.223	4.179	5.167	7.128
1998	0.409	0.877	1.515	2.288	3.162	4.099	5.069	6.884
1999	0.399	0.857	1.480	2.236	3.089	4.005	4.952	6.831
2000	0.389	0.834	1.440	2.176	3.007	3.898	4.820	6.649
2001	0.377	0.810	1.398	2.112	2.918	3.783	4.677	6.452
2002	0.365	0.784	1.353	2.044	2.824	3.661	4.527	6.245
2003	0.353	0.757	1.307	1.974	2.728	3.537	4.373	6.046
2004	0.340	0.730	1.260	1.904	2.631	3.411	4.218	5.545
2005	0.328	0.704	1.215	1.835	2.535	3.287	4.065	5.214
2006	0.316	0.678	1.170	1.767	2.442	3.166	3.915	5.778
2007	0.304	0.653	1.127	1.703	2.353	3.050	3.771	5.062
2008	0.293	0.629	1.086	1.641	2.268	2.940	3.635	5.109
2009	0.283	0.607	1.048	1.584	2.188	2.837	3.508	4.902
2010	0.274	0.587	1.013	1.531	2.116	2.743	3.392	4.683
2011	0.265	0.569	0.982	1.484	2.050	2.658	3.286	4.245
2012	0.257	0.553	0.954	1.441	1.992	2.582	3.193	4.193
2013	0.251	0.539	0.93	1.405	1.941	2.517	3.112	3.995
2014	0.246	0.527	0.91	1.375	1.900	2.463	3.045	4.081
2015	0.241	0.518	0.894	1.351	1.867	2.421	2.993	4.157
2016	0.238	0.512	0.883	1.335	1.844	2.391	2.956	4.156
2017	0.237	0.508	0.877	1.325	1.831	2.374	2.936	4.106
2018	0.237	0.508	0.876	1.324	1.830	2.372	2.933	4.015
2019	0.238	0.510	0.881	1.331	1.840	2.385	2.949	4.009

Table 21.2.4. Turbot in Area 4. Natural mortality at age and maturity at age.

Age	1	2	3	4	5	6	7	8
natural mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
maturity	0	0.04	0.47	0.95	1	1	1	1

Table 21.2.5. Turbot in Area 4. Fraction of harvest before spawning and fraction of natural mortality before spawning.

Age	1	2	3	4	5	6	7	8
Harvest	0	0	0	0	0	0	0	0
Natural mortality	0	0	0	0	0	0	0	0

Table 21.3.1. Turbot in Area 4. SNS survey index

	Age					
Year	1	2	3	4	5	6
2004	186.515	27.029	18.756	4.090	2.998	3.422
2005	75.391	155.548	23.663	0.000	0.000	0.000
2006	196.154	97.472	14.868	3.614	1.089	0.000
2007	89.742	55.605	33.782	11.845	1.324	0.000
2008	52.090	99.743	40.828	11.867	10.922	1.200
2009	26.267	20.311	5.646	14.467	5.090	0.000
2010	96.019	35.812	9.257	5.367	3.700	6.756
2011	116.690	36.889	0.000	0.000	0.000	1.690
2012	39.858	33.511	9.464	1.232	0.000	0.000
2013	110.160	16.116	15.640	0.440	0.000	0.000
2014	102.714	18.306	9.447	6.165	4.741	1.200
2015	273.794	45.873	2.000	2.000	0.000	0.000
2016	52.833	115.686	26.710	2.000	1.310	0.500
2017	271.896	54.705	60.336	0.500	0.000	0.500
2018	118.210	84.248	16.844	21.938	8.645	3.184
2019	148.661	81.427	17.072	1.526	4.367	0.833

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

	Age						
Year	1	2	3	4	5	6	7
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

Table 21.3.3. Turbot in Area 4. Dutch_BT2_LPUE survey index (biomass)

Year	
1995	0.0423
1996	0.0369
1997	0.0373
1998	0.0345
1999	0.0345
2000	0.0441
2001	0.0457
2002	0.0454
2003	0.0469
2004	0.0477
2005	0.0471
2006	0.0484
2007	0.0641
2008	0.0666
2009	0.0659
2010	0.0582
2011	0.0588
2012	0.0726
2013	0.0743
2014	0.0734
2015	0.0854
2016	0.0949
2017	0.0910
2018	0.0725
2019	0.0814

Table 21.4.1a. Fbar (Ages 2–6) of turbot in Area 4.

Year	Fbar	Low	High
1981	0.387	0.312	0.480
1982	0.374	0.305	0.458
1983	0.411	0.338	0.499
1984	0.458	0.378	0.554
1985	0.500	0.412	0.607
1986	0.477	0.390	0.583
1987	0.488	0.399	0.598
1988	0.471	0.380	0.584
1989	0.593	0.487	0.721
1990	0.720	0.577	0.898
1991	0.769	0.609	0.970
1992	0.802	0.634	1.015
1993	0.832	0.662	1.046
1994	0.842	0.675	1.051
1995	0.821	0.662	1.018
1996	0.747	0.612	0.913
1997	0.685	0.548	0.856
1998	0.649	0.524	0.804
1999	0.615	0.496	0.763
2000	0.637	0.514	0.788
2001	0.699	0.568	0.860
2002	0.763	0.607	0.958
2003	0.708	0.589	0.852
2004	0.628	0.520	0.757
2005	0.559	0.459	0.681
2006	0.433	0.350	0.536
2007	0.404	0.327	0.499
2008	0.375	0.305	0.461
2009	0.431	0.352	0.527

Year	Fbar	Low	High
2010	0.409	0.335	0.499
2011	0.367	0.297	0.453
2012	0.348	0.284	0.427
2013	0.331	0.270	0.406
2014	0.330	0.271	0.402
2015	0.331	0.270	0.406
2016	0.357	0.289	0.442
2017	0.357	0.291	0.438
2018	0.368	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	19573	15883	24122	15371	11903	19850
1982	18262	14745	22618	13709	10447	17990
1983	18405	15023	22549	12330	9312	16327
1984	19401	16142	23318	11346	8614	14946
1985	18702	15750	22206	11463	8980	14631
1986	16200	13526	19402	10916	8574	13898
1987	14723	12218	17741	9747	7522	12630
1988	13823	11554	16537	8032	6102	10571
1989	14173	11846	16957	8015	6131	10479
1990	14067	11387	17379	6935	5187	9274
1991	13966	10622	18363	5774	4093	8146
1992	13292	10039	17599	5403	3877	7529
1993	12084	9255	15779	4877	3575	6655
1994	10795	8438	13811	4088	3026	5522
1995	9970	8121	12240	3696	2875	4753
1996	9295	7718	11195	3234	2547	4106
1997	8932	7578	10528	3541	2915	4301

Year	TSB	Low	High	SSB	Low	High
1998	8767	7509	10237	3769	3207	4430
1999	8959	7301	10994	3658	2876	4651
2000	9949	8109	12208	4032	3187	5102
2001	9728	7983	11854	3881	3094	4867
2002	9286	7813	11037	3707	3060	4492
2003	8697	7596	9958	3065	2589	3629
2004	8606	7566	9787	2882	2405	3454
2005	8566	7483	9807	2978	2456	3609
2006	8857	7713	10170	3263	2652	4014
2007	9995	8750	11417	4057	3324	4950
2008	10048	8768	11516	4914	4021	6005
2009	10012	8643	11598	6009	4930	7324
2010	9712	8266	11411	5727	4564	7187
2011	10498	8879	12411	5391	4216	6892
2012	11269	9554	13292	5921	4677	7497
2013	11242	9532	13259	6894	5536	8584
2014	11954	10081	14175	8080	6497	10049
2015	13501	11321	16100	7896	6165	10113
2016	14135	11879	16818	8125	6338	10417
2017	13808	11657	16355	9023	7227	11265
2018	13280	11124	15855	8957	7123	11262
2019	13948	11385	17087	8218	6357	10622

Table 21.4.1c. Recruitment (Age 1) of turbot in Area 4. (Thousands)

Year	Value	Low	High
1981	2542.90	1845.60	3503.66
1982	4216.84	3125.13	5689.91
1983	6527.78	4800.39	8876.76
1984	5039.51	3635.08	6986.55
1985	2452.77	1769.16	3400.53

Year	Value	Low	High
1986	3390.38	2514.41	4571.51
1987	3968.36	2934.99	5365.56
1988	3709.16	2709.93	5076.85
1989	4494.52	2956.73	6832.10
1990	5841.81	3614.65	9441.23
1991	5023.08	3223.28	7827.83
1992	4451.61	2852.97	6946.04
1993	4921.06	3227.70	7502.81
1994	3796.70	2497.66	5771.38
1995	4863.78	3396.57	6964.77
1996	3332.76	2416.66	4596.13
1997	2851.82	2042.25	3982.32
1998	4103.81	2862.80	5882.80
1999	3468.63	2354.78	5109.36
2000	5582.86	3872.46	8048.72
2001	3555.07	2382.98	5303.68
2002	5772.53	4229.90	7877.75
2003	4834.57	3624.27	6449.04
2004	6178.87	4704.92	8114.59
2005	4638.24	3554.89	6051.74
2006	6391.48	4866.30	8394.66
2007	5324.15	4067.78	6968.56
2008	3238.63	2411.55	4349.38
2009	3997.72	3000.64	5326.11
2010	5531.76	4245.74	7207.30
2011	6928.60	5102.64	9407.98
2012	4170.35	3133.46	5550.34
2013	3216.30	2431.52	4254.36
2014	6480.99	4943.90	8495.96

Year	Value	Low	High
2015	8959.86	6678.83	12019.94
2016	3016.33	2226.52	4086.31
2017	5142.11	3867.46	6836.86
2018	6308.32	4440.60	8961.60
2019	8102.49	4750.14	13820.71

Table 21.4.2. Turbot in Area 4. Estimated fishing mortality

	Age							
Year	1	2	3	4	5	6	7	8
1981	0.002	0.118	0.617	0.532	0.355	0.313	0.230	0.230
1982	0.002	0.112	0.573	0.510	0.354	0.321	0.243	0.243
1983	0.003	0.134	0.605	0.558	0.399	0.358	0.276	0.276
1984	0.004	0.178	0.672	0.612	0.441	0.384	0.287	0.287
1985	0.005	0.206	0.730	0.673	0.486	0.406	0.290	0.290
1986	0.005	0.210	0.682	0.632	0.468	0.390	0.278	0.278
1987	0.006	0.245	0.726	0.629	0.462	0.379	0.273	0.273
1988	0.007	0.259	0.723	0.567	0.437	0.370	0.279	0.279
1989	0.009	0.330	0.919	0.712	0.554	0.448	0.354	0.354
1990	0.012	0.385	1.068	0.854	0.706	0.585	0.514	0.514
1991	0.014	0.411	1.123	0.915	0.764	0.629	0.568	0.568
1992	0.016	0.443	1.166	0.950	0.796	0.658	0.615	0.615
1993	0.019	0.486	1.215	0.978	0.812	0.669	0.646	0.646
1994	0.022	0.511	1.243	0.983	0.810	0.662	0.653	0.653
1995	0.022	0.504	1.204	0.961	0.790	0.645	0.653	0.653
1996	0.018	0.402	1.052	0.885	0.762	0.636	0.672	0.672
1997	0.014	0.326	0.900	0.812	0.743	0.644	0.713	0.713
1998	0.014	0.299	0.821	0.758	0.723	0.644	0.754	0.754
1999	0.016	0.322	0.777	0.717	0.668	0.592	0.700	0.700
2000	0.025	0.440	0.837	0.735	0.642	0.528	0.587	0.587
2001	0.041	0.600	0.934	0.800	0.657	0.504	0.525	0.525

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2002	0.064	0.822	1.010	0.849	0.663	0.471	0.459	0.459
2003	0.067	0.808	0.924	0.785	0.605	0.419	0.390	0.390
2004	0.070	0.785	0.853	0.690	0.487	0.323	0.263	0.263
2005	0.062	0.687	0.785	0.603	0.422	0.297	0.250	0.250
2006	0.047	0.541	0.596	0.441	0.327	0.260	0.241	0.241
2007	0.040	0.514	0.536	0.407	0.308	0.254	0.229	0.229
2008	0.036	0.461	0.492	0.377	0.297	0.248	0.210	0.210
2009	0.049	0.615	0.583	0.415	0.299	0.240	0.201	0.201
2010	0.044	0.562	0.553	0.397	0.290	0.243	0.202	0.202
2011	0.034	0.483	0.496	0.366	0.265	0.224	0.185	0.185
2012	0.028	0.422	0.467	0.371	0.260	0.220	0.177	0.177
2013	0.024	0.380	0.432	0.367	0.259	0.218	0.168	0.168
2014	0.015	0.291	0.412	0.390	0.297	0.261	0.209	0.209
2015	0.011	0.257	0.402	0.402	0.321	0.273	0.209	0.209
2016	0.010	0.236	0.423	0.460	0.371	0.297	0.216	0.216
2017	0.009	0.219	0.427	0.472	0.374	0.293	0.207	0.207
2018	0.011	0.238	0.442	0.479	0.382	0.299	0.201	0.201
2019	0.013	0.251	0.446	0.477	0.374	0.288	0.184	0.184

Table 21.4.3. Turbot in Area 4. Estimated population abundance (units: thousands)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	2542.90	3111.43	1614.68	1321.53	1772.54	717.54	360.02	600.01
1982	4216.84	2011.00	2298.71	673.54	629.86	1030.60	432.47	634.91
1983	6527.78	3460.23	1477.72	1066.19	329.09	364.81	619.80	694.04
1984	5039.51	5572.50	2523.24	684.98	489.36	179.95	210.35	809.74
1985	2452.77	4232.87	3792.55	1086.03	317.76	255.58	99.26	622.71
1986	3390.38	1869.53	2965.25	1409.56	442.38	163.10	136.87	445.84
1987	3968.36	2791.85	1161.29	1384.40	580.73	220.01	90.14	361.04

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1988	3709.16	3305.36	1775.11	451.02	599.23	291.67	122.78	286.06
1989	4494.52	2949.49	2035.67	738.57	236.88	321.77	161.05	256.46
1990	5841.81	3628.83	1727.57	620.72	300.68	118.68	176.07	245.56
1991	5023.08	4880.48	2032.01	472.44	212.32	120.88	54.74	206.54
1992	4451.61	4139.72	2670.98	538.70	153.73	79.74	52.46	121.35
1993	4921.06	3555.77	2195.59	673.28	172.29	56.23	33.15	77.03
1994	3796.70	4033.06	1707.83	539.58	206.54	62.19	23.72	47.34
1995	4863.78	2861.60	1943.12	395.27	169.86	76.03	26.31	30.37
1996	3332.76	4008.89	1327.60	478.41	124.98	65.15	33.30	24.22
1997	2851.82	2759.21	2188.20	366.00	161.69	47.42	29.18	24.27
1998	4103.81	2283.90	1634.77	736.12	131.45	62.56	20.00	22.00
1999	3468.63	3342.88	1403.77	575.97	289.83	51.57	26.55	16.15
2000	5582.86	2667.69	2029.72	556.12	229.90	128.29	23.39	17.37
2001	3555.07	4444.04	1318.61	711.16	224.47	97.71	64.01	18.59
2002	5772.53	2653.96	1998.00	408.68	258.50	98.55	47.82	40.51
2003	4834.57	4470.60	893.65	597.65	137.09	106.83	51.50	46.80
2004	6178.87	3607.43	1594.65	290.50	222.17	56.99	56.19	52.40
2005	4638.24	4675.24	1337.69	539.85	111.61	109.31	31.58	71.10
2006	6391.48	3594.26	1935.39	425.04	227.41	57.69	67.23	66.86
2007	5324.15	5115.76	1732.44	918.25	224.63	138.71	36.85	84.88
2008	3238.63	4409.42	2525.89	817.66	491.65	138.08	88.95	77.14
2009	3997.72	2440.63	2407.81	1397.40	479.76	272.70	85.00	109.98
2010	5531.76	3289.08	998.22	1076.33	756.19	302.78	171.49	127.40
2011	6928.60	4344.78	1663.90	435.36	607.51	462.89	190.91	190.23
2012	4170.35	5799.55	2238.54	905.82	253.66	391.67	313.76	245.82
2013	3216.30	3379.40	3473.84	1160.77	522.79	169.29	267.33	370.48
2014	6480.99	2337.18	1979.20	2107.37	678.96	351.27	118.90	469.14
2015	8959.86	5308.63	1530.46	1120.41	1240.48	425.55	223.61	406.31

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2016	3016.33	7540.77	3256.91	911.00	649.03	738.34	261.80	415.72
2017	5142.11	2248.58	5073.90	1675.41	467.07	353.39	447.75	430.29
2018	6308.32	4089.91	1437.05	2581.34	842.88	263.79	218.48	554.41
2019	8102.49	5129.94	2654.59	739.50	1328.37	467.56	159.24	511.23

Table 21.5.1a. Turbot in Area 4. Predicted catch numbers at age (units: thousands)

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1981	5.34	315.14	681.01	498.65	482.74	175.92	67.42	112.37
1982	8.22	192.83	917.63	246.03	171.23	257.73	84.90	124.64
1983	16.11	394.30	614.11	417.31	98.74	100.14	136.06	152.36
1984	17.95	826.29	1131.96	287.06	159.24	52.38	47.77	183.88
1985	10.57	717.19	1802.65	487.57	111.66	77.75	22.75	142.71
1986	14.95	322.07	1343.66	604.93	151.07	48.08	30.25	98.54
1987	21.37	552.75	549.72	592.06	196.35	63.28	19.59	78.47
1988	22.77	687.25	837.61	178.55	193.77	82.26	27.22	63.41
1989	38.37	755.45	1125.99	345.05	92.13	106.04	43.78	69.71
1990	61.99	1057.68	1045.56	327.55	139.56	48.13	64.71	90.25
1991	61.55	1501.84	1265.33	260.62	104.10	51.69	21.69	81.85
1992	63.61	1351.92	1698.18	304.04	77.50	35.22	22.06	51.03
1993	84.03	1250.95	1427.06	386.76	88.02	25.14	14.46	33.59
1994	73.45	1475.55	1123.65	311.00	105.31	27.60	10.42	20.79
1995	97.69	1036.18	1256.82	224.66	85.17	33.11	11.56	13.35
1996	52.99	1209.93	796.43	258.38	61.17	28.09	14.94	10.86
1997	36.81	699.47	1194.69	186.95	77.76	20.62	13.64	11.35
1998	50.22	537.55	840.67	358.99	62.06	27.20	9.71	10.69
1999	49.70	838.75	696.08	270.43	129.36	21.08	12.26	7.45
2000	126.70	866.86	1057.83	265.60	99.81	48.12	9.50	7.06
2001	128.06	1834.63	736.74	359.53	99.07	35.36	23.89	6.94

Year	Age 1	2	3	4	5	6	7	8
2002	326.53	1366.24	1170.16	214.91	114.79	33.81	16.07	13.62
2003	284.44	2276.33	495.97	298.39	56.95	33.38	15.17	13.79
2004	376.49	1801.70	840.81	132.74	78.21	14.33	11.84	11.04
2005	253.70	2130.31	667.83	223.90	35.09	25.55	6.35	14.30
2006	265.54	1374.31	795.70	138.35	57.77	12.02	13.09	13.02
2007	190.55	1878.24	657.16	280.22	54.29	28.34	6.87	15.84
2008	103.35	1487.36	896.83	234.47	115.21	27.57	15.29	13.26
2009	174.54	1026.51	973.32	433.50	112.91	52.99	14.05	18.17
2010	214.00	1294.24	387.70	321.75	173.47	59.37	28.49	21.16
2011	212.41	1521.61	594.30	121.61	128.53	84.66	29.30	29.20
2012	104.64	1821.22	763.11	256.13	52.92	70.45	46.33	36.29
2013	68.63	973.69	1112.36	324.88	108.45	30.20	37.47	51.93
2014	85.14	537.66	609.46	620.35	158.86	73.40	20.44	80.64
2015	89.39	1094.56	461.77	338.34	310.36	92.42	38.42	69.81
2016	26.39	1441.54	1024.75	306.63	183.62	172.63	46.17	73.32
2017	39.86	401.78	1610.19	575.39	133.03	81.78	76.06	73.10
2018	65.10	788.66	468.50	897.53	243.94	62.02	36.16	91.77
2019	95.53	1037.47	871.82	256.44	377.69	106.70	24.38	78.28

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	2.313	0.911	2.659	0.249	1.477	0.341	0.105
1982	0.000	0.756	2.784	0.000	-3.351	-1.247	-0.175	0.020
1983	0.000	1.346	0.012	0.946	0.351	-0.106	0.124	-0.038
1984	0.000	2.186	-0.019	0.598	-0.094	-0.101	-0.260	-0.902
1985	0.000	-0.465	-0.318	0.622	0.960	-0.185	-0.771	-0.917
1986	0.000	-1.089	-0.428	-1.004	-0.043	0.210	-0.746	-0.208
1987	0.342	0.786	-1.812	1.371	-1.019	-1.105	-0.085	-0.684

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1988	0.732	0.911	-0.757	-1.462	-0.029	-0.023	0.077	0.077
1989	0.000	-0.491	0.202	0.847	2.562	-0.336	-0.355	-0.010
1990	0.599	0.306	-0.150	-1.395	0.738	1.872	1.930	0.353
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.000	-0.121	-0.367	0.379	0.625	0.081	-0.253	0.805
1999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	1.283	0.437	-2.573	-0.268	-0.564	-1.184	0.211	0.846
2004	0.929	0.109	-1.155	-0.242	-0.473	-2.343	-2.151	-1.975
2005	0.177	-0.594	0.229	-0.768	-1.572	-0.415	-2.393	1.421
2006	1.379	0.476	-0.958	-3.179	-1.679	-0.849	1.215	0.974
2007	-1.265	1.200	-0.846	0.899	-0.409	0.882	0.523	-0.459
2008	0.007	-0.088	-0.364	-0.354	1.528	1.495	-0.774	-1.036
2009	-0.073	0.312	1.281	1.181	-0.506	-2.343	-0.533	0.241
2010	0.681	0.998	-1.162	-0.524	0.034	1.583	0.002	-0.406
2011	-0.128	0.521	1.053	-1.076	0.170	-0.236	0.098	-0.893
2012	0.000	-0.085	0.206	1.645	-0.618	0.002	1.203	-1.644
2013	0.056	0.541	0.881	0.514	-0.288	0.135	0.322	-2.192
2014	-0.773	-2.436	0.724	2.004	0.145	2.062	1.922	0.542
2015	-0.976	0.395	1.098	0.497	0.729	0.512	-0.137	0.182

Year	Age 1	2	3	4	5	6	7	8
2016	0.000	-1.518	-0.083	1.983	2.315	0.058	-0.539	-0.294
2017	-1.424	-0.960	1.139	-0.077	-0.013	-0.972	0.487	-0.733
2018	1.742	-0.617	-0.375	-0.528	0.050	0.388	0.396	-1.045
2019	1.045	0.149	-0.010	-0.292	-0.184	0.159	-0.588	-0.761

Table 21.5.2a. Turbot in Area 4. Predicted index at age SNS

Year	Age 1	2	3	4	5	6
2004	108.031	38.080	9.903	1.007	0.889	0.256
2005	81.515	52.879	8.714	1.990	0.467	0.500
2006	113.545	45.055	14.399	1.757	1.019	0.271
2007	95.027	65.401	13.451	3.887	1.020	0.654
2008	57.985	58.501	20.228	3.534	2.249	0.654
2009	70.898	29.048	18.084	5.881	2.192	1.299
2010	98.501	40.627	7.659	4.589	3.476	1.439
2011	124.177	56.739	13.289	1.898	2.844	2.229
2012	75.076	79.105	18.243	3.933	1.191	1.891
2013	58.075	47.481	29.020	5.056	2.457	0.819
2014	117.786	34.952	16.773	9.032	3.106	1.649
2015	163.244	81.332	13.063	4.760	5.580	1.981
2016	55.009	117.255	27.387	3.716	2.818	3.379
2017	93.850	35.389	42.530	6.777	2.023	1.621
2018	114.903	63.492	11.923	10.387	3.633	1.205
2019	147.412	78.903	21.961	2.979	5.758	2.152

Table 21.5.2b. Turbot in Area 4. Index at age residuals SNS

Year	Age 1	2	3	4	5	6
2004	0.593	-1.355	1.333	0.901	0.553	1.922
2005	-0.686	1.966	0.478	0.000	0.000	0.000

	Age					
Year	1	2	3	4	5	6
2006	0.938	1.053	-0.290	0.725	-0.337	0.000
2007	0.022	-0.098	1.910	0.505	-0.205	0.000
2008	-0.602	1.693	0.585	0.645	0.831	-0.205
2009	-1.276	-0.511	-1.241	1.928	0.545	0.000
2010	0.602	0.059	0.123	0.050	-0.018	1.496
2011	0.375	-0.559	0.000	0.000	0.000	-0.213
2012	-1.201	-0.091	-0.201	-0.695	0.000	0.000
2013	0.507	-1.764	0.474	-2.136	0.000	0.000
2014	1.082	-1.199	-0.153	0.071	0.660	-0.496
2015	1.736	-1.211	-2.137	0.486	0.000	0.000
2016	-1.364	0.956	-0.220	-0.666	-0.502	-1.525
2017	2.221	-0.718	0.138	-3.003	0.000	-0.509
2018	-0.253	0.370	0.183	0.482	0.464	0.526
2019	0.165	0.031	-0.398	-0.526	0.093	-0.870

Table 21.5.3a. Turbot in Area 4. Predicted index at age BTS-ISIS

	Age						
Year	1	2	3	4	5	6	7
1991	1.653	1.213	0.190	0.051	0.019	0.012	0.006
1992	1.463	1.007	0.242	0.057	0.013	0.008	0.005
1993	1.613	0.839	0.192	0.070	0.015	0.005	0.003
1994	1.242	0.934	0.147	0.056	0.018	0.006	0.002
1995	1.591	0.666	0.172	0.041	0.015	0.007	0.002
1996	1.094	1.003	0.131	0.053	0.011	0.006	0.003
1997	0.938	0.729	0.239	0.043	0.014	0.005	0.003
1998	1.350	0.615	0.189	0.089	0.012	0.006	0.002
1999	1.140	0.885	0.167	0.072	0.027	0.005	0.002
2000	1.822	0.650	0.232	0.068	0.022	0.013	0.002
2001	1.148	0.967	0.141	0.083	0.021	0.010	0.007

Year	Age 1	2	3	4	5	6	7
2002	1.833	0.494	0.202	0.046	0.024	0.011	0.005
2003	1.532	0.840	0.096	0.071	0.013	0.012	0.006
2004	1.955	0.689	0.180	0.037	0.024	0.007	0.007
2005	1.475	0.957	0.159	0.073	0.012	0.013	0.004
2006	2.054	0.815	0.262	0.064	0.027	0.007	0.009
2007	1.719	1.183	0.245	0.142	0.027	0.017	0.005
2008	1.049	1.059	0.368	0.129	0.060	0.017	0.012
2009	1.283	0.526	0.329	0.215	0.058	0.035	0.011
2010	1.782	0.735	0.139	0.168	0.093	0.038	0.022
2011	2.247	1.027	0.242	0.069	0.076	0.059	0.025
2012	1.358	1.431	0.332	0.144	0.032	0.050	0.042
2013	1.051	0.859	0.529	0.185	0.065	0.022	0.036
2014	2.131	0.632	0.305	0.330	0.083	0.044	0.015
2015	2.954	1.472	0.238	0.174	0.149	0.053	0.029
2016	0.995	2.122	0.499	0.136	0.075	0.090	0.034
2017	1.698	0.640	0.775	0.248	0.054	0.043	0.058
2018	2.079	1.149	0.217	0.380	0.097	0.032	0.028
2019	2.667	1.428	0.400	0.109	0.153	0.057	0.021

Table 21.5.3b. Turbot in Area 4. Index at age residuals BTS-ISIS

Year	Age 1	2	3	4	5	6	7
1991	-0.577	0.727	-1.031	-2.245	-0.925	0.000	0.204
1992	-0.077	0.526	0.206	-1.273	-0.338	-0.258	-1.031
1993	0.247	0.805	-0.465	-0.771	0.933	-1.544	-1.730
1994	0.165	0.780	-1.558	-0.658	-0.901	-0.345	0.654
1995	0.014	-1.093	-0.959	-1.157	0.292	-0.163	0.000
1996	-1.521	1.859	-0.196	1.273	1.854	0.000	1.356
1997	-0.484	1.759	1.379	-0.506	1.258	1.187	1.642

Year	Age						
	1	2	3	4	5	6	7
1998	1.380	0.787	0.721	0.936	-1.081	0.000	-0.488
1999	-0.174	0.415	0.158	0.596	-0.304	-0.561	-0.717
2000	1.749	-0.662	0.755	1.251	1.075	1.845	0.000
2001	-1.342	-0.169	-1.641	0.359	0.000	0.000	2.215
2002	1.072	-1.666	-1.787	-0.666	-0.010	0.792	-1.536
2003	-0.543	-0.258	0.125	-0.589	0.000	-0.052	0.897
2004	-0.325	-0.314	1.414	0.000	1.011	0.695	0.000
2005	-0.746	0.524	2.244	0.415	0.970	-0.915	1.048
2006	-0.440	-0.068	0.670	1.051	-1.831	0.000	0.000
2007	-0.267	-0.148	2.588	1.230	1.427	1.349	0.000
2008	0.073	0.451	0.561	0.108	0.049	-0.116	2.115
2009	0.105	-0.975	0.216	0.565	1.205	0.339	-0.959
2010	0.497	-1.002	-0.676	-1.164	0.027	-1.085	-0.565
2011	0.027	0.206	-0.257	0.035	-0.074	-1.337	0.000
2012	-0.499	0.250	-0.048	1.064	-0.211	0.009	0.725
2013	-1.700	0.247	0.763	0.143	-1.180	0.785	0.176
2014	1.209	-2.230	0.055	0.335	0.543	0.178	-0.007
2015	1.077	0.016	0.253	-0.708	-0.295	0.000	-0.859
2016	-1.443	0.326	-0.265	-1.355	-0.854	-0.898	-0.326
2017	0.743	-1.397	-0.132	-2.330	-1.571	-1.199	-0.484
2018	-0.684	-0.142	0.312	-0.497	0.525	-0.065	0.000
2019	0.266	-0.555	-0.009	-1.606	-0.291	-1.349	0.000

Table 21.5.4. Turbot in Area 4. Predicted index and residuals of the Dutch LPUE

year	Index	Resid
1995	0.041	0.448
1996	0.038	-0.874
1997	0.039	-1.542
1998	0.036	-0.423

year	Index	Resid
1999	0.037	-0.365
2000	0.044	-0.088
2001	0.048	-0.249
2002	0.044	0.166
2003	0.044	0.976
2004	0.047	-0.633
2005	0.052	-2.462
2006	0.053	-0.841
2007	0.064	0.296
2008	0.068	-0.120
2009	0.064	0.142
2010	0.056	1.528
2011	0.061	0.427
2012	0.073	1.589
2013	0.075	1.852
2014	0.071	2.176
2015	0.074	2.676
2016	0.084	1.686
2017	0.087	0.129
2018	0.078	-1.416
2019	0.077	0.950

Table 21.5.5. Turbot in Area 4. Fit parameters

Name	value	std.dev
logFpar	-3.856	0.140
logFpar	-4.339	0.195
logFpar	-5.037	0.264
logFpar	-7.869	0.075
logFpar	-8.345	0.090
logFpar	-8.662	0.170

Name	value	std.dev
logFpar	-9.795	0.094
logSdLogFsta	-0.843	0.383
logSdLogFsta	-1.395	0.229
logSdLogFsta	-1.935	0.217
logSdLogN	-1.846	0.275
logSdLogN	-1.570	0.328
logSdLogObs	-0.830	0.166
logSdLogObs	-2.205	0.361
logSdLogObs	-0.156	0.218
logSdLogObs	-1.225	0.274
logSdLogObs	-2.318	0.431
logSdLogObs	-1.120	0.143
logSdLogObs	-1.051	0.156
logSdLogObs	-0.502	0.150
logSdLogObs	-0.265	0.175
transfIRARdist	0.118	0.128
itrans_rho	-0.905	0.094

Table 21.5.6. Turbot in Area 4. Negative Log-Likelihood

403.450

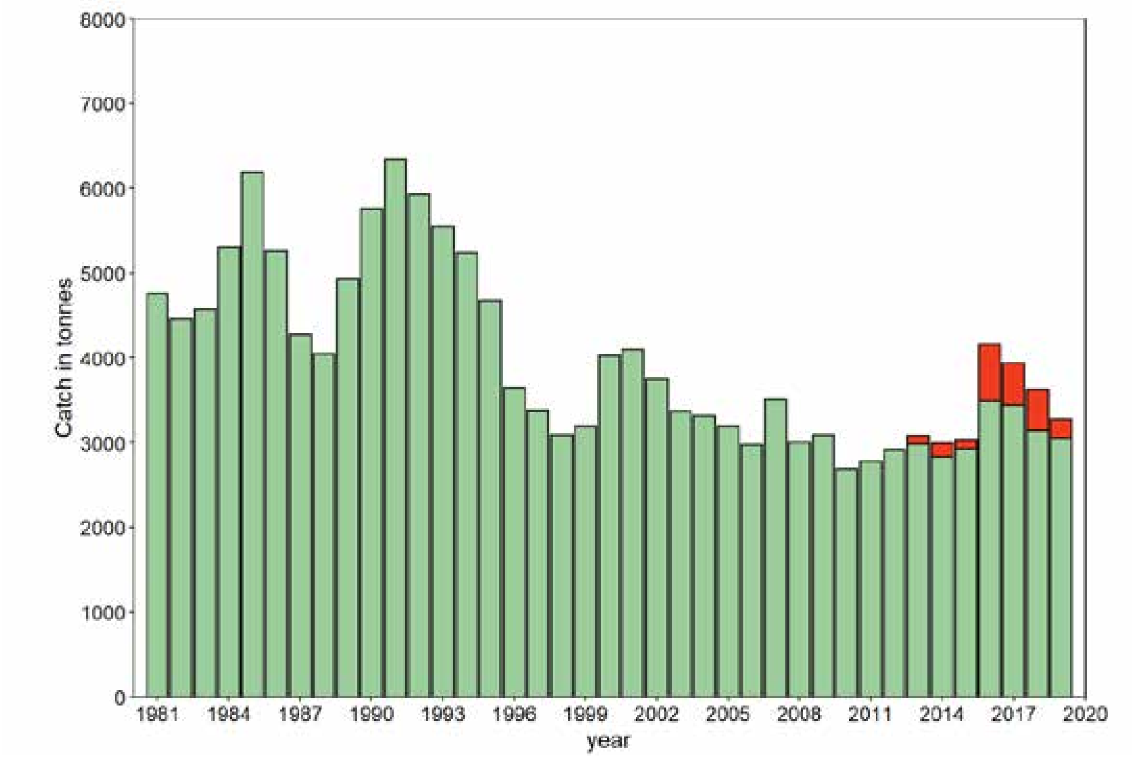


Figure 21.2.1. Turbot in 27.4.20. Total catches 1981–2019. ICES estimated landings (green) and discards (red).

Figure 21.2.2. Turbot in 27.4.20. Landings at age for the years with available data between 1975–2019. Data for 1991-1997 and 1999 – 2002 are missing.

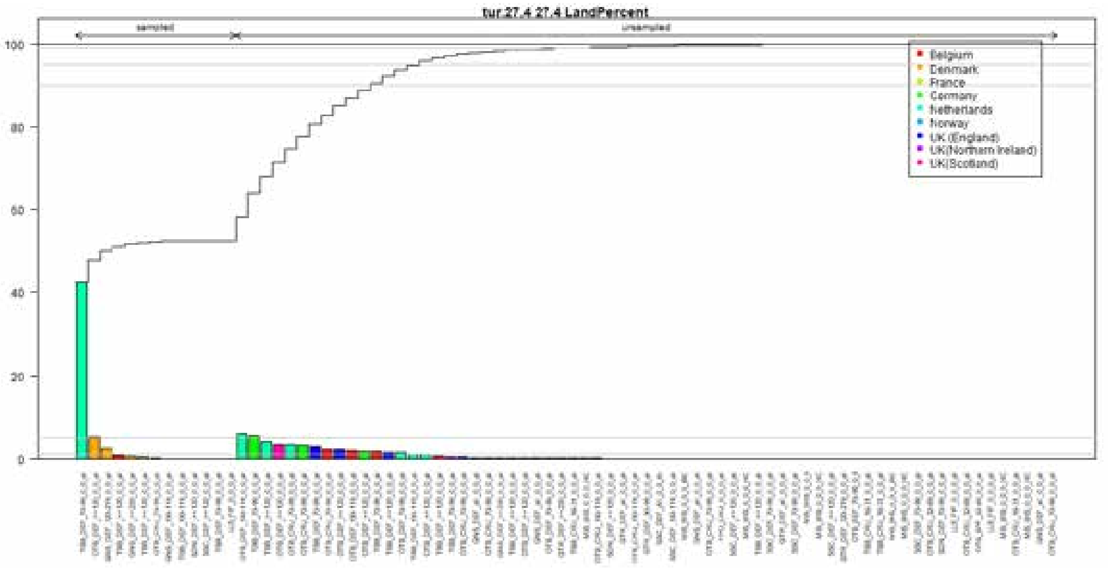


Figure 21.2.3. Turbot in 27.4.20: Total landings by métier in 2019 sorted by sampled/unsampled for numbers at age in InterCatch.

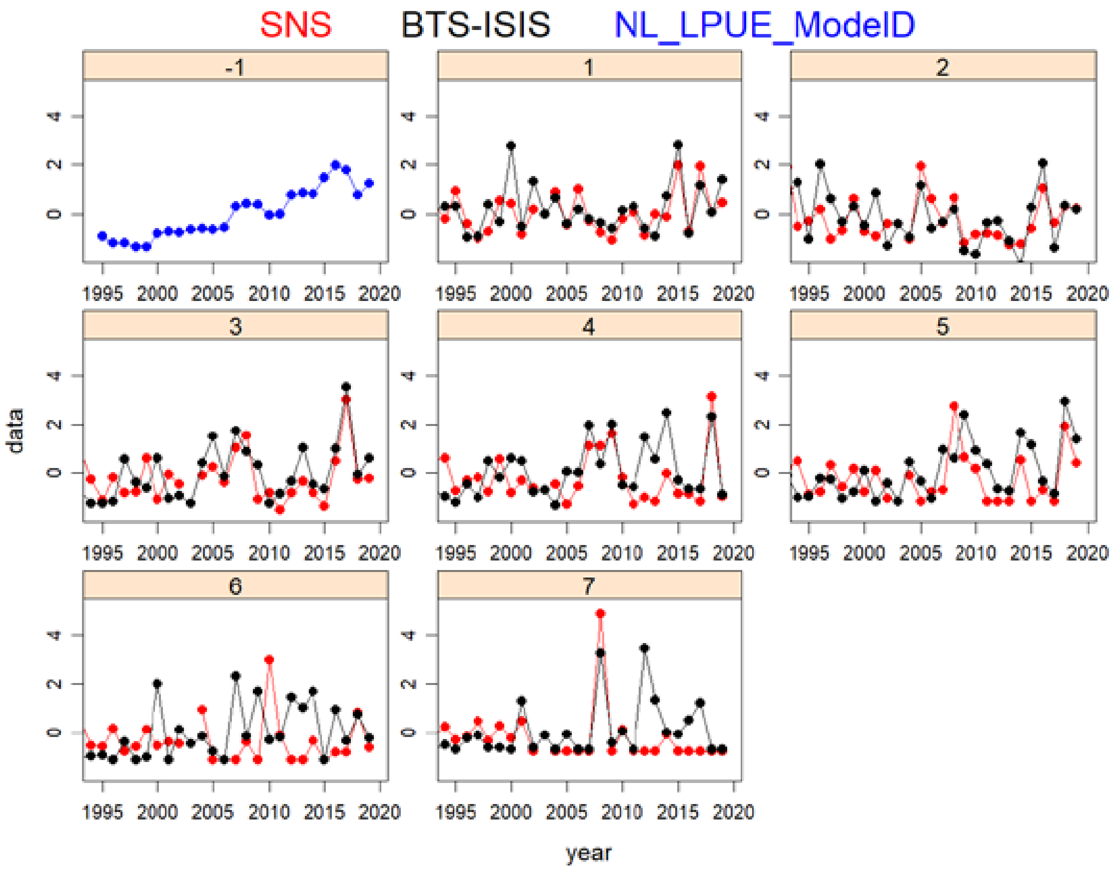


Figure 21.2.4. Turbot in 27.4.20. Time series of the standardized indices for ages 1 to 7 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE (shown in the "-1" panel).

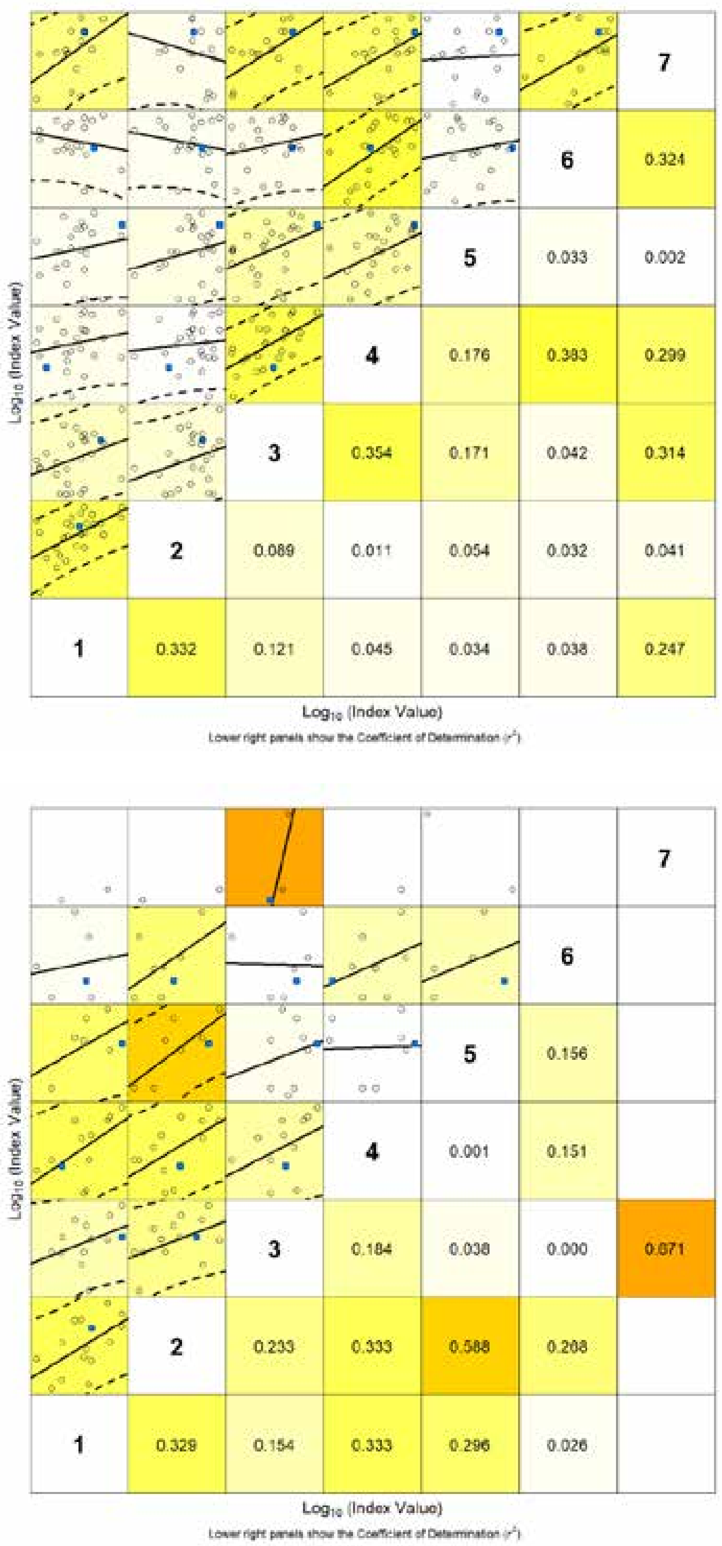


Figure 21.2.5. Turbot in 27.4.20. Internal consistency of the two tuning indices available for the assessment : BTS-ISIS from 1991–2019 (top), and SNS 2004–2019 (bottom).

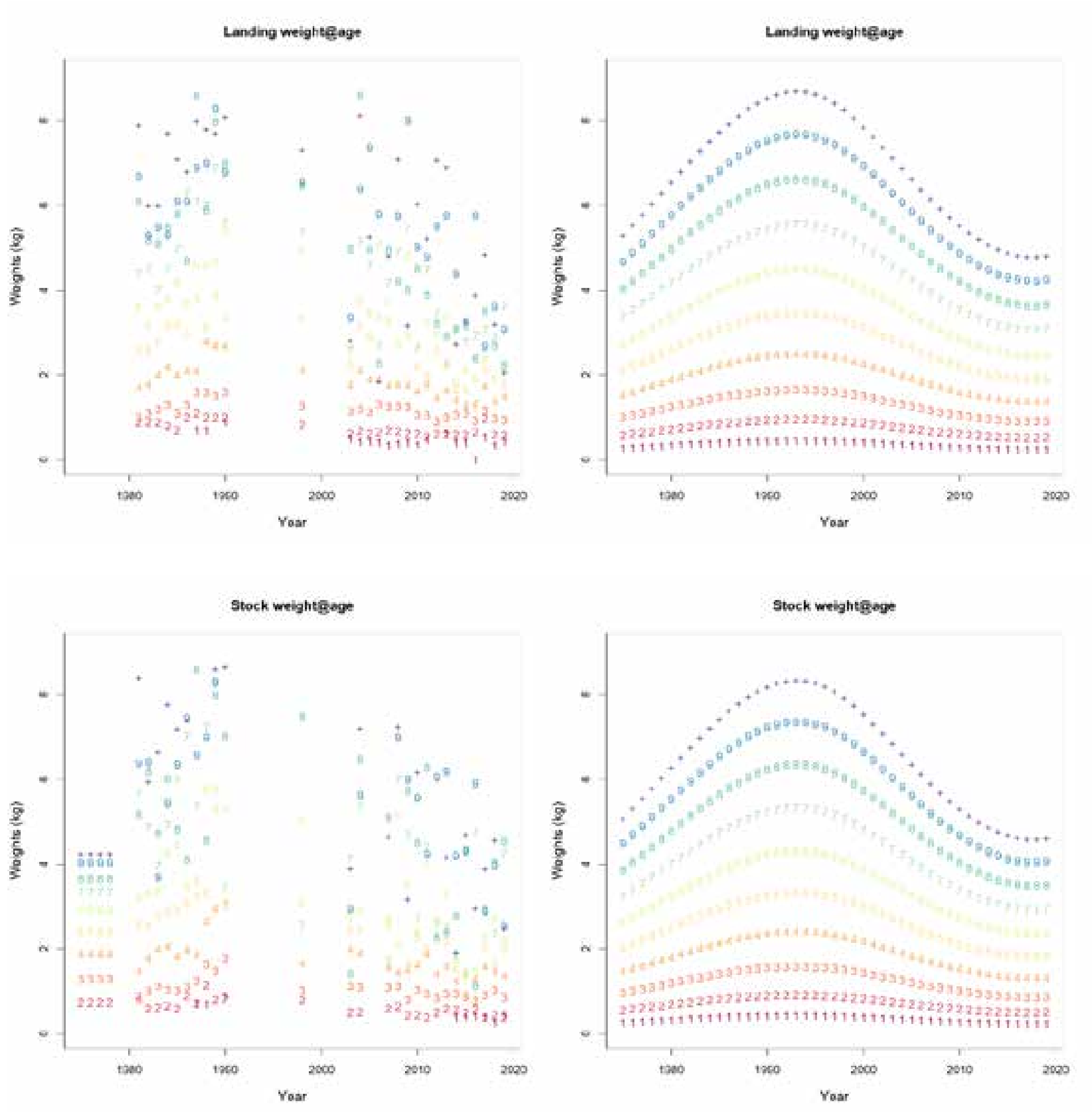


Figure 21.2.6. Raw landings (top-left), modelled landings (top right) and raw stock (bottom left) and modelled (bottom right) weight at age.

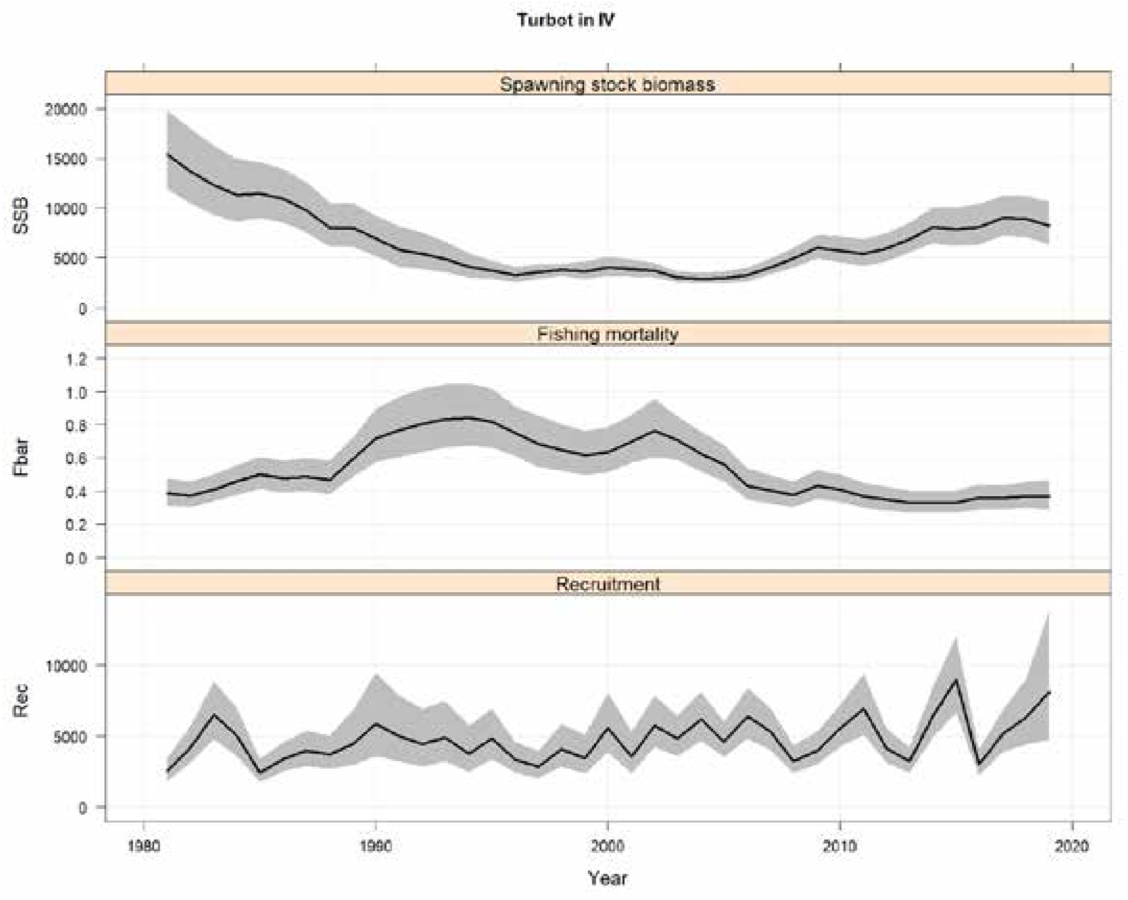


Figure 21.4.1. Summary plot of SSB, F and Recruitment, including the uncertainty bounds.

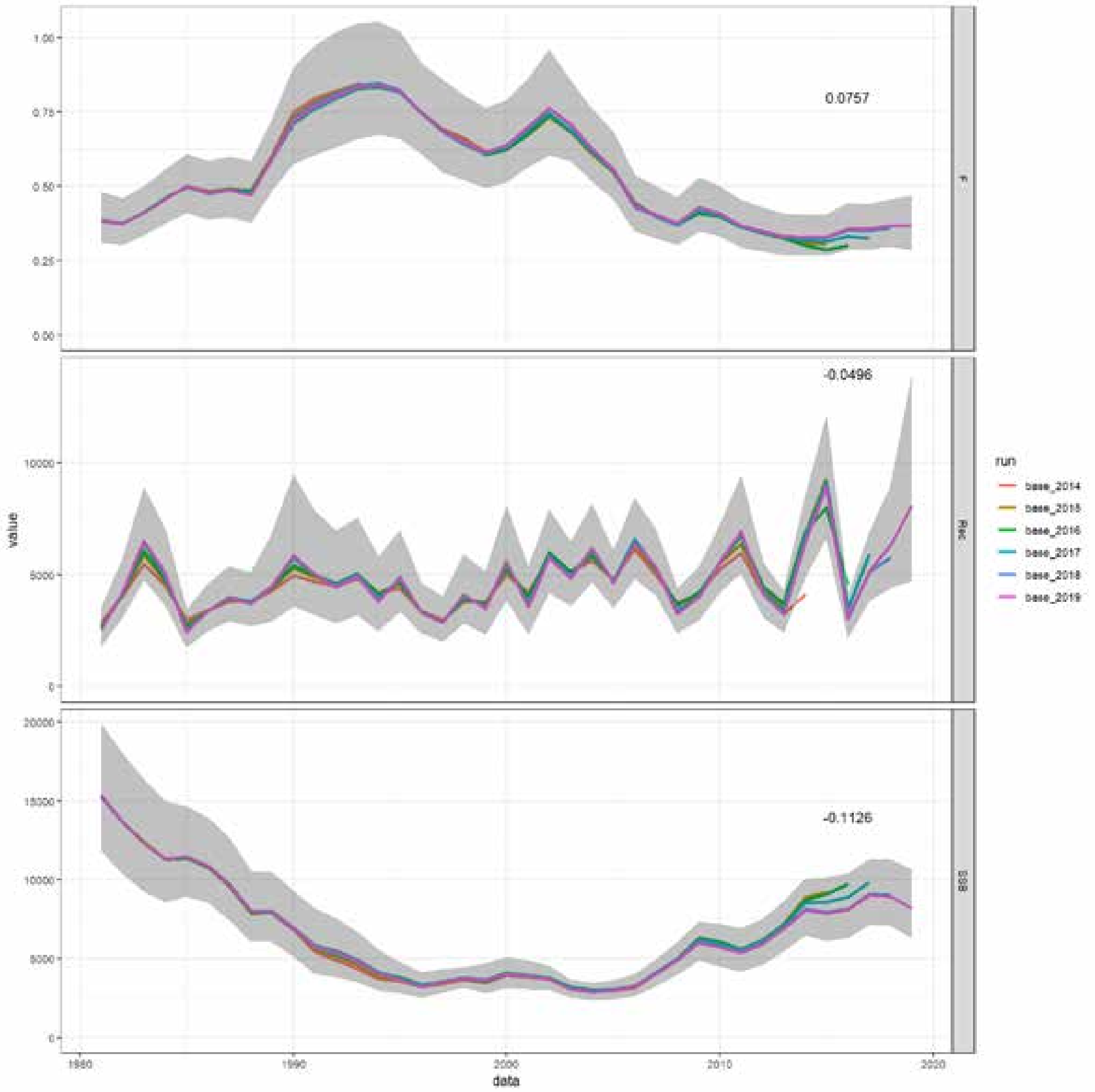


Figure 21.4.2. Retrospective analysis plot on SSB, F and R including confidence band last year assessment and Mohns rho values.

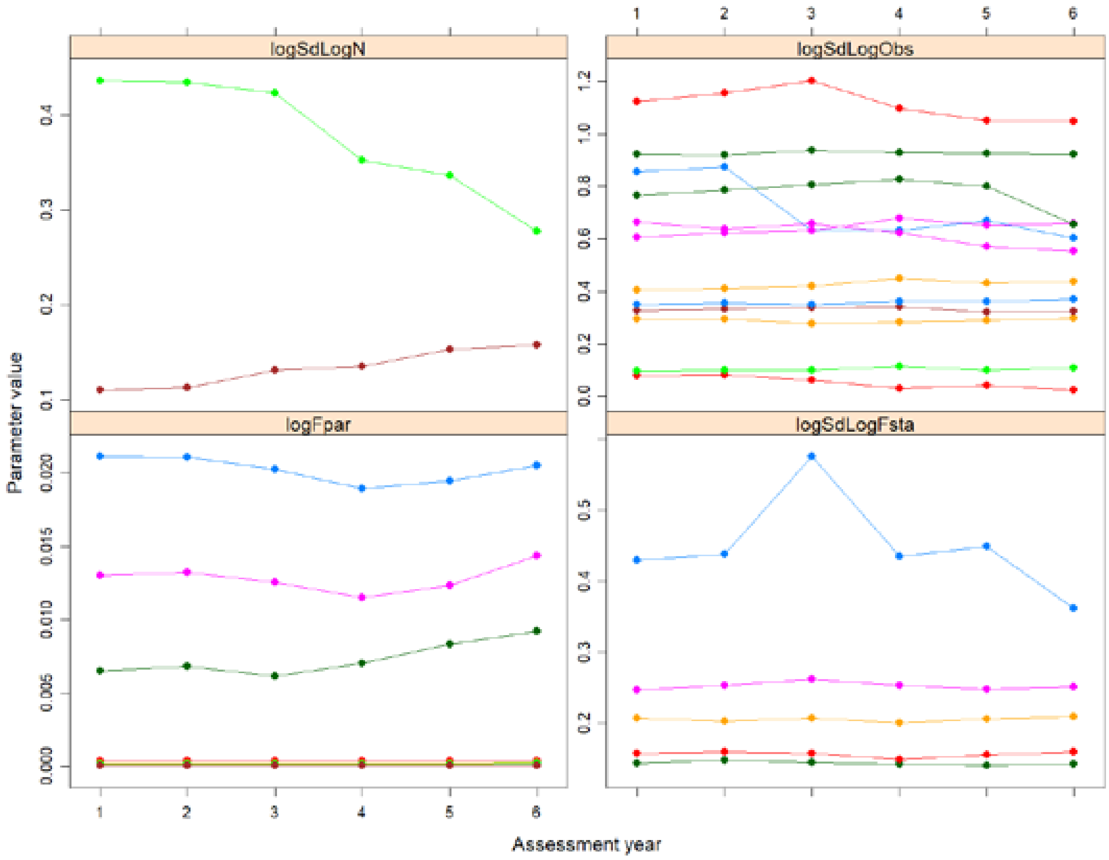


Figure 21.4.3. Retrospective analysis plot on the value of the estimated parameters, ideally, all show a flat line indicating that with reducing the model with a year's worth of data does not affect the parameters to be estimated: logSdLogN = the random walk in N, logSdLogObs is the observation variance in the surveys and catch, logFpar are the catchability parameters and logSdLogFsta are the sd's of the random walks in F.

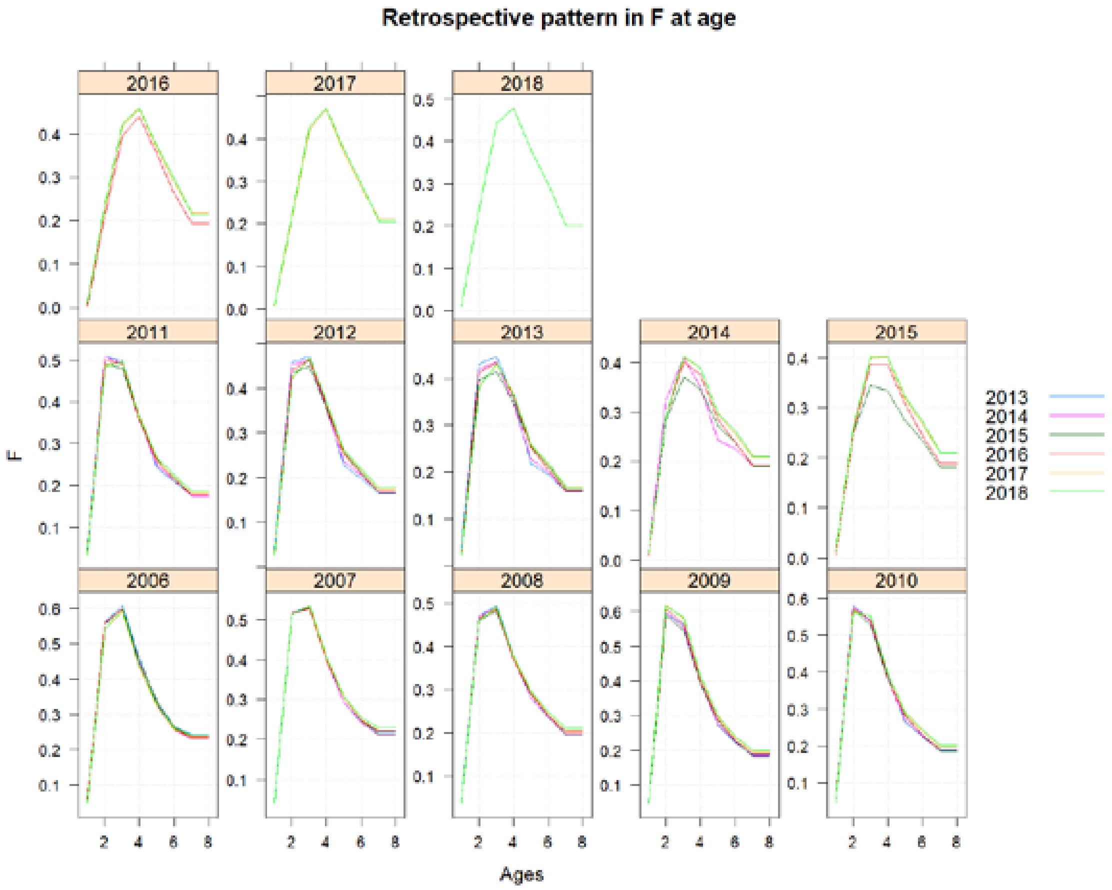


Figure 21.4.4. Retrospective analysis plot of selectivity pattern.

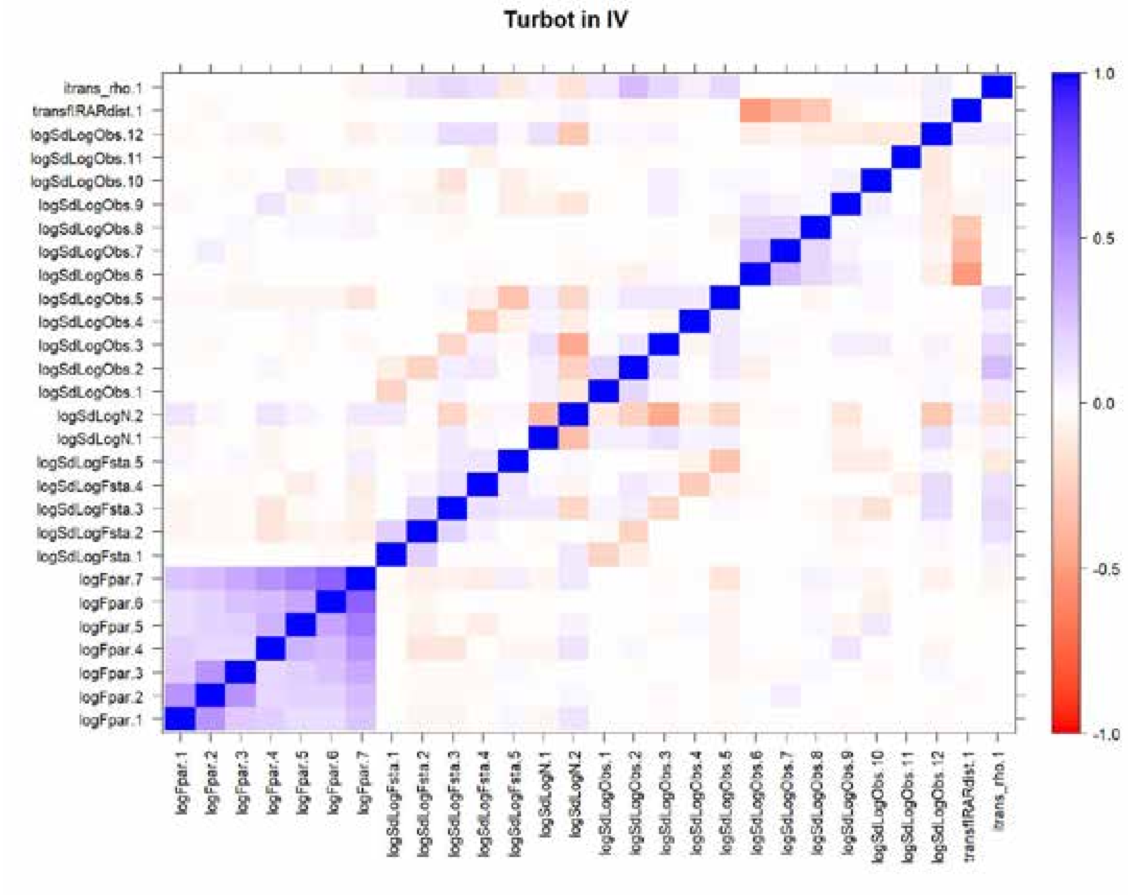


Figure 21.5.1. Parameter-correlation plot. It shows the correlation among all parameters that are estimated in the model. Fpar parameters refer to catchabilities, Fstates to the random walk in F, logN to the random walk in N, logObs to the observation variances, fRARdist to the auto-correlation in the surveys and trans_rho to the correlation in the F-random walks.

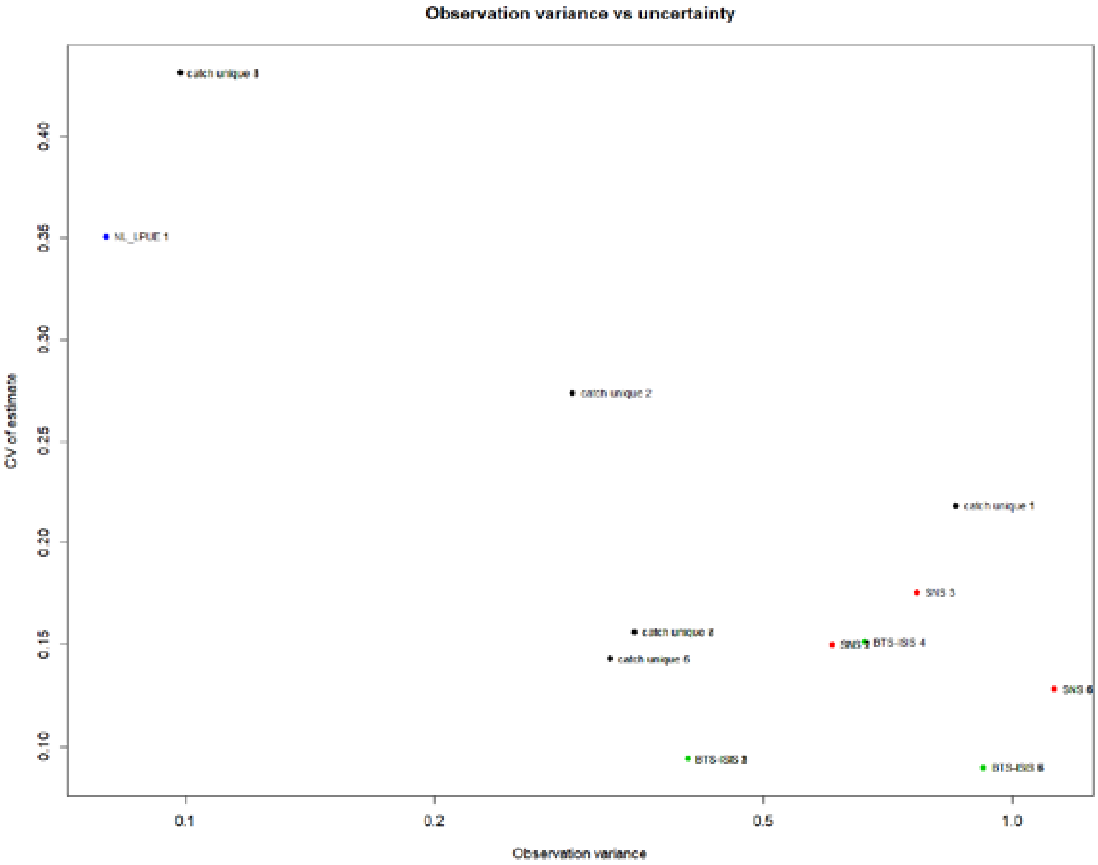


Figure 21.5.2. Plot showing the observation variance vs the CV of that estimate.

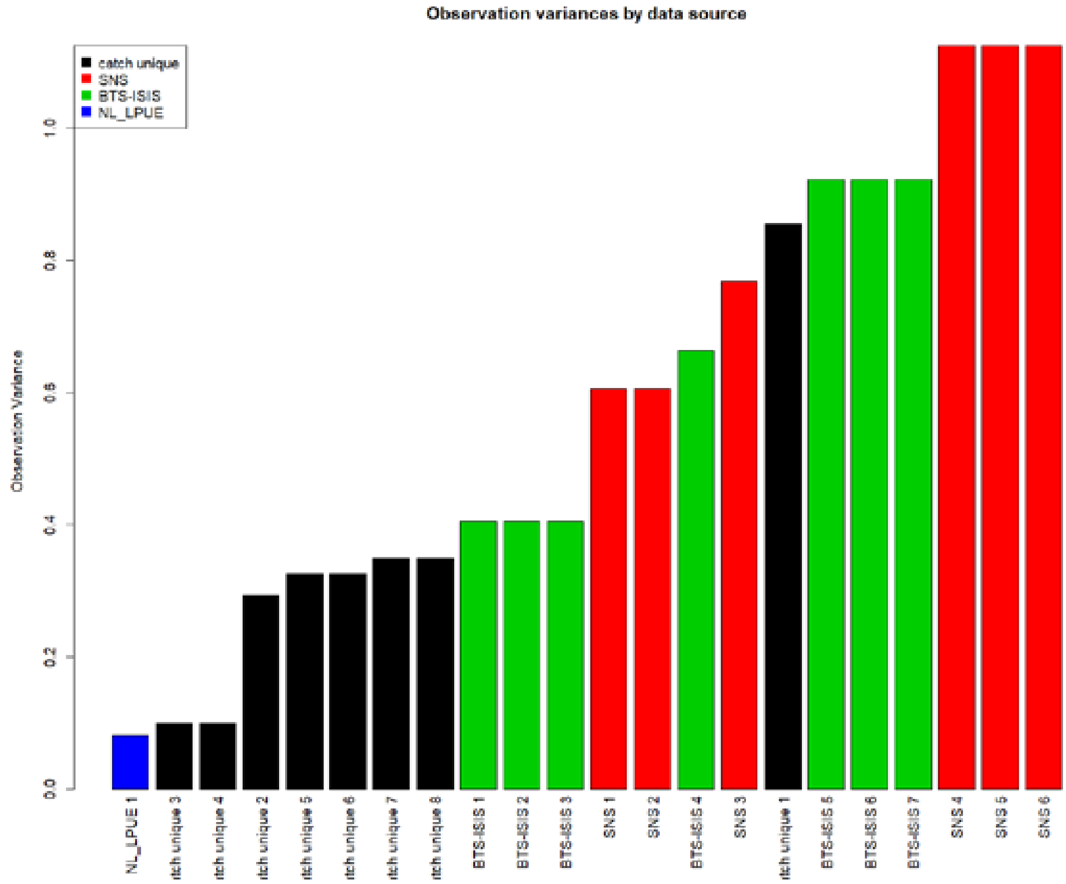


Figure 21.5.3. Estimated observation variances (scaling factor for each of the surveys), ordered from the best to the worst survey fit and has colour coding to show which bars belong to one dataset.

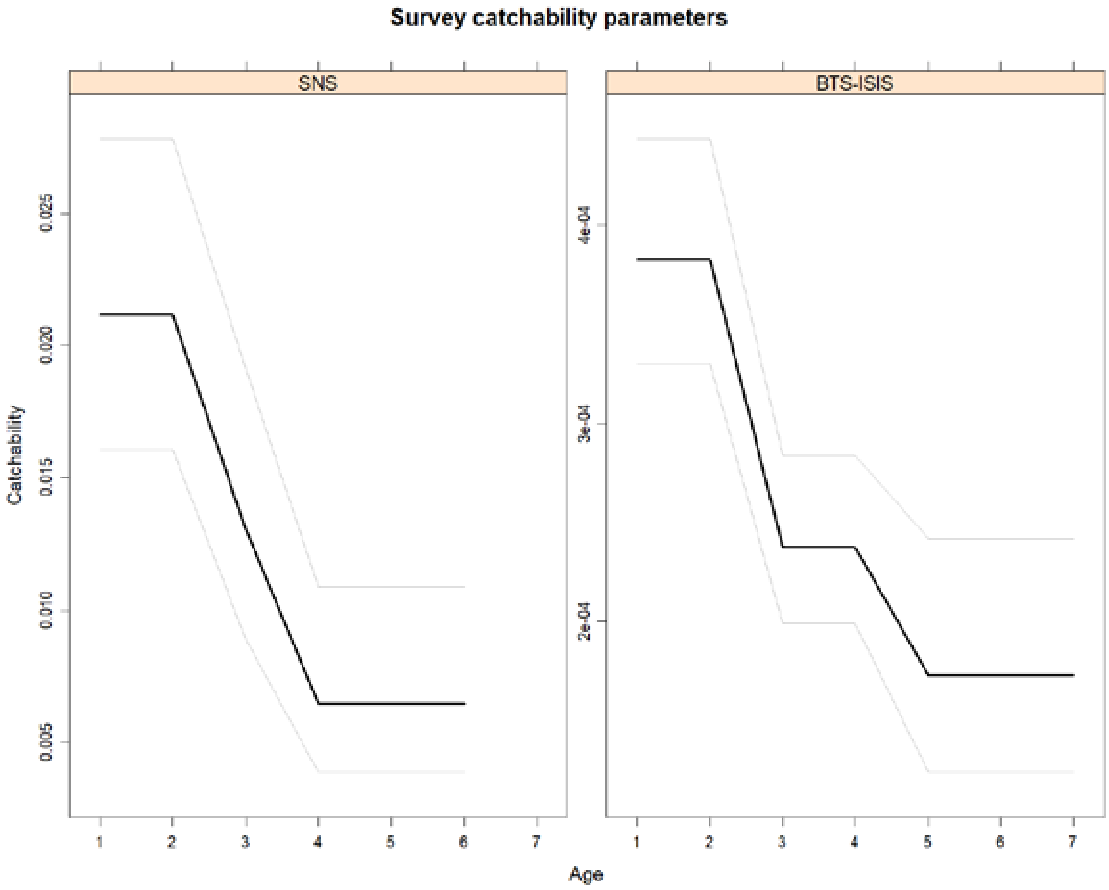


Figure 21.5.4. Catchabilities of the surveys for all surveys with more than 1 age-group.

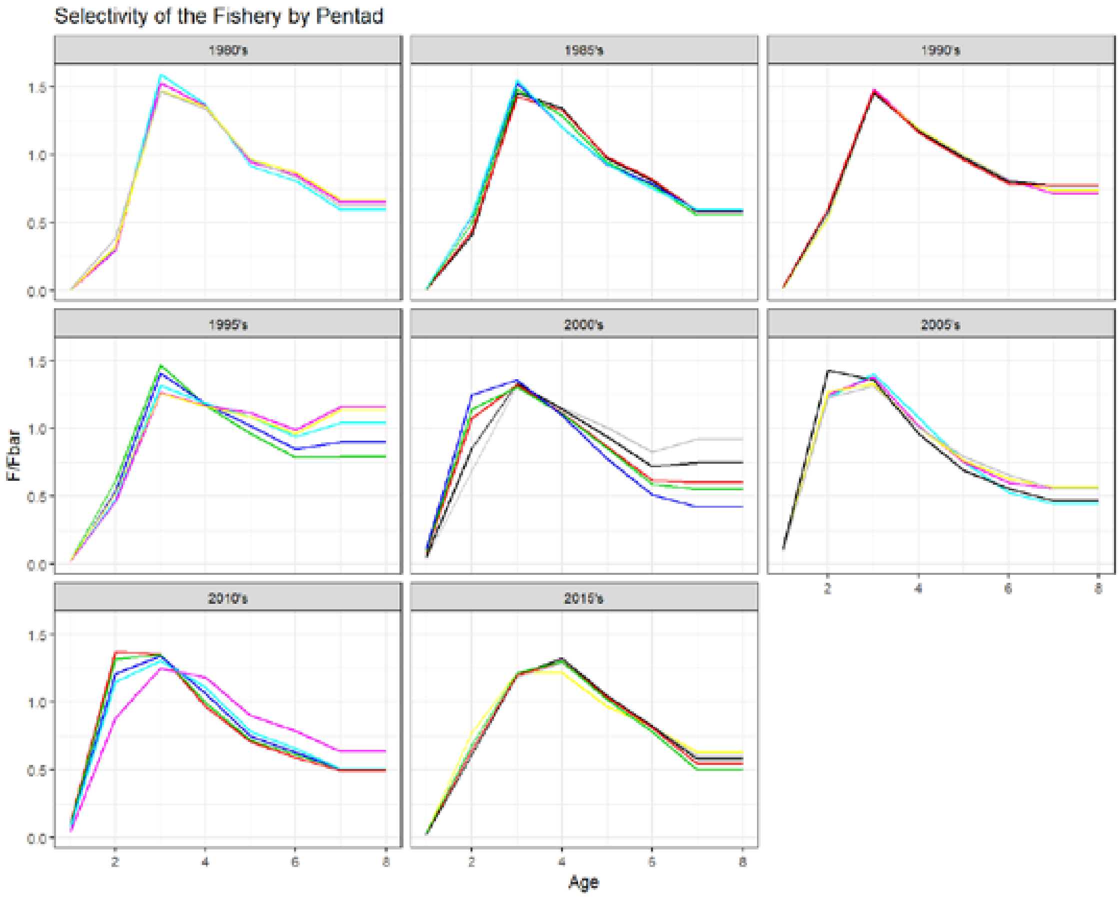


Figure 21.5.5. Estimated selectivity from 1981 to 2019, grouped by a 5-year period. Note the 1980s are 1981 up to 1984, 2015s is 2015 up to 2019. Values represent actual F-at-age.

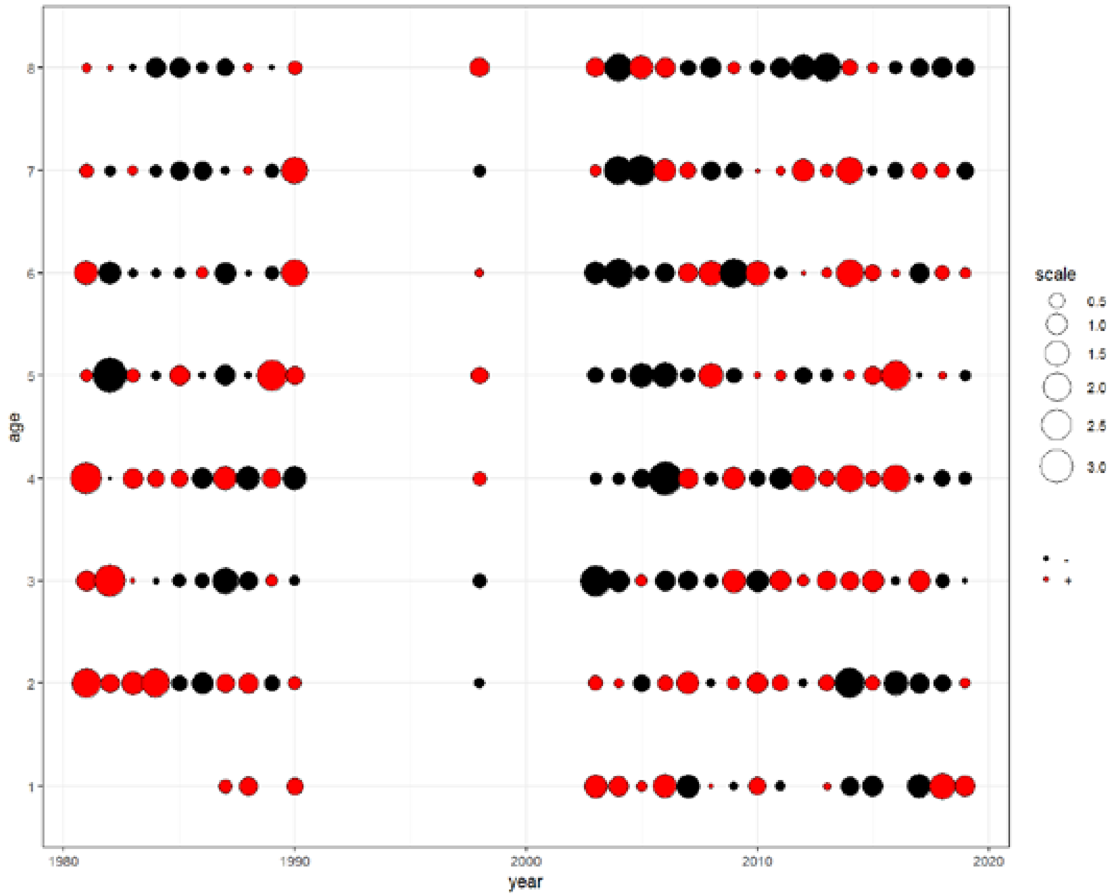


Figure 21.5.6. Residual bubble plot of landings

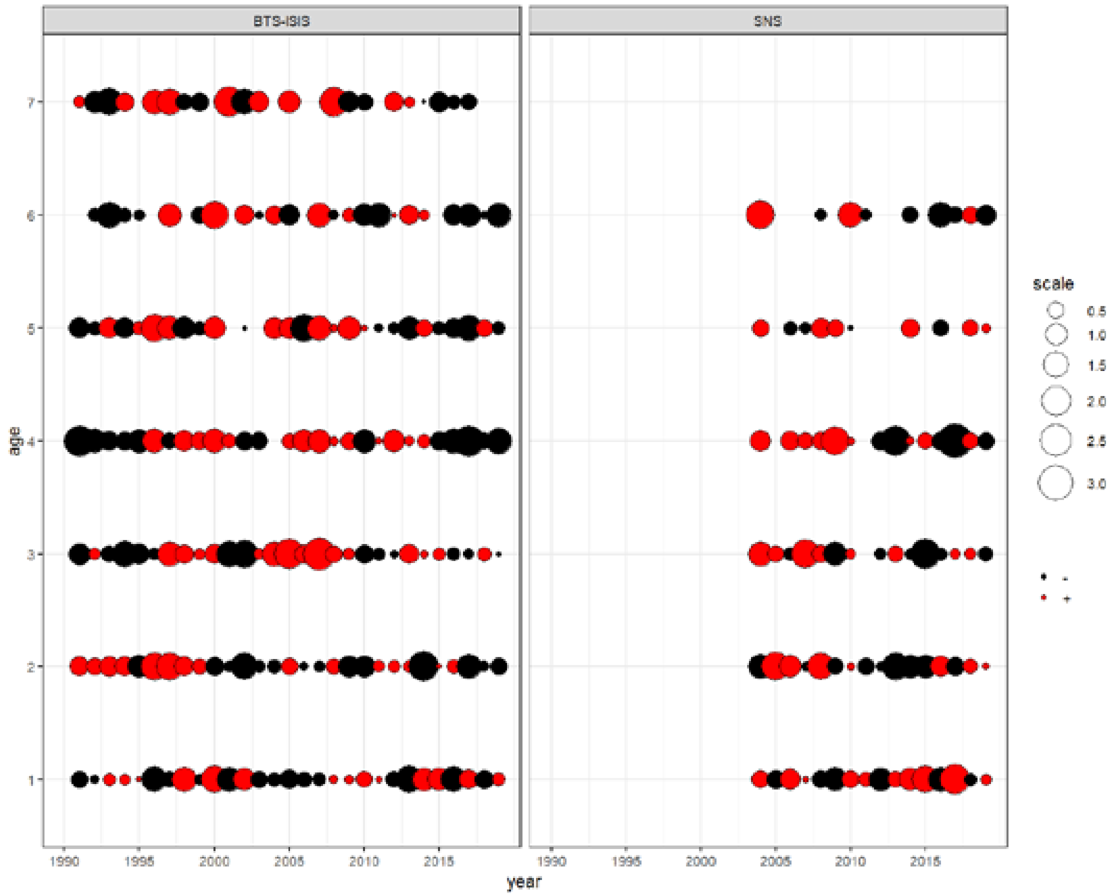


Figure 21.5.7. Residual bubble plot of SNS and BTS-ISIS survey.

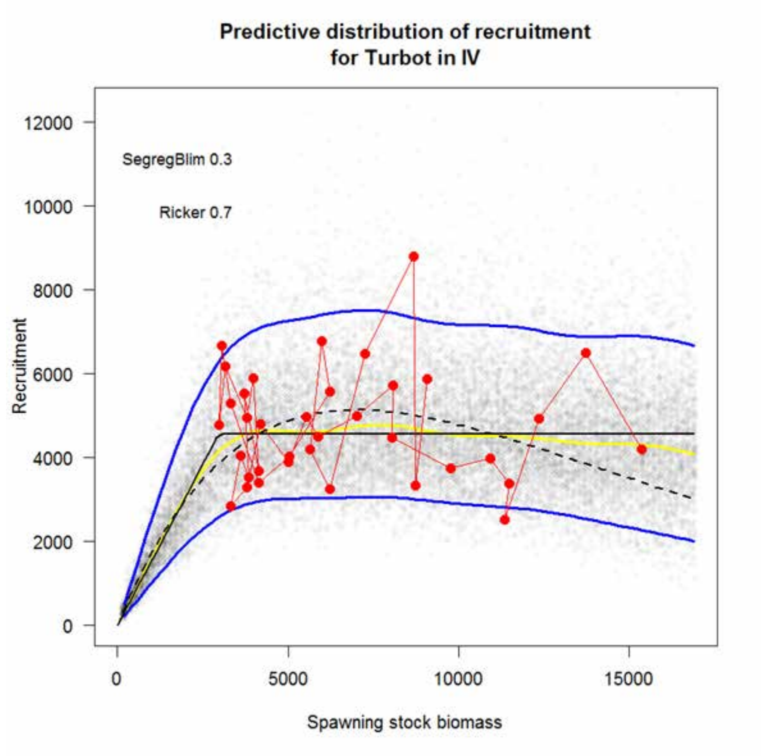


Figure 21.6.1. Stock recruitment pairs over time.

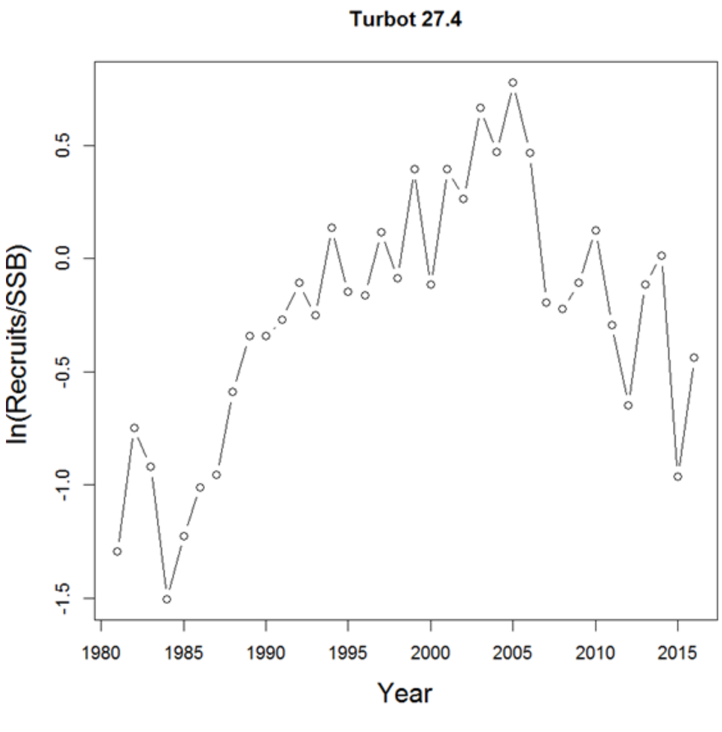


Figure 21.6.2 Productivity over time

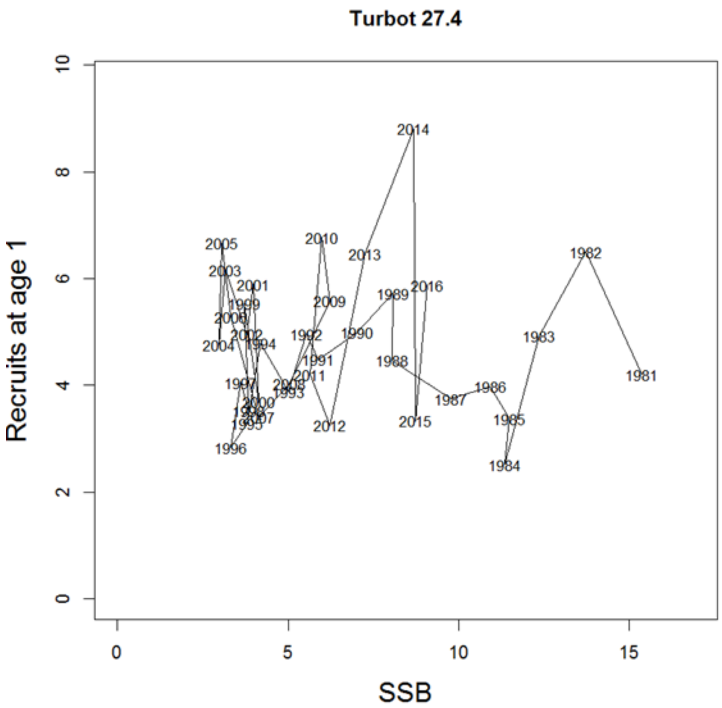


Figure 21.6.3. Stock recruitment pairs over time

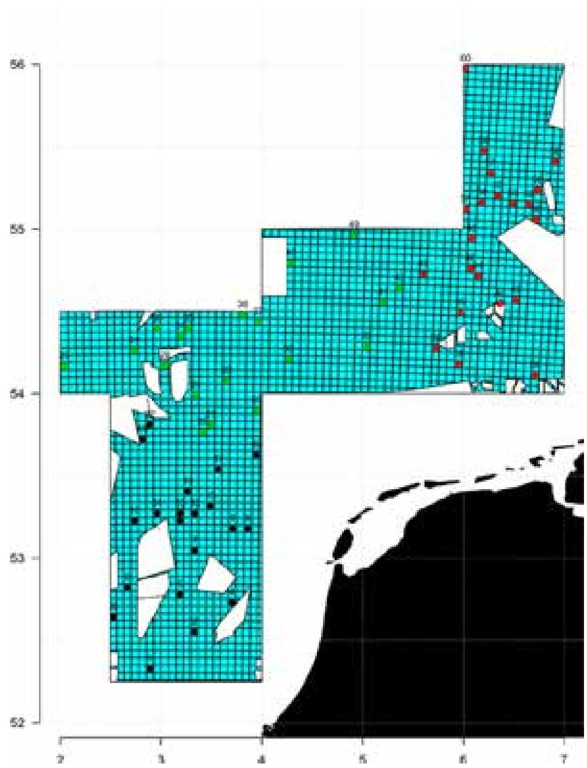


Figure 21.9.1. Map showing the area survey design to be monitored during the new Dutch industry-based survey. The squares are 5 x 5 km zones. Map showing the 60 randomly selected monitored stations during the 2019 survey.

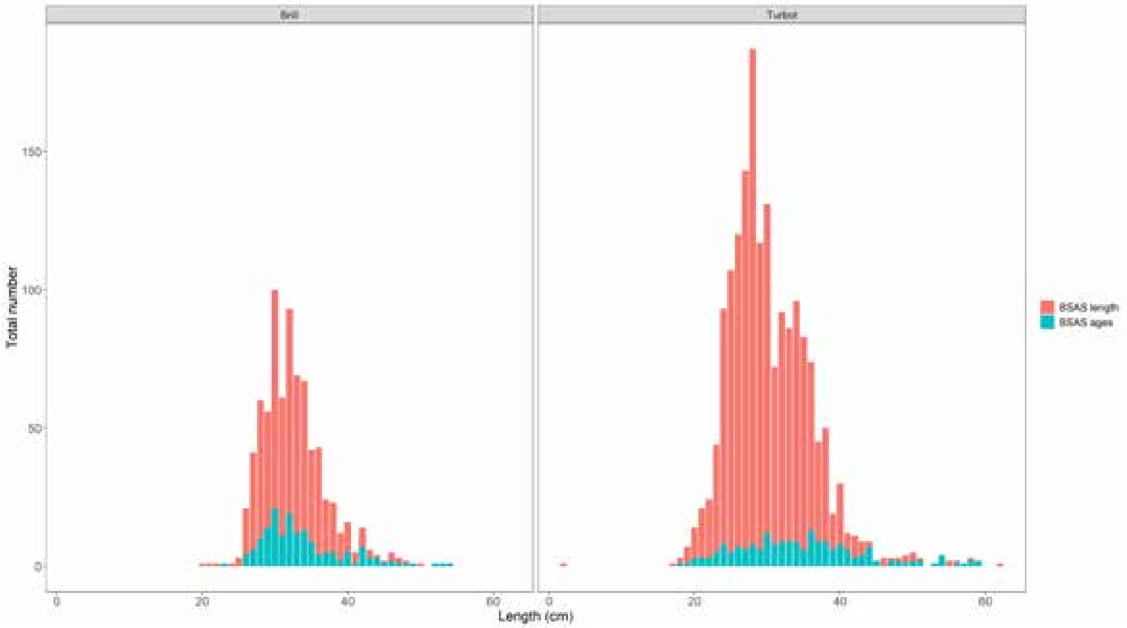


Figure 21.9.2 Total number of individuals of turbot and brill sampled within the Dutch industry survey distributed over 1cm-classes. Red are the total number of individuals of which length was measured, blue are those of which length and age were sampled.

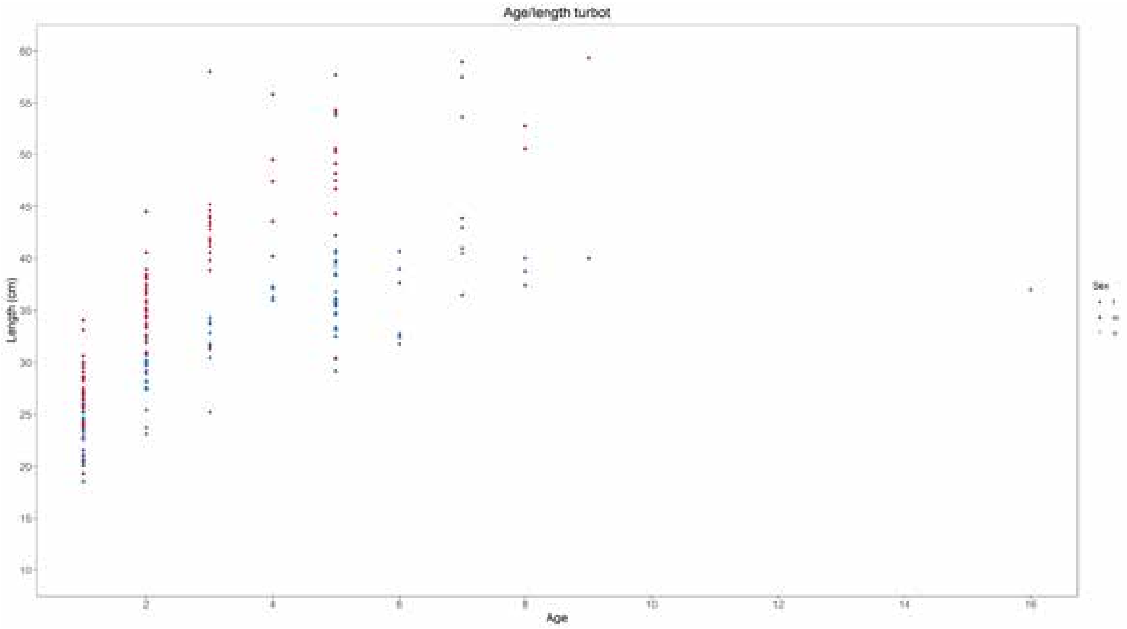


Figure 21.9.3 age-length distribution of turbot sampled in the 2019 industry survey. Females are red, males are blue, orange are unknown.

22 Whiting (*Merlangius merlangus*) in Division 3.a (Skagerrak and Kattegat)

22.1 General

22.1.1 Stock definition

There is a paucity of information on the population structure of whiting in Division 3.a (the Skagerrak-Kattegat area). No genetic or otolith-based surveys have been conducted. Tagging of whiting has previously been undertaken, but these data need to be re-examined. Results from previously modelled survey data (SURBAR) were inconclusive regarding independent population dynamics in Division 3.a in comparison with the North Sea (ICES, 2016), presumably due to the need of age readings in 3.a (age information used in SURBAR was borrowed from Subarea 4). The drop in landings in the beginning of the 1990s gives, however, an indication of local stock structure as this reduction was not paralleled by any similar event in the North Sea. There are also findings of locally spawned whiting eggs in Kattegat 3.aS (Börjesson *et al.*, 2013).

22.1.2 Ecosystem aspect

No new information was presented at the Working Group. A summary of available information on ecosystem aspects is presented in the Stock Annex 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%

Catch category	Imported or Raised	Catch (tonnes)	Percent
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

$$\log(\mu i) = \mathrm{Gear}(i) + f_1(\mathrm{lon}_i, \mathrm{lat}_i) + f_2(\mathrm{timeOfYear}_i, \mathrm{lon}_i, \mathrm{lat}_i) + f3(\mathrm{time}_i, \mathrm{lon}_i, \mathrm{lat}_i) + f_4(\mathrm{depth}_i) + U(i)_{\mathrm{ship:gear}} + \log(\mathrm{HaulDur}_i)$$

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 (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, apart from reporting catches at length, no biological data are collected for this species; in order to understand better their growth and maturity in this area, it is recommendable that otoliths and maturity information should be collected during surveys.

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 con-sumption	Total in-dustrial	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).**

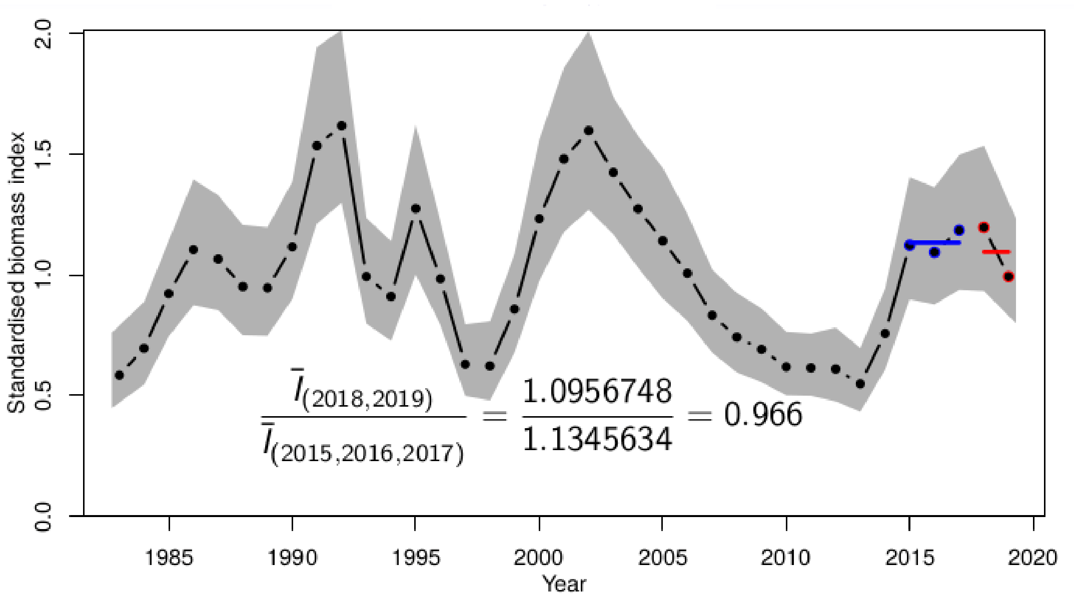


Figure 22.1. Whiting in Division 3.a (Skagerrak and Kattegat): Combined biomass index (Q1) using survey data from the two international bottom trawl surveys and two Danish national surveys. The average of the last two years (red line) and the average of the three years before that (blue line) are used 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. The assessment in 2020 follows the stock annex and the decisions made during the benchmark in 2018. 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 2020 assessment of whiting in 27.4 and 7d the historical time series of survey indices obtained with the new automated substitution procedure are used. See annex 9 for more details.

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 unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2015–2017), this implies wanted catch of no more than 13 052 tonnes and human consumption catch of no more than 21 088 tonnes.

ICES advice for 2020

In May 2019, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 22 082 tonnes. If unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2016–2018), this implies wanted catch of no more than 12 737 tonnes and human consumption catch of no more than 19 354 tonnes.

23.4 Management

Management of whiting is implemented by TAC and technical measures. The TACs for this stock are split between two areas: (i) Subarea 4 and Division 2.a (EU waters), and (ii) Divisions 7b–k. Since 1996 the North Sea and eastern Channel whiting assessments have been combined into one.

The TAC 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 wanted catch for human consumption. Since 2018, with introduction of the landing obligation the TAC accounts for total human consumption catch in Subarea 4, including discards and landings below minimum landings size (BMS) but excluding industrial bycatch (IBC). The TAC in Subarea 4 for 2019 was set to 17 191 tonnes and for 2020 was 17 158 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). 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 2019, 82% 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 2019 data, no logbook registered discards are submitted. Minor whiting landings have been reported as BMS landings into InterCatch since 2016. In 2019 data, these mostly originated from Scotland OTB_DEF métiers (44 t). Generally, BMS was treated as unwanted catch as in previous years.

Due to correction in French data for the year 2018, InterCatch data were raised for both 2018 and 2019. The re-raising of the InterCatch data for the year 2018 made little difference to the landings and number at age estimates (Fig. 23.1a). In addition, Swedish landing data in area 4 were missing from the submission to InterCatch and the Swedish catches (6 tonnes) have been added manually in the assessment after InterCatch. InterCatch data will therefore need to be raised for both 2019 and 2020 prior to the 2021 assessment. In 2019 data, 67% 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 2019 are illustrated in Figure 23.1b. Discards were raised from discard ratios from Subarea 4 and Division 7.d combined. The data were stratified by gear type, TR1 and TR2, and quarter to raise discards for fleets without imported discards. For other gear types, discards were raised by quarter using discard rates from all available fleets. The raised discards amounted to 31% of total discards (Table 23.3b). Industrial bycatch landings were excluded from the discard raising, as no discards occur in that fleet. Throughout this report minor BMS landings were grouped together with discards as “unwanted catch”, for age allocations as well as estimation of mean weights-at-age.

Figure 23.2a shows métier specific landings in percent of the total landings in 2019 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 67% of the overall landings, and are available for 12 métiers (Table 23.3.c).

However, although the unsampled fleets provide considerable landings overall (33%), 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 6% of the total landings, all of which occurred in the Danish fishery and were not sampled.

For raising discard rates from sampled to unsampled fleets all samples were used with splitting of fleets on the basis of quarter or gear type. Discard rates for unsampled whiting fleet components were obtained from discards reported by France, UK (England, Scotland), Netherlands, Denmark, Belgium and Germany.

Of the total discards, 69% were imported into InterCatch. 41% 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, unwanted catch and industrial bycatch) are given in tables 23.4–23.11. In 2019, unwanted catch represented 34% 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 unwanted catch were based on samples provided by France, UK (England, Scotland) and Denmark. Age compositions were applied to landings with splitting of fleets on the basis of quarter (1,2 vs 3,4) and gear type (TR1 and TR2). Unwanted catch age compositions were allocated using all discard samples with splitting of fleets on the basis of gear type (TR1) and quarter (1,2 vs 3,4). For the remaining gear types age compositions were allocated using all available samples.

Limited sampling of the industrial bycatch component resulted in the 2006 data appearing as an outlier and the 2007 to 2010 data were deemed unreliable. This applies to both the age compositions and the estimates of mean weights at age. Thus the data for 2006 to 2010 were replaced with estimates derived from the years 1990 to 2005 (as described in the Stock Annex). For the industrial bycatch in 2011 and 2012, age compositions were inferred in InterCatch from corresponding age samples taken from small-mesh fisheries of France and the UK. In recent years, age compositions for industrial bycatch are estimated from all samples (wanted and unwanted catch) without splitting of fleets. Minor BMS landings (below minimum landing size) were not sampled. BMS was treated the same as discards, and age compositions are inferred from discard samples only. BMS and discards were combined as unwanted catch.

Total international catch numbers at age (Subarea 4 and Division 7.d combined) as estimated by ICES are presented in Table 23.4. Numbers for human consumption landings, unwanted, and industrial bycatch are given in tables 23.5 to 23.7. Total catches, and catch components, as estimated by ICES are listed in Table 23.12.

23.5.3 Weight at age

Mean weights at age (Subarea 4 and Division 7.d combined) in the catch are presented in Table 23.8. Mean weights at age (both areas combined) in human consumption landings are presented in Table 23.9, and for the unwanted catch and industrial by-catch in the North Sea in tables 23.10

and 23.11, respectively. Weights-at-age are depicted graphically in Figure 23.5, which indicates an increasing trend (with annual fluctuations) in mean weight-at-age in the landings, unwanted catch and total catch for ages > 2 since the early 2000s. In recent years, mean weights at age have stabilized on the higher level. Mean weights at age in landings have decreased for age 0 since the late 2000s.

Unrepresentative sampling of industrial bycatch in 2006 to 2010 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values). From 2009 onwards, the weights at ages of total catches were used for weights at ages of industrial bycatch.

Stock mean weights at age are estimated from commercial catch weights at age scaled to the level of weights at age estimated in IBTS Q1 (WKNSEA 2018, Figure 23.6).

Unsmoothed values of weights at age are used in the assessment (Table 23.13).

23.5.4 Maturity and natural mortality

Values for proportion mature at age are estimated using IBTS Q1, in Table 23.14 and Figure 23.7. The estimation procedure is discussed in the Stock Annex. Values prior 1991 are assumed constant using values of 1991, due to data quality issues and high variability in results in the earlier time period. The same maturation proportion was assumed for individuals 6 years and older.

Estimates of natural mortality (M) are taken from the 2017 update key run from of the SMS multispecies model (ICES WGSAM, 2018) (Table 23.15 and Figure 23.8). At the benchmark WKNSEA 2018, the most recent estimates of natural mortality values were smoothed. The new natural mortality values for 2017, 2018 and 2019 are assumed to be the same as in 2016 (Figure 23.8). The same natural mortality was assumed for individuals 6 years and older.

23.5.5 Research vessel data

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 2020 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 1983–2020 and 1991–2019, respectively. The report of the 2001 meeting of WGNSSK (ICES WGNSSK, 2002), and the ICES advice for 2002 (ICES ACFM, 2001) provide arguments for the exclusion of commercial CPUE tuning series from calibration of the catch-at-age analysis. Such arguments remain valid and only survey data have been considered for tuning purposes. All available tuning series are presented in the Stock Annex prepared at ICES WKNSEA (2018).

In Figure 23.9, survey distribution maps based on the IBTS–Q1 survey in the North Sea, for ages 1–3+ of the first quarter (Q1) 2016–2020, are presented. Figure 23.10, the third quarter is represented (Q3) for ages 0–3+ for the years 2016-2019 For ages 2–3+ CPUE is higher along the UK east coast. Whiting at age 0 are found in the Northern North Sea and Scottish east coast as well as in the German Bight. CPUE at age 0 in Q3 is lower in 2017 and 2018 than in 2016, but is higher again in 2019.

23.6 Benchmark

The ICES Benchmark Workshop on North Sea Stocks 2018 (WKNSEA) was held at ICES in Copenhagen in early 2018. Analyses focused on a number of key issues (maturity, natural mortality, stock-weights at age, stock identity, assessment model) details can be found in WKNSEA report (ICES, 2018a) and stock annex.

No changes were made to the use of survey indices. Catch data was updated in Intercatch following a data call for 2009–2016. A new stratification design to allocate discard ratios and age distributions was introduced, details of the allocation scheme can be found in the Stock Annex and in Section 23.5. The assessment model was updated from XSA to SAM and new reference points were estimated.

As before, Area 27.4 represents the management unit with TAC advice to be given. WGNSSK and WKNSEA recommended, that the stock identity issue should be reviewed in the future when firm evidences become available. Until then it is recommended to monitor area-specific stock development based on survey data when it is available (see Section 23.15). The feasibility of combining Division 3.a with Subarea 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks.

23.7 Data analyses

23.7.1 Exploratory survey-based analyses

In Figure 23.11, time-series of survey log CPUE at age (ages 1–5+) 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) 2019 is estimated to have been relatively low although higher than in 2018, while SSB and TSB are at an intermediate level compared to the historical time series. The log survey residuals (Figure 23.17) suggest in most recent years some negative residuals in Q1 and positive residuals in Q3 that should be investigated if trends continue in the coming year.

23.7.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 23.19 and show numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 2 for some cohorts. Also evident is the persistence of the 1999 to 2001 year classes in past catches and the recent low catches of the 2002–2011 year classes.

The negative gradients of log catches per cohort, averaged over ages 2–6 are given in Figure 23.20. The gradients 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, unwanted catch and industrial bycatch data for the period and two survey tuning indices. The used time range for input data for SAM was agreed at WKNSEA and is detailed in the stock annex (ICES, 2018a). The assessment model, including input data, results and diagnostics can be found on www.stockassessment.org as “NSwhiting_2020_new_method_new1”.

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 5 years of recent data. There is very low retrospective bias in SSB, catches, and fishing mortality. Some retrospective bias in recruitment is estimated for the most recent years. Mohn's rho measures the retrospective bias, values are given in Table 23.21 and confirm the relatively higher retrospective bias in recruitment. There is tendency to overestimate recruitment in the final year. Retrospective peels are generally covered by the confidence interval.

Final SAM run model parameters are given in Table 23.22.

The spawning stock recruitment relationship shows no apparent pattern, confirming that the assumed random walk in recruitment in the model is appropriate (Figure 23.31).

Finally, Figure 23.32 compares the SURBAR results with the final SAM assessment. Dynamics in SAM and SURBAR are similar with higher variability in the SSB estimates from SURBAR. The comparison of recruitment (at age 1) shows similar dynamics with more variability in SURBAR results. The mean Z (total mortality, ages 2–4) estimates from SURBAR show higher mortalities since 1990 than SAM and some increase in mortality in recent years, but the trends are similar. The relative constant mortality estimated by SAM in recent years follows the lower variability in SSB from SAM and relatively constant catches, data which are included only in the SAM assessment.

23.8 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 23.22. These show that mean F has been declining since 1990 and reached the minimum of time-series in 2005 of 0.163, but is slightly increasing since. In recent years fishing mortality decreased to levels around 0.2. The SSB was at extremely high levels before 1983 (no survey information included prior 1983). The medium level of 1990 has not been reached since. Some recent increase in SSB indicate that SSB to be at a similar level as in the early 2000s. Recruitment is fluctuating around a recent (post 2001) lower average. 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. In the most recent year, landings, unwanted catch and industrial bycatch have also all remained at or around a recent average. The stock–recruitment plot in Figure 23.31 does not show a clear relationship between SSB and subsequent recruitment.

23.9 Biological reference points

The 2013 benchmark meeting (ICES WKROUND, 2013) attempted to calculate F_{MSY} for North Sea whiting, but concluded that this value was inestimable using standard equilibrium considerations and would need to be determined as part of a management strategy evaluation. After the considerable revisions in the 2012 assessment, caused by new estimates of natural mortality, the target F of 0.3 was no longer considered applicable. The management plan was re-evaluated in October 2013 (ICES, 2013) and ICES advised that updating the target F from 0.3 to 0.15 within the management plan. New revisions of natural mortalities were presented at WGSAM 2014. An interbenchmark was performed for whiting in the North Sea and Division 7.d in early 2016 (ICES, 2016). This included Eqsim runs and MSE. A target F of 0.15 together with a TAC constraint of 15% according to the EU–Norway Management Plan may not be sufficient to keep SSB above B_{lim}. It was concluded to use instead the MSY approach with target F of 0.15.

In the WKNSEA 2018 benchmark new data and assessment model were introduced, Eqsim was run to determine new reference points (ICES, 2018a). $F_{p.05}$ was calculated by running Eqsim to ensure that the long term risk of SSB < B_{lim} of any F used does not exceed 5% when applying the advice rule. Accordingly, F_{MSY} had to be set to $F_{p.05}$ = 0.172. Current reference points are listed in Table 23.23.

It is 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 Blim =119 970 and FMSY =0.172 were set for North Sea whiting and are suggested to remain unchanged (ICES, 2018a). The new indices result 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 indicate 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).

The use of both new and old survey indices would lead to higher but similar Fmsy reference points if recalculated using EqSim this year. Even though new survey indices would lead to a slight increase in the reference points even when used with benchmark data, it is not recommended to change the reference points due to the issue of precautionarity. Previous management strategy evaluations indicate that the current Fmsy may not be precautionary. A further increase in the reference point Fmsy by recalculating Fmsy with EqSim is therefore not recommended at this point (see Annex 9 for more details).

23.10 Short-term forecasts

A short-term forecast was carried out based on the final SAM assessment. SAM survivors from 2019 were used as input population numbers for ages 0 and older in 2020. Recruitment assumptions are detailed in Table 23.24. In the intermediate and following two years the geometric mean of recruitment from 2002–2019 is used.

The exploitation pattern is chosen as the mean exploitation pattern over the most recent three years 2017–2019. The mean exploitation pattern was scaled to the mean $F_{2–6}$ in 2019 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 2017–

2019. The F at age used in the forecast is compared with the F at age estimates for 2017–2019 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 2017–2019 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_{2020} equal to mean F_{2019} (using the average selectivity over the last 3 historical years) results in human consumption catches in the intermediate year 2020 of 28 930 tonnes from a total catch of 31 080 tonnes, giving an SSB in 2020 of 169 998 tonnes (Table 23.26).

Carrying the same fishing mortality forward into 2021 (the status quo F option, F_{sq}) would result in human consumption catches of 29 310 tonnes out of total catches of 31 512 tonnes, and would result in an SSB of 181 394 tonnes in 2022 (a 0.69% increase in SSB relative to 2021).

Since SSB in 2021 are predicted to be higher than MSY $B_{trigger}$, following the MSY approach allows for applying F_{MSY} leading to an F_{target} of 0.172.

Applying the F_{MSY} of 0.172 in 2021 would generate human consumption catches of 24 071 tonnes out of total catches of 26 304 tonnes, and result in an SSB of 185 094 tonnes in 2022 (a 2.7% increase in SSB relative to 2021). In 2022, SSB would be above B_{lim} and MSY Bt_{rigger}. F of 0.172 would cause the TAC (relative to the TAC in 2020) to be changed by +15.2%.

23.11 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting.

23.12 Quality of the assessment

Previous meetings of WGNSSK and the benchmark workshop (ICES WKROUND 2009; ICES WKROUND 2013) have concluded that the historical survey data and commercial catch data contain different signals concerning the stock. Analyses by Working Group members and by the ICES Study Group on Stock Identity and Management Units of Whiting (ICES SGSIMUW, 2005) indicate that data since the early to mid–1990s are sufficiently consistent to undertake a catch-at-age analysis calibrated against survey data from 1990. WKNSEA (ICES, 2018a) considered the question of time series length again and concluded that the divergence between survey-based and catch-based analysis are not sufficient to exclude pre-1990 data. Survey data was included since 1983 with standardization of survey design.

Given the spatial structure of the whiting stock and of the fleets exploiting it, it is important to have data that covers all fleets. Considering that age 1 and age 2 whiting make up a large proportion of the total stock biomass, good information of the discarding practices of the major fleets is important.

The survey information for Division 7.d were not available in a form that could be used by WGNSSK. Due to the recent changes in distribution of the stock, tuning information from this area would be extremely useful, and could improve the estimate of recruitment in the most recent year. However, previous analyses of the survey in Division 7.d showed it did not track cohorts well (ICES WKROUND, 2009).

Age distributions and mean weights at age have been estimated for the industrial bycatch from 2006 to 2010. This was due to low sampling levels of the Danish industrial bycatch fisheries. In recent years, no samples of industrial bycatch were available. Age distributions and weights at age were inferred from sampling of landings and discards from other fleets.

In 2017, French samples for quarter 1 and 2 particularly in Subdivision 7.d are sparse due a disruption in the onshore sampling scheme. Therefore, a percentage of data was simulated randomly from previous year's data. This affected about 8% of total catch weight (landings more than discards, in particular TR2 fleet in 7.d).

There have been issues with regard to the age readings of North Sea whiting as compared to other gadoids in the past (Norway as compared to Netherlands and UK (Scotland)). This applies in particular to the age readings used for the IBTS indices. An otholith workshop took place in late 2016, to improve consistency in preparation techniques and readings (ICES WKARWHG2, 2016). This exercise showed an improvement in age reading compared to the same read in the 2015 exchange. A recommendation was made to investigate the quality of age readings further. The historical performance of the assessment is summarized in Figure 23.34. The difference in SSB is due to new benchmark model and input data. SSB is estimated using new, scaled stock weights at age and maturity estimates. As the assessment model operates on numbers at age rather than biomass the new stock weights at age and maturities did not directly affect estimates of fishing mortality. Since 2018, recruitment is estimated at age 0 instead of age 1 such that previous assessment results are not plotted in Standardgraphs. Catch data and natural mortalities were updated. Estimates of fishing mortality remained at a similar level as before above F_{MSY}. Retrospective bias compared to the 2019 assessment is low, despite the update of the survey time series.

23.13 Status of the stock

For North Sea whiting, SSB has a generally downwards trend since the start of the assessment time-series. SSB is estimated to be above B_{lim} since 2008 (figures 23.22, 23.34). The stock, at the level of the entire North Sea and Eastern Channel, was at an historical low level in the late 2000s (relative to the period since 1978), and the recent increase in SSB is in large part due to relatively improved perception of recruitment in 2007–2010 and 2014–2016. All indications are that fishing mortality has been declining over most of the time-series, currently fluctuating around a low level. Since 2006, fishing mortality remained above F_{MSY} = 0.172, but has been below F_{pa} and F_{lim}. While landings have been relatively stable and even decreased slightly in recent years, unwanted catch and industrial bycatch increased in recent years slightly. Recruitment is varying around a recent mean, but that mean is lower relative to recruitment in the late 1990s. Recruitment in 2014–2016 was above the average of recent years. The development of whiting biomass depends on the size of recruitment. Low recruitment estimated for 2017 continued in 2018 but higher recruitment was estimated for 2019. Stock biomass estimated for 2020 increased and is now 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 10 billion). In recent years and increased proportion of whiting mature already at age 1 and grow quickly at young ages; therefore an increase in SSB is seen the year immediately after a good recruitment. Managers should consider the age structure of the population as well as the SSB since at low stock sizes short term forecasts are highly sensitive to recruitment assumptions.

Catches of whiting have been declining since 1980 (from 243 570 tonnes in 1979 to 31 286 tonnes in 2019, 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 2019, 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 2020 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.

23.16.1 Data and assessment

Stock weights at age are estimated each year by scaling the catch-at-weight time series by using the NS-IBTS quarter 1 weights at age (shorter time series). Even though the entire time series of stock weights at age is re-estimated each year, so far historical values did not change. If estimated stock weights at age in the historical time period differ significantly from one year to the next, the estimation should be reconsidered, i.e. only add newly estimated most recent data point (not an issue this year).

Natural mortality: When new natural mortality estimates (WGSAM) become available these data need to be included and potentially reference points may need to be revised (not an issue this year).

Stock identity: In the last benchmark, stock identity was considered for North Sea whiting distinguishing a northern and a southern stock component. Analysis (see Section 23.1.1) suggest similar dynamics in the northern and southern component with dynamics being dominated by the northern component. At this point in time, a separate assessment is not considered necessary from reviewed literature and SURBAR analyses.

23.16.2 Forecast

Forecast continues to be done in MFDP. A SAM forecast is being considered which allows fleet separation (human consumption and industrial bycatch fleet) and stochastic forecast.

Table 23.1. Whiting in Subarea 4 and Division 7.d: Whiting in Subarea 4. Nominal landings (in tonnes) as officially reported to ICES, ICES estimates of catch components, and TACs. *Before 2015, the official landings from Denmark are likely to exclude Industrial bycatch.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
belgium.4	1040	913	1030	944	1042	880	843	391	268	529	536
denmark.4	1206	1528	1377	1418	549	368	189	103	46	58	105
faroe.4	26	0	16	7	2	21	0	6	1	1	0
france.4	4951	5188	5115	5502	4735	5963	4704	3526	1908	0	2527
germany.4	692	865	511	441	239	124	187	196	103	176	424
netherlands.4	3273	4028	5390	4799	3864	3640	3388	2539	1941	1795	1884
norway.4	55	103	232	130	79	115	66	75	65	68	33
sweden.4	16	48	22	18	10	1	1	1	0	9	4
uk.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
england.wales.4	2338	2676	2528	2774	2722	2477	2329	2638	2909	2268	1782
scotland.4	27486	31257	30821	31268	28974	27811	23409	22098	16696	17206	17158
total.landings.4	41083	46606	47042	47301	42216	41400	35116	31573	23937	22110	24453
unallocated.landings.4	-1097	396	1832	691	346	850	-434	633	247	-3590	173
ices.landings.4	42180	46210	45210	46610	41870	40550	35550	30940	23690	25700	24280
ices.unwanted.catch.4	52270	30840	28470	41400	31840	28940	27130	16660	12480	22110	21931
ices.ibc.4	51337	39755	25045	20723	17473	27379	5116	6213	3494	5038	9160
ices.catch.4	145787	116805	98725	108733	91183	96869	67796	53813	39664	52848	55371
tac.4.2a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30000

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.4	454	270	248	144	105	93	45	116	162	147	74
denmark.4	105	96	89	62	57	251	78	42	79	158	135
faroe.4	0	17	5	0	0	0	0	0	2	0	0
france.4	3455	3314	2675	1721	1261	2711	3336	3076	2305	2644	2794
germany.4	402	354	334	296	149	252	76	76	124	156	111
netherlands.4	2478	2425	1442	977	805	702	618	656	718	614	514
norway.4	44	47	38	23	16	17	11	92	73	118	28
sweden.4	6	7	10	2	0	2	1	2	4	8	6
uk.4	NA	NA	NA	NA	NA	11632	12110	10391	8853	7845	8892
england.wales.4	1301	1322	680	1209	2560	NA	NA	NA	NA	NA	NA
scotland.4	10589	7756	5734	5057	3441	NA	NA	NA	NA	NA	NA
total.landings.4	18834	15608	11255	9491	8394	15660	16275	14451	12320	11690	12554
unallocated.landings.4	-426	738	805	541	-2286	563	609	972	-124	-1111	-706
ices.landings.4	19260	14870	10450	8950	10680	15097	15666	13479	12444	12801	13260
ices.unwanted.catch.4	16130	17144	26135	18142	10300	14018	5206	8356	6597	8451	7989
ices.ibc.4	940	7270	2730	1210	890	2190	1240	0	1344	1907	1035
ices.catch.4	36330	39284	39315	28302	21870	31305	22112	21835	20385	23159	22283
tac.4.2.a	29700	41000	16000	16000	28500	23800	23800	17850	15173	12897	14832

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
belgium.4	45	33	46	70	65	71	71	141	
denmark.4	131	124	160	2375	4727	2803	2026	2357	
faroe.4	0	0	0	0	8	1	NA	80	
france.4	1925	942	1884	1131	1232	952	918	890	
germany.4	25	44	31	73	111	81	99	81	
netherlands.4	471	495	464	581	644	687	679	853	
norway.4	94	560	918	1088	1150	993	1025	1102	
sweden.4	4	1	2	0	6	11	8	18	
uk.4	9893	11162	10290	10015	9412	9120	10625	11897	
england.wales.4	NA	NA	NA	NA	NA	NA	NA	NA	
scotland.4	NA	NA	NA	NA	NA	NA	NA	NA	
total.landings.4	12588	13361	13795	15333	17355	14719	15451	17419	
unallocated.landings.4	-356	-456	-52	2101	5113	2891	2682	1632	
ices.landings.4	12944	13817	13847	13232	12242	11828	12769	15787	
ices.unwanted.catch.4	9307	4608	7016	12265	10413	9799	7629	8044	
ices.ibc.4	1117	1654	1623	2097	4551	2635	1698	1788	
ices.catch.4	23368	20079	22486	27593	27206	24262	22160	25619	
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.unwanted.catch.7.d	3330	4220	4090	2970	3850	3240	3370	3000	3210	3570	4129
ices.catch.7.d	6810	9940	9830	8180	10470	8630	8320	7620	7810	8000	8429
tac.7b.k	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22000

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.7.d	75	58	67	46	45	73	75	68	71	88	78
france.7.d	6338	5172	6654	5006	4638	3487	3135	2875	6248	5512	4833
netherlands.7.d	67	19	175	132	128	117	118	162	112	275	282
uk.7.d	NA	NA	NA	NA	NA	72	63	87	138	258	271
england.wales.7.d	134	112	109	99	90	NA	NA	NA	NA	NA	NA
scotland..7.d	0	0	0	0	0	NA	NA	NA	NA	NA	NA
total.landings.7.d	6614	5361	7005	5283	4901	3749	3391	3192	6569	6133	5464
unalloc.landings.7.d	814	-439	1295	933	111	306	137	-1279	649	-967	315
ices.landings.7.d	5800	5800	5710	4350	4790	3443	3254	4471	5920	7100	5149
ices.unwanted.catch.7.d	3109	1356	604	907	2219	2291	1763	1943	2086	4532	3183
ices.catch.7.d	8909	7156	6314	5257	7009	5734	5017	6414	8006	11632	8332
tac.7b.k	21000	31700	31700	27000	21600	19940	19940	19940	16949	14407	16568

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
belgium.7.d	66	95	90	121	146	128	138	144	
france.7.d	3093	3076	2126	3102	2771	2378	2720	2095	
netherlands.7.d	437	650	663	565	556	584	467	603	
uk.7.d	261	472	345	379	259	354	283	259	
england.wales.7.d	NA	NA	NA	NA	NA	NA	NA	NA	
scotland.7.d	NA	NA	NA	NA	NA	NA	NA	NA	
total.landings.7.d	3857	4293	3224	4167	3732	3444	3608	3101	
unalloc.landings.7.d	-556	-15	99	190	32	90	-156	78	
ices.landings.7.d	4413	4308	3125	3977	3700	3354	3626	3023	
ices.unwanted.catch.7.d	2389	2186	2709	4627	2313	1550	2249	2569	
ices.catch.7.d	6802	6494	5834	8604	6013	4904	5875	5591	
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	1.062
Discards	1.057
Landings (incl. IBC)	1.029
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	49.25	100
Discards	Imported	6914	69
Discards	Raised	3079	31
Landings (incl. IBC)	Imported	20477	100
Logbook Registered Discards	Imported	0	NA

Table 23.3.c. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of the imported/raised/sampled or estimated data (uploads in weight).

Catch Category	Raised or Imported	Sampled or estimated distribution	CATON tonnes	Percent
Logbook Registered Discard	Imported	Estimated	0	NA
Landings (incl. IBC)	Imported	Sampled	13829	68
Landings (incl. IBC)	Imported	Estimated	6648	32
Discards	Imported	Sampled	4086	41
Discards	Imported	Estimated	2828	28
Discards	Raised	Estimated	3079	31
BMS landing	Imported	Estimated	5.631	11
BMS landing	Imported	Sampled	43.62	89

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
Landings	Imported	Sampled	27.7.d	1536	50
Landings	Imported	Estimated	27.7.d	1530	50
Discards	Imported	Sampled	27.7.d	947.7	38
Discards	Raised	Estimated	27.7.d	1160	47
Discards	Imported	Estimated	27.7.d	359.1	15
BMS landing	Imported	Estimated	27.7.d	0.03	100
Landings	Imported	Estimated	27.4.c	716.4	100
Discards	Raised	Estimated	27.4.c	406.7	89
Discards	Imported	Estimated	27.4.c	50.06	11
Logbook Registered Discard	Imported	Estimated	27.4.b	0	NA
Landings	Imported	Estimated	27.4.b	158	100
Discards	Imported	Estimated	27.4.b	69.55	52
Discards	Raised	Estimated	27.4.b	65.41	48
BMS landing	Imported	Estimated	27.4.b	0	NA
Logbook Registered Discard	Imported	Estimated	27.4.a	0	NA
Landings	Imported	Estimated	27.4.a	88.83	100
Discards	Raised	Estimated	27.4.a	25.75	100
BMS landing	Imported	Estimated	27.4.a	0	NA
Landings	Imported	Sampled	27.4	12293	75
Landings	Imported	Estimated	27.4	4155	25
Discards	Imported	Sampled	27.4	3138	45
Discards	Imported	Estimated	27.4	2349	34
Discards	Raised	Estimated	27.4	1422	21
BMS landing	Imported	Estimated	27.4	5.601	11
BMS landing	Imported	Sampled	27.4	43.62	89

Table 23.4. Whiting in Subarea 4 and Division 7.d: Total catch numbers at age (thousands). Age 8 is a plus-group. Estimated by ICES, input data for SAM. Ages 0–8+ are included in the final assessment. Model input.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	687238	418909	313391	242369	90047	7564	7564	1851	253	11	9	4	0	0	0	0	277
1979	476383	615525	467538	218283	100976	29267	3111	1657	264	35	1	4	0	0	0	0	304
1980	332209	265359	416009	286077	90719	52969	10752	1153	689	58	14	5	1	0	0	0	767
1981	516869	162899	346343	266518	102295	27776	12297	3540	244	45	37	1	0	0	0	0	327
1982	101057	192641	114443	245247	88137	26796	6909	2082	400	53	26	4	1	0	0	0	484
1983	668604	205647	184747	118411	131507	37231	8688	1780	793	101	35	0	0	0	0	0	929
1984	157819	323408	175965	124886	49504	59817	13860	2964	410	182	21	0	0	0	0	0	613
1985	186723	203321	141716	82037	37847	14420	17446	3329	805	89	9	1	0	0	0	0	904
1986	225202	576732	167078	169578	46516	13368	3487	3975	497	71	0	1	0	0	0	0	569
1987	84863	267051	368230	122748	85240	11391	4555	928	930	98	7	0	0	0	0	0	1035
1988	416924	430344	307429	179503	39635	17902	2174	544	59	72	37	0	0	0	0	0	168
1989	87325	331672	173676	191942	78464	14367	5051	517	291	37	6	1	0	0	0	0	335
1990	289174	258102	501373	127967	84147	31102	1933	719	93	16	0	0	0	0	0	0	109
1991	1057999	135797	194921	184960	36290	25554	5339	526	249	17	1	0	0	0	0	0	267
1992	259390	230302	167479	87820	91081	11654	6634	2546	104	7	1	0	0	0	0	0	112
1993	628301	223424	172049	125599	46181	45300	3898	1501	682	56	15	0	0	0	0	0	753
1994	218287	191544	158369	97559	51041	18683	17905	1258	441	73	0	0	0	0	0	0	514
1995	1597900	148169	144023	112416	35649	15061	5117	4472	314	101	54	0	0	0	0	0	469
1996	96515	86318	118910	99644	48304	14087	4638	1282	897	166	24	6	2	0	0	0	1095
1997	19001	60946	80471	84336	41975	18303	3333	1012	305	135	16	0	0	0	0	0	456
1998	72289	92556	50362	43424	36295	17628	6343	1417	306	66	34	0	0	0	0	0	406
1999	76975	189162	95415	45920	33921	18271	7443	2021	565	95	12	0	0	0	0	0	672
2000	1970	82546	129582	63706	23913	16199	8758	4309	969	244	47	3	0	0	0	0	1263

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2001	18012	52567	83085	52076	20800	9256	4826	2233	896	246	124	2	0	0	0	0	1268
2002	135848	51338	62462	84600	34659	8099	2048	1461	621	102	13	9	9	0	0	0	754
2003	60744	83680	111144	55866	41841	14217	2359	473	329	50	16	1	0	0	0	0	396
2004	34210	47966	23009	32557	30400	21755	8342	1352	198	93	12	1	4	0	0	0	308
2005	17622	47805	34626	12204	18146	14931	8979	3041	540	83	29	1	0	0	0	0	653
2006	15673	73908	42199	21651	8642	15077	11822	4618	1300	142	14	0	0	0	0	0	1456
2007	2490	39041	34001	24900	9906	4008	7657	5268	2560	476	82	0	0	0	0	0	3118
2008	5631	62163	28301	22741	13571	4305	1847	3954	2134	631	143	43	0	0	0	0	2951
2009	12139	57412	31004	15181	12782	7432	3380	2153	2601	1801	1967	20	1	0	0	0	6390
2010	3930	33756	33320	25516	9932	7776	6263	2136	4347	1491	1053	30	1	0	3	0	6925
2011	3563	31377	42201	28903	12537	3813	3178	2090	877	472	1293	31	1	0	0	0	2674
2012	3548	53445	32509	18882	14862	6952	2773	1558	1213	624	482	15	37	0	0	0	2371
2013	4341	20378	15548	25362	15593	10812	3343	1048	643	660	292	0	0	0	0	0	1595
2014	6225	29785	14623	17450	19683	11351	4710	2038	1018	641	431	0	0	0	0	0	2090
2015	7705	48349	53345	15714	10220	14163	5068	2086	1210	607	401	4	0	0	0	0	2222
2016	17208	27639	36165	36788	9129	7813	6046	2548	691	694	376	0	0	0	0	0	1761
2017	28724	27355	27315	24442	18432	4176	2421	2683	1349	1165	26	5	0	0	0	0	2545
2018	15656	17302	41274	26023	17040	6786	1437	1013	803	36	163	38	0	0	0	0	1040
2019	8896	35944	25417	42120	17595	7750	3256	1083	538	237	84	0	0	0	0	0	859

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	414	4049	6052	21836	12463	6630	2632	979	470	192	77	0	0	0	0	0	739

Table 23.6. Whiting in Subarea 4 and Division 7.d: Unwanted catch numbers at age (thousands), as estimated by ICES. Age 8 is a plus–group. Data used to calculate the unwanted catch fraction from the model estimate of catches.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	28587	52684	114965	37682	7154	255	110	0	0	0	0	0	0	0	0	0	0
1979	4577	473830	126724	31601	7322	1263	27	7	0	0	0	0	0	0	0	0	0
1980	3144	103203	250735	88399	14135	10795	786	0	0	0	0	0	0	0	0	0	0
1981	867	50407	96509	57403	7313	1285	149	10	0	0	0	0	0	0	0	0	0
1982	18639	53753	26922	52349	18230	2972	343	22	0	0	0	0	0	0	0	0	0
1983	71016	152488	85318	33325	23442	4309	295	25	9	0	0	0	0	0	0	0	9
1984	16724	200589	82563	16814	4437	4495	1034	151	0	0	0	0	0	0	0	0	0
1985	8497	154232	48791	15117	2985	761	801	65	0	0	0	0	0	0	0	0	0
1986	7966	404604	120492	43479	5242	627	108	63	12	0	0	0	0	0	0	0	12
1987	9978	158531	202154	34824	9776	582	49	0	31	0	0	0	0	0	0	0	31
1988	21321	65021	87197	51135	5877	846	16	0	3	0	0	0	0	0	0	0	3
1989	6898	150598	36712	61442	21267	3276	103	8	12	0	0	0	0	0	0	0	12
1990	147764	83152	241924	33084	23009	11665	246	85	0	0	0	0	0	0	0	0	0
1991	7208	81678	82053	75035	5176	1885	91	60	0	0	0	0	0	0	0	0	0
1992	7587	105838	63830	27659	23115	1231	355	1064	2	0	0	0	0	0	0	0	2
1993	48873	128248	104844	51054	9205	10727	521	131	0	0	0	0	0	0	0	0	0
1994	8352	96890	102020	37751	9867	2885	2338	7	0	0	0	0	0	0	0	0	0
1995	33363	53830	81783	50019	7136	1336	206	113	6	0	0	0	0	0	0	0	6
1996	4575	43126	86878	49817	11506	2205	240	179	0	0	0	0	0	0	0	0	0
1997	11525	26188	34948	32473	9398	2412	400	2	16	0	1	0	0	0	0	0	17
1998	6098	50703	24200	17053	11076	2987	936	213	87	2	18	0	0	0	0	0	107
1999	14762	96413	56365	15228	9016	3104	862	167	51	34	0	0	0	0	0	0	85
2000	1682	48162	81086	24082	3075	2311	1560	478	107	0	0	0	0	0	0	0	107
2001	17352	39826	52156	23055	2795	471	283	142	19	0	0	0	0	0	0	0	19

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2002	1158	10597	33371	45125	10136	1182	218	131	110	3	3	0	0	0	0	0	116
2003	3584	65829	94497	39301	21654	4314	449	30	0	0	0	1	0	0	0	0	1
2004	10478	31169	15698	21879	16951	9909	3922	605	24	9	0	0	0	0	0	0	33
2005	5499	25753	23486	6041	7192	4616	2992	688	211	5	0	0	0	0	0	0	216
2006	15662	51961	25906	10935	2474	2595	1598	493	219	37	8	0	0	0	0	0	264
2007	2350	22508	16283	7153	1784	572	940	1037	380	93	5	0	0	0	0	0	478
2008	5631	48929	15967	8621	4465	741	328	1449	653	63	0	0	0	0	0	0	716
2009	11540	51883	12179	3192	1382	653	139	52	64	32	24	0	0	0	0	0	120
2010	3701	30464	22610	8713	2444	1038	1988	99	2775	34	18	4	0	0	3	0	2834
2011	3430	25925	23211	13753	2053	862	760	272	24	13	29	0	0	0	0	0	66
2012	3471	49677	21362	6943	2497	493	633	154	259	37	59	0	0	0	0	0	355
2013	4149	17715	7711	8710	2899	693	343	40	44	217	43	0	0	0	0	0	304
2014	5943	25159	6425	7025	6438	2597	1193	239	155	38	79	0	0	0	0	0	272
2015	7249	43271	34943	6950	2940	3947	888	313	238	39	13	0	0	0	0	0	290
2016	14941	22682	22342	15500	1889	2536	1075	432	42	23	11	0	0	0	0	0	76
2017	26493	24515	18650	11973	3735	1111	476	804	129	100	0	0	0	0	0	0	229
2018	14985	15331	27274	10665	4071	914	172	145	13	1	0	0	0	0	0	0	14
2019	8097	30337	18250	17875	4002	555	408	22	34	33	0	0	0	0	0	0	67

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	1558	1115	2409	1130	565	216	82	34	12	7	0	0	0	0	0	53

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 1978–2019 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	0.029	0.100	0.190	0.263	0.344	0.415	0.437	0.440	0.391	0.398	0.592	0.736	0.000	0.000	0.000	0.000	0.412

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	0.191	0.258	0.317	0.384	0.429	0.468	0.441	0.400	0.406	0.592	0.736	0.000	0.000	0.000	0.000	0.422

Table 23.10. Whiting in Subarea 4 and Division 7.d: Unwanted catch mean weights at age (kg), as estimated by ICES. Age 8 is a plus-group.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.036	0.145	0.158	0.185	0.209	0.222	0.239	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.080	0.104	0.158	0.191	0.189	0.234	0.265	0.295	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.030	0.107	0.166	0.202	0.244	0.253	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.071	0.131	0.164	0.197	0.230	0.289	0.252	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.047	0.091	0.182	0.211	0.225	0.241	0.244	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.036	0.114	0.167	0.235	0.264	0.290	0.317	0.277	0.365	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.365
1984	0.038	0.101	0.162	0.216	0.246	0.265	0.248	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.022	0.105	0.169	0.213	0.238	0.242	0.253	0.255	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.028	0.123	0.166	0.190	0.208	0.227	0.194	0.217	0.311	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.311
1987	0.016	0.090	0.149	0.206	0.205	0.263	0.257	0.000	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292
1988	0.030	0.063	0.146	0.181	0.210	0.219	0.235	0.000	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.284
1989	0.033	0.083	0.164	0.191	0.213	0.227	0.241	0.351	0.221	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.221
1990	0.024	0.095	0.130	0.183	0.186	0.196	0.249	0.302	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.041	0.089	0.154	0.177	0.213	0.230	0.253	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.037	0.093	0.173	0.210	0.215	0.241	0.245	0.220	1.183	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.183
1993	0.023	0.087	0.160	0.205	0.237	0.235	0.225	0.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.040	0.090	0.151	0.203	0.230	0.244	0.254	0.332	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.032	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.290
1996	0.031	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.031	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.320	0.601	0.773	0.000	0.000	0.000	0.000	0.000	0.347
1998	0.026	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.191	0.180	0.284	0.000	0.000	0.000	0.000	0.000	0.206
1999	0.062	0.100	0.166	0.197	0.201	0.225	0.231	0.212	0.231	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.227
2000	0.033	0.127	0.167	0.195	0.226	0.209	0.219	0.222	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.264
2001	0.023	0.084	0.183	0.217	0.259	0.248	0.240	0.225	0.243	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.243
2002	0.039	0.130	0.167	0.196	0.224	0.224	0.225	0.272	0.334	1.120	0.217	0.000	0.000	0.000	0.000	0.000	0.351

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2003	0.048	0.062	0.105	0.170	0.214	0.262	0.257	0.293	0.237	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.079	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.204	0.351	0.000	0.000	0.000	0.000	0.000	0.000	0.244
2005	0.070	0.124	0.177	0.207	0.221	0.223	0.235	0.245	0.222	0.293	0.000	0.000	0.000	0.000	0.000	0.000	0.224
2006	0.093	0.131	0.161	0.193	0.229	0.233	0.247	0.273	0.239	0.279	0.289	0.000	0.000	0.000	0.000	0.000	0.246
2007	0.050	0.065	0.170	0.214	0.225	0.247	0.237	0.215	0.229	0.166	0.241	0.350	0.000	0.000	0.000	0.000	0.217
2008	0.027	0.072	0.181	0.213	0.230	0.265	0.328	0.244	0.291	0.317	0.057	0.000	0.000	0.000	0.000	0.000	0.293
2009	0.042	0.086	0.177	0.240	0.333	0.360	0.375	0.265	0.426	0.273	0.594	0.000	0.000	0.000	0.000	0.000	0.419
2010	0.049	0.102	0.207	0.283	0.331	0.381	0.242	0.277	0.182	0.362	0.521	0.337	0.000	0.000	0.368	0.000	0.187
2011	0.048	0.100	0.176	0.231	0.264	0.285	0.316	0.346	0.291	0.305	0.251	0.000	0.000	0.000	0.000	0.000	0.276
2012	0.038	0.100	0.175	0.229	0.290	0.296	0.261	0.405	0.333	0.877	0.746	0.000	0.000	0.000	0.000	0.000	0.458
2013	0.028	0.101	0.199	0.236	0.283	0.353	0.346	0.578	0.484	0.205	0.484	0.000	0.000	0.000	0.000	0.000	0.285
2014	0.055	0.130	0.189	0.245	0.270	0.294	0.348	0.556	0.547	0.550	0.361	0.000	0.000	0.000	0.000	0.000	0.493
2015	0.043	0.120	0.202	0.254	0.293	0.289	0.358	0.454	0.253	0.271	0.393	0.000	0.000	0.000	0.000	0.000	0.262
2016	0.030	0.117	0.188	0.241	0.291	0.267	0.287	0.290	0.309	0.305	0.315	0.000	0.000	0.000	0.000	0.000	0.309
2017	0.026	0.076	0.199	0.257	0.322	0.298	0.255	0.335	0.392	0.291	0.362	0.459	0.000	0.000	0.000	0.000	0.348
2018	0.029	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	0.029	0.088	0.167	0.196	0.219	0.249	0.238	0.399	0.265	0.350	0.000	0.000	0.000	0.000	0.000	0.000	0.307

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	0.029	0.101	0.190	0.263	0.344	0.415	0.437	0.440	0.391	0.398	0.592	0.736	0.000	0.000	0.000	0.000	0.419

Table 23.12. Whiting in Subarea 4 and Division 7.d: Catch component as estimated by ICES in tonnes, model input. Unwanted catch includes discards and BMS.

Year	Catch	Wanted Catch	Unwanted Catch	IBC
1978	188222	97553	35382	55287
1979	243570	107231	77391	58948
1980	223361	100775	77003	45584
1981	192119	89583	35894	66641
1982	140250	80576	26620	33055
1983	161316	88002	49562	23753
1984	145636	86275	40483	18878
1985	100330	56059	28961	15310
1986	161494	64019	79523	17953
1987	138737	68317	53901	16519
1988	133215	56100	28146	48969
1989	123533	45103	35787	42643
1990	152602	45662	55603	51337
1991	126742	51929	35058	39755
1992	108555	50946	32564	25045
1993	116911	51818	44370	20723
1994	101650	48486	35692	17473
1995	105494	45938	32176	27379
1996	76123	40503	30505	5116
1997	61435	35563	19660	6213
1998	47475	28288	15693	3494
1999	60845	30130	25677	5038
2000	63806	28583	26063	9160
2001	45242	25061	19237	944
2002	46450	20675	18501	7275
2003	45640	16161	26745	2734
2004	33557	13295	19048	1214
2005	28883	15471	12525	888
2006	36769	18535	16310	1924
2007	26974	18915	6971	1088
2008	28247	17951	10296	0
2009	28430	18403	8684	1344
2010	34436	19846	12683	1907
2011	30668	18461	11173	1035
2012	30221	17407	11697	1117
2013	26573	18211	6795	1654
2014	28375	17027	9725	1623
2015	36287	17299	16891	2097

Year	Catch	Wanted Catch	Unwanted Catch	IBC
2016	33396	16118	12726	4551
2017	29344	15361	11348	2635
2018	28407	16160	10588	1658
2019	31286	18883	10614	1788

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	0.093	0.159	0.252	0.388	0.411	0.485	0.747	0.003	0.025	0.093	0.159	0.252	0.388	0.411	0.485
1979	0.003	0.033	0.085	0.176	0.236	0.372	0.436	0.512	0.671	0.003	0.033	0.085	0.176	0.236	0.372	0.436	0.512
1980	0.004	0.025	0.090	0.171	0.257	0.305	0.438	0.478	0.659	0.004	0.025	0.090	0.171	0.257	0.305	0.438	0.478
1981	0.004	0.028	0.086	0.165	0.252	0.343	0.394	0.462	0.829	0.004	0.028	0.086	0.165	0.252	0.343	0.394	0.462
1982	0.010	0.020	0.094	0.172	0.246	0.341	0.458	0.525	0.847	0.010	0.020	0.094	0.172	0.246	0.341	0.458	0.525
1983	0.005	0.036	0.097	0.186	0.255	0.348	0.409	0.471	0.619	0.005	0.036	0.097	0.186	0.255	0.348	0.409	0.471
1984	0.007	0.030	0.096	0.184	0.264	0.345	0.374	0.481	0.653	0.007	0.030	0.096	0.184	0.264	0.345	0.374	0.481
1985	0.005	0.031	0.098	0.193	0.260	0.363	0.417	0.514	0.506	0.005	0.031	0.098	0.193	0.260	0.363	0.417	0.514
1986	0.005	0.035	0.093	0.173	0.249	0.343	0.456	0.487	0.721	0.005	0.035	0.093	0.173	0.249	0.343	0.456	0.487
1987	0.004	0.026	0.075	0.168	0.233	0.340	0.364	0.564	0.673	0.004	0.026	0.075	0.168	0.233	0.340	0.364	0.564
1988	0.004	0.018	0.074	0.152	0.236	0.314	0.407	0.527	0.800	0.004	0.018	0.074	0.152	0.236	0.314	0.407	0.527
1989	0.008	0.023	0.080	0.153	0.209	0.288	0.375	0.449	0.455	0.008	0.023	0.080	0.153	0.209	0.288	0.375	0.449
1990	0.005	0.028	0.070	0.143	0.198	0.253	0.394	0.518	0.684	0.005	0.028	0.070	0.143	0.198	0.253	0.394	0.518
1991	0.006	0.035	0.086	0.148	0.227	0.277	0.325	0.380	0.461	0.006	0.035	0.086	0.148	0.227	0.277	0.325	0.380
1992	0.004	0.028	0.094	0.175	0.217	0.300	0.332	0.326	0.588	0.004	0.028	0.094	0.175	0.217	0.300	0.332	0.326
1993	0.004	0.024	0.089	0.170	0.248	0.297	0.332	0.416	0.437	0.004	0.024	0.089	0.170	0.248	0.297	0.332	0.416
1994	0.004	0.028	0.085	0.173	0.257	0.346	0.361	0.436	0.497	0.004	0.028	0.085	0.173	0.257	0.346	0.361	0.436
1995	0.003	0.030	0.092	0.175	0.267	0.348	0.411	0.452	0.483	0.003	0.030	0.092	0.175	0.267	0.348	0.411	0.452
1996	0.006	0.031	0.085	0.160	0.237	0.352	0.390	0.449	0.498	0.006	0.031	0.085	0.160	0.237	0.352	0.390	0.449
1997	0.009	0.032	0.091	0.165	0.231	0.303	0.368	0.402	0.485	0.009	0.032	0.091	0.165	0.231	0.303	0.368	0.402
1998	0.006	0.030	0.091	0.161	0.220	0.285	0.326	0.347	0.425	0.006	0.030	0.091	0.161	0.220	0.285	0.326	0.347
1999	0.008	0.026	0.089	0.158	0.201	0.262	0.293	0.324	0.336	0.008	0.026	0.089	0.158	0.201	0.262	0.293	0.324
2000	0.011	0.039	0.093	0.162	0.225	0.259	0.265	0.286	0.309	0.011	0.039	0.093	0.162	0.225	0.259	0.265	0.286

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
2001	0.008	0.034	0.098	0.166	0.221	0.242	0.286	0.296	0.336	0.008	0.034	0.098	0.166	0.221	0.242	0.286	0.296
2002	0.003	0.023	0.079	0.148	0.214	0.275	0.336	0.357	0.387	0.003	0.023	0.079	0.148	0.214	0.275	0.336	0.357
2003	0.004	0.019	0.060	0.131	0.203	0.271	0.340	0.401	0.424	0.004	0.019	0.060	0.131	0.203	0.271	0.340	0.401
2004	0.010	0.037	0.076	0.145	0.198	0.259	0.273	0.298	0.404	0.010	0.037	0.076	0.145	0.198	0.259	0.273	0.298
2005	0.011	0.041	0.101	0.163	0.196	0.256	0.293	0.310	0.330	0.011	0.041	0.101	0.163	0.196	0.256	0.293	0.310
2006	0.031	0.044	0.092	0.157	0.215	0.261	0.345	0.359	0.364	0.031	0.044	0.092	0.157	0.215	0.261	0.345	0.359
2007	0.020	0.033	0.105	0.175	0.255	0.313	0.296	0.322	0.369	0.020	0.033	0.105	0.175	0.255	0.313	0.296	0.322
2008	0.009	0.035	0.111	0.192	0.247	0.364	0.390	0.330	0.408	0.009	0.035	0.111	0.192	0.247	0.364	0.390	0.330
2009	0.014	0.030	0.108	0.195	0.290	0.339	0.358	0.358	0.392	0.014	0.030	0.108	0.195	0.290	0.339	0.358	0.358
2010	0.016	0.037	0.119	0.254	0.318	0.413	0.340	0.478	0.399	0.016	0.037	0.119	0.254	0.318	0.413	0.340	0.478
2011	0.016	0.038	0.109	0.203	0.293	0.376	0.407	0.379	0.391	0.016	0.038	0.109	0.203	0.293	0.376	0.407	0.379
2012	0.013	0.035	0.099	0.212	0.349	0.372	0.412	0.446	0.455	0.013	0.035	0.099	0.212	0.349	0.372	0.412	0.446
2013	0.009	0.037	0.113	0.186	0.306	0.424	0.476	0.484	0.445	0.009	0.037	0.113	0.186	0.306	0.424	0.476	0.484
2014	0.018	0.046	0.116	0.200	0.260	0.401	0.446	0.488	0.454	0.018	0.046	0.116	0.200	0.260	0.401	0.446	0.488
2015	0.015	0.042	0.111	0.209	0.289	0.350	0.450	0.483	0.437	0.015	0.042	0.111	0.209	0.289	0.350	0.450	0.483
2016	0.010	0.040	0.107	0.198	0.313	0.352	0.398	0.508	0.529	0.010	0.040	0.107	0.198	0.313	0.352	0.398	0.508
2017	0.009	0.026	0.108	0.218	0.321	0.395	0.467	0.462	0.507	0.009	0.026	0.108	0.218	0.321	0.395	0.467	0.462
2018	0.010	0.036	0.100	0.187	0.292	0.369	0.493	0.477	0.561	0.010	0.036	0.100	0.187	0.292	0.369	0.493	0.477
2019	0.010	0.033	0.097	0.179	0.270	0.376	0.419	0.458	0.475	0.010	0.033	0.097	0.179	0.270	0.376	0.419	0.458

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	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1980	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1981	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1982	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1983	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1984	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1985	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1986	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1991	0.000	0.187	0.838	0.997	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.187	0.830	0.992	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.188	0.821	0.987	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.190	0.811	0.982	0.999	1.000	1.000	1.000	1.000
1995	0.000	0.193	0.800	0.976	0.996	0.999	1.000	1.000	1.000
1996	0.000	0.198	0.789	0.969	0.994	0.998	1.000	1.000	1.000
1997	0.000	0.205	0.777	0.961	0.991	0.998	1.000	1.000	1.000
1998	0.000	0.215	0.764	0.951	0.988	0.997	1.000	1.000	1.000
1999	0.000	0.228	0.750	0.942	0.985	0.997	1.000	1.000	1.000
2000	0.000	0.245	0.737	0.934	0.983	0.996	1.000	1.000	1.000
2001	0.000	0.262	0.728	0.929	0.982	0.996	1.000	1.000	1.000
2002	0.000	0.279	0.726	0.928	0.982	0.996	1.000	1.000	1.000
2003	0.000	0.295	0.729	0.930	0.984	0.997	1.000	1.000	1.000
2004	0.000	0.309	0.737	0.934	0.986	0.998	1.000	1.000	1.000
2005	0.000	0.321	0.749	0.940	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	0.777	0.954	0.993	0.999	1.000	1.000	1.000
2008	0.000	0.348	0.791	0.960	0.995	1.000	1.000	1.000	1.000
2009	0.000	0.354	0.804	0.965	0.996	1.000	1.000	1.000	1.000
2010	0.000	0.360	0.815	0.969	0.997	1.000	1.000	1.000	1.000
2011	0.000	0.364	0.823	0.972	0.998	1.000	1.000	1.000	1.000
2012	0.000	0.367	0.829	0.973	0.998	1.000	1.000	1.000	1.000
2013	0.000	0.368	0.832	0.974	0.998	1.000	1.000	1.000	1.000
2014	0.000	0.369	0.834	0.975	0.998	1.000	1.000	1.000	1.000

Age	0	1	2	3	4	5	6	7	8+
2015	0.000	0.369	0.837	0.975	0.998	1.000	1.000	1.000	1.000
2016	0.000	0.369	0.839	0.976	0.998	1.000	1.000	1.000	1.000
2017	0.000	0.367	0.839	0.976	0.998	1.000	1.000	1.000	1.000
2018	0.000	0.364	0.839	0.977	0.998	1.000	1.000	1.000	1.000
2019	0.000	0.360	0.837	0.977	0.997	1.000	1.000	1.000	1.000

Table 23.15. Whiting in Subarea 4 and Division 7.d: Natural mortality at age estimates based on ICES WGSAM (2018b). Model input.

Age	0	1	2	3	4	5	6	7	8+
1978	1.297	1.285	0.660	0.518	0.484	0.416	0.337	0.337	0.337
1979	1.315	1.300	0.648	0.520	0.487	0.433	0.346	0.346	0.346
1980	1.332	1.309	0.637	0.522	0.489	0.446	0.354	0.354	0.354
1981	1.347	1.311	0.626	0.522	0.491	0.457	0.361	0.361	0.361
1982	1.356	1.303	0.615	0.521	0.491	0.464	0.366	0.366	0.366
1983	1.361	1.287	0.604	0.518	0.489	0.468	0.369	0.369	0.369
1984	1.365	1.266	0.592	0.514	0.487	0.469	0.372	0.372	0.372
1985	1.368	1.244	0.580	0.510	0.484	0.470	0.374	0.374	0.374
1986	1.373	1.224	0.569	0.506	0.482	0.470	0.377	0.377	0.377
1987	1.381	1.208	0.559	0.502	0.479	0.469	0.381	0.381	0.381
1988	1.392	1.196	0.551	0.499	0.478	0.469	0.387	0.387	0.387
1989	1.406	1.187	0.544	0.496	0.477	0.470	0.396	0.396	0.396
1990	1.425	1.181	0.539	0.494	0.477	0.470	0.406	0.406	0.406
1991	1.449	1.177	0.536	0.493	0.477	0.471	0.416	0.416	0.416
1992	1.479	1.176	0.535	0.492	0.477	0.471	0.427	0.427	0.427
1993	1.517	1.176	0.535	0.491	0.477	0.471	0.437	0.437	0.437
1994	1.564	1.179	0.536	0.492	0.478	0.472	0.446	0.446	0.446
1995	1.621	1.185	0.538	0.493	0.479	0.472	0.454	0.454	0.454
1996	1.688	1.193	0.541	0.496	0.481	0.474	0.461	0.461	0.461
1997	1.762	1.202	0.543	0.498	0.483	0.476	0.468	0.468	0.468
1998	1.840	1.213	0.546	0.502	0.486	0.479	0.474	0.474	0.474
1999	1.919	1.225	0.550	0.506	0.488	0.482	0.480	0.480	0.480
2000	1.997	1.238	0.556	0.511	0.492	0.487	0.486	0.486	0.486
2001	2.070	1.252	0.563	0.517	0.497	0.492	0.492	0.492	0.492
2002	2.135	1.266	0.572	0.525	0.503	0.499	0.499	0.499	0.499
2003	2.186	1.276	0.583	0.533	0.510	0.506	0.505	0.505	0.505
2004	2.224	1.280	0.596	0.540	0.516	0.512	0.510	0.510	0.510
2005	2.247	1.276	0.609	0.547	0.522	0.517	0.512	0.512	0.512
2006	2.259	1.266	0.621	0.552	0.526	0.520	0.510	0.510	0.510
2007	2.261	1.251	0.633	0.555	0.529	0.520	0.504	0.504	0.504
2008	2.255	1.234	0.644	0.557	0.531	0.518	0.494	0.494	0.494

Age	0	1	2	3	4	5	6	7	8+
2009	2.246	1.217	0.653	0.559	0.531	0.515	0.480	0.480	0.480
2010	2.236	1.203	0.661	0.560	0.532	0.510	0.462	0.462	0.462
2011	2.222	1.193	0.668	0.561	0.533	0.505	0.443	0.443	0.443
2012	2.202	1.187	0.676	0.564	0.535	0.501	0.423	0.423	0.423
2013	2.174	1.183	0.684	0.567	0.538	0.498	0.404	0.404	0.404
2014	2.142	1.180	0.692	0.572	0.541	0.497	0.385	0.385	0.385
2015	2.106	1.179	0.701	0.576	0.544	0.498	0.369	0.369	0.369
2016	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355
2017	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355
2018	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355
2019	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355

Table 23.16a. Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series used in the assessment and forecast; model input.

IBTS–Q1					
Age	1	2	3	4	5
1978	5.257	2.520	0.883	0.235	0.074
1979	4.253	2.201	1.085	0.334	0.049
1980	6.361	3.673	1.140	0.314	0.103
1981	2.202	4.532	2.181	0.448	0.108
1982	1.456	2.348	2.779	0.701	0.115
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

IBTS–Q1					
Age	1	2	3	4	5
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
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

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

IBTS-Q3						
Age	0	1	2	3	4	5
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
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

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	0.024	0.110	0.310	0.559	0.709	0.793	1.000	1.234	1.234
1979	0.025	0.115	0.326	0.581	0.707	0.783	0.915	1.069	1.069
1980	0.023	0.106	0.312	0.613	0.803	0.946	1.090	1.280	1.280
1981	0.023	0.107	0.296	0.580	0.782	0.962	1.138	1.305	1.305
1982	0.023	0.107	0.268	0.492	0.630	0.776	0.924	1.033	1.033
1983	0.026	0.131	0.326	0.572	0.695	0.831	0.972	1.106	1.106
1984	0.028	0.146	0.361	0.647	0.809	0.955	1.114	1.234	1.234
1985	0.024	0.128	0.306	0.568	0.772	0.973	1.161	1.347	1.347
1986	0.027	0.148	0.361	0.638	0.865	1.038	1.190	1.316	1.316
1987	0.026	0.146	0.383	0.688	0.949	1.207	1.355	1.468	1.468
1988	0.026	0.149	0.370	0.609	0.807	1.038	1.102	1.099	1.099
1989	0.023	0.136	0.363	0.599	0.805	1.148	1.251	1.307	1.307
1990	0.024	0.143	0.399	0.607	0.740	0.969	1.029	1.090	1.090
1991	0.020	0.121	0.340	0.516	0.607	0.798	0.878	1.029	1.029
1992	0.020	0.123	0.331	0.498	0.578	0.718	0.834	0.930	0.930
1993	0.019	0.125	0.343	0.546	0.635	0.754	0.871	0.968	0.968
1994	0.017	0.115	0.318	0.537	0.664	0.796	0.902	0.963	0.963
1995	0.014	0.101	0.282	0.484	0.610	0.758	0.882	0.954	0.954
1996	0.012	0.088	0.249	0.428	0.554	0.691	0.803	0.879	0.879
1997	0.010	0.077	0.219	0.364	0.467	0.555	0.616	0.677	0.677
1998	0.008	0.072	0.201	0.326	0.426	0.509	0.563	0.611	0.611

Age	0	1	2	3	4	5	6	7	8+
1999	0.008	0.077	0.226	0.370	0.483	0.572	0.608	0.650	0.650
2000	0.006	0.062	0.200	0.356	0.509	0.662	0.745	0.805	0.805
2001	0.005	0.048	0.144	0.252	0.382	0.536	0.630	0.700	0.700
2002	0.005	0.051	0.136	0.212	0.295	0.391	0.462	0.514	0.514
2003	0.006	0.073	0.163	0.202	0.241	0.284	0.312	0.330	0.330
2004	0.005	0.066	0.137	0.163	0.195	0.236	0.272	0.286	0.286
2005	0.005	0.067	0.135	0.154	0.171	0.199	0.234	0.252	0.252
2006	0.005	0.079	0.160	0.189	0.197	0.215	0.243	0.256	0.256
2007	0.004	0.071	0.147	0.187	0.195	0.198	0.223	0.245	0.245
2008	0.004	0.066	0.138	0.186	0.198	0.192	0.207	0.229	0.229
2009	0.003	0.059	0.128	0.191	0.228	0.241	0.276	0.313	0.313
2010	0.003	0.052	0.123	0.199	0.255	0.292	0.349	0.393	0.393
2011	0.003	0.049	0.115	0.185	0.232	0.265	0.305	0.333	0.333
2012	0.003	0.051	0.111	0.177	0.236	0.285	0.312	0.325	0.325
2013	0.002	0.042	0.097	0.165	0.232	0.299	0.305	0.307	0.307
2014	0.002	0.040	0.103	0.185	0.262	0.351	0.360	0.366	0.366
2015	0.002	0.043	0.122	0.219	0.296	0.388	0.388	0.398	0.398
2016	0.002	0.035	0.109	0.216	0.298	0.380	0.381	0.396	0.396
2017	0.002	0.029	0.092	0.188	0.269	0.318	0.323	0.361	0.361
2018	0.002	0.028	0.089	0.177	0.239	0.252	0.233	0.251	0.251
2019	0.002	0.033	0.101	0.197	0.257	0.257	0.229	0.235	0.235

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	30524396	7291281	1633386	710838	183906	21177	13193	2662	437
1979	23569238	8374830	1824002	625740	254823	57311	6244	3424	619
1980	13263783	6400396	2011329	685685	203715	80246	18072	1769	1028
1981	11915739	3205194	1746336	778791	216877	53836	19939	4492	538
1982	11416021	2971948	777415	770937	257914	59277	12715	4396	937
1983	15039151	2770491	730775	333882	301941	84904	17418	3372	1375
1984	13083007	3919208	659561	291054	108993	102582	22821	4725	1070
1985	20240329	3029343	973472	245922	89200	28853	26428	5017	1208
1986	18307121	5398126	733013	435793	84485	26285	6476	5900	1062
1987	15801931	4548877	1397155	278018	147320	20893	6202	1328	1308
1988	19289686	3736050	1290919	538240	81919	35660	3808	1118	390
1989	13533359	4994356	879004	539683	180425	22509	7881	838	376
1990	11741650	3171826	1425995	350748	186646	53207	4088	1496	215
1991	12891338	2661557	826342	535094	117524	54061	13271	931	399

Age	0	1	2	3	4	5	6	7	8+
1992	14439252	3003238	726881	334728	198533	41132	13874	4068	289
1993	14041392	3216127	773422	304511	128034	82980	10876	3577	1182
1994	12508211	3026691	841307	301427	112223	40570	27758	2800	1123
1995	10103274	2641651	812684	348176	108265	34818	10916	7579	949
1996	8508724	1899703	727360	355283	131757	37065	9870	2774	2102
1997	13261176	1478208	506001	332079	137778	50231	10970	2679	1233
1998	21381453	2157260	392261	231496	134011	55661	17589	3756	1209
1999	22391261	3407905	550712	186690	104379	52772	21671	6072	1697
2000	19691138	3222400	838451	241476	73019	39756	18583	7805	2577
2001	19880336	2601031	913323	355526	90299	25825	12477	5327	2878
2002	11681507	2518923	737013	499128	162337	35156	7910	3995	2392
2003	11122803	1329642	713362	402246	244297	76190	13829	2703	2127
2004	12346238	1231628	295717	331480	208917	118017	36348	6259	1956
2005	11717533	1329154	313083	140674	163685	109956	55850	16466	3691
2006	9689112	1325947	356174	146167	72531	85253	58378	26689	9121
2007	14055054	975492	342551	171072	70042	33469	45280	28340	17030
2008	14076546	1526980	277063	153662	83895	34191	16229	23745	21732
2009	13280096	1483818	424856	122923	70750	43953	17041	8687	25503
2010	12908918	1407247	398604	187325	54314	37059	21684	8058	17687
2011	9733569	1445440	422177	185041	84354	24703	15882	9551	11165
2012	7533155	1094668	485196	181046	84544	39784	11521	7344	9715
2013	11429425	776117	288531	236037	90473	40868	17276	5424	8063
2014	15206992	1354176	232908	134576	110343	43974	17903	8411	6980
2015	14077390	1775090	440067	109541	61081	50294	18974	8171	7357
2016	15367324	1587988	510831	191542	51254	26759	20448	9012	7028
2017	9926469	2045564	458176	214604	85261	22578	10681	9394	7690
2018	12006098	1216729	634541	206628	96831	39313	9718	5273	7311
2019	17760036	1569994	375355	284077	97334	43672	18597	5553	6329

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	30524396	22370262	41650776	333448	290373	382913	0.674	0.582	0.78	608112	531994	695120
1979	23569238	17407079	31912820	376353	331053	427851	0.663	0.58	0.757	696593	606744	799748
1980	13263783	9964731	17655063	382786	336187	435844	0.753	0.662	0.856	601933	529737	683969
1981	11915739	8972939	15823671	351450	308428	400474	0.752	0.66	0.856	493741	437102	557719
1982	11416021	8600983	15152401	295988	260151	336762	0.618	0.539	0.709	469181	416014	529143
1983	15039151	11338827	19947043	255229	227059	286894	0.679	0.596	0.774	423411	377566	474822
1984	13083007	9824501	17422268	203665	182066	227827	0.777	0.684	0.883	396696	350864	448515
1985	20240329	15195782	26959514	192014	169586	217408	0.756	0.666	0.859	380297	334481	432388
1986	18307121	13816964	24256463	204181	180496	230975	0.818	0.723	0.927	461530	402530	529179
1987	15801931	11925318	20938729	201152	177087	228488	0.916	0.811	1.035	382837	337407	434384
1988	19289686	14473101	25709209	206271	180698	235463	0.785	0.692	0.892	361651	319282	409641
1989	13533359	10265121	17842148	210072	185386	238046	0.833	0.735	0.945	421302	371278	478066
1990	11741650	8910070	15473093	201936	178449	228515	0.749	0.658	0.852	354120	313823	399592
1991	12891338	9880954	16818882	201691	178475	227927	0.628	0.549	0.718	366043	324955	412325
1992	14439252	11079312	18818136	192344	171056	216280	0.592	0.515	0.68	336450	299967	377370
1993	14041392	10772284	18302589	184057	164325	206157	0.63	0.551	0.72	316952	283083	354873
1994	12508211	9585315	16322399	180081	160823	201645	0.643	0.562	0.736	317695	283144	356462
1995	10103274	7687946	13277428	183373	163032	206252	0.603	0.524	0.694	296922	264368	333484
1996	8508724	6352495	11396842	165772	147278	186587	0.545	0.47	0.632	279768	248113	315462
1997	13261176	9955340	17664769	150311	133410	169352	0.444	0.381	0.519	324687	280710	375552
1998	21381453	16057581	28470449	129114	114968	145000	0.405	0.345	0.475	319191	273868	372016
1999	22391261	16747473	29936970	127894	113033	144708	0.452	0.387	0.529	382661	323002	453339
2000	19691138	14679061	26414558	158909	138348	182524	0.494	0.415	0.59	500970	417435	601223

Year	R (age 0)	Low	High	SSB	Low	High	F (2–6)	Low	High	TSB	Low	High
2001	19880336	14773340	26752770	174706	148537	205486	0.389	0.316	0.479	427670	357080	512216
2002	11681507	8768913	15561520	175804	148858	207628	0.299	0.237	0.377	278608	238783	325076
2003	11122803	8393027	14740420	163859	138968	193210	0.24	0.191	0.302	242456	209058	281189
2004	12346238	9291148	16405893	159560	135412	188014	0.201	0.16	0.252	328692	278998	387237
2005	11717533	8795657	15610043	145341	123892	170505	0.178	0.142	0.223	317695	268728	375585
2006	9689112	7259500	12931867	136596	117504	158791	0.201	0.164	0.247	485457	396762	593980
2007	14055054	10579744	18671958	124293	107268	144022	0.19	0.155	0.233	431833	352864	528475
2008	14076546	10608354	18678595	127177	110406	146495	0.184	0.151	0.225	296397	251193	349737
2009	13280096	9976718	17677252	130622	113325	150559	0.213	0.175	0.259	355972	296384	427540
2010	12908918	9557635	17435291	154317	133086	178934	0.244	0.198	0.299	409310	337999	495665
2011	9733569	7275390	13022308	142719	122262	166599	0.22	0.178	0.273	343027	286058	411342
2012	7533155	5544078	10235863	147948	125919	173831	0.224	0.18	0.28	277201	232975	329821
2013	11429425	8440375	15477009	139669	117859	165516	0.22	0.174	0.277	271243	225798	325835
2014	15206992	11088288	20855573	132966	111395	158713	0.252	0.197	0.322	456634	361628	576599
2015	14077390	10151079	19522350	141379	116224	171980	0.283	0.216	0.37	403594	319614	509640
2016	15367324	10867800	21729756	148121	118934	184470	0.277	0.204	0.377	352028	276892	447553
2017	9926469	6867181	14348652	156088	122342	199142	0.238	0.168	0.336	285118	223495	363731
2018	12006098	8004035	18009216	161215	123413	210595	0.198	0.137	0.286	316667	240746	416529
2019	17760036	10259800	30743180	154803	115338	207772	0.208	0.142	0.305	367578	258421	522844

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	184794	154480	221057
1979	218921	186857	256487
1980	213986	182967	250264
1981	187472	160009	219650
1982	145656	124165	170868
1983	145672	125809	168672
1984	133792	115594	154855
1985	113696	97633	132401
1986	145516	124232	170447
1987	138678	118550	162223
1988	129113	109746	151899
1989	135503	116019	158260
1990	130042	110563	152953
1991	113012	96742	132018
1992	104614	90077	121497
1993	104797	90370	121528
1994	101154	87297	117209
1995	93633	80499	108909
1996	76430	65812	88760
1997	61493	52981	71373
1998	50335	43654	58037
1999	56088	48444	64937
2000	64606	55488	75222
2001	52562	44470	62127
2002	45914	39306	53634
2003	40749	34987	47459
2004	33756	29345	38830
2005	29744	25984	34048
2006	33334	28948	38386
2007	27666	24096	31764
2008	26981	23501	30976
2009	28774	25087	33004
2010	34813	30284	40021
2011	29619	25738	34085
2012	30117	26185	34640
2013	27034	23483	31121
2014	28990	25379	33115
2015	32905	28709	37715

Year	Catch	Low	High
2016	31776	27659	36506
2017	29735	25736	34355
2018	27980	24140	32432
2019	30103	25677	35291

Table 23.21. Whiting in Subarea 4 and Division 7.d: SAM model parameters.

	par	sd(par)	exp(par)	Low	High
logFpar_0	-6.332	0.091	0.002	0.001	0.002
logFpar_1	-5.285	0.089	0.005	0.004	0.006
logFpar_2	-5.227	0.088	0.005	0.005	0.006
logFpar_3	-5.396	0.087	0.005	0.004	0.005
logFpar_4	-6.357	0.105	0.002	0.001	0.002
logFpar_5	-5.426	0.103	0.004	0.004	0.005
logFpar_6	-5.194	0.101	0.006	0.005	0.007
logFpar_7	-5.365	0.1	0.005	0.004	0.006
logFpar_8	-5.4	0.101	0.005	0.004	0.006
logSdLogFsta_0	-1.649	0.14	0.192	0.145	0.254
logSdLogN_0	-1.176	0.17	0.309	0.219	0.434
logSdLogN_1	-2.213	0.178	0.109	0.077	0.156
logSdLogObs_0	0.178	0.128	1.195	0.924	1.545
logSdLogObs_1	-1.617	0.097	0.198	0.163	0.241
logSdLogObs_2	-0.609	0.084	0.544	0.46	0.643
logSdLogObs_3	-0.728	0.085	0.483	0.407	0.572
transfIRARdist_0	-0.592	0.334	0.553	0.284	1.079
transfIRARdist_1	-1.152	0.243	0.316	0.194	0.514
transfIRARdist_2	1.015	0.493	2.76	1.03	7.395
transfIRARdist_3	-0.966	0.309	0.381	0.205	0.706
itrans_rho_0	1.145	0.155	3.141	2.304	4.284

Table 23.22. Whiting in Subarea 4 and Division 7.d: Mohn's rho.

	Mohn's rho
R(age 0)	0.135
SSB	0.0641
Fbar(2-6)	-0.0718

Table 23.23. Whiting in Subarea 4 and Division 7.d: Reference points as determined in the Benchmark 2018 (ICES, 2018a).

Reference point	value
B_{lim}	119 970 t (B_{loss})
F_{lim}	0.458
B_{pa}	166 708 t (MSY $B_{trigger}$)
F_{pa}	0.330
$F_{p.05}$ (with $B_{trigger}$)	0.172 (final F_{MSY})

Table 23.24. Whiting in Subarea 4 and Division 7.d: Recruitment estimates (in millions) as used in the short-term forecast.

Year	Geometric mean of recruitment Time series 2002–2019
2020	12204
2021	12204
2022	12204

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 (2017–2019).

MFDP version 1a						
Run: run						
Time and date: 19:02 28/04/2020						
Fbar age range (Total) : 2-6						
Fbar age range Fleet 1 : 2-6						
2020*						
Age	N	M	Mat	PF	PM	SWt
0	12203728	2.06628	0	0	0	0.009352
1	2314943	1.17847	0.3637	0	0	0.031841
2	457359	0.70979	0.8383	0	0	0.10163
3	166666	0.58177	0.9767	0	0	0.19448
4	131222	0.54811	0.9977	0	0	0.294261
5	43177	0.49981	1	0	0	0.379916
6	20490	0.35489	1	0	0	0.459681
7	10376	0.35489	1	0	0	0.465674
8	6588	0.35489	1	0	0	0.514176
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00003	0.034333	0.00181	0.028		
1	0.00207	0.169333	0.02562	0.089		

2	0.02349	0.248667	0.06301	0.181333		
3	0.08946	0.343	0.08056	0.224		
4	0.17329	0.411333	0.05528	0.262667		
5	0.20342	0.449667	0.04199	0.279667		
6	0.19516	0.516333	0.03712	0.301333		
7	0.20848	0.473	0.04192	0.358		
8	0.23437	0.453835	0.01642	0.323298		
IBC						
Age	Sel	CWt				
0	0.00011	0.028				
1	0.00157	0.095342				
2	0.00519	0.199647				
3	0.01251	0.286095				
4	0.01931	0.375262				
5	0.0213	0.419225				
6	0.0199	0.479441				
7	0.02117	0.447448				
8	0.02079	0.446471				
2021						
Age	N	M	Mat	PF	PM	SWt
0	12203728	2.06628	0	0	0	0.009352
1	.	1.17847	0.3637	0	0	0.031841
2	.	0.70979	0.8383	0	0	0.10163
3	.	0.58177	0.9767	0	0	0.19448
4	.	0.54811	0.9977	0	0	0.294261
5	.	0.49981	1	0	0	0.379916
6	.	0.35489	1	0	0	0.459681
7	.	0.35489	1	0	0	0.465674
8	.	0.35489	1	0	0	0.514176
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00003	0.034333	0.00181	0.028		
1	0.00207	0.169333	0.02562	0.089		
2	0.02349	0.248667	0.06301	0.181333		
3	0.08946	0.343	0.08056	0.224		
4	0.17329	0.411333	0.05528	0.262667		
5	0.20342	0.449667	0.04199	0.279667		
6	0.19516	0.516333	0.03712	0.301333		
7	0.20848	0.473	0.04192	0.358		
8	0.23437	0.453835	0.01642	0.323298		
IBC						

Age	Sel	CWt				
0	0.00011	0.028				
1	0.00157	0.095342				
2	0.00519	0.199647				
3	0.01251	0.286095				
4	0.01931	0.375262				
5	0.0213	0.419225				
6	0.0199	0.479441				
7	0.02117	0.447448				
8	0.02079	0.446471				
2022						
Age	N	M	Mat	PF	PM	SWt
0	12203728	2.06628	0	0	0	0.009352
1	.	1.17847	0.3637	0	0	0.031841
2	.	0.70979	0.8383	0	0	0.10163
3	.	0.58177	0.9767	0	0	0.19448
4	.	0.54811	0.9977	0	0	0.294261
5	.	0.49981	1	0	0	0.379916
6	.	0.35489	1	0	0	0.459681
7	.	0.35489	1	0	0	0.465674
8	.	0.35489	1	0	0	0.514176
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.00003	0.034333	0.00181	0.028		
1	0.00207	0.169333	0.02562	0.089		
2	0.02349	0.248667	0.06301	0.181333		
3	0.08946	0.343	0.08056	0.224		
4	0.17329	0.411333	0.05528	0.262667		
5	0.20342	0.449667	0.04199	0.279667		
6	0.19516	0.516333	0.03712	0.301333		
7	0.20848	0.473	0.04192	0.358		
8	0.23437	0.453835	0.01642	0.323298		
IBC						
Age	Sel	CWt				
0	0.00011	0.028				
1	0.00157	0.095342				
2	0.00519	0.199647				
3	0.01251	0.286095				
4	0.01931	0.375262				
5	0.0213	0.419225				
6	0.0199	0.479441				

7	0.02117	0.447448
8	0.02079	0.446471
Input units are thousands and kg - output in tonnes		

Table 23.26. Whiting in Subarea 4 and Division 7.d: MFDP output table for short-term forecasts.

MFDP version 1a; Run: run1. Time and date: 19:02 28/04/2020; Basis: F(2020) = average exploitation (2017-2019), scaled to F(2019) = 0.208; Fbar age range: 2–6; Recruitment (2020–2022) = 12 204 million (geometric mean 2002–2019); TAC 27.4 (2020) = 17 158.

Output units in tonnes

2020																
			Catch		Landings					Discards			IBC		0.75*Fbar	1.25*Fbar
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	27.4+27.7d HC catch	27.4 HC catch	27.7d HC catch	FBar	Yield	FMult	FBar	Yield	0.149	0.2485
339389	169998	1	0.2082	31080	0.137	17926	28930	23748	5182	0.0556	11004	1	0.0156	2150		

2021																2022		2020 TAC 27.4	17158
			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	
337884	180147	0	0.016	2376	0.000	0	0	0	0	0.000	0	1	0.016	2376	357111	202269	-100.0%	12.3%	No HC fishery
.	180147	0.1	0.035	5568	0.014	1963	3210	2635	575	0.006	1247	1	0.016	2358	354746	199946	-84.6%	11.0%	
.	180147	0.2	0.054	8711	0.027	3891	6372	5231	1141	0.011	2481	1	0.016	2339	352422	197663	-69.5%	9.7%	
.	180147	0.3	0.073	11809	0.041	5786	9489	7789	1700	0.017	3703	1	0.016	2320	350137	195420	-54.6%	8.5%	
.	180147	0.4	0.093	14861	0.055	7646	12559	10309	2250	0.022	4913	1	0.016	2302	347892	193216	-39.9%	7.3%	
.	180147	0.5	0.112	17869	0.069	9475	15585	12793	2792	0.028	6110	1	0.016	2284	345684	191049	-25.4%	6.1%	
.	180147	0.6	0.131	20834	0.082	11271	18567	15241	3326	0.033	7296	1	0.016	2267	343514	188920	-11.2%	4.9%	
.	180147	0.7	0.150	23754	0.096	13036	21505	17653	3852	0.039	8469	1	0.016	2249	341380	186827	2.9%	3.7%	
.	180147	0.8	0.170	26633	0.110	14770	24401	20030	4371	0.045	9631	1	0.016	2232	339283	184770	16.7%	2.6%	
.	180147	0.9	0.189	29471	0.123	16474	27256	22374	4882	0.050	10782	1	0.016	2215	337220	182748	30.4%	1.4%	
.	180147	1	0.208	32267	0.137	18148	30069	24683	5386	0.056	11921	1	0.016	2198	335192	180760	43.9%	0.3%	Fsq
.	180147	1.1	0.228	35025	0.151	19794	32843	26960	5883	0.061	13049	1	0.016	2182	333198	178805	57.1%	-0.7%	

2021															2022			2020 TAC 27.4	17158
			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	
.	180147	1.2	0.247	37743	0.164	21411	35578	29205	6373	0.067	14167	1	0.016	2165	331237	176884	70.2%	-1.8%	
.	180147	1.3	0.266	40422	0.178	23000	38273	31418	6855	0.072	15273	1	0.016	2149	329309	174995	83.1%	-2.9%	
.	180147	1.4	0.285	43064	0.192	24562	40931	33600	7331	0.078	16369	1	0.016	2133	327412	173138	95.8%	-3.9%	
.	180147	1.5	0.304	45669	0.205	26098	43552	35751	7801	0.083	17454	1	0.016	2117	325546	171312	108.4%	-4.9%	
.	180147	1.6	0.324	48238	0.219	27607	46136	37872	8264	0.089	18529	1	0.016	2102	323712	169516	120.7%	-5.9%	
.	180147	1.7	0.343	50771	0.233	29091	48685	39965	8720	0.095	19594	1	0.016	2086	321907	167750	132.9%	-6.9%	
.	180147	1.8	0.362	53268	0.247	30549	51197	42027	9170	0.100	20648	1	0.016	2071	320131	166013	144.9%	-7.8%	
.	180147	1.9	0.381	55732	0.260	31983	53676	44062	9614	0.106	21693	1	0.016	2056	318385	164305	156.8%	-8.8%	
.	180147	2	0.401	58162	0.274	33393	56121	46069	10052	0.111	22728	1	0.016	2041	316666	162625	168.5%	-9.7%	
.	180147	0.75	0.160	24573	0.103	13451	22329	18330	3999	0.042	8878	1	0.016	2244	340859	186324	6.8%	3.4%	0.75 * Fsq
.	180147	0.88	0.186	28310	0.121	15687	26089	21416	4673	0.049	10402	1	0.016	2221	338151	183669	24.8%	2.0%	Fmsy SSB(2020)/MSYBtrigger
.	180147	1.25	0.256	38498	0.171	21782	36338	29829	6509	0.069	14556	1	0.016	2160	330768	176432	73.9%	-2.1%	1.25 * Fsq
.	180147	0.59	0.129	20038	0.081	10735	17767	14584	3182	0.033	7031	1	0.016	2271	344148	189547	-15.0%	5.2%	15% TAC decrease (27.4)
.	180147	0.81	0.172	26271	0.111	14466	24037	19732	4305	0.045	9572	1	0.016	2234	339630	185119	15.0%	2.8%	15% TAC increase (27.4)
.	180147	0.70	0.150	23154	0.096	12600	20902	17158	3744	0.039	8301	1	0.016	2252	341889	187333	0.0%	4.0%	Rollover TAC
.	180147	1.00	0.208	31512	0.137	17603	29310	24060	5250	0.056	11707	1	0.016	2202	335830	181394	40.2%	0.7%	Fsq
.	180147	1.63	0.330	49161	0.224	28162	47065	38635	8430	0.091	18903	1	0.016	2096	323040	168858	125.2%	-6.3%	Fpa
.	180147	2.30	0.458	67677	0.315	39240	65693	53926	11767	0.128	26452	1	0.016	1985	309621	155705	214.3%	-13.6%	Flim
.	180147	1.74	0.351	52144	0.238	29946	50065	41098	8968	0.097	20119	1	0.016	2078	320879	166708	139.5%	-7.4%	Bpa, MSY Btrigger
.	180147	4.10	0.804	117801	0.561	69230	116118	95319	20799	0.228	46888	1	0.016	1684	273295	119970	455.5%	-33.3%	Blim
.	180147	0.74	0.158	24279	0.101	13275	22033	18087	3947	0.041	8758	1	0.016	2246	341072	186532	5.4%	3.5%	Fmsylower
.	180147	0.51	0.115	18006	0.070	9522	15723	12907	2816	0.029	6201	1	0.016	2283	345618	190988	-24.8%	6.0%	A
.	180147	0.67	0.144	22271	0.091	12073	20013	16429	3585	0.037	7940	1	0.016	2258	342528	187959	-4.3%	4.3%	B

2021																2022		2020 TAC 27.4	17158
			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	
.	180147	0.51	0.115	18006	0.070	9522	15723	12907	2816	0.029	6201	1	0.016	2283	345618	190988	-24.8%	6.0%	C
.	180147	0.52	0.115	18101	0.071	9579	15818	12985	2833	0.029	6240	1	0.016	2283	345550	190921	-24.3%	6.0%	A+D
.	180147	0.63	0.137	21278	0.087	11480	19014	15609	3406	0.035	7535	1	0.016	2264	343247	188664	-9.0%	4.7%	B+E
.	180147	0.53	0.117	18418	0.072	9769	16138	13247	2891	0.029	6369	1	0.016	2281	345320	190695	-22.8%	5.9%	C+E
.	180147	0.81	0.172	26304	0.111	14487	24071	19759	4311	0.045	9584	1	0.016	2233	339605	185094	15.2%	2.7%	Fmsy,Fmsyupper
.	180147	0.55	0.122	18999	0.075	10113	16721	13726	2995	0.031	6608	1	0.016	2277	344901	190286	-20.0%	5.6%	20% TAC decrease (27.4)
.	180147	0.89	0.186	28348	0.121	15709	26127	21448	4680	0.049	10418	1	0.016	2221	338124	183642	25.0%	1.9%	25% TAC increase (27.4)
.	180147	0.81	0.171	26122	0.110	14377	23887	19609	4279	0.045	9510	1	0.016	2235	339737	185223	14.3%	2.8%	Fmsylower SSB(2020)/MSYBtrigger

Table 23.27 Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series for northern component used in the area-specific SURBAR analysis.

	Q1	North				Q3	North				
Age	1	2	3	4	5	0	1	2	3	4	5
1978	555.148	312.326	127.843	32.887	9.221						
1979	556.108	275.022	154.252	48.264	6.900						
1980	767.338	497.615	127.575	28.429	12.955						
1981	232.787	545.080	280.626	49.209	11.474						
1982	117.953	269.458	385.779	95.280	14.710						
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	39.830	12.625						
1987	707.640	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	26.920	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	52.180	339.611	578.148	248.966	55.832	30.695	21.417
1994	1058.430	853.101	299.173	105.475	20.999	237.937	712.663	324.467	57.501	16.051	11.430
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	74.550	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	343.710	77.607	29.033	291.479	642.804	296.602	111.774	25.051	9.898
2002	513.057	428.163	386.740	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	413.410	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	63.200	36.431

	Q1	North				Q3	North				
Age	1	2	3	4	5	0	1	2	3	4	5
2005	160.630	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
2007	62.938	202.914	93.486	31.871	16.757	346.981	74.776	78.557	48.200	22.754	12.043
2008	198.753	195.499	78.913	27.568	14.458	848.142	334.740	72.776	39.989	18.660	9.790
2009	156.742	239.482	72.965	20.130	20.976	560.618	257.218	134.847	32.409	13.392	10.651
2010	302.330	269.377	239.438	76.001	110.690	70.104	248.174	175.906	57.992	16.820	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	145.620	58.537	44.488	316.803	238.565	268.773	84.896	30.912	21.170
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	633.780	210.029	107.555	34.800	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	473.600	186.579	100.513	70.269	21.467						

Table 23.28 Whiting in Subarea 4 and Division 7.d: NS IBTS tuning series for southern component used in the area-specific SURBAR analysis.

	Q1	South				Q3	South				
Age	1	2	3	4	5	0	1	2	3	4	5
1978	469.507	130.996	16.165	6.606	4.103						
1979	169.514	116.812	20.571	4.657	1.167						
1980	370.468	118.234	91.217	38.522	5.402						
1981	195.122	299.475	111.823	37.529	8.838						
1982	168.681	168.502	93.834	25.940	7.758						
1983	85.450	99.851	52.686	19.987	5.019						
1984	593.881	84.243	43.152	4.049	2.825						
1985	114.689	330.400	30.889	11.822	3.018						
1986	155.459	93.190	215.536	54.700	7.664						
1987	542.592	86.810	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	32.480	4.558						

	Q1	South				Q3	South				
Age	1	2	3	4	5	0	1	2	3	4	5
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	117.670	56.676	27.940	1200.775	406.283	311.477	40.846	30.723	26.147
1993	140.264	59.430	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	951.750	640.529	84.975	43.115	25.091	10.090
1995	222.579	239.969	49.752	19.783	6.470	1219.269	222.510	80.845	7.972	6.656	1.232
1996	231.472	233.724	70.389	33.571	37.795	499.520	417.706	205.879	47.990	11.737	6.928
1997	67.325	43.278	13.870	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	2794.070	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	2.950
2001	942.456	448.546	84.966	70.175	31.130	8867.757	697.026	218.850	36.408	18.910	5.883
2002	457.447	120.386	34.448	13.216	7.754	385.891	989.146	113.490	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	34.870	14.430	10.014	1641.775	81.054	65.172	14.855	5.381	3.609
2005	89.895	67.155	22.920	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	20.520	6.177	1.968	0.942
2008	427.504	247.607	26.007	4.196	2.120	546.391	596.203	54.246	16.160	4.215	0.806
2009	438.147	459.551	74.428	18.350	15.819	634.897	1044.568	664.476	76.080	11.132	6.005
2010	508.820	81.019	64.927	17.960	9.475	914.230	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	51.980	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	17.160	13.996	1884.952	283.798	169.738	124.258	70.136	15.764
2015	340.564	393.710	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	266.910	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						

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	0.173	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	0.814	0.984	1	1	1	1	1
1994	0	0.182	0.808	0.982	0.999	1	1	1	1
1995	0	0.187	0.802	0.978	0.998	0.999	1	1	1
1996	0	0.194	0.794	0.974	0.997	0.999	1	1	1
1997	0	0.203	0.786	0.969	0.995	0.998	1	1	1
1998	0	0.214	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	0.756	0.95	0.991	0.997	1	1	1
2001	0	0.26	0.75	0.946	0.99	0.997	1	1	1
2002	0	0.275	0.749	0.946	0.99	0.998	1	1	1
2003	0	0.288	0.753	0.947	0.991	0.998	1	1	1
2004	0	0.297	0.761	0.95	0.992	0.999	1	1	1
2005	0	0.303	0.773	0.955	0.993	0.999	1	1	1
2006	0	0.306	0.786	0.961	0.994	0.999	1	1	1
2007	0	0.306	0.8	0.967	0.996	1	1	1	1
2008	0	0.306	0.813	0.973	0.997	1	1	1	1
2009	0	0.306	0.824	0.977	0.998	1	1	1	1
2010	0	0.307	0.833	0.98	0.999	1	1	1	1
2011	0	0.308	0.838	0.982	1	1	1	1	1
2012	0	0.308	0.841	0.982	1	1	1	1	1
2013	0	0.307	0.841	0.982	1	1	1	1	1
2014	0	0.305	0.84	0.982	1	1	1	1	1
2015	0	0.303	0.84	0.981	1	1	1	1	1
2016	0	0.301	0.839	0.981	0.999	1	1	1	1
2017	0	0.3	0.837	0.98	0.999	1	1	1	1
2018	0	0.299	0.834	0.978	0.998	1	1	1	1
2019	0	0.296	0.831	0.977	0.998	1	1	1	1
2020	0	0.293	0.828	0.976	0.997	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	0.296	0.865	0.994	1	1	1	1	1
1992	0	0.297	0.824	0.981	1	1	1	1	1
1993	0	0.294	0.789	0.967	0.999	1	1	1	1
1994	0	0.287	0.762	0.954	0.996	1	1	1	1
1995	0	0.27	0.737	0.939	0.99	0.999	1	1	1
1996	0	0.247	0.709	0.918	0.98	0.993	0.997	0.998	0.999
1997	0	0.226	0.687	0.893	0.965	0.984	0.992	0.996	0.998
1998	0	0.22	0.675	0.866	0.944	0.972	0.985	0.992	0.996
1999	0	0.228	0.655	0.831	0.917	0.956	0.976	0.988	0.994
2000	0	0.249	0.621	0.794	0.892	0.942	0.968	0.984	0.992
2001	0	0.275	0.593	0.771	0.878	0.935	0.965	0.983	0.992
2002	0	0.306	0.582	0.767	0.879	0.938	0.966	0.984	0.993
2003	0	0.337	0.587	0.777	0.888	0.944	0.97	0.987	0.994
2004	0	0.367	0.602	0.792	0.899	0.952	0.975	0.99	0.996
2005	0	0.391	0.625	0.811	0.913	0.961	0.981	0.992	0.997
2006	0	0.415	0.655	0.835	0.928	0.969	0.987	0.995	0.998
2007	0	0.442	0.693	0.862	0.943	0.978	0.992	0.997	0.999
2008	0	0.467	0.732	0.889	0.957	0.984	0.996	0.999	1
2009	0	0.488	0.767	0.912	0.968	0.99	0.999	1	1
2010	0	0.502	0.794	0.928	0.976	0.993	1	1	1
2011	0	0.51	0.811	0.939	0.981	0.995	1	1	1
2012	0	0.514	0.818	0.943	0.982	0.996	1	1	1
2013	0	0.513	0.817	0.943	0.982	0.997	1	1	1
2014	0	0.511	0.821	0.945	0.983	0.997	1	1	1
2015	0	0.509	0.83	0.951	0.985	0.997	1	1	1
2016	0	0.501	0.84	0.957	0.988	0.998	1	1	1
2017	0	0.491	0.846	0.962	0.99	0.998	1	1	1
2018	0	0.482	0.844	0.964	0.991	0.998	1	1	1
2019	0	0.478	0.837	0.963	0.991	0.997	1	1	1
2020	0	0.479	0.832	0.962	0.99	0.997	1	1	1

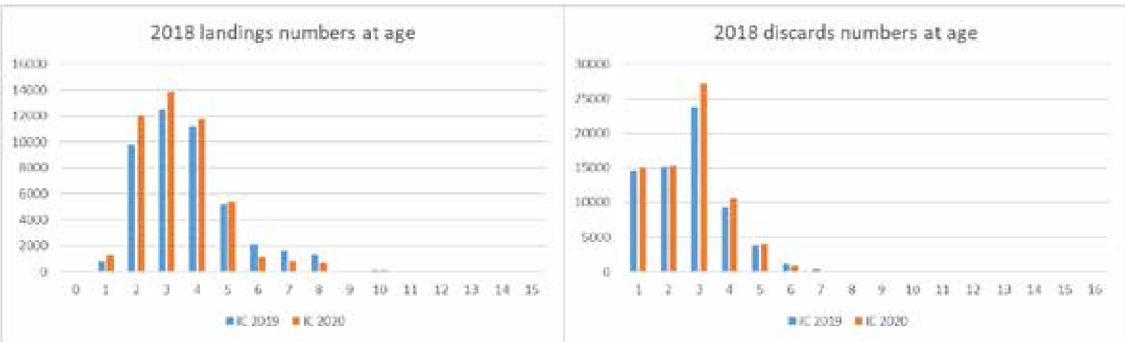


Figure 23.1a. Whiting in Subarea 4 and Division 7.d: landings (left) and discards (right) numbers at age for 2018 as estimated using InterCatch in 2019 and in 2020 following reprocessing of data by France.

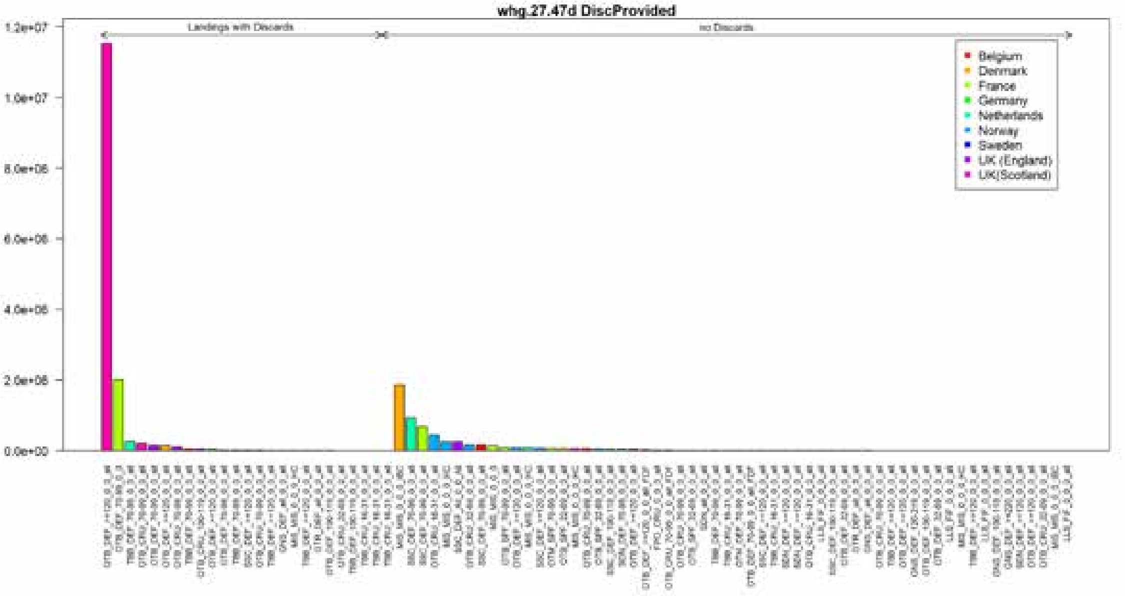


Figure 23.1b. Whiting in Subarea 4 and Division 7.d: Landings with provided discards. Métier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

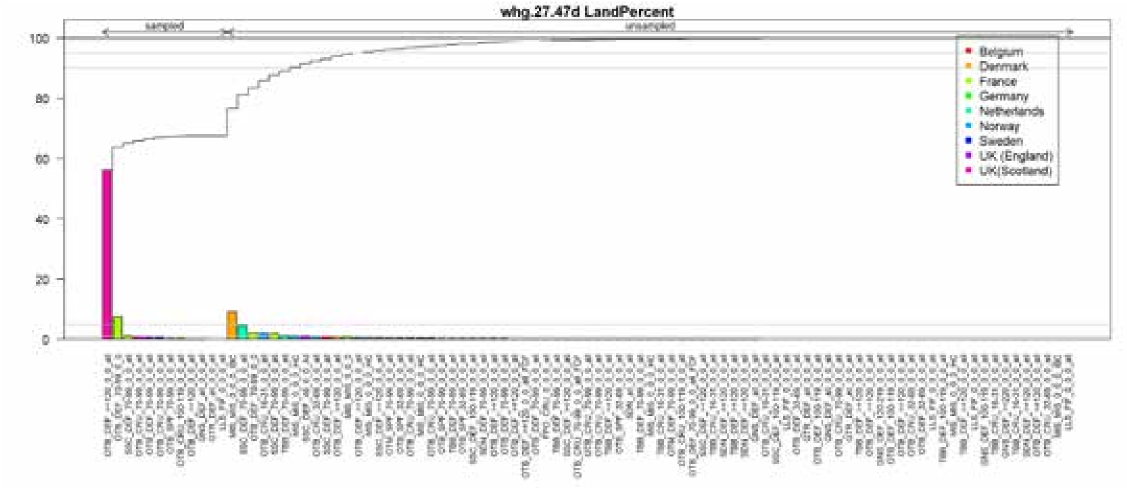


Figure 23.2a. Whiting in Subarea 4 and Division 7.d: Reported landings (in percent, colored bars) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

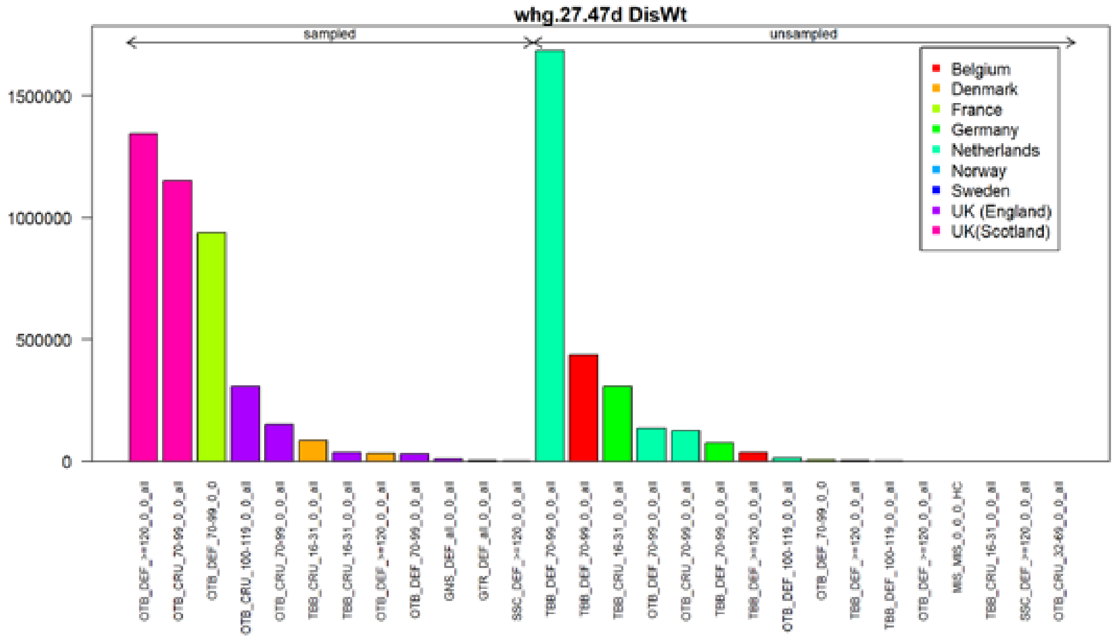


Figure 23.2b. Whiting in Subarea 4 and Division 7.d: Reported discards (in tonnes, colored bars) for each sampled and unsampled fleet, in descending order of yield.

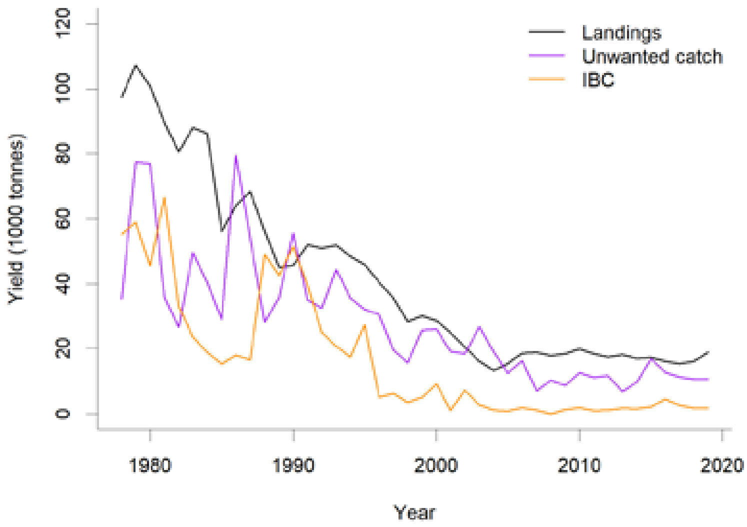


Figure 23.3. Whiting in Subarea 4 and Division 7.d: Yield by catch component. Unwanted catch includes discards and BMS landings as estimated by ICES.

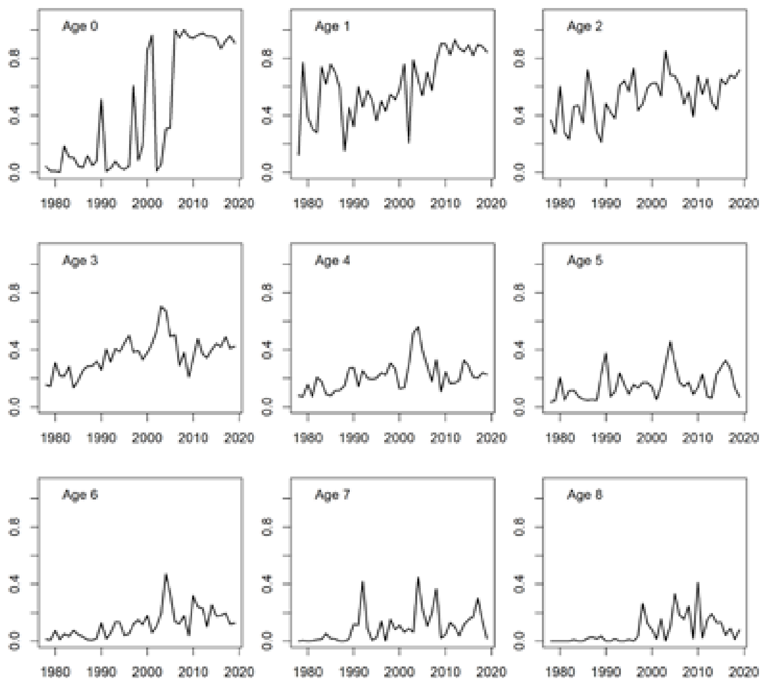


Figure 23.4. Whiting in Subarea 4 and Division 7.d: Proportion of unwanted catch in total catch, by age and year.

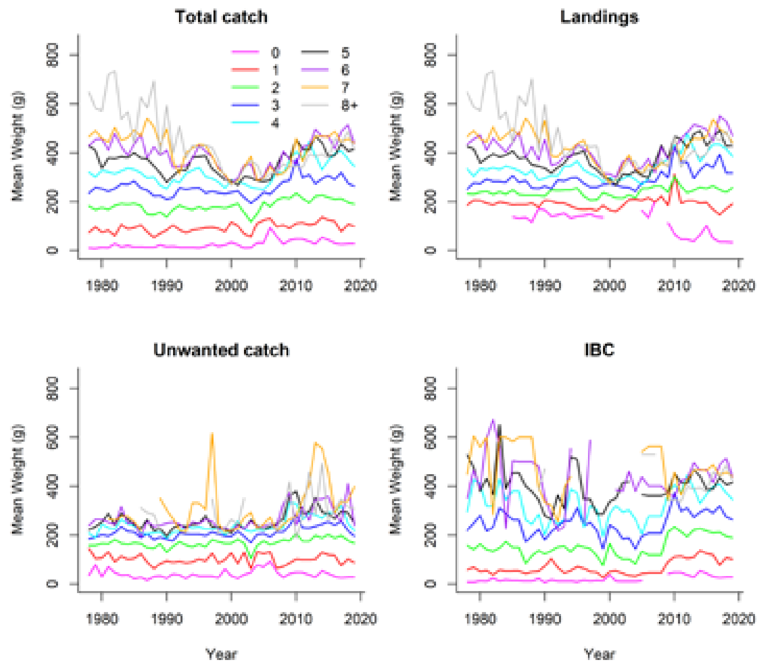


Figure 23.5. Whiting in Subarea 4 and Division 7.d: Mean weights-at-age (g) by catch component (black lines, age 0-8+).

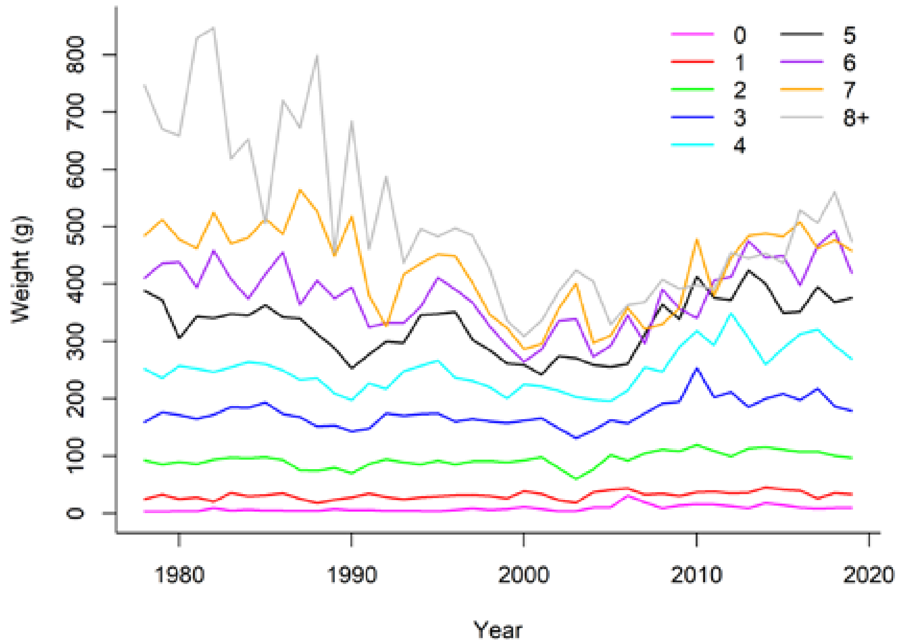


Figure 23.6. Whiting in Subarea 4 and Division 7.d: Stock mean weights-at-age (g) (age 0-8+).

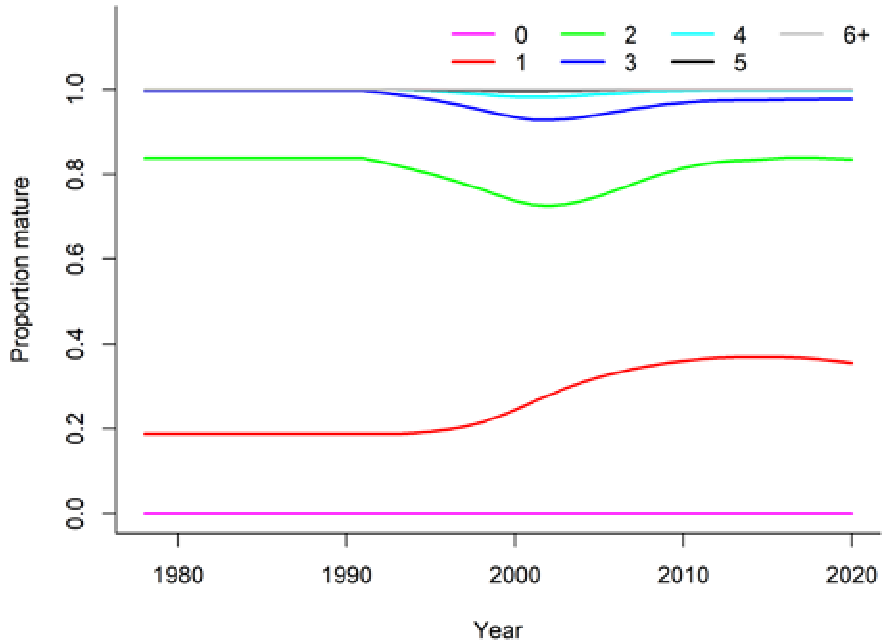


Figure 23.7. Whiting in Subarea 4 and Division 7.d: Maturity estimates from NS IBTS Q1 data. Ages 6-8+ have the same maturity values. Estimates prior 1991 are assumed constant using values of 1991.

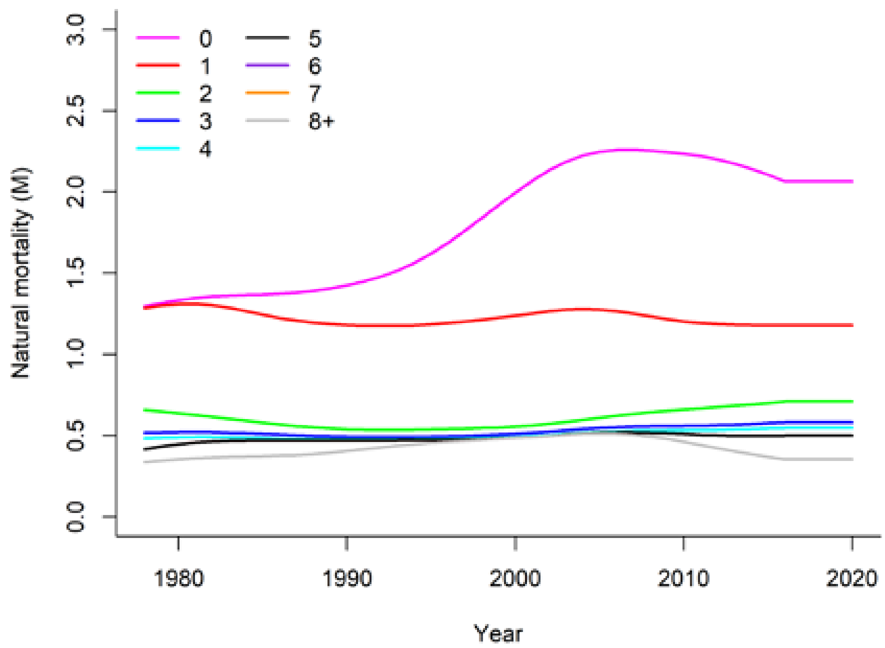


Figure 23.8. Whiting in Subarea 4 and Division 7.d: Natural mortality estimates from the 2017 update of SMS key run (WGSAM, 2018b) used in assessment. Ages 6–8+ have the same natural mortality.

Figure 23.9. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for Ages 1–3+ Q1 2016–2020. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–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 2016–2019. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q3 survey in the North Sea.

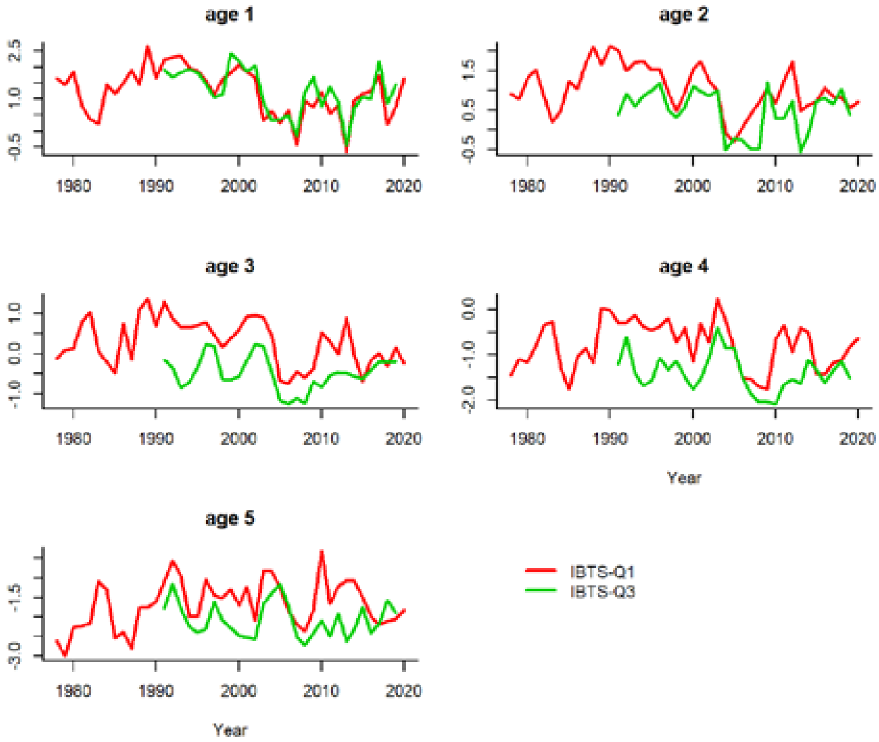


Figure 23.11. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) at age.

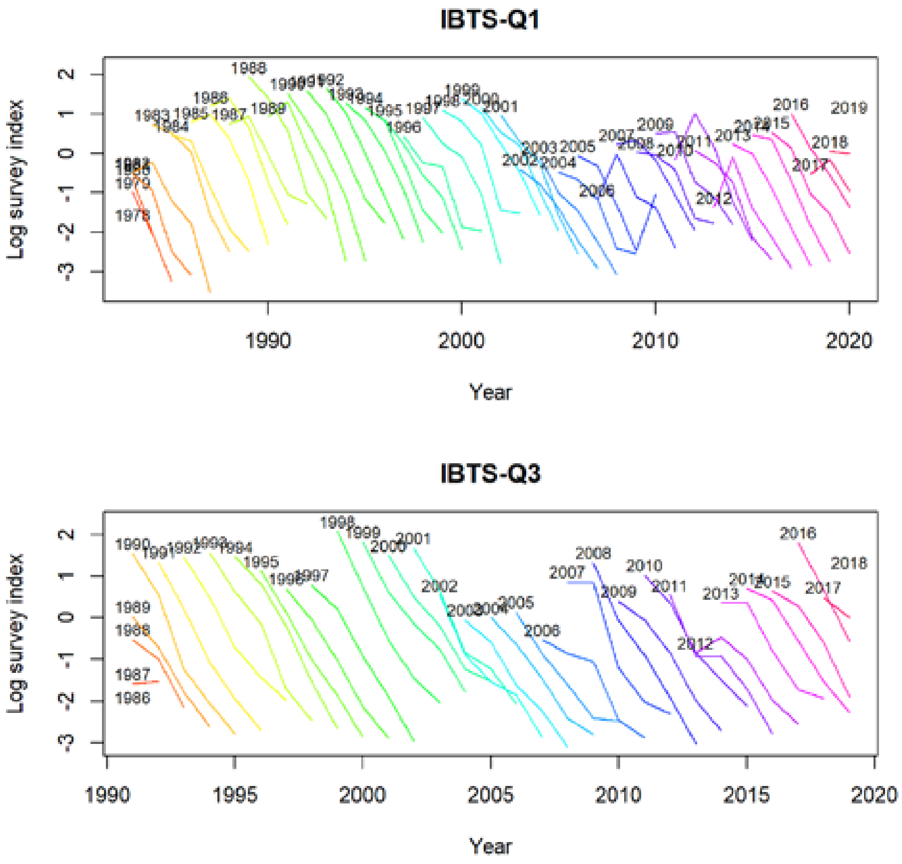


Figure 23.12. Whiting in Subarea 4 and Division 7.d: Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

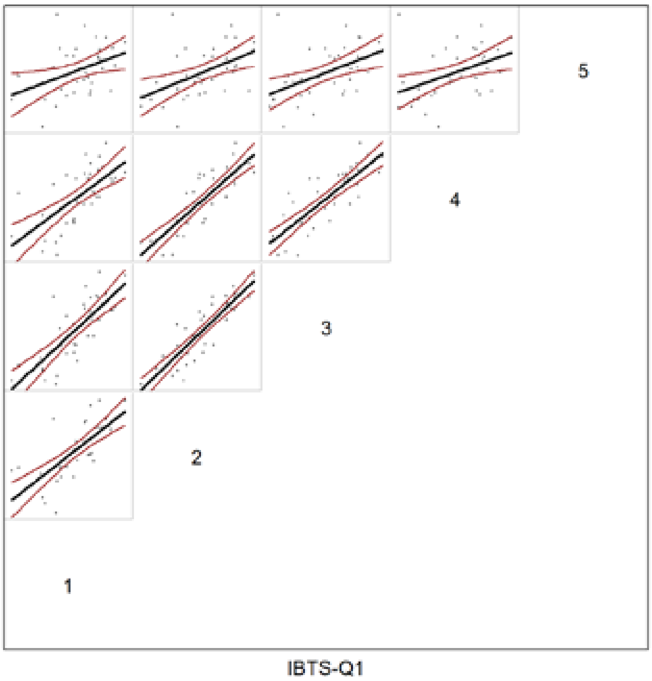


Figure 23.13. Within-survey correlations for the IBTS–Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximatee 95% confidence intervals for each fit are also shown.

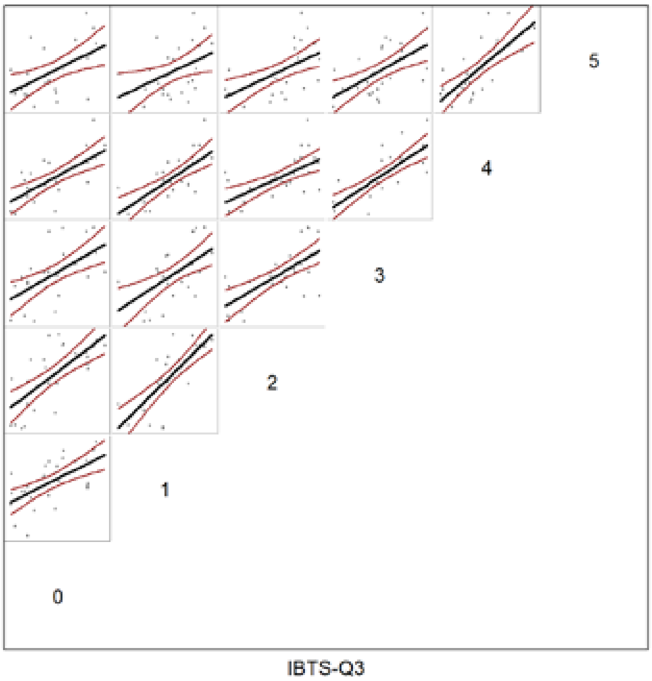


Figure 23.14. Within-survey correlations for the IBTS–Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

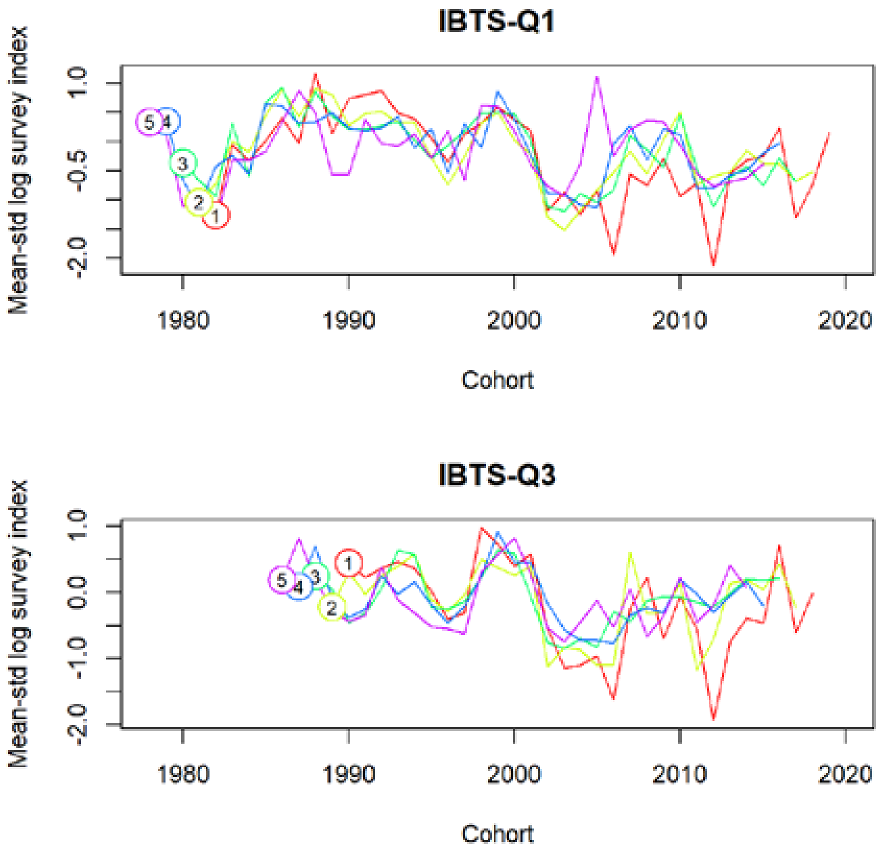


Figure 23.15. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) for the IBTS–Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

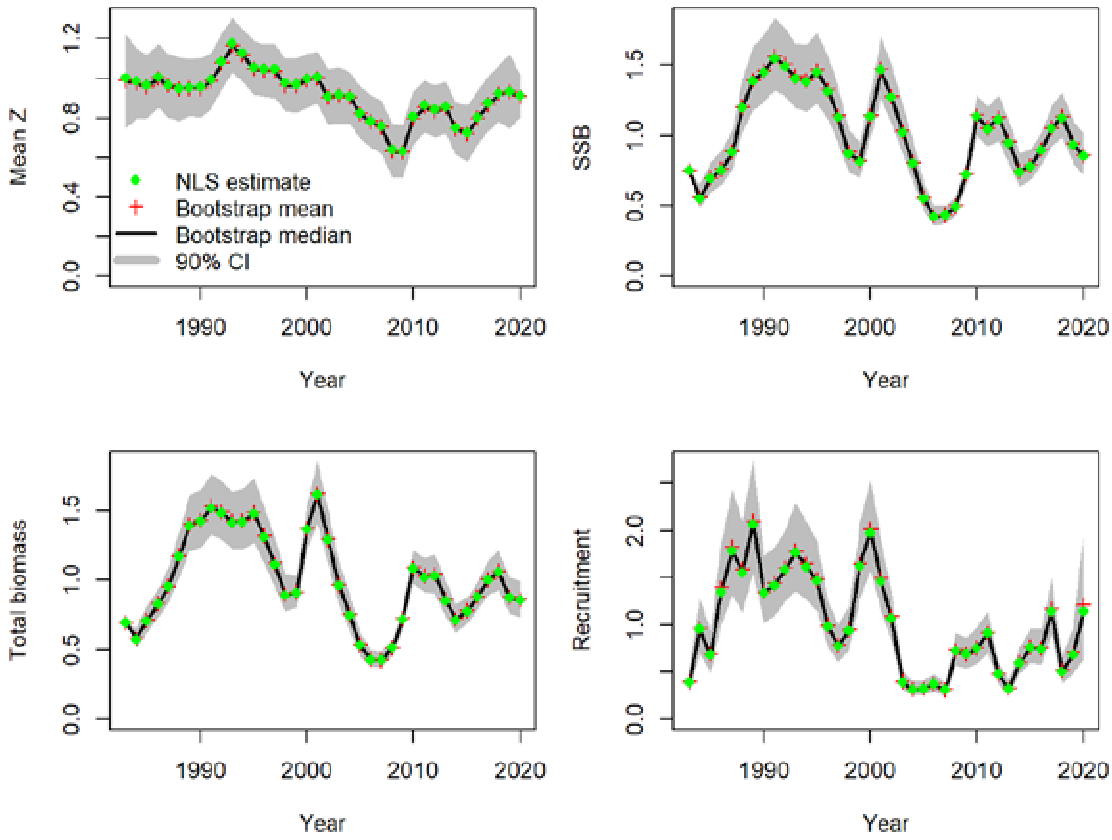


Figure 23.16. Whiting in Subarea 4 and Division 7.d: Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment (age 1). Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

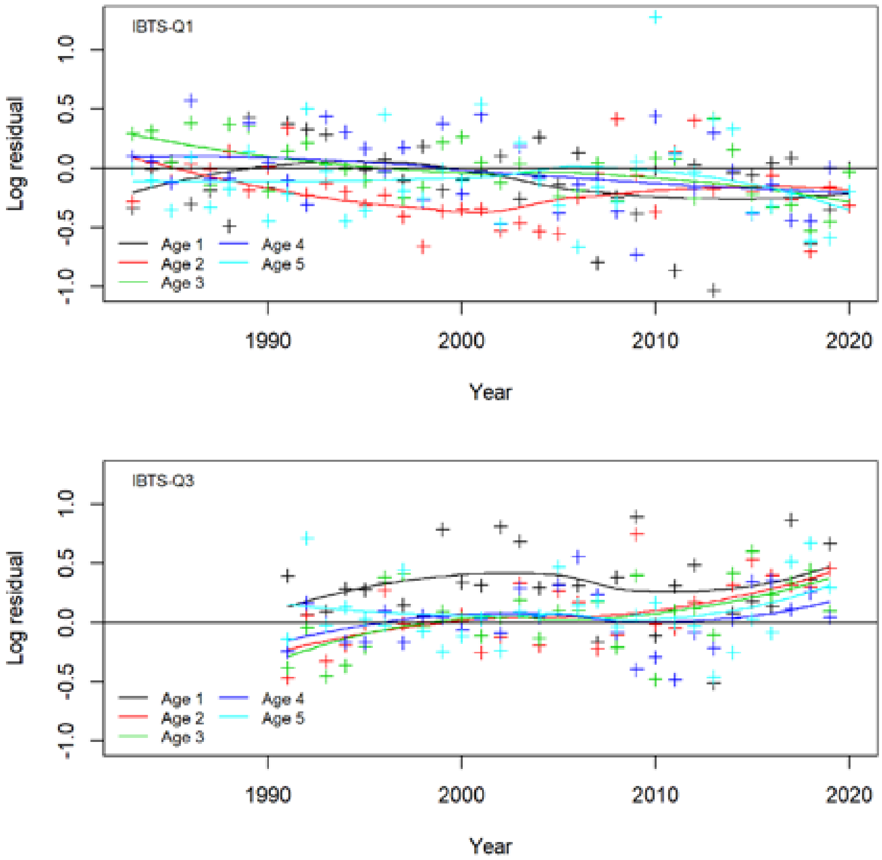


Figure 23.17. Whiting in Subarea 4 and Division 7.d: Log survey residuals from the SURBAR analysis. Ages are color-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

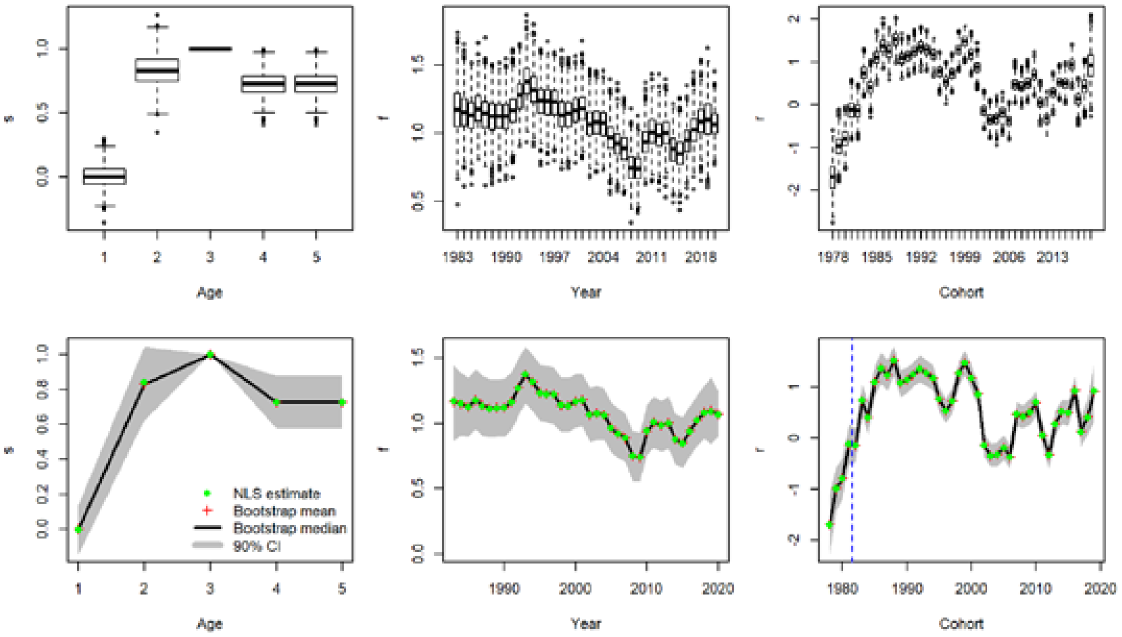


Figure 23.18. Whiting in Subarea 4 and Division 7.d: Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

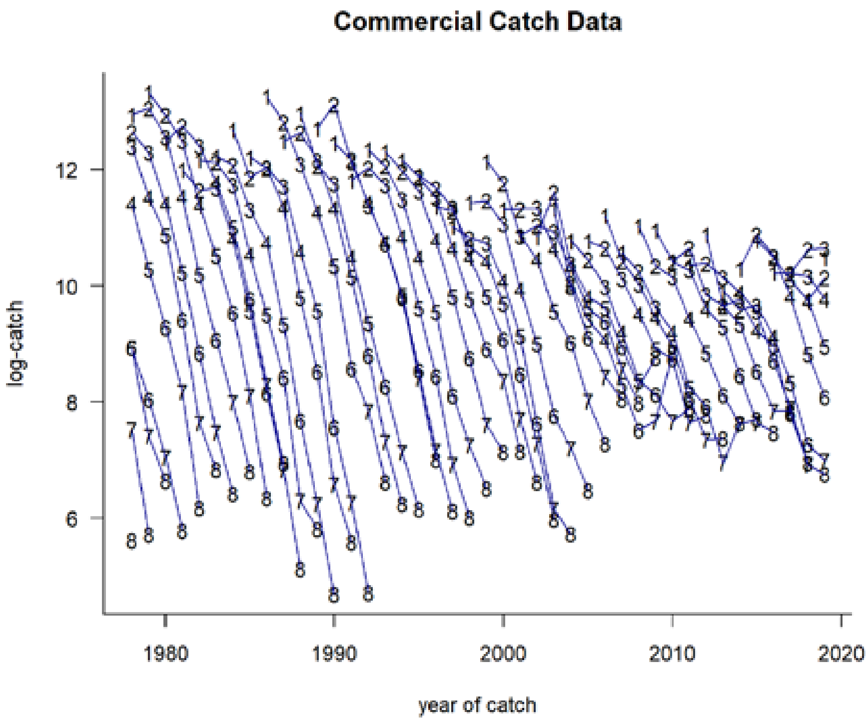


Figure 23.19. Whiting in Subarea 4 and Division 7.d: Log-catch curves by cohort for total catches (ages 1–8+).

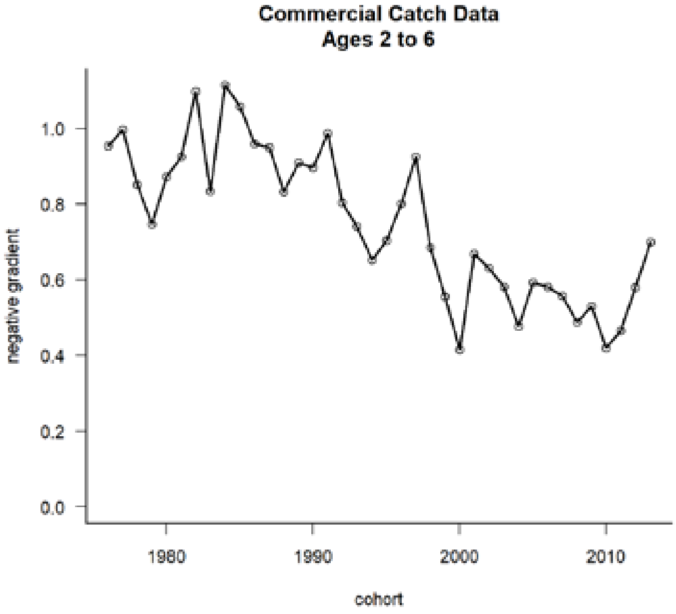


Figure 23.20. Whiting in Subarea 4 and Division 7.d: Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

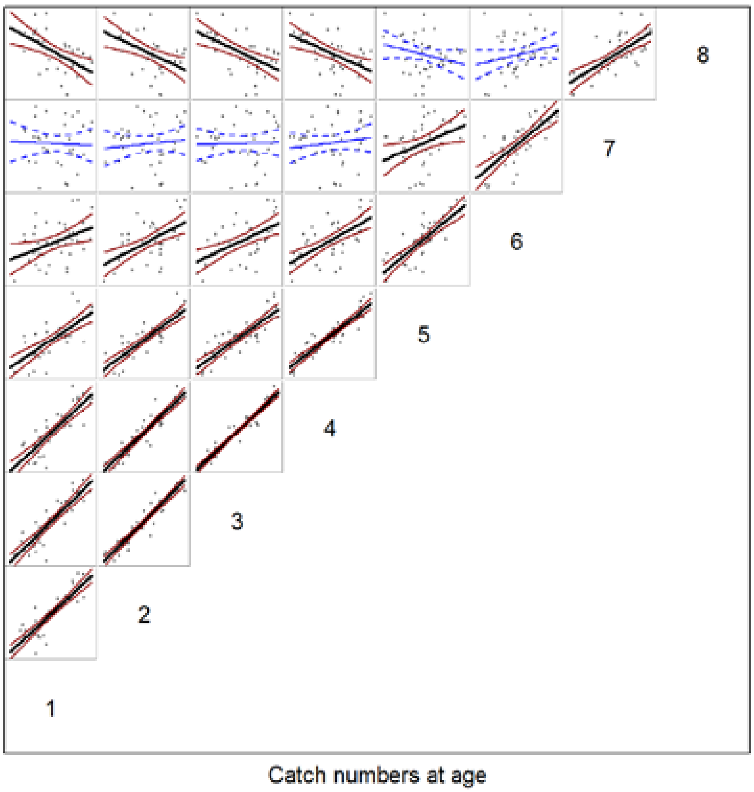
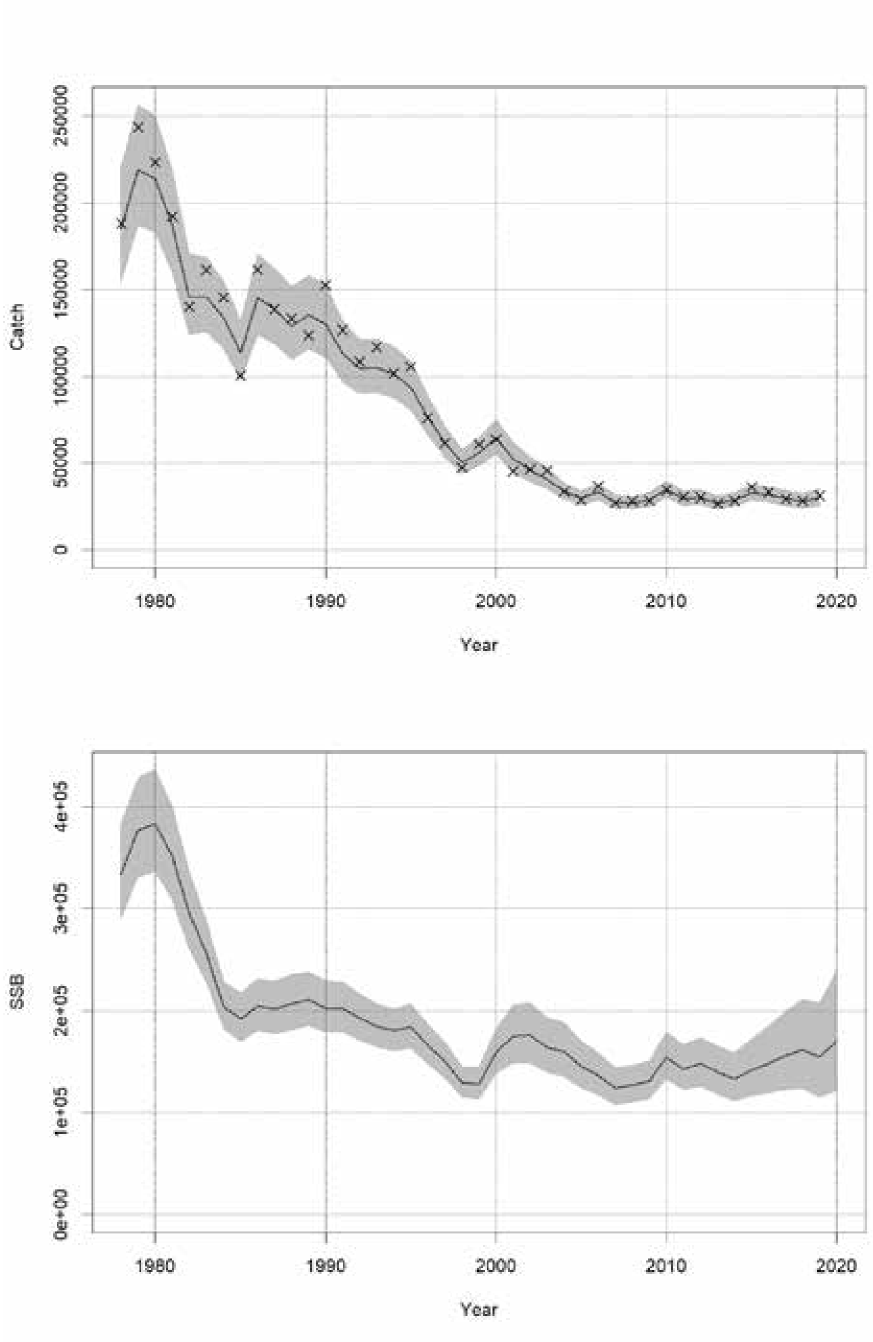


Figure 23.21. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.


Catch
250000
200000
150000
100000
50000
0
1980
1990
2000
2010
2020
Year
SSB
4e+05
3e+05
2e+05
1e+05
0e+00
1980
1990
2000
2010
2020
Year

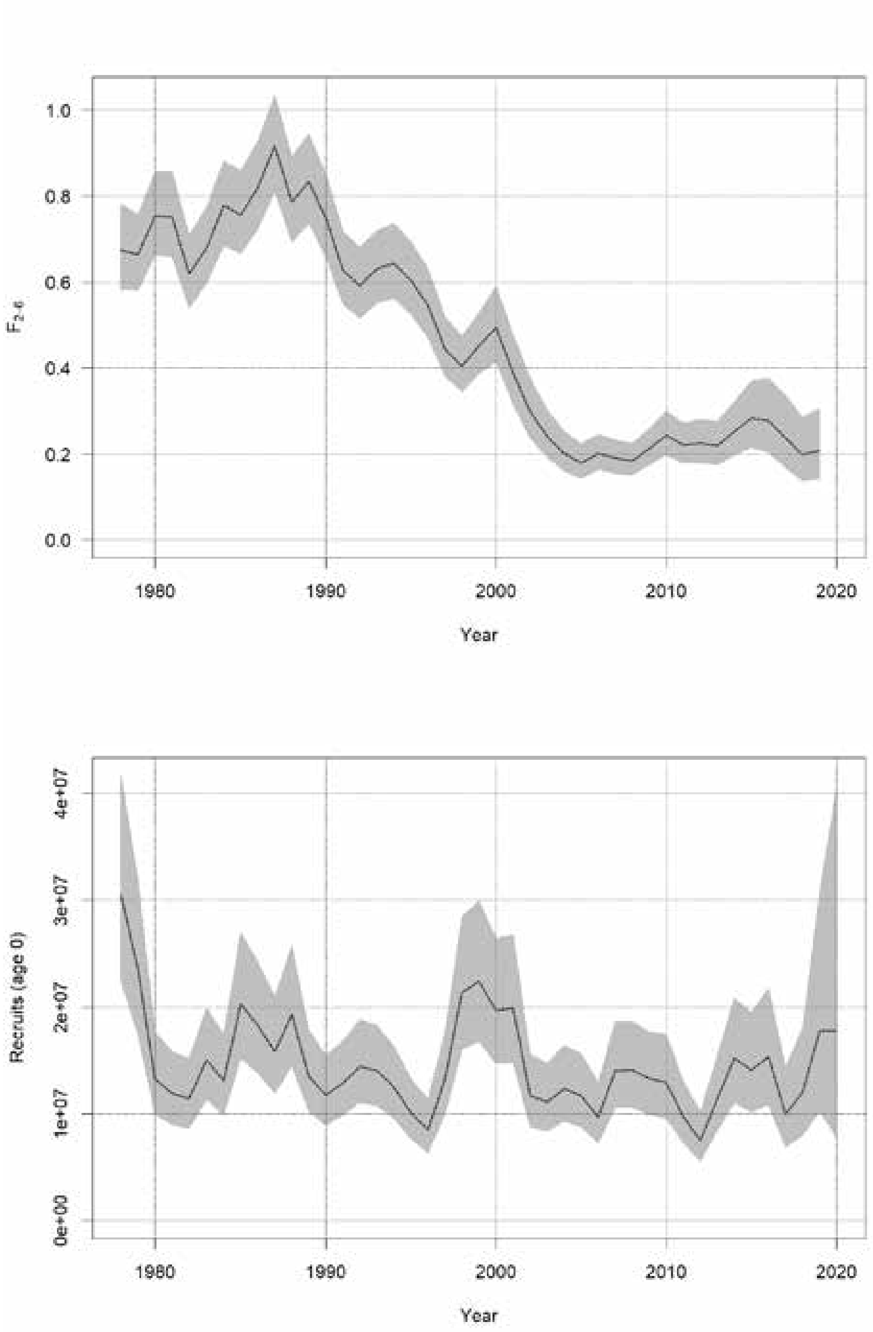


Figure 23.22. Whiting in Subarea 4 and Division 7.d: SAM assessment results using catch data series (1978–2019) with IBTS survey data starting in 1983 (Q1) and 1991 (Q3). Estimates with 95% Confidence intervals for total catch weight, SSB, mean fishing mortality and recruitment (at age 0).

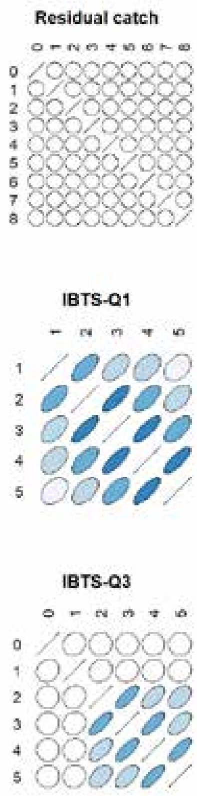


Figure 23.23. Whiting in Subarea 4 and Division 7.d: SAM estimated correlations between age groups for each fleet.

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).

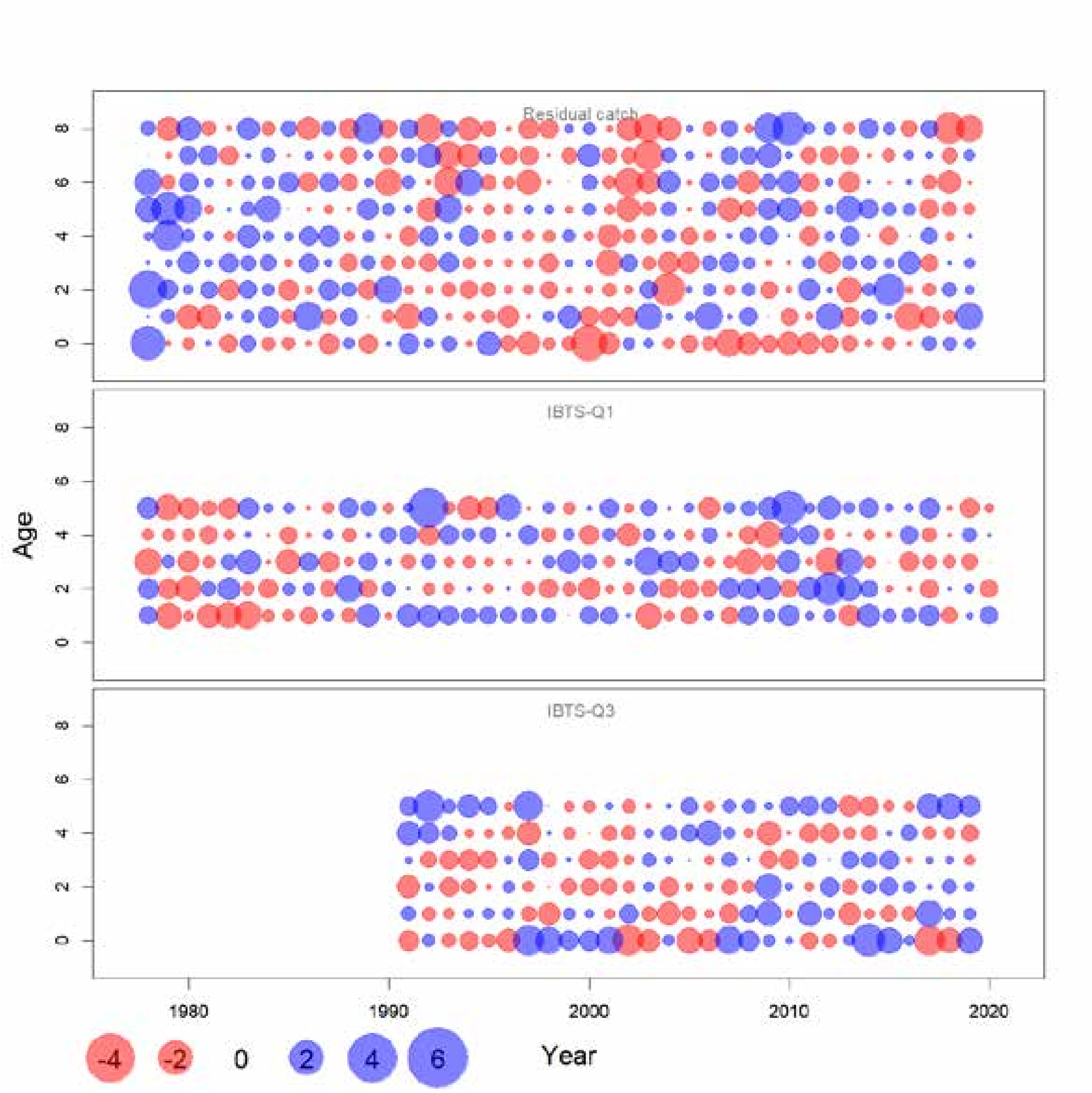


Figure 23.25. Whiting in Subarea 4 and Division 7.d: SAM standardized one-observation-ahead residuals.

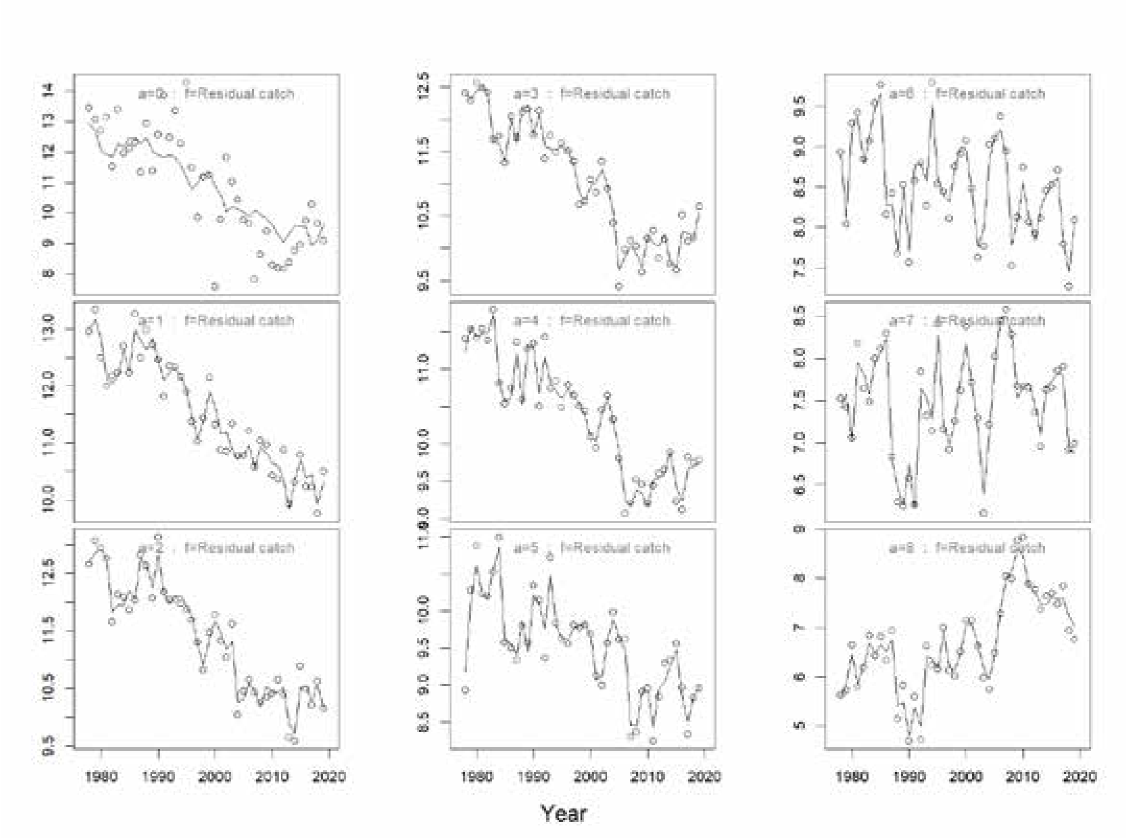


Figure 23.26. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale) for the catch fleet.

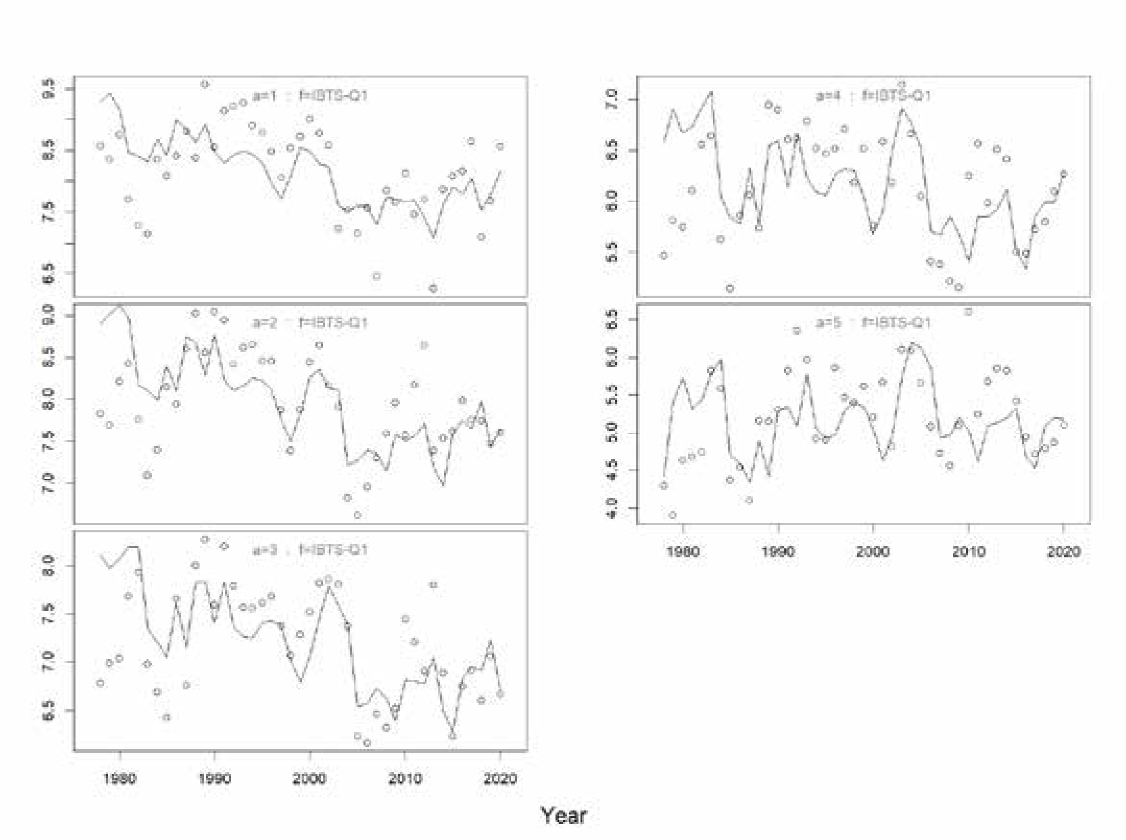


Figure 23.27. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q1.

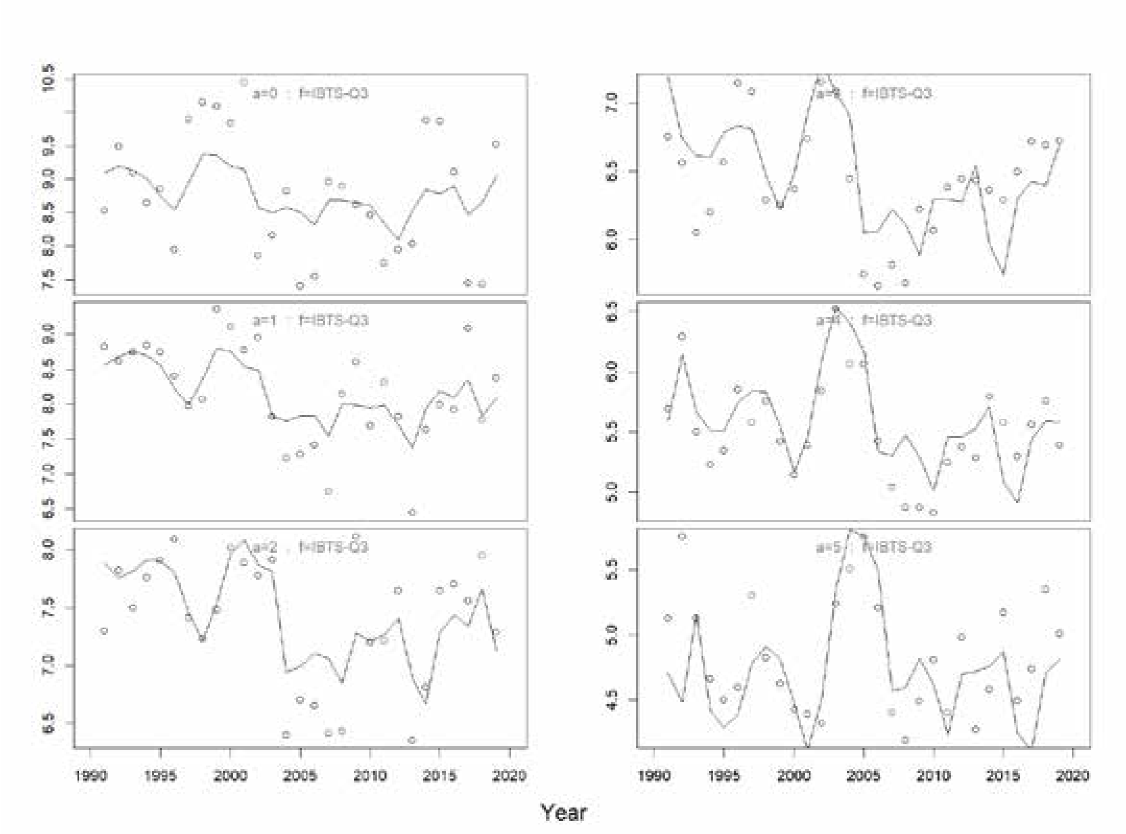
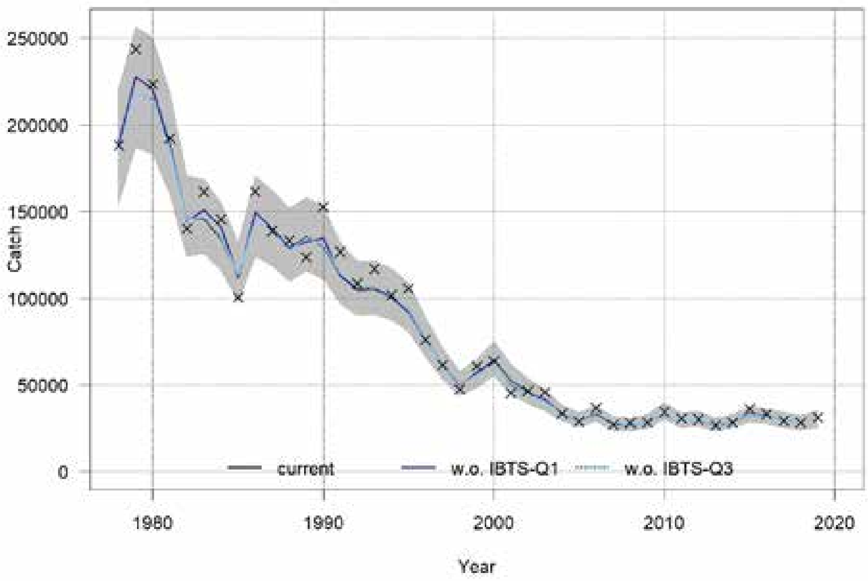
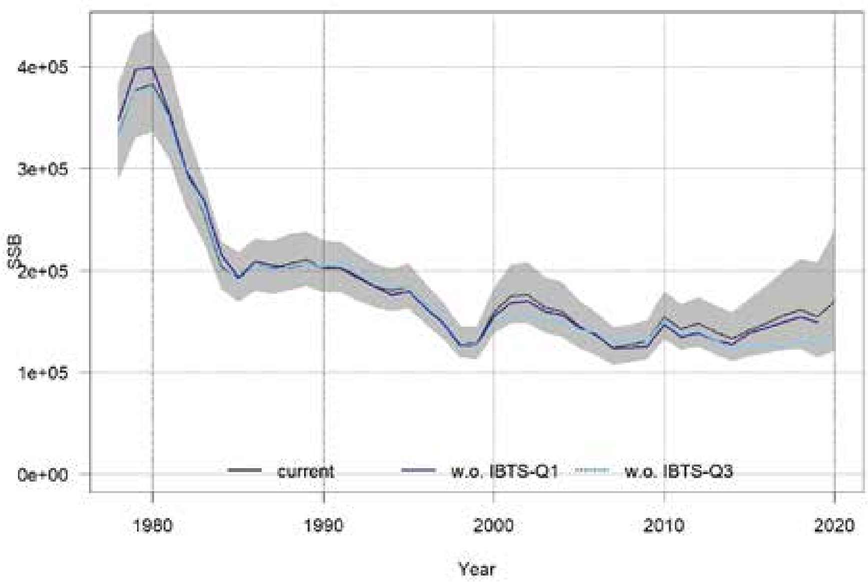
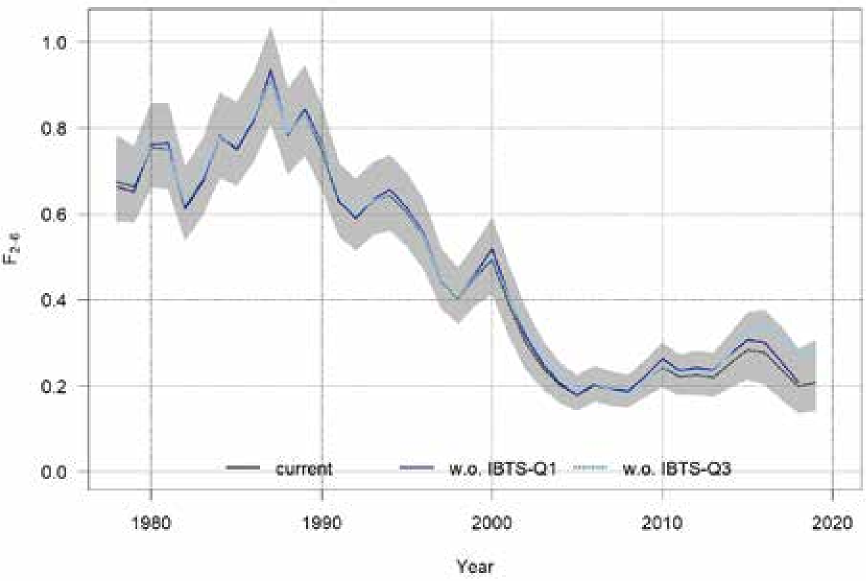


Figure 23.28. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q3.


250000
200000
150000
100000
50000
0
Catch
current
w.o. IBTS-Q1
w.o. IBTS-Q3
1980
1990
2000
2010
2020
Year


4e+05
3e+05
2e+05
1e+05
0e+00
SSB
current
w.o. IBTS-Q1
w.o. IBTS-Q3
1980
1990
2000
2010
2020
Year



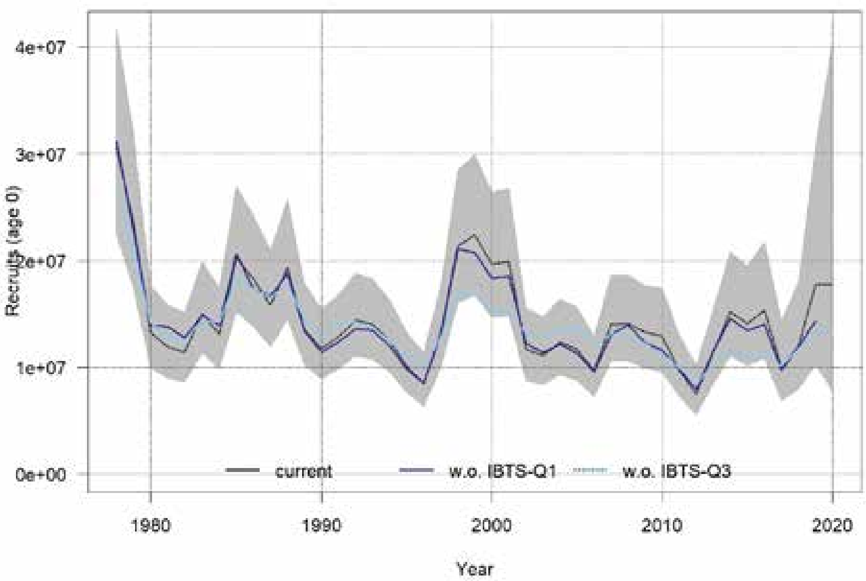
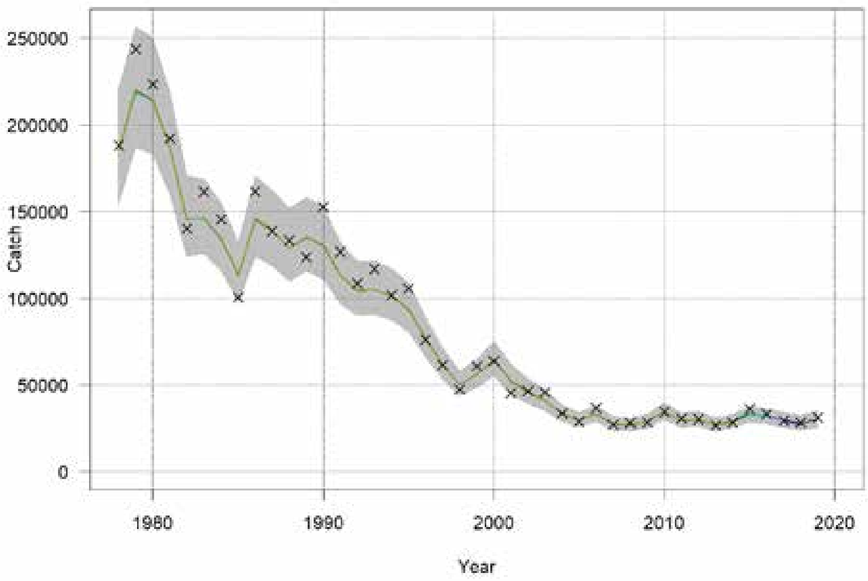
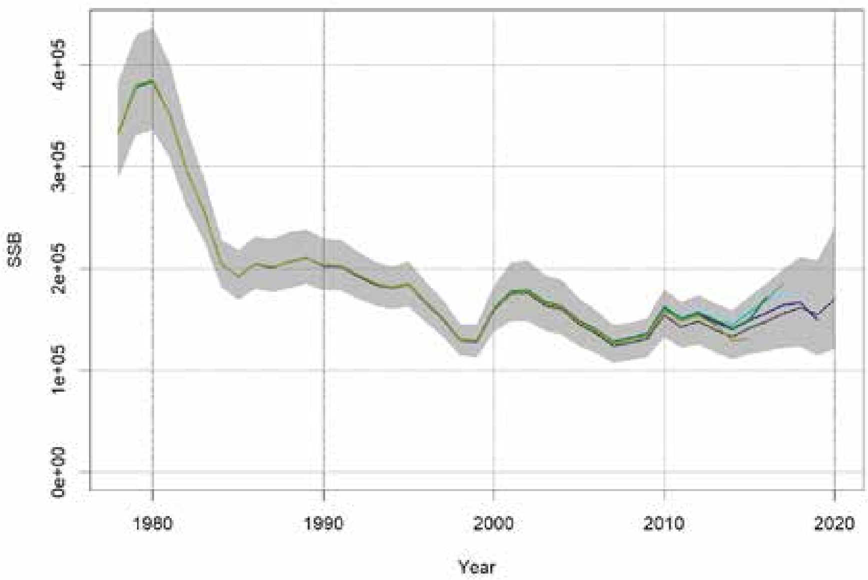


Figure 23.29. Whiting in Subarea 4 and Division 7.d: SAM leave-one-out diagnostics. Final run (black), run without IBTS Q1 (dark blue), run without IBTS Q3 (light blue).



250000
200000
150000
100000
50000
0
Catch
1980
1990
2000
2010
2020
Year



4e+05
3e+05
2e+05
1e+05
0e+00
SSB
1980
1990
2000
2010
2020
Year

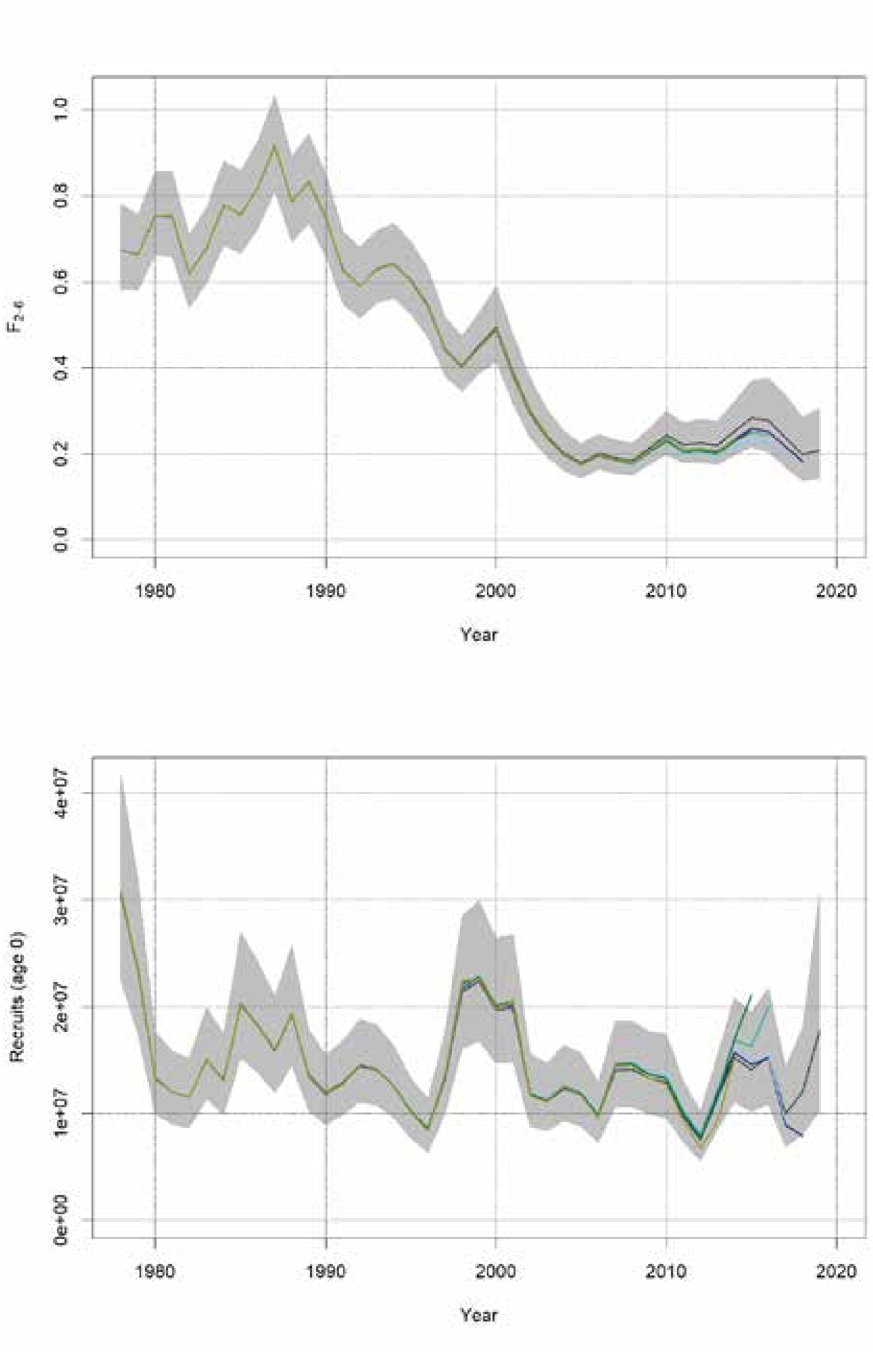


Figure 23.30. Whiting in Subarea 4 and Division 7.d: SAM Retrospective pattern in catch estimates, SSB, fishing mortality and recruitment.

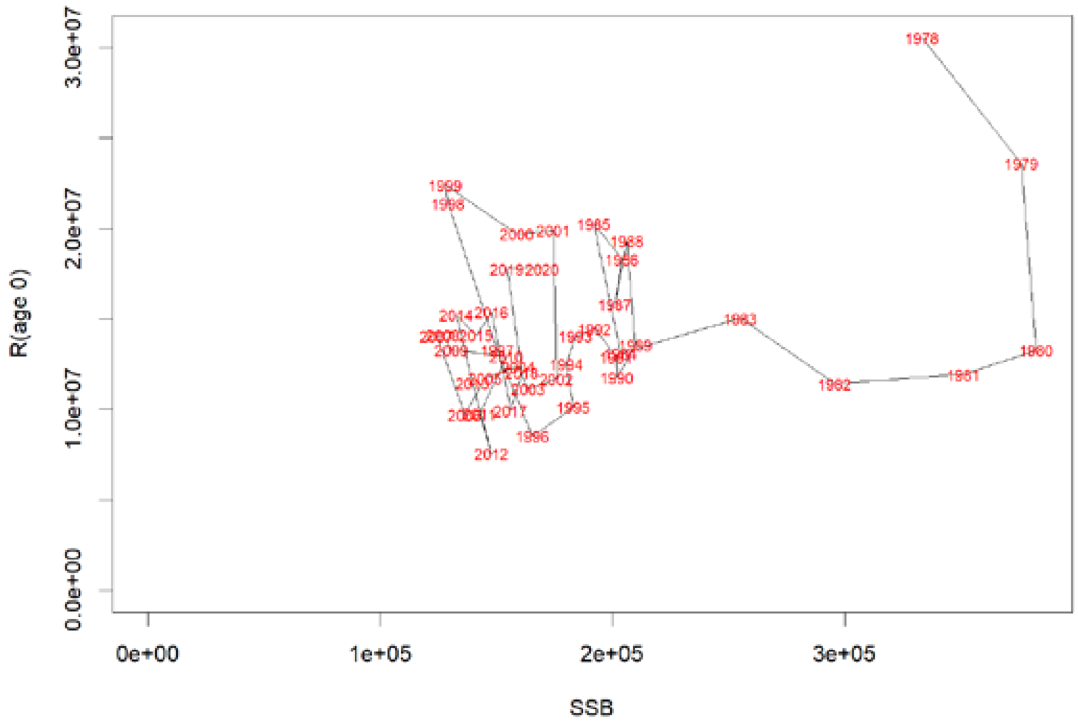


Figure 23.31. Whiting in Subarea 4 and Division 7.d: Stock-recruitment relationship.

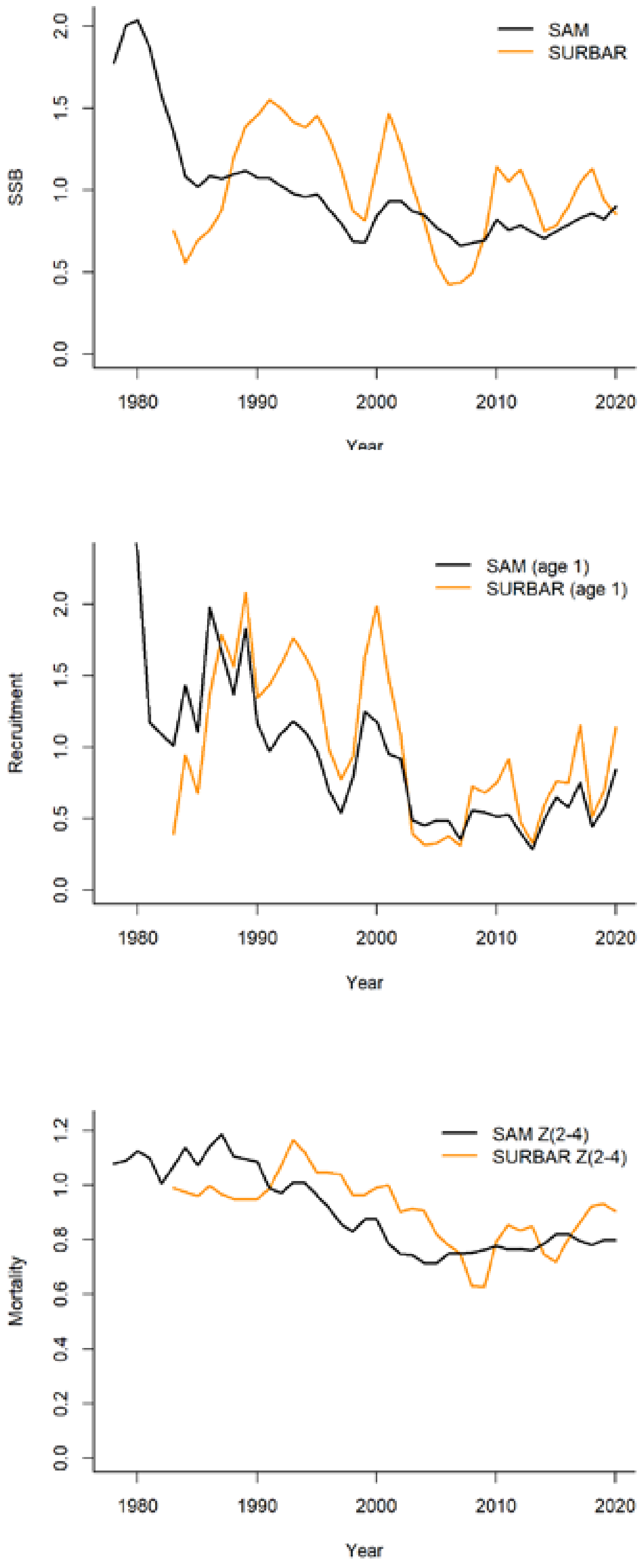


Figure 23.32. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final SAM (black) and SURBAR (orange) models. To facilitate comparison, recruitment and SSB values have been mean-standardised using

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.

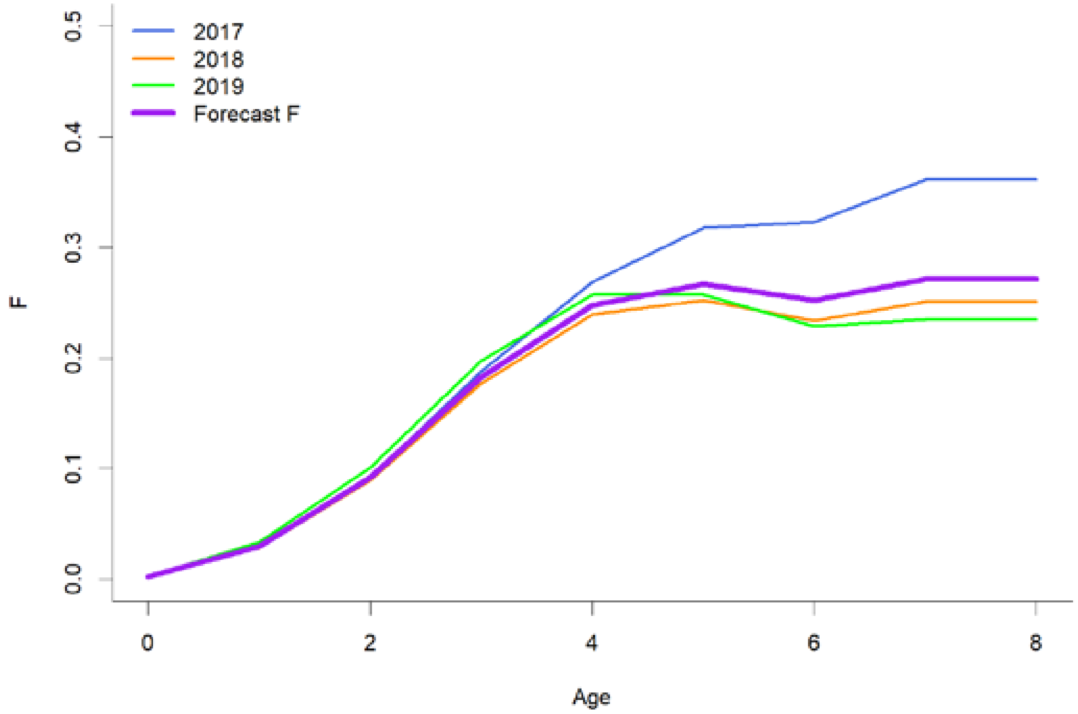


Figure 23.33. Whiting in Subarea 4 and Division 7.d: SAM F at age estimates for 2017–2019, along with scaled mean exploitation used for the forecast.

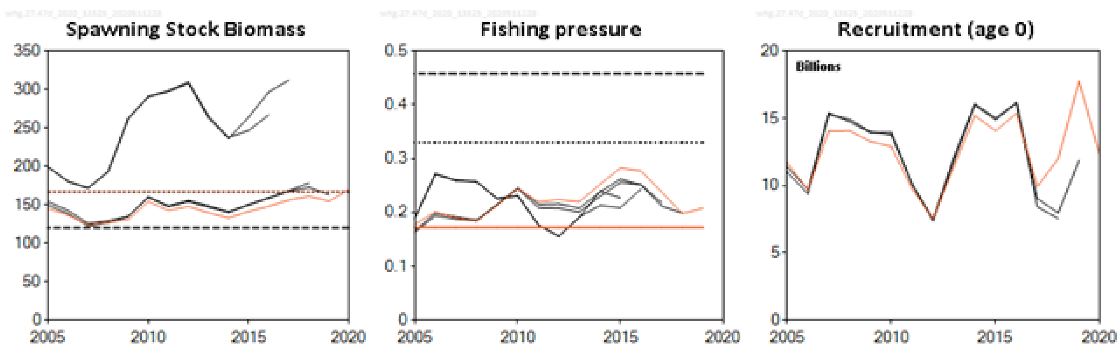


Figure 23.34. Whiting in Subarea 4 and Division 7.d: Historical assessments from Standard graphs.

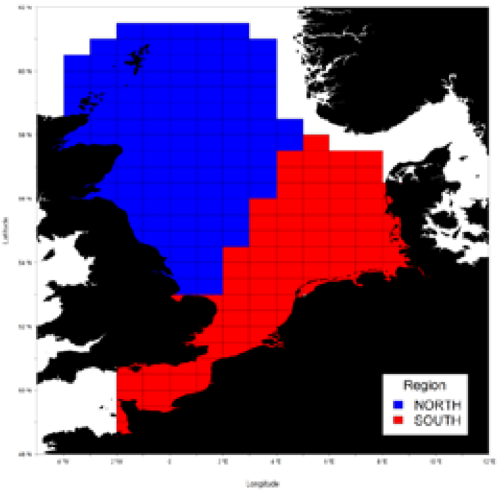


Figure 23.35. Whiting in Subarea 4 and Division 7.d: Components suggested by Holmes *et al*. (2014) to analyse spatial differences in maturation and SURBAR analysis.

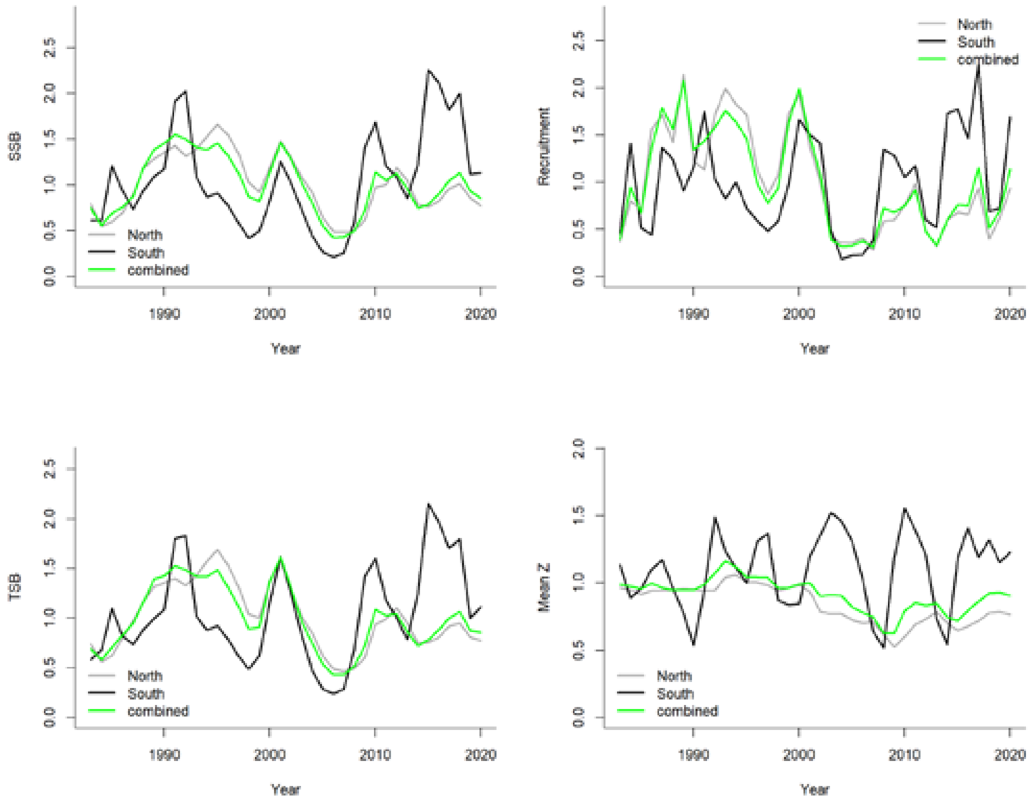


Figure 23.36. Whiting in Subarea 4 and Division 7.d: SURBAR results comparison combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018. Recruitment at age 1, total mortality is mean Z for ages 2–4.

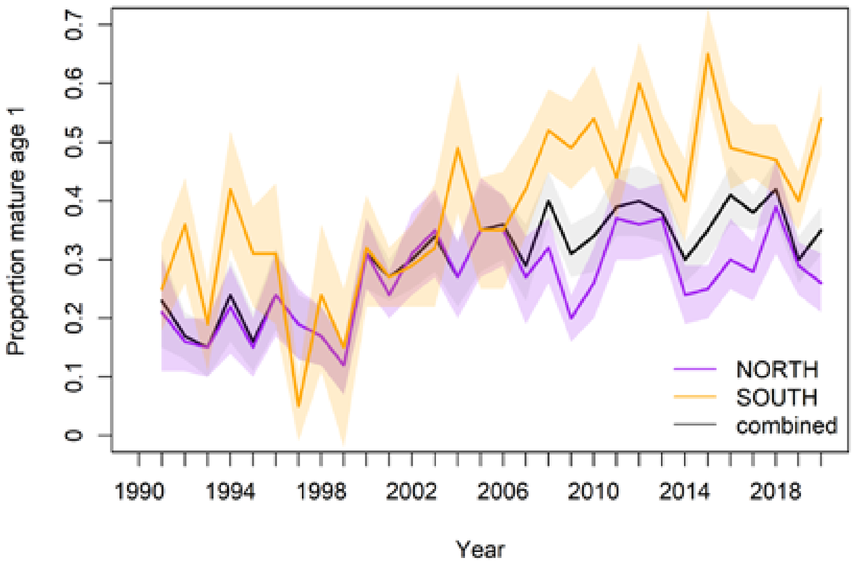


Figure 23.37. Whiting in Subarea 4 and Division 7.d: Trends in proportion mature individuals at age 1 for combined (whg.27.4.47d) and northern and southern component as defined in WKNSEA 2018.

24 Witch in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat) and 7.d (Eastern Channel)

24.1 General

Witch flounder (*Glyptocephalus cynoglossus*) was assessed, between 2010 and 2013, by the Working Group on Assessment of New MoU Species (WGNEW, ICES 2013a). The main task of WGNEW was to provide information on the new species of the MoU between ICES and the EC. Since 2014 WGNEW was dissolved thus this species was included in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).

Following the ICES guidelines for data limited stocks (ICES, 2012) witch was defined as a category 3 stock as only official landings and survey data were available. The biennial advice, drafted in 2013 (ICES, 2013b), was based on stock size indicators (DATRAS standardized CPUE in number per hour) derived from IBTS (both Q1 and Q3) and exploratory estimates (merely indicative of trends and not used for catch forecast) suggested that fishing mortality was above potential F_{MSY} proxies. In 2015, witch flounder was included in the official data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated by this group. The data call for the WGNSSK 2016 included landing and discard data for the years 2012–2015 in order to provide catch advice for this species. The same was done in 2017, with landing and discard data updated up to 2016. The new data-call in 2017 for the Benchmark Workshop (WKNSEA, 2018) included landing and discards data, by age and length, for the years 2002–2016. Following WKNSEA 2018 the stock became category 1. Hence a full analytical assessment was made at WGNSSK 2018 based on data up to 2017. However, being biennial, the advice was not re-opened in 2018. At WGNSSK 2019, the stock assessment was extended in order to include also 2018 data and a new advice was released. From 2019 onwards, the advice will be updated on an annual basis.

24.1.1 Biology and ecosystem aspects

The existing knowledge of witch biology is summarized in the Stock Annex.

In 2009, witch flounder has been included as a mandatory species in the EU Data Collection Framework (DCF). Accordingly, Denmark and Sweden started the regular sampling of biological data, i.e. length, weight, maturity status and age, in 3.a and 4 both for discards and landings. Scotland has also been collecting biological samples since 2009 but only from the landings.

Up to 2016, age determination has been conducted by Sweden, also for Scotland and Denmark (only landings). Age readings techniques are now well established but an inter-calibration among readers will be planned at the next WGBIOP (Working Group on Biological parameters) as from 2017; also Scotland has started to read otoliths for age estimation. The macroscopic evaluation of maturity status is still uncertain and gonadal histological analysis is under development. A fixed maturity ogive was employed in the assessment model. Data exploration and reason for the final decision are elucidated in WKNSEA 2018, WD3.

24.1.2 Management regulations

According to EU–Regulations a precautionary TAC is given in EU waters of 2.a and 4 together with lemon sole (*Microstomus kitt*). The TACs have been stable, varying around 6000 tonnes since

2006. There is no official Minimum Landing Size (MLS) specified in EU waters. However, in most of the countries reporting catches, the landing of witch below 28 cm is prohibited. Currently, lemon sole and witch flounder are managed under a combined species TAC, which prevents the effective control of the single species exploitation rates and could potentially lead to the overexploitation of either species. Furthermore, witch flounder is mainly a bycatch species in mixed fisheries (although some limited seasonal target fisheries occurs in 3.a; see Feekings, 2011) thus a TAC alone may not be appropriate as a management tool. Hence, 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).

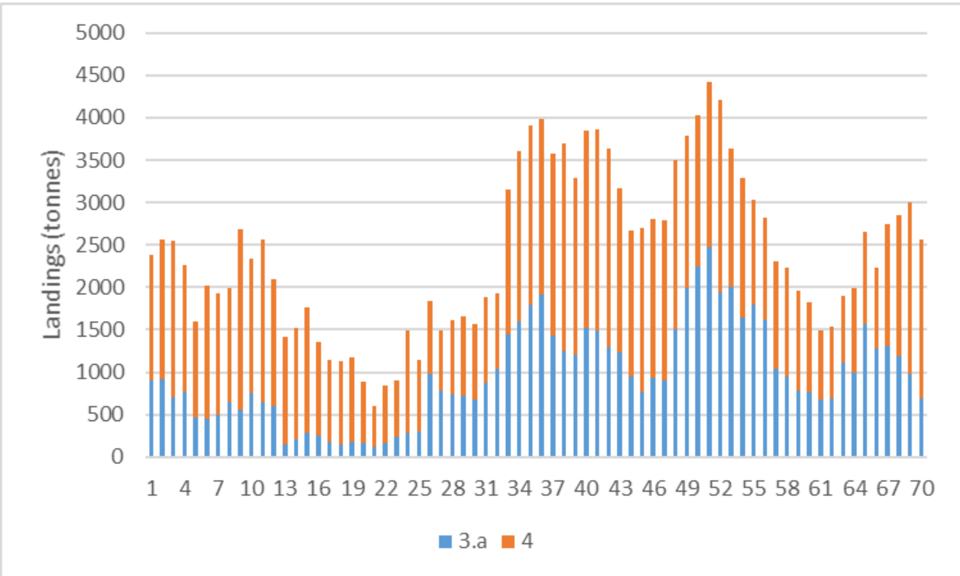


Figure 24.2.1.1. Witch flounder in Subarea 4 and Division 3.a: Total official landings (in tonnes).

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 2019, landings, discards and total catch at age and mean weight at age were updated up to 2019.

The ICES estimated catches for 2019 is 2797 tonnes, split as follows for the separate areas and catch categories:

Area	Landings	Discards	BMS landings
3.a	706.54	60.01	0
4	1872.37	155.95	1.01
7.d	0.77	0.02	0
Total	**2579.68**	**215.98**	**1.01**

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 2009–2019 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 2019. 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 2019 data required for the assessment.

The proportion of landings with associated discards (same strata) is 91 percent. In general, fleets using passive gears had no reported discards while fleets using selectivity devices (used only in Area 3.a) had always reported discards. The approach used for unmatched discard was to merge 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. 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 (63 tonnes in 2019) and is included in the landings.

The landings and discards imported or raised in InterCatch for 2019 are as follows (weights in tonnes; note any differences in landings and discards values to those given above are due to SOP correction; also 2.765 tonnes of landings and 0.23 tonnes of raised discards from Sweden are not included as they were not submitted to InterCatch):

CatchCategory	Imported/Raised	Catch(tonnes)	%
Landings	Imported Data	2580	100
Discards	Imported Data	184	85
Discards	Raised Discards	32	14.8
BMS landing	Imported Data	1	100
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 2019 are as follows (tonnes; note any differences in landings and discards values to those given above are due to SOP correction):

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	1732	67
Landings	Imported_Data	Estimated_Distribution	847.7	33
Discards	Imported_Data	Estimated_Distribution	129.6	60
Discards	Imported_Data	Sampled_Distribution	54.6	25
Discards	Raised_Discards	Estimated_Distribution	31.81	15
BMS landing	Imported_Data	Estimated_Distribution	1.007	100

For 2019, the largest amount of landings and discards in Subarea IV was reported by Scotland using respectively the métiers OTB_DEF_>=120_0_0_all and the OTB_CRU_70-99_0_0_all (Figures 24.1 and 24.2 middle plots). In Division 3.a Denmark (landings) and Sweden (discards), both using the OTB_CRU_90-119_0_0_all métier, showed the highest amount (Figures 24.1 and 24.2, upper plots). The total catch estimated with InterCatch in 2019 was 2797 tonnes, of which 216 tonnes were discards and 1 tonne were BMS. The unwanted catches were thus 7.8% of the total catch.

Swedish landings in Area 4, were not submitted to InterCatch and were made available during the WGNSSK group meeting. For witch, 2.765 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. The Swedish data are not included in the tables and totals above.

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—2019 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. 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. An overview of the reported landings and discards and the resulting discard rates combined for all fleets is given in Table 24.11. 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.

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.

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.

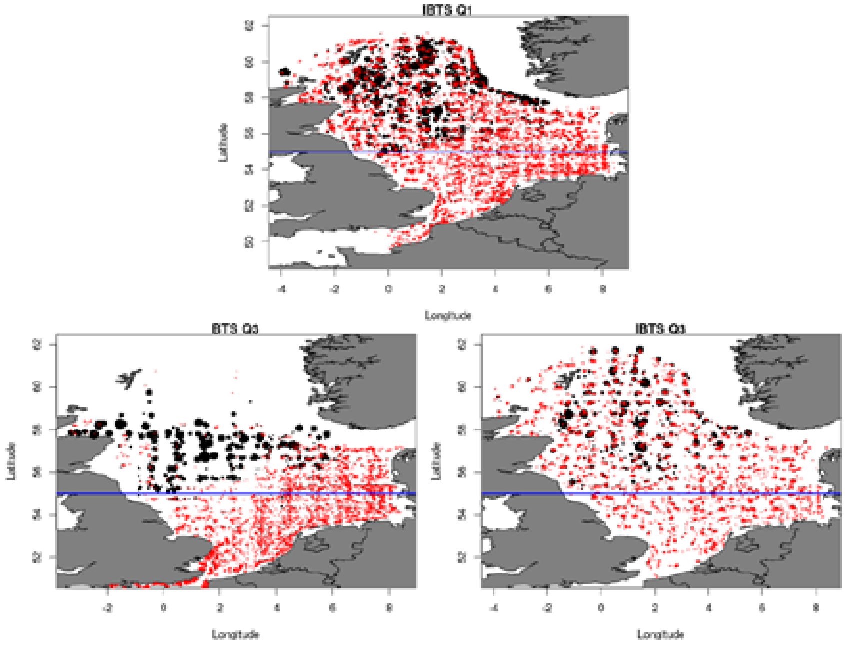


Figure 24.2.5.1. Witch flounder in Subarea 4 and Division 3.a: Aggregated distribution over the period 1983—2017 in the North Sea derived from IBTS–Q1 (upper) and Q3 (lower); data from that period are used to estimate the total biomass indices that are included in the assessment. The sizes of bubbles 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.

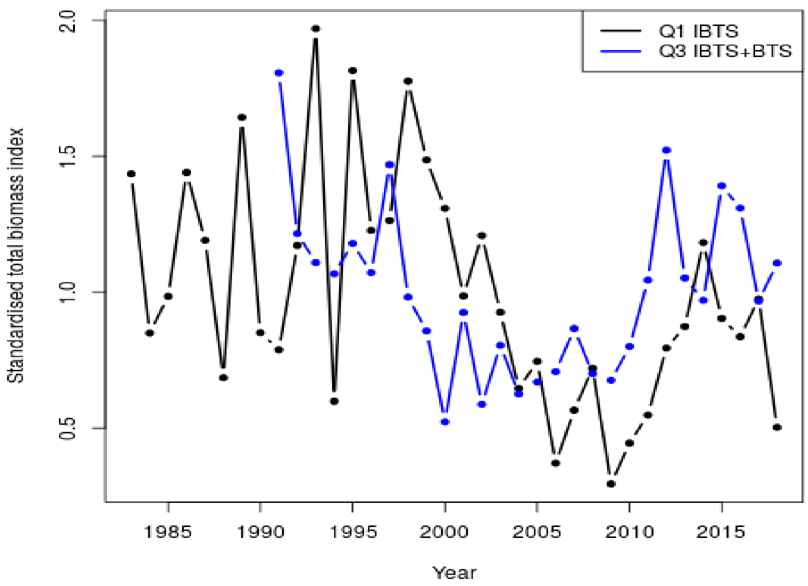


Figure 24.2.5.2. Witch flounder in Subarea 4 and Division 3.a: Q1 and Q3 indices of total biomass (rescaled to mean 1, until 2018). The assessment includes only the time-series up to and including 2008.

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 2019 is presented in Figures 24.4–24.7.

24.3.1 Assessment audit

24.3.2 Final assessment

The basic state-space assessment model (SAM) is described in Nielsen & Berg (2014). The current implementation (https://github.com/fishfollower/SAM) is an R-package based on Template Model Builder (TMB) (Kristensen *et al.*, 2016). The data set used to assess witch uses catches at age and age-specific indices from two scientific surveys from 2009 to 2019. The complete age-specific data set only covers a relative short time period; therefore, the time series is extended using total landings (1950–2008) and fishable stock biomass (FSB) indices (IBTS Q1: 1983–2008, IBTS + BTSQ3: 1991–2008).

The added observation equation for the total landed weight (TLW) was:

$$\log TLW_y = \log\left(\sum_{a=1}^{10^+}\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right)\overline{\Psi}_{a,}\overline{W}_{a,}^{(l)}\right) + \varepsilon_y^{(tlw)},$$

where $\epsilon^{(tlw)}$ is normally distributed with mean zero and a standard deviation, which is computed via the delta method from the standard deviation parameters of the age-specific log-catches. No additional model parameters are required.

The observation equation for the fishable stock biomass (FSB) was:

$$logF\,SB_y = logQ^{(s)} + log\widehat{F\,SB}_y + \varepsilon_y{}^{(s)}$$

where $\boldsymbol{Q}^{(s)}$ is the survey specific catchability, $\boldsymbol{s}$ denotes the survey and $\boldsymbol{\epsilon}_{\boldsymbol{y}}^{(s)}$ is normally distributed with mean zero and a standard deviation specific to the survey.

The parameter estimation was done by maximizing the joint likelihood (of random effects and observations and inference was made using the marginal likelihood calculated by integrating out the random effects using the Laplace approximation.

In order to obtain convergence, artificial catch-at-age data were added in the beginning of the time series (1940–1944) and leaving a period of five years without data before the total landings series started in 1950. The artificial catches at age were chosen to be equal to the average of the observed period (2009–2016). Sensitivity analysis showed that there was no influence of the choice of the artificial catches during the assessment period (1950–2016).

In addition to the observations on catches and surveys a set of biological parameters are available, these include: Mean weight in stock, mean weight in catch, mean weight in landing, proportion mature, and an estimate of natural mortality. The stock weight at age is shown in Table 24.6 and the maturity ogive in Table 24.7. Both are assumed constant for the whole time series. Landing/discard/catch weight at age are shown in Tables 24.5a–c. Natural mortality was assumed to be equal to 0.2 y^{-1} for all ages and years. The spawning stock biomass was calculated in the middle of the year, i.e. the proportion of F and M before spawning were set equal to 0.5.

During the WKNSEA 2018 benchmark an alternative SAM assessment was considered that only used the period where age information was available (2009–2016) termed as “standard”. The results of the “standard” assessment were consistent (but more optimistic) with the extended model during the period of the “standard” model.

The assessment estimates are shown in Figure 24.4 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__2020”. 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.

Catch at age	2009 – 2019	ages 1 – 10
Survey index IBTS Q1, by age	2009 – 2019	ages 1 – 7
Survey index IBTS Q3, by age	2009 – 2019	ages 1 – 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

$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
   0   1   2   3   4   5   5   5   5   5
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2

$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered
by fishing mortality).
```

```
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
   0   1   2   3   4   5   5  -1  -1  -1
   6   7   8   9  10  10  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  11  -1  -1  -1  -1  -1  -1  -1  -1  -1
  12  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyQpow
# Density dependent catchability power parameters (if any).
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
   0   0   0   0   0   0   0   0   0   0
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1

$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
   0   0   0   0   0   0   0   0   0   0
   1   1   1   1   1   1   1  -1  -1  -1
   2   2   2   2   2   2  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
   3  -1  -1  -1  -1  -1  -1  -1  -1  -1
   4  -1  -1  -1  -1  -1  -1  -1  -1  -1

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). |
Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID" "ID" "ID" "ID"

$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  NA  NA  -1  -1  -1
  NA  NA  NA  NA  NA  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  -1
```

```
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 0

$keyScaledYears
# A vector of the years where catch scaling is applied.


$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
# lowest and highest age included in Fbar
4 8

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1 4 2 2

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

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight,
1 fix variance to weight).
 0
```

24.4 Biological reference points

During WKNSEA 2018 EQSIM simulations were conducted using data from the accepted SAM assessment for the witch stock in the Greater North Sea. These followed the ICES advice technical guidelines as published 20 January 2017 (ICES, 2017) for the estimation of the reference points implemented in an R-script by D.C.M. Miller.

Recruitment at-age 1 from the assessment was used. Though strong autocorrelation in recruitment values was evident, no historic trends were observed in the stock–recruitment relation and therefore the entire time-series from 1940 was utilized in the estimation of reference points.

The average mean weight at age and exploitation pattern from 2009–2016 was used. The total number of simulations was set to 1001.

Three stock-recruitment models (Ricker, Beverton-Holt and segmented regression) were applied to the time series (1940–2016) with Beverton-Holt weighted highest (0.92) of the three methods. The stock was categorised as Type 2: “Stocks with a wide dynamic range of SSB, and evidence that recruitment is or has been impaired”. Furthermore, high autocorrelation was observed in the recruitment time series and was taken into account in the fitting of the segmented regression. B_{lim} was estimated as the change point of the segmented regression with autocorrelation equal to

3069 tonnes. B_{pa} was set equal to the 95th percentile of the distribution of the estimated SSB when SSB was set equal to B_{lim} (i.e. $B_{lim} * e^{-1.645\ sigmaSSB}$, where sigmaSSB is the standard deviation estimate of ln(SSB) in the final year of the assessment). Similarly, F_{pa} was calculated as the 95th percentile of the distribution of F, when F is equal to F_{lim} (i.e. $F_{lim} * e^{-1.645\ sigmaF}$, where sigmaF is the standard deviation estimate of ln(F) in the final year of the assessment).

The recommended default values of cvF = 0.212, phiF = 0.423 and cvSSB = 0 were applied to the simulation since no assessment/advice history is available for this stock. F_{MSY} was estimated equal to 0.154, which is below the originally-estimated F_{pa} (0.21) and the re-estimated F_{pa} (capped by $F_{P.05}$ without AR; 0.20).

MSY $B_{trigger}$ was set equal to B_{pa}, as it was not considered likely that the stock had been fished at F_{MSY} in the last 5 years.

The fishing mortality that leads to 5% probability of SSB falling below B_{lim} ($F_{P.05}$) was estimated during the benchmark meeting both including the ICES advice rule (AR), leading to 0.28 y^{-1}., and excluding the AR, leading to 0.20 y^{-1}. The former was greater than the originally estimated $F_{MSY\ upper}$, (0.21 y^{-1}) so was not used to cap $F_{MSY\ upper}$, but the latter was less than the originally-estimated F_{pa} (0.21 y^{-1}), and was therefore used to cap F_{pa}. All the reference points are shown in Table 24.12.

24.5 Short-term forecasts

Short-term forecasts were carried out based on the final SAM assessment. Recruitment in the intermediate year (2020) and the following two years was resampled from the recruitment estimates of the years 2017–2019; median was 24 699 thousand individuals (range: 18 465–36 285 thousand individuals). The fishing mortality in 2020 is assumed to be equal to the last estimate ($F_{2019} = F_{2020} = 0.20\ y^{-1}$) and the corresponding catch was 2 472 tonnes. The spawning stock biomass in the intermediate year was 5 644 tonnes.

The weight at age in the forecast is assumed to be the average over the years 2017–2019. Natural mortality and maturity ogives were constant and equal to the ones used in the assessment. No TAC constraint is assumed for the intermediate year.

In total, 11 forecast scenarios were run, and the summary of the results is shown in Table 24.11. The forecasted fishing morality, recruitment and catch of the MSY approach scenario ($F=F_{MSY}$), 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)	-0.1933
SSB	-0.1025
F_{4-8}	0.1392

Age information is only available for the last 11 years of the assessment, i.e. 2009–2019, not allowing for an assessment based solely on age specific information. The estimates during the period prior to 2009 have higher uncertainty. The model is informed only by landings from 1950 to 1983, therefore, the results during that period should be considered with caution. Sensitivity tests during WKNSEA 2018 showed that there is minimal effect from the initialisation period (1940–1949) on the estimates during recent years, which are important for management of the stock. As the catch at age time series grows over the years, a pure age-based assessment should be considered as the final assessment.

24.7 Status of the stock

Witch is being overfished; the fishing mortality in 2019 was equal to 0.20 y^{-1}, above F_{MSY} (0.154 y^{-1}). The biomass of the stock (5993 tonnes) was above the MSY $B_{trigger}$ (4745 tonnes) and the stock was at full reproductive capacity, i.e. the biomass is above B_{lim} (3069 tonnes). The recruitment shows a decreasing trend since 2009 and catches have increased in the same period.

24.8 Management consideration

The decreasing recruitment in the last decade in connection with the increasing catches could potentially reduce the biomass of the stock below the biological reference point. The advice is based on the assumption that the recruitment will be in the range of the observed recruitment in the last decade, i.e. for each simulation the value of the recruitment is sampled randomly from the estimates of that period.

Witch and lemon sole are managed using a common TAC. Furthermore, the TAC area (Subarea 4 and Division 2.a) does not coincide with the stock area (Subarea 4 and divisions 3.a and 7.d). This increases the risk of both stocks of being overexploited.

24.9 Issues for future benchmarks

Witch was benchmarked in 2018, implementing a new assessment and raising from category to 3 to category 1 (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 whole time series (1940–2016), which includes the period before the data start (1940–1949) and the period where catch is the only available information (1950–1982). The adequacy of the assessment to estimate SSB and recruitment during that period should be evaluated.

24.10 References

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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

*** 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 are preliminary.

Year	3.a	4	Tot
1950	902	1477	2379
1951	923	1645	2568
1952	713	1841	2554
1953	767	1496	2263
1954	463	1127	1590
1955	450	1577	2027
1956	502	1434	1936
1957	643	1348	1991
1958	559	2119	2678
1959	752	1581	2333
1960	640	1923	2563
1961	594	1499	2093
1962	148	1271	1419
1963	209	1314	1523
1964	288	1472	1760
1965	260	1096	1356
1966	175	962	1137
1967	152	973	1125
1968	185	989	1174
1969	156	735	891
1970	118	479	597
1971	162	681	843

Year	3.a	4	Tot
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
2010	675	815	1490
2011	693	837	1530

Year	3.a	4	Tot
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

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

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

Year	Number of age measurements		Number of age samples	
	Denmark	Sweden	Denmark	Sweden
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

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

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

Year/Age	1	2	3	4	5	6	7	8	9	10+
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

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

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

Year/Age	1	2	3	4	5	6	7	8	9	10+
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

Table 24.6. Witch flounder in Subarea 4 and Division 3.a and 7.d: Stock weights at age (kg).

1	2	3	4	5	6	7	8	9	10+
0.00547	0.03279	0.07720	0.15139	0.23394	0.33624	0.37684	0.42882	0.44348	0.49543

Table 24.7. Witch flounder in Subarea 4 and Division 3.a and 7.d: Constant maturity ogive.

1	2	3	4	5	6	7	8	9	10*	11*	12*
0	0	0.114	0.136	0.275	0.376	0.428	0.524	0.631	0.671	0.882	1

*** The assessment uses age 10 as a plus group, therefore maturation of age 10 is the average of ages 10–12, 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		
	R	Low	High	SSB	Low	High	F(4-8)	Low	High
1950	26092	14012	48585	3586	1730	7437	0.289	0.159	0.528
1951	27044	14818	49358	3539	1705	7348	0.301	0.164	0.552
1952	30071	16589	54510	3378	1601	7128	0.31	0.167	0.575
1953	33611	18819	60031	3109	1431	6753	0.303	0.159	0.578
1954	35468	19852	63367	2870	1296	6356	0.278	0.142	0.543
1955	33889	18567	61854	2873	1287	6413	0.292	0.149	0.569
1956	28582	15267	53510	2899	1310	6415	0.289	0.148	0.565
1957	23517	12326	44866	3016	1389	6545	0.291	0.151	0.562
1958	20808	11086	39058	3172	1487	6768	0.314	0.166	0.593
1959	20108	10995	36773	3133	1477	6649	0.315	0.167	0.596
1960	19120	10237	35710	2990	1382	6467	0.33	0.174	0.629
1961	17021	8987	32237	2676	1189	6025	0.323	0.165	0.63
1962	15159	8106	28351	2384	1028	5533	0.295	0.148	0.589
1963	13898	7433	25986	2254	960	5290	0.306	0.154	0.606
1964	12279	6374	23652	2121	900	5000	0.33	0.167	0.65
1965	10724	5492	20941	1879	796	4437	0.322	0.161	0.64
1966	10601	5552	20242	1674	705	3974	0.314	0.157	0.629
1967	12461	6807	22811	1526	640	3637	0.325	0.163	0.649
1968	16976	9554	30164	1377	568	3336	0.342	0.17	0.689
1969	21685	12224	38470	1196	482	2964	0.323	0.156	0.67
1970	24555	13709	43981	1095	443	2706	0.285	0.135	0.602
1971	24667	13809	44062	1165	488	2783	0.297	0.144	0.614
1972	24574	13587	44446	1325	587	2988	0.296	0.147	0.597
1973	24318	13459	43938	1580	732	3412	0.314	0.161	0.613
1974	24791	13654	45011	1762	841	3690	0.293	0.152	0.567
1975	26682	14703	48422	1989	965	4101	0.314	0.167	0.59
1976	30814	17132	55421	2065	1007	4235	0.302	0.162	0.563
1977	39048	22077	69067	2159	1055	4417	0.302	0.164	0.556
1978	50079	28995	86497	2238	1102	4546	0.3	0.166	0.545
1979	58533	33292	102911	2354	1183	4682	0.29	0.162	0.519
1980	59534	33302	106428	2614	1367	4997	0.29	0.167	0.505
1981	56338	31372	101173	3033	1679	5481	0.283	0.168	0.475
1982	53336	29683	95837	3715	2180	6330	0.305	0.192	0.486

Year	R (age 1)			SSB (tonnes)			Fishing pressure		
	R	Low	High	SSB	Low	High	F(4-8)	Low	High
1983	51850	28927	92936	4305	2659	6972	0.315	0.205	0.484
1984	53591	30278	94854	4631	2936	7302	0.32	0.213	0.482
1985	55711	31885	97341	4774	3053	7466	0.32	0.215	0.476
1986	55875	31739	98365	4816	3086	7515	0.31	0.21	0.459
1987	50965	28478	91206	4847	3105	7566	0.308	0.209	0.455
1988	45161	24882	81967	4877	3147	7559	0.296	0.202	0.432
1989	41189	22693	74762	5120	3343	7840	0.299	0.207	0.432
1990	41001	22851	73568	5204	3454	7842	0.296	0.208	0.422
1991	43042	24252	76389	5205	3506	7729	0.285	0.202	0.403
1992	46962	26723	82529	5042	3424	7424	0.269	0.191	0.379
1993	49993	28472	87783	4891	3326	7191	0.253	0.179	0.358
1994	51693	29065	91937	4803	3271	7054	0.252	0.178	0.356
1995	51326	28890	91185	4911	3343	7214	0.254	0.18	0.36
1996	50610	28802	88930	4972	3404	7261	0.26	0.184	0.368
1997	48402	27545	85053	5137	3521	7497	0.286	0.203	0.405
1998	45209	25452	80304	5060	3441	7440	0.316	0.222	0.45
1999	41633	23176	74789	4812	3211	7211	0.35	0.243	0.505
2000	39745	22091	71509	4454	2908	6822	0.39	0.268	0.565
2001	41347	23952	71374	4068	2638	6275	0.412	0.286	0.593
2002	40283	23678	68533	3613	2352	5551	0.423	0.299	0.601
2003	35667	21215	59963	3223	2155	4820	0.425	0.308	0.585
2004	27864	16630	46689	2895	2021	4147	0.425	0.319	0.566
2005	24109	14467	40178	2724	2006	3699	0.414	0.322	0.533
2006	25322	15659	40946	2609	2013	3381	0.376	0.3	0.471
2007	22939	13774	38203	2608	2071	3283	0.355	0.286	0.44
2008	48202	31839	72974	2516	2021	3132	0.346	0.278	0.431
2009	89970	61467	131692	2294	1819	2893	0.359	0.284	0.454
2010	86319	58315	127772	2220	1731	2847	0.316	0.245	0.407
2011	42216	28243	63101	2621	2020	3403	0.238	0.179	0.315
2012	32683	21820	48954	3441	2620	4519	0.203	0.15	0.274
2013	34382	22784	51884	4451	3329	5950	0.192	0.14	0.262
2014	34253	22351	52493	5448	3995	7430	0.207	0.152	0.283
2015	22471	14457	34928	5642	4056	7848	0.196	0.14	0.274
2016	13406	8263	21750	5910	4154	8409	0.189	0.132	0.27
2017	24699	14820	41163	6217	4223	9154	0.204	0.14	0.297
2018	18469	10509	32457	6276	4067	9684	0.192	0.126	0.292
2019	36285	18652	70587	5993	3642	9860	0.202	0.128	0.318

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 2009–2019.

Year	1	2	3	4	5	6	7	8	9	10+
1950	0.022	0.072	0.098	0.165	0.26	0.34	0.34	0.34	0.34	0.34
1951	0.023	0.075	0.102	0.171	0.27	0.36	0.36	0.36	0.36	0.36
1952	0.023	0.077	0.105	0.176	0.28	0.37	0.37	0.37	0.37	0.37
1953	0.023	0.076	0.102	0.172	0.27	0.36	0.36	0.36	0.36	0.36
1954	0.021	0.069	0.094	0.158	0.25	0.33	0.33	0.33	0.33	0.33
1955	0.022	0.073	0.098	0.166	0.26	0.34	0.34	0.34	0.34	0.34
1956	0.022	0.072	0.098	0.164	0.26	0.34	0.34	0.34	0.34	0.34
1957	0.022	0.073	0.098	0.165	0.26	0.34	0.34	0.34	0.34	0.34
1958	0.024	0.078	0.106	0.178	0.28	0.37	0.37	0.37	0.37	0.37
1959	0.024	0.079	0.106	0.179	0.28	0.37	0.37	0.37	0.37	0.37
1960	0.025	0.082	0.112	0.188	0.29	0.39	0.39	0.39	0.39	0.39
1961	0.024	0.08	0.109	0.183	0.29	0.38	0.38	0.38	0.38	0.38
1962	0.022	0.074	0.100	0.168	0.26	0.35	0.35	0.35	0.35	0.35
1963	0.023	0.076	0.103	0.174	0.27	0.36	0.36	0.36	0.36	0.36
1964	0.025	0.082	0.111	0.188	0.29	0.39	0.39	0.39	0.39	0.39
1965	0.024	0.08	0.109	0.183	0.29	0.38	0.38	0.38	0.38	0.38
1966	0.024	0.078	0.106	0.179	0.28	0.37	0.37	0.37	0.37	0.37
1967	0.025	0.081	0.11	0.185	0.29	0.38	0.38	0.38	0.38	0.38
1968	0.026	0.085	0.116	0.194	0.31	0.4	0.4	0.4	0.4	0.4
1969	0.024	0.08	0.109	0.183	0.29	0.38	0.38	0.38	0.38	0.38
1970	0.022	0.071	0.096	0.162	0.25	0.34	0.34	0.34	0.34	0.34
1971	0.022	0.074	0.100	0.169	0.27	0.35	0.35	0.35	0.35	0.35
1972	0.022	0.074	0.100	0.168	0.26	0.35	0.35	0.35	0.35	0.35
1973	0.024	0.078	0.106	0.179	0.28	0.37	0.37	0.37	0.37	0.37
1974	0.022	0.073	0.099	0.167	0.26	0.35	0.35	0.35	0.35	0.35
1975	0.024	0.078	0.106	0.178	0.28	0.37	0.37	0.37	0.37	0.37
1976	0.023	0.075	0.102	0.172	0.27	0.36	0.36	0.36	0.36	0.36
1977	0.023	0.075	0.102	0.172	0.27	0.36	0.36	0.36	0.36	0.36
1978	0.023	0.075	0.102	0.171	0.27	0.35	0.35	0.35	0.35	0.35
1979	0.022	0.072	0.098	0.165	0.26	0.34	0.34	0.34	0.34	0.34
1980	0.022	0.072	0.098	0.165	0.26	0.34	0.34	0.34	0.34	0.34
1981	0.021	0.07	0.095	0.161	0.25	0.33	0.33	0.33	0.33	0.33
1982	0.023	0.076	0.103	0.174	0.27	0.36	0.36	0.36	0.36	0.36
1983	0.024	0.078	0.106	0.179	0.28	0.37	0.37	0.37	0.37	0.37
1984	0.024	0.08	0.108	0.182	0.29	0.38	0.38	0.38	0.38	0.38
1985	0.024	0.08	0.108	0.182	0.29	0.38	0.38	0.38	0.38	0.38
1986	0.023	0.077	0.105	0.176	0.28	0.37	0.37	0.37	0.37	0.37
1987	0.023	0.077	0.104	0.175	0.28	0.36	0.36	0.36	0.36	0.36
1988	0.022	0.074	0.100	0.168	0.26	0.35	0.35	0.35	0.35	0.35

Year	1	2	3	4	5	6	7	8	9	10+
1989	0.023	0.075	0.101	0.17	0.27	0.35	0.35	0.35	0.35	0.35
1990	0.022	0.074	0.1	0.168	0.26	0.35	0.35	0.35	0.35	0.35
1991	0.022	0.071	0.096	0.162	0.25	0.34	0.34	0.34	0.34	0.34
1992	0.02	0.067	0.091	0.153	0.24	0.32	0.32	0.32	0.32	0.32
1993	0.0191	0.063	0.086	0.144	0.23	0.3	0.3	0.3	0.3	0.3
1994	0.019	0.063	0.085	0.143	0.22	0.3	0.3	0.3	0.3	0.3
1995	0.0192	0.063	0.086	0.144	0.23	0.3	0.3	0.3	0.3	0.3
1996	0.0196	0.065	0.088	0.148	0.23	0.31	0.31	0.31	0.31	0.31
1997	0.022	0.071	0.097	0.163	0.26	0.34	0.34	0.34	0.34	0.34
1998	0.024	0.079	0.107	0.18	0.28	0.37	0.37	0.37	0.37	0.37
1999	0.026	0.087	0.118	0.199	0.31	0.41	0.41	0.41	0.41	0.41
2000	0.029	0.097	0.132	0.22	0.35	0.46	0.46	0.46	0.46	0.46
2001	0.031	0.103	0.139	0.23	0.37	0.49	0.49	0.49	0.49	0.49
2002	0.032	0.106	0.143	0.24	0.38	0.5	0.5	0.5	0.5	0.5
2003	0.032	0.106	0.144	0.24	0.38	0.5	0.5	0.5	0.5	0.5
2004	0.032	0.106	0.144	0.24	0.38	0.5	0.5	0.5	0.5	0.5
2005	0.031	0.103	0.14	0.24	0.37	0.49	0.49	0.49	0.49	0.49
2006	0.028	0.094	0.127	0.21	0.34	0.44	0.44	0.44	0.44	0.44
2007	0.027	0.089	0.12	0.20	0.32	0.42	0.42	0.42	0.42	0.42
2008	0.026	0.086	0.117	0.197	0.31	0.41	0.41	0.41	0.41	0.41
2009	0.027	0.09	0.121	0.20	0.32	0.42	0.42	0.42	0.42	0.42
2010	0.024	0.079	0.107	0.18	0.28	0.37	0.37	0.37	0.37	0.37
2011	0.0179	0.059	0.08	0.135	0.21	0.28	0.28	0.28	0.28	0.28
2012	0.0153	0.05	0.068	0.115	0.181	0.24	0.24	0.24	0.24	0.24
2013	0.0145	0.048	0.065	0.109	0.171	0.23	0.23	0.23	0.23	0.23
2014	0.0157	0.052	0.07	0.118	0.185	0.24	0.24	0.24	0.24	0.24
2015	0.0148	0.049	0.066	0.112	0.175	0.23	0.23	0.23	0.23	0.23
2016	0.0143	0.047	0.064	0.107	0.169	0.22	0.22	0.22	0.22	0.22
2017	0.0154	0.051	0.069	0.116	0.182	0.24	0.24	0.24	0.24	0.24
2018	0.0145	0.048	0.065	0.109	0.171	0.23	0.23	0.23	0.23	0.23
2019	0.0152	0.05	0.068	0.115	0.18	0.24	0.24	0.24	0.24	0.24

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 2009–2019.

Year	1	2	3	4	5	6	7	8	9	10+
1950	26092	21790	19255	15873	11165	6983	4278	2666	1504	1925
1951	27044	20512	16376	14415	11233	7197	4124	2518	1564	2017
1952	30071	21332	15289	11931	9968	7104	4178	2384	1453	2073
1953	33611	24025	15935	11038	7987	6091	3995	2362	1350	1994
1954	35468	27216	18218	11575	7369	4782	3361	2225	1329	1861
1955	33889	29024	21042	13688	8239	4815	2874	2012	1325	1911
1956	28582	27849	22554	15722	9398	5161	2786	1667	1166	1873
1957	23517	23013	21767	17095	11039	5931	3003	1621	971	1767
1958	20808	18555	17613	16627	12331	7270	3538	1772	950	1616
1959	20108	16338	13839	12981	11445	7604	4108	2003	1003	1452
1960	19120	16129	12143	10045	8957	7248	4381	2348	1139	1400
1961	17021	15477	12202	8707	6628	5350	3965	2410	1295	1401
1962	15159	13599	11852	8968	5760	3899	2880	2152	1321	1469
1963	13898	12065	10343	8958	6401	3683	2279	1678	1254	1627
1964	12279	11204	9098	7640	6317	4158	2160	1324	971	1689
1965	10724	9829	8514	6594	5069	3768	2282	1192	732	1461
1966	10601	8354	7445	6301	4458	3063	2085	1271	666	1218
1967	12461	8179	6165	5506	4401	2796	1750	1189	723	1075
1968	16976	9656	5959	4408	3766	2761	1590	990	670	1022
1969	21685	13726	7042	4176	2841	2195	1472	857	536	910
1970	24555	17763	10507	5003	2713	1648	1171	794	468	775
1971	24667	20168	13888	8059	3544	1753	976	692	468	736
1972	24574	19781	15716	10474	5631	2215	1009	562	399	693
1973	24318	19702	15069	11993	7563	3701	1301	588	326	637
1974	24791	19323	14935	11003	8028	4489	2040	727	330	539
1975	26682	19632	14616	11202	7910	5344	2691	1202	424	508
1976	30814	21026	14697	10623	7505	4786	2978	1512	678	526
1977	39048	24192	15737	10771	7319	4702	2757	1715	870	692
1978	50079	31172	18021	11453	7341	4564	2698	1584	984	897
1979	58533	40856	23621	13046	7727	4504	2593	1539	906	1075
1980	59534	48248	31719	17544	8980	4874	2622	1510	895	1154
1981	56338	48399	37812	23912	12077	5570	2801	1514	875	1183
1982	53336	45148	37485	29252	17649	8026	3343	1664	894	1220
1983	51850	42440	34252	27931	20384	11225	4646	1923	954	1214
1984	53591	40924	31898	25061	18984	12492	6336	2627	1087	1225
1985	55711	42791	30606	23359	17097	11715	7042	3572	1478	1301
1986	55875	44863	32363	22270	15855	10482	6582	3957	2008	1562
1987	50965	45561	34205	23810	15115	9813	5955	3745	2248	2029
1988	45161	41009	35213	25318	16171	9180	5497	3354	2118	2411

Year	1	2	3	4	5	6	7	8	9	10+
1989	41189	35959	31487	26926	18181	10561	5439	3231	1959	2659
1990	41001	32374	27132	23361	18778	11475	6120	3145	1865	2669
1991	43042	32478	24222	20022	16262	11990	6719	3569	1826	2641
1992	46962	34210	24475	17646	13718	10193	6970	3919	2085	2610
1993	49993	37864	25962	18049	12111	8676	5996	4121	2324	2780
1994	51693	40374	29133	19229	12579	7735	5186	3597	2482	3059
1995	51326	41897	31339	22143	13728	8339	4760	3185	2201	3406
1996	50610	41255	32330	23502	15539	8815	5008	2870	1924	3368
1997	48402	40889	31691	24459	16922	10360	5417	3057	1743	3239
1998	45209	38953	31263	23361	16820	10660	6047	3166	1786	2911
1999	41633	36243	29587	23029	15812	10268	5979	3403	1783	2642
2000	39745	32955	27293	21643	15551	9467	5568	3242	1845	2398
2001	41347	31063	24427	19850	14465	9189	4977	2913	1688	2216
2002	40283	33263	22565	17321	12898	8226	4655	2518	1472	1974
2003	35667	32588	24893	15783	11113	7275	4115	2327	1256	1722
2004	27864	29012	24438	17837	9909	6143	3589	2036	1154	1475
2005	24109	21637	21966	17711	11640	5445	3021	1773	1007	1302
2006	25322	18380	15637	15970	11431	6460	2608	1476	876	1133
2007	22939	20782	13193	11123	11140	7047	3511	1338	765	1037
2008	48202	15368	16021	9182	7286	6954	3965	1941	700	935
2009	89970	39367	9681	11957	5920	4314	4013	2269	1087	834
2010	86319	83482	30010	6149	7998	3245	2391	2161	1087	927
2011	42216	75275	63226	20448	3971	5425	1857	1418	1078	938
2012	32683	35474	57200	43486	12461	2793	3750	1232	836	1163
2013	34382	26143	25183	35893	26476	7080	2157	2633	868	1556
2014	34253	26461	21414	21314	25175	15882	4326	1627	1857	2070
2015	22471	27600	22601	18254	16695	15826	9045	2652	987	2249
2016	13406	16584	22432	19552	14420	12711	9907	5496	1769	1835
2017	24699	9490	12861	18823	15691	10582	8861	5997	3446	2595
2018	18469	21199	7320	10565	15891	11171	7998	5788	3282	3541
2019	36285	15031	19850	6339	8752	11734	7791	5599	3525	3716

Table 24.11. Witch flounder in Subarea 4 and Division 3.a and 7.d: Short-term forecasting scenarios and results.

Basis	Total catch (2021)	Projected landings (2021)	Projected discards (2021) *	F_{total} ages 4–8 (2021 & 2022)	SSB (2021)	SSB (2022)	% SSB change **	% Advice change ***
ICES advice basis								
MSY approach: F_{MSY}	1733	1681	53	0.154	5490	5476	-0.25	5.0
Other scenarios								
$F_{MSY\text{-}upper}$	2295	2228	67	0.21	5327	5006	-6.0	39
$F_{MSY\text{-}lower}$	1243	1210	33	0.108	5635	5898	4.7	-25
F = 0	0	0	0	0	5976	6992	17.0	-100
F_{pa}	2195	2131	65	0.20	5353	5082	-5.1	33
F_{lim}	3135	3033	103	0.30	5074	4341	-14.4	90
F_{sq}	2215	2150	66	0.20	5348	5063	-5.3	34
SSB (2022) = B_{lim}	4942	4793	149	0.53	4508	3069	-32	199
SSB (2022) = B_{pa}	2629	2547	82	0.24	5222	4745	-9.1	59
SSB (2022) = MSY B_{trig}	2629	2547	82	0.24	5222	4745	-9.1	59
Roll-over advice	1651	1603	48	0.146	5515	5561	0.85	0

*** Including BMS landings (EU stocks), assuming recent discard rate (average of 2017—2019).**

**** SSB in 2022 relative to SSB in 2021.**

***** Total catch in 2021 relative to advice for 2020 (1651 tonnes).**

Table 24.12 Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Reference points estimated using EQSIM.

Reference Point	Estimate
MSY $B_{trigger}$	4745 tonnes
B_{lim}	3069 tonnes
B_{pa}	4745 tonnes
F_{MSY}	0.154 y^{-1}
$F_{MSY\ upper}$	0.21 y^{-1}
$F_{MSY\ lower}$	0.108 y^{-1}
F_{lim}	0.30 y^{-1}
F_{pa}*	0.20 y^{-1}

$F_{P0.5}$ (with AR)	0.28 y^{-1}
$F_{P0.5}$ (without AR)	0.20 y^{-1}

*** The original F_{PA} was 0.21, but this is greater than $F_{P.05}$ (without AR), and is therefore capped by the latter**

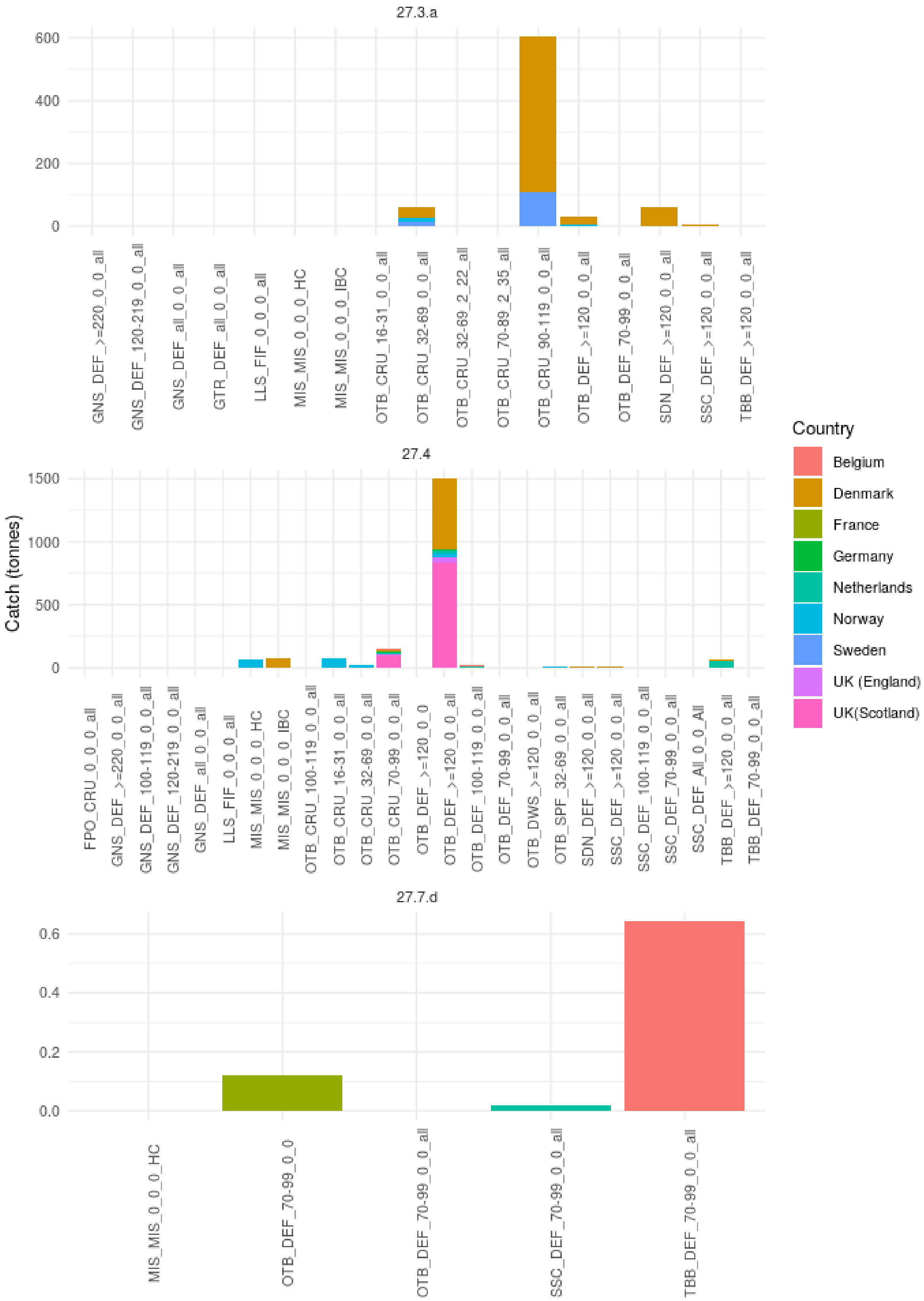

Figure 24.1. Witch flounder Division 3.a (upper plot), in Subarea 4 (middle plot) and Division 7.d (lower plot): Catches in tonnes by métier and country in 2019.

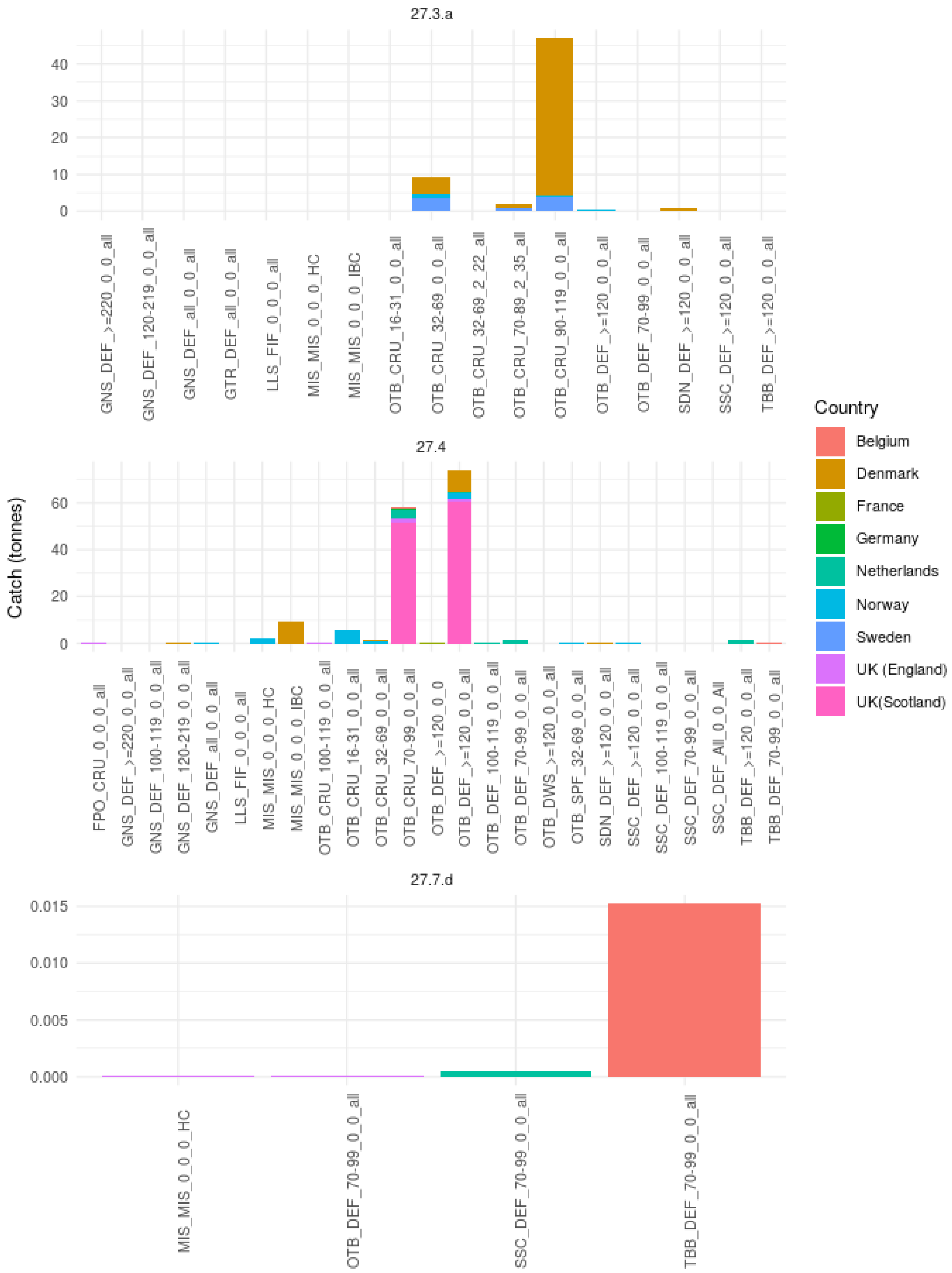

Figure 24.2. Witch flounder in Division 3.a (upper plot), Subarea 4 (middle plot) and Division 7.d (lower plot): Discards by métier and country in 2019.

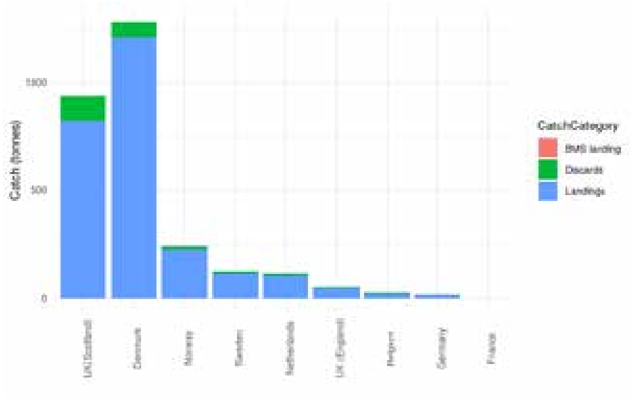

Figure 24.3. Witch flounder in Subarea 4 and Division 3.a: Estimated catch categories by countries in 2019.

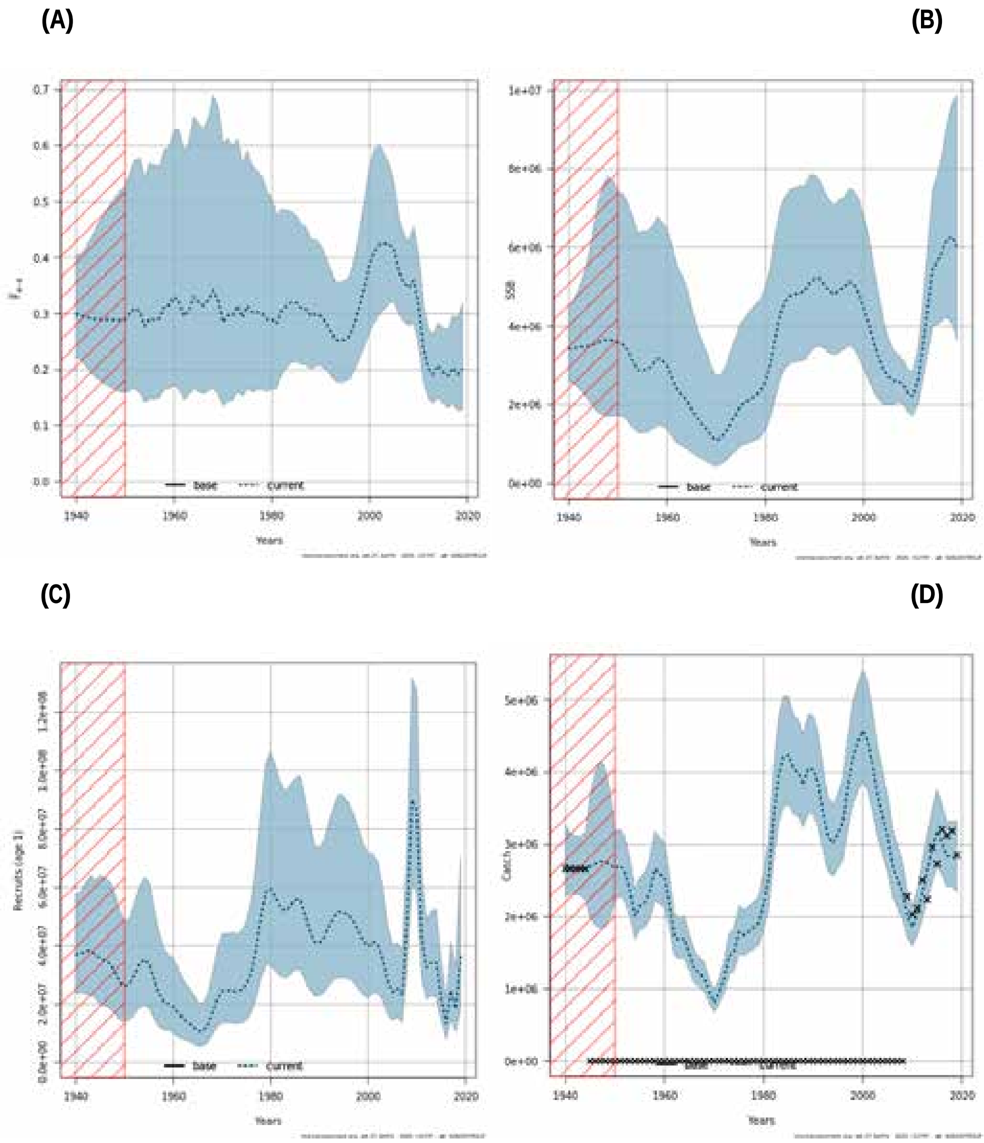

Figure 24.4. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model, fishing mortality (A), SSB (B), Recruits (C) and Catch (D). Median estimates (dashed lines) and point wise 95% confidence intervals (shaded area). The red line shaded area shaded is the period prior to the observations, used for initialization.

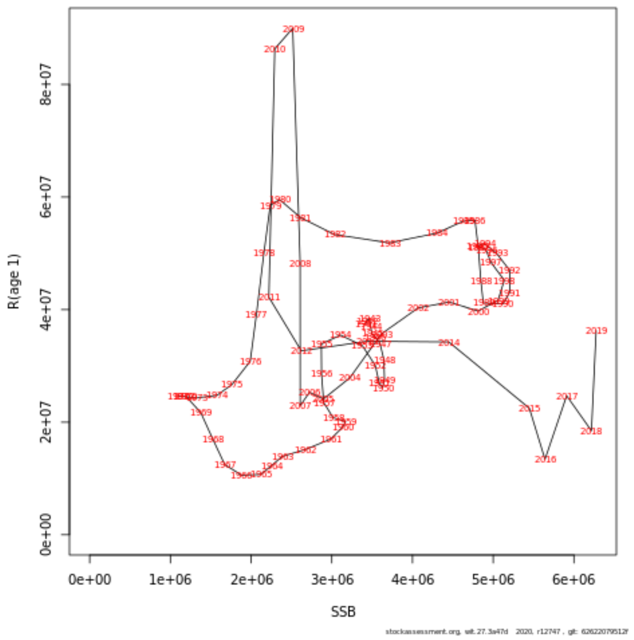

Figure 24.5. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Recruits over spawning stock biomass (SSB).

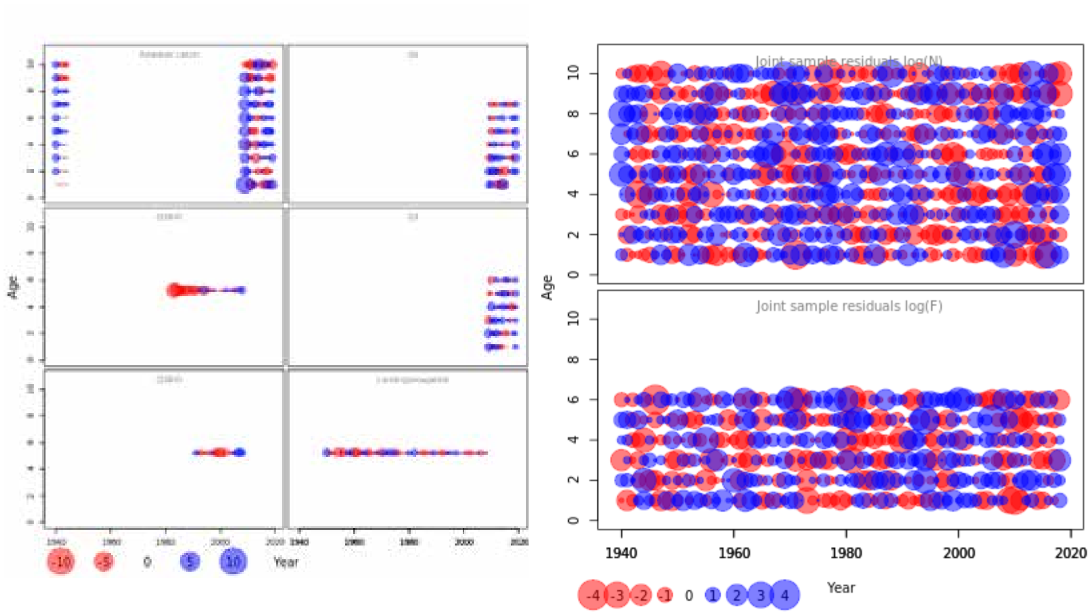

Figure 24.6. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Residual plots, standardized one-observation-ahead residuals (left) and standardized single-joint-sample residuals of process increments (right).

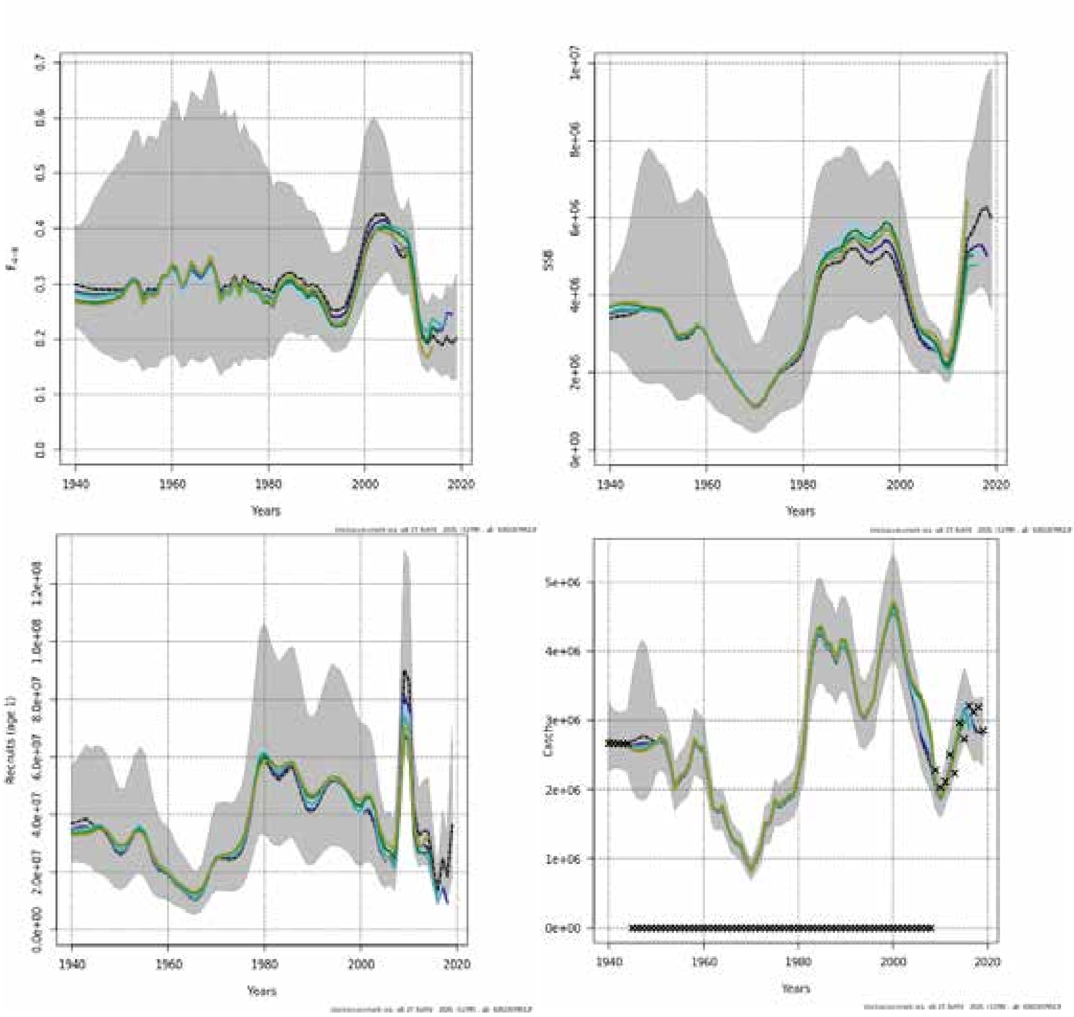

Figure 24.7. Witch flounder in Subarea 4 and Divisions 3.a and 7.d: Results of the SAM model. Retrospective analysis, for fishing mortality (top left), spawning stock biomass (SSB, top right), recruits (bottom left) and catch (bottom right).

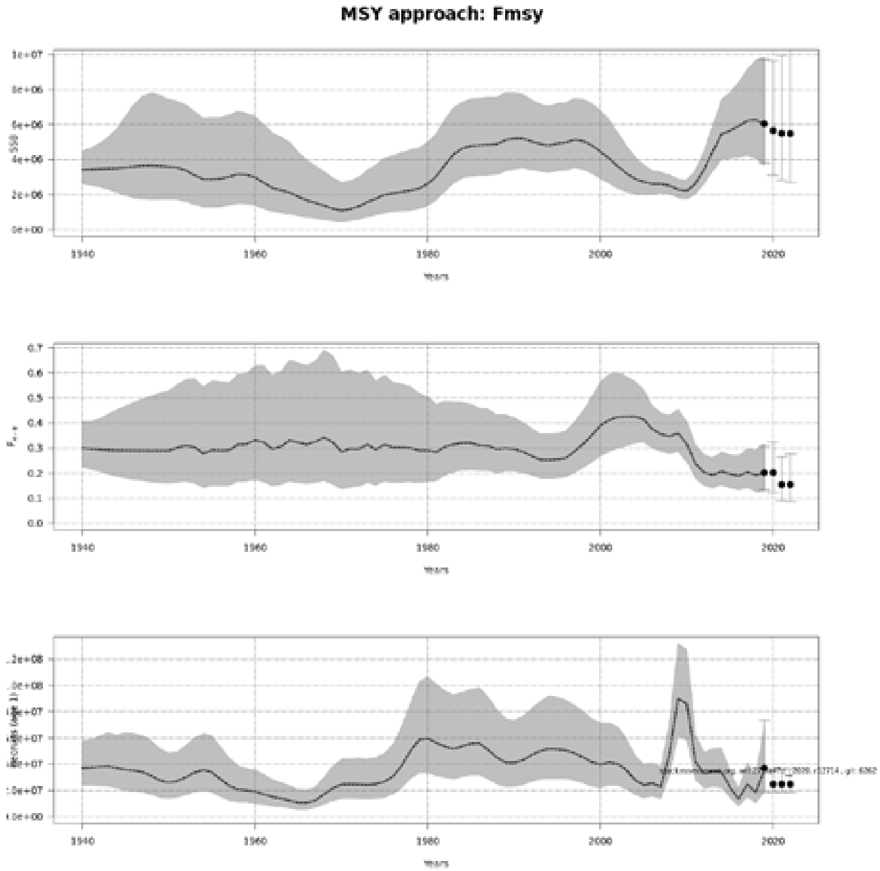

Figure 24.8. Witch flounder in Subarea 4 and Division 3.a: Short-term forecast under the MSY approach scenario (F_{2021} = F_{MSY} = 0.154 y^{-1}) of the spawning stock biomass (SSB, in kg, top), the fishing pressure (F_{4-8}, middle) and recruits (bottom).

Annex 1: List of participants

Name	Country
Anja Helene Alvestad	Norway
Jurgen Batsleer	Netherlands
Alan Baudron	United Kingdom
Ewen D. Bell	United Kingdom
Chun Chen	Netherlands
Harriet Cole	United Kingdom
José De Oliveira	United Kingdom
Jordan P. Feekings	Denmark
Raphaël Girardin	France
Ghassen Halouani	France
Holger Haslob	Germany
Alexander Kempf	Germany
Alexandros Kokkalis	Denmark
Tiago Malta	Denmark
Carlos Mesquita	United Kingdom
Tanja Miethe	United Kingdom
Iago Mosqueira	Netherlands
Nikolai Nawri	United States
Coby Needle	United Kingdom
Anders Nielsen	Denmark
J. Rasmus Nielsen	Denmark
Erik Olsen	Norway
Alessandro Orio	Sweden
Yves Reecht	Norway
Jon Egil Skjæraasen	Norway
Andreas Sundelöf	Sweden
Jon Svendsen	Denmark

Guldborg Søvik	Norway
Marc Taylor	Germany
Mats Ulmestrand	Sweden
Wouter van Broekhoven	Netherlands
Lies Vansteenbrugge	Belgium
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

2019/2/FRSG18 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, 22 April – 1 May 2020 and by correspondence in September 2020 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;

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 2020 ICES data call.

WGNSSK will report by 15 May 2020, and by 25 September 2020 (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

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C.4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller subgroups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
   - zero TAC has been advised in recent years and no change likely,
   - category 3 or greater roll over advice, except if due to be reviewed in 2020
   - long lived stable stocks, with no strong trends in dynamics in recent years
   - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list.
Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant. **Check the list of the stocks to be done in detail and those to roll over.**

   i) Input data and examination of data quality;
   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.
   v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
   vi) The state of the stocks against relevant reference points;
   vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;
   viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

a) Consider and comment on Ecosystem and Fisheries overviews where available;

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

    i) descriptions of ecosystem impacts of fisheries
    ii) descriptions of developments and recent changes to the fisheries
    iii) mixed fisheries considerations, and
    iv) emerging issues of relevance for the management of the fisheries;

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Annex 3: Resolution for 2021 meeting

Generic ToRs for Regional and Species Working Groups

2019/2/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 for the fisheries relevant to the working group on:

i) descriptions of ecosystem impacts of fisheries

ii) descriptions of developments and recent changes to the fisheries

iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarising where the item is relevant:

i) Input data and examination of data quality;

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

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

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

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

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

viii) Historical and analytical performance of the assessment and catch options with a succint description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

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

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

g) Identify research needs of relevance for the work of the Expert Group.
h) Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice.

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

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

2019/2/FRSG18 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, 20 April – 29 April 2021 and by correspondence in September 2020 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;

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 2020 ICES data call.
WGNSSK will report by 15 May 2020, and by 25 September 2020 (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

Annex 4: List of stock annex edits

The table below provides an overview of the WGBIE Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under, 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.

	Title	Name
1	cod.27.47d20_SA	Cod (*Gadus morhua*) in Subarea 4 and divisions 7.d and 20 (North Sea, eastern English Channel, Skagerrak)
2	ple.27.7d_SA	Plaice (*Pleuronectes platessa*) in Division 7.d (eastern English Channel)
3	pok.27.3a46_SA_updated_WGNSSK_2020	Saithe (*Pollachius virens*) in subareas 4, 6 and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)
4	sol.27.4_SA	Sole (*Solea solea*) in Subarea 4 (North Sea)
5	Stock Annex Nephrops FU 32_2020	FU32 Norwegian Deep
6	Stock Annex PLE 420_update_2020	Plaice in 4 and 3a20
7	Stock Annex_sol27.7d_October2019	Sole in Division 27.7.d
8	tur.27.3a_SA_JCS_AK	Turbot (Scophthalmus maximus) in Division 3.a (Skag-errak and Katte-gat)
9	tur.27.4_SA	Turbot (Scophthalmus maximus) in Subarea 4 (North Sea)
10	whg.27.3a_SA	Whiting (Merlangius merlangus) in Division 3.a (Skag-errak and Katte-gat)
11	wit.27.3a47d_SA	Witch (Glyptocephalus cynoglossus) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)

Annex 5: Audit reports

Audit of Bll.27.3a47de

Date: 15/05/2020
Auditor: Alessandro Orio

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.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes

- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes, no management plan
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes (assessment)
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes.

Audit of (Whiting in 4 and 7d)

Date: 18.05.2020
Auditor: Alexander Kempf

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

9) **Assessment type: update**
10) **Assessment**: analytical
11) **Forecast**: presented
12) **Assessment model**: SAM, 2 survey tuning indices (IBTS q1 and q3)
13) **Data issues:** All data available, age reading may be uncertain/biased.
14) **Consistency**: Update from 2019 assessment, but the procedure for age allocations in IBTS survey indices changed. This also changed the survey indices to a minor extent. Retrospective patterns could be improved by using the new time series with automated age allocations. In addition, the impact on reference points as calculated during the last benchmark was minor compared to an an update with new data ➔ Decision was made to use the new time series.
15) **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 at MSY $B_{trigger}$ and B_{pa},
16) **Management Plan**: Part of the EU plan. Shared stock with Norway ➔ Advice based on the MSY approach

General comments

Overall, this was a well documented, well ordered and considered section. It was easy to follow and interpret. However, some of the paragraphs are a bit outdated and not all numbers (i.e. years) are updated. Please check carefully once more. I tried to make comments where it catched my eyes.

Technical comments

Sometimes the numbering of tables and figures is not in line with the order the tables are referenced in the text.

Please state at the beginning of the chapter that the assessment follwos the stock annex and benchmark deicsions, but that new time series for IBTS q1 and q3 are used. Maybe even write a short paragraph on this decision.

A paragraph and at least a figure regarding the reference point checks made is missing.

At least a figure comparing the 2018 Intercatch output to the new output for 2018 could be added.

The paragraph on the negative gradients in the catch cohort analysis seems to be outdated.

In the Excel tables to produce the forecast, there is a discrepancy between the table under "Outputwg2020" and the "final table with rounding". In the Fsq scenario (F= 0.208 in 2020 and 2021) in the WG2020 output the yield is 32267, but in the final rounded table it is 31512. Please check!

There is an inconsistency in ICES catch estimates between the report and advice sheet. In table 23.12 the total catch is 31216 and in table 4 of the advice sheet the total catch is 31286 and in table 5 it are 31195 tonnes. Please check!

The SM option tbale is outdated and there are more options (i.e. $conf$predVarObsLink) in the new version of SAM. Please update in the stock Annex and in the report ().

Further minor issues are directly mentioned in the report.

Conclusions

The assessment has been performed correctly, however, consistency of forecast outputs and catch input to the assessment need to be checked!

The report needs also one more careful checking whether all numbers, years etc are updated in the text. I tried to find these errors as much as possible.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes, EU plan (but not agreed by Norway)
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes

- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of (Stock name)

Date: 24/4-2020 (preliminary version) and final version 6/5-2020
Auditor: J. Rasmus Nielsen

- *Audience to write for: ICES WGNSSK Stock Assessor; ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

The Gug43a7d stock is a data limited DLS Category 3.2 stock where only survey data (IBTS Q1 and Q3) and limited catch data are available. ICES is not requested to provide advice for the stock, and it is a non-targeted stock with no TAC advice. It is a mixed fishery stock, and there are very high discard rates among the commercial fisheries harvesting the stock. ICES produces a biennial advice sheet for the stock.

To analyse stock trends a mature biomass index was calculated based on the LBI method (Length Based Index). This is done by estimating Lmax (and from here the Linf) from commercial fishery InterCatch data covering all commercial fleets and fisheries (?, see technical comment below) from 2015-2019 and by applying a length-weight relationship and a maturity ogive obtained from the IBTS Q1 and Q3 survey CA records for the same period (?, see technical comments below).

The preliminary comments relates to the presentation of the assessment to ICES WGNSSK the 23/4-2020 and this is updated by 6/5-20 with final comments based on the draft working group report available by the end of WGNSSK meeting.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

17) **Assessment type:** Update (SALY - every second year; biennial advice);
18) **Assessment**: Trends (check of stock status according to MSY Proxies using a Length Based Index (LBI) for mature stock biomass;
19) **Forecast**: Not presented;
20) **Assessment model**: MSY Proxies using a Length Based Indicator (LBI) for mature stock biomass using InterCatch data for all commercial fleets and fisheries from 2015-2019 and applying IBTS Q1+Q3 based condition (length-weight) factor and maturity ogive (see technical comments below). Thus, input from several commercial fleets and 2 research surveys are used (see also technical comments below).

21) **Data issues:** Data are available; Updated data up to 2019 have been used; Data have been presented in the WGNSSK report and presentation (data are more extensively described here than in the stock annex); See specific technical comments below in relation to the input data;
22) **Consistency:** This assessment is consistent with the last assessment conducted for the stock.
23) **Stock status**: B_{MSY} (L(mean) / L(F=M)) > 1 (1.07).
24) **Management Plan**: There is no management plan agreed, and ICES is not requested to provide advice for the stock. It is a non-targeted stock with no TAC advice.

General comments

This is a well documented, well ordered and considered assessment (and section). The assessment is easy to follow and interpret.

Technical comments

Comment 1:

It is in accordance with the issues list of the assessment working group report noted that there are some issues with the reporting of grey gurnard for some nations (e.g. Germany, UK England), where for example 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.

Additional to this note it could be emphasized that the discards estimates will most often be based on observer on board monitoring where specific species are identified, while in the landings there occur this grouping. Furthermore, there may be different targeting between species in the combined species group among other because of price differences, and there is also different selectivity according to the different species in the commercial fishery, and also in relation to selectivity in the survey trawls. This may result in, that the survey species ratios (and biological data) are not representative for the landing species ratios (and biological data and parameters).

Furthermore, it is also in accordance with the issues list of the assessment working group report noted that 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. It should in future benchmark be investigated to what extent on-board-observer monitoring information and data actually exist (are available) for these fleets and fisheries. This could maybe give indication of catch/discard for these fleets/fisheries.

Comment 2:

It was during the presentation of the assessment discussed whether the method used for estimating Lmax is the most appropriate one. Lmax is used for estimating the Linf which again is used as input in the LBI method for assessing the stock (mature stock biomass index). Currently (up to this years assessment working group meeting), the Lmax is calculated based on length frequency distribution from InterCatch where the data are averaged. It was questioned whether the Lmax estimate would change much if the data were all pooled. Furthermore, it is by the auditor noted that it could be a good idea at a certain point to test whether Linf estimated based on survey data would differ much from the InterCatch data based estimate. It is recommended that the above analyses are only conducted for a check whether the Lmax and Linf are very different using the different methods and data sources, and accordingly commented upon. If there are significant changes then a change of method should be implemented in a coming benchmark. Different methods for estimating Lmax were investigated during the working group meeting and it was on this basis concluded that the method used so far is robust.

Comment 3:

It is noted that the p-mega in the LBI analysis is below 30% in 2019, however, main focus should be put on that the L(mean) / L(F=M) is above 1 (1.07) in 2019 which indicates that the stock is on a sustainable level.

Comment 4:

It could with advantage be indicated that the data time series for applying a length-weight relationship and a maturity ogive obtained from the IBTS survey CA records cover the same period (2015-2019) as the InterCatch data used for estimating the LBI (Length Based Index) as a MSY proxy.

It is noted that biological data are not collected on a routine basis for grey gurnard in the IBTS. Accordingly, it is important to indicate what specific survey data sources and time series have been used for the above calculations.

It could with advantage be indicated whether the InterCatch data used for estimating the LBI index cover all commercial fleets and fisheries, i.e. not only selected fleets, and it could with advantage be indicated whether the condition (length-weight) factor is calculated from both the IBTS Q1 and Q3 or only one of them, as well as whether the maturity ogive is based on only IBTS Q1 data or both IBTS Q1 and Q3.

Comment 5:

The slight change made in groupings for discard raising compared to previous data years is justified by the fact it was not possible to make raising in some cases for the groupings used in previous years assessment because of lack of available data according to used data resolution. It could with advantage be detailed a bit more for which of the previous years groups this was not possible in order to document further the extent of this problem and that this change was necessary. The revised groupings is based on gear type and mesh size over areas and season which appears sensible and appropriate.

Comment 6:

In general the working group report contain much more extensive and detailed information on management, fishery and fishery data, surveys and survey data, biological sampling, population dynamic parameters, analysis of stock trends (assessment) and assessment method used compared to the Stock Annex that was last updated in 2014.

Some parts of the biological information on the species/stocks in the first sections of the working group report is also of a general and long term / fixed character that in some cases belong more to the stock annex than the regularly updated working group report.

It is recommended that this extensive information in the assessment working group report is merged into the stock annex - at least for the planned benchmark of the stock for 2021.

Minor technical and editorial comments in relation to working group report and draft advice sheet:

a) Working Group Report: The units in Tables 7.4 to 7.6 should be indicated in the table captions.

b) Working Group Report, section 7.2.1 third paragraph: The described official landings for “Compared to 2018 the official landings in 2019 increased slightly to 1621 tonnes (1620 tonnes in 2018)” cannot be found in Tables 7.4 to 7.6? Furthermore, these two numbers does not indicate a slight increase but rather a constant level. In the draft advice sheet the official landings for 2018 are indicated to be 1600 tonnes which is not consistent with the above. Please, check carefully all the numbers in the text against the numbers in the tables as well as the numbers in the draft advice sheet.

c) Draft Advice Sheet: The discards in tonnes for 2019 does not match in Tables 5 and 6 in the draft advice sheet.

d) Working Group Report Figure 7.2: Check that correct year ranges are given in the figure caption. It seems to be 1994 instead of 1993, and maybe also 1981 instead of 1980?

e) Working Group Report Section 7.5: In section 7.5 second paragraph there is referred to section 4. This must be section 7.4?

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of lemon sole in Subarea 4 and divisions 3.a and 7.d.

Date: 15/05/2020
Auditor: Jon C. Svendsen

General

Audit was based on the report, powerpoint presentations, stock annex and benchmark report.

For single stock summary sheet advice:

1) **Assessment type:** Updated assessment and advice according to the benchmark winter 2017/2018.
2) **Assessment**: Lemon sole is a category 3 species according to the ICES guidelines.
3) **Forecast**: presented.
4) **Assessment model**: The GAM estimation approach was used to generate updated Q1 (IBTS) and Q3 (IBTS and BTS) survey series for lemon sole. The stock assessment model used for the basis of the advice is SURBAR, including ad hoc adjustments for low catchability of available surveys. 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 length-based indicators (LBIs).
5) **Data issues:**
   For 2013, there are issues with Dutch discard samples. The problem has been identified in previous years as well and is described in the benchmark report. The 2013 data were therefore considered erroneous and left out.
   The Stock Annex for this assessment highlights the full age range (1-5) to be used from the Q1 (IBTS) series, but following presentations at the 2018 meeting, it was 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, consistent with the 2019 meeting. For Q3 (IBTS+BTS), ages 1-9 were used according to the Stock Annex.
   During the WG meeting, it was discovered that Sweden had uploaded catch data incorrectly to InterCatch. Therefore, 3.820 tonnes of Swedish landings were missing together with an unknown quantity of discards. The missing landings were added manually. The overall estimated discard rate for the stock (15.49%) was used to generate Swedish discards, which were also added manually to the total catch.
   Consistency: Consistent with the benchmark.
6) **Stock status**: Results of LBI suggest that F_{msy} is not exceeded for this stock, in agreement with WGNSSK meetings in 2017-2019.
7) **Management Plan**: None.

General comments

The work is well described in the report and presented during the WGNSSK meeting.

Technical comments

In Figure 9.6.2., data for 2013 are described in the figure caption, but the 2013 data are not present in the associated graph.

Conclusions

The assessment has been performed correctly.

Audit of Saithe (Pollachius virens) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat) (pok.27.3a46)

Date: 12 May 2020
Auditor: Coby Needle

General

Overall a good, clear stock section, with just a couple of technical typos to be addressed.

For single stock summary sheet advice:

25) **Assessment type:** update
26) **Assessment**: analytical
27) **Forecast**: presented
28) **Assessment model**: state-space stock assessment model (SAM) – tuning by one commercial CPUE index and one age-structured survey index
29) **Data issues:**
    a. The WG report mentions that discard ratios of greater than 0.5 were not used in raising for unsampled fleets. This stipulation is not mentioned in the Stock Annex, so I wonder if it is accepted practice. It seems a little extreme – for lemon sole we used a 1.5 ratio cut-off.
    b. Otherwise, the data are as described in the Stock Annex.
30) **Consistency**: The SAM assessment has been carried out as stipulated in the Stock Annex.
31) **Stock status**: B > MSY Btrigger since 1998, while F > Fmsy since 2016. Recent R estimates have fluctuated around a low mean level.
32) **Management Plan**: No agreed management plan (EU-Norway plan still in development), so advice is based on the ICES MSY approach.

General comments

This stock section was clear for the most part, and followed the Stock Annex (with a couple of exceptions). The closing comments on the quality of the assessment and issues for future benchmarks are extensive, which (I think) reflects continuing uncertainty over how robust and representative the assessment is.

Technical comments

1. See comment on "Data issues" above regarding the use of a discard ratio cut-off, which is not stipulated in the Stock Annex.
2. Section 16.3.2, second paragraph: Tables 16.3 and 16.3.3 are mentioned, but I don't think they are the correct tables to reference here.
3. Figure 16.3.9 only includes catches and discards, not landings.
4. Section 16.3.5, first line: Table 16.3.11 is referred to, but this should be Table 16.4.1. "2018" at the end of that first paragraph should be "2019".
5. Section 16.6: this states that the recruitment is resampled from 2010-2019, but the Stock Annex stipulates that the resampling should be from 1998-present. Should the SA be updated?
6. Section 16.7, second paragraph, third line: 2018 should be 2019.

Conclusions

The assessment has been performed correctly and the stock section summarises it clearly.

Audit of Sole in 7d (sol.27.7d)

Date: 12.05.2020
Auditor: H. Haslob

General

The sole 27.d stock was inter-benchmarked in 2019. Analyses revealed that the XSA model had problems to correctly estimate the plus group and that there were issues with French commercial data for 2016 and 2017. Therefore, the assessment was downgraded to a category 3 assessment indicative of trends only for the latest advice. The issues should be solved in a full benchmark in 2020. However, the problems could not be solved during this benchmark and the working group decided to keep the category 3 methods previously used as the basis for the new advice.

The remaining issues will be investigated during a new upcoming benchmark, probably in 2021.

The results of the current assessment revealed that the relative fishing pressure is below relative reference points and the SSB is above the relative reference points. The index ratio of the category 3 method was 1.14, thus the new catch advice of 3428 is 14% higher compared to the advised catch for 2020.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

33) **Assessment type:** Update assessment
34) **Assessment**: Category 3 stock; XSA indicative of trends
35) **Forecast**: presented, but not used for the Category 3 advice
36) **Assessment model**: XSA
37) **Data issues:** Updated InterCatch data up to 2019 have been used; Data have been presented in the WGNSSK report and presentation; there are issues with French commercial data for the years 2016 – 2017, which have to be solved in an upcoming benchmark assessment.
38) **Consistency:** This assessment is consistent with the last assessment conducted for the stock.
39) **Stock status**: F below $F_{MSY\ proxy}$, F_{pa}, F_{lim}; SSB above MSY $_{Btrigger\ proxy}$ and above B_{pa}, B_{lim}.
40) **Management Plan**: EU multiannual plan (MAP) for the Western waters

General comments

This is a well documented, well ordered and considered assessment and section. The section also contains all the work which was done treating sole 7d as a category 1 stock (recruitment estimates, short term forecast, previously used reference points).

The assessment has been conducted following the methods and procedures described in the stock annex. The 2-over-3 rule was performed correctly.

Technical comments

Working group report:

18.1.3.1

For Belgian beam trawlers in 7.d (and 27.7.fg, 27.7.a) it is mandatory since 1 April 2015 to incorporate a 3 m long section (tunnel) with a 120 mm mesh size before the cod-end (Flemish panel), in order to reduce the catches of small sole (reduction of undersized sole with 40% and marketable sole with 16%). -> *Is this the correct mesh size, seems quite large mesh size to prevent small sole to be caught?*

Table 18.1: remove asterisks from recent years TACs. Or move explanation from caption to foot note.

18.2.7

Last sentence -> *four fleets!?*

Advice sheet:

Table 6: 2018 ICES landings -> 2287^; *probably the cap can be deleted or is a caption missing?*

Conclusions

The assessment has been performed correctly.

Audit of (Stock name)

Date: 14/05/2020
Auditor: Chun Chen

For the attention of the ADG, ACOM, WGNSSK, benchmark groups and EG.

General

For single stock summary sheet advice:

41) **Assessment type: update**
42) **Assessment**: analytical
43) **Forecast**: presented
44) **Assessment model**: Art and Poos statistical cath-at-age model, using catch data in model and forecast, tuning by BTS (NL, BE and DE). Some structures were re-specified during the 2020 benchmark (see table below).
45)

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

46) **Data issues:** No issues

47) **Consistency**: The new stock assessment has led to a substantial revision of the estimates of spawning biomass and fishing mortality over the last 10 years. This change appears to be driven by the use of the GAM-standardized index of abundance.

48) **Stock status**: 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 between B_{pa}, and B_{lim}.

49) **Management Plan**: EU multiannual plan (MAP).

General comments

Well documented, easy to follow. Below are only few typo and editting issues.

Technical comments

Advice sheet:

Table 9: TAC 2018 and 2019 were not correct

Table 10: the 2019 discards should be ICES_discards-official_BMS = ices discards-48 t

Report:

Section 17.7, the geometric mean period was 1957-2016

Section 17.9, reference point Blim=30828

It would be nice to have a table of estimated SSB from AAP model, in addition to stock.n and F table. It makes easier to check the results (e.g. SSB 2019, SSb 2020)

Stock annex:

Page 7: I think you dont need to specifically mention actions taken in a specific year. Fsatus quo, average of last 3 years exploitation pattern was taken if there was no trend in F. In case there is a trend in F, we take status quo, re-scaled to the Fbar of last year.

Conclusions
The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of turbot in the Skagerrak (tur.27.3a)

Date: 21/05/2020
Auditor: Alessandro Orio

For the attention of ADGNS, ACOM, WGNSSK, benchmark groups and EGs.

General

For single stock summary sheet advice:

50) **Assessment type:** Category 3 (only stock status)
51) **Assessment**: Proxy reference points for relative exploitable biomass and relative fishing pressure coming from SPiCT
52) **Forecast**: No forecast
53) **Assessment model**: SPiCT
54) **Data issues:** The newly developed biomass index obtained by combining information from survey indices covering Division 3.a shows residual autocorrelation in the model.
55) **Consistency**: No comparative assessment in previous years.
56) **Stock status**: SPiCT analysis indicates that the stock is fished above the proxy reference point for F_{MSY}, while the relative exploited biomass is above the biomass reference point.
57) **Management Plan**: No management plan exists for this stock. ICES have not been requested to provide management advice, so the WGNSSK report and advice sheet only summarise perceptions of stock status.

General comments

The draft report section for this stock was available at time of the audit. The report summarises stock status through landings and discards data, along with an illustrative SPiCT run.

Technical comments

Advice sheet:

- The advice sheet has been updated as required, and appears to cover the available information. No advice is requested for this stock, so the advice sheet only summarises catch and survey data and presents a SPiCT run to give information on stock status.

Report section:

- Few inconsistencies were reported to the assessor and have already been fixed in the report.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? No advice for this stock.

Audit of Cod in Subarea 4 and divisions 7.d and 20 (North Sea, eastern Engli5h Channel, Skagerrak)

Date: 15. May 2020

Auditor: Alexander Kempf

For the attention of the advisory drafting group, ACOM, WGNSSK and scientists contributing data and analyses before the working group meeting.

General

The assessment approach is identical to last year's "final assessment" with one additional year of data. The calculation of maturity at age was more difficult this year as there were not enough fish caught in the southern part of the Noreth Sea to derive an age length key. Therefore, the ALK had to be borrowed from the north western part of the North Sea. The influence on the results is very minor and the main source of changes in the assessment compared to last year (retro) was the addition of one data year for catches and surveys. Although the retrospective performance of the assessment became a bit better, it is still a major source of concern.

For single stock summary sheet advice:

58) **Assessment type:** Update of last year's assessment
59) **Assessment**: analytical
60) **Forecast**: Same approach as decided in 2017.
61) **Assessment model**: SAM model with commercial catch data and two survey indices (IBTS q1 and q3) as input.
62) **Data issues:** ALK in the estimation procedure for maturity at age had to be borrowed for the southern component. Influence on results is very minor. French data were re-uploaded for 2018. Intercatch raising was redone with very minor changes to the output. Swedish catches for area 4 were not available in Intercatch and had to be added manually.

63) **Consistency**: Consistent with last year's assessment except for changes to historic values used as input (slight revisions in maturity at age and delta GAM indices, re-upload of French Intercatch data for 2018). All settings and assumptions identical to 2019 assessment

64) **Stock status:** F is above F_{lim} and point estimate of spawning stock size is below $B_{lim.}$

65) **Man. Plan.**: There is currently no management plan agreed by all parties. Advice should be given according to ICES F_{MSY} approach

General comments

The assessment is very well described and visualized. However, the report would benefit from substantial shortening of the text. Lots of historical developments are described that are no longer relevant. This could be moved to the stock annex at the next benchmark as it confuses more than it helps.

Technical comments

In the tables showing the Intercatch output, it could be made more clear whether SOP values or uploads in weight are shown. In addition, there is a potential inconsistency with tbale 4.2c that need to be checked.

Only 36 tonnes are landed in 7d in 2019! Either this is a serious data issue (but official landings are also only 37 tonnes) or this needs to be highlighted in the report as it speaks for a complete collapse of the stock in 7d. It could be also mentioned in the advice sheet. But also last year it were only 84 tonnes and there is no text allowed this year. But to my opinion this is extremely worrying and deserves attention by managers.

A graph showing changes in the Delta GAM index from one year to the next could be added.

There is still a serious contradiction between negative gradients calculated based on commercial catch and based on the surveys. I think this deserves some more discussion.

Description of the intermediate year recruitment assumption is a bit unclear. Is only the median taken into account or also the distribution around the median? Is also not clearly specified in the stock annex.

The SAM configuration table in the stock annex is outdated. The new versions of SAM have more options (e.g., `$obsCorStruct and $keyCorObs). An update of the table would be beneficial to make clear to everyone that the settings used in the update assessment are in line with the stock annex.`

There is no official BMS column in the summary of the assessment in the advice sheet as for other stocks. This is maybe ok because for cod SAM predicted catches (landings and discards) are tabulated and not the input. But it should be checked by the ADG as reported BMS for cod may be of high interest to stakeholders.

Further minor comments were provided directly in the document.

Conclusions

The assessment has been run in accordance with the benchmark choices. Check after potential inconsistency is clarified.

Audit of Turbot in Subarea 4 (North Sea)

Date: 19 May 2020

Auditor: José De Oliveira

For the attention of the advisory drafting group, ACOM, WGNSSK and scientists contributing data and analyses before the working group meeting.

General

Turbot underwent an inter-benchmark in 2018 (IBPTurbot 2018) to fix an error in the way the LPUE index was treated in the assessment; during this inter-benchmark, the assessment model fit was substantially improved, to the extent that the stock was upgraded to a Category 1 stock (from Category 3), and reference points estimated. It was decided during 2019 to set F_{PA} to $F_{P.05}$ (without the advice rule, i.e. "without AR"), and the headline advice for 2020 was on the basis of PA using F_{PA}=$F_{P.05}$ (without AR)=0.47. The advice for 2021 was on the basis of the MSY approach.

The stock annex is comprehensive and well-written, but needs to be updated to reflect the new calculation of F_{PA} (as explained above). The report section is also well-written, but there are some discrepancies with the advice sheet (see below).

Detailed edits and comments have been included in the stock annex and the report section, submitted to the stock assessor. Relatively minor issues were found with the advice sheet.

For single stock summary sheet advice:

66) **Assessment type:** Update of last year's assessment
67) **Assessment**: analytical (Category 1)
68) **Forecast**: Same approach as decided during IBPTurbot in 2018, but with new calculation of F_{PA} (see above).
69) **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.
70) **Data issues:** Discards are not included in the assessment due to poor sampling (especially for age); the surveys have low catch rates of turbot and poor internal consistency; the LPUE index dominates the assessment; weights-at-age are modelled due to gaps in the time series and noisy data; age information from all nations exploiting turbot is limited and could be improved. Natural mortality is time- and age-invariant (M=0.2 yr^{-1}), and maturity is a time-invariant vector. The advice is converted to catch advice by applying a 3-year average discard rate.
71) **Consistency**: The assessment for 2020 is very consistent with that for 2019; Mohn's rho is relatively low for this stock for SSB (-11%), F (+8%) and recruitment (-5%).
72) **Stock status:** F is only slightly above F_{MSY} and SSB well above MSY $B_{trigger}$.

73) **Man. Plan.**: The EU Multiannual Plan for the North Sea takes bycatch of this species into account.

General comments

The assessment is very well described and visualised, and both the stock annex and report sections are in good shape and provide the reader with sufficient detail to understand the issues concerning turbot in the North Sea. There were some discrepancies between the advice sheet and the report, but these are easily remedied.

Technical comments

Stock Annex

The stock annex is a well-written and comprehensive document. Some issues to be considered include the following:

(a) The stock definition section should contain the latest information from WKFlatNSCS regarding links between turbot in subdivision 20 and subarea 4.
(b) There appears to be an error in the von Bertalanffy equation in Section B.2.1.
(c) There is some concern about whether ALKs pooled over years have been used to assign ages to length frequencies each year – there is a danger that doing this will smear cohort signals in the data; please check this out. Furthermore, this would be a rather odd approach to take given that L_∞ is modelled as time-varying in the weights-at-age modelling. If ALK pooling is used (which essentially assumes growth does not vary much from year to year), then that is an issue that should be looked at carefully during the next benchmark.
(d) Figure 3.8 is missing, and if included should be Figure B.3 (to keep numbering consistent).
(e) There are some inconsistencies in the equation notation of Section C, which is at odds with the configuration file and will confuse the reader.
(f) At least one of the "live" links in the stock annex are broken – please check these out.
(g) In Section D, the reference point table gives F_{PA} as 0.43. This should be updated to $F_{PA}=F_{P.05}$ (without AR)=0.47 to reflect the decision during WGNSSK 2019 to change the way F_{PA} was calculated. Furthermore, to distinguish it from the above, I would write in that table $F_{P.05}$ (with AR) = 0.86 – this is the $F_{P.05}$ that is used to check the F_{MSY} range and truncate it if necessary, so it should be kept in the table (just correctly labelled).
(h) The stock annex could include more details about maturity (how the maturity ogive was derived) and natural mortality in Section B.2 (Biological data).

Report

As with the stock annex, the report section is well-written and clear. Again, some issues to be considered include the following:

(a) Section 21.2.2: the reason for not including discards is not so much that they are negligible, but rather that the sampling is poor, isn't it? At least, that is the impression from the stock annex.
(b) Section 21.2.6: you could include an additional between-survey consistency plot to illustrate the point that the general trends are reasonably consistent between surveys.
(c) Section 21.6: in the reference point table, I suggest removing the old F_{PA} (row 4) and replacing it with $F_{PA}=F_{P.05}$ (without AR)=0.47. Then I suggest that $F_{P.05}$ (with AR) also be

included (replace row 6) as that is also an important metric the check wither the F_{MSY} range is truncated. This would then be consistent with the stock annex (see above).

(d) Table 21.2.1: observed landings instead of catch?

(e) Table 21.4.1a: should "Low" and "High" also be included with landings since these are model estimates?

(f) Tables 21.4.1b-c: in the version I saw, these tables did not correspond with summary Table 5 in the advice sheet.

Advice Sheet

Only a few issues noted in the advice sheet, as follows:

(a) Figure 2: should there not be a black line in the recruitment plot to show last year's recruitment estimates?

(b) Table 5: as noted above, the SSB and Recruitment values are different from the corresponding values in Tables 21.4.1b-c in the report.

(c) Table 5: The 2020 SSB value should be changes from 9161 (which is actually the 2021 value) to 8393.

Conclusions

The assessment has been run in accordance with the benchmark settings, as reflected in the stock annex (apart from F_{PA}, which needs to be updated in the stock annex).

Audit of (Stock name)

Date: 13-05-2020
Auditor: Jurgen Batsleer

For the attention of the ADG, ACOM and WGNSSK.

General

Audit was based on the report, powerpoint presentations, stock annex, advice sheet, scripts and data files on the ICES sharepoint. Some minor edits necessary in report see technical comments below, otherwise input data used as described in stock annex.

For single stock summary sheet advice:

74) **Assessment type: update**
75) **Assessment**: analytical
76) **Forecast**: presented
77) **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.
78) **Data issues:** Large changes in the French 2018 discard data given the revised raising procedure.
79) **Consistency**: largely consistent with last years assessment and forecasts. Some minor deviations back to the method as described in the stock annex .
80) **Stock status**: SSB > Btrigger; F > FMSY; recruitment is above the average of the time series.
81) **Management Plan**: EU multiannual management plan (MAP) plan for the Western Waters (EU, 2019)

General comments

The assessment and forecasts are well described in the report and presented during the Working Group.

Technical comments

Input data:

- Changes in the raising method applied on French data caused a revision of the 2018 landings and discard data. For this stock a major change is observed in the discards which in 2018 increased by 81%.
- From 2001, second quarter catch weights are used as stock weights, however, in 2020 these Q2 weights are lacking for age 1 and 2. These are filled in with the average of Q3-Q4 catch weights.
- The starting years of the tuning indices are 1989 and 1993 for the UK BTS and FR GFS surveys respectively, and not 1988 as stated in the stock annex and report.
- The survey residuals in the FR-GFS (ages 1 and 2) show continuous under are

Assessment:

- Due to higher observed discard at age ratios from 2012, the assessment uses the actual discard ratio to estimate discards for 2012–2019 and the average logistic curve based on the average discard ratio at age over 2006 to 2011. This is slightly different then described in the stock annex but it is taken up in the report and consistent with the approach taken since 2015.
- Mohns Rho for recruitment is -32%. No explanation is provided. In previous report the following sentence was added: "Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated." I would recommend to add this sentence in this years report as well.

Forecasts:

- Spawning migrations of plaice from the North Sea and Bay of Biscay are taken into account by a 65% removal of mature fish from the catch in quarter 1, following the stock annex. While this %-removal is based on tagging data, there probably is some interannual variability which is not taken into account.
- There seems to be confusion/inconsistency in the way the initial stock for the forecast is set and descibed in the Stock Annex. The applied approach: age 2 survivors in the assessment year (i.e. interim year) are derived from the age 1 of the previous year defined by the GM of y-5 and y-2. In the Stock Annex it says survivors at age 2 and greater are obtained from the Aarts and Poos assessment. The aplied approach is the one agreed in the benchmark, the text in the Stock Annex should be updated.
- In previous year advice the Rage 1 in table 2 was wrongly stated, should have been 2018-2020. Also in previous year advice the geometric mean of the whole time-series (1980–2017) was used instead, as the recruitment had significantly decreased from 2014 to 2017
- A status quo F was assumed in the intermediate year rather than full utilization of the TAC as landings in 2019 were significantly lower than the TAC. For Fsq 2 options were presented; i)Fsq= F2019 & using Geom mean all time series or ii) Fsq = F2019 and using the GM 2014-2017. These options were discussed and option 2 was agreed at the WG.
- Plaice in 7d is part of the landing obligation since 1st of January 2019. A method has been developed and presented to assess whether the TAC will be fully taken under the landing obligation. If no exemption under the LO, the TAC would be fully taken, however, due to the survival exemption the TAC will not be exhausted. While the method is described in the report I would higly recommend to take it up in the stock annex.

- The rounding of $F_{MSY\ lower}$ and $F_{MSY\ upper}$ is different between stock annex (2 digits) and advice sheet (3 digits). The values given in the advice sheet were used to conduct the forecasts for these catch scenarios.

Report:

- Some minor comments and some editing in the text was done.
- Make clear the tuning index UK-BTS starts in 1989. In the Stock annex its 1988

Advice

- Table 3 % change in projected landings ^^ are correct, but are not calculated in the output file STF_2020_option2_F2019_GM2.csv
- Please look at the layout of table 5. Put the column BMS landings next to Discards and adjust column widths.

Conclusions

The assessment and forecast have been performed correctly. All data are uploaded on the Sharepoint. Advice has been adjusted to comments from the group which came in after the WG had taken place (i.e. discussion on the use of GM 2014-2017 for age 2 in interim year).

Audit of plaice ple.27.420

Date:

Auditor: Jon Egil Skjæraasen

General

For single stock summary sheet advice:

82) **Assessment type:** update
83) **Assessment**: analytical
84) **Forecast**: presented, deterministic forecast in FLR
85) **Assessment model**: update assessment, AAP age-structured assessment based Aarts & Poos (2009), using catch data in model and forecast, tuning by 6 survey indices (combined BTS 1996–2019), BTS-Isis (1985–1995), SNS1 1970–1999, SNS2 2000–2019), IBTS Q1 (2007–2020), and IBTS Q3 (1997–2019).
86) **Data issues:** Some difficulty in estimating ages 1-3 and older individuals as surveys give conflicting information. Potentially individuals undergo northwards expansion, affecting estimates of older individuals. The issue list also includes amongs other items consideration of combined index (delta-GAM method), trial runs with alternative assessment model (SAM) and dealing with consistent negative/positive residual patterns in both catch and survey data in recent years.
87) **Consistency**: The inclusion of an additional year of data has again elevated SSB levels considerably in the past in the advice retrospective. This is presumably due to the yearly updating of the survey indices with the delta gam model.
88) **Stock status**: B>MSYBtrigger marked increase since 2008, F<Fmsy<Fpa<Flim, Rec generally fluctuating around long-term average (since 1990), but 2018 year class estimated to be very large. Otherwise SSB again higher estimate than last year.
89) **Management Plan**: Advice is based on MSY approach. The EU management plan (MAP), is not adopted by Norway and is given only as a catch option.

General comments

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

- The scaled average of fishing mortality in 2016-2018 are used in the intermediate year forecast (variation from stock annex where wording gives the impression it is supposed to be unscaled). However, the reasoning behind this is clearly stated in the report.

Stock annex

- Page 8 it is stated that "The three different survey indices are…", should be six diffent survey indices.

Report

- Table 13.2.1. Footnote saying official landings not available for these years, but no years in table are marked with an asterix.
- Figure 13.2.9. Consider giving the year(s) used to in the model to depict the spatial distribution of plaice year classes.

Conclusions

The assessment has been performed correctly

Audit of Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)

Date: 06/05/2020

Auditor: Harriet Cole

For single stock summary sheet advice:

90) **Assessment type:** update assessment
91) **Assessment:** analytical
92) **Forecast:** presented
93) **Assessment model:** SAM – tuning by 2 age indices and 2 biomass indices
94) **Data issues:** data available are as described in stock annex. Some manual raising of the catch data was needed due to a small amount of landings from Sweden not being submitted on time.
95) **Consistency:** Last year's assessment was accepted. Stock was benchmarked in 2018.

96) **Stock status**: B>MSY Btrigger and has been for a few years, F> Fmsy but relatively constant. R has decreased since 2009 while catches have increased.

97) **Management Plan**: The EU MAP for the North Sea and adjacent waters applied to bycatches of this stock. This stock had a joint TAC with lemon sole (SubArea 27.4 and Division 27.2.a)

General comments

- The report section is well written and easy to follow and interpret. The stock annex needs a few updates to bring it into line with what is described in the report (see technical comments).
- Input data
  - All data described in the stock annex was available and used in the assessment.
  - A small amount of landings in SubArea 27.4 from Sweden were not submitted in time for the WG and so some manual raising of the catch data was needed to account for this. This has been documented in the data input files.
  - At the benchmark it was decided that BMS landings data should be combined with the landings data as the majority of the data came from Norway and Norway were including fish above the MCRS in their BMS submission. In future, consideration may want to be made as to whether it is more appropriate to combine BMS with landings or discard data depending on the characteristics of the BMS data submitted each year. It should be noted that BMS represents a very small proportion of the stock and therefore the allocation to landings or discards is expected to make little difference to the overall result.
- The model settings/configuration used are as described in the stock annex and the report. The output data from the assessment are consistent.
- The forecast settings used are as described in the report. The stock annex does not detail the settings needed for the forecast.
- The advice sheet is consistent with the assessment and forecast results presented in the report section. The correct basis for advice has been used.

Technical comments

- Stock annex
  - The stock weights listed in the stock annex use age 8 as plus group but age 10 is used in the assessment.
  - The stock annex states that the two aged survey indices were used but makes no mention of the biomass indices used (under heading “survey data used”).
  - The mean weights at age for the landings are used as a data input in the model but this is not described in the stock annex.
  - The stock annex does not list all model setting listed in the report or on stockassessment.org
  - The stock annex does not provide details of forecast settings.
- Report
  - ICES estimated catch table (by category and area) has a * symbol for BMS landings but the associated footnote seems to be missing.
  - The report could do with a paragraph on the Swedish missing data and that some manual raising of the InterCatch data was needed to account for it.
  - The table detailing the input data used in the report is missing a header.
  - Mohn’s rho values are not reported.
- Advice sheet

- I think one value in the official BMS column in Table 5 needs rounding (0.378 to 0.38) as per the rounding rules.

Conclusions

The assessment has been performed correctly.

Audit of (had.27.46a20)

Date: 15-05-2020
Auditor: Marc Taylor

For single stock summary sheet advice:

98) **Assessment type:** update
99) **Assessment**: analytical
100) **Forecast**: presented
101) **Assessment model**: Age-based analytical assessment (TSA) that uses catches in the model and in the forecast + 2 survey indices
102) **Data issues:** No issues reported
103) **Consistency**: Update assessment, consistent between years.
104) **Stock status**: Fishing pressure on the stock is below F_{MSY} and spawning stock size is above MSY $B_{trigger}$
105) **Management Plan**: There is currently no agreed management plan for haddock for the full stock area. EU-Norway have requested an evaluation of multiple management strategies, which are currently under consideration. Scenarios are provided in the advice.

General comments

There was no deviation from the standard procedure. Data, assessment and forecast are done as specified in the stock annex.

Technical comments

TAF:

- I recommend putting package calls at the top of script to aid in reproducibility. Also, .readme should maybe specify that 32-Bit R is needed for the TSA model.

Advice:

- Table 4a-c shows "41 819" as the agreed TAC for 2020, rather than the values by area. Is this correct? Are there TACs by area, or is this filled in later? Perhaps a footnote is required. Also, the report quotes the value as "41 818" in Section 8.1.3.2,
- Footnote of Table 4b still refers to non-existing Table 7a. I assume this to mean Table 4a (editted).

Stock Annex:

- I would suggest making the procedure for defining large year-classes more prevelent.The footnote of the table listing the TSA model options is the only location of the annex that mentions that large year-classes can only be defined following a benchmark (or inter-benchmark) procedure. Making this information more prevalent, along with the model settings regarding recruitment smoothing, should make for a clearer procedure in future years.
- This may be resolved following the WGNSROP meeting on reopening guidelines, but I would recommend the addition of the reoping protocol at some point.

Report**:**

- Unclear what data is in Table 8.2.17 (and especially the first column with values of "100").
- There was a comment

Conclusions

The assessment has been performed correctly.

Audit of whiting in division 3.a

Date: 12/05/2020

Auditor: Nicola Walker

General

The stock was benchmarked in 2020 and raised from Category 5 to Category 3. Advice is now given according to a trends-based assessment using a combined index from four surveys. The index ratio was applied to average catches because it is the first time the rule is applied and results in a large increase compared to the previous advice. The precautionary buffer was applied because stock status is unknown.

For single stock summary sheet advice:

106) **Assessment type:** update following benchmark in 2020
107) **Assessment**: trends
108) **Forecast**: not presented
109) **Assessment model**: survey-based trends (2-over-3 rule) based on a combined index of four surveys (NS-IBTS, BITS and two Danish surveys for cod and sole) derived using a Tweedie-GAM model.
110) **Data issues:** no data issues
111) **Consistency**: there is a large change in advice (132%) following benchmark of the stock and change of category and assessment. As the first advice with a trends-based assessment, the 2-over-3 rule was applied to the average catch from 2010–2019 (1203 tonnes) rather than the last advice (400 tonnes).
112) **Stock status**: unknown. SPiCT models considered during the benchmark were deemed unsuitable.
113) **Management Plan**: No management plan. Advice is biennial and according to the precautionary approach. The precautionary buffer was applied in 2020.

General comments

The assessment and advice are well presented and described.

Technical comments

The assessment has been conducted following the procedures established at the recent benchmark and according to the stock annex. The application of the 2-over-3 rule to average catches is in accordance with the guidelines for single species advice because this is the first time the rule is applied. The precautionary buffer has been applied correctly.

Some technical comments were made on the advice sheet and have been addressed by the stock assessor.

Conclusions

The assessment has been performed correctly.