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

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

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## i Executive summary

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

## Benchmarks and Inter-benchmarks in 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 Blim, 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 Fmsy levels (haddock in 4, 6.a, plaice in 4 and 20 and sole in 7.d); however, several others are being fished above Fmsy (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.34) are currently above MSY $B_{\text {trigger, }}$ and all Nephrops stocks with defined Fmsy (Category 1 stocks, including) are being fished above $\mathrm{F}_{\mathrm{MSY}}$ in 2019, apart from Nephrops in FU 7 (nep.fu.7) and FU 34 (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 7 d and striped red mullet in 3.a, 4 and 7.d. Biennial precautionary approach (PA) advice was provided in 2015 for the first time, and again in 2017 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 Fmsy. 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 Btrigger. The harvest rate has shown an increase since 2018, and is above $^{\text {2 }}$ FMSY in 2019.
c) FU 7 (nep.fu.7): The stock size has been above MSY Btrigger for most of the time-series. The harvest rate has increased in 2019 but remains below Fmsy.
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 Fmsу.
e) FU 9 (nep.fu.9): The stock has been above MSY Btrigger for the entire time-series. The harvest rate has fluctuated around $\mathrm{Fmsy}_{\text {in }}$ in recent years and is now above Fmš.

## 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 Flim in 2019. Spawning-stock biomass has decreased since 2015 and is now below Blim. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above $\mathrm{F}_{\mathrm{ms}}, \mathrm{F}_{\mathrm{pa}}$ and $F_{\text {lim; }}$ the spawning-stock size is below MSY $\mathrm{B}_{\text {trigger }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.
3 ) Haddock (had.27.46a20): Fishing pressure has declined since the beginning of the 2000s, but it has been above Fmsy for most of the time-series. Only in 2019, fishing pressure is at FmsY. Spawning-stock biomass has been above MSY Btrigger in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019 yearclass is estimated to be one of the largest since 2000. Currently, fishing pressure on the stock is at $\mathrm{F}_{\text {mSY, }}$ but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim, }}$ and spawning stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and Blim.

4 ) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY Btrigger since the mid-1980s and is just above it in 2020. Fishing pressure has been above Fmsу 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 $\mathrm{F}_{\mathrm{msY}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim; }}$ spawning-stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.

5 ) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY Btriger since 1996. Fishing pressure has decreased and stabilized at or above Fmsy 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 $\mathrm{F}_{\mathrm{msy}}$ and $\mathrm{F}_{\mathrm{pa}}$, but below Flim; spawning-stock size is above MSY $\mathrm{B}_{\text {trigger }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.

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 Fmsy. Currently, fishing pressure on the stock is below $\mathrm{F}_{\text {MSY }}, \mathrm{F}_{\mathrm{pa}}$ and $\mathrm{Flim}_{\text {, and }}$ and spawning-stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\text {pa }}$ and $\mathrm{B}_{\text {lim }}$.

7 ) Sole (sol.27.4): The spawning-stock biomass has fluctuated around Blim since 2003, and has been estimated to be below MSY Btrigger since 1999. Fishing pressure has declined since 1999 and is above Fmsy 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 $\mathrm{F}_{\mathrm{MSY}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim, }}$, and spawning-stock size is above MSY $\mathrm{B}_{\text {trigger }}, \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {lim }}$.

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 Btrigger, despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly above Fmsy. Recruitment in 2019 is currently estimated to be highest in the time series since 1980. Currently, fishing pressure on the stock is above $\mathrm{F}_{\mathrm{msy}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and Flim, and spawning stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {lim }}$.
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 Fmsy since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY Btrigger 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 $\mathrm{F}_{\mathrm{mSy}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim; }}$ spawning stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.
10 ) Witch (wit.27.3a47d): Fishing pressure has been above FmSY since the beginning of the time-series. Spawning-stock biomass that was below $\mathrm{Blim}_{\mathrm{lim}}$ around 2010, has increased since then and is now above MSY B trigger. Recruitment has declined since 2010 and is currently $^{\text {R }}$ 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 $F_{\text {mSY }}$ and at $\mathrm{F}_{\mathrm{pa}}$, but below Flim, and spawning stock size is above MSY $B_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {lim }}$.
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 $\mathrm{B}_{\mathrm{pa}}$ 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 $B_{p a}$ and Blim; no reference points for fishing pressure or for MSY $B_{\text {trigger }}$ 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 timeseries until 2015, and has then decreased. Currently, fishing pressure on the stock is below FMSY proxy and spawning stock size is above MSY $B_{\text {trigger proxy. }}$
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 $\mathrm{F}_{\text {MSY }}$ 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. Spawningstock 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 Fmsy 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 ( $\mathrm{B} / \mathrm{Bmsy}$ ) 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 $\mathrm{F}_{\text {MSY }}$ proxy and spawning stock size is above MSY $\mathrm{B}_{\text {trig- }}$ ger 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 Fmsy 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 $\operatorname{cod} 47 \mathrm{~d}$ 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 ( $\mathrm{F}_{\mathrm{MSY}}$ ) in the forecast for 2021 is well below the $\mathrm{F}_{05}$ 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 <br> (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 $\mathrm{R}, \mathrm{SSB}$ 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.

[^2]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 climatechange, 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 stockbased 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 | Haddock | 51.0285 | gug.27.3a47d |
| HAD | Halibut | 112.1597 | had.27.46a20 |
| HAL | Lemon sole | 3.0661 | hal.27.3a47de |
| NOM | Plaice | 15.185 | lem.27.3a47d |
| PLE | Saithe | 2.9763 | pout |

### 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 | Exp | No |


| 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 FMSY 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 $\mathrm{F}_{\mathrm{MSY}}$ range, but with more stringent conditions (related to the need to meet mixed fisheries objectives) for using the part of the range above Fmsy, 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):
$\rightarrow \quad$ There is an increased risk of over-exploitation if fishing opportunities are set in line with the upper limits of the FMSY ranges, particularly if several stocks in a mixed fishery are involved.
and furthermore that:
$\rightarrow \quad$ The use of the FMSY range approach should only be employed when informed by objective mixed fishery advice which demonstrates that attaining $F_{M S Y}$ for the key driver species can not be achieved simultaneously and the application of $F_{M S Y}$ 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 $F_{\text {MSY }}$ 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 $\mathrm{F}_{\text {MSY }}$ 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 Fmsy 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 Fmsy in a multi species context. The multi species considerations can be found under: http://www.ices.dk/sites/pub/Publication\ Re-ports/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 Fmsy for the exploitation of some populations. This will allow a policy choice to be made within the limits defined and explained by ICES. Fmsy 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 $x 5 \mathrm{~km}$ 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:

## Survey haul locations



General statistics for the $\mathbf{2 0 1 9}$ survey:

| vessel: | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ |
| :--- | :---: | :---: | :---: |
| \# 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: | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ |
| :--- | :--- | :--- | :--- |
| brill $>27 \mathrm{~cm}$ | $93.8 \%$ | $94.0 \%$ | $98.1 \%$ |
| turbot $>27 \mathrm{~cm}$ | $74.4 \%$ | $51.3 \%$ | $82.3 \%$ |

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 500000 tonnes

## (http://www.ices.dk/sites/pub/Publication\%20Reports/Advice/2019/2019/FisheriesOver-

 view 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\ Reports/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. Mixedfisheries 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 FMSY 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-

## 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) (') | Mesh size | Species subject to the landing obligation |
| :---: | :---: | :---: |
| Trawls: <br> OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV | $\geq 100 \mathrm{~mm}$ | All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting. |
| Trawls: <br> OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM. TMS, TM, TX. SDN, SSC, SPR, TB, SX, SV | $70-99 \mathrm{~mm}$ | All catches of cod (1), common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting. |
| Trawls <br> OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV | $32-69 \mathrm{~mm}$ | All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting. |
| Beam trawls: TBB | $\geq 120 \mathrm{~mm}$ | All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting. |
| Beam trawls: TBB | $80-119 \mathrm{~mm}$ | All catches of cod, common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting. |
| Gillnets, trammel nets and entangling nets: <br> GN, GNS, GND, GNC, GTN, GTR, GEN, GNF |  | All catches of cod ( ${ }^{1}$ ), common sole, haddock, saithe, Northern prawn, and Norway lobster and whiting. |
| Hooks and lines: <br> LLS, LLLD, LL, LTL, LX, L.HP, LHM |  | All catches of cod, common sole, haddock, hake, plaice, saithe, Northern prawn, and Norway lobster and whiting. |
| Traps: <br> FPO, FIX, FYK, FPN |  | All catches of cod, common sole, haddock, plaice, saithe, Northern prawn, and Norway lobster and whiting. |

(9) 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 (O) L. 112, 30.4.2011, p. 1).
(7) For the vessels whose LOA is less than 10 metres, gear codes used in this table refer to the codes from the EMO gear classification. () The landing obligation for cod shall not apply in ICES subdivision IIlaS.

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 (Gatus morina), Haddock (Mclanognammus acglefinus), Whiting (Merlangius merlangus) and Saithe (Polladius virens) | OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS OTM, PTM, TB, SX, SV, OT, PT, TX | Trawls \& Scines | 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 (Neplirops nornggicus) | 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 bycatches 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 (Pollachites virms) | OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX | Trawls | $\geq 100 \mathrm{~mm}$ | 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 (Aplatnopes carbo) | OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX | Trawls \& Scines | $\geq 100 \mathrm{~mm}$ | 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 \& Scines | $\geq 100 \mathrm{~mm}$ | 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 (Corphacides nupestris, Macrounus berglax) | OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX | Trawls \& Scines | $\geq 100 \mathrm{~mm}$ | All catches of grenadiers where total landings per vessel of all species in 2015 and 2016 (*) consisted of more than $20 \%$ of grenadiers. |

(e) Vessek lised as subject to the landing obligation in this fishery in accordance with Commission Delegared 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 | Meh Size | Species to be landed |
| :--- | :--- | :--- | :--- | :--- |
| Common Sole (Solaa solea) | TBB | All Beam trawls | All | All catches of common sole |
| Common Sole (Solat solea) | OTT, OTB, TBS, TBN, <br> TB, PTB, OT, PT, TX | Trawls | $<100 \mathrm{~mm}$ | All catches of common sole |


| Fishery | Gear Code | Fishing gear | Mesh Sier | Species to be landed |
| :---: | :---: | :---: | :---: | :---: |
| Common Sole (Soleu solea) | GNS, GN, GND, GNC, GTN, GTR, GEN | All Trammel nets \& Gill nets | All | All catches of common sole |
| Cod (Gadus morlua), Haddock (Mdanogrammus acglefinus). 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 Scines | 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 |

[^3]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-

$$
100 \mathrm{~mm}), \mathrm{T} \quad 70 \text { and }<100 \quad 16 \text { and }
$$

$<32$
120 80 and $<120 \mathrm{~mm}$ ); 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 <br> gear | BE | DK | DE | ES | FR | IE | NL | SE | UK |  |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| TR1 | 895 | 3385928 | 954390 | 1409 | 1505354 | 157 | 257266 | 172064 | 6185460 |  |
| TR2 | 193676 | 2841906 | 357193 | 0 | 6496811 | 10976 | 748027 | 604071 | 5037332 |  |
| TR3 | 0 | 2545009 | 257 | 0 | 101316 | 0 | 36617 | 1024 | 8482 |  |
| BT1 | 1427574 | 1157265 | 29271 | 0 | 0 | 0 | 999808 | 0 | 1739759 |  |
| BT2 | 5401395 | 79212 | 1375400 | 0 | 1202818 | 0 | 28307 | 876 | 0 | 6116437 |
| GN | 163531 | 2307977 | 224484 | 0 | 342579 | 0 | 438664 | 74925 | 546303 |  |
| GT | 0 | 224124 | 467 | 0 | 4338315 | 0 | 0 | 48968 | 14004 |  |
| LL | 0 | 56312 | 0 | 245 | 125141 | 0 | 0 | 110468 | 134880 |  |

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 | 5693620 | 1432092 | 1972158 | 39475162 | 10568178 |

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/CES 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 deepsea 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 |
|  | $85 \mathrm{~mm}(25 \mathrm{~mm})$ | $105 \mathrm{~mm} \mathrm{(32} \mathrm{~mm})$ |

### 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 $70-99 \mathrm{~mm}$, 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 $70-99 \mathrm{~mm}$ 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 $110-119 \mathrm{~mm}$, 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 $100-119 \mathrm{~mm}$, 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 $56^{\circ} 00^{\prime} \mathrm{N}$. 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 $55^{\circ} 00^{\prime} \mathrm{N}$ and $56^{\circ} 00^{\prime} \mathrm{N}$ and by straight lines sequentially joining the following geographical coordinates: a point on the east coast of the United Kingdom at $55^{\circ} 00^{\prime} \mathrm{N}, 55^{\circ} 00^{\prime} \mathrm{N} 05^{\circ} 00^{\prime} \mathrm{E}, 56^{\circ} 00^{\prime} \mathrm{N} 05^{\circ} 00^{\prime} \mathrm{E}$, a point on the east coast of the United Kingdom at $56^{\circ} 00^{\prime}$ 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 $56^{\circ} \mathrm{N}$ with $80-99 \mathrm{~mm}$ 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 $99 \mathrm{~mm}, 100$ 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 $51^{\circ} \mathrm{N}$ 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 $53^{\circ} \mathrm{N}$ and $57^{\circ} \mathrm{N}$ has been closed to fishing for trawlers with engine power of more than $221 \mathrm{kw}(300 \mathrm{hp})$ 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 (longterm 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\ Reports/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 $7 . \mathrm{d}$ 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 Blim, 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 Btrigger at the beginning of 2020. Several North Sea stocks are exploited at or below Fmsy levels (haddock in 4, 6.a and 20, plaice in 4 and 20, sole in 7.d); however, several others are being fished above FMSY (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.34) are currently above MSY Btrigger, and all Nephrops stocks with defined Fmsy (Category 1 stocks, including) are being fished above Fmsy in 2019, apart from Nephrops in FU 7 (nep.fu.7) and FU 34 (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 datalimited 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 Fms\%. 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 $B_{\text {trigger. }}$ The harvest rate has shown an increase since 2018, and is above FMSY in 2019.
c) FU 7 (nep.fu.7): The stock size has been above MSY Btrigger for most of the time-series. The harvest rate has increased in 2019 but remains below Fmsy.
d) FU 8 (nep.fu.8): The stock size has been above MSY Btrigger for the entire time-series. The harvest rate is varying, increased in 2019 and is now above Fmsу.
e) FU 9 (nep.fu.9): The stock has been above MSY Btrigger for the entire time-series. The harvest rate has fluctuated around Fmsy in recent years and is now above Fmš.

## 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 Flim in 2019. Spawning-stock biomass has decreased since 2015 and is now below Blim. Recruitment since 1998 remains poor. Currently, fishing pressure on the stock is above FmsY, $\mathrm{F}_{\mathrm{pa}}$ and Flim; the spawning-stock size is below MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.
3 ) Haddock (had.27.46a20): Fishing pressure has declined since the beginning of the 2000s, but it has been above Fmsy for most of the entire time-series. Only in 2019, fishing pressure is at Fmsy. Spawning-stock biomass has been above MSY Btrigger 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 $\mathrm{F}_{\text {mSy }}$ but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim }}$, and spawning stock size is above MSY $\mathrm{B}_{\text {trigger }}$, $\mathrm{B}_{\mathrm{pa}}$ and Blim.

4 ) Whiting (whg.27.47d): Spawning-stock biomass has fluctuated around MSY Btrigger since the mid-1980s and is just above it in 2020. Fishing pressure has been above Fmsy throughout the time-series, apart from 2005. Recruitment $(\mathrm{R})$ 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 $\mathrm{F}_{\mathrm{MSY}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim; }}$ spawning-stock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim. }}$.
5 ) Saithe (pok.27.3a46): Spawning-stock biomass has fluctuated without trend and has been above MSY Btrigger since 1996. Fishing pressure has decreased and stabilized at or above FMSY 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 Fmsy and $\mathrm{F}_{\mathrm{pa}}$, but below Flim; spawning-stock size is above MSY $B_{\text {trigger }} B_{\text {pa }}$ and $B_{l i m}$.
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 Fmsy. Currently, fishing pressure on the stock is below $\mathrm{F}_{\text {mSY }}, \mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim, }}$, and spawning-stock size is above MSY $\mathrm{B}_{\text {trigger }}, \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{B}_{\text {lim }}$.
7 ) Sole (sol.27.4): The spawning-stock biomass has fluctuated around Blim since 2003, and has been estimated to be below MSY Btrigger since 1999. Fishing pressure has declined since 1999 and is above FMSY 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 FMSY, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim, }}$, and spawning-stock size is above MSY $\mathrm{B}_{\text {trigger }}, \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {l }}$.
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 $B_{\text {trigger, }}$ despite a decline since 2016. Fishing pressure has declined since the early 2000s, with an increase in the recent years to slightly above Fmsy. Recruitment in 2019 is currently estimated to be highest in the time series. Currently, fishing pressure on the stock is above $\mathrm{F}_{\mathrm{MSY}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{Flim}_{\text {, and }}$ and spawning stock size is above MSY $\mathrm{B}_{\text {trigger, }}$, $B_{p a}$ and Blim.
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 Fmsy since 2012. The spawning-stock biomass has increased since 2005 and has been above MSY Btrigger 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 $\mathrm{F}_{\mathrm{MSY}}$, but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{F}_{\text {lim; }}$ spawning stock size is above MSY $B_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {lim }}$
10 ) Witch (wit.27.3a47d): Fishing pressure has been above Fmsy since the beginning of the time-series. Spawning-stock biomass that was below $\mathrm{Blim}_{\text {lim }}$ around 2010, has increased since then and is now above MSY $B_{\text {trigger }}$. 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 Fmsy and at $\mathrm{F}_{\text {pa }}$, but below Flim, and spawning stock size is above MSY $B_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$ and $\mathrm{Blim}_{\text {l }}$
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 timeseries until 2015, and has then decreased. Currently, fishing pressure on the stock is below FMSY proxy and spawning stock size is above MSY $B_{\text {trigger proxy. }}$
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 FMSY 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. Spawningstock 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 $\mathrm{Fmsy}_{\text {proxy. }}$. 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 ( $\mathrm{B} / \mathrm{Bmsy}$ ) 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 Fmsy proxy and spawning stock size is above MSY Btrigger .
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 Fmsy 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 $\mathrm{B}_{\mathrm{pa}}$ 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 $B_{p a}$ and $B_{\text {lim; }}$ no reference points for fishing pressure or for MSY $B_{\text {trigger }}$ 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 $>221 \mathrm{~kW}$ ). 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 $7 . \mathrm{d}$, 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 | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 $218 \pm 197$ 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 ( $\pm 10 \%$ ). The TAC in 2017 was 4937 tonnes, but at the end of the year, it was increased to 5924 tonnes ( $\pm 20 \% ; 10 \%$ 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

[^4]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:


### 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:


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 Skager-rak-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:
o TBB
o OTB, OTT, SSC and SDN
o 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 27.3 a). 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 /ength 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 $20-30 \mathrm{~cm}$. 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 $40 \mathrm{~kg} /$ 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: | $\mathbf{1}$ (northern area) | $\mathbf{2}$ (southern area) | $\mathbf{3}$ (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 17 cm to 62 cm for turbot and 21 cm to 54 cm for brill (Figure 3.18). Ageing was done over 1 cm -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 M SY 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 Fmsy proxy and the relative biomass is well-above the reference $\mathrm{BMSY}^{*} 0.5$ 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 SPiCTestimated values of the ratios $\mathrm{F} / \mathrm{F}$ msy and $\mathrm{B} / \mathrm{B}$ мsy are used to estimate stock status relative to the proxy MSY reference points.

| Framework | Reference point | Value | Technical basis | Source |
| :---: | :---: | :---: | :---: | :---: |
| M SY approach | M SY $\mathrm{B}_{\text {trigger }}^{\text {proxy }}$ | $\frac{B}{B_{M S Y}}=0.5$ | Relative value from SPiCT model. $\mathrm{Bmsy}_{\text {ms }}$ is estimated directly from the SPiCT assessment model and changes when the assessment is updated. | ICES (2017) |
|  | $\mathrm{FmSr}_{\text {proxy }}$ | $\frac{F}{F_{M S Y}}=1$ | Relative value from SPiCT model. FMSY is estimated directly from the SPiCT assessment model and changes when the assessment is updated. | ICES (2017) |
| Precautionary approach | $\mathrm{Blim}_{\text {l }}$ | Not defined |  |  |
|  | $\mathrm{B}_{\mathrm{pa}}$ | Not defined |  |  |
|  | Flim | Not defined |  |  |
|  | $\mathrm{F}_{\mathrm{pa}}$ | Not defined |  |  |
| M anagement plan | SSB ${ }_{\text {mgt }}$ | Not defined |  |  |
|  | $F_{\text {mgt }}$ | Not defined |  |  |

### 3.4 Quality of the assessment

- The advice is based on a commercial biomass index (Dutch beam-trawl fleet, vessels $>221 \mathrm{~kW}$ ) 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 $>221 \mathrm{~kW}$ ) 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 . | M odel Dutch Ipue series | Dutch catch, effort and fleet information | Dutch experts in Ipue 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 M ember 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/ <br> possible direc- <br> tion of solution | Data needed to be able <br> to do this: are these <br> available / where <br> should these come <br> from? | External expertise <br> needed at bench- <br> mark type of ex- <br> pertise / proposed <br> names |
| :--- | :--- | :--- | :--- | :--- |
| Discards | Discards are not included in the 'as- <br> sessment' (LPUE biomass index) | Considering that <br> discarding of <br> larger length clas- <br> ses occurs when <br> the TAC is restric- | Discard data from all <br> countries involved in <br> the brill fisheries | Dutch experts to <br> revise the LPUE in- <br> dex |

### 3.7 References

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Table 3.1: BLL 27.3a47de - Official landings (tonnes) of brill in Subdivision 27.3a (Skagerrak/ Kattegat) by country, over the period 1950-2019 (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 BM S 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 | 3.9 | 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 | $\mathbf{3 a}$ | $\mathbf{4}$ | 7de | TOTAL | $\mathbf{3 a}$ | $\mathbf{4}$ | 7de |
| $\mathbf{2 0 1 0}$ | 122 | 1500 | 699 | $\mathbf{2 3 2 1}$ | 0.05 | 0.65 | 0.30 |
| $\mathbf{2 0 1 1}$ | 131 | 1497 | 666 | $\mathbf{2 2 9 4}$ | 0.06 | 0.65 | 0.29 |
| $\mathbf{2 0 1 2}$ | 120 | 1532 | 625 | $\mathbf{2 2 7 7}$ | 0.05 | 0.67 | 0.27 |
| $\mathbf{2 0 1 3}$ | 92 | 1390 | 605 | $\mathbf{2 0 8 7}$ | 0.04 | 0.67 | 0.29 |
| $\mathbf{2 0 1 4}$ | 78 | 1256 | 644 | $\mathbf{1 9 7 8}$ | 0.04 | 0.63 | 0.33 |
| $\mathbf{2 0 1 5}$ | 145 | 1695 | 698 | $\mathbf{2 5 3 8}$ | 0.06 | 0.67 | 0.28 |
| $\mathbf{2 0 1 6}$ | 168 | 1526 | 721 | $\mathbf{2 4 1 5}$ | 0.07 | 0.63 | 0.30 |
| $\mathbf{2 0 1 7}$ | 170 | 1460 | 663 | $\mathbf{2 2 9 2}$ | 0.07 | 0.64 | 0.29 |
| $\mathbf{2 0 1 8}$ | 125 | 1163 | 659 | $\mathbf{1 9 4 7}$ | 0.06 | 0.60 | 0.34 |
| $\mathbf{2 0 1 9}$ | 139 | 1378 | 655 | $\mathbf{2 1 7 2}$ | 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 | $\mathbf{3 a}$ | $\mathbf{4}$ | 7d | 7e | Total |
| :--- | :---: | :---: | :---: | :---: | :---: |
| DRB | 0 | 0 | 6 | 2 | $\mathbf{8}$ |
| FPO | 0 | 0 | 0 | 0 | $\mathbf{0}$ |
| GNS | 7 | 35 | 5 | 9 | $\mathbf{5 6}$ |
| GTR | 1 | 4 | 9 | 147 | $\mathbf{1 6 2}$ |
| LLS | 0 | 0 | 0 | 0 | $\mathbf{0}$ |
| MIS | 1 | 3 | 9 | 21 | $\mathbf{3 4}$ |
| OTB | 99 | 361 | 21 | 114 | $\mathbf{5 9 5}$ |
| SDN | 2 | 1 | 0 | 0 | $\mathbf{4}$ |
| SSC | 0 | 3 | 3 | 1 | $\mathbf{7}$ |
| TBB | 28 | 915 | 145 | 193 | $\mathbf{1 2 8 1}$ |
| Total | $\mathbf{1 3 9}$ | $\mathbf{1 3 2 3}$ | $\mathbf{1 9 8}$ | $\mathbf{4 8 7}$ | $\mathbf{2 1 4 7}$ |

Table 3.8: BLL 27.3a47de - Overall discards and discard rates (all countries and métiers) for brill over the period 20142019 (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 | $\mathbf{0 . 0 9}$ | $\mathbf{0 . 1 5}$ | $\mathbf{0 . 1 6}$ |

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 | $\mathbf{0 . 0 9}$ | $\mathbf{0 . 1 5}$ | $\mathbf{0 . 1 6}$ |

Table 3.11: BLL 27.3a47de - Survey index ( $\mathbf{N} / \mathrm{h}$ ) for brill in the BTS_ISI_Q3, Subarea 27.4.

| Year | $\mathbf{N} / \mathbf{h r}$ | Year | $\mathbf{N} / \mathbf{h r}$ |
| :---: | :---: | :---: | :---: |
| 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 ( $\mathrm{N}^{\circ} / \mathrm{h}$ ) for brill in the BITS_HAF_Q1, Division 27.3 a 21 (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 ( $\mathrm{N}^{\circ} / \mathrm{h}$ ) for brill in the BITS_HAF_Q4, Division 27.3 a 21 (Kattegat).

| Year | $\mathbf{N} / \mathrm{hr}$ |
| :---: | :---: |
| 1999 | 2.857143 |
| 2000 | 0.315789 |
| 2001 | 1.800000 |
| 2002 | 2.071429 |
| 2003 | 1.928571 |
| 2004 | 3.310345 |
| 2006 | 2.896552 |
| 2007 | 4.758621 |
| 2008 | 5.117241 |
| 2010 | 4.400000 |
| 2011 | 3.750000 |
| 2013 | 4.838710 |
| 2015 | 5.034483 |
| 2016 | 3.000000 |
| 2017 | 3.830889 |
| 2018 | 6.090370 |
| 2019 | 6.636364 |
|  | 4.666667 |
|  | 3.636364 |
|  | 10.869565 |
|  | 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 |
| 1994 | 3141 |
| 1995 | 2628 |
| 1996 | 2143 |


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

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



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


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


Figure 3.3: $B \amalg$ 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 (19872019) (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 > $\mathbf{2 2 1} \mathbf{~ k W}$ (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 ( $5 \times 5 \mathrm{~km}$ ) 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 $\mathrm{B}_{\text {MSY }}$, and prior and posterior parameter distributions. The dashed lines are $95 \% \mathrm{Cl}$ bounds for absolute estimated values, shaded blue regions are $95 \%$ Cls for relative estimates, shaded grey regions are $95 \%$ Cls 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)


#### Abstract

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 | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ | $\mathbf{2 0 2 0}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20(Skagerrak) | 3.8 | 3.8 | 3.8 | 4.0 | 4.2 | 4.8 | 5.7 | 8.0 | 4.2 | 2.1 |
| $2 . \mathrm{a}+4$ | 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) $\mathrm{N}^{\circ} 57 / 2011$, $\mathrm{N}^{\circ} 44 / 2012$, $\mathrm{N}^{\circ} 297 / 2013$, $\mathrm{N}^{\circ} 432 / 2014$, $\mathrm{N}^{\circ} 2015 / 104$ and $\mathrm{N}^{\circ} 2016 / 72$ allocated different amounts of $\mathrm{Kw}^{*}$ days by Member State and area to different effort groups of vessels depending on gear and mesh size as stipulated by Council Regulation (EC) $\mathrm{N}^{\circ} 43 / 2009$. The effort regime has now been discontinued, and the TACs for 20172020 are given in Council Regulations (EC) $\mathrm{N}^{\circ} 2017 / 127, \mathrm{~N}^{\circ} 2018 / 120, \mathrm{~N}^{\circ} 2019 / 124$ and $\mathrm{N}^{\circ} 2020 / 123$ 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 $B_{p a}$. 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 Fmsy 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 35684 tonnes, split as follows for the separate areas (tonnes):

|  | TAC | Landings | Discards* | andings** |
| :---: | :---: | :---: | :---: | :---: |
| 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 $7 . \mathrm{d}$ 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 | Estimated | 2697 | 76 |
| Discards | Estimated | 792 | 22 |  |
| Discards | Imported | Sampled | 54 | 2 |
| BMS landing | Imported | Estimated | 30 | 100 |
| BMS landing | Imported |  | $<1$ | 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 4.2 b ). 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 4.5 b 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 19762020. 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 19912019. 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 yearclass 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 inde-
pendently 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 4.4 b . 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 yearclass 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 4.8 b 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 $\mathrm{F}(\mathrm{y}, \mathrm{a})$, where ( $\mathrm{y}, \mathrm{a}$ ) denotes year and age. SAM considers a random walk over time for $\log [\mathrm{F}(\mathrm{y}, \mathrm{a})]$, 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 19932005, 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 $\log \mathrm{F}$ 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, $\mathrm{F}_{2-4}$, 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 $F_{\text {bar }}(2-4)$ 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, $\mathrm{F}_{\text {lim }}$ and $\mathrm{F}_{\mathrm{pa}}$, and $\mathrm{F}_{\mathrm{msy}}$.

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 Blim. 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 |  |
| :--- | :---: |
| $F_{\text {MSY }}$ | 0.31 |
| $F_{\text {MSY }}$ lower | 0.198 |
| $F_{\text {MSY }}$ upper | 0.46 |
| FP.05 (5\% risk to Blim, with HCR included) | 0.48 |
| $F_{\text {MSY }}$ upper precautionary | $0.46^{*}$ |
| MSY | 77651 t |
| Median SSB at $F_{\text {MSY }}$ | 346032 t |
| Median SSB at $F_{\text {MSY }}$ upper precautionary | 219876 t |
| Median SSB at $F_{\text {MSY }}$ lower | 510886 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 Fmsy 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 16305 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 <br> the intermediate year (including co-variances). |
| :--- | :--- |
| Maturity | Maturity for the intermediate year is taken from the smoothed maturity ogive. Ma- <br> turity 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. |
| Wand M before spawning taken as zero. |  |
| Weight at age in the stock | Average of final three years of assessment data. |
| Exploitation pattern | Fishing mortalities taken as a three-year average divided by the three-year average <br> fishing mortality for ages 2-4. |
| Intermediate year assumptions | Median total catch in the intermediate year set equal to the TAC in the intermediate <br> year. |
| Stock recruitment model used | Recruitment for the intermediate (the year the WG meets) is sampled from a normal <br> distribution of the SAM estimate and reported as the median. Recruitment for the <br> TAC year onwards is sampled, with replacement, from 1998 to the final year of catch <br> 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, $B_{\text {trigger }}=B_{p a}=150000$ tonnes, and $\mathrm{F}_{\text {MSY }}=0.31$; see Section 4.9):

1. $\quad$ MSY framework: $F_{b a r}(2021)=F_{M S Y} \times \min \left\{1 ; S S B_{2021} / B_{\text {trigger }}\right\}$
2. EU-MAP: $\mathrm{F}_{\text {bar }}(2021)=\mathrm{FMSY}_{\text {lower }} \times \min \left\{1 ; \mathrm{SSB}_{2021} / \mathrm{B}_{\text {trigger }}\right\}$
3. Zero catch: Fbar $(2021)=0$
4. $\quad \mathrm{F}_{\mathrm{pa}}: \mathrm{Fbar}^{(2021)}=\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\text {lim }} / 1.4=0.39$
5. $\quad F_{\text {lim }}: F_{\text {bar }}(2021)=F_{\text {lim }}=0.54$
6. $\quad$ SSB (2022) $=$ Blim: F corresponding to SSB (2022) $=B_{\lim }$
7. $\quad$ SSB $(2022)=B_{\mathrm{pa}}: F$ corresponding to SSB $(2022)=\mathrm{B}_{\mathrm{pa}}$
8. $\quad \operatorname{SSB}(2022)=B_{\text {trigger: }}$ F corresponding to $\operatorname{SSB}(2022)=B_{\text {trigger }}$
9. Lower TAC constraint: Fbar (2021) such that TAC (2021) $=0.8 \times$ TAC (2020)
10. Rollover TAC $15 \%$ : Fbar (2021) such that TAC $(2021)=0.85 \times$ TAC (2020)
11. Rollover TAC $10 \%$ : Fbar (2021) such that TAC (2021) $=0.9 \times$ TAC (2020)
12. Rollover TAC 5\%: Fbar (2021) such that TAC (2021) $=0.95 \times$ TAC (2020)
13. Rollover TAC: Fbar (2021) such that TAC (2021) = TAC (2020)
14. Rollover TAC $+5 \%$ : Fbar (2021) such that TAC $(2021)=1.05 \times$ TAC (2020)
15. Rollover TAC $+10 \%$ : $\mathrm{Fbar}_{\text {b }}(2021)$ such that TAC $(2021)=1.1 \times \mathrm{TAC}(2020)$
16. Rollover TAC $+15 \%$ : $\mathrm{Fbar}^{(2021)}$ such that TAC $(2021)=1.15 \times \mathrm{TAC}(2020)$
17. Upper TAC constraint: $\mathrm{F}_{\text {bar }}(2021)$ such that TAC (2021) $=1.2 \times$ TAC (2020)
18. Status quo - constant F: $\mathrm{F}_{\text {bar }}(2021)=\mathrm{F}_{\text {bar }}(2020)$
19. $\quad$ FMSY lower: $F_{\text {bar }}(2021)=F_{\text {FMY lower }}=0.198$
20. $\quad$ Fmsy: $_{\text {bar }}(2021)=F_{f m y}=0.31$

These scenarios do not include FMSY upper because SSB(2021) < MSY Btrigger.
EU-Norway requested an evaluation of multiple management strategies comprising harvest control rules (HCRs) and stability mechanisms (ICES WKNSMSE, 2019):

1. A: $\mathrm{F}_{\text {target }}=0.38, \mathrm{~B}_{\text {trigger }}=170000 \mathrm{t}$, no constraints on TAC variation
2. B: $F_{\text {target }}=0.38, B_{\text {trigger }}=160000 t$, no constraints on TAC variation
3. $C: F_{\text {target }}=0.38, B_{\text {trigger }}=170000 t$, no constraints on TAC variation
4. $A+D: F_{\text {target }}=0.40, B_{\text {trigger }}=190000 t$, constraints on TAC variation of $+25 \%$ and $-20 \%$, where SSB at the start of the TAC year is above MSY Btrigger
5. $B+E: F_{\text {target }}=0.36, B_{\text {trigger }}=130000 t$, constraints on TAC variation of $+25 \%$ and $-20 \%$, where SSB at the start of the TAC year is above MSY Btrigger
6. $C+E: F_{\text {target }}=0.36, B_{\text {trigger }}=140000 t$, constraints on TAC variation of $+25 \%$ and $-20 \%$, where SSB at the start of the TAC year is above MSY $B_{\text {trigger }}$
7. $A^{*}+\mathrm{D}: \mathrm{F}_{\text {target }}=\mathrm{F}_{\mathrm{MSY}}=0.31, \mathrm{~B}_{\text {trigger }}=\mathrm{MSY} \mathrm{B}_{\text {trigger }}=150000 \mathrm{t}$, constraints on TAC variation of $+25 \%$ and $-20 \%$, where SSB at the start of the TAC year is above MSY Btrigger

Harvest control rules A, B and C differ by the extent of reduction below Blim 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. $\mathrm{F}=\mathrm{FmSY}_{\mathrm{M} \times} \times \mathrm{SSB}_{2021} / \mathrm{B}_{\text {trig- }}$ ger where this brings SSB above Blim in 2022, and the F corresponding to SSB (2022) = Blim otherwise) assuming different multipliers on $\mathrm{F}(2019)$ 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 $\mathrm{B}_{\text {trigger }}$ | 150000 t | The default option of $\mathrm{B}_{\mathrm{pa}}(=1.4 \times$ Blim $)$ |  |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.31 | EQSim analysis based on recruitment period 1988-2016 | 2017 <br> assessment |
| Precautionary approach | $\mathrm{Blim}^{\text {m }}$ | 107000 t | SSB associated with the 1996-year class | 2017 <br> assessment |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 150000 t | $\mathrm{B}_{\text {lim }}$ multiplied by 1.4. This is the current ICES default approach. |  |
|  | $F_{\text {lim }}$ | 0.54 | EQSim analysis based on recruitment period 1998-2016 | 2017 <br> assessment |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.39 | $\mathrm{F}_{\text {lim }} / 1.4$ |  |

### 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 Blim.

Fishing mortality appears to have increased and is now above both the precautionary reference points, $\mathrm{F}_{\text {lim }}$ and $\mathrm{F}_{\mathrm{pa}}$, and the level that achieves the long-term objective of maximum yield, $\mathrm{F}_{\text {msy. }}$

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 mixedstocks 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 overand 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 $7 . \mathrm{d}$ 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 <br> quality | 2. Opportunity to <br> improve | 3. Management <br> importance | 4. Perceived stock <br> status | 5. Time since last <br> benchmark | Total <br> 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 reevaluated 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 $\left(\mathrm{Q}_{\mathrm{n}=5}=0.52\right)$ 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.


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.


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 num | s at age | nous ands) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AGE/YEAR | 1983 | 1984 | 1985 | 1988 | 1987 | 1988 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 |
| 1 | 3198 | 5004 | 15734 | 18133 | 10749 | 5800 | 2932 | 54219 | 44599 | 3813 | 25838 | 15484 |
| 2 | 42377 | 22373 | 51628 | 62202 | 70539 | 83416 | 22561 | 33747 | 154565 | 188744 | 31598 | 58624 |
| 3 | 6995 | 20003 | 17557 | 29695 | 32529 | 42373 | 31419 | 18395 | 17132 | 47885 | 54655 | 11347 |
| 4 | 3519 | 4285 | 9135 | 6153 | 11205 | 12330 | 13841 | 13272 | 6720 | 5853 | 14002 | 15745 |
| 5 | 2774 | 1908 | 2375 | 3362 | 3255 | 6048 | 4542 | 6268 | 7065 | 2713 | 2195 | 4601 |
| 6 | 1207 | 1809 | 946 | 1272 | 1964 | 1407 | 2881 | 1754 | 2686 | 3184 | 1103 | 958 |
| 7 | 81 | 596 | 655 | 475 | 884 | 868 | 585 | 958 | 888 | 1671 | 1055 | 438 |
| 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 | 58 | 40 | 111 | 48 | 97 | 77 | 112 | 57 | 80 |
| +gp | 0 | 4 | 8 | 83 | 17 | 24 | 77 | 40 | 93 | 17 | 161 | 188 |
| TOTALNUM | 60859 | 56203 | 98480 | 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 | 5095 | 75130 | 29693 | 34827 | 62394 | 20131 | 68220 | 25488 | 64358 | 8795 | 99841 |
| 2 | 46907 | 99779 | 50928 | 174912 | 91143 | 104358 | 187826 | 64755 | 128396 | 66026 | 117383 | 32308 |
| 3 | 18849 | 18481 | 25525 | 17178 | 44384 | 34938 | 34567 | 59907 | 21456 | 31087 | 18888 | 33973 |
| 4 | 4840 | 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 | 1248 | 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 | 38 | 27 | 28 | 44 | 18 | 44 |
| +gp | 63 | 43 | 96 | 44 | 17 | 25 | 21 | 16 | 23 | 19 | 31 | 23 |
| TOTALNUM | 114215 | 136872 | 161191 | 236214 | 178997 | 218034 | 256998 | 208843 | 192083 | 170937 | 158139 | 178355 |
| TONSLAND | 204215 | 232994 | 208370 | 295845 | 268342 | 292658 | 333047 | 300723 | 258815 | 226904 | 213422 | 203242 |
| SOPCOF \% | 100 | 100 | 100 | 100 | 101 | 100 | 100 | 99 | 100 | 100 | 100 | 101 |
| AGE/YEAR | 1987 | 1988 | 1589 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| 1 | 24816 | 21382 | 22072 | 11629 | 13288 | 27162 | 4888 | 15368 | 15486 | 4871 | 23443 | 1243 |
| 2 | 127774 | 55025 | 36084 | 53783 | 23145 | 31472 | 54171 | 24969 | 62850 | 38303 | 28793 | 80948 |
| 3 | 9781 | 43712 | 18058 | 11795 | 16554 | 8523 | 11134 | 20885 | 12753 | 23048 | 18390 | 18794 |
| 4 | 8889 | 3117 | 9791 | 4299 | 3267 | 4916 | 3126 | 3045 | 5223 | 3125 | 6409 | 5909 |
| 5 | 1528 | 2543 | 994 | 2445 | 1372 | 1041 | 1548 | 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 | 68 | 139 | 54 | 137 | 51 | 108 | 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 | 84898 | 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 | 2008 | 2007 | 2008 | 2009 | 2010 |
| 1 | 5831 | 8087 | 2164 | 4425 | 438 | 1470 | 1009 | 1288 | 778 | 338 | 519 | 1120 |
| 2 | 9549 | 22457 | 20309 | 8029 | 8893 | 3511 | 8175 | 4401 | 6334 | 3288 | 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 | 1148 | 2888 | 1582 |
| 5 | 1419 | 996 | 1053 | 396 | 397 | 939 | 479 | 520 | 398 | 708 | 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 | 26879 | 33315 | 38748 |
| 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 | 685 | 683 | 2240 | 688 | 167 | 351 | 170 | 892 |  |  |  |
| 2 | 4540 | 2230 | 2688 | 4207 | 6384 | 2035 | 2240 | 6004 | 1860 |  |  |  |
| 3 | 4046 | 5987 | 3083 | 4378 | 4903 | 5844 | 3233 | 3599 | 6022 |  |  |  |
| 4 | 1408 | 1983 | 2592 | 1805 | 1933 | 3150 | 3495 | 2039 | 1098 |  |  |  |
| 5 | 610 | 633 | 885 | 1288 | 745 | 1012 | 1660 | 1778 | 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 | 11289 | 10208 | 14156 | 15411 | 12534 | 11571 | 14789 | 11788 |  |  |  |
| TONSLAND | 31950 | 32074 | 30386 | 34873 | 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 | 1983 | 1984 | 1965 | 1968 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 |
| 1 | 16150 | 8049 | 97921 | 108375 | 50214 | 31115 | 2502 | 52958 | 258920 | 38250 | 85915 | 124151 |
| 2 | 19902 | 6188 | 6599 | 22125 | 24736 | 22957 | 10279 | 8856 | 37224 | 59342 | 17387 | 15878 |
| 3 | 33 | 115 | 89 | 71 | 160 | 197 | 113 | 152 | 47 | 177 | 248 | 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 | 104809 | 130570 | 75110 | 54288 | 12894 | 61768 | 296192 | 97788 | 103548 | 140100 |
| TONSDISC | 12186 | 4707 | 29104 | 37918 | 23320 | 17487 | 4792 | 17838 | 83968 | 33678 | 30038 | 39807 |
| SOPCOF \% | 100 | 101 | 100 | 100 | 100 | 100 | 101 | 101 | 100 | 100 | 100 | 100 |
| AGE/YEAR | 1975 | 1978 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| 1 | 136851 | 226781 | 472599 | 28908 | 581071 | 1185889 | 155732 | 181946 | 54949 | 537521 | 63301 | 583508 |
| 2 | 16214 | 83210 | 48009 | 78114 | 5270 | 17892 | 34307 | 8377 | 11130 | 12518 | 38573 | 5781 |
| 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 | 152888 | 310182 | 521072 | 107022 | 588341 | 1203381 | 190118 | 190421 | 68103 | 550043 | 99989 | 509571 |
| 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 | 1998 | 1994 | 1995 | 1996 | 1997 | 1998 |
| 1 | 24834 | 15376 | 176920 | 33875 | 47473 | 102410 | 33433 | 320725 | 44758 | 14254 | 88109 | 15458 |
| 2 | 61948 | 17084 | 8885 | 48244 | 8383 | 9881 | 28538 | 18804 | 43434 | 23058 | 13701 | 90259 |
| 3 | 0 | 216 | 489 | 78 | 448 | 2 | 11 | 160 | 30 | 784 | 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 | 32876 | 186094 | 82197 | 58304 | 112293 | 61983 | 337889 | 88220 | 38075 | 99851 | 107216 |
| TONSDISC | 27729 | 10855 | 61650 | 26770 | 18306 | 36244 | 21425 | 98358 | 31714 | 14081 | 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 | 30982 | 37031 | 5460 | 26267 | 5898 | 20336 | 10213 | 26890 | 16171 | 10847 | 9608 | 9887 |
| 2 | 5830 | 5509 | 33094 | 13238 | 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 | 68 | 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 | 20388 |
| 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 | 7758 | 3980 | 3067 | 9767 | 2771 | 4118 |  |  |  |
| 2 | 7851 | 5190 | 6055 | 6504 | 8935 | 4942 | 2814 | 9039 | 1618 |  |  |  |
| 3 | 925 | 1422 | 858 | 1434 | 1985 | 3110 | 1271 | 737 | 916 |  |  |  |
| 4 | 81 | 115 | 397 | 163 | 180 | 257 | 493 | 147 | 16 |  |  |  |
| 5 | 6 | 5 | 83 | 58 | 55 | 31 | 98 | 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 | 13835 | 15921 | 15201 | 11409 | 14453 | 12704 | 6872 |  |  |  |
| TONSDISC | 8745 | 8889 | 10324 | 10888 | 12562 | 12315 | 8731 | 7824 | 3812 |  |  |  |
| 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.

| atch numb | tage (th | ds) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AGE/YEAR | 1983 | 1984 | 1985 | 1968 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 |
| 1 | 19347 | 13052 | 113855 | 126508 | 60962 | 30915 | 5434 | 107177 | 303519 | 42062 | 111751 | 139635 |
| 2 | 62280 | 28541 | 58227 | 84327 | 95275 | 108373 | 32840 | 42403 | 191789 | 248088 | 48983 | 74502 |
| 3 | 7028 | 20118 | 17846 | 29788 | 32689 | 42569 | 31532 | 18547 | 17179 | 48062 | 54901 | 11418 |
| 4 | 3519 | 4285 | 9135 | 6153 | 11205 | 12330 | 13841 | 13272 | 6720 | 5853 | 14002 | 15745 |
| 5 | 2774 | 1908 | 2375 | 3362 | 3255 | 6048 | 4542 | 6268 | 7065 | 2713 | 2195 | 4601 |
| 6 | 1207 | 1809 | 946 | 1272 | 1964 | 1407 | 2881 | 1754 | 2688 | 3184 | 1103 | 958 |
| 7 | 81 | 596 | 655 | 475 | 884 | 868 | 585 | 958 | 888 | 1671 | 1055 | 438 |
| 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 | 58 | 40 | 111 | 48 | 97 | 77 | 112 | 57 | 80 |
| +gp | 0 | 4 | 8 | 83 | 17 | 24 | 77 | 40 | 93 | 17 | 161 | 188 |
| TOTALNUM | 98744 | 70535 | 203089 | 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 | 615898 | 1248084 | 175863 | 248168 | 80437 | 601879 | 72096 | 683347 |
| 2 | 63121 | 182989 | 98935 | 253025 | 96413 | 122048 | 221933 | 73132 | 139526 | 78543 | 153957 | 38069 |
| 3 | 18849 | 18872 | 25989 | 17178 | 44384 | 34938 | 34848 | 60005 | 21480 | 31092 | 19003 | 34277 |
| 4 | 4840 | 6707 | 4597 | 9398 | 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 | 1248 | 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 | 38 | 42 | 55 | 38 | 27 | 28 | 44 | 16 | 44 |
| +gp | 63 | 43 | 96 | 44 | 17 | 25 | 21 | 18 | 23 | 19 | 31 | 23 |
| TOTALNUM | 267081 | 446854 | 682263 | 343235 | 785338 | 1421415 | 447116 | 397064 | 258188 | 720980 | 258129 | 745925 |
| TONSLAND | 241089 | 305488 | 347888 | 328077 | 430835 | 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 | 338092 | 60242 | 19124 | 109552 | 16701 |
| 2 | 189722 | 72109 | 44788 | 102027 | 31528 | 41353 | 82709 | 41773 | 108084 | 59360 | 42494 | 171208 |
| 3 | 9781 | 43929 | 18544 | 11873 | 17002 | 8525 | 11145 | 21045 | 12783 | 23809 | 18430 | 18293 |
| 4 | 8889 | 3117 | 9791 | 4299 | 3267 | 4916 | 3126 | 3045 | 5223 | 3125 | 6409 | 5909 |
| 5 | 1528 | 2543 | 994 | 2445 | 1372 | 1041 | 1548 | 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 | 108 | 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 | 168895 | 115368 | 186327 | 137419 | 403578 | 185825 | 107947 | 179034 | 215299 |
| TONSLAND | 243085 | 193878 | 200531 | 150914 | 119428 | 148178 | 140748 | 207837 | 165805 | 138859 | 155808 | 184692 |
| SOPCOF \% | 100 | 100 | 100 | 100 | 100 | 99 | 100 | 100 | 99 | 100 | 100 | 100 |
| AGE/YEAR | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2008 | 2007 | 2008 | 2009 | 2010 |
| 1 | 38793 | 45118 | 7824 | 30892 | 6135 | 21807 | 11222 | 28177 | 16947 | 11185 | 10127 | 10987 |
| 2 | 15180 | 27985 | 53403 | 21265 | 14975 | 12452 | 16478 | 39743 | 29381 | 12599 | 13887 | 14188 |
| 3 | 39904 | 6310 | 6797 | 17012 | 4328 | 7460 | 4831 | 6375 | 4921 | 11721 | 5494 | 5831 |
| 4 | 3969 | 6829 | 1114 | 2805 | 3127 | 1650 | 1863 | 1020 | 2043 | 1369 | 3539 | 1648 |
| 5 | 1419 | 996 | 1053 | 395 | 397 | 944 | 548 | 524 | 451 | 720 | 648 | 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 | 70280 | 72673 | 29113 | 44524 | 35370 | 78174 | 53992 | 37928 | 34050 | 34288 |
| TONSLAND | 108347 | 82956 | 61989 | 64098 | 34274 | 36259 | 38200 | 37826 | 54873 | 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 | 4868 | 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 | 2188 | 1114 |  |  |  |
| 5 | 616 | 638 | 949 | 1345 | 800 | 1044 | 1758 | 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 | 30812 | 23942 | 26024 | 27493 | 18458 |  |  |  |
| TONSLAND SOPCOF \% | 40895 100 | 40783 100 | 40710 100 | 45339 100 | 49767 100 | 50544 100 | 46725 101 | 47836 100 | 35884 <br> 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 |  |
| $+g p$ | 2 | 2 | 2 | 1 | 0 | 7 |  |
| TOTALNUM | 1988 | 2994 | 3220 | 3243 | 216 | 11661 |  |

Discards numbers at age (including BMS landings; thousands)


Catch numbers at age (thousands)

| Age/Season Q1 | Q2 |  | Q3 |  | Q4 |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |
| $+g p$ | 2 | 2 | 2 | 1 | 0 | 7 |
| TOTALNUMALNUM |  |  |  |  |  |  |
|  | 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 | $96 \%$ | $86 \%$ | $86 \%$ | $94 \%$ | $40 \%$ |
| $27.3 . \mathrm{a}$.20 | $98 \%$ | $96 \%$ | $95 \%$ | $95 \%$ | - |
| $27.7 . \mathrm{d}$ | $37 \%$ | - | $16 \%$ | $53 \%$ | - |

Discards age composition coverage

| Area/ Season | Q1 | Q2 | Q3 | Q4 | annual |
| :--- | :---: | :---: | :---: | :---: | :---: |
| 27.4 | $95 \%$ | $66 \%$ | $78 \%$ | $87 \%$ | $99 \%$ |
| $27.3 . a .20$ | $100 \%$ | $100 \%$ | $95 \%$ | $98 \%$ | - |
| $27.7 . \mathrm{d}$ | - | - | - | - | - |

Contribution to total (before raising)

| Area/Type | Landings | Discards |
| :--- | :--- | :--- |
| 27.4 | $89 \%$ | $71 \%$ |
| $27.3 . \mathrm{a} .20$ | $11 \%$ | $29 \%$ |
| $27.7 . \mathrm{d}$ | $0 \%$ | $0 \%$ |

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


Table 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Discard weights-at-age (includes BMS landings from 2016; kg ).

| D is cards | at |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AGE/YEAF | 1963 | 1984 | 1985 | 1968 | 1987 | 1988 | 1989 | 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 | 0.508 | 0.509 | 0.506 | 0.505 | 0.504 | 0.505 | 0.508 | 0.507 | 0.507 | 0.508 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| +gp | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AGE/YEAF | 1975 | 1978 | 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 | 0.278 | 0.242 |
| 2 | 0.359 | 0.354 | 0.382 | 0.309 | 0.381 | 0.411 | 0.396 | 0.489 | 0.458 | 0.469 | 0.378 | 0.365 |
| 3 | 0.000 | 0.412 | 0.378 | 0.000 | 0.000 | 0.000 | 0.517 | 0.593 | 0.534 | 0.509 | 0.652 | 0.437 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| +gp | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AGE/YEAF | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| 1 | 0.237 | 0.300 | 0.326 | 0.260 | 0.315 | 0.314 | 0.274 | 0.287 | 0.316 | 0.342 | 0.313 | 0.358 |
| 2 | 0.353 | 0.339 | 0.431 | 0.371 | 0.386 | 0.408 | 0.429 | 0.382 | 0.404 | 0.380 | 0.453 | 0.375 |
| 3 | 0.000 | 0.463 | 0.484 | 0.526 | 0.395 | 2.309 | 0.705 | 0.483 | 0.553 | 0.515 | 0.616 | 0.481 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| +gp | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AGE/YEAF | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| 1 | 0.257 | 0.298 | 0.232 | 0.243 | 0.262 | 0.236 | 0.302 | 0.224 | 0.288 | 0.404 | 0.385 | 0.292 |
| 2 | 0.389 | 0.422 | 0.361 | 0.314 | 0.345 | 0.270 | 0.585 | 0.116 | 0.814 | 0.735 | 0.984 | 0.785 |
| 3 | 0.422 | 0.000 | 0.408 | 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 | 0.884 | 2.223 | 2557 | 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 | 13.484 | 6.728 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 15.908 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 8.100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 12.014 | 0.000 |
| +gp | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AGE/YEAF | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |  |  |  |
| 1 | 0.277 | 0.234 | 0.334 | 0.311 | 0.326 | 0.384 | 0.231 | 0.281 | 0.327 |  |  |  |
| 2 | 0.677 | 0.556 | 0.796 | 0.742 | 0.759 | 0.939 | 0.771 | 0.607 | 0.558 |  |  |  |
| 3 | 2.057 | 1.867 | 1.493 | 1.772 | 1.617 | 1.787 | 1.881 | 1.410 | 1.381 |  |  |  |
| 4 | 4.099 | 3.803 | 3.375 | 3.128 | 3.158 | 3.092 | 3.002 | 2.682 | 2.284 |  |  |  |
| 5 | 5.578 | 6.458 | 4.048 | 3.826 | 3.983 | 4.887 | 3.629 | 3.580 | 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.


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 |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | landinqs | 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 |
| 2019 | 6019 | 3018 |  |
| 2000 | 69567 | 13360 | 82927 |
| 2013 | 3013 | 30362 | 3559 |

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

\left.|  |  |  |  | Aqe |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  | 2 | 3 | 4 | 5 |$\right] 6+\quad$.

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

| y | Aqe |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 DeltaGAM indices). Data used in the assessment are highlighted in bold font.

| IBTS_Q1 _gam $\begin{array}{r}1983\end{array}$ | 2020 |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 0.25 |  |  |  |
| 1 | 1 | 0 |  |  |  |  |
| 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
    -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
    0
    5
$keyQpow
# Density dependent catchability power parameters (if any).
    -1
    -1
    -1
```

\$keyvarF
\# Coupling of process variance parameters for $\log (F)$-process (normally only first row
is used)
$\begin{array}{llllll}0 & 1 & 1 & 1 & 1 & 1\end{array}$
$\begin{array}{llllll}-1 & -1 & -1 & -1 & -1 & -1\end{array}$
$\begin{array}{llllll}-1 & -1 & -1 & -1 & -1 & -1\end{array}$
\$keyvarLogn
\# Coupling of process variance parameters for $\log (\mathrm{N})$-process
011111
\$keyvarobs
\# Coupling of the variance parameters for the observations.
$\begin{array}{llllll}0 & 1 & 2 & 2 & 2 & 2\end{array}$
$\begin{array}{llllll}3 & 4 & 4 & 4 & 4 & -1\end{array}$
$\begin{array}{llllll}5 & 6 & 6 & 6 & -1 & -1\end{array}$
\$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 $A R(1)$ 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 $-1 \quad-1$
\$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.
199319941995 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).
\begin{tabular}{llllll}
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
\end{tabular}
```


## \$fbarRange

```
\# lowest and highest age included in Fbar
24
\$keyBiomassTreat
\# To be defined only if a biomass survey is used ( 0 SSB index, 1 catch index, and 2 FSB index).
\(\begin{array}{lll}-1 & -1 & -1\end{array}\)
\$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 (o 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 $\operatorname{logN}$ increment distribution
0
\$fracmixobs
\# A vector with same length as number of fleets, where each element is the fraction of $\mathrm{t}(3)$ distribution used in the distribution of that fleet
000

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 |



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 | $\begin{array}{r} \text { TSB } \\ \text { (tonnes) } \end{array}$ | Low | High | $\begin{array}{r} \text { SSB } \\ \text { (tonnes) } \end{array}$ | Low | High | Total removals (tonnes) | Low | High | Fbar 2-4 | Low | High |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1963 | 397861 | 288785 | 548135 | 464815 | 401447 | 538185 | 145332 | 115009 | 183650 | 118055 | 104939 | 132810 | 0.487 | 0.422 | 0.563 |
| 1964 | 648833 | 471772 | 392346 | 591607 | 507557 | 639576 | 156998 | 126565 | 194595 | 144080 | 131083 | 158365 | 0.527 | 0.463 | 0.5 |
| 1965 | 874576 | 633410 | 1198107 | 754709 | 653155 | 872053 | 192122 | 159523 | 231384 | 198223 | 177382 | 221511 | 0.58 | 0.511 | 0.658 |
| 1966 | 1061485 | 773598 | 1452749 | 904386 | 783529 | 1043753 | 213317 | 177928 | 255745 | 241058 | 216245 | 268715 | 0.586 | 0.518 | 0.653 |
| 1967 | 891940 | 651352 | 1221394 | 959934 | 340751 | 1095012 | 242052 | 202313 | 289595 | 286656 | 236779 | 320008 | 0.621 | 0.551 | 0.699 |
| 1968 | 448109 | 326570 | 614880 | 821615 | 735009 | 917178 | 254923 | 219032 | 296595 | 292971 | 265653 | 321888 | 0.657 | 0.583 | 0.741 |
| 1969 | 391264 | 283229 | 540507 | 680719 | 605035 | 754507 | 251103 | 213477 | 295361 | 225331 | 208739 | 243185 | 0.624 | 0535 | 0.703 |
| 1970 | 1319001 | 961192 | 1810006 | 1065134 | 835710 | 1279450 | 261273 | 222836 | 306341 | 251642 | 221578 | 285785 | 0.664 | 0.593 | 0.743 |
| 1971 | 1735275 | 1259157 | 2391427 | 1203522 | 1019839 | 1420288 | 264824 | 226257 | 309965 | 350638 | 301595 | 407655 | 0.748 | 0.672 | 0.834 |
| 1972 | 431001 | 312283 | 594849 | 864632 | 766909 | 974307 | 235810 | 201592 | 275837 | 362786 | 318194 | 413625 | 0.807 | 0.723 | 0.9 |
| 1973 | 634169 | 459742 | 874773 | 691200 | 614969 | 776880 | 209602 | 184592 | 238000 | 259812 | 237012 | 284805 | 0.795 | 0.714 | 0.885 |
| 1974 | 630369 | 456309 | 870823 | 662430 | 587137 | 747379 | 224993 | 197494 | 256321 | 236305 | 211382 | 254165 | 0.762 | 0.584 | 0.849 |
| 1975 | 1085628 | 778775 | 1513338 | 746384 | 636740 | 874909 | 203495 | 177299 | 233561 | 247507 | 215710 | 283990 | 0.816 | 0.735 | 0.505 |
| 1976 | 754498 | 536945 | 1050195 | 603230 | 529856 | 685766 | 172037 | 147979 | 200007 | 248057 | 215452 | 285595 | 0.869 | 0.781 | 0.967 |
| 1977 | 1831202 | 1312523 | 2534635 | 901575 | 734881 | 1105081 | 145750 | 125744 | 163939 | 264717 | 217212 | 322613 | 0.829 | 0.746 | 0.921 |
| 1978 | 1115005 | 795324 | 1551720 | 1020001 | 853602 | 1218837 | 144872 | 128519 | 153179 | 357383 | 295196 | 432670 | 0.912 | 0.822 | 1011 |
| 1979 | 1396762 | 1000594 | 1949589 | 954241 | 815136 | 1117085 | 143234 | 128040 | 160231 | 341262 | 292292 | 398438 | 0.858 | 0.774 | 0.951 |
| 1980 | 2247728 | 1501687 | 3154351 | 1143956 | 950940 | 1376151 | 156274 | 140349 | 174007 | 395105 | 327248 | 477032 | 0.93 | 0.842 | 1027 |
| 1981 | 874072 | 625035 | 1272332 | 962960 | 835042 | 1109146 | 164889 | 149311 | 182092 | 397436 | 339488 | 455275 | 0.946 | 0.859 | 1042 |
| 1982 | 1405138 | 1014950 | 1945330 | 1007901 | 348945 | 1195617 | 163862 | 147848 | 181510 | 382353 | 325153 | 449602 | 1.05 | 0.954 | 1.155 |
| 1983 | 778856 | 571939 | 1050533 | 798036 | 688553 | 924921 | 135231 | 121678 | 150294 | 319729 | 273074 | 374355 | 1.046 | 0.952 | 1.15 |
| 1984 | 1427094 | 1043957 | 1941546 | 810999 | 681909 | 954527 | 117474 | 105439 | 130883 | 277239 | 235253 | 325719 | 0.985 | 0.897 | 1083 |
| 1985 | 351191 | 255692 | 482359 | 551714 | 487814 | 623984 | 116908 | 104794 | 130422 | 241107 | 208933 | 278235 | 0.95 | 0.854 | 1045 |
| 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 | 302315 | 111274 | 100492 | 123213 | 257172 | 217121 | 304612 | 0.983 | 0.896 | 1079 |
| 1988 | 415364 | 305958 | 562054 | 512026 | 449529 | 583212 | 110252 | 101047 | 120296 | 205961 | 182954 | 231851 | 1.007 | 0.918 | 1.105 |
| 1989 | 725003 | 533345 | 983530 | 511065 | 432347 | 604114 | 102131 | 93109 | 112027 | 178693 | 153314 | 207597 | 1.024 | 0.933 | 1.124 |
| 1990 | 290041 | 215063 | 391159 | 350496 | 308370 | 398377 | 89061 | 80581 | 98312 | 138279 | 120931 | 158115 | 0.959 | 0.87 | 1057 |
| 1991 | 331095 | 245058 | 443519 | 319830 | 278325 | 367526 | 87527 | 78569 | 97505 | 117936 | 104343 | 132663 | 0.95 | 0.859 | 1049 |
| 1992 | 755064 | 560591 | 1016821 | 487745 | 401201 | 592959 | 83873 | 74935 | 93878 | 139496 | 117505 | 165459 | 0.947 | 0.85 | 1056 |
| 1993 | 383798 | 235911 | 513403 | 383156 | 323019 | 454488 | 84866 | 71802 | 100308 | 142415 | 116458 | 174142 | 0.948 | 0.841 | 1058 |
| 1994 | 914881 | 671823 | 1245876 | 486912 | 394702 | 500554 | 91184 | 75499 | 100583 | 146512 | 117593 | 182543 | 0.958 | 0.849 | 1.082 |
| 1995 | 523283 | 387969 | 705792 | 521253 | 429513 | 632587 | 104979 | 87300 | 125519 | 180109 | 143557 | 225956 | 0.993 | 0.879 | 1.121 |
| 1996 | 336084 | 250574 | 450594 | 395554 | 332155 | 471053 | 105387 | 88245 | 125859 | 148245 | 120542 | 182163 | 0.995 | 0.881 | 1.125 |
| 1997 | 1021714 | 747419 | 1396674 | 584620 | 453435 | 737493 | 90973 | 76622 | 108014 | 146098 | 115671 | 184528 | 0.98 | 0.859 | 1.105 |
| 1998 | 108417 | 50317 | 146348 | 304422 | 253635 | 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 | 105073 | 1.053 | 0.934 | 1.185 |
| 2000 | 404922 | 303069 | 541003 | 258741 | 212331 | 315296 | 57987 | 48358 | 69533 | 75515 | 50984 | 93510 | 1.047 | 0.928 | 1.18 |
| 2001 | 148931 | 111216 | 199437 | 182815 | 154255 | 216554 | 56600 | 47554 | 67365 | 65046 | 53201 | 79527 | 0.978 | 0.857 | 1.103 |
| 2002 | 223024 | 157073 | 297711 | 155929 | 130845 | 185822 | 51327 | 43124 | 61090 | 51411 | 42368 | 62335 | 0.929 | 0.82 | 1052 |
| 2003 | 111362 | 83144 | 149158 | 131343 | 111558 | 154537 | 53034 | 44473 | 63242 | 48463 | 39705 | 59152 | 0.91 | 0.803 | 1031 |
| 2004 | 189388 | 143893 | 249257 | 115138 | 97598 | 135831 | 42657 | 35851 | 50741 | 35324 | 29105 | 42872 | 0.862 | 0.76 | 0.979 |
| 2005 | 152981 | 114712 | 204018 | 133820 | 114356 | 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 | 0.571 | 0.839 |
| 2007 | 166035 | 127113 | 216876 | 191116 | 158104 | 217278 | 74120 | 65654 | 83665 | 52339 | 45905 | 59674 | 0.704 | 0.526 | 0.791 |
| 2008 | 186679 | 142825 | 243997 | 197967 | 173182 | 226299 | 81504 | 72328 | 91845 | 51927 | 47353 | 56942 | 0.677 | 0597 | 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 | 248773 | 85417 | 72754 | 100270 | 48291 | 44042 | 52950 | 0.601 | 0.515 | 0.702 |
| 2011 | 129315 | 98580 | 169633 | 196574 | 168094 | 229879 | 91220 | 74953 | 111015 | 44197 | 40103 | 43709 | 0.501 | 0.422 | 0.595 |
| 2012 | 176577 | 135053 | 230857 | 170361 | 144838 | 200381 | 88072 | 71169 | 108989 | 40056 | 37178 | 43158 | 0.468 | 0391 | 0.561 |
| 2013 | 218392 | 157001 | 285596 | 215966 | 183205 | 254583 | 93409 | 75478 | 115599 | 41614 | 33392 | 45107 | 0.463 | 0.388 | 0.552 |
| 2014 | 303724 | 231925 | 397749 | 265032 | 273834 | 313812 | 98484 | 80021 | 121208 | 45622 | 41777 | 49821 | 0.468 | 0397 | 0.552 |
| 2015 | 148305 | 113504 | 193776 | 234185 | 199545 | 274701 | 109640 | 87997 | 138505 | 51093 | 45658 | 55939 | 0.464 | 0395 | 0.544 |
| 2016 | 111470 | 83334 | 145512 | 203189 | 174254 | 236929 | 108512 | 87718 | 134237 | 51421 | 47888 | 55215 | 0.466 | 0.395 | 0.549 |
| 2017 | 284201 | 211402 | 382070 | 200381 | 168751 | 237941 | 97868 | 77997 | 122801 | 47535 | 44413 | 50877 | 0.521 | 0.45 | 0.504 |
| 2018 | 72495 | 54002 | 97321 | 155914 | 129937 | 187086 | 88071 | 65002 | 114062 | 48315 | 44230 | 52778 | 0.645 | 0.56 | 0.744 |
| 2019 | 156655 | 105409 | 230528 | 152107 | 121493 | 190435 | $65581$ | $48221$ | $83455$ | 37659 | 34743 | 40813 | 0.638 | 0.538 | 0.758 |
| 2020 | 262978 | 112362 | 615439 |  |  |  | 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 <br> 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 |
| :--- | ---: |
| $\operatorname{SSB}(2021)$ | 78300 |
| R(2020) | 268197 |
| $R(2021)$ | 176577 |
| Catch(2020) | 17679 |
| Landings(2020) | 15132 |
| Discards(2020) | 2547 |


| Bas is | $\begin{gathered} \text { Total } \\ \text { catch } \\ (2021) \\ \hline \end{gathered}$ | Projected landings (2021) | Projected discards (2021 | $\begin{array}{r} F_{\text {xotal }} \\ (2021) \\ \hline \end{array}$ | $\mathrm{F}_{\text {prokeced }}$ landings (2021) | $\mathrm{F}_{\text {poj\|ected }}$ discards (2021) | $\begin{array}{r} \text { SSB } \\ (2022) \\ \hline \end{array}$ | $\begin{array}{r} \% \text { SSB } \\ \text { change } \end{array}$ | \% TAC change | \%Advice change |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| MSY a pproach | 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 |
| $\mathrm{F}=0$ | 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 |


| Basis | Total catch (2021) | Projected landings (2021) | Projected discards (2021) | $\begin{array}{r} \mathrm{F}_{\text {wal }} \\ (2021) \end{array}$ | $\mathrm{F}_{\text {propected }}$ landings (2021) | $\mathrm{F}_{\text {projected }}$ discards (2021) | $\begin{array}{r} \text { SSB } \\ (2022) \\ \hline \end{array}$ | $\begin{array}{r} \text { \% SSB } \\ \text { change } \end{array}$ | \% TAC <br> 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 |
| $\mathrm{B}+\mathrm{E}$ | 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 | $\begin{array}{r} \text { Total } \\ \text { catch } \\ (2021) \\ \hline \end{array}$ | $\begin{array}{r} \text { Projected } \\ \text { landing } \\ (2021) \\ \hline \end{array}$ | $\begin{array}{r} \text { Projected } \\ \text { discards } \\ (2021) \\ \hline \end{array}$ | $\begin{array}{r} \mathrm{F}_{\text {toul }} \\ (2021) \end{array}$ | $\begin{aligned} & \mathrm{F}_{\text {propected }} \\ & \text { landings } \\ & (2021) \\ & \hline \end{aligned}$ | $\begin{array}{r} \hline F_{\text {properand }} \\ \text { discards } \\ (2021) \\ \hline \end{array}$ | $\begin{array}{r} \text { SSB } \\ (2022) \\ \hline \end{array}$ | $\begin{array}{r} \text { \% SSB } \\ \text { change } \end{array}$ | \% TAC <br> 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 |


| Basis | $\begin{aligned} & \text { Total } \\ & \text { catch } \\ & (2020) \end{aligned}$ | Wanted catch <br> (2020) | $\begin{aligned} & \text { vanted } \\ & \text { catch } \\ & (2020) \end{aligned}$ | $\begin{array}{r} \mathrm{F}_{\text {total }} \\ (2020) \\ \hline \end{array}$ | $\begin{aligned} & F_{\text {wanted }} \\ & (2020) \\ & \hline \end{aligned}$ | $\mathrm{F}_{\text {unwanted }}$ <br> (2020) | $\begin{array}{r} \text { SSB } \\ (2021) \\ \hline \end{array}$ | $\begin{array}{r} \text { \%SSB } \\ \text { change } \end{array}$ | $\begin{array}{r} \text { \%TAC } \\ \text { change } \end{array}$ | \%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).


Proportion of all cod discarded (by weight)



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.


$$
A L K \rightarrow \text { Exclude } \rightarrow N W \rightarrow N W \& V \rightarrow V
$$

Solid $=2020 ;$ dashed $=2019$


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 DeltaGAM 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 DeltaGAM 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.

Age 1


Log-numbers: IBTS_Q1_gam

Age 3


Log-numbers: IBTS_Q1_gam

Age 2


Age 4


Log-numbers: IBTS_Q1_gam

Age 5


Log-numbers: IBTS_Q1_gam
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 NSIBTS Delta-GAM indices, ages 1-5). The smoothing parameter I 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 I 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-atage 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.


## Ages 2 to 4



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 19932005 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 $B_{\text {lim }}=107000 t$ and $B_{p a}=150000 t$, and in the $F_{\text {bar }}$ plot $F_{\text {lim }}=0.54, F_{p a}=0.39$ and $F_{\text {MSy }}=0.31$. 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. $F=F_{M S Y} \times$ SSB $_{2021} / B_{\text {trigger }}$ where this brings SSB above $B_{\text {lim }}$ in 2022, and the $F$ corresponding to $\operatorname{SSB}(2022)=B_{\text {lim }}$ 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) 

## $5.1 \quad$ 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 40725 tonnes (compared to 44792 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 FMSY proxy and the relative biomass is above the reference BMSY 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 ( $\sim 90 \%$ ). 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 万95).

### 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 10000 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 ( 21335 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 40725 tonnes ( -4067 tonnes compared to 2018) from which 5024 tonnes were landings and 35702 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: $\quad$ 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_7099_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:
o TBB_CRU_16-31_0_0_all (10 métiers)
o OTB_CRU_16-31_0_0_all (7 métiers)
o OTB_CRU_32-69_0_0_all (NOR, 5 métiers)
o OTB_SPF_70-99_0_0_all (FRA, 3 métiers)
o OTM_SPF_70-99_0_0_all (FRA, 3 métiers)
o MIS_MIS_0_0_0_IBC (16 métiers)
o OTB_SPF_32-69_0_0_all (3 métiers)
o 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 20152016. 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 $\mathrm{kg} h$ (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 ( $\mathrm{n} /$ 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 <br> BTS) . Delta GAM M ethod 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 M SY 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. $>12 \mathrm{~cm}$ 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 | $1987-2002,>12 \mathrm{~cm}$ |
| BTS Tridens | $1996-2002,>12 \mathrm{~cm}$ |
| Combined BTS (Isis, Tridens, Solea) | $2003-2019$, Age $>1 \mathrm{yr}$ |
| 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 FMSY proxy and the relative biomass is above the reference $B_{\text {MSY }}{ }^{*} 0.5$ proxy. Also the estimated uncertainty boundaries around the relative $F$ values show that these are below the reference Fmsy proxy for recent years, and those estimated for the relative biomass are above the reference $\mathrm{B}_{\mathrm{Ms}}{ }^{*} 0.5$ 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 5.225.28.


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 $\mathrm{B}_{\mathrm{MSY}}$ (right panel).


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


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


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

### 5.6 Issues list

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


### 5.7 References

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### 5.8 Tables

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

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


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

[^5]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 |

[^6]Table 5.5. Official dab landings in ICES Division 3.a.

| Year | Bel | Deu | Dnk | Fra | Nid | 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 | NId | 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 |

[^7]Table 5.6. Dab in Subarea 4 and Division 3.a.: InterCatch landings, discards and total catch (2002-2018).

| Year | Landings | Imported discards | Raised <br> discards | Total <br> 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 Fmsy 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 $25-40 \mathrm{~m}$ 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 $(\sim 40 \%)$. 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_1632_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, $\sim 56 \%$ 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 $>20 \mathrm{~cm}$ 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).

FLE IBTS Q1


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.

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

$$
g\left(\mu_{i}\right)=\operatorname{Year}(i)+f_{1}\left(\operatorname{lon}_{i}+l a t_{i}\right)+f_{2}(\operatorname{dept}
$$

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 $P_{\text {mega }}$ indicator decreased since 2014 and dropped below the $30 \%$ reference point for 2018 and 2019. The Lc /Lmat ratio fluctuated around 1 but was above in 2019. In terms of the Fmsy proxy Lmean $/ \mathrm{LF}_{\mathrm{f}} \mathrm{m}$ 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 Fmsy.

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

| Parameter | Sex combined |
| :--- | :--- |
| von Bertalanffy ${\mathrm{k}\left(\mathrm{yr}^{-1}\right)}^{\text {Length-weight a }}$ | 41 |
| Length weight b | 0.36 |
| Natural mortality M (yr-1) | 0.00867 |
| Length-at-maturity $(\mathrm{mm})$ | 3.06 |
| 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 ( $>150 \mathrm{~mm}$, 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 $L_{\text {mean }}$ Lopt | $\begin{gathered} M S Y \\ L_{\text {mean }} / L_{F=M} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\mathrm{LC} / \mathrm{L}_{\text {mat }}$ | $\mathrm{L}_{25 \%} / \mathrm{L}_{\text {mat }}$ | $L_{\text {max } 5 \%} / L_{\text {inf }}$ | $\mathrm{P}_{\text {mega }}$ |  |  |
| Ref | >1 | >1 | $>0.8$ | >30\% | $\sim 1(>0.9)$ |  |
| 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 7.17.3; Table 7.4-7.6). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46598 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 (20102019) 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/HistoricalLand-ings1950-2010.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 /ogin.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 19802019.


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 19942019 (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_7099_0_0_all; 104 tonnes, TBB_DEF_>=120_0_0_all), Germany ( 82 tonnes, TBB_DEF_7099_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_7099_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 9295 tonnes from which 1709 tonnes were landings (18\%) and 7586 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 sea-
son. 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.


### 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 $50-100 \mathrm{~m}$, 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 $56^{\circ} \mathrm{N}$ 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 $13^{\circ} \mathrm{C}$ (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 IBTSQ3 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.

## IBTS Mature biomass index



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 $\operatorname{Linf}(37.2 \mathrm{~cm})$ and Lmat $(16.3 \mathrm{~cm})$. 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 $\mathrm{LC} / \mathrm{Lmat}^{2}$ and $\mathrm{L}_{25 \%} / \mathrm{L}_{\text {mat }}$ for the recent five years (Figure 7.11 and Table 7.2 and Table 7.3). For the $\mathrm{Lmax}_{\mathrm{x} 5 \%}$ / Linf reference point the indicator is only above the reference point for the last two years. The $P_{\text {mega }}$ 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 Fmsy 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 | LT75 | LL25 | Lmed | L-90 | 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.


### 7.7 Data requirements

For management purposes, information should be available on catches and landings. Traditionally the quality of landings data has been poor for this species because in the past often only landings of "gurnards" were reported which is still the case for some countries today (e.g. Germany, UK England). Further, this species is highly discarded and discard data are only available for the recent years (2012-2019).

Given the high level of discarding, observation at sea under DCF is the main source of information to better estimate the total catches.

For a better understanding of this species an increase in our knowledge of biological parameters is required. In the context of ecosystem considerations, it would be useful to obtain more information on age composition of the stock and its diet composition.

From the information presented here, it can be concluded that grey gurnard is currently of very limited commercial interest.

### 7.8 Issues list

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

The used survey indices are well suitable for this stock as the IBTS covers most of the stock distribution area and shows a good catchability for this species.

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

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

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

### 7.9 References

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### 7.10 Catch and index tables

Table 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 3.a (tonnes).

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


| 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 <br> 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 | 1600 | 3451 | 17121 | 13670 | 0.80 |  |
| 2018 | 1621 | 13 | 1137 | 11418 | 10281 | 0.90 |
| 2019 |  |  | 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 had-
dock 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 33956 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 41818 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 RTC 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 28950 tonnes and 35653 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 weightlength 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 | EngGFSQ3 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-WIBTSQ1 | 1985-2010 | 1-8 |
| Subarea 6.a | Scotland | Q1 | New ScoGFS-WIBTS Q1 | 2011-present | 1-8 |
| Subarea 6.a | Scotland | Q4 | ScoGFS-WIBTSQ4 | 1996-2009 | 0-7 |
| Subarea 6.a | Scotland | Q4 | New ScoGFS-WIBTSQ4 | 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 $\pm 15 \%$ 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 Fmsy 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 $(I Y=2020)$ and in the quota year $(\mathrm{IY}+1=2021)$ 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 | 5406 |
| 2020 | 0 | 5406 |  |
| 2021 | Age 0 in 2021 | 5406 |  |
| 2022 | Age 0 in 2022 |  |  |

### 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 cohortbased 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 41819 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 timesmoothed 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 210875 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 13023 t .

Several alternative options for 2021 have been highlighted in Table 8.6.2. These are based on various reference points including Fmsy, $\mathrm{F}_{\mathrm{pa}}$, Flim, $\mathrm{B}_{\text {pa }}$, Blim, $\mathrm{B}_{\text {trigger }}$ as well as $\mathrm{F}_{2020}$, Fmsy-upper, Fmsy-lower. Under the assumption of FMSY, the $^{2021}$ total catch is forecast to be 69280 tonnes, which corresponds (if 2020 discard+BMS rates remain unchanged) to a wanted-catch yield of 49061 tonnes and unwanted catch of 20110 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 471256 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 FMSY 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 Fmsy 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 timeseries 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, Blim was revised to 94 kt (the estimated SSB for 1979, the smallest stock size to produce a good recruitment), and $B_{p a}$ was revised to $1.4 \times$ $B_{\lim }=132 \mathrm{kt}$ (which was also used as the MSY Btrigger value). An EqSim run with no advice error or rule generated $\mathrm{F}_{\lim }=\mathrm{F}_{\mathrm{p} 50}=0.38$, and $\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\lim } / 1.4=0.27$. A second EqSim run with advice error but no advice rule produced an estimate of $\mathrm{Fmš}=0.24$ 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 $\mathrm{F}_{\mathrm{p} 05}=0.19$ < Fmsy (Figure 8.8.1, bottom plot) so both Fmsy and the upper limit of the Fmsy range were constrained resulting in an $\mathrm{F}_{\text {MSY }}$ 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 Fmsy range should be redefined when the

FMSY range is constrained by $\mathrm{F}_{\mathrm{p} 05}$. The new guidelines define the lower limit of the $\mathrm{F}_{\text {msy }}$ range as the F that delivers $95 \%$ of the yield at $\mathrm{F}_{\mathrm{MSY}}=\mathrm{F}_{\mathrm{p} 05}$. The new EqSim run followed the same procedure as used in the IBP though with the new definition for the lower limit of the FmsY range and resulted in a Fmsy range of $0.167-0.194$ (see Figure 8.2.2). This rerun resulted in minor differences in the estimation of FMSY ( 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 |
| :--- | :---: | :---: | :---: |
| $\mathrm{B}_{\text {lim }}$ | 63 kt | 94 kt | 94 kt |
| $\mathrm{B}_{\mathrm{pa}}$ | 88 kt | 132 kt | 132 kt |
| $\mathrm{F}_{\text {lim }}$ | $\mathrm{n} / \mathrm{a}$ | 0.38 | 0.384 |
| $\mathrm{~F}_{\mathrm{pa}}$ | $\mathrm{n} / \mathrm{a}$ | 0.27 | 0.274 |
| $\mathrm{~F}_{\mathrm{MSY}}$ | 0.37 | 0.19 | 0.194 |
| $\mathrm{~F}_{\mathrm{MSY} \text { lower }}$ | $\mathrm{n} / \mathrm{a}$ | 0.18 | 0.167 |
| $\mathrm{~F}_{\mathrm{MSYupper}}$ | $\mathrm{n} / \mathrm{a}$ | 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 FMSY (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 $B_{p a}(132 \mathrm{kt})$ 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 Fmš. 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.
o 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.
o This applies to haddock.
- The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) $<=1.1 \times \mathrm{F}_{\text {msy }}$ OR if $\mathrm{Fmsy}_{\text {m }}$ range has been defined: F (latest assessment year) is $<=$ F $_{\text {upper }}$ (upper bound in F range) AND SSB(start of intermediate year) $>=$ MSY $B_{\text {trigger }}$
o 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.
o 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 <br> quality | 2. Opportunity to <br> improve | 3. Management im- <br> portance | 4. Perceived stock <br> status | 5. Time since last <br> benchmark | Total <br> 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
- $\quad$ Stock ID and substructure
o Otolith micro-chemistry study to track fish from nursery to first and subsequent spawnings
o Tagging data to determine migration rates
o Assess spatial range of genetic structure
- $\quad$ 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).
- $\quad$ 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 <br> (tonnes) | Proportion |
| :--- | :--- | :--- | ---: | :--- |
| BM S 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 |
|  | Riscards | Raised | Estimated | 494 |
| Discards | Imported | Estimated | 25 | 0 |
|  | Imported | Estimated | 153 | 91 |
|  | 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 |
| BM S landings | Imported | Sampled | 27.6.a | 0 | 0 |
| BM S 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 |
| BM S landings | Imported | Estimated | 27.4 | 1 | 0 |
| BM S 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 |
| BM S 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 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\frac{1}{8}$ | $\begin{aligned} & 8 \\ & 6 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { 易 } \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\underline{y}$ | 長 | $\begin{aligned} & 8 \\ & 6 \\ & 0 \\ & 0 \end{aligned}$ |  |  | $\begin{aligned} & \sqrt[3]{8} \\ & 0 \end{aligned}$ |  | $\begin{aligned} & \text { 昌 } \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | 采 | $\begin{aligned} & 8 \\ & 8 \\ & \frac{8}{8} \\ & 0 \end{aligned}$ | \％ | $\sum_{i}^{n} \underbrace{0}_{0}$ | － | \％ |
| 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 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\stackrel{y}{\delta}$ | $\begin{aligned} & 8 \\ & 0 \\ & 0 \\ & \hline 6 \end{aligned}$ | $\begin{aligned} & \text { 曷 } \\ & 0 \\ & 0 \end{aligned}$ |  | Y | $\frac{\sqrt{6}}{6}$ | 8 8 6 | $\begin{aligned} & \text { en } \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\sum_{0}^{n}$ | $\frac{\sqrt{6}}{6}$ | $\begin{aligned} & 8 \\ & \frac{5}{6} \\ & 6 \end{aligned}$ | $\begin{aligned} & \text { 苞 } \\ & \text { 合 } \end{aligned}$ | $\sum_{\boxed{4}}^{n}$ | $\frac{5}{6}$ | 8 6 6 | \％ 0 0 0 | $\sum_{i=1}^{n}$ | Y | $\frac{\sqrt{6}}{6}$ |
| 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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5 +}$ | $\mathbf{8 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1 9 6 5}$ | 650218 | 36850 | 16491 | 721514 | 36301 | 4954 | 2245 | 626 | 118 | $\mathbf{9 7}$ | 47 | 0 | 0 | 0 | 0 | 0 | $\mathbf{2 6 2}$ |
| 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5 +}$ | $\mathbf{8 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |  |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 2008 | 0 | 299 | 6472 | 50965 | 4461 | 1986 | 1378 | 563 | 1402 | $\mathbf{2 5 6 6}$ | 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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5 +}$ |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 | 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |

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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |

## 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.

|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 | 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathbf{2 0 0 1}$ | 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |

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 |
| BM S landings | Ages | 0-8+ |
|  | Years | 2016-2019 |
| Survey: NSIBTSQ1 | Ages | 1-5 |
|  | Years | 1983-2020 |
| Survey: NSIBTSQ3 | 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 |  | $H(a)=(2,2,1,1,1,1,1,1,1,1)$ |
| F plateau |  | $a_{m}=7$ |
| M easurement-error multiplier for landings |  | $B_{\text {landings }}(a)=(, 3.7,1.3,1,1.1,1.4,1.6,2.7,2.8)$ |
| M easurement-error multiplier for discards+bycatch+bms |  | $B_{\text {discards }}(a)=(2.0,1.7,1,1.5,1.8,2.4$, , , $)$ |
| Downweighted landings outliers |  | 1996, age 7 ( $\omega=3$ ) |
| Downweighted discards+bycatch + bms outliers |  | 1982, age 5; 2002, age 0 ; 2012, age 2 ( $\omega=3$ for all) |
| Downweighted survey outliers |  | NSIBST Q1: 2011, age 5; 2014, age 4 ( $\omega=3$ 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | Mean $\mathbf{F ( 2 - 4 )}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | ---: |
| 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 |


|  | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |
|  |  |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |  |

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

| $\underset{\gamma}{8}$ | 5 0 0 | $\begin{aligned} & \text { y } \\ & \text { t } \\ & \text { 0 } \end{aligned}$ | $\begin{aligned} & 8 \\ & 8 \\ & 8 \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { B } \\ & \text { B } \\ & 0 \\ & \hline \end{aligned}$ | 4 6 6 6 6 | $\begin{aligned} & 8 \\ & \text { 8 } \\ & \frac{1}{8} \\ & \frac{1}{10} \end{aligned}$ |  |  |  | $\begin{aligned} & \not y \\ & 4 \\ & 4 \\ & \text { y } \\ & \Sigma \end{aligned}$ | $\begin{aligned} & 8 \\ & 4 \\ & 4 \\ & \vdots \\ & \Sigma \end{aligned}$ | $y$ 易 | $\begin{aligned} & 8 \\ & \frac{8}{4} \end{aligned}$ | $\begin{aligned} & \text { \$ } \\ & \text { 出 } \end{aligned}$ | $\begin{aligned} & 8 \\ & \text { \% } \\ & \hline 1 \end{aligned}$ |  | $\begin{aligned} & 8 \\ & \text { \% } \\ & \text { E } \\ & \text { 8 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |


| $\frac{1}{8}$ | $\begin{aligned} & \text { \& } \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { y } \\ & \text { t } \\ & \text { t } \end{aligned}$ | $\begin{aligned} & 8 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & 8 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\$$ 6 6 6 6 | $\begin{aligned} & 8 \\ & \text { 6 } \\ & \text { E } \\ & \text { E } \\ & \text { ! } \end{aligned}$ | $\begin{aligned} & \text { F } \\ & \frac{0}{6} \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  | $\begin{aligned} & y \\ & 4 \\ & 4 \\ & y \\ & \Sigma \\ & \Sigma \end{aligned}$ | $\begin{aligned} & 8 \\ & 4 \\ & 4 \\ & 8 \\ & \Sigma \end{aligned}$ | $\begin{aligned} & y \\ & y \\ & \text { b } \end{aligned}$ | $\begin{aligned} & 8 \\ & \text { 8 } \\ & \text { 4 } \end{aligned}$ | $\begin{aligned} & \text { y } \\ & \text { tin } \\ & \text { H } \end{aligned}$ | $\begin{aligned} & 8 \\ & \text { 인 } \end{aligned}$ |  | $\begin{aligned} & 8 \\ & \text { 8 } \\ & \text { 8 } \\ & 0 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |


| $\underset{\sim}{8}$ | $\begin{aligned} & \text { § } \\ & \text { 可 } \end{aligned}$ | $\begin{aligned} & \neq \\ & \text { y } \\ & \text { y } \\ & 0 \end{aligned}$ | $\begin{aligned} & 8 \\ & \frac{y}{0} \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & 8 \\ & \frac{8}{6} \\ & \hline \end{aligned}$ |  | 8 8 8 8 | $\begin{aligned} & \frac{3}{6} \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{aligned} & 8 \\ & 8 \\ & \text { eg } \\ & \frac{0}{6} \end{aligned}$ |  | $\begin{aligned} & 8 \\ & \stackrel{8}{4} \\ & \frac{8}{\Sigma} \end{aligned}$ | $\begin{aligned} & y \\ & \text { オ } \end{aligned}$ | $\begin{aligned} & 8 \\ & \frac{8}{4} \end{aligned}$ | $\begin{aligned} & \text { y } \\ & \text { क्रि} \end{aligned}$ | $\begin{aligned} & 8 \\ & \text { \% } \\ & \text { Hi } \end{aligned}$ |  | $\begin{aligned} & 8 \\ & 8 \\ & 6 \\ & 8 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |  | and kg - outpu |  |  |  |  |  |

## 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) | $\begin{gathered} \text { Projected } \\ \text { discards } \\ * * \\ (2021) \end{gathered}$ | $\begin{aligned} & \text { IBC*** } \\ & *(2021) \end{aligned}$ | $\begin{gathered} \text { HC } \\ \text { catch (2021) } \end{gathered}$ | $\begin{gathered} \text { Ftotal } \\ \text { (ages 2-4) } \\ (2021) \end{gathered}$ | $\begin{gathered} \text { Fprojected land- } \\ \text { ings } \\ \text { (ages 2-4) } \\ (2021) \end{gathered}$ | $\begin{gathered} F_{\text {projected dis- }} \\ \text { cards } \\ \text { (ages 2-4) } \\ (2021) \end{gathered}$ | $\begin{gathered} \text { FIBC }^{\text {(ages 2-4) }} \\ (2021) \end{gathered}$ | $\begin{gathered} \text { SSB } \\ \text { (2022) } \end{gathered}$ | $\% \text { SSB }$ <br> change | \% TAC change | \% Advice change ヘヘ^ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |  |  |  |  |  |  |  |  |
| M SY approach: $\mathrm{F}_{\mathrm{MSY}}$ | 69280 | 49061 | 20110 | 110 | 69170 | 0.194 | 0.158 | 0.035 | 0.00040 | 471256 | 129\% | 65\% | 66\% |
| Other scenarios |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & \mathrm{F}=\mathrm{MAP} \text { A } \\ & \text { F MSY lower }^{2} \end{aligned}$ | 60139 | 42609 | 17419 | 111 | 60028 | 0.167 | 0.136 | 0.030 | 0.00040 | 480443 | 133\% | 44\% | 44\% |
| $\begin{aligned} & \mathrm{F}=\text { M AP } \mathrm{F}_{\text {MSY up }} \\ & \text { per }^{\# \#} \end{aligned}$ | 69280 | 49061 | 20110 | 110 | 69170 | 0.194 | 0.158 | 0.035 | 0.00040 | 471256 | 129\% | 65\% | 66\% |
| $\mathrm{F}=0$ \#\# | 119 | 0 | 0 | 119 | 0 | 0 | 0 | 0 | 0.00040 | 542133 | 163\% | -100\% | -100\% |
| $\mathrm{F}_{\mathrm{pa}}$ | 95457 | 67474 | 27876 | 107 | 95350 | 0.274 | 0.224 | 0.050 | 0.00040 | 445065 | 116\% | 128\% | 128\% |
| $\mathrm{F}_{\text {lim }}$ | 129323 | 91152 | 38069 | 102 | 129220 | 0.384 | 0.314 | 0.070 | 0.00040 | 411465 | 100\% | 209\% | 209\% |
| SSB (2022) $=\mathrm{Bl}_{\text {lim }}$ | 493824 | 327191 | 166580 | 52 | 493771 | 2.66 | 2.17 | 0.49 | 0.00040 | 94000 | -54\% | 1081\% | 1081\% |
| $\begin{aligned} & \text { SSB (2022)=B } \begin{array}{l} \text { pa } \\ =M \text { SY Btrigger } \end{array} \end{aligned}$ | 436337 | 293347 | 142930 | 61 | 436276 | 2.06 | 1.68 | 0.38 | 0.00040 | 132000 | -36\% | 943\% | 943\% |
| $\mathrm{F}_{2020}$ | 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\% |
| M SE HCR A | 97366 | 68814 | 28446 | 106 | 97260 | 0.280 | 0.23 | 0.051 | 0.00040 | 443161 | 115\% | 133\% | 133\% |
| M SE HCR B | 100533 | 71034 | 29393 | 106 | 100427 | 0.290 | 0.24 | 0.053 | 0.00040 | 440007 | 114\% | 140\% | 140\% |
| M SE HCR C | 97366 | 68814 | 28446 | 106 | 97260 | 0.280 | 0.23 | 0.051 | 0.00040 | 443161 | 115\% | 133\% | 133\% |
| M SE HCR AD | 97366 | 68814 | 28446 | 106 | 97260 | 0.280 | 0.23 | 0.051 | 0.00040 | 443161 | 115\% | 133\% | 133\% |
| M SE HCR BE | 94180 | 66578 | 27495 | 107 | 94073 | 0.270 | 0.22 | 0.049 | 0.00040 | 446338 | 117\% | 125\% | 125\% |
| M SE HCR CE | 90972 | 64326 | 26539 | 107 | 90865 | 0.260 | 0.21 | 0.047 | 0.00040 | 449539 | 118\% | 117\% | 118\% |
| M SE 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.
$\wedge$ Human Consumption fishery (HCF) catch in 2021 relative to TAC in 2020: Subdivision $20(2193 \mathrm{t})+$ Subarea $4(35653 \mathrm{t})+$ Division $6 . a(3973 \mathrm{t})=41819 \mathrm{t}$.
$\wedge \wedge \wedge$ Total catch 2021 relative to advice value $2020(41818 \mathrm{t})$.
\# EU multiannual plan (MAP) for the North Sea (EU, 2018).
\#\# For this stock, FmsY upper = FmsY.


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


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.

Northern Shell haddock (W, 目a, Val) Log commercial CPU[


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

Northern Shelf haddock (IV, illa, Via). Commercial catch curve gradients


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.


Northem Shelf haddock (IV, lla, Vla). Commercial catch correlations

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. M odel 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 $90 \% \mathrm{Cl}$. 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+BC+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 $95 \% \mathrm{Cl}$ ) 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\% Cl 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 $\mathbf{0}$ 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.

IBTS Q1


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.

IBTS Q3


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 Cls 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 (msr) with the advice error but no rule (top) and of Fp 05 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 (WKM SYREF4).

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

## $9.1 \quad$ 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 2005present). 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-atage 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 Fmsy 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 (ICESWGNSSK 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 $F_{m s y}$ 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 |

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 $\pm 20 \%$, 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 $\mathrm{F}_{\text {myy }}$ proxy estimation

Length-based indicators (LBIs) for $F_{m s y}$ 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 $L_{50 \% \text { mat }}$ was 150 mm , and $L_{\infty}$ 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 $L_{50 \% \text { mat }}$ 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 $L_{\infty}$ value of 283 mm , derived from all available survey data (the corresponding value from WGNSSK 2019 was 284 mm ). WGNSSK was concerned that the sur-vey-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 $L_{\infty}$ 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 | $\boldsymbol{L}_{\text {max }}$ | $\boldsymbol{L}_{\infty}$ |
| :--- | :---: | :--- |
| Trimmed $L_{\max }$ | 385 mm | 375 mm |
| Observed $L_{\text {max }}$ | 685 mm | 642 mm |
| Survey data | - | 283 mm |

WGNSSK conclude that $L_{\infty}$ 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 $L_{\infty}$, along with the new estimate of $L_{50 \% \text { mat }}$ 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 $\left(L_{c}\right)$ is below $L_{m a t}$ for the full time-series, which indicates many immature individuals in the catches.
- The ratio of the mean length of the upper $5^{\text {th }}$ percentile of catches to $L_{\infty}$ is around 1.0 throughout the time series, which would suggest a reasonable number of large (and hence old) fish in the population.
- The $L_{\text {mean }} L_{\text {opt }}$ ratio is greater than 1.0 for most of the time series, which suggests that the exploitation is targeting the most productive length classes.
- $L_{\text {mean }} L_{F=M}$ 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) $F_{m s y}$.

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 $L_{\text {mean }} L_{F=M}$ is greater than 1.0 throughout the time-series would suggest that $F_{m s y}$ 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 $F_{m s y}$ proxies indicates that fishing is occurring at or below $F_{m s y}$, 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.

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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 |


| $\stackrel{\text { ¢ }}{\substack{\text { c }}}$ | (1000 | V | $\mathbb{4}$ | 8 | $\underline{y}$ | \% | 8 | ¢ | 㟧 | V | $\mathbb{4}$ | O | $\underline{5}$ | \% | 8 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |


| $\stackrel{8}{¢}$ | 㟧 | $\underset{Z}{Z}$ | ¢ | 6 | $\frac{1}{2}$ | $\frac{8}{2}$ | J | $\frac{y}{8}$ | $\frac{\sqrt{6}}{8}$ | $\stackrel{y}{8}$ |  | $\underset{\sim}{z}$ | 4 | 负 | $\frac{0}{2}$ | \% | J | $\frac{8}{8}$ | ¢ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 195 | 112 | 43 | 13 | 31 | 156 | 0 | 285 | 26 | 375 | 198 | 98 | 555 | 15 | 26 | 0 | 0 | 470 | 5 | 643 |
| 0 |  | 5 | 9 |  |  |  | 5 |  | 4 | 5 | 9 |  | 7 |  |  |  | 3 |  | 5 |
| 195 | 115 | 84 | 90 | 21 | 167 | 0 | 343 | 42 | 471 | 198 | 51 | 577 | 10 | 16 | 0 | 0 | 383 | 1 | 504 |
| 1 |  | 5 |  |  |  |  | 0 |  | 0 | 6 | 1 |  | 3 |  |  |  | 9 |  | 7 |
| 195 | 98 | 39 | 22 | 26 | 168 | 0 | 395 | 59 | 492 | 198 | 44 | 742 | 17 | 14 | 0 | 0 | 413 | 1 | 551 |
| 2 |  | 1 | 7 |  |  |  | 3 |  | 2 | 7 | 8 |  | 4 |  |  |  | 7 |  | 6 |
| 195 | 73 | 40 | 18 | 18 | 132 | 0 | 459 | 29 | 544 | 198 | 53 | 639 | 18 | 14 | 30 | 0 | 422 | 1 | 589 |
| 3 |  | 9 | 9 |  |  |  | 0 |  | 0 | 8 | 9 |  | 4 |  | 1 |  | 0 |  | 8 |
| 195 | 2 | 27 | 17 | 24 | 112 | 0 | 336 | 17 | 397 | 198 | 44 | 828 | 17 | 40 | 39 | 0 | 408 | 2 | 596 |
| 4 |  | 2 | 7 |  |  |  | 8 |  | 2 | 9 | 1 |  | 6 |  | 7 |  | 3 |  | 7 |
| 195 | 49 | 31 | 0 | 15 | 78 | 0 | 337 | 9 | 383 | 199 | 49 | 100 | 20 | 49 | 0 | 0 | 443 | 4 | 619 |
| 5 |  | 1 |  |  |  |  | 4 |  | 6 | 0 | 1 | 7 | 8 |  |  |  | 1 |  | 0 |
| 195 | 48 | 22 | 0 | 19 | 58 | 0 | 303 | 14 | 339 | 199 | 54 | 109 | 25 | 41 | 0 | 12 | 466 | 6 | 661 |
| 6 |  | 2 |  |  |  |  | 4 |  | 5 | 1 | 4 | 9 | 0 |  |  |  | 6 |  | 8 |
| 195 | 39 | 24 | 0 | 24 | 64 | 0 | 303 | 11 | 341 | 199 | 57 | 114 | 17 | 30 | 0 | 13 | 417 | 5 | 612 |
| 7 |  | 9 |  |  |  |  | 2 |  | 9 | 2 | 7 | 9 | 7 |  |  |  | 5 |  | 6 |
| 195 | 30 | 17 | 0 | 13 | 43 | 0 | 283 | 12 | 310 | 199 | 52 | 966 | 24 | 37 | 0 | 9 | 405 | 3 | 583 |
| 8 |  | 1 |  |  |  |  | 5 |  | 4 | 3 | 5 |  | 0 |  |  |  | 9 |  | 9 |
| 195 | 85 | 24 | 0 | 40 | 43 | 0 | 322 | 11 | 364 | 199 | 43 | 597 | 43 | 27 | 0 | 11 | 375 | 1 | 526 |
| 9 |  | 2 |  |  |  |  | 6 |  | 7 | 4 | 6 |  | 6 |  |  |  | 4 |  | 2 |
| 196 | 155 | 57 | 0 | 46 | 67 | 0 | 317 | 12 | 403 | 199 | 58 | 585 | 41 | 70 | 0 | 9 | 304 | 2 | 471 |
| 0 |  | 7 |  |  |  |  | 8 |  | 5 | 5 | 8 |  | 2 |  |  |  | 6 |  | 2 |
| 196 | 286 | 48 | 0 | 79 | 102 | 0 | 393 | 11 | 490 | 199 | 59 | 547 | 53 | 67 | 0 | 18 | 297 | 3 | 473 |
| 1 |  | 8 |  |  |  |  | 4 |  | 0 | 6 | 2 |  | 4 |  |  |  | 6 |  | 7 |
| 196 | 175 | 50 | 0 | 54 | 106 | 0 | 379 | 0 | 463 | 199 | 50 | 499 | 22 | 76 | 0 | 29 | 339 | 4 | 472 |
| 2 |  | 1 |  |  |  |  | 4 |  | 0 | 7 | 4 |  | 4 |  |  |  | 1 |  | 7 |
| 196 | 365 | 22 | 0 | 36 | 71 | 0 | 309 | 0 | 379 | 199 | 81 | 796 | 19 | 14 | 83 | 23 | 364 | 5 | 646 |
| 3 |  | 2 |  |  |  |  | 7 |  | 1 | 8 | 5 |  | 7 | 9 | 8 |  | 3 |  | 6 |
| 196 | 484 | 35 | 0 | 62 | 75 | 0 | 314 | 0 | 412 | 199 | 66 | 101 | 0 | 62 | 68 | 24 | 386 | 6 | 631 |
| 4 |  | 8 |  |  |  |  | 2 |  | 1 | 9 | 2 | 5 |  |  | 1 |  | 6 |  | 6 |
| 196 | 562 | 38 | 0 | 91 | 93 | 0 | 381 | 0 | 494 | 200 | 71 | 127 | 18 | 72 | 49 | 17 | 322 | 5 | 598 |
| 5 |  | 5 |  |  |  |  | 8 |  | 9 | 0 | 1 | 7 | 4 |  | 2 |  | 2 |  | 0 |
| 196 | 594 | 54 | 0 | 98 | 65 | 0 | 411 | 0 | 541 | 200 | 69 | 128 | 19 | 77 | 45 | 22 | 266 | 7 | 538 |
| 6 |  | 8 |  |  |  |  | 0 |  | 5 | 1 | 4 | 1 | 1 |  | 1 |  | 6 |  | 9 |
| 196 | 601 | 79 | 0 | 13 | 61 | 0 | 459 | 0 | 618 | 200 | 60 | 971 | 19 | 11 | 40 | 17 | 152 | 6 | 382 |
| 7 |  | 1 |  | 6 |  |  | 9 |  | 8 | 2 | 4 |  | 0 | 6 | 2 |  | 1 |  | 7 |
| 196 | 422 | 77 | 0 | 96 | 34 | 0 | 494 | 0 | 627 | 200 | 51 | 100 | 23 | 13 | 36 | 16 | 139 | 4 | 368 |
| 8 |  | 5 |  |  |  |  | 3 |  | 0 | 3 | 7 | 8 | 9 | 6 | 9 |  | 9 |  | 8 |



| ¢ | 品 | $\underset{\square}{V}$ | 6 | $\frac{\text { in }}{\text { 年 }}$ | 荇 | $\frac{1}{4}$ | ¢0 | ¢ | 品 | $\underset{\square}{V}$ | 6 | $\frac{9}{2}$ | 耑 | \％ | ¢ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathbf{2 0 0 5}$ | 0.0896 | 0.0757 | 0.1163 | 0.2227 | 0.3000 | 0.3476 | 0.3796 | 0.2237 | 0.2669 |
| $\mathbf{2 0 0 6}$ | 0.0794 | 0.0763 | 0.1208 | 0.2264 | 0.3031 | 0.3391 | 0.3691 | 0.2383 | 0.2614 |
| $\mathbf{2 0 0 7}$ | 0.0699 | 0.0762 | 0.1240 | 0.2281 | 0.3042 | 0.3322 | 0.3609 | 0.2533 | 0.2600 |
| $\mathbf{2 0 0 8}$ | 0.0611 | 0.0753 | 0.1258 | 0.2278 | 0.3032 | 0.3268 | 0.3548 | 0.2680 | 0.2618 |
| $\mathbf{2 0 0 9}$ | 0.0531 | 0.0739 | 0.1265 | 0.2256 | 0.3005 | 0.3222 | 0.3499 | 0.2822 | 0.2673 |
| $\mathbf{2 0 1 0}$ | 0.0455 | 0.0717 | 0.1258 | 0.2212 | 0.2955 | 0.3183 | 0.3463 | 0.2961 | 0.2762 |
| $\mathbf{2 0 1 1}$ | 0.0383 | 0.0692 | 0.1241 | 0.2153 | 0.2887 | 0.3152 | 0.3449 | 0.3097 | 0.2903 |
| $\mathbf{2 0 1 2}$ | 0.0320 | 0.0655 | 0.1201 | 0.2063 | 0.2772 | 0.3129 | 0.3458 | 0.3218 | 0.3045 |
| $\mathbf{2 0 1 3}$ | 0.0282 | 0.0619 | 0.1158 | 0.1969 | 0.2665 | 0.3117 | 0.3471 | 0.3334 | 0.3255 |
| $\mathbf{2 0 1 4}$ | 0.0252 | 0.0586 | 0.1114 | 0.1871 | 0.2575 | 0.3089 | 0.3496 | 0.3451 | 0.3461 |
| $\mathbf{2 0 1 5}$ | 0.0222 | 0.0556 | 0.1070 | 0.1775 | 0.2490 | 0.3112 | 0.3548 | 0.3562 | 0.3531 |
| $\mathbf{2 0 1 6}$ | 0.0200 | 0.0528 | 0.1024 | 0.1676 | 0.2411 | 0.3178 | 0.3630 | 0.3687 | 0.3516 |
| $\mathbf{2 0 1 7}$ | 0.0180 | 0.0504 | 0.0978 | 0.1577 | 0.2334 | 0.3281 | 0.3734 | 0.3817 | 0.3435 |
| $\mathbf{2 0 1 8}$ | 0.0165 | 0.0484 | 0.0930 | 0.1477 | 0.2258 | 0.3420 | 0.3865 | 0.3953 | 0.3291 |
| $\mathbf{2 0 1 9}$ | 0.0154 | 0.0466 | 0.0882 | 0.1377 | 0.2187 | 0.3600 | 0.4029 | 0.4106 | 0.3081 |
| $\mathbf{2 0 2 0}$ | 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 |



|  | 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 | $\begin{array}{r} - \\ 0.036 \end{array}$ | 0.176 | 0.537 | 0.633 | 0.821 | 0.725 | 0.970 | 1.283 |
| 2010 | -0.230 | $\begin{array}{r} - \\ 0.003 \end{array}$ | 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\% | $\sim 1(>0.9)$ | $>=1$ |
| 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 |

















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).


## Agen











North Sea IBTS Q1 (GAM) no age 1


North Sea IBTS+BTS Q3 (GAM)



North Sea IBTS+BTS Q3 (GAM)


















(a) Conservation

(b) Optimal Yield

(c) Maximum Sustainable Yield

(a) Conservation

(b) Optimal yield

(c) Maximum sustainable yield


# 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 Fmsy.'

## Management for FU 3 and FU 4

The TAC for Nephrops in ICES area 3.a was increased from 5318 tonnes in 2015 to 11001 tonnes in 2016, 12715 tonnes in 2017, 11738 tonnes in 2018 and 13733 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 2670 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/pue, 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/pue, 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 WKNEPH (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 ef- <br> fect | Detection <br> rate | Species identifica- <br> tion | Occu- <br> pancy | Cumulative <br> bias |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 3 and <br> 4 | Skagerrak and Katte- <br> gat | 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.

## M SY 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 Fmsy directly and hence proxies for Fmsy are determined. WGNSSK (2010) developed a framework for proposing FMSY 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 $\mathrm{F}_{\mathrm{msy}}$ are $\mathrm{F}_{0.1}, \mathrm{~F}_{35 \%} \mathrm{SSpr}^{2}$ and $\mathrm{Fmax}^{\text {. There may be strong }}$
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 FMSY 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 FmSy proxies (ICES, 2010a). These proxies may be modified following further data exploration and analysis. The combined sex Fmsy 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 $\mathrm{F}_{\text {MSY }}$ proxy should be picked instead of the combined proxy.

|  |  | Low | M edium | 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 $\left(0.3-0.8 / \mathrm{m}^{2}\right)$, the observed harvest rate is below $\mathrm{F}_{0.1}$ and historically the fishery is stable both spatially and temporally. This means that $\mathrm{F}_{0.1}$ may be selected as a proxy for Fmsy. As the MLS has been decreased in 2016 it is recommended to use $\mathrm{F}_{\max }$ as a proxy for $\mathrm{F}_{\text {msy }}$ as in last years. For 2019 this corresponds to a TAC of 13733 tonnes if a landing obligation is applied. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with Fmsy as total catches would be subjected to $100 \%$ mortality (current discard survival is estimated to be $25 \%$ ).

Harvest rate as proxy for $\mathrm{F}_{\mathrm{msy}}$ 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) Aotal stock abundance) equivalent to Fmsy 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 Fmsy 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 re- <br> movals | Wanted <br> catch | Dead un- <br> wanted <br> catch | Surviving un- <br> wanted catch | Harvest <br> rate* | \% advice <br> change <br> $* *$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | WC+DUC+SUC | WC+DUC | WC | DUC | SUC | for <br> WC+DUC |  |
| ICES advice basis |  |  |  |  |  |  |  |
| EU M AP^: F FMY | 19904 | 19313 | 17540 | 1773 | 591 | 7.9 | $-8.02 \%$ |
| F=MAP F FSY lower | 14109 | 13690 | 12433 | 1257 | 419 | 5.6 | $-34.80 \%$ |
| F=MAP FMSY upper*** | 19904 | 19313 | 17540 | 1773 | 591 | 7.9 | $-8.02 \%$ |
| Other scenarios |  |  |  |  |  |  |  |
| F 2018 | 9019 | 8751 | 7948 | 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 M AP^ $\mathrm{F}_{\text {MSY }}$ | 18643 | 16429 | 2214 | 7.9 | -13.85\% |
| $\mathrm{F}=$ M AP $\mathrm{F}_{\text {MSY }}$ lower | 13215 | 11646 | 1569 | 5.6 | -38.93\% |
| $\mathrm{F}=$ M AP $\mathrm{F}_{\text {MSY upper }}{ }^{* * *}$ | 18643 | 16429 | 2214 | 7.9 | -13.85\% |
| Other scenarios |  |  |  |  |  |
| $\mathrm{F}_{2018}$ | 8448 | 7445 | 1003 | 3.58 | -60.96\% |

[^8]*** FMSY upper $=$ FMSY 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 $\mathrm{F}_{\text {msy }}$ 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 (20112019; 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 | M oray 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 | 4222 | 2082 | 5211 |
| 2018 | 4625 | 2878 | 7100 |
| 2019 | 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 | Ipue |
| 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 | 7.1 | 41.3 | 18.0 |
| $2009^{*}$ | 211 | 125 | 59 | 29.5 | 17.5 |
| $2010^{*}$ | 165 | 202 | 120 | 27.8 | 16.7 |
| $2011^{*}$ | 29 |  | 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 timated total effort by Danish trawlers, 1991-2019.

| Year | kW days | Days at sea | Fishing days | Ipue |
| :---: | :---: | :---: | :---: | :---: |
| 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 ( $\mathrm{kg} /$ hour trawling) of Swedish 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 | Ipue |
| 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 | Ipue |
| 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 | 11.0 | 28.2 | 14.6 |
| $2009^{*}$ | 309 | 161 | 9.2 | 32.2 | 18.1 |
| $2010^{*}$ | 297 | 157 | 9.7 | 27.3 | 16.3 |
| $2011^{*}$ | 266 |  |  |  |  |


| 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 total effort by Danish trawlers, 1991-2019.

| Year | kW days | Days at sea | Fishing days | Ipue |
| :---: | :---: | :---: | :---: | :---: |
| 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 (km²) | 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.

Illa catches, 2019.
By landings and discards


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.


## Skagerrak (FU3) Mean sizes in Skagerrak catches



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.

## Mean sizes in Kattegat catches



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



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).

## M anagement at ICES Subarea Level

The 2018 EC TAC for Nephrops in ICES Subarea 2.a and 4 was 24518 tonnes in EC waters (plus 800 tonnes in Norwegian waters). For 2019, this was decreased to 22103 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 $80-99 \mathrm{~mm}$ 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 ( $\mathrm{kW}^{*}$ day) have reduced opportunities for directed whitefish fishing. STECF 2010 stated that the overall effort ( $\mathrm{kW} W^{*}$ 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 $70-99 \mathrm{~mm}$, 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 $57^{\circ} 30^{\prime} \mathrm{N}$.

Official catch statistics for Subarea 4 are presented in Table 11.2.1. The preliminary officially reported landings in 2018 are 13164 tonnes, 18\% lower than in 2017 ( 16049 tonnes), and 54\% lower than the peak observed in 2009 ( 24597 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 $1850 \mathrm{~km}^{2}$ 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 | LW [t] |  | 324.3 | 11.5 | 14.3 | 16.1 |  | 48.2 |  |
| 414 t of 681 t (60.8\%) | 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 | LW [t] |  |  |  |  | 13.0 | 0.8 | 7.6 |  |
| 21 t of 801 t (2.6\%) | LW [\%] |  |  |  |  | 1.6 | 0.1 | 0.9 |  |
|  | NoS |  |  |  |  | 2 | 2 | 3 |  |


|  | LWpS[\%] |  |  | 30.4 | 1.9 | 11.8 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & 2017 \\ & 42 \mathrm{t} \text { of } 745 \mathrm{t}(5.7 \%) \end{aligned}$ | 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 |  |
| $\begin{aligned} & 2018 \\ & 9 \mathrm{t} \text { of } 429 \mathrm{t}(2.2 \%) \end{aligned}$ | LW [t] |  |  | 3.4 |  |  | 6.0 |
|  | LW [\%] |  |  | 0.8 |  |  | 1.4 |
|  | NoS |  |  | 3 |  |  | 1 |
|  | LWpS [\%] |  |  | 12.1 |  |  | 63.6 |
| 2019 | LW [t] | 157.8 |  | 6.2 | 9.8 |  |  |
| 174 of 551 t (31.5\%) | 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 $\mathrm{m}^{2}$. 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 $\mathrm{m}^{-2}$ ) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 0.05 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 |
| $0.5 \times$ 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\% |
| $0.5 \times$ 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\% |
| $\mathrm{F}_{\text {MSY }}$ | 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 $(<35 \mathrm{~mm})$ 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 $\sim 100$ and $\sim 250$ 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 $70-99 \mathrm{~mm}$. 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 $>15 \mathrm{~m}$ 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 $0.7-1.4 \mathrm{~kg} / \mathrm{kWd}$, 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 ( $\sim 10 \%$ ) 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 ( $\sim 5$ 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 $\mathrm{m}^{2}$, and 1163 million individuals in 2019 ( $\pm 26$ 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 biascorrection 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 ( $\pm 26$ million $95 \% \mathrm{CI}$ ), above the 2007 estimate of 858 million used as MSY Btriger. 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 Fmsy 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 Fmsy 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 $\mathrm{F} 35 \% \mathrm{SpR}$. 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 Fmsy 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 $\mathrm{B}_{\text {trigger }}$.

### 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 ap- <br> plies in scenarios where discarding is allowed |

Nephrops FU 6. Catch options assuming discarding continues at recent average. All weights are in tonnes.

## Catch options assuming recent discard rates

| Basis | Total catch | Dead removals | Landings | Dead discards | Surviving discards | Harvest rate* |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | L+DD+SD | L+DD | L | DD | SD | for L+DD |
| 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\% |
| FM SY 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 |  |

### 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 $B_{\text {trigger. The harvest rate, estimated as the proportion of the stock that has been fished, has signifi- }}^{\text {the }}$ cantly increased from 2018 and is about twice the Fmsy 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. $30000 \mathrm{~km}^{2}$ ). 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 $80 / 90 \mathrm{~mm}$ 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 $100-109 \mathrm{~mm} / 120 \mathrm{~mm}$, 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 12552 tonnes and 14263 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 $<100 \mathrm{~mm}$ ) 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 FmSy 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 $620 \mathrm{~kg} /$ day in 2009. It has fallen since then until 2015 to values similar to those observed in the early 2000s ( $\sim 200 \mathrm{~kg} / \mathrm{day}$ ). 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 201718). 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 ( $>35 \mathrm{~mm}$ ) 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 ( $<35 \mathrm{~mm}$ ) 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 $\langle 35 \mathrm{~mm}$ 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 30.6 g to 28.3 g 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 $28153 \mathrm{~km}^{2}$ 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 FMSY. 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 $>35 \mathrm{~mm}$ 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 $B_{\text {trigger }}$ 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 Fmsy. 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 Fmsy 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 $<35 \mathrm{~mm}$ (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

Fmsy proxies for Nephrops are obtained from the per-recruit analysis as documented in the WGNSSK 2015 report. The most recent analysis used 2012-14 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. Length frequency data in Fladen have 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 Fmsy proxies is given in the table below and the basis for choosing an appropriate FMSY proxy remains the same and is described in WGNSSK 2010 report.

| WGNSSK 2015 |  | $\mathrm{F}_{\text {bar }}(\mathbf{2 0 - 4 0} \mathrm{mm})$ |  | HR (\%) | SPR (\%) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | M | F |  | M | F | T |
| $\mathrm{F}_{0.1}$ | 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 |
| $\mathrm{F}_{\text {max }}$ | 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 |
| $\mathrm{F}_{35 \% \text { SpR }}$ | 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 $0.2 \mathrm{~m}^{-2}$ ) 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 wellstudied and biological parameters are considered particularly uncertain. Furthermore, historical harvest ratios in this FU have been below that equivalent to fishing at $\mathrm{F}_{0.1}$. For these reasons, it is suggested that a conservative proxy is chosen for $\mathrm{F}_{\mathrm{msy}}$ such as $\mathrm{F}_{0.1(\mathrm{~T})}$.

The Fmsy proxy harvest ratio is $7.5 \%$.

The Btrigger 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 $28200 \mathrm{~km}^{2}$ 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 $30633 \mathrm{~km}^{2}$. 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 Btrigger level. Landings taken from this FU in 2019 (9032 tonnes) were lower than the 2018 total catch advice (for 2019) of 13178 tonnes. The harvest rate doubled in 2019 (in relation to the previous year) to $5.6 \%$ but remains below FMSY. Length frequencies in the caches have evolved towards larger animals, suggesting a selec- $_{\text {en }}$ tivity 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 $>17 \mathrm{~mm}$ 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 $915 \mathrm{~km}^{2}$, 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 12 m in length with about 10 in 12-15 m category and a few above 15 m . Engine power ranges from just under 100 kw to around the 300 kw . The trip length for most of the fleet is one day. In the winter, most vessels fish from around dawn till 16:00-19:00. In spring/summer, vessels switch to nights, working from around 19:00 to 07:0010:00. 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 Btriger for the entire time-series. The harvest rate is varying, and is now below Fмsч. "

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 Fmsy for Nephrops are described in the WGNSSK 2010 report.

## Data available

## Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 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 $3^{\text {rd }}$ 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 ( $80-95 \mathrm{~mm}$ 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 ( $>35 \mathrm{~mm}$ ) 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 $<35 \mathrm{~mm}$ 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 $915 \mathrm{~km}^{2}$. 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 <br> 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 Fmsy (previously below FMSY). 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 $>35 \mathrm{~mm}$ 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 $\mathrm{FMSY}^{(16.3 \%)}$ ).

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

| WGNSSK 2011 |  | $\mathrm{F}_{\text {bar }}(\mathbf{2 0 - 4 0} \mathrm{mm})$ |  | 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 $\sim 0.7 \mathrm{~m}^{-2}$ ). Harvest ratios (which are likely to have been underestimated prior to 2006) have mostly been well above $\mathrm{F}_{\max }$ and in addition there is a long time series of relatively stable landings (average reported landings $\sim 2000$ 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 $\mathrm{F}_{\max (\mathrm{T})}$ is chosen as the FMSY proxy.

The Fmsy proxy harvest ratio is $16.3 \%$.
The Btrigger 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 Btrigger 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 FMSY. 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 FMSY 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 $2195 \mathrm{~km}^{2}$. 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 toffrom 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 Btrigger for the entire time-series. The harvest rate has fluctuated around $F_{\text {msy }}$ in recent years and is now just below Fmsy. $^{\text {m }}$

## The ICES advice in 2019 (for 2020) (Single-stock exploitation boundaries) was as follows: <br> M SY approach <br> "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 FMSY for Nephrops are described in the WGNSSK 2010 report.

## Data available <br> 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 ( $>35 \mathrm{~mm}$ ) 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 $<35 \mathrm{~mm}$ 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.

## 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 $2195 \mathrm{~km}^{2}$. General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

## Data analyses <br> 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 Fmsy (previously at FMSY). The mean size of individuals $>35 \mathrm{~mm}$ 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 Fmsy 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 FMSy proxies were obtained from the per-recruit analysis for Nephrops as documented in the WGNSSK 2010 report. The analysis was updated in 2011 using 2008-10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery and since previous estimates were derived several years before. An update was not performed this year. The complete range of the per-recruit FMSY proxies is given in the table below and the process for choosing an appropriate Fmsy proxy is described in WGNSSK 2010 report.

|  |  | $\mathrm{F}_{\text {bar }}(\mathbf{2 0}-\mathbf{4 0} \mathrm{mm})$ |  | 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 $\sim 0.2 \mathrm{~m}^{-2}$ ). Harvest ratios (which are likely to have been underestimated prior to 2006) appear to
have been above $\mathrm{F}_{35 \% \text { SPR }}$ and in addition there is a long time series of relatively stable landings (average reported landings $\sim 1300$ tonnes, above those predicted by currently fishing at $\mathrm{F}_{35 \% \text { SPR }}$ ). For these reasons, it is suggested that $\mathrm{F}_{35} \%$ SPR(T) is used as the FMSY proxy.

The Fmsy proxy harvest ratio is $11.8 \%$.
The Btrigger 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 Btrigger 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 $\mathrm{FMSY}^{\mathrm{M}}(11.8 \%)$. 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 Fmsy but the abundance (as estimated by the UWTV survey) in recent years is just above the MSY Btrigger, 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.

## $11.8 \quad \operatorname{Noup}(F U 10)$

### 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 $/ \mathrm{m}^{2}$ ) similar to that found in 1999 which is significantly higher than the previous survey ( 51 million, 0.13 burrows $/ \mathrm{m}^{2}$ ). 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 20132015, 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 $04-\mathrm{N}$ ) 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 mid1980s 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 $40 \mathrm{~mm}=\mathrm{MLS}$ ) 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 ( $<40 \mathrm{~mm}$ ) 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 elec15 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 20082009 (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 mid1990s 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 $0.1 \mathrm{~m}^{-}$ ${ }^{2}$ 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${ }^{2}$ | M inimum 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 num- <br> bers) |
| Discard survival rate | $25 \%$ | Discard survival is assumed to be 25\%. |
| Surface area estimate | $3613 \mathrm{~km}^{2}$ | Benchmark estimate WKNEP (2016) |

Sensitivity analysis of harvest rates for a range of potential densities. All weights in tonnes.

## Discarding allowed

| Basis | Live discards | Dead discards | Landings | Dead removals | Range of potential densities (Nephrops $\mathrm{m}^{2}$ ) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | 0.05 | 0.1* | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 |
|  |  |  |  |  | Harvest rate in \% |  |  |  |  |  |  |  |  |
| Average landings (2010 2019) | 0 | 1 | 235 | 236 | 1.7\% | 0.9\% | 0.4\% | 0.3\% | 0.2\% | 0.2\% | 0.1\% | 0.1\% | 0.1\% |
| $0.5 \times$ 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\% |
| M aximum 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 <br> 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.

## 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 300000 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 1300000 kW days in 2013 to 1000000 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 1550000 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 $1.7 \mathrm{~kg} / \mathrm{kW}$ 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 $0.8 \mathrm{~kg} / \mathrm{kW}$ day and $0.2 \mathrm{~kg} / \mathrm{kW}$ day, in 2017 and 2018, respectively. In 2019, the Danish LPUE increased to $0.7 \mathrm{~kg} / \mathrm{kW}$ 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 $0.3 \mathrm{~kg} / \mathrm{kW}$ day in 2005 to around $0.7 \mathrm{~kg} / \mathrm{kW}$ day in 2007, and has since fluctuated between 0.2 and $0.5 \mathrm{~kg} / \mathrm{kW}$ 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 $\mathrm{m}^{2}$ ) 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 20122013. 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 $\mathrm{m}^{2}$ ) 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 $20-30 \mathrm{~km}$. 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 <br> 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 $400 \mathrm{~kg} /$ 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 Linf and Lmat 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 Linf $=66 \mathrm{~mm} \mathrm{CL}$ and $L_{\text {mat }}=25 \mathrm{~mm}$ 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 (Lc/Lmat and $\mathrm{L} 25 \%$ /Lmat) 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 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Le/Lmat | L25\%/ Lmat | Lmax5\%/ Linf | Pmega | Lmean/ Lopt | Lmean/L(F=M) |
| Ref | >1 | >1 | $>0.8$ | >0.3 | $\sim 1(>0.9)$ |  |
| 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 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Le/ Lmat | L25\%/ Lmat | Lmax5\%/ Linf | Pmega | Lmean/ Lopt | Lmean/L(F=M) |
| Ref | >1 | >1 | >0.8 | >0.3 | $\sim 1(>0.9)$ |  |
| 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 $/ \mathrm{m}^{2}$, 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 Fmsy 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."

## M anagement

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.

|  | $\mathbf{1 9 9 9}$ | $\mathbf{2 0 0 0}$ | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ | $\mathbf{2 0 1 1}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Belgium | 350 | 252 | 283 | 284 | 229 | 213 | 180 | 214 | 205 | 200 | 265 | 115 | 295 |
| Denmark | 1963 | 1747 | 1935 | 2154 | 2128 | 2244 | 2339 | 2024 | 1408 | 1078 | 875 | 603 | 828 |
| Faeroe Islands | 1 | 0 | - | - | - | - | - | - | - | - | - | - |  |
| France | 0 | 0 | - | - | - | - | - | - | - | - | - | + |  |
| Germany | 104 | 79 | 140 | 125 | 50 | 50 | 109 | 288 | 602 | 266 | 410 | 373 | 552 |
| Netherlands | 662 | 572 | 851 | 966 | 940 | 918 | 1019 | 982 | 1147 | 737 | 882 | 701 | 1012 |
| Norway | 144 | 147 | 115 | 130 | 100 | 93 | 132 | 96 | 99 | 143 | 139 | 123 | 70 |
| Sweden | 4 | 37 | 26 | 14 | 1 | 1 | 3 | 1 | 5 | 26 | 2 | 1 | 1 |
| UK (Eng +Wales +NI) | 2431 | 2210 | 2691 | 1964 | 2295 | 2241 | 3236 | 4937 | 3295 | 1679 | 3437 | - | 1 |
| UK (Scotland) | 10715 | 9834 | 9681 | 11045 | 10094 | 12912 | 10565 | 16165 | 17930 | 17960 | 18587 | - |  |
| UK | - | - | - | - | - | - |  | - | - | - | - | 18941 | 14190 |
| Total | 16374 | 14878 | 15722 | 16682 | 15838 | 18674 | 17583 | 24707 | 24691 | 22089 | 24597 | 20857 | 16948 |

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 |  |  | $>15 \mathrm{~m}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Landings <br> [t] | Effort <br> [kWd] | LPUE [kg/kWd] | Landings [t] | Effort <br> [kWd] | LPUE [kg/kWd] | Landings <br> [t] | Effort <br> [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 <br> burrows/ $\mathbf{m}^{2}$ | Absolute Abundance <br> millions | 95\% confidence interval <br> 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 | Geostatistics |  |
| 2017 | 110 | Summer | 0.29 | 902 | Geostatistics |  |
| 2018 | 109 | Summer | 0.31 | 950 | Geostatistics |  |
| 2019 | 86 | Summer | 0.37 | 1163 | Geostatistics |  |
|  |  |  |  | 26 |  |  |

Table 11.4.5. Nephrops in FU 6: Historical harvest rate determination.

| Year | TV abundance index | Landings <br> (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 | $\measuredangle 0.5$ | 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) |  |
| :---: | :---: | :---: | :---: |
| 2000 | 5462 | 35367 | LPUE (kg/ day) |
| 2001 | 5476 | 28558 | 154.4 |
| 2002 | 7057 | 28586 | 191.8 |
| 2003 | 6208 | 21960 | 246.9 |
| 2004 | 8593 | 21562 | 282.7 |
| 2005 | 10357 | 23555 | 398.5 |
| 2006 | 10496 | 22836 | 439.7 |
| 2007 | 11789 | 21603 | 459.6 |
| 2008 | 12098 | 22856 | 545.7 |
| 2009 | 13187 | 21153 | 529.3 |
| 2010 | 12832 | 20968 | 623.4 |
| 2011 | 7495 | 15273 | 612.0 |
| 2012 | 4338 | 11994 | 490.7 |
| 2013 | 2938 | 11933 | 361.7 |
| 2014 | 4134 | 12629 | 246.2 |
| 2015 | 1772 | 10562 | 327.3 |
| 2016 | 2395 | 12297 | 167.8 |
| 2017 | 5144 | 15205 | 194.8 |
| 2018 | 4413 | 14431 | 338.3 |
| $2019 *$ | 9006 | 15244 | 305.8 |

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, 19912019.

| 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 | M oray 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 | Mean density | 95\% confidence interval |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Millions | burrows/m2 | millions |
| 1992 | 69 | 3661 | 0.13 | 376 |
| 1993 | 74 | 4450 | 0.16 | 569 |
| 1994 | 59 | 6170 | 0.22 | 814 |
| 1995 | 61 | 4987 | 0.18 | 896 |
| 1996 | No survey |  |  |  |
| 1997 | 56 | 2767 | 0.10 | 510 |
| 1998 | 60 | 3838 | 0.13 | 717 |
| 1999 | 62 | 4146 | 0.15 | 649 |
| 2000 | 68 | 3628 | 0.13 | 491 |
| 2001 | 50 | 4981 | 0.17 | 970 |
| 2002 | 54 | 6087 | 0.21 | 757 |
| 2003 | 55 | 5547 | 0.20 | 1076 |
| 2004 | 52 | 5725 | 0.20 | 1030 |
| 2005 | 72 | 4325 | 0.16 | 662 |
| 2006 | 69 | 4862 | 0.17 | 619 |
| 2007 | 82 | 7017 | 0.25 | 730 |
| 2008 | 74 | 7360 | 0.26 | 1019 |
| 2009 | 59 | 5457 | 0.19 | 772 |
| 2010 | 67 | 5224 | 0.19 | 710 |
| 2011 | 73 | 3382 | 0.12 | 435 |
| 2012 | 70 | 2748 | 0.10 | 392 |
| 2013 | 71 | 2902 | 0.10 | 336 |
| 2014 | 70 | 2990 | 0.11 | 412 |
| 2015 | 71 | 2569 | 0.09 | 320 |
| 2016 | 78 | 4449 | 0.16 | 662 |
| 2017 | 71 | 7036 | 0.25 | 968 |
| 2018 | 71 | 5656 | 0.20 | 689 |
| 2019 | 70 | 6129 | 0.22 | 802 |

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 <br> (ranges of \% <br> silt clay) | Area <br> $\mathbf{( k m 2 )}$ | Number of <br> Stations | Mean burrow <br> density <br> (no./ $\mathbf{m 2}$ ) | Observed <br> variance | Abundance <br> (millions) | Stratum <br> variance | Proportion <br> of total vari- <br> ance |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |
| $\mathbf{2 0 1 8 ~ T V ~ s u r v e y ~}$ |  |  |  |  |  |  |  |
| $>80$ | 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 |

## 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 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 | 2637 | 6440 | 378.4 |
| 2009 | 1928 | 5852 | 449.1 |
| 2010 |  | 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 $\mathbf{3 5} \mathbf{~ m m}$ 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 |  |  | 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 | Abundance | 95\% conf interval |
| :---: | :---: | :---: | :---: | :---: |
|  |  | burrows/ $\mathbf{m}^{\mathbf{2}}$ | millions | millions |
| 1993 | 37 | 0.61 | 555 | 142 |
| 1994 | 30 | 0.49 | 448 | 78 |
| 1995 | no survey |  |  |  |
| 1996 | 27 | 0.41 | 375 | 88 |
| 1997 | no survey |  |  |  |
| 1998 | 32 | 0.32 | 292 | 81 |
| 1999 | 49 | 0.51 | 463 | 78 |
| 2000 | 53 | 0.48 | 443 | 70 |
| 2001 | 46 | 0.46 | 419 | 79 |
| 2002 | 41 | 0.56 | 508 | 119 |
| 2003 | 36 | 0.84 | 767 | 138 |
| 2004 | 37 | 0.69 | 630 | 141 |
| 2005 | 54 | 0.78 | 710 | 143 |
| 2006 | 43 | 0.91 | 827 | 125 |
| 2007 | 49 | 0.76 | 692 | 132 |
| 2008 | 38 | 0.97 | 881 | 297 |
| 2009 | 45 | 0.80 | 732 | 142 |
| 2010 | 39 | 0.75 | 682 | 147 |
| 2011 | 45 | 0.58 | 533 | 87 |
| 2012 | 66 | 0.57 | 522 | 64 |
| 2013 | 51 | 0.73 | 668 | 125 |
| 2014 | 51 | 0.47 | 428 | 80 |
| 2015 | 51 | 0.73 | 664 | 127 |
| 2016 | 50 | 0.87 | 797 | 146 |
| 2017 | 52 | 0.73 | 670 | 133 |
| 2018 | 50 | 1.12 | 1025 | 190 |
| 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 | $\begin{aligned} & \text { Area } \\ & \left(\mathbf{k m}^{2}\right) \end{aligned}$ | Number of Stations | $\begin{aligned} & \text { Mean burrow } \\ & \text { density } \\ & \left(\text { no. } / \mathrm{m}^{2}\right) \end{aligned}$ | 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 |
| M S(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 |  |  |  |  |  |  |  |
| $M \& S M$ | 170 | 9 | 0.694 | 0.855 | 118 | 2760 | 0.306 |
| M S(west) | 139 | 8 | 0.790 | 0.954 | 110 | 2302 | 0.255 |
| M S(mid) | 211 | 11 | 1.714 | 0.432 | 361 | 1744 | 0.193 |
| M S (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 |
| M S(west) | 139 | 9 | 0.593 | 0.246 | 82 | 529 | 0.117 |
| MS(mid) | 211 | 12 | 1.264 | 0.306 | 266 | 1130 | 0.25 |
| M S (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) | $\begin{gathered} 95 \% \\ \text { CI } \end{gathered}$ | Harvest ratio | Landings numbers | Discards numbers | Removals numbers | Landings (tonnes) | Discards (tonnes) | Dead Discards (tonnes) | Discard rate | Mean weight in landings | Mean weight in discards | Dead discard rate |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1993 | 555 | 142 | 24.1 | 97 | 49 | 134 | 2368 | 426 | 426 | 33.3 | 24.3 | 11.64 | 27.3 |
| 1994 | 448 | 78 | 51.3 | 95 | 180 | 230 | 1850 | 1188 | 1188 | 65.5 | 19.51 | 8.79 | 58.8 |
| 1995 | NA | NA | NA | 90 | 59 | 134 | 1762 | 465 | 465 | 39.5 | 19.55 | 10.54 | 32.9 |
| 1996 | 375 | 88 | 37.3 | 81 | 78 | 140 | 1687 | 697 | 697 | 49.2 | 20.81 | 11.85 | 42.1 |
| 1997 | NA | NA | NA | 116 | 56 | 158 | 2193 | 371 | 371 | 32.6 | 18.87 | 8.79 | 26.6 |
| 1998 | 292 | 81 | 55.7 | 118 | 60 | 163 | 2144 | 434 | 434 | 33.9 | 18.23 | 9.6 | 27.8 |
| 1999 | 463 | 78 | 39.6 | 110 | 97 | 183 | 2207 | 704 | 704 | 47 | 20.05 | 9.63 | 39.9 |
| 2000 | 443 | 70 | 33.7 | 82 | 90 | 150 | 1785 | 774 | 774 | 52.5 | 21.83 | 11.42 | 45.3 |
| 2001 | 419 | 79 | 25.3 | 72 | 45 | 106 | 1527 | 327 | 327 | 38.7 | 21.22 | 9.59 | 32.1 |
| 2002 | 508 | 119 | 21.1 | 68 | 52 | 107 | 1340 | 316 | 316 | 43.1 | 19.62 | 8.16 | 36.2 |
| 2003 | 767 | 138 | 12.4 | 51 | 59 | 95 | 1127 | 546 | 410 | 53.9 | 22.31 | 9.25 | 46.7 |
| 2004 | 630 | 140 | 16.4 | 74 | 40 | 103 | 1657 | 406 | 304 | 34.9 | 22.45 | 10.25 | 28.7 |
| 2005 | 710 | 143 | 19.4 | 89 | 65 | 138 | 1989 | 602 | 452 | 42.1 | 22.33 | 9.28 | 35.3 |
| 2006 | 827 | 126 | 26.7 | 115 | 142 | 221 | 2458 | 1510 | 1133 | 55.2 | 21.43 | 10.67 | 48.1 |
| 2007 | 692 | 132 | 22.9 | 126 | 43 | 159 | 2651 | 614 | 461 | 25.3 | 20.97 | 14.34 | 20.3 |
| 2008 | 881 | 297 | 21.1 | 142 | 58 | 186 | 2450 | 796 | 597 | 29.1 | 17.23 | 13.65 | 23.5 |


| Year | Adjusted abundance (millions) | $\begin{aligned} & 95 \% \\ & \text { CI } \end{aligned}$ | Harvest ratio | Landings numbers | Discards numbers | Removals numbers | Landings (tonnes) | Discards (tonnes) | Dead Discards (tonnes) | Discard rate | Mean weight in landings | Mean weight in discards | Dead discard rate |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2009 | 732 | 142 | 26 | 137 | 71 | 190 | 2663 | 573 | 430 | 34.1 | 19.41 | 8.09 | 27.9 |
| 2010 | 682 | 147 | 19.2 | 99 | 43 | 131 | 1950 | 407 | 305 | 30.2 | 19.76 | 9.55 | 24.5 |
| 2011 | 533 | 87 | 22.1 | 100 | 24 | 118 | 1889 | 231 | 173 | 19.5 | 19.75 | 9.56 | 15.3 |
| 2012 | 522 | 64 | 24.6 | 100 | 38 | 129 | 2129 | 379 | 284 | 27.2 | 21.66 | 10.10 | 21.9 |
| 2013 | 668 | 126 | 15.6 | 81 | 31 | 104 | 1503 | 301 | 226 | 27.4 | 19.30 | 9.82 | 22.0 |
| 2014 | 428 | 80 | 29.1 | 102 | 30 | 124 | 2384 | 353 | 265 | 22.9 | 24.30 | 11.66 | 18.3 |
| 2015 | 664 | 127 | 16.8 | 90 | 29 | 112 | 1897 | 311 | 234 | 24.4 | 21.84 | 10.74 | 19.5 |
| 2016 | 797 | 146 | 12.3 | 85 | 17 | 98 | 1937 | 165 | 123 | 16.4 | 23.62 | 9.86 | 12.8 |
| 2017 | 670 | 133 | 19.7 | 111 | 28 | 132 | 2493 | 280 | 210 | 20 | 23.07 | 10.07 | 15.8 |
| 2018 | 1025 | 190 | 12.9 | 114 | 24 | 132 | 2690 | 275 | 206 | 17.4 | 24.29 | 11.42 | 13.6 |
| 2019 | 865 | 135 | 18.3 | 127 | 42 | 158 | 2684 | 411 | 308 | 24.9 | 21.81 | 9.76 | 19.9 |

Table 11.7.1. Nephrops, M oray Firth (FU 9), Nominal Landings (tonnes) of Nephrops, 1981-2019, as reported to the WG.

| Year | Nephrops trawl | UK Scotland Other trawl | Creel | Sub-total | UK* <br> England | Total ** |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1981 | 1299 | 117 | 0 | 1416 | 0 | 1416 |
| 1982 | 1033 | 86 | 0 | 1119 | 0 | 1119 |
| 1983 | 850 | 91 | 0 | 941 | 0 | 941 |
| 1984 | 960 | 209 | 0 | 1169 | 0 | 1169 |
| 1985 | 1908 | 173 | 0 | 2081 | 0 | 2081 |
| 1986 | 1932 | 211 | 0 | 2143 | 0 | 2143 |
| 1987 | 1724 | 268 | 0 | 1992 | 0 | 1992 |
| 1988 | 1637 | 322 | 0 | 1959 | 0 | 1959 |
| 1989 | 2102 | 474 | 0 | 2576 | 0 | 2576 |
| 1990 | 1698 | 339 | 0 | 2037 | 0 | 2037 |
| 1991 | 1285 | 235 | 0 | 1520 | 0 | 1520 |
| 1992 | 1285 | 306 | 0 | 1591 | 0 | 1591 |
| 1993 | 1505 | 304 | 0 | 1809 | 0 | 1809 |
| 1994 | 1179 | 358 | 0 | 1537 | 0 | 1537 |
| 1995 | 967 | 312 | 0 | 1279 | 0 | 1279 |
| 1996 | 1084 | 364 | 1 | 1449 | 2 | 1451 |
| 1997 | 1103 | 343 | 0 | 1446 | 1 | 1447 |
| 1998 | 739 | 289 | 4 | 1032 | 0 | 1032 |
| 1999 | 813 | 194 | 2 | 1009 | 0 | 1009 |
| 2000 | 1341 | 196 | 2 | 1539 | 0 | 1539 |
| 2001 | 1186 | 213 | 2 | 1401 | 0 | 1401 |
| 2002 | 883 | 247 | 2 | 1132 | 0 | 1132 |
| 2003 | 873 | 196 | 11 | 1080 | 0 | 1080 |
| 2004 | 1222 | 103 | 8 | 1333 | 0 | 1333 |
| 2005 | 1526 | 64 | 12 | 1602 | 3 | 1605 |
| 2006 | 1751 | 42 | 11 | 1804 | 1 | 1805 |
| 2007 | 1818 | 17 | 6 | 1841 | 2 | 1843 |
| 2008 | 1444 | 68 | 3 | 1515 | 0 | 1515 |
| 2009 | 1033 | 31 | 2 | 1066 | 1 | 1067 |
| 2010 | 1026 | 28 | 9 | 1063 | 0 | 1063 |
| 2011 | 1358 | 23 | 9 | 1390 | 1 | 1391 |
| 2012 | 834 | 24 | 8 | 866 | 0 | 866 |
| 2013 | 497 | 116 | 7 | 620 | 3 | 623 |
| 2014 | 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 |  | $\Rightarrow 35 \mathrm{~mm} \mathrm{CL}$ |  |
|  | 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/ $\mathbf{m}^{2}$ | 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 | $\begin{aligned} & \text { Area } \\ & \left(\mathbf{k m}^{2}\right) \end{aligned}$ | Number of Stations | Mean burrow density (no./ m²) | Observed variance | Abundance (millions) | Stratum variance | Proportion of total variance |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2017 TV survey |  |  |  |  |  |  |  |
| $M \& S M$ | 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 |  |  |  |  |  |  |  |
| $M \& S M$ | 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 |
| M S(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) | $\begin{gathered} 95 \% \\ \text { CI } \end{gathered}$ | 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) | $\begin{gathered} 95 \% \\ \text { CI } \end{gathered}$ | 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 | 9 | 0 | 23 | 0 | 23 |
| 2017 | 0 | 4 | 0 | 4 | 0 | 9 |
| 2018 | 0 | 21 | 0 | 21 | 0 | 4 |
| $2019 *$ | 0 | 14 | 0 | 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.

| Year | Landings |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | < 35 mm CL |  | $\Rightarrow 35 \mathrm{~mm} \mathrm{CL}$ |  |
|  | 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/ $\mathbf{m}^{2}$ | 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 | $25^{\text {th }}$ percentile | median | $75^{\text {th }}$ 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 <br> burrows $/ \mathbf{m}^{2}$ | Abundance <br> millions | $95 \%$ confidence interval <br> 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 <br> (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 <br> (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 | 4.5 |  | 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) |
| :---: | ---: | ---: | ---: |
| 2000 | 184 | 3391 | LPUE (kg/day) |
| 2001 | 271 | 3142 | 54.3 |
| 2002 | 343 | 2022 | 86.3 |
| 2003 | 675 | 2614 | 169.6 |
| 2004 | 488 | 1551 | 258.2 |
| 2005 | 378 | 1545 | 314.6 |
| 2006 | 448 | 1440 | 244.7 |
| 2007 | 717 | 1824 | 311.1 |
| 2008 | 937 | 1673 | 393.1 |
| 2009 | 1305 | 1921 | 560.1 |
| 2010 | 838 | 1465 | 679.3 |
| 2011 | 422 | 1041 | 572.0 |
| 2012 | 550 | 1255 | 405.4 |
| 2013 | 106 | 438 | 438.2 |
| 2014 | 307 | 758 | 242.0 |
| 2015 | 401 | 1222 | 405.0 |
| 2016 | 744 | 1640 | 328.2 |
| 2017 | 522 | 1088 | 453.7 |
| 2018 | 304 | 620 | 479.8 |
| $2019 *$ | 1149 | 1291 | 490.3 |

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 |  | $\Rightarrow 35 \mathrm{~mm} \mathrm{CL}$ |  |
|  | 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/ $\mathbf{m}^{\mathbf{2}}$ | 95\% confidence interval burrows/ $\mathbf{m}^{2}$ |
| :---: | :---: | :---: | :---: |
| 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 <br> (England) | UK <br> (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 <br> (England) | UK <br> (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.

## Length frequencies for catches (dotted) and landings (solid)



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 $\mathrm{B}_{\text {trigger }}$ 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.

FU6: Quarterly Male Sex Ratio


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 $\mathbf{m}^{2}$ ) 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 $\mathbf{2 5 \%}$ selection and $50 \%$ selection. Bottom left shows residual numbers (ob-served-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.


LPUE - Scottish trawlers



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.

## Landings




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.

## Mean weight in landings


11.5.4 Nephrops, (FUs 7-9 and 34, Fladen, Firth of Forth, M oray 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.
fladen


Figure 11.5.6 Nephrops, Fladen (FU 7), Time series of TV survey abundance estimates with $95 \%$ confidence intervals, 1992-2019.

Fladen Male sex ratio


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\%); M F: medium fine sediment (55\% < silt and clay <80); MC: medium coarse sediment ( $40 \%$ < silt and clay <55); C: coarse sediment (silt and clay <40\%).

## Landings - International



Effort - Scottish trawlers


LPUE - Scottish trawlers



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 11.6.3 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.
firth forth


Figure 11.6.5 Nephrops, Firth of Forth (FU 8), Time series of TV survey abundance estimates with $95 \%$ confidence intervals, 1993-2019.

Firth_of_Forth Male sex ratio


Figure 11.6.6 Nephrops, Firth of Forth (FU 8), Quarterly sex ratio (by number) in catches.

## Landings - International



Effort - Scottish trawlers


LPUE - Scottish trawlers



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.

## Landings



## Quarterly Landings




Figure 11.7.3 Nephrops M oray 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.
moray firth


Figure 11.7.5 Nephrops, M oray 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.

Dansh Landings (tons) of Nephrops from FU 32 per rectangle and year and sampled hauls, 2000-2019 Only includirg lancinge with know reatangle and sarplad hauld with Nophropo


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 $\quad 15 \mathrm{~m}$ (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).

## Length frequencies for catch:

 Nephrops in FU32

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.

## Length frequencies for catch: <br> Nephrops in FU33



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.

## Effort - Scottish trawlers



LPUE - Scottish trawlers


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 M onitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.
devils hole


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 $>\mathbf{3 0} \%$ 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 $B_{\text {trigger }}=B_{\lim }$ and $\mathrm{F}_{\text {cap }}=0.7$ reference points were evaluated in Brooks and Nielsen (2020). Despite only a slight change in Blim of less than $10 \%$ from $B_{l i m}=39447 \mathrm{t}$ (Benchmark ICES WKPOUT 2016 estimate) to $\mathrm{Blim}_{\mathrm{lim}}=42573 \mathrm{t}$ 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 $\mathrm{B}_{\mathrm{lim}}$ reference point, and on this basis to calculate a new $B_{\text {pa }}$ reference point. The sustainability of the currently implemented $F_{\text {cap }}=0.7$ was accordingly evaluated with this new $B_{\text {lim }}$ reference point (Brooks and Nielsen, 2020). These evaluations showed that the current $\mathrm{F}_{\text {cap }}$ was also sustainable with the slightly revised Blim 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 $2^{\text {nd }}$ half year 2019 and for the quarters 1, 2 and 3 in 2020. The assessment includes the new $3^{\text {rd }}$ quarter 2020 survey information also covering the 0-group 2020 year class information, which is used real time in $3^{\text {rd }}$ quarter. Consequently, the assessment does not backshift this survey information to $2^{\text {nd }}$ 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 $\left(>57^{\circ} \mathrm{N}\right)$ 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 2and 3-groups in $1^{\text {st }}$ 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).

### 12.1.2Fisheries

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 $3^{\text {rd }}$ and $4^{\text {th }}$ quarters of the year with also high catches in $1^{\text {st }}$ quarter of the year especially previous to 1999. Recent catches in $1^{\text {st }}$ quarter are relatively low. Some catch also originates from Norwegian fishery in the $2^{\text {nd }}$ 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 bycatch 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 Blim 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 Blim 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 Blim after the fishery has taken place, SSB is calculated for quarter 4 as a proxy for $\operatorname{SSB}$ at spawning time (quarter 1). Consequently, the Blim was adjusted in the benchmark assessment in 2016. The Blim estimate in the $4^{\text {th }}$ quarter is lower than the previous value of Blim for the $1^{\text {st }}$ 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 $\mathrm{F}_{\text {cap }}$ of 0.70 and that the $5^{\text {th }}$ percentile of the spawning-stock biomass in the $4^{\text {th }}$ quarter 2020 will remain above a reference level of Blim ( 39450 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 198000 t in the EC zone and 50000 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 $115 \mathrm{kt}(\mathrm{EU}), 116 \mathrm{kt}(\mathrm{EU})$ for 2009, 163 kt (EU) for 2010, 8 kt for 2011, 96 kt for 2012, 323 kt for $2013,251 \mathrm{kt}$ for 2014, 328 kt for 2015, 360 kt for $2016,346 \mathrm{kt}$ 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 bycatch 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 $\mathrm{F}_{\text {cap }}$ 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\ Reports/Advice/2018/Special requests/euno.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 ( $\mathrm{TAC}_{\max }$ ) and upper ( $\mathrm{TAC}_{\max }$ ) bounds on TAC and optional use of upper fishing mortality values ( $\mathrm{F}_{\text {cap }}$ ) (ICES WKNPOUT, 2018). Several HCRs were identified that combined TAC Tax in the range of $20000-$ 40000 t and TACmax less than or equal to $200000 \mathrm{t}\left(150000 \mathrm{t}\right.$ or 200000 t ) and $\mathrm{F}_{\text {cap }}$ values of 0.3 and 0.4 , resulting in no more than a $5 \%$ probability of the spawning-stock biomass falling below Blim.

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 (TACmax) and upper bounds (TAC $\mathrm{Taxax}^{\text {}}$. For some HCRs, an upper limit on F ( $\mathrm{F}_{\text {cap }}$ ) 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 ; Fhistorical), 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 $\mathrm{TAC}_{\text {max }}, \mathrm{TAC}_{\text {max }}$, and $\mathrm{F}_{\text {cap }}$ 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


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 $\mathrm{F}_{\text {cap }}$ 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 Bescapement:
$\rightarrow \quad$ which scenarios of $T A C_{\max }$ and $T A C_{\max }$ would be precautionary, if the $F_{\text {cap }}$ is set at 0.7 (building on request part 2 and 3, pages 3 and 4 of the advice).
$\rightarrow \quad$ which scenarios of $T A C_{\max }$ and $T A C_{\max }$ 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 $F_{\text {cap }}$ 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 ( $\mathrm{TAC}_{\max }$ ) and upper ( $\mathrm{TAC}_{\max }$ ) bounds on TAC and use of an upper fishing mortality ( $\mathrm{F}_{\text {cap }}$ ) 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 ; $\mathrm{F}_{\text {historical) }}$ ), 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\ Reports/Advice/2018/Special requests/eu.2018.19.pdf.
Several HCRs were identified that combined TAC max in the range of $20000-40000 \mathrm{t}$ and $\mathrm{TAC}_{\max }$ less than or equal to 200000 t , resulting in no more than a $5 \%$ probability of the spawning-stock biomass falling below Blim. Increasing the $\mathrm{F}_{\text {cap }}$ 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 Blim. It also results in a higher probability of being constrained by the TACmax.

The evaluations and ACOM approval of this led to identification of an expanded set of sustainable scenarios with a $\mathrm{F}_{\text {cap }}$ of 0.7. Tables 1 and 2 in
http://ices.dk/sites/pub/Publication\ Reports/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 Blim 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 $\pm 10 \%$ 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 $\mathrm{F}_{\text {cap }}$ of 0.7 and with no $\mathrm{TAC}_{\max }$ or $\mathrm{TAC}_{\text {max }}$ 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

### 12.2.2 Landings / catches

Data for annual nominal landings of Norway pout as officially reported to ICES are shown in Table 12.2.1. The landings equal the catches of Norway pout as discard in this small meshed fishery is negligible (see also Nielsen et al., 2016a). Historical data for annual landings (catches) as provided by ICES (Working Group members) are presented in Table 12.2.2, and data for national landings (catches) by quarter of year and by geographical area are given in Table 12.2.3. Total observed and predicted (by the SESAM stochastic assessment model) catches by quarter is given in Table 12.2.3a. Both the Danish and Norwegian landings (catches) of Norway pout were low in 2007 and 2011. The landings were moderate in 2008-09, 2012, 2014 and 2017-2018, higher in 2013 and 2015-2016, and high in 2010 ( 126 kt ) and 2019 ( $98 \mathrm{kt)}$ ). The TAC was not reached in any of those recent years. The most recent catches have been included in the assessment. Catches for $3^{\text {rd }}$ quarter 2020 include Danish and Norwegian catches up to 20 September 2020. Catches in the last 10 days of $3^{\text {rd }}$ 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.

### 12.2.5Maturity 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 $1^{\text {st }}$ 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.

### 12.2.6Summary 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 12.2.112.2.5 and Figure 12.2.1. Catches in all of 2005, $1^{\text {st }}$ 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 1 ${ }^{\text {st }}$ and $3^{\text {rd }}$ 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 $1^{\text {st }}$ quarter 2020 IBTS and the $3^{\text {rd }}$ quarter 2019 IBTS research surveys have been included in this September 2020 assessment as well as the $3^{\text {rd }}$ 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 $3^{\text {rd }}$ 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 $3^{\text {rd }}$ 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 4 A and 49 in 4B in the SGFS. In 2017, this was slightly more unbalanced with 43 hauls taking place in 4 A and 33 in 4 B . 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 $3^{\text {rd }}$ 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 20052006 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 $\operatorname{lag} 4$ and correlated increments, i.e. the log F-at-age in a given quarter is given by the $\log \mathrm{F}$-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 $\log \mathrm{F}$ on the estimated random walk variance due to periods where the fishery was closed. This option reduced the estimated $\log \mathrm{F}$ 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, $\mathrm{B}_{\mathrm{lim}}$ is set equal to Bloss 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 Blim to be evaluated immediately following the fishing season.

Stock indices and assessment settings used in the assessment are presented in tables 12.3.112.3.2.

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, $\mathrm{F}_{\text {bar }}$ ), 12.3.4 (recruitment), 12.3.5 (yield, catches on yearly and quarterly basis), and 12.3.6-12.3.7 (stockrecruitment 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 $1^{\text {st }}$ and $2^{\text {nd }}$ quarter has in general decreased in recent years, while fishing mortality for $3^{\text {rd }}$ and especially $4^{\text {th }}$ 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 Blim in 2005 which is the lowest level ever recorded. By 1 January 2007 and 2008 the stock was at $\mathrm{B}_{\mathrm{pa}}$ (= MSY Bescapement) (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 $B_{p a}$ (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 $B_{p a}$ (= MSY Bescapement) 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 $B_{p a}$ 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 Bloss 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 $\mathrm{F}_{\mathrm{bar}(1-2) \text {, because of the introduction of the revised IBTS }}$

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 $0,2^{\text {nd }}$ 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 $\mathrm{B}_{\mathrm{lim}}$ 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 $\log \mathrm{Ft}=\log \mathrm{Ft}-4+\log \mathrm{Gt}$, for all future values of t where Gt is some chosen vector of multipliers of the F-process. If $\mathrm{Gt}=1$ for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year.
4. Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution.

It should be noted that the short term forecast only uses the observed 2020 recruitment (Q3 2020) in the SSB estimate by $4^{\text {th }}$ quarter 2020 The recruits in 2021 do not become a part of SSB by $4^{\text {th }}$ quarter (1 October) 2021 because they have not reached maturity yet by $4^{\text {th }}$ quarter 2021, but will do that by 1 January 2022 ( $20 \%$ mature as 1 -group here). However, the forecast is just run up to $4^{\text {th }}$ 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 Gt such that the $5^{\text {th }}$ (or any other) percentile of the catches (total mass) in the projections equal some desired level such as $\mathrm{B}_{\lim }$ (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:
$E\left(\sqrt{C W_{a, q, t}}\right)=\mu_{a, q}+s($ cohort,$a)+U_{t}$
where $\mu \mathrm{a}, \mathrm{q}$ 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 Blim 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 $\mathrm{B}_{\lim }$ 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 Blim, i.e. where the probability of SSB being below Blim 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 $349 \mathrm{kt}(349090 \mathrm{t}$ ) in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a Fbar(1-2) of 1.093 and a SSB at $166 \mathrm{kt}(166810 \mathrm{t})$ 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 $\mathrm{F}_{\mathrm{bar}(1-2)}$ of 0.00 and a SSB at $368 \mathrm{kt}(368180 \mathrm{t}$ ) 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 $\mathrm{F}_{\mathrm{bar}(1-2)}$ of 0.243 and a SSB at $299 \mathrm{kt}(299940 \mathrm{t})$ 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 $\mathrm{Blim}_{\mathrm{lim}}$. 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 Fbar(1-2) of 4.065 and a SSB of 42 kt (42573 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 $B_{p a}$. 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 $\mathrm{Fbar}(1-2)$ of 2.798 and a SSB of $70 \mathrm{kt}\left(70000 \mathrm{t}=\mathrm{B}_{\mathrm{pa}}\right)$ 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 $\mathrm{F}_{\text {cap }}=0.3$. 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 $\mathrm{Fbar}^{(1-2)}$ of 0.305 and a SSB of 125 kt ( 125191 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 $\mathrm{F}_{\text {cap }}=0.4$. 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 Fbar(1-2) of 0.405 and a SSB of $262 \mathrm{kt}(262700 \mathrm{t})$ 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 $\mathrm{F}_{\text {cap }}=0.5$. 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 Fbar(1-2) of 0.505 and a SSB of $243 \mathrm{kt}(243520 \mathrm{t})$ 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 $\mathrm{F}_{\text {cap }}=0.6$. 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 Fbar(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 $\mathrm{F}_{\text {cap }}=0.7$. The results of the forecast are presented in Table 12.6.11 and Figure 12.6.10 where catches up to $254 \mathrm{kt}(254038 \mathrm{t})$ can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a $\operatorname{Fbar}(1-2)$ of 0.708 and a SSB of $211 \mathrm{kt}(211550 \mathrm{t})$ 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\ Reports/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 Blim by 1 October in the forecast year is less than $5 \%$ is only precautionary with the addition of an $\mathrm{F}_{\text {cap }}$ 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 Blim $=$ 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 Blim reference point, because the probability of SSB being below Blim 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 Blim 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 Bloss estimates which equals Blim according to the ICES WKPOUT 2016 benchmark assessment which by 1 October is $B_{\lim }=39450 \mathrm{t}$ (ICES, 2016).

The Blim 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 Blim 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 Bloss level in the start of Q4 in 2005 between assessments.

|  | Type | Value | Technical basis |
| :---: | :---: | :---: | :---: |
| MSY <br> Approach | MSY | 39450 t , quarter 4 | $\mathrm{B}_{\text {lim }}=\mathrm{B}_{\text {loss, }}$, the lowest observed biomass in 2005 |
|  | $\mathrm{F}_{\mathrm{MSY}}$ | Undefined | None advised |
| Precautionary Approach | $\mathrm{Bl}_{\text {lim }}$ | 39450 t , quarter 4 | $\mathrm{B}_{\text {lim }}=\mathrm{B}_{\text {loss, }}$, the lowest observed biomass in 2005 |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 65000 t , quarter 4 | $=B_{\text {lim }} \mathrm{e}^{0.3^{* 1.645}}$ |
|  | $\mathrm{F}_{\text {lim }}$ | Undefined | None advised |
|  | $\mathrm{F}_{\mathrm{pa}}$ | Undefined | None advised |

No F-based reference points are advised for this stock except for an Fcap (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 Blim 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 $\mathrm{Blim}_{\text {lim }}$ 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\ Reports/Advice/2018/Special requests/euno.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 Blim by 1 October in the forecast year is less than $5 \%$ is only precautionary with the addition of an $\mathrm{F}_{\text {cap }}$ at 0.7.
$\mathrm{B}_{\mathrm{pa}}$ has been calculated from

$$
\mathrm{B}_{\mathrm{pa}}=\mathrm{B}_{\lim } \mathrm{e}^{0.3^{*} 1.645}(\mathrm{SD}) .
$$

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 Blim ${ }_{\text {lim }}$ and $\mathrm{B}_{\mathrm{pa}}$ (39 450 and 65000 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 Bloss as well as more observations above than below the inflection point).

The Blim = Bloss = 39450 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 $B_{\text {lim }}$ and $F_{\text {cap }}=0.7$ reference points were during summer 2020 evaluated and presented in Brooks and Nielsen (2020).

The analyses showed a slight change in Blim of less than $10 \%$ from $\mathrm{Blim}_{\lim }=39447 \mathrm{t}$ (Benchmark ICES WKPOUT, 2016 estimate) to $B_{\lim }=42573 \mathrm{t}$ 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 Blim value and simulated to be restricted by a combination of an upper limit on F values ( $\mathrm{F}_{\text {cap }}$ ), different $\mathrm{F}_{\text {max }}$ values (between the historical observed $F_{\text {max }}$ of 0.67 , i.e. the $F_{\text {historical }}$ for the assessment using the revised IBTS data, and up to a $\mathrm{F}_{\text {max }}$ value of 2 ) as well as different TAC upper bounds ( $\mathrm{TAC}_{\max }$ ) 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 $\mathrm{F}_{\text {cap }}=0.7$ was through long term management strategy evaluation simulations evaluated with the new $B_{\text {lim }}$ reference point and according to the different $\mathrm{F}_{\max }$ and $\mathrm{TAC}_{\text {max }}$ values applied as described above and detailed in Brooks and Nielsen (2020)

These evaluations showed that the currently implemented $\mathrm{F}_{\text {cap }}$ of 0.7 is also precautionary and sustainable with the slightly revised Blim reference point (Brooks and Nielsen, 2020).

This is the case also in extremely unrealistic scenarios of an infinite $\mathrm{TAC}_{\max }$ and with $\mathrm{F}_{\max }$ values between 0.67 and up to 2 (Brooks and Nielsen, 2020). All scenarios for $\mathrm{F}_{\max }=0.67$ and for a very unrealistic high $\mathrm{F}_{\max }=1$ with infinite $\mathrm{TAC}_{\max }$ are sustainable. Even with the totally unrealistically high maximum implementable F of 2 then the risk only goes above 0.05 with an $\mathrm{F}_{\text {cap }}=0.7$ (when rounded to the nearest 0.01 units) for the risk3.long. Q 4 . All other scenarios for $\mathrm{F}_{\max }=2$ values are sustainable (Brooks and Nielsen, 2020). This means that if there were a totally unrealistic high $\mathrm{F}_{\max }$ of around 1.6 which is similar to the natural mortality level for the stock then all scenarios of $\mathrm{F}_{\text {cap }}=0.7$ would obviously be sustainable.

The WGNSSK working group has on this basis decided to switch to the new Blim reference point, and on this basis to calculate a new $B_{p a}$ reference point, and continue with the currently implemented $\mathrm{F}_{\text {cap }}$ of 0.7 . It should again be noted that no $\mathrm{TAC}_{\max }$ or $\mathrm{TAC}_{\max }$ 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 Bloss estimates which equals Blim which by 1 October is $B_{\lim }=42573 \mathrm{t}$, i.e. based on the lowest observed SSBs in 2005.

|  | Type | Value | Technical basis |
| :--- | :--- | :--- | :--- |
| MSY <br> Approach | MSY | 42573 t , quarter 4 | $\mathrm{B}_{\text {lim }}=\mathrm{B}_{\text {loss, }}$ the lowest observed biomass in 2005 |
|  | $\mathrm{F}_{\text {MSY }}$ | Undefined | None advised |
| Precautionary <br> Approach | $\mathrm{B}_{\text {lim }}$ | 42573 t , quarter 4 | $\mathrm{B}_{\text {lim }}=\mathrm{B}_{\text {loss }}$, the lowest observed biomass in 2005 |
|  | 70000 t , quarter 4 | $=\mathrm{B}_{\text {lim }} \mathrm{e}^{0.3^{*} 1.645}$ |  |
|  | $\mathrm{~F}_{\text {lim }}$ | Undefined | None advised |
|  | $\mathrm{F}_{\text {pa }}$ | Undefined | None advised |

The relationship between the $\mathrm{B}_{\mathrm{lim}}$ and $\mathrm{B}_{\mathrm{pa}}(42573$ and 70000 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 $\mathrm{F}_{\mathrm{bar}}$ 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 $\mathrm{F}_{\mathrm{bar}}$, 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 $3^{\text {rd }}$ 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 $\mathrm{F}_{\text {cap }}=0.7$ catches up to 167 kt ( 167105 t ) can be taken in the directed Norway pout fishery in the period 1 October 2019 to 31 October 2020 which corresponds to a $F_{b a r(1-2)}$ of 0.708 and a SSB of $139 \mathrm{kt}(139130 \mathrm{t})$ 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 $\mathrm{F}_{\text {cap }}=0.7$ catches up to $254 \mathrm{kt}(254038 \mathrm{t})$ can be taken in the directed Norway pout fishery in the period 1 October 2020 to 31 October 2021 which corresponds to a Fbar(1-2) of 0.708 and a SSB of $211 \mathrm{kt}(211550 \mathrm{t})$ 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 ( $\mathrm{F}=0.35$ ), Fixed TAC ( 50000 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 $B_{p a}=$ MSY Bescapement, i.e. away from Blim 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 $\mathrm{F}=0.35$ (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 $100 \mathrm{kt}\left(\mathrm{F}_{\text {max } / \mathrm{cap}}=0.8\right.$ ) or with maximum TAC of $200 \mathrm{kt}\left(\mathrm{F}_{\mathrm{max} / \mathrm{cap}}=0.6\right)$ will be long term sustainable with some level of F control according to those $\mathrm{F}_{\text {cap }}$ 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 $\mathrm{F}_{\text {cap }}$ 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\ Reports/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 2628 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 ( $\mathrm{TAC}_{\max }$ ) and upper (TACmax) bounds on TAC and optional use of upper fishing mortality values ( F cap). Several HCRs were identified that combined TACmax in the range of $20000-40000 \mathrm{t}$ and $\mathrm{TACmax}_{\text {max }}$ less than or equal to 200000 t ( 150000 t or 200000 t ) and $\mathrm{F}_{\text {cap }}$ values of 0.3 and 0.4, resulting in no more than a $5 \%$ probability of the spawning-stock biomass falling below Blim.

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 $F$ ( $\mathrm{F}_{\text {cap }}$ ) 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 ; Fhistorical), 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 $\mathrm{TAC}_{\text {max }}, \mathrm{TAC}_{\text {max }}$, and $\mathrm{F}_{\text {cap }}$ 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 Fhistorical. Therefore, the HCR should be re-evaluated if future F exceeds Fhistorical (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 $\mathrm{F}_{\text {cap }}$ 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 Bescapement:
$\rightarrow \quad-$ which scenarios of TAC max and TACmax would be precautionary, if the $F_{\text {cap }}$ is set at 0.7 (building on request part 2 and 3 , pages 3 and 4 of the advice).
$\rightarrow \quad$-which scenarios of $T A C_{\max }$ 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 $F_{\text {cap }}$ 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 ( $\mathrm{TAC}_{\max }$ ) and upper ( $\mathrm{TAC}_{\max }$ ) bounds on TAC and use of an upper fishing mortality ( $\mathrm{F}_{\text {cap }}$ ) 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 ; Fhistorical), 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\ Reports/Advice/2018/Special requests/eu.2018.19.pdf.
Several HCRs were identified that combined TAC max in the range of $20000-40000 \mathrm{t}$ and TACmax less than or equal to 200000 t , resulting in no more than a $5 \%$ probability of the spawning-stock biomass falling below Blim. Increasing the $\mathrm{F}_{\text {cap }}$ 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 Blim. It also results in a higher probability of being constrained by the TACmax.

The evaluations and ACOM approval of this led to identification of an expanded set of sustainable scenarios with a $\mathrm{F}_{\text {cap }}$ of 0.7 . Tables 1 and 2 in
http://ices.dk/sites/pub/Publication\ Reports/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 $\mathrm{B}_{\mathrm{lim}}$ 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 $\pm 10 \%$ 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 $B_{\text {lim }}$ and $F_{\text {cap }}=0.7$ 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 $B_{\lim }=39447 \mathrm{t}$ (Benchmark ICES WKPOUT, 2016 estimate) to $B_{\lim }=42573 \mathrm{t}$ 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 ( $\mathrm{F}_{\text {cap }}$ ), different $\mathrm{F}_{\text {max }}$ values (between the historical observed $\mathrm{F}_{\text {max }}$ of 0.67 , i.e. the Fhistorical for the assessment using the revised IBTS data, and up to a Fmax 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 $\mathrm{F}_{\text {cap }}=0.7$ was through long term management strategy evaluation simulations evaluated with the new $\mathrm{B}_{\mathrm{lim}}$ reference point and according to the different $\mathrm{F}_{\max }$ and $\mathrm{TAC}_{\max }$ values applied as described above and detailed in Brooks and Nielsen (2020).

These evaluations showed that the currently implemented $\mathrm{F}_{\text {cap }}$ of 0.7 is also precautionary and sustainable with the slightly revised Blim reference point (Brooks and Nielsen, 2020).

This is the case also in extremely unrealistic scenarios of an infinite $\mathrm{TAC}_{\max }$ and with $\mathrm{F}_{\max }$ values between 0.67 and up to 2 (Brooks and Nielsen, 2020). All scenarios for $\mathrm{F}_{\max }=0.67$ and for a very unrealistic high $\mathrm{F}_{\max }=1$ with infinite $\mathrm{TAC}_{\max }$ are sustainable. Even with the totally unrealistically high maximum implementable F of 2 then the risk only goes above 0.05 with an $\mathrm{F}_{\text {cap }}=0.7$ (when rounded to the nearest 0.01 units) for the risk3.long. Q 4 . All other scenarios for $\mathrm{F}_{\max }=2$ 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 $\mathrm{F}_{\text {cap }}=0.7$ would obviously be sustainable.

The WGNSSK working group has on this basis decided to switch to the new Blim reference point, and on this basis to calculate a new $\mathrm{B}_{\mathrm{pa}}$ reference point, and continue with the currently implemented $\mathrm{F}_{\text {cap }}$ of 0.7. It should again be noted that no $\mathrm{TAC}_{\max }$ or $\mathrm{TAC}_{\max }$ 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.

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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.

| 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 IIla (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 |  | 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 | $150.000 \times$ | 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 |  |
| * provisional / preliminary <br> ** provisional / preliminary <br> *** 781 ton from trial fishery (directed fishe <br> **** A by-catch qouta of 5000 t has been <br> ***** 681 t taken in trial fishery; 1300 t in <br> + Landings less than 1 <br> n/a not available <br> x EU Agreed TAC | ry); 160 to et. y-catches | from by-ca <br> other (sm | ches in oth meshed) fis | fisheries <br> sheries. |  |  |  |  |  |  |  |

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).


[^9]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). (Bycatch of Norway pout in other (small meshed) fisheries included).

| Year | Quarter <br> Area | Denmark |  |  |  |  |  |  |  |  | Norway |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | IllaN | Illas | Div. Illa | IVaE | IVaW | IVb | IVc | Div. IV | Div. IV + IllaN | IVaE | Div. IV | Div. IV + IllaN |
| 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 | - | $\cdots$ | - | 211 | 211 | 211 |
|  | Total | - | - | - | 941 | - | - | - | 941 | 941 | 962 | 962 | 1.903 |
| 2006 | 1 | - | - | - | 75 | 83 | - | - | 158 | 158 | 2.205 | 2205 | 2.363 |
|  | 2 | - | - | 11 | - | - | 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 | 15 | - | - | - | 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 | , | - | , | - | 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 |  |  | - | - |  |  |  |  |  |  |  | 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 | - | - | $\cdot$ | - | 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 | 2 | - | 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 | - | - | i20 | - | 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 | , | - | - | 5 | 20.135 | 1 | - | 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 |
|  |  | - | - | - | - | 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 |
|  |  | 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 |  | - | - | - | 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 |  | , | , | 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 | 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 |  | 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 |
| Age |  | 36206 | 29291 | 62290 | 53470 | 34575 | 15373 | 53799 | 79838 | 36942 | 28019 | 69763 | 97048 |
|  | 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 | 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 | - | 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 |  |  |  |  |  |  |  |  |  |
| 2007-08 |  | 3808 | 10960 | 47422 |  |  |  |  |  |  |  |  |  |

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).


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 <br> 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.


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.

| Year | Fishing days |  |  |  |  | CPUE (ton/fishing day) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 ( $1^{\text {st }} \mathrm{Q}$ ) |  |  | EGFS ${ }^{2,3}$ August |  |  |  | SGFS ${ }^{4}$ August |  |  |  | IBTS $3^{\text {rd }}$ 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 |  |  |  |  |

International Bottom Trawl Survey (IBTS), arithmetic mean catch in no./h in standard area. In general the quarter 1 (Q1) and quarter $\mathbf{3}$ (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 $\mathbf{2 0 0 0}$. 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. 2nd quarter (SXSA), autumn assessm.$4+(\mathrm{SXSA})$ | 3rd quarter SESAM (1984-2020) <br> 3rd quarter SESAM (1984-2020) <br> $3+$ (SESAM) (1984-2020) |
| Last season in last year |  | 3rd quarter | 2nd quarter (SXSA) | 3rd quarter (SMS); 2nd quarter (SXSA |  |  |
| Plus-group |  | $4+$ | 4+ (SXSA) | None (SMS); 4+ (SXSA) |  |  |
| FLT01: comm Q1 |  |  |  |  |  |  |
|  | Year range | 1982-2003 | 1982-2004 | 1982-2004 | $1983-2004,2006$1 | NOT USED |
|  | Quarter | 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 ( $\mathrm{F}_{\mathrm{bar}}=\mathrm{F} 12$ ) 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ |
| :---: | :---: | :---: | :---: | :---: |
| $\mathbf{0}$ | 4.796 | 6.342 | 4.545 | 6.113 |
| $\mathbf{1}$ | 6.257 | 9.956 | 19.684 | 22.486 |
| $\mathbf{2}$ | 17.119 | 19.945 | 27.602 | 31.700 |
| $\mathbf{3}$ | 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) $=230750$ tonnes;
$R(2020)=$ estimated / observed from in year assessment 1 July 2020 (age 0 in start of Q3) = 103267 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 $\mathrm{B}_{\text {lim }}$ (optional).

|  | F12 | SSB | SSB 5th quantile | median catch |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 2.19 | 235.52 | 118.33 | 173010.79 |
| $\mathbf{2 0 2 1}$ | 0.03 | 384.90 | 137.98 | 2150.34 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.57 | 308.25 | 111.05 | 47433.26 |
| $\mathbf{2 0 2 1 . 5}$ | 1.58 | 329.99 | 106.07 | 126495.81 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 0.00 | 235.52 | 118.33 | 0.00 |
| $\mathbf{2 0 2 1}$ | 0.00 | 561.18 | 277.12 | 0.00 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.00 | 440.66 | 207.78 | 0.00 |
| $\mathbf{2 0 2 1 . 5}$ | 0.00 | 517.53 | 224.86 | 0.00 |
| $\mathbf{2 0 2 1 . 7 5}$ | 368.18 | 149.05 | 0.00 |  |
| Sum |  |  |  |  |

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 |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 0.48 | 235.52 | 118.33 | 45619.81 |
| $\mathbf{2 0 2 1}$ | 0.01 | 510.82 | 233.75 | 615.40 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.13 | 403.23 | 177.70 | 13721.52 |
| $\mathbf{2 0 2 1 . 5}$ | 0.35 | 463.67 | 191.97 | 41494.17 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 $\mathrm{B}_{\text {lim }}$.

Basis: Same as above.

|  | F12 | SSB | SSB 5th quantile | median catch |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 8.17 | 235.52 | 118.33 | 392731.07 |
| $\mathbf{2 0 2 1}$ | 0.09 | 189.04 | 53.70 | 4506.27 |
| $\mathbf{2 0 2 1 . 2 5}$ | 2.12 | 164.98 | 46.54 | 102260.94 |
| $\mathbf{2 0 2 1 . 5}$ | 5.88 | 149.37 | 35.38 | 205486.01 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 5.62 | 235.52 | 118.33 | 325311.02 |
| $\mathbf{2 0 2 1}$ | 0.06 | 244.85 | 69.22 | 3777.26 |
| $\mathbf{2 0 2 1 . 2 5}$ | 1.46 | 205.75 | 59.00 | 85317.21 |
| $\mathbf{2 0 2 1 . 5}$ | 4.05 | 197.95 | 51.42 | 191611.08 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 0.61 | 235.52 | 118.33 | 56914.89 |
| $\mathbf{2 0 2 1}$ | 0.01 | 498.66 | 224.31 | 760.02 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.16 | 393.85 | 171.41 | 16964.99 |
| $\mathbf{2 0 2 1 . 5}$ | 0.44 | 450.62 | 183.54 | 50550.94 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 $0.4\left(F_{\text {cap }}=0.4\right)$ for the period 1 October 2020 to 1 October 2021.

Basis: Same as above.

|  | F12 | SSB | SSB 5th quantile | median catch |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 0.81 | 235.52 | 118.33 | 74036.86 |
| $\mathbf{2 0 2 1}$ | 0.01 | 480.33 | 209.98 | 975.89 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.21 | 380.13 | 162.42 | 21822.39 |
| $\mathbf{2 0 2 1 . 5}$ | 0.59 | 431.04 | 171.06 | 63917.04 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 1.02 | 235.52 | 118.33 | 90285.76 |
| $\mathbf{2 0 2 1}$ | 0.01 | 462.37 | 196.36 | 1182.89 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.26 | 367.84 | 153.45 | 26272.20 |
| $\mathbf{2 0 2 1 . 5}$ | 0.73 | 412.53 | 157.73 | 76232.50 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 ( $\mathrm{F}_{\text {cap }}=0.6$ ) for the period 1 October 2020 to 1 October 2021.

Basis: Same as above.

|  | F12 | SSB | SSB 5th quantile | median catch |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 1.22 | 235.52 | 118.33 | 106310.21 |
| $\mathbf{2 0 2 1}$ | 0.01 | 448.30 | 184.70 | 1375.10 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.32 | 356.89 | 145.28 | 30501.65 |
| $\mathbf{2 0 2 1 . 5}$ | 0.88 | 396.19 | 147.03 | 86929.60 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 ( $\mathrm{F}_{\text {cap }}=0.7$ ) for the period 1 October 2020 to 1 October 2021.

Basis: Same as above.

|  | F12 | SSB | SSB 5th quantile | median catch |
| :--- | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 2 0 . 7 5}$ | 1.42 | 235.52 | 118.33 | 121300.33 |
| $\mathbf{2 0 2 1}$ | 0.02 | 434.38 | 172.52 | 1554.73 |
| $\mathbf{2 0 2 1 . 2 5}$ | 0.37 | 345.52 | 137.02 | 34561.47 |
| $\mathbf{2 0 2 1 . 5}$ | 1.02 | 381.03 | 136.41 | 96621.79 |
| $\mathbf{2 0 2 1 . 7 5}$ |  | 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 $\mathrm{B}_{\mathrm{lim}}$ according to the ICES WKPOUT 2016 benchmark assessment which by 1 October is $B_{\text {lim }}=39450$ 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.stockassessment.org) with new IBTS Q1 and Q3 survey indices made available in 2020. The estimates are quarterly minima in tonnes estimated at the beginning of the season. The estimates are Bloss estimates which equals $B_{\text {lim }}$ according to the assessment run above which by 1 October is $B_{\text {lim }}=42573 \mathrm{t}$.

| 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: $\mathrm{F}_{1-2}=\mathrm{F}_{\text {bar }}$, 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 $B_{l i m}$.


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 $B_{l i m}$.


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 $B_{p a}$.


Figure 12.6.6 Norway pout 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to $0.3\left(F_{\text {cap }}=0.3\right)$ 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 ( $\mathrm{F}_{\text {cap }}=0.4$ ) 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 $0.5\left(F_{\text {cap }}=0.5\right)$ 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 $0.6\left(F_{\text {cap }}=0.6\right)$ 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 ( $\mathrm{F}_{\text {cap }}=0.7$ ) for the period 1 October 2020 to 1 October 2021.

# 13 Plaice in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak) 


#### Abstract

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 $B_{\text {MSY }}$ 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 162607 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 |
| BM S 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 |
| BM Slanding | 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/ 0 TB_CRU_16-31 is raised from $0 T B<100$, 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 48745 tonnes. Of these 39973 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 $80-\mathrm{mm}$ 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 125435 tonnes catch TAC for 2019. The catches of 2019 in Subdivision 20 reached $69 \%$ of the 16782 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 $1^{\text {st }}$ 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;
- $\quad$ Sole Net Survey 1 (SNS1); (1970-1999); Age 1-6
- $\quad$ 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 ( $3^{\text {rd }}$ Quarter) and the IBTS ( $1^{\text {st }}$ and $3^{\text {rd }}$ 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 IBTSQ3, 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-GermanyDenmark 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 BTSQ3, 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 <br> 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 | 9 |
| reaches a plateau >= |  |
| 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 1052312 tonnes and it is well above MSY Btrigger. 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 FMSY since 2009. The estimated recruitment in 2019 is 2865930 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 | $\underline{2442455}$ | 1963968 | 1072476 | AAP survivors |
| 2019 | 1 | 1012237 | $\underline{1363360}$ | GM 2007-2016* |  |
| 2020 | 0 | $\underline{1363360}$ | 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" ( $\mathrm{F}_{\mathrm{sq}}$ ), 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, $\mathrm{F}_{\mathrm{sq}}$ 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 | $\mathbf{F}_{(2-6)} \mathbf{2 0 2 0}$ | SSB 2021 | Recruitment 2020 | Landings 2020 | Discards 2020 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| F2020 $=$ Fsq-re- <br> 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 Blim can be set at $B_{\text {loss }}=160000$ tonnes and that $B_{p a}$ can then be set at 230000 tonnes using A multiplier of 1.44. Flim was set at $\mathrm{F}_{\text {loss }}(0.74)$. $\mathrm{F}_{\mathrm{pa}}$ was proposed to be set at 0.6 which is the $5^{\text {th }}$ percentile of Floss and gave a $50 \%$ probability that SSB is around $B_{p a}$ in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230000 tonnes.

### 13.7.2 FM SY 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 $(\mathrm{F})$ that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 2014, the joint ICES MYFISH Workshop (WKMSYREF3, ICES, 2014) held place to consider the basis for Fmsy ranges. The workshop was convened in response to a request from the European Commission for advice on potential intervals above and below $\mathrm{F}_{\text {msy. }}$ This resulted in an Fmsy range for North Sea plaice of 0.13-0.27. The point value of Fmsy was set at 0.19.

This values differs from the previous value of $\mathrm{Fmsy}^{2}=0.25$ (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 Flim is proposed as the $F$ that, in equilibrium from a long-term stochastic projection, gives $50 \%$ probability of thou $>$ Blim. The value of $\mathrm{F}_{\mathrm{pa}}$ is estimated as the F value such that when F is estimated to be at $\mathrm{F}_{\mathrm{pa}}$, the probability that true $\mathrm{F}<\mathrm{Flim}_{\mathrm{l}}$ is at least $95 \%$. Thus $\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\text {lim }}$
the final assessment year. In case of
$\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\text {lim }}$ /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 Blim. The estimated $\mathrm{F}_{\mathrm{lim}}$ is 0.63 and the corresponding $\mathrm{F}_{\mathrm{pa}}=0.45$ using the default ratio of 1.4. The updated values of both $F_{\text {lim }}$ and $\mathrm{F}_{\mathrm{pa}}$ 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 |
| :---: | :---: | :---: | :---: | :---: |
| M SY approach | M SY Btrigger | 230000 t | Default to value of Bpa |  |
|  | FMSY | 0.19 | Combined stock | ICES (2014) |
| Precautionary approach | Blim | 160000 t | Bloss $=160000 \mathrm{t}$, the lowest observed biomass in 1997 as assessed in 2004 | ICES (2004) |
|  | Bpa | 230000 t | $1.44 \times \lim$ | ICES (2004) |
|  | Flim | 0.63 | The $F$ that in equilibrium will maintain the stock above Blim with a 50\% probability | ICES (2016a) |
|  | Fpa | 0.45 | $\mathrm{Fpa}=\mathrm{Flim} \quad \mathrm{F} \quad \mathrm{F}=0.20$ | ICES (2016a) |

A series of discussions have been carried out on the value of the new MSY Btrigger: F has been below (at) FMSY in more than 5 years, which triggers a revision of MSY $\mathrm{B}_{\text {trigger. According to }}$ ICES guidelines the new MSY $B_{\text {trigger }}$ should in this case be the 5 th 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 Btrigger value shown in the table below reflects this decision. MSY $B_{\text {trigger }}$ is therefore the maximum of the following: $\mathrm{B}_{\mathrm{pa}}$, or the $5^{\text {th }}$ percentile of current SSB (SSB from the benchmark final run divided by $1.4=564599 \mathrm{t}$ ).

The updated reference points are listed as below:

| Framework | Reference point | Value | Technical basis | Source |
| :---: | :---: | :---: | :---: | :---: |
| M SY approach | MSY Btrigger | 564599 t | Fifth percentile of current SSB (SSB2015/1.4) as estimated at the benchmark. | WKNSEA 2017 WKM SYREF4 |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.210 | Estimated by application of EqSIM evaluation | WKNSEA 2017; WKM SYREF4 |
|  | FmSYlower | 0.146 | Estimated by application of EqSIM evaluation | WKNSEA 2017 WKM SYREF4 |
|  | $\mathrm{F}=\mathrm{F}_{\text {MSY upper }}$ | 0.30 | Estimated by application of EqSIM evaluation | WKNSEA 2017 WKM SYREF4 |
| Precautionary approach | Blim | 207288 t | Break-point of hockey stick stock-recruit relationship | WKNSEA 2017 <br> WKM SYREF4 |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 290203 t | $\mathrm{B}_{\mathrm{pa}}=\mathrm{B}_{\mathrm{lim}} \times \exp \left(1.645 \times \quad \times \mathrm{B}_{\text {lim }}\right.$ | WKNSEA 2017; <br> WKM SYREF4 |
|  | $F_{\text {lim }}$ | 0.516 | Estimated by application of EqSIM evaluation | WKNSEA 2017 WKM SYREF4 |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.369 | $\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\text {lim }} \times \exp \left(-1.645 \times \quad \mathrm{F}_{\text {lim }} / 1.4\right.$ | WKNSEA 2017 <br> WKM SYREF4 |

And the proposed MSY reference points:

| Reference point | Value |
| :---: | :---: |
| $\mathrm{FmSr}_{\text {without }} \mathrm{B}_{\text {trigger }}$ | 0.21 |
| $\mathrm{F}_{\text {MSY lower }}$ without $\mathrm{B}_{\text {trigger }}$ | 0.146 |
| $\mathrm{F}_{\text {MSY upper }}$ without $\mathrm{B}_{\text {trigger }}$ | 0.3 |
| FP. 05 ( $5 \%$ risk to $\mathrm{Bl}_{\text {lim }}$ without $\mathrm{B}_{\text {trigger }}$ ) | 0.43 |
| $\mathrm{F}_{\text {MSY }}$ with $\mathrm{B}_{\text {trigger }}$ | 0.21 |
| $\mathrm{F}_{\text {MSY lower }}$ With $\mathrm{B}_{\text {trigger }}$ | 0.15 |
| $\mathrm{F}_{\text {MSY upper }}$ with $\mathrm{B}_{\text {trigger }}$ | 0.3 |
| FP. 05 ( $5 \%$ risk to $\mathrm{Blim}_{\text {lim }}$ with $\mathrm{B}_{\text {trigger }}$ ) | 0.77 |
| MSY | 104113 t |
| Median SSB at $\mathrm{F}_{\text {MSY }}$ | 1104120 t |
| Median SSB lower precautionary (median at $\mathrm{F}_{\text {MSY upper }}$ precautionary) | 690328 t |
| Median SSB upper (median at $\mathrm{F}_{\text {MSY }}$ (ower) | 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 1052312 tonnes which is well above MSY $B_{\text {trigger, }} B_{p a}$, and $B_{l i m}$. Fishing mortality in 2019 is estimated to be at a value of 0.166 (below $\mathrm{F}_{\mathrm{pa}}$ of 0.369 , below the longterm management target F of 0.30 and below FMSY 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 Fmsy to be between 0.13 and 0.27 . ICES identified the point estimate for the North Sea stock to be 0.19 (ADGMSYREF3).

Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years. The plaice stock has been within safe biological limits $(\mathrm{F}=0.6)$ 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 ( $\mathrm{B}_{\mathrm{pa}}=35 \mathrm{kt}$ ) in the latest years. According to the management plan (Article 3.2), this signals the end of stage one. Consequently, utilisation of the plan as a basis for advice is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). In 2012, ICES evaluated a proposal by the Netherlands for an amended management plan, which could serve as the 'stage 2' plan (Coers et al., 2012). ICES concluded that the plan, subject to those amendments, is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY). However, implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Since the management plan is now in stage 2, the EU regulation stipulates that the stocks should be managed on the basis of MSY. For plaice, the ICES Fmsy estimate is 0.21 , which is below the target $\mathrm{F}(0.3)$ defined in the plan. Considering that the plan specifies that fishing mortality in stage 2 should not be below the target of 0.3 (which coincides with the upper bound of a range of Fmsy values suggested by ICES), the current advice for plaice is still on the basis of moving towards the target of 0.3 , rather than on the basis of Fmsy point estimate of 0.21 (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 $>300 \mathrm{HP}$ all year round since 1995. The most recent EUfunded 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 IBTScausing 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．

| 氐 | $\begin{aligned} & \text { E } \\ & \frac{5}{0} \\ & \hline \mathbf{N} \end{aligned}$ |  | $8$ |  | $\begin{aligned} & \frac{\pi}{6} \\ & \frac{\pi}{1} \\ & \frac{1}{6} \\ & \frac{1 \pi}{2} \end{aligned}$ | North Sea |  |  | $\begin{aligned} & \text { y } \\ & \frac{8}{8} \end{aligned}$ | 雨 | $\begin{aligned} & \overline{8} \\ & \frac{d}{0} \\ & \frac{8}{\pi} \\ & \frac{b}{5} \end{aligned}$ | $\begin{aligned} & \mathscr{E} \\ & E \\ & E \\ & \text { E } \end{aligned}$ | $n$$y$$i$ | Skagerrak |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | $\begin{aligned} & \text { à } \\ & \text { en } \\ & 0 \\ & 2 \end{aligned}$ | $\begin{aligned} & 5 \\ & \frac{8}{8} \\ & 6 \\ & 6 \end{aligned}$ | $\underline{y}$ |  |  |  |  |  | 장 | $\begin{aligned} & \text { ど } \\ & y^{\prime} \\ & \text { F } \end{aligned}$ |
| 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 |


|  | $\begin{aligned} & \text { E } \\ & \text { on } \\ & \hline \mathbf{W} \end{aligned}$ | $\begin{aligned} & \frac{V}{\epsilon} \\ & \text { E } \\ & 0 \end{aligned}$ | $\begin{aligned} & \mathbb{8} \\ & \text { EV } \end{aligned}$ |  | $\begin{aligned} & \frac{\pi}{6} \\ & \frac{\pi}{6} \\ & \frac{1}{6} \\ & \frac{1}{2} \end{aligned}$ | North Sea |  |  | $\begin{aligned} & n \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{gathered} \sqrt{6} \\ \hline 1 \end{gathered}$ | $\begin{aligned} & \overline{8} \\ & \frac{8}{8} \\ & \frac{8}{10} \\ & 5 \end{aligned}$ | $\begin{aligned} & 8 \\ & 8 \\ & 8 \\ & 8 \\ & 0 \end{aligned}$ | $\begin{aligned} & n \\ & \text { n } \\ & \text { y } \end{aligned}$ | Skagerrak |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | $\begin{aligned} & \text { तe } \\ & { }_{0}^{0} \\ & 2 \end{aligned}$ |  | $\stackrel{y}{5}$ |  |  |  |  |  | 骨 | $\begin{aligned} & \text { 凶゙ } \\ & y^{\prime} \\ & \text { ¹ } \end{aligned}$ |
| 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 |



* Official estimates not available

Table 13.2.2. Plaice in Subarea 4 and Subdivision 20: Landings (SOP corrected) in numbers by age (including 1 $^{\text {st }}$ 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 |


| age | year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :--- | ---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 $1^{\text {st }}$ quarter of $7 . \mathrm{d}$ ) in thousands.

| year | age | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |  |  |  |  |  |  |  |  |  |  |
| :--- | :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

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 | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 2019 | 0.058 | 0.084 | 0.121 | 0.137 | 0.149 | 0.152 | 0.159 | 0.179 | 0.196 | $N A$ |
|  | 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| 1985 | 137 | 173.9 | 36.1 | 11 | 1.27 | 0.973 | 0.336 | 0.155 | 0.091 |


| BTS-Isis | age |  |  |  |  |  |  |  |  |
| :---: | ---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| 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 |




| IBTS-Q3 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathbf{1 9 9 7}$ | 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 |
|  |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |


| 2019 | 5956.2 | 5398.9 | $4184.8 \quad 2059.1$ | 1333.5 | 1051.1 | 738.8 | $627.5 \quad 342.9$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 $0.410410-0.0206114$
$-1.327900 .2710060 .00605274$
-0.638444-0.431894 0.0483787
-0.691592-0.477648 0.0631315


#### Abstract

\# log_sel_coff1: $-1.30440-0.649506-0.721507-1.29145-0.962371-0.230279-0.3100940 .02527580 .3732880 .151231-0.1170920 .188729$ $0.180333-0.2030520 .00429395-0.405724-0.671373-0.480066-0.480950-0.153045-0.573577-0.452209-1.13938-0.556370-$ $0.734712-1.47342-0.1166050 .2915510 .3106970 .5779860 .2919390 .4725600 .4180190 .6570950 .5397990 .8520530 .868759$ $0.6685080 .9009620 .7967080 .8731170 .6277631 .214140 .5889820 .8809200 .6136260 .367561-0.215860-0.214395-0.204196$ $0.105768-0.08637230 .1549090 .3349530 .3332370 .4796140 .4041190 .3181810 .5328120 .7722720 .6205250 .7865140 .902632$ 0.8602000 .9578960 .9226780 .8475540 .9369580 .9422211 .051530 .723380 0.368225-0.106030-0.420303-0.318141-0.347321 $-0.0780339-0.358650-0.1845130 .2208940 .3412900 .4719690 .4241220 .4349820 .4330340 .6338330 .5349570 .736088$ $0.5558500 .6591811 .056260 .9251911 .151800 .8562351 .021760 .7598700 .7401340 .134512-0.450962-1.02574-0.851174-$ $0.942484-0.653576-1.01319-0.106315-0.1331280 .06454150 .1621560 .04665450 .3197320 .2701470 .4255730 .339306$ $0.5348600 .4342260 .3658050 .7626550 .6441610 .7612960 .8897380 .6919590 .1659570 .0951252-0.336087-1.02882-1.34639$ $-1.77214-1.70168-1.61004-1.72304-0.249898-0.0335808-0.3159210 .0827175-0.2138720 .01601520 .2244510 .414903$ $0.2071210 .1912180 .3041650 .2269230 .4528330 .4672460 .6603350 .4401290 .486936-0.232691-0.798872-1.59878-1.97674-$ 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: 12.489912 .800612 .317911 .917611 .008711 .050710 .810010 .355011 .129313 .077113 .473913 .682113 .603913 .668013 .3275 13.317614 .716413 .406313 .267812 .969912 .946513 .417413 .422912 .960412 .799614 .172213 .904413 .578213 .408313 .8457 13.683213 .732713 .909113 .815214 .465614 .117414 .083414 .433115 .301814 .442014 .366414 .062913 .942613 .802713 .6066 13.194913 .336313 .839513 .692714 .618713 .617113 .567613 .739113 .344814 .394713 .373814 .184013 .763113 .752914 .2477 14.112914 .039814 .268214 .338914 .153814 .240114 .295113 .737813 .820314 .157313 .778514 .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 | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |


| 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 | SNSO | SNS1 | SNS2 | BTS1 | BTS2 | DFSO |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | SNSO | SNS1 | SNS2 | BTS1 | BTS2 | DFSO |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 SNSO $0.87994 .69760 .35870 .528441412 .156 \quad 15.390 .5056$ DFSO 2.6935 -0.1081 $1.33290 .084362318 .391 \quad 14.411 .4298 \quad 0.04948$ $\begin{array}{lllllllll}\text { VPA Mean NA NA NA NA } 38 & \text { NA } & 13.96 & 0.4269 & 0.55491\end{array}$

WAP logWAP int.se
yearclass:2018 208483014.550 .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 $=\mathbf{C}$
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
SNSO $0.86664 .8860 .34840 .507421510 .119 \quad 13.650 .3929 \quad 0.51561$

SNS1 2.7623 -12.419 1.0276 0.0822316 NA NA NA NA
SNS2 1.0053 5.395 0.8970 0.18167 37 NA NA NA NA
BTSC1 $1.2909-0.0180 .58330 .2801421$ NA NA NA NA
BTSC2 0.6857 6.890 0.25280 .6644622 NA NA NA NA
DFSO 3.2791 -3.033 $1.65840 .0530024 \quad 5.299 \quad 14.341 .77040 .02539$
VPA Mean NA NA NA NA 38 NA $13.990 .4164 \quad 0.45899$

WAP logWAP int.se
yearclass:2019 101223713.830 .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 | $\mathbf{f}$ | f.disc | f.land | stock.n | catch.wt | landings.wt | discards.wt | stock.wt | mat | M |

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| 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 |

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Table 13.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short term forecast assuming $F_{2019}=F_{\text {-statusquo }}$ (rescaled).

| Basis | Total catch (2021) | Projected landings * (2021) | Projected discards** (2021) | $\begin{gathered} F_{\text {total }} \\ \text { ages 2-6 } \\ (2021)^{\text {M }} \end{gathered}$ | $\begin{gathered} \text { Fprojected land- } \\ \text { ings } \\ \text { ages 2-6 } \\ (2021) \end{gathered}$ | $\begin{gathered} \text { Fprojected dis- } \\ \text { cards } \\ \text { ages 2-3 } \\ (2021) \\ \hline \end{gathered}$ | SSB (2022) | $\begin{gathered} \% \text { SSB } \\ \text { change } * * * \end{gathered}$ | \% TAC change ^ | \% Advice change ^^ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |  |  |  |  |  |
| MSY approach: FMSY | 162607 | 87576 | 75031 | 0.21 | 0.083 | 0.22 | 1374316 | 5.5 | -2.3 | -2.3 |
| Other scenarios |  |  |  |  |  |  |  |  |  |  |
| $\mathrm{F}=\mathrm{MAP} \quad \mathrm{F}_{\mathrm{MSY}}$ upper | 222956 | 120730 | 102226 | 0.30 | 0.118 | 0.31 | 1316942 | 1.08 | 34 | 34 |
| $F=M A P \quad F_{M S Y}$ <br> lower | 116260 | 62400 | 53860 | 0.146 | 0.057 | 0.152 | 1418596 | 8.9 | -30 | -30 |
| $\mathrm{F}=0$ | 0 | 0 | 0 | 0 | 0 | 0 | 1531915 | 17.6 | -100 | -100 |
| $\mathrm{F}_{\mathrm{pa}}$ | 265735 | 144515 | 121220 | 0.369 | 0.145 | 0.38 | 1276485 | -2 | 60 | 60 |
| $\mathrm{F}_{\text {lim }}$ | 347946 | 190981 | 156965 | 0.516 | 0.20 | 0.54 | 1199290 | -8 | 109 | 109 |
| SSB (2022) $=\mathrm{B}_{\mathrm{lim}}$ | 1524539 | 1136496 | 388043 | 16.9 | 6.6 | 10.2 | 207288 | -84 | 816 | 816 |
| SSB (2022) = $\mathrm{B}_{\mathrm{pa}}$ | 1434040 | 1041759 | 392281 | 12.5 | 4.9 | 13.0 | 290203 | -78 | 760 | 760 |
| $\begin{aligned} & \text { SSB } \quad \text { (2022) }= \\ & \text { M SY Btrigger } \end{aligned}$ | 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 |
| $\mathrm{F}_{2021}=\mathrm{F}_{2020}$ | 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.
* M arketable landings.

Table 13.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming $\mathrm{F}_{2019}=\mathrm{F}_{\text {-status }}$ quo, , rescaled.


| 1 | 2020 | 0.073 | 0.073 | 0.000 | 1363360 | 0.051 | 0.126 | 0.051 | 0.030 | 0 | 0.1 | 91244 | 15 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 2020 | 0.168 | 0.162 | 0.007 | 2442455 | 0.089 | 0.246 | 0.082 | 0.065 | 0.5 | 0.1 | 360571 | 14115 |
| 3 | 2020 | 0.240 | 0.184 | 0.057 | 616924 | 0.154 | 0.264 | 0.120 | 0.122 | 0.5 | 0.1 | 125745 | 29600 |
| 4 | 2020 | 0.195 | 0.099 | 0.096 | 599535 | 0.214 | 0.294 | 0.137 | 0.173 | 1 | 0.1 | 101106 | 49911 |
| 5 | 2020 | 0.136 | 0.042 | 0.094 | 294361 | 0.280 | 0.337 | 0.152 | 0.242 | 1 | 0.1 | 35613 | 24525 |
| 6 | 2020 | 0.090 | 0.017 | 0.073 | 202284 | 0.342 | 0.385 | 0.165 | 0.290 | 1 | 0.1 | 16588 | 13469 |
| 7 | 2020 | 0.054 | 0.007 | 0.047 | 292553 | 0.397 | 0.429 | 0.175 | 0.346 | 1 | 0.1 | 14554 | 12761 |
| 8 | 2020 | 0.027 | 0.002 | 0.025 | 252953 | 0.469 | 0.493 | 0.186 | 0.405 | 1 | 0.1 | 6436 | 5944 |
| 9 | 2020 | 0.012 | 0.000 | 0.012 | 221933 | 0.528 | 0.528 | 0.297 | 0.434 | 1 | 0.1 | 2547 | 2547 |
| 10 | 2020 | 0.012 | 0.000 | 0.012 | 1131835 | 0.652 | 0.653 | 0.000 | 0.532 | 1 | 0.1 | 12990 | 12989 |


| 1 | 2021 | 0.073 | 0.073 | 0.000 | 1363360 | 0.051 | 0.126 | 0.051 | 0.030 | 0 | 0.1 | 91244 | 15 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 2021 | 0.168 | 0.162 | 0.007 | 1146914 | 0.089 | 0.246 | 0.082 | 0.065 | 0.5 | 0.1 | 169315 | 6628 |
| 3 | 2021 | 0.240 | 0.184 | 0.057 | 1867662 | 0.154 | 0.264 | 0.120 | 0.122 | 0.5 | 0.1 | 380677 | 89610 |
| 4 | 2021 | 0.195 | 0.099 | 0.096 | 438893 | 0.214 | 0.294 | 0.137 | 0.173 | 1 | 0.1 | 74015 | 36538 |
| 5 | 2021 | 0.136 | 0.042 | 0.094 | 446503 | 0.280 | 0.337 | 0.152 | 0.242 | 1 | 0.1 | 54020 | 3747200 |
| 6 | 2021 | 0.090 | 0.017 | 0.073 | 232525 | 0.342 | 0.385 | 0.165 | 0.290 | 1 | 0.1 | 19068 | 15483 |


| age | year | $\mathbf{f}$ | f.disc | f.land | stock.n | catch.wt | landings.wt | discards.wt | stock.wt | mat | $\mathbf{M}$ | 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)

(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)

(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.
catch number


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



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


Figure 13.2.9. The estimated spatial age distribution for (a) BTS-Q3, (b) IBTS-Q3 and (c) IBTS-Q1, estimated using deltaGAM 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 (20002019, 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.




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.

## standardized survey residual



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.

BTSQ3_combined indices: original scale

work_year - $2017-2018-2019-2020$

IBTSQ3 indices: original scale


IBTSQ1 indices: original scale


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. $q$ (catchability 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-one-out Recruitment (age 1)



Figure 13.3.11. Sensitivity analysis by leave one out of each survey used in the assessment. The black curve (and $95 \% \mathrm{Cl}$ in gray) is the base run with all surveys included, the red curve is the run without BTS and the blue curve(and $95 \% \mathrm{Cl}$ 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 12029 tonnes. According to the MAP, catches higher than those corresponding to FMSY (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 (M IS, 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 (M IS, 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 AgeLength 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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: |  | $\mathbf{2 0 2 0}$ |
| :--- | :--- | :--- |
| Assessment model: | AAP |  |
| Assessment software | FLR/ADM B |  |
| Fleets: | Age range <br> Year range | $1-$ |
| UK Beam Trawl Survey |  |  |

### 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 $R N$ Gwen Drez to the $R N$ 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

Fmsy 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, FMSY was determined using the EqSim method from the R library MSY.

In 2016, $\mathrm{F}_{\lim }$ and $\mathrm{F}_{\mathrm{pa}}$ 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/andings 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 $7 . \mathrm{d}$ 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 FMSY lower, FMSY upper and Fmsy 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 11130 tonnes. According to the MAP, catches higher than those corresponding to FMSY (8402 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

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 13192 tonnes. Again, catches higher than those corresponding to Fmsy ( 9959 tonnes) can only be taken under conditions specified in the MAP.

### 14.6 Quality of the assessment

The sampling for plaice in $7 . \mathrm{d}$ 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.

[^10]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 $\mathrm{F}_{\mathrm{Ms}}$; and spawning stock size is above MSY Btrigger (Figure 14.3.1.3).


### 14.8 M anagement 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 $\mathrm{F}_{\mathrm{MSY}}$ ).

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 N Gwen Drez to the R $N$ 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 CancheAuthie, 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

Auber Arnaud, Ernande Bruno, Travers-Trolet Morgane, Coppin Franck, Marchal Paul (2015). Intercalibration of research survey vessels: "GWEN DREZ" and "THALASSA". 27p.

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Travers-Trolet Morgane, Girardin Raphael, Coppin Franck (2016). Calcul des indices d'abondance issus de CGFS. 28p.

Table 14.2.1.1. Plaice in 7.d: Nominal landings (tonnes) as officially reported to ICES, 1976-2019.

| 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.
$\left.\begin{array}{lccccc}\hline \text { Year } & \text { Total Landings } & \text { Q1 Remov. } & \begin{array}{c}\text { Landings as used } \\ \text { by WG (1) }\end{array} & \text { Estim. discards } & \begin{array}{c}\text { Discards Q1 } \\ \text { remov. }\end{array} \\ \hline \text { Discards as used } \\ \text { by WG (1) }\end{array}\right]$.

| 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 $\mathbf{6 5 \%}$ 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7 +}$ |
| 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 |  | 2 | 3 | 4 | 5 | 6 | 7+ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| year | 1 |  |  |  |  |  |  |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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.

|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |  | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $N A$ |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 19892019 |  |  |  |  |  |  |
| 110.50 .75 |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |
| 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 |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 19932019 |  |  |  |  |  |  |
| 110.751 |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ |  | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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.

| $\begin{aligned} & \text { UK } \\ & \text { BTS } \end{aligned}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | tonne S | tonne S | $\begin{gathered} \text { Ages } \\ 3-6 \end{gathered}$ | 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) |  | Landings | Discards |  | F |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Age 1 | High | Low |  | High | Low | tonne s | tonne S | $\begin{gathered} \text { Ages } \\ 3-6 \end{gathered}$ | 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 |
| :--- | :---: | :---: | :--- |
| Fages 3-6 (2020) | 0.30 | AAP | Correspond to F F2019 (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 <br> (2017-2019) by age |
| Discards (2020) | 5707 | AAP | STF, in tonnes; projection based on the average landing ratio <br> (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) | $\begin{gathered} F_{\text {total }} \\ \text { (ages 3-6 2021) } \end{gathered}$ | $\begin{gathered} \text { SSB } \\ (2021) \end{gathered}$ | \% SSB change | \% change in projected landings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| EU MAP ***: $\mathrm{F}_{\text {MSr }}$ | 8402 | 3424 | 4978 | 0.25 | 39205 | 2.7 | 21 |
| EU M AP ***: $\mathrm{F}=\mathrm{F}_{\text {MSY }}$ lower | 6066 | 2470 | 3596 | 0.175 | 41913 | 9.7 | -12.9 |
| EU M AP ***: $\mathrm{F}=\mathrm{F}_{\text {MSY upper }}$ | 11130 | 4540 | 6589 | 0.344 | 36088 | -5.5 | 60 |
| $\mathrm{F}=0$ | 0 | 0 | 0 | 0 | 49099 | 29 | -100 |
| $\mathrm{F}_{\mathrm{pa}}$ | 11573 | 4722 | 6851 | 0.36 | 35586 | -6.8 | 66 |
| Flim | 15216 | 6214 | 9002 | 0.50 | 31521 | -17.5 | 119 |
| SSB (2022) $=\mathrm{Bl}_{\text {lim }}$ | 27772 | 11341 | 16430 | 1.15 | 18447 | -52 | 300 |
| SSB (2022) $=\mathrm{B}_{\mathrm{pa}}$ | 20495 | 8377 | 12118 | 0.736 | 25826 | -32 | 195 |
| SSB (2022) $=$ M SY $\mathrm{B}_{\text {trigger }}$ | 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.


FR GFS


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.


SSB retrospecive with interval of confidence (low and high SSb)



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


#### Abstract

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 $>35 \mathrm{~cm}$, 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 $62^{\circ} \mathrm{N}$. 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 $62^{\circ}$ 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 $60-80 \mathrm{~cm}$ (Figure 15.3) compared to $50-70 \mathrm{~cm}$ 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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ICES 2012. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

Heino, M., Svåsand, T., Nordeide, J. T., Otterå, H., 2012. Seasonal dynamics of growth and mortality suggest contrasting population structure and ecology for cod, pollack, and saithe in a Norwegian fjord. - ICES Journal of Marine Science 69: 537-546

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S.,Wienerroither, R., 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery. ICES Journal of Marine Science. 68: 1785-1791

Table 15.1. Pollack in Subarea 4 and Division 3.a. Landings (tonnes) by country as officially reported to ICES 1977-2019.

|  | 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 |
| 2015 | 190 | 14 | 1 | 138 | 48 | Official Total |  |
| 2016 | 151 | 8 | 1 | 134 | 47 | 390 |  |
| 2017 | 185 | 7 | 4 | 117 | 44 | 341 |  |
| 2018 | 226 | 10 | 1 | 105 | 64 | 357 |  |
| 2019 | 196 | 5 | 1 | 81 | 30 | $406^{*}$ |  |

* Preliminary

|  | ICES Subarea 4 |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Belgium | Denmark | Faeroes | France | Germany | Netherl. | Norway | Poland | Sweden | UK | Total |
| 1977 | 121 | 275 |  | 75 | 142 | 38 | 419 | 9 | 0 | 442 | 1521 |
| 1978 | 102 | 249 |  | 98 | 154 | 21 | 492 | 2 | 0 | 471 | 1589 |
| 1979 | 62 | 333 |  | 72 | 64 | 8 | 563 | 11 | 31 | 429 | 1573 |
| 1980 | 82 | 407 |  | 66 | 58 | 2 | 1095 |  | 38 | 355 | 2103 |
| 1981 | 59 | 500 |  | 173 | 21 | 2 | 1261 |  | 12 | 362 | 2390 |
| 1982 | 46 | 431 |  | 59 | 40 | 1 | 1169 | 33 | 23 | 270 | 2072 |
| 1983 | 58 | 481 |  | 79 | 44 | 1 | 1081 |  | 57 | 300 | 2101 |
| 1984 | 52 | 402 |  | 108 | 37 | 0 | 880 | 2 | 106 | 315 | 1902 |
| 1985 | 14 | 308 |  | 69 | 23 | 0 | 686 |  | 51 | 363 | 1514 |
| 1986 | 44 | 550 |  | 45 | 21 | 0 | 602 |  | 67 | 362 | 1691 |
| 1987 | 21 | 427 |  | 988 | 21 | 0 | 471 |  | 40 | 290 | 2258 |
| 1988 | 32 | 432 |  | 367 | 30 | 10 | 560 |  | 20 | 296 | 1747 |
| 1989 | 31 | 273 |  | 0 | 21 | 4 | 568 |  | 37 | 269 | 1203 |
| 1990 | 44 | 924 |  | 0 | 34 | 3 | 651 |  | 126 | 366 | 2148 |
| 1991 | 31 | 1464 |  | 0 | 48 | 4 | 887 |  | 153 | 684 | 3271 |
| 1992 | 49 | 794 |  | 18 | 59 | 7 | 1051 |  | 141 | 1310 | 3429 |
| 1993 | 46 | 1161 |  | 8 | 161 | 19 | 1429 |  | 217 | 1561 | 4602 |
| 1994 | 42 | 635 |  | 12 | 55 | 14 | 845 |  | 113 | 872 | 2588 |
| 1995 | 56 | 532 | 1 | 7 | 84 | 18 | 1203 |  | 175 | 1525 | 3601 |
| 1996 | 13 | 366 |  | 4 | 99 | 13 | 909 |  | 82 | 945 | 2431 |
| 1997 | 20 | 272 | 1 | 1 | 115 | 11 | 733 |  | 82 | 1185 | 2420 |
| 1998 | 21 | 265 |  | 7 | 44 | 5 | 567 |  | 75 | 780 | 1764 |
| 1999 | 21 | 288 |  | 0 | 62 | 5 | 768 |  | 72 | 636 | 1852 |
| 2000 | 45 | 291 |  | 24 | 38 | 5 | 880 |  | 91 | 877 | 2251 |
| 2001 | 36 | 156 |  | 6 | 40 | 1 | 860 |  | 63 | 809 | 1971 |
| 2002 | 27 | 234 |  | 6 | 112 | 0 | 879 |  | 68 | 711 | 2037 |
| 2003 | 13 | 191 |  | 9 | 82 | 1 | 971 |  | 36 | 837 | 2140 |
| 2004 | 28 | 162 |  | 5 | 57 | 0 | 517 |  | 16 | 612 | 1397 |
| 2005 | 26 | 173 |  | 3 | 128 | 3 | 511 |  | 46 | 477 | 1367 |
| 2006 | 18 | 152 |  | 4 | 80 | 1 | 545 |  | 12 | 587 | 1399 |


|  | 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 20132020.

| ICES Division 3.a |  |  |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ |
| Denmark | 214 | 192 | 192 | 152 | 187 | 229 | 196 |
| Germany | 11 | 6 | 35 | 7 | 11 | 13 | 5 |
| Netherlands | 60.5 | 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 | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  | 17 | 24 | 20 | 21 | 18 | 14 | 20 |
| Belgium | 150 | 122 | 183 | 127 | 187 | 139 | 184 |
| Denmark | 2 | 32 | 2 | 2 | 8 | 46 | 24 |
| France | 59 | 145 | 216 | 107 | 267 | 151 | 159 |
| Germany | 3 | 1 | 2 | 2 | 2 | 2 | 4 |
| Netherland. | 379 | 481 | 466 | 440 | 508 | 738 | 901 |
| Norway | 29 | 41 | 50 | 36 | 44 | 30 | 38 |
| Sweden | 456 | 377 | 626 | 423 | 508 | 488 | 569 |
| UK | 1103 | 1227 | 1567 | 1159 | 1543 | 1608 | $1899^{* *}$ |
| Ices Total | 1080 | 1215 | 1594 | 1174 | 1551 | $1586^{*}$ | $1881^{*}$ |
| Official Total | 23 | 12 | -27 | -15 | -8 | 22 | 18 |
| Diff ICES-Off |  |  |  |  |  |  |  |

* 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, 20132020.

|  |  | ICES Division 3.a |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  | Belgium | Denmark | Germany | Netherl. | Norway | Sweden | UK |
| 2013 | 1.949 | 0.139 |  | 1.795 | 1.528 | Total |  |
| 2014 | 0.62 | 0.008 |  | 0.441 | 0.473 | 5.41 |  |
| 2015 | 2.026 | 0.385 |  | 0.667 | 0.094 | 1.54 |  |
| 2016 | 1.436 | 0.021 | 0.002 | 1.706 | 1.685 | 3.17 |  |
| 2017 | 1.152 | 0.047 | 0.001 | 0.892 | 0.237 | 4.85 |  |
| 2018 | 2.39 |  |  |  | 0.28 | 2.32 |  |
| 2019 |  | 0.856 |  |  |  | 2.67 |  |


|  | ICES Subarea 4 |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Belgium | Denmark | Faeroes | France | Germany | Netherl. | Norway | Poland | Sweden | UK | Total |
| 2013 | 0.111 | 22.785 |  | 0.050 | 0.229 | 1.320 | 7.967 |  | 0.662 | 8.923 | 42.05 |
| 2014 | 0.181 | 0.973 |  | 0.241 | 0.154 | 0.009 | 5.200 |  | 0.309 | 4.461 | 12.16 |
| 2015 |  | 0.069 |  | 0.005 | 0.075 | 0.001 | 0.691 |  | 0.090 | 1.59 | 2.52 |
| 2016 | $<0.001$ | 0.109 |  | 0.001 | 0.073 | ¢0.001 | 0.357 |  | 0.021 | 0.278 | 0.84 |
| 2017 |  |  |  |  |  |  |  |  |  |  | 0 |
| 2018 |  | 0.026 |  | 22.49 |  |  |  |  |  |  | 22.47 |
| 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 <br> Saithe (Pollachius virens) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat) 


#### Abstract

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.


#### Abstract

Advice for 2019 "ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 88093 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 38, 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-oneout 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 6 a.

### 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 195000 tonnes in the 2010's, which is below the average of the 2000's (around 235000 tonnes). Short term variations show a slight decline since 2017. The final year estimate of SSB is just above $B_{p a}$ and MSY $B_{\text {trigger }}$. 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 $\mathrm{F}_{\mathrm{MSY}}$ and even slightly above $\mathrm{F}_{\text {pa }}$.

### 16.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The resampling among 2010-2019 values (with a geometric mean about 78102000 ) 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 39247000 and 51955 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 $\mathrm{F}_{4-7}$ 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 num-bers-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 $\mathrm{F}_{2020}$ of 0.46 and a SSB in 2021 of 151404 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 65687 tonnes, where wanted catch is 61056 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 $62^{\circ} \mathrm{N}$ 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. $\mathrm{SSB}_{(2022)}=\mathrm{B}_{\mathrm{pa}}$ or $\mathrm{Blim}_{\text {lim }}$ 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 $\mathrm{F}_{\mathrm{MSY}}$ and $\mathrm{F}_{\mathrm{pa}}$, and below $\mathrm{F}_{\text {lim }}$; spawningstock size is above MSY $\mathrm{B}_{\text {trigger, }} \mathrm{B}_{\mathrm{pa}}$, and $\mathrm{Blim}_{\text {lim }}$.

### 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 EUNorway 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 |  |  |  |  |  |  |  |  | 687 |  |  |  |  |  |
| UK (Scotland) | 6170 | 9128** | 9625** | 11804** | 12584** | 11887** | 10250** | 7287** | 仿9** | 7686 | 8888** | 8561** | 8640** | 12415** | 11875** |
| 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 |  | *** | 2955** | ** | 3168** |  |  | 3646** | 97 |  | 2770** | 2652** | 2684** |  |
| 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 ${ }^{\text {\# }}$ | 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 |
| BM S 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+).

| Catch Category | Raised Or Imported | Sampled Or Estimated | 2018 (update) |  | 2019 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 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 |
| BM S landing | Imported_Data | Estimated_Distribution | 90.62 | 100 | 10.26 | 99.6 |
| BM S 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |  | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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. M odel configuration for the SAM assessment.

```
M in Age:
3
M ax Age:
10
M ax 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=\mathrm{ 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 PARAM ETERS
    -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 logN RW VARIANCES
01111111
Coupling of OBSERVATION VARIANCES
    O O O O O O O O
    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)
O
Years in which catch data are to be scaled by an estimated parameter
O
Fbar range:
4 to }
Observation correlation coupling ( }0=\mathrm{ 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9 +}$ |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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.



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 | $\mathbf{R}_{\text {(age 3) }}$ | Low | High | SSB | Low | High | $F_{\text {bar }}(4-7)$ | 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 | $\mathbf{R}_{\text {(age 3) }}$ | Low | High | SSB | Low | High | $F_{\text {bar }}(4-7)$ | 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 | $\mathbf{R}_{\text {(age 3) }}$ | Low | High | SSB | Low | High | F $_{\text {bar(4-7) }}$ | Low | High | TSB | Low |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2016 | 114203 | 83680 | 155859 | 185528 | 157493 | 218552 | 0.362 | 0.299 | 0.437 | 380424 | 329113 |
| 2017 | 78090 | 56164 | 108575 | 206143 | 175503 | 242131 | 0.393 | 0.322 | 0.479 | 396364 | 343934 |
| 2018 | 39247 | 26511 | 58104 | 204242 | 173213 | 240829 | 0.419 | 0.335 | 0.524 | 346805 | 298589 |
| 2019 | 51955 | 30029 | 89889 | 196167 | 161126 | 238829 | 0.461 | 0.347 | 0.611 | 324614 | 263929 |

Table 16.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

| Variable | Value | Notes |
| :--- | :---: | :--- |
| Fages 4-7 (2020) | 0.46 | Average exploitation pattern (2017-2019) scaled to F4-7 in 2019 |
| SSB (2021) | 151404 | SSB at the beginning of the TAC year, in tonnes |
| Rage 3 (2020) $^{78287}$ | Geometric mean recruitment re-sampled from the years 2010-2019, in <br> thousands |  |
| Rage 3 (2021) | 77918 | Geometric mean recruitment re-sampled from the years 2010-2019, in <br> thousands |
| Total catch (2020) | 80363 | Short-term forecast, in tonnes |
| Wanted catch (2020) | 81897 | Assuming 2017-2019 ave. landing fraction by age from numbers, in tonnes |
| Unwanted catch (2020) | 6812 | Assuming 2017-2019 ave. discards fraction by age from numbers, in <br> 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 |
| :---: | :---: | :---: | :---: | :---: |
| M SY approach | M SY Btrrigger | 149098 t | $\mathrm{B}_{\mathrm{pa}}$ | ICES (2019a) |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.363 | EQsim analysis based on the recruitment period 1998-2017. | ICES (2019a) |
| Precautionary approach | Blim | 107297 t | $\mathrm{B}_{\text {loss }}$ | ICES (2019a) |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 149098 t | $\mathrm{Blim}_{l}$ lim | ICES (2019a) |
|  | Flim | 0.620 | EQsim analysis based on the recruitment period 1998-2017. | ICES (2019a) |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.446 | Flim $\quad \lim / 1.4$ | ICES (2019a) |
| M anagement plan* | MAP MSY $B_{\text {trig }}$. ger | 149098 t | M SY $\mathrm{B}_{\text {trigger }}$ | ICES (2019a) |
|  | MAP Blim | 107297 t | $\mathrm{Blim}_{\text {im }}$ | ICES (2019a) |
|  | MAP $\mathrm{F}_{\text {MSY }}$ | 0.363 | $\mathrm{F}_{\text {MSY }}$ | ICES (2019a) |
|  | M AP range Flower | 0.210 | Consistent with ranges provided by ICES, resulting in no more than $5 \%$ reduction in long-term yield compared with M SY | ICES (2019a) |
|  | M AP range Fupper | 0.536 | Consistent with ranges provided by ICES, resulting in no more than 5\% reduction in long-term yield compared with M SY | 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*\# 3 a 4 | Wanted catch*\# 6 | $\begin{gathered} F_{\text {total }} \\ (\text { ages 4-7) } \\ (2020) \end{gathered}$ | $\begin{gathered} F_{\text {wanted }} \\ \text { (ages 4-7) } \\ \text { (2020) } \end{gathered}$ | $F_{\text {unwanted }}$ (ages 4-7) (2020) | $\begin{gathered} \text { SSB } \\ (2021) \end{gathered}$ | \% SSB change ** | \% TAC change *** | \% advice change ^ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |  |  |  |  |  |  |  |
| M SY approach: $\mathrm{F}_{\text {MSY }}$ | 65687 | 61056 | 4631 | 55317 | 5739 | 0.36 | 0.34 | 0.024 | 164624 | 8.7 | -25 | -25 |
| Other scenarios |  |  |  |  |  |  |  |  |  |  |  |  |
| $\mathrm{F}=\mathrm{M} \mathrm{AP}{ }^{\wedge}$ ^ $\mathrm{F}_{\text {MSY lower }}$ | 40391 | 37551 | 2840 | 34021 | 3530 | 0.21 | 0.196 | 0.0140 | 187780 | 24 | -54 | -54 |
| $F=M A P^{\wedge}$ <br> $\mathrm{F}_{\mathrm{MSY} \text { upper }}$ | 90731 | 84297 | 6434 | 76373 | 7924 | 0.54 | 0.50 | 0.035 | 142255 | -6.0 | 3.0 | 3.0 |
| $\mathrm{F}=0$ | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 225332 | 49 | -100 | -100 |
| $\mathrm{F}_{\mathrm{pa}}$ | 78122 | 72613 | 5509 | 65787 | 6826 | 0.45 | 0.42 | 0.030 | 153407 | 1.32 | -11.3 | -11.3 |
| $\mathrm{F}_{\text {lim }}$ | 101721 | 94499 | 7222 | 85616 | 8883 | 0.620 | 0.58 | 0.041 | 132683 | -12.4 | 15.5 | 15.5 |
| $\mathrm{SSB}_{2022}=\mathrm{Bl}_{\text {lim }}$ | 131384 | 121862 | 9522 | 110407 | 11455 | 0.88 | 0.82 | 0.058 | 107297 | -29 | 49 | 49 |
| $\mathrm{SSB}_{2022}=\mathrm{B}_{\mathrm{pa}}$ | 83429 | 77541 | 5888 | 70252 | 7289 | 0.48 | 0.45 | 0.031 | 149098 | -1.52 | -5.3 | -5.3 |
| $\begin{aligned} & \mathrm{SSB}_{2022}= \\ & \mathrm{MSY}_{\text {trigger }} \end{aligned}$ | 83429 | 77541 | 5888 | 70252 | 7289 | 0.48 | 0.45 | 0.031 | 149098 | -1.52 | -5.3 | -5.3 |
| $\mathrm{F}=\mathrm{F}_{2020}$ | 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.

DATRAS Q3 3-8


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 $\mathrm{F}_{4-7}$ 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 13237 tonnes and 32920 tonnes. According to the MAP, catch higher than those corresponding to FMSY ( 21361 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:

- $\quad T B B \_D E F$ and $O T B \_D E F<100$, separately and by quarter if possible.
- $\quad T B B \_D E F$ and $O T B \_D E F>100$, separately and by quarter if possible.
- TBB_CRU and OTB_CRU <100.
- $\quad T B B_{-} C R U$ and $O T B \_C R U>100$.
- 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 20022019 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 RVIsis 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).

[^11]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 20202022 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, 17545 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. FMš: $F_{b a r}(2021)=0.207$
2. FMSY lower: $\mathrm{F}_{\mathrm{bar}}(2021)=0.123$
3. FMSY upper: $F_{b a r}(2021)=0.123$
4. Zero catch: Fbar $(2021)=0$
5. $\quad F_{p a}: F_{b a r}(2021)=0.302$
6. Flim: $\operatorname{Fbar}(2021)=0.42$
7. $\quad B_{p a}: \operatorname{SSB}(2022)=42838$
8. Flim: SSB $(2022)=30828$
9. MSY Btrigger: $\operatorname{SSB}(2022)=42838$
10. $\quad F_{2020}: F_{\text {bar }}(2021)=0.256$

[^12]11. $\mathrm{F}_{\mathrm{mp}}: \mathrm{Fbar}(2021)=0.20$
12. Roll-over TAC: Catch $(2021)=17545 \mathrm{t}$

### 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 <br> point | Value | Technical basis |
| :--- | :--- | :--- |
| MSY $B_{\text {trigger }}$ | 42838 t |  |
| $\mathrm{F}_{\mathrm{MSY}}$ | 0.207 | EQsim analysis based on the recruitment period 1958-2015 |
| $\mathrm{B}_{\text {lim }}$ | 30828 t | Break-point of hockey stick stock-recruit relationship, based on the recruitment period <br> 1958-2018 |
| $\mathrm{B}_{\text {pa }}$ | 42838 t | $B_{\text {lim }}$ |

### 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 Blim 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, $28244 t$, is lower than Blim, although it is expected to have moved already above that limit at the start of 2020, up to 34569 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 M anagement 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, 17545 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, 10607 t . The TAC proposal for 2021 that would bring the stock to Fmsy levels in 2022, 21361 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 2011 | 3457 | 10298 | 5482 | 1273 | 354 | 33 | 0 | 0 | 0 | 0 |
| 2012 | 1132 | 19556 | 9444 | 984 | 230 | 232 | 36 | 4 | 7 | 1 |
| 2013 | 4653 | 5733 | 12558 | 3649 | 340 | 125 | 19 | 3 | 0 | 0 |
| 2014 | 7162 | 5836 | 2371 | 3488 | 1366 | 238 | 198 | 6 | 0 | 0 |
| 2015 | 9454 | 9166 | 3913 | 1991 | 1528 | 415 | 15 | 50 | 8 | 1 |
| 2016 | 5145 | 5338 | 5048 | 1393 | 291 | 536 | 226 | 4 | 1 | 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |  | 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1957 | $1.259 \mathrm{e}-$ <br> 05 | 0.03530 | 0.1971 | 0.3083 | 0.3008 | 0.2365 | 0.2495 | 0.1228 | 0.2035 | 0.2035 |
| 1958 |  |  |  |  |  |  |  |  |  |  |
|  | $1.298 \mathrm{e}-$ <br> 05 | 0.03177 | 0.2262 | 0.2550 | 0.2883 | 0.2552 | 0.2294 | 0.1831 | 0.1705 | 0.1705 |
| 1959 | $1.552 \mathrm{e}-$ <br> 05 | 0.03175 | 0.2583 | 0.2398 | 0.2996 | 0.2780 | 0.2277 | 0.2640 | 0.1646 | 0.1646 |
| 1960 | $2.461 \mathrm{e}-$ | 0.03842 | 0.2913 | 0.2851 | 0.3596 | 0.3083 | 0.2602 | 0.3551 | 0.2060 | 0.2060 |
|  |  |  |  |  |  |  |  |  |  |  |


| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1976 | $\begin{aligned} & 1.885 \mathrm{e}- \\ & 02 \end{aligned}$ | 0.23682 | 0.6504 | 0.5869 | 0.4971 | 0.4297 | 0.3603 | 0.3637 | 0.2988 | 0.2988 |
| 1977 | $\begin{aligned} & 1.057 \mathrm{e}- \\ & 02 \end{aligned}$ | 0.28172 | 0.6833 | 0.5308 | 0.4959 | 0.3868 | 0.3215 | 0.4540 | 0.3161 | 0.3161 |
| 1978 | $\begin{aligned} & 5.501 e- \\ & 03 \end{aligned}$ | 0.30177 | 0.7142 | 0.5425 | 0.5099 | 0.3677 | 0.3215 | 0.4931 | 0.3317 | 0.3317 |
| 1979 | $\begin{aligned} & 3.904 \mathrm{e}- \\ & 03 \end{aligned}$ | 0.26885 | 0.7129 | 0.6302 | 0.5295 | 0.3882 | 0.3783 | 0.4313 | 0.3364 | 0.3364 |
| 1980 | $\begin{aligned} & \text { 4.631e- } \\ & 03 \end{aligned}$ | 0.24854 | 0.7147 | 0.7019 | 0.5466 | 0.4345 | 0.4357 | 0.3659 | 0.3404 | 0.3404 |
| 1981 | $\begin{aligned} & 9.471 e- \\ & 03 \end{aligned}$ | 0.28082 | 0.7511 | 0.6668 | 0.5555 | 0.4912 | 0.4303 | 0.3518 | 0.3515 | 0.3515 |
| 1982 | $\begin{aligned} & 1.961 e- \\ & 02 \end{aligned}$ | 0.33894 | 0.8172 | 0.6134 | 0.5621 | 0.5470 | 0.4145 | 0.3704 | 0.3588 | 0.3588 |
| 1983 | $\begin{aligned} & 2.269 \mathrm{e}- \\ & 02 \end{aligned}$ | 0.36405 | 0.8956 | 0.6400 | 0.5745 | 0.5890 | 0.4571 | 0.3973 | 0.3509 | 0.3509 |
| 1984 | $\begin{aligned} & 1.434 \mathrm{e} \\ & 02 \end{aligned}$ | 0.34311 | 0.9434 | 0.7186 | 0.5916 | 0.6072 | 0.5379 | 0.4197 | 0.3553 | 0.3553 |
| 1985 | $\begin{aligned} & 6.551 e- \\ & 03 \end{aligned}$ | 0.30545 | 0.9042 | 0.7404 | 0.6071 | 0.5963 | 0.5595 | 0.4310 | 0.4232 | 0.4232 |
| 1986 | $\begin{aligned} & 2.933 \mathrm{e}- \\ & 03 \end{aligned}$ | 0.26605 | 0.7996 | 0.6781 | 0.6113 | 0.5609 | 0.4916 | 0.4197 | 0.5444 | 0.5444 |
| 1987 | $\begin{aligned} & 1.787 \mathrm{e}- \\ & 03 \end{aligned}$ | 0.22446 | 0.7159 | 0.6203 | 0.5922 | 0.5145 | 0.4115 | 0.3730 | 0.5416 | 0.5416 |
| 1988 | $\begin{aligned} & 1.774 \mathrm{e}- \\ & 03 \end{aligned}$ | 0.18527 | 0.6790 | 0.6119 | 0.5535 | 0.4702 | 0.3654 | 0.3100 | 0.3659 | 0.3659 |
| 1989 | $\begin{aligned} & 2.336 e- \\ & 03 \end{aligned}$ | 0.16031 | 0.6241 | 0.6202 | 0.5311 | 0.4414 | 0.3623 | 0.2906 | 0.2580 | 0.2580 |
| 1990 | $\begin{aligned} & 3.193 e- \\ & 03 \end{aligned}$ | 0.15576 | 0.5131 | 0.6100 | 0.5539 | 0.4382 | 0.4117 | 0.3588 | 0.2883 | 0.2883 |
| 1991 | $\begin{aligned} & 4.114 \mathrm{e}- \\ & 03 \end{aligned}$ | 0.17135 | 0.4221 | 0.5867 | 0.6051 | 0.4676 | 0.4961 | 0.4692 | 0.4105 | 0.4105 |
| 1992 | $\begin{aligned} & 4.862 e- \\ & 03 \end{aligned}$ | 0.20964 | 0.4149 | 0.5710 | 0.6461 | 0.5399 | 0.5668 | 0.4633 | 0.4792 | 0.4792 |
| 1993 | $\begin{aligned} & 6.374 \mathrm{e} \\ & 03 \end{aligned}$ | 0.26492 | 0.4952 | 0.5882 | 0.6668 | 0.6402 | 0.5997 | 0.3719 | 0.4358 | 0.4358 |
| 1994 | $\begin{aligned} & 1.348 \mathrm{e}- \\ & 02 \end{aligned}$ | 0.30627 | 0.6348 | 0.6770 | 0.6915 | 0.7025 | 0.6199 | 0.3726 | 0.4116 | 0.4116 |
| 1995 | $\begin{aligned} & 3.973 e- \\ & 02 \end{aligned}$ | 0.30739 | 0.7876 | 0.8464 | 0.7336 | 0.6896 | 0.6418 | 0.5408 | 0.4680 | 0.4680 |


| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1996 | $5.193 \mathrm{e}-$ <br> 02 | 0.29058 | 0.8905 | 0.9553 | 0.7757 | 0.6703 | 0.6447 | 0.7598 | 0.5595 | 0.5595 |
| 1997 |  |  |  |  |  |  |  |  |  |  |
|  | $1.442 \mathrm{e}-$ <br> 02 | 0.28238 | 0.8851 | 0.8529 | 0.7977 | 0.7000 | 0.6143 | 0.7336 | 0.6114 | 0.6114 |
| 1998 | $4.164 \mathrm{e}-$ <br> 03 | 0.29594 | 0.8115 | 0.7211 | 0.8008 | 0.7291 | 0.5841 | 0.5953 | 0.6014 | 0.6014 |
|  |  |  |  |  |  |  |  |  |  |  |


| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 2016 | $9.449 \mathrm{e}-$ <br> 02 | 0.17607 | 0.3939 | 0.4891 | 0.4735 | 0.5466 | 0.6410 | 0.6839 | 0.6232 | 0.6232 |
| 2017 | $6.361 \mathrm{e}-$ <br> 02 | 0.14931 | 0.4269 | 0.4810 | 0.4388 | 0.4729 | 0.4996 | 0.6817 | 0.7583 | 0.7583 |
| 2018 | $4.254 \mathrm{e}-$ <br> 02 | 0.15507 | 0.3754 | 0.3893 | 0.3784 | 0.3760 | 0.3495 | 0.5083 | 0.7848 | 0.7848 |
| 2019 | $2.860 \mathrm{e}-$ <br> 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 deltalognormal 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.

## 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 <br> 18.1.1 Stock definition

During the WKNSEA 2017 benchmark, the available information on stock identity was investigated, including genetic, tagging and otolith information. Sole in the eastern English Channel (7.d) is still considered to be a stock separated from the larger North Sea stock (27.4) to the east and the smaller geographically-separated stock to the west in 27.7.e (western English Channel).

Considering the sub-stock structure, three regions with low connectivity were identified within Division 7.d for both larvae and juveniles, and adults. More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES, 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 $80-99 \mathrm{~mm}$ 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 $80-119 \mathrm{~mm}$ 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 | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| TAC | 4100 | 4600 | 5200 | 5400 | 5900 | 5700 | 5720 | 6220 | 6590 | 5274 | 4219 |
| Year | $\mathbf{2 0 1 1}$ | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6 *}$ | $\mathbf{2 0 1 7 *}$ | $\mathbf{2 0 1 8 *}$ | $\mathbf{2 0 1 9 *}$ | $\mathbf{2 0 2 0 *}$ |  |
| 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:


### 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:


### 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: $3832 \mathrm{t}-6247 \mathrm{t}$ ), 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 ( $\sim 30 \%$ Belgium, $\sim 20 \%$ UK, and $\sim 50 \%$ 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 $\geq 75 \%$. 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).
- $\quad$ 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:

ТВВ
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 $\geq 75 \%$. 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 20032010 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}(+)$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 19862019 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


## XSA assessment:

The final settings are specified in the Stock Annex and detailed below.

|  | 2019 ASSESSM ENT |  |  |
| :--- | :---: | :---: | :---: |
| Fleets | Years | Ages | $\alpha-\beta$ |
| 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 | 1 |  |  |
| -Last age | $11+$ |  |  |
| Time series weights | None |  |  |
| $-M$ odel | 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 |  |  |
| -M in 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 interbenchmark 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.
Tuning fleets as biomass indices:
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 <br> $\mathbf{K g} / \mathbf{h}$ | FRACOTB <br> $\mathrm{Kg} / \mathrm{kWh}$ | UKCBT <br> $\mathrm{Kg} / \mathrm{activity}$ <br> day | UKBTS <br> $\mathbf{K g} / \mathbf{h}$ |
| :---: | :---: | :---: | :---: | :---: |
| 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.


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).

## Landings only:

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 Btrigger. From 2011 onwards, SSB exceeded MSY Btrigger, 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 Btrigger. 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 Fmsy and occasionally exceeding Flim. From 2007 onwards, fishing mortality has been decreasing and is below Fmsy 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 $=\mathrm{Z}$ ) of age 1 in 2019 as follows: ( $\mathrm{e}^{-\mathrm{Z}}$ @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 |
| :--- | :--- | :--- | :--- |

$\qquad$
$\qquad$
$\qquad$
$\qquad$

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 $2020(2797 \mathrm{t})$ with $11.5 \%$. The predicted catch for 2021 is 3749 tonnes when fishing at FmSY. 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 <br> $\mathbf{2 0 2 0}$ | SSB <br> $\mathbf{2 0 2 1}$ | SSB <br> change | TAC <br> change | Advice <br> change |
| :--- | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathrm{F}_{\text {MSY }}$ | 3749 | 3429 | 320 | 0.192 | 0.172 | 0.055 | 21628 | 21262 | $-2.0 \%$ | $34 \%$ | $32 \%$ |
| $\mathrm{~F}_{\text {MSY_lower }}$ | 2344 | 2146 | 198 | 0.116 | 0.104 | 0.033 | 21628 | 22688 | $5.0 \%$ | $-16.0 \%$ | $-18 \%$ |


| F MS__ $^{\text {_upper }}$ | 5888 | 5378 | 510 | 0.32 | 0.29 | 0.092 | 21628 | 19093 | $-12.0 \%$ | $111 \%$ | $107 \%$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| F $_{\text {pa }}$ | 5583 | 5101 | 482 | 0.30 | 0.27 | 0.087 | 21628 | 19402 | $-10.0 \%$ | $100 \%$ | $96 \%$ |
| Flim $_{\text {lim }}$ | 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 | $-30 \%$ | $253 \%$ |
| SSB>B | lim | 14155 | 12828 | 1327 | 1.02 | 0.92 | 0.30 | 21628 | 10766 | $-50 \%$ | $406 \%$ |
| 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 | $\begin{gathered} \text { SSB } \\ 2020 \end{gathered}$ | $\begin{gathered} \text { SSB } \\ 2021 \end{gathered}$ | $\begin{gathered} \text { SSB } \\ \text { change } \end{gathered}$ | TAC change | Advice change |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{F}_{\text {MSY }}$ | 3806 | 3484 | 322 | 0.192 | 0.172 | 0.055 | 21960 | 21539 | -2.0\% | 36\% | 34\% |
| FmsY_lower | 2379 | 2180 | 199 | 0.116 | 0.104 | 0.033 | 21960 | 22987 | 5.0\% | -15.0\% | -16.4\% |
| $\mathrm{F}_{\text {MsY_ }}$ upper | 5977 | 5464 | 513 | 0.32 | 0.29 | 0.092 | 21960 | 19339 | -12.0\% | 114\% | 110\% |
| $\mathrm{F}_{\mathrm{pa}}$ | 5668 | 5182 | 486 | 0.30 | 0.27 | 0.087 | 21960 | 19652 | -11.0\% | 103\% | 99\% |
| Flim | 7546 | 6891 | 655 | 0.42 | 0.38 | 0.121 | 21960 | 17751 | -19.0\% | 170\% | 165\% |
| SSB $>_{\text {pa }}$ | 10201 | 9294 | 907 | 0.62 | 0.55 | 0.178 | 21960 | 15072 | -31\% | 265\% | 258\% |
| SSB>8 ${ }_{\text {lim }}$ | 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 $2020 \times$ index ratio
*** Advised catch for 2020 x index ratio x (1-discard rate)
$\wedge$ 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 $\mathrm{Btrigger}^{\text {rem }}$ | 15072 t | $\mathrm{B}_{\mathrm{pa}}$ | $\begin{gathered} \hline \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
|  | FmSY | 0.192 | EQsim analysis based on the recruitment period 1982-2016 | $\begin{gathered} \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
| Precautionary approach | $\mathrm{Blim}_{\text {l }}$ | 10766 t | Bloss | $\begin{gathered} \hline \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 15072 t | $\mathrm{B}_{\text {lim }} \times \exp \left(1.645 \times \quad 1.4 \times \mathrm{Bl}_{\text {lim }}\right.$ | $\begin{gathered} \hline \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
|  | Flim | 0.421 | EQsim analysis, based on the recruitment period 1982-2016 | $\begin{gathered} \hline \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.300 | $\mathrm{F}_{\text {lim }} \times \quad \times \quad \mathrm{F}_{\text {lim }} / 1.4$ | $\begin{gathered} \hline \text { ICES } \\ (2016,2019 b) \end{gathered}$ |
| Management plan | MAP MSY $B_{\text {trigger }}$ | 15072 t | MSY Btrigger | ICES (2019b) |
|  | M AP B lim | 10766 t | Blim | ICES (2019b) |
|  | MAP F $\mathrm{MSY}^{\text {r }}$ | 0.192 | $\mathrm{F}_{\text {MSY }}$ | ICES (2019b) |
|  | M AP range Flower | $\begin{gathered} 0.116- \\ 0.192 \end{gathered}$ | Consistent with ranges provided by ICES (2019b), resulting in no more than $5 \%$ reduction in long-term yield compared with MSY | ICES (2019b) |
|  | M AP range $\mathrm{F}_{\text {upper }}$ | $\begin{gathered} 0.192- \\ 0.319 \end{gathered}$ | 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 | M SY Btrigger | 0.92 | $\mathrm{B}_{\mathrm{pa}}$ | ICES (2019b) |
|  | $\overline{F_{\text {MSY }}}$ | 0.57 | EQsim analysis based on the recruitment period 19822016 | ICES (2019b) |
| Precautionary approach | Blim | 0.66 | Bloss | ICES (2019b) |
|  | $\mathrm{B}_{\text {pa }}$ | 0.92 | $\mathrm{B}_{\text {lim }} \times \exp \left(1.645 \times 1.4 \times \mathrm{Bl}_{\text {lim }}\right.$ | ICES (2019b) |
|  | $\overline{F_{\text {lim }}}$ | 1.25 | EQsim analysis, based on the recruitment period 19822016 | ICES (2019b) |
|  | $\overline{\mathrm{F}_{\mathrm{pa}}}$ | 0.89 | $\begin{array}{ccc}\mathrm{F}_{\text {lim }} \times & \times \quad \mathrm{F}_{\text {lim }} / 1.4\end{array}$ | ICES (2019b) |


| M anagement <br> plan | M AP MSY 0.92 MSY B Brigger proxy ICES (2019b) <br>  $B_{\text {trigger proxy }}$   <br>  M AP F FSY proxy 0.57 F MSY proxy |
| :--- | :--- | :--- | :--- | :--- |

### 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)).





F@A WGNSSK2O



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 (2002-5) age 3-8 | $X(\xi=2018)$ | $x(5)=2018)$ | $X(* ; ¢=2019)$ |
| 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.
- $\quad$ Consider the output of the French SMAC project on sol in Division 27.7d which investigated the presence of subpopulations in this stock.
- $\quad$ Currently, six tuning fleets are used in the assessment. Most of them are only covering a small part of Division 27.7 d . 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

- $\quad$ 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 $80-99 \mathrm{~mm}$ 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 80119 mm equipped with the Flemish panel (max. 3\% of annual catches).
- $\quad$ 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 <br> 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 |
| BM Slanding | 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 | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{1 9 9 8}$ | $\mathbf{1 9 9 9}$ | $\mathbf{2 0 0 0}$ | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ | $\mathbf{2 0 1 1}$ | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathbf{1}$ | 0.115 | 0.149 | 0.081 | 0.081 | 0.039 | 0.039 | 0.048 | 0.067 | 0.110 | 0.096 | 0.079 |
| 2 | 0.151 | 0.130 | 0.142 | 0.120 | 0.097 | 0.105 | 0.128 | 0.122 | 0.135 | 0.130 | 0.129 |
| 3 | 0.207 | 0.206 | 0.192 | 0.199 | 0.179 | 0.180 | 0.174 | 0.174 | 0.184 | 0.173 | 0.180 |
| 4 | 0.243 | 0.257 | 0.235 | 0.245 | 0.231 | 0.237 | 0.224 | 0.227 | 0.238 | 0.210 | 0.216 |
| 5 | 0.159 | 0.301 | 0.275 | 0.295 | 0.259 | 0.295 | 0.262 | 0.268 | 0.262 | 0.253 | 0.271 |
| 6 | 0.299 | 0.313 | 0.316 | 0.329 | 0.299 | 0.305 | 0.322 | 0.282 | 0.276 | 0.306 | 0.286 |
| 7 | 0.377 | 0.354 | 0.337 | 0.334 | 0.342 | 0.378 | 0.335 | 0.321 | 0.324 | 0.309 | 0.296 |
| 8 | 0.392 | 0.388 | 0.354 | 0.382 | 0.322 | 0.432 | 0.393 | 0.340 | 0.376 | 0.344 | 0.274 |
| 9 | 0.420 | 0.385 | 0.417 | 0.378 | 0.381 | 0.392 | 0.408 | 0.405 | 0.351 | 0.422 | 0.325 |
| 10 | 0.449 | 0.384 | 0.462 | 0.430 | 0.443 | 0.462 | 0.475 | 0.355 | 0.407 | 0.415 | 0.374 |
| 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 | $\mathbf{1 9 9 7}$ | $\mathbf{1 9 9 8}$ | $\mathbf{1 9 9 9}$ | $\mathbf{2 0 0 0}$ | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ | $\mathbf{2 0 1 1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathbf{2 0 0 4}$ | 1 | 0.894 | 0.338 | 0.497 | 0.178 | 0.040 | 0.038 |
| $\mathbf{2 0 0 5}$ | 1 | 0.516 | 0.474 | 0.125 | 0.090 | 0.067 | 0.034 |
| $\mathbf{2 0 0 6}$ | 1 | 0.471 | 0.402 | 0.374 | 0.156 | 0.150 | 0.076 |
| $\mathbf{2 0 0 7}$ | 1 | 0.747 | 0.348 | 0.144 | 0.277 | 0.110 | 0.137 |
| $\mathbf{2 0 0 8}$ | 1 | 0.923 | 0.864 | 0.199 | 0.137 | 0.117 | 0.064 |
| $\mathbf{2 0 0 9}$ | 1 | 0.695 | 0.684 | 0.449 | 0.111 | 0.064 | 0.068 |
| $\mathbf{2 0 1 0}$ | 1 | 0.697 | 0.222 | 0.362 | 0.184 | 0.064 | 0.036 |
| $\mathbf{2 0 1 1}$ | 1 | 1.005 | 0.313 | 0.176 | 0.131 | 0.091 | 0.028 |
| $\mathbf{2 0 1 2}$ | 1 | 1.584 | 0.997 | 0.272 | 0.084 | 0.100 | 0.098 |
| $\mathbf{2 0 1 3}$ | 1 | 0.473 | 0.918 | 0.714 | 0.213 | 0.102 | 0.121 |
| $\mathbf{2 0 1 4}$ | 1 | 0.569 | 0.724 | 0.879 | 0.511 | 0.134 | 0.065 |
| $\mathbf{2 0 1 5}$ | 1 | 0.591 | 0.564 | 0.630 | 0.770 | 0.536 | 0.185 |
| $\mathbf{2 0 1 6}$ | 1 | 0.565 | 0.355 | 0.439 | 0.413 | 0.424 | 0.321 |
| $\mathbf{2 0 1 7}$ | 1 | 0.802 | 0.497 | 0.255 | 0.290 | 0.261 | 0.358 |
| $\mathbf{2 0 1 8}$ | 1 | 0.629 | 0.913 | 0.368 | 0.289 | 0.230 | 0.205 |
| $\mathbf{2 0 1 9}$ | 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 |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1 9 8 6}$ | 1 | 162.44 | 112.77 | 31.47 | 32.33 | 44.26 | 1.34 |
| $\mathbf{1 9 8 7}$ | 1 | 78.60 | 106.47 | 73.61 | 13.82 | 10.83 | 27.91 |
| $\mathbf{1 9 8 8}$ | 1 | 225.13 | 45.09 | 50.32 | 31.68 | 7.17 | 9.20 |
| $\mathbf{1 9 8 9}$ | 1 | 61.47 | 113.52 | 14.34 | 24.98 | 18.22 | 3.99 |
| $\mathbf{1 9 9 0}$ | 1 | 197.36 | 28.74 | 39.85 | 8.52 | 9.12 | 9.12 |
| $\mathbf{1 9 9 1}$ | 1 | 57.20 | 80.19 | 3.44 | 12.62 | 2.08 | 3.04 |
| $\mathbf{1 9 9 2}$ | 1 | 138.66 | 21.81 | 44.95 | 2.99 | 5.44 | 1.73 |
| $\mathbf{1 9 9 3}$ | 1 | 67.48 | 66.39 | 10.49 | 15.97 | 1.59 | 3.25 |
| $\mathbf{1 9 9 4}$ | 1 | 85.69 | 47.31 | 37.21 | 9.03 | 14.93 | 1.46 |
| $\mathbf{1 9 9 5}$ | 1 | 34.65 | 71.43 | 34.87 | 30.66 | 5.95 | 12.15 |
| $\mathbf{1 9 9 6}$ | 1 | 90.22 | 28.52 | 60.65 | 30.36 | 24.18 | 6.29 |
| $\mathbf{1 9 9 7}$ | 1 | 109.13 | 52.24 | 13.98 | 41.26 | 16.75 | 16.05 |
| $\mathbf{1 9 9 8}$ | 1 | 93.30 | 53.69 | 35.91 | 12.20 | 28.49 | 15.87 |
| $\mathbf{1 9 9 9}$ | 1 | 181.49 | 63.89 | 26.36 | 19.24 | 7.43 | 15.89 |
| $\mathbf{2 0 0 0}$ | 1 | 104.70 | 100.41 | 32.05 | 15.14 | 10.64 | 4.05 |
| $\mathbf{2 0 0 1}$ | 1 | 120.75 | 45.49 | 50.43 | 19.82 | 8.54 | 8.82 |
| $\mathbf{2 0 0 2}$ | 1 | 211.47 | 104.63 | 33.78 | 25.88 | 10.77 | 8.74 |
| $\mathbf{2 0 0 3}$ | 1 | 118.43 | 80.17 | 34.77 | 14.58 | 17.19 | 8.05 |
| $\mathbf{2 0 0 4}$ | 1 | 282.90 | 66.29 | 39.98 | 20.95 | 6.17 | 11.68 |
| $\mathbf{2 0 0 5}$ | 1 | 89.39 | 188.76 | 34.80 | 36.23 | 17.73 | 8.73 |
|  |  |  |  |  |  |  |  |


|  | Effort | Age3 | Age4 | Age5 | Age6 | Age7 | Age8 |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{2 0 0 6}$ | 1 | 163.34 | 52.87 | 88.06 | 14.78 | 13.10 | 6.32 |
| $\mathbf{2 0 0 7}$ | 1 | 195.95 | 74.11 | 22.34 | 66.31 | 15.48 | 15.20 |
| $\mathbf{2 0 0 8}$ | 1 | 270.29 | 81.46 | 17.93 | 10.87 | 15.08 | 5.54 |
| $\mathbf{2 0 0 9}$ | 1 | 46.24 | 111.19 | 40.27 | 6.24 | 5.08 | 10.81 |
| $\mathbf{2 0 1 0}$ | 1 | 103.83 | 34.78 | 69.08 | 23.20 | 8.14 | 5.34 |
| $\mathbf{2 0 1 1}$ | 1 | 99.27 | 48.73 | 13.52 | 30.40 | 8.83 | 2.05 |
| $\mathbf{2 0 1 2}$ | 1 | 241.22 | 44.42 | 25.58 | 4.38 | 11.91 | 6.36 |
| $\mathbf{2 0 1 3}$ | 1 | 90.10 | 164.95 | 30.00 | 17.55 | 5.54 | 7.43 |
| $\mathbf{2 0 1 4}$ | 1 | 61.86 | 139.85 | 81.08 | 12.10 | 7.26 | 0.87 |
| $\mathbf{2 0 1 5}$ | 1 | 83.98 | 44.78 | 86.01 | 64.58 | 9.00 | 5.78 |
| $\mathbf{2 0 1 6}$ | 1 | 123.84 | 73.89 | 25.59 | 50.21 | 35.62 | 10.40 |
| $\mathbf{2 0 1 7}$ | 1 | 103.74 | 49.10 | 30.84 | 13.11 | 30.97 | 27.45 |
| $\mathbf{2 0 1 8}$ | 1 | 58.32 | 117.89 | 25.02 | 16.19 | 6.69 | 15.78 |
| $\mathbf{2 0 1 9}$ | 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 | Agel | 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 | Agel |
| :---: | :---: | ---: |
| $\mathbf{1 9 8 7}$ | 1 | 1.38 |
| $\mathbf{1 9 8 8}$ | 1 | 1.87 |
| $\mathbf{1 9 8 9}$ | 1 | 0.62 |
| $\mathbf{1 9 9 0}$ | 1 | 1.9 |
| $\mathbf{1 9 9 1}$ | 1 | 3.69 |
| $\mathbf{1 9 9 2}$ | 1 | 1.5 |
| $\mathbf{1 9 9 3}$ | 1 | 1.33 |
| $\mathbf{1 9 9 4}$ | 1 | 2.68 |
| $\mathbf{1 9 9 5}$ | 1 | 2.91 |
| $\mathbf{1 9 9 6}$ | 1 | 0.57 |
| $\mathbf{1 9 9 7}$ | 1 | 1.12 |
| $\mathbf{1 9 9 8}$ | 1 | 1.12 |
| $\mathbf{1 9 9 9}$ | 1 | 1.47 |
| $\mathbf{2 0 0 0}$ | 1 | 2.47 |
| $\mathbf{2 0 0 1}$ | 1 | 0.38 |
| $\mathbf{2 0 0 2}$ | 1 | 4.15 |
| $\mathbf{2 0 0 3}$ | 1 | 1.44 |
| $\mathbf{2 0 0 4}$ | 1 | 2.72 |
| $\mathbf{2 0 0 5}$ | 1 | 4.07 |
| $\mathbf{2 0 0 6}$ | 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 |
| ---: | :---: | ---: |
| $\mathbf{1 9 8 7}$ | 1 | 0.07 |
| $\mathbf{1 9 8 8}$ | 1 | 0.17 |
| $\mathbf{1 9 8 9}$ | 1 | 0.14 |
| $\mathbf{1 9 9 0}$ | 1 | 0.54 |
| $\mathbf{1 9 9 1}$ | 1 | 0.38 |
| $\mathbf{1 9 9 2}$ | 1 | 0.22 |
| $\mathbf{1 9 9 3}$ | 1 | 0.03 |
| $\mathbf{1 9 9 4}$ | 1 | 0.7 |
| $\mathbf{1 9 9 5}$ | 1 | 0.28 |
| $\mathbf{1 9 9 6}$ | 1 | 0.15 |
| $\mathbf{1 9 9 7}$ | 1 | 0.03 |
| $\mathbf{1 9 9 8}$ | 1 | 0.1 |
| $\mathbf{1 9 9 9}$ | 1 | 0.35 |
| $\mathbf{2 0 0 0}$ | 1 | 0.31 |
| $\mathbf{2 0 0 1}$ | 1 | 1.21 |
| $\mathbf{2 0 0 2}$ | 1 | 0.11 |


|  | Effort | Agel |
| :---: | :---: | ---: |
| $\mathbf{2 0 0 3}$ | 1 | 0.32 |
| $\mathbf{2 0 0 4}$ | 1 | 0.15 |
| $\mathbf{2 0 0 5}$ | 1 | 0.82 |
| $\mathbf{2 0 0 6}$ | 1 | 0.83 |
| $\mathbf{2 0 0 7}$ | 1 | 0.08 |
| $\mathbf{2 0 0 8}$ | 1 | 0.06 |
| $\mathbf{2 0 0 9}$ | 1 | 2.78 |
| $\mathbf{2 0 1 0}$ | 1 | 0.1 |
| $\mathbf{2 0 1 1}$ | 1 | 0.32 |
| $\mathbf{2 0 1 2}$ | 1 | 0.35 |
| $\mathbf{2 0 1 3}$ | 1 | 0.052 |
| $\mathbf{2 0 1 4}$ | 1 | 0.04 |
| $\mathbf{2 0 1 5}$ | 1 | 0.09 |
| $\mathbf{2 0 1 6}$ | 1 | 0.04 |
| $\mathbf{2 0 1 7}$ | 1 | 0.05 |
| $\mathbf{2 0 1 8}$ | 1 | 0.03 |
| $\mathbf{2 0 1 9}$ | 1 | 0.45 |

Table 18.12: Sole 27.7.d - XSA diagnostics of the 2020 assessment


Time series weights :
Tapered time weighting not applied
Catchability analysis :
Catchability independent of size for all ages
Catchability independent of age for ages > 7
Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.
S.E. of the mean to which the estimates are shrunk $=2$

Minimum standard error for population
estimates derived from each fleet $=0.3$
prior weighting not applied
Regression weights
year
age 2010201120122013201420152016201720182019
$\begin{array}{lllllllllll}\text { all } & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1\end{array}$

Fishing mortalities
year
age 2010201120122013201420152016201720182019
10.0190 .0050 .0140 .0180 .0510 .0150 .0430 .0170 .0270 .006
20.2250 .1890 .1320 .1800 .1390 .1760 .0730 .0860 .0780 .084
30.3530 .3080 .2710 .2440 .3340 .2150 .2130 .1120 .1720 .135
40.4460 .3440 .3410 .2890 .4110 .2700 .1880 .2060 .1680 .157
50.3760 .3830 .2780 .2330 .2660 .2930 .2300 .1870 .1630 .130
60.3660 .3010 .4340 .2130 .2360 .2250 .1940 .2170 .1830 .117
70.2790 .1780 .1760 .3880 .2380 .2230 .1330 .1280 .1970 .091 80.3340 .2340 .1950 .1730 .4710 .2360 .1670 .1210 .1450 .089 90.1910 .2310 .1910 .1240 .1660 .2200 .3280 .1270 .0820 .101 100.1770 .0780 .1030 .1490 .1000 .1420 .2970 .2790 .1220 .069 110.1770 .0780 .1030 .1490 .1000 .1420 .2970 .2790 .1220 .069

XSA population number (Thousand)

## age

$\begin{array}{llllllllllll}\text { year } & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11\end{array}$
201061953408791651190121004956971393108219505342214 20114678354981295411049252226240357795370114572475 20122380842134411941964767313222418127086825032956 2013173342124033417284151264646131888317120165101378 20142078615411160452368819254906233721159241316123231 20153011217870121341039114205133506478240565518492050

2016157342684713561885571809589964246901720476927
20173877213632225909913664051637147763735901121661
2018375953449911320182677297498537605691612528622963
2019991353310828870862413979560837552795445651053677

Estimated population abundance at 1st Jan 2020
age
$\begin{array}{llllllllllll}\text { year } & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11\end{array}$
2020089172275542283466691111145133104231536474313

## Fleet: BE-CBT-CPUE

Log catchability residuals.
year
 $3-0.161-0.0380 .062-0.156-0.1250 .2860 .192-0.0450 .060-0.9520 .0090 .2700 .113-0.0950 .3810 .200$ $4-0.198-0.4170 .1270 .1680 .4400 .003-0.431-0.2860 .243-0.232-0.2310 .278-0.0640 .1680 .1470 .286$ $50.248-0.752-0.201-0.4370 .1890 .259-0.113-0.177-0.0440 .2690 .0720 .0560 .347-0.1380 .1230 .299$ $60.051-0.776-0.0040 .1000 .1170 .240-0.154-0.615-0.3360 .1320 .3430 .3600 .0530 .3300 .346-0.187$ $7-0.501-0.4800 .1710 .186-0.221-0.0320 .203-0.436-0.4980 .4150 .0380 .7650 .090-0.0990 .450-0.054$ $8-0.513-0.148-0.0010 .5260 .173-0.422-0.094-0.265-0.075-0.0330 .4910 .6980 .5480 .148-0.104-0.480$
Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time
$\begin{array}{llllll}3 & 4 & 5 & 6 & 7 & 8\end{array}$
Mean_Logq -10.0463-9.9199-9.8892-9.9627-10.0074-10.0074
S.E_Logq 0.32030 .32030 .32030 .32030 .32030 .3203

Fleet: UK(E\&W)-CBT-new
Log catchability residuals.
year
age $198619871988198919901991 \quad 199219931994199519961997199819992000200120021003$ $30.6010 .4020 .7620 .5210 .493-0.085-0.315-0.863-0.603-0.822-0.2980 .2780 .0530 .2570 .4040 .0380 .3040 .027$ $40.3230 .7740 .4600 .7700 .4830 .097-0.466-0.587-0.730-0.344-0.431-0.1840 .2140 .2980 .2270 .118-0.423-0.211$ $50.3310 .4840 .7310 .1670 .547-0.8700 .204-0.516-0.528-0.3160 .159-0.2410 .2270 .2320 .3230 .2370 .4700 .023$ $60.3770 .0820 .1070 .5770 .4060 .053-0.365-0.349-0.090-0.1690 .1620 .3610 .4390 .1630 .2280 .3680 .0850 .228$ 7 0.157-0.166 0.050-0.016 0.114-0.410-0.159-0.391 0.0150 .0750 .1510 .1770 .4990 .6130 .0650 .1330 .2600 .377 $8-0.309-0.0910 .017-0.231-0.506-0.698-0.182-0.367-0.0870 .0420 .5270 .0830 .4550 .1890 .4100 .0790 .3850 .219$ year
 $30.474-0.0050 .7890 .2910 .433-0.6390 .073-0.575-0.036-0.825-0.4250 .1040 .381-0.355-0.211-0.628$ $40.0890 .5780 .0140 .537-0.0060 .102-0.369-0.230-0.952-0.0330 .041-0.3400 .282-0.2300 .016-0.734$ $5-0.1180 .1230 .506-0.147-0.0640 .0020 .384-0.589-0.254-0.747-0.1570 .218-0.341-0.097-0.4120 .030$ $60.1430 .546-0.1280 .902-0.185-0.4060 .0070 .156-1.058-0.132-1.1680 .1140 .178-0.534-0.304-0.795$ $70.0050 .5660 .1080 .6000 .105-0.1900 .516-0.394-0.251-0.123-0.502-0.947-0.0120 .145-0.712-0.460$ $80.6820 .867-0.1130 .7020 .1010 .1140 .373-0.505-0.435-0.448-1.448-0.393-0.506-0.046-0.293-0.633$
Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

## $\begin{array}{llllll}3 & 4 & 5 & 6 & 7 & 8\end{array}$

Mean_Logq -4.9241-4.9279-5.1352-5.2870-5.4746-5.4746
S.E_Logq 0.42720 .42720 .42720 .42720 .42720 .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
    80.021
    Mean log catchability and standard error of ages with catchability
    independent of year class strength and constant w.r.t. time
    3
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
    10.711 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 . 5 5 2
    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 1987198819891990199119921993199419951996199719981999200020012002200320042005
$10.021-0.0130 .2970 .6180 .543-0.015-1.2311 .3660 .7860 .19-1.828-0.1630 .710 .2681 .725-1.0330 .810 .2351 .241$
year
age 20062007200820092010201120122013201420152016201720182019
$11.161-0.49-0.9182 .377-1.2290 .2050 .977-0.611-1.034-0.616-0.76-1.455-1.929-0.204$
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 0.4551653112018
FR-YFS $0.428 \quad 727322018$
fshk $0.117 \quad 171082018$
Age 2 Year class $=2017$
source
scaledWts survivors yrcls
UK(E\&W)-BTS-Q3 0.944385182017
fshk 0.056205952017
Age 3 Year class $=2016$
source
scaledWts survivors yrcls
BE-CBT-CPUE $0.320 \quad 278802016$
UK(E\&W)-CBT-new 0.135121892016
FR-COTB $\quad 0.347 \quad 173452016$
UK(E\&W)-BTS-Q3 $0.190 \quad 338272016$
fshk 0.009140882016
Age 4 Year class $=2015$
source
scaledWts survivors yrcls
BE-CBT-CPUE 0.40288782015
UK(E\&W)-CBT-new 0.18932022015
FR-COTB $0.166 \quad 57142015$
UK(E\&W)-BTS-Q3 $0.233 \quad 31432015$
fshk 0.01140112015
Age 5 Year class $=2014$
source
scaledWts survivors yrcls
BE-CBT-CPUE 0.366149782014
UK(E\&W)-CBT-new $0.221 \quad 114532014$

```
FR-COTB 0.234 46192014
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 20382013
FR-COTB 0.194 22692013
UK(E&W)-BTS-Q3 0.237 8205 2013
fshk 0.012 23832013
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 19012010
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
21
Survivors 38518.00035870 .000
Raw weights 4.2510 .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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
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 $=U K(E \& W)-B T S-Q 3$
$3 \quad 2 \quad 1$
Survivors 33827.00035841 .00053673 .000
$\begin{array}{llll}\text { Raw weights } & 5.298 & 3.737 & 0.775\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
43
Survivors 8878.0009764 .000
Raw weights 9.4957 .352
Fleet $=$ FR-COTB
43
Survivors 5714.0007102 .000
Raw weights 3.9297 .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
$\begin{array}{llll}4 & 3 & 2\end{array}$
Survivors 3143.0008795 .00011073 .00014342 .000
$\begin{array}{lllll}\text { Raw weights } & 5.506 & 4.361 & 3.052 & 0.617\end{array}$
Fleet = UK(E\&W)-CBT-new
43
Survivors 3202.0005398 .000
Raw weights 4.4673 .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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
543
Survivors 14978.00012866 .00010100 .000
$\begin{array}{llll}\text { Raw weights } & 9.304 & 8.254 & 6.784\end{array}$
Fleet $=$ FR-COTB
543
Survivors 4619.0007391 .0007020 .000
Raw weights $\begin{array}{llll}5.939 & 3.415 & 7.376\end{array}$
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
$\begin{array}{lllll}5 & 4 & 3 & 2 & 1\end{array}$
Survivors 12843.00021759 .00017273 .00020283 .00030438 .000
$\begin{array}{llllll}\text { Raw weights } & 4.326 & 4.786 & 4.024 & 2.854 & 0.593\end{array}$
Fleet $=$ UK(E\&W)-CBT-new
543
Survivors 11453.00011285 .0007791 .000
$\begin{array}{lllll}\text { Raw weights } & 5.613 & 3.883 & 2.858\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
$6 \quad 5 \quad 4 \quad 3$
Survivors 3743.0005104 .0005340 .0005053 .000
$\begin{array}{lllll}\text { Raw weights } & 7.248 & 8.001 & 6.828 & 5.073\end{array}$
Fleet $=$ FR-COTB
$6 \quad 5 \quad 4 \quad 3$
Survivors 2269.0004414 .0004279 .0005647 .000
$\begin{array}{lllll}\text { Raw weights } & 4.057 & 5.108 & 2.825 & 5.516\end{array}$
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
$\begin{array}{llllll}6 & 5 & 4 & 3 & 2 & 1\end{array}$
Survivors 8205.0004428 .0004317 .008550 .0008509 .00018431 .000
$\begin{array}{lllllll}\text { Raw weights } & 4.963 & 3.721 & 3.96 & 3.009 & 1.925 & 0.386\end{array}$
Fleet = UK(E\&W)-CBT-new
$6 \quad 5 \quad 4 \quad 3$
Survivors 2038.0002990 .0003584 .0006604 .000
$\begin{array}{lllll}\text { Raw weights } & 4.382 & 4.827 & 3.212 & 2.137\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
$\begin{array}{lllll}7 & 6 & 5 & 4 & 3\end{array}$
Survivors 2941.0004385 .0002703 .0002911 .0004065 .000
$\begin{array}{llllll}\text { Raw weights } & 6.271 & 6.197 & 6.682 & 5.809 & 4.309\end{array}$
Fleet $=$ FR-COTB
$\begin{array}{lllll}7 & 6 & 5 & 4 & 3\end{array}$
Survivors 2153.0004113 .0002946 .0002893 .0002260 .000
$\begin{array}{llllll}\text { Raw weights } & 3.856 & 3.469 & 4.266 & 2.403 & 4.685\end{array}$
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
$\begin{array}{llllll}6 & 5 & 4 & 3 & 2 & 1\end{array}$
Survivors 5569.0004157 .0003888 .0003557 .0005075 .000422 .000
$\begin{array}{lllllll}\text { Raw weights } & 4.243 & 3.107 & 3.369 & 2.556 & 1.696 & 0.352\end{array}$
Fleet $=$ UK(E\&W)-CBT-new
$\begin{array}{lllll}7 & 6 & 5 & 4 & 3\end{array}$
Survivors 1960.0002289 .0002816 .0004115 .0003444 .000
$\begin{array}{llllll}\text { Raw weights } & 6.567 & 3.747 & 4.031 & 2.733 & 1.815\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 1432.0003630 .0003219 .0003275 .0003055 .002334 .000
$\begin{array}{lllllll}\text { Raw weights } & 6.017 & 5.162 & 4.931 & 5.093 & 4.08 & 2.686\end{array}$
Fleet $=$ FR-COTB
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 2364.0003102 .0003045 .003275 .0002700 .0003199 .00
$\begin{array}{lllllll}\text { Raw weights } & 1.955 & 3.174 & 2.76 & 3.251 & 1.688 & 2.92\end{array}$
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
$\begin{array}{llllll}6 & 5 & 4 & 3 & 2 & 1\end{array}$
Survivors 2922.0004382 .0001884 .0004429 .0001536 .000556 .000
$\begin{array}{lllllll}\text { Raw weights } & 3.376 & 2.368 & 2.366 & 1.593 & 1.014 & 0.211\end{array}$
Fleet $=$ UK(E\&W)-CBT-new
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 1229.0001135 .0001356 .0001645 .0001647 .0001513 .000
$\begin{array}{lllllll}\text { Raw weights } & 3.911 & 5.405 & 2.981 & 3.073 & 1.919 & 1.131\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 3285.0003304 .0003846 .0003855 .0002894 .0001407 .000
$\begin{array}{lllllll}\text { Raw weights } & 5.145 & 4.728 & 4.622 & 4.482 & 3.116 & 2.245\end{array}$
Fleet $=$ FR-COTB
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 3150.0003230 .0003546 .0004544 .0006288 .0004821 .000
$\begin{array}{lllllll}\text { Raw weights } & 1.672 & 2.907 & 2.587 & 2.861 & 1.289 & 2.441\end{array}$
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
$\begin{array}{llllll}6 & 5 & 4 & 3 & 2 & 1\end{array}$
Survivors 4854.0005164 .0007403 .0003860 .0001291 .003457 .000
$\begin{array}{lllllll}\text { Raw weights } & 3.165 & 2.084 & 1.807 & 1.332 & 0.89 & 0.187\end{array}$
Fleet $=$ UK(E\&W)-CBT-new

$$
\begin{array}{llllll}
8 & 7 & 6 & 5 & 4 & 3
\end{array}
$$

Survivors 2719.0004214 .0004357 .0004535 .0003797 .0001598 .000
$\begin{array}{lllllll}\text { Raw weights } & 3.344 & 4.951 & 2.795 & 2.704 & 1.466 & 0.946\end{array}$
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 $=\mathrm{BE}-\mathrm{CBT}-\mathrm{CPUE}$

$$
\begin{array}{llllll}
8 & 7 & 6 & 5 & 4 & 3
\end{array}
$$

Survivors 4998.0004717 .006183 .004635 .0003419 .0004579 .00
$\begin{array}{lllllll}\text { Raw weights } & 5.011 & 4.58 & 4.34 & 4.322 & 3.395 & 2.38\end{array}$
Fleet $=$ FR-COTB
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4 & 3\end{array}$
Survivors 3129.0002915 .0003654 .0005420 .0004870 .0007283 .000
$\begin{array}{lllllll}\text { Raw weights } & 1.628 & 2.816 & 2.429 & 2.759 & 1.405 & 2.588\end{array}$
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

$$
\begin{array}{llllll}
6 & 5 & 4 & 3 & 2 & 1
\end{array}
$$

Survivors 2896.0005001 .005516 .0001875 .0003566 .0003785 .000
$\begin{array}{lllllll}\text { Raw weights } & 2.971 & 2.01 & 1.969 & 1.412 & 0.892 & 0.184\end{array}$
Fleet $=$ UK(E\&W)-CBT-new
$\begin{array}{llllll}8 & 7 & 6 & 5 & 4\end{array}$
Survivors 4120.0004260 .0004832 .0003684 .0004173 .0004158 .000
$\begin{array}{lllllll}\text { Raw weights } & 3.257 & 4.796 & 2.624 & 2.608 & 1.597 & 1.003\end{array}$
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 <br> tonnes | Landings <br> tonnes | Discards <br> tonnes | $\begin{gathered} \hline F \\ \text { Ages 3-7 } \\ \text { Year }^{1} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 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 timeseries.

| Year | Relative recruitment Age 1 | Relative SSB | Relative F <br> Ages 3-7 | Landings tonnes | Discards <br> 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











 | 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 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |



[^13]
## Stock numbers 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 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |













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



$$
\begin{aligned}
& \begin{array}{lllllllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{lllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{llllllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{lllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{llllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{lllllllllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{llllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{llllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{llllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{lllllllllllllllllllllllllllllllllllllllllllll}
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
\end{array} \\
& \begin{array}{lllllllllllllllllllllllllllllllllllllllllll}
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
\end{array}
\end{aligned}
$$

## F WGNSSK 2020



$$
\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllllllllllll}
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 & 0.0 & 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 & 0.0 & 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
\end{array}
$$

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 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

$\begin{array}{llllllllllllllllllllllllllllllllllllllllllllll}1201 & 930 & 1711 & 1548 & 923 & 1967 & 873 & 1781 & 1245 & 3485 & 2697 & 2452 & 1005 & 1910 & 1613 & 1453 & 2234 & 1306 & 1813 & 2593 & 2530 & 4121 & 1377 & 1367 & 2704 & 2779 & 1712 & 1473 & 2733 & 2239 & 1170 & 917 & 859 & 612 & 1546 & 851 & 2551\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllll}4538 & 2685 & 1893 & 3513 & 2902 & 1875 & 4168 & 1274 & 4828 & 2461 & 6274 & 4693 & 3851 & 1654 & 3596 & 2355 & 2327 & 4230 & 1824 & 3026 & 4514 & 4509 & 4945 & 2895 & 2056 & 3966 & 5707 & 2765 & 2826 & 5164 & 5367 & 4465 & 2342 & 1619 & 1767 & 3136 & 1653\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllll}1012 & 5200 & 2328 & 1549 & 3053 & 2199 & 1309 & 2763 & 1007 & 3882 & 1691 & 5101 & 3616 & 3566 & 1963 & 2488 & 1687 & 1667 & 2799 & 1435 & 2473 & 4505 & 2486 & 4587 & 2454 & 1500 & 3823 & 4757 & 2017 & 2546 & 4329 & 5988 & 4213 & 2100 & 1616 & 1754 & 3123\end{array}$ $\begin{array}{llllllllllllllllllllllllllllllllllllllllllllll}900 & 828 & 4550 & 1925 & 1243 & 2507 & 1673 & 953 & 2096 & 734 & 2681 & 1390 & 3772 & 2294 & 2952 & 1079 & 1678 & 1028 & 1735 & 1841 & 1178 & 2505 & 2967 & 1927 & 3377 & 1407 & 1222 & 2630 & 2833 & 1563 & 1765 & 3844 & 4310 & 2877 & 1777 & 1257 & 1637\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllll}1103 & 956 & 585 & 4573 & 1690 & 1069 & 2290 & 1061 & 499 & 1328 & 556 & 2373 & 815 & 3207 & 1942 & 2080 & 681 & 1016 & 1116 & 668 & 1325 & 1257 & 1499 & 1633 & 1560 & 1899 & 1238 & 909 & 1795 & 2372 & 1088 & 1695 & 2955 & 3195 & 1891 & 1454 & 1108\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllll}600 & 1077 & 690 & 343 & 3716 & 1473 & 769 & 1946 & 980 & 394 & 879 & 453 & 1897 & 633 & 2494 & 1487 & 1572 & 317 & 981 & 418 & 605 & 1219 & 607 & 1458 & 1395 & 863 & 1576 & 952 & 520 & 1558 & 2088 & 1003 & 1172 & 2078 & 2401 & 1467 & 1054\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllll}322 & 473 & 809 & 553 & 255 & 3382 & 1074 & 549 & 1671 & 670 & 287 & 904 & 317 & 1361 & 487 & 1997 & 966 & 1097 & 348 & 492 & 318 & 815 & 645 & 613 & 979 & 817 & 680 & 1260 & 438 & 429 & 1242 & 2052 & 634 & 1035 & 1766 & 2044 & 1180\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllll}202 & 262 & 314 & 740 & 413 & 187 & 3369 & 1001 & 453 & 1222 & 479 & 244 & 591 & 269 & 1518 & 489 & 1680 & 681 & 1074 & 109 & 533 & 368 & 557 & 599 & 393 & 595 & 669 & 407 & 660 & 454 & 381 & 1234 & 1168 & 552 & 676 & 1501 & 1552\end{array}$ $\begin{array}{lllllllllllllllllllllllllllllllllllllllllllllllll}154 & 169 & 203 & 277 & 543 & 321 & 148 & 2726 & 704 & 269 & 1102 & 688 & 134 & 389 & 145 & 1399 & 208 & 982 & 630 & 567 & 135 & 734 & 291 & 537 & 446 & 187 & 504 & 529 & 275 & 888 & 398 & 363 & 1006 & 1080 & 372 & 679 & 1166\end{array}$ $\begin{array}{llllllllllllllllllllllllllllllllllllllllllllll}439 & 422 & 577 & 653 & 1069 & 1034 & 574 & 4565 & 3103 & 1532 & 2672 & 996 & 482 & 1456 & 602 & 2922 & 404 & 2907 & 1689 & 2586 & 479 & 1495 & 1022 & 1399 & 698 & 715 & 952 & 1214 & 1018 & 1315 & 1555 & 1134 & 2312 & 1473 & 948 & 546 & 3795\end{array}$

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 |

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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).

Landings weight at age for Sole in 7.d


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.
catch ( $\mathrm{L}+\mathrm{D}$ ) prop at age relative to average prop 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).

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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.

## Relative contribution of yearclasses to catch in 2021



Figure 18.26: Sole 27.7.d - Relative contribution of year classes to catch in 2021 for TAC constraint option.

## Relative contribution of yearclasses to SSB in 2022



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) 


#### Abstract

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 $70-99 \mathrm{~mm}$ 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 $201916 \%$ 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| M aturity | 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 | $\sim$ s(year, $k=8)+$ factor(age) |
| Survey catchability | $\sim$ factor(age) |
| Recruitment | $\sim$ 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 <br> Discards are assumed negligible. |
| Tuning indices | FR CGFS (since 2004 ages 0-4+) |
| Plus group | 4 |
| First tuning year | $\sim 2004$ |
| Fishing mortality | $\sim s(y e a r, k=10)+s($ age, $k=3)+s(y e a r, ~ k=5$, Age 0) |
| Survey catchability | $\sim s(a g e, k=3)$ |
| Recruitment | $\sim$ factor(year) |
| Variance | $\mathrm{F} \sim s(a g e, k=3) \&$ Survey $\sim s(a g e, k=3)$ |

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 $\operatorname{Linf}(40 \mathrm{~cm})$ 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; IBTSNKK 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.


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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 |
| 19991) | 0 | 4 | NA | 0 | 103 | 107 |
| 2000 | 0 | 4 | 3201 | 464 | 133 | 3802 |
| 2001 | 0 | 10 | 1789 | 915 | 183 | 2897 |
| 2002 | 0 | 24 | 1658 | 560 | 141 | 2383 |
| 2003 | 28 | 0 | 3256 | 626 | 177 | 4087 |
| 2004 | 31 | 0 | 4137 | 1148 | 129 | 5445 |
| 2005 | 29 | 0 | 1918 | 914 | 136 | 2997 |
| 2006 | 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 | 1601 | 0 | 1476 | 2002 |  |
| 2015 | 1649 | 0.03 | 3727 | 5328 |  |
| 2016 | 1304 | 0 | 1789 | 3438 |  |
| 2017 | 385 | 0.018 | 1552 | 2856 |  |
| 2018 | 1282 | 0.022 | 1266 | 1651 |  |
| 2019 |  |  | 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 <br> corresp. to advice | Official landings <br> 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 | 162162162 | M ahé et al., 2013 |
| von Bertalanffy growth parameter (Linf) | 400400400 | M ahé 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 | M ean 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 $L_{\text {mat }}$ (length at $50 \%$ maturity); and for large fish: mean length of the largest $5 \%$ in the catch $\left(L_{m a x 5 \%}\right)$ relative to asymptotic length $L_{\text {inf }}$ and the proportion of mega spawners ( $\mathrm{P}_{\text {mega }}$ ). Optimising yield criterion: the mean length $\mathrm{L}_{\text {mean }}$ is compared to the theoretical length of optimal biomass ( $L_{\text {opt }}$ ). MSY criterion: $L_{\text {mean }}$ 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 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $L_{d} / L_{\text {mat }}$ | $L_{25 \%} / L_{\text {mat }}$ | $L_{\text {max5\%/ }} / L_{\text {inf }}$ | $\mathbf{P}_{\text {mega }}$ | $L_{\text {mean }} / L_{\text {opt }}$ |  |  |  |  |  |
| $L_{\text {mean }} / L_{f=M}$ |  |  |  |  |  |  |  |  |  |  |
| Ref | $>1$ | $>1$ | $>0.8$ | $>30 \%$ | $\sim 1(>0.9)$ |  |  |  |  |  |



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).

## Landings N@A



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.

CGFS


Lower right panels show the Coefficient of Determination $\left(r^{2}\right)$

Figure 19.5.4.1. CGFS internal consistencies.

CGFS, index 2019 (Abundance Index per km²)


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 $\mathbf{Z}(1-2)$, relative $\operatorname{SSB}$, 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 improve-
ment 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 (В/ВМیу) remained above the proxy reference point of 0.5 . By the end of 2019, fishing pressure ( $\mathrm{F} / \mathrm{FMSY}_{\text {) }}$ ) 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 | $\mathbf{2 2 5 2 8}$ | $\mathbf{1 5 3 3 9 8}$ | $\mathbf{1 7 5 9 2 6}$ | $\mathbf{1 2 . 8 0 \%}$ |
| 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 | $\mathbf{2 0 4 3 5 6}$ | $\mathbf{2 4 6 2 5 9}$ | $\mathbf{1 7 . 0 0 \%}$ |
| 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 | $\mathbf{2 0 4 3 5 6}$ |  |
| Imported Data | 204356 |  |
| Grand Total | $\mathbf{2 4 6 2 5 9}$ |  |



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 $\mathbf{3 0}$ 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 $\mathbf{2 0 . 4}$ ( A - D ). Turbot in 27.3a. Exploitable biomass survey indices by quarter ( Q 1 - 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 $B / B_{\text {MSy }} 35^{\text {th }}$ percentile is above the proxy reference point of 0.5 (see single datum; 0.95 ). The $F / F_{\text {MSY }} 65^{\text {th }}$ 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 ( $\sim 50 \%$ of the landings). In recent years, most of the landings stem from the Netherlands ( $\sim 50-60 \%$ ). 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 ( $\sim 4$ \% 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 $600 \mathrm{~kg} \mathrm{wk}^{-1}$. 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 $2000 \mathrm{~kg} \mathrm{wk}^{-1}$. 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 $2^{\text {nd }}$ 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-atage 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).

[^14]
### 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: 230172 /(discards + landings: 3044778 ) 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 ( 57 kg ) 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 $<100 \mathrm{~mm}$ | Within metier, by quarter |
| TBB $>100 \mathrm{~mm}$ | Within metier, by quarter |


| OTB/TBB $<70 \mathrm{~mm}$ (DEF and CRU) | Within metier, all quarter |
| :--- | :--- |
| OTB $<100 \mathrm{~mm}$ | Within metier, by quarter |
| OTB $>100 \mathrm{~mm}$ | Within metier, by quarter |
| SSC/ SDN $>70 \mathrm{~mm}$ | 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 $\mathrm{R}^{2}$ 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 $\mathrm{R}^{2}$ 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 timeseries 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.

## M aturity

See Stock Annex for full details.

## Natural mortality

A constant value of $\mathrm{M}=0.2$ 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 | $\mathbf{2 0 2 0}$ |
| :--- | :--- |
| 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 <br> varying Linf |
| Catch weights at age | Von Bertalanffy growth curve with time <br> varying Linf |
| Total Landings | Not used |
| Landings at age | $1981-1990,1998,2000-$ present <br> DiscardsNot used (assumed 0) <br> Abundance indicesBTS-ISIS 1991-present <br> SNS 2004-present |
| Standardized NL-BT2 LPUE age-aggre- <br> gated 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 Btrigger ( 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 atage 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 SRpairs (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 $\mathrm{F}_{\mathrm{pa}}$ with $\mathrm{Fp}_{\mathrm{p} .05}$. $\mathrm{Fp}_{\mathrm{p} .05}$ 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. Fr. 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. M SY $\mathrm{B}_{\text {trigger }}$ | 6353 |
| 2. $\mathrm{B}_{\mathrm{pa}}$ | 4163 |
| 3. $\mathrm{B}_{\mathrm{lim}}$ | 2974 |
| 4. $\mathrm{F}_{\mathrm{pa}}=\mathrm{F}_{\mathrm{P} .05}$ | 0.47 |
| 5. $\mathrm{F}_{\text {lim }}$ | 0.61 |
| 7. $\mathrm{F}_{\mathrm{MSY}}$ | 0.36 |
| 8. $\mathrm{F}_{\mathrm{MSY} \text { lower }}$ | 0.25 |
| 9. $\mathrm{F}_{\mathrm{MSY} \text { upper }}$ | 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 |
| :--- | :---: | :--- |
| $\mathrm{F}_{\text {ages 2-6 (2020) }}$ | 0.36 | $\mathrm{~F}_{\text {sq }}=\mathrm{F}_{\text {average }}$ of F (2017-2019) |
| SSB (2021) | 9161 | Short-term forecast |
| $\mathrm{R}_{\text {agei }}$ (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) | $\begin{aligned} & \text { F (2-6) } \\ & (2021) \end{aligned}$ | SSB (2022) | \% SSB change | \% advice change |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| M SY approach: FM SY | 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 |
| $\mathrm{F}=0$ | 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) $=$ M SY Btrigger | 7194 | 6402 | 792 | 0.79 | 6353 | -31 | 59 |
| Rollover advise | 4537 | 4038 | 499 | 0.43 | 8879 | -3 | 0 |
| Multi-options table |  |  |  |  |  |  |  |
| $\mathrm{F}=0$ | 0 | 0 | 0 | 0 | 13303 | 46 | -100 |
| $\mathrm{F}=0.05$ | 635 | 565 | 70 | 0.05 | 12671 | 39 | -86 |
| $\mathrm{F}=0.10$ | 1238 | 1102 | 136 | 0.10 | 12073 | 32 | -73 |
| $\mathrm{F}=0.15$ | 1813 | 1613 | 200 | 0.15 | 11506 | 26 | -60 |
| $\mathrm{F}=0.20$ | 2359 | 2099 | 260 | 0.20 | 10968 | 20 | -48 |
| $\mathrm{F}=0.25$ | 2879 | 2562 | 317 | 0.25 | 10458 | 14.5 | -37 |
| $\mathrm{F}=0.30$ | 3375 | 3003 | 371 | 0.30 | 9974 | 9.2 | -26 |
| $\mathrm{F}=0.35$ | 3846 | 3423 | 423 | 0.35 | 9515 | 4.2 | -15.2 |
| $\mathrm{F}=0.40$ | 4296 | 3823 | 473 | 0.40 | 9079 | -0.6 | -5.3 |
| $\mathrm{F}=0.45$ | 4724 | 4204 | 520 | 0.45 | 8666 | $-5.1$ | 4.1 |
| $\mathrm{F}=0.50$ | 5132 | 4567 | 565 | 0.50 | 8274 | -9.4 | 13.1 |

[^15]
### 21.7 M anagement 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 $5 \times 5$ 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 17 cm to 62 cm for turbot and 21 cm to 54 cm for brill (Figure 21.9.2). Ageing was done over 1 cm -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 |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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 | 1 |
| 2007 | 3509 | 1 |  |
| 2008 | 3005 | 1 | 1 |
| 2009 | 3089 | 1 | 97 |
| 2010 | 2692 | 1 | 158 |
| 2011 | 2771 | 1 | 112 |
| 2012 | 2914 | 1 | 666 |
| 2013 | 2982 | 1 | 496 |
| 2014 | 3922 | 1 | 486 |
| 2015 | 3493 | 3140 | 1 |

Table 21.2.2a. Turbot in Area 4. Raw weights at age in the landings (units: kg ).

| Year | Age |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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 |  |  | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |  |  |  |
| 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 |


| Year | Age |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |


|  | Age |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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: $\mathbf{~ g g}$ )

| 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 |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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: $\mathbf{k g}$ )

| Year | Age |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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

| Year | Age |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |  | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |  |  |
| 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 |


| Year | Age |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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

| Year | Age |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |


| Year | Age |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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 | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ |  |  |  |  |  |  |
| 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

|  | Age |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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 |


| Year | Age |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |


| Age |  |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ |
| 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

|  | Age |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ |
| 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 |  | $\mathbf{Z}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |  |  |
| 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 |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ |
| 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).

## Landings at age



Figure 21.2.2. Turbot in 27.4.20. Landings at age for the years with available data between 1975-2019. Data for 19911997 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.

## Retrospective pattern in F at age



Figure 21.4.4. Retrospective analysis plot of selectivity pattern.

Turbot in IV


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 $F, \log N$ to the random walk in $N, \operatorname{logObs}$ 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.

Observation variances by data source


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.

Turbot 27.4


Figure 21.6.2 Productivity over time

Turbot 27.4


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 $5 \times 5 \mathrm{~km}$ 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 1 cm -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 (M erlangius 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 20000 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 |  |
| BM S 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

$$
\begin{aligned}
& \log (\mu \mathrm{i})=\operatorname{Gear}(\mathrm{i})+\mathrm{f}_{1}\left(\operatorname{lon}_{\mathrm{i}}, \text { lati }_{\mathrm{i}}\right)+\mathrm{f}_{2}\left(\text { timeOfYear }_{\mathrm{i}}, \operatorname{lon}_{\mathrm{i}}, \text { lat }_{\mathrm{i}}\right)+\mathrm{f} 3\left(\text { time }_{\mathrm{i}}, \operatorname{lon}_{\mathrm{i}}, \text { lati }_{\mathrm{i}}\right)+\mathrm{f}_{4}\left(\text { depth }_{\mathrm{i}}\right)+ \\
& \mathrm{U}(\mathrm{i})_{\text {ship:gear }}+\log \left(\text { HaulDuri }_{\mathrm{i}}\right)
\end{aligned}
$$

that includes a time-invariant spatial effect ( $\mathrm{f}_{1}$ ), a seasonal repeating pattern ( $\mathrm{f}_{2}$ ), a space-time interaction effect ( $\mathrm{f}_{3}$ ) 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 ( $\mathbf{t}$ ) 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 20022018 were updated in WKDEM 2020 (ICES, 2020).

| Year | Denmark (1) |  |  | Norway | Sweden | Others | Total | WG estimate of Discards |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1975 | 19,018 |  |  | 57 | 611 | 4 | 19,690 |  |
| 1976 | 17,870 |  |  | 48 | 1,002 | 48 | 18,968 |  |
| 1977 | 18,116 |  |  | 46 | 975 | 41 | 19,178 |  |
| 1978 | 48,102 |  |  | 58 | 899 | 32 | 49,091 |  |
| 1979 | 16,971 |  |  | 63 | 1,033 | 16 | 18,083 |  |
| 1980 | 21,070 |  |  | 65 | 1,516 | 3 | 22,654 |  |
|  | Total consumption | Total industrial | Total |  |  |  |  |  |
| 1981 | 1,027 | 23,915 | 24,942 | 70 | 1,054 | 7 | 26,073 |  |
| 1982 | 1,183 | 39,758 | 40,941 | 40 | 670 | 13 | 41,664 |  |
| 1983 | 1,311 | 23,505 | 24,816 | 48 | 1,061 | 8 | 25,933 |  |
| 1984 | 1,036 | 12,102 | 13,138 | 51 | 1,168 | 60 | 14,417 |  |
| 1985 | 557 | 11,967 | 12,524 | 45 | 654 | 2 | 13,225 |  |
| 1986 | 484 | 11,979 | 12,463 | 64 | 477 | 1 | 13,005 |  |
| 1987 | 443 | 15,880 | 16,323 | 29 | 262 | 43 | 16,657 |  |
| 1988 | 391 | 10,872 | 11,263 | 42 | 435 | 24 | 11,764 |  |
| 1989 | 917 | 11,662 | 12,579 | 29 | 675 | - | 13,283 |  |
| 1990 | 1,016 | 17,829 | 18,845 | 49 | 456 | 73 | 19,423 |  |
| 1991 | 871 | 12,463 | 13,334 | 56 | 527 | 97 | 14,041 |  |
| 1992 | 555 | 3,340 | 3,895 | 66 | 959 | 1 | 4,921 |  |
| 1993 | 261 | 1,987 | 2,248 | 42 | 756 | 1 | 3,047 |  |
| 1994 | 174 | 1,900 | 2,074 | 21 | 440 | 1 | 2,536 |  |
| 1995 | 85 | 2,549 | 2,634 | 24 | 431 | 1 | 3,090 |  |
| 1996 | 55 | 1,235 | 1,290 | 21 | 182 | - | 1,493 |  |
| 1997 | 38 | 264 | 302 | 18 | 94 | - | 414 |  |
| 1998 | 35 | 354 | 389 | 16 | 81 | - | 486 |  |
| 1999 | 37 | 695 | 732 | 15 | 111 | - | 858 |  |
| 2000 | 59 | 777 | 836 | 17 | 138 | 1 | 992 |  |
| 2001 | 61 | 970 | 1,031 | 27 | 126 | + | 1,184 |  |
| 2002 | 164 | 1347 | 1510 | 23 | 134 | 1 | 1669 | 2373 |
| 2003 | 104 | 641 | 745 | 20 | 72 | 2 | 839 | 1837 |
| 2004 | 252 | 954 | 1206 | 17 | 74 | 1 | 1298 | 2782 |
| 2005 | 110 | 853 | 962 | 13 | 73 | 0 | 1048 | 1625 |
| 2006 | 71 | 410 | 481 | 11 | 86 | 0 | 578 | 1497 |
| 2007 | 57 | 275 | 332 | 14 | 82 | 1 | 429 | 1524 |
| 2008 | 54 | 286 | 340 | 14 | 52 | 0 | 407 | 795 |
| 2009 | 73 | 172 | 245 | 10 | 34 | 0 | 289 | 778 |
| 2010 | 49 | $158$ | 207 | 10 | 30 | 1 | 248 | 803 |


| Year | Denmark (1) |  |  | Norway | Sweden | Others | TotalWG estimate of <br> 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 (M erlangius 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 7 d 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 24195 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 13052 tonnes and human consumption catch of no more than 21088 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 22082 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 12737 tonnes and human consumption catch of no more than 19354 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 13678 tonnes and for 2017 the TAC was increased to 16003 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 17191 tonnes and for 2020 was 17158 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, 27500 tonnes in 2017, 22213 tonnes in 2018, 19184 tonnes in 2019, 10863 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 $7 . \mathrm{d}$ is 27 cm . The minimum mesh size for targeting whiting in Subarea 4 is 120 mm and in Division $7 . \mathrm{d}$ 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 ( $1,2 \mathrm{vs} 3,4$ ). 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 7 d 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 19912019, 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
Survey: IBTS Q1
Survey: IBTS Q3
$minAge
    0
$maxAge
    8
$maxAgePlusGroup
    1
```

```
$keyLogFsta
    0
    -1 
    -1 
$corFlag
2
$keyLogFpar
\begin{tabular}{rrrrrrrrr}
-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
\end{tabular}
$keyQpow
    -1 
    -1
    -1
$keyVarF
\begin{tabular}{rrrrrrrrr}
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
\end{tabular}
$keyVarLogN
0 1 1 1 1 1 1 1 1
$keyVarObs
\begin{tabular}{rrrrrrrrr}
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
\end{tabular}
$obsCorStruct
    "ID" "AR" "AR"
$keyCorObs
    NA NA NA NA NA NA NA NA
    -1
    2
$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 $\log (\mathrm{N})$ ) 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 FmsY 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 Blim. 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). $\mathrm{F}_{\mathrm{p} .05}$ was calculated by running Eqsim to ensure that the long term risk of SSB < Blim of any F used does not exceed $5 \%$ when applying the advice rule. Accordingly, $\mathrm{Fmsy}_{\text {had }}$ had to be set to $\mathrm{F}_{\mathrm{p} .05}=0.172$. 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 $\mathrm{F}_{2020}$ equal to mean $\mathrm{F}_{2019}$ (using the average selectivity over the last 3 historical years) results in human consumption catches in the intermediate year 2020 of 28930 tonnes from a total catch of 31080 tonnes, giving an SSB in 2020 of 169998 tonnes (Table 23.26).

Carrying the same fishing mortality forward into 2021 (the status quo F option, $\mathrm{F}_{\mathrm{sq}}$ ) would result in human consumption catches of 29310 tonnes out of total catches of 31512 tonnes, and would result in an SSB of 181394 tonnes in 2022 (a $0.69 \%$ increase in SSB relative to 2021).

Since SSB in 2021 are predicted to be higher than MSY Btrigger, following the MSY approach allows for applying Fmsy leading to an $\mathrm{F}_{\text {target }}$ of 0.172 .

Applying the FMSY of 0.172 in 2021 would generate human consumption catches of 24071 tonnes out of total catches of 26304 tonnes, and result in an SSB of 185094 tonnes in 2022 (a $2.7 \%$ increase in SSB relative to 2021). In 2022, SSB would be above $B_{\lim }$ and MSY Btrigger. 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-atage 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 Fmsy. 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 $B_{\text {lim }}$ 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 $\mathrm{F}_{\mathrm{MSY}}=0.172$, but has been below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{Flim}_{\text {. }}$ 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 20142016 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 $B_{\text {trigger. }}$

### 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 243570 tonnes in 1979 to 31286 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 | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ | $\mathbf{2 0 1 1}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | 1301 | 1322 | 680 | 1209 | 2560 | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ |
| england.wales.4 | 10589 | 7756 | 5734 | 5057 | 3441 | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ |
| scotland.4 | 18834 | 15608 | 11255 | 9491 | 8394 | 15660 | 16275 | 14451 | 12320 | 11690 | 12554 |
| total.landings.4 | -426 | 738 | 805 | 541 | -2286 | 563 | 609 | 972 | -124 | -1111 | -706 |
| unallocated.landings.4 | 19260 | 14870 | 10450 | 8950 | 10680 | 15097 | 15666 | 13479 | 12444 | 12801 | 13260 |
| ices.landings.4 | 16130 | 17144 | 26135 | 18142 | 10300 | 14018 | 5206 | 8356 | 6597 | 8451 | 7989 |
| ices.unwanted.catch.4 | 940 | 7270 | 2730 | 1210 | 890 | 2190 | 1240 | 0 | 1344 | 1907 | 1035 |
| ices.ibc.4 | 36330 | 39284 | 39315 | 28302 | 21870 | 31305 | 22112 | 21835 | 20385 | 23159 | 22283 |
| ices.catch.4 | 29700 | 41000 | 16000 | 16000 | 28500 | 23800 | 23800 | 17850 | 15173 | 12897 | 14832 |
| tac.4.2.a |  |  |  |  |  |  |  |  |  |  |  |


| Year | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ | $\mathbf{2 0 2 0}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $N A$ | 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 | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ |  |
| scotland.4 | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ | $N A$ |  |
| 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 | $\mathbf{1 9 9 1}$ | $\mathbf{1 9 9 2}$ | $\mathbf{1 9 9 3}$ | $\mathbf{1 9 9 4}$ | $\mathbf{1 9 9 5}$ | $\mathbf{1 9 9 6}$ | $\mathbf{1 9 9 7}$ | $\mathbf{1 9 9 8}$ | $\mathbf{1 9 9 9}$ | $\mathbf{2 0 0 0}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $\mathbf{2 0 0 1}$ | $\mathbf{2 0 0 2}$ | $\mathbf{2 0 0 3}$ | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | $\mathbf{2 0 1 0}$ | $\mathbf{2 0 1 1}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 4}$ | $\mathbf{2 0 1 5}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 9}$ | $\mathbf{2 0 2 0}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |
| :--- | :---: |
| BM S 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 <br> tonnes | Percent |
| :--- | :--- | :---: | :---: |
| BM S 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 <br> distribution | CATON <br> 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 |
| BM S landing | Imported | Estimated | 5.631 | 11 |
| BM S 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 |
| BM S 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 |
| BM S 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 |
| BM S 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 |
| BM S landing | Imported | Estimated | 27.4 | 5.601 | 11 |
| BM S 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ | $\mathbf{8 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1 9 7 8}$ | 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |

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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ | $\mathbf{8 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ | $\mathbf{8 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ | $\mathbf{8 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |

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 | $\mathbf{0}$ |  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |  |  |  |  |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| :---: | :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| ---: | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8 +}$ |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 | $\begin{gathered} R \\ (\text { age } 0) \end{gathered}$ | Low | High | SSB | Low | High | $\underset{(2-6)}{F}$ | 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 | $\begin{gathered} R \\ (\text { age } 0) \end{gathered}$ | Low | High | SSB | Low | High | $\begin{gathered} F \\ (2-6) \end{gathered}$ | 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 |
| transflRARdist_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 |
| :--- | :---: |
| $\mathrm{B}_{\text {lim }}$ | $119970 \mathrm{t}\left(\mathrm{B}_{\text {loss }}\right)$ |
| $\mathrm{F}_{\text {lim }}$ | 0.458 |
| $\mathrm{~B}_{\mathrm{pa}}$ | $166708 \mathrm{t}\left(\mathrm{MSY} \mathrm{B}_{\text {trigger }}\right)$ |
| $\mathrm{F}_{\mathrm{pa}}$ | 0.330 |
| $\mathrm{~F}_{\mathrm{p} .05}$ (with $\left.\mathrm{B}_{\text {trigger }}\right)$ | 0.172 (final $\left.\mathrm{F}_{\mathrm{MSY}}\right)$ |

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 <br> 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).



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: M FDP 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) $=\mathbf{1 2}$ 204 million (geometric mean 2002-2019); TAC 27.4 (2020) $=17158$.

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 | $\begin{aligned} & 27.4 \mathrm{HC} \\ & \text { catch } \end{aligned}$ | $\begin{gathered} 27.7 \mathrm{~d} \\ \text { HC catch } \end{gathered}$ | 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 |  |  |





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 |  |  |  |  |  |  |


| Age | $\begin{gathered} \text { Q1 } \\ 1 \end{gathered}$ | South <br> 2 | 3 | 4 | 5 | $\begin{gathered} \text { Q3 } \\ 0 \end{gathered}$ | South <br> 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.


age 3




$$
\begin{aligned}
& \text { - IBTS-Q1 } \\
& -\quad \text { IBTS-Q3 }
\end{aligned}
$$

Figure 23.11. Whiting in Subarea 4 and Division 7.d: Survey log CPUE (catch per unit effort) at age.

IBTS-Q1


IBTS-Q3


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.


IBTS-Q3

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 $\mathbf{9 0} \% \mathrm{Cl}$. 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.

## Commercial Catch Data



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 26. The $x$-axis represents the spawning year of each cohort.


Figure 23.21. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ( $p<0.05$ ) regression, while a thin line (and blue points) is not significant. Approximate $95 \%$ confidence intervals for each fit are also shown.



Figure 23.22. Whiting in Subarea 4 and Division 7.d: SAM assessment results using catch data series (1978-2019) 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 $\mathbf{N}$ and fishing mortality F processes).


Figure 23.25. Whiting in Subarea 4 and Division 7.d: SAM standardized one-observation-ahead residuals.


Figure 23.26. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale) for the catch fleet.


Figure 23.27. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q1.


Figure 23.28. Whiting in Subarea 4 and Division 7.d: SAM predicted line and observed points (log scale), for survey fleet IBTS Q3.



Figure 23.29. Whiting in Subarea 4 and Division 7.d: SAM leave-one-out diagnostics. Final run (black), run without IBTS Q1 (dark blue), run without IBTS Q3 (light blue).



Figure 23.30. Whiting in Subarea 4 and Division 7.d: SAM Retrospective pattern in catch estimates, SSB, fishing mortality and recruitment.


Figure 23.31. Whiting in Subarea 4 and Division 7.d: Stock-recruitment relationship.


Figure 23.32. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final SAM (black) and SURBAR (orange) models. To facilitate comparison, recruitment and SSB values have been mean-standardised using
the year range for which estimates are available from all three models. Mortality is presented as total mortality $\mathbf{Z}(2-4)$ 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


#### Abstract

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 Fmsy 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 |
| $7 . \mathrm{d}$ | 0.77 | 0.02 | 0 |
| Total | $\mathbf{2 5 7 9 . 6 8}$ | $\mathbf{2 1 5 . 9 8}$ | $\mathbf{1 . 0 1}$ |

### 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 20092017 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 $0.2 \mathrm{y}^{-1}$ 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 agespecific 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:

$$
\log T L W_{y}=\log \left(\sum_{a=1}^{10^{+}}\left(\frac{F_{a, y}}{Z_{a, y}}\left(1-e^{-Z_{a, y}}\right) N_{a, y}\right) \bar{\psi}_{a,} \bar{W}_{a,}^{(l)}\right)+\varepsilon_{y}^{(t l w)}
$$

where $\epsilon^{(t l w)}$ 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 logcatches. No additional model parameters are required.

The observation equation for the fishable stock biomass (FSB) was:

$$
\log F S B_{y}=\log Q^{(s)}+\log \widehat{F S B}_{y}+\varepsilon_{y}^{(s)}
$$

where $\boldsymbol{Q}^{(\boldsymbol{s})}$ is the survey specific catchability, $\boldsymbol{s}$ denotes the survey and $\boldsymbol{\epsilon}_{\boldsymbol{y}}^{(\boldsymbol{s})}$ 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 $24.5 \mathrm{a}-\mathrm{c}$. Natural mortality was assumed to be equal to $0.2 \mathrm{y}^{-1}$ 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. $27.3 \mathrm{a} 47 \mathrm{~d} \_2020$ ". 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 |

[^16]| -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)

$$
\begin{array}{rrrrrrrrrr}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1
\end{array}
$$

## \$keyVarLogN

\# Coupling of process variance parameters for $\log (N)$-process 0111111111

## \$keyVarObs

\# Coupling of the variance parameters for the observations.

$$
\begin{array}{rrrrrrrrrr}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 \\
2 & 2 & 2 & 2 & 2 & 2 & -1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
3 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
4 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1
\end{array}
$$

## \$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 $A R(1)$ 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
$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. Blim was estimated as the change point of the segmented regression with autocorrelation equal to

3069 tonnes. $B_{\text {pa }}$ was set equal to the $95^{\text {th }}$ percentile of the distribution of the estimated SSB when SSB was set equal to $B_{\lim }$ (i.e. $B_{\lim }{ }^{*} \mathrm{e}^{-1.645}$ sigmaSSB, where sigmaSSB is the standard deviation estimate of $\ln (\mathrm{SSB})$ in the final year of the assessment). Similarly, $\mathrm{F}_{\mathrm{pa}}$ was calculated as the $95^{\text {th }}$ percentile of the distribution of F , when F is equal to $\mathrm{Flim}_{\text {(i.e. }}^{\operatorname{Flim}}{ }^{*} \mathrm{e}^{-1.645}$ sigmaF , where sigmaF is the standard deviation estimate of $\ln (\mathrm{F})$ in the final year of the assessment).

The recommended default values of $\operatorname{cvF}=0.212$, $\mathrm{phiF}=0.423$ and $\operatorname{cvSSB}=0$ were applied to the simulation since no assessment/advice history is available for this stock. Fmsy was estimated equal to 0.154 , which is below the originally-estimated $\mathrm{F}_{\mathrm{pa}}(0.21)$ and the re-estimated $\mathrm{F}_{\mathrm{pa}}$ (capped by Fr. 05 without AR; 0.20).

MSY $B_{\text {trigger }}$ was set equal to $\mathrm{B}_{\mathrm{pa}}$, as it was not considered likely that the stock had been fished at Fmsy in the last 5 years.
The fishing mortality that leads to $5 \%$ probability of SSB falling below $\operatorname{Blim}$ ( Fp .05 ) was estimated during the benchmark meeting both including the ICES advice rule (AR), leading to $0.28 \mathrm{y}^{-1}$., and excluding the AR, leading to $0.20 \mathrm{y}^{-1}$. The former was greater than the originally estimated FMSY upper, ( $0.21 \mathrm{y}^{-1}$ ) so was not used to cap $\mathrm{F}_{\mathrm{MSY}}$ upper, but the latter was less than the originally-estimated $\mathrm{F}_{\mathrm{pa}}\left(0.21 \mathrm{y}^{-1}\right)$, and was therefore used to cap $\mathrm{F}_{\mathrm{pa}}$. 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 24699 thousand individuals (range: 18 46536285 thousand individuals). The fishing mortality in 2020 is assumed to be equal to the last estimate ( $\mathrm{F}_{2019}=\mathrm{F}_{2020}=0.20 \mathrm{y}^{-1}$ ) and the corresponding catch was 2472 tonnes. The spawning stock biomass in the intermediate year was 5644 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 ( $\mathrm{F}=\mathrm{F}$ 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 (M ohn's rho) for the recruits ( R , age 1 ), spawning stock biomass (SSB) and fishing pressure ( $\mathrm{F}_{4.8}$ ).

| Quantity | Mohn's rho |
| :--- | :--- |
| R(age 1) | -0.1933 |
| SSB | -0.1025 |
| $\mathrm{~F}_{4-8}$ | 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 (19401949) 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 $0.20 \mathrm{y}^{-1}$, above Fmsy ( $0.154 \mathrm{y}^{-1}$ ). The biomass of the stock ( 5993 tonnes) was above the MSY Btrigger ( 4745 tonnes) and the stock was at full reproductive capacity, i.e. the biomass is above $\mathrm{B}_{\lim }$ ( 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 ( $\mathrm{F}_{\mathrm{prop}}$ and $\mathrm{M}_{\text {prop }}$ ) 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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Kristensen, K., Nielsen, A., Berg, C. W., Skaug, H. J., \& Bell, B. (2016). TMB: Automatic differentiation and laplace approximation. Journal of Statistical Software, 70(5), 1-21.

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 | $\begin{aligned} & \text { ICES } \\ & \text { catches } \end{aligned}$ | ICES discards | IBTS-Q1 index | IBTS-Q3 in- dex | 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 <br> landings | ICES Landings | ICES <br> catches | ICES discards | IBTS-Q1 index | IBTS-Q3 in- <br> dex | Discard <br> 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 | $\mathbf{4}$ | 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 | $\mathbf{4}$ | 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 |  | 110 | 57 |

Table 24.4. Witch flounder in Subarea 4 and Division 3.a and 7.d: Catch in numbers at age.

| Year/ Age | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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).

| $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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.

| $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 *}$ | $\mathbf{1 1 *}$ | $\mathbf{1 2 *}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1 9 8 9}$ | 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 cat <br> ch <br> (20 <br> 21) | Projected landings (2021) | Projected discards (2021)* | $\begin{gathered} F_{\text {total }} \\ \text { ages 4-8 } \\ \text { (2021 \& } \\ \text { 2022) } \end{gathered}$ | $\begin{gathered} \text { SSB } \\ (2021) \end{gathered}$ | $\begin{gathered} \text { SSB } \\ (2022) \end{gathered}$ | \% SSB change ** | \% Advice change *** |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |  |  |  |
| MSY approach: $\mathrm{F}_{\text {MSY }}$ | $\begin{gathered} 173 \\ 3 \end{gathered}$ | 1681 | 53 | 0.154 | 5490 | 5476 | -0.25 | 5.0 |
| Other scenarios |  |  |  |  |  |  |  |  |
| $F_{\text {mss-upper }}$ | $\begin{gathered} 229 \\ 5 \end{gathered}$ | 2228 | 67 | 0.21 | 5327 | 5006 | -6.0 | 39 |
| $\mathrm{F}_{\text {MSY-ower }}$ | $\begin{gathered} 124 \\ 3 \end{gathered}$ | 1210 | 33 | 0.108 | 5635 | 5898 | 4.7 | -25 |
| $\mathrm{F}=0$ | 0 | 0 | 0 | 0 | 5976 | 6992 | 17.0 | -100 |
| $\mathrm{F}_{\mathrm{pa}}$ | $\begin{gathered} 219 \\ 5 \end{gathered}$ | 2131 | 65 | 0.20 | 5353 | 5082 | -5.1 | 33 |
| Flim | $\begin{gathered} 313 \\ 5 \end{gathered}$ | 3033 | 103 | 0.30 | 5074 | 4341 | -14.4 | 90 |
| $\mathrm{F}_{\text {sq }}$ | $\begin{gathered} 221 \\ 5 \end{gathered}$ | 2150 | 66 | 0.20 | 5348 | 5063 | -5.3 | 34 |
| SSB (2022) $=\mathrm{Bl}_{\text {lim }}$ | $\begin{gathered} 494 \\ 2 \end{gathered}$ | 4793 | 149 | 0.53 | 4508 | 3069 | -32 | 199 |
| SSB (2022) $=\mathrm{B}_{\text {pa }}$ | $\begin{gathered} 262 \\ 9 \end{gathered}$ | 2547 | 82 | 0.24 | 5222 | 4745 | -9.1 | 59 |
| SSB (2022) $=$ M SY $\mathrm{B}_{\text {trig }}$ | $\begin{gathered} 262 \\ 9 \end{gathered}$ | 2547 | 82 | 0.24 | 5222 | 4745 | -9.1 | 59 |
| Roll-over advice | $\begin{gathered} 165 \\ 1 \end{gathered}$ | 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 Btrrigger | 4745 tonnes |
| Blim | 3069 tonnes |
| $\mathrm{B}_{\mathrm{pa}}$ | 4745 tonnes |
| $\mathrm{F}_{\text {MSY }}$ | $0.154 \mathrm{y}^{-1}$ |
| $\mathrm{F}_{\text {MSY upper }}$ | $0.21 \mathrm{y}^{-1}$ |
| Fmstlower | $0.108 \mathrm{y}^{-1}$ |
| Flim | $0.30 \mathrm{y}^{-1}$ |
| $\mathrm{Fpa}^{*}$ | $0.20 \mathrm{y}^{-1}$ |


| $\mathrm{FP}_{\mathrm{P} .5}$ (with AR) | $0.28 \mathrm{y}^{-1}$ |
| :--- | :--- |
| $\mathrm{~F}_{\mathrm{P} 0.5}$ (without AR) | $0.20 \mathrm{y}^{-1}$ |

* The original FpA was 0.21 , but this is greater than Fr.0s (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.
(A)

(C)

(B)

(D)


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 ( $\mathrm{F}_{2021}=$ $F_{\text {MSY }}=0.154 \mathrm{y}^{-1}$ ) of the spawning stock biomass (SSB, in kg, top), the fishing pressure ( $\mathrm{F}_{4-8}$, 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 | United Kingdom |
| Nicola Walker | Norway |
| Fabian Zimmermann |  |

## 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

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)

International Council for the Exploration of the Sea

## Conseil international pou

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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 allocationneeds 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 $1^{1{ }^{\text {th }}}$ March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by $25^{\text {m }}$ 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 $19^{\text {th }}$ 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 Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season<br>Herring Assessment Working Group for the Area South of $62^{\circ} \mathrm{N}$<br>Working Group on North Atlantic Salmon*<br>Assessment Working Group on Baltic Salmon and Trout*<br>Baltic Fisheries Assessment Working Group<br>Arctic Fisheries Working Group<br>Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak<br>North-Western Working Group<br>Working Group on the Biology and Assessment of Deep-sea Fisheries Resources<br>Working Group for the Bay of Biscay and the Iberian Waters Ecoregion<br>Working Group for the Celtic Seas Ecoregion<br>Working Group on Southern Horse Mackerel, Anchovy, and Sardine<br>Working Group on Elasmobranch Fishes<br>*These groups already have different approaches.

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 agestructured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for $\mathrm{R}, \mathrm{SSB}$ 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.

[^17]
## 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

civ) 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 agestructured 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, <br> 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, <br> 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- <br> gat) |
| 9 | tur.27.4_SA | Turbot (Scophthalmus maximus) in Subarea 4 <br> (North Sea) |
| 10 | whit.27.3a47d_SA | Whiting (Merlangius merlangus) in Division 3.a (Skag-errak and Katte- <br> gat) |

## Annex 5: Audit reports

## Audit of B11.27.3a47de

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 $\rightarrow$ Decision was made to use the new time series.
15) Stock status: ICES assesses that fishing pressure on the stock is above Fmsy but below $\mathrm{F}_{\mathrm{p}}$ and Flim; spawning-stock size is at MSY $\mathrm{B}_{\text {trigger }}$ and $\mathrm{B}_{\mathrm{pa}}$,
16) Management Plan: Part of the EU plan. Shared stock with Norway $\rightarrow$ 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 ( $\mathrm{F}=0.208$ 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: $\mathrm{BmSY}_{\text {M }}(\mathrm{L}($ mean $) / \mathrm{L}(\mathrm{F}=\mathrm{M}))>1$ (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 $\mathrm{L}($ mean $) / \mathrm{L}(\mathrm{F}=\mathrm{M})$ 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 $\mathrm{F}_{\text {msy }}$ 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 $\mathrm{F}_{\mathrm{msy}}$ 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 $F_{M S Y}$ proxy, $F_{p a}, F_{\text {lim; }}$; SSB above MSY Btrigger proxy and above $B_{p a}, B_{l i m}$.
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 7 d 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. 6 <br> knots  <br> Tensor spline for F-at-age, ages, no. knots 8 <br> Tensor spline for F-at-age, years, no. knots 28 $\mathbf{l}$ |  |

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 $\mathrm{F}_{\mathrm{msy}}$ but below $\mathrm{F}_{\mathrm{pa}}$ and $\mathrm{Flim}_{\text {; }}$ and spawning-stock size is below MSY $B_{\text {trigger }}$ and between $B_{p a}$, and $B_{l i m}$.
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 FMSy, 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 reuploaded 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 $\mathrm{F}_{\text {lim }}$ and point estimate of spawning stock size is below $\mathrm{Blim}_{\mathrm{lim}}$.
65) Man. Plan.: There is currently no management plan agreed by all parties. Advice should be given according to ICES FMSY 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 7 d 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.

[^18]
## 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 Fpa to Fp. 05 (without the advice rule, i.e. "without AR"), and the headline advice for 2020 was on the basis of PA using $\mathrm{FPA}_{P A}=\mathrm{Fr}_{\mathrm{P} .05}$ ( 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 FPA (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 $\mathrm{F}_{\mathrm{PA}}$ (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 ( $\mathrm{M}=0.2 \mathrm{yr}^{-1}$ ), 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 ( $-11 \%$ ), $\mathrm{F}(+8 \%)$ and recruitment $(-5 \%)$.
72) Stock status: F is only slightly above Fmsy and SSB well above MSY Btriger.
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 $L_{\infty}$ 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 $\mathrm{F}_{\text {PA }}$ as 0.43 . This should be updated to $\mathrm{F}_{\text {PA }}=\mathrm{FP}_{\mathrm{P} .05}$ (without AR)=0.47 to reflect the decision during WGNSSK 2019 to change the way Fpa was calculated. Furthermore, to distinguish it from the above, I would write in that table $\mathrm{Fp}_{\mathrm{P} .05}$ (with AR ) $=0.86$ - this is the $\mathrm{F}_{\mathrm{P} .05}$ that is used to check the FMSY 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 Fpa (row 4) and replacing it with $F_{P A}=F_{p .05}$ (without $A R$ ) $=0.47$. 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 Fmsy 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 FPA, 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 Q3Q4 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 20182020. Also in previous year advice the geometric mean of the whole time-series (19802017) 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 $1^{\text {st }}$ 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 $\mathrm{F}_{\text {mSY }}$ lower and $\mathrm{F}_{\text {msY upper }}$ 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 ${ }^{\wedge \wedge}$ 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: $\mathrm{B}>$ 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:
92) Forecast:
93) Assessment model:
94) Data issues:
95) Consistency:

## analytical

presented
SAM - tuning by 2 age indices and 2 biomass indices
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.

Last year's assessment was accepted. Stock was benchmarked in 2018
96) Stock status:
97) Management Plan:
$B>$ MSY Btrigger and has been for a few years, F> Fmsy but relatively constant. R has decreased since 2009 while catches have increased.

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 FmSY and spawning stock size is above MSY $\mathrm{B}_{\text {trigger }}$
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 " 41818 " in Section 8.1.3.2,
- Footnote of Table 4 b still refers to non-existing Table 7a. I assume this to mean Table 4 a (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.


[^0]:    General rights
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[^1]:    ICES
    INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
    CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

[^2]:    ${ }^{1}$ These do not apply to WGNAS.

[^3]:    (") Vessels listed as subject to the landing obligation in this fishery in accordance with Commission Delegated Regulation (6U) 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:

[^4]:    ${ }^{1}$ At WGNSSK 2018, a mistake was discovered in the final inter-benchmark run of turbot. This involved an even higher increase.

[^5]:    * preliminary catch statistics

[^6]:    * preliminary catch statistics

[^7]:    * preliminary catch statistics

[^8]:    $\wedge$ 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).

[^9]:    * 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.
    ** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

[^10]:    ${ }^{1}$ 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).

[^11]:    1 Input data, source code and output of the index standardization will be available at the https://github.com/icestaf/2020 sol.27.4 survey/TAF repository.

[^12]:    2 https:/flr-project.org
    3 https:/flr-project.org/FLasher
    $4 \underline{\mathrm{https}: / / g i t h u b . c o m / i c e s-t a f / 2020}$ sol.27.4 forecast/

[^13]:    
    
    
    
    
    

     | 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 |
    | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

    
    
    
    

[^14]:    ${ }^{1}$ see Stock Annex for turbot 27.4 for full details

[^15]:    * (projected landings) / ( 1 - average discard rate); average discard rate 2017-2019 = 11.0\%
    ** Marketable landings
    *** Including BMS landings (EU stocks), assuming recent discard rate.
    $\wedge$ SSB 2022 relative to SSB 2021.
    $\wedge \wedge$ Total catch in 2021 relative to advice value for 2020 (4538 t).

[^16]:    \$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).

[^17]:    ' Thesedo not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

[^18]:    Further minor comments were provided directly in the document.

