HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62° NORTH (HAWG)

VOLUME 06 | ISSUE 24

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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ISSN number: 2618-1371

Please note: This report will be published in parts. Estimated publication dates for the various sections and the full report are outlined below.

31 May 2024

- Section 3 Herring in Division 3a and subdivisions 22–24

29 February 2024

- Section 9 Sandeel in Division 3.a and Subarea 4 and Division 6.a

18 April 2024

- Section 10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)
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28 June 2024

- Full report

ICES Scientific Reports

Volume 06 | Issue 24

HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62° NORTH (HAWG)

Recommended format for purpose of citation:

ICES. 2024. Herring assessment Working group for the area south of 62° North (HAWG). ICES Scientific Reports. 06:24. 289 pp. https://doi.org/10.17895/ices.pub.25305532

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i Expert group information

Expert group name	Herring Assessment Working Group for the area south of 62° north (HAWG)
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chair(s)	Aaron Brazier, UK
	Nis Sand Jacobsen, Denmark
Meeting venue(s) and dates	23-25 January 2024, Copenhagen, Denmark and Online (11 participants)
	12-21 March 2024 Aberdeen, Scotland and Online (xx participants – tbd)

9 Sandeel in Division 3.a and Subarea 4 and Division 6.a

Larval drift models and studies on recruitment and growth differences have indicated that the assumption of a single stock unit in the area is invalid. As a result, the total stock is divided in several sub-populations (ICES, 20, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these eight areas (sandeel area (SA) 1r, 2r, 3r, 4, and 6 and subdivision 6a). Analytical stock assessments are currently carried out in SA 1r–3r and 4, whereas SA5, SA 6, SA 7r and subdivision 6a is managed under the ICES approach for data limited stocks (Category 6, 5, 6 and 6, respectively).

In 2010, the SMS-effort model was used for the first time to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2010. This model assumes that fishing mortality is proportional to fishing effort and is still used to assess sandeel in SAs 1r, 2r, 3r and 4.

Further information on the stock areas and assessment model can be found in the Stock Annexes and in the benchmark report (ICES, 2024a).

9.1 General

9.1.1 Ecosystem aspects

Sandeel in the North Sea can be divided into a number of more or less reproductively isolated sub-populations (see the Stock Annex). A decline in the sandeel population from 20001 to 2007 concurrent with a marked change in distribution increased the concern about local depletion, of which there has been some evidence (ICES, 2007; ICES, 2008; ICES 2016a). Since 2010 this has been accounted for by dividing the North Sea and 3.a into seven management areas.

Local depletion of sandeel aggregations at a distance less than 100 km from seabird colonies may affect some species of birds, especially black-legged kittiwake, and sandwich tern, whereas the more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

The Stock Annex contains a comprehensive description of ecosystem aspects.

9.1.2 Fisheries

General information about the sandeel fishery can be found in the Stock Annex.

The size distribution of the Danish fleet has changed through time, with a clear tendency towards fewer and larger vessels (ICES, 2007). During the last two decades, the number of Danish vessels participating in the North Sea sandeel fishery has been stable with around 100 active vessels.

The same tendency has been seen for the Norwegian vessels towards fewer and larger vessels. In 2008, 42 vessels participated in the sandeel fishery, but in 2023, 26 vessels participated in the fishery. From 2011 to 2023, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1677 tonnes.

The rapid changes of the structure of the fleet that have occurred in the past may introduce more uncertainty in the assessment, as the fishing pattern and efficiency of the current fleet may differ from the previous fleet and the participation of fewer vessels has limited the spatial coverage of the fishery. This is to some degree accounted for in the stock assessments through the introduction of separate catchability periods.

The sandeel fishery in 2023 was opened 1 April and continued until the end of July. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2023 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2024 (Escapement strategy). This approach resulted in an advised catch / TAC for 2023 in SA 1r, SA 2r, SA 3r, and 4 of 120 428 t/ 116 815 t, 40 997/40997 t t, 30 570 t / 62446 t and 35 020 t / 33 969 t, respectively. Advised catches for SA 5, SA 6, SA 7 and subdivision 6a for 2023 and 2024 are based on data limited approaches and set at 0 t, 140 t, 0 t and 0 t, respectively.

9.1.4 Norwegian advice

Based on a recommendation from the Norwegian Institute for Marine Research, an opening TAC of 60 000 tonnes for 2023 was given. The in-season acoustic survey biomass estimate of age 1+ was 105 480 tonnes (RSE=16%), which resulting in no TAC increase. Fishery was allowed in the subareas 1b, 1c, 2a, 2c, 3a, 3c (see Stock Annex for area definitions).

9.1.5 Management

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EEZ was fully implemented in 2011 but was also partly used in 2010. The areas with known sandeel fishing grounds are divided into 5 areas (each divided into subareas). An area is closed for fishery unless the biomass (Age1+) is at least 20 000 tonnes. If an Area is open for fishery, one of the sub-areas is closed. A preliminary TAC for all Areas combined is given in February based on a precautionary prediction of total biomass and a harvesting rate of 0.4. An updated in-season TAC is given 15 May as the 40% percentile of the survey biomass estimate and harvesting rate of 0.4. Areas can be opened based on the updated information (Johnsen, 2022).

Closed periods

Since 2005, Danish vessels have not been allowed to fish sandeel before 31 March and after 1 August.

From 2005 to 2007, the fishery in the Norwegian EEZ opened 1 April and closed again 23 June. In 2008, the ordinary fishery was stopped 2 June, and only a restricted fishery with five vessels continued. No fishery was allowed in 2009. From 2010 to 2014 the fishing season was 23 April–23 June, and from 2015 and onwards from 15 April to 23 June in the Norwegian EEZ.

Closed areas

The Norwegian EEZ was only open for an exploratory fishery in 2006 based on the results of a three-week RTM fishery. In 2007, no regular fishery was allowed north of 57°30′N and in the ICES rectangles 42F4 and 42F5 after the RTM fishery ended. In 2008, the ordinary fishery was closed except in ICES rectangles 42F4 and 44F4, and for five vessels only, the ICES rectangles

44F3, 45F3, 44F2 and 45F2 were open. The Norwegian EEZ was closed to fishery in 2009. In accordance with the Norwegian sandeel management plan, many of the Norwegian management subareas have been closed each year (see Stock Annex for details).

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, there has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000 (ICES rectangles 40-43E7 and 40-44E8). Note that a limited fishery for stock monitoring purposes occurs in May–June in this area.

9.1.6 Catch

Adjustment of official catches

In 2014 and 2015, there was substantial misreporting of catches between areas (ICES, 2015, 2016b (HAWG)). Since 2015, the Danish regulation has not allowed fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German, and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see ICES 2017a, HAWG). Because of this, the 2023 benchmark in accordance with previous year's reallocated reported catches (14 781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1r in 2015. From 2016 onwards, no correction was made.

Catch and trends in catches

Catch statistics for Division 4 are given by country in Table 9.1.1. Catch statistics and effort by assessment area are given in Tables 9.1.2–9.1.7. Figure 9.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and catches peaked in 1997 and 1998 with more than 1 million t. Since 1983 the total catches have fluctuated between 1.2 million t (1997) and 73 420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2023 distributed by ICES rectangle are shown in Figure 9.1.2 (with no spatial adjustment of official catches distribution in 2014 and 2015). The spatial distribution is variable from one year to the next, however with common characteristics. The Dogger Bank area includes the most important fishing banks for SA 1r sandeel. The fishery in SA 3r has varied over time, primarily as a result of changes in regulations and very low abundance of sandeel on the northern fishing grounds.

Table 9.1.2 shows catch weight by area. There are large differences in the regional patterns of the catches. SAs 1r and 3r have consistently been the most important regarding sandeel catches. On average, these areas together have contributed 77% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2r. In the period since 2003 catches from this area contributed 17% of the total catches on average.

SA 4 has contributed 6% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 18, 19 and 19% of the total catches, respectively). In 2017 and 2018, the first non-monitoring fishery was advised in the area since 2011 with a catch advice and TAC at of 54 043 t and 59 345 t, respectively. Catch advice for 2019 was 5000 t for monitoring and for 2020, 39 611 t. In 2021 the catch advice was 77 512 t, followed by zero catch advised in 2022 and in 2023, the catch advice was 35 020 t.

Several banks in the northern areas of Norwegian EEZ have not provided catches between 2001 and 2008. In this period, almost all catches from the Norwegian EEZ came from the Vestbank area (Norwegian management area 3 in Figure 9.1.5). From 2010, catches have been taken mainly from the Norwegian management areas 1, 2 and 3, and from area 4 from 2016.

Effect of vessel size on CPUE

To avoid bias in effort introduced by changes in the average size of fishing vessels over time, the CPUEs are used to estimate a vessel standardization coefficient, *b*. The parameter *b* was estimated using a mixed model for separate periods. Because the model estimates the parameter from several years of data, the time-series for the most recent period is updated for all years as the parameter *b* is updated with the most recent data. More information can be found in the Stock Annex.

9.1.7 Sampling the catch

Sampling activity for commercial catches is shown in Table 9.1.8.

9.1.8 Survey indices

Abundance of sandeel is monitored by a Danish/Norwegian dredge survey (covering SA 1r–3r) and a Scottish dredge survey (SA 4), both in in November/December. See the Stock Annex for more details. An acoustic survey is carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2024a).

The dredge survey in 2023 was carried out as planned in areas 1r, 2r, 3r and 4 and nearly all planned positions were covered in accordance with the survey protocol.

9.2 Sandeel in SA 1r

9.2.1 Catch data

Total catch weight by year for SA 1r is given in Table 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.2.1.

In 2023 as in previous years, the majority of catches were comprised of 1-group (Figure 9.2.1).

9.2.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.2.2 and Figure 9.2.2 by half year. Mean weight-at-age in the first half year increased in 2023 and is just below the long term mean for all age-groups.

9.2.3 Maturity

Maturity estimates are obtained from the average observed in the Danish dredge survey in December as described in the Stock Annex. The values used are given in Table 9.2.3.

9.2.4 Natural mortality

WGSAM 2023 provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, ICES WGSAM, 2024b). Natural mortality was therefore updated. The full time-series was replaced and 3-year moving averages was used (same procedure as last time the time-series was updated). The new time-series did not affect the stock-recruitment plot to an extent that required a revision of reference points. The new time-series contains values of M that are higher than the values in the old time-series in the most recent years, due to an increase in haddock predation. Natural mortalities are listed in Table 9.2.8.

9.2.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.2.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 2001, after which substantial effort reduction has taken place. Effort has fluctuated without a trend since 2006.

The average CPUE in the period 1994 to 2002 was around 60 t^{-day}. In 2003, CPUE declined to the all-time lowest at 21 t^{-day}. Since 2004, the CPUE has increased and reached the all-time highest (101 t^{-day}) in 2010 followed by progressively lower CPUEs ending with CPUEs in 2013–2014 below long-term average. CPUE peaked again in 2015–2017 but have decreased to levels below average in 2018–2023.

Tuning series used in the assessments

A commercial tuning series (RTM) describing the average catch in numbers-at-age per fishing day of a standard vessel in April/early May is used in the assessment.

The index estimated from CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2023 show increases for both age-groups. The indices are below and above the average of age 0 and 1, respectively. The internal consistency, i.e., the ability of the dredge survey to follow cohorts, is low ($R^2 = 0.20$).

9.2.6 Data analysis

Following the three latest Benchmark assessments (ICES, 2010, 2016a and 2024a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2023. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.2.5.

The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is rather constant over the 5-year ranges used. The "age selection" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the assessment period, to a fishery targeting age 1+ in a similar way, and then in the most recent period back to mainly targeting 2+ sandeel.

The CV of the dredge survey ("sqrt (Survey variance) ~CV" in the table) is low (0.38) for age 0 and high (0.75) for age 1 and no boundary effects are detected. The survey residual plot (Figure 9.2.6a) shows no clear patterns.

The CV of the RTM time-series is low to moderate for ages 1, and 2-3 (0.49, 0.47, respectively) and no boundary effects are detected. The survey residual plot (Figure 9.2.6b) shows no clear patterns.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.2.5 is low (0.47) for age 1 and age 2 in the first half of the year and moderate to high (> 0.75) for the remaining ages and season combinations. The catch-at-age residuals (Figure 9.2.7) show a tendency for the cohorts to die out more rapidly than expected in 2019, 2020 and 2021 (negative catch residuals for all ages), whereas 2022 and 2023 showed the opposite tendency.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.77), which is also indicated by the stock recruitment plot (Figure 9.2.8). The high CV of recruitment is probably due to biological characteristic of the stock (i.e., weak stock-recruitment relationship) and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.2.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 9.2.9) shows consistent assessment results from one year to the next for F with a low Mohn's rho (-0.007). For recruitment and SSB, there seems to have been an overestimation in the previous assessments. It is likely that this is connected to the short period used for the latest exploitation pattern, a decision made under the benchmark to accommodate an intermediate period around 2009 with a significantly different exploitation pattern. Further, the negative catch and dredge residuals observed in 2019–2021 will tend to decrease the recruitment estimate as fish of the different cohorts are observed less frequently than expected after the initial dredge index of recruitment. The stability of F estimates is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years. Recruitment and SSB estimates show a retrospective bias (5-year Mohn´s rho for R and SSB is 0.228 and 0.512, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.2.10) are in general small. The overall pattern with a lower F:effort ratio for older data indicates that the model assumption of no efficiency creeping is violated across periods but not within catchability periods.

9.2.7 Final assessment

The output from the assessment is presented in Tables 9.2.6 (fishing mortality-at-age by year), 9.2.7 (fishing mortality-at-age by half year), 9.2.9 (stock numbers-at-age) and 9.2.10 (stock summary).

9.2.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). The stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{pa} in 2004, 2013–2015, 2019, and 2021-2022, whereas in 2023 SSB has been above B_{pa}. The stock has only been below B_{lim} in 2014. F_{1-2} is estimated to have been below the long-time average since 2014, and have been historically low in 2021 and 2022 due to low TAC and zero catches (i.e., monitoring TAC). Recruitment in 2017 was estimated to be the lowest observed in the time-series and since then the recruitment have been below the long-term average.

9.2.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2023 is the geometric mean of the recruitment 1983–2022 (101 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2023. However, as the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is probably not critical. Mean weight-at-age in the catch and in the sea is the average value for the years 2018–2023. Natural mortality and maturity is the same as applied in the assessment in the final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.2.12) shows that to obtain an SSB equal to MSY $B_{trigger}$, a TAC of 132 315 t should be set for 2023. The predicted F that follows from this TAC is 0.36. The TAC according to the escapement strategy ($B_{escapement}$ = B_{pa}) is therefore 132 315 t in 2024.

9.2.10 Biological reference points

B_{lim} is set at 105 809 t and B_{pa} at 140 824 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in 1 can be found in the Stock Annex.

9.2.11 Quality of the assessment

The quality of the present assessment has improved compared to the combined assessment for the whole of the North Sea previously presented by ICES before 2010. This is mainly because the present division of stock assessment areas better reflects the spatial stock structure and dynamics of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Together with the application of the statistical assessment model SMS-effort, this has removed the retrospective bias in F, whereas SSB and recruitment still seem to have some bias. The model provides rather narrow confidence limits for the model estimates of F, SSB and recruitment, but a poorer fit for the oldest data.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international catches. Danish catches are by far the largest in the area, but effort data from the other countries could improve the quality of the assessment.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0.

9.2.12 Status of the stock

The SSB has only been below B_{lim} in 2014. The SSB in 2024 is within the level expected from the forecast in 2023, where recruitment were around average. SSB is above B_{pa} in 2024. As noted in a previous HAWG report (ICES, 2019), the status of the stock may be impacted in cases where catches is exceeding TAC advice (due to “borrowing and banking”).

9.2.13 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the so-called escapement strategy, i.e., to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the latest benchmark (ICES, 2024a) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the escapement strategy corresponds to an F_{bar} that exceeds F_{cap}, then the escapement strategy should be disqualified, and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 1r is 0.36 (ICES, 2024a).

Based on the misreporting of catches as observed in 2014 and 2015, management measures to avoid area misreporting (only one fishing area per trip) have been mandatory for the Danish fishery since 2015. There are indications of area misreporting for other nations (e.g., Sweden) in 2015 but likely not in the most recent years. Similar management measures as used for the Danish fishery would reduce further the risk of misreporting for other nations as well.

The so-called to "borrowing and banking", allocating catches that are not taken within a TAC in a previous year to the next (~10%), have been flagged as unsustainable several times by the expert group. The effects was investigated further at the latest benchmark (ICES 2024a) and it was concluded that while this did increase the risk, the effect on the risk of SSB falling below B_{lim} when fishing on Fcap was less than 0.2%. In individual years of low biomass the risk of SSB falling below B_{lim} in the subsequent year may be higher. This can potentially be investigated through adding an option to the forecast table investigating this.

Self-sampling on board the commercial vessels for biological data should be mandatory for all nations utilising a monitoring TAC. Today, samples are only obtained from the Danish fishery.

9.3 Sandeel in SA 2r

9.3.1 Catch data

Total catch weight by year for SA 2r is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year are given in Table 9.3.1.

The majority of the individuals caught were 1-group in the period 2020–2023, although the proportion was not as high as in 2017 (98%), following the high recruitment in 2016 (Figure 9.3.1).

9.3.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.3.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time-series of mean weight in the catch and in the stock is shown in Figure 9.3.2. Mean weight-at-age for all age groups seem to have increased since 2019, except for decreases 2020 for age-1 and in 2021 for age-1, 2 and 3. In 2023, weights had decreased across all age-groups compared to 2022.

9.3.3 Maturity

Maturity estimates are obtained from the average observed in the Danish dredge survey in December as described in the Stock Annex. The values used are given in Table 9.3.3.

9.3.4 Natural mortality

Long-term averages of natural mortality-at-age from WGSAM 2023 (ICES, 2024b) multispecies modelling of southern and northern sandeel (SMS) were used. More details are given in the Stock Annex. Natural mortalities are listed in Table 9.3.8. Mortalities were updated in response to the WGSAM 2023 key run (ICES, 2024b) as the update did not affect long-term averages greatly.

9.3.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.3.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size and does not take changes in efficiency into account.

Total international standardized effort in 2022 and 2023 was above the long term average. The CPUE increased accordingly coming up from a record low CPUE in 2022.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

The dredge survey in SA 2r (Table 9.3.4 and Figure 9.3.5) increased coverage in 2010 and this is therefore used as the start year of the dredge time-series for the assessment. The coverage has however varied somewhat in this period and the time-series is still short. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2016a). Dredge CPUEs of age 0 were very low in 2023, resulting in the third lowest age-0 index in the time-series. SA 2r has high internal consistency (R^2 = 0.57 on log-scale), i.e., the ability of the dredge survey to follow cohorts is good.

9.3.6 Data analysis

The diagnostics output from SMS-effort are shown in Table 9.3.5.

The CV of the dredge survey (Table 9.3.5) is moderate for the 0-group (0.60). The CV for age-1 is low (0.48). The residual plot (Figure 9.3.6) shows no clear bias for this time-series, although seemingly negative values have been apparent since 2017.

The model CV of catch-at-age 1 and 2 is low (0.47) in the first half of the year and high (> 0.82) for the remaining ages and season combinations. The residual plots for catch-at-age (Figure 9.3.7) confirm that the fit is generally poor except for age 1 and 2 in the first half year. The residual plot shows no long-term bias for this time-series for ages 1 and 2 in the first half year.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.95) which is also indicated by the stock recruitment plot (Figure 9.3.8). The high CV of recruitment is probably due to highly variable recruitment success and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set relatively low (0.05in "objective function weight" in Table 9.3.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.3.10) are in general low, which gives narrow confidence limits on estimated values (Figure 9.3.11).

The plot of standardized fishing effort (Figure 9.3.12) shows a good relationship between effort and F as specified by the model. An effort unit in the early part of the time-series gives a smaller F than an effort unit in the most recent years. This indicates technical creep, i.e., a standard 200 GT vessel has become more efficient over time (see Stock Annex for further discussion, ICES 2024a).

The retrospective analysis (Figure 9.3.9) shows consistent assessment estimates of F from one year to the next. The 5-year Mohn´s rho values are moderate for SSB (0,158) and high for recruitment (0.86). Reasons for this pattern can be connected to lower than expected survival of the cohorts, or lower than expected catchability of the older ages in the fishery.

9.3.7 Final assessment

The output from the assessment is presented in tables 9.3.6 (fishing mortality-at-age by year), 9.3.7 (fishing mortality-at-age by half year), 9.3.9 (stock numbers-at-age) and 9.3.10 (stock summary).

9.3.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). The stock summary (Figure 9.3.13 and Table 9.3.10) show that recruitment has been highly variable and with a decreasing trend over the full time-series until the 2016 year-class, which is estimated to be the fifth strongest on record. In recent times, the recruitment was above the long-term average only in 2016 and 2021, but being below average in 2022 and 2023. The lowest recruitment on record were in 2023, similar to the observed recruitment in 2017. SSB has been at or below B_{lim} in 2006-2007 and 2016-2017. In the same periods SSB has been below B_{pa}, as well as in 2009-2010 and 2021. Since 2022, SSB has been above B_{lim} and B_{pa}. $F_{1–2}$ is estimated to have been below the long-time average since 2010 except for 2013, 2017, 2020 and 2022.

9.3.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.3.11. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in 2024 is the geometric mean of the recruitment in 2013–2022. The exploitation pattern and F_{sq} (2023-value) is taken from the 2024-assessment. As the SMS-model assumes a fixed exploitation pattern since 2010, the choice of year is not critical. Mean weight-at-age in the catch and in the sea is the average (i.e., 5-year mean) value for the years 2019–2023. Natural mortality and proportion mature are the values applied in the terminal year in the assessment.

Output

The short-term forecast (Table 9.3.12) shows that a fishing mortality of 0.51 will bring SSB down to B_{pa} in 2024. Accordingly, a TAC of 35 925 t should be set for 2023 to keep SSB equal to MSY $B_{trigger}$.

9.3.10 Biological reference points

B_{lim} is set at 18 949 t and B_{pa} at 27 757 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.52 (ICES, 2024a). Further information about biological reference points can be found in the Stock Annex and Benchmark report (ICES, 2024a).

9.3.11 Quality of the assessment

This stock was benchmarked in 2023 (ICES, 2024a). The assessment includes fisheries independent information from a dredge survey representative for the area and temporally variable maturity while natural mortality is constant over time. There seems to be issues with time variability in survival from age 0 to 1 and age 1 to 2 which cannot be explained by F. The assessment is considered to be of medium to good quality.

9.3.12 Status of the Stock

A moderate F being under the long-term averaged in most of the years from 2010, except high in 2017 and low in 2021 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004-2010. SSB in the period for 2019-2024 were estimated above B_{lim}, where SSB only have been blow B_{pa} in 2021. The recruitment have generally been low compared to the period before 1997. The recruitment in 2023 is the lowest on record and currently the relative low F in recent times in combination with increasing build-up in SSB are keeping the biomass above reference points.

9.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e., to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 2024a) established that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality and estimated this F_{cap} for SA 2r at 0.52. This means that if the TAC that results from the escapement strategy corresponds to an $F_{bar(1-2)}$ that exceeds F_{cap}, then the TAC is determined based on a fishing mortality corresponding to F_{cap}.

9.4 Sandeel in SA 3r

9.4.1 Catch data

Total catch weight by year for SA 3r is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.4.1.

In 2023, the catches consisted of almost equal proportions of all age groups, where the proportion in numbers of 1-, 2-, 3- and 4-group, respectively, were 25%, 22%, 17% and 27%. This pattern reflects the age composition of the stock and is caused by the progressive decline in recruitment since the very high 2019 yearclass (see below)

9.4.2 Weight-at-age

The mean weights-at-age observed in the catch are given in Table 9.4.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time-series of mean weight in the catch and in the stock is shown in Figure 9.4.2. Mean weight-at-age in the first half-year hincreased from 2018 to 2020 and has remained fairly stable since 2020 at a level 26% and 17% above the long term average for ages 1 and 2 respectively, while weight at age of older ages are below the long term average.

9.4.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey in December as described in the Stock Annex. The values used are given in Table 9.4.3.

9.4.4 Natural mortality

In 2023, WGSAM (ICES, 2024b) provided updated estimates of natural mortality-at-age from multispecies modelling of northern sandeel (SMS).

The effect of using 3-year averages of these new values on historical development and stock recruitment relationship of the stock was evaluated by the working group and it was decided that the new natural mortality values did not result in a substantial change in the historic perception of the stock, including possible changes to reference points. Further, the recent increase in mortality induced by the increasing haddock populations agreed with the impression of increased mortality derived from the surveys. For this reason, it was decided to use the new natural mortalities in the 2024 assessment.

As described in the stock annex, 3-year averages of natural mortality-at-age from the WGSAM 2023 (ICES, 2024b) multispecies modelling of northern sandeel (SMS) were used. The last value provided was used for all years following the latest data point. More details are given in the stock annex. Natural mortalities are listed in Table 9.4.8.

9.4.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.4.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 1998 and declined thereafter and has been less than 2000 days per year between 2003 and 2019. The effort increased to 3492 days in 2020. In 2021 and 2022, the effort decreased to about the same level as in 2019 and in 2023 it fell to a level below that observed in the past 6 years.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2023 show very low indices for both age 0 and age 1 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e., $r^2 = 0.34$on log scales). In 2014, 13 new positions were included in the survey in SA 3r. Only two of the new positions were taken in squares not included before (42F5 and 42F6). All the new positions have been included in the survey index since 2014 (Table 9.4.4) for assessment purposes, to obtain a better spatial coverage. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2024a).

The Norwegian acoustic survey (2009–2023) carried out in Norwegian EEZ is used as tuning series in the assessment in SA 3r (Table 9.4.13 and Figures 9.4.14–9.4.16). The survey covers the main sandeel grounds in SA 3r. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.13. The internal consistency plot (Figure 9.4.16) shows high consistency for age 1 vs. age 2 (r^2 = 0.87 on log scales), age 2 vs. age 3 (r^2 = 0.88 on log scales), and age 3 vs. age 4 (r^2 = 0.41 on log scales).

9.4.6 Data Analysis

The diagnostics output from SMS-effort model is shown in Table 9.4.5.

The CV of the dredge survey (Table 9.4.5) is low for age 0 (0.30) and high for age 1 (1.14), showing an overall poor consistency between the results from the dredge survey of age 1 and the overall model results. The internal consistency of the survey seems to indicate the large and small year-classes can be followed in the dredge, but the exact size of small or large cohorts cannot.

The CV of the acoustic survey (Table 9.4.5) is medium for all ages (0.63), showing an overall medium consistency between the results from the acoustic survey and the overall model results. After a string of 3 years from 2020 to 2022 where the survey consistently reported a larger abundance of sandeel than could be seen in the catches, this pattern has now disappeared (Fig 9.8.5-9.8.6.).

The model CV of catch-at-age is high (0.829) for age 1 and age 2 in the first half of the year (Table 9.4.5). For the older ages and for all ages in the second half year, the CVs are higher (> 0.96). The catch residual plots for catch-at-age (Figure 9.4.7) confirm that the fits are generally very poor. There is a tendency for clusters of negative or positive residuals for ages 1, 2 and 3, in particular in later years where the cacthes show substantially less fish than expected in the model.

The recruitment CV (Table 9.4.5) is very high (1.54), which is also indicated by the stock recruitment plot (Figure 9.4.8). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.4.5) such that SSB-R estimates do not contribute much to the overall model likelihood and fit.

There used to be a large retrospective pattern in recruitment that consistently overestimated large recruiting year-classes, resulting in a retrospective pattern also in SSB. However, after the adjustment made at the benchmark in 2023, the retrospective bias was reduced (Mohn´s rho for R and SSB of 0.237 and -0.029, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.4.10) are in general medium, which gives wide confidence limits (Figure 9.4.11) on output variables.

The plot of standardized fishing effort and estimated F (Figure 9.4.12) shows a moderate relation between effort and F as assumed by the model specification. The the model assumes that the relation between effort and F is constant over time, corresponding to no technical creep(ICES, 2024a).

9.4.7 Final assessment

The output from the final assessment is presented in Tables 9.4.6 (fishing mortality-at-age), 9.4.7 (fishing mortality-at-age by half year), 9.4.9 (stock numbers-at-age) and 9.4.10 (Stock summary).

9.4.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). SSB has been below below B_{pa} in 2000, 2004, 2006 and 2009, where SSB was under B_{lim} in a single year 2004 (Figure 9.4.13 and Table 9.4.10). Above average recruitments in 2016, 2018, 2019 and 2020 together with a fishing mortality below average in most years and increased weights have resulted in SSB being above B_{pa} the last decade. Yet, a recent drop in recruitment have been observed, where the recent three years have been below the long-term average.

9.4.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.4.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2024 is the geometric mean of the recruitment 1987–2022 (18 491 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2023. As the SMS-model assumes a fixed exploitation pattern, the choice of year is not critical. Mean weight-at-age in the catch and in the sea is the average value (i.e., 5-year mean) for the years 2019–2023. Proportion mature and natural mortality are equal to the terminal assessment year.

The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.4.12) shows that even in the absence of fishing SSB in 2025 will be at 106 889 t which is below B_{pa}. Accordingly, the advised catch is zero ton. A monitoring fishery of 5000 t is recommended to achieve the necessary samples to monitor the age distribution of the stock. This will lead to an SSB in 2025 at 107627t.

9.4.10 Biological reference points

B_{lim} is set at 72 713 t and B_{pa} is estimated to 108 978 t. MSY $B_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex and in the benchmark report (ICES, 2024a).

9.4.11 Quality of the assessment

This stock was benchmarked in 2023 (ICES, 2024a). Sandeel area 3r mainly consists of fishing grounds in Norwegian EEZ. There is a large variation in the various sources of information with low agreement between commercial catch age composition and age composition of 1+ fish in the surveys This pattern may be caused by a variety of issues in the assessment, most likely of which are the shift in 2011 from using Danish to using Norwegian effort data, the change in the spatial coverage of the dredge survey and the management system of surveying all grounds but only allowing fishing in a subset of the grounds in a year and then changing this in the subsequent year. Even though the new assessment for SA 3r sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

9.4.12 Status of the Stock

The SSB has increased since 2013, due to above average recruitment in 2016, 2018-2020 combined with a low fishing mortality. However, fishing mortality has increased since 2016, peaking in 2020, but decreased in last three years, where SSB have decreased considerably in the same period. This may be a result of high fishing mortality and decreasing recruitment (but SSB is still well above B_{pa}). Recruitment have been below average in the same period. Recruitment in 2023 was the fourth lowest on record.

9.4.13 Management Considerations

Since 2011 the Norwegian sandeel fishery in the current SA3r has been managed according to an area-based management plan for the Norwegian EEZ and an advice provided by the IMR in Bergen.

9.5 Sandeel in SA 4

9.5.1 Catch data

Catch numbers-at-age by half-year from area SA 4 is given in Table 9.5.1. Total catch weight by year for SA 4 is given in Table 9.5.2. In 2022, catch numbers were dominated by age 1-group and, to a lower extent, age 3-group as a result of their relatively large number (as age 2-group) in 2021. Other age-groups were not common (Figure 9.5.1). In 2023, the same two cohorts remained abundant while the proportion of 1-year olds was 23%, the lowest since 2011.Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex. The mean weights-at-age observed in the catch are given in Table 9.5.2 and Figure 9.5.2 by half year. Mean weight-at-age in the first half year seems to have recovered to around average and currently stable for all ages after the very low levels in 2001 to 2005. The second half year mean weights are affected by the very limited sampling at this time of year.

9.5.2 Maturity

Maturity estimates are constant throughout the times series in Area 4. Maturities are listed in Table 9.5.3.

9.5.3 Natural mortality

Long-term averages of natural mortality-at-age from the WGSAM 2023 (ICES, 2024b) multi-species modelling of northern sandeel (SMS) were used. More details are given in the stock annex. Natural mortalities are listed in Table 9.5.8. Mortalities were updated in response to the new WGSAM 2023 key run (ICES, 2024b) as the update did not appear to affect long-term averages and model output greatly.

9.5.4 Effort and research vessel data

Trends in overall effort and CPUE

Table 9.1.5–9.1.7 and Figure 9.5.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 1994, after which substantial effort reduction has taken place and the effort is now fluctuating around a lower level than before 2003. The effort in 2023 was relatively low, but above the effort in the period 2004–2016 and 2022 which reflect either a closed or very limited monitoring fishery.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment. CPUE data from the dredge survey (Table 9.5.4 and Figure 9.5.5) show that 2023 recruitment is extremely low.

The internal consistency, i.e., the ability of the survey to follow cohorts, (Figure 9.5.4) shows a low correlation between the 0-group and 1-group explaining 36% of the variation.

9.5.5 Data analysis

Following the Benchmark assessment (ICES, 2024a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2023. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.5.5. The CV of the new dredge survey (going from 2008–2023) ("sqrt (Survey variance) ~CV" in the table) is low to moderate (<0.30) for age 0 and high for age 1 (0.81). The old dredge survey CV (years 1999–2003) is on the lower boundary of 0.3 for both 0- and 1-year olds. The survey residuals appear to fluctuate without a trend for both ages (Figure 9.5.6).

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.69) for all ages. While they look similar, they are freely estimated for ages 1+2 and 3+4 and the similar value for the two groups is a model estimate. The catch-at-age residuals (Figure 9.5.7) show no alarming patterns.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.48, which is also indicated by the stock recruitment plot (Figure 9.5.8). The high CV of recruitment is probably due to biological characteristic of the stock and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.5.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 9.5.9) shows very consistent assessment results from one year to the next (Monhs rho for R and SSB of 0.145 and 0.067, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.5.10) are moderate to high.

9.5.6 Final assessment

The output from the assessment is presented in tables 9.5.6 (fishing mortality-at-age by year), 9.5.7 (fishing mortality-at-age by half year), 9.5.9 (stock numbers-at-age) and 9.5.10 (stock summary).

9.5.7 Historic Stock Trends

The perception of the stock have changed after the last benchmark (ICES, 2024a). The stock summary (Figure 9.5.13 and Table 9.5.10) shows that SSB have been below B_{lim} in 2008 to 2009. Furthermore, SSB have been in 2004-2005, 2007-2010, 2014-2015 2020, and 2022-2024. As such, SSB have decreased in recent years. $F_{1\text{–}2}$ is estimated to have been low throughout the time-series peaking in 1994. 2004-2017 represent a period with no or very limited fishing, whereas sporadic fishing activity have been evident since, e.g. in 2018, 2021 and 2023. The fishing mortality in 2021 where the second largest in the time-series. Recruitment has been variable through time with highs in 2014, 2016, 2019 and 2022. The 2023 recruitment were the lowest in the time-series.

9.5.8 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.5.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2023 is the geometric mean of the recruitment 2012–2021 (61 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2022. However, as the SMS-model assumes a fixed exploitation pattern, the choice of years is not critical. Mean weight-at-age in the catch and in the sea is the average value (i.e., 5-year mean) for the years 2018–2022. Natural mortality and maturity are as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.5.12) shows that even in the absence of fishing SSB in 2025 will be at 69 406 t which is below B_{pa}. Accordingly, the advised catch is zero ton. A monitoring fishery of 5000 t is recommended to achieve the necessary samples to monitor the age distribution of the stock. This will lead to an SSB in 2025 at 66 570 t.

Biological reference points

B_{lim} is set at 44 716 t and B_{pa} at 88 995 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in SA 4 can be found in the Stock Annex.

9.5.9 Quality of the assessment

The analytical assessment of SA 4 was initiated in 2017 following the 2016 benchmark of the stock.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0 but the CV on SSB in the terminal year is high (Figure 9.5.10).

9.5.10 Status of the Stock

Recruitment in 2014, 2016, 2019, and 2022 are above the long-term average, while the remaining years after 2010 are below. A very restrictive F since 2004, with the exception of 2018, 2021 and 2023, together with recruitment peaks has resulted in a SSB fluctuating around B_{pa} since 2019, but have been below B_{pa} in recent three years.

9.5.11 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e., to maintain SSB above

MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the latest benchmark (ICES, 2024a) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 4 is set at 0.36 (ICES, 2024a).

However, it is important to acknowledge that the assessment model does not consider that a significant part of SA 4 (East coast of Scotland, sand banks covered by the dredge survey) is closed to fishing. Accordingly, the estimated TAC would in practice be achieved in a much smaller region than the whole SA 4 which raises concerns of local depletion.

9.6 Sandeel in SA 5r

9.6.1 Catch data

Total catch weight by year for SA 5 is given in tables 9.1.2–9.1.4. No catches from this area have been taken since 2004. Acoustic surveys have been carried out since 2009 on Vikingbanken, which is the main sandeel ground in SA 5. The survey estimates (2009–2023) show that the biomass of sandeel on Vikingbanken still is very low (Table 9.6.1).

9.7 Sandeel in SA 6

9.7.1 Catch data

Total catch weight by year for SA 6 is given in tables 9.1.2–9.1.4.

9.8 Sandeel in SA 7

9.8.1 Catch data

Total catch weight by year for SA 7 is given in tables 9.1.2–9.1.4. No catches from this area have been taken since 2003.

9.9 Sandeel in ICES Division 6.a

9.9.1 Catch data

Total catch weight by year for sandeel in ICES Division 6.a is given in Table 9.9.1. Catches from this area have been zero or very low since 2005 with the exception of 2020. There was anecdotal evidence presented at HAWG that indicated that the catch recorded in that year was the result of a sampling error.

9.10 References

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9.11 Stock annexes

San.sa.1r – stock annex

ICES. 2018. Stock Annex: Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank). ICES Stock Annexes. 45 pp. https://doi.org/10.17895/ices.pub.18623159.v1

San.sa.2r – stock annex

ICES. 2020. Stock Annex: Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, and Subdivision 20, Sandeel Area 2r (Skagerrak, central and southern North Sea). ICES Stock Annexes. 40 pp. https://doi.org/10.17895/ices.pub.18623168.v1

San.sa.3r – stock annex

ICES. 2020. Stock Annex: Sandeel (*Ammodytes* spp.) in Divisions 4.a and 4.b, and Subdivision 20, Sandeel Area 3r (Skagerrak, northern and central North Sea). ICES Stock Annexes. 45 pp. https://doi.org/10.17895/ices.pub.18623180.v1

San.sa.4 – stock annex

ICES. 2016. Stock Annex: Sandeel (*Ammodytes* spp.) in divisions 4.a and 4.b, Sandeel Area 4 (northern and central North Sea). ICES Stock Annexes. 36 pp. https://doi.org/10.17895/ices.pub.18623186.v1

San.sa.5r – stock annex

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San.sa.6 – stock annex

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ICES. 2016. Stock Annex: Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 7r (northern North Sea, Shetland). ICES Stock Annexes. 9 pp. https://doi.org/10.17895/ices.pub.18623150

9.12 Tables and Figures

Table 9.1.1 Sandeel. Official catches ('000 t), 1952-2023 for area 27.4 and 27.3.a. Note that catches from 27.3.a are only available form 1973-2023.

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1952	27.4	1.6	-	-	-	-	-	-	-	-	-	1.6
1953	27.4	4.5	-	-	-	-	-	-	-	-	-	4.5
1954	27.4	10.8	-	-	-	-	-	-	-	-	-	10.8
1955	27.4	37.6	-	-	-	-	-	-	-	-	-	37.6
1956	27.4	81.9	5.3	-	-	-	1.5	-	-	-	-	88.7
1957	27.4	73.3	25.5	-	-	3.7	3.2	-	-	-	-	105.7
1958	27.4	74.4	20.2	-	-	1.5	4.8	-	-	-	-	100.9
1959	27.4	77.1	17.4	-	-	5.1	8	-	-	-	-	107.6
1960	27.4	100.8	7.7	-	-	-	12.1	-	-	-	-	120.6
1961	27.4	73.6	4.5	-	-	-	5.1	-	-	-	-	83.2
1962	27.4	97.4	1.4	-	-	-	10.5	-	-	-	-	109.3
1963	27.4	134.4	16.4	-	-	-	11.5	-	-	-	-	162.3
1964	27.4	104.7	12.9	-	-	-	10.4	-	-	-	-	128.0
1965	27.4	123.6	2.1	-	-	-	4.9	-	-	-	-	130.6
1966	27.4	138.5	4.4	-	-	-	0.2	-	-	-	-	143.1
1967	27.4	187.4	0.3	-	-	-	1	-	-	-	-	188.7
1968	27.4	193.6	-	-	-	-	0.1	-	-	-	-	193.7
1969	27.4	112.8	-	-	-	-	-	-	0.5	-	-	113.3

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1970	27.4	187.8	-	-	-	-	-	-	3.6	-	-	191.4
1971	27.4	371.6	0.1	-	-	-	2.1	-	8.3	-	-	382.1
1972	27.4	329.0	-	-	-	-	18.6	8.8	2.1	-	-	358.5
1973	27.3.a + 27.4	282.9	-	1.4	-	-	17.2	1.1	4.2	-	-	306.8
1974	27.3.a + 27.4	432.0	-	6.4	-	-	78.6	0.2	15.5	-	-	532.7
1975	27.3.a + 27.4	372.0	-	4.9	-	-	54	0.2	13.6	-	-	444.7
1976	27.3.a + 27.4	446.1	-	-	-	-	44.2	0.1	18.7	-	-	509.1
1977	27.3.a + 27.4	680.4	-	11.4	-	-	78.7	6.1	25.5	-	-	802.1
1978	27.3.a + 27.4	669.2	-	12.1	-	-	93.5	2.3	32.5	-	-	809.7
1979	27.3.a + 27.4	483.1	-	13.2	-	-	101.4	-	13.4	-	-	611.1
1980	27.3.a + 27.4	581.6	-	7.2	-	-	144.8	-	34.3	-	-	767.9
1981	27.3.a + 27.4	523.8	-	4.9	-	-	52.6	-	46.7	-	-	628.1
1982	27.3.a + 27.4	528.4	-	4.9	-	-	46.5	0.4	52.2	-	-	632.4
1983	27.3.a + 27.4	515.2	-	2	-	-	12.4	0.2	37	-	-	566.8
1984	27.3.a + 27.4	618.9	-	11.3	-	-	28.3	-	32.6	-	-	691.1
1985	27.3.a +	601.7	-	3.9	-	-	13.1	-	17.2	-	-	635.9

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
	27.4											
1986	27.3.a + 27.4	832.7	-	1.2	-	-	82.1	-	12	-	-	928.0
1987	27.3.a + 27.4	609.2	-	18.6	-	-	193.4	-	7.2	-	-	828.4
1988	27.3.a + 27.4	708.8	-	15.5	-	-	185.3	-	5.8	-	-	915.3
1989	27.3.a + 27.4	841.6	-	16.6	-	-	186.8	-	11.5	-	-	1056.3
1990	27.3.a + 27.4	512.1	-	2.2	-	0.3	89	-	3.9	-	-	607.5
1991	27.3.a + 27.4	726.5	-	11.2	-	-	128.8	-	1.2	-	-	867.7
1992	27.3.a + 27.4	803.7	-	9.1	-	-	89.3	0.6	4.9	-	-	907.6
1993	27.3.a + 27.4	533.4	-	0.3	-	-	95.5	-	1.5	-	-	630.8
1994	27.3.a + 27.4	688.6	-	10.3	-	-	165.8	-	5.9	-	-	870.7
1995	27.3.a + 27.4	672.6	-	-	-	-	263.4	-	6.7	-	-	942.8
1996	27.3.a + 27.4	649.5	-	5	-	-	160.7	-	9.7	-	-	824.8
1997	27.3.a + 27.4	831.8	-	11.2	-	-	350.2	-	24.6	-	-	1217.8
1998	27.3.a + 27.4	628.2	-	11	-	-	343.3	8.6	23.8	-	-	1014.8
1999	27.3.a + 27.4	511.3	-	13.2	0.4	-	187.6	23.2	11.5	-	-	747.1
2000	27.3.a +	557.3	-	-	-	-	119	28.6	10.8	-	-	715.7

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
	27.4											
2001	27.3.a + 27.4	650.0	-	-	-	-	183	50	1.3	-	-	884.3
2002	27.3.a + 27.4	659.5	-	-	-	-	176	19.2	4.9	-	-	859.6
2003	27.3.a + 27.4	282.8	-	-	-	-	29.6	21.8	0.5	-	-	334.7
2004	27.3.a + 27.4	288.8	2.7	-	-	-	48.5	33.3	-	-	-	373.3
2005	27.3.a + 27.4	158.9	-	-	-	-	17.3	0.5	-	-	-	176.6
2006	27.3.a + 27.4	255.4	3.2	-	-	-	5.6	27.9	-	-	-	292.8
2007	27.3.a + 27.4	166.9	1	2	-	-	51.1	7.9	1	-	-	229.9
2008	27.3.a + 27.4	246.9	4.4	2.4	-	-	81.6	12.5	-	-	-	347.8
2009	27.3.a + 27.4	293.0	12.2	2.5	-	1.8	27.4	12.4	3.6	-	-	352.9
2010	27.3.a + 27.4	285.9	13	-	-	-	78	32.7	4	0.6	-	414.2
2011	27.3.a + 27.4	278.5	9.8	-	-	-	109	32.7	6.1	1.6	-	437.8
2012	27.3.a + 27.4	51.8	1.7	-	-	0.3	42.5	5.7	-	-	-	101.9
2013	27.3.a + 27.4	208.7	7.9	-	-	0.4	30.4	26.8	2.4	1.3	-	278.0
2014	27.3.a + 27.4	156.5	5.1	-	-	-	82.5	18.8	-	0.8	-	263.8
2015	27.3.a +	166.5	9.1	-	-	-	100.9	33.4	2	-	-	311.9

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
	27.4											
2016	27.3.a + 27.4	28.4	-	-	-	-	40.9	4.3	-	-	-	73.5
2017	27.3.a + 27.4	353.9	5.8	-	-	-	120.2	42.3	3.3	-	-	525.5
2018	27.3.a + 27.4	175.6	5.9	-	-	-	69.5	16.7	1.8	-	-	269.6
2019	27.3.a + 27.4	93.7	4	-	-	-	124.8	11.5	1.1	-	-	235.1
2020	27.3.a + 27.4	169.2	3.8	-	-	-	244.4	25.5	3.9	-	-	446.8
2021	27.3.a + 27.4	69.5	1.8	-	-	-	146.4	14.8	-	-	-	232.6
2022	27.3.a + 27.4	72.7	-	-	-	-	81.7	12.3	-	-	-	166.6
2023	27.3.a + 27.4	118.6	4	-	-	-	15.9	26	-	-	-	164.5

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839
1998	372604	99305	474843	58911	3010	941	5228	1014841
1999	425478	70085	193621	53338	145	0	4415	747083
2000	374724	101952	196525	37792	303	0	4371	715667
2001	540248	97210	196209	47918	1678	26	971	884260
2002	610161	120520	115207	12762	8	493	453	859604
2003	178642	56248	35365	64049	44	111	260	334718
2004	215352	116837	33658	6882	0	573	0	373302
2005	126261	34569	13994	1557	0	259	0	176640
2006	247510	37952	7094	86	0	161	0	292802
2007	110395	44069	75376	11	4	0	0	229855
2008	236069	35655	74943	1168	0	0	0	347836
2009	309712	37049	6161	0	0	0	0	352922
2010	300896	52470	60542	275	0	0	0	414183
2011	320241	24310	92450	270	0	489	0	437761
2012	45954	12672	40141	2618	0	214	0	101599
2013	214787	48172	9838	5119	0	72	0	277989
2014	96430	64707	98055	4505	0	65	0	263762
2015	160764	39492	106703	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	132213	20226	76656	42515	0	0	0	271610
2019	86539	5132	138674	6648	0	96	0	237089
2020	108944	70198	247411	20116	0	97	0	446765
2021	17082	4146	157524	53765	0	93	0	232610

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2022	5195	71614	84240	5541	0	38	0	166628
2023	88581	39653	18955	17269	0	77	0	164535
arith.mean	273220	97266	147233	29697	5265	1066	894	554642

Table 9.1.3 Sandeel. Total catch (tonnes) by area, first half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	314744	92566	21008	2782	0	364	0	431465
1984	419640	86141	43578	2563	5821	735	744	559223
1985	377702	76422	17131	37900	3004	973	0	513132
1986	346053	181733	138020	12539	108	12020	7832	698305
1987	307194	36400	394339	7833	1713	1091	0	748570
1988	395186	107289	288174	1257	0	2114	0	794020
1989	435721	173510	371557	4382	1587	897	450	988104
1990	285321	101899	105554	2926	0	485	0	496185
1991	257591	153869	215770	17140	1168	17	2529	648083
1992	521575	135823	83068	67068	1099	4270	3455	816357
1993	129403	86179	155984	123143	250	4393	3	499354
1994	177685	184792	242027	147019	2754	3222	4	757503
1995	365681	70518	203151	52497	152269	1829	0	845945
1996	257507	63193	110862	48496	14551	1168	0	495777
1997	345199	178735	394181	47668	8615	2194	2448	979040
1998	352275	70075	354639	57373	2907	939	4565	842773
1999	395813	27461	94655	51183	145	0	2152	571409
2000	333044	82405	192474	37792	288	0	3808	649812
2001	368782	49319	59951	47492	1678	26	735	527983
2002	604584	105397	114646	12762	8	493	101	837991
2003	155006	25111	22803	62580	44	111	187	265841
2004	199483	91405	21632	6860	0	571	0	319951
2005	121795	24841	13982	1557	0	259	0	162434
2006	241345	23497	6959	55	0	160	0	272015

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2007	110389	44069	75376	11	4	0	0	229849
2008	232249	32602	74943	1168	0	0	0	340963
2009	293529	25399	6024	0	0	0	0	324952
2010	293359	44910	60251	275	0	0	0	398796
2011	316351	24045	92450	270	0	489	0	433605
2012	45946	11520	40141	2618	0	213	0	100438
2013	207886	43818	9838	5119	0	72	0	266733
2014	92393	62110	97310	4505	0	65	0	256383
2015	160763	38723	106703	4736	0	197	0	311123
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	125610	19943	76081	42515	0	0	0	264149
2019	71464	5129	138669	6648	0	96	0	222006
2020	107762	69894	247411	19896	0	97	0	445060
2021	16615	4142	157397	51448	0	93	0	229695
2022	5193	71613	84240	5541	0	38	0	166626
2023	88111	38426	18950	17269	0	77	0	162833
arith.mean	247100	70856	124674	25356	4830	973	708	474496

Table 9.1.4 Sandeel. Total catch (tonnes) by area, second half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	67885	63641	3820	0	0	0	0	135345
1984	79031	47257	5532	0	0	55	0	131875
1985	82355	35468	3728	222	0	953	0	122726
1986	36791	43848	144314	179	519	1199	2818	229668
1987	65828	12667	959	321	0	72	0	79847
1988	27619	44254	48744	81	0	612	0	121310
1989	10407	53782	2694	2	1316	12	0	68214
1990	20981	31896	57670	388	374	14	0	111323
1991	74613	61697	59069	24232	0	0	0	219611

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1992	37027	48418	3954	1837	0	6	0	91243
1993	14986	61785	44138	9993	336	97	78	131414
1994	15557	60152	25254	11671	3	526	0	113163
1995	35078	51637	10017	94	5	1	0	96831
1996	34202	123267	48441	109994	13020	95	1	329019
1997	81215	63945	79912	10779	2157	179	613	238799
1998	20329	29230	120203	1538	103	1	663	172068
1999	29666	42624	98967	2155	0	0	2263	175674
2000	41680	19547	4051	0	15	0	562	65855
2001	171466	47891	136258	426	0	0	236	356277
2002	5577	15123	561	0	0	0	352	21613
2003	23636	31137	12562	1469	0	0	73	68877
2004	15869	25432	12026	22	0	2	0	53351
2005	4466	9728	11	0	0	0	0	14206
2006	6165	14455	136	30	0	0	0	20787
2007	6	0	0	0	0	0	0	6
2008	3821	3053	0	0	0	0	0	6873
2009	16183	11650	137	0	0	0	0	27970
2010	7537	7560	291	0	0	0	0	15387
2011	3891	265	0	0	0	0	0	4156
2012	8	1153	0	0	0	0	0	1161
2013	6902	4354	0	0	0	0	0	11256
2014	4037	2598	744	0	0	0	0	7379
2015	1	769	0	0	0	0	0	771
2016	0	50	0	0	0	0	0	51
2017	2327	10673	0	0	0	0	0	13000
2018	6603	283	576	0	0	0	0	7461
2019	15074	3	5	0	0	0	0	15082
2020	1182	304	0	220	0	0	0	1705

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2021	468	3	126	2317	0	0	0	2915
2022	2	0	0	0	0	0	0	2
2023	470	1227	5	0	0	0	0	1702
arith.mean	26120	26410	22559	4341	435	93	187	80146

Table 9.1.5 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	8982	4290	840	64	8	0	0	14184
1984	10155	3794	1362	47	45	213	37	15653
1985	10887	3485	614	657	62	140	0	15845
1986	7375	5049	4659	284	470	12	145	17995
1987	5766	1123	5167	181	41	65	0	12343
1988	7938	3987	7504	41	97	0	0	19568
1989	8619	6302	7759	57	40	31	0	22808
1990	8412	4394	5175	52	27	0	0	18060
1991	6130	4794	6069	365	1	21	0	17381
1992	8945	4480	2413	602	161	0	0	16601
1993	3935	4206	5311	1436	235	29	0	15153
1994	3159	4126	4956	1627	104	0	0	13972
1995	5871	2519	3837	437	50	1953	0	14667
1996	5627	4511	4425	1501	44	572	0	16681
1997	5685	5085	8142	680	47	0	6	19645
1998	7077	2704	12062	683	19	105	0	22650
1999	8871	1974	6125	848	0	0	0	17819
2000	7314	2590	4271	438	0	5	153	14770
2001	11285	2481	4901	692	1	0	0	19361
2002	8533	3050	2560	151	12	1	0	14305
2003	7018	2342	1698	1153	6	20	0	12236
2004	7355	4191	1313	216	25	0	0	13099
2005	3788	1171	519	102	9	0	0	5587

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2006	5163	1144	213	2	3	0	0	6525
2007	1838	863	1382	1	0	0	0	4085
2008	3960	810	1660	10	0	0	0	6440
2009	4872	710	124	0	0	0	0	5707
2010	3348	1067	1453	4	0	0	0	5871
2011	4874	564	1364	10	13	0	0	6824
2012	696	425	688	78	12	0	0	1898
2013	5202	1680	327	44	7	0	0	7260
2014	2398	1512	1095	52	5	0	0	5062
2015	1860	1386	1107	40	8	0	0	4401
2016	195	431	711	118	5	0	0	1460
2017	3818	2497	1460	249	0	0	0	8023
2018	3352	593	1405	610	0	0	0	5960
2019	2466	168	1496	169	3	0	0	4302
2020	3390	1606	3935	226	5	0	0	9162
2021	434	259	1799	1297	3	0	0	3792
2022	132	1693	2127	113	2	0	0	4067
2023	2623	1136	983	385	4	0	0	5131
arith.mean	5350	2468	3049	384	38	77	8	11374

Table 9.1.6 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, first half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	6922	2777	717	64	8	0	0	10488
1984	7899	2353	1164	47	41	213	37	11755
1985	8462	2499	506	653	28	140	0	12289
1986	6570	3891	2517	281	438	4	81	13781
1987	4353	757	5136	165	38	65	0	10515
1988	7134	2743	6045	40	74	0	0	16034
1989	8306	4655	7668	57	38	31	0	20756
1990	7895	3522	3770	47	27	0	0	15260

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1991	4715	3337	4903	119	1	21	0	13096
1992	8056	3416	2319	327	160	0	0	14278
1993	3537	2487	4081	1239	226	29	0	11599
1994	2865	3024	4497	1440	89	0	0	11915
1995	5273	1544	3629	436	50	1953	0	12885
1996	4931	1593	3203	535	44	408	0	10714
1997	4229	3247	6131	533	41	0	0	14181
1998	6455	1645	7787	643	19	101	0	16650
1999	7841	771	3151	848	0	0	0	12612
2000	6335	1988	4190	438	0	5	153	13108
2001	8236	1350	1754	678	1	0	0	12019
2002	8300	2387	2560	151	12	1	0	13410
2003	6095	1026	1297	1077	6	20	0	9521
2004	6881	3155	895	214	25	0	0	11169
2005	3642	838	519	102	9	0	0	5109
2006	4938	734	208	2	3	0	0	5886
2007	1838	863	1382	1	0	0	0	4085
2008	3843	708	1660	10	0	0	0	6222
2009	4653	538	123	0	0	0	0	5314
2010	3200	889	1442	4	0	0	0	5535
2011	4709	554	1364	10	13	0	0	6650
2012	696	403	688	78	12	0	0	1876
2013	5005	1520	327	44	7	0	0	6903
2014	2310	1434	1091	52	5	0	0	4892
2015	1860	1362	1107	40	8	0	0	4377
2016	195	418	711	118	5	0	0	1447
2017	3759	2207	1460	249	0	0	0	7674
2018	3044	587	1393	610	0	0	0	5634
2019	2130	168	1496	169	3	0	0	3967

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2020	3347	1530	3935	226	5	0	0	9043
2021	405	242	1791	1197	3	0	0	3636
2022	132	1693	2127	113	2	0	0	4067
2023	2602	1097	982	385	4	0	0	5069
arith.mean	4722	1755	2481	328	35	73	7	9401

Table 9.1.7 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	2060	1513	123	0	0	0	0	3696
1984	2256	1441	198	4	0	0	0	3899
1985	2425	985	108	34	3	0	0	3556
1986	805	1159	2142	32	3	8	64	4214
1987	1413	366	31	3	16	0	0	1828
1988	805	1244	1460	23	2	0	0	3533
1989	313	1647	90	1	0	0	0	2052
1990	517	872	1405	0	5	0	0	2800
1991	1415	1457	1167	0	246	0	0	4285
1992	890	1064	94	0	275	0	0	2323
1993	398	1719	1231	9	197	0	0	3554
1994	294	1102	459	15	186	0	0	2057
1995	598	975	208	0	1	0	0	1782
1996	696	2919	1222	0	966	165	0	5967
1997	1457	1837	2011	6	147	0	6	5464
1998	622	1059	4276	0	40	3	0	6000
1999	1030	1203	2974	0	0	0	0	5207
2000	979	602	81	0	0	0	0	1663
2001	3050	1132	3146	0	14	0	0	7342
2002	233	663	0	0	0	0	0	895
2003	923	1316	400	0	76	0	0	2715
2004	474	1036	417	0	2	0	0	1929

2005	145	333	0	0	0	0	0	478
2006	224	410	5	0	0	0	0	639
2008	116	102	0	0	0	0	0	219
2009	219	172	2	0	0	0	0	393
2010	148	178	11	0	0	0	0	336
2011	165	10	0	0	0	0	0	174
2012	0	22	0	0	0	0	0	22
2013	198	160	0	0	0	0	0	358
2014	88	78	4	0	0	0	0	170
2015	0	24	0	0	0	0	0	24
2016	0	13	0	0	0	0	0	13
2017	59	290	0	0	0	0	0	349
2018	307	6	12	0	0	0	0	325
2019	335	0	0	0	0	0	0	335
2020	43	76	0	0	0	0	0	118
2021	30	18	8	0	100	0	0	156
2023	22	39	1	0	0	0	0	62
arith.mean	660	750	597	3	58	5	2	2075

Table 9.1.8 Sandeel. Number of samples from commercial catches by year and area.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	79	49	0	0	0	1	0	129
1984	116	46	13	0	2	3	0	180
1985	103	32	1	19	2	3	0	160
1986	27	17	37	1	0	1	0	83
1987	63	12	70	1	0	2	0	148
1988	43	15	75	0	0	1	0	134
1989	40	9	48	0	0	1	0	98
1990	1	4	39	0	0	2	0	46
1991	25	32	39	1	1	0	0	98
1992	56	42	31	5	2	7	0	143

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1993	24	63	72	16	0	7	0	182
1994	22	38	61	15	1	4	0	141
1995	41	33	59	7	66	2	0	208
1996	43	63	170	26	78	1	0	381
1997	41	78	153	26	8	4	0	310
1998	54	31	158	7	0	3	0	253
1999	267	54	49	45	2	2	0	419
2000	110	48	53	73	0	3	0	287
2001	226	47	59	97	1	1	0	431
2002	307	112	50	72	1	6	0	548
2003	303	115	34	175	1	4	0	632
2004	464	219	30	48	2	1	0	764
2005	327	43	35	30	0	1	0	436
2006	565	60	101	4	2	2	0	734
2007	299	167	124	1	0	1	0	592
2008	297	134	113	5	0	1	0	550
2009	317	123	15	0	0	1	0	456
2010	176	272	57	1	0	3	0	509
2011	173	54	50	4	0	11	0	292
2012	227	115	45	24	0	12	0	423
2013	287	224	62	5	0	3	0	581
2014	143	134	72	18	0	5	0	372
2015	307	121	187	41	0	4	0	660
2016	154	157	156	47	0	0	0	514
2017	280	205	79	40	0	0	0	604
2018	350	136	179	78	0	0	0	743
2019	287	86	187	32	0	0	0	592
2020	255	196	194	40	0	1	0	686
2021	70	53	172	123	0	2	0	420

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2022	25	160	126	24	0	1	0	336
2023	164	94	69	75	0	0	0	402
arith.mean	175	90	81	30	4	3	0	382

Table 9.2.1 Sandeel 1r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	790	1846	28971	772	320	10223	264	3085	564	2
1984	15	47117	1701	10002	333	0	9241	90	566	43
1985	5249	6221	31386	1989	212	8556	1359	2314	1601	214
1986	0	44940	7553	1652	31	87	4163	228	188	14
1987	0	4504	23572	1199	171	187	1938	4173	123	32
1988	1207	1997	8564	15229	2354	0	0	162	1439	47
1989	41	62503	6364	1346	4737	0	757	77	16	58
1990	0	16850	13920	2060	622	522	1257	417	62	18
1991	0	14939	6870	983	338	7344	6917	209	67	0
1992	2	50883	8451	845	524	104	3041	298	122	26
1993	3700	2317	6359	1732	524	1625	371	240	145	41
1994	0	22720	2979	1545	1103	0	1694	119	66	102
1995	3	38499	6461	750	307	21	3654	955	108	26
1996	8752	11404	13642	5157	966	6809	1062	1071	249	72
1997	0	40182	2558	4269	1032	0	9097	166	243	107
1998	9	9699	30835	2449	1749	1	502	1566	167	124
1999	313	42153	5531	10580	851	559	1597	164	884	313
2000	17555	34456	3435	688	1188	6291	3270	202	129	269
2001	5302	59492	8277	1069	863	63785	3105	418	41	75
2002	705	82675	10768	1279	425	10	594	111	27	53
2003	12786	3739	13443	1265	496	2025	368	4213	155	48
2004	5134	30780	814	2350	498	655	2191	114	244	49
2005	1558	11137	4007	258	424	153	387	154	12	26

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	2212	33506	2528	792	158	40	767	103	47	22
2007	171	10257	4416	301	164	0	1	0	0	0
2008	469	26721	4168	1315	214	8	268	80	48	7
2009	3659	16911	13219	1532	341	832	1923	387	40	3
2010	140	42232	2226	1033	123	28	1116	35	3	1
2011	229	1848	31984	1417	315	8	53	418	35	4
2012	0	392	340	3174	108	0	0	0	0	0
2013	130	18403	7515	2205	4362	8	791	184	79	54
2014	6987	8133	3083	364	360	931	69	57	14	14
2015	206	26828	1729	550	167	0	0	0	0	0
2016	0	136	1246	99	16	0	0	0	0	0
2017	64	35135	3165	4808	112	3	268	41	40	7
2018	653	1844	15538	1032	365	93	164	824	44	12
2019	12111	5708	857	1972	107	6021	321	16	17	0
2020	938	12644	1170	285	478	46	89	13	3	5
2021	23	1141	991	53	33	2	49	28	2	1
2022	58	554	35	31	5	0	0	0	0	0
2023	2512	9582	3167	399	291	45	45	13	1	1

Table 9.2.2 Sandeel 1r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	5.51	9.96	13.74	16.90	2.42	7.50	10.75	14.12	17.71
1984	5.51	9.96	13.74	16.95	3.05	7.50	10.75	14.12	17.71
1985	5.51	9.96	13.74	16.51	2.42	7.50	10.75	14.12	18.66
1986	5.51	9.96	13.74	16.30	2.42	7.50	10.75	14.12	18.76
1987	5.80	11.00	15.60	18.04	3.05	8.90	10.80	21.40	19.85
1988	4.00	12.50	15.50	18.73	3.05	6.46	14.00	17.00	19.11
1989	4.00	12.50	15.50	18.01	3.05	10.50	14.00	17.00	19.01
1990	4.00	12.50	15.50	19.28	3.05	10.50	14.00	17.00	20.05

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1991	8.20	16.40	16.90	17.20	2.60	7.50	13.60	12.00	18.70
1992	7.43	13.83	17.51	22.60	3.40	9.43	16.61	20.04	22.58
1993	7.42	10.75	15.00	20.54	4.07	6.68	11.76	15.28	20.82
1994	5.11	8.33	13.50	14.54	3.05	6.46	11.04	15.42	18.70
1995	7.09	12.23	14.57	22.47	3.03	6.33	10.01	15.49	26.68
1996	5.02	7.59	10.83	17.36	1.69	5.34	10.86	13.71	21.71
1997	6.84	7.10	8.96	13.44	2.94	7.88	13.21	15.62	17.17
1998	5.84	8.03	10.17	14.23	3.27	4.70	9.40	11.24	17.01
1999	5.14	8.18	11.35	15.27	4.23	5.53	10.51	13.39	16.18
2000	6.58	9.98	14.22	16.45	2.94	4.43	9.72	16.25	17.50
2001	4.10	8.46	12.60	21.17	2.37	4.63	8.32	15.76	27.67
2002	6.01	7.86	10.62	16.89	3.05	6.46	11.04	15.42	18.70
2003	3.44	6.95	12.29	12.65	1.39	1.48	4.30	11.68	5.33
2004	4.87	7.89	9.69	11.91	2.69	4.70	8.33	9.24	12.76
2005	6.48	9.22	11.22	13.31	3.05	6.46	11.04	15.42	18.70
2006	5.88	10.68	12.82	14.61	3.05	6.46	11.04	15.42	18.70
2007	5.50	10.59	15.89	16.25	3.05	6.46	11.04	15.42	18.70
2008	6.12	11.41	13.67	16.10	3.05	6.46	11.04	15.42	18.70
2009	5.85	11.79	17.10	18.54	3.05	6.46	11.04	15.42	18.70
2010	5.87	12.79	14.99	19.72	3.05	6.46	11.04	15.42	18.70
2011	5.53	8.80	13.37	17.26	3.05	6.46	11.04	15.42	18.70
2012	6.67	9.84	12.08	15.84	3.05	6.46	11.04	15.42	18.70
2013	4.37	6.63	11.19	12.28	3.05	6.46	11.04	15.42	18.70
2014	4.48	8.39	12.80	18.54	3.05	6.46	11.04	15.42	18.70
2015	5.19	8.46	10.29	14.24	3.05	6.46	11.04	15.42	18.70
2016	4.35	10.67	13.17	14.37	3.05	6.46	11.04	15.42	18.70
2017	4.84	7.11	9.64	11.02	3.05	5.41	8.69	10.84	11.44
2018	3.78	6.63	9.73	11.87	3.05	6.46	11.04	15.42	18.70
2019	3.99	7.97	9.00	11.04	2.23	3.50	11.45	18.05	18.65

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2020	6.64	9.65	13.08	14.59	3.05	6.46	11.04	15.42	18.70
2021	5.31	9.56	11.50	13.08	3.05	6.46	11.04	15.42	18.70
2022	4.91	8.18	10.59	12.32	2.89	5.66	10.65	15.03	17.24
2023	4.73	8.85	11.21	13.49	2.38	5.09	8.67	12.25	14.72
2024	5.12	8.84	11.08	12.90	2.72	5.43	10.57	15.23	17.60

Table 9.2.3 Sandeel 1r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1984	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1985	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1986	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1987	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1988	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1989	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1990	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1991	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1992	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1993	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1994	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1995	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1996	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1997	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1998	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1999	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2000	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2001	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2002	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2003	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2004	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2005	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2006	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2007	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2008	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2009	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2010	0.03	0.57	0.90	0.96	0	0.03	0.57	0.90	0.96
2011	0.04	0.58	0.89	0.98	0	0.04	0.58	0.89	0.98
2012	0.03	0.58	0.88	0.97	0	0.03	0.58	0.88	0.97
2013	0.03	0.54	0.88	0.97	0	0.03	0.54	0.88	0.97
2014	0.03	0.52	0.87	0.96	0	0.03	0.52	0.87	0.96
2015	0.04	0.61	0.91	0.97	0	0.04	0.61	0.91	0.97
2016	0.04	0.61	0.91	0.97	0	0.04	0.61	0.91	0.97
2017	0.03	0.55	0.91	0.98	0	0.03	0.55	0.91	0.98
2018	0.04	0.54	0.91	0.98	0	0.04	0.54	0.91	0.98
2019	0.04	0.49	0.87	0.94	0	0.04	0.49	0.87	0.94
2020	0.03	0.52	0.87	0.95	0	0.03	0.52	0.87	0.95
2021	0.03	0.45	0.84	0.93	0	0.03	0.45	0.84	0.93
2022	0.03	0.48	0.84	0.93	0	0.03	0.48	0.84	0.93
2023	0.03	0.47	0.78	0.91	0	0.03	0.47	0.78	0.91
2024	0.03	0.49	0.85	0.94	0	0.03	0.49	0.85	0.94

Table 9.2.4 Sandeel 1r. Survey index scaled.

year	survey	0	1	2	3
2004	Dredge	482257027	2.769312e+07	-	-
2005	Dredge	991192952	1.675959e+07	-	-
2006	Dredge	522762576	6.074692e+07	-	-
2007	Dredge	1620640116	2.853984e+07	-	-
2008	Dredge	134823329	4.917682e+07	-	-

year	survey	0	1	2	3
2009	Dredge	1199268186	3.634360e+07	-	-
2010	Dredge	194486093	4.551273e+08	-	-
2011	Dredge	201832528	1.048964e+08	-	-
2012	Dredge	467160953	1.334699e+07	-	-
2013	Dredge	166480345	3.137431e+07	-	-
2014	Dredge	1030765513	1.574684e+07	-	-
2015	Dredge	104487552	5.916521e+07	-	-
2016	Dredge	910488504	2.474110e+07	-	-
2017	Dredge	120804876	1.681141e+08	-	-
2018	Dredge	495120015	5.108405e+07	-	-
2019	Dredge	664965965	7.956823e+07	-	-
2020	Dredge	241867263	3.444528e+07	-	-
2021	Dredge	223843312	3.784715e+07	-	-
2022	Dredge	397653294	6.815302e+07	-	-
2023	Dredge	393520342	2.537684e+07	-	-
2014	RTM	-	5.100920e+04	12911.888	820.822
2015	RTM	-	1.102658e+05	9547.949	3017.843
2016	RTM	-	6.223111e+03	88696.479	7252.466
2017	RTM	-	1.010084e+05	12984.292	21850.023
2018	RTM	-	1.016697e+04	77981.871	5679.823
2019	RTM	-	4.634750e+04	10103.263	26144.144
2020	RTM	-	5.714265e+04	6802.857	2379.535
2023	RTM	-	3.295690e+04	15763.386	2713.564

Table 9.2.5 Sandeel 1r. SMS settings and statistics.

```
Model evaluation date:  2024-02-02 13:02:24.009385

Time to run model (seconds):  4.3

number of parameters: 64

Maximum gradient:  0.0041

AIC: 884
```

```
Observations used in likelihood:
Catch: 302 Survey: 64 Stock recruitment: 41 Sum: 407
Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.4000124	0	Dredge
0.7438342	1	Dredge
0.4770372	1	RTM
0.4898499	2	RTM
0.4898499	3	RTM
catchCV	ages	season
0.4689274	1	1
0.4689274	2	1
0.7568953	3	1
0.7568953	4	1
0.5562196	1	2
0.5562196	2	2
1.2048231	3	2
1.2048231	4	2

Table 9.2.6 Sandeel 1r.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0	0.5044581	0.8942963	1.1418737	1.1418737	0.6993772
1984	0	0.5700776	1.0106256	1.2904077	1.2904077	0.7903516
1985	0	0.6111931	1.0835147	1.3834754	1.3834754	0.8473539
1986	0	0.4113427	0.7292226	0.9311009	0.9311009	0.5702826
1987	0	0.3241361	0.5746239	0.7337031	0.7337031	0.4493800
1988	0	0.4425888	0.7846152	1.0018285	1.0018285	0.6136020
1989	0	0.4787653	0.8487485	1.0837165	1.0837165	0.6637569
1990	0	0.4679246	0.8295303	1.0591779	1.0591779	0.6487275
1991	0	0.3442880	0.6103490	0.7793183	0.7793183	0.4773185
1992	0	0.4986747	0.8840436	1.1287827	1.1287827	0.6913592

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0	0.2193623	0.3888825	0.4965409	0.4965409	0.3041224
1994	0	0.1760563	0.3121102	0.3985149	0.3985149	0.2440833
1995	0	0.3273376	0.5802996	0.7409500	0.7409500	0.4538186
1996	0	0.3141481	0.5569173	0.7110946	0.7110946	0.4355327
1997	0	0.3198007	0.5669383	0.7238897	0.7238897	0.4433695
1998	0	0.3942354	0.6988950	0.8923774	0.8923774	0.5465652
1999	0	0.7494755	1.0014002	0.7765438	0.7765438	0.8754379
2000	0	0.6187041	0.8266720	0.6410494	0.6410494	0.7226881
2001	0	0.9637147	1.2876526	0.9985205	0.9985205	1.1256837
2002	0	0.7164517	0.9572759	0.7423273	0.7423273	0.8368638
2003	0	0.5935845	0.7931089	0.6150226	0.6150226	0.6933467
2004	0	0.6191288	0.8272394	0.6414894	0.6414894	0.7231841
2005	0	0.3182598	0.4252379	0.3297542	0.3297542	0.3717489
2006	0	0.4339876	0.5798658	0.4496616	0.4496616	0.5069267
2007	0	0.1540227	0.2057951	0.1595854	0.1595854	0.1799089
2008	0	0.3325348	0.4443113	0.3445448	0.3445448	0.3884231
2009	0	0.4095691	0.5472394	0.4243612	0.4243612	0.4784042
2010	0	0.2814347	0.3760346	0.2915990	0.2915990	0.3287346
2011	0	0.4093886	0.5469983	0.4241742	0.4241742	0.4781935
2012	0	0.0583214	0.0779253	0.0604278	0.0604278	0.0681233
2013	0	0.4193981	0.5603723	0.4345452	0.4345452	0.4898852
2014	0	0.2014784	0.2692023	0.2087551	0.2087551	0.2353404
2015	0	0.1558805	0.2082774	0.1615104	0.1615104	0.1820790
2016	0	0.0163295	0.0218184	0.0169193	0.0169193	0.0190740
2017	0	0.3202913	0.4279523	0.3318590	0.3318590	0.3741218
2018	0	0.2826800	0.3776986	0.2928894	0.2928894	0.3301893
2019	0	0.2086044	0.2787235	0.2161384	0.2161384	0.2436640
2020	0	0.2843133	0.3798808	0.2945816	0.2945816	0.3320971
2021	0	0.0365488	0.0488342	0.0378688	0.0378688	0.0426915

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2022	0	0.0110479	0.0147614	0.0114469	0.0114469	0.0129046
2023	0	0.2199799	0.2939228	0.2279248	0.2279248	0.2569514
arith.mean	0	0.3712078	0.5641906	0.5763476	0.5763476	0.4676992

Table 9.2.7 Sandeel 1r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.384	0.680	0.868	0.868	0.121	0.214	0.273	0.273
1984	0.438	0.776	0.991	0.991	0.132	0.234	0.299	0.299
1985	0.469	0.831	1.062	1.062	0.142	0.252	0.322	0.322
1986	0.364	0.646	0.824	0.824	0.047	0.084	0.107	0.107
1987	0.241	0.428	0.546	0.546	0.083	0.147	0.188	0.188
1988	0.395	0.701	0.895	0.895	0.047	0.084	0.107	0.107
1989	0.460	0.816	1.042	1.042	0.018	0.033	0.042	0.042
1990	0.438	0.776	0.991	0.991	0.030	0.054	0.069	0.069
1991	0.261	0.463	0.592	0.592	0.083	0.147	0.188	0.188
1992	0.447	0.792	1.011	1.011	0.052	0.092	0.118	0.118
1993	0.196	0.348	0.444	0.444	0.023	0.041	0.053	0.053
1994	0.159	0.282	0.359	0.359	0.017	0.031	0.039	0.039
1995	0.292	0.518	0.662	0.662	0.035	0.062	0.079	0.079
1996	0.273	0.485	0.619	0.619	0.041	0.072	0.092	0.092
1997	0.234	0.416	0.531	0.531	0.085	0.151	0.193	0.193
1998	0.358	0.634	0.810	0.810	0.036	0.065	0.083	0.083
1999	0.657	0.878	0.681	0.681	0.092	0.123	0.096	0.096
2000	0.531	0.709	0.550	0.550	0.088	0.117	0.091	0.091
2001	0.690	0.922	0.715	0.715	0.274	0.365	0.283	0.283
2002	0.696	0.929	0.721	0.721	0.021	0.028	0.022	0.022
2003	0.511	0.682	0.529	0.529	0.083	0.111	0.086	0.086
2004	0.577	0.770	0.597	0.597	0.042	0.057	0.044	0.044
2005	0.305	0.408	0.316	0.316	0.013	0.017	0.014	0.014

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0.414	0.553	0.429	0.429	0.020	0.027	0.021	0.021
2007	0.154	0.206	0.160	0.160	0.000	0.000	0.000	0.000
2008	0.322	0.430	0.334	0.334	0.010	0.014	0.011	0.011
2009	0.390	0.521	0.404	0.404	0.020	0.026	0.020	0.020
2010	0.268	0.358	0.278	0.278	0.013	0.018	0.014	0.014
2011	0.395	0.527	0.409	0.409	0.015	0.020	0.015	0.015
2012	0.058	0.078	0.060	0.060	0.000	0.000	0.000	0.000
2013	0.419	0.560	0.435	0.435	0.000	0.000	0.000	0.000
2014	0.194	0.259	0.201	0.201	0.008	0.011	0.008	0.008
2015	0.156	0.208	0.162	0.162	0.000	0.000	0.000	0.000
2016	0.016	0.022	0.017	0.017	0.000	0.000	0.000	0.000
2017	0.315	0.421	0.326	0.326	0.005	0.007	0.006	0.006
2018	0.255	0.341	0.264	0.264	0.028	0.037	0.029	0.029
2019	0.179	0.239	0.185	0.185	0.030	0.040	0.031	0.031
2020	0.280	0.375	0.291	0.291	0.004	0.005	0.004	0.004
2021	0.034	0.045	0.035	0.035	0.003	0.004	0.003	0.003
2022	0.011	0.015	0.011	0.011	0.000	0.000	0.000	0.000
2023	0.218	0.291	0.226	0.226	0.002	0.003	0.002	0.002

Table 9.2.8 Sandeel 1r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.38	0.36	0.29	0.27	0.44	0.42	0.35	0.29	0.29
1984	0.38	0.36	0.29	0.27	0.44	0.42	0.35	0.29	0.29
1985	0.36	0.34	0.28	0.26	0.46	0.44	0.36	0.31	0.31
1986	0.37	0.35	0.29	0.27	0.46	0.44	0.37	0.32	0.32
1987	0.38	0.37	0.30	0.28	0.47	0.45	0.38	0.34	0.34
1988	0.39	0.38	0.30	0.28	0.48	0.46	0.37	0.34	0.34
1989	0.41	0.40	0.32	0.29	0.48	0.46	0.36	0.34	0.34
1990	0.41	0.40	0.32	0.29	0.49	0.46	0.35	0.33	0.33

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1991	0.41	0.39	0.32	0.29	0.49	0.46	0.34	0.33	0.33
1992	0.41	0.39	0.31	0.29	0.48	0.44	0.32	0.31	0.31
1993	0.40	0.37	0.30	0.28	0.47	0.44	0.31	0.30	0.30
1994	0.39	0.36	0.29	0.27	0.49	0.45	0.32	0.31	0.31
1995	0.38	0.37	0.29	0.26	0.48	0.46	0.34	0.32	0.32
1996	0.35	0.34	0.27	0.24	0.51	0.48	0.35	0.33	0.33
1997	0.35	0.35	0.29	0.24	0.51	0.48	0.36	0.32	0.32
1998	0.38	0.38	0.31	0.25	0.57	0.53	0.37	0.32	0.32
1999	0.41	0.41	0.33	0.26	0.59	0.53	0.40	0.32	0.32
2000	0.42	0.42	0.35	0.27	0.59	0.53	0.41	0.32	0.32
2001	0.38	0.38	0.33	0.25	0.59	0.52	0.44	0.31	0.31
2002	0.42	0.41	0.37	0.28	0.61	0.55	0.49	0.31	0.31
2003	0.44	0.44	0.39	0.29	0.63	0.56	0.53	0.31	0.31
2004	0.49	0.49	0.44	0.32	0.64	0.58	0.57	0.32	0.31
2005	0.50	0.50	0.44	0.33	0.66	0.58	0.58	0.33	0.31
2006	0.54	0.54	0.46	0.35	0.71	0.62	0.62	0.35	0.33
2007	0.55	0.55	0.46	0.37	0.72	0.63	0.63	0.37	0.35
2008	0.55	0.55	0.46	0.38	0.67	0.61	0.61	0.37	0.36
2009	0.48	0.48	0.40	0.34	0.63	0.58	0.58	0.37	0.36
2010	0.46	0.46	0.39	0.34	0.66	0.61	0.61	0.40	0.38
2011	0.51	0.51	0.43	0.36	0.74	0.68	0.68	0.44	0.41
2012	0.58	0.57	0.47	0.39	0.77	0.71	0.71	0.44	0.41
2013	0.59	0.58	0.47	0.38	0.72	0.67	0.67	0.40	0.37
2014	0.52	0.52	0.43	0.35	0.70	0.64	0.63	0.38	0.35
2015	0.53	0.53	0.44	0.34	0.69	0.62	0.62	0.37	0.34
2016	0.49	0.49	0.42	0.33	0.71	0.63	0.63	0.38	0.35
2017	0.50	0.50	0.44	0.33	0.67	0.60	0.59	0.37	0.33
2018	0.47	0.47	0.41	0.31	0.62	0.55	0.55	0.35	0.31
2019	0.47	0.47	0.42	0.32	0.59	0.52	0.51	0.33	0.29

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2020	0.48	0.48	0.43	0.34	0.59	0.51	0.51	0.32	0.30
2021	0.47	0.47	0.43	0.34	0.58	0.49	0.49	0.31	0.29
2022	0.33	0.32	0.30	0.23	0.58	0.49	0.49	0.31	0.29
2023	0.33	0.32	0.30	0.23	0.58	0.50	0.50	0.32	0.30
2024	0.38	0.37	0.34	0.27	0.58	0.50	0.50	0.32	0.30

Table 9.2.9 Sandeel 1r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1983	245077047	11170752	45056399	2527705.7	296978.9
1984	65500662	158077493	3035165	9026892.7	507594.9
1985	424615323	42248675	40222756	541306.2	1475160.0
1986	59675539	268028389	10270949	6722640.8	285254.4
1987	44482724	37785011	79411660	2415233.8	1505634.0
1988	183632700	27726572	11834301	21258329.4	1008884.7
1989	92470964	113379874	7570935	2548229.3	4320094.6
1990	138818658	56993222	29303504	1510590.5	1227182.1
1991	148637372	84986617	14873051	6052802.5	500177.9
1992	42105123	90632596	25227277	3881656.7	1586113.5
1993	181486231	26097958	23425763	5125029.4	958494.3
1994	252848163	112949497	9007341	7995443.3	2037833.5
1995	59314859	155550354	40773652	3318023.7	3712598.6
1996	421303514	36534591	48529513	11319759.3	1853319.2
1997	63014491	253227808	11740702	13894780.3	3566989.9
1998	109972300	37662894	80020168	3277079.4	4661883.0
1999	158808396	62235559	10262904	18739081.5	1790080.5
2000	220876438	88425827	11495420	1687708.9	4942841.7
2001	406183593	122893006	18495920	2194454.3	1912315.9
2002	31700748	225871200	19092356	2251392.0	829531.3
2003	180874509	17185889	42071356	2957358.8	761010.8

years	Age 0	Age 1	Age 2	Age 3	Age 4
2004	94940920	96403304	3472734	7197320.0	1016581.9
2005	223195839	49891375	17805203	526068.5	2073334.6
2006	130334943	114795305	12271400	3965375.6	962550.4
2007	273978793	64146249	23294049	2163975.9	1429724.1
2008	95050587	133241247	16839593	5826231.0	1390535.2
2009	580173032	48500976	29941455	3393989.8	2275839.7
2010	48548431	309330017	11182949	6031087.4	1760748.2
2011	51769630	25160003	79694693	2627470.7	2677882.1
2012	132646258	24716796	5081149	14067668.6	1536821.8
2013	79321813	61634834	6453416	1305656.7	5941835.5
2014	296846755	38527521	11547286	1053434.7	2156650.6
2015	44965443	147914395	9901009	2780587.4	1257612.6
2016	339725775	22563802	40166732	2557986.2	1589418.4
2017	30615606	166511673	7241909	12863615.7	1921269.0
2018	61316958	15687840	40318748	1580861.5	4827021.7
2019	117436752	32848216	4248887	9971933.5	2487132.7
2020	37768054	65409788	9907859	1200158.7	4880001.1
2021	62569563	21005282	18290141	2533522.2	2350944.2
2022	86161161	35115172	7688947	6669990.0	2360642.6
2023	97295785	48355204	15288549	3360468.1	4953337.5

Table 9.2.10 Sandeel 1r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1983	245077047	550062	321665	261037	0.699
1984	65500662	1033870	178732	412388	0.79
1985	424615323	665201	292091	330970	0.847
1986	59675539	1676154	216717	513689	0.57
1987	44482724	1157521	619474	382150	0.449
1988	183632700	607236	420061	289486	0.614

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1989	92470964	665459	190141	260450	0.664
1990	138818658	641341	284383	273180	0.649
1991	148637372	1051704	285638	286674	0.477
1992	42105123	1126107	345202	450175	0.691
1993	181486231	542094	256539	129776	0.304
1994	252848163	789676	199871	132564	0.244
1995	59314859	1732448	485214	489051	0.454
1996	421303514	706234	383415	245386	0.436
1997	63014491	1989065	287049	494242	0.443
1998	109972300	961867	507826	380516	0.547
1999	158808396	643472	288918	292683	0.875
2000	220876438	801946	197260	304390	0.723
2001	406183593	728827	184353	379927	1.126
2002	31700748	1544684	187478	672407	0.837
2003	180874509	397452	229151	161922	0.693
2004	94940920	578435	113179	215125	0.723
2005	223195839	520913	148957	122249	0.372
2006	130334943	870476	171502	248318	0.507
2007	273978793	656857	224112	81603	0.18
2008	95050587	1109584	250450	255801	0.388
2009	580173032	736912	328266	223510	0.478
2010	48548431	2084846	245337	416704	0.329
2011	51769630	921973	488400	294826	0.478
2012	132646258	408969	206415	19117	0.068
2013	79321813	399429	114639	111267	0.49
2014	296846755	323155	105780	50876	0.235
2015	44965443	897524	124022	104672	0.182
2016	339725775	583119	319035	9364	0.019
2017	30615606	1003326	183835	223171	0.374

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2018	61316958	399102	217841	95795	0.33
2019	117436752	282167	125157	44826	0.244
2020	37768054	616539	144524	128988	0.332
2021	62569563	346142	134493	11502	0.043
2022	86161161	335075	120968	3395	0.013
2023	97295785	468573	159384	87113	0.257
2024	115580737		175408		

Table 9.2.11 Sandeel 1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	116079425	54439791.000	16990940.000	5023326.000	3772938.000
Exploitation pattern season 1	-	0.848	1.134	0.879	0.879
Exploitation pattern season 2	-	0.008	0.010	0.008	0.008
west season 1	2.18	5.115	8.842	11.075	12.902
weca season 1	2.18	5.115	8.842	11.075	12.902
weca season 2	2.719	5.434	10.570	15.230	17.603
Proportion mature (2024)	-	0.026	0.465	0.783	0.914
Proportion mature (2025)	-	0.026	0.465	0.783	0.914
Natural mortality season 1	-	0.327	0.324	0.299	0.232
Natural mortality season 2	0.581	0.499	0.495	0.316	0.296

Table 9.2.12 Sandeel 1r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	132314.85	0.36	166003.0	-5	10
F = 0	0.00	0.00	229840.1	31	-100
Bescapement (no cap)	185442.71	0.55	140824.0	-20	54
Blim	260656.89	0.87	105809.0	-40	116
F = F 2023	98713.66	0.26	182077.7	4	-18
Obs TAC	5000.00	0.01	227404.1	30	-96

Table 9.3.1 Sandeel 2r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	147	4162	6191	203	67	12882	476	877	104	0
1984	2	10284	912	1154	38	0	3846	186	193	10
1985	830	1406	5479	472	109	1795	387	760	381	49
1986	5	24479	3144	436	6	1443	3495	208	95	7
1987	0	831	2621	131	20	45	512	591	17	4
1988	400	1030	3379	3163	478	5602	545	226	775	31
1989	1237	23364	1666	938	909	2819	3809	273	10	34
1990	0	7328	3964	587	177	5046	854	196	29	9
1991	0	14203	2099	451	156	10053	3628	110	35	1
1992	117	12016	4066	475	298	6830	886	85	34	7
1993	7835	6341	873	467	220	18579	548	440	153	35
1994	0	35123	3616	158	54	0	5885	683	217	71
1995	901	4230	1381	201	66	1000	1669	1646	201	143
1996	4447	4614	708	420	107	28160	6457	258	156	39
1997	43	37584	1381	387	55	29	8809	207	125	38
1998	1920	850	4805	201	115	1081	42	1493	91	76
1999	736	1343	104	706	118	6817	682	100	484	81
2000	0	8296	430	255	583	0	1043	179	108	167
2001	2273	4438	735	82	310	7117	2691	559	73	229
2002	15	17190	250	142	58	3	1415	195	51	31
2003	559	297	1689	96	59	6843	221	488	39	15
2004	1283	10301	671	454	170	741	1921	198	252	51
2005	26	1896	640	66	165	2	514	317	31	90
2006	0	2249	291	96	28	0	1123	105	46	18
2007	32	4961	302	40	5	0	0	0	0	0
2008	37	3658	479	50	16	0	247	51	7	1
2009	482	3128	337	14	5	271	1950	24	3	2
2010	0	7164	85	90	15	1	1247	40	26	5

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2011	0	548	1351	226	46	0	3	14	3	1
2012	8	291	315	308	41	5	12	81	1	0
2013	0	4501	1045	320	77	0	372	38	15	3
2014	39	5543	2978	318	81	191	38	34	16	34
2015	0	2146	853	655	228	0	10	20	17	7
2016	2451	310	144	103	63	24	4	0	0	0
2017	0	22369	233	82	13	0	1269	5	24	1
2018	0	53	1996	57	12	0	0	19	2	0
2019	12	206	50	171	4	0	0	0	0	0
2020	408	7526	426	180	349	4	15	2	1	3
2021	0	606	96	3	3	0	0	0	0	0
2022	160	5925	1016	459	278	0	0	0	0	0
2023	0	4257	1049	179	166	0	57	45	9	9

Table 9.3.2 Sandeel 2r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	5.63	10.45	18.34	20.78	3.01	13.08	23.79	25.47	17.71
1984	5.58	12.48	14.62	18.41	3.51	10.73	26.64	23.52	17.71
1985	5.54	10.20	17.66	33.85	2.60	10.10	19.57	22.17	30.20
1986	5.60	11.75	18.16	16.30	3.01	9.90	18.74	14.12	18.76
1987	5.72	11.15	16.16	21.51	1.96	10.76	11.00	21.40	19.85
1988	5.20	12.84	16.04	18.87	3.03	13.23	24.06	18.82	26.93
1989	5.00	12.86	16.06	18.01	5.00	9.11	15.64	17.00	19.01
1990	4.85	12.65	18.80	26.30	3.00	12.67	23.73	30.51	36.87
1991	7.62	15.80	19.68	24.18	3.13	7.72	13.76	12.43	44.00
1992	6.07	11.32	18.36	28.95	5.47	9.86	16.90	20.04	22.58
1993	7.02	15.66	16.81	21.19	2.34	13.84	15.80	17.32	19.33
1994	4.20	9.10	22.13	27.48	3.51	7.26	16.63	23.34	23.86
1995	9.31	15.37	19.86	20.84	5.27	9.26	14.75	19.08	20.97

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1996	5.79	15.90	19.48	28.83	3.03	4.60	17.59	19.22	26.10
1997	4.35	7.99	9.33	18.45	4.55	6.68	11.47	16.12	17.77
1998	6.15	10.96	16.25	21.03	3.73	14.45	14.48	16.86	17.71
1999	7.10	13.15	15.98	18.52	3.83	6.83	12.59	17.58	26.67
2000	7.25	13.67	16.97	20.10	3.49	11.54	13.50	18.60	18.76
2001	5.66	13.84	17.54	20.60	2.97	4.59	12.68	18.41	22.00
2002	5.67	12.57	17.41	20.48	3.50	7.69	14.66	15.73	17.81
2003	6.10	11.51	13.91	15.73	3.23	5.84	12.56	25.04	29.76
2004	7.03	10.53	13.29	16.51	3.61	8.70	11.90	12.80	13.61
2005	7.32	11.83	14.25	14.45	3.51	9.15	15.76	19.27	25.06
2006	8.39	11.36	13.27	14.48	3.51	9.15	15.76	19.27	25.06
2007	7.12	14.37	15.91	19.30	3.51	9.15	15.76	19.27	25.06
2008	5.83	14.99	22.76	30.57	3.51	9.15	15.76	19.27	25.06
2009	6.19	12.09	16.50	17.89	3.31	5.08	24.89	38.52	18.16
2010	5.63	10.76	23.29	25.17	3.51	9.15	15.76	19.27	25.06
2011	7.25	12.01	13.83	14.70	3.51	9.15	15.76	19.27	25.06
2012	8.73	12.73	14.07	15.63	3.51	9.15	15.76	19.27	25.06
2013	6.39	8.66	15.11	15.38	3.51	9.65	12.85	15.19	16.44
2014	5.04	9.89	12.65	16.42	3.51	9.15	15.76	19.27	25.06
2015	6.87	12.63	14.72	15.71	3.51	9.15	15.76	19.27	25.06
2016	3.37	12.73	14.22	15.25	3.51	9.15	15.76	19.27	25.06
2017	5.76	8.87	12.79	18.89	3.50	8.13	13.47	11.05	21.17
2018	4.97	9.42	13.03	14.58	3.51	9.15	15.76	19.27	25.06
2019	7.97	12.96	15.91	18.62	3.51	9.15	15.76	19.27	25.06
2020	6.73	14.98	17.60	24.35	3.51	9.15	15.76	19.27	25.06
2021	4.85	11.77	16.64	18.85	3.51	9.15	15.76	19.27	25.06
2022	6.06	11.60	15.20	19.06	3.51	8.94	15.31	17.63	24.28
2023	5.34	10.34	13.64	14.43	2.74	7.02	11.89	14.58	19.38
2024	6.19	12.33	15.80	19.06	3.36	8.68	14.90	18.01	23.77

Table 9.3.3 Sandeel 2r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1984	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1985	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1986	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1987	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1988	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1989	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1990	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1991	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1992	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1993	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1994	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1995	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1996	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1997	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1998	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1999	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2000	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2001	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2002	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2003	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2004	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2005	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2006	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2007	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2008	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2009	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2010	0.03	0.78	0.95	1.00	0	0.03	0.78	0.95	1.00

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2011	0.03	0.79	0.95	1.00	0	0.03	0.79	0.95	1.00
2012	0.03	0.78	0.95	1.00	0	0.03	0.78	0.95	1.00
2013	0.03	0.68	0.95	1.00	0	0.03	0.68	0.95	1.00
2014	0.03	0.67	0.99	1.00	0	0.03	0.67	0.99	1.00
2015	0.01	0.77	0.99	1.00	0	0.01	0.77	0.99	1.00
2016	0.01	0.64	0.98	1.00	0	0.01	0.64	0.98	1.00
2017	0.02	0.64	0.98	1.00	0	0.02	0.64	0.98	1.00
2018	0.01	0.60	0.98	1.00	0	0.01	0.60	0.98	1.00
2019	0.02	0.58	0.98	0.99	0	0.02	0.58	0.98	0.99
2020	0.01	0.59	0.97	0.99	0	0.01	0.59	0.97	0.99
2021	0.01	0.50	0.97	0.99	0	0.01	0.50	0.97	0.99
2022	0.02	0.59	0.98	0.99	0	0.02	0.59	0.98	0.99
2023	0.02	0.59	0.97	0.99	0	0.02	0.59	0.97	0.99
2024	0.02	0.57	0.98	0.99	0	0.02	0.57	0.98	0.99

Table 9.3.4 Sandeel 2r. Survey index scaled.

year	survey	0	1
2004	Dredge	2068867991	396885535
2005	Dredge	2703278191	394345595
2006	Dredge	10570111832	399752088
2007	Dredge	6962204638	1351598928
2008	Dredge	1657628704	252831436
2009	Dredge	3993255249	260845097
2010	Dredge	702870863	1501230744
2011	Dredge	1208675259	283802056
2012	Dredge	4007437682	198514104
2013	Dredge	3280449563	1305205108
2014	Dredge	4322256934	749308778
2015	Dredge	329351448	147881716

year	survey	0	1
2016	Dredge	23624078663	85417595
2017	Dredge	391037552	2680128753
2018	Dredge	1473864070	228801528
2019	Dredge	12397583925	501892168
2020	Dredge	5030520985	712723398
2021	Dredge	19349964817	470303399
2022	Dredge	10759723421	2054281329
2023	Dredge	433200143	1971456343

Table 9.3.5 Sandeel 2r. SMS settings and statistics.

```
Model evaluation date:  2024-01-31 16:02:33.104762

Time to run model (seconds):  3.4

number of parameters: 67

Maximum gradient:  5e-04

AIC: 976

Observations used in likelihood:

Catch: 312 Survey: 40 Stock recruitment: 41 Sum: 393

Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.5992212	0	Dredge
0.4802853	1	Dredge
catchCV	ages	season
0.4656523	1	1
0.4656523	2	1
0.9325990	3	1
0.9325990	4	1
0.8194081	1	2
0.8194081	2	2
1.2988993	3	2

surveyCV	ages	survey
1.2988993	4	2

Table 9.3.6 Sandeel 2r.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0	0.4923959	0.7742001	0.9916167	0.9916167	0.6332980
1984	0	0.4337831	0.6820426	0.8735788	0.8735788	0.5579129
1985	0	0.4040066	0.6352245	0.8136129	0.8136129	0.5196155
1986	0	0.5898270	0.9273923	1.1878294	1.1878294	0.7586097
1987	0	0.1294137	0.2034787	0.2606211	0.2606211	0.1664462
1988	0	0.4602725	0.7236921	0.9269246	0.9269246	0.5919823
1989	0	0.7328974	1.1523438	1.4759533	1.4759533	0.9426206
1990	0	0.5155158	0.8105519	1.0381770	1.0381770	0.6630339
1991	0	0.5541209	0.8712512	1.1159223	1.1159223	0.7126860
1992	0	0.5227433	0.8219158	1.0527322	1.0527322	0.6723295
1993	0	0.4788645	0.7529246	0.9643663	0.9643663	0.6158945
1994	0	0.4794717	0.7538793	0.9655892	0.9655892	0.6166755
1995	0	0.2876803	0.4523232	0.5793479	0.5793479	0.3700017
1996	0	0.4958449	0.7796231	0.9985626	0.9985626	0.6377340
1997	0	0.5828766	0.9164641	1.1738322	1.1738322	0.7496703
1998	0	0.3086226	0.4852512	0.6215229	0.6215229	0.3969369
1999	0	0.5495992	0.4415786	0.5299354	0.5299354	0.4955889
2000	0	0.6301615	0.5063069	0.6076154	0.6076154	0.5682342
2001	0	0.6554768	0.5266466	0.6320249	0.6320249	0.5910617
2002	0	0.7378099	0.5927976	0.7114123	0.7114123	0.6653037
2003	0	0.6418037	0.5156609	0.6188410	0.6188410	0.5787323
2004	0	1.0255684	0.8239989	0.9888754	0.9888754	0.9247837
2005	0	1.2574156	1.1822128	0.9223706	0.9223706	1.2198142
2006	0	1.2884489	1.2113901	0.9451349	0.9451349	1.2499195
2007	0	0.7539890	0.7088949	0.5530847	0.5530847	0.7314420

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2008	0	0.7800267	0.7333753	0.5721845	0.5721845	0.7567010
2009	0	0.7421778	0.6977900	0.5444206	0.5444206	0.7199839
2010	0	0.3251831	0.4793922	0.4989766	0.4989766	0.4022876
2011	0	0.1745138	0.2572721	0.2677824	0.2677824	0.2158929
2012	0	0.1310028	0.1931273	0.2010171	0.2010171	0.1620651
2013	0	0.5158548	0.7604846	0.7915525	0.7915525	0.6381697
2014	0	0.4662145	0.6873038	0.7153820	0.7153820	0.5767592
2015	0	0.4289722	0.6324004	0.6582357	0.6582357	0.5306863
2016	0	0.1332219	0.1963987	0.2044221	0.2044221	0.1648103
2017	0	0.7649472	1.1277021	1.1737718	1.1737718	0.9463247
2018	0	0.1834955	0.2705132	0.2815644	0.2815644	0.2270044
2019	0	0.0521417	0.0768684	0.0800087	0.0800087	0.0645051
2020	0	0.4953729	0.7302897	0.7601241	0.7601241	0.6128313
2021	0	0.0748727	0.1103790	0.1148883	0.1148883	0.0926259
2022	0	0.5246523	0.7734541	0.8050518	0.8050518	0.6490532
2023	0	0.3508933	0.5172948	0.5384277	0.5384277	0.4340941
arith.mean	0	0.5159062	0.6462461	0.7257877	0.7257877	0.5810762

Table 9.3.7 Sandeel 2r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.335	0.527	0.674	0.674	0.157	0.248	0.317	0.317
1984	0.284	0.446	0.571	0.571	0.150	0.236	0.302	0.302
1985	0.301	0.474	0.607	0.607	0.103	0.161	0.207	0.207
1986	0.469	0.738	0.945	0.945	0.121	0.190	0.243	0.243
1987	0.091	0.144	0.184	0.184	0.038	0.060	0.077	0.077
1988	0.331	0.520	0.666	0.666	0.129	0.204	0.261	0.261
1989	0.561	0.883	1.131	1.131	0.171	0.270	0.345	0.345
1990	0.425	0.668	0.855	0.855	0.091	0.143	0.183	0.183
1991	0.402	0.633	0.811	0.811	0.152	0.238	0.305	0.305

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1992	0.412	0.648	0.830	0.830	0.111	0.174	0.223	0.223
1993	0.300	0.472	0.604	0.604	0.179	0.281	0.360	0.360
1994	0.365	0.574	0.735	0.735	0.115	0.180	0.231	0.231
1995	0.186	0.293	0.375	0.375	0.101	0.160	0.204	0.204
1996	0.192	0.302	0.387	0.387	0.304	0.478	0.612	0.612
1997	0.392	0.616	0.789	0.789	0.191	0.301	0.385	0.385
1998	0.198	0.312	0.400	0.400	0.110	0.173	0.222	0.222
1999	0.171	0.137	0.165	0.165	0.379	0.304	0.365	0.365
2000	0.441	0.354	0.425	0.425	0.189	0.152	0.183	0.183
2001	0.299	0.240	0.289	0.289	0.356	0.286	0.343	0.343
2002	0.529	0.425	0.510	0.510	0.209	0.168	0.201	0.201
2003	0.228	0.183	0.219	0.219	0.414	0.333	0.399	0.399
2004	0.699	0.562	0.674	0.674	0.326	0.262	0.314	0.314
2005	0.732	0.688	0.537	0.537	0.526	0.494	0.386	0.386
2006	0.641	0.603	0.470	0.470	0.648	0.609	0.475	0.475
2007	0.754	0.709	0.553	0.553	0.000	0.000	0.000	0.000
2008	0.618	0.581	0.454	0.454	0.162	0.152	0.119	0.119
2009	0.470	0.442	0.345	0.345	0.272	0.256	0.200	0.200
2010	0.276	0.406	0.423	0.423	0.050	0.073	0.076	0.076
2011	0.172	0.253	0.264	0.264	0.003	0.004	0.004	0.004
2012	0.125	0.184	0.192	0.192	0.006	0.009	0.009	0.009
2013	0.471	0.695	0.723	0.723	0.045	0.066	0.068	0.068
2014	0.445	0.655	0.682	0.682	0.022	0.032	0.033	0.033
2015	0.422	0.622	0.648	0.648	0.007	0.010	0.010	0.010
2016	0.130	0.191	0.199	0.199	0.004	0.005	0.006	0.006
2017	0.684	1.008	1.050	1.050	0.081	0.119	0.124	0.124
2018	0.182	0.268	0.279	0.279	0.002	0.002	0.002	0.002
2019	0.052	0.077	0.080	0.080	0.000	0.000	0.000	0.000
2020	0.474	0.699	0.728	0.728	0.021	0.031	0.032	0.032

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2021	0.075	0.110	0.115	0.115	0.000	0.000	0.000	0.000
2022	0.525	0.773	0.805	0.805	0.000	0.000	0.000	0.000
2023	0.340	0.501	0.522	0.522	0.011	0.016	0.017	0.017

Table 9.3.8 Sandeel 2r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1984	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1985	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1986	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1987	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1988	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1989	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1990	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1991	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1992	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1993	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1994	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1995	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1996	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1997	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1998	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1999	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2000	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2001	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2002	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2003	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2004	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2005	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2007	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2008	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2009	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2010	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2011	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2012	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2013	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2014	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2015	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2016	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2017	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2018	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2019	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2020	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2021	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2022	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2023	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2024	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36

Table 9.3.9 Sandeel 2r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1983	123674288	15406883	12669477.1	589390.72	46788.09
1984	37915230	55619583	3063416.4	2340445.72	111922.53
1985	246491158	17051477	11726655.9	620539.51	484510.06
1986	44948897	110853561	3703738.0	2489260.86	238466.76
1987	28008431	20214702	19995262.2	587015.56	394788.36
1988	135635566	12596129	5778295.9	6536242.36	367375.18
1989	60457329	60998884	2586302.8	1122729.20	1293797.53

years	Age 0	Age 1	Age 2	Age 3	Age 4
1990	102968083	27189252	9535964.9	327335.85	270748.67
1991	60145601	46307457	5282599.2	1698701.80	103209.74
1992	75439939	27049060	8656361.0	885602.47	279621.92
1993	144703712	33927326	5217515.2	1524588.36	195183.47
1994	48867331	65077068	6837817.6	984562.91	311821.98
1995	63569666	21976925	13107870.3	1289088.15	236935.78
1996	321307369	28588952	5362472.2	3340883.90	407873.20
1997	11037585	144500381	5664891.4	985257.51	656634.68
1998	22353693	4963893	26246112.3	907709.81	246467.55
1999	53824536	10053044	1186111.1	6472824.15	296995.82
2000	29975024	24206310	1887755.7	305577.18	1885734.48
2001	114610572	13480557	4193619.2	455858.66	598466.29
2002	10933558	51543391	2277057.4	992293.19	275327.01
2003	36690057	4917109	8018300.2	504308.14	298224.32
2004	16675214	16500484	842003.9	1918246.28	209426.02
2005	17952422	7499282	1925014.7	147988.05	376028.45
2006	27481310	8073677	693852.4	236470.12	103438.53
2007	19025175	12359069	724171.1	82782.36	63698.98
2008	14268916	8556122	1891770.9	142804.79	41007.53
2009	55854309	6417107	1276003.2	364031.04	49725.49
2010	12431878	25119153	993920.5	254434.57	114227.82
2011	11203734	5590943	5903585.2	246561.36	107978.02
2012	46404649	5038614	1527674.2	1828751.56	130801.55
2013	24182165	20869392	1437981.7	504576.87	759684.43
2014	9620241	10875356	4053339.4	269308.34	282126.90
2015	4071265	4326476	2219755.6	816754.35	131963.08
2016	126157455	1830955	916579.3	472528.36	234062.09
2017	2823549	56736328	521382.2	301749.06	278268.22
2018	7724069	1269824	8589837.9	67635.10	87567.71

years	Age 0	Age 1	Age 2	Age 3	Age 4
2019	30045964	3473717	343865.5	2625870.54	57527.12
2020	19397165	13512461	1072718.3	127578.01	1170245.10
2021	59290298	8723416	2678753.8	207059.71	305174.10
2022	51921706	26664407	2633333.4	961095.47	224797.40
2023	2641494	23350558	5133509.9	486821.46	253551.02

Table 9.3.10 Sandeel 2r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1983	123674288	230902	118395	99697	0.633
1984	37915230	384786	79907	124031	0.558
1985	246491158	241509	124414	85325	0.52
1986	44948897	713203	111897	269793	0.759
1987	28008431	356546	196406	44285	0.166
1988	135635566	251535	167687	109202	0.592
1989	60457329	379706	81564	172560	0.943
1990	102968083	265816	113277	108860	0.663
1991	60145601	472158	116884	163345	0.713
1992	75439939	286639	107921	110241	0.672
1993	144703712	349609	103943	120621	0.616
1994	48867331	366206	91380	125420	0.617
1995	63569666	436778	196073	97463	0.37
1996	321307369	327614	148225	102140	0.638
1997	11037585	695586	87607	247469	0.75
1998	22353693	338217	244183	99565	0.397
1999	53824536	195918	119667	52876	0.496
2000	29975024	244366	71577	86969	0.568
2001	114610572	154672	68805	44462	0.591
2002	10933558	343908	58997	134824	0.665
2003	36690057	133988	84526	38418	0.579

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2004	16675214	153800	40439	74132	0.925
2005	17952422	85199	27861	45661	1.22
2006	27481310	80290	14007	41151	1.25
2007	19025175	100954	14980	42862	0.731
2008	14268916	82723	28871	34304	0.757
2009	55854309	62038	20579	23754	0.72
2010	12431878	161024	21666	36829	0.402
2011	11203734	116388	61971	19091	0.216
2012	46404649	91193	43172	11155	0.162
2013	24182165	165112	30961	56827	0.638
2014	9620241	102967	36502	36231	0.577
2015	4071265	71855	36076	24806	0.531
2016	126157455	28128	17687	3901	0.165
2017	2823549	340313	18301	146210	0.946
2018	7724069	89399	50406	16858	0.227
2019	30045964	75004	44909	4131	0.065
2020	19397165	137766	41060	49040	0.613
2021	59290298	83031	25217	5900	0.093
2022	51921706	210892	39671	75240	0.649
2023	2641494	188096	44234	50139	0.434
2024	32828956		60736		

Table 9.3.11 Sandeel 2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	18491928	1187949.000	5348627.000	1226103.000	208948.000
Exploitation pattern season 1	-	0.783	1.154	1.202	1.202
Exploitation pattern season 2	-	0.025	0.037	0.039	0.039
west season 1	3.587	6.190	12.331	15.797	19.061
weca season 1	3.587	6.190	12.331	15.797	19.061
weca season 2	3.355	8.682	14.897	18.006	23.766

	Age 0	Age 1	Age 2	Age 3	Age 4
Proportion mature (2024)	-	0.023	0.589	0.972	0.991
Proportion mature (2025)	-	0.023	0.589	0.972	0.991
Natural mortality season 1	-	0.516	0.455	0.369	0.319
Natural mortality season 2	0.799	0.607	0.459	0.383	0.362

Table 9.3.12 Sandeel 2r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	35924.97	0.51	27757.00	-54	-12
F = 0	0.00	0.00	49824.05	-18	-100
Bescapement (no cap)	35924.97	0.51	27757.00	-54	-12
Blim	51026.01	0.85	18949.00	-69	24
F = F 2023	31637.98	0.43	30321.71	-50	-23
Obs TAC	5000.00	0.06	46687.99	-23	-88

Table 9.4.1 Sandeel 3r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0	33760	14020	453	200	5	65	4	0	0
1988	1639	6584	17321	893	19	8769	853	233	144	13
1989	5075	47004	1844	2806	4	159	190	13	0	0
1990	0	9302	2791	413	125	9793	1377	286	43	13
1991	0	24009	1391	526	184	14442	942	30	9	3
1992	95	7100	2862	342	215	525	87	8	3	1
1993	5672	14068	734	263	1606	8541	944	172	73	14
1994	0	24557	5200	1185	475	0	532	657	77	11
1995	3	34567	2245	275	15	606	255	107	22	23
1996	70	4555	3735	492	419	5334	3013	101	35	242
1997	1565	70877	1082	1003	688	175	15588	194	102	11
1998	1675	5352	30538	1774	248	32690	647	1679	29	5
1999	271	5535	1183	1773	287	19750	1347	88	453	307

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2000	1806	18127	4229	228	634	312	182	28	33	30
2001	1842	4365	1719	12	205	26259	10521	52	4	41
2002	0	8655	2953	817	337	0	35	5	8	3
2003	483	965	918	41	215	3845	98	57	4	1
2004	623	2096	249	222	112	1826	951	13	4	10
2005	0	1492	235	7	27	0	1	0	0	0
2006	0	590	200	35	19	0	7	2	1	1
2007	39	7505	584	100	29	0	0	0	0	0
2008	78	3332	1800	381	134	0	0	0	0	0
2009	1	890	91	5	1	5	31	1	0	0
2010	0	1758	1531	333	122	0	48	2	1	0
2011	0	255	5397	353	68	0	0	0	0	0
2012	0	3	48	1063	326	0	0	0	0	0
2013	0	517	91	16	108	0	0	0	0	0
2014	1480	6070	938	90	92	34	26	23	0	2
2015	0	7115	1781	147	119	0	0	0	0	0
2016	728	132	2308	224	216	0	0	0	0	0
2017	87	12266	246	525	144	0	0	0	0	0
2018	0	405	6426	48	393	0	2	45	1	1
2019	388	6584	757	4135	157	0	0	0	0	0
2020	529	20203	1764	367	1056	0	0	0	0	0
2021	25	2293	4239	997	2359	10	7	1	0	0
2022	238	1712	1147	888	766	0	0	0	0	0
2023	99	290	247	199	305	0	0	0	0	0

Table 9.4.2 Sandeel 3r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	5.64	13.02	27.07	43.68	3.03	13.23	27.01	21.40	19.85
1988	5.64	13.05	27.20	40.73	3.03	13.23	27.27	26.17	39.03

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1989	6.20	14.00	16.30	18.01	5.00	9.00	15.82	17.00	19.01
1990	5.63	13.04	27.16	44.02	3.03	13.14	27.12	35.21	42.76
1991	7.44	14.34	22.29	30.60	3.41	9.18	14.75	15.38	44.00
1992	5.51	10.89	18.48	29.85	5.47	9.79	16.85	20.04	22.58
1993	5.52	19.58	20.56	25.13	3.52	9.47	33.76	43.33	45.74
1994	5.63	14.00	18.41	21.85	3.63	8.40	25.99	43.54	31.25
1995	5.07	11.93	22.65	21.85	5.07	14.08	19.93	27.83	42.78
1996	7.54	12.59	30.23	43.49	2.99	5.72	23.21	30.89	44.48
1997	4.66	9.97	24.28	43.23	1.81	5.32	18.56	26.19	25.64
1998	5.31	9.05	13.91	29.26	2.63	5.53	15.46	20.40	32.67
1999	6.77	9.16	14.27	34.26	3.05	9.86	16.05	19.84	34.07
2000	7.09	8.70	12.22	25.17	3.60	9.17	19.87	25.79	31.69
2001	5.81	14.06	18.89	30.65	3.32	5.87	22.58	31.85	45.57
2002	7.95	11.30	17.40	34.17	3.60	9.17	19.87	25.79	31.69
2003	4.57	13.50	20.52	30.01	2.80	4.79	23.84	24.65	30.30
2004	5.62	9.06	15.06	22.72	3.38	4.87	10.17	26.00	16.22
2005	6.98	16.16	21.23	27.80	3.60	9.17	19.87	25.79	31.69
2006	6.94	13.50	16.23	35.03	3.60	9.17	19.87	25.79	31.69
2007	8.19	19.73	28.06	41.72	3.60	9.17	19.87	25.79	31.69
2008	8.74	17.76	25.46	33.20	3.60	9.17	19.87	25.79	31.69
2009	5.87	8.16	15.08	17.78	3.60	9.17	19.87	25.79	31.69
2010	8.37	22.17	23.35	29.45	3.60	9.17	19.87	25.79	31.69
2011	9.16	14.87	26.01	34.31	3.60	9.17	19.87	25.79	31.69
2012	7.42	15.03	26.43	35.16	3.60	9.17	19.87	25.79	31.69
2013	10.90	14.69	17.51	28.65	3.60	9.17	19.87	25.79	31.69
2014	12.24	15.91	19.10	36.26	3.60	9.17	19.87	25.79	31.69
2015	9.35	17.79	27.89	39.46	3.60	9.17	19.87	25.79	31.69
2016	5.50	12.98	23.90	38.36	3.60	9.17	19.87	25.79	31.69
2017	7.81	14.52	21.31	39.28	3.60	9.17	19.87	25.79	31.69

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2018	4.60	9.81	16.28	26.86	3.60	9.17	19.87	25.79	31.69
2019	8.95	11.52	16.19	24.44	3.60	9.17	19.87	25.79	31.69
2020	9.05	16.53	23.36	27.62	3.60	9.17	19.87	25.79	31.69
2021	7.66	14.10	19.39	25.97	3.60	9.17	19.87	25.79	31.69
2022	7.66	14.10	19.39	25.97	3.60	9.17	19.87	25.79	31.69
2023	9.28	15.52	20.04	26.81	3.87	9.44	20.59	25.03	31.39
2024	9.28	15.52	20.04	26.81	3.87	9.44	20.59	25.03	31.39

Table 9.4.3 Sandeel 3r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1988	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1989	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1990	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1991	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1992	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1993	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1994	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1995	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1996	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1997	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1998	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1999	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2000	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2001	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2002	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2003	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2004	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2005	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2007	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2008	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2009	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2010	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2011	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2012	0.04	0.65	0.97	1	0	0.04	0.65	0.97	1
2013	0.03	0.70	0.99	1	0	0.03	0.70	0.99	1
2014	0.03	0.78	0.99	1	0	0.03	0.78	0.99	1
2015	0.03	0.78	0.99	1	0	0.03	0.78	0.99	1
2016	0.02	0.73	0.99	1	0	0.02	0.73	0.99	1
2017	0.02	0.70	0.97	1	0	0.02	0.70	0.97	1
2018	0.02	0.71	0.95	1	0	0.02	0.71	0.95	1
2019	0.03	0.66	0.93	1	0	0.03	0.66	0.93	1
2020	0.05	0.68	0.93	1	0	0.05	0.68	0.93	1
2021	0.05	0.68	0.93	1	0	0.05	0.68	0.93	1
2022	0.05	0.75	0.94	1	0	0.05	0.75	0.94	1
2023	0.05	0.78	0.95	1	0	0.05	0.78	0.95	1
2024	0.05	0.78	0.95	1	0	0.05	0.78	0.95	1

Table 9.4.4 Sandeel 3r. Survey index scaled.

year	survey	0	1	2	3	4
2006	Dredge	109489700	3.960227e+06	-	-	-
2007	Dredge	53539271	3.228496e+07	-	-	-
2008	Dredge	44505681	2.785160e+07	-	-	-
2009	Dredge	171710032	5.117976e+07	-	-	-
2010	Dredge	8077222	8.141064e+07	-	-	-
2011	Dredge	4089183	6.532610e+06	-	-	-
2012	Dredge	109828602	1.981268e+06	-	-	-

year	survey	0	1	2	3	4
2013	Dredge	237153171	3.009294e+06	-	-	-
2014	Dredge	191222557	1.929739e+07	-	-	-
2015	Dredge	4678592	5.071715e+07	-	-	-
2016	Dredge	843113265	7.223742e+06	-	-	-
2017	Dredge	10329906	1.049193e+08	-	-	-
2018	Dredge	428303012	9.432981e+07	-	-	-
2019	Dredge	371715138	1.128082e+08	-	-	-
2020	Dredge	227560452	1.527814e+08	-	-	-
2021	Dredge	72413279	3.845242e+07	-	-	-
2022	Dredge	51221588	1.652314e+07	-	-	-
2023	Dredge	12349458	1.553681e+06	-	-	-
2009	Acoustic	-	8.436308e+04	46177.178	11347.5859	967.7967
2010	Acoustic	-	1.623198e+05	64604.721	15295.8361	9536.0285
2011	Acoustic	-	9.539135e+03	86770.207	8847.8131	2324.0455
2012	Acoustic	-	1.680344e+03	3289.784	36767.6958	5401.5010
2013	Acoustic	-	2.153535e+04	2851.779	761.6271	6502.7392
2014	Acoustic	-	2.195769e+05	18920.349	1890.2820	29109.5963
2015	Acoustic	-	9.514132e+04	22304.581	7034.4082	8076.3331
2016	Acoustic	-	7.411159e+02	48870.046	6038.7513	9310.7153
2017	Acoustic	-	3.520750e+05	1216.158	36144.0271	11878.2135
2018	Acoustic	-	1.657811e+04	174487.632	862.0764	4296.8746
2019	Acoustic	-	1.125712e+05	7256.262	154383.3986	10552.6611
2020	Acoustic	-	4.147335e+05	101528.664	5465.6095	102700.8503
2021	Acoustic	-	1.483761e+05	128431.156	27911.8539	43578.9152
2022	Acoustic	-	4.810194e+04	50351.985	56016.2514	21435.6213
2023	Acoustic	-	2.120757e+04	13668.419	13951.6308	36452.5770

Table 9.4.5 Sandeel 3r. SMS settings and statistics.

```
Model evaluation date:  2024-02-08 04:02:18.444161
Time to run model (seconds):  1.6
```

```
number of parameters: 55
Maximum gradient:  0.001
AIC: 1037
Observations used in likelihood:
Catch: 232 Survey: 96 Stock recruitment: 37 Sum: 365
Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	**ages**	**survey**
0.3000009	0	Dredge
1.1180297	1	Dredge
0.6262946	1	Acoustic
0.6262946	2	Acoustic
0.6262946	3	Acoustic
0.6262946	4	Acoustic
catchCV	ages	season
0.8247664	1	1
0.8247664	2	1
1.0000648	3	1
1.0000648	4	1
0.9526143	1	2
0.9526143	2	2
2.6900616	3	2
2.6900616	4	2

Table 9.4.6 Sandeel 3r.

	Age 0	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Avg. 1-2**
1987	0	0.4743313	0.6884416	0.4840461	0.4840461	0.5813864
1988	0	0.6549013	0.9505199	0.6683145	0.6683145	0.8027106
1989	0	0.7111642	1.0321794	0.7257297	0.7257297	0.8716718
1990	0	0.4420670	0.6416134	0.4511210	0.4511210	0.5418402
1991	0	0.5300002	0.7692391	0.5408552	0.5408552	0.6496196
1992	0	0.2196047	0.3187329	0.2241024	0.2241024	0.2691688

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0	0.4587739	0.6658617	0.4681701	0.4681701	0.5623178
1994	0	0.4446172	0.6453146	0.4537234	0.4537234	0.5449659
1995	0	0.3477578	0.5047336	0.3548803	0.3548803	0.4262457
1996	0	0.3775087	0.5479139	0.3852405	0.3852405	0.4627113
1997	0	0.7003001	1.0164114	0.7146431	0.7146431	0.8583558
1998	0	1.0063208	1.4605679	1.0269314	1.0269314	1.2334444
1999	0	0.4917449	0.7137155	0.5018164	0.5018164	0.6027302
2000	0	0.3907317	0.5671057	0.3987344	0.3987344	0.4789187
2001	0	0.3750067	0.5442824	0.3826872	0.3826872	0.4596445
2002	0	0.2353314	0.3415586	0.2401512	0.2401512	0.2884450
2003	0	0.1464683	0.2125831	0.1494681	0.1494681	0.1795257
2004	0	0.1106526	0.1606006	0.1129189	0.1129189	0.1356266
2005	0	0.0476834	0.0692074	0.0486600	0.0486600	0.0584454
2006	0	0.0194980	0.0282992	0.0198973	0.0198973	0.0238986
2007	0	0.1270801	0.1844432	0.1296828	0.1296828	0.1557617
2008	0	0.1526641	0.2215758	0.1557909	0.1557909	0.1871200
2009	0	0.0113927	0.0165352	0.0116260	0.0116260	0.0139639
2010	0	0.1333110	0.1934868	0.1360414	0.1360414	0.1633989
2011	0	0.1253909	0.1819916	0.1279590	0.1279590	0.1536912
2012	0	0.0632306	0.0917725	0.0645256	0.0645256	0.0775016
2013	0	0.0300189	0.0435693	0.0306337	0.0306337	0.0367941
2014	0	0.1005818	0.1459838	0.1026418	0.1026418	0.1232828
2015	0	0.1018146	0.1477731	0.1038999	0.1038999	0.1247938
2016	0	0.0653853	0.0948999	0.0667245	0.0667245	0.0801426
2017	0	0.1341944	0.1947689	0.1369428	0.1369428	0.1644817
2018	0	0.1280825	0.1858982	0.1307058	0.1307058	0.1569904
2019	0	0.1375732	0.1996729	0.1403909	0.1403909	0.1686231
2020	0	0.3617862	0.5250943	0.3691960	0.3691960	0.4434402
2021	0	0.1646214	0.2389305	0.1679931	0.1679931	0.2017760

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2022	0	0.1955899	0.2838780	0.1995958	0.1995958	0.2397340
2023	0	0.0902406	0.1309747	0.0920889	0.0920889	0.1106077
arith.mean	0	0.2785790	0.4043279	0.2842846	0.2842846	0.3414534

Table 9.4.7 Sandeel 3r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.472	0.685	0.482	0.482	0.002	0.003	0.002	0.002
1988	0.556	0.807	0.567	0.567	0.099	0.144	0.101	0.101
1989	0.705	1.023	0.719	0.719	0.006	0.009	0.006	0.006
1990	0.347	0.503	0.354	0.354	0.095	0.138	0.097	0.097
1991	0.451	0.654	0.460	0.460	0.079	0.115	0.081	0.081
1992	0.213	0.310	0.218	0.218	0.006	0.009	0.006	0.006
1993	0.375	0.545	0.383	0.383	0.084	0.121	0.085	0.085
1994	0.413	0.600	0.422	0.422	0.031	0.045	0.032	0.032
1995	0.334	0.484	0.340	0.340	0.014	0.021	0.014	0.014
1996	0.295	0.427	0.301	0.301	0.083	0.120	0.085	0.085
1997	0.564	0.818	0.575	0.575	0.137	0.198	0.139	0.139
1998	0.716	1.039	0.731	0.731	0.290	0.422	0.296	0.296
1999	0.290	0.421	0.296	0.296	0.202	0.293	0.206	0.206
2000	0.385	0.559	0.393	0.393	0.006	0.008	0.006	0.006
2001	0.161	0.234	0.165	0.165	0.214	0.310	0.218	0.218
2002	0.235	0.342	0.240	0.240	0.000	0.000	0.000	0.000
2003	0.119	0.173	0.122	0.122	0.027	0.039	0.028	0.028
2004	0.082	0.119	0.084	0.084	0.028	0.041	0.029	0.029
2005	0.048	0.069	0.049	0.049	0.000	0.000	0.000	0.000
2006	0.019	0.028	0.020	0.020	0.000	0.000	0.000	0.000
2007	0.127	0.184	0.130	0.130	0.000	0.000	0.000	0.000
2008	0.153	0.222	0.156	0.156	0.000	0.000	0.000	0.000
2009	0.011	0.016	0.012	0.012	0.000	0.000	0.000	0.000

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2010	0.133	0.192	0.135	0.135	0.001	0.001	0.001	0.001
2011	0.125	0.182	0.128	0.128	0.000	0.000	0.000	0.000
2012	0.063	0.092	0.065	0.065	0.000	0.000	0.000	0.000
2013	0.030	0.044	0.031	0.031	0.000	0.000	0.000	0.000
2014	0.100	0.146	0.102	0.102	0.000	0.000	0.000	0.000
2015	0.102	0.148	0.104	0.104	0.000	0.000	0.000	0.000
2016	0.065	0.095	0.067	0.067	0.000	0.000	0.000	0.000
2017	0.134	0.195	0.137	0.137	0.000	0.000	0.000	0.000
2018	0.128	0.186	0.131	0.131	0.000	0.000	0.000	0.000
2019	0.138	0.200	0.140	0.140	0.000	0.000	0.000	0.000
2020	0.362	0.525	0.369	0.369	0.000	0.000	0.000	0.000
2021	0.165	0.239	0.168	0.168	0.000	0.000	0.000	0.000
2022	0.196	0.284	0.200	0.200	0.000	0.000	0.000	0.000
2023	0.090	0.131	0.092	0.092	0.000	0.000	0.000	0.000

Table 9.4.8 Sandeel 3r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.59	0.46	0.32	0.29	1.10	0.53	0.37	0.33	0.28
1988	0.57	0.45	0.30	0.29	1.18	0.54	0.35	0.32	0.28
1989	0.54	0.43	0.30	0.29	1.17	0.48	0.31	0.31	0.27
1990	0.54	0.44	0.28	0.27	1.22	0.48	0.31	0.31	0.25
1991	0.56	0.47	0.29	0.28	1.29	0.51	0.33	0.32	0.25
1992	0.60	0.51	0.32	0.29	1.31	0.54	0.35	0.34	0.27
1993	0.60	0.52	0.34	0.31	1.32	0.55	0.36	0.35	0.29
1994	0.61	0.54	0.38	0.31	1.29	0.61	0.40	0.40	0.33
1995	0.62	0.56	0.42	0.34	1.13	0.61	0.40	0.40	0.34
1996	0.58	0.53	0.41	0.33	1.04	0.65	0.42	0.42	0.35
1997	0.55	0.49	0.40	0.33	0.86	0.63	0.38	0.38	0.34
1998	0.52	0.47	0.37	0.31	0.94	0.69	0.37	0.36	0.32

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1999	0.59	0.52	0.42	0.31	0.98	0.77	0.43	0.43	0.35
2000	0.66	0.59	0.49	0.36	1.06	0.85	0.53	0.52	0.44
2001	0.67	0.61	0.52	0.40	1.08	0.91	0.62	0.61	0.54
2002	0.69	0.62	0.52	0.46	1.04	0.88	0.60	0.59	0.57
2003	0.66	0.58	0.47	0.44	1.00	0.83	0.54	0.54	0.53
2004	0.67	0.58	0.45	0.43	1.00	0.81	0.49	0.48	0.48
2005	0.67	0.56	0.43	0.40	1.00	0.81	0.48	0.47	0.47
2006	0.68	0.55	0.43	0.40	1.03	0.81	0.47	0.46	0.46
2007	0.66	0.53	0.42	0.38	0.98	0.79	0.47	0.47	0.47
2008	0.63	0.48	0.40	0.38	0.92	0.74	0.43	0.42	0.42
2009	0.57	0.44	0.38	0.35	0.87	0.71	0.44	0.43	0.43
2010	0.56	0.43	0.38	0.35	0.91	0.75	0.47	0.45	0.45
2011	0.60	0.44	0.40	0.37	0.96	0.79	0.50	0.48	0.48
2012	0.64	0.44	0.41	0.40	0.94	0.79	0.48	0.46	0.46
2013	0.63	0.42	0.39	0.38	0.89	0.73	0.43	0.41	0.41
2014	0.57	0.39	0.35	0.35	0.89	0.73	0.44	0.42	0.42
2015	0.59	0.41	0.37	0.36	0.88	0.71	0.42	0.41	0.41
2016	0.57	0.40	0.35	0.34	0.89	0.72	0.43	0.42	0.42
2017	0.58	0.41	0.36	0.35	0.83	0.68	0.40	0.39	0.39
2018	0.54	0.39	0.33	0.32	0.84	0.65	0.39	0.39	0.38
2019	0.57	0.42	0.34	0.32	0.90	0.66	0.41	0.41	0.41
2020	0.63	0.49	0.39	0.34	1.00	0.73	0.50	0.50	0.50
2021	0.70	0.58	0.47	0.42	1.08	0.82	0.61	0.61	0.61
2022	0.51	0.43	0.36	0.32	1.08	0.82	0.61	0.61	0.61
2023	0.51	0.43	0.36	0.32	1.05	0.79	0.58	0.57	0.57
2024	0.51	0.43	0.36	0.32	1.05	0.79	0.58	0.57	0.57

Table 9.4.9 Sandeel 3r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1987	86715893	81656023	4681670.2	343756.2	207689.2
1988	219977880	28800532	16589234.2	1020719.4	183412.8
1989	84317199	67894271	4911107.6	2877580.4	334843.1
1990	125005644	26241222	11962081.8	830479.1	855114.1
1991	87163822	37033166	6073266.1	2982922.3	616719.5
1992	265964656	23924181	7516062.3	1268369.8	1158195.2
1993	241912613	71950287	6161237.7	2295457.4	1051694.7
1994	232731426	64513525	14361722.7	1312731.0	1080989.6
1995	120214686	63781623	12190139.7	2922649.4	743077.6
1996	1197825192	38851934	13165423.6	2817524.0	1167277.8
1997	55247762	423879628	7762634.6	2952913.8	1239874.2
1998	87991855	23373701	64832999.1	1169427.6	969595.5
1999	206799693	34290771	2564137.1	6554254.9	386296.3
2000	172160493	77451608	5420051.9	482443.3	1818935.1
2001	137530718	59691252	11539549.9	1003373.7	665638.8
2002	25139688	46800566	8454299.7	1958338.7	395928.0
2003	73649650	8883765	7707230.4	1780002.2	617637.0
2004	63755131	27131635	1728605.8	2018584.3	761324.6
2005	46410572	23547061	5532252.7	506344.3	980265.4
2006	118784433	16996225	5150669.0	1821242.0	583169.0
2007	76088361	42564065	3762143.9	1801937.3	970960.1
2008	86967836	28505469	8797245.2	1151006.1	1017845.8
2009	241108896	34785641	6248696.3	2817477.1	821868.3
2010	9748930	100547174	9582364.3	2541382.7	1617015.3
2011	5427574	3943230	23875957.7	3211916.8	1593891.2
2012	83632997	2083939	864158.3	7718593.0	1759291.6
2013	156484318	32585774	467509.3	311753.5	3710187.1

years	Age 0	Age 1	Age 2	Age 3	Age 4
2014	175105274	64517218	8133553.4	190862.4	1759835.5
2015	4875538	72082384	15906747.3	3065800.8	817476.7
2016	848067977	2024831	17580507.6	5964257.9	1613812.0
2017	18292832	348680534	522050.7	6936906.1	3284865.0
2018	313817694	7938666	86163219.9	192492.5	4213098.7
2019	497920180	135851298	2121724.3	32902617.3	1909054.8
2020	207650536	203230225	34709972.1	754317.3	14336326.6
2021	74536731	76737529	36490658.0	7615404.5	4473453.8
2022	46067439	25277096	14197654.7	8747367.0	3545936.1
2023	15134722	15622514	5474844.1	3771990.2	3845714.6

Table 9.4.10 Sandeel 3r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1987	86715893	539907	81993	165981	0.581
1988	219977880	414148	206315	191772	0.803
1989	84317199	542418	119958	231440	0.872
1990	125005644	364043	184435	128079	0.542
1991	87163822	447818	160422	152658	0.65
1992	265964656	271637	124843	47482	0.269
1993	241912613	591653	179449	183665	0.562
1994	232731426	612179	214617	189729	0.545
1995	120214686	551570	204034	138789	0.426
1996	1197825192	594422	271160	153792	0.463
1997	55247762	2177049	256093	835625	0.858
1998	87991855	755296	497937	462333	1.233
1999	206799693	362337	130751	106350	0.603
2000	172160493	647634	107942	162190	0.479
2001	137530718	548213	175928	115554	0.46
2002	25139688	515080	133675	86134	0.288

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2003	73649650	199657	135149	24748	0.18
2004	63755131	215923	64462	15618	0.136
2005	46410572	291864	112206	11674	0.058
2006	118784433	237528	106750	3939	0.024
2007	76088361	513892	159355	49592	0.156
2008	86967836	468512	191104	58828	0.187
2009	241108896	312348	102535	2995	0.014
2010	9748930	1160745	299208	122680	0.163
2011	5427574	529398	408934	65059	0.154
2012	83632997	294331	268840	15289	0.078
2013	156484318	473700	127421	10860	0.037
2014	175105274	986652	191651	77992	0.123
2015	4875538	1074780	356106	91206	0.125
2016	848067977	443814	368589	28754	0.08
2017	18292832	3007640	321290	291856	0.164
2018	313817694	998445	718756	135172	0.157
2019	497920180	1819211	588119	188167	0.169
2020	207650536	2827005	885195	721251	0.443
2021	74536731	1365962	631739	181789	0.202
2022	46067439	655408	409270	107890	0.24
2023	15134722	408699	247285	31691	0.111
2024	94904752		145862		

Table 9.4.11 Sandeel 3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	99870116	5281662	3875842	1756337	2773642
Exploitation pattern season 1	-	0.816	1.184	0.833	0.833
Exploitation pattern season 2	-	-	-	-	-
west season 1	2.583	8.52	14.354	19.671	26.16
weca season 1	2.514	9.284	15.521	20.037	26.81

	Age 0	Age 1	Age 2	Age 3	Age 4
weca season 2	3.874	9.443	20.589	25.028	31.394
Proportion mature (2024)	-	0.046	0.78	0.949	0.996
Proportion mature (2025)	-	0.046	0.78	0.949	0.996
Natural mortality season 1	-	0.515	0.43	0.365	0.324
Natural mortality season 2	1.053	0.789	0.576	0.574	0.574

Table 9.4.12 Sandeel 3r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	0.00	0.00	107626.60	-26	-100
F = 0	0.00	0.00	107626.60	-26	-100
Bescapement (no cap)	0.00	0.00	107626.60	-26	-100
Blim	68509.06	0.51	72712.99	-50	124
F = F 2023	17552.67	0.11	98555.61	-32	-43
Obs TAC	5000.00	0.03	105035.23	-28	-84

Table 9.5.1 Sandeel 4. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	88	1196	6103	1791	517	735	152	368	118	37
1994	0	1139	1741	5945	2353	0	243	58	245	151
1995	0	2983	1411	606	34	4	4	1	0	0
1996	0	0	0	0	0	2419	2417	3190	204	991
1997	0	3000	321	1829	442	0	1383	36	43	10
1998	0	2373	4072	250	139	0	66	102	7	4
1999	0	1543	1057	1439	236	0	84	44	44	11
2000	25	5819	343	325	345	0	0	0	0	0
2001	3	2143	5103	623	403	10	64	19	1	0
2002	10	342	792	477	88	0	0	0	0	0
2003	169	4080	864	2543	1247	165	162	11	6	2
2004	0	938	217	44	69	0	4	1	0	0
2005	0	54	159	35	19	0	0	0	0	0

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0
2012	0	92	50	213	3	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0
2014	59	480	161	15	13	0	0	0	0	0
2015	0	919	33	10	16	0	0	0	0	0
2016	14	189	374	19	34	0	0	0	0	0
2017	0	711	436	523	27	0	0	0	0	0
2018	0	893	1262	347	1111	0	0	0	0	0
2019	2	316	161	144	61	0	0	0	0	0
2020	10	2452	259	72	85	27	22	0	0	0
2021	398	3321	2167	349	373	1	20	78	12	40
2022	11	331	72	124	40	0	0	0	0	0
2023	52	342	531	226	324	0	0	0	0	0

Table 9.5.2 Sandeel 4. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	6.70	11.96	15.82	23.54	3.64	8.23	14.48	17.64	25.64
1994	10.10	8.57	12.97	18.71	3.64	8.23	14.48	17.64	25.64
1995	5.80	15.14	19.20	21.85	3.64	8.23	14.48	17.64	25.64
1996	5.84	14.74	20.67	31.93	3.10	4.72	16.10	25.33	34.34
1997	6.39	7.12	10.51	17.41	3.64	8.23	14.48	17.64	25.64
1998	4.93	9.51	13.21	13.40	3.64	8.23	14.48	17.64	25.64
1999	5.35	11.13	18.11	22.57	3.64	8.23	14.48	17.64	25.64
2000	4.10	8.89	14.31	18.54	3.64	8.23	14.48	17.64	25.64

2001	3.59	5.68	8.70	14.17	3.64	8.23	14.48	17.64	25.64
2002	3.68	6.10	10.43	19.93	3.64	8.23	14.48	17.64	25.64
2003	3.77	7.54	9.57	12.93	2.44	4.93	13.03	15.88	23.07
2004	3.99	7.53	9.69	15.61	3.64	8.23	14.48	17.64	25.64
2005	3.79	4.77	6.86	18.24	3.64	8.23	14.48	17.64	25.64
2006	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2007	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2008	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2009	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2010	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2011	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2012	3.46	7.40	8.88	12.25	3.64	8.23	14.48	17.64	25.64
2013	4.18	7.73	13.02	15.04	3.64	8.23	14.48	17.64	25.64
2014	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2015	4.40	9.42	11.22	16.62	3.64	8.23	14.48	17.64	25.64
2016	4.47	10.80	20.96	28.74	3.64	8.23	14.48	17.64	25.64
2017	6.93	10.99	15.64	22.17	3.64	8.23	14.48	17.64	25.64
2018	4.49	9.30	13.77	20.12	3.64	8.23	14.48	17.64	25.64
2019	5.77	9.95	13.71	20.34	3.64	8.23	14.48	17.64	25.64
2020	6.19	9.25	15.61	14.18	3.64	8.23	14.48	17.64	25.64
2021	5.52	9.78	12.98	18.58	3.63	9.77	13.31	19.62	21.04
2022	5.78	9.85	14.34	19.08	3.64	8.54	14.25	18.04	24.72
2023	4.98	10.91	13.27	20.23	3.78	8.56	15.59	18.65	26.24
2024	5.65	9.95	13.98	18.48	3.66	8.67	14.42	18.32	24.65

Table 9.5.3 Sandeel 4. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1994	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1995	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1996	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1997	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1998	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1999	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2000	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2001	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2002	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2003	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2004	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2005	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2006	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2007	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2008	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2009	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2010	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2011	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2012	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2013	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2014	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2015	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2016	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2017	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2018	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2019	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2020	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2021	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2022	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2023	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2024	0.08	0.53	0.81	0.98	-	-	-	-	-

Table 9.5.4 Sandeel 4. Survey index scaled.

year	survey	0	1
1999	Dredge	61500000	49400000
2000	Dredge	58600000	317000000
2001	Dredge	4800000	265600000
2002	Dredge	24300000	40400000
2003	Dredge	58000000	-
2008	Dredge2	94510377	281322558
2009	Dredge2	5148033831	832577971
2010	Dredge2	245679534	3108360870
2011	Dredge2	200732519	466969729
2012	Dredge2	315658858	78508071
2013	Dredge2	250401011	303751827
2014	Dredge2	1092995067	61578361
2015	Dredge2	698757894	2249006428
2016	Dredge2	1807022574	178026284
2017	Dredge2	590032532	984803970
2018	Dredge2	291927930	323876495
2019	Dredge2	900897159	606608010
2020	Dredge2	602635232	1569864813
2021	Dredge2	510112080	943304521
2022	Dredge2	1481784839	714129399
2023	Dredge2	27546360	848904427

Table 9.5.5 Sandeel 4. SMS settings and statistics.

```
Model evaluation date:  2024-01-31 15:51:23.676403

Time to run model (seconds):  4.5

number of parameters: 49

Maximum gradient:  1e-04

AIC: 423

Observations used in likelihood:

Catch: 132 Survey: 41 Stock recruitment: 31 Sum: 204
```

```
Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.300000	0	Dredge
0.300000	1	Dredge
0.300000	0	Dredge2
0.809663	1	Dredge2
catchCV	ages	season
0.6850183	1	1
0.6850183	2	1
0.6873710	3	1
0.6873710	4	1
0.4133140	1	2
0.4133140	2	2
1.0585777	3	2
1.0585777	4	2

Table 9.5.6 Sandeel 4.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0	0.2434999	0.4602684	0.5096903	0.5096903	0.3518841
1994	0	0.2777569	0.5250217	0.5813965	0.5813965	0.4013893
1995	0	0.0772658	0.1460493	0.1617316	0.1617316	0.1116576
1996	0	0.2138312	0.4041880	0.4475882	0.4475882	0.3090096
1997	0	0.1123765	0.2124164	0.2352249	0.2352249	0.1623965
1998	0	0.1187371	0.2244393	0.2485387	0.2485387	0.1715882
1999	0	0.1500821	0.2836883	0.3141497	0.3141497	0.2168852
2000	0	0.0773992	0.1463016	0.1620109	0.1620109	0.1118504
2001	0	0.1217153	0.2300687	0.2547726	0.2547726	0.1758920
2002	0	0.0266427	0.0503605	0.0557680	0.0557680	0.0385016
2003	0	0.1998782	0.3778139	0.4183821	0.4183821	0.2888461
2004	0	0.0380374	0.0718990	0.0796193	0.0796193	0.0549682
2005	0	0.0180329	0.0340862	0.0377462	0.0377462	0.0260596

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2006	0	0.0003169	0.0005991	0.0006634	0.0006634	0.0004580
2007	0	0.0002239	0.0004232	0.0004686	0.0004686	0.0003235
2008	0	0.0017318	0.0032735	0.0036250	0.0036250	0.0025026
2009	0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
2010	0	0.0007175	0.0013562	0.0015019	0.0015019	0.0010369
2011	0	0.0017598	0.0033264	0.0036836	0.0036836	0.0025431
2012	0	0.0137374	0.0259667	0.0287549	0.0287549	0.0198520
2013	0	0.0078330	0.0148061	0.0163960	0.0163960	0.0113196
2014	0	0.0091900	0.0173711	0.0192364	0.0192364	0.0132806
2015	0	0.0070634	0.0133515	0.0147851	0.0147851	0.0102074
2016	0	0.0209373	0.0395761	0.0438256	0.0438256	0.0302567
2017	0	0.0440418	0.0832488	0.0921877	0.0921877	0.0636453
2018	0	0.1079430	0.2040360	0.2259446	0.2259446	0.1559895
2019	0	0.0298539	0.0564305	0.0624897	0.0624897	0.0431422
2020	0	0.0400254	0.0756569	0.0837807	0.0837807	0.0578412
2021	0	0.2240578	0.4235186	0.4689944	0.4689944	0.3237882
2022	0	0.0200759	0.0379478	0.0420225	0.0420225	0.0290118
2023	0	0.0681098	0.1287426	0.1425665	0.1425665	0.0984262
arith.mean	0	0.0733185	0.1385881	0.1534692	0.1534692	0.1059533

Table 9.5.7 Sandeel 4. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.219	0.414	0.459	0.459	0.024	0.046	0.051	0.051
1994	0.255	0.482	0.533	0.533	0.023	0.043	0.048	0.048
1995	0.077	0.146	0.161	0.161	0.000	0.000	0.000	0.000
1996	0.095	0.179	0.198	0.198	0.119	0.225	0.250	0.250
1997	0.094	0.178	0.197	0.197	0.018	0.034	0.038	0.038
1998	0.114	0.215	0.238	0.238	0.005	0.009	0.010	0.010
1999	0.150	0.284	0.314	0.314	0.000	0.000	0.000	0.000

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2000	0.077	0.146	0.162	0.162	0.000	0.000	0.000	0.000
2001	0.120	0.227	0.251	0.251	0.002	0.003	0.004	0.004
2002	0.027	0.050	0.056	0.056	0.000	0.000	0.000	0.000
2003	0.191	0.360	0.399	0.399	0.009	0.018	0.020	0.020
2004	0.038	0.071	0.079	0.079	0.000	0.000	0.001	0.001
2005	0.018	0.034	0.038	0.038	0.000	0.000	0.000	0.000
2006	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.002	0.003	0.004	0.004	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.001	0.001	0.002	0.002	0.000	0.000	0.000	0.000
2011	0.002	0.003	0.004	0.004	0.000	0.000	0.000	0.000
2012	0.014	0.026	0.029	0.029	0.000	0.000	0.000	0.000
2013	0.008	0.015	0.016	0.016	0.000	0.000	0.000	0.000
2014	0.009	0.017	0.019	0.019	0.000	0.000	0.000	0.000
2015	0.007	0.013	0.015	0.015	0.000	0.000	0.000	0.000
2016	0.021	0.040	0.044	0.044	0.000	0.000	0.000	0.000
2017	0.044	0.083	0.092	0.092	0.000	0.000	0.000	0.000
2018	0.108	0.204	0.226	0.226	0.000	0.000	0.000	0.000
2019	0.030	0.056	0.062	0.062	0.000	0.000	0.000	0.000
2020	0.040	0.076	0.084	0.084	0.000	0.000	0.000	0.000
2021	0.212	0.400	0.443	0.443	0.012	0.023	0.026	0.026
2022	0.020	0.038	0.042	0.042	0.000	0.000	0.000	0.000
2023	0.068	0.129	0.143	0.143	0.000	0.000	0.000	0.000

Table 9.5.8 Sandeel 4. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1994	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1995	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1996	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1997	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1998	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1999	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2000	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2001	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2002	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2003	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2004	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2005	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2006	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2007	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2008	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2009	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2010	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2011	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2012	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2013	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2014	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2015	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2016	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2017	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2018	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2019	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2020	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2021	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2022	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2023	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2024	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44

Table 9.5.9 Sandeel 4. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1993	96871460	25056431	24862791.7	8771227.6	1856323.1
1994	221564535	36094561	5101590.3	6023879.7	2727250.4
1995	61533546	82555530	7101506.6	1158537.1	2109157.5
1996	310958592	22927561	19848472.3	2355811.3	1224312.3
1997	87716707	115863991	4808716.6	5086380.9	988354.6
1998	40484216	32683476	26895584.7	1492781.8	2049632.2
1999	207666431	15084526	7538733.5	8249481.7	1211696.8
2000	173122934	77377060	3372009.8	2179277.6	2943243.9
2001	22249691	64506062	18600952.3	1118328.2	1910050.7
2002	78402088	8290294	14834649.0	5673303.9	1032869.0
2003	140952392	29212825	2096699.4	5415323.7	2705903.0
2004	10874687	52519233	6213045.8	551660.8	2307130.5
2005	6651044	4051937	13132154.1	2219717.1	1174755.2
2006	4435231	2478196	1033637.2	4872489.9	1412196.3
2007	15960674	1652579	643480.1	396575.9	2691966.6
2008	10141960	5946989	429142.9	246927.7	1379304.4
2009	329532842	3778921	1541991.8	164209.7	722899.1
2010	23253475	122784806	981532.8	591971.1	394944.1
2011	17791747	8664306	31869117.6	376300.0	427236.8
2012	31842437	6629252	2246500.6	12193933.9	350052.2
2013	24466035	11864576	1698382.3	840326.0	5156829.7
2014	148981236	9116109	3057647.5	642426.8	2633992.6
2015	52223991	55510801	2346147.8	1153617.0	1429891.9
2016	121200949	19458797	14316831.3	888741.2	1114609.7
2017	45545811	45159793	4949485.4	5282963.9	839728.1

years	Age 0	Age 1	Age 2	Age 3	Age 4
2018	33126323	16970489	11224366.5	1748332.4	2379470.6
2019	109961138	12342955	3956875.0	3513731.2	1443997.2
2020	42993895	40971810	3111650.3	1435698.8	2004973.3
2021	49966979	16019639	10224435.5	1107520.6	1388053.9
2022	94156062	18617828	3325696.9	2569957.7	683752.8
2023	2482901	35082797	4739660.1	1229194.4	1335944.1

Table 9.5.10 Sandeel 4. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1993	96871460	647771	327310	172563	0.352
1994	221564535	537362	167124	126318	0.401
1995	61533546	654853	160125	46918	0.112
1996	310958592	514437	244237	41055	0.309
1997	87716707	845373	140018	73994	0.162
1998	40484216	463915	191897	63092	0.172
1999	207666431	341288	199515	64756	0.217
2000	173122934	432971	121244	31758	0.112
2001	22249691	373772	109679	44438	0.176
2002	78402088	200792	118872	7703	0.039
2003	140952392	212672	94070	43907	0.289
2004	10874687	297660	81947	11105	0.055
2005	6651044	114694	67937	2998	0.026
2006	4435231	129768	97532	0	0
2007	15960674	77886	64312	0	0
2008	10141960	69573	36380	0	0.003
2009	329532842	54457	27135	0	0
2010	23253475	700364	76885	0	0.001
2011	17791747	396692	194679	0	0.003
2012	31842437	152130	102971	3200	0.02

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2013	24466035	151218	96225	0	0.011
2014	148981236	146742	83070	1812	0.013
2015	52223991	303051	65887	1970	0.01
2016	121200949	292336	135801	7910	0.03
2017	45545811	468728	140341	20958	0.064
2018	33126323	252450	128252	33420	0.156
2019	109961138	188188	94839	7184	0.043
2020	42993895	333251	82485	12541	0.058
2021	49966979	228571	97382	53479	0.324
2022	94156062	190298	69103	4270	0.029
2023	2482901	269823	81750	18430	0.098
2024	46694233		81162		

Table 9.5.11 Sandeel 4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	61501687	925135	8512390	1599755	971892
Exploitation pattern season 1	-	0.692	1.308	1.448	1.448
Exploitation pattern season 2	-	-	-	-	-
west season 1	2.045	5.649	9.949	13.982	18.48
weca season 1	2.045	5.649	9.949	13.982	18.48
weca season 2	3.664	8.667	14.423	18.319	24.654
Proportion mature (2024)	-	0.083	0.53	0.813	0.983
Proportion mature (2025)	-	0.083	0.53	0.813	0.983
Natural mortality season 1	-	0.608	0.493	0.404	0.361
Natural mortality season 2	0.987	0.74	0.464	0.458	0.437

Table 9.5.12 Sandeel 4. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	0.00	0.00	69406.25	-14	-100
F = 0	0.00	0.00	69406.25	-14	-100
Bescapement (no cap)	0.00	0.00	69406.25	-14	-100

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Blim	44422.77	0.41	44715.99	-45	31
F = F 2023	12846.93	0.10	62145.95	-23	-62
Obs TAC	5000.00	0.04	66571.04	-18	-85

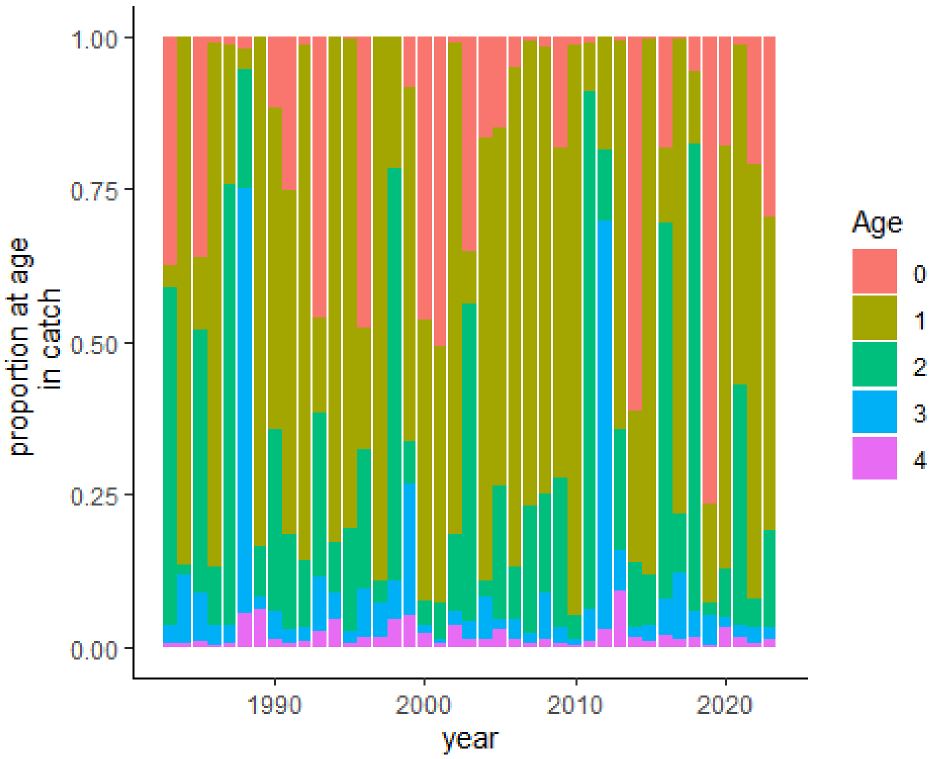


Figure 9.2.1 Sandeel 1r. Catch numbers, proportion at age.

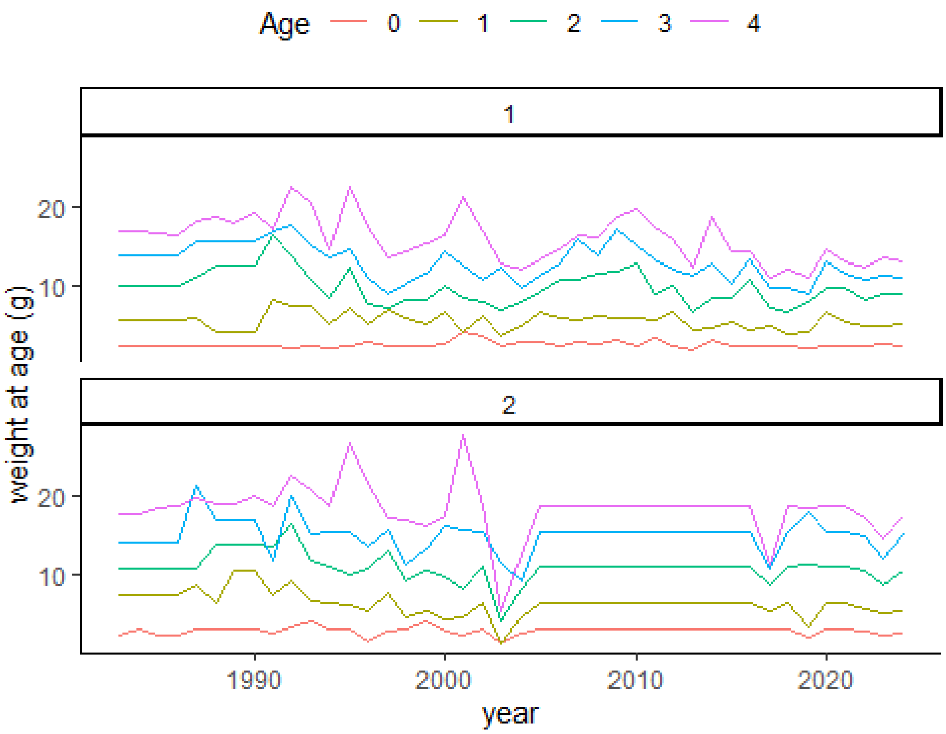


Figure 9.2.2 Sandeel 1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

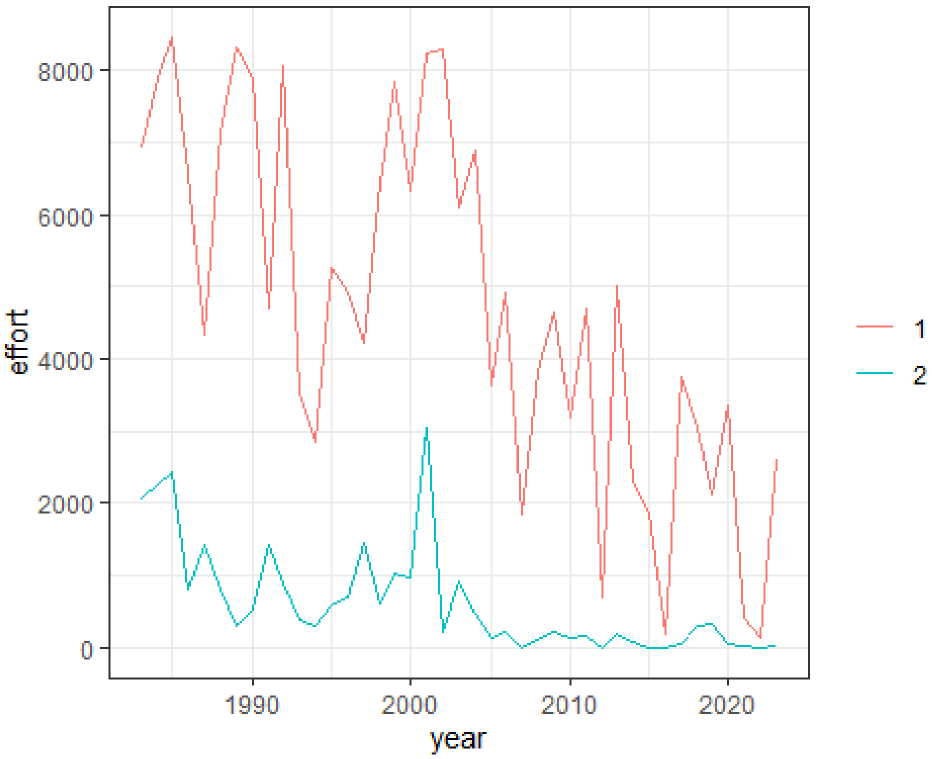
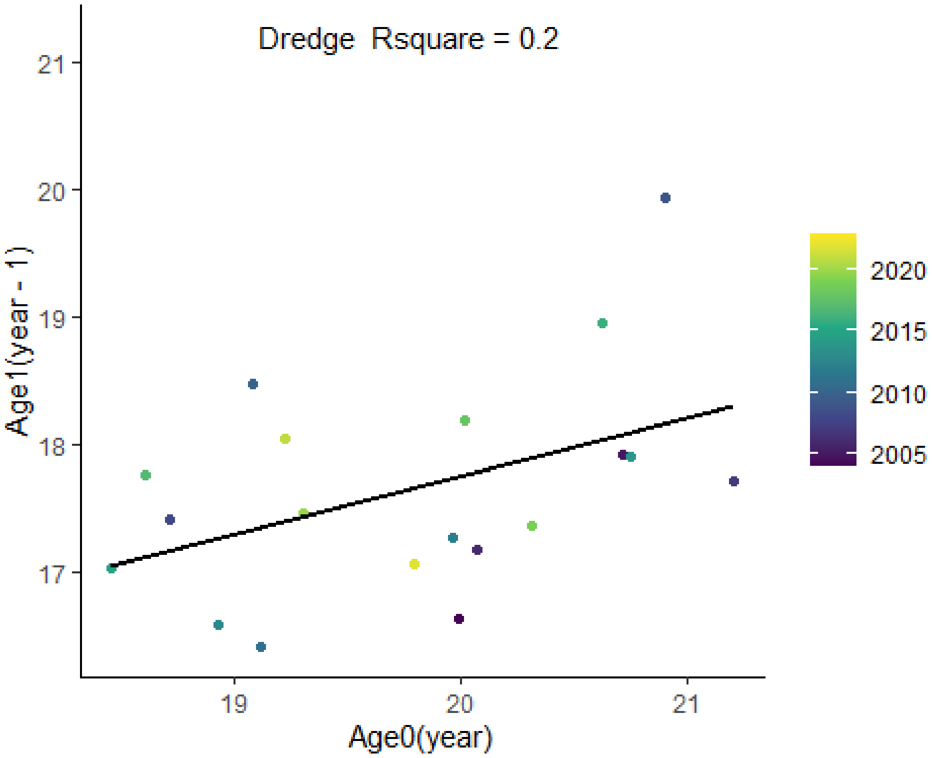


Figure 9.2.3 Sandeel 1r. Standardized effort. Line color denotes the season.



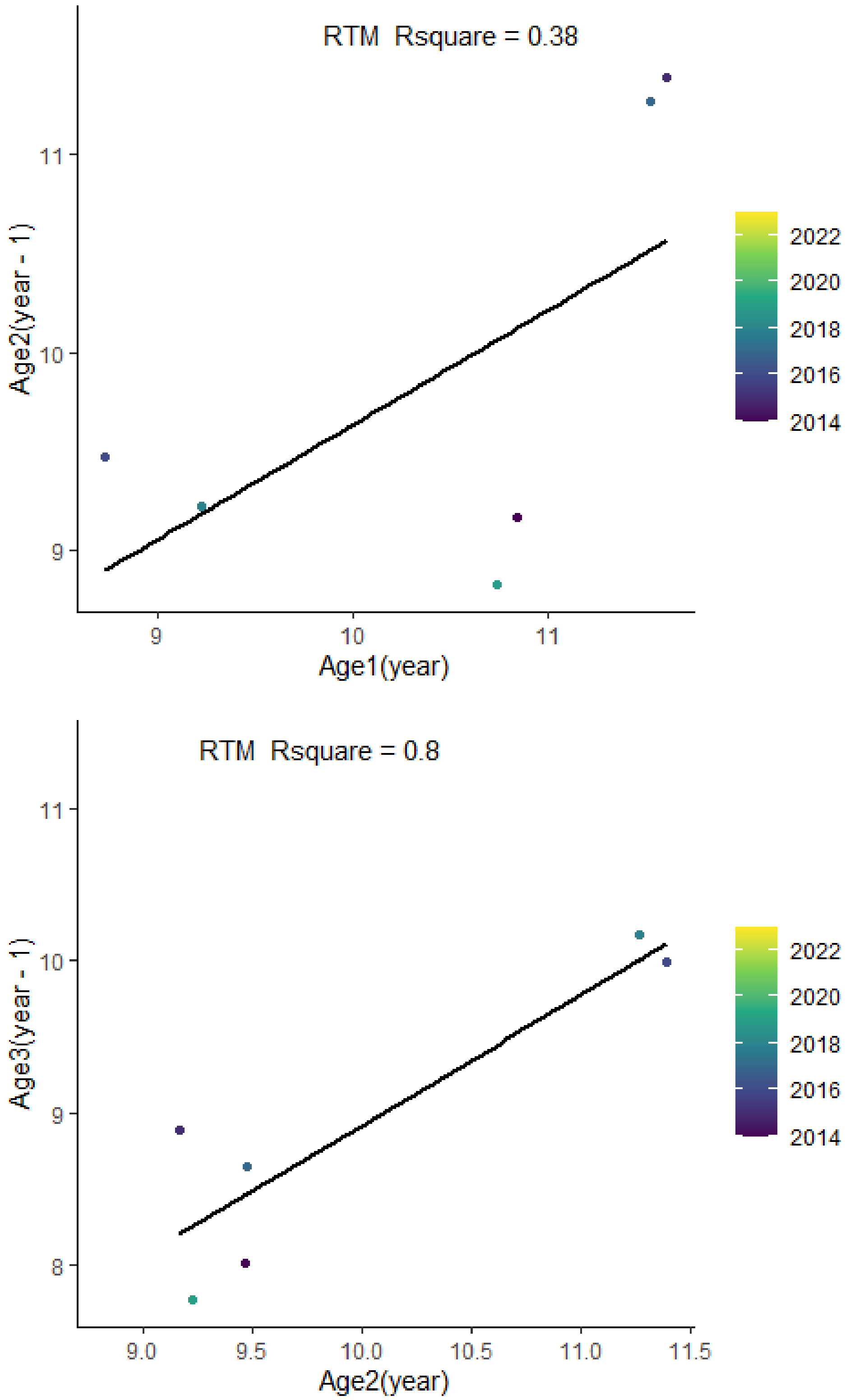


Figure 9.2.4 Sandeel 1r. Internal consistency by ages in the survey.

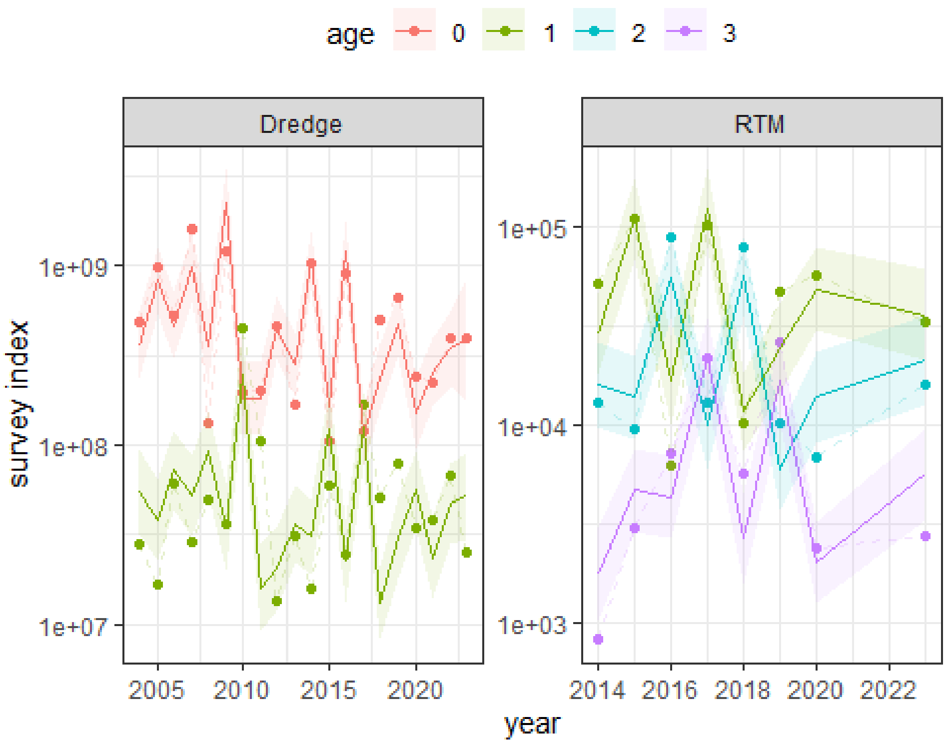


Figure 9.2.5 Sandeel 1r. Surveys (dots) and model fit (full lines). Color denotes the age.

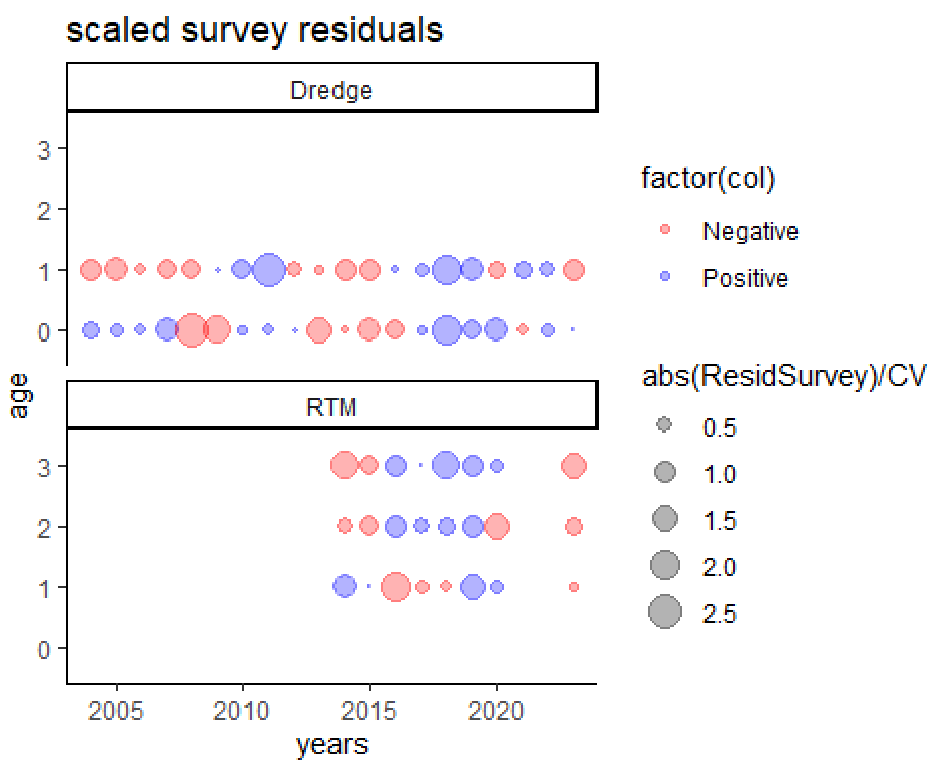


Figure 9.2.6 Sandeel 1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

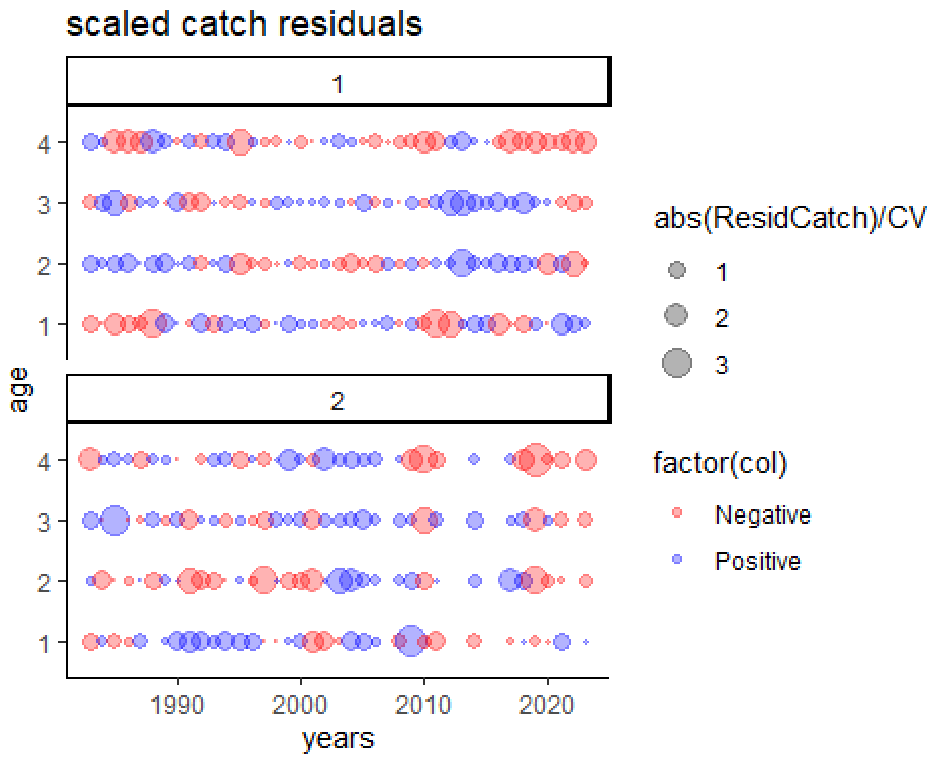


Figure 9.2.7 Sandeel 1r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

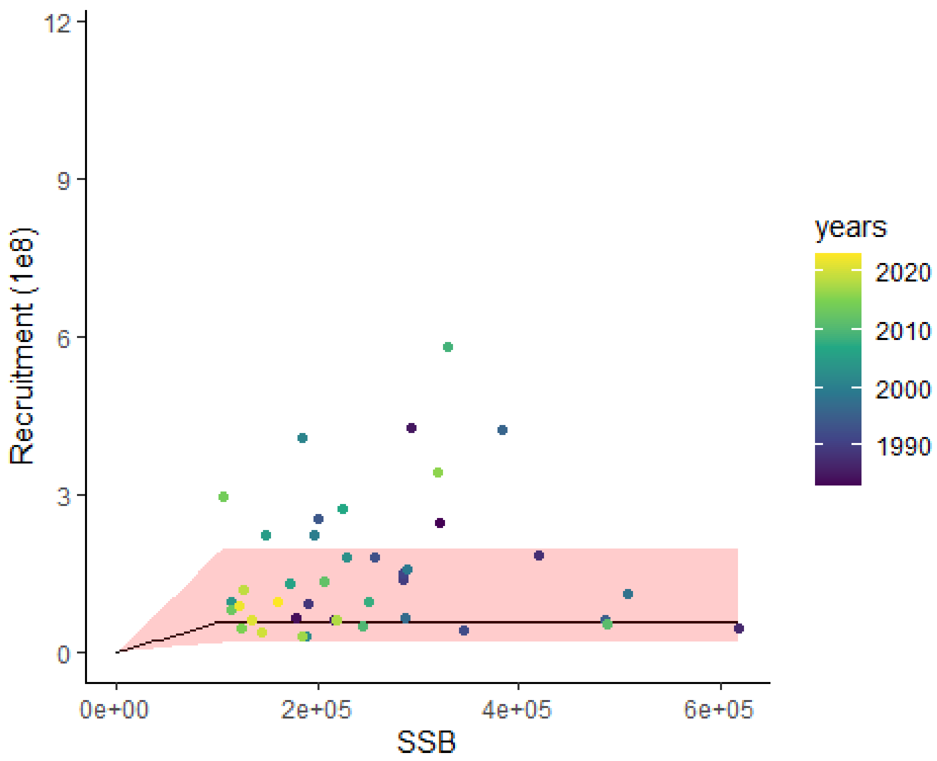


Figure 9.2.8 Sandeel 1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

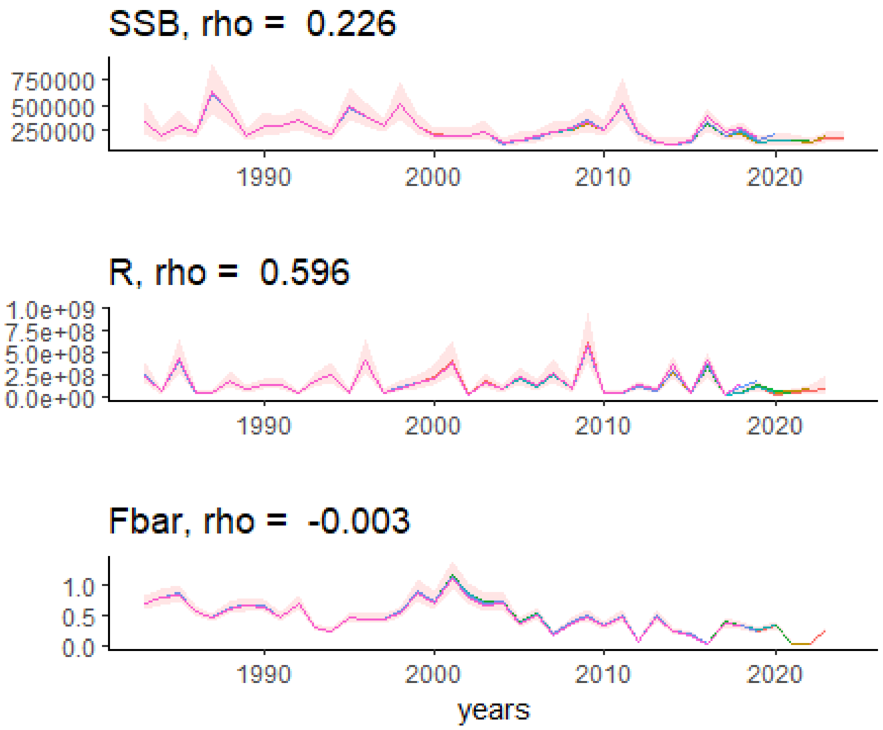


Figure 9.2.9 Sandeel 1r. Retrospective analysis.

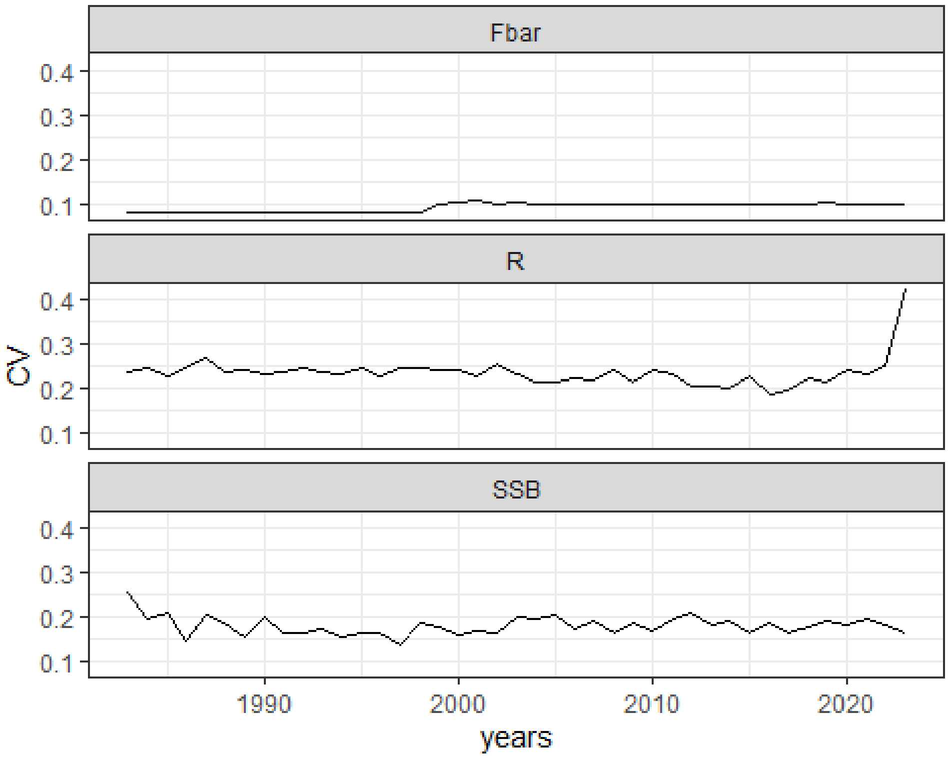


Figure 9.2.10 Sandeel 1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

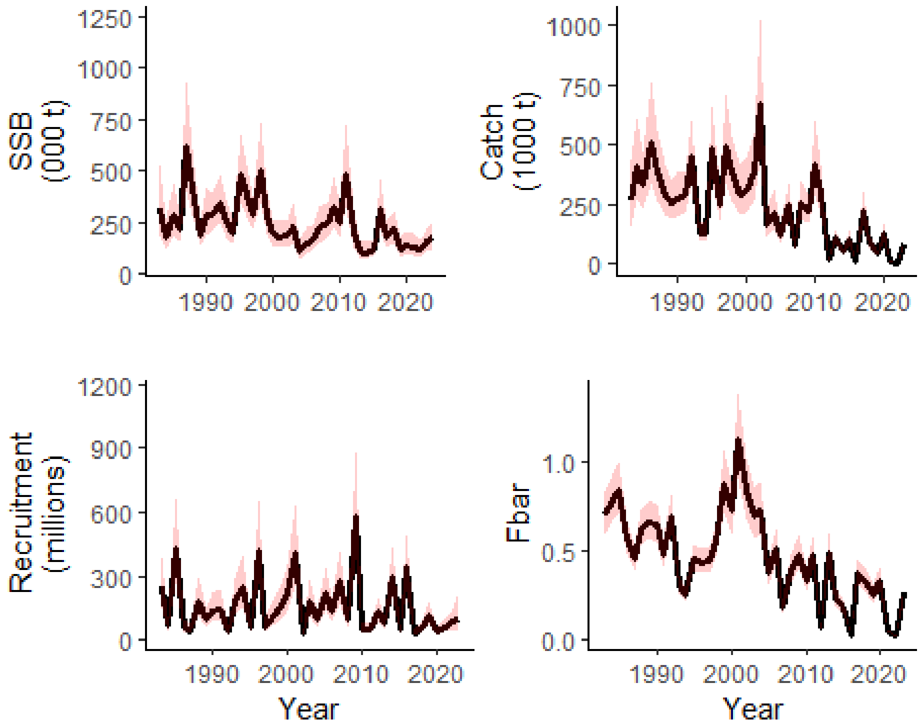


Figure 9.2.11 Sandeel 1r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

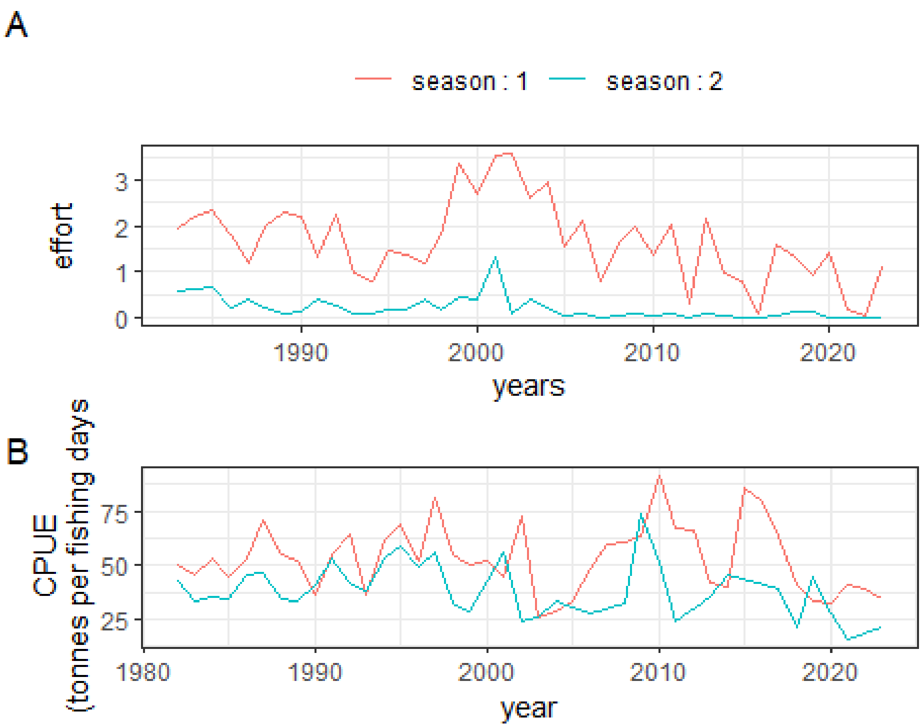


Figure 9.2.12 Sandeel 1r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

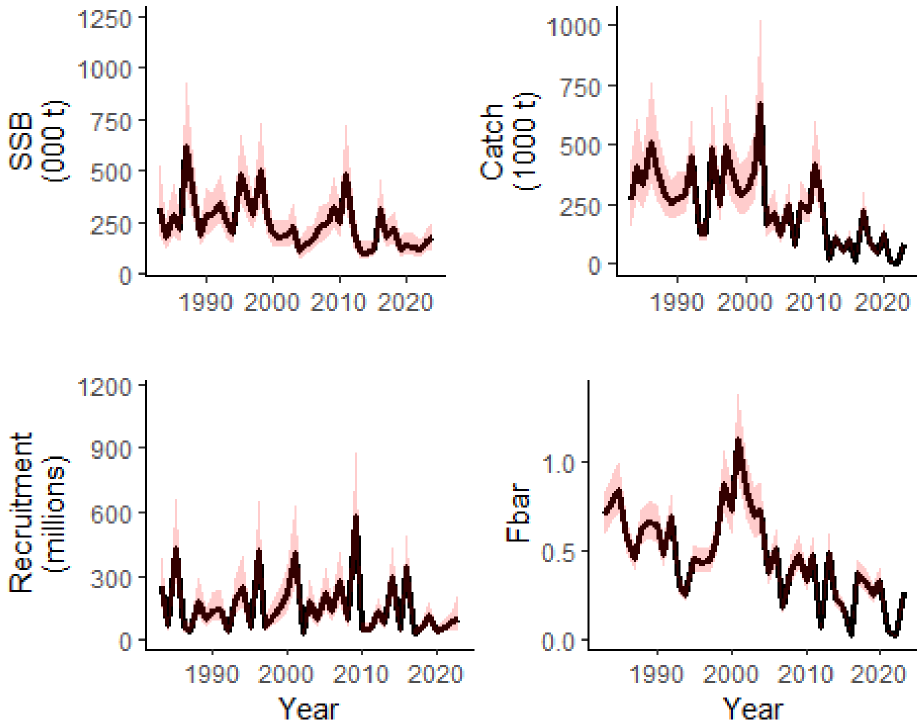


Figure 9.2.13 Sandeel 1r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

Figure 9.3.1 Sandeel 2r. Catch numbers, proportion at age.

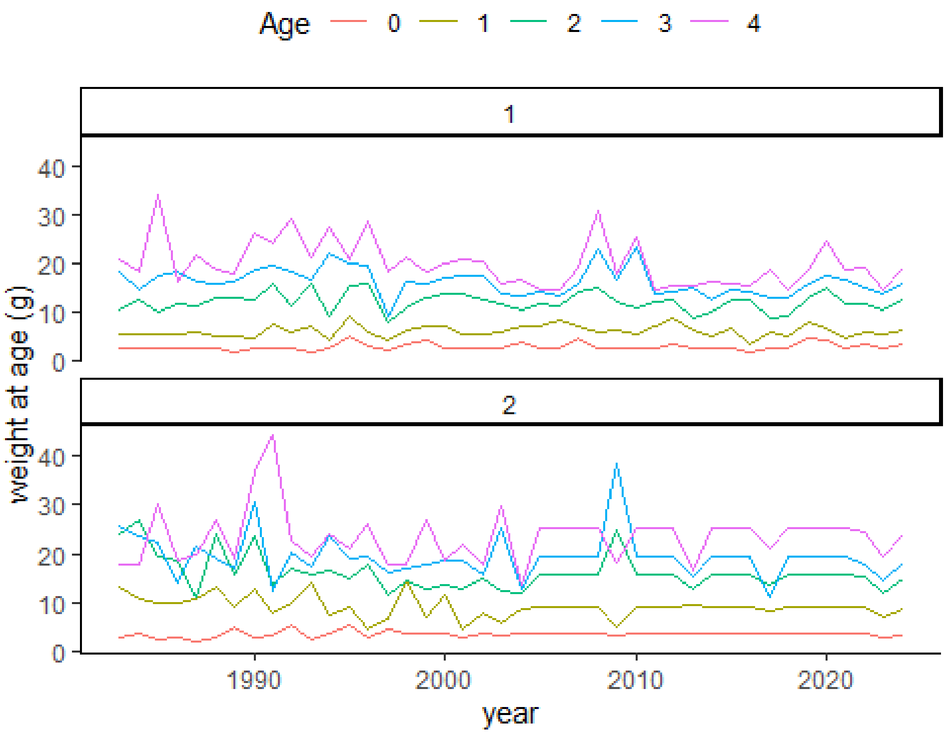


Figure 9.3.2 Sandeel 2r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

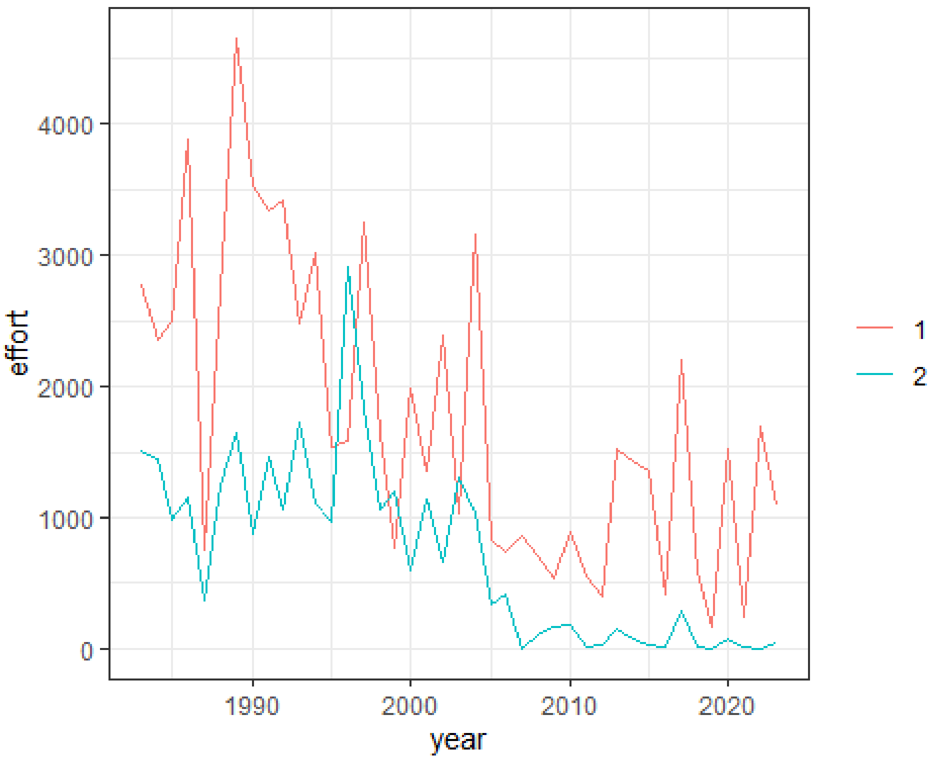


Figure 9.3.3 Sandeel 2r. Standardized effort. Line color denotes the season.

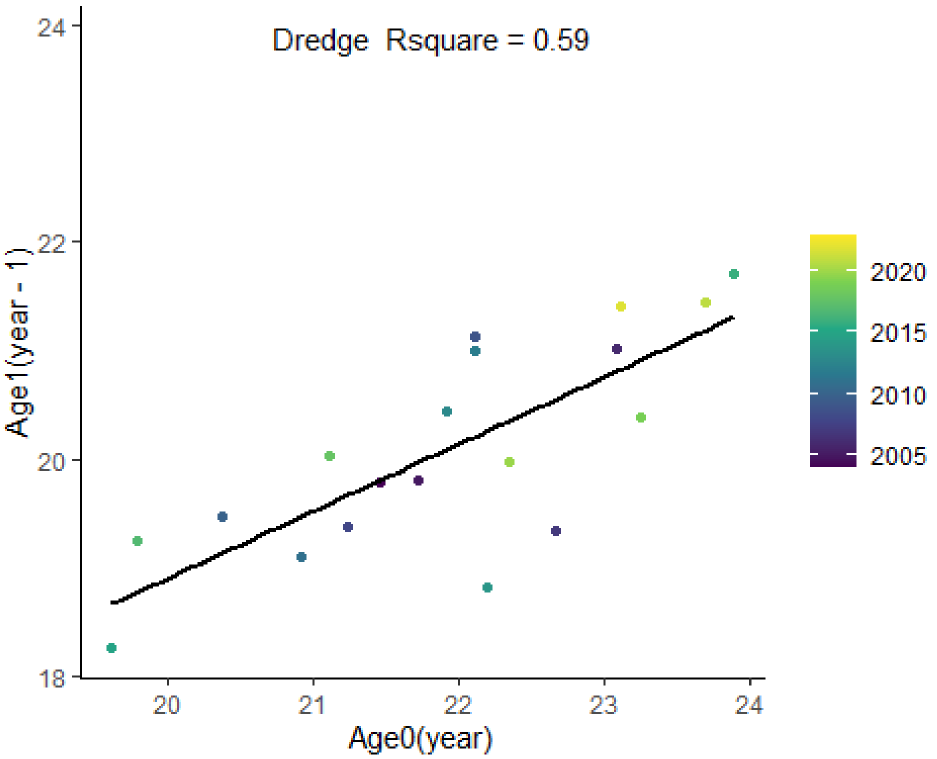


Figure 9.3.4 Sandeel 2r. Internal consistency by ages in the survey.

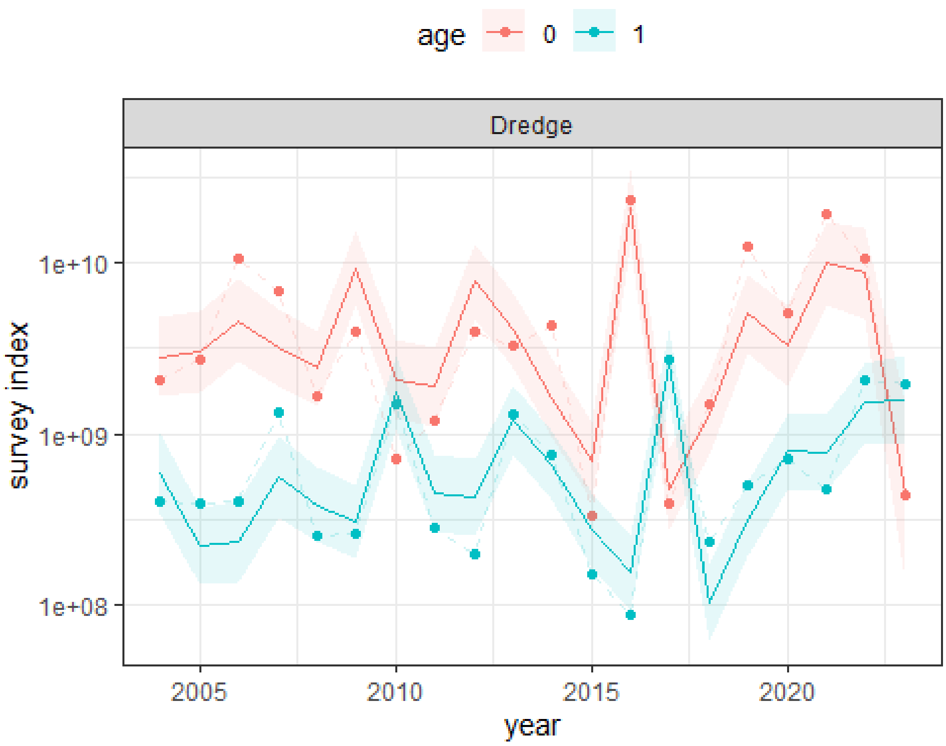


Figure 9.3.5 Sandeel 2r. Surveys (dots) and model fit (full lines). Color denotes the age.

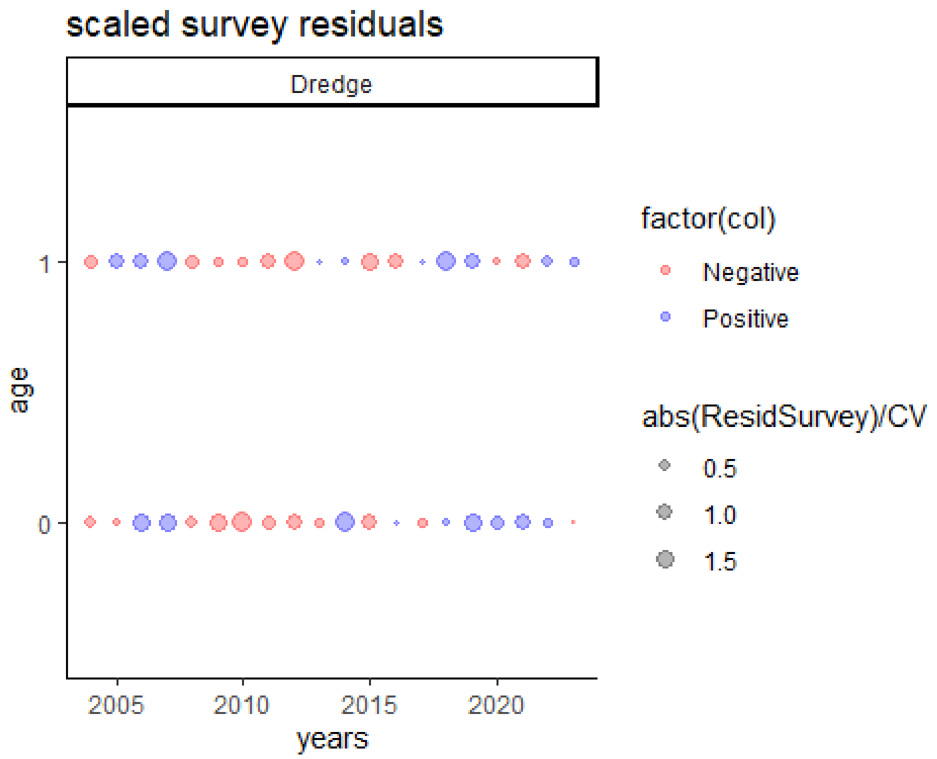


Figure 9.3.6 Sandeel 2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

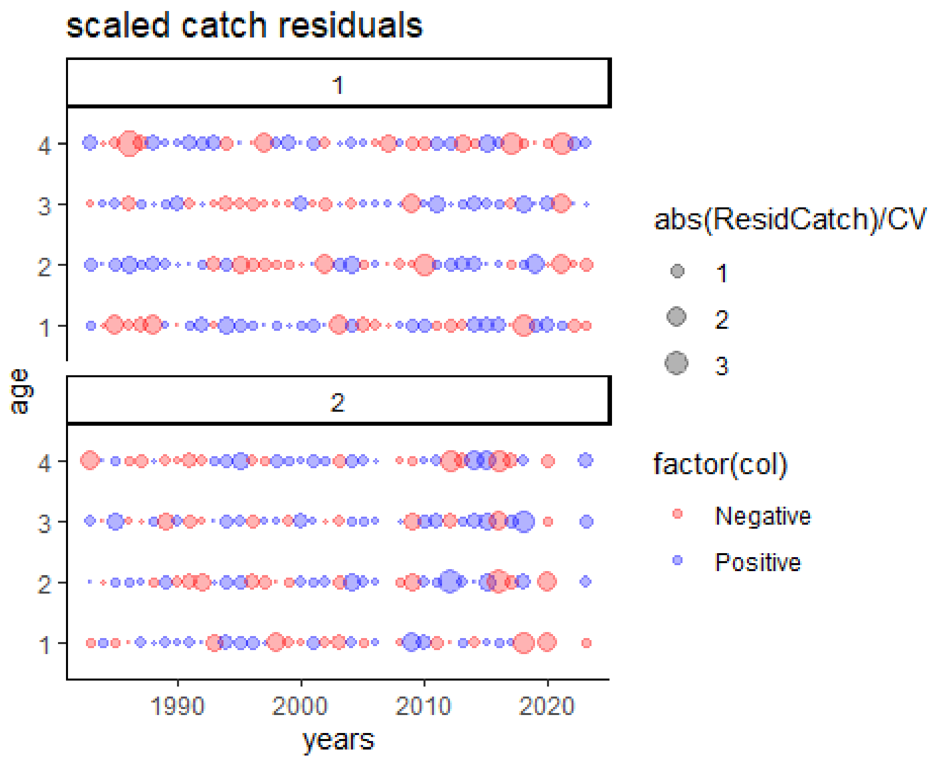


Figure 9.3.7 Sandeel 2r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

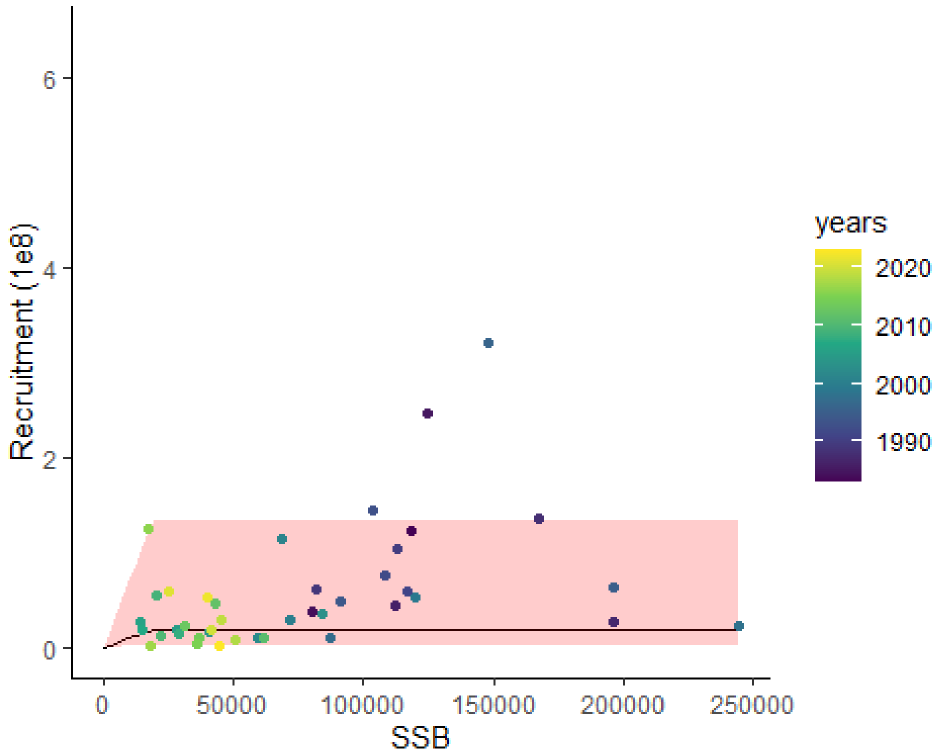


Figure 9.3.8 Sandeel 2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

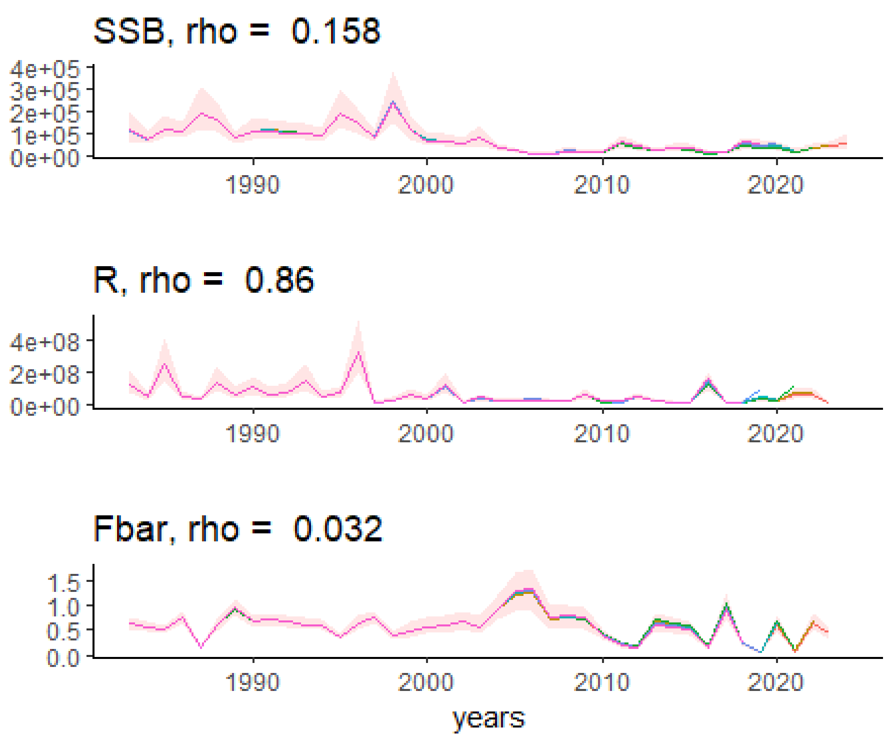


Figure 9.3.9 Sandeel 2r. Retrospective analysis.

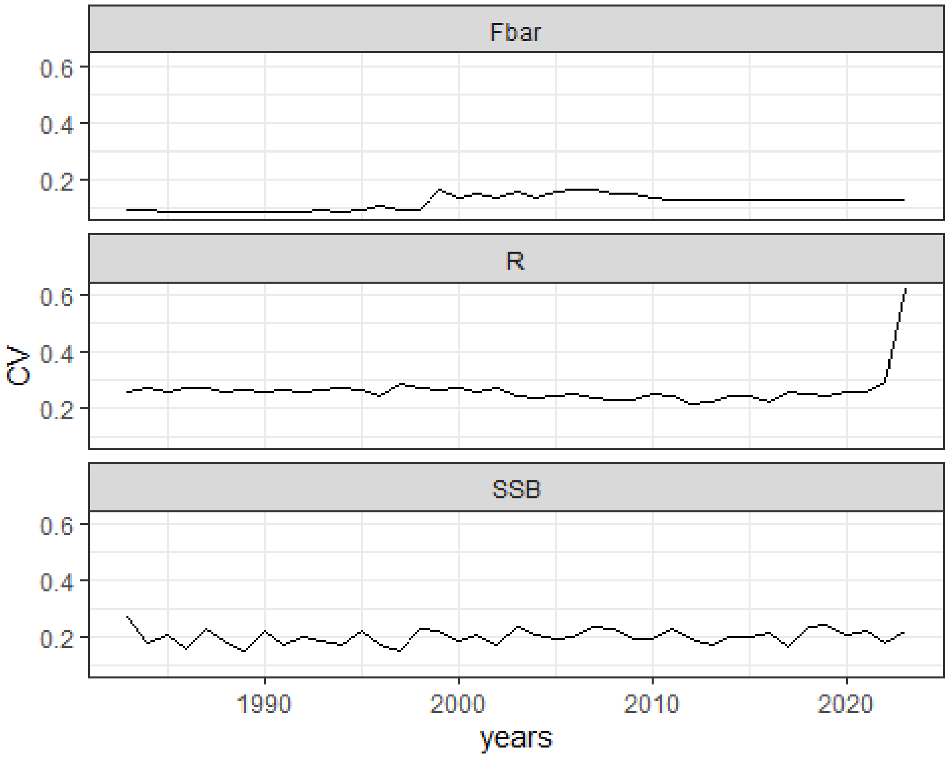


Figure 9.3.10 Sandeel 2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

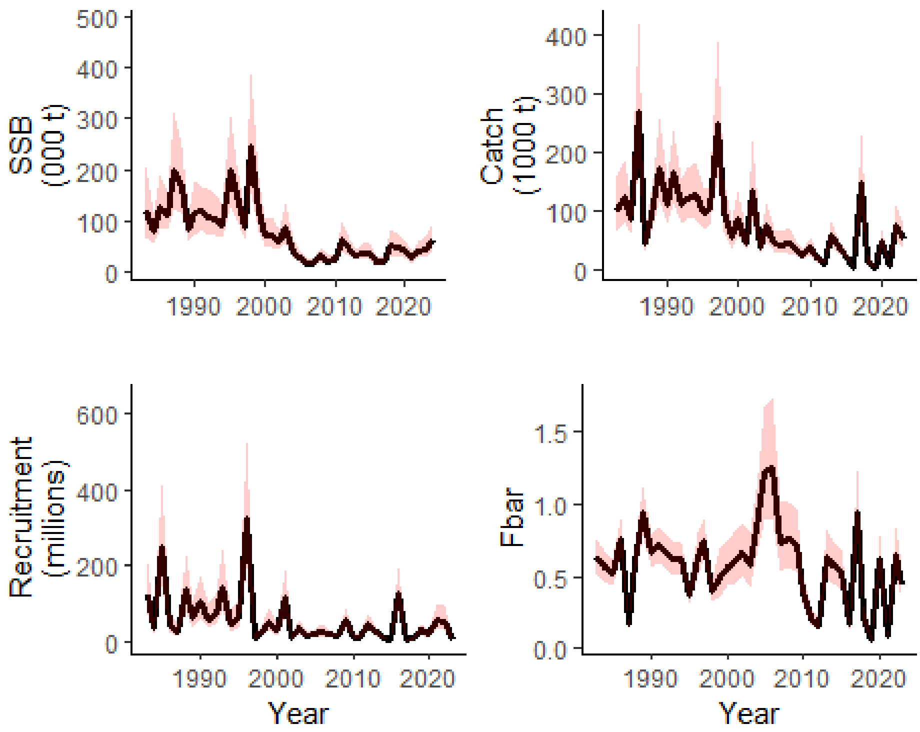


Figure 9.3.11 Sandeel 2r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

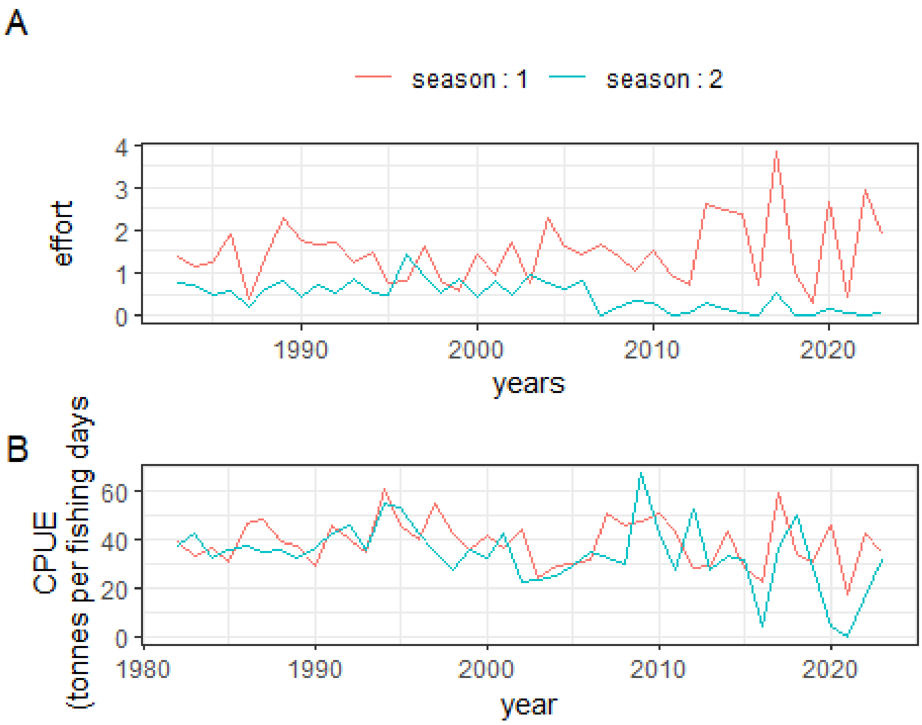


Figure 9.3.12 Sandeel 2r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

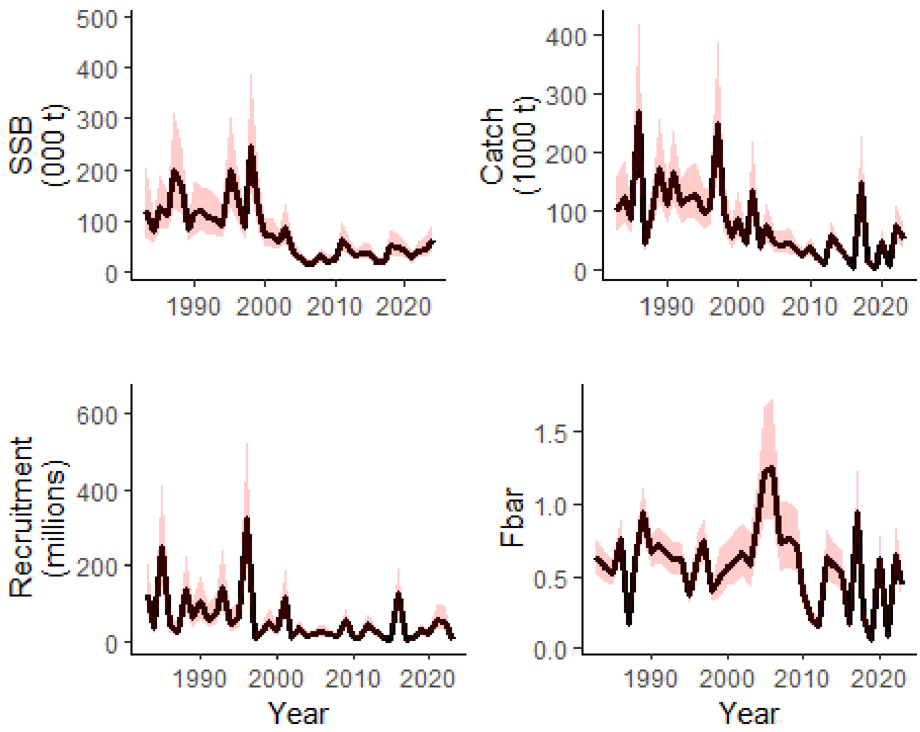


Figure 9.3.13 Sandeel 2r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

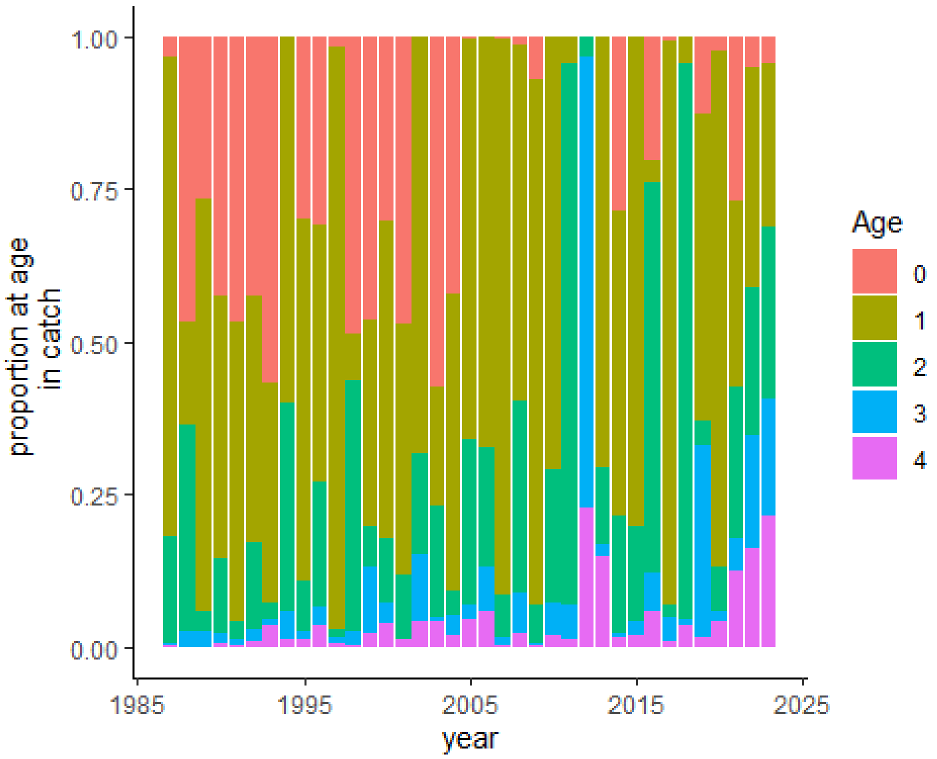


Figure 9.4.1 Sandeel 3r. Catch numbers, proportion at age.

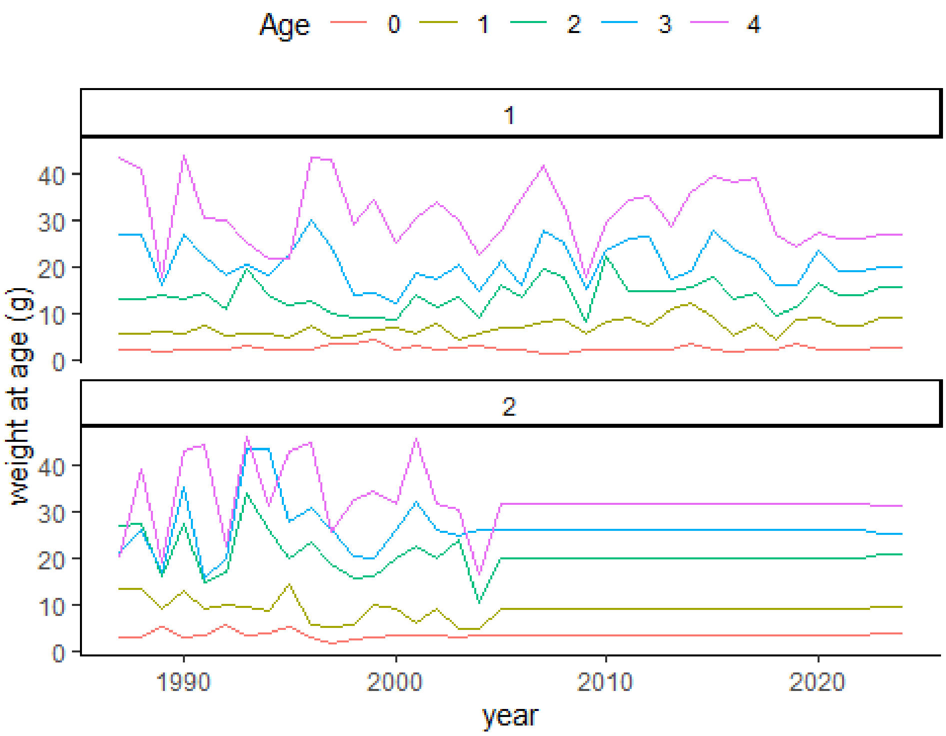


Figure 9.4.2 Sandeel 3r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

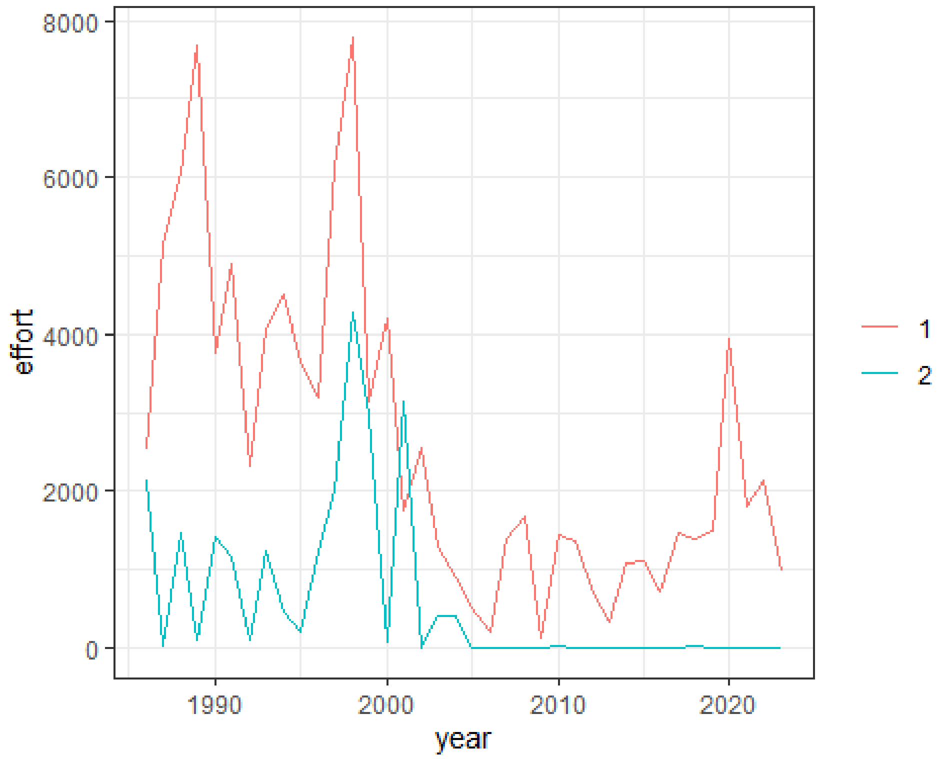
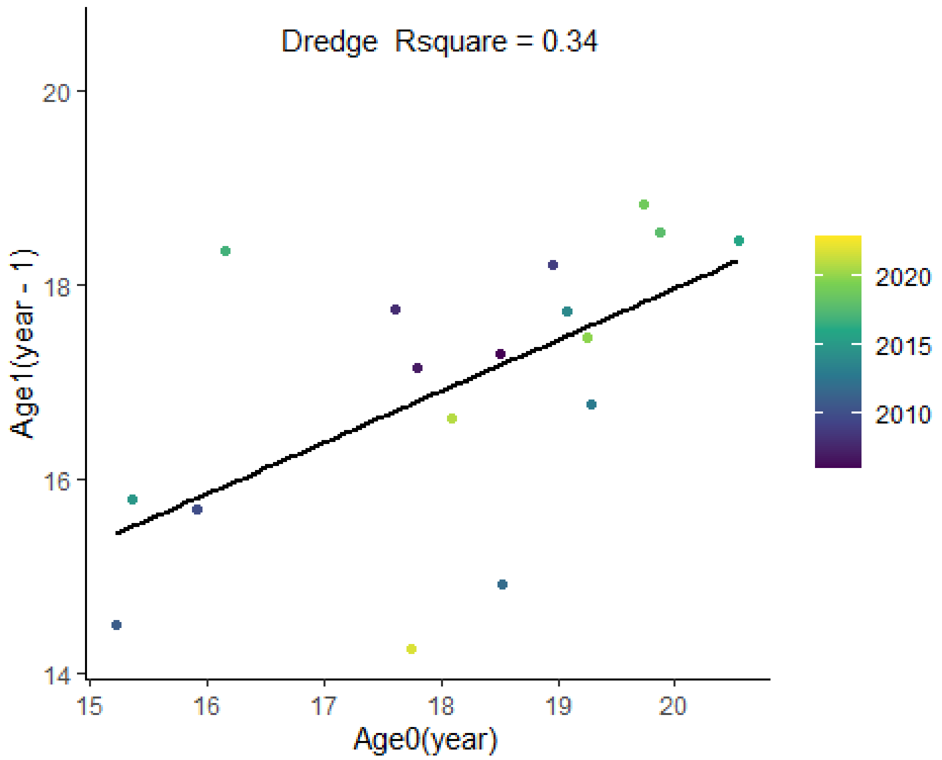
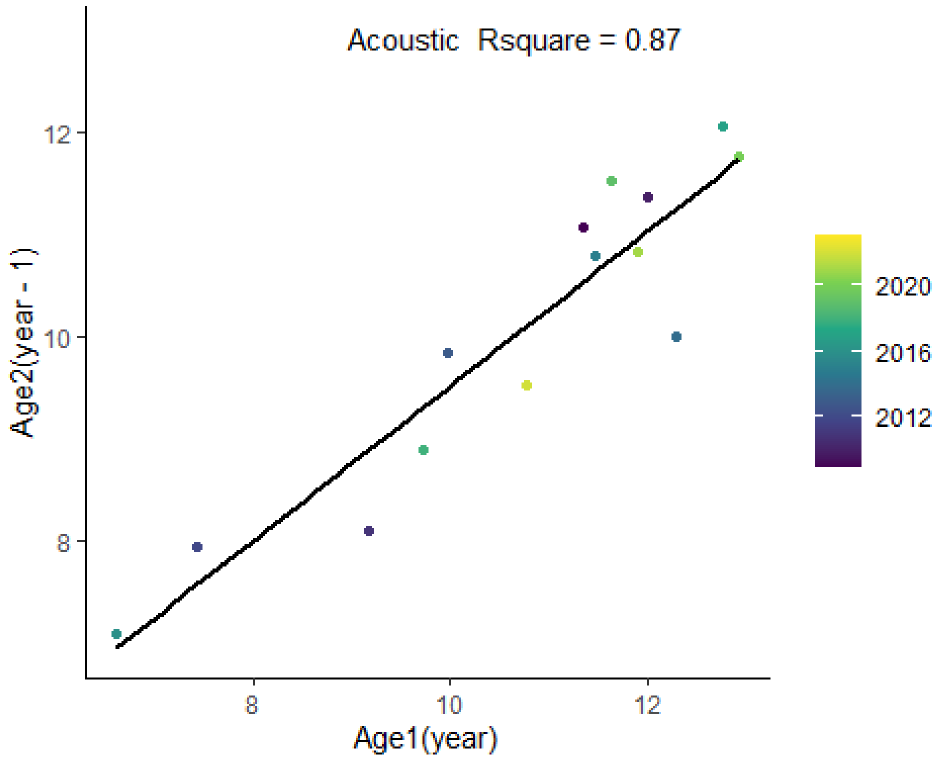
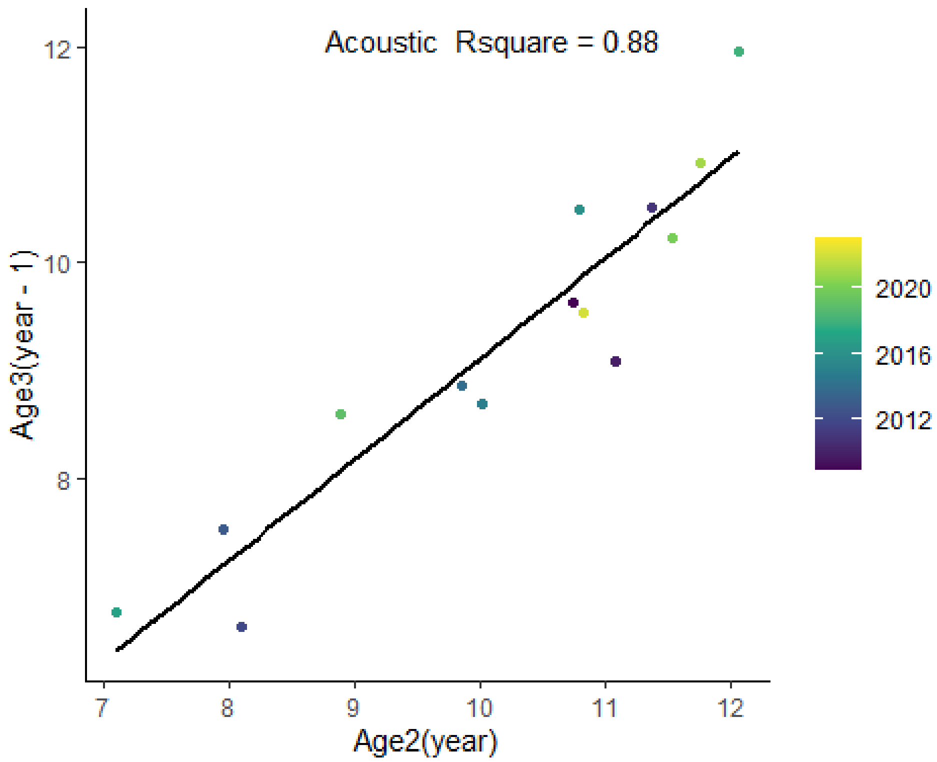


Figure 9.4.3 Sandeel 3r. Standardized effort. Line color denotes the season.




Acoustic Rsquare = 0.87
Age2(year - 1)
Age1(year)
12
10
8
8
10
12
2020
2016
2012


Acoustic Rsquare = 0.88
Age3(year - 1)
Age2(year)
12
10
8
7
8
9
10
11
12
2020
2016
2012

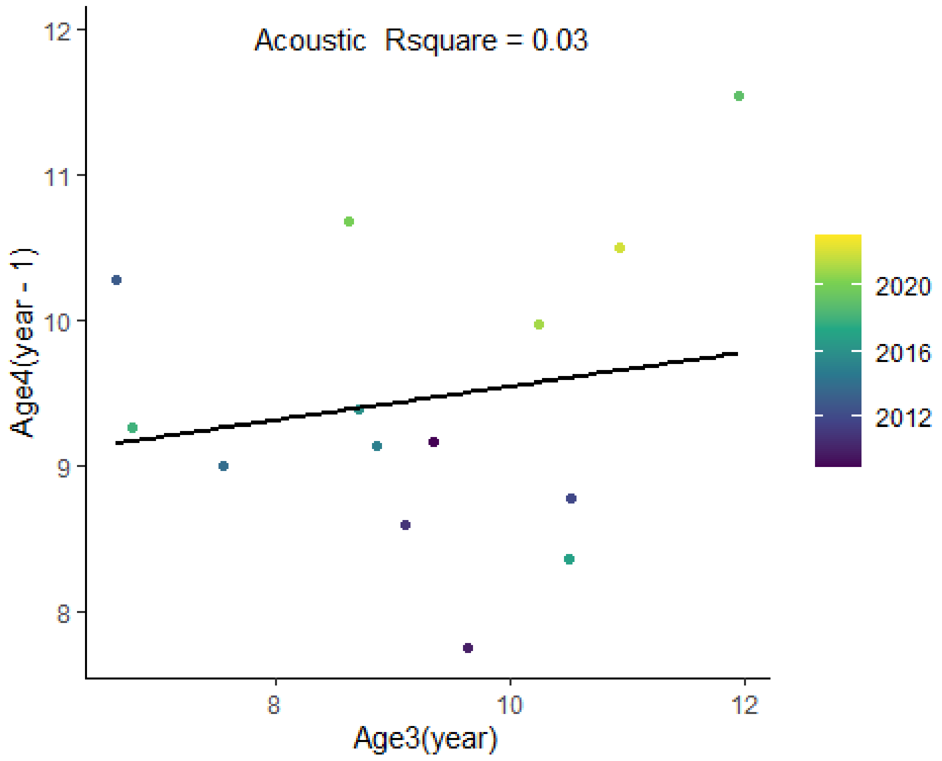


Figure 9.4.4 Sandeel 3r. Internal consistency by ages in the survey.

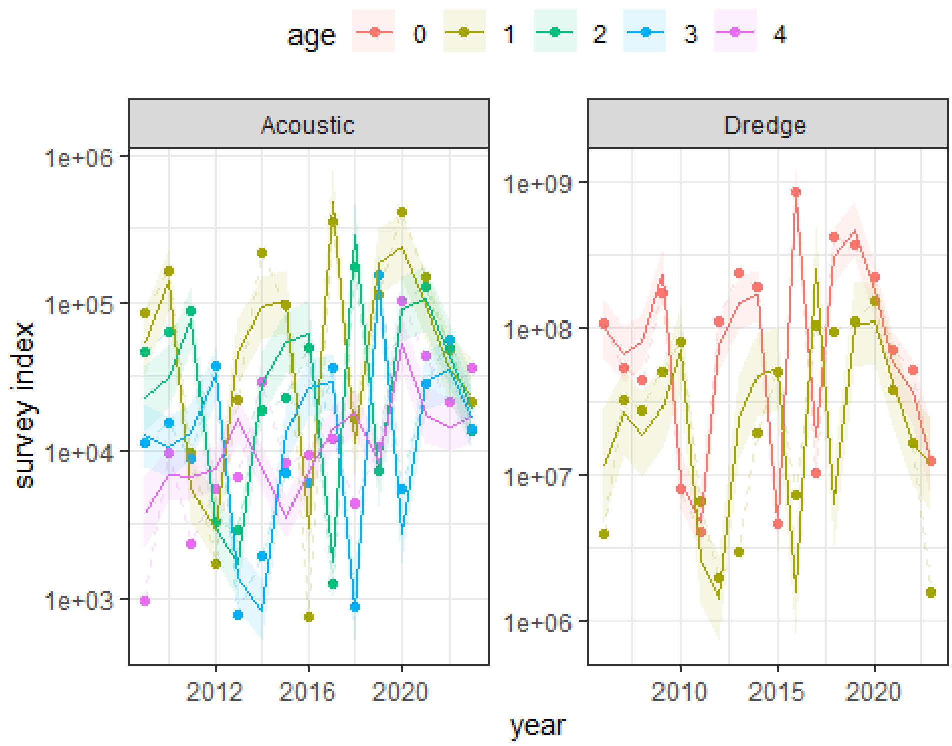


Figure 9.4.5 Sandeel 3r. Surveys (dots) and model fit (full lines). Color denotes the age.

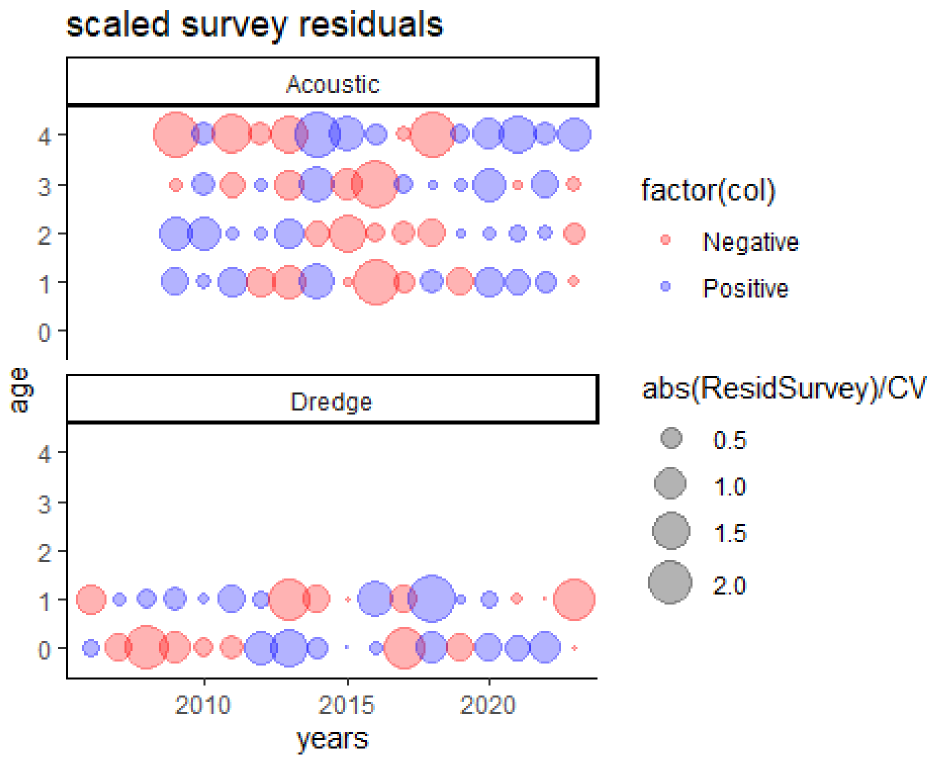


Figure 9.4.6 Sandeel 3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

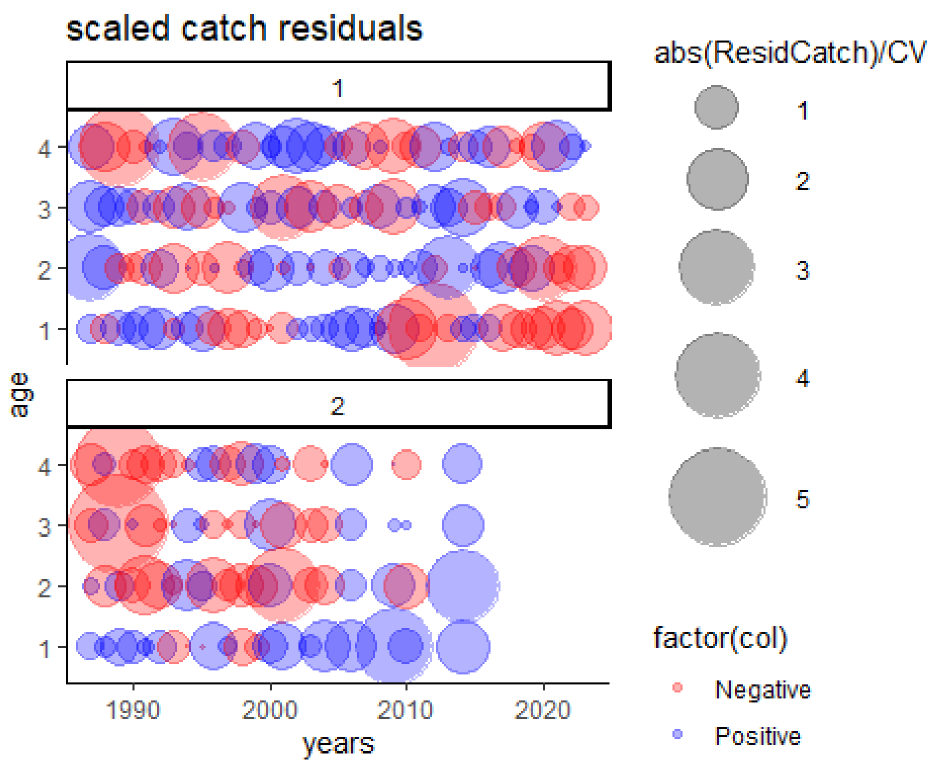


Figure 9.4.7 Sandeel 3r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

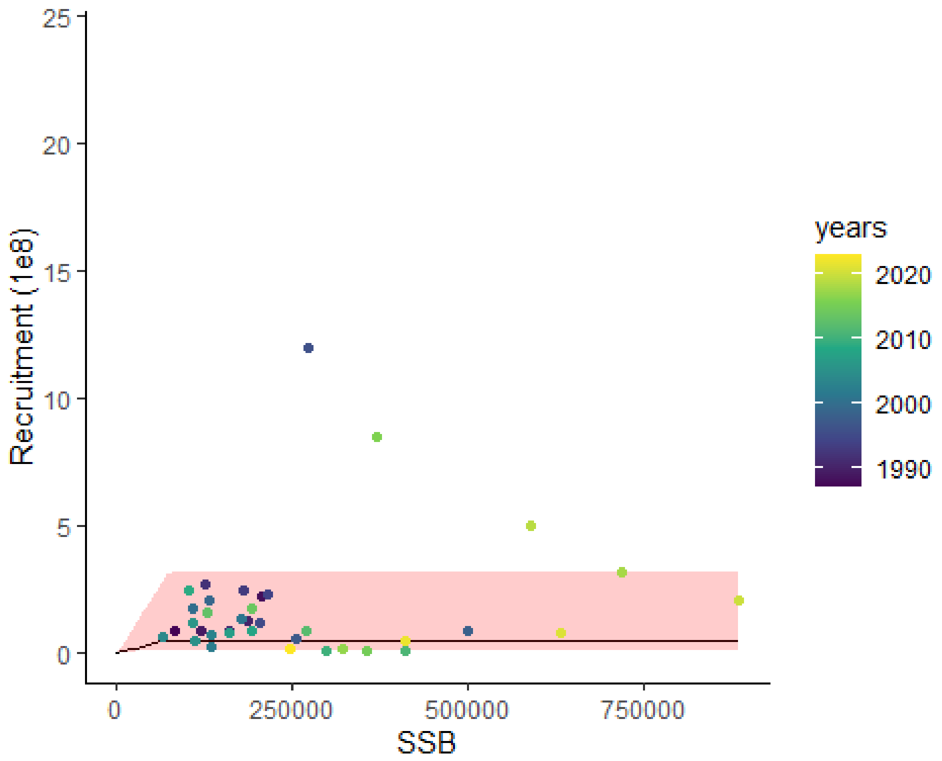


Figure 9.4.8 Sandeel 3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

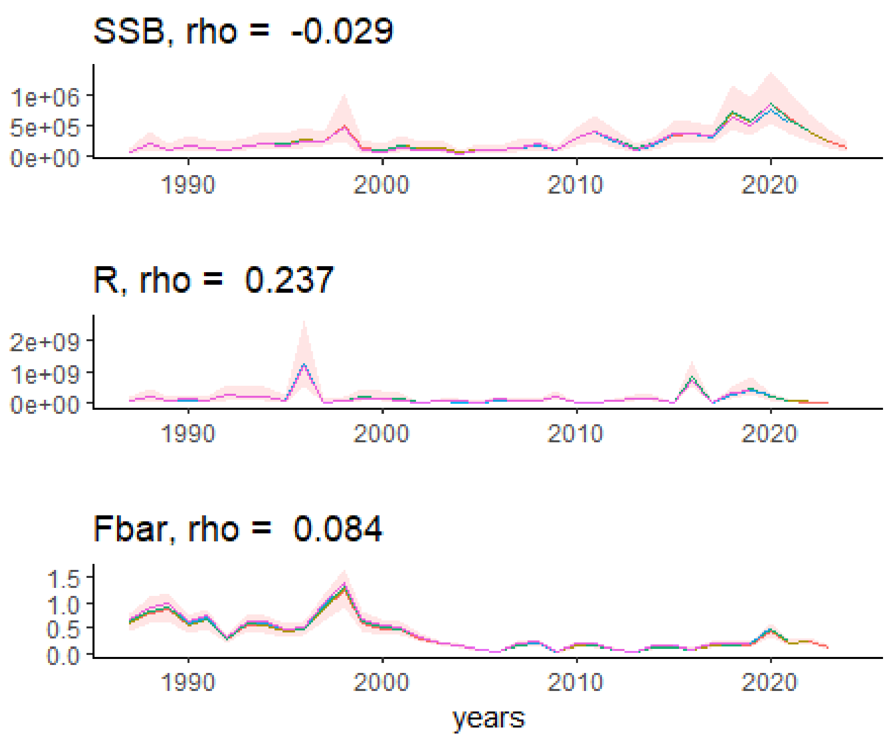


Figure 9.4.9 Sandeel 3r. Retrospective analysis.

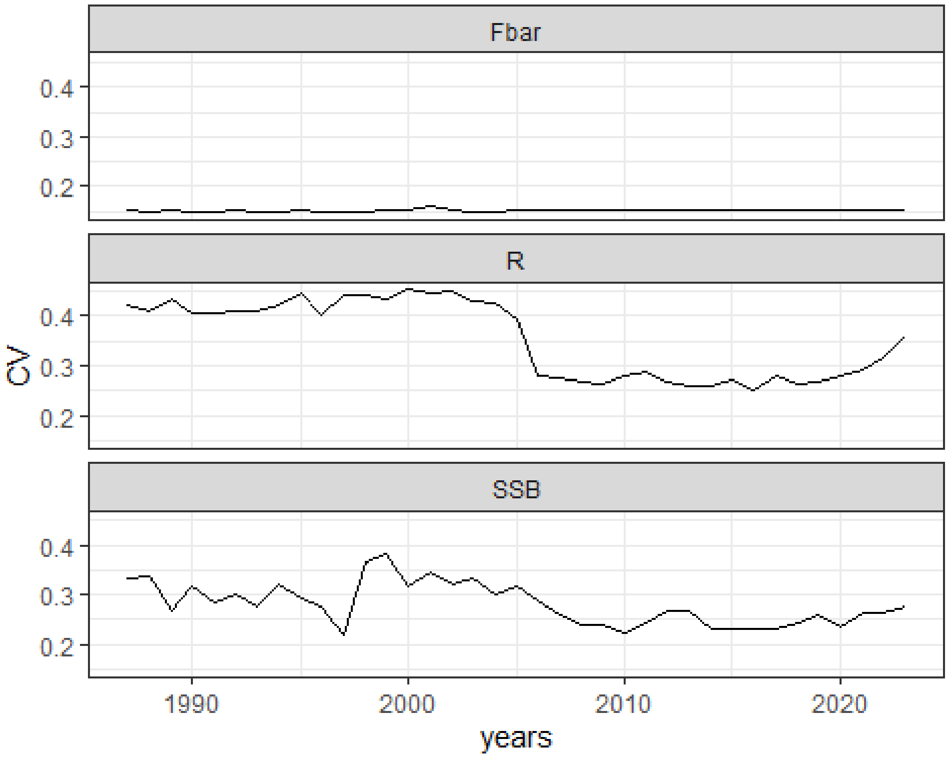


Figure 9.4.10 Sandeel 3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

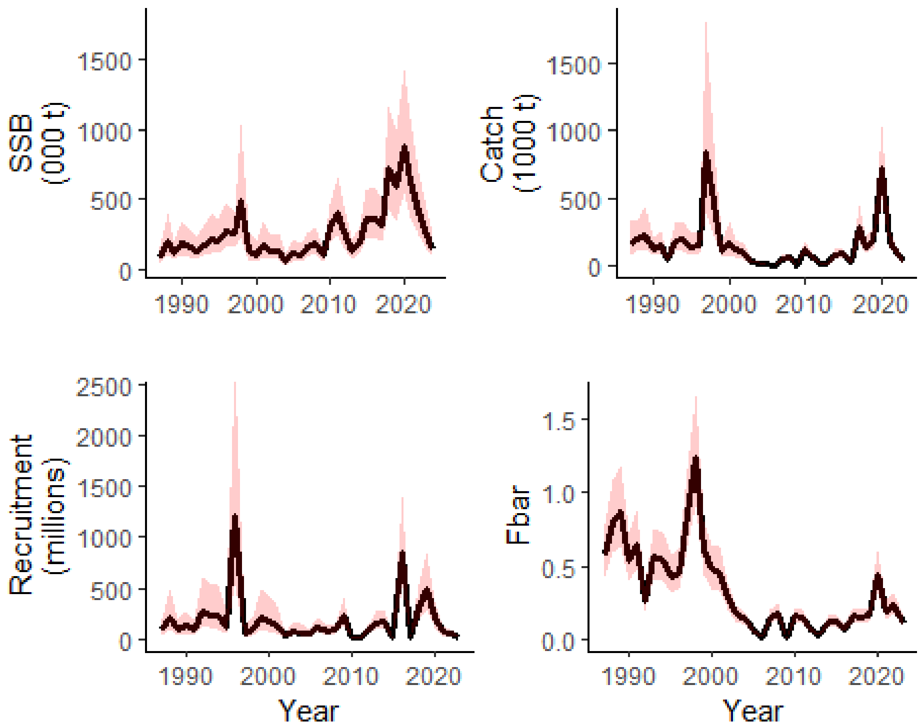


Figure 9.4.11 Sandeel 3r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

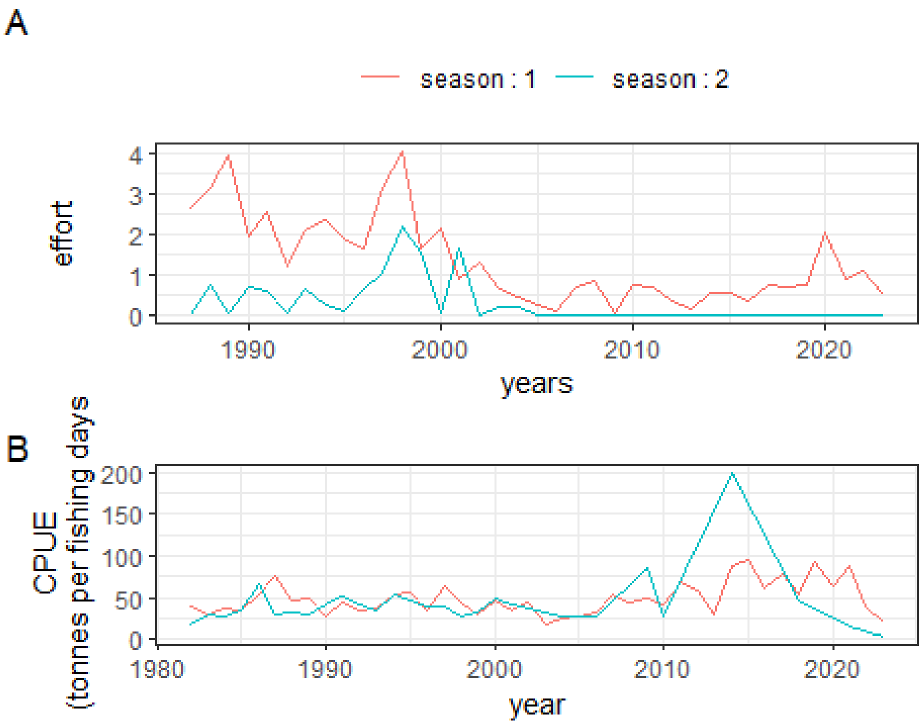


Figure 9.4.12 Sandeel 3r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

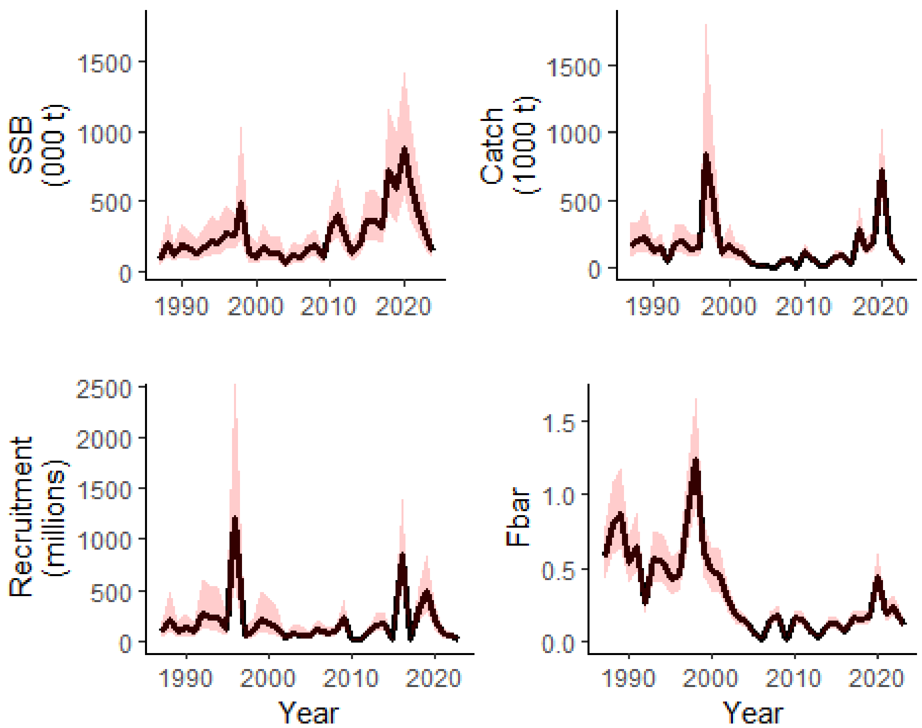


Figure 9.4.13 Sandeel 3r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

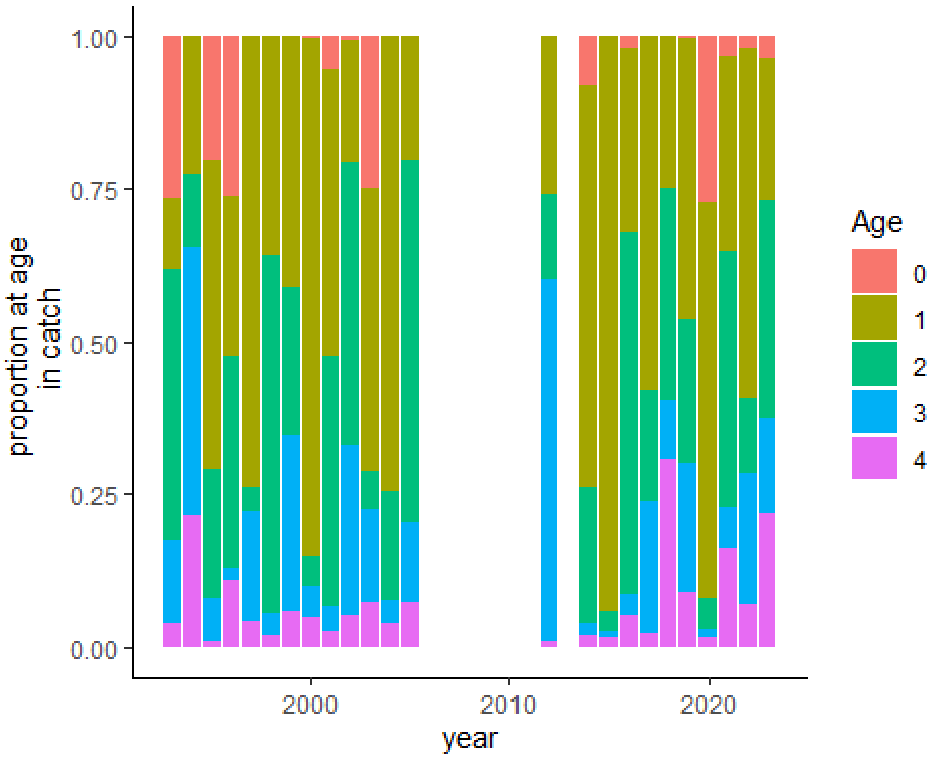


Figure 9.5.1 Sandeel 4. Catch numbers, proportion at age.

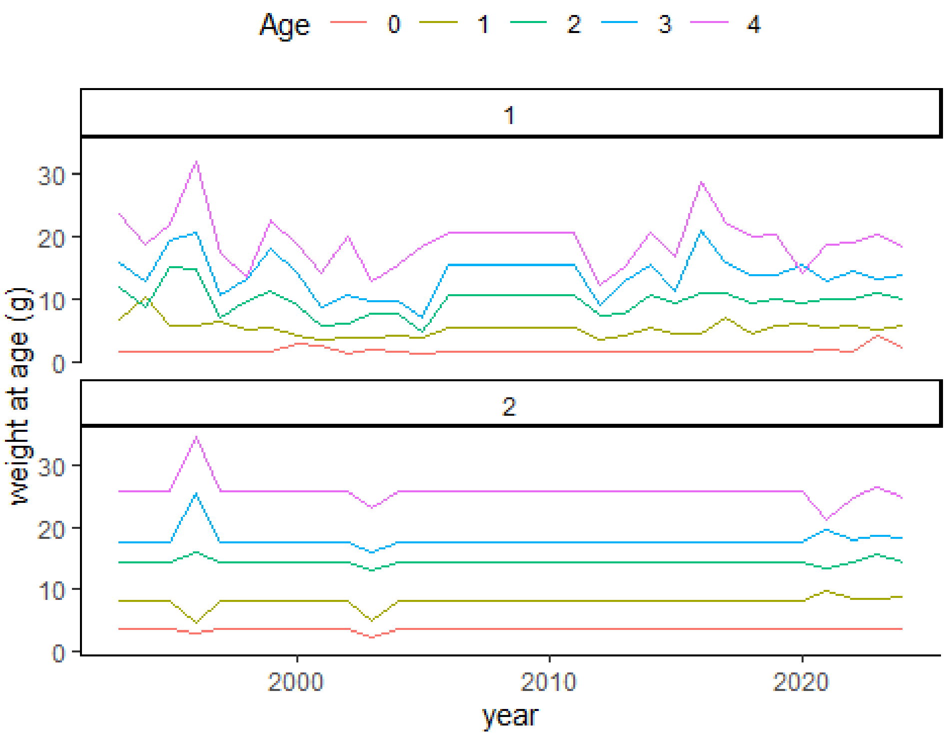


Figure 9.5.2 Sandeel 4. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

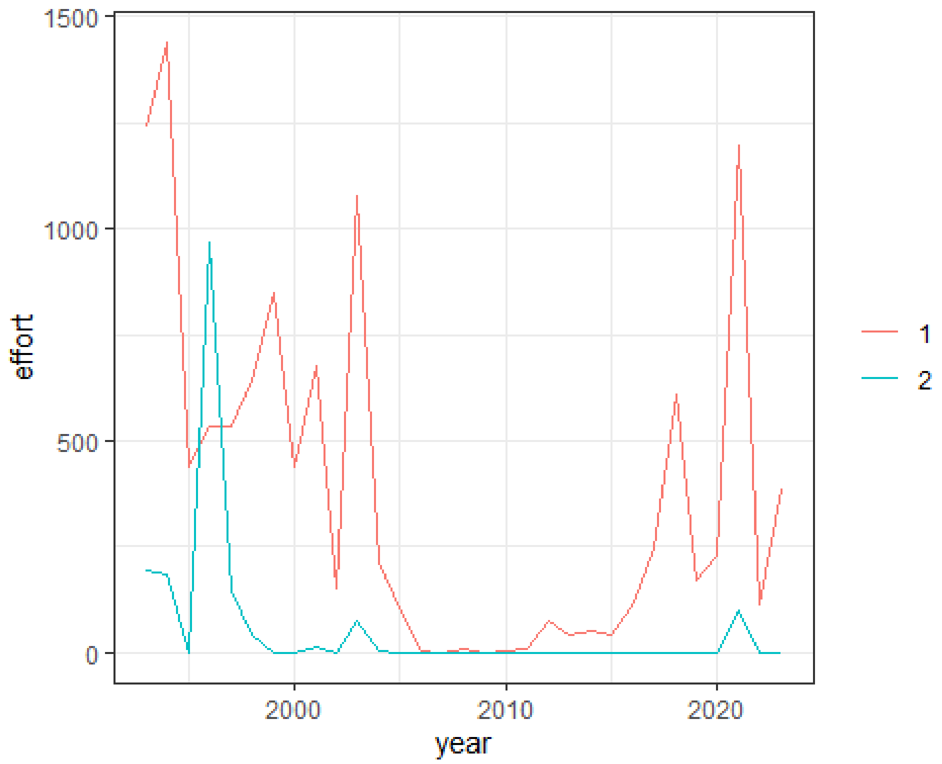
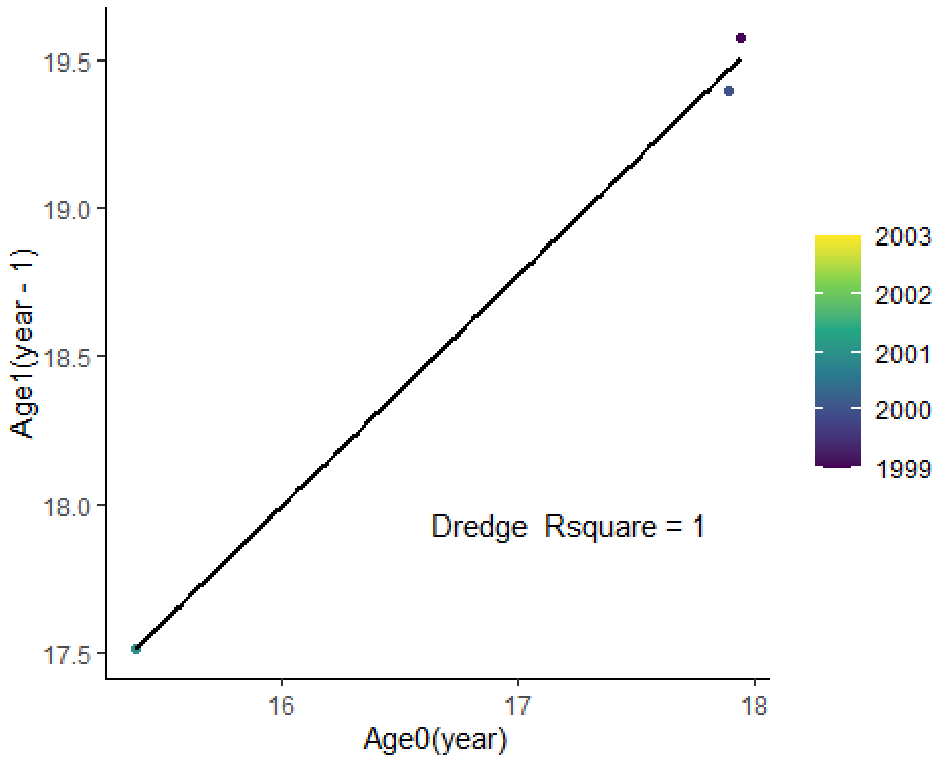


Figure 9.5.3 Sandeel 4. Standardized effort. Line color denotes the season.



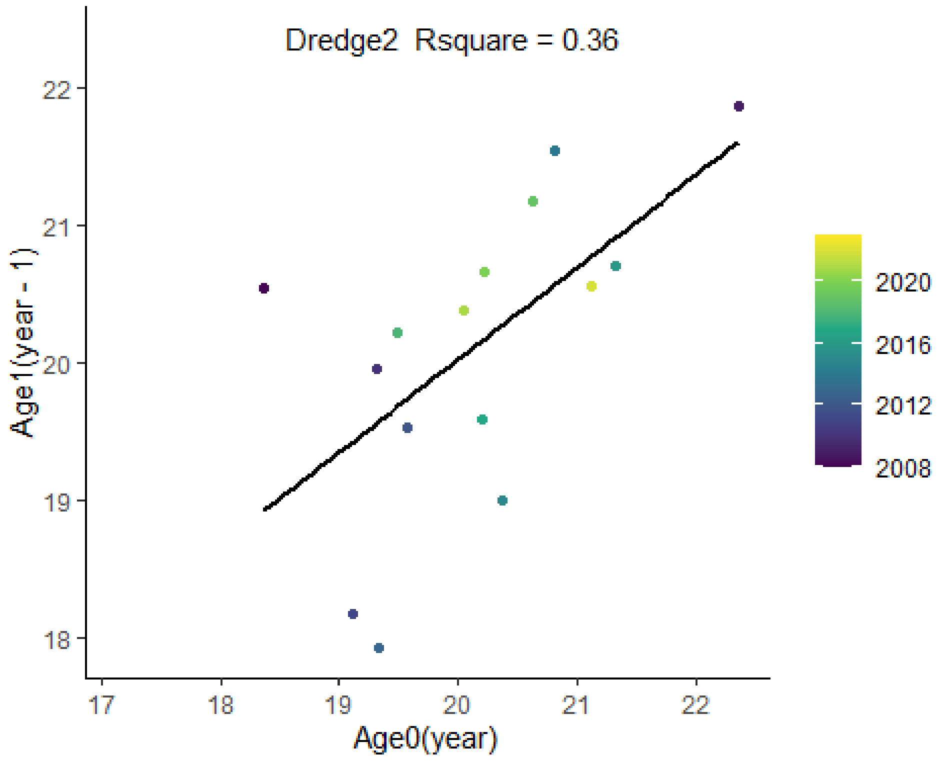


Figure 9.5.4 Sandeel 4. Internal consistency by ages in the survey.

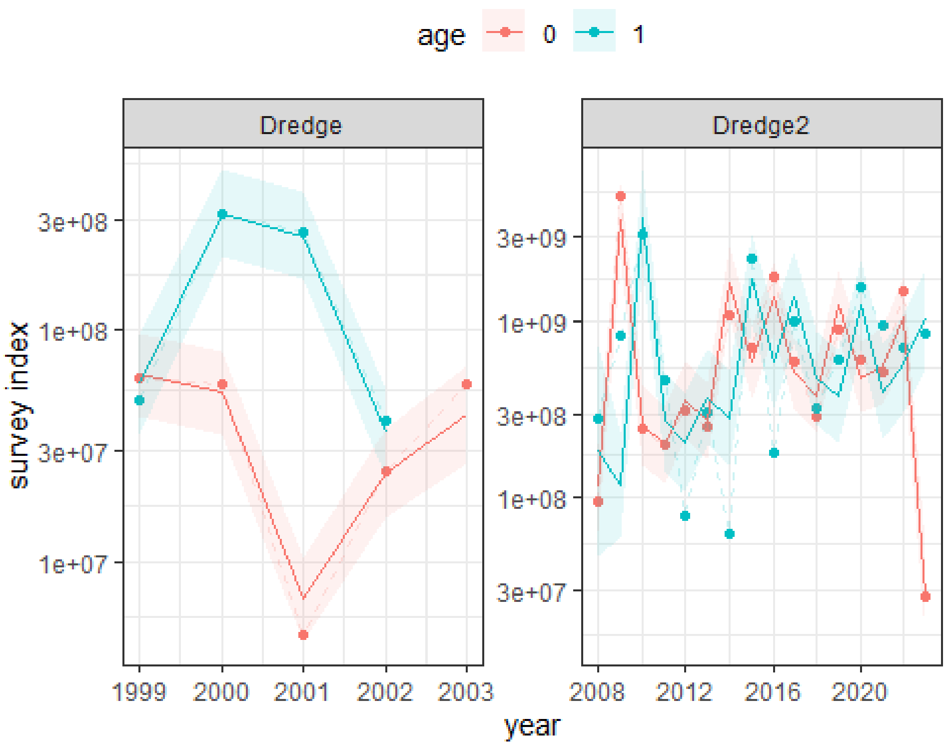


Figure 9.5.5 Sandeel 4. Surveys (dots) and model fit (full lines). Color denotes the age.

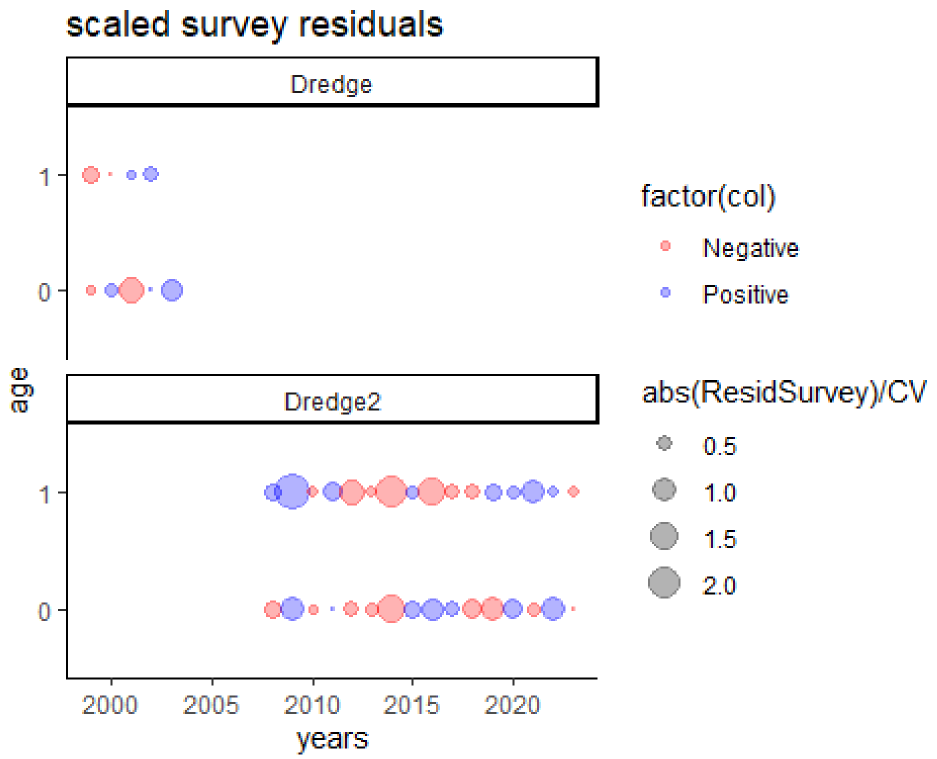


Figure 9.5.6 Sandeel 4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

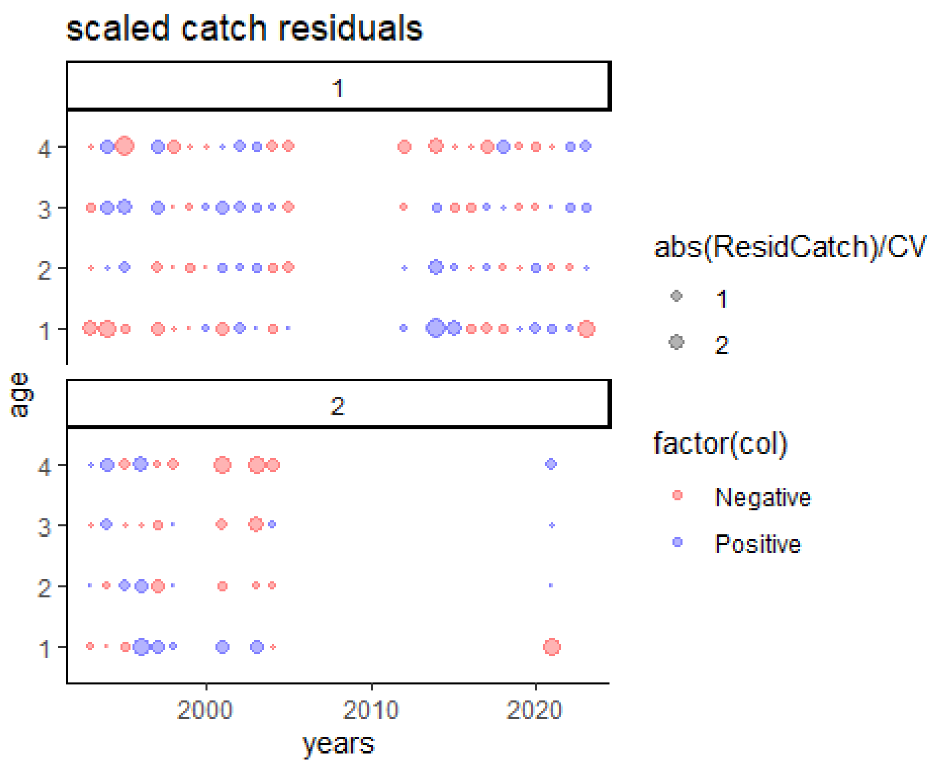


Figure 9.5.7 Sandeel 4. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

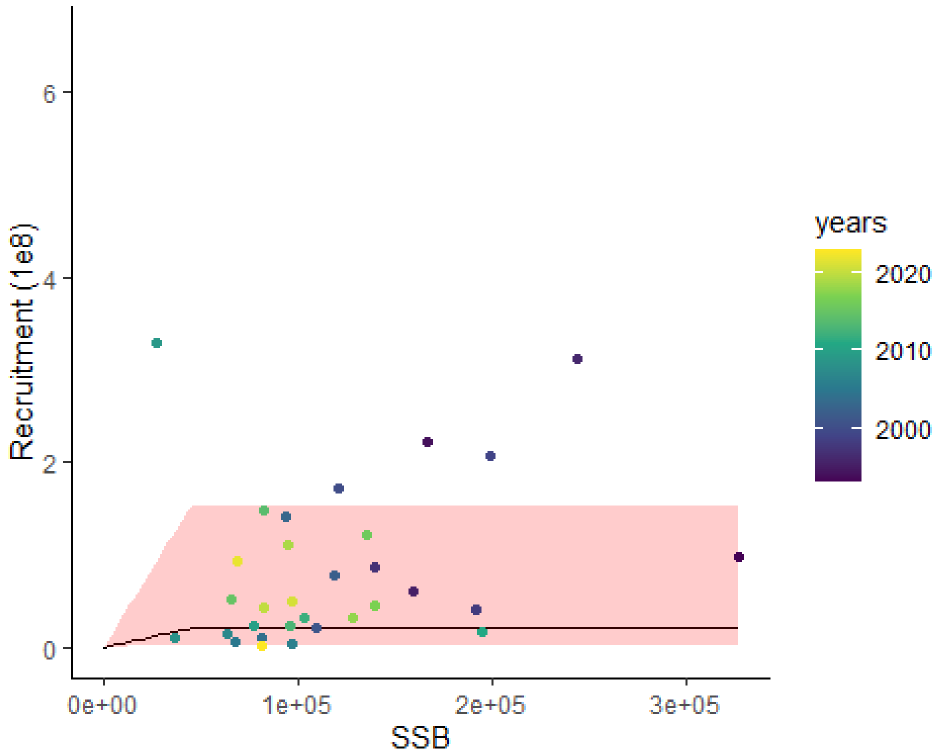


Figure 9.5.8 Sandeel 4. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

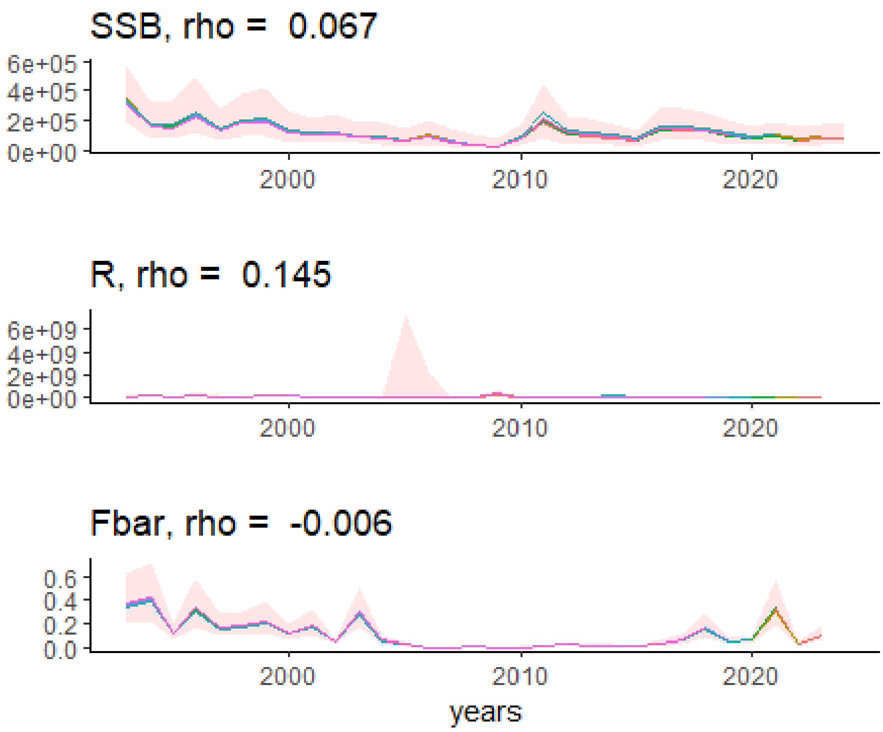


Figure 9.5.9 Sandeel 4. Retrospective analysis.

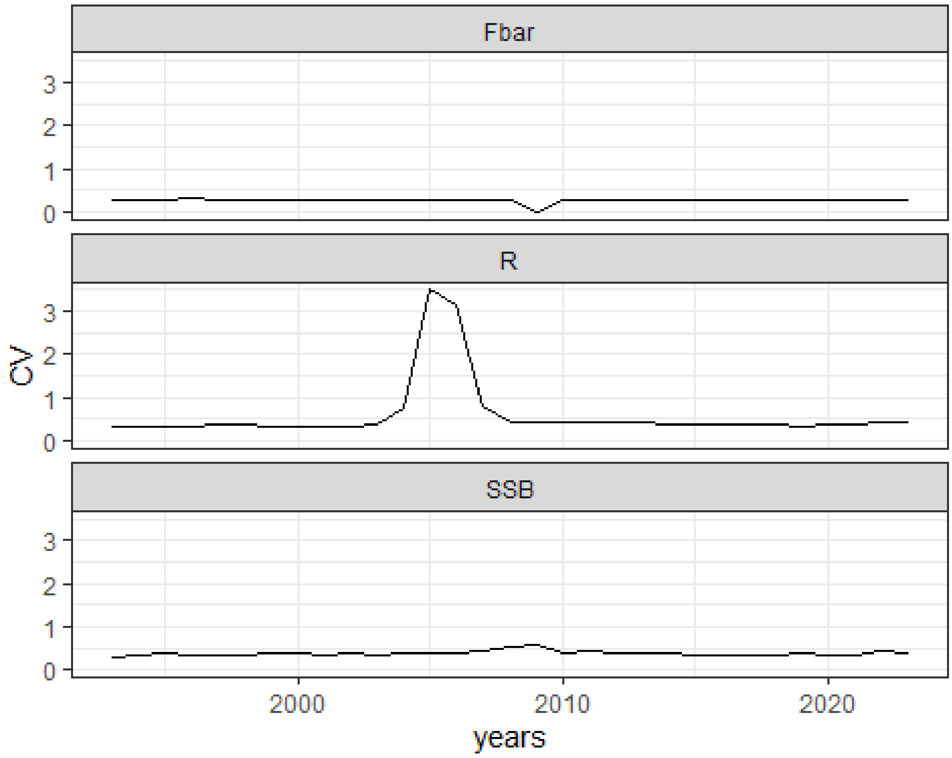


Figure 9.5.10 Sandeel 4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

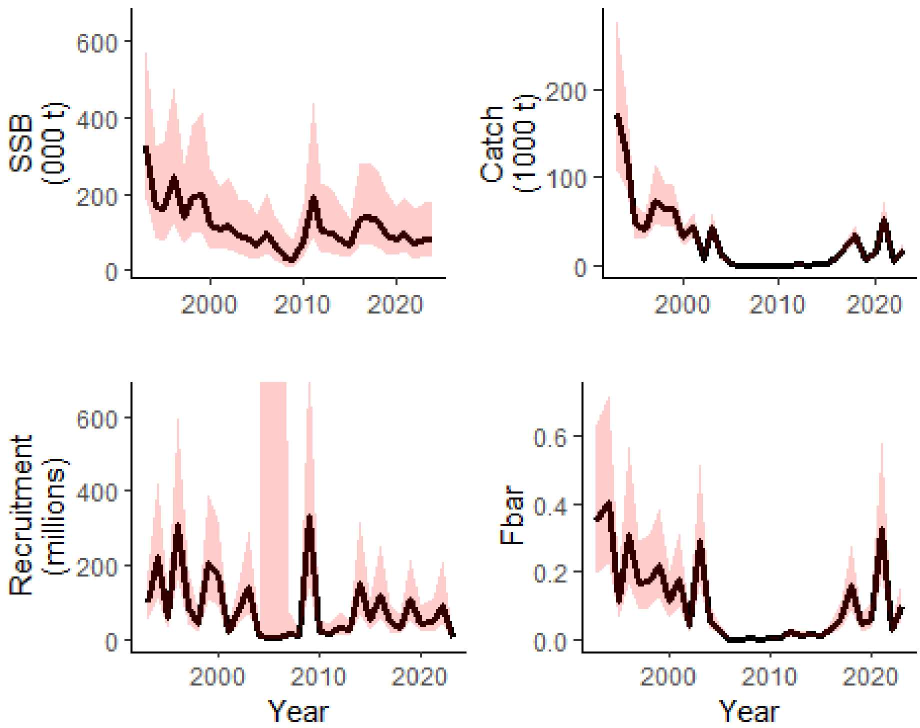


Figure 9.5.11 Sandeel 4. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

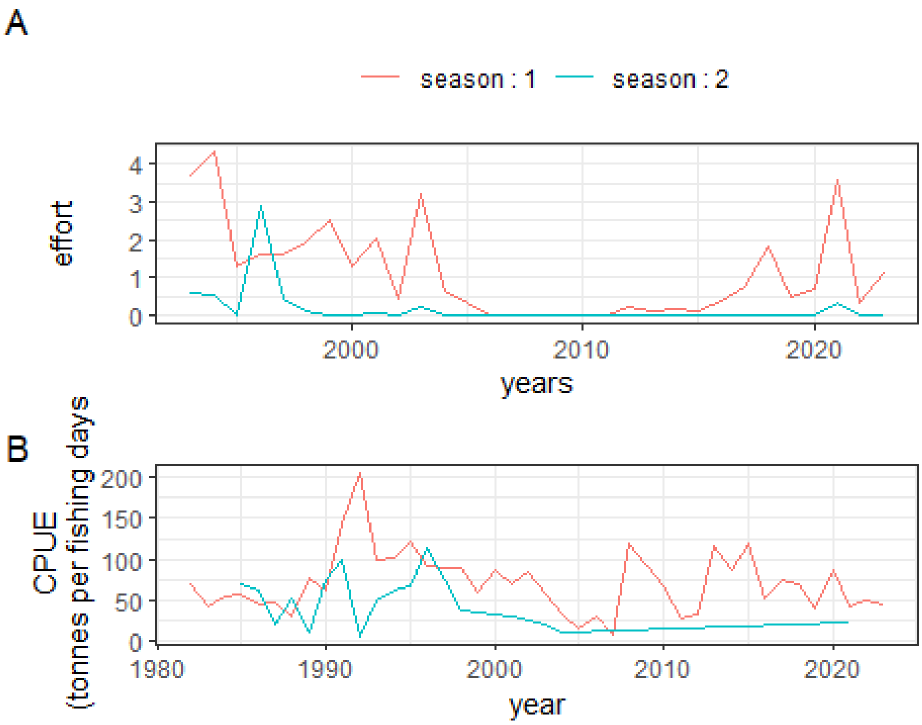


Figure 9.5.12 Sandeel 4. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

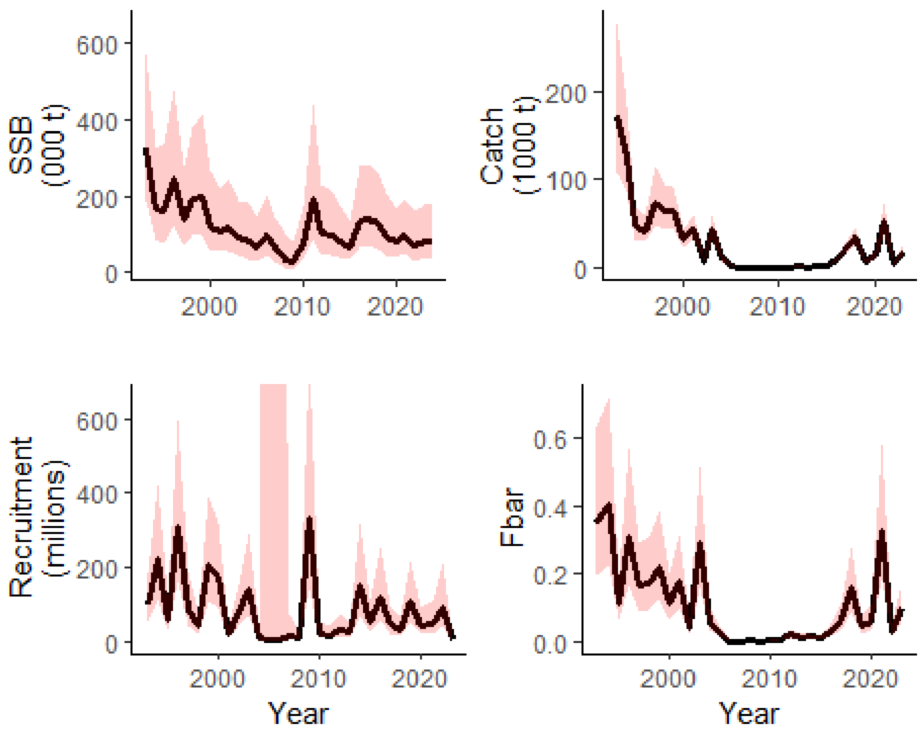


Figure 9.5.13 Sandeel 4. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

Annex 1: Audits

Annex 1 from the Guidelines for Review Groups*

Reporting formats to be used

1. **Format for audits** (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, HAWG 2024, 23-25 January

Reviewers: Espen Johnsen

Expert group Chair: Aaron Brazier and Nis Sand Jacobsen.

Secretariat representative:

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice
san.sa.4

Short description of the assessment as follows (examples in grey text):

1) **Assessment type:** *Update*
2) **Assessment:** *Accepted*
3) **Forecast:** *Accepted*
4) **Assessment model:** *Analytical assessment based on the SMS-model run in single-species mode. Assumes a relationship between F and fishing effort. There is one single commercial fleet, and one old dredge survey (199-2003) and a new dredge survey (2008-2022). Each year has two time steps (half-year): Jan-Jun, and Jul-Dec. The 2024 assessment has updated the natural mortalities based on the 2023 WGSAM key-run which are a better reflection of predation.*
5) **Consistency:** *Accepted – consistent with last year.*
6) **Stock status:** $B < B_{pa}$ and B_{msy}, but $B > B_{lim}$. After a long period with low SSB, the SSB has fluctuated from a level between B_{pa} and B_{lim} with several years above Bpa. The recruitment has also fluctuated in since 2009, with some very strong years classes.
7) **Management plan:** No management plan are in place for SA4, but a closed area have been in place since 2000.

General comments
No catch in many years, and several years with low fishing mortality make the assessment uncertain due to little input data from the commercial fishery. In addition, the research vessel used for the dredge survey is not allowed to sail all the distance to the main fishing grounds and it a concern that the dredge survey area does not cover the main fishing areas in SA4. It is not clear if recruitment and density structures are homogeneous within the SA4, or if there are spatial differences between the fishing grounds and the more inshore dredge survey areas. There are strong retrospective patterns for both recruitment and SSB in recent years, and it seems like the dredge survey estimates may overestimate the year class strength.

Technical comments

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*ICES. 2021. Guidelines for review processes. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.5.4. https://doi.org/10.17895/ices.advice.7682.

Conclusions

The assessment has been performed correctly and according to procedure. The retrospective downscaling of the SSB is of high concern.

Annex 1 from the Guidelines for Review Groups*

Reporting formats to be used

1. **Format for audits** (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (HAWG) *(2024*) (08.02.2024)

Reviewers: Norbert Rohlf

Expert group Chair: Nis Sand Jacobsen, Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: san.sa.2r

The stock is separated in seven management areas. Fishing takes place in five of these seven areas (sandeel area 1r-3r, 4 and 6). The stock was last benchmarked in 2016.

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Age-based SMS-effort model, half-yearly time steps. Tuned by dredge survey.
5) Consistency: Benchmarked in 2023. Mortalities updated with WGSAM run.
6) Stock status: SSB above B_{lim}, B_{pa} resp. $MSYB_{escapement}$. Recruitment is very low in 2023.
7) Management plan: There is no agreed management plan for this stock.

General comments

The report is very concise and documents all decisions and settings made in the assessment well.

Technical comments

Sources and references need to be updated.

Conclusions

The assessment has been performed correctly and considered adequate as the basis for TAC advice. A management plan needs to be developed.

ICES stock advice

*ICES. 2021. Guidelines for review processes. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.5.4. https://doi.org/10.17895/ices.advice.7682.

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

~~☐ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).~~

~~☐ Check if the labels for the years are correct.~~

~~☐ Compare the status table with the F and SSB plots they should show the same information.~~

~~☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.~~

Catch options

Basis of catch options table:

~~For each of the rows in the table ensure that:~~

~~☐ The year is correct,~~

~~☐ The value is correct,~~

~~☐ The notes are correct and~~

~~☐ The sources are correct.~~

Catch options table:

~~☐ The forecast should be re-run to ensure all values are correct.~~

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☐ ~~Confirm if the F values for the options F_{lim}; F_{pa}; are correct.~~

☐ ~~For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.~~

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ ~~Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)~~

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☐ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

~~☐ If there is no change from the previous year the table should be the same.~~

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders

~~☐ If no information is available the standard sentence should be "There is no **additional** available information"~~

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☐ ~~Ensure that the values for the last row are correct check against the preliminary landings (link to be added)~~

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

In Table 8, the estimated recruitment is given, not the geometric mean as stated in the footnote,

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☐ Ensure all references are correct.

☐ Ensure all references in the advice sheet are referenced in this section

Update needed

Annex 1 from the Guidelines for Review Groups*

Reporting formats to be used

1. **Format for audits** (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, HAWG, 2024, 23rd-25th January

Reviewers: Ole Henriksen

Expert group Chair: Nis Sand Jacobsen and Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: san.sa.1r

Short description of the assessment as follows (examples in grey text):

1) **Assessment type:** Update (Benchmarked in 2023, approved in jan-2024 with no changes in stock unit components/area divisions)
2) **Assessment:** Accepted
3) **Forecast:** Accepted
4) **Assessment model:** Age-based analytical single-species SMS model that can have time-variant/seasonal processes included. The model is run with two time-steps, half-year, which assumes a relationship between *F* and fishing effort. The model have one survey (divided into two time-series) to inform on the incoming recruitment.
5) **Consistency:** last year's assessment rejected – this year's accepted; the view of the review group was that last year's assessment should have been accepted.
6) **Stock status:** In the absence of fishing(F=0) SSB will be blow B_{pa} in 2025 ($B < B_{pa}$). The advised TAC is therefore zero. The incoming recruitment from 2023 is the lowest in the time-series. However, my personal view considers the survey uncertain (See technical comments below). record
7) **Management plan:** There is no agreed management plan for this stock. A closed area have been in place since 2000.

General comments

Technical comments
A comment that are evident yearly, is that the Scottish dredge survey covers the closed area off the coast of Scotland, but have poor cover in much of the actual fished area in years when fishing is possible and evident. Furthermore, the Scottish dredge survey are performed during day, whereas the Danish survey are performed during night. The dredge survey have previously been adjusted to account for skewness in the spatial coverage. The latter because the catchability is assumed to be better during the night, which also have been highlighted during the benchmark. Thus, there seems to be both poor overlap with commercial catches and a possible bias

*ICES. 2021. Guidelines for review processes. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.5.4. https://doi.org/10.17895/ices.advice.7682.

when sampling during day, which is of a concern. It should be encouraged to look into whether this is a problem, and how well banks correlate to each other in terms of recruitment and stock fluctuations. One may suspect that spatial heterogeneity in the population dynamics and survival may affect the assessment, perception of the stock and lead to some added uncertainty for the advice.

Conclusions

The assessment has been performed correctly and according to normal procedure and ICES standards. There is still no management plan for this stock, or any of the sandeel stocks, which in general is recommended.

Annex 1 from the Guidelines for Review Groups[1]

Reporting formats to be used

1. **Format for audits** (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, HAWG 2024, 31st January

Reviewers: Valerio Bartolino

Expert group Chair: Aaron Brazier (CEFAS) and Nis Sand Jacobsen (DTU)

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Assessment and forecasts conform to the procedure described in the stock annex which has been recently updated with the benchmark completed in 2023.
- internal consistency of the age0-1 indices from the dredge survey is low (R^2=0.2) similarly to the previous assessment.
- Analytical retrospective is relatively low considering the life history of the stock and considerably improved with the benchmark SSB (Mohn's ρ=0.228, it was 0.56 in the 2023 assessment) and R (ρ=0.512, it was 1.09 in the 2023 assessment). A couple of peels are noticed at the edge of the CI.
- The impact of updated natural mortality provided by WGSAM 2023 results in a small impact on the assessment output (SSB, R, F) and it shows some small improvement in the CV of SSB and F. The relationship between SSB and R is substantially unchanged and adoption of the new M does not compromise the Blim selected at the benchmark.
- The catches in 2023 have been 88 581 t which is 24% lower than the TAC.
- The advice is in line with the Bescapement strategy and makes use of the Fcap (0.36) to avoid excessive increase in F (hitting the Bescapement would result in an F=0.55).
- Uncertainty on the terminal year R substantially contributes to the uncertainty in the forecasts (not different from previous years)

For single-stock summary sheet advice

Stock: san.sa.1r

1 ICES. 2021. Guidelines for review processes. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.5.4. https://doi.org/10.17895/ices.advice.7682.

Short description of the assessment as follows:

1) Assessment type: update (benchmarked in 2023)
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: analytical assessment based on SMS assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey (+ 1 monitoring CPUE with almost no influence on the assessment), two timesteps per year (Jan-Jun and Jul-Dec).
5) Consistency:
   - The dredge survey continues to have a low internal consistency between age0 and age1. Intense fishing on age1 is considered one of the possible contributing factors of the poor consistency.
   - The retrospective is substantially reduced after the recent benchmark
   - CV for the catches and age0 in the dredge are comparable or lower than in other sandeel areas.
   - CVs of both catches and survey are overall comparable with to the benchmark run
6) Stock status: SSB is estimated above Bpa at the beginning of 2024 also as a result of the low 2023 catches (-24% of the TAC). 2023 recruitment was quite good.
7) Management plan: no MP is in place for SA1r.

Technical comments
Nothing to add

Conclusions
The assessment has been performed correctly and according to procedure.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results. This should be automatically the same

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☒ The forecast should be re-run to ensure all values are correct.

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder) input data changed according to the recent benchmark

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct. F=F2022 should be F=F2023

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct. NA

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options". Now called "Other scenarios". It was discussed to change the name of the basis into "SSB 2025 ≥ MSY B escapement with Fcap" and possibly add a scenario based on MSY Bescapement without Fcap which is available on the sharepoint 'presentations/Forecast 2024.pdf'

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.) No MP for SA1r

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines. A bit hard to see exactly the 5 lines but they probably just overlap

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same. Maturity is now time variable, I've changed it in the advice text table 5.

Some of the text was misplaced in the table. It should be fixed now

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used. Correctly described the model and consistent with previous years

History of advice, catch and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown. No discards.

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected. I've changed the recruitment 2024 to correspond to the geometric mean as in table 1.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☒ If the stock is category 5 or 6 then it should read "There is no assessment for this stock" NA

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

still few to be updated:

- ICES 2024a (benchmark report which is not publishde yet)

- HAWG 2023 replaced with HAWG 2024

Annex 1 from the Guidelines for Review Groups[*]

Reporting formats to be used

1. **<u>Format for audits</u>** (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, HAWG sandeel, 23-25 January 2023

Reviewers: Cecilie Kvamme

Expert group Chair: Aaron Brazier and Nis Sand Jacobsen

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Sandeel (*Ammodytes marinus*) in the North Sea area 3r (SA3r)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Benchmark assessment (WKSANDEEL 2022 – ended 2023)
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Age-structured model (SMS-effort), half-yearly time-step. Acoustic survey index (A6823; 2009–2023) and dredge survey index (D9376; 2006–2023). Total international catch and fishing effort. Constant maturity-at-age estimated from the dredge survey. Natural mortality estimated from multispecies assessment (ICES, 2024), updated in the benchmark. Age frequencies from catch sampling.
5) Consistency: both last year's and this year's assessment accepted. The stock has been benchmarked since last year's assessment.
6) Stock status: B > Blim after 2004, and above Bpa after 2013; R very low in recent years (after 2020). The stock is estimated to be at Bpa in 2025 with no catches.
7) Management plan: no management plan.

<u>General comments</u>

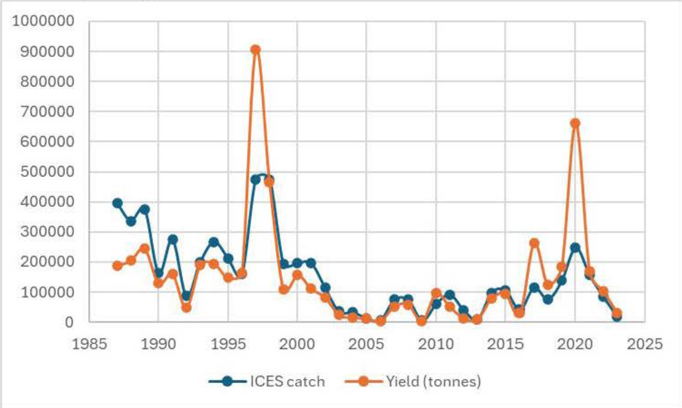
The report of the assessment and forecast is well written and mostly thorough. I would however have appreciated a summary in the WG report of the most important changes due to the benchmark, as well as the reason behind the changes – preferably one paragraph for each sandeel area.

For SA3 I would suggest including:
The change in starting year of the assessment and the reason for it.
The constant exploitation pattern used. Is this a change from last benchmark? (and is this a reasonable assumption?)
The change in natural mortality
The change in starting year in both survey indices (dredge and acoustic) and the reason for the change.

[*]ICES. 2021. Guidelines for review processes. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.5.4. https://doi.org/10.17895/ices.advice.7682.

The large change in Fcap after the benchmark – do we have an explanation for this large change?
There are perhaps also other things that should be mentioned (e.g. that the SA3r area is the same as in the last benchmark)

There is a quite large difference between the modelled catches and ICES catches for some of the years:



Since last assessment, the Mohn's rho pattern has changed. Last year R had a very low Mohn's rho value, whereas SSB and F were higher. In the 2024 it is the opposite.

	2023	2024
R	0.08	0.237
SSB	0.3	-0.029
F	0.34	0.084

<u>Technical comments</u>

Some comments and suggested changes are put directly into the advice sheet.

The recruitment assumption (using the long-term geometric mean) is quite high considering that the recruitment has been estimated to be very low the last few years. However, since the proportion mature age 1 is low (5%), this will not influence the SSB in 2025 much and thus not the advice either.

Conclusions

The assessment and forecast are both accepted.

10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)

10.1 The Fishery

10.1.1 ACOM advice applicable to 2023 and 2024

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2023 to June 2024) was set to 143 598 t for sprat in Subarea 4 and Division 3.a. Sprat catches often have some herring as bycatch. There is a herring bycatch quota, and the sprat fishery may be limited by this quota. The 2023 and 2024 herring bycatch quotas were both years 7 716 t for the North Sea and 6 659 t for Division 3.a. For 2023 and 2024 EU agreed to only fish 969 t of herring in total in Division 3.a, including both the directed fishery and bycatch. During the WKSPRAT benchmark meeting in 2018, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, several other modifications were made to the configurations of the assessment model (see (WKSPRAT: ICES, 2018a) for further details). Furthermore, at HAWG 2024 the expert group decided to accept changes to the model configurations and input data (catch data and natural mortalities), which also lead to a re-calculation of reference points for the biomass (B_{lim} and B_{pa}) and fishing mortality (F_{cap}) (Please see below for more details and WD01).

10.1.2 Catches in 2023

Catch statistics for 2000–2023 for sprat in the North Sea and Division 3.a by area and country are presented in Table 10.1.1. Catch data prior to 1996 are considered less reliable due to uncertainty of potential bycatches of North Sea herring (see Stock Annex). The small catches of sprat from the fjords of Norway are neither included in the catch tables nor the assessment (Table 10.1.1–10.1.2). The WG estimate of total catches for the North Sea and Division 3.a in 2023 was 92 206 t (total official catches amounted to 91 420 t). The Danish catches represent 85% of the total catches.

The spatial distribution of landings was overall like most years, although catches were seen closer to the coast (Figure 10.1.1). Since 2019, less than 1% on average of the catches have been taken in season 3 (quarter 1) compared to the period of 2014-2018 (range; 2-17%, Figure 10.6.1a) (Figure 10.6.1a).

10.1.3 Regulations and their effects

Most sprat catches are taken in an industrial fishery where catches are limited by herring bycatch quantities. Bycatches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. Bycatch is especially considered to be a problem in area 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where large bycatches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation showed that fishing inside the sprat box would be expected to reduce unwanted catches of herring by weight but not in number and concluded that other management measures are sufficient to control herring bycatch. The sprat box was removed in 2017.

The Norwegian vessels have a maximum vessel quota of 550 t when fishing in the North Sea. A herring bycatch of up to 10% in biomass is allowed in Norwegian sprat catches.

10.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years, the Norwegian catches were mainly taken by purse-seine, and the catches taken by trawl were low. In recent years, the share of the total Norwegian catches taken by trawl has increased (2023: 100% taken by trawl).

10.2 Biological composition of the catch

Only data on bycatch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 7% and 19% bycatch of herring in 2023 in the North Sea and Division 3.a, respectively. The percentage of by-catch in division 3.a is high in 2023, but due to the reduced sprat fishery in 3.a only accounted for 4 t of herring. The total amount of herring caught as bycatch in the sprat fishery has mostly been less than 10%. From 1st of April 2020 the Danish methodology behind the bycatch estimation in the fisheries for reduction changed. Before, the Danish fishery control regularly sampled the landings for reduction, and afterwards a species composition was estimated per month, square and fishery. Now, each and every landing for reduction into Denmark is subsampled by the buyer and the estimated species composition is reported directly in the sale slips. Many of the buyers use independent companies, 3rd party, for sampling.

The estimated quarterly landings at age in numbers for the period 1974–2023 is presented in Table 10.2.2. In the model year 2023, 1-year-old sprat so far has contributed 63% of the total landings. 2-year-olds contributed 26%, which is above the 1990–2020 average (15%). 0-year-olds contributed 10% of the total landings, whereas other older age-groups contributed with 2% (Figure 10.6.1b). Since 2019, the proportion of catches during season 3 (quarter 1) has dropped to less than 1% on average, in contrast to the period spanning 2014 to 2018, where it ranged from 2% to 17% (Figure 10.6.1a).

Denmark, Norway, and Sweden provided age data of commercial landings in 2023 (Table 10.2.4). Quarters 1, 3 and 4 were covered. Quarter 1 in 2023 had very low catches and only a single sample. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by the Netherlands (29 t), UK-England and Wales (141 t) and Belgium (<1 t) were unsampled and Germany and UK-Scotland didn't catch the stock in 2023.

The Danish sampling has been greatly improved since 2014 because of the implementation of a sampling programme for collecting haul-based samples from the Danish sprat fishery. However, the sampling in 2020 (model year) was substantially reduced with only 0.6 samples taken per 2000 t, which was caused by a not fully implemented change in the Danish sampling program with the introduction of the new bycatch estimation method (see above). Since this change, samples from most of the buyers / 3rd party companies have been regularly obtained. The sampling strategy from 2020 targets vessels above 24 meters, which are sampled with a higher frequency than smaller vessels. Vessels above 24 meters are still being encouraged to deliver self-samples, but if not, a 3rd party sample is used as a substitute. All samples from vessels below 24 meters comes from the 3rd party companies. In general, the new sampling strategy has secured a high level of sampling. Since 2019, the number of samples has dropped in season 3 (quarter 1), presumably due to negligible catches in this season.

The 2022-2024 Swedish sampling of sprat in the area 3a and 4 is part of a self-sampling program designed to sample small pelagic vessels targeting herring and sprat. Fishing trips are sampled from both consumption and industrial small-pelagic vessels. The sampling follows a stratified multi-stage cluster design where a random draw of vessels is taken using simple random sampling without replacement (SRSWOR) from pre-defined lists every week of each quarter. In such a set-up vessel*week is considered the PSU. Each week vessels are contacted and asked to collect samples from a trip starting the following week (SSU). In each haul/set (TSU) registering herring or sprat in the trip a sample of 3-5 kg (QSU) is collected from the catch. In the lab the boxes are stratified by subdivision and a subsample of 2 to 4 hauls analysed.

The number of samples used for the assessment, both length and age-length samples, is shown in Table 10.2.4–5 and Figure 10.2.1.

10.3 Fishery Independent Information

10.3.1 IBTS Q1 and Q3

Tables 10.3.1a-b and Figures 10.3.1-2 give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report for further details, ICES, 2018a)). The data source is the IBTS Q1 from 1983–2024 and IBTS Q3 from 1992-2023. The index for IBTS Q1 1-year-old in 2023 (age-0 in the model and the table, serving as a recruitment index) was the fourth lowest since 2000, being 44% of the 10 year geometric mean and 85% lower than last year's index. Overall, there has been a tendency for an increasing trend in the IBTS Q1 age-0 in the time-series since 1990. Furthermore, older age-groups of age-1 and age-2 decreased by 80% and 84% compared to the year before. The coverage of the survey was good and the CV for the index was reported to be similar to the average. Spatial pattern in residuals was checked and did not raise any concerns. The model is designed to handle issues of varying coverage to some extent.

IBTS Q3 survey indices were also used in the assessment for older age-groups, and the 2023 values increased by 97% and 148% from indices for 2022 for age-1 and age-2, respectively.

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2023) (see Section 1.4.2). The abundance indices for Subarea 4 and Division 3.a were summed (Table 10.3.2 and Figure 10.3.3). The 2023 values decreased by 20% for age-1, and increased by 15% and 143% for age-2 and age-3, respectively, compared to 2022.

10.4 Mean weights- and maturity-at-age

Mean weights-at-age in catches are given in Table 10.2.3 and Figure 10.4.1. Mean weights in model season 1 and 2 (S1 and S2; quarter 3 and 4), where most of the catches are taken, has shown a declining trend over the past decade for the younger age-groups. In 2019, the mean weights of age-1 and age-3 fish in S1 were the lowest observed for nearly two decades but since 2020 this decline have been arrested. In 2023-2022 mean weights were similar to the year before in S1, whereas it declined for all age-groups in S2 (Figure 10.4.1).

Proportion of mature fish was derived from IBTS Q1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2014).

10.5 Recruitment

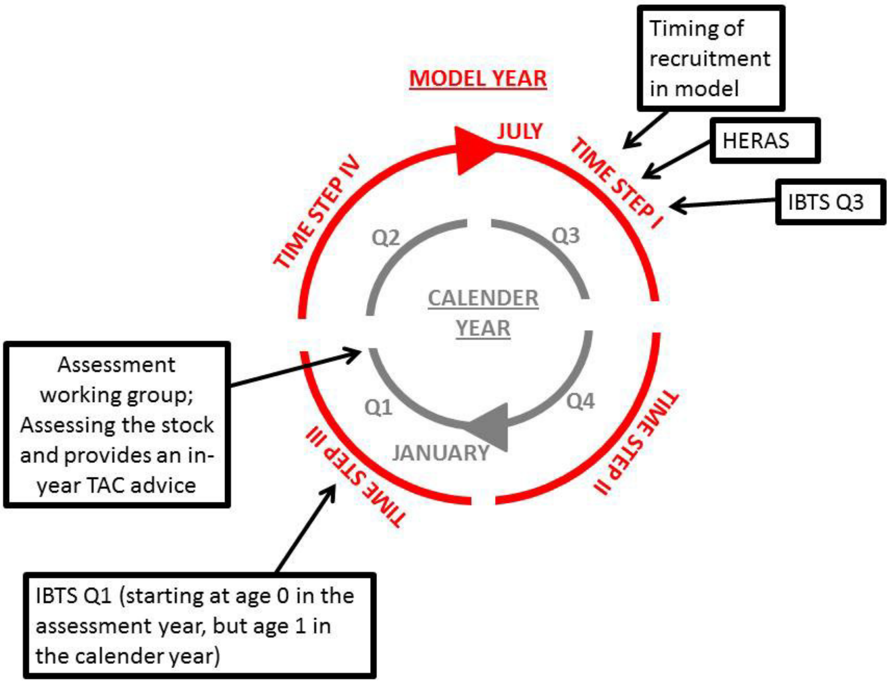
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1a) is used as a recruitment index for this stock. At the most recent benchmark, it was decided to implement a power model (directly within the assessment model) to the age-0 IBTS Q1 index to dampen the effect of very high index values. This was done to reduce the retrospective bias on recruitment (see WKSPRAT (ICES, 2018) for further details). At HAWG 2023, it was noticed that the model had issues with convergence (revealed by a very high maximum gradient of 81.52). The problem was tracked back to the 2019 assessment, when the power model was implemented for the first time. Basically, SMS has convergence problems when the catchability parameters are very different in magnitude. This is solved in SMS by scaling all numbers by a fixed factor per survey. Therefore, a small hack was applied to achieve an acceptable maximum gradient (<0.001) for the model, by splitting the IBTS Q1 into two fleets: one for the recruiting fish, IBTS Q1 Rec, and one for all other ages, IBTS Q1. The two fleets were scaled differently, $0.1e^{-7}$ and 0.1, respectively. Scaling has no effect on model results or forecast otherwise. The 2024 IBTS Q1 Rec value, indicative of the 2023 recruitment, was the lowest observed since 2000, experiencing a decrease by 85% from the 2023 index. The 2024 recruitment estimated by the model is only 44% of the 2014-2023 geometric mean (Table 10.6.4).

10.6 Stock Assessment

The stock assessment was benchmarked in November 2018 (WKSPRAT: ICES, 2018a). During this benchmark meeting, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, several other modifications were made to the configuration of the assessment model (see WKSPRAT report (ICES, 2018a) for further details).

In-year advice is the only possible type of advice for this short-lived species with catches dominated by 1- and 2-year-old fish. This, however, requires information about incoming 1-year-old fish. To meet this requirement and to come up with a model that logically matches the natural life cycle of sprat, the annual time-step in the model was shifted, relative to the calendar year, to a time-step going from July to June (see text table below). SSB and recruitment were estimated at 1st July. In figures and tables with assessment output and input, the years refer to the shifted model year (July to June) and in each figure and table it is noted whether model year or calendar year applies (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 1st July 2000 to 30th June 2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Model year		Calendar year	
2000	Season 1	2000	Quarter 3
2000	Season 2	2000	Quarter 4
2000	Season 3	2001	Quarter 1
2000	Season 4	2001	Quarter 2



Timing of recruitment in model
MODEL YEAR
JULY
HERAS
TIME STEP I
IBTS Q3
TIME STEP IV
Q2
Q3
CALENDER YEAR
Assessment working group; Assessing the stock and provides an in-year TAC advice
Q1
Q4
JANUARY
TIME STEP III
TIME STEP II
IBTS Q1 (starting at age 0 in the assessment year, but age 1 in the calender year)

10.6.1 Input data

10.6.1.1 Catch data

Information on catch data is provided in Tables 10.1.1–2 and in Figures 10.1.1 and 10.6.1ab. Sampling effort is presented in Table 10.2.5 and Figure 10.2.1.

Catches in quarter 2 (season 4 in the model, S4) are often less than 5000 tonnes, these are poorly estimated by the model and the number of samples from these catches are low (sometimes no samples). Furthermore, at the time of the assessment working group, S4 catches are unknown. Therefore, during the latest benchmark it was decided to move S4 catches into S1 in the following model year. A recent shift in fishing patterns during S3 appears to have resulted in similar issues as observed in S4. The catch input data indicates a decline in catches since 2019. On average, catches accounted for only 0.6% of the total catch tonnage during the period 2019-2022 (1.2% in 2019, 0.5% in 2020, 0.6% in 2021, and 0.2% in 2022), compared to 8.6% during the period 2015-2018 (Table 10.2.2 and Figure 10.6.1a). Furthermore, the number of biological samples collected from the fishery for generating the catch-at-age matrix in the assessment model has also decreased significantly compared to pre-2019 levels (Table 10.2.5). These sudden changes caused estimation problems for the predicted fishery mortalities in the model, similarly to what was found for S4 during WKSPRAT. Therefore, HAWG decided to move catches from S3 to S2 for 2019-2022 and exclude catch estimation for S3 in this period. HAWG found that this improved the model without changing historical dynamics, and recommended its adoption, which were reviewed by external experts in 2024 (WD01).

10.6.1.2 Weight-at-age

The mean weight-at-age by season for all age-groups observed in the catch are given in Table 10.2.3 and Figure 10.4.1. It is assumed that the mean weights in the stock are the same as in the catch. The mean weight-at-age of S1 is used to calculate SSB 1st of July.

10.6.1.3 Surveys

Three surveys, divided into four fleets as described below, were included (Tables 10.3.1ab–2), IBTS Q1 (1983–present), IBTS Q3 (1992–present), and HERAS (Q3) (2006–present). The IBTS Q1 indices were divided into two fleets in the model: IBTS Q1 Rec age-1 representing recruitment, i.e., age-0 in the model, and IBTS Q1 for all other age-groups. 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and for this reason these age indices were excluded from the model.

10.6.1.4 Natural mortality

HAWG 2021 (ICES. 2021a) reviewed natural mortalities (M) available from the 2020 North Sea key run from WGSAM , but did not update (for more details see annual HAWG reports; ICES, 2021-23). Therefore, the use of the old mortalities from the 2017 North Sea key run (ICES, 2018b) was continued. Variable mortality was applied as three-year averages up till 2015, and after 2015 the average mortality for 2013–2015 is used. During HAWG 2024, new natural mortalities were available from the 2023 North Sea key run from WGSAM (ICES, 2023). Compared to 2021, the recent removal of the inter-benchmark process decided by ACOM Leadership gave the WG more responsibility making them eligible for decisions on more drastic changes to the configurations and settings of the assessment model, as well as a potential re-calculation of reference points. HAWG 2024 reviewed stock assessments based on both the old and new M's. The retrospective patterns where improved for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), whereas it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22). The AIC for the model fit increased with the updated M's (AIC = 863) compared to a model with the current M's (AIC = 860), but the difference was evaluated and found to be small and acceptable.

HAWG 2024 inspected the stock-recruitment plot and found substantial changes to the stock-recruitment relationship and perception of the stock. The changes included an upward shift in both recruitment (since 1991) and SSB (since 1982), as well as a downscaling of fishing mortality (since 1981). Furthermore, the stock-recruitment relationship showed that the changes in both recruitment and SSB resulted in a down-scaling causing points to be less variable in the early part of the time-series, whereas the period from 1981 and onwards became more variable. As such, HAWG deemed the old M's from the 2015 key run to be obsolete and not able not capture the trophodynamics that characterise the North Sea food web during the last decade. Enhancements to the multispecies model since 2015, such as integrating more precise data on seabirds, and recent shifts in predator biomass (e.g., whiting and mackerel), significantly affect the estimated M's for all age-groups in all seasons (quarters) for sprat. Consequently, the notable alterations in natural mortalities for sprat led HAWG to their conclusive decision to revise the assessment's mortality estimates. The expert group have documented the changes in a revised working document, which were reviewed by external experts and approved by the ADG (WD01). Natural mortalities used in the model are given in Table 10.6.1.

10.6.1.5 Proportion mature

Proportion of mature fish was derived from IBTS Q1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+, respectively). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2014).

10.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther, 2004) with quarterly time-steps (referred to as season S1–S4). Three surveys divided into four fleets were included, IBTS Q1 Rec age 1, IBTS Q1 ages 2 to 4+ (age 0, 1, 2 and 3+ in the model), IBTS Q3 ages 1–3 and HERAS (Q3) ages 1–3. 0-group sprat is unlikely to be fully recruited to the IBTSQ3 or HERAS in Q3 and these age indices were excluded from runs. External consistency between IBTS Q1, IBTS Q3 and HERAS can be found in the benchmark report (WKSPRAT2018: ICES, 2018a). As described above in more detail, it was noticed that the model had issues with convergence after the introduction of the power model for the recruitment index, and therefore two different scaling estimators were used for IBTS Q1 Rec and IBTS Q1 in order to attain acceptable values for the maximum gradient. The model hack by scaling has no effect on model results and forecast otherwise. Additionally, during HAWG 2024, the expert group approved alterations to the model configurations and input data, including catch data and natural mortalities. These changes necessitated a recalculation of reference points for biomass (B_{lim} and B_{pa}) and fishing mortality (F_{cap}) (WD01).

The model converged and fitted the catches of the main ages of 1 and 2 caught in the main seasons of S1 and S2 reasonably well and having a maximum gradient at $5.5e^{-5}$ (Table 10.6.2). The CVs for the catches were high, possibly getting close to upper boundaries set in the model. As such, the model has difficulties in following the catches and therefore catches add little information to the assessment. All surveys had low CVs (<0.54), with IBTS Q1 Rec hitting the lower CV boundary of 0.3 (Table 10.6.2). There were no patterns in the residuals raising concern (Figures 10.6.2–3). Although, there appears to be a periodic cycling (on a decadal timescale) between positive and negative residuals in the IBTS Q3 survey and the catches (Figures 10.6.2–3). Common CVs were estimated for the following groups: 1- to 3-year-olds in IBTS Q1 and 2- and 3-year-olds in IBTS Q3 and HERAS.

The retrospective analyses have shown a tendency to overestimate recruitment in for large year-classes and underestimate recruitment at low year-classes (Figure 10.6.5). As 41% of the recruiting year-class mature in their first year and thus contributes to the SSB at the end of the year, there is a similar retrospective pattern in SSB (5-year Mohn´s rho = 0.25). The assessment model was improved with this respect to the retrospective pattern during the last benchmark and Mohn´s rho was reduced by roughly a factor of 3 due to the improvement. In 2024, the inclusion of new natural mortalities and changes to the model configurations (WD01) improved the retrospective pattern for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), although it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22).

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 10.6.4–7 and Tables 10.6.3–4.

10.7 Reference points

During HAWG 2024, modifications to both model configurations and input data (catch data and natural mortalities) were approved. These adjustments prompted a recalculation of reference points for biomass, which were reviewed by external experts. A decision was made to set B_{lim} based on the average SSB of the two years with lowest SSB with recruitment above the median. Consequently, the average of the SSBs from 1991 and 2013 was used to establish reference points at B_{lim} = 107 598 t and $B_{escapement}$ = B_{pa} = 135 952 t. (Figure 10.7.1, but see WD01). This is higher than the estimates from the last benchmark (B_{lim} = 94 000 t and B_{pa} = 125 000 t). B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.173.

10.8 State of the stock

The stock has been well above B_{pa} since 2013 and above B_{lim} since 1992, with the exception of 2024 where it is estimated to be below B_{pa}. Fishing mortality has fluctuated without a trend, but the F of 2.654 in 2023 was the highest in the time-series. The advised TAC was based on the predicted catch at F equal to F_{cap}. A large overshoot of the F used as basis for advice is often seen in simulations applying the escapement strategy on large incoming year-classes, where the uncertainty on absolute numbers and hence the TAC matching a given F is large. This trait is the reason for implementing F_{cap} as otherwise, the escapement strategy is not precautionary when incoming recruitment is estimated to be large.

A stock summary from the assessment output can be found in Table 10.6.4 and Figure 10.6.7.

10.9 Short-term projections

Management strategy evaluations for this stock were made in December 2018 (WKSPRATMSE: ICES, 2019). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). During the benchmark, the optimal F_{cap} value was found to be 0.69 (from both a full MSE and a shortcut MSE - see WKSPRATMSE report for further details), which were a revision of the previous value of 0.7. The most recent modifications to both model configurations and input data prompted the EG to also re-calculate F_{cap} using a shortcut MSE, which resulted in an F_{cap} of 1.01 (WD Ref). This means, that the fishing mortality ($F_{bar(1–2)}$) derived from the $B_{escapement}$ strategy, should not exceed 1.01. The realized fishing mortality is often higher than the fishing mortality used to provide advice in recent years (F_{cap}). This pattern was also observed when the escapement strategy advice rule was evaluated. Thus, despite the mismatch between the predicted and realized fishing mortalities, the escapement strategy is considered adequate to provide advice.

The forecast input is given in Table 10.9.1.

SSB in 2025 is expected to be higher than in 2024, above the long-term average and above B_{pa}. Using the input and assumptions detailed above, the F = 0 catch option projects an SSB in July 2025 of 187 012 t (Table 10.9.2). The F_{MSY} approach prescribes the use of an F value of 1.01 (F_{cap}, see explanation above) and results in a catch advice of 75 321 t (July 2024–June 2025), which is expected to result in an SSB of 158 851 t in July 2025 above B_{pa}.

10.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2018 WKSPRAT benchmark and during HAWG 2024. A complete overview of the choices made during the benchmark can be found in the report (ICES, 2018a) and working document (WD01). These are also described in the Stock Annex for sprat in Division 3.a and Subarea 4.

The assessment shows medium to high CVs for the catches but low CVs for surveys. The CVs of F, SSB and recruitment are generally low (see Table 10.6.2 and Figure 10.6.4). The model converged and fitted the catches of the main ages caught in the main seasons (the periods with most samples) reasonably well (ages 1–2, season 2, Table 10.6.2). The retrospective pattern in SSB and recruitment (5-years Mohn´s rho of 0.04 for both), although the retrospective pattern has increased for fishing mortality (Mohn's rho of 0.22). Yet, all are below the advised limit for Mohn's rhoof 0.3 agreed in WKFORBIAS (ICES, 2020).

There appears to be a systematic pattern in the catch residuals in model season 1 (quarter 3), which remains unexplained. Furthermore, the model gets very little information from the catches (as shown by the high CVs). This should be investigated further.

10.11 Management Considerations

A management plan needs to be developed for this stock. Sprat is an important forage fish; thus, also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year-class. Thus, the fishery in a given year will be dependent on that year's incoming year-class.

Industrial fisheries are allocated a bycatch of 7716 t and 6659 t of juvenile herring in 2024 in the North Sea and Division 3.a, respectively. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation.

10.11.1 Stock unit

After the latest benchmark, sprat in the Subarea 4 and Division 3.a is considered to be one cohesive stock. This is documented in the WKSPRAT report (ICES, 2018a). In addition, there are several peripheral areas of the North Sea and Division 3.a where there may be populations of sprat that behave as separate stocks from the main stock. Local depletion of sprat in such areas can be an issue of ecological concern.

10.12 Ecosystem Considerations

Sprat is an important prey species in the North Sea ecosystem. The influence of the sprat fishery on other fish species and seabirds are at present not documented to be substantial.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds though this information is as described under natural mortality not up to date. Impacts of changes in zooplankton communities and consequent changes in food densities for sprat are not included in the assessment, but it may be useful to explore the possibility of including this, or a similar proxy bottom-up driver, in future assessments. However, the effect of changes in productivity is included in the observed quarterly weight-at-age and in the estimated recruitment, as a decline in e.g., available food can lead to lower observed weights and lower estimated recruitment even in the absence of a causal link in the model.

10.13 Changes in the environment

Temperatures in this area have been increasing over the last few decades. This may have implications for sprat, although the correlation between temperature and recruitment from the model has been found to be low (see WKSPRAT: ICES, 2018a).

10.14 Tables and Figures

Table 10.1.1. North Sea & 3.a sprat. Landings (' 000 t) 2004–2023. See ICES (2006) for earlier data. Catch in coastal areas of Norway excluded. Data provided by Working Group members. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Division 27.4.a																				
Denmark	*		*	0.8	*	*					*	*	0.1	0.1		*	0.5	*	*	
Norway						*		*								0.1	*			
Sweden																				
UK (Scotland)								0.5						*	*					
Germany												*	*						*	
Netherlands												*								
France																			*	
Total	*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1	0.5	*	*	
Division 27.4.b																				
Denmark	175.9	204	79.5	55.5	51.4	115.6	80.8	90.9	65.7	44.7	121.3	234.4	177.6	100.6	156.5	110.3	138.4	66	79.7	76.4
Norway	0.1		0.8	3.7	1.3	4	8	0.1	6.2	*	8.9	0.3	19.6	9.7	9.3	10	9.3			3.6
Sweden		*				0.3	0.6	1.1	1.8	0.1	3.9	5.5	11.7	8.1	7.6	7.5	3.5	5.9	6.6	8.7
UK (Scotland)				0.1		2.5	1.1	1.9	0.7						*	1.3	1.7	*	0.4	
UK (Engl. & Wales)						*								*	*		0.1		0.2	*
Germany								3.3	0.5	0.6	1.5	3.1	5.4	6	3.7	3.4	10	3.6	2.4	
Netherlands								1.1	2.7	0.4	2.4	1.2	1	1.6	1.6		0.5		0.4	*
Faroe Islands													4.7	1	1		1			
Total	176	204.1	80.3	59.3	52.7	122.4	90.4	98.4	77.5	45.8	138	244.6	220	127	179.7	132.6	164.7	75.5	89.6	88.7
Division 27.4.c																				
Denmark	16.8	2	23.8	20.6	8.1	8.2	48.5	20	3.2	15.4	2.2	34	18.7	1.5	6.2	8.9	2.4	2.7		2

Norway			9	2.9		1.8	3.2	9.9	3	1.7	0.1	8.8	0.6		0.5	0.6	0.7			
Sweden						0.6	0.6	0.2	0.4	1.3		1.2	0.4					1.1		0.5
UK (Scotland)					0.2			0.4					*				0.7	0.1		
UK (Engl. & Wales)	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	0.1	0.2	0.1	*	0.1	0.1
Germany								*	*	1		0.6	0.2				0.1			
Netherlands								4.2	1	0.7	*	1.2	0.8	*	0.7		1.6	0.1	*	*
Belgium								*		*	*	*	*	*		*	*	*	*	*
France												*		*						
Total	18.3	3.6	33.4	23.8	8.4	10.6	53	35.2	8	20.1	2.3	45.8	20.6	1.6	7.5	9.6	5.6	4	0.1	2.6
Division 27.3.a																				
Denmark	14.4	31.9	7.8	9.9	5.8	6.9	8.4	8	8.4	1.9	16.7	11.7	6.7	1	2.9	3.9	9.5	0.6	0.3	*
Sweden	6.5	7.7	4.4	4.2	2.4	1.6	1.4	2	1.5	1.1	1.5	1.3	1.1	0.2	1.1	1.7	2.4	0.7	0	0.1
Germany											*				*					
Faroe Islands													*							
Total	20.9	39.6	12.2	14.1	8.2	8.5	9.8	10	9.9	3	18.3	13	7.9	1.2	4	5.6	11.9	1.3	0.4	0.1
Total North Sea and Skagerrak-Kattegat																				
Denmark	207.1	237.9	111.2	86.7	65.4	130.7	137.7	119	77.4	62.1	140.2	280.1	203.1	103.3	165.6	123.1	150.9	69.3	80.1	78.4
Norway	0.1		9.8	6.7	1.3	5.8	11.1	10	9.1	1.7	9	9.1	20.2	9.7	9.8	10.6	10			3.6
Sweden	6.5	7.8	4.4	4.2	2.4	2.5	2.6	3.3	3.7	2.5	5.4	8.1	13.2	8.3	8.7	9.2	5.9	7.6	6.6	9.2
UK (Scotland)				0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3	2.5	0.1	0.4	
UK (Engl. & Wales)	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	*	0.2	0.2	*	0.3	0.1
Germany								3.3	0.5	1.6	1.6	3.7	5.6	6	3.7	3.4	10.1	3.6	2.4	
Netherlands								5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3		2.1	0.1	0.4	*
Faroe Islands													4.7	1	1		1			
Belgium								*		*	*	*	*	*		*	*	*	*	*
France												*		*					*	
Total	215.2	247.3	125.9	97.9	69.3	141.6	153.3	144.1	95.5	68.9	158.7	303.3	248.5	129.9	191.2	147.8	182.7	80.8	90.1	91.4

Table 10.1.2. North Sea & 3.a sprat. Catches (tonnes) by quarter. Catches in coastal areas of Norway excluded. Data for 1996–1999 in ICES (2006).

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total	Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
2000	1		18 126	28 063		46 189	2012	1		81	1649	4668	6399
	2		1722	45		1767		2		2924	0	909	3832
	3		131 306	1216		132 522		3		26 779	307	1631	28 717
	4		12 680	2718		15 398		4		47 765	6060	2728	56 553
	Total		163 834	32 042		195 876		Total		77 549	8016	9936	95 501
2001	1	115	40 903	9716		50 734	2013	1		1281	3158	1296	5734
	2		1071			1071		2		32	0	443	474
	3		44 174	481		44 655		3		25 577	720	211	26 509
	4	79	65 102	8538		73 719		4		18 892	16 276	943	36 110
	Total	194	151 249	18 735		170 177		Total		45 781	20 154	2893	68 827

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
2002	1	1 136	2182	2790		6108
	2		435	93		528
	3		70 504	647		71 151
	4		52 942	12 911		65 853
	Total	1 136	126 063	16 441		143 640
2003	1		11 458	7727	5217	24 402
	2		625	26	1397	2049
	3		56 207	165	1720	58 092
	4		84 629	15 651	7349	107 629
	Total		152 919	23 570	15 683	192 172
2004	1		827	1831	4456	7113
	2	7	260	16	1510	1793
	3		54 161	496	4138	58 794
	4		120 685	15 937	10 775	147 397
	Total	7	175 932	18 280	20 879	215 097
2005	1		11 538	2457	8148	22 143
	2		2515	123	4722	7360
	3		107 530		19 418	126 948
	4		82 474	1033	7296	90 803
	Total		204 057	3613	39 584	247 254
2006	1	47	13 713	33 534	8105	55 399
	2		190	8	324	522
	3		40 051	8	1440	41 499
	4	2	26 579	77	2335	28 993
	Total	49	80 533	33 627	12 204	126 413
2007	1		582	247	2646	3475
	2		241	3	1291	1535
	3		16 603		5357	21 960
	4	769	41 850	23 531	4761	70 911
	Total	769	59 276	23 781	14 055	97 881
2008	1		2872	43	2890	5805
	2		52	*	1017	1069
	3		21 787		636	22 423
	4		27 994	8334	3672	40 001
	Total		52 706	8377	8215	69 298
2009	1		36	1268	2600	3904
	2		2526	1	300	2827
	3	22	41 513		3300	44 835
	4		78 373	9336	2400	90 109
	Total	22	122 448	10 604	8600	141 675
2010	1		10 976	17 072	1462	29 510
	2		3235	3	648	3886
	3		14 220		3405	17 625
	4		62 006	35 973	4278	102 257

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
2014	1		59	125	384	568
	2		11 631	3	1415	13 050
	3	1	88 457	1428	9622	99 507
	4	7	37 851	822	6905	45 586
	Total	8	137 999	2378	18 327	158 711
2015	1	*	14 816	16 972	1442	33 230
	2		16 843	107	619	17 568
	3		124 512	335	6528	131 375
	4	25	88 395	28 375	4389	121 184
	Total	25	244 566	45 789	12 978	303 358
2016	1	68	18 487	5969	746	25 250
	2		8927	51	669	9 647
	3	*	158 522	111	4664	163 297
	4	2	34 070	14 466	1764	50 301
	Total	70	220 007	20 596	7843	248 516
2017	1	1	3432	1220	92	4 745
	2		1327	0	33	1 360
	3	*	92 885	217	227	93 329
	4	94	29 310	174	849	30 426
	Total	95	126 954	1611	1200	129 860
2018	1	*	8994	1628	168	10 790
	2		11 898	0	224	12 122
	3		112 361	1	1328	113 690
	4		46 411	5922	2249	54 582
	Total	*	179 664	7551	3969	191 184
2019	1		389	9 592	627	10 609
	2	2	3 606	11	379	3 999
	3	2	95 829	7	2 249	98 087
	4	49	32 750	3	2 296	35 098
	Total	53	132 574	9 614	5 551	147 793
2020	1	3	298	1 076	378	1 746
	2		19 430	*	173	19 603
	3	2	120 890	*	4 268	125 160
	4	520	24 049	4 489	7 087	36 145
	Total	526	164 667	5 566	11 896	182 654
2021	1	0	137	236	445	818
	2	*	326	1	11	338
	3	1	63 401	902	57	64 361
	4	1	11 601	2 850	791	15 244
	Total	2	75 464	3 989	1 305	80 761
2022	1		82	85	331	499
	2		19 449		16	19 465
	3	*	52 852			52 852
	4	8	17 237	8	36	17 289

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
	Total		90 437	53 048	9793	153 278
2011	1		3747	21 039	3216	28 002
	2		2067	3	617	2687
	3		22 309	451	2311	25 072
	4	8	70 256	13 759	3887	87 910
	Total	8	98 380	35 252	10 031	143 671

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
	Total	8	89 620	94	383	90 105
2023	1		7	130	1	138
2023	2		479	0	34	512
2023	3		69 151	1	17	69 168
2023	4		19 062	2475	64	21 601
2023	Total		88 698	2606	116	91 420
2024	1**		535	424	1	959
2024	2					
2024	3					
2024	4					
2024	Total					

* < 0.5 t

** Until the 1st of March

Table 10.2.1. North Sea & 3.a sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch. Left: North Sea, right: Division 3.a.

Unit	Year	Area	Sprat	Herring	Horse mackerel	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
t	1998	27.4	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
t	1999	27.4	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
t	2000	27.4	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
t	2001	27.4	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
t	2002	27.4	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
t	2003	27.4	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
t	2004	27.4	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
t	2005	27.4	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
t	2006	27.4	103 236	8 983	577	343	25	905	4	5 384	576	120 033
t	2007	27.4	74 734	6 596	168	900	6	126	18	6	253	82 807
t	2008	27.4	61 093	7 928	26	380	10	367	0	23	1 735	71 563
t	2009	27.4	112 721	7 222	44	307	3	116	1	1 526	407	122 345
t	2010	27.4	112 395	4 410	11	119	2	18	0	1 236	577	118 769
t	2011	27.4	109 376	8 073	35	191	0	127	0	1 881	345	120 026
t	2012	27.4	67 263	8 573	2	354	0	246	0	93	411	76 943
t	2013	27.4	55 792	5 176	47	445	0	277	2	1	369	62 109
t	2014	27.4	123 180	11 402	0	897	0	70	16	16	1 700	137 280
t	2015	27.4	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
t	2016	27.4	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
t	2017	27.4	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394
t	2018	27.4	161 536	7 528	174	716	0	366	0	24	344	170 687
t	2019	27.4	118 302	2 757	1	897	1	176	0	3	503	122 639
t	2020	27.4	140 954	6 227	19	898	93	1 188	0	11	724	150 114
t	2021	27.4	68 492	5 518	39	1 064	345	747	0	3	602	76 809
t	2022	27.4	78 825	3 829	1	488	124	397		4	227	83 895
t	2023	27.4	78 222	6 390	14	1 802	1 120	686		4	375	88 613
%	1998	27.4	89	8	0	1	0	0	0	2	1	100
%	1999	27.4	91	4	0	1	0	0	0	3	0	100
%	2000	27.4	90	6	2	1	0	0	0	0	1	100
%	2001	27.4	80	8	0	1	0	0	0	10	1	100
%	2002	27.4	84	10	1	2	0	0	0	2	1	100
%	2003	27.4	89	5	0	1	0	0	0	3	2	100
%	2004	27.4	90	5	0	0	0	2	0	2	1	100
%	2005	27.4	86	9	1	0	0	0	0	3	0	100
%	2006	27.4	86	8	1	0	0	1	0	5	1	100
%	2007	27.4	90	8	0	1	0	0	0	0	0	100
%	2008	27.4	85	11	0	1	0	1	0	0	2	100
%	2009	27.4	92	6	0	0	0	0	0	1	0	100
%	2010	27.4	95	4	0	0	0	0	0	1	1	100
%	2011	27.4	91	7	0	0	0	0	0	2	0	100
%	2012	27.4	87	11	0	1	0	0	0	0	1	100
%	2013	27.4	90	8	0	1	0	0	0	0	1	100
%	2014	27.4	90	8	0	1	0	0	0	0	1	100
%	2015	27.4	96	2	0	1	0	0	0	0	1	100
%	2016	27.4	92	5	0	2	0	0	0	0	1	100
%	2017	27.4	84	4	0	1	0	0	0	0	10	100
%	2018	27.4	95	4	0	0	0	0	0	0	0	100
%	2019	27.4	97	2	0	1	0	0	0	0	0	100
%	2020	27.4	94	4	0	1	0	1	0	0	1	100
%	2021	27.4	90	6	0	1	1	1	0	0	1	100
%	2022	27.4	94	5	0	1	0	0	0	0	0	100
%	2023	27.4	88	7	0	2	1	1	0	0	0	100
t	1998	27.3.a	9 143	3 385	230	467	54	0	49	7	2 866	16 202
t	1999	27.3.a	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
t	2000	27.3.a	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
t	2001	27.3.a	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
t	2002	27.3.a	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
t	2003	27.3.a	8 182	4 928	340	252	4	4	4	1	567	14 282
t	2004	27.3.a	13 374	4 620	97	976	18	24	27	116	2 155	21 408
t	2005	27.3.a	30 157	6 171	244	871	63	18	20	746	1 758	40 047
t	2006	27.3.a	6 814	2 852	215	276	13	3	45	1	232	10 451
t	2007	27.3.a	7 116	2 043	34	190	31	8	4	1	469	9 896
t	2008	27.3.a	4 805	1 948	14	285	0	0	11	462	39	7 563
t	2009	27.3.a	4 839	3 016	37	169	15	0	1	53	47	8 177
t	2010	27.3.a	2 851	2 134	25	142	6	1	2	135	171	5 466
t	2011	27.3.a	4 754	2 461	0	43	0	7	1	141	40	7 447
t	2012	27.3.a	5 707	5 495	9	149	7	10	5	0	228	11 610
t	2013	27.3.a	1 143	1 751	2	46	0	0	1	1	27	2 971
t	2014	27.3.a	16 751	3 777	5	343	1	20	5	12	888	21 801
t	2015	27.3.a	11 448	5 831	0	565	0	29	8	1	154	18 036
t	2016	27.3.a	7 001	2 140	0	335	1	19	3	0	78	9 579
t	2017	27.3.a	963	328	0	172	0	19	1	0	32	1 515
t	2018	27.3.a	2 872	257	2	150	1	11	0	0	12	3 304
t	2019	27.3.a	3 429	351	0	59	0	2	0	0	8	3 850
t	2020	27.3.a	9 494	551	4	249	5	41	1	0	27	10 372
t	2021	27.3.a	638	82	0	13	1	1	0	0	32	767
t	2022	27.3.a	316	19	0	1	0	0	0	0	31	368
t	2023	27.3.a	17	4		0	0				0	21
%	1998	27.3.a	56	21	1	3	0	0	0	0	18	100

%	1999	27.3.a	51	26	0	3	1	0	0	10	9	100
%	2000	27.3.a	49	31	0	4	1	0	0	0	14	100
%	2001	27.3.a	55	25	0	4	0	0	0	13	4	100
%	2002	27.3.a	40	46	0	4	0	0	0	2	8	100
%	2003	27.3.a	57	35	2	2	0	0	0	0	4	100
%	2004	27.3.a	63	22	1	5	0	0	0	1	10	100
%	2005	27.3.a	75	15	1	2	0	0	0	2	4	100
%	2006	27.3.a	65	27	2	3	0	0	0	0	2	100
%	2007	27.3.a	72	21	0	2	0	0	0	0	5	100
%	2008	27.3.a	64	26	0	4	0	0	0	6	1	100
%	2009	27.3.a	59	37	1	2	0	0	0	1	1	100
%	2010	27.3.a	52	39	1	3	0	0	0	3	3	100
%	2011	27.3.a	64	33	0	1	0	0	0	2	1	100
%	2012	27.3.a	49	47	0	1	0	0	0	0	2	100
%	2013	27.3.a	39	59	0	2	0	0	0	0	1	100
%	2014	27.3.a	77	17	0	2	0	0	0	0	4	100
%	2015	27.3.a	64	32	0	3	0	0	0	0	1	100
%	2016	27.3.a	73	22	0	4	0	0	0	0	1	100
%	2017	27.3.a	64	22	0	11	0	1	0	0	2	100
%	2018	27.3.a	87	8	0	5	0	0	0	0	0	100
%	2019	27.3.a	89	9	0	2	0	0	0	0	0	100
%	2020	27.3.a	92	5	0	2	0	0	0	0	0	100
%	2021	27.3.a	83	11	0	2	0	0	0	0	4	100
%	2022	27.3.a	86	5	0	0	0	0	0	0	8	100
%	2023	27.3.a	81	19	0	0	0	0	0	0	0	100

Table 10.2.2. North Sea & 3.a sprat. Catch in numbers by age (1000's) by season and year. (Model year, e.g., 2021 = July 2021–June 2022)

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022

Year	Season	age 0	age 1	age 2	age 3
1974	1	0	16101061	2155723	475613
1974	2	1884146	11544114	866399	48228
1974	3	2842702	11091303	1336036	34534
1974	4	1302331	2511315	359117	14822
1975	1	250931	27723510	10052550	260182
1975	2	1179567	14541887	4378415	166807
1975	3	5240024	4755878	2206781	66186
1975	4	0	0	0	0
1976	1	2143211	42209830	2888653	180913
1976	2	7439656	18762732	1613139	88604
1976	3	7703416	6925346	267638	8289
1976	4	0	0	0	0
1977	1	2690194	12786056	5181867	109712
1977	2	2520082	4904593	3679153	67688
1977	3	15857197	1843468	2200876	37836
1977	4	0	0	0	0
1978	1	454090	32184524	427473	96435
1978	2	5517665	10344970	1209584	116695
1978	3	6154606	4973568	1119045	29941
1978	4	0	0	0	0
1979	1	3579389	36866800	644042	117139
1979	2	1052920	11355949	2152261	63386

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022

Year	Season	age 0	age 1	age 2	age 3
1979	3	3882781	6399259	332781	25964
1979	4	0	0	0	0
1980	1	0	14237558	17421360	1481066
1980	2	0	9415158	11520576	979415
1980	3	2536060	3866612	389674	8724
1980	4	0	0	0	0
1981	1	428776	12322431	1483241	130805
1981	2	40632	3540737	3025289	202048
1981	3	374254	3854059	319763	9835
1981	4	0	0	0	0
1982	1	545769	6350511	601581	64879
1982	2	818525	5021082	1070960	55333
1982	3	2530673	401839	46913	3525
1982	4	0	0	0	0
1983	1	5613728	2819244	969599	155653
1983	2	2375763	1334333	588678	91112
1983	3	1697718	596857	7271	0
1983	4	0	0	0	0
1984	1	954757	6475021	417235	2532
1984	2	521866	2535354	247654	4803
1984	3	405095	612407	10648	1053
1984	4	0	0	0	0
1985	1	0	1304457	1972027	37680
1985	2	0	576004	870780	16638
1985	3	84760	215856	150819	14916
1985	4	0	0	0	0
1986	1	0	177780	452745	347620
1986	2	0	156913	399604	306818
1986	3	580936	58710	740	0
1986	4	0	0	0	0
1987	1	2236	2250587	128512	2525
1987	2	49451	1790264	267597	978
1987	3	209788	826994	34626	32980
1987	4	0	0	0	0
1988	1	4082942	2096911	2830054	42364
1988	2	1163964	314106	527986	11526
1988	3	1817700	637489	129384	5491

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1988	4	0	0	0	0
1989	1	12451	1706824	3613841	5716
1989	2	783	76415	88925	342
1989	3	469458	416920	34789	12751
1989	4	0	0	0	0
1990	1	1568	2633068	2234213	342514
1990	2	1225	2058041	1746290	267714
1990	3	291837	62050	1941	429
1990	4	0	0	0	0
1991	1	40504	1684266	2416750	8159
1991	2	1552315	2936717	614233	9587
1991	3	208352	64565	1036	99
1991	4	0	0	0	0
1992	1	18948	9695465	1315325	177584
1992	2	222991	1185132	132166	16491
1992	3	1279875	1583952	259251	5821
1992	4	0	0	0	0
1993	1	264173	3026867	5339043	247839
1993	2	1441317	4911453	1324444	31435
1993	3	1867838	1819506	338969	43965
1993	4	0	0	0	0
1994	1	445326	40720484	516854	100737
1994	2	1856101	7146622	1455656	142774
1994	3	818875	2936362	559871	22813
1994	4	0	0	0	0
1995	1	170693	24466578	3192395	371759
1995	2	612010	8620522	2863267	505875
1995	3	1797666	4488224	533786	128194
1995	4	0	0	0	0
1996	1	299367	233497	816511	286503
1996	2	1083655	776795	2208631	911256
1996	3	1670742	289815	113580	49534
1996	4	0	0	0	0
1997	1	6447	2286585	130593	202822
1997	2	148657	4395265	1078225	277615
1997	3	596223	728240	181187	46667
1997	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1998	1	86124	3567341	1498339	258993
1998	2	5465889	2665032	1451844	326463
1998	3	1615982	1096547	489541	241493
1998	4	0	0	0	0
1999	1	830	15939248	477815	69219
1999	2	90557	2456063	254931	44836
1999	3	1967130	3351942	641059	183015
1999	4	0	0	0	0
2000	1	6101	9822669	1767256	70160
2000	2	81906	801375	384854	49827
2000	3	1093613	2807143	1310052	176418
2000	4	0	0	0	0
2001	1	13056	5767627	315550	7694
2001	2	550512	3967343	1528712	498496
2001	3	143017	531588	59709	13418
2001	4	0	0	0	0
2002	1	63416	6586442	594557	108679
2002	2	927294	4326530	661656	59022
2002	3	1182692	1199165	296900	65718
2002	4	0	0	0	0
2003	1	197639	4003316	594498	68144
2003	2	2785630	6826281	1115905	218400
2003	3	713229	39824	29774	26427
2003	4	0	0	0	0
2004	1	229309	4217281	731500	78913
2004	2	24806798	4735686	264373	53425
2004	3	5233945	309955	44145	15707
2004	4	0	0	0	0
2005	1	97602	13409729	479222	88858
2005	2	839944	7903545	228337	22051
2005	3	1089274	5408581	230703	38557
2005	4	0	0	0	0
2006	1	0	1987696	1401797	295158
2006	2	319709	493221	1003837	235542
2006	3	176742	129541	176585	10933
2006	4	0	0	0	0
2007	1	0	1693273	189551	67672

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2007	2	609939	4186796	1681648	254768
2007	3	404452	329724	19675	20964
2007	4	0	0	0	0
2008	1	11590	422430	1447939	329770
2008	2	2087187	1901763	1006626	260966
2008	3	893785	131774	41692	21858
2008	4	0	0	0	0
2009	1	0	4776947	219922	39037
2009	2	231412	8163927	554425	137328
2009	3	168362	3385107	519516	88967
2009	4	0	0	0	0
2010	1	12414	1732171	689166	90040
2010	2	349703	3105417	3011291	2157387
2010	3	298472	2412405	683264	90603
2010	4	0	0	0	0
2011	1	2469	1847215	1105017	281708
2011	2	420004	4234059	2917969	999295
2011	3	57320	250247	95834	42266
2011	4	0	0	0	0
2012	1	147896	2527701	729427	121665
2012	2	187098	3756225	1690250	281071
2012	3	78240	463743	86910	30157
2012	4	0	0	0	0
2013	1	10002	1973364	411558	72705
2013	2	462029	2176971	745578	144434
2013	3	193678	1554	2447	4794
2013	4	0	0	0	0
2014	1	2640874	9499013	627237	105519
2014	2	1215080	4046244	323320	92685
2014	3	1755944	2496884	177328	21685
2014	4	0	0	0	0
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022

Year	Season	age 0	age 1	age 2	age 3
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	2420231	9775216	3342785	163696
2019	2	1010279	2433674	1045309	140003
2019	3	0	0	0	0
2019	4	0	0	0	0
2020	1	207574	10153348	3429492	429318
2020	2	97488	2773937	394226	139520
2020	3	0	0	0	0
2020	4	0	0	0	0
2021	1	539434	5840604	1505982	255540
2021	2	286005	813983	392934	138813
2021	3	0	0	0	0
2021	4	0	0	0	0
2022	1	362805	7103177	813995	99384
2022	2	829589	282596	350985	101007
2022	3	0	0	0	0
2022	4	0	0	0	0
2023	1	578572	4943797	1984638	98171
2023	2	389454	1497984	618160	68121
2023	3	0	0	0	0
2023	4	0	0	0	0

Table 10.2.3. North Sea & 3.a sprat. Mean weight at age (kg) in catches by season and year. (Model year, e.g., 2021 = July 2021–June 2022)

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1974	1	0.0063	0.0083	0.0135	0.0184
1974	2	0.0058	0.0089	0.0150	0.0197
1974	3	0.0050	0.0077	0.0150	0.0197
1974	4	0.0066	0.0107	0.0183	0.0163
1975	1	0.0048	0.0086	0.0129	0.0172
1975	2	0.0075	0.0111	0.0168	0.0216
1975	3	0.0048	0.0106	0.0154	0.0192
1975	4	0.0062	0.0116	0.0170	0.0171
1976	1	0.0049	0.0070	0.0113	0.0134
1976	2	0.0043	0.0090	0.0153	0.0190
1976	3	0.0022	0.0059	0.0104	0.0126
1976	4	0.0034	0.0057	0.0085	0.0106
1977	1	0.0054	0.0082	0.0126	0.0180
1977	2	0.0059	0.0110	0.0146	0.0196
1977	3	0.0023	0.0080	0.0106	0.0138
1977	4	0.0025	0.0063	0.0083	0.0122
1978	1	0.0038	0.0069	0.0122	0.0146
1978	2	0.0044	0.0103	0.0155	0.0196
1978	3	0.0031	0.0089	0.0123	0.0166
1978	4	0.0020	0.0052	0.0087	0.0094
1979	1	0.0050	0.0058	0.0087	0.0113
1979	2	0.0057	0.0105	0.0150	0.0173
1979	3	0.0032	0.0077	0.0129	0.0165
1979	4	0.0029	0.0106	0.0121	0.0153
1980	1	0.0063	0.0052	0.0068	0.0083
1980	2	0.0051	0.0052	0.0069	0.0083
1980	3	0.0032	0.0086	0.0131	0.0168
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156
1981	2	0.0082	0.0126	0.0153	0.0194
1981	3	0.0049	0.0089	0.0157	0.0194
1981	4	0.0060	0.0139	0.0191	0.0192
1982	1	0.0085	0.0089	0.0171	0.0155
1982	2	0.0071	0.0110	0.0160	0.0219
1982	3	0.0029	0.0075	0.0115	0.0174
1982	4	0.0044	0.0078	0.0114	0.0160
1983	1	0.0044	0.0092	0.0128	0.0152

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1983	2	0.0042	0.0124	0.0169	0.0211
1983	3	0.0034	0.0094	0.0174	0.0163
1983	4	0.0038	0.0093	0.0127	0.0156
1984	1	0.0060	0.0081	0.0121	0.0166
1984	2	0.0053	0.0122	0.0168	0.0164
1984	3	0.0093	0.0135	0.0197	0.0197
1984	4	0.0093	0.0135	0.0197	0.0197
1985	1	0.0063	0.0093	0.0135	0.0197
1985	2	0.0051	0.0093	0.0135	0.0197
1985	3	0.0073	0.0099	0.0166	0.0166
1985	4	0.0073	0.0099	0.0166	0.0166
1986	1	0.0063	0.0073	0.0099	0.0166
1986	2	0.0051	0.0073	0.0099	0.0166
1986	3	0.0083	0.0164	0.0228	0.0163
1986	4	0.0084	0.0156	0.0208	0.0156
1987	1	0.0066	0.0086	0.0117	0.0153
1987	2	0.0060	0.0093	0.0112	0.0165
1987	3	0.0064	0.0125	0.0175	0.0206
1987	4	0.0068	0.0125	0.0167	0.0189
1988	1	0.0042	0.0088	0.0115	0.0138
1988	2	0.0046	0.0085	0.0113	0.0137
1988	3	0.0052	0.0132	0.0208	0.0158
1988	4	0.0063	0.0117	0.0155	0.0175
1989	1	0.0054	0.0086	0.0099	0.0170
1989	2	0.0044	0.0082	0.0109	0.0130
1989	3	0.0048	0.0077	0.0125	0.0155
1989	4	0.0046	0.0086	0.0115	0.0129
1990	1	0.0046	0.0070	0.0092	0.0115
1990	2	0.0038	0.0069	0.0092	0.0113
1990	3	0.0044	0.0099	0.0133	0.0156
1990	4	0.0048	0.0089	0.0119	0.0135
1991	1	0.0128	0.0143	0.0154	0.0168
1991	2	0.0048	0.0146	0.0189	0.0168
1991	3	0.0052	0.0101	0.0147	0.0172
1991	4	0.0062	0.0118	0.0152	0.0186
1992	1	0.0081	0.0099	0.0124	0.0148
1992	2	0.0058	0.0121	0.0153	0.0178
1992	3	0.0035	0.0096	0.0141	0.0179

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1992	4	0.0042	0.0078	0.0104	0.0118
1993	1	0.0065	0.0109	0.0123	0.0138
1993	2	0.0075	0.0107	0.0135	0.0164
1993	3	0.0022	0.0080	0.0116	0.0152
1993	4	0.0023	0.0128	0.0154	0.0134
1994	1	0.0068	0.0067	0.0095	0.0129
1994	2	0.0087	0.0104	0.0125	0.0151
1994	3	0.0030	0.0082	0.0097	0.0140
1994	4	0.0038	0.0068	0.0090	0.0131
1995	1	0.0032	0.0082	0.0117	0.0121
1995	2	0.0051	0.0101	0.0133	0.0155
1995	3	0.0084	0.0096	0.0129	0.0158
1995	4	0.0058	0.0107	0.0142	0.0161
1996	1	0.0071	0.0108	0.0142	0.0175
1996	2	0.0079	0.0115	0.0150	0.0169
1996	3	0.0029	0.0062	0.0087	0.0103
1996	4	0.0031	0.0057	0.0077	0.0086
1997	1	0.0071	0.0128	0.0148	0.0163
1997	2	0.0058	0.0120	0.0161	0.0199
1997	3	0.0071	0.0097	0.0122	0.0147
1997	4	0.0052	0.0095	0.0127	0.0144
1998	1	0.0056	0.0139	0.0166	0.0186
1998	2	0.0050	0.0124	0.0153	0.0177
1998	3	0.0043	0.0061	0.0095	0.0094
1998	4	0.0039	0.0073	0.0097	0.0110
1999	1	0.0053	0.0097	0.0115	0.0121
1999	2	0.0046	0.0116	0.0135	0.0164
1999	3	0.0036	0.0094	0.0118	0.0138
1999	4	0.0052	0.0097	0.0129	0.0146
2000	1	0.0067	0.0122	0.0148	0.0185
2000	2	0.0062	0.0149	0.0174	0.0183
2000	3	0.0051	0.0105	0.0131	0.0150
2000	4	0.0036	0.0046	0.0080	0.0135
2001	1	0.0078	0.0109	0.0118	0.0159
2001	2	0.0048	0.0116	0.0136	0.0166
2001	3	0.0062	0.0127	0.0150	0.0162
2001	4	0.0065	0.0120	0.0161	0.0181
2002	1	0.0073	0.0109	0.0141	0.0154

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2002	2	0.0077	0.0122	0.0142	0.0158
2002	3	0.0047	0.0101	0.0133	0.0145
2002	4	0.0060	0.0116	0.0129	0.0155
2003	1	0.0042	0.0125	0.0146	0.0228
2003	2	0.0058	0.0108	0.0145	0.0167
2003	3	0.0049	0.0115	0.0135	0.0141
2003	4	0.0050	0.0092	0.0123	0.0139
2004	1	0.0088	0.0116	0.0139	0.0154
2004	2	0.0041	0.0094	0.0126	0.0153
2004	3	0.0030	0.0097	0.0112	0.0130
2004	4	0.0044	0.0093	0.0115	0.0129
2005	1	0.0076	0.0097	0.0130	0.0154
2005	2	0.0066	0.0103	0.0115	0.0141
2005	3	0.0055	0.0080	0.0114	0.0138
2005	4	0.0047	0.0087	0.0115	0.0130
2006	1	0.0063	0.0108	0.0133	0.0152
2006	2	0.0055	0.0143	0.0158	0.0180
2006	3	0.0041	0.0095	0.0129	0.0134
2006	4	0.0050	0.0093	0.0124	0.0139
2007	1	0.0063	0.0119	0.0131	0.0149
2007	2	0.0065	0.0101	0.0127	0.0151
2007	3	0.0045	0.0075	0.0106	0.0126
2007	4	0.0048	0.0089	0.0118	0.0133
2008	1	0.0088	0.0103	0.0114	0.0131
2008	2	0.0044	0.0076	0.0126	0.0142
2008	3	0.0034	0.0076	0.0082	0.0085
2008	4	0.0044	0.0068	0.0090	0.0081
2009	1	0.0063	0.0096	0.0123	0.0142
2009	2	0.0046	0.0095	0.0130	0.0160
2009	3	0.0043	0.0077	0.0103	0.0135
2009	4	0.0087	0.0096	0.0105	0.0141
2010	1	0.0066	0.0080	0.0097	0.0137
2010	2	0.0047	0.0094	0.0114	0.0148
2010	3	0.0050	0.0072	0.0094	0.0130
2010	4	0.0038	0.0071	0.0095	0.0107
2011	1	0.0052	0.0085	0.0101	0.0134
2011	2	0.0044	0.0089	0.0114	0.0145
2011	3	0.0042	0.0102	0.0128	0.0171

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2011	4	0.0050	0.0092	0.0123	0.0139
2012	1	0.0085	0.0087	0.0106	0.0150
2012	2	0.0072	0.0087	0.0119	0.0152
2012	3	0.0040	0.0069	0.0113	0.0146
2012	4	0.0047	0.0087	0.0117	0.0132
2013	1	0.0061	0.0096	0.0120	0.0150
2013	2	0.0043	0.0097	0.0124	0.0156
2013	3	0.0026	0.0051	0.0071	0.0084
2013	4	0.0022	0.0094	0.0128	0.0153
2014	1	0.0086	0.0086	0.0104	0.0168
2014	2	0.0070	0.0079	0.0116	0.0139
2014	3	0.0053	0.0083	0.0116	0.0119
2014	4	0.0065	0.0099	0.0101	0.0115
2015	1	0.0076	0.0082	0.0104	0.0150
2015	2	0.0072	0.0088	0.0109	0.0155
2015	3	0.0038	0.0078	0.0107	0.0153
2015	4	0.0044	0.0082	0.0109	0.0123
2016	1	0.0041	0.0077	0.0112	0.0145
2016	2	0.0051	0.0074	0.0118	0.0145
2016	3	0.0073	0.0143	0.0199	0.0235
2016	4	0.0076	0.0141	0.0188	0.0212
2017	1	0.0064	0.0083	0.0103	0.0139
2017	2	0.0038	0.0078	0.0099	0.0162
2017	3	0.0042	0.0064	0.0098	0.0130
2017	4	0.0076	0.0141	0.0188	0.0212
2018	1	0.0046	0.00664	0.0086	0.0126
2018	2	0.0053	0.0074	0.0097	0.0134
2018	3	0.0041	0.0067	0.0095	0.0136
2018	4	0.0057	0.0065	0.00762	0.0129
2019	1	0.0034	0.0064	0.0088	0.0116
2019	2	0.0041	0.0076	0.0098	0.0141
2019	3	0.0059	0.0100	0.0130	0.0164
2019	4	0.0064	0.0078	0.0105	0.0157
2020	1	0.0049	0.0093	0.0121	0.0162
2020	2	0.0071	0.0107	0.0141	0.0168
2020	3	0.0061	0.0087	0.0108	0.0138
2020	4	0.0064	0.0102	0.0133	0.0160
2021	1	0.0061	0.0071	0.0110	0.0131

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2021	2	0.0061	0.0087	0.0117	0.0158
2021	3	0.0072	0.0124	0.0161	0.0203
2021	4	0.0070	0.0088	0.0103	0.0157
2022	1	0.0062	0.0084	0.0109	0.0135
2022	2	0.0076	0.0123	0.0166	0.0183
2022	3	0.0058	0.0100	0.0143	0.0165
2022	4	0.0065	0.0102	0.0132	0.0160
2023	1	0.0048	0.0091	0.0107	0.0125
2023	2	0.0051	0.0083	0.0108	0.0133
2023	3	0.0058	0.0100	0.0143	0.0165
2023	4	0.0065	0.0102	0.0132	0.0160

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2023. This table only shows age-length samples, and therefore the number of samples may differ from Table 10.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	0.0	0	0	0
	2	0.5	0	0	0
	3	60.0	62	6538	3027
	4	17.9	45	4989	2313
	Total	78.4	107	11527	5340
Norway	1	0.0	0	0	0
	2	0.0	0	0	0
	3	3.6	4	400	120
	4	0.0	0	0	0
	Total	3.6	4	400	120
Sweden	1	0.0	1	60	60
	2	0.0	0	0	0
	3	5.5	12	900	900
	4	3.7	6	293	293
	Total	9.2	19	1253	1253
All countries	1	0.1	1	60	60

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
	2	0.5	0	0	0
	3	69.2	78	7838	4047
	4	21.6	51	5282	2606
Total	Total	91.4	130	13180	6713

Table 10.2.5. North Sea and Division 3.a sprat. Number of biological samples taken from 1974 and onward. The number of samples may differ from Table 10.2.4, since this table shows both length and age-length samples. These are the samples used to generate the catch-at-age matrix for the assessment model (Model year, e.g., 2021 = July 2021–June 2022).

Year	S1	S2	S3	S4
1974	15	31	102	25
1975	67	46	40	11
1976	54	70	53	16
1977	37	51	32	18
1978	52	78	47	22
1979	86	55	90	9
1980	0	0	49	28
1981	61	32	29	14
1982	27	48	13	16
1983	11	44	27	8
1984	9	23	29	7
1985	4	4	0	4
1986	4	1	0	1
1987	16	15	4	3
1988	8	4	9	1
1989	13	0	7	2
1990	4	0	13	1
1991	6	56	15	8
1992	42	35	24	4
1993	21	30	24	7
1994	42	50	32	5
1995	40	47	41	4
1996	2	12	8	3
1997	9	34	12	1
1998	25	38	16	3
1999	41	25	25	1
2000	29	23	22	14
2001	23	9	17	4
2002	26	37	28	7

Year	S1	S2	S3	S4
2003	12	60	17	2
2004	26	43	24	15
2005	77	56	56	2
2006	23	7	13	0
2007	34	40	13	4
2008	10	9	14	5
2009	33	36	18	5
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	2	12
2020	27	30	6	0
2021	85	22	0	8
2022	41	29	1	0
2023	78	49	NA	NA

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q1

IBTS Q1 survey index (area 4 and 3a combined; years apply to the calendar year and ages the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
1983	252619	551262	574173	47111
1984	619180	553686	100186	25687
1985	374594	292408	75083	19254
1986	116338	137304	39250	9993
1987	503284	86061	25143	9769
1988	248663	789924	77117	15148
1989	744970	154929	114877	11326
1990	360108	185946	47580	21180
1991	1412224	176334	33438	7582
1992	1882139	281520	36961	9645
1993	1863182	1224852	103248	10709
1994	1195289	887347	132008	8288
1995	2258852	2257140	263386	10391
1996	604673	967027	199658	28253

IBTS Q1 survey index (area 4 and 3a combined; years apply to the calendar year and ages the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
1997	599335	270098	168138	27513
1998	1072937	1104108	180777	16056
1999	5183400	583736	73757	5308
2000	2017439	1164352	150449	25036
2001	1997862	1309083	239142	13995
2002	1191954	968965	87712	10393
2003	2493114	589410	66441	5540
2004	4084377	685280	106637	9076
2005	8918279	675529	29062	2718
2006	1230441	1416990	58676	7654
2007	1917763	1035569	162880	12506
2008	1526985	803061	47400	8526
2009	4133598	312030	34043	3833
2010	3288300	2489705	118665	17586
2011	1078333	926246	206207	47562
2012	3356603	3143308	245116	36666
2013	1137772	1116849	203191	29306
2014	3886605	443621	50655	9871
2015	7727188	3460669	317090	26651
2016	2112309	3409890	675849	37763
2017	10317128	1707447	128002	15146
2018	10440866	1547476	94598	11384
2019	6097175	2511994	226057	9585
2020	7316245	2219294	421523	40023
2021	3308192	1977916	196830	16693
2022	1810546	769303	57700	6537
2023	84401712	1710545	93914	7639
2024	1229364	336007	14974	3206

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q3

IBTS Q3 survey index (area 4 and 3a combined; years and ages apply to both the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
1992	14555861	2633020	104865
1993	5767651	3015219	217792
1994	16468664	1326478	95089
1995	30622687	7433288	454582
1996	2317117	2219591	215543

IBTS Q3 survey index (area 4 and 3a combined; years and ages apply to both the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
1997	13080865	1171944	200385
1998	2676263	1107920	117795
1999	13792780	1719505	82599
2000	8212868	3228536	133847
2001	8998081	2277278	187452
2002	10011480	1319291	102476
2003	11610320	1272970	66231
2004	14371331	1945227	122791
2005	52835449	2266372	102272
2006	9340785	5459057	155440
2007	10549586	1552282	184767
2008	7894186	2085499	130785
2009	35252950	3032568	337850
2010	35355908	9422666	428224
2011	16742275	8341042	1191533
2012	11469646	5231406	575643
2013	9052264	3060010	414534
2014	63182232	3573736	215965
2015	59775893	18619852	653613
2016	27891385	4266699	482295
2017	27754797	2886164	173266
2018	18709889	3123833	200733
2019	40210818	8468920	521293
2020	53930015	16906066	1479519
2021	21858420	5602150	519985
2022	29786037	3579909	464099
2023	58581633	8893743	524218

Table 10.3.2. North Sea and Division 3.a sprat. HERAS survey index.

HERAS abundance index (area 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to both the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2006	21923	21368	1413
2007	42862	5837	2252
2008	17188	7868	840
2009	47690	16920	2815
2010	20328	14087	1174
2011	26581	14207	3412
2012	22036	12831	4693

HERAS abundance index (area 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to both the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2013	9347	6342	2049
2014	59020	20274	3982
2015	27082	22676	10142
2016	58604	33989	8160
2017	38135	3664	1465
2018	109180	10113	779
2019	93775	28020	5275
2020	38415	17993	2055
2021	46918	7051	1509
2022	60224	16200	2882
2023	48125	18542	7015

Table 10.6.1. North Sea and Division 3.a sprat. Natural mortality input (Model year, e.g., 2021 = July 2021–June 2022). From multispecies SMS (WKSAM: ICES, 2023) 2023 key run.

Year	Season	age 0	age 1	age 2	age 3
1974	1	0.4533	0.4350	0.4200	0.3973
1974	2	0.3640	0.2157	0.1903	0.1630
1974	3	0.2493	0.2153	0.1680	0.1680
1974	4	0.3283	0.2923	0.2640	0.2640
1975	1	0.4533	0.4350	0.4200	0.3973
1975	2	0.3640	0.2157	0.1903	0.1630
1975	3	0.2633	0.2287	0.1723	0.1723
1975	4	0.3433	0.3227	0.2987	0.2987
1976	1	0.4250	0.4077	0.3917	0.3770
1976	2	0.3720	0.2280	0.2087	0.1800
1976	3	0.2890	0.2503	0.1907	0.1907
1976	4	0.3430	0.3237	0.2983	0.2983
1977	1	0.3687	0.3513	0.3290	0.3207
1977	2	0.3793	0.2310	0.2117	0.1833
1977	3	0.2940	0.2797	0.2190	0.2190
1977	4	0.3340	0.3170	0.2993	0.2993
1978	1	0.3230	0.3330	0.3097	0.2977
1978	2	0.3453	0.2137	0.2053	0.1807
1978	3	0.2837	0.2703	0.2123	0.2123
1978	4	0.3037	0.2780	0.2603	0.2603
1979	1	0.3453	0.3650	0.3357	0.3270
1979	2	0.3680	0.2767	0.2370	0.2163
1979	3	0.2973	0.2773	0.2257	0.2257

Year	Season	age 0	age 1	age 2	age 3
1979	4	0.3087	0.2917	0.2737	0.2737
1980	1	0.3733	0.3867	0.3647	0.3560
1980	2	0.3940	0.2900	0.2577	0.2227
1980	3	0.2917	0.2703	0.2043	0.2043
1980	4	0.3083	0.2890	0.2537	0.2537
1981	1	0.4007	0.4050	0.3843	0.3553
1981	2	0.3637	0.2963	0.2647	0.2180
1981	3	0.2770	0.2457	0.1887	0.1887
1981	4	0.2910	0.2697	0.2213	0.2213
1982	1	0.4017	0.3883	0.3760	0.3267
1982	2	0.3013	0.2227	0.2097	0.1627
1982	3	0.2237	0.1990	0.1533	0.1533
1982	4	0.2537	0.2203	0.1773	0.1773
1983	1	0.4143	0.3983	0.3880	0.3333
1983	2	0.2967	0.2237	0.1980	0.1680
1983	3	0.2137	0.1773	0.1357	0.1357
1983	4	0.2337	0.1990	0.1543	0.1543
1984	1	0.4243	0.4027	0.3990	0.3420
1984	2	0.3330	0.2293	0.2007	0.1730
1984	3	0.2283	0.1997	0.1393	0.1393
1984	4	0.2410	0.2097	0.1713	0.1713
1985	1	0.4513	0.4367	0.4303	0.3880
1985	2	0.4050	0.3040	0.2513	0.2143
1985	3	0.2423	0.1973	0.1390	0.1390
1985	4	0.2480	0.2123	0.1513	0.1513
1986	1	0.4777	0.4700	0.4583	0.4123
1986	2	0.4310	0.3310	0.2870	0.2357
1986	3	0.2627	0.2073	0.1483	0.1483
1986	4	0.2687	0.2230	0.1483	0.1483
1987	1	0.5007	0.4917	0.4810	0.4263
1987	2	0.4617	0.3457	0.3047	0.2507
1987	3	0.2730	0.1927	0.1653	0.1653
1987	4	0.2767	0.2223	0.1610	0.1610
1988	1	0.5227	0.5043	0.4927	0.4167
1988	2	0.4687	0.3283	0.3137	0.2753
1988	3	0.2863	0.2073	0.1850	0.1850
1988	4	0.2897	0.2340	0.1930	0.1930
1989	1	0.5177	0.5013	0.4883	0.4113
1989	2	0.4537	0.3327	0.3097	0.2857
1989	3	0.2857	0.2253	0.2017	0.2017

Year	Season	age 0	age 1	age 2	age 3
1989	4	0.2963	0.2530	0.2340	0.2340
1990	1	0.4920	0.4827	0.4627	0.4187
1990	2	0.4417	0.3290	0.2940	0.2850
1990	3	0.2730	0.2430	0.2133	0.2133
1990	4	0.2993	0.2617	0.2380	0.2380
1991	1	0.4580	0.4530	0.4373	0.4177
1991	2	0.4060	0.2917	0.2673	0.2480
1991	3	0.2627	0.2527	0.2080	0.2080
1991	4	0.3013	0.2717	0.2473	0.2473
1992	1	0.4283	0.4173	0.4087	0.3990
1992	2	0.3677	0.2557	0.2430	0.2130
1992	3	0.2527	0.2437	0.1953	0.1953
1992	4	0.2853	0.2560	0.2350	0.2350
1993	1	0.4133	0.4103	0.4007	0.3887
1993	2	0.2997	0.2310	0.2297	0.2053
1993	3	0.2417	0.2300	0.1833	0.1833
1993	4	0.2707	0.2420	0.2197	0.2197
1994	1	0.4487	0.4233	0.4057	0.4013
1994	2	0.3127	0.2430	0.2330	0.2193
1994	3	0.2363	0.2187	0.1833	0.1833
1994	4	0.2613	0.2243	0.2063	0.2063
1995	1	0.4543	0.4277	0.4100	0.3953
1995	2	0.3160	0.2433	0.2330	0.2193
1995	3	0.2107	0.1980	0.1727	0.1727
1995	4	0.2460	0.2017	0.1793	0.1793
1996	1	0.4607	0.4160	0.3983	0.3670
1996	2	0.3893	0.2580	0.2470	0.2170
1996	3	0.2107	0.1827	0.1527	0.1527
1996	4	0.2380	0.1867	0.1520	0.1520
1997	1	0.4237	0.3853	0.3690	0.3377
1997	2	0.3780	0.2380	0.2357	0.1880
1997	3	0.2070	0.1887	0.1473	0.1473
1997	4	0.2450	0.2027	0.1623	0.1623
1998	1	0.4117	0.3757	0.3533	0.3323
1998	2	0.4030	0.2313	0.2290	0.1907
1998	3	0.2237	0.2000	0.1620	0.1620
1998	4	0.2563	0.2210	0.1810	0.1810
1999	1	0.4050	0.3680	0.3537	0.3467
1999	2	0.3393	0.2263	0.2253	0.2037
1999	3	0.2323	0.2267	0.1927	0.1927

Year	Season	age 0	age 1	age 2	age 3
1999	4	0.2757	0.2447	0.2117	0.2117
2000	1	0.3900	0.3643	0.3583	0.3447
2000	2	0.3527	0.2370	0.2350	0.2223
2000	3	0.2157	0.2007	0.1840	0.1840
2000	4	0.2437	0.2080	0.1710	0.1710
2001	1	0.3923	0.3607	0.3600	0.3357
2001	2	0.3380	0.2507	0.2497	0.2383
2001	3	0.2200	0.2113	0.1897	0.1897
2001	4	0.2617	0.2263	0.1873	0.1873
2002	1	0.4010	0.3677	0.3670	0.3197
2002	2	0.3573	0.2537	0.2517	0.2417
2002	3	0.2100	0.1953	0.1683	0.1683
2002	4	0.2540	0.2123	0.1833	0.1833
2003	1	0.3867	0.3543	0.3537	0.3130
2003	2	0.3300	0.2520	0.2397	0.2397
2003	3	0.2307	0.2133	0.1907	0.1907
2003	4	0.3020	0.2590	0.2350	0.2350
2004	1	0.3910	0.3697	0.3607	0.3307
2004	2	0.3063	0.2393	0.2257	0.2257
2004	3	0.2140	0.1970	0.1840	0.1840
2004	4	0.2950	0.2523	0.2310	0.2310
2005	1	0.4023	0.3840	0.3747	0.3747
2005	2	0.3130	0.2490	0.2247	0.2247
2005	3	0.2067	0.1830	0.1693	0.1693
2005	4	0.2970	0.2493	0.2133	0.2133
2006	1	0.4503	0.4310	0.4217	0.4217
2006	2	0.3223	0.2417	0.2273	0.2250
2006	3	0.1927	0.1813	0.1653	0.1653
2006	4	0.2820	0.2410	0.2030	0.2030
2007	1	0.4697	0.4453	0.4417	0.4417
2007	2	0.3397	0.2560	0.2333	0.2310
2007	3	0.1867	0.1617	0.1440	0.1440
2007	4	0.2640	0.2213	0.1830	0.1830
2008	1	0.4720	0.4573	0.4473	0.4473
2008	2	0.3217	0.2377	0.2223	0.2077
2008	3	0.1803	0.1693	0.1583	0.1583
2008	4	0.2513	0.2237	0.1957	0.1957
2009	1	0.4547	0.4497	0.4350	0.4300
2009	2	0.3237	0.2507	0.2223	0.2073
2009	3	0.1807	0.1700	0.1593	0.1593

Year	Season	age 0	age 1	age 2	age 3
2009	4	0.2460	0.2187	0.1943	0.1943
2010	1	0.4997	0.4903	0.4680	0.4623
2010	2	0.3517	0.2760	0.2407	0.2257
2010	3	0.1970	0.1883	0.1630	0.1630
2010	4	0.2667	0.2237	0.2030	0.2030
2011	1	0.5360	0.5267	0.5007	0.4947
2011	2	0.3690	0.3050	0.2590	0.2520
2011	3	0.2113	0.2013	0.1767	0.1767
2011	4	0.2937	0.2517	0.2320	0.2320
2012	1	0.5507	0.5320	0.5067	0.4797
2012	2	0.3617	0.3000	0.2603	0.2507
2012	3	0.2017	0.1837	0.1457	0.1457
2012	4	0.2783	0.2273	0.1970	0.1970
2013	1	0.4817	0.4723	0.4517	0.4023
2013	2	0.3110	0.2633	0.2313	0.2217
2013	3	0.1847	0.1787	0.1527	0.1527
2013	4	0.2580	0.2270	0.2030	0.2030
2014	1	0.4363	0.4270	0.4077	0.3460
2014	2	0.3030	0.2487	0.2200	0.2133
2014	3	0.2013	0.1823	0.1547	0.1547
2014	4	0.2580	0.2283	0.2043	0.2043
2015	1	0.4373	0.4303	0.4060	0.3703
2015	2	0.3090	0.2713	0.2177	0.2163
2015	3	0.2217	0.2010	0.1750	0.1750
2015	4	0.2653	0.2450	0.2320	0.2320
2016	1	0.4573	0.4423	0.4140	0.4013
2016	2	0.3363	0.3033	0.2290	0.2277
2016	3	0.2460	0.2163	0.1927	0.1927
2016	4	0.2833	0.2643	0.2447	0.2447
2017	1	0.4567	0.4353	0.4080	0.4080
2017	2	0.3363	0.3140	0.2277	0.2277
2017	3	0.2387	0.2153	0.1937	0.1937
2017	4	0.2753	0.2577	0.2390	0.2390
2018	1	0.4257	0.4047	0.3787	0.3787
2018	2	0.3300	0.3080	0.2190	0.2190
2018	3	0.2437	0.2230	0.2120	0.2120
2018	4	0.2880	0.2720	0.2530	0.2530
2019	1	0.4243	0.4037	0.3800	0.3800
2019	2	0.3447	0.3227	0.2280	0.2280
2019	3	0.2670	0.2493	0.2390	0.2390

Year	Season	age 0	age 1	age 2	age 3
2019	4	0.3107	0.2943	0.2750	0.2750
2020	1	0.4447	0.4240	0.4007	0.4007
2020	2	0.3707	0.3490	0.2600	0.2600
2020	3	0.2953	0.2810	0.2717	0.2717
2020	4	0.3353	0.3190	0.2993	0.2993
2021	1	0.4453	0.4267	0.4050	0.4050
2021	2	0.3713	0.3527	0.2760	0.2760
2021	3	0.2953	0.2810	0.2717	0.2717
2021	4	0.3353	0.3190	0.2993	0.2993
2022	1	0.4453	0.4267	0.4050	0.4050
2022	2	0.3713	0.3527	0.2760	0.2760
2022	3	0.2953	0.2810	0.2717	0.2717
2022	4	0.3353	0.3190	0.2993	0.2993
2023	1	0.4453	0.4267	0.4050	0.4050
2023	2	0.3713	0.3527	0.2760	0.2760
2023	3	0.2953	0.2810	0.2717	0.2717
2023	4	0.3353	0.3190	0.2993	0.2993

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 04/02/24 Start time:22:15:02 run time:19 seconds

objective function (negative log likelihood): 284.005

Number of parameters: 147

Maximum gradient: 5.51547e-05

Akaike information criterion (AIC): 862.01

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
800	318	50	0	1168

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.10

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
383.4	-100.1	6.5	0.0	0.0	0.00	290

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.48	-0.31	0.13	0.00

contribution by fleet:

IBTS Q1 Rec total: -31.471 mean: -0.749

IBTS Q1 total: -31.705 mean: -0.252

IBTS Q3 total: -23.856 mean: -0.249

Acoustic total: -13.035 mean: -0.241

F, Year effect:

1974: 1.000

1975: 1.797

1976: 1.829

1977: 1.746

1978: 1.163

1979: 0.704

1980: 2.408

1981: 1.132

1982: 0.939

1983: 1.629

1984: 0.768

1985: 1.207

1986: 1.150

1987: 0.331

1988: 1.164

1989: 0.276

1990: 1.497

1991: 0.638

1992: 0.809

1993: 1.402

1994: 0.665

1995: 1.191

1996: 1.173

1997: 0.809

1998: 1.453

1999: 0.783

2000: 1.390

2001: 1.333

2002: 1.487

2003: 1.177

2004: 1.812

2005: 1.180

2006: 1.427

2007: 1.296

2008: 1.092

2009: 0.646

2010: 0.763

2011: 0.609

2012: 1.152

2013: 0.755

2014: 0.498

2015: 0.975

2016: 1.893

2017: 1.019

2018: 1.043

2019: 1.001

2020: 1.612

2021: 1.502

2022: 0.604

2023: 3.003

F, season effect:

----

age: 0

1974-2023: 0.038 0.199 0.408 0.250

age: 1

1974-2023: 0.594 0.550 0.255 0.250

age: 2

1974-2023: 0.274 0.530 0.149 0.250

age: 3

1974-2023: 0.245 0.553 0.302 0.250

F, age effect:

	0	1	2	3
1974-2023:	0.046	0.438	1.392	1.392

Exploitation pattern (scaled to mean F=1)

	0	1	2	3
1974-2023 season 1:	0.001	0.217	0.318	0.284
season 2:	0.008	0.201	0.616	0.643
season 3:	0.016	0.093	0.173	0.351
season 4:	0.010	0.091	0.290	0.290

sqrt(catch variance) ~ CV:

----

season

----

age	1	2	3	4
0	1.414	1.414	1.100	0.100
1	0.864	0.834	1.399	0.100
2	0.951	1.050	1.414	0.100
3	0.951	1.050	1.414	0.100

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	18.340			
IBTS Q1		1.428	2.280	3.148
IBTS Q3		0.821	1.088	0.888
Acoustic		1.091	2.404	5.103

Stock size dependent catchability (power model)

---	age 0	age 1	age 2	age 3
IBTS Q1 Rec	1.72			
IBTS Q1		1.00	1.00	1.00
IBTS Q3		1.00	1.00	1.00
Acoustic		1.00	1.00	1.00

sqrt(Survey variance) ~ CV:

----

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			

IBTS Q1	0.47	0.47	0.47
IBTS Q3	0.53	0.45	0.45
Acoustic	0.44	0.50	0.50

Average F:

----

sp. 1

1974: 1.158

1975: 1.788

1976: 1.849

1977: 1.819

1978: 1.220

1979: 0.750

1980: 2.429

1981: 1.146

1982: 0.927

1983: 1.563

1984: 0.750

1985: 1.161

1986: 1.103

1987: 0.321

1988: 1.124

1989: 0.276

1990: 1.478

1991: 0.649

1992: 0.818

1993: 1.390

1994: 0.664

1995: 1.160

1996: 1.135

1997: 0.797

1998: 1.437

1999: 0.800

2000: 1.378

2001: 1.335

2002: 1.471

2003: 1.200

2004: 1.810

2005: 1.177

2006: 1.388

2007: 1.241

2008: 1.052

2009: 0.630

2010: 0.738

2011: 0.594

2012: 1.089

2013: 0.733

2014: 0.494

2015: 0.971

2016: 1.868

2017: 1.024

2018: 1.067

2019: 0.917

2020: 1.472

2021: 1.377

2022: 0.571

2023: 2.654

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1269.427	9.000e+04	0.478	0.691

Table 10.6.3. North Sea and Division 3.a Sprat. Assessment output: Stock numbers (thousands) (years, seasons (S1-S4), and age (A0-A3+) refer to the model year, e.g., 2021 = July 2021–June 2022)

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
1974	396298000	251406000	173095000	132368000	122228000	60983000	38638000	27859400	11266100	5054130	1997470	1371770	548399	262192	103112	57240
1975	519480000	329090000	224920000	167068000	94221400	38201500	19978400	13003100	18641100	6169400	1353920	784478	774838	282374	60099	23756
1976	234629000	152900000	103638000	74985000	118519000	48973800	25103700	15931600	9417060	3167220	666487	376638	599554	220562	45026	17241
1977	375634000	259012000	174414000	125762000	53212200	23772800	12395600	7710750	11526300	4260800	950667	531350	292279	117031	25391	9788
1978	640638000	462856000	324197000	238813000	90052500	47689600	29112200	19509400	5615980	2643790	912745	579696	401153	200460	68323	33881
1979	366682000	259283000	178293000	130683000	176269000	101880000	65215500	45682400	14774400	8073760	3789130	2612240	472942	268332	125675	74589
1980	203892000	139773000	92184800	65795800	95976600	34834800	14599500	8512910	34125600	9454060	1235610	610708	2043570	630332	78939	23372
1981	60089600	40172300	27634600	20504700	48338200	24014900	13598700	9373330	6376280	2819160	938617	614380	492015	234571	78896	40591
1982	32970100	22027300	16155800	12690300	15327600	8140590	5197320	3835140	7157790	3434330	1392430	982725	524926	274984	113368	65518
1983	49315300	32493300	23791700	18631400	9847080	4327270	2337970	1632280	3076750	1121220	276521	172127	877904	361231	87103	38340
1984	29746800	19434200	13831500	10849200	14749100	8074150	5336300	4011150	1337740	669648	310896	230578	180367	98641	45929	28929
1985	19110800	12143500	8009700	6143970	8525720	4023480	2220070	1592490	3252460	1334220	425692	288254	218646	98319	31308	16397
1986	56723000	35110100	22575800	16987000	4794510	2221470	1209740	864667	1287840	525107	168679	114519	261866	117197	38187	20299
1987	36156000	21902400	13761500	10408500	12984800	7286710	4762640	3785550	691833	376973	217781	172338	116232	67805	40907	30172

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
1988	58410200	34562600	21399300	15720900	7892810	3520200	1915350	1366780	3030890	1187480	367435	239748	172395	76440	23670	12055
1989	45003800	26805200	16985900	12698700	11767300	6634100	4451280	3445440	1081620	597448	357638	276045	207607	125262	76124	55409
1990	70847500	43202300	27396400	20268900	9441990	3946660	1980940	1314320	2675280	951398	234915	139054	262300	103646	24606	10592
1991	103894000	65643900	43482400	33036500	15025500	8090220	5183080	3748790	1011720	512128	244769	174117	117951	62506	29837	18530
1992	98170500	63876300	43895800	33577200	24441400	13045500	8315530	5954200	2856990	1394450	602100	418658	150434	76637	33220	19447
1993	104347000	68849400	50366200	38518200	25242100	11627300	6586290	4474450	4609400	1808650	510955	317893	346353	145679	40304	18609
1994	109041000	69539200	50556500	39416500	29384400	16186300	10818100	8071270	3512690	1816930	881392	639123	270140	144211	69415	43698
1995	39378300	24947800	17989600	14247600	30351600	14514600	8543240	6135290	6449340	2716850	893565	587025	555517	249359	80008	40794
1996	60154400	37870900	25381600	20108800	11140500	5415430	3154750	2305210	5014790	2152070	707320	475838	524749	243809	79506	41672
1997	58709800	38379200	26103000	20899800	15849800	8734030	5666010	4286270	1912680	971188	422315	308063	444535	240758	106974	65692
1998	132527000	87580500	57751600	44924900	16358300	7697720	4305590	2996940	3499960	1412050	384387	241722	317751	138951	37504	17313
1999	80733300	53773000	38023700	29697300	34766700	19624700	12960900	9466440	2402690	1251130	560280	392692	216148	117041	52225	30985
2000	77038300	52031800	36102600	28343600	22542200	10906400	6158820	4314380	7411890	3048010	864130	538608	342854	151312	41540	19264
2001	63241400	42618100	30023300	23493900	22214300	10946500	6180710	4310800	3504170	1469870	428067	268426	470187	213438	60220	28435
2002	87377200	58359100	40267900	31734600	18084900	8501550	4611580	3212480	3437660	1350130	350229	217282	246147	107733	26904	12163
2003	115953000	78606000	55901400	43408500	24616300	12715300	7445370	5274000	2597920	1164210	384434	248792	191011	93557	29743	14985
2004	184669000	124509000	90135700	70317300	32093600	13835400	7040310	4721570	4070590	1421210	297681	169937	208535	80813	15965	6198

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
2005	63078800	42096900	30450100	24218100	52353500	26231900	15395100	11237400	3668590	1608030	537832	355352	139805	64316	20708	10645
2006	84932300	54001300	38609800	30995200	17995100	8065960	4492930	3195440	8757520	3332410	926085	583543	295684	119293	31734	14760
2007	69623600	43430200	30555100	24738100	23378900	10689100	6057820	4458910	2511110	984726	299698	198252	488381	201967	59089	29669
2008	140051000	87189500	62573300	51179400	18998200	9049600	5485830	4099230	3573590	1506010	538531	366344	189806	83652	29304	15801
2009	110047000	69762900	50172800	41370900	39805400	21459200	14295800	11220900	3277670	1657940	823987	614351	314232	164032	81048	52666
2010	91477200	55427700	38720700	31341400	32348900	16243600	10258500	7803260	9016960	4220840	1889740	1370180	549211	266760	118290	72919
2011	99565900	58192000	40010100	32017400	24005200	12099800	7703700	5884750	6239340	2998060	1476710	1090560	1177970	583821	283952	184229
2012	74985400	43146400	29734400	23780100	23869800	10390400	5834100	4269050	4575420	1776450	585359	398335	1010840	422701	135508	72174
2013	166704000	102845000	74832500	61331200	18002600	9221510	5908360	4541650	3400960	1622730	737301	540966	386377	199771	89442	55880
2014	196841000	127127000	93465000	75703600	47384200	27156300	18784400	14805900	3619340	1990750	1106090	854401	487193	290898	160114	111240
2015	110892000	71486200	52013700	40910700	58488200	29510000	17791800	13050200	11783400	5412260	2120200	1453440	787181	389970	148234	82580
2016	199512000	125865000	88358600	66658300	31376500	12317100	5766250	3759080	10214500	3278690	644943	358942	1217980	427891	79288	29497
2017	235741000	149048000	105481000	81498600	50211600	24920700	14245700	10249900	2885910	1300870	488415	325638	304135	142941	51932	27876
2018	201033000	131101000	93349100	71732900	61883400	31475600	17998200	12817100	7921700	3644070	1356200	883431	278362	133641	48092	25094
2019	193661000	126471000	88775500	67973000	53782600	27680700	15754700	12278000	9764790	4557690	1733420	1364920	705441	343057	126328	99472

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
2020	138842000	88750700	60357900	44923400	49821400	21433600	10258000	7745050	9147450	3312920	777611	592624	1112310	430362	95896	73084
2021	125288000	80048800	54458700	40532700	32124700	14182200	6943370	5242440	5629690	2116750	530133	404019	493497	197339	47085	35884
2022	204585000	130920000	89808200	66842800	28984900	16164900	9823200	7416800	3810600	2018240	980523	747264	326105	177050	84356	64288
2023	75569500	48155300	32310300	24048000	47799300	14278000	4870900	3677670	5391090	1143240	94586	72085	601614	144294	10836	8258
2024	0				17196700				2673210				59559			

Table 10.6.4. North Sea & 3.a Sprat. Assessment output: Estimated recruitment, spawning-stock biomass (SSB), average fishing mortality (F), and landings weight (Yield). All estimates refer to the model year, e.g., 2022 = July 2022–June 2023.

Year	Recruitment	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
1974	396298000	711911137	220606332	558968	896742	348423	463344	1.158	1.8	0.745
1975	519480000	918665062	293751751	554695	900682	341615	732312	1.788	2.606	1.226
1976	234629000	411465735	133791864	440558	717994	270325	628598	1.849	2.633	1.298
1977	375634000	638410603	221019045	311303	485669	199538	385257	1.819	2.569	1.289
1978	640638000	1176455494	348858966	318256	498981	202987	458804	1.22	1.959	0.76
1979	366682000	660303640	203627060	536507	893956	321984	463638	0.75	1.394	0.403
1980	203892000	326036507	127507033	423353	720116	248888	387434	2.429	3.309	1.783
1981	60089600	91855385	39309182	273781	406650	184326	280582	1.146	1.734	0.757
1982	32970100	42591842	25521965	169910	252859	114172	162357	0.927	1.367	0.629
1983	49315300	63613897	38230621	83997	109721	64303	115440	1.563	1.978	1.235
1984	29746800	39404087	22456354	65770	81664	52969	113444	0.75	1.127	0.5
1985	19110800	25660170	14233057	74879	95165	58917	62514	1.161	1.581	0.852
1986	56723000	73126086	43999329	29448	38267	22662	27520	1.103	1.527	0.796
1987	36156000	47374518	27594082	54530	68560	43370	53942	0.321	0.505	0.204
1988	58410200	76463302	44619463	61122	75536	49458	103652	1.124	1.467	0.861
1989	45003800	58743006	34478011	54176	68250	43004	58420	0.276	0.505	0.151
1990	70847500	90129129	55690855	51176	64259	40757	78180	1.478	1.877	1.164
1991	103894000	131479870	82095938	103464	128833	83090	125815	0.649	0.986	0.426
1992	98170500	123940686	77758542	132086	162128	107611	156471	0.818	1.145	0.585
1993	104347000	132682435	82062833	166541	203671	136180	208848	1.39	1.731	1.116
1994	109041000	138409534	85904051	112818	138028	92213	424206	0.664	0.91	0.484
1995	39378300	50492493	30710516	173878	211928	142659	446555	1.16	1.466	0.918
1996	60154400	76218031	47476323	120347	148126	97778	95496	1.135	1.471	0.876
1997	58709800	74589846	46210587	114437	140225	93392	125174	0.797	1.109	0.574
1998	132527000	167668591	104750721	149639	183230	122206	188907	1.437	1.766	1.17
1999	80733300	102440506	63625864	165023	204136	133404	243158	0.8	1.129	0.567
2000	77038300	97676463	60760796	214321	263232	174498	222027	1.378	1.761	1.078
2001	63241400	80074041	49947207	141908	174850	115172	153321	1.335	1.739	1.025
2002	87377200	110781456	68917447	126308	155475	102612	174713	1.471	1.83	1.182
2003	115953000	147018629	91451664	162718	200699	131925	174988	1.2	1.567	0.92
2004	184669000	234835193	145219458	204387	251957	165798	231352	1.81	2.183	1.5
2005	63078800	79077234	50317074	251165	313111	201475	280275	1.177	1.511	0.916
2006	84932300	106347320	67829594	185788	229090	150671	78028	1.388	1.734	1.111
2007	69623600	86843717	55818035	149229	182149	122259	99902	1.241	1.581	0.975
2008	140051000	174813651	112201093	118162	143396	97369	69892	1.052	1.401	0.79

Year	Recruitment	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
2009	110047000	137346415	88173705	195548	238352	160431	170934	0.63	0.911	0.436
2010	91477200	114670665	72974881	189055	228205	156622	145415	0.738	1.029	0.53
2011	99565900	124676821	79512522	153530	184541	127730	122472	0.594	0.887	0.397
2012	74985400	93667155	60029689	141307	170634	117021	96030	1.089	1.4	0.847
2013	166704000	210149710	132240123	111731	135652	92029	60207	0.733	1.23	0.437
2014	196841000	251184113	154254896	206623	253735	168258	190268	0.494	0.714	0.342
2015	110892000	140259814	87673264	313569	384768	255545	298227	0.971	1.285	0.734
2016	199512000	250113462	159147924	215611	264938	175468	227169	1.868	2.199	1.587
2017	235741000	298472248	186194259	200416	247001	162617	135824	1.024	1.356	0.773
2018	201033000	257582120	156898573	230073	282653	187274	190779	1.067	1.402	0.812
2019	193661000	247769334	151368946	223301	275491	180998	137029	0.917	1.292	0.651
2020	138842000	174661154	110368565	303434	376056	244836	182205	1.472	1.847	1.173
2021	125288000	160261473	97946703	153180	187372	125228	80183	1.377	1.808	1.049
2022	204585000	268500743	155884195	140181	172691	113791	89625	0.571	0.94	0.347
2023	75569500	102140781	55910571	235389	297419	186296	92204	2.654	3.195	2.206
2024	172781786*			83754	107867	65031				

* Geometric mean recruitment (2012–2021)

Table 10.9.1. North Sea and Division 3.a Sprat. Input to forecast (years and age refer to the model year, e.g., 2022 = July 2022–June 2023).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2023) (millions)	172782	17197	2673	60
Exploitation pattern S1	0.0011	0.1573	0.2306	0.2058
Exploitation pattern S2	0.0056	0.1454	0.4459	0.4654
Exploitation pattern S3	0.0000	0.0000	0.0000	0.0000
Exploitation pattern S4	0.0000	0.0000	0.0000	0.0000
Weight in the stock S1 (gram)	5.6797	8.1980	10.8618	13.0539
Weight in the catch S1 (gram)	5.6797	8.1980	10.8618	13.0539
Weight in the catch S2 (gram)	6.2849	9.7338	13.0368	15.7918
Weight in the catch S3 (gram)	6.2703	10.7911	14.8726	17.7723
Weight in the catch S4 (gram)	6.6799	9.7275	12.2439	15.8939
Proportion mature(2021)	0.0000	0.4093	0.8719	0.9468
Proportion mature(2022)	0.0000	0.4093	0.8719	0.9468
Natural mortality S1	0.4453	0.4267	0.4050	0.4050
Natural mortality S2	0.3713	0.3527	0.2760	0.2760
Natural mortality S3	0.2953	0.2810	0.2717	0.2717
Natural mortality S4	0.3353	0.3190	0.2993	0.2993

Table 10.9.2. Sprat North Sea Division 3.a. Short-term predictions options table. Years refer to the model year, e.g., 2023 = July 2023–June 2024.

Catch options. Catches and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2022) = geometric average 2012–2021.					
Basis	**Catches(2023)**	**F(2023)**	**SSB(2024)**	**SSB change***	**TAC change****
F_{cap}	75321	1.01	158851	90%	-48%
F=0.0	1	0	187012	123%	-100%
F=0.1	9943	0.1	183123	119%	-93%
F=0.2	19196	0.2	179543	114%	-87%
F=0.3	27825	0.3	176241	110%	-81%
F=0.4	35884	0.4	173192	107%	-75%
F=0.5	43425	0.5	170371	103%	-70%
F=0.6	50493	0.6	167759	100%	-65%
F=0.7	57128	0.7	165335	97%	-60%
F=0.8	63367	0.8	163084	95%	-56%
F=0.9	69242	0.9	160990	92%	-52%
F=1.0	74784	1	159039	90%	-48%
$B_{escapement}$ without F_{cap}	149495	3.275	135952	62%	4%

* SSB 1st July 2024 relative to SSB 1st July 2023

** Catch (July 2023-June 2024) relative to the sum of the TACs (68 690 tonnes) for July 2022–June 2023 in Subarea 4 and Division 3.a.

Figure 10.1.1. North Sea and Division 3.a sprat. Sprat catches in the North Sea and Division 3.a (in tonnes) for each calendar year by statistical rectangle.

Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

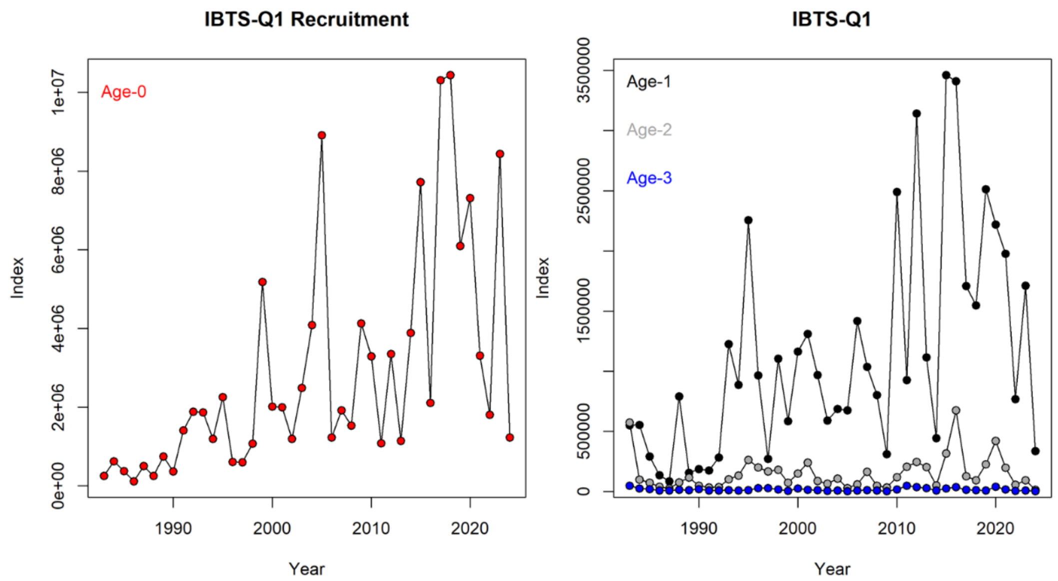


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

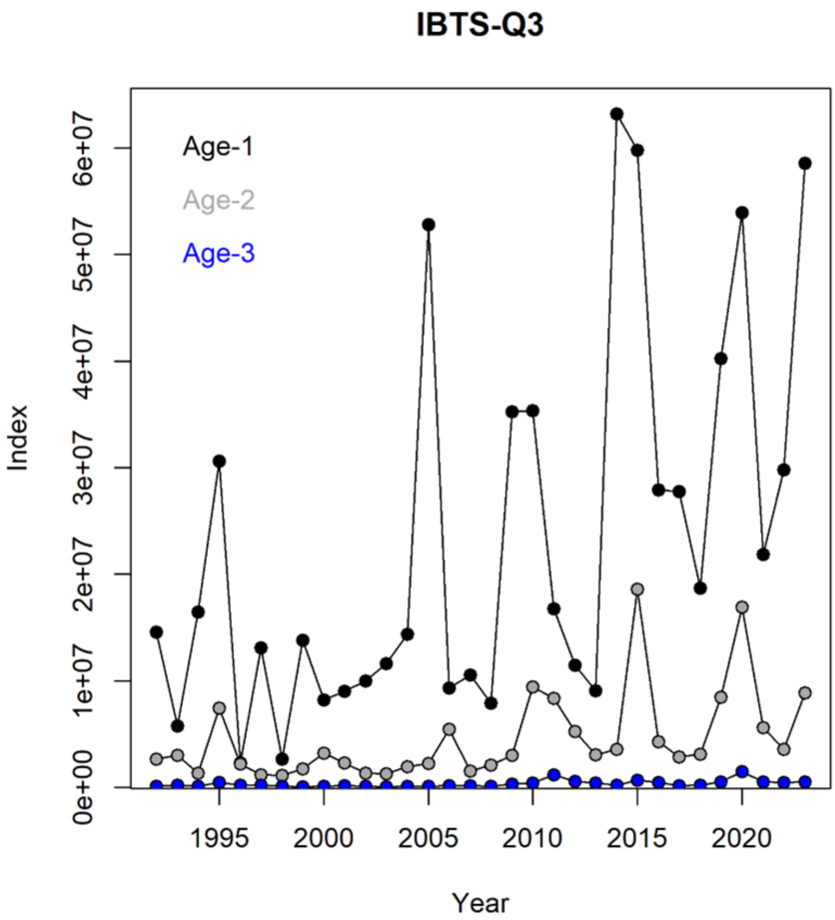


Figure 10.3.2. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

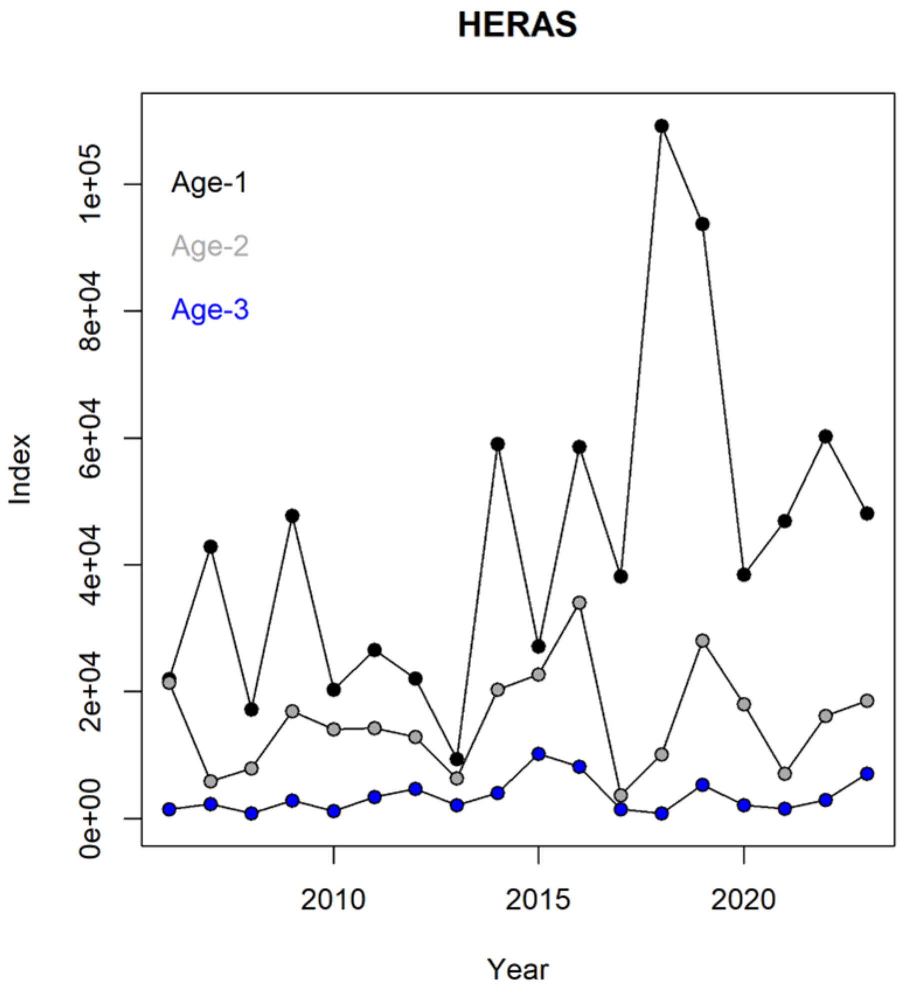


Figure 10.3.3. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS [ICES *in press*]). Years refer to the calendar year.

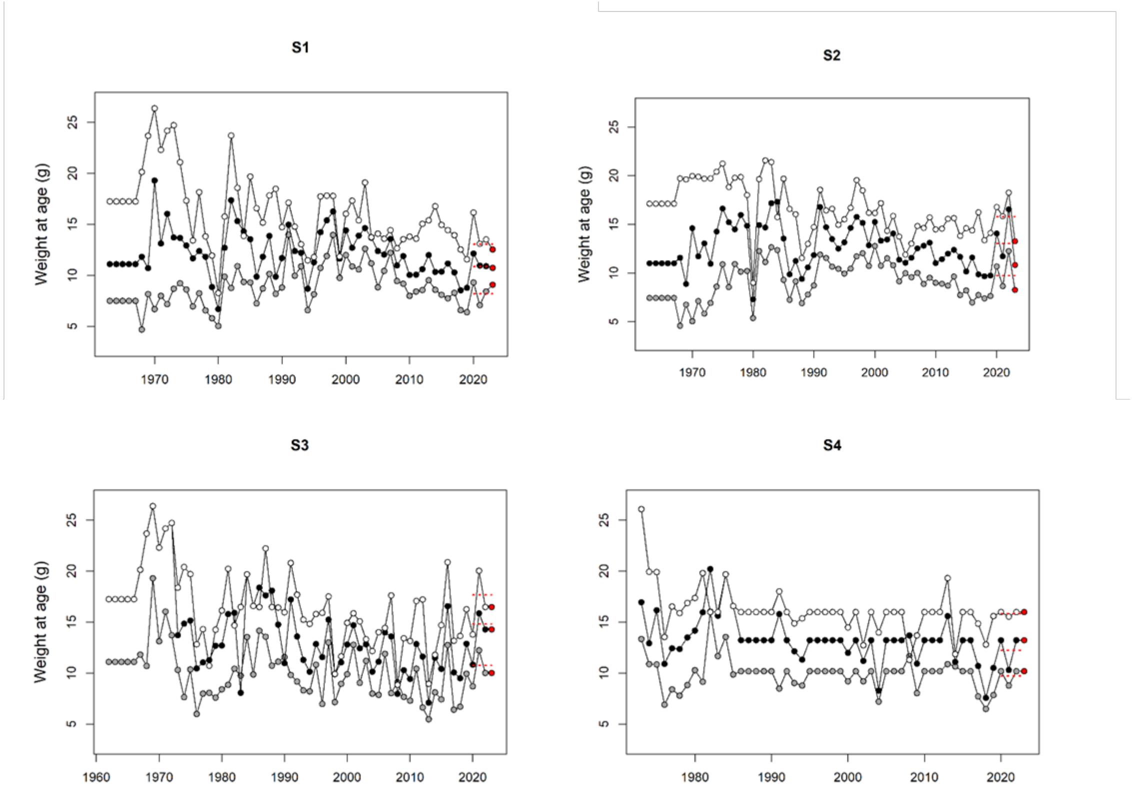


Figure 10.4.1. North Sea & 3.a sprat. Mean weight at age in season 1–4 (S1–S4) (years refer to the model year, e.g., 2021 = July 2021–June 2022). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year.

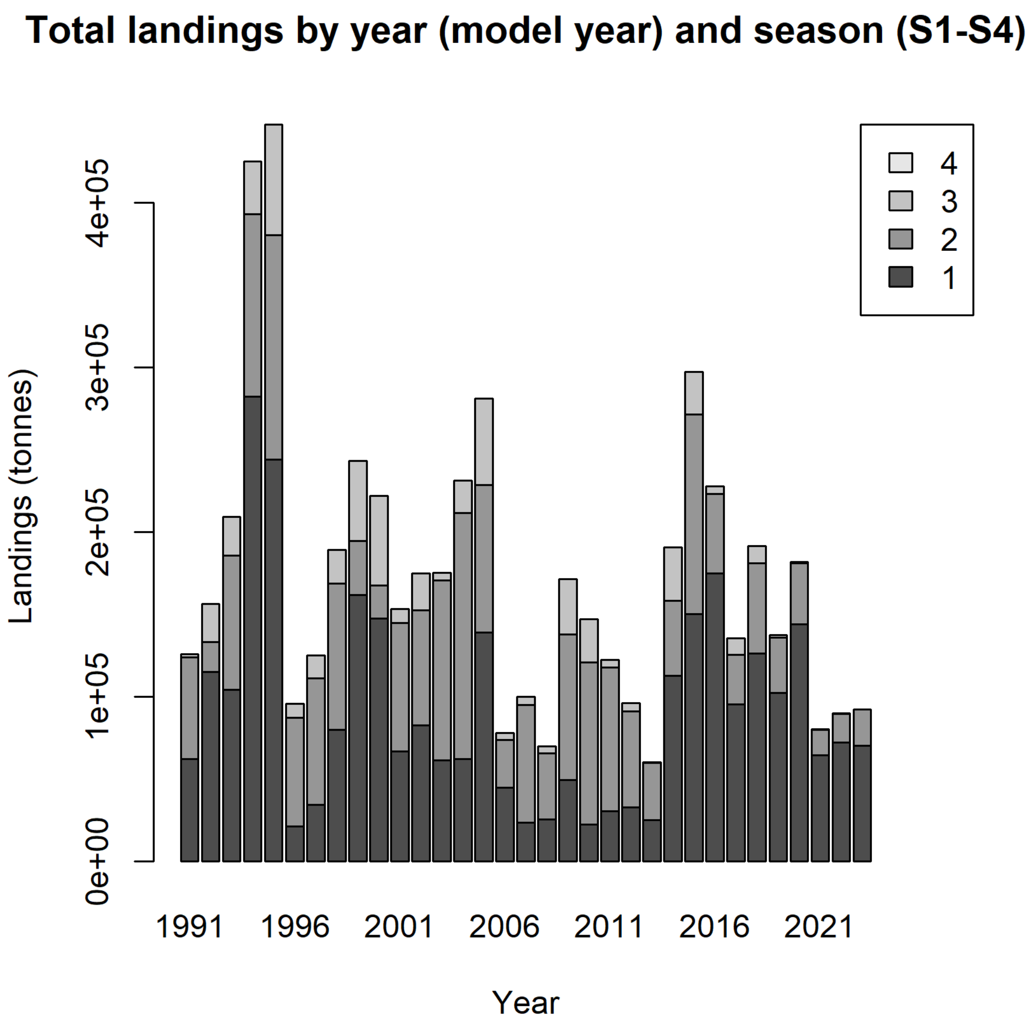


Figure 10.6.1a. North Sea & 3.a sprat. Seasonal distribution of catches. Year and season 1-4 refer to the time-steps of the model (e.g., 2021 = July 2021–June 2022). Note that since the model year of 2022 is not yet finished, the 2022 column

will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT 2018 report (ICES, 2018a) for details).

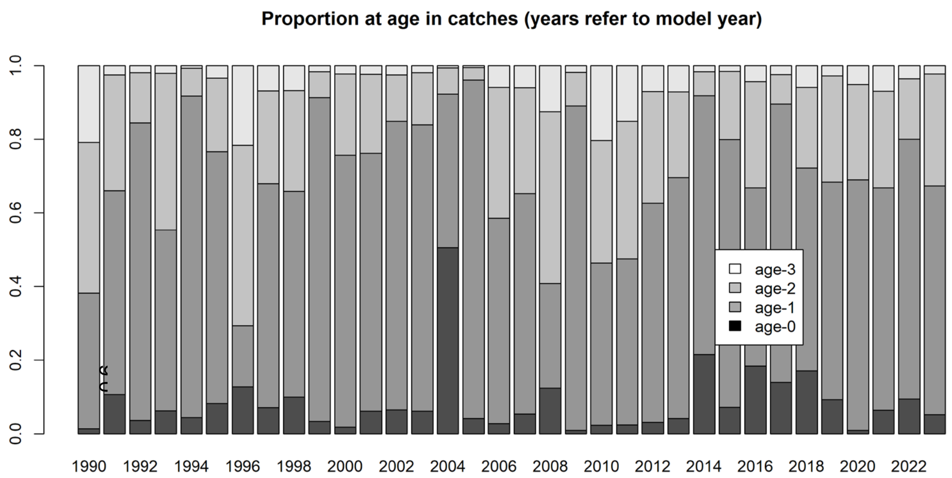


Figure 10.6.1b. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year (e.g., 2021 = July 2021–June 2022).

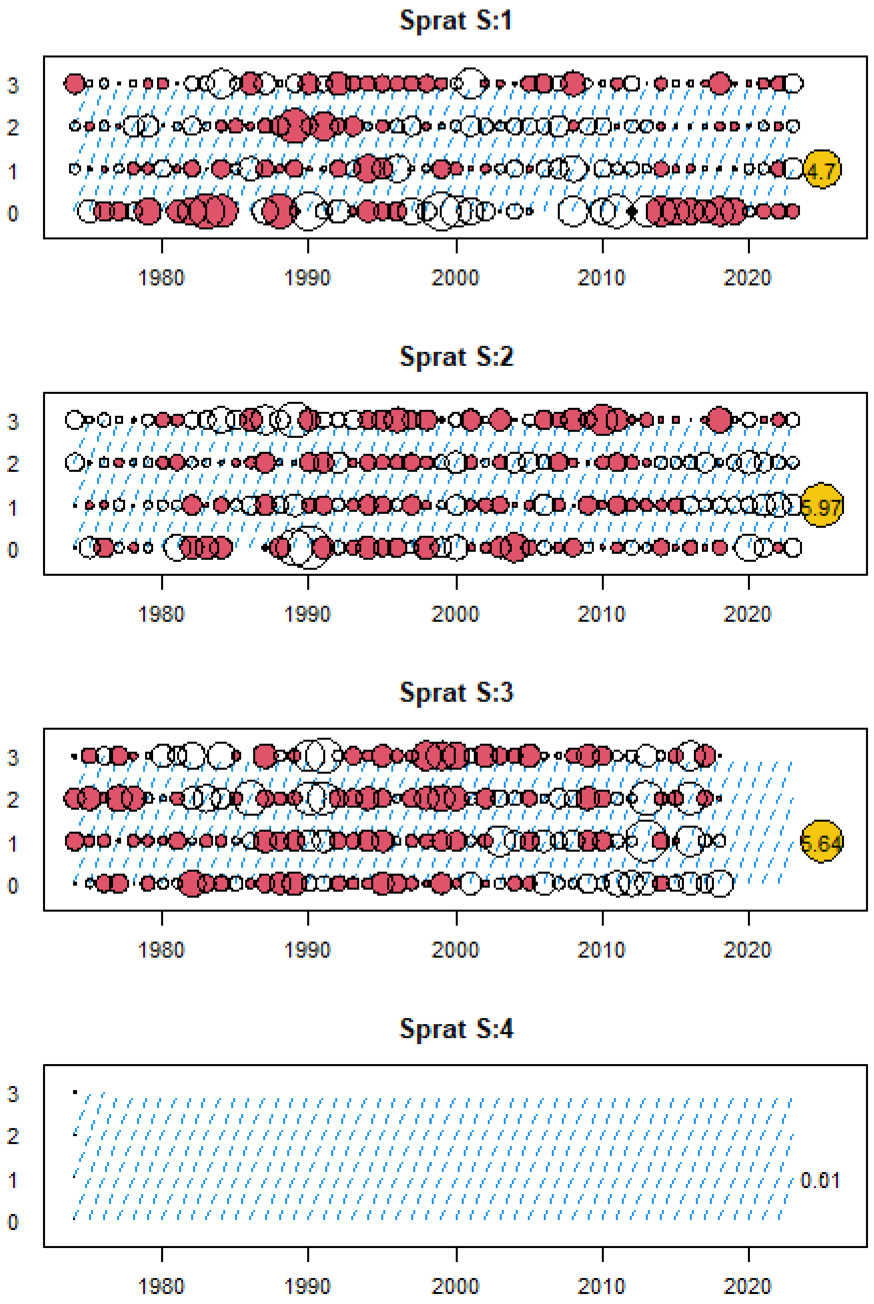


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

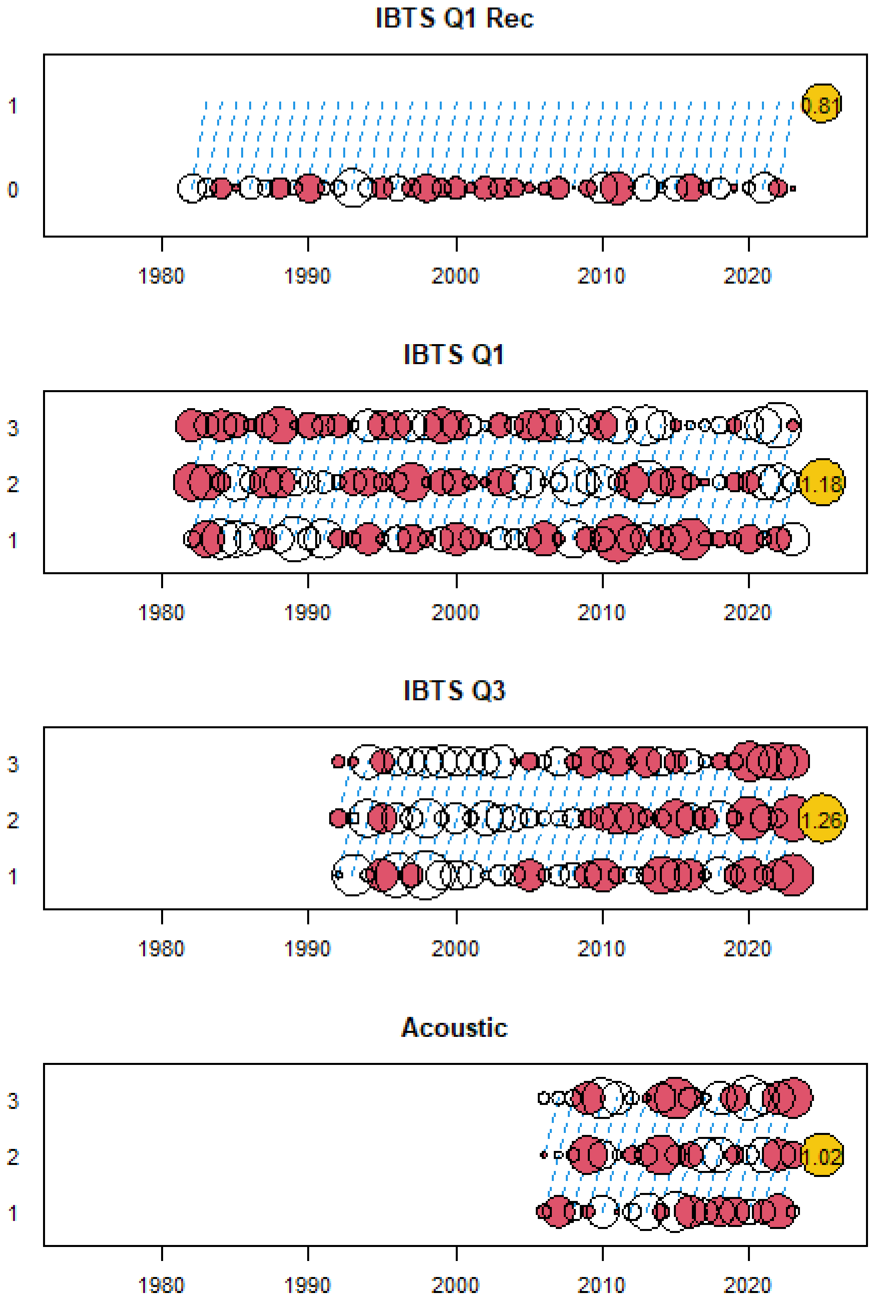


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

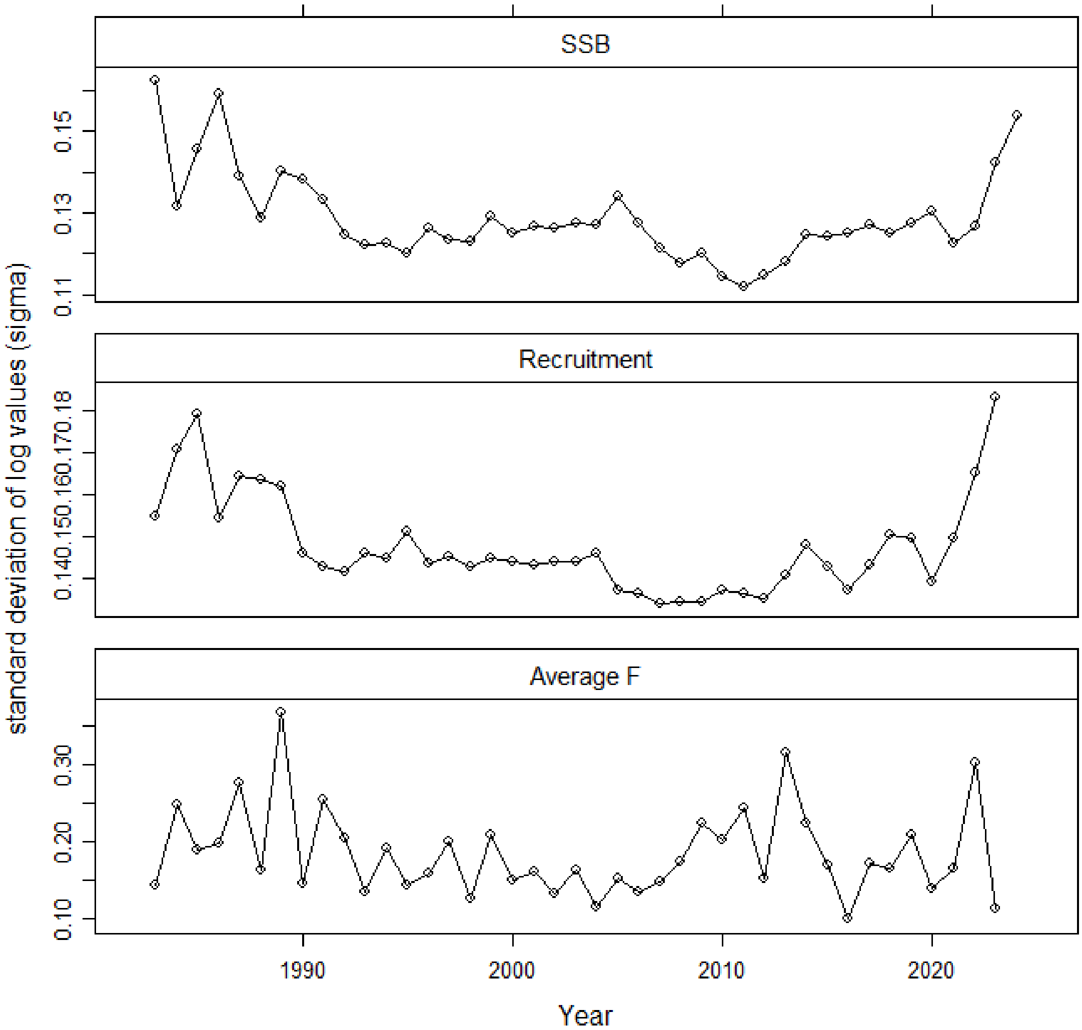


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year, e.g., 2021 = July 2021–June 2022).

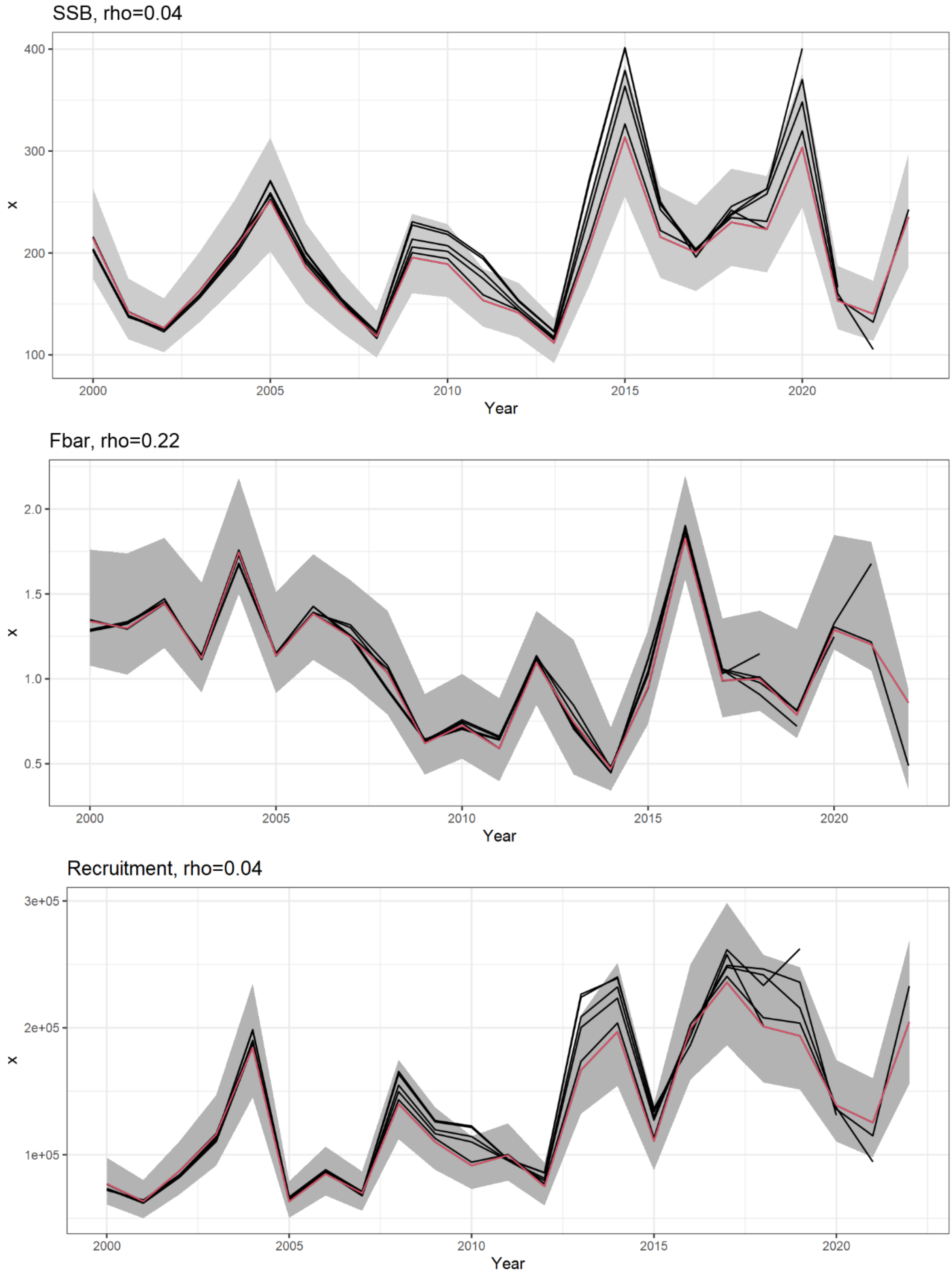


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year, e.g., 2021 = July 2021–June 2022)

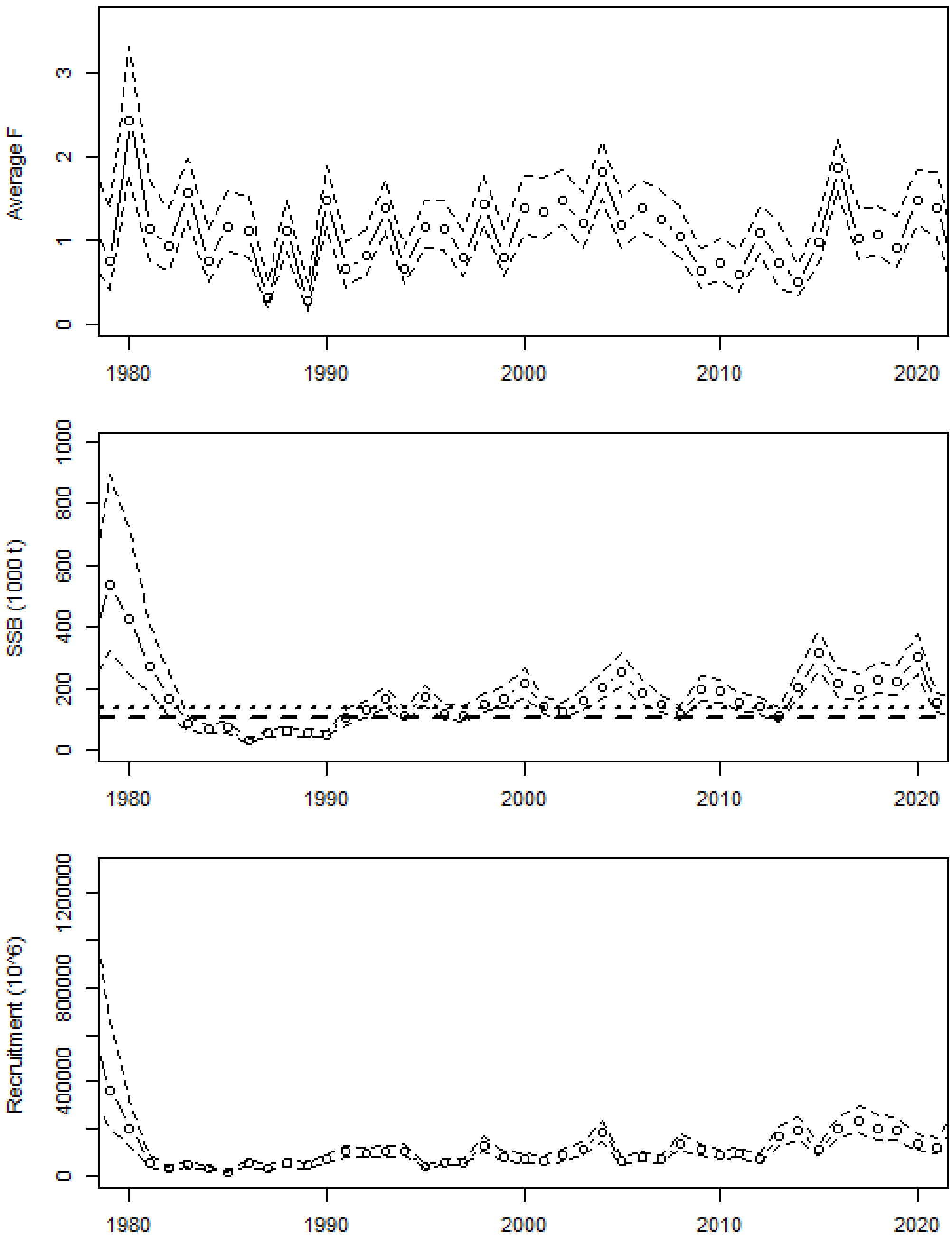


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year, e.g., 2021 = July 2021–June 2022).

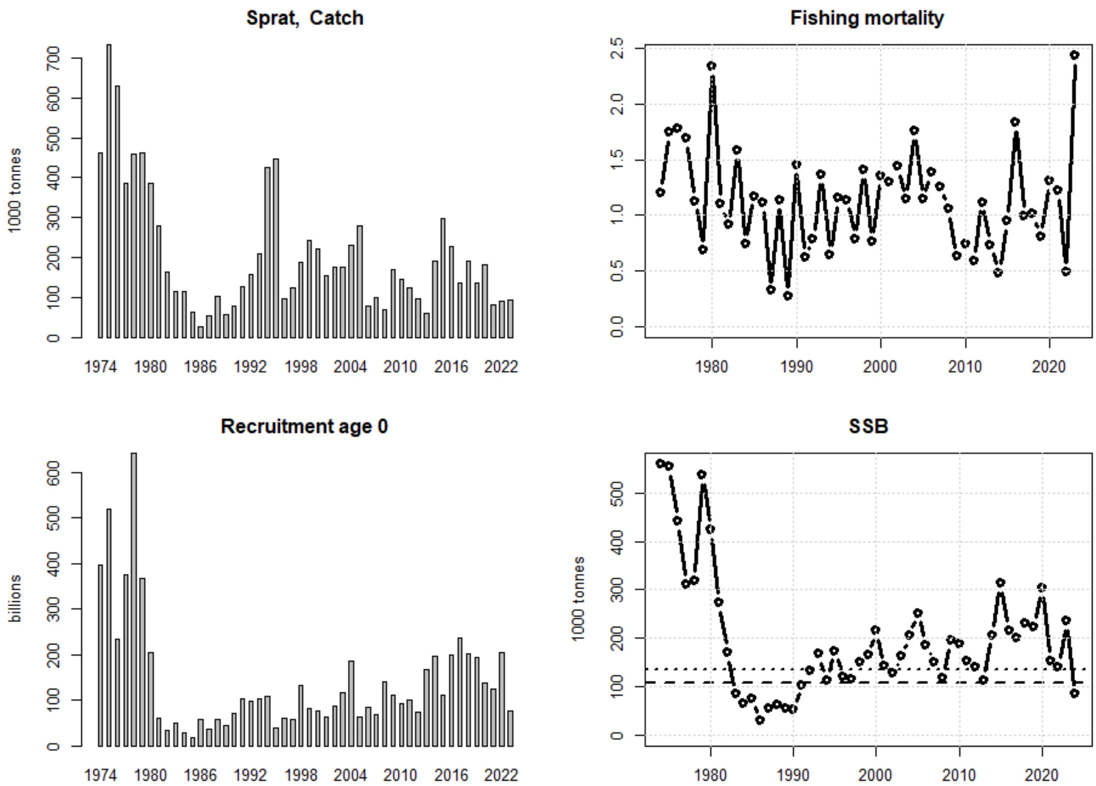


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year, e.g., 2021 = July 2021–June 2022).

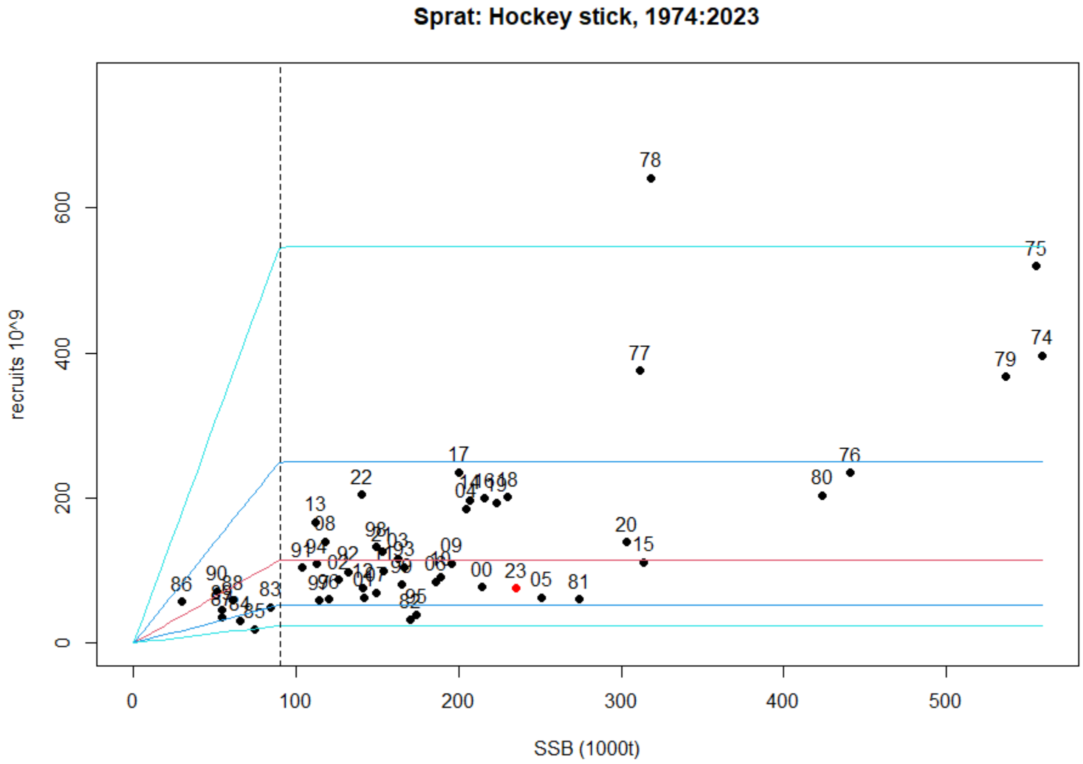


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year, e.g., 2021 = July 2021–June 2022).

10.15 References

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Lusseau et al. 2022.

11 Sprat in the English Channel (divisions 7. de)

The stock structure of sprat populations in this region is not clear, despite evidence from acoustic surveys suggesting the stock is mainly confined to the UK side of 7.e. Further investigations and work are required to resolve this uncertainty.

11.1 The Fishery

11.1.1 ICES advice applicable for 2023

The advised catch for the English Channel (7.d and e) was set equal to 5 250 tonnes.

11.1.2 Landings

The total sprat landings by country from 1986-2023 are provided in Table 11.1.1. Total landings from the international sprat fishery are available since 1950 (Figure 11.1.1.). Sprat landings prior to 1985 in 7.de were extracted from official catch statistics dataset (STATLANT27, Historical Nominal Catches 1950–2010, Official Nominal Catches 2006–2013), from 1985 onwards they come from WG estimates. Since 1985 sprat catch has been taken mainly by the UK (England, Wales and Northern Ireland). According to official catch statistics large catches were taken by Danish trawlers in the English Channel between the late 1970s and 1980s. The identity of these catches was not confirmed by the Danish data managers, raising the question of whether those reported catches were the result of species misreporting (i.e. herring misreported as sprat). Therefore, ICES cannot verify the quality of catch data prior to 1988.

The fishery starts in August and runs into February and sometimes March of the following year. Most of the catch is taken in 7.e, in the Lyme Bay area. In the last decade catch from the UK covered about 93% of landed sprat, however in 2015 and 2016 this percentage diminished, with the Netherlands and Denmark taking a portion of the catch. Denmark and the Netherlands represent the two principle “transient fishing fleets” that appear occasionally in the time series and have been allocated a portion of the TAC under the common fisheries policy in previous years. Since 2021, landings have been very low and this has been attributed to inadequate large sprat in the catch, leading to a short season for the UK fleet.

Sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation. This offshore/near shore shift may be related to environmental variability such as spatial and temporal changes in temperature and/or salinity.

11.1.3 Fleets

In the English Channel the primary gear used for the capture of sprat is midwater trawl. Within that gear type three vessels under 15 m have actively targeted sprat and have been responsible for the majority of landings. Since 2003 the UK fleet took on average 96% of the total landings. Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

11.1.4 Regulations and their effects

There is a TAC for sprat in ICES divisions 7.de, English Channel. Figure 11.1.2. shows the agreed TAC and the ICES catch from 2000-2023 and shows the catch is always below the agreed TAC.

11.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

11.2 Biological Composition of the Catch

11.2.1 Catches in number and weight-at-age

During the 2017/2018 fishing season a pilot self-sampling program started in the southwest of the UK, involving sprat fishers from Lyme Bay. This program has continued through to 2024 however very few sprat data have been received since 2021 as fish have not been of a marketable size. The graphs have therefore not been updated as data collected in 2019-2020 better represents the stock, when taken by the fishery. The 2019-2020 data shown are raw numbers-at-length in the samples, and not raised to the total catches (Figure 11.2.1 and Figure 11.2.2).

The skippers have collected length measurements from the catches and recorded information on fishing trips since 2018. In 2019, the sprat lengths in the fishers' samples ranged from 7.5 to 15 cm (Figure 11.2.1). The main processors for the fishery were engaged in 2019 and have provided length and weight data from landings subsamples. The length distributions recorded by the processors was reasonably consistent in 2020 (Figure 11.2.2). Due to low uptake in the fishery during 2021, the fishery operated for only two months of the season (August and September) and the FSP program provided very little data.

In 2021, the PELTIC survey reported a huge increase in sprat biomass combined with very strong recruitment (0-group) (Figure 11.3.3). These small fish were very widespread throughout the survey area. Anecdotal evidence from the fisheries self-sampling program (FSP) and fishers also support the survey findings, with the pelagic fisheries noting difficulties in being able to fish because of too much "whitebait" below marketable size. The demand in the fishery is tied more to size and marketability than stock biomass, with the processors reluctant to take catches with small fish.

11.3 Fishery-independent information

PELTIC Acoustic Survey (A6259)

Cefas carried out the annual PELTIC survey (Pelagic Ecosystem Survey of the Celtic Sea and Western Channel) in autumn in the English Channel and the Celtic Sea to acoustically assess the biomass of the small pelagic fish community within this area (divisions 7.e–f). Sprat is a target species of the PELTIC. The survey, conducted from the RV *Cefas Endeavour*, started in 2013, when it first focused only on UK waters but, from 2017, it expanded to also cover the southern area of division 7.e (French waters). In 2018 a one-off extension of the survey was conducted into division 7.d to investigate the presence of the stocks in the eastern Channel, the survey found almost no sprat present. This does not rule out the presence of the sprat in the eastern Channel, but was used in the absence of other evidence.

As detailed in the ICES survey manual (Doray *et al*., 2021), calibrated acoustic data were collected during daylight hours only at three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2 m below the surface. All non-fish acoustic targets were removed by creating a multi-frequency filter and only backscatter from swimbladder fish was retained for further analyses. The resulting echotraces were further partitioned by species based on the trawl catches and were converted into abundance and biomass estimates (plus Coefficient of Variation) in StoX software.

To convert acoustic biomass to abundance, a Target Strength (TS) equation is used. As no dedicated sprat specific TS equation is available for the area, the generic clupeid value of b20 = -71.2 dB is used. This was found to be an acceptable conversion and it was noted that more negatively values (leading to a higher biomass) have been used for sprat stocks in adjacent waters.

As part of the 2021 sprat inter benchmark process (IBP), the ability of the survey to capture the sprat stock (catchability) was evaluated, as this feeds heavily into assumptions of the management strategy evaluation (MSE). It was noted that the assessment is based on a biomass estimate from only a small area of the total management unit and is therefore likely to be a conservative estimate.

The survey also provides age and length structure for sprat aged 0–6 (Figure 11.3.2 and Figure 11.3.3). While there is high variability in the age distributions, this does not affect the overall estimate of biomass. However, it does preclude cohort tracking in the survey. The IBP found that the survey provided a robust estimate of biomass for application of a constant harvest rate (CHR) and is evaluated at two ICES working groups, WGIPS and WGACEGG, each year.

Biological data

Biological information from trawl catches carried out during the 2021 PELTIC acoustic survey, identified 5 age classes from 0 to 4 contributing on average to 91.61%, 2.1%, 5.9%,0.32%, and 0.02% respectively in the samples collected. The age structure observed in 2021 is shown in Figure 11.3.2 and 11.3.3.

2022 saw a large reduction in the PELTIC biomass index for the western survey stratum, down from 107 kt in 2021 to 28 kt in 2022. The number of age 1 fish identified by the PELTIC survey in 2022 was an order of magnitude below the number of age 0 fish identified in 2021 (7%), which may indicate either high mortality or migration of sprat. However, similar to 2021, age 0 sprat contributed the highest proportion of numbers of sprat observed.

In 2023, age 0 sprat also constituted the highest proportion of numbers of sprat observed. 25% of the number of age 0 fish identified in 2022 were observed as age 1 in 2023. Biological information from trawl catches for the 2023 survey were not made available in time for HAWG in 2024.

The large abundance of age 0 sprat identified during the PELTIC in recent years supports information from the fishery and is linked to the reduced catches in recent years, due to a high volume of small fish which are not of marketable size.

11.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

11.5 Recruitment

The acoustic surveys may provide an index of sprat recruitment in divisions 7.d–e.

11.6 Stock Assessment

This stock is considered a category 3 stock with the assessment and advice based on survey trends (ICES Advice 2018).

The stock went through an interbenchmark in February 2021 to update the assessment method based on the new guidance issued by WKLIFEX and developed by WKDLSSSLS2. The IBP tested the available data against the updated guidelines and assessed the suitability of three data limited methods for the stock.

1. 1 over 2 ratio-based advice with a 20% and an 80% uncertainty cap
2. Constant Harvest Rate
3. Surplus Production model (SPiCT)

Three exploratory SPiCT assessments were performed:

- an annual model using calendar year (January–December)
- an annual model using fishing year (July–June);
- a model using quarterly data.

The IBP concluded that SPICT analysis of the stock was not viable at this point in time due to the limited time series available for the PELTIC survey (2014–2020). There is also a strong transient component to the fishery from Denmark and the Netherlands which has not been present in recent years. The IBP determined that SPICT should be re-examined in the future.

A constant harvest rate (CHR) was determined by management strategy evaluation (MSE). The CHR was tested alongside the 1o2 with 80% and 20% uncertainty caps. The MSE tested three survey catchability options, with an assumption of 0%, 50% and 100% over estimation of the underlying biomass from the PELTIC survey. Assuming that some overestimation may take place on the survey, the IBP determined that the 50% overestimation should be adopted. Three scenarios of fishing pressure, prior to implementation of the catch advice options, were simulated for 25 years to establish starting points for the stock.

This MSE was carried out on a seasonal time step due to limitations in the framework. The IBP recommended that the annual advice move to an annual-seasonal calendar toreduce the time lag between survey and advice, while keeping the stock within the HAWG. WKDLSSLS determined that the reduced lag between survey and advice was the key component of providing precautionary advice for short lived species. A CHR determined on a seasonal timestep will still be applicable to the stock and is more precautionary than the 1o2 rule.

The CHR was found to be more precautionary for the stock than the current 1o2 rule (with both UC values), supporting the findings of WKDLSSL1 & 2. The CHR of 12% was the maximum value estimated under the 50% survey catchability overestimation level that kept the risk <5% in the long term under all fishing histories while giving the highest yield. A correction factor to the CHR was applied to account for a mismatch between survey weight at age in the PELTIC biomass and the weight at age in survey biomass simulated in the MSE. This was done to account for in year growth and results in a correction factor of 0.714 equal to the ratio of the MSEindex/"PelticIndex", where PelticIndex equates to the weight-at-age structure present at the time of the survey. This time-step accounts for a seven-month growth period, comprising the months between spawning in March and the survey in October. The IBP concluded that an adjusted CHR to 8.57% was the most appropriate assessment method for the stock (ICES, 2021).

Further investigation of the CHR, specifically using sprat in 7.de, was conducted at WKDLSSLS3 in 2021. The group examined the effect of applying an 80% uncertainty cap (UC) to the CHRs. The conclusion from this was an UC resulted in minimal risk reduction for CHR's below the 5% risk threshold. It did reduce risk for CHR's that are too high but could not bring them below the

ICES risk threshold. The only significant difference between CHR and CHR+UC was a decrease in interannual variability in the stock. This contrasts with work by other members of the WKDLSSLS group, who note that UC's may introduce unnecessary risks to the stock when requiring rapid reduction of catches. Alternatively following a drop of catch advice, may prevent recovery of yield (Fischer *et al*. 2020, 2021 and Sánchez-Maroño *et al*. 2021). The group found that unconstrained CHRs appear robust to past fishing history, initial stock status and advice schedule but are sensitive to survey catchability. No recommendations from the WKDLSSLS were made in regard to applying a UC to CHR's. Application of uncertainty cap is a current research topic and future guidelines may clarify how they are applied as part of a CHR.

11.6.1 Data exploration

Biomass Index

A 11-year time-series of biomass estimates from the PELTIC survey is shown in Table 11.6.1. The extension of the survey into ICES division 7.d and the southern part of 7.e suggests that the stock is mainly located in the more northerly part of division 7.e during October. The survey conducted in 2021 showed a very large concentration of age 0 sprat in Lyme bay (Figure 11.6.1 and 11.3.2). The 2022 survey only covered the western Channel substratum (Figure 11.6.2), however, did not identify large amounts of age 1 or 2 sprat in this area, indicating that these age 0 sprat either migrated or succumbed to high mortality between the 2021 and 2022 autumn surveys.

As in previous years, the highest sprat densities in autumn 2023 were found in the Lyme Bay region, although high numbers were also found in coastal waters further west around Eddystone (Figure 11.6.3).

In 2018, the PELTIC survey was extended into the eastern Channel and found no discernible sprat biomass, indicating a separation between 27.7.de and Sprat in the eastern Channel.

For more details on the survey design see Figure 11.3.1 and ICES (2022).

A 2015 analysis of the age distribution of sprat in the survey area shows a marked distinction between the young fish (0 and 1) found in the Bristol Channel and the older age classes that occupy the western English Channel (ICES 2015). Whether the two clusters belong to the same stock has yet to be determined: the circulation pattern of the area would allow sprat eggs/larvae to travel northward, from division 7.e to 7.g; however, the formation of a front in late spring/early summer seems to suggest these may be two different stocks.

The stock was examined using RAD-seq-derived SNPs (Restriction-site-associated DNA *sequencing* and single nucleotide polymorphisms) in 2020 (McKeown *et al*., 2020). This was part of a larger study of North Sea and Baltic sprat. The study found that amongst the North Sea population there was a lack of genetic differentiation between sampled stocks, indicating a high gene flow in the North Sea population. This would indicate that all sprat in the North Sea form one genetic unit, however the study suggests further work is needed. Specifically, for fisheries management, it should be noted that genetically connected stocks may still be isolated on the time scale of fisheries management.

11.7 State of the Stock

The acoustic estimates for 2017 (32 751 t) saw a threefold increase compared to the all-time low value in 2016 (9826 t), although the biomass is still half of the high levels recorded in the period 2013–2015 (70 680 t, 85 184 t and 65 219 t respectively) (Table 11.6.1). The PELTIC biomass increased substantially from 36 798 tonnes in 2020 to 107 355 tonnes in 2021, and reduced to 28 439 tonnes in 2022. In 2023, the biomass increased to 61 270 t which is comparable to the long-term average. The harvest rate has been less than 0.001%, attributed to a large number small sprat mixed in with the catch in 2021 and a continued absence of large marketable sprat since.

11.8 Catch Advice

Applying the constant harvest rate of 8.57% to the current estimate of PELTIC biomass gives an advised catch of 5 250 tonnes.

11.9 Short-term projections

No projections are presented for this stock.

Reasons for change in advice

The increase in advised catch this year is caused by the increased PELTIC biomass index in 2023, as the advised catch is derived by multiplying the survey index in tonnes by 0.0857.

Survey year	Advice year	Western Channel stratum tonnage	Advice (surveyed tonnage x 0.0857)
2022	2023	28439	2437
2023	2024	61270	5250

11.10 Reference Points

The IBP suggested the use of the Istat value developed as part of WKDSLLS2 (ICES, 2021b) as a proxy B_{lim} for the stock. The Istat is defined as:

Geomean(*Ihist*)*exp(-1.645*sd(log(*Ihist*))

Where *Ihist* refers to the biomass index, this gives a value of 11527.9 tonnes biomass for the stock. Note this should not be referred to as SSB or total biomass as SSB cannot be derived for the stock and the PELTIC does not capture the total biomass of the stock. Length based F (MSY) proxies were suggested by the ADG as being possibly applicable to the stock and providing useful information. They have not been explored to date but could be looked at in the future. The inclusion of the FSP sampling data (which includes length frequencies) could also be incorporated into these methods and provide interesting comparison between survey and fisheries derived data.

11.11 Quality of the Assessment

The coverage of the PELTIC acoustic survey was extended in 2017 towards the southern part of Division 7.e: this extension confirmed that the bulk of the sprat distribution in 7.e is located in Lyme Bay and surrounding areas, and it does not tend to extend outside the western Channel stratum. The transects carried out off the French coast found very little sprat, mostly of ages 0 and 1. Sprat have since been recorded off the coast of France and around the Channel Islands in 2018, 2019, whilst 2021 also saw sprat present off the coast of France. These fish do not feed into the advice, as they lie outside of the core Lyme bay area.

The extent to which the population migrates into division 7.d was investigated during the 2018 survey. The survey showed that very little sprat was found on the eastern border of division 7.e and very little found in 7.d.

Concerns have been raised about the connection between the western English Channel stock and the Bristol Channel, where large numbers of juveniles are found. It is currently believed the Bristol Channel may represent a separate stock. See the data exploration section for details.

Material presented in 2023 to HAWG on the channel groundfish survey (CGFS) indicated that the amount of sprat in 7.d should not be assumed to be negligible. Issues may exist with indices derived from this survey due to a vessel change in 2015, however it is advised that a comparison is made with the PELTIC index from 2015 onwards. The survey gear is a GOV like for the IBTS, and hence not targeted to sprat. However, CGFS results indicate a large presence of sprat on the French side of the Channel around the Baie de la Seine (Figure 11.1.1; Figure 11.1.2). Also shown in CGFS data are a decreasing mean length of sprat over the last decade in both the eastern and the western English Channel (Figure 11.1.3). Considering the low fishing pressure in the stock area over the last decade, this is suspected to be ecologically (climate change) driven.

11.12 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat annual landings from 7.d–e over the past 20 years have been 2 338 tonnes on average. The average harvest rate for the 10-year time-series is 0.06%.

The strong biomass fluctuations observed in the acoustic index and the relatively large increase in biomass observed in 2017 and 2021 suggests that the low level of catch is not impairing the stock.

As of 2021, an agreement has been reached between the ICES members to move the advice to a seasonal calendar in line with the fishery for 2022/2023. The advice will now run across the fishing season (1 July–30 June) instead of on an annual basis.

The PELTIC survey takes place in October of the advice year minus 1, with the advice issued in April of the advice year for the fishing season. The fishing season runs from 1 July advice year, to 30 June advice year plus 1. Therefore, there is an 8-month delay between survey and advice. This is a weakness in the advice as sprat can undergo rapid changes in biomass. The TAC issued separately to the ICES advice has been issue on a seasonal basis since 2022. A small delay is still present but has been greatly reduced. A further improvement to better respond to changing stock conditions would be a review mechanism at the time of the PELTIC in October to update the advice, if needed. However, this would present problems for issuing of the advice and there is currently little appetite to reopen advice mid-year for stocks in ICES or member states.

11.13 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no analysis available on the total amount of sprat, and in general of other pelagic species, taken by seabirds, marine mammals, and large predators in the Celtic Seas Ecoregion. However, a wide spectrum of data that covers the whole trophic chain have been collected during the PELTIC acoustic survey: these data will in the future provide a substantial contribution to the knowledge base for the area.

11.14 Tables and Figures

Table 11.1.1 Sprat in 7.d-e. Landings of sprat, 1988–2023.

Country	Denmark	France	Germany	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Total
1988	2529	2	0	1	2944	0	5476
1989	2092	10	0	0	1520	0	3622
1990	608	79	0	0	1562	0	2249
1991	0	0	0	0	2567	0	2567
1992	5389	35	0	0	1791	0	7215
1993	0	3	0	0	1798	0	1801
1994	3572	1	0	0	3176	40	6789
1995	2084	0	0	0	1516	0	3600
1996	0	2	0	0	1789	0	1791
1997	1245	1	0	0	1621	0	2867
1998	3741	0	0	0	1973	0	5714
1999	3064	0	0	1	3558	0	6623
2000	0	1	0	1	1693	0	1695
2001	0	0	0	0	1349	0	1349
2002	0	0	0	0	1196	0	1196
2003	0	2	0	72	1368	0	1442
2004	0	6	0	0	836	0	842
2005	0	0	0	0	1635	0	1635
2006	0	7	0	0	1969	0	1976
2007	0	0	0	0	2706	0	2706
2008	0	0	0	0	3367	0	3367
2009	0	2	0	0	2773	0	2776
2010	0	2	0	0	4408	0	4411
2011	0	1	0	37	3138	0	3176
2012	6	2	0	8	4458	0	4474
2013	0	2	0	0	3793	0	3795
2014	45	3	0	268	3357	0	3674

Coun-try	Denmark	France	Germany	Nether-lands	UK Eng+Wales+N.Irl.	UK Scotland	Total
2015	0	1	0	352	2659	0	3012
2016	185	7	49	227	2867	0	3334
2017	0	0	34	232	2496	0	2762
2018	474	1	0	0	1804	0	2279
2019	0	1	28	0	1544	0	1573
2020	0	1	0	0	873	0	873
2021	0	0.3	0	0	48.7	0	49
2022	0	4	0	0	8	0	12
2023	0	0	0	4	37	0	41

Table 11.6.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas PELTIC acoustic survey)

Year	Western Channel stratum	Full survey area
2013	70680	96682.4
2014	85184	153126.9
2015	65219	286902.8
2016	9826	30788.8
2017	32751	198454.2
2018	21772	106431.2
2019	36789	111072.8
2020	33798	61222.1
2021	107355	265765.9
2022	28439	NA
2023	61270	NA

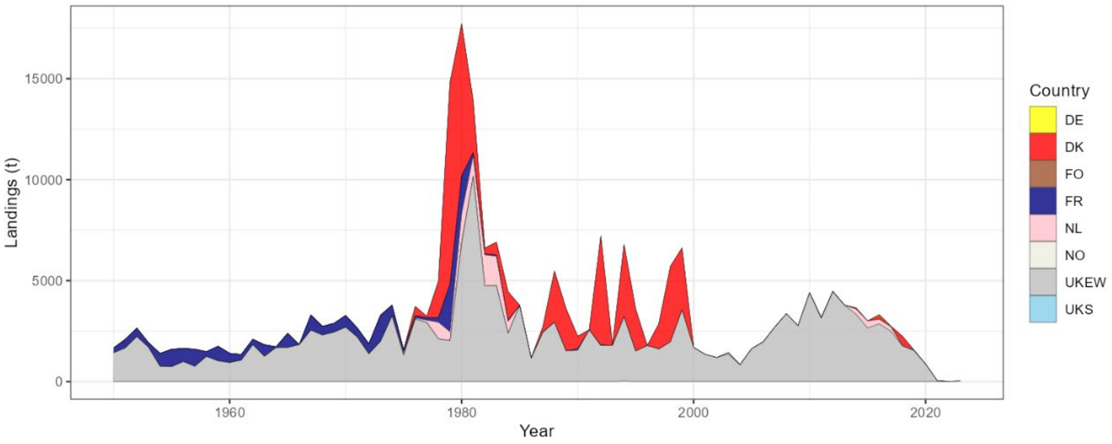

Figure 11.1.1. Sprat in 7.d-e. Landings of sprat 1950–2023.

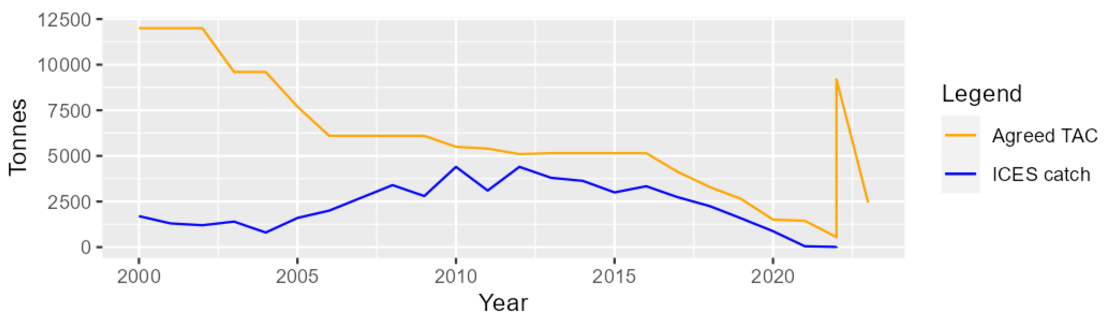

Figure 11.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2023. The two TAC values for 2022 reflect the change in advice period in the same year from calendar year to 1st July-30th June. The lower TAC value (550 t) represents the agreed TAC for 1st January 2022-30th June 2022 while the higher TAC value represents the agreed TAC for 1st July 2022-30th June 2023.

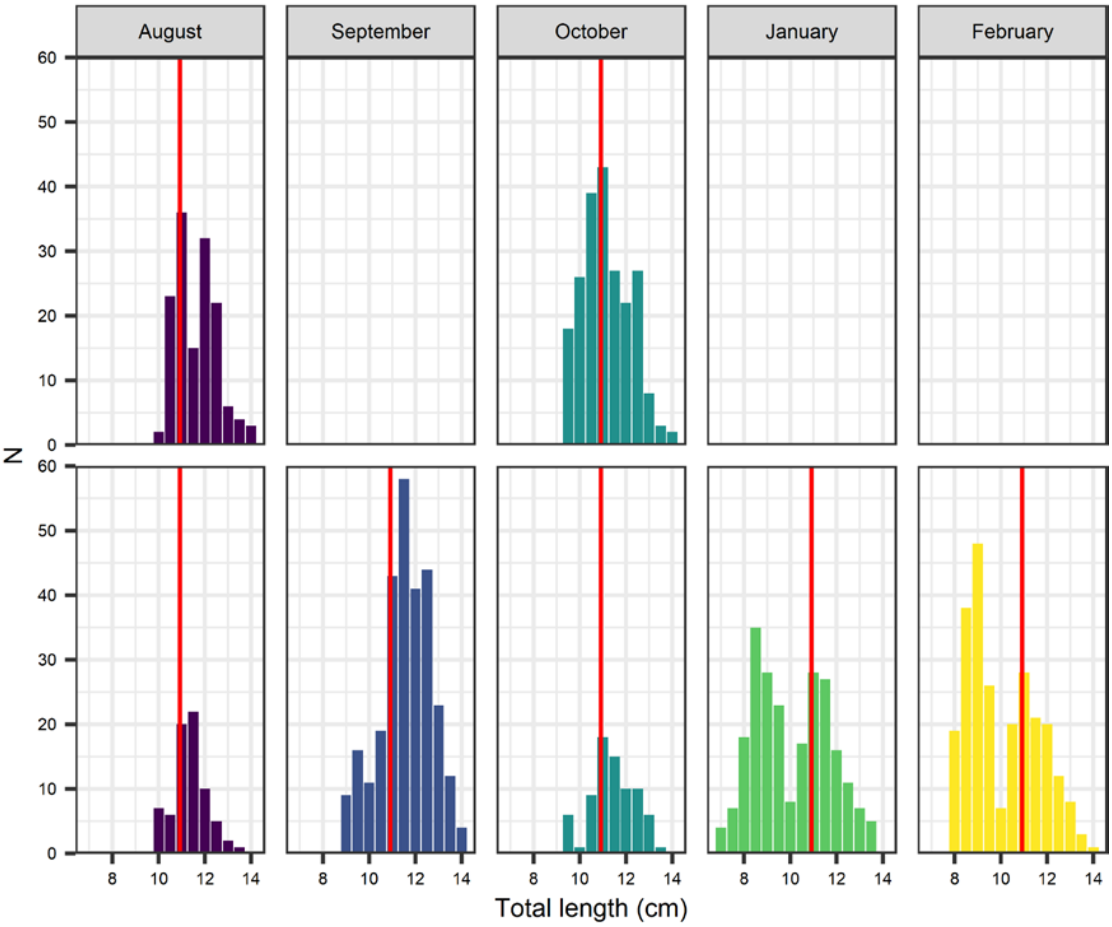

Figure 11.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month 2019, for the two boats supplying the FSP program.

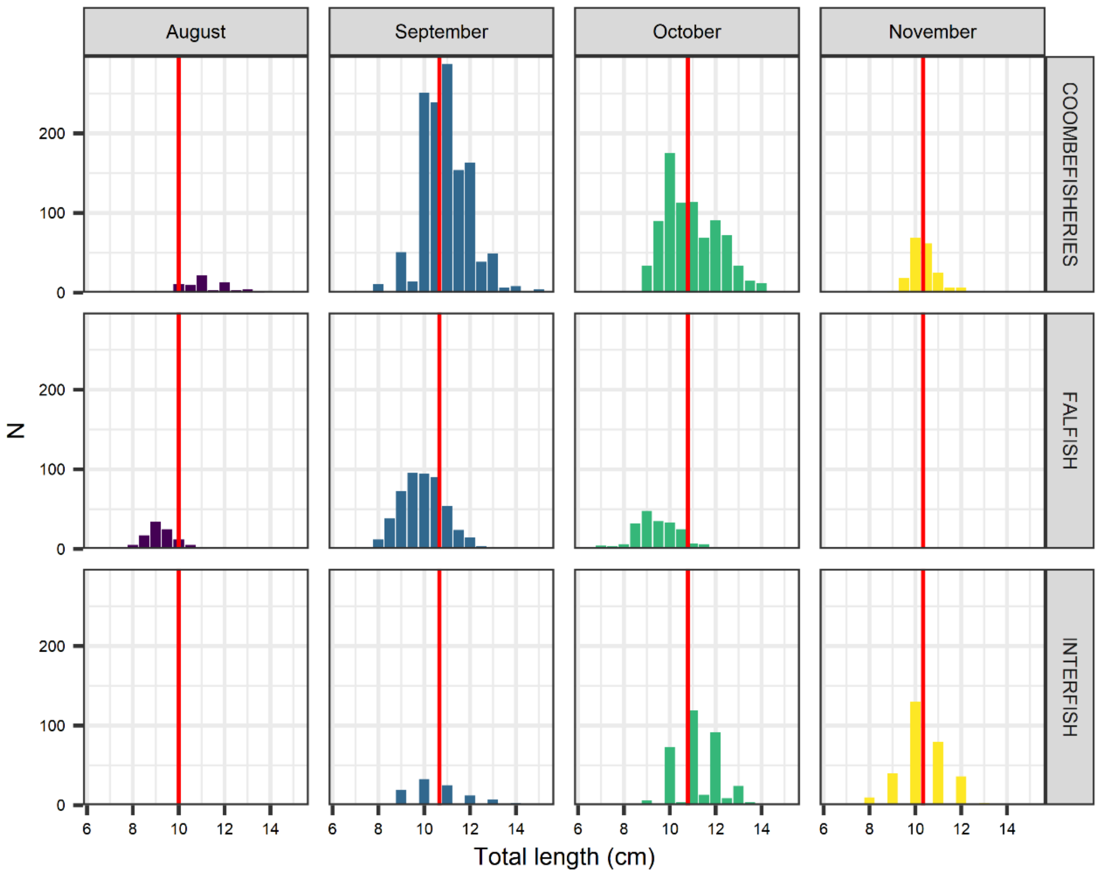

Figure 11.2.2. Monthly sprat total length distribution collected by the three processors in the 2020 season. Red line indicates weighted mean length at each month.

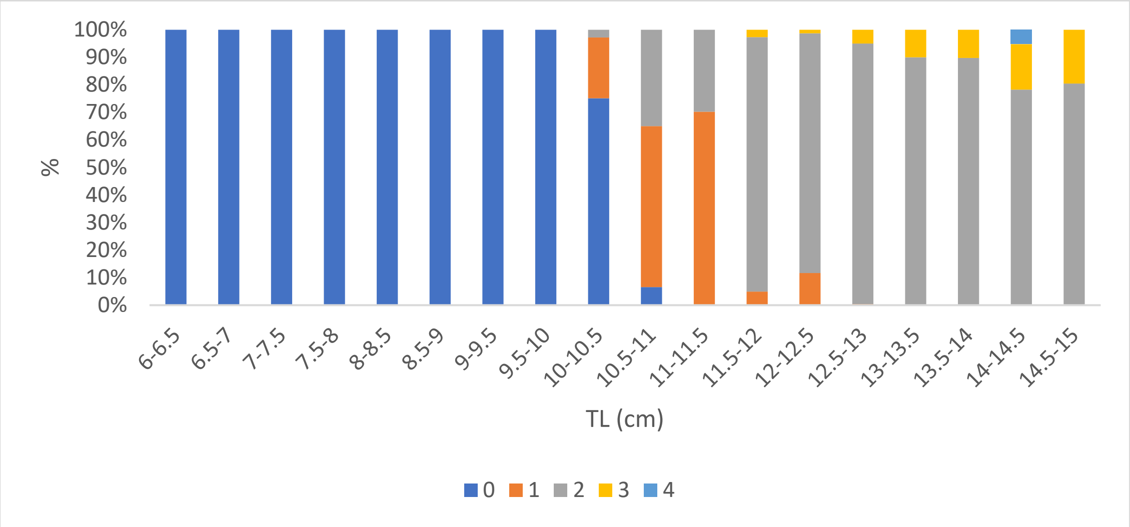

Figure 11.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2021 PELTIC acoustic survey.

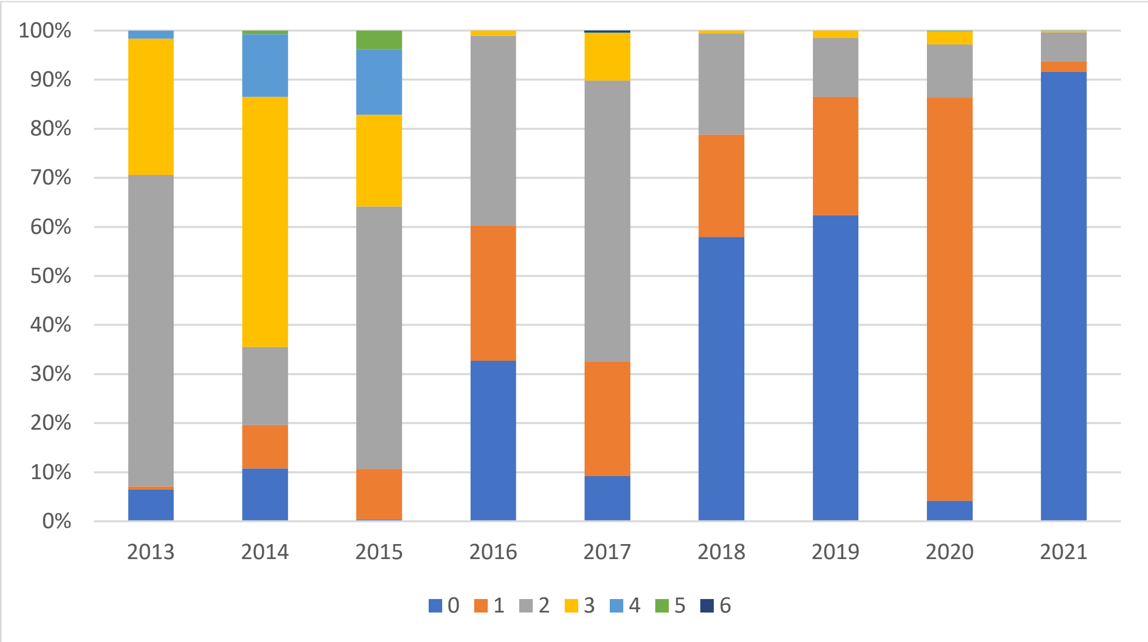

Figure 11.3.3. Sprat in 7.d-e. Proportion of numbers-at-age in the biological samples collected during the 2013–2021 PELTIC acoustic surveys.

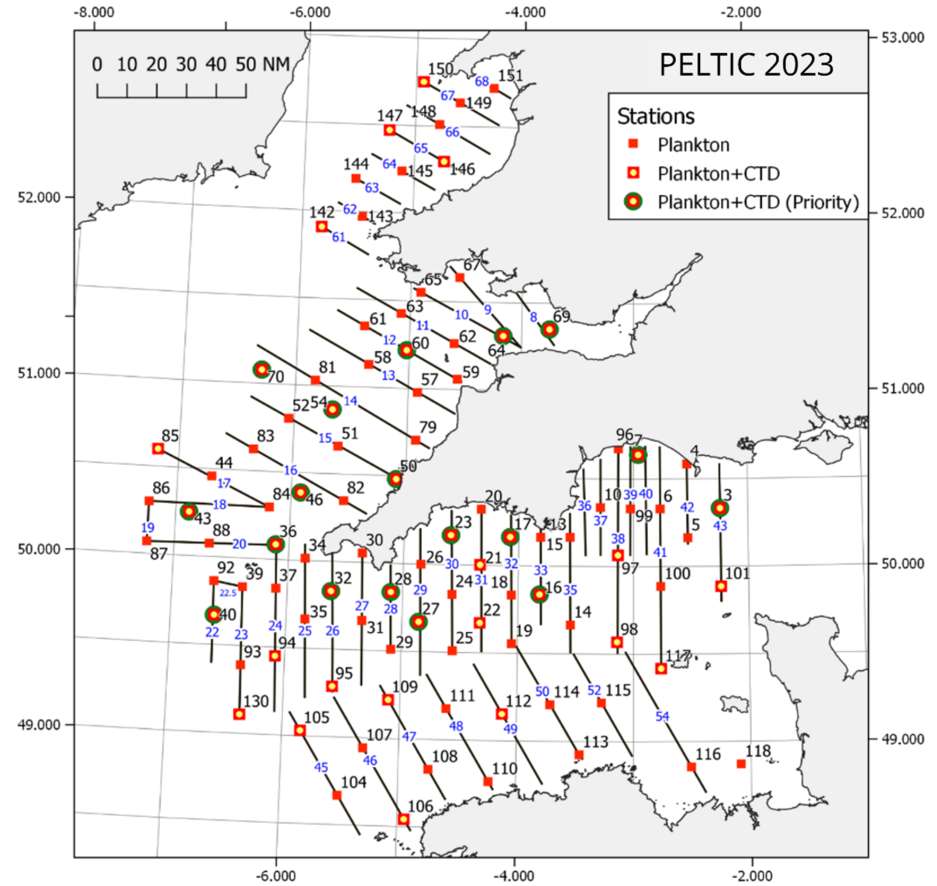

Figure 11.3.1. Sprat in 7.d–e. Survey design (2023) with acoustic transects (black lines, numbers in blue), plankton stations (red squares) and hydrographic stations (yellow circles).

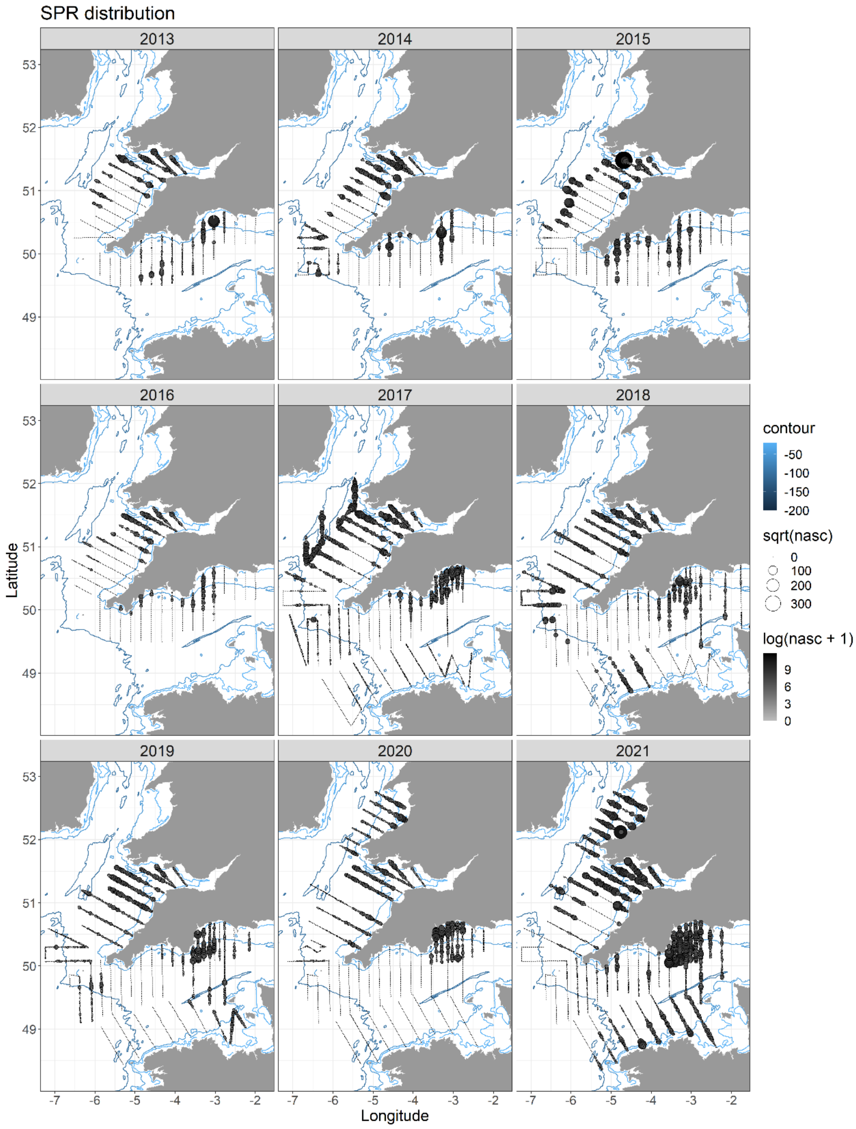

Figure 11.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2013–2021 PELTIC surveys.

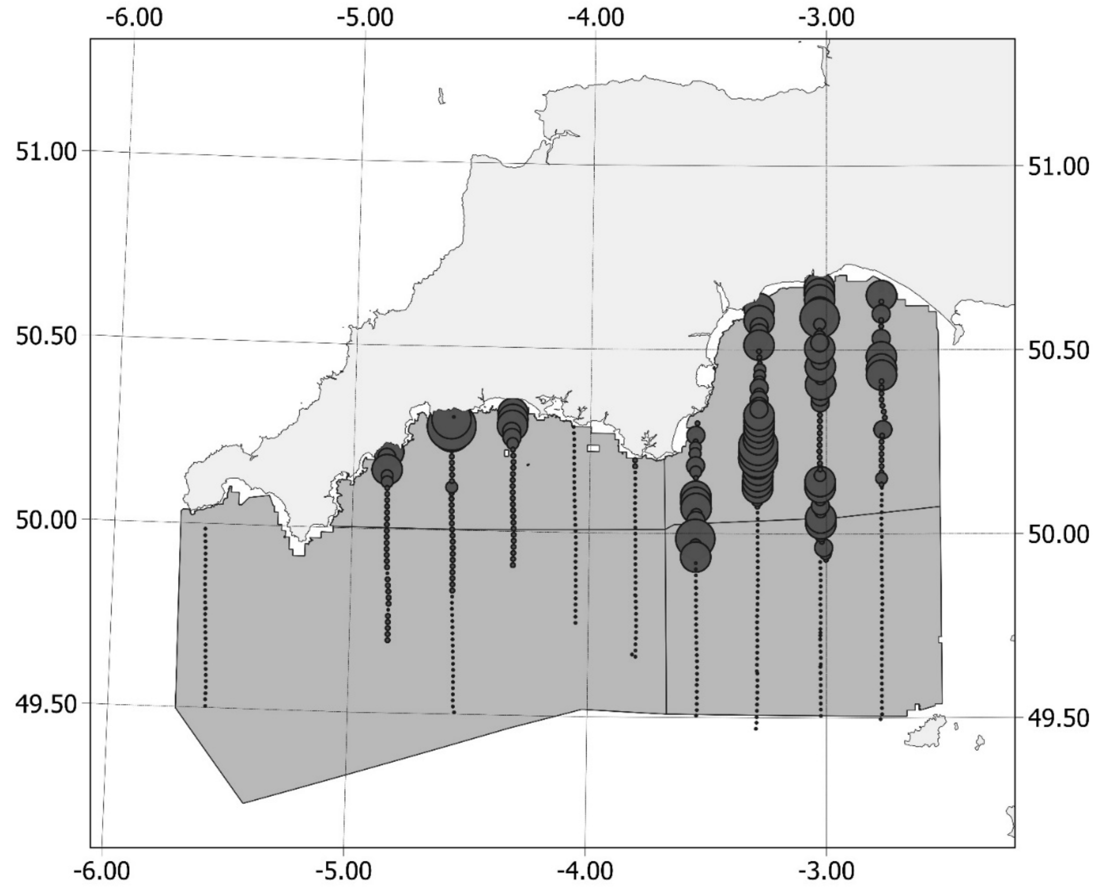

Figure 11.6.2. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2022 PELTIC survey, which reduced spatial coverage.

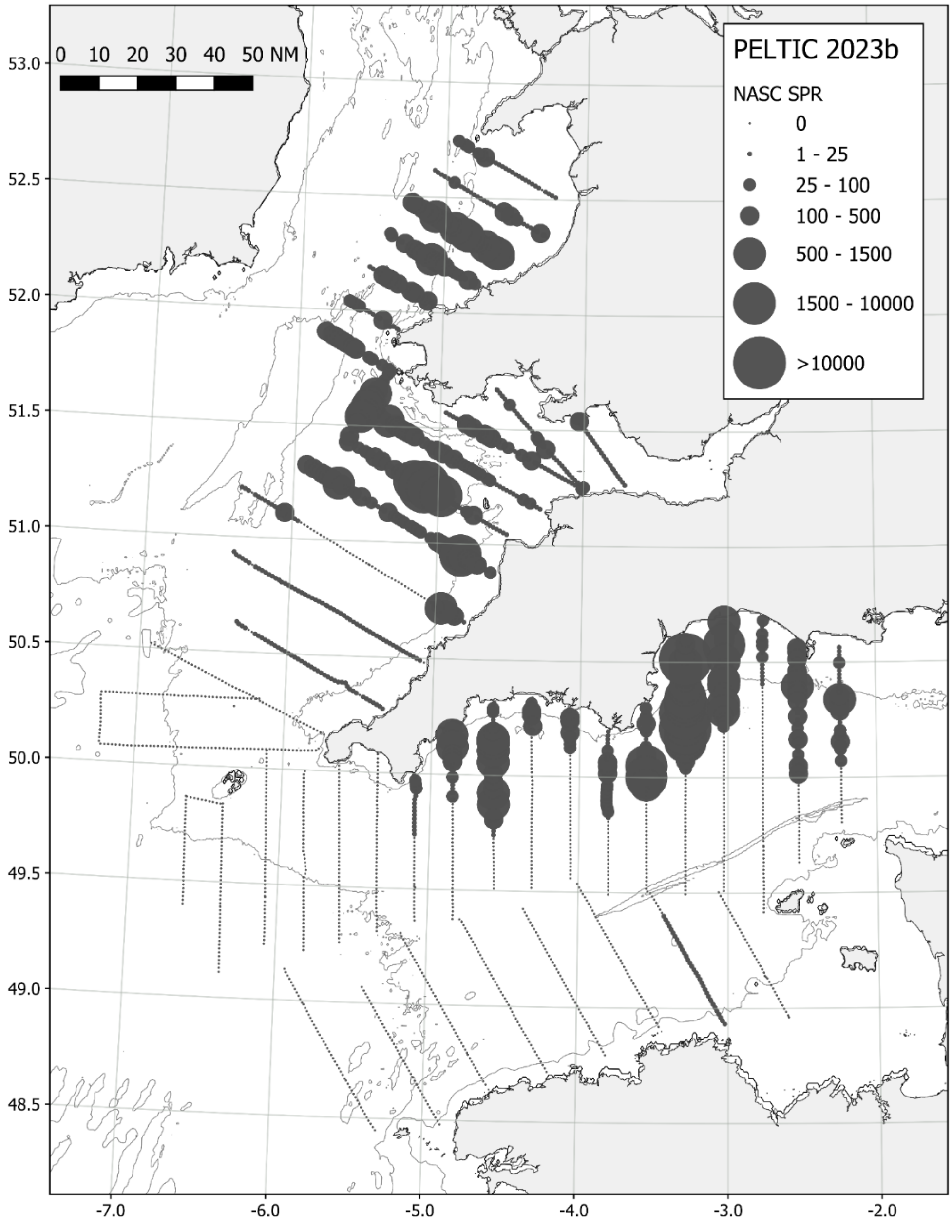

Figure 11.6.3. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2023 PELTIC survey.

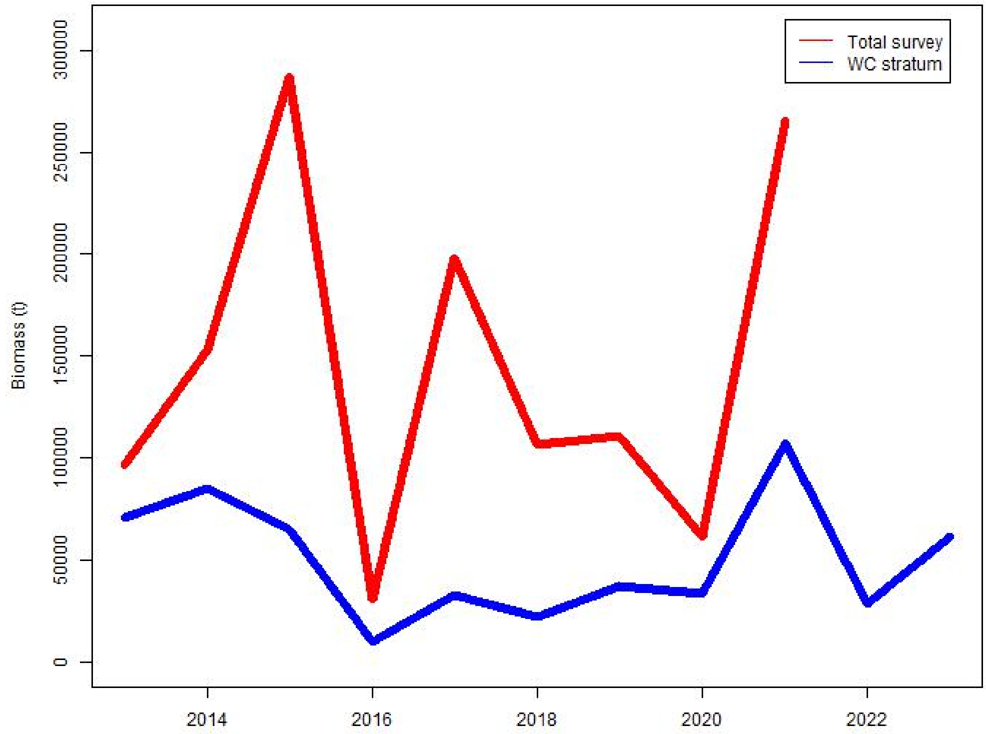

Figure 11.6.4. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2023 for the total survey area (red line) and the western Channel substratum (blue line). A biomass estimate for the total survey area could not be estimated for 2022 due to reduced survey coverage. A total survey area biomass estimate for 2023 was not yet available for HAWG 2024.

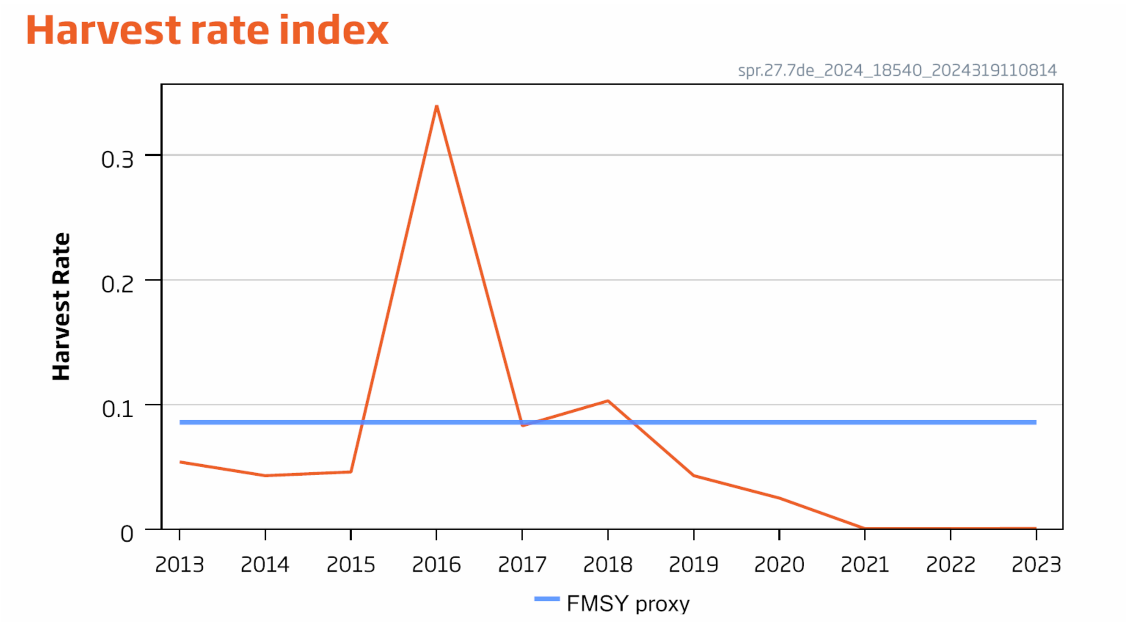

Figure 11.7.1. Sprat in 7.d-e. Constant Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

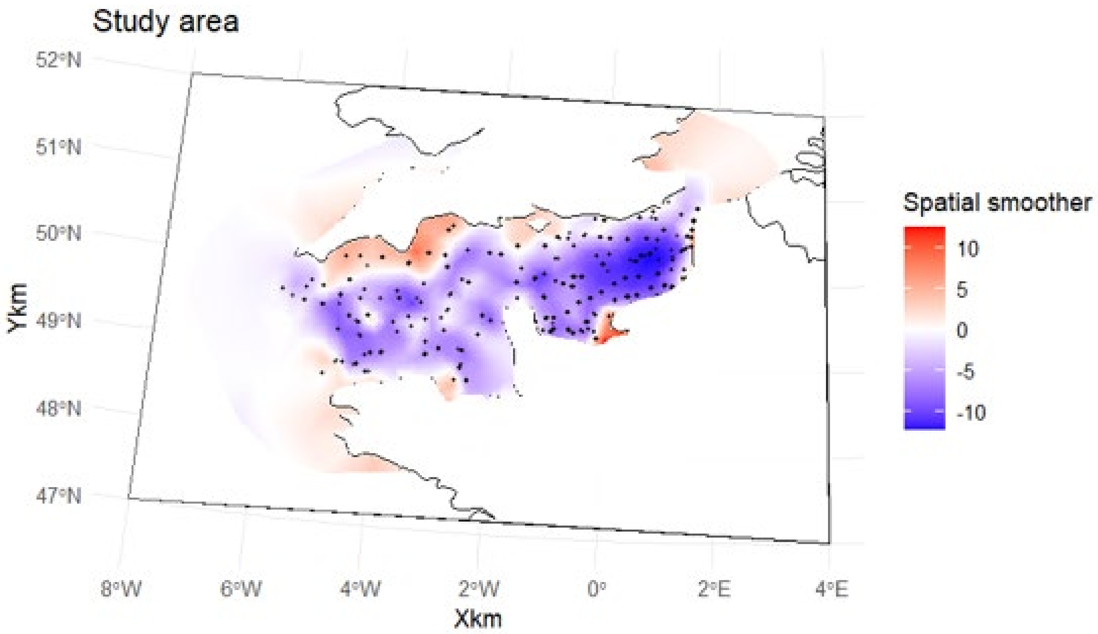

Figure 11.11.1. Spatial distribution of sprat in the English Channel estimated during the CGFS groundfish survey over the period 2018-2023.

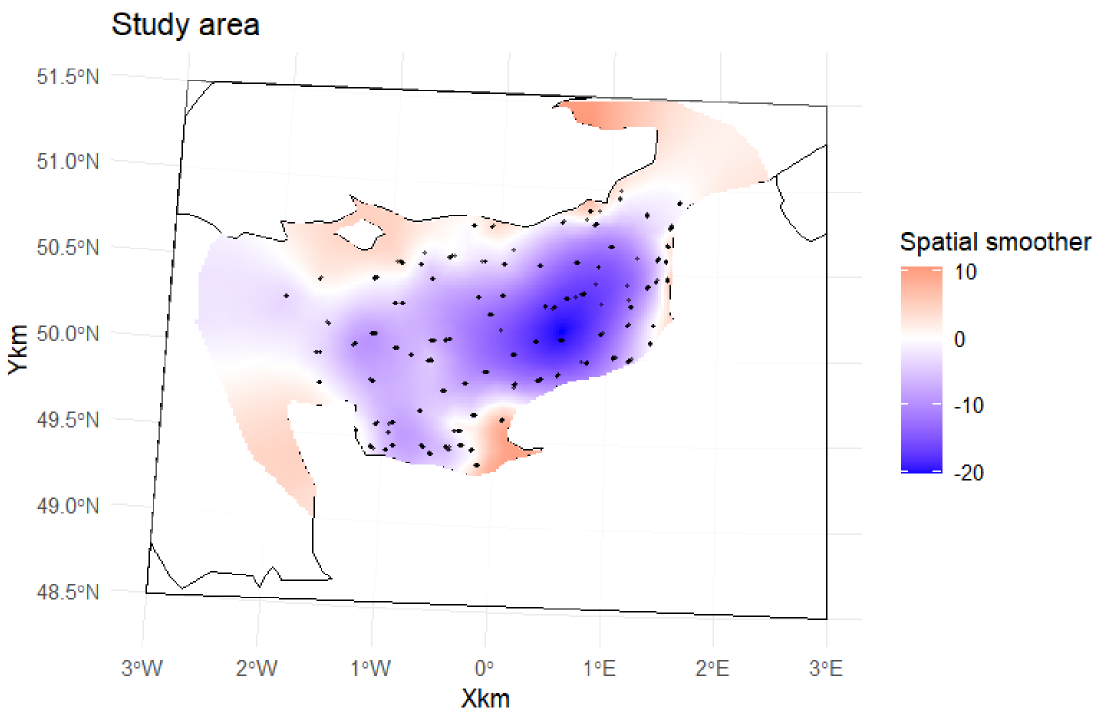

Figure 11.11.2. Spatial distribution of sprat in the eastern English Channel estimated during the CGFS groundfish survey over the period 2015-2023.

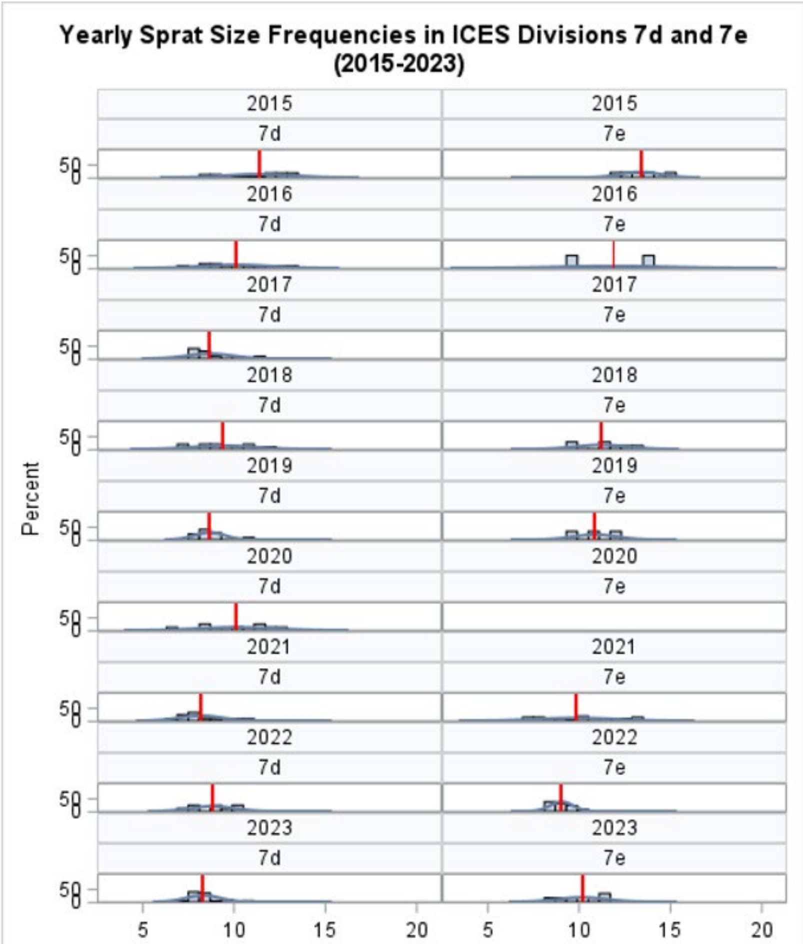

Figure 11.11.3. Length frequency (%) plots for 7d and 7e from the IBTS groundfish survey between 2015-2023. Red vertical line indicates mean length.

11.15 References

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12 Sprat in the Celtic Seas (Subarea 6 and divisions 7.a-c and 7.f-k)

Most sprat fisheries in the Celtic Seas area are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (6.aN); in Donegal Bay (6.aS); Galway Bay and in the Shannon Estuary (7.b); in various bays in 7.j; in 7.aS; in the Irish Sea. A map of these areas is provided in Figure 12.1.

The stock structure of sprat populations in this ecoregion is not clear. In 2014, HAWG presented an update of the available data on these sprat populations, in a single chapter. However, HAWG does not necessarily advocate that subareas 6 and 7 constitutes a management unit for sprat, and further work is required to resolve the problem.

12.1 The Fishery

12.1.1 ICES advice applicable for 2024 and 2025

ICES analysed data for sprat in the Celtic Sea and West of Scotland. Currently there is no TAC for sprat in these areas, and it is not clear whether there should be one or several management units. ICES stated that there is insufficient information to evaluate the status of sprat in this area. There- fore, when the precautionary approach is applied, ICES advises that catches should be no more than 2240 t in 2024 and 2025. The TAC for the English Channel (7.d and e) is the only one in place for sprat in this area.

12.1.2 Catches

The total sprat catches, by ICES Subdivision (where available) are provided in Tables 12.1.1–12.1.7, with the total catches in Table 12.1.8, and in Figures 12.2.1–12.2.8. Only Ireland and the United Kingdom (Scotland) recorded catches from the stock in 2023, with Ireland taking the majority of the catches (Table 12.1.8).

12.1.3 Division 6.a (West of Scotland and Northwest of Ireland)

Catches have been dominated by UK-Scotland and Ireland (Table 12.1.1). The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in catches between the two countries are similar. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

The Scottish fishery is mainly for human consumption and is typically a winter fishery taking place in November and December, occasionally continuing into January. Catches were high in the early part of the time-series, with two periods of intense fishing pressure where annual catches exceeded 10000 t in the period 1972 to 1978 (Figure 12.2.1) and again in the period 1995 to 2000. In 2005 to 2009. The fishery was virtually absent but has fluctuated greatly since 2010, with only 1 t taken in 2018 followed by of 4575 t in 2019. A total of 976 tonnes was taken in 2023, by both Ireland and Scotland.

12.1.4 Division 7.a

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea. This was an industrial fishery and catches were high throughout the 1970s, peaking at over 8000 t in 1978 (figures for 7.aN are presented in Table 12.1.2 and 7.aS presented in Table 12.1.3). The fishery came to an end in 1979, due to the closure of the fishmeal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s, UK vessels landed up to 500 t per year.

Irish Catches from 1950–1994 may be from 7.aN or 7.aS. Very high catches in 7.aS were reported in 2012 (Table 12.1.3) with a decrease in 2013 and only 16 t reported in 2014. In 2015 the catches increased to over 3500 t and dropped again to less than 1000 t in 2016. Despite the high catches registered in some years, those figures should be interpreted with caution because they may be overestimated. In 2020 catches from 7.aS were 6888 tonnes up from 2785 tonnes in 2019. Another 7861 t were landed in 2021 and 2026 t were landed in 2022. A total of 1432 t were landed in 2023. Irish catches from 7.aS are predominantly from Waterford Harbour (Table 12.1.3)

No catches from 7.aN were reported by Ireland in 2009–2013 or 2018 (Table 12.1.2), however there have been reported catches of 522 t in 2014, 771 t in 2015 and 150 t in 2016 and 2017. Irish catches in 2020 were 2521 tonnes up from 9 tonnes in 7.aN in 2019. Scotland reported less than a tonne of catches over 2021-2022 while Ireland took 381 tonnes in 2021 and 491 tonnes in 2022. No catches from 7.aN were reported in 2023.

12.1.5 Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the River Shannon. The highest recorded catches were taken during the winter of 1980-1981, when over 5000 t were landed by Irish boats (Table 12.1.4, Figure 12.2.4) in Galway Bay (Department of Fisheries and Forestry, 1982). Since the early 1990s, catches fluctuated from very low levels to no more than 700 t per year in 2000. Zero catches were reported for 2016, increasing to above 500 tonnes in the two subsequent years. Irish catches were 1308 tonnes in 2020, 295 tonnes in 2021, 197 tonnes in 2022, and 59 tonnes in 2023. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.6 Divisions 7.g–k (Celtic Sea)

Sprat catches in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated catches. Patterns of Irish catches in divisions 7.g and 7.j are similar, though the 7.j catches have been higher. Catches for 7.g and 7.j were aggregated in this report. Catches have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4200 t in 2005 (Table 12.1.7). The average catches in the last 10 years were equal to 3164 t. Irish catches increased to 5524 tonnes in 2021 and decreased to 2793 tonnes in 2022 and 1170 tonnes in 2023. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.7 Fleets

Most sprat in the Celtic Seas Ecoregion are caught by small pelagic vessels that also target herring, mainly Irish, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as other small pelagics. Targeted fishing takes place when there are known sprat abundances. However, the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery around Ireland.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown, but based on a limited number of samples available to the working group this is estimated to be less than 1% of the catch.

In Ireland, larger sprats are sold for human consumption while smaller ones for fishmeal. Other countries mainly land catches for industrial purposes.

12.1.8 Regulations and their effects

There is a TAC for sprat for 7.d–e, English Channel. No other TACs or quotas for sprat exist in this ecoregion. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fishmeal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

In 2019 the Irish government changed the regulation relating to the access of the inshore fishing grounds. The plan (Policy Directive No 1 of 2019) was that vessels >18 m LOA would not have access to the 6nm inshore zone from 1 January 2020. For vessels targeting sprat, an exemption from this regulation was in place to phase in this regulation gradually by 2022 . However, the policy directive was subject to a protracted legal case and as of 2023 the Court of Appeal has quashed Policy Directive No 1 of 2019. Despite being quashed for 2023 onwards, the policy will have placed temporary restrictions on sprat fishing in the interim period 2020-2023.

12.1.9 Changes in fishing technology and fishing patterns

There is insufficient information available.

12.2 Biological Composition of the Catch

12.2.1 Catches by number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

12.2.2 Biological sampling from the Scottish Fishery (6.a)

Between 1985 and 2002 the fishery was relatively well sampled and length and age data exists for this period with some gaps. Unfortunately, the data are not available electronically at the present time.

Sampling of sprat in 6.a came to an end in 2003 and no information on biological composition of catches exists in the period 2003–2011. Sampling was resumed in 2012 where a total of 8 catches were sampled. The sampling programme has been carried out since and it is anticipated that it will continue in the future.

12.3 Fishery-independent information

12.3.1 Celtic Sea Acoustic Survey (A4057)

The Irish Celtic Sea Herring Acoustic Survey (CSHAS) calculates an annual estimate of sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2020 are shown in Figure 12.3.1 and Table 12.3.1. However, the survey results prior to 2002 are not comparable with the latter surveys because different survey designs were applied.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 38 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large interannual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al*., 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time-series up to 2009 is highly variable, more so than could be accounted for by 'normal' inter survey variability (Table 12.3.1**)**. The variability in the latter years is in part due to the behaviour of sprats in the Celtic Sea which are often seen in the highest numbers after the survey has ended in November/December and again in spring during spawning. The survey is placed to coincide with peak herring abundance and is temporally mismatched with what would be considered sprat peak abundance. The CSHAS survey design has changed over time and the survey primarily aims to quantify the nominal herring biomass. Any sprat biomass identified is incidental as it is not the target species, meaning the index will not be completely comparable between years. Survey trends should be interpreted with this in mind, and so should be perceived as a potential lower bound for the sprat abundance in the area.

2020 saw the lowest sprat biomass in the last decade, with each subsequent year showing an increase in biomass identified except in 2023 when the biomass decreased to a value similar to that estimated in 2021.

12.3.2 Scottish Acoustic Surveys (A9481)

A Clyde herring and sprat acoustic survey was carried out in June/July 1985–1990 and then discontinued (Figure 12.3.2 for coverage). Biomass estimates from all years as well as lengths and ages from some years are available from this survey but not presented here.

In 2012 this survey was reinstated as an October/November survey for herring mainly. Full results from these surveys for sprats are not available at the moment. Age and length distribution from the survey in 2012 are in Figure 12.3.4. In 2013 the survey was called off due to technical problems. The survey was resumed between 2012-2018. Total Biomass results from 2015 and 2018 are unavailable however data on the distribution of sprat in the Clyde are available for these years. These surveys were not conducted during the years 2019 – 2021.

12.3.3 DATRAS-hosted groundfish surveys

A number of groundfish surveys are carried out in the Celtic Seas ecoregion. These are freely available public datasets. Whilst these surveys do not target sprat, some sprat can be caught incidentally and may provide a coarse indication of sprat presence. The catchability is very low and it would not be meaningful to compare groundfish-derived biomass indices year-on-year for small pelagics (this is in contrast to acoustic surveys). Despite this, when records are considered across many months, multiple years and multiple surveys, presences can be confirmed.

Figure 12.3.3 shows a presence map using these groundfish data, however it is important to interpret this in the context that the summed number is reflective of the amount of sampling effort.

12.3.4 Northern Ireland Groundfish Survey (G7144)

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) groundfish survey of ICES Division 7.aN are carried out in March and October at standard stations between 53° 20′N and 54° 45′N (see Stock Annex for more detail on the survey). Sprat is routinely caught in the groundfish surveys however; data were not available at the time of submission of this report.

12.3.5 AFBI Acoustic Survey (A4075)

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) carries out an annual acoustic survey in the Irish Sea each September (see the Stock Annex for a description of the survey).

The annual calculated sprat biomass from 1998–2023 is shown in Figure 12.3.5 and from 1994-2023 in Table 12.3.2. The biomass is estimated to have peaked in 2002 with 405 000 t and it declined to just under 95 000 t in 2010. This was followed by an increase with 2014 being the second highest estimate in the time-series, followed by a decline each year between 2016 and 2022, terminating at a new 15-year minimum in 2022. However, the biomass estimate doubled in 2023 to 169 520 t. Spatial distribution of sprat at the time of the survey is shown in Figure 12.3.6. The AFBI survey is taken on a consistent annual survey grid, meaning the index is considered more comparable between years than the CSHAS survey index. Despite this, further work is required to investigate which populations the survey index applies to.

12.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

12.5 Recruitment

The various groundfish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

12.6 Stock Assessment

There is currently no assessment for sprat in Subarea 6 and divisions 7.a-c and 7.f-k. The only assessment carried out in the Celtic Seas ecoregion is for sprat in 7.d-e and it is based on a survey index of biomass (Please refer to Section 11 - Sprat in divisions 7.d-e).

12.7 State of the Stock

The state of the sprat stock in the Celtic Seas is currently unknown and the data available are not enough to provide any indication on its status. There has been no change in advice this year. The precautionary buffer was applied in 2021 and therefore it is not applied in this advice period.

12.8 Short-term projections

No projections are presented for this stock.

12.9 Reference Points

No precautionary reference points are defined for sprat populations in the region.

12.10 Quality of the Assessment

The stock status is unknown and the Working Group does not have enough information to assess the status of the stock in relation to reference points.

Work to improve the information available for sprat in the Celtic Seas began with the Workshop on a Research Roadmap for Channel and Celtic Seas sprat (WKRRCCSS). A second iteration of this workshop met in September 2023 (ICES, 2023d).

12.11 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat are mainly fished together with herring. The human consumption fishery only accounts for a minor proportion of the total catch. Within the current management regime, where there is a bycatch ceiling limitation of herring as well as bycatch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in 7.d–e, English Channel, which has not been fully utilized.

12.12 Ecosystem Considerations

In the North Sea, multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem for both fish and seabirds. At present, there are no data available on the total amount of sprat, and in general of other pelagic species, taken by seabirds in the Celtic Seas Ecoregion.

The Celtic Seas Ecoregion is a feeding ground for several species of large baleen whales (O'Donnell *et al.*, 2004–2009). These whales feed primarily on sprat and herring from September to February.

12.13 Tables and Figures

Table 12.1.1 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, Division 6.a. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1985	0	0	51	557	0	2946	0	3554
1986	0	0	348	0	2	520	0	870
1987	269	0	0	0	0	582	0	851
1988	364	0	150	0	0	3864	0	4378
1989	0	0	147	0	0	1146	0	1293
1990	0	0	800	0	0	813	0	1613
1991	0	0	151	0	0	1526	0	1677
1992	28	0	360	0	0	1555	0	1943
1993	22	0	2350	0	0	2230	0	4602
1994	0	0	39	0	0	1491	0	1530
1995	241	0	0	0	0	4124	0	4365
1996	0	0	269	0	0	2350	0	2619
1997	0	0	1596	0	0	5313	0	6909
1998	40	0	94	0	0	3467	0	3601
1999	0	0	2533	0	310	8161	0	11004
2000	0	0	3447	0	0	4238	0	7685
2001	0	0	4	0	98	1294	0	1396
2002	0	0	1333	0	0	2657	0	3990
2003	887	0	1060	0	0	2593	0	4540
2004	0	0	97	0	0	1416	0	1513
2005	0	252	1134	0	13	0	0	1399
2006	0	0	601	0	0	0	0	601
2007	0	0	333	0	0	14	0	347
2008	0	0	892	0	0	0	0	892
2009	0	0	104	0	0	70	0	174
2010	0	0	332	0	0	537	0	869
2011	0	0	468	0	248	507	0	1223
2012	0	0	113	0	0	1688	0	1801

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	487	0	0	968	0	1455
2014	0	0	3	0	0	1540	0	1543
2015	0	0	1305	0	0	1060	0	2365
2016	0	0	431	0	0	2177	0	2608
2017	0	0	604	0	0	1354	0	1958
2018	0	0	1	0	0	0	0	1
2019	0	1	3243	0	66	1265	1	4575
2020	0	0	796	0	0	724	0	1520
2021	0	0	85	0	0	161	0	246
2022	0	0	1697	0	0	161	0	1858
2023	0	0	701	0	0	275	0	976

Table 12.1.2 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2023 from Division 7.aN. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
1985	668	0	20	0	688
1986	1152	1	6	0	1159
1987	41	0	0	0	41
1988	0	0	4	6	10
1989	0	0	1	0	1
1990	0	0	0	0	0
1991	0	0	3	0	3
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	30	0	30
1996	0	0	0	0	0
1997	0	0	2	0	2
1998	0	0	3	0	3

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
1999	0	0	146	0	146
2000	0	0	371	0	371
2001	0	0	269	3	272
2002	0	0	306	0	306
2003	0	0	592	0	592
2004	0	0	134	0	134
2005	0	0	591	0	591
2006	0	0	563	0	563
2007	0	0	0	0	0
2008	0	0	2	0	2
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	522	0	0	0	522
2015	792	0	0	0	792
2016	150	0	0	0	150
2017	150	0	0	0	150
2018	0	0	0	0	0
2019	9	0	0	0	9
2020	2521	0	0	0	2521
2021	381	0	0	0.078	381
2022	491	0	0	0	491
2023	0	0	0	0	0

Table 12.1.3 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2023 from Division 7.aS. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	7
1999	25
2000	123
2001	7
2002	0
2003	3103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	433
2011	1535
2012	6261

Country	Ireland
2013	2545
2014	16
2015	3659
2016	935
2017	935
2018	1117
2019	2785
2020	6888
2021	7861
2022	2026
2023	1432

Table 12.1.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, from divisions 7.b–c. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland
1985	0
1986	0
1987	100
1988	0
1989	0
1990	400
1991	40
1992	50
1993	3
1994	145
1995	150
1996	21
1997	28
1998	331
1999	5

Country	Ireland
2000	698
2001	138
2002	11
2003	38
2004	68
2005	260
2006	40
2007	32
2008	1
2009	238
2010	0
2011	0
2012	23
2013	237
2014	0
2015	250
2016	0
2017	874
2018	508
2019	842
2020	1308
2021	294
2022	197
2023	59

Table 12.1.6 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, Division 7.f. (tonnes)

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
1985	273	0	273
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	1	1
1992	0	0	0
1993	0	0	0
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	0	1	1
2012	0	2	2

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
2013	0	2	2
2014	0	1	1
2015	0	0	0
2016	0	1	1
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	3	3
2021	0	0.35	0.35
2022	0	0.017	0.017
2023	0	0	0

Table 12.1.7 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, divisions 7.g–k. Irish data may be underestimated due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
1985	0	0	3245	0	0	0	3245
1986	538	0	3032	0	0	2	3572
1987	0	1	2089	0	0	0	2090
1988	0	0	703	1	0	0	704
1989	0	0	1016	0	0	0	1016
1990	0	0	125	0	0	0	125
1991	0	0	14	0	0	0	14
1992	0	0	98	0	0	0	98
1993	0	0	0	0	0	0	0
1994	0	0	48	0	0	0	48
1995	250	0	649	0	0	0	899
1996	0	0	3924	0	0	0	3924
1997	0	0	461	0	0	6	467
1998	0	0	1146	0	0	0	1146

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
1999	0	0	3263	0	0	0	3263
2000	0	0	1764	0	0	0	1764
2001	0	0	306	0	0	0	306
2002	0	0	385	0	0	0	385
2003	0	0	747	0	0	0	747
2004	0	0	3523	0	0	0	3523
2005	0	0	4173	0	0	0	4173
2006	0	0	768	0	0	0	768
2007	0	0	3380	0	1	0	3381
2008	0	0	1358	0	0	0	1358
2009	0	0	3431	0	0	0	3431
2010	0	0	2436	0	0	0	2436
2011	0	0	1767	0	0	12	1779
2012	0	0	2632	0	0	0	2632
2013	0	0	1648	0	0	0	1648
2014	0	0	2311	0	0	0	2311
2015	0	0	3322	0	0	0	3322
2016	0	0	3248	0	0	0	3248
2017	0	0	1755	0	0	0	1755
2018	10	0	1955	0	0	0	1965
2019	0	0	6148	0	0	0	6148
2020	0	0	2933	0	0	0	2933
2021	0	0	5524	0	0	0	5524
2022	0	0	2793	0	0	0	2793
2023	0	0	1170	0	0	0	1170

Table 12.1.8 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023 in Subarea 6 and divisions 7.a–c and 7.f–k.

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
1985	538	0	0	4532	1	0	0	0	10	520	5601
1986	269	0	1	2230	0	0	0	0	0	582	3082
1987	364	0	0	853	0	1	0	0	4	3870	5092
1988	0	0	0	1163	0	0	0	0	1	1146	2310
1989	0	0	0	1325	0	0	0	0	0	813	2138
1990	0	0	0	205	0	0	0	0	4	1526	1735
1991	28	0	0	508	0	0	0	0	0	1555	2091
1992	22	0	0	2353	0	0	0	0	0	2230	4605
1993	0	0	0	232	0	0	0	0	2	1491	1725
1994	491	0	0	799	0	0	0	0	30	4124	5444
1995	0	0	0	4214	0	0	0	0	0	2350	6564
1996	0	0	0	2085	0	0	0	0	8	5313	7406
1997	40	0	0	1578	0	0	0	0	54	3467	5139
1998	0	0	0	5826	0	0	0	0	456	8161	14443
1999	0	0	0	6032	0	0	0	0	371	4238	10641
2000	0	0	0	455	0	0	0	0	367	1297	2119
2001	538	0	0	4532	1	0	0	0	10	520	5601
2002	0	0	0	1729	0	0	0	0	306	2657	4692
2003	887	0	0	4948	0	0	0	0	592	2593	9020
2004	0	0	0	4096	0	0	0	0	134	1416	5646
2005	0	252	0	5928	0	0	0	0	604	0	6784
2006	0	0	0	1523	0	0	0	0	563	0	2086
2007	0	0	0	3745	0	0	0	1	2	14	3762
2008	0	0	0	2353	0	0	0	0	2	0	2355
2009	0	0	0	3773	0	0	0	0	1	70	3844
2010	0	0	0	3200	0	0	0	0	7	537	3744
2011	0	0	0	3770	0	0	0	0	261	507	4538

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
2012	0	0	0	9029	0	0	0	0	2	1688	10719
2013	0	0	0	4917	0	0	0	0	2	968	5887
2014	0	0	0	2852	0	0	0	0	1	1540	4393
2015	0	0	0	9328	0	0	0	0	0	1060	10388
2016	0	0	0	4763	0	0	0	0	1	2177	6941
2017	0	0	0	4318	0	0	0	0	0	1354	5672
2018	10	0	0	3580	0	0	0	0	0	0	3590
2019	0	1	0	13018	0	3	0	0	66	1265	14353
2020	0	0	0	14446	0	0	0	0	3	724	15173
2021	0	0	0	14145	0	0	0	0	0.35	0.078	14145
2022	0	0	0	7204	0	0	0	0	0.017	161	7365
2023	0	0	0	3362	0	0	0	0	0	275	3637

Table 12.3.1. Sprat in the Celtic Seas Ecoregion. Sprat biomass by year from the MI Celtic Sea Herring Acoustic Survey.

Year	Biomass (t)
Nov/Dec-91	36880
Jan-92	15420
Jan-92	5150
Nov-92	27320
Jan-93	18420
Nov-93	95870
Jan-94	8035
Nov-95	75440
2002	20600
2003	1395
2004	50810
2005	29019
2008	5493

Year	Biomass (t)
2009	16229
2011	31593
2012	35114
2013	44685
2014	54826
2015	83779
2016	42694
2017	70745
2018	47806
2019	60608
2020	4523
2021	12376
2022	34508
2023	11342

Table 12.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.a (Source: AFBI annual herring acoustic survey).

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
1994	68 600	0.1	95	65,200
1995	348 600	0.13	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	45 600	0.2	n/a	n/a
1998	228 000	0.11	97	221 300
1999	272 200	0.1	98	265 400
2000	234 700	0.11	94	221 400
2001	299 700	0.08	99	295 100
2002	413 900	0.09	98	405 100
2003	265 900	0.1	95	253 800
2004	281 000	0.07	96	270 200

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
2005	141 900	0.1	96	136 100
2006	143 200	0.09	87	125 000
2007	204 700	0.09	91	187 200
2008	252 300	0.12	83	209 800
2009	175 200	0.08	78	136 200
2010	107 400	0.1	87	93 700
2011	280 000	0.11	85	238 400
2012	171 200	0.11	95	162 600
2013	255 300	0.09	77	197 500
2014	393 000	0.1	93	367 100
2015	237 000	0.09	84	199 100
2016				236 000
2017				222 000
2018				219 000
2019				146 000
2020				117 000
2021				110 000
2022				84 000
2023				169 520

Figure 12.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

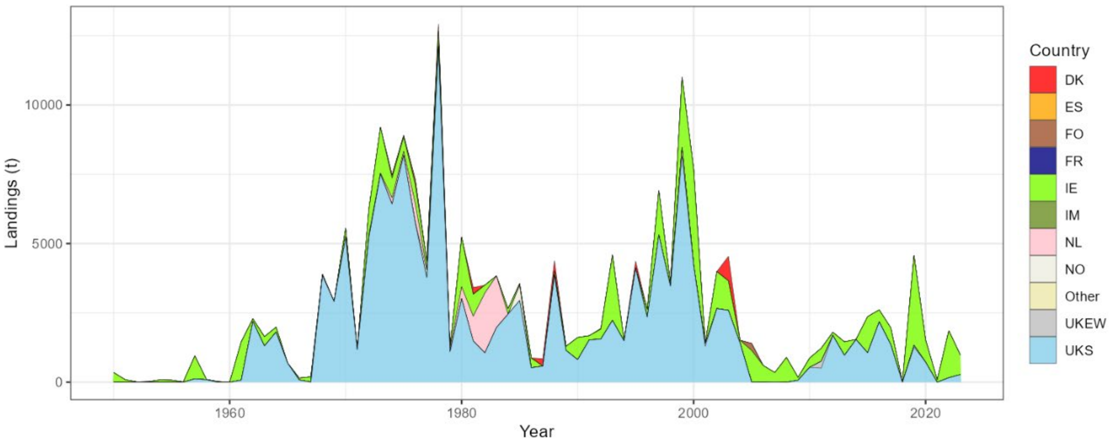

Figure 12.2.1. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 6.a.

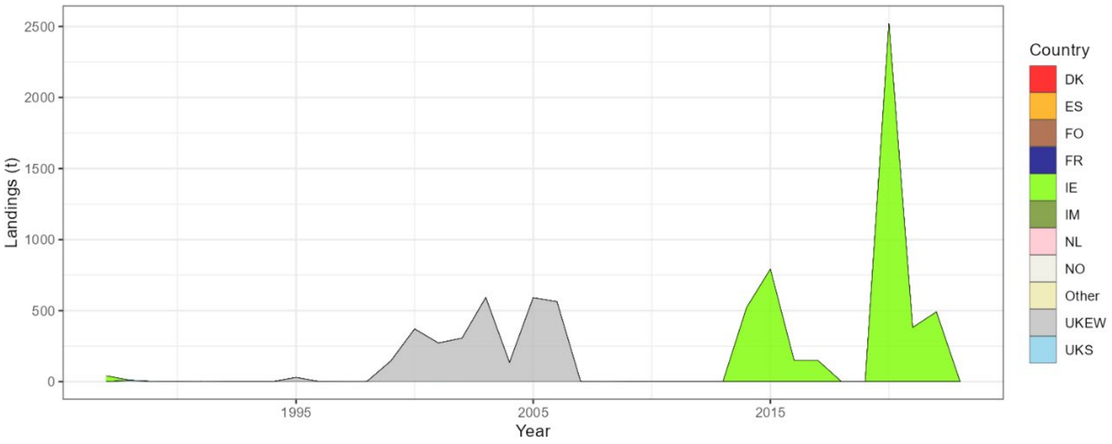

Figure 12.2.2. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.aN. Note: Irish catches from 1973–1995 may be from 7.aN or 7.aS.

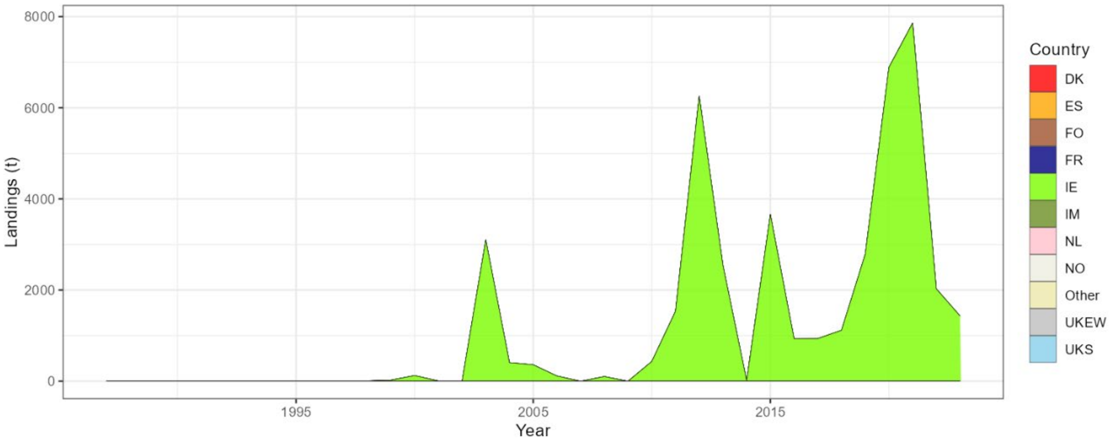

Figure 12.2.3. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.aS.

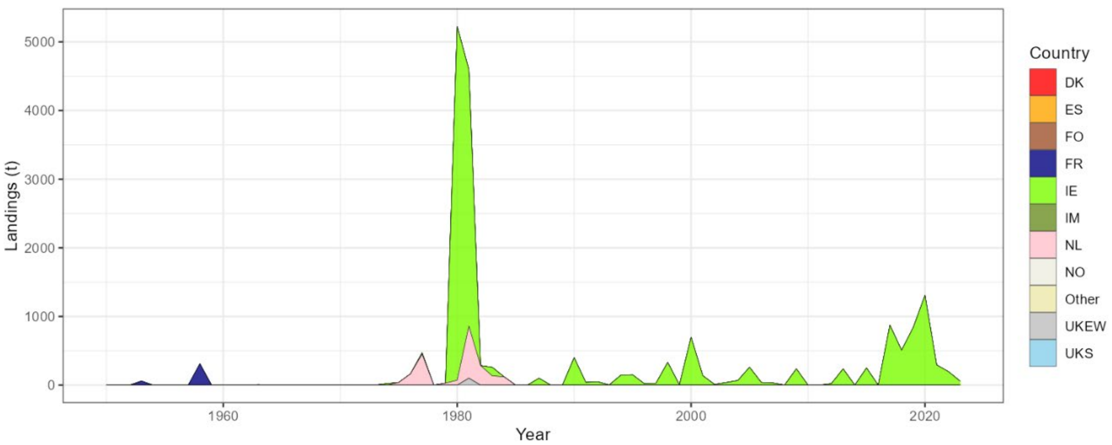

Figure 12.2.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES divisions 7.b–c.

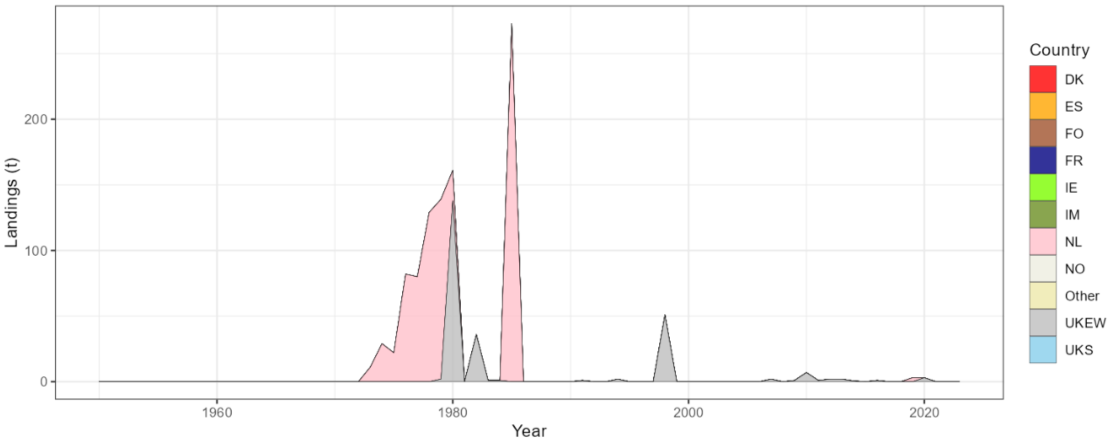

Figure 12.2.6. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.f.

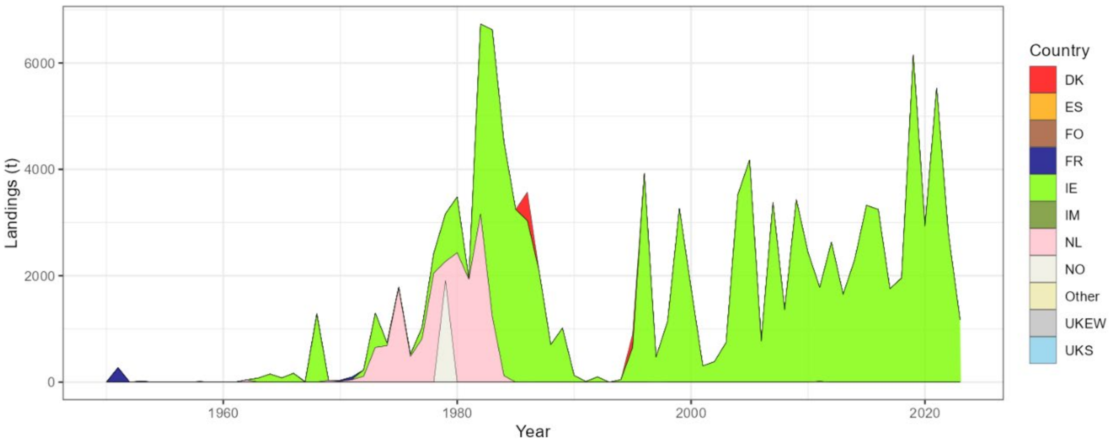

Figure 12.2.7. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES divisions 7.g–k.

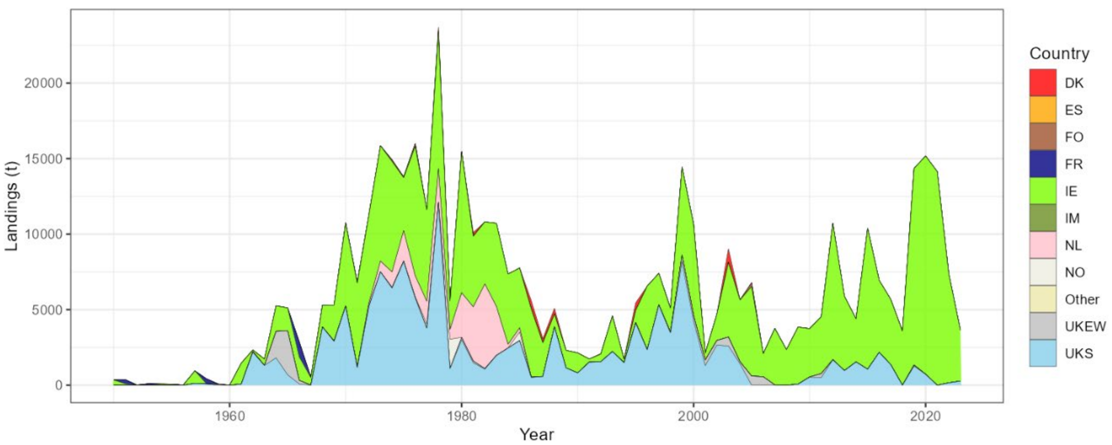

Figure 12.2.8. Catches of sprat 1987–2023 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by country.

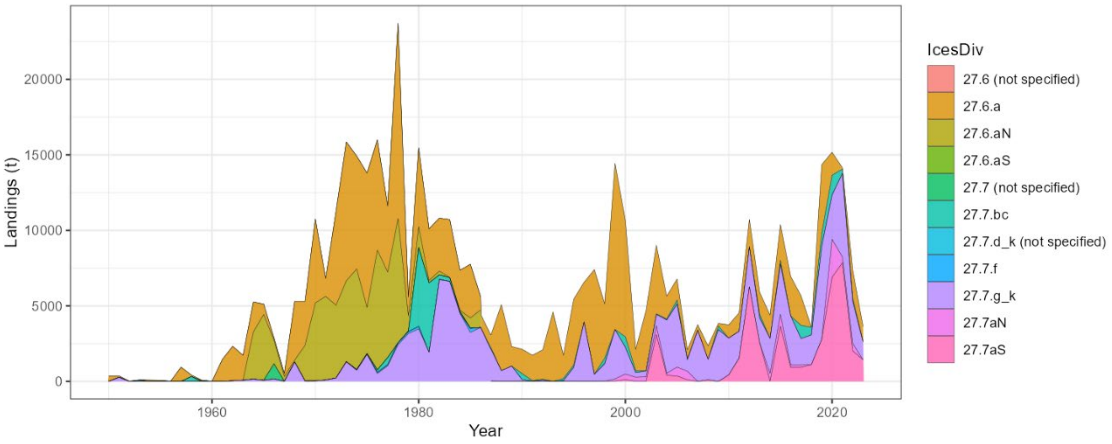

Figure 12.2.9.Catches of sprat 1987–2023 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by Ices Division.

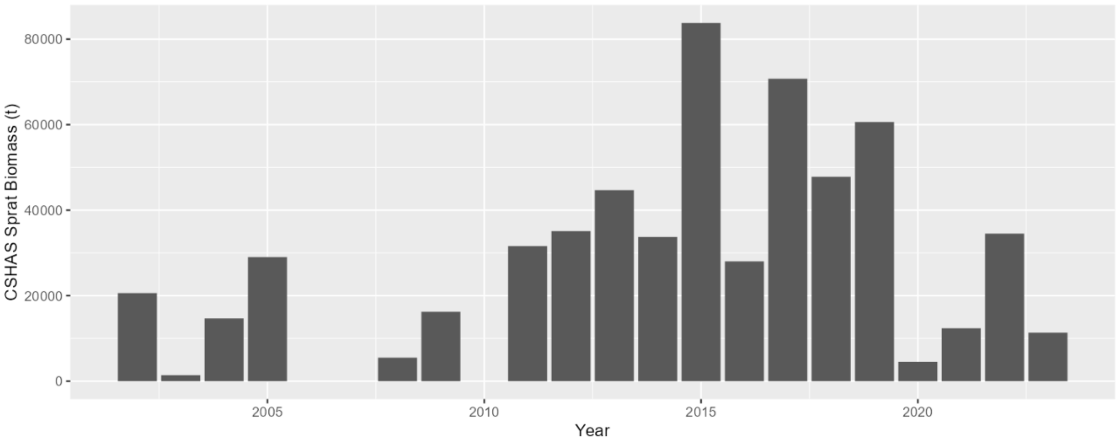

Figure 12.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass from the MI Celtic Sea Herring Acoustic Survey 2004–2023 (A4705).

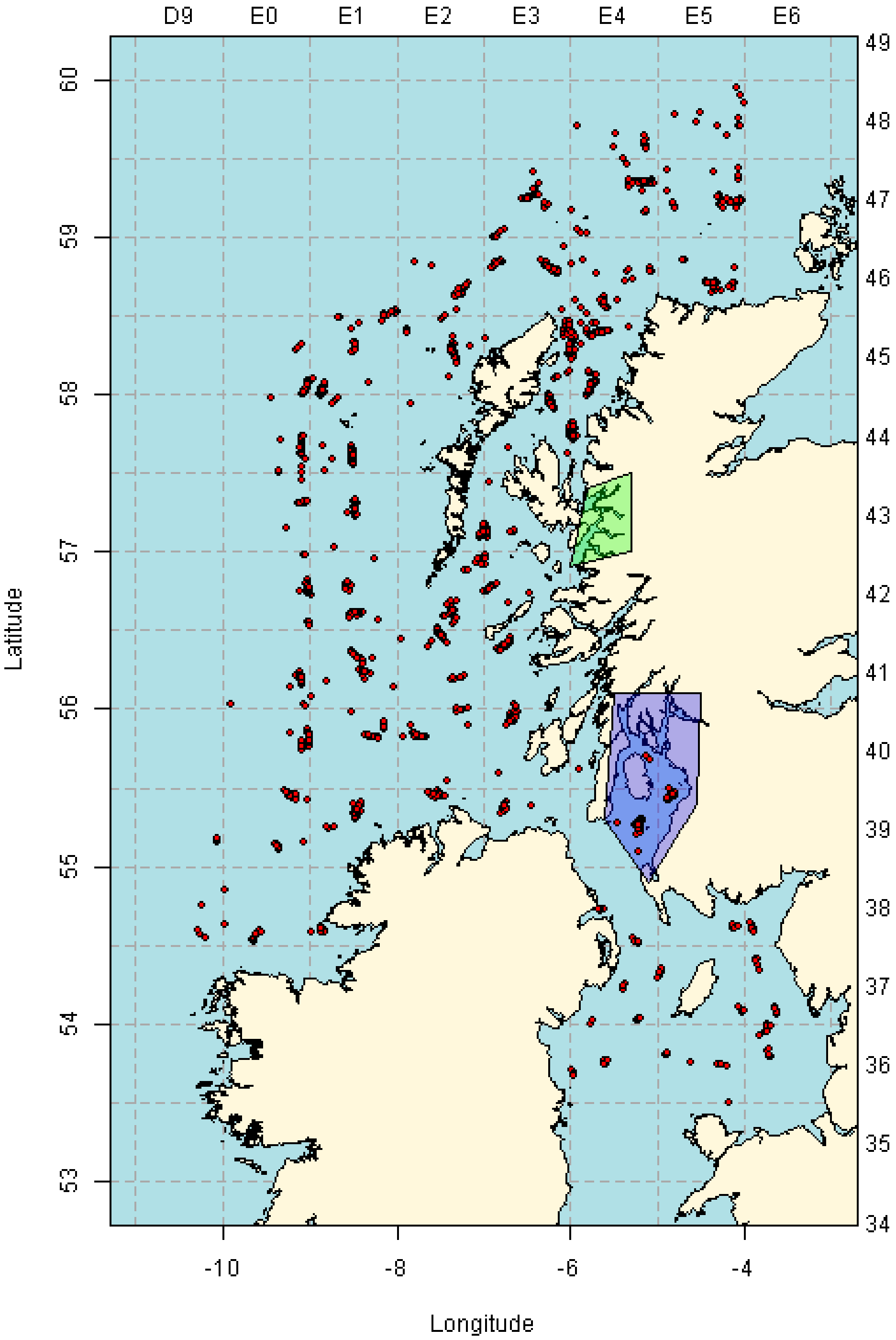

Figure 12.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually in Q1 and Q4 between 2001 and 2005. Red markers indicate all hauls from the Q1 and Q4 Scottish West Coast IBTS between 1985 and 2012 (G7144).

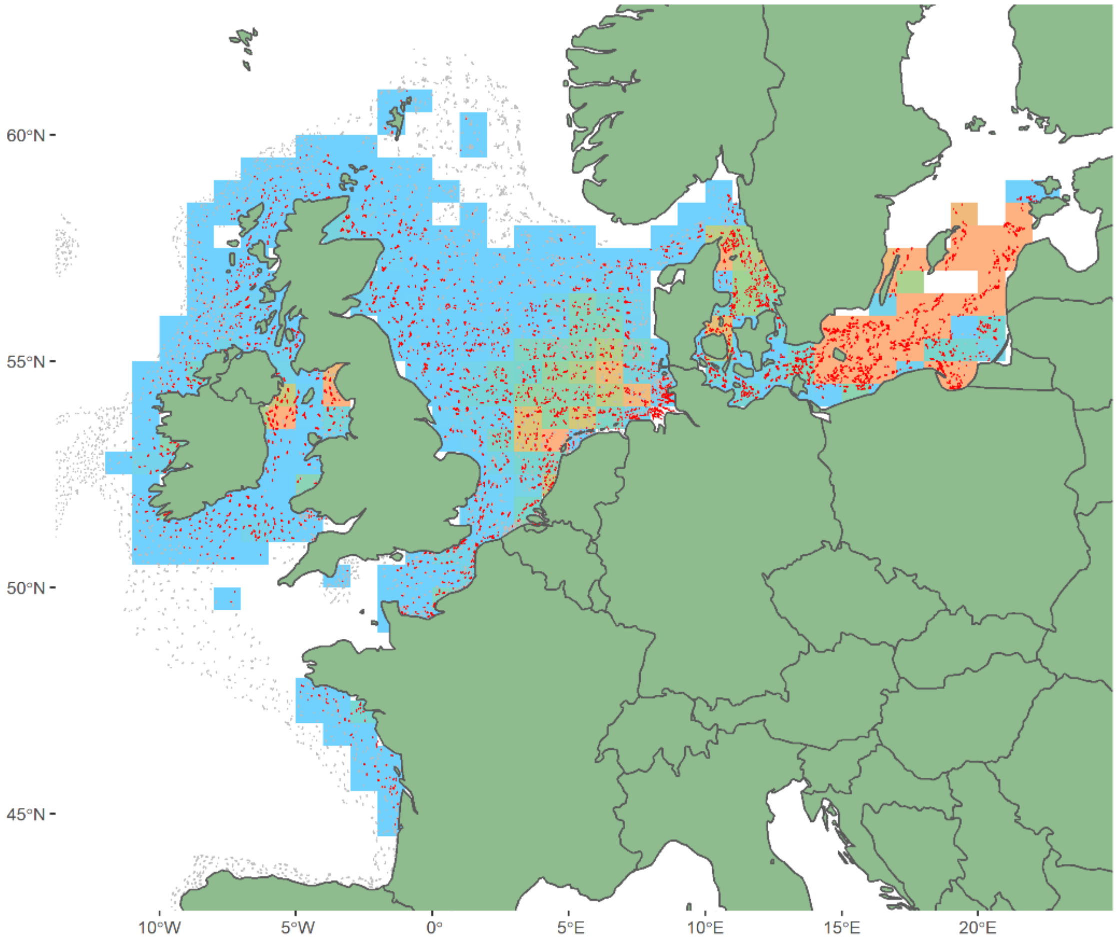

Figure 12.3.3. Total numbers of sprat caught by DATRAS surveys by ICES rectangle, adjusted for tow duration but not adjusted for number of hauls. Since this is a sum, no compensation is made for the varying number of hauls per rectangle. Generated using DATRAS records downloaded 29 Oct 2022, Figure applies to sum over time period 2011-2022. Red dots indicate hauls which caught sprat, grey dots indicate hauls with no sprat recorded. Combined DATRAS survey data for the surveys of acronym: BITS, BTS, BTS-VIII, DYFS, FR-CGFS, IE-IGFS, NIGFS, NS-IBTS, PT-IBTS, SCOROC, SCOWCGFS, SNS, SP-ARSA, SP-NORTH, SP-PORC, EVHOE. See DATRAS website for details on survey acronyms.

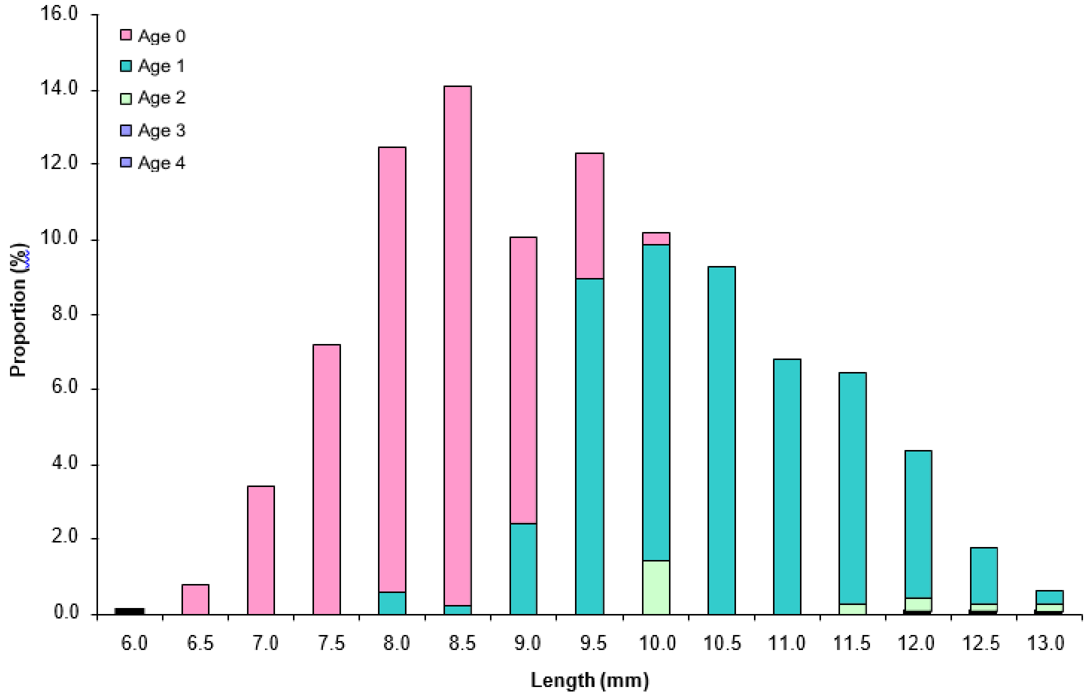

Figure 12.3.4. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged (G7144).

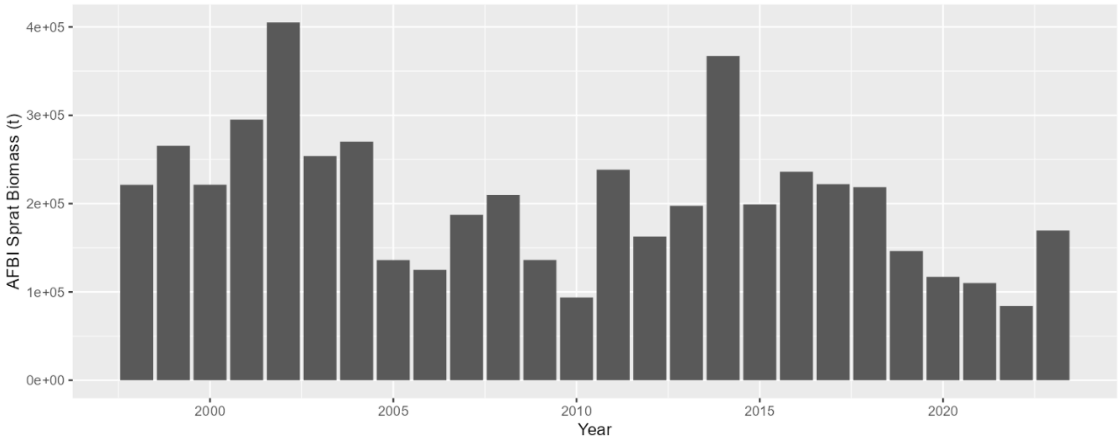

Figure 12.3.5. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN from the AFBI Acoustic Survey (A4075)

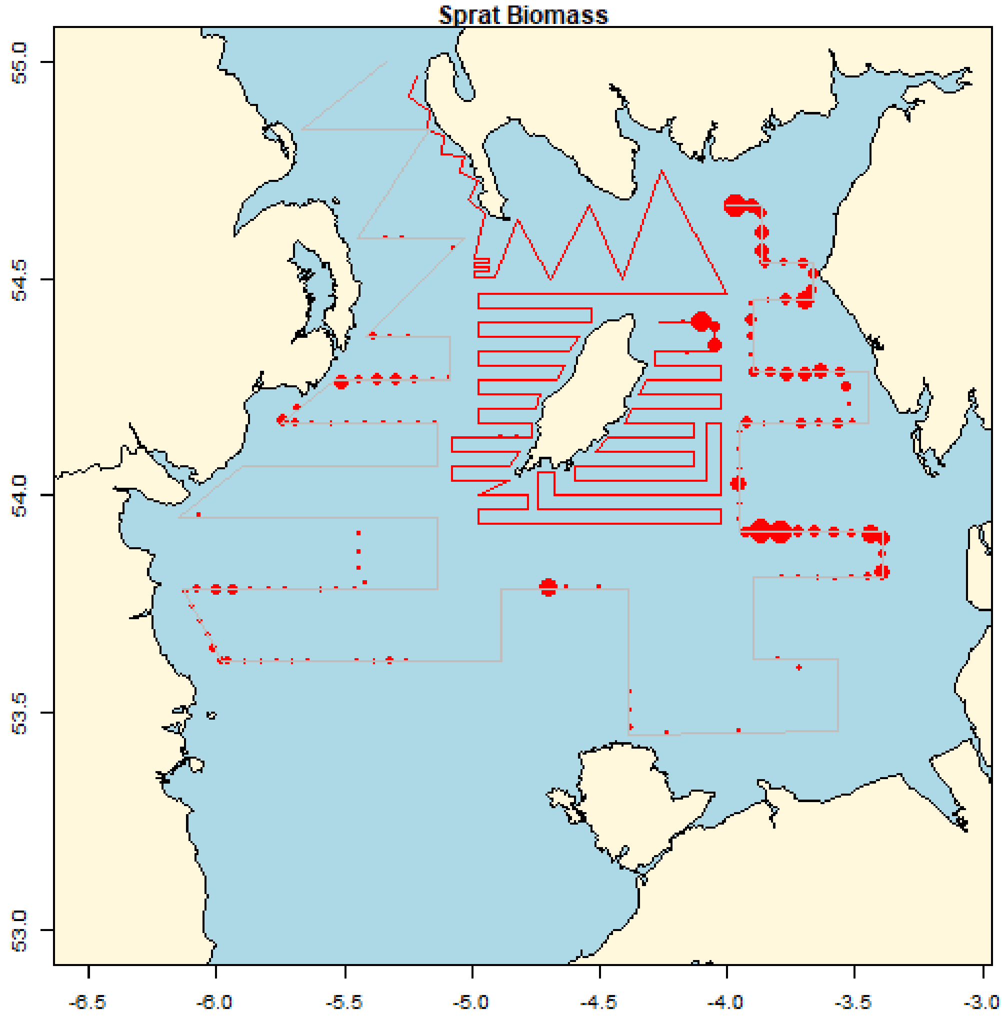

Figure 12.3.6. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) which include juvenile herring and sprat. Obtained during the 2021 AFBI acoustic survey (A4705).

Annex 1: Working Documents

Working document

1 Revision of data input, model configuration and reference points used for the stock assessment of sprat in the North Sea and 3.a

During the annual meeting for Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) the input data used in the assessment model for sprat in the North Sea and 3.a (Skagerrak-Kattegat) were revised. This included 1) a change in catch input data and associated model adjudgments, 2) an update of natural mortalities from the SMS key run 2023, 3) re-calculation of biomass reference points (Blim and Bpa) and 4) re-calculation of reference point set on fishing mortality (harvest control rule, F_{cap}). In short, the assessment for sprat uses the SMS model (Lewy and Vinther, 2004) with quarterly time steps. The model was benchmarked in 2018 (WKSPRAT, ICES 2018;). Due to the short lifespan and fishery composition of sprat, only in-year advice is viable. To align with sprat's lifecycle, the model is based on TAC years from July to June rather than calendar years, estimating SSB and recruitment on 1 July. Output and input data refer to the adjusted model year, i.e. TAC year (S1-S4; season 1 is quarter 3, season 2 is quarter 4, season 3 is quarter 1, and season 4 is quarter 2). The management of the sprat stock in the North Sea and 3.a employs an escapement strategy ($B_{escapement}$), which involves aiming to fish the stock down to B_{pa} (= $B_{escapement}$). However, it has been demonstrated that this approach is not precautionary for this type of stock without the implementation of a reference point for F as a limit control rule (ICES, 2014). For a more detailed description please see stock annex and report.

The changes were reviewed by external experts Mikel Aristegui and Amy Schueller, and the expert group have revised the working document to accommodate both reviewers by extending the justification and conclusive remarks on the choice of method for the calculation of B_{lim} based on the stock-recruitment relationship, as well as extending the F_{cap} estimation to include the target risk of 0.05.

1.1 Catch data input and model configuration

The SMS-model faces challenges with extended time-series of low catches used as input for the quarterly time-steps. Such catch data can lead to inaccurate estimation of fishing pressure and associated CV's. Historically, catches below a threshold were set to zero to prevent model misfits. During WKSPRAT, a redistribution of low catches from specific seasons provided appropriate model adjudgments, which proved to be successful. Specifically, the inclusion of catches from season 4 in season 1 the following year in combination with model modifications that prevented fits or estimation of any catch parameters in S4 improved the variance and CV in the model, as well as resolved some retrospective patterns. The consensus was to incorporate this change into the final model, recognizing its positive impact on model accuracy (WKSPRAT, 2018). A recent change in the fishing pattern in season 3 seems to have caused similar issues as seen for season 4 during WKSPRAT. The catch input data revealed that since 2019 the catches have been low. On average the catches were 0.6% of the total catch in tonnage for the period 2019-2022 (1.2% in 2019, 0.5 % in 2020, 0.6% in 2021 and 0.2% in 2022) compared to 8.6% for the period 2015-2018 (Table 1). In addition, the number of biological samples taken from the fishery used to generate the catch-at-age matrix for the assessment model has also been low compared to before 2019 (Table 2). These sudden changes caused estimation problems for the predicted fishery mortalities in the model, similarly to what found for S4 during WKSPRAT. Therefore, the expert group decided to test the effect of moving the catches from season 3 to season 2 for the period 2019-2022 and configuring the model to not estimate any catches for the season.

1.1.1 Results

The high CV in 2022 for the fishing mortality were corrected by moving the catches to season 2 (Figure 1). The large positive catch residuals for season 3 for all age-groups were removed without causing any drastic changes to the catch residuals in season 2 (Figure 2). The most recent estimated fishing mortalities became less variable. Specifically, the predicted 2022 fishing mortality went from being unrealistic low to being just below the long-time average in 2022 and the record high fishing mortality in 2023 was marginally down-scaled (Figure 3). Furthermore, the AIC were greatly improved from 1062 to 860.

1.1.2 Conclusion

HAWG agreed that the inclusion of season 3 catches for the period in season 2 improved the model significantly without changing the estimated historical dynamics of the stock and exploitation, and concluded that this change should be adopted in the final model. A sensitivity analysis was also conducted only moving the catches from season 3 to season 2 in 2022, which provided comparable improvements to the CV and predicted fishing mortality, but not to the catch residuals. Furthermore, considering that the low number of biological samples extended back to 2019, the group was confident to keep the changes for the period 2019-2022.

1.2 Updating natural mortalities

The current assessment is based on natural mortalities (M) from the 2015 SMS key run. Consequently, a varying M (3-y running means) is implemented up to 2015, and a constant M is used thereafter (2013–2015 average). In 2021, HAWG reviewed the updated Ms from the 2020 SMS key run. Despite no significant changes in recruitment, SSB, F and stock-recruitment relationship, HAWG decided at that time to retain the old M from the 2015 key run, mainly due to the guidelines that necessitated an inter-benchmark process, which was deemed unfeasible because of the tight advisory schedule and the extensive nature of MSE for reference point estimation (HAWG, 2021). After inspecting the updated mortalities from the most recent key run from 2023, HAWG decided that the changes are now so profound that they cannot be ignored and should be implemented from this update assessment. Notably, Ms have increased for all age-groups in all seasons in the most recent time-period (Figure 4).

1.2.1 Results

The inclusion of updated natural mortalities from the most recent SMS 2023 key run changed the perception of the stock, causing an upward shift in both recruitment (s. 1991) and SSB (s. 1982), as well as a downscaling of fishing mortality (s. 1981) (Figure 5). Furthermore, the stock-recruitment relationship showed that the changes in both recruitment and SSB resulted in a down-scaling causing points to be more compact in the early time of the time-series, whereas the period from 1981 and onward became more variable (Figure 6). The median recruitment also increased from being 87849 using the old Ms to 101730 using the updated Ms (Figure 6). There were no drastic changes detected in the CV's and residuals for both the catches and surveys (Figure 7, 8 and 9). The retrospective pattern where improved for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), whereas it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22) (Figure 10). The AIC for the model fit increased with the updated Ms (AIC = 863) compared to a model with the current Ms (AIC = 860), but the difference in delta-AIC were evaluated to be negligible.

1.2.2 Conclusion

The natural mortalities from the 2015 key run are obsolete and do not capture the trophodynamics that characterise the North Sea food web during the last decade. Improvements of the multispecies model since 2015, e.g. incorporating more accurate information on seabird and recent shifts in predator biomass (e.g. whiting and mackerel), have substantial influence on the estimated Ms for sprat. In conclusion, the significant changes in natural mortalities of sprat prompted HAWG to their final decision of updating the Ms for the assessment.

1.3 Reference points

As a result of the change in the stock delimitation and the assessment settings, the reference points were revised and re-estimated. The reference points were revised based on the model run with all revised input data and model configurations (see above). It was decided to follow a similar procedure as WKSPRAT and accordingly all years before 1981 were omitted because they appeared to be in a different regime. It was agreed that the stock-recruitment relationship could be estimated as a type 1 or 2 relationship, which can be estimated by using the R-package *StockRecruitSET* available at https://github.com/mebrooks/StockRecruit. The method for a type 1 gives B_{lim} at the lowest SSB with medium recruitment. The B_{lim} estimate for a type 2 is the break point of a hockey-stick model. The current B_{lim} is based on a hockey-stick breakpoint (WKSPRAT, 2018). The evaluation of B_{lim} is also subjected to expert judgement. Drawing from the experience from the benchmark of sandeel (WKSAND, 2023), it was decided to calculate an alternative B_{lim} based on the average SSB for two years that produced recruitments above the median recruitment.

1.3.1 Results

Using the ICES guidelines for type 1 (spasmodic) stocks, B_{lim} was calculated to be 103464 t (i.e. lowest SSB that gives median recruitment), which gives the following $B_{escapement} = B_{pa} = B_{lim}*exp(1.645*\sigma) = 130728$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The type 2 stock using a hockey-stick model, the breakpoint for Blim was calculated to be 131184 t, which gives the following $B_{escapement} = B_{pa} = B_{lim}*exp(1.645*\sigma) = 167759$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). A calculation of an alternative B_{lim} (mean SSB for two years that have R > median R) yielded 107598 t using the years 1991 and 2013, which gives the following $B_{escapement} = B_{pa} = B_{lim}*exp(1.645*\sigma) = 135952$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The evaluation how the different alternative reference points changed the perception of the stock compared to current perception showed that using type 1 stock method and a simple average of two years gave a similar perception to the current (Figure 11 and Figure 12). On the contrary, using the type 2 stock method would change the historical perception of the stock increasing the number of years under B_{lim} and B_{pa} (Figure 12).

1.3.2 Conclusion

The group had thorough discussions on how to evaluate the estimated reference points and the changed perception of the stock. Considering the stock recruitment relationship as a type 1 or a type 2 did affect the estimation of B_{lim} and perception of the stock substantially. The expert group judged the type 2 estimation method to be risk prone because it included four years of recruitments over the median, where 2008 and 2013 were judged to be higher than expected. Therefore, the group where in doubt whether a type 2 relationship could be supported and worries on a ever-increasing trend causing an overestimation of the hockey-stick break-point were raised. As stated above, the estimation of B_{lim} and perception of the stock where very different depending on method compared to the last benchmark where both type 1 and type 2 relationships gave closely related reference points. As such the expert group preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark. The decision was made to set B_{lim} based on the average SSB of two years with recruitment above the median, deemed to reflect a reasonable and precautionary perception of stock changes. Consequently, the average SSB from 1991 and 2013 was used to establish reference points at B_{lim} = 107598 t and $B_{escapement}$ = B_{pa} = 135952 t. The expert group also wanted to highlight that ICES should be aware that one of the down-sides by discontinuing the inter-benchmark process are very short time frames for these important decisions that are affected by subjective choices to be made, which puts a lot of pressure on the assessment expert groups.

1.4 MSE and F_{cap}

1.4.1 Methods

We used the short-cut method developed for WKspratMSE (ICES 2019). We conditioned the MSE using the assessment from 2024 instead of 2018 and accordingly, we modified the MSE code so that the start year of the MSE was 2023 and so that risk was calculated over years 2038 to 2058.

We ran the MSE for a range of Fcap values from 0.5 to 1.0, and thereafter small increments 1.01-1.05 to include the target risk of 0.05.

1.4.2 Results

Fcap	risk
0.5	0.022
0.6	0.027
0.7	0.032
0.8	0.038
0.9	0.044
1.0	0.049
1.01	0.050
1.02	0.051
1.03	0.051
1.04	0.052
1.05	0.053

Please see supplementary materials for figures and further results.

1.4.3 Conclusion

An Fcap of 1.01 produced risk of 0.05.

1.5. References

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp.

ICES. 2019. Workshop on the management strategy evaluation of the reference point, F_{cap}, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69. 35 pp. https://doi.org/10.17895/ices.pub.19291148

Table 1. Catch in numbers by age (1000's) by season and year (Model year) from 2015 and onward. Note that the time-series used in the model goes back to 1974.

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	2420231	9775216	3342785	163695
2019	2	799272.1	2399200	1041391	139590
2019	3	121303.8	19818	2252.614	237
2019	4	0	0	0	0
2020	1	207574	10153348	3429492	429318
2020	2	69142	2695178	385767	137741
2020	3	28346	78759	8459	1779

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2020	4	0	0	0	0
2021	1	539434	5840604	1505982	255540
2021	2	233795	803968	392200	138805
2021	3	52211	10015	734	8
2021	4	0	0	0	0
2022	1	362805	7103177	813995	99384
2022	2	826841	281637	350919	100995
2022	3	2748	959	67	12
2022	4	0	0	0	0
2023	1	578572	4943797	1984638	98171
2023	2	389454	1497984	618160	68121
2023	3	0	0	0	0
2023	4	0	0	0	0

Table 2. Number of biological samples taken from 2010 and onward. Note that the time-series used in the model goes back to 1974.

Year	S1	S2	S3	S4
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	2	12
2020	27	28	0	0
2021	85	22	0	8
2022	41	29	1	0
2023	78	49	*	*

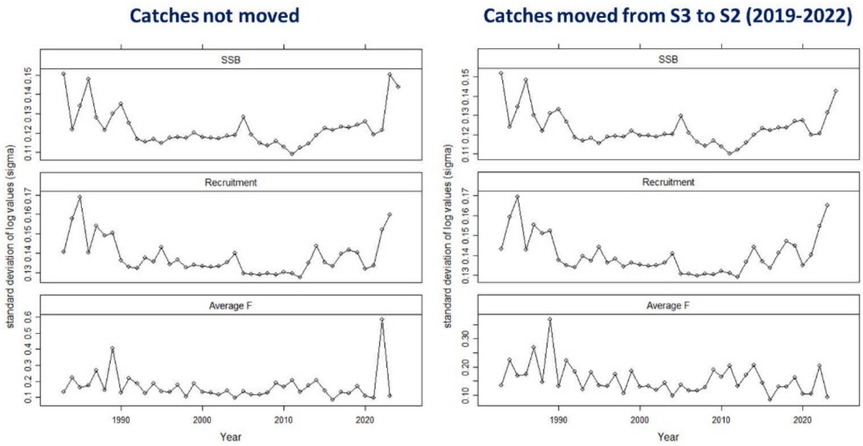

Figure 1. Coefficients of variance (Model year) for recruitment, SSB and fishing mortality for the model without moving catches and a model where catches are moved from S3 to S2.

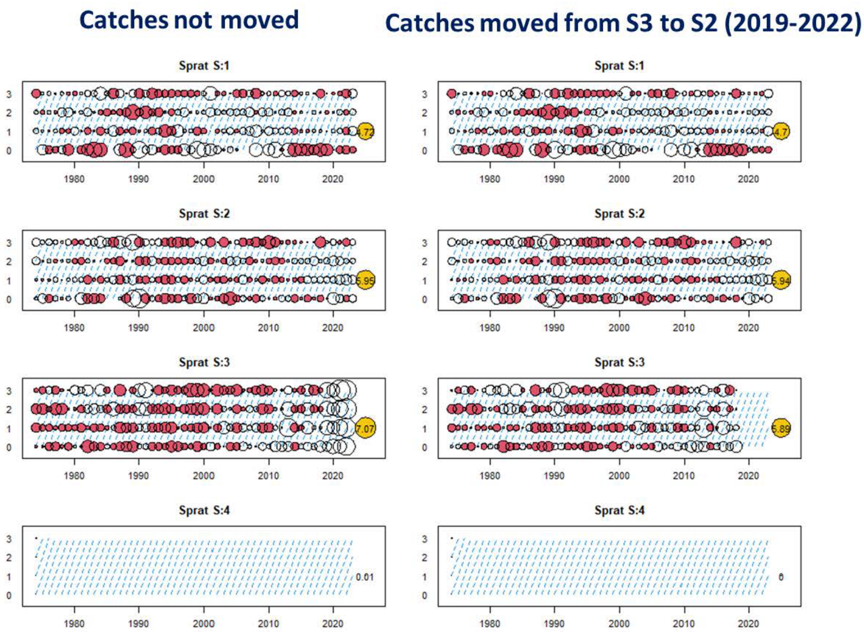

Figure 2. Catch residuals by age and season (Model year) for the model without moving catches and a model where catches are moved from S3 to S2. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

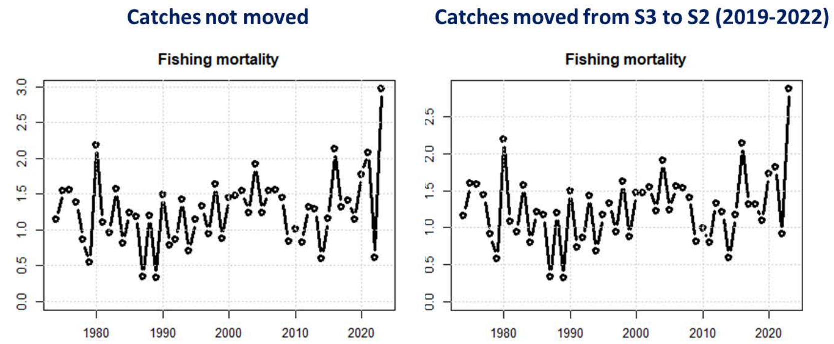

Figure 3. Predicted fishing mortality (Model year) for the model without moving catches and a model where catches are moved from S3 to S2.

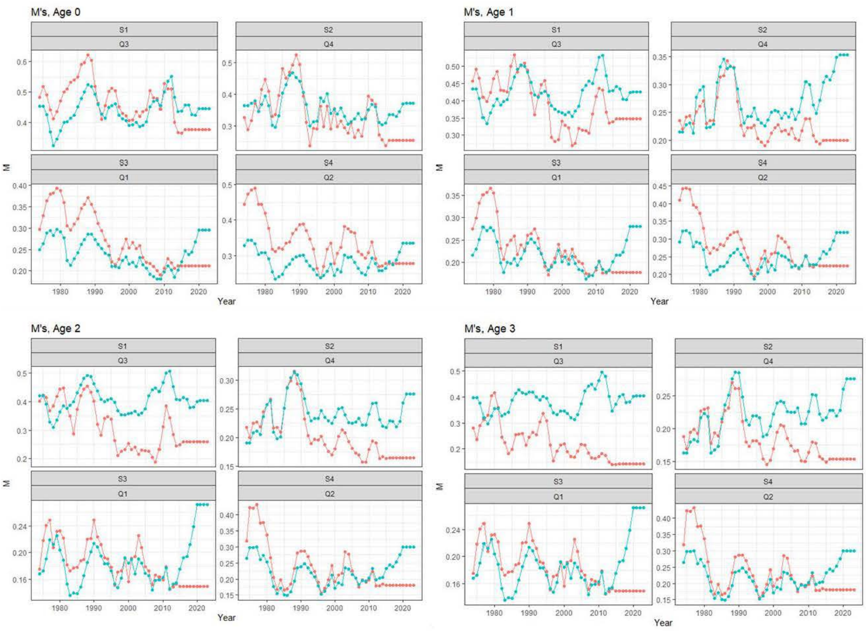

Figure 4. Natural mortalities for sprat for all age-groups, seasons and quarters (Model year). The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

Figure 5. Predicted recruitment, SSB and fishing mortality for models that have old and updated M's. The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

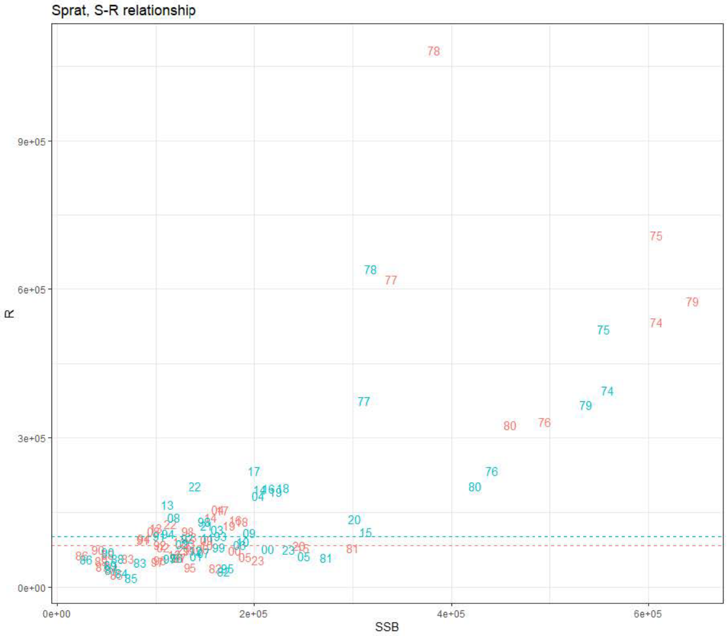

Figure 6. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The red numbers are the current M's from the 2015 SMS key run and the blue numbers is the updated M's from the most recent SMS key run from 2023. The median recruitments are shown (dashed lines).

Old Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.118	0.100
1	0.909	0.877	1.414	0.100
2	0.975	1.048	1.414	0.100
3	0.975	1.048	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.43	0.43	0.43
IBTS Q3		0.54	0.44	0.44
Acoustic		0.44	0.53	0.53

New Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.100	0.100
1	0.864	0.835	1.399	0.100
2	0.950	1.050	1.414	0.100
3	0.950	1.050	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.47	0.47	0.47
IBTS Q3		0.53	0.45	0.45
Acoustic		0.44	0.50	0.50

Figure 7. Catch and survey CVs for models that have old and updated M's.

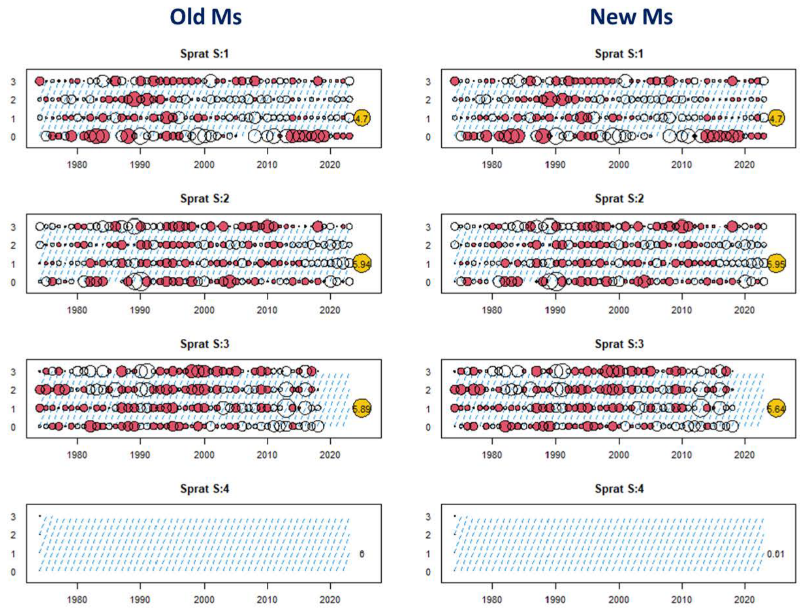

Figure 8. Catch residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

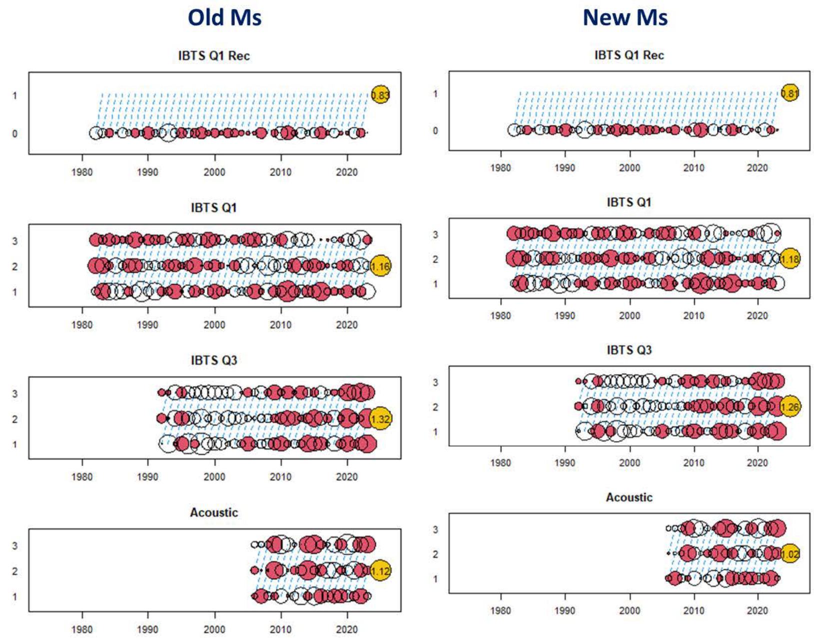

Figure 9. Survey residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

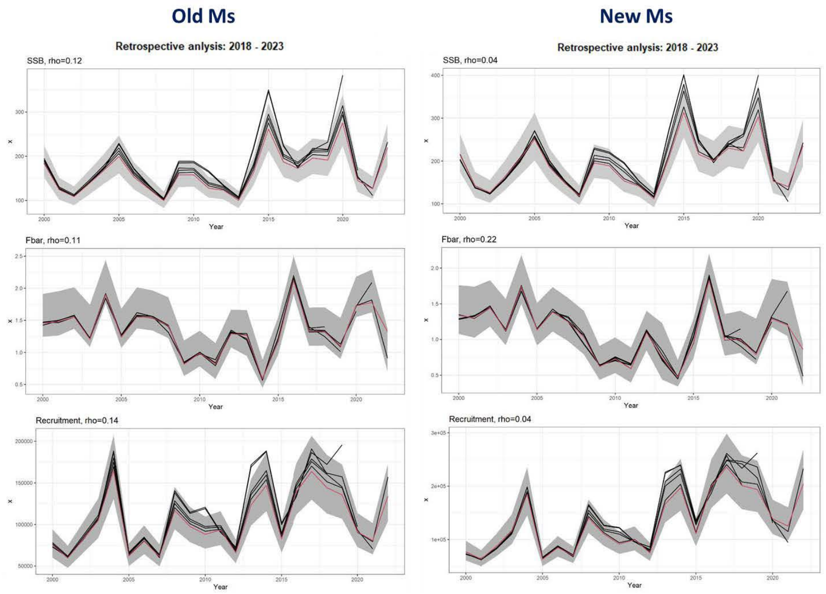

Figure 10. Retrospective bias and Mohn´s rho for the models that have old and updated M's.

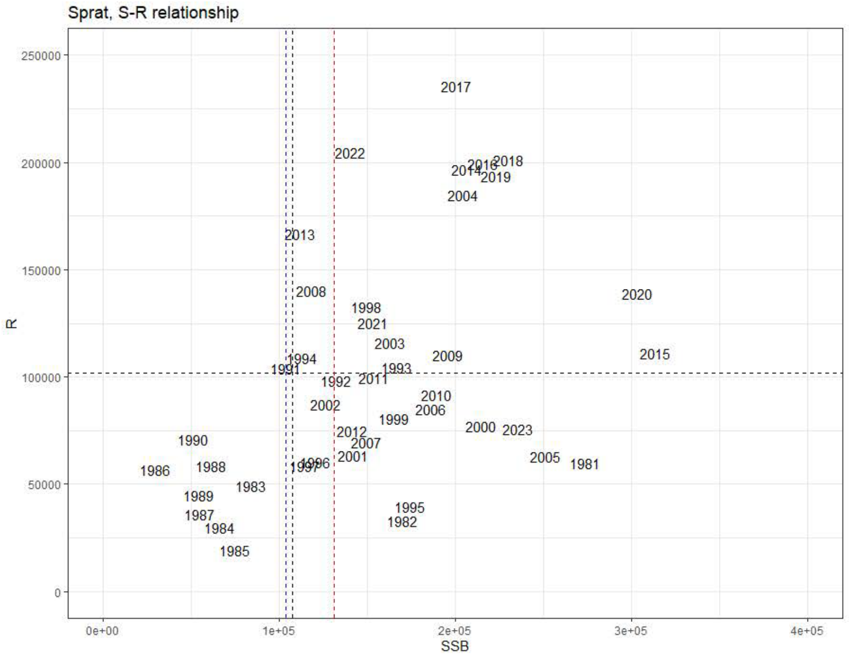

Figure 11. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Lines show type 1 method (minimum SSB that produce above median recruitment, blue dashed line), type 2 method (hockey-stick breakpoint, red dashed line) and an alternative calculation (mean SSB in the two years that produced above recruitment, black dashed vertical line) of B_{lim}. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The median recruitment are also shown (black dashed horizontal line).

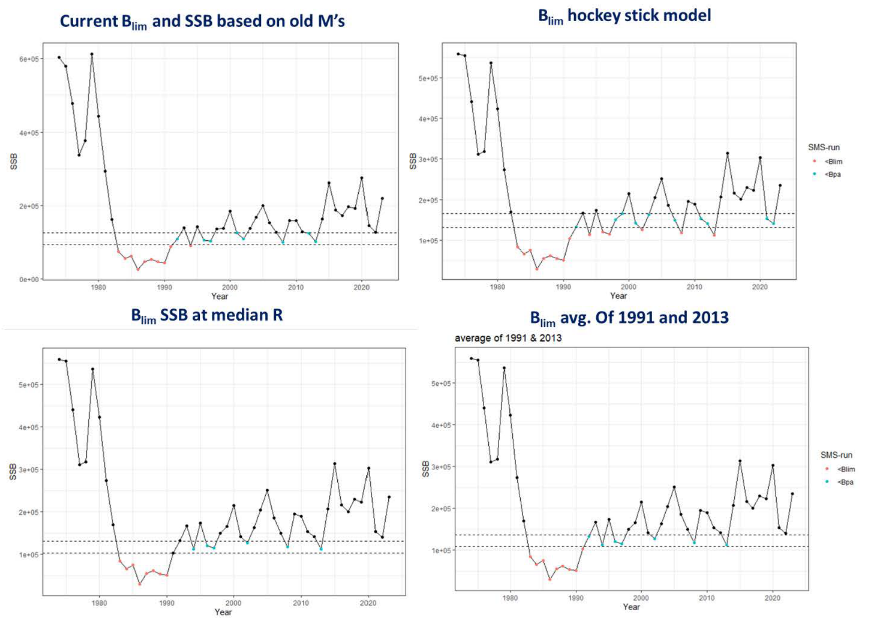

Figure 12. Perception of the stock using the current assessment model and input data (old M's, upper left panel), and a model that include the new M's and biomass reference points calculated as type 1 (lower left panel), tape 2 (upper right panel), and a simple average between two years (lower right panel). Please also see details in Figure 11 for information on the calculation of B_{lim}. The blue points signify years where SSB < B_{pa} and > B_{lim}, and the red points signify years where SSB < B_{lim}.

2 Working documents Reviews

2.1 Review from Mikel Aristegui

The purpose of this external review is to check that the reasoning for the decisions made during the annual meeting of the Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) about the stock assessment and reference points of sprat in Division 3.a and Subarea 4 are in line with ICES guidelines.

HAWG implemented two main changes to the input data and settings of the sprat model: moving catch data from season 3 to season 2 for the period of 2019-2022, and updating the natural mortalities (M's) for all ages. As a result of these changes, reference points were revised and re-estimated.

1. Changes to input data and model settings

a. Catch data input

HAWG identified a change in fishing patterns in recent years (2019-2022), where catches in season 3 have been very low. Subsequently, the number of samples from these catches are also low. HAWG followed the steps and decisions that were made in the last Benchmark Workshop on Sprat (WKSPRAT; ICES 2018), where a similar issue was identified with very low catches in season 4. WKSPRAT decided to move catches from season 4 to season 1, improving the model considerably.

Now, HAWG showed that moving season 3 catches to season 2 (in 2019-2022 period) improved the CV's in the model. Additional efforts were made by the group by also testing that this change removed the large positive catch residuals for season 3, and significantly improved the model's AIC. However, it would be still interesting to know if moving catches from season 3 to season 2 affected the retrospective pattern (WKSPRAT showed that their change reduced Mohn's rho significantly).

HAWG agreed to move catches from season 3 to season 2 between 2019 and 2022, which looks adequate.

b. Natural mortality

The current assessment model uses M's from the 2015 SMS key run. HAWG identified a high increase in M's on the 2023 SMS key run, which significantly changed the perception of the stock (recruitment, SSB and fishing mortality). HAWG tested how applying the new M's would affect CV's, residuals, retrospective patterns and AIC of the model; which in combination were acceptable.

HAWG agreed to update the M's for the assessment, which looks adequate.

2. Reference points

HAWG reviewed the reference points after the changes to input data and model settings mentioned above, and including the most recent data.

a. B_{lim} and $B_{escapement}$ (= B_{pa})

The group followed a methodology similar to that in WKSPRAT, where stock-recruitment relationship types 1 and 2 were considered, and also added an alternative option that WKSANDEEL (ICES 2024) used to improve precaution: to use the average of the two lowest SSB that produced above-median recruitments (modified type 1).

HAWG agreed to use the alternative method, which deviates from the decision made in WKSPRAT; a more thorough justification for this decision would be welcome.

b. F_{cap}

HAWG ran the short-cut MSE method used in WKspratMSE (ICES, 2019) for six F_{cap} values (0.5, 0.6, 0.7, 0.8, 0.9, 1.0) that resulted in risks from 0.022 to 0.049. It would be beneficial to spend more time on this section, exploring higher F_{cap} values to include the target risk of 0.050. For example, WKspratMSE used a finer grid of 0.01 F_{cap} values, getting risks of 0.049, 0.050 and 0.051 (ICES 2019, table 3.4).

General comments

In general, the decisions made by HAWG 2024 were adequate and followed correct methodologies specified by ICES guidelines. However, an optimal review process like the current one, according to ICES most updated guidelines (ICES 2023), is a one-year process. Probably having more time to work on this type of reviews intersessionally decreases the pressure on everyone involved and increases the quality of the job.

Comments on the Working Document draft

The captions in Figures 4, 5 and 6 do not match with the text in the section 1.2 "Updating natural mortalities". The colours (red/blue) seem to be swapped in the captions.

In Figure 12 caption, points are named as "green", but to be consistent with other figures in the document, they should be called "blue", as they all look to use the same colours.

References

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp. https://doi.org/10.17895/ices.pub.19291145

ICES. 2019. Workshop on the management strategy evaluation of the reference point, F_{cap}, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69. 35 pp. https://doi.org/10.17895/ices.pub.19291148

ICES. 2023. ICES Guidelines for Benchmarks. Version 1. ICES Guidelines and Policies - Advice Technical Guidelines. 26 pp. https://doi.org/10.17895/ices.pub.22316743

ICES. 2024. Benchmark workshop on sandeel (ammodytes spp.) (Outputs from 2022 and 2023 meetings) (WKSANDEEL). ICES Scientific Reports. 6:10. 328 pp. https://doi.org/10.17895/ices.pub.21581151

2.2 Review from Amy Schueller

Two major changes were made in the model. The first change was to move Season 3 catches to Season 2 in the years 2019-2022 to account for the low catch values in Season 3. This change seems to have a favorable effect on the stock assessment, as there was difficulty estimating some parameters with a lack of catch and age data in the latter years. The figures provided suggest that the change was justified and had a small overall effect on the results, yet allowed for better estimation and fitting of the data.

The second change was an update of the natural mortality (M) values from the North Sea multispecies food web model, which has had improvements since it was last used for sprat. M's have increased for all age groups and seasons in the most recent years in the SMS model, so they were incorporated here. The changes in M led to relatively small changes in recruitment estimates in the middle part of the time series, but led to larger differences in the most recent years. However, the stock-recruitment plots look very similar, especially at lower stock sizes between the two runs. The fits to the survey age data were also comparable. These two changes make sense as they updated information to include the best available science and increase the robustness of the model estimation.

The benchmark values were also redetermined using a choice different than the previous assessment. The updated model formulation was appropriate for redetermining the benchmarks. The group discussed using 3 different options for determining B_{lim}: type 1 (spasmodic stocks; median recruitment), type 2 (hockey stick), and a modified type 1 based on the sandeel assessment (spasmodic stocks; mean of two recruitment values above the median recruitment and at the lowest SSB values). The group decided to use the modified type 1 option; however, the justification for this is unclear based on the documentation that was provided. This decision is a deviation from the last assessment where a hockey stick approach was used. While the methods are consistent with what was done in the sandeel assessment, the stock-recruitment plots between the two species do not necessarily have a similar appearance. The sandeel stock-recruitment plots were generally spasmodic with no identifiable area of decreased recruitment at low stock sizes. Based on Figure 11 provided in the documentation, there is a sprat stock size below which there are no recruitment values larger than the median (with 8 years in that region). A hockey stick approach would make more sense here. From the documentation: "The expert group judged the type 2 estimation method to be unsupported and risk prone, and preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark." This last sentence is the justification that was used to make this change. An explanation of how the method is unsupported would be useful. In addition, the statement of the method being more risk prone doesn't make sense without further explanation. The fact that the hockey stick method provides more years with SSB below B_{lim} is not a reason in and of itself to reject this option.

The MSE was updated to reflect the new assessment and used the same methods as were previously used. Very limited information was provided on the MSE; thus, one would infer that the methods were approved during the last assessment and remain consistent.

Comments on the Working Document draft

Figure 4 – The text states that the M values are increasing with the newest SMS model; however, the figure caption states that the red is the updated version (but has lower M values). Is this a caption mistake? This needs some clarity.

Supplementary materials

Sprat Fcap 2024

Mollie Brooks

2024-03-22

Worm plots

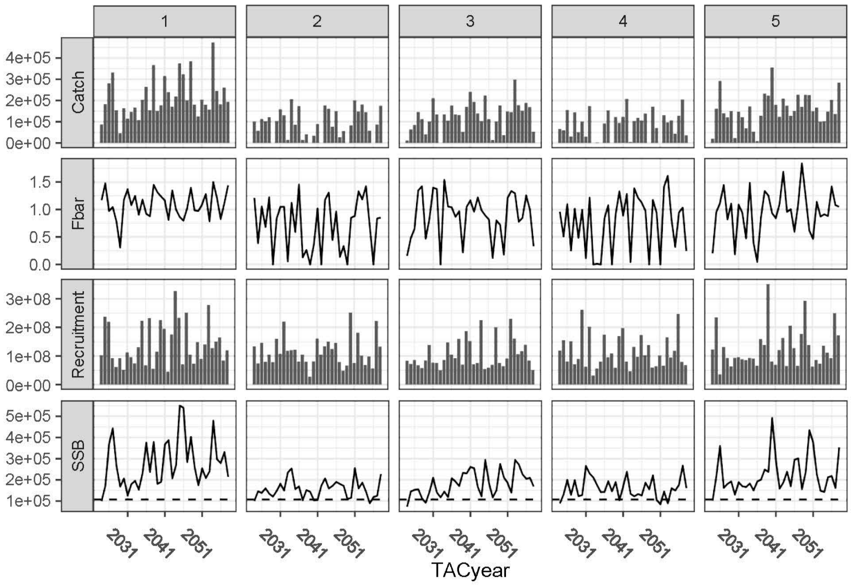

Figure 1: These are 5 simulation trials for one HCR with Fcap = 1

Risk by TACyear by Fcap and TACmin

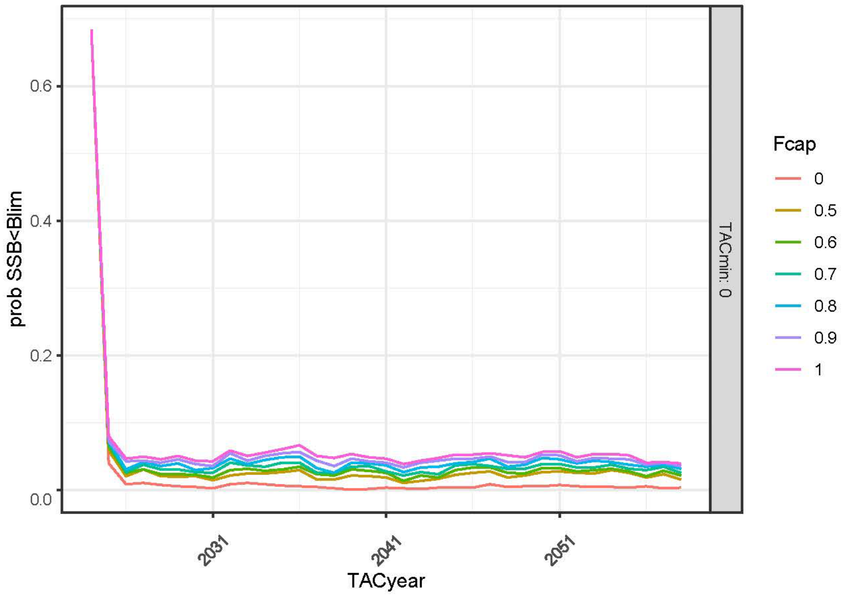

Figure 2: Risk by TACyear for different HCRs.

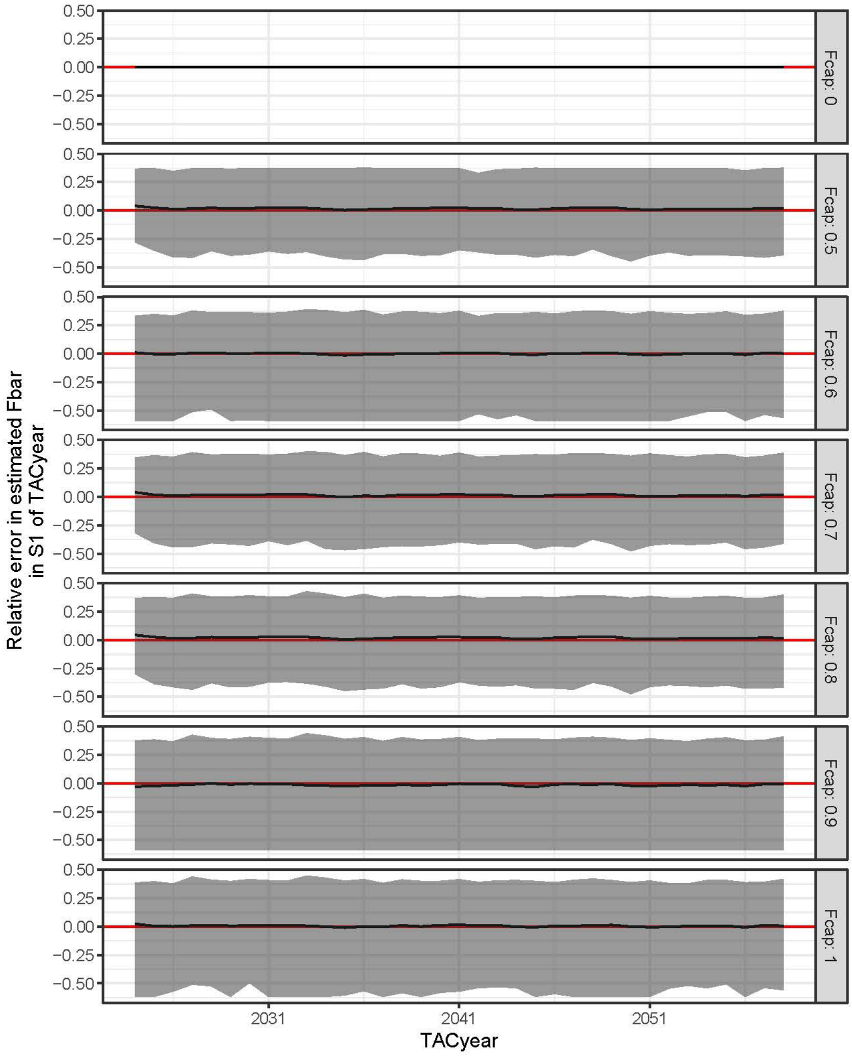

Figure 4: Error rate over time in estimated annual F for ages 1 and 2 (Fbar). The solid black line is the mean. The grey ribbons are 0.025 and 0.975 quantiles. The red line is 0.

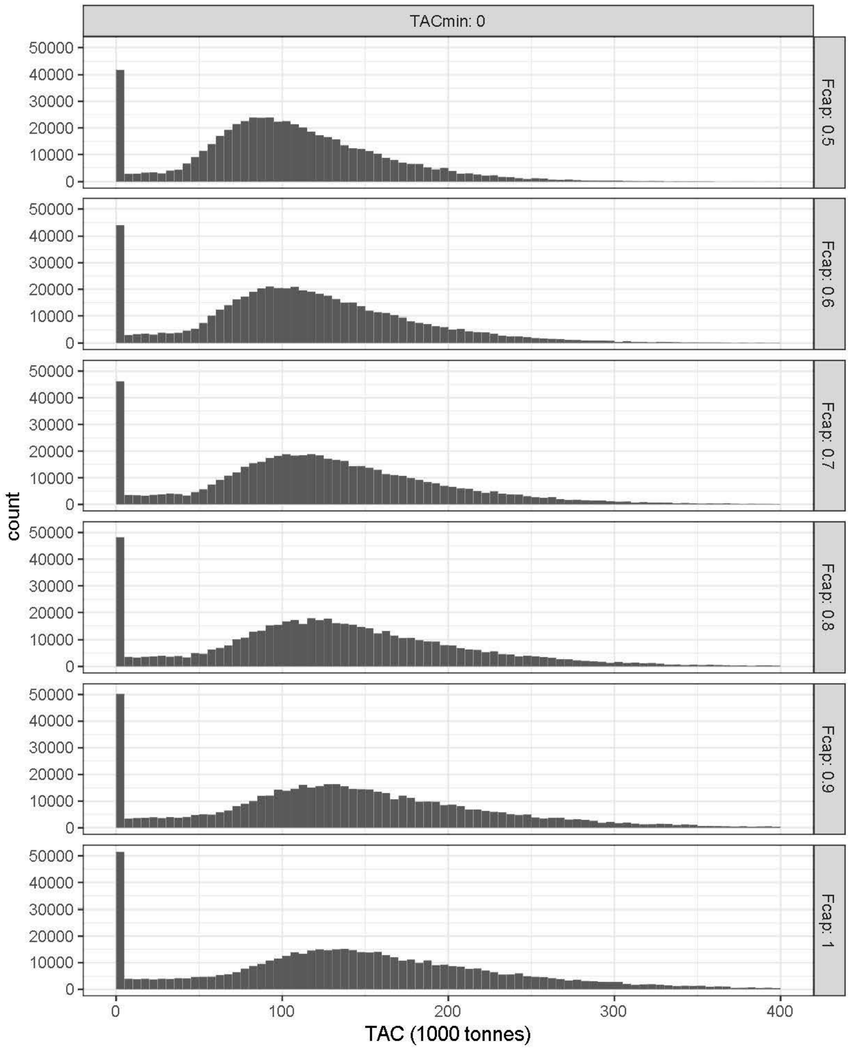

Figure 5: These are the TACs across all years of all simulation trials. The scale of the histogram is too big to see the values near 0.

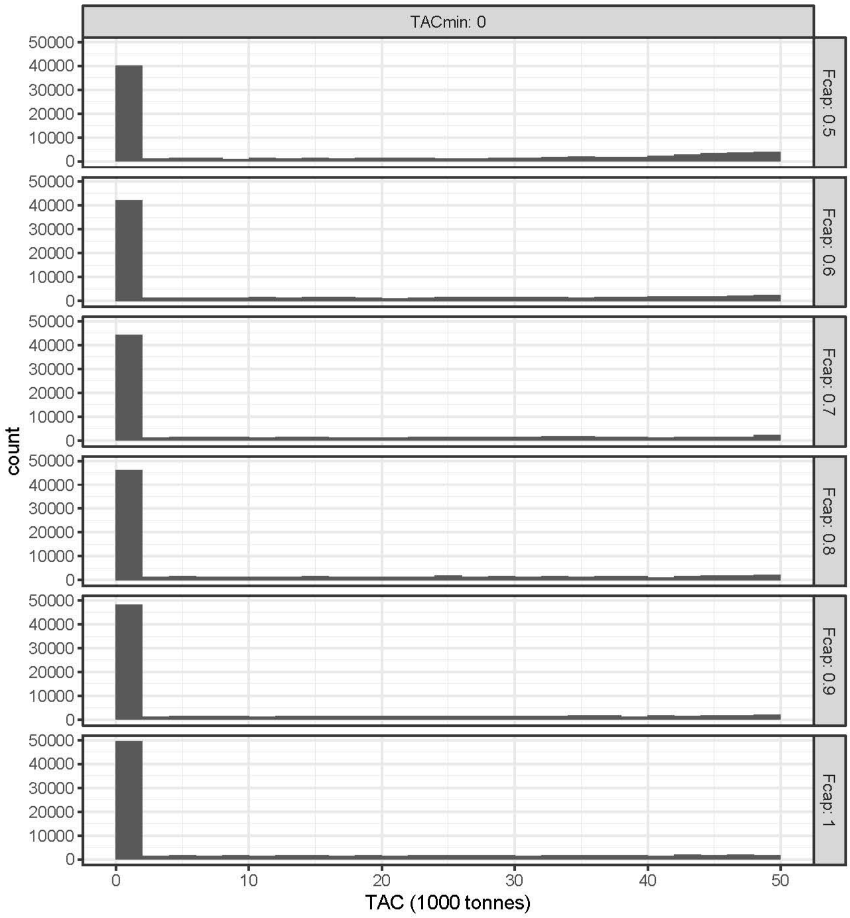

Figure 6: In this zoomed in portion of the histogram (only up to 50,000 tonnes), we can see the stacks at the minimum TAC value.

Summary plots

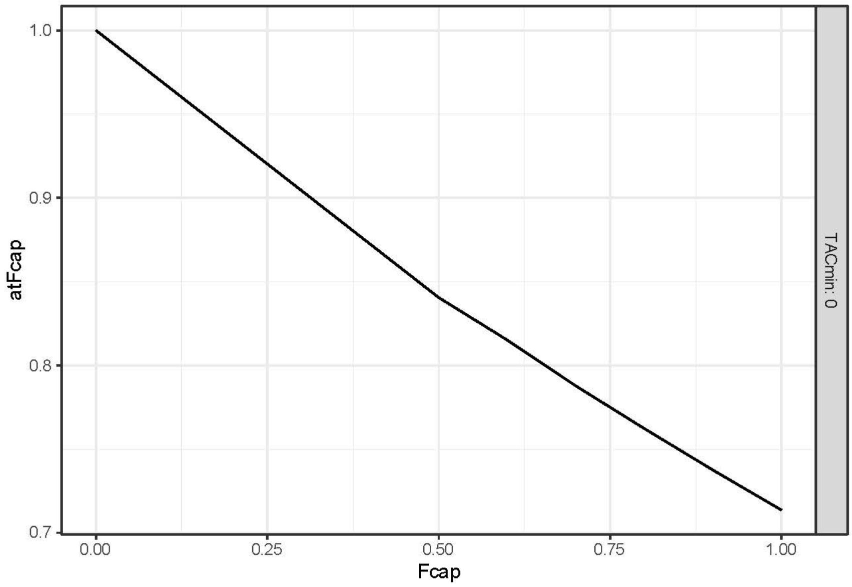

Figure 7: Probability that TAC is based on Fcap in years 2038 to 2058

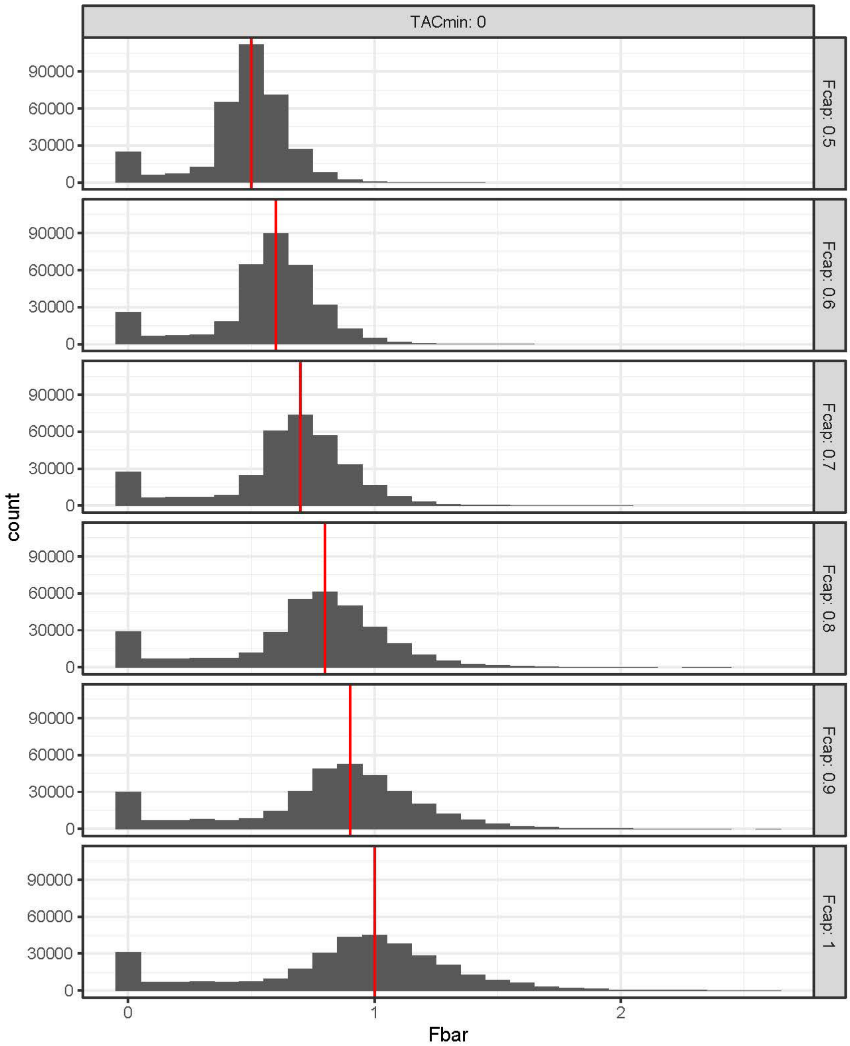

Figure 8: Implemented average F for ages 1 and 2. It can be over Fcap (red vertical line) because there is error in the values going into the forecast (estimated stock numbers, exploitation pattern) that is used to set the TAC. Our implementation model assumes that it will not exceed the highest estimated past effort 2.65.

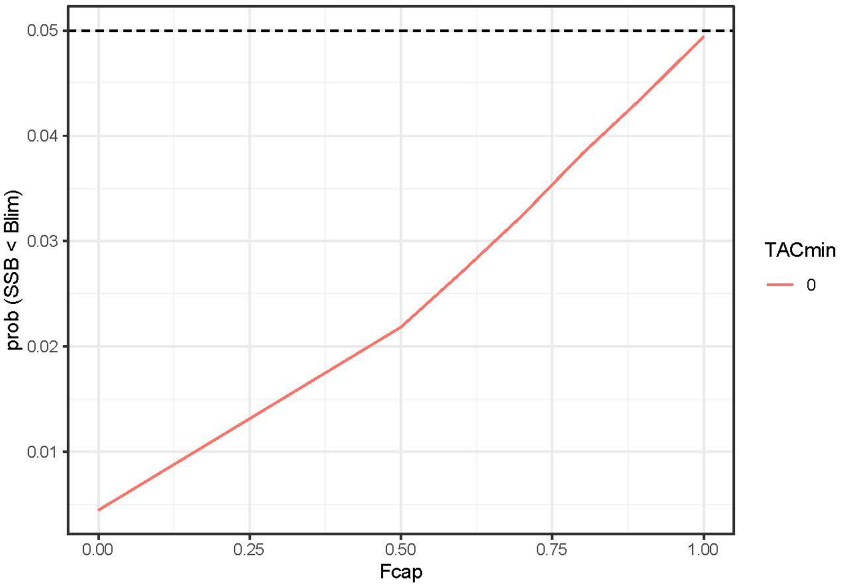

Figure 9: Average risk of SSB<Blim in 2038 to 2058 increases with Fcap. The dashed line is 0.05.

Acknowledgement

European Union
European Maritime and Fisheries Fund

HAV & FISK