

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, 2016a, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these seven areas (sandeel area (SA) 1r, 2r, 3r, 4, and 6). Analytical stock assessments are currently carried out in SA 1r–3r and 4, whereas SA 6 is managed under the ICES approach for data limited stocks (Category 5).

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, 2016a).

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 in several areas in recent years concurrent with a marked change in distribution has 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 2022, 26 vessels participated in the fishery. From 2011 to 2020, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1636 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 2022 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 2022 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2023 (Escapement strategy). This approach resulted in an advised catch / TAC for 2022 in SA 1r, SA 2r, SA 3r, and 4 of 0 t / 5000 t, 71 859 t, 85 559 t / 101 845 t and 0 t / 5000 t, respectively. Advised catches for SA 5, SA 6, and SA 7 for 2021 and 2022 were based on data limited approaches and set at 0 t, 140 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 2022 was given. As the acoustic survey abundance estimate of age 1 and the total biomass estimate (256 000 000 tonnes, RSE=25%) the final TAC increased to 95 000 tonnes. Fishery was allowed in the subareas 1a, 1c, 2b, 2c, 3b, 3c, 4a (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

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.

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

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

Previously, there has been 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 working 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 2000–2022 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 76% 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 16% 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, but for 2022 zero catch was advised.

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 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, 2016a).

The dredge survey in 2022 was carried out as planned in areas 1r, 2r and 3r 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 2022, the majority of catches were comprised of 1-group. The catches contained very few older age-groups (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 2022 and is above the long term mean for all age-groups. For all age-groups the mean weights-at-age are either the highest or in top-3 of all mean weights-at-age in the last two decades.

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 2020 provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, ICES, 2021b). 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 equal to or slightly higher than the values in the old time-series, except for 2018 and onward where the new values are slightly lower in the 1st half of the year. The values used in the 2018

and 2019 assessments were simply replicates of the 3-year average value from 2015. 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 2018–2022.

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 2022 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 ($R^2 = 0.17$).

9.2.6 Data analysis

Following the two latest Benchmark assessments (ICES, 2010, 2016a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2022. 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 (" $\sqrt{\text{Survey variance}} \sim CV$ " in the table) is low (0.51) for age 0 and high (0.76) 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, 2, and 3 (0.56, 0.44, and 0.46) 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 (" $\sqrt{\text{catch variance}} \sim CV$ ", in Table 9.2.5 is low (0.40) for age 1 and age 2 in the first half of the year and moderate to high (> 0.68) 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 showed the opposite tendency.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.84), 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 ρ (-0.07). 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 ρ for R and SSB is 0.56 and 1.09, 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 stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{lim} in periods from 2004–2007, 2013–2015 and 2019–2020, whereas in last two years SSB has been above B_{lim} . F_{1-2} is estimated to have been just below the long-time average since 2010 but have been historically low the last two years 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. In 2018, 2020 and 2021 the recruitment was below average, whereas 2019 and 2022 shows around average recruitment.

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 1983–2021 (101 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 since 2010, 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 2018–2022. Natural mortality 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 120 428 t should be set for 2023. The predicted F that follows from this TAC is 0.424. The TAC according to the escapement strategy ($B_{escapement} = B_{pa}$) is therefore 120 428 t in 2022.

9.2.10 Biological reference points

B_{lim} is set at 110 000 t and B_{pa} at 145 000 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 biases. 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. There are indications of a retrospective pattern in recent years as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g., overwintering mortality increasing when fish condition is low.

9.2.12 Status of the stock

The SSB was below B_{lim} in 2019 and 2020, but above in 2021 and 2022. As noted in a previous HAWG report (ICES, 2019), the introduction of a very low recruitment in 2018 combined with a continued decrease in mean weight-at-age and catches exceeding TAC advice (due to “borrowing and banking”) led to a stock below $MSY B_{lim}$ and $B_{trigger}$ at the beginning of 2020. The SSB in 2023 is within the level expected from the forecast in 2022. There can be several reasons for that, such as increased weight-at-age to some of the highest levels observed the last two decades and low catches following TAC advice in preceding years.

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 ICES WKMSYREF2 and WKMSYREF5 meetings (ICES, 2014, 2017b) 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 0.49 (ICES, 2017b).

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, and the effects should be investigated further to provide more firm conclusions on such management.

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 proportion of ages comprised 1-group in the catch in the period 2020–2022, although not as high as in 2017 (98%), following the high recruitment in 2016. The 2016 year-class was even seen in the 2019 catch as a high proportion of 3-group fish. Older fish constitutes smaller proportions compared to the 2010s (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 2022, weights had increased across all age-groups compared to 2021 being among the record highs for age-2 and above. A drastic increase to highest in the time-series for age-4 were noted but judging from the number of samples from the commercial fleet there were no reason to believe that the mean weight was biased.

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 WGAM 2015 (ICES, 2016c) 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 not updated in response to the WGSAM 2020 key run (ICES, 2021b) as the update is not likely to 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 was on the level of years of 2018–2020 and 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 were moderate in 2022, and in particularly higher in the Northern parts, resulting in the fourth highest age-0 index in the time-series. In 2021 a few explorative hauls were taken close to some of the existing stations. However, catch rates in these hauls were not much different from the adjacent fixed station hauls. In 2022, two of the explorative stations were visited again. The explorative hauls were uploaded to the database as valid hauls and were therefore included in the survey index. SA 2r have the highest internal consistency ($R^2 = 0.57$ on log-scale) across management areas, i.e., the ability of the dredge survey to follow cohorts.

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. In 2020, during an inter-benchmark (ICES, 2020b), the working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run and considered that the retrospective pattern could be caused by ignoring density dependence in catchability (increased catchability at high abundance). The relationship seemed to be well fitted using a power relationship between dredge index and abundance, with no indication of this given errors in estimated abundance in high or low abundance years. The use of a power model for survey catchability of the youngest age groups is routinely used for North Sea sprat (ICES, 2018). It is an adjustment of the model where one additional parameter is estimated. HAWG evaluated the retrospective bias in recruitment in 2020 without density dependent catchability (Mohn's $\rho = 0.63$) and with density dependent catchability (Mohn's $\rho = 0.52$). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 (ICES, 2020a) decided to include density dependent catchability in the final run. HAWG 2023 re-examined the density dependent parameter and found that it is still well above 1 (1.4).

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 hitting the bound (model restrictions that has a bound of 0.30) for the 0-group. This indicates that the model has high confidence in the survey after the introduction of the density dependent catchability for age 0, indicating a high consistency between the results from the dredge survey and the overall model results. The CV for age-1 is moderately high, indicating that the model has difficulty in following this age-group. 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 (0.45) 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 (0.99) 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 (0.10 in “objective function weight” in Table 9.3.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit. Although, this weight has been set lower for SA 1r, and similarly a lower weight may solve these issues.

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 and estimated F (Figure 9.3.12) shows a good relationship between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the five periods 1983–1988, 1989–1998, 1999–2004, 2005–2009, and 2010–2022, the relation between effort and F varies between these periods. 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 2016a).

The retrospective analysis (Figure 9.3.9) shows consistent assessment estimates of F from one year to the next. There has been a systematic overestimation of SSB in most years since around 2011 (with few exceptions), sometimes, but not always, as a result of an overestimation of recruitment (and therefore lower than expected abundance of these cohorts in the subsequent catches). This pattern was improved by the introduction of density dependent catchability in the model. The 5-year Mohn’s rho values are, however, still fairly high (0.45 and 0.45 for SSB and recruitment, respectively). Reasons for the previous pattern can be connected to either overestimation of recruitment in the dredge survey, lower than expected survival of the two cohorts, or lower than expected catchability of these cohorts in the fishery. Also, possible overestimation of mean weight-at-age in some years can be part of the explanation. Both the selectivity pattern and the dredge survey are based on a relatively short time-series, and hence variation between years is to be expected.

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 stock summary (Figure 9.3.13 and Table 9.3.10) show that recruitment has been highly variable and with a weak decreasing trend over the full time-series until the 2016 year-class, which is estimated to be the fourth strongest on record, followed by a 2017 year-class which is estimated to be the lowest observed and a 2018 year-class which was the fifth lowest on record. In recent times, the recruitment was above average in 2019, 2021 and 2022 but being below average in 2020. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2012 to 2017 and 2019 to 2021. Since 2022, SSB has been above B_{lim} . Since 2004, SSB has been below B_{pa} in all years. 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 2023 is the geometric mean of the recruitment in 2012–2021. The exploitation pattern and F_{sq} (2022-value) is taken from the 2023-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 2018–2022. Natural mortality and proportion mature are the fixed values applied in the terminal year in the assessment.

Output

The short-term forecast (Table 9.3.12) shows that a fishing mortality of 0.29 will bring SSB down to B_{pa} in 2024. Accordingly, a TAC of 40 997 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 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa} . F_{cap} is set at 0.44 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex and Benchmark report from 2016 (ICES, 2016a).

9.3.11 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessments where the ICES statistical rectangles included in SA 2r changed. The assessment now includes fisheries independent information from a dredge survey representative for the area. The assessment is considered to be of medium to good quality but with some indications of a retrospective pattern in recent time periods as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g., overwintering mortality increasing when fish condition is low (van Deurs *et al.*, 2011.). HAWG also highlighted that the pattern might also have a link to the possible multispecies fishery within this area (i.e., suspected to catch *Ammodytes tobianus*). The dredge survey time-series in SA 2r is still short (2010–2022) and the quality of the assessment will likely improve once a longer time-series becomes available. Next benchmark will take place in 2022 and is still ongoing due to an extension.

9.3.12 Status of the Stock

A moderate F in most of the years from 2010 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004 to 2010. SSB in the period for 2019–2021 were estimated below B_{lim} . In 2022 the stock was estimated to be above and remain above B_{lim} in 2023. The stock has been below B_{lim} in 16 out of the last 20 years never reaching above B_{pa} . Recruitment in 2016 is estimated to be the fourth highest on record. The 2019–recruitment was estimated to be the fifth highest since 1997. Recruitment in 2017 and 2018 were extremely low. Recruitment in 2019 was average and recruitment in 2020 was low. The recruitment in 2021 were high and appears to remain high in 2022. However, based on the retrospective patterns of this stock, we anticipate some down-scaling in the coming years.

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, 2016a) 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 0.44. 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 2022, the catches consisted of all age groups, where the proportion in numbers of 1-, 2-, 3- and 4-group, respectively, were 38%, 25%, 20% and 17%.

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 has increased for four consecutive years in all age-groups and is now the highest ever observed for age-1 and the second highest for age-2.

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 2020, WGSAM (ICES, 2021b) 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 resulted in a substantial change in the historic perception of the stock, including possible changes to reference points. For this reason, it was decided not to use the new natural mortalities but to refer to HAWG for consideration of whether new reference points should be estimated.

3-year averages of natural mortality-at-age from the WGSAM 2015 (ICES, 2016c) multispecies modelling of southern and 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.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2022 show 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., $r^2 = 0.37$ 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, 2016a).

The Norwegian acoustic survey (2009–2022) 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 0 vs. age 1 ($r^2 = 0.84$ on log scales), age 1 vs. age 2 ($r^2 = 0.89$ on log scales), and age 2 vs. age 3 ($r^2 = 0.6$ on log scales).

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. In 2020 an inter-benchmark (ICES, 2020b) decided to include density dependent catchability in the final run to reduce the recruitment overestimation problem. This approach was continued in 2021–2023.

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 medium for age 0 (0.61) and high for age 1 (0.73), 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 both age 1 and age 2 (0.54) and high for age 3 (1.08), showing an overall medium consistency between the results from the acoustic survey and the overall model results. The residual plot shows high positive residuals in recent years, indicating that high acoustic indices were not confirmed by the model.

The model CV of catch-at-age is high (0.72) 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 (> 1.00). 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.

The recruitment CV (Table 9.4.5) is very high (1.49), 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 (0.01 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 the recruitment that consistently overestimated large recruiting year-classes. However, after implementing density dependence on the relationship between recruitment and the dredge survey in 2020 (i.e., increasing catchability with increasing densities), the retrospective bias was reduced (Mohn’s ρ).

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. As the model assumes a different catchability-at-age for the three periods 1986–1998, 1999–present, the relation between effort and F varies between these periods. There is a shift in the ratio between effort and F over the full time-series. In the year range 1986–1998, F is in generally lower than effort on the plot, while the opposite is the case for the remaining periods, corresponding to a technical creep over time (ICES, 2016a).

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

SSB has been at or below B_{lim} from 1999 to 2006 after which SSB increased to above B_{pa} in 2008. This was followed by SSB below B_{lim} in 2013 (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} in 2015 onwards. However, a steep drop in SSB from 2022 to 2023 is estimated.

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 2023 is the geometric mean of the

recruitment 1986–2021 (118 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2021. As the SMS-model assumes a fixed exploitation pattern since 1999, 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 2018–2022. 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 a fishing mortality of 0.13 will bring SSB down to B_{pa} . Accordingly, the advised catch of maximum 30 570 t for 2023 is forecasted to keep SSB at or above $MSY B_{trigger}$ ($=B_{pa}$).

9.4.10 Biological reference points

B_{lim} is set at 80 000 t and B_{pa} is estimated to 129 000 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 from 2016 (ICES, 2016a).

9.4.11 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessment. The new sandeel area 3r is slightly different from the previous sandeel area 3, and mainly consists of fishing grounds in Norwegian EEZ. There is a large retrospective pattern in the recruitment that overestimates high recruitments. 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 and the change in the spatial coverage of the dredge survey. 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 from below B_{lim} in 2013 to above B_{pa} since 2015, due to above average recruitment in 2013, 2014, 2016, 2018 to 2020 combined with a low fishing mortality. However, fishing mortality has increased since 2016, peaking in 2020, but decreased in 2021 and 2022 SSB decreased considerably between 2021 and 2022, due to high fishing mortality and decreasing recruitment (but SSB is still well above B_{pa}). Recruitment estimates for 2018–2020 were all above average but declining since 2019. Recruitment in 2021 and 2022 were estimated to be below average.

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).

9.5.2 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 9.5.2 and Figure 9.5.2 by half year. Mean weight-at-age in the first half year seems to have recovered to above average and currently stable for all ages after the very low levels in 2001 to 2005. The second half year the mean weights are affected by the very limited sampling at this time of year.

9.5.3 Maturity

Maturity estimates are obtained from the averages observed in the dredge survey (1983–2016) in December as described in the Stock Annex. Maturities are listed in Table 9.5.3.

9.5.4 Natural mortality

Long-term averages of natural mortality-at-age from the WGSAM 2015 (ICES, 2016c) 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 not updated in response to the new WGSAM 2020 key run (ICES, 2021b) as the update is not likely to affect long-term averages greatly.

9.5.5 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. Effort in 2021 was the third highest in the time-series reflecting the high TAC given that year. The effort in 2022 was low, but slightly above the effort in the period 2004–2016 which reflects either a closed or very limited fishery. This low level of effort reflects the 5000 tonnes monitoring TAC for 2022.

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 2022 recruitment is slightly above average. Recruitment was below average in 2021 but preceded by two strong year-classes (2019 and 2020).

An error discovered in the code used to calculate the 2020 indices was discovered and resulted in overestimated abundance indices for age 0-, 1- and 2-groups in 2020. The corrected indices (for 2020) were used in 2022.

The ability of the area 4 dredge survey to provide accurate estimates of abundance by age was discussed in detail in 2021. All the values are estimated as stratified mean values (mean within position followed by mean within square followed by mean across squares), an approach which is known to be sensitive to skewed data at low sampling levels. Up to 2018, indices of cohorts at age 1 averaged at 1.22 times the catch of the index of the cohort at age 0 (range 0.6–2.35). The corresponding number from age 1 to 2 was 0.43 (range 0.09–1.58). In 2019, the index of 1-year olds (2018 cohort) was 5.75 times the index of the cohort at age 0. This pattern persisted in 2020 where the index of 1-year olds (2019 cohort) was 3.49 times the index of the cohort at age 0, corresponding to the 2nd all-time highest appearances relative to earlier estimates of the cohort. The 2020 index of the 2018 cohort was 1.22 times the 2019 index of the cohort, corresponding to the second highest appearance relative to earlier estimates of the cohort. In all cases, these values represent all time high appearance relative to earlier estimates of the cohort. In the 2021 survey index, the 2019 and the 2020 cohorts were registered as 0.24 and 0.03 times the values observed in 2020. Both values are the lowest relative changes observed in the time series. In the 2022 survey index, the 2020 and the 2021 cohorts were registered as 0.9 and 2.81 times the values observed in 2021. While still high, these values are respectively within and closer to the ranges observed before 2018. It was suggested that some of these issues might be related to the stratified mean approach in years with reduced sampling at the most productive stations and that adopting the approach in place for the other management areas (as explored at the benchmark) might alleviate some of these issues.

The internal consistency, i.e., the ability of the survey to follow cohorts, (Figure 9.5.4) shows a high correlation between the 0-group and 1-group explaining 56% of the variation.

9.5.6 Data analysis

Following the Benchmark assessment (ICES, 2016a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2022. 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 2008–2022) (“sqrt (Survey variance) ~CV” in the table) is low to moderate (<0.52) for all ages. The CV remained similar for age 0 between the 2022 and 2023 assessments (0.55 to 0.52). The CV for age 1 is on the pre-determined boundary of 0.3. 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 in 2020 are large and positive for both ages (Figure 9.5.6), indicating that the large observed indices in 2020 are not supported by other information about the abundance of these cohorts. Survey residuals in 2022 are also positive for both age groups but are small to moderate.

The model CV of catch-at-age (“sqrt(catch variance) ~CV”, in Table 9.5.5 is moderate (0.73) for age 1 and 2. The catch-at-age residuals (Figure 9.5.7) show no alarming patterns, except for a negative tendency in the residuals (observed catch is lower than model catch) for age 1 in season 1 in the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.49), 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 except for the 2020 peel. The high recruitment in the 2019 and 2020 cohort expected from the 2020 survey was downscaled after adding the 2021 survey, leading to a high retrospective bias in both recruitment and SSB in 2019 and 2020. While 2021 recruitment has been upscaled with the inclusion of the 2022 survey, little to no change was observed in SSB.

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

9.5.7 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).

9.5.8 Historic Stock Trends

The stock summary (Figure 9.5.13 and Table 9.5.10) shows that SSB have been at or below B_{lim} from 2007 to 2010. Since 2010, SSB has been above B_{lim} in 2011, 2016 and 2021, but below B_{pa} in 2015 only. SSB is estimated at 97 538 in 2023. F_{1-2} is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004 with a decrease in 2019 and 2020, to a record-high (second) F in 2021 and was low again in 2022. Recruitment has been high in 2014, 2016, 2017, 2019, 2021 and 2022. The high F in 2021 was the result of the lack of confirmation in the 2021 survey of the high survey indices in 2020. The biomass did however not decline below B_{lim} .

9.5.9 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) a fishing mortality of 0.15 (F_{cap}) will bring SSB above B_{pa} in 2024. The catch advice is 35 020 t for 2023.

9.5.10 Biological reference points

B_{lim} is set at 48 000 t and B_{pa} at 102 000 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.

9.5.11 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 2022 is high (0.30, see Figure 9.5.10).

9.5.12 Status of the Stock

Recruitment in 2014, 2016, 2017, 2019, 2021 and 2022 are above the long-term geometric average, while the remaining years after 2010 are below. A very restrictive F since 2005, with the exception of 2018 and 2021, together with the return of recruitment to historic levels in 2009, 2014, 2019 and 2022 has resulted in SSB above B_{pa} in 2016 to 2019 and in 2021. It is between B_{lim} and B_{pa} in 2020, 2022 and 2023.

9.5.13 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 presented at the ICES WKMSYREF2 and WKMSYREF5 meeting (ICES, 2014, 2017b) 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 (in accordance with the concepts of a conventional management strategy evaluation and a selection criterion of 0.05 probability of $SSB < B_{lim}$) is set at 0.15 (ICES, 2017b).

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. Therefore, such a high TAC may not be sustainable and future work should consider how to incorporate the spatial management in place in future advice.

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 (2009–2022) (see Johnsen, 2022) 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.

9.10 References

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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

- ICES. 2016. Stock Annex: Sandeel (*ammodytes marinus*) in Division 4.a, the North Sea area 5 (SA5). ICES Stock Annexes. 17 pp. <https://doi.org/10.17895/ices.pub.18623153>

San.sa.6 – stock annex

- ICES. 2016. Stock Annex: Sandeel (*Ammodytes* spp.) in subdivisions 20-22, Sandeel Area 6 (Kattegat). ICES Stock Annexes. 16 pp. <https://doi.org/10.17895/ices.pub.18623189>

San.sa.7r – stock annex

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>

9.11 Tables and Figures

Table 9.1.1 Sandeel. Official catches ('000 t), 1952–2022 for area 27.4 and 27.3.a. Note that catches from 27.3.a are only available from 1973–2022.

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
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	0.179	13.6	-	-	444.7

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1976	27.3.a + 27.4	446.1	-	-	-	-	44.2	0.067	18.7	-	-	509.1
1977	27.3.a + 27.4	680.4	-	11.4	-	-	78.7	6.132	25.5	-	-	802.1
1978	27.3.a + 27.4	669.2	-	12.102	-	-	93.5	2.321	32.5	-	-	809.7
1979	27.3.a + 27.4	483.1	-	13.2	-	-	101.4	0.003	13.4	-	-	611.1
1980	27.3.a + 27.4	581.6	-	7.2	-	-	144.8	0.009	34.3	-	-	767.9
1981	27.3.a + 27.4	523.8	-	4.9	-	-	52.6	0.044	46.7	-	-	628.1
1982	27.3.a + 27.4	528.4	-	4.9	-	-	46.5	0.405	52.2	-	-	632.4
1983	27.3.a + 27.4	515.2	-	2	-	-	12.378	0.23	37	-	-	566.8
1984	27.3.a + 27.4	618.9	-	11.3	-	-	28.3	-	32.6	-	-	691.1
1985	27.3.a + 27.4	601.7	-	3.9	-	-	13.1	-	17.2	-	-	635.9
1986	27.3.a + 27.4	832.7	-	1.2	-	-	82.1	0.002	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	-	-	185.265	-	5.8	-	-	915.3
1989	27.3.a + 27.4	841.6	-	16.6	-	-	186.84	-	11.5	-	-	1056.3
1990	27.3.a + 27.4	512.1	-	2.2	-	0.3	88.999	-	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	-	-	89.349	0.588	4.9	-	-	907.6
1993	27.3.a + 27.4	533.4	-	0.344	-	-	95.5	-	1.5	-	-	630.8
1994	27.3.a + 27.4	688.6	-	10.3	-	-	165.8	0.02	5.9	-	-	870.7
1995	27.3.a + 27.4	672.6	-	-	-	-	263.4	0.04	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	-	-	350.209	0.001	24.6	-	-	1217.8
1998	27.3.a + 27.4	628.2	-	11	-	-	343.3	8.565	23.8	-	-	1014.8
1999	27.3.a + 27.4	511.3	-	13.2	0.4	-	187.6	23.21	11.5	-	-	747.1
2000	27.3.a + 27.4	557.3	-	-	-	-	119	28.643	10.8	-	-	715.7

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
2001	27.3.a + 27.4	650.0	-	-	-	-	183	49.979	1.3	-	-	884.3
2002	27.3.a + 27.4	659.5	-	0.025	-	-	176	19.211	4.9	-	-	859.6
2003	27.3.a + 27.4	282.8	-	-	-	-	29.6	21.822	0.5	-	-	334.7
2004	27.3.a + 27.4	288.8	2.7	-	-	-	48.5	33.331	-	-	-	373.3
2005	27.3.a + 27.4	158.9	-	-	-	-	17.3	0.472	-	-	-	176.6
2006	27.3.a + 27.4	255.4	3.2	-	-	-	5.6	27.858	-	-	-	292.8
2007	27.3.a + 27.4	166.9	1	2	-	-	51.1	7.875	1	-	-	229.9
2008	27.3.a + 27.4	246.9	4.4	2.4	-	-	81.6	12.51	-	-	-	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	32.72	4	0.6	-	414.2
2011	27.3.a + 27.4	278.5	9.8	-	-	-	109	32.717	6.1	1.65	-	437.8
2012	27.3.a + 27.4	51.8	1.70844	-	-	0.317	42.4804	5.652	-	-	0.00328	101.9
2013	27.3.a + 27.4	208.7	7.89833	-	-	0.387	30.44615	26.811	2.436	1.32035	0.00387	278.0
2014	27.3.a + 27.4	156.5	5.05196	-	-	-	82.49885	18.815	0.03	0.82463	0.00262	263.8
2015	27.3.a + 27.4	166.5	9.09745	-	-	-	100.85862	33.43879	2.00003	-	4e-05	311.9
2016	27.3.a + 27.4	28.4	-	-	-	-	40.86736	4.2595	-	-	-	73.5
2017	27.3.a + 27.4	353.9	5.7985	-	-	-	120.20534	42.33624	3.32389	-	-	525.5
2018	27.3.a + 27.4	175.6	5.937	-	-	-	69.53076	16.655512	1.848779	-	-	269.6
2019	27.3.a + 27.4	93.7	3.95	-	-	1.2e-05	124.7855	11.54334	1.05792	-	-	235.1
2020	27.3.a + 27.4	169.2	3.81522	-	-	-	244.37908	25.5189974	3.89595	-	2e-05	446.8
2021	27.3.a + 27.4	69.5	1.81976	-	-	-	146.4421	14.837449	-	-	4.7e-05	232.6
2022	27.3.a + 27.4	72.7	-	-	-	-	81.675654	11.828	0.003066	-	-	166.2

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

Year	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
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	99059	64707	95426	4505	0	65	0	263762
2015	162861	39492	104607	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	131898	20240	75143	42298	0	0	0	269579

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2019	86723	5151	136901	6666	0	96	0	235537
2020	108944	70198	247411	20116	0	97	0	446765
2021	17082	4146	157524	53765	0	93	0	232610
2022	5156	71569	83964	5507	0	42	0	166238

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

Year	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
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	94278	62110	95426	4505	0	65	0	256383
2015	162860	38723	104607	4736	0	197	0	311123

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	125303	19957	74567	42298	0	0	0	262126
2019	71590	5148	136896	6666	0	96	0	220396
2020	107762	69894	247411	19896	0	97	0	445060
2021	16615	4142	157397	51448	0	93	0	229695
2022	5154	71569	83964	5507	0	42	0	166236

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

Year	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
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

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2013	6902	4354	0	0	0	0	0	11256
2014	4781	2598	0	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	6595	283	576	0	0	0	0	7453
2019	15133	3	5	0	0	0	0	15141
2020	1182	304	0	220	0	0	0	1705
2021	468	3	126	2317	0	0	0	2915
2022	2	0	0	0	0	0	0	2

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

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	8992	4719	864	63	0	9	0	14649
1984	10166	4009	1378	48	212	50	37	15901
1985	10876	3570	619	655	139	65	0	15923
1986	7372	5038	4641	284	12	469	145	17962
1987	5680	1153	5094	177	64	45	0	12213
1988	7980	3876	7472	42	0	90	0	19460
1989	8553	6552	7677	57	31	44	0	22914
1990	8529	4209	5143	55	0	24	0	17960
1991	5991	5117	5864	338	19	1	0	17330
1992	8805	4944	2383	571	0	197	0	16900
1993	3893	4396	5124	1387	29	265	0	15093
1994	3149	4230	4854	1588	0	114	0	13934
1995	5899	2497	3791	437	1915	50	0	14589
1996	5497	4608	4352	1464	605	48	0	16573
1997	5366	5308	7749	622	0	60	6	19111
1998	6580	2743	11062	611	96	26	0	21118
1999	8900	1975	6179	850	0	0	0	17904
2000	7141	2597	4117	421	5	0	149	14429
2001	11021	2505	4726	669	0	1	0	18921
2002	8162	3162	2491	140	1	13	0	13968
2003	6805	2351	1634	1098	19	6	0	11913
2004	7057	4208	1264	203	0	27	0	12758
2005	3412	1131	468	88	0	10	0	5109
2006	4160	1235	205	1	0	5	0	5606
2007	1560	874	1214	1	0	0	0	3650
2008	2878	906	1344	7	0	0	0	5136
2009	3551	802	111	0	0	0	0	4464

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2010	2859	1136	1446	4	0	0	0	5444
2011	3195	677	924	7	0	18	0	4821
2012	585	472	561	68	0	13	0	1699
2013	3876		273	37	0	8	0	5992
2014	2270	1416	1072	51	0	4	0	4812
2015	2073	1233	1412	43	0	5	0	4767
2016	146	429	561	79	0	6	0	1220
2017	2711	2082	1198	166	0	0	0	6157
2018	3126	563	1437	524	0	0	0	5651
2019	2823	136	1957	203	0	3	0	5121
2020	2696	1384	3392	165	0	5	0	7642
2021	434	259	1799	1297	0	3	0	3792
2022	128	1656	2104	114	0	1	0	4002

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

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	6926	3032	739	63	0	9	0	10770
1984	7910	2471	1172	48	212	46	37	11896
1985	8449	2564	508	652	139	29	0	12341
1986	6568	3884	2508	281	4	437	81	13763
1987	4287	779	5063	161	64	42	0	10395
1988	7172	2660	6030	40	0	69	0	15970
1989	8240	4852	7586	56	31	42	0	20808
1990	8008	3380	3738	49	0	24	0	15201
1991	4588	3538	4750	111	19	1	0	13008
1992	7926	3793	2290	309	0	197	0	14514
1993	3496	2597	3950	1200	29	256	0	11527
1994	2852	3097	4411	1410	0	98	0	11867
1995	5298	1527	3589	436	1915	50	0	12815
1996	4805	1627	3147	519	441	48	0	10587
1997	3997	3440	5895	490	0	52	0	13874
1998	6011	1707	7059	576	93	26	0	15473
1999	7875	772	3204	850	0	0	0	12702
2000	6181	1991	4040	421	5	0	149	12786
2001	8041	1362	1681	656	0	1	0	11741
2002	7942	2489	2491	140	1	13	0	13076
2003	5907	1034	1246	1027	19	6	0	9239
2004	6601	3179	862	201	0	27	0	10870
2005	3288	816	468	88	0	10	0	4670
2006	3982	858	200	1	0	5	0	5046

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2007	1560	874	1214	1	0	0	0	3650
2008	2793	797	1344	7	0	0	0	4942
2009	3377	608	110	0	0	0	0	4094
2010	2725	948	1436	4	0	0	0	5113
2011	3070	665	924	7	0	18	0	4684
2012	585	447	561	68	0	13	0	1674
2013	3704	1618	273	37	0	8	0	5639
2014	2174	1344	1072	51	0	4	0	4645
2015	2073	1214	1412	43	0	5	0	4748
2016	146	413	561	79	0	6	0	1205
2017	2661	1827	1198	166	0	0	0	5852
2018	2817	558	1425	524	0	0	0	5324
2019	2489	136	1957	203	0	3	0	4788
2020	2656	1304	3392	165	0	5	0	7522
2021	405	242	1791	1197	0	3	0	3636
2022	128	1656	2104	114	0	1	0	4002

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

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	2066	1687	126	0	0	0	0	3879
1984	2256	1538	207	0	0	4	0	4005
1985	2427	1005	110	3	0	35	0	3582
1986	804	1154	2133	3	8	32	64	4199
1987	1393	374	31	16	0	3	0	1817
1988	809	1215	1442	2	0	22	0	3490
1989	313	1700	92	0	0	1	0	2106
1990	520	828	1405	5	0	0	0	2759
1991	1403	1579	1113	227	0	0	0	4322
1992	879	1151	93	262	0	0	0	2385
1993	398	1799	1174	187	0	10	0	3567
1994	297	1133	443	178	0	16	0	2067
1995	601	970	201	1	0	0	0	1774
1996	691	2981	1205	945	163	0	0	5986
1997	1369	1868	1854	132	0	7	6	5237
1998	568	1036	4003	35	3	0	0	5645
1999	1024	1203	2975	0	0	0	0	5202
2000	960	606	78	0	0	0	0	1643
2001	2979	1143	3044	13	0	0	0	7180
2002	220	672	0	0	0	0	0	892
2003	898	1316	388	71	0	0	0	2673

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2004	456	1028	402	2	0	0	0	1888
2005	124	316	0	0	0	0	0	439
2006	178	377	5	0	0	0	0	560
2007	0	0	0	0	0	0	0	0
2008	85	109	0	0	0	0	0	194
2009	174	194	2	0	0	0	0	370
2010	134	187	10	0	0	0	0	331
2011	126	11	0	0	0	0	0	137
2012	0	25	0	0	0	0	0	25
2013	172	181	0	0	0	0	0	353
2014	96	71	0	0	0	0	0	167
2015	0	19	0	0	0	0	0	19
2016	0	15	0	0	0	0	0	15
2017	50	255	0	0	0	0	0	305
2018	309	6	12	0	0	0	0	327
2019	334	0	0	0	0	0	0	334
2020	40	80	0	0	0	0	0	120
2021	30	18	8	100	0	0	0	156
2022	0	0	0	0	0	0	0	0

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

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	79	49	0	0	0	0	0	128
1984	116	46	13	0	2	3	0	180
1985	101	32	1	19	2	3	0	158
1986	26	17	27	1	0	1	0	72
1987	62	12	60	1	0	1	0	136
1988	42	15	67	0	0	1	0	125
1989	40	9	43	0	0	1	0	93
1990	1	4	37	0	0	2	0	44
1991	25	32	30	1	0	0	0	88
1992	56	42	24	4	0	7	0	133
1993	23	63	64	15	0	7	0	172
1994	20	38	50	15	0	4	0	127
1995	41	32	58	7	7	2	0	147
1996	43	62	113	27	19	1	0	265
1997	41	84	116	25	8	3	0	277
1998	53	30	145	7	0	2	0	237
1999	263	42	40	44	0	0	0	389
2000	102	34	47	59	0	0	0	242

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
2001	213	39	32	90	1	0	0	375
2002	288	97	50	62	0	0	0	497
2003	281	75	30	160	0	1	0	547
2004	451	217	26	47	0	1	0	742
2005	320	42	34	30	0	1	0	427
2006	550	56	72	2	0	2	0	682
2007	295	79	95	0	0	0	0	469
2008	290	100	45	1	0	0	0	436
2009	302	102	3	0	0	0	0	407
2010	169	194	30	1	0	0	0	394
2011	167	54	17	4	0	4	0	246
2012	220	112	31	21	0	12	0	396
2013	292	220	41	5	0	3	0	561
2014	143	133	29	18	0	5	0	328
2015	308	117	48	38	0	4	0	515
2016	154	159	42	35	0	0	0	390
2017	279	204	50	40	0	0	0	573
2018	350	136	162	71	0	0	0	719
2019	282	81	140	32	0	0	0	535
2020	241	182	184	36	0	1	0	644
2021	69	51	169	121	0	2	0	412
2022	25	159	125	24	0	1	0	334

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	10223	1846	264	28971	3085	772	564	320	2
1984	0	47117	9241	1701	90	10002	566	333	43
1985	8524	6217	1354	31364	2305	1987	1595	211	213
1986	87	44940	4163	7553	228	1652	188	31	14
1987	187	4504	1938	23572	4173	1199	123	171	32
1988	0	1997	0	8564	162	15229	1439	2354	47
1989	0	62503	757	6364	77	1346	16	4736	58
1990	522	16846	1257	13917	417	2060	62	622	18
1991	7344	14939	6917	6870	209	983	67	338	0
1992	104	50883	3041	8451	298	845	122	524	26
1993	1624	2181	362	5882	271	1638	156	491	43
1994	0	22172	1533	2669	126	1195	55	882	78
1995	76	36677	3440	6236	940	737	109	289	28
1996	6470	10402	1064	12301	1027	4527	211	860	65

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1997	19	38667	8899	2332	177	3522	164	713	56
1998	211	9387	438	28364	1384	2164	136	1505	90
1999	440	44621	2498	5433	205	10158	717	699	149
2000	7887	32625	2760	3355	170	630	84	1076	122
2001	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	208	0	1193	0	97	0	17	0
2017	3	33038	253	3015	40	4604	38	103	7
2018	91	1699	158	14468	792	971	44	331	10
2019	5947	4703	96	830	18	1885	19	101	0
2020	54	11911	80	1098	12	270	2	457	5
2021	2	1141	49	991	28	53	2	33	1
2022	0	549	0	35	0	31	0	5	0
arith. mean	2549	21836	1571	8434	564	2182	179	647	36

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	4.9	4.0	9.7	8.3	17.2	13.2	20.5	11.6
1984	3.7	5.5	7.3	10.1	12.8	14.1	16.8	13.4	15.8
1985	3.0	5.1	5.8	9.2	10.7	16.4	12.9	17.9	16.6
1986	3.0	5.3	7.5	11.7	12.7	11.7	12.8	13.6	14.7
1987	4.0	7.2	7.8	10.6	11.2	18.5	20.2	14.7	16.1
1988	3.9	6.1	6.8	10.4	12.0	16.0	17.0	17.8	24.4
1989	6.2	5.0	9.6	8.6	15.5	9.1	17.2	12.0	28.3
1990	5.0	6.6	9.0	9.6	13.1	14.2	19.3	17.0	23.1

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1991	3.8	7.8	6.1	14.2	11.8	37.8	32.0	19.6	17.2
1992	4.9	7.8	9.5	11.9	15.3	17.7	19.7	19.0	21.2
1993	4.0	7.3	7.5	11.5	10.5	14.4	13.6	20.2	18.2
1994	4.4	5.5	7.6	8.7	12.3	12.7	16.3	19.8	18.8
1995	3.8	7.6	6.8	11.3	9.9	14.1	14.1	19.0	19.0
1996	2.9	5.6	4.6	8.4	7.6	12.2	9.5	17.7	14.2
1997	3.7	7.3	8.5	8.3	14.2	9.9	15.5	14.4	16.1
1998	3.2	6.3	6.7	8.9	10.0	11.5	11.9	13.5	14.5
1999	3.4	5.3	5.9	7.5	9.6	10.3	12.8	13.1	14.7
2000	3.1	6.3	4.8	8.7	7.9	11.9	10.6	14.5	12.2
2001	3.1	4.5	5.0	8.7	12.1	11.5	16.5	16.6	23.6
2002	3.8	6.0	6.7	7.4	10.8	9.8	14.4	13.8	16.5
2003	2.2	3.6	2.7	7.2	3.6	9.5	8.4	12.8	9.1
2004	3.5	5.1	4.5	8.3	6.6	9.0	6.7	10.4	8.8
2005	3.0	6.5	5.3	8.7	8.5	10.3	11.3	12.1	13.0
2006	3.2	5.9	5.5	9.7	8.9	11.6	11.9	13.0	13.7
2007	4.1	5.6	7.0	9.4	11.3	13.5	15.1	14.7	17.3
2008	4.5	6.3	7.8	10.9	12.6	13.3	16.8	15.8	19.3
2009	2.8	6.2	4.9	9.4	7.9	12.1	10.5	13.2	12.1
2010	3.4	6.3	5.9	12.4	9.5	13.9	12.6	17.2	14.5
2011	2.8	5.3	4.9	8.7	7.8	12.7	10.4	14.8	12.0
2012	3.8	6.4	6.6	9.5	10.6	11.3	14.1	14.5	16.2
2013	3.8	4.7	6.5	6.5	10.5	10.1	14.0	11.3	16.1
2014	3.0	4.7	5.2	7.1	8.5	9.5	11.3	11.7	13.0
2015	4.0	5.5	6.9	8.3	11.1	10.6	14.8	14.0	17.0
2016	3.2	5.2	5.4	10.1	8.7	12.5	11.6	14.7	13.3
2017	2.9	5.3	6.0	7.1	8.2	9.2	10.5	10.7	12.4
2018	3.3	4.7	8.2	7.0	10.6	9.5	13.9	11.5	15.5
2019	3.3	4.7	8.2	7.7	10.6	8.4	13.9	10.7	15.5
2020	3.3	7.1	8.2	9.6	10.6	12.3	13.9	13.8	15.5
2021	3.0	5.3	6.5	9.6	11.0	11.5	15.6	13.1	18.8
2022	3.0	7.3	6.5	12.0	11.0	16.2	15.6	17.0	18.8
arith. mean	3.6	5.9	6.5	9.4	10.4	12.9	14.2	14.9	16.2

Table 9.2.3 Sandeel Area-1r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0.02	0.8	0.99	1

Table 9.2.4. Sandeel Area-1r. Dredge survey indices.

Year	Age 0	Age 1
2004	140061.87	7077.655
2005	277241.20	3288.987
2006	117233.03	12244.596
2007	402355.16	5326.731
2008	35633.70	13619.791
2009	474590.87	9040.642
2010	49722.00	125308.581
2011	77113.07	27178.527
2012	136586.42	3922.222
2013	80356.85	13156.382
2014	235943.73	3413.488
2015	23030.02	13597.662
2016	304655.46	7277.881
2017	32663.00	38561.000
2018	165064.00	11168.000
2019	199148.10	18720.400
2020	71890.40	7497.200
2021	65614.29	8315.977
2022	136688.00	21760.000

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

Date: 01/19/23 Start time:11:57:31 run time:6 seconds

objective function (negative log likelihood): 32.5703
Number of parameters: 81
Maximum gradient: 2.23032e-006
Akaike information criterion (AIC): 227.141
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
360	77	40	0	954

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.05

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
39.8	-7.8	13.0	0.0	0.0	0.00	45

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.11	-0.10	0.33	0.00

contribution by fleet:

RTM 2007-2021	total:	-8.679	mean:	-0.223
Dredge survey 2004-2022	total:	0.847	mean:	0.022

F, season effect:

age: 0
 1983-1988: 0.000 1.000
 1989-1998: 0.000 1.000
 1999-2004: 0.000 1.000
 2005-2009: 0.000 1.000
 2010-2022: 0.000 1.000

age: 1 - 4
 1983-1988: 0.457 0.500
 1989-1998: 0.467 0.500
 1999-2004: 0.371 0.500
 2005-2009: 0.249 0.500
 2010-2022: 0.532 0.500

F, age effect:

```
-----
              0      1      2      3      4
1983-1988: 0.025 0.266 0.942 1.406 1.406
1989-1998: 0.011 0.552 0.708 0.726 0.726
1999-2004: 0.067 1.022 1.137 1.146 1.146
2005-2009: 0.007 1.503 2.246 2.254 2.254
2010-2022: 0.015 0.299 0.593 0.922 0.922
```

Exploitation pattern (scaled to mean F=1)

```
-----
              0      1      2      3      4
1983-1988 season 1: 0 0.332 1.176 1.755 1.755
           season 2: 0.021 0.108 0.383 0.572 0.572

1989-1998 season 1: 0 0.842 1.080 1.108 1.108
           season 2: 0.001 0.034 0.044 0.045 0.045

1999-2004 season 1: 0 0.806 0.896 0.903 0.903
           season 2: 0.018 0.141 0.157 0.158 0.158

2005-2009 season 1: 0 0.745 1.114 1.118 1.118
           season 2: 0.001 0.056 0.084 0.085 0.085

2010-2022 season 1: 0 0.641 1.270 1.974 1.974
           season 2: 0.003 0.030 0.059 0.091 0.091
```

sqrt(catch variance) ~ CV:

```
-----
              season
age 1 2
0      1.720
1      0.402 0.575
2      0.402 0.575
3      0.682 1.013
4      0.682 1.013
```

Survey catchability:

```
-----
              age 0   age 1   age 2   age 3
RTM 2007-2021              0.954  2.011  3.016
Dredge survey 2004-2022 2.806  1.239
```

sqrt(Survey variance) ~ CV:

```
-----
              age 0   age 1   age 2   age 3
RTM 2007-2021              0.56  0.44  0.46
Dredge survey 2004-2022 0.51  0.76

Recruit-SSB      alfa      beta      recruit s2      recruit s
Area-1r      994.572  1.100e+005  0.705      0.840
```

Table 9.2.6 Sandeel Area-1r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.012	0.295	1.011	1.494	1.502	0.653
1984	0.014	0.334	1.143	1.687	1.696	0.738
1985	0.015	0.358	1.223	1.813	1.808	0.790
1986	0.005	0.252	0.860	1.263	1.258	0.556
1987	0.008	0.188	0.649	0.960	0.958	0.418
1988	0.005	0.274	0.933	1.360	1.355	0.603
1989	0.001	0.840	1.046	1.062	1.054	0.943
1990	0.002	0.836	1.041	1.056	1.052	0.939
1991	0.005	0.562	0.708	0.725	0.726	0.635
1992	0.003	0.844	1.060	1.077	1.078	0.952
1993	0.001	0.372	0.465	0.478	0.477	0.419
1994	0.001	0.308	0.383	0.390	0.388	0.345
1995	0.002	0.577	0.714	0.727	0.725	0.646
1996	0.003	0.541	0.668	0.679	0.678	0.604
1997	0.005	0.510	0.633	0.645	0.648	0.571
1998	0.002	0.669	0.812	0.823	0.823	0.741
1999	0.017	1.011	1.070	1.065	1.067	1.041
2000	0.016	0.808	0.851	0.853	0.852	0.830
2001	0.049	1.225	1.310	1.318	1.322	1.267
2002	0.004	0.937	1.001	0.976	0.969	0.969
2003	0.015	0.780	0.836	0.820	0.823	0.808
2004	0.007	0.822	0.870	0.849	0.849	0.846
2005	0.000	0.919	1.297	1.293	1.290	1.108
2006	0.001	1.123	1.585	1.572	1.568	1.354
2007	0.000	0.424	0.601	0.597	0.593	0.513
2008	0.000	0.792	1.118	1.101	1.098	0.955
2009	0.001	0.978	1.387	1.376	1.368	1.182
2010	0.002	0.480	0.900	1.338	1.330	0.690
2011	0.001	0.546	1.001	1.497	1.482	0.774
2012	0.000	0.103	0.192	0.288	0.286	0.148
2013	0.000	0.623	1.124	1.709	1.700	0.873
2014	0.001	0.363	0.659	1.012	1.010	0.511
2015	0.000	0.349	0.629	0.968	0.960	0.489
2016	0.000	0.025	0.045	0.070	0.069	0.035
2017	0.001	0.465	0.864	1.304	1.291	0.665
2018	0.004	0.461	0.877	1.315	1.311	0.669

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2019	0.004	0.450	0.858	1.289	1.285	0.654
2020	0.000	0.438	0.830	1.237	1.231	0.634
2021	0.000	0.070	0.134	0.201	0.200	0.102
2022	0.000	0.021	0.041	0.061	0.060	0.031
arith. mean	0.005	0.549	0.836	1.009	1.006	0.692

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.012	0.198	0.065	0.701	0.229	1.047	0.341	1.047	0.341
1984	0.014	0.226	0.071	0.801	0.250	1.195	0.373	1.195	0.373
1985	0.015	0.242	0.076	0.855	0.268	1.276	0.400	1.276	0.400
1986	0.005	0.188	0.025	0.665	0.089	0.993	0.133	0.993	0.133
1987	0.008	0.123	0.044	0.434	0.154	0.648	0.230	0.648	0.230
1988	0.005	0.205	0.025	0.726	0.090	1.084	0.134	1.084	0.134
1989	0.001	0.682	0.028	0.874	0.036	0.897	0.036	0.897	0.036
1990	0.002	0.662	0.046	0.849	0.059	0.871	0.061	0.871	0.061
1991	0.005	0.380	0.124	0.486	0.159	0.499	0.164	0.499	0.164
1992	0.003	0.656	0.078	0.840	0.100	0.862	0.102	0.862	0.102
1993	0.001	0.289	0.035	0.371	0.045	0.380	0.046	0.380	0.046
1994	0.001	0.236	0.026	0.302	0.034	0.310	0.035	0.310	0.035
1995	0.002	0.438	0.053	0.562	0.068	0.576	0.070	0.576	0.070
1996	0.003	0.397	0.061	0.509	0.078	0.523	0.081	0.523	0.081
1997	0.005	0.331	0.121	0.424	0.155	0.435	0.159	0.435	0.159
1998	0.002	0.504	0.050	0.646	0.064	0.663	0.066	0.663	0.066
1999	0.017	0.730	0.128	0.812	0.142	0.819	0.144	0.819	0.144
2000	0.016	0.573	0.120	0.638	0.133	0.643	0.134	0.643	0.134
2001	0.049	0.746	0.372	0.829	0.414	0.836	0.418	0.836	0.418
2002	0.004	0.737	0.027	0.819	0.031	0.826	0.031	0.826	0.031
2003	0.015	0.548	0.112	0.609	0.125	0.614	0.126	0.614	0.126
2004	0.007	0.612	0.057	0.680	0.063	0.686	0.064	0.686	0.064
2005	0.000	0.712	0.054	1.063	0.081	1.067	0.081	1.067	0.081
2006	0.001	0.861	0.077	1.286	0.116	1.291	0.116	1.291	0.116
2007	0.000	0.337	0.000	0.504	0.000	0.506	0.000	0.506	0.000
2008	0.000	0.604	0.037	0.902	0.055	0.906	0.055	0.906	0.055
2009	0.001	0.730	0.076	1.090	0.113	1.095	0.113	1.095	0.113
2010	0.002	0.356	0.016	0.706	0.033	1.097	0.051	1.097	0.051
2011	0.001	0.402	0.012	0.796	0.023	1.237	0.036	1.237	0.036
2012	0.000	0.077	0.000	0.152	0.000	0.237	0.000	0.237	0.000
2013	0.000	0.483	0.000	0.958	0.000	1.488	0.000	1.488	0.000

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0.001	0.278	0.010	0.550	0.020	0.854	0.031	0.854	0.031
2015	0.000	0.271	0.000	0.537	0.000	0.834	0.000	0.834	0.000
2016	0.000	0.019	0.000	0.038	0.000	0.058	0.000	0.058	0.000
2017	0.001	0.361	0.006	0.716	0.012	1.112	0.019	1.112	0.019
2018	0.004	0.346	0.036	0.685	0.071	1.065	0.110	1.065	0.110
2019	0.004	0.334	0.042	0.661	0.082	1.027	0.128	1.027	0.128
2020	0.000	0.347	0.005	0.688	0.010	1.069	0.015	1.069	0.015
2021	0.000	0.053	0.004	0.105	0.007	0.163	0.011	0.163	0.011
2022	0.000	0.017	0.000	0.033	0.000	0.052	0.000	0.052	0.000
arith. mean	0.005	0.407	0.053	0.648	0.085	0.796	0.103	0.796	0.103

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.499	0.400	0.462	0.357	0.378	0.261	0.326	0.243	0.337
1984	0.499	0.400	0.462	0.357	0.378	0.261	0.326	0.243	0.337
1985	0.519	0.385	0.468	0.345	0.382	0.281	0.358	0.253	0.337
1986	0.534	0.376	0.475	0.342	0.409	0.270	0.368	0.249	0.353
1987	0.550	0.387	0.490	0.344	0.422	0.269	0.371	0.252	0.358
1988	0.553	0.396	0.484	0.357	0.418	0.282	0.358	0.270	0.344
1989	0.532	0.415	0.460	0.377	0.392	0.303	0.356	0.271	0.333
1990	0.544	0.403	0.471	0.341	0.395	0.282	0.355	0.267	0.343
1991	0.560	0.394	0.457	0.326	0.384	0.230	0.344	0.227	0.344
1992	0.549	0.397	0.434	0.311	0.371	0.218	0.328	0.221	0.331
1993	0.530	0.407	0.404	0.343	0.331	0.240	0.318	0.221	0.309
1994	0.530	0.386	0.447	0.327	0.362	0.243	0.329	0.217	0.315
1995	0.521	0.380	0.470	0.337	0.376	0.247	0.339	0.217	0.324
1996	0.552	0.340	0.492	0.304	0.391	0.244	0.351	0.211	0.341
1997	0.567	0.372	0.508	0.323	0.389	0.271	0.349	0.224	0.341
1998	0.615	0.416	0.546	0.350	0.392	0.305	0.352	0.237	0.343
1999	0.620	0.456	0.566	0.379	0.401	0.315	0.350	0.249	0.340
2000	0.608	0.469	0.551	0.391	0.369	0.322	0.334	0.243	0.309
2001	0.614	0.410	0.528	0.366	0.366	0.297	0.326	0.227	0.297
2002	0.671	0.454	0.566	0.424	0.456	0.354	0.357	0.272	0.329
2003	0.690	0.475	0.585	0.442	0.472	0.388	0.377	0.320	0.368
2004	0.709	0.544	0.629	0.473	0.476	0.417	0.375	0.356	0.368
2005	0.695	0.542	0.554	0.426	0.396	0.395	0.371	0.318	0.354
2006	0.729	0.571	0.580	0.441	0.417	0.346	0.365	0.288	0.348
2007	0.769	0.549	0.566	0.405	0.433	0.312	0.396	0.270	0.376

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2008	0.725	0.541	0.610	0.414	0.456	0.300	0.385	0.268	0.375
2009	0.704	0.460	0.597	0.346	0.452	0.282	0.406	0.250	0.383
2010	0.715	0.475	0.667	0.366	0.540	0.299	0.443	0.256	0.419
2011	0.787	0.528	0.731	0.367	0.544	0.321	0.472	0.273	0.437
2012	0.787	0.593	0.710	0.454	0.541	0.368	0.455	0.321	0.433
2013	0.732	0.591	0.655	0.495	0.435	0.369	0.407	0.324	0.388
2014	0.723	0.522	0.605	0.481	0.390	0.324	0.364	0.302	0.357
2015	0.718	0.578	0.622	0.442	0.391	0.299	0.380	0.276	0.356
2016	0.725	0.526	0.617	0.394	0.396	0.288	0.384	0.268	0.354
2017	0.673	0.534	0.600	0.425	0.454	0.307	0.394	0.286	0.363
2018	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2019	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2020	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2021	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2022	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
arith. mean	0.628	0.457	0.544	0.388	0.421	0.304	0.367	0.266	0.352

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

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1983	285026	13418	50882	2905	229
1984	75507	170943	4358	9620	435
1985	518333	45234	53651	730	1166
1986	75342	304118	14022	8438	193
1987	49079	43975	104960	3115	1481
1988	201059	28085	15490	27081	1017
1989	90935	115096	9252	3157	4390
1990	136383	53383	23596	1728	1586
1991	160226	79030	10966	4557	699
1992	37824	91022	20400	2827	1528
1993	159213	21780	19030	4025	959
1994	225498	93537	6997	6398	1873
1995	56290	132577	31276	2509	3337
1996	410037	33370	34668	8163	1749
1997	62133	235544	9178	9614	3014
1998	116846	35070	62189	2522	3801
1999	154573	63019	7697	14548	1658
2000	244381	81766	9619	1358	3208
2001	422468	131038	14751	2082	1173
2002	28060	217798	16759	2046	517

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	163711	14297	36570	2969	547
2004	68572	80944	2560	7039	791
2005	157839	33487	12833	471	1687
2006	76729	78731	5205	1797	343
2007	182569	36969	9740	543	261
2008	74861	84604	8652	2545	244
2009	549178	36254	14106	1392	540
2010	34856	271487	5630	1905	295
2011	38661	17030	59671	1087	336
2012	98194	17577	3198	10575	184
2013	56200	44691	4426	1015	3733
2014	192702	27042	7923	670	519
2015	34426	93456	6575	1874	250
2016	254748	16788	21476	1671	471
2017	19225	123434	5250	9390	1043
2018	28676	9800	27496	1053	1678
2019	81354	15392	2516	5352	437
2020	29518	43644	3978	496	921
2021	58360	15893	11541	821	249
2022	84015	31426	5649	4279	457
2023		45257	11623	2266	2273

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

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	285000075	615279	452254	378795	0.596
1984	75526942	1118720	194269	498626	0.674
1985	518266424	753676	431059	437114	0.720
1986	75376039	1875330	265402	382844	0.484
1987	49081856	1508460	977741	373021	0.377
1988	201037095	783049	577810	413646	0.523
1989	90966330	734865	157157	446028	0.809
1990	136386047	631692	240626	306240	0.808
1991	160210639	957620	321258	332204	0.575
1992	37806817	1030230	287219	558599	0.837
1993	159252253	455531	254995	132024	0.370
1994	225538177	693410	176840	193241	0.299
1995	56288454	1461400	402721	400588	0.561
1996	410136258	607428	366224	265869	0.523
1997	62146186	1922600	234216	426089	0.515

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1998	116803080	854793	527551	377073	0.632
1999	154545638	566146	223463	422718	0.906
2000	244322590	660654	140505	299167	0.732
2001	422626767	764051	158419	531265	1.181
2002	28064051	1449670	154045	606466	0.807
2003	163774330	350978	247212	148039	0.697
2004	68544930	502053	96086	203646	0.706
2005	157825413	355213	119731	123422	0.955
2006	76745092	539216	75207	240646	1.170
2007	182634966	308354	88965	109624	0.421
2008	74850249	662345	123624	234447	0.799
2009	549214701	380377	134726	290995	1.004
2010	34865209	1811450	122884	300508	0.556
2011	38647784	629904	437574	318840	0.616
2012	98149266	264658	147119	46117	0.115
2013	56175990	290482	79858	214359	0.721
2014	192768395	196284	59814	78830	0.429
2015	34414894	590547	77653	163381	0.404
2016	254802680	332204	203414	14613	0.028
2017	19230344	787376	140225	241916	0.548
2018	28688302	269049	185350	133659	0.569
2019	81327925	141771	66304	66444	0.559
2020	29532444	367906	55770	106100	0.525
2021	58351755	207309	102744	17245	0.084
2022	84056521	373410	135266	5011	0.025
2023			146825		
arith. mean	144840168	720137	229035	270986	0.597
geo. mean	101340835				

arith. mean for the period 1983–2022

geo. mean for the period 1983–2021

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	101314.11	45257.3	11622.8	2265.98	2273.16
Exploitation pattern 1st half		0.017	0.033	0.052	0.052
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.824	9.164	11.589	13.220
Weight in the catch 1st half		5.824	9.164	11.589	13.220
Weight in the catch 2nd half	3.191	7.501	10.761	14.595	16.825
Proportion mature (2023)	0.000	0.021	0.801	0.988	1.000
Proportion mature (2024)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.440	0.427	0.328	0.293
Natural mortality 2nd half	0.619	0.538	0.454	0.360	0.345

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

Basis: $F_{sq} = F(2022) = 0.025$; $Yield(2022) = 5.011$; $Recruitment(2022) = 84.056521$; $Recruitment(2023) = \text{geometric mean (GM 1983–2021)} = 101.314110$ billions; $SSB(2023) = 146.825$

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
$SSB(2024) = MSY B_{\text{escapement}} = B_{pa}$	120 428	0.424	145 000	-1	2309
$F = 0$	0	0	217 821	48	-100
B_{lim}	180 743	0.741	110 000	-25	3515
$F = F_{2022}$	8 827	0.025	212 382	45	77

* SSB2024 relative to SSB2023.

** Catch scenario for 2023 relative to TAC in 2022 (5000 t).

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	12882	4162	476	6190	877	203	104	67	0
1984	0	10284	3846	912	186	1154	193	38	10
1985	1827	1411	392	5501	768	473	387	109	50
1986	1443	24479	3495	3144	208	436	95	6	7
1987	45	831	512	2621	591	131	17	20	4
1988	5602	1030	545	3379	226	3163	775	478	31
1989	2819	23364	3809	1666	273	938	10	909	34
1990	5046	7332	854	3967	196	587	29	177	9
1991	10053	14203	3628	2099	110	451	35	156	1
1992	6830	12016	886	4066	85	475	34	298	7
1993	14083	4814	873	1294	660	642	226	475	56
1994	0	25596	4477	3619	919	341	275	199	118
1995	1798	4897	1316	1598	1777	209	211	88	159
1996	26463	2472	7161	1573	475	905	278	260	186
1997	284	29071	8330	1640	193	628	83	207	47

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1998	1070	645	106	4749	1424	437	136	348	144
1999	4130	841	1113	177	102	855	501	186	149
2000	519	8160	1066	566	164	217	98	518	134
2001	5767	2625	2414	1010	563	129	73	367	228
2002	4	15855	1379	891	185	393	35	85	28
2003	3711	267	79	1723	453	136	43	67	17
2004	755	10761	2034	711	212	537	297	174	55
2005	15	2171	490	513	336	48	32	116	91
2006	8	2441	1030	276	125	100	64	27	39
2007	0	6431	0	240	0	32	0	5	0
2008	1	4621	187	434	64	90	36	15	5
2009	103	2817	1867	671	145	42	25	4	1
2010	2	6490	1308	193	35	374	27	60	4
2011	0	404	19	1474	91	236	17	59	3
2012	0	168	6	194	51	293	6	60	10
2013	0	4824	431	1158	47	296	16	99	5
2014	301	2987	141	2371	28	340	3	119	5
2015	0	2275	42	772	9	561	2	197	2
2016	4	272	1	136	3	108	0	66	0
2017	0	23040	1325	243	5	51	25	20	2
2018	0	50	0	1949	22	63	2	11	0
2019	0	226	0	52	0	172	0	4	0
2020	4	8068	16	433	1	173	1	356	3
2021	0	606	0	96	0	3	0	3	0
2022	0	5950	0	1000	0	450	0	271	0
arith. mean	2639	6974	1391	1633	290	422	105	168	41

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	5.2	9.9	10.8	16.5	12.8	22.9	15.0	27.3
1984	5.9	5.6	10.2	11.1	14.1	15.6	25.8	18.8	30.1
1985	4.5	6.7	10.7	9.9	16.8	17.5	23.3	24.1	27.5
1986	3.2	5.9	9.8	10.3	15.8	12.7	15.0	15.0	17.0
1987	2.8	5.8	8.7	11.1	12.9	16.4	21.1	14.6	19.4
1988	3.5	5.5	7.2	11.1	15.3	16.1	21.0	23.1	30.6
1989	4.8	5.7	9.4	9.1	13.4	10.1	14.4	12.1	18.0
1990	4.4	7.1	8.1	9.7	11.8	14.4	17.4	17.3	20.8
1991	3.8	7.7	5.7	12.1	11.0	35.8	32.6	21.2	20.1
1992	4.7	6.9	15.0	9.9	20.6	13.5	29.3	17.9	29.2
1993	2.8	7.7	9.3	15.1	14.8	16.9	17.5	22.3	22.0
1994	3.6	5.4	7.6	10.5	18.8	15.3	23.0	19.5	20.7
1995	5.2	7.6	8.9	12.4	13.2	16.0	17.6	19.2	21.1
1996	2.7	7.0	4.9	12.4	13.2	17.0	15.8	27.9	24.5
1997	3.2	5.3	7.1	8.0	11.2	13.1	13.8	15.9	14.9
1998	3.4	6.2	6.7	11.4	14.0	14.7	16.5	17.4	18.3
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
2001	4.0	6.0	5.0	12.9	16.1	16.6	21.7	20.4	26.2
2002	3.2	5.7	8.3	8.4	13.2	9.6	15.3	17.3	17.7
2003	5.4	6.0	8.1	11.3	16.0	15.1	21.4	18.2	27.2
2004	4.8	6.5	7.4	9.4	10.9	12.4	12.2	13.1	13.7
2005	3.4	7.5	7.4	11.8	11.9	14.4	15.4	14.8	17.5
2006	4.6	7.6	9.9	11.5	15.9	13.9	20.6	14.8	23.4
2007	5.8	6.2	6.2	12.4	12.4	15.4	15.4	17.8	17.8
2008	3.4	5.5	7.5	12.5	12.0	16.1	15.6	18.0	17.7
2009	6.0	6.1	5.0	8.7	10.9	16.5	18.6	12.2	11.0
2010	2.5	5.7	5.3	10.3	8.4	11.5	11.0	13.2	12.5
2011	3.6	6.9	7.6	11.1	12.2	13.8	15.8	14.6	18.0
2012	4.4	8.2	9.4	12.4	15.1	14.8	19.6	21.8	22.3
2013	3.9	5.9	8.8	7.9	11.5	14.2	14.4	14.1	16.5
2014	3.3	5.3	7.0	9.9	11.2	12.0	14.6	18.6	16.6
2015	5.3	6.8	11.4	12.4	18.4	15.3	23.9	17.3	27.1
2016	2.6	3.3	5.5	12.2	8.9	14.6	11.5	16.0	13.1
2017	2.9	5.5	7.8	7.8	10.7	13.1	10.8	14.8	15.5
2018	3.8	4.6	8.2	9.6	13.9	12.4	18.6	14.0	20.7

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2019	3.8	7.7	8.2	12.4	13.9	15.4	18.6	18.7	20.7
2020	3.8	6.6	8.2	12.8	13.9	16.2	18.6	20.4	20.7
2021	3.6	4.8	9.1	11.8	15.5	16.6	19.0	18.8	25.2
2022	3.6	6.6	9.1	13.7	15.5	18.5	19.0	35.1	25.2
arith. mean	3.9	6.3	8.2	11.0	13.7	15.2	18.3	18.1	20.7

Table 9.3.3 Sandeel Area-2r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0.02	0.83	1	1

Table 9.3.4. Sandeel Area-2r. Dredge survey indices.

Year	Age 0	Age 1
2010	938.752	1482.382
2011	2290.448	259.021
2012	11342.580	94.156
2013	7546.966	2103.482
2014	5760.235	810.806
2015	706.350	106.920
2016	53839.804	113.297
2017	899.000	2976.000
2018	2326.000	372.000
2019	26129.000	522.000
2020	7662.000	665.000
2021	45488.020	499.877
2022	21982.000	2124.000

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

Date: 01/18/23 Start time:09:52:51 run time:12 seconds

objective function (negative log likelihood): 86.2127

Number of parameters: 76

Maximum gradient: 7.0277e-005

Akaike information criterion (AIC): 324.425

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
360	26	40	0	426

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
92.0	-7.7	19.6	0.0	0.0	0.00	104

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.26	-0.30	0.49	0.00

contribution by fleet:

Dredge survey 2010-2022 total: -7.716 mean: -0.297

F, season effect:

age: 0

1983-1988:	0.000	1.000
1989-1998:	0.000	1.000
1999-2004:	0.000	1.000
2005-2009:	0.000	1.000
2010-2022:	0.000	1.000

age: 1 - 4

1983-1988:	0.474	0.500
1989-1998:	0.686	0.500
1999-2004:	0.421	0.500
2005-2009:	0.190	0.500
2010-2022:	0.563	0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.041	0.281	0.903	1.489	1.489
1989-1998:	0.099	0.336	0.401	0.474	0.474
1999-2004:	0.041	0.598	0.714	0.720	0.720
2005-2009:	0.001	1.955	1.656	1.730	1.730
2010-2022:	0.001	0.289	0.467	0.599	0.599

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1983-1988	season 1:	0	0.299	0.962	1.587	1.587
	season 2:	0.051	0.175	0.564	0.930	0.930
1989-1998	season 1:	0	0.726	0.867	1.024	1.024
	season 2:	0.109	0.185	0.221	0.261	0.261
1999-2004	season 1:	0	0.310	0.370	0.373	0.373
	season 2:	0.082	0.602	0.718	0.724	0.724
2005-2009	season 1:	0	0.537	0.455	0.475	0.475
	season 2:	0.001	0.546	0.462	0.483	0.483
2010-2022	season 1:	0	0.638	1.033	1.324	1.324
	season 2:	0.001	0.125	0.203	0.260	0.260

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		1.651
1	0.415	0.829
2	0.415	0.829
3	0.874	1.076
4	0.874	1.076

Survey catchability:

	age 0	age 1
Dredge survey 2010-2022	0.105	24.492

Stock size dependent catchability (power model)

	age 0	age 1
--	-------	-------

Dredge survey 2010-2022 1.40 1.00

sqrt(Survey variance) ~ CV:

 age 0 age 1
Dredge survey 2010-2022 0.30 0.72

Recruit-SSB alfa beta recruit s2 recruit s
Area-2r 1070.765 5.600e+004 0.982 0.991

Table 9.3.6 Sandeel Area-2r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.037	0.370	1.176	1.934	1.932	0.773
1984	0.034	0.310	0.992	1.636	1.635	0.651
1985	0.022	0.291	0.917	1.497	1.495	0.604
1986	0.025	0.417	1.303	2.112	2.108	0.860
1987	0.008	0.092	0.293	0.481	0.481	0.192
1988	0.027	0.310	0.981	1.607	1.605	0.646
1989	0.075	0.729	0.852	0.994	0.992	0.790
1990	0.037	0.490	0.570	0.663	0.661	0.530
1991	0.070	0.552	0.648	0.759	0.757	0.600
1992	0.051	0.561	0.655	0.763	0.762	0.608
1993	0.080	0.442	0.523	0.617	0.616	0.482
1994	0.050	0.470	0.550	0.642	0.641	0.510
1995	0.043	0.255	0.302	0.355	0.355	0.279
1996	0.132	0.379	0.459	0.553	0.553	0.419
1997	0.083	0.556	0.654	0.768	0.767	0.605
1998	0.046	0.286	0.338	0.397	0.397	0.312
1999	0.036	0.370	0.454	0.470	0.471	0.412
2000	0.017	0.549	0.646	0.647	0.646	0.598
2001	0.036	0.479	0.579	0.593	0.594	0.529
2002	0.020	0.664	0.780	0.780	0.779	0.722
2003	0.037	0.441	0.535	0.551	0.551	0.488
2004	0.030	0.896	1.055	1.058	1.056	0.975
2005	0.001	1.170	0.998	1.056	1.056	1.084
2006	0.001	1.222	1.049	1.115	1.116	1.136
2007	0.000	0.746	0.615	0.627	0.625	0.681
2008	0.000	0.803	0.672	0.697	0.696	0.737
2009	0.000	0.768	0.655	0.692	0.692	0.712
2010	0.000	0.377	0.594	0.749	0.747	0.486
2011	0.000	0.243	0.381	0.479	0.477	0.312
2012	0.000	0.139	0.218	0.273	0.272	0.178
2013	0.000	0.602	0.943	1.183	1.179	0.773
2014	0.000	0.457	0.712	0.891	0.888	0.585

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2015	0.000	0.402	0.625	0.780	0.778	0.514
2016	0.000	0.173	0.271	0.339	0.337	0.222
2017	0.001	0.782	1.222	1.532	1.528	1.002
2018	0.000	0.234	0.365	0.456	0.454	0.300
2019	0.000	0.055	0.085	0.106	0.106	0.070
2020	0.000	0.537	0.837	1.046	1.043	0.687
2021	0.000	0.098	0.153	0.190	0.190	0.125
2022	0.000	0.657	1.017	1.266	1.262	0.837
arith. mean	0.025	0.484	0.667	0.834	0.832	0.576

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.037	0.217	0.127	0.696	0.408	1.149	0.674	1.149	0.674
1984	0.034	0.176	0.116	0.567	0.372	0.936	0.614	0.936	0.614
1985	0.022	0.184	0.076	0.591	0.245	0.974	0.404	0.974	0.404
1986	0.025	0.277	0.087	0.892	0.279	1.472	0.461	1.472	0.461
1987	0.008	0.056	0.028	0.179	0.091	0.295	0.150	0.295	0.150
1988	0.027	0.190	0.092	0.611	0.294	1.008	0.486	1.008	0.486
1989	0.075	0.502	0.128	0.599	0.153	0.708	0.181	0.708	0.181
1990	0.037	0.350	0.062	0.417	0.074	0.493	0.088	0.493	0.088
1991	0.070	0.366	0.119	0.437	0.142	0.516	0.168	0.516	0.168
1992	0.051	0.392	0.087	0.468	0.103	0.553	0.122	0.553	0.122
1993	0.080	0.269	0.135	0.321	0.162	0.379	0.191	0.379	0.191
1994	0.050	0.320	0.085	0.382	0.102	0.452	0.120	0.452	0.120
1995	0.043	0.158	0.073	0.189	0.087	0.223	0.103	0.223	0.103
1996	0.132	0.168	0.224	0.201	0.268	0.237	0.317	0.237	0.317
1997	0.083	0.356	0.141	0.425	0.168	0.502	0.198	0.502	0.198
1998	0.046	0.179	0.078	0.214	0.093	0.253	0.110	0.253	0.110
1999	0.036	0.138	0.267	0.164	0.319	0.166	0.322	0.166	0.322
2000	0.017	0.359	0.127	0.428	0.152	0.432	0.153	0.432	0.153
2001	0.036	0.222	0.267	0.265	0.319	0.267	0.322	0.267	0.322
2002	0.020	0.440	0.144	0.526	0.171	0.530	0.173	0.530	0.173
2003	0.037	0.191	0.269	0.229	0.321	0.231	0.323	0.231	0.323
2004	0.030	0.579	0.222	0.692	0.266	0.698	0.268	0.698	0.268
2005	0.001	0.579	0.588	0.490	0.498	0.512	0.520	0.512	0.520
2006	0.001	0.554	0.702	0.469	0.595	0.490	0.622	0.490	0.622
2007	0.000	0.596	0.000	0.505	0.000	0.527	0.000	0.527	0.000
2008	0.000	0.525	0.188	0.445	0.159	0.464	0.167	0.464	0.167
2009	0.000	0.387	0.374	0.328	0.317	0.342	0.331	0.342	0.331

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2010	0.000	0.266	0.052	0.430	0.085	0.551	0.108	0.551	0.108
2011	0.000	0.179	0.019	0.290	0.031	0.372	0.040	0.372	0.040
2012	0.000	0.105	0.007	0.169	0.011	0.217	0.015	0.217	0.015
2013	0.000	0.445	0.054	0.720	0.087	0.923	0.112	0.923	0.112
2014	0.000	0.349	0.020	0.564	0.033	0.723	0.042	0.723	0.042
2015	0.000	0.314	0.005	0.507	0.009	0.650	0.011	0.650	0.011
2016	0.000	0.133	0.004	0.215	0.007	0.276	0.009	0.276	0.009
2017	0.001	0.580	0.071	0.939	0.116	1.203	0.148	1.203	0.148
2018	0.000	0.183	0.002	0.296	0.003	0.379	0.003	0.379	0.003
2019	0.000	0.043	0.000	0.069	0.000	0.088	0.000	0.088	0.000
2020	0.000	0.412	0.023	0.666	0.036	0.854	0.047	0.854	0.047
2021	0.000	0.076	0.000	0.123	0.000	0.158	0.000	0.158	0.000
2022	0.000	0.523	0.000	0.846	0.000	1.084	0.000	1.084	0.000
arith. mean	0.025	0.308	0.127	0.439	0.164	0.557	0.203	0.557	0.203

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1984	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1985	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1986	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1987	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1988	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1989	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1990	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1991	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1992	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1993	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1994	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1995	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1996	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1997	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1998	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1999	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2000	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2001	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2002	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2003	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2004	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2005	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2006	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2014	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2015	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2016	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2017	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2018	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2019	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2020	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2021	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2022	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
arith. mean	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41

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

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1983	157383	16389	14516	728	27
1984	47378	60438	3644	1898	58
1985	280436	18254	14146	562	198
1986	60233	109302	4413	2421	92
1987	35679	23403	23803	540	174
1988	173459	14102	6747	7173	219
1989	87334	67305	3336	1077	793
1990	158618	32283	11240	621	370
1991	113517	60939	6703	2712	266
1992	117645	42188	11766	1483	719
1993	231388	44557	8193	2621	538
1994	108060	85161	9325	1995	855
1995	78575	40960	17798	2267	772
1996	418249	29999	10193	5330	1053
1997	16194	146099	6351	2517	1756
1998	27125	5942	27884	1386	1021

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1999	74989	10326	1440	8093	806
2000	44207	28818	2160	351	2613
2001	132798	17315	5558	477	802
2002	10297	51032	3329	1223	343
2003	47428	4024	8921	654	371
2004	19076	18223	796	2032	283
2005	19254	7376	2562	121	422
2006	26874	7667	720	376	94
2007	40617	10700	684	98	74
2008	26112	16187	1849	163	49
2009	78766	10404	2487	399	54
2010	8395	31375	1524	515	110
2011	11261	3344	7155	359	155
2012	43005	4487	860	2048	163
2013	25006	17137	1258	283	838
2014	17712	9960	3261	221	193
2015	5075	7057	2160	709	93
2016	114737	2022	1608	508	198
2017	4026	45723	553	508	255
2018	9869	1603	7472	76	95
2019	42395	3933	418	2188	56
2020	23501	16895	1182	154	981
2021	79240	9364	3431	231	224
2022	52864	31579	2720	1197	187
2023		21067	5871	461	224

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

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	157352646	251236	141634	155664	0.724
1984	47393706	407379	71182	133343	0.616
1985	280476360	276568	133252	110546	0.548
1986	60249209	718400	82951	225470	0.768
1987	35676401	412520	233515	49070	0.177
1988	173380646	273508	184425	149466	0.593
1989	87312134	437127	53370	223507	0.691
1990	158616516	353043	110525	133874	0.452
1991	113464435	651357	179512	215508	0.532
1992	117623570	442708	135944	184033	0.525
1993	231479066	522587	165877	139826	0.443

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1994	108038694	603217	137585	244939	0.445
1995	78609255	584603	240386	113899	0.253
1996	418421560	456214	228891	182562	0.431
1997	16191549	883035	118421	242094	0.544
1998	27125912	392585	302549	99814	0.282
1999	75000100	241040	156061	69427	0.444
2000	44189599	270505	74236	92908	0.533
2001	132752892	199277	85905	90200	0.536
2002	10293261	334383	46583	117388	0.641
2003	47441124	141416	100710	53710	0.505
2004	19077115	154107	37459	110546	0.879
2005	19249584	93284	34235	34396	1.078
2006	26882874	72786	14647	37860	1.160
2007	40629298	77095	11167	43090	0.550
2008	26114467	116388	24441	35604	0.658
2009	78766631	91810	26370	35687	0.703
2010	8393767	202252	24005	51670	0.416
2011	11262622	110039	73718	24896	0.260
2012	43012443	81362	43478	10594	0.146
2013	25015345	126753	26134	47814	0.653
2014	17716377	91240	34201	48033	0.483
2015	5075827	87466	35668	37902	0.418
2016	114719434	36772	26984	5230	0.180
2017	4024857	268282	19051	141314	0.853
2018	9869897	81683	62193	20307	0.241
2019	42414464	70085	39656	5091	0.056
2020	23511495	148811	37235	68932	0.568
2021	79240651	93714	42574	4147	0.100
2022	52851677	275877	63831	71128	0.684
2023			73350		
arith. mean*	76719418	278313	91075	96537	0.519
geo. mean**	45037228				

* arith. mean for the period 1983-2022

** geo. mean for the period 1983-2021

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	22601.859	21067.2	5870.66	460.717	224.027
Exploitation pattern 1st half		0.523	0.846	1.084	1.084
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.065	12.057	15.806	21.403
Weight in the catch 1st half		6.065	12.057	15.806	21.403
Weight in the catch 2nd half	3.724	8.573	14.565	18.802	22.521
Proportion mature (2023)	0.000	0.020	0.830	1.000	1.000
Proportion mature (2024)	0.000	0.020	0.830	1.000	1.000
Natural mortality 1st half		0.570	0.440	0.320	0.310
Natural mortality 2nd half	0.920	0.590	0.490	0.420	0.410

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

Basis: $F_{sq} = F(2022) = 0.684$; $Yield(2022) = 71.128$; $Recruitment(2022) = 52.851677$; $Recruitment(2023) = \text{geometric mean (GM 2012-2021)} = 22.601859$ billions; $SSB(2023) = 73.35$

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
$SSB_{2024} = MSY \ B_{escapement} = B_{pa}^{\wedge}$	40 997	0.291	84 000	15	-43
$F = 0$	0	0	110 821	51	-100
B_{lim}	85 165	0.73	56 000	-24	19
$F_{2023} = F_{sq}$	81 334	0.684	58 379	-20	13

* SSB_{2024} relative to SSB_{2023}

** Catch scenario for 2023 relative to TAC in 2022 (71 859 t)

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	7965	18939	7987	2063	533	161	2	0	0
1987	5	33760	65	14020	4	453	0	200	0
1988	8769	6584	853	17321	233	893	144	19	13
1989	159	47004	190	1844	13	2806	0	4	0
1990	9793	9302	1377	2791	286	413	43	125	13
1991	14442	24009	942	1391	30	526	9	184	3
1992	525	7100	87	2862	8	342	3	215	1
1993	9663	15164	851	558	155	211	71	1336	12
1994	0	23742	615	4818	684	938	78	386	10
1995	1020	25037	484	1894	78	238	13	156	17
1996	6263	4319	3111	3394	97	465	33	399	248
1997	2975	66856	10388	2912	134	607	13	194	9
1998	30136	3954	992	28137	740	2553	192	290	32

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1999	6444	5182	1835	1554	118	1979	401	421	169
2000	0	18793	344	3286	4	541	1	533	9
2001	18263	5327	3968	992	9	163	2	160	6
2002	0	9075	21	2680	3	387	1	135	0
2003	2755	939	61	808	53	130	2	78	1
2004	1091	1976	737	256	16	74	6	92	1
2005	0	1404	1	146	0	21	0	12	0
2006	0	769	3	47	1	27	0	4	0
2007	0	8600	0	571	0	86	0	19	0
2008	0	4077	0	2012	0	460	0	73	0
2009	1	827	12	69	2	8	0	0	0
2010	0	3042	51	740	1	1006	1	173	0
2011	0	1304	0	5224	0	825	0	24	0
2012	0	32	0	186	0	1157	0	356	0
2013	0	648	0	211	0	55	0	42	0
2014	0	5384	0	2373	0	643	0	319	0
2015	0	6451	0	2340	0	956	0	99	0
2016	0	156	0	2006	0	415	0	284	0
2017	0	11734	0	671	0	434	0	409	0
2018	0	413	6	6631	48	40	1	305	1
2019	0	7105	0	716	0	4241	0	131	0
2020	0	21133	0	1981	0	391	0	1249	0
2021	10	2273	7	4215	1	995	0	2357	0
2022	0	1683	0	1115	0	864	0	747	0
arith. mean	3251	10922	946	3374	88	716	27	312	15

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	4.0	6.1	12.7	9.7	21.0	12.4	18.9	15.9	20.4
1987	6.9	6.4	12.8	11.7	20.4	20.5	31.6	22.5	29.6
1988	4.1	5.1	6.4	13.1	16.1	23.0	22.5	36.2	31.5
1989	4.8	6.1	9.3	10.5	12.7	14.3	14.0	18.8	17.5
1990	4.4	7.5	7.7	9.8	11.2	15.2	16.5	20.2	19.8
1991	3.7	7.3	5.7	11.4	13.8	36.4	27.5	26.3	16.3
1992	4.6	6.1	13.4	10.3	26.7	14.7	28.7	23.0	30.9
1993	3.5	5.8	7.3	16.4	16.7	17.9	20.8	23.3	22.4
1994	3.6	6.1	13.0	14.6	20.8	20.6	35.2	21.1	27.1
1995	4.7	5.6	8.2	9.7	10.2	13.8	13.7	16.5	16.1

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1996	2.5	8.8	8.0	13.3	14.0	26.1	15.7	38.5	24.0
1997	2.9	5.2	6.7	10.1	10.2	13.7	14.2	18.3	14.4
1998	3.2	5.0	7.0	10.1	15.2	13.7	17.3	20.3	20.7
1999	8.7	7.4	14.5	10.1	19.4	14.1	21.1	26.3	30.7
2000	5.2	6.9	10.8	10.5	17.4	15.3	23.7	20.5	25.6
2001	5.6	6.8	8.9	13.7	16.0	17.8	15.9	23.2	25.5
2002	9.4	8.1	19.7	12.7	31.6	14.6	43.2	19.2	46.7
2003	4.3	5.3	5.4	14.6	15.3	20.3	24.1	26.9	26.7
2004	5.8	7.3	7.3	9.5	14.1	14.5	18.4	15.1	12.7
2005	3.4	7.8	7.0	16.5	11.2	19.9	15.3	22.6	16.6
2006	11.0	7.5	23.1	13.5	36.9	17.1	50.5	26.9	54.5
2007	4.1	7.5	8.6	15.1	13.9	21.7	18.9	14.6	20.5
2008	4.1	8.0	8.6	15.0	13.9	22.0	18.9	25.8	20.5
2009	4.2	6.3	8.8	10.4	14.1	19.9	19.2	12.1	20.8
2010	2.5	7.5	5.2	17.7	8.3	20.7	11.4	24.3	12.3
2011	4.1	7.7	8.6	12.6	13.9	19.4	18.9	36.2	20.5
2012	4.1	9.9	8.6	15.2	13.9	22.7	18.9	30.0	20.5
2013	4.1	9.1	8.6	11.6	13.9	14.3	18.9	16.2	20.5
2014	4.1	8.6	8.6	12.7	13.9	13.9	18.9	18.3	20.5
2015	3.8	8.3	8.4	12.7	15.4	19.3	20.2	30.1	21.9
2016	3.8	4.0	8.4	12.4	15.4	19.8	20.2	32.1	21.9
2017	3.8	7.7	8.4	11.9	15.4	17.7	20.2	24.2	21.9
2018	3.8	5.8	8.4	9.9	15.4	13.5	20.2	20.6	21.9
2019	3.8	8.5	8.4	11.6	15.4	15.2	20.2	20.2	21.9
2020	3.8	8.8	8.4	14.6	15.4	17.2	20.2	19.3	21.9
2021	3.6	7.7	9.3	14.1	20.3	19.4	26.5	26.0	32.6
2022	3.6	11.3	9.3	16.6	20.3	21.4	26.5	36.6	32.6
arith. mean	4.5	7.2	9.5	12.6	16.5	18.2	21.8	23.5	23.8

Table 9.4.3 Sandeel Area-3r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983-2016	0.04	0.77	1	1

Table 9.4.4. Sandeel Area-3r. Dredge survey indices.

Year	Age 0	Age 1
2005	68667.988	
2006	55709.239	1225.934
2007	10611.085	3717.149
2008	16658.095	1521.160
2009	37088.951	16328.039
2010	1844.740	5076.749
2011	973.111	1961.856
2012	47713.266	767.514
2013	174467.733	790.887
2014	92703.238	5349.152
2015	2667.397	11100.794
2016	194644.941	322.967
2017	6359.000	15640.000
2018	82359.000	5980.000
2019	112538.400	10448.300
2020	69976.000	20816.000
2021	23486.023	6259.908
2022	12369.000	1818.000

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

Date: 01/19/23 Start time:11:53:59 run time:2 seconds

objective function (negative log likelihood): 125.393

Number of parameters: 62

Maximum gradient: 2.55801e-005

Akaike information criterion (AIC): 374.785

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
333	91	37	0	461

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.01

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
108.7	16.5	19.2	0.0	0.0	0.00	144

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.33	0.18	0.52	0.00

contribution by fleet:

Acoustic survey	total:	13.094	mean:	0.234
Dredge survey 2004-2022	total:	3.453	mean:	0.099

F, season effect:

age: 0

```

1986-1998: 0.000 1.000
1999-2022: 0.000 1.000
age: 1 - 4
1986-1998: 0.879 0.500
1999-2022: 1.014 0.500

```

F, age effect:

```

-----
              0      1      2      3      4
1986-1998: 0.102 0.377 0.414 0.333 0.333
1999-2022: 0.052 0.150 0.216 0.209 0.209

```

Exploitation pattern (scaled to mean F=1)

```

-----
              0      1      2      3      4
1986-1998 season 1: 0 0.642 0.706 0.567 0.567
              season 2: 0.168 0.310 0.342 0.274 0.274

1999-2022 season 1: 0 0.564 0.810 0.785 0.785
              season 2: 0.177 0.257 0.369 0.357 0.357

```

sqrt(catch variance) ~ CV:

```

-----
              season
age          1      2
0              1.126
1          0.716 1.039
2          0.716 1.039
3          1.018 1.248
4          1.018 1.248

```

Survey catchability:

```

-----
              age 0    age 1    age 2    age 3    age 4
Acoustic survey              2.732    5.015    4.165    4.165
Dredge survey 2004-2022    0.446    0.446

```

Stock size dependent catchability (power model)

```

-----
              age 0    age 1    age 2    age 3    age 4
Acoustic survey              1.00    1.00    1.00    1.00
Dredge survey 2004-2022    1.03    1.00

```

sqrt(Survey variance) ~ CV:

```

-----
              age 0    age 1    age 2    age 3    age 4
Acoustic survey              0.54    0.54    1.08    1.08
Dredge survey 2004-2022    0.61    0.73

```

```

Recruit-SSB      alfa      beta      recruit s2      recruit s
Area-3r          1495.466  8.000e+004  1.040          1.020

```

Table 9.4.6 Sandeel Area-3r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1986	0.075	0.457	0.496	0.397	0.398	0.476
1987	0.001	0.719	0.758	0.593	0.592	0.738
1988	0.051	0.923	0.975	0.773	0.773	0.949
1989	0.003	1.041	1.097	0.879	0.876	1.069
1990	0.050	0.585	0.624	0.499	0.499	0.604
1991	0.039	0.707	0.753	0.599	0.598	0.730
1992	0.003	0.328	0.346	0.268	0.268	0.337
1993	0.041	0.609	0.651	0.516	0.514	0.630
1994	0.016	0.651	0.692	0.537	0.533	0.671
1995	0.007	0.518	0.553	0.431	0.430	0.536
1996	0.043	0.508	0.547	0.429	0.429	0.527
1997	0.065	0.914	0.982	0.785	0.781	0.948
1998	0.139	1.158	1.256	1.007	1.001	1.207
1999	0.127	0.637	0.909	0.867	0.863	0.773
2000	0.003	0.657	0.910	0.839	0.833	0.783
2001	0.132	0.411	0.595	0.575	0.578	0.503
2002	0.000	0.431	0.591	0.569	0.566	0.511
2003	0.017	0.230	0.318	0.310	0.309	0.274
2004	0.017	0.160	0.223	0.218	0.218	0.191
2005	0.000	0.077	0.106	0.101	0.101	0.092
2006	0.000	0.033	0.045	0.043	0.043	0.039
2007	0.000	0.195	0.269	0.255	0.254	0.232
2008	0.000	0.210	0.290	0.280	0.279	0.250
2009	0.000	0.018	0.025	0.023	0.023	0.021
2010	0.000	0.228	0.317	0.302	0.300	0.273
2011	0.000	0.147	0.205	0.196	0.194	0.176
2012	0.000	0.089	0.124	0.120	0.119	0.107
2013	0.000	0.043	0.060	0.059	0.058	0.052
2014	0.000	0.173	0.241	0.234	0.232	0.207
2015	0.000	0.228	0.317	0.307	0.305	0.272
2016	0.000	0.089	0.124	0.120	0.119	0.107
2017	0.000	0.197	0.274	0.266	0.264	0.236
2018	0.000	0.211	0.293	0.284	0.282	0.252
2019	0.000	0.317	0.440	0.426	0.423	0.378
2020	0.000	0.531	0.737	0.714	0.710	0.634
2021	0.000	0.283	0.393	0.381	0.378	0.338
2022	0.000	0.332	0.460	0.446	0.443	0.396
arith. mean	0.022	0.407	0.486	0.423	0.421	0.446

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	0.075	0.288	0.139	0.317	0.153	0.254	0.123	0.254	0.123
1987	0.001	0.581	0.002	0.639	0.002	0.513	0.002	0.513	0.002
1988	0.051	0.691	0.094	0.761	0.103	0.611	0.083	0.611	0.083
1989	0.003	0.870	0.006	0.957	0.007	0.768	0.005	0.768	0.005
1990	0.050	0.429	0.092	0.472	0.101	0.379	0.081	0.379	0.081
1991	0.039	0.545	0.073	0.599	0.080	0.481	0.064	0.481	0.064
1992	0.003	0.263	0.006	0.289	0.007	0.232	0.005	0.232	0.005
1993	0.041	0.453	0.077	0.498	0.084	0.400	0.068	0.400	0.068
1994	0.016	0.506	0.029	0.556	0.032	0.447	0.026	0.447	0.026
1995	0.007	0.411	0.013	0.453	0.014	0.364	0.012	0.364	0.012
1996	0.043	0.361	0.079	0.397	0.086	0.319	0.069	0.319	0.069
1997	0.065	0.676	0.121	0.744	0.133	0.597	0.107	0.597	0.107
1998	0.139	0.800	0.257	0.881	0.283	0.707	0.227	0.707	0.227
1999	0.127	0.407	0.185	0.585	0.266	0.567	0.258	0.567	0.258
2000	0.003	0.514	0.005	0.738	0.007	0.715	0.007	0.715	0.007
2001	0.132	0.214	0.192	0.308	0.276	0.298	0.267	0.298	0.267
2002	0.000	0.320	0.000	0.459	0.000	0.444	0.000	0.444	0.000
2003	0.017	0.159	0.025	0.228	0.037	0.220	0.035	0.220	0.035
2004	0.017	0.110	0.025	0.157	0.036	0.152	0.035	0.152	0.035
2005	0.000	0.059	0.000	0.085	0.000	0.083	0.000	0.083	0.000
2006	0.000	0.025	0.000	0.036	0.000	0.035	0.000	0.035	0.000
2007	0.000	0.154	0.000	0.221	0.000	0.214	0.000	0.214	0.000
2008	0.000	0.171	0.000	0.245	0.000	0.238	0.000	0.238	0.000
2009	0.000	0.014	0.000	0.021	0.000	0.020	0.000	0.020	0.000
2010	0.000	0.185	0.001	0.265	0.001	0.257	0.001	0.257	0.001
2011	0.000	0.117	0.000	0.169	0.000	0.163	0.000	0.163	0.000
2012	0.000	0.071	0.000	0.102	0.000	0.099	0.000	0.099	0.000
2013	0.000	0.035	0.000	0.050	0.000	0.048	0.000	0.048	0.000
2014	0.000	0.139	0.000	0.199	0.000	0.193	0.000	0.193	0.000
2015	0.000	0.183	0.000	0.263	0.000	0.255	0.000	0.255	0.000
2016	0.000	0.071	0.000	0.102	0.000	0.099	0.000	0.099	0.000
2017	0.000	0.158	0.000	0.227	0.000	0.220	0.000	0.220	0.000
2018	0.000	0.169	0.000	0.243	0.000	0.235	0.000	0.235	0.000
2019	0.000	0.255	0.000	0.366	0.000	0.355	0.000	0.355	0.000
2020	0.000	0.431	0.000	0.619	0.000	0.599	0.000	0.599	0.000
2021	0.000	0.227	0.000	0.327	0.000	0.316	0.000	0.316	0.000
2022	0.000	0.267	0.000	0.384	0.000	0.372	0.000	0.372	0.000
arith. mean	0.022	0.306	0.038	0.377	0.046	0.332	0.040	0.332	0.040

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	1.340	0.760	0.600	0.600	0.470	0.420	0.370	0.360	0.35
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.34
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.34
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.32
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.29
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.28
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.29
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.31
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.32
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.34
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.35
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.36
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.33
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.30
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.37
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.49
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.61
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.60
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.53
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.45
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.41
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.39
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.37
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.33
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.35
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.39
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2019	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2020	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2021	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2022	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
arith. mean	1.166	0.712	0.569	0.565	0.462	0.419	0.407	0.386	0.39

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

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1986	503091	77959	5442	285	678
1987	117504	122181	13058	1167	317
1988	361037	28089	18226	2431	417
1989	108557	73560	3525	2825	684
1990	193477	28618	9511	541	794
1991	128746	51194	5606	2316	456
1992	259479	36546	9193	1227	870
1993	192127	78680	8671	2837	901
1994	176753	58952	14098	1949	1207
1995	161467	57347	9701	2909	993
1996	726851	58394	10639	2214	1267
1997	66017	258837	11000	2413	1132
1998	93171	25140	36217	1770	815
1999	122192	30735	2793	4600	494
2000	140654	38020	4583	434	1127
2001	135298	45739	5309	682	350
2002	35570	36067	6150	783	220
2003	83569	10501	5082	968	194
2004	53715	24245	1764	1002	274
2005	88232	15743	4497	404	354
2006	122917	27938	3343	1219	271
2007	67307	40097	6516	1020	590
2008	103013	23553	8909	1773	564
2009	156425	38277	6101	2696	828
2010	15888	58119	13071	2503	1714
2011	12398	5234	16237	4197	1604
2012	81284	3697	1388	5201	2236
2013	218978	24728	996	461	2894
2014	236936	66618	6912	349	1413
2015	7251	72072	16776	2083	640
2016	770851	2206	17368	4745	904
2017	34617	234509	594	5768	2183
2018	286415	10531	57924	174	2737
2019	561044	87134	2573	16714	1021
2020	172419	170682	19539	656	5279
2021	69807	52454	32103	3872	1442
2022	46069	21237	12092	8520	1662
2023		14015	4705	3031	2996

Table 9.4.10 Sandeel Area-3r. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), catch weight (modelled yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1986	502949336	544524	72042	282315	0.448
1987	117506005	968835	175958	395296	0.612
1988	360859773	453212	258849	330358	0.825
1989	108580240	541124	97831	350409	0.920
1990	193541013	331037	103570	163224	0.546
1991	128700686	535431	158895	274839	0.648
1992	259430655	355996	118658	86788	0.282
1993	192190956	668299	197008	175786	0.556
1994	176706372	629452	235861	267281	0.561
1995	161497464	470081	140365	173607	0.446
1996	726682345	761475	233281	159024	0.461
1997	65989091	1517900	187775	470670	0.837
1998	93175931	530096	324487	462081	1.110
1999	122179276	332069	107689	191253	0.722
2000	140680230	338972	76039	186837	0.632
2001	135299311	404532	87029	193684	0.495
2002	35569532	385592	86077	116298	0.389
2003	83553692	154806	83700	34673	0.224
2004	53704105	211796	37835	31285	0.164
2005	88189635	212375	77265	13991	0.072
2006	122914555	282686	70193	7094	0.031
2007	67322159	428400	116774	74972	0.188
2008	102975330	376269	163081	74933	0.208
2009	156411357	369593	120813	6261	0.018
2010	15886814	760964	286932	61241	0.226
2011	12397433	383412	297152	92452	0.143
2012	81246638	242788	202602	40116	0.087
2013	218872516	290720	70404	9844	0.042
2014	236864783	688106	118302	90876	0.169
2015	7253539	870137	243775	104631	0.223
2016	770846639	347260	288370	42845	0.087
2017	34622004	1962260	225032	115642	0.193
2018	286428643	690940	498321	75388	0.206
2019	560870164	1044490	324811	135899	0.311
2020	172343477	1904080	386157	246139	0.525

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2021	69789910	967283	473544	157480	0.277
2022	46085089	684731	405550	83420	0.325
2023			178439		
arith. mean*	181381734	611938	192919	156187	0.384
geo. mean**	118805707				

* arith. mean for the period 1986–2022

** geo. mean for the period 1986–2021

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	118831.84	14015	4704.64	3030.81	2996.03
Exploitation pattern 1st half		0.267	0.384	0.372	0.372
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		8.428	13.371	17.334	24.526
Weight in the catch 1st half		8.428	13.371	17.334	24.526
Weight in the catch 2nd half	3.708	8.780	17.355	22.714	26.159
Proportion mature (2023)	0.000	0.036	0.766	1.000	1.000
Proportion mature (2024)	0.000	0.036	0.766	1.000	1.000
Natural mortality 1st half		0.700	0.550	0.420	0.390
Natural mortality 2nd half	1.190	0.540	0.450	0.440	0.420

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

Basis: $F_{sq} = F(2022) = 0.3254$; $Yield(2022) = 83.42$; $Recruitment(2022) = 46.085089$; $Recruitment(2023) = \text{geometric mean (GM 1986-2021)} = 118.831839$ billions; $SSB(2023) = 178.439$

Basis	Total catch (2023)	F_{total} (2023)	SSB (2024)	% SSB change *	% TAC change **
ICES advice basis					
$SSB_{2024} \geq MSY B_{escapement} = B_{pa}$	30 570	0.133	129 000	-28	-70
Other scenarios					
$F = 0$	0	0	146 667	-18	-100
$SSB_{2024} = B_{lim}$	118 388	0.65	80 000	-55	16
$F = F_{2022}$	68 521	0.33	107 456	-40	-33

* SSB in 2024 relative to SSB in 2023

** Catch in 2023 relative to TAC in 2022

Table 9.4.13. Sandeel Area-3r. Acoustic survey indices (millions of individuals).

Year	Age 1	Age 2	Age 3	Age 4
2009	8436.31 (CV=0.27)	4617.72 (CV=0.321)	1134.76 (CV=0.342)	96.78 (CV=0.47)
2010	16231.98 (CV=0.181)	6460.47 (CV=0.209)	1529.58 (CV=0.335)	953.6 (CV=0.328)
2011	953.91 (CV=0.713)	8677.02 (CV=0.179)	884.78 (CV=0.366)	232.4 (CV=0.414)
2012	168.03 (CV=1.12)	328.98 (CV=0.474)	3676.77 (CV=0.197)	540.15 (CV=0.226)
2013	2153.53 (CV=0.233)	285.18 (CV=0.392)	76.16 (CV=0.408)	650.27 (CV=0.431)
2014	21957.69 (CV=0.211)	1892.03 (CV=0.353)	189.03 (CV=0.559)	2910.96 (CV=0.449)
2015	9514.13 (CV=0.132)	2230.46 (CV=0.226)	703.44 (CV=0.342)	807.63 (CV=0.259)
2016	74.11 (CV=0.831)	4887 (CV=0.222)	603.88 (CV=0.268)	931.07 (CV=0.416)
2017	35207.5 (CV=0.154)	121.62 (CV=0.655)	3614.4 (CV=0.252)	1187.82 (CV=0.24)
2018	1657.81 (CV=0.245)	17448.76 (CV=0.086)	86.21 (CV=0.36)	429.69 (CV=0.185)
2019	11257.12 (CV=0.165)	725.63 (CV=0.222)	15438.34 (CV=0.125)	1055.27 (CV=0.542)
2020	41473.35 (CV=0.23)	10152.87 (CV=0.256)	546.56 (CV=0.362)	10270.09 (CV=0.192)
2021	14837.61 (CV=0.19)	12843.12 (CV=0.165)	2791.19 (CV=0.172)	4357.89 (CV=0.232)
2022	4810.19 (CV=0.312)	5035.2 (CV=0.24)	5601.63 (CV=0.339)	2143.56 (CV=0.28)

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	674	1235	149	6337	381	1861	122	534	39
1994	0	1070	256	1522	62	5144	257	2092	159
1995	4	2690	4	1229	1	529	0	30	0
1996	2666	754	2584	2536	3461	476	227	130	1110
1997	0	2879	1369	291	35	1683	43	413	10
1998	0	2159	61	3766	97	235	6	130	3
1999	0	1472	86	1137	46	1543	47	252	11
2000	0	6537	0	376	0	323	0	297	0
2001	0	2048	64	4961	20	601	1	377	0
2002	0	337	0	807	0	511	0	101	0
2003	145	4322	148	1002	10	2721	5	1253	1
2004	0	920	4	220	1	45	0	82	0
2005	0	49	0	145	0	32	0	17	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0
2012	0	83	0	40	0	196	0	3	0
2013	0	182	0	100	0	71	0	133	0

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0	346	0	54	0	15	0	47	0
2015	0	866	0	29	0	9	0	14	0
2016	0	181	0	406	0	20	0	36	0
2017	0	719	0	468	0	578	0	30	0
2018	0	874	0	1259	0	355	0	1133	0
2019	0	314	0	159	0	143	0	60	0
2020	33	2363	17	256	0	72	0	82	0
2021	1	3310	20	2155	78	347	12	372	40
2022	0	331	0	72	0	124	0	40	0
arith. mean	117	1201	159	978	140	588	24	255	46

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	3.0	7.4	6.7	11.9	12.0	14.9	14.0	20.1	18.9
1994	3.8	10.9	8.6	11.1	15.5	14.7	18.0	20.5	24.4
1995	4.4	8.4	10.1	15.7	18.0	19.1	21.0	15.5	28.5
1996	6.3	5.3	7.3	12.9	13.1	18.6	18.0	23.0	22.3
1997	3.1	6.7	7.0	7.5	12.4	11.2	14.5	18.1	19.6
1998	2.6	6.1	6.0	10.4	10.7	13.6	12.5	14.6	16.9
1999	3.2	6.1	7.2	10.8	12.9	16.1	15.1	20.2	20.4
2000	4.0	3.9	9.0	8.0	16.2	13.2	18.8	17.3	25.5
2001	1.8	3.4	4.2	6.0	7.5	9.0	8.7	14.2	11.8
2002	4.0	3.8	9.0	5.9	16.2	9.5	18.8	17.9	25.5
2003	3.6	4.6	5.6	6.6	6.2	8.1	7.8	10.9	10.1
2004	1.4	4.0	3.3	7.4	5.8	9.3	6.8	13.8	9.2
2005	4.0	4.2	9.0	6.1	16.2	8.6	18.8	11.0	25.5
2006	4.0	5.5	9.0	10.0	16.2	14.3	18.8	18.1	25.5
2007	4.0	4.8	9.0	8.8	16.2	12.6	18.8	16.0	25.5
2008	4.0	4.8	9.0	8.7	16.2	12.4	18.8	15.7	25.5
2009	4.0	5.8	9.0	10.7	16.2	15.2	18.8	19.3	25.5
2010	4.0	5.1	9.0	9.4	16.2	13.4	18.8	17.0	25.5
2011	4.0	4.9	9.0	8.9	16.2	12.7	18.8	16.1	25.5
2012	4.0	4.0	9.0	8.2	16.2	9.6	18.8	12.2	25.5
2013	4.0	5.3	9.0	9.3	16.2	14.7	18.8	17.1	25.5
2014	4.0	7.1	9.0	12.4	16.2	17.2	18.8	20.0	25.5
2015	4.4	4.4	7.7	9.5	10.7	11.4	14.6	16.2	17.6
2016	4.4	5.0	7.7	9.9	10.7	18.1	14.6	24.7	17.6
2017	4.4	7.5	7.7	10.2	10.7	13.4	14.6	18.5	17.6

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	4.4	5.7	7.7	9.4	10.7	13.1	14.6	18.3	17.6
2019	4.4	5.9	7.7	10.2	10.7	13.7	14.6	20.2	17.6
2020	4.4	6.7	7.7	8.6	10.7	11.9	14.6	12.4	17.6
2021	7.5	5.5	9.8	9.8	13.3	13.0	19.6	18.6	21.0
2022	3.8	6.1	8.6	9.6	15.7	15.3	18.8	22.1	27.7
arith. mean	4.0	5.6	8.0	9.5	13.4	13.3	16.3	17.3	21.4

Table 9.5.3 Sandeel Area-4. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0	0.79	0.98	1

Table 9.5.4. Sandeel Area-4. Dredge survey indices.

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	
2004		
2005		
2006		
2007		
2008	52	24
2009	832	87
2010	147	1032
2011	89	165
2012	95	135
2013	62	85
2014	445	43
2015	136	1044
2016	300	81
2017	346	223
2018	16	461
2019	371	92
2020	441	1296
2021	160	194
2022	356	451

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

Date: 01/20/23 Start time:16:12:43 run time:2 seconds

objective function (negative log likelihood): 12.4168

Number of parameters: 49

Maximum gradient: 7.46213e-005

Akaike information criterion (AIC): 122.834

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
270	39	30	0	339

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.05

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
35.2	-23.8	21.0	0.0	0.0	0.00	32

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.13	-0.61	0.70	0.00

contribution by fleet:

Old Dredge survey 1999-2003	total:	-9.527	mean:	-1.059
New Dredge survey 2008-2022	total:	-14.315	mean:	-0.477

F, season effect:

age: 0

1993-2022: 0.000 1.000

age: 1 - 4

1993-2022: 0.704 0.500

F, age effect:

	0	1	2	3	4
1993-2022:	0.002	0.097	0.188	0.268	0.268

Exploitation pattern (scaled to mean F=1)

	0	1	2	3	4
1993-2022 season 1:	0	0.612	1.189	1.697	1.697
season 2:	0.002	0.068	0.131	0.187	0.187

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		2.272
1	0.732	0.521
2	0.732	0.521
3	0.672	1.251
4	0.672	1.251

Survey catchability:

	age 0	age 1
Old Dredge survey 1999-2003	0.772	17.707
New Dredge survey 2008-2022	0.742	4.405

sqrt(Survey variance) ~ CV:

age 0 age 1
Old Dredge survey 1999-2003 0.30 0.30
New Dredge survey 2008-2022 0.52 0.30

Recruit-SSB alfa beta recruit s2 recruit s
Area-4 1318.189 4.800e+004 1.490 1.221

Table 9.5.6 Sandeel Area-4. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0.001	0.346	0.650	0.902	0.900	0.498
1994	0.001	0.401	0.753	1.042	1.039	0.577
1995	0.000	0.120	0.224	0.308	0.307	0.172
1996	0.005	0.236	0.469	0.687	0.691	0.352
1997	0.001	0.147	0.280	0.391	0.390	0.214
1998	0.000	0.161	0.302	0.417	0.415	0.231
1999	0.000	0.233	0.434	0.598	0.595	0.334
2000	0.000	0.116	0.216	0.298	0.297	0.166
2001	0.000	0.181	0.339	0.467	0.465	0.260
2002	0.000	0.039	0.072	0.100	0.099	0.056
2003	0.000	0.288	0.539	0.745	0.742	0.414
2004	0.000	0.056	0.104	0.144	0.143	0.080
2005	0.000	0.024	0.046	0.063	0.063	0.035
2006	0.000	0.000	0.001	0.001	0.001	0.001
2007	0.000	0.000	0.001	0.001	0.001	0.000
2008	0.000	0.002	0.004	0.005	0.005	0.003
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.002	0.003	0.003	0.002
2011	0.000	0.002	0.003	0.005	0.005	0.003
2012	0.000	0.019	0.035	0.048	0.048	0.027
2013	0.000	0.010	0.019	0.027	0.027	0.015
2014	0.000	0.014	0.026	0.035	0.035	0.020
2015	0.000	0.011	0.021	0.028	0.028	0.016
2016	0.000	0.022	0.040	0.056	0.055	0.031
2017	0.000	0.047	0.089	0.122	0.121	0.068
2018	0.000	0.135	0.252	0.347	0.346	0.193
2019	0.000	0.057	0.107	0.148	0.147	0.082
2020	0.000	0.045	0.085	0.117	0.117	0.065
2021	0.001	0.336	0.629	0.870	0.867	0.483
2022	0.000	0.031	0.059	0.081	0.081	0.045
arith. mean	0.000	0.103	0.193	0.269	0.268	0.148

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	0.001	0.259	0.029	0.503	0.055	0.718	0.079	0.718	0.079
1994	0.001	0.304	0.027	0.591	0.053	0.843	0.076	0.843	0.076
1995	0.000	0.094	0.000	0.182	0.000	0.260	0.001	0.260	0.001
1996	0.005	0.112	0.145	0.217	0.281	0.310	0.401	0.310	0.401
1997	0.001	0.106	0.020	0.205	0.039	0.293	0.056	0.293	0.056
1998	0.000	0.124	0.005	0.241	0.010	0.344	0.015	0.344	0.015
1999	0.000	0.184	0.000	0.357	0.000	0.510	0.000	0.510	0.000
2000	0.000	0.091	0.000	0.177	0.000	0.252	0.000	0.252	0.000
2001	0.000	0.142	0.002	0.275	0.004	0.393	0.006	0.393	0.006
2002	0.000	0.030	0.000	0.059	0.000	0.084	0.000	0.084	0.000
2003	0.000	0.222	0.011	0.431	0.021	0.616	0.030	0.616	0.030
2004	0.000	0.043	0.000	0.084	0.001	0.120	0.001	0.120	0.001
2005	0.000	0.019	0.000	0.037	0.000	0.053	0.000	0.053	0.000
2006	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
2008	0.000	0.002	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.000	0.002	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2012	0.000	0.015	0.000	0.028	0.000	0.040	0.000	0.040	0.000
2013	0.000	0.008	0.000	0.016	0.000	0.022	0.000	0.022	0.000
2014	0.000	0.011	0.000	0.021	0.000	0.030	0.000	0.030	0.000
2015	0.000	0.009	0.000	0.017	0.000	0.024	0.000	0.024	0.000
2016	0.000	0.017	0.000	0.033	0.000	0.047	0.000	0.047	0.000
2017	0.000	0.037	0.000	0.072	0.000	0.103	0.000	0.103	0.000
2018	0.000	0.106	0.000	0.206	0.000	0.294	0.000	0.294	0.000
2019	0.000	0.045	0.000	0.087	0.000	0.125	0.000	0.125	0.000
2020	0.000	0.036	0.000	0.069	0.000	0.099	0.000	0.099	0.000
2021	0.001	0.258	0.015	0.501	0.030	0.716	0.043	0.716	0.043
2022	0.000	0.025	0.000	0.048	0.000	0.068	0.000	0.068	0.000
arith. mean	0.000	0.077	0.009	0.149	0.017	0.212	0.024	0.212	0.024

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

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1994	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1995	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1996	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1997	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1998	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1999	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2000	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2001	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2002	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2003	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2004	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2005	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2006	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2007	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2008	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2009	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2010	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2011	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2012	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2013	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2014	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2015	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2016	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2017	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2018	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2019	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2020	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2021	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2022	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
arith. mean	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378

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

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1993	120289	25195	23838	7704	1488
1994	240283	38432	4856	4586	1834
1995	64443	76772	7088	858	1140
1996	342465	20610	17951	1985	694
1997	94866	108963	4096	3667	585
1998	43209	30318	24684	1079	1326
1999	228380	13816	6845	6457	757
2000	187255	73040	2953	1610	1913
2001	23562	59888	17133	832	1233
2002	81975	7535	13324	4356	626
2003	154821	26217	1878	4224	2024
2004	11616	49496	5335	402	1460
2005	7042	3715	12172	1648	752
2006	4309	2252	936	3943	1014
2007	6051	1378	578	315	2197
2008	18725	1935	354	194	1148
2009	276364	5988	496	119	611
2010	47497	88387	1539	167	333
2011	34775	15190	22690	516	226
2012	27966	11122	3897	7607	330
2013	18210	8944	2816	1274	3354
2014	252959	5824	2279	932	2056
2015	34198	80901	1480	751	1316
2016	73781	10937	20606	489	913
2017	93158	23597	2763	6705	606
2018	22866	29794	5842	864	2909
2019	212587	7313	6884	1598	1281
2020	56007	67990	1796	2121	1140
2021	90615	17912	16856	563	1319
2022	128823	28964	3500	3331	400
2023		41200	7261	1122	1539

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

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1993	120239964	612310	365492	132599	0.423
1994	240204211	576474	146239	158690	0.488
1995	64424207	791616	121662	52591	0.139
1996	342574599	393194	234685	158490	0.378
1997	94868284	811425	74757	58446	0.185
1998	43228044	473578	235861	58746	0.190
1999	228489314	277262	175782	53334	0.270
2000	187258393	360816	72620	37714	0.134
2001	23558565	331134	105979	47902	0.212
2002	81981158	160077	114348	12736	0.045
2003	154855038	189367	65513	63731	0.343
2004	11617231	261881	54940	6882	0.064
2005	7039164	112414	80741	1557	0.028
2006	4308068	96413	80983	0	0.000
2007	6052609	50904	43088	0	0.000
2008	18718071	32768	22880	0	0.002
2009	276300611	53755	17732	0	0.000
2010	47488589	475105	19235	0	0.001
2011	34760770	285750	169397	0	0.002
2012	27979985	153782	101013	2585	0.021
2013	18201235	149706	96568	5225	0.012
2014	253025289	126783	79142	4314	0.016
2015	34209023	396783	40864	4392	0.013
2016	73809647	290463	192914	6188	0.025
2017	93175931	306416	121540	18474	0.055
2018	22862304	290383	107796	42296	0.156
2019	212616366	161211	102642	6651	0.066
2020	56007715	507996	51021	20101	0.052
2021	90603192	295548	161943	53081	0.403
2022	128829451	270418	85477	5490	0.036
2023			97538		
arith. mean	99969892	309858	110973	33740	0.125
geo. mean	55839943				

arith. mean for the period 1993–2022**geo. mean for the period 1993–2021**

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	61281.945	41199.9	7261.05	1122.02	1538.65
Exploitation pattern 1st half		0.025	0.048	0.068	0.068
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.993	9.508	13.413	18.335
Weight in the catch 1st half		5.993	9.508	13.413	18.335
weight in the catch 2nd half	4.917	8.289	12.248	16.417	20.292
Proportion mature (2023)	0.000	0.000	0.790	0.980	1.000
Proportion mature (2024)	0.000	0.000	0.790	0.980	1.000
Natural mortality 1st half		0.767	0.602	0.431	0.398
Natural mortality 2nd half	1.140	0.592	0.488	0.392	0.378

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

Basis: $F_{sq} = F(2022) = 0.0361$; $Yield(2022) = 5.49$; $Recruitment(2022) = 128.829451$; $Recruitment(2023) = \text{geometric mean (GM 2012-2021)} = 61.281945$ billions; $SSB(2023) = 97.538$

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
ICES advice basis					
$SSB(2024) \geq MSY B_{\text{escapement}}$ with F_{cap}	35 020	0.15	114 743	18	538
Other scenarios					
$F = 0$	0	0	133 616	37	-100
$SSB(2024) = MSY B_{\text{escapement}} = B_{\text{pa}}$	59 252	0.27	102 000	5	979
$SSB(2024) = B_{\text{lim}}$	170 570	1.10	48 000	-51	3 007
$F = F_{2022}$	8 947	0.036	128 747	32	32

* SSB in 2024 relative to SSB in 2023

** Catch in 2023 relative to catches in 2022

Table 9.6.1. Area-5r. Acoustic survey sandeel biomass estimates (tonnes).

Year	Biomass (tonnes)	CV
2009	255	0.57
2010	5724	0.92
2011	3280	0.38
2012	739	0.60
2013	3910	0.24
2014	1283	0.40
2015	12751	0.57
2016	667	0.53
2017	465	0.34
2018	938	0.35
2019	3903	0.31

Year	Biomass (tonnes)	CV
2020	3221	0.37
2021	121	0.48
2022	71	0.97

Table 9.9.1 Sandeel in Division 6.a. History of the total catch (in tonnes) as estimated by ICES.

Year	Denmark	Faroe Islands	Norway	UK – Scotland	Total
1970	-	.	-	-	0
1971	-	.	-	-	0
1972	-	.	-	-	0
1973	-	.	-	-	0
1974	-	.	-	< 0.5	0
1975	-	.	-	< 0.5	0
1976	-	.	17	< 0.5	17
1977	-	.	54	13	67
1978	-	.	-	5	0
1979	-	.	-	-	0
1980	-	.	-	211	211
1981	-	.	-	5972	5972
1982	-	.	-	10873	10873
1983	-	.	-	13051	13051
1984	-	.	-	14166	14166
1985	-	.	-	18586	18586
1986	-	.	-	24469	24469
1987	-	.	-	14479	14479
1988	-	.	-	24465	24465
1989	-	.	-	18785	18785
1990	-	.	-	16515	16515
1991	-	.	-	8532	8532
1992	-	.	-	4985	4985
1993	80	.	-	6156	6236
1994	-	.	-	10627	10627
1995	-	.	-	7111	7111
1996	-	.	-	13257	13257
1997	-	.	-	12679	12679
1998	-	.	-	5320	5320
1999	-	.	-	2627	2627
2000	-	.	-	5771	5771
2001	-	.	-	295	295
2002	-	.	-	706	706
2003	-	.	-	-	0

Year	Denmark	Faroe Islands	Norway	UK – Scotland	Total
2004	-	.	-	566	566
2005	-	.	-	-	0
2006	-	-	-	.	0
2007	.	57	-	.	57
2008	.	-	.	.	0
2009	.	.	.	.	0
2010	.	.	.	.	0
2011	-	-	-	-	0
2012	-	-	-	-	0
2013	-	-	-	-	0
2014	-	-	-	-	0
2015	-	-	-	-	0
2016	-	-	-	-	0
2017	-	-	-	-	0
2018	-	-	-	-	0
2019	-	-	-	-	0
2020	2.7	-	-	-	2.7
2021	-	-	-	-	0
2022*	-	-	-	-	0

* Preliminary

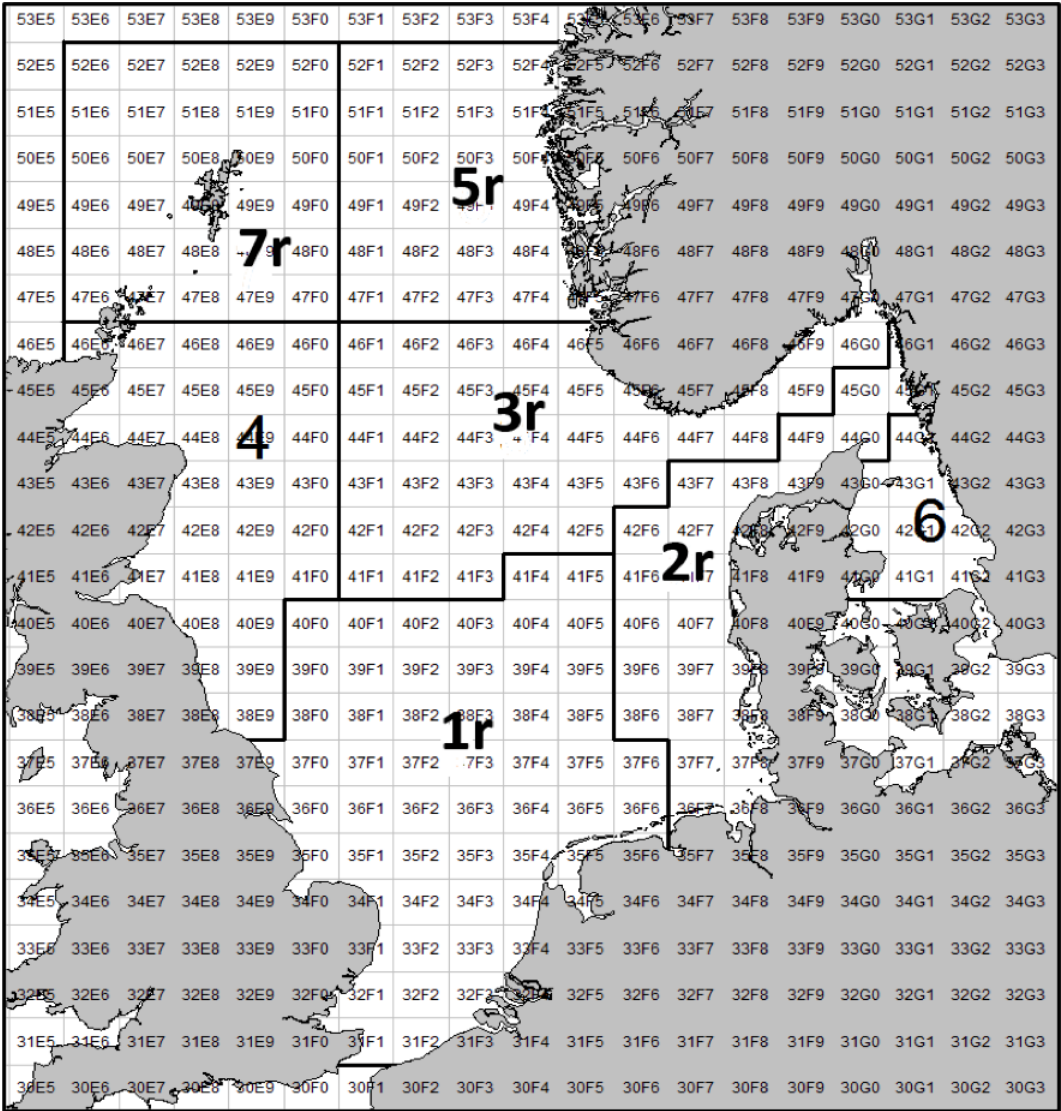


Figure 9.1.1 Sandeel in ICES Subarea 4 and Div. 3.a. Sandeel management areas.





Figure 9.1.2 Sandeel in ICES Subarea 4 and Div. 3.a. Catch by ICES rectangles 2006–2022 (upper, red circles). Number of samples per ICES square in commercial catches (lower, blue circles). Area of the circles is proportional to catch by rectangle.

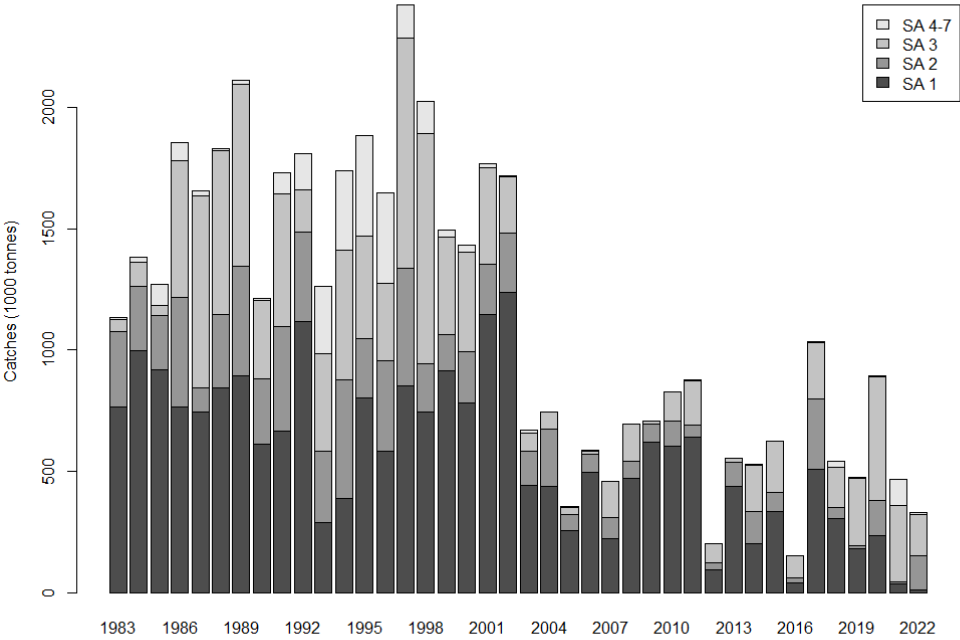


Figure 9.1.3 Sandeel in ICES Subarea 4 and Div. 3.a. Total catches by year and area.

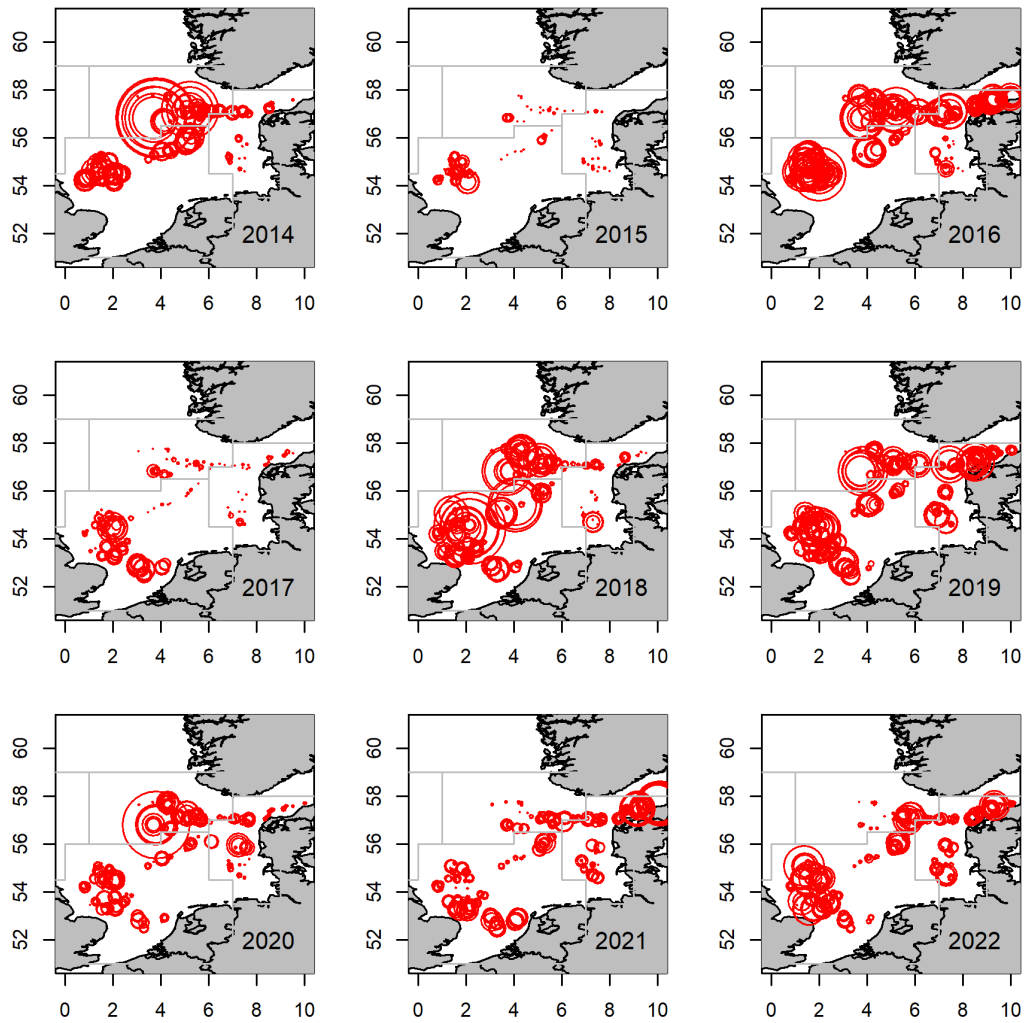


Figure 9.1.4 Sandeel in ICES Subarea 4 and Div. 3.a. Danish dredge survey catches by haul for 0-group. Area of the circles is proportional to catch number.

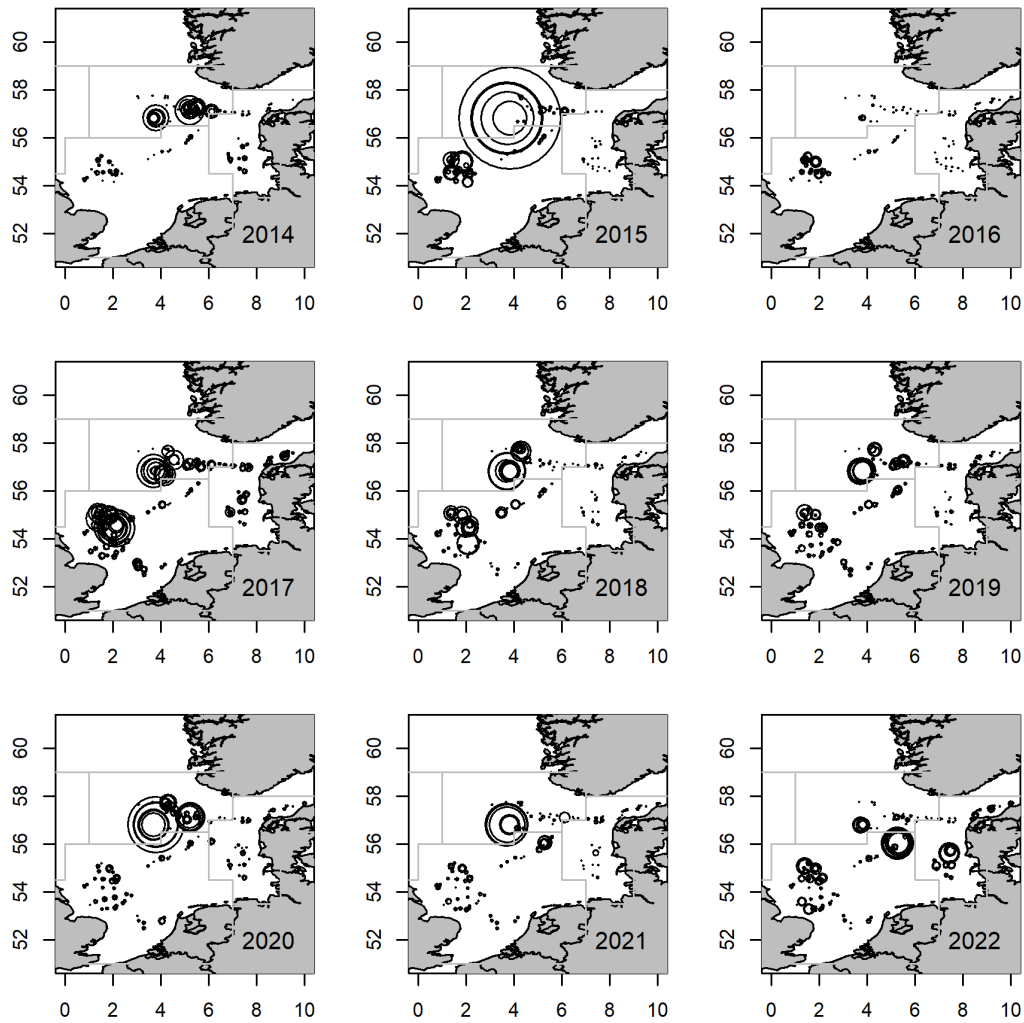


Figure 9.1.5 Sandeel in ICES Subarea 4 and Div. 3.a. Danish dredge survey catches by haul for 1-group. Area of the circles is proportional to catch number.

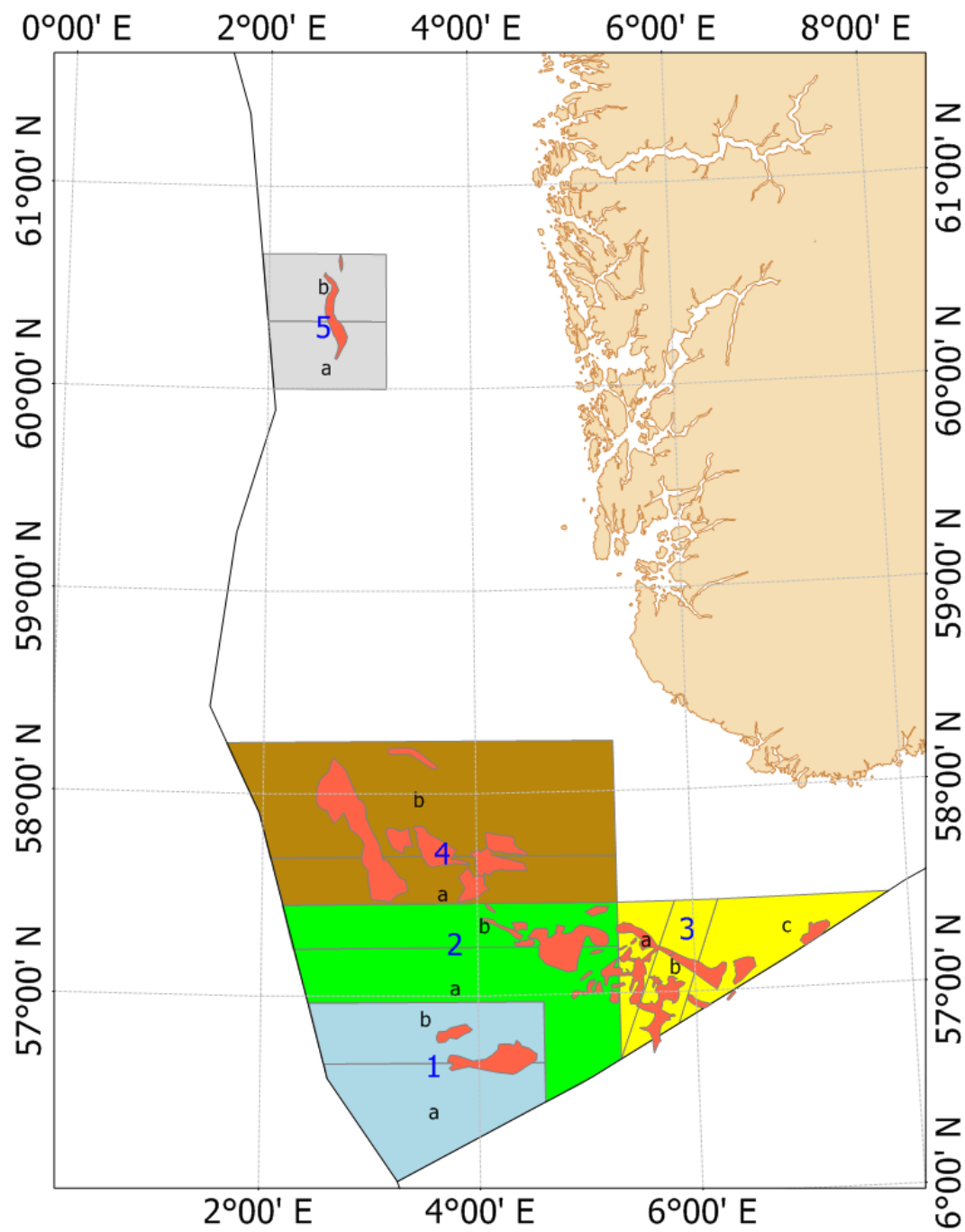


Figure 9.1.6 Sandeel in ICES Subarea 4 and Div. 3.a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.

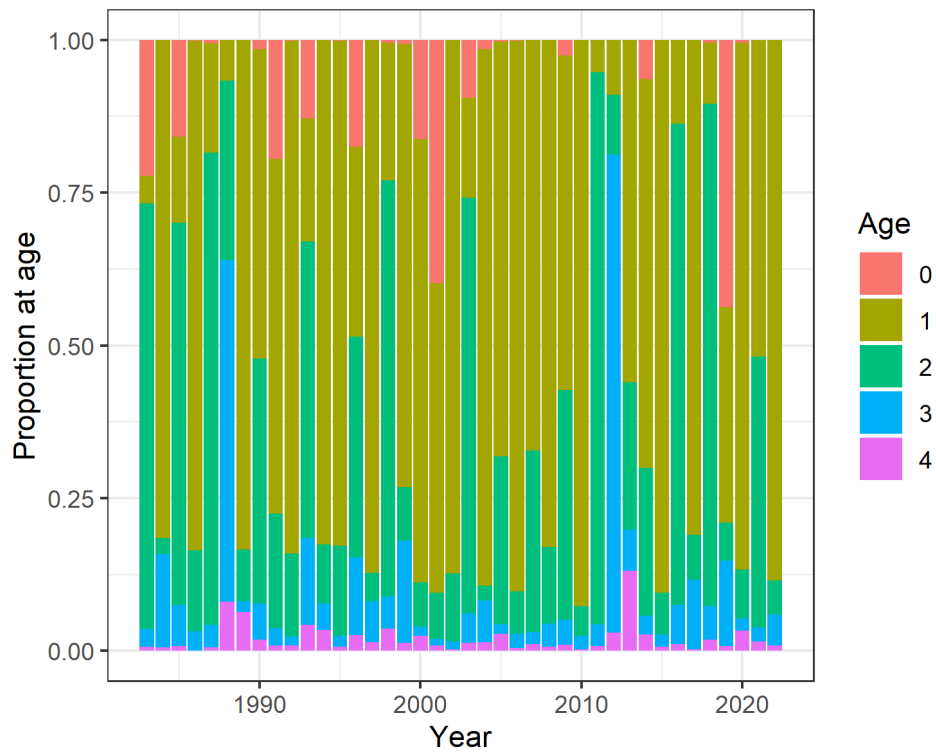


Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

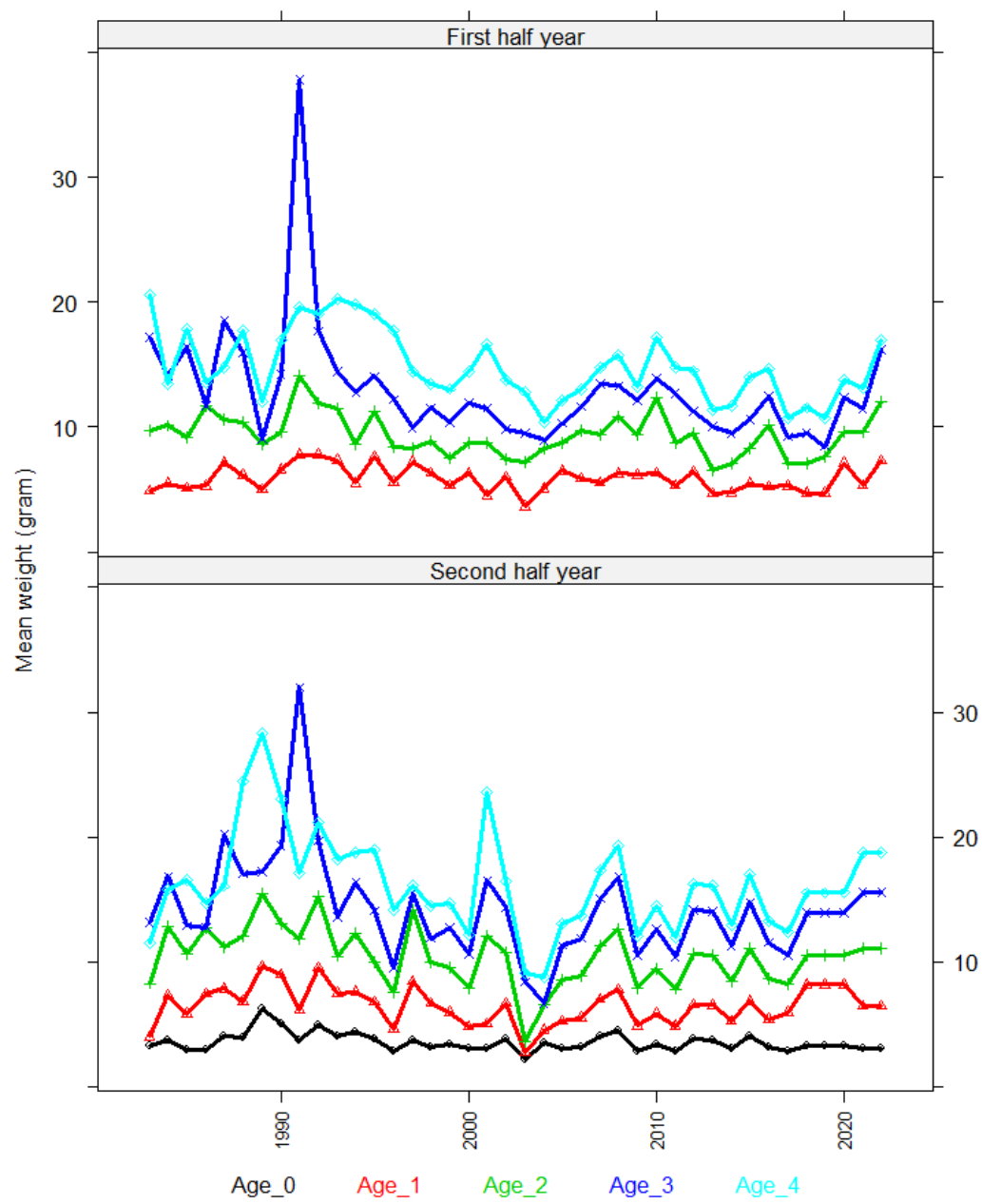


Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

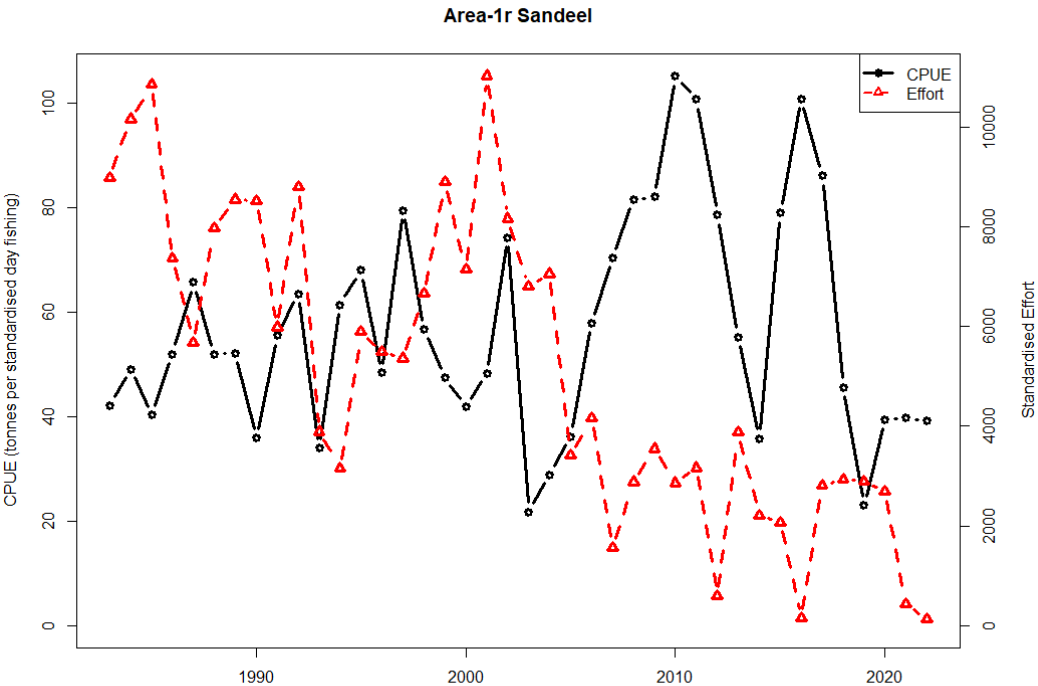


Figure 9.2.3 Sandeel Area-1r. Commercial CPUE and effort.

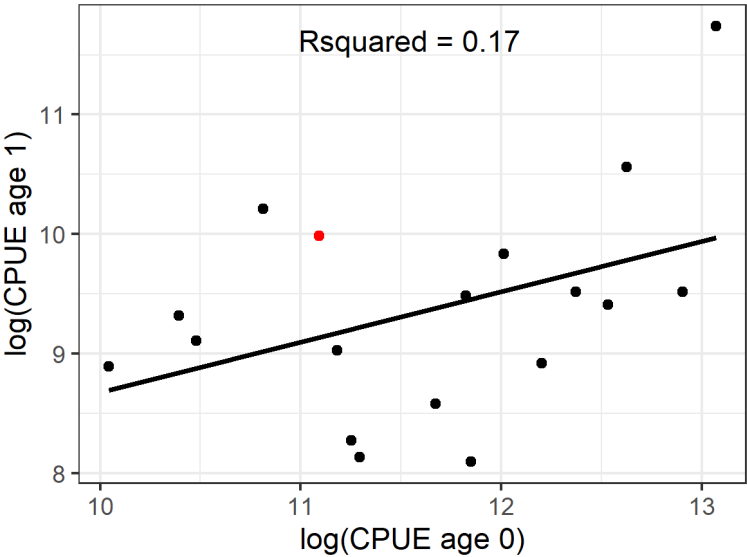


Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

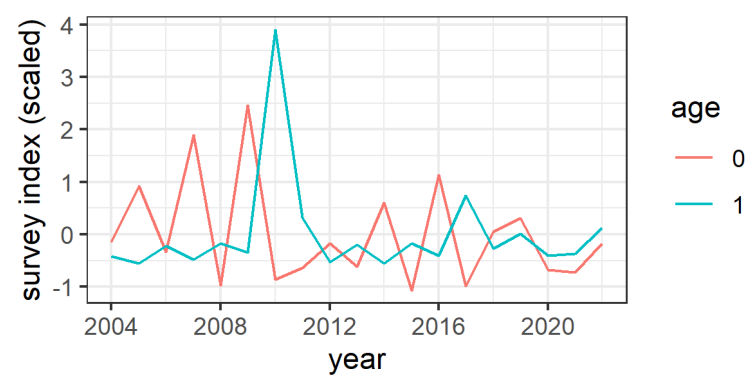


Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.

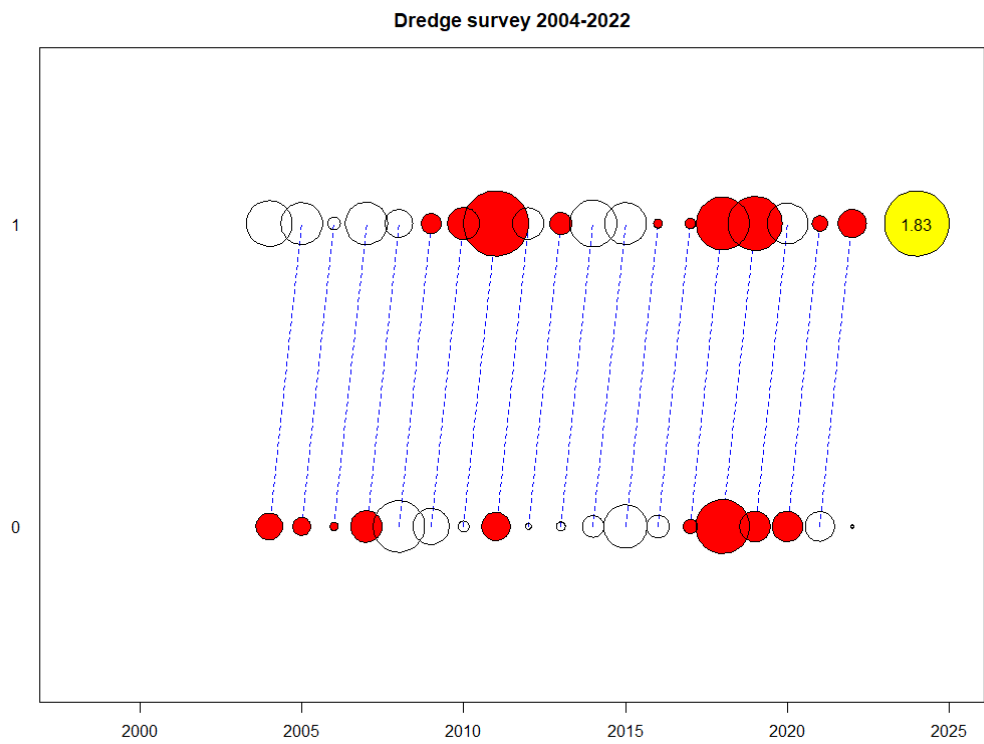


Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

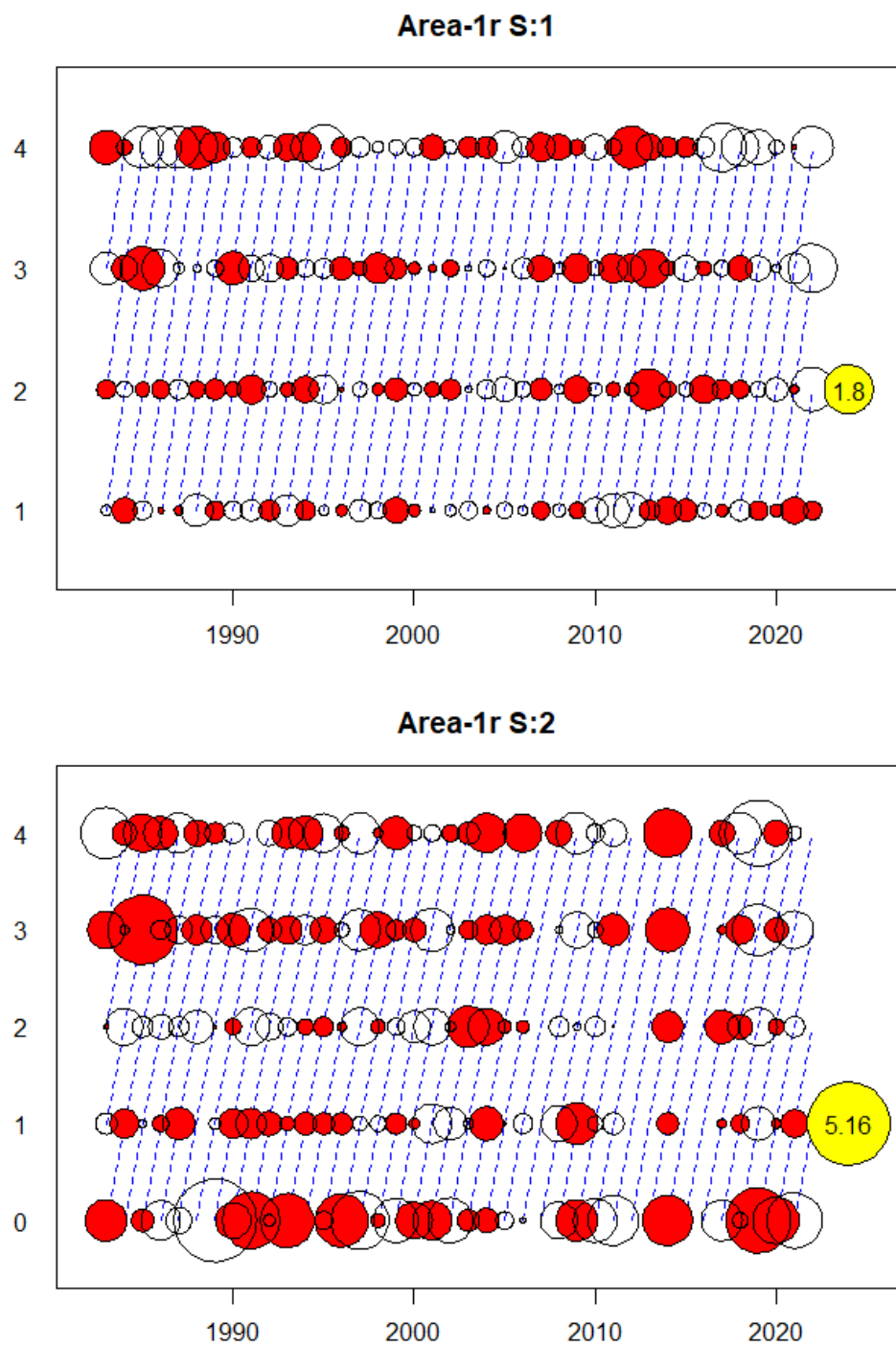


Figure 9.2.7 Sandeel Area-1r. Catch at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

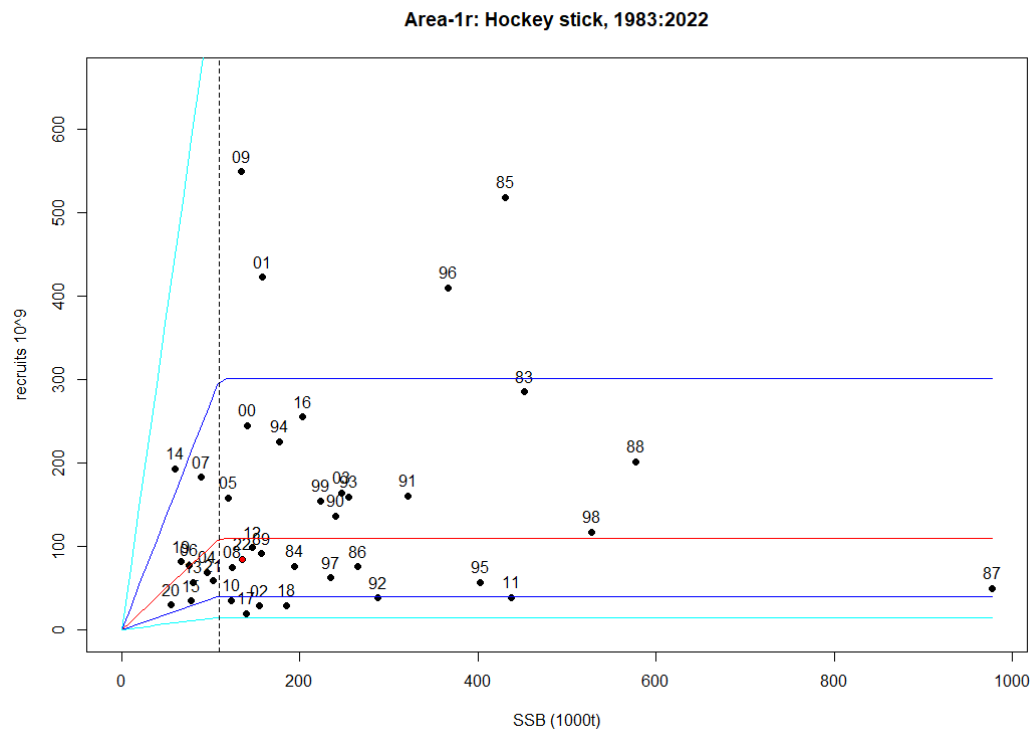


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

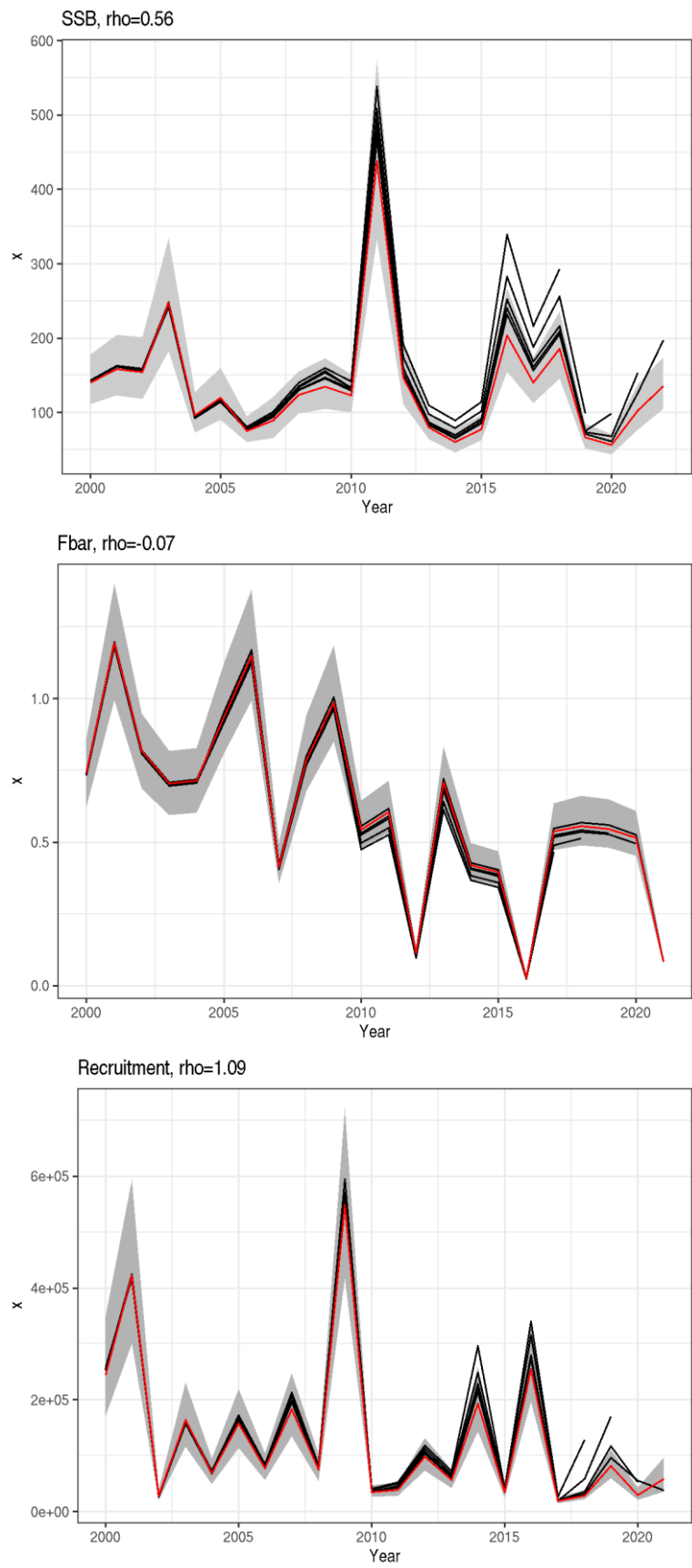


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

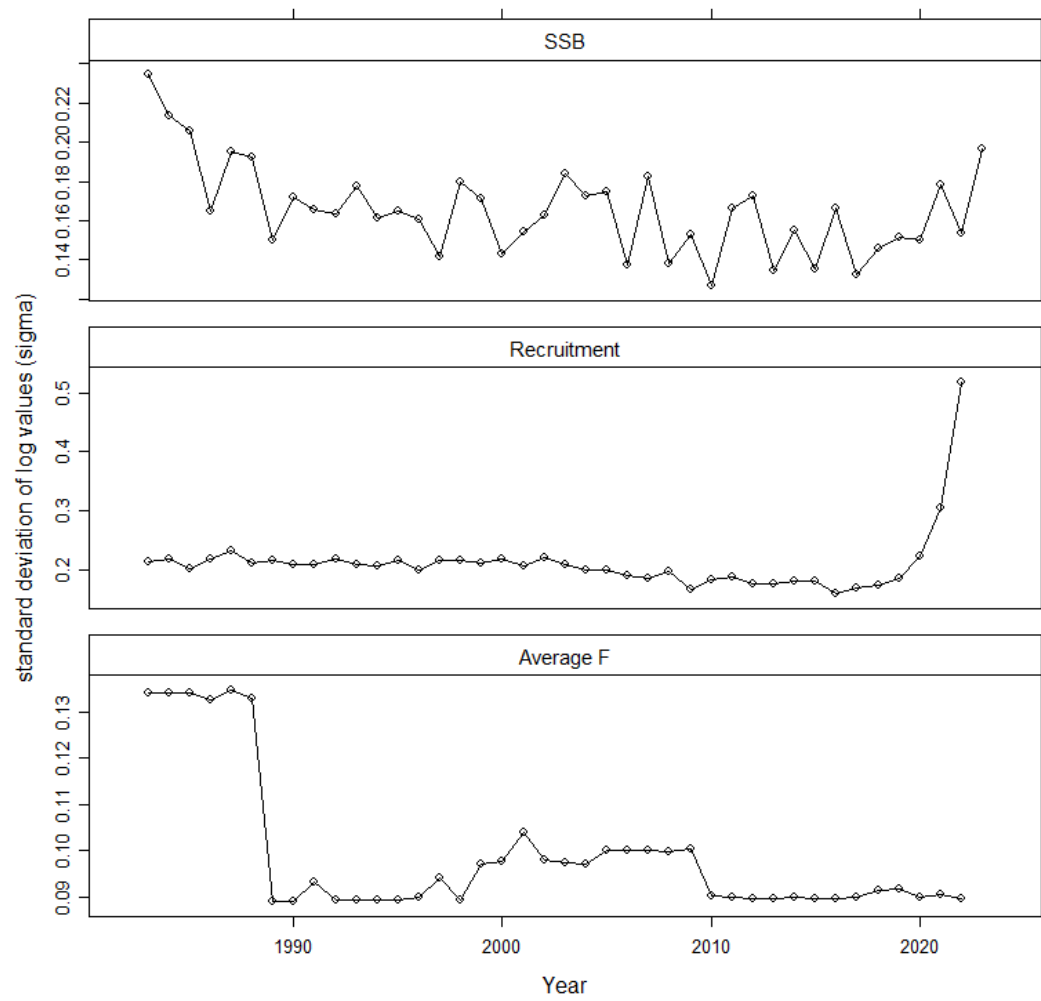


Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

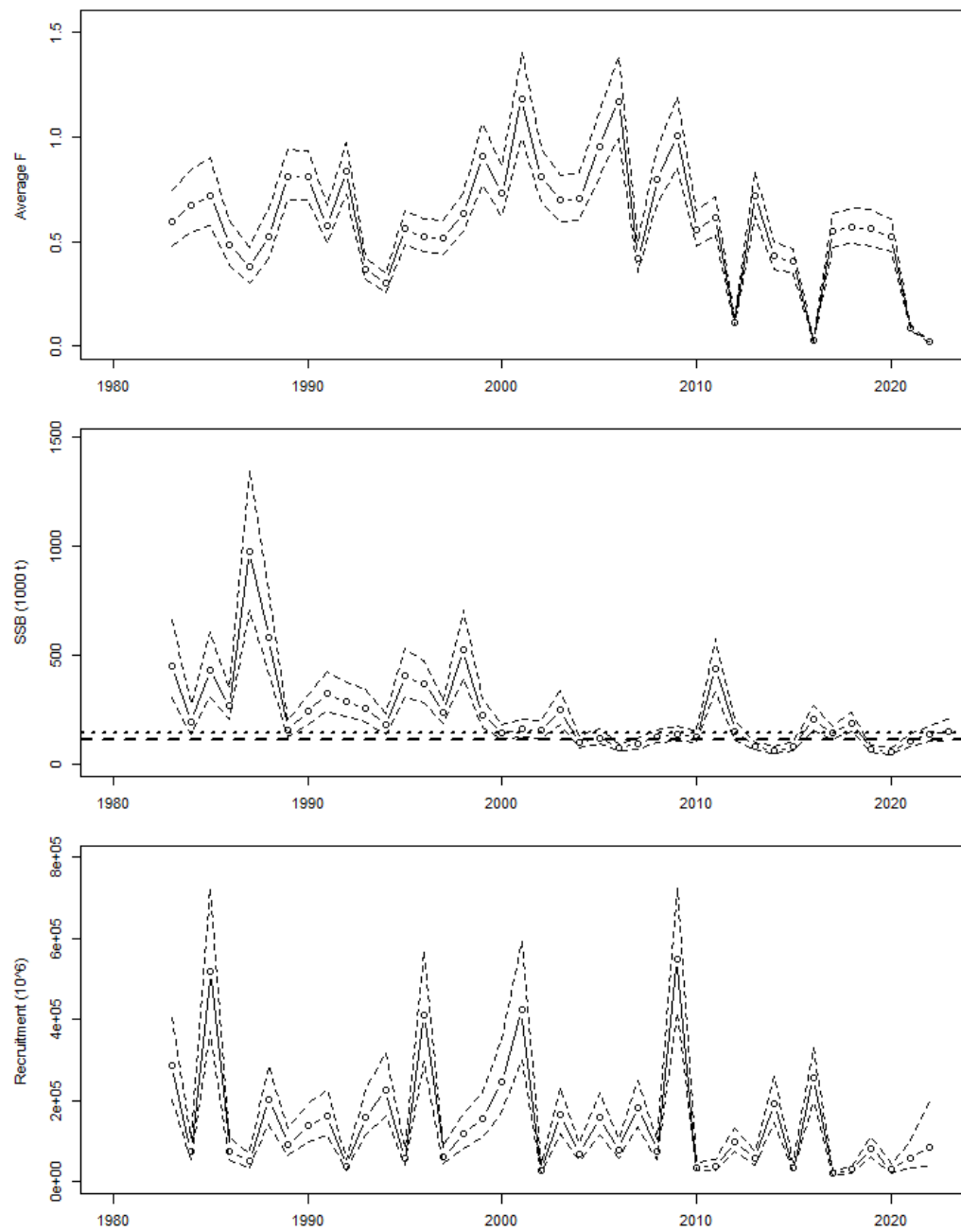


Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

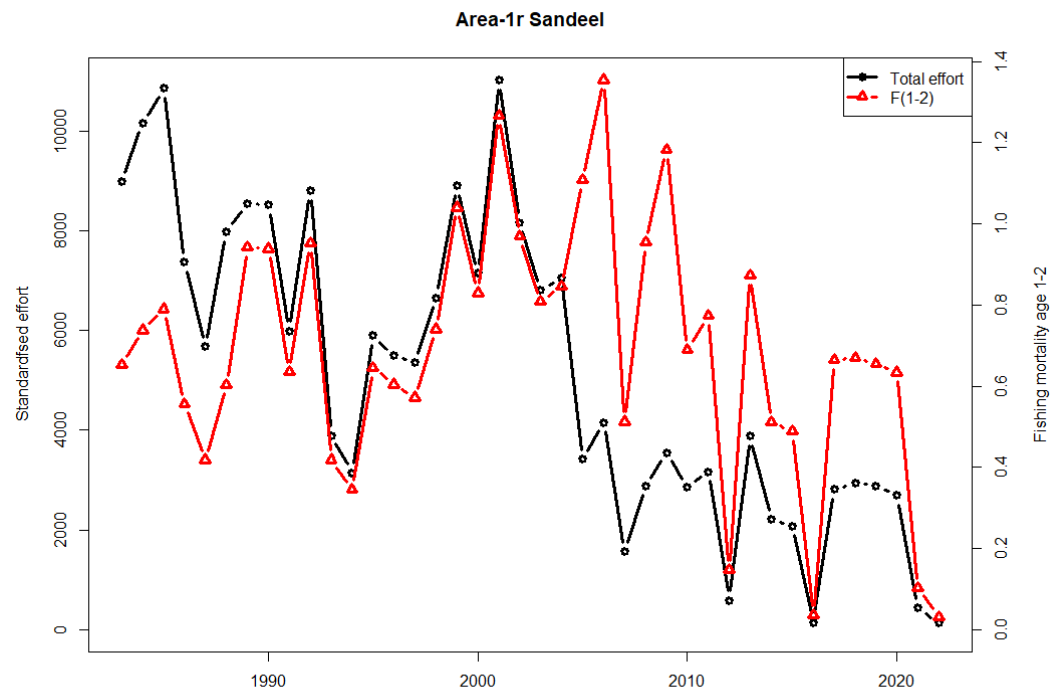


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

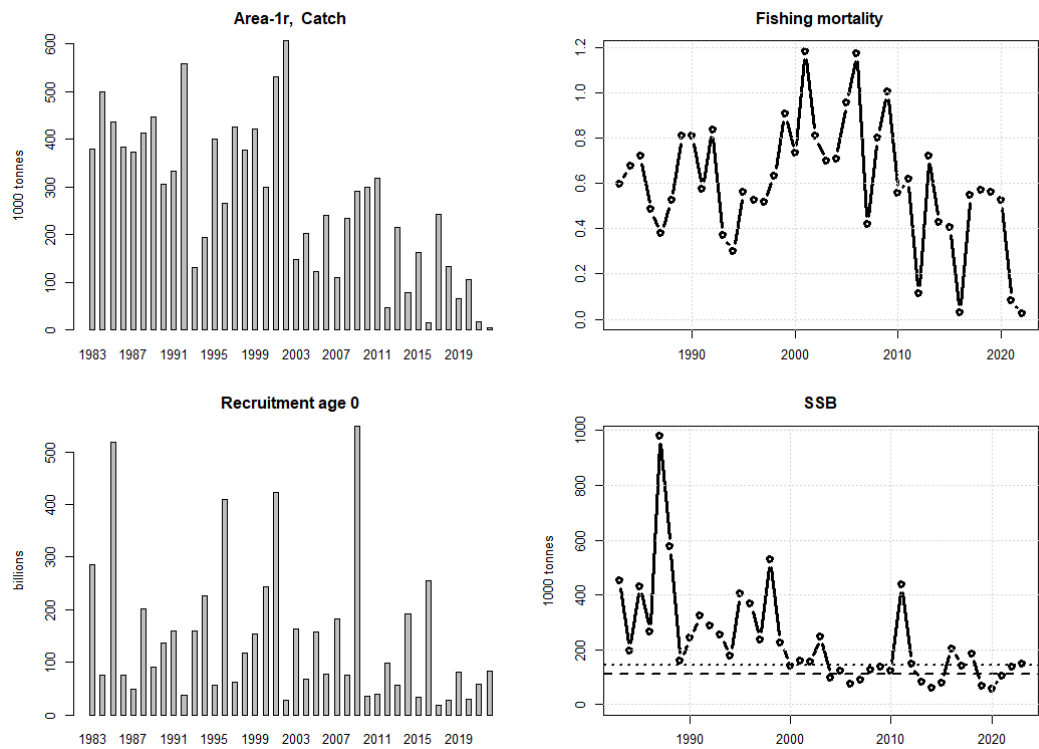


Figure 9.2.13 Sandeel Area-1r. Stock summary.

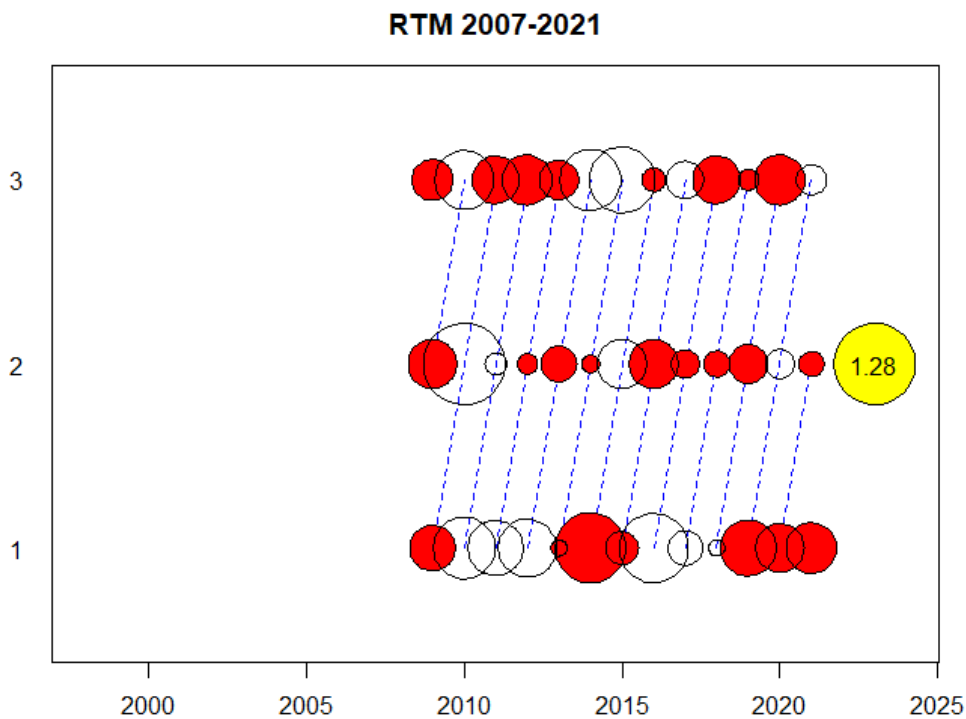


Figure 9.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

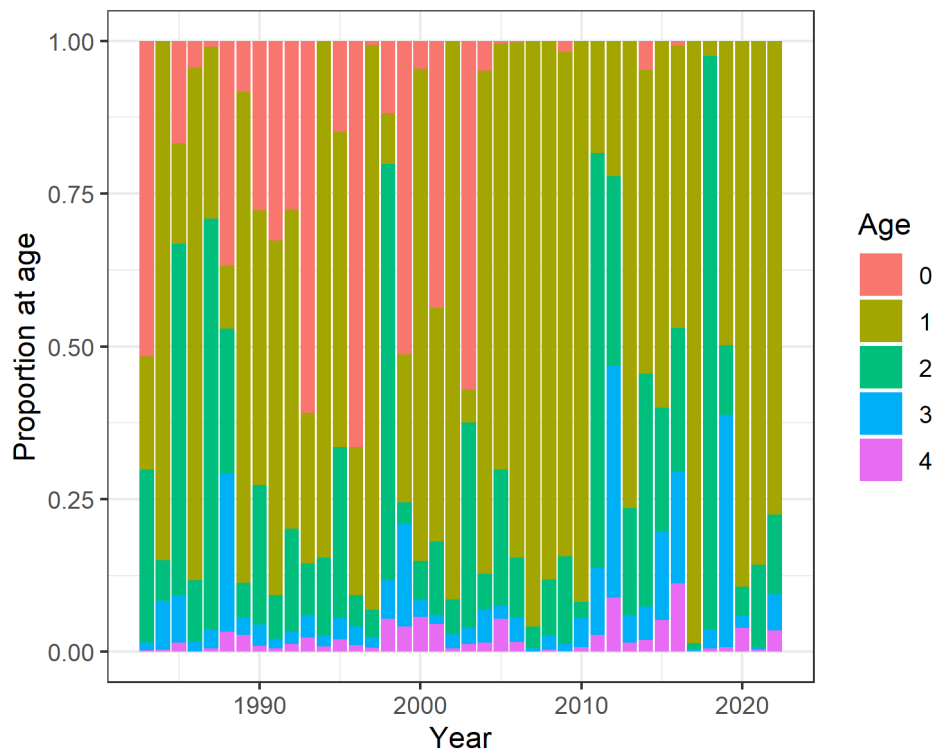


Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

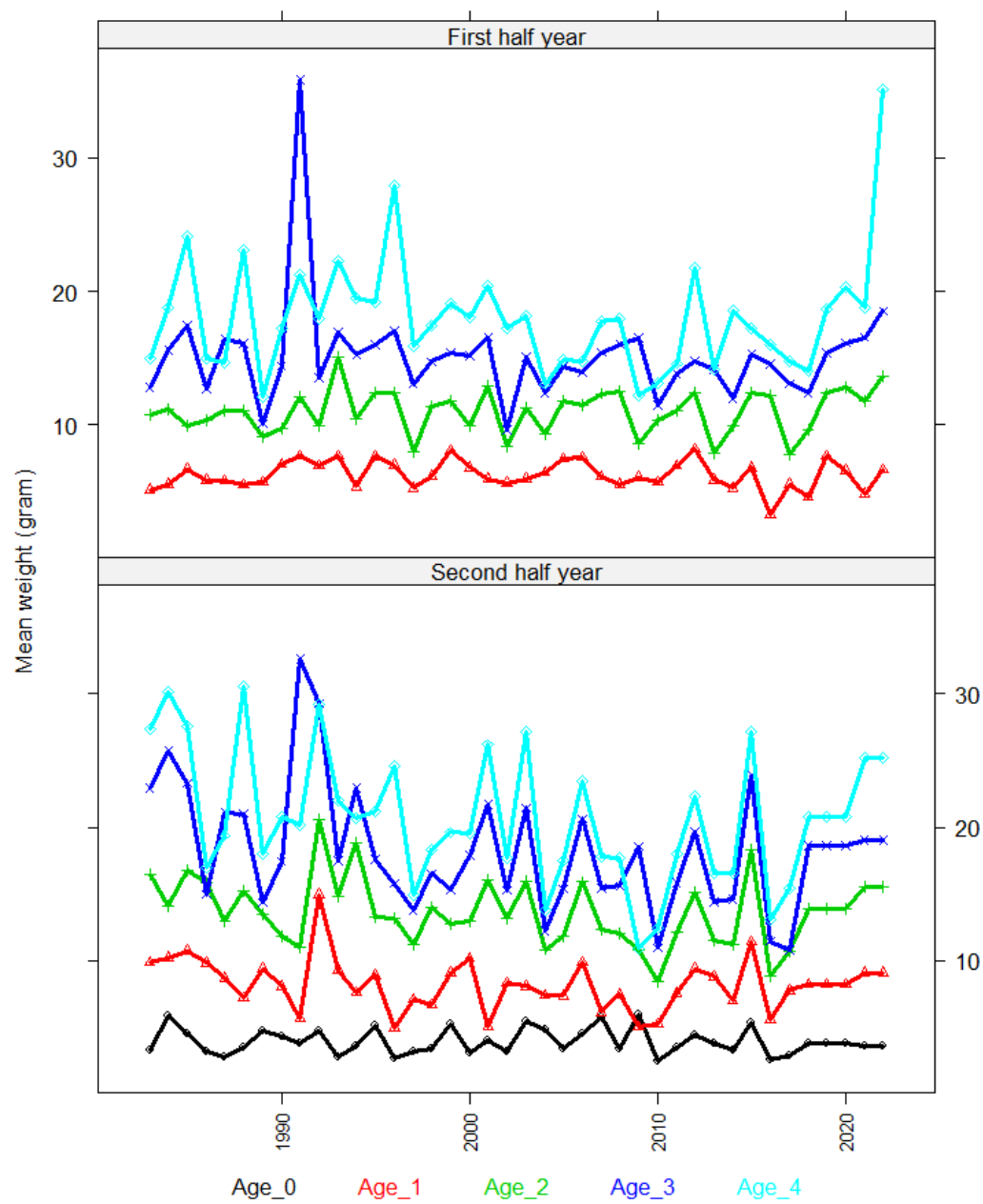


Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

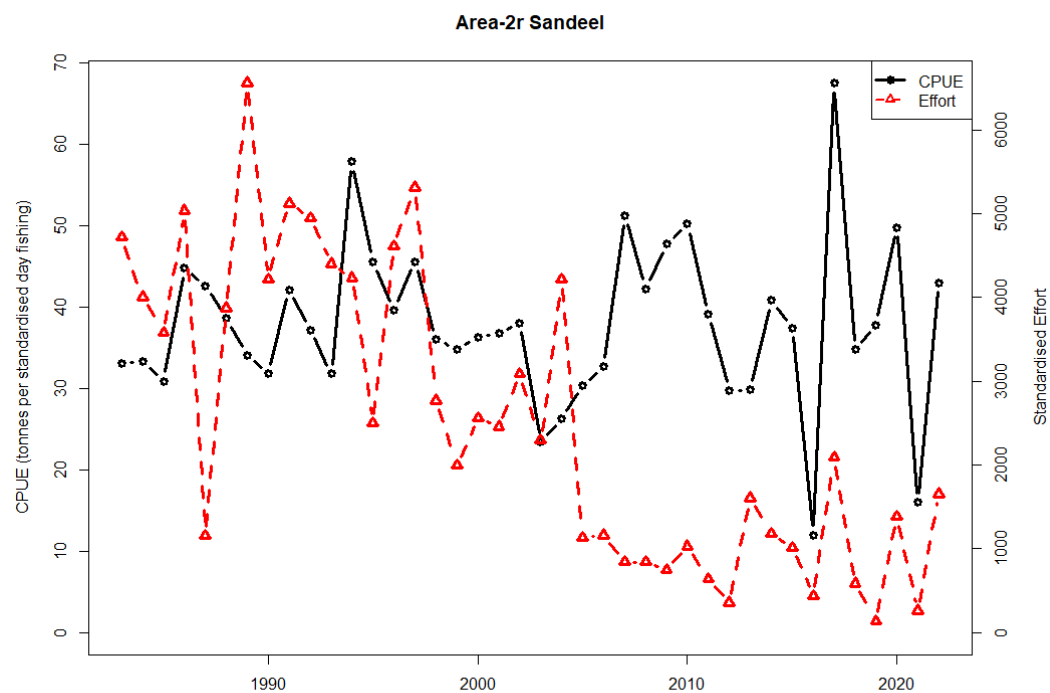


Figure 9.3.3 Sandeel Area-2r. Commercial CPUE and effort.

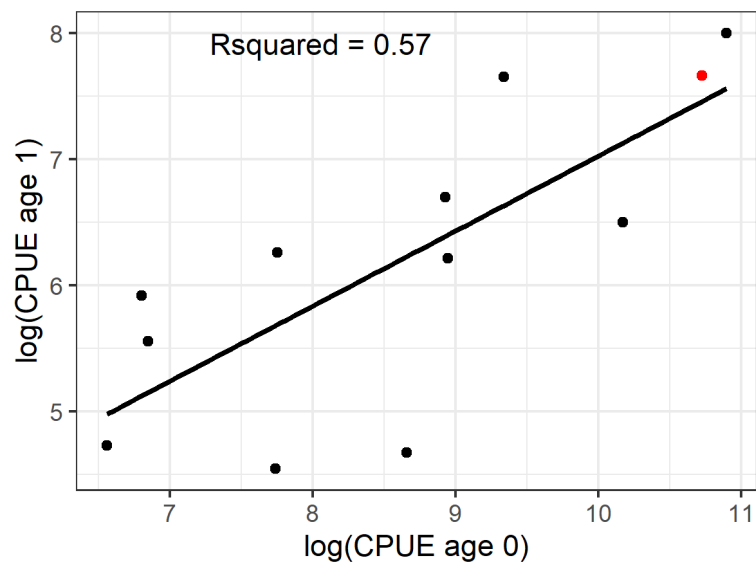


Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

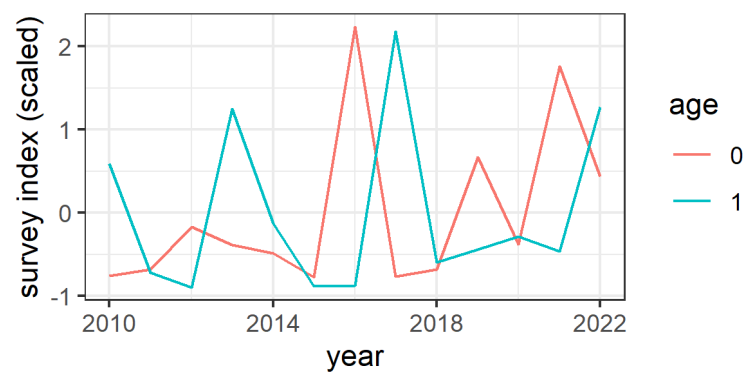


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

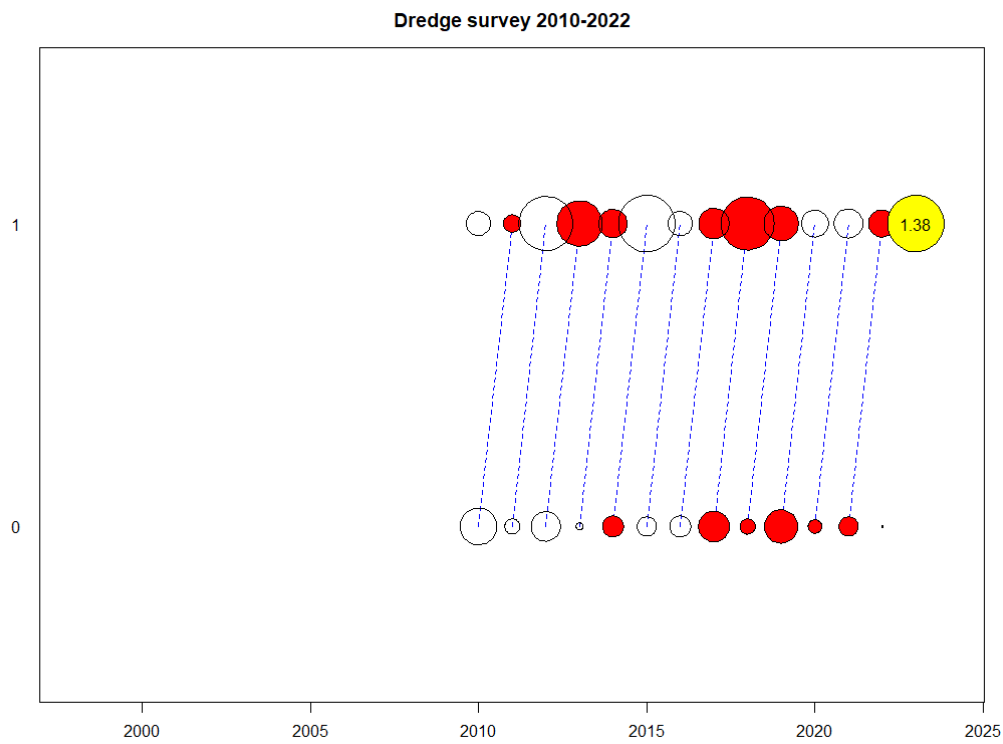


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

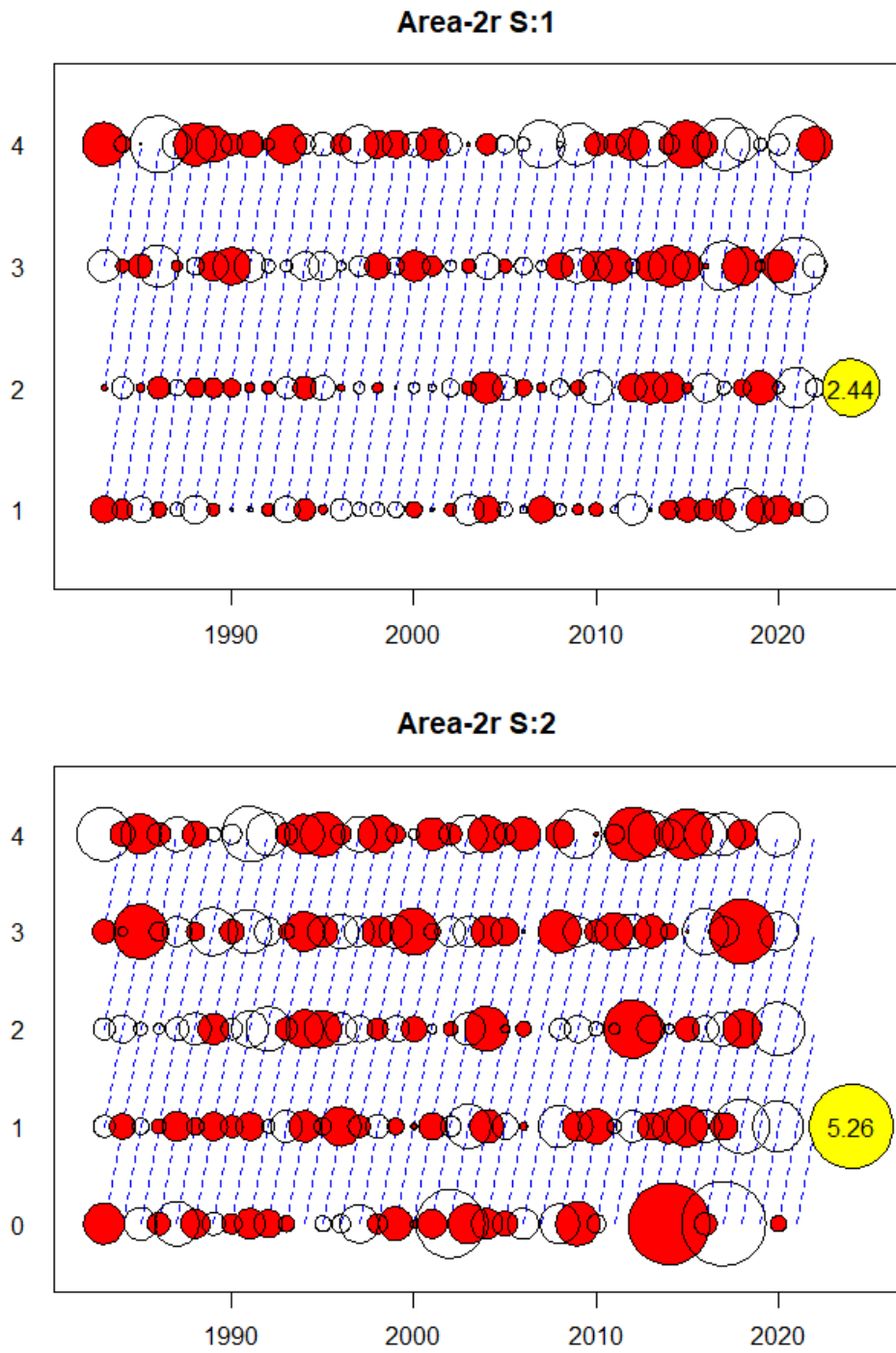


Figure 9.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). “Red” dots show a positive residual.

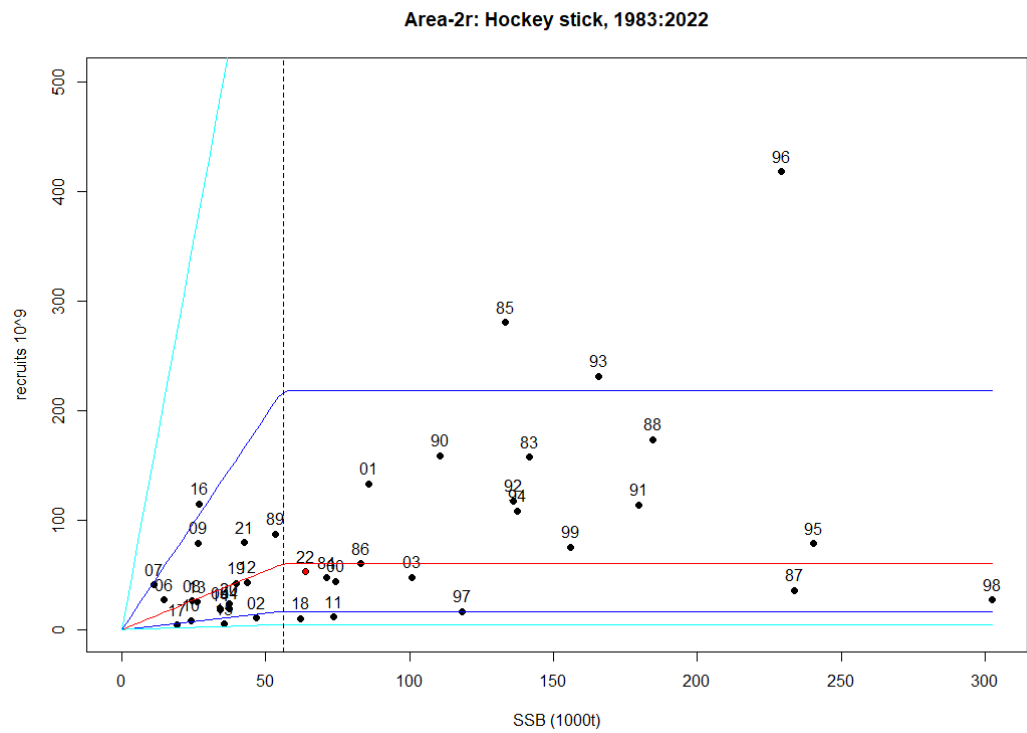


Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years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

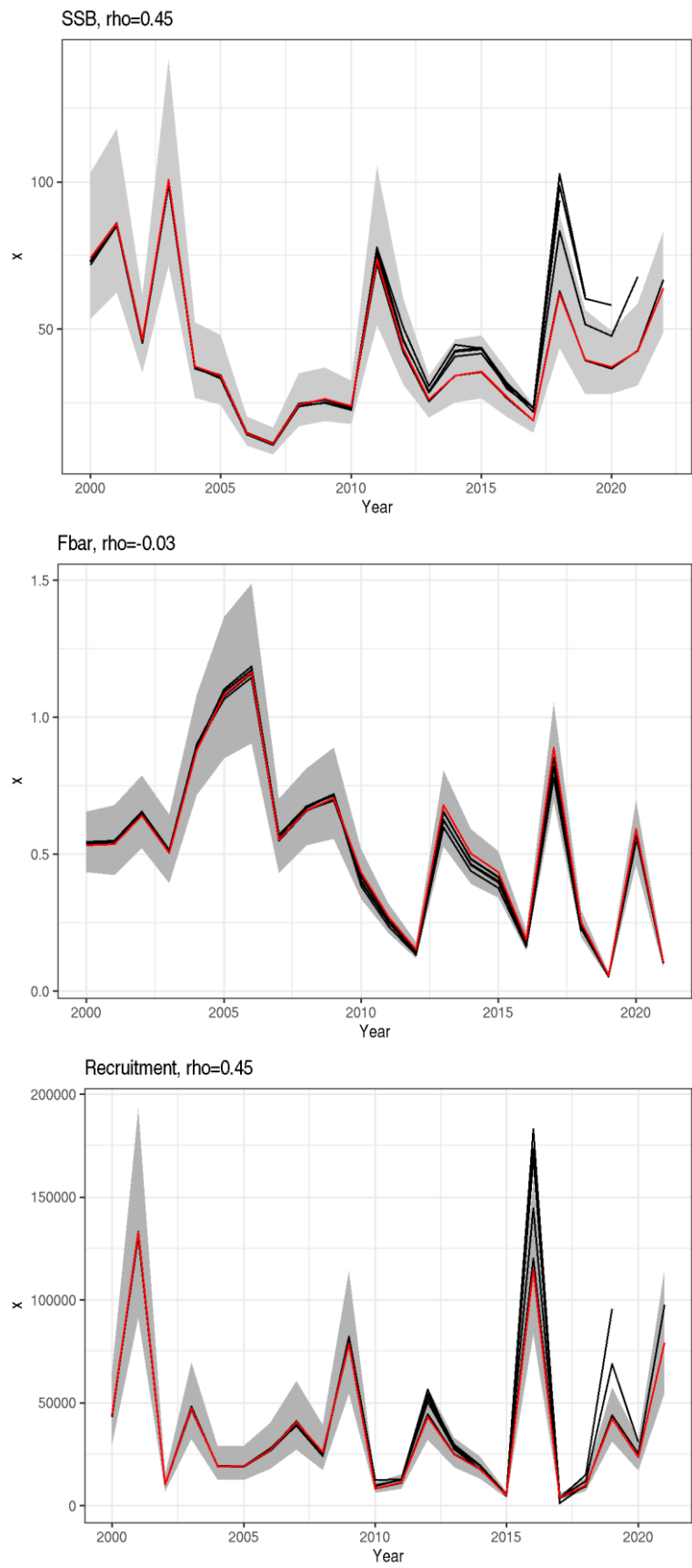


Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.

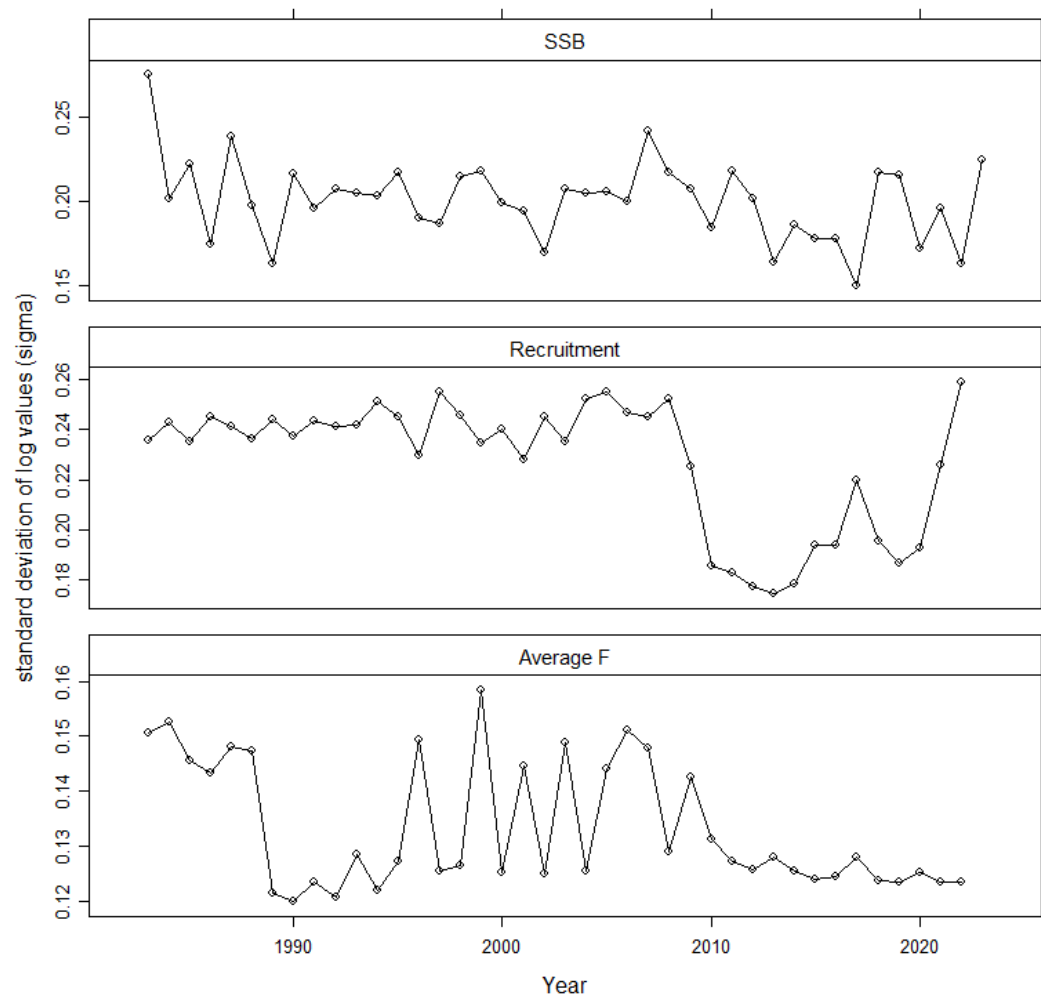


Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

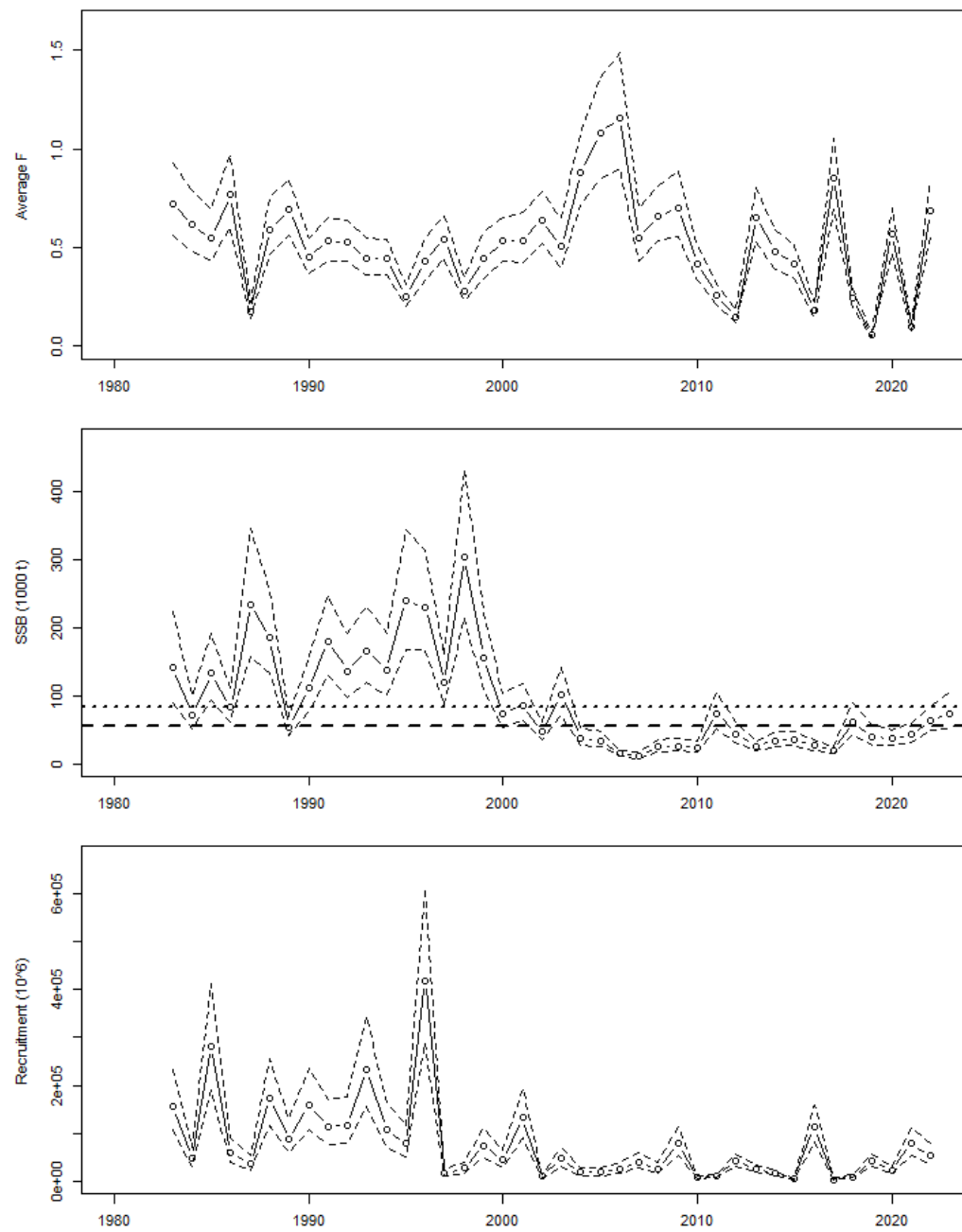


Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

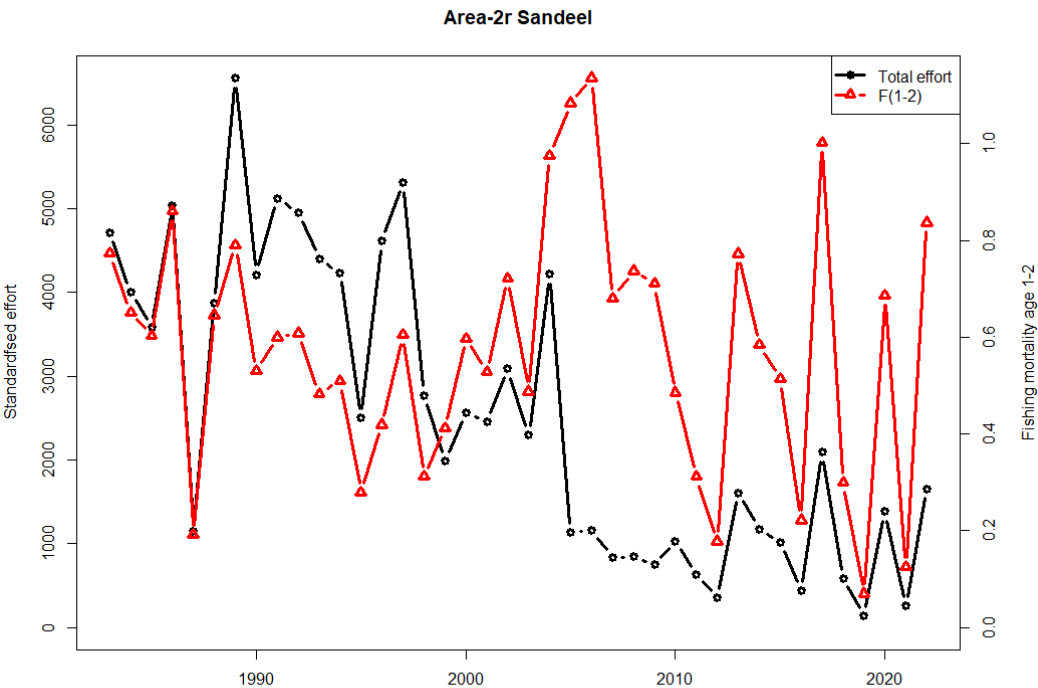


Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

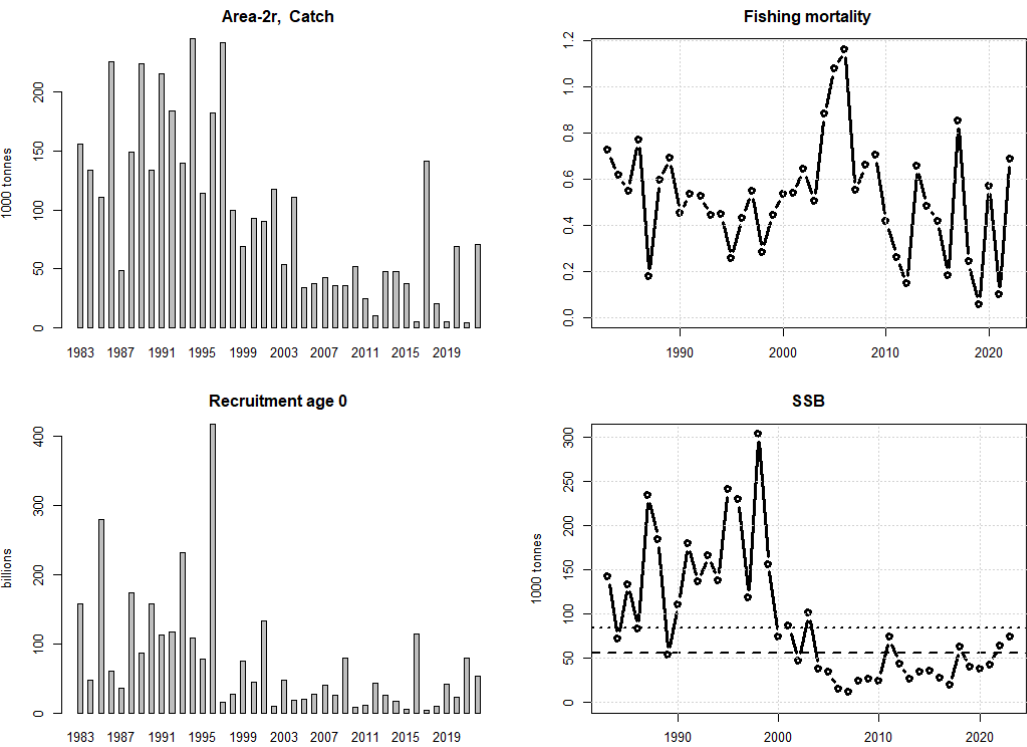


Figure 9.3.13 Sandeel Area-2r. Stock summary.

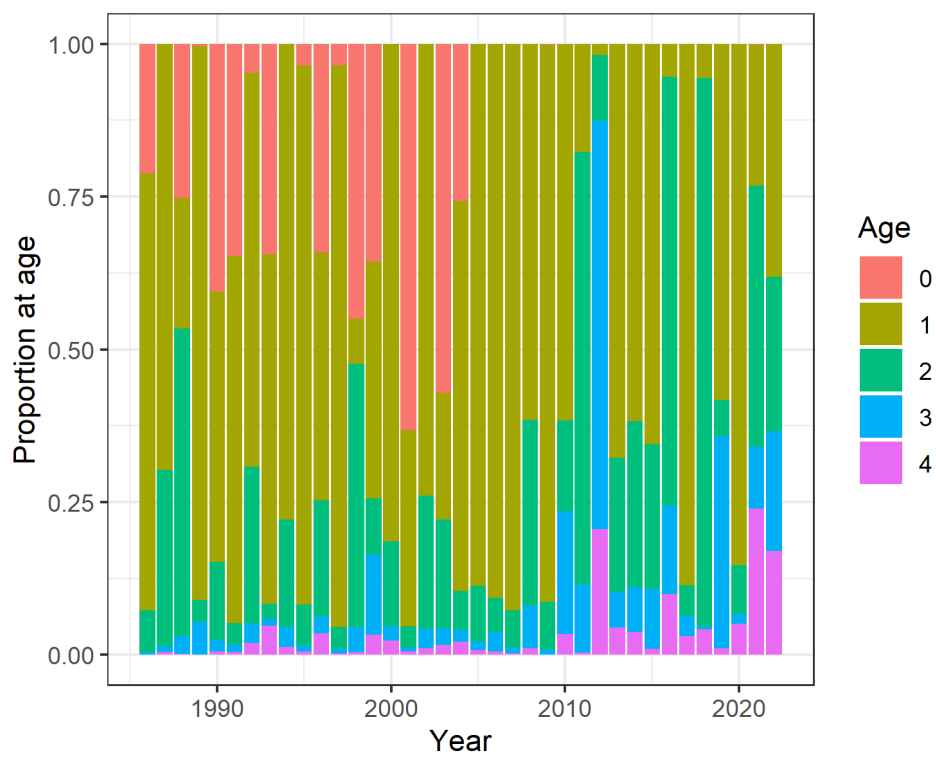


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

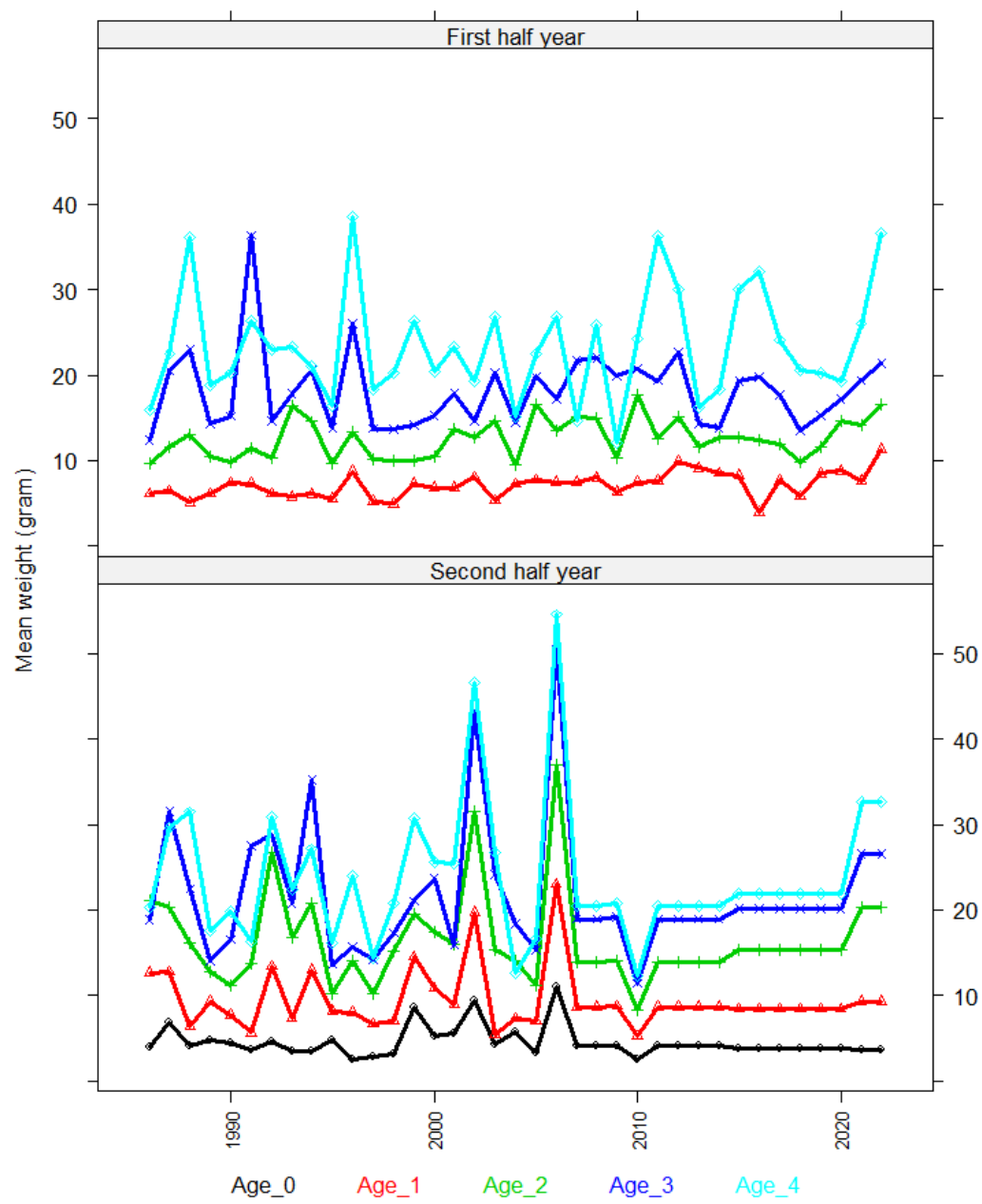


Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

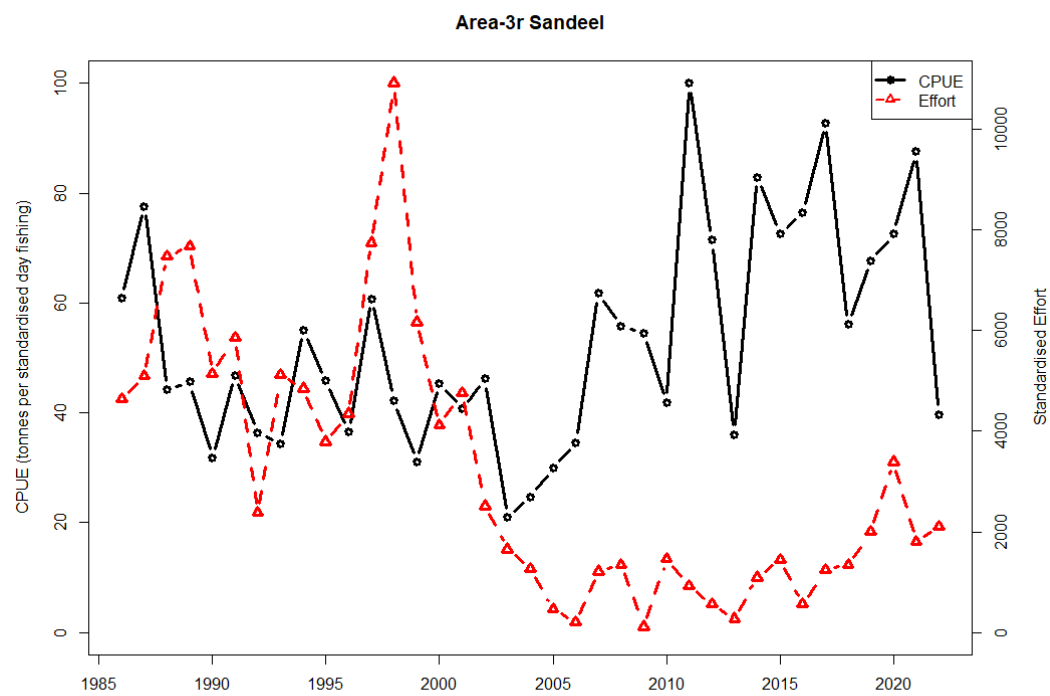


Figure 9.4.3 Sandeel Area-3r. Commercial CPUE and effort.

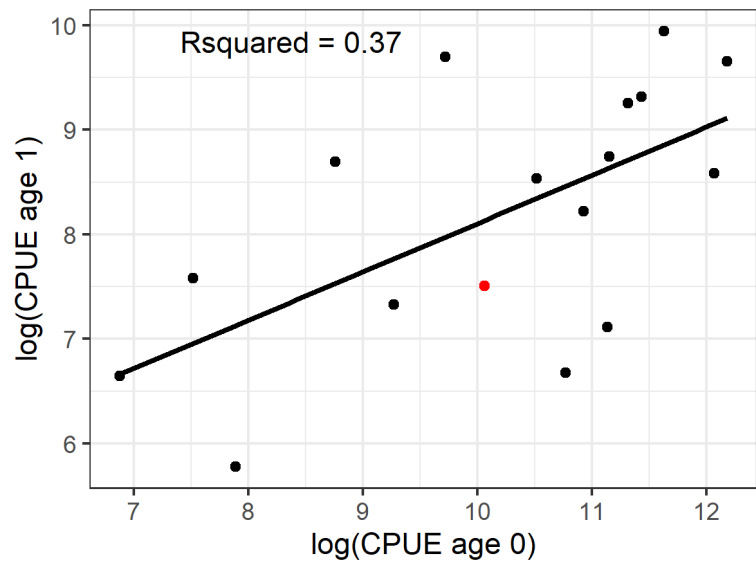


Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

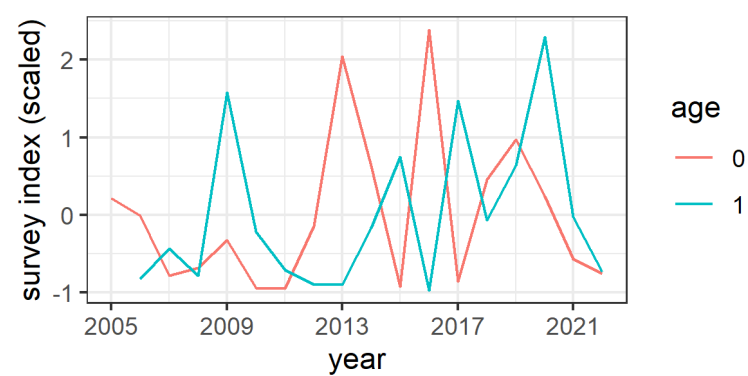


Figure 9.4.5 Sander Area-3r. Dredge survey index timeline.

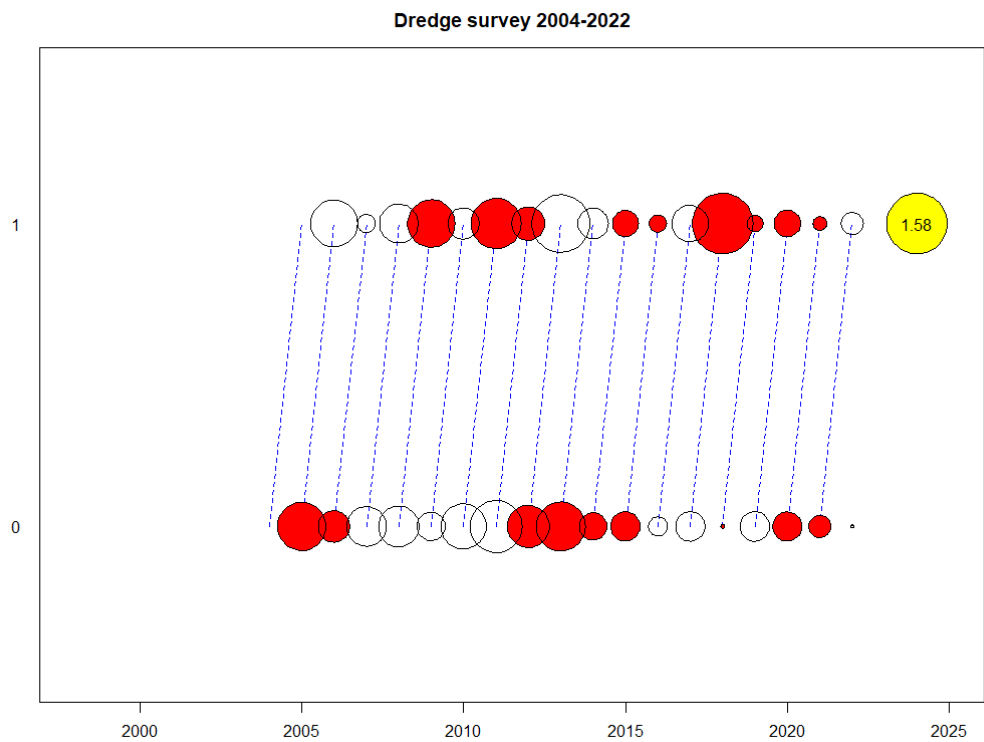


Figure 9.4.6 Sander Area-3r. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

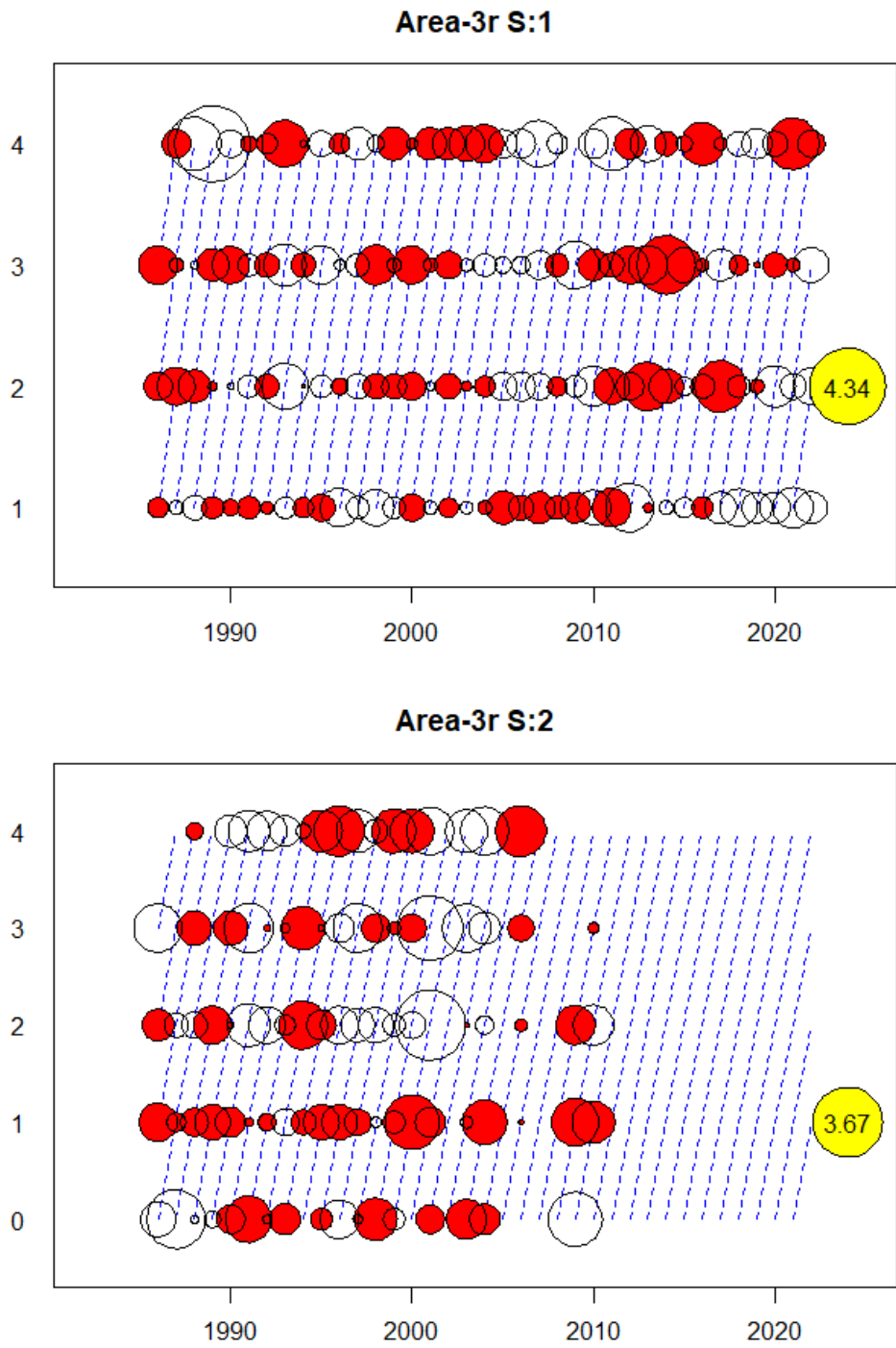


Figure 9.4.7 Sandeel Area-3r. Catch at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

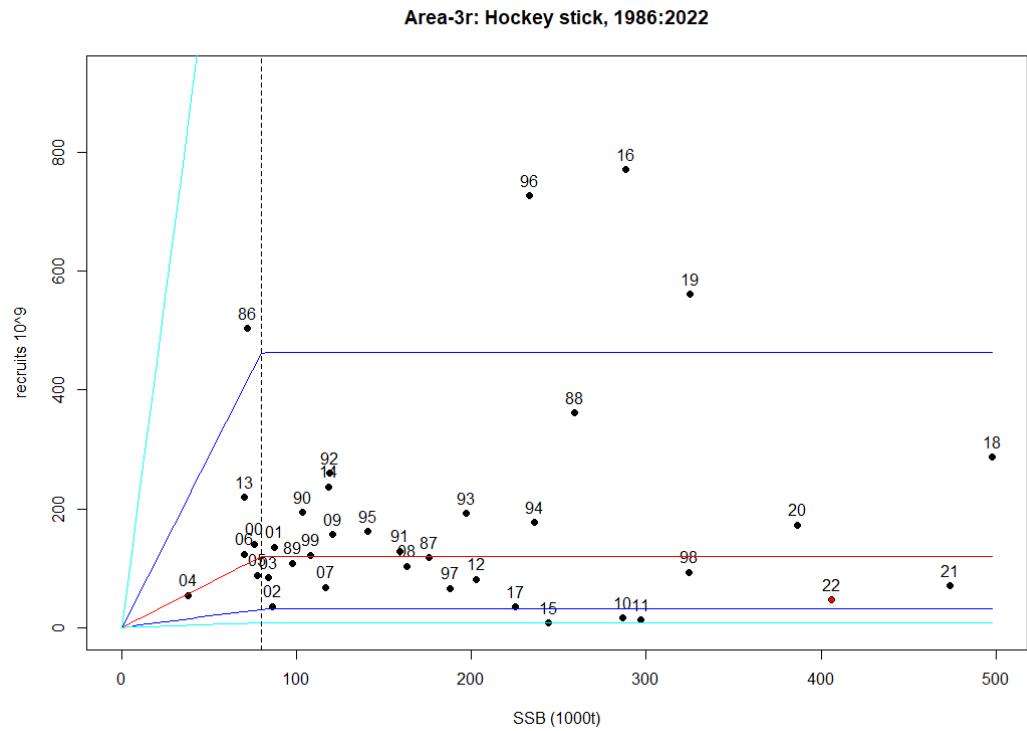


Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

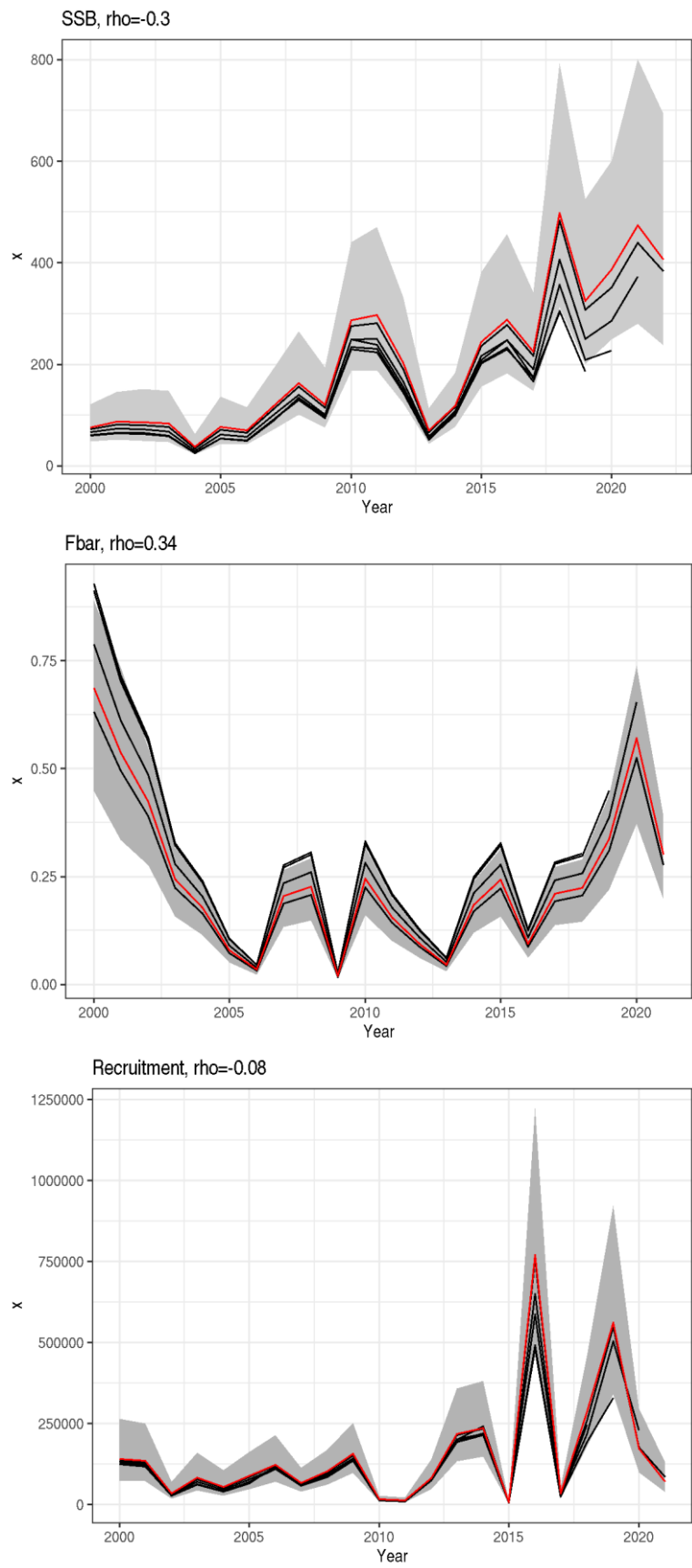


Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.

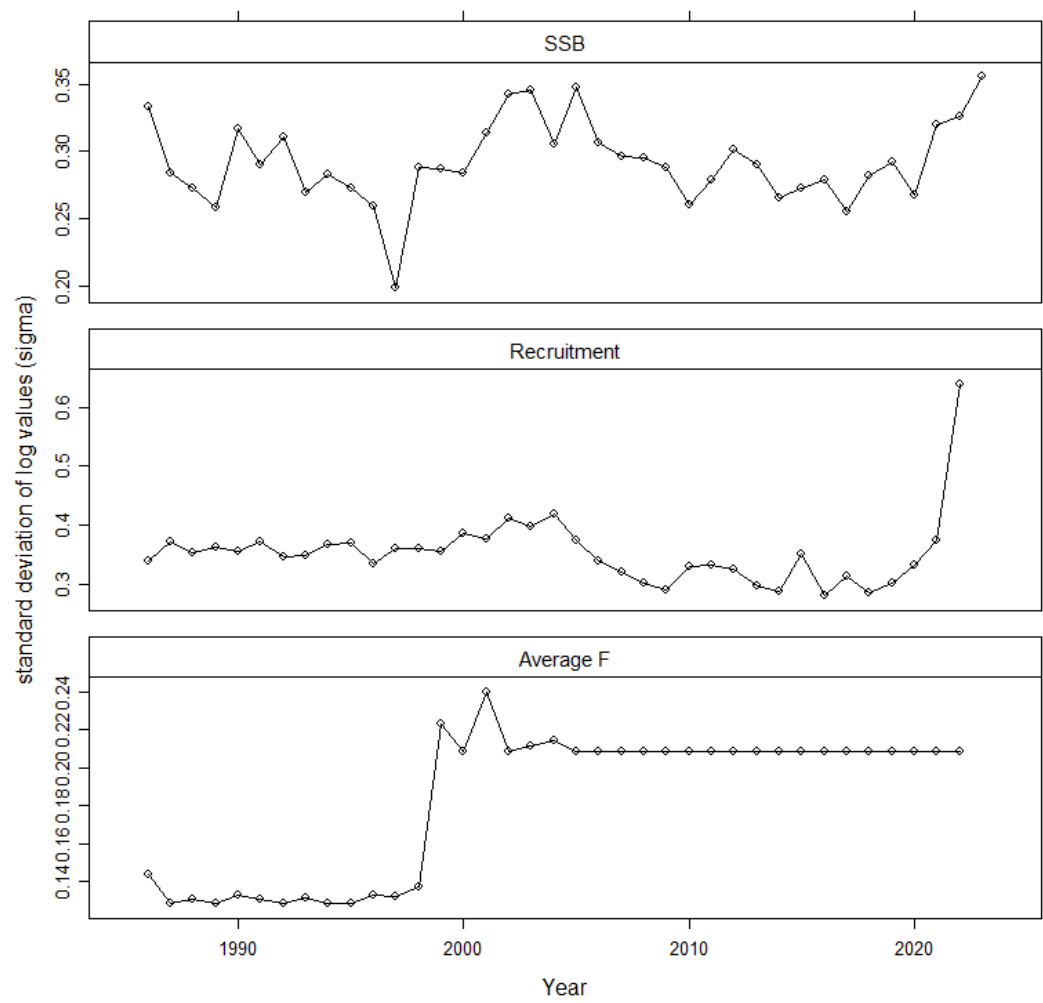


Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

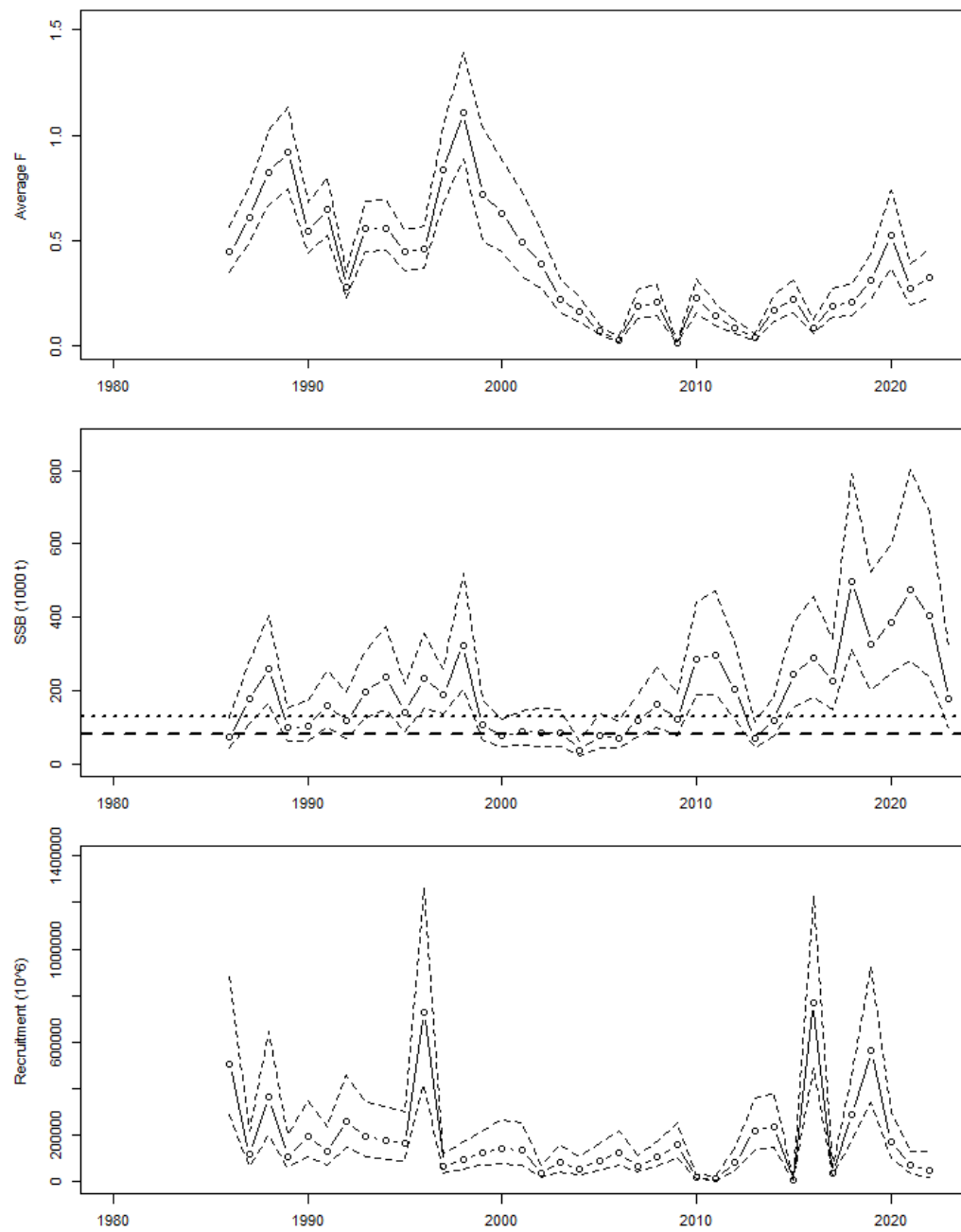


Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

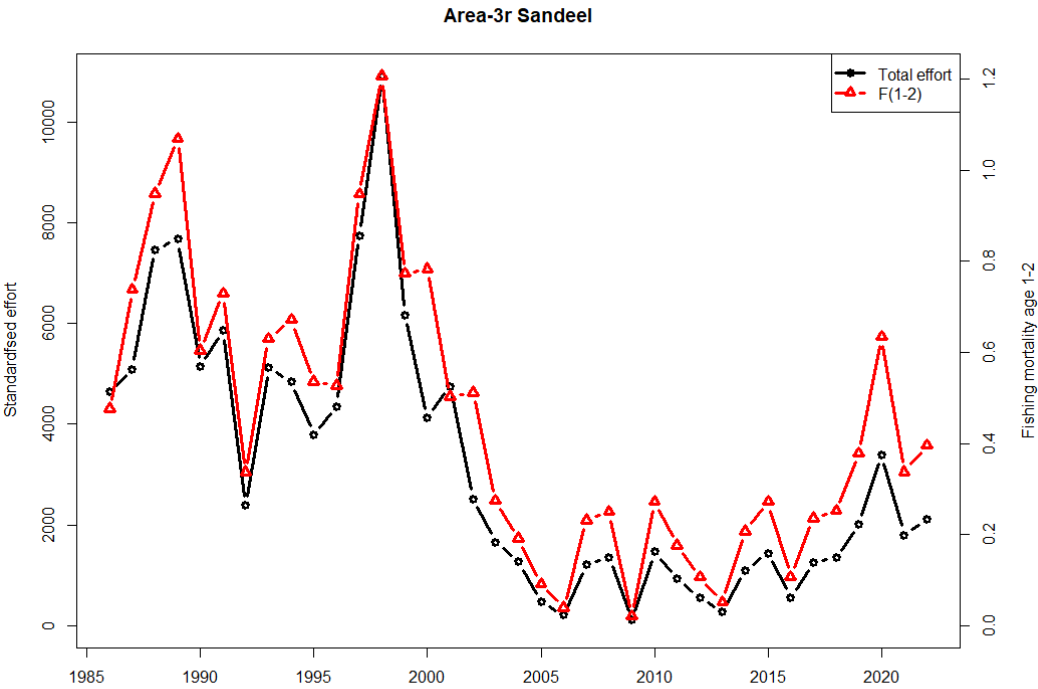


Figure 9.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

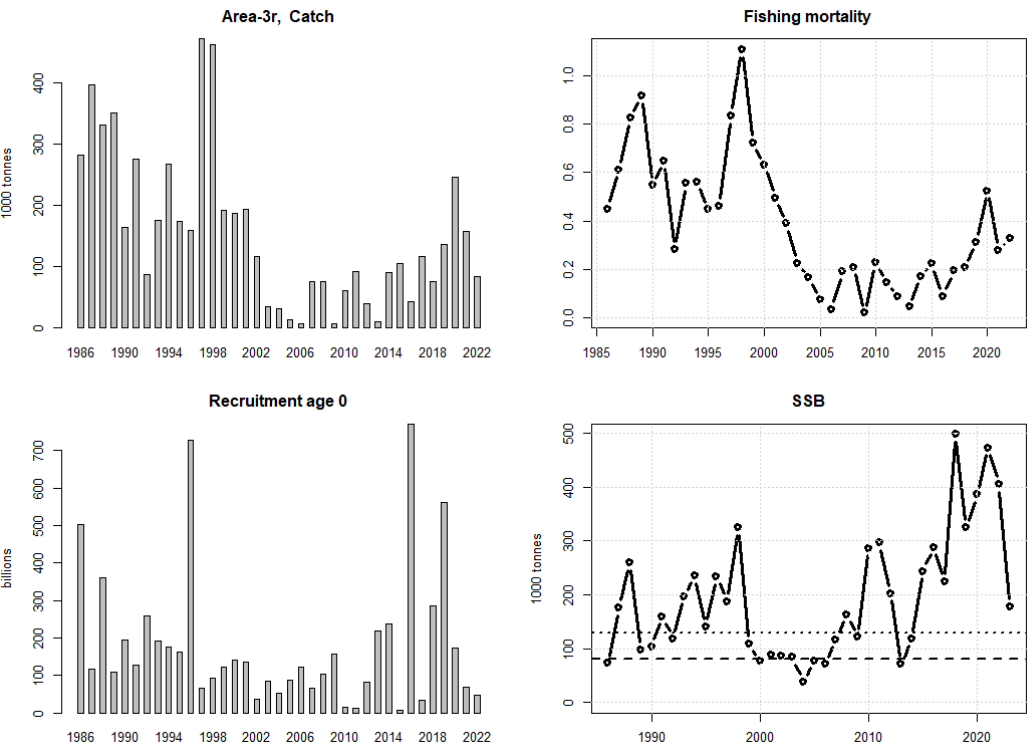


Figure 9.4.13 Sandeel Area-3r. Stock summary.

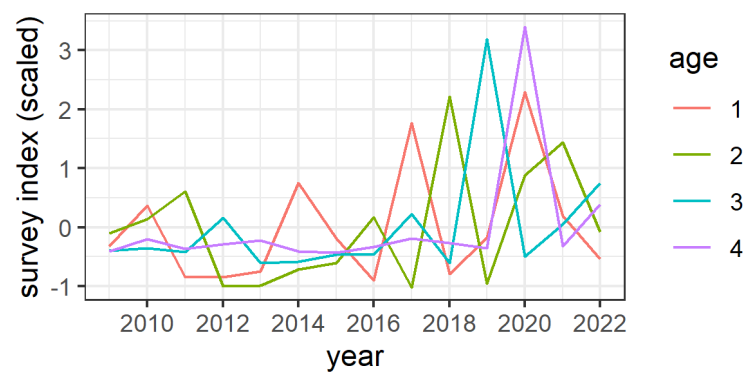


Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.

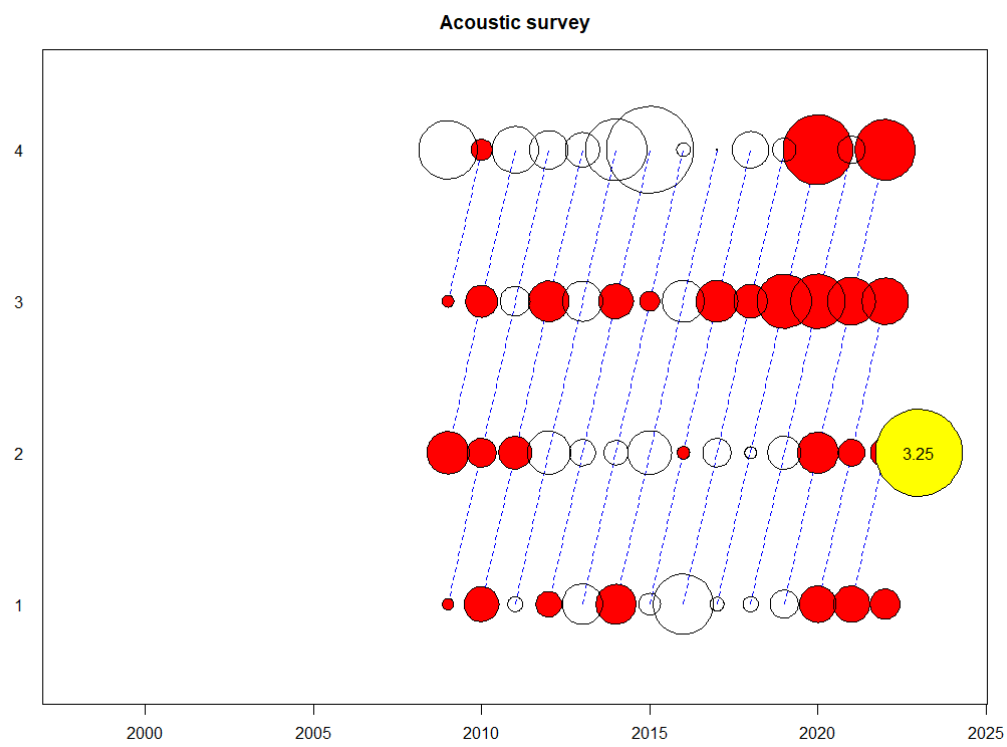


Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). "Red" dots show a positive residual.

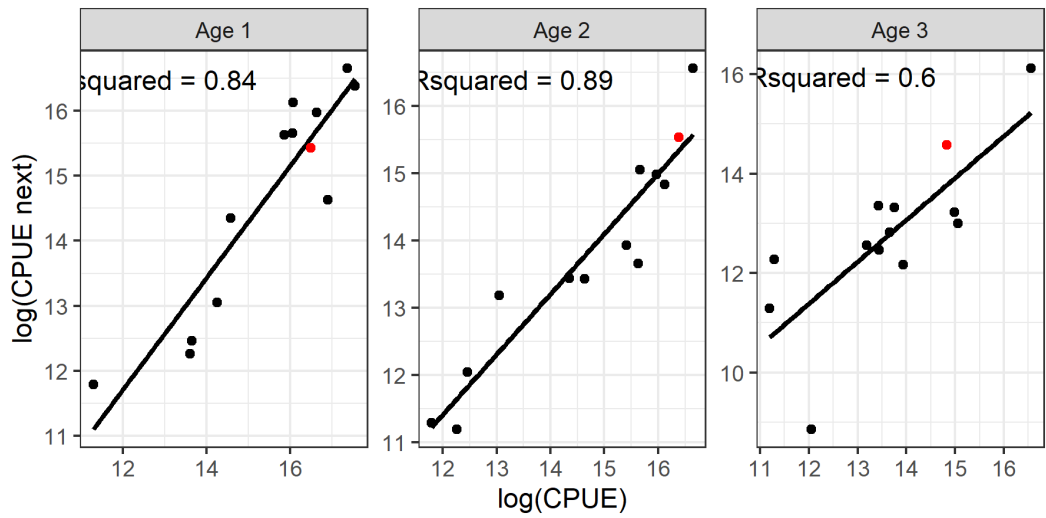


Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

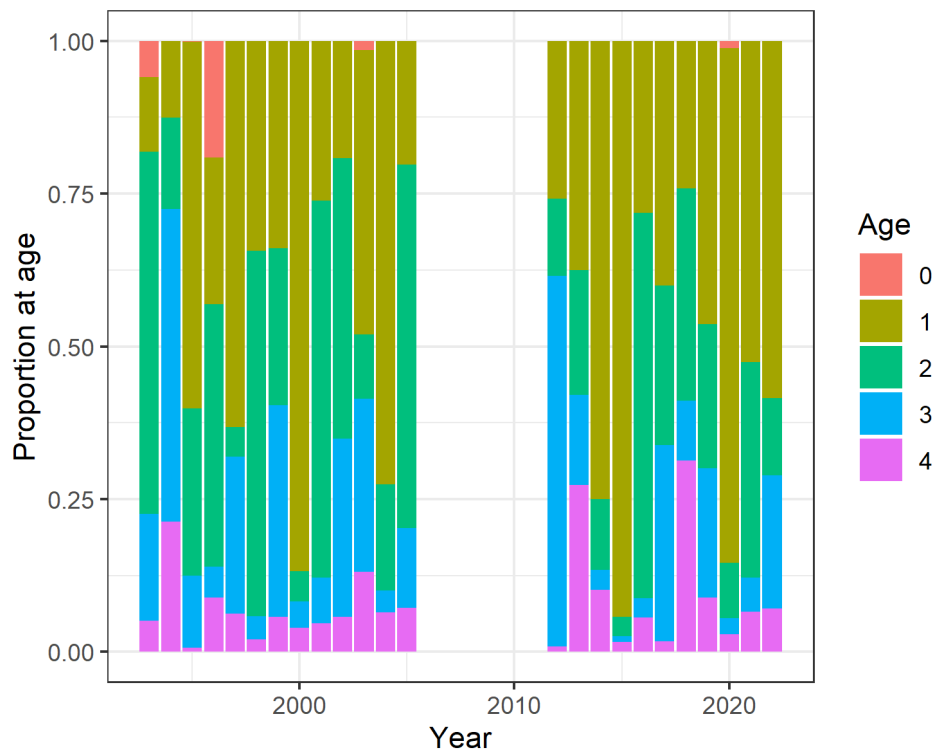


Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.

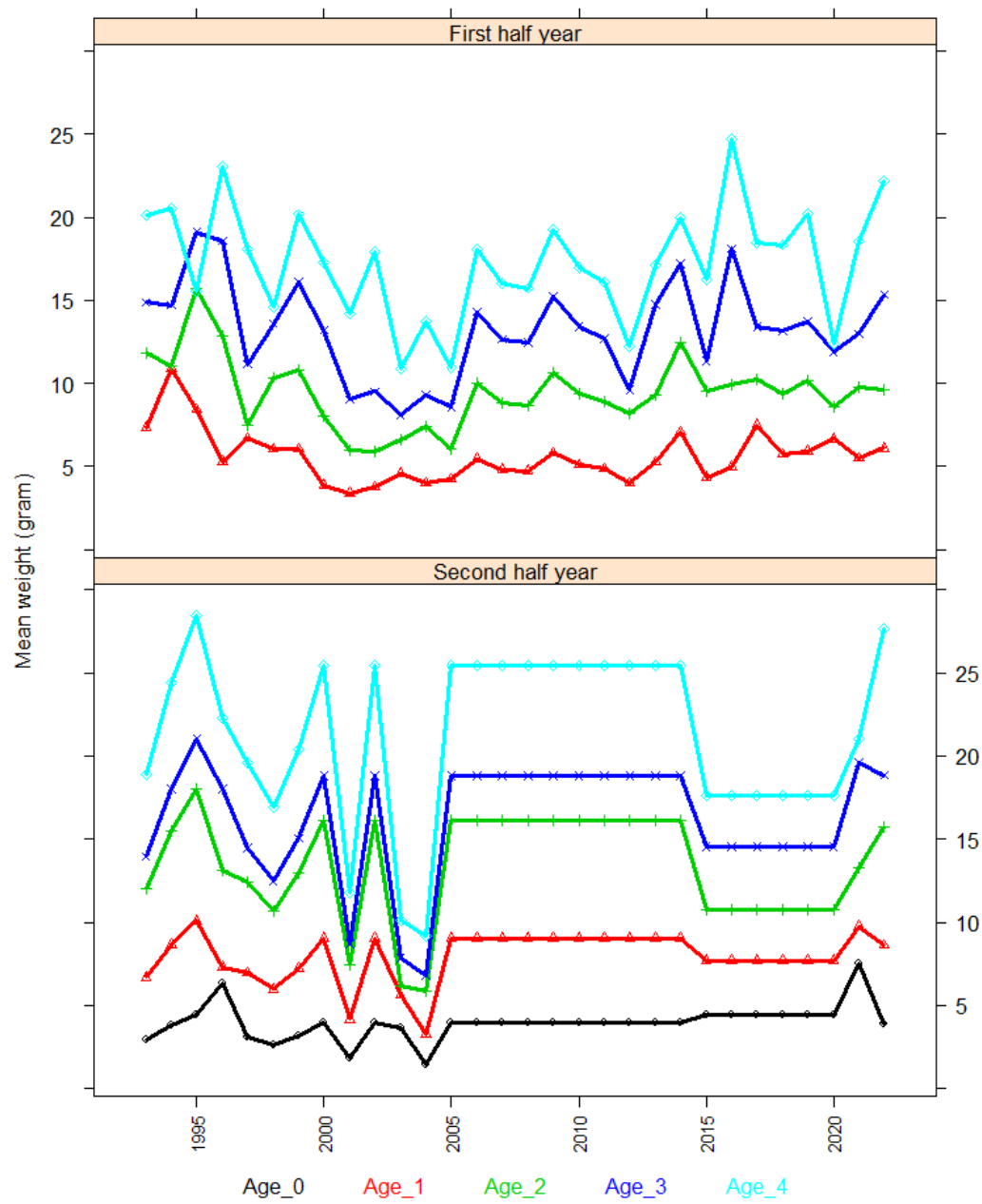


Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

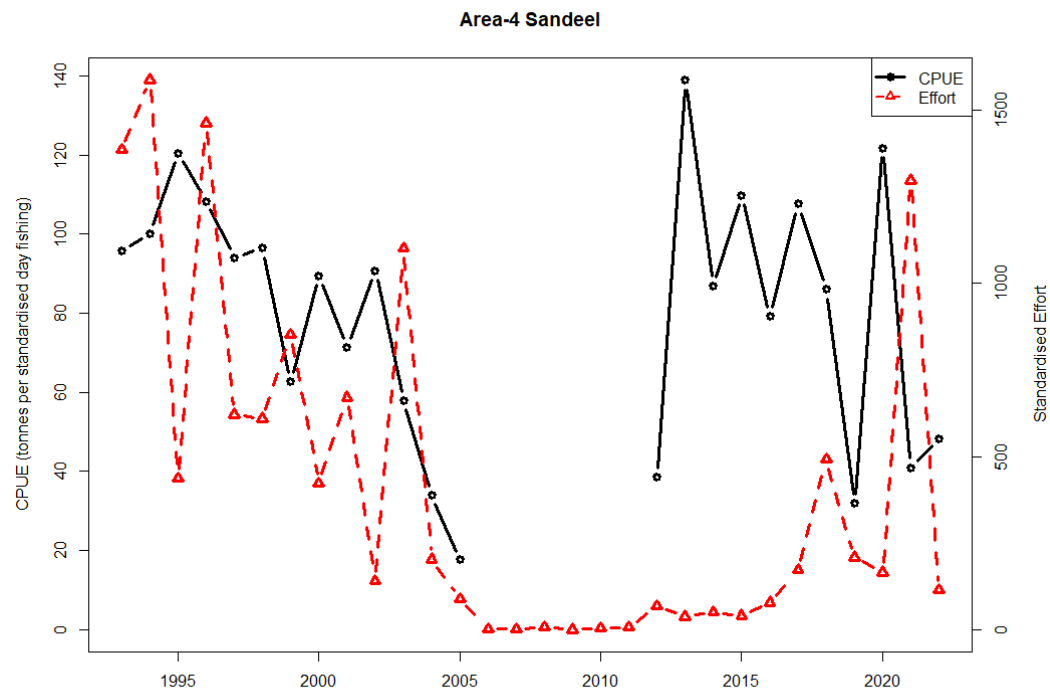


Figure 9.5.3 Sandeel Area-4. Commercial CPUE and effort.

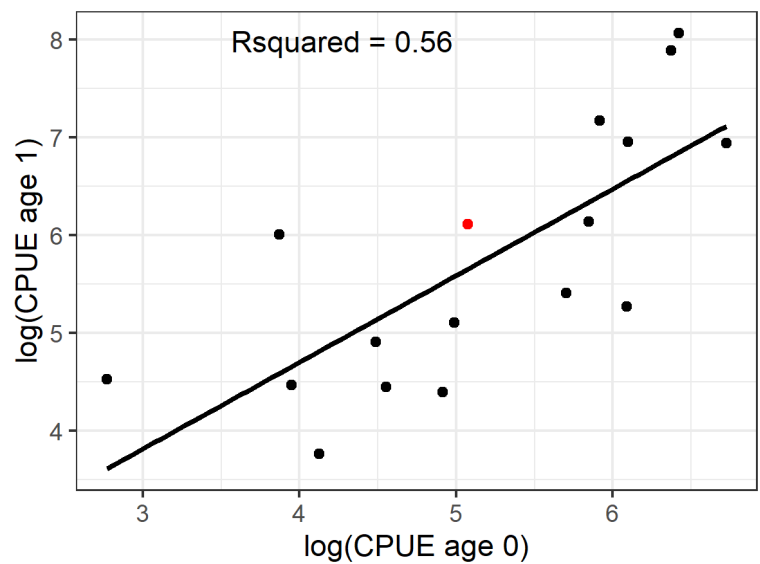


Figure 9.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

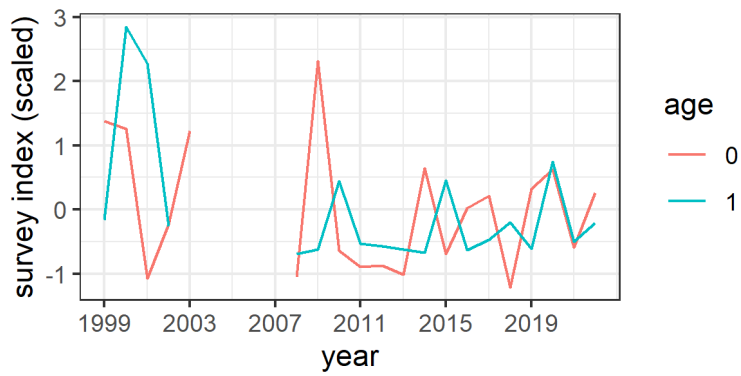


Figure 9.5.5 Sander Area-4. Dredge survey index timeline.

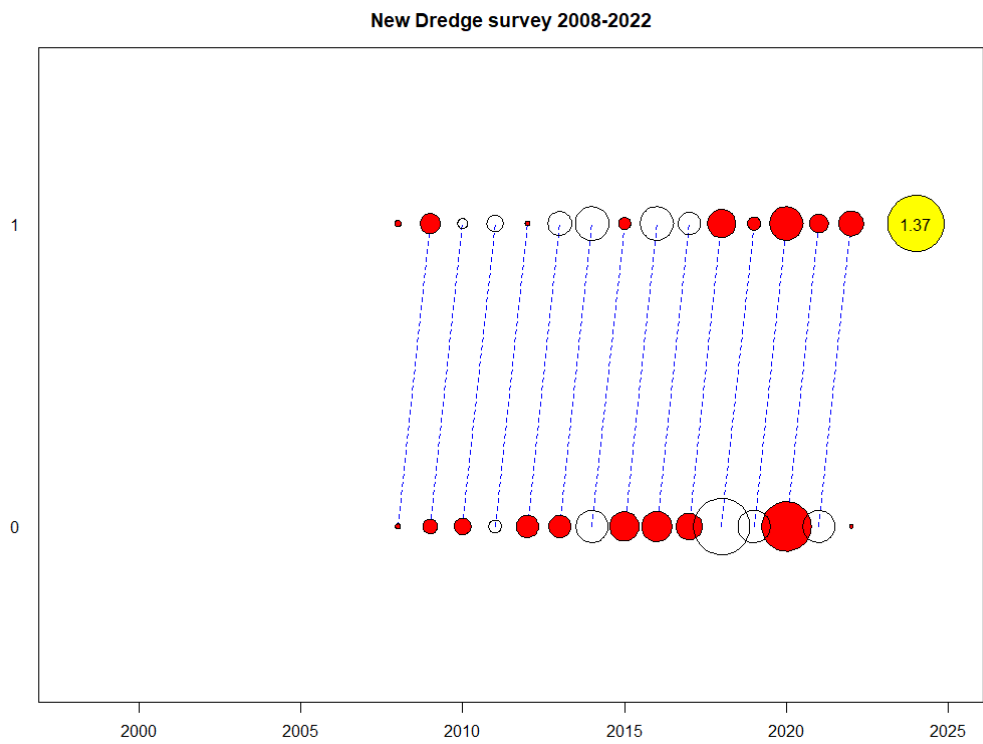


Figure 9.5.6 Sander Area-4. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.

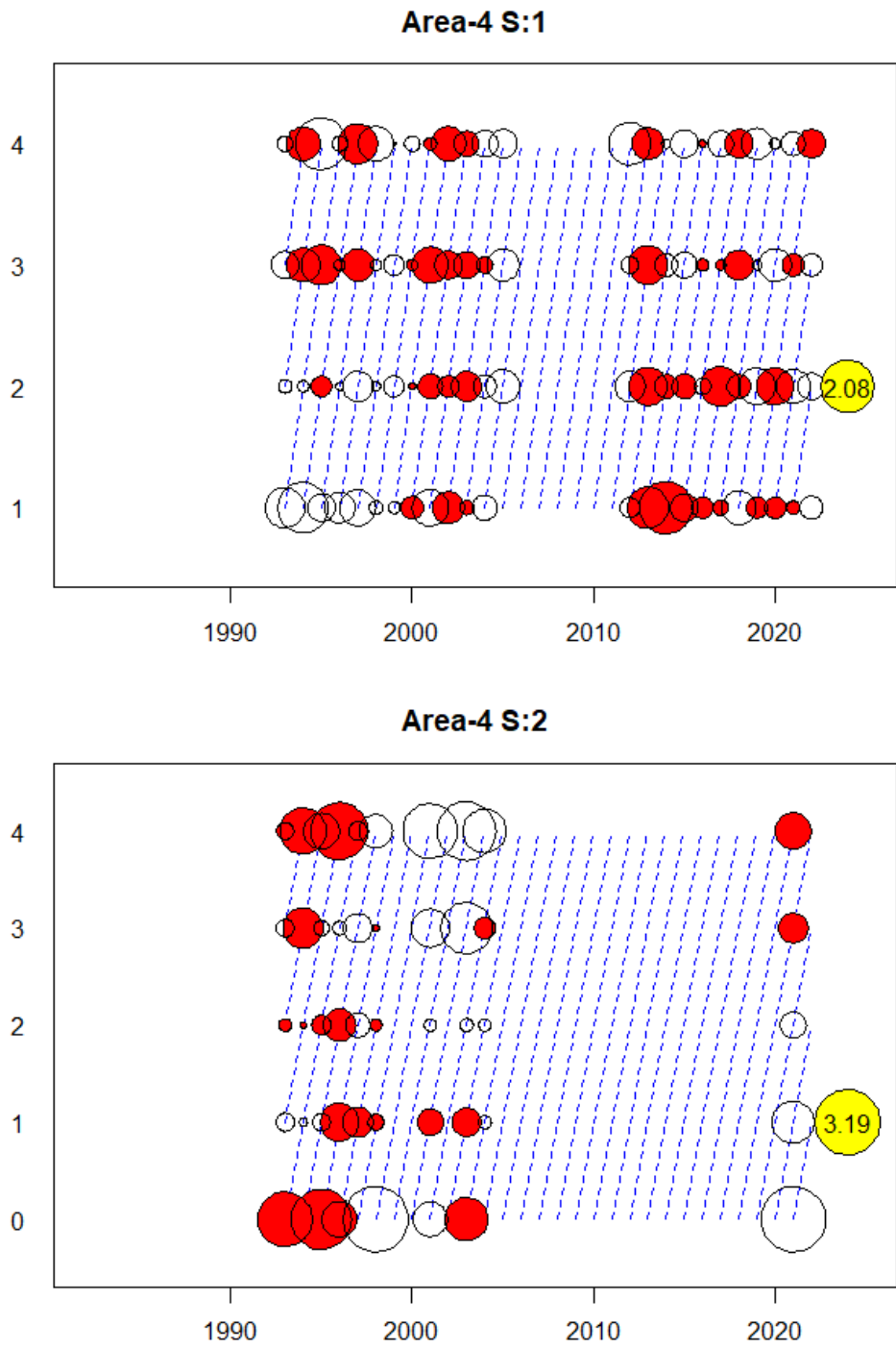


Figure 9.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). “Red” dots show a positive residual.

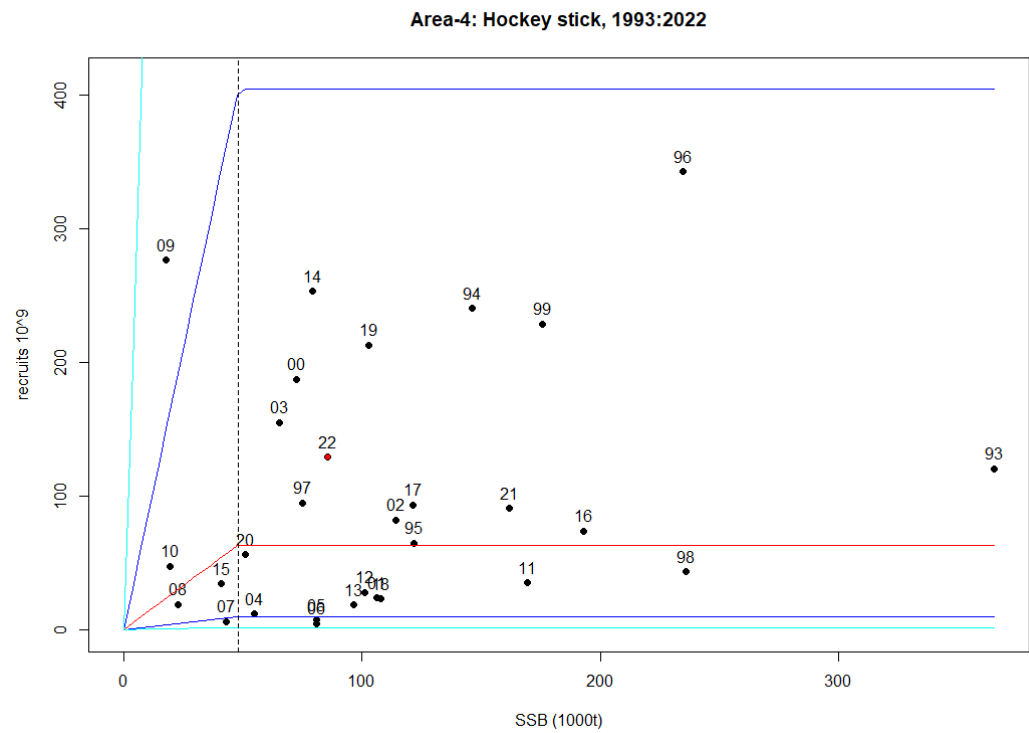


Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

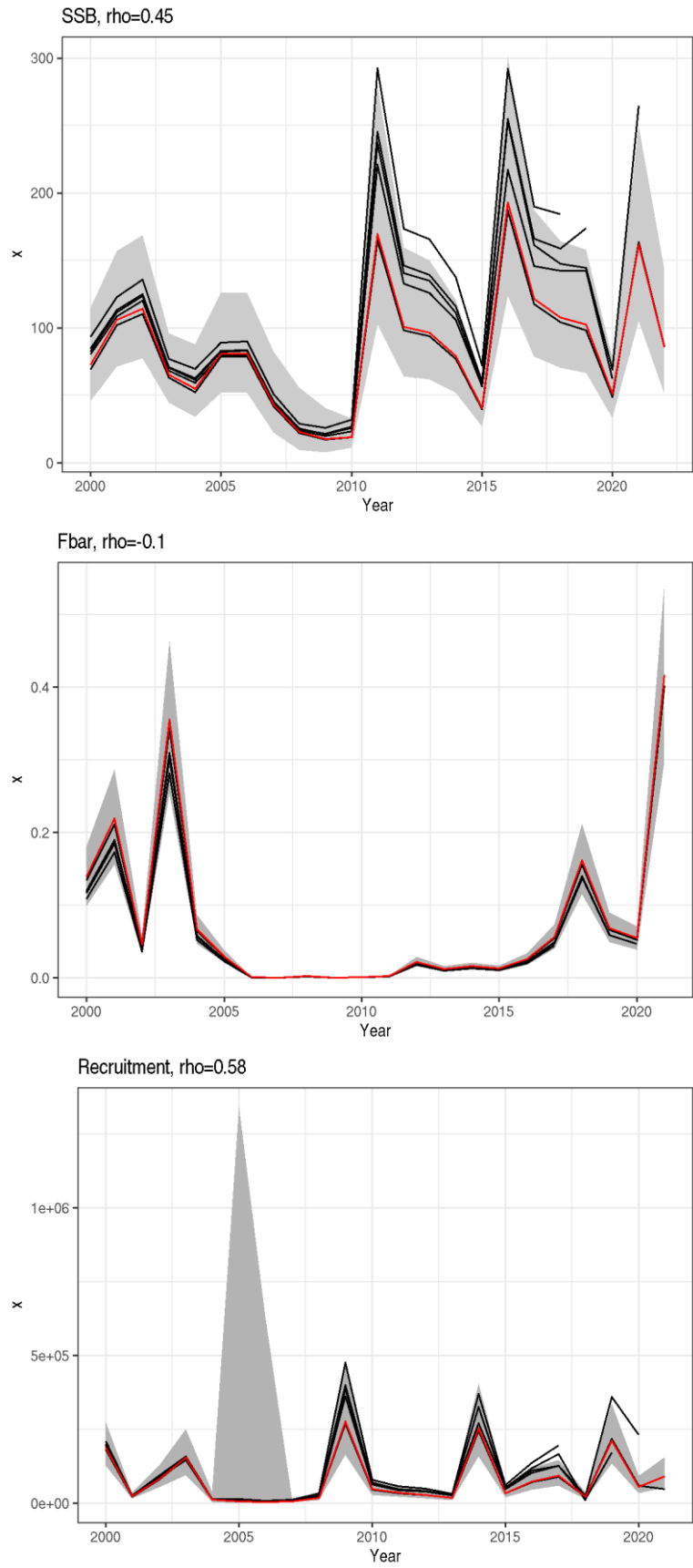


Figure 9.5.9 Sandeel Area-4. Retrospective analysis.

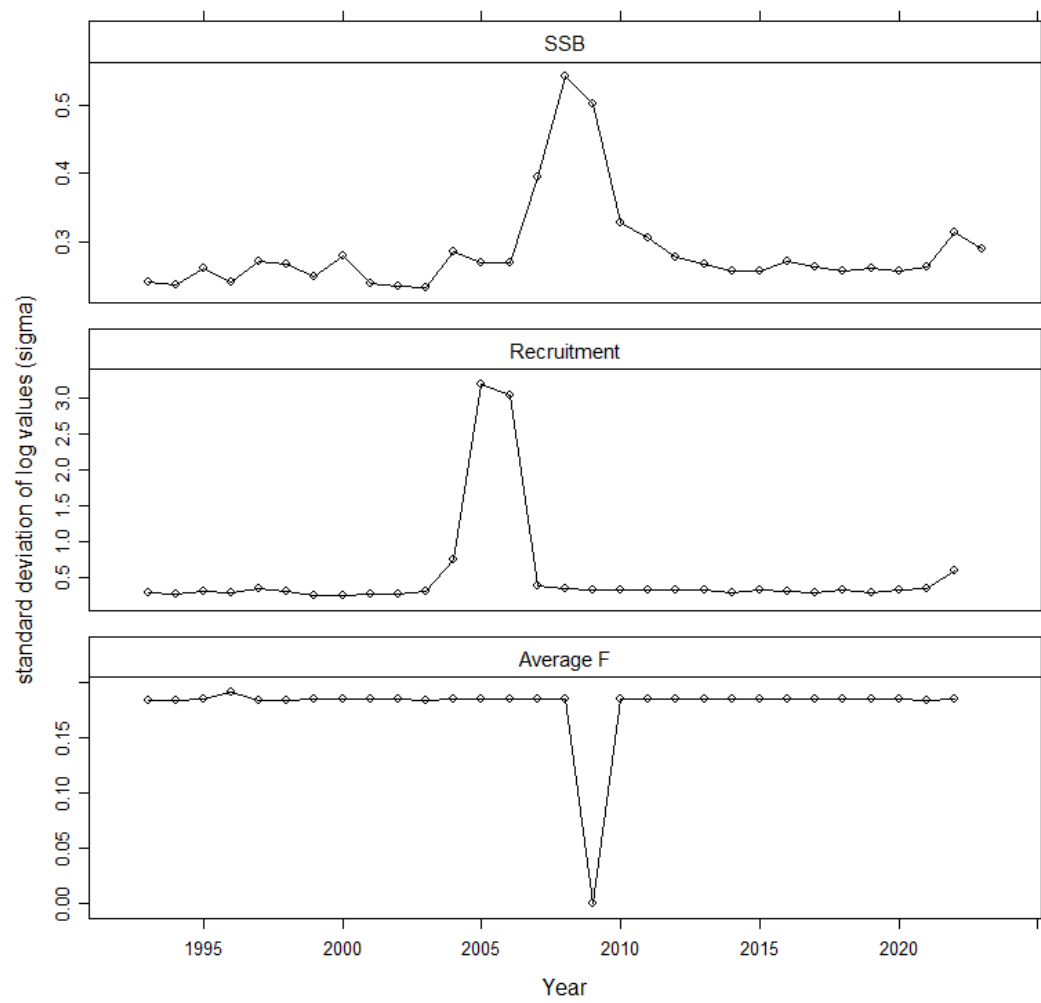


Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

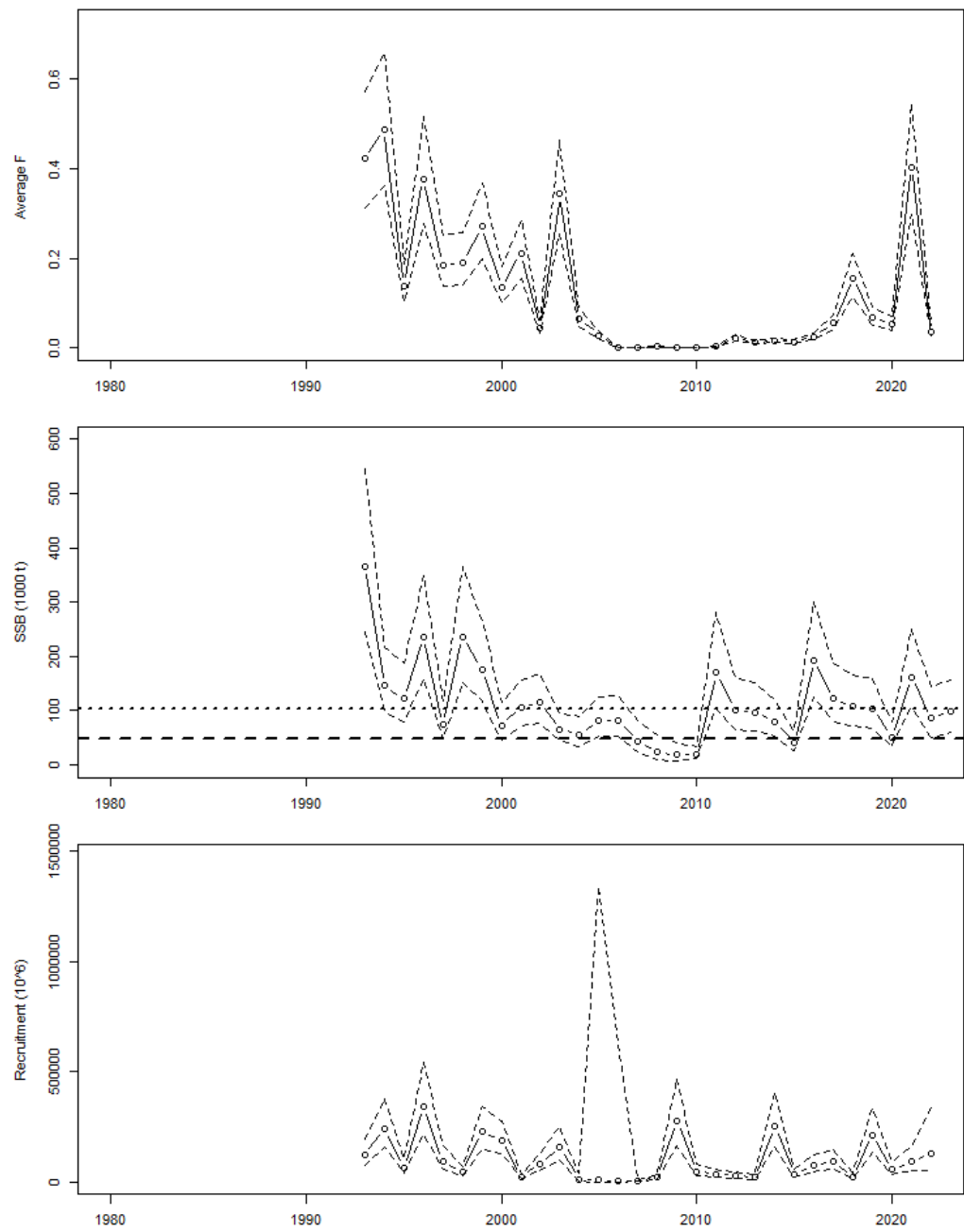


Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

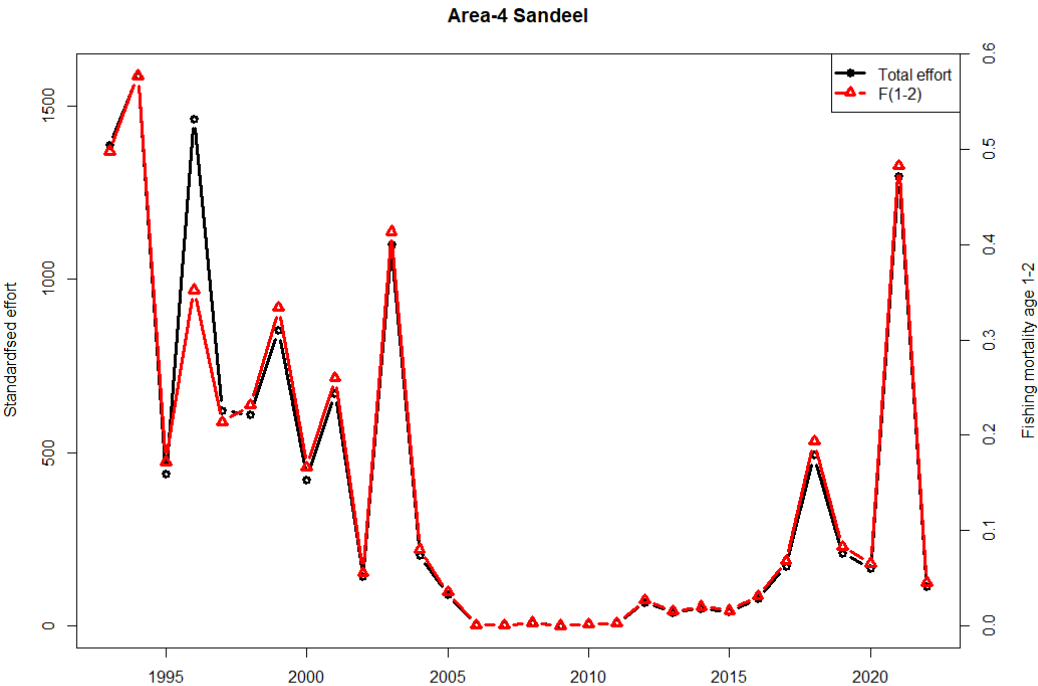


Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

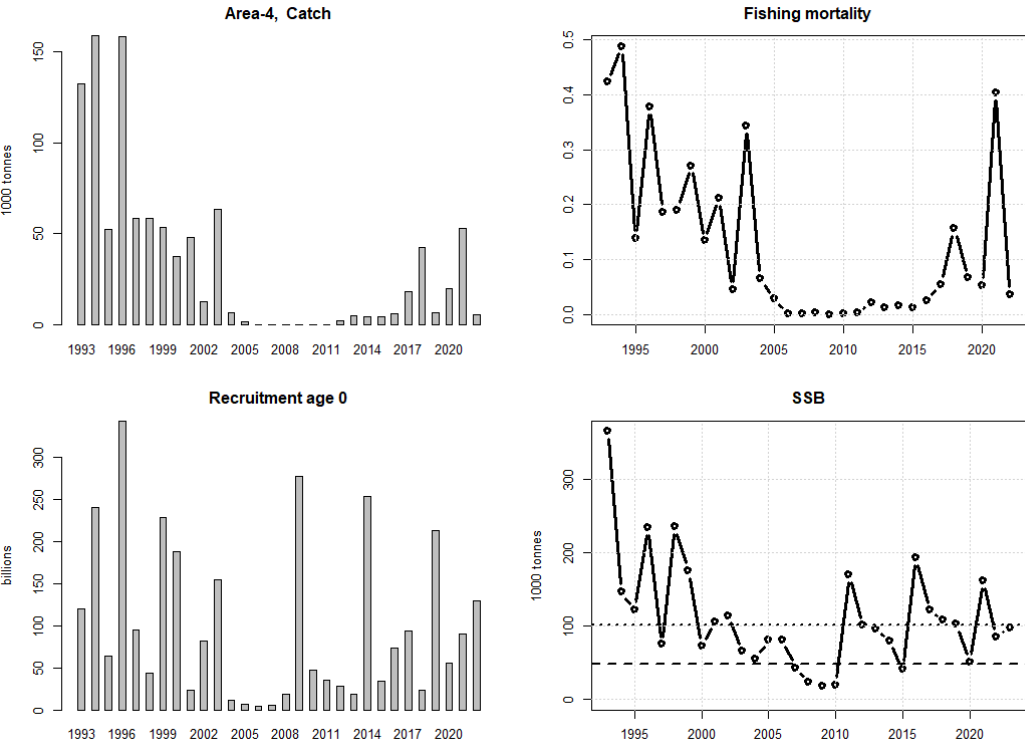


Figure 9.5.13 Sandeel Area-4. Stock summary.

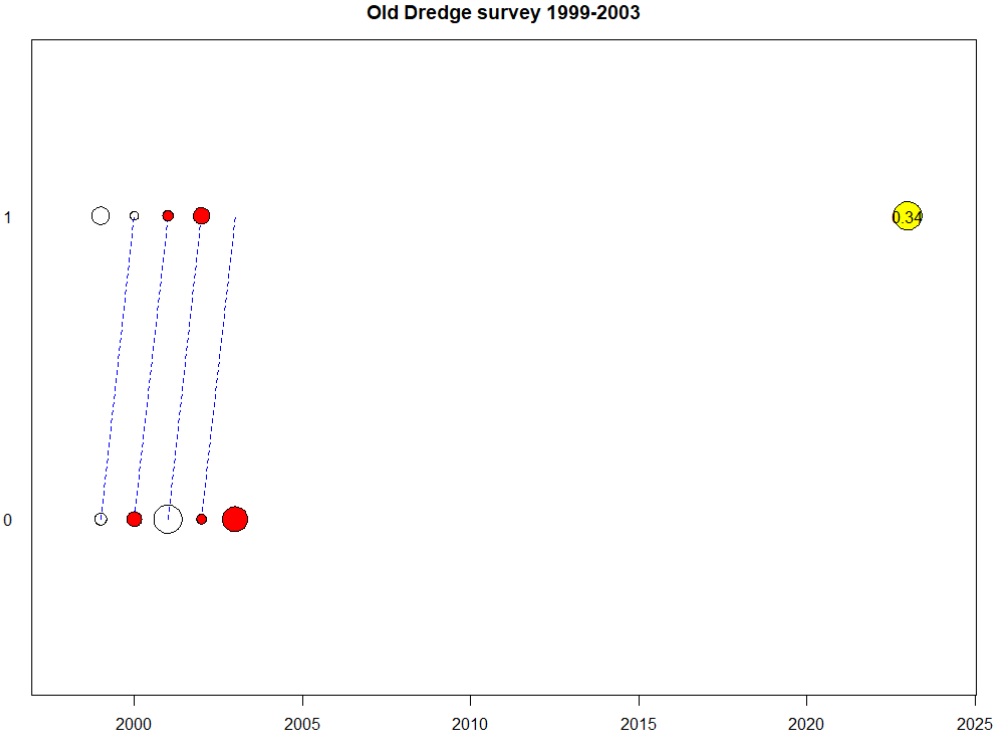


Figure 9.5.1 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals ($\log(\text{observed CPUE}) - \log(\text{expected CPUE})$). “Red” dots show a positive residual.