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, 2016, 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 Annex and in the benchmark report (ICES, 2016).

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 2016). 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 fifteen years, 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 2020, 27 vessels participated in the fishery. From 2011 to 2020, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1540 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 2020 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 2020 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2021 (Escapement strategy). This approach resulted in an advised TAC for 2020 in SA 1r, SA 2r, SA 3r, and 4 of 113 987t, 62 658 t, 155 072t and 39 611 t, respectively. Advised catches for SA 5, SA 6, and SA 7 for 2019 and 2020 were based on data limited approaches and set at 0 t, 175 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 70 000 tonnes for 2020 was given. As the acoustic survey abundance estimate of age 1 and the total biomass estimate (659 000 tonnes, RSE=0.18%) was the highest observed in the time series the final TAC increased to 250 000 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 2020).

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. 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 HAWG 2017). Because of this, the working in accordance with previous year's reallocated reported catches (14781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1 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 73420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2020 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 with regard to 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 about 6% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively). In 2017 and 2018, the first non-monitoring fishery was advised in the area since 2011 with a total TAC of 54043 t and 59345 t, respectively. In 2019, only a monitoring TAC was advised but in 2020, a TAC of 39 611t 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

In order 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) in November/December. See the Stock Annex for more details. An acoustic survey was carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2010a).

The dredge survey in 2020 was carried out as planned in areas 1r, 2r and 3r and nearly all planned positions were covered in accordance with the survey protocol. However, because of bad weather and a temporary technical obstacle, the survey was extended by 1 week and a few of the low-priority stations were not visited (all high-priority stations were visited).. The survey in area 1r and 2r was expanded to the south in 2017, where new positions were visited south of 54°N. Since 2017 two vessels were used to complete the survey. This was arranged to ensure that all positions can be visited within the 3-week period of the survey (note that new positions have been included gradually over time). All available data were included in the estimated dredge index by area. In area 4, the coverage of the dredge survey was low in 2020, and only 11 stations were sampled and only two out of four main banks (compared to around 50 stations in 2019).

9.2 Sandeel in SA 1r

9.2.1 Catch data

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

In 2020, 1-group dominated the catches (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 2020 and thereby ending the decreasing trend in weight at age.

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

In 2020, WGSAM provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, WGSAM 2020). 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 2016-2017, but have decreased to levels below average in 2018, 2019, and 2020.

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.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2020 show indices of age 0 and 1 well below the average.

The internal consistency, i.e. the ability of the RTM to follow cohorts, (shows a good consistency correlation between the 1-group and 2-group as well as between 2 and 3-group (i.e. r^2 =0.47 and 0.54, respectively on log scales). .

9.2.6 Data analysis

Following the two latest Benchmark assessments (ICES, 2010, 2016) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2020. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.2.5. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is rather constant over the 5-year ranges used. The "age selection" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the assessment period, to a fishery targeting age 1+ in a similar way, and then in the most recent period back to mainly targeting 2+ sandeel.

The CV of the dredge survey ("sqrt (Survey variance) ~CV" in the table) is low (0.48) for age 0 and high (0.80) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time-series is low to moderate for ages 1, 2, and 3 (0.53, 0.45, and 0.51). The survey residual plot (Figure 9.2.6b) shows no clear patterns.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.2.5 is low (0.35) for age 1 and age 2 in the first half of the year and moderate to high (> 0.5) 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 and 2020 (negative catch residuals for all ages).

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.85), 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. 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 and 2020 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, F and SSB estimates show virtually no retrospective pattern in the last three years.

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} from 2004 to 2007 and again in 2013-2015. $F_{(1–2)}$ is estimated to have been just below the long-time average since 2010. Recruitment in 2017 was estimated to be the lowest observed in the time-series. 2018 recruitment was also low whereas 2019 shows average recruitment. In 2020 the recruitment was below average.

9.2.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2021 is the geometric mean of the recruitment 1983–2019 (111 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the

assessment values in 2020. However, as the SMS-model assumes a fixed exploitation pattern since 2010, the choice of years is not critical. Mean weight-at-age in the catch and in the sea is the average value for the years 2016–2020. Natural mortality is the fixed M as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.2.12) shows that to obtain an SSB equal to MSY $B_{trigger}$, a TAC of 5464 t should be set for 2020. The predicted F that follows from this TAC is 0.022. The TAC according to the escapement strategy is therefore 5464 t in 2020.

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 due to the fact that 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 and SSB for the most recent years. 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 (van Deurs *et al.*, 2011).

9.2.11.1   Status of the stock

The SSB was below B_{lim} in 2019 and 2020. In 2021 it is estimated to be above B_{lim}, but below B_{pa}. As noted in last year's report (ICES, 2019), the introduction of a very low recruitment in 2018 combined with a continued decrease in mean weight-at-age led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 2020. The SSB in 2021 is lower than expected from the forecast in 2020, due to the lower than expected occurrence of age 1 in dredge survey and catches leading to a downscaling of recruitment in 2019.

9.2.12   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, 2014a, 2017) 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, 2017).

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.

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 proportion of the 1-group in the catch has decreased since 2013 only to increase to the record high level of 98% in 2017 originating from a high recruitment in 2016. This year class is seen in the 2019 catch with highest proportion of 3-group in the time-series (52%). Catches in 2020 were dominated by 1-group (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 in 2019 was above the historic average, reaching 108% of the long-term average on average. In 2020, a slight decrease in weights was observed for the 1-group compared to 2019, whereas weight at age of older age-groups increased.

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 multispecies modelling of southern and northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 new WGSAM key run (WGSAM 2020) 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 2019 was the lowest in the time-series and CPUE was about average. In 2020 effort increased, and there was an overall increase in CPUE to a level similar to 2010 (the year after the strong 2009-recruitment).

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, 2016).

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, 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 ro = 0.63) and with density dependent catchability (Mohn's ro = 0.52). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 decided to include density dependent catchability in the final run. HAWG 2021 re-examined the density dependent parameter and found it still to be significant.

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 low (0.30 for the 0-group) 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 residual plot (Figure 9.3.6) shows no bias for this time-series.

The model CV of catch-at-age 1 and 2 is low (0.38) in the first half of the year and medium or high (> 0.70) 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 (Figure 9.3.7) shows no long-term bias for this time-series for ages 1 and 2 in the first half year.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.01 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.

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 2010–2020, 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 2016).

The retrospective analysis (Figure 9.3.9) shows consistent assessment estimates of F from one year to the next. There has been an overestimation of SSB in 2015 and 2016 as a result of an overestimation of recruitment in 2013 and 2014, and the 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. 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. 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 4th 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 2019, the recruitment was average and in 2020 below average. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2012 to 2017 and 2019 to 2020. 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 with the exception of 2013, 2017 and 2020.

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 2021 is the geometric mean of the recruitment in 2010–2019 (20 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the

assessment values in 2020. 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 2016–2020. 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 even with no fishing in 2020 (F=0), the stock will be below Bpa in 2022. Hence, the default advice according to MSY would be 0 catch in 2020. However, in order to achieve data for the assessment model a monitoring TAC of 5000 t is advised to maintain the quality of the assessment consistent with previous year's advice (HAWG 2019).

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 0.45 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex.

9.3.10 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessments where the ICES statistical rectangles included in sandeel area 2 changed. The assessment now includes fisheries independent information from a dredge survey representative for the area. The assessment is considered to be of good quality but with some 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 (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 2 is still short (2010–2020) and the quality of the assessment will likely improve once a longer time-series becomes available.

9.3.11 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 2020 are estimated below B_{lim} for the second year in a row. In 2021 the stock is expected to be just above B_{lim}. The stock has been below B_{lim} in 16 out of the last 20 years and only at or above B_{pa} in 2 out of 20 years., 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 is medium.

9.3.12 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, 2016) 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 sandeel at 0.44. This means that if the TAC that results from the escapement strategy corresponds to an F_{bar} 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 3 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 2019, the 3-group provided the second largest contribution to the catches (44%) a bit below the 65% reported in 2012 when the large 2009 year class were 3 years old (Figure 9.4.1). The proportion of group-1 was 67% in 2020.

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 since 2013 but has declined recently. The 2020 mean weight was above the long-term average.

9.4.3 Maturity

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

9.4.4 Natural mortality

In 2020, WGSAM provided updated estimates of natural mortality-at-age from multispecies modelling of northern sandeel (SMS, WGSAM 2020).

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 2015 multispecies modelling of southern and northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 since 2003. The last two years, effort has increased, reaching 3492 days in 2020.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2020 show above average indices for both age 0 and age 1 in 2020 (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, 2016).

The Norwegian acoustic survey (2009–2020) 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.

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. The working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run (see figure below, where I is the survey index of age-0 and N0 the number of recruits) 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 without density dependent catchability (Mohn's ro = 0.57) and with density dependent catchability (Mohn's ro = 0.13). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 decided to include density dependent catchability in the final run. This approach was continued in 2021.

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 (0.64) and high for age 1 (0.78), 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 (0.60) 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 2020, indicating that the very high acoustic indices were not confirmed by the model.

The model CV of catch-at-age is medium (0.68) 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 high (> 1.00). The catch residual plots for catch-at-age (Figure 9.4.7) confirm that the fits are generally very poor except for age 1 and 2 in the first half year. There is a tendency for clusters of negative or positive residuals for ages 1 and 2 but no trend in recent years.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.07), 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 from a Mohn´s Rho > 0.5 to -0.10 in the present year´s assessment.

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, 2016).

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 9.4.16 and Table 9.4.17). Above average recruitments in 2016, 2018, 2019 and 2020 together with a fishing mortality below average in most years and an increased weight at age in 2020 have resulted in SSB being above B_{pa} in 2015 onwards.

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 2021 is the geometric mean of the recruitment 1986–2019 (112 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2020. 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 2016–2020. 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 TAC of 161 335 t in 2021 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 299 368 t, well above MSY $B_{trigger}$ of 129 000 t, in 2021. The TAC according to the escapement strategy is therefore 161 335 t in 2021.

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.

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. Recruitment estimates for 2018-2020 are all above 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 tables 9.5.2–9.5.4. In 2020, age group 1 completely dominated the catches to an extent seen previously only in 2000 and 2015 (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 for all ages after the very low levels in 2001 to 2005. The second half year mean weights and mean weights of older ages in some years are affected by the very limited sampling at this time of year.

9.5.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey 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 multispecies modelling of northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 key run (WGSAM 2020) 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 9.5.5–9.5.7 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. The effort in 2018 was the highest since 2004 reflecting the TAC given followed by a much lower effort in 2019 and 2020. CPUE in later years has been around the average prior to 2004 from 2013-2018 but high in 2020.

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 the 2019 and 2020 year classes are both among the 6 highest recruitments on record.

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.

In 2020, a substantially lower than usual number of stations was sampled due to limitations in survey time. HAWG conducted an analysis of the relationship between the index based on this limited survey coverage and the index based on all stations sampled in previous years. The analyses showed that there was a high correlation between the two indices but that the 11 stations sampled in 2020 generally resulted in a substantially higher survey index. HAWG concluded that using the 2020 index directly would therefore introduce a positive bias in the 2020 survey index. This was confirmed by performing an explorative assessment using the observed 2020 index from the 11 stations and the 2020 index corrected using the historical relationship between the index on the 11 stations and throughout the area. The assessment based on the 11 stations showed substantial retrospective bias in 2019 and patterns in 2020 survey residuals whereas this was not the case when using the corrected index. Hence, the corrected index was used in the final assessment.
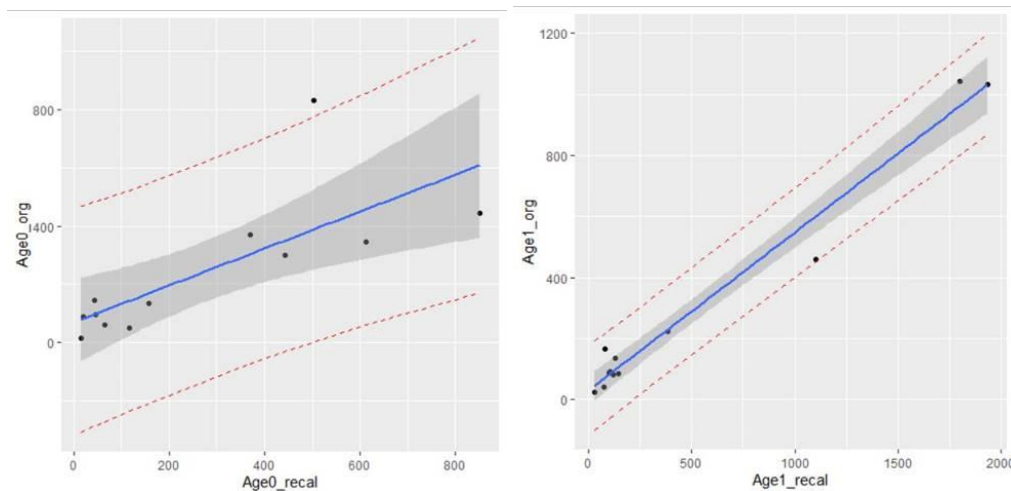
Relationship between index estimated for all stations (vertical axis) and index estimated for the 11 stations sampled in 2020 (horizontal axis).

9.5.6 Data analysis

Following the Benchmark assessment (ICES, 2016) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2020. 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 dredge survey ("sqrt (Survey variance) ~CV" in the table) is very low (0.30 to 0.37) for all ages. In fact, the CV of the dredge survey hits the lower bound for age 0 and this suggests that the model due to very low catches in recent years is essentially only using the survey to estimate stock size etc.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.72) for age 1 and age 2. The catch-at-age residuals (Figure 9.5.6) show no alarming patterns, except for a tendency to positive residuals (observed catch is higher than model catch) for age 1 in the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.53), which is also indicated by the stock recruitment plot (Figure 9.5.7). 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. This is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.5.9) 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} but below B_{pa} in 2015 only. SSB is estimated at 67,914 in 2020. $F_{(1-2)}$ is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004 and decreased in 2019 and 2020. Recruitment has been high in 2014, 2016, 2017, 2019 and 2020.

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 2021 is the geometric mean of the recruitment 1993–2019 (74 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2020. 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 2016–2020. 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 9.3.12) shows that a SSB will be above the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2021 with an F of 0.15 (= Fcap) and a TAC of 77 512t. The TAC according to the escapement strategy and an Fcap of 0.15 is therefore 77 512 t in 2021.

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.

9.5.10.1   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 2021 is high (0.40).

9.5.10.2   Status of the Stock
Recruitment in 2014, 2016, 2017, 2019 and 2020 are all above the long-term average, while 2018 is low. A very restrictive F since 2005 together with the return of recruitment to historic levels has resulted in SSB above B_{pa} in 2016 to 2019 and between B_{lim} and B_{pa} in 2020. The spawning stock size is above B_{pa} in 2021.

9.5.10.3   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, 2014a, 2017) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (Fcap) 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 criteria of 0.05 probability of SSB < B_{lim}) is set at 0.15 (ICES, 2016).

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 2005 on Vikingbanken, which is the main sandeel ground in SA 5. The survey estimates 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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Table 9.1.1 Sandeel. Catches ('000 t), 1952-2020. (Data provided by Working Group Members).

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithuania	Total
1952	1.6	-	-	-	-	-	-	-	-	1.6
1953	4.5	-	-	-	-	-	-	-	-	4.5
1954	10.8	-	-	-	-	-	-	-	-	10.8
1955	37.6	-	-	-	-	-	-	-	-	37.6
1956	81.9	5.3	-	-	-	1.5	-	-	-	88.7
1957	73.3	25.5	-	-	3.7	3.2	-	-	-	105.7
1958	74.4	20.2	-	-	1.5	4.8	-	-	-	100.9
1959	77.1	17.4	-	-	5.1	8	-	-	-	107.6
1960	100.8	7.7	-	-	-	12.1	-	-	-	120.6
1961	73.6	4.5	-	-	-	5.1	-	-	-	83.2
1962	97.4	1.4	-	-	-	10.5	-	-	-	109.3
1963	134.4	16.4	-	-	-	11.5	-	-	-	162.3
1964	104.7	12.9	-	-	-	10.4	-	-	-	128.0
1965	123.6	2.1	-	-	-	4.9	-	-	-	130.6
1966	138.5	4.4	-	-	-	0.2	-	-	-	143.1
1967	187.4	0.3	-	-	-	1	-	-	-	188.7
1968	193.6	-	-	-	-	0.1	-	-	-	193.7
1969	112.8	-	-	-	-	-	-	0.5	-	113.3
1970	187.8	-	-	-	-	-	-	3.6	-	191.4
1971	371.6	0.1	-	-	-	2.1	-	8.3	-	382.1
1972	329.0	-	-	-	-	18.6	8.8	2.1	-	358.5
1973	273.0	-	1.4	-	-	17.2	1.1	4.2	-	296.9
1974	424.1	-	6.4	-	-	78.6	0.2	15.5	-	524.8
1975	355.6	-	4.9	-	-	54	0.1	13.6	-	428.2
1976	424.7	-	-	-	-	44.2	-	18.7	-	487.6
1977	664.3	-	11.4	-	-	78.7	5.7	25.5	-	785.6
1978	647.5	-	12.1	-	-	93.5	1.2	32.5	-	786.8
1979	449.8	-	13.2	-	-	101.4	-	13.4	-	577.8
1980	542.2	-	7.2	-	-	144.8	-	34.3	-	728.5
1981	464.4	-	4.9	-	-	52.6	-	46.7	-	568.6
1982	506.9	-	4.9	-	-	46.5	0.4	52.2	-	610.9
1983	485.1	-	2	-	-	12.2	0.2	37	-	536.5
1984	596.3	-	11.3	-	-	28.3	-	32.6	-	668.5
1985	587.6	-	3.9	-	-	13.1	-	17.2	-	621.8
1986	752.5	-	1.2	-	-	82.1	-	12	-	847.8
1987	605.4	-	18.6	-	-	193.4	-	7.2	-	824.6
1988	686.4	-	15.5	-	-	185.1	-	5.8	-	892.8
1989	824.4	-	16.6	-	-	186.8	-	11.5	-	1039.1
1990	496.0	-	2.2	-	0.3	88.9	-	3.9	-	591.3

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithuania	Total
1991	701.4	-	11.2	-	-	128.8	-	1.2	-	842.6
1992	751.1	-	9.1	-	-	89.3	0.5	4.9	-	854.9
1993	482.2	-	-	-	-	95.5	-	1.5	-	579.2
1994	603.5	-	10.3	-	-	165.8	-	5.9	-	785.5
1995	647.8	-	-	-	-	263.4	-	6.7	-	917.9
1996	601.6	-	5	-	-	160.7	-	9.7	-	776.9
1997	751.9	-	11.2	-	-	350.1	-	24.6	-	1137.8
1998	617.8	-	11	-	-	343.3	8.5	23.8	-	1004.4
1999	500.1	-	13.2	0.4	-	187.6	22.4	11.5	-	735.1
2000	541.0	-	-	-	-	119	28.4	10.8	-	699.1
2001	630.8	-	-	-	-	183	46.5	1.3	-	861.6
2002	629.7	-	-	-	-	176	0.1	4.9	-	810.7
2003	274.0	-	-	-	-	29.6	21.5	0.5	-	325.6
2004	277.1	2.7	-	-	-	48.5	33.2	-	-	361.5
2005	154.8	-	-	-	-	17.3	-	-	-	172.1
2006	250.6	3.2	-	-	-	5.6	27.8	-	-	287.9
2007	144.6	1	2	-	-	51.1	6.6	1	-	206.3
2008	234.4	4.4	2.4	-	-	81.6	12.4	-	-	335.2
2009	285.7	12.2	2.5	-	1.8	27.4	12.4	3.6	-	345.6
2010	275.1	13	-	-	-	78	32	4	0.6	402.7
2011	278.0	9.8	-	-	-	109	32.7	6.1	1.65	437.2
2012	50.1	1.70844	-	-	0.317	42.4804	5.652	-	-	100.2
2013	192.8	7.89833	-	-	0.387	30.44615	26.811	2.436	1.32035	262.1
2014	148.0	5.05196	-	-	-	82.49885	18.815	0.03	0.82463	255.2
2015	163.2	9.09745	-	-	-	100.85862	33.43875	2.00003	-	308.6
2016	27.8	-	-	-	-	40.86736	4.2595	-	-	72.9
2017	316.9	5.7985	-	-	-	120.20534	42.23271	3.32389	-	488.4
2018	167.3	5.937	-	-	-	69.53076	16.655512	1.848779	-	261.3
2019	93.6	3.94972	-	-	-	124.7855	11.5433	1.05792	-	235.0
2020	157.3	4.198	-	-	-	244.379129	25.720324	3.8959461	-	435.5

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
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
2019	86723	5151	136901	6666	0	96	0	235537
2020	105928	73921	247616	19707	0	177	0	447349
arith. mean	291915	102007	151790	30010	5681	1147	965	583514

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	314744	92566	21008	2782	0	364	0	431465
1984	419640	86141	43578	2563	5821	735	744	559223
1985	377702	76422	17131	37900	3004	973	0	513132
1986	346053	181733	138020	12539	108	12020	7832	698305
1987	307194	36400	394339	7833	1713	1091	0	748570
1988	395186	107289	288174	1257	0	2114	0	794020
1989	435721	173510	371557	4382	1587	897	450	988104
1990	285321	101899	105554	2926	0	485	0	496185
1991	257591	153869	215770	17140	1168	17	2529	648083
1992	521575	135823	83068	67068	1099	4270	3455	816357
1993	129403	86179	155984	123143	250	4393	3	499354
1994	177685	184792	242027	147019	2754	3222	4	757503
1995	365681	70518	203151	52497	152269	1829	0	845945
1996	257507	63193	110862	48496	14551	1168	0	495777
1997	345199	178735	394181	47668	8615	2194	2448	979040
1998	352275	70075	354639	57373	2907	939	4565	842773
1999	395813	27461	94655	51183	145	0	2152	571409
2000	333044	82405	192474	37792	288	0	3808	649812
2001	368782	49319	59951	47492	1678	26	735	527983
2002	604584	105397	114646	12762	8	493	101	837991
2003	155006	25111	22803	62580	44	111	187	265841
2004	199483	91405	21632	6860	0	571	0	319951
2005	121795	24841	13982	1557	0	259	0	162434
2006	241345	23497	6959	55	0	160	0	272015
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
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	104779	73620	247616	19487	0	177	0	445678
arith. mean	263737	73544	127474	25387	5211	1046	763	497162

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	67885	63641	3820	0	0	0	0	135345
1984	79031	47257	5532	0	0	55	0	131875
1985	82355	35468	3728	222	0	953	0	122726
1986	36791	43848	144314	179	519	1199	2818	229668
1987	65828	12667	959	321	0	72	0	79847
1988	27619	44254	48744	81	0	612	0	121310
1989	10407	53782	2694	2	1316	12	0	68214
1990	20981	31896	57670	388	374	14	0	111323
1991	74613	61697	59069	24232	0	0	0	219611
1992	37027	48418	3954	1837	0	6	0	91243
1993	14986	61785	44138	9993	336	97	78	131414
1994	15557	60152	25254	11671	3	526	0	113163
1995	35078	51637	10017	94	5	1	0	96831
1996	34202	123267	48441	109994	13020	95	1	329019
1997	81215	63945	79912	10779	2157	179	613	238799
1998	20329	29230	120203	1538	103	1	663	172068
1999	29666	42624	98967	2155	0	0	2263	175674
2000	41680	19547	4051	0	15	0	562	65855
2001	171466	47891	136258	426	0	0	236	356277
2002	5577	15123	561	0	0	0	352	21613
2003	23636	31137	12562	1469	0	0	73	68877
2004	15869	25432	12026	22	0	2	0	53351
2005	4466	9728	11	0	0	0	0	14206
2006	6165	14455	136	30	0	0	0	20787
2007	6	0	0	0	0	0	0	6
2008	3821	3053	0	0	0	0	0	6873
2009	16183	11650	137	0	0	0	0	27970
2010	7537	7560	291	0	0	0	0	15387
2011	3891	265	0	0	0	0	0	4156
2012	8	1153	0	0	0	0	0	1161
2013	6902	4354	0	0	0	0	0	11256
2014	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	1149	302	0	220	0	0	0	1671
arith. mean	28178	28463	24317	4622	470	101	202	86352

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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
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	1799	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	2779	2089	1230	170	0	0	0	6268
2018	3203	556	1474	537	0	0	0	5770
2019	2889	135	2008	209	0	3	0	5243
2020	2684	1467	3492	165	0	8	0	7817
arith. mean	5382	2635	3060	349	83	44	9	11562

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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
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	2728	1834	1230	170	0	0	0	5962
2018	2886	550	1463	537	0	0	0	5436
2019	2551	135	2008	209	0	3	0	4905
2020	2646	1388	3492	165	0	8	0	7700
arith. mean	4720	1850	2466	294	78	41	7	9456

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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
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	51	255	0	0	0	0	0	306
2018	316	6	12	0	0	0	0	334
2019	338	0	0	0	0	0	0	338
2020	39	79	0	0	0	0	0	118
arith. mean	662	785	593	55	5	3	2	2105

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

	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
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	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0
Sum	6206	2779	1772	850	39	71	0	11717

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

	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	91	1699	158	14468	792	971	44	331	10
2019	5947	4703	96	830	18	1885	19	101	0
2020	53	11640	78	1082	12	263	2	442	5
arith. mean	2683	22933	1652	8850	593	2294	189	680	37

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

	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
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

	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	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	2.6	4.7	4.3	7.0	6.6	9.5	8.4	11.5	10.0
2019	2.4	4.7	5.2	7.7	7.7	8.4	9.2	10.7	10.8
2020	7.4	7.1	7.1	9.5	9.6	12.3	11.7	13.8	13.2
arith. mean	3.7	5.8	6.3	9.3	10.2	12.9	13.8	14.9	15.7

Table 9.2.3 Sandeel Area-1r. Proportion mature.

	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

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

```
Date: 01/20/21  Start time:08:58:50 run time:0 seconds


objective function (negative log likelihood):  20.5411
Number of parameters: 79
Maximum gradient: 9.30556e-005
Akaike information criterion (AIC):   199.082
Number of observations used in the likelihood:
                           Catch    CPUE    S/R Stomach    Sum
                            342      70      38      0      450


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
              26.6     -6.6    12.7    0.0     0.0     0.00       33



unweighted objective function contributions (per observation):
              Catch   CPUE    S/R    Stomachs
              0.08    -0.09   0.33    0.00



contribution by fleet:
----------------------
RTM 2007-2020              total: -7.277   mean:  -0.202
Dredge survey 2004-2020    total:  0.634   mean:   0.019


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
    2010-2020:   0.000 1.000
age: 1 - 4
    1983-1988:   0.455 0.500
    1989-1998:   0.467 0.500
    1999-2004:   0.374 0.500
    2005-2009:   0.255 0.500
    2010-2020:   0.542 0.500


F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.259  0.961  1.425  1.425
1989-1998:  0.011  0.538  0.720  0.730  0.730
1999-2004:  0.067  1.027  1.140  1.135  1.135
2005-2009:  0.007  1.422  2.153  2.243  2.243
2010-2020:  0.019  0.269  0.668  1.260  1.260
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                     0     1     2     3     4
1983-1988 season 1:     0  0.320  1.186  1.760  1.760
          season 2:  0.020  0.105  0.388  0.576  0.576


1989-1998 season 1:     0  0.822  1.100  1.115  1.115
          season 2:  0.001  0.033  0.045  0.045  0.045


1999-2004 season 1:     0  0.807  0.896  0.893  0.893
          season 2:  0.018  0.140  0.156  0.155  0.155


2005-2009 season 1:     0  0.741  1.122  1.168  1.168
          season 2:  0.001  0.055  0.083  0.086  0.086


2010-2020 season 1:     0  0.550  1.363  2.571  2.571
          season 2:  0.004  0.025  0.062  0.117  0.117



sqrt(catch variance) ~ CV:
--------------------------


            season
----------------------
age      1      2

 0             1.659
 1     0.348  0.587
 2     0.348  0.587
 3     0.661  1.019
 4     0.661  1.019



Survey catchability:
--------------------
                      age 0    age 1    age 2    age 3
 RTM 2007-2020                          0.829    1.756    2.769
 Dredge survey 2004-2020       2.550    1.069

sqrt(Survey variance) ~ CV:
---------------------------
                      age 0    age 1    age 2    age 3
 RTM 2007-2020                          0.53     0.45     0.51
 Dredge survey 2004-2020       0.48     0.80

 Recruit-SSB          alfa      beta      recruit s2     recruit s
 Area-1r          1054.203  1.100e+005    0.717          0.847
```

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

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.012	0.286	1.027	1.508	1.517	0.657
1984	0.013	0.324	1.162	1.704	1.712	0.743
1985	0.014	0.347	1.243	1.831	1.826	0.795
1986	0.005	0.244	0.874	1.275	1.270	0.559
1987	0.008	0.182	0.660	0.969	0.967	0.421
1988	0.005	0.265	0.948	1.373	1.368	0.607
1989	0.001	0.819	1.063	1.067	1.059	0.941
1990	0.002	0.815	1.058	1.061	1.057	0.937
1991	0.005	0.548	0.720	0.729	0.729	0.634
1992	0.003	0.823	1.077	1.082	1.083	0.950
1993	0.001	0.363	0.473	0.480	0.479	0.418
1994	0.001	0.300	0.389	0.391	0.390	0.344
1995	0.002	0.562	0.726	0.731	0.728	0.644
1996	0.003	0.527	0.679	0.682	0.681	0.603
1997	0.005	0.497	0.643	0.648	0.651	0.570
1998	0.002	0.653	0.825	0.827	0.827	0.739
1999	0.017	1.023	1.080	1.063	1.065	1.051
2000	0.016	0.818	0.859	0.851	0.850	0.838
2001	0.049	1.237	1.321	1.314	1.317	1.279
2002	0.004	0.948	1.011	0.974	0.967	0.980
2003	0.015	0.788	0.844	0.818	0.821	0.816
2004	0.007	0.832	0.878	0.847	0.848	0.855
2005	0.000	0.893	1.276	1.319	1.316	1.085
2006	0.001	1.091	1.560	1.603	1.599	1.325
2007	0.000	0.412	0.592	0.610	0.605	0.502
2008	0.000	0.769	1.100	1.123	1.120	0.935
2009	0.001	0.949	1.364	1.402	1.394	1.157
2010	0.002	0.389	0.910	1.630	1.620	0.649
2011	0.001	0.443	1.012	1.821	1.804	0.727
2012	0.000	0.083	0.194	0.353	0.350	0.139
2013	0.000	0.506	1.136	2.079	2.069	0.821
2014	0.001	0.294	0.666	1.236	1.234	0.480
2015	0.000	0.282	0.636	1.182	1.172	0.459
2016	0.000	0.020	0.045	0.085	0.084	0.033
2017	0.001	0.377	0.874	1.590	1.574	0.625
2018	0.004	0.373	0.886	1.604	1.599	0.630
2019	0.005	0.364	0.867	1.572	1.567	0.616
2020	0.001	0.352	0.835	1.501	1.494	0.593
arith. mean	0.005	0.547	0.882	1.130	1.127	0.715

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

	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	0.192	0.063	0.712	0.233	1.056	0.346	1.056	0.346
1984	0.013	0.220	0.069	0.814	0.255	1.206	0.378	1.206	0.378
1985	0.014	0.234	0.074	0.868	0.273	1.288	0.405	1.288	0.405
1986	0.005	0.182	0.025	0.676	0.091	1.002	0.135	1.002	0.135
1987	0.008	0.119	0.042	0.441	0.157	0.654	0.233	0.654	0.233
1988	0.005	0.199	0.025	0.738	0.091	1.094	0.135	1.094	0.135
1989	0.001	0.664	0.027	0.889	0.036	0.901	0.037	0.901	0.037
1990	0.002	0.645	0.045	0.863	0.060	0.875	0.061	0.875	0.061
1991	0.005	0.370	0.121	0.495	0.162	0.502	0.164	0.502	0.164
1992	0.003	0.639	0.076	0.855	0.102	0.867	0.103	0.867	0.103
1993	0.001	0.282	0.034	0.377	0.046	0.382	0.047	0.382	0.047
1994	0.001	0.230	0.026	0.307	0.034	0.312	0.035	0.312	0.035
1995	0.002	0.427	0.052	0.571	0.069	0.579	0.070	0.579	0.070
1996	0.003	0.387	0.060	0.518	0.080	0.525	0.081	0.525	0.081
1997	0.005	0.322	0.118	0.431	0.158	0.437	0.160	0.437	0.160
1998	0.002	0.491	0.049	0.657	0.066	0.666	0.066	0.666	0.066
1999	0.017	0.739	0.129	0.821	0.143	0.817	0.142	0.817	0.142
2000	0.016	0.580	0.120	0.644	0.134	0.642	0.133	0.642	0.133
2001	0.049	0.755	0.374	0.838	0.415	0.835	0.414	0.835	0.414
2002	0.004	0.746	0.028	0.828	0.031	0.825	0.031	0.825	0.031
2003	0.015	0.555	0.113	0.616	0.125	0.613	0.125	0.613	0.125
2004	0.007	0.619	0.057	0.688	0.064	0.685	0.063	0.685	0.063
2005	0.000	0.692	0.051	1.047	0.077	1.091	0.080	1.091	0.080
2006	0.001	0.836	0.073	1.267	0.111	1.319	0.116	1.319	0.116
2007	0.000	0.328	0.000	0.496	0.000	0.517	0.000	0.517	0.000
2008	0.000	0.587	0.035	0.889	0.053	0.926	0.055	0.926	0.055
2009	0.001	0.709	0.072	1.074	0.108	1.118	0.113	1.118	0.113
2010	0.002	0.288	0.013	0.714	0.032	1.347	0.061	1.347	0.061
2011	0.001	0.325	0.009	0.806	0.023	1.519	0.043	1.519	0.043
2012	0.000	0.062	0.000	0.154	0.000	0.290	0.000	0.290	0.000
2013	0.000	0.391	0.000	0.969	0.000	1.827	0.000	1.827	0.000
2014	0.001	0.224	0.008	0.556	0.020	1.049	0.038	1.049	0.038
2015	0.000	0.219	0.000	0.543	0.000	1.024	0.000	1.024	0.000
2016	0.000	0.015	0.000	0.038	0.000	0.072	0.000	0.072	0.000
2017	0.001	0.292	0.005	0.724	0.012	1.365	0.023	1.365	0.023

	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	0.004	0.280	0.028	0.693	0.070	1.307	0.133	1.307	0.133
2019	0.005	0.270	0.033	0.669	0.082	1.261	0.154	1.261	0.154
2020	0.001	0.280	0.004	0.693	0.009	1.308	0.018	1.308	0.018
arith. mean	0.005	0.405	0.054	0.684	0.090	0.897	0.110	0.897	0.110

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

	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
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

	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	0.723	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	0.538	0.538	0.454	0.454	0.360	0.360	0.345	0.345
arith. mean	0.629	0.460	0.544	0.386	0.419	0.303	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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	297690	13338	52047	2853	240
1984	76038	178554	4365	9687	424
1985	513050	45556	56528	719	1154
1986	77447	301050	14253	8723	187
1987	47574	45205	104561	3128	1512
1988	206012	27225	16001	26710	1017
1989	92592	117936	9030	3218	4281
1990	131552	54356	24621	1661	1568
1991	163589	76230	11370	4683	679
1992	37068	92932	19932	2899	1553
1993	155962	21345	19797	3871	976
1994	223793	91628	6914	6610	1818
1995	56293	131574	30844	2466	3393
1996	403944	33371	34841	7965	1748
1997	63135	232044	9286	9566	2945
1998	120886	35635	61974	2527	3754
1999	159236	65197	7933	14324	1641
2000	252914	84231	9856	1387	3168
2001	418489	135611	15079	2118	1172
2002	26773	215731	17156	2071	525
2003	161142	13641	35888	3013	555
2004	68801	79672	2425	6860	804
2005	164045	33598	12533	443	1654
2006	79474	81828	5344	1789	326
2007	198202	38293	10416	571	250
2008	77811	91849	9047	2742	246
2009	560978	37682	15608	1479	567
2010	35039	277327	5998	2153	305

	Age 0	Age 1	Age 2	Age 3	Age 4
2011	43620	17116	65488	1149	289
2012	104200	19828	3480	11502	139
2013	60949	47425	5067	1103	3826
2014	219740	29327	9224	759	384
2015	36922	106556	7537	2169	196
2016	274693	18006	25792	1904	433
2017	19676	133098	5652	11272	1121
2018	36416	10029	31817	1124	1540
2019	122185	19539	2772	6148	327
2020	52633	65515	5430	543	793
2021		28337	16838	1085	176

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

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	297820049	625560	460469	378795	0.600
1984	76057485	1161140	196025	498626	0.678
1985	513109587	781239	451802	437114	0.725
1986	77438916	1865050	270493	382844	0.487
1987	47583661	1513710	975787	373021	0.380
1988	205920350	777165	576079	413646	0.526
1989	92618550	746348	155127	446028	0.808
1990	131563476	646740	247459	306240	0.807
1991	163610637	945850	329720	332204	0.574
1992	37058192	1041310	284930	558599	0.835
1993	155942826	459259	260146	132024	0.369
1994	223741069	683800	177726	193241	0.299
1995	56288454	1449330	399113	400588	0.560
1996	404030125	606448	364762	265869	0.522
1997	63148522	1896650	233048	426089	0.515
1998	120842669	855882	525445	377073	0.631
1999	159252253	577015	222571	422718	0.916
2000	253025289	677987	142201	299167	0.740
2001	418421560	787972	161458	531265	1.191
2002	26775558	1440670	156530	606466	0.816
2003	161174792	344182	243775	148039	0.704
2004	68819659	493032	93620	203646	0.714
2005	164102206	352620	116891	123422	0.934
2006	79478730	558479	76344	240646	1.144
2007	198242185	322305	94466	109624	0.412

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2008	77827080	714745	130614	234447	0.782
2009	560870164	404737	147709	290995	0.981
2010	35039971	1856400	130875	300508	0.524
2011	43618852	681238	478303	318840	0.581
2012	104218478	291530	159213	46117	0.108
2013	60976555	309383	85391	214359	0.680
2014	219749759	215531	66636	78830	0.404
2015	36910256	672741	87904	163381	0.381
2016	274647770	384531	240867	14613	0.027
2017	19677767	859488	161619	241916	0.517
2018	36433528	299653	208772	129525	0.536
2019	122179276	168832	73718	60678	0.526
2020	52640692	533747	68734	103282	0.493
2021			128284		
arith. mean	153699032	763218	240631	284329	0.616
geo. mean	110662988				

arith. mean for the period 1983–2020

geo. mean for the period 1983–2019

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	110640.139	28337.4	16838.2	1085.1	175.995
Exploitation pattern 1st half		0.280	0.693	1.308	1.308
Exploitation pattern 2nd half	0.001	0.004	0.009	0.018	0.018
Weight in the stock 1st half		5.396	8.291	10.389	12.257
Weight in the catch 1st half		5.396	8.291	10.389	12.257
weight in the catch 2nd half	3.695	5.581	8.146	10.281	11.948
Proportion mature (2021)	0.000	0.021	0.801	0.988	1.000
Proportion mature (2022)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.538	0.454	0.360	0.345
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: Fsq = F(2020) = 0.4931; Yield(2020) = 103.282; Recruitment(2020) = 52.640692; Recruitment(2021) = geometric mean (GM 1983–2019) = 110.640139 billions; SSB(2021) = 128.284

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
$SSB_{2022} \geq$ MSY $B_{escapement}$ with F_{cap}	5464	0.022	145000	32.287	95.683	95.683
Other scenarios						
F = 0	0	0	148321	52.531	-100.000	-100.000
SSB_{2022} = MSY $B_{escapement}$ = B_{pa}	5464	0.022	145000	-49.403	958.466	958.466
B_{lim}	64243	0.30	110000	-76.190	1302.520	1302.520
F = F_{2020}	96104	0.49	91699	45.954	-36.914	-36.914

* SSB_{2022} relative to SSB_{2021}.

** Catch scenario for 2021 relative to TAC in 2020 (113 987 t).

*** Advice value 2021 relative to advice value 2020 (113 987 t).

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

	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
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	8836	16	436	1	171	1	362	3
arith. mean	2778	7189	1465	1690	306	432	110	170	43

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

	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

	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
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	3.5	4.6	7.4	9.6	11.4	12.4	13.8	14.0	16.1
2019	8.0	7.7	8.7	12.4	12.6	15.4	13.9	18.7	14.1
2020	10.1	6.4	11.4	12.8	16.1	16.2	13.8	20.2	19.3
arith. mean	4.2	6.3	8.3	10.9	13.5	15.1	17.9	17.6	20.1

Table 9.3.3 Sandeel Area-2r. Proportion mature.

	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

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

```
Date: 01/18/21  Start time:17:30:47 run time:1 seconds


objective function (negative log likelihood):  74.5286
Number of parameters: 74
Maximum gradient: 4.0253e-005
Akaike information criterion (AIC):   297.057
Number of observations used in the likelihood:
                          Catch    CPUE    S/R Stomach    Sum
                           342      22      38      0      402


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
              78.6    -6.1    19.5    0.0     0.0      0.00       92



unweighted objective function contributions (per observation):
              Catch    CPUE    S/R    Stomachs
              0.23    -0.28    0.51    0.00



contribution by fleet:
----------------------
Dredge survey 2010-2020    total: -6.060   mean: -0.275


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
    2010-2020:   0.000 1.000
age: 1 - 4
    1983-1988:   0.471 0.500
    1989-1998:   0.687 0.500
    1999-2004:   0.426 0.500
    2005-2009:   0.185 0.500
    2010-2020:   0.618 0.500


F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.040  0.278  0.908  1.517  1.517
1989-1998:  0.100  0.334  0.402  0.470  0.470
1999-2004:  0.041  0.600  0.720  0.733  0.733
2005-2009:  0.001  2.016  1.721  1.834  1.834
2010-2020:  0.001  0.232  0.418  0.611  0.611
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                      0     1     2     3     4
1983-1988 season 1:   0   0.295 0.962 1.607 1.607
          season 2: 0.051 0.174 0.569 0.950 0.950


1989-1998 season 1:   0   0.723 0.870 1.018 1.018
          season 2: 0.110 0.184 0.222 0.260 0.260


1999-2004 season 1:   0   0.312 0.374 0.381 0.381
          season 2: 0.081 0.597 0.717 0.730 0.730


2005-2009 season 1:   0   0.528 0.451 0.480 0.480
          season 2: 0.001 0.551 0.470 0.501 0.501


2010-2020 season 1:   0   0.605 1.091 1.597 1.597
          season 2: 0.001 0.108 0.195 0.286 0.286



sqrt(catch variance) ~ CV:
--------------------------


            season
----------------------
age      1      2

 0             1.641
 1     0.376  0.834
 2     0.376  0.834
 3     0.791  1.097
 4     0.791  1.097



Survey catchability:
--------------------
                     age 0    age 1
 Dredge survey 2010-2020    0.616   20.690


Stock size dependent catchability (power model)
-----------------------------------------------   age 0    age 1
Dredge survey 2010-2020        1.27     1.00


sqrt(Survey variance) ~ CV:
---------------------------
                     age 0    age 1
 Dredge survey 2010-2020     0.30     0.79


Recruit-SSB          alfa      beta      recruit s2    recruit s
Area-2r           1080.247  5.600e+004   1.028          1.014
```

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

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.037	0.364	1.177	1.958	1.957	0.770
1984	0.033	0.306	0.992	1.657	1.656	0.649
1985	0.022	0.286	0.917	1.516	1.513	0.601
1986	0.025	0.411	1.303	2.136	2.133	0.857
1987	0.008	0.091	0.293	0.487	0.487	0.192
1988	0.026	0.305	0.981	1.627	1.625	0.643
1989	0.076	0.725	0.855	0.987	0.985	0.790
1990	0.037	0.488	0.572	0.659	0.657	0.530
1991	0.071	0.550	0.650	0.753	0.752	0.600
1992	0.052	0.559	0.657	0.758	0.756	0.608
1993	0.081	0.440	0.524	0.612	0.611	0.482
1994	0.051	0.468	0.552	0.638	0.636	0.510
1995	0.043	0.254	0.303	0.353	0.352	0.278
1996	0.133	0.377	0.460	0.549	0.549	0.419
1997	0.084	0.553	0.656	0.763	0.761	0.605
1998	0.046	0.285	0.339	0.394	0.394	0.312
1999	0.036	0.373	0.460	0.481	0.482	0.416
2000	0.017	0.556	0.657	0.665	0.663	0.607
2001	0.037	0.483	0.587	0.608	0.608	0.535
2002	0.020	0.672	0.793	0.802	0.800	0.733
2003	0.037	0.445	0.543	0.564	0.564	0.494
2004	0.030	0.907	1.073	1.087	1.085	0.990
2005	0.001	1.187	1.021	1.102	1.103	1.104
2006	0.001	1.242	1.075	1.166	1.167	1.158
2007	0.000	0.750	0.622	0.647	0.645	0.686
2008	0.000	0.810	0.683	0.724	0.722	0.747
2009	0.000	0.779	0.670	0.722	0.722	0.724
2010	0.000	0.338	0.593	0.852	0.849	0.466
2011	0.000	0.219	0.382	0.547	0.546	0.301
2012	0.000	0.126	0.219	0.313	0.312	0.172
2013	0.000	0.543	0.944	1.347	1.344	0.743
2014	0.000	0.413	0.716	1.019	1.016	0.564
2015	0.000	0.364	0.630	0.895	0.892	0.497
2016	0.000	0.157	0.273	0.389	0.387	0.215
2017	0.001	0.705	1.223	1.743	1.739	0.964
2018	0.000	0.212	0.368	0.524	0.522	0.290
2019	0.000	0.049	0.086	0.123	0.122	0.068
2020	0.000	0.515	0.892	1.267	1.263	0.703
arith. mean	0.026	0.482	0.677	0.880	0.878	0.580

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

	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	0.213	0.126	0.695	0.411	1.161	0.686	1.161	0.686
1984	0.033	0.173	0.115	0.566	0.374	0.946	0.625	0.946	0.625
1985	0.022	0.181	0.075	0.589	0.246	0.984	0.411	0.984	0.411
1986	0.025	0.273	0.086	0.890	0.281	1.487	0.469	1.487	0.469
1987	0.008	0.055	0.028	0.179	0.091	0.298	0.152	0.298	0.152
1988	0.026	0.187	0.091	0.610	0.296	1.019	0.494	1.019	0.494
1989	0.076	0.500	0.127	0.601	0.153	0.703	0.179	0.703	0.179
1990	0.037	0.348	0.062	0.419	0.075	0.490	0.087	0.490	0.087
1991	0.071	0.364	0.118	0.438	0.142	0.512	0.166	0.512	0.166
1992	0.052	0.390	0.086	0.470	0.104	0.549	0.121	0.549	0.121
1993	0.081	0.267	0.135	0.322	0.162	0.376	0.190	0.376	0.190
1994	0.051	0.319	0.085	0.383	0.102	0.448	0.119	0.448	0.119
1995	0.043	0.157	0.073	0.189	0.087	0.221	0.102	0.221	0.102
1996	0.133	0.167	0.223	0.201	0.269	0.236	0.314	0.236	0.314
1997	0.084	0.354	0.140	0.426	0.168	0.498	0.197	0.498	0.197
1998	0.046	0.178	0.078	0.215	0.093	0.251	0.109	0.251	0.109
1999	0.036	0.140	0.268	0.168	0.321	0.171	0.327	0.171	0.327
2000	0.017	0.364	0.127	0.437	0.153	0.445	0.156	0.445	0.156
2001	0.037	0.225	0.268	0.270	0.322	0.275	0.328	0.275	0.328
2002	0.020	0.447	0.144	0.536	0.173	0.546	0.176	0.546	0.176
2003	0.037	0.194	0.269	0.233	0.323	0.238	0.329	0.238	0.329
2004	0.030	0.588	0.223	0.706	0.268	0.719	0.272	0.719	0.272
2005	0.001	0.581	0.607	0.496	0.518	0.529	0.552	0.529	0.552
2006	0.001	0.556	0.725	0.475	0.619	0.506	0.659	0.506	0.659
2007	0.000	0.598	0.000	0.511	0.000	0.544	0.000	0.544	0.000
2008	0.000	0.527	0.194	0.450	0.166	0.480	0.177	0.480	0.177
2009	0.000	0.389	0.386	0.332	0.329	0.354	0.351	0.354	0.351
2010	0.000	0.241	0.043	0.434	0.078	0.635	0.114	0.635	0.114
2011	0.000	0.162	0.016	0.293	0.028	0.429	0.041	0.429	0.041
2012	0.000	0.095	0.006	0.171	0.010	0.250	0.015	0.250	0.015
2013	0.000	0.403	0.045	0.726	0.080	1.063	0.118	1.063	0.118
2014	0.000	0.316	0.017	0.569	0.030	0.833	0.044	0.833	0.044
2015	0.000	0.284	0.004	0.512	0.008	0.749	0.012	0.749	0.012
2016	0.000	0.120	0.004	0.217	0.006	0.318	0.009	0.318	0.009
2017	0.001	0.525	0.059	0.947	0.106	1.386	0.155	1.386	0.155

	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	0.000	0.165	0.001	0.298	0.002	0.436	0.003	0.436	0.003
2019	0.000	0.038	0.000	0.069	0.000	0.102	0.000	0.102	0.000
2020	0.000	0.397	0.018	0.715	0.033	1.047	0.048	1.047	0.048
arith. mean	0.026	0.302	0.133	0.441	0.174	0.585	0.219	0.585	0.219

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

	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
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

	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	0.92	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
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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	158074	16256	14431	699	33
1984	47887	60736	3632	1884	55
1985	284653	18459	14274	559	192
1986	62145	110982	4480	2442	89
1987	35828	24155	24304	548	171
1988	176792	14163	6972	7322	220
1989	88517	68625	3364	1112	793
1990	158512	32691	11493	624	379
1991	110362	60871	6801	2769	271
1992	116043	40981	11780	1502	737
1993	228332	43923	7976	2619	550
1994	109306	83955	9210	1940	862
1995	77036	41406	17578	2236	762
1996	416172	29396	10315	5260	1041
1997	16087	145141	6235	2544	1741
1998	26467	5897	27766	1358	1029
1999	75439	10070	1431	8052	801
2000	43490	28987	2101	346	2572
2001	132993	17033	5561	460	777
2002	10253	51101	3262	1214	327
2003	46668	4007	8874	633	359
2004	19249	17928	790	2007	271
2005	19241	7442	2499	118	404
2006	27032	7662	711	358	86
2007	41197	10763	667	94	66
2008	25410	16418	1855	158	45
2009	80369	10124	2502	395	50
2010	9437	32013	1463	510	105

	Age 0	Age 1	Age 2	Age 3	Age 4
2011	12789	3759	7557	346	139
2012	50386	5096	986	2163	146
2013	27845	20079	1445	325	846
2014	19281	11092	4024	254	174
2015	5445	7683	2495	872	86
2016	144917	2170	1805	585	214
2017	4078	57750	601	570	276
2018	11716	1624	10097	83	87
2019	69684	4669	431	2950	53
2020	31049	27770	1408	159	1295
2021		12372	5750	263	236

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

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	158141380	249343	140646	155664	0.722
1984	47870021	408634	70827	133343	0.614
1985	284715217	279021	134188	110546	0.546
1986	62146186	729160	83952	225470	0.765
1987	35819393	422562	238470	49070	0.176
1988	176706372	278751	188905	149466	0.592
1989	88543100	445320	54068	223507	0.690
1990	158457979	358610	112758	133874	0.452
1991	110331497	654165	182590	215508	0.531
1992	115988314	435054	136489	184033	0.525
1993	228260939	514683	163244	139826	0.443
1994	109342968	594799	135673	244939	0.445
1995	77052688	584611	237518	113899	0.253
1996	416334674	451991	228662	182562	0.430
1997	16094691	877164	117712	242094	0.544
1998	26456171	390689	301040	99814	0.282
1999	75451453	238135	155282	69427	0.448
2000	43488192	270271	72984	92908	0.540
2001	133018663	196839	85136	90200	0.542
2002	10252171	333860	45752	117388	0.650
2003	46688106	140240	99708	53710	0.510
2004	19249584	151674	36901	110546	0.892
2005	19249584	92730	33323	34396	1.101
2006	27044656	72273	14192	37860	1.187
2007	41202109	77071	10800	43090	0.555

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2008	25418810	117590	24367	35604	0.668
2009	80357822	90144	26344	35687	0.718
2010	9435597	205142	23435	51670	0.398
2011	12787773	116978	77111	24896	0.250
2012	50374719	89241	46212	10594	0.141
2013	27840434	146256	28424	47814	0.627
2014	19288122	104842	40660	48033	0.465
2015	5443866	98287	41606	37902	0.404
2016	144964581	41035	30364	5230	0.174
2017	4077522	336480	21820	141314	0.818
2018	11710542	107067	83200	20239	0.233
2019	69650470	87561	51534	5090	0.054
2020	31046604	224808	47240	72612	0.581
2021			61329		
arith. mean	79478481	289818	94472	99732	0.525
geo. mean	47063109				

arith. mean for the period 1983–2020

geo. mean for the period 1983–2019

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2021)	19648.759	12371.6	5749.69	263.042	236.226
Exploitation pattern 1st half		0.397	0.715	1.047	1.047
Exploitation pattern 2nd half	0.000	0.018	0.033	0.048	0.048
Weight in the stock 1st half		5.497	10.949	14.321	16.739
Weight in the catch 1st half		5.497	10.949	14.321	16.739
weight in the catch 2nd half	5.423	8.173	11.924	12.738	15.609
Proportion mature(2021)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2022)	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: Fsq = F(2020) = 0.5814; Yield(2020) = 72.612; Recruitment(2020) = 31.046604; Recruitment(2021) = geometric mean (GM 2010-2019) = 19.648759 billions; SSB(2021) = 61.329

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
$SSB_{2022} \geq$ MSY $B_{escapement}$ with F_{cap}	0	0	72623	18.415	-100%	-100.000
Other scenarios						
F = 0	0	0	72623	18.415	-100%	-100.000
SSB_{2022} = MSY $B_{escapement}$ = B_{pa}	0	0	72623	18.415	-100.000	-100.000
B_{lim}	25615	0.26	56000	-8.689	-59.119	-59.119
$F_{2021} = F_{sq}$	49562	0.58	40867	-33.364	-20.901	-20.901
5000 t monitoring TAC	5000	0.045	69351	13.080	-92.020	-92.020

* SSB_{2021} relative to SSB_{2020}.

** Catch scenario for 2021 relative to TAC in 2020 (62 658 t).

*** Advice value 2021 relative to advice value 2020 (62 658 t).

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

	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
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	17857	0	2268	0	482	0	1643	0
arith. mean	3436	11339	999	3423	93	707	29	252	16

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

	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
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

	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
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	5.6	8.3	11.7	12.7	18.8	19.3	25.7	30.1	27.7
2016	1.5	4.0	3.1	12.4	5.0	19.8	6.8	32.1	7.4
2017	4.3	7.7	8.8	11.9	14.1	17.7	18.9	24.2	20.5
2018	3.9	5.8	7.0	9.9	10.7	13.5	13.6	20.6	15.2
2019	6.9	8.5	9.6	11.6	14.8	15.2	16.6	20.2	19.2
2020	0.0	9.3	0.0	15.6	0.0	20.1	0.0	22.0	0.0
arith. mean	4.6	7.0	9.2	12.5	15.4	18.2	20.4	23.1	22.2

Table 9.4.3 Sandeel Area-3r. Proportion mature.

	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

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

```
 Date: 01/22/21  Start time:09:53:17 run time:1 seconds


 objective function (negative log likelihood):  119.868
 Number of parameters: 60
 Maximum gradient: 3.0805e-005
 Akaike information criterion (AIC):   359.736
 Number of observations used in the likelihood:
                             Catch    CPUE    S/R Stomach     Sum
                              315      79      35      0      429


 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
              101.4    18.3    18.7    0.0     0.0     0.00      138



 unweighted objective function contributions (per observation):
               Catch   CPUE    S/R    Stomachs
               0.32    0.23    0.53    0.00



 contribution by fleet:
 ----------------------
 Acoustic survey           total:  13.733   mean:   0.286
 Dredge survey 2004-2020   total:   4.570   mean:   0.147


 F, season effect:
 -----------------
 age: 0
     1986-1998:   0.000 1.000
     1999-2020:   0.000 1.000
 age: 1 - 4
     1986-1998:   0.883 0.500
     1999-2020:   1.036 0.500


 F, age effect:
 --------------
               0      1      2      3      4
 1986-1998:  0.103  0.372  0.412  0.336  0.336
 1999-2020:  0.057  0.173  0.266  0.256  0.256



 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                        0      1      2      3      4
 1986-1998 season 1:    0   0.641  0.709  0.579  0.579
           season 2:  0.170  0.308  0.341  0.278  0.278


 1999-2020 season 1:    0   0.544  0.839  0.807  0.807
```

```
        season 2:  0.160  0.243  0.374  0.359  0.359
```

sqrt(catch variance) ~ CV:

```
             season
---------------------
age        1       2

 0                1.141
 1        0.678   1.036
 2        0.678   1.036
 3        1.019   1.226
 4        1.019   1.226
```

Survey catchability:

```
                          age 0    age 1    age 2    age 3    age 4
 Acoustic survey                   2.808    5.491    4.550    4.550
 Dredge survey 2004-2020   0.504   0.504
```

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 2004-2020     1.03    1.00
```

sqrt(Survey variance) ~ CV:

```
                          age 0    age 1    age 2    age 3    age 4
 Acoustic survey                    0.60     0.60     1.08     1.08
 Dredge survey 2004-2020    0.64    0.78
```

```
Recruit-SSB         alfa      beta      recruit s2     recruit s
Area-3r          1533.600   8.000e+004   1.070           1.035
```

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

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1986	0.076	0.453	0.495	0.403	0.404	0.474
1987	0.001	0.715	0.758	0.603	0.601	0.736
1988	0.051	0.917	0.974	0.785	0.784	0.946
1989	0.003	1.035	1.097	0.893	0.890	1.066
1990	0.050	0.581	0.623	0.507	0.506	0.602
1991	0.040	0.702	0.752	0.608	0.607	0.727
1992	0.003	0.326	0.345	0.272	0.273	0.336
1993	0.042	0.605	0.651	0.523	0.522	0.628
1994	0.016	0.647	0.691	0.545	0.541	0.669
1995	0.007	0.515	0.553	0.438	0.436	0.534
1996	0.043	0.504	0.546	0.435	0.435	0.525
1997	0.066	0.908	0.981	0.797	0.793	0.945
1998	0.140	1.151	1.254	1.022	1.016	1.202
1999	0.141	0.747	1.142	1.081	1.076	0.944
2000	0.004	0.770	1.142	1.047	1.040	0.956
2001	0.147	0.481	0.747	0.716	0.719	0.614
2002	0.000	0.506	0.743	0.710	0.706	0.625
2003	0.019	0.270	0.401	0.388	0.386	0.335
2004	0.019	0.188	0.281	0.272	0.272	0.234
2005	0.000	0.091	0.134	0.127	0.126	0.113
2006	0.000	0.039	0.057	0.054	0.054	0.048
2007	0.000	0.229	0.339	0.319	0.318	0.284
2008	0.000	0.247	0.366	0.350	0.349	0.306
2009	0.000	0.021	0.031	0.029	0.029	0.026
2010	0.000	0.268	0.400	0.378	0.376	0.334
2011	0.000	0.173	0.259	0.246	0.243	0.216
2012	0.000	0.105	0.157	0.151	0.150	0.131
2013	0.000	0.051	0.076	0.074	0.073	0.064
2014	0.000	0.204	0.304	0.293	0.291	0.254
2015	0.000	0.268	0.400	0.384	0.382	0.334
2016	0.000	0.105	0.157	0.151	0.150	0.131
2017	0.000	0.232	0.346	0.333	0.331	0.289
2018	0.000	0.248	0.370	0.356	0.353	0.309
2019	0.000	0.372	0.554	0.533	0.530	0.463
2020	0.000	0.641	0.953	0.917	0.911	0.797
arith. mean	0.025	0.438	0.545	0.478	0.476	0.491

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

	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	0.076	0.286	0.138	0.316	0.152	0.258	0.124	0.258	0.124
1987	0.001	0.577	0.002	0.639	0.002	0.521	0.002	0.521	0.002
1988	0.051	0.687	0.093	0.761	0.103	0.620	0.084	0.620	0.084
1989	0.003	0.864	0.006	0.957	0.007	0.780	0.005	0.780	0.005
1990	0.050	0.426	0.091	0.472	0.100	0.385	0.082	0.385	0.082
1991	0.040	0.541	0.072	0.599	0.079	0.489	0.065	0.489	0.065
1992	0.003	0.261	0.006	0.289	0.007	0.236	0.005	0.236	0.005
1993	0.042	0.450	0.076	0.498	0.084	0.406	0.068	0.406	0.068
1994	0.016	0.503	0.029	0.556	0.032	0.454	0.026	0.454	0.026
1995	0.007	0.409	0.013	0.453	0.014	0.369	0.012	0.369	0.012
1996	0.043	0.359	0.078	0.397	0.086	0.324	0.070	0.324	0.070
1997	0.066	0.672	0.120	0.743	0.132	0.606	0.108	0.606	0.108
1998	0.140	0.795	0.254	0.880	0.281	0.718	0.229	0.718	0.229
1999	0.141	0.480	0.214	0.740	0.330	0.711	0.317	0.711	0.317
2000	0.004	0.605	0.006	0.933	0.009	0.897	0.008	0.897	0.008
2001	0.147	0.252	0.222	0.389	0.342	0.374	0.328	0.374	0.328
2002	0.000	0.376	0.000	0.580	0.000	0.558	0.000	0.558	0.000
2003	0.019	0.187	0.029	0.288	0.045	0.277	0.043	0.277	0.043
2004	0.019	0.129	0.029	0.199	0.045	0.191	0.043	0.191	0.043
2005	0.000	0.070	0.000	0.108	0.000	0.104	0.000	0.104	0.000
2006	0.000	0.030	0.000	0.046	0.001	0.044	0.001	0.044	0.001
2007	0.000	0.182	0.000	0.280	0.000	0.269	0.000	0.269	0.000
2008	0.000	0.201	0.000	0.310	0.000	0.298	0.000	0.298	0.000
2009	0.000	0.017	0.000	0.026	0.000	0.025	0.000	0.025	0.000
2010	0.000	0.217	0.001	0.335	0.001	0.322	0.001	0.322	0.001
2011	0.000	0.138	0.000	0.213	0.000	0.205	0.000	0.205	0.000
2012	0.000	0.084	0.000	0.129	0.000	0.124	0.000	0.124	0.000
2013	0.000	0.041	0.000	0.063	0.000	0.061	0.000	0.061	0.000
2014	0.000	0.164	0.000	0.252	0.000	0.242	0.000	0.242	0.000
2015	0.000	0.216	0.000	0.332	0.000	0.319	0.000	0.319	0.000
2016	0.000	0.084	0.000	0.129	0.000	0.124	0.000	0.124	0.000
2017	0.000	0.186	0.000	0.287	0.000	0.276	0.000	0.276	0.000
2018	0.000	0.199	0.000	0.307	0.000	0.295	0.000	0.295	0.000
2019	0.000	0.300	0.000	0.463	0.000	0.445	0.000	0.445	0.000
2020	0.000	0.522	0.000	0.805	0.000	0.774	0.000	0.774	0.000
arith. mean	0.025	0.329	0.042	0.422	0.053	0.374	0.046	0.374	0.046

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

	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	0.350
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.340
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.340
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.320
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.290
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.280
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.290
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.310
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.320
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.340
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.350
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.360
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.330
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.300
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.370
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.490
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.610
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2019	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2020	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.165	0.712	0.571	0.565	0.463	0.419	0.405	0.386	0.388

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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1986	509547	80884	5591	273	692
1987	116894	123691	13592	1200	317
1988	359557	27943	18516	2531	423
1989	107723	73235	3525	2872	702
1990	197118	28397	9519	541	799
1991	124635	52141	5583	2320	454
1992	258379	35370	9401	1223	864
1993	190474	78345	8406	2902	893
1994	179393	58430	14088	1891	1217
1995	154365	58198	9647	2908	971
1996	750882	55823	10825	2202	1252
1997	64175	267325	10548	2457	1117
1998	93100	24429	37605	1699	812
1999	121047	30685	2735	4784	474
2000	132155	37144	4138	342	949
2001	124438	42959	4730	506	241
2002	31203	32697	5399	602	139
2003	70853	9212	4353	753	128
2004	45685	20516	1499	801	194
2005	78537	13364	3718	327	263
2006	114072	24868	2808	985	206
2007	60131	37211	5774	849	467
2008	92488	21042	8045	1482	436
2009	143306	34366	5287	2282	639
2010	15258	53244	11705	2158	1413
2011	11283	5026	14394	3504	1271
2012	79319	3364	1305	4409	1764
2013	203732	24130	895	422	2341
2014	220869	61980	6704	309	1148
2015	7331	67184	15227	1916	503
2016	665706	2230	15672	4018	752
2017	32198	202522	593	5066	1797
2018	224104	9795	48636	164	2232
2019	487420	68177	2323	13161	791
2020	232333	148283	14610	538	3794
2021		70681	25452	2403	883

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

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1986	509530362	563961	73865	282315	0.446
1987	116919942	985434	181680	395296	0.610
1988	359419217	458761	264342	330358	0.822
1989	107715064	540144	98716	350409	0.917
1990	197056294	329578	103673	163224	0.544
1991	124647461	542199	159054	274839	0.646
1992	258395005	350751	119850	86788	0.281
1993	190468998	662990	194464	175786	0.554
1994	179376947	625122	234685	267281	0.560
1995	154391169	473912	139804	173607	0.445
1996	751062929	740454	233515	159024	0.460
1997	64167025	1558000	186093	470670	0.834
1998	93082802	539525	334035	462081	1.106
1999	121084596	333193	109316	191253	0.882
2000	132090784	323214	67171	186837	0.776
2001	124398415	372014	74608	193684	0.602
2002	31202226	344587	73571	116298	0.478
2003	70844649	131166	69148	34673	0.275
2004	45672184	178041	30822	31285	0.201
2005	78530685	177469	63196	13991	0.089
2006	114033178	246715	58105	7094	0.038
2007	60128831	390143	101926	74972	0.231
2008	92525977	333436	142629	74933	0.256
2009	143235402	325833	102950	6261	0.022
2010	15263883	685717	252458	61241	0.277
2011	11285170	333177	253723	92452	0.176
2012	79319932	206126	169397	40116	0.107
2013	203667638	274588	59755	9844	0.052
2014	220851260	640406	109426	90876	0.208
2015	7333768	802634	220136	104631	0.274
2016	665467261	307037	252963	42845	0.107
2017	32184644	1694930	194464	115642	0.237
2018	224188999	584584	417483	75143	0.253

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2019	487597096	821969	258074	135899	0.382
2020	232406837	1697520	318061	246825	0.664
2021			319656		
arith. mean	179991717	559295	167863	158242	0.423
geo. mean	112335445				

arith. mean for the period 1986–2020

geo. mean for the period 1986–2019

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	112353.137	70680.7	25451.8	2402.56	883.364
Exploitation pattern 1st half		0.522	0.805	0.774	0.774
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.050	12.275	17.247	23.809
Weight in the catch 1st half		7.050	12.275	17.247	23.809
weight in the catch 2nd half	3.314	5.691	8.920	11.187	12.454
Proportion mature (2021)	0.000	0.036	0.766	1.000	1.000
Proportion mature (2022)	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: Fsq = F(2020) = 0.6638; Yield(2020) = 246.825; Recruitment(2020) = 232.406837; Recruitment(2021) = geometric mean (GM 1986-2019) = 112.353137 billions; SSB(2021) = 319.656

Basis	Total catch (2021)	F_{total} (2021)	SSB (2021)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
$SSB_{2022} \geq$ MSY $B_{escapement}$ with F_{cap}	161335	0.29	299368	-6.3	-39	4.0
Other scenarios						
F = 0	0	0	396106	24	-100	-100
$SSB_{2022} = B_{pa}$	468489	1.20	129000	-60	79	202
$SSB_{2022} = B_{lim}$	569582	1.76	80000	-75	117	267
F_{2020}	316361	0.66	207977	-35	21	104

* SSB_{2022} relative to SSB_{2021}.

** Catch scenario for 2021 relative to the TAC in 2020 (262 406 t – the sum of the Norwegian and EU TAC, 250 000t and 12 406 t, respectively).

*** Advice value 2021 relative to the advice value 2020 (155 072 t).

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

Year	Age 1	Age 2	Age 3	Age 4
2009	7709.06 (CV=0.29)	4923.33 (CV=0.34)	945.29 (CV=0.3)	64.03 (CV=0.47)
2010	16852.06 (CV=0.19)	6133.6 (CV=0.18)	1123.19 (CV=0.38)	608.57 (CV=0.4)
2011	816.16 (CV=0.73)	8622.2 (CV=0.19)	855.81 (CV=0.33)	192.37 (CV=0.49)
2012	846.68 (CV=0.81)	211.31 (CV=0.67)	3226.29 (CV=0.25)	368.16 (CV=0.24)
2013	2154.47 (CV=0.2)	258.25 (CV=0.36)	72.62 (CV=0.41)	554.48 (CV=0.43)
2014	21889.62 (CV=0.23)	1711.1 (CV=0.36)	170.41 (CV=0.64)	80.34 (CV=0.85)
2015	9466.6 (CV=0.12)	2254.92 (CV=0.27)	686.55 (CV=0.29)	7.03 (CV=1.18)
2016	79.55 (CV=1)	6317.38 (CV=0.29)	679.13 (CV=0.25)	259.1 (CV=0.37)
2017	35267.58 (CV=0.16)	131.65 (CV=0.77)	3465.88 (CV=0.27)	631.09 (CV=0.27)
2018	1544.39 (CV=0.31)	16989.62 (CV=0.1)	79.82 (CV=0.34)	440.33 (CV=0.31)
2019	9564.52 (CV=0.16)	464.24 (CV=0.25)	15573.73 (CV=0.12)	214.53 (CV=0.33)
2020	42141.65 (CV=0.27)	10064.47 (CV=0.27)	535.24 (CV=0.42)	9944.09 (CV=0.2)

Table 9.5.1 Sandeel Area-4. Catch at age numbers (million) by half 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
2014	0	346	0	54	0	15	0	47	0
2015	0	866	0	29	0	9	0	14	0

	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
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	2333	17	245	0	67	0	80	0
arith. mean	126	1156	169	967	147	613	25	259	48

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

	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	4.7	4.4	7.7	9.5	12.2	11.4	16.6	16.2	19.2
2016	4.7	5.0	7.7	9.9	12.2	18.1	16.6	24.7	19.2
2017	4.7	7.5	7.7	10.2	12.2	13.4	16.6	18.5	19.2

	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	3.3	5.7	4.8	9.4	7.6	13.1	11.1	18.3	13.9
2019	0.0	5.9	0.0	10.2	0.0	13.7	0.0	20.2	0.0
2020	2.7	6.6	7.3	8.6	10.5	12.0	13.6	12.4	14.7
arith. mean	3.6	5.6	7.5	9.4	12.9	13.2	15.6	17.1	20.5

Table 9.5.3 Sandeel Area-4. Proportion mature.

	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. No formal survey was in place before 2008, but surveys covering only Firth of Forth have been included for 1999-2003. Years were data is not available (NA) is either because of limited cover-age (2003, age 1) or no survey (2004-2007).

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	NA
2004	NA	NA
2005	NA	NA
2006	NA	NA
2007	NA	NA
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	585	1010

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

```
Date: 01/28/21  Start time:09:23:11 run time:1 seconds


objective function (negative log likelihood):  4.4314
Number of parameters: 47
Maximum gradient: 8.91362e-005
Akaike information criterion (AIC):   102.863
Number of observations used in the likelihood:
                          Catch    CPUE    S/R Stomach    Sum
                           252      35     28       0     315


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
             29.1   -25.6    20.0     0.0     0.0      0.00       23



unweighted objective function contributions (per observation):
             Catch    CPUE    S/R    Stomachs
             0.12    -0.73    0.71     0.00



contribution by fleet:
----------------------
Old Dredge survey 1999-2003     total:  -9.469   mean:  -1.052
New Dredge survey 2008-2020     total: -16.171   mean:  -0.622


F, season effect:
-----------------
age: 0
    1993-2020:   0.000 1.000
age: 1 - 4
    1993-2020:   0.599 0.500


F, age effect:
--------------
                0      1      2      3      4
1993-2020:  0.003  0.102  0.181  0.226  0.226



Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                       0      1      2      3      4
1993-2020 season 1:    0  0.641  1.130  1.411  1.411
          season 2: 0.004  0.083  0.147  0.183  0.183



sqrt(catch variance) ~ CV:
--------------------------
```

```
          season
        ----------------------
age       1       2


0                 2.004
1       0.717   0.377
2       0.717   0.377
3       0.732   1.256
4       0.732   1.256



Survey catchability:
--------------------
                        age 0    age 1
 Old Dredge survey 1999-2003     0.745   16.977
 New Dredge survey 2008-2020     0.518    3.059


sqrt(Survey variance) ~ CV:
--------------------------
                        age 0    age 1
 Old Dredge survey 1999-2003     0.30     0.30
 New Dredge survey 2008-2020     0.30     0.37


Recruit-SSB          alfa       beta      recruit s2    recruit s
Area-4            1585.112   4.800e+004    1.533         1.238
```

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

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0.002	0.327	0.561	0.683	0.682	0.444
1994	0.002	0.380	0.648	0.789	0.786	0.514
1995	0.000	0.112	0.191	0.230	0.229	0.151
1996	0.008	0.236	0.429	0.553	0.557	0.333
1997	0.001	0.140	0.243	0.298	0.297	0.191
1998	0.000	0.151	0.258	0.313	0.312	0.205
1999	0.000	0.218	0.371	0.447	0.445	0.295
2000	0.000	0.109	0.184	0.223	0.222	0.147
2001	0.000	0.170	0.289	0.350	0.348	0.230
2002	0.000	0.036	0.062	0.074	0.074	0.049
2003	0.001	0.271	0.462	0.561	0.559	0.367
2004	0.000	0.052	0.089	0.107	0.107	0.070
2005	0.000	0.023	0.039	0.047	0.047	0.031
2006	0.000	0.000	0.001	0.001	0.001	0.000
2007	0.000	0.000	0.000	0.001	0.001	0.000
2008	0.000	0.002	0.003	0.004	0.004	0.003
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.002	0.002	0.002	0.001

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2011	0.000	0.002	0.003	0.004	0.004	0.002
2012	0.000	0.017	0.030	0.036	0.035	0.023
2013	0.000	0.010	0.017	0.020	0.020	0.013
2014	0.000	0.013	0.022	0.026	0.026	0.017
2015	0.000	0.010	0.018	0.021	0.021	0.014
2016	0.000	0.020	0.034	0.041	0.041	0.027
2017	0.000	0.044	0.075	0.091	0.091	0.060
2018	0.000	0.126	0.215	0.259	0.258	0.171
2019	0.000	0.054	0.092	0.110	0.110	0.073
2020	0.000	0.043	0.073	0.088	0.087	0.058
arith. mean	0.000	0.092	0.157	0.192	0.192	0.125

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

	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	0.002	0.243	0.032	0.428	0.056	0.535	0.069	0.535	0.069
1994	0.002	0.285	0.030	0.503	0.053	0.628	0.066	0.628	0.066
1995	0.000	0.088	0.000	0.155	0.000	0.194	0.001	0.194	0.001
1996	0.008	0.105	0.160	0.185	0.282	0.231	0.352	0.231	0.352
1997	0.001	0.099	0.022	0.175	0.039	0.218	0.049	0.218	0.049
1998	0.000	0.116	0.006	0.205	0.010	0.256	0.013	0.256	0.013
1999	0.000	0.172	0.000	0.304	0.000	0.380	0.000	0.380	0.000
2000	0.000	0.085	0.000	0.150	0.000	0.188	0.000	0.188	0.000
2001	0.000	0.133	0.002	0.234	0.004	0.293	0.005	0.293	0.005
2002	0.000	0.028	0.000	0.050	0.000	0.063	0.000	0.063	0.000
2003	0.001	0.208	0.012	0.367	0.021	0.459	0.027	0.459	0.027
2004	0.000	0.041	0.000	0.072	0.001	0.090	0.001	0.090	0.001
2005	0.000	0.018	0.000	0.032	0.000	0.039	0.000	0.039	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.001	0.000	0.003	0.000	0.003	0.000	0.003	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	0.001	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.002	0.000	0.003	0.000	0.003	0.000
2012	0.000	0.014	0.000	0.024	0.000	0.030	0.000	0.030	0.000
2013	0.000	0.008	0.000	0.013	0.000	0.017	0.000	0.017	0.000
2014	0.000	0.010	0.000	0.018	0.000	0.022	0.000	0.022	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.018	0.000	0.018	0.000
2016	0.000	0.016	0.000	0.028	0.000	0.035	0.000	0.035	0.000
2017	0.000	0.035	0.000	0.061	0.000	0.077	0.000	0.077	0.000

	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	0.000	0.099	0.000	0.175	0.000	0.219	0.000	0.219	0.000
2019	0.000	0.042	0.000	0.074	0.000	0.093	0.000	0.093	0.000
2020	0.000	0.033	0.000	0.059	0.000	0.074	0.000	0.074	0.000
arith. mean	0.000	0.068	0.009	0.119	0.017	0.149	0.021	0.149	0.021

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

	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
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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1993	119348	22328	24139	7675	1680
1994	260863	38106	4361	5004	2265
1995	70960	83296	7143	841	1618
1996	384442	22694	19591	2055	917
1997	98763	121919	4475	4131	740
1998	43969	31549	27744	1215	1649
1999	235190	14058	7174	7522	988
2000	202006	75218	3040	1780	2571
2001	23996	64606	17745	879	1628
2002	88164	7674	14499	4701	843
2003	152682	28196	1916	4637	2303
2004	12507	48799	5812	437	1906
2005	9897	4000	12033	1817	977
2006	6263	3165	1009	3920	1199
2007	8661	2003	813	339	2272
2008	26359	2770	514	273	1194
2009	400538	8430	711	173	667
2010	69005	128100	2166	239	383
2011	46958	22069	32886	727	281
2012	42814	15018	5662	11030	447
2013	28874	13693	3806	1859	4900
2014	297508	9235	3491	1263	3020
2015	55825	95149	2349	1153	1902
2016	116198	17854	24248	779	1357
2017	130044	37162	4515	7929	934
2018	18334	41591	9222	1428	3623
2019	259495	5864	9674	2602	1843
2020	303835	82992	1444	3019	1814
2021		97172	20620	458	2007

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

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F$_{1-2}$
1993	119401223	598197	371759	132599	0.379
1994	260991918	582447	156686	158690	0.436
1995	70986480	854498	129444	52591	0.122
1996	384325343	431789	257816	158490	0.366
1997	98739932	908953	84881	58446	0.168
1998	43969202	519333	267533	58746	0.169
1999	235212519	304098	199985	53334	0.238
2000	202044797	383556	86682	37714	0.118
2001	23986459	356866	114921	47902	0.187
2002	88189635	174734	127007	12736	0.039
2003	152702173	205127	72042	63731	0.304
2004	12509514	269071	64151	6882	0.057
2005	9899551	116709	83952	1557	0.025
2006	6261936	105146	84626	0	0.000
2007	8658049	57513	46212	0	0.000
2008	26350558	39831	25642	0	0.002
2009	400410168	72159	21420	0	0.000
2010	69026428	686235	25668	0	0.001
2011	46969077	413384	244507	0	0.002
2012	42797917	218251	146093	2585	0.019
2013	28860949	219101	138690	5225	0.011
2014	297522378	190999	115844	4314	0.014
2015	55839943	481278	61390	4392	0.011
2016	116220522	377265	237518	6188	0.022
2017	129994149	448613	157787	18474	0.048
2018	18329090	410270	153277	42296	0.137
2019	259430655	206080	149941	6651	0.058
2020	303836413	622656	67914	19638	0.046
2021			201592		
arith. mean	125482093	366220	134308	34042	0.106
geo. mean	66852550				

arith. mean for the period 1993–2020

geo. mean for the period 1993–2019

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	73785.221	97172.1	20620.3	457.757	2007.24
Exploitation pattern 1st half		0.033	0.059	0.074	0.074
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.161	9.668	14.075	18.825
Weight in the catch 1st half		6.161	9.668	14.075	18.825
Weight in the catch 2nd half	3.067	5.496	8.484	11.591	13.385
Proportion mature (2021)	0.000	0.000	0.790	0.980	1.000
Proportion mature (2022)	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: Fsq = F(2020) = 0.0462; Yield(2020) = 19.637; Recruitment(2020) = 303.836413; Recruitment(2021) = geometric mean (GM 2010-2019) = 73.785221 billions; SSB(2021) = 201.592

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
$SSB_{2022} \geq$ MSY $B_{escapement}$ with F_{cap}	77512	0.15	266680	32.287	95.683	95.683
Other scenarios						
F = 0	0	0	307491	52.531	-100.000	-100.000
$SSB_{2022} =$ MSY $B_{escapement}$ = B_{pa}	419269	1.22	102000	-49.403	958.466	958.466
B_{lim}	555552	2.13	48000	-76.190	1302.520	1302.520
F = F_{2020}	24989	0.046	294232	45.954	-36.914	-36.914

* SSB_{2022} relative to SSB_{2021}.

** Catch scenario for 2021 relative to the TAC in 2020 (39 611 t).

*** Advice value 2021 relative to the advice value 2020 (39 611 t).

Table 9.6.1. Acoustic survey index (Area-5) is estimated as biomass (tonnes) methods and acoustic target strength described in ICES (2016) (Benchmark report).

Year	Biomass (tonnes)
2009	256.5
2010	6320.9
2011	3300.2
2012	732.2
2013	3949.1
2014	1331.8
2015	10477.6
2016	733.2
2017	493.1
2018	945.0
2019	3844.6
2020	3315.7

Table 9.9.1 Total catch weight by year for sandeel in ICES Division 6.a

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

Year	Denmark	Faroe Islands	Norway	UK-Scotland	Total
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
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
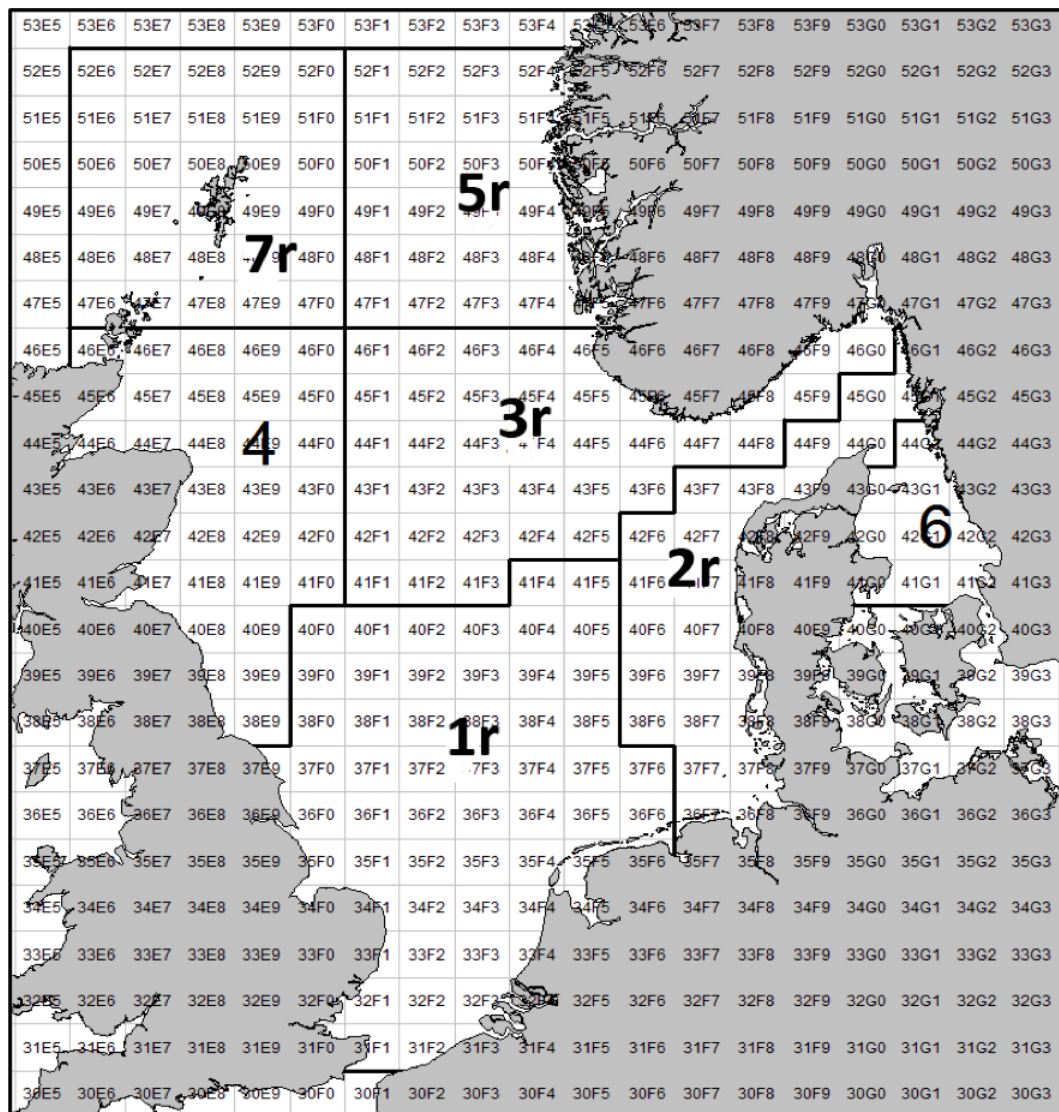
Figure 9.1.1 Sandeel in ICES div IV and IIIa. Sandeel management areas.
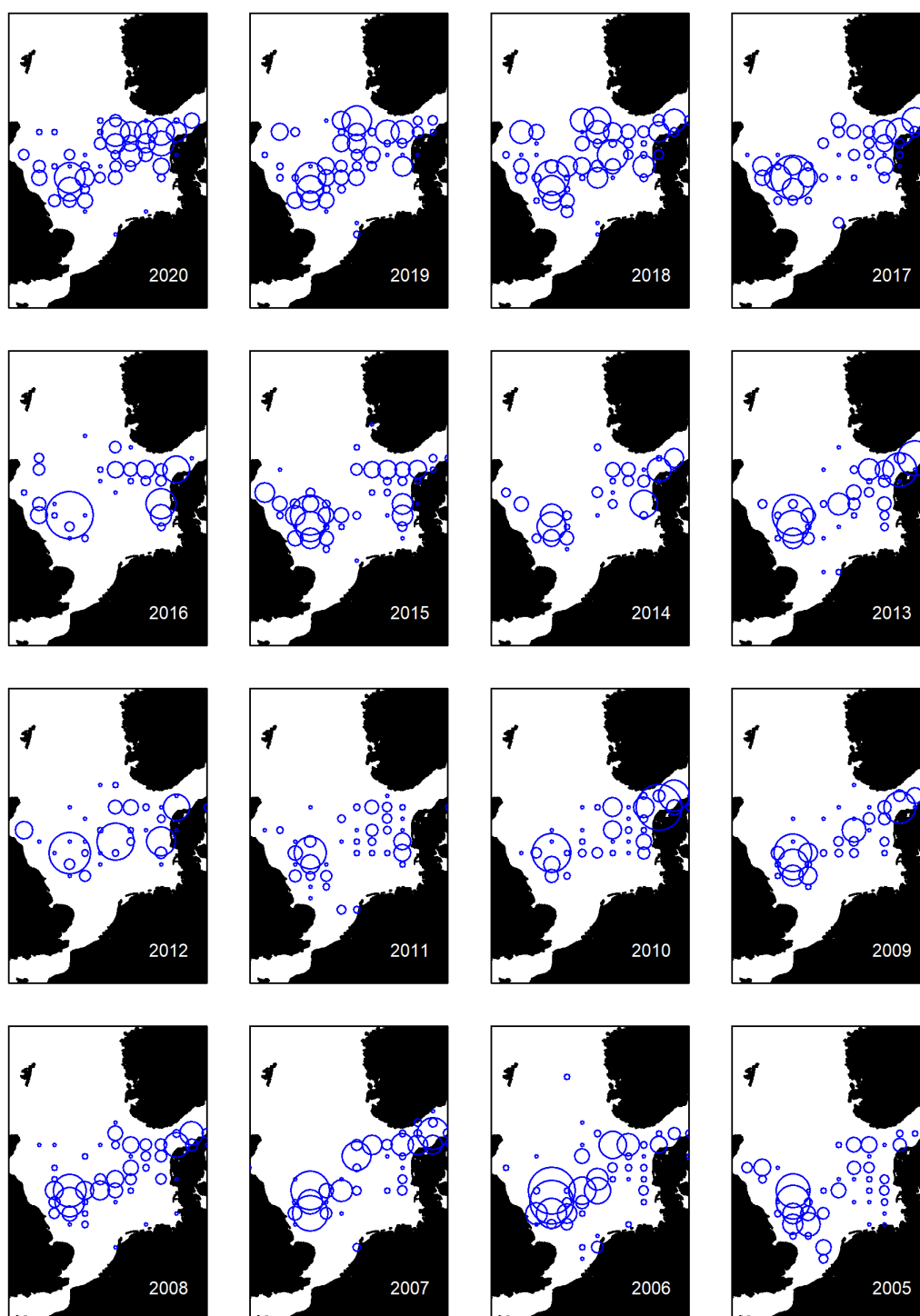
Figure 9.1.2 Sandeel in ICES div IV and IIIa. Catch by ICES rectangles 2005–2020 (upper, red circles). Number of samples per ICES square in commercial catches (lower, blue circles). Area of the circles is proportional to catch by rectangle.
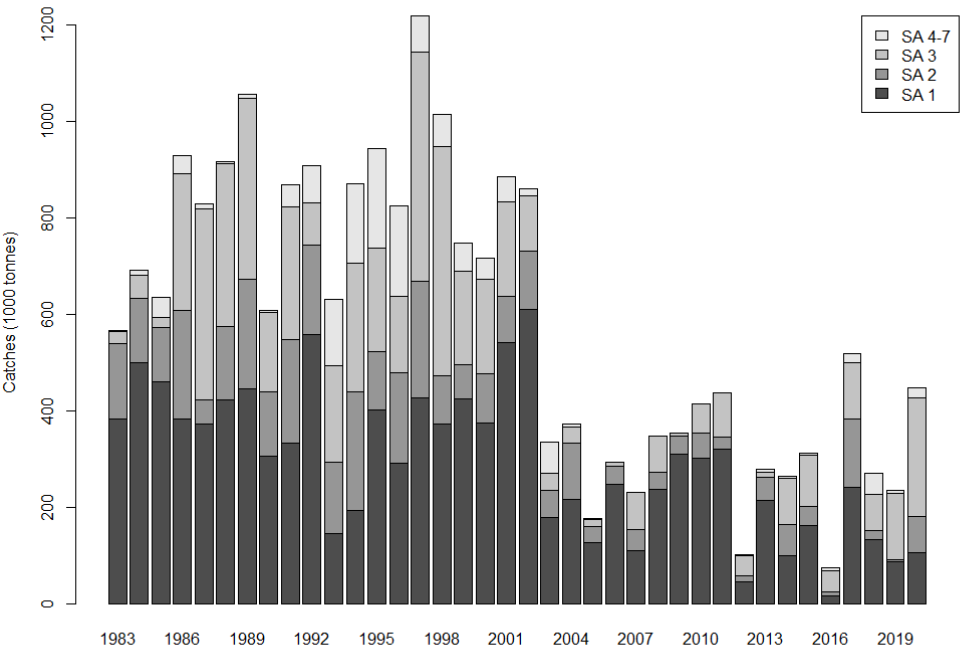
Figure 9.1.3 Sandeel in ICES div IV and IIIa. Total catches by year and area.
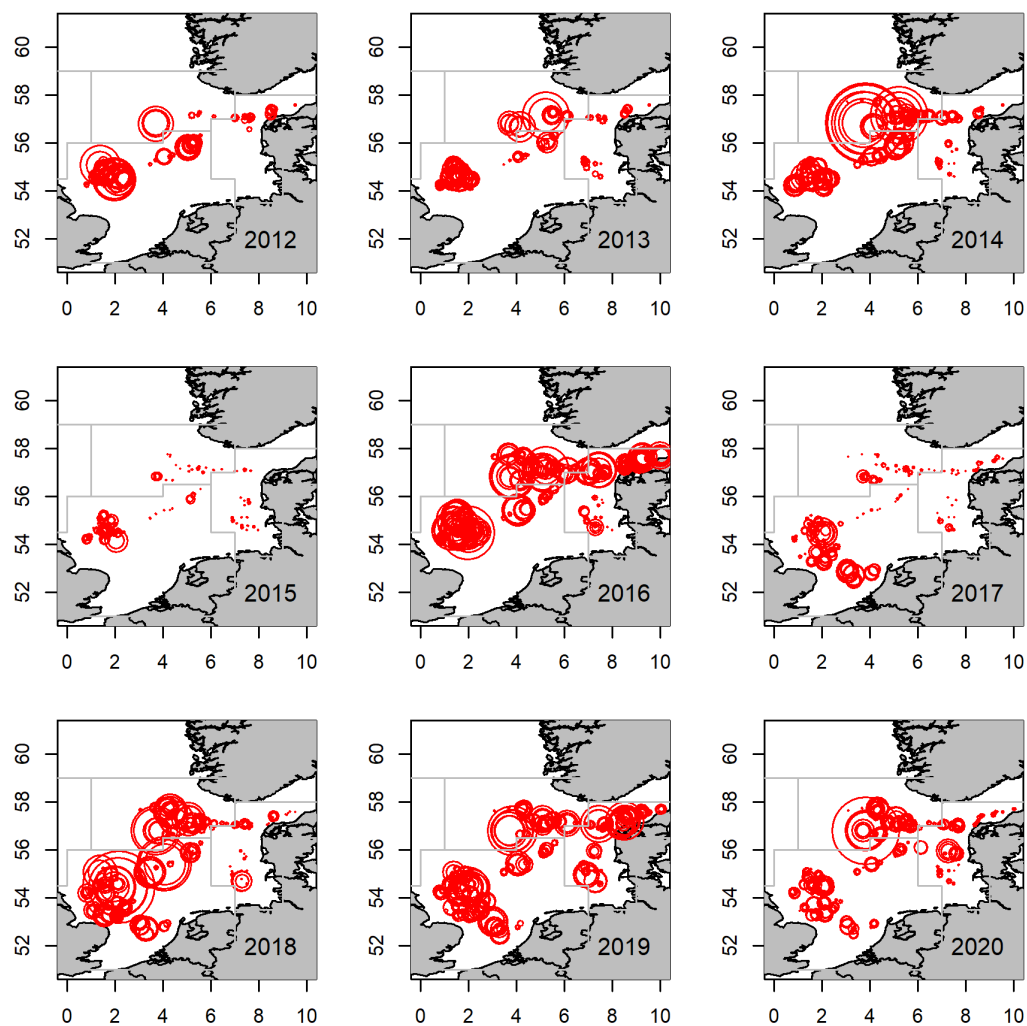
Figure 9.1.4 Sandeel in ICES div IV and IIIa. Danish survey catches by haul for 0-group. Area of the circles is proportional to catch number.
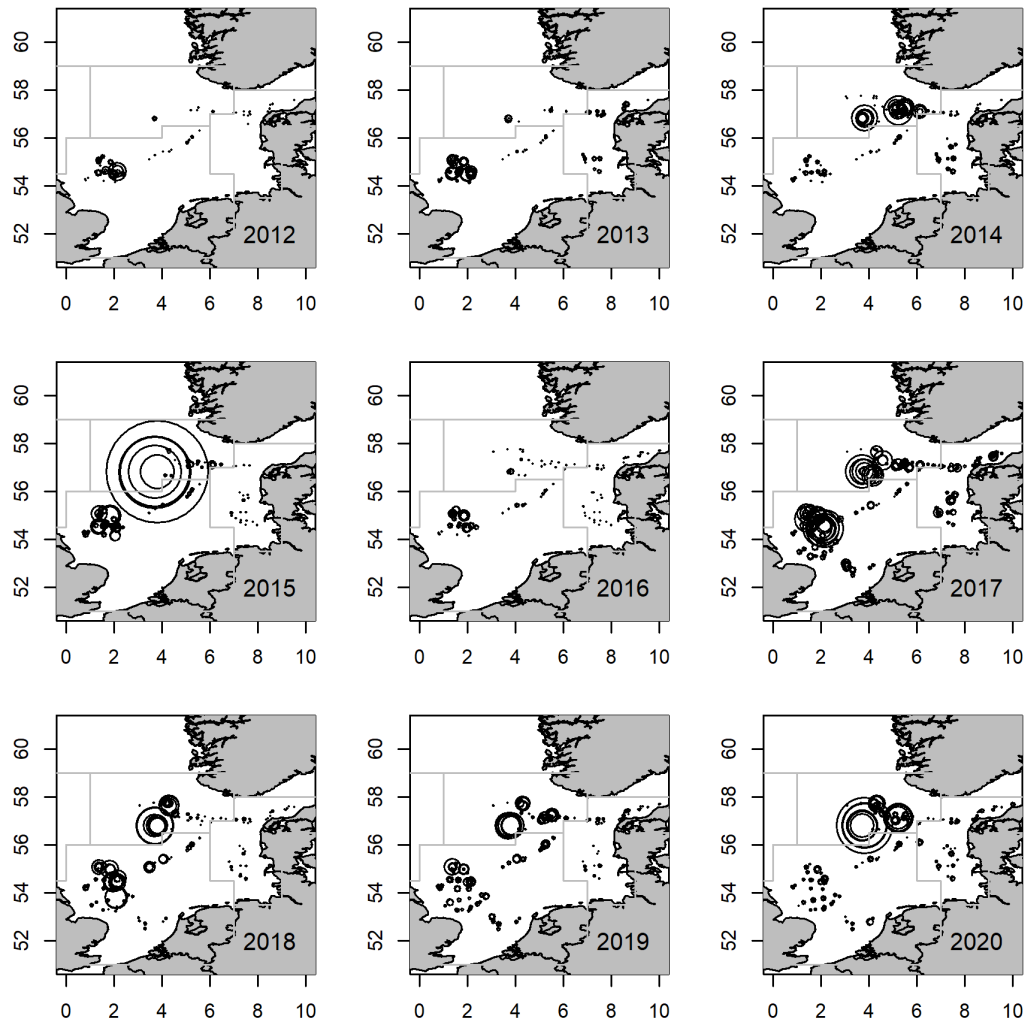
Figure 9.1.5 Sandeel in ICES div IV and IIIa. Danish survey catches by haul for 1-group. Area of the circles is proportional to catch number.
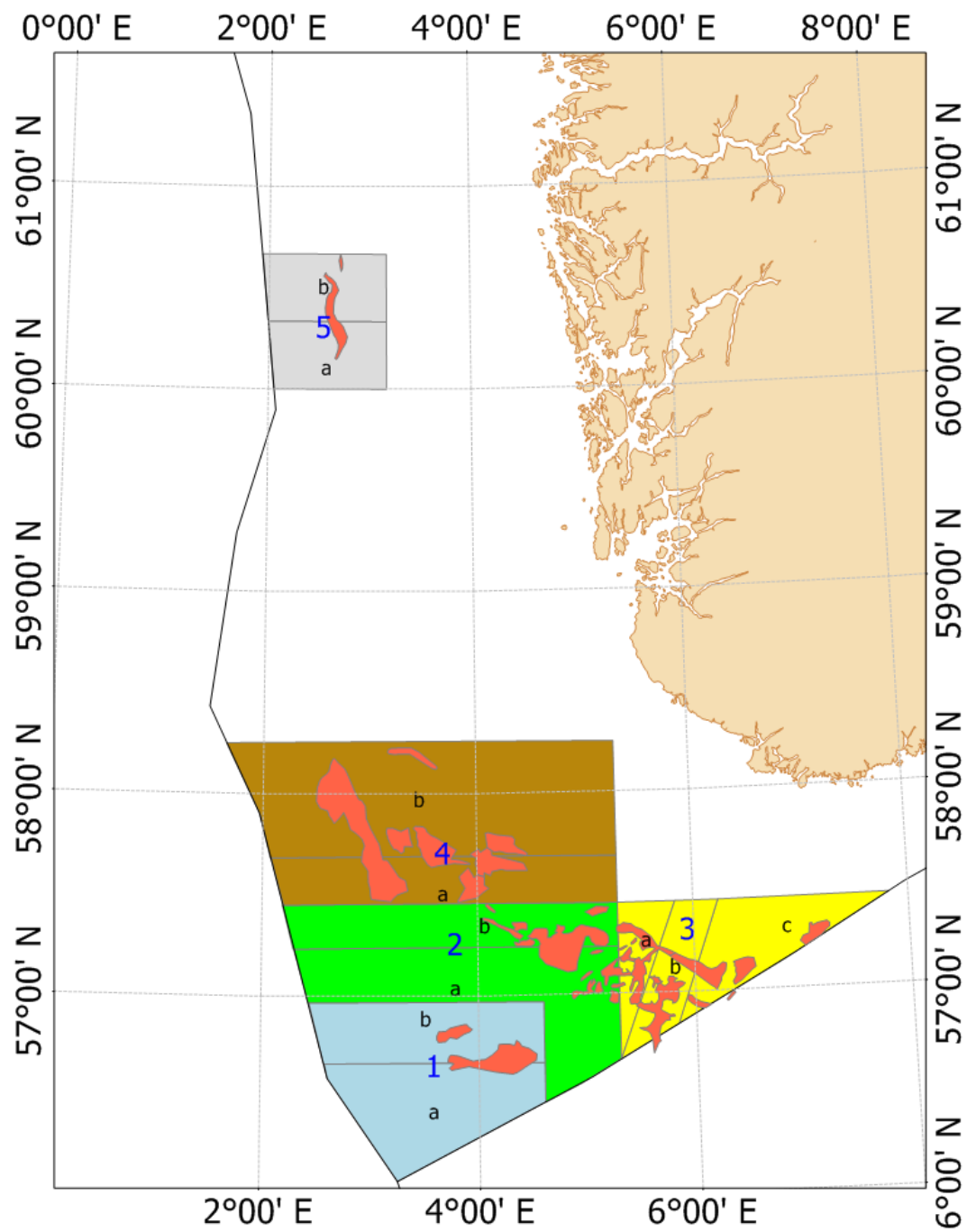
Figure 9.1.6 Sandeel in ICES div IV and IIIa. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.
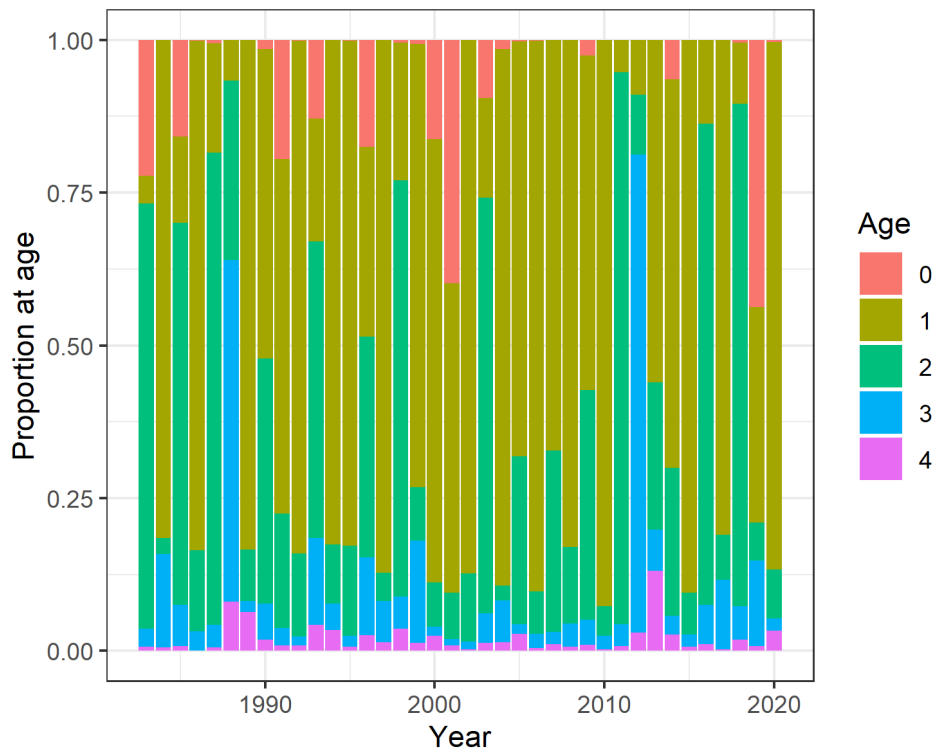
Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.
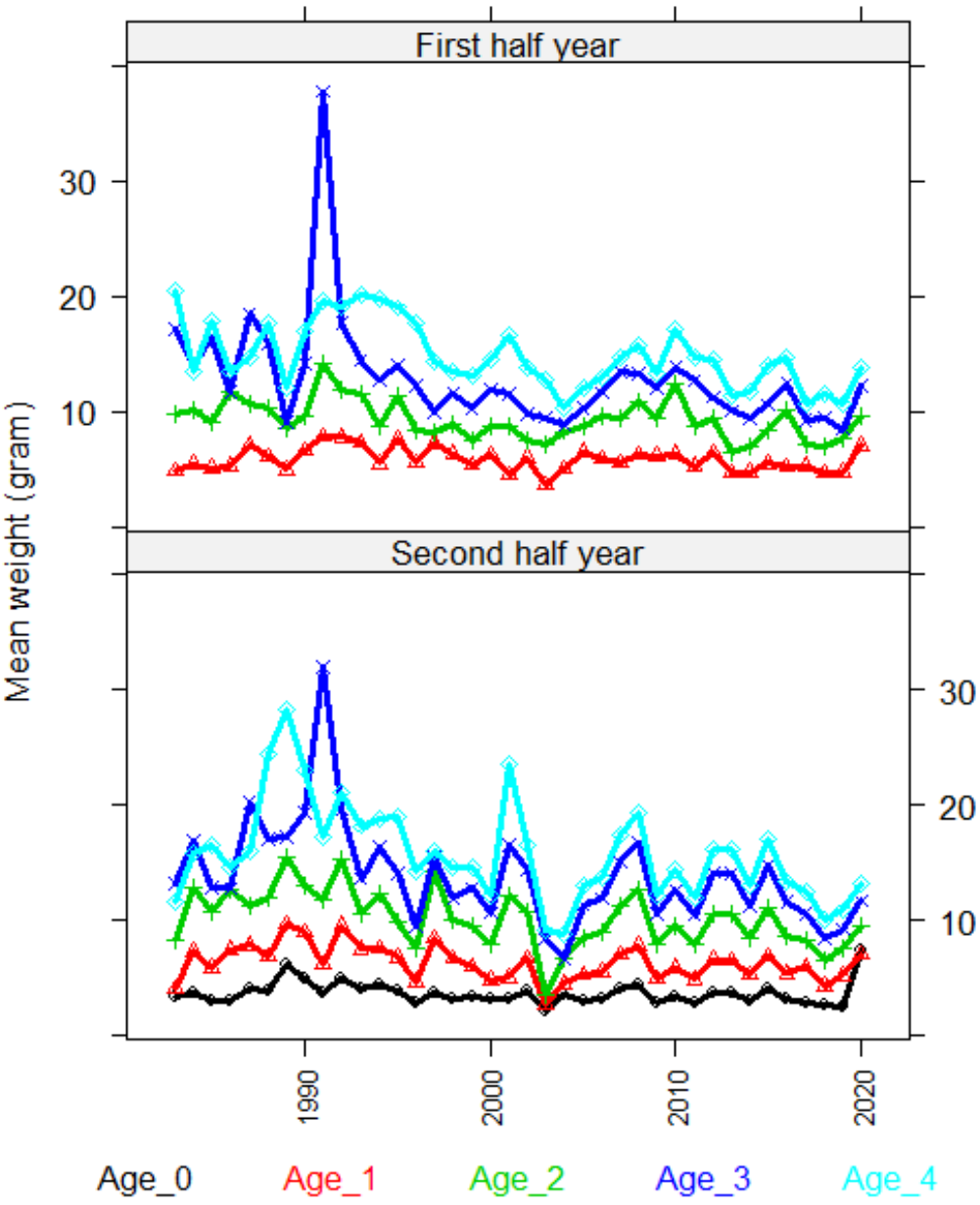
Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).
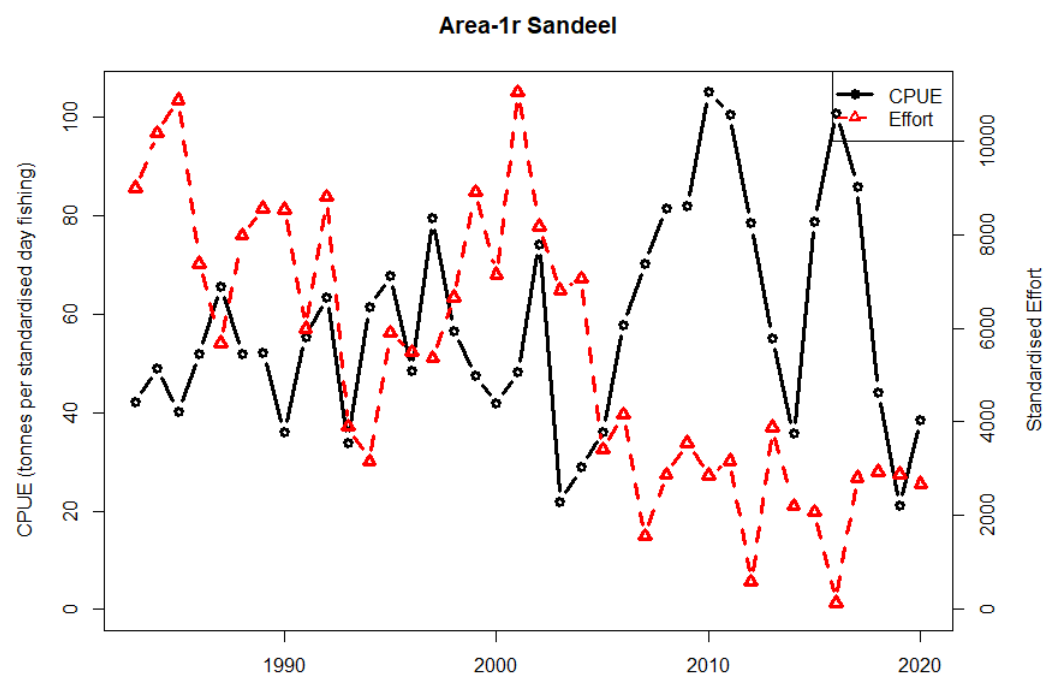
Area-1r Sandeel

Figure 9.2.3 Sandeel Area-1r. CPUE and effort.
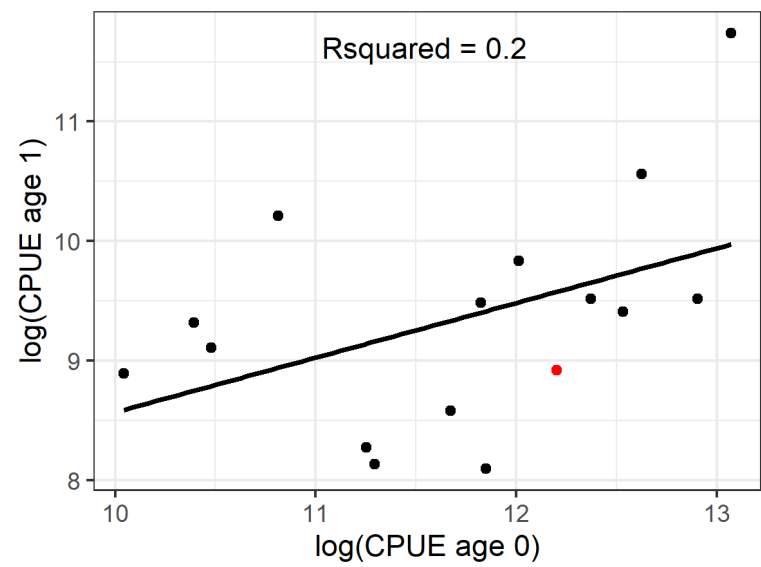
Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.
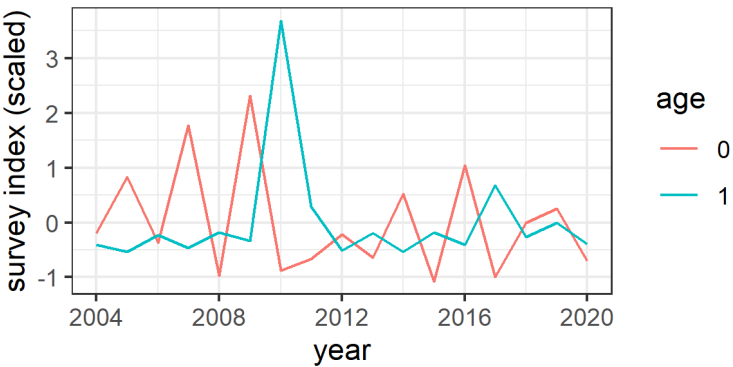
Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.
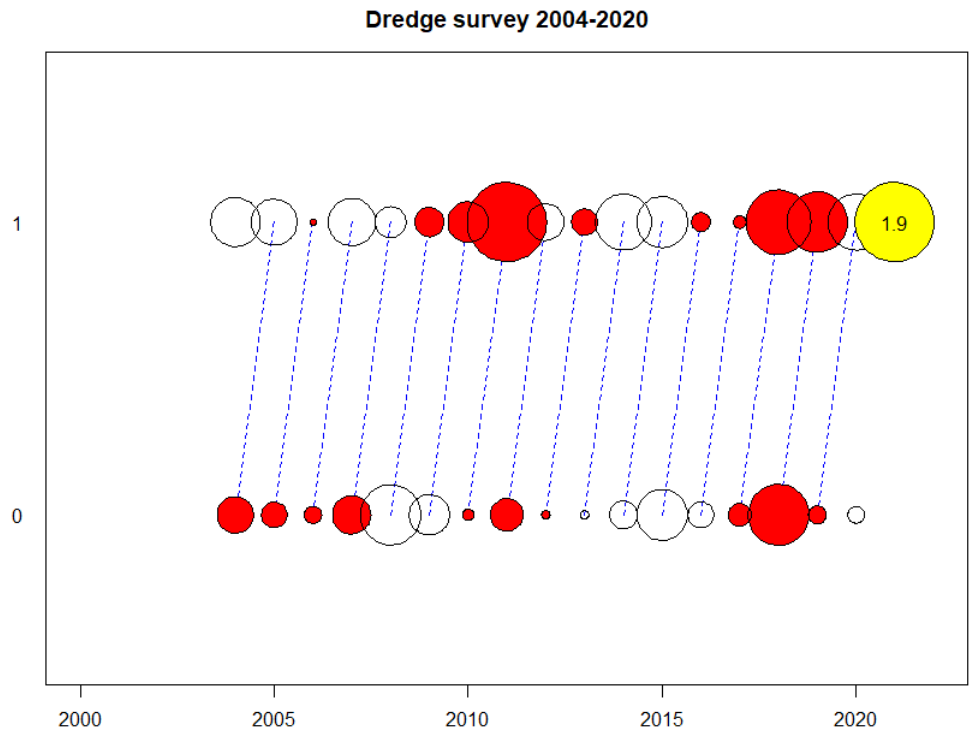
Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.
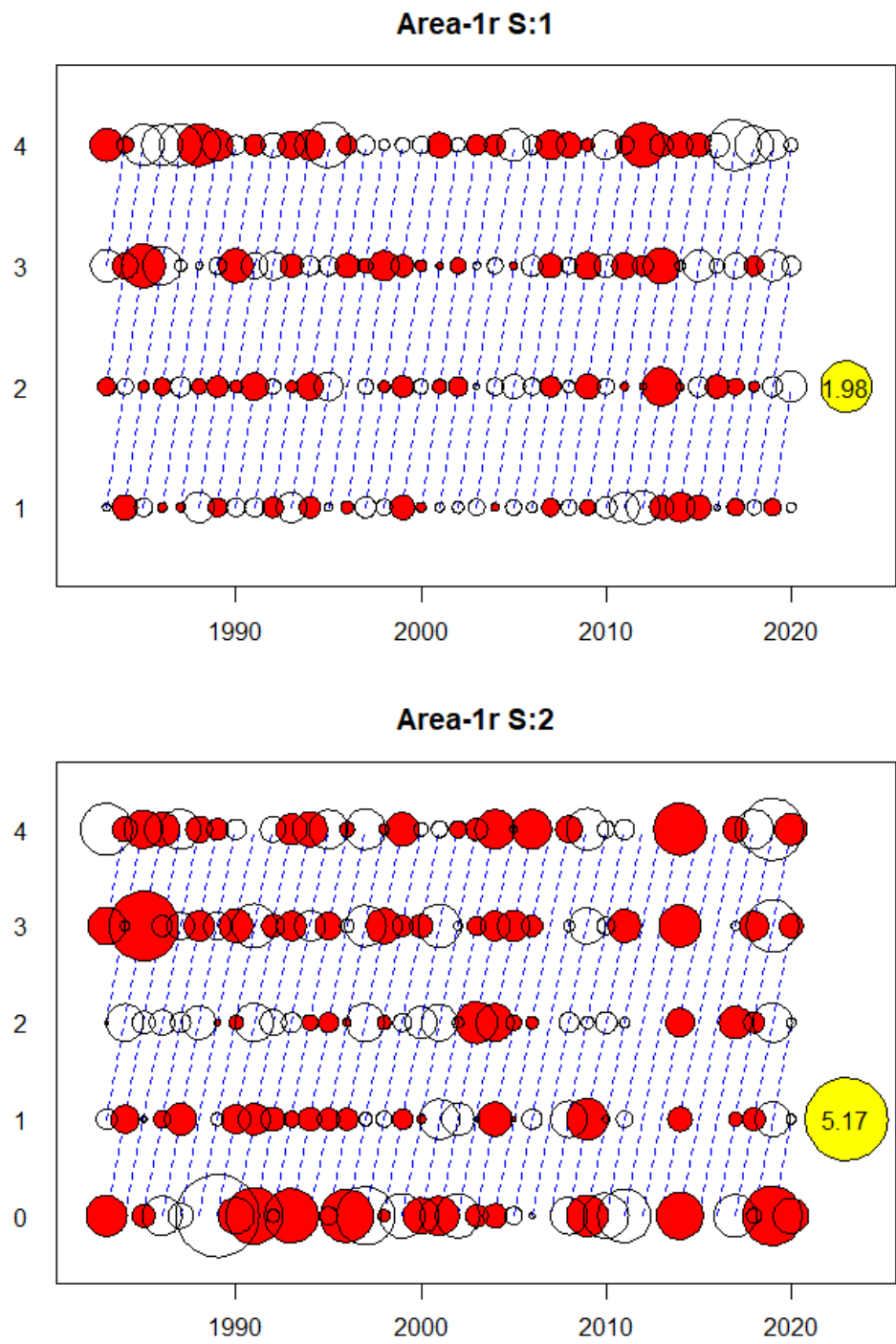
Figure 9.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.
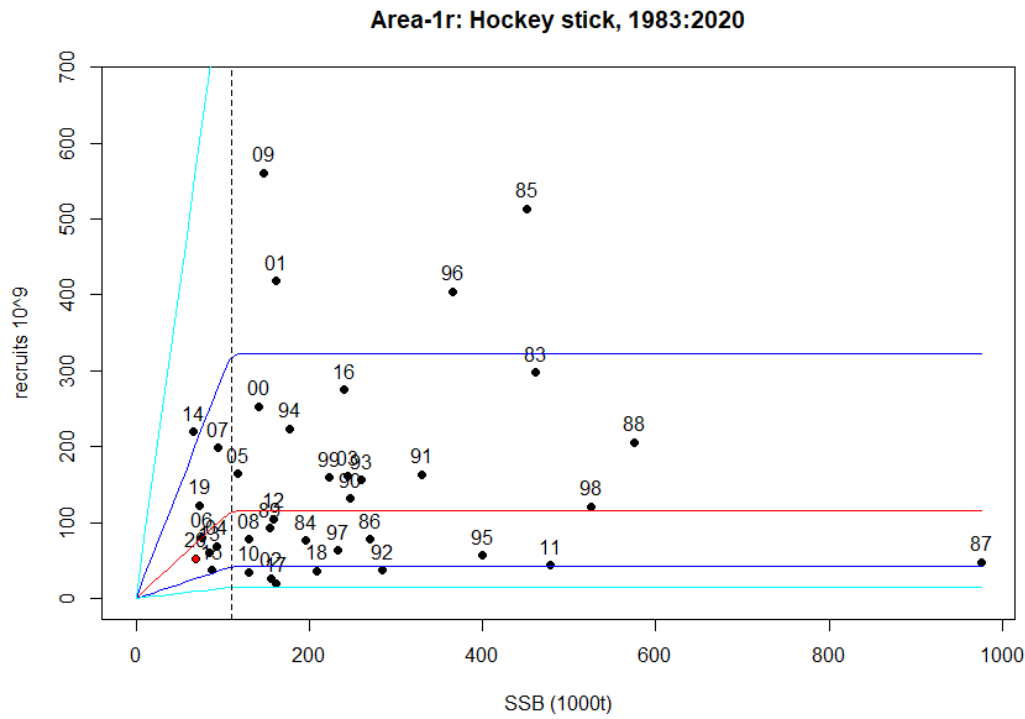
Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.
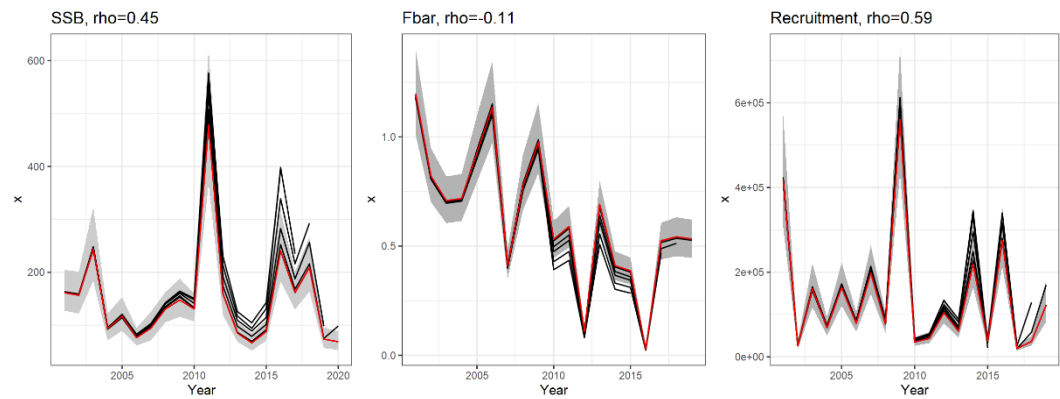
Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.
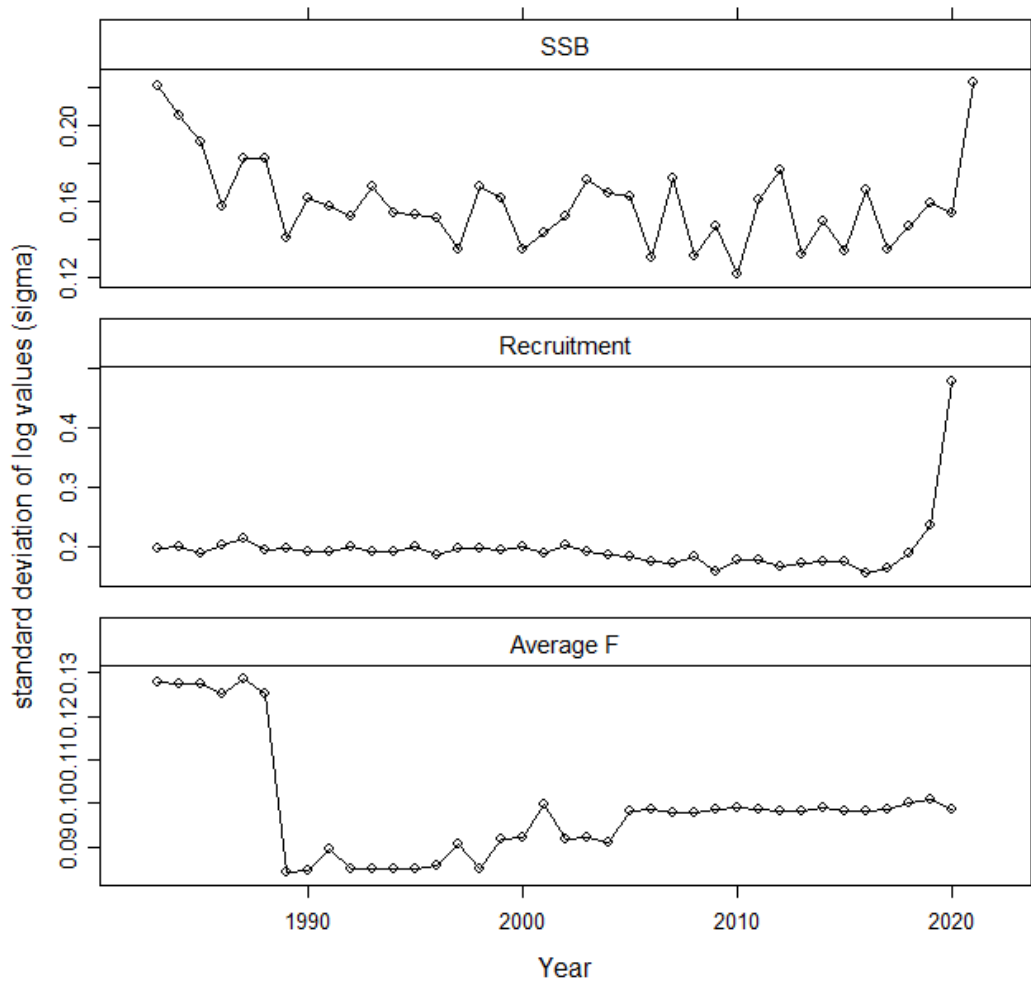
Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.
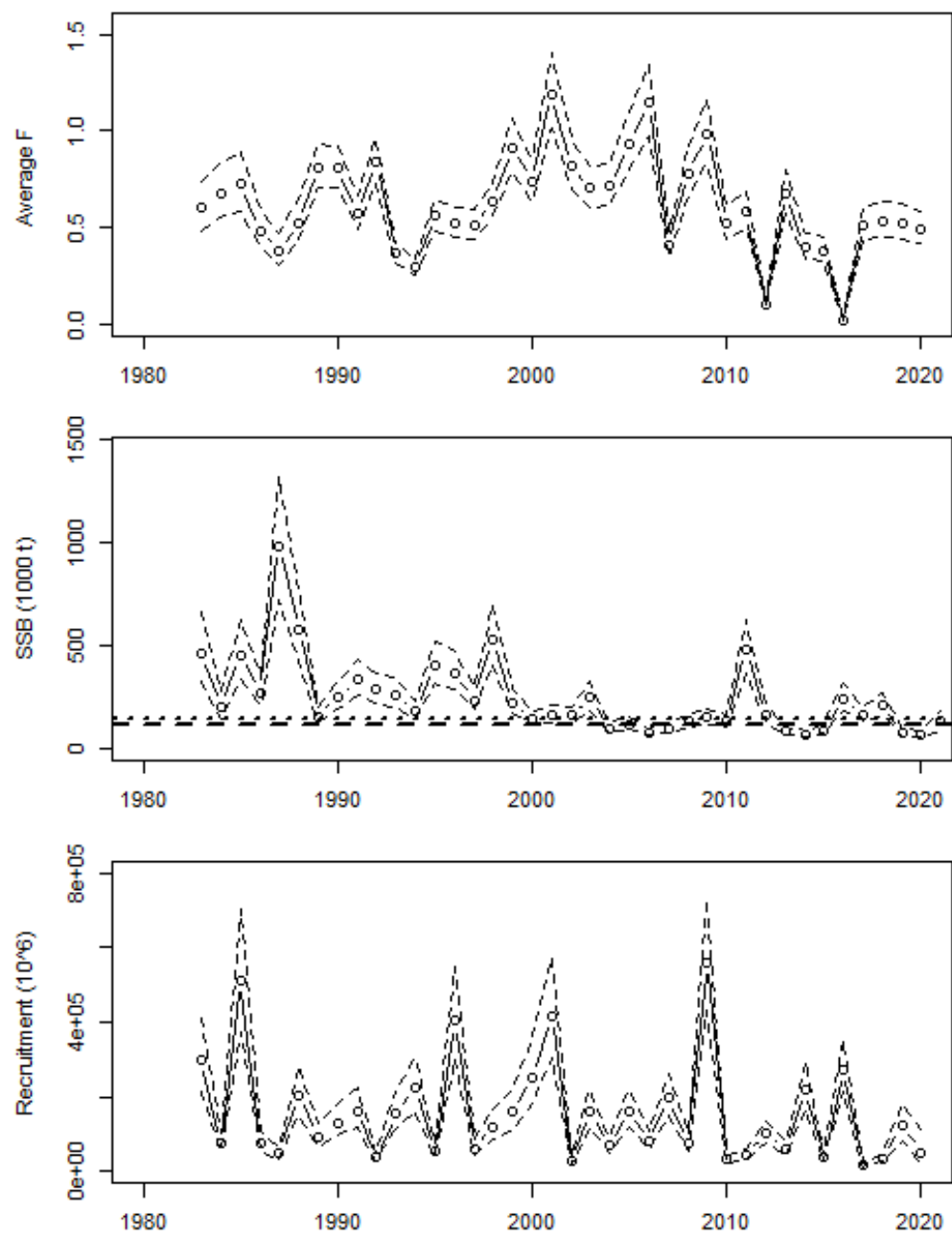
Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.
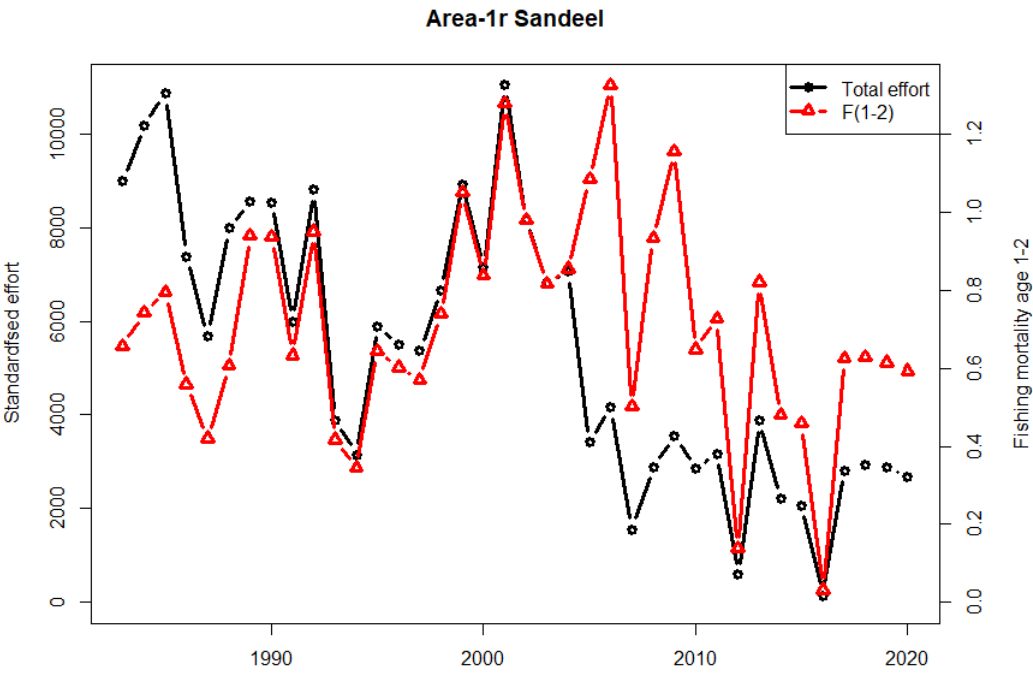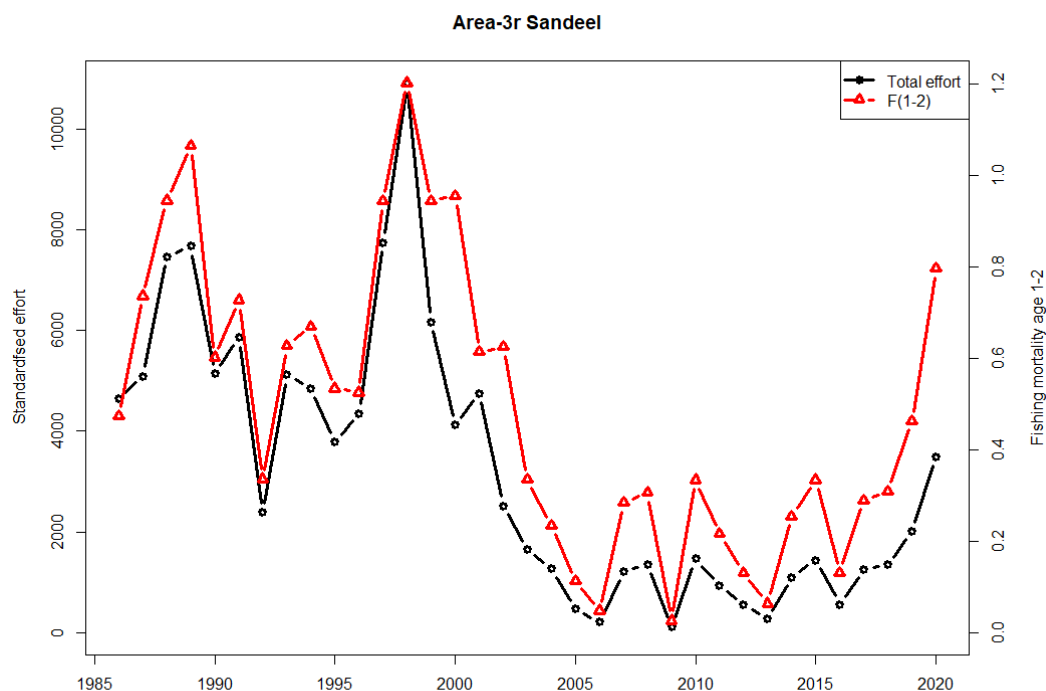
Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.
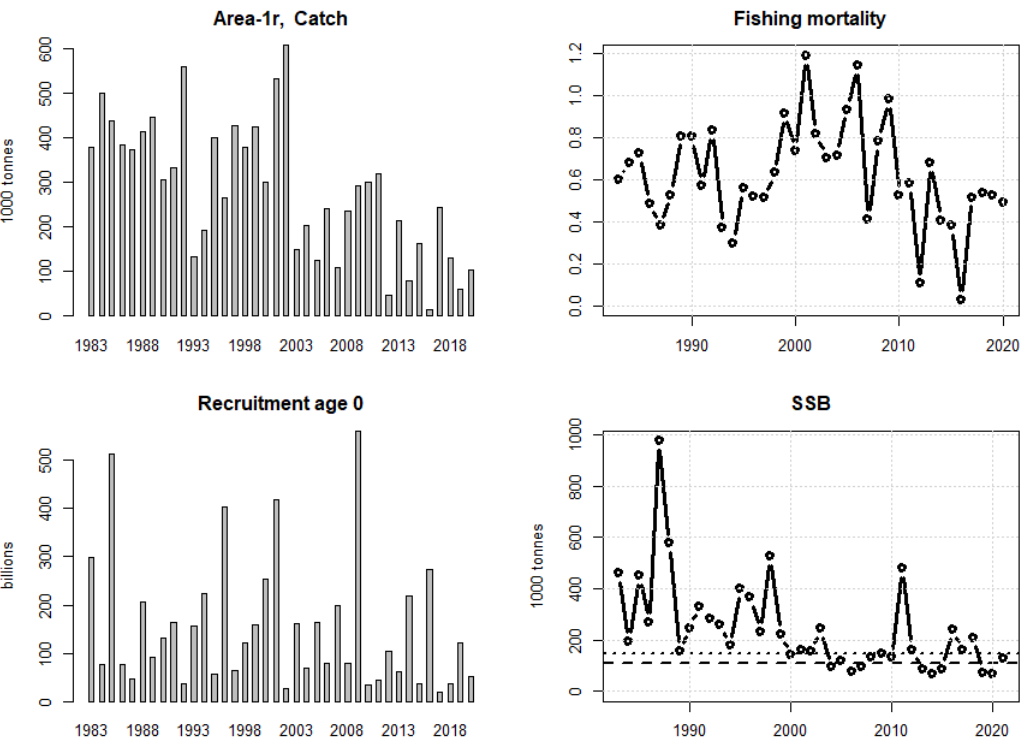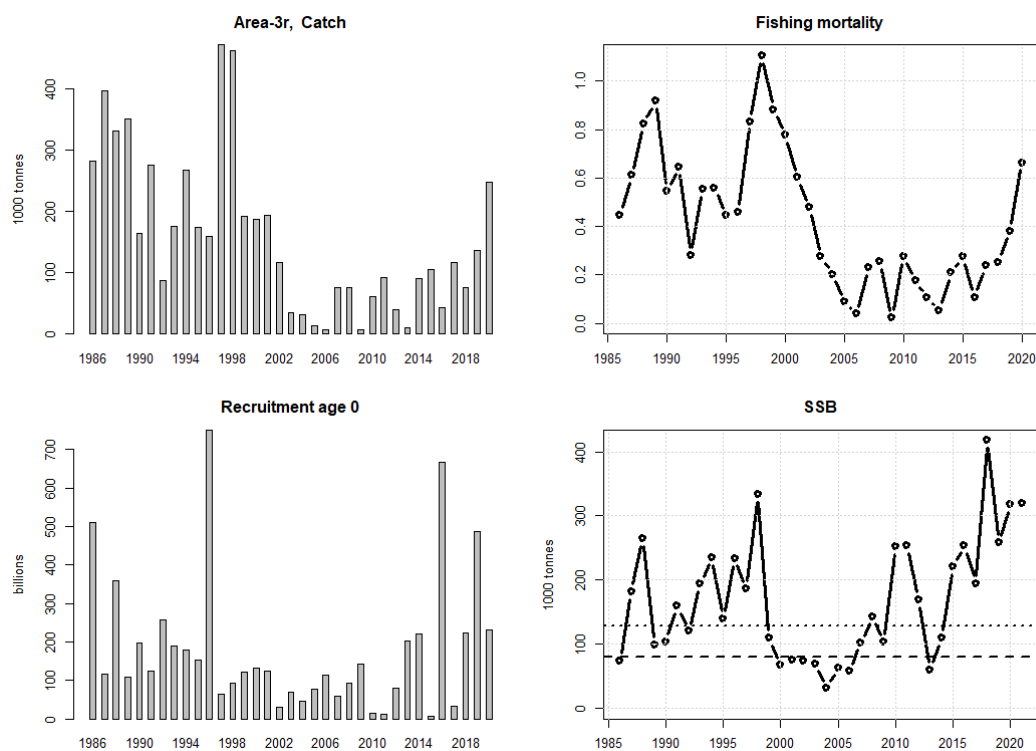

**Figure 9.2.13 Sandeel Area-1r. Stock summary.**

RTM 2007-2020
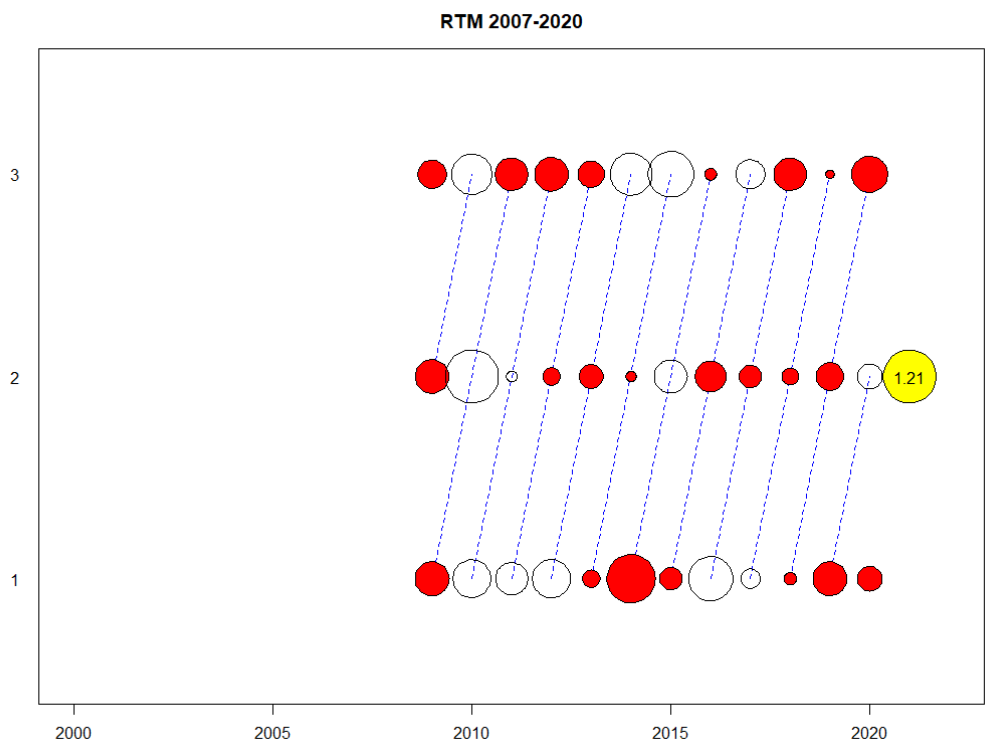
Figure 9.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.
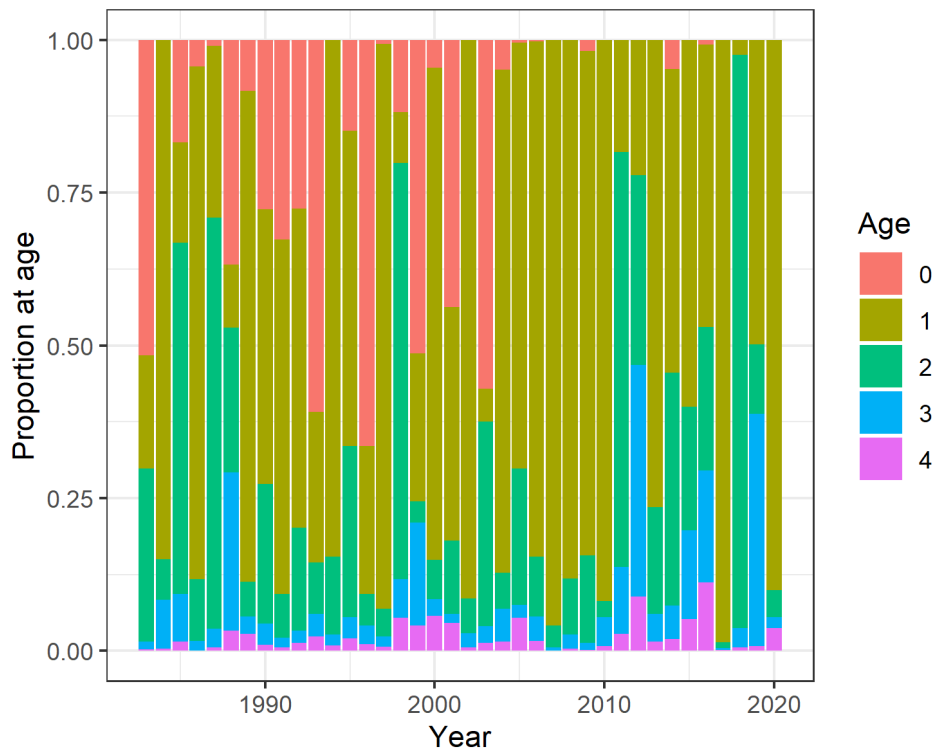
Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.
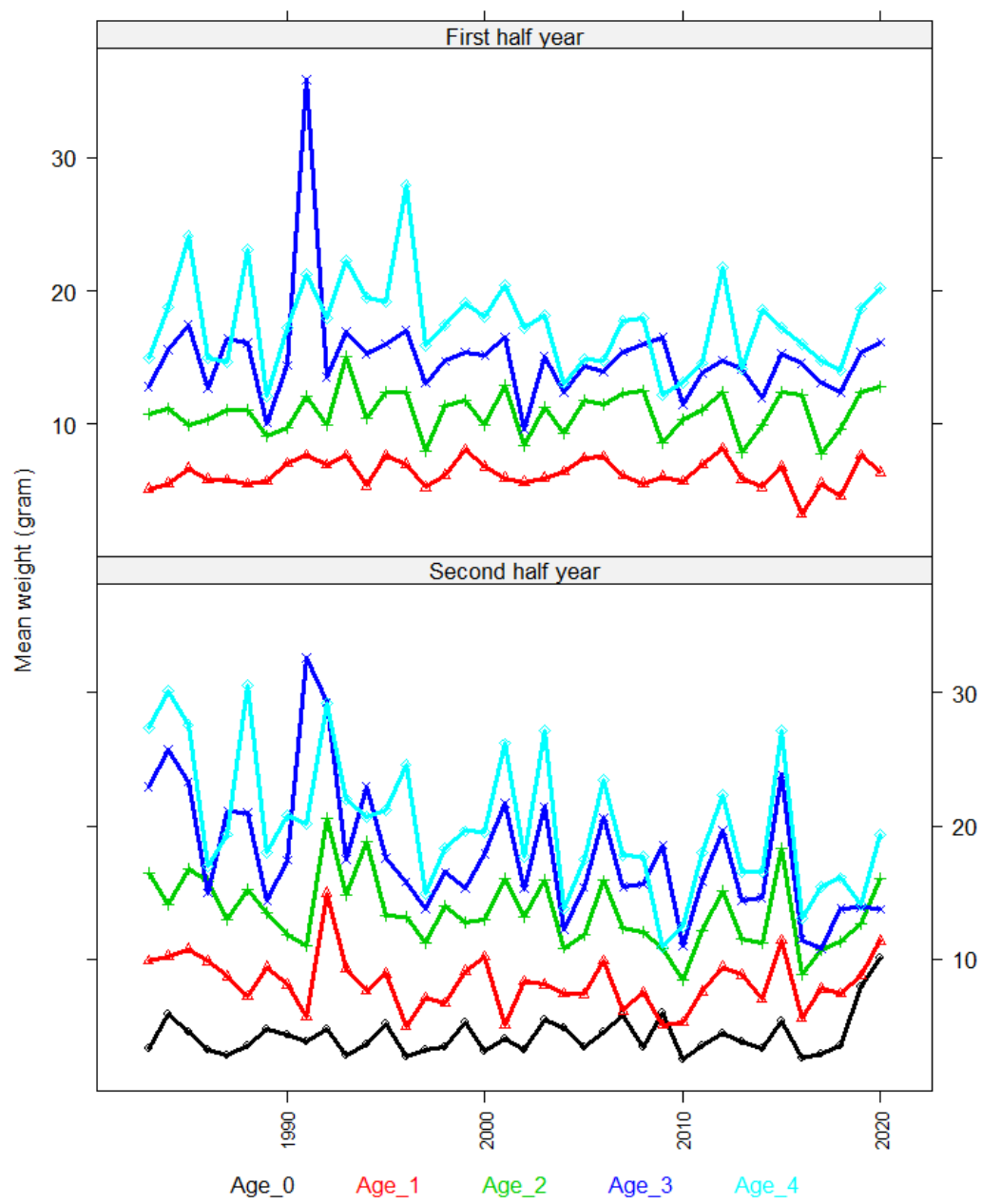
Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).
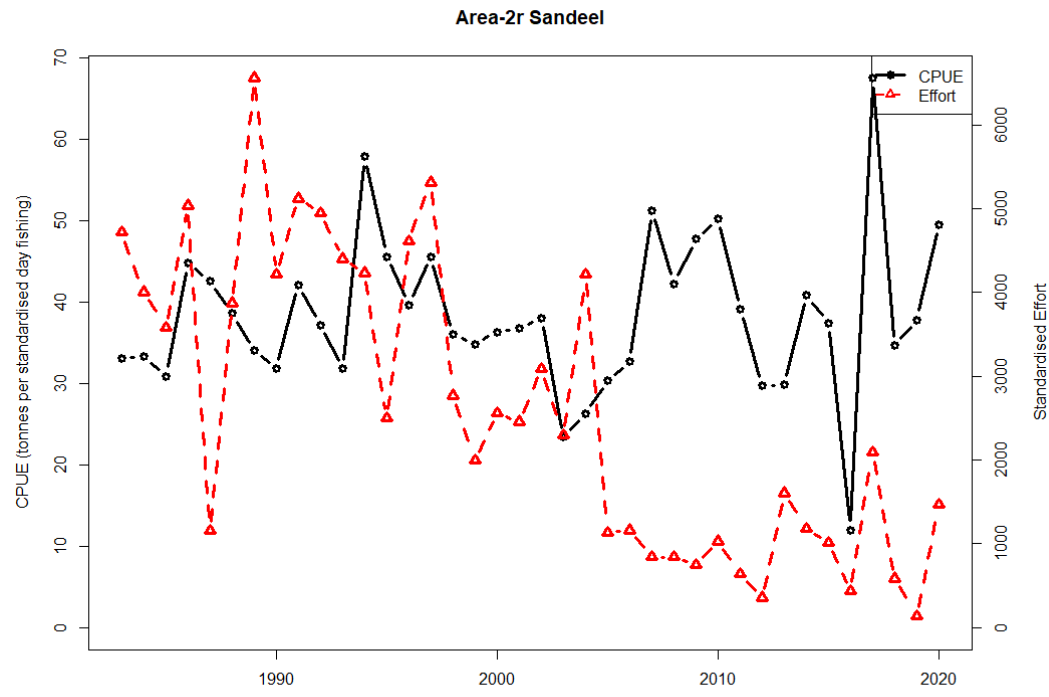
Figure 9.3.3 Sandeel Area-2r. CPUE and effort.
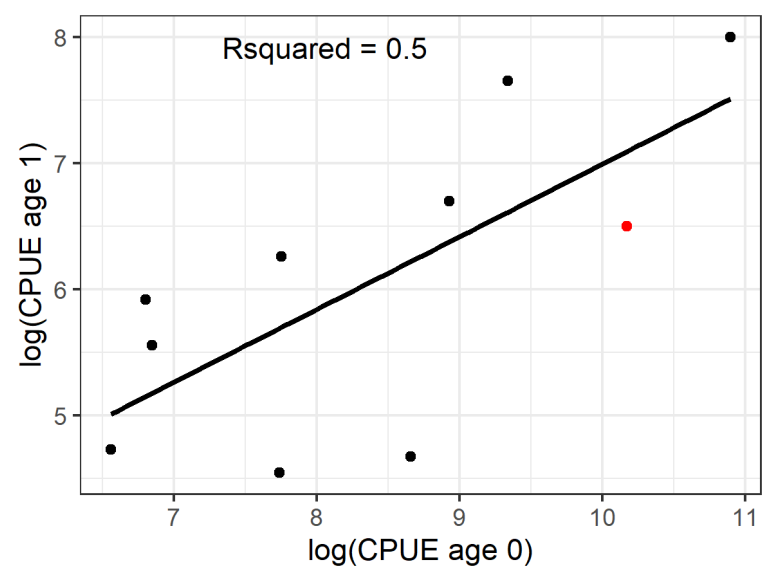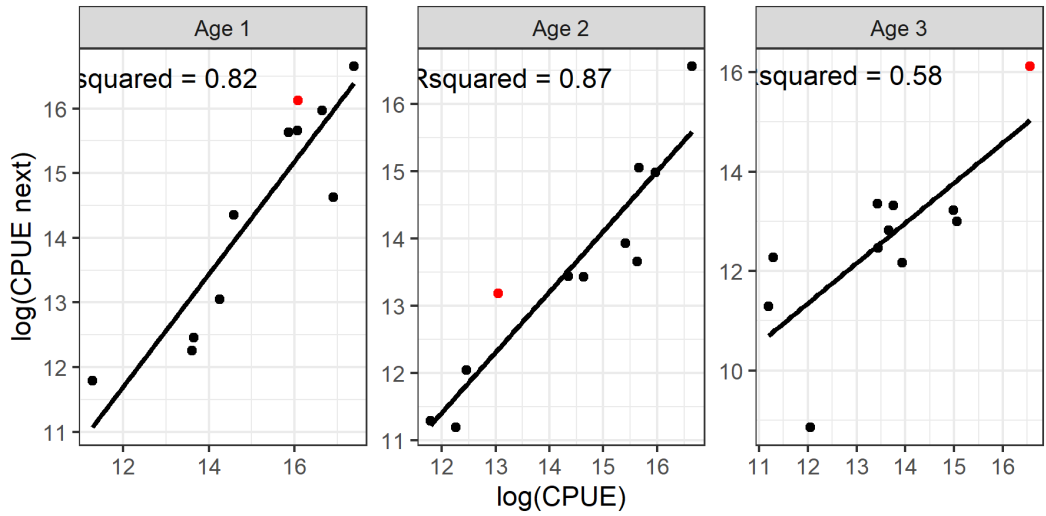

Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.
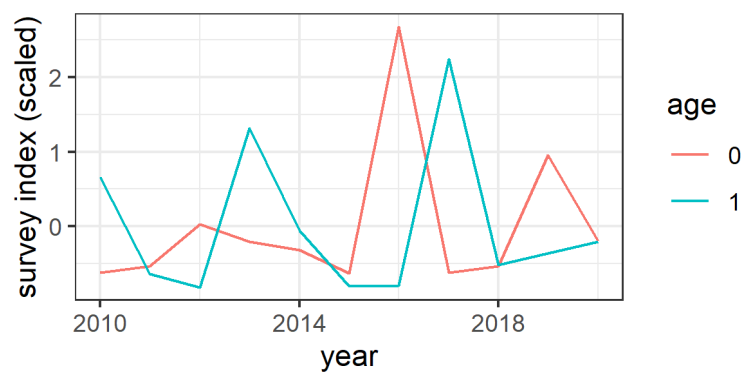
Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.
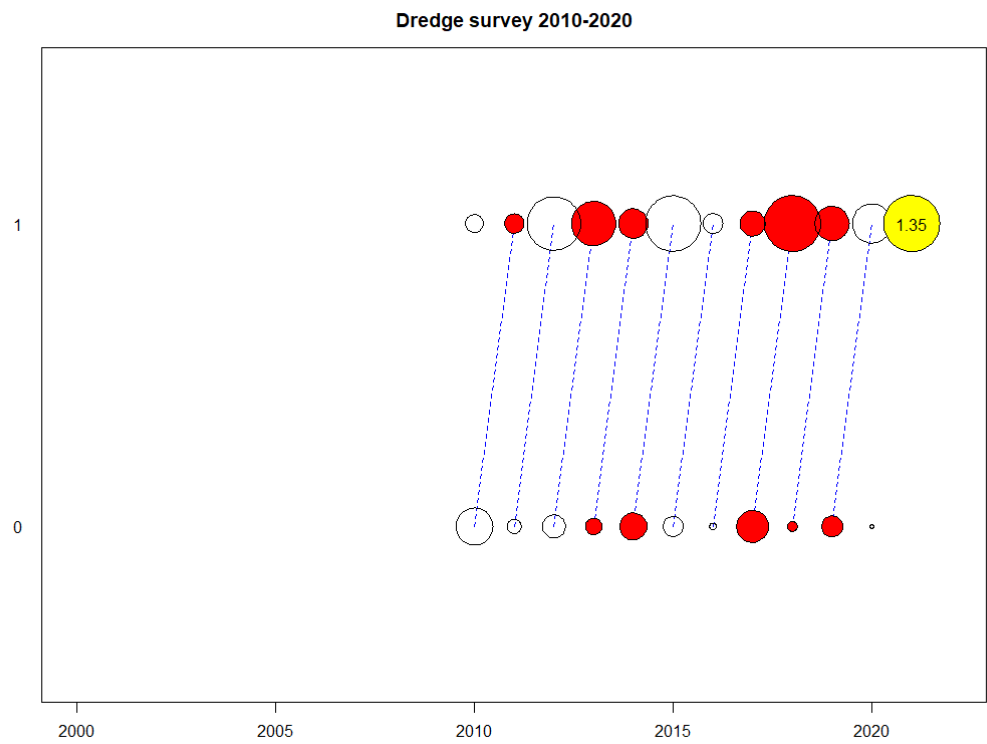
Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.
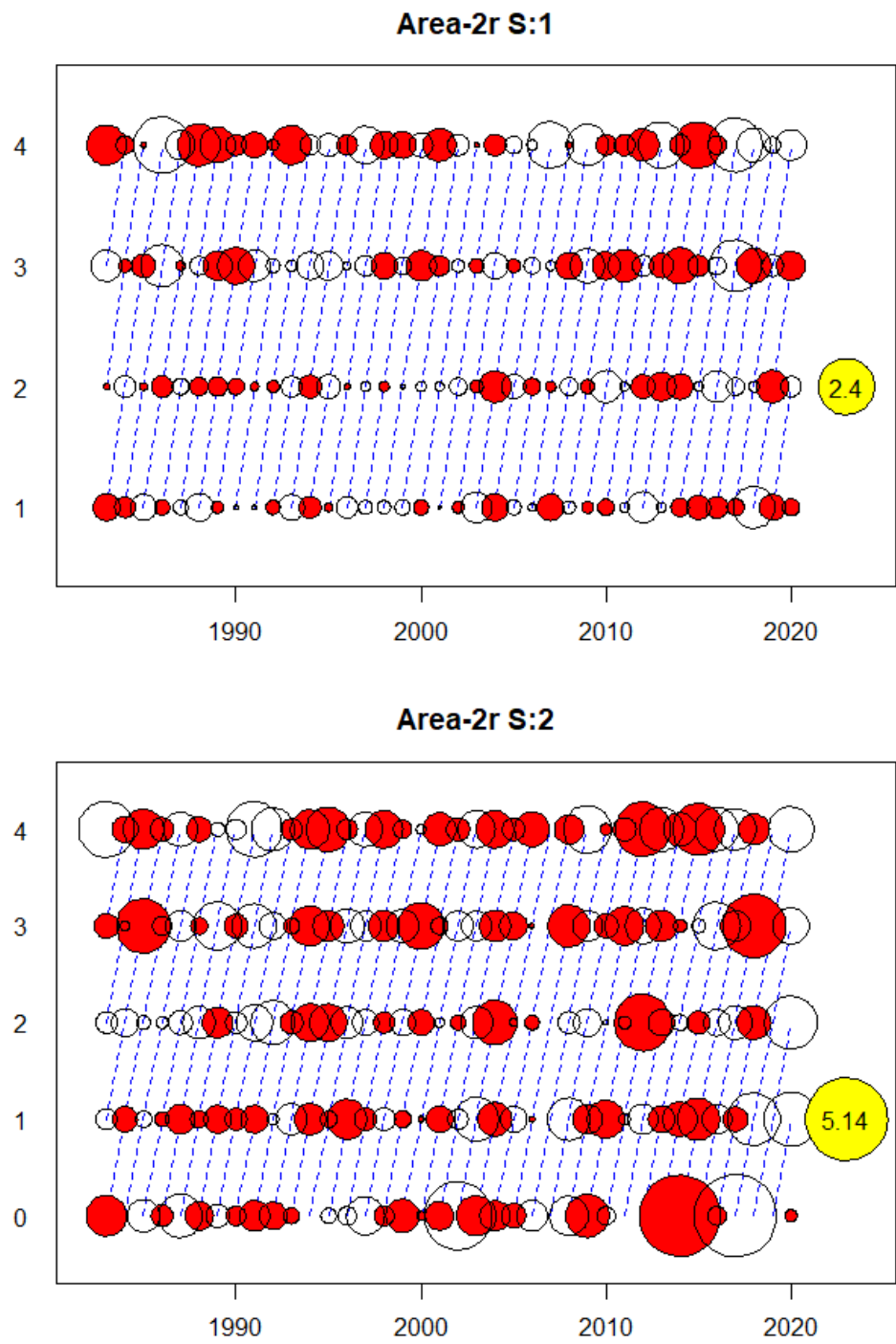
Area-2r S:1

Area-2r S:2

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

Area-2r: Hockey stick, 1983:2020
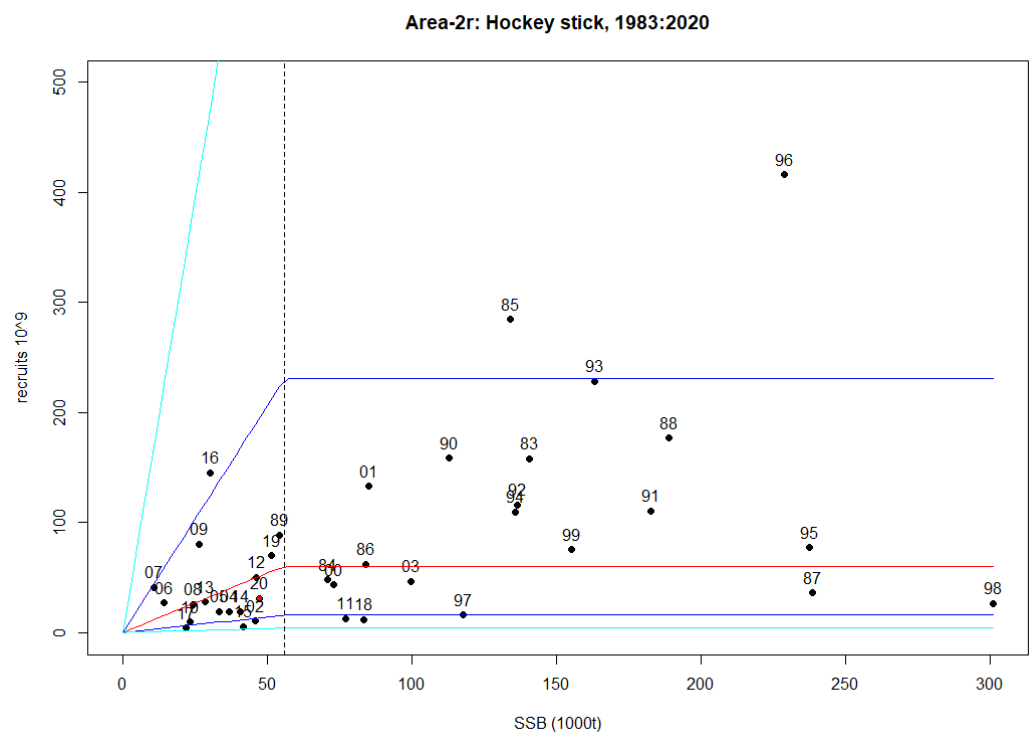
Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.
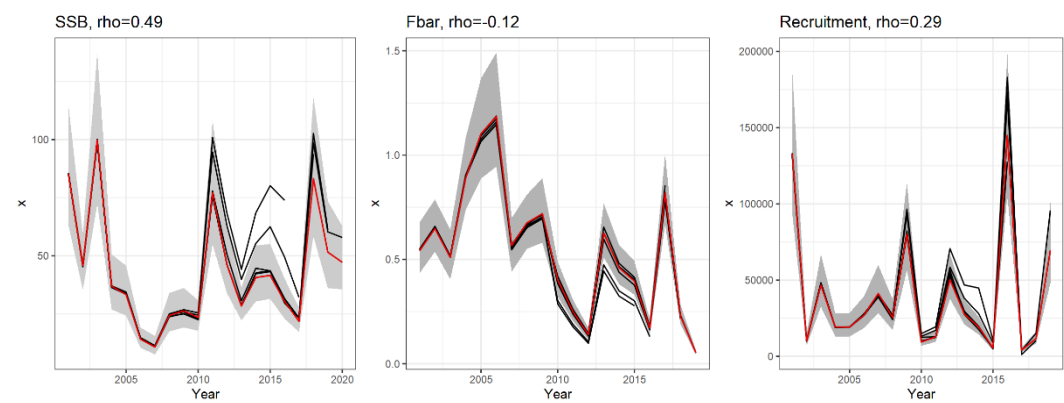
Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.
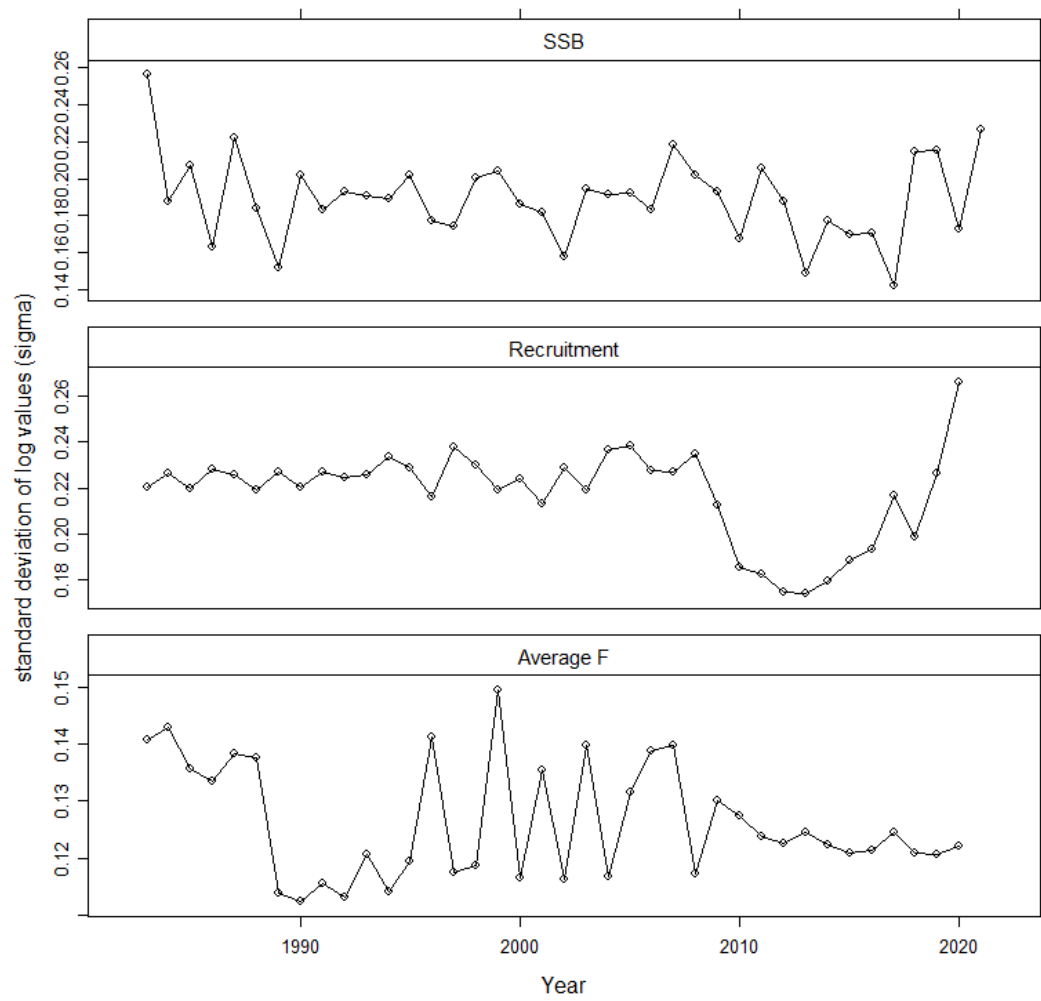
Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.
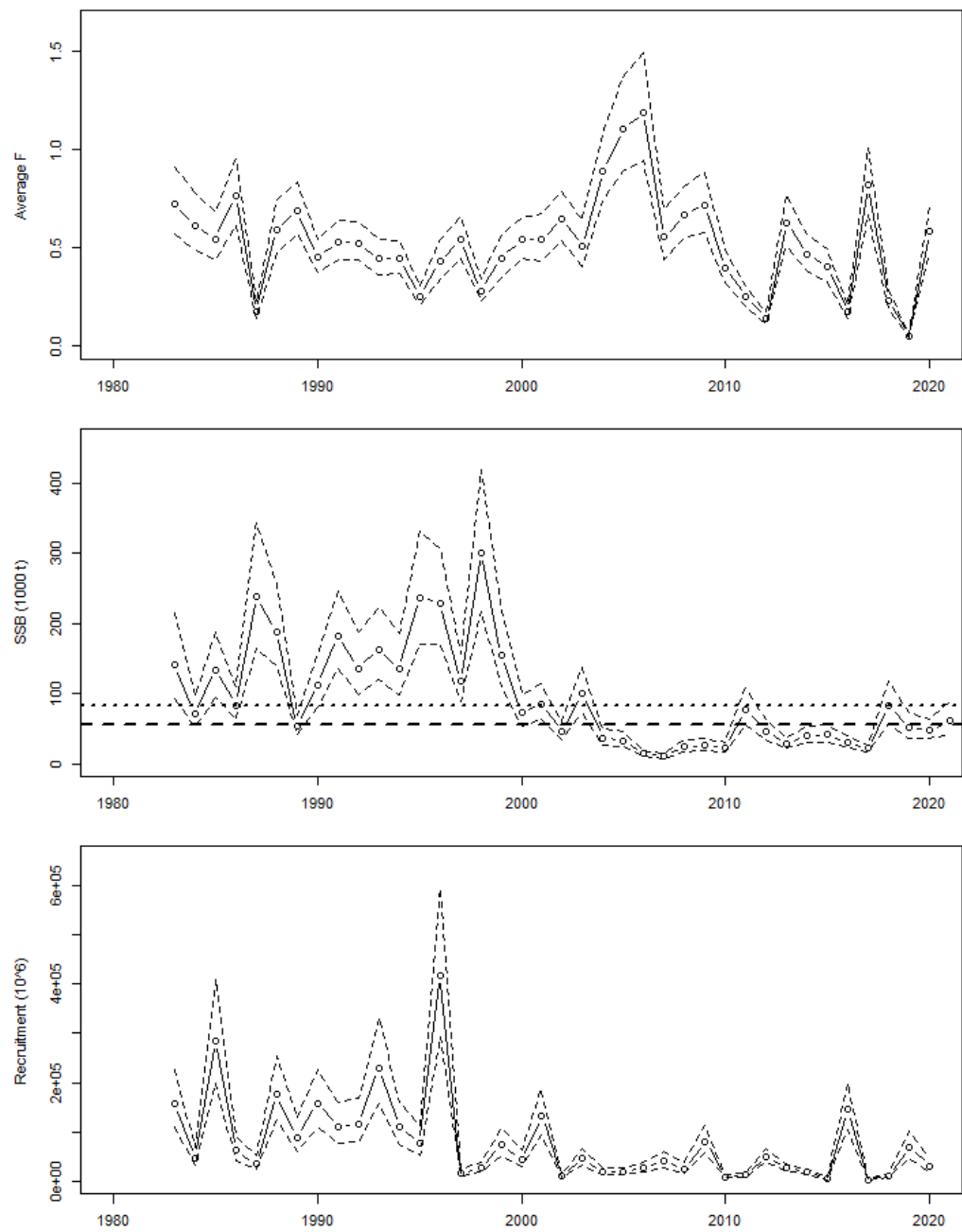
Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.
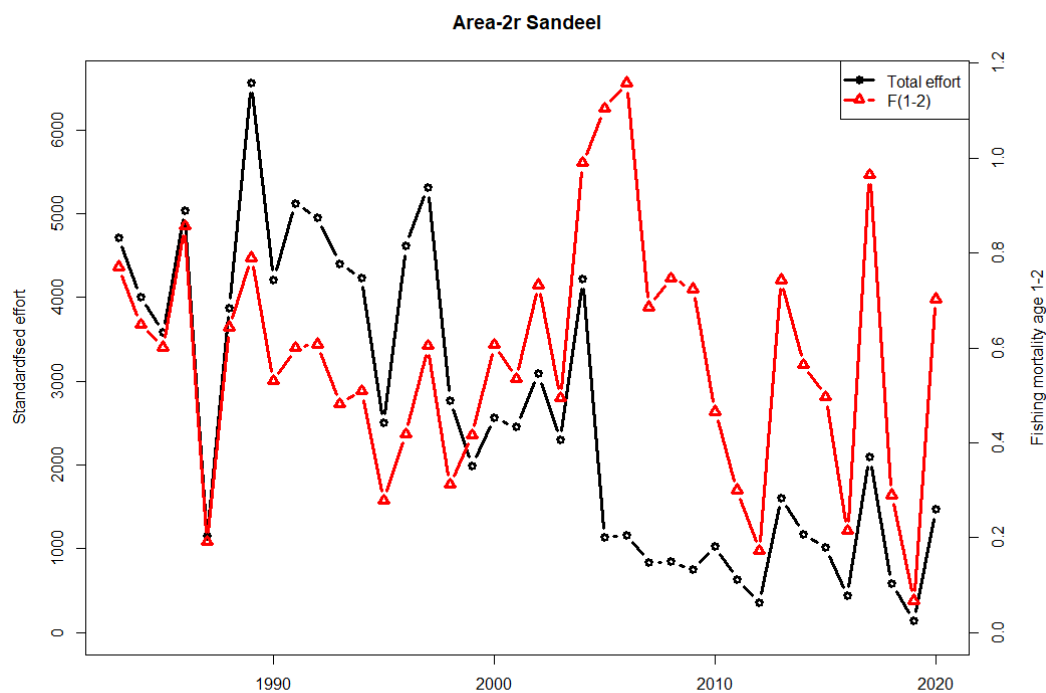
Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.
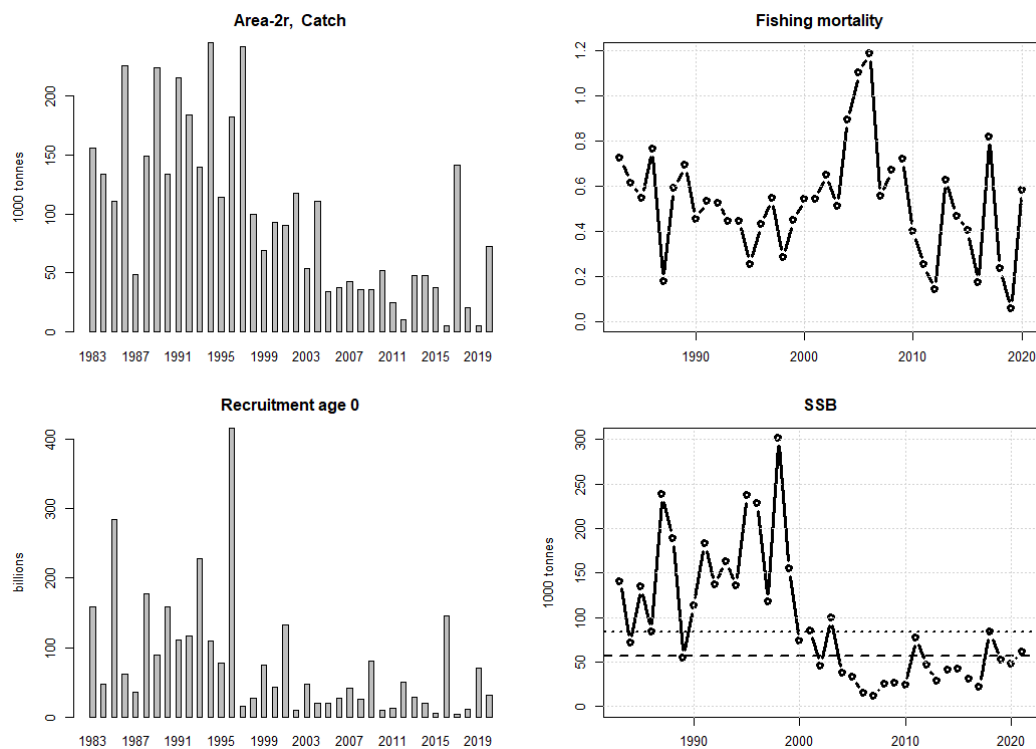
Figure 9.3.13 Sandeel Area-2r. Stock summary.
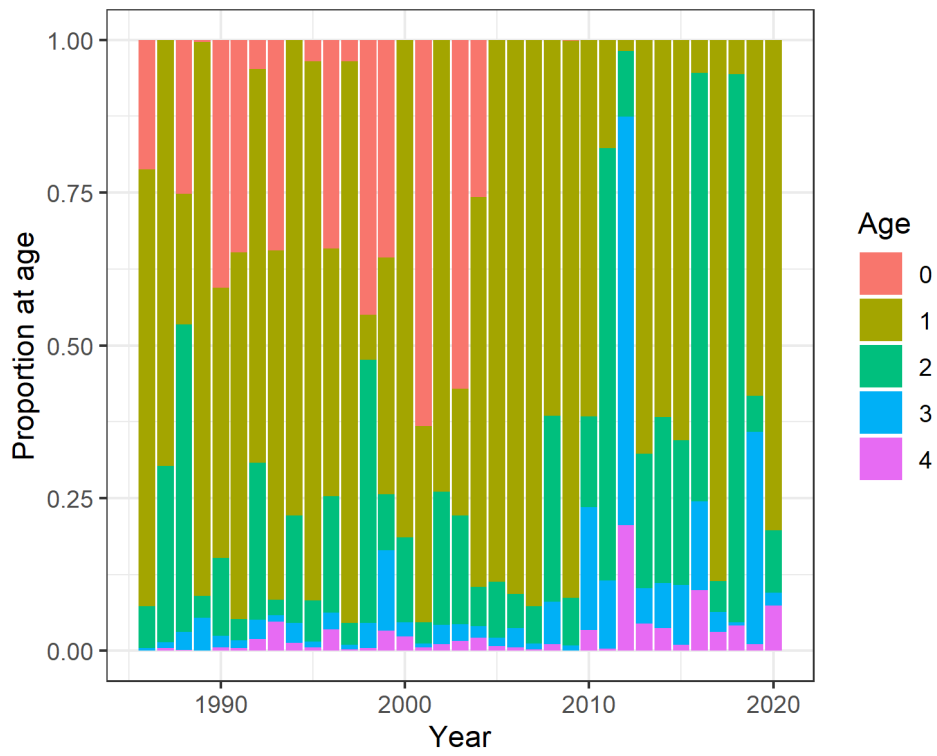
Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.
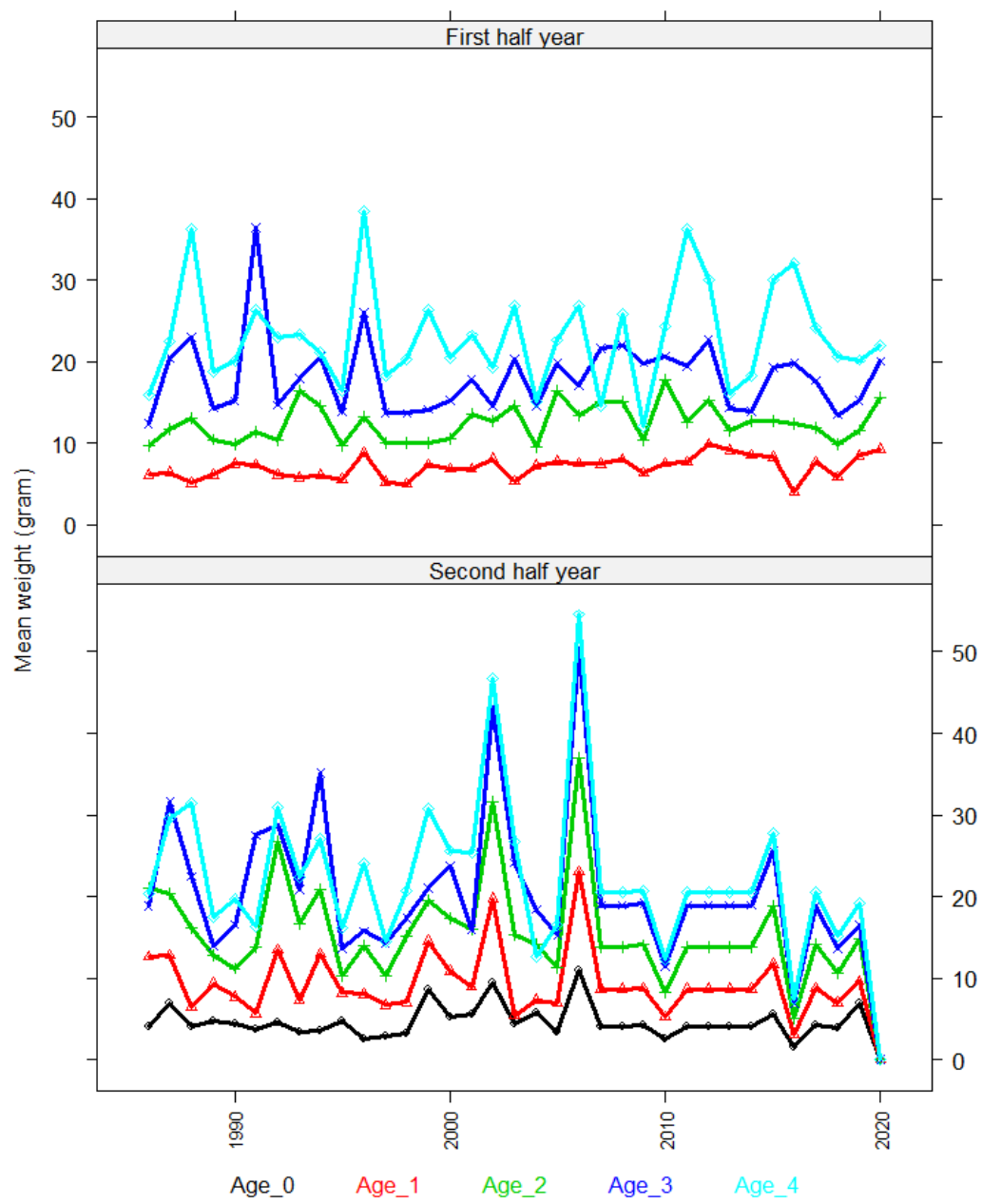
Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).
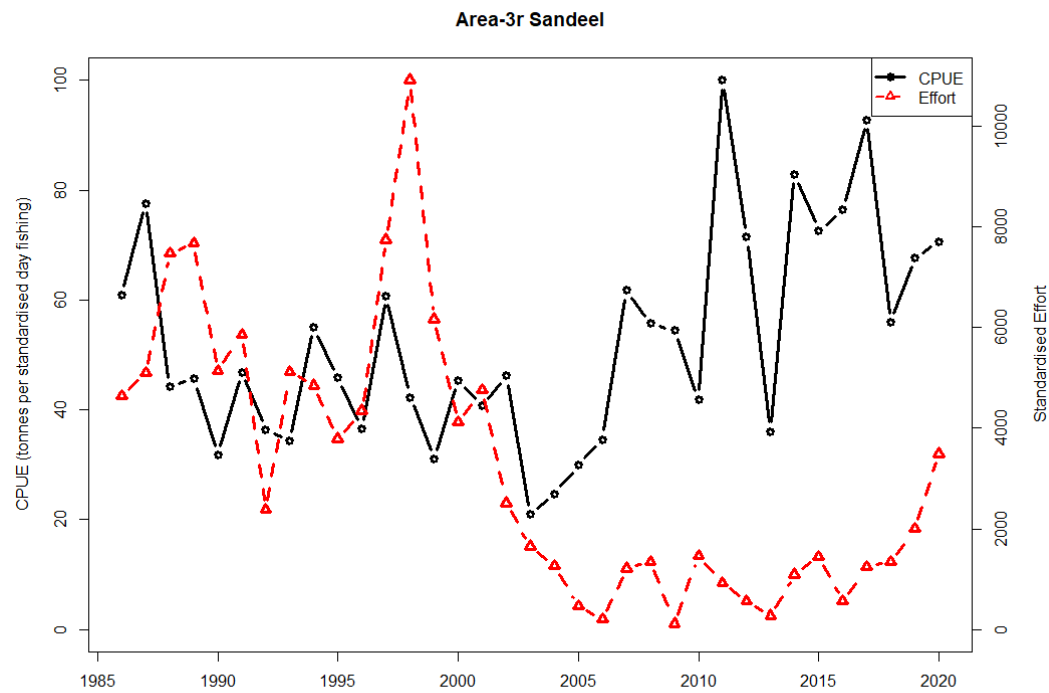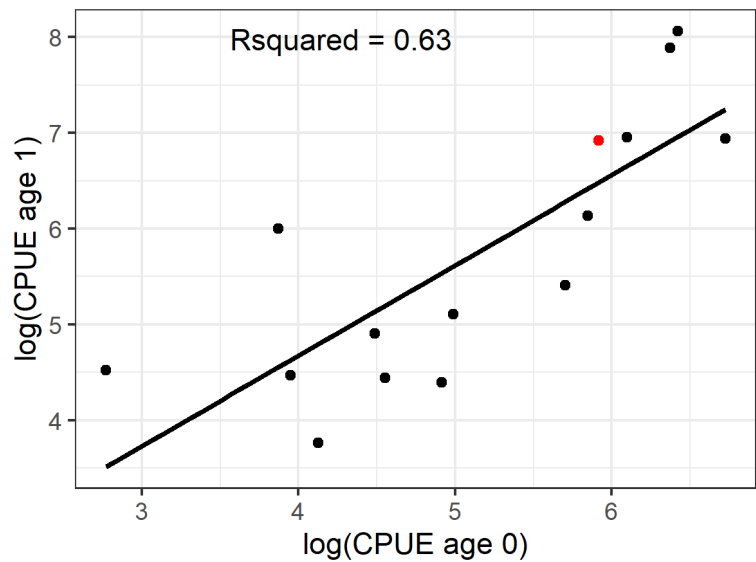
Figure 9.4.3 Sandeel Area-3r. CPUE and effort.
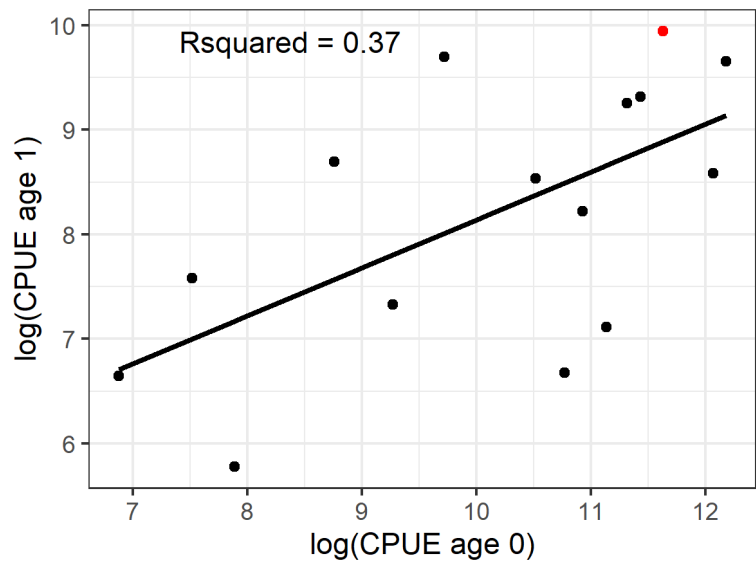
Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.
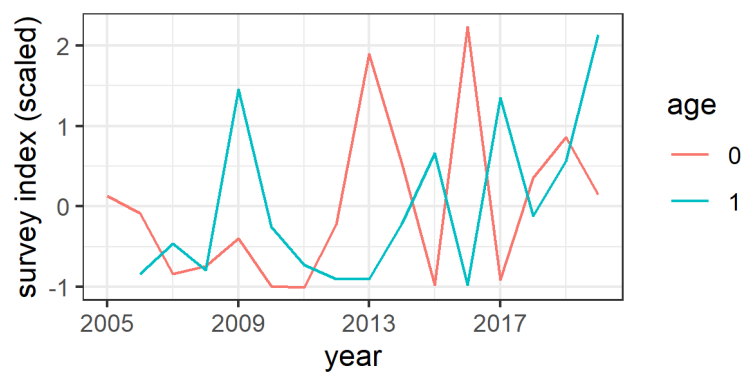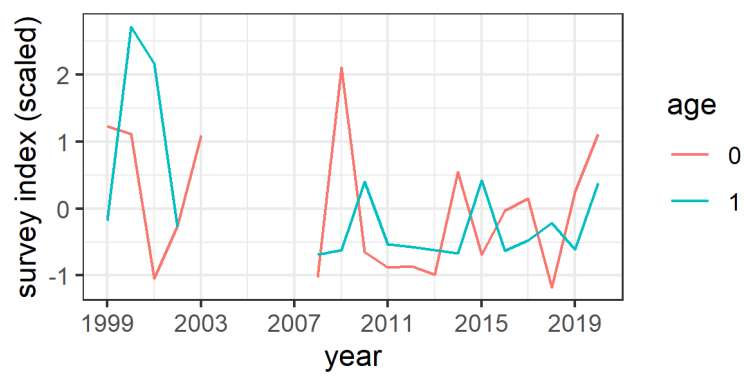
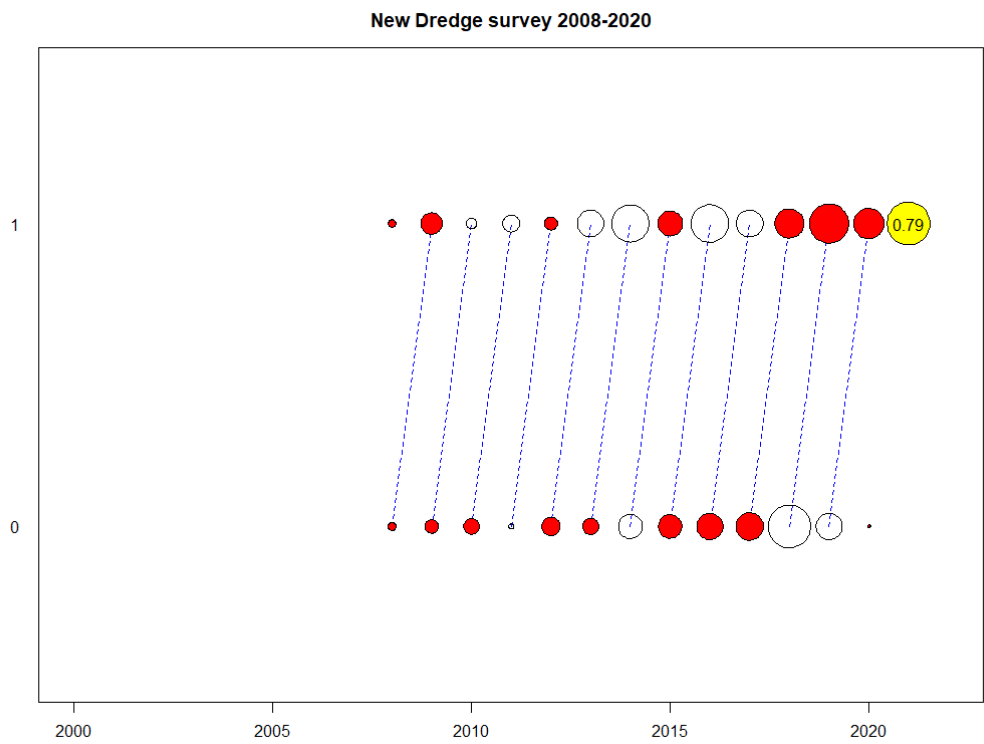**Figure 9.4.5 Sandeel Area-3r. Dredge survey index timeline.**
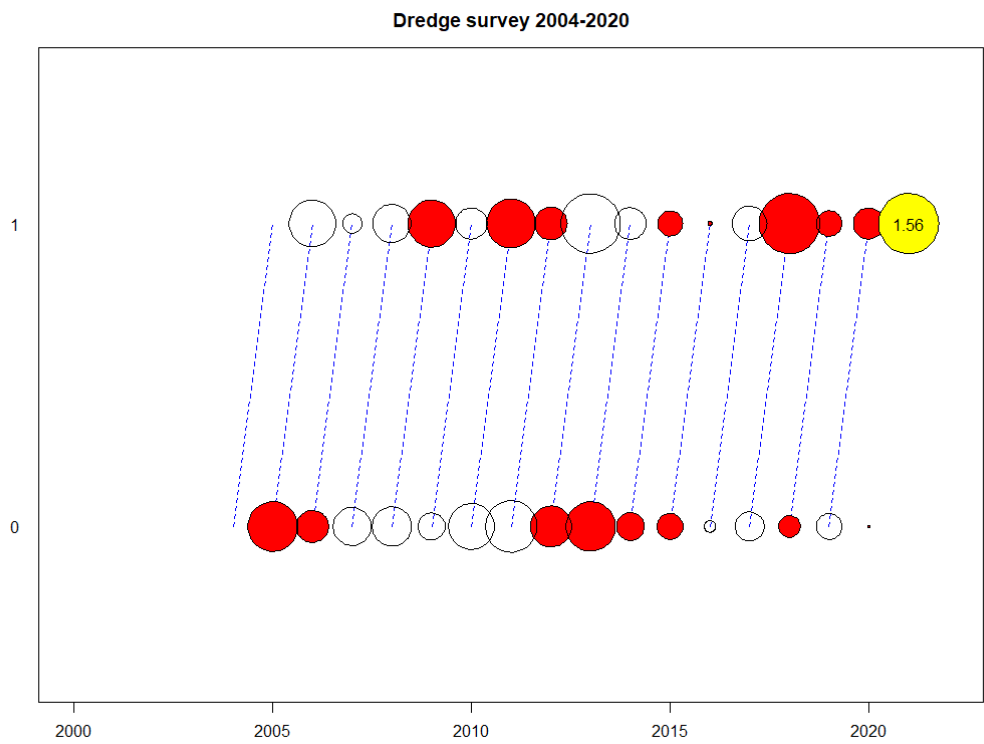
Figure 9.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.
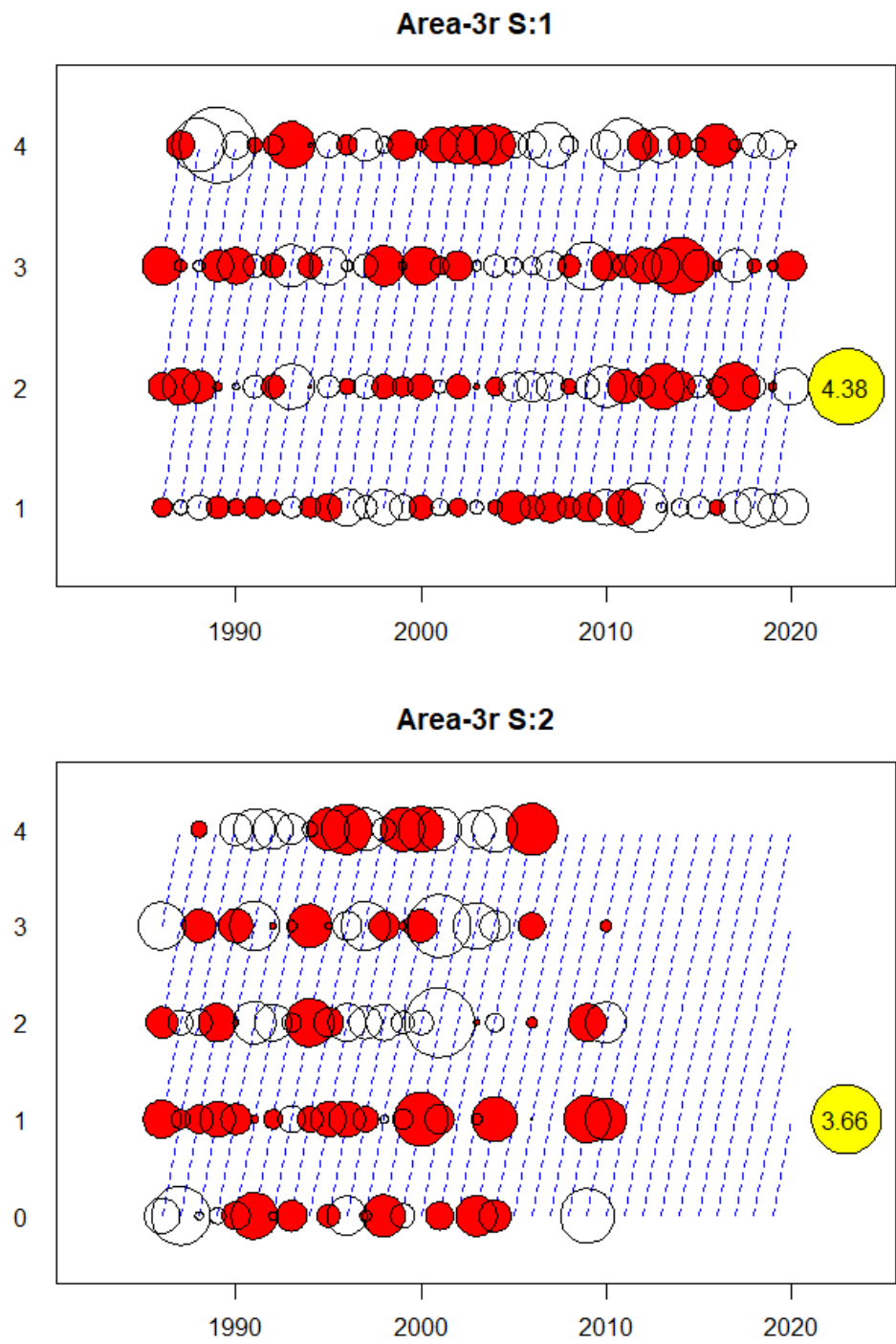
Area-3r S:1

Area-3r S:2

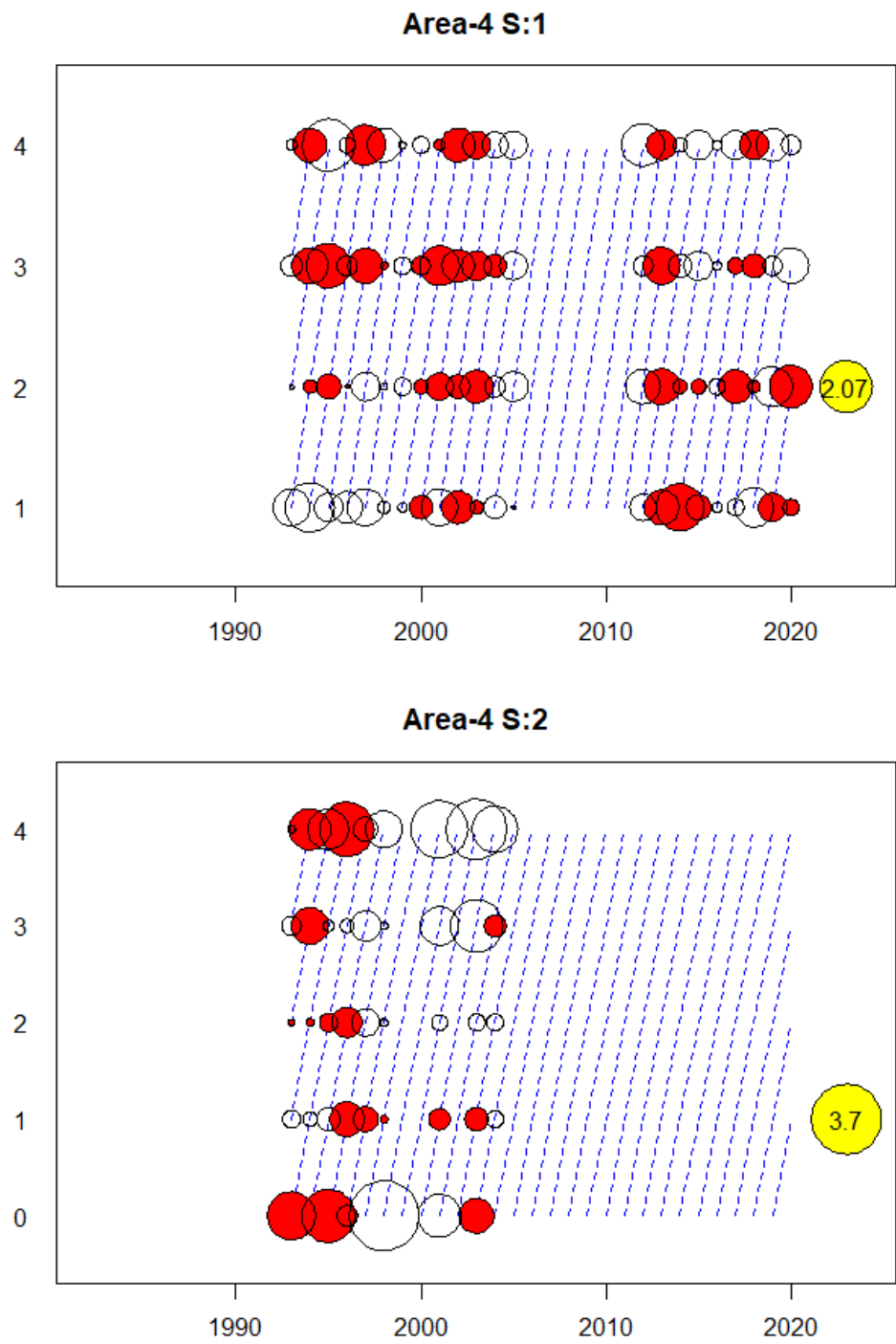**Figure 9.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.**

Area-3r: Hockey stick, 1986:2020
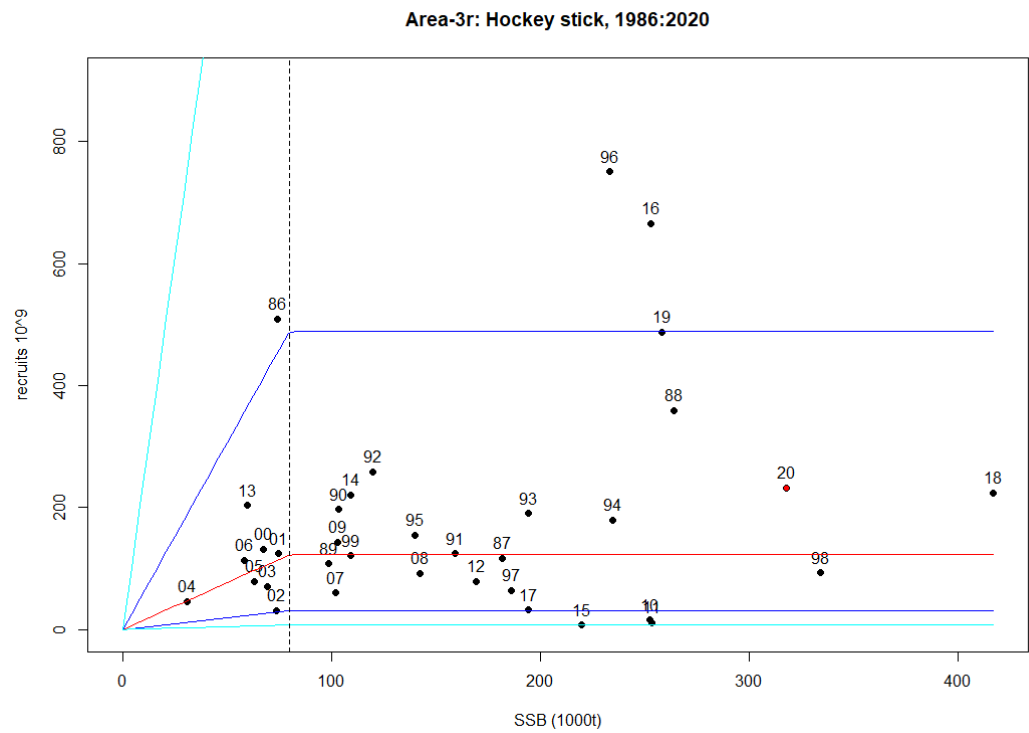
Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.
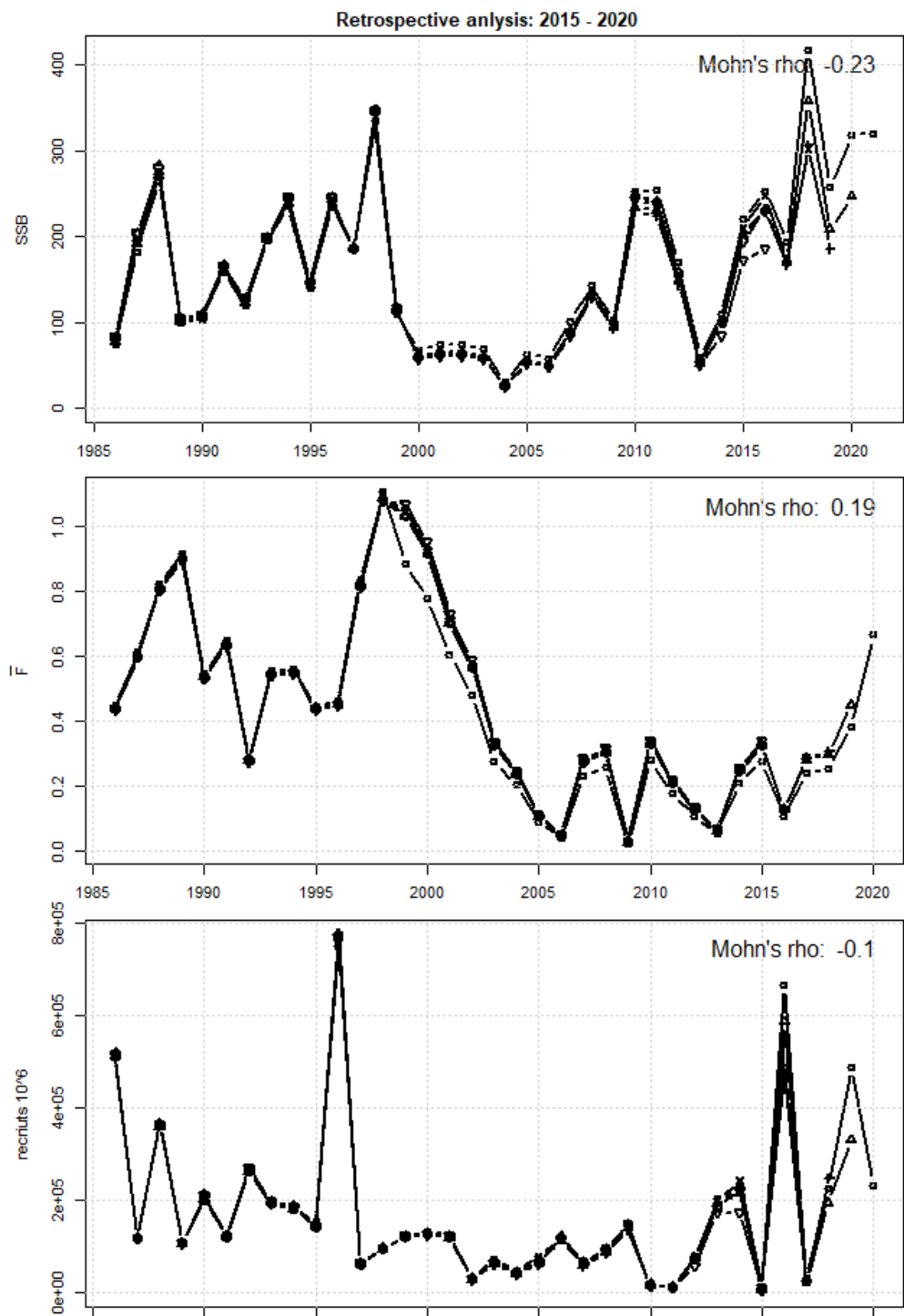
Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.
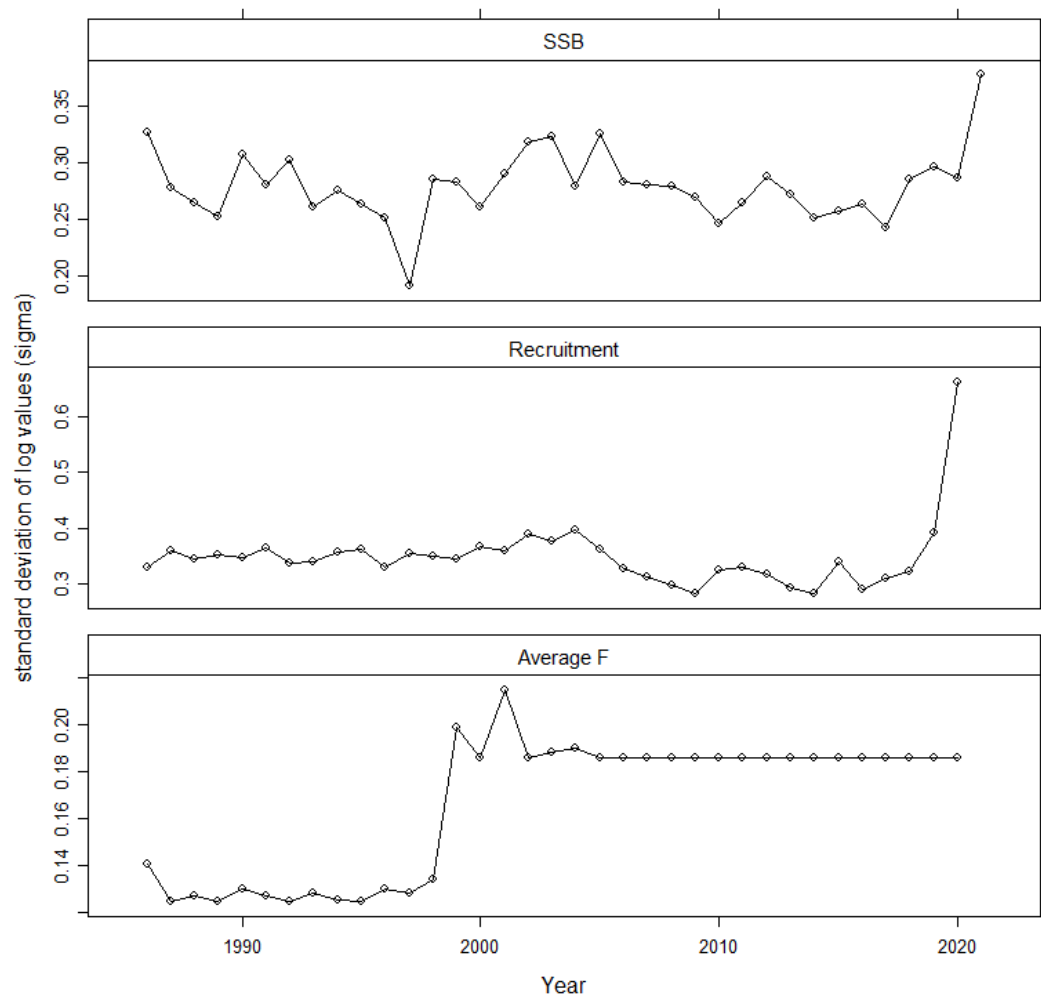
Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.
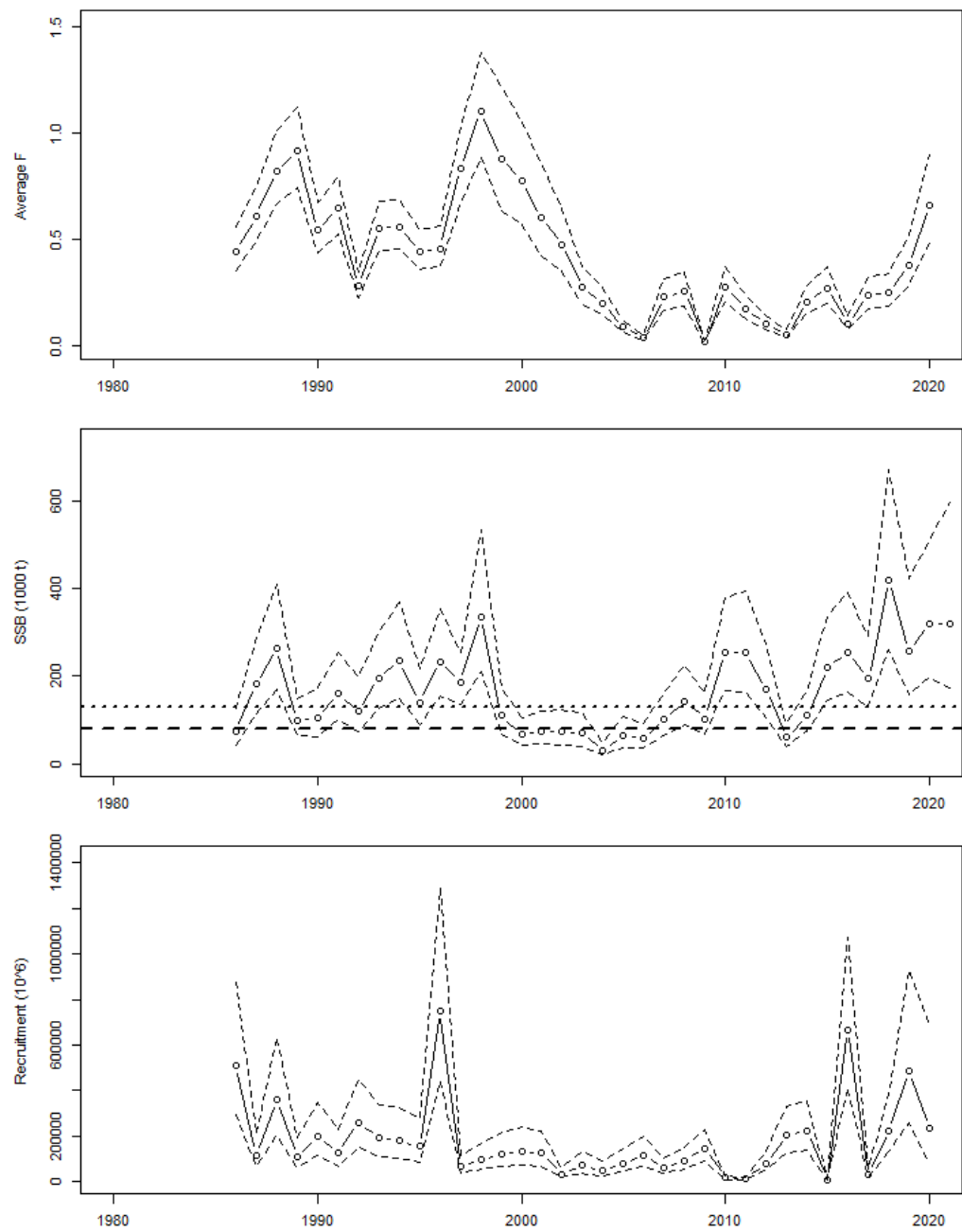
Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * stand-ard deviation.

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.
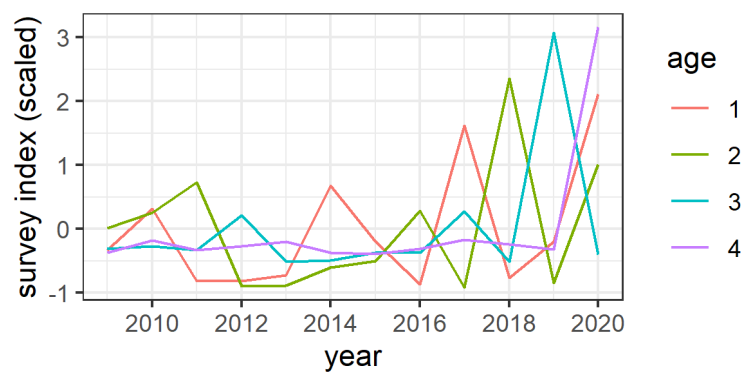
Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.
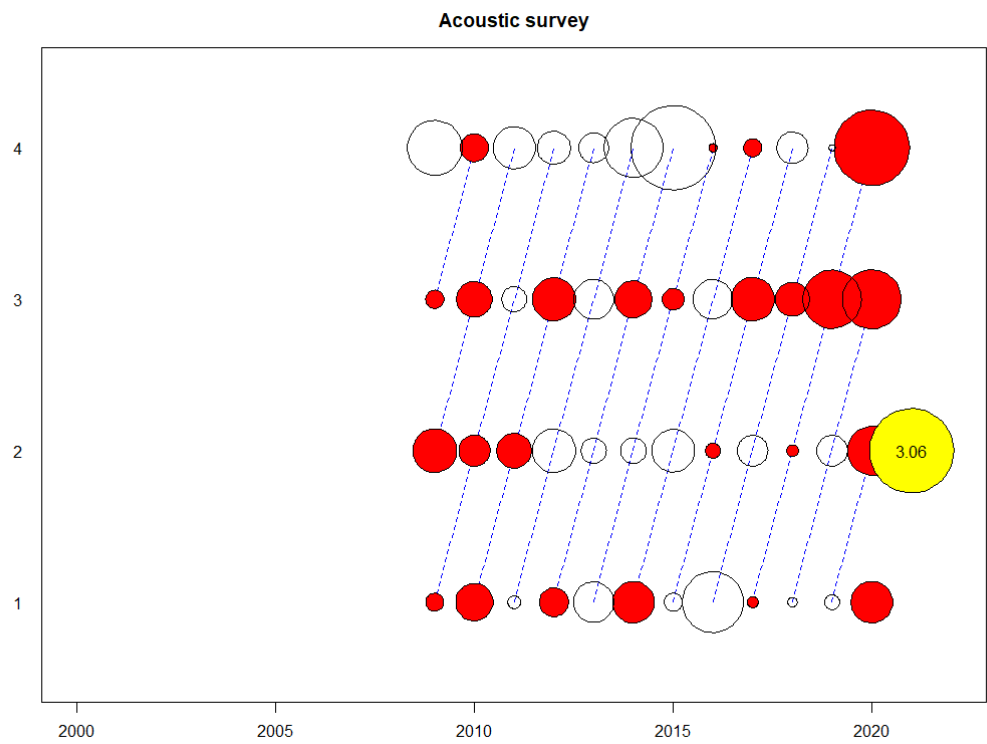
Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(ex-pected CPUE). "Red" dots show a positive residual.

Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.
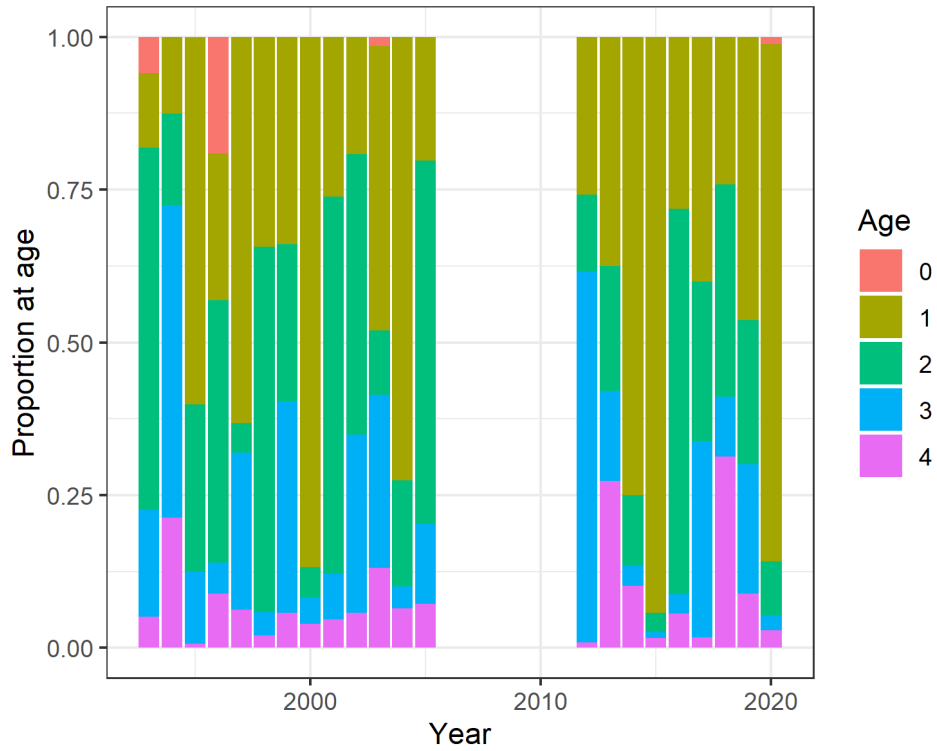
Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.
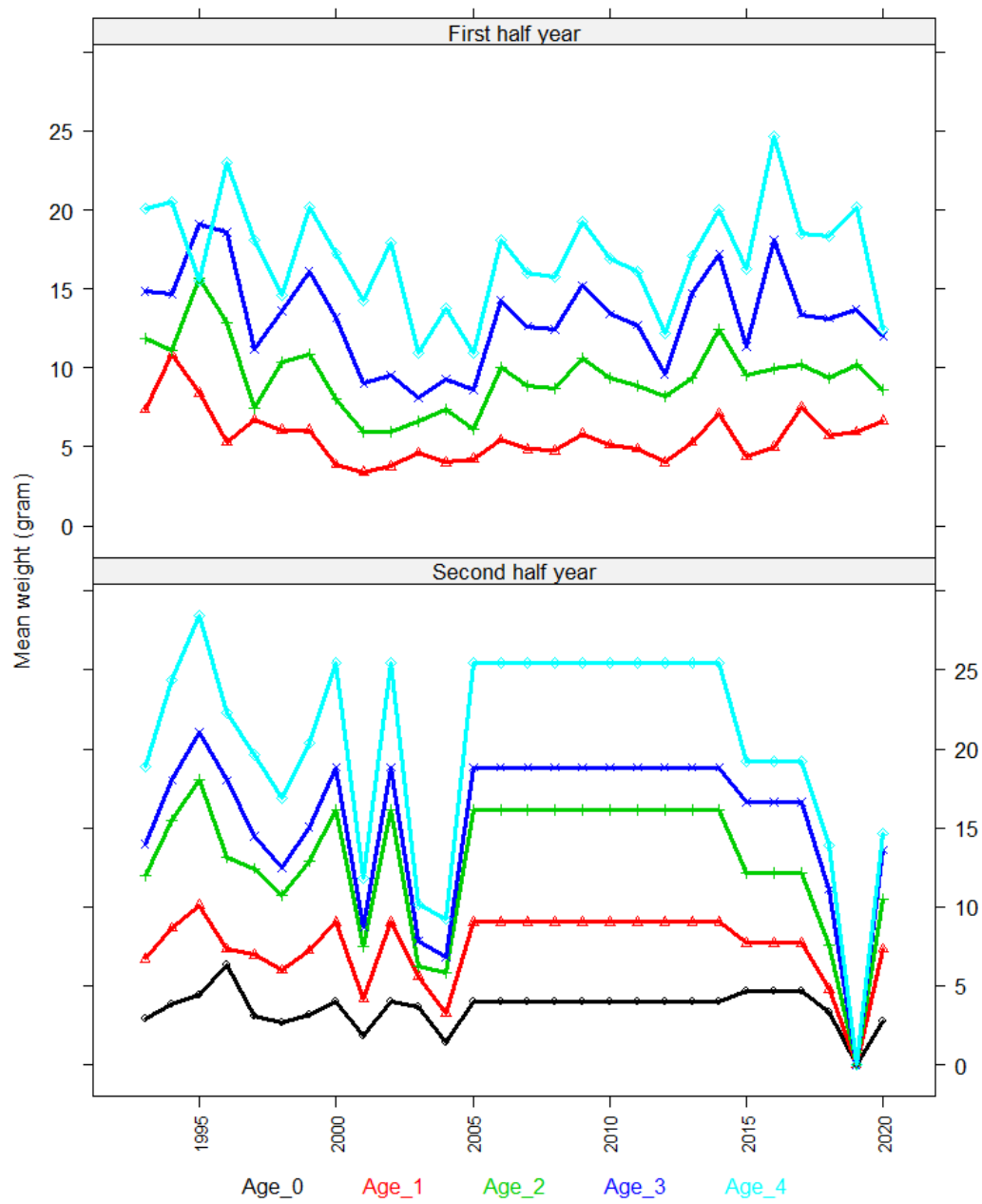
Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).
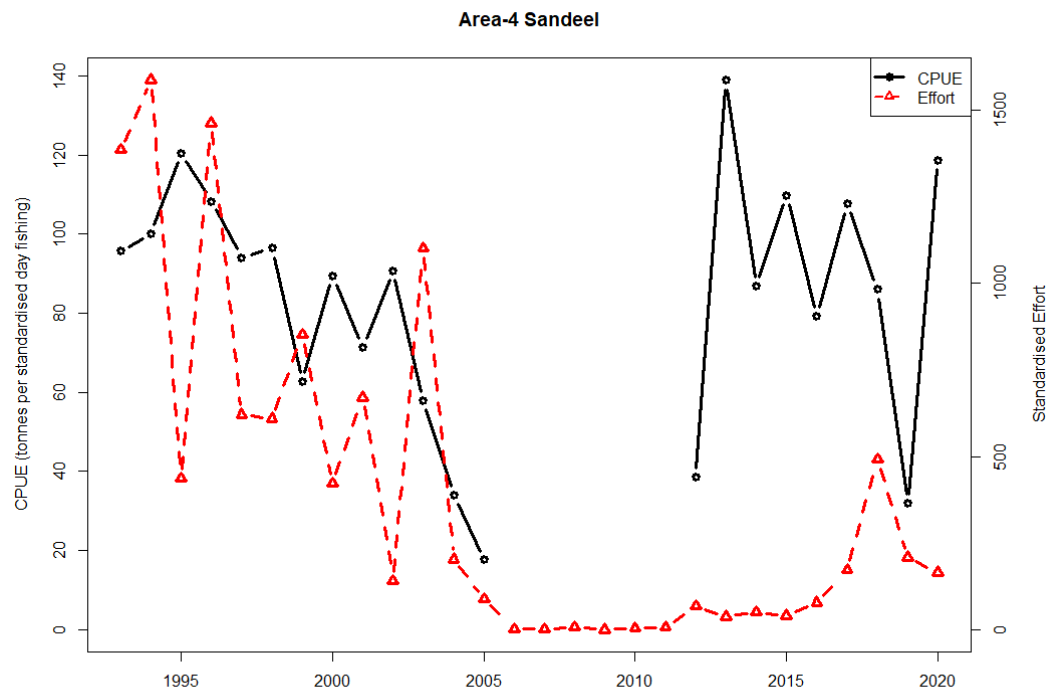
Area-4 Sandeel

Figure 9.5.3 Sandeel Area-4. 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 Sandeel Area-4. Dredge survey index timeline.

Figure 9.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(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.

Area-4: Hockey stick, 1993:2020
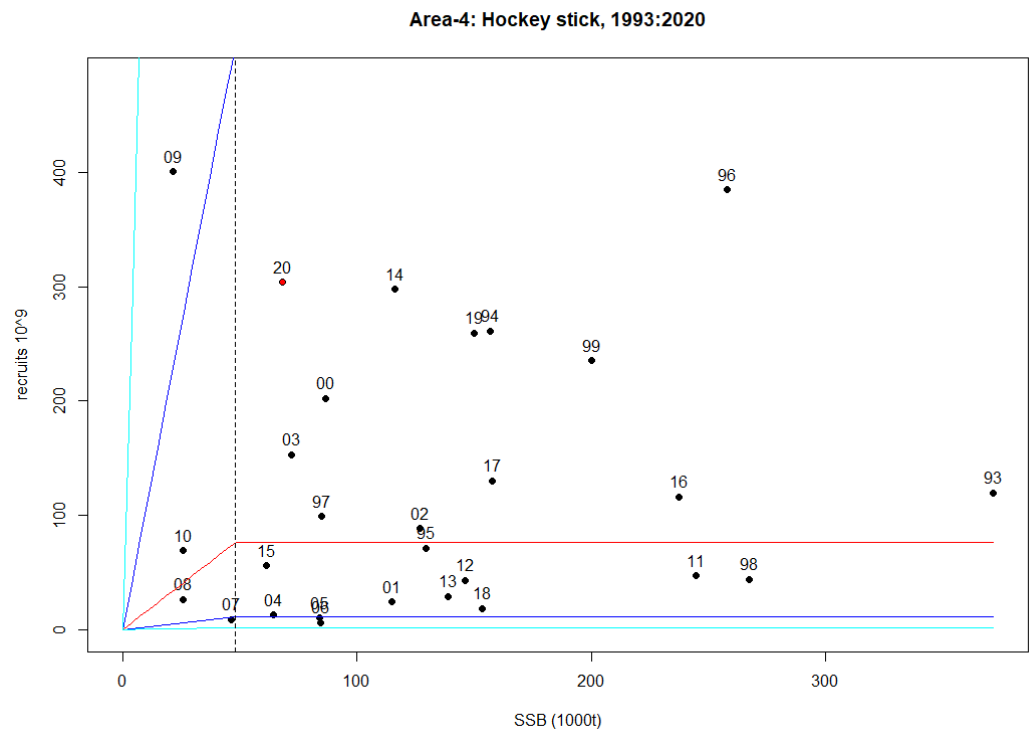
Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.
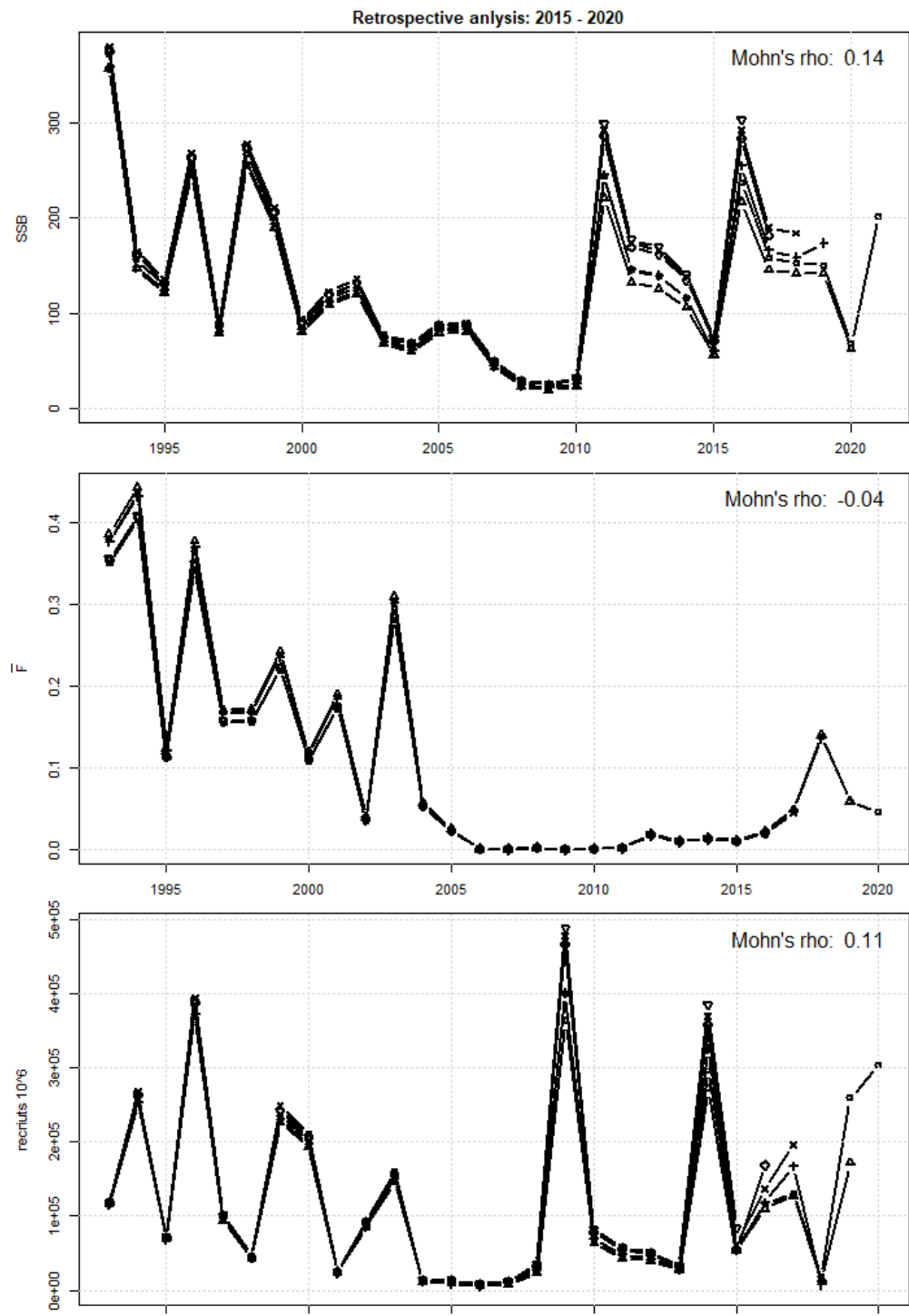
Figure 9.5.9 Sandeel Area-4. Retrospective analysis.
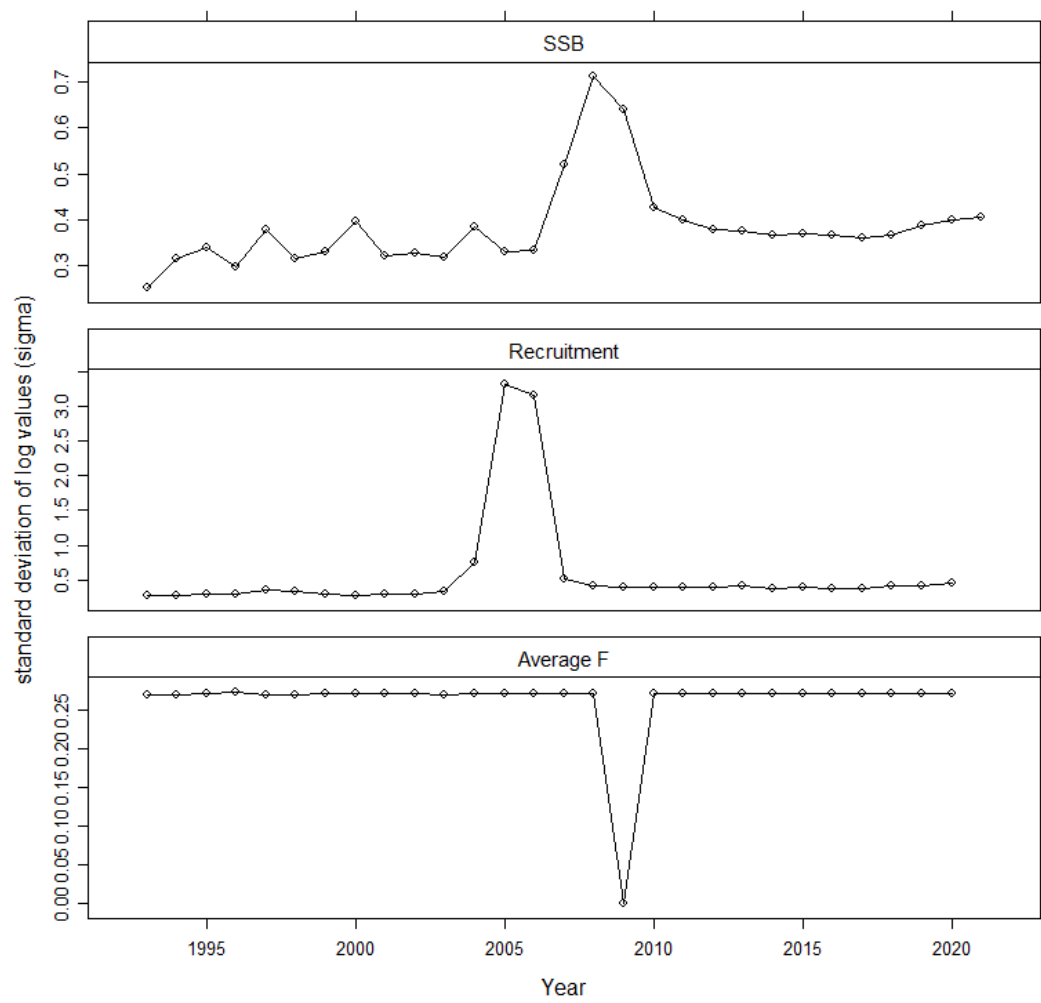
Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.
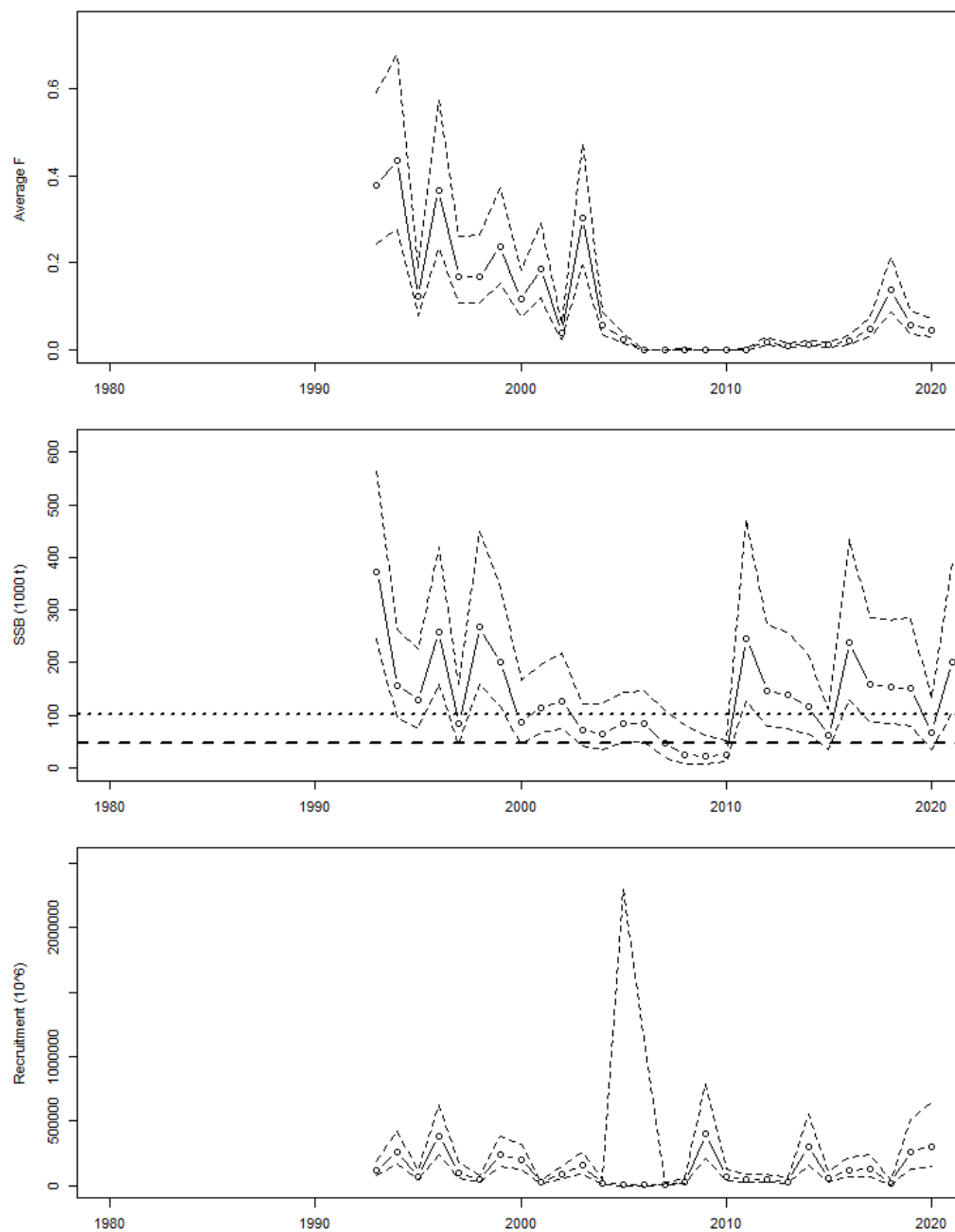
Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.
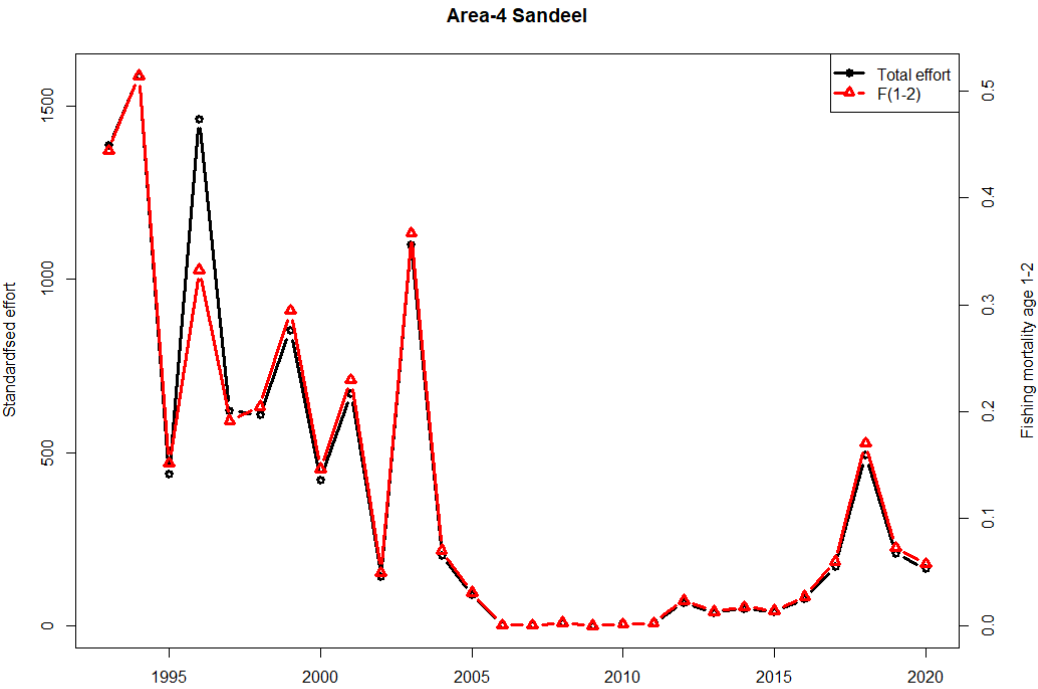
Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.
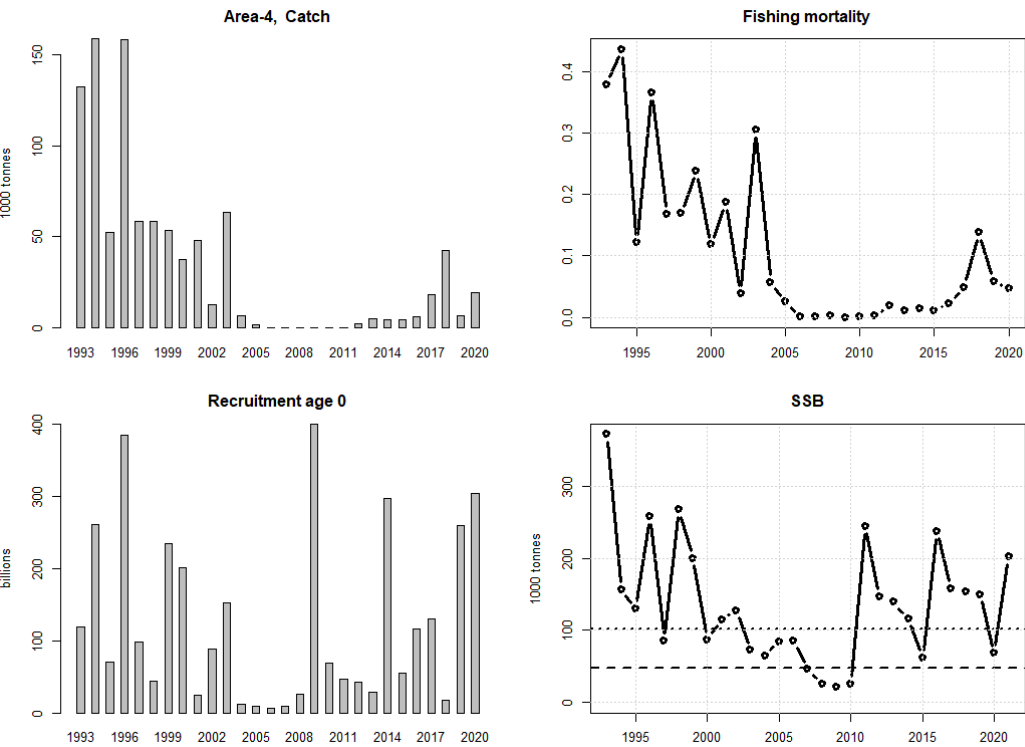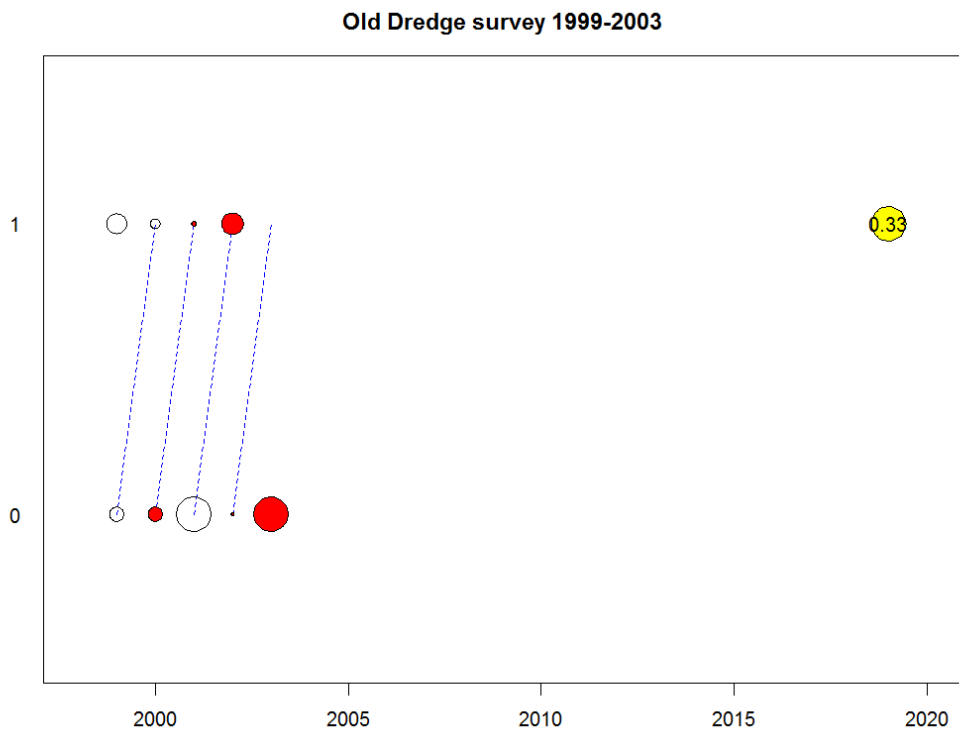

Figure 9.5.13 Sandeel Area-4. Stock summary.

Old Dredge survey 1999-2003

Figure 9.5.14 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.