9 Sandeel in Division 3.a and Subarea 4

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 subpopulations (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 1–4, 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 subpopulations (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, 2008a, 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 2019, 25 vessels participated in the fishery. From 2011 to 2018, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1325 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 2019 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 2019 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2020 (Escapement strategy). This approach resulted in an advised TAC for 2019 in SA 1r, SA 2r, SA 3r, and 4 of 91 916 t, 5000 t (monitoring catch), 133 610 t and 5000 t (monitoring catch), respectively. Advised catches for SA5, SA6, and SA7 for 2018 and 2019 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 55 000 tonnes for 2019 was given. As the acoustic survey abundance estimate of age 1 showed a relatively good year class the final TAC increased to 125 000 tonnes. Fishery was allowed in the subareas 1b, 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 (see Stock Annex for details).

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 UK 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 2000–2019 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.

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 in 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 2019 was carried out as planned and nearly all planned positions were covered in accordance with the survey protocol without notable problems related to weather or other potentially obstructive factors in areas 1r, 2r, 3r, and 4. 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.

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 2019, the proportion 3-group was 26% by weight, corresponding to the large 2016 cohort (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 has decreased since 2016 to levels observed in 2014.

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 2017, WGSAM provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, WGSAM 2017). 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 in 2018 and it was decided that the effect on reference points was minor and all natural mortalities were therefore updated to the new values from WGSAM. The last value provided was used for all years following the latest data point. In later years, natural mortality has been historically high as a result of the increasing grey gurnard and mackerel stocks. More details are given in the Stock Annex and in WGSAM (2017). 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 2016-2018, but have decreased to levels below average in 2018 and 2019.

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. This time-series was not updated in 2018 due to the low catches and hence small number of samples in this period.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2019 show indices of age 0 and 1 just above and below the average, respectively.

The internal consistency, i.e. the ability of the survey to follow cohorts, (Figure 9.2.4) still shows a low correlation between the 0-group and 1-group (i.e. r^2 = 0.22 on log scales). This can be a result of highly variable total mortality.

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 2019. 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 at 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 (0.36) for age 0 and moderate (0.71) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time-series is moderate (0.52) for age 1 and age 3 and low (0.45) for age 2. 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 (0.33) for age 1 and age 2 in the first half of the year and moderate to high (> 0.60) for the remaining ages and season combinations. The catch-at-age residuals (Figure 9.2.7) show no alarming patterns.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.86), 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 except for SSB, where 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. 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, whereas 2019 shows average recruitment.

9.2.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2019 is the geometric mean of the recruitment 1983–2018 (108 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2014–2019. 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 113 987 t should be set for 2020. This will leave SSB at 169 415 t in 2019 and predicted F at F_{cap} (0.49). The TAC according to the escapement strategy is therefore 113 987 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. 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.

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 utilizing 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 9.1.29–.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 largest proportion of 3-group in the time-series (52%)(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.

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 2017) 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 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 in 2019 was the lowest in the time-series and CPUE was well below levels observed in 2015–2018.

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. 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 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 decided to include density-dependent catchability in the final run.

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) 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 (0.37) 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 (1.03 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 2010–2019, 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 is 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 and continued to be low in 2019. In 2020 the year class was above average. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2011 to 2016 and 2019. Since 2004, SSB has been below B_{pa} in all years except 2018 and 2019. F_{1-2} is estimated to have been below the long-time average since 2010 with the exception of 2013 and 2017, but has dropped to the fourth lowest in the time-series in 2019.

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 2020 is the geometric mean of the recruitment in 2009–2018 (21 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2015–2019. Natural mortality and proportion mature are the fixed values applied in the terminal year in the assessment.

Output

The short-term forecast (Table 9.3.12) shows that a TAC of 62 658 corresponding to $F_{cap} = 0.45$ results in an SSB of 91 553 will be above the MSY $B_{escapement}$ of 84 000 t and B_{lim} of 55 000 t in 2021 The TAC according to the escapement strategy is therefore 62 658 t in 2020. Biological reference points

B_{lim} is set at 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.45 (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 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 SA2 is still short (2010–2019) 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. F in 2019 was the lowest on record. SSB in 2019 are estimated below B_{pa} and in 2020 below B_{lim}, which is consistent with prediction (HAWG, 2019). Recruitment in 2016 is estimated to be the fourth highest on record and 2019 is the third highest since 1997, while the 2017 and 2018 year classes are extremely low.

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 SA2r sandeel at 0.45. 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 SA3 is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.4.1.

The proportions of age groups in the 2013–2015 catches are quite similar with approximately 47% 1-group, but 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-2 was only 6% in 2018.

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. 2019 mean weight was just below 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 2017, WGSAM provided updated estimates of natural mortality-at-age from multispecies modelling of northern sandeel (SMS, WGSAM 2017). In later years, natural mortality has been historically high as a result of the increasing grey seal population as well as grey gurnard and saithe stocks.

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 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 1998, and declined thereafter and has been less than 2000 days per year since 2003.

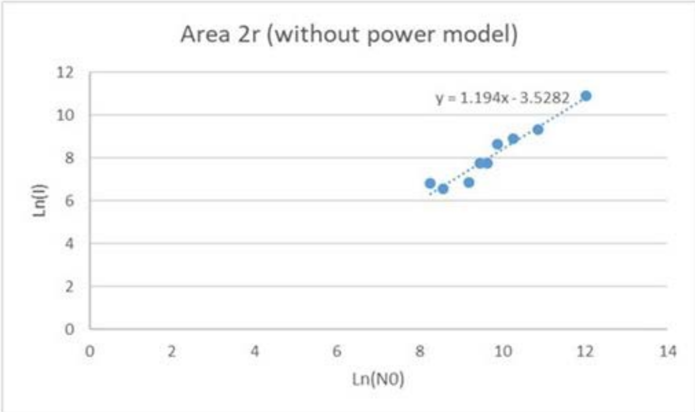
Tuning series used in the assessments

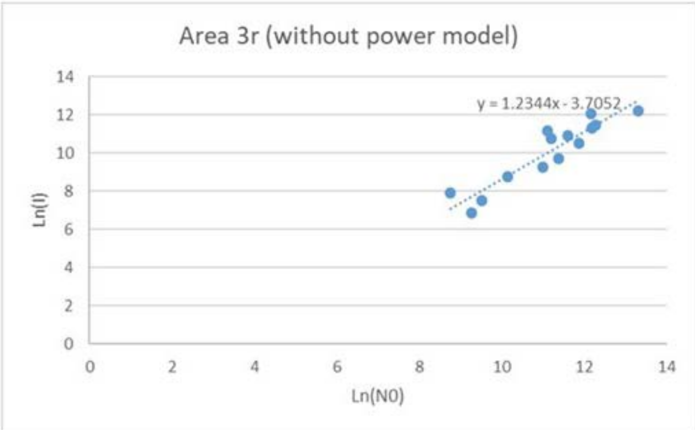
CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2019 show above average indices for both age 0 and age 1 in 2019 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e. $r^2 = 0.33$ on log scales). In 2014, 13 new positions were 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 (2009–2019) 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 decided to include density-dependent catchability in the final run.





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 high for both age 0 (0.65) and age 1 (0.83), showing an overall poor consistency between the results from the dredge survey and the overall model results. The dredge survey residuals (Figure 9.4.6) plot shows a series of negative residuals from 2007–2011 for the 0 group followed by positive residuals, while the residuals for the 1-group are more randomly distributed. 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 (0.55) and high for age 3 (0.92), showing an overall medium consistency between the results from the dredge survey and the overall model results.

The model CV of catch-at-age is medium (0.66) 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.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.05), 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 (i.e. increasing catchability with increasing densities), the retrospective bias was reduced from a Mohn´s Rho > 0.5 to 0.13 in the present year´s assessment (see working document about this change).

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 2013, 2014 and 2016 together with a fishing mortality below average have resulted in SSB above B_{pa} in 2015 onwards.

The estimated recruitment in 2016 is the highest in the time-series, and the recruitment in 2018 is also estimated to be among the five highest recruitments.

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 2019 is the geometric mean of the recruitment 1986–2017 (105 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018, corresponding to a 23% decrease in mean weight-at-age 2 compared to the values used in the forecast for 2018. 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 155 072 t in 2020 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 298 955 t, well above MSY $B_{trigger}$ of 129 000 t, in 2020. The TAC according to the escapement strategy is therefore 155 072 t in 2020.

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. Although 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, and 2016 combined with a low fishing mortality. Recruitment estimate for 2019 is third largest since 2008 when the stock started recovering.

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 2019, age group 1 contributed more to the catches than ages 2 and 3 which were almost equal (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 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 2017) 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. Effort since 2004 has been extremely low. CPUE in later years has been around the average prior to 2004 from 2013-2018 but low in 2019.

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 year class is the 6th highest recruitment 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 (see WD01 on sandeel dredge in SA4).

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 2019. 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) for all ages. In fact, the CV of the dredge survey hits the lower bound 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 (0.71) 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 at the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.24), 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 substantially above B_{pa} in 2016 to 2019 and between B_{lim} and B_{pa} 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. Recruitment in 2014, 2016, 2017 and 2019.

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 2020 is the geometric mean of the recruitment 1993–2018 (60 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2015–2019. 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 2020 with a TAC of 39 611 t. The TAC according to the escapement strategy is therefore 39 611 t in 2020.

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 2020 is high (0.37).

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016, 2017 and 2019 are all above the long-term average, while 2018 is the second lowest on record. 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.

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 (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 4 (in accordance with the concepts of a conventional management strategy evaluation and a selection criteria of 0.05 probability of SSB < B_{lim}) is set at 0.15 (ICES, 2016).

9.6 Sandeel in SA 5

9.6.1 Catch data

Total catch weight by year for SA 5 is given in tables 9.1.2–9.1.4. No landings 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 SA5. 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 References

ICES. 2016. Report of the Benchmark on Sandeel (WKSand 2016), 31 October - 4 November 2016, Bergen, Norway. ICES CM 2016/ACOM:33. 301pp.

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35.60 pp.

ICES. 2019. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 1:2. 971 pp. http://doi.org/10.17895/ices.pub.5460 - WD01 Marine Scotland Science sandeel dredge survey indices for SA4.

van Deurs, M., Hartvig, M., & Steffensen, J. F. (2011). Critical threshold size for overwintering sandeels (*Ammodytes marinus*). Marine biology, 158(12), 2755-2764.

Table 9.1.1 Sandeel. Catches ('000 t), 1952-2019. (Data provided by Working Group Members).

Year	Denmark	Germany	Faroes	Ireland	Netherlands	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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
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
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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
2010	275.1	13	-	-	-	78	32	4	0.6	402.7
2011	278.5	9.8	-	-	-	109	32.7	6.1	1.65	437.8
2012	51.5	1.706	-	-	-	42.46	5.652	-	-	101.4
2013	208.7	7.9	-	-	0.4	30.446	26.8	2.436	1.3	278.0
2014	148.0	5.052	-	-	-	82.499	18.815	0.03	0.825	255.2
2015	163.2	9.097	-	-	-	100.859	33.439	2	-	308.6
2016	28.9	-	-	-	-	40.867	4.139	-	-	73.9
2017	307.0	-	-	-	-	120.204	41.123	-	3.324	471.7
2018	168.6	5.905	-	-	-	69.531	16.387	1.849	-	262.2
2019	93.6	3.9	-	-	-	124.8	11.4	1.119	-	234.9

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	86066	5274	136732	6603	0	103	0	234778
arith. mean	296923	102769	149196	30287	5834	1174	991	587174

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	71072	5271	136727	6603	0	103	0	219777
arith. mean	268019	73545	124222	25545	5352	1070	784	498537

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	14993	3	5	0	0	0	0	15001
arith. mean	28905	29224	24974	4741	482	103	207	88637

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	2211	1416	1096	51	0	4	0	4777
2015	2046	1233	1441	43	0	5	0	4769
2016	146	429	561	79	0	6	0	1220
2017	2813	2093	1247	172	0	0	0	6324
2018	2936	584	1344	491	0	0	0	5356

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2019	2639	142	1828	187	0	3	0	4799
arith. mean	5440	2667	3042	352	85	45	9	11640

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	2130	1344	1094	51	0	4	0	4623
2015	2046	1214	1441	43	0	5	0	4749
2016	146	413	561	79	0	6	0	1205
2017	2762	1838	1247	172	0	0	0	6018
2018	2645	579	1332	491	0	0	0	5047
2019	2320	142	1828	187	0	3	0	4480
arith. mean	4763	1863	2432	295	80	42	7	9483

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	81	71	2	0	0	0	0	155
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	291	6	12	0	0	0	0	309
2019	319	0	0	0	0	0	0	319
arith. mean	678	804	609	56	5	4	2	2158

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

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
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	284	83	177	32	0	0	0	576
Sum	6490	2862	1949	882	39	71	0	12293

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

	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	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	208	0	1193	0	97	0	17	0
2017	3	33038	253	3015	40	4604	38	103	7
2018	91	1699	158	14468	792	971	44	331	10
2019	6193	5435	328	832	16	1916	16	95	0
arith. mean	2761	23258	1701	9060	609	2350	194	686	38

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

	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
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
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

	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	2.6	4.7	4.3	7.0	6.6	9.5	8.4	11.5	10.0
2019	2.2	4.1	3.1	7.2	7.4	8.0	9.2	10.0	10.8
arith. mean	3.6	5.8	6.2	9.3	10.2	12.9	13.9	14.9	15.8

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. Dregde 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

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

```
Date: 01/24/20  Start time:10:11:30 run time:13 seconds

objective function (negative log likelihood):  18.7273
Number of parameters: 78
Maximum gradient: 7.47598e-005
Akaike information criterion (AIC):   193.455
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             333      65      37       0     435

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
               28.2   -10.1    13.0     0.0     0.0      0.00      31


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.08   -0.16    0.35    0.00


contribution by fleet:
----------------------
RTM 2007-2019               total:  -6.774   mean:  -0.205
Dredge survey 2004-2019     total:  -3.307   mean:  -0.103

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
    2010-2019:   0.000 1.000
age: 1 - 4
    1983-1988:   0.461 0.500
    1989-1998:   0.466 0.500
    1999-2004:   0.377 0.500
    2005-2009:   0.257 0.500
    2010-2019:   0.538 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.252  0.936  1.379  1.379
1989-1998:  0.012  0.539  0.723  0.722  0.722
1999-2004:  0.070  1.058  1.161  1.131  1.131
2005-2009:  0.007  1.487  2.184  2.282  2.282
```

```
2010-2019:  0.016  0.297  0.774  1.411  1.411

Exploitation pattern (scaled to mean F=1)
----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.321  1.190  1.755  1.755
          season 2:  0.021  0.104  0.385  0.567  0.567

1989-1998 season 1:      0  0.821  1.101  1.098  1.098
          season 2:  0.001  0.033  0.045  0.045  0.045

1999-2004 season 1:      0  0.813  0.892  0.869  0.869
          season 2:  0.019  0.140  0.154  0.150  0.150

2005-2009 season 1:      0  0.755  1.109  1.159  1.159
          season 2:  0.001  0.055  0.081  0.085  0.085

2010-2019 season 1:      0  0.531  1.382  2.520  2.520
          season 2:  0.003  0.024  0.063  0.115  0.115


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

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

 0                1.675
 1       0.332   0.595
 2       0.332   0.595
 3       0.690   1.054
 4       0.690   1.054


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2019                        0.856    1.895    2.678
 Dredge survey 2004-2019       2.667    1.147

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2019                         0.52     0.45     0.52
 Dredge survey 2004-2019        0.39     0.77

Recruit-SSB            alfa       beta       recruit s2     recruit s
Area-1r            1016.962   1.100e+005   0.741          0.861
```

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	0.283	1.014	1.482	1.485	0.649
1984	0.013	0.319	1.145	1.669	1.678	0.732
1985	0.014	0.341	1.224	1.792	1.787	0.782
1986	0.005	0.241	0.862	1.252	1.246	0.551
1987	0.008	0.178	0.648	0.948	0.946	0.413
1988	0.005	0.260	0.934	1.350	1.348	0.597
1989	0.001	0.816	1.068	1.057	1.055	0.942
1990	0.002	0.818	1.065	1.052	1.053	0.942
1991	0.005	0.547	0.723	0.720	0.721	0.635
1992	0.003	0.821	1.079	1.068	1.071	0.950
1993	0.001	0.362	0.474	0.474	0.474	0.418
1994	0.001	0.299	0.389	0.386	0.386	0.344
1995	0.002	0.562	0.729	0.722	0.721	0.645
1996	0.003	0.526	0.681	0.673	0.673	0.603
1997	0.005	0.497	0.645	0.640	0.642	0.571
1998	0.002	0.649	0.824	0.815	0.815	0.737
1999	0.018	1.053	1.102	1.064	1.065	1.078
2000	0.016	0.842	0.878	0.852	0.851	0.860
2001	0.051	1.277	1.350	1.316	1.320	1.314
2002	0.004	0.978	1.033	0.977	0.972	1.006
2003	0.015	0.813	0.862	0.819	0.822	0.837
2004	0.008	0.856	0.896	0.848	0.849	0.876
2005	0.001	0.932	1.297	1.346	1.344	1.115
2006	0.001	1.139	1.585	1.638	1.633	1.362
2007	0.000	0.430	0.600	0.621	0.617	0.515
2008	0.000	0.802	1.117	1.145	1.143	0.960
2009	0.001	0.989	1.384	1.428	1.421	1.187
2010	0.002	0.422	1.019	1.801	1.787	0.720
2011	0.001	0.477	1.127	2.002	1.981	0.802

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2012	0.000	0.090	0.215	0.387	0.383	0.152
2013	0.000	0.543	1.291	2.288	2.279	0.917
2014	0.001	0.315	0.759	1.363	1.361	0.537
2015	0.000	0.299	0.718	1.293	1.285	0.509
2016	0.000	0.021	0.051	0.093	0.092	0.036
2017	0.001	0.402	0.965	1.733	1.724	0.684
2018	0.003	0.406	0.983	1.776	1.768	0.694
2019	0.004	0.362	0.879	1.593	1.586	0.620
arith. mean	0.006	0.567	0.909	1.148	1.145	0.738

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	0.189	0.061	0.702	0.227	1.035	0.335	1.035	0.335
1984	0.013	0.216	0.067	0.802	0.248	1.182	0.366	1.182	0.366
1985	0.014	0.231	0.072	0.856	0.266	1.262	0.392	1.262	0.392
1986	0.005	0.180	0.024	0.666	0.088	0.982	0.130	0.982	0.130
1987	0.008	0.117	0.041	0.435	0.153	0.641	0.226	0.641	0.226
1988	0.005	0.196	0.024	0.727	0.089	1.072	0.131	1.072	0.131
1989	0.001	0.665	0.027	0.892	0.036	0.890	0.036	0.890	0.036
1990	0.002	0.646	0.045	0.867	0.060	0.864	0.060	0.864	0.060
1991	0.005	0.370	0.121	0.497	0.163	0.495	0.162	0.495	0.162
1992	0.003	0.640	0.076	0.858	0.102	0.856	0.102	0.856	0.102
1993	0.001	0.282	0.034	0.378	0.046	0.377	0.046	0.377	0.046
1994	0.001	0.230	0.026	0.309	0.034	0.308	0.034	0.308	0.034
1995	0.002	0.427	0.052	0.573	0.070	0.572	0.070	0.572	0.070
1996	0.003	0.388	0.060	0.520	0.080	0.519	0.080	0.519	0.080
1997	0.005	0.322	0.118	0.433	0.159	0.431	0.158	0.431	0.158
1998	0.002	0.492	0.049	0.660	0.066	0.658	0.066	0.658	0.066
1999	0.018	0.768	0.133	0.843	0.145	0.821	0.142	0.821	0.142
2000	0.016	0.603	0.124	0.662	0.136	0.645	0.133	0.645	0.133

	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	0.051	0.784	0.386	0.860	0.423	0.838	0.412	0.838	0.412
2002	0.004	0.775	0.028	0.850	0.031	0.828	0.030	0.828	0.030
2003	0.015	0.576	0.116	0.632	0.127	0.616	0.124	0.616	0.124
2004	0.008	0.643	0.059	0.706	0.065	0.688	0.063	0.688	0.063
2005	0.001	0.729	0.053	1.070	0.078	1.118	0.082	1.118	0.082
2006	0.001	0.881	0.077	1.295	0.112	1.353	0.118	1.353	0.118
2007	0.000	0.345	0.000	0.507	0.000	0.530	0.000	0.530	0.000
2008	0.000	0.618	0.037	0.908	0.054	0.949	0.056	0.949	0.056
2009	0.001	0.747	0.075	1.098	0.110	1.147	0.115	1.147	0.115
2010	0.002	0.318	0.015	0.827	0.038	1.508	0.069	1.508	0.069
2011	0.001	0.358	0.010	0.933	0.027	1.701	0.048	1.701	0.048
2012	0.000	0.068	0.000	0.178	0.000	0.325	0.000	0.325	0.000
2013	0.000	0.431	0.000	1.122	0.000	2.046	0.000	2.046	0.000
2014	0.001	0.247	0.009	0.644	0.023	1.175	0.042	1.175	0.042
2015	0.000	0.241	0.000	0.629	0.000	1.146	0.000	1.146	0.000
2016	0.000	0.017	0.000	0.044	0.000	0.080	0.000	0.080	0.000
2017	0.001	0.322	0.006	0.838	0.014	1.529	0.026	1.529	0.026
2018	0.003	0.308	0.032	0.803	0.082	1.464	0.150	1.464	0.150
2019	0.004	0.270	0.035	0.704	0.090	1.284	0.164	1.284	0.164
arith. mean	0.006	0.423	0.057	0.712	0.093	0.917	0.113	0.917	0.113

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	0.512	0.396	0.481	0.353	0.388	0.295	0.355	0.269	0.351
1984	0.502	0.401	0.466	0.360	0.386	0.274	0.336	0.256	0.348
1985	0.516	0.385	0.468	0.346	0.385	0.290	0.363	0.264	0.344
1986	0.531	0.376	0.478	0.342	0.412	0.282	0.380	0.267	0.361
1987	0.538	0.387	0.477	0.349	0.418	0.287	0.381	0.271	0.366
1988	0.546	0.394	0.475	0.360	0.419	0.298	0.373	0.293	0.366

	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
1989	0.523	0.416	0.449	0.382	0.393	0.319	0.366	0.291	0.357
1990	0.543	0.402	0.476	0.343	0.404	0.292	0.368	0.285	0.368
1991	0.550	0.394	0.452	0.330	0.386	0.246	0.349	0.246	0.355
1992	0.533	0.391	0.424	0.313	0.365	0.234	0.328	0.235	0.335
1993	0.512	0.400	0.392	0.340	0.325	0.252	0.315	0.234	0.312
1994	0.512	0.378	0.435	0.324	0.355	0.253	0.327	0.229	0.320
1995	0.510	0.370	0.463	0.329	0.374	0.250	0.341	0.227	0.331
1996	0.538	0.334	0.483	0.299	0.385	0.246	0.350	0.219	0.343
1997	0.552	0.364	0.497	0.316	0.380	0.267	0.346	0.229	0.340
1998	0.591	0.409	0.525	0.344	0.377	0.299	0.343	0.244	0.336
1999	0.594	0.444	0.542	0.369	0.383	0.306	0.341	0.254	0.333
2000	0.582	0.458	0.527	0.381	0.356	0.314	0.327	0.247	0.306
2001	0.589	0.403	0.512	0.359	0.357	0.293	0.323	0.233	0.301
2002	0.645	0.445	0.549	0.416	0.445	0.347	0.353	0.277	0.332
2003	0.663	0.465	0.566	0.433	0.456	0.380	0.368	0.322	0.363
2004	0.679	0.525	0.601	0.456	0.458	0.403	0.366	0.346	0.360
2005	0.662	0.518	0.527	0.407	0.380	0.378	0.359	0.306	0.342
2006	0.695	0.543	0.551	0.417	0.399	0.329	0.355	0.277	0.338
2007	0.731	0.526	0.536	0.387	0.411	0.299	0.379	0.264	0.362
2008	0.694	0.523	0.582	0.396	0.437	0.289	0.371	0.266	0.364
2009	0.669	0.445	0.566	0.332	0.432	0.271	0.387	0.247	0.368
2010	0.675	0.451	0.624	0.344	0.453	0.281	0.413	0.246	0.384
2011	0.723	0.488	0.665	0.336	0.442	0.294	0.426	0.255	0.388
2012	0.716	0.544	0.638	0.414	0.434	0.333	0.407	0.295	0.381
2013	0.653	0.541	0.581	0.452	0.390	0.335	0.365	0.296	0.348
2014	0.635	0.473	0.524	0.439	0.348	0.297	0.327	0.278	0.319
2015	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2016	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2017	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304

	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	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2019	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
arith. mean	0.598	0.448	0.516	0.371	0.389	0.294	0.354	0.263	0.342

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	315012	13309	53330	2987	243
1984	76638	186509	4311	10033	429
1985	514496	45793	59051	715	1209
1986	78625	302763	14417	9256	197
1987	46010	46005	105237	3188	1605
1988	208826	26656	16546	27126	1043
1989	93442	120394	8969	3357	4327
1990	128891	55321	25387	1633	1568
1991	163784	74709	11528	4758	658
1992	35715	94019	19613	2915	1546
1993	149079	20888	20333	3812	974
1994	215905	89212	6895	6839	1785
1995	54367	129296	30626	2482	3449
1996	385539	32585	34775	7970	1763
1997	60715	224447	9201	9625	2966
1998	116741	34763	61064	2538	3822
1999	152587	64509	7959	14385	1685
2000	245619	82763	9774	1397	3233
2001	399337	135076	14930	2106	1192
2002	24856	210490	16792	2022	526
2003	147740	12989	34894	2942	546
2004	64700	74966	2318	6707	795
2005	155315	32565	12043	430	1652

	Age 0	Age 1	Age 2	Age 3	Age 4
2006	73255	80034	5240	1739	322
2007	190172	36539	10283	567	242
2008	67170	91564	8950	2788	246
2009	476968	33554	15743	1486	575
2010	29244	244053	5365	2192	306
2011	37244	14874	59739	1017	260
2012	87465	18048	3250	10513	110
2013	49402	42727	5171	1165	3663
2014	173022	25710	9042	725	323
2015	27463	91618	7342	2112	168
2016	214650	14986	25698	1904	401
2017	17201	117129	5261	11954	1183
2018	67277	9380	30144	1090	1537
2019	145971	36589	2384	6047	296
2020		79361	9630	524	824

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	314973794	640289	473071	378795	0.590
1984	76668386	1208990	201390	498626	0.667
1985	514651227	806470	471182	437114	0.712
1986	78609255	1882390	278452	382844	0.479
1987	45993011	1529080	983625	373021	0.373
1988	208823509	786450	587129	413646	0.518
1989	93455879	759875	156686	446028	0.810
1990	128829451	660083	252963	306240	0.809
1991	163774330	938693	333701	332204	0.575
1992	35712096	1046130	282377	558599	0.838
1993	149080949	461159	264078	132024	0.370
1994	215829651	672629	179512	193241	0.299

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1995	54352436	1430820	398316	400588	0.561
1996	385480051	601826	364762	265869	0.524
1997	60733136	1841750	232118	426089	0.516
1998	116686336	843316	520216	377073	0.633
1999	152549547	574742	223910	422718	0.944
2000	245547262	669085	142486	299167	0.762
2001	399210738	784460	160653	531265	1.226
2002	24865702	1406250	153277	606466	0.842
2003	147745240	333863	237044	148039	0.726
2004	64682420	466877	90944	203646	0.737
2005	155320301	341463	113210	123422	0.965
2006	73221526	546287	74682	240646	1.183
2007	190088441	311131	93060	109624	0.426
2008	67187649	712496	130353	234447	0.808
2009	476987098	380721	148301	290995	1.015
2010	29238591	1639520	120813	300508	0.598
2011	37243947	617085	435827	318840	0.664
2012	87486933	266390	145801	46117	0.123
2013	49377233	286848	84204	214359	0.777
2014	173034231	196107	64216	78830	0.462
2015	27453384	588221	83952	163381	0.435
2016	214753196	367446	239187	14613	0.030
2017	17192779	779268	164555	241916	0.590
2018	67254871	284464	198988	129525	0.612
2019	145982893	218684	67711	59584	0.550
2020			84881		
arith. mean	148390381	753550	243096	289192	0.642
geo. mean	104114311				

arith. mean for the period 1983-2019

geo. mean for the period 1983-2018

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	104153.964	79361.2	9629.89	523.733	824.273
Exploitation pattern 1st half		0.270	0.704	1.284	1.284
Exploitation pattern 2nd half	0.004	0.035	0.090	0.164	0.164
Weight in the stock 1st half		4.952	7.964	9.961	12.162
Weight in the catch 1st half		4.952	7.964	9.961	12.162
weight in the catch 2nd half	2.984	5.119	8.389	10.898	12.703
Proportion mature(2020)	0.000	0.021	0.801	0.988	1.000
Proportion mature(2021)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.514	0.390	0.271	0.251
Natural mortality 2nd half	0.606	0.516	0.331	0.323	0.304

Table 9.2.12 Sandeel Area-1r. Short-term forecast (000 tonnes). Basis: Fsq=F(2019)=0.5497; Yield(2019)=59.584; Recruitment(2019)=145.982893; Recruitment(2020)=geometric mean (GM 1983-2018)=104.153964 billions;SSB(2020)=84.881

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	242.708	186 %	-100
0.890	Fsq*0.89	0.490	113.987	169.415	100 %	24
1.000	Fsq*1	0.550	124.970	162.636	92 %	36
2.000	Fsq*2	1.100	206.343	114.297	35 %	124
1.000	Fsq*1	0.550	124.970	162.636	92 %	36
1.400	Fsq*1.4	0.770	161.272	140.640	66 %	75
1.800	Fsq*1.8	0.989	192.317	122.372	44 %	109
2.200	Fsq*2.2	1.209	219.157	107.024	26 %	138
2.400	Fsq*2.4	1.319	231.251	100.255	18 %	152
1.314	MSY	0.723	153.990	144.999	71 %	68

***SSB in 2021 relative to SSB in 2020**

**** Catch scenario for 2020 relative to TAC in 2019 (91 916 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
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

	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
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	246	0	54	0	181	0	3	0
arith. mean	2853	7145	1504	1724	314	439	113	165	44

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
2001	4.0	6.0	5.0	12.9	16.1	16.6	21.7	20.4	26.2
2002	3.2	5.7	8.3	8.4	13.2	9.6	15.3	17.3	17.7
2003	5.4	6.0	8.1	11.3	16.0	15.1	21.4	18.2	27.2
2004	4.8	6.5	7.4	9.4	10.9	12.4	12.2	13.1	13.7
2005	3.4	7.5	7.4	11.8	11.9	14.4	15.4	14.8	17.5
2006	4.6	7.6	9.9	11.5	15.9	13.9	20.6	14.8	23.4
2007	5.8	6.2	6.2	12.4	12.4	15.4	15.4	17.8	17.8
2008	3.4	5.5	7.5	12.5	12.0	16.1	15.6	18.0	17.7
2009	6.0	6.1	5.0	8.7	10.9	16.5	18.6	12.2	11.0
2010	2.5	5.7	5.3	10.3	8.4	11.5	11.0	13.2	12.5
2011	3.6	6.9	7.6	11.1	12.2	13.8	15.8	14.6	18.0
2012	4.4	8.2	9.4	12.4	15.1	14.8	19.6	21.8	22.3
2013	3.9	5.9	8.8	7.9	11.5	14.2	14.4	14.1	16.5
2014	3.3	5.3	7.0	9.9	11.2	12.0	14.6	18.6	16.6
2015	5.3	6.8	11.4	12.4	18.4	15.3	23.9	17.3	27.1
2016	2.6	3.3	5.5	12.2	8.9	14.6	11.5	16.0	13.1
2017	2.9	5.5	7.8	7.8	10.7	13.1	10.8	14.8	15.5
2018	3.5	4.6	7.4	9.6	11.4	12.4	13.8	14.0	16.1
2019	4.0	7.3	8.3	12.0	12.7	15.0	15.4	18.3	18.0
arith. mean	4.0	6.3	8.2	10.8	13.5	15.0	18.0	17.5	20.2

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. Dregde 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

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

```
Date: 01/20/20  Start time:15:43:07 run time:0 seconds

objective function (negative log likelihood):  65.6094
Number of parameters: 73
Maximum gradient: 5.39924e-005
Akaike information criterion (AIC):   277.219
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                              333      20      37       0     390

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
               68.4    -4.7    19.6      0.0     0.0      0.00      83


unweighted objective function contributions (per observation):
                Catch   CPUE      S/R   Stomachs
               0.21   -0.24    0.53    0.00


contribution by fleet:
----------------------
Dredge survey 2010-2019     total:  -4.701   mean:  -0.235

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
    2010-2019:   0.000 1.000
age: 1 - 4
    1983-1988:   0.480 0.500
    1989-1998:   0.674 0.500
    1999-2004:   0.421 0.500
    2005-2009:   0.193 0.500
    2010-2019:   0.503 0.500
```

```
F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.040  0.277  0.889  1.488  1.488
1989-1998:  0.100  0.344  0.410  0.480  0.480
1999-2004:  0.041  0.600  0.725  0.735  0.735
2005-2009:  0.001  1.982  1.687  1.806  1.806
2010-2019:  0.001  0.256  0.491  0.709  0.709
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                          0      1      2      3      4
1983-1988 season 1:       0  0.301  0.966  1.616  1.616
          season 2:  0.051  0.174  0.559  0.936  0.936

1989-1998 season 1:       0  0.724  0.863  1.012  1.012
          season 2:  0.109  0.188  0.224  0.263  0.263

1999-2004 season 1:       0  0.308  0.373  0.378  0.378
          season 2:  0.081  0.597  0.722  0.732  0.732

2005-2009 season 1:       0  0.540  0.459  0.492  0.492
          season 2:  0.001  0.541  0.460  0.493  0.493

2010-2019 season 1:       0  0.562  1.077  1.556  1.556
          season 2:  0.001  0.124  0.237  0.342  0.342
```

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

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

 0              1.662
 1      0.374   0.739
 2      0.374   0.739
 3      0.805   1.090
```

```
 4       0.805   1.090

Survey catchability:
---------------------
                            age 0    age 1
 Dredge survey 2010-2019       1.992   20.938

Stock size dependent catchability (power model)
---------------------------------------------    age 0    age 1
Dredge survey 2010-2019        1.19     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                            age 0    age 1
 Dredge survey 2010-2019        0.30     0.79

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-2r            1110.019   5.600e+004   1.060          1.029
```

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	0.368	1.169	1.949	1.947	0.769
1984	0.033	0.309	0.985	1.648	1.647	0.647
1985	0.022	0.289	0.912	1.510	1.508	0.601
1986	0.025	0.416	1.297	2.130	2.127	0.856
1987	0.008	0.091	0.291	0.485	0.485	0.191
1988	0.026	0.308	0.976	1.620	1.618	0.642
1989	0.076	0.733	0.857	0.992	0.990	0.795
1990	0.037	0.493	0.573	0.661	0.660	0.533
1991	0.071	0.556	0.652	0.758	0.756	0.604
1992	0.051	0.565	0.659	0.762	0.760	0.612
1993	0.080	0.446	0.527	0.616	0.616	0.486
1994	0.051	0.473	0.553	0.641	0.639	0.513
1995	0.043	0.257	0.304	0.355	0.354	0.281
1996	0.133	0.383	0.464	0.555	0.555	0.424
1997	0.083	0.560	0.659	0.767	0.766	0.609
1998	0.046	0.288	0.340	0.397	0.396	0.314
1999	0.036	0.371	0.461	0.481	0.481	0.416

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2000	0.017	0.552	0.656	0.661	0.660	0.604
2001	0.036	0.481	0.588	0.606	0.606	0.534
2002	0.020	0.667	0.793	0.797	0.796	0.730
2003	0.037	0.442	0.544	0.563	0.563	0.493
2004	0.030	0.900	1.072	1.081	1.079	0.986
2005	0.001	1.196	1.026	1.111	1.111	1.111
2006	0.001	1.249	1.077	1.173	1.173	1.163
2007	0.000	0.767	0.635	0.663	0.661	0.701
2008	0.000	0.823	0.692	0.735	0.734	0.757
2009	0.000	0.786	0.673	0.728	0.728	0.729
2010	0.000	0.327	0.610	0.866	0.864	0.468
2011	0.000	0.210	0.389	0.550	0.549	0.299
2012	0.000	0.120	0.221	0.313	0.312	0.171
2013	0.000	0.521	0.963	1.358	1.355	0.742
2014	0.000	0.393	0.724	1.019	1.015	0.559
2015	0.000	0.345	0.634	0.889	0.886	0.489
2016	0.000	0.149	0.275	0.387	0.386	0.212
2017	0.001	0.677	1.248	1.759	1.755	0.962
2018	0.000	0.201	0.370	0.519	0.517	0.285
2019	0.000	0.049	0.091	0.128	0.127	0.070
arith. mean	0.027	0.480	0.674	0.871	0.870	0.577

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	0.216	0.125	0.695	0.402	1.162	0.673	1.162	0.673
1984	0.033	0.176	0.114	0.566	0.367	0.947	0.613	0.947	0.613
1985	0.022	0.183	0.075	0.589	0.241	0.986	0.404	0.986	0.404
1986	0.025	0.277	0.086	0.890	0.275	1.489	0.460	1.489	0.460
1987	0.008	0.056	0.028	0.178	0.089	0.298	0.149	0.298	0.149
1988	0.026	0.190	0.090	0.609	0.290	1.020	0.485	1.020	0.485

	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
1989	0.076	0.504	0.131	0.601	0.156	0.704	0.183	0.704	0.183
1990	0.037	0.351	0.064	0.418	0.076	0.491	0.089	0.491	0.089
1991	0.071	0.367	0.122	0.438	0.145	0.513	0.170	0.513	0.170
1992	0.051	0.394	0.089	0.470	0.106	0.550	0.124	0.550	0.124
1993	0.080	0.270	0.139	0.322	0.165	0.377	0.194	0.377	0.194
1994	0.051	0.321	0.087	0.383	0.104	0.449	0.122	0.449	0.122
1995	0.043	0.159	0.075	0.189	0.089	0.222	0.104	0.222	0.104
1996	0.133	0.169	0.229	0.201	0.274	0.236	0.321	0.236	0.321
1997	0.083	0.357	0.144	0.426	0.171	0.499	0.201	0.499	0.201
1998	0.046	0.180	0.080	0.215	0.095	0.252	0.111	0.252	0.111
1999	0.036	0.138	0.268	0.167	0.324	0.169	0.328	0.169	0.328
2000	0.017	0.360	0.128	0.435	0.154	0.441	0.156	0.441	0.156
2001	0.036	0.223	0.268	0.269	0.324	0.273	0.329	0.273	0.329
2002	0.020	0.442	0.144	0.535	0.174	0.542	0.176	0.542	0.176
2003	0.037	0.192	0.269	0.233	0.326	0.236	0.330	0.236	0.330
2004	0.030	0.582	0.223	0.704	0.270	0.713	0.273	0.713	0.273
2005	0.001	0.595	0.596	0.506	0.508	0.542	0.543	0.542	0.543
2006	0.001	0.569	0.712	0.485	0.606	0.519	0.649	0.519	0.649
2007	0.000	0.612	0.000	0.521	0.000	0.558	0.000	0.558	0.000
2008	0.000	0.539	0.191	0.459	0.162	0.492	0.174	0.492	0.174
2009	0.000	0.398	0.379	0.339	0.323	0.362	0.346	0.362	0.346
2010	0.000	0.227	0.050	0.435	0.096	0.629	0.138	0.629	0.138
2011	0.000	0.153	0.018	0.294	0.035	0.425	0.051	0.425	0.051
2012	0.000	0.089	0.007	0.171	0.013	0.247	0.019	0.247	0.019
2013	0.000	0.381	0.052	0.729	0.099	1.053	0.143	1.053	0.143
2014	0.000	0.298	0.019	0.571	0.037	0.825	0.053	0.825	0.053
2015	0.000	0.268	0.005	0.514	0.010	0.742	0.014	0.742	0.014
2016	0.000	0.114	0.004	0.218	0.008	0.315	0.011	0.315	0.011
2017	0.001	0.496	0.068	0.950	0.131	1.372	0.189	1.372	0.189

	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	0.156	0.002	0.299	0.003	0.432	0.004	0.432	0.004
2019	0.000	0.038	0.000	0.073	0.000	0.106	0.000	0.106	0.000
arith. mean	0.027	0.298	0.137	0.435	0.180	0.573	0.225	0.573	0.225

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

	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	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2014	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2015	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2016	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2017	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2018	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2019	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
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	159523	16053	14304	705	32
1984	47353	61293	3577	1885	56
1985	282607	18254	14375	555	195
1986	61498	110185	4419	2472	90
1987	36103	23904	24038	544	174
1988	177505	14272	6894	7257	220
1989	87111	68902	3382	1107	793
1990	156075	32177	11450	626	376
1991	110958	59939	6662	2755	270
1992	116562	41208	11525	1468	730
1993	235244	44124	7974	2558	538

	Age 0	Age 1	Age 2	Age 3	Age 4
1994	107622	86510	9196	1934	838
1995	77669	40772	18021	2229	752
1996	421155	29641	10123	5384	1032
1997	15752	146917	6239	2484	1760
1998	26856	5775	27911	1355	1014
1999	75388	10219	1396	8080	793
2000	44074	28968	2134	337	2578
2001	130967	17262	5576	467	779
2002	10300	50323	3313	1216	330
2003	47353	4025	8776	643	361
2004	19000	18192	795	1981	274
2005	19124	7345	2550	119	402
2006	26769	7615	700	365	85
2007	39196	10658	663	93	67
2008	24925	15620	1811	155	44
2009	79247	9931	2359	384	49
2010	9770	31566	1431	480	102
2011	12833	3892	7498	332	129
2012	52422	5114	1028	2129	138
2013	28683	20890	1456	337	830
2014	19509	11426	4250	251	171
2015	5290	7774	2608	913	84
2016	168519	2108	1854	610	224
2017	3868	67156	587	584	288
2018	15268	1541	11971	79	88
2019	95720	6084	413	3492	52
2020		38146	1836	151	1522

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	159571076	246986	139525	155664	0.719
1984	47346336	411151	70404	133343	0.611
1985	282729170	278633	134996	110546	0.544
1986	61527821	724264	83700	225470	0.764
1987	36107097	418134	235861	49070	0.176
1988	177592117	277453	187213	149466	0.590
1989	87137684	447017	54176	223507	0.696
1990	156098847	354515	112308	133874	0.455
1991	110995476	644819	180593	215508	0.536
1992	116569708	433509	133786	184033	0.529
1993	235212519	514895	161943	139826	0.447
1994	107607403	607841	135266	244939	0.448
1995	77671581	584929	241591	113899	0.256
1996	421360787	453183	228662	182562	0.437
1997	15744474	886091	117360	242094	0.549
1998	26856005	391280	302247	99814	0.285
1999	75376039	239211	155127	69427	0.448
2000	44057229	270455	73204	92908	0.539
2001	130907300	198555	85477	90200	0.542
2002	10303560	329938	46074	117388	0.648
2003	47346336	139427	99012	53710	0.510
2004	19000959	153147	36717	110546	0.889
2005	19115307	92589	33759	34396	1.102
2006	26775558	71882	14167	37860	1.186
2007	39192658	76365	10735	43090	0.567
2008	24915484	112565	23766	35604	0.676
2009	79240651	87530	25084	35687	0.719
2010	9771690	201884	22743	51670	0.404

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2011	12839026	116911	76191	24896	0.250
2012	52430550	89235	45982	10594	0.140
2013	28688302	151078	28538	47814	0.630
2014	19501462	108747	42447	48033	0.463
2015	5288261	100908	43391	37902	0.398
2016	168593323	41938	31351	5230	0.172
2017	3867040	388900	23133	141314	0.823
2018	15263883	124709	98125	20239	0.230
2019	95725952	102578	58454	5216	0.056
2020			47240		
arith. mean	82373452	293872	95803	100469	0.525
geo. mean	47016069				

arith. mean for the period 1983-2019
geo. mean for the period 1983-2018

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	20825.766	38146.4	1835.81	151.273	1521.51
Exploitation pattern 1st half		0.038	0.073	0.106	0.106
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.499	10.797	14.083	16.071
Weight in the catch 1st half		5.499	10.797	14.083	16.071
weight in the catch 2nd half	3.663	8.091	12.395	15.077	17.955
Proportion mature(2020)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2021)	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(2019)=0.0557; Yield(2019)=5.216; Recruitment(2019)=95.725952; Recruitment(2020)=geometric mean (GM 2009-2018)=20.825766 billions;SSB(2020)=47.24

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	131.351	178 %	-100
7.890	Fsq*7.89	0.440	62.658	91.553	94 %	1153
1.000	Fsq*1	0.056	9.447	125.298	165 %	89
3.040	Fsq*3.04	0.169	27.193	113.970	141 %	444
5.000	Fsq*5	0.279	42.578	104.204	121 %	752
7.000	Fsq*7	0.390	56.763	95.255	102 %	1035
9.000	Fsq*9	0.502	69.620	87.196	85 %	1292
11.000	Fsq*11	0.613	81.308	79.922	69 %	1526
13.000	Fsq*13	0.725	91.963	73.341	55 %	1739
9.854	MSY	0.549	74.745	84.000	78 %	1395

***SSB in 2021 relative to SSB in 2020**

** **Catch scenario for 2020 relative to the monitoring TAC in 2019 (5000 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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1998	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
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	7901	0	747	0	4282	0	147	0
arith. mean	3537	11171	1029	3457	96	715	30	212	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
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

	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	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	5.2	8.1	9.3	10.8	14.2	14.1	18.2	18.8	20.2
arith. mean	4.7	7.0	9.4	12.3	15.9	18.1	21.1	23.1	22.8

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. Dregde 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

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

```
Date: 01/23/20  Start time:11:26:37 run time:0 seconds

objective function (negative log likelihood):  111.639
Number of parameters: 59
Maximum gradient: 8.75414e-005
Akaike information criterion (AIC):   341.279
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             306      73      34       0     413

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
               99.3    12.2    18.8     0.0     0.0      0.00     130


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.32    0.17    0.55    0.00


contribution by fleet:
----------------------
Acoustic survey             total:   6.814   mean:   0.155
Dredge survey 2004-2019     total:   5.357   mean:   0.185

F, season effect:
-----------------
age: 0
    1986-1998:   0.000 1.000
    1999-2019:   0.000 1.000
age: 1 - 4
    1986-1998:   0.893 0.500
    1999-2019:   1.059 0.500

F, age effect:
--------------
                0      1      2      3      4
1986-1998:  0.102  0.366  0.401  0.322  0.322
1999-2019:  0.057  0.179  0.291  0.285  0.285


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1986-1998 season 1:      0  0.646  0.709  0.568  0.568
          season 2:  0.172  0.308  0.338  0.271  0.271
```

```
1999-2019 season 1:      0  0.530  0.863  0.843  0.843
          season 2:  0.147  0.231  0.376  0.367  0.367


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

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

 0                1.155
 1       0.658   1.027
 2       0.658   1.027
 3       1.053   1.205
 4       1.053   1.205


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                    2.868    5.602    4.527    4.527
 Dredge survey 2004-2019       0.534    0.534

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 2004-2019        1.03     1.00

sqrt(Survey variance) ~ CV:
--------------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                     0.55     0.55     0.92     0.92
 Dredge survey 2004-2019        0.65     0.83

Recruit-SSB            alfa       beta        recruit s2     recruit s
Area-3r           1472.216   8.000e+004   1.111          1.054
```

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	0.449	0.486	0.388	0.390	0.467
1987	0.001	0.709	0.745	0.583	0.582	0.727
1988	0.051	0.909	0.958	0.759	0.758	0.933
1989	0.003	1.027	1.079	0.864	0.861	1.053
1990	0.050	0.576	0.612	0.489	0.489	0.594

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1991	0.039	0.696	0.739	0.587	0.586	0.718
1992	0.003	0.324	0.340	0.263	0.264	0.332
1993	0.042	0.600	0.639	0.505	0.504	0.620
1994	0.016	0.642	0.680	0.527	0.523	0.661
1995	0.007	0.511	0.544	0.423	0.422	0.527
1996	0.043	0.500	0.537	0.420	0.420	0.518
1997	0.066	0.900	0.964	0.770	0.766	0.932
1998	0.140	1.139	1.231	0.987	0.981	1.185
1999	0.151	0.843	1.359	1.308	1.302	1.101
2000	0.004	0.871	1.359	1.268	1.260	1.115
2001	0.156	0.543	0.889	0.866	0.869	0.716
2002	0.000	0.573	0.886	0.860	0.856	0.730
2003	0.021	0.306	0.479	0.471	0.469	0.392
2004	0.020	0.213	0.336	0.331	0.330	0.274
2005	0.000	0.103	0.161	0.155	0.154	0.132
2006	0.000	0.044	0.068	0.065	0.065	0.056
2007	0.000	0.260	0.406	0.388	0.387	0.333
2008	0.000	0.280	0.438	0.426	0.425	0.359
2009	0.000	0.024	0.037	0.036	0.036	0.030
2010	0.001	0.304	0.479	0.460	0.457	0.391
2011	0.000	0.197	0.310	0.299	0.296	0.253
2012	0.000	0.119	0.188	0.183	0.182	0.153
2013	0.000	0.058	0.092	0.090	0.089	0.075
2014	0.000	0.231	0.364	0.356	0.353	0.298
2015	0.000	0.304	0.478	0.467	0.464	0.391
2016	0.000	0.119	0.188	0.183	0.182	0.153
2017	0.000	0.263	0.414	0.405	0.402	0.339
2018	0.000	0.281	0.442	0.432	0.429	0.362
2019	0.000	0.385	0.604	0.591	0.587	0.494

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
arith. mean	0.026	0.450	0.574	0.506	0.504	0.512

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	0.284	0.135	0.311	0.148	0.250	0.119	0.250	0.119
1987	0.001	0.572	0.002	0.628	0.002	0.504	0.002	0.504	0.002
1988	0.051	0.682	0.091	0.748	0.100	0.600	0.080	0.600	0.080
1989	0.003	0.857	0.006	0.941	0.006	0.754	0.005	0.754	0.005
1990	0.050	0.423	0.089	0.464	0.098	0.372	0.078	0.372	0.078
1991	0.039	0.537	0.070	0.589	0.077	0.472	0.062	0.472	0.062
1992	0.003	0.259	0.006	0.284	0.006	0.228	0.005	0.228	0.005
1993	0.042	0.446	0.074	0.490	0.082	0.393	0.065	0.393	0.065
1994	0.016	0.498	0.028	0.547	0.031	0.439	0.025	0.439	0.025
1995	0.007	0.406	0.013	0.445	0.014	0.357	0.011	0.357	0.011
1996	0.043	0.356	0.076	0.390	0.084	0.313	0.067	0.313	0.067
1997	0.066	0.666	0.117	0.731	0.129	0.586	0.103	0.586	0.103
1998	0.140	0.789	0.249	0.866	0.274	0.694	0.220	0.694	0.220
1999	0.151	0.545	0.238	0.887	0.387	0.867	0.378	0.867	0.378
2000	0.004	0.687	0.006	1.119	0.010	1.093	0.010	1.093	0.010
2001	0.156	0.287	0.246	0.466	0.401	0.456	0.392	0.456	0.392
2002	0.000	0.427	0.000	0.696	0.000	0.680	0.000	0.680	0.000
2003	0.021	0.212	0.033	0.345	0.053	0.337	0.052	0.337	0.052
2004	0.020	0.147	0.032	0.239	0.052	0.233	0.051	0.233	0.051
2005	0.000	0.079	0.000	0.129	0.000	0.126	0.000	0.126	0.000
2006	0.000	0.034	0.000	0.055	0.001	0.054	0.001	0.054	0.001
2007	0.000	0.206	0.000	0.336	0.000	0.328	0.000	0.328	0.000
2008	0.000	0.228	0.000	0.372	0.000	0.363	0.000	0.363	0.000
2009	0.000	0.019	0.000	0.031	0.000	0.031	0.000	0.031	0.000
2010	0.001	0.247	0.001	0.402	0.001	0.392	0.001	0.392	0.001
2011	0.000	0.157	0.000	0.255	0.000	0.250	0.000	0.250	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
2012	0.000	0.095	0.000	0.155	0.000	0.152	0.000	0.152	0.000
2013	0.000	0.046	0.000	0.075	0.000	0.074	0.000	0.074	0.000
2014	0.000	0.186	0.000	0.302	0.000	0.295	0.000	0.295	0.000
2015	0.000	0.245	0.000	0.398	0.000	0.389	0.000	0.389	0.000
2016	0.000	0.095	0.000	0.155	0.000	0.152	0.000	0.152	0.000
2017	0.000	0.212	0.000	0.345	0.000	0.337	0.000	0.337	0.000
2018	0.000	0.226	0.000	0.368	0.000	0.360	0.000	0.360	0.000
2019	0.000	0.311	0.000	0.505	0.000	0.494	0.000	0.494	0.000
arith. mean	0.026	0.337	0.045	0.443	0.058	0.395	0.051	0.395	0.051

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

	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
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
arith. mean	1.164	0.713	0.571	0.566	0.463	0.419	0.404	0.386	0.387

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	511454	85279	5876	262	713
1987	116770	124178	14400	1273	325
1988	359650	27914	18678	2710	453
1989	107078	73263	3547	2942	770
1990	202638	28228	9591	554	852
1991	123415	53608	5578	2362	484
1992	261819	35028	9721	1237	904
1993	191801	79389	8343	3015	924

	Age 0	Age 1	Age 2	Age 3	Age 4
1994	181907	58843	14348	1896	1284
1995	148761	59016	9760	2992	1010
1996	777484	53797	11016	2246	1308
1997	63136	276825	10209	2523	1165
1998	94126	24038	39242	1671	859
1999	120659	31034	2721	5104	494
2000	126550	36680	3829	277	814
2001	118051	41127	4300	388	167
2002	28428	30719	4874	478	89
2003	63135	8393	3886	606	87
2004	40332	18258	1327	670	142
2005	70254	11783	3241	276	204
2006	111300	22245	2453	841	164
2007	59086	36306	5144	734	390
2008	87236	20676	7658	1249	351
2009	140677	32415	5056	2042	499
2010	13783	52267	11015	2052	1221
2011	10571	4540	13719	3084	1084
2012	74946	3152	1157	4028	1472
2013	195640	22800	829	365	2028
2014	218094	59518	6299	283	981
2015	6698	66339	14302	1712	414
2016	593191	2038	15029	3533	616
2017	26436	180461	536	4735	1520
2018	202344	8042	42256	140	1914
2019	334269	61557	1856	10758	635
2020		101692	13058	412	2950

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	511572565	593822	77188	282315	0.439
1987	116803080	999662	190804	395296	0.602
1988	359778816	465938	271034	330358	0.811
1989	107070708	542831	101215	350409	0.905
1990	202651842	330283	105451	163224	0.536
1991	123407198	555224	161781	274839	0.637
1992	261776070	353078	123500	86788	0.278
1993	191806959	670738	196614	175786	0.546
1994	181905886	632964	239187	267281	0.552
1995	148783085	481372	142629	173607	0.439
1996	777815572	728497	238232	159024	0.453
1997	63148522	1606030	187025	470670	0.822
1998	94112365	554639	347319	462081	1.089
1999	120601225	340687	114348	191253	1.028
2000	126531266	313028	60779	186837	0.911
2001	118095007	349849	65907	193684	0.700
2002	28431266	319131	65121	116298	0.561
2003	63148522	115899	59695	34673	0.321
2004	40345886	157299	26291	31285	0.235
2005	70280153	154987	54339	13991	0.104
2006	111328962	218642	50111	7094	0.045
2007	59115280	370279	90762	74972	0.271
2008	87224865	317369	130744	74933	0.300
2009	140680230	304604	94278	6261	0.025
2010	13783737	659317	235861	61241	0.325
2011	10574965	306092	232350	92452	0.206
2012	74925137	184366	150242	40116	0.125
2013	195681716	255792	52892	9844	0.061

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2014	217998775	610801	101316	90876	0.244
2015	6695860	777262	204230	104631	0.322
2016	593174986	284316	232815	42845	0.125
2017	26429728	1512330	175255	115642	0.278
2018	202246943	504599	361855	75143	0.297
2019	334116402	684291	197402	135590	0.408
2020			221239		
arith. mean	170050526	507530	153141	155628	0.441
geo. mean	102975330				

arith. mean for the period 1986-2019
geo. mean for the period 1986-2018

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	102992.005	101692	13057.7	411.9	2950.35
Exploitation pattern 1st half		0.311	0.505	0.494	0.494
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.782	11.533	16.879	25.136
Weight in the catch 1st half		6.782	11.533	16.879	25.136
weight in the catch 2nd half	4.095	7.982	12.575	16.638	18.197
Proportion mature(2020)	0.000	0.036	0.766	1.000	1.000
Proportion mature(2021)	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(2019)=0.408; Yield(2019)=135.59; Recruitment(2019)=334.116402; Recruitment(2020)=geometric mean (GM 1986-2018)=102.992005 billions;SSB(2020)=221.239

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	385.956	74 %	-100
0.710	Fsq*0.71	0.290	155.072	298.955	35 %	14
1.000	Fsq*1	0.408	208.340	269.841	22 %	54

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.400	Fsq*0.4	0.163	91.844	334.055	51 %	-32
0.600	Fsq*0.6	0.245	133.299	310.979	41 %	-2
0.800	Fsq*0.8	0.326	172.066	289.619	31 %	27
0.100	Fsq*0.1	0.041	24.151	372.212	68 %	-82
0.120	Fsq*0.12	0.049	28.882	369.527	67 %	-79
0.140	Fsq*0.14	0.057	33.582	366.863	66 %	-75
3.167	MSY	1.292	482.681	129.001	-42 %	256

***SSB in 2021 relative to SSB in 2020**

**** Catch scenario for 2020 relative to TAC in 2019 (135 689 t, sum of the Norwegian 125000 t and EU TAC 10689 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)

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1996	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
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	162	0	149	0	57	0
arith. mean	129	1113	175	994	152	633	26	265	49

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
2018	3.3	5.7	4.8	9.4	7.6	13.1	11.1	18.3	13.9
2019	3.3	5.9	4.8	10.0	7.6	13.5	11.1	19.6	13.9
arith. mean	3.8	5.6	7.7	9.5	13.3	13.2	16.1	17.3	21.2

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. Dregde survey indices.

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

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

```
Date: 01/20/20  Start time:15:07:04 run time:0 seconds

objective function (negative log likelihood):  3.22347
Number of parameters: 46
Maximum gradient: 8.9242e-005
Akaike information criterion (AIC):   98.4469
```

```
Number of observations used in the likelihood:
                             Catch    CPUE     S/R Stomach     Sum
                              243      33      27       0     303

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
               27.6   -25.3    19.3     0.0     0.0     0.00      22


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.11   -0.77    0.71    0.00


contribution by fleet:
----------------------
Old Dredge survey 1999-2003     total:  -9.450   mean:  -1.050
New Dredge survey 2008-2019     total: -15.848   mean:  -0.660

F, season effect:
-----------------
age: 0
    1993-2019:   0.000 1.000
age: 1 - 4
    1993-2019:   0.583 0.500

F, age effect:
--------------
                 0      1      2      3      4
1993-2019:  0.003  0.109  0.188  0.264  0.264


Exploitation pattern (scaled to mean F=1)
------------------------------------------
                         0      1      2      3      4
1993-2019 season 1:      0  0.649  1.116  1.567  1.567
          season 2:  0.004  0.086  0.149  0.209  0.209


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

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

 0                2.004
 1       0.709   0.375
 2       0.709   0.375
```

```
 3       0.723   1.267
 4       0.723   1.267


Survey catchability:
--------------------
                           age 0    age 1
 Old Dredge survey 1999-2003       0.773   17.637
 New Dredge survey 2008-2019       0.570    3.164

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Old Dredge survey 1999-2003        0.30     0.30
 New Dredge survey 2008-2019        0.30     0.40

Recruit-SSB             alfa      beta       recruit s2     recruit s
Area-4              1419.336   4.800e+004   1.532          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	0.337	0.563	0.770	0.768	0.450
1994	0.002	0.390	0.651	0.888	0.886	0.520
1995	0.000	0.115	0.191	0.259	0.258	0.153
1996	0.009	0.245	0.435	0.631	0.636	0.340
1997	0.001	0.144	0.244	0.336	0.336	0.194
1998	0.000	0.156	0.259	0.353	0.351	0.207
1999	0.000	0.224	0.371	0.503	0.501	0.298
2000	0.000	0.111	0.185	0.251	0.249	0.148
2001	0.000	0.175	0.290	0.394	0.392	0.232
2002	0.000	0.037	0.062	0.084	0.083	0.049
2003	0.001	0.279	0.464	0.631	0.629	0.371
2004	0.000	0.054	0.089	0.121	0.120	0.071
2005	0.000	0.023	0.039	0.053	0.053	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	0.018	0.030	0.040	0.040	0.024
2013	0.000	0.010	0.017	0.022	0.022	0.013
2014	0.000	0.013	0.022	0.030	0.030	0.018
2015	0.000	0.011	0.018	0.024	0.024	0.014
2016	0.000	0.021	0.034	0.047	0.046	0.028
2017	0.000	0.045	0.076	0.102	0.102	0.061
2018	0.000	0.130	0.215	0.292	0.290	0.173
2019	0.000	0.049	0.082	0.111	0.111	0.066
arith. mean	0.001	0.096	0.161	0.221	0.220	0.128

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	0.249	0.033	0.429	0.057	0.602	0.080	0.602	0.080
1994	0.002	0.293	0.032	0.504	0.055	0.707	0.077	0.707	0.077
1995	0.000	0.090	0.000	0.156	0.000	0.219	0.001	0.219	0.001
1996	0.009	0.108	0.168	0.185	0.289	0.260	0.406	0.260	0.406
1997	0.001	0.102	0.023	0.175	0.040	0.246	0.057	0.246	0.057
1998	0.000	0.119	0.006	0.205	0.011	0.288	0.015	0.288	0.015
1999	0.000	0.177	0.000	0.305	0.000	0.428	0.000	0.428	0.000
2000	0.000	0.088	0.000	0.151	0.000	0.212	0.000	0.212	0.000
2001	0.000	0.136	0.002	0.235	0.004	0.330	0.006	0.330	0.006
2002	0.000	0.029	0.000	0.050	0.000	0.070	0.000	0.070	0.000
2003	0.001	0.214	0.013	0.368	0.022	0.517	0.031	0.517	0.031
2004	0.000	0.042	0.000	0.072	0.001	0.101	0.001	0.101	0.001
2005	0.000	0.018	0.000	0.032	0.000	0.044	0.000	0.044	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	0.001	0.000	0.001	0.000
2008	0.000	0.002	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2010	0.000	0.001	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	0.034	0.000	0.034	0.000
2013	0.000	0.008	0.000	0.013	0.000	0.019	0.000	0.019	0.000
2014	0.000	0.010	0.000	0.018	0.000	0.025	0.000	0.025	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.020	0.000	0.020	0.000
2016	0.000	0.016	0.000	0.028	0.000	0.039	0.000	0.039	0.000
2017	0.000	0.036	0.000	0.061	0.000	0.086	0.000	0.086	0.000
2018	0.000	0.102	0.000	0.176	0.000	0.247	0.000	0.247	0.000
2019	0.000	0.039	0.000	0.067	0.000	0.094	0.000	0.094	0.000
arith. mean	0.001	0.070	0.010	0.121	0.018	0.170	0.025	0.170	0.025

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2008	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
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	116157	21644	23310	7442	1549
1994	250967	37085	4193	4821	2012
1995	68533	80132	6888	807	1389
1996	370244	21918	18803	1981	798
1997	94522	117381	4274	3932	635
1998	42629	30193	26611	1159	1492
1999	227134	13629	6843	7209	883
2000	194316	72642	2934	1697	2329
2001	23129	62146	17098	848	1470
2002	84912	7396	13897	4527	750
2003	146616	27156	1846	4444	2174
2004	12149	46860	5563	420	1708
2005	8840	3885	11542	1739	876

	Age 0	Age 1	Age 2	Age 3	Age 4
2006	5523	2827	980	3760	1116
2007	8305	1766	726	329	2163
2008	24104	2656	454	244	1140
2009	368411	7709	681	152	629
2010	64554	117825	1981	229	356
2011	43688	20646	30248	665	264
2012	40514	13972	5297	10145	412
2013	27753	12957	3540	1739	4491
2014	277178	8876	3303	1174	2777
2015	53937	88647	2257	1091	1750
2016	112981	17250	22587	748	1259
2017	131608	36134	4361	7385	873
2018	14597	42091	8958	1379	3344
2019	175399	4668	9764	2526	1675
2020		56096	1154	3071	1712

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	116104360	577242	357897	132599	0.384
1994	251009162	561609	147414	158690	0.441
1995	68544930	819658	122027	52591	0.123
1996	370365162	413415	245733	158490	0.375
1997	94489568	872976	79618	58446	0.170
1998	42627068	496312	255250	58746	0.171
1999	227122482	290757	190232	53334	0.241
2000	194316727	367455	80822	37714	0.119
2001	23138304	342115	109316	47902	0.189
2002	84901303	166795	120813	12736	0.040
2003	146567994	196899	68734	63731	0.308
2004	12151947	256567	59814	6882	0.057

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2005	8841791	111459	79858	1557	0.025
2006	5520616	99216	80660	0	0.000
2007	8301942	53740	43783	0	0.000
2008	24106691	37542	24029	0	0.002
2009	368517958	66605	20137	0	0.000
2010	64553184	631281	23718	0	0.001
2011	43706177	381954	225032	0	0.002
2012	40507593	202118	134996	2585	0.019
2013	27757038	203949	128027	5225	0.011
2014	277130757	179737	107689	4314	0.014
2015	53919352	448870	57584	4392	0.011
2016	113011484	354774	221461	6188	0.022
2017	131563476	430908	148301	18474	0.049
2018	14592234	404892	145510	42296	0.139
2019	175473747	192614	143774	6598	0.053
2020			84120		
arith. mean	110692564	339313	125219	34574	0.110
geo. mean	60008693				

arith. mean for the period 1993-2019
geo. mean for the period 1993-2018

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	72089.623	56095.8	1153.77	3070.97	1712.31
Exploitation pattern 1st half		0.039	0.067	0.094	0.094
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.695	9.821	13.905	19.478
Weight in the catch 1st half		5.695	9.821	13.905	19.478
weight in the catch 2nd half	4.109	6.534	10.335	14.417	17.065
Proportion mature(2020)	0.000	0.000	0.790	0.980	1.000
Proportion mature(2021)	0.000	0.000	0.790	0.980	1.000

	Age 0	Age 1	Age 2	Age 3	Age 4
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(2019)=0.0528; Yield(2019)=6.598; Recruitment(2019)=175.473747; Recruitment(2020)=geometric mean (GM 2009-2018)=72.089623 billions;SSB(2020)=84.12

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	158.773	89 %	-100
2.840	Fsq*2.84	0.150	39.611	136.457	62 %	692
1.000	Fsq*1	0.053	14.645	150.454	79 %	193
2.000	Fsq*2	0.106	28.509	142.651	70 %	470
3.000	Fsq*3	0.158	41.645	135.328	61 %	733
4.000	Fsq*4	0.211	54.102	128.450	53 %	982
5.000	Fsq*5	0.264	65.923	121.986	45 %	1218
6.000	Fsq*6	0.317	77.151	115.906	38 %	1443
7.000	Fsq*7	0.369	87.822	110.183	31 %	1656
8.543	MSY	0.451	103.276	102.000	21 %	1966

***SSB in 2021 relative to SSB in 2020**
**** Catch scenario for 2020 relative to TAC in 2019 (5000 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

Year	Biomass (tonnes)
2018	945.0
2019	3844.6

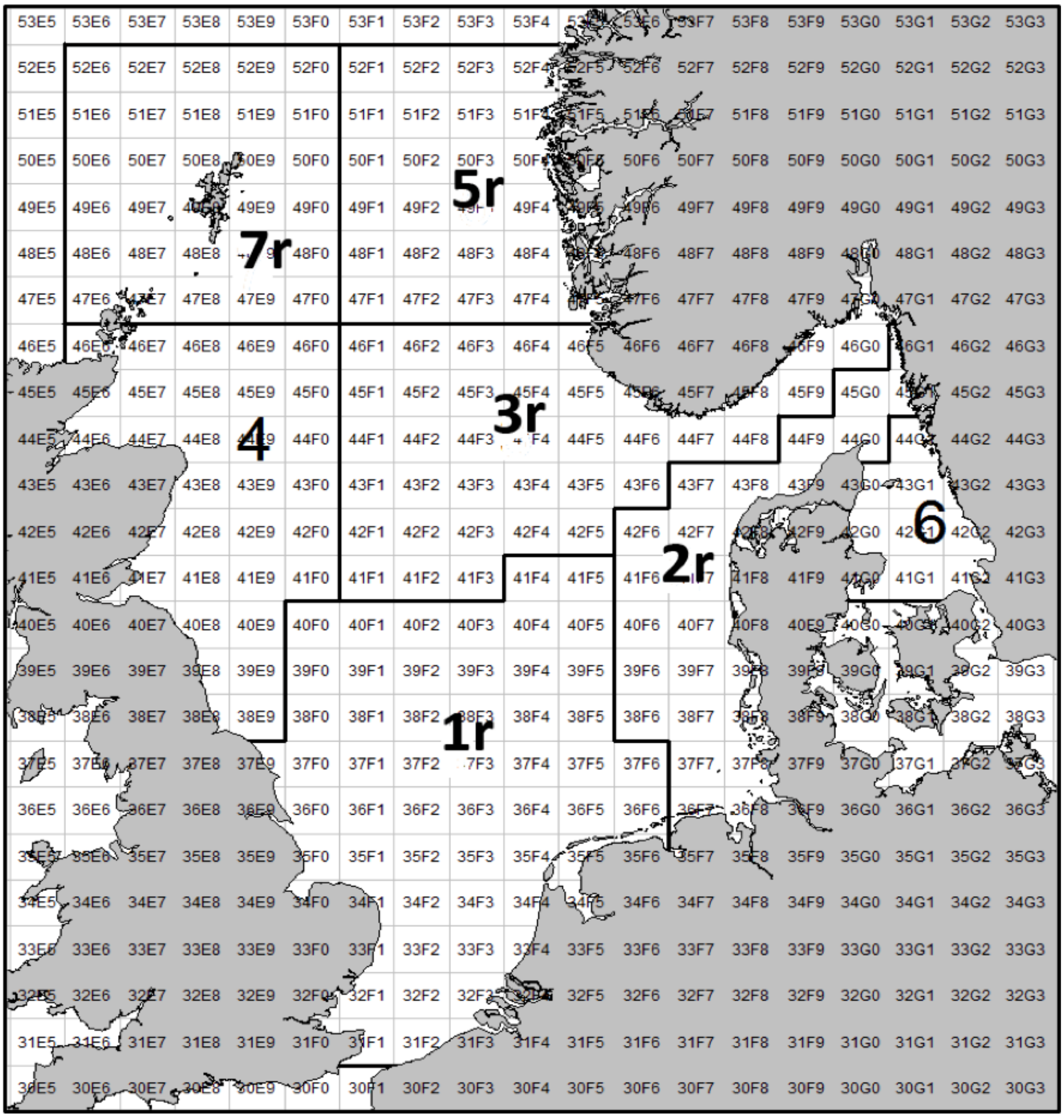


Figure 9.1.1. Sandeel in ICES divisions 4 and 3.a. Sandeel management areas.

Figure 9.1.2. Sandeel in ICES divisions 4 and 3.a. Catch by ICES rectangles 2004-2019. Area of the circles is proportional to catch by rectangle.

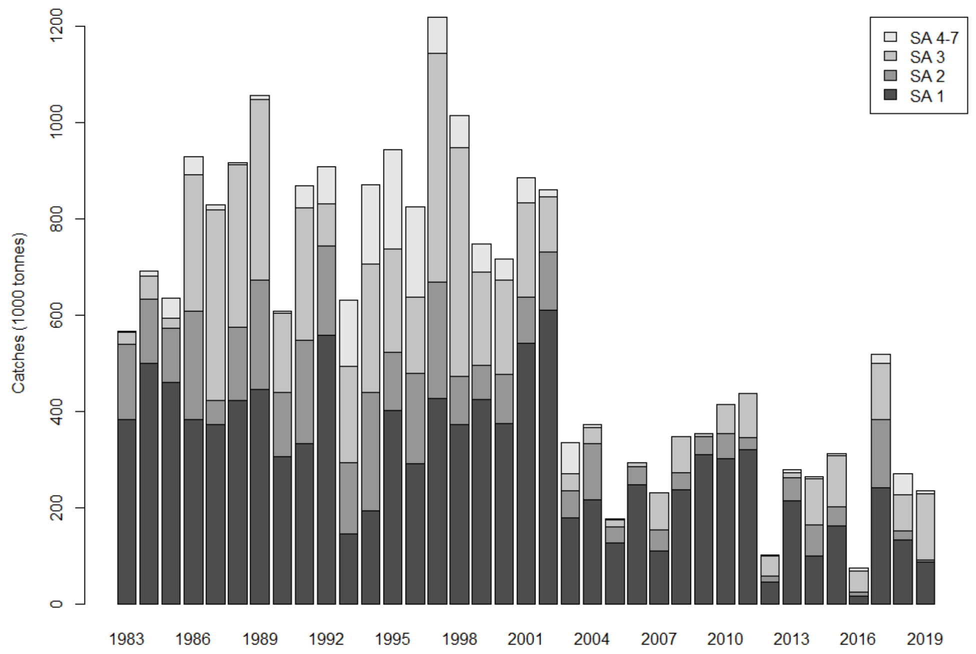


Figure 9.1.3 Sandeel in ICES divisions 4 and 3.a. Total catches by year and area.

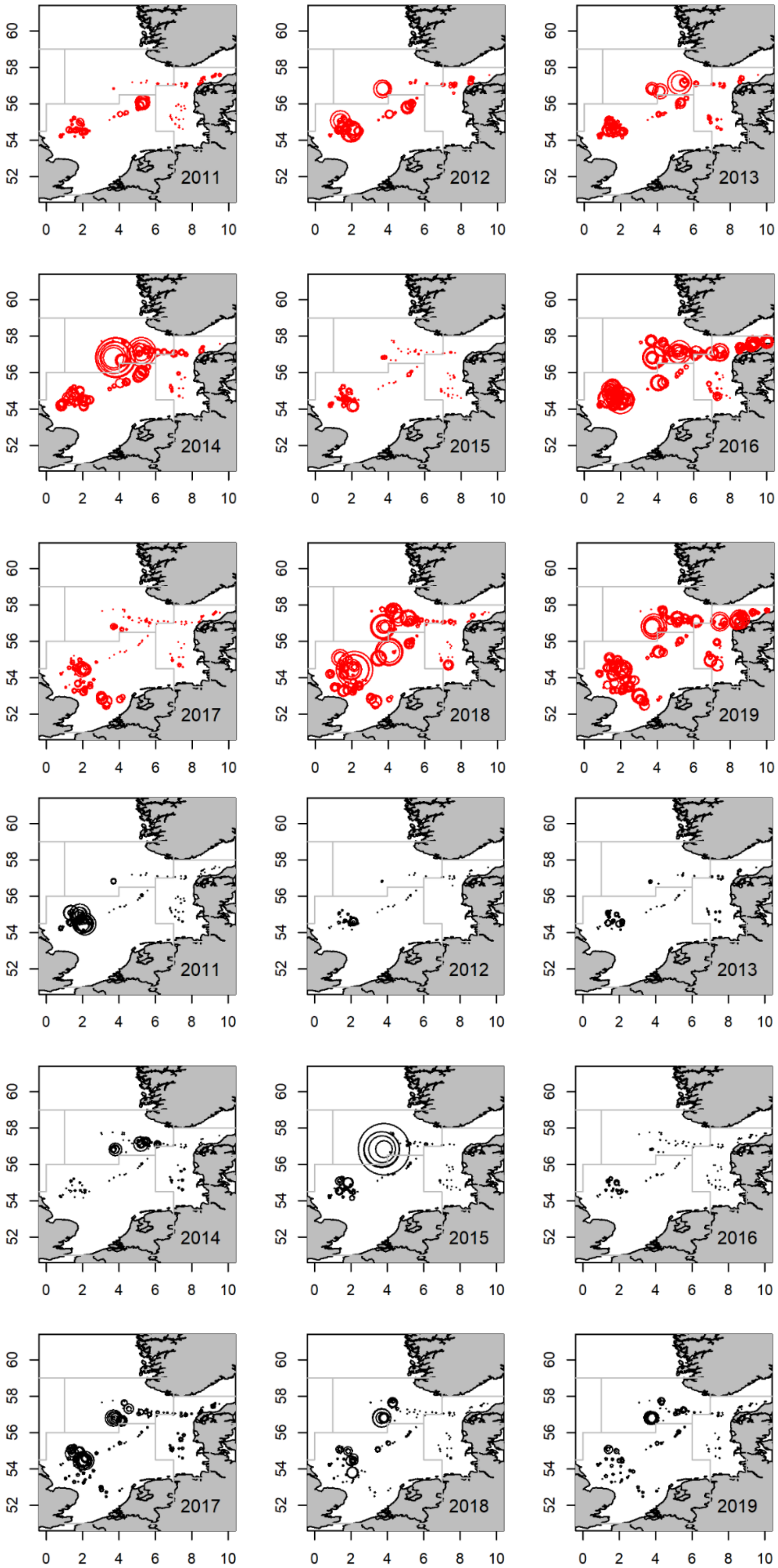


Figure 9.1.4. Sandeel in ICES divisions 4 and 3.a. Sandeel in ICES divisions 4 and 3.a. Danish survey catches by haul for 0-group (upper and red) and 1-group (lower and black). Area of the circles is proportional to catch number.

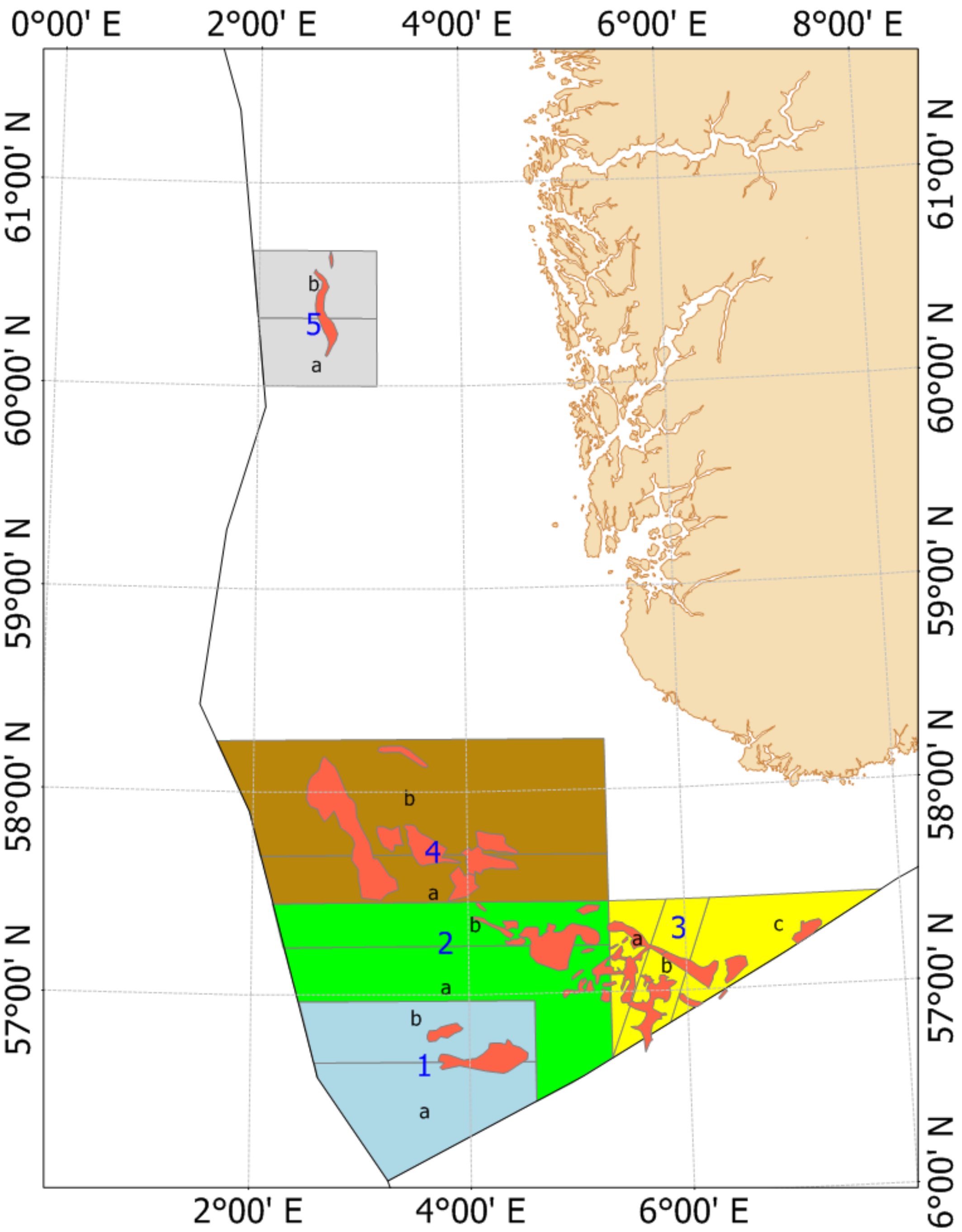


Figure 9.1.5. Sandeel in ICES divisions 4 and 3.a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Subarea3 consist of three subareas a, b, and c.

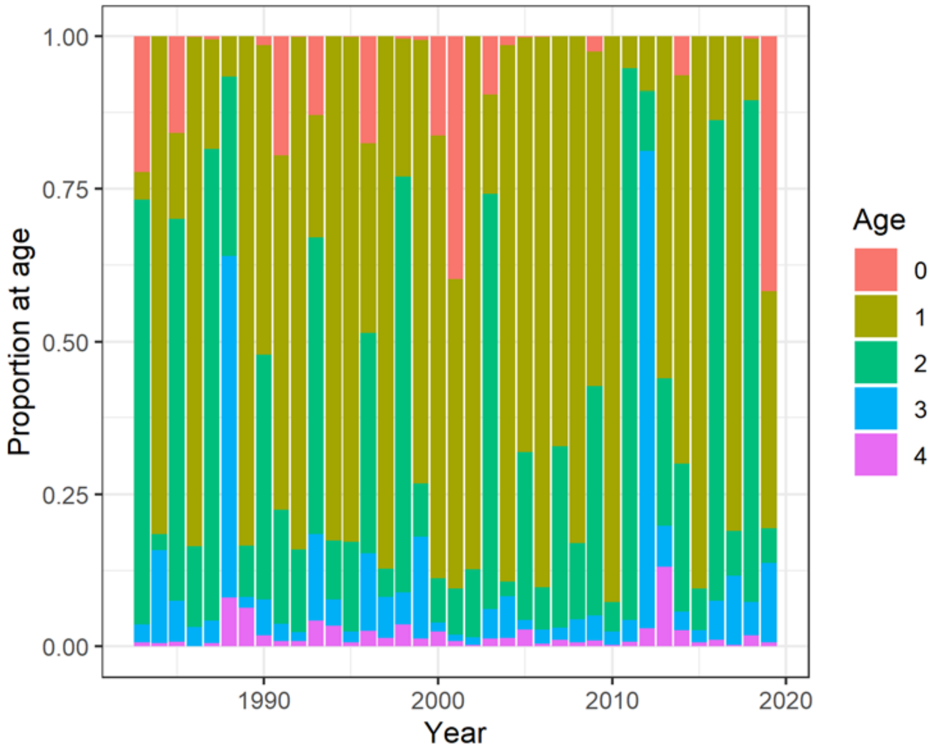


Figure 9.2.1. Sandeel Area-1r. Catch numbers, proportion-at-age.

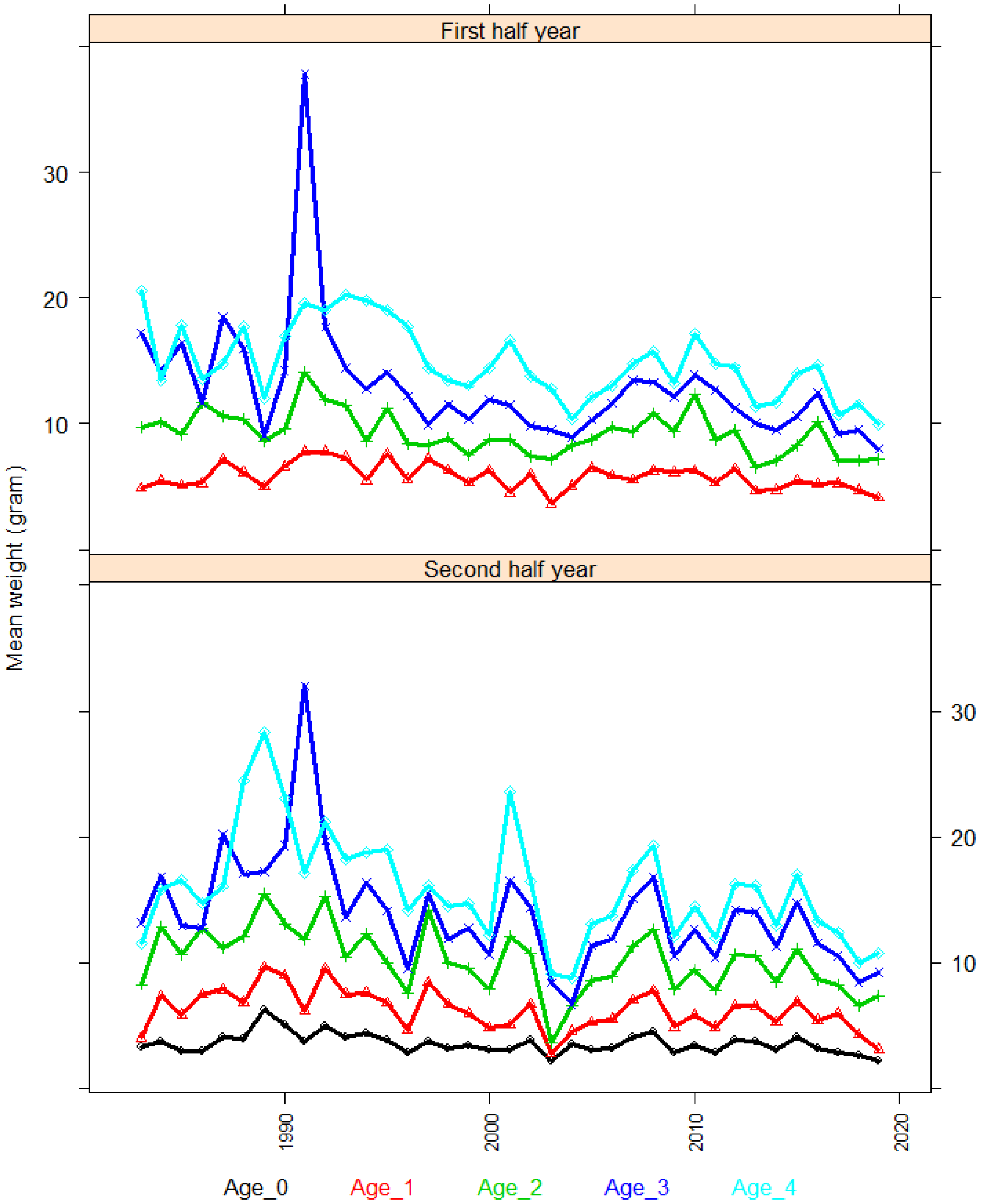


Figure 9.2.2. Sandeel Area-1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

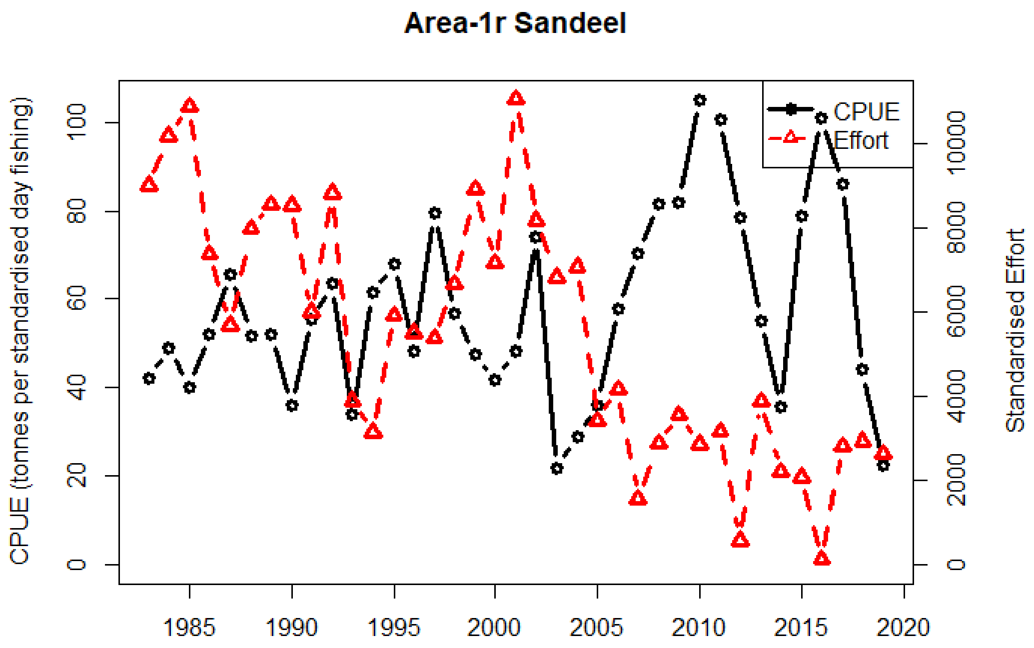


Figure 9.2.3. Sandeel Area-1r. CPUE and effort.

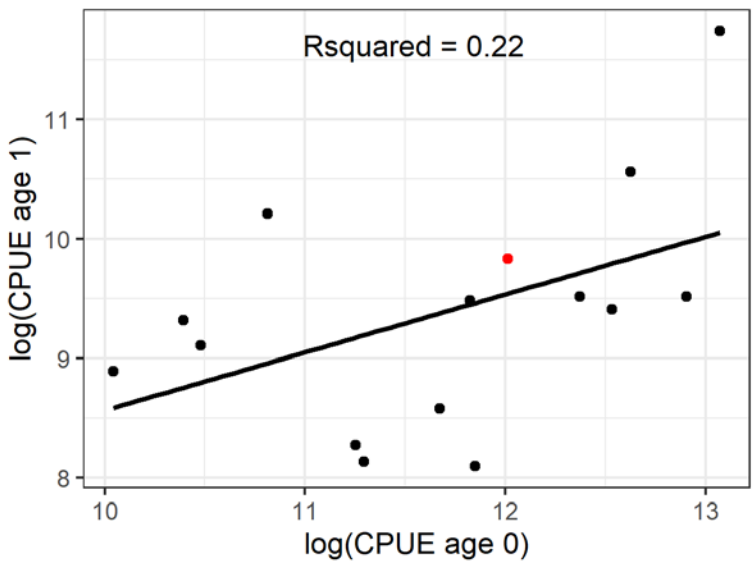


Figure 9.2.4. Sandeel Area-1r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

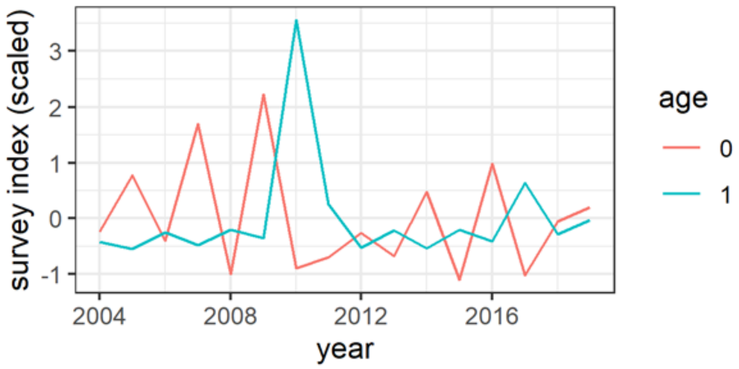


Figure 9.2.5. Sandeel Area-1r. Dredge survey index timeline.

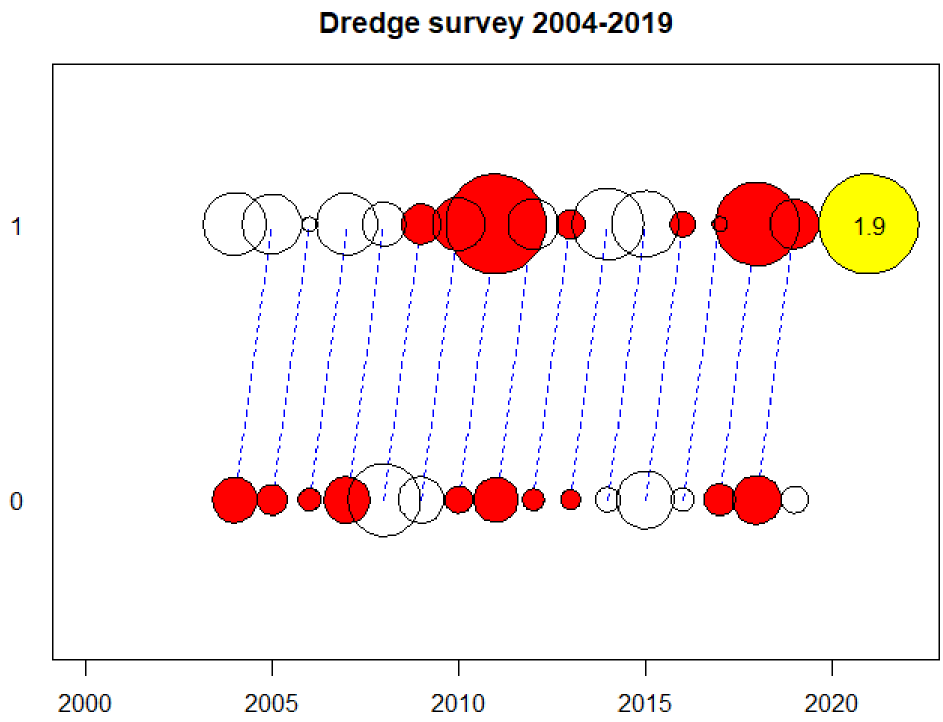


Figure 9.2.6. Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

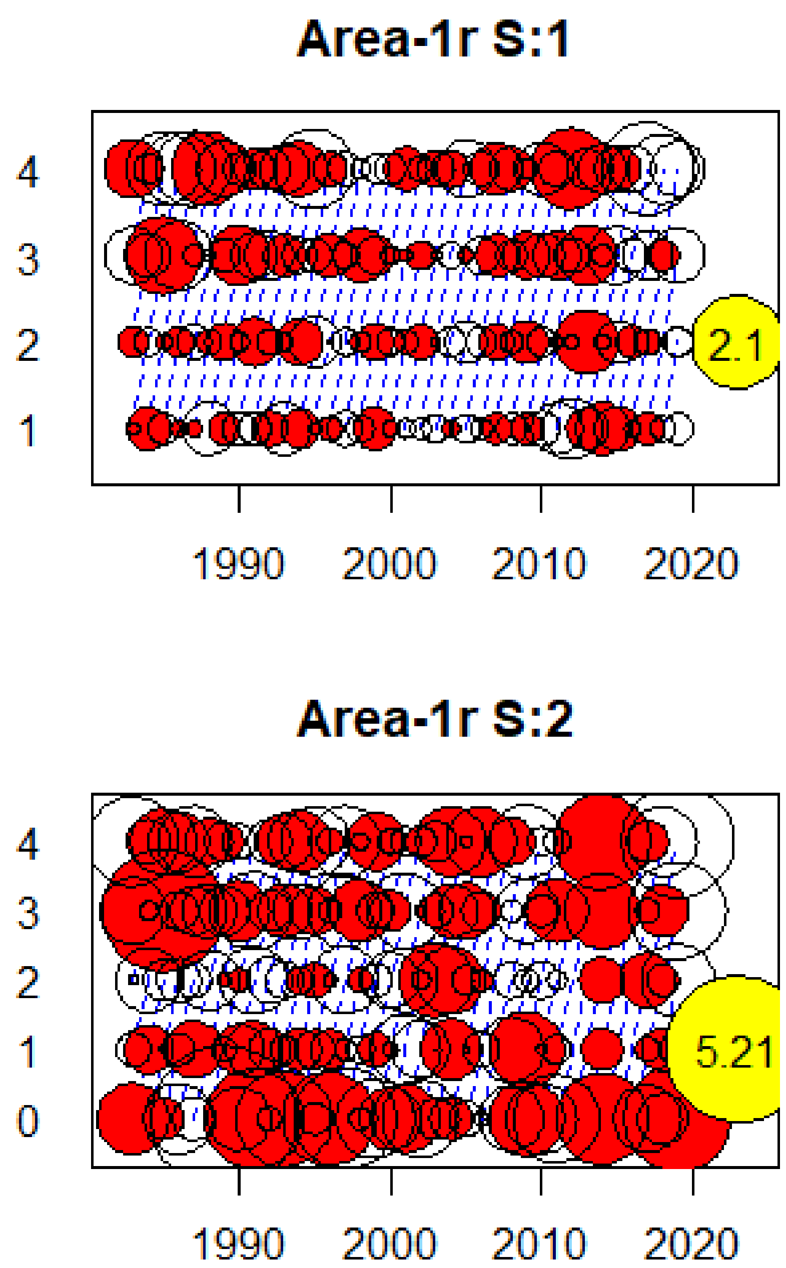


Figure 9.2.7. Sandeel Area-1r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

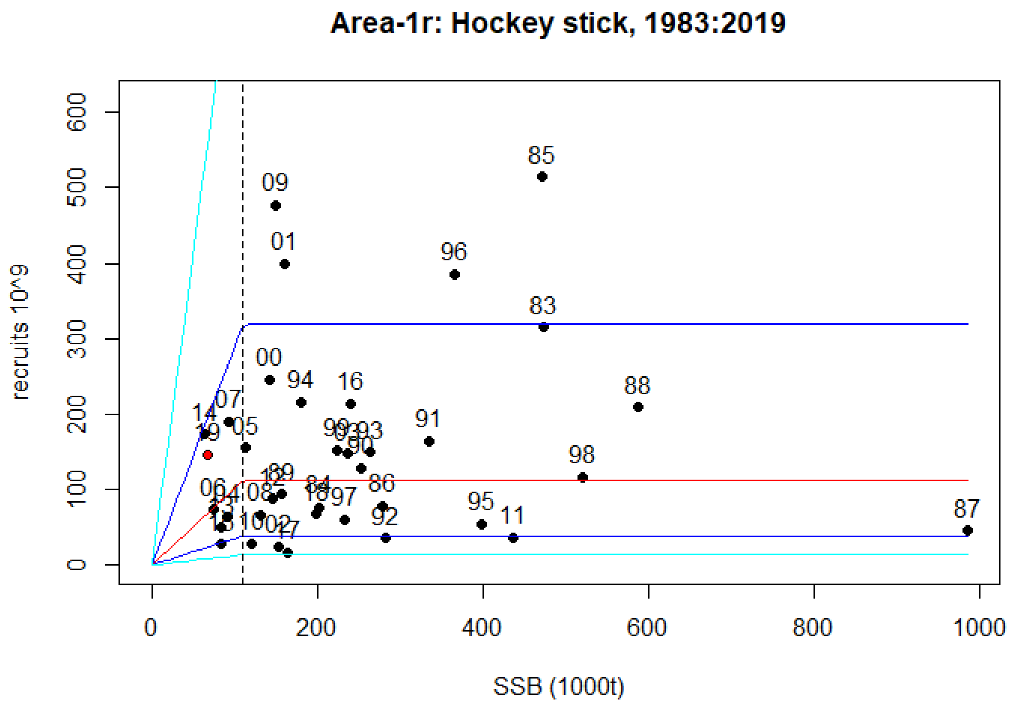


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years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

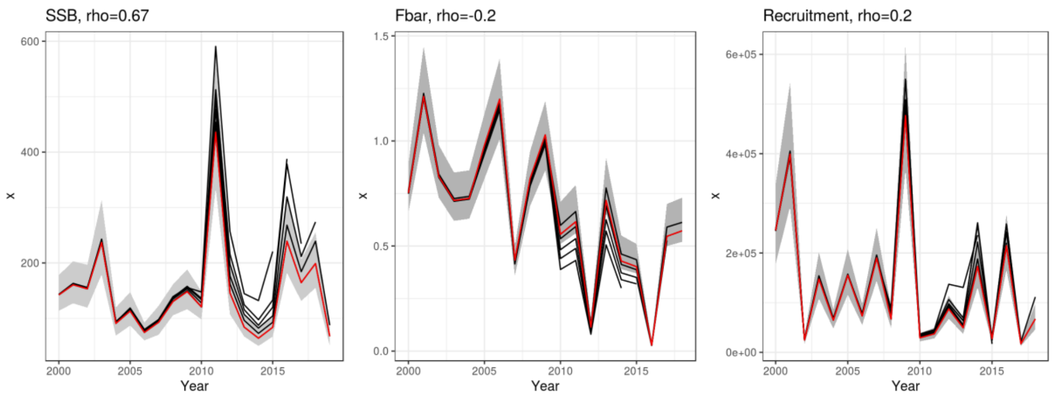


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

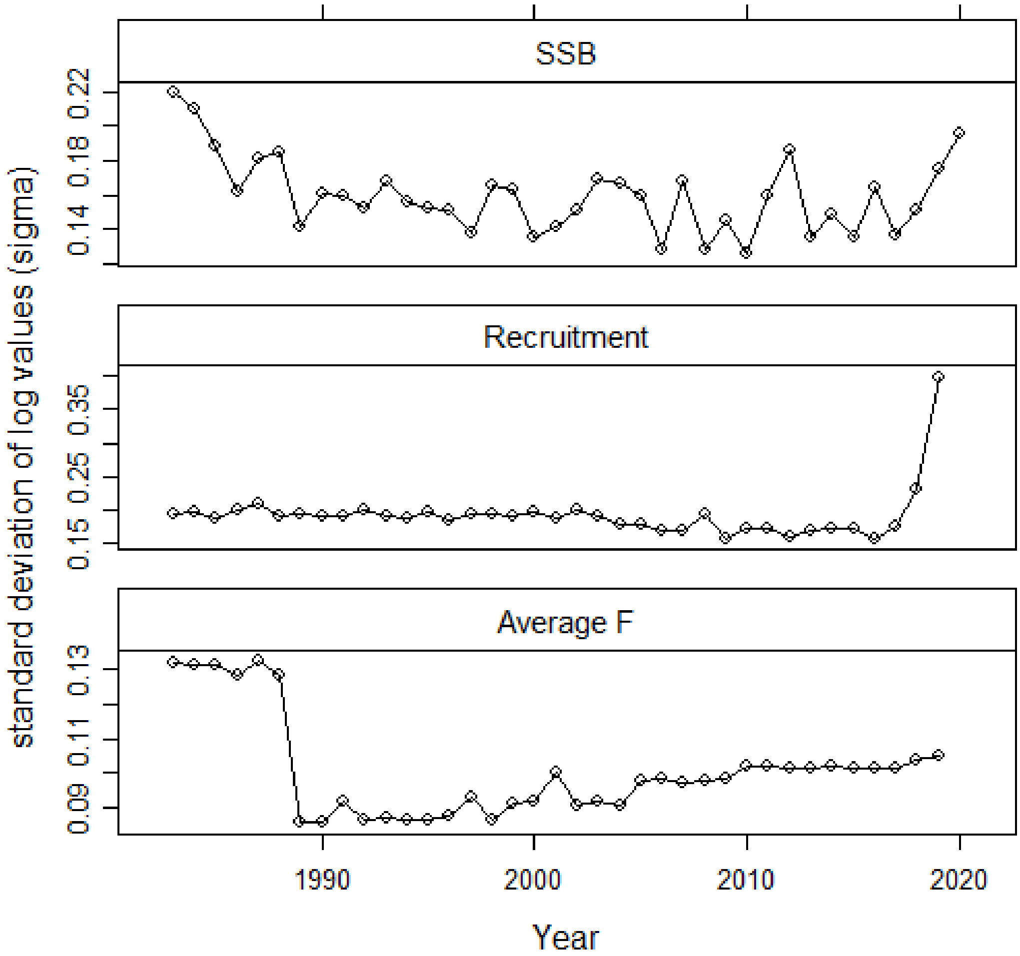


Figure 9.2.10. Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

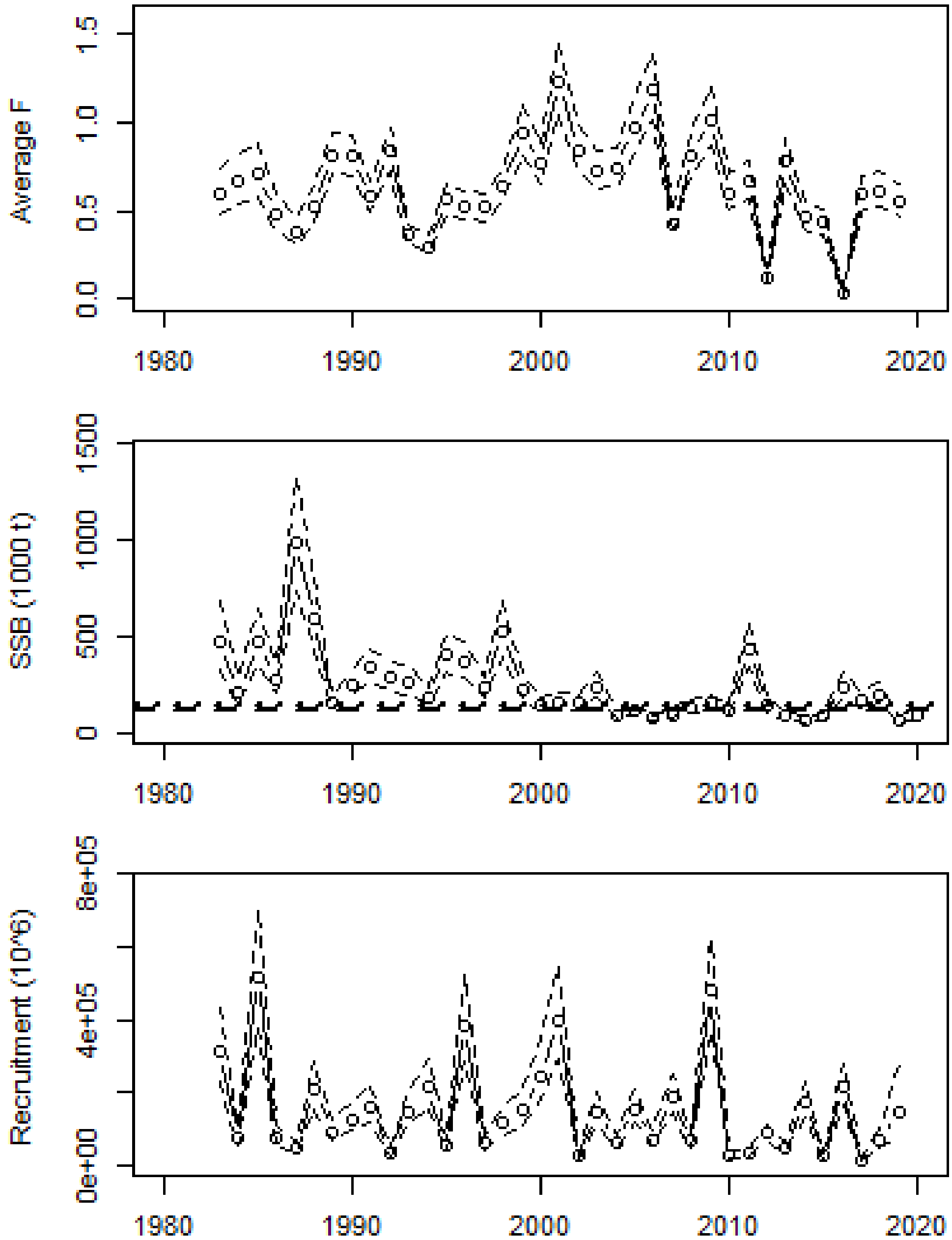


Figure 9.2.11. Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

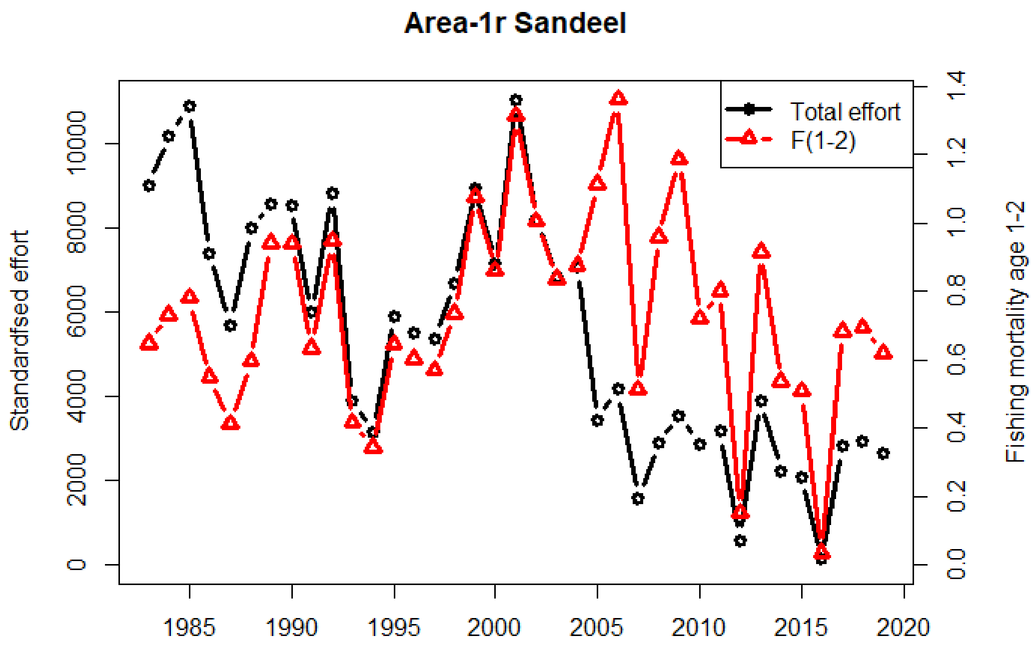


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

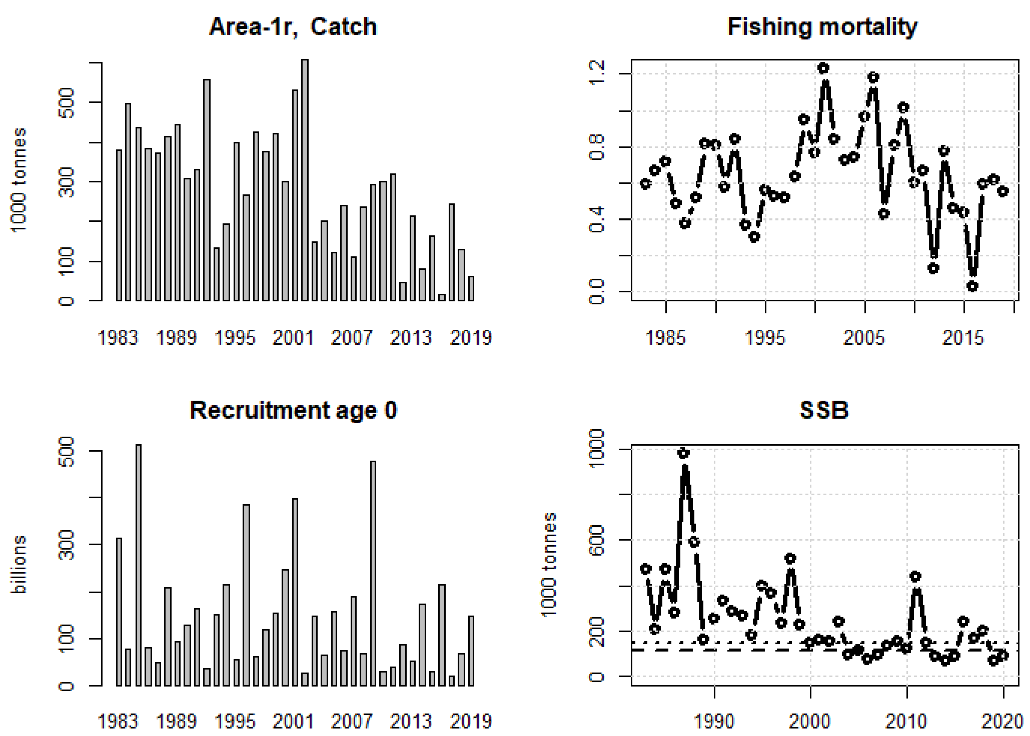


Figure 9.2.13 Sandeel Area-1r. Stock summary.

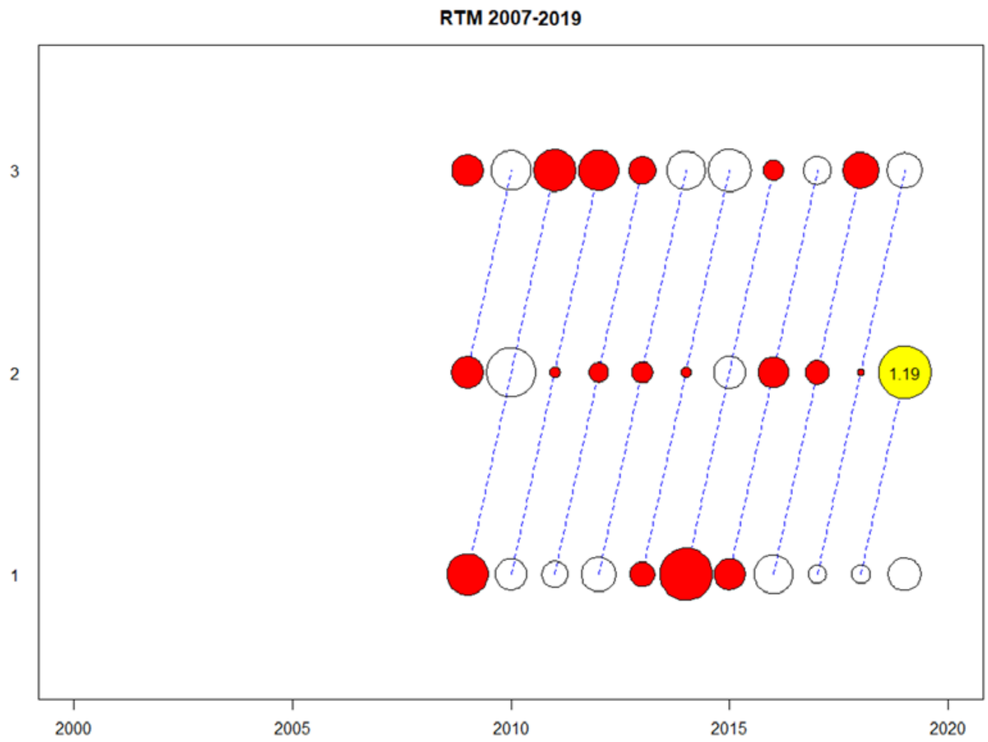


Figure 9.2.14. Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

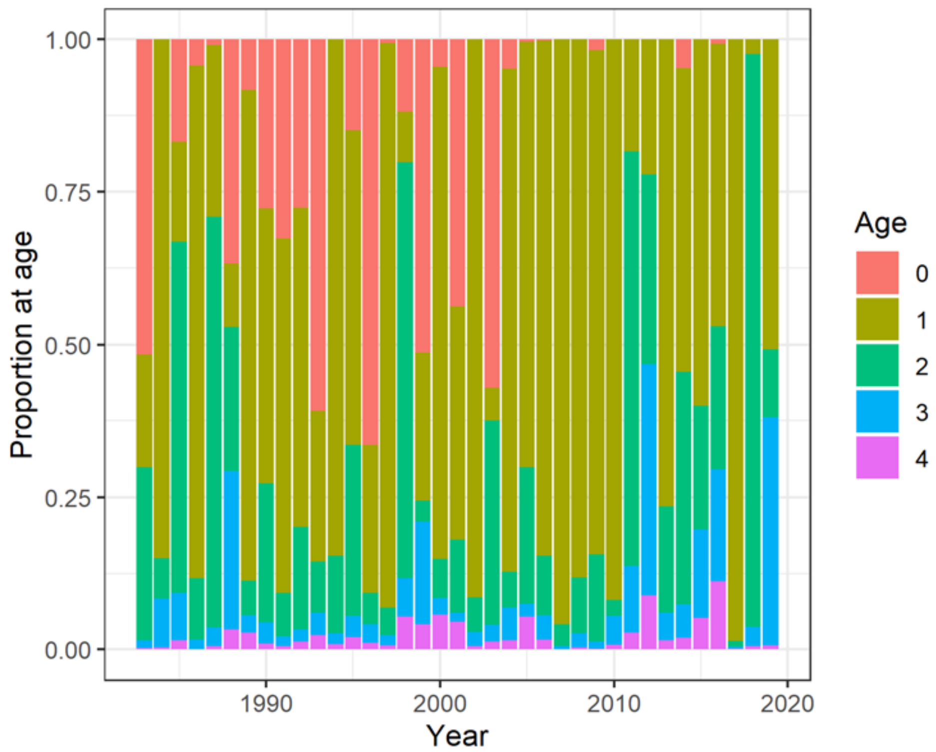


Figure 9.3.1. Sandeel Area-2r. Catch numbers, proportion-at-age.

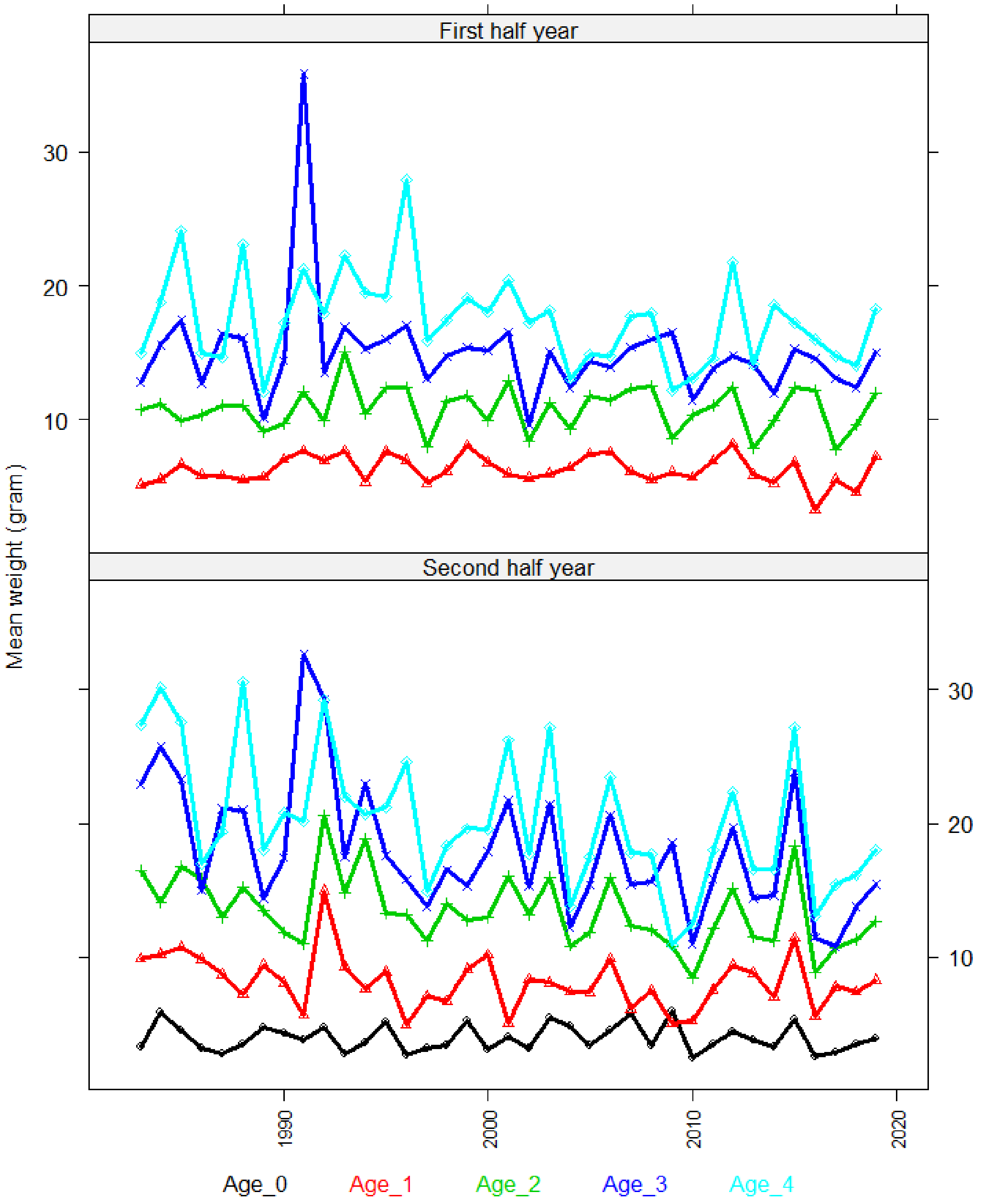


Figure 9.3.2. Sandeel Area-2r. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

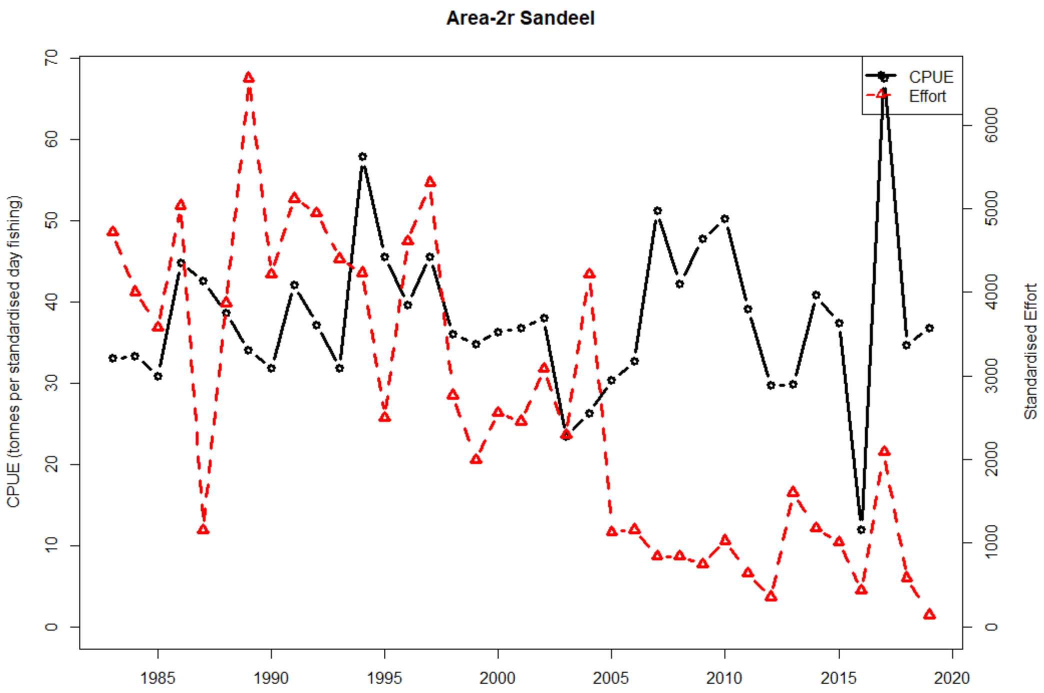


Figure 9.3.3. Sandeel Area-2r. CPUE and effort.

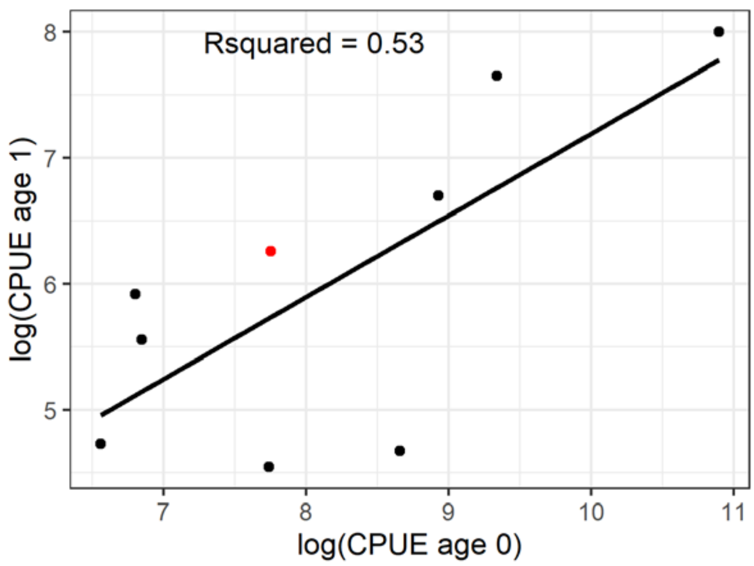


Figure 9.3.4. Sandeel Area-2r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

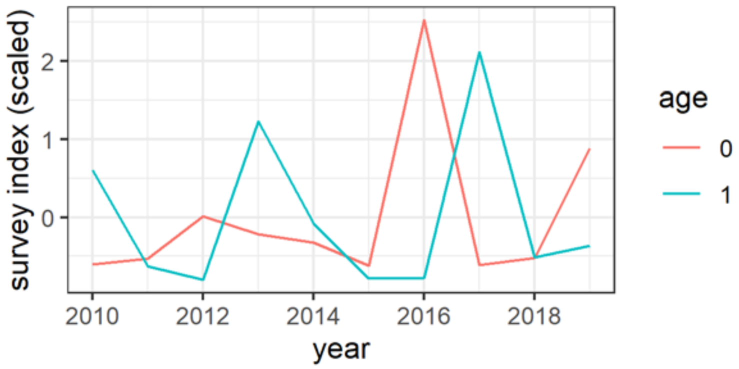


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

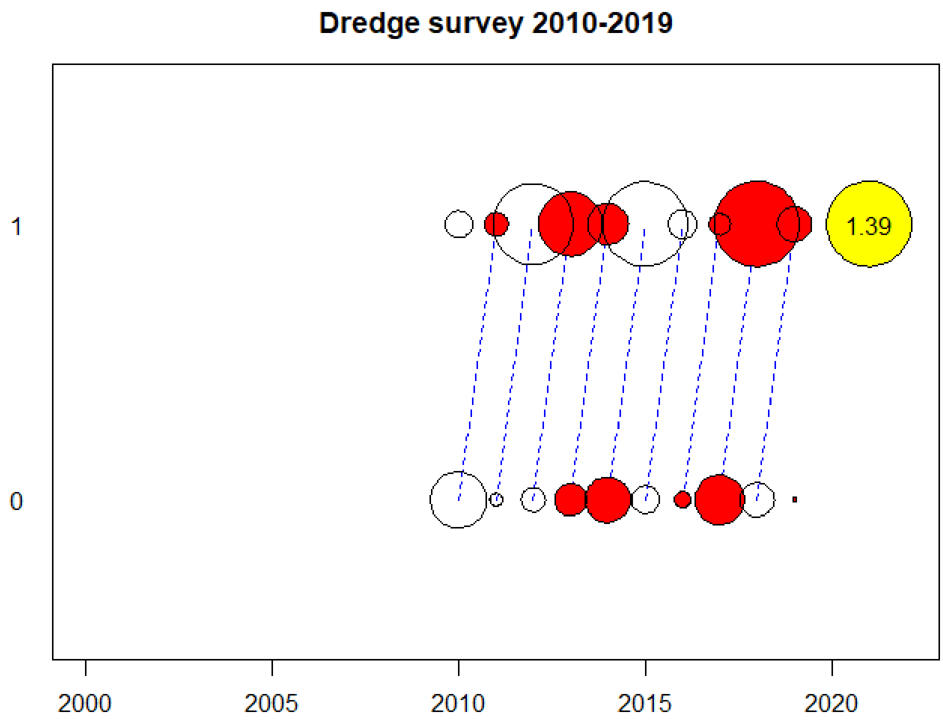
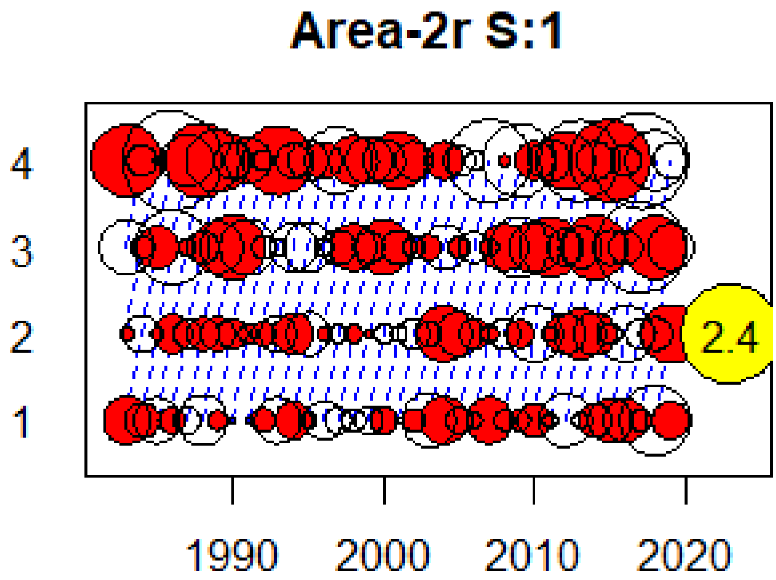


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



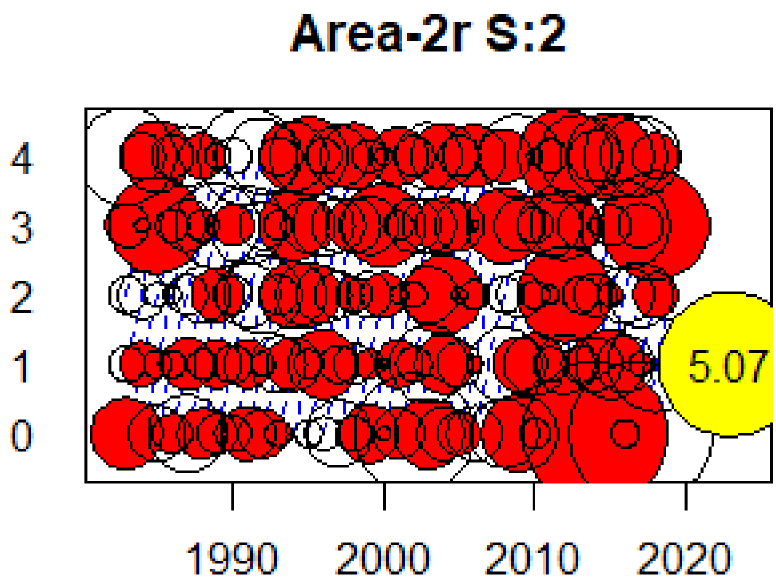


Figure 9.3.7 Sandeel Area-2r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

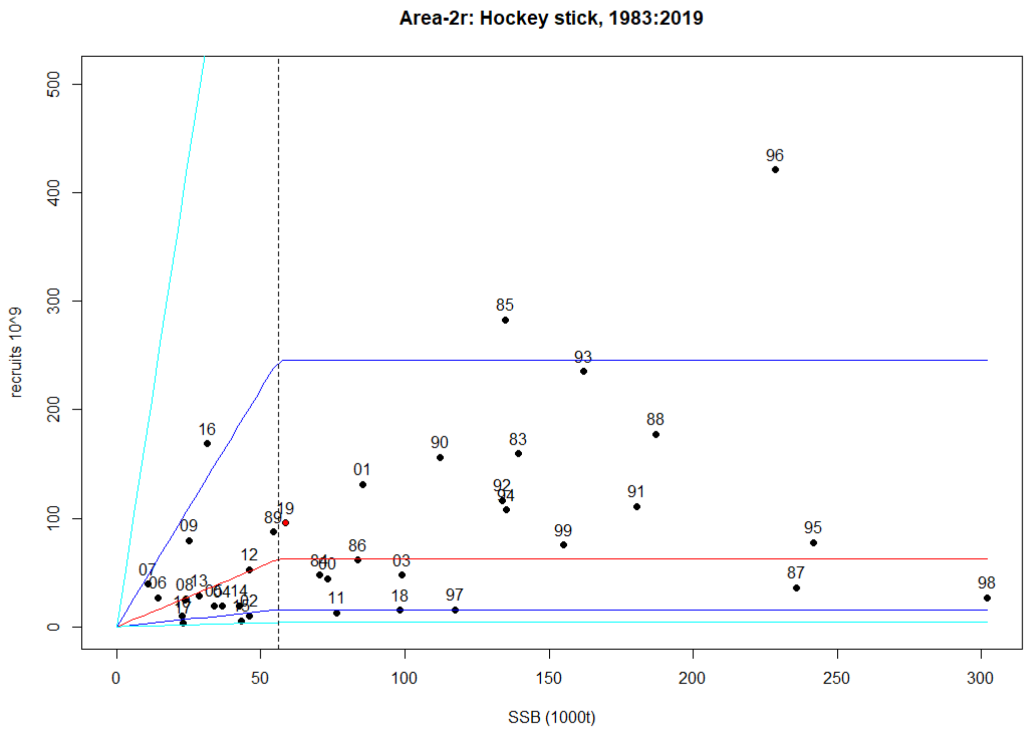


Figure 9.3.8. Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years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

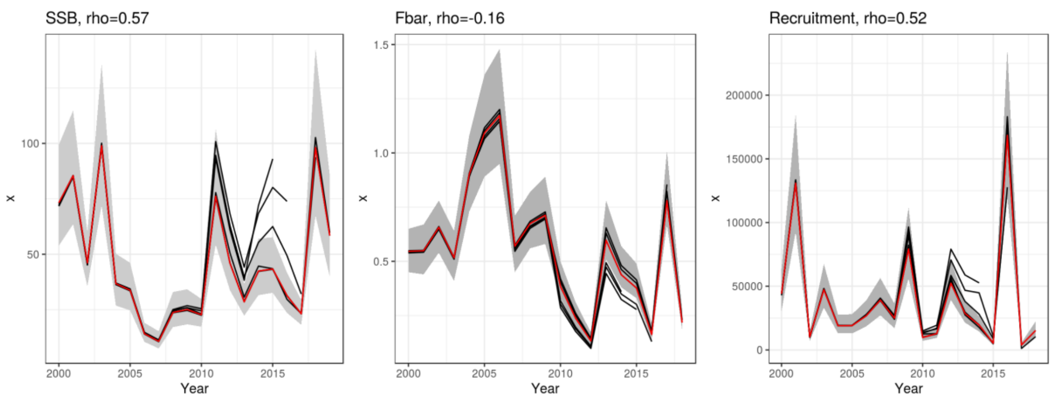


Figure 9.3.9. Sandeel Area-2r. Retrospective analysis.

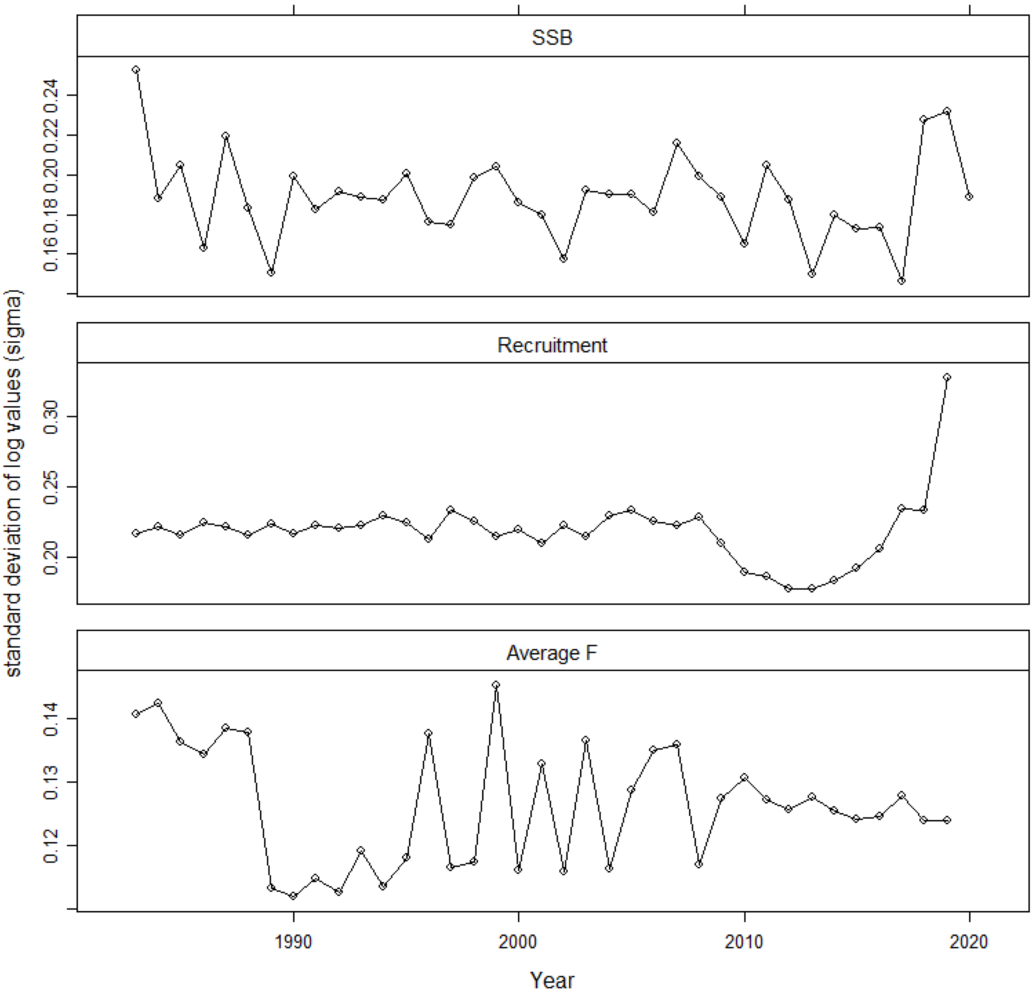


Figure 9.3.10. Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

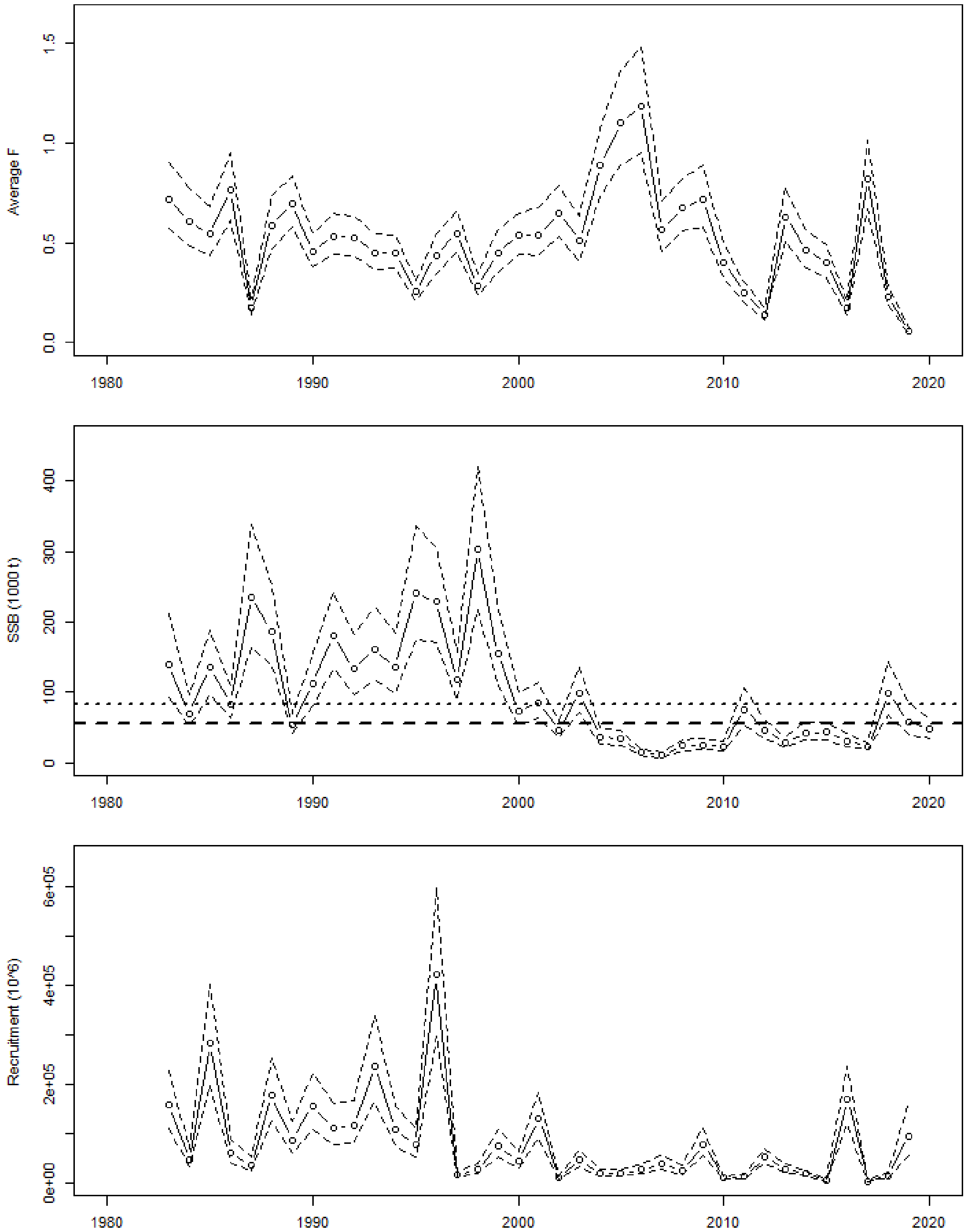


Figure 9.3.11. Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

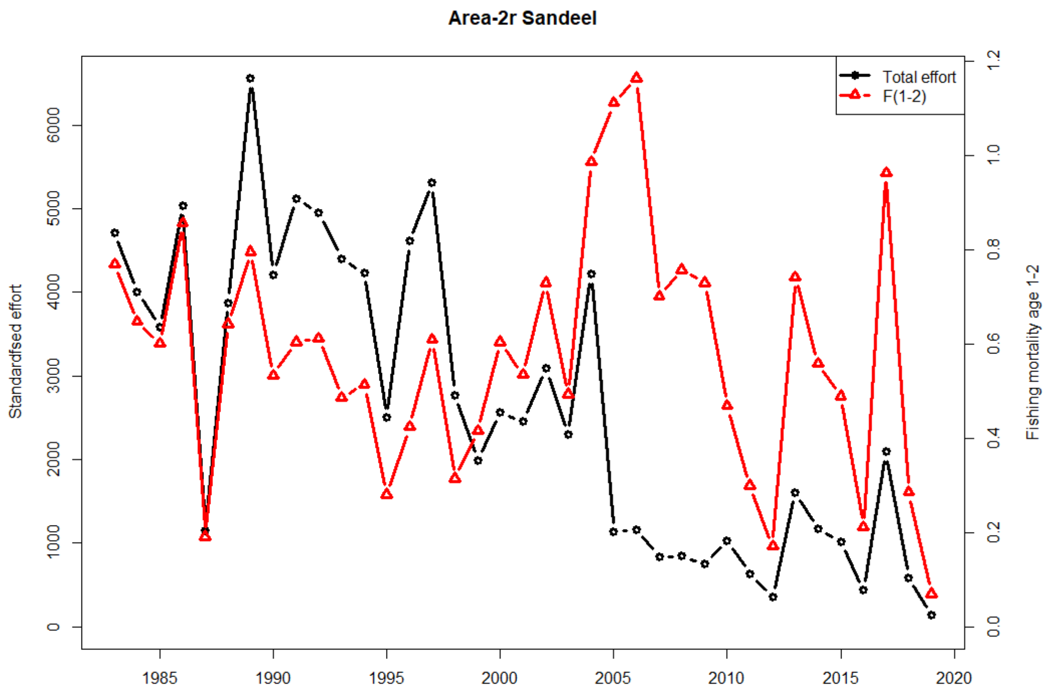


Figure 9.3.12. Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

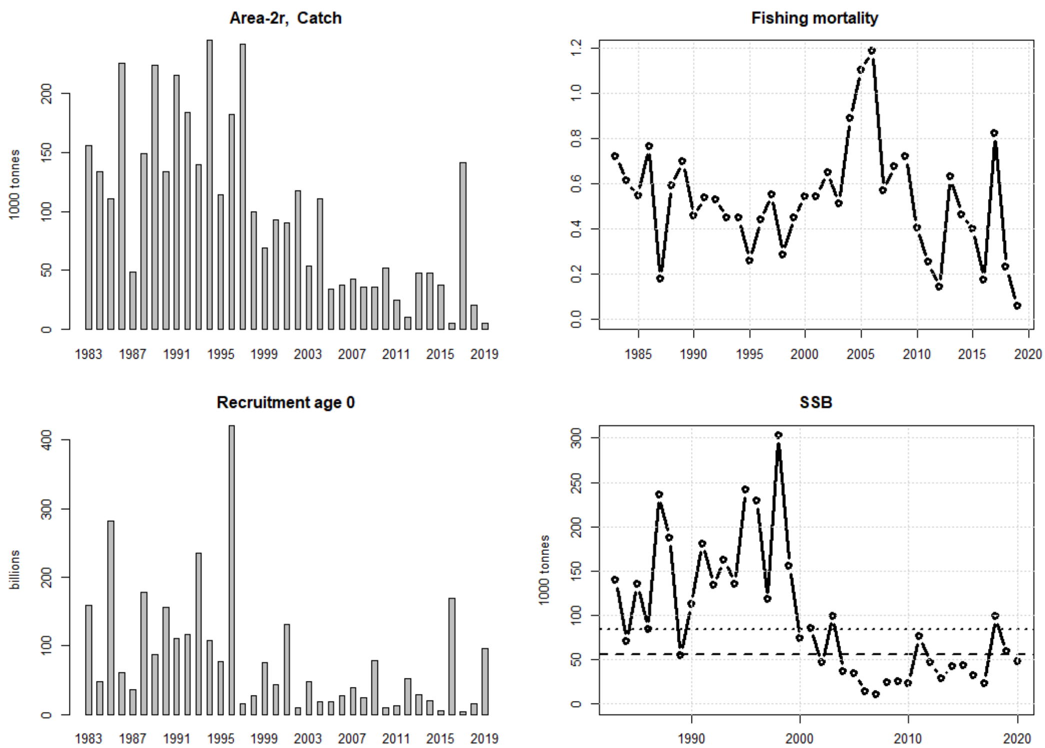


Figure 9.3.13 Sandeel Area-2r. Stock summary.

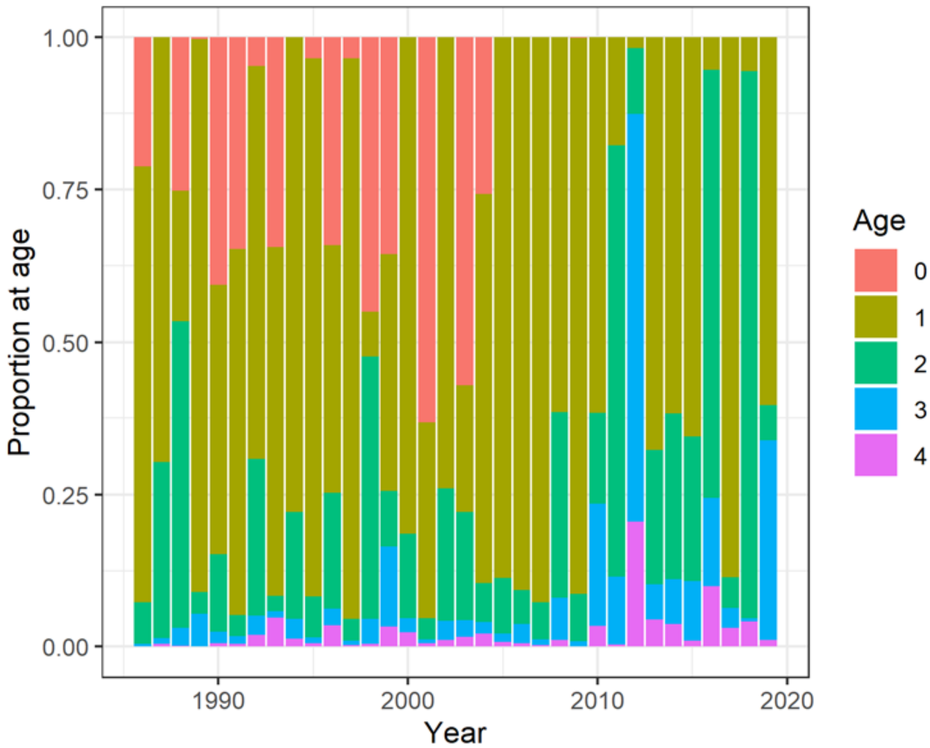


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion-at-age.

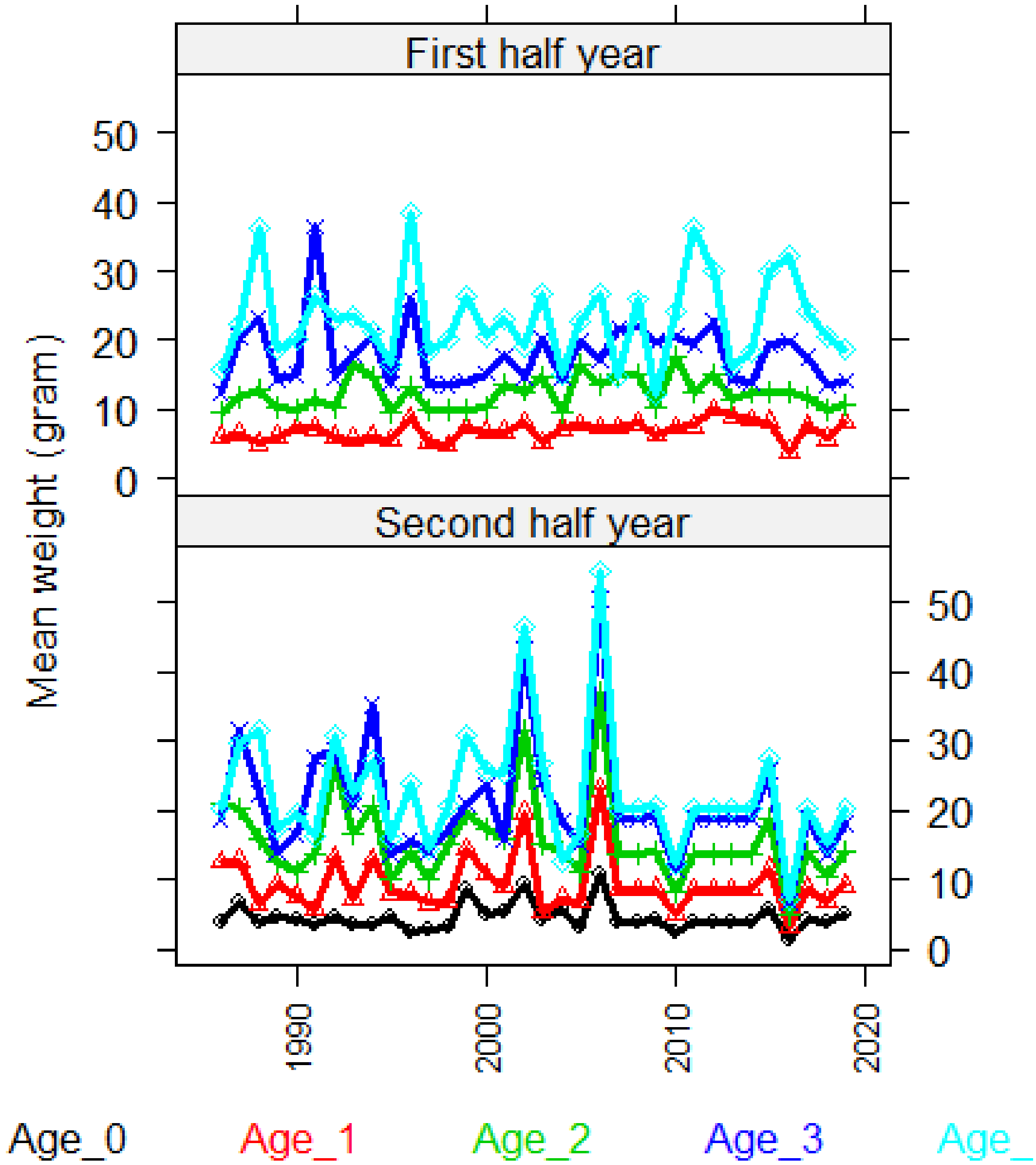


Figure 9.4.2. Sandeel Area-3r. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

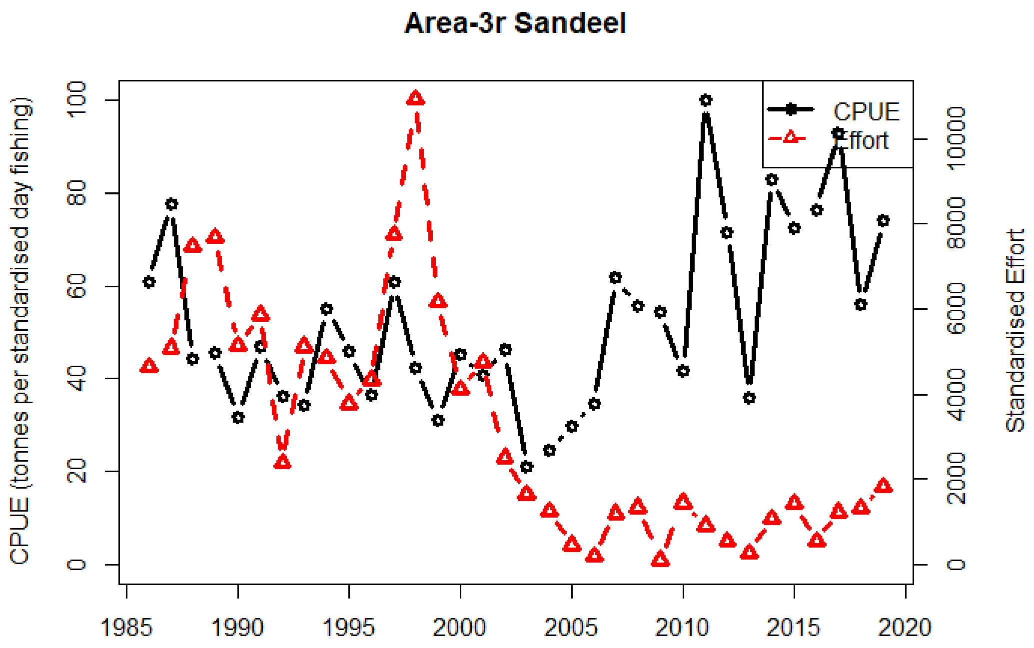


Figure 9.4.3. Sandeel Area-3r. CPUE and effort.

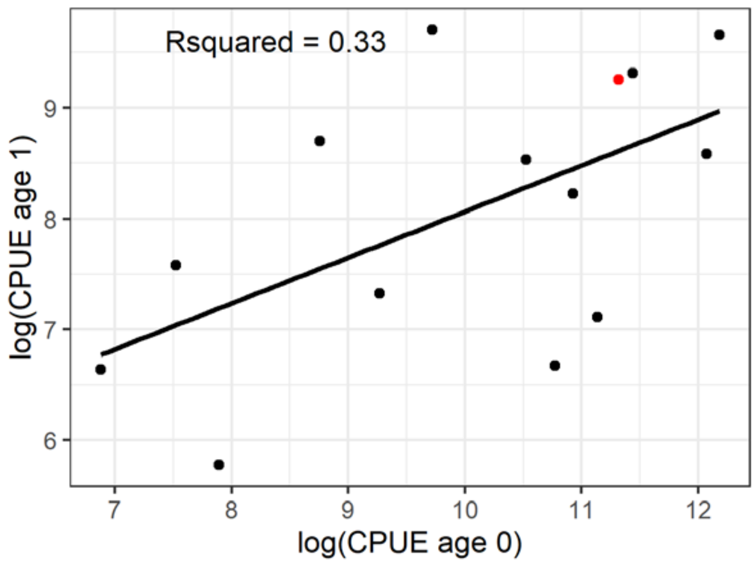


Figure 9.4.4. Sandeel Area-3r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

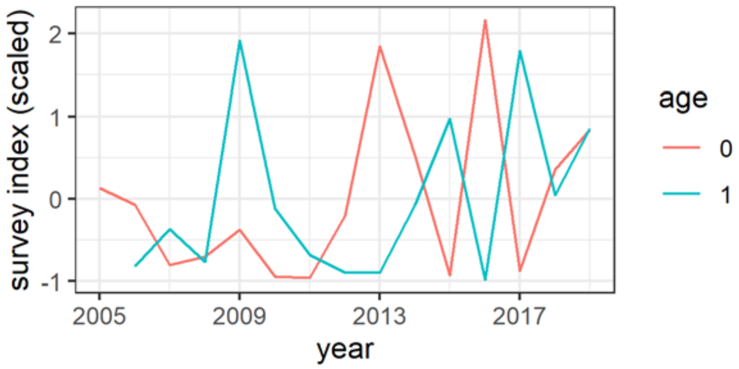


Figure 9.4.5. Sandeel Area-3r. Dredge survey index timeline.

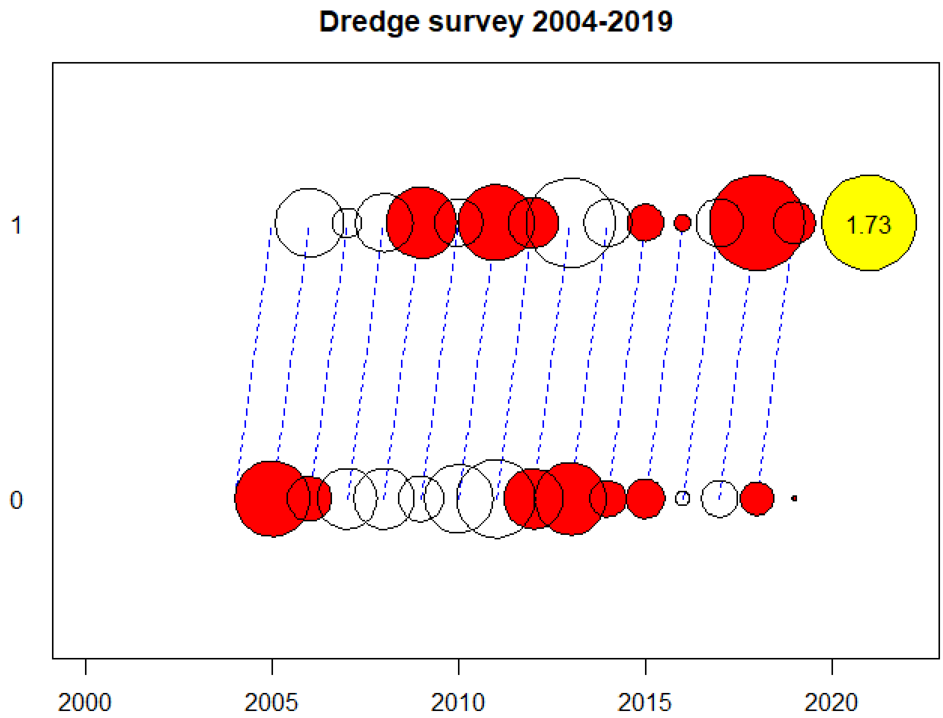
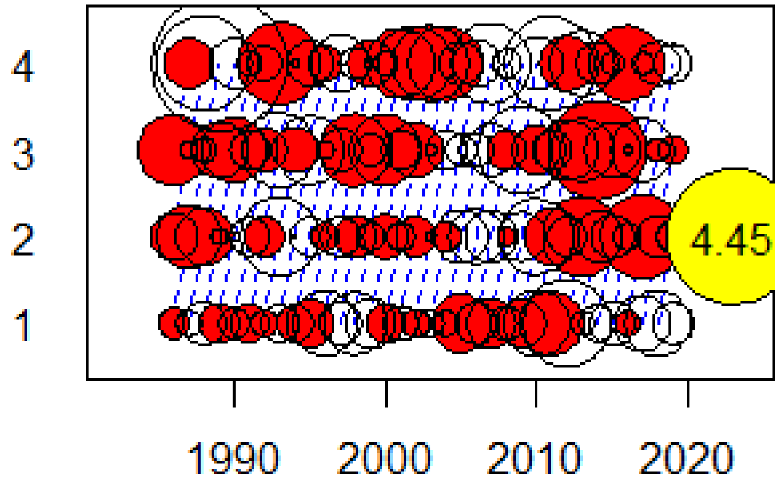


Figure 9.4.6. Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

Area-3r S:1



Area-3r S:2

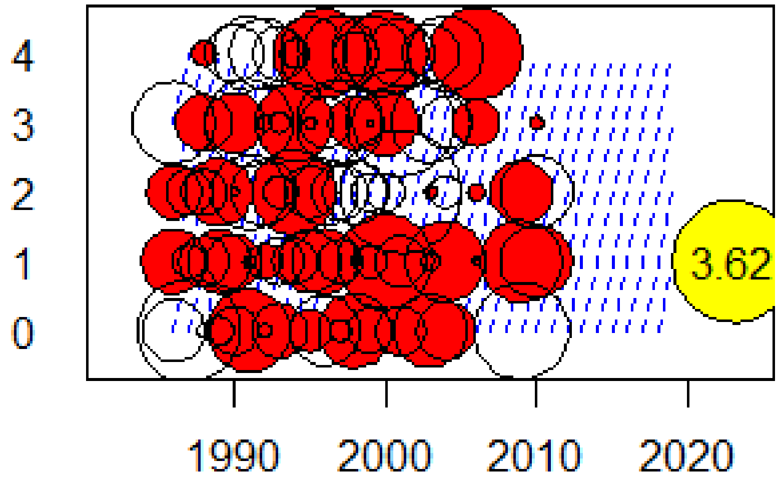


Figure 9.4.7. Sandeel Area-3r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

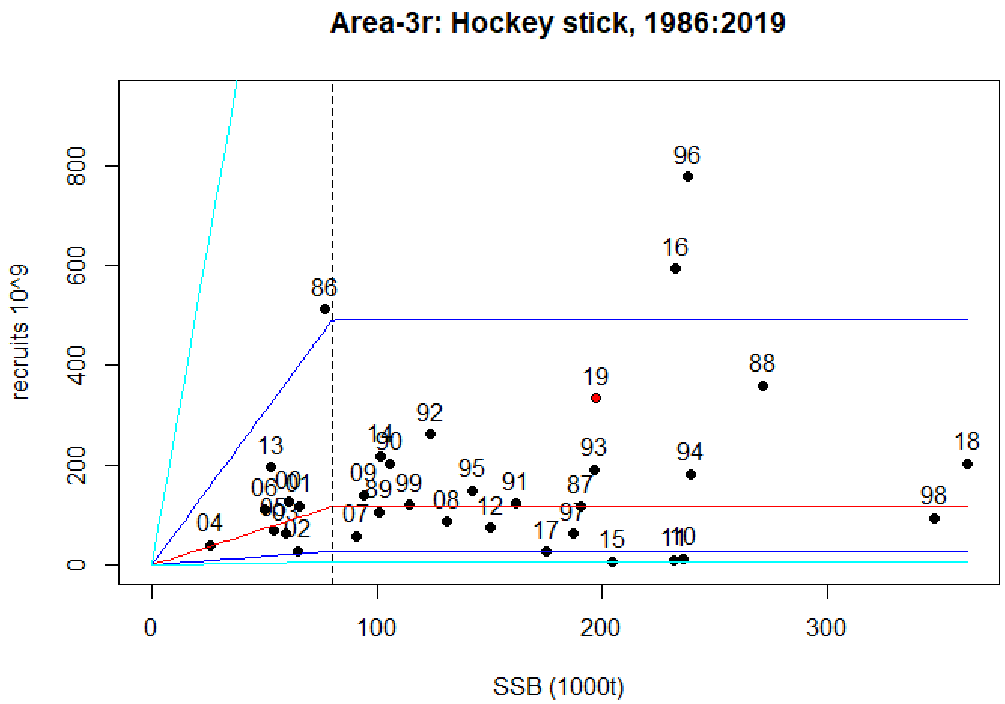


Figure 9.4.8. Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years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

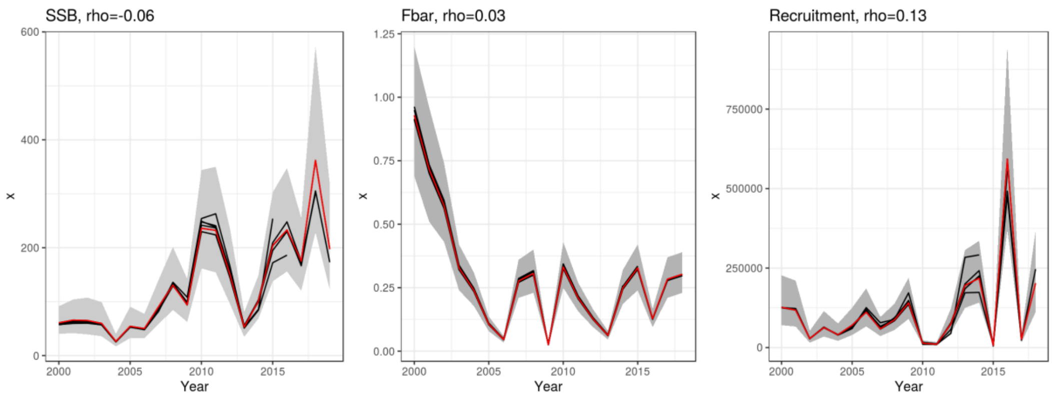


Figure 9.4.9. Sandeel Area-3r. Retrospective analysis.

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

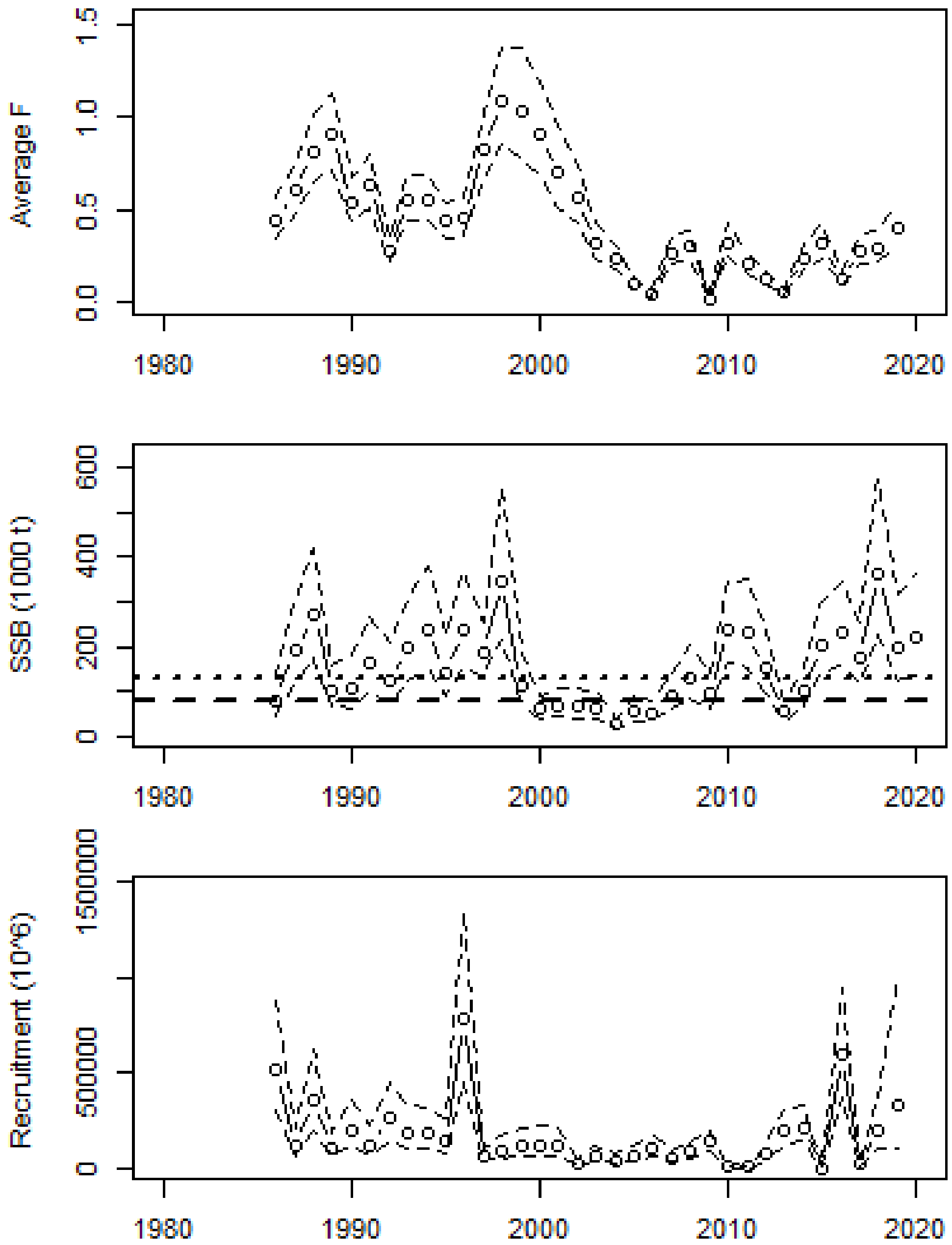


Figure 9.4.11. Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

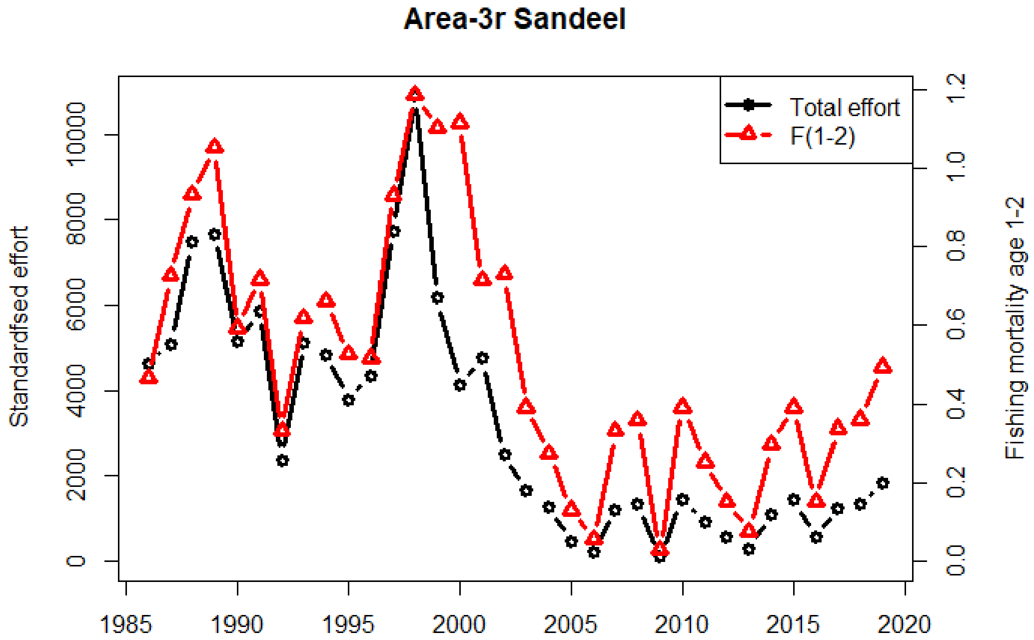


Figure 9.4.12. Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

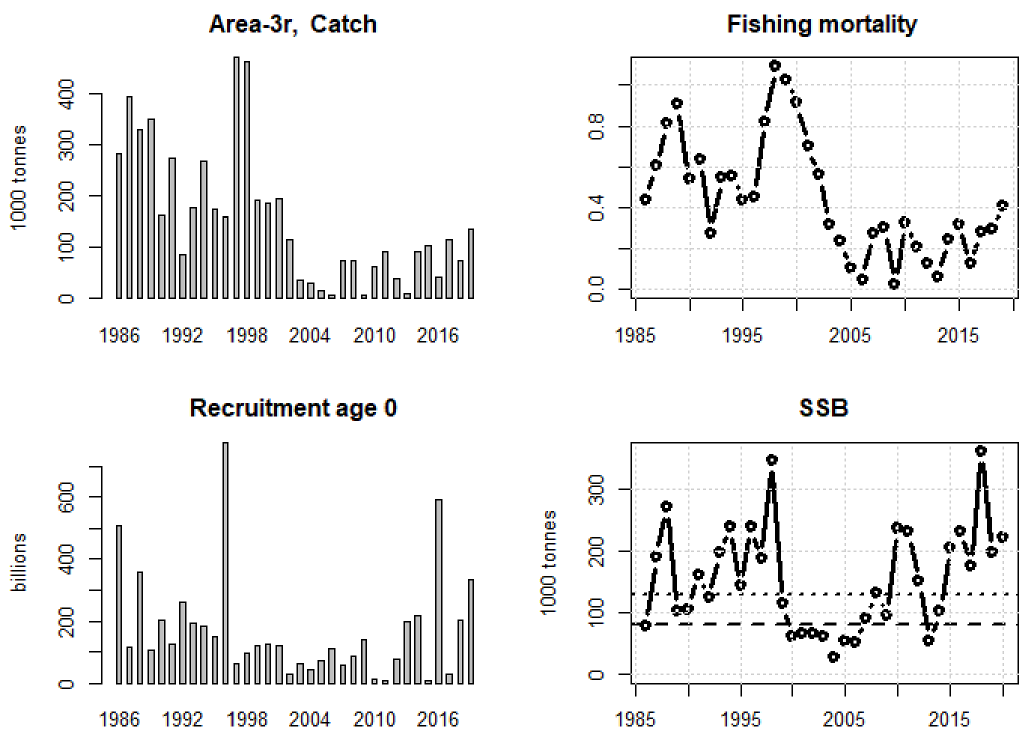


Figure 9.4.13. Sandeel Area-3r. Stock summary.

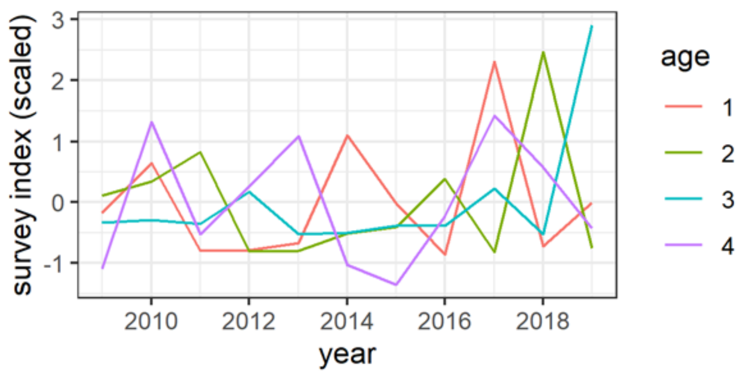


Figure 9.4.14. Sandeel Area-3r. Acoustic survey index timeline.

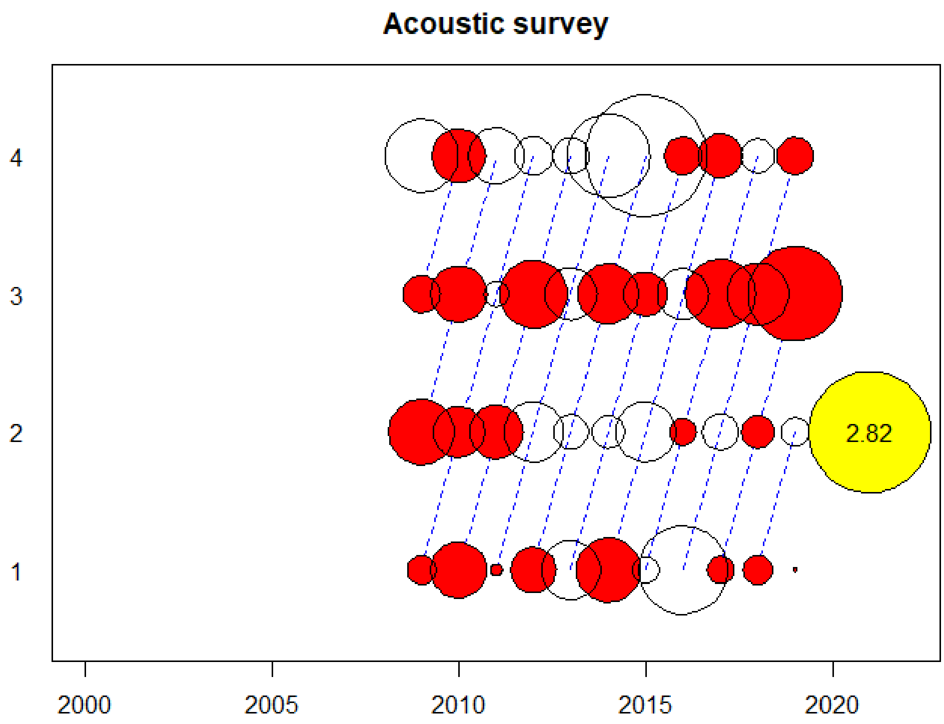


Figure 9.4.15. Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

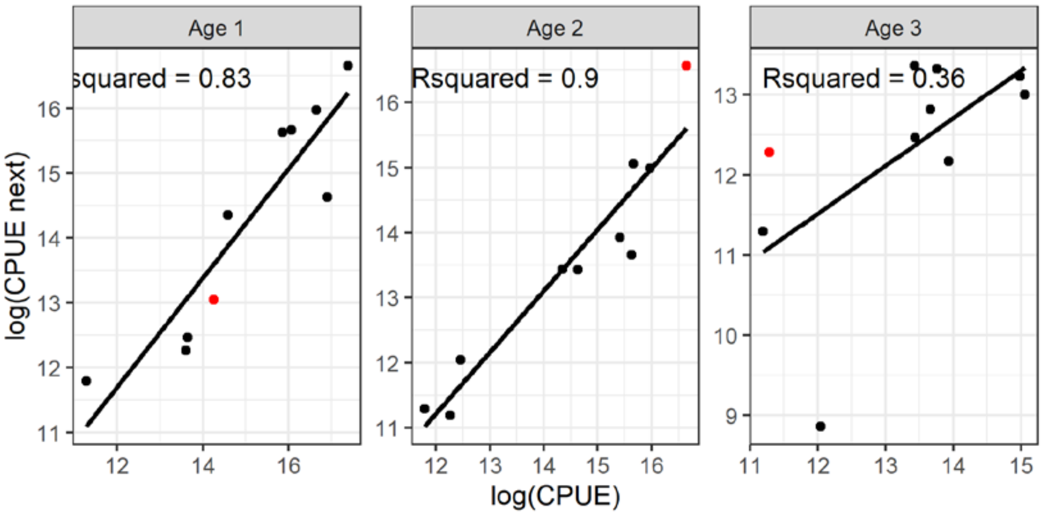


Figure 9.4.16. Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

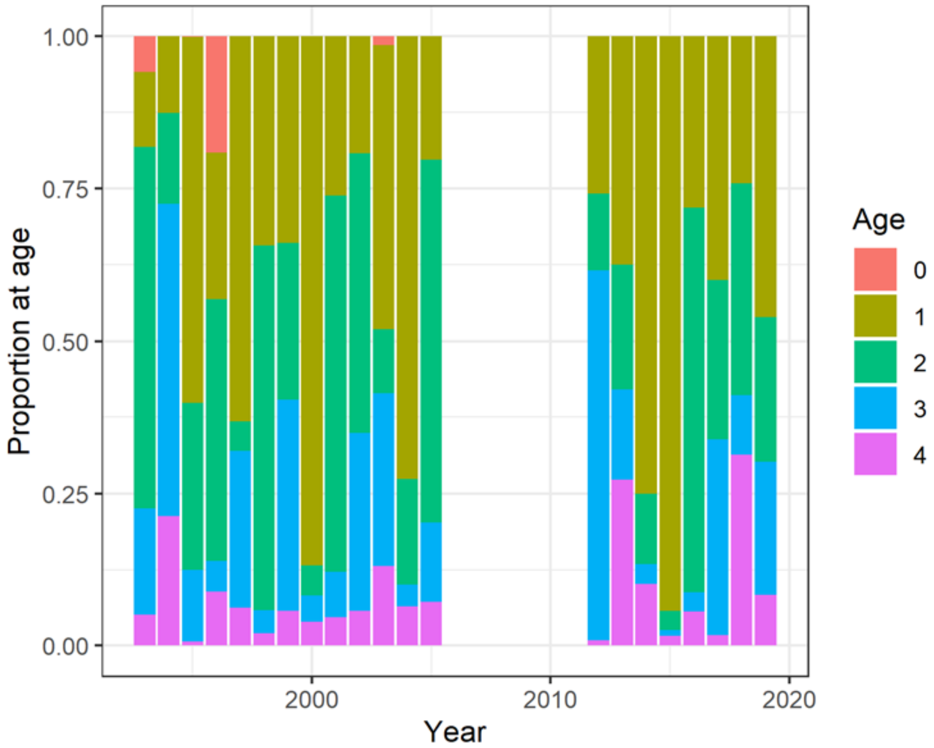


Figure 9.5.1. Sandeel Area-4. Catch numbers, proportion-at-age.

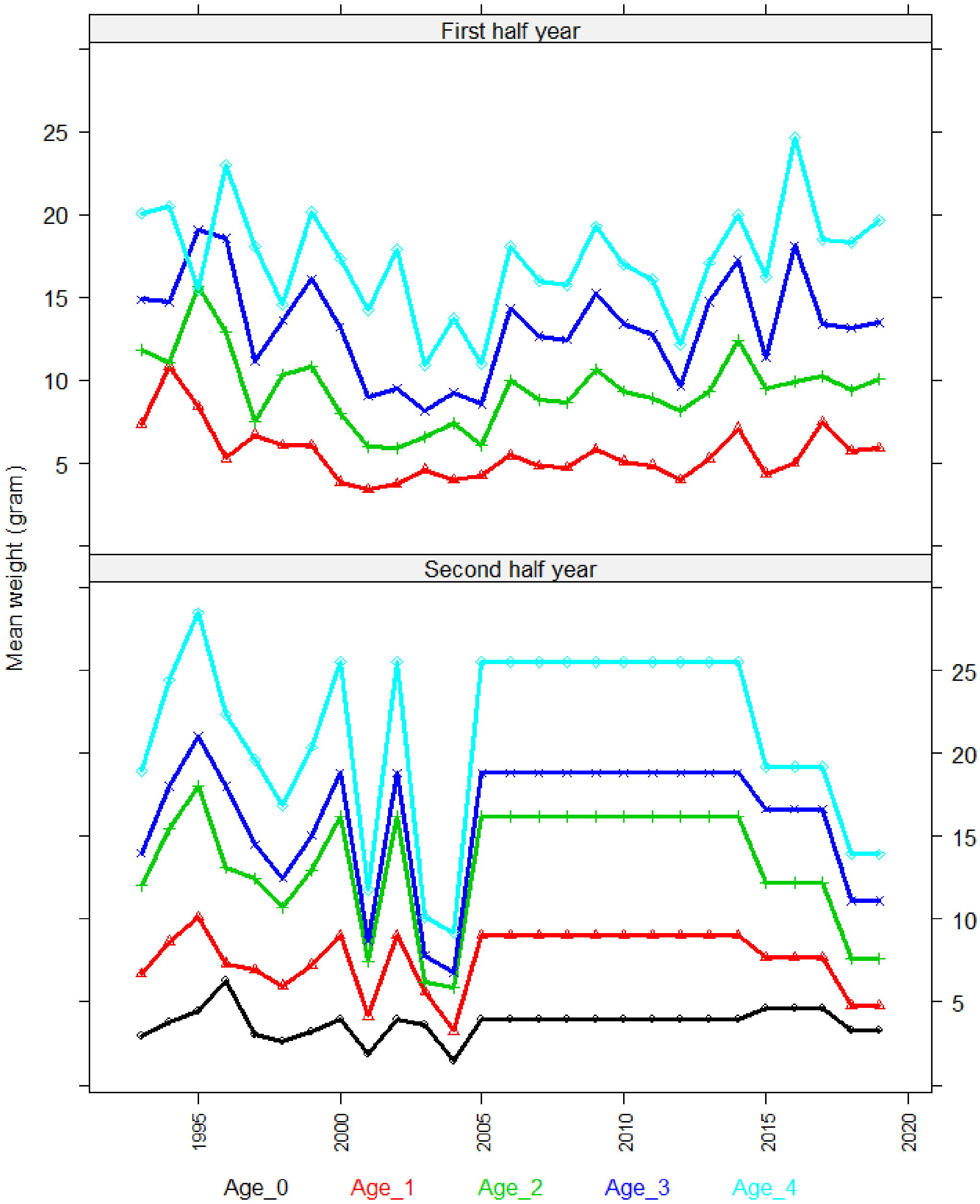


Figure 9.5.2. Sandeel Area-4. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

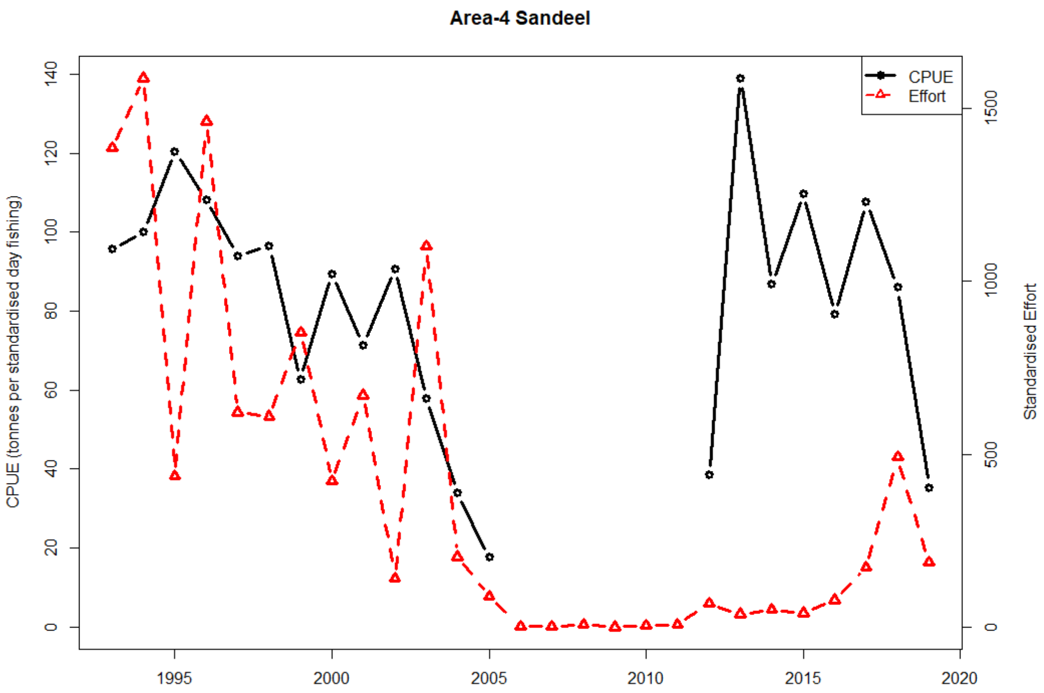


Figure 9.5.3. Sandeel Area-4. CPUE and effort.

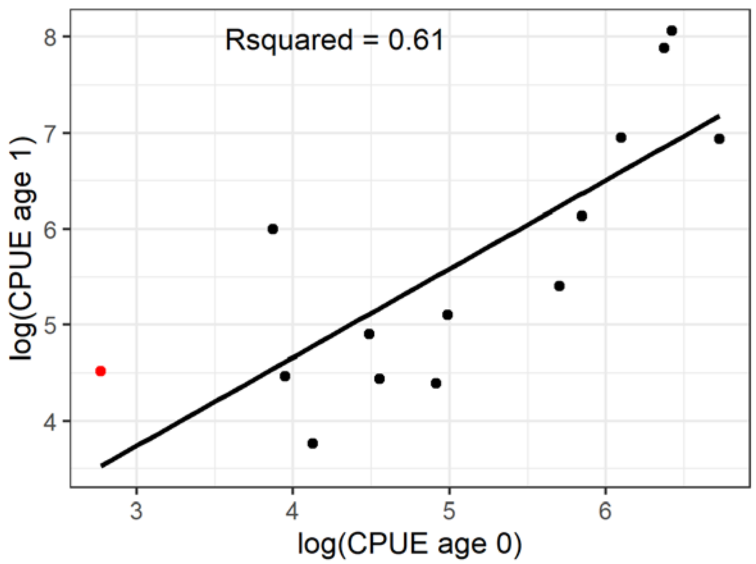


Figure 9.5.4. Sandeel Area-4. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

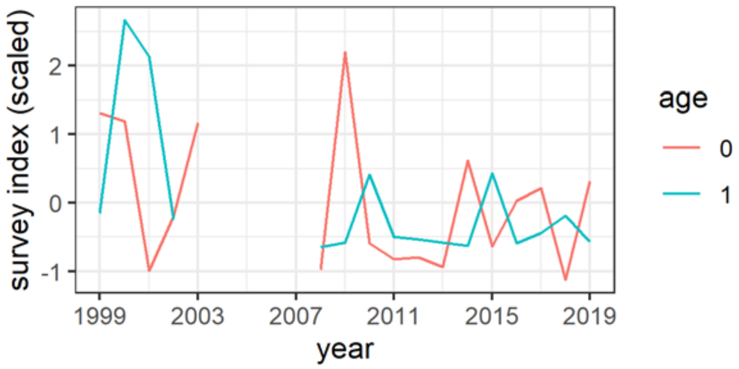


Figure 9.5.5. Sandeel Area-4. Dredge survey index timeline.

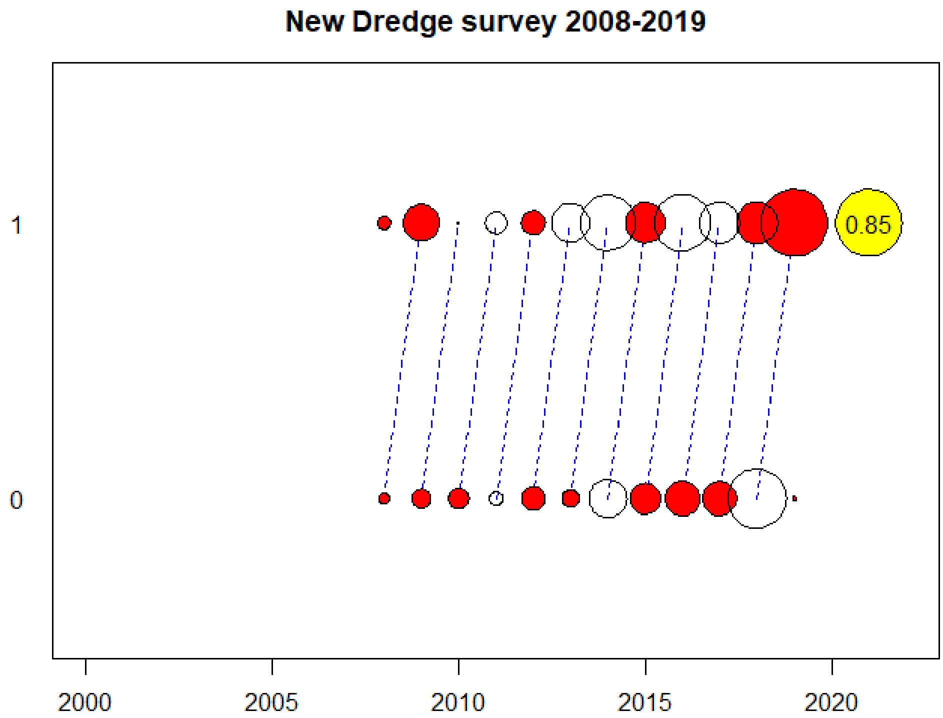
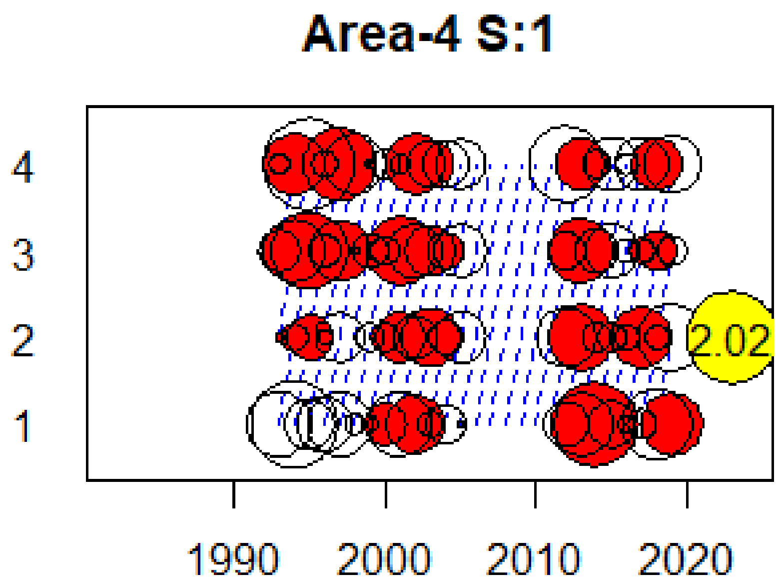


Figure 9.5.6. Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



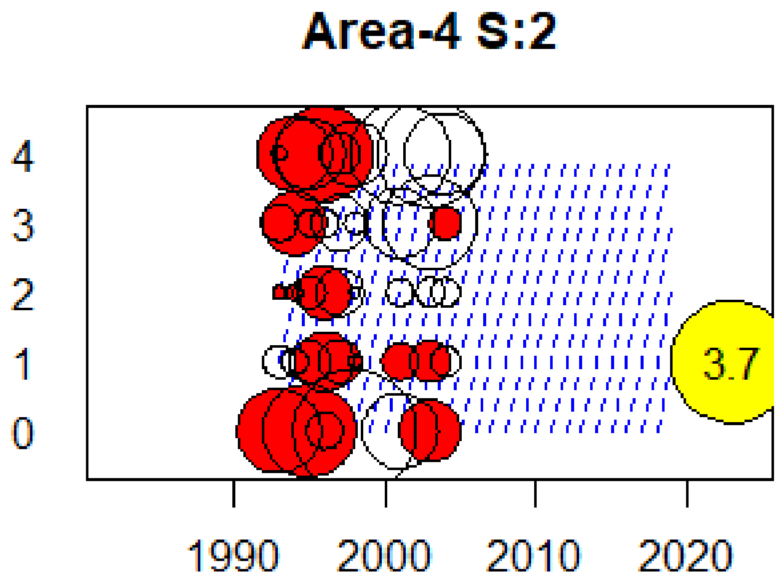


Figure 9.5.7. Sandeel Area-4. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

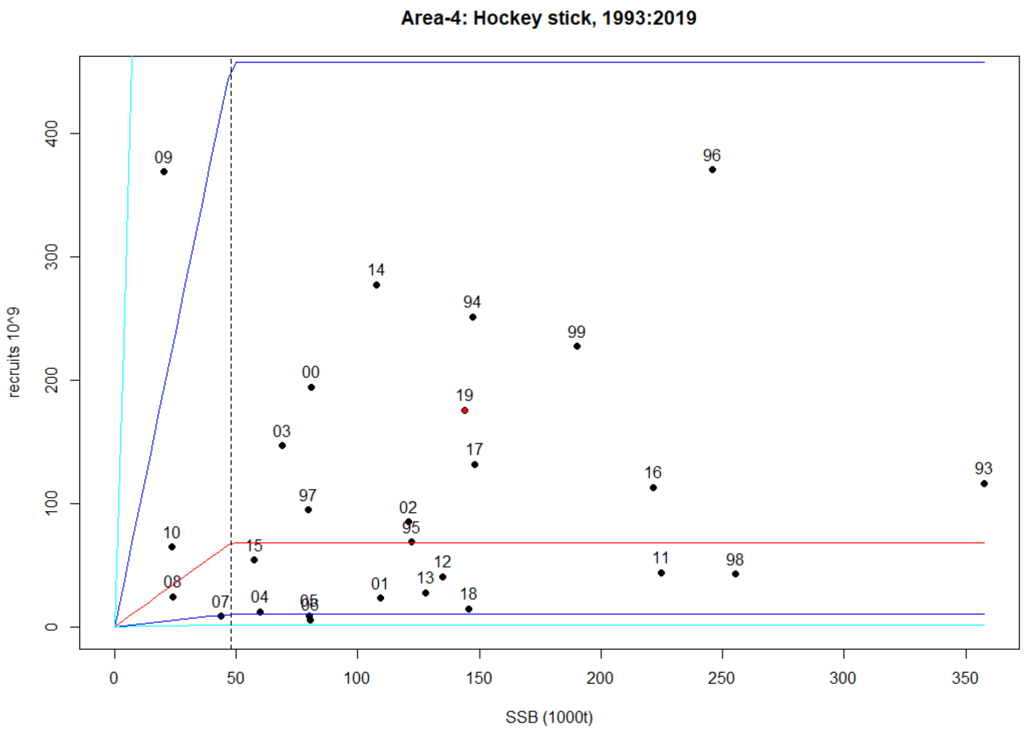


Figure 9.5.8. Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years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

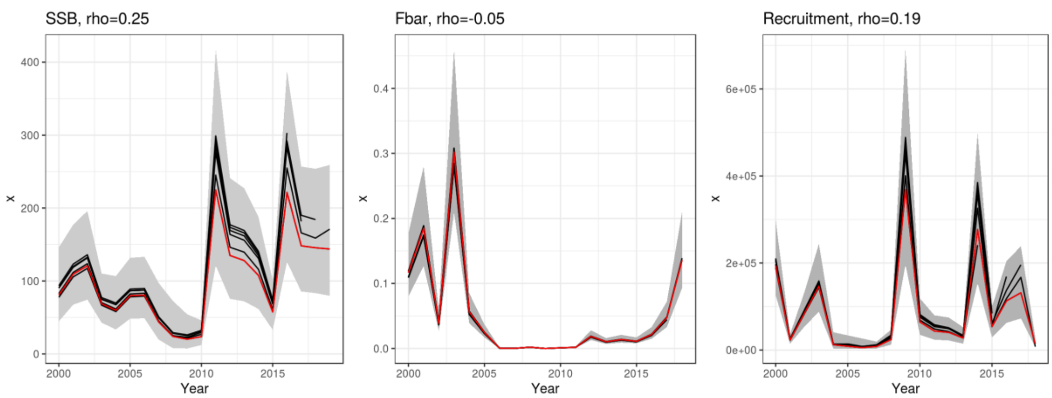


Figure 9.5.9. Sandeel Area-4. Retrospective analysis.

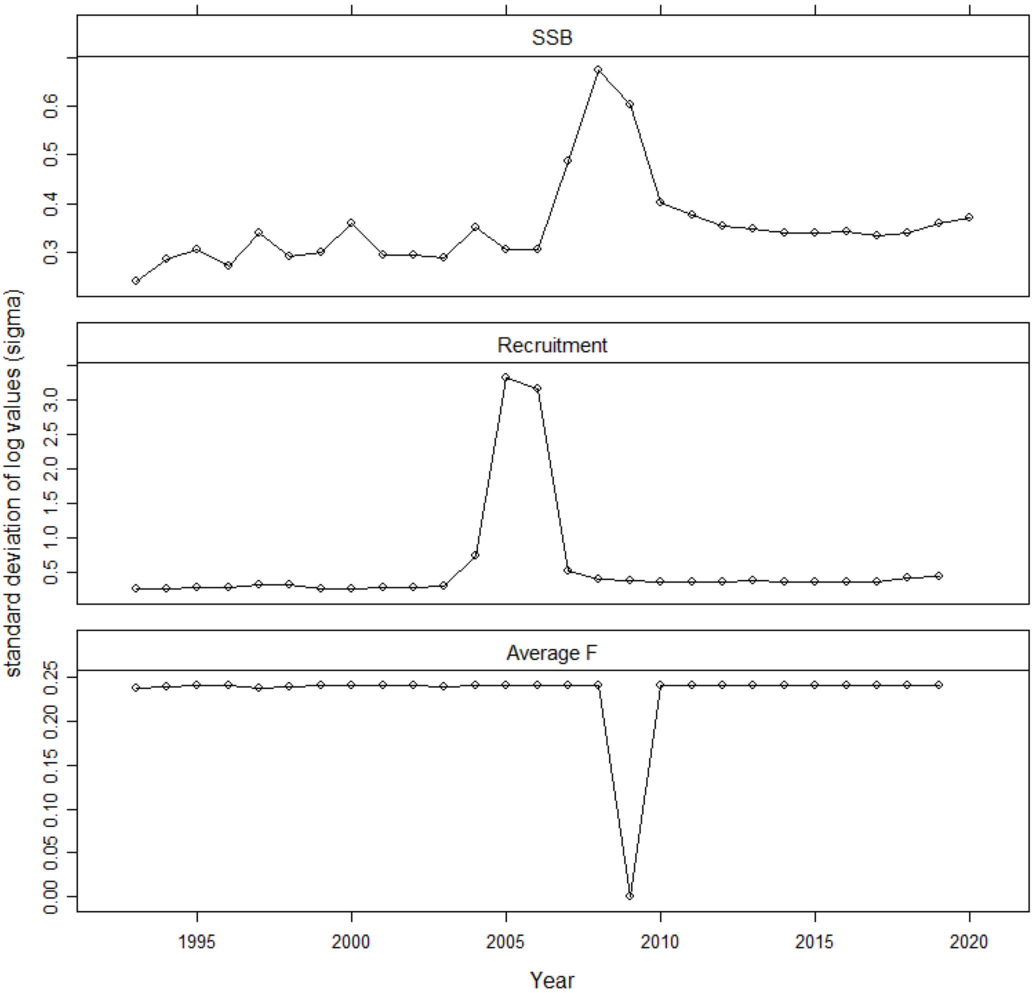


Figure 9.5.10. Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

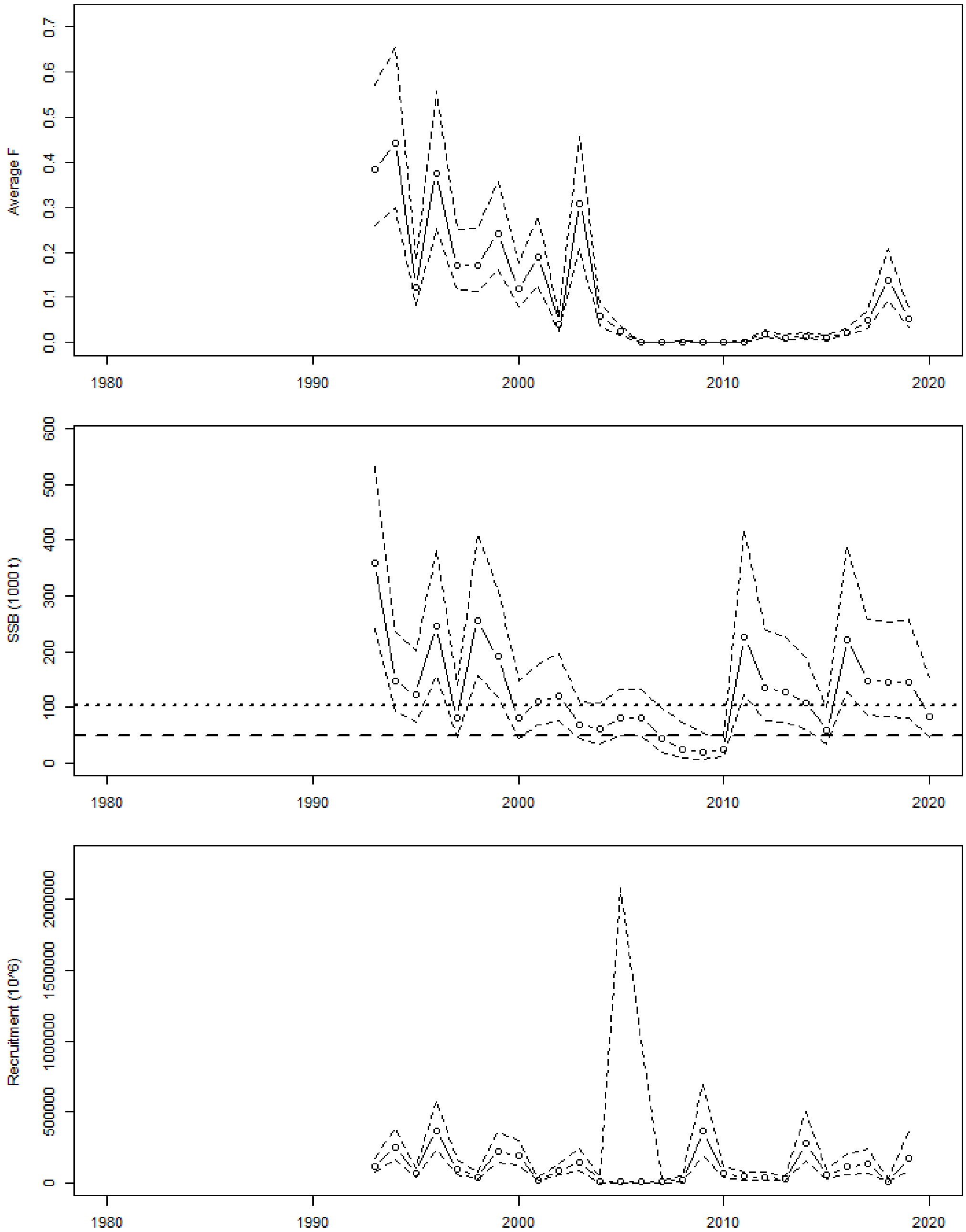


Figure 9.5.11. Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

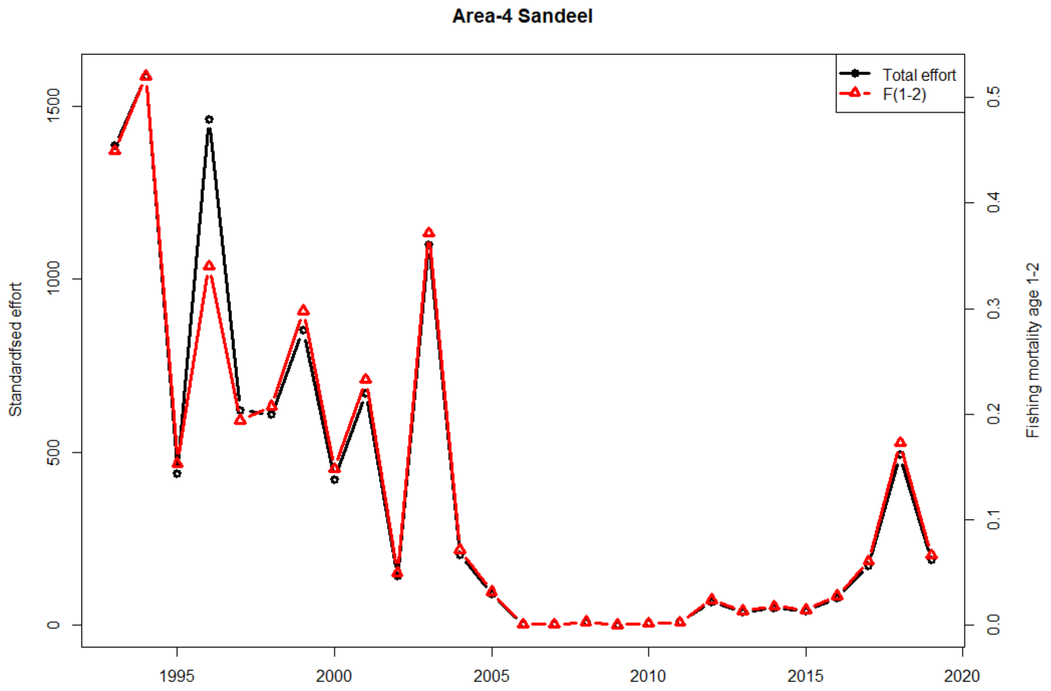


Figure 9.5.12. Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

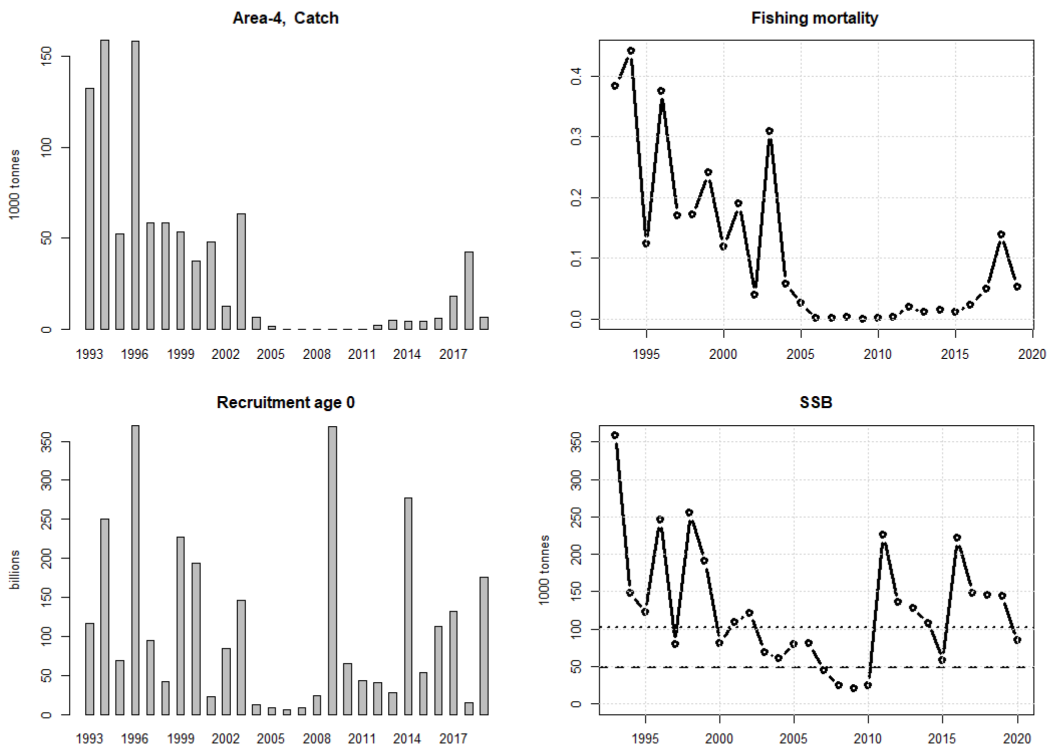


Figure 9.5.13. Sandeel Area-4. Stock summary.

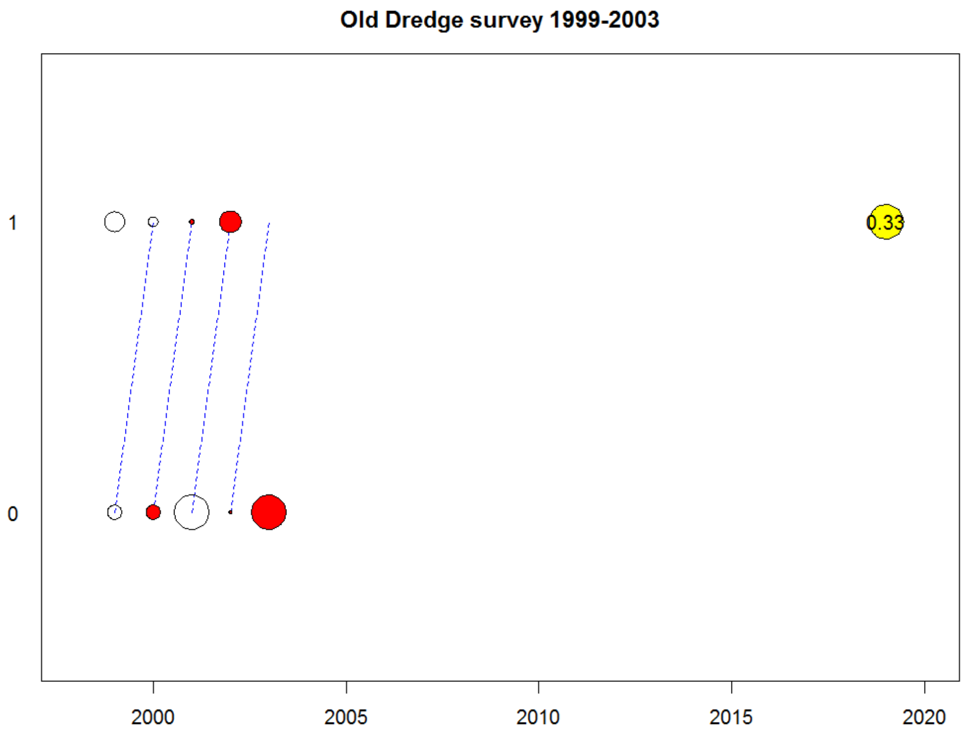


Figure 9.5.1. Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.