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 sub-populations (ICES, 2016, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these seven areas (sandeel area (SA) 1r–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 sub-populations (see the Stock Annex). A decline in the sandeel population in several areas in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence (ICES, 2007; ICES, 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 2018 25 vessels participated in the fishery. From 2011 to 2018, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1340 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 2018 was opened 1 April and continued until the middle of July. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2018 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2019 (Escapement strategy). This approach resulted in an advised TAC for 2018 in SA 1r, SA 2r, SA 3r, and 4 of 134 461 t, 5000 t (monitoring catch), 108 365 t and 59 345 t, 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 70 000 tonnes for 2018 was given. The acoustic survey abundance estimate of age 1 was low, and the individual growth was also low, which together gave a low biomass estimate. Therefore, there was no increase in the final TAC. Fishery was allowed in the subareas 1b, 1c, 2a, 2c, 3a, 3b, 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 U.K. coast since 2000. Note that a limited fishery for stock monitoring purposes occurs in May–June in this area.

9.1.6 Catch

Adjustment of official catches

Previously, there has been substantial misreporting of catches between areas (ICES, 2015, 2016b (HAWG)). Since 2015, the Danish regulation has not allowed fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see HAWG 2017). Because of this, the working group decided to keep the practice from last year's assessment and reallocate reported catches (14 781 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 73 420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2018 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 ~75% of the total sandeel catches in the period since 1983.

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

SA 4 has contributed about 5% 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 54 043 and 59 345 t, respectively.

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 (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 2016, 2017 and 2018.

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 time 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 2018 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 and 3r. In area 4, the northern part (Turbot bank) was not surveyed due to poor weather and hence the index only covers the Firth of Forth area. As this is the case for the majority of the time series, the lack of coverage is not expected to bias the index. 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 2018, the proportion 2-group was 81% by weight, corresponding to the very high catch of the 2016 cohort in the 2016 and 2017 dredge survey (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 generally decreased since 2017 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 2014 below long-term average. CPUE peaked again in 2016, but have decreased to levels below average in 2018.

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 low number of samples in this time period.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2018 show a increase from the second lowest observed index for age 0 and a decreased index for the 1-group to levels seen before 2017.

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 2018. 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 five year ranges used. The “age selection” (“F, age effect” in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the assessment period, to a fishery targeting age 1+ in a similar way, and then in the most recent period back to mainly targeting 2+ sandeel.

The CV of the dredge survey ("sqrt (Survey variance) ~CV" in the table) is low (0.36) for age 0 and moderate (0.77) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time series is moderate (0.57 and 0.59, respectively) for age 1 and age 3 and low (0.41) 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 (0.341) for age 1 and age 2 in the first half of the year and moderate to high (> 0.57) for the remaining ages and season combinations. The catch at age residuals (Figure 9.2.7) show no alarming patterns, except for a tendency to positive residuals (observed catch is more than model catch) for age 1 in 2013–2017, followed by negative residuals in 2018.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.848), 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 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 2014 and 2019. Since 2008, SSB has been above B_{lim} but below B_{pa} in 2008, 2010, 2013 and 2015, and below B_{lim} in 2019. $F_{(1–2)}$ is estimated to have been below the long-time average since 2010. Recruitment in 2017 was estimated to be the lowest observed in the time series, whereas 2018 show 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 1983–2017 (108 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018. 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 91 916 t should be set for 2019. This will leave SSB at the MSY $B_{trigger}$ of 145 000 t in 2019 and predicted F below F_{cap} (0.5). The TAC according to the escapement strategy is therefore 91 916 t in 2019.

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 very high recruitment in 2016 and the restrictive F below average in 2017 resulted in an SSB above B_{pa} in 2018. As noted in last year's report (ICES, 2018), the introduction of a very low recruitment in 2018 combined with a decrease in mean weight at age led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 2019.

9.2.12 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the ICES WKMSYREF2 and WKMSYREF5 meetings (ICES, 2014a, 2017) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the escapement strategy corresponds to an F_{bar} that exceeds F_{cap}, then the escapement strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 1r is 0.49 (ICES, 2017).

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

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

9.3 Sandeel in SA 2r

9.3.1 Catch data

Total catch weight by year for SA 2r is given in tables 9.1.29–.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 2018 catch with highest proportion of 2-group in the time-series (94%). Furthermore, the proportion of age 1 is the lowest on record (1%) (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 2018 was below the historic average, reaching only 89% of the long term average for age 2.

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 standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account.

Total international standardized effort in 2018 was the third lowest in the time-series and CPUE was decreased to the levels observed in 2014–2015.

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).

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 medium (0.57) for age 0 indicating a reasonable 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 (0.323) 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. However, in 2017 and 2018, the model consistently finds fewer fish in the catch of the 2014 and 2015 cohorts than it expects from the high F. The 2014 and 2015 cohorts also showed large negative residuals at ages 2+ indicating that the year classes seen in the dredge and at age 1 in the catches were less abundant than expected in the subsequent catches.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.12 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 2010–2018, 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 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. However, a systematic bias like this is not expected. Possible causes suggested were:

Spatial distribution of recruitment and/or catch differs from other years: There was no indication that the spatial distribution of recruitment and catch were outside those previously observed.

Survival of older age groups is low: There was no information to assess whether predation mortality has changed. Overwintering mortality can be linked to sandeel condition at the end of the season, but there was no evidence of the weight at age 3 and 4+ being outside the historical range in the last decade.

The fishery has changed selection pattern in 2017 and 2018 as it was probably targeting the very large 2016 year class. There are historical examples of a change in selection pattern towards the most abundant year class in 1997 and 2002 where there was both a large incoming year class and a large catch. In both cases, 3 and 4+ showed negative catch residuals in the year with abundant age 1 and positive catch residuals of age 4+ in the subsequent year, indicating that the cohorts remained in the stock but were underrepresented in the catches in the year of abundant 1-group.

Based on these considerations, HAWG considered that there was not sufficient information to determine the cause of the low catch of 2+ fish in 2017 and 1 and 3+ fish in 2018 or the balance between different co-occurring effects. The problem with assuming a constant selection pattern was discussed at the benchmark in 2016, in particular the presence of density dependent catchability. Ideally, such a relationship should be considered and possibly included in the model formulation at the next benchmark of the stock. The very high CPUE and the high dredge catch of the 2016 cohort confirmed that there was a large year class this year. The downscaling of this cohort in the 2018 assessment is within the range of the downscaling of recruitment observed in the previous years and the 2019 confirms the 2018 assessment. Given that there is not sufficient information to decide whether it is most appropriate to assume that selectivity has changed, that there is a survival issue for 3+ sandeel or there is a bias in the dredge survey catches of 0-group, HAWG decided to keep the benchmarked settings for the assessment.

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 is the fifth lowest on record. 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. 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 2018.

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 2019 is the geometric mean of the recruitment in 2008–2017 (20 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 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 2014–2018. 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 SSB will be below the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2020 even in the complete absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 44 435 t.

9.3.10 Biological reference points

B_{lim} is set at 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.45 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex.

9.3.11 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 multi-species fishery within this area (i.e. suspected to catch *Ammodytes tobianus*). The dredge survey time-series in SA2 is still short (2010–2018) and the quality of the assessment will likely improve once a longer time-series becomes available.

During the meeting, an analysis was made of the effect of having age composition and weight at age in the catch available from a monitoring fishery in years with a zero TAC. Such effect was evaluated from the monitoring fishery in 2016 by removing the age composition from the likelihood and assuming average weight at age from the previous 5 years. Not including age composition and mean weight at age from the monitoring fishery led to an estimate of SSB in the assessment following the monitoring fishery that was twice as large as that estimated when including the monitoring fishery age composition and mean weight. In following year, the availability of age composition and weight at age of catch (2017) compensated for the lack of 2016 data and the two methods provided similar results. However, this fishery was dependent on the assessment in 2017, and hence on the SSB in 2017, and an overestimation of this SSB would have led to an overestimation of the sustainable TAC.

		Value relative to 2019 assessment*		
Assessment year		N (average of 2015–2017)	SSB 2017	Mean weight at age 1 and 2 2016
2017	no monitoring in 2016	2.06	3.05	1.46
2017	monitoring in 2016	1.39	1.56	1
2018	no monitoring in 2016	1.17	1.42	1.46
2018	monitoring in 2016	1.31	1.41	1

*** a value of 1 corresponds to identical estimates**

9.3.12 Status of the Stock

A moderate F in most of the years from 2010 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004 to 2010. F in 2017 was the highest in recent years. SSB in 2016 and 2017 are estimated below B_{lim}. Recruitment in 2016 is estimated to be the fourth highest on record while the 2017 and 2018 year classes are extremely low.

9.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 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 65% 1-group, but in 2018, the 2-group provided the largest contribution to the catches similar to what has been reported in 2011 when the large 2009 year-class were 2 years old (Figure 9.4.1). The proportion of group-1 was low 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.

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 multi-species 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 standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peaked in 1998, and declined thereafter and has been less than 2000 days per year since 2003.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2018 show an above average recruitment in 2018 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e. $r^2 = 0.30$ 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 (2009–2018) 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 9.4.12. The age 1 index in 2017 and the age 2 index in 2018 is the highest observed in the time series supporting that the 2016 year class was very strong.

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 (0.68) and age 1 (0.92), 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 0 (0.78) and age 1 (0.61), showing an overall medium consistency between the results from the dredge survey and the overall model results. The acoustic survey residuals (Figure 9.4.15) plot shows a series of positive residuals followed by a series of negative residuals for the 2-group, while the residuals for the 1-group are more randomly distributed.

The model CV of catch at age is medium (0.65) 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 (> 1.01). 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 cluster of negative or positive residuals for ages 1 and 2.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.06), 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 is a large retrospective pattern in the recruitment that consistently overestimates large recruiting year-classes by more than 100%.

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, 1999–2018, 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 2 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 133 610 t in 2019 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 262 800 t, well above MSY $B_{trigger}$ of 129 000 t, in 2020. The TAC according to the escapement strategy is therefore 133 610 t in 2019.

9.4.10 Biological reference points

B_{lim} is set at 80 000 t and B_{pa} is estimated to 129 000 t. MSY $B_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex.

9.4.11 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessment. The new sandeel area 3r is slightly different from the previous sandeel area 3, and mainly consists of fishing grounds in Norwegian EEZ. There is a large retrospective pattern in the recruitment that overestimates high recruitments. This pattern may be caused by a variety of issues in the assessment, most likely of which are the shift in 2011 from using Danish to using Norwegian effort data and the change in the spatial coverage of the dredge survey. Even though the new assessment for SA 3r sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

9.4.12 Status of the Stock

The SSB has increased from below B_{lim} in 2013 to above B_{pa} since 2015, due to above average recruitment in 2013, 2014 and 2016 combined with a low fishing mortality. Recruitment estimate for 2018 is fifth largest on record.

9.4.13 Management Considerations

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

9.5 Sandeel in SA 4

9.5.1 Catch data

Catch numbers at age by half-year from area SA 4 is given in Table 9.5.1. Total catch weight by year for SA 4 is given in tables 9.5.2–9.5.4. In 2018, age groups 1, 3 and 4 contributed almost equally to the catches (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 historical levels 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. Effort since 2004 has been extremely low. CPUE in later years has been around the average prior to 2004.

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 2018 year-class lowest 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 2018. 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 (0.70) for age 1 and age 2. The catch at age residuals (Figure 9.5.6) show no alarming patterns, except for a tendency to positive residuals (observed catch is higher than model catch) for age 1 in the beginning of the time series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.29), 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. $F_{(1-2)}$ is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004. Recruitment in

2014, 2016 and 2017 are estimated to be above average, whereas 2018 show the second lowest in record.

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 2019 is the geometric mean of the recruitment 1993–2017 (81 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018. 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 below the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2020 even in the complete absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 38 915 t.

The short-term forecast (Table 9.5.12) shows that that a SSB will be below the MSY $B_{trigger}$ of 102 000 t in 2020 even in the absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 97 744 t.

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 2019 is high (0.37). The assessment accuracy is improved compared to the 2018 assessment as catches were increased in 2018.

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016 and 2017 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.

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.

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

WD01 Marine Scotland Science sandeel dredge survey indices for SA4.

Table 9.1.1 Sandeel. Catches ('000 t), 1955–2018. (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
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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
1995	647.8	-	-	-	-	263.4	-	6.7	-	917.9
1996	601.6	-	5	-	-	160.7	-	9.7	-	776.9
1997	751.9	-	11.2	-	-	350.1	-	24.6	-	1137.8
1998	617.8	-	11	-	-	343.3	8.5	23.8	-	1004.4
1999	500.1	-	13.2	0.4	-	187.6	22.4	11.5	-	735.1
2000	541.0	-	-	-	-	119	28.4	10.8	-	699.1
2001	630.8	-	-	-	-	183	46.5	1.3	-	861.6
2002	629.7	-	-	-	-	176	0.1	4.9	-	810.7
2003	274.0	-	-	-	-	29.6	21.5	0.5	-	325.6
2004	277.1	2.7	-	-	-	48.5	33.2	-	-	361.5
2005	154.8	-	-	-	-	17.3	-	-	-	172.1
2006	250.6	3.2	-	-	-	5.6	27.8	-	-	287.9
2007	144.6	1	2	-	-	51.1	6.6	1	-	206.3
2008	234.4	4.4	2.4	-	-	81.6	12.4	-	-	335.2
2009	285.7	12.2	2.5	-	1.8	27.4	12.4	3.6	-	345.6
2010	275.1	13	-	-	-	78	32	4	0.6	402.7
2011	278.5	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

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839
1998	372604	99305	474843	58911	3010	941	5228	1014841
1999	425478	70085	193621	53338	145	0	4415	747083
2000	374724	101952	196525	37792	303	0	4371	715667
2001	540248	97210	196209	47918	1678	26	971	884260
2002	610161	120520	115207	12762	8	493	453	859604
2003	178642	56248	35365	64049	44	111	260	334718
2004	215352	116837	33658	6882	0	573	0	373302
2005	126261	34569	13994	1557	0	259	0	176640
2006	247510	37952	7094	86	0	161	0	292802
2007	110395	44069	75376	11	4	0	0	229855
2008	236069	35655	74943	1168	0	0	0	347836
2009	309712	37049	6161	0	0	0	0	352922
2010	300896	52470	60542	275	0	0	0	414183
2011	320241	24310	92450	270	0	489	0	437761
2012	45954	12672	40141	2618	0	214	0	101599
2013	214787	48172	9838	5119	0	72	0	277989
2014	99059	64707	95426	4505	0	65	0	263762
2015	162861	39492	104607	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	132828	20569	74933	42528	0	0	0	270858
arith. mean	302806	105486	149536	30951	5996	1203	1019	596998

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	314744	92566	21008	2782	0	364	0	431465
1984	419640	86141	43578	2563	5821	735	744	559223
1985	377702	76422	17131	37900	3004	973	0	513132
1986	346053	181733	138020	12539	108	12020	7832	698305
1987	307194	36400	394339	7833	1713	1091	0	748570
1988	395186	107289	288174	1257	0	2114	0	794020
1989	435721	173510	371557	4382	1587	897	450	988104
1990	285321	101899	105554	2926	0	485	0	496185
1991	257591	153869	215770	17140	1168	17	2529	648083
1992	521575	135823	83068	67068	1099	4270	3455	816357
1993	129403	86179	155984	123143	250	4393	3	499354
1994	177685	184792	242027	147019	2754	3222	4	757503
1995	365681	70518	203151	52497	152269	1829	0	845945
1996	257507	63193	110862	48496	14551	1168	0	495777
1997	345199	178735	394181	47668	8615	2194	2448	979040
1998	352275	70075	354639	57373	2907	939	4565	842773
1999	395813	27461	94655	51183	145	0	2152	571409
2000	333044	82405	192474	37792	288	0	3808	649812
2001	368782	49319	59951	47492	1678	26	735	527983
2002	604584	105397	114646	12762	8	493	101	837991
2003	155006	25111	22803	62580	44	111	187	265841
2004	199483	91405	21632	6860	0	571	0	319951
2005	121795	24841	13982	1557	0	259	0	162434
2006	241345	23497	6959	55	0	160	0	272015
2007	110389	44069	75376	11	4	0	0	229849
2008	232249	32602	74943	1168	0	0	0	340963
2009	293529	25399	6024	0	0	0	0	324952
2010	293359	44910	60251	275	0	0	0	398796
2011	316351	24045	92450	270	0	489	0	433605
2012	45946	11520	40141	2618	0	213	0	100438
2013	207886	43818	9838	5119	0	72	0	266733
2014	94278	62110	95426	4505	0	65	0	256383
2015	162860	38723	104607	4736	0	197	0	311123
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	126182	20284	74352	42528	0	0	0	263346
arith. mean	273514	75451	123869	26078	5500	1097	806	506314

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	67885	63641	3820	0	0	0	0	135345
1984	79031	47257	5532	0	0	55	0	131875
1985	82355	35468	3728	222	0	953	0	122726
1986	36791	43848	144314	179	519	1199	2818	229668
1987	65828	12667	959	321	0	72	0	79847
1988	27619	44254	48744	81	0	612	0	121310
1989	10407	53782	2694	2	1316	12	0	68214
1990	20981	31896	57670	388	374	14	0	111323
1991	74613	61697	59069	24232	0	0	0	219611
1992	37027	48418	3954	1837	0	6	0	91243
1993	14986	61785	44138	9993	336	97	78	131414
1994	15557	60152	25254	11671	3	526	0	113163
1995	35078	51637	10017	94	5	1	0	96831
1996	34202	123267	48441	109994	13020	95	1	329019
1997	81215	63945	79912	10779	2157	179	613	238799
1998	20329	29230	120203	1538	103	1	663	172068
1999	29666	42624	98967	2155	0	0	2263	175674
2000	41680	19547	4051	0	15	0	562	65855
2001	171466	47891	136258	426	0	0	236	356277
2002	5577	15123	561	0	0	0	352	21613
2003	23636	31137	12562	1469	0	0	73	68877
2004	15869	25432	12026	22	0	2	0	53351
2005	4466	9728	11	0	0	0	0	14206
2006	6165	14455	136	30	0	0	0	20787
2007	6	0	0	0	0	0	0	6
2008	3821	3053	0	0	0	0	0	6873
2009	16183	11650	137	0	0	0	0	27970
2010	7537	7560	291	0	0	0	0	15387
2011	3891	265	0	0	0	0	0	4156
2012	8	1153	0	0	0	0	0	1161
2013	6902	4354	0	0	0	0	0	11256
2014	4781	2598	0	0	0	0	0	7379
2015	1	769	0	0	0	0	0	771
2016	0	50	0	0	0	0	0	51
2017	2327	10673	0	0	0	0	0	13000
2018	6646	285	581	0	0	0	0	7512
arith. mean	29292	30036	25668	4873	496	106	213	90684

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	8992	4719	864	63	0	9	0	14649
1984	10166	4009	1378	48	212	50	37	15901
1985	10876	3570	619	655	139	65	0	15923
1986	7372	5038	4641	284	12	469	145	17962
1987	5680	1153	5094	177	64	45	0	12213
1988	7980	3876	7472	42	0	90	0	19460
1989	8553	6552	7677	57	31	44	0	22914
1990	8529	4209	5143	55	0	24	0	17960
1991	5991	5117	5864	338	19	1	0	17330
1992	8805	4944	2383	571	0	197	0	16900
1993	3893	4396	5124	1387	29	265	0	15093
1994	3149	4230	4854	1588	0	114	0	13934
1995	5899	2497	3791	437	1915	50	0	14589
1996	5497	4608	4352	1464	605	48	0	16573
1997	5366	5308	7749	622	0	60	6	19111
1998	6580	2743	11062	611	96	26	0	21118
1999	8900	1975	6179	850	0	0	0	17904
2000	7141	2597	4117	421	5	0	149	14429
2001	11021	2505	4726	669	0	1	0	18921
2002	8162	3162	2491	140	1	13	0	13968
2003	6805	2351	1634	1098	19	6	0	11913
2004	7057	4208	1264	203	0	27	0	12758
2005	3412	1131	468	88	0	10	0	5109
2006	4160	1235	205	1	0	5	0	5606
2007	1560	874	1214	1	0	0	0	3650
2008	2878	906	1344	7	0	0	0	5136
2009	3551	802	111	0	0	0	0	4464
2010	2859	1136	1446	4	0	0	0	5444
2011	3195	677	924	7	0	18	0	4821
2012	585	472	561	68	0	13	0	1699
2013	3876	1799	273	37	0	8	0	5992
2014	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	3265	561	1489	547	0	0	0	5862
arith. mean	5527	2737	3079	358	87	47	9	11844

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	6926	3032	739	63	0	9	0	10770
1984	7910	2471	1172	48	212	46	37	11896
1985	8449	2564	508	652	139	29	0	12341
1986	6568	3884	2508	281	4	437	81	13763
1987	4287	779	5063	161	64	42	0	10395
1988	7172	2660	6030	40	0	69	0	15970
1989	8240	4852	7586	56	31	42	0	20808
1990	8008	3380	3738	49	0	24	0	15201
1991	4588	3538	4750	111	19	1	0	13008
1992	7926	3793	2290	309	0	197	0	14514
1993	3496	2597	3950	1200	29	256	0	11527
1994	2852	3097	4411	1410	0	98	0	11867
1995	5298	1527	3589	436	1915	50	0	12815
1996	4805	1627	3147	519	441	48	0	10587
1997	3997	3440	5895	490	0	52	0	13874
1998	6011	1707	7059	576	93	26	0	15473
1999	7875	772	3204	850	0	0	0	12702
2000	6181	1991	4040	421	5	0	149	12786
2001	8041	1362	1681	656	0	1	0	11741
2002	7942	2489	2491	140	1	13	0	13076
2003	5907	1034	1246	1027	19	6	0	9239
2004	6601	3179	862	201	0	27	0	10870
2005	3288	816	468	88	0	10	0	4670
2006	3982	858	200	1	0	5	0	5046
2007	1560	874	1214	1	0	0	0	3650
2008	2793	797	1344	7	0	0	0	4942
2009	3377	608	110	0	0	0	0	4094
2010	2725	948	1436	4	0	0	0	5113
2011	3070	665	924	7	0	18	0	4684
2012	585	447	561	68	0	13	0	1674
2013	3704	1618	273	37	0	8	0	5639
2014	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	2942	555	1477	547	0	0	0	5522
arith. mean	4839	1910	2453	300	83	43	7	9635

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	2066	1687	126	0	0	0	0	3879
1984	2256	1538	207	0	0	4	0	4005
1985	2427	1005	110	3	0	35	0	3582
1986	804	1154	2133	3	8	32	64	4199
1987	1393	374	31	16	0	3	0	1817
1988	809	1215	1442	2	0	22	0	3490
1989	313	1700	92	0	0	1	0	2106
1990	520	828	1405	5	0	0	0	2759
1991	1403	1579	1113	227	0	0	0	4322
1992	879	1151	93	262	0	0	0	2385
1993	398	1799	1174	187	0	10	0	3567
1994	297	1133	443	178	0	16	0	2067
1995	601	970	201	1	0	0	0	1774
1996	691	2981	1205	945	163	0	0	5986
1997	1369	1868	1854	132	0	7	6	5237
1998	568	1036	4003	35	3	0	0	5645
1999	1024	1203	2975	0	0	0	0	5202
2000	960	606	78	0	0	0	0	1643
2001	2979	1143	3044	13	0	0	0	7180
2002	220	672	0	0	0	0	0	892
2003	898	1316	388	71	0	0	0	2673
2004	456	1028	402	2	0	0	0	1888
2005	124	316	0	0	0	0	0	439
2006	178	377	5	0	0	0	0	560
2007	0	0	0	0	0	0	0	0
2008	85	109	0	0	0	0	0	194
2009	174	194	2	0	0	0	0	370
2010	134	187	10	0	0	0	0	331
2011	126	11	0	0	0	0	0	137
2012	0	25	0	0	0	0	0	25
2013	172	181	0	0	0	0	0	353
2014	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	322	6	12	0	0	0	0	340
arith. mean	688	826	626	58	5	4	2	2209

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

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	79	49	0	0	0	0	0	128
1984	116	46	13	0	2	3	0	180
1985	101	32	1	19	2	3	0	158
1986	26	17	27	1	0	1	0	72
1987	62	12	60	1	0	1	0	136
1988	42	15	67	0	0	1	0	125
1989	40	9	43	0	0	1	0	93
1990	1	4	37	0	0	2	0	44
1991	25	32	30	1	0	0	0	88
1992	56	42	24	4	0	7	0	133
1993	23	63	64	15	0	7	0	172
1994	20	38	50	15	0	4	0	127
1995	41	32	58	7	7	2	0	147
1996	43	62	113	27	19	1	0	265
1997	41	84	116	25	8	3	0	277
1998	53	30	145	7	0	2	0	237
1999	263	42	40	44	0	0	0	389
2000	102	34	47	59	0	0	0	242
2001	213	39	32	90	1	0	0	375
2002	288	97	50	62	0	0	0	497
2003	281	75	30	160	0	1	0	547
2004	451	217	26	47	0	1	0	742
2005	320	42	34	30	0	1	0	427
2006	550	56	72	2	0	2	0	682
2007	295	79	95	0	0	0	0	469
2008	290	100	45	1	0	0	0	436
2009	302	102	3	0	0	0	0	407
2010	169	194	30	1	0	0	0	394
2011	167	54	17	4	0	4	0	246
2012	220	112	31	21	0	12	0	396
2013	292	220	41	5	0	3	0	561
2014	143	133	29	18	0	5	0	328
2015	308	117	48	38	0	4	0	515
2016	154	159	42	35	0	0	0	390
2017	279	204	50	40	0	0	0	573
2018	350	136	166	71	0	0	0	723
Sum	6206	2779	1776	850	39	71	0	11721

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	10223	1846	264	28971	3085	772	564	320	2
1984	0	47117	9241	1701	90	10002	566	333	43
1985	8524	6217	1354	31364	2305	1987	1595	211	213
1986	87	44940	4163	7553	228	1652	188	31	14
1987	187	4504	1938	23572	4173	1199	123	171	32
1988	0	1997	0	8564	162	15229	1439	2354	47
1989	0	62503	757	6364	77	1346	16	4736	58
1990	522	16846	1257	13917	417	2060	62	622	18
1991	7344	14939	6917	6870	209	983	67	338	0
1992	104	50883	3041	8451	298	845	122	524	26
1993	1624	2181	362	5882	271	1638	156	491	43
1994	0	22172	1533	2669	126	1195	55	882	78
1995	76	36677	3440	6236	940	737	109	289	28
1996	6470	10402	1064	12301	1027	4527	211	860	65
1997	19	38667	8899	2332	177	3522	164	713	56
1998	211	9387	438	28364	1384	2164	136	1505	90
1999	440	44621	2498	5433	205	10158	717	699	149
2000	7887	32625	2760	3355	170	630	84	1076	122
2001	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	208	0	1193	0	97	0	17	0
2017	3	33038	253	3015	40	4604	38	103	7
2018	91	1702	159	14567	797	975	43	343	11
arith. mean	2665	23753	1739	9291	625	2362	198	703	39

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	4.9	4.0	9.7	8.3	17.2	13.2	20.5	11.6
1984	3.7	5.5	7.3	10.1	12.8	14.1	16.8	13.4	15.8
1985	3.0	5.1	5.8	9.2	10.7	16.4	12.9	17.9	16.6
1986	3.0	5.3	7.5	11.7	12.7	11.7	12.8	13.6	14.7
1987	4.0	7.2	7.8	10.6	11.2	18.5	20.2	14.7	16.1
1988	3.9	6.1	6.8	10.4	12.0	16.0	17.0	17.8	24.4
1989	6.2	5.0	9.6	8.6	15.5	9.1	17.2	12.0	28.3
1990	5.0	6.6	9.0	9.6	13.1	14.2	19.3	17.0	23.1
1991	3.8	7.8	6.1	14.2	11.8	37.8	32.0	19.6	17.2
1992	4.9	7.8	9.5	11.9	15.3	17.7	19.7	19.0	21.2
1993	4.0	7.3	7.5	11.5	10.5	14.4	13.6	20.2	18.2
1994	4.4	5.5	7.6	8.7	12.3	12.7	16.3	19.8	18.8
1995	3.8	7.6	6.8	11.3	9.9	14.1	14.1	19.0	19.0
1996	2.9	5.6	4.6	8.4	7.6	12.2	9.5	17.7	14.2
1997	3.7	7.3	8.5	8.3	14.2	9.9	15.5	14.4	16.1
1998	3.2	6.3	6.7	8.9	10.0	11.5	11.9	13.5	14.5
1999	3.4	5.3	5.9	7.5	9.6	10.3	12.8	13.1	14.7
2000	3.1	6.3	4.8	8.7	7.9	11.9	10.6	14.5	12.2
2001	3.1	4.5	5.0	8.7	12.1	11.5	16.5	16.6	23.6
2002	3.8	6.0	6.7	7.4	10.8	9.8	14.4	13.8	16.5
2003	2.2	3.6	2.7	7.2	3.6	9.5	8.4	12.8	9.1
2004	3.5	5.1	4.5	8.3	6.6	9.0	6.7	10.4	8.8
2005	3.0	6.5	5.3	8.7	8.5	10.3	11.3	12.1	13.0
2006	3.2	5.9	5.5	9.7	8.9	11.6	11.9	13.0	13.7
2007	4.1	5.6	7.0	9.4	11.3	13.5	15.1	14.7	17.3
2008	4.5	6.3	7.8	10.9	12.6	13.3	16.8	15.8	19.3
2009	2.8	6.2	4.9	9.4	7.9	12.1	10.5	13.2	12.1
2010	3.4	6.3	5.9	12.4	9.5	13.9	12.6	17.2	14.5
2011	2.8	5.3	4.9	8.7	7.8	12.7	10.4	14.8	12.0
2012	3.8	6.4	6.6	9.5	10.6	11.3	14.1	14.5	16.2
2013	3.8	4.7	6.5	6.5	10.5	10.1	14.0	11.3	16.1
2014	3.0	4.7	5.2	7.1	8.5	9.5	11.3	11.7	13.0
2015	4.0	5.5	6.9	8.3	11.1	10.6	14.8	14.0	17.0
2016	3.2	5.2	5.4	10.1	8.7	12.5	11.6	14.7	13.3
2017	2.9	5.3	6.0	7.1	8.2	9.2	10.5	10.7	12.4
2018	2.4	4.7	4.1	7.0	6.6	9.5	8.8	11.5	10.1
arith. mean	3.6	5.8	6.3	9.3	10.3	13.0	14.0	15.0	16.0

Table 9.2.3 Sandeel Area-1r. Proportion mature.

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

Table 9.2.4. Sandeel Area-1r. Dredge survey indices (number/hour).

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

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

Date: 01/30/19 Start time:12:09:14 run time:2 seconds

objective function (negative log likelihood): 8.6934
Number of parameters: 77
Maximum gradient: 3.91354e-005
Akaike information criterion (AIC): 171.387
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
324	60	36	0	420

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
16.9	-8.8	12.0	0.0	0.0	0.00	20

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.05	-0.15	0.33	0.00

contribution by fleet:

RTM 2007-2017 total: -4.737 mean: -0.158
Dredge survey 2004-2018 total: -4.049 mean: -0.135

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
2010-2018:	0.000	1.000
age: 1 -		4
1983-1988:	0.457	0.500
1989-1998:	0.470	0.500
1999-2004:	0.374	0.500
2005-2009:	0.261	0.500
2010-2018:	0.472	0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.025	0.256	0.926	1.353	1.353
1989-1998:	0.012	0.540	0.712	0.702	0.702
1999-2004:	0.069	1.054	1.151	1.127	1.127
2005-2009:	0.007	1.508	2.221	2.237	2.237
2010-2018:	0.008	0.315	0.829	1.265	1.265

Exploitation pattern (scaled to mean F=1)

	0	1	2	3	4
1983-1988 season 1:	0	0.326	1.181	1.726	1.726

	season	2:	0.021	0.107	0.386	0.564	0.564
1989-1998	season	1:		0	0.829 1.094	1.079	1.079
	season	2:	0.001	0.033	0.044	0.044	0.044
1999-2004	season	1:		0	0.814 0.889	0.871	0.871
	season	2:	0.019	0.142	0.155	0.152	0.152
2005-2009	season	1:		0	0.754 1.111	1.119	1.119
	season	2:	0.001	0.054	0.080	0.081	0.081
2010-2018	season	1:		0	0.523 1.378	2.102	2.102
	season	2:	0.001	0.027	0.072	0.110	0.110

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

season
----

age	1	2
0		1.610
1	0.341	0.572
2	0.341	0.572
3	0.691	0.911
4	0.691	0.911

Survey catchability:
----

	age 0	age 1	age 2		age 3
RTM 2007-2017			0.863	1.681	2.133
Dredge survey 2004-2018			2.475		1.049

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

	age 0	age 1	age 2		age 3
RTM 2007-2017			0.57	0.41	0.59
Dredge survey 2004-2018			0.36		0.77

Recruit-SSB	alfa	beta	recruit s2	recruit s
Area-1r	1021.404	1.100e+005	0.718	0.848

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	0.252	0.913	1.333	1.333	0.583	0.252
1984	0.285	1.032	1.507	1.507	0.659	0.285
1985	0.305	1.102	1.610	1.610	0.704	0.305
1986	0.204	0.741	1.082	1.082	0.473	0.204
1987	0.160	0.578	0.845	0.845	0.369	0.160
1988	0.221	0.801	1.170	1.170	0.511	0.221
1989	0.698	0.921	0.908	0.908	0.810	0.698
1990	0.697	0.919	0.907	0.907	0.808	0.697
1991	0.494	0.653	0.644	0.644	0.574	0.494
1992	0.721	0.951	0.938	0.938	0.836	0.721
1993	0.318	0.420	0.415	0.415	0.369	0.318
1994	0.258	0.340	0.335	0.335	0.299	0.258
1995	0.483	0.638	0.629	0.629	0.561	0.483
1996	0.451	0.595	0.587	0.587	0.523	0.451
1997	0.444	0.585	0.577	0.577	0.515	0.444
1998	0.545	0.719	0.709	0.709	0.632	0.545
1999	0.890	0.972	0.952	0.952	0.931	0.890
2000	0.719	0.785	0.768	0.768	0.752	0.719
2001	1.158	1.264	1.239	1.239	1.211	1.158
2002	0.792	0.866	0.848	0.848	0.829	0.792
2003	0.684	0.747	0.732	0.732	0.716	0.684
2004	0.694	0.757	0.742	0.742	0.726	0.694
2005	0.803	1.183	1.191	1.191	0.993	0.803
2006	0.984	1.448	1.459	1.459	1.216	0.984
2007	0.355	0.523	0.527	0.527	0.439	0.355
2008	0.673	0.991	0.998	0.998	0.832	0.673
2009	0.844	1.243	1.252	1.252	1.044	0.844
2010	0.304	0.801	1.222	1.222	0.553	0.304
2011	0.337	0.887	1.352	1.352	0.612	0.337
2012	0.062	0.164	0.250	0.250	0.113	0.062
2013	0.392	1.033	1.575	1.575	0.713	0.392
2014	0.234	0.617	0.941	0.941	0.426	0.234
2015	0.219	0.579	0.882	0.882	0.399	0.219
2016	0.015	0.041	0.062	0.062	0.028	0.015
2017	0.299	0.787	1.200	1.200	0.543	0.299
2018	0.348	0.918	1.400	1.400	0.633	0.348
arith. mean	0.482	0.792	0.939	0.939	0.637	0.482

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	0.190	0.062	0.688	0.225	1.005	0.328	1.005	0.328
1984	0.013	0.217	0.068	0.786	0.246	1.148	0.359	1.148	0.359
1985	0.014	0.232	0.073	0.839	0.263	1.225	0.385	1.225	0.385
1986	0.005	0.180	0.024	0.653	0.088	0.954	0.128	0.954	0.128
1987	0.008	0.118	0.042	0.426	0.152	0.623	0.222	0.623	0.222
1988	0.005	0.197	0.024	0.713	0.088	1.041	0.129	1.041	0.129
1989	0.001	0.671	0.027	0.885	0.036	0.873	0.035	0.873	0.035
1990	0.002	0.652	0.045	0.860	0.059	0.848	0.059	0.848	0.059
1991	0.005	0.373	0.121	0.493	0.160	0.486	0.158	0.486	0.158
1992	0.003	0.645	0.076	0.851	0.100	0.839	0.099	0.839	0.099
1993	0.001	0.284	0.034	0.375	0.045	0.370	0.045	0.370	0.045
1994	0.001	0.232	0.026	0.306	0.034	0.302	0.033	0.302	0.033
1995	0.002	0.431	0.052	0.569	0.069	0.561	0.068	0.561	0.068
1996	0.003	0.391	0.060	0.516	0.079	0.509	0.078	0.509	0.078
1997	0.005	0.325	0.119	0.429	0.156	0.423	0.154	0.423	0.154
1998	0.002	0.496	0.049	0.654	0.065	0.645	0.064	0.645	0.064
1999	0.017	0.758	0.132	0.828	0.144	0.811	0.141	0.811	0.141
2000	0.016	0.595	0.124	0.650	0.135	0.636	0.132	0.636	0.132
2001	0.050	0.774	0.384	0.845	0.419	0.828	0.411	0.828	0.411
2002	0.004	0.764	0.028	0.835	0.031	0.818	0.030	0.818	0.030
2003	0.015	0.568	0.116	0.621	0.126	0.608	0.124	0.608	0.124
2004	0.008	0.635	0.059	0.693	0.064	0.679	0.063	0.679	0.063
2005	0.001	0.749	0.054	1.103	0.080	1.111	0.080	1.111	0.080
2006	0.001	0.906	0.078	1.334	0.114	1.344	0.115	1.344	0.115
2007	0.000	0.355	0.000	0.523	0.000	0.527	0.000	0.527	0.000
2008	0.000	0.636	0.037	0.936	0.055	0.943	0.055	0.943	0.055
2009	0.001	0.768	0.076	1.131	0.112	1.139	0.113	1.139	0.113
2010	0.001	0.289	0.015	0.761	0.040	1.161	0.061	1.161	0.061
2011	0.001	0.326	0.011	0.859	0.028	1.310	0.042	1.310	0.042
2012	0.000	0.062	0.000	0.164	0.000	0.250	0.000	0.250	0.000
2013	0.000	0.392	0.000	1.033	0.000	1.575	0.000	1.575	0.000
2014	0.000	0.225	0.009	0.593	0.024	0.904	0.037	0.904	0.037
2015	0.000	0.219	0.000	0.579	0.000	0.882	0.000	0.882	0.000
2016	0.000	0.015	0.000	0.041	0.000	0.062	0.000	0.062	0.000
2017	0.000	0.293	0.006	0.772	0.015	1.177	0.023	1.177	0.023
2018	0.002	0.312	0.036	0.822	0.096	1.254	0.146	1.254	0.146
arith. mean	0.006	0.424	0.057	0.699	0.093	0.830	0.109	0.830	0.109

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
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
2018	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
arith. mean	0.598	0.446	0.516	0.370	0.390	0.295	0.355	0.263	0.343

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	307789	13764	53428	3205	202
1984	76138	182227	4452	10216	469
1985	518904	45492	57608	753	1286
1986	77487	305345	14299	9210	218
1987	46882	45338	106044	3207	1651
1988	205021	27161	16292	27615	1082
1989	93494	118199	9130	3357	4557
1990	132179	55351	24779	1675	1645
1991	161729	76615	11469	4680	695
1992	36290	92840	20047	2919	1556
1993	149627	21225	19966	3929	995
1994	215287	89540	6989	6740	1852
1995	54971	128926	30677	2523	3461
1996	387500	32947	34546	8028	1801
1997	60464	225590	9272	9612	3032
1998	113895	34620	61198	2573	3887
1999	150716	62937	7892	14506	1736
2000	244417	81770	9640	1408	3303
2001	405754	134449	14880	2105	1224
2002	25513	214039	16920	2053	538
2003	151085	13333	35859	3010	561
2004	67761	76681	2399	6978	821
2005	149597	34110	12429	451	1733
2006	74627	77088	5374	1735	341
2007	206138	37224	9653	558	246
2008	66094	99251	9030	2577	245
2009	479825	33017	16764	1457	539
2010	31323	245514	5164	2254	299
2011	40855	15945	61825	1044	379
2012	91537	19809	3598	11700	183
2013	51269	44716	5711	1308	4418
2014	189591	26682	9841	876	614
2015	28959	100443	7791	2417	315
2016	233749	15802	28799	2123	627
2017	20795	127551	5556	13443	1441
2018	110803	11344	33794	1230	2485
2019		60357	2860	6562	519

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	307812072	646348	476870	378795	0.583
1984	76133581	1190140	205048	498626	0.658
1985	518784950	793723	462314	437114	0.703
1986	77516393	1894430	277340	382844	0.472
1987	46875232	1533910	991526	373021	0.369
1988	205098313	795387	593623	413646	0.511
1989	93455879	753101	160332	446028	0.809
1990	132222941	656341	250196	306240	0.808
1991	161659043	950504	331042	332204	0.574
1992	36288085	1042360	286359	558599	0.836
1993	149678467	461536	262761	132024	0.370
1994	215183132	675313	180232	193241	0.299
1995	54953614	1429380	399512	400588	0.560
1996	387412277	603306	364397	265869	0.523
1997	60490688	1851450	233748	426089	0.515
1998	113919202	844877	522301	377073	0.632
1999	150729892	567762	225258	422718	0.931
2000	244322590	662828	142629	299167	0.752
2001	405649482	781692	160653	531265	1.211
2002	25520689	1428820	154972	606466	0.829
2003	151031654	342920	243531	148039	0.716
2004	67795068	478922	94278	203646	0.726
2005	149528864	356073	117243	123422	0.993
2006	74626035	530434	75584	240646	1.216
2007	206126373	308942	88345	109624	0.439
2008	66121201	758791	129314	234447	0.832
2009	479857623	386188	155127	290995	1.043
2010	31327285	1646980	119731	300508	0.552
2011	40873807	643056	452707	318840	0.612
2012	91513769	295400	163081	46117	0.113
2013	51289674	309657	97246	214359	0.712
2014	189519030	211182	73644	78830	0.426
2015	28947662	645626	93153	163381	0.399
2016	233805469	409101	270493	14613	0.028
2017	20790361	852929	183689	241916	0.543
2018	110773707	331641	231886	130460	0.633
2019			97636		
arith. mean	151612992	779751	253196	295596	0.637
geo. mean	107822833				

arith. mean for the period 1983–2018

geo. mean for the period 1983–2017

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	107870.298	60357.3	2860.25	6561.6	519.456
Exploitation pattern 1st half		0.312	0.822	1.254	1.254
Exploitation pattern 2nd half	0.002	0.036	0.096	0.146	0.146
Weight in the stock 1st half		5.077	7.927	10.257	12.511
Weight in the catch 1st half		5.077	7.927	10.257	12.511
weight in the catch 2nd half	3.099	5.519	8.615	11.384	13.154
Proportion mature(2019)	0.000	0.021	0.801	0.988	1.000
Proportion mature(2020)	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(2018) = 0.6328; Yield(2018) = 130.461; Recruitment(2018) = 110.773707; Recruitment(2019) = geometric mean (GM 1983–2017) = 107.870298 billions; SSB(2019) = 97.636

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	206.479	111 %	-100 %
1.000	Fsq*1	0.633	130.568	120.774	24 %	0 %
1.100	Fsq*1.1	0.696	139.421	115.390	18 %	7 %
1.200	Fsq*1.2	0.759	147.775	110.368	13 %	13 %
1.300	Fsq*1.3	0.823	155.675	105.674	8 %	19 %
1.400	Fsq*1.4	0.886	163.159	101.278	4 %	25 %
1.500	Fsq*1.5	0.949	170.261	97.152	0 %	31 %
1.600	Fsq*1.6	1.013	177.012	93.273	-4 %	36 %
1.700	Fsq*1.7	1.076	183.439	89.618	-8 %	41 %
0.624	MSY	0.395	91.916	145.001	49 %	-30 %

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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
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	51	0	1984	22	62	2	13	0
arith. mean	2932	7336	1545	1771	322	447	116	169	46

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	5.2	9.9	10.8	16.5	12.8	22.9	15.0	27.3
1984	5.9	5.6	10.2	11.1	14.1	15.6	25.8	18.8	30.1
1985	4.5	6.7	10.7	9.9	16.8	17.5	23.3	24.1	27.5
1986	3.2	5.9	9.8	10.3	15.8	12.7	15.0	15.0	17.0
1987	2.8	5.8	8.7	11.1	12.9	16.4	21.1	14.6	19.4
1988	3.5	5.5	7.2	11.1	15.3	16.1	21.0	23.1	30.6
1989	4.8	5.7	9.4	9.1	13.4	10.1	14.4	12.1	18.0
1990	4.4	7.1	8.1	9.7	11.8	14.4	17.4	17.3	20.8
1991	3.8	7.7	5.7	12.1	11.0	35.8	32.6	21.2	20.1
1992	4.7	6.9	15.0	9.9	20.6	13.5	29.3	17.9	29.2
1993	2.8	7.7	9.3	15.1	14.8	16.9	17.5	22.3	22.0
1994	3.6	5.4	7.6	10.5	18.8	15.3	23.0	19.5	20.7
1995	5.2	7.6	8.9	12.4	13.2	16.0	17.6	19.2	21.1
1996	2.7	7.0	4.9	12.4	13.2	17.0	15.8	27.9	24.5
1997	3.2	5.3	7.1	8.0	11.2	13.1	13.8	15.9	14.9
1998	3.4	6.2	6.7	11.4	14.0	14.7	16.5	17.4	18.3
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
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	3.2	4.6	7.0	9.6	11.3	12.4	14.5	14.4	16.5
arith. mean	4.0	6.3	8.1	10.8	13.5	15.0	18.1	17.5	20.3

Table 9.3.3 Sandeel Area-2r. Proportion mature.

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

Table 9.3.4. Sandeel Area-2r. Dredge survey indices (number/hour).

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

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

Date: 01/28/19 Start time:13:44:17 run time:0 seconds

objective function (negative log likelihood): 60.0717
Number of parameters: 71
Maximum gradient: 7.27768e-005
Akaike information criterion (AIC): 262.143
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
324	18	36	0	378

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
53.6	4.3	22.2	0.0	0.0	0.00	80

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.17	0.24	0.62	0.00

contribution by fleet:

Dredge survey 2010-2018 total: 4.283 mean: 0.238

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
2010-2018:	0.000	1.000
age: 1	-	4
1983-1988:	0.482	0.500
1989-1998:	0.668	0.500
1999-2004:	0.424	0.500
2005-2009:	0.199	0.500
2010-2018:	0.494	0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.040	0.273	0.880	1.494	1.494
1989-1998:	0.101	0.346	0.418	0.489	0.489
1999-2004:	0.041	0.600	0.738	0.739	0.739
2005-2009:	0.001	1.949	1.623	1.762	1.762
2010-2018:	0.001	0.280	0.453	0.739	0.739

Exploitation pattern (scaled to mean F=1)

	0	1	2	3	4
1983-1988 season 1:	0	0.300	0.968	1.644	1.644
season 2:	0.051	0.173	0.558	0.948	0.948

1989-1998	season	1:		0	0.718	0.867	1.014	1.014
	season	2:	0.110	0.188	0.227		0.266	0.266
1999-2004	season	1:		0	0.307	0.377	0.378	0.378
	season	2:	0.080	0.590	0.726		0.727	0.727
2005-2009	season	1:		0	0.553	0.461	0.500	0.500
	season	2:	0.001	0.538	0.448		0.487	0.487
2010-2018	season	1:		0	0.624	1.010	1.647	1.647
	season	2:	0.001	0.140	0.226		0.369	0.369

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

season
----

age	1	2
0		1.563
1	0.323	0.703
2	0.323	0.703
3	0.808	1.094
4	0.808	1.094

Survey catchability:
----

	age 0	age 1
Dredge survey 2010-2018	49.001	22.100

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

	age 0	age 1
Dredge survey 2010-2018	0.57	1.04

Recruit-SSB		alfa	beta	recruit s2	recruit s
Area-2r	1056.582	5.600e+004	1.266	1.125	

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	0.337	1.088	1.848	1.848	0.713	0.337
1984	0.286	0.925	1.571	1.571	0.606	0.286
1985	0.256	0.824	1.399	1.399	0.540	0.256
1986	0.358	1.156	1.963	1.963	0.757	0.358
1987	0.082	0.265	0.451	0.451	0.174	0.082
1988	0.277	0.893	1.515	1.515	0.585	0.277
1989	0.635	0.766	0.897	0.897	0.701	0.635
1990	0.414	0.501	0.586	0.586	0.458	0.414
1991	0.489	0.591	0.691	0.691	0.540	0.489
1992	0.482	0.583	0.681	0.681	0.533	0.482
1993	0.409	0.494	0.577	0.577	0.452	0.409
1994	0.409	0.494	0.577	0.577	0.452	0.409
1995	0.233	0.282	0.330	0.330	0.258	0.233
1996	0.400	0.483	0.565	0.565	0.442	0.400
1997	0.501	0.605	0.709	0.709	0.553	0.501
1998	0.260	0.314	0.367	0.367	0.287	0.260
1999	0.407	0.501	0.501	0.501	0.454	0.407
2000	0.489	0.603	0.604	0.604	0.546	0.489
2001	0.492	0.606	0.606	0.606	0.549	0.492
2002	0.589	0.725	0.725	0.725	0.657	0.589
2003	0.462	0.569	0.570	0.570	0.516	0.462
2004	0.808	0.995	0.996	0.996	0.902	0.808
2005	1.189	0.990	1.075	1.075	1.090	1.189
2006	1.277	1.063	1.154	1.154	1.170	1.277
2007	0.620	0.517	0.561	0.561	0.569	0.620
2008	0.735	0.611	0.664	0.664	0.673	0.735
2009	0.776	0.647	0.701	0.701	0.712	0.776
2010	0.289	0.467	0.761	0.761	0.378	0.289
2011	0.178	0.289	0.471	0.471	0.234	0.178
2012	0.100	0.162	0.264	0.264	0.131	0.100
2013	0.450	0.727	1.186	1.186	0.589	0.450
2014	0.329	0.533	0.870	0.870	0.431	0.329
2015	0.283	0.459	0.748	0.748	0.371	0.283
2016	0.122	0.198	0.322	0.322	0.160	0.122
2017	0.586	0.950	1.548	1.548	0.768	0.586
2018	0.157	0.255	0.414	0.414	0.206	0.157
arith. mean	0.449	0.615	0.819	0.819	0.532	0.449

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	0.036	0.214	0.123	0.690	0.398	1.172	0.676	1.172	0.676
1984	0.033	0.174	0.112	0.562	0.363	0.955	0.616	0.955	0.616
1985	0.022	0.182	0.074	0.585	0.239	0.994	0.405	0.994	0.405
1986	0.025	0.274	0.084	0.884	0.272	1.501	0.462	1.501	0.462
1987	0.008	0.055	0.027	0.177	0.088	0.301	0.150	0.301	0.150
1988	0.026	0.188	0.089	0.606	0.287	1.028	0.487	1.028	0.487
1989	0.077	0.503	0.132	0.607	0.159	0.711	0.186	0.711	0.186
1990	0.038	0.350	0.064	0.423	0.078	0.495	0.091	0.495	0.091
1991	0.072	0.367	0.122	0.443	0.148	0.518	0.173	0.518	0.173
1992	0.052	0.393	0.089	0.475	0.108	0.555	0.126	0.555	0.126
1993	0.082	0.269	0.140	0.325	0.169	0.380	0.197	0.380	0.197
1994	0.051	0.321	0.088	0.388	0.106	0.453	0.124	0.453	0.124
1995	0.044	0.158	0.075	0.191	0.091	0.224	0.106	0.224	0.106
1996	0.135	0.169	0.231	0.204	0.279	0.238	0.327	0.238	0.327
1997	0.085	0.356	0.145	0.430	0.175	0.504	0.205	0.504	0.205
1998	0.047	0.180	0.080	0.217	0.097	0.254	0.113	0.254	0.113
1999	0.036	0.139	0.268	0.171	0.330	0.171	0.330	0.171	0.330
2000	0.017	0.362	0.127	0.446	0.157	0.447	0.157	0.447	0.157
2001	0.036	0.224	0.268	0.276	0.330	0.276	0.330	0.276	0.330
2002	0.020	0.445	0.144	0.548	0.177	0.548	0.177	0.548	0.177
2003	0.037	0.193	0.269	0.238	0.331	0.238	0.332	0.238	0.332
2004	0.030	0.585	0.223	0.721	0.274	0.721	0.275	0.721	0.275
2005	0.001	0.603	0.586	0.502	0.488	0.545	0.530	0.545	0.530
2006	0.001	0.577	0.700	0.480	0.583	0.521	0.633	0.521	0.633
2007	0.000	0.620	0.000	0.517	0.000	0.561	0.000	0.561	0.000
2008	0.000	0.547	0.188	0.455	0.156	0.494	0.170	0.494	0.170
2009	0.000	0.403	0.373	0.336	0.311	0.364	0.337	0.364	0.337
2010	0.000	0.236	0.053	0.382	0.085	0.622	0.139	0.622	0.139
2011	0.000	0.159	0.019	0.258	0.031	0.420	0.051	0.420	0.051
2012	0.000	0.093	0.007	0.150	0.012	0.245	0.019	0.245	0.019
2013	0.000	0.395	0.055	0.639	0.088	1.042	0.144	1.042	0.144
2014	0.000	0.309	0.020	0.500	0.033	0.816	0.054	0.816	0.054
2015	0.000	0.278	0.005	0.450	0.009	0.734	0.014	0.734	0.014
2016	0.000	0.118	0.004	0.191	0.007	0.311	0.011	0.311	0.011
2017	0.001	0.514	0.072	0.833	0.117	1.358	0.190	1.358	0.190
2018	0.000	0.155	0.002	0.252	0.003	0.410	0.004	0.410	0.004
arith. mean	0.028	0.309	0.141	0.432	0.183	0.587	0.232	0.587	0.232

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1984	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1985	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1986	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1987	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1988	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1989	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1990	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1991	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1992	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1993	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1994	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1995	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1996	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1997	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1998	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1999	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2000	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2001	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2002	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2003	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2004	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2005	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2006	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
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
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	165822	16306	14367	709	32
1984	46688	63735	3647	1909	56
1985	282288	18002	14996	571	195
1986	62255	110082	4371	2595	91
1987	35120	24204	24107	542	180
1988	182143	13884	6987	7292	221
1989	86859	70719	3300	1129	788
1990	156507	32044	11752	605	376
1991	109124	60069	6636	2810	263
1992	115520	40480	11548	1450	736
1993	234965	43693	7834	2544	531
1994	108021	86295	9102	1886	826
1995	74724	40890	17976	2192	731
1996	420437	28496	10150	5350	1008
1997	15316	146350	5990	2471	1730
1998	26134	5608	27794	1290	995
1999	75890	9937	1356	8011	762
2000	43060	29162	2074	324	2540
2001	132731	16866	5602	448	761
2002	10221	51003	3233	1206	318
2003	48018	3994	8872	618	353
2004	19015	18448	788	1980	264
2005	19132	7352	2577	115	396
2006	27522	7619	702	378	85
2007	39049	10958	666	96	70
2008	24271	15562	1847	157	45
2009	82924	9670	2341	395	50
2010	12435	33031	1395	484	106
2011	12992	4953	7759	345	132
2012	56377	5177	1299	2293	143
2013	27880	22466	1469	436	894
2014	18017	11105	4493	280	197
2015	5480	7179	2504	1040	96
2016	185342	2184	1695	624	257
2017	1386	73859	606	549	306
2018	11059	552	12878	92	87
2019		4407	148	3941	57

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	165751461	249032	140225	155664	0.713
1984	46688106	425883	71682	133343	0.606
1985	282164276	283374	140225	110546	0.540
1986	62270602	724736	84881	225470	0.758
1987	35110121	420706	236570	49070	0.174
1988	182087883	276926	188528	149466	0.585
1989	86876663	456875	53960	223507	0.701
1990	156567847	356203	114462	133874	0.458
1991	109124501	647313	182225	215508	0.540
1992	115525287	428556	133786	184033	0.533
1993	234977424	509086	159692	139826	0.451
1994	108038694	604749	133519	244939	0.451
1995	74700698	584284	240386	113899	0.258
1996	420518907	444242	227521	182562	0.441
1997	15309743	880457	115036	242094	0.553
1998	26140594	387628	299839	99814	0.287
1999	75905523	234779	153123	69427	0.454
2000	43055477	270282	71898	92908	0.546
2001	132752892	195834	85050	90200	0.549
2002	10221460	332832	45342	117388	0.657
2003	48013847	139811	99409	53710	0.516
2004	19019969	154594	36534	110546	0.902
2005	19134432	92820	33894	34396	1.090
2006	27508346	72096	14354	37860	1.170
2007	39036201	78340	10895	43090	0.568
2008	24276030	112737	24173	35604	0.673
2009	82887929	85996	25135	35687	0.711
2010	12434681	209963	22675	51670	0.378
2011	12994022	127403	78984	24896	0.234
2012	56401144	95666	51328	10594	0.131
2013	27868289	162764	31101	47814	0.588
2014	18020130	110302	45252	48033	0.431
2015	5482107	97711	44356	37902	0.371
2016	185395141	40989	30516	5230	0.160
2017	1386094	426022	23813	141314	0.768
2018	11061708	128861	105345	20568	0.206
2019			55770		
arith. mean	82631198	301385	97596	103124	0.532
geo. mean	47583661				

arith. mean for the period 1983–2018

geo. mean for the period 1983–2017

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	20477.415	4407.14	147.917	3940.91	57.258
Exploitation pattern 1st half		0.155	0.252	0.410	0.410
Exploitation pattern 2nd half	0.000	0.002	0.003	0.004	0.004
Weight in the stock 1st half		5.103	10.386	13.482	16.195
Weight in the catch 1st half		5.103	10.386	13.482	16.195
weight in the catch 2nd half	3.469	7.760	12.086	15.070	17.762
Proportion mature(2019)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2020)	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(2018) = 0.2056; Yield(2018) = 20.568; Recruitment(2018) = 11.061708; Recruitment(2019) = geometric mean (GM 2008–2017) = 20.477415 billions; SSB(2019) = 55.77

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	44.435	-20 %	-100 %
1	Fsq*1	0.206	18.622	32.046	-43 %	-9 %
0.24	Fsq*0.24	0.048	5.004	41.080	-26 %	-76 %
0.4	Fsq*0.4	0.082	8.248	38.915	-30 %	-60 %
0.5	Fsq*0.5	0.103	10.132	37.660	-32 %	-51 %
0.6	Fsq*0.6	0.123	11.952	36.452	-35 %	-42 %
0.7	Fsq*0.7	0.144	13.708	35.288	-37 %	-33 %
0.8	Fsq*0.8	0.164	15.403	34.166	-39 %	-25 %
0.9	Fsq*0.9	0.185	17.041	33.086	-41 %	-17 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	7965	18939	7987	2063	533	161	2	0	0
1987	5	33760	65	14020	4	453	0	200	0
1988	8769	6584	853	17321	233	893	144	19	13
1989	159	47004	190	1844	13	2806	0	4	0
1990	9793	9302	1377	2791	286	413	43	125	13
1991	14442	24009	942	1391	30	526	9	184	3
1992	525	7100	87	2862	8	342	3	215	1
1993	9663	15164	851	558	155	211	71	1336	12
1994	0	23742	615	4818	684	938	78	386	10
1995	1020	25037	484	1894	78	238	13	156	17
1996	6263	4319	3111	3394	97	465	33	399	248
1997	2975	66856	10388	2912	134	607	13	194	9
1998	30136	3954	992	28137	740	2553	192	290	32
1999	6444	5182	1835	1554	118	1979	401	421	169
2000	0	18793	344	3286	4	541	1	533	9
2001	18263	5327	3968	992	9	163	2	160	6
2002	0	9075	21	2680	3	387	1	135	0
2003	2755	939	61	808	53	130	2	78	1
2004	1091	1976	737	256	16	74	6	92	1
2005	0	1404	1	146	0	21	0	12	0
2006	0	769	3	47	1	27	0	4	0
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	276	9	6114	44	758	2	216	1
arith. mean	3644	11266	1060	3524	98	628	31	211	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
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	3.3	5.9	6.8	9.4	10.9	14.6	14.6	18.4	15.9
arith. mean	4.6	6.9	9.4	12.4	15.9	18.2	21.2	23.1	22.9

Table 9.4.3 Sandeel Area-3r. Proportion mature.

	Age 1	Age 2	Age 3	Age 4
1983–2016	0.04	0.77	1	1

Table 9.4.4. Sandeel Area-3r. Dredge survey indices (number/hour).

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

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

Date: 01/28/19 Start time:14:20:26 run time:1 seconds

objective function (negative log likelihood): 118.007
Number of parameters: 57
Maximum gradient: 6.39117e-005
Akaike information criterion (AIC): 350.014
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
297	67	33	0	397

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
102.3	15.5	18.3	0.0	0.0	0.00	136

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.34	0.23	0.55	0.00

contribution by fleet:

Acoustic survey total: 7.943 mean: 0.199
Dredge survey 2004-2018 total: 7.607 mean: 0.282

F, season effect:
----

age:		0
1986-1998:	0.000	1.000
1999-2018:	0.000	1.000
age: 1 - 4		
1986-1998:	0.901	0.500
1999-2018:	1.034	0.500

F, age effect:

	0	1	2	3	4
1986-1998:	0.102	0.359	0.387	0.293	0.293
1999-2018:	0.058	0.190	0.301	0.323	0.323

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1986-1998	season 1:	0	0.654	0.705	0.535	0.535
	season 2:	0.176	0.309	0.332	0.252	0.252
1999-2018	season 1:	0	0.535	0.847	0.909	0.909
	season 2:	0.145	0.239	0.378	0.406	0.406

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

season
----

age	1	2
0		1.146
1	0.651	1.019
2	0.651	1.019
3	1.149	1.194
4	1.149	1.194

Survey catchability:
----

	age 0	age 1	age 2	age 3	age 4
Acoustic survey		3.060	5.975	4.438	4.438
Dredge survey 2004-2018			0.779		0.779

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

	age 0	age 1	age 2	age 3	age 4
Acoustic survey		0.65	0.65	0.84	0.84
Dredge survey 2004-2018			0.68		0.96

Recruit-SSB	alfa	beta	recruit s2	recruit s
Area-3r	1430.788	8.000e+004	1.114	1.056

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	0.414	0.446	0.338	0.338	0.430	0.414
1987	0.570	0.613	0.466	0.466	0.592	0.570
1988	0.766	0.825	0.625	0.625	0.796	0.766
1989	0.857	0.922	0.700	0.700	0.890	0.857
1990	0.506	0.545	0.413	0.413	0.526	0.506
1991	0.602	0.648	0.492	0.492	0.625	0.602
1992	0.263	0.282	0.215	0.215	0.273	0.263
1993	0.516	0.556	0.422	0.422	0.536	0.516
1994	0.523	0.562	0.427	0.427	0.543	0.523
1995	0.415	0.446	0.339	0.339	0.431	0.415
1996	0.428	0.461	0.349	0.349	0.445	0.428
1997	0.776	0.835	0.634	0.634	0.806	0.776
1998	1.028	1.107	0.839	0.839	1.068	1.028
1999	0.832	1.316	1.413	1.413	1.074	0.832
2000	0.732	1.159	1.243	1.243	0.946	0.732
2001	0.568	0.900	0.966	0.966	0.734	0.568
2002	0.451	0.714	0.766	0.766	0.583	0.451
2003	0.259	0.410	0.440	0.440	0.335	0.259
2004	0.190	0.300	0.322	0.322	0.245	0.190
2005	0.084	0.133	0.143	0.143	0.109	0.084
2006	0.036	0.058	0.062	0.062	0.047	0.036
2007	0.218	0.345	0.370	0.370	0.282	0.218
2008	0.241	0.382	0.410	0.410	0.312	0.241
2009	0.020	0.032	0.034	0.034	0.026	0.020
2010	0.261	0.413	0.443	0.443	0.337	0.261
2011	0.166	0.262	0.281	0.281	0.214	0.166
2012	0.101	0.159	0.171	0.171	0.130	0.101
2013	0.049	0.077	0.083	0.083	0.063	0.049
2014	0.196	0.310	0.333	0.333	0.253	0.196
2015	0.258	0.409	0.439	0.439	0.334	0.258
2016	0.101	0.159	0.171	0.171	0.130	0.101
2017	0.224	0.354	0.380	0.380	0.289	0.224
2018	0.265	0.419	0.450	0.450	0.342	0.265
arith. mean	0.391	0.502	0.460	0.460	0.447	0.391

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	0.281	0.133	0.303	0.143	0.230	0.108	0.230	0.108
1987	0.001	0.568	0.002	0.611	0.002	0.464	0.002	0.464	0.002
1988	0.051	0.676	0.090	0.728	0.097	0.552	0.073	0.552	0.073
1989	0.003	0.851	0.006	0.916	0.006	0.695	0.005	0.695	0.005
1990	0.050	0.419	0.087	0.451	0.094	0.342	0.071	0.342	0.071
1991	0.039	0.533	0.069	0.573	0.075	0.435	0.057	0.435	0.057
1992	0.003	0.257	0.006	0.276	0.006	0.210	0.005	0.210	0.005
1993	0.042	0.443	0.073	0.477	0.079	0.362	0.060	0.362	0.060
1994	0.016	0.495	0.028	0.532	0.030	0.404	0.023	0.404	0.023
1995	0.007	0.402	0.013	0.433	0.013	0.329	0.010	0.329	0.010
1996	0.043	0.353	0.075	0.380	0.081	0.288	0.061	0.288	0.061
1997	0.066	0.661	0.115	0.711	0.124	0.540	0.094	0.540	0.094
1998	0.140	0.783	0.245	0.843	0.264	0.639	0.200	0.639	0.200
1999	0.156	0.575	0.257	0.910	0.406	0.977	0.436	0.977	0.436
2000	0.004	0.725	0.007	1.148	0.011	1.232	0.011	1.232	0.011
2001	0.162	0.302	0.266	0.479	0.421	0.514	0.452	0.514	0.452
2002	0.000	0.451	0.000	0.714	0.000	0.766	0.000	0.766	0.000
2003	0.021	0.224	0.035	0.354	0.056	0.380	0.060	0.380	0.060
2004	0.021	0.155	0.035	0.245	0.055	0.263	0.059	0.263	0.059
2005	0.000	0.084	0.000	0.133	0.000	0.143	0.000	0.143	0.000
2006	0.000	0.036	0.000	0.057	0.001	0.061	0.001	0.061	0.001
2007	0.000	0.218	0.000	0.345	0.000	0.370	0.000	0.370	0.000
2008	0.000	0.241	0.000	0.382	0.000	0.410	0.000	0.410	0.000
2009	0.000	0.020	0.000	0.032	0.000	0.034	0.000	0.034	0.000
2010	0.001	0.260	0.001	0.412	0.001	0.442	0.001	0.442	0.001
2011	0.000	0.166	0.000	0.262	0.000	0.281	0.000	0.281	0.000
2012	0.000	0.101	0.000	0.159	0.000	0.171	0.000	0.171	0.000
2013	0.000	0.049	0.000	0.077	0.000	0.083	0.000	0.083	0.000
2014	0.000	0.196	0.000	0.310	0.000	0.333	0.000	0.333	0.000
2015	0.000	0.258	0.000	0.409	0.000	0.439	0.000	0.439	0.000
2016	0.000	0.101	0.000	0.159	0.000	0.171	0.000	0.171	0.000
2017	0.000	0.224	0.000	0.354	0.000	0.380	0.000	0.380	0.000
2018	0.000	0.265	0.000	0.419	0.000	0.450	0.000	0.450	0.000
arith. mean	0.027	0.345	0.047	0.442	0.060	0.406	0.054	0.406	0.054

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	1.340	0.760	0.600	0.600	0.470	0.420	0.370	0.360	0.350
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.340
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.340
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.320
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.290
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.280
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.290
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.310
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.320
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.340
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.350
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.360
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.330
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.300
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.370
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.490
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.610
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.164	0.713	0.572	0.566	0.463	0.419	0.403	0.385	0.386

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	508628	92585	6386	245	747
1987	115398	123493	15707	1403	341
1988	361602	27585	18660	3006	514
1989	105977	73662	3530	3010	905
1990	211506	27937	9711	565	956
1991	124520	55954	5548	2430	544
1992	269677	35341	10203	1253	986
1993	196507	81772	8436	3190	985
1994	185145	60288	14851	1949	1412
1995	143194	60066	10045	3146	1108
1996	779957	51784	11252	2340	1433
1997	61168	277707	9868	2612	1276
1998	92780	23289	39659	1655	958
1999	117131	30591	2665	5333	551
2000	121434	35424	3593	260	723
2001	117009	39459	3996	353	131
2002	27690	30286	4512	430	69
2003	61734	8175	3742	550	70
2004	39343	17840	1274	637	121
2005	67318	11486	3133	262	183
2006	115686	21315	2380	810	150
2007	57000	37736	4919	712	370
2008	79747	19946	7869	1184	324
2009	129990	29632	4816	2078	449
2010	13397	48296	10059	1953	1209
2011	9867	4413	12503	2786	997
2012	78759	2942	1115	3647	1294
2013	188227	23960	770	350	1786
2014	214535	57263	6603	262	867
2015	8452	65256	13619	1780	356
2016	463596	2571	14585	3328	588
2017	19835	141036	673	4576	1408
2018	297171	6034	32639	174	1753
2019		90406	1340	7895	544

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	508512319	643843	82951	282315	0.430
1987	115409820	1013520	205253	395296	0.592
1988	361582215	473076	279847	330358	0.795
1989	106005337	548609	104715	350409	0.889
1990	211555937	331555	108445	163224	0.526
1991	124522876	576107	166209	274839	0.625
1992	269748338	362098	129444	86788	0.273
1993	196466011	690574	202805	175786	0.536
1994	185209838	652850	248948	267281	0.542
1995	143235402	493734	148747	173607	0.431
1996	780152522	721161	247212	159024	0.444
1997	61159759	1610440	187775	470670	0.806
1998	92803972	556904	352216	462081	1.067
1999	117154016	341576	118539	191253	1.074
2000	121448395	299796	56444	186837	0.946
2001	117036920	332856	60840	193684	0.734
2002	27701580	309932	60415	116298	0.583
2003	61712681	111061	56444	34673	0.334
2004	39349743	152965	25009	31285	0.245
2005	67322159	150168	52156	13991	0.108
2006	115640870	209789	48194	7094	0.047
2007	57024981	376789	87816	74972	0.281
2008	79717524	312560	130875	74933	0.311
2009	129994149	284576	91766	6261	0.026
2010	13403146	610233	219476	61241	0.338
2011	9869897	280906	211504	92452	0.214
2012	78766631	167654	135673	40116	0.130
2013	188197029	261581	48582	9844	0.063
2014	214538550	592986	101215	90876	0.253
2015	8452730	759194	196811	104631	0.334
2016	463816705	275985	223686	42845	0.130
2017	19835821	1205740	160011	115642	0.289
2018	297225004	378095	272120	74933	0.342
2019			182590		
arith. mean	163150899	487543	147203	156228	0.447
geo. mean	98542649				

arith. mean for the period 1986–2018

geo. mean for the period 1986–2017

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

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	93435.991	90405.7	1339.86	7895.09	544.185
Exploitation pattern 1st half		0.265	0.419	0.450	0.450
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.870	11.821	17.056	24.603
Weight in the catch 1st half		6.870	11.821	17.056	24.603
weight in the catch 2nd half	3.759	7.820	12.550	16.993	18.389
Proportion mature(2019)	0.000	0.036	0.766	1.000	1.000
Proportion mature(2020)	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(2018) = 0.3421; Yield(2018) = 74.933; Recruitment(2018) = 297.225004; Recruitment(2019) = geometric mean (GM 1986–2017) = 98.516877 billions; SSB(2019) = 182.59

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	340.918	87 %	-100 %
0.850	Fsq*0.85	0.290	133.610	262.800	44 %	78 %
1.000	Fsq*1	0.342	154.348	250.965	37 %	106 %
1.500	Fsq*1.5	0.513	216.496	216.044	18 %	189 %
2.000	Fsq*2	0.684	270.594	186.399	2 %	261 %
2.500	Fsq*2.5	0.855	317.819	161.186	-12 %	324 %
3.000	Fsq*3	1.026	359.162	139.705	-23 %	379 %
3.500	Fsq*3.5	1.197	395.459	121.370	-34 %	428 %
4.000	Fsq*4	1.368	427.414	105.696	-42 %	470 %
3.282	MSY	1.123	380.226	129.000	-29 %	407 %

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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=0.30940475)	16989.62 (CV=0.09694092)	79.82 (CV=0.34325033)	440.33 (CV=0.30654509)

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	674	1235	149	6337	381	1861	122	534	39
1994	0	1070	256	1522	62	5144	257	2092	159
1995	4	2690	4	1229	1	529	0	30	0
1996	2666	754	2584	2536	3461	476	227	130	1110
1997	0	2879	1369	291	35	1683	43	413	10
1998	0	2159	61	3766	97	235	6	130	3
1999	0	1472	86	1137	46	1543	47	252	11
2000	0	6537	0	376	0	323	0	297	0
2001	0	2048	64	4961	20	601	1	377	0
2002	0	337	0	807	0	511	0	101	0
2003	145	4322	148	1002	10	2721	5	1253	1
2004	0	920	4	220	1	45	0	82	0
2005	0	49	0	145	0	32	0	17	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0
2012	0	83	0	40	0	196	0	3	0
2013	0	182	0	100	0	71	0	133	0
2014	0	346	0	54	0	15	0	47	0
2015	0	866	0	29	0	9	0	14	0
2016	0	181	0	406	0	20	0	36	0
2017	0	719	0	468	0	578	0	30	0
2018	0	876	0	1259	0	349	0	1150	0
arith. mean	134	1143	182	1026	158	652	27	274	51

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	4.7	5.8	7.7	9.4	12.2	13.1	16.6	18.3	19.2
arith. mean	3.8	5.6	7.9	9.4	13.7	13.2	16.5	17.2	21.7

Table 9.5.3 Sandeel Area-4. Proportion mature.

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

Table 9.5.4. Sandeel Area-4. Dredge survey indices (number/hour).

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

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

Date: 01/24/19 Start time:14:58:39 run time:1 seconds

objective function (negative log likelihood): -2.24692
Number of parameters: 45
Maximum gradient: 3.94028e-005
Akaike information criterion (AIC): 85.5062
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
234	31	26	0	291

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
27.3	-30.5	19.6	0.0	0.0	0.00	16

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.12	-0.98	0.75	0.00

contribution by fleet:

Old Dredge survey 1999-2003 total: -9.491 mean: -1.055
New Dredge survey 2008-2018 total: -20.998 mean: -0.954

F, season effect:
----
age: 0
1993-2018: 0.000 1.000
age: 1 - 4
1993-2018: 0.579 0.500

F, age effect:

	0	1	2	3	4
1993-2018:	0.003	0.106	0.193	0.265	0.265

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1993-2018	season 1:	0	0.626	1.138	1.562	1.562
	season 2:	0.005	0.084	0.153	0.210	0.210

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

season
----

age	1	2
0		2.006
1	0.700	0.382

2	0.700	0.382
3	0.730	1.270
4	0.730	1.270

Survey catchability:
----

	age 0	age 1
Old Dredge survey 1999-2003	0.763	17.355
New Dredge survey 2008-2018	0.570	2.724

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

	age 0	age 1
Old Dredge survey 1999-2003	0.30	0.30
New Dredge survey 2008-2018	0.30	0.30

Recruit-SSB	alfa	beta	recruit s2	recruit s
Area-4	1372.548	4.800e+004	1.655	1.287

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	0.269	0.488	0.670	0.670	0.379	0.269
1994	0.308	0.561	0.770	0.770	0.435	0.308
1995	0.086	0.156	0.215	0.215	0.121	0.086
1996	0.263	0.479	0.657	0.657	0.371	0.263
1997	0.119	0.217	0.297	0.297	0.168	0.119
1998	0.119	0.217	0.298	0.298	0.168	0.119
1999	0.168	0.306	0.420	0.420	0.237	0.168
2000	0.083	0.151	0.208	0.208	0.117	0.083
2001	0.132	0.240	0.330	0.330	0.186	0.132
2002	0.028	0.050	0.069	0.069	0.039	0.028
2003	0.215	0.391	0.537	0.537	0.303	0.215
2004	0.040	0.073	0.100	0.100	0.057	0.040
2005	0.017	0.032	0.044	0.044	0.025	0.017
2006	0.000	0.000	0.001	0.001	0.000	0.000
2007	0.000	0.000	0.001	0.001	0.000	0.000
2008	0.001	0.003	0.004	0.004	0.002	0.001
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.001	0.001	0.002	0.002	0.001	0.001
2011	0.001	0.002	0.003	0.003	0.002	0.001
2012	0.013	0.024	0.033	0.033	0.019	0.013
2013	0.007	0.013	0.019	0.019	0.010	0.007
2014	0.010	0.018	0.024	0.024	0.014	0.010
2015	0.008	0.014	0.020	0.020	0.011	0.008
2016	0.015	0.028	0.038	0.038	0.022	0.015
2017	0.034	0.062	0.085	0.085	0.048	0.034
2018	0.108	0.196	0.270	0.270	0.152	0.108
arith. mean	0.079	0.143	0.197	0.197	0.111	0.079

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	0.237	0.032	0.430	0.058	0.591	0.079	0.591	0.079
1994	0.002	0.278	0.030	0.506	0.055	0.694	0.076	0.694	0.076
1995	0.000	0.086	0.000	0.156	0.000	0.214	0.001	0.214	0.001
1996	0.009	0.102	0.161	0.186	0.293	0.255	0.402	0.255	0.402
1997	0.001	0.097	0.022	0.176	0.041	0.241	0.056	0.241	0.056
1998	0.000	0.113	0.006	0.206	0.011	0.283	0.015	0.283	0.015
1999	0.000	0.168	0.000	0.306	0.000	0.420	0.000	0.420	0.000
2000	0.000	0.083	0.000	0.151	0.000	0.208	0.000	0.208	0.000
2001	0.000	0.130	0.002	0.236	0.004	0.324	0.006	0.324	0.006
2002	0.000	0.028	0.000	0.050	0.000	0.069	0.000	0.069	0.000
2003	0.001	0.203	0.012	0.369	0.022	0.507	0.030	0.507	0.030
2004	0.000	0.040	0.000	0.072	0.001	0.099	0.001	0.099	0.001
2005	0.000	0.017	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	0.001	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.000	0.001	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	0.013	0.000	0.024	0.000	0.033	0.000	0.033	0.000
2013	0.000	0.007	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	0.024	0.000	0.024	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.020	0.000	0.020	0.000
2016	0.000	0.015	0.000	0.028	0.000	0.038	0.000	0.038	0.000
2017	0.000	0.034	0.000	0.062	0.000	0.085	0.000	0.085	0.000
2018	0.000	0.108	0.000	0.196	0.000	0.270	0.000	0.270	0.000
arith. mean	0.001	0.069	0.010	0.125	0.019	0.171	0.026	0.171	0.026

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1994	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1995	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1996	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1997	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1998	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1999	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2000	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2001	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2002	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2003	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2004	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2005	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2006	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2007	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2008	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2009	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2010	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2011	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2012	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2013	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2014	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2015	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2016	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2017	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2018	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
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	115583	21689	23227	7439	1561
1994	253303	36902	4260	4793	2038
1995	68529	80879	6965	818	1409
1996	371687	21917	19064	2002	812
1997	96739	117846	4327	3971	649
1998	42876	30902	26879	1172	1517
1999	229416	13708	7047	7276	900
2000	196908	73371	2977	1745	2372
2001	23448	62975	17346	860	1510
2002	85668	7498	14180	4588	772
2003	150258	27398	1874	4533	2211
2004	12750	48024	5676	426	1757
2005	8752	4078	11854	1774	901
2006	5422	2799	1029	3861	1143
2007	9747	1734	719	346	2220
2008	27273	3117	445	242	1173
2009	392249	8723	800	149	644
2010	67444	125449	2241	269	362
2011	47438	21570	32206	752	284
2012	41282	15172	5534	10802	460
2013	26934	13203	3846	1816	4793
2014	317986	8614	3367	1276	2949
2015	52262	101698	2191	1112	1871
2016	114852	16714	25923	726	1323
2017	163314	36732	4229	8475	893
2018	7625	52231	9123	1337	3797
2019		2439	12046	2520	1783

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	115525287	576799	357182	132599	0.378
1994	253278441	560500	148153	158690	0.435
1995	68544930	827656	123500	52591	0.121
1996	371849589	417494	248948	158490	0.371
1997	96784750	877167	80660	58446	0.168
1998	42883599	503930	257816	58746	0.168
1999	229405101	294876	193300	53334	0.237
2000	196859336	372014	82454	37714	0.117
2001	23441066	347081	111190	47902	0.186
2002	85668864	169830	123130	12736	0.039
2003	150278380	199332	69982	63731	0.303
2004	12749467	262814	61267	6882	0.056
2005	8753814	114747	81961	1557	0.025
2006	5422134	101481	82951	0	0.000
2007	9742419	54635	44846	0	0.000
2008	27261881	40157	24465	0	0.002
2009	392089230	74002	21367	0	0.000
2010	67456938	673402	26265	0	0.001
2011	47441124	405289	240145	0	0.002
2012	41284596	215777	143344	2585	0.019
2013	26936694	214438	136626	5225	0.010
2014	318139333	183842	113437	4314	0.014
2015	52273494	507367	59278	4392	0.011
2016	114834211	386423	248948	6188	0.022
2017	163283743	449019	161943	18474	0.048
2018	7625436	473207	154508	42526	0.152
2019			169058		
arith. mean	112682460	357818	132091	35659	0.111
geo. mean	65857245				

arith. mean for the period 1993–2018

geo. mean for the period 1993–2017

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	80801.276	2438.59	12045.9	2520.43	1782.86
Exploitation pattern 1st half		0.108	0.196	0.270	0.270
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.940	10.295	14.642	19.545
Weight in the catch 1st half		5.940	10.295	14.642	19.545
weight in the catch 2nd half	4.522	7.967	12.959	17.069	20.434
Proportion mature(2019)	0.000	0.000	0.790	0.980	1.000
Proportion mature(2020)	0.000	0.000	0.790	0.980	1.000
Natural mortality 1st half		0.767	0.602	0.431	0.398
Natural mortality 2nd half	1.140	0.592	0.488	0.392	0.378

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

Basis: Fsq = F(2018) = 0.1522; Yield(2018) = 42.526; Recruitment(2018) = 7.625436; Recruitment(2019) = geometric mean (GM 2008–2017) = 80.801276 billions; SSB(2019) = 169.058

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	100.879	-40 %	-100 %
0.99	Fsq*0.99	0.150	31.408	81.351	-52 %	-26 %
0.14	Fsq*0.14	0.022	5.001	97.744	-42 %	-88 %
2.65	Fsq*2.65	0.403	72.062	56.804	-66 %	69 %
3	Fsq*3	0.456	79.026	52.708	-69 %	86 %
3.5	Fsq*3.5	0.533	88.183	47.383	-72 %	107 %
4	Fsq*4	0.609	96.495	42.618	-75 %	127 %
4.5	Fsq*4.5	0.685	104.048	38.350	-77 %	145 %
5	Fsq*5	0.761	110.918	34.528	-80 %	161 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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

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

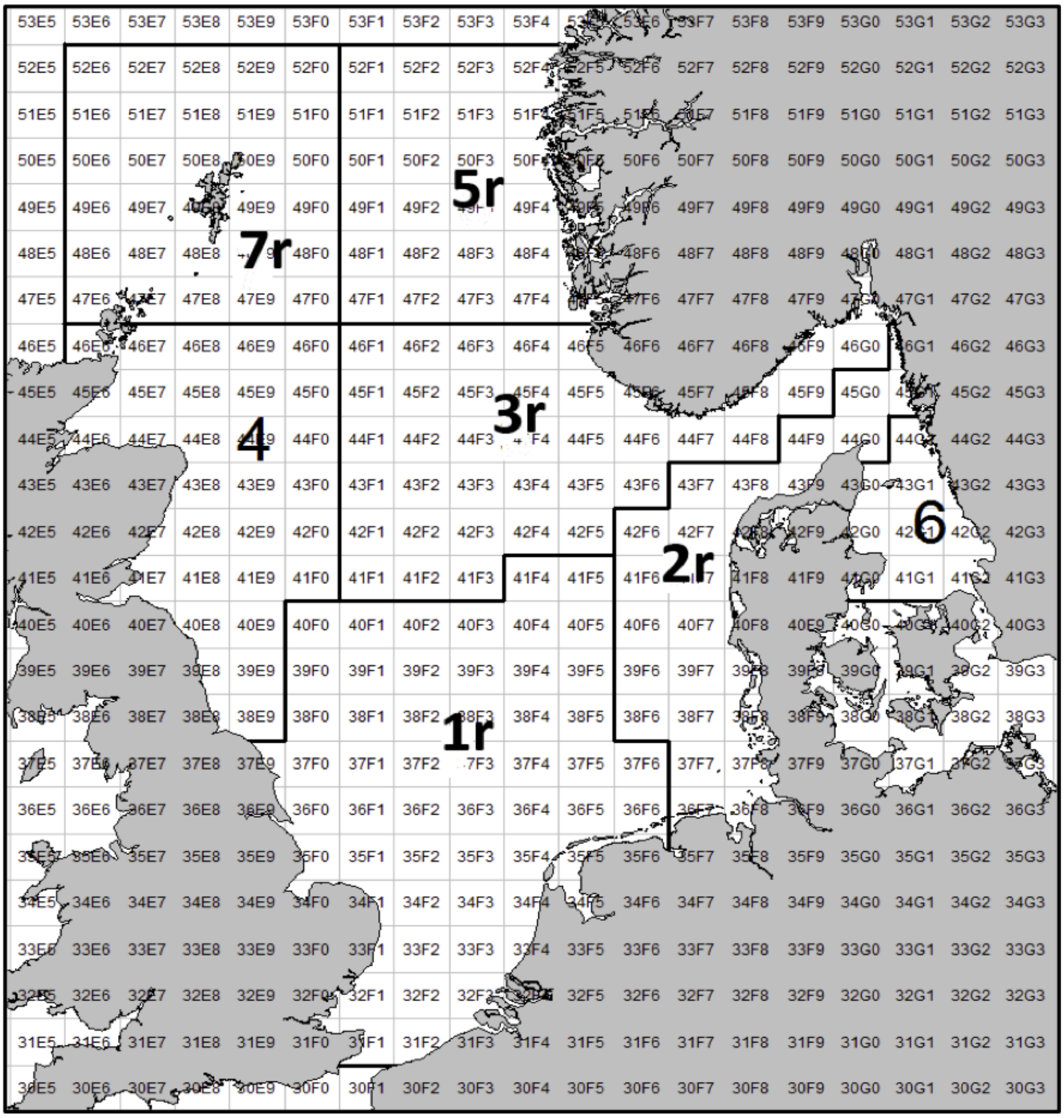

Figure 11.1.1 Sandeel in ICES Division 4 and 3.a. Sandeel management areas.

Figure 11.1.2 Sandeel in ICES Division 4 and 3.a. Catch by ICES rectangles 2003–2018. Area of the circles is proportional to catch by rectangle.

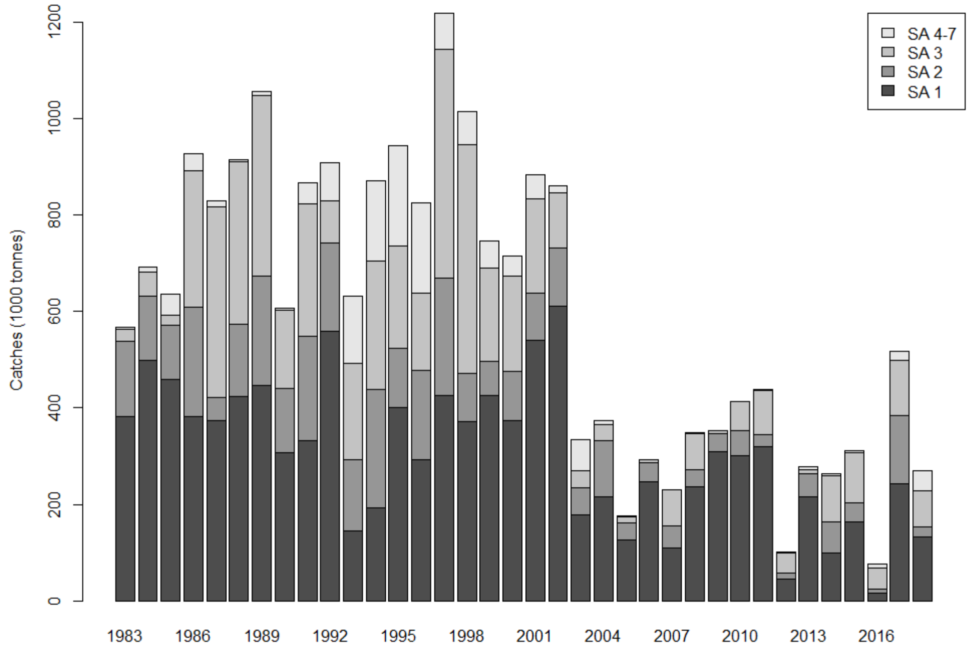

Figure 11.1.3 Sandeel in ICES Division 4 and 3.a. Total catches by year and area.

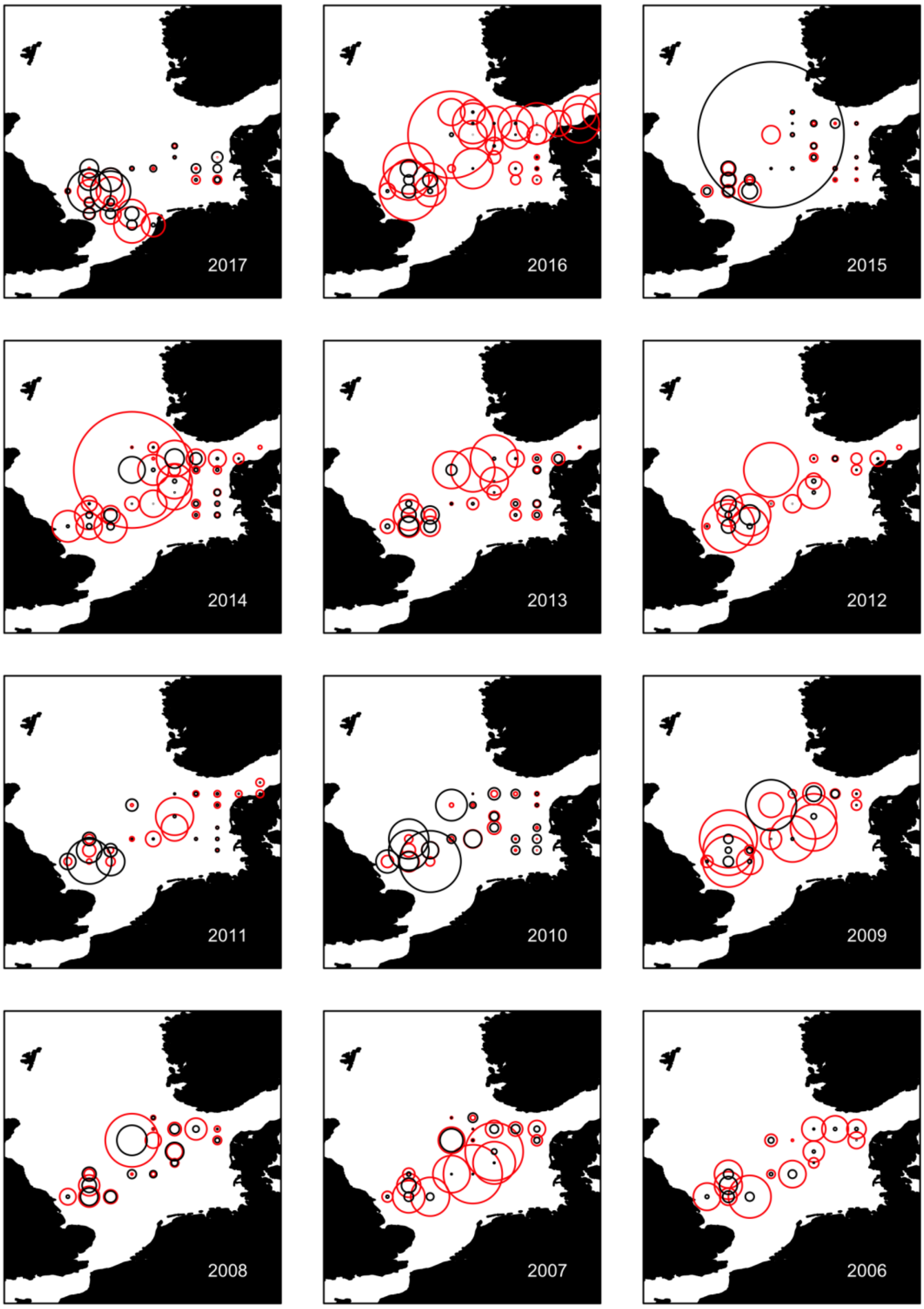

Figure 11.1.4 Sandeel in ICES Division 4 and 3.a. Danish survey indices by year and ICES rectangles. Red circles: 0-group, black circles: 1-group. Area of the circles is proportional to catch numbers by rectangle.

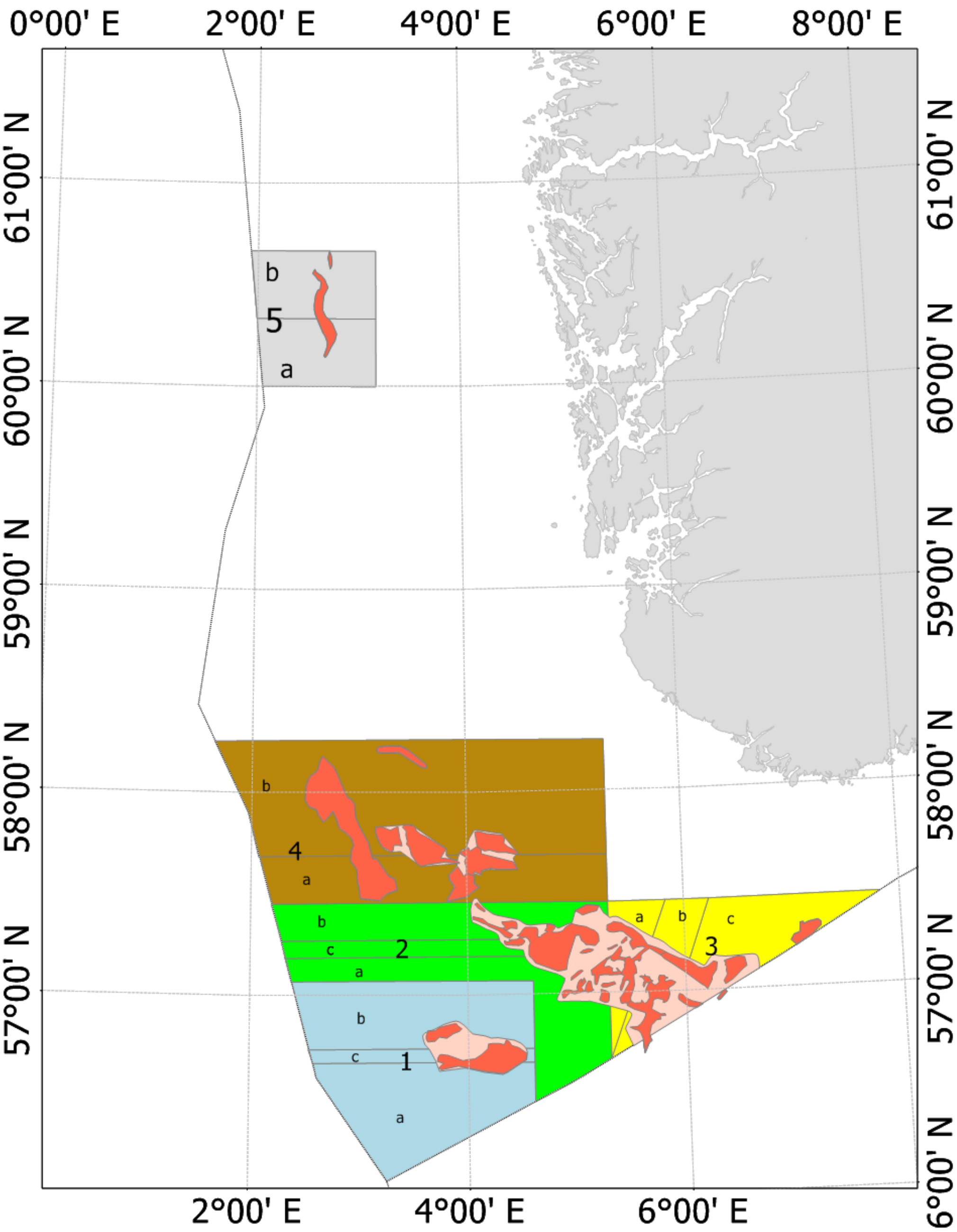

Figure 11.1.5 Map of the Norwegian sandeel management areas and sub-areas in the North Sea . Historical important fishing grounds are depicted in red, and areas with suitable sandeel habitat are depicted in pink. Areas valid from 2017.

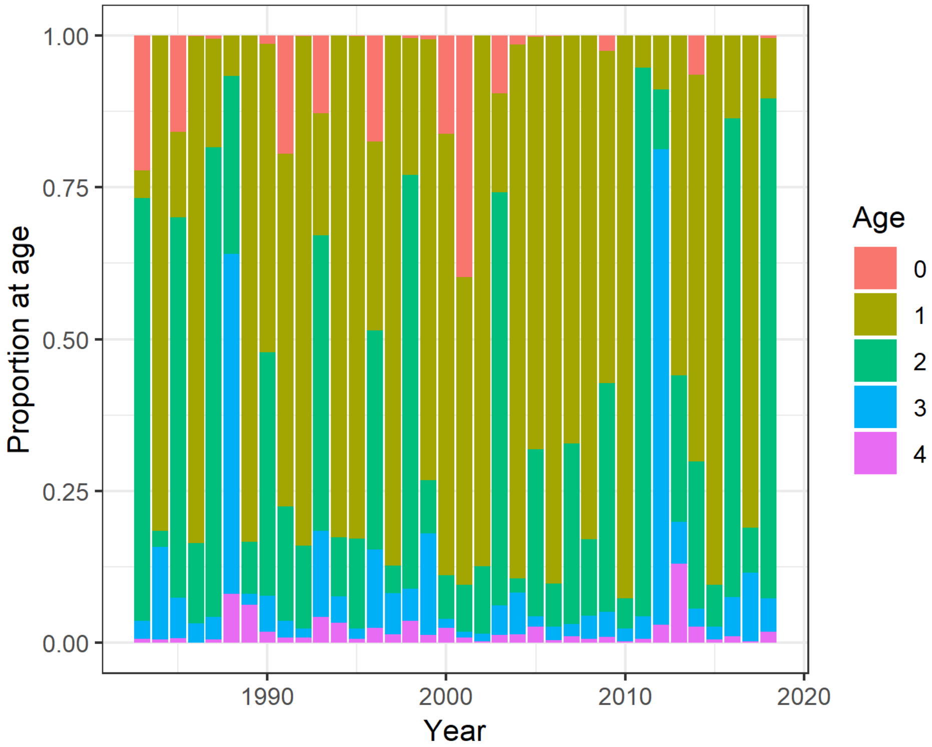

Figure 11.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

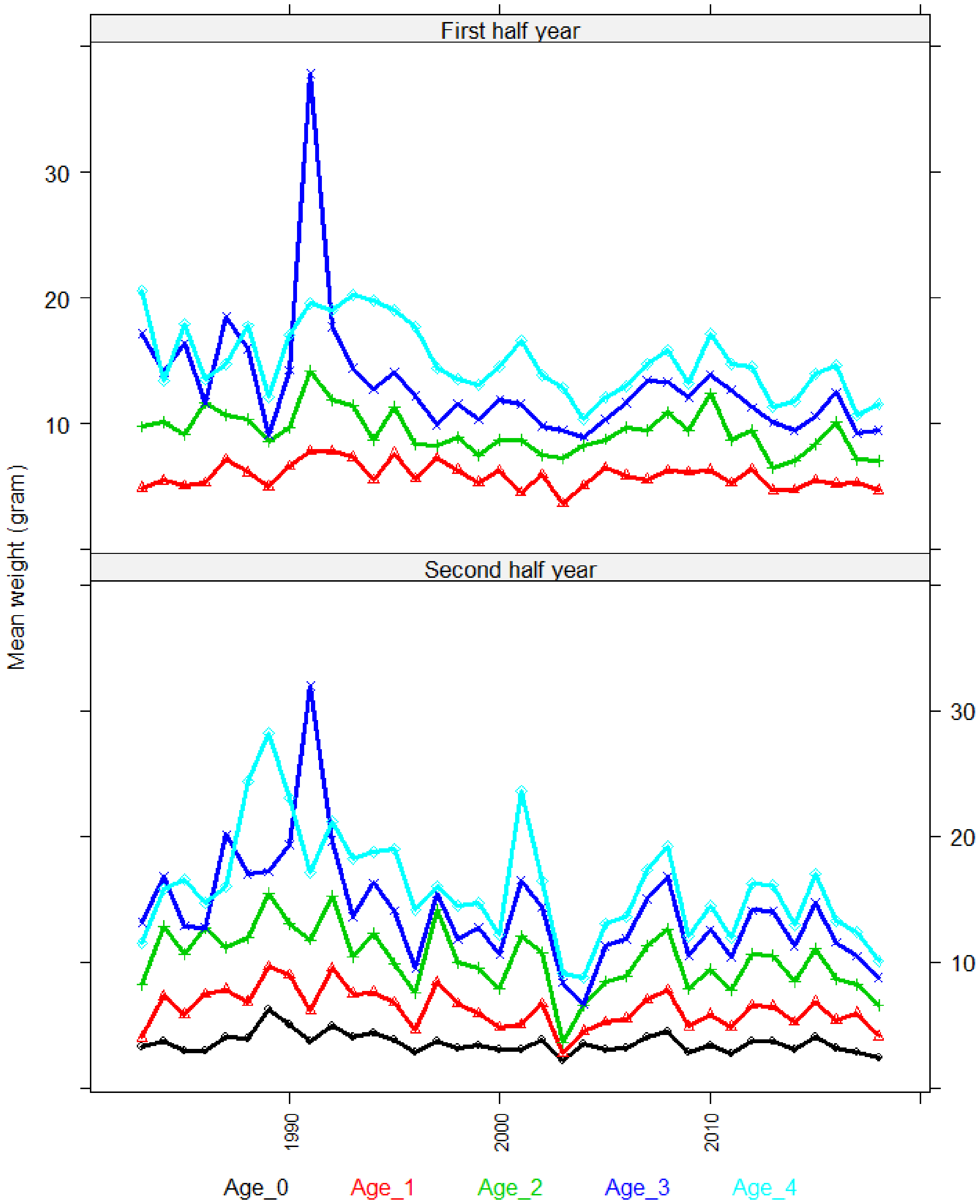

Figure 11.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

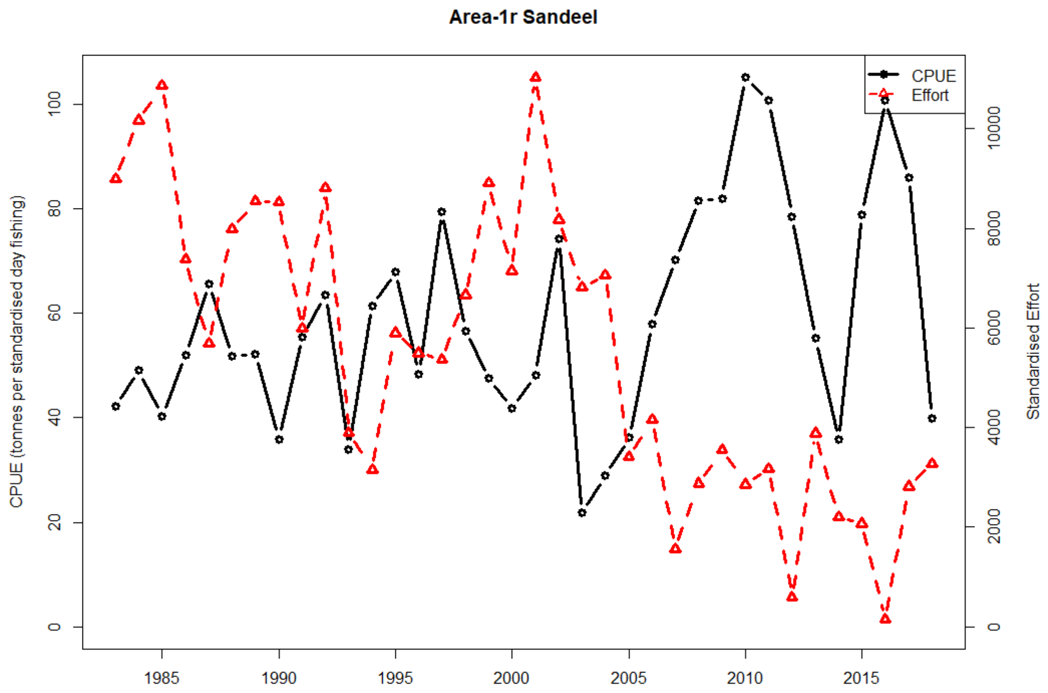

Figure 11.2.3 Sandeel Area-1r. CPUE and effort.

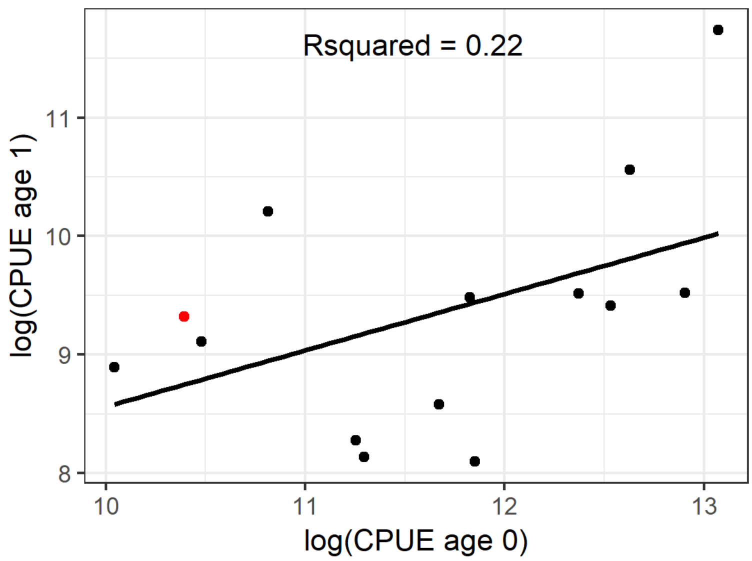

Figure 11.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

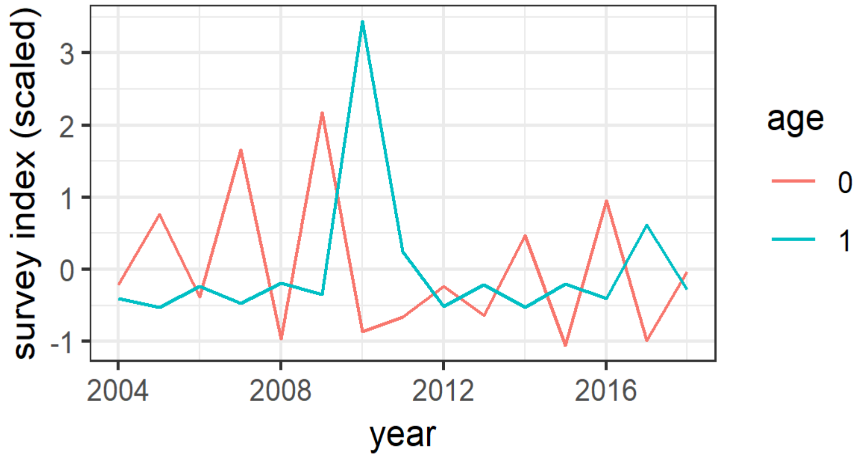

Figure 11.2.5 Sandeel Area-1r. Dredge survey index timeline.

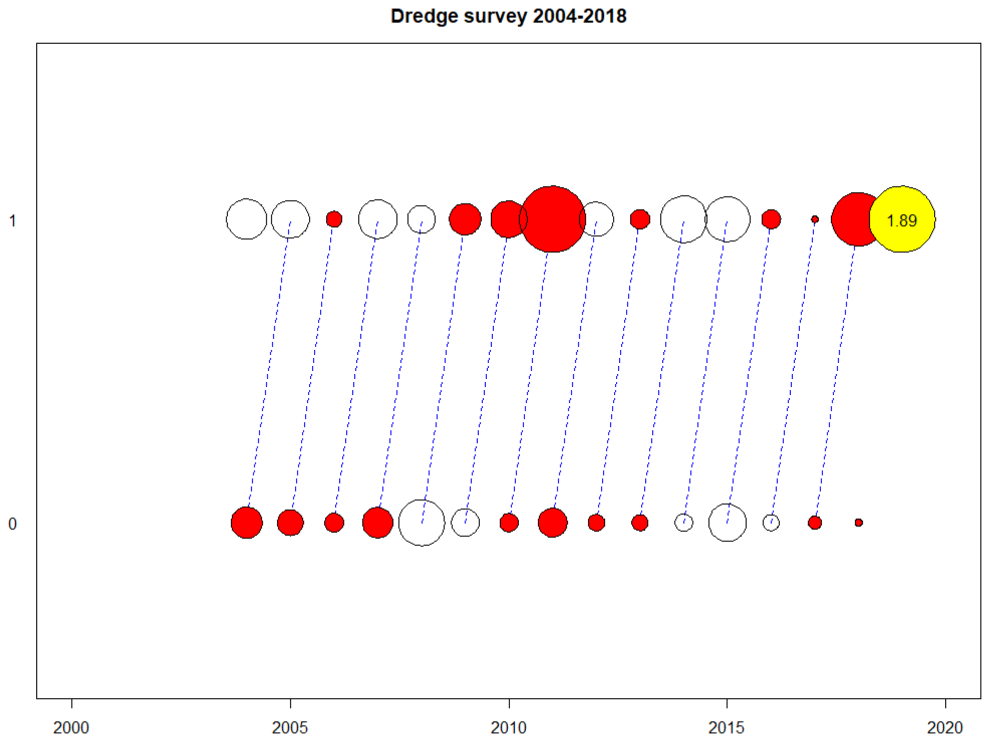

Figure 11.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

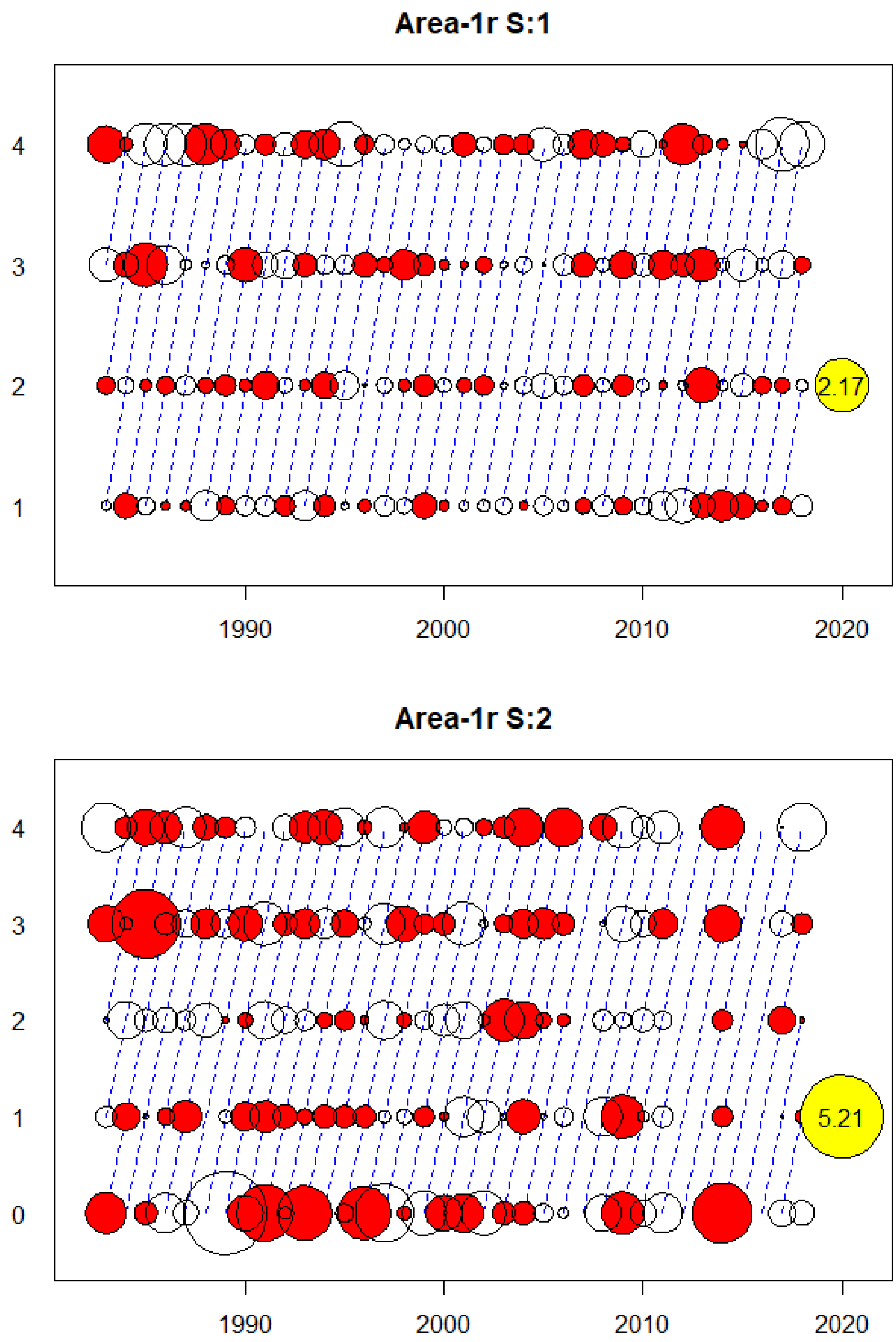

Figure 11.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

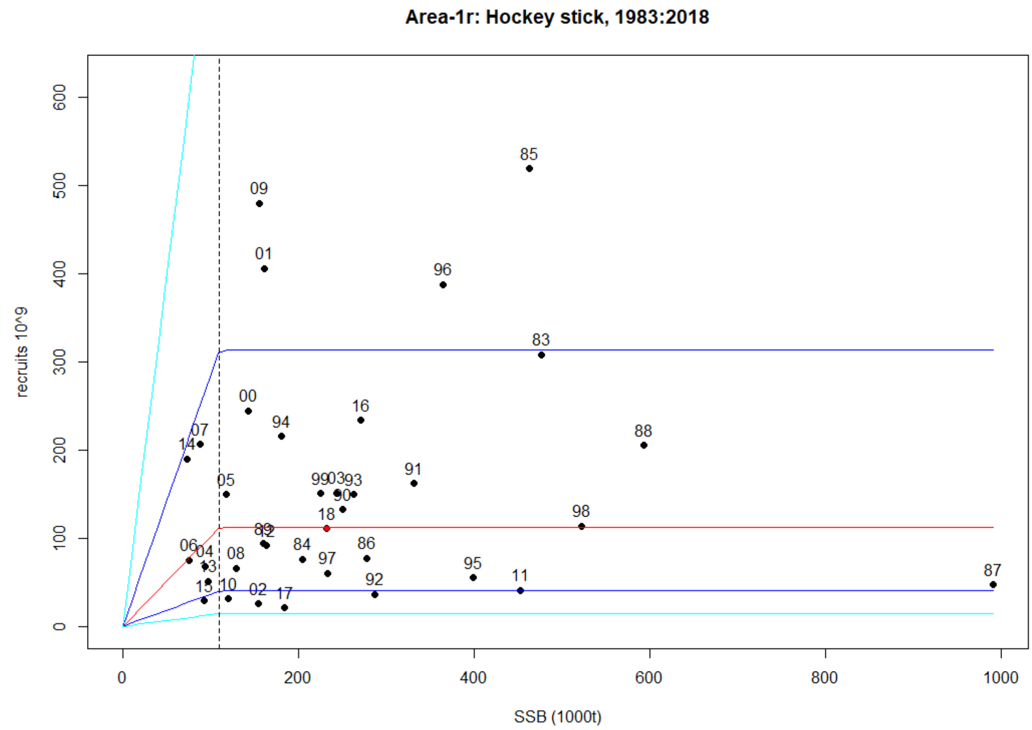

Figure 11.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

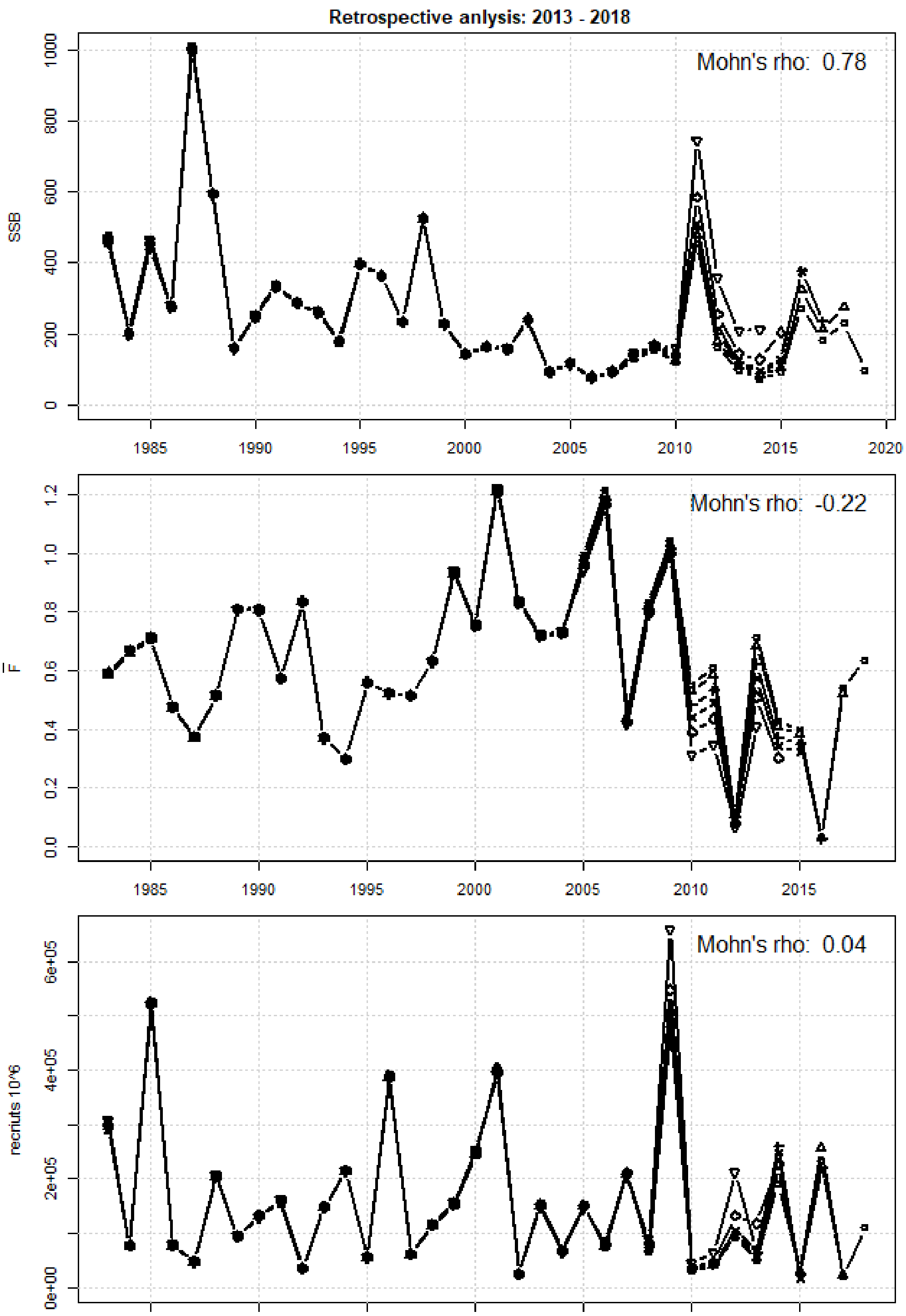

Figure 11.2.9 Sandeel Area-1r. Retrospective analysis.

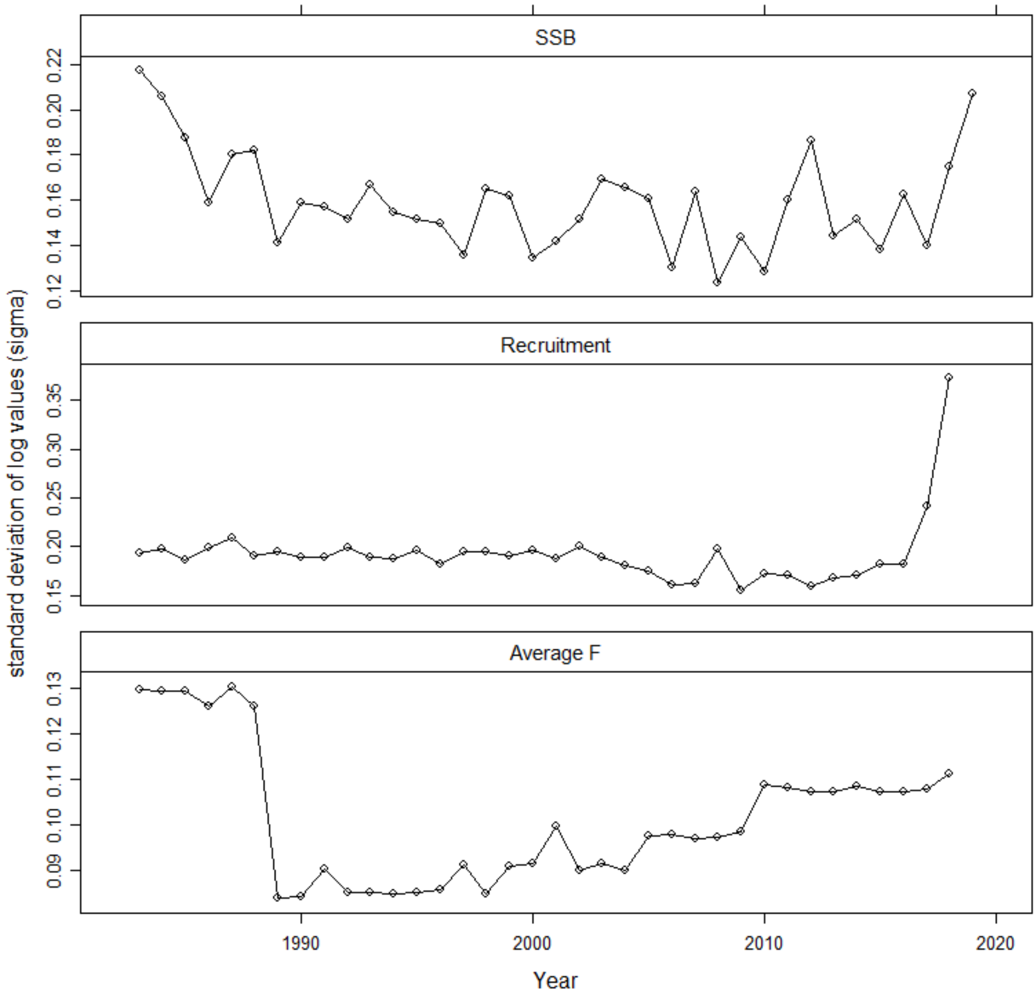

Figure 11.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

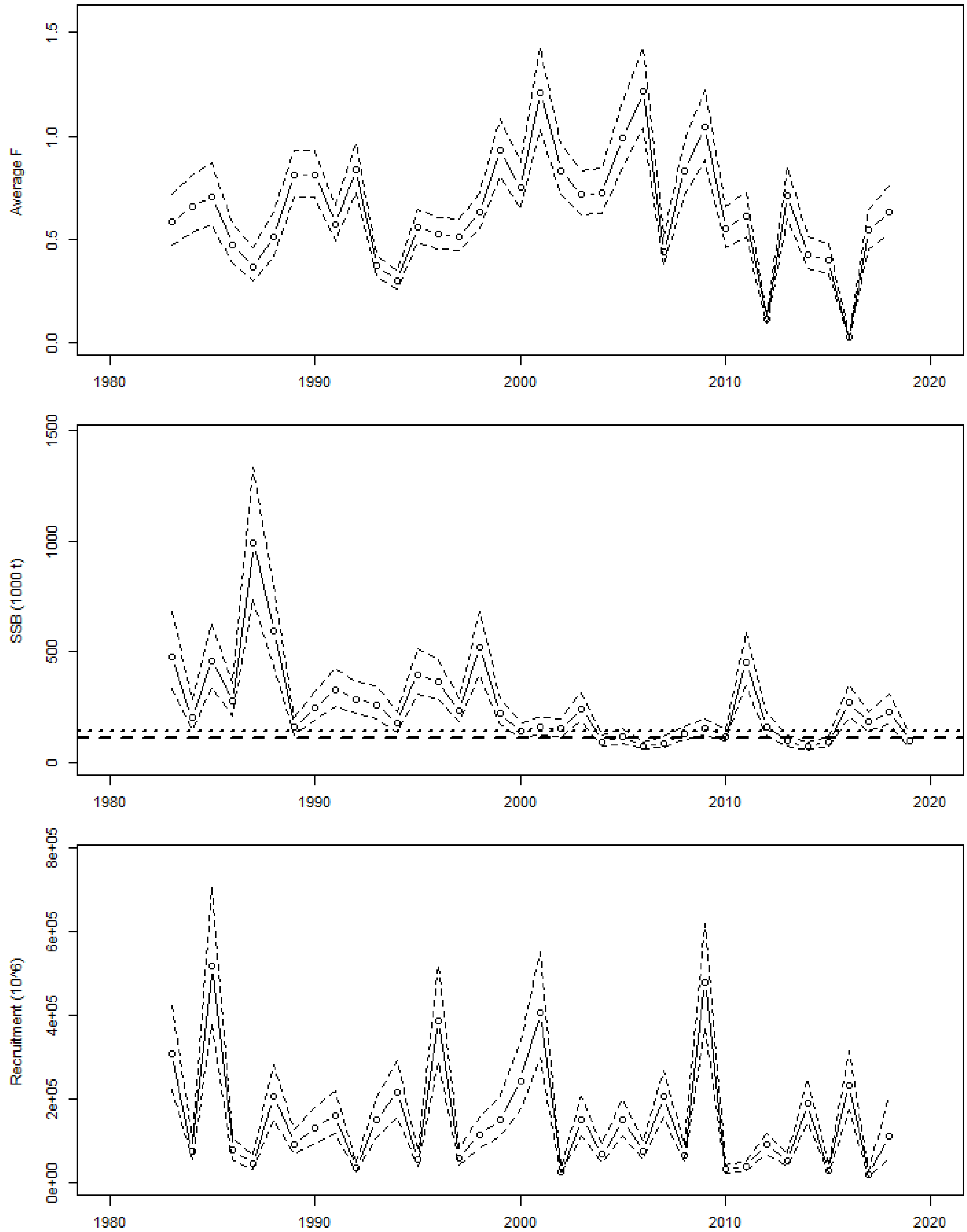

Figure 11.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

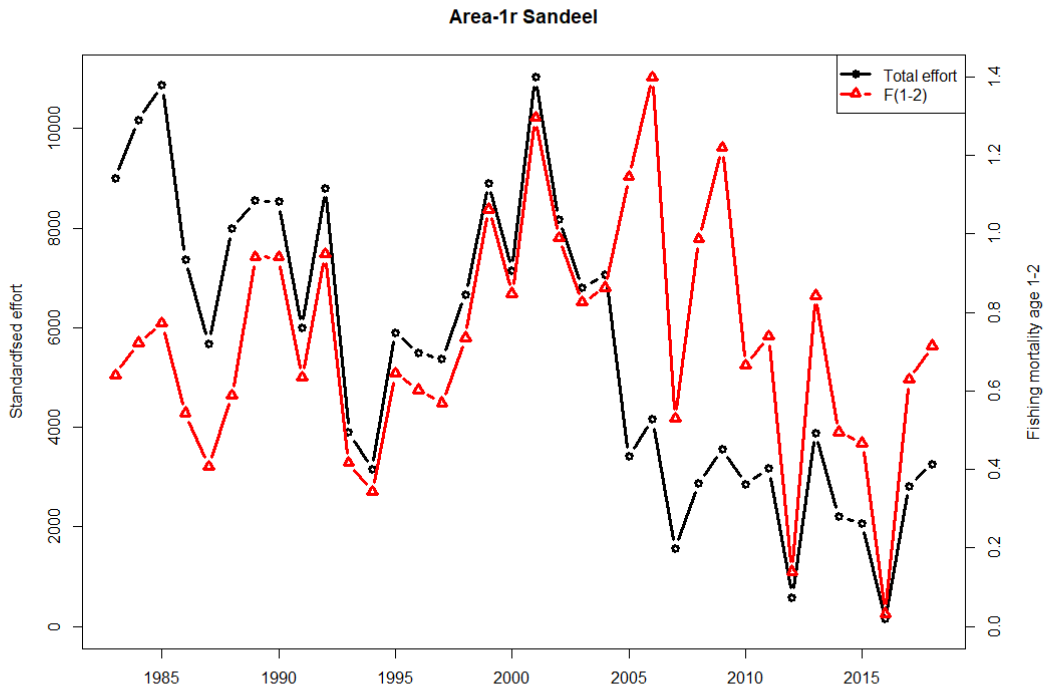

Figure 11.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

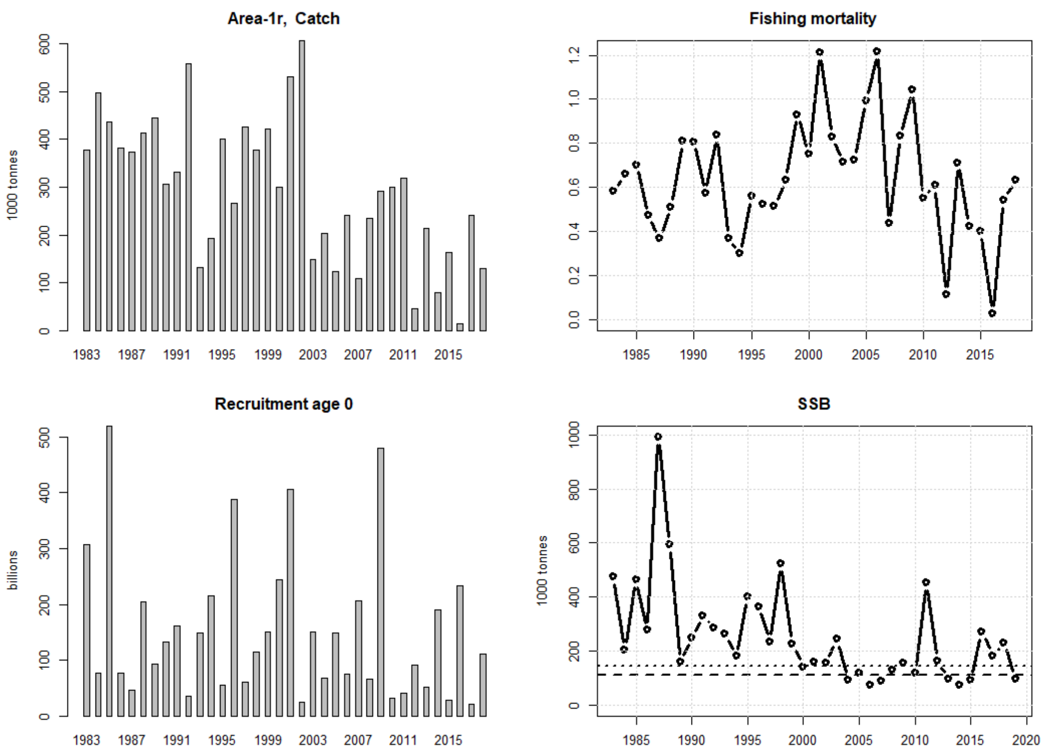

Figure 11.2.13 Sandeel Area-1r. Stock summary.

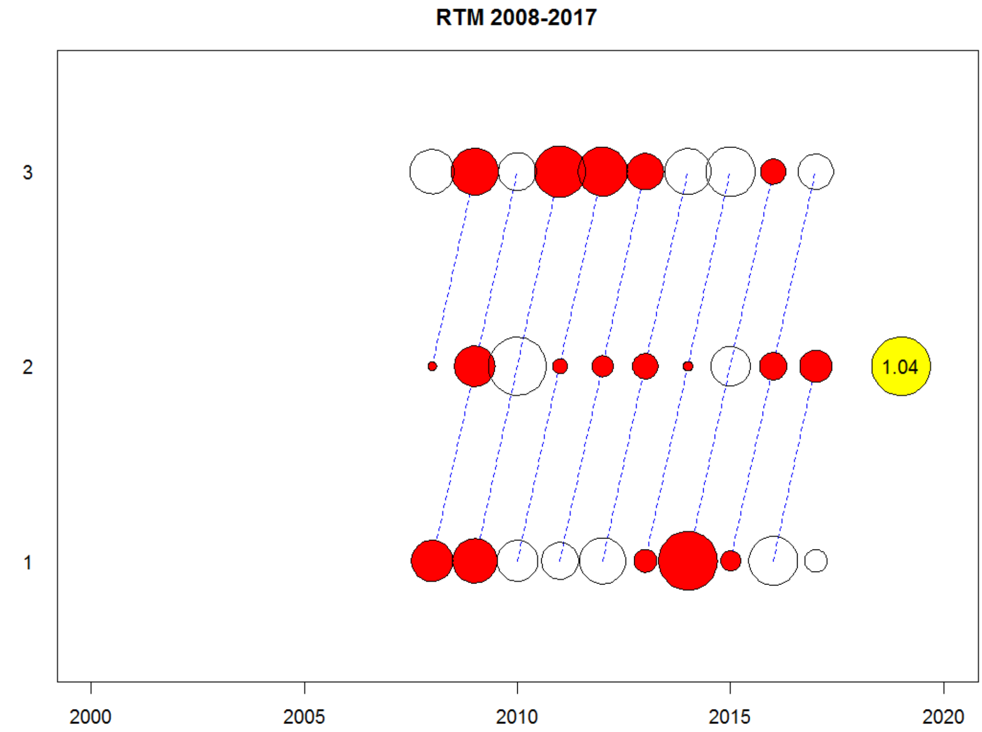

Figure 11.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)-log(expected CPUE). "Red" dots show a positive residual.

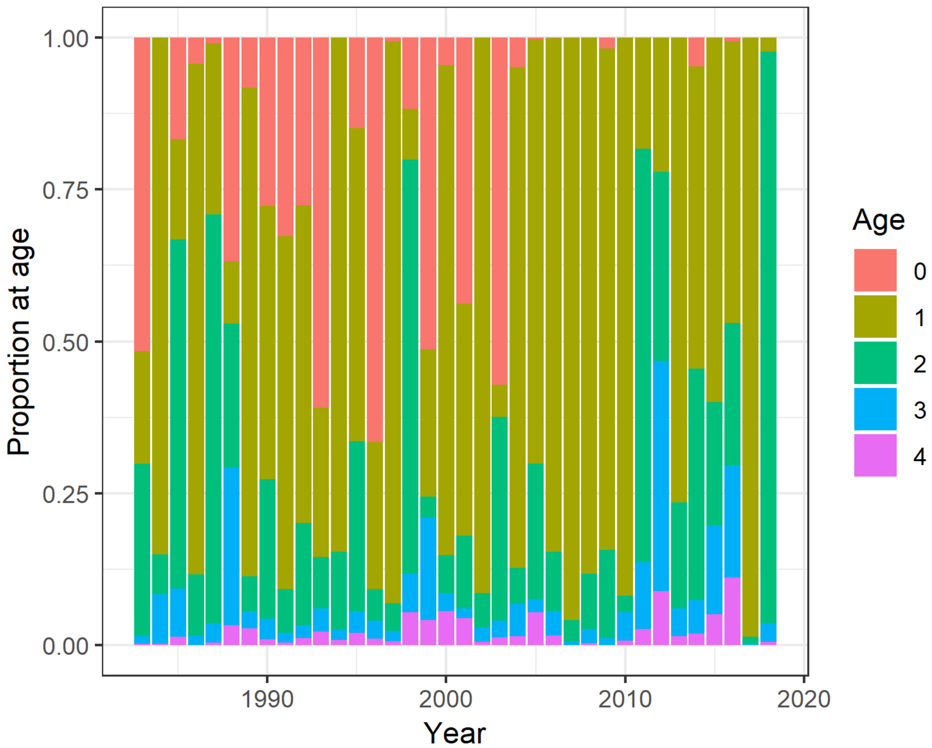

Figure 11.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

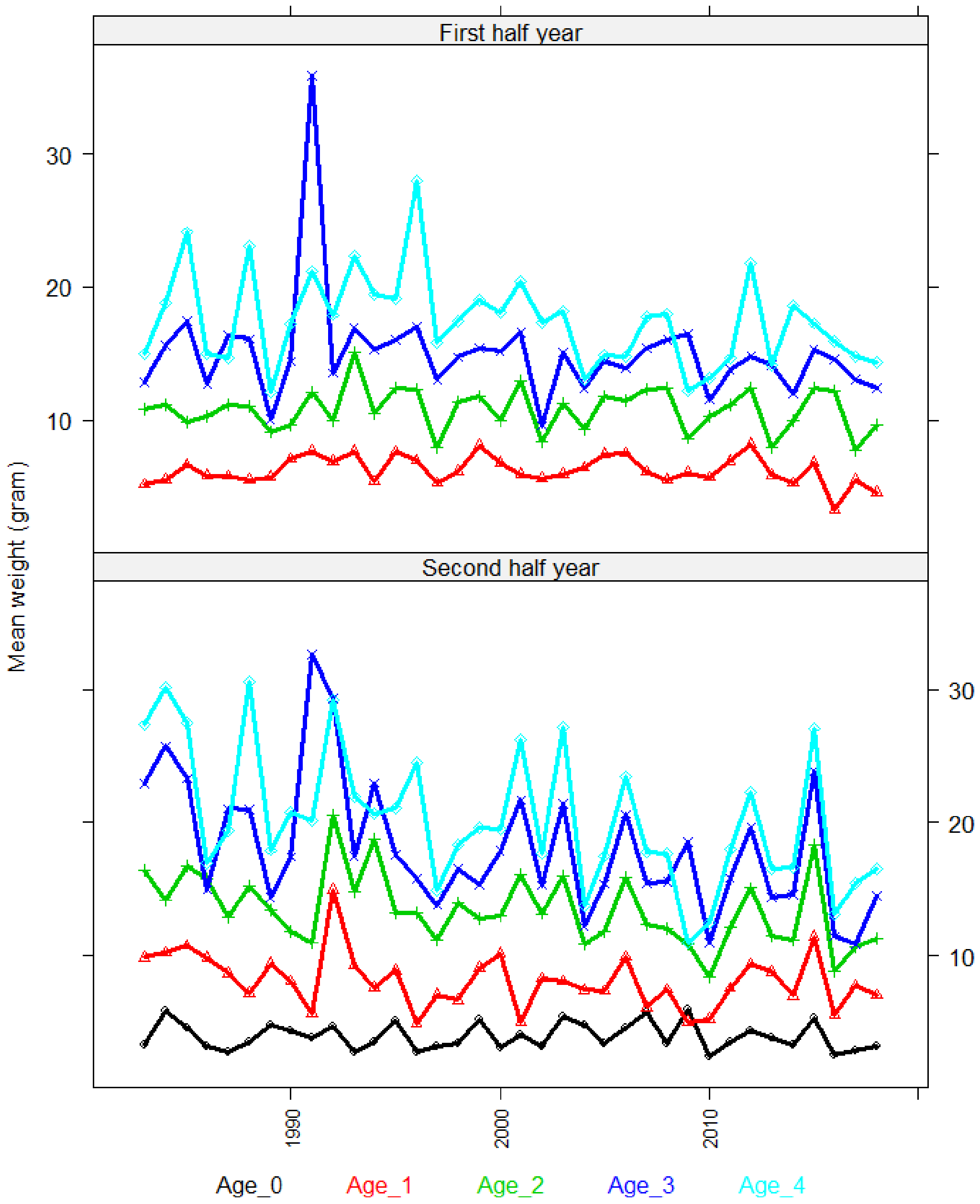

Figure 11.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

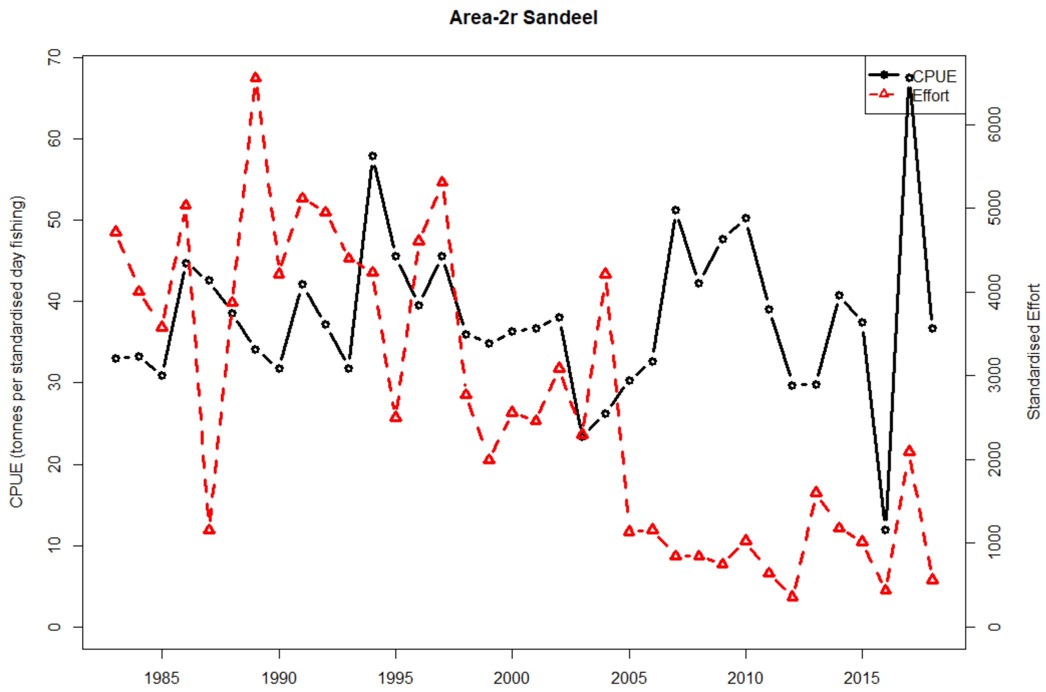

Figure 11.3.3 Sandeel Area-2r. CPUE and effort.

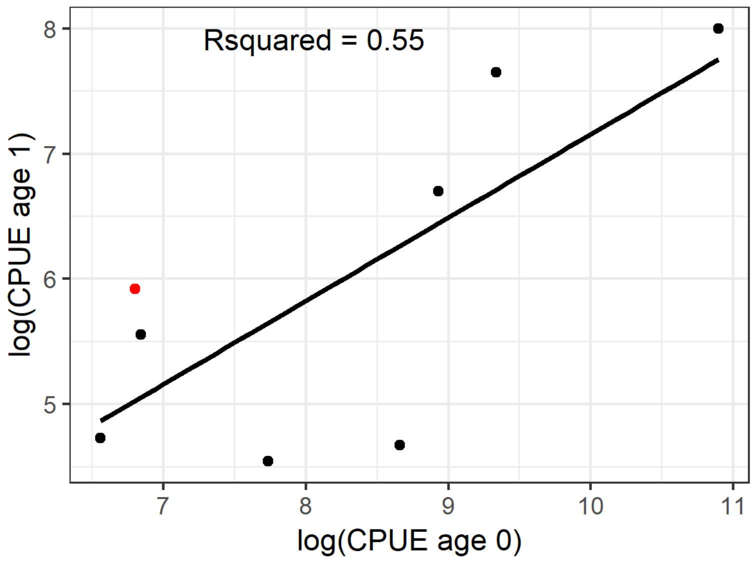

Figure 11.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

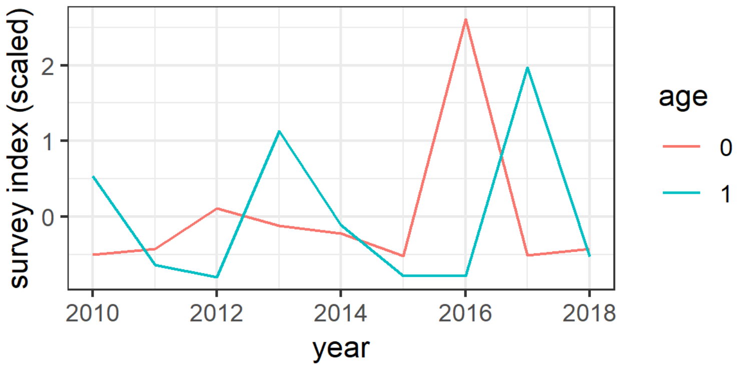

Figure 11.3.5 Sandeel Area-2r. Dredge survey index timeline.

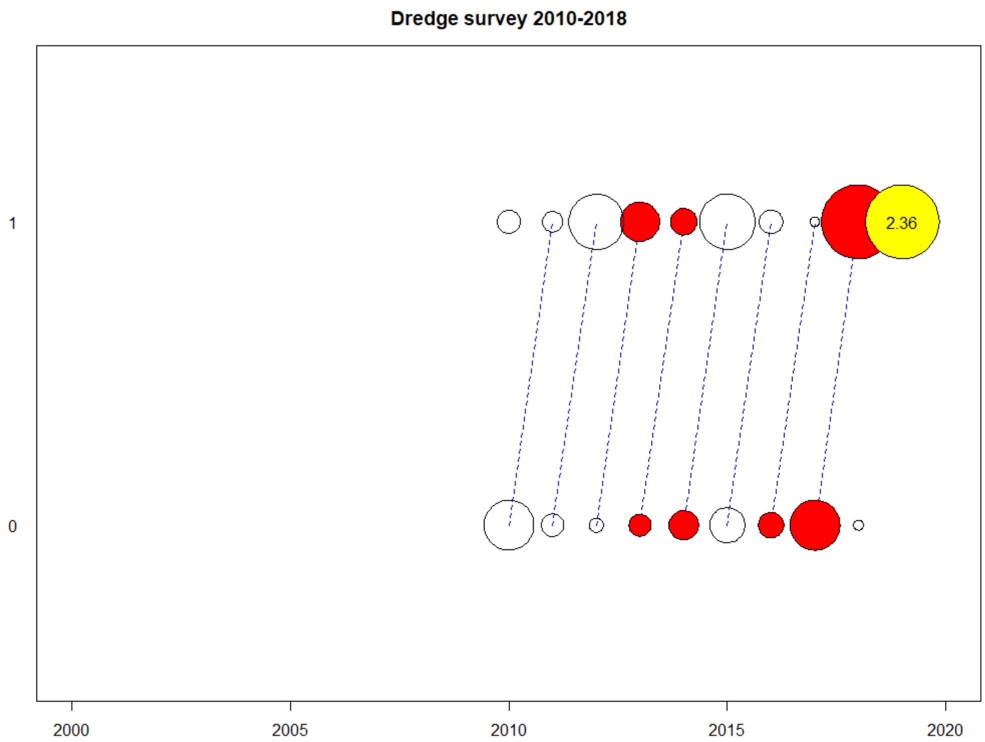

Figure 11.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

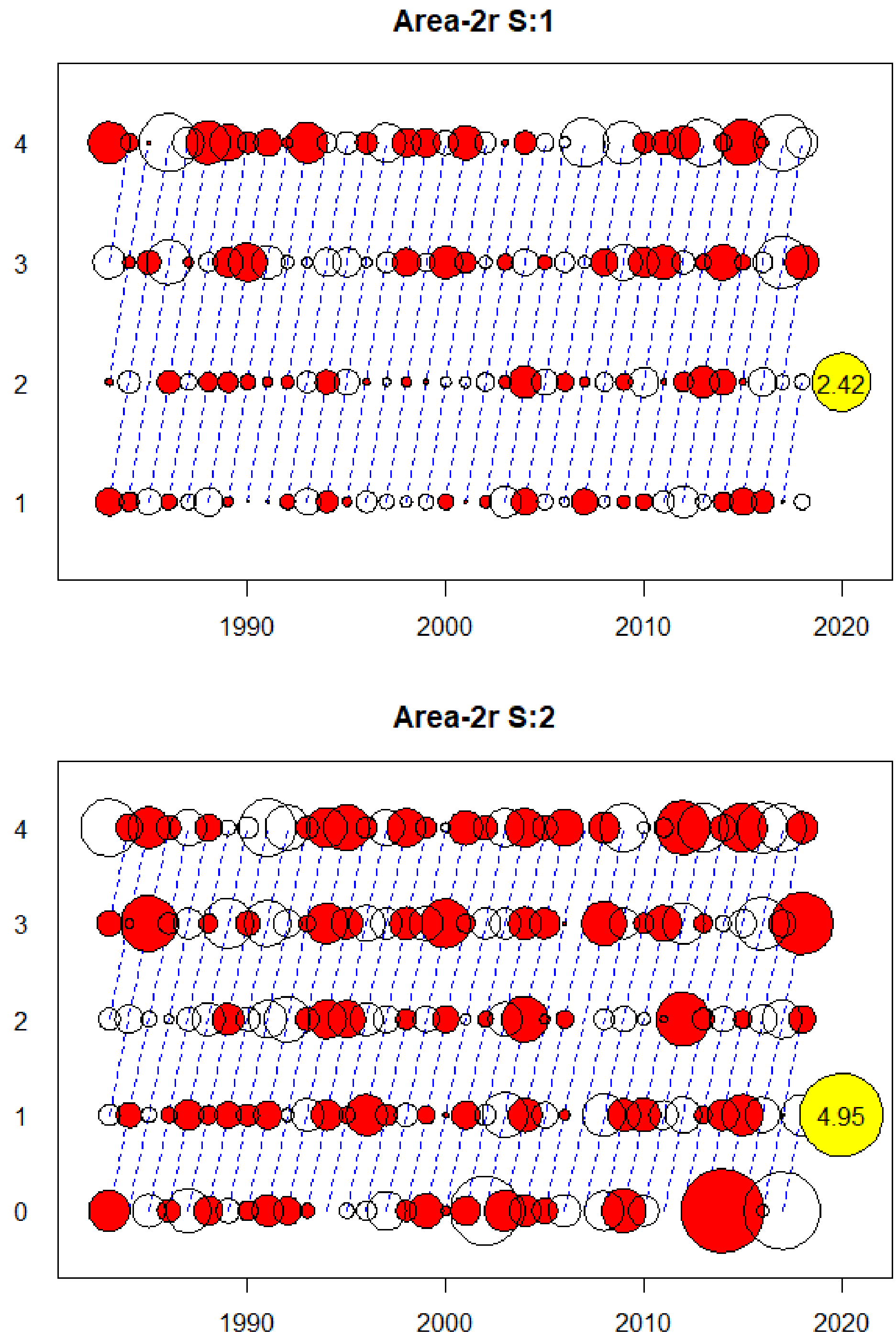

Figure 11.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

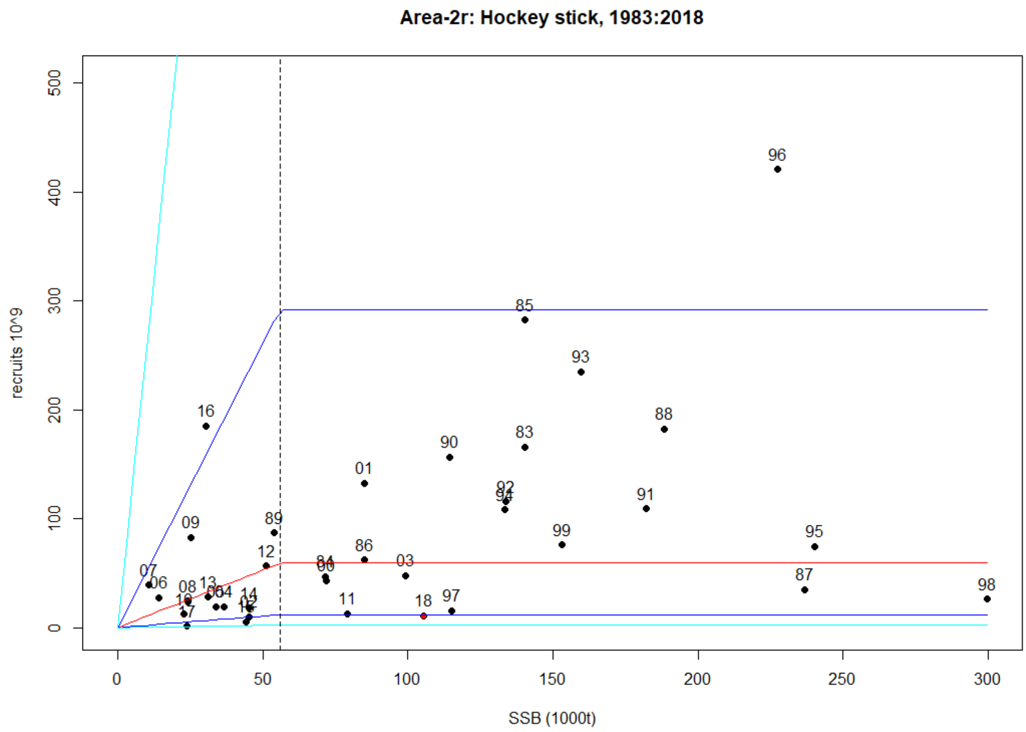

Figure 11.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

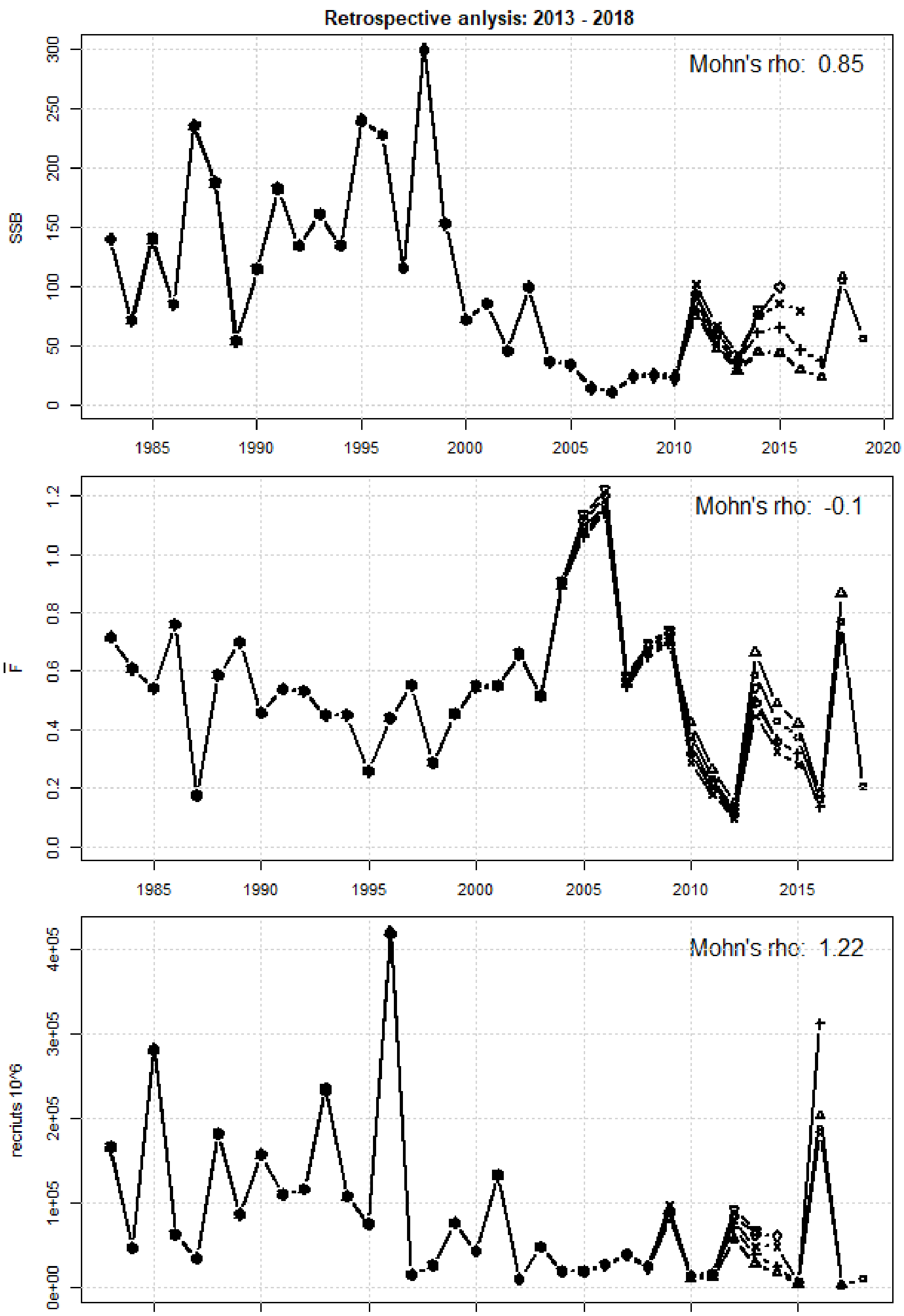

Figure 11.3.9 Sandeel Area-2r. Retrospective analysis.

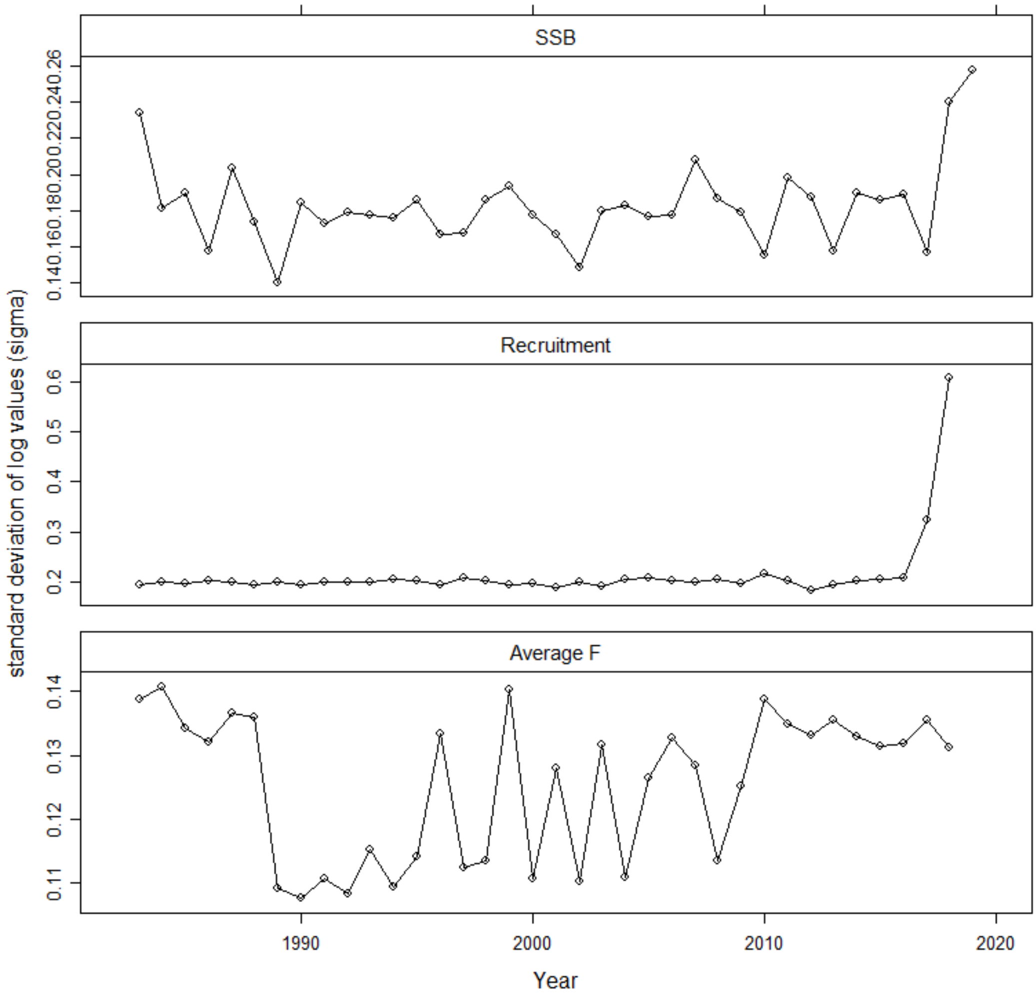

Figure 11.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

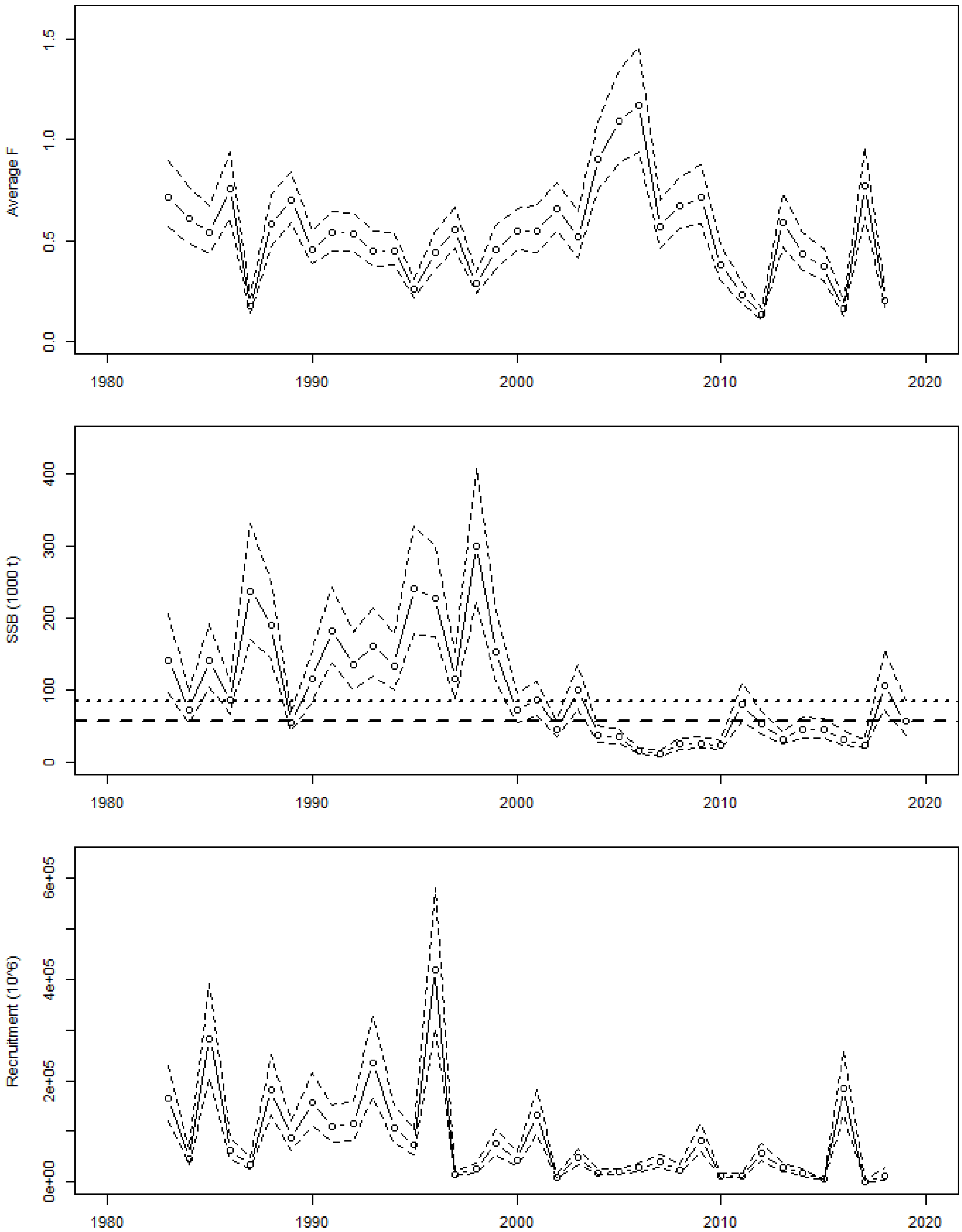

Figure 11.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

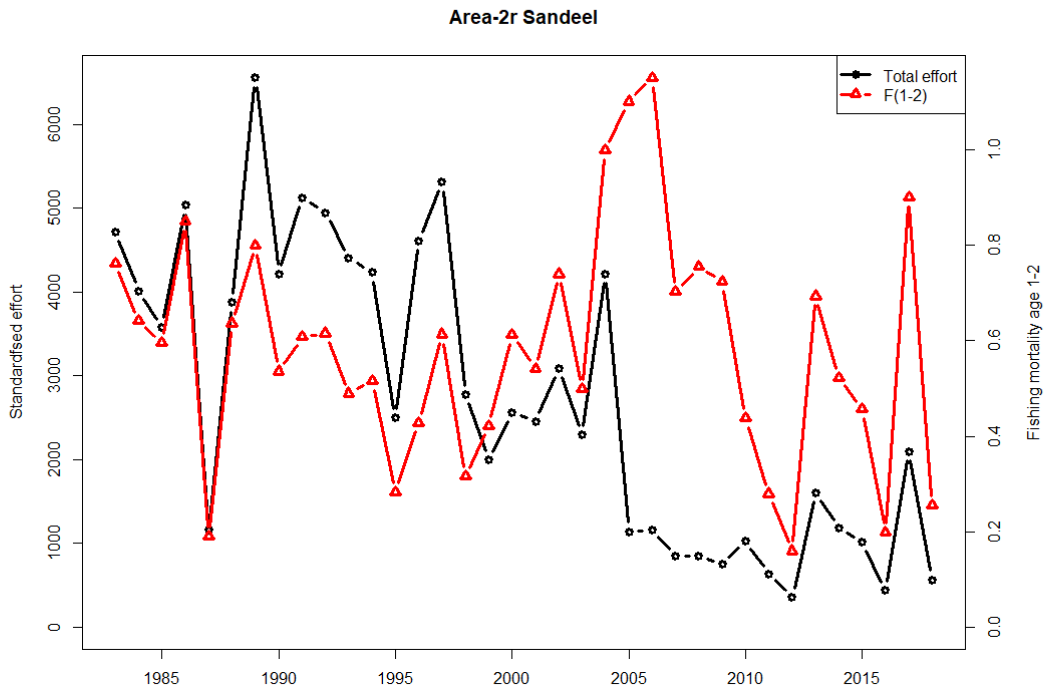

Figure 11.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

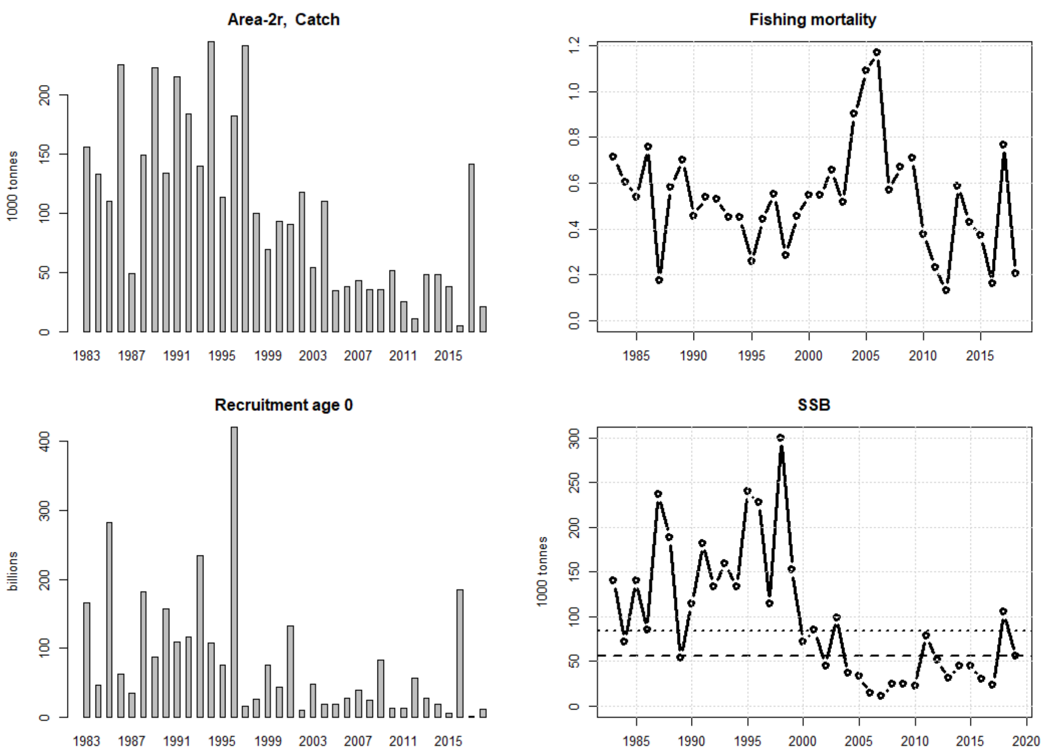

Figure 11.3.13 Sandeel Area-2r. Stock summary.

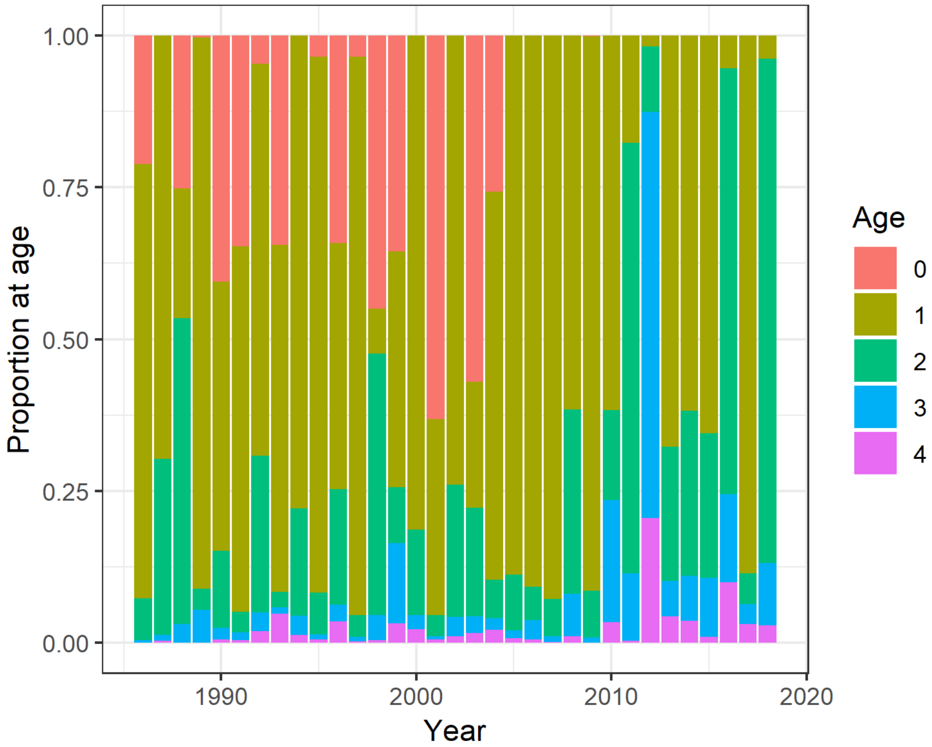

Figure 11.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

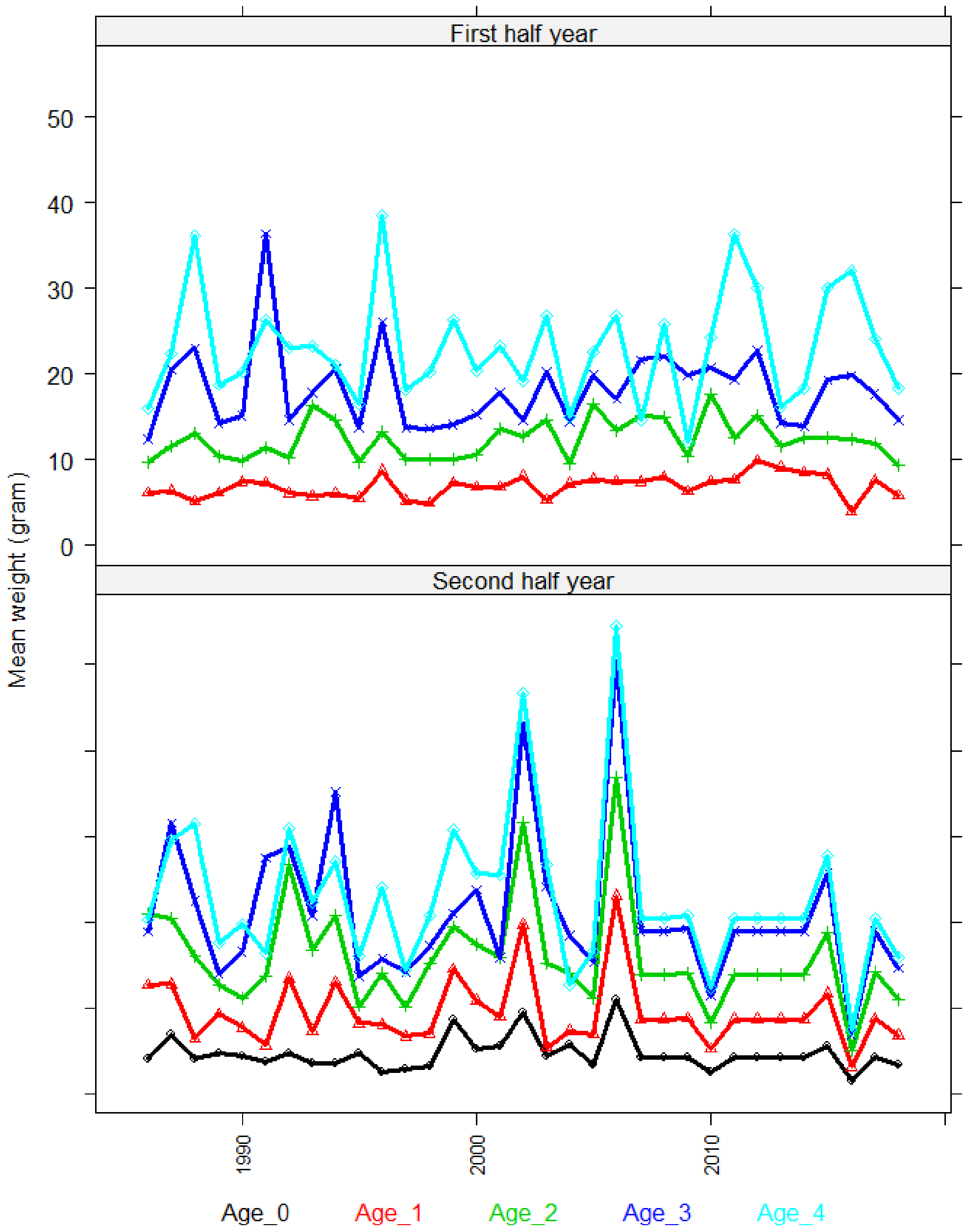

Figure 11.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

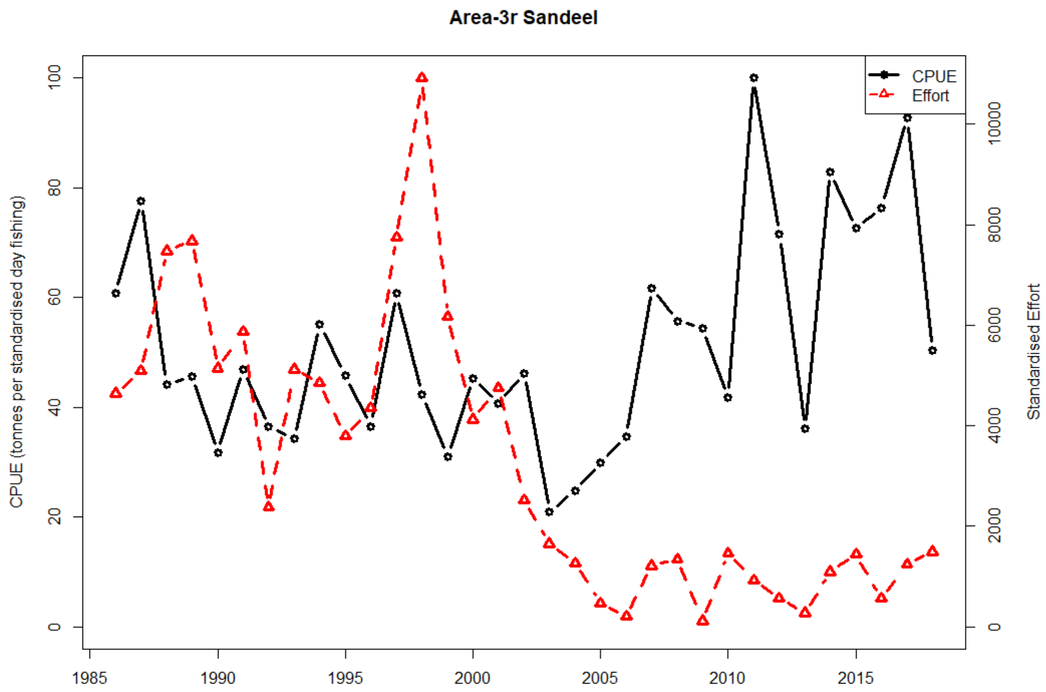

Figure 11.4.3 Sandeel Area-3r. CPUE and effort.

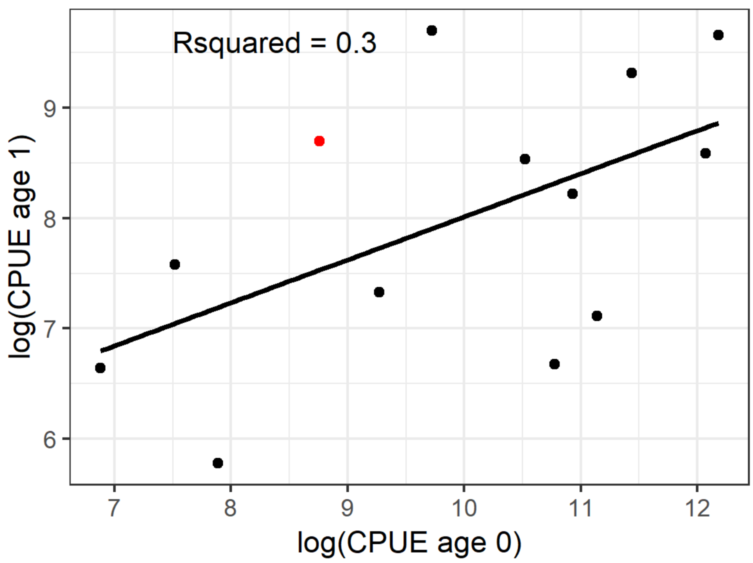

Figure 11.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

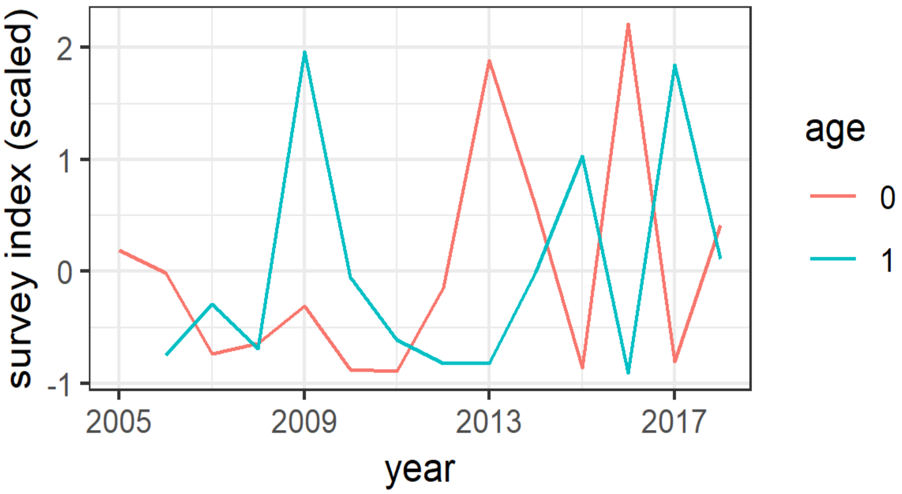

Figure 11.4.5 Sandeel Area-3r. Dredge survey index timeline.

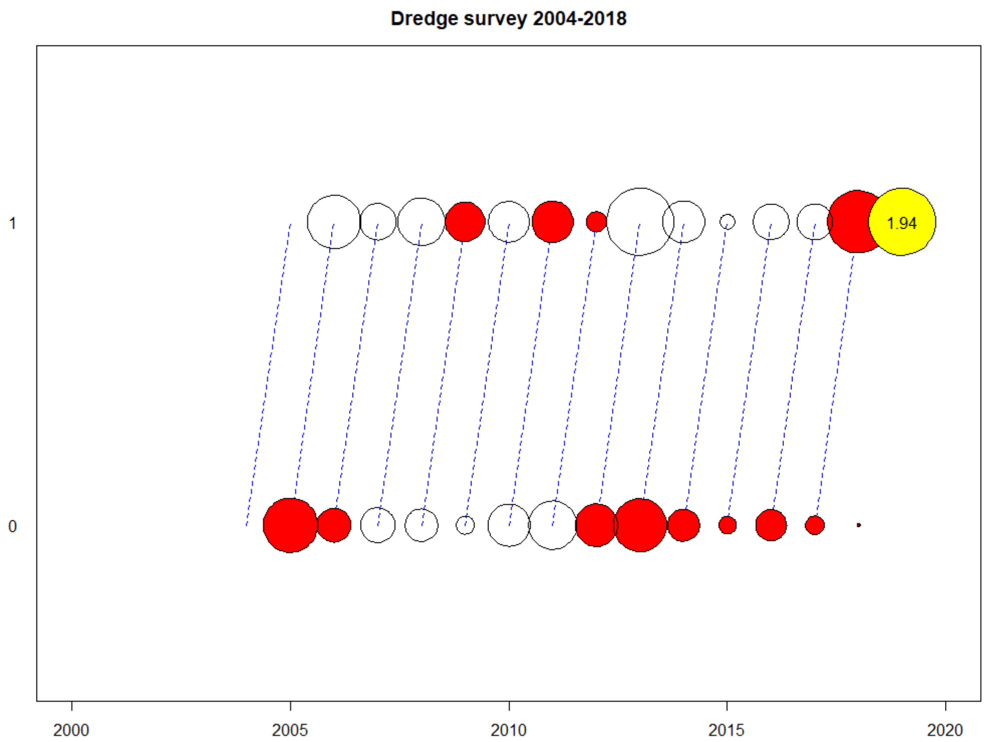

Figure 11.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

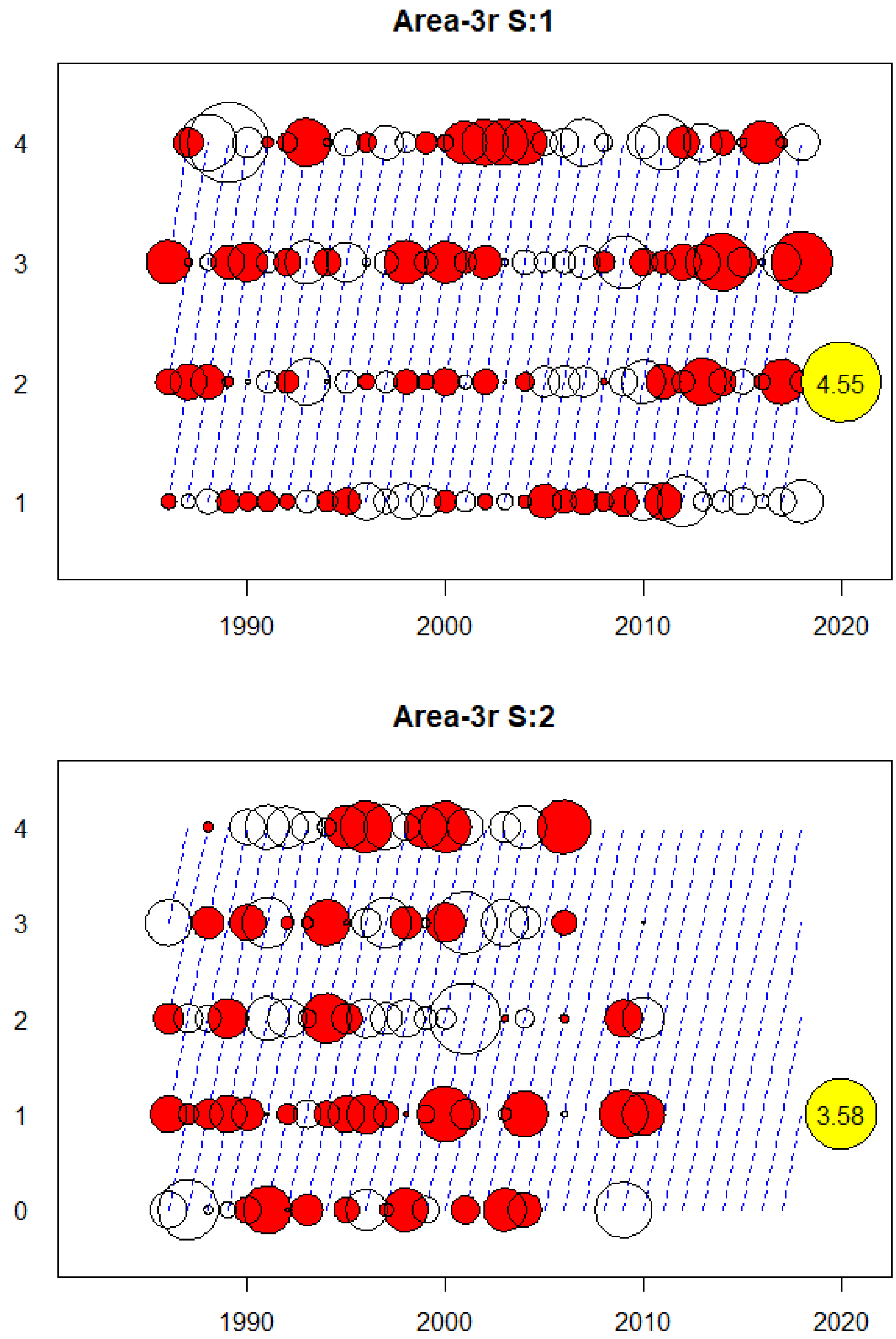

Figure 11.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

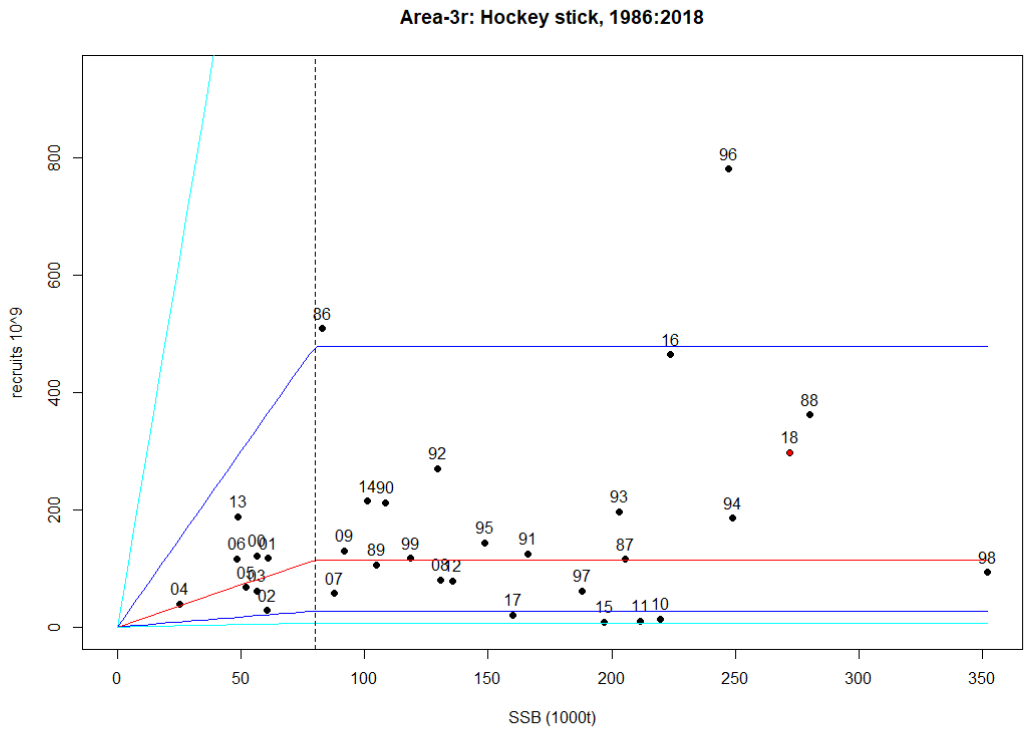

Figure 11.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

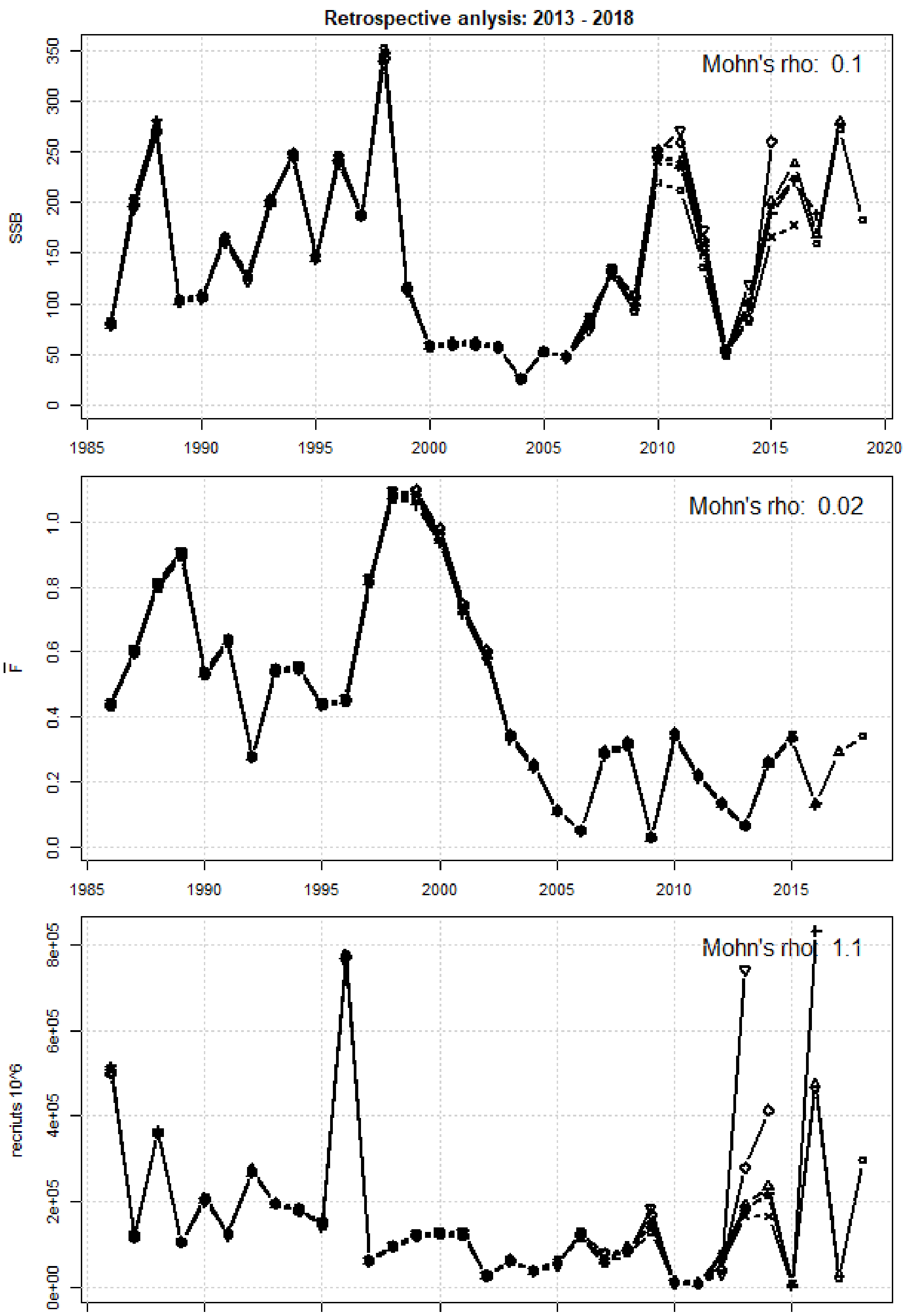

Figure 11.4.9 Sandeel Area-3r. Retrospective analysis.

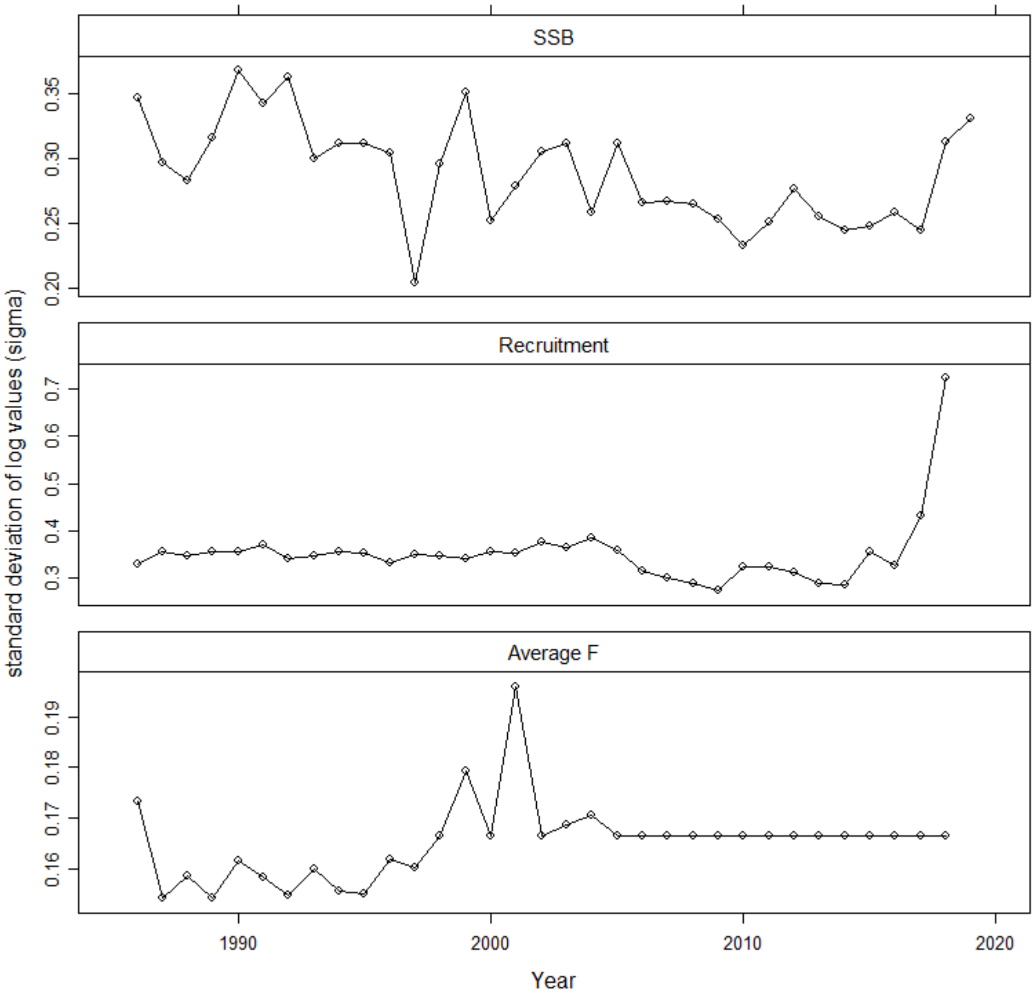

Figure 11.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

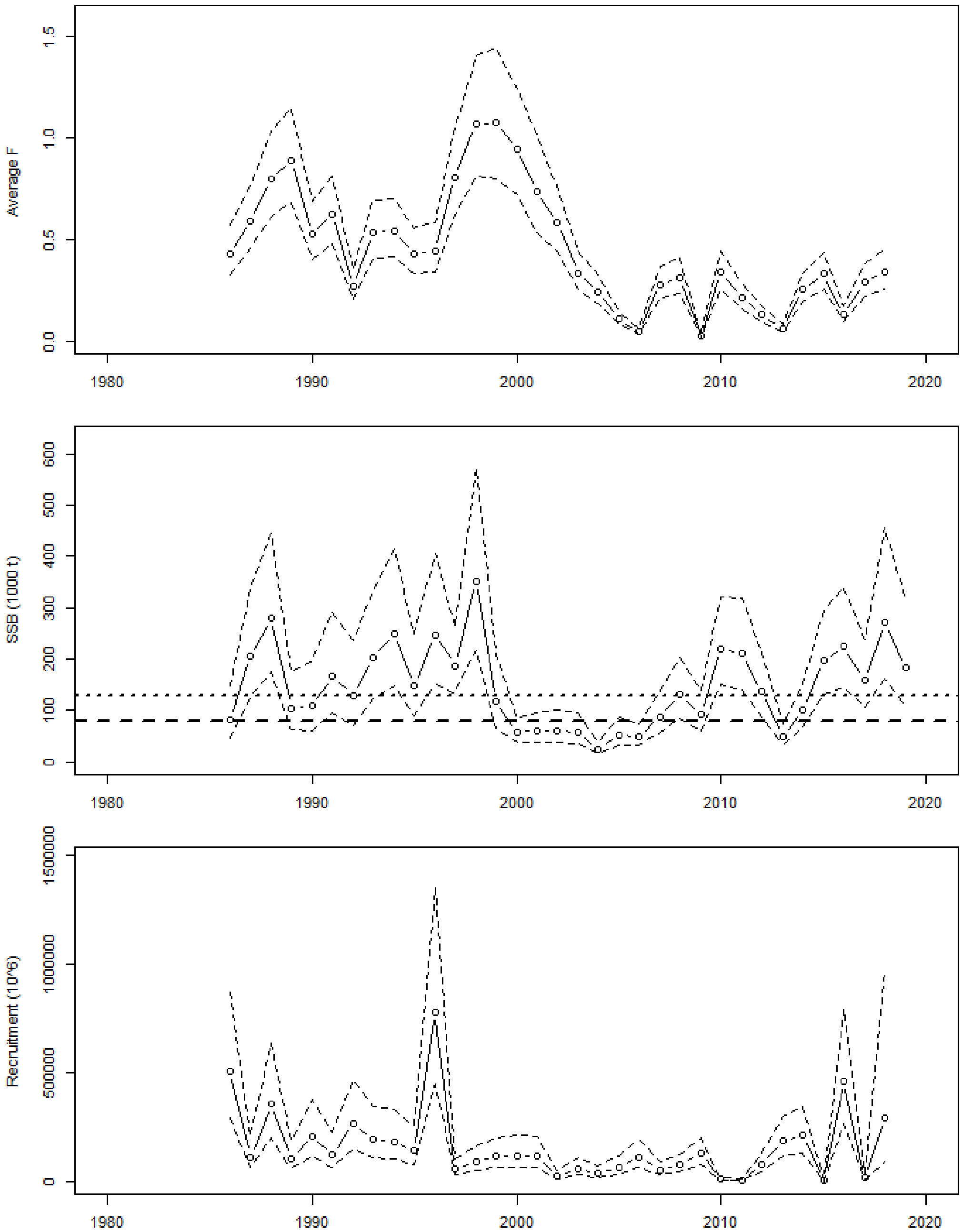

Figure 11.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

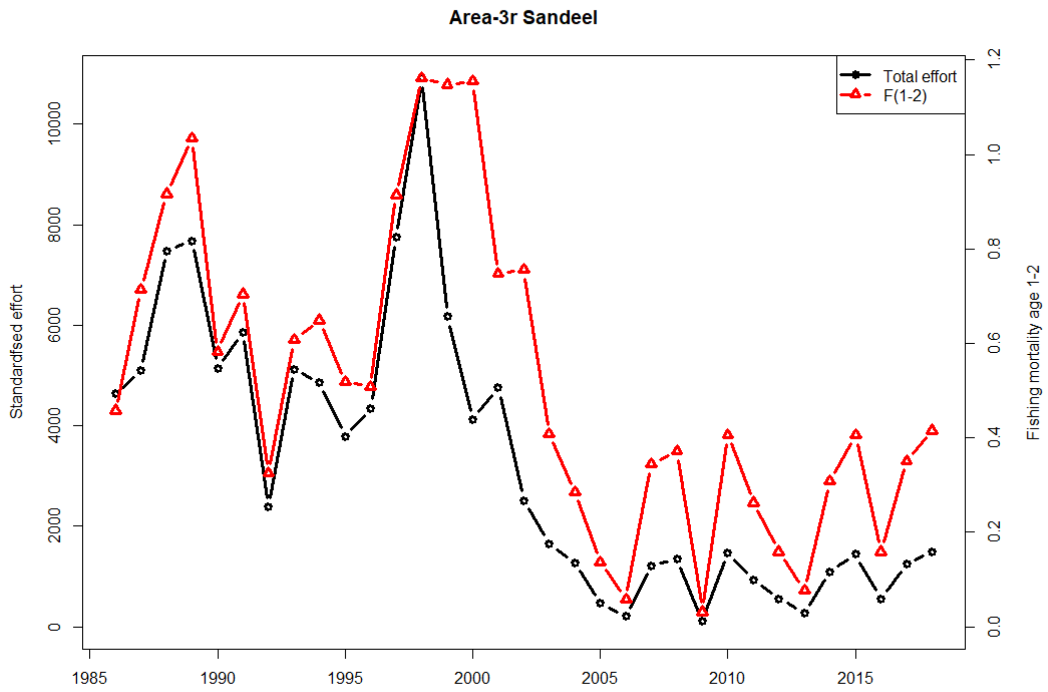

Figure 11.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

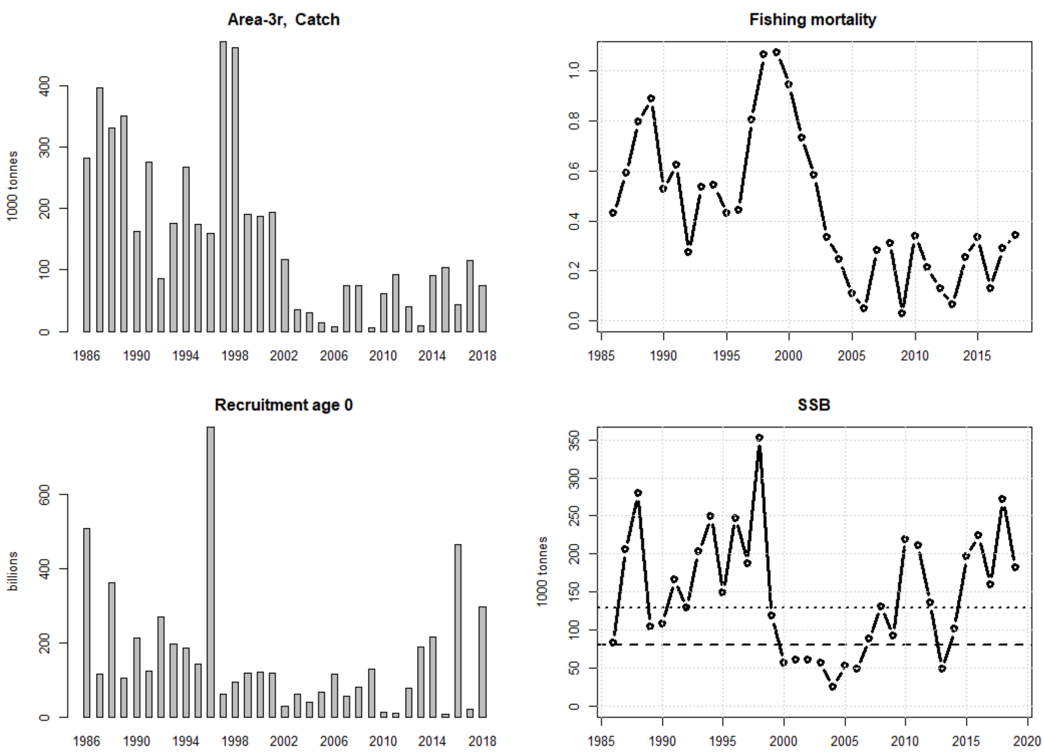

Figure 11.4.13 Sandeel Area-3r. Stock summary.

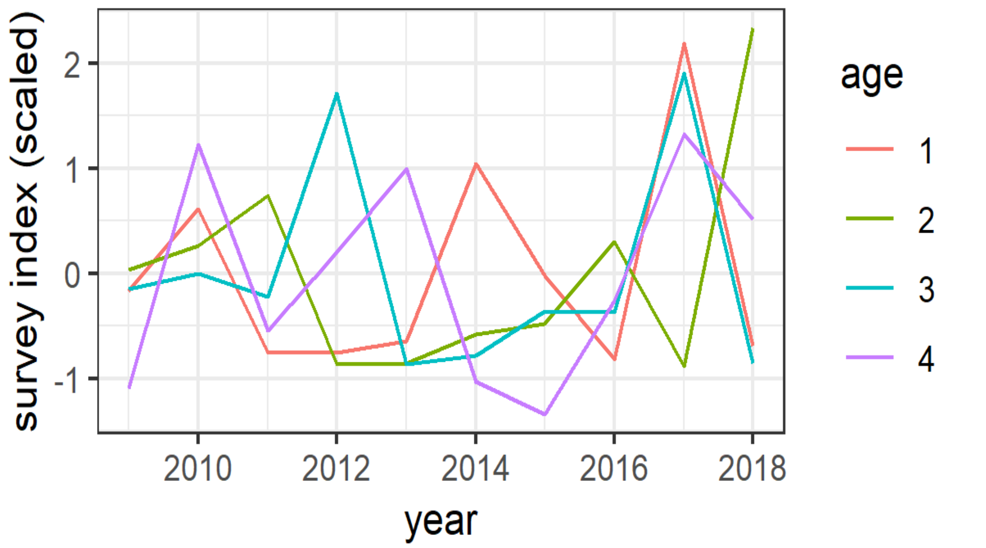

Figure 11.4.14 Sandeel Area-3r. Acoustic survey index timeline.

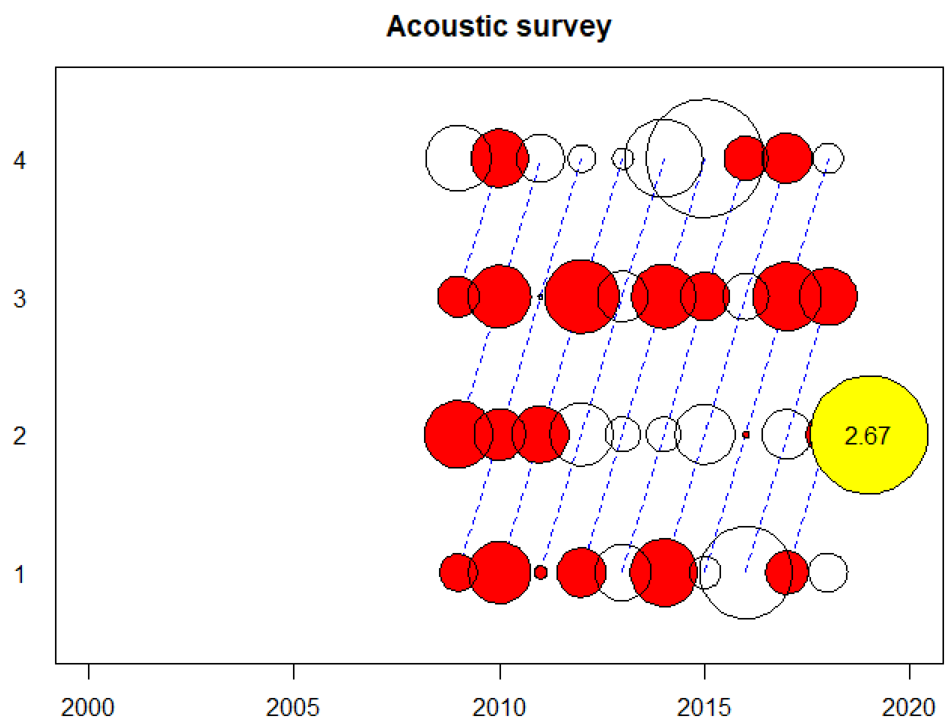

Figure 11.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

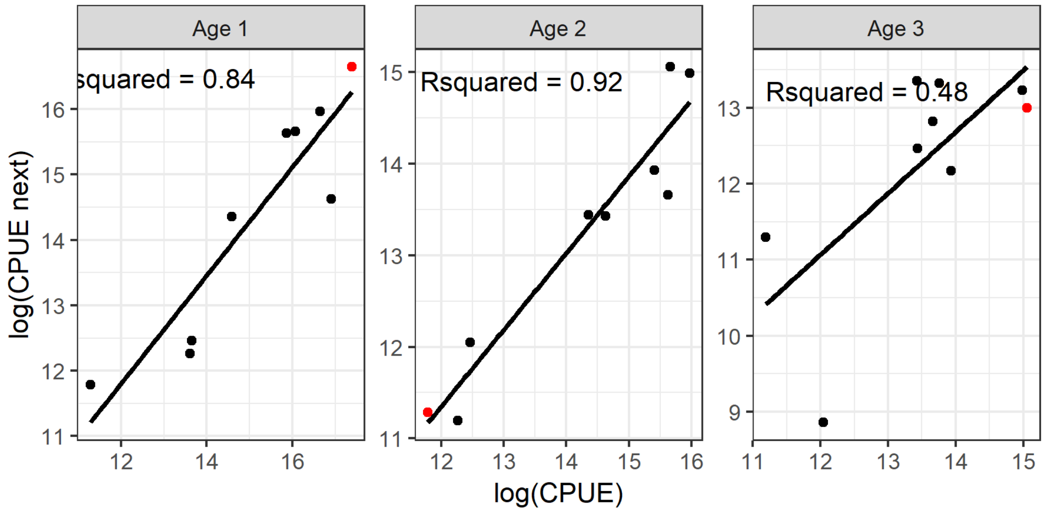

Figure 11.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

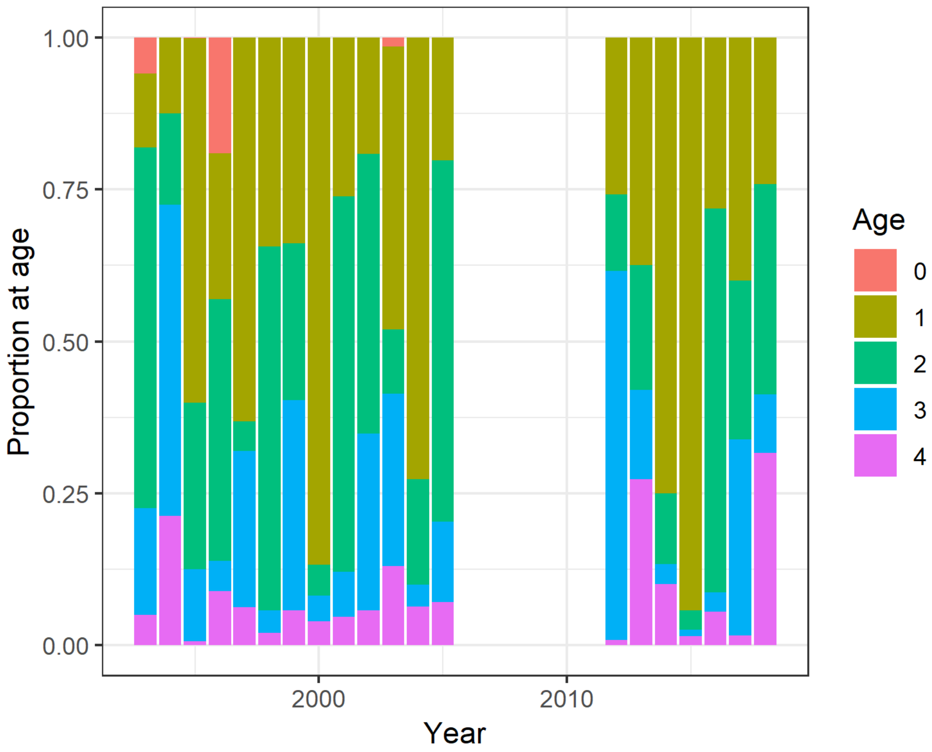

Figure 11.5.1 Sandeel Area-4. Catch numbers, proportion at age.

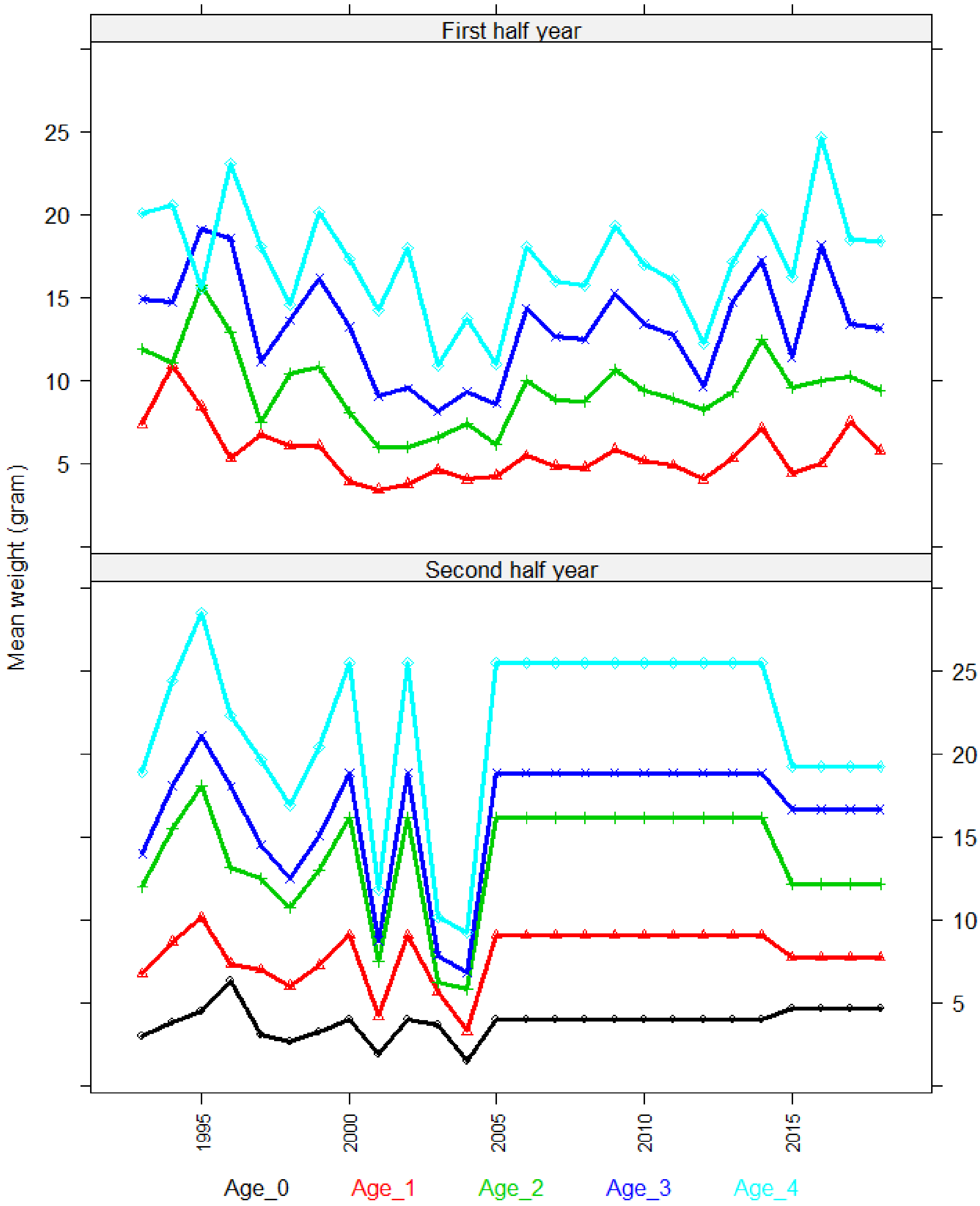

Figure 11.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

Figure 11.5.3 Sandeel Area-4. CPUE and effort.

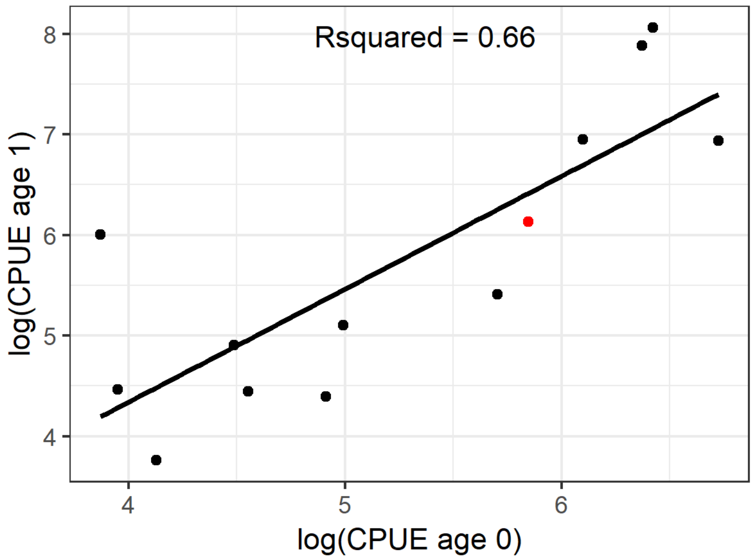

Figure 11.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

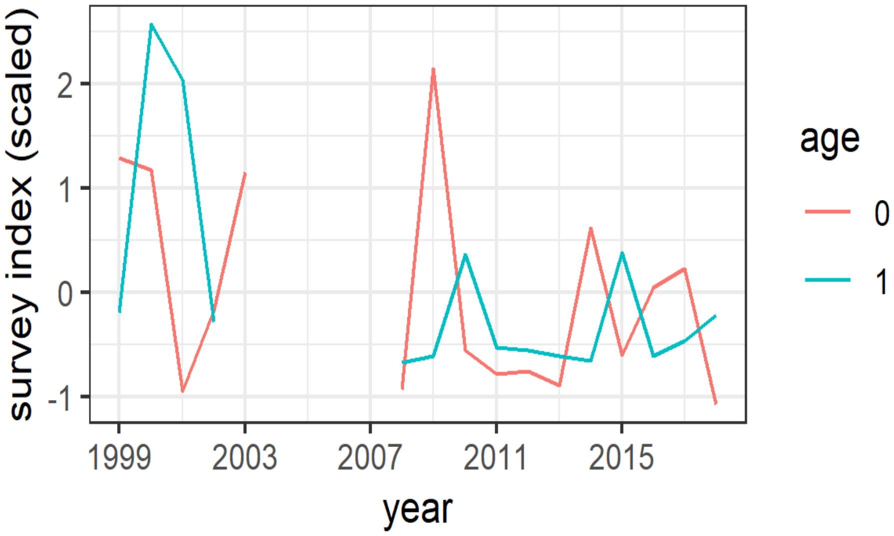

Figure 11.5.5 Sandeel Area-4. Dredge survey index timeline.

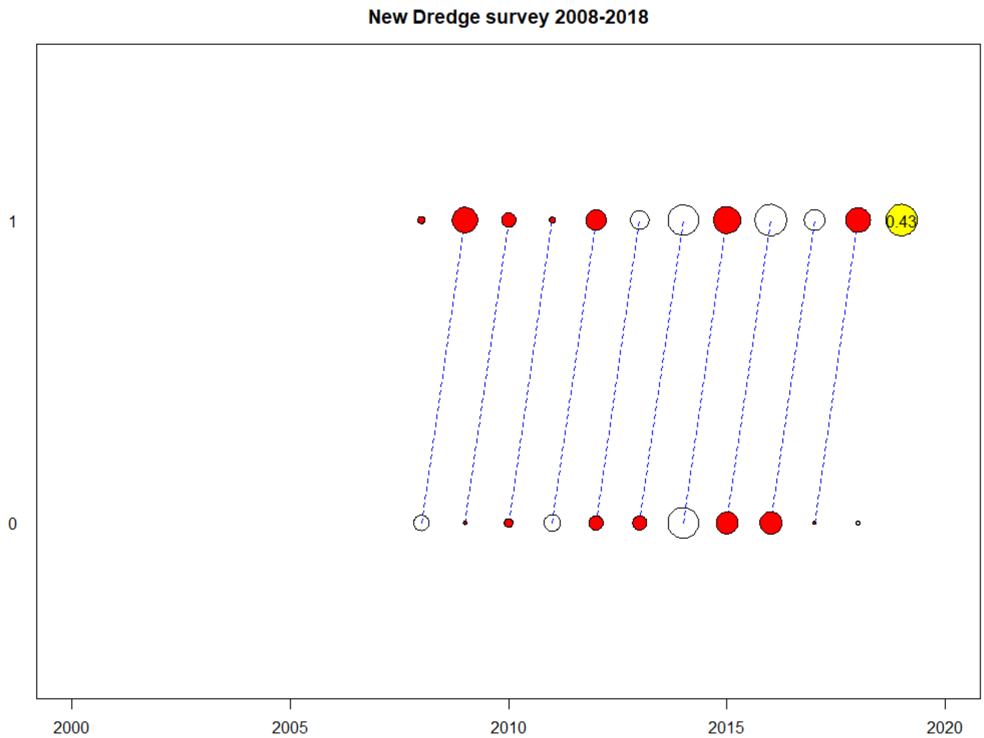

Figure 11.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

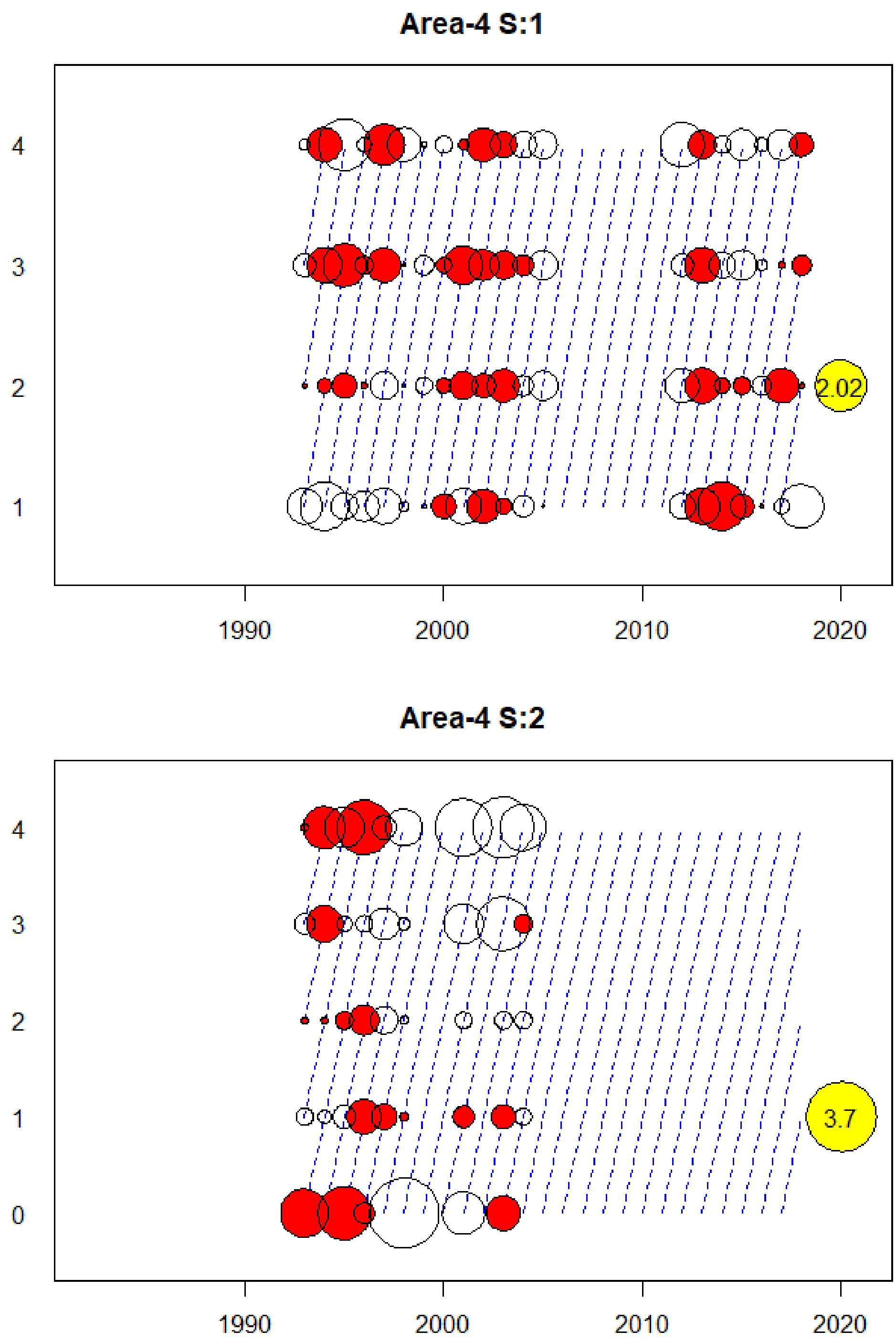

Figure 11.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

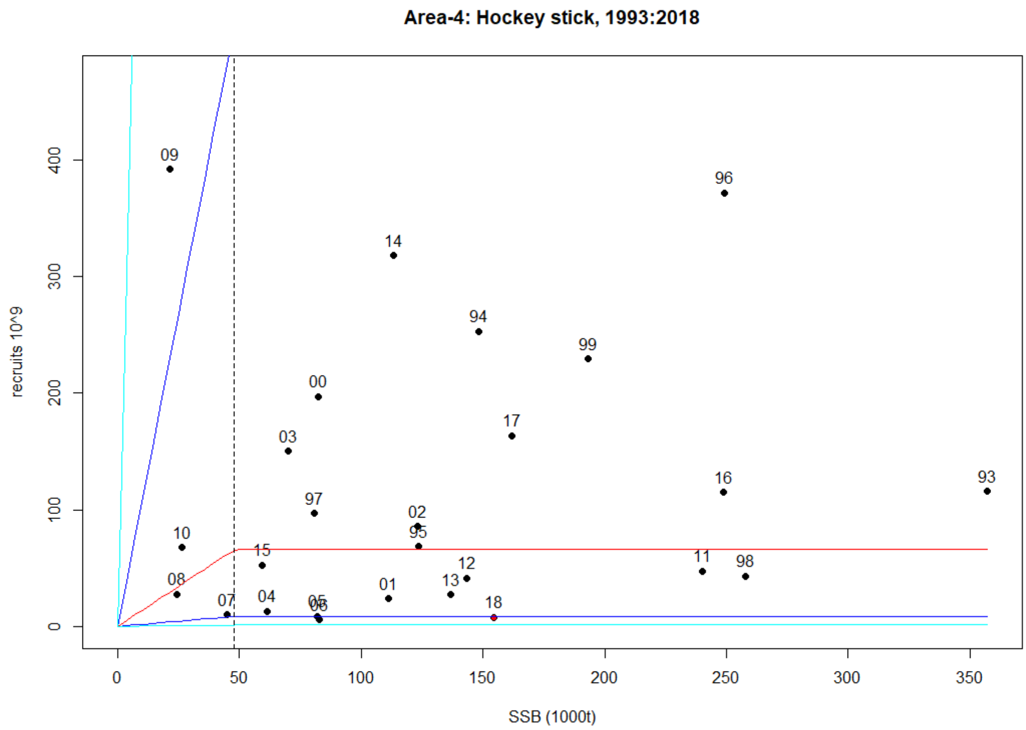

Figure 11.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

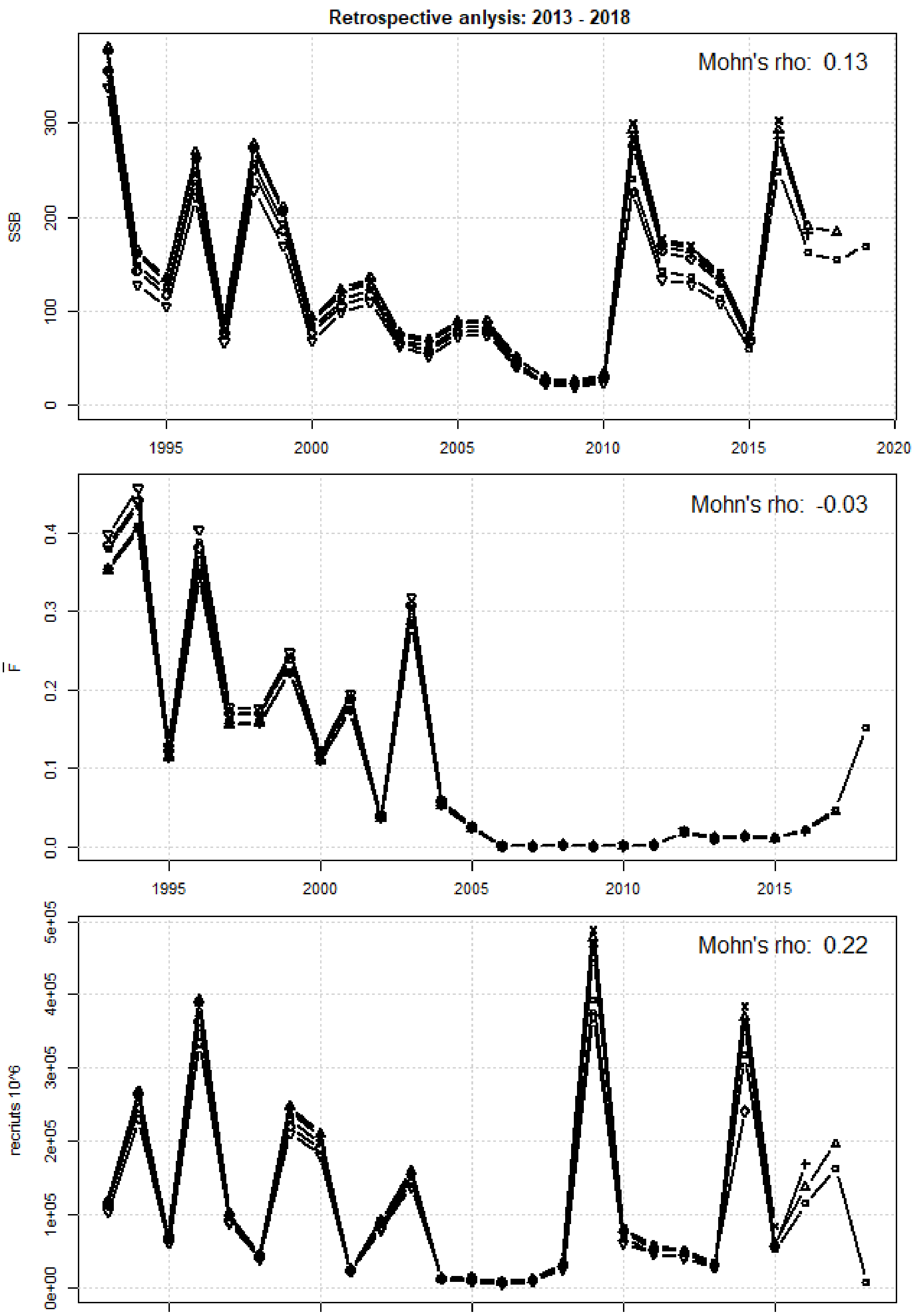

Figure 11.5.9 Sandeel Area-4. Retrospective analysis.

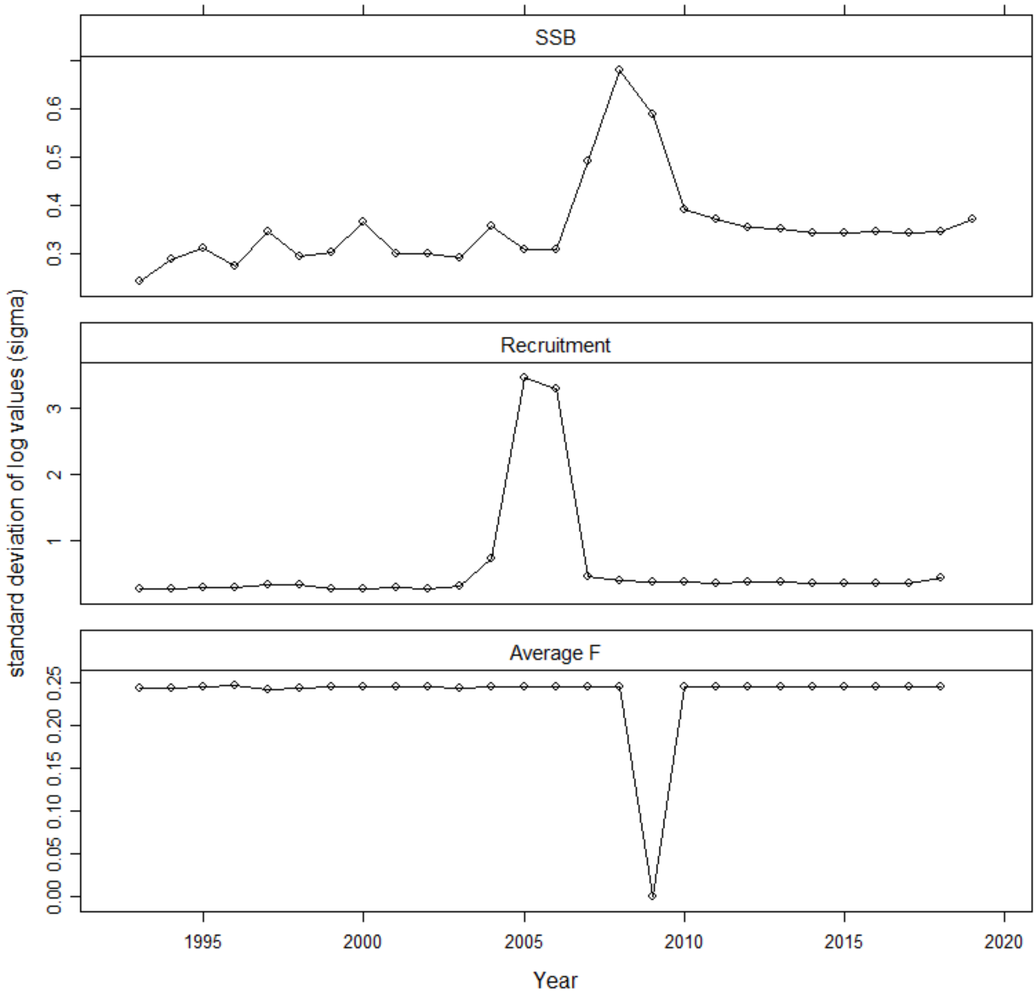

Figure 11.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

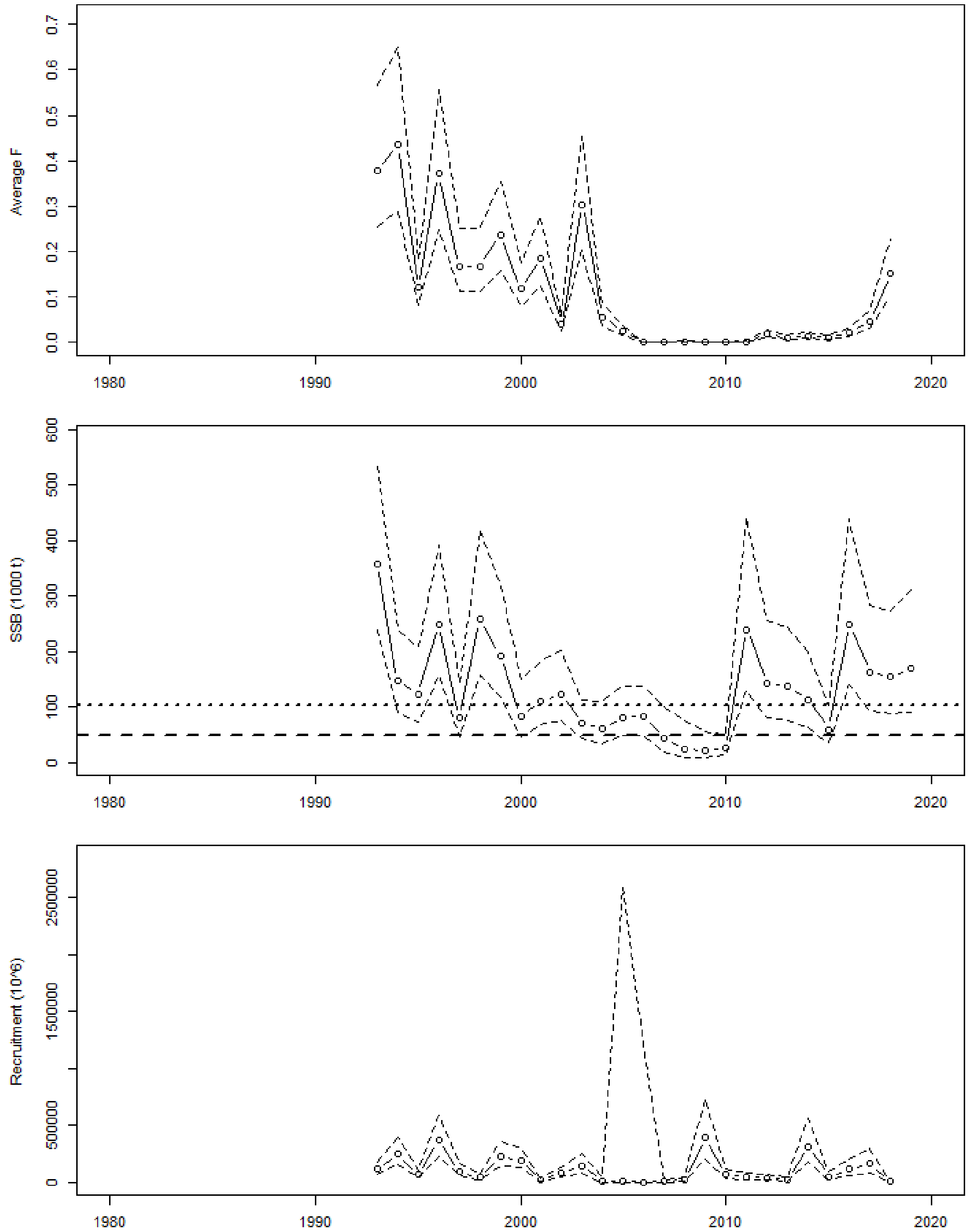

Figure 11.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

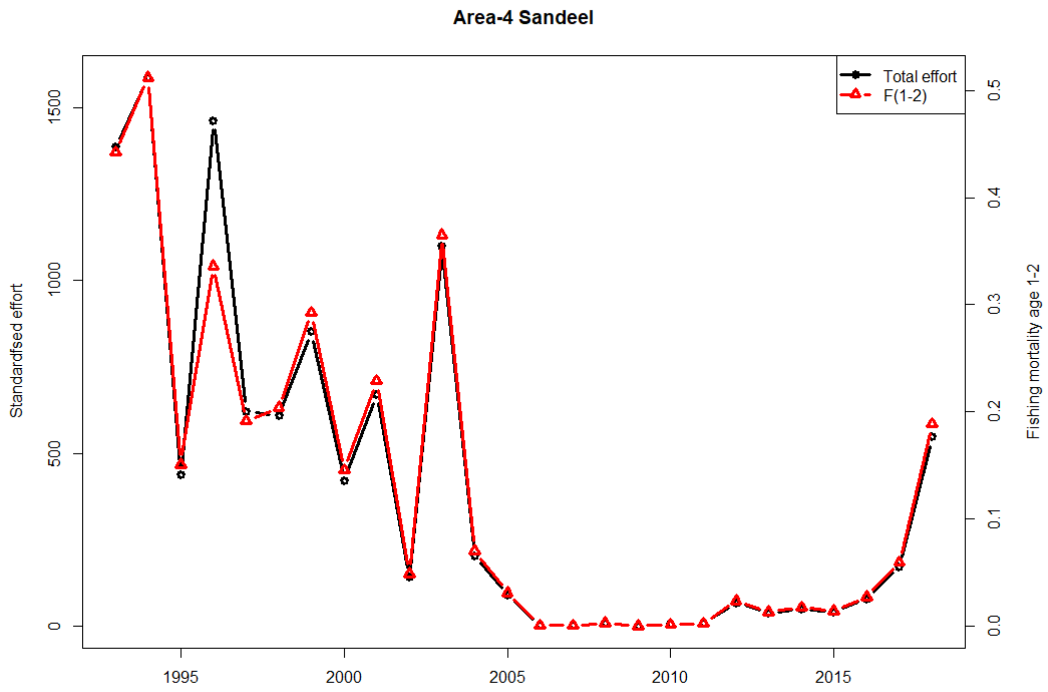

Figure 11.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

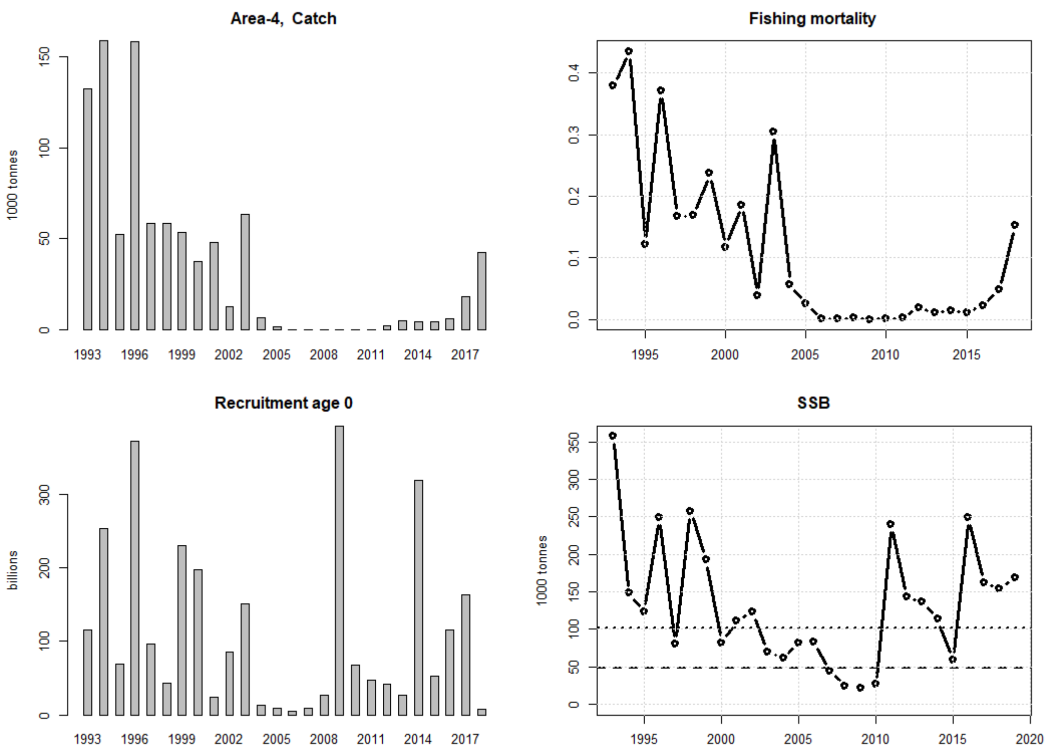

Figure 11.5.13 Sandeel Area-4. Stock summary.

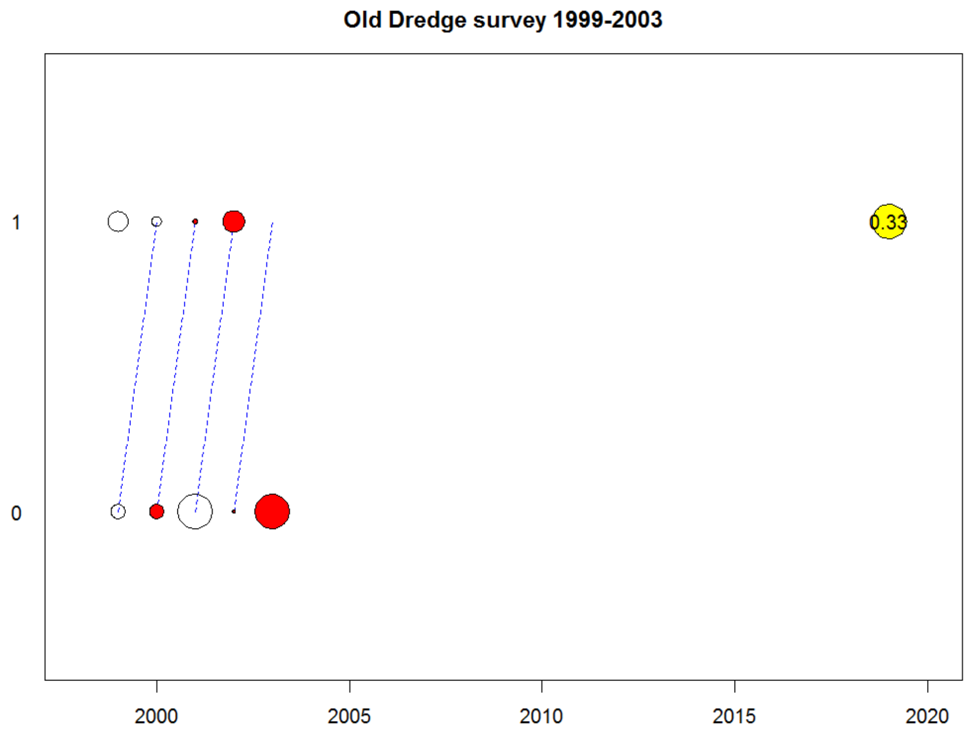

Figure 11.5.1 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.