16 Saithe (*Pollachius virens*) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat)

The assessment of saithe in Division 3.a and subareas 4 and 6 follows the protocol defined during the inter-benchmark in January 2019, which revised errors in the assessment code that existed from 2016–2018 and triggered a revised advice for 2018 (published 22 February 2019). With the code error corrected, the model produced lower biomass estimates in recent years, slightly different reference points, and a lower recommended TAC, which explain part of the retrospective pattern observed in the advice prior to 2018.

16.1 General

16.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

16.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK in 2021. A summary of available information, prepared during WKBENCH 2011 (ICES WKBENCH, 2011), can be found in the Stock Annex.

16.1.3 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex.

Saithe are taken mainly in the trawler fisheries by Norway, Germany, and France. Changes in the fishing pattern of these three fleets began in 2009, but all fleets had largely reverted to their original fishing patterns by 2011 (see Stock Annex for years 2000–2015). For the German and Norwegian fleets, the original fishing pattern is mainly along the shelf edge in Subarea 4 and Division 3.a, while French fleets fish along the northern shelf and west of Scotland (subareas 4 and 6). But in 2017, there appeared to be minimal overlap in the areas fished by the three nations.

A restructuring of the German fleet began in recent years and, in 2016, two vessels switched from otter trawls to paired trawls. This change had an impact on the CPUE index (see Section 16.3.5). This change was only for one year; these vessels reverted to otter trawling in 2017. In 2019, two new vessels entered the German fleet while 2 old vessels left. CPUE index calculations with and without the two new vessels were very similar. The French fishery is currently at capacity for processing the catch at the vessel; this fishery cannot increase their catches.

The Scottish fleets catch a large amount of saithe in subareas 4 and 6, a large part of which is then discarded due to lack of quota. Discarding continued in 2020 in areas 4 and 3.a despite a full landing obligation in place. In area 6, fisheries targeting saithe were under the landing obligation. Discards can also be high in a few Danish and Swedish fisheries in the Skagerrak because these fleets do not have sufficient quota allocations.

16.1.4 ICES Advice

The information in this section is taken from the 2020 Advice sheet.

Advice for 2021

"ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 65 687 *tonnes."*

The agreed TAC (trilateral agreement) was in line with the ICES advice.

16.2 Management

Changes to the stock assessment and reference points during the benchmark in 2016 and the interbenchmark in 2019, further corrected during WGNSSK 2021 (this document), imply a need to re-evaluate the EU-Norway management strategy to ascertain if it can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice will be given according to the ICES MSY approach.

16.3 Data available

16.3.1 Catch

Official landings for each country participating in the fishery, together with the corresponding WG estimates and the agreed international quota ("total allowable catch" or TAC) and ICES estimated discards and BMS landings are presented in Table 16.3.1. No resubmission of earlier data to Intercach occurred, and only 2020 estimates were appended.

In 2020, official landings and ICES estimates were very close in both 3.a-4 and 6. ICES estimates correspond to the sum of products (SOP) uploaded to Intercatch and present a good match for overall catch (100.1%).

In 2020, 92% of discards were imported to Intercatch while 8% were raised (Table 16.3.2). Discard observations were not available for some of the fleets landing larger amounts of saithe (Figure 16.3.1). This is mainly the case for the Norwegian fleets. While Norway has a landings obligation policy for all métiers and in all areas, discarding is not monitored and discard information is not collected; therefore, discards for the Norwegian, French, and German trawler fleets (TR1) were raised using provided discard information from the French and German trawler fleets (i.e., targeted saithe fisheries; quarterly stratification). Because of the absence of discard sampling in Q4 within these fleets, discards in Q4 were raised using sampling in Q1, expected to be the most similar season. Trawler fleets (TR1) from other countries were raised with trawler fleets from these countries. Because of lack of sampling data in 2020, likely linked to the Covid-19 situation, all seasons were raised together for this segment. Discards for other fleets (all countries), were raised using a stratification by quarter and area (4/6 and 3.a were distinguished). Information on discarding from Scottish métiers were not included when raising discards for active gears because rates were typically high.

The complete time series of catch, landings, and discards as used in the assessment is summarized in Table 16.3.3 and illustrated in Figure 16.3.2. Catch has been relatively stable from 1990 through 2008 and then declined slightly. The WG estimates of saithe discards (as a proportion of total catch) has remained relatively constant since 2003. Discard estimates were lowest for the period when the saithe trawler fleet changed its exploitation pattern (2009–2011). Prior to 2002, discards were estimated using a constant age-specific discarding rate (see ICES, 2016b). High discards, particularly in 2016, were due to reported discarding by Scottish fisheries.

Targeted saithe fisheries were covered by the EU Landing Obligation since 2016. Since 2018 saithe is under the landing obligation in all fleets in areas 4 and 3.a. Very few BMS landings and no logbook reported discards were reported into InterCatch in since 2018 (Table 16.3.2). Sampled and estimated discard rates as well, show a reduction after 2018.

16.3.2 Age compositions

International catch data was collated and catch-at-age was generated using InterCatch. Age composition in the landings was based on samples, provided by Denmark, France, Scotland, Germany, Ireland, and Norway, which accounted for 68% of the total landings in 2020 (Table 16.3.4; Figure 16.3.3), down from ≥90% in the previous years. This was mostly due to the French OTB_DEF_>=120_0_0 stratum (reported without selectivity device suffix) not being sampled in 2020, unlike previous years, and is likely due to the Covid-19 situation. Although this may induce some noise, it is not believed to impair substantially the quality of the assessment. A large number of fleets do not provide samples for the landings, but these do not usually contribute to a large proportion of the catch. However, the number of samples taken, especially in the targeted trawl fisheries, is an issue (see ICES, 2016b). Stratification for age compositions was by quarter and area for the unsampled landings, as described in ICES (2016b). This is because the fleets, particularly the target trawl fishery, are targeting the spawning fish in the first two quarters, while a wider range of age classes are captured in the latter part of the year. Smaller and younger fish are generally found in Division 3.a.

99 percent of the discards were sampled for age distributions in 2020 (Table 16.3.4). All age information from discards were from Denmark and Scotland (Figure 16.3.4) which also have by far the largest amounts of discards. While the proportion of discards sampled for age distribution was high (Table 16.3.4), the number of age samples per metier is often low (ICES, 2016b). Due to a very uneven spatial and temporal coverage, especially poor in area 3 and 6, catch-at-age information was estimated for areas 3 and 6 based on all information available (all areas and seasons together), and for area 4 for all seasons together. This is however believed not to be a critical issue for the quality of assessment as discards are typically low. Catch-at-age for the BMS landings was generated from the discards age information.

Total catch-at-age data are given in Table 16.3.5, while catch-at-age data for each catch component are given in Tables 16.3.6 and 16.3.7. Age 3 fish make up a smaller portion of the landings in recent years (Figure 16.3.5). The last strong year class in the catch appears to be the 2009 year-class as seen in the discards in 2012 at age 3 and landings in 2013 at age 4. A slightly stronger year class appears to be entering the discards at age 3 in 2016 and at age 4 in the landings in 2017, while 2018–2020 appears to show weak cohorts entering in at age 3.

16.3.3 Weight-at-age

Weight-at-age from the catch, landing and discard components for ages 3–10+ are presented in tables 16.3.8–16.3.10 and Figure 16.3.6. Catch weights are also used as stock weights in the assessment. There was a decreasing trend in mean weight for ages 6 and older, but that has stopped or been reversed after 2008 (Figure 16.3.6). Weights-at-age for ages 3–5 have been relatively stable, with some variation, over the last decade.

16.3.4 Maturity and natural mortality

The following maturity ogive, revised during the 2016 benchmark, is used for all years (see Stock Annex for details):

Age	1	2	3	4	5	6	7	8+
Proportion mature	0.0	0.0	0.0	0.2	0.65	0.84	0.97	1.0

A natural mortality rate of 0.2 is used for all ages and years.

16.3.5 Catch per unit effort and research vessel data

Indices used in the final assessment are included in Table 16.3.11. Data for the Norwegian, French, and German commercial trawler fleets were combined into one standardized CPUE index (integrating Year, Quarter, Nation Power and Area effects, without interactions), which is then tuned to the exploitable biomass (see Stock Annex for details). One fisheries-independent survey index was included for tuning of the assessment; the survey is the IBTS quarter 3, ages 3–8, 1992–2019 (“IBTS-Q3”).

Errors were found in 2021, which affected (*i*) the SAS code formerly used to calculate the CPUE index and (*ii*) previously submitted French data for the CPUE index. The code issue was a wrong coding of the quarter, based on the month, causing some records to be attributed to the wrong season. Despite a slight but noticeable offset (Figure 16.3.7 left), the correction was shown to have a negligible impact on the previous year’s assessment, with deviations on the final year’s estimates and management scenarios outcomes typically well below 1%. A nearly exact replication of the former SAS-based estimates could moreover be achieved by replicating the error in the new R implementation (Figure 16.3.7 right), demonstrating the innocuity of changing the software, and the R implementation was therefore retained for instilling further corrections and assessment purpose. The mistakes in French data were linked to a wrong discretization of the engine power (>75% of vessels misclassified; Figure 16.3.8 top-left) and an error in the estimate of percent saithe in the catch (in weight), which lead to about two thirds of the data entries to be formerly dismissed (Figure 16.3.8 top-right). Although a much more remarkable downscaling of the index while using the corrected series of data, the trends were still quite similar (Figure 16.3.8 bottom) and the impact on last year’s stock assessment outcomes (corrected French data up to 2019) fairly mild. The figures regarding the MSY scenarios, for instance, deviated by just about 1.5% for catch advices and forecasted SSB (after the TAC year), and by 0.6-1.5% for population-wide estimates (SSB, TSB, F_{bar}, recruitment) in the final year. WGNSSK agreed that the whole series should be updated for consistency.

The absence of effect of the above-mentioned corrections on the reference points estimates was further investigated and presented to the group (see dedicated section, 16.7.1 and working document in Annex 8).

The CPUE index continued to exhibit, in 2020, the decline observed over the last years (Figure 16.3.9), but not as steeply as the year before. Although the model was still performing decently, it showed once again signs of strains on assumptions, such as the absence of Year:Nation or Year:Area interactions. The inability of the model to account for spatial-temporal interactions, in particular, lead to strong residual patterns in space, fluctuating through time (Figure 16.3.10) which are in breach of the modelling assumptions regarding residuals independence and may lead to biases. A leave-one-nation-out analysis (Figure 16.3.11) shows a good consistency in the trends exhibited by data from different countries, except for a few years. The downwards trends in the last years of the series, in particular, is consistently captured by all three fleets, although with different magnitudes, and the observed variations may be linked to differences in spatial coverage among fleets (making the absence of Year:Nation interactions a minor concern).

Inspection of the commercial CPUE model assumptions and consideration of alternative modelling approaches have consequently been kept on the list of issues for the next benchmark, and mention to spatial-temporal modelling explicitly added.

16.4 Data analyses

16.4.1 Exploratory survey-based analyses

Numbers-at-age for saithe ages 3 to 8 (IBTS–Q3) on the log–scale, linked by cohort, showed year effects (for example, low values around 2010) (Figure 16.4.1, top-left panel). The ability to track cohorts has been diminished in later years of the survey (post-2000) (Figure 16.4.1, top right panel). The survey catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages (Figures 16.4.1, top-right panel, and 16.4.2). This is likely because age 3 fish are not consistently fully represented in the survey ("hook" patterns at age 3 in the abundances of some cohort: Figure 16.4.1, bottom-left); fish begin migrating out of the inshore nursery areas at age 3, but do not fully recruit to the more oceanic population (and fishery) until after age 5.

A high degree of uncertainty in the IBTS–Q3 index has been commented on previously (ICES 2016b), especially in terms of the influence of single samples that may influence the overall index, or lack of sampling of un-trawlable areas on the northern part of the shelf where dense aggregations are common. Despite this, the index is still currently used in the assessment, although it is clear that the assessment places more weight on the CPUE index, as observed in the leave-one-out analysis (see Section 16.4.4). IBTS–Q3 indices used in the final assessment are in Table 16.4.1.

16.4.2 Exploratory catch-at-age-based analyses

The outcome of WKNSEA 2016 was to remove the 3 CPUE series for the targeted trawl fisheries, partially due to concerns over using information in the catch-at-age matrix in both the CPUE and in the catch-at-age and because more weight was given to 3 indices within the former assessment model (artificially giving higher weighting to the CPUE indices). A standardized combined CPUE index was created for the French, German, and Norwegian trawl fleet targeting saithe, which was then tuned to the exploitable biomass, removing the need to use the information in the catch-at-age matrix twice (see ICES (2016b) for details).

The partial year effects for each of the main fleets show that CPUE declined in 2016 for all fleets, but the decline was most pronounced for the German fleet (ICES, 2017). Fleet restructuring has been occurring for several years within the German fleet and 2016 saw two vessels change to paired trawls (they are not included in the otter trawl CPUE index of 2016). In 2017 and 2018, these vessels returned to otter trawling. The fit of the CPUE to the exploitable biomass shows limited ability to render annual variations between 2010–2016, but then reflects well the index increase again in 2017 as well as the substantial decline in the following years (Figure 16.4.3). In addition to changes in resource abundance, the CPUE index may also reflect changes in the spatial distribution of the effort and/or resource, as well as a possible drift in fishing strategy and experience, which are not accounted for in the model and may in turn contribute to the weaker fit over some periods.

16.4.3 Assessments

The assessment of North Sea saithe was carried out using a state-space stock assessment model (SAM; Nielsen and Berg 2014; Berg and Nielsen 2016). The assessment was an update assessment. Settings used in the final assessment are given in Table 16.4.2.

16.4.4 Final assessment

Estimated fishing mortality-at-age are given in Table 16.4.3 and Figure 16.4.4. F for age 3 has declined drastically from 1990 and is now close to 0.1, while F for the older age classes has also decreased slightly until 2016. The change in F at age 3 occurred when the catches in the purse seine fishery declined. Age 4 moreover shows a declining trend in relative catchability in recent years (Figure 16.4.4, right panel). For ages 5+, catchability shows a dome shaped pattern, with highest catchability for age 6 in recent years. With the lower fishing mortalities up to 2016, fish have been allowed to increase in size (and age) and are likely targeted more than the younger age classes up to age 4 (as observed in Figure 16.4.4). Fishing mortality, in the last four years has however increased again for age classes 4+ (with a slight decrease in 2020, more pronounced for older ages), but recruitment was also very low from 2018 to 2020. Estimated population numbers-at-age are in Table 16.4.4.

The survey index at age fit and residuals are shown in Figure 16.4.5. They exhibit strong patterns, with a consistent underestimation over the last years. After accounting for the correlation between ages within years, the IBTS–Q3 residuals show less of a pattern (one-step ahead residuals, Figure 16.4.6). Even then, the DATRAS series reveals rather positive residuals for ages 4–7 in the last years, while the CPUE residuals shows consistent overestimation over the same period. This is likely due to conflicting signals borne by both sources of information. The strength of the correlation between survey residuals is strong between subsequent ages for all ages (Figure 16.4.7).

The retrospective analysis shows a retrospective pattern for SSB and F while recruitment is well estimated for the last 5 years (Figure 16.4.8). Although SSB tends to be overestimated and F to be underestimated, the peels for SSB all fall within the confidence intervals of the most recent assessment. For F, however, two out of five peels fall out of the confidence interval of the whole series, which may be due to the persistent mismatch of signals carried by the CPUE and survey indices. Mohn’s rho, estimated using the last 5 years, is 0.112 for SSB, -0.147 for F, and -0.034 for recruitment, all within acceptable limits.

The final assessment and leave-one out results are in Figure 16.4.9. Removing the IBTS Q3 indices leads to a slightly lower SSB and higher F, especially in the last 5 years. Conversely, using only the IBTS Q3 indices gives a distinctly more optimistic view of the stock and its exploitation level; the estimated SSB an F then fall outside of the 95% confidence interval of the final assessment in the three or four final years. Recruitment, on the other hand, is not as severely affected by the choice of data series and mostly exhibits slightly less optimistic estimates in “good recruitment years” when leaving the IBTS series out.

16.5 Historic stock trends

The historic stock and fishery trends from the final assessment are presented in Figure 16.5.1 and Table 16.5.1. Because of the inter-benchmark in January 2019, the historic perception of the stock has changed. Recruitment has been low and highly variable since 1990. Both 2015 and 2016 show slightly higher recruitment than the average of the last ten years, while 2018, 2019 and 2020 were the lowest estimates for the time series. SSB, has fluctuated around 195 000 tonnes in the 2010s, which is below the average of the 2000s (around 235 000 tonnes). Short term variations show a decline since 2017. The final year estimate of SSB is just above B_{pa} and MSY $B_{trigger}$, while survivors from 2020 amount for an SSB in 2021 below $B_{trigger}$ (not dependent on recruitment forecast assumption as the proportion mature at age 3 is null) but still above B_{lim}. Fishing mortality has generally declined since the mid–1980s but has exhibited a distinct raise over the last four years. Its hike seems to have been stopped in 2020 though. It is currently estimated to be above F_{MSY} but below F_{pa}.

16.6 Recruitment estimates

Currently, no independent survey provides an estimate of incoming recruitment. The resampling among 2011–2020 values (with a geometric mean about 71 million individuals) used in the short-term forecast is a conservative assumption taking into account recent low recruitment, although still considerably higher than the estimated recruitments for 2018–2020 (between 31 and 53 million individuals).

16.7 Short-term forecasts and reference points

16.7.1 Reference points update

While investigating possible effects of the corrected CPUE index on the reference points, mistakes were found in the way the reference points were evaluated during the last interbenchmark protocol (ICES, 2019a; hereafter referred to as "2019 IBP report"). Some reference point values (F_{lim}, F_{pa} and $F_{MSY\ upper}$) were based on EqSim simulations using the 2016 assessment results with 10 years of selectivity patterns, while the 2019 IBP report documented the decision of basing all reference points on the 2018 assessment outputs together with a limitation to selectivity patterns from the last five years (2013–2017). Investigations and corrections of mistakes from the 2019 IBP report are documented in the working document in Annex 8.

ICES (2021) further prescribed consistent used of "the fishing mortality including the advice rule that […] would lead to SSB ≥ B_{lim} with a 95% probability" ($F_{p.05}$) as the value for F_{pa}. The technical basis for F_{pa} was therefore changed accordingly and is also described in Annex 8.

The reference point reported in Table 16.7.2 reflect these changes.

16.7.2 Short-term forecast

A short-term forecast was carried out based on the final assessment.

Weight-at-age in the stock and catch were the mean values for the last 3 years. The exploitation pattern (selectivity pattern) was chosen as the mean exploitation pattern over the last three years scaled to $F_{4\text{–}7}$ in 2020. The fishing mortality in the intermediate year was F status quo, which, in 2021, leads to projected catches only a few tonnes away from the agreed TAC (65 687 tonnes; https://ec.europa.eu/oceans-and-fisheries/system/files/2021-03/2021-eu-uk-norway-fisheries-consultations_en.pdf). Population numbers-at-age for ages 4 and older in 2021 were survivor estimates, while numbers at age 3 were resampled from the past 10 years (2011–2020). The short-term projection was run in SAM.

The intermediate year assumptions for the short-term forecast are given in Table 16.7.1. Given the options above results in an F_{2021} of 0.45 and a SSB in 2022 of 127 092 tonnes, below MSY $B_{trigger}$ (149 098 tonnes). Reference points and their technical basis are in Table 16.7.2.

The management options are given in Table 16.7.3. Because reference points were re-estimated during the last inter-benchmark and Brexit, the management plan for this shared stock (EU, Norway and the UK – as of early 2021) is no longer in use (a new EU-Norway-UK management plan is under discussion); therefore, the MSY approach is used as the basis for advice. The total catch in 2022 is advised to be no more than 49 614 tonnes, where wanted catch is 46 644 tonnes; this is a 24% decrease when compared to the advised total catch in 2021, in part because of the standard advice rule being triggered due to the low projected SSB in 2022 (< $B_{trigger}$). More catch options can be found in Table 16.7.3.

The contribution of the 2013–2019 year-classes to landings in 2022 are shown in Table 16.7.4. The2016-2019 year-classes are expected to contribute the most to the landings in numbers, while landings weights should be dominated by the year-classes 2016-2018. The weaker 2015 year-class is expected to contribute substantially less. Recruitment at age 3 is not expected to contribute greatly to the catches in 2022; rather, ages 4–6 are the main contributors (59% of projected landings for 2022). This is clearly seen in the catch-at-age (Figure 16.3.5) and F at age (Figure 16.4.4).

16.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

16.9 Quality and benchmark planning

16.9.1 Quality of the assessment and forecast

Many of the issues noted after the benchmark and last years' assessment still hold.

The commercial CPUE indices may introduce biases into the assessment if changes in fishing patterns occur. Factors, such as vessel experience and fishing behaviour, likely contribute to the variability in CPUE for all fleets, but these factors are not captured in the CPUE model.

The scientific survey used in the assessment does not cover the whole stock distribution; however, it is considered generally representative. The number of observations (trawl stations) where saithe is caught is low, and can be influenced by occasional large catches. The resulting survey index is uncertain.

Conflicting signals between the survey and fishable biomass index contributes to the assessment uncertainty and a retrospective pattern observed.

The fraction of fish at age 3 migrating into the survey area (and the fishery) is low and varying between years with no obvious trend. Observations of saithe at age 3 are not suitable for predicting year class strength. This means that estimated recruitment values in the final assessment year are highly uncertain. Estimates of recruitment for a given year class tend to be revised considerably with successive assessments.

16.9.2 Issues for future benchmark

16.9.2.1 Data

Stock definition

The North Sea saithe stock is influenced by migrations to and from the North Sea. This can potentially lead to the observed year effects in survey indices. It needs to be analyzed if the inclusion of spawning grounds north of 62°N could improve the assessment. An intended tagging study (IMR) may help inform on this issue, although results would most probably not be available by the next benchmark.

New survey indices

IMR-Norway has set-up a new hydro-acoustic survey targeting spawning aggregations in Quarter 1. Germany has also participated in this survey in recent years. The inclusion of this survey in the assessment should be evaluated once a sufficiently long time series has been developed.

The inclusion of the summer acoustic series (Noracu – IMR), dropped from the assessment in 2016 on account of now addressed inconsistencies, should also be re-evaluated.

Catch-per-effort index

The current commercial CPUE index is standardized for fleet, area, quarter and engine power effects. The explanatory variables included should be reviewed (e.g. examine need for a vessel random effect) and alternative modelling approaches evaluated. The model in its current formulation cannot account for different dynamics in space (Figure 16.3.10). The prospect to include spatial-temporal interactions in the model should therefore also be evaluated. Furthermore, different countries seem to report data with different levels of aggregation (although this is difficult to formally investigate, given the sensitive nature of the commercial data). Weighting of observations (*e.g.*, based on effort) could therefore be additionally considered, and the associated risks of bias (or absence thereof) evaluated.

Maturity ogive

A constant over time maturity ogive is currently used in the assessment and exploration of recent data indicates possible deviations from this ogive. The assumption should be re-evaluated, especially in the light of improved sampling during the spawning season (Q1 acoustic survey).

16.9.2.2 Assessment

Variance by age

The last inter-benchmark for saithe in 2019 revealed that uncoupling of the variance parameters for the observations by age (i.e. age 3 receiving a separate parameter) could improve the model fit statistics (e.g. log-likelihood, AIC). This should be investigated further.

16.9.2.3 Forecast and reference points

Forecast

The SAM forecast assumption for recruitment is based on resampling from historical recruitment values from a defined number of historical years. Depending on the time-series, this may result in a bimodal distribution for the assumed recruitment in forecasted years. Forecasted numbers (and SSB) are likely to be smoother in their distribution due to forecast stochasticity, but the effect of this behaviour on advice should be investigated further. Use of a geometric mean of historical recruitment is not currently possible in SAM, but could be suggested in order to reduce this effect.

The setting of a random seed value is important for comparing between forecast scenarios. Forecast scenarios involving a prescribed F had consistent median recruitment; however, scenarios that solve for an F that results in a given stock size (e.g. $SSB_{(2022)} = B_{pa}$ or B_{lim} scenarios), which involve a further iteration process with additional random number generation, resulted in different median recruitment values. This is a reporting issue that arise from instability of the median value resampled from an even number of values (while a reported geometric mean would be more stable, and often more informative). It does not affect the quality of the assessment, only the consistency of reported figures. We have therefore made the choice, since the 2020 assessment, to report the geometric mean of resampled recruitments values in the forecast assumption (not to be mistaken for the use of a geometric mean in the forecast).

Reference points

The effect of the current low productivity regime of the stock (i.e. lower recruitment) on reference points should be investigated.

16.10 Status of the stock

Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.

16.11 Management considerations

The assessment is sensitive to relatively small changes in the input data. Because this stock suffers from 'poor data', the assessment is relatively uncertain. Recruitment is currently at a low level and it appears that strong recruitment pulses are more sporadic than in the past.

The reported landings have been relatively stable since the early 1990s. Landings have been lower than the TAC in most years since 2002, despite the reductions in the TAC between 2013 and 2016.

Information from fishers' survey (Napier, 2014) has been moved to the Stock Annex.

Bycatch of other demersal fish species does occur in the target trawl fishery for saithe. Saithe is also taken as unintentional bycatch in other fisheries, and discards do occur.

16.11.1 Evaluation of the management plan

Because reference points were re-estimated after the inter-benchmark, the management plan is no longer valid. New EU/Norway management strategies have been proposed and evaluated (ICES, 2019b).

16.12 References

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Table 16.3.1. Saithe in subareas 4 and 6 and Division 3.a. Official nominal landings (tonnes) of saithe by nation, 2005–2020. ICES estimates are landings reported to ICES and the Working Group.

	Subarea 4 and Division 3.a															
Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019***	**2020***
Belgium	28	15	18	7	27	15	2	2	3	5	6	16	15	14	7	5
Denmark	7498	7471	5443	8068	8802	8018	6331	5171	5695	4913	4512	4084	5690	7017	5275	3777
Faroe Isl.	463	60	15	108	841	146	2	8	3	1	0	18	16	4	5	28
France	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7910	11574	10794	10334	12598	11366	9487
Germany	12401	14397	12791	14140	13410	11193	10234	8052	9690	8602	7954	6279	7943	7952	7048	6853
Greenland	1042	924	564	888	927	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	1	0	0	0	0	0	0	0	0	0	<1	4
Lithuania	149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Netherlands	40	28	5	3	16	3	24	34	168	43	75	112	191	267	178	181
Norway	68122	61318	45396	61464	57708	52712	46809	33288	35701	37519	35631	31596	49580	38787	50311	39630
Poland	1100	1084	1384	1407	988	654	584	0	0	0	0	0	0	0	0	0
Portugal		228	68											0		0
Russia	35	2	5	5	13	0	0	0	0	0	0	0	0	0	0	0
Sweden	2132	1746	1381	1639	1363	1545	1335	1306	1402	1329	1156	1198	1186	1316	1409	1181
UK (E/W/NI)	960	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	687	8888**	8561**	8640**	12575**	11875**	8557**
UK (Scotland)	6170									7686						
Total reported	111970	113354	91778	115414	103883	90755	89427	69241	71516	68695	69796	62658	83594	80531	87473	69705
Unallocated	1418	−1509	824	57	2090	6012	2101	1623	−110	677	−393	-154	−2024	1335	176	153
BMS landings													< 1	11	20	10
ICES estimate	113388	111845	92602	115471	105973	96767	91528	70864	71406	69372	69403	62504#	81570#	81866#	87649#	69858
TAC	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696	100287ǂǂ	105793ǂǂ	93614	79813

*** Official values are preliminary.**
**** Scotland+E/W/NI combined.**
ǂǂ Includes top-up (4.1% in 2017, 12.57% in 2018)
 # Since 2016, landings correspond to wanted catch, which includes the Norwegian component of BMS landings.

	Subarea 6															
Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019***	**2020***
Denmark	0	0	0	0	0	0	0	0	0	20	0	0	5	1	7	0
Faroe Islands	25	76	32	23	60	24	5	6	25	29	3	7	13	21	7	3
France	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2299	3968	3626	1335	1263
Germany	373	532	580	148	298	257	0	9	0	0	0	9	< 1	<1	<1	0
Ireland	168	267	322	288	407	520	359	364	313	128	105	185	171	231	109	125
Netherlands	0	3	36	1	0	0	0	0	0	0	6	12	3	100	4	<1
Norway	20	28	377	78	68	121	240	5	715	442	677	555	633	955	478	1
Russia	25	7	2	50	4	2	0	0	0	9	1	0	2	0	2	0
Spain	3	6	3	4	8	18	31	13	21	9	15	15	4	7	24	15
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK (E/W/NI)	133	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	97	3286**	2770**	2652**	2764**	2822**	2666**
UK (Scotland)	2922									3191						
Total reported	7623	9759	7103	7717	6438	6118	7492	7558	8534	6829	7577	5852	7453	7706	4787	4074
Unallocated	−1167	−1191	−501	−1005	−144	145	−575	−9	119	191	−43	−279	−337	-1065	88	7
BMS landings													0	31	<1	<1
ICES estimate	6456	8568	6602	6712	6294	6263	6917	7549	8653	7020	7534	5573 ǂ	7116 ǂ	6641 ǂ	4875 ǂ	4081 ǂ
TAC	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816	10404 ǂǂ	10215ǂǂ	9713	8280

*** Official values are preliminary.**

**** Scotland+E/W/NI combined.**

ǂ Does not include BMS landings.

ǂǂ Includes top-up (4.1% in 2017, 4.76% in 2018).

	Subareas 4 and 6 and Division 3.a															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ICES estimate	119844	121320	99204	122184	112267	103030	98446	78414	80059	76392	76936	68709 #	88686 #	88507 #	92524 #	73938 #
TAC	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512	110691 ǂǂ	116008 ǂǂ	103327	88093 ǂǂ

ǂǂ Agreed upon TAC including landings top-up.

 # Since 2016, landings correspond to wanted catch, which includes Norwegian component of BMS landings.

Table 16.3.2. Saithe in subareas 4 and 6 and Division 3.a. Catch data (2020; all ages, not the sum over products for ages 3–10+ used in the assessment) imported into InterCatch and proportion of sampling strata for discards raised within InterCatch.

		2020	
Catch Category	**Raised or Imported**	**Weight (tonnes)**	**Proportion**
BMS landing	Imported data	5.2	100
Discards	Imported data	2933	92
Discards	Raised discards	248	8
Landings	Imported data	73868	100
Logbook registered discard	Imported data	0	0

Table 16.3.3. Saithe in subareas 4 and 6 and Division 3.a. Working Group estimates of catch components by weight (t) for ages 3–10+, as used in the assessment. Norway was under landings obligations since 1988, but records are unclear whether saithe was fully in the landings obligation from that time.

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
1967	101331	88339		12992	13
1968	134559	113741		20818	15
1969	150293	130580		19713	13
1970	270829	235012		35817	13
1971	309177	265356		43821	14
1972	296481	261914		34567	12
1973	275164	242513		32651	12
1974	337021	298347		38674	11
1975	304645	271610		33035	11
1976	423347	343898		79449	19
1977	239913	216393		23520	10
1978	176851	155124		21727	12
1979	142647	128352		14295	10
1980	145289	131897		13392	9
1981	148244	132273		15971	11
1982	202111	174336		27775	14
1983	203018	180040		22978	11
1984	240566	200843		39723	17
1985	273672	220870		52802	19
1986	232795	198605		34190	15
1987	192380	167503		24877	13
1988	154252	135176		19076	12
1989	124599	108892		15707	13
1990	124450	103831		20619	17
1991	130973	108071		22902	17
1992	115537	99745		15792	14
1993	132618	111499		21119	16

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
1994	126759	109621		17138	14
1995	141190	121795		19395	14
1996	128896	114968		13928	11
1997	120103	107348		12755	11
1998	117222	106126		11096	9
1999	119467	110531		8936	7
2000	93795	85781		8014	9
2001	102859	91741		11118	11
2002	129847	110911		18936	15
2003	121656	110282		11374	9
2004	113792	107356		6436	6
2005	121217	118625		2592	2
2006	128711	120414		8297	6
2007	106333	94958		11375	11
2008	129887	121618		8269	6
2009	114520	110972		3548	3
2010	104723	102128		2595	2
2011	102006	98034		3972	4
2012	87049	78144		8905	10
2013	87271	79859		7412	8
2014	82172	76057		6115	7
2015	81445	76748		4697	6
2016	77672	67620[#]	0	10052[##]	13
2017	94581.5	88010[#]	0.5	6571[##]	7
2018	95447	88328[#]	42	7076[##]	7
2019^	96634	92390[#]	19.85	4224[##]	4
2020	76820	73791	10	3019[##]	4

 # Since 2016, landings include the Norwegian component of BMS landings.

Since 2016, discards minus BMS landings from EU fleets officially reported in logbooks.

^ Includes 937 tonnes of missing Swedish landings and corresponding 109 tonnes of discards (based on discard rate estimated in division 4.a).

Table 16.3.4. Saithe in subareas 4 and 6 and Division 3.a. Amount (weight and proportion) of sampled or estimated age distributions of catch data (2020) imported or raised in InterCatch. Weight in tonnes corresponds to the catch in tonnes imported for all ages, and not to the SOP used in the assessment for ages 3–10+).

Catch Category	Raised or Imported	Sampled or Estimated	2020	
			Weight	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	0
Landings	Imported_Data	Sampled_Distribution	49998	68
Landings	Imported_Data	Estimated_Distribution	23871	32
Discards	Imported_Data	Sampled_Distribution	2919	92
Discards	Raised_Discards	Estimated_Distribution	247 5	8
Discards	Imported_Data	Estimated_Distribution	13.94	<1
BMS landing	Imported_Data	Sampled_Distribution	0	0
BMS landing	Imported_Data	Estimated_Distribution	5.243	100

Table 16.3.5. Saithe in subareas 4 and 6 and Division 3.a. Catch numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	26948	19395	16672	2358	1610	299	203	185
1968	36111	25387	14153	6166	433	247	127	147
1969	47014	21142	11869	7790	5795	810	642	151
1970	57920	91668	16102	12416	3932	1834	326	270
1971	108549	69105	35143	4848	4290	2910	1922	782
1972	74755	79033	27178	21711	3709	3014	1682	1625
1973	84484	45078	28822	16443	8511	2047	1391	2407
1974	104086	40345	15160	21179	14810	5321	1514	1977
1975	88613	30927	11077	7746	13792	9577	3591	2717
1976	323156	63447	12556	6401	4016	5488	3678	3528
1977	42701	65727	15839	5620	3814	3528	3909	4753
1978	54515	32608	19389	3390	1149	1057	788	3522
1979	25395	16999	12004	8906	2833	750	554	2112
1980	27203	14757	9677	6878	5714	1177	522	2327
1981	40705	9971	7235	3763	3368	3475	674	2564
1982	49595	48533	9848	6120	2166	1489	1007	1268
1983	43916	24637	27924	5813	4942	1529	1062	1342
1984	125848	38470	13910	13320	1673	1281	344	653
1985	208401	66489	14257	4878	3034	698	409	750
1986	86198	109080	16302	5509	2629	1490	457	910
1987	48545	116551	15019	3233	1829	1269	933	707
1988	50657	31577	37919	3918	1927	1130	796	687
1989	34408	36772	14156	11211	1572	757	430	493
1990	63454	23416	12154	4826	2803	762	288	368
1991	71710	35719	8016	3669	1733	976	376	463

Year/Age	3	4	5	6	7	8	9	10+
1992	28617	40193	13691	3269	1539	712	531	426
1993	58813	24905	12715	3199	1583	1547	835	1037
1994	31034	48062	13992	4399	957	354	438	803
1995	41461	31130	15884	3864	3529	690	566	809
1996	17208	46468	12653	7915	3194	827	215	496
1997	23380	23077	32395	3763	2666	1036	299	292
1998	16113	37088	17570	16459	2253	1234	581	280
1999	14661	16588	28645	8588	10169	2401	914	665
2000	10985	20680	9597	12632	3190	3302	657	446
2001	24961	21100	24068	3429	3621	1814	1655	248
2002	17570	37489	14736	13731	2309	2544	1321	1575
2003	28296	31752	20631	6836	6855	1535	2000	2042
2004	13642	24479	15649	15220	2037	2164	1300	1066
2005	12690	15473	19060	20042	7956	1628	1188	1151
2006	17313	31972	10381	11286	8395	3824	1008	1281
2007	24614	13314	20919	7175	5564	3610	1218	930
2008	7620	30911	12540	14941	5088	3285	3551	3118
2009	7438	15507	14222	5847	8512	2994	1519	2945
2010	8766	9249	9440	6511	2671	4773	1679	2707
2011	12786	24269	8980	3674	2867	1208	1564	3877
2012	14334	13053	16948	4075	1977	1268	541	2611
2013	7267	30318	5312	7869	1890	1241	616	1658
2014	4055	14322	15195	3957	4124	1040	429	1389
2015	8369	8323	14259	8254	1862	1623	715	977
2016	7382	14241	9661	5729	2758	1430	853	1317
2017	4977	18989	9773	6247	5364	1876	820	1113
2018	2603	16250	18858	7376	2142	2027	978	1178
2019	6240	8570	14841	10394	2881	1127	1027	1236
2020	2511	11823	7627	7436	4246	967	381	627

Table 16.3.6. Saithe in subareas 4 and 6 and Division 3.a. Landings numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	17330	16220	15531	2303	1594	292	198	183
1968	23223	21231	13184	6023	429	242	123	145
1969	30235	17681	11057	7609	5738	791	626	150
1970	37249	76661	15000	12128	3894	1792	318	267
1971	69808	57792	32737	4736	4248	2843	1874	774
1972	48075	66095	25317	21207	3672	2944	1641	1607
1973	54332	37698	26849	16061	8428	2000	1357	2381
1974	66938	33740	14123	20688	14666	5199	1477	1955
1975	56987	25864	10319	7566	13657	9357	3501	2687
1976	207823	53060	11696	6253	3976	5362	3586	3490
1977	27461	54967	14755	5490	3777	3447	3812	4701
1978	35059	27269	18062	3312	1138	1033	768	3484
1979	16332	14216	11182	8699	2805	733	540	2089
1980	17494	12341	9015	6718	5658	1150	509	2302
1981	26178	8339	6739	3675	3335	3396	657	2536
1982	31895	40587	9174	5978	2145	1454	982	1254
1983	28242	20604	26013	5678	4893	1494	1036	1327
1984	80933	32172	12957	13011	1657	1252	335	646
1985	134024	55605	13281	4765	3005	682	399	742
1986	55435	91223	15186	5381	2603	1456	445	900
1987	31220	97470	13990	3158	1811	1240	910	700
1988	32578	26408	35323	3828	1908	1104	776	680
1989	22128	30752	13187	10951	1557	739	419	488
1990	40808	19583	11322	4714	2776	745	281	364
1991	46117	29871	7467	3583	1716	953	367	458
1992	18404	33614	12753	3193	1524	696	518	422
1993	37823	20828	11845	3125	1568	1511	814	1026
1994	19958	40193	13034	4297	947	346	427	794
1995	26664	26034	14797	3774	3494	674	552	800
1996	11066	38861	11786	7731	3163	808	210	491
1997	15036	19299	30177	3676	2640	1012	291	288
1998	10363	31017	16367	16077	2231	1206	567	277
1999	9429	13872	26684	8389	10070	2346	891	657
2000	7064	17295	8940	12339	3159	3226	641	441
2001	16052	17646	22421	3349	3586	1772	1614	245
2002	9131	31779	12286	13307	2245	2220	1199	1479
2003	13009	24646	20397	6836	6855	1535	2000	2042
2004	8037	20071	15649	15220	2037	2164	1300	1066
2005	9191	15473	19060	20042	7956	1628	1188	1151

Year/Age	3	4	5	6	7	8	9	10+
2006	12200	26690	9986	11286	8395	3824	1008	1281
2007	15181	10163	19157	7078	5564	3610	1218	930
2008	6924	23230	10930	14196	4977	3276	3551	3118
2009	6607	14349	13827	5817	8419	2978	1505	2934
2010	7880	8859	9174	6394	2670	4762	1679	2669
2011	10150	22799	8852	3630	2860	1183	1563	3869
2012	7029	11712	15572	4016	1971	1267	537	2610
2013	4999	25516	4974	7645	1886	1241	616	1658
2014	3099	12117	13380	3737	4047	1036	429	1388
2015	6206	7392	13555	8021	1844	1621	715	975
2016	3508	10374	8756	5156	2732	1423	852	1317
2017	3033	15139	8795	6179	5362	1876	820	1111
2018	2017	12994	16936	7043	2125	2016	976	1177
2019	5456	8125	13826	9797	2842	1116	1025	1235
2020	1997	10870	7243	7326	4113	959	377	619

Table 16.3.7. Saithe in subareas 4 and 6 and Division 3.a. Discards numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	9617	3175	1141	55	16	7	5	2
1968	12888	4156	969	143	4	6	3	2
1969	16779	3461	813	181	57	19	16	2
1970	20671	15007	1102	288	38	42	8	3
1971	38741	11313	2406	112	42	67	48	9
1972	26680	12938	1861	504	36	69	42	18
1973	30152	7380	1973	381	83	47	35	26
1974	37148	6605	1038	491	144	122	38	22
1975	31626	5063	758	180	135	220	89	30
1976	115333	10387	860	148	39	126	92	38
1977	15240	10760	1084	130	37	81	97	52
1978	19456	5338	1327	79	11	24	20	38
1979	9063	2783	822	207	28	17	14	23
1980	9709	2416	662	160	56	27	13	25
1981	14527	1632	495	87	33	80	17	28
1982	17700	7945	674	142	21	34	25	14
1983	15673	4033	1912	135	48	35	26	15
1984	44915	6298	952	309	16	29	9	7
1985	74378	10885	976	113	30	16	10	8
1986	30764	17857	1116	128	26	34	11	10
1987	17326	19080	1028	75	18	29	23	8

Year/Age	3	4	5	6	7	8	9	10+
1988	18079	5169	2596	91	19	26	20	7
1989	12280	6020	969	260	15	17	11	5
1990	22647	3833	832	112	27	18	7	4
1991	25593	5847	549	85	17	22	9	5
1992	10213	6580	937	76	15	16	13	5
1993	20990	4077	871	74	15	36	21	11
1994	11076	7868	958	102	9	8	11	9
1995	14797	5096	1087	90	34	16	14	9
1996	6141	7607	866	184	31	19	5	5
1997	8344	3778	2218	87	26	24	7	3
1998	5751	6072	1203	382	22	28	14	3
1999	5233	2716	1961	199	99	55	23	7
2000	3920	3386	657	293	31	76	16	5
2001	8908	3454	1648	80	35	42	41	3
2002	8439	5710	2451	425	64	324	121	96
2003	15288	7106	234	0	0	0	0	0
2004	5605	4407	0	0	0	0	0	0
2005	3498	0	0	0	0	0	0	0
2006	5114	5282	394	0	0	0	0	0
2007	9433	3152	1762	97	0	0	0	0
2008	696	7682	1610	745	111	9	0	0
2009	831	1158	395	30	93	16	14	11
2010	886	390	266	117	1	11	0	38
2011	2636	1470	129	44	7	25	1	8
2012	7305	1341	1377	58	7	1	4	1
2013	2268	4801	339	224	4	0	0	1
2014	955	2205	1816	220	77	4	0	1
2015	2163	931	704	232	17	3	0	2
2016	3874	3867	905	573	26	7	1	0
2017	1943	3850	978	69	2	0	0	2
2018	586	3256	1922	333	17	11	2	1
2019	785	445	1016	597	39	11	1	1
2020	514	953	383	110	133	8	4	8

Table 16.3.8. Saithe in subareas 4 and 6 and Division 3.a. Catch weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.898	1.339	2.094	3.183	3.753	5.316	5.891	7.719
1968	1.234	1.624	1.979	3.007	4.039	4.428	6.136	7.406
1969	0.933	1.530	2.251	2.711	3.558	4.406	5.220	6.767
1970	0.908	1.416	2.049	2.716	3.599	4.463	5.687	6.845
1971	0.811	1.325	2.167	2.934	3.765	4.634	5.172	6.163
1972	0.780	1.175	1.952	2.367	3.793	4.228	4.630	6.326
1973	0.792	1.382	1.633	2.569	3.356	4.684	4.814	6.445
1974	0.831	1.534	2.372	2.751	3.428	4.498	5.713	7.857
1975	0.862	1.472	2.479	3.298	3.764	4.296	5.540	7.562
1976	0.678	1.287	2.250	3.068	4.034	4.383	5.112	7.147
1977	0.733	1.234	1.926	3.108	4.161	4.605	4.859	6.542
1978	0.793	1.304	2.145	3.338	4.521	4.900	5.449	7.400
1979	1.069	1.595	2.228	3.093	4.049	5.274	6.308	7.955
1980	0.921	1.790	2.380	3.028	4.089	5.126	5.939	8.148
1981	0.927	1.790	2.705	3.584	4.535	5.478	6.980	8.724
1982	1.048	1.548	2.518	3.218	4.206	5.125	5.905	8.823
1983	0.992	1.688	2.139	3.135	3.690	4.632	5.505	8.453
1984	0.767	1.586	2.286	2.688	3.895	4.665	6.183	8.474
1985	0.640	1.244	1.941	2.769	3.406	4.950	5.865	8.854
1986	0.670	1.018	1.786	2.430	3.571	4.209	5.651	8.218
1987	0.650	0.861	1.815	3.072	4.209	5.330	6.128	8.603
1988	0.752	0.964	1.379	2.789	4.023	5.254	6.322	8.649
1989	0.864	1.018	1.413	1.997	3.913	5.017	6.430	8.431
1990	0.815	1.175	1.575	2.245	3.241	4.858	6.315	8.416
1991	0.764	1.138	1.744	2.363	3.165	4.222	6.066	8.191
1992	0.930	1.169	1.599	2.240	3.667	4.330	5.412	7.045
1993	0.868	1.239	1.746	2.634	3.184	3.980	5.080	6.891
1994	0.911	1.100	1.594	2.432	3.617	4.787	6.548	8.326
1995	0.967	1.272	1.807	2.560	3.554	4.767	5.267	7.891
1996	0.933	1.167	1.798	2.366	2.951	4.705	6.092	8.382
1997	0.873	1.125	1.445	2.585	3.555	4.525	6.158	8.866
1998	0.861	0.949	1.386	1.743	2.948	3.883	4.996	7.227
1999	0.850	1.042	1.206	1.752	2.337	3.493	4.844	6.745
2000	0.992	1.107	1.532	1.683	2.593	3.084	4.773	7.461
2001	0.774	1.053	1.307	2.093	2.546	3.485	4.141	6.141
2002	0.776	1.014	1.495	1.791	2.961	3.761	4.638	5.750
2003	0.636	0.889	1.167	1.810	2.368	3.176	3.768	5.065
2004	0.794	1.010	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.715	1.155	1.325	1.710	2.132	3.026	3.622	5.713

Year/Age	3	4	5	6	7	8	9	10+
2006	0.904	1.012	1.489	1.906	2.424	3.058	4.318	5.734
2007	0.769	1.124	1.286	1.834	2.328	2.887	3.600	4.975
2008	0.916	1.065	1.488	1.692	2.210	2.792	3.206	4.565
2009	1.033	1.333	1.672	1.994	2.566	3.086	3.651	4.790
2010	1.037	1.474	2.033	2.597	3.163	3.488	3.968	5.223
2011	0.955	1.192	1.787	2.571	3.068	3.418	3.718	4.289
2012	0.910	1.287	1.383	2.196	3.221	3.536	4.181	4.482
2013	0.878	1.132	1.586	1.957	3.076	3.841	4.541	5.648
2014	1.091	1.265	1.568	2.334	2.607	4.010	5.530	6.679
2015	0.951	1.253	1.621	2.180	3.037	3.793	4.228	7.285
2016	0.937	1.239	1.611	2.231	2.888	3.450	4.331	6.208
2017	0.956	1.228	1.755	2.356	2.987	4.232	4.473	6.287
2018	1.095	1.239	1.549	2.234	3.112	3.867	4.465	6.708
2019	1.133	1.442	1.809	2.320	3.081	3.897	4.677	6.613
2020	1.061	1.529	1.914	2.439	3.106	4.038	4.918	6.985

Table 16.3.9. Saithe in subareas 4 and 6 and Division 3.a. Landings weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.931	1.362	2.104	3.186	3.754	5.316	5.891	7.719
1968	1.278	1.652	1.989	3.009	4.040	4.428	6.136	7.406
1969	0.966	1.557	2.261	2.713	3.559	4.406	5.220	6.768
1970	0.941	1.441	2.059	2.718	3.600	4.463	5.687	6.845
1971	0.840	1.348	2.178	2.936	3.766	4.634	5.173	6.163
1972	0.808	1.196	1.961	2.369	3.794	4.228	4.630	6.326
1973	0.821	1.406	1.641	2.571	3.357	4.684	4.814	6.445
1974	0.861	1.561	2.383	2.753	3.429	4.498	5.713	7.857
1975	0.893	1.498	2.490	3.300	3.765	4.296	5.540	7.562
1976	0.702	1.309	2.260	3.071	4.035	4.383	5.112	7.147
1977	0.760	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.340	4.522	4.901	5.449	7.400
1979	1.107	1.623	2.238	3.095	4.050	5.274	6.308	7.955
1980	0.955	1.821	2.391	3.030	4.090	5.126	5.939	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.980	8.724
1982	1.086	1.575	2.529	3.220	4.207	5.125	5.905	8.823
1983	1.028	1.718	2.149	3.138	3.691	4.632	5.505	8.453
1984	0.795	1.614	2.297	2.690	3.896	4.665	6.183	8.474
1985	0.663	1.265	1.951	2.772	3.407	4.950	5.865	8.854
1986	0.694	1.035	1.794	2.432	3.572	4.209	5.651	8.218
1987	0.674	0.876	1.824	3.075	4.210	5.330	6.128	8.603
1988	0.779	0.981	1.386	2.791	4.024	5.254	6.322	8.649

Year/Age	3	4	5	6	7	8	9	10+
1989	0.895	1.036	1.420	1.998	3.914	5.018	6.430	8.431
1990	0.844	1.196	1.583	2.247	3.242	4.858	6.315	8.416
1991	0.791	1.158	1.752	2.365	3.165	4.222	6.066	8.191
1992	0.964	1.189	1.607	2.242	3.668	4.330	5.413	7.046
1993	0.899	1.260	1.754	2.636	3.185	3.980	5.080	6.891
1994	0.944	1.119	1.601	2.434	3.618	4.787	6.548	8.326
1995	1.002	1.294	1.816	2.562	3.555	4.767	5.267	7.891
1996	0.967	1.187	1.807	2.368	2.952	4.705	6.092	8.382
1997	0.905	1.145	1.452	2.587	3.556	4.525	6.158	8.866
1998	0.892	0.966	1.393	1.744	2.949	3.883	4.996	7.227
1999	0.881	1.061	1.211	1.754	2.337	3.493	4.844	6.745
2000	1.027	1.127	1.539	1.684	2.594	3.084	4.773	7.462
2001	0.802	1.072	1.313	2.095	2.546	3.485	4.141	6.141
2002	0.923	1.035	1.478	1.769	2.947	3.426	4.407	5.674
2003	0.833	0.980	1.173	1.810	2.368	3.176	3.768	5.065
2004	0.918	1.084	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.921	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.945	1.069	1.514	1.906	2.424	3.058	4.318	5.734
2007	0.837	1.143	1.317	1.840	2.328	2.887	3.600	4.975
2008	0.944	1.193	1.565	1.720	2.226	2.795	3.206	4.565
2009	1.036	1.340	1.664	1.992	2.563	3.085	3.648	4.793
2010	1.036	1.479	2.034	2.597	3.164	3.488	3.968	5.199
2011	1.007	1.207	1.783	2.573	3.068	3.404	3.717	4.284
2012	1.015	1.321	1.408	2.201	3.223	3.536	4.177	4.482
2013	0.898	1.156	1.614	1.976	3.078	3.841	4.541	5.648
2014	1.126	1.300	1.607	2.384	2.617	4.013	5.530	6.679
2015	0.977	1.244	1.625	2.190	3.043	3.796	4.228	7.287
2016	0.998	1.292	1.628	2.283	2.892	3.453	4.333	6.208
2017	1.047	1.302	1.809	2.361	2.988	4.232	4.473	6.292
2018	1.153	1.287	1.575	2.266	3.107	3.868	4.463	6.707
2019	1.147	1.448	1.829	2.343	3.094	3.905	4.680	6.616
2020	1.066	1.542	1.938	2.447	3.132	4.043	4.912	6.984

Table 16.3.10. Saithe in subareas 4 and 6 and Division 3.a. Discards weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.748	1.076	1.818	2.972	3.590	5.316	5.891	7.719
1968	1.028	1.306	1.719	2.808	3.864	4.428	6.136	7.406
1969	0.777	1.230	1.955	2.531	3.403	4.406	5.220	6.767
1970	0.757	1.139	1.780	2.536	3.442	4.463	5.687	6.845
1971	0.676	1.065	1.882	2.739	3.601	4.634	5.172	6.163
1972	0.650	0.945	1.695	2.210	3.628	4.228	4.630	6.326
1973	0.660	1.111	1.419	2.399	3.210	4.684	4.814	6.445
1974	0.692	1.233	2.060	2.568	3.279	4.498	5.713	7.857
1975	0.718	1.184	2.153	3.079	3.600	4.296	5.540	7.562
1976	0.565	1.035	1.954	2.865	3.858	4.383	5.112	7.147
1977	0.611	0.993	1.673	2.902	3.980	4.605	4.859	6.542
1978	0.661	1.049	1.862	3.116	4.325	4.900	5.449	7.400
1979	0.890	1.283	1.935	2.888	3.873	5.274	6.308	7.955
1980	0.768	1.439	2.067	2.827	3.911	5.126	5.939	8.148
1981	0.773	1.439	2.349	3.346	4.338	5.478	6.980	8.724
1982	0.873	1.245	2.186	3.004	4.023	5.125	5.905	8.823
1983	0.826	1.358	1.858	2.927	3.529	4.632	5.505	8.453
1984	0.639	1.276	1.985	2.510	3.726	4.665	6.183	8.474
1985	0.533	1.000	1.686	2.586	3.258	4.950	5.865	8.854
1986	0.558	0.818	1.551	2.269	3.416	4.209	5.651	8.218
1987	0.542	0.693	1.576	2.869	4.026	5.330	6.128	8.603
1988	0.626	0.775	1.198	2.604	3.848	5.254	6.322	8.649
1989	0.720	0.819	1.227	1.865	3.743	5.017	6.430	8.431
1990	0.679	0.945	1.368	2.097	3.100	4.858	6.315	8.416
1991	0.636	0.915	1.515	2.206	3.027	4.222	6.066	8.191
1992	0.775	0.940	1.389	2.092	3.508	4.330	5.412	7.045
1993	0.723	0.996	1.517	2.460	3.046	3.980	5.080	6.891
1994	0.759	0.884	1.384	2.271	3.459	4.787	6.548	8.326
1995	0.806	1.023	1.570	2.390	3.400	4.767	5.267	7.891
1996	0.778	0.938	1.562	2.209	2.823	4.705	6.092	8.382
1997	0.728	0.905	1.255	2.413	3.400	4.525	6.158	8.866
1998	0.717	0.764	1.204	1.627	2.820	3.883	4.996	7.227
1999	0.708	0.838	1.047	1.636	2.235	3.493	4.844	6.745
2000	0.826	0.890	1.330	1.571	2.480	3.084	4.773	7.461
2001	0.645	0.847	1.135	1.955	2.435	3.485	4.141	6.141
2002	0.616	0.896	1.580	2.483	3.469	6.058	6.935	6.927
2003	0.469	0.571	0.641	1.689	2.265	3.176	3.768	5.065
2004	0.617	0.676	1.203	1.769	2.735	3.687	4.814	7.059
2005	0.741	0.913	1.146	1.595	2.038	3.026	3.622	5.713

Year/Age	3	4	5	6	7	8	9	10+
2006	0.808	0.724	0.859	1.778	2.318	3.058	4.318	5.734
2007	0.660	1.062	0.949	1.365	2.227	2.887	3.600	4.975
2008	0.633	0.680	0.967	1.161	1.495	1.820	3.206	2.797
2009	1.010	1.253	1.946	2.403	2.838	3.388	3.934	3.911
2010	1.046	1.374	1.987	2.561	3.025	3.351	3.968	6.895
2011	0.756	0.971	2.054	2.445	3.170	4.072	4.369	6.618
2012	0.808	0.997	1.101	1.831	2.675	3.411	4.804	5.313
2013	0.835	1.003	1.180	1.300	2.298	3.841	4.541	5.861
2014	0.977	1.072	1.274	1.487	2.077	3.223	5.530	7.568
2015	0.877	1.326	1.531	1.848	2.410	2.184	4.228	5.911
2016	0.882	1.096	1.440	1.764	2.384	2.864	2.634	4.282
2017	0.815	0.937	1.269	1.907	2.484	4.232	4.473	2.817
2018	0.894	1.049	1.318	1.554	3.770	3.715	5.371	7.697
2019	1.033	1.336	1.537	1.932	2.162	2.991	2.816	2.969
2020	1.042	1.379	1.456	1.937	2.306	3.448	5.480	7.101

Table 16.4.1. Saithe in subareas 4 and 6 and Division 3.a. Data available for calibration of the final assessment. Indices include one commercial standardized CPUE index (year effects), tuned to the exploitable biomass within SAM, and indices for age 3–8 from one research survey, the third quarter NS-IBTS.

Year	IBTS–Q3 (DATRAS standard index)						CPUE
	3	4	5	6	7	8	
1992	1.077	2.760	0.516	0.098	0.057	0.050	
1993	7.965	2.781	1.129	0.197	0.011	0.040	
1994	1.117	1.615	0.893	0.609	0.091	0.040	
1995	13.959	2.501	1.559	0.533	0.172	0.049	
1996	3.825	6.533	1.112	0.971	0.212	0.069	
1997	3.756	3.351	7.461	0.698	0.534	0.181	
1998	1.181	4.134	1.351	1.580	0.149	0.179	
1999	2.086	1.907	3.155	0.619	0.632	0.074	
2000	3.479	8.836	1.081	0.868	0.114	0.152	2.240
2001	21.475	6.169	3.936	0.356	0.444	0.113	2.155
2002	10.748	18.974	1.327	1.090	0.162	0.264	1.824
2003	19.272	23.802	13.402	0.393	0.439	0.168	1.687
2004	4.930	6.727	3.237	0.921	0.064	0.085	2.064
2005	8.916	7.512	4.428	1.914	1.082	0.104	2.149
2006	10.553	29.579	2.835	1.177	0.445	0.242	2.265
2007	34.006	5.578	11.700	1.016	0.743	0.358	1.961
2008	3.312	5.584	0.907	1.997	0.254	0.254	2.165
2009	1.346	1.703	0.568	0.101	0.229	0.200	1.775
2010	1.361	0.964	0.471	0.205	0.045	0.166	1.644
2011	4.520	8.451	1.059	1.114	0.426	0.080	1.740
2012	11.134	2.497	2.968	0.503	0.483	0.344	1.611
2013	14.701	16.279	1.830	1.858	0.308	0.146	1.725
2014	1.649	3.923	2.822	0.481	0.520	0.114	1.556
2015	11.001	5.613	4.611	1.581	0.289	0.285	1.865
2016	37.901	17.439	3.255	2.681	0.945	0.195	1.630
2017	11.447	13.102	3.068	1.267	0.942	0.473	1.852
2018	1.877	6.885	6.027	1.450	0.322	0.183	1.708
2019	2.143	3.189	3.071	0.999	0.194	0.077	1.372
2020	1.445	2.8	1.618	1.115	0.644	0.188	1.285

Table 16.4.2. Saithe in subareas 4 and 6 and Division 3.a. Model configuration for the SAM assessment.

Min Age:
3
Max Age:
10
Max Age considered a plus group:
Yes
The following matrix describes the coupling of fishing mortality STATES, where rows represent fleets (catch, IBTSQ3 index, commercial CPUE index) and columns represent ages (-1 = not estimated):

```
 0  1  2  3  4  5  6  6
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Use correlated random walks for the fishing mortalities: (2=AR1)
2
Coupling of catchability PARAMETERS

```
-1 -1 -1 -1 -1 -1 -1 -1
 0  1  2  3  4  5 -1 -1
 6 -1 -1 -1 -1 -1 -1 -1
```

Coupling of power law model EXPONENTS (if used)

```
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Coupling of fishing mortality RW VARIANCES

```
 0  1  1  1  1  1  1  1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
```

Coupling of log N RW VARIANCES
0 1 1 1 1 1 1 1
Coupling of OBSERVATION VARIANCES

```
 0  0  0  0  0  0  0  0
 1  1  1  1  1  1 -1 -1
 2 -1 -1 -1 -1 -1 -1 -1
```

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt)
0
Years in which catch data are to be scaled by an estimated parameter
0
Fbar range:
4 to 7
Observation correlation coupling (0 = uncorrelated). Rows represent fleets, columns represent adjacent age groups, i.e. the first column is the correlation between the first and 2nd age group. An NA in all non-empty age groups for a fleet specifies unstructured correlation. NA's and positive numbers cannot be mixed within fleets.

```
NA NA NA NA NA NA NA
NA NA NA NA NA -1 -1
NA -1 -1 -1 -1 -1 -1
```

Table 16.4.3. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortalities at age for the final assessment model.

Year/Age	3	4	5	6	7	8	9+
1967	0.263	0.385	0.357	0.355	0.314	0.283	0.318
1968	0.237	0.347	0.305	0.287	0.247	0.222	0.253
1969	0.252	0.371	0.325	0.314	0.278	0.254	0.279
1970	0.303	0.420	0.353	0.329	0.284	0.254	0.269
1971	0.370	0.469	0.377	0.346	0.308	0.285	0.299
1972	0.449	0.522	0.403	0.368	0.331	0.307	0.313
1973	0.529	0.573	0.426	0.379	0.344	0.319	0.319
1974	0.644	0.661	0.492	0.434	0.396	0.364	0.350
1975	0.661	0.691	0.531	0.472	0.441	0.409	0.385
1976	0.758	0.773	0.605	0.528	0.484	0.443	0.407
1977	0.633	0.708	0.594	0.539	0.510	0.474	0.429
1978	0.507	0.586	0.491	0.439	0.417	0.390	0.354
1979	0.421	0.522	0.459	0.423	0.411	0.383	0.347
1980	0.405	0.520	0.479	0.455	0.451	0.427	0.389
1981	0.361	0.495	0.471	0.461	0.469	0.459	0.421
1982	0.431	0.583	0.553	0.523	0.513	0.485	0.438
1983	0.511	0.699	0.673	0.629	0.602	0.559	0.495
1984	0.591	0.795	0.727	0.630	0.562	0.505	0.443
1985	0.633	0.875	0.774	0.624	0.539	0.481	0.435
1986	0.587	0.900	0.822	0.652	0.562	0.510	0.479
1987	0.535	0.847	0.796	0.629	0.550	0.509	0.494
1988	0.524	0.833	0.805	0.645	0.566	0.522	0.508
1989	0.517	0.816	0.786	0.629	0.538	0.483	0.468
1990	0.506	0.791	0.755	0.593	0.501	0.439	0.425
1991	0.469	0.752	0.725	0.566	0.480	0.417	0.413
1992	0.413	0.701	0.702	0.562	0.485	0.419	0.419
1993	0.390	0.685	0.713	0.605	0.565	0.505	0.512
1994	0.320	0.602	0.634	0.541	0.519	0.471	0.489
1995	0.273	0.557	0.622	0.561	0.574	0.542	0.564
1996	0.216	0.470	0.551	0.513	0.520	0.498	0.514
1997	0.182	0.407	0.480	0.449	0.445	0.433	0.450
1998	0.181	0.402	0.484	0.460	0.444	0.435	0.450
1999	0.174	0.400	0.501	0.498	0.481	0.482	0.497
2000	0.149	0.351	0.437	0.433	0.400	0.394	0.408
2001	0.147	0.343	0.419	0.412	0.368	0.356	0.367
2002	0.155	0.358	0.450	0.471	0.425	0.413	0.436
2003	0.164	0.365	0.451	0.500	0.463	0.452	0.481
2004	0.138	0.319	0.387	0.434	0.406	0.401	0.424
2005	0.136	0.321	0.391	0.436	0.405	0.395	0.404

Year/Age	3	4	5	6	7	8	9+
2006	0.155	0.349	0.413	0.445	0.410	0.394	0.393
2007	0.148	0.346	0.405	0.421	0.381	0.359	0.350
2008	0.157	0.386	0.468	0.481	0.435	0.413	0.398
2009	0.154	0.393	0.488	0.501	0.450	0.424	0.397
2010	0.139	0.373	0.473	0.484	0.443	0.423	0.390
2011	0.145	0.385	0.481	0.476	0.428	0.412	0.378
2012	0.126	0.358	0.452	0.450	0.399	0.384	0.351
2013	0.104	0.321	0.416	0.423	0.377	0.364	0.330
2014	0.091	0.295	0.399	0.413	0.367	0.353	0.320
2015	0.088	0.291	0.403	0.418	0.366	0.350	0.317
2016	0.080	0.283	0.405	0.426	0.378	0.364	0.329
2017	0.082	0.296	0.438	0.480	0.428	0.402	0.357
2018	0.090	0.318	0.475	0.523	0.464	0.431	0.378
2019	0.105	0.354	0.523	0.571	0.503	0.460	0.397
2020	0.098	0.336	0.493	0.528	0.454	0.405	0.344

Table 16.4.4. Saithe in subareas 4 and 6 and Division 3.a: Estimated population numbers-at-age for the final assessment model.

Year/Age	3	4	5	6	7	8	9	10+
1967	141089	81065	57130	7130	4903	1149	747	683
1968	161066	92033	50272	31616	3684	2504	655	773
1969	284618	90317	54269	30911	20405	2825	1951	812
1970	292306	217382	49066	35395	18565	11604	1788	1612
1971	354885	191047	119393	24464	19360	11878	7772	2502
1972	223862	209224	102548	67440	14438	11331	7261	6458
1973	201393	111015	105072	63167	35676	8647	6290	8567
1974	199985	90312	48159	62773	42087	20473	5387	8475
1975	234780	76303	35335	24181	36250	25201	11954	8475
1976	409407	102826	29661	17404	12873	19095	13255	11561
1977	148463	148465	35692	12445	8689	7218	10759	13978
1978	120589	72218	58167	14194	5085	3997	3381	13116
1979	87000	53647	34749	29273	7786	2795	2198	9495
1980	85247	46705	25637	18711	16070	4010	1658	7671
1981	162764	41543	24779	12235	9600	8258	2121	5905
1982	140710	108765	22957	15072	6248	4788	3726	4054
1983	147846	69202	55182	11349	8303	3123	2512	3786
1984	257046	76112	29949	23980	4714	3470	1320	2759
1985	359692	108645	29458	12746	9444	2214	1583	2291
1986	289076	142918	32171	11776	6368	4469	1192	2261
1987	148255	165108	36228	10132	5138	3296	2287	1799

Year/Age	3	4	5	6	7	8	9	10+
1988	137847	71191	61897	11334	4538	2597	1747	1920
1989	102041	69393	27646	21858	4673	2083	1240	1634
1990	151289	47776	25620	11102	8342	2293	1019	1390
1991	175748	71276	17222	10195	5238	3757	1226	1376
1992	102977	89442	25782	6694	5157	2843	2031	1460
1993	177601	58088	34068	9139	2823	3142	1796	2224
1994	118545	97302	28209	13424	3392	1381	1452	2110
1995	212660	66060	42237	12841	6320	1583	905	1872
1996	117718	147221	29446	19673	6911	2430	682	1286
1997	151334	78059	89496	12995	9176	3346	1068	917
1998	89503	122009	44749	48899	7135	4533	1804	975
1999	118060	56140	74686	22574	26806	4202	2305	1519
2000	101270	100567	29618	38007	11110	12800	1958	1622
2001	201421	67858	66134	14049	17673	6299	6768	1485
2002	150151	139906	34269	34306	8066	9419	3771	4726
2003	157142	112890	80518	15770	16724	5080	5021	4670
2004	111772	101846	68991	45616	7429	7798	3072	4251
2005	139655	71930	62518	45835	25991	4603	4146	3884
2006	98787	122319	40142	34896	25160	13189	2812	4359
2007	153319	53306	78043	23359	18777	14123	6662	3948
2008	72344	95871	30077	47601	14668	10590	9489	7565
2009	56582	51324	42848	14136	24540	9274	5592	9810
2010	88254	36978	27482	19600	6879	12963	5424	9291
2011	81176	78841	21886	13948	9804	3569	6478	10000
2012	133296	46561	47628	11597	7282	4864	1962	9458
2013	91239	98514	22342	25584	6578	3904	2603	6572
2014	56033	66830	50914	12320	13604	3887	2020	5361
2015	94763	41759	44497	26340	7127	6918	2496	4410
2016	117456	63611	26639	23513	12519	4467	3684	4366
2017	80693	90270	34796	15051	13456	6736	2686	4481
2018	41095	64433	55447	18343	7001	6422	3509	4012
2019	52781	32399	38702	26602	8003	3333	3219	3877
2020	31492	40439	19797	18841	12646	3686	1613	3258

Table 16.5.1. Saithe in subareas 4 and 6 and Division 3.a. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 7 ($F_{4–7}$), 1967–2020. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1967	141089	100544	197983	152157	120638	191910	0.353	0.276	0.451	411713	337816	501774
1968	161066	116612	222467	209694	168688	260670	0.296	0.233	0.377	578449	477541	700681
1969	284618	206037	393169	275978	224821	338775	0.322	0.259	0.400	710282	589890	855245
1970	292306	212952	401232	345461	286009	417271	0.347	0.282	0.426	909843	763316	1084498
1971	354885	261078	482397	460472	382230	554731	0.375	0.308	0.457	1054869	894593	1243860
1972	223862	165791	302274	488880	408450	585148	0.406	0.335	0.491	957444	820014	1117906
1973	201393	149313	271640	520691	435100	623120	0.431	0.358	0.518	892648	770340	1034375
1974	199985	148133	269986	576387	483969	686454	0.496	0.417	0.591	925284	803243	1065867
1975	234780	174771	315393	517286	433304	617547	0.534	0.450	0.634	856928	744098	986867
1976	409407	299762	559158	399145	332407	479281	0.598	0.502	0.711	815959	700234	950809
1977	148463	109687	200946	325855	270916	391934	0.588	0.489	0.707	612669	527235	711947
1978	120589	89354	162743	297083	246003	358769	0.483	0.403	0.580	519943	446970	604831
1979	87000	64220	117858	278199	232986	332185	0.454	0.378	0.544	482135	416395	558255
1980	85247	62920	115497	260607	219921	308819	0.476	0.399	0.567	438407	380519	505102
1981	162764	119306	222053	249047	211186	293697	0.474	0.397	0.566	491226	424110	568964
1982	140710	104305	189821	219768	188935	255631	0.543	0.461	0.639	530640	457085	616033
1983	147846	109526	199573	220003	188655	256559	0.651	0.554	0.765	508023	439827	586792
1984	257046	190065	347632	188325	162185	218677	0.679	0.580	0.793	516905	443938	601865
1985	359692	263320	491334	165577	143317	191294	0.703	0.602	0.820	530506	448283	627810
1986	289076	213931	390617	156663	135871	180637	0.734	0.623	0.864	492079	419561	577132
1987	148255	109764	200245	165372	143409	190699	0.706	0.604	0.825	404197	349005	468117
1988	137847	102428	185512	154784	132796	180414	0.712	0.609	0.833	348777	302705	401861
1989	102041	75721	137511	126134	108610	146484	0.693	0.591	0.811	292055	253426	336570
1990	151289	112084	204206	113904	97896	132530	0.660	0.563	0.774	300988	258158	350924

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
1991	175748	130564	236570	106632	92153	123388	0.631	0.538	0.740	320601	273134	376318
1992	102977	76888	137917	112232	97527	129154	0.613	0.520	0.721	309080	265319	360059
1993	177601	132235	238529	118955	102689	137796	0.642	0.543	0.758	355607	302763	417676
1994	118545	88373	159018	123621	106671	143263	0.574	0.486	0.678	338524	289262	396176
1995	212660	157029	287999	142904	122667	166480	0.578	0.487	0.687	448433	377968	532036
1996	117718	86949	159375	154032	132550	178994	0.513	0.431	0.611	427902	363170	504173
1997	151334	111016	206296	191359	162074	225935	0.445	0.372	0.533	445381	379849	522218
1998	89503	64569	124065	189136	160564	222792	0.447	0.376	0.533	394805	339534	459073
1999	118060	86591	160966	200308	169886	236177	0.470	0.393	0.562	387199	334799	447801
2000	101270	74419	137810	194362	166377	227054	0.406	0.338	0.487	410834	355246	475120
2001	201421	146321	277270	197910	170281	230022	0.385	0.320	0.465	447354	384765	520124
2002	150151	110448	204126	216544	186167	251877	0.426	0.354	0.512	474972	407528	553578
2003	157142	115460	213873	202253	172643	236942	0.445	0.370	0.535	421092	363796	487412
2004	111772	82749	150975	249787	213372	292415	0.387	0.320	0.467	468984	407869	539255
2005	139655	102193	190850	241160	207860	279794	0.388	0.324	0.466	450717	393219	516622
2006	98787	71790	135938	256097	220262	297763	0.404	0.338	0.484	477820	417842	546407
2007	153319	108779	216096	239997	205880	279767	0.388	0.324	0.465	449115	389954	517252
2008	72344	53538	97754	243151	208951	282949	0.442	0.372	0.526	420631	367378	481602
2009	56582	41830	76535	241012	205553	282588	0.458	0.384	0.546	385652	337111	441184
2010	88254	65157	119538	226343	191689	267263	0.443	0.372	0.528	389816	338795	448521
2011	81176	59022	111644	182692	154849	215541	0.443	0.371	0.528	355778	308059	410887
2012	133296	98563	180270	166751	140970	197246	0.415	0.346	0.497	363792	312627	423332
2013	91239	67460	123400	170951	144687	201983	0.384	0.319	0.463	361304	311876	418566
2014	56033	41047	76489	189913	161200	223741	0.369	0.306	0.445	352306	305427	406381
2015	94763	69318	129548	195498	165918	230351	0.370	0.306	0.446	362588	313564	419276
2016	117456	86077	160276	181261	153559	213960	0.373	0.309	0.451	378904	326203	440118

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$F_{bar(4-7)}$	Low	High	TSB	Low	High
2017	80693	58556	111197	199348	168693	235572	0.411	0.339	0.497	393465	341750	453006
2018	41095	29411	57421	194749	165769	228795	0.445	0.365	0.542	340876	297672	390350
2019	52781	35995	77394	184317	155858	217971	0.488	0.391	0.608	316615	272368	368051
2020	31492	18121	54730	159269	130225	194791	0.453	0.348	0.590	263951	217092	320924

Table 16.7.1. Saithe in subareas 4 and 6 and Division 3.a. The basis for the catch options.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2021)	0.45	Average exploitation pattern (2018-2020) scaled to $F_{4–7}$ in 2020
SSB (2022)	127092	SSB at the beginning of the TAC year, in tonnes
$R_{age\ 3}$ (2021)	71483	Geometric mean of the recruitment re-sampled from the years 2011–2020, in thousands
$R_{age\ 3}$ (2022)	71215	Geometric mean of the recruitment re-sampled from the years 2011–2020, in thousands
Total catch (2021)	65704	Short-term forecast, in tonnes
Landings (2021)	62233	Assuming 2018–2020 average landing fraction by age from numbers, in tonnes
Discards (2021)	3471	Assuming 2018–2020 average discards fraction by age from numbers, in tonnes

Table 16.7.2. Saithe in subareas 4 and 6 and Division 3.a. Reference points and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	149 098 t	B_{pa}	ICES (2019a)
	F_{MSY}	0.363	Eqsim analysis based on the recruitment period 1998–2017.	ICES (2019a)
Precautionary approach	B_{lim}	107 297 t	B_{loss}	ICES (2019a)
	B_{pa}	149 098 t	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2019a)
	F_{lim}	0.668	Eqsim analysis based on the recruitment period 1998–2017.*	ICES (2019a)
	F_{pa}	0.576	$F_{p.05}$ with AR; the F that leads to SSB ≥ B_{lim} with 95% probability. Eqsim analysis based on the recruitment period 1998–2017.	ICES (2021)
Management plan*	MAP MSY $B_{trigger}$	149 098 t	MSY $B_{trigger}$	ICES (2019a)
	MAP B_{lim}	107 297 t	B_{lim}	ICES (2019a)
	MAP F_{MSY}	0.363	F_{MSY}	ICES (2019a)
	MAP range F_{lower}	0.210	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2019a)
	MAP range F_{upper}	0.564	Consistent with ranges provided by ICES, resulting in no more than 5% reduction in long-term yield compared with MSY.*	ICES (2019a)

*** updated in 2021 following detection of mistakes in the 2019 IBP analyses (ICES, 2019a). See working document in Annex 8.**

Table 16.7.3. Saithe in subareas 4 and 6, and in Division 3.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	Projected landings (2022)	projected discards (2022)	Projected landings# 3a4	Projected landings# 6	F_{total} (ages 4-7) (2022)	$F_{projected\ landings}$ (ages 4-7) (2022)	$F_{projected\ discards}$ (ages 4-7) (2022)	SSB (2023)	% SSB change *	% TAC change **	% advice change ^
ICES advice basis												
MSY approach: F_{MSY} × SSB (2022) /MSY $B_{trigger}$	49614	46644	2970	42259	4385	0.31	0.29	0.0170	153272	21	-24	-24
Other scenarios												
F = $F_{MSY\ lower}$ × SSB (2022) /MSY $B_{trigger}$	30204	28397	1807	25728	2669	0.179	0.169	0.0100	170840	34	-54	-54
F_{MSY}	57046	53596	3450	48558	5038	0.363	0.34	0.0200	146645	15.4	-13.2	-13.2
F = $F_{MSY\ lower}$	35009	32911	2098	29817	3094	0.210	0.198	0.0120	166510	31	-47	-47
F = $F_{MSY\ upper}$	82159	77129	5030	69879	7250	0.564	0.53	0.032	124350	-2.2	25	25
F = 0	0	0	0	0	0	0.00	0.00	0.00	198814	56	-100	-100
F_{pa} ($F_{p.05}$ with AR)	83556	78420	5136	71049	7371	0.576	0.54	0.032	123198	-3.1	27	27
$F_{p.05}$ without AR	73736	69267	4469	62756	6511	0.49	0.46	0.028	131729	3.6	12.3	12.3
F_{lim}	93718	87921	5797	79656	8265	0.668	0.63	0.037	114361	-10.0	43	43
SSB_{2023} = B_{lim}	102288	95980	6308	86958	9022	0.75	0.71	0.042	107297	-15.6	56	56
SSB_{2023} = B_{pa}	54770	51467	3303	46629	4838	0.35	0.33	0.0190	149098	17.3	-16.6	-16.6
SSB_{2023} = MSY $B_{trigger}$	54770	51467	3303	46629	4838	0.35	0.33	0.0190	149098	17.3	-16.6	-16.6
F = F_{2021}	68786	64585	4201	58514	6071	0.45	0.43	0.025	136046	7.0	4.7	4.7
TAC_{2021}	65687	61675	4012	55878	5797	0.43	0.40	0.024	138834	9.2	0.00	0.00
TAC_{2021} −15%	55835	52458	3377	47527	4931	0.35	0.33	0.0200	147736	16.2	-15.0	-15.0
TAC_{2021} +15%	75540	70969	4571	64298	6671	0.51	0.48	0.029	130131	2.4	15.0	15.0
TAC_{2021} −20%	52551	49373	3178	44732	4641	0.33	0.31	0.0180	150648	18.5	-20.0	-20.0
TAC_{2021} +25%	82110	77084	5026	69838	7246	0.56	0.53	0.032	124392	-2.1	25	25

*** SSB2023 relative to SSB2022. ** Total catch in 2022 relative to the TAC in 2021 (65 687 t). # Wanted catch split according to the average in 1993–1998, i.e. 90.6% in Subarea 4 and Subdivision 3.a.20 and 9.4% in Subarea 6. ^ Total catch 2022 relative to the advice value 2021 (65 687 t).**

Table 16.7.4. Saithe in subareas 4 and 6 and Division 3.a. Contribution of the year classes to the landings in 2022.

Year class	Contribution to landings (%)	
	Numbers	Weight
2019	16.1	9.1
2018	40.5	29.1
2017	14.4	12.9
2016	13.9	16.5
2015	5.1	7.9
2014	4.6	9.2
2013	3.0	7.2

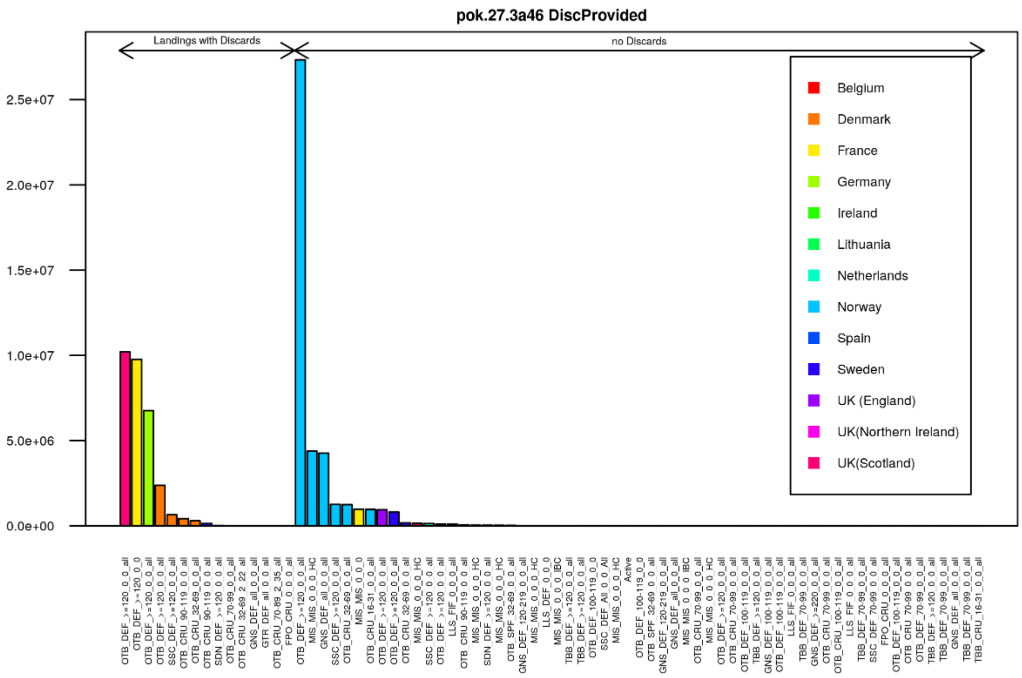

Figure 16.3.1. Saithe in subareas 4 and 6 and Division 3.a: Landings with associated discards for areas and quarters combined by métier for 2020.

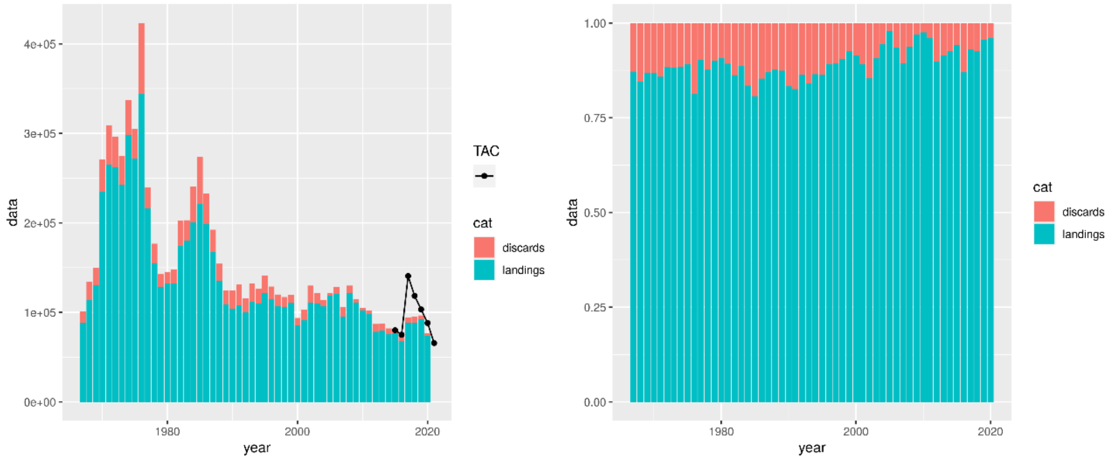

Figure 16.3.2. Saithe in subareas 4 and 6 and Division 3.a: Yield as stacked plot for landings and discards in tonnes (left panel) and as percent (right panel). Landings include BMS landings from Norway since 2016. Discards correspond to unwanted catch (discards + EU/UK BMS) since 2016.

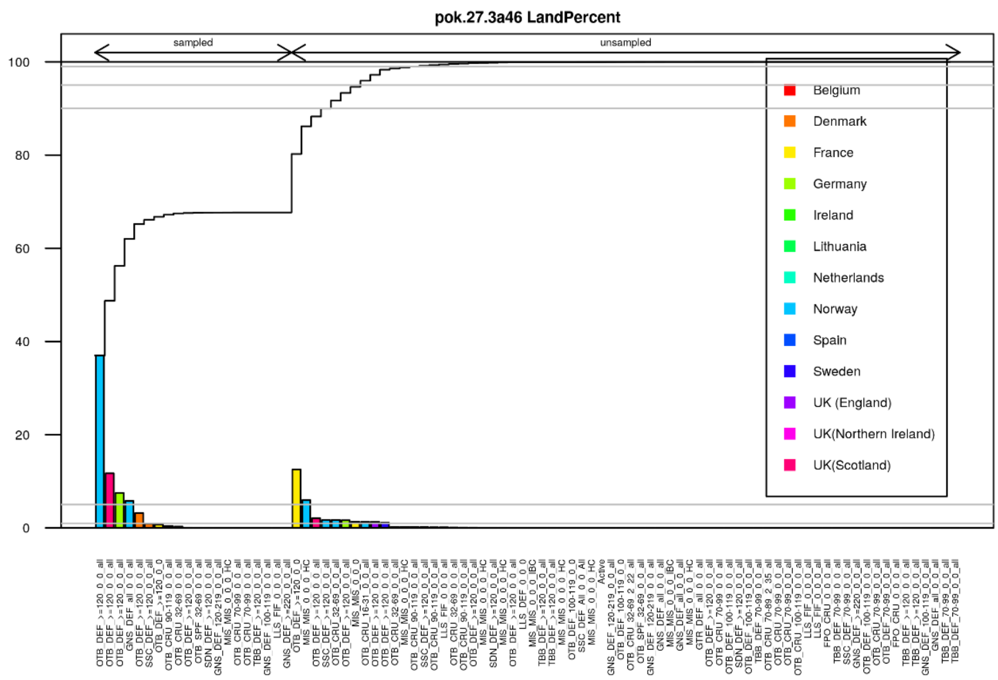

Figure 16.3.3. Saithe in subareas 4 and 6 and Division 3.a: Overview of percent of sampled and unsampled landings by country and métier for 2020.

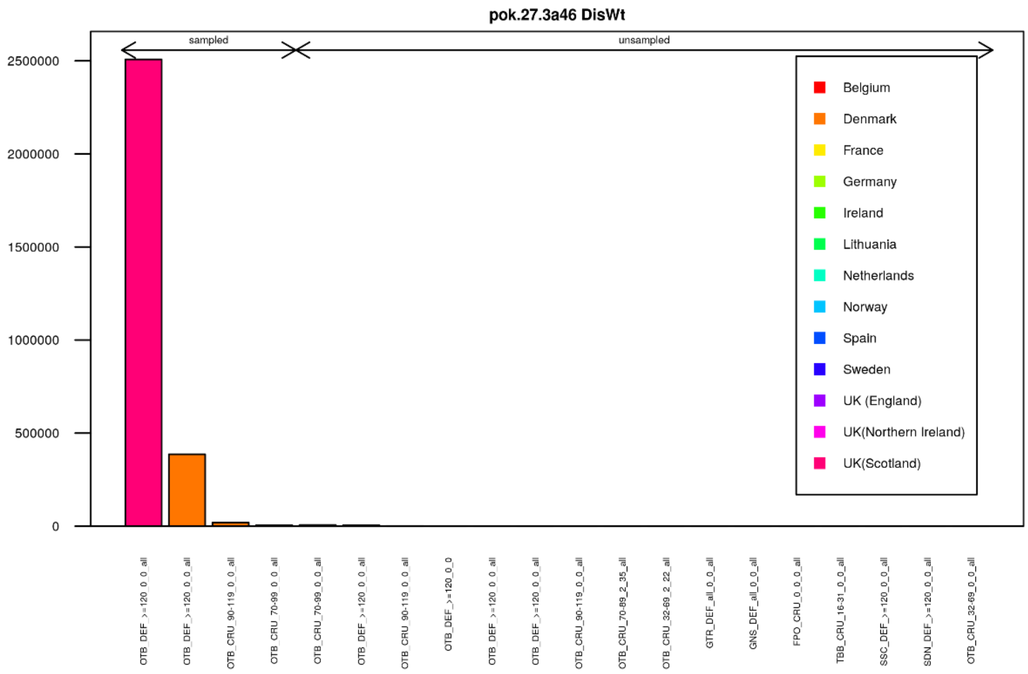

Figure 16.3.4. Saithe in subareas 4 and 6 and Division 3.a: Overview of age sampled and unsampled imported discards by country and métier for 2020.

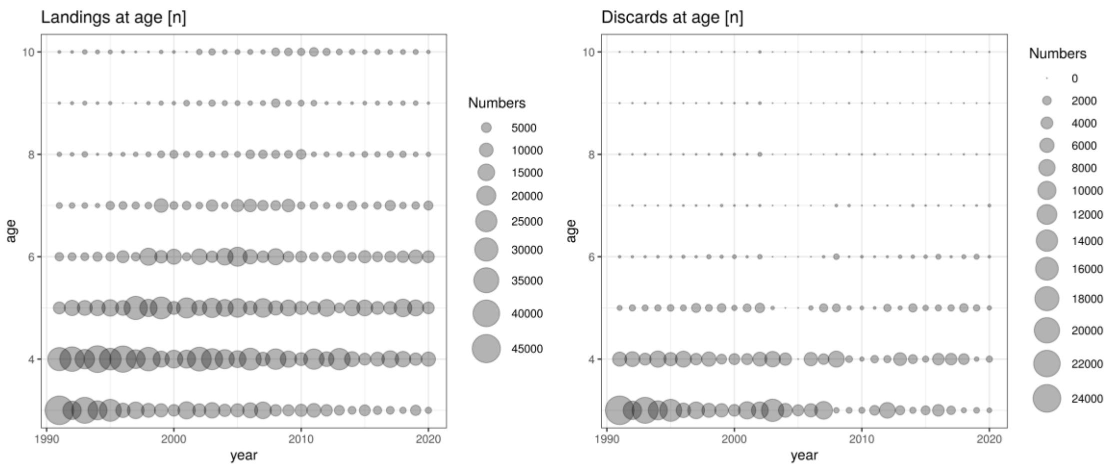

Figure 16.3.5. Saithe in subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2020. (Right) Discard numbers at age for saithe ages 3–10+, 1990–2020.

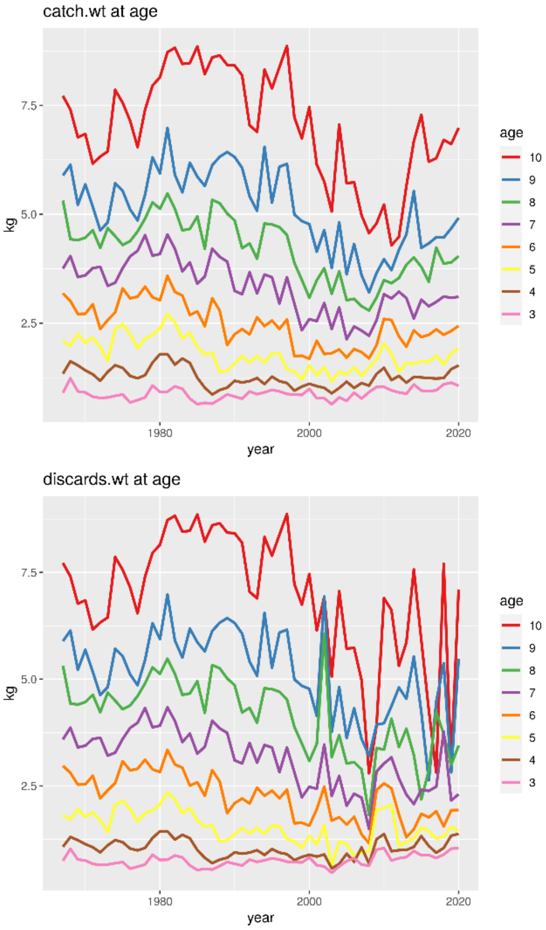

Figure 16.3.6. Saithe in subareas 4 and 6 and Division 3.a. Catch weight-at-age (top left pane), landing weight-at-age (bottom left panel) and discard weights-at-age (bottom right panel), in kilograms, for saithe ages 3–10+, 1967–2020.

Figure 16.3.7. Saithe in subareas 4 and 6 and Division 3.a. CPUE index based on (uncorrected) data 2000–2019. Left panel: comparison of the series used in the 2020 assessment (SAS; including error on the quarter coding) and using the corrected R implementation. Right panel: replication of the quarter coding mistake in R, that shows there is only negligible influence of the software. Mean + 95% confidence intervals.

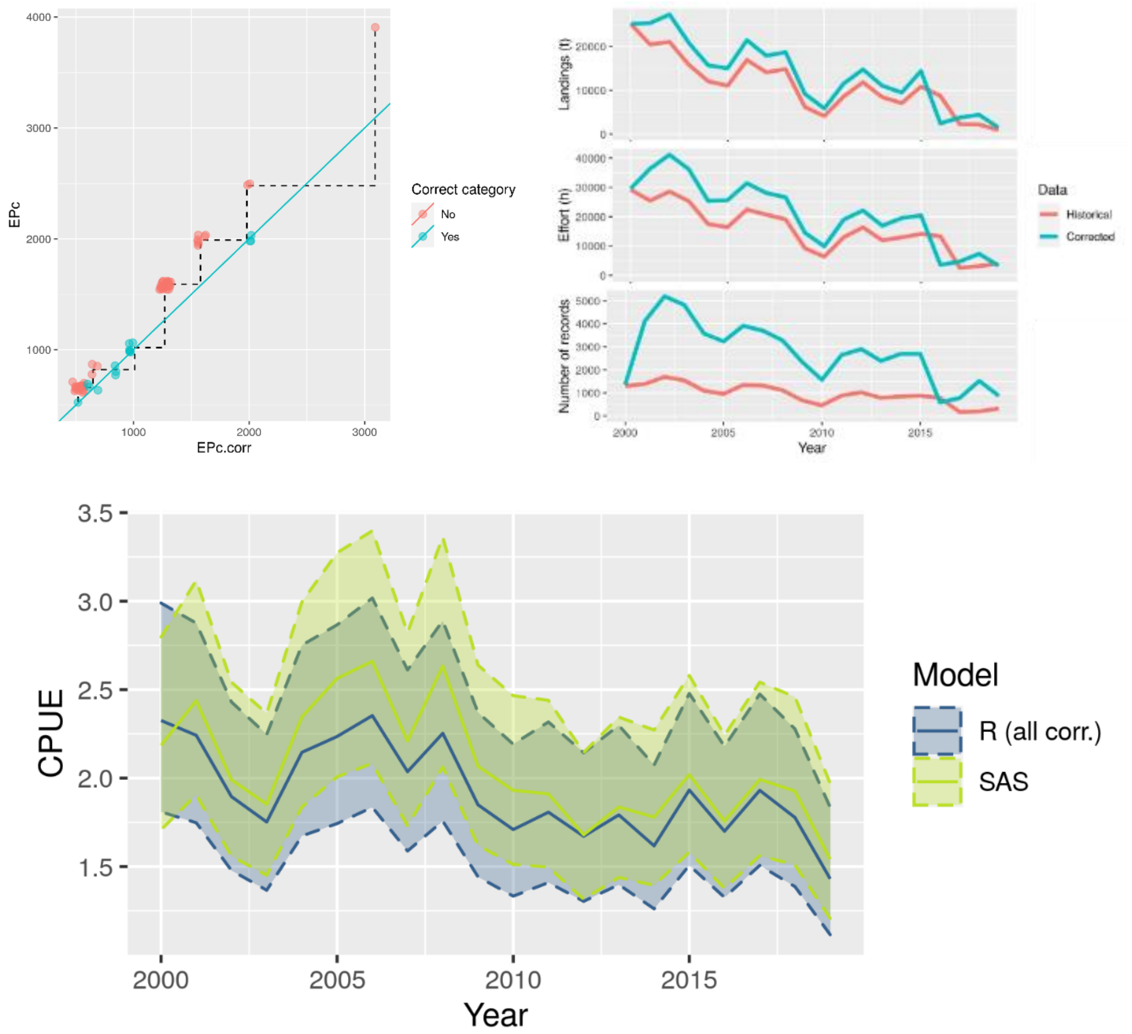

Figure 16.3.8. Saithe in subareas 4 and 6 and Division 3.a. Illustration of French data errors and repercussions on the CPUE index series. Top left: jittered corrected engine power (kW) category (x-axis) vs. historical category (y-axis) with one to one line. Top right sum of entries, effort and landings, per year, compared between historical and corrected data. Bottom: CPUE series (2000–2019) including all corrections (R (all corr.)), compared to the series used in the 2020 assessment (SAS); mean + 95% confidence intervals.

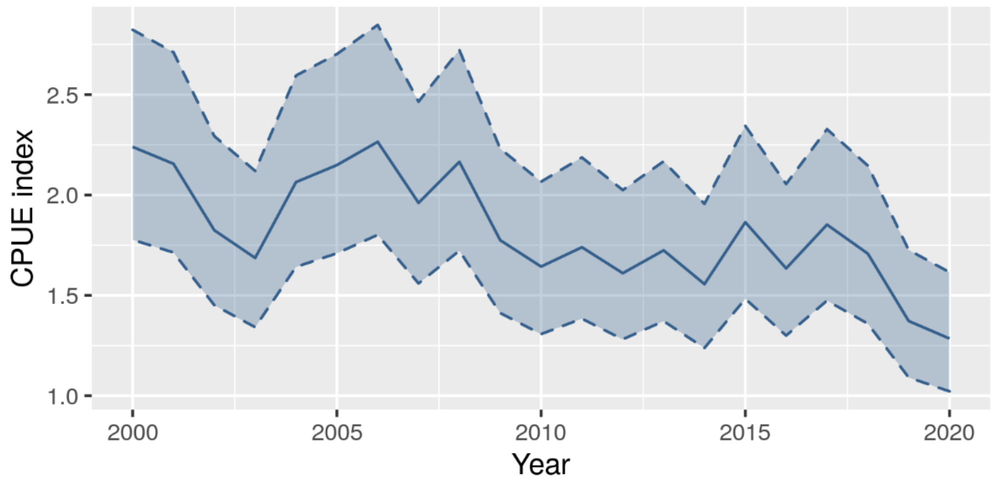

Figure 16.3.9. Saithe in subareas 4 and 6 and Division 3.a: Standardised commercial CPUE index time series and 95% confidence interval. Based on logbook data from France, Germany and Norway.

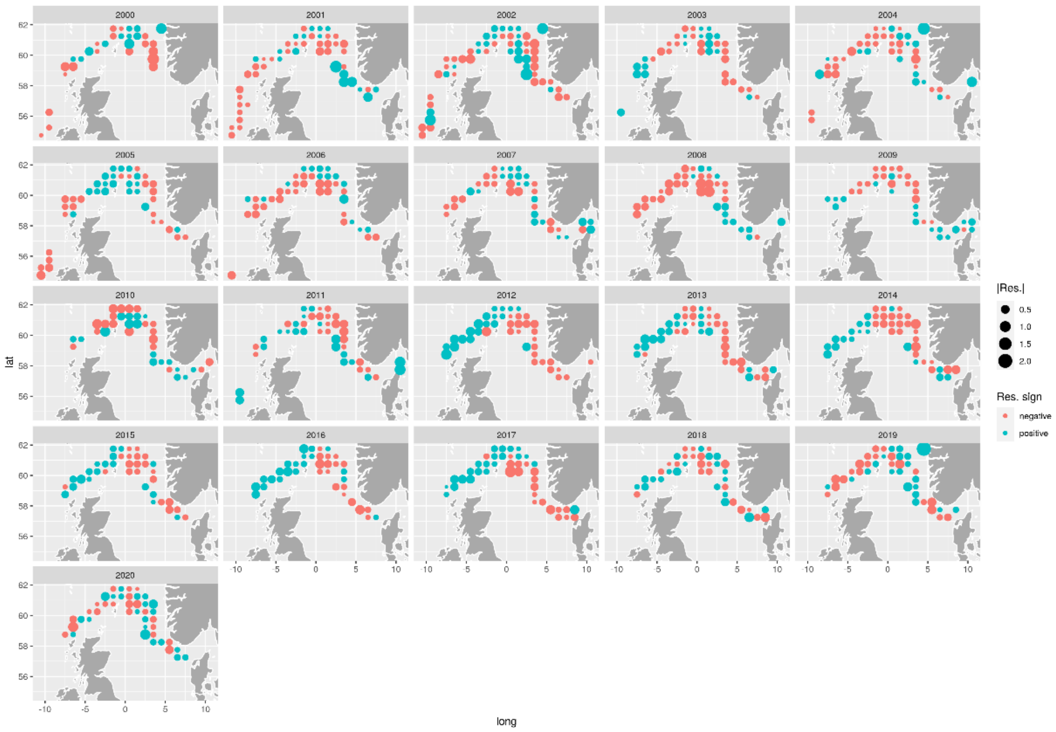

Figure 16.3.10. Saithe in subareas 4 and 6 and Division 3.a. Maps of mean residuals from the CPUE index model per 0.5°x0.5° grid cell, per year (2000–2020).

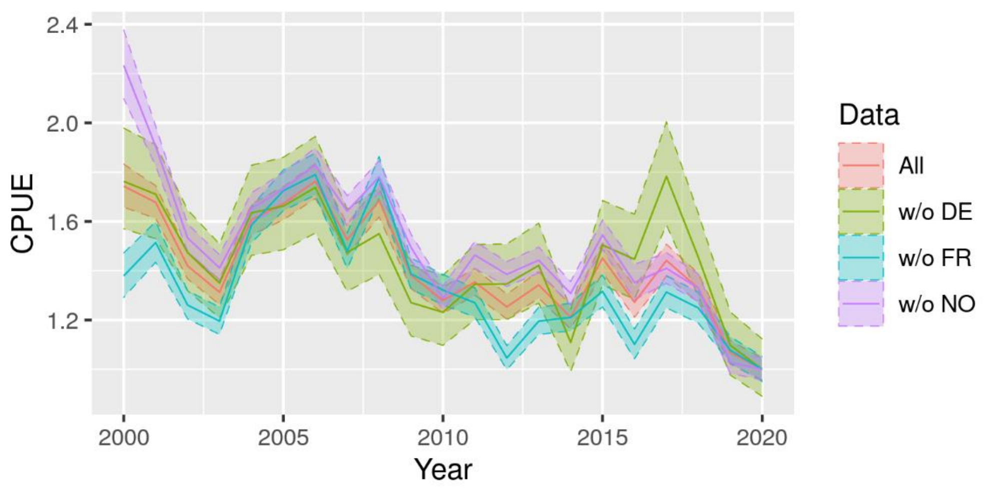

Figure 16.3.11. Saithe in subareas 4 and 6 and Division 3.a: Commercial CPUE index (standardized to one in 2020) fitted with data from one nation sequentially taken out, compared to all data (leave-one-nation-out analysis).

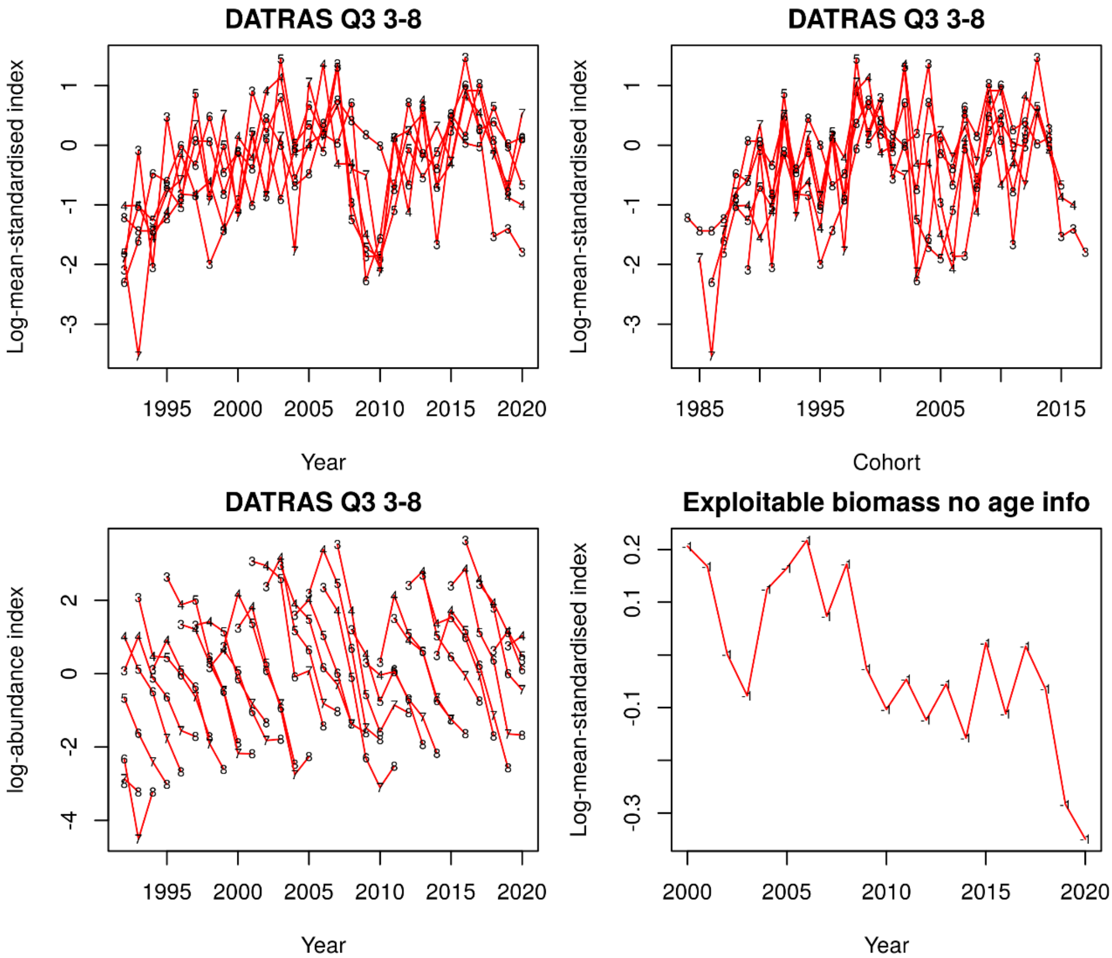

Figure 16.4.1. Saithe in subareas 4 and 6 and Division 3.a: Research survey index, IBTS–Q3, for ages 3 to 8, 1992–2020 is shown in terms of indices by age and year (top-left panel), indices by age and cohort (top-right panel), and log-catch curves by cohort (bottom-left panel). Commercial catch-per-unit-effort (CPUE) is shown in the bottom-right panel.

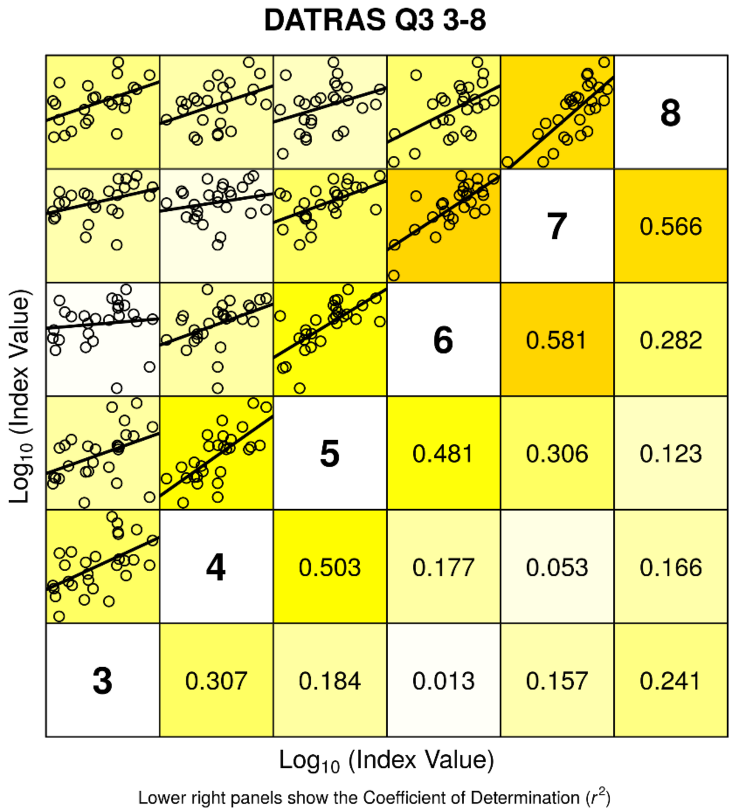

Figure 16.4.2. Saithe in subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2020 ages 3 to 8.

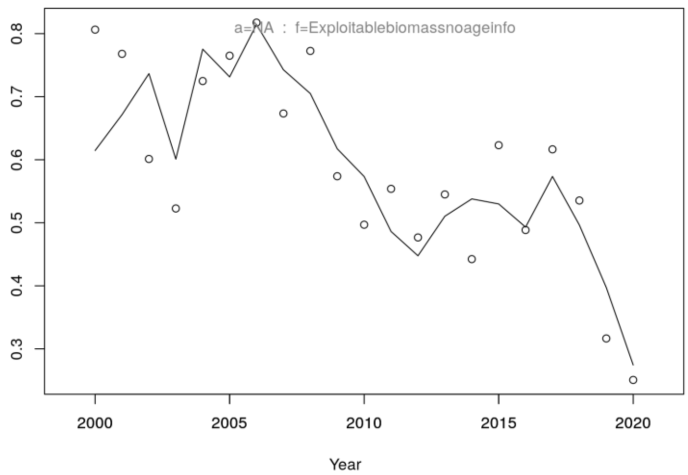

Figure 16.4.3. Saithe in subareas 4 and 6 and Division 3.a. Standardized combined CPUE index (year effects, open circles) and fit of model after tuning to the exploitable biomass (solid line), 2000–2020.

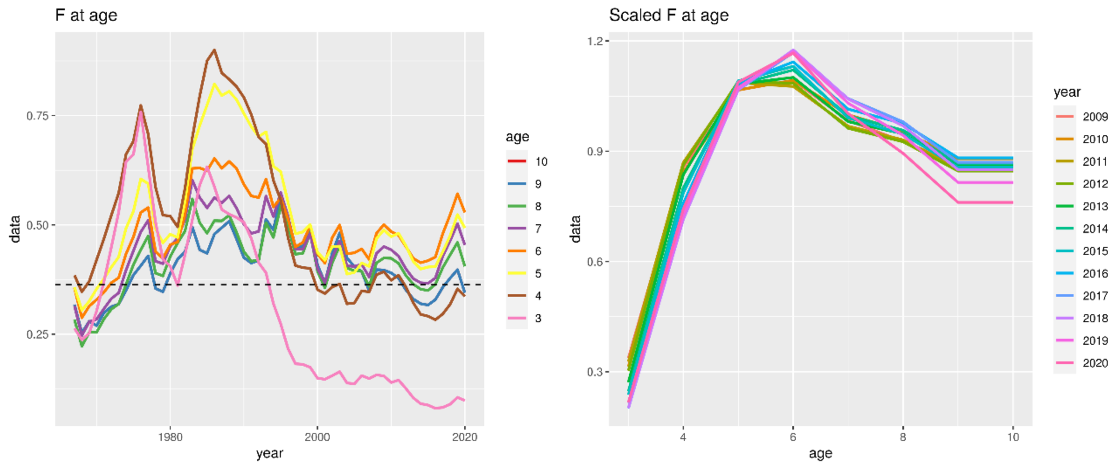

Figure 16.4.4. Saithe in subareas 4 and 6 and Division 3.a. Fishing mortality at age for the final assessment model. Time series (left panel) and scaled at F_{4-7} for the last 12 years (right panel).

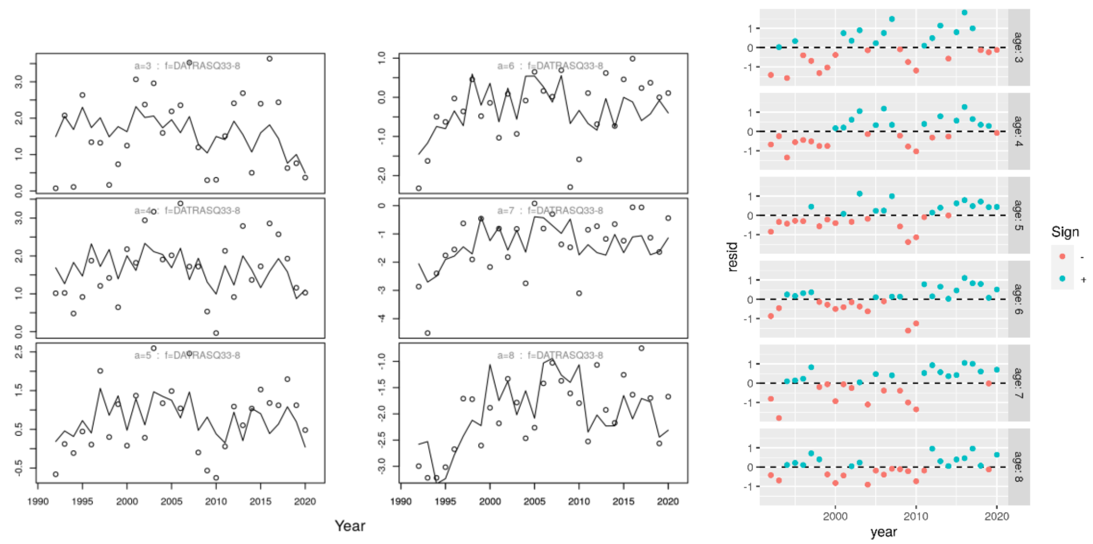

Figure 16.4.5. Saithe in subareas 4 and 6 and Division 3.a. Left: DATRAS Q3 index at age (age 3-8, open circles) and model fit (solid line), 1992–2020. Right: residuals (conditioned on all the data)

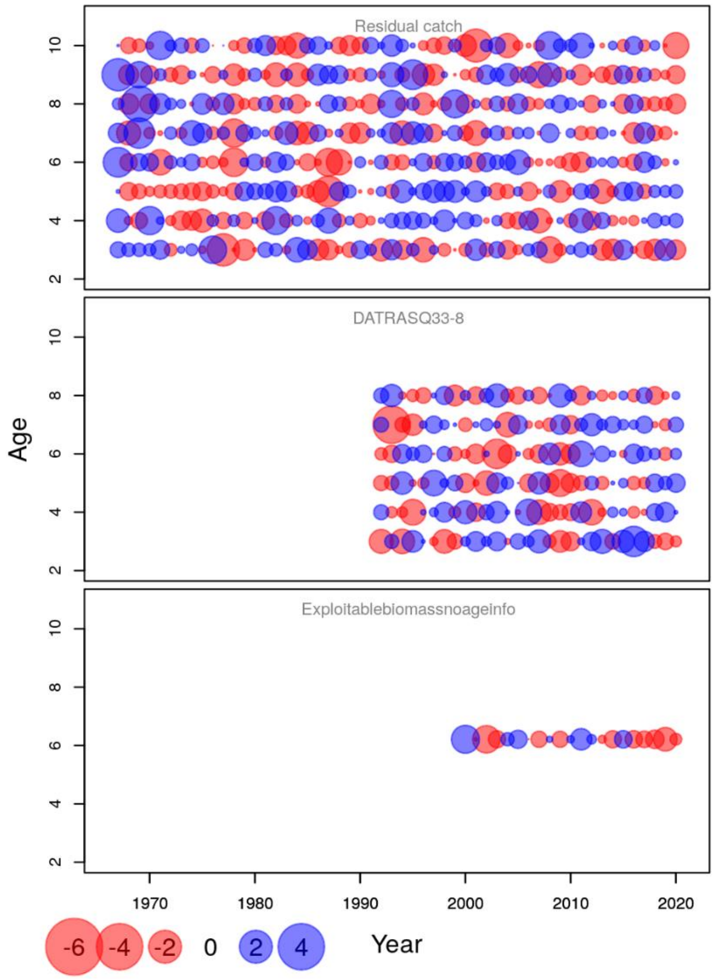

Figure 16.4.6. Saithe in subareas 4 and 6 and Division 3.a. One-step ahead (serially independent) residual patterns of observations for the final SAM model.

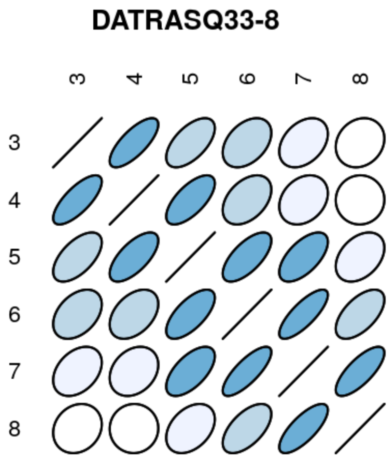

Figure 16.4.7. Saithe in subareas 4 and 6 and Division 3.a. Correlation between age classes within years for IBTS Q3 (ages 3–8). The darker the blue colour, the stronger the correlation.

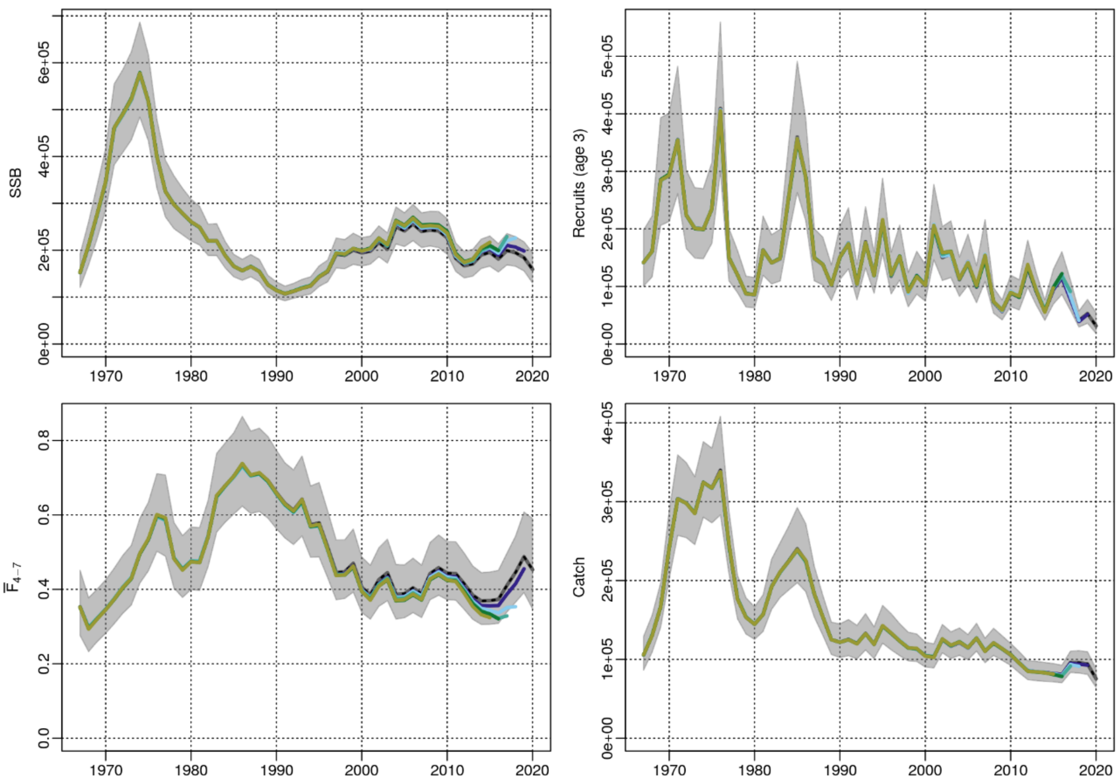

Figure 16.4.8. Saithe in subareas 4 and 6 and Division 3.a. Five-year retrospective pattern in SSB, F_{4-7}, recruitment, and catches for the final assessment.

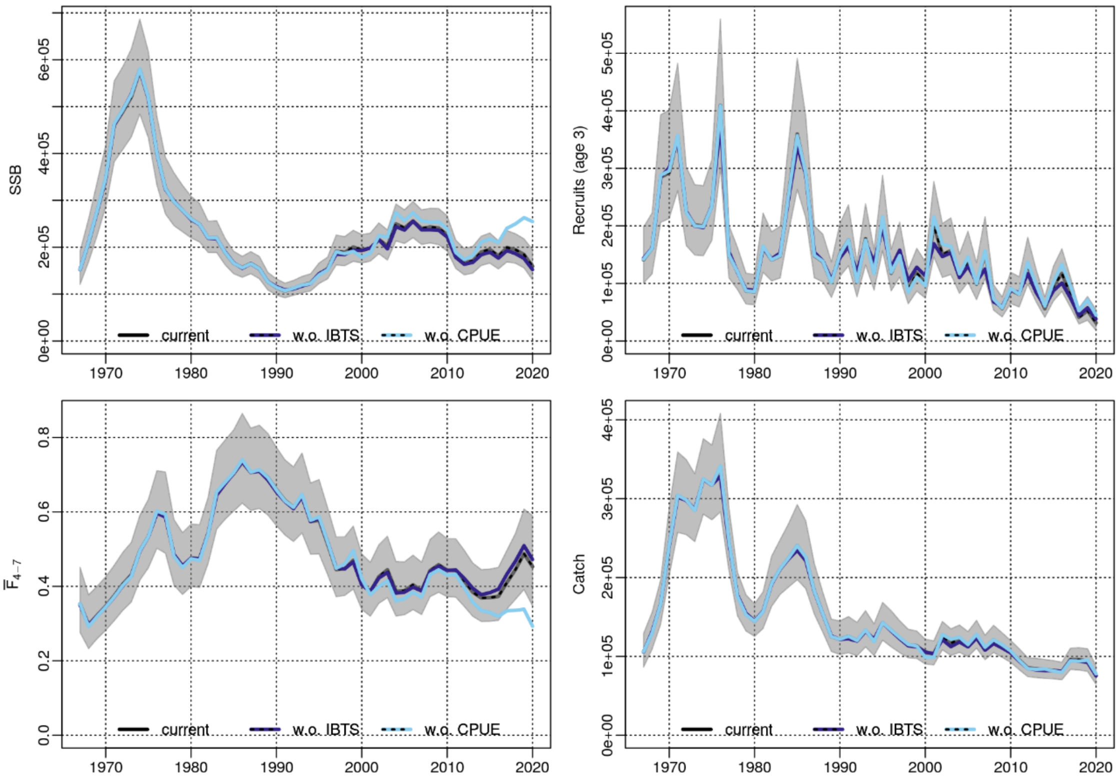

Figure 16.4.9. Saithe in subareas 4 and 6 and Division 3.a. Stock summary of trends in SSB, F_{4-7}, recruitment, and catches for the final assessment model. Black lines and grey-shaded confidence interval indicate the final assessment model, including the IBTS Q3 indices for ages 3–8 and the CPUE index. The light blue line is the assessment with only the IBTS Q3 tuning series, while the dark blue one is the assessment with only the CPUE index.

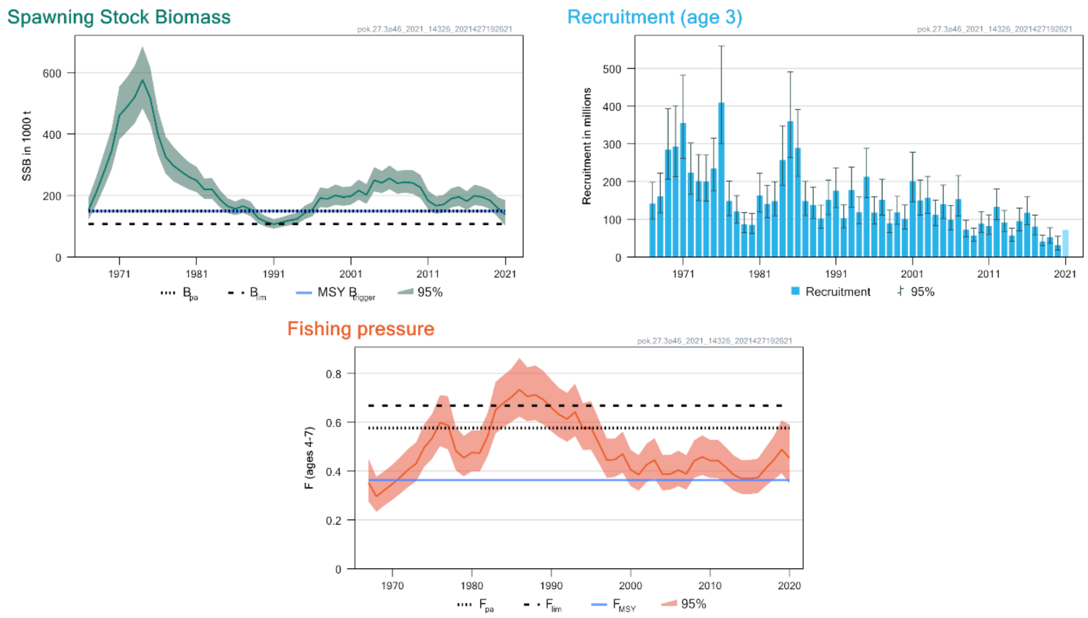

Figure 16.5.1. Saithe in subareas 4 and 6 and Division 3.a. Summary of stock assessment in relation to reference points for SSB and F. Predicted recruitment values are light shaded. Shaded areas (F, SSB) and error bars (R) indicate point-wise 95% confidence intervals.