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Report of the Benchmark Workshop on North Sea Stocks (WKNSEA 2018)

5-9 February 2018

Copenhagen, Denmark

ICES CIEM

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Contents

Executive summary

The ICES Benchmark Workshop on North Sea Stocks 2018 (WKNSEA) convened at two meetings, one data compilation workshop at ICES HQ, Copenhagen (6–10 November 2017) and the final benchmark meeting at ICES HQ, Copenhagen (5–9 February 2018). Four stocks were benchmarked: flounder 27.3a4, lemon sole 27.3a47d, whiting.27.47d, and witch flounder 27.3a47d. The most important conclusions for each stock were:

Lemon sole 27.3a47d

Alternate survey indices were explored. The agreed upon method was the GAM estimation for Q1 and Q3, where the Q3 incorporates both IBTS and BTS survey data. The length coverage of the surveys was concluded to be sufficiently representative of the stock as a whole, and that therefore advice could appropriately be based on survey data alone.

SMALK data were used to determine the proportion mature at-age, mean weight-at-age in the stock, and an annual length–weight relationship. Natural mortality (*M*) estimates for lemon sole are not available; total mortality is an output of the survey-based assessment.

Age data were sparse; therefore, an age-based assessment was not possible. The stochastic production model SPiCT was assessed but was deemed unsuitable for use as an assessment model for lemon sole at this time. The age- and survey-based assessment model SURBAR was agreed upon. No new reference points could be proposed by WKNSEA. It is proposed that the status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis through the LBI analyses.

Flounder 27.3a4

Age data were sparse in the surveys and catch data. Survey indices were based on the catch weight per haul applying a general length–weight relationship with the length distribution data by haul. Indices were generated using the deltaGAM method for Q1 from IBTS data and Q3 by combining information from three beam trawl surveys and the IBTS. Length-based data show that most flounder reach maturity above 20 cm in length. Lack of data prevented analyses of interannual trends in weight-at-age or growth. Natural mortality estimates were not available for flounder.

A SPiCT model was agreed upon, which obtained robust results in terms of relative fishing mortality and relative biomass. The status of the stock in relation to a proxy for F_{MSY} is determined on an annual basis by updating the SPiCT model, where the relative values of biomass and fishing mortality gives an indication for the stock status in relation to F_{MSY} and B_{MSY}.

Whiting 27.47d

A complex population structure for whiting in the North Sea has been proposed, based on studies about movements, life-history traits, genetic data, identification of spawning aggregation, population temporal asynchrony observed in SSB, recruitment and egg abundance between areas. While exploratory SURBAR assessments were run for individual components and the combined stock, data could not be provided to revise management units to account for stock structure. The feasibility of combining Subdivision 3a with area 4 components was explored, but data showed there were biological reasons to leave the components as separate stocks.

No changes were made to the survey indices. The maturity ogive, stock weights-at-age, and natural mortality were updated with new information.

The assessment model was changed from XSA to SAM and new reference points were estimated. Reference points at WKNSEA were modified post-WKNSEA. The final decision, after external review, are included in Appendix 1 to Annex 7.

Witch flounder 37.3a47d

The deltaGAM approach was used to generate survey indices for IBTS Q1 and Q3 for years with age data, 2009–present. Total biomass indices were also estimated for use in the SPiCT model. Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. Stock weights-at-age and a new constant maturity ogive were estimated from survey data; natural mortality was left at 0.2.

A SAM assessment model was used. The catch time-series was extended back in time by using landings from 1950 to 2008. Two new surveys of fishable stock biomass for Q1 (1983 to 2008) and Q3 (1991 to 2008) were included. Age-specific information for surveys and catches were available from 2009. New reference points were estimated.

1 Introduction

A **Benchmark Workshop for North Sea Stocks** (WKNSEA), chaired by External Chair Beatriz Roel, UK and ICES Chair Jennifer Devine, Norway, and attended by two invited external experts Daniel Ricard, Canada and Cóilín Minto, Ireland, met at ICES HQ in Copenhagen, Denmark 6–10 November 2017 for a data evaluation meeting and again for a five-day Benchmark meeting 5–9 February 2018 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:
   - i) Stock identity and migration issues;
   - ii) Life-history data;
   - iii) Fishery-dependent and fishery-independent data;
   - iv) Further inclusion of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.

b) Agree and document the preferred method for evaluating stock status and (where applicable) short-term forecast and update the stock annex as appropriate. Knowledge of environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology
   - i) If no analytical assessment method can be agreed, then an alternative method (the former method, or following the ICES data-limited stock approach) should be put forward;

c) Re-examine and update (if necessary) MSY and PA reference points according to ICES guidelines (see Technical document on reference points);

d) Develop recommendations for future improving of the assessment methodology and data collection;

e) As part of the evaluation:
   - i) Conduct a three-day data evaluation workshop (DEWK). Stakeholders are invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data evaluation workshop consider the quality of data including discard and estimates of misreporting of landings;
   - ii) Following the DEWK, produce working documents to be reviewed during the Benchmark meeting at least seven days prior to the meeting.

Stocks	Stock leader
Lemon sole *Microstomus kitt* in Subarea 4 and Divisions 3a and 7d	Coby Needle
Flounder *Platichthys flesus* in Subarea 4 and Division 3a	Holger Haslob
Whiting *Merlangius merlangus* in Subarea 4 and Division 7d	Tanja Miethe
Witch flounder *Glyptocephalus cynoglossus* in Subarea 4 and Divisions 3a and 7d	Francesca Vitale

The Benchmark Workshop will report by 1 April 2017 for the attention of ACOM.

2 Adoption of the agenda

The following were dropped from the agenda:

> Further inclusion of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.

3 Description of the Benchmark Process

The ICES benchmark on North Sea stocks included the following steps:

1) A data call was issued 13 September 2017 for the North Sea stocks to be benchmarked in WKNSEA. The deadline of the data call was 16 October 2017.

2) One WebEx meeting was held on October 12th to go through the data issues list. External reviewers and chair were invited to attend. A summary of each meeting was sent to all WKNSEA participants.

3) Data compilation workshop 6–10 November 2017 (Annex 3).

4) Two WebEx meetings were held on January 24 and 26, 2018, to discuss progress on working documents. Externals were invited to attend.

5) The deadline for all working documents except those related to the assessment models was February 2, 2018. Most working documents were completed by the deadline.

The data issues are in Annex 4 and summarized, including working paper references, below. Working papers for each stock are in Annexes 5–8.

Lemon sole 27.3a47d			
Title	Description	Contributors	Working Papers
1. Biological data	a) Stock weights-at-age b) Maturity ogive c) Length–weight relationship	Coby Needle	WP1
2. Survey indices	a) IBTS Q1 b) Combined IBTS-BTS Q3 b) Biomass indices	Casper Berg, Coby Needle	WP1 and WP 2
3. InterCatch data	a) 2002–2016 catch data b) Raising of discards	Coby Needle	WP1
4. Assessment models	a) SPiCT b) SURBAR c) GeoPop (exploratory)	Rasmus Nielsen Coby Needle Tanja Buch	WP1 and WP 3

Flounder 27.3a4			
Title	Description	Contributors	Working Papers
1. Biological data	a) Stock weights-at-age b) Maturity ogive c) Length–weight relationship	Holger Haslob	WD 3
2. Survey indices	a) IBTS Q1 b) IBTS-BTS-SNS Q3 combined index c) Biomass indices	Casper Berg, Holger Haslob,	WD 1
3. InterCatch data	a) 2002–2016 catch data b) Raising of discards	Hogler Haslob	WD 2
4. Assessment models	a) SPiCT b) S6 (exploratory)	Holger Haslob, Casper Berg, Alexandros Kokkalis	WD 4

Whiting 27.47d			
Title	Description	Contributors	Working Papers
1. Stock identiy		Tanja Miethe	WD 1
2. Biological data	a) Stock weights-at-age b) Maturity ogive c) Natural maturity	Tanja Miethe, Thomas Regnier, Peter Wright	a) WD 6 b)WD 4 c) WD 3
3. Survey indices	a) IBTS Q1 & Q3	Tanja Miethe	WD 5
4. InterCatch data	a) 2002–2016 catch data b) Raising of discards	Tanja Miethe	WD 2
5. Assessment models	a) SAM b) SURBAR c) XSA	Tanja Miethe, Anders Nielsen	a) WD 7 b) WD 8 c) WD 9
6. Reference Points		Tanja Miethe	WD 10

Witch 27.3a47d			
Title	Description	Contributors	Working Papers
1. Biological data	a) Stock weights-at-age b) Maturity ogive c) Length–weight relationship	Francesca Vitale	WD 3
2. Survey indices	a) IBTS Q1 & Q3 b) Biomass indices	Francesca Vitale, Casper Berg	WD 2
3. InterCatch data	a) 2002–2016 catch data b) Raising of discards	Francesca Vitale	WD 1
4. Assessment models	a) SAM b) SPiCT	Anders Nielsen Alexander Kokkalis, Rasmus Nielsen	a) WD 4 b) WD 5

The first three days of the benchmark were devoted to biological parameters, survey and cpue indices, and the InterCatch raising and allocation procedures. After each presentation, discussions were held and participants reached a consensus on the outcome, e.g. which data to use in the assessment runs. This process involved several iterations, where more work was completed on a topic until a consensus was reached.

The last two days of the benchmark were devoted to the assessments and reference points.

Notes on the benchmark process

Not all data arrived by the deadline of the data call or the data workshop. There were also errors in InterCatch for lemon sole, which were not resolved for the benchmark but will be by the WGNSSK meeting. Despite these issues, nearly all working documents for both species were completed by the deadline.

4 Lemon Sole in 27.3a47d

This section relates to the stock of lemon sole (*Microstomus kitt*) stock in the North Sea (Subarea 4), Skagerrak (Division 3.a) and eastern English Channel (Division 7d).

4.1 Stock ID and substock structure

No results were presented on stock ID or substock structure during the benchmark.

4.2 Issue list

The issue list is taken from Annex 6 of ICES, WGNSSK (2017) and communication after WGNSSK 2017. The issue list is in Annex 4.

Expected working documents

The following gives the list of working documents that were expected for the benchmark. In the event, results and conclusions were mostly given through presentations and *ad hoc* discussions rather than specific working documents, and are therefore summarized throughout Section 4 rather than being lost.

1. 2002–2016 catch data – InterCatch (Coby Needle)
2. Biological parameters: stock weights-at-age, maturity, length–weight relationship (Coby Needle)
3. Survey indices tuning series (Casper Berg, Coby Needle)
4. SPiCT assessment (Rasmus Nielsen), SURBAR (Coby Needle), GeoPop (Tanja Buch)

The working documents that were completed can be found in Annex 6.

4.3 Scorecard on data quality

A scorecard was not used for this benchmark.

4.4 Multispecies and mixed fisheries issues

No new information was presented at the benchmark meeting.

4.5 Ecosystem drivers

No new information was presented at the benchmark meeting.

4.6 Stock assessment

4.6.1 Catch: quality, misreporting, discards

Catch data for the years 2002–2016 were provided by several participating nations following the WKNSEA data call and were collated using the InterCatch system. Commercial age samples proved sparse (see Tables 4.1 to 4.3). They were only provided by two countries (Denmark and Belgium). Although these do provide 27% and 17% respectively of international landings by weight in area 4 (average 2014–2016), and the reported effort of the Danish fleet does cover most of the survey-implied distribution of lemon sole (see Figures 4.1 and 4.2), the age data (for discards in particular) were not deemed by WKNSEA to be of sufficient quantity or coverage to warrant further consideration of an age-based assessment using commercial data. For this reason, collation in InterCatch used length-based sampling only.

WKNSEA considered whether areas should be considered separately for raising discards and length compositions, but the prevailing view was that there was no evidence of distinct stocks between areas (say, between areas 4 and 3.a), and that therefore all areas should be treated together for raising. Initial exploration demonstrated that final discard raising was significantly influenced by a small number of métiers with discard ratios greater than 1.5 (in other words, those métiers for which discards/landings >1.5). Subsequently, these métiers were discounted in calculating raising factors as they were thought to be non-representative for a high-value stock such as lemon sole. Otherwise, discards for all unsampled fleets were inferred by a discard rate generated using all sampled fleets (weighted by the landings CATON), as it was not thought likely that discard rates for an (essentially) bycatch stock would vary a great deal between different métiers (apart from the extreme and unrepresentative examples discussed above).

The use of a discard ratio of 1.5 as a cut-off point for inclusion of métiers in the raising factor was explored further. InterCatch raising was repeated for 2016 only, and only those métiers landing more than 10 tonnes of lemon sole were included in the calculation of the raising factor. The results for the two collation methods are compared in the following text table:

Fleets included in raising factor	Official landings	WG Landings	WG Discards	WG Total Catch	Discard rate
Discard ratio <1.5	3805	3834	1167	5000	23.33%
Landings >10 tonnes	3805	3834	1273	5107	24.92%

The collation method does have a minor effect on the estimated discard rate, but time did not permit a full exploration of the potential impact of this on the full time-series; and the effect is in any case small. WKNSEA suggests that further work on this issue be considered for the next benchmark.

Length-distribution allocations were conducted in the same way (weighted by mean numbers-at-length), with the only distinction being made between landings and discards. Length samples are reasonably well spread across the main countries catching lemon sole, albeit with a large spike in the final year for some countries following the relevant data call, and length-based allocations are likely to be sufficiently representative (see Tables 4.4 to 4.6). It is worth noting that the InterCatch raising procedure took a very long time for this stock; on average, each year of data took around half a day to produce due to very slow database operations. The resultant estimates for landings and discards for 2002-2016 are given in Table 4.7. We note that the official landings for 2012 did not include estimates for the UK, which is why they are considerably lower than the new InterCatch estimates. It can also be seen that the 2013 discard estimate is very high. The estimation was repeated three times during the WKNSEA meeting and does not appear to be in error. The problem appears to originate in the discard estimates provided by the Netherlands. Finally, length distributions in landings data from Belgium have been submitted with (probably) the wrong units. This does not affect yield estimates, but does need to be corrected for LBI analyse (see Section 4.7.5).

> *Alas, alack, the ages' samples sought, // Were few and far between, though try we may, // Forsooth, the surveys seemed the safest bet, // And survey-based assessment ruled the day.* (Needle, 2018).

4.6.2 Surveys

4.6.2.1 Research surveys

Three survey indices were developed for WKNSEA, based on the IBTS Q1 and Q3 and BTS Q3 surveys (either individually or in combination). These are considered further below.

Direct index estimation

The simplest of the indices, derived for IBTS Q1 and Q3 separately, is based on a post-graduate course in fisheries science given at the University of Aberdeen (Needle, 2014). The approach used was intended to demonstrate survey index generation clearly to students who may not have a mathematical background, and is therefore a) quite simplistic, and b) probably not statistically optimal. It is included here as it was presented to the WKNSEA data meeting in November 2017 (ICES, 2017d), and it remains a useful fallback should more complicated indices not be available. The course also included methods for estimating weights and maturities, and these are used here (see Section 4.6.3).

The procedure for each year can be summarised as follows:

- Generate an age–length key for the year, using data from the *SMALK* subset of the DATRAS database.
- Collate length data for all lemon sole caught during that year's survey, using the *cpue per length per haul* subset of DATRAS.
- Apply the age–length key to determine a distribution of inferred ages for each length class, and thereby derive the inferred number of fish caught per age during the survey.
- Rescale as number of fish caught per hour.

The resulting survey index can be used in a survey-based assessment method (see ICES, 2017a), but caution must be used; the approach takes no account of statistical issues such as spatial autocorrelation, and as a result may not be particularly reliable.

ICES estimation

ICES staff have developed indices for lemon sole following the standard ICES approaches (including area fill-ins as necessary). These are based on the same data as the procedure outlined above, but a different estimation approach is likely to lead to differences in the final indices.

The internal consistency of the ICES estimation indices is analysed in Figures 4.3 to 4.7. Catch curves (Figure 4.3) should be regular diagonal lines from left to right, with the slope of the line giving a rough indication of total mortality Z (possibly with a hook at the top caused by low survey catchability at younger ages). No such pattern is visible here, for either quarter. Similarly, the lines in Figure 4.4 should all show peaks and troughs at the same points, as this would indicate that year-class strength is being tracked consistently through all ages seen in the survey; there is no such evidence here. This consistency should also be evident in the bivariate scatterplots in Figures 4.5 and 4.6: if the survey can tracks cohorts through ages, then these plots should show significant regressions with positive slopes. Finally, the ICES estimation index is not very good at consistently measuring year-class strength within a year (comparing Q1 and

Q3; Figure 4.7). By all these metrics, the ICES estimation can be seen to track cohorts poorly through time.

GAM model

At the WKNSEA data meeting (ICES, 2017d), IBTS indices for Q1 and combined IBTS-BTS indices for Q3 were produced using the same code that is currently employed to derive indices for North Sea cod (amongst other stocks) and which therefore has been extensively tested and verified (Berg *et al*., 2014). The method used is covered in a separate WP (Berg, 2018).

The internal consistency of the GAM estimation indices are analysed in Figures 4.8 to 4.12. Although the ability to track cohort strength remains quite poor, there are some improvements over the ICES estimation, particularly for the bivariate scatterplots (Figure 4.10 and 4.11), which show slightly more significant regressions (and more with positive slopes). The within-year comparison (Figure 4.12) is also more favourable for GAM estimation.

Index comparisons

The three estimation approaches are compared in Figures 4.13 (Q1) and 4.14 (Q3). We note that the GAM model method for Q3 incorporates both IBTS and BTS survey data. Thus utilising the available data more fully than both the direct and ICES estimations. From Figure 4.13, we see some consistency between the methods for ages 2–5 (comparisons are limited to age 5 because the GAM model output was for ages 1–5 only), but there is little similarity between the estimates for age 1 and this must be considered to be a problematic age for IBTS Q1. Consistency is better for Q3 (Figure 4.14), even allowing for the fact that the GAM method uses both IBTS and BTS data for this quarter (and noting that the youngest age is still poorly estimated).

Finally, both GAM and ICES indices were used in exploratory SURBAR runs (see Section 4.6.4 for model settings). Summary plots are given in Figure 4.15, from which we can see that the results are relatively similar apart from recruitment. The ICES estimates of recruitment have very high uncertainty, particularly towards recent years. This may be a consequence of the poor cohort tracking at younger ages of the ICES-estimated index (see Figures 4.5 and 4.6), although this is also a weak area for the GAM-estimated index. In any case, the SURBAR run using the GAM-estimated index looks to be more reliable for advisory purposes.

The direct estimation method would not be recommended in this context, as it is a teaching tool rather than an optimised data-generation method. For the key ages in both Q1 and Q3, the results of the GAM and ICES methods show that the GAM estimation tends to lead to slightly better internal consistency, and results in a better-performing SURBAR run. The GAM estimation index is still not particularly good at tracking year-class strength, but it has the advantage of integrating observations from both IBTS and BTS in Q3. For this reason, and for the slight improvements in internal consistency and model performance, WKNSEA concludes that the GAM estimation indices for Q1 and Q3 should be used as the basis for advice.

Survey age sample coverage

Before considering an age- and survey-based assessment model further, it was important to determine from where in the North Sea the available age samples originated, and if this distribution covered the observed spatial distribution of the stock. Figure 4.1 shows the latter, while Figure 4.16 gives the distribution of age samples in the IBTS

Q1 and Q3 surveys (BTS Q3 distributions were not collated during WKNSEA). The IBTS Q1 lacks age samples in the northernmost roundfish areas, but samples in those areas are much more prevalent in Q3 so the lack may not be critical if data from both quarters are used to provide advice. Figure 4.1 also indicates that the stock is distributed more towards the central area of the North Sea, and that therefore a lack of age samples from the northern area in one quarter may not render the age-based approach invalid.

To investigate this issue further, plots were generated of the length distributions in "northern" (areas 1-3) and "southern" (areas 4–10; see Figure 4.17) roundfish sampling areas. We hypothesised that if the length distributions in the two areas were similar, then the lack of age data from the northern area in Q1 would probably not influence the assessment unduly. Figures 4.18 to 4.20 summarise the analysis for years 2014–2016. While the means are generally different through strict application of the *t*-test (across all years, 44 out of 52 means were different), the distributions are visually very similar. Therefore, there appears to be no strong reason to expect that fish in the north would have different length distributions than fish in the south, which adds confidence to our hypothesis that missing northern ages in one quarter will not unduly affect results.

Survey length sample coverage

WKNSEA also expressed concerns about the length coverage of the surveys, and whether this was representative of the catch length coverage (and hence, by implication, the stock length coverage). Figure 4.21 shows the sampled length distributions for commercial catch (from InterCatch) and for the surveys, combined over all available years, and indicates that the length distributions are broadly similar (although surveys are potentially lacking fish towards the extremes of the catch distributions). The presence of a persistent bimodal peak in commercial data also suggests that these may be questionable: large year classes should pass through the length distribution without resulting in a peak at smaller lengths when data are collated over all years. WKNSEA concluded that the length distributions in the survey data were sufficiently representative of the stock as a whole, and that therefore advice could appropriately be based on survey data alone.

4.6.2.2 Catch and effort series

As there are no catch-at-age data for North Sea lemon sole (see Section 4.6.1), there are no relevant age-based cpue series that can be used in assessment.

4.6.3 Weights, growth, maturity, natural mortality

4.6.3.1 Maturity

SMALK data were used to determine the proportion mature at-age for each available year (2006–2017). We used a fairly rough-and-ready procedure that converts the range of different maturity indicators used in the *SMALK* dataset to a common mature/not mature indicator, and then summarises the mature proportion across ages (Needle, 2014). The analysis further attempts to fit the following model.

$$Mat = \frac{\gamma}{1+e^{\alpha+\beta A}} \qquad (4.1)$$

where *A* denotes age. Figure 4.22 (upper) shows the results for maturity-at-age in 2016, using *SMALK* data from IBTS Q1, while the full maturity estimates for available years are given in Table 4.8.

Figure 4.23 gives time-series of maturity estimates for each age in the *SMALK* dataset, summarised with fitted smoothers (using the loess() R function with span = 1; R Core Team, 2017), along with the mean maturity for each age. Lemon sole appear to be fully mature by age 3, on average. While there does look to be an upwards trend in the early years for several ages, this perception seems to be driving principally by anomalously low values in 2007, and overall an assumption of fixed maturity-at-age is likely to be appropriate. Furthermore, the non-zero mean at-age 1 is also driven by a single early point that is unlikely to be representative; and the smoothed values for ages greater than 2 tend to overlap with the full maturity level (Mat = 1). WKNSEA therefore suggests the following values for future use in assessments:

- Mat = 0 at-age 1;
- Mat = age 2 average (= 0.72) at-age 2;
- Mat = 1 for age 3 and upwards.

4.6.3.2 Weight and growth

A similar calculation was also carried out to determine the mean weight-at-age in the IBTS Q3 survey, which could (in the absence of other information) be used as a proxy for mean weight-at-age in the stock. Figure 4.22 (lower) shows the results for 2016 from the IBTS Q3 survey, along with a line tracing the mean weight at each age. The mean weight-at-age estimates are also given in Tables 4.9 (IBTS Q1) and 4.10 (IBTS Q3).

As for maturity, the mean weights-at-age estimates are summarised by year and age in Figure 4.24 (IBTS Q1) and 4.25 (IBTS Q3). While the Q1 estimates are noisy for certain ages, in no case is there evidence of a significant trend with time, and WKNSEA concluded that fixed weights-at-age through time would be appropriate. Lemon sole spawn for a considerable period in the North Sea, starting as early as April in the north and ending as late as November in the south (Rae, 1965), so WKNSEA concluded further that a combined estimate including both Q1 and Q3 weights would be appropriate. For each age, the available weights were plotted together (Figure 4.26), positioned so that Q1 weights were at y+0.25 and Q3 weights at y+0.75 (an additional point was added at the start of each time-series to enable extrapolation). A loess smoother (span = 1) was then fitted through all points for each age, so that the final estimate was (effectively) an average of consecutive weight estimates. The final values are given in Figure 4.26 and Table 4.11.

Finally, a length–weight relationship was also derived for each year for which *SMALK* data were available. Figure 4.27 shows the fitted model $W = L^{\beta}$ for data from the IBTS Q1 and Q3 surveys in 2016.

4.6.3.3 Natural mortality

Natural mortality (*M*) estimates for lemon sole are not available. For current advisory purposes, however, estimates of *M* are not required, as the assessment is survey-based (see Section 4.6.4) and hence estimates total mortality *Z*.

4.6.4 Assessment models

Currently, there exist very few age data samples from commercial catches for North Sea lemon sole (see Section 4.6.1), and WKNSEA concluded that these were insufficient to warrant the application of a catch-at-age-based assessment model. A spatio-temporal model based on length data from surveys is in development, but was not thought to be in a stage yet to enable use as a final assessment (GeoPop; Buch, 2018). No other length-based model, which used commercial catch or survey data, was presented to WKNSEA. Finally, the stochastic production model SPiCT (Pedersen and Berg, 2017) proved to be unsuitable for use as an assessment model for lemon sole (see Section 4.7.4).

4.6.4.1 SURBAR

The remaining approach presented to WKNSEA was the age- and survey-based assessment model SURBAR (Needle, 2015a). This applies a separable model of total mortality to standard age-based survey data to generate estimates of total mortality, along with relative estimates of recruitment and (given stock weights and maturities) spawning–stock biomass. SURBAR is widely used within ICES and elsewhere to provide exploratory assessments, and is used in some cases (for example, dab in this WKNSEA Report) for which catch data are missing or very uncertain.

4.6.4.2 Sensitivity analyses

SURBAR requires a number of user-defined run-time settings, which are to a large extent *ad hoc* and based on a qualitative evaluation, and the impact of these had to be explored before a final configuration could be agreed. The key settings to be tested were the penalty smoother λ on interannual and interage mortality variation, the reference age a_r (that is, the age at which the age-effect in mortality is fixed to 1.0), which surveys to use (GAM IBTS Q1, GAM IBTS & BTS Q3, or both), and the assumed catchability on older (and hence larger) fish. Full details of these settings can be found in Needle (2015a).

The sensitivity analyses used a base-case in which $\lambda = 3$, $a_r = 3$, both surveys were included, and full catchability was assumed on older fish (q = 1.0 for ages 6-9). Initial analysis of catch curves suggested that assumed catchability on the youngest ages should be reduced substantially, to avoid "hooks" in catch curves, and consequently $q_1 = 0.1, q_2 = 0.5$ throughout. Sensitivity runs then varied each of these, one at a time, to explore the impact of the run-time settings.

The runs are summarised below.

1) The smoother λ is essentially *ad hoc*, as it is a user-defined penalty on "excessive" variation in mortality (and "excessive" is difficult to define). λ was set to three values ($\lambda = 1,3,5$) and the base-case SURBAR model was run for each. Figure 4.28 shows that setting $\lambda = 1$ results in high variability of mortality estimates, with consequent impacts on recruitment and SSB. The choice between setting $\lambda = 3$ or 5 has very little impact, so the lower value (3) was chosen to avoid over-smoothing.

2) Fixing the age effect on mortality to 1.0 at the reference age a_r is necessary to ensure the model will be determinate with a unique solution. a_r is generally chosen to lie within the age range for estimating mean mortality, which for lemon sole is currently 3 to 5. However, a_r must be less than the second-oldest age in all surveys, and must be greater than the youngest age in all surveys. This means that sensitivity runs could only use $a_r = 2$ or 3. Figure 4.29 shows that the choice makes very little difference in this case, so the base-case value of $a_r = 3$ was retained.

3) The effect of the choice of survey(s) to use is illustrated in Figure 4.30. While the different surveys do lead to slightly different perceptions of stock dynamics, the overall trends in all cases are very similar. The base-case (using both Q1 and Q3 surveys) was retained in order to include as many data in the analysis as possible. Age data are somewhat scarce for this stock, and it is important to try to use as much as we can.

4) WKNSEA expressed concern about the ability of surveys to catch larger sole (Figure 4.21 suggested that this may be compromised to a certain extent). Catchability q is a user-defined parameter in SURBAR, and Figure 4.31 shows the impact of setting q on the oldest ages (6 to 9) to 1.0, 0.75 and 0.5. SSB, TSB and recruitment (all derived from estimated abundance) remain largely unchanged. The only significant effect on is estimates of mortality, which is reduced as assumed catchability is reduced. Any mortality-based reference points which are subsequently estimated, will be relative to the scale of the estimated mortality, and as the trends in mortality are very similar, the choice of assumed catchability will have little or no effect on advice. For this reason, the catchability of older ages was fixed to 1.0 as in the base case.

Following the sensitivity analyses, WKNSEA concluded that there was no reason to deviate from the base-case runtime settings, and these were adopted in subsequent runs.

4.6.4.3 Final SURBAR run

WKNSEA produced a final SURBAR run to illustrate the method, using the agreed runtime settings and based on the GAM-estimated IBTS Q1 and IBTS+BTS Q3 surveys. The run is summarised in Figures 4.32 to 4.38. The stock summary (Figure 4.32) shows that mean Z has been relatively stable since 2009, although the wide confidence intervals hinder a strong conclusion about trends. It can also be seen that the mean Z estimate is negative in several years. This is a result of positive slopes in catch curves, and can be a consequence of using noisy survey data. SSB estimates show a steady increase, also since 2009, although the final point is highly uncertain. As maturity is assumed to be fixed through time (see Section 4.6.3.1), total biomass matches the trend in SSB. Finally, recruitment at-age 1 appears to have fluctuated without obvious trend until a significant decline in 2017. This indication of a low year class cannot be accounted for in the standard 3:2 advice decision rule, and this is discussed further below. The stock summary is also given in Table 4.12.

Log residuals for IBTS Q1 are given in Figures 4.33 (lines) and 4.34 (points with smoothers), while Figures 4.35 and 4.36 give the residuals for IBTS+BTS Q3. The latter have smaller residuals overall, suggesting that the model is driven more by Q3 than by Q1 data (which would make sense given the better internal consistency of Q3 data; see Section 4.6.2.1). The Q1 residuals tend to be negative, balanced by the largely positive Q3 residuals, implying that the Q1 survey suggests that stock is smaller than the final model would indicate. Similarly, the Q3 survey would suggest that the stock is larger. We note that there are also two large negative outlier residuals: at-age 1 in 2008 for IBTS Q1, and at-age 1 in 2013 for IBTS+BTS Q3. A further sensitivity run was performed with both of these datapoints downweighted in the SURBAR model fit (setting weighting $\omega = 0.5$ rather than the usual $\omega = 1.0$). The only impact of this was to increase the estimates of recruitment in 2008 and 2013 by a small amount, but the scale of the downweighting is difficult to justify quantitatively and this approach was not taken further.

Figure 4.37 gives the SURBAR parameter estimates for the age and year effects in mortality and the cohort effect. Finally, the retrospective plots in Figure 4.38 show that generally there is little retrospective noise or bias. The exception is two years of recruitment (2013 and 2015), the sizes of which were underestimated when they first appeared. General conclusions can't be drawn from two instances, but if there is a tendency to underestimate year classes then this should be considered when interpreting the historical low recruitment estimate for 2017.

So SURBAR cameth forth, as well it might, // The status of the stock did it suggest, // Advice be based on rule of 3-to-2, // A valid scheme for kitt *from east to west.* Needle (2018).

4.7 Appropriate reference points (MSY)

4.7.1 Reference points prior to benchmark

Prior to the WKNSEA meeting, there were no existing reference points for North Sea lemon sole.

4.7.2 Source of data

Age-based and biomass indices are available for reference point estimation, from the IBTS (Q1 and Q3) and BTS (Q3) surveys. Length distributions from commercial catches are also now available, and are collated in InterCatch for 2002–2017.

4.7.3 Stock–recruitment relationship and new B_{lim} and B_{pa} reference points

B_{lim} and B_{pa} reference points were not considered at the WKNSEA meeting.

4.7.4 Methods and settings used to determine ranges for F_{MSY}

During its 2017 meeting, WGNSSK estimated length-based indicators (LBIs) following the standard approach outlined by WKLIFE (ICES, 2017b) and WKMSYCat34 (ICES, 2017c). At that time, only length samples for 2016 had been submitted to InterCatch (principally from England), and the analysis was therefore limited to a single year (meaning that few robust conclusions could be drawn).

In advance of the November 2017 and February 2018 WKNSEA meetings, an extensive data call led to length distributions being submitted to InterCatch from eight countries for 2002–2016 (see Tables 4.4 to 4.6). In light of concerns over the validity of the survey data required for converging SPiCT runs (see below), WKNSEA therefore decided to rerun the length-based indicator analysis using this expanded dataset. Results are given and discussed in Section 4.7.5 below.

The principal approach to estimating F(MSY) at the 2017 WGNSSK meeting was the SPiCT production model (Pedersen and Berg, 2017), widely used for F(MSY) estimation for relatively data-poor stocks in the North Sea. Considerable effort at WKNSEA went into a re-evaluation of the SPiCT model for lemon sole, including consideration of the IBTS survey series used. In order to achieve a converged SPiCT run using data with sufficient contrast, a long IBTS Q1 survey time-series was required, including available data back to 1966. However, concerns were expressed at WKNSEA that IBTS data prior to 1983 may have been of dubious quality. Few countries (only Scotland and the Netherlands) reported lemon sole on their surveys prior to 1983, and gear and survey methodologies were not necessarily standardised. The perception (see ICES, 2017a) of lower lemon sole abundance in the early period may have been due to these factors, rather than reduced stock size, and it could not be robustly concluded that the long time-series for IBTS Q1 was a reliable indicator of stock trends. Removing the early years reduced the contrast in the survey data, and SPiCT did not converge as a consequence. For these reasons, WKNSEA concluded that a SPiCT analysis could not currently be used to provide proxy F(MSY) reference points for this stock, and length-based indicators were considered subsequently.

A SPiCT assessment did not pass the test, // The IBTS survey was too brief, // And lackéd contrast in the index seen, // Much work was lost, yet gave we not to grief. (Needle 2018).

4.7.5 Final length-based MSY proxies

Length distributions were taken from the relevant InterCatch submissions. We note that the discard length data for 2013 (see also Section 4.6) were an order of magnitude higher than anything else seen in the full time-series, and on the assumption that these were in error the numbers-at-length in the estimated population were reduced by a factor of 10, for 2013 and for lengths 120 mm to 200 mm. This is an *ad hoc* fix to attempt to ensure an interpretable LBI analysis, and the data problem will need to be fixed at source in time for the next WGNSSK meeting.

Figure 4.39 gives the resultant length distributions following this fix. LBI analysis works best when there is a smooth increase from the start of the observed length distribution, and bimodal peaks such as can be seen in Figure 4.39 can cause false estimates of L_c (length at first catch). For this reason, the length distributions were modified further: lengths less than 100 mm were removed (these would not be representative of the commercial catch in any case, and probably arose mostly through incorrect units in Belgian data), and the bin widths were increased from 10 mm to 20 mm to improve smoothness. The new length distributions on which LBI analyses were conducted are given in Figure 4.40.

Figure 4.41 and Table 4.13 summarise the output from the LBI analysis. Considering each estimate in turn:

- The length at first catch (L_c) is close to $L_{maturity}$, which indicates immature individuals in the catches.
- The catch length distribution is well below the optimum fishing length (L_{opt}), which suggests that lemon sole are being caught at smaller sizes than would be ideal for a sustainable fishery.
- $L_{F=M}$ is greater than L_{mean}, which suggests fishing above F_{msy}.
- The ratio of the mean length of upper 5th percentile of catches to L_{inf} is around 0.55, which suggests a lack of large (and hence old) fish in the population.
- L_{mean}/L_{opt} ~0.6, which suggests that fishing does not target the most productive length classes.
- Finally, $L_{mean}/L_{F=M} < 1$, which again suggests fishing above F_{msy}.

Overall, the LBI analysis suggests that $F > F_{msy}$, principally because there appear to be few large fish in catches. On this basis alone, one would need to consider the potential to reduce the stock advice (because the stock status relative to reference points is poor). However, some problems remain with catch data that need to be addressed before the

WGNSSK meeting in late April 2018, and it would be precipitate to jump to conclusions. Furthermore, the analysis doesn't account for selectivity; this is often domed for flatfish, and this could be an alternative hypothesis for the lack of older fish in catches.

4.7.6 Sensitivity runs

Sensitivity runs for the SURBAR assessment model are presented in Sections 4.6.4.2 and 4.6.4.3 above.

4.7.7 Proposed MSY reference points

No new reference points could be proposed by WKNSEA. It is proposed that the status of the stock in relation to a proxy for F_{msy} is determined on an annual basis through the LBI analyses presented in Section 4.7.5.

4.8 Future research and data requirements

Prior to the 2018 meeting of WGNSSK, it will be important to check InterCatch data submissions further to determine whether there are errors. This applies in particular to length distributions from Belgium, for which the wrong units appear to have been used for some data, and to discard data from the Netherlands, which (for smaller fish) are at least an order of magnitude larger than expected. It would also be useful to determine the reason for the large increase (72 to 9000) in the number of Scottish length samples in 2016 (see Table 4.4).

The current version of SURBAR assumes that all survey data are equally valid and reliable. However, the code does allow for downweighting of points in the overall model SSQ, and it would be possible to account for index estimation CVs. A good proxy might be the square root of the number of age samples in the estimation. This should be considered for a future implementation. Over the longer term, length-based approaches to assessment should be explored further as length data are far more numerous than age data.

More speculatively, WKNSEA discussed the possibility of basing the 3:2 advice rule not on historical data alone, but on a combination of historical and forecast data. The idea would be to run a deterministic short-term (two-year) forecast within the SURBAR model, and then apply the 3:2 rule using the last three historical years and the two forecast years. This would require assumptions about mortality, growth and recruitment, but it would (importantly) allow consideration of low (or high) incoming year classes, which currently is not possible. Application of the standard 3:2 rule to the current lemon sole assessment, without consideration of the low incoming year class, is likely to allow for more fishing than would be sustainable.

The SPiCT model was dependent on the inclusion of IBTS Q1 data prior to 1983 for convergence; these data provide contrast to the SPiCT model, from which the population growth parameter is estimated. The 1968 to 1982 data were questioned as to whether they were representative of the stock given the spatial and survey design changes during this period. A brief investigation of other flatfish stocks showed a similar increase in this period, which meant that an increase in catchability of the survey for flatfish could not be ruled out. Because of time constraints, this period could not be explored further during the benchmark meeting. The IBTS Q1 survey data prior to 1983 should be re-examined to identify e.g. any changes in survey design, gear, area covered, data processing, data reporting, that could have had an impact on the lemon sole abundance index.

4.9 References

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4.10 Tables

Table 4.1. North Sea lemon sole. Number of age samples provided to InterCatch (area 4). Years with no samples are highlighted in red.

Area	27.4			
	Belgium		Denmark	
	Landings	Discards	Landings	Discards
2002	0	0	772	0
2003	0	0	764	0
2004	0	0	868	0
2005	0	0	1	0
2006	0	0	171	0
2007	0	0	103	0
2008	0	0	225	5
2009	0	0	339	54
2010	0	0	477	1
2011	0	0	265	11
2012	0	0	423	0
2013	237	0	211	0
2014	0	0	799	0
2015	76	0	1418	0
2016	135	0	1637	0

Table 4.2. North Sea Lemon Sole. Number of age samples provided to InterCatch (area 3.a). Years with no samples are highlighted in red.

Area	27.3.a			
	Belgium		Denmark	
	Landings	Discards	Landings	Discards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	3
2009	0	0	0	3
2010	0	0	0	28
2011	0	0	0	15
2012	0	0	0	16
2013	365	0	0	9
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	379	10

Table 4.3. North Sea Lemon Sole. Number of age samples provided to InterCatch (area 7.d). Years with no samples are highlighted in red.

Area	27.7.d			
	Belgium		Denmark	
	Landings	Discards	Landings	Discards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	175	282	0	0
2015	126	388	0	0
2016	197	184	0	0

Table 4.4. North Sea lemon sole. Number of length samples provided to InterCatch (area 4), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

Area	Category	Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	199
		Denmark	61	52	212	80	113	84	69	88	29	87	126	87	66	121	145
		France	0	0	64	0	74	0	0	0	0	0	0	0	0	0	0
		Germany	49	235	20	20	1	32	50	13	6	114	51	153	73	44	2
		Netherlands	0	0	0	0	0	0	0	0	0	47	39	18	46	444	1153
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	200	678	1374	396	287	747	1043	280	177	313	99	302	234	323	559
		UK (Scotland)	0	0	0	0	0	0	0	183	0	0	43	13	0	260	4322
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2616
		Denmark	772	764	868	0	171	103	225	0	0	0	0	99	0	124	1637
		France	0	0	0	0	0	0	0	0	0	0	0	0	59	0	0
		Germany	69	45	30	61	48	32	150	277	182	48	236	98	100	332	392
		Netherlands	0	0	0	0	0	0	0	0	0	31	135	72	169	185	0
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	5804	6434	11189	5860	1296	1270	748	294	343	208	0	269	71	394	683
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	72	0	72	0	9135

	3 year average landings
UK	38%
DNK	27%
BEL	17%
NED	14%
GER	2%
FRA	1%
NOR	1%
Other	0%

Table 4.5. North Sea lemon sole. Number of length samples provided to InterCatch (area 3.a), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

Area	Category	Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.3.a	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Denmark	430	0	0	65	133	116	86	261	293	288	389	222	94	263	357
		France	0	0	71	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	294	0	0	368	445	316	217	204	335	239	251	336	205	62	385
		UK (England)	0	12	245	0	0	0	0	0	0	0	0	0	0	0	0
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379
		France	0	0	106	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	7	0	4	0	0	3	17	0	0	53	3	22
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	59	0
		Sweden	368	0	0	598	1016	222	69	255	347	88	118	65	41	0	0
		UK (England)	0	274	2983	0	0	0	0	0	0	0	0	0	0	0	0
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	3 year average landings
BEL	0%
DNK	90%
GER	2%
NED	3%
SWE	3%
Other	2%

Table 4.6. North Sea lemon sole. Number of length samples provided to InterCatch (area 7.d), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

Area	Catch	Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.7.d	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3053
		Denmark	0	1	410	0	0	0	0	0	0	0	0	0	0	0	0
		France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	0	0	132	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	1	0	0	110	81	20	80	10	82	99	77	20	45	2	29
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7443
		Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		France	0	0	0	0	0	0	147	0	0	0	0	0	65	0	391
		Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	0	0	184	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	45	0	0	1932	90	137	0	272	160	0	167	189	169	156	1148
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	3 year average landings
BEL	47%
DNK	0%
FRA	31%
NED	3%
UK	19%
Other	0%

Table 4.7. North Sea lemon sole. InterCatch estimates of landings, discards, and total catch along with officially reported landings, for 2002–2016 (all values in tonnes). The high discard estimate in 2013 is highlighted.

Year	Official landings	InterCatch landings	InterCatch discards	InterCatch total catch	Discard rate
2002	4823	4011	511	4522	11.30%
2003	4722	4575	1036	5611	18.46%
2004	4574	4394	635	5028	12.62%
2005	4468	4429	527	4955	10.63%
2006	4290	4294	1515	5809	26.08%
2007	4488	4468	451	4919	9.18%
2008	3976	4153	898	5051	17.77%
2009	3397	3405	996	4401	22.64%
2010	3198	3234	673	3907	17.21%
2011	4019	4030	1024	5055	20.27%
2012	2959	4099	2461	6560	37.52%
2013	3761	3725	5938	9663	61.45%
2014	3688	3645	1690	5335	31.68%
2015	3393	3480	1636	5116	31.97%
2016	3805	3834	1161	4995	23.25%
				Average	17.22%

Table 4.8. North Sea lemon sole. Estimated proportion mature-at-age from IBTS Q1. *SMALK* data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006–2017. The full age-range (0–18) is given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1984	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1985	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1986	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1987	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1988	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1989	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1990	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1991	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1992	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1993	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1994	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1995	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1996	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1997	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1998	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1999	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2000	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2001	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2002	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2003	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2004	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2005	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2006	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2007	NA	NA	0.000	0.667	0.565	0.676	0.690	0.833	0.800	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
2008	NA	NA	0.933	0.898	1.000	0.943	0.846	0.972	0.846	0.875	1	1	0.955	1	1	1	NA	1	NA
2009	NA	1.000	0.933	1.000	0.917	1.000	1.000	1.000	1.000	1.000	1	NA	1.000	1	NA	NA	NA	NA	1
2010	NA	0.000	0.675	0.843	0.957	0.875	0.500	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	0.909	1.000	1.000	0.952	1.000	NA	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	0.900	0.983	0.923	0.933	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	0.000	0.767	0.949	0.950	1.000	1.000	NA	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	0.379	0.587	0.969	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	0.727	0.922	0.976	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	0.818	0.979	1.000	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	0.864	0.913	0.980	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4.9. North Sea lemon sole. Estimated mean weight-at-age from IBTS Q1 survey. *SMALK* data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006–2017. The full age-range (0–18) is given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1984	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1985	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1986	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1987	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1988	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1989	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1990	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1991	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1992	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1993	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1994	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1995	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1996	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1997	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1998	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1999	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2000	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2001	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2002	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2003	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2004	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2005	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2006	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2007	NA	NA	0.056	0.099	0.173	0.326	0.412	0.530	0.220	NA	NA	0.226	NA	NA	NA	NA	NA	NA	NA
2008	NA	NA	0.061	0.111	0.193	0.289	0.230	0.166	0.104	0.112	0.129	0.150	0.137	0.145	0.098	0.153	NA	0.209	NA
2009	NA	0.030	0.085	0.136	0.218	0.242	0.187	0.216	0.164	0.122	0.205	NA	0.142	0.164	NA	NA	NA	NA	0.150
2010	NA	0.013	0.059	0.106	0.159	0.291	0.292	0.315	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	0.060	0.102	0.170	0.231	0.368	NA	0.485	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	0.063	0.152	0.245	0.358	0.372	0.658	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	0.016	0.057	0.139	0.220	0.316	0.510	NA	0.442	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	0.013	0.058	0.110	0.172	0.257	0.218	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	0.046	0.094	0.185	0.174	0.273	0.334	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	0.055	0.099	0.161	0.197	0.139	0.158	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	0.065	0.128	0.197	0.310	0.409	0.494	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4.10. North Sea lemon sole. Estimated mean weight-at-age from IBTS Q3 survey. *SMALK* data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006–2017. Ages 0–15 are given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1991	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1992	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1993	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1994	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1995	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1996	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1997	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1998	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
1999	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2000	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2001	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2002	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2003	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2004	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2005	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433
2006	0.010	0.051	0.083	0.127	0.264	0.251	0.296	0.258	0.250	0.272	0.404	0.290	0.365	NA	NA	NA
2007	0.032	0.055	0.071	0.125	0.259	0.327	0.371	0.340	0.379	0.301	0.408	NA	0.292	0.309	NA	0.325
2008	NA	0.046	0.081	0.135	0.225	0.377	0.307	0.408	0.287	0.410	0.374	0.452	0.316	NA	0.452	0.178
2009	0.014	0.054	0.098	0.170	0.259	0.269	0.330	0.276	0.404	NA	NA	0.105	NA	0.138	NA	NA
2010	0.002	0.039	0.062	0.098	0.245	0.235	0.202	0.291	0.283	0.326	0.259	0.393	0.331	0.706	0.162	0.174
2011	NA	0.053	0.067	0.104	0.235	0.272	0.293	0.347	0.337	0.286	0.406	0.346	0.325	0.520	0.412	0.403

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2012	0.022	0.046	0.088	0.171	0.239	0.318	0.304	0.304	0.391	0.295	0.351	0.333	0.307	0.223	0.200	NA
2013	NA	NA	0.015	0.063	0.101	0.220	0.307	0.284	0.239	0.294	0.395	0.362	0.350	NA	NA	0.970
2014	0.024	0.036	0.072	0.080	0.141	0.225	0.246	0.312	0.256	0.384	0.305	0.280	0.415	0.269	0.340	0.377
2015	NA	0.006	0.048	0.091	0.162	0.207	0.276	0.299	0.374	0.391	0.387	0.370	0.350	0.352	0.223	0.630
2016	NA	0.022	0.056	0.080	0.141	0.235	0.246	0.304	0.327	0.335	0.346	0.287	0.475	0.254	0.660	0.446
2017	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433

Table 4.11. North Sea lemon sole. Final weights-at-age estimates, derived from loess-smoothed estimates-at-age for both IBTS Q1 and Q3.

	1	2	3	4	5	6	7	8	9
2007	0.0531	0.0648	0.1110	0.2068	0.3238	0.3562	0.3914	0.2415	0.2735
2008	0.0483	0.0694	0.1197	0.2159	0.3115	0.3301	0.3604	0.2708	0.2594
2009	0.0441	0.0715	0.1255	0.2209	0.3018	0.3153	0.3433	0.2986	0.2540
2010	0.0404	0.0715	0.1283	0.2215	0.2935	0.3089	0.3380	0.3229	0.2576
2011	0.0373	0.0694	0.1279	0.2179	0.2857	0.3093	0.3468	0.3463	0.2688
2012	0.0343	0.0633	0.1230	0.2090	0.2818	0.3304	0.3597	0.3606	0.2906
2013	0.0295	0.0580	0.1147	0.1945	0.2669	0.3218	0.3570	0.3658	0.3164
2014	0.0264	0.0548	0.1076	0.1818	0.2528	0.3072	0.3515	0.3583	0.3347
2015	0.0252	0.0546	0.1045	0.1750	0.2459	0.2969	0.3401	0.3466	0.3448
2016	0.0266	0.0575	0.1041	0.1735	0.2428	0.2865	0.3306	0.3311	0.3503
2017	0.0300	0.0630	0.1063	0.1766	0.2433	0.2756	0.3215	0.3133	0.3508

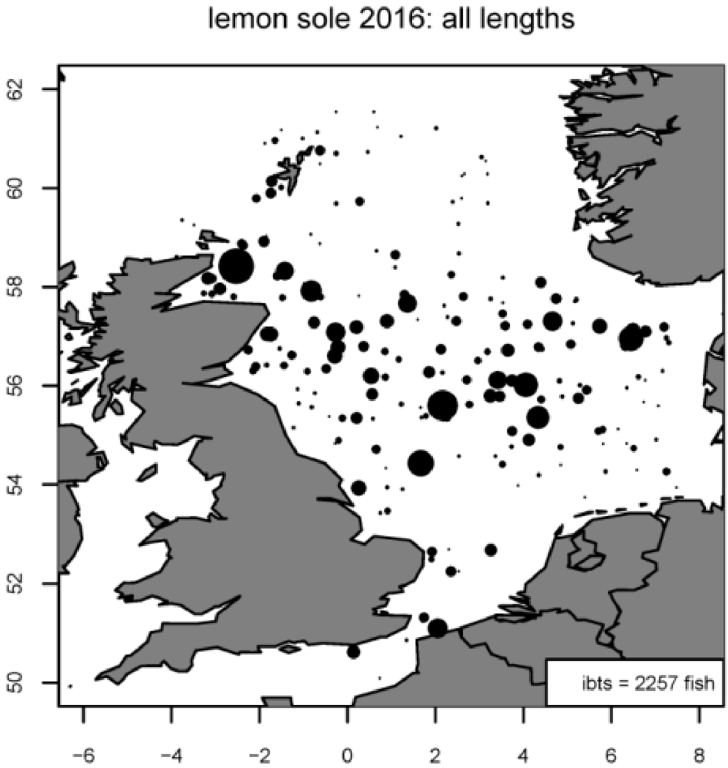
Table 4.12. North Sea lemon sole. Final SURBAR stock summary.

Year	Recruitment-at-age 1	SSB	TSB	Mean Z(3-5)
2005	1.389	1.288	1.414	0.165
2006	1.459	1.327	1.456	0.178
2007	1.932	1.676	1.826	0.431
2008	1.171	1.354	1.461	0.379
2009	1.726	1.084	1.229	-0.075
2010	2.381	1.245	1.381	-0.001
2011	2.082	1.669	1.846	0.111
2012	2.004	2.087	2.272	0.210
2013	1.310	1.313	1.388	0.184
2014	2.304	1.512	1.635	0.112
2015	1.124	1.753	1.801	0.007
2016	1.395	1.901	1.970	0.007
2017	0.297	2.497	2.558	0.042

Table 4.13. North Sea lemon sole. Summary table from LBI analysis. "Good" indicators are highlighted in green, "bad" in red.

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/LF=M
Ref	>1	>1	>0.8	>30%	~1 (>0.9)	≥1
2002	1.667	1.567	0.578	0.00	0.707	0.875
2003	1.000	1.500	0.575	0.00	0.620	0.976
2004	1.533	1.633	0.578	0.00	0.693	0.897
2005	1.667	1.633	0.525	0.00	0.650	0.805
2006	1.667	1.633	0.555	0.00	0.680	0.842
2007	1.667	1.633	0.562	0.00	0.664	0.822
2008	1.267	1.500	0.575	0.00	0.638	0.906
2009	0.733	1.500	0.574	0.00	0.623	1.101
2010	1.533	1.633	0.583	0.00	0.680	0.880
2011	0.867	1.167	0.553	0.00	0.541	0.902
2012	1.267	1.300	0.547	0.00	0.588	0.835
2013	0.867	1.033	0.551	0.00	0.486	0.811
2014	1.000	1.300	0.574	0.00	0.566	0.892
2015	1.133	1.300	0.573	0.00	0.574	0.857
2016	1.267	1.367	0.583	0.00	0.625	0.888

4.11 Figures



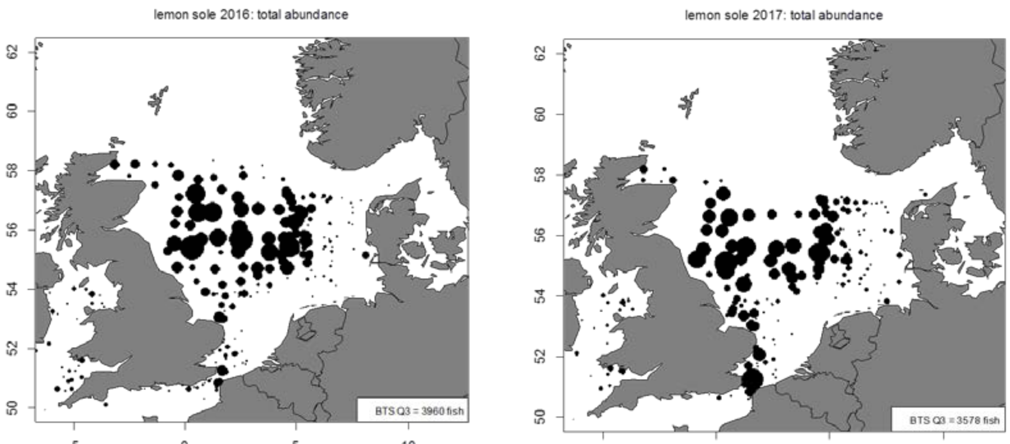


Figure 4.1. North Sea lemon sole. Distribution of lemon sole in the North Sea, as indicated by surveys. Upper: distribution by number of lemon sole caught per hour at each survey station during the IBTS Q1 survey in 2016. Lower: distributions by number for 2016 and 2017 in the BTS Q3 survey.

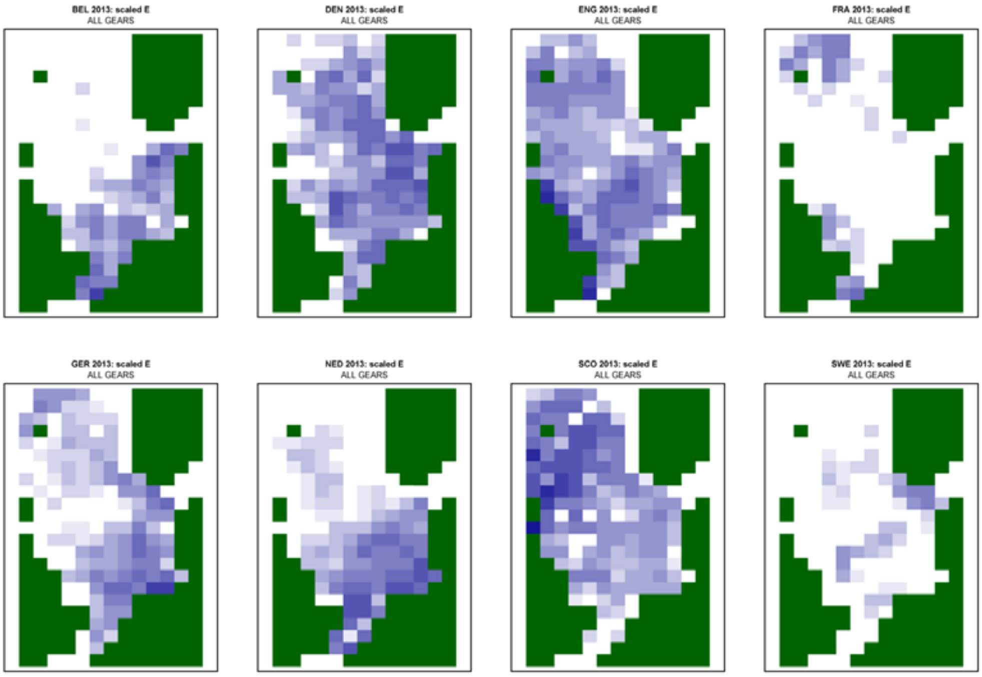


Figure 4.2. North Sea lemon sole. Reported effort distributions for all gears in the North Sea in 2013, presented separately for the main participating nations. Darker colours indicate more days at sea, as recorded in the STECF database. More details on the scaling used can be found in Needle (2015b).

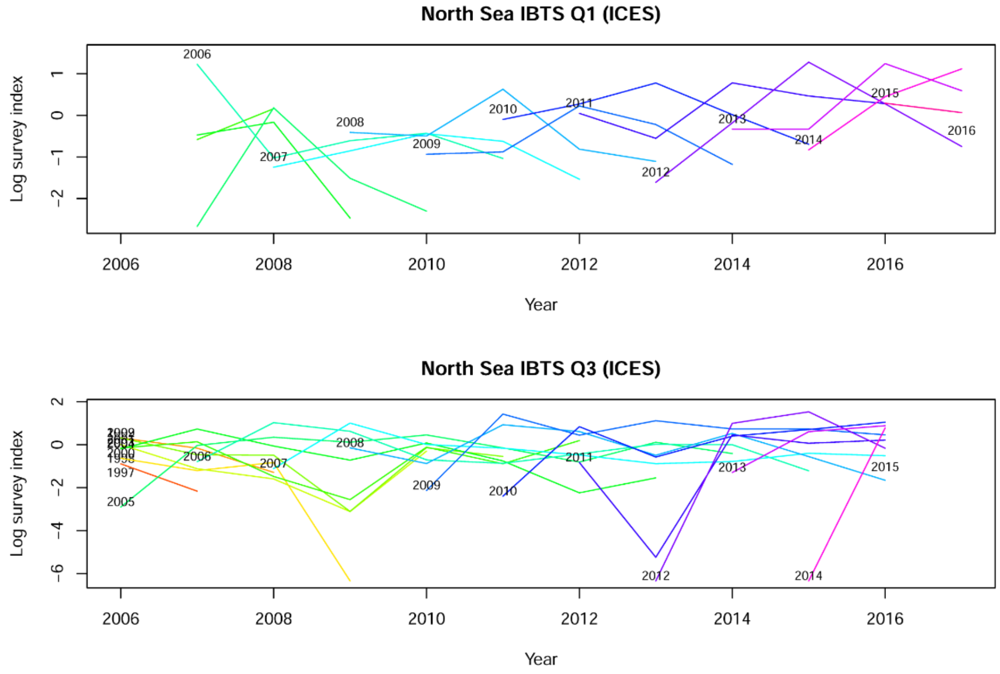


Figure 4.3. North Sea lemon sole. ICES estimation: catch curves (survey index on a log scale with one line for each cohort.

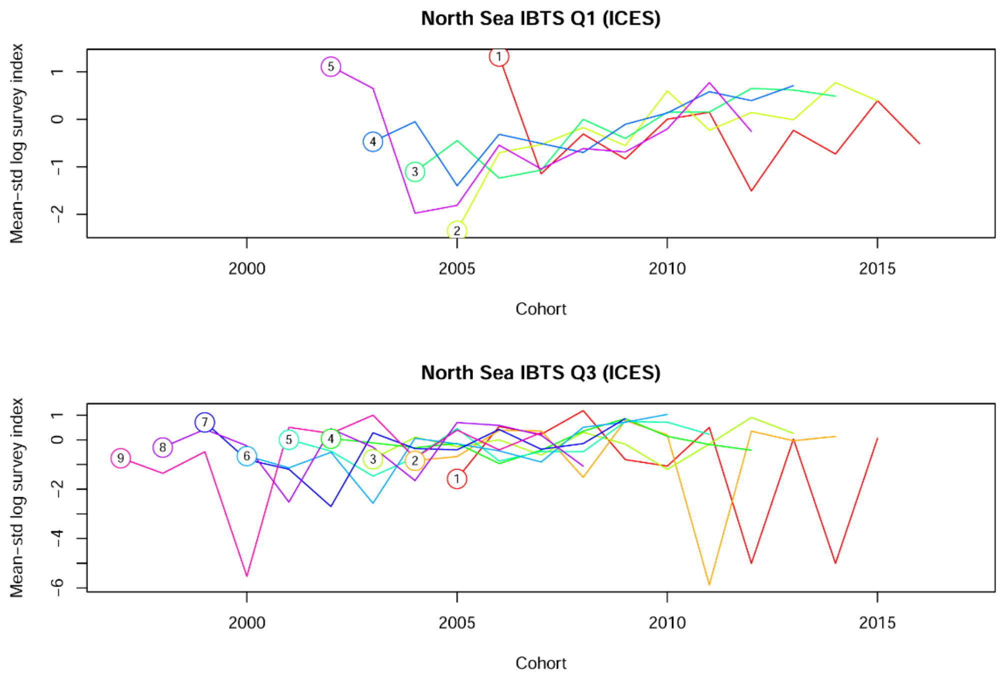


Figure 4.4. North Sea lemon sole. ICES estimation: catch by year class (one line for each age with cohort on the x-axis).

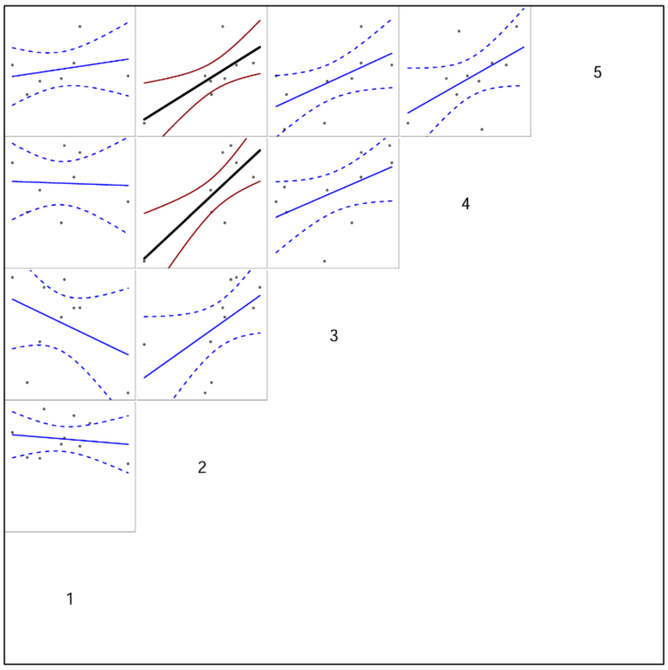


Figure 4.5. North Sea lemon sole. ICES estimation: bivariate scatterplots comparing index values for each cohort from age *a* to *a*+1 for IBTS Q1. Lines give linear regressions with approximate 95% confidence intervals: significant regressions are shown in black and red, non-significant regressions in blue.

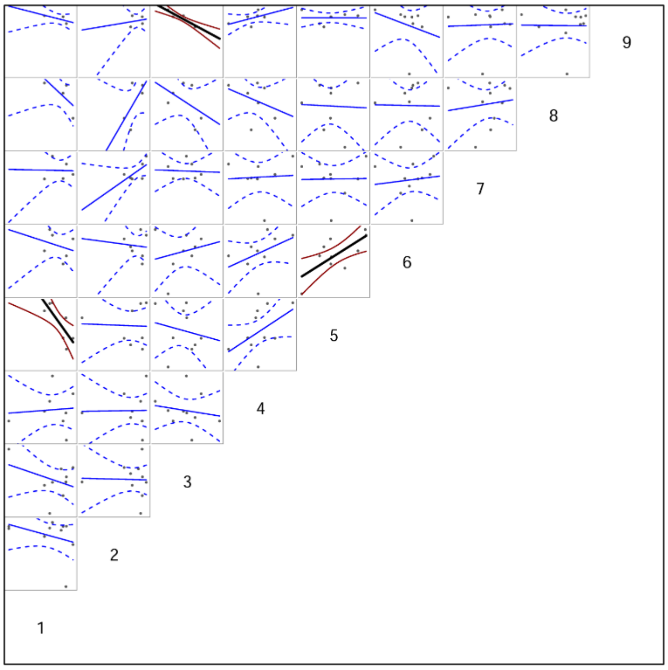


Figure 4.6. North Sea lemon sole. ICES estimation: bivariate scatterplots comparing index values for each cohort from age *a* to *a*+1 for IBTS Q3. Lines give linear regressions with approximate 95% confidence intervals: significant regressions are shown in black and red, non-significant regressions in blue.

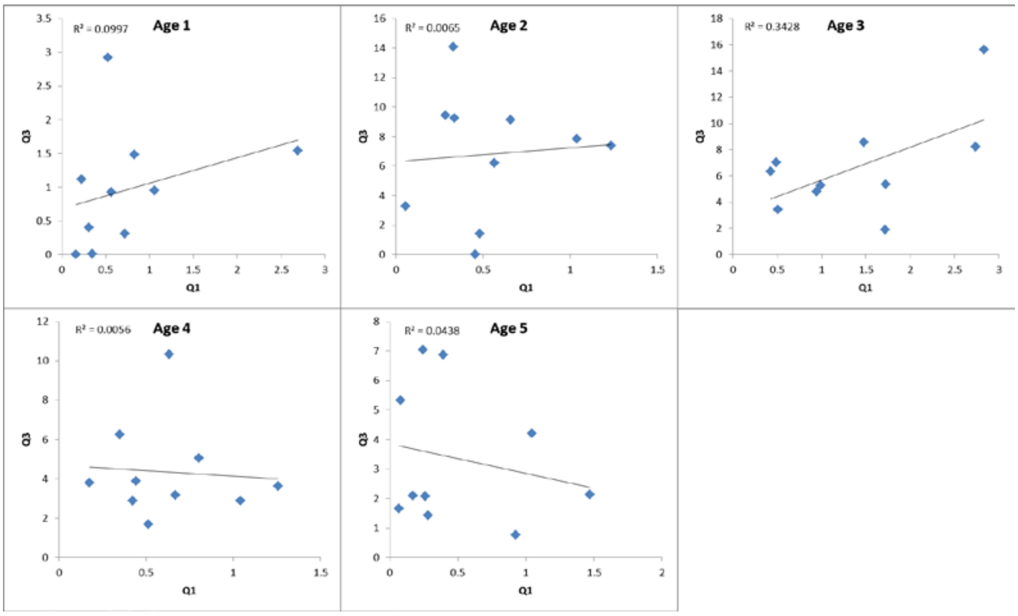


Figure 4.7. North Sea lemon sole. ICES estimation: scatterplots of index values, comparing estimates at Q1 and Q3 within a year. A fitted linear regression is also shown in each case, along with the relevant R^2 value.

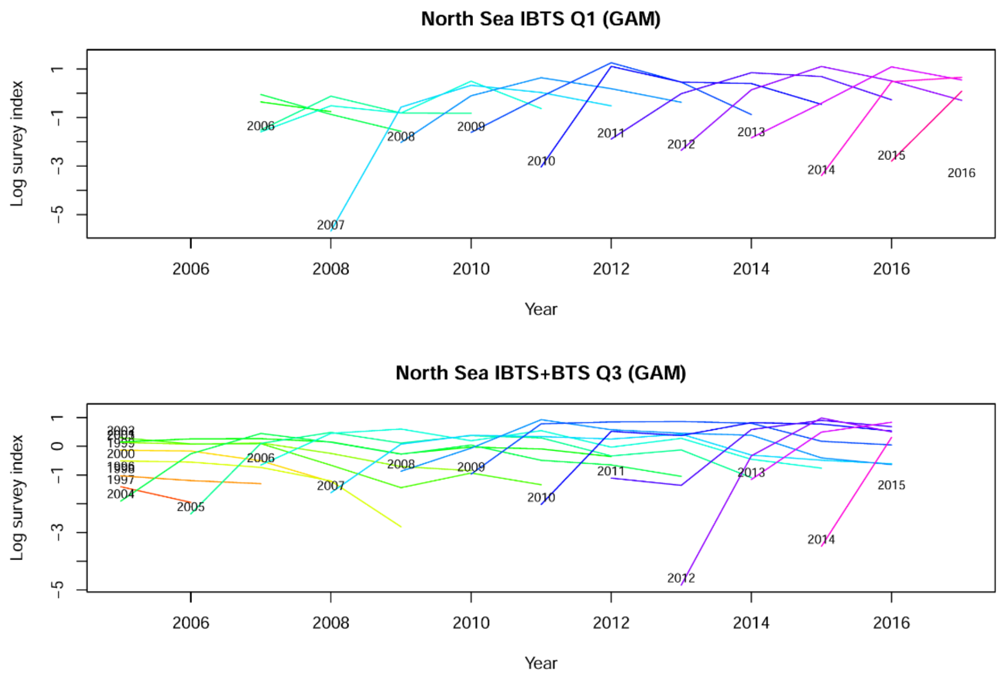


Figure 4.8. North Sea lemon sole. GAM estimation: catch curves (survey index on a log scale with one line for each cohort.

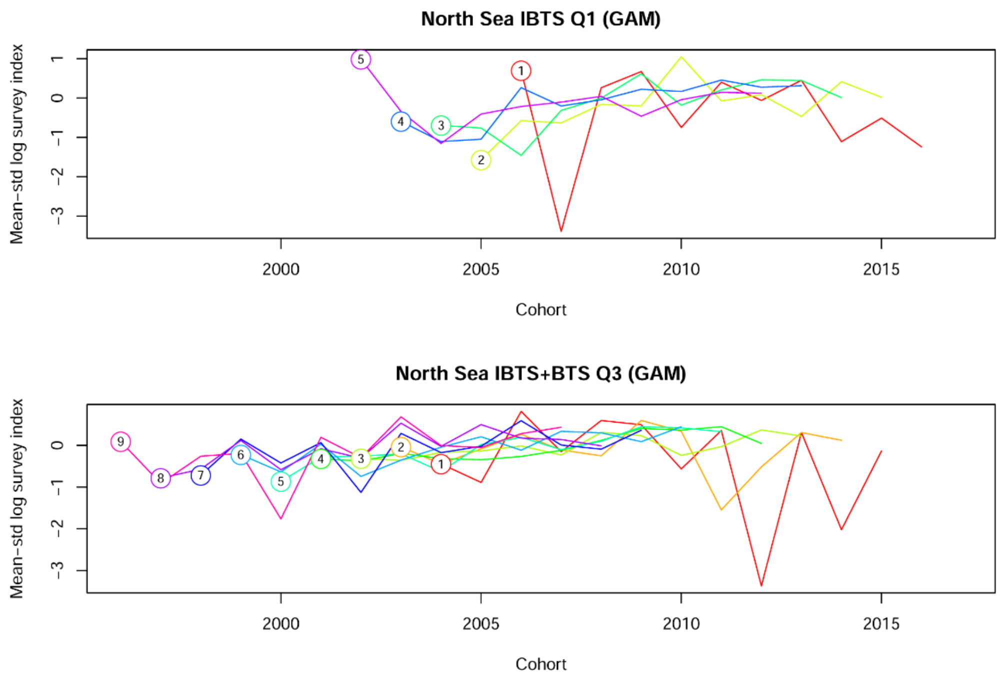


Figure 4.9. North Sea lemon sole. GAM estimation: catch by year class (one line for each age with cohort on the x-axis).

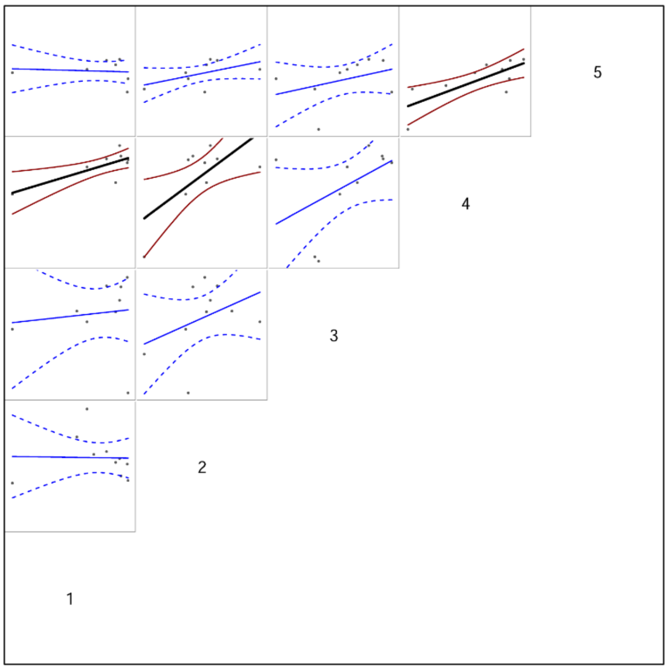


Figure 4.10. North Sea lemon sole. GAM estimation: bivariate scatterplots comparing index values for each cohort from age *a* to *a*+1 for IBTS Q1. Lines give linear regressions with approximate 95% confidence intervals: significant regressions are shown in black and red, non-significant regressions in blue.

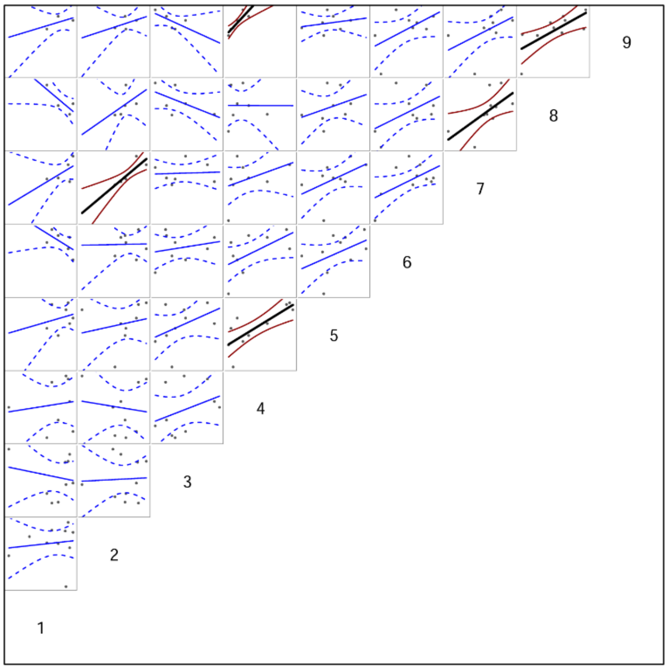


Figure 4.11. North Sea lemon sole. GAM estimation: bivariate scatterplots comparing index values for each cohort from age *a* to *a*+1 for IBTS Q3. Lines give linear regressions with approximate 95% confidence intervals: significant regressions are shown in black and red, non-significant regressions in blue.

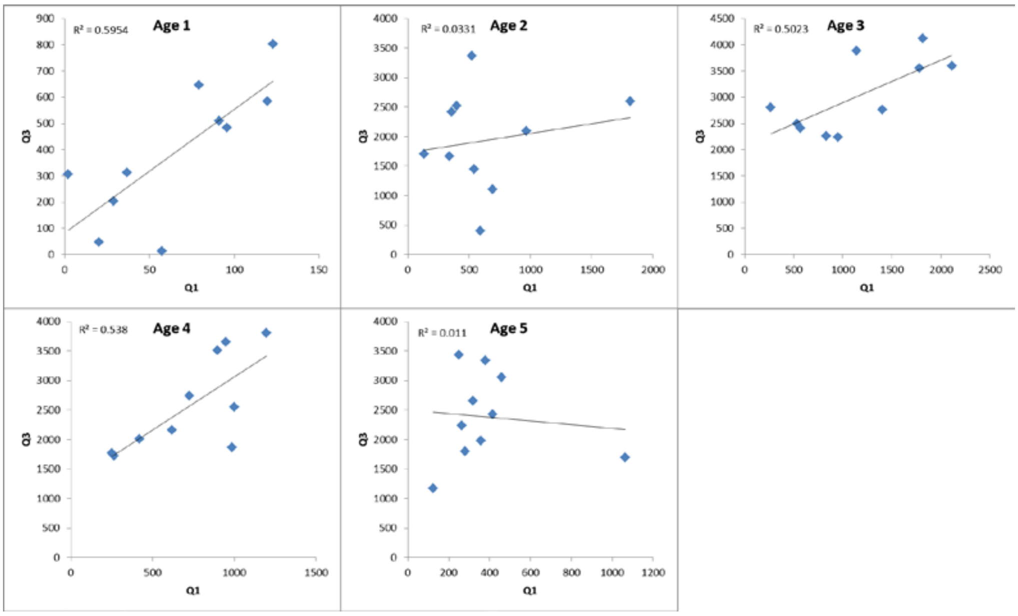


Figure 4.12. North Sea lemon sole. GAM estimation: scatterplots of index values, comparing estimates at Q1 and Q3 within a year. A fitted linear regression is also shown in each case.

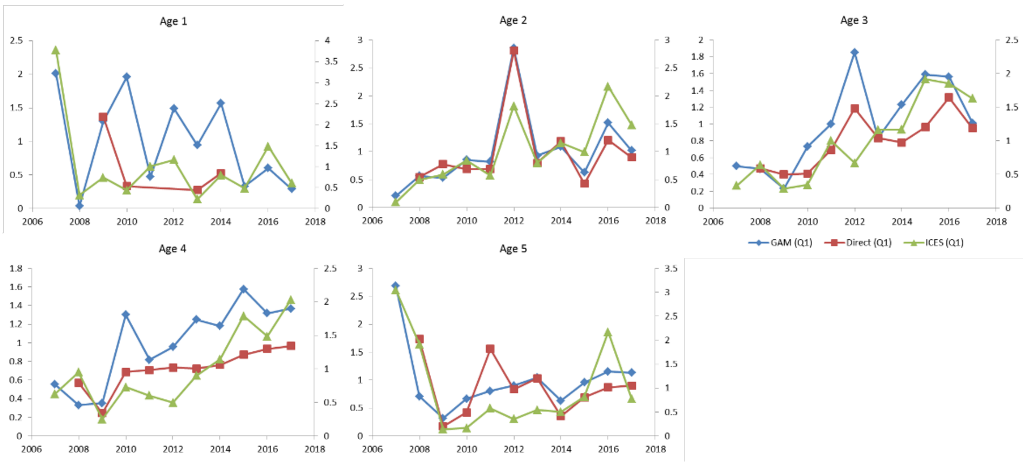


Figure 4.13. North Sea lemon sole. Comparison plots for Q1 survey indices-at-age for the direct, GAM and ICES estimation methods (ages 1–5, years 2007–2017). Lines are mean-standardised so that the average of each over years 2007–2017 is 1.0, to allow for direct comparison.

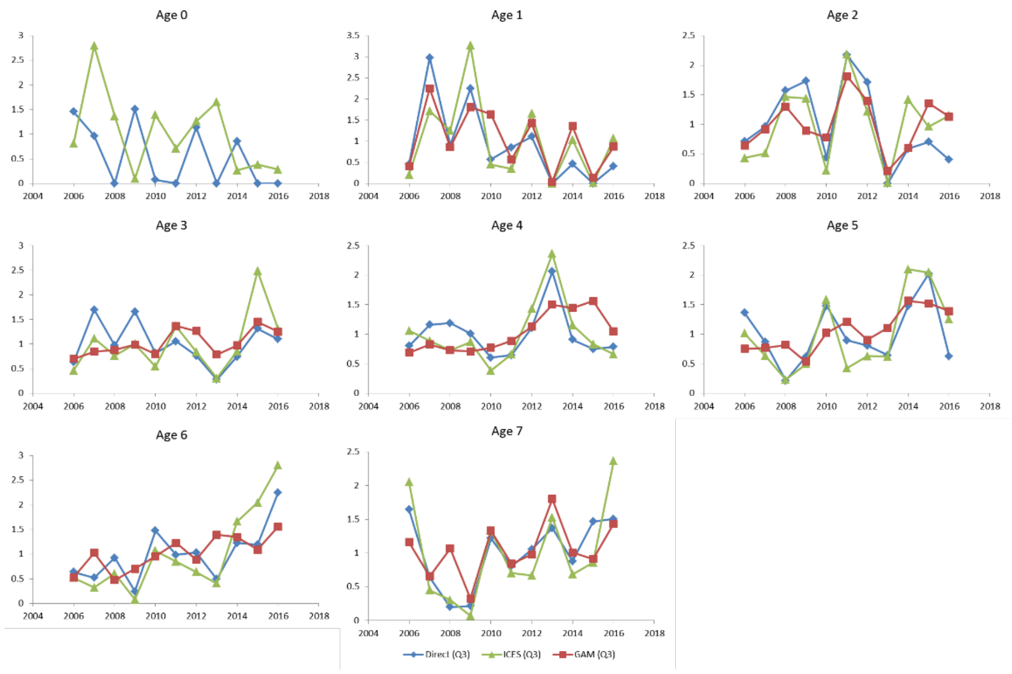
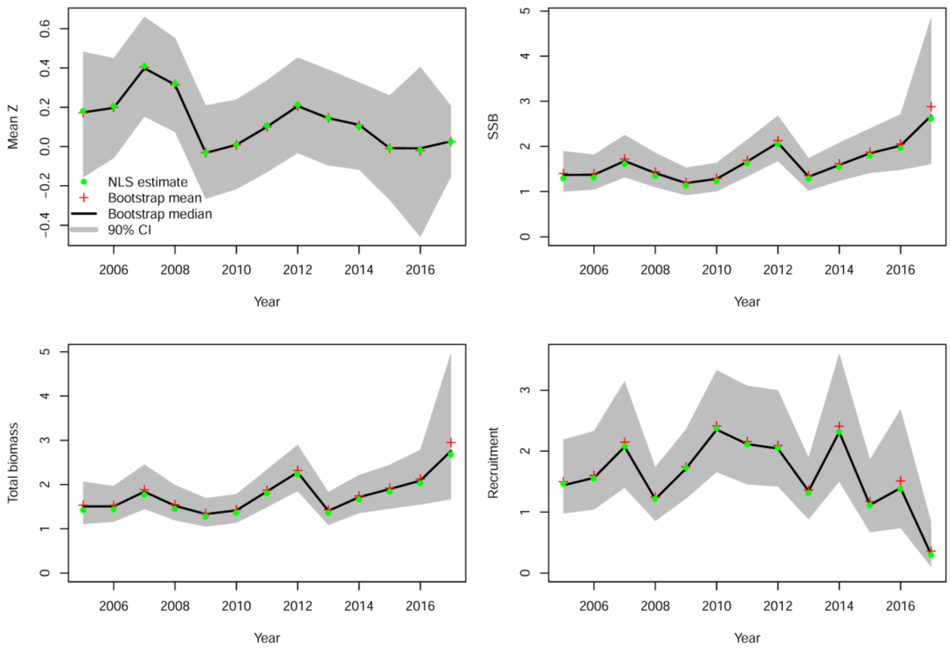


Figure 4.14. North Sea lemon sole. Comparison plots for Q3 survey indices-at-age for the direct, GAM and ICES estimation methods (ages 1–5, years 2005–2016). Lines are mean-standardised so that the average of each over years 2005–2016 is 1.0, to allow for direct comparison.

a. GAM index estimation



b. ICES index estimation

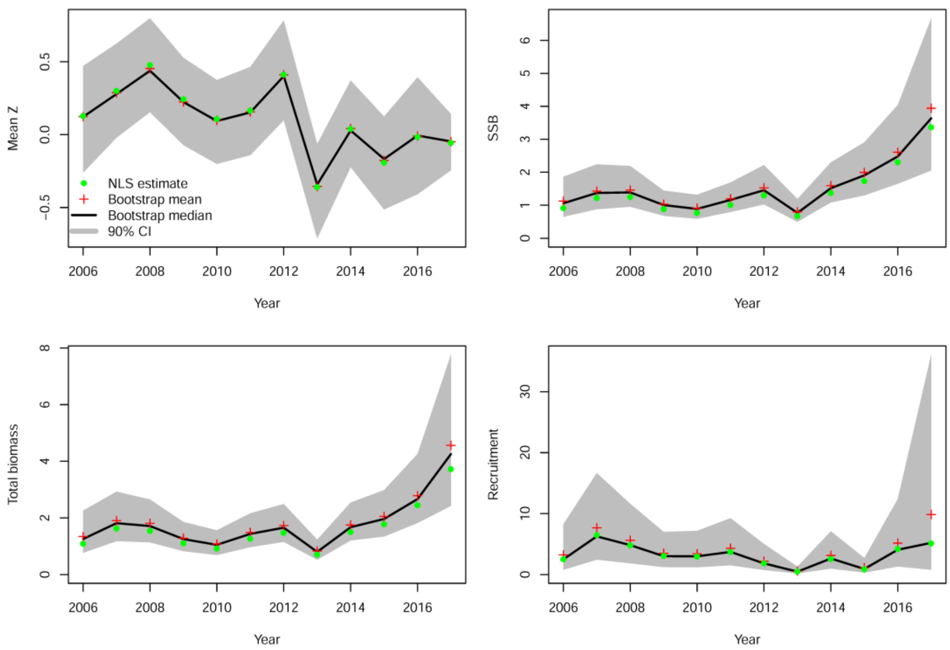


Figure 4.15. North Sea lemon sole. Summary plots from exploratory SURBAR runs using GAM index estimation (IBTS Q1, IBTS + BTS Q3) and ICES index estimation (IBTS Q1, IBTS Q3).

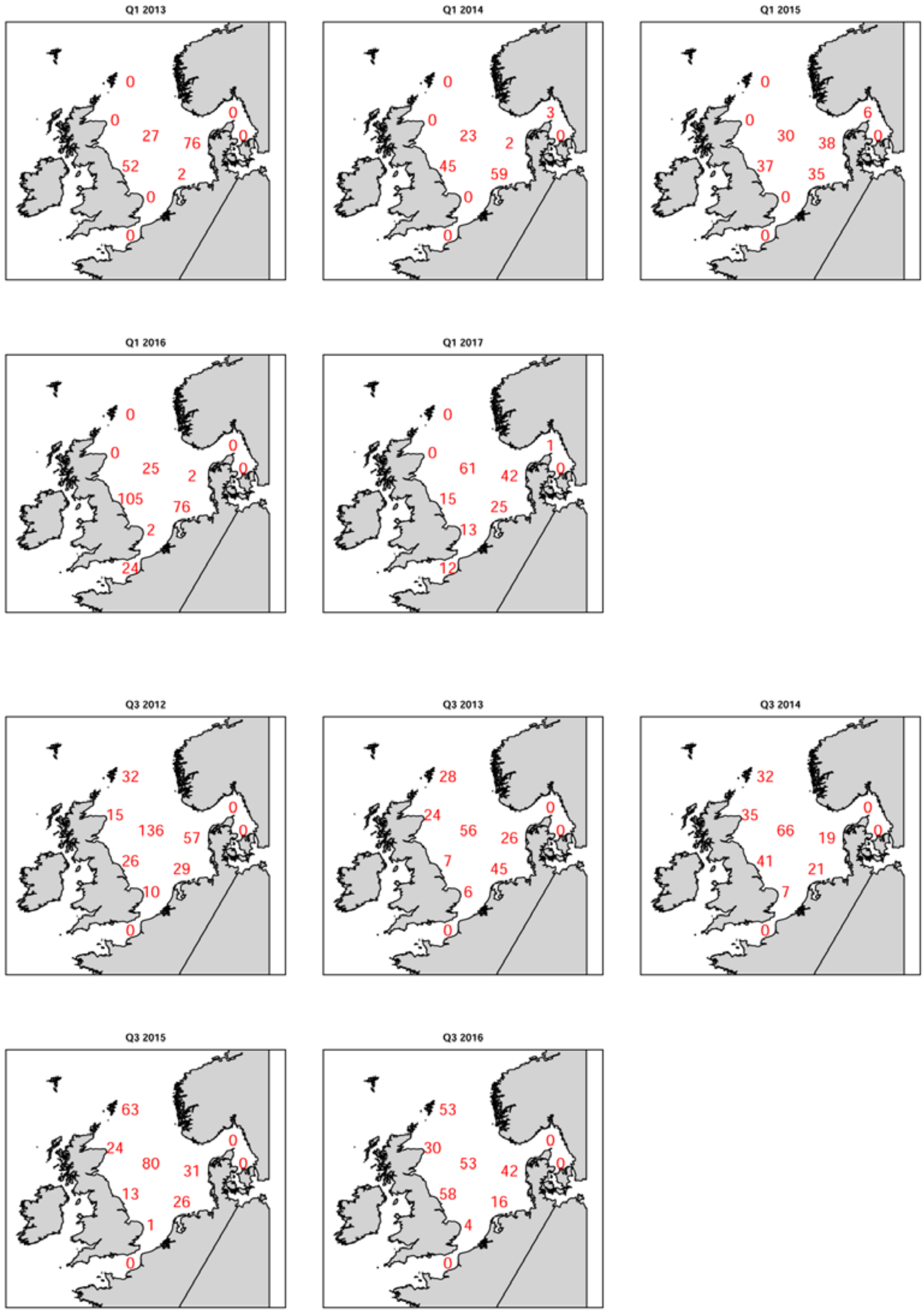


Figure 4.16. North Sea lemon sole. Spatial distributions by year of age samples in the IBTS Q1 (upper two rows) and Q3 (lower two rows) surveys. The number of lemon sole sampled for age in each roundfish sampling area is shown.

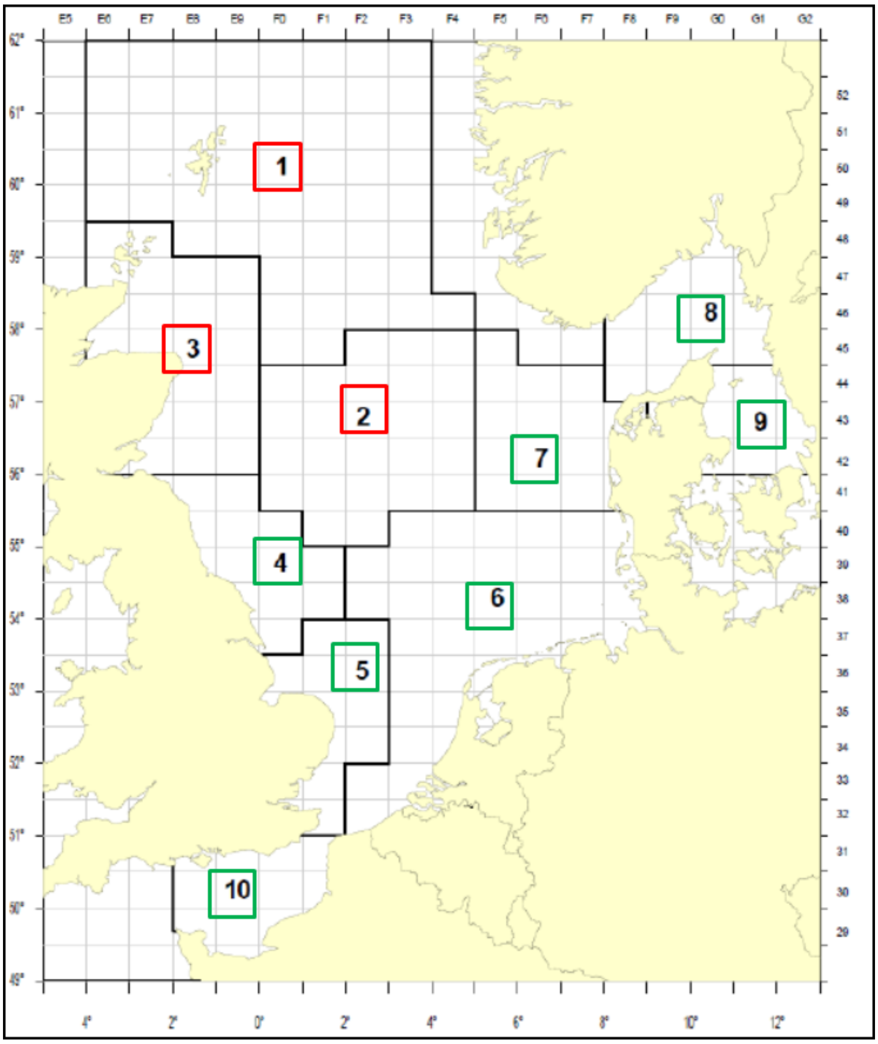


Figure 4.17. North Sea lemon sole. ICES roundfish sampling areas. Red boxes denote "northern" areas (1–3), green boxes denote "southern" areas (4–10).

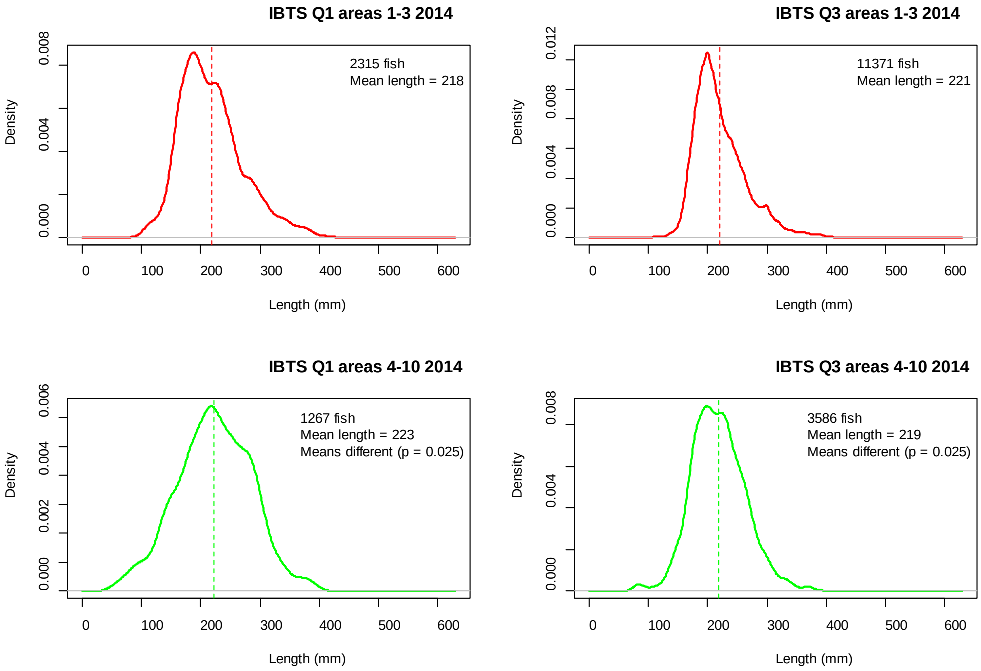


Figure 4.18. North Sea lemon sole. Sampled length distributions for "northern" (top) and "southern" (bottom) areas, from IBTS Q1 (left) and Q3 (right) surveys in 2014. *p*-values for *t*-tests to compare distribution means between "northern" and "southern" are also given.

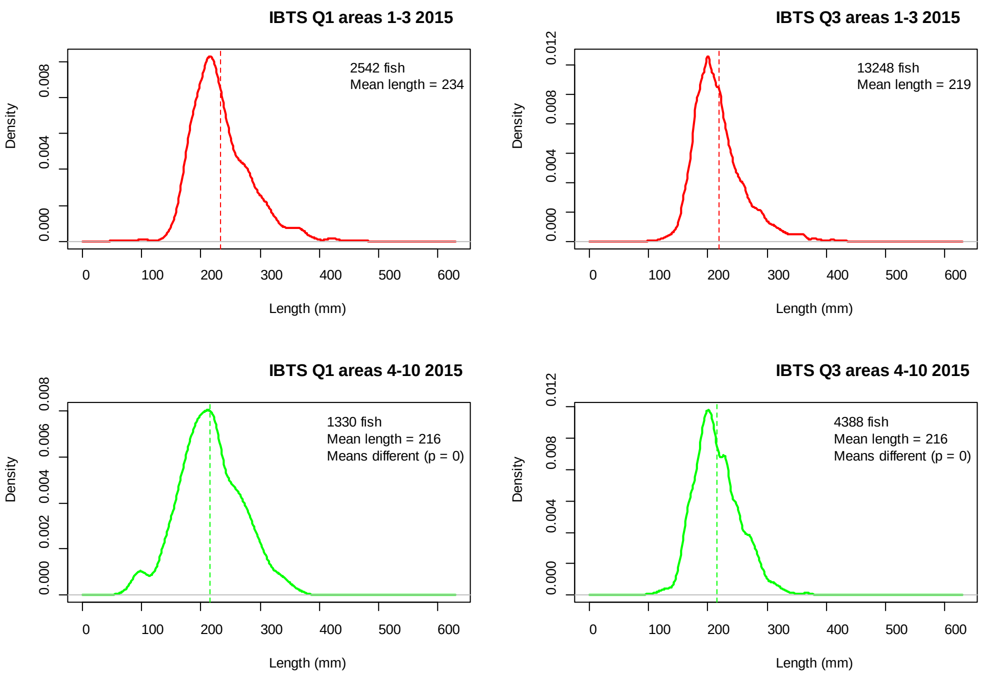


Figure 4.19. North Sea lemon sole. Sampled length distributions for "northern" (top) and "southern" (bottom) areas, from IBTS Q1 (left) and Q3 (right) surveys in 2015. *p*-values for *t*-tests to compare distribution means between "northern" and "southern" are also given.

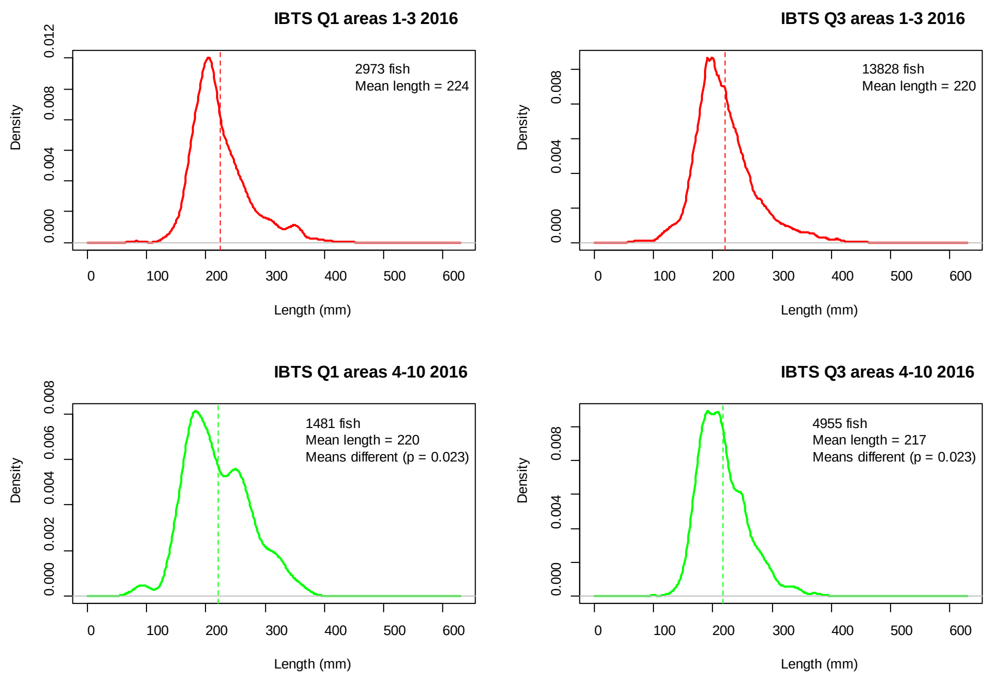


Figure 4.20. North Sea lemon sole. Sampled length distributions for "northern" (top) and "southern" (bottom) areas, from IBTS Q1 (left) and Q3 (right) surveys in 2016. *p*-values for *t*-tests to compare distribution means between "northern" and "southern" are also given.

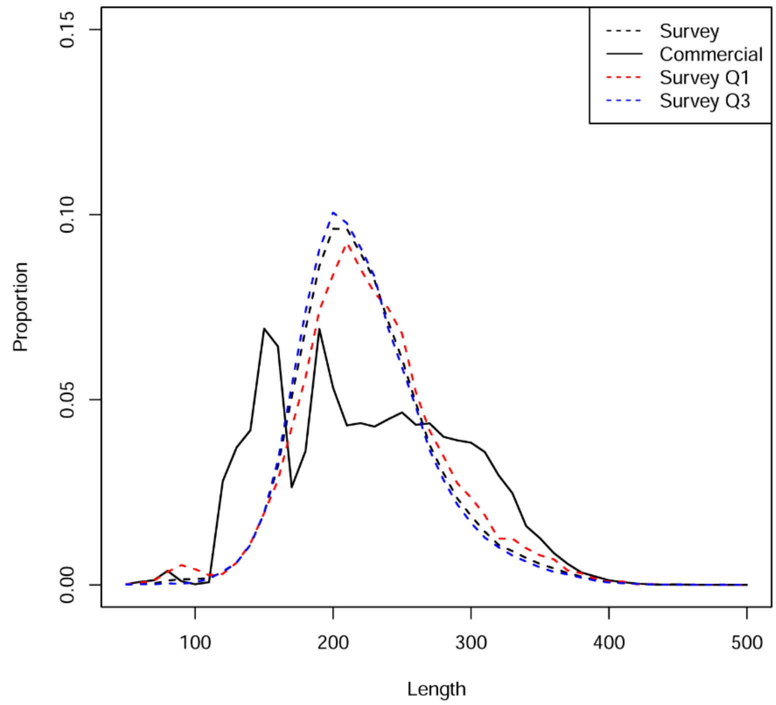


Figure 4.21. North Sea lemon sole. Observed length distributions from different data sources, combined over all available years.

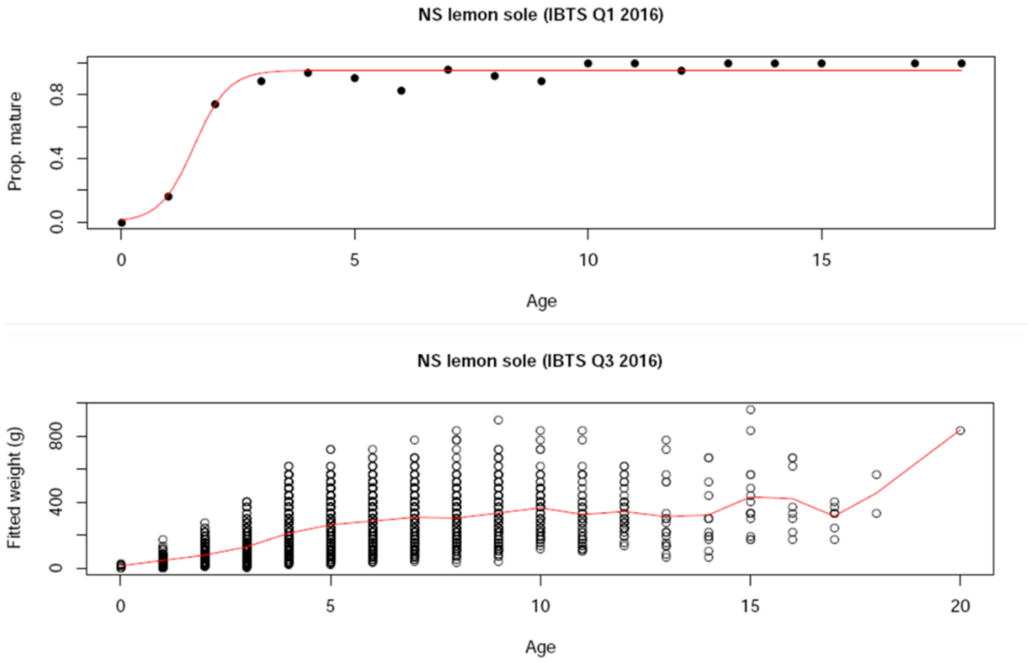


Figure 4.22. North Sea lemon sole. Upper: estimated proportion mature at-age, using *SMALK* data from IBTS Q1 survey in 2016. The red line shows the fit of Equation 4.1. Lower: observed weights-at-age from the IBTS Q3 survey in 2016. The red line traces the mean weight for each age.

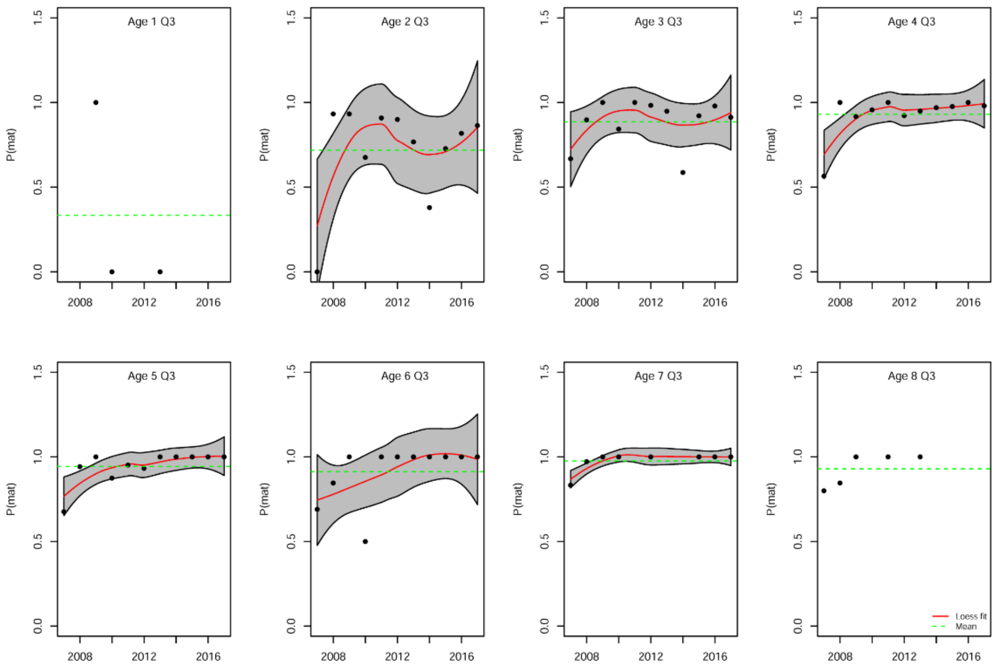


Figure 4.23. North Sea lemon sole. Time-series of estimated maturity-at-age derived from DATRAS *SMALK* IBTS Q1 data (dots). Green dashed lines give the mean of each time-series, while the red lines give the fit of a loess smoother (span = 1) with approximate 95% confidence intervals as grey bands (the loess smoother could not be fitted with span = 1 for ages 1 and 8).

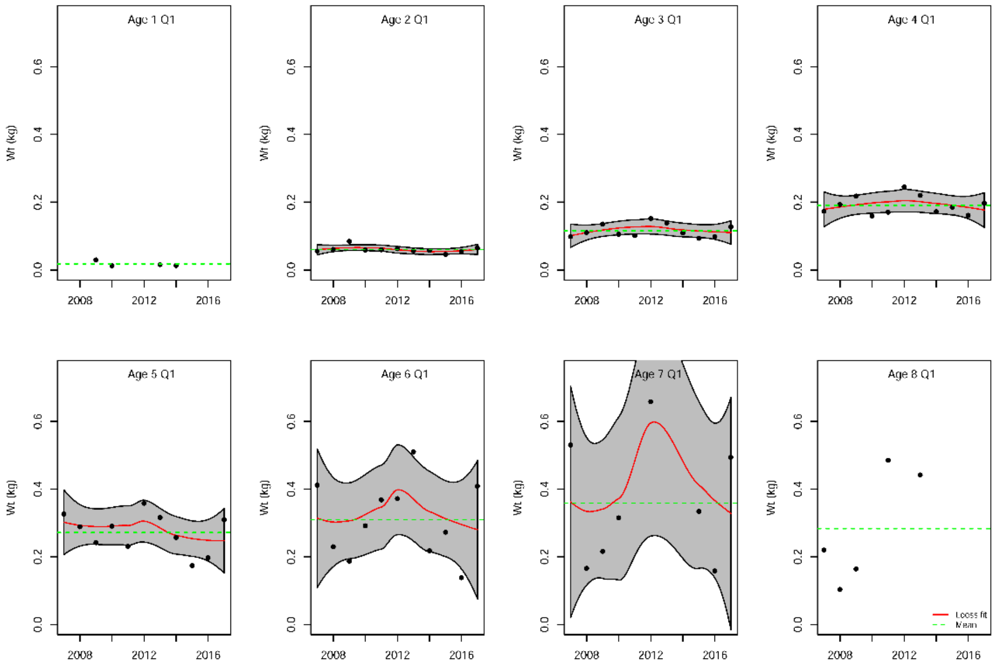


Figure 4.24. North Sea lemon sole. Time-series of estimated weights-at-age derived from DATRAS *SMALK* IBTS Q1 data (dots). Green dashed lines give the mean of each time-series, while the red lines give the fit of a loess smoother (span = 1) with approximate 95% confidence intervals as grey bands (the loess smoother could not be fitted with span = 1 for ages 1 and 8).

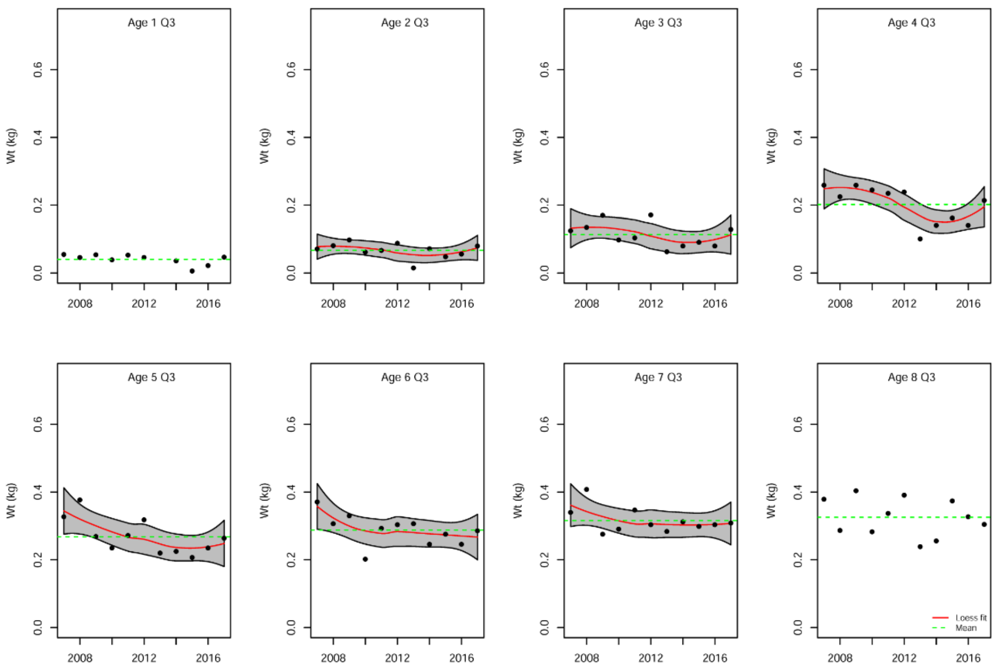


Figure 4.25. North Sea lemon sole. Time-series of estimated weights-at-age derived from DATRAS *SMALK* IBTS Q3 data (dots). Green dashed lines give the mean of each time-series, while the red lines give the fit of a loess smoother (span = 1) with approximate 95% confidence intervals as grey bands (the loess smoother could not be fitted with span = 1 for ages 1 and 8).

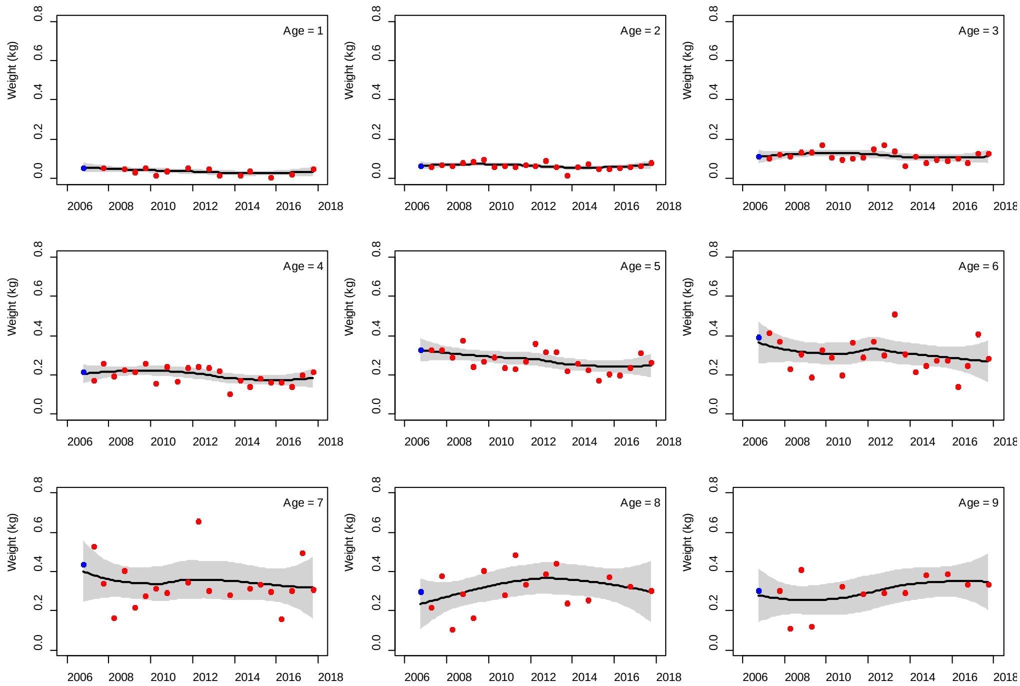


Figure 4.26. North Sea lemon sole. Collated weights-at-age estimates, with Q1 values plotted at *y*+0.25 and Q3 values at *y*+0.75. Black lines give loess smoothers (span = 1) with approximate 95% confidence intervals. The blue point at the start of each time-series is the mean of the first two observed values, plotted at 2006.5 to enable loess extrapolation.

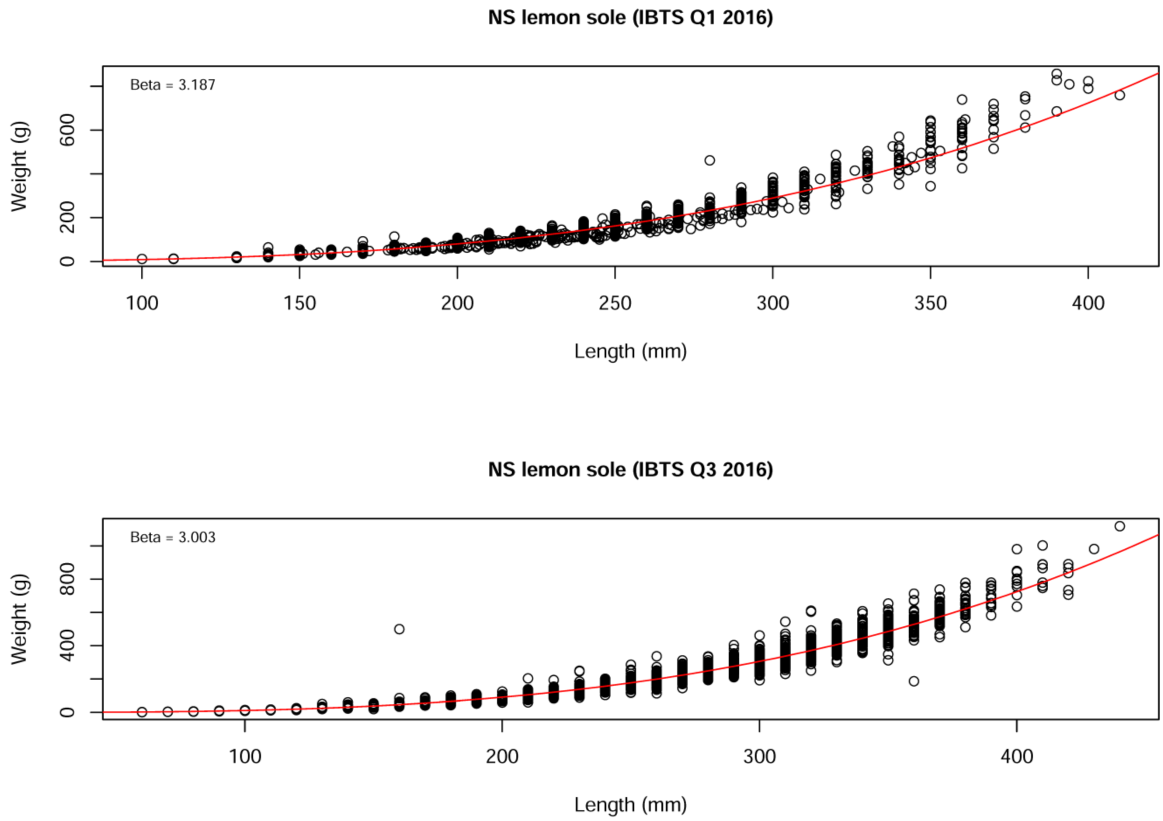


Figure 4.27. North Sea lemon sole. Length–weight relationships for IBTS Q1 (upper) and Q3 (lower) in 2016, along with the fitted model $W = L^{\beta}$. Parameters were estimated by fitting the linearised model $\ln W = \beta \ln L$, assuming normal errors.

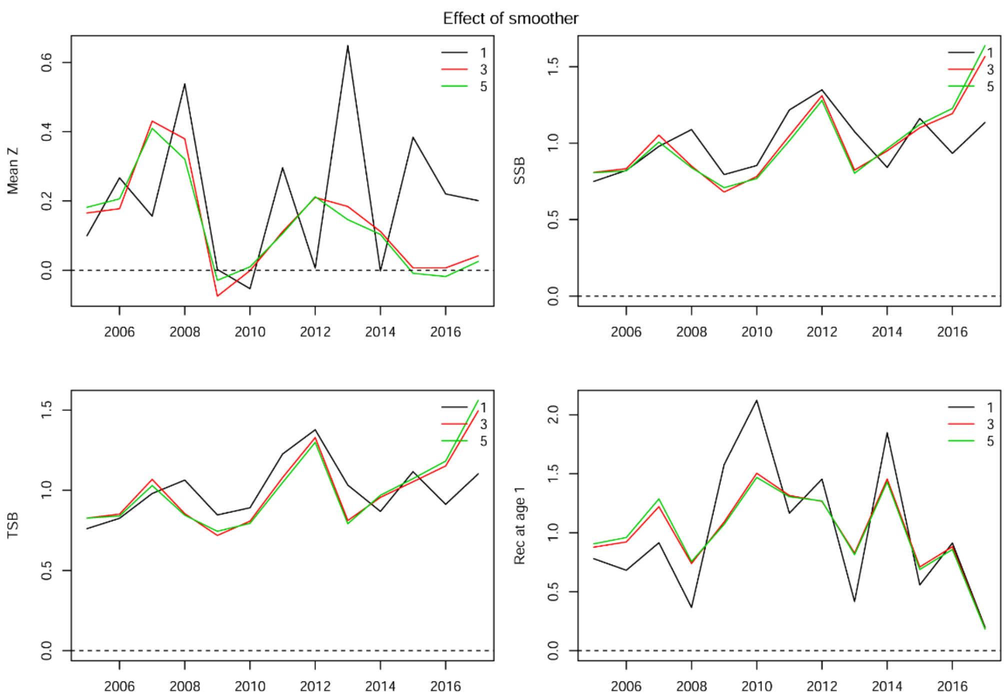


Figure 4.28. North Sea lemon sole. Sensitivity analysis for the SURBAR assessment. All runtime settings are fixed to base case values here apart from the penalty smoother λ.

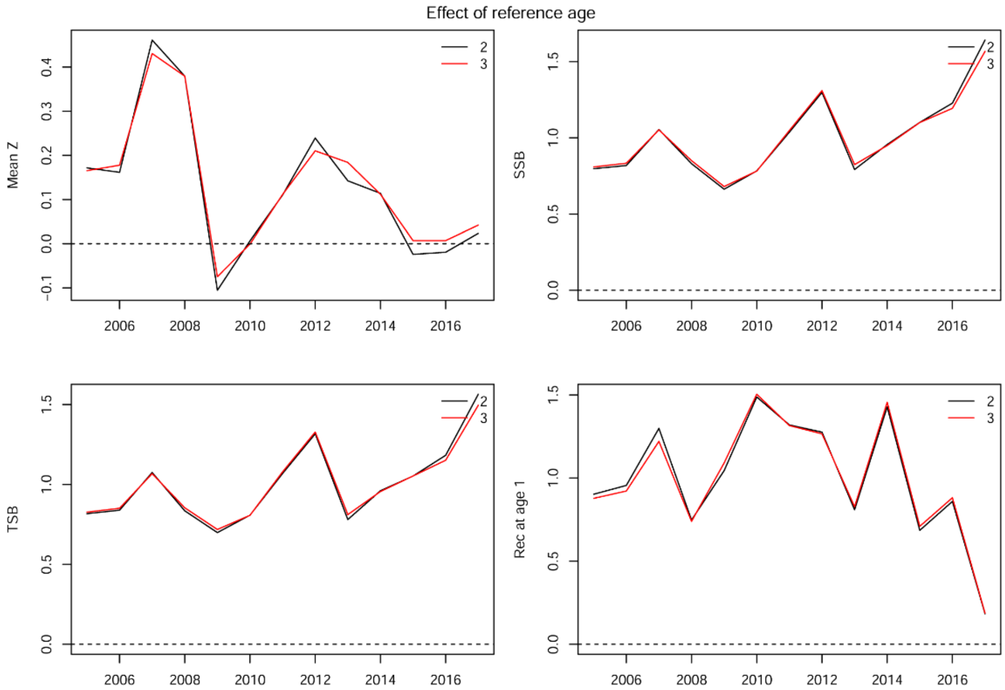


Figure 4.29. North Sea lemon sole. Sensitivity analysis for the SURBAR assessment. All runtime settings are fixed to base-case values here apart from the reference age a_r.

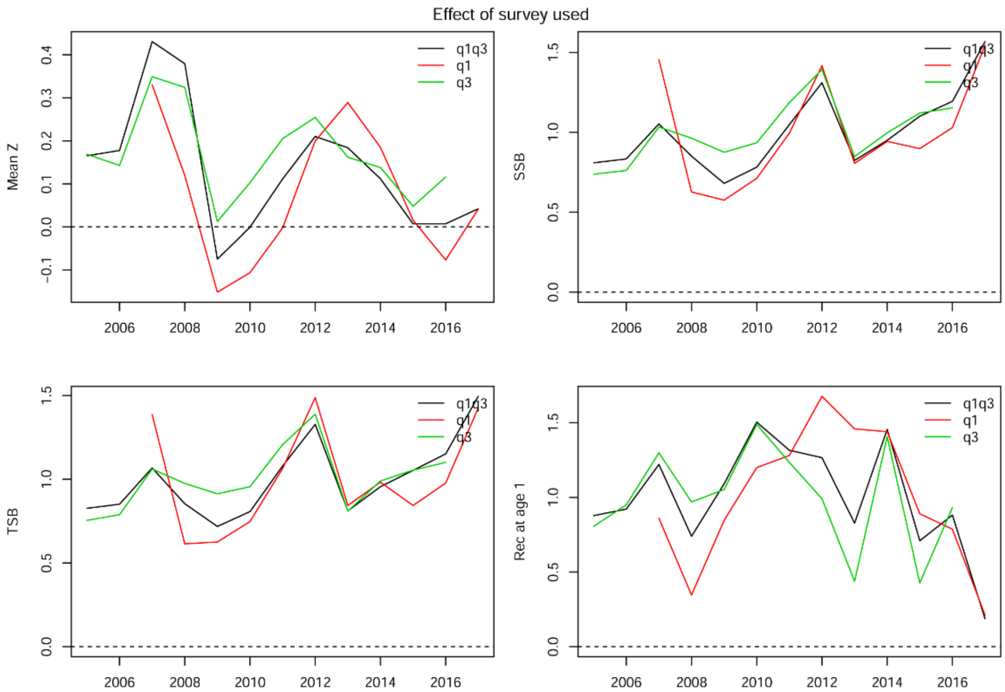


Figure 4.30. North Sea lemon sole. Sensitivity analysis for the SURBAR assessment. All runtime settings are fixed to base case values here apart from choice of survey(s) to use (Q1, Q3, or both Q1 and Q3).

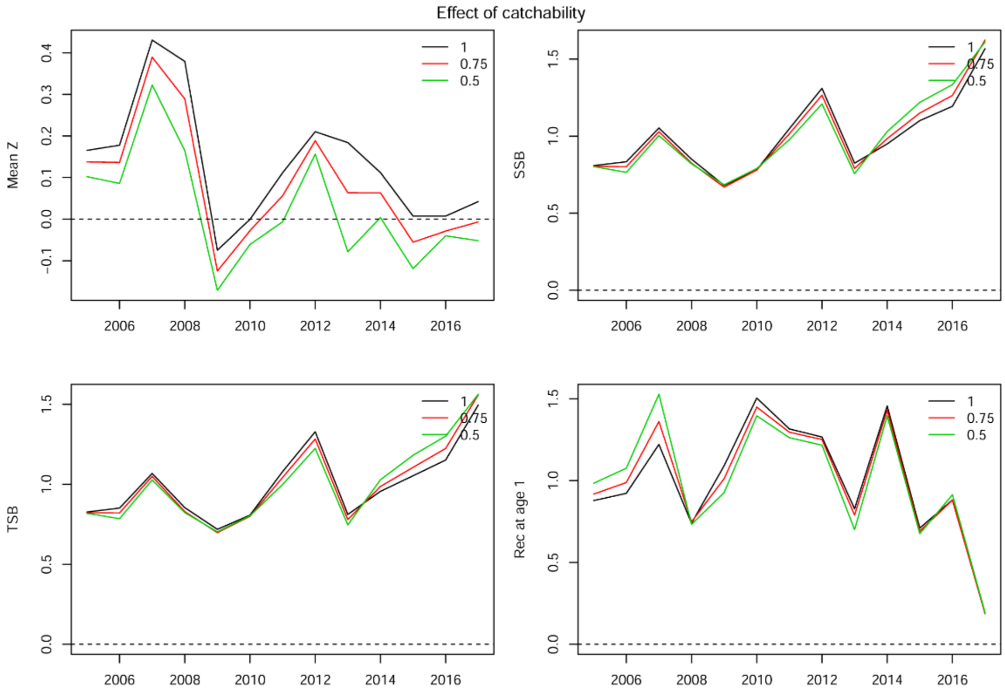


Figure 4.31. North Sea lemon sole. Sensitivity analysis for the SURBAR assessment. All runtime settings are fixed to base-case values here apart from choice of catchability *q* on ages 6–9 (set to 1.0, 0.75 or 0.5).

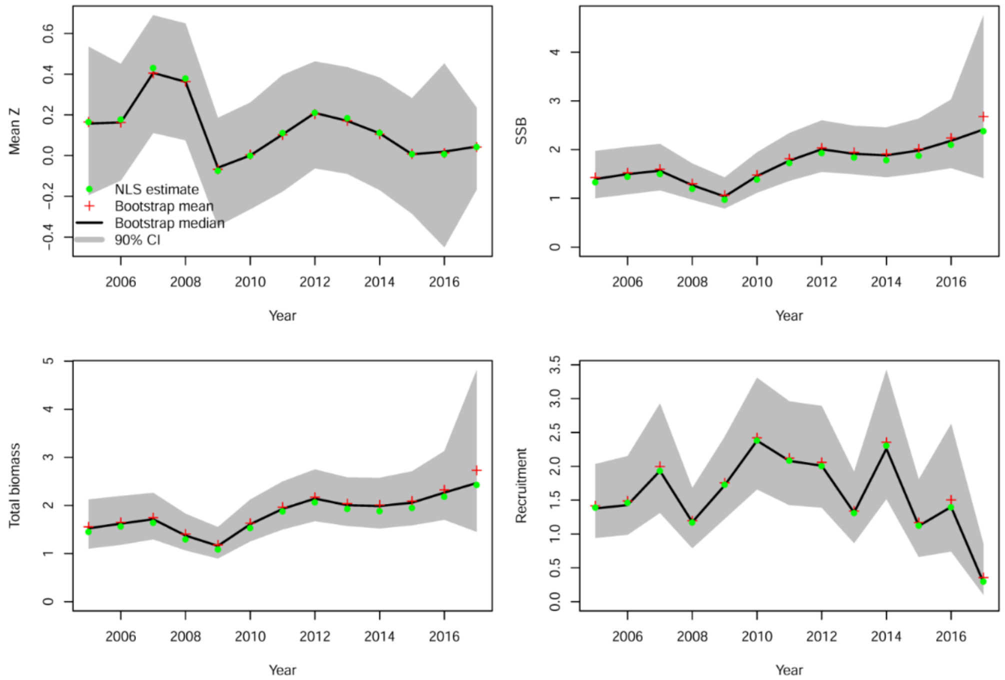


Figure 4.32. North Sea lemon sole. Summary plots from final SURBAR model configuration. Green points give the non-linear least-squares estimates, while red crosses, black lines and the grey polygon give respectively the mean, median and 90% confidence interval of the bootstrap uncertainty estimation (see Needle, 2015a).

Figure 4.33. North Sea lemon sole. Log residuals (lines) from final SURBAR model configuration, for the GAM-estimated IBTS Q1 survey.

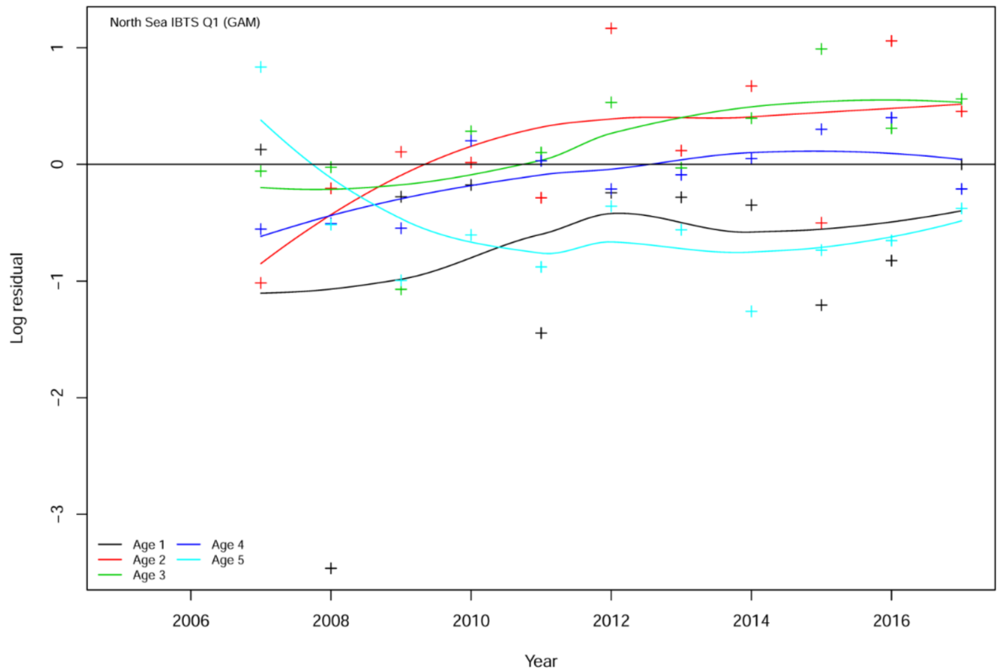


Figure 4.34. North Sea lemon sole. Log residuals (points) from final SURBAR model configuration, for the GAM-estimated IBTS Q1 survey. Lines give loess smoothers (span = 1) fitted through residuals for each age.

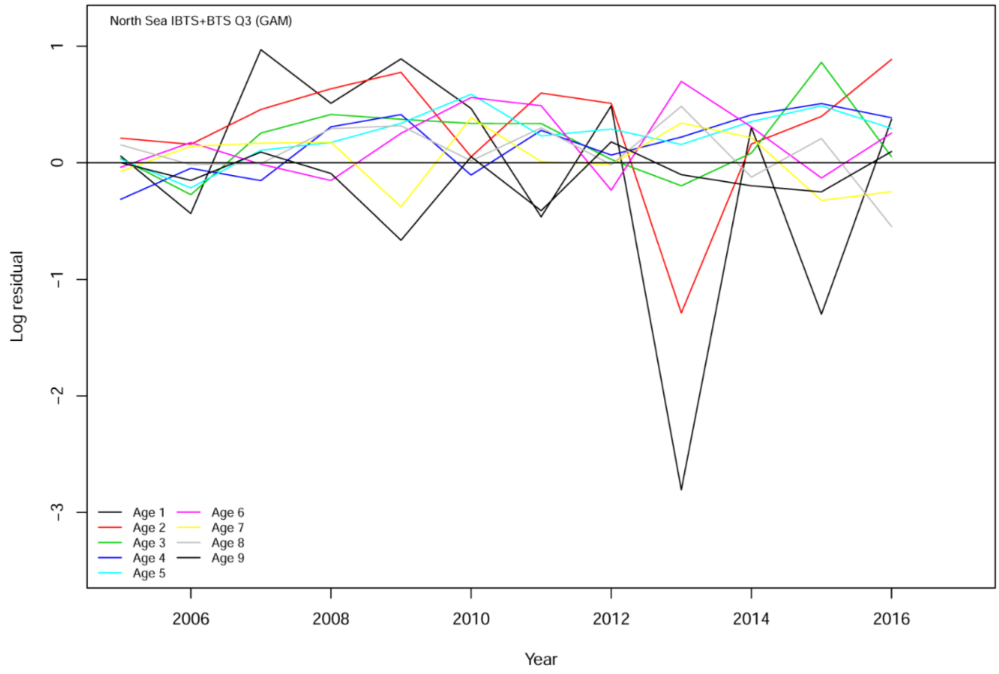


Figure 4.35. North Sea lemon sole. Log residuals (lines) from final SURBAR model configuration, for the GAM-estimated IBTS+BTS Q3 survey.

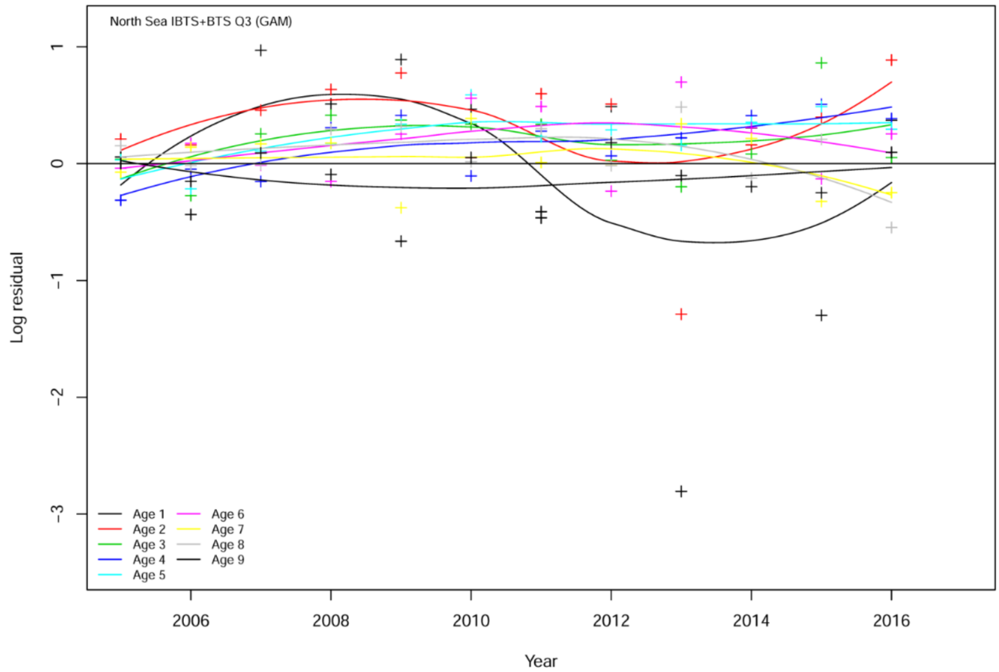


Figure 4.36. North Sea lemon sole. Log residuals (points) from final SURBAR model configuration, for the GAM-estimated IBTS+BTS Q3 survey. Lines give loess smoothers (span = 1) fitted through residuals for each age.

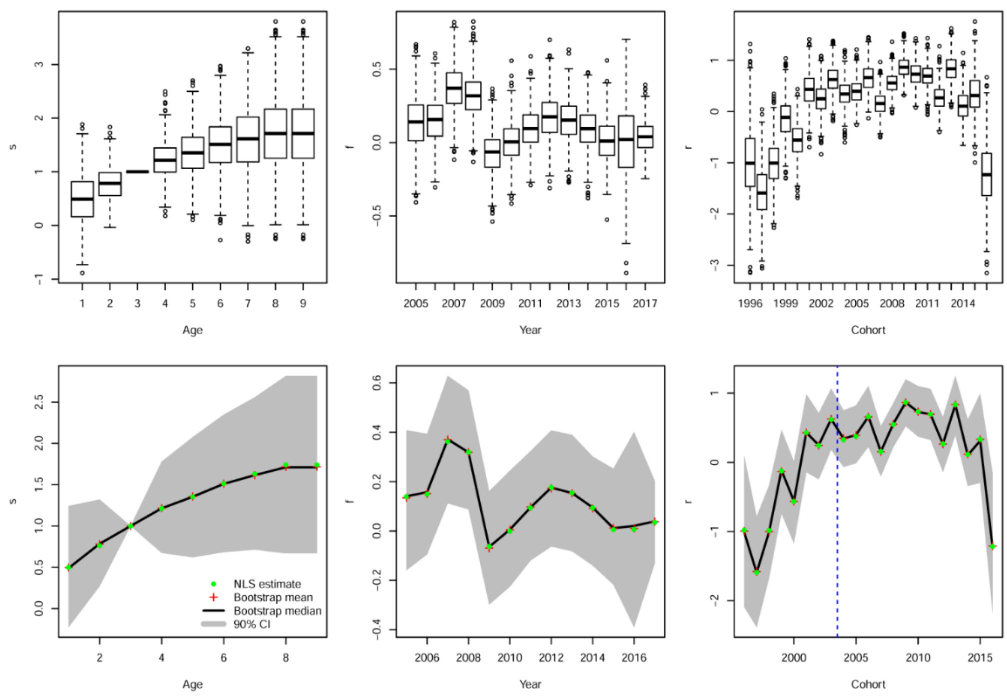


Figure 4.37. North Sea lemon sole. Parameter estimates from the final SURBAR model configuration. Upper row: box-and-whisker plots showing estimated distributions of (from left to right) the age-effect *s* and year-effect *f* in total mortality *Z*, and the cohort effect *r*. Lower row: line summaries of the same estimates, in which green points give the non-linear least-squares estimates, while red crosses, black lines and the grey polygon give respectively the mean, median and 90% confidence interval of the bootstrap uncertainty estimation (see Needle, 2015a).

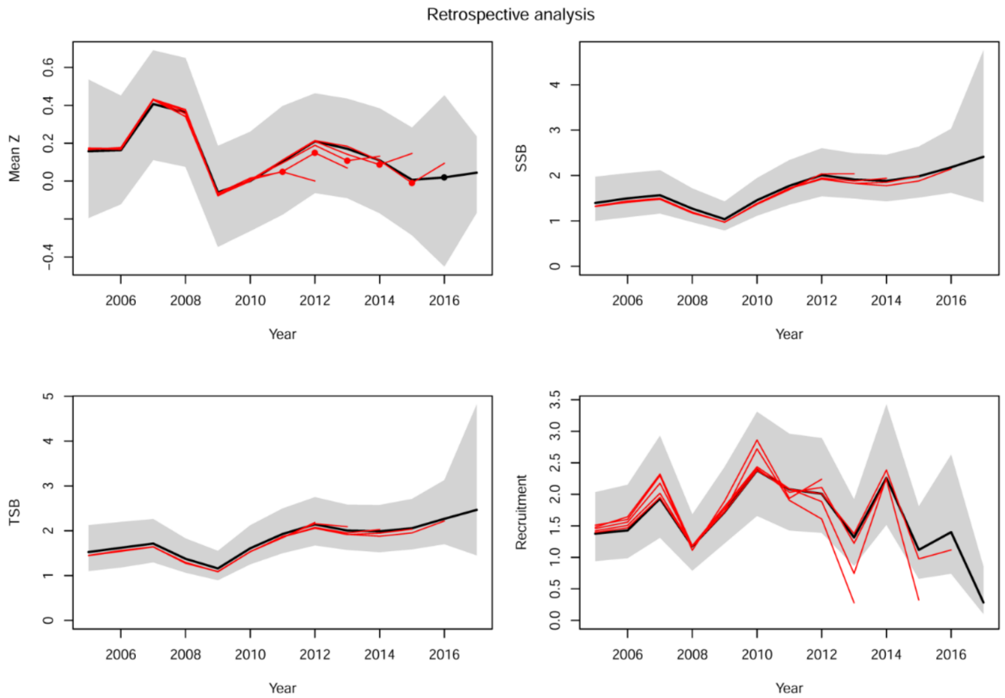


Figure 4.38. North Sea lemon sole. Retrospective analysis from the final SURBAR model configuration, covering five peels. In each plot, the black line gives the final-year estimate (with the 90% confidence interval shown by the grey band), and the red lines give the retrospective estimates. For mean Z, the final true estimate is shown with a dot: the estimate following that is based on a three-year mean (see Needle, 2015a).

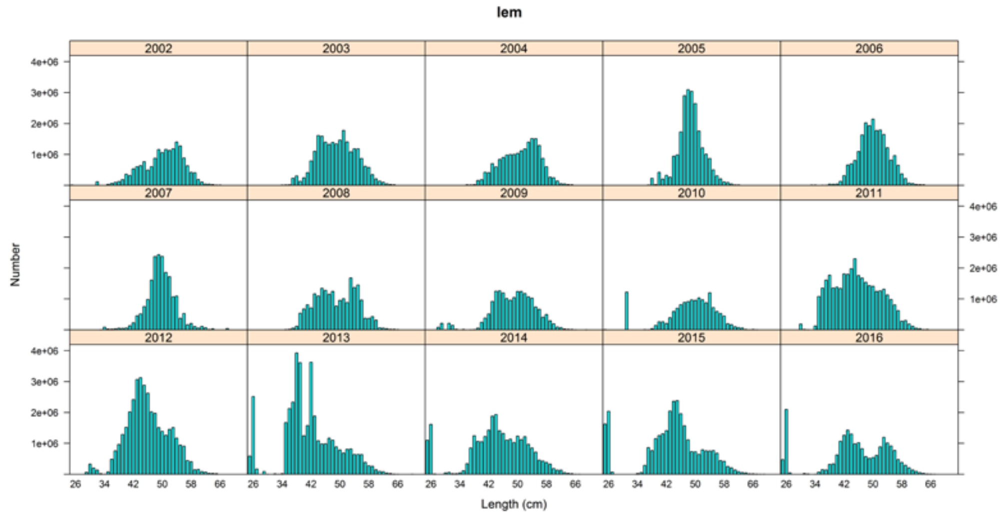


Figure 4.39. North Sea lemon sole. Commercial catch length distributions, modified for 2013 (see text).

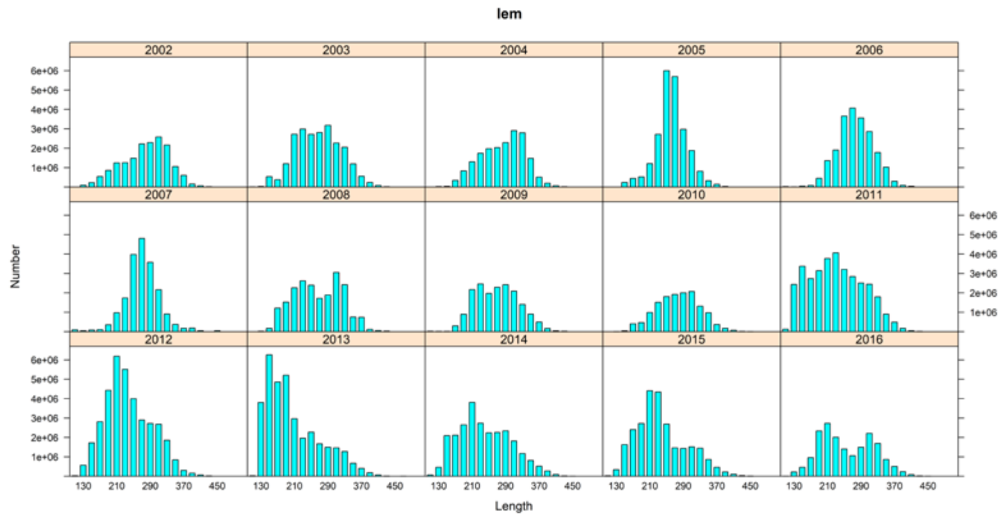


Figure 4.40. North Sea lemon sole. Commercial catch length distributions following removal of lengths less to 100 mm and widening of histogram bins to 20 mm.

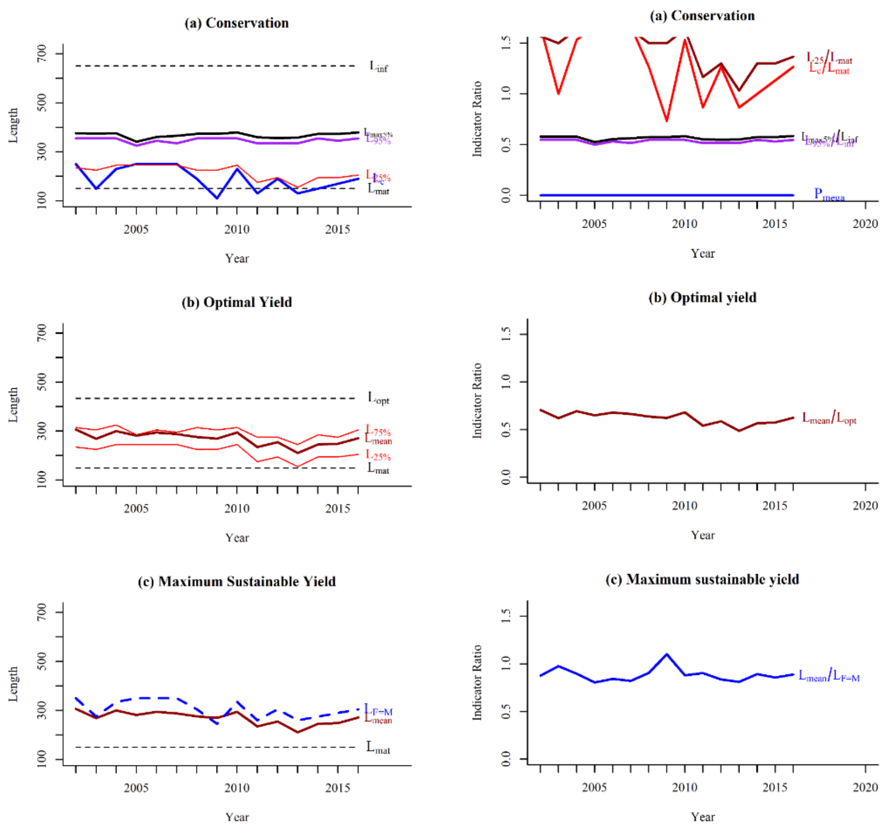


Figure 4.41. North Sea lemon sole. LBI analysis output.

5 Flounder in 27.3a4

This section relates to the stock of flounder (*Plathichthys flesus*) stock in the North Sea (Subarea 4) and Skagerrak (Division 3.a).

5.1 Stock ID and substock structure

No results were presented on stock ID or substock structure during the benchmark.

5.2 Issue list

The issue list is taken from Annex 6 of ICES, WGNSSK (2017) and communication after WGNSSK 2017. The issue list is in Annex 4.

Expected working documents

The following gives the list of working documents that were expected for the benchmark.

1) WD1 - Survey indices tuning series (Holger Haslob, Casper Berg);
2) WD2 - InterCatch raising 2002–2016 (Holger Haslob);
3) WD3 - Biological parameters: stock weights-at-age, maturity, length–weight relationship (Holger Haslob);
4) WD4 - SPiCT assessment (Casper Berg, Alexandros Kokkalis, Holger Haslob).

The working documents that were completed can be found in Annex 5.

5.3 Scorecard on data quality

A scorecard was not used for this benchmark.

5.4 Multispecies and mixed fisheries issues

No new information was presented at the benchmark meeting.

5.5 Ecosystem drivers

No new information was presented at the benchmark meeting.

5.6 Stock assessment

5.6.1 Catch: quality, misreporting, discards

Catch data for the years 2002–2016 were provided by all countries fishing in Subarea 4 and Division 3a, following the WKNSEA data call (ICES, 2017d). All data were uploaded to the InterCatch data portal, and subsequent discard raisings and sample allocations were performed with the InterCatch online tool. For each year all nations provided their landings data for Subarea 4, with the exception of Belgium for 2002. This missing datapoint was substituted by the official landings in the subsequent analyses. By far the largest proportion of total landings is taken by Dutch fleets in Subarea 4 (Figure 5.1a), followed by the Belgium fleets in Subarea 4 (Figure 5.1b). The landings in Subarea 4 of all other countries together were only around 5% of the total landings (last three years average). The Dutch flounder landings show a steep decline from 2007 to 2013 and only increased slightly from 2014 to 2015. Apart from the Belgium fleet very similar trends were observed for all other nations (Figure 5.1b). Discard data were only partly provided (Table 5.1) and show high variability between years (Figure 5.2). Unfortunately, no discard data were uploaded for the Dutch fleets before 2011 and no Belgium and Scottish discard data before 2009. Therefore, the most important fleets in terms of landings and discards are missing for the period 2002–2008 in Subarea 4, which made it impossible to set up a reliable raising scheme for these years. The discard coverage dropped from around 90% in the period 2011–2016 to 14% on average for the period 2002–2010 (Figure 5.3). Thus, in order to estimate discards for métiers for which no raising was possible due to missing data, average discard ratios based on years with data were applied and the raising was done manually besides the InterCatch raising tool (see WD2 for details). For Division 3a landings and discards for the most important countries and fleets were provided for the whole time-series (Figure 5.4, Table 5.2). However, also for this area the reported discards are highly variable between years (Figure 5.4b).

Table 5.3 gives details on the applied average discard ratios. Table 5.4 displays the results of the raising procedure in terms of landings, discards and total catch. The official landings are for all years quite close to the obtained InterCatch landings (Figure 5.5). The trend in total catch decreases from 2002 onwards and follows the trend in landings. As expected the raised discards for the earlier years in the time-series (2002–2010) show higher variability because the discard coverage was low for these years. For the years with a high discard coverage (2011–2016) the discards are quite stable with comparable low variability between years, but a relative sharp drop-off for the last data year (Figure 5.5).

5.6.2 Surveys

5.6.2.1 Research surveys

The International Bottom Trawl Survey (Quarter 1 and Quarter 3) and the different Beam Trawl Surveys (Quarter 3 inshore and offshore surveys; ICES, 2017b) catching flounder. However, since flounder is not a target species in the fishery and it is of only limited commercial value, it has never been a target species on these surveys with respect to collecting biological data such as age, individual weight or maturity. Further, flounder is a more coastal species spending part of its life cycle in brackish waters and river estuaries, and is thus only caught in quite small numbers by the offshore surveys. Beside the IBTS and BTS the coastal near Dutch Sole Net Survey (SNS) and the Demersal Young Fish Surveys (DFS and DYFS) might provide useful data on flounder abundance and distribution. However, the inshore beam trawl survey data were only partly available via the DATRAS trawl survey database in a standard format which hampered the straightforward analysis of these data so far.

All available survey data were downloaded from the DATRAS trawl survey database. In addition, data from the Dutch Sole Net Survey (SNS) where analysed which were provided as data files by the Dutch institute. The haul distribution for each survey was plotted by year in order to display the general distribution and abundance of flounder in area 4 and 3a as obtained by the survey hauls (see Flounder WD 1). While for quarter 1, only data from the NS-IBTS Q1 were available, for quarter 3 all data from the suitable surveys were combined. For both indices the deltaGAM method (Berg et al., 2014) was applied.

The majority of flounder catches in quarter 1 is distributed along the southeast coast of the North Sea and in the Kattegat (area 3a.21; Figure 5.6). For quarter 3 different beam trawl survey data (BTS and SNS) and data from the IBTS Q3 were available (Figure 5.6). The catch distribution of flounder was very similar compared to the IBTS Q1 data. The flounder abundance in the Kattegat area seems not that high in quarter 3 compared to quarter 1. Because of the similar distribution, for both quarters the same index area was defined excluding all hauls northwest of the displayed blue line (southwestern point λ=53.600, ϕ=001.733; northeastern point λ=57.329, ϕ=005.378) where only very few flounder were caught (Figures 5.6 and 5.7).

Due to insufficient age data from the surveys it was not possible to create an age-based index. Thus, the indices were based on the catch weight per haul applying a general length–weight relationship to the length distribution data by haul. The length–weight relationship was estimated from biological flounder data available in DATRAS.

In quarter 1 more than 70% of the IBTS flounder catches were taken in the Kattegat (3a.21). Thus, a comparison between indices without the Kattegat, only the Kattegat and the whole survey area was conducted (Figure 5.8). The results show that overall the trend is very similar between the Kattegat and the North Sea and no further weighting was applied to the data. In quarter 3, four gear types were used in the different beam trawl surveys (BT8, BT7, BT6, and BT4) and the GOV in the IBTS survey. Therefore, a gear effect was included to model a combined quarter 3 index for flounder.

The following models where formulated:

Quarter 1 - NS-IBTS (GOV)

$$g(\mu_i) = Year(i) + f_1(lon_i + lat_i) + f_2(depth_i) + \log(HaulDur_i)$$

Quarter 3 - with gear effect including BTS (BT4, BT6, BT7, and BT8) and NS-IBTS (GOV)

$$g(\mu_i) = Year(i) + Gear(i) + f_1(lon_i + lat_i) + f_2(depth_i) + log(HaulDur_i)$$

The NS-IBTS Q1 index obtained by the deltaGAM method shows somewhat higher abundances between 1987 and 1992. After this period, the index drops until 2002 and is fluctuating since then without any clear trend (Figure 5.9, upper left panel). The new NS-IBTS Q1 index follows quite well an index using the stratified mean method with ICES statistical rectangles as strata (displayed by the red circles in the same panel). In a first step one index for each available quarter 3 survey was estimated and the indices were compared (Figure 5.10). Especially the NS-IBTS Q3 and BTS show similar trends, and also the SNS shows quite a good accordance for most of the available years. The combined quarter 3 index fluctuates without a clear trend since the start of the time-series (Figure 5.11). However, from 2004 until 2014 the index values are above the long-term mean, while the index values for the last three years fell below the long-term mean again.

5.6.2.2 Catch and effort series

As there are no catch-at-age data for North Sea flounder (see Section 5.6.1), there are no relevant age-based cpue series that can be used in assessment.

5.6.3 Weights, growth, maturity, natural mortality

Biological data which are available for flounder from the different surveys are listed in Table 5.5. The DATRAS data portal provides SMALK data from the NS-BTSQ3 surveys. However, data are sparse and unlikely to be representative for the whole stock.

5.6.3.1 Maturity

The DATRAS data portal provides SMALK data from the NS-BTSQ3 surveys. Data from the BTS did not reveal any conclusive results but a negative trend in maturity with age (Figure 5.12). This latter result is probably due to insufficient number of observations. The length-based data show that most of flounder reach maturity above 20 cm length (Figure 5.13).

5.6.3.2 Weight and growth

Due to the insufficient number of observations, it was not possible to analyse any interannual trends in weight-at-age or growth. The available data were pooled and age–weight and length–weight relationships were derived for cases for which data were available (details in WD 3; Figure 5.14). However, these data were not used in the subsequent analyses.

5.6.3.3 Natural mortality

Natural mortality (*M*) estimates for flounder were not available.

5.6.4 Assessment models

The newly available data for flounder, InterCatch data and new survey indices, were used as input data for the SPiCT model and different model runs and scenarios were tested in order to obtain an improved assessment for North Sea flounder. It was possible to set up a SPiCT model which converged and which obtained robust results in terms of relative fishing mortality and relative biomass (Figure 5.15). This final run used a catch time-series from 1983–2016 and two indices (NS-IBTS Q1 and a combined Q3 index). However, still the uncertainty was high and the model only converged by setting a prior on sd log(n). Details on the used input data, the different tested scenarios and tested model settings can be found in WD4.

5.7 Appropriate reference points (MSY)

5.7.1 Reference points prior to benchmark

Prior to the WKNSEA meeting, there were no existing reference points for North Sea flounder. MSY proxy reference points were determined during the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak Kattegat (WGNSSK ICES, 2017) by using the length base indicator method. These results showed no signs of fishing beyond the F_{MSY} proxy for North Sea flounder.

5.7.2 Source of data

Biomass indices are available for reference point estimation, from the IBTS (Q1 and Q3), BTS (Q3) and the SNS (Q3) surveys. Length distributions from commercial catches are also now available for the most recent years, and are collated in the InterCatch system.

5.7.3 Stock–recruitment relationship and new B_{lim} and B_{pa} reference points

B_{lim} and B_{pa} reference points were not considered at the WKNSEA meeting.

5.7.4 Methods and settings used to determine ranges for F_{MSY}

The principal approach to estimating proxy reference points for F_{MSY} was the SPiCT production model (Pedersen and Berg, 2017) and the Length-based indicator method, widely used for F_{MSY} estimation for relatively data-poor stocks in the North Sea. Considerable effort at WKNSEA went into a re-evaluation of the SPiCT model for North Sea flounder. The SPiCT model was the only assessment model used for flounder since for other, e.g. age-based SAM model, no sufficient data were available.

5.7.5 Proposed MSY reference points

It is suggested that the status of the stock in relation to a proxy for F_{msy} is determined on an annual basis by updating the SPiCT model (ICES, 2017c). The absolute values for F_{MSY} obtained by this model in case of the data-poor situation of North Sea flounder must not be used. However, the relative values of biomass and fishing mortality gives an indication for the stock status in relation to F_{MSY} and B_{MSY}.

5.8 Future research and data requirements

In order to update the SPiCT model on an annual basis, it is necessary to get information on the total catch, i.e. landings and discards, each year also in future. Good quality of these data, especially for the estimated discards, is a prerequisite for a robust production model. The InterCatch data, which were available for the current WKNSEA, showed that there is high variability of the amount of reported discards. It should be explored whether this variability is an artefact due to specific raising procedures in the national labs or a real signal in the data.

No discard data were uploaded for the Dutch fleets before 2011, and no Belgium and Scottish discard data before 2009. Therefore, the most important fleets in terms of landings and discards are missing for the period 2002–2008 in Subarea 4, which made it impossible to set up a reliable discard raising scheme for these years with the InterCatch tool. It should be explored if a method based on e.g. effort to raise discards could be a better approach to estimate the total catch for the early years of the time-series.

Length-based assessment methods should be explored further as length data are more numerous and available than age data.

5.9 References

Berg, C. W., Nielsen, A. and Kristensen, K. 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151, 91–99.

ICES. 2017a. Report of the Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 26 April–5 May 2017, ICES HQ, Copenhagen. ICES CM 2017/ACOM:21. 1077 pp.

ICES. 2017b. Report of the Working Group on Beam Trawl Surveys (WGBEAM), 04–07 April, Marine Institute, Galway. ICES CM 2017/ACOM:xx.

ICES. 2017c. Report of the Workshop on the Development of the ICES approach to providing MSY advice for category 3 and 4 stocks (WKMSYCat34), 6–10 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:47. 53 pp.

ICES. 2017d. WKNSEA data meeting report. ICES, Copenhagen, November 2017.

Pedersen, M. W. and Berg, C. W. 2017. A stochastic surplus production model in continuous time. *Fish and Fisheries*, 18: 226–243. doi:10.1111/faf.12174.

5.10 Tables

Table 5.1. Flounder in Subarea 4 and Division 3a. Discards and landings in tonnes provided to InterCatch (Subarea 4). Years with no data reported are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium								12	260	147	107	729	3	31	61
		Denmark	23	2	0	2	14	0	0	0	0	0	0	0	43	21	10
		France		0	13	21	0								5	2	3
		Germany	0	8	2	1	1	8	76	21	63	122	65	33	336	9	37
		Netherlands										336	420	154	114	116	146
		Norway													0	0	1
		Sweden															
		UK (England)	402	12	9	0	4	40	6	37	78	64	6	24	26	17	24
		UK(Scotland)								421	292	21	194	77	37	766	290
	Landings	Belgium	165*	206	335	241	165	287	291	241	205	262	347	345	374	284	216
		Denmark	56	71	67	117	101	59	66	56	34	24	27	14	22	15	22
		France	52	36	54	25	21	56	56	40	20	17	11	13	15	18	20
		Germany	2	3	5	6	3	45	39	46	58	25	23	28	30	19	26
		Netherlands	3382	3054	3596	3228	3900	2895	2215	2090	2555	2505	1626	1154	1241	1333	1335
		Norway	3	9	18	38	38	11	3	3	6	1	0	0	1	0	0
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	31	67	45	74	172	66	38	44	76	65	36	20	31	15	25
		UK(Scotland)	0	0	0	0	45	52	19	15	10	0	1	4	0	0	0

* official landings

Table 5.2. Flounder in Subarea 4 and Division 3a. Discards and landings in tonnes provided to InterCatch (Division 3a). Years with no data are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.3a	Discards	Denmark	615	207	14	24	89	341	93	348	356	771	188	308	631	189	83
		Germany													0		
		Netherlands													0		0
		Norway													0	0	0
		Sweden	348	270	4	195	122	141	50	26	29	201	62	31	75	106	31
	Landings	Denmark	496	454	463	467	377	409	320	234	183	126	108	160	189	73	103
		Germany	0	3	2	1	1	2	4	2	0		0	0	0		
		Netherlands				1	0	1	0	0					0		0
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Sweden	30	18	14	15	13	22	16	32	17	16	8	11	4	3	3

Table 5.3. Flounder in Subarea 4 and Division 3a. Average discard ratios which were applied for cases where no suitable data were available.

Métier	Country	Years	Mean discard ratio
OTB_CRU_70-99_0_0_all	all countries	2013	2.81
TBB_DEF_70-99_0_0_all	Netherlands	2002–2010	0.13
OTB_DEF_70-99_0_0_all	Netherlands	2002–2010	0.30
SSC_DEF_100-119_0_0_all	Netherlands	2010	1.41
TBB_DEF_70-99_0_0_all	BEL, GER, UK ENG, UK SCO	2003, 2005, 2007, 2008	0.60
all passive gears	all countries	2002–2004	0.22

Table 5.4. Flounder in Subarea 4 and Division 3a. Official landings and InterCatch estimates of landings, discards.

Year	Official landings	IC landings	IC discards	IC total catch	Discard rate
2002	4414	4217	2084	6300	33.07%
2003	4110	3922	1370	5292	25.89%
2004	4772	4601	637	5239	12.16%
2005	4428	4214	1265	5479	23.09%
2006	5009	4837	1026	5863	17.50%
2007	4065	3908	2082	5991	34.76%
2008	3240	3067	1376	4444	30.97%
2009	3088	2804	1342	4146	32.38%
2010	3365	3166	2002	5168	38.73%
2011	3193	3041	1694	4735	35.77%
2012	2310	2189	1205	3394	35.49%
2013	1876	1750	1415	3165	44.71%
2014	2062	1907	1127	3035	37.15%
2015	1883	1762	1228	2990	41.07%
2016	1738	1750	628	2377	26.41%

Table 5.5. Flounder in Subarea 4 and Division 3a. Available survey data for flounder in the North Sea (Area 4), Skagerrak and Kattegat (Area 3a).

Survey	Year survey started	DATRAS	Standard Gear	Length distribution	Age	Individual Weight	Maturity
IBTS Q1	1965–2017	1983–2017	GOV	1983–2017	2012–2013	2012–2013	2012–2013
IBTS Q3	1991–2017	1991–2017	GOV	1991–2017	n.a.	2009–2010 (only RV END)	n.a.
BTS Isis (NDL)	1985–2017	1987–2017	BT8	1987–2017	2005; 2011; 2013–2014; 2016	2005; 2011; 2013–2014; 2016	2016
BTS Tridens (NDL)	1996–2017	1996–2017	BT8	1996–2017	2005–2006; 2008–2010; 2014–2015	2005–2006; 2008–2010; 2014–2015; 2017	2005–2006; 2008–2009
BTS Belgica (BEL)	1992–2017	2010–2017	BT4	2010–2017	n.a.	n.a.	n.a.
BTS Endevour (UK)	2008–2016	2008–2017	BT4	2008–2017	n.a.	2014–2016	n.a.
BTS Corystes (UK)	1988–2007	1990–2007	BT4	1990–2007	1995; 1996; 2000	1995; 1996; 2000	n.a.
BTS Solea (GER)	1991–2016	1998–1999; 2001–2005; 2007–2016	BT7	1998–1999; 2001–2005; 2007–2016	n.a.	n.a.	n.a.
SNS (NDL)	1969–2016	Not available yet	BT6	2002; 2004–2016	2007–2008; 2012–2014; 2016	2004–2016	2005–2006; 2008–2009
DFS (NDL)	1970–2016	2002–2016	BT3 and BT6	2002–2016	2006–2016	2004–2016	2005–2016
DYFS (GER)	1972–2016	Not available yet	BT3	2002–2016	n.a.	n.a.	n.a.
DFYS (BEL)	1973–2016	Not available yet	BT3	n.a.	n.a.	n.a.	n.a.

5.11 Figures

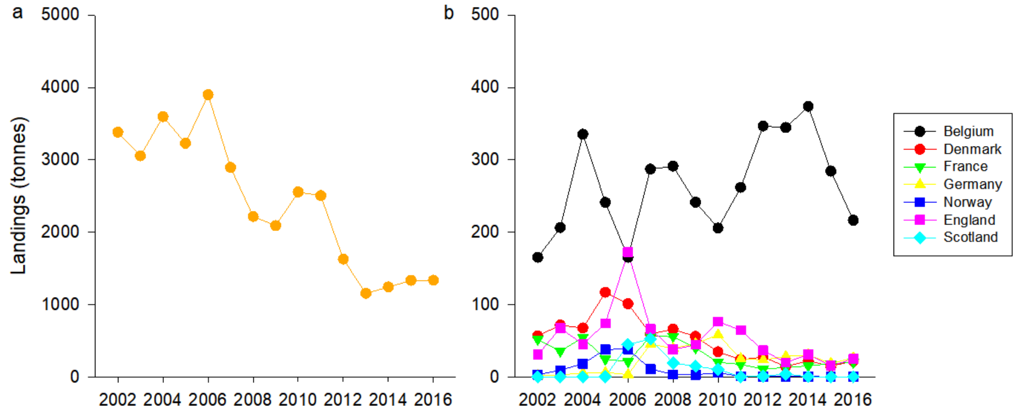


Figure 5.1. Flounder in Subarea 4 and Division 3a. Flounder landings in Subarea 4 provided to InterCatch for (a) the Netherlands and (b) for all other countries (b).

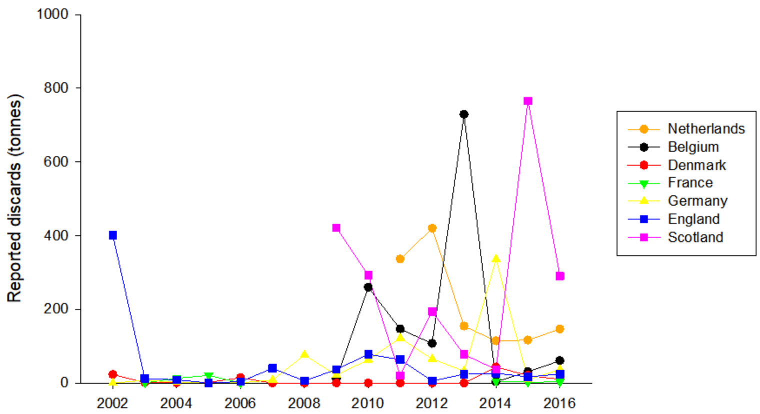


Figure 5.2. Flounder in Subarea 4 and Division 3a. Flounder discards in Subarea 4 provided to InterCatch by country.

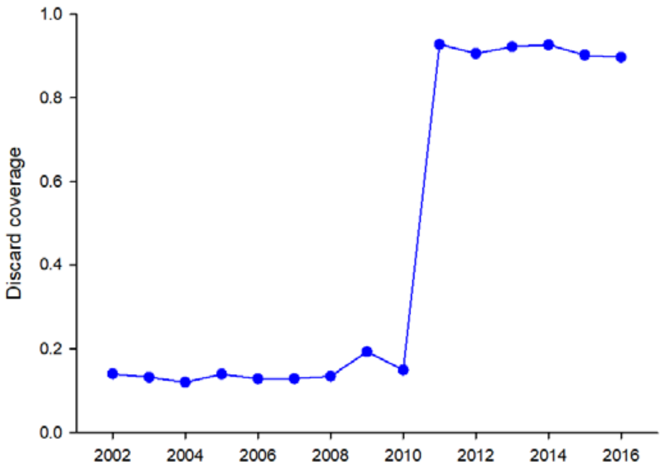


Figure 5.3. Flounder in Subarea 4 and Division 3a. The discard coverage as proportion of landings for which also discards were reported.

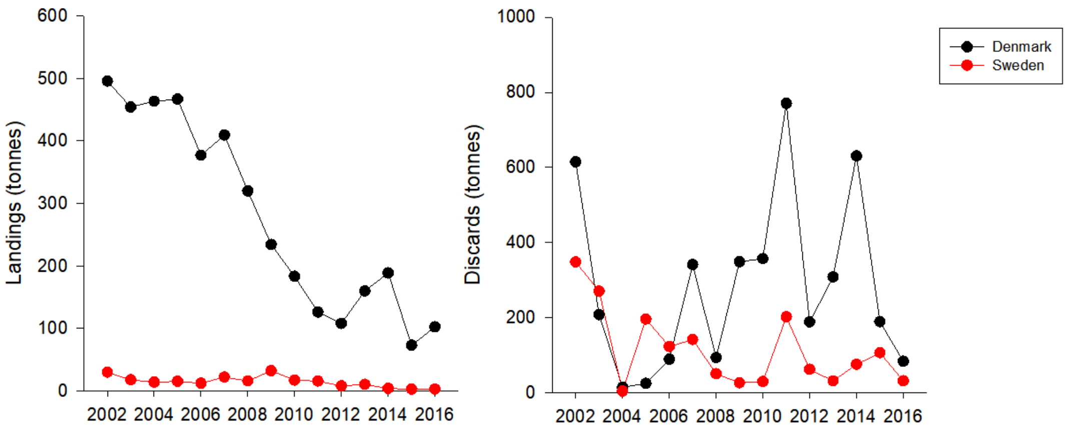


Figure 5.4. Flounder in Subarea 4 and Division 3a. Flounder landings (a) and discards (b) in Division 3a provided to InterCatch by country.

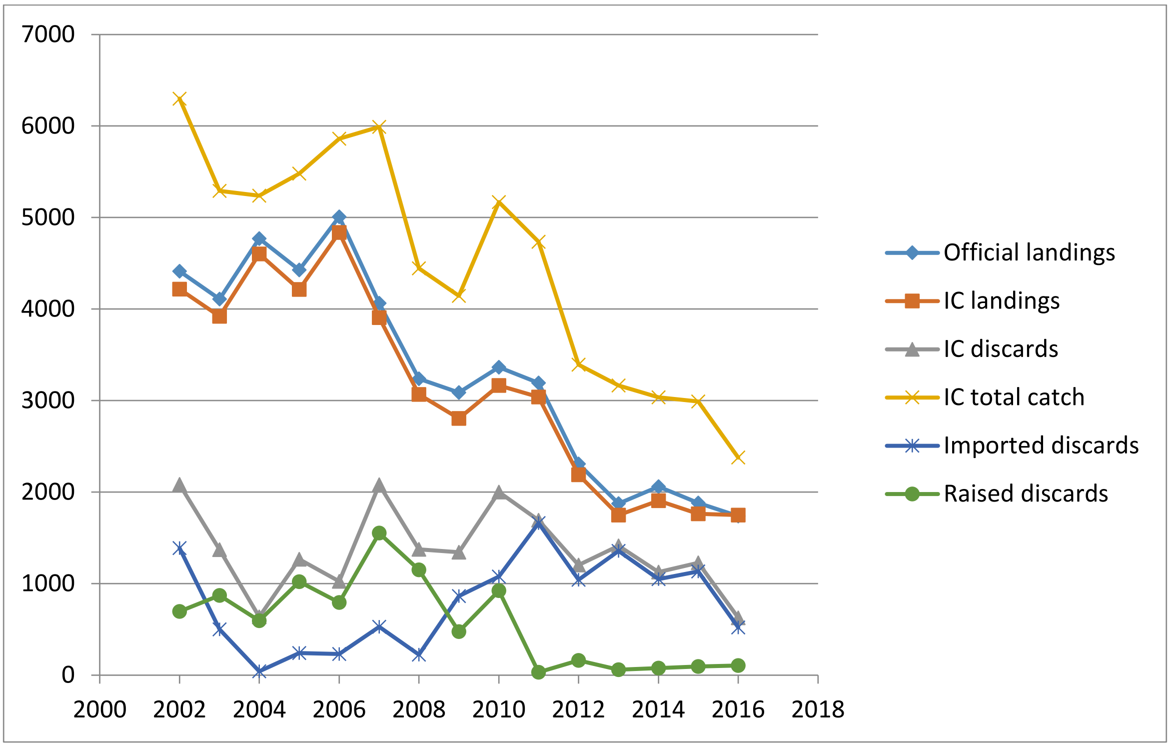


Figure 5.5. Flounder in Subarea 4 and Division 3a. Overview of total landings and discards (tonnes) uploaded to InterCatch, the official landings, and the resulting total catch raised with the InterCatch tool.

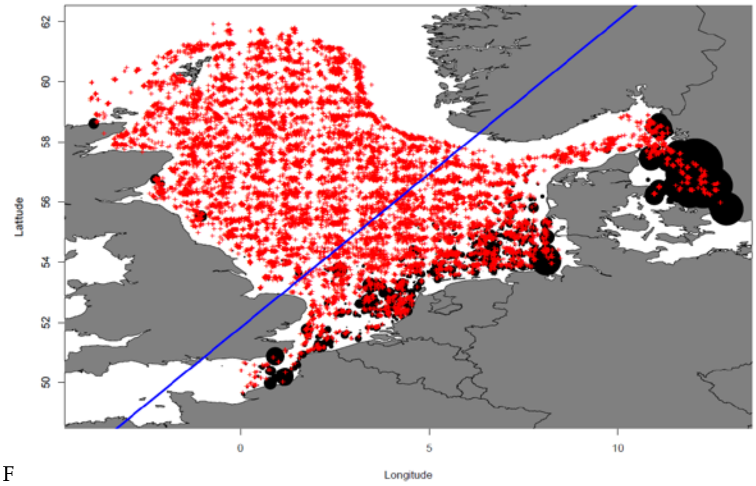


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Figure 5.6. Flounder in Subarea 4 and Division 3a. IBTS quarter 1 hauls (1983–2016). Red crosses display hauls with zero flounder caught, black bubbles display flounder catches.

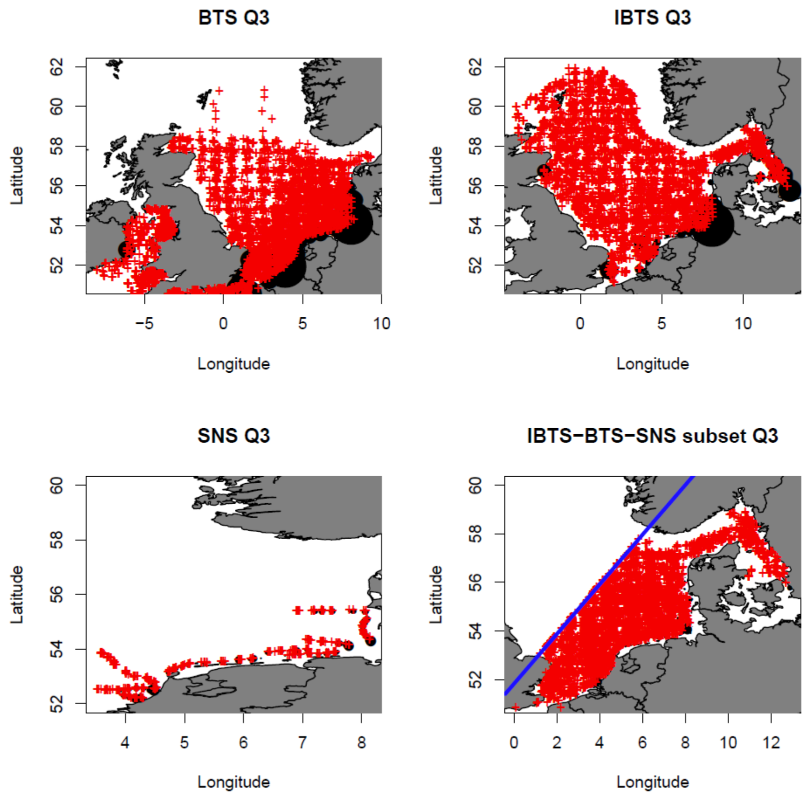

Figure 5.7. Flounder in Subarea 4 and Division 3a. Survey area BTS, IBTS, and SNS (Quarter 3, all available years). Lower right panel displays the index area subset for combined index calculation.

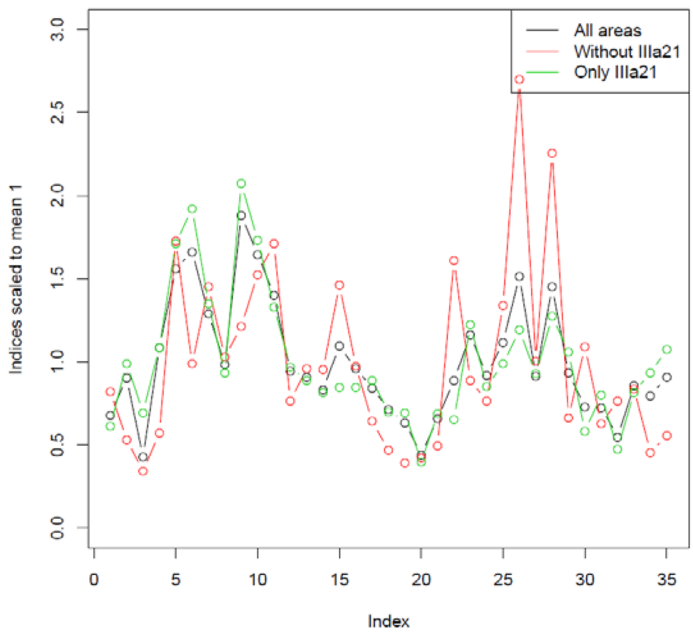

Figure 5.8. Flounder in Subarea 4 and Division 3a. Comparing IBTS Q1 indices: red line without Kattegat (3a.21), green line only Kattegat and black line whole survey area.

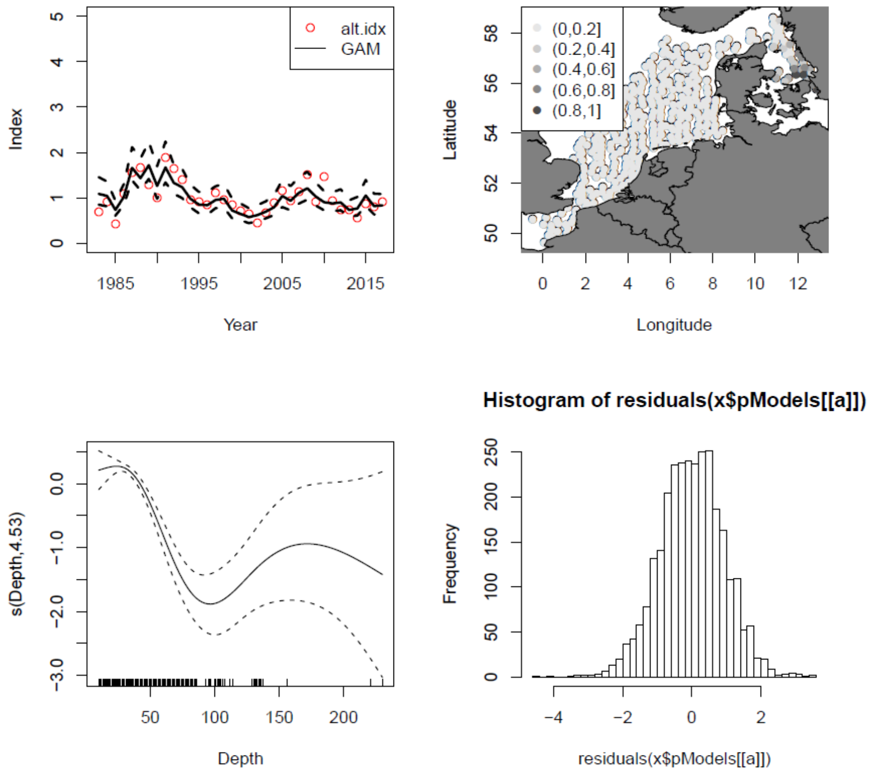

Figure 5.9. Flounder in Subarea 4 and Division 3a. IBTS Quarter 1 deltaGAM index (top left panel). Distribution of flounder catches within the index area (top right panel). Estimated depth effect (lower left panel). Histogram of residuals (lower right panel).

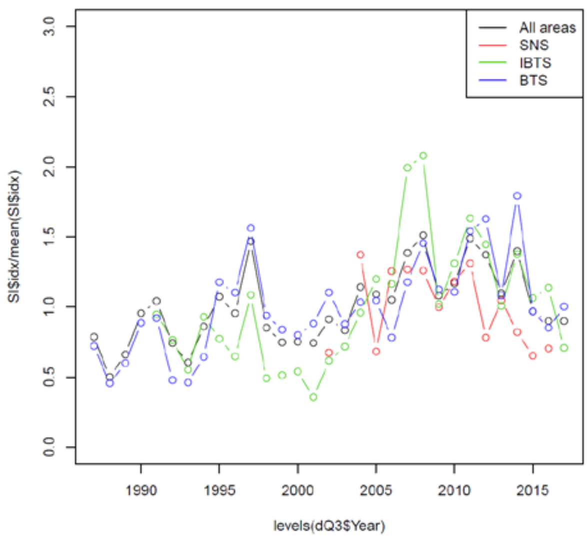

Figure 5.10. Flounder in Subarea 4 and Division 3a. Comparison of different quarter 3 survey indices obtained by the deltaGAM method. "All areas" = combined index, taking into account SNS, IBTS and BTS quarter 3 data.

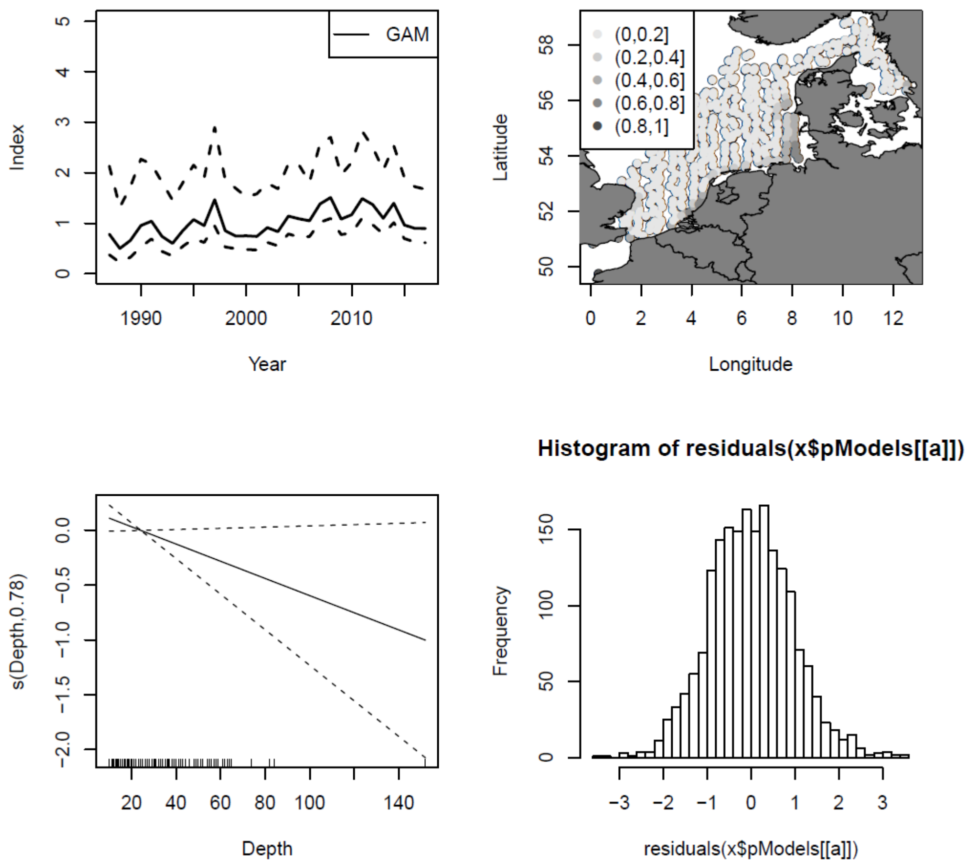

Figure 5.11. Flounder in Subarea 4 and Division 3a. Combined quarter 3 deltaGAM index (top left panel). Distribution of flounder catches within the index area (top right panel). Estimated depth effect (lower left panel). Histogram of residuals (lower right panel).

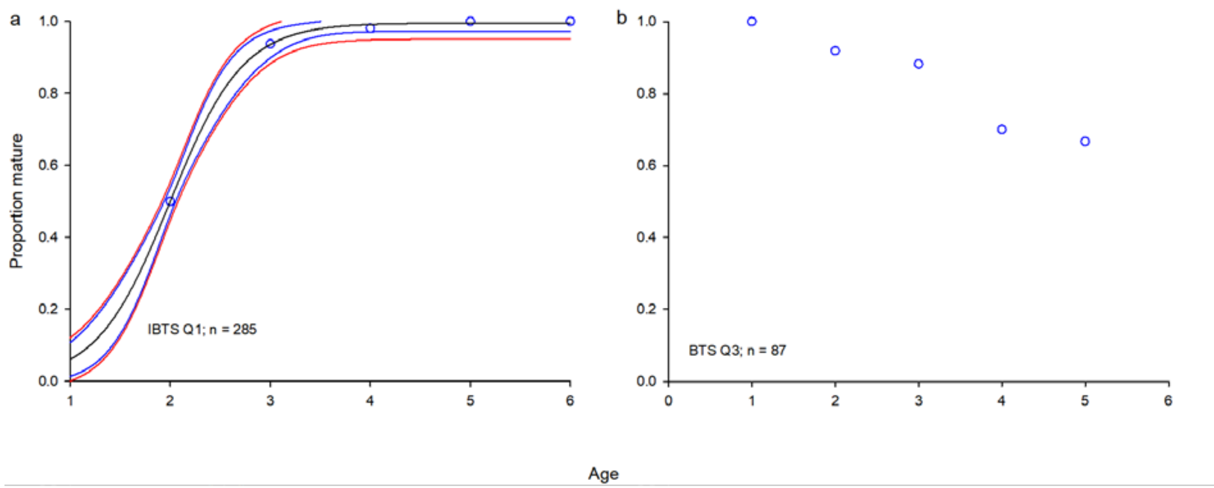

Figure 5.12. Flounder in area 4 and Division 3a. Age-based maturity data obtained from the NS-IBTSQ1 (a) and the BTSQ3 (b).

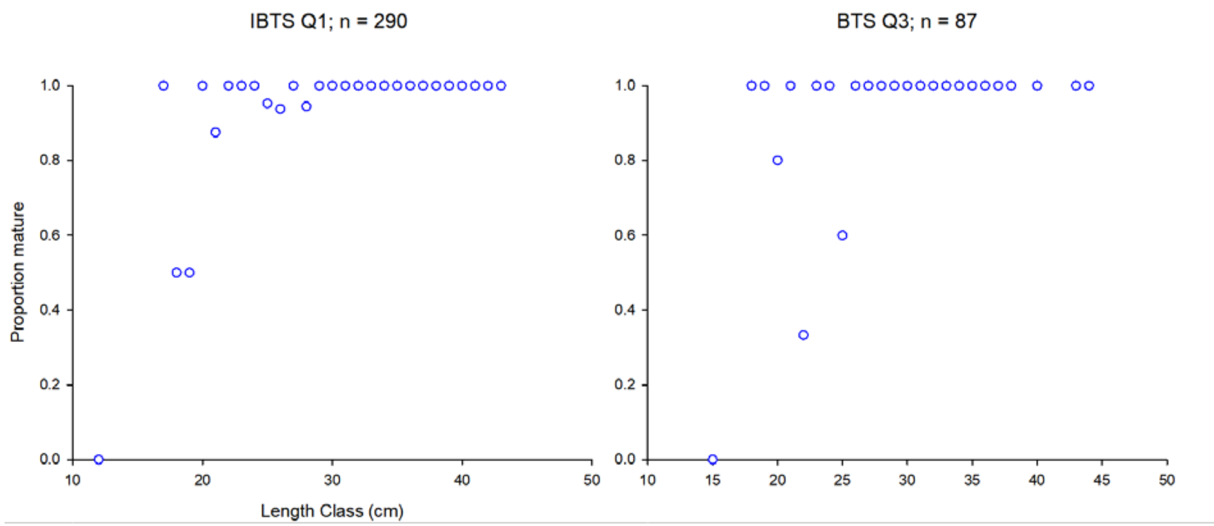

Figure 5.13. Flounder in area 4 and Division 3a. Length based maturity data obtained from the NS-IBTSQ1 (a) and the BTSQ3 (b).

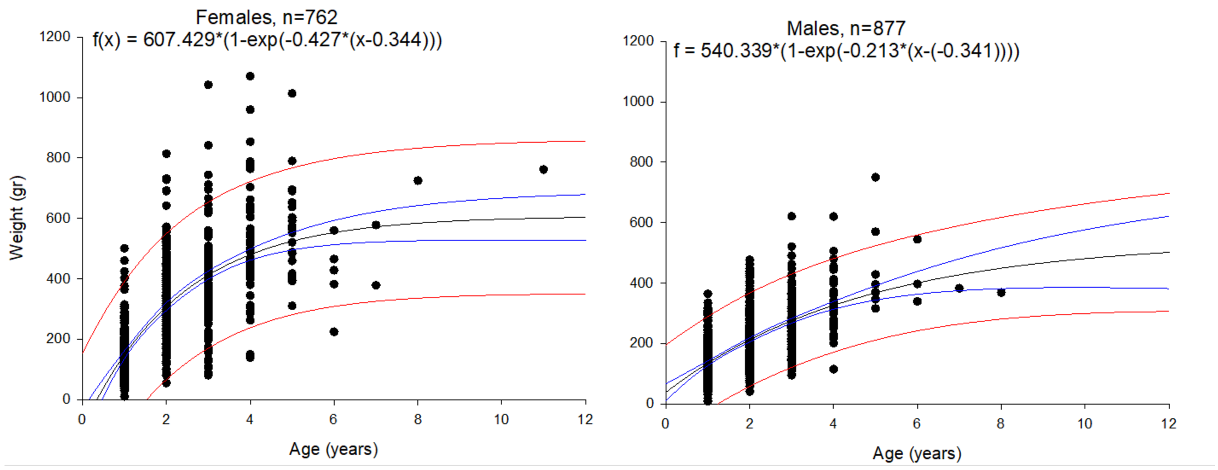

Figure 5.14. Flounder in area 4 and Division 3a. Growth curves for female flounder (a) and male flounder (b) with the respective growth functions.

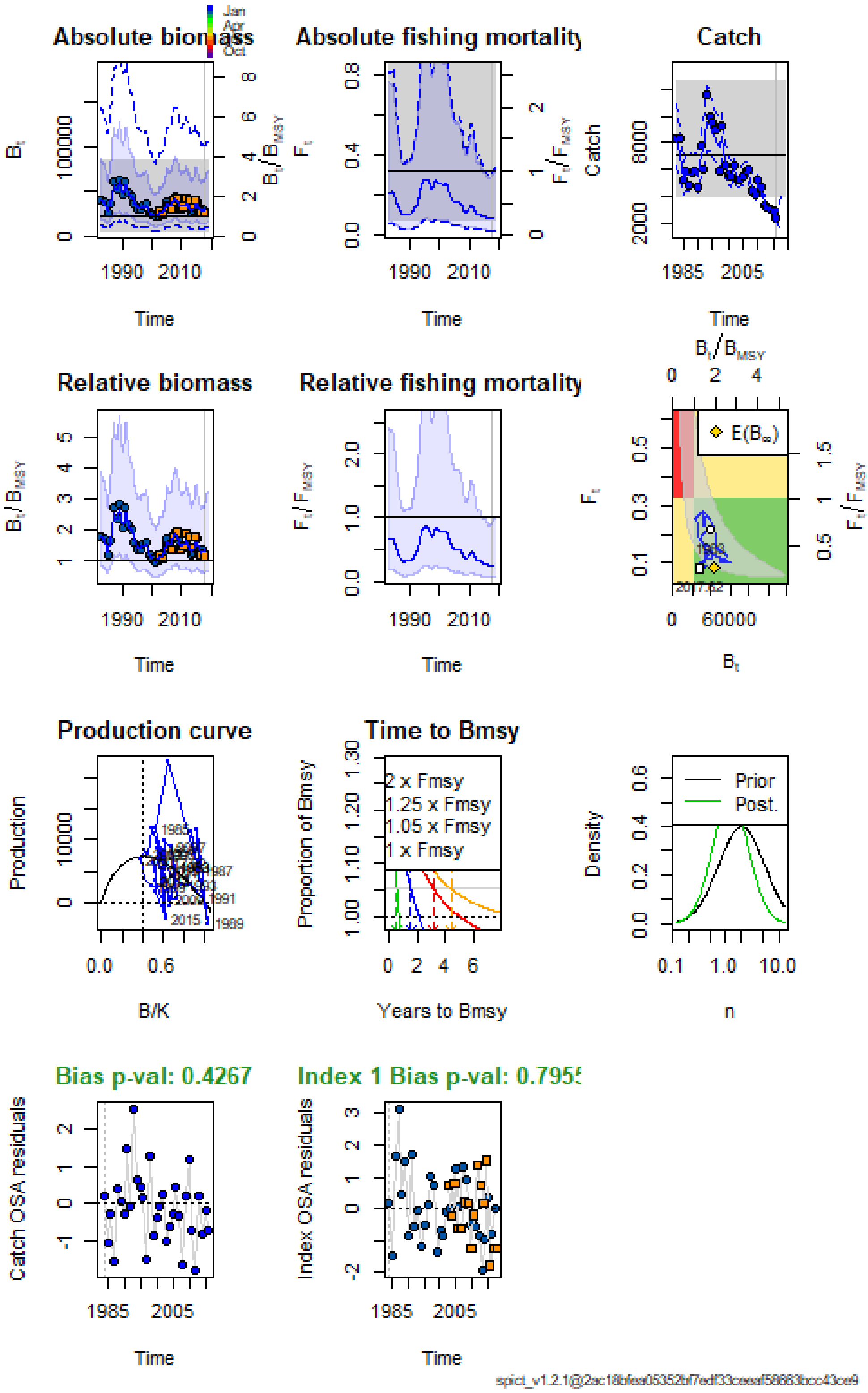

Figure 5.15. Flounder in area 4 and Division 3a. Results obtained by the final SPiCT model run.

6 Whiting in 27.47d

This section relates to the whiting stock in the North Sea (Subarea 4) and eastern English Channel (Division 7d).

6.1 Stock ID and substock structure

During the benchmark, a literature review on stock identity was presented (WD 1). A complex population structure for whiting in the North Sea has been proposed repeatedly based on studies about movements, life-history traits, genetic data, identification of spawning aggregation, population temporal asynchrony observed in SSB, recruitment and egg abundance between areas (for references and details see WD 1). The Dogger Bank, along the 50 m depth contour, has repeatedly been suggested as a natural barrier separating a northern and a southern subpopulation (Hislop and MacKenzie, 1976; Pilcher *et al.*, 1989; De Castro *et al.*, 2013; Holmes *et al.*, 2014). Even if studies suggested separate spawning units, they still did not rule out mixing outside the spawning season during the rest of the year. Further research is needed.

A region-specific stock assessment would require considerable effort to provide a historical series of national catch data with separate age samples for the northern and southern component. Previously and currently, such data could not be provided to revise management units to account for stock structures (ICES, 2005; WKNSEA 2018).

It was not clear whether a separate TAC for a northern and southern component could be given, even if separate assessments are run. For example, currently there is a mismatch between assessment and advice area for Division 7d. Assessment for 7d is done together with Subarea 4, while advice is given together with Divisions 7b–k. If separate assessments for the northern and southern component were done but the TAC was given combined, asynchronous dynamics may still lead to overexploitation of one component. To evaluate status and dynamics of putative stock components, preliminary SURBAR were run for each component (WD 8).

While no region-specific estimates of natural mortality and stock weights-at-age were available, new region-specific maturity ogives (WD 4) and survey indices (WD 5) could be used in separate SURBAR analyses for northern and southern components (WD 8). The indices from North Sea International Bottom Trawl Survey (NS IBTS) for a northern and a southern component were provided by ICES following the area definitions for substock structure suggested by Holmes *et al.* (2014). From SURBAR, it can be inferred that stock dynamics in northern and southern component showed roughly similar dynamics in terms of SSB and recruitment (Figure 6.1, WD 8). The SURBAR assessment results for the combined North Sea better reflected the dynamics of the northern component. The survey indices for the southern component showed lower within survey correlations between age groups of a cohort and maturity ogives showed higher temporal variability (WD 4, 5). As a result, estimated SSB as well as total mortality were more variable in the South with larger confidence intervals. Potentially, connectivity with the northern component or additional substock structure within the South could affect survey indices and results for the southern component. The survey signals for the northern component showed higher consistency. In recent years, the southern component showed an upwards trend in SSB and recruitment. Therefore currently, management decisions appropriate to the combined stock are not expected to negatively impact the southern component.

Considering the evidence from literature, current management and the workload to provide a split input data, the issue of stock identity was not included in the 2018 benchmark. This conclusion is similar as in 2005 (ICES, 2005), although additional literature was published since confirming a stock separation. It is recommended that the stock identity issue should be revisited in future when further evidence of a continuous split of subpopulations in the North Sea are presented, appropriate his-toric catch data can be provided and management structures are in place to support a stock-specific quota following a stock-specific assessment and advice.

The assessment of North Sea and Area 3a (Skagerrak, Kattegat) are currently run separately. Preliminary analysis of maturity ogives shows a significant difference between North Sea, both northern and southern component, and Skagerrak/Kattegat (WD 4). Individuals in area 3a mature later, with smaller proportions of mature fish at-ages 1 to 3. It is therefore not recommended that the assessment of area 3a should was joined with North Sea at this this stage.

6.2 Issue list

The issue list is taken from Annex 6 of ICES, WGNSSK (2017) and communication after WGNSSK 2017. The issue list is in Annex 4.

Expected working documents

1) Stock identity (Tanja Miethe);
2) 2009–2016 catch data – InterCatch (Tanja Miethe);
3) Survey indices tuning series (Tanja Miethe);
4) Biological parameters: stock weights-at-age, maturity, M (Tanja Miethe, Thomas, Peter, WGSAM);
5) SAM assessment (Tanja Miethe, Anders Nielsen), SURBAR (Tanja Miethe), XSA (Tanja Miethe).

The working documents that were completed can be found in Annex 7.

6.3 Scorecard on data quality

A scorecard was not used for this benchmark.

6.4 Multispecies and mixed fisheries issues

No new information was presented at the benchmark meeting.

6.5 Ecosystem drivers

No new information was presented at the benchmark meeting.

6.6 Stock assessment

6.6.1 Catch: quality, misreporting, discards

The landings, discard and industrial bycatch (IBC) and the respective age compositions were estimated using InterCatch. New data were submitted for 2002–2016. Major landings in area 4 originated from the UK (Scotland, England) and in area 7d from France. Landing weights were submitted by all required countries for the entire time period. Discard data and age samples from the French fleet, dominating catches in area 7d, were submitted for the entire period. However, for the Scottish fleet, dominant in area 4, no discard information or age samples could be provided for 2002–2008. Therefore, catch data were reraised in InterCatch only for the period 2009–2016 where sufficient data on landings, discards as well as age samples from countries with major catches in areas 4 and 7d are available in InterCatch. Raising procedures were tested as detailed in WD 2. For 1978–2008, the available historical catch time-series was used and not updated.

In some cases gear stratification was used for TR1 and TR2, other gear types were grouped together for raising.

- TR1 bottom trawls and seines (OTB, OTT, PTB, SDN, SSC, SPR) =>100 mm;
- TR2 bottom trawls and seines (OTB, OTT, PTB, SDN, SSC, SPR) 70–100 mm.

Submitted annual discards were manually matched to the respective available quarterly landings by country, area and fleet. Only matched landings and discards were used to estimate discard-landings ratios, to estimate discards for landings without provided discards.

Discard allocation for area 27.4 and 27.7d combined:

a) stratification for gear types (TR1, TR2) and quarter (1, 2, 3, 4).
b) MIS_MIS_0_0_0_IBC: no raising of discards.
c) rest all with all by quarter (1, 2, 3, 4) (no stratification by gear).

Weighting: Landings CATON

Age allocations were done for area 27.4 and 27.7d combined for each catch category separately:

Landings:

a) stratification for gear types (TR1, TR2) and half year (quarters 1, 2 and quarters 3, 4 together)

If landings were submitted annually for TR1 and TR2, ages allocated by gear type with all quarters combined.

b) rest all with all (no stratification by gear or quarter)

Weighting: CATON

IBC age allocation:

a) all with all (no stratification by gear or quarter)

Weighting: CATON

Discard and BMS age allocation:

a) stratification for some gear types (TR1 only) and per half year (quarter 1,2 and quarter 3,4)
b) annual TR1 with all TR1
c) rest including TR2 with all (no stratification by gear, quarter)

Weighting: CATON

CATON, CANUM and WECA files were used to update the catch time-series. Industrial bycatch (IBC) only occurred in area 4. Individual catch weights-at-age were used for IBC. Since 2015, some landings below minimum landing size were reported as an extra category (BMS landing). For age allocations and export of data, BMS landing were combined with discards (unwanted catch).

6.6.2 Surveys

6.6.2.1 Research surveys

The North Sea International Bottom Trawl Survey (NS IBTS) is conducted annually, in quarter 1 and quarter 3. The survey's aim to provide consistent and standardized data, which allow evaluation of spatial and temporal changes in the distribution and relative abundance of fish and of the biological parameters (maturity, weights-at-age) The IBTS survey combines data from sampling survey stations of multiple vessels from national institutes by haul (Figure 1 for Q3, ICES (2017b)). Q1 survey is undertaken in January to March (target month February). The Q3 survey takes place in July to September (target month August). Since 1983, all nations participating in the survey were required to use GOV trawl. In 1991 survey effort was extended to quarter 3.

The abundance indices per age group were routinely calculated for the North Sea (Subarea 4) and the Eastern Channel (Division 7d) combined. For this benchmark separate indices for a northern and a southern component were also provided by ICES following the area definitions for substock structure suggested by Holmes *et al*. (2014). Details on survey data, index calculation and diagnostics were included in WD 5 to this report. In conclusion, the NS IBTS Q1 and Q3 surveys were found to be consistent both in terms of within survey correlations and between survey comparisons and deemed appropriate to estimation of abundance of whiting in the entire North Sea.

6.6.2.2 Catch and effort series

There are no relevant age-based cpue series that can be used in the assessment.

6.6.3 Weights, growth, maturity, natural mortality

6.6.3.1 Weights and growth

In the XSA assessment of year 2017, stock weights-at-age were assumed to be equal to catch weights-at-age aggregated for the entire year. In the assessment model, SSB was calculated at the beginning of the year. This can lead to an overestimate of SSB as weights-at-age were expected to increase during the year. Also, catch weight-at-age may not reflect stock weights-at-age due to size selectivity of the fishery.

Following the evaluation of weights-at-age in commercial catches and survey catches, it was concluded that commercial catch weights needed to be corrected (WD 6). A complete survey time-series was not available for the period 1978–2016, since survey weights-at-age were recorded for Q1 only since 2000. Instead, the time-series of commercial catch weight-at-age was scaled using a correction factor to fit the IBTS Q1 survey weight-at-age level for 2000 onwards (WD 6). Characteristic dynamics of the catch weights-at-age were preserved, while the effect of size selectivity and timing of measurements were corrected. Further smoothing was found to introduce error when weights for different ages changed simultaneously in the same direction. Therefore, raw corrected weights were suggested to be used as stock weights-at-age (Figure 6.2).

6.6.3.2 Maturity

The maturity ogive was updated during the benchmark based on North Sea IBTS quarter 1 data (WD 4). The calculation was carried out on combined sex using "Exchange data" downloaded from ICES DATRAS (https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx).

Data were raised following ICES, WKMOG (ICES, 2008). Composite maturity ogives was calculated using maturity data for northern and southern North Sea weighted by area-specific catch rates. Maturity ogives were produced by modelling maturity data as a binomial GLM with logit link. Maturity data were smoothed for all ages, with individuals older than six as a plus group. The age at 50% maturity (A50) was relatively constant until 2000 than the value decreased. This was mainly driven by an increase in the estimated proportion of mature individuals at-age 1 (Figure 6.3). This occurred in both northern and southern component (stronger increase in the south, WD 4). In recent years, the composite maturity ogive was influenced equally by northern and southern component due to an increase in catch rates in the south.

6.6.3.3 Natural mortality

For the whiting benchmark 2018, new natural mortality estimates were available as produced by WGSAM in the 2017 key run of the North Sea SMS model (ICES, 2018). The new key run included revisions and updates to the input data and a few modifications of the structure of the model. Whiting was considered to be both predator and prey. For age 0 whiting, main predator was grey gurnard. Later in life, predation of harbour porpoise, saithe and cod intensified. There was cannibalism, in particular on age 0 and age 1 whiting. Predation mortality on age 0 whiting increased in recent years due to an increase in grey gurnard abundance. The new raw natural mortality data from the latest key run were smoothed to reduce the effect of interannual variability while tracing the change in natural mortality over time (Figure 6.4).

Further details can be found in the Annex for the ICES North Sea SMS configuration of WGSAM (ICES, 2018) and WD 3 for whiting in this report.

6.6.4 Assessment models

For the final assessment SAM, a state-based assessment model, was used (Nielsen and Berg, 2014). Details on the model and exploration of model settings were given in WD 7. For comparison, also SURBAR and XSA assessment were run on updated input data. A survey-based assessment, SURBAR was detailed in WD 8. The XSA results were described in WD 9.

Due to the standardization of the survey only in 1983 for NS IBTS Q1 and negative residuals for this fleet in the SAM assessment for earlier years (WD 7), it was recommended not to use indices for years before 1983 in the SAM assessment.

SURBAR, XSA and SAM results of mean-standardized values of SSB and mortality were compared in in Figure 6.5 and 6.6, respectively. Mean standardized SSB showed similar dynamics in SAM and XSA, with slightly higher SSB estimates from the XSA in recent years (Figure 6.5). SURBAR estimates were more variable but showed similar dynamics over time. Fishing mortality in both XSA and SAM decreased from 0.8 in the early 1980s to around 0.2 and 0.25, respectively. Total mortality in SURBAR decreased from 1.2 to 0.9 (Figure 6.6). Mortality in all three models showed stable high mortality up to around 1990 and a decrease until the early 2000s. Differences in the pre-1990 period between survey-based assessment and XSA/SAM which make use of catch data, were not large enough to justify a truncation of the assessment time period.

6.7 Appropriate reference points (MSY)

6.7.1 Reference points prior to benchmark

The existing reference points are listed in the current ICES advice.

6.7.2 Source of data

The EqSim was run using the results from the final accepted SAM assessment (WD 7) which was run on www.stockassessment.org as WHG2017_AN_010_surv_catch_mort_mat_cc_1978".

The assessment included updated input data, on survey, catches, natural mortality, maturity as well as new corrected stock weights-at-age, agreed during the benchmark. All input data were given since 1978, except survey data which started in 1983 (IBTS Q1) and 1991 (IBTS Q3). Recruitment was estimated at-age 0. New reference points were estimated in a stepwise process, using the EqSim analysis (standardized ICES code) and ICES technical guidelines (ICES, 2014; ICES, 2016; ICES, 2017a).

6.7.3 Stock-recruitment relationship and new B_{lim} and B_{pa} reference points

North Sea whiting was characterized as a type 5 stock, with B_{lim}=B_{loss} (B_{loss}=119 970 the lowest observed SSB in 2007). There was no apparent stock–recruitment relationship; stock dynamics below B_{lim} were unknown.

EqSim was run without assessment/advice error and without AR rule (without $B_{trigger}$) to retrieve F_{lim}, as the F (F_{50}) that ensures a 50% probability for SSB to remain above given B_{lim}. The stock–recruitment relationship was modelled as a segmented regression with B_{lim} as the breakpoint. F_{lim} was estimated as 0.445.

B_{pa} and F_{pa} were calculated using the default value for σ_{SSB} and σ_F of 0.2 because values estimated in SAM were found too low:

$$B_{pa} = B_{lim}e^{(1.645\sigma_{SSB})} = 166708$$
$$F_{pa} = F_{lim}e^{(-1.645\sigma_F)}=0.32$$

6.7.4 Methods and settings used to determine ranges for F_{MSY}

Following the guidelines, if the estimated $F_{MSYupper}$ exceeds the estimated $F_{p.05}$, $F_{MSYupper}$ is capped and specified as $F_{p.05}$, which was estimated using EqSim with error and advice rule (ICES, 2016). $F_{MSYlower}$ is redefined as the lower fishing mortality providing 95% of the yield at $F_{p.05}$ ($F_{p.05lower}$). The initially estimated F_{msy} (0.251) and the respective $F_{MSYupper}$ (0.336) were greater than $F_{p.05}$ (0.139). F_{msy} ranges are detailed in Table 6.2 (Figure 6.12).

6.7.5 Final Eqsim run

The final EqSim run was based on the complete time-series of SAM assessment results. The average of biological parameters of the recent 20 years and the average of the recent three years of fishing selectivity was used. Default value 0.2 was used for σ_F and σ_{SSB}. Further settings are detailed in Table 6.3.

F_{MSY} was initially calculated based on an EqSim with assessment/advice error, which should give maximum yield without advice rule (without MSY $B_{trigger}$). For the spawning stock–recruitment relationship a segmented regression was used with a freely estimated breakpoint. The initial F_{MSY} was 0.251.

For most stocks that lack data on fishing at F_{MSY}, MSY $B_{trigger}$ is set at B_{pa}. However, as a stock starts to be fished consistently with F_{MSY}, a value for MSY $B_{trigger}$ could be set to reflect the 5th percentile definition of MSY $B_{trigger}$. F_{MSY} was 0.251 and fishing mortality was lower or around that value in recent years (Table 6.1). The 5th percentile of B_{Fmsy} was calculated running an EqSim without assessment/advice error and without advice rule, using a segmented regression with freely estimated breakpoint. The 5th percentile of B_{Fmsy} was 330, which was smaller than B_{pa}=166 708. Therefore, B_{pa} was selected as MSY $B_{trigger}$.

$F_{p.05}$ was calculated by running EqSim with assessment/advice error and with advice rule to ensure that the long-term risk of SSB<B_{lim} of any F used does not exceed 5% when applying the advice rule. Accordingly, F_{MSY} had to be reduced to $F_{p.05}$=0.139 (Table 6.2).

6.7.6 Sensitivity runs

Autocorrelation in recruitment was significant in the first lag (0.49, Figure 6.9). However, including autocorrelation in recruitment led to F_{MSY} of 0.08 which was extremely low considering the estimated historical fishing mortality (Figure 6.7).

The reference points were therefore further investigated in WD 10. Above detailed EqSim settings were not satisfactory considering autocorrelation in recruitment, recent changes in biological parameters and uncertain value of B_{lim}.

After a second review following the benchmark, the following reference points (Section 6.7.7) were agreed. The suggested final setting includes the time-series starting in 1983, using the average of the last ten years of biological data and the last three years of fishing selectivity data, default values of sigmaF and sigmaSSB (0.2), and autocorrelation in recruitment.

6.7.7 Proposed MSY reference points

Reference point	Value
$B_{trigger}$	166 708
B_{pa}	166 708
B_{lim}	119 970
F_{lim}	0.458
F_{pa}	0.330
F_{MSY} (final)	0.172
F_{MSY} without $B^{trigger}$	0.392
F_{MSY} lower without $B^{trigger}$	0.158
F_{MSY} upper without $B^{trigger}$	0.172
$F_{P.05}$ (5% risk to B_{lim} with $B_{trigger}$)	0.172

6.8 Future research and data requirements

6.9 References

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6.10 Tables

Table 6.1. Whiting in Subarea 4 and Division 7d. Results from SAM assessment.

Year	Recruitment (age 0)	SSB	F (2-6)
2012	7 431 796	152 003	0.213
2013	12 025 687	145 632	0.206
2014	16 459 840	138 819	0.235
2015	15 764 353	149 974	0.259
2016	19 203 521	160 931	0.252
2017	9 657 024	184 350 (current)	

Table 6.2. Whiting in Subarea 4 and Division 7d. MSY ranges.

Reference point	Value	Technical basis
$F_{MSYlower}$	0.127	$F_{p.05lower}$ (EqSim)
F_{MSY}	0.139	$F_{p.05}$
$F_{MSYupper}$	0.139	$F_{p.05}$

Table 6.3. Whiting in Subarea 4 and Division 7d. Settings for EqSim.

	Value	
stockName	WHG2747d	
runName	WHG2017_AN_010_surv_catch_mort_mat_cc_1978_20yearav	
SAOAssessment	WHG2017_AN_010_surv_catch_mort_mat_cc_1978	
sigmaF	0.2	
sigmaSSB	0.2	
noSims	2000	
SRused	Segreg	
SRyears_min	1978	
SRyears_max	2016	
acfRecLag1	0.49	
rhoRec	FALSE	
numAvgYrsB	20	
numAvgYrsS	3	
cvF	0.212	
phiF	0.423	
cvSSB	0	
phiSSB	0	

6.11 Figures

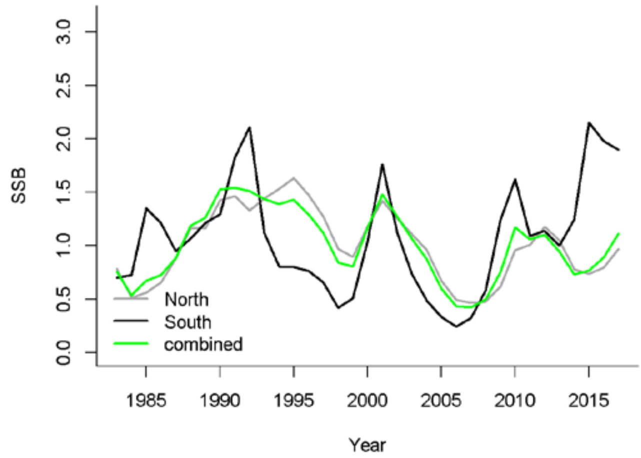

Figure 6.1. Whiting in Subarea 4 and Division 7d. Mean standardized SSB estimated using SURBAR, comparison for region-specific (North in grey, South in black) and combined North Sea (green) values.

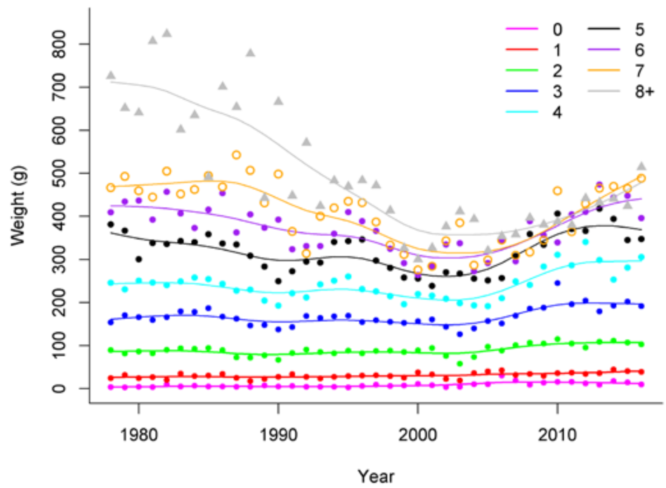

Figure 6.2. Whiting in Subarea 4 and Division 7d. Stock weights-at-age using corrected catch weights-at-age at age (by NS IBTS Q1 2000-2016, with smoothed values as lines).

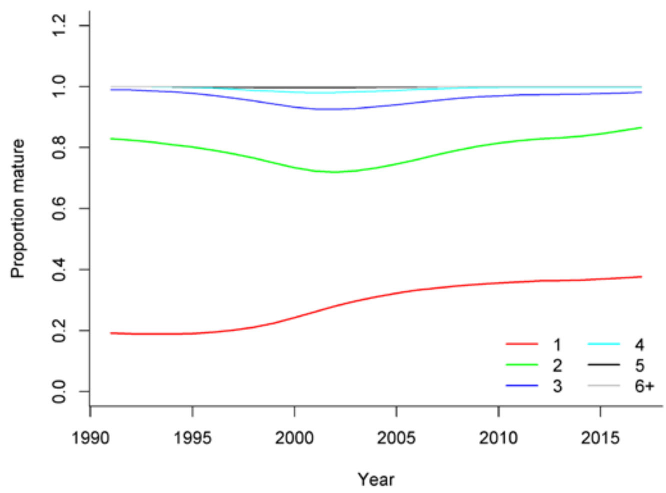

Figure 6.3. Whiting in Subarea 4 and Division 7d. Proportion mature at-age smoothed values (lines) and with plus-group containing ages 6+.

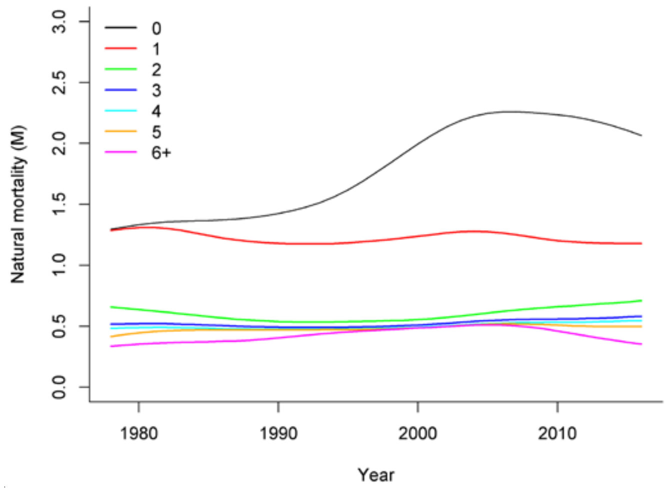

Figure 6.4. Whiting in Subarea 4 and Division 7d. Smoothed natural mortality estimates (using the output from the latest 2017 key run). Ages 0 to 6+ estimated separately.

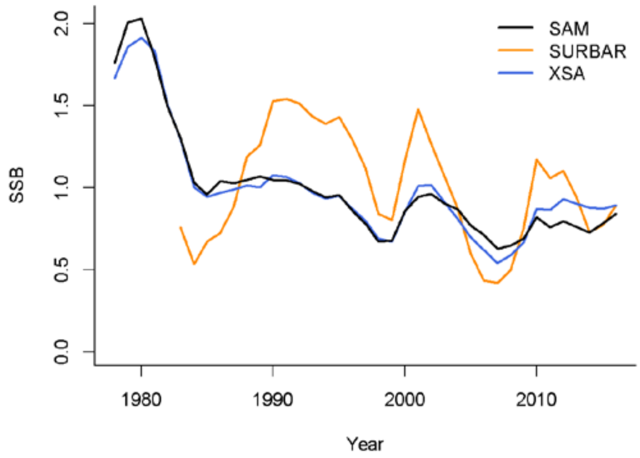

Figure 6.5. Whiting in Subarea 4 and Division 7d. Mean standardized SSB comparing SAM assessment, SURBAR and XSA, using the new input data with NS IBTS Q1 indices starting in 1983.

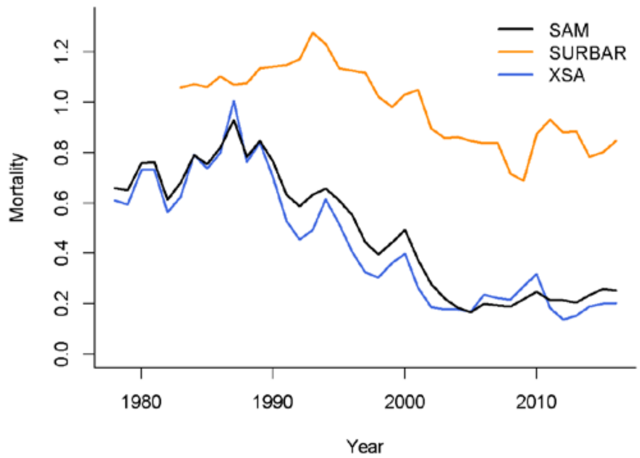

Figure 6.6. Whiting in Subarea 4 and Division 7d. Comparing mean fishing mortality (age 2–6) in the SAM assessment, to mean fishing mortality (age 2–6) from XSA, to total mortality Z (age 2–4) from SURBAR.

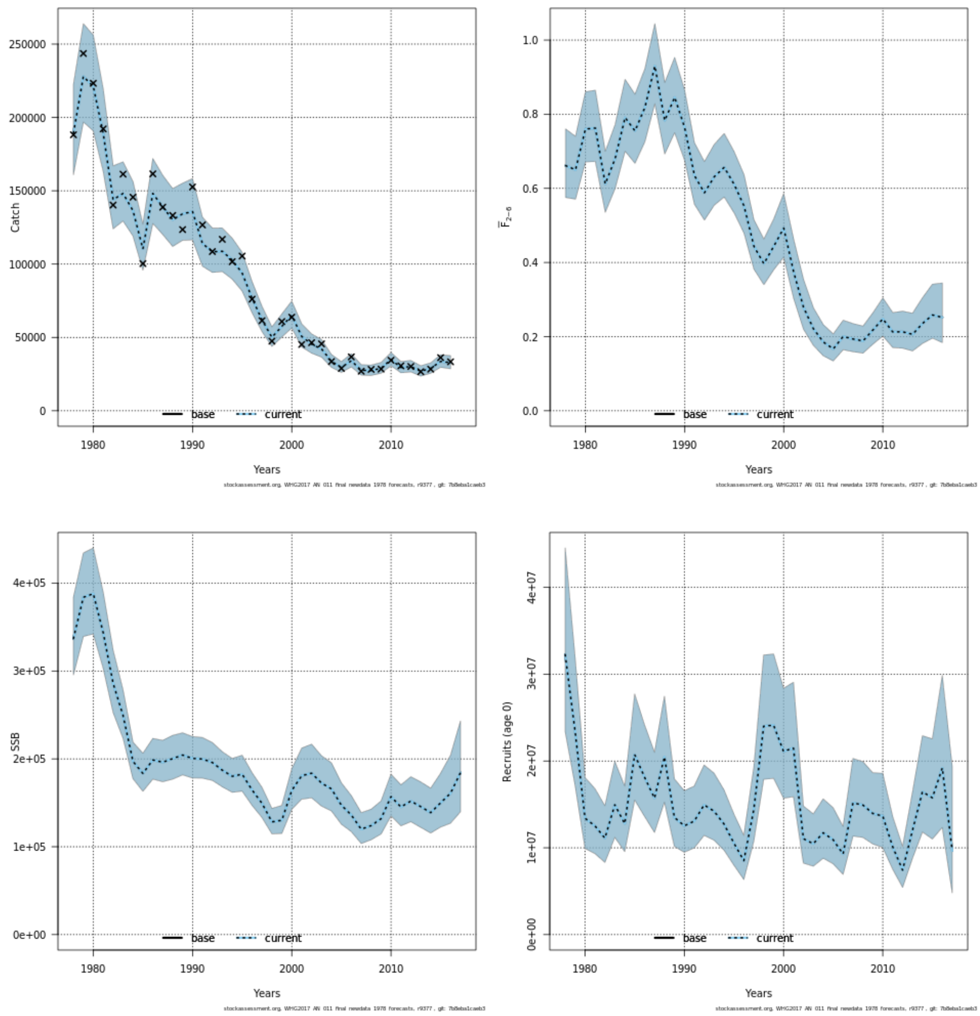

Figure 6.7. Whiting in Subarea 4 and Division 7d. Final SAM assessment results with survey data starting in 1983 and catch data starting in 1978. Estimates with 95% Confidence intervals for total catch weight, mean fishing mortality (age 2–6), SSB and recruitment (at-age 0).

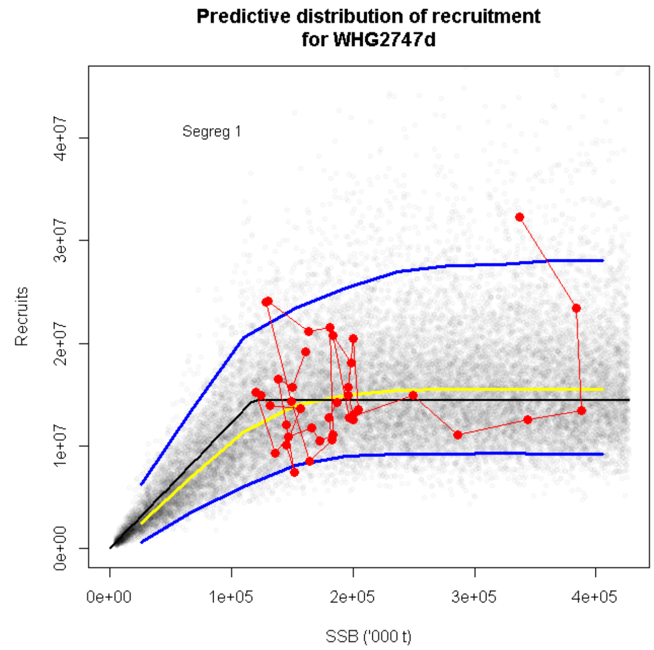

Figure 6.8. Whiting in Subarea 4 and Division 7d. Stock–recruitment relationship using segmented regression with freely estimated breakpoint.

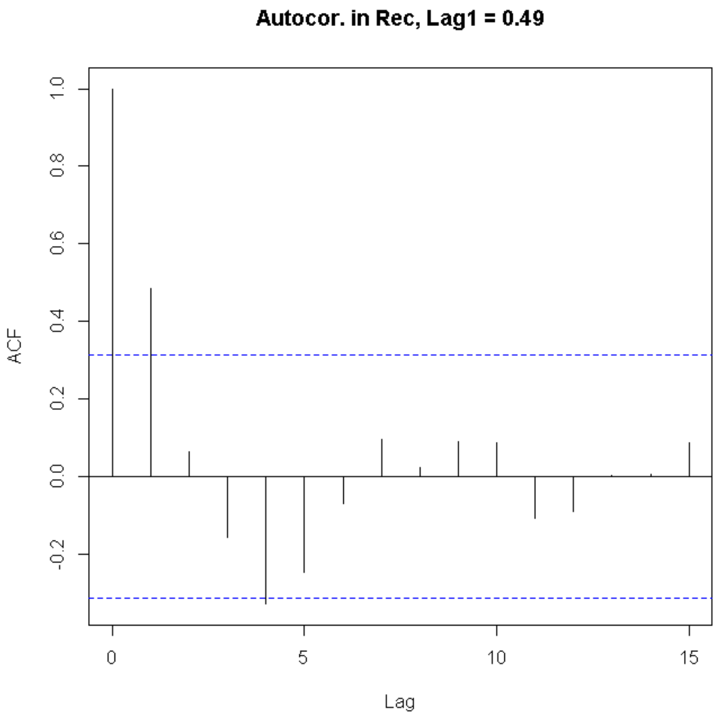

Figure 6.9. Whiting in Subarea 4 and Division 7d. Autocorrelation in recruitment, 1978–2016.

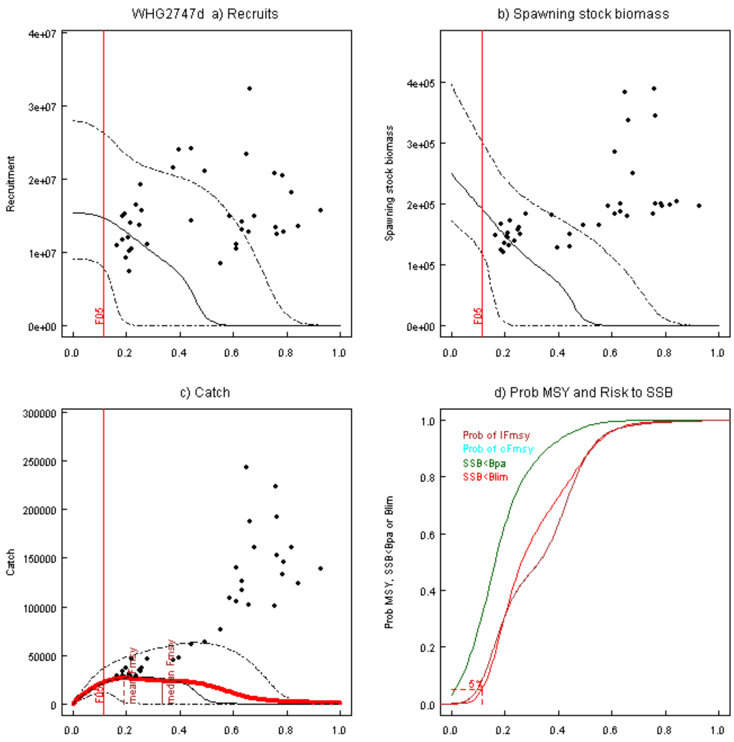

Figure 6.10. Whiting in Subarea 4 and Division 7d. EqSim with assessment/advice error and without $B_{trigger}$.

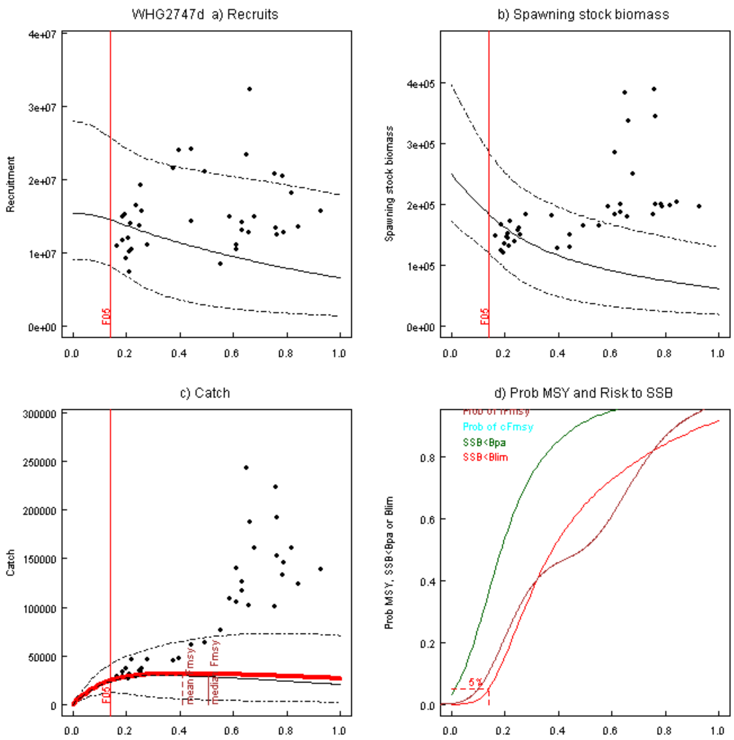

Figure 6.11. Whiting in Subarea 4 and Division 7d. EqSim with assessment/advice error and with $B_{trigger}$.

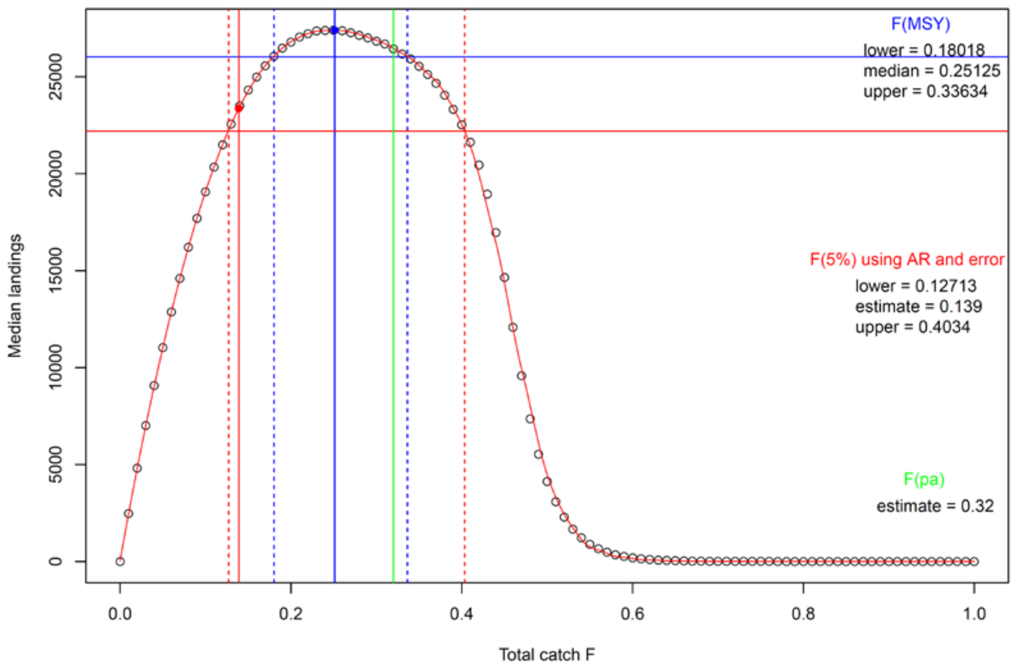

Figure 6.12. Whiting in Subarea 4 and Division 7d. Median yield curve and upper and lower ranges (vertical dashed lines). For F_{MSY}=$F_{p.05}$=0.139 (with error and AR) upper and lower bound are given (red) as well as F_{pa} (green).

7 Witch in 27.3a47d

This section relates to the witch stock in the Skagerrak/Kattegat (Division 3.a and subdivisions 20 and 21), North Sea (Subarea 4) and the Eastern English Channel (Division 7d).

7.1 Stock ID and substock structure

No results were presented on the stock ID during the benchmark.

7.2 Issue list

The issue list is taken from Annex 6 of ICES, WGNSSK (2017) and communication after WGNSSK 2017. The issue list is in Annex 4.

Expected working documents

1) 2002–2016 catch data - InterCatch (Francesca Vitale);

2) Survey indices tuning series (Francesca Vitale, Casper Berg);

3) Biological parameters: stock weights-at-age, maturity, length–weight relationship (Francesca Vitale);

4) SAM assessment (Anders Nielsen, Rasmus Nielsen, Francesca Vitale)

5) SPiCT assessment (Rasmus Nielsen, Alexandros Kokkalis).

The working documents that were completed can be found in Annex 8.

7.3 Scorecard on data quality

A scorecard was not used for this benchmark.

7.4 Multispecies and mixed fisheries issues

No new information was presented at the benchmark meeting.

7.5 Ecosystem drivers

No new information was presented at the benchmark meeting.

7.6 Stock assessment

7.6.1 Catch: quality, misreporting, discards

InterCatch data 2002–2016

InterCatch was previously used only to estimate 2012–2016 discard ratio while now it was used for estimation of both landings and discards numbers, length composition (2002–2016) and age compositions (2009–2016) as describer in WD1.

The approach used for unmatched discard was to merge areas and quarters (when samples were not enough) and treat métiers separately, combined in two categories, i.e. fleets with and without selectivity devices (including passive and active gears). Discards in 2002 needed to be re-raised excluding some Swedish and Danish fleets with discard ratio > 2 in quarter 4 (OTB_DEF_>=120_0_0_all and OTB_CRU_90-119_0_0_all) that were resulting in really high discard percentage by country, compared to the following years ((WD1 Table 1 and 2). Observed and raised discards by country and year are shown in WD1 Figure 1.

Concerning the length-distributed stock (2002–2016), no stratification was made in landings for most of the year, i.e. allocations were made combining all fleets, all areas and all quarters, due to low sample size. Only in few years, it was possible to apply quarter and area stratifications. Discards were allocated ignoring fleets and areas while quarters were stratified when possible.

For the age-distributed stock (2009–2016), landings were generally allocated using areas and fleets combined but Q stratified in all years except for 2011.

For discards data métiers were treated in two categories, i.e. fleets with and without selectivity devices, in all years except 2011 where fleets were combined. Areas were always combined while quarters were always combined only for fleets with grids.

The obtained overall tonnage estimates of landings and discards and relative discard ratio by year are shown in WD 1 Table 1 while Total catch and landings by country and year are shown in WD1 Figure 2.

Discards data from 2012 and 2013 reported by the Netherlands caused some issues during the raising and needs to be investigated in future.

7.6.2 Surveys

7.6.2.1 Research surveys

Two survey time-series exist which are potentially useful for the witch 3a47d stock assessment model to be used as tuning indices. Those surveys for demersal fish species in the greater North Sea area are the International Bottom Trawl Survey (IBTS, 1st and 3rd Quarter) and the Beam Trawl Surveys (BTS, 3rd Quarter). While the BTS cover areas 4.b, 4.c and the English Channel (Division 7d), the IBTS covers area 4a, the Skagerrak (Division 3aS) and Kattegat (Division 3aS). Data exploration and results are included in Working Document 2.

The delta-GAM approach was used to generate survey indices by age from IBTS Q1 (ages 1–7) and IBTS Q3 (ages 1–6) for 2009–2016; no age data exist prior to 2009. No age data for witch existed in the BTS data. DATRAS-generated IBTS Q1 and Q3 indices by age were also provided by the ICES DataCentre for comparison.

Total biomass indices were also generated for combined BTS-IBTS Q3.

Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. The use of the IMR deep-water shrimp survey (held in national database) was mentioned as a potential future data source, but will not be explored for this benchmark.

7.6.2.2 Catch and effort series

There are no relevant age-based cpue series that can be used in the assessment.

7.6.3 Weights, growth, maturity, natural mortality

7.6.3.1 Weights and growth

The landings, discards and catch weights-at-age were estimated after raising national observed data in InterCatch for the period 2009–2016 while the stock weights-at-age were obtained using IBTS data, quarter combined, from the same period (WD1, Figure 3). All weights show no real trend over time and become noisy at older age. For these reasons, it was suggested to use 8 as plus-group and use constant stock weights instead of annual values (WD3, Table 1).

Also, von Bertalanffy growth curve and length–weight relationship were estimated using IBTS data (2009–2017) quarter combined (WD3, Figures 6 and 7).

7.6.3.2 Maturity

The maturity ogive is an important population attribute, and it is used for estimating SSB in the stock assessment. For witch flounder, a fixed maturity ogive was employed in the assessment model (WD3, Table 3). Data exploration and reason for the final decision are elucidated in WD3.

7.6.3.3 Natural mortality

The assessment currently uses a constant natural mortality rate of 0.2 for all ages and years.

7.6.4 Assessment models

The accepted assessment model during WKNSEA2018 was a SAM (State–space Assessment Model). A SPiCT (stochastic surplus production model in continuous time) was run in parallel and considered as exploratory. The descriptions of those assessment models are clearly outlined in Nielsen and Berg (2014), Berg *et al*. (2014), and Pedersen and Berg (2017), so will not be presented here. Data inputs into both models are in Table 7.1 and results are in Figure 7.1. The model is fitting to all data sources (Figure 7.2). The leave-one-out diagnostics show that all data sources are in agreement; this analysis was done with one the time period with age data (2009–2016, Figure 7.3) The retrospective runs show that removing the last two years does not result in a pattern, but removing additional years does (Figure 7.4). The retrospective runs are difficult to evaluate because of the very short time-series (eight years). The time-series becomes too short to obtain reliable convergence, which is a likely explanation for the pattern seen when using only 3 or 4 years of data.

Because SAM is an age-based model, convergence was problematic when the first years of data were only total landings. To obtain convergence over the entire time period, artificial catches-at-age were produced from the period 1940–1944, followed by a 5-year period of no data. The artificial catches-at-age were the average catches-at-age for 2009–2016. Sensitivity runs were performed to ensure the artificial catches did not influence the assessment, where artificial catches were doubled or halved. The sensitivity runs showed no important influence in the 1950-2016 assessment period (Figure 7.5).

Detailed information on settings and results for the SAM assessment can be found in WD4 and for SPiCT, in WD 5.

7.7 Appropriate reference points (MSY)

7.7.1 Reference points prior to benchmark

The existing reference points are listed in the current ICES advice.

7.7.2 Source of data

EQSIM simulations were conducted for the witch stock in the Greater North Sea (wit.27.3a47d). These followed the ICES advice technical guidelines as published 20 January 2017 (ICES, 2017) for the estimation of the reference points.

Data from the accepted SAM assessment (run 'witch_2018_007' on stockassessment.org) were used for the following simulations.

Recruitment at-age 1 from the assessment was used. Though strong autocorrelation in recruitment values was evident, no historic trends were observed in the stock–recruitment relation and therefore the entire time-series from 1940 was utilized in the estimation of reference points.

7.7.3 Stock-recruitment relationship and new B_{lim} and B_{pa} reference points

Three different models, Ricker, Beverton & Holt and segmented regression were run and applied to the time-series, 1940–2016 (Figure 7.7.3.1). Beverton & Holt was clearly weighted highest (0.92) of the three methods.

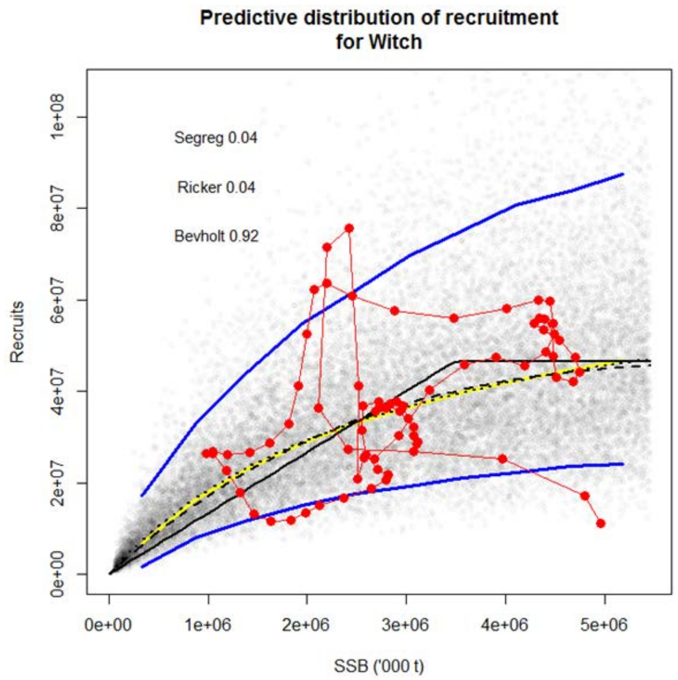

Figure 7.7.3.1. Combined stock–recruit fits for wit.27.3a47d. Black line is segmented regression, dashed line is Ricker, and dotted line is Beverton & Holt. Yellow line is average fit weighted by Buckland method.

For estimating B_{lim} a categorization of the stock–recruitment relationship into type is required (ICES, 2017). The group agreed that the Type 2- S–R relationship corresponded best to the stock–recruitment relationship: Stocks with a wide dynamic range of SSB, and evidence that recruitment is or has been impaired.

According to this SR type B_{lim} is based on the breakpoint in a segmented regression. Fitting a regular segmented regression curve gives a breakpoint at 3483 t. (Figure 7.7.3.2). However, given the high autocorrelation evident in the recruitment time-series, the group felt it would be more appropriate to fit a segmented regression curve that accounts for this in the fit. This resulted in a breakpoint at 3069 t (Figure 7.7.3.3). This value was proposed by the group for B_{lim}.

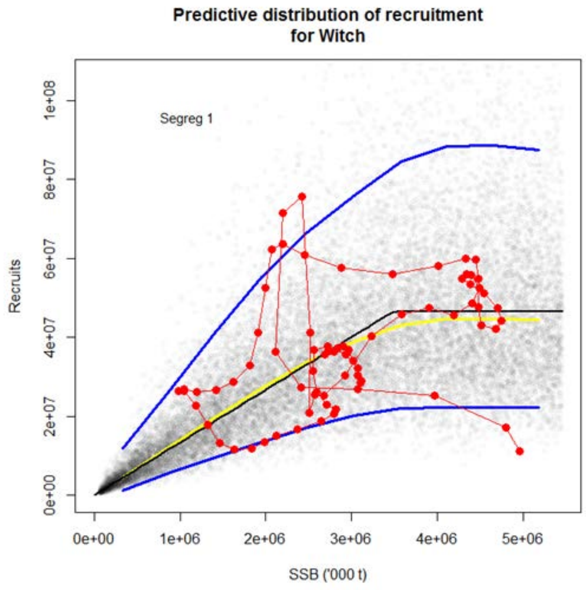

Figure 7.7.3.2. Segmented regression fit for wit.27.3a47d.

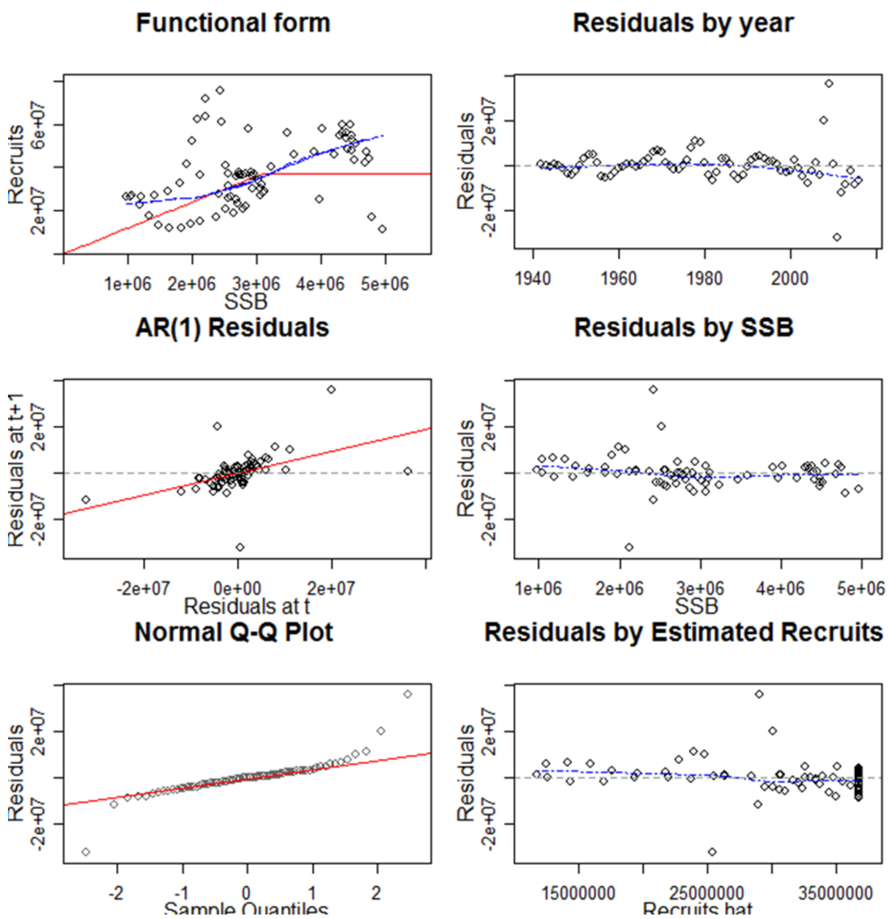

Figure 7.7.3.3. Segmented regression fit for wit.27.3a47d, accounting for autocorrelation in recruitment (AR1).

B_{pa} was calculated from B_{lim} by: B_{lim} * exp(1.645 *σ), where σ is SD of ln(SSB) in 2017 (the last year with estimates from the model) - here estimated by SAM to 0.265. B_{pa} is then estimated at 4745 t.

F_{lim} was estimated by simulation using the above values of B_{lim} and B_{pa}, setting F_{cv}, F_{phi} and SSB_{cv} = 0 (no assessment and advice noise) and with no MSY $B_{trigger}$. F_{50} is median F_{lim}, here estimated to 0.30.

F_{pa} is calculated from the formula $F_{pa} = F_{lim} * \exp(-1.645 * \sigma)$, where σ is SD of ln(F) in 2016 (the last year with estimates from the model) - here estimated by SAM to 0.221. F_{pa} is estimated to 0.21.

7.7.4 Methods and settings used to determine ranges for F_{MSY}

F_{MSY} is initially estimated as the F that maximize median long-term yield in the simulation under constant F exploitation (Figure 7.7.4.1). The recommended default values of cvF = 0.212, phiF = 0.423 and cvSSB = 0 were applied to the simulation since no assessment/advice history is available for this stock. The initial F_{MSY} was estimated at 0.154, which is below the above estimated F_{pa} (0.21).

MSY $B_{trigger}$ was set as equal to B_{pa}, since it was not considered likely that the stock had been fished at F_{MSY} for the last five years.

The initial F_{MSY} estimate was then check for precautionarity in simulations using the initial estimate of F_{MSY} in combination with MSY $B_{trigger}$ in the ICES advice rule (Figure 7.7.4.2). F_{p05}, the F that leads to a 5% P(SSB<B_{lim}), was estimated at 0.28. The precautionary principle states that if $F_{MSY} > F_{p05}$, then F_{MSY} should be reduced to F_{p05}. This is not the case here and the final F_{MSY} therefore equals initial F_{MSY} = 0.154.

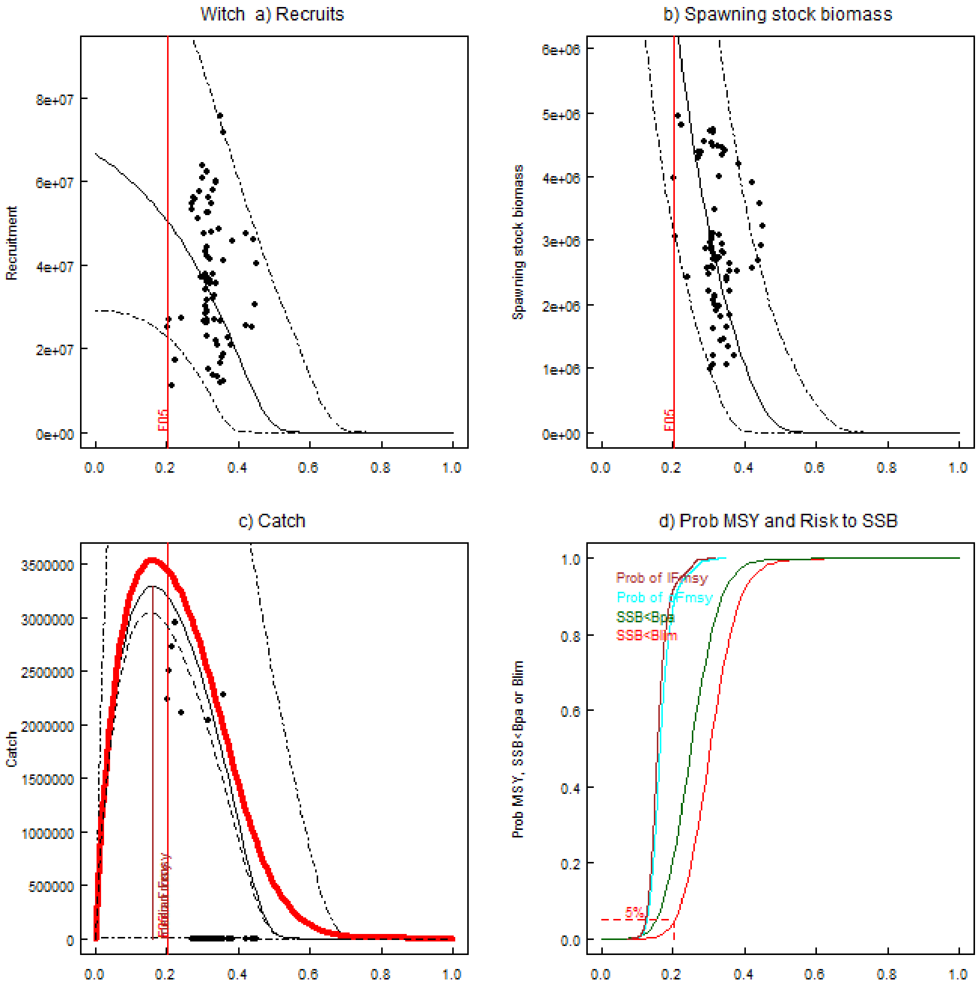

Figure 7.7.4.1. Simulation results for constant F (i.e. without MSY $B_{trigger}$). Equilibrium relationships between F and (a) recruits, (b) SSB, (c) catch; and (d) the probability of F_{MSY} and SSB<B_{lim}.

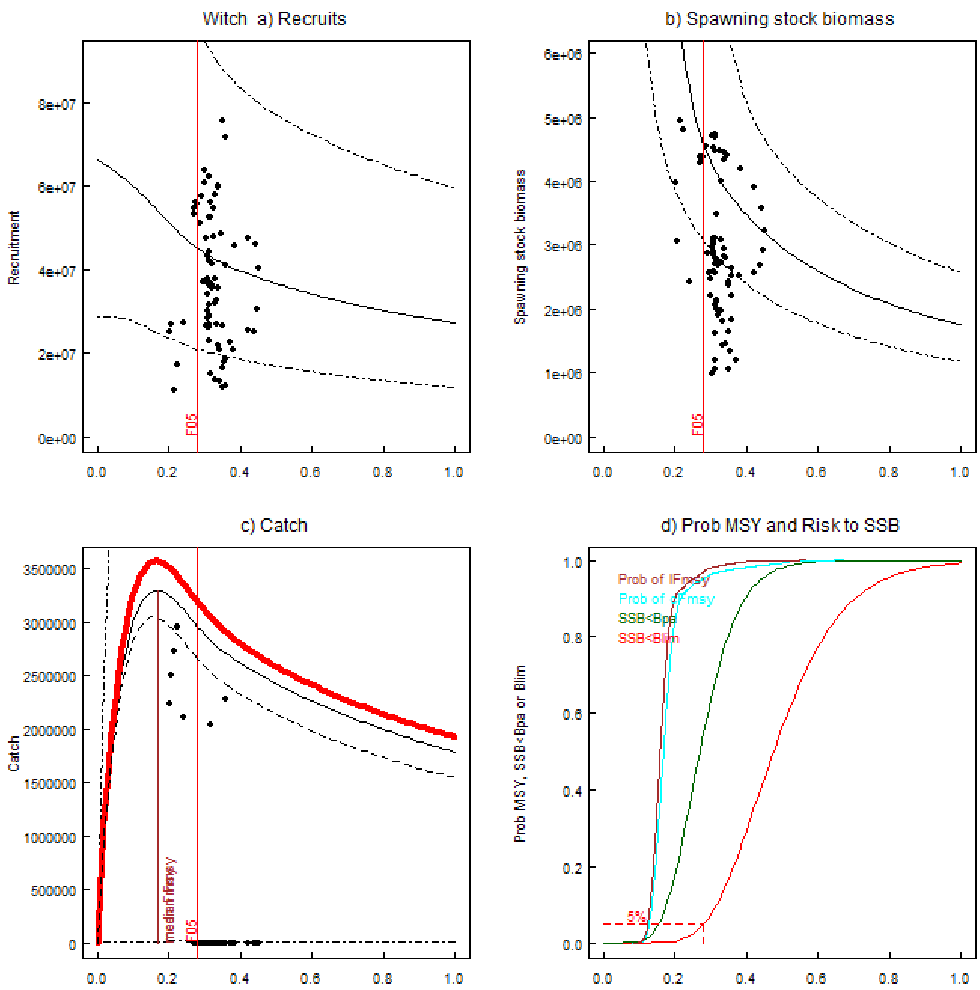

Figure 7.7.4.2. Simulation results applying the ICES MSY advice rule (i.e. with MSY $B_{trigger}$). Equilibrium relationships between F and (a) recruits, (b) SSB, (c) catch; and (d) the probability of F_{MSY} and SSB<B_{lim}.

7.7.5 Final Eqsim run

The Eqsim software (ICES, 2015) was used to explore S–R relations and define both PA and MSY reference points. An R script was used to read input data and assessment results directly from the required SAM run at assessment.org. The text table below (Table 7.7.5.1) provides the simulation settings and the justification. The number of simulations was set to 1001.

Table 7.7.5.1. Settings for the EqSim runs for wit.27.3a47d.

Data and parameters	Setting	Comments
SSB-recruitment data	Full range of data (1940–2016)	The group did not recognize any specific regime shift in productivity
Mean weights and proportion mature	2009–2016	Eight year average over the time period with data available for weight-at-age
Exploitation pattern	2009–2016	Eight year average to reflect recent fishery pattern. Selectivity was not considered to have changed significantly over this time.
Assessment error in the advisory year. CV of F and SSB	F: 0.212 SSB: 0.000	Default values
Autocorrelation in assessment error of the advisory year, F_{phi}	0.423	Default value

7.7.6 Sensitivity runs

As a sensitivity analysis, a run was conducted excluding the last estimated year of recruitment (2016), based on the assumption that the limited observations of this year class would make its estimate less reliable. However, given the length of the recruitment time-series, removing this one point had very little impact on the stock–recruitment fits (very slightly shifting the proportion of fits away from Ricker towards Beverton and Holt. BH proportions increased from 0.92 to 0.93; Ricker proportions decreased from 0.04 to 0.03). Reference point values were not significantly different (F_{MSY} = 0.151).

A run excluding autocorrelation in recruitment similarly had limited impact on estimated reference points.

7.7.7 Proposed MSY reference points

Final estimated reference points for wit.27.3a47d. Weights in t.

Reference point	Value
F_{MSY} with $B_{trigger}$	0.154
$F_{P.05}$ (5% risk to B_{lim} with $B_{trigger}$)	0.28
MSY $B_{trigger}$	4745
B_{pa}	4745
B_{lim}	3069
F_{pa}	0.21
F_{lim}	0.3

7.8 Future research and data requirements

7.9 References

Berg, C., Nielsen, A., Christensen, K. 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research 151: 91–99.

ICES. 2015. Report of the Joint ICES-MYFISH Workshop to consider the basis for F_{MSY} ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 156 pp.

ICES. 2017. ICES fisheries management reference points for category 1 and 2 stocks. DOI: 10.17895/ices.pub.3036.

Nielsen, A. and C.W. Berg. 2014. Estimation of time-varying selectivity in stock assessments using state–space models. Fisheries Research 158, 96–101.

Pedersen, M.W. and Berg, C.W. 2017. A stochastic surplus production model in continuous time. Fish and Fisheries 18:226–243.

7.10 Data inputs

Table 7.1. Data inputs for SAM and SPiCT models.

	SAM	SPiCT
Catch	Catch-at-age 2009–2016, ages 1–10+	InterCatch landings and discards, 2002–2016
	Total landing weights, 1950–2008	Official landings, 1983–2002
Surveys	IBTS Q1, 2009–2016, ages 1–7	IBTS Q1 biomass index, 1983–2016
	IBTS Q3, 2009–2016, ages 1–6	Combined IBTS Q3 + BTS Q3 biomass index, 1991–2016
	Biomass index, IBTS Q1, 1983–2008	
	Biomass index, IBTS Q3, 1991–2008	
Biological parameters	Mean stock, catch, and landing weights, 2009–2016	
	Proportion mature, 2009–2016	
	Natural mortality, 2009–2016	

7.11 Data input figures

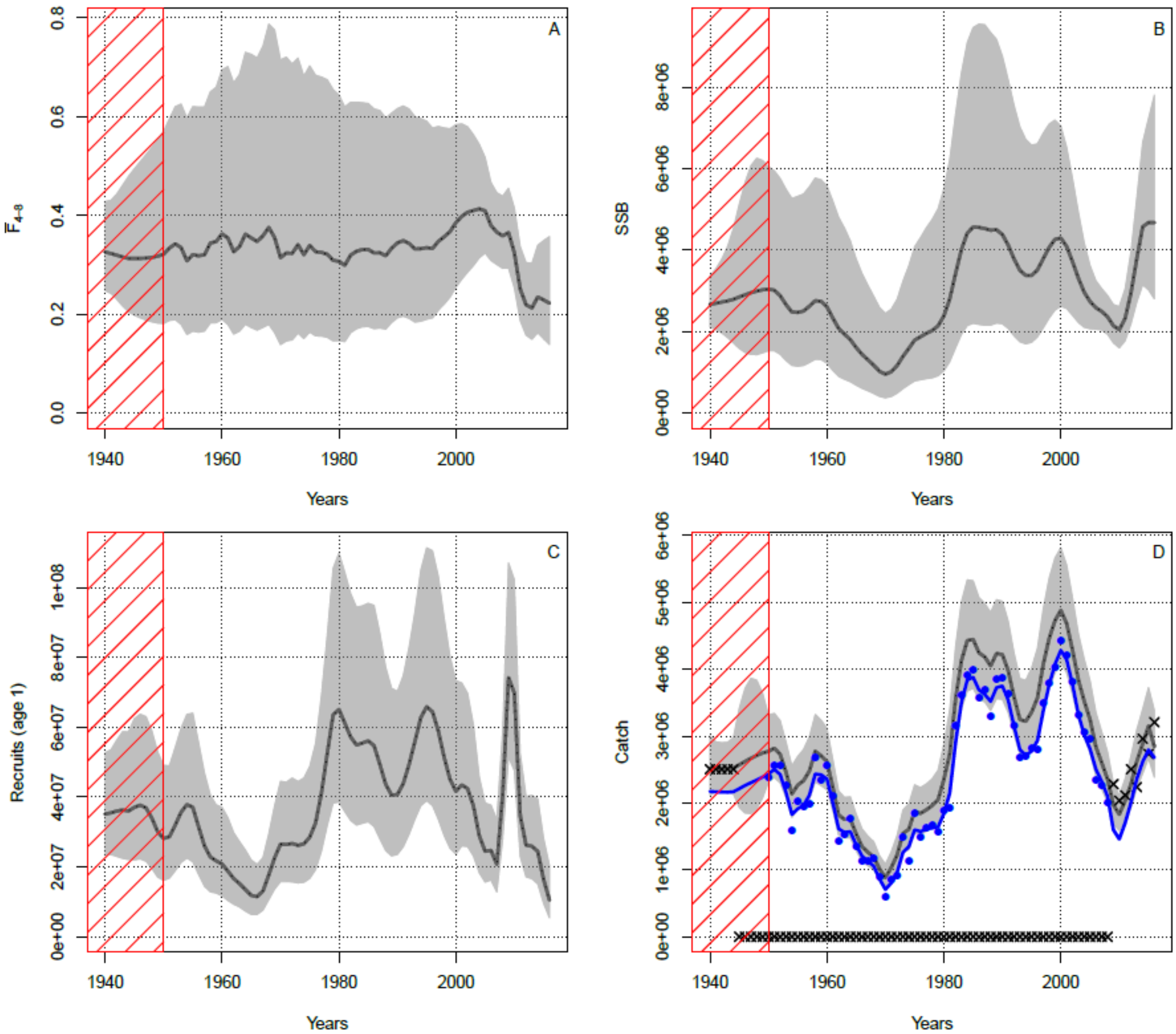

Figure 7.1. Estimates and point wise 95% condence intervals of F_{bar} (A), spawning–stock biomass (B), recruitment (C), and catch weight (D). The area shaded with red lines is the period prior to the observations used for initialization. The blue line and blue points (D) are the predicted and observed total landings.

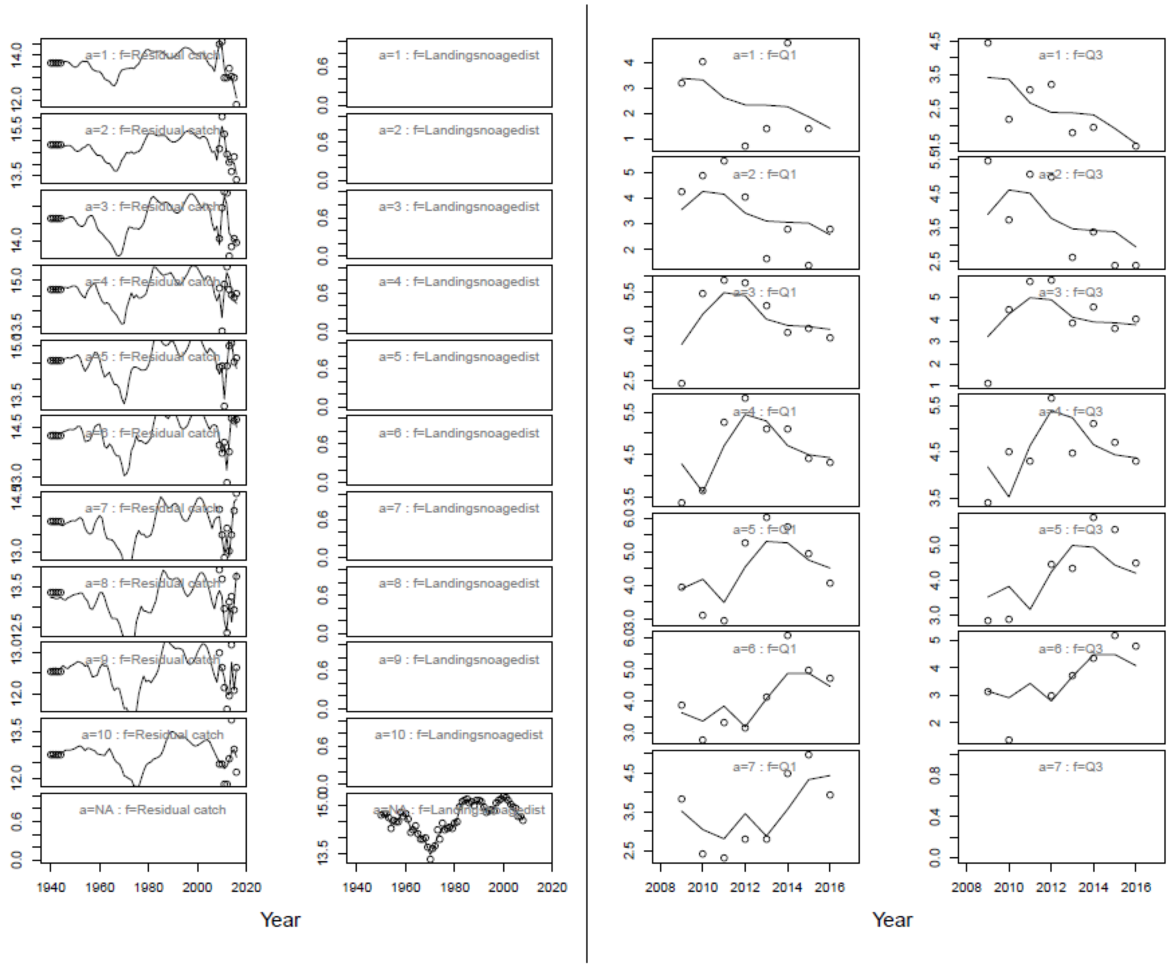

Figure 7.2. Log-scale observations (circles) and fitted values (lines) for each fleet (columns) and age group (rows).

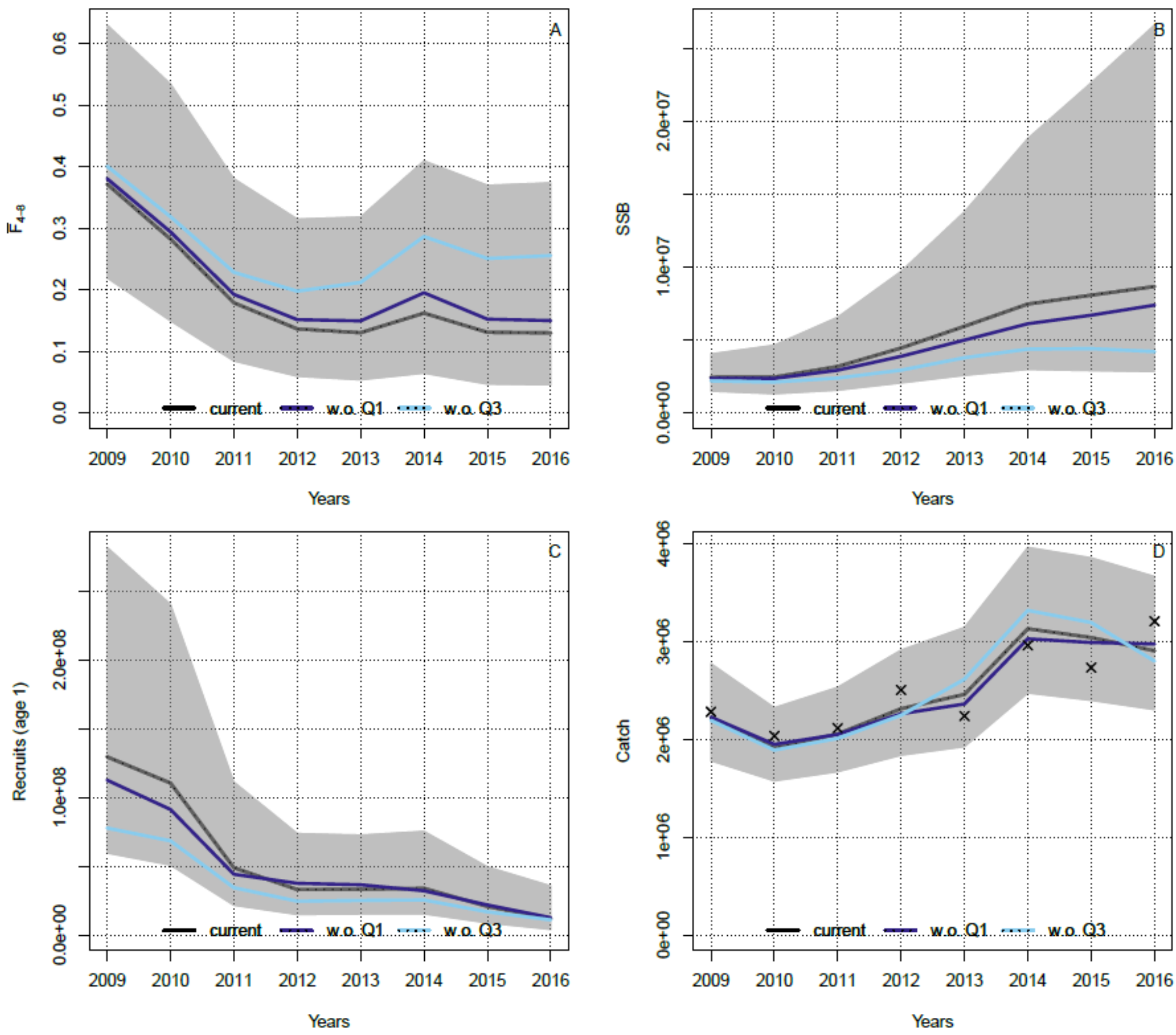

Figure 7.3. Leave out diagnostics for F_{bar} (A), spawning–stock biomass (B), recruitment (C), and catch weight (D).

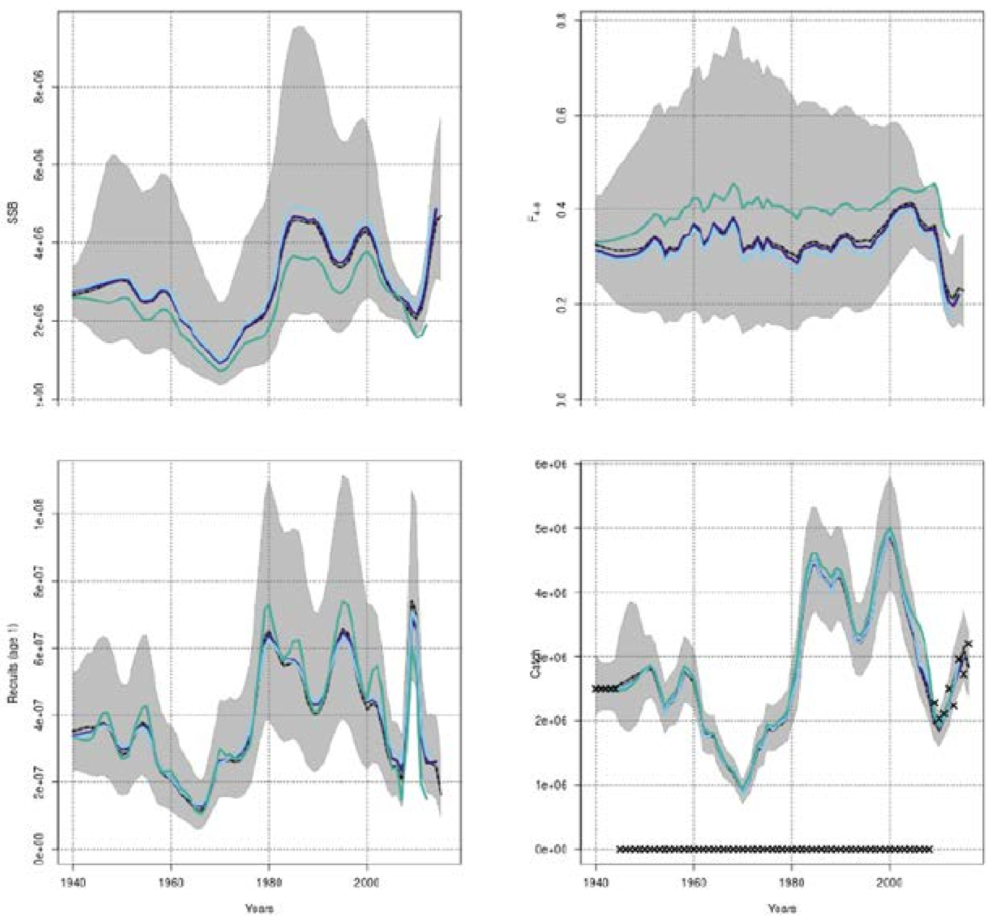

Figure 7.4. Retrospective pattern for the extended model for F_{bar} (A), spawning–stock biomass (B), recruitment (C), and catch weight (D).

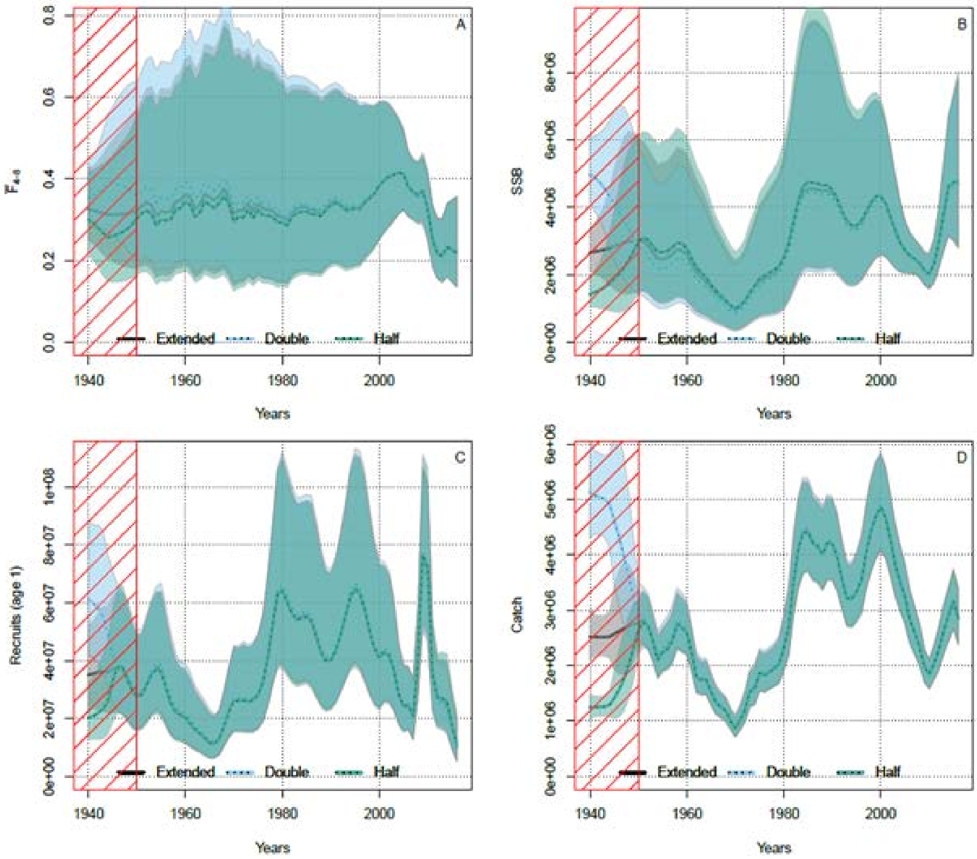

Figure 7.5. Sensitivity to artificial initial catch in 1940–1944. Estimates and pointwise 95% confidence intervals of F_{bar} (A), spawning–stock biomass (B), recruitment (C), and catch weight (D) compared to runs with half and double initial catch. The area shaded with red lines is the period prior to the observations used for initialization.

8 External Reviewers' Report

Beatriz Roel (Chair), Cóilín Minto and Daniel Ricard served as the external reviewers for the WKNSEA benchmark of Flounder (4 and 3.a), Lemon Sole (4 and 3.a), Whiting (4 and 7.d) and Witch (4, 3.a and 7.d).

A data evaluation workshop took place from 6 to 10 November 2017, and catch data, survey indices and data on biological parameters were examined. The external experts did not attend that meeting, but progress made there was presented and discussed during two WebEx meetings that took place in January 2018. Catch data for the period 2002–2016 (available in response to a data call) were revised at the data workshop. However, the assessment models required longer time-series and the approaches taken to reconstruct the historic series were presented and discussed during the Benchmark meeting which was tasked with agreeing and documenting the preferred method to evaluate stock status and, when applicable, short-term forecast and reference points. Tuning series generated using a delta-GAM method (Berg *et al.*, 2014) were presented at the Data Workshop; the methodology was discussed and considered appropriate and more precise than the stratified mean method previously used.

The Benchmark Workshop met from 5 to 9 February 2018 and was attended by the assessment analysts for each stock and the external reviewers. Survey indices, focusing on North Sea International Bottom Trawl Surveys (IBTS) and Bottom Trawl Surveys (BTS) were evaluated for internal and external consistency for all stocks, and the appropriateness of implementing the Berg method, as opposed to the ICES stratified mean method, was investigated. During the course of the meeting additional data explorations and assessment runs were requested by both participants and reviewers, and the responsible scientists responded efficiently to all requests.

The Benchmark meeting was conducted to a high scientific standard, the debate was thorough and constructive and a healthy working atmosphere was enjoyed by all. On a lighter note, meeting endeavours focusing on lemon sole were circulated on the last day in the form of a poem, and the reviewers support the initiative to include this contribution in the Benchmark Report.

Reference points were agreed for witch flounder. Flounder and lemon sole remain as category 3 stocks and no absolute reference points were estimated. Reference points for whiting were not agreed upon during the benchmark meeting, and will be addressed by a separate process reviewed by Cóilín Minto and Daniel Ricard. A review of the issues raised at the Benchmark Workshop is presented by stock in the sections that follow.

8.1 Lemon Sole 27.3a47d

8.1.1 Major issues raised at the benchmark

A working paper was presented at the data workshop summarising the data analyses carried out. Major issues addressed resulted from the examination of the catch data. Catch for the years 2002–2016 were provided by several nations in response to a WKNSEA data call and were collated using the InterCatch system.

Survey length compositions looked much like those for discards and do not match the commercial catch length composition. The problem was examined for particular years that showed the same mismatch. Further, the length composition from the surveys was compared with the total catch, and it showed less of a difference between the two distributions. The possible discrepancy was also investigated running the Survey based assessment model SURBAR for different assumptions of survey selectivity at age. Whereas selectivity scaled the assessment, the trends in biomass were similar, so it would not make a difference to the advice whether the survey missed the larger fish. All in all, the issue was investigated thoroughly and was resolved at the meeting.

Samples from the commercial catch for age determination were sparse and the age data, for discards in particular, were considered insufficient by WKNSEA to support an age-based assessment using commercial catch data.

8.1.2 Input data

8.1.2.1 Biological analysis

Sex ratios (IBTS Q1 and 3) and proportion mature at-age and length (IBTS Q1) for the years 2006–2017 were derived from a subset of the DATRAS database. It appears that neither Q1 nor Q3 pick the main spawning period (May –October). However, maturity was finally based on data from IBTS Q1, resulting in zero at age 1, long-term average at ages 2 and 3, full maturity-at-ages 4 and above, because Q1 is the closest to 1 January, the start of the year in the assessment.

Data from IBTS Q3 were used initially to compute mean weight-at-age or length which (in the absence of better information), could be used as a proxy for weight-at-age in the stock. However, mature fish in Q3 could increase the weight-at-age. The problem with Q1 is that older ages are not that well represented. It was decided to use a linear model including Q1 and Q3 data to estimate weight-at-age. Plots showing the stock weights inferred from Q1 and Q3 IBTS data by loess interpolation were presented and agreed for input to SURBAR.

8.1.2.2 Landings and discards

Incorrect submissions from Belgium resulting in large number of very small fish were investigated. The issue was further investigated by comparing InterCatch landings with the official landings for a few years. It was concluded that the incorrect submissions did not affect the total yield, just the length compositions. Bias in the data from France and the Netherlands was suspected when examining the international landings proportion by country.

It was concluded that for the purpose of discard raising factors, all areas should be treated together because there was no evidence of distinctive stocks in areas 4 and 3.a. Initial exploration showed that the final discard raising was influenced by a small number of métiers with discard ratios greater than 1.5. This cut-off point was discussed and it was agreed that discard ratios >1.5 would not be representative for a high-value fish such as lemon sole, so they were not included in the calculation of discard raising factors. As a second step, discards were raised in all unsampled fleets by a discard rate estimated using all the sampled fleets. The resulting estimates for landings and discards for the years 2002–2016 were presented. A very high discard rate in 2013 needed checking, and we had not seen the results from that review at the time of writing. An increasing discard rate for the period was noted, with no clear explanation given; it is noted that the quota is not restrictive.

8.1.2.3 Survey indices

Three surveys indices, Needle, ICES and Berg, were developed based on IBTS Q1, Q3 and BTS Q3 data. Whereas the first two indices use IBTS Q1 and Q3 only, the Berg index combines IBTS Q3 and BTS using a Delta-GAM model. The indices were compared, with ICES and Berg methods giving similar results. It was decided to consider further testing using survey-based assessment methods to determine which method results in the most robust assessment for advice.

Internal consistency scatterplots were used to compare the GAM method with the ICES for Q1 and Q3. Q1 seemed to perform better than Q3 for GAM, but the ICES index did not perform well in either. It was concluded that the GAM approach was more consistent. The reviewers suggest considering a length-based assessment, but little is known of growth of this species, which would make any length-based assessment difficult.

A problem identified in IBTS was that the length composition looked much like that for discards and did not match the commercial catch length composition. This issue could create problems running SPiCT, which assumes that the survey is assessing the exploitable biomass.

8.1.3 Assessment models

SURBAR

Exploratory runs based on the SURBAR model were presented using GAM and ICES indices for IBTS Q1 and Q3. The GAM index for quarter 3 included the BTS series. Comparison of the estimates of Z, total biomass, SSB and Recruitment showed similar trends in biomass and SSB, but not in recruitment. This could be the result of the inclusion in the GAM index of an additional series, Q3 (BTS), which could reduce uncertainty and result in a different trend. The GAM index performed better. It was requested to run SURBAR with one survey at a time.

Diagnostics. A large number of sensitivity runs were conducted, some standard and others requested by participants. Sensitivity to the reference age, surveys used, lambda smoothing and catchability assumptions were tested, and in each of the 54 runs the stock summary and the deviance were recorded. A base case with both Q1 and Q3 surveys where the GAM method had been applied was defined. The outputs from the scenarios explored were presented clearly and the impact of the changes was easy to grasp. The final run resulted in an increasing trend in biomass in recent years, with 90% confidence intervals becoming narrower from 2013 towards the centre of the time-series. Recruitment was more uncertain and followed a downward trend from 2014. Uncertainty in Z was large and related directly to the strength of the lambda smoothing. The retrospective analysis showed no strong patterns, which was not a surprise given that SURBAR does not need to reconcile survey with catch data.

Conclusions. No good reason was found to depart from the base case; *ad hoc* down-weighting was considered difficult to justify. The results from the sensitivity tests were presented clearly and communication up front of the objectives of the exploration and the overall conclusions at the end facilitated discussion of the main issues.

SPiCT

A number of scenarios were presented, some resulting in no convergence. The model was very dependent on the inclusion of the IBTS Q1 long time-series starting in 1968, which was considered potentially non-representative of the stock given the spatial distribution and implementation of the survey pre-1983. That period provides contrast to the SPiCT model from which it estimates the population growth-rate parameter. A brief investigation on trends for other flatfish stocks showed similar increase during the period, so an increase in catchability related to survey design could not be ruled out over biological increase. Given the steer from the reviewers, a decision was made not to use the SPiCT assessment as the basis for advice for this stock.

8.1.3.1 Short-term forecast and reference points

Being a category 3 stock, a short-term forecast not carried out.

No reference points in terms of absolute values were defined.

8.1.4 Basis for advice

Based on ICES advice guidelines, lemon sole is a data-limited stock (DLS) where the advisory rule is the so-called "2 over 3". The benchmark assessment used SURBAR SSB estimates instead of survey biomass estimates. As there is some indication that recruitment in the most recent years may be lower than previously, using SURBAR forecast in the "2 over 3" could allow taking into account the impact of reduced incoming recruitment in the advice. There were issues with the length data that would need to be resolved at the WGNSSK 2018, but overall a length-based analysis provided an indication that fishing mortality was above F_{MSY} and of truncated length distributions relative to that which would be considered optimal. On that basis, a precautionary buffer or cap (20% additional reduction) for the "2 over 3" rule should be considered.

8.1.5 Recommendations for future work

- Examine the IBTS Q1 data prior to 1983. The exercise should identify any changes in survey design, gear, area covered, data processing, etc. that could have had an impact on lemon sole abundance index;
- Request resubmission of Belgian length data;
- Further investigation of high 2013 discard estimate;
- Incorporate estimation CVs for survey indices into SURBAR;
- Determine reason for large increase (72 to 9000) in the number of Scottish length samples in 2016;
- Consider re-evaluation of length-based indicators;
- Length-based assessment (a long-term goal);
- Consider using the forecast from SURBAR within the "2 over 3" rule.

8.2 Flounder 27.3a4

8.2.1 Major issues raised at the benchmark

Existing uncertainty in the landings data and how to account for it in the surplus production population model, dominated the discussions during the benchmark. The procedures used to raise the discard and landings data, so as to obtain total catch information are difficult because of variable reporting of discard ratios by different countries over the period of the time-series. A large gap without Dutch landings data is present from 1984 to 1997. Approaches to fill this gap were trialled during the Benchmark.

8.2.2 Input data

8.2.2.1 Biological analysis

Length–weight analysis based on the IBTS and BTS data appeared sound. An IBTS first quarter (Q1) maturity ogive over age was presented, but given that the assessment is age aggregated, no age-specific biological parameter data were used further.

8.2.2.2 Landings and discards

As stated above, a major gap in landings data exists for this species for the period 1984–1997. It is due to a lack of reporting from the Dutch fleet that takes a large proportion of the catch. This issue was addressed within the assessment by scenarios using the proportion of Dutch landings to total landings over: 1) the entire period when both were available; 2) pre-1984; and 3) post-1997. A problem with the Danish landings prior to 1998, when changes in regulations led to a mixture of flounder and dab being landed as flounder, was also identified.

Discard ratios were obtained from InterCatch and used to adjust landings data to be used in the population model. As flounder is a low-value species, discards were often of considerable magnitude. Procedures for raising the discards were presented and consisted of using discard ratios from similar métiers from 2011 to 2016; a sensitivity raising procedure showed the raising to be relatively robust in recent years. The procedure was, however, sensitive to situations where high discard ratios were present for some countries (as flounder is predominantly a bycatch species), leading to large increases in landings attributable to high multiplicative factors. After consideration, the average discard ratio from 2002 to 2016 was applied between 1974 and 2001. Overall, the discard raising was deemed appropriate to allow that component of the catch to be used in the aggregated assessment.

8.2.2.3 Survey indices

Several surveys were available practically covering the distribution of flounder (partial as related to seasonal inshore/offshore migrations). Quarter 1 (Q1) and quarter 3 (Q3) indices were computed in order to fit the assessment model. For Q3, multiple indices (including beam trawl, GOV and SNS) were combined using a Delta-GAM method. This included categorical gear and year effects and does not therefore smooth the annual trends but rather accounts for the gear differences in the surveys in addition to spatial overlap. The analysis represents an improvement in approach over one that includes multiple surveys of various geographical coverage in the assessment.

8.2.3 Assessment models

The age-aggregated stochastic Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2016) was selected for the assessment of flounder given that age samples are only available from the Dutch landings from 2009 on and that age determination of discards was sparse.

A greater level of uncertainty was implemented to deal with the problematic missing landings for the period 1984–1997. The large spike in catch estimated for 2010 was probably due to the raising procedure, and it was addressed by replacing some high discard ratios with the discard ratio for 2011, because the landings for the two years were similar.

The most appropriate model run, the run ultimately selected for the provision of advice, used the Q1 index and the Q3 index for dedicated flatfish surveys.

In order to evaluate the effect of including uncertainty in the input data, the model was run under a variety of configurations, including assigning different levels of variance on the catch and indices.

Five initial scenarios were run, using for example only official landings or various assumptions on the Dutch landings during the missing period. Scenario 2 was chosen as the most realistic model run (in terms of parameter estimates) to be subsequently tested for sensitivities. That scenario used the Dutch landings proportion of total landings from 1974 to 1997 to reconstruct Dutch landings for the period 1983–2001 and had the catch time-series truncated to 1983–2016 to start with the first survey year, because the model did not perform well otherwise. Sensitivity testing revealed that the model was generally sensitive to starting values on the shape parameter of the Pella–Tomlinson model. Although a sensitivity fit using only the IBTS Q1 survey had the best performing retrospective patterns, the importance of the Q3 surveys (including dedicated flatfish surveys) led to the decision to also include those surveys within the finally selected model.

As is often the case, absolute biomass or fishing mortality displayed much stronger retrospective patterns than relative biomass or fishing mortality. Retrospectives showed that relative F was typically biased high whereas relative biomass presented minor negative bias. All retrospectives were within the uncertainty of the most recent assessment, which was high. While exhibiting some autocorrelation in the residual patterns, the final model was deemed appropriate to the provision of relative (category 3) advice.

For the flounder stock in areas 4 and 3a, the final model was uncertain, with some minor retrospective bias. However, the diagnostics of the model were comparatively good and the final results from most models showed the same general trend of low relative fishing mortality and high relative biomass. As such the model was deemed acceptable for relative advice.

No short-term forecast was run for flounder given that the assessment is classified as category 3.

8.2.4 Reference points

There is no need for absolute reference points for management advice for flounder. The estimated SPiCT model parameters are only useful for the computation of relative biomass and fishing mortality (B/B_{MSY} and F/F_{MSY}).

8.2.5 Basis for advice

The SPiCT model and the resulting estimates for relative biomass and fishing mortality set flounder as a category 3 stock. The advice is biannual and there is no need for advice for the coming year.

8.2.6 Recommendations for future work

Ensuring that all countries report their landings and discard information to InterCatch is essential to facilitating the update of the stock assessment for flounder. Investigation of the missing Dutch landings from the period 1983–1997 and the change in Danish landings around 1998 are recommended.

8.3 Whiting 27.47d

8.3.1 Major issues raised at the benchmark

Biological data on maturity and weights were revised, and the issue of stock identity reviewed during the benchmark. Landings and discard data were updated, including previously unreported data. The previous XSA model for North Sea whiting displayed strong patterns in residuals and retrospectives, including a negative bias on SSB, positive bias on F and strong negative bias on recruitment. By fitting a stochastic State–Space Model (SAM) that allows for observation error in the catches, the benchmark assessment represents a considerable improvement on the previous assessment, as indicated by the disappearance of patterns in model residuals and retrospectives. The model choice also allowed the assessment to be run farther back in time (avoiding a previous conflict between the surveys and catches) and providing a longer term perspective on the stock. Each of the changes discussed at the benchmark and implemented is reviewed below.

8.3.1.1 Stock identity

Based on tag–recapture, parasite and life-history data, it appears likely that there is a complex of substocks of whiting in the North Sea. Genetic microsatellite data point towards a north/south split. Similar results were found in an analysis of spawning fish. West of the British Isles, data do not seem differentiated from the northern North Sea. Therefore, it appears as if there is a split into north and south in the North Sea, but that the northern North Sea may be more closely related to the west of the British Isles, although it is noted that Holmes *et al.* (2014) split west of Scotland whiting from northern North Sea whiting. Growth and fecundity data also support a north/south split.

Within the assessment literature review, the fact that stock units were mostly identified from the IBTS Q1 data was highlighted. This raises a question as to whether the split remains throughout the whole spawning period, which is protracted over a longer part of the year. Tag–recapture and parasite data support a view that the split may remain throughout the year, but there is a requirement for more spatially and temporally extensive sampling to establish the persistence of the split. The assessment further argues that given the population size and extensive transfer of eggs and larvae between locations, the likely differentiation between the subcomponents is low.

Spatial maps of the survey indices show that age 1+ whiting have a somewhat continuous distribution in the North Sea, whereas there is very clear separation of age 0 whiting in the northern and southern North Sea. This points to separation at spawning but some mixing of older age groups. Given the notable mixing at older ages, a separate assessment would be difficult to justify, although the north/south age 0 indices should be monitored for evidence of differential mortality on either component.

8.3.2 Input data

Natural mortality

Natural mortality estimates for North Sea whiting come from the key 2017 WGSAM run of the Stochastic Multi Species Model (SMS). Natural mortality accounts for a significant proportion of total mortality for whiting of all age groups. Estimates of natural mortality were smoothed to reduce interannual variability, an approach that seems appropriate to capture the main trends in mortality while avoiding large interannual changes. Updated estimates of natural mortality are slightly lower than those from the previous assessment, and reflect changes in the estimation of consumption rates by harbour porpoise, but this may not explain the slight increase for age 0 whiting, which are not preyed on much by that species. Overall, the estimation and treatment of natural mortality appears sound and appropriate to use in the assessment.

Maturity

Previously, the maturity ogive for whiting was assumed constant since the 1980s. In this benchmark, considerable work was carried out to update this assumption. Maturity was analysed separately for north and south, but was combined for the assessment. Separate north and south estimation suggests that there may be a separation at spawning time.

Both components (north and south) showed an earlier age at maturation in relation to the previous maturity ogive, with the effect more evident in the south than in the north, where maturity was more stable over time. The combined maturity ogive was weighted by the yearly average survey cpue value for north and south, reflective of the fact that the size of the components has changed over time (previously dominated by the northern, but recently closer to an even split). This approach appears appropriate to estimate a combined maturity ogive.

Considerable interannual variability of the proportion mature was estimated for ages 1 and 2 whiting. This was smoothed appropriately for use in the assessment model. Overall, the work on maturity represents a considerable improvement for the whiting assessment.

Weight-at-age

Stock weights-at-age were previously computed from catch samples collected through the entire year. Given that the assessment estimates stock numbers on 1 January 1, it was considered inappropriate to use weights from the catches. Simply using IBTS Q1 weights was not appropriate as the IBTS Q1 weights do not extend back in time to the start of the assessment. To address this concern, the catch weights for the entire period were scaled to have the same average weight-at-age as the IBTS Q1 weights for the period of overlap. The Q1-adjusted catch weights were smoothed to reduce interannual variability, but there are issues in that the age 4+ weights-at-age appear oversmoothed. This is because a single smoothness parameter is estimated across all ages. This assumption can be relaxed or the unsmoothed weights-at-age used. The latter option is less preferable to smoothing because there is considerable interannual variability of the older age-group weights (e.g. ages 5–7 whiting were heavier than ages 8+ in 2009). Smoothing may correct this under the assumption that the values reflect sampling variability rather than differential cohort growth that could result in the same phenomenon.

8.3.2.1 Landings and discards

For both landings and discards, InterCatch data were re-raised for the period 2009–2016. For the period prior to that, no discard data were available for the Scottish fleet in the InterCatch dataset. The data pre-2009 are therefore based on previously raised data not updated in the benchmark.

Treatment of landings appears appropriately extracted with suitable age allocation.

There were substantial differences in the updated discards from the previous assessment. The large differences between old discards and new is for age 0 in 2016 and for all ages in 2009. The causes for these changes were, respectively, new submissions from the Danish beam trawl shrimp trawl (TBB_CRU) and a new French submission for otter trawls. The changes were well documented by the assessment scientist, and appropriately reflect the updated data submissions.

8.3.2.2 Survey indices

Survey indices for North Sea whiting were derived from the IBTS Q1 and IBTS Q3 surveys. There is good external consistency between Q1 and Q3 surveys. In addition, there is very good internal consistency between all age groups for both surveys. When split into northern and southern components, the internal consistency of the southern component is considerably reduced, indicating that cohort tracking in the survey is improved by treating the entire region. This lends strength to the argument for an assessment to be made of the regions combined.

8.3.3 Assessment models

SAM

Previous XSA runs had very strong residual patterns, with IBTS Q1 (all ages) typically overestimated by the model (negative residuals) in addition to clear autocorrelated residual patterns for IBTS Q1 age 1. These residual patterns represent a conflict within the model and resulted in previously strong retrospective patterns (SSB and recruitment negatively biased; fishing mortality positively biased). To address those difficulties, a SAM model that allows for both process and observation errors in the catches and surveys, and propagates all uncertainties was developed for the benchmark.

Model configuration settings chosen for the SAM runs were standard and appropriate. Runs that updated with the new catch data mainly resulted in an estimated increase in recruitment (appropriately changed to age 0, because there is good consistency between age 0 and age 1 in IBTS Q3), as would be expected given the updates from the Danish and French InterCatch data. Only recruitment was found to be sensitive to assuming unsmoothed or smoothed estimates of natural mortality. This reflects the fact that the age 0 values display high interannual variability. Assuming smoothed natural mortality is recommended by multispecies experts and will result in more stable advice, so it is an appropriate choice here. Updates of the proportions mature at-age resulted, expectedly, in a change in SSB. Assuming either raw or smoothed maturity did not alter the results appreciably, only decreasing the interannual variability marginally when maturity was smoothed.

Considerable discussion arose during the benchmark on the approach to be followed to compute stock weights-at-age. Two potential solutions were proposed: 1) to use IBTS Q1 corrected catch weights (see above), and 2) to update the SSB timing to midyear. Both scenarios were run during the benchmark. The midyear option assumes that a proportion of natural and fishing mortality take place prior to the point in time when SSB is calculated. Although there is no difficulty running this in SAM, extending the time period over which assumptions on intermediate fishing mortality may be required has potential implications for advice. The impact of such a change should be investigated, and it was not considered appropriate to implement it during this benchmark. The reviewers recommended that a management strategy evaluation (MSE) be carried out to compare the quality of management advice for the stock under 1 January and midyear spawning assumptions in the assessment.

A final requested run excluding survey data prior to 1983 improved residual diagnostics by removing a conflict between the catch and survey indices in the earliest part of the time-series. In addition, pre-1983 IBTS data are commonly not used given changes in survey design. This run was chosen as the final run to carry out complete diagnostics.

Diagnostics (residuals and retrospectives)

Residuals for the final assessment run were overall acceptable. Some autocorrelation of age 0 catch residuals was evident, but this did not result in strong retrospective patterns in recruitment in the most recent years. Some negative retrospective patterns in recruitment were evident for older peels but these were generally within the confidence limits and improved recently. Some year effects were present in the catch residuals (2002–2003 and 2009–2010 ages 5–8+), but retrospectives on fishing mortality were good, indicating an absence of interannual bias in F. Leave-out performance was also good.

Modelling conclusions

Based on good catch and survey residual diagnostics, acceptable retrospective patterns and relatively low uncertainty in the estimates overall, the final assessment run was considered to be of high quality. A category 1 assessment assignment was considered appropriate to North Sea whiting.

8.3.4 Reference points

A first step in reference point estimation is the determination of B_{lim}. In the stock–recruitment relationship, no evidence of impaired recruitment is observed with decreasing SSB. Given the relatively wide range of SSB values observed, a type 5 B_{lim} choice category is appropriate. This results in B_{lim} being set to the lowest observed spawning–stock biomass B_{loss}, an acceptable conclusion although one that may result in a low value of F_{MSY}, given that recruitment is assumed to decrease linearly from that point.

EqSim was used to fit weighted stock–recruitment pairs, which were simulated initially using the assessment sigma values. These were below 0.2, but a run with sigma values set to 0.2 was considered appropriate. Autocorrelation was significant at lag 1 and resulted in a very low F_{MSY} value (0.08). When placed in the context of the stock's high rates of natural mortality, which are time-varying, it was considered that more work was required on the reference points for whiting, which will be conducted in a separate report (submitted as an Annex to this reviewer's report).

8.3.5 Basis for advice

Based on ICES advice guidelines, this stock is category 1 and relies on an age-structured assessment.

8.3.6 Recommendations for future work

An MSE should be used to investigate the implications of a midyear assumption of SSB. Also, there would be value in investigating the time of peak spawning and aligning the estimation of SSB to that date. However, there would then need to be a question as to whether it alters the quality of management advice.

8.4 Witch flounder 27.3a47d

8.4.1 Input data

8.4.1.1 Biological analysis

Age determination of witch flounder is conducted by Sweden and forms the basis of the catch-at-age data for the commercial landings and the survey indices.

Maturity ogives showing the proportion mature-at-age show protracted maturation over a wide range of ages. Such a long period of maturation was investigated further by producing maturity ogives as a function of fish length, and also by looking at growth curves for the stock.

The main source of misidentification of maturity stages is between mature spent and immature, making the interpretation of maturity data difficult. The use of maturity information from surveys conducted in all quarters was preferred over information from Q3 and Q4 only. The lack of 100% proportion mature in the Q3 and Q4 data was deemed inappropriate in the estimation of the maturity ogive, and the inclusion of data from all quarters was selected instead.

8.4.1.2 Landings and discards

Landings information from InterCatch are available for witch flounder since 2002 and provide a basis for the population model. The majority of landings for the stock come from Denmark and Scotland. The quality of the input data depends naturally on the comprehensiveness of the reporting to InterCatch by member states and is deemed appropriate to this stock. Reconstructed landings were available for the period 1983–2001.

Because the species was only recently directly targeted by fishing, the discard information from other fleets is a critical component of the input data. Reported discards from InterCatch and raised discards derived from landings are used to calculate total removals experienced by the stock during prosecution of the fishery.

8.4.1.3 Survey indices

Witch flounder are distributed in deep water and the IBTS Q1 does not cover some of that habitat. The deeper Norwegian Trench in particular is a known habitat for the species and is not sampled by the IBTS. As the species also inhabits waters deeper than the 200 m limit of the survey, it was deemed important to ascertain that the surveyed portion of the stock was representative of the stock as a whole. Comparison between the Skagerrak Deep-water Shrimp Survey and the IBTS showed similar trends. Further, the length distribution of the commercial samples was similar to that of the IBTS samples, so the survey may be regarded as representative of the exploitable stock biomass.

Two indices were considered for fitting the population model. One was the IBTS Q1 survey index and the other a combined IBTS Q3 survey with the International Beam Trawl (BTS) survey. Comparison of the internal consistency of the two indices, as indicated by the correlation of the log-transformed index values for cohorts, showed a better performance of the IBTS Q1 survey index.

Internal consistency correlation coefficients for survey indices computed using two different methods to construct survey indices were compared. Some discrepancies were noted, so the correlation coefficients were recalculated to the satisfaction of the reviewers, and the selection of survey indices based on the ICES stratified mean method as the basis for model fitting was agreed.

Survey indices of exploitable biomass calculated using a delta lognormal model for IBTS Q1 and a combined NS-IBTS Q3 and BTS data were presented at the Benchmark meeting (see Berg, 2018).

8.4.2 Assessment models

Both the Surplus Production in Continuous Time (SPiCT) model and the State–space assessment model (SAM), an age-structured population model, were used to assess witch flounder. SPiCT was run for various data and model configurations, and the diagnostics for the scenario with extended landings time-series and no *n* prior (shape parameter of Pella-Tomlinson) indicated that the model could potentially be used to provide management advice.

Three SAM models were implemented: 1) a standard model that fitted a short time-series starting in 2009, 2) an extended model that was run extending the time-series back in time (landings data from 1950), and 3) an extended model with two new exploitable biomass surveys presented at the Benchmark meeting. Model 1) performed well, but the retrospective runs were difficult to evaluate because of the very short time-series (just eight years). The results of models 2) and 3) show similar trends, but the confidence intervals in the period covered by the two new exploitable biomass surveys were narrower.

Both models provided a similar perception of the stock. All modelling approaches were presented clearly and were considered technically sound by the meeting. SAM, however, makes use of all the data available and would allow estimation of absolute reference points based on an age-based analysis. On that basis, the SAM model 3) was selected as the analytical platform to provide management advice for witch flounder. SPiCT, however, will be run by the assessment WG for comparison.

8.4.2.1 Conclusions from the assessment

Witch flounder in areas 4, 3.a and 7.d is estimated to be above its limit reference point, but caution is warranted in the determination of the TAC because the model indicates a lack of recruitment to the stock for the past 5–10 years. Although spawning–stock biomass is currently in the healthy zone, it is predicted to diminish under any catch scenario because of the collapse in recruitment recorded in recent years.

8.4.3 Reference points

Reference points derived from the spawning–stock biomass and recruitment estimated by the SAM model formed the basis of the estimation of reference points for witch flounder. The software EqSim was used to estimate precautionary and MSY reference points for the species. In discussion, it was agreed to include autocorrelation in recruitment for consistency with the output from the agreed model. The effect of removing the last recruitment estimate was minimal. The final estimate of F_{MSY} was considered appropriate.

8.4.4 Recommendations for future work

Validation of age data by bomb radiocarbon dating would unequivocally improve the reliability of age estimates for witch flounder.

The inclusion of survey information from the deeper Norwegian trench would improve the credibility of the population model, because it would explicitly include the component of the population that is currently assumed to represent a constant proportion of the stock.

Where SPiCT is trialled and does not converge, this should be further investigated by gridding the log-likelihood surface to help discover where the problems might be.

Appendix 1: Review of reference points for North Sea Whiting in area 27.4 and 7.d

Cóilín Minto and Daniel Ricard

Following the benchmark, concerns were raised regarding the estimation of reference points for whiting. A full reference points working document (referred to hereafter as 'WD') was submitted post-meeting and is reviewed here.

B_{lim}

As per ICES guidelines, assuming a type 4 stock–recruitment pattern and setting B_{lim} = B_{loss} (lowest observed spawning–stock biomass) is appropriate to whiting as recruitment does not appear to be impaired at the lowest SSB values observed. Sensitivity runs to reducing B_{lim} showed that as B_{lim} is decreased F_{MSY} increases (as expected, and almost in direct proportion). Given that nothing is known of recruitment dynamics in the reduced B_{lim} regions, it is recommended to keep B_{lim} = B_{loss}., as used in the WD.

B_{pa} and F_{pa}

Given that the standard errors of the terminal SSB and F were less than 0.2 (sigmaSSB = 0.128 and sigmaF = 0.157), these were set according to convention to 0.2 in the calculation of F_{pa} and B_{pa}. This had minimal impact on the estimated F_{MSY} (increased from 0.132 to 0.139). It is interesting and somewhat concerning that F_{MSY} increased with increasing uncertainty but given the minor difference made, the choice to use default settings is acceptable.

MSY $B_{trigger}$

This was calculated according to standard ICES procedures and is appropriate.

F_{MSY} calculation

F_{MSY} was initially estimated without the constraint of a harvest rule based on MSY $B_{trigger}$. This is the unconstrained F_{MSY}. This value was greater than F_{pa} so F_{MSY} was set to F_{pa}. F_{MSY} was subsequently constrained by 5% probability of not going below B_{lim} in accordance with the ICES approach.

Sensitivity runs were conducted to test the effect of changing assumptions on F_{MSY}. These are reviewed below.

Autocorrelation

Significant lag 1 autocorrelation was found in the residuals of the SR fits so was appropriately included in the calculation of F_{MSY}. Autocorrelation results in periods of elevated and depressed non i.i.d recruitments reflective of persistent environmental or other changes.

Average biological parameters

Whether the biological parameters were averaged over 20, ten, or five years had a large influence on F_{MSY}. Given recent changes in weight-at-age and maturity-at-age, using a long time window does not seem appropriate. Similarly using a short time window (five years) may risk ignoring previously observed values. As such, a ten year average accounts for the recent change but also maintains some of the influence of previous values prior to the shift. This approach is acceptable but should in future be tested via appropriately conditioned MSEs.

Time-series of SSB and R

Four different lengths of the SSB and recruitment time-series were also tested, the effect of shortening was to slightly increase the estimated F_{MSY}. It was proposed to use the SSB and recruitment data from 1983 onwards, as this is when the surveys start. In the period 1978–1983, estimates of SSB and recruitment were derived solely from catches. This is the period with low survival rate (R/SSB) driving a low estimate of F_{MSY}. Given that a comparative SURBAR run was not able to recover the very high SSB values prior to 1983, it appears reasonable to restrict the data to 1983 onwards.

Conclusions

A considerable amount of additional work was conducted in the WD to test sensitivity of F_{MSY} to assumptions used in the calculation. F_{MSY} was shown to be highly sensitive to whether the earliest pre-survey years were included in the SSB and recruitment pairs used and also sensitive to the time period over which the biological parameters were averaged. Removing the earliest years from the SSB and recruitment pairs is appropriate given that the high and uncertain SSB values could not be reproduced using surveys only. An intermediate choice of ten years to average the biological parameters also seems practically reasonable to account for recent changes while maintaining previous dynamics as possibilities in the EqSim simulations. As such, the approach proposed to estimate F_{MSY} is acceptable to the reviewers. We broadly recommend that the consequences of such decisions be further explored via appropriately conditioned MSEs in future.

Annex 1: List of participants

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Annex 2: Stock Annexes

The table below provides an overview of the WGNSSK Stock Annexes updated at WKNSEA 2018 (or to be updated at WGNSSK 2018). Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
fle.27.3a4	Flounder (*Platichthys flesus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	March 2013	North Sea flounder
lem.27.3a47d	Lemon sole (*Microstomus kitt*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	February 2018	North Sea lemon sole
wit.27.3a47d	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	March 2013	North Sea witch
whg.27.47d	Whiting (*Merlangius merlangus*) in Subarea 4 and Division 7.d (North Sea and eastern English Channel)	April 2018	North Sea whiting

Annex 3: Data Evaluation

Flounder 27.3a4

Summary of data workshop

Removed from the issue list: literature reviews of M, prey–predator relations, and ecosystem drivers.

Tuning series: delta-GAM method used to generate biomass indices for IBTS Q1 and combined IBTS-BTS-SNS Q3. Biomass indices are generated for the total, landed, and discarded proportion of the stock (generated using a single length–weight relationship). DFS/DFYS will not be used for the assessment model (0-group only), but these data will be further explored as a potential recruitment index.

Raising of discards / InterCatch data: data were uploaded to InterCatch. Development of an effort-based discard index is not possible as the effort data in InterCatch are uncertain (do not match those reported to STEFC). Several scenarios for raising the discards were attempted and discussed, a final raising stratification was chosen.

There were large gaps in sampling coverage for some countries that take a large proportion of the catch. The amount of age information in InterCatch was sparse; length information was slightly more abundant (but could be better for the earlier years). Data will be used for a SPiCT analysis; SAM was not an option due to the paucity of age samples.

Compilation of biological parameters: no additional information was uploaded to ICES accessions for this purpose. Data are available in DATRAS will be investigated for use in developing maturity ogives and stock weights-at-age. The SMS model does not included flatfish and cannot provide an estimate of M.

Assessment method: SPiCT model under development. S6 model - exploratory.

Expected working documents

1) Survey indices tuning series (Holger Haslop, Casper Berg);
2) 2002–2016 catch data - InterCatch (Holger Haslop);
3) Biological parameters: stock weights-at-age, maturity, length–weight relationship (Holger Haslop);
4) SPiCT assessment (Holger Haslop, Casper Berg, Alexandros Kokkalis), S6 - exploratory (Alexandros Kokkalis).

Lemon sole 27.3a47d

Summary of data workshop

InterCatch: data were uploaded to InterCatch. Several scenarios for raising the discards were discussed, a final raising scheme was chosen.

There were large gaps in sampling coverage for some countries that take a large proportion of the catch. The amount of age information in InterCatch was sparse; only Denmark sampled consistently throughout the time period, but only for landings. Effort of Danish catches were explored to determine whether these age samples were representative of all fleets. In the end, it was agreed that the lack of age samples for discards and lack of knowledge of Danish sampling of the landings meant a SAM assessment was not an option.

Length information was uploaded to InterCatch and sampling coverage was better than for age samples. This information will be used in a SPiCT assessment.

Biological parameters: no additional information was uploaded to ICES accessions for this purpose. DATRAS data will be investigated for use in developing maturity ogives and stock weights-at-age. The SMS model does not included flatfish and cannot provide an estimate of M.

Survey data (IBTS and BTS): The delta-GAM approach was explored. Age structure indices were developed for IBTS Q1 (ages 1–5, 2007–2017) and combined IBTS-BTS Q3 (ages 1–10, 2005–2016).

Biomass indices are in the process of being generated for the total, landed proportion, and discarded proportion of the stock from the surveys (longer time-series) for the SPiCT model.

Survey index area for Q1 may need to be trimmed due to paucity of data; the Q1 survey is poor for young fish. DATRAS-generated indices will also be produced by the ICES DataCenter for comparison.

Assessment methods: SURBAR, SPiCT, GeoPop (exploratory only).

Expected working documents

1) 2002–2016 catch data - InterCatch (Coby Needle);

2) Biological parameters: stock weights-at-age, maturity, length–weight relationship (Coby Needle);

3) Survey indices tuning series (Casper Berg, Coby Needle);

4) SPiCT assessment (Casper Berg, Alexandros Kokkalis, Rasmus), SURBAR (Coby Needle), GeoPop (Tanja Buch).

Whiting 27.47d

Summary of data workshop

InterCatch: data were uploaded to InterCatch. Several scenarios for raising the discards were attempted and discussed, a final raising scheme was chosen. A method for stratification of the age allocations was discussed and chosen, based on the age distributions in the different quarters and by the different métiers.

Survey indices: DATRAS-generated indices are already computed for this stock. New indices for the southern and northern stock components were requested for exploration.

Biological parameters: no additional information was uploaded to ICES accessions for this purpose. The latest SMS run will provide new M estimates; expected by December. New maturity ogives for the assessment and potentially for the different stock areas are being explored; preliminary results were discussed.

Assessment method: SAM will be used for the assessment. Preliminary models are set up. SURBAR and XSA with the new data will also be run for comparison.

Expected working documents

1) Stock identity (Tanja Miethe);

2) 2009–2016 catch data - InterCatch (Tanja Miethe);

3) Survey indices tuning series (Tanja Miethe);

4) Biological parameters: stock weights-at-age, maturity, M (Tanja Miethe, Thomas, Peter, WGSAM);

5) SAM assessment (Tanja Miethe, Anders Nielsen), SURBAR (Tanja Miethe), XSA (Tanja Miethe).

Witch flounder 27.3a47d

Summary of data workshop

InterCatch: data were uploaded to InterCatch, which will be used to generate both age- and length-based information. A discard raising procedure and stratification methods for the age and length allocations were agreed. Age information is from a relatively short period, 2009–2016, but the amount of data for both landings and discards was determined to be good enough to run a SAM assessment.

Survey indices: The delta-GAM approach was used to generate survey indices by age from IBTS Q1 (ages 1–7) and IBTS Q3 (ages 1–6) for 2009–2016; no age data exist prior to 2009. No age data for witch existed in the BTS data. DATRAS-generated IBTS Q1 and Q3 indices by age were also requested from the ICES DataCenter for comparison.

Biomass indices are in the process of being generated for the total, mature proportion, landed proportion, and discarded proportion of the stock from the surveys (longer time-series). A combined BTS-IBTS Q3 index is also being investigated.

Witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys. The use of the IMR deep-water shrimp survey (held in national database) was mentioned as a potential future data source, but will not be explored for this benchmark.

Biological parameters: no additional information was uploaded to ICES accessions for this purpose. Data are available in DATRAS will be investigated for use in developing maturity ogives and stock weights-at-age. The SMS model does not included flatfish and cannot provide an estimate of M.

Assessment methods: SAM, SPiCT. Preliminary models were developed. A SAM model using a longer series of landings data (no age information) was also explored and will be further developed.

Expected working documents

1) 2002–2016 catch data - InterCatch (Francesca Vitale);

2) Survey indices tuning series (Francesca Vitale, Casper Berg);

3) Biological parameters: stock weights-at-age, maturity, length–weight relationship (Francesca Vitale);

4) SAM assessment (Anders Nielsen, Rasmus Nielsen), SPiCT assessment (Rasmus Nielsen, Alexandros Kokkalis).

Annex 4: WKNSEA 2018 issue lists

Lemon sole Issue list

Data needed

- Catch (landings and discards) data, for as many years and countries as possible. Yield, ages and lengths should all be sought. We note here that historical catch data to this level of detail may be difficult to find.
- Effort data by single métiers as potential additional source of information to estimate the amount of discards where no sufficient information from sampling programs is available.
- Available IBTS and BTS survey data on lemon sole.
- Available biological data from scientific surveys and sampling programs of the commercial fleets (length distributions, age distributions, spatial distributions, weight, maturity, sex ratios).

Current assessment issues

Currently lemon sole is treated as a data-limited species and the stock perception is derived from simple survey trends and catch data, along with the application of a surplus production model to evaluate stock status against proxy reference points. For the current assessment method, the IBTS-Q1 index (mature biomass in kg per hour) is used as basis for the trend-based analysis (DLS 3.2. method). The IBTS surveys appear to cover the stock distribution well, but may not provide representative indices as the GOV gear is not optimized for flatfish sampling. The available beam trawl surveys could provide a more representative index in terms of catchability, but may not cover the full stock distribution. Survey data need to be analysed to see if these issues can be circumvented. Further, it was often argued within the WGNSSK that the indices used for the DLS 3.2 method do not come with uncertainty estimates and that these estimates should be calculated. The generation of appropriate survey time-series (biomass, length-based, and potentially age-based) should be a key task for the benchmark.

For commercial catches to be used in assessments, discards need to be quantified for lemon sole. Data are available to do this for 2013–2016, but more discard data sampled under the DCF should be available and should be uploaded into the InterCatch data portal by all relevant institutes. In general, additional data from commercial catches should be sought, covering more years and countries, and including yield, lengths and ages (it is recognized, however, that such historical data may be difficult to find and collate).

Although lemon sole is treated as a data-limited stock, many data exist which are not utilized today. The available surveys can provide biological data for a number of years (including lengths, ages, maturity, weights and spatial location), and national catch-sampling programmes may be able to provide further valuable information. Age-based stock abundance indices can be generated from survey data, and could be used as the basis for survey-based assessment methods such as SURBAR. The distribution of age samples would need to be evaluated first, to ensure that they cover the likely stock distribution. If age–length keys can be generated for commercial data, then further work could explore the possibility of an age-based assessment model such as SAM. Concurrent developments in spatial length-based assessment methods (in Denmark and Scotland) could also be used to indicate stock trends in the absence of age estimates, and a variety of data-limited assessment methods could be explored as exploratory analyses.

WGNSSK (2017) proposed exploratory MSY proxy reference points. The benchmark should explore if these are appropriate, or if the use of alternative indicators would be preferred.

The key first task of the benchmark will be to determine whether or not sufficient historical data exist to warrant a move towards a full analytic assessment, and to evaluate whether management of the stock on this basis would improve the efficacy of decision-making over the existing data-limited approach.

Workplan

Compilation of catch data in InterCatch format (years to be confirmed): all national institutes; prior to the benchmark.

Compilation of survey data (IBTS and BTS): probably via DATRAS, although would also need to check that biological information for lemon sole has been uploaded. Scotland in collaboration with contributing institutes; prior to the benchmark.

Evaluation of survey indices: Scotland; prior to the benchmark.

Compilation of input data for age- and length-based (and potentially spatial) assessment models: relevant counties; prior to the benchmark.

Exploratory assessment runs: Scotland; during the benchmark.

Other working groups to be involved

WGBEAM, IBTS-WG (age-based indices, index uncertainty estimate, combination of IBTS and BTS indices).

Stock	lem-nsea	
Stock coordinator	Name: Coby Needle	E-mail: needlec@marlab.ac.uk
Stock assessor	Name: Coby Needle	E-mail: needlec@marlab.ac.uk
Data contact	Name: Coby Needle	E-mail: needlec@marlab.ac.uk

Flounder Issue list

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified[1]	Additional M - predator relations	Literature review		
	Prey relations	Literature review		
	Ecosystem drivers	Literature review		
	Other ecosystem parameters that may need to be explored?	Literature review		
Tuning series	Currently a mature biomass index is used as the basis for the advice. Methodology to estimate the mature biomass should be revised. Alternative survey time-series (e.g. SNS, DFS, DYFS) could possibly be used to inform the stock status of flounder, which is a more coastal related fish species. A meaningful abundance index for flounder could be used either to improve the DLS method used or to be used as input into a SPiCT model. Some of these data are not available via the DATRAS system at the moment.	Survey data of DFS, SNS, DYFS (GER, NED, BEL, UK) to be quality checked and uploaded into DATRAS. This is partly already done or work is in progress for the DFS, SNS and BEL/GER DYFS but should be extended to earlier years.		Ingeborg DeBoois (Survey Expert, IMARES), Loes Bolle (Survey Expert).
Discards	Inter Catch data only available for 2012–	National Institutes to	Information on landings and	Chun Chen, Ruben Verkempynck

[1] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
	2016. Time-series should be extended with available data. Assess the possible impact of the shrimper fleet on the flounder stock (TBB_CRU_16-32_0_0_all). A lot of fleets in InterCatch report Zero-Landings for flounder. It is therefore not possible to raise any discards for these fleets. This could have quite some impact on the estimation of total catch. Develop a method based on e.g. effort to raise discards?	upload data into InterCatch (UK SCO, UK ENG, FRA, NDL, BEL, DNK, GER, SWE). Development of effort based discard time-series or/and exploration of the alternative datasets (e.g. STECF discard estimates).	discards per fleet (InterCatch). Effort data per fleet.	(IMARES, data experts)
Biological Parameters	Biological data are scarce for flounder. Compilation of all available data is needed.	National Institutes to provide data if these are not already available (UK SCO, UK ENG, FRA, NDL, BEL, DNK, GER, SWE).		
Assessment method	Set up of SPiCT assessment; Length-based methods with extended time-series from commercial catch sampling (Then model taking into account effort and recruitment, e.g. same methodology as was used for dab benchmark).			Casper Berg or Alex K. (DTU AQUA, assessment/statistics) to assist with set up a final SPiCT model

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Reference Points				

Stock	fle.4.3a	
Stock coordinator	Name: Holger Haslob	E-mail:holger.haslob@thuenen.de
Stock assessor	Name:	E-mail:

Whiting Issue list

Data needed

- Historical catch (landings, discards, IBC) data (BEL, DNK, FR, GER, NDL, NOR, SWE, UK ENG, UK SCO). Numbers and weights-at-age back to per catch components from 1990 onwards for the combined areas 27.4 and 27.7d.
- Biological data available from commercial sampling and IBTS surveys (including (maturity, length distributions, age distributions, individual weights, sex ratios)
- Natural mortality estimates from the most recent key run from SMS multi-species model (WGSAM)
- IBTS survey data (from 1990 onwards)

Current assessment and forecast

1) Currently, assessment is done using a FLXSA, assuming catches to be exact. For comparison, a SURBAR analysis is run using IBTS survey indices quarter 1 and 3. Alternative assessment model should be explored, i.e. SAM, taking into account uncertainty and variability of catches.

2) According to the stock annex, the maturity ogive is based on North Sea IBTS quarter 1 data, averaged over the period 1981–1985. The calculation was carried out at some point during the mid-to-late 1980s. There was no information available to WKROUND to allow a determination of whether the estimates are based on combined sex or females only, and exactly how the calculation was done. Recent biological data should be used to check whether used values for the maturity ogive are still appropriate.

3) The short-term forecast inputs should be checked whether they are still appropriate. The weight-at-age are taken from the final historical year while exploitation rates are taken as an average of the recent three years. The settings will be checked.

Proposed analysis

1) An update of the assessment model is suggested. Available models include SAM. This would address issues with variability of catches, and catchability changes. An exploratory run has been set up. The exploratory run showed a generally similar fit to XSA results. In more recent years, estimates of fishing mortality diverge somewhat. Further, sensitivity analysis for settings and correlation between ages will be considered to improve the fit (led by Anders Nielsen).

2) Maturity values at-age used in the XSA originate in analysis from the 1980s. A check is suggested whether an update of the used values is necessary. National catch sampling and survey data can provide this information. An analysis of probabilistic maturation reaction norms by Marty *et al.*, 2014 analysing whiting maturity data for 1975–2005 indicate a reduction A50 over time. Further analysis including recent data will be done and compared to previous study and data currently used in the assessment (led by Peter Wright).

3) Within the framework of a benchmark the choice of input data into a short-term forecast will be reviewed (individual weights-at-age, recruitment estimates, fishing mortality-at-age estimates). In particular, the assumption of using only the final historical year's data of mean weights-at-age for the short-term forecast will be reviewed. While there has been an increase in mean weights-at-age over the last decade, taking an average of the most recent three years may be required due to variability of mean weights for older ages in recent years (led by Tanja Miethe).

Workplan

Data compilation workshop in autumn

- Compilation of historical time-series catch data by catch components (Landings, Discards and IBC, BMS).
- Compilation of IBTS survey data including biological information, maturity data (autumn 2017) (WG to be involved: IBTS WG, WGBIOP).
- New natural mortality estimates from WGSAM recent SMS key run (autumn 2017).

Exploratory assessment runs, refine settings of SAM model (autumn 2017).

Analysis of maturity data for an update maturity ogive for assessment input (winter 2017).

Evaluation of new natural mortality estimates.

Exploration of short-term forecast settings (winter 2017).

Witch flounder Issue list

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified[2]	Additional M - predator relations	None		
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			
Tuning series by age	IBTS Q1 and Q3, BTS Q1 and Q3	The series are available	DATRAS	
Discards by age	Partially available on Intercatch only for Sweden, Netherland and Denmark in 2013	MS to submit discards information for the rest of the time-series	Estimation of discards by country and by area via InterCatch	
Biological Parameters survey by age	MO, WAA, NM	The series are available and need to be updated. Ongoing maturity studies.	SLU AQUA will collate and update the biological data	Barbara Bland, SLU AQUA
Biological Parameters catches by age		MS to submit landings information (number-at-age and weight-at-age) for the entire time-series	SLU AQUA will collate and compile the biological data	Barbara Bland, SLU AQUA
Assessment method	SpICT, SAM	The work will conducted during the benchmark	The work will conducted during the benchmark.	

[2] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Reference Points	MSY library	It will be fitted after the assessment is ready	Final assessment model	To be conduted after the benchmark

Stock	wit.27.3a47d	
Stock coordinator	Name: Francesca Vitale	E-mail: francesca.vitale@slu.se
Stock assessor	Name: Rasmus Nielsen	E-mail: rn@aqua.dtu.dk
Data contact	Name:	E-mail:

Annex 5: Flounder working documents

In the following pages, the flounder working documents available at WKNSEA 2018 are inserted.

WD 1 Flounder 3a4_Indices_DRAFT.docx	26/01/2018 14:41	Microsoft Word D...	4,198 KB
WD 2 Flounder 3a4 - InterCatch_raisin...	05/02/2018 16:51	Microsoft Word D...	1,660 KB
WD 4 SPiCT fle3a4.docx	31/03/2018 16:50	Microsoft Word D...	975 KB
WD3 Biological parameters flounder.d...	26/01/2018 14:42	Microsoft Word D...	1,095 KB

WD 1 Flounder 27.3a4 - Survey indices

Introduction

Flounder (*Platichthys flesus*) in Subarea 4 and Division 3.a was assessed until 2013 in the Working Group on Assessment of New MoU Species (WGNEW ICES, 2013a). Because only official landings and survey data were available for this stock, flounder was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Since 2014 the North Sea flounder stock is assessed by the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK ICES, 2014) and the previous assessment of flounder was based on survey trends.

A number of scientific ground fish surveys are conducted in the North Sea which could potentially be useful for providing stock indices for flounder (*Platichthys flesus*) in area 4 and 3a.

The International Bottom Trawl Survey (Quarter 1 and Quarter 3) and the different Beam Trawl Surveys (Quarter 3 inshore and offshore surveys; ICES 2017) catching flounder. However, since flounder is not a target species in the fishery and is of only limited commercial value it has never been a target species on these surveys with respect to collecting biological data such as age, individual weight or maturity. Further, flounder is a more coastal species spending part of its life cycle in brakish waters and river estuaries and is thus only caught in quite low numbers by the off shore surveys. Beside the IBTS and BTS the coastal near Dutch Sole Net Survey (SNS) and the Demersal Young Fish Surveys (DFS and DYFS) might provide useful data on flounder abundance and distribution. However, the inshore beam trawl survey data are only partly available via the DATRAS trawl survey data base in a standard format which hampered the straightforward analysis of these data so far.

The WGNEW agreed on using a mature biomass index from the International Bottom Trawl Survey in quarter 1 (IBTS Q1) because this survey covers the whole distribution area of the stock and shows a higher catchability compared to the beam trawl surveys. However, the IBTS Q1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. The Beam Trawl Surveys (BTS) use a beam trawl, but they are carried out in quarter 3, in a time of year in which flounder is usually distributed in more coastal, shallow and brackish waters. Therefore, it was decided by WGNEW to use the IBTS Q1 to analyze survey trends for this species. This biomass index was updated during the last WGNSSK meeting in 2017 (ICES, 2017). It was based on a weight-length relationship and few maturity data available from the IBTS DATRAS data base (Figure 1). Round fish area 1 and 2 were excluded from the index area because of the coastal distribution of flounder. The index was then calculated as mature biomass (kg/h) using the stratified mean method with ICES statistical rectangles as strata.

Total catch in numbers, total catch in weight and length measurements for most of the surveys were recorded and are partly available via the DATRAS data portal (Table 1). Age readings, individual weights, and maturity data were only collected sporadically for flounder on the aforementioned surveys and the amount of data is not sufficient to develop any age based survey indices (see working document WD3 for available biological data).

Ideally one would have one standardized survey covering the whole distribution area of the stock and providing all data. Since this is obviously not the case different options were tested to make best use of the different data sources available: (1) compare abundance or biomass indices obtained by the different surveys, (2) if possible combine different surveys to estimate one abundance or biomass index covering most of the distribution range of flounder.

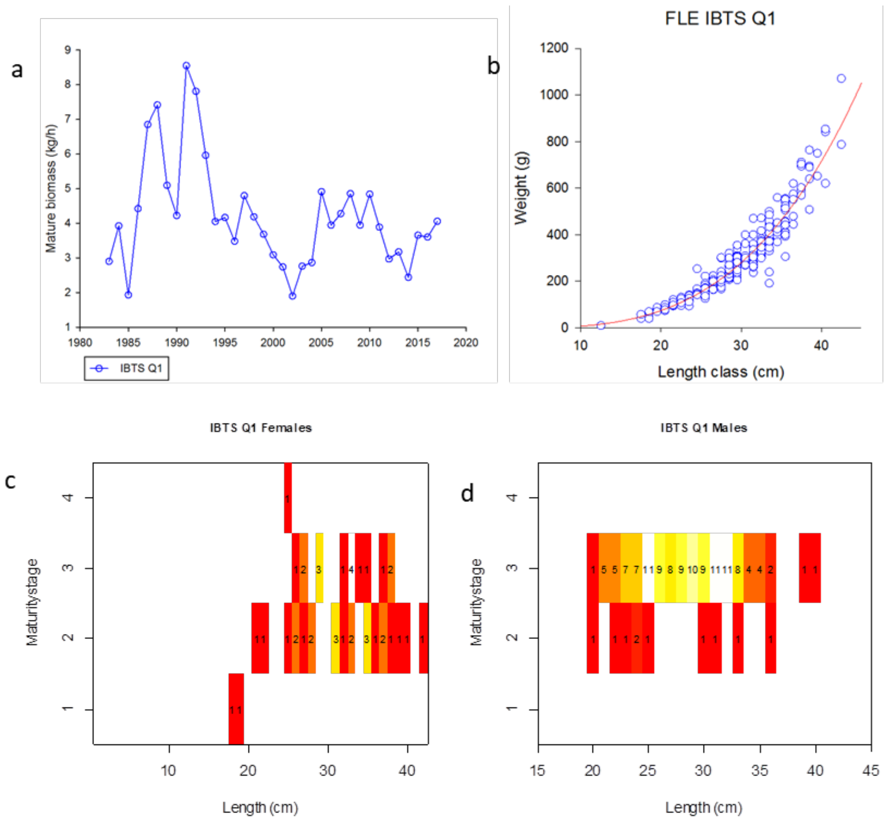

Figure 1

Figure 1 Flounder in Subarea 4 and Division 3a. Mature biomass index for flounder (fle 27.3a4) as used previously in the assessment (a), length-weight relationship from IBTS Q1 data (b), female maturity (c) and male maturity (d).

Material & Methods

All available survey data where downloaded from the DATRAS trawl survey data base (Annex Table 2). In addition data from the Dutch Sole Net Survey (SNS) where analyzed which were provided as data files by the Dutch institute. The haul distribution for each survey was plotted by year in order to display the general distribution and abundance of flounder in area 4 and 3a as obtained by the survey hauls (see Annex). While for quarter 1 only data from the NS-IBTS Q1 were available, for quarter 3 all data from the suitable surveys were combined. For both indices the deltaGAM method (Berg et al., 2014) was applied.

Index area

Flounder is a coastal species which is clearly reflected by the distribution of flounder survey catches (Figure 2 and Figure 3). For quarter 1 only data from the International Bottom Trawl using the GOV trawl are available (Figure 2). The vast majority of flounder catches in quarter 1 is distributed along the south eastern coast and in the Kattegat (area 3a.21). For quarter 3 different beam trawl survey data (BTS and SNS) and data from the IBTS Q3 are available (Figure 3). The catch distribution of flounder is very similar compared to the IBTS Q1 data. The flounder abundance in the Kattegat area seems not that high in quarter 3 compared to quarter 1. Because of the similar distribution, for both quarters the same index area was defined excluding all hauls north west of the displayed blue line (south western point λ=53.600, φ=001.733; north eastern point λ=57.329, φ=005.378) where only very few flounder were caught.

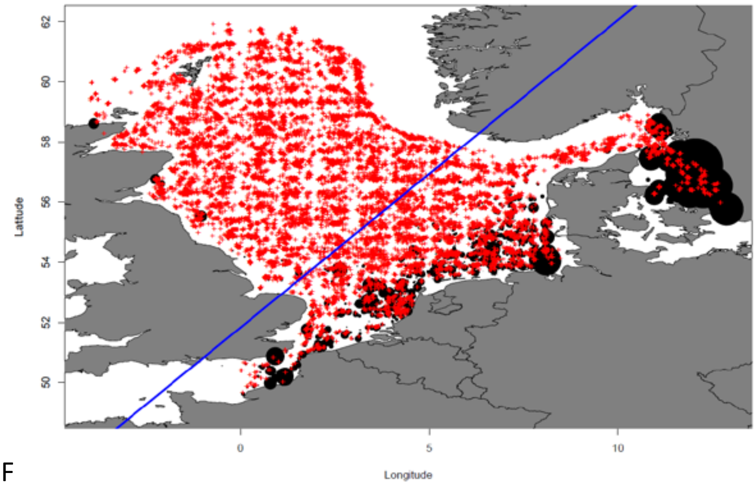

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Figure 2 Flounder in Subarea 4 and Division 3a. IBTS quarter 1 hauls (1983-2016). Red crosses display hauls with zero flounder caught, black bubbles display flounder catches.

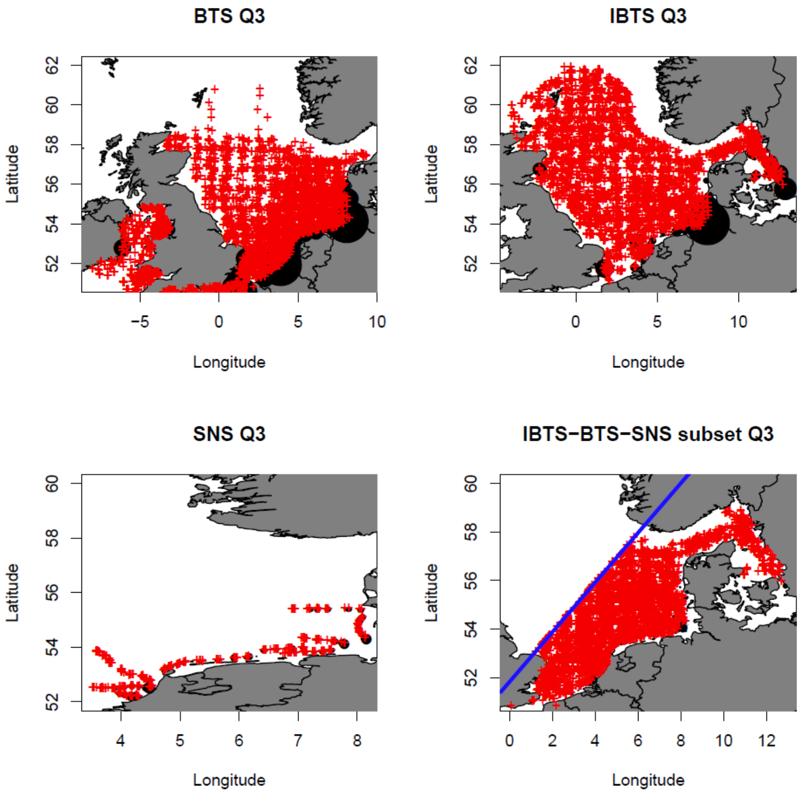


Figure 3 Flounder in Subarea 4 and Division 3a. Survey area BTS, IBTS, and SNS (Quarter 3, all available years). Lower right panel displays the index area subset for combined index calculation.

DeltaGAM model survey indices

Due to insufficient age data from the surveys it was not possible to create an age based index. Thus the indices were based on the catch weight per haul applying a general length weight relationship to the length distribution data by haul.

In quarter 1 more than 70% of the IBTS flounder catches were taken in the Kattegat (3a.21). Thus a comparison between indices without the Kattegat, only the Kattegat and the whole survey area was conducted (Figure 4). The results show that overall the trend is very similar between the Kattegat and the North Sea and no further weighting was applied to the data. In quarter 3 four gear types were used in the different beam trawl surveys (BT8, BT7, BT6, and BT4) and the GOV in the IBTS survey (Table 1). Therefore, a gear effect was included to model a combined quarter 3 index for flounder.

The following models where formulated:

Quarter 1 – NS-IBTS (GOV)

$$g(\mu_i) = Year(i) + f_1(lon_i + lat_i) + f_2(depth_i) + \log(HaulDur_i)$$

Quarter 3 – with gear effect including BTS (BT4, BT6, BT7, and BT8) and NS-IBTS (GOV)

$$g(\mu_i) = Year(i) + Gear(i) + f_1(lon_i + lat_i) + f_2(depth_i) + log(HaulDur_i)$$

The NS-IBTS Q1 index obtained by the deltaGAM method shows somewhat higher abundances between 1987 and 1992. After this period the index drops until 2002 and is fluctuating since then without any clear trend (Figure 5, upper left panel). The new NS-IBTS Q1 index follows quite well an index using the stratified mean method with ICES statistical rectangles as strata (displayed by the red circles in the same panel). In a first step one index for each available quarter 3 survey was estimated and the indices were compared (Figure 6). Especially the NS-IBTS Q3 and BTS show similar trends and also the SNS shows quite a good accordance for most of the available years. The combined quarter 3 index fluctuates without a clear trend since the start of the time series (Figure 7). However, from 2004 until 2014 the index values are above the long term mean, while the index values for the last three years fell below the long term mean again.

Table 1 Flounder in Subarea 4 and Division 3a. Number of hauls by gear and year BTS and NS-IBTS Q3.

Year	BT8	BT4A	BT7	GOV	BT6
1987	64	0	0	0	0
1988	70	0	0	0	0
1989	82	0	0	0	0
1990	94	14	0	0	0
1991	98	16	0	148	0
1992	96	4	0	224	0
1993	100	5	0	231	0
1994	91	7	0	203	0
1995	87	21	0	140	0
1996	103	22	0	196	0
1997	100	19	0	107	0
1998	89	19	54	120	0
1999	112	17	55	152	0
2000	113	16	0	110	0
2001	95	16	54	149	0
2002	109	15	40	140	50
2003	113	20	39	141	0
2004	115	50	50	142	46
2005	119	12	45	143	51
2006	105	20	0	145	51
2007	107	35	44	136	42
2008	96	20	41	148	51
2009	102	29	53	135	51
2010	76	78	50	129	50
2011	84	61	52	135	43
2012	113	65	50	130	49
2013	98	66	60	122	49
2014	76	68	30	132	51
2015	107	67	60	140	51
2016	111	63	60	149	51
2017	96	48	60	137	0

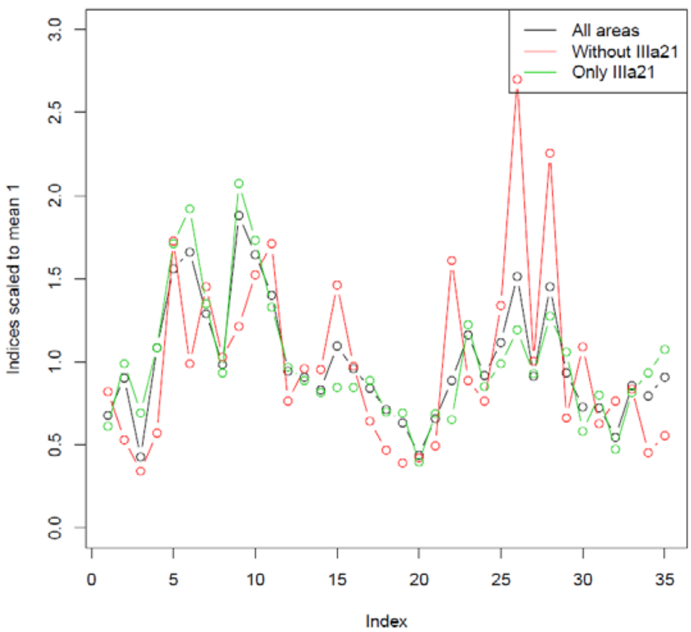


Figure 4 Flounder in Subarea 4 and Division 3a. Comparing IBTS Q1 indices: red line without Kattegat (3a.21), green line only Kattegat and black line whole survey area.

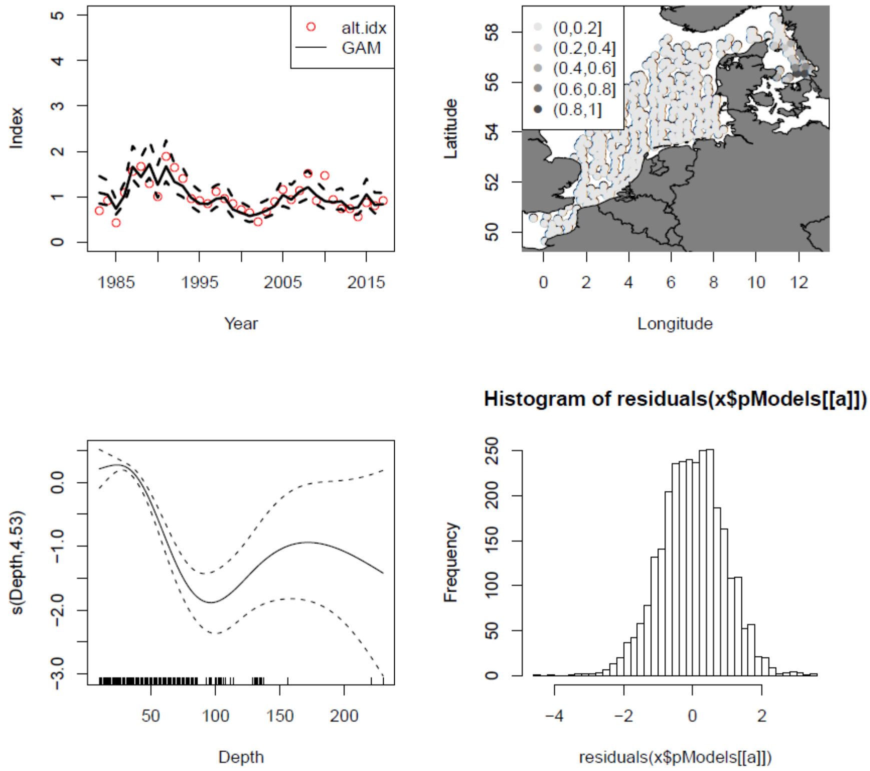


Figure 5 Flounder in Subarea 4 and Division 3a. IBTS Quarter 1 deltaGAM index (top left panel). Distribution of flounder catches within the index area (top right panel). Estimated depth effect (lower left panel). Histogram of residuals (lower right panel).

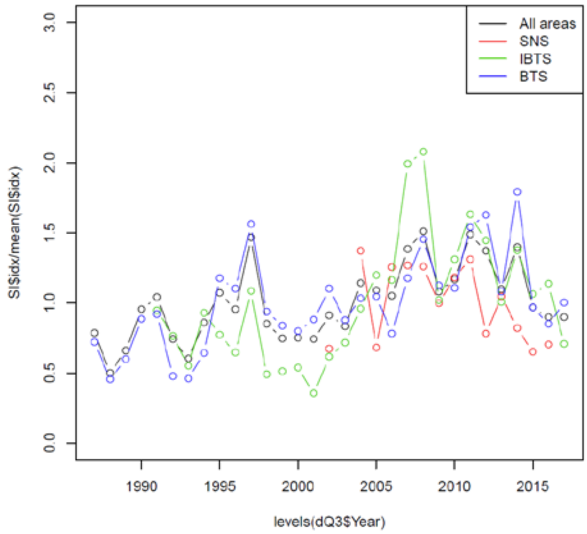


Figure 6 Flounder in Subarea 4 and Division 3a. Comparison of different quarter 3 survey indices obtained by the deltaGAM method. “All areas” = combined index taking into account SNS, IBTS and BTS quarter 3 data.

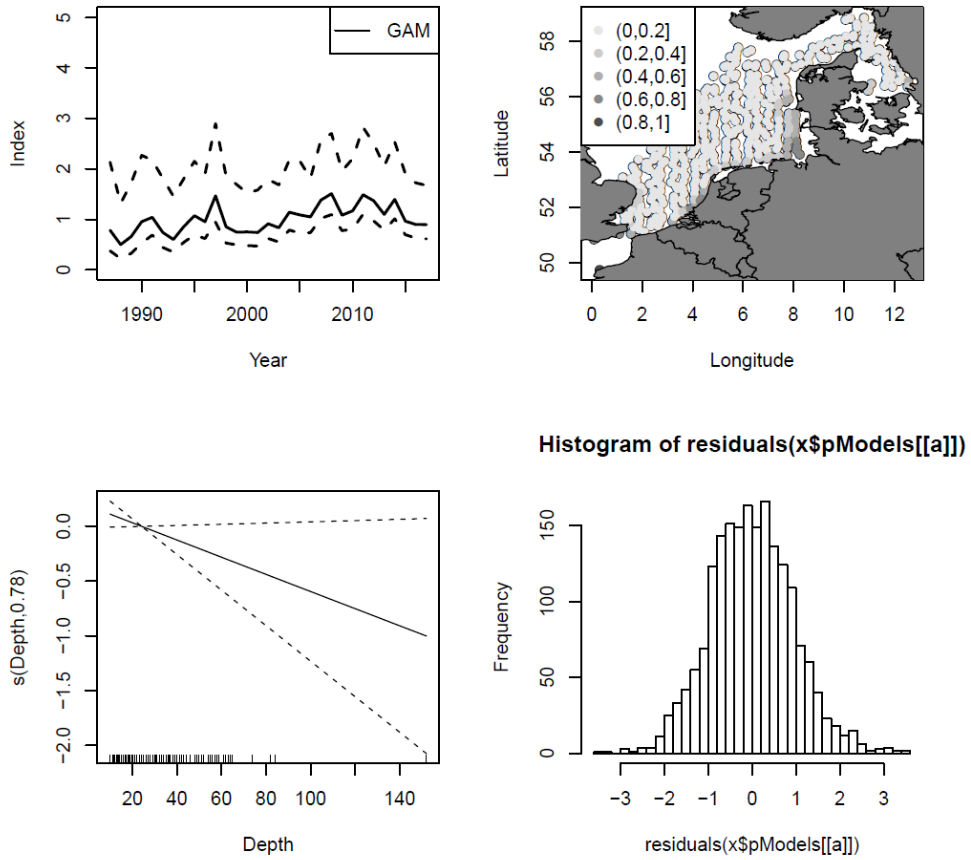


Figure 7 Flounder in Subarea 4 and Division 3a. Combined quarter 3 deltaGAM index (top left panel). Distribution of flounder catches within the index area (top right panel). Estimated depth effect (lower left panel). Histogram of residuals (lower right panel).

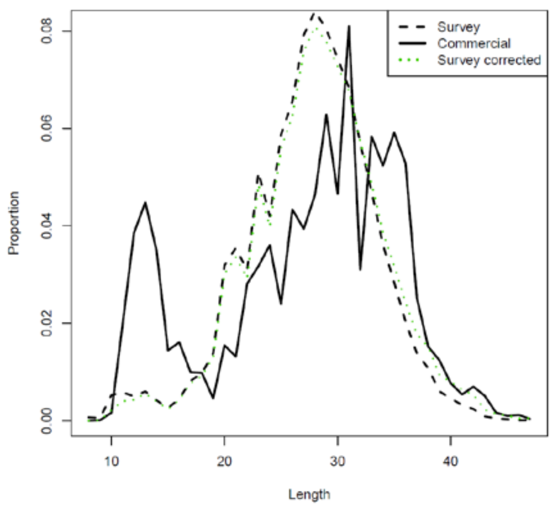
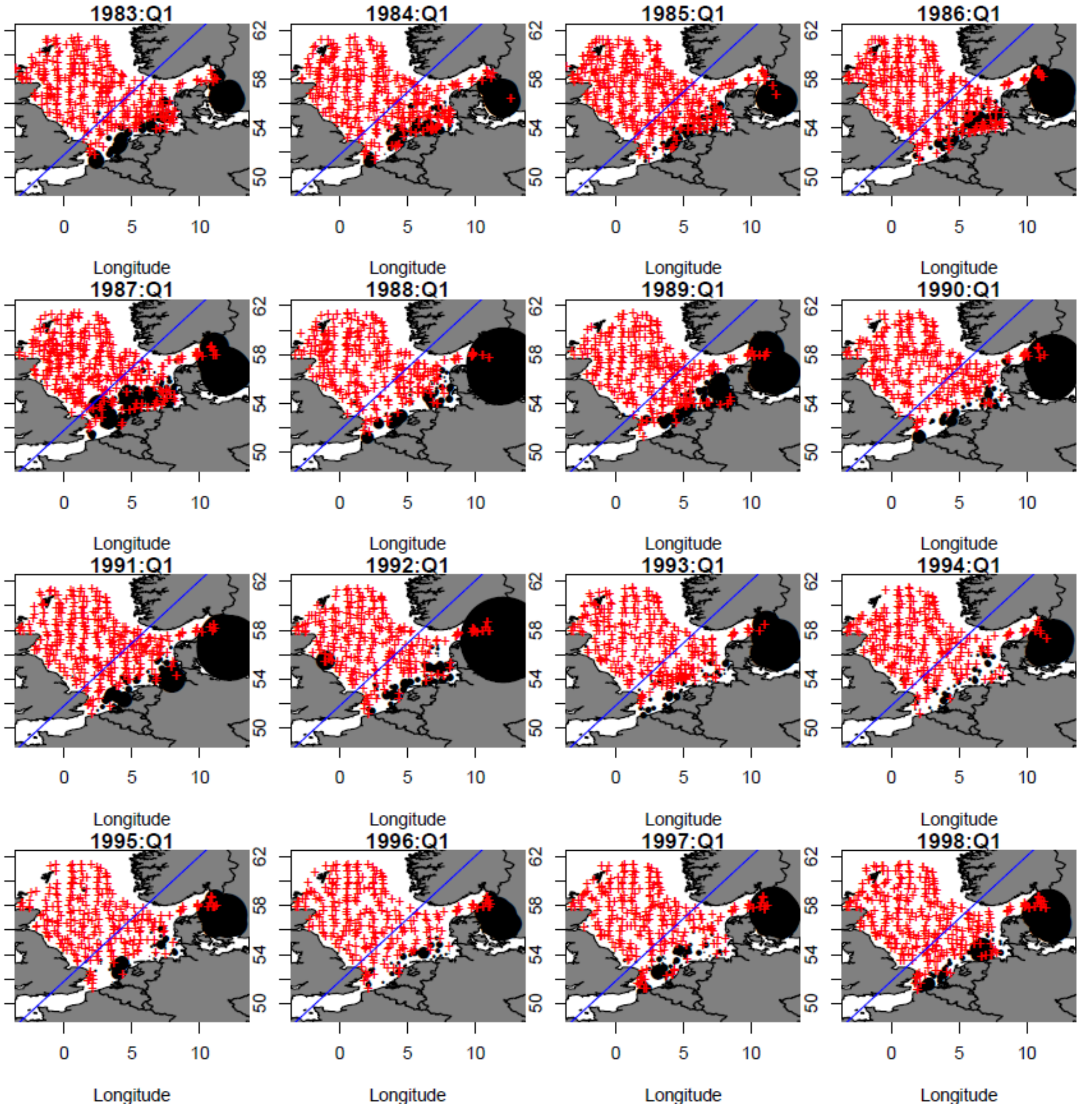


Figure 8 Flounder in Subarea 4 and Division 3a. Comparison between the survey length distribution and length distribution from commercial fleets (2014-2016).

Annex

Table 1 Flounder in Subarea 4 and Division 3a. Available survey data for flounder in the North Sea (Area 4), Skagerrak and Kattegat (Area 3a).

Survey	Year survey started	DATRAS	Standard Gear	Length distribution	Age	Individual Weight
IBTS Q1	1965 – 2017	1983 – 2017	GOV	1983 – 2017	2012 – 2013	2012 – 2013
IBTS Q3	1991 – 2017	1991 – 2017	GOV	1991 – 2017	n.a.	2009 – 2010 (only RV END)
BTS Isis (NDL)	1985 – 2017	1987 – 2017	BT8	1987 – 2017	2005; 2011; 2013 – 2014; 2016	2005; 2011; 2013 – 2014; 2016
BTS Tridens (NDL)	1996 – 2017	1996 – 2017	BT8	1996 – 2017	2005 – 2006; 2008 – 2010; 2014 – 2015	2005 – 2006; 2008 – 2010; 2014 – 2015; 2017
BTS Belgica (BEL)	1992 – 2017	2010 – 2017	BT4	2010 – 2017	n.a.	n.a.
BTS Endevour (UK)	2008 – 2016	2008 – 2017	BT4	2008 – 2017	n.a.	2014 – 2016
BTS Corystes (UK)	1988 – 2007	1990 – 2007	BT4	1990 – 2007	1995; 1996; 2000	1995; 1996; 2000
BTS Solea (GER)	1991 – 2016	1998 – 1999; 2001 – 2005; 2007 - 2016	BT7	1998 – 1999; 2001 – 2005; 2007 – 2016	n.a.	n.a.
SNS (NDL)	1969 - 2016	Not available yet	BT6	2002; 2004 – 2016	2007 – 2008; 2012 – 2014; 2016	2004 – 2016
DFS (NDL)	1970 – 2016	2002 - 2016	BT3 and BT6	2002 – 2016	2006 - 2016	2004 – 2016
DYFS (GER)	1972 – 2016	Not available yet	BT3	2002 – 2016	n.a.	n.a.
DFYS (BEL)	1973 - 2016	Not available yet	BT3	n.a.	n.a.	n.a.


1983:Q1
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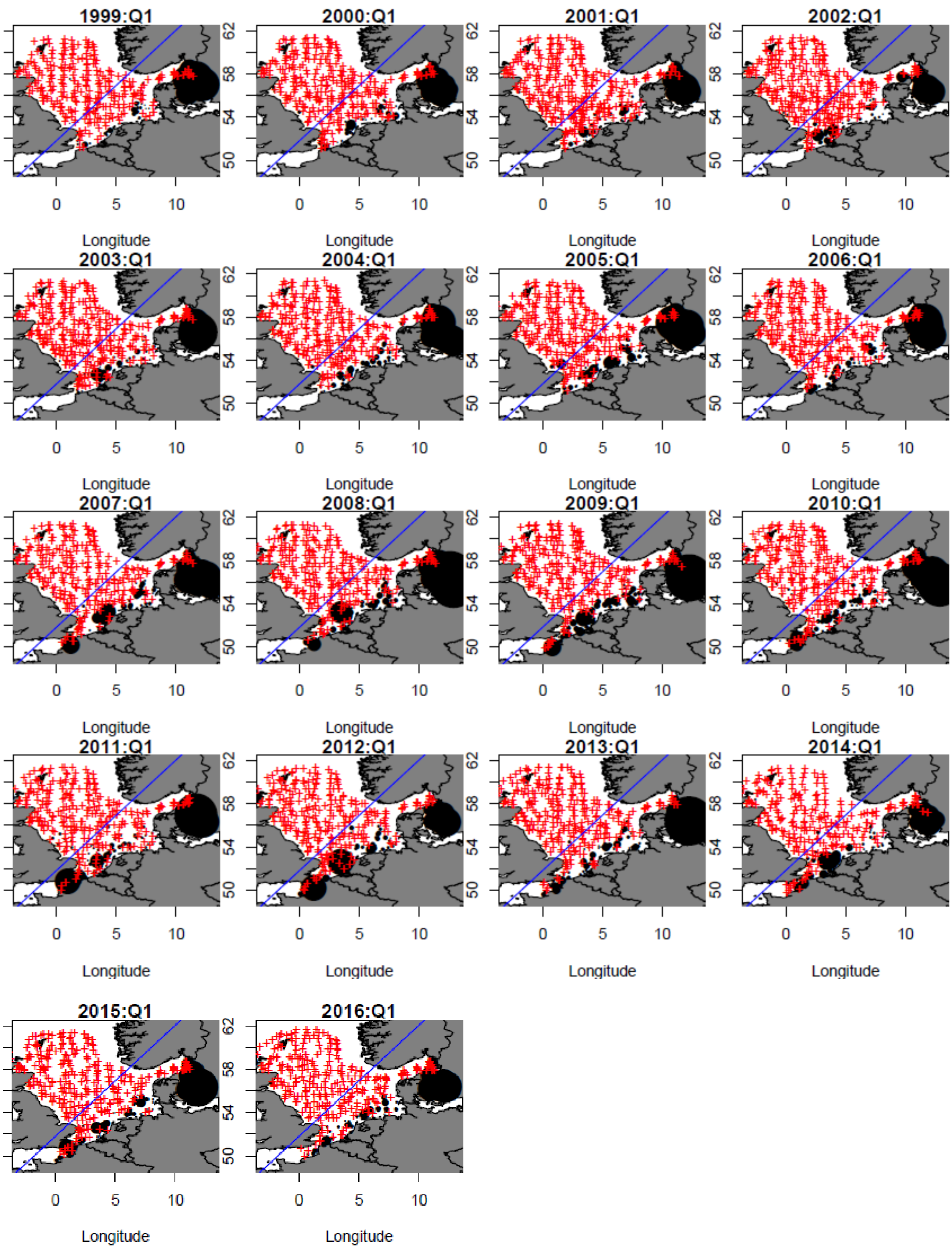
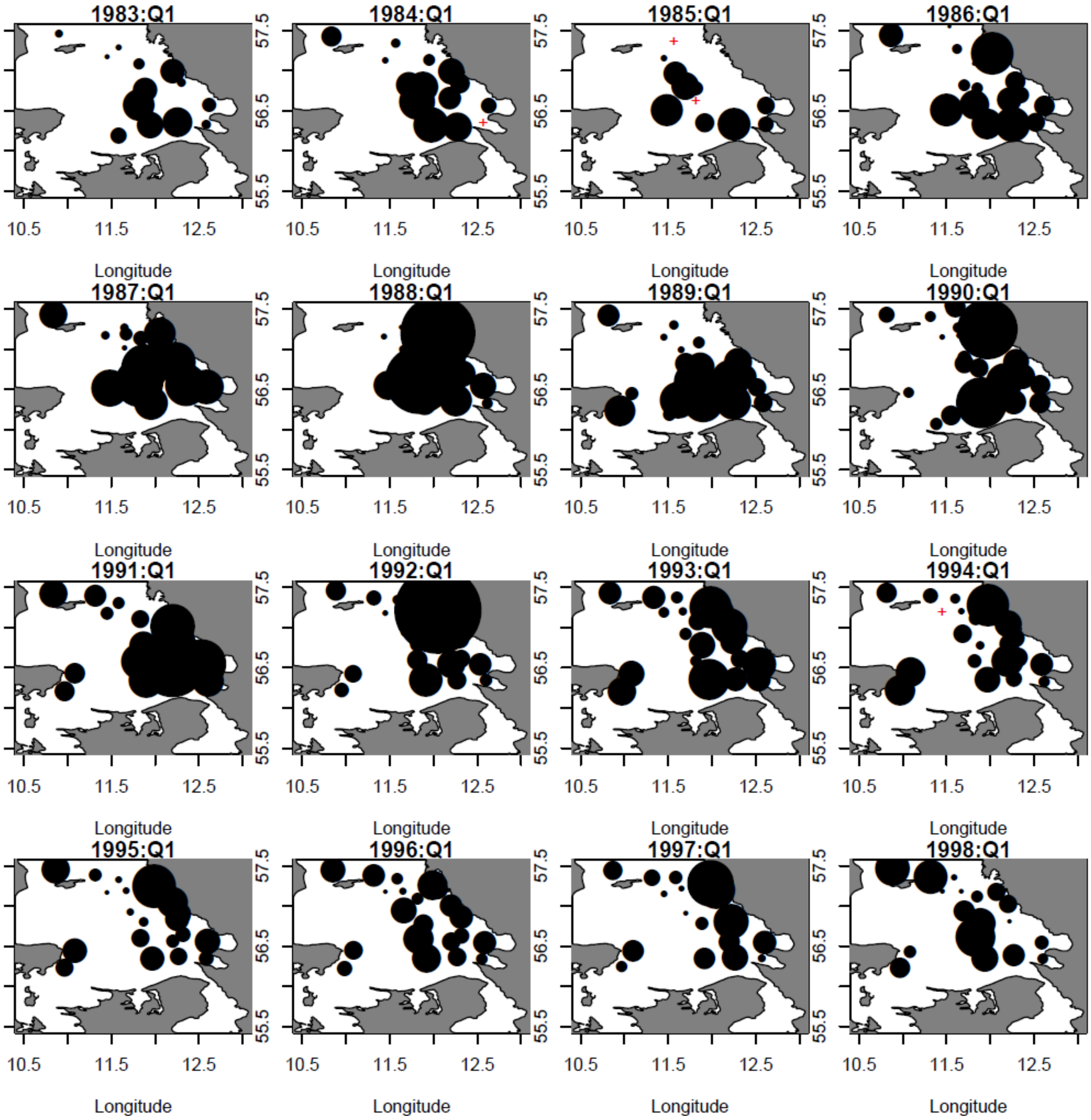


Figure 8 Flounder in Subarea 4 and Division 3a. Subset of IBTS Quarter 1 hauls by year corresponding to the area where positive flounder hauls occur. Red crosses display hauls with zero flounder caught, black bubbles display flounder catches.


1983:Q1
1984:Q1
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56.5
57.5

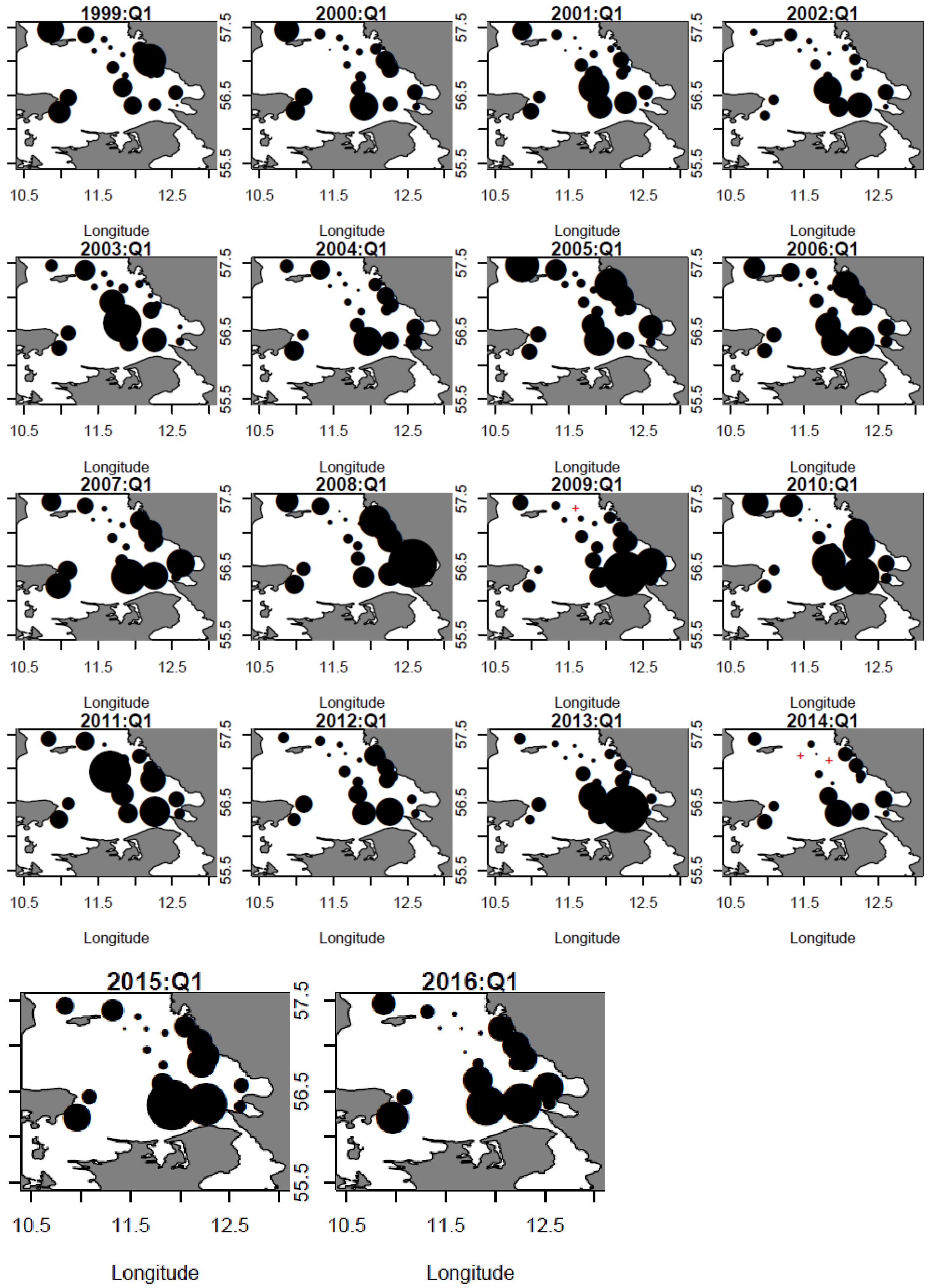
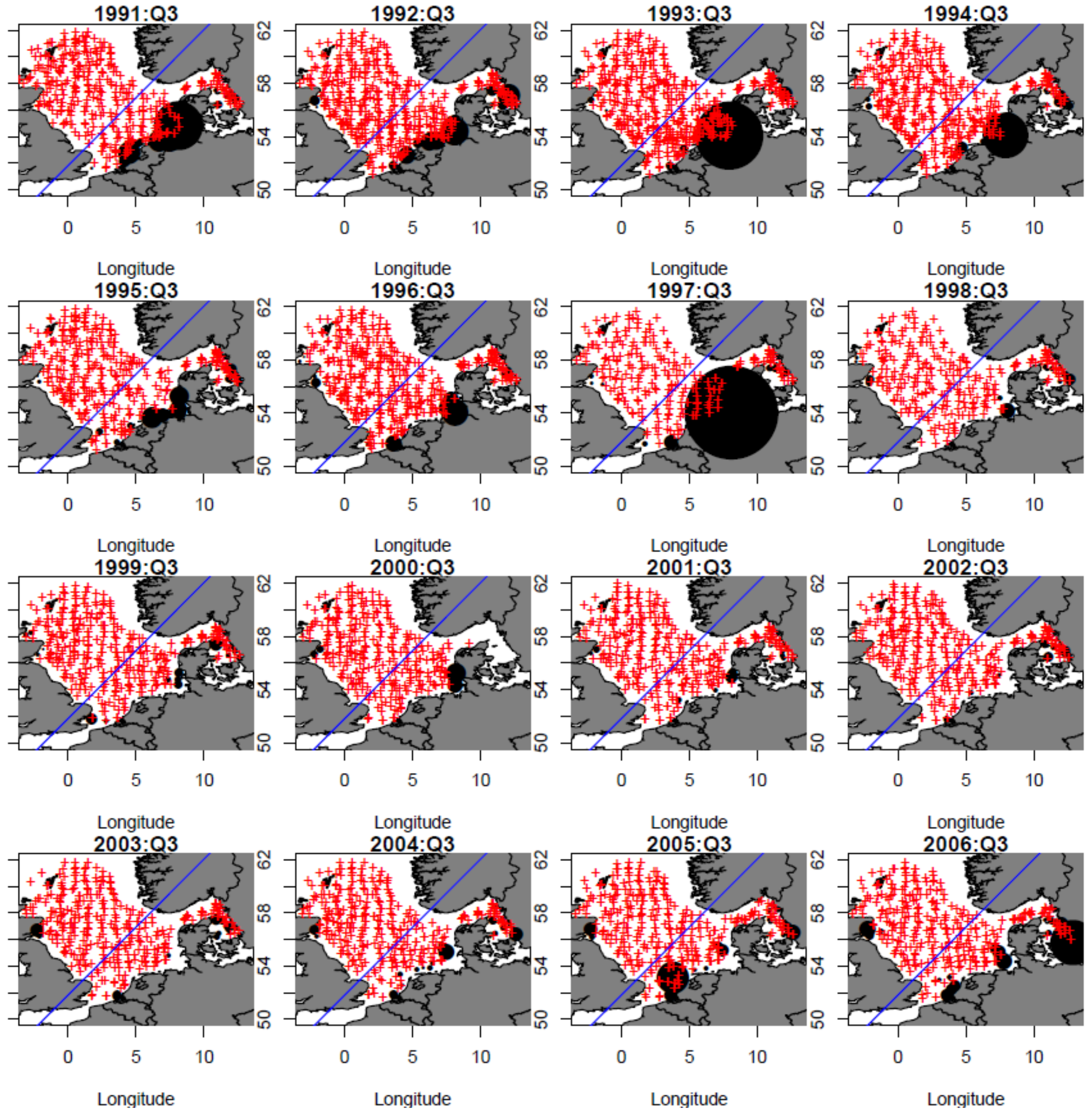


Figure 9 Flounder in Subarea 4 and Division 3a. IBTS quarter 1 hauls in the Kattegat (area 3.21) by year. Red crosses display hauls with zero flounder caught, black bubbles display flounder catches.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50 54 58 62

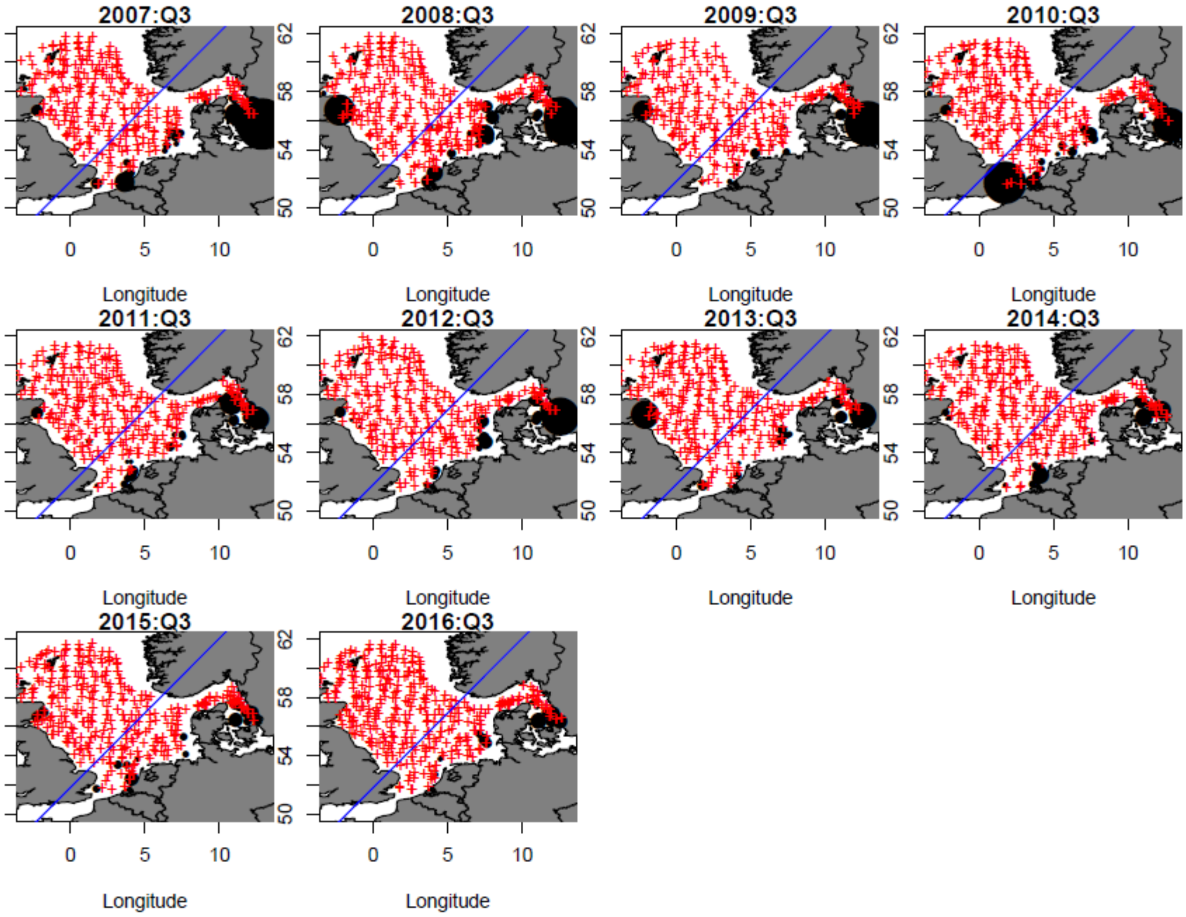
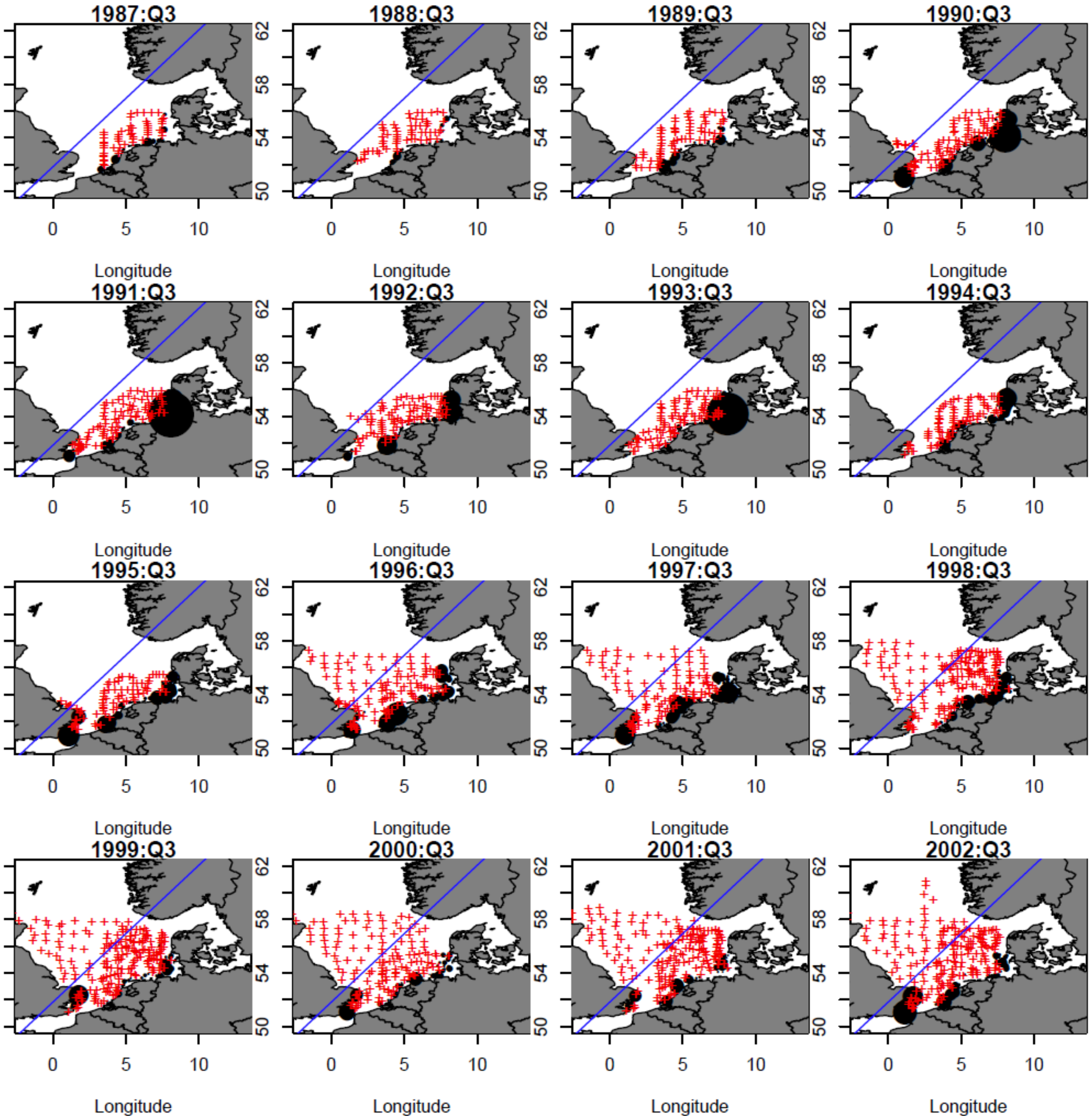


Figure 10 Flounder in Subarea 4 and Division 3a. Subset of IBTS Quarter 3 hauls by year where positive flounder hauls occur. Red crosses display hauls with zero flounder caught, black bubbles display flounder catches. Data north west of the blue line are not taken into account because only zero hauls.


1987:Q3
1988:Q3
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2000:Q3
2001:Q3
2002:Q3
Longitude
0 5 10
50 54 58 62

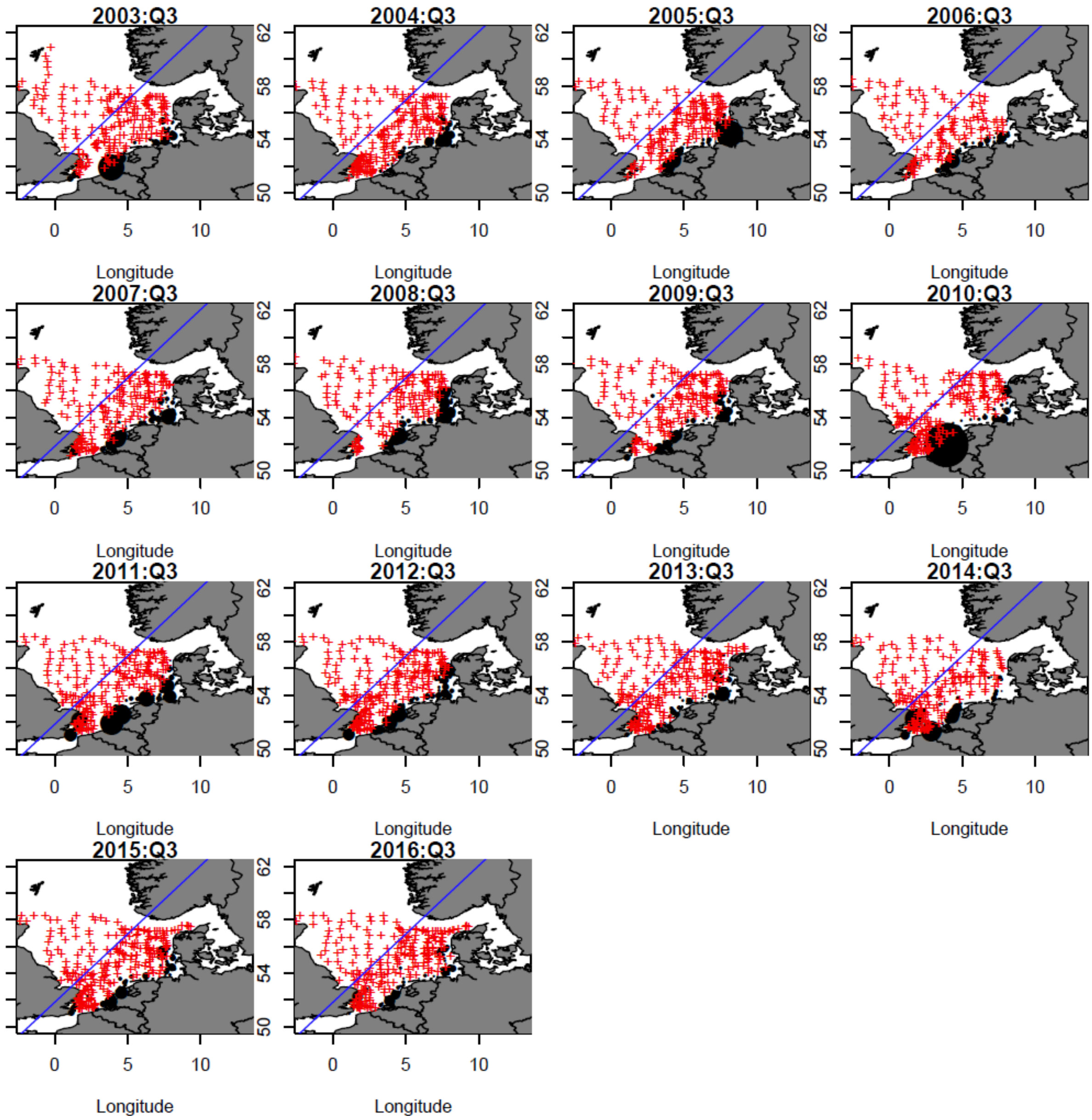

Figure 11 Flounder in Subarea 4 and Division 3a. BTS Quarter 3 hauls by year where positive flounder hauls occur. Red crosses display hauls with zero flounder caught, black bubbles display flounder catches. Data north west of the blue line were not taken into account because only zero hauls.

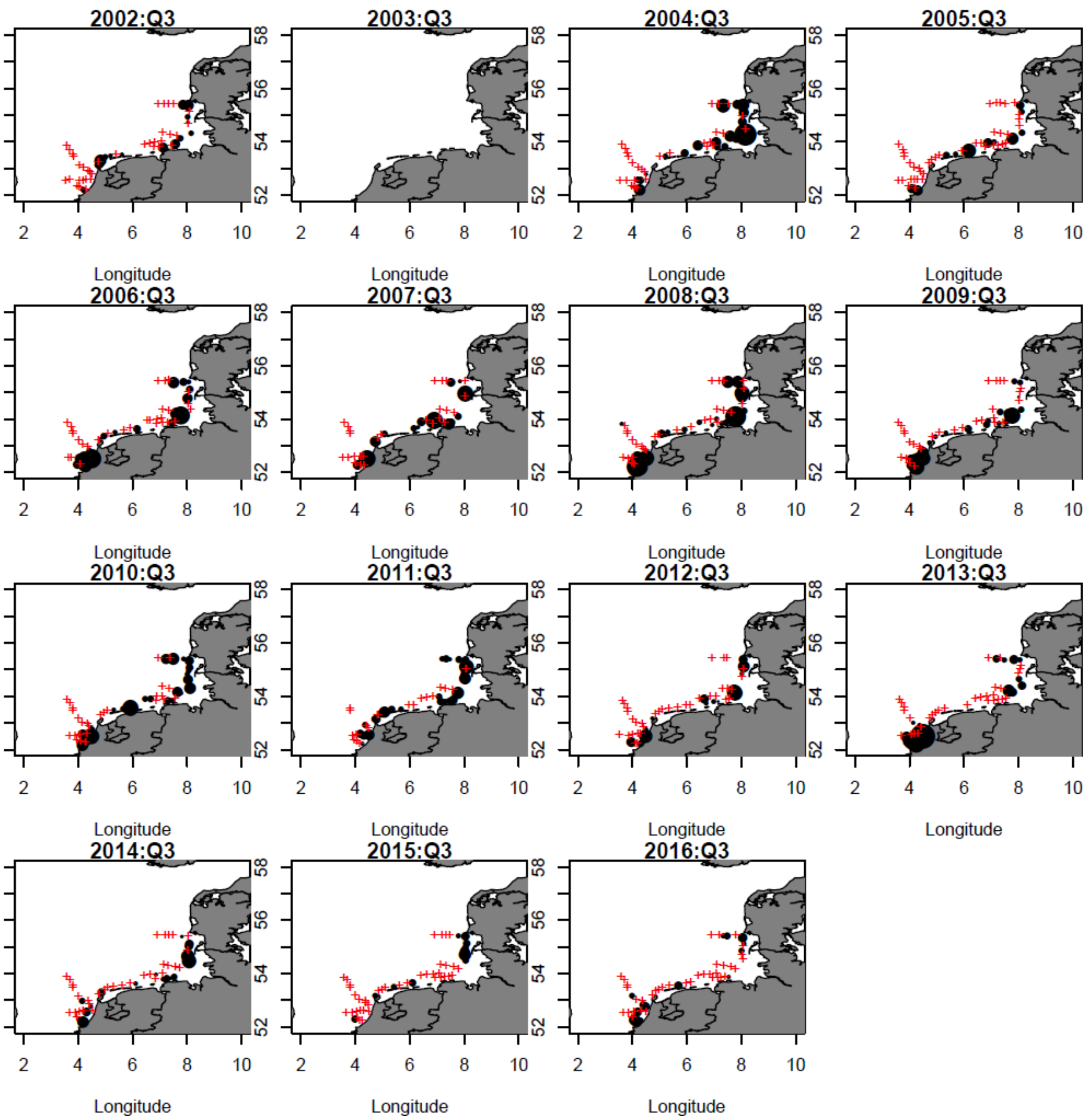

Figure 12 Flounder in Subarea 4 and Division 3a. Survey area SNS Quarter 3 by year.

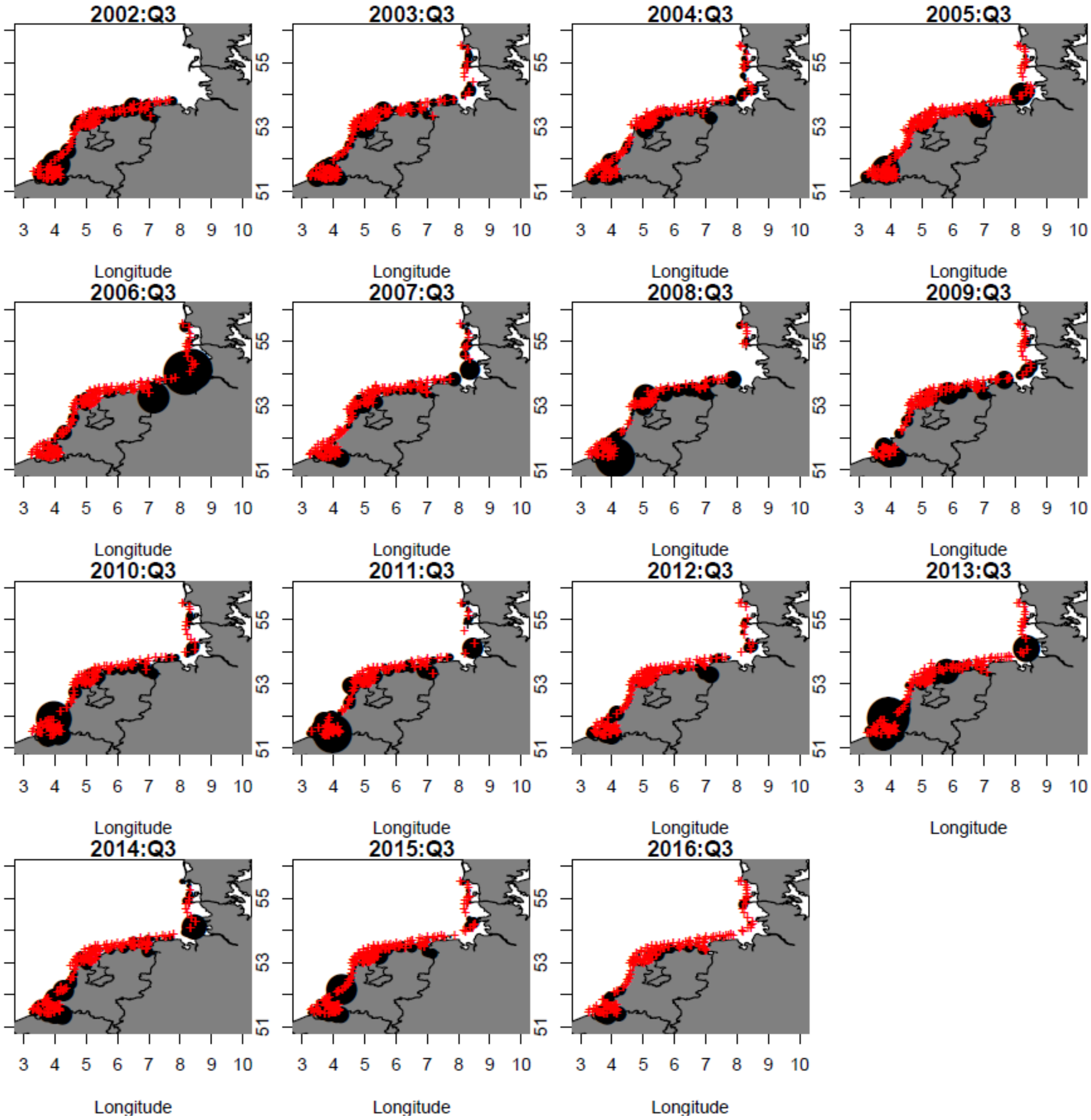

Figure 13 Flounder in Subarea 4 and Division 3a. Survey area Dutch DFS Quarter 3 by year.

Figure 14 Flounder in Subarea 4 and Division 3a. Survey area DYFS Quarter 3 by year.

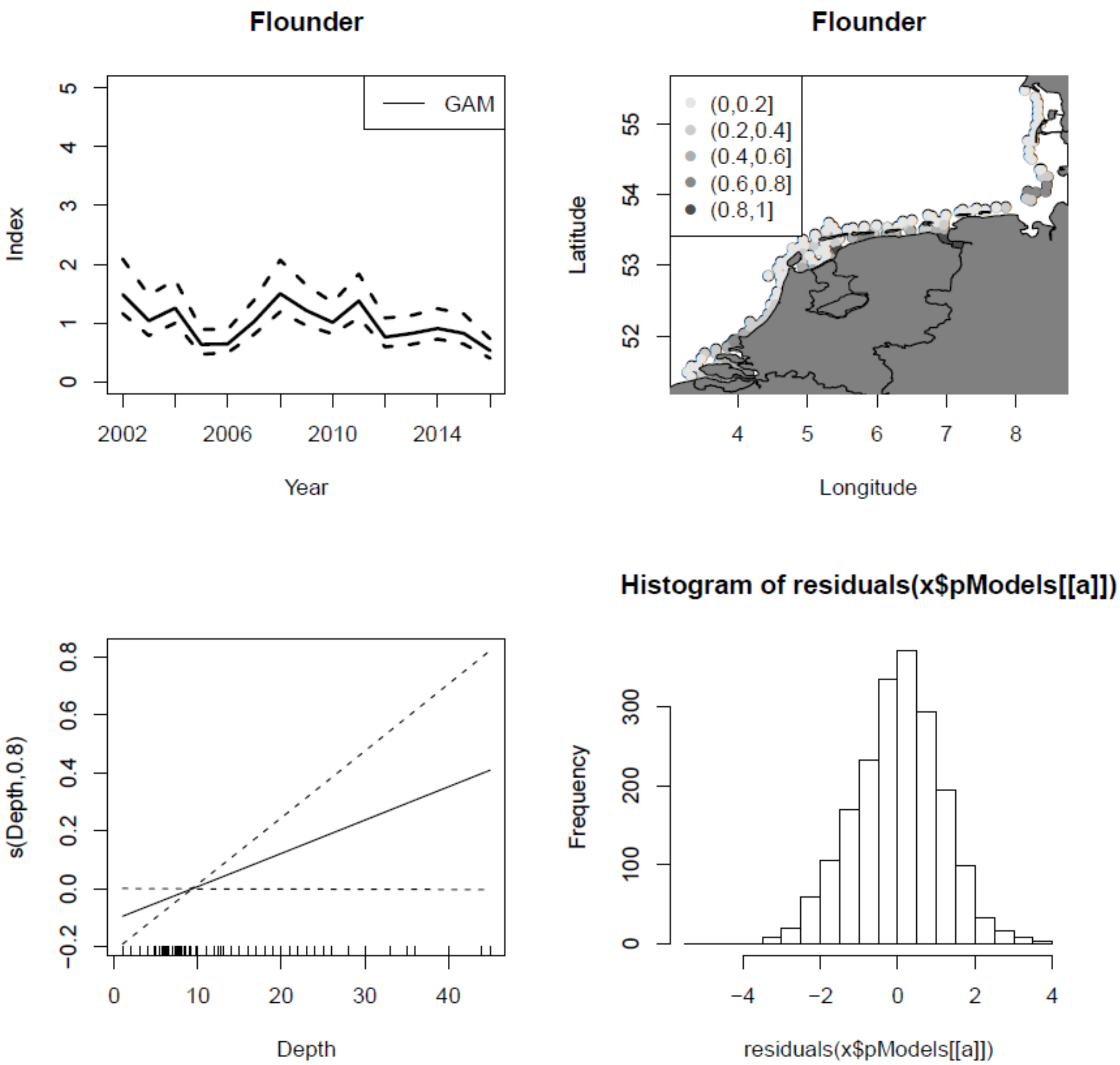

Figure 15 Flounder in Subarea 4 and Division 3a. Combined Dutch deltaGAM DFS Q3 index taking into account BT§ and BT6 gears.

WD 2 Flounder 3a4 – InterCatch raising of discards and sample data

Introduction

For the WGNSSK2017 (ICES, 2017) flounder landings and discards data from 2012-2016 were available in the InterCatch system. For the years 2014-2016 also length sampling data were uploaded by most countries in 2017 and were analyzed and used for the current assessment by the Working Group on the Assessment of North Sea and Skagerrak Demersal Stocks (WGNSSK, 2017). The data call for the benchmark assessment in 2018 requested all available data from 2002-2016. Although all countries uploaded their available data, still essential data gaps remain for the amount of discards and biological samples from the commercial fleets. Therefore, it remains a difficult task to properly raise discards for flounder in Area 4 and Division 3a in order to obtain a reliable catch time series, which is needed as input for production models, e.g. SPiCT. However, this working document describes the available InterCatch data on landings and discards by nation and métiers, age and length data from sampling commercial fleets and the most appropriate procedure to raise discards and to allocate the available samples.

Flounder 27.3a4 InterCatch data 2002 – 2016

Catch data for the years 2002-2016 were provided by all countries fishing in subarea 4 and Division 3a, following the WKNSEA data call. All data were uploaded to the InterCatch data portal and subsequent discard raisings and sample allocations were performed with the InterCatch online tool. For each year all nations provided their landings data for subarea 4, with the exception of Belgium for 2002. This missing data point was substituted by the official landings. By far the largest proportion of total landings is taken by Dutch fleets in subarea 4 (Figure 1a), followed by the Belgium fleets in subarea 4 (Figure 1b). The landings in subarea 4 of all other countries together were only around 5% of the total landings (last three years average). The Dutch flounder landings show a steep decline from 2007 to 2013 and only increased slightly from 2014 to 2015. Apart from the Belgium fleet very similar trends were observed for all other nations (Figure 1b). Discard data were only partly provided (Table 1) and show high variability between years (Figure 2). Unfortunately no discard data were uploaded for the Dutch fleets before 2011 and no Belgium and Scottish discard data before 2009. Therefore, the most important fleets in terms of landings and discards are missing for the time period 2002 – 2008 in subarea 4, which makes it impossible to set up a reliable raising scheme for these years. The discard coverage dropped from around 90% in the period 2011 – 2016 to 14% on average for the period 2002 – 2010 (Figure 4). Thus, in order to estimate discards for métiers for which no raising was possible, because of missing data, average discard ratios based on years with data were applied and the raising was done manually besides the InterCatch raising tool. For division 3a landings and discards for the most important countries and fleets were provided for the whole time series (Figure 3). However, also for this area the reported discards are highly variable between years (Figure 3b).

Commercial age samples were only provided by The Netherlands and Belgium for the most recent years. Further, no samples from Dutch discards were available. Therefore, it was agreed during the WKNSEA data collection work shop that these data were not sufficient for any age based assessment model. For this reason, the sample allocation was only done with the length samplings. The length samples provided within InterCatch did not reveal any major differences of length distributions between areas or métiers. Thus only one landings group and one discard group was used. For the year 2008 only one (!) length sample is available for landings and also for some of the earlier years length data are sparse (Table 4 and Table 5).

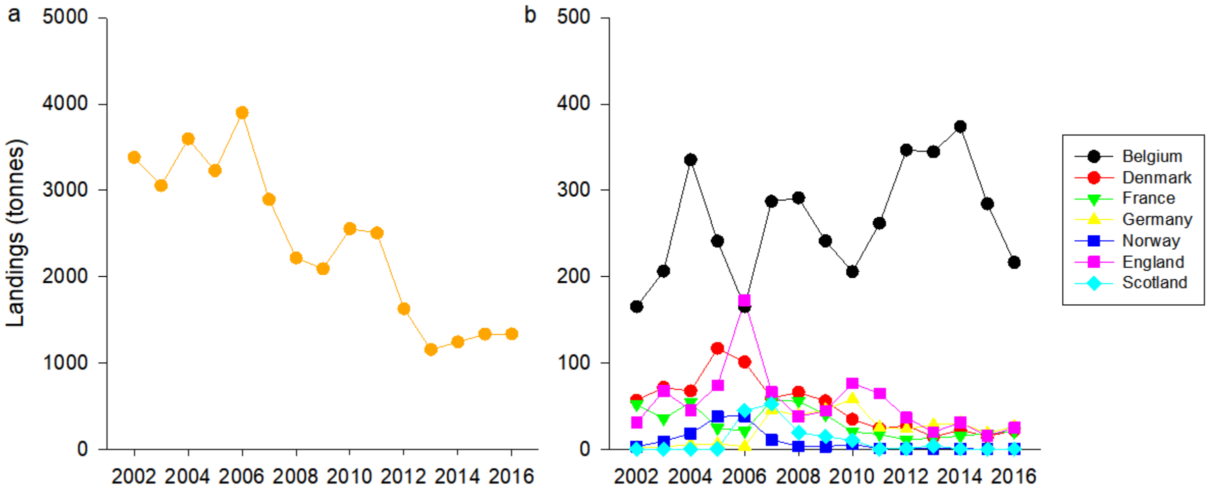

Figure 1 Flounder in Subarea 4 and Division 3a. Flounder landings in subarea 4 provided to InterCatch for (a) the Netherlands and (b) for all other countries (b).

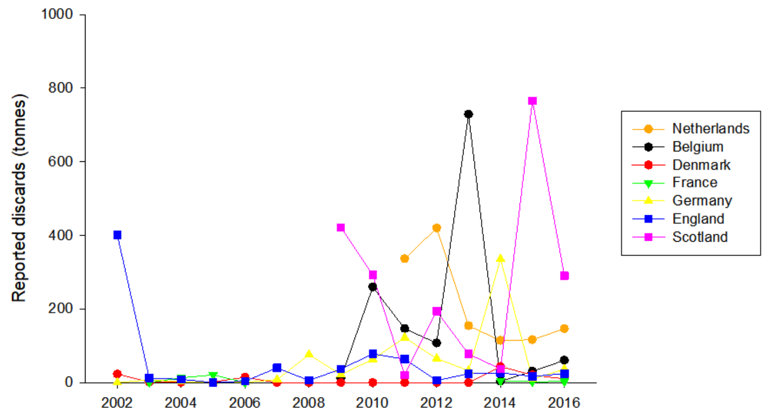

Figure 2 Flounder in Subarea 4 and Division 3a. Flounder discards in subarea 4 provided to InterCatch by country.

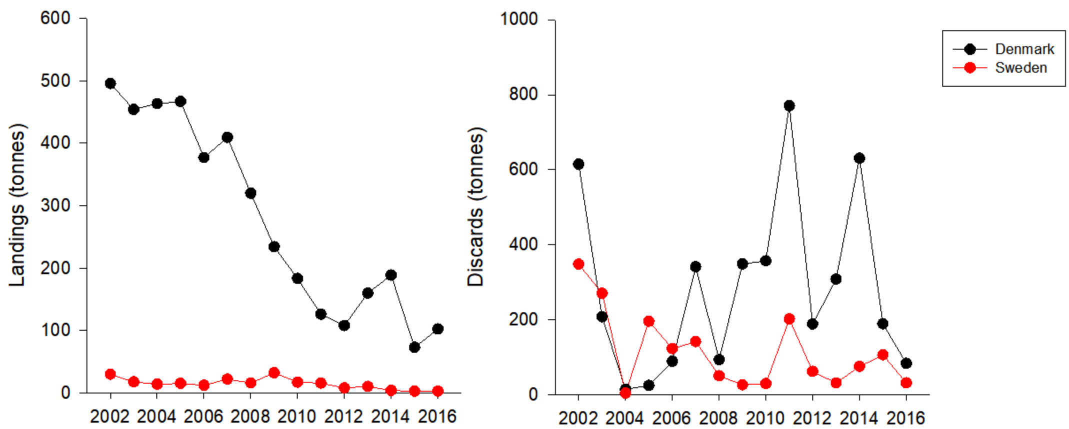

Figure 3 Flounder in Subarea 4 and Division 3a. Flounder landings (a) and discards (b) in Division 3a provided to InterCatch by country.

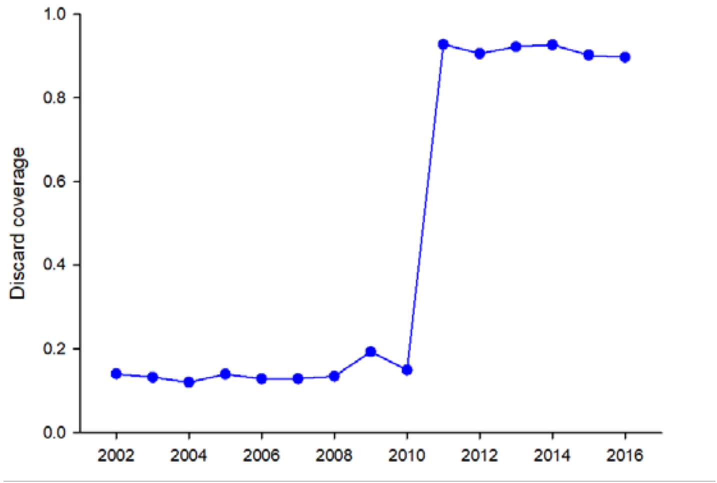

Figure 4 Flounder in Subarea 4 and Division 3a. The discard coverage as proportion of landings for which also discards were reported.

Table 1. Flounder in Subarea 4 and Division 3a. Discards and landings in tonnes provided to InterCatch (Subarea 4). Years with no data reported are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium								12	260	147	107	729	3	31	61
		Denmark	23	2	0	2	14	0	0	0	0	0	0	0	43	21	10
		France		0	13	21	0								5	2	3
		Germany	0	8	2	1	1	8	76	21	63	122	65	33	336	9	37
		Netherlands										336	420	154	114	116	146
		Norway													0	0	1
		Sweden															
		UK (England)	402	12	9	0	4	40	6	37	78	64	6	24	26	17	24
		UK(Scotland)								421	292	21	194	77	37	766	290
	Landings	Belgium	165*	206	335	241	165	287	291	241	205	262	347	345	374	284	216
		Denmark	56	71	67	117	101	59	66	56	34	24	27	14	22	15	22
		France	52	36	54	25	21	56	56	40	20	17	11	13	15	18	20
		Germany	2	3	5	6	3	45	39	46	58	25	23	28	30	19	26
		Netherlands	3382	3054	3596	3228	3900	2895	2215	2090	2555	2505	1626	1154	1241	1333	1335
		Norway	3	9	18	38	38	11	3	3	6	1	0	0	1	0	0
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	31	67	45	74	172	66	38	44	76	65	36	20	31	15	25
		UK(Scotland)	0	0	0	0	45	52	19	15	10	0	1	4	0	0	0

* official landings

Table 2. Flounder in Subarea 4 and Division 3a. Discards and landings in tonnes provided to InterCatch (Division 3a). Years with no data are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.3a	Discards	Denmark	615	207	14	24	89	341	93	348	356	771	188	308	631	189	83
		Germany													0		
		Netherlands													0		0
		Norway													0	0	0
		Sweden	348	270	4	195	122	141	50	26	29	201	62	31	75	106	31
	Landings	Denmark	496	454	463	467	377	409	320	234	183	126	108	160	189	73	103
		Germany	0	3	2	1	1	2	4	2	0		0	0	0		
		Netherlands				1	0	1	0	0					0		0
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Sweden	30	18	14	15	13	22	16	32	17	16	8	11	4	3	3

Table 3. Flounder in Subarea 4 and Division 3a. Age samples (number of age readingss) provided to InterCatch (Subarea 4). Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	135	0	145	200
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	89	0	254	253
		Netherlands	0	0	0	0	0	0	0	865	900	900	950	850	850	893	900

Table 4. Flounder in Subarea 4 and Division 3a. Length samples (number of measurements) provided to InterCatch (Subarea 4). Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	359	14	0	0
		Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		France	0	0	0	58	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	1	138	2	1	2	1	0	0	5	20	25	4	6	50
		Netherlands	0	0	0	0	0	0	0	0	0	160	461	141	88	98	168
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	330	102	128	4	47	1237	492	778	914	187	256	329	259	186	153
		UK (Scotland)	0	0	0	0	0	0	0	9	60	34	107	122	134	166	256
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	303	407	0	0
		Denmark	163	2	6	2	42	0	0	0	0	0	2	0	2	9	6
		France	0	0	0	0	0	0	0	0	0	0	0	0	74	122	93
		Germany	84	15	187	303	256	71	1	33	70	21	35	102	284	65	91
		Netherlands	0	0	0	0	0	0	0	3822	3915	1638	1674	2014	1631	0	1639
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	89	0	0	0	0	74	0	127	217	275	49	58	32	182	153
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5. Flounder in Subarea 4 and Division 3a. Length samples (number of measurements) provided to InterCatch (Division 3a). Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.3a	Discards	Denmark	411	225	389	210	144	214	151	575	897	1660	1094	587	252	374	195
		Sweden	2011	1270	0	1176	552	1048	590	0	0	0	0	173	598	636	339
	Landings	Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0
		Sweden	0	406	0	0	0	281	0	0	0	0	0	0	0	0	0

Raising of discard data 2011 – 2016

In a first step a rather complex raising procedure was applied with the following groupings:

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
3. OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
4. SSC_DEF_70-99-119_all raised with all other SSC_DEF and SDN_DEF
5. OTB_CRU_70-99_0_0_all raised with all other OTB_CRU_70-99_0_0_all
6. All passive gears with all passive gears
7. OTB_DEF>=120 with all OTB_DEF_>=120
8. SDN_SSC_DEF_>=120 with all other SDN_SSC_DEF_>120
9. OTB_DEF_100-119_0_0_all with OTB_DEF_100-119_0_0_all

   Not taken into account:

10. 10 MIS_MIS_0_0_0_IBC (negligible, pelagic fishery)
11. 11 TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
12. 12 TBB_DEF_>=120_0_0_0_all (negligible, low effort)
13. 13 OTB_DEF_<16 (negligible, low effort)

In a second step a simple "all vs all raising" was tested in order to explore how this would change the estimated total catch. For a number of years the latter approach did not reveal large differences compared to the complex raising procedure (Figure 4). For the years 2011 to 2013 the difference was around 100t higher total catch compared to the complex raising procedure and 121t and 67t less for the years 2014 and 2015 respectively. However, for the most recent data year the difference was 488t less total catch compared to the complex raising procedure. Further, the estimated total catch estimated by the "all vs all raising scheme" deviates much stronger from the results obtained by the more complex raising procedure for the earlier years of the time series, years for which no discard data were provided for the most important métiers in terms of flounder landings and discards. This is because the most important métier, the Dutch beam trawlers (TBB_DEF_70-99_0_0_all), outweighs all other métiers because of the comparable high landings (Figure 1a) in the years for which data were provided. The discard ratio for this fleet is comparable low, and thus the estimated discard ratio obtained by the raising with other TBB métiers is much higher, and probably overestimates the discards for this particular fleet.

Raising of discard data 2002 – 2010

Whenever possible the same groupings were kept as for the more recent years, but the Dutch beam trawl fleet was left out of the raising procedure for each year. This was done because the Dutch beam trawl discard ratio was observed to be lower compared to other beam trawl fleets (on average 0.13 compared to on average 0.60 for all other countries together in the time period 2011-2016). Therefore the average Dutch discard ratio was applied to the Dutch beam trawl landings for the time period 2002 – 2010 to take discards for this important métier into account. For some other métiers it was not possible to match with the same métier because no data were available. In these cases the most similar gear in terms of type and mesh size was used for raising, e.g. in 2009 SSC_DEF_70-99_all raised with OTB_DEF_70-99_0_0_all. In that cases were even this was not possible an average was applied taking into account all observations with data for the particular métier. Table 7 gives information on the applied average discard ratios.

Allocation of length samples

In general one landings and one discard group was used. In years for which data from the shrimper fleet (TBB_CRU_16-31_0_0_all) was available, the discards of this métier were treated separately. However, the latter was only possible for the years 2011 – 2016. Only samples with at least 30 length measurements were used for the allocation. Only for the shrimper discards samples with fewer measurements were used, because otherwise no samples would have been available. For the years 2002 – 2007 all length data from Denmark and Germany were removed from the analyses because of lacking length-weight relationships.

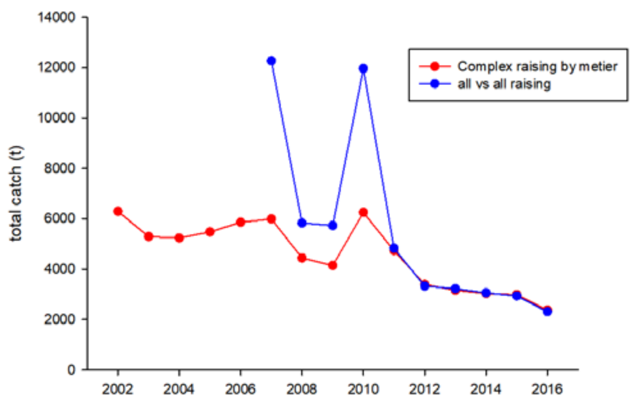

Figure 4 Flounder in Subarea 4 and Division 3a. Comparison between the complex grouping and raising “all vs all”. The difference between the raising schemes are given as percentage.

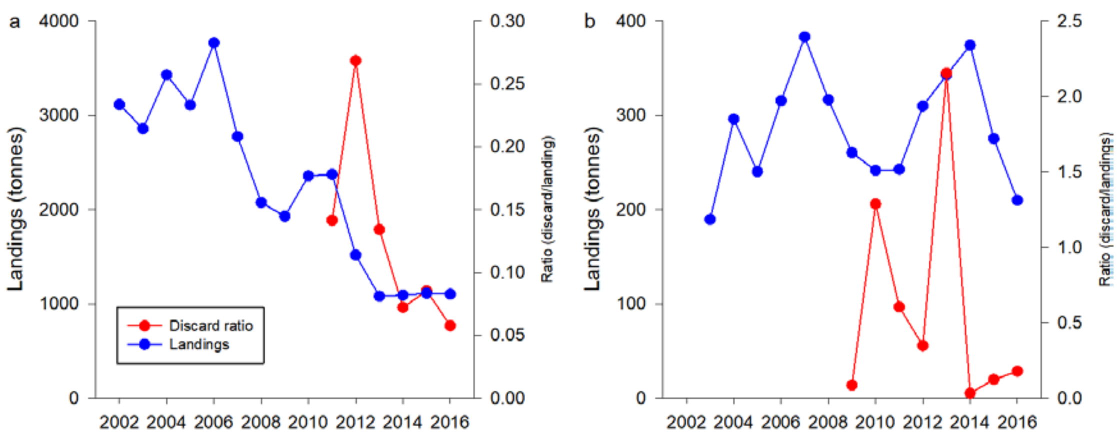

Figure 5 Flounder in Subarea 4 and Division 3a. Discard ratio and flounder landings of the Dutch beam trawl fleet in subarea 4 (a) and the beam trawl fleets of all other countries (b). InterCatch landings and InterCatch reported discards were used to calculate the discard ratio (discard/landings).

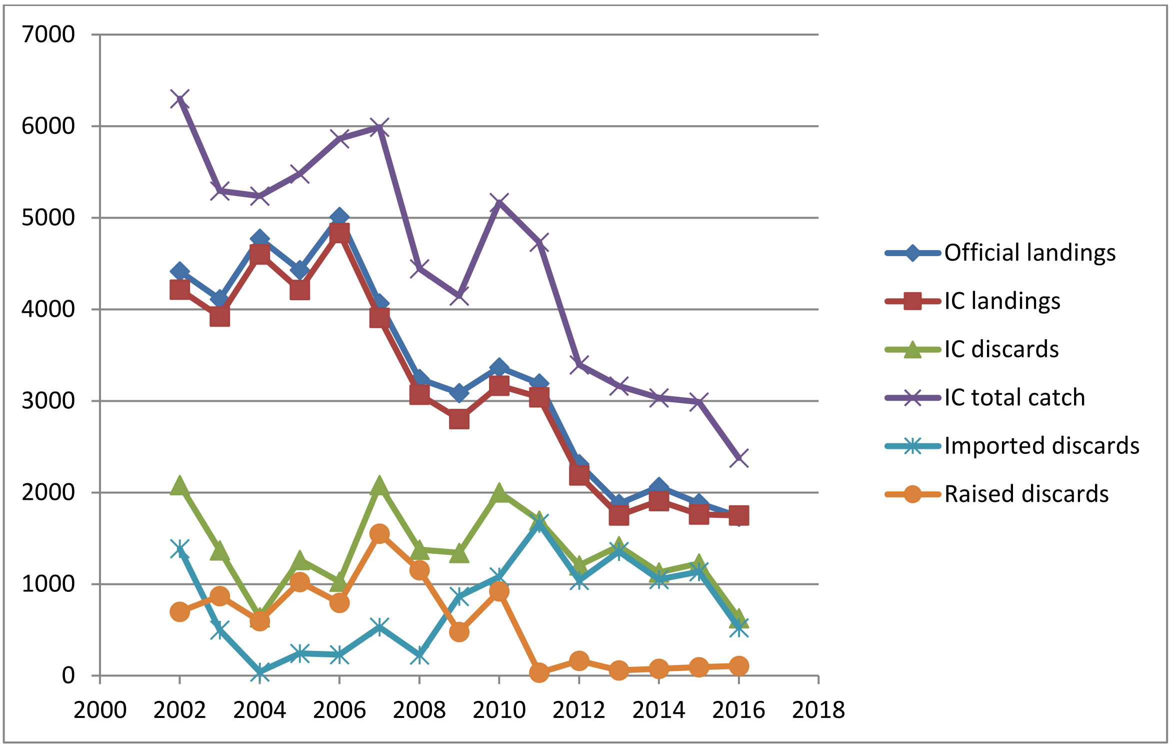

Figure 6 Flounder in Subarea 4 and Division 3a. Overview of total landings and discards (tonnes) uploaded to InterCatch, the official landings, and the resulting total catch raised with the InterCatch tool (complex raising scheme).

Table 7 Flounder in Subarea 4 and Division 3a. Average discard ratios which were applied for cases where no suitable data were available.

Métier	Country	Years	Mean discard ratio

OTB_CRU_70-99_0_0_all	all countries	2013	2.81
TBB_DEF_70-99_0_0_all	Netherlands	2002 - 2010	0.13
OTB_DEF_70-99_0_0_all	Netherlands	2002 - 2010	0.30
SSC_DEF_100-119_0_0_all	Netherlands	2010	1.41
TBB_DEF_70-99_0_0_all	BEL, GER, UK ENG, UK SCO	2003, 2005, 2007, 2008	0.60
all passive gears	all countries	2002 - 2004	0.22

Table 8 Flounder in Subarea 4 and Division 3a. Official landings and InterCatch estimates of landings, discards.

Year	Official landings	IC landings	IC discards	IC total catch	Discard rate
2002	4414	4217	2084	6300	33.07%
2003	4110	3922	1370	5292	25.89%
2004	4772	4601	637	5239	12.16%
2005	4428	4214	1265	5479	23.09%
2006	5009	4837	1026	5863	17.50%
2007	4065	3908	2082	5991	34.76%
2008	3240	3067	1376	4444	30.97%
2009	3088	2804	1342	4146	32.38%
2010	3365	3166	2002	5168	38.73%
2011	3193	3041	1694	4735	35.77%
2012	2310	2189	1205	3394	35.49%
2013	1876	1750	1415	3165	44.71%
2014	2062	1907	1127	3035	37.15%
2015	1883	1762	1228	2990	41.07%
2016	1738	1750	628	2377	26.41%

Annex – Groupings used for raising in InterCatch 2006 – 2010

IC fle 2016

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
- SSC_DEF_70-99-119_all raised with all other SSC_DEF and SDN_DEF
- OTB_CRU_70-99_0_0_all raised with all other OTB_CRU_70-99_0_0_all
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_SSC_DEF_>=120 with all other SDN_SSC_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_100-119_0_0_all
    - MIS_MIS_0_0_0_IBC (negligible)
    - TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - TBB_DEF_>=120_0_0_0_all (negligible)
    - OTB_DEF_<16

Length allocations for 2016 data: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2015

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
- SSC_DEF_70-99-119_all raised with all other SSC_DEF and SDN_DEF
- OTB_CRU_70-99_0_0_all raised with all other OTB_CRU_70-99_0_0_all
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_DEF_>=120 with all other SDN_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_100-119_0_0_all (0 Discards)
    - MIS_MIS_0_0_0_IBC (negligible)
    - TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - TBB_DEF_>=120_0_0_0_all (negligible)
    - OTB_DEF_<16
    - OTB_DEF_all_all

Length allocations for 2015 data: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2014

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all -> only data from Netherlands available
    - New data from France (Q1) and UK England (Q3 and Q4)
- SSC_DEF_70-99-119_all raised with all other SSC_DEF and SDN_DEF
- OTB_CRU_70-99_0_0_all raised with all other OTB_CRU_70-99_0_0_all
    - Changes in UK England data!
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_DEF_>=120 with all other SDN_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_>=120 -> only for area 27.4.
- The following métiers were not raised:
    - MIS_MIS_0_0_0_IBC (negligible)
    - TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - TBB_DEF_>=120_0_0_0_all (negligible)
    - OTB_CRU_32-69_0_0_0_all (negligible)

Length allocations for 2014 data: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2013:

Belgium imported length sample data in cm. These data were therefore not taken into account for the sample allocations. This error was corrected manually for the final results and outputs.

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
- SSC_DEF_70-99-119_all raised with all other OTB_DEF_70-99_0_0_all
- OTB_CRU_70-99-119_0_0_all -> no suitable data available (only one UK ENG métier with an extreme discard ratio of >500). Apply average discard ratio (discards/Landings) over years (2011 – 2016) for this métier was applied: 2.81.
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_DEF_>=120 with all other SDN_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_>=120 -> only for area 27.4.
- The following métiers were not raised:
    - MIS_MIS_0_0_0_IBC (negligible)
    - TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - TBB_DEF_>=120_0_0_0_all (negligible)
    - OTB_CRU_32-69_0_0_0_all (negligible)

Length allocations for 2014 data: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2012:

Belgium imported length sample data in cm. These data were therefore not taken into account for the sample allocations. This error was corrected manually for the final results and outputs.

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
- SSC_DEF_70-99-119_all raised with all other OTB_DEF_70-99_0_0_all
- OTB_CRU_70-99-119_0_0_all -> all other OTB_CRU_70-99-119 métiers.
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_DEF_>=120 with all other SDN_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_>=120 -> only for area 27.4.
- TBB_DEF_>=120_0_0_0_all with all other TBB_DEF_119->=120_0_0_0_all
- The following métiers were not raised:
    - o MIS_MIS_0_0_0_IBC (negligible)
    - o TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - o OTB_CRU_32-69_0_0_0_all (negligible)

Length allocations for 2014 data: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2011

- TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all
- MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> only from 3a.21 available
- OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
- SSC_DEF_70-99-119_all raised with SSC_DEF_70-99-119 (only NDL data with zero discards)
- OTB_CRU_70-99-119_0_0_all -> all other OTB_CRU_70-99-119 métiers.
- All passive gears with all passive gears
- OTB_DEF>=120 with all OTB_DEF_>=120
- SDN_DEF_>=120 with all other SDN_DEF_>120
- OTB_DEF_100-119_0_0_all with OTB_DEF_>=120 -> only for area 27.4.
- TBB_DEF_119->=120_0_0_0_all with all TBB_DEF_70-99
- The following métiers were not raised:
    - o MIS_MIS_0_0_0_IBC (negligible)
    - o TBB_CRU_16-32_0_0_0_all (probably not negligible but no suitable data available)
    - o OTB_CRU_32-69_0_0_0_all (negligible)

Length allocations: three groups discards, landings and TBB_CRU_16-31 discards

IC fle 2010

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included; average discard ratio of 0.13 applied

2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all (only UK England data available -> overestimation of Dutch fleet with high landings, therefore apply average of 0.3 to Dutch OTB_DEF_70-99 fleet 2011-2016)
4. SSC_DEF_100-119_all -> raise with average discard ratio of this fleets taken from previous years: 1.4
5. All passive gears with all passive gears
6. OTB_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all -> remove UK SCO and SWE métiers because of extreme discard ratios
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_100-119_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_119->=120
10. SSC_DEF_70-99_all raised with OTB_DEF_70-99_0_0_all

Not taken into account:

11. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
12. OTB_DEF_<16 (negligible, low effort)

Length allocations: two groups discards, landings. No data for TBB_CRU_16-31 discards

IC fle 2009

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a

3. OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all (UK England data available)
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all (UK England data available)
5. All passive gears with all passive gears
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_99-119_0_0_all -> data only available for 3a
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_70-99

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)

Length allocations: two groups discards, landings. No data for TBB_CRU_16-31 discards

IC fle 2008

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included -> only German data available, ZERO DISCARDS! -> use average of period 2011 – 2016 of 0.60 manually.
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all (only UK England data available)
4. SSC_SDN_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all (only UK England data available)
5. All passive gears with all passive gears (only two métiers with discard data…)
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_>=120 with all TBB_DEF_70-99

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)

No length data available for 2008 Landings; only discard data used for sample allocation; two groups: landings and discards; no data available for TBB_CRU_16-31
No length data available for 2008

IC fle 2007

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included -> only German data available, ZERO DISCARDS! -> use average of period 2011 – 2016 of 0.60 manually.

2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all (only UK England data available)
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all (only UK England data available)
5. All passive gears with all passive gears (only three UK England available)
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_70-99

Not taken into account:

10. 11 TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all
13. TBB_DEF_<16_0_0_all
14. OTB_CRU_70-89_2_35_all

Length sample allocations: Two groups, landings and discards; no data available for TBB_CRU_16-31; Danish and German length data were not used because of missing or bad length-weight relationship.

IC fle 2006

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included -> only two metiers available GER and UK England.
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_PTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all (only one French metier available)
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all (only one French metier available)
5. All passive gears with all passive gears (only three metiers available)
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_70-99

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)
13. TBB_DEF_<16_0_0_all (negligible, low effort)
14. OTB_CRU_70-89_2_35_all (negligible)

Length sample allocations: Two groups, landings and discards; only discard data available from SWE; no data available for TBB_CRU_16-31; Danish and German length data were not used because of missing or bad length-weight relationship.

IC fle 2005

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included -> no data available, apply average for all fleets. Dutch 0.13; others 0.6.
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_PTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all
5. All passive gears with all passive gears raised with all other passive gears
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_70-99

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)

Length sample allocations: Two groups, landings and discards; only discard data available from FRA and SWE; no data available for TBB_CRU_16-31; Danish and German length data were not used because of missing length-weight relationship.

IC fle 2004

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included, apply average 0.13.
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_PTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all
5. All passive gears with all passive gears -> no suitable data available, apply average of 0.22
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all with all TBB_DEF_70-99

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)

Length sample allocations: Two groups, landings and discards; only discard data available from UK England; no data available for TBB_CRU_16-31; Danish and German length data were not used because of missing length-weight relationship.

IC fle 2003

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included, apply average 0.13; average of 0.6 to all others.
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_PTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all
5. All passive gears with all passive gears -> no suitable data available, apply average of 0.22
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all -> apply averages of TBB_DEF_70-99 (Dutch 0.13; others 0.6)

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)

Length sample allocations: Two groups, landings and discards; landings from SWE, discards from SWE and UK ENG; Danish and German length data were not used because of missing length-weight relationship.

IC fle 2002

No Belgium landings uploaded for 2002; official landings for landings split to quarters

1. TBB_DEF_70-99_0_0_all raised with all other TBB_DEF_70-99_0_0_all -> Dutch fleet not included, apply average 0.13;
2. MIS_MIS_0_0_0_HC raised with all other MIS_MIS_0_0_0_HC -> data only available for 3a
3. OTB_PTB_DEF_70-99_0_0_all raised with OTB_DEF_70-99_0_0_all
4. SSC_DEF_70-99-119_all raised with OTB_DEF_70-99_0_0_all
5. All passive gears with all passive gears -> no suitable data available, apply average of 0.22
6. OTB_SSC_DEF>=120 with all OTB_DEF_>=120
7. OTB_CRU_70-99-119_0_0_all with all OTB_CRU_70-99-119_0_0_all
8. OTB_DEF_100-119_0_0_all with all OTB_DEF_70-99_0_0_all
9. TBB_DEF_119_>=120_0_0_0_all -> apply average

Not taken into account:

10. TBB_CRU_16-31_0_0_0_all (probably not negligible but no suitable data available)
11. OTB_CRU_32-69_0_0_all (negligible, low effort)
12. OTB_CRU_16-31_0_0_all (negligible, low effort)
13. TBB_DEF_<16_0_0_all

Length sample allocations: Two groups, landings and discards; landings from SWE, discards from SWE and UK ENG; Danish and German length data were not used because of missing length-weight relationship.

WD3 Biological parameters: length distributions, length-weight relationship, maturity

The International Bottom Trawl Survey (Quarter 1 and Quarter 3) and the different Beam Trawl Surveys (Quarter 3 inshore and offshore surveys; ICES 2017) catching flounder. However, since flounder is not a target species in the fishery and is of only limited commercial value it has never been a target species on these surveys with respect to collecting biological data such as age, individual weight or maturity. Further, flounder is a more coastal species spending part of its life cycle in brakish waters and river estuaries and is thus only caught in quite low numbers by the off shore surveys. Biological data which are available for flounder from the different surveys are listed in table 1. The DATRAS data portal provides SMALK data from the NS-IBTSQ1 and BTSQ3 surveys.

Length distributions

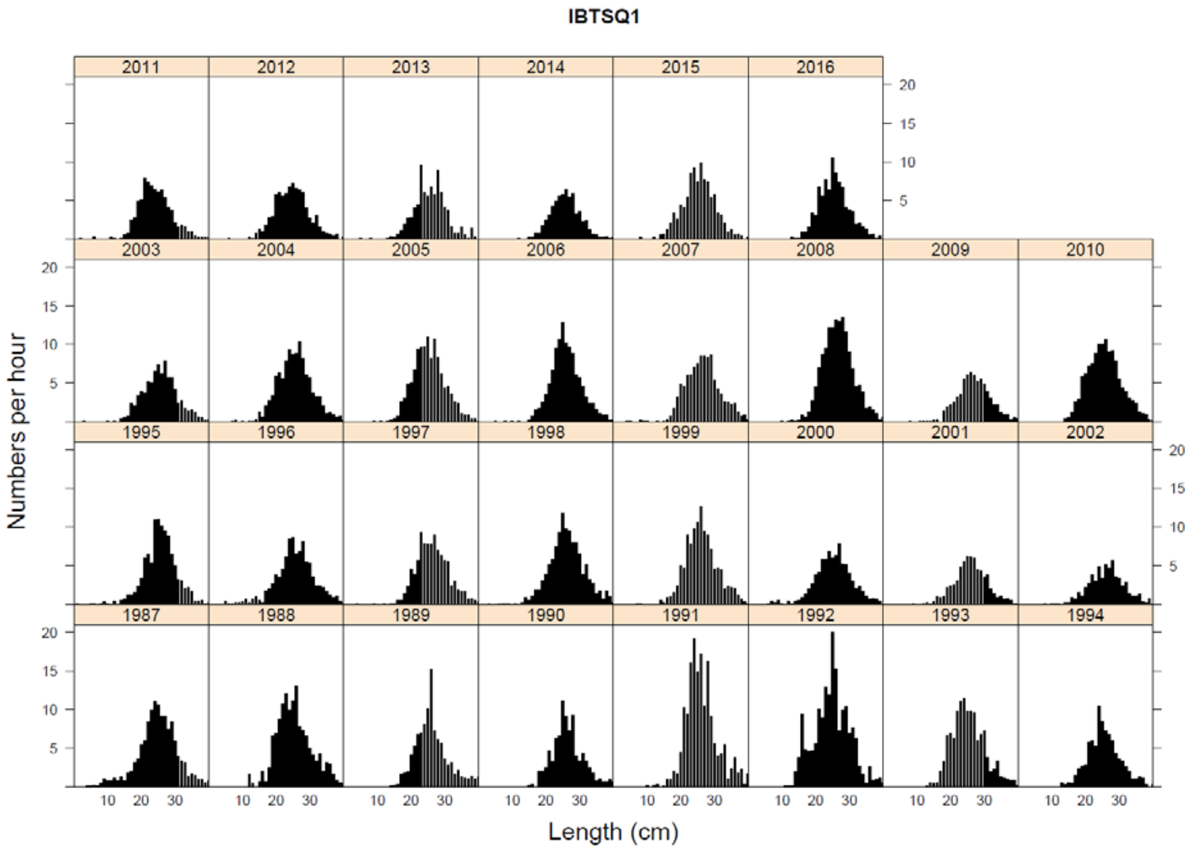

Figure 1 Flounder in area 4 and division 3a. Length distribution for flounder obtained from the NS-IBTS Q1.

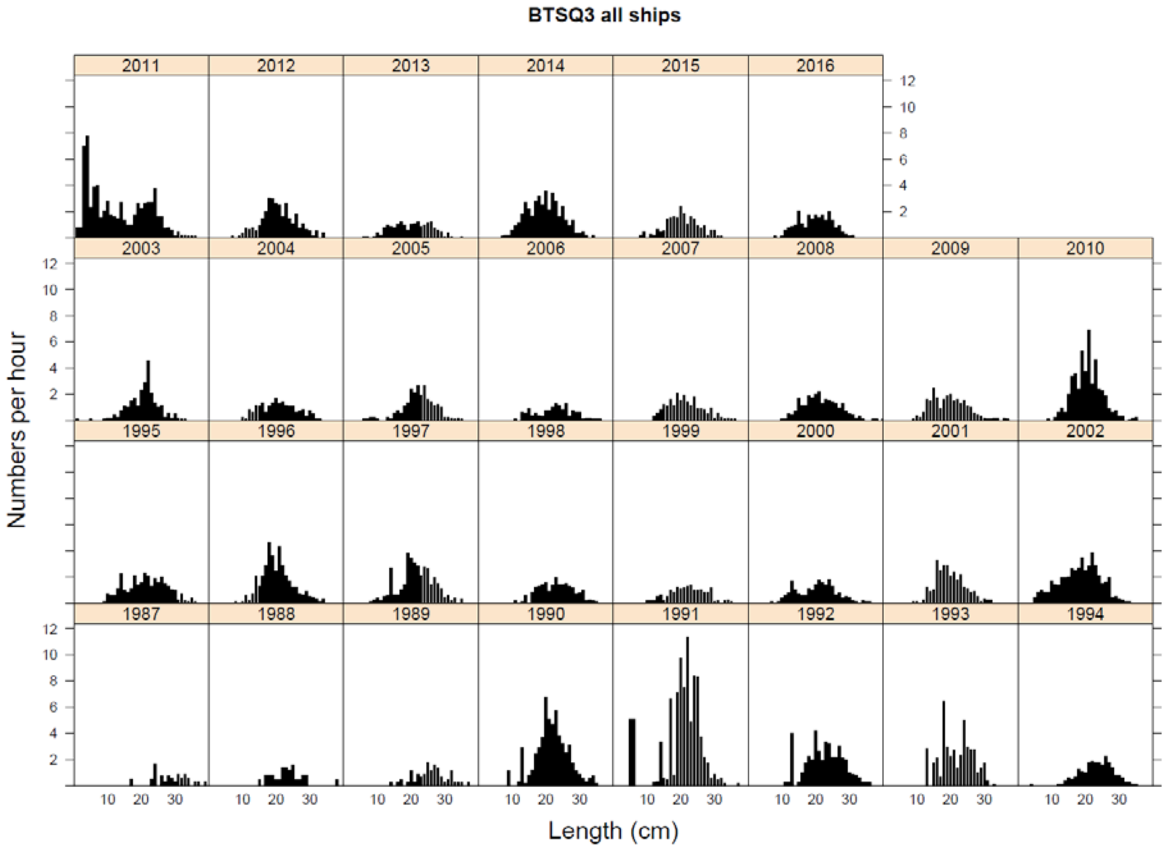

Figure 2 Flounder in area 4 and division 3a. Length distribution for flounder obtained from the BTS Q3.

Length-weight relationship

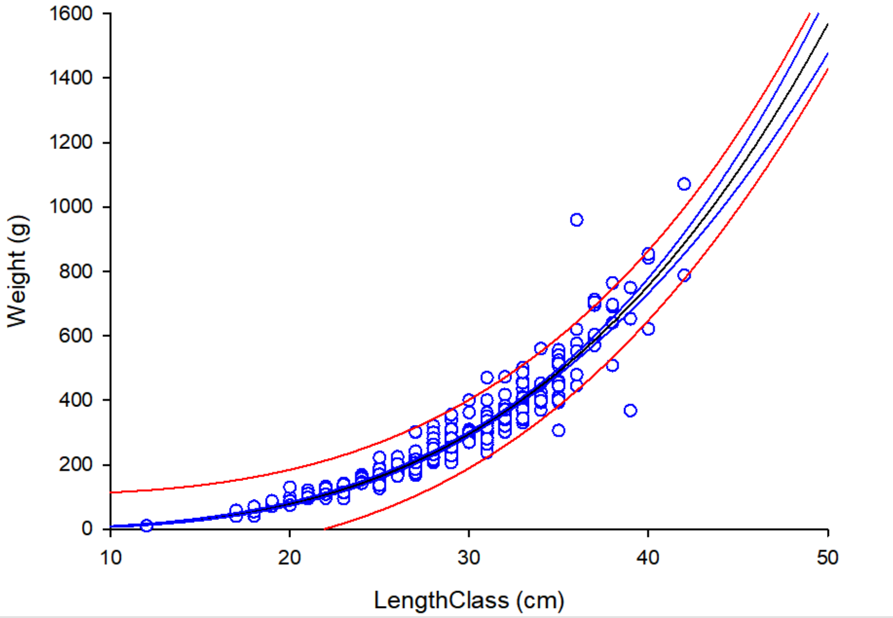

Figure 3 Flounder in area 4 and division 3a. Length-weight relationship obtained from the international bottom trawl survey Q1. W = 0.004 * LngtClass^3.264 (n=302).

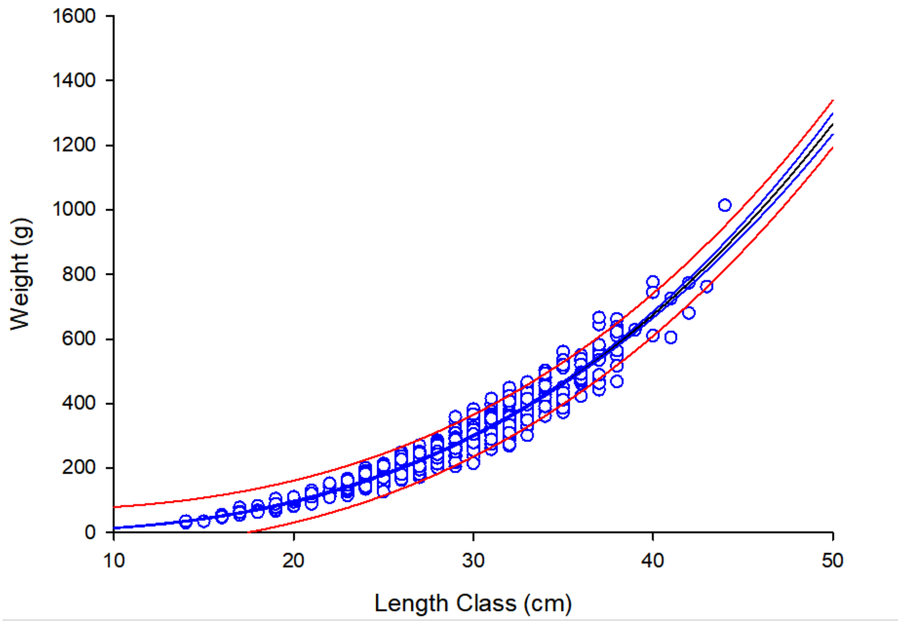

Figure 4 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey Q3. W = 0.020 * LngtClass^2.822 (n=671).

Maturity

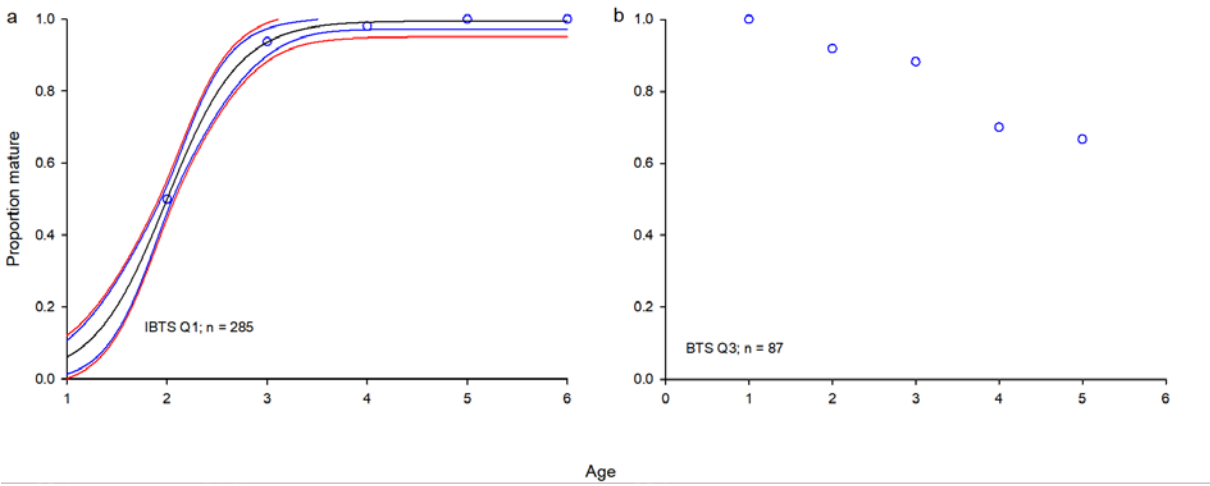

Figure 5 Flounder in area 4 and division 3a. Age based maturity data obtained from the NS-IBTSQ1 (a) and the BTSQ3 (b).

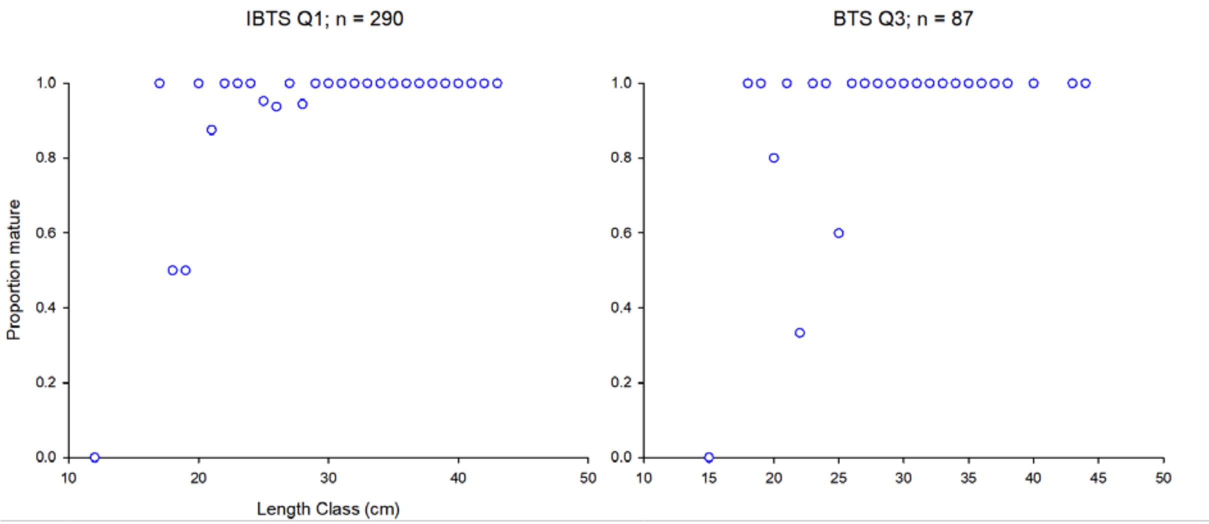

Figure 6 Flounder in area 4 and division 3a. Length based maturity data obtained from the NS-IBTSQ1 (a) and the BTSQ3 (b).

Annex

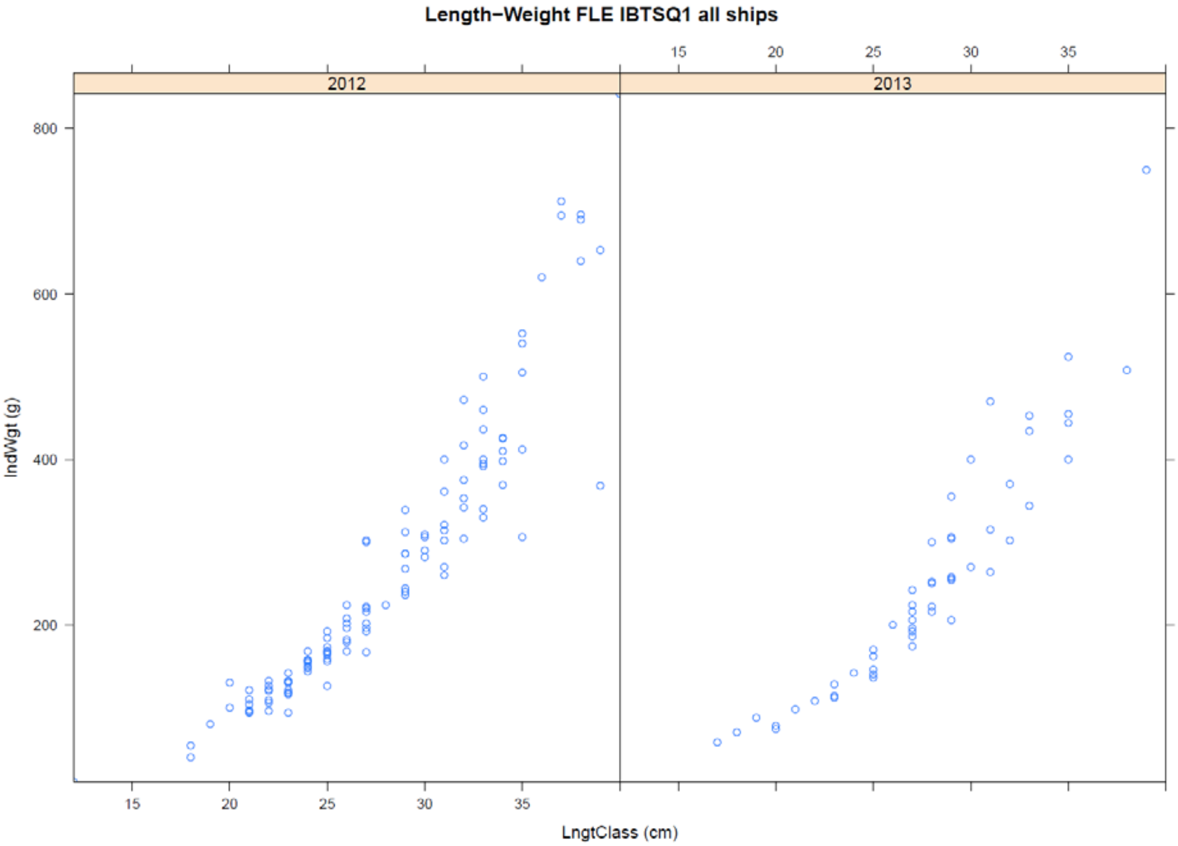

Figure 7 Flounder in area 4 and division 3a. Length-weight relationship obtained from the international bottom trawl survey NS-IBTS Quarter 1.

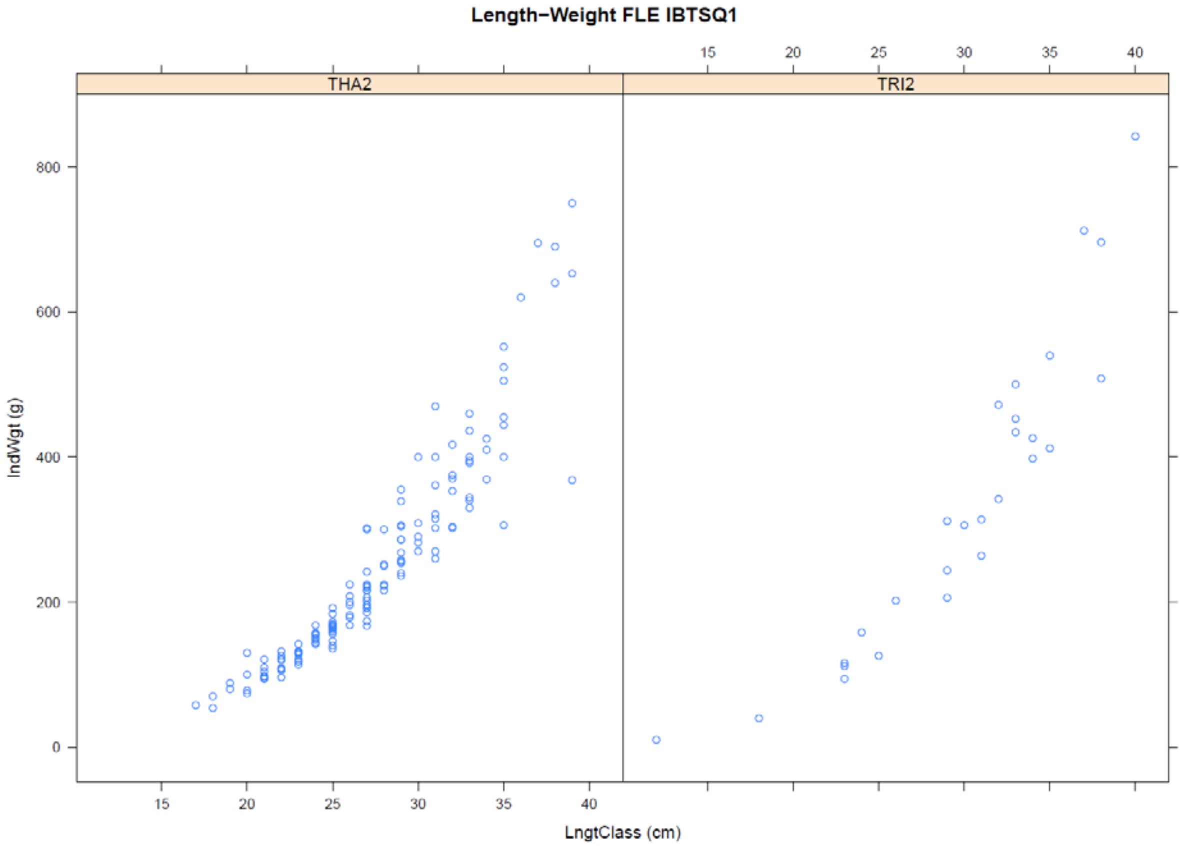

Figure 8 Flounder in area 4 and division 3a. Length-weight relationship obtained from the international bottom trawl survey IBTS Quarter 1 by ship. THA2 = RV Thalassa, TRI2 = RV Tridens.

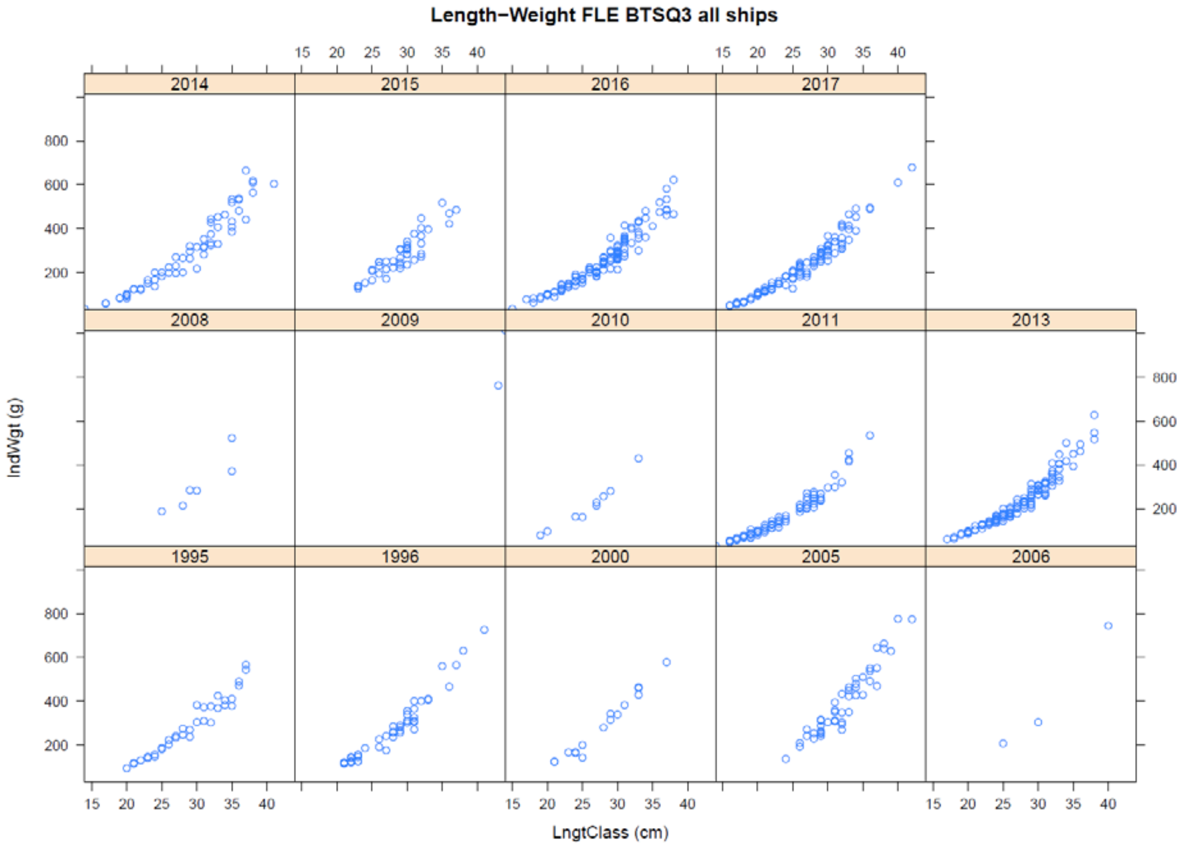

Figure 9 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey BTS Quarter 3.

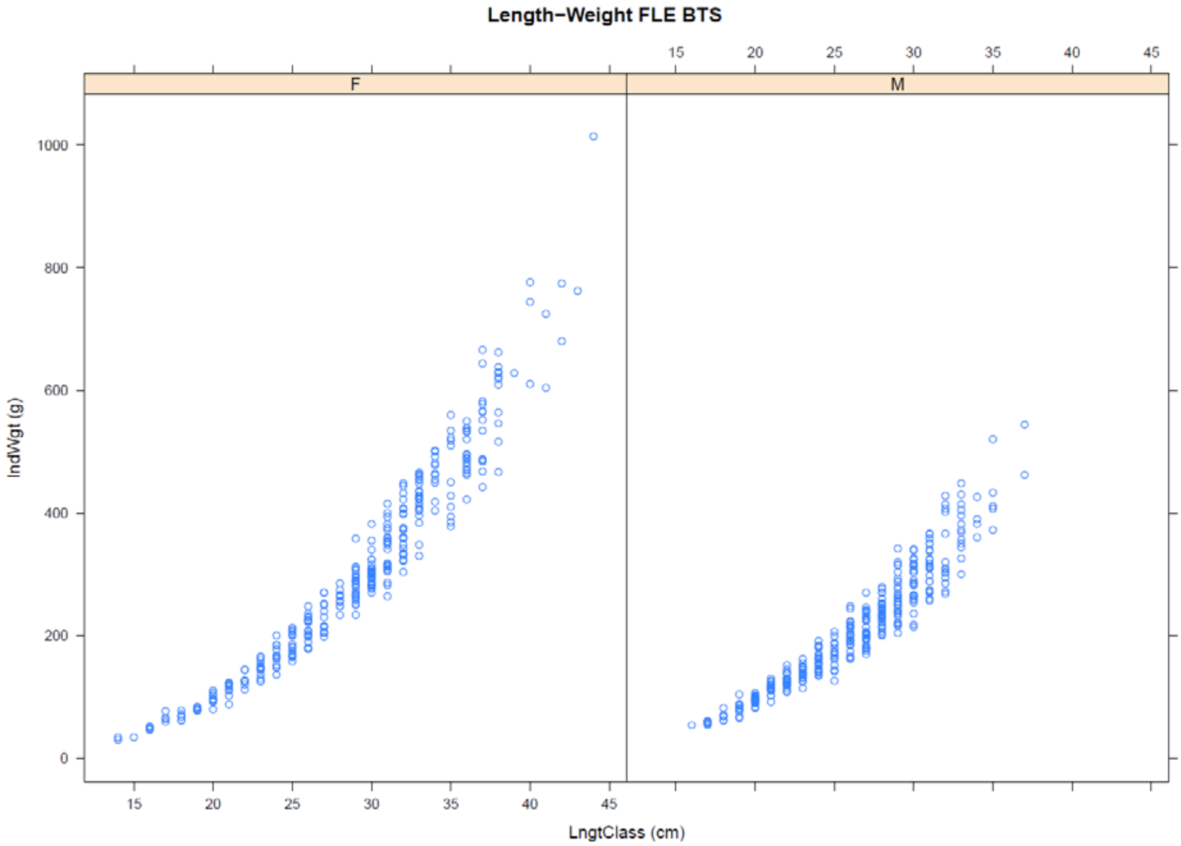

Figure 10 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey BTS Quarter 3 by sex. F = females, M = males.

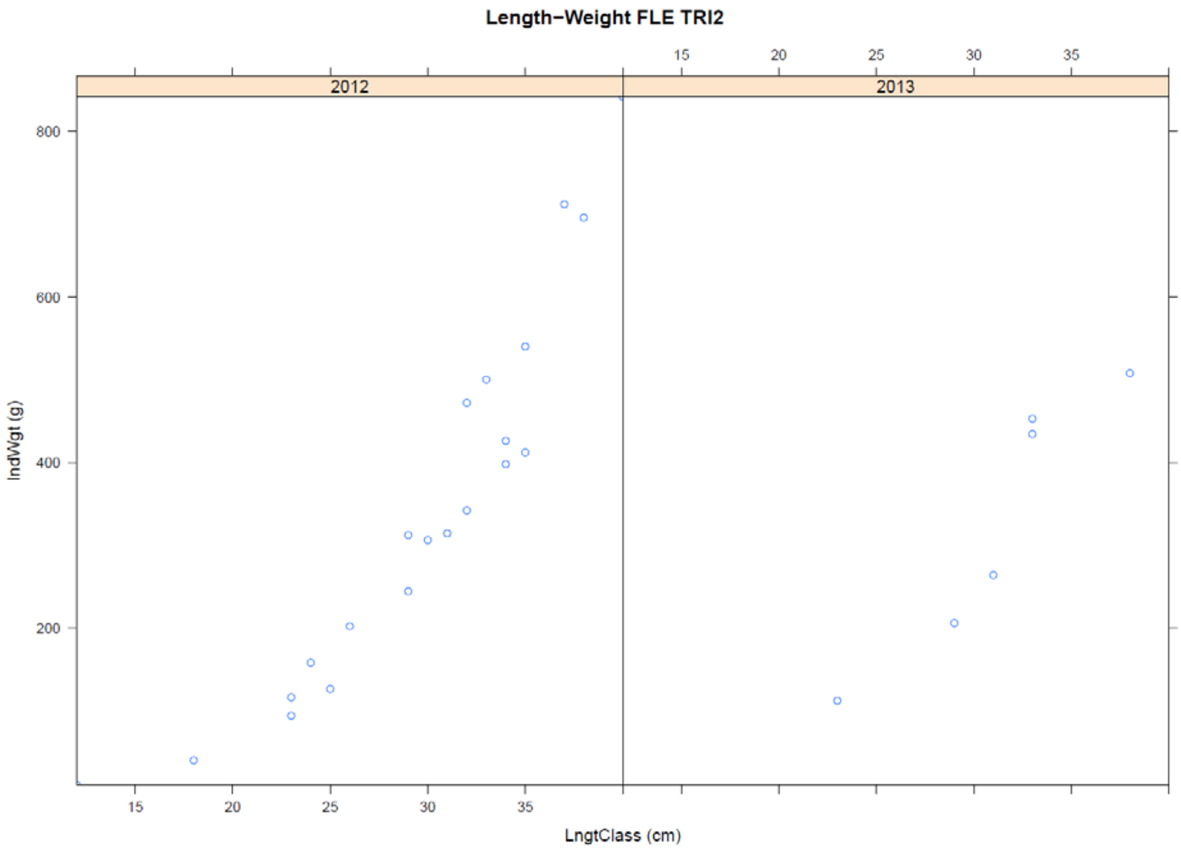

Figure 11 Flounder in area 4 and division 3a. Length-weight relationship obtained from the international bottom trawl survey NS-IBTSQ1 RV Tridens.

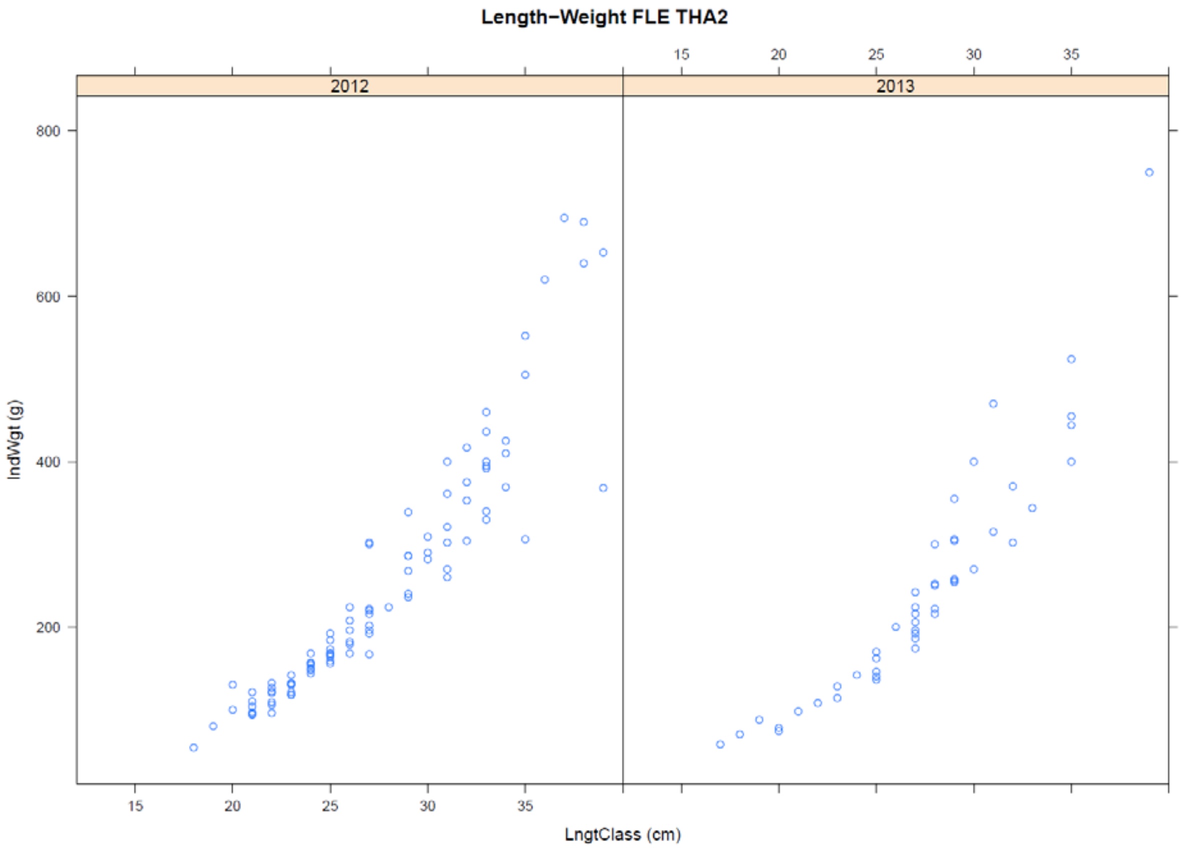

Figure 12 Flounder in area 4 and division 3a. Length-weight relationship obtained from the international bottom trawl survey NS-IBTSQ1 RV Thalassa.

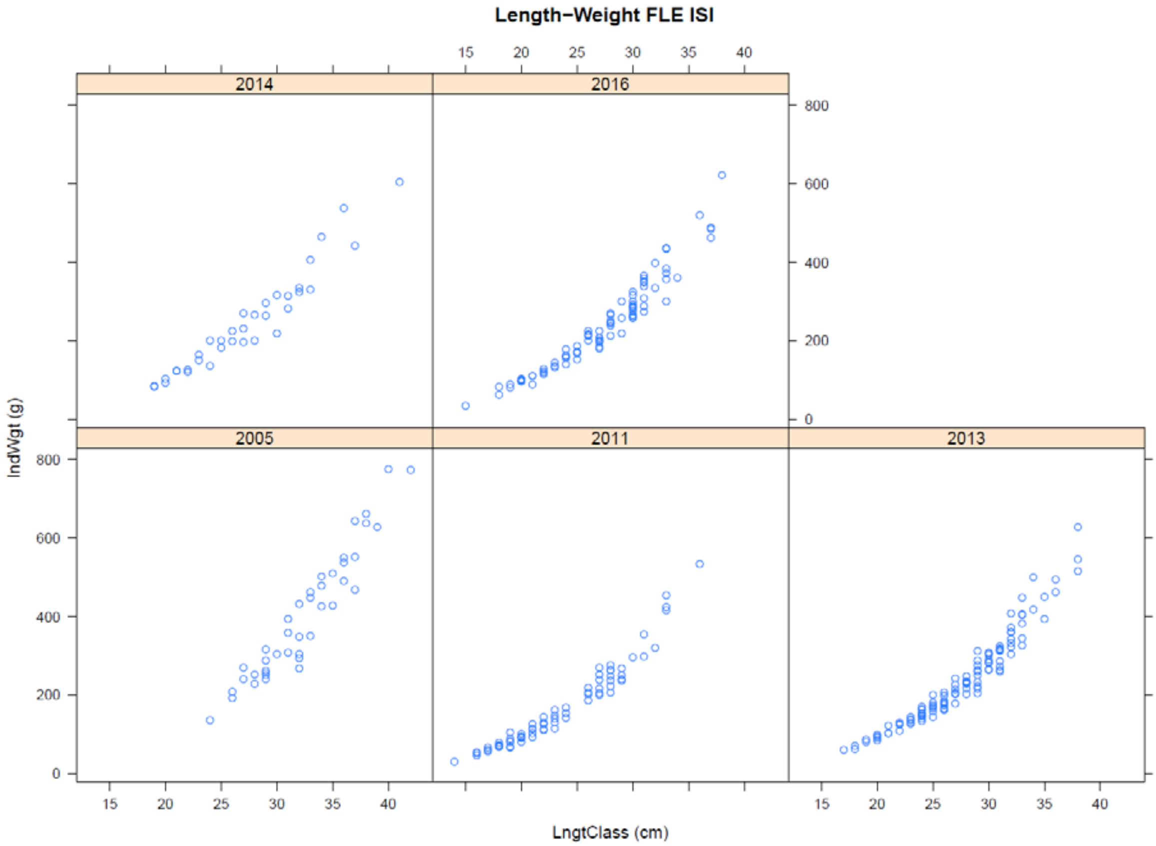

Figure 13 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey BTS Isis.

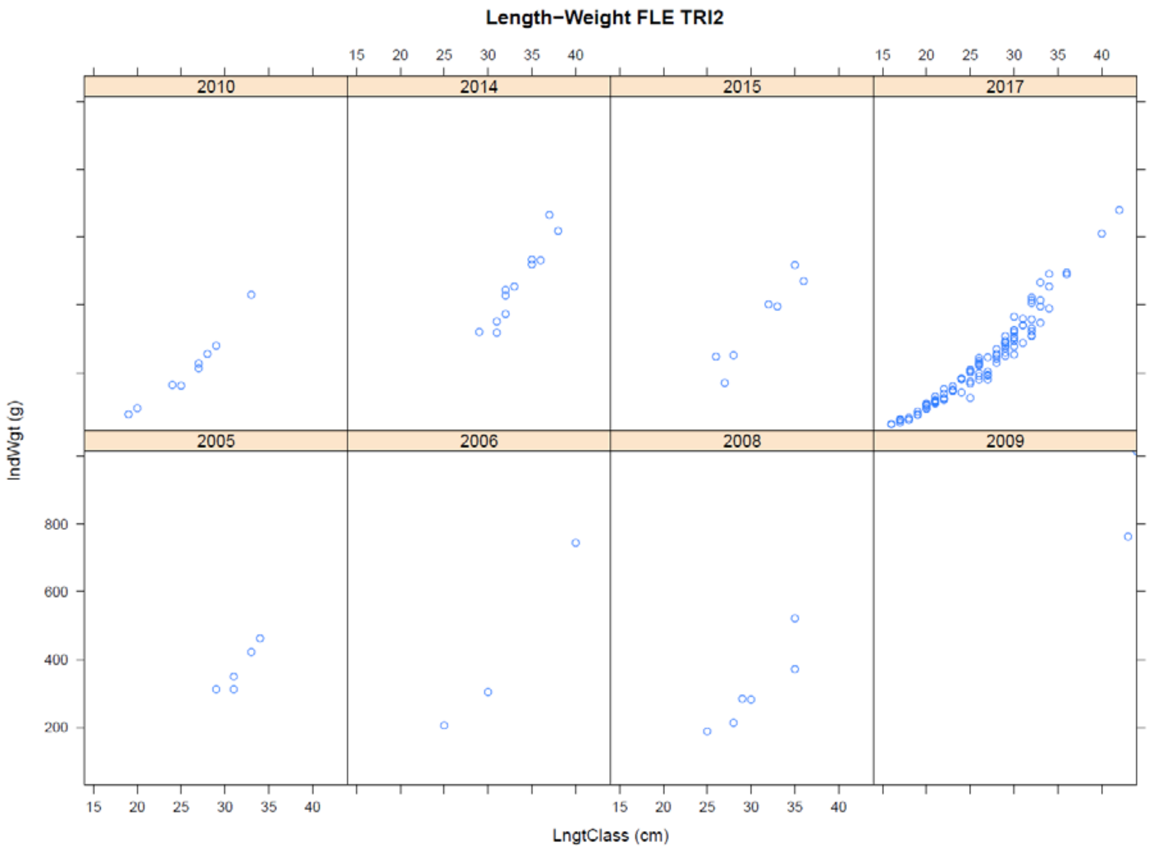

Figure 14 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey BTS Tridens.

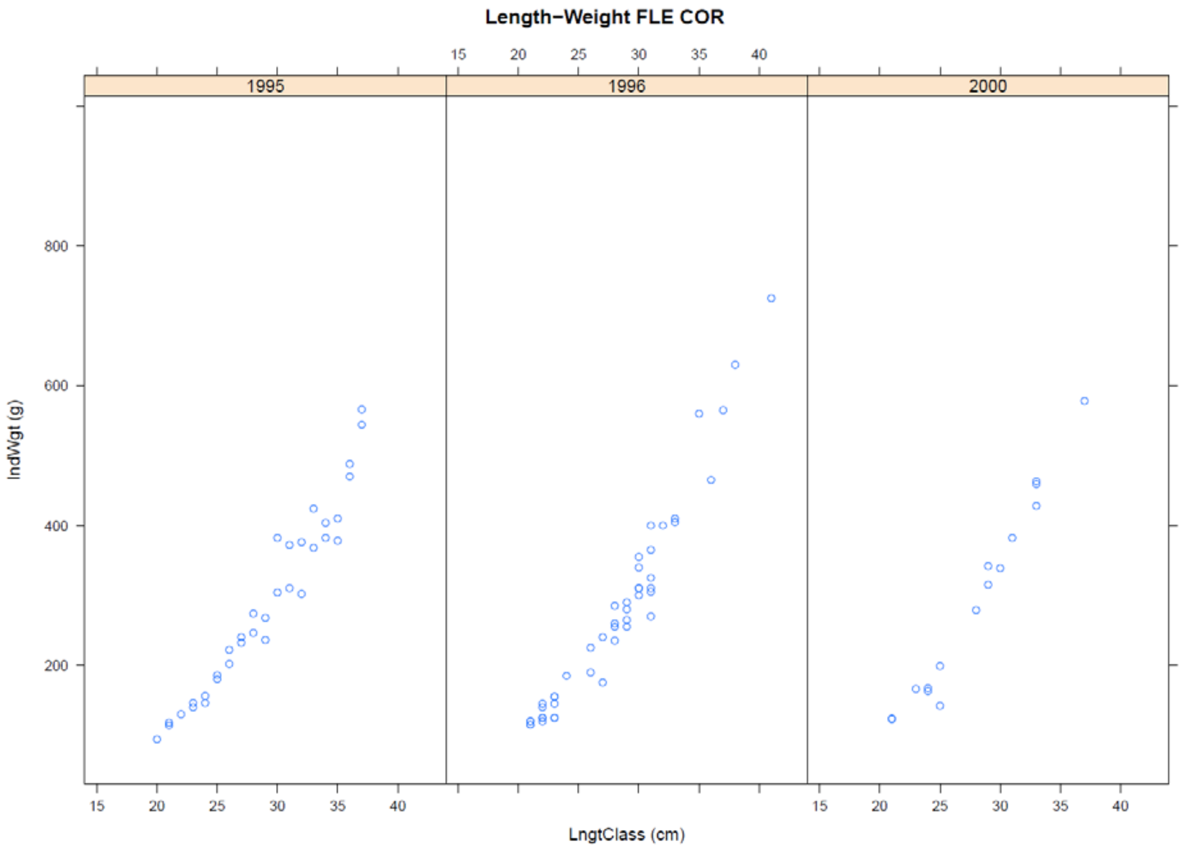

Figure 15 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam trawl survey BTS Corystes.

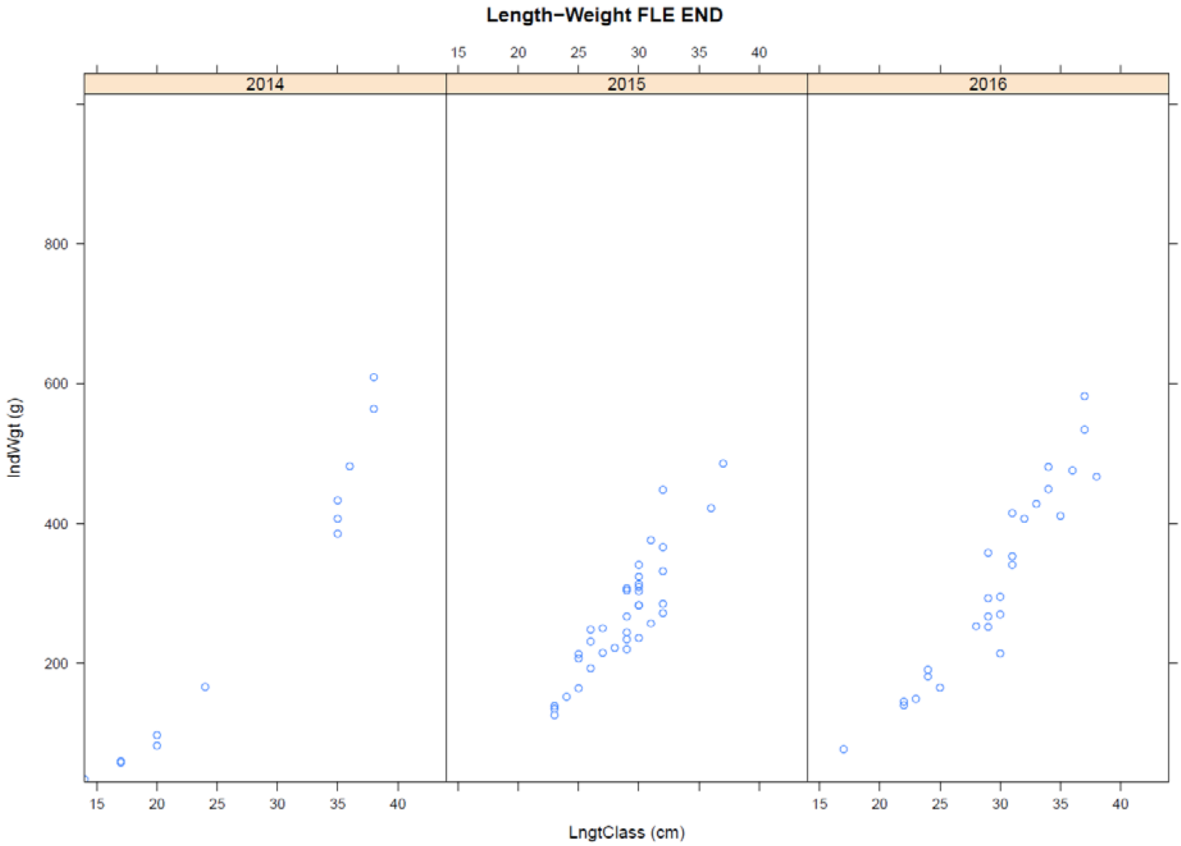

Figure 16 Flounder in area 4 and division 3a. Length-weight relationship obtained from the beam

Table 1 Flounder in Subarea 4 and Division 3a. Available survey data for flounder in the North Sea (Area 4), Skagerrak and Kattegat (Area 3a).

Survey	Year survey started	DATRAS	Standard Gear	Length distribution	Age	Individual Weight	Maturity
IBTS Q1	1965 – 2017	1983 – 2017	GOV	1983 – 2017	2012 – 2013	2012 – 2013	2012 – 2013
IBTS Q3	1991 – 2017	1991 – 2017	GOV	1991 – 2017	n.a.	2009 – 2010 (only RV END)	n.a.
BTS Isis (NDL)	1985 – 2017	1987 – 2017	BT8	1987 – 2017	2005; 2011; 2013 – 2014; 2016	2005; 2011; 2013 – 2014; 2016	2016
BTS Tridens (NDL)	1996 – 2017	1996 – 2017	BT8	1996 – 2017	2005 – 2006; 2008 – 2010; 2014 – 2015	2005 – 2006; 2008 – 2010; 2014 – 2015; 2017	2005 – 2006; 2008 - 2009
BTS Belgica (BEL)	1992 – 2017	2010 – 2017	BT4	2010 – 2017	n.a.	n.a.	n.a.
BTS Endevour (UK)	2008 – 2016	2008 – 2017	BT4	2008 – 2017	n.a.	2014 – 2016	n.a.
BTS Corystes (UK)	1988 – 2007	1990 – 2007	BT4	1990 – 2007	1995; 1996; 2000	1995; 1996; 2000	n.a.
BTS Solea (GER)	1991 – 2016	1998 – 1999; 2001 – 2005; 2007 - 2016	BT7	1998 – 1999; 2001 – 2005; 2007 – 2016	n.a.	n.a.	n.a.
SNS (NDL)	1969 - 2016	Not available yet	BT6	2002; 2004 – 2016	2007 – 2008; 2012 – 2014; 2016	2004 – 2016	2005 – 2006; 2008 - 2009
DFS (NDL)	1970 – 2016	2002 - 2016	BT3 and BT6	2002 – 2016	2006 - 2016	2004 – 2016	2005 – 2016
DYFS (GER)	1972 – 2016	Not available yet	BT3	2002 – 2016	n.a.	n.a.	n.a.
DFYS (BEL)	1973 - 2016	Not available yet	BT3	n.a.	n.a.	n.a.	n.a.

WD 4 – Flounder (27.3a4) SPiCT assessment

Holger Haslob, Casper Berg, Alexandros Kokkalis

Introduction

Flounder was defined as a category 3.2 stock following the ICES DLS guideline (ICES, 2012). The previous assessment of flounder was based on an IBTS quarter 1 mature biomass index. MSY proxy reference points were determined during the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak Kattegat (WGNSSK ICES, 2017) by using the length base indicator method (ICES, 2018). During the WGNSSK in 2017 also a SPiCT assessment run (Pedersen and Berg, 2017) was tried, but that model was not acceptable by that time. For the benchmark assessment in February 2018 landings and discard data were requested in InterCatch format from 2002 – 2016 and alternative survey indices were produced. These newly available data were used as input data for an improved SPiCT model and different model runs and scenarios were tested. The obtain final SPiCT assessment for North Sea flounder revealed that the flounder stock in the North Sea and Skagerrak is fished below the F_{MSY} proxy reference point.

Input Data

Based on the InterCatch raising procedure described in WD2 a catch time series for the years 2002 – 2016 was available and used (Figure 1a). Prior to 2002 only official landings for flounder were available (1950 – 2001), but no discard information. To account for the missing discard information the average discard ratio of 0.48 (2002 – 2016) obtained from the InterCatch data was used (Figure 1b) to top up the official landings. However, Dutch landings for the time period 1984 – 1997 are not available and these landings had to be reconstructed. This was done by raising the available official landing with a factor. This factor was based on the proportion of Dutch landings to the total landings for the time period with full data available. Because there are different patterns visible in the proportion of Dutch landings over the whole time series (Figure 2a), different years were used to calculate the average Dutch landings proportion to reconstruct the official landings (Figure 2b,c,d). Dutch landings before 1974 are remarkably low and thus it was decided not to use these data to reconstruct the landings time series. Further, there seem to be an issue with Danish and German official landings which drastically dropped after 1997 (Figure 2a, red and black bars). At least the drastic decline in Danish landings could be explained by a combined TAC for dab and flounder which was established in 1998, i.e. that before 1998 partly combined dab and flounder landings may have been reported by the Danish fishery. Another reason maybe misreporting to flounder from other quota species from the fishery in area 4 before the TAC came in force in 1998. Therefore, in the model set up higher uncertainties were put on the catches for the time periods where landings and catches were reconstructed.

The indices used are described in detail in WD1. A biomass index from the IBTS quarter 1 (1983 – 2016) and a biomass index combining the quarter 3 surveys IBTS, BTS and SNS (1987 – 2016) were used. Also for the indices different options were tested with the SPiCT model.

Scenarios tested

The reconstructed catch time series show that using the average Dutch landings for the time period 1998 – 2016 alone (Figure 2c) probably results in too high total catches. Therefore, this data set was not further tested in any SPiCT model run. In the first scenario run only the official landings were used as catch time series in order to compare the results of this run, which is obviously not realistic, to the results of the other runs. Scenarios 2 – 5 used different reconstructed landings time series and catch input data (Table 1). Very poor results were obtained by using only a short catch time series (Scenario 4 and 5). Thus, these scenarios were not further tested. The best results in terms of uncertainty was obtained with scenario 2, using the reconstructed catch time series by applying the average Dutch landing proportion of the time period 1974-1983. However, the diagnostics for scenario 2 (but also for scenario 3) revealed some autocorrelation issues with the two indices used. A strong pattern in the residuals was detected especially in the early period of the quarter 3 index (see Annex model output for Scenario 2). However, given the best results in terms of uncertainty around the relative biomass and relative fishing mortality, this scenario was further tested (Table 2). Detailed information on the different scenarios and model runs is displayed in table 1 and table 2.

First, it was tested to reduce the catch time series of scenario 2 (1983 – 2016), because the SPiCT model tend to perform better when the input time series, i.e. catch and survey indices in this case, start at the same year. This reduced the uncertainty around the relative biomass and the relative F (scenario 2a). However, this model did only converge when a prior on sd log(n) was used and the model was also quite sensitive to the used prior value. It only converged by setting the prior on sd log(n) = 0.8. Further, the strong residual pattern of the used survey indices remained. Therefore, the model was also tested by only using one index, either the IBTSQ1 index or the combined quarter 3 index (scenarios 2b and 2c). By removing one of the index time series the autocorrelation problem was solved. The model of scenario 2b converged but only by setting the prior on log(n) to 0.8. The model of scenario 2c also converged by only setting the prior on log(n) to 0.8, but this model run revealed a bad retro pattern (see Annex).

Final run

In a final run both indices were kept in the model, but the combined quarter 3 index was truncated to the time period 2002 – 2016, i.e. the time period for which all of the used surveys provide data. This model only converged by setting the prior on sd log(n) to 1. However, the strong residual pattern of the indices disappeared and the retro runs revealed good results. Thus, it was decided to keep this model as final run because it produced the best results in terms of uncertainty and the retro analyses, while keeping most information possible from the different surveys without any issues in the model diagnostics. This run showed that the relative fishing mortality (F_t/F_{MSY}) is below 1.0 and the relative biomass (B_t/B_{MSY}) is above 0.5 (see ANNEX III final run for detailed results and model ouputs). It should be noted here that the use of the prior probably leads to a slight underestimation of the uncertainties. However, all scenarios tested showed similar results with relative fishing mortality below the F_{MSY} proxy and relative biomass above the B_{MSY} proxy within their observed uncertainties.

Table 1 Flounder in Area 4 and 3a. Different scenarios tested with the SPiCT model.

	Catch time series	Reconstruction of catch	Index IBTSQ1	combined IndexQ3 (BTS, IBTS, SNS)	Uncertainties around catch time series	priors	Comment
Scenario 1	1974 - 2016	only official landings	1983 - 2016	1987 - 2016	(2) 1974 - 1982; (3) 1983 - 1997; (1) 1998 - 2016	default priors	converged; unrealistic and high uncertainty
Scenario 2	1974 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1974 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	1987 - 2016	(3) 1974 - 1982; (4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	default priors	converged; high uncertainty
Scenario 3	1974 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1974 - 1997 applying average Dutch proportion of landings (1974-1983; 1998 - 2016; 0.76); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	1987 - 2016	(3) 1974 - 1982; (4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	default priors	converged; even higher uncertainty compared to scenario 2
Scenario 4	1998 - 2016	InterCatch data 2002 - 2016; landings 1998 - 2001 * average discard ratio;	1983 - 2016	1987 - 2016	(3) 1998 - 2001, (2) 2002 - 2010, (1) 2011 - 2016	default priors	converged; lousy results with extreme uncertainties
Scenario 5	2002 - 2016	InterCatch data 2002 - 2016	1983 - 2016	1987 - 2016	(2) 2002 - 2010, (1) 2011 - 2016	default priors	converged; lousy results with extreme uncertainties

Table 2 Flounder in Area 4 and Division 3a. Different settings and input parameters testing scenario 2 with the SPiCT model.

	Catch time series	Reconstruction of catch	Index IBTSQ1	combined IndexQ3 (BTS, IBTS, SNS)	Uncertainties around catch time series	priors	diagnostics	Comment
Scenario 2 = base run	1974 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1974 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	1987 - 2016	(3) 1974 - 1982; (4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	default priors	issue with autocorrelation of survey indices	converged; high uncertainty
Scenario 2a -> truncated catch time series	1983 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1983 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	1987 - 2016	(4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	sd log n 0.8	issue with autocorrelation of survey indices	lower uncertainty; but only converges by setting prior: logn 0.8; very sensitive to the prior; strong retro pattern
Scenario 2b -> only IBTS Q1 index	1983 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1983 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	not used	(4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	default priors	o.k.	only converges by setting prior: logn 0.8; very sensitive to the prior; retro o.k.
Scenario 2c -> only IBTS Q3 index	1987 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1987 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	not used	1987 - 2016	(4) 1987 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	default priors	o.k.	very high uncertainties; retro bad
final run -> IBTS Q1 and truncated combined Q3 index	1983 - 2016	InterCatch data 2002 - 2016; reconstruct landings 1983 - 1997 applying average Dutch proportion of landings (1974-1983; 0.64); reconstruct discards with ratio 0.48 1974 - 2001 (average 2002 - 2016)	1983 - 2016	2002 - 2016	(4) 1983 - 1997; (3) 1998 - 2001; (2) 2002 - 2010; (1) 2011 - 2016	sd log n 1	o.k.	sensitive to prior setting; retro o.k.; no autocorrelation for indices

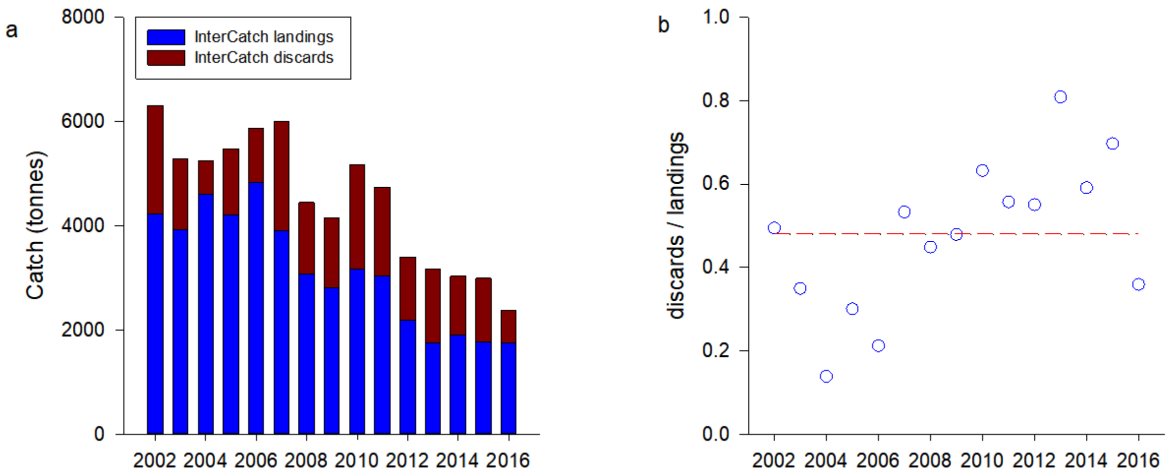

Figure 1 Flounder in Area 4 and Division 3a. InterCatch landings and discards (a), discard ratio and average discard ratio (0.48, dashed red line).

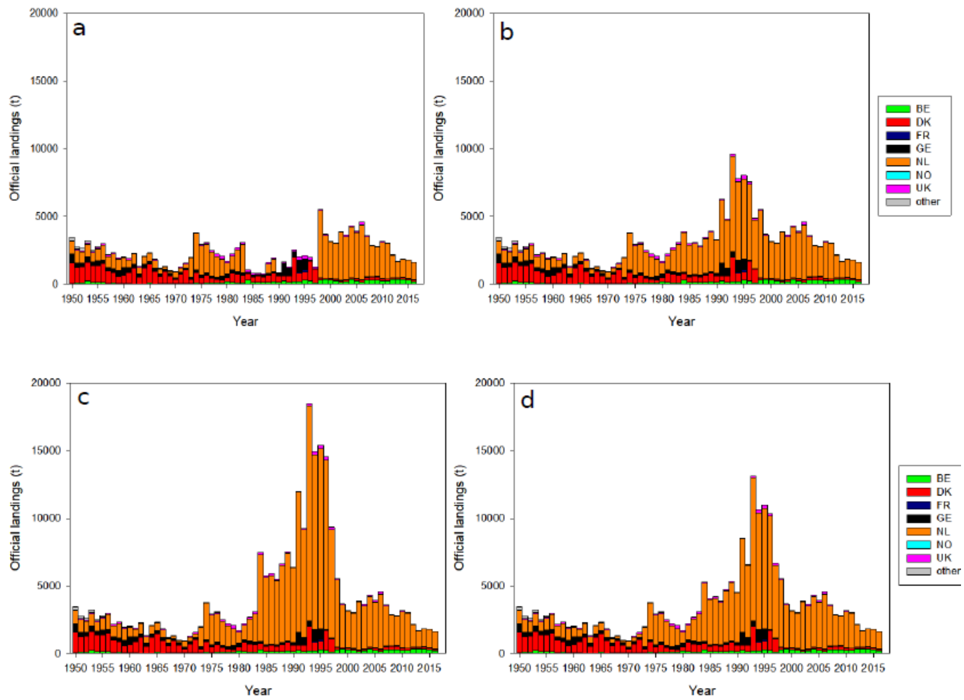

Figure 2 Flounder in area 4 and Division 3a. Official landings 1950 – 2016 (area 4) with Dutch data gap for the years 1984 – 1997 (a), and reconstructed time series applying different average Dutch landings proportion: 1974 – 1983 (b), 1998 – 2016 (c), 1974 – 1983 and 1998 – 2016 (d).

References

ICES 2018. Technical Guidelines - ICES reference points for stocks in categories 3 and 4. Doi: 10.17895/ices.pub.4128

ICES 2017. Report of the Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (2017). ICES CM 2017/ACOM: 21.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Pedersen, M. W., Berg C. W., 2017. A stochastic surplus production model in continuous time. Fish and Fisheries, 18: 226-243. DOI: 10.1111/faf.12174.

Annex I

Table Annex 1 Flounder in area 4 and Division 3a. Different reconstructed flounder catch time series used as input for SPiCT scenarios.

	Year	Official landings		Reconstructed landings Area 4			Reconstructed Catch (Total Landings * 1.48)		
		Area 4	Division 3a	factor = 2.78*	factor = 6.25*	factor = 4.17*	Catch_1	Catch_2	Catch_3
official landings complete	1974	3790	1658				8063	8063	8063
	1975	2939	1467				6521	6521	6521
	1976	3079	1099				6183	6183	6183
	1977	2505	1119				5364	5364	5364
	1978	2211	1648				5711	5711	5711
	1979	2077	1319				5026	5026	5026
	1980	1698	561				3343	3343	3343
	1981	2248	1905				6146	6146	6146
	1982	2689	1311				5920	5920	5920
	1983	3069	2512				8260	8260	8260
Dutch official landings missing	1984	1030	2746	2861	6438	4292	8299	13592	10416
	1985	793	1305	2203	4956	3304	5192	9267	6822
	1986	814	1751	2261	5088	3392	5938	10121	7611
	1987	754	1169	2094	4713	3142	4830	8705	6380
	1988	1598	1313	2544	5725	3817	5709	10416	7592
	1989	1951	1129	2875	6469	4313	5926	11245	8053
	1990	881	708	2447	5506	3671	4670	9197	6481
	1991	1659	624	4608	10369	6913	7744	16269	11154
	1992	1276	507	3544	7975	5317	5996	12553	8619
	1993	2545	743	7069	15906	10604	11562	24641	16794
	1994	2063	943	5731	12894	8596	9877	20478	14117
	1995	2125	498	5903	13281	8854	9473	20393	13841
	1996	2005	542	5569	12531	8354	9045	19348	13166
	1997	1290	437	3583	8063	5375	5950	12579	8602
official landings complete	1998	5560	725				9302	9302	9302
	1999	3672	588				6305	6305	6305
	2000	3165	656				5655	5655	5655
	2001	3022	705				5516	5516	5516
InterCatch years	2002	3890	524				6300	6300	6300
	2003	3637	473				5292	5292	5292
	2004	4294	478				5239	5239	5239
	2005	3946	482				5479	5479	5479
	2006	4616	393				5863	5863	5863
	2007	3620	445				5991	5991	5991
	2008	2894	346				4444	4444	4444
	2009	2815	273				4146	4146	4146
	2010	3160	205				5168	5168	5168
	2011	3048	145				4735	4735	4735
	2012	2192	118				3394	3394	3394
	2013	1703	173				3165	3165	3165
	2014	1874	194				3035	3035	3035
	2015	1806	77				2990	2990	2990
	2016	1630	108				2377	2377	2377

*factor based on the average proportion of Dutch landings to total landings for different time periods: 1973 - 1983 = 0.64; 1998 – 2016 = 0.84; 1973 – 1983 and 1998 – 2016 = 0.76.

Annex II

Flounder in area 4 and 3a - SPiCT assessment scenarios 1 – 5, WKNSEA Benchmark Meeting, 04. – 09.02.2018, ICES HQ Copenhagen.

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06 February 2018

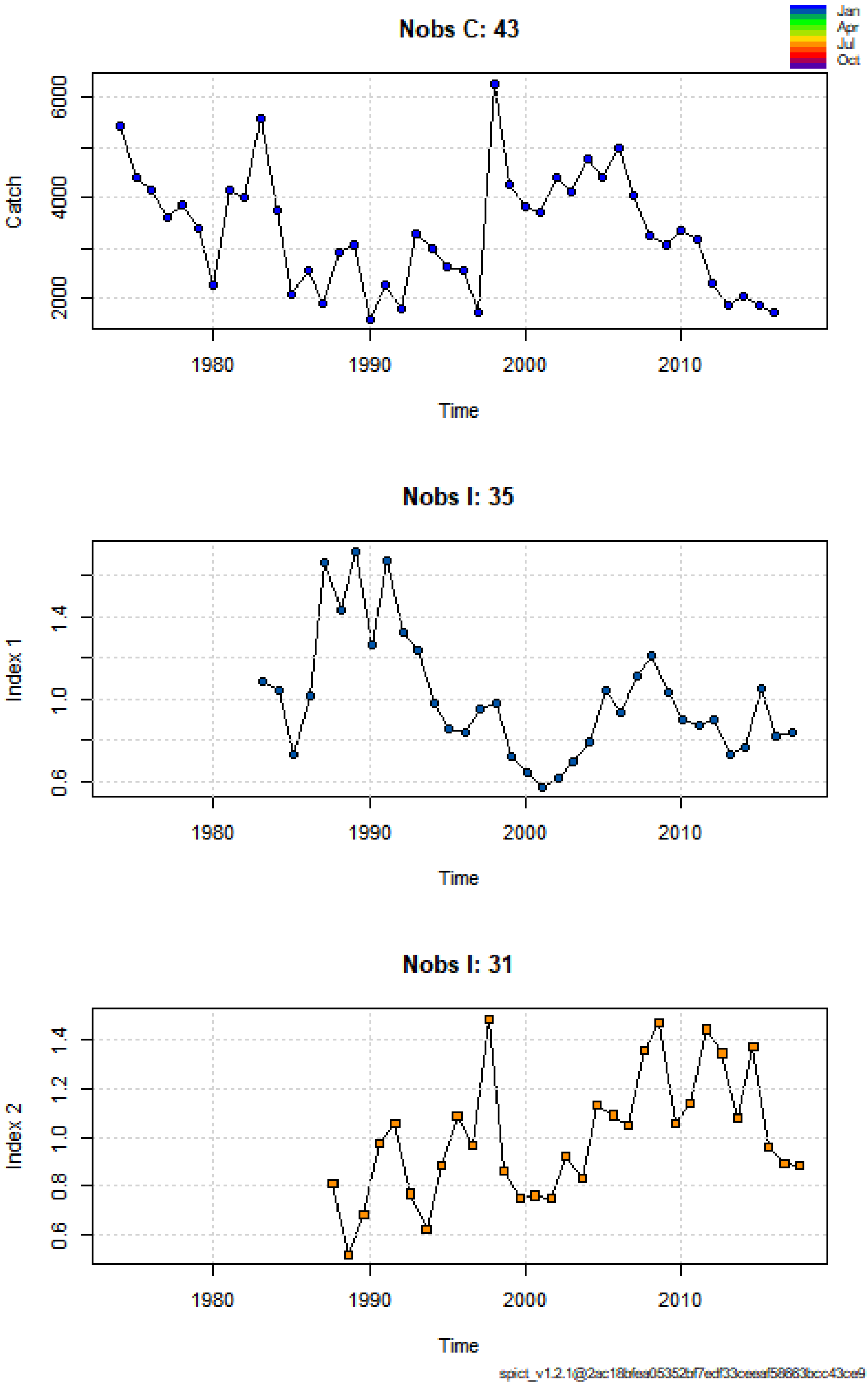
```
library(spict)

## Loading required package: TMB

## Welcome to spict_v1.2.1@2ac18bfea05352bf7edf33ceeaf58663bcc43ce9

load("FLE.Rdata")
load("fle_catch.Rdata")
```

SPiCT Scenario 1:

- using only official landings 1974 – 2016
- Index Q1 (1983 - 2016), combined index Q3 (1987 - 2016)
- Different uncertainties were applied for different time periods:
    - (2) 1974 - 1982
    - (3) 1983 - 1997
    - (1) 1998 – 2016
- Priors set to default

```
starty <- fle_catch[[3]]$time_start>=1974

stdevfacC <-  c(rep(3,length(1974:1982)),
                rep(4,length(1983:1997)),
                rep(3,length(1998:2001)),
                rep(2, length(2002:2010)),
                rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[3]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index),
                      newidxQ3$Index/mean(newidxQ3$Index)),

            timeC=fle_catch[[3]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),

            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())

inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0
```

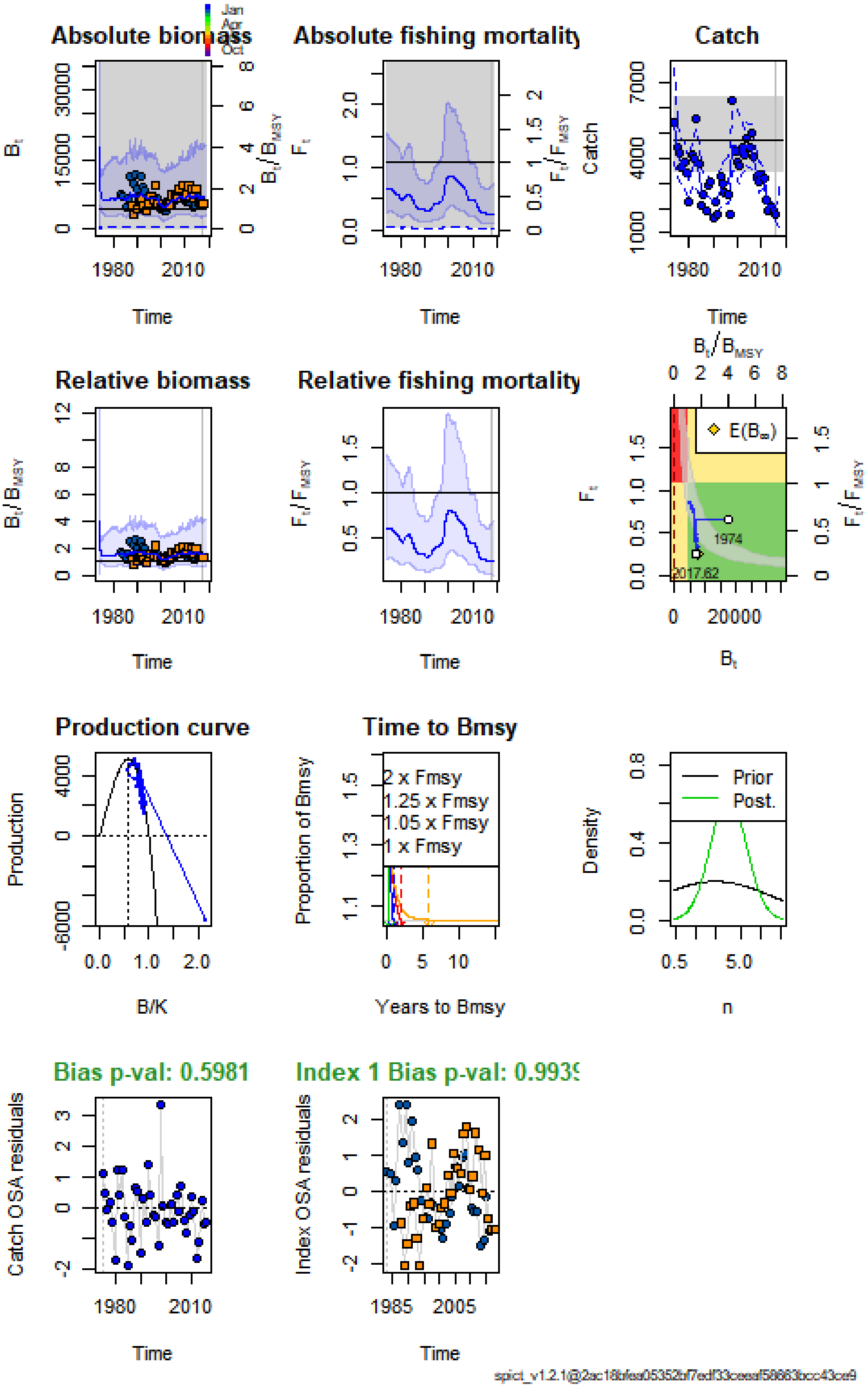
```
inp <- check.inp(inp)
plotspict.data(inp)
```



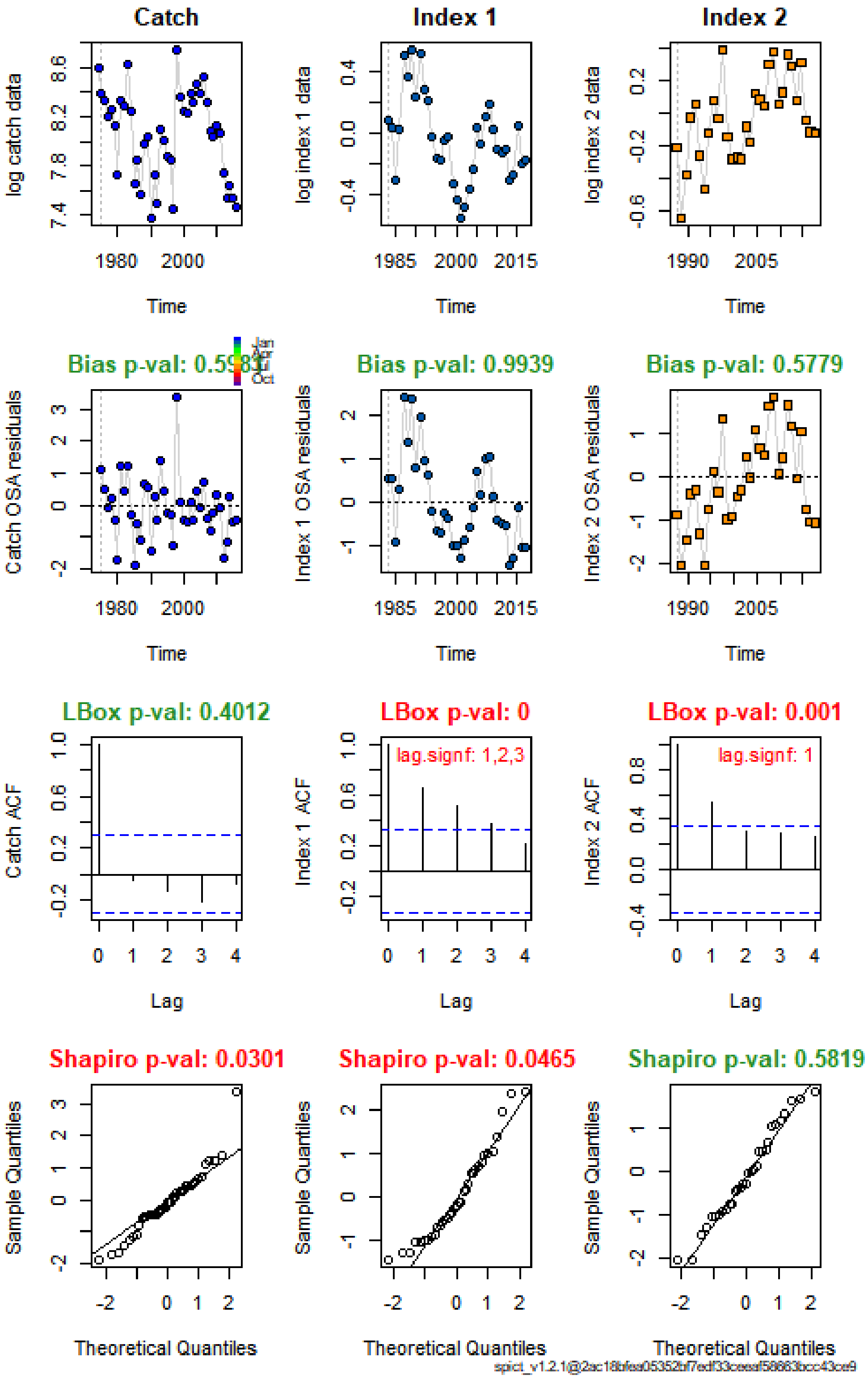

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 21.2346716
```

```
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 43,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.0301 0.5981 0.1656 0.4012       *    -   -    -
##  I1  0.0465 0.9939 0.0001 0.0000       *    - ***  ***
##  I2  0.5819 0.5779 0.0031 0.0010       -    -  **   **
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp    log.est
##  alpha1    1.0546090    0.2409360 4.616164e+00  0.0531701
##  alpha2    1.1052120    0.2650538 4.608475e+00  0.1000372
##  beta      1.0021909    0.5211218 1.927355e+00  0.0021885
##  r         3.4047292    0.5144979 2.253105e+01  1.2251654
##  rc        2.1404332    0.0975582 4.696122e+01  0.7610082
##  rold      1.5608387    0.0408742 5.960282e+01  0.4452233
##  m      5096.2760840 3768.1985467 6.892426e+03  8.5362654
##  K      8094.5828123  557.1138480 1.176102e+05  8.9989503
##  q1        0.0001479    0.0000092 2.378700e-03 -8.8189475
##  q2        0.0001555    0.0000098 2.470500e-03 -8.7688051
##  n         3.1813460    0.9394863 1.077287e+01  1.1573044
##  sdb       0.2068476    0.0532102 8.040921e-01 -1.5757729
##  sdf       0.1898710    0.1142556 3.155296e-01 -1.6614102
##  sdi1      0.2181434    0.1524104 3.122262e-01 -1.5226028
##  sdi2      0.2286105    0.1671132 3.127386e-01 -1.4757357
##  sdc       0.1902870    0.1373387 2.636485e-01 -1.6592217
##
## Deterministic reference points (Drp)
##           estimate        cilow        ciupp  log.est
##  Bmsyd 4761.910992  225.2447554 100671.80588 8.468404
##  Fmsyd    1.070217    0.0487791     23.48061 0.067861
##  MSYd  5096.276084 3768.1985467   6892.42608 8.536265
## Stochastic reference points (Srp)
##           estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 4402.487386  125.2320400 154767.86276 8.3899250 -0.081641030
##  Fmsys    1.077797    0.0341671     33.99897 0.0749193  0.007033348
##  MSYs  4747.712966 3495.5053972   6448.50339 8.4654183 -0.073417058
##
## States w 95% CI (inp$msytype: s)
##                     estimate       cilow        ciupp    log.est
##  B_2017.62      6988.5162054 470.5080841 1.038013e+05  8.8520235
##  F_2017.62         0.2560766   0.0172185 3.808420e+00 -1.3622788
##  B_2017.62/Bmsy    1.5874018   0.6464918 3.897721e+00  0.4620986
##  F_2017.62/Fmsy    0.2375926   0.0885524 6.374781e-01 -1.4371980
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
##  B_2017.62      6988.5162054  470.5080841 1.038013e+05  8.8520235
##  F_2017.62         0.2560766    0.0172185 3.808420e+00 -1.3622788
```

```
## B_2017.62/Bmsy     1.5874018    0.6464918 3.897721e+00  0.4620986
## F_2017.62/Fmsy     0.2375926    0.0885524 6.374781e-01 -1.4371980
## Catch_2017.62   1857.4270696 1180.0148771 2.923722e+03  7.5269475
## E(B_inf)        7283.9827763           NA           NA  8.8934331
plot(fit)
```



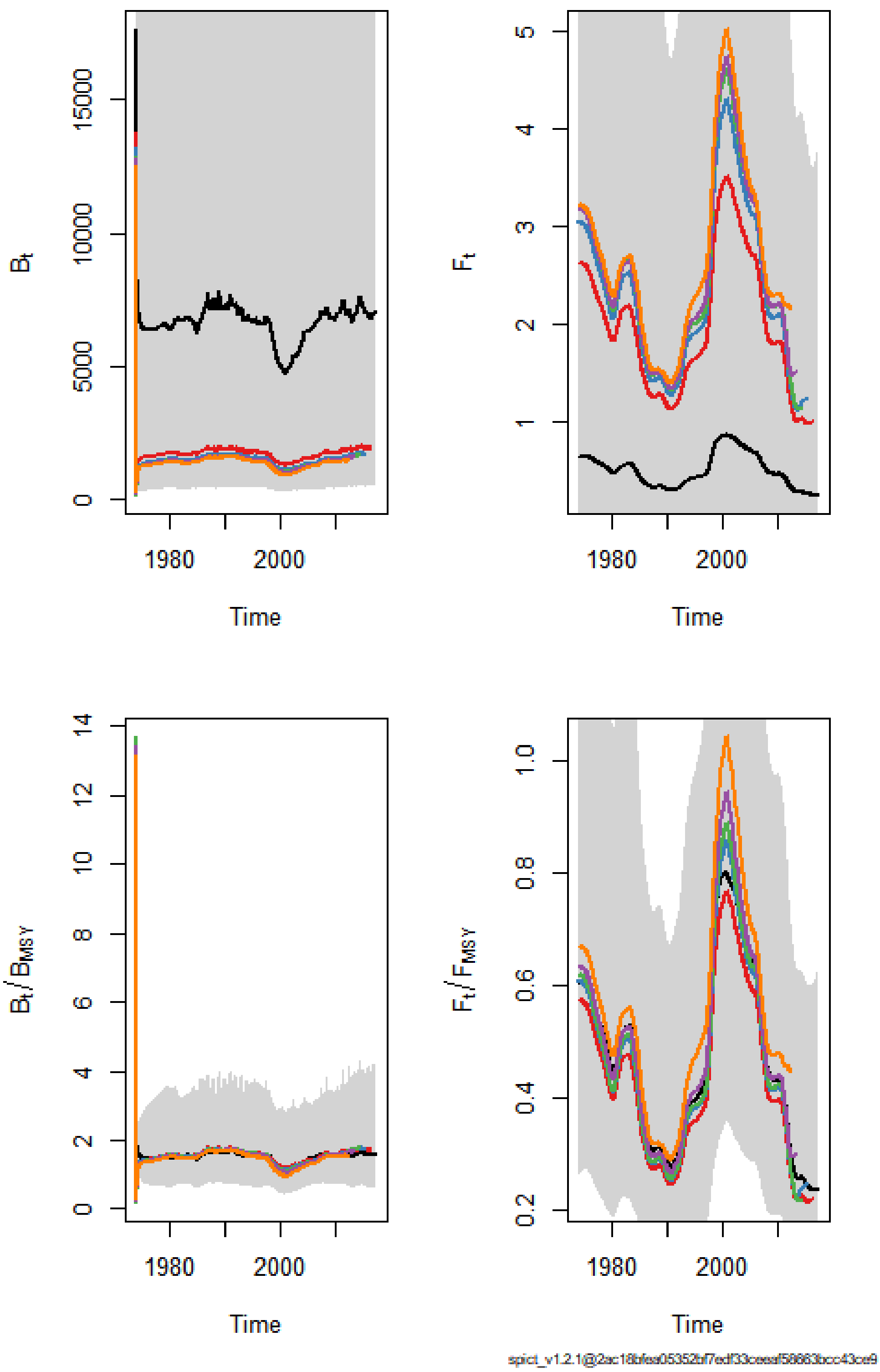
```
plotspict.diagnostic(fit)
```



There are some issues in the model diagnostics.

```
retro<-retro(fit)
```

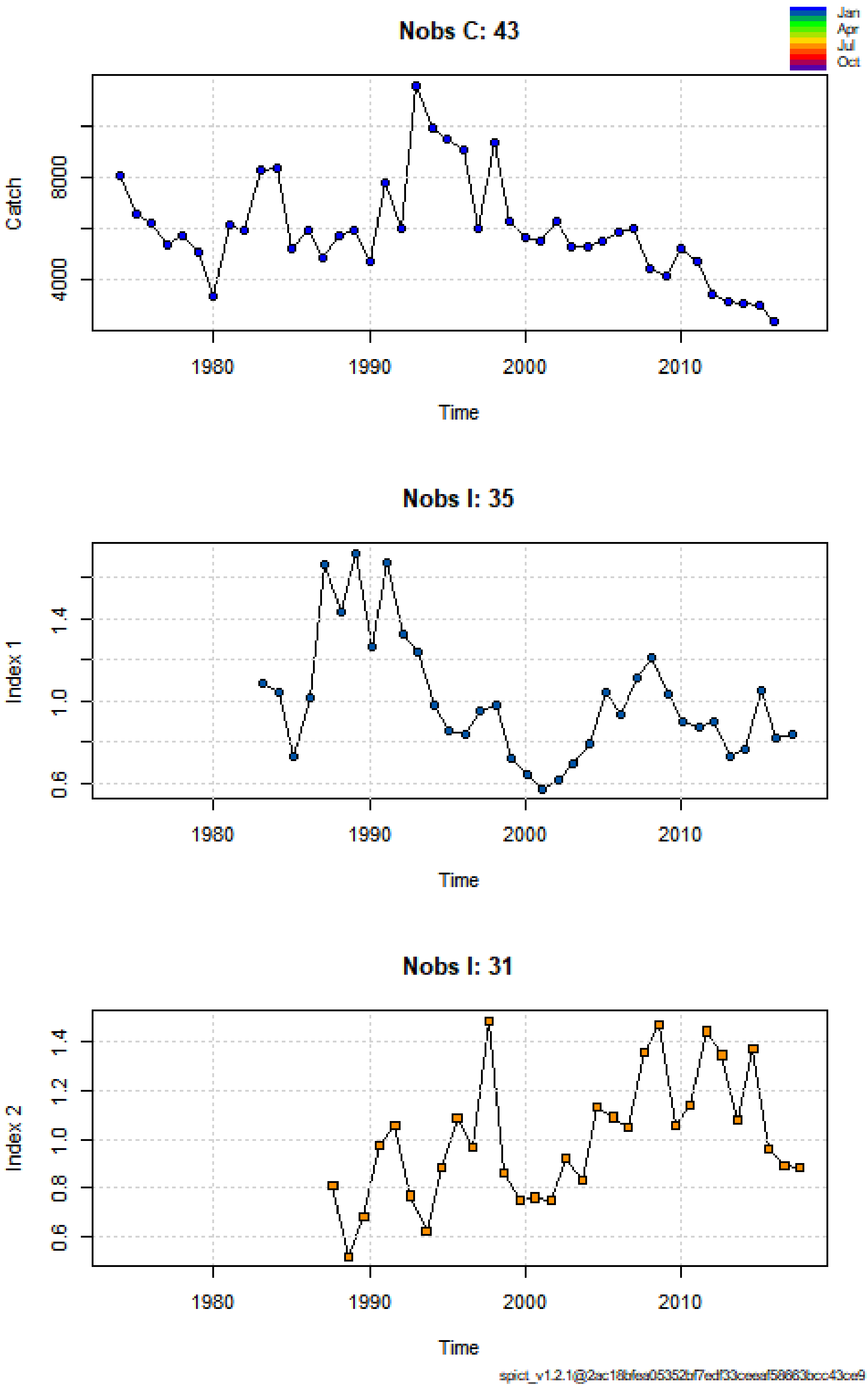
```
## Warning in sqrt(diag(cov)): NaNs wurden erzeugt

## Warning in sqrt(diag(cov)): NaNs wurden erzeugt
plotspict.retro(retro)

## Warning in sqrt(rep$diag.cov.random[indran]): NaNs wurden erzeugt

## Warning in sqrt(rep$diag.cov.random[indran]): NaNs wurden erzeugt
```



SPiCT scenario 2 – base run:

- InterCatch data 2002-2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- Index Q1 (1983 - 2016), combined index Q3 (1987 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (3) 1974 - 1982
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 – 2016
- Priors set to default

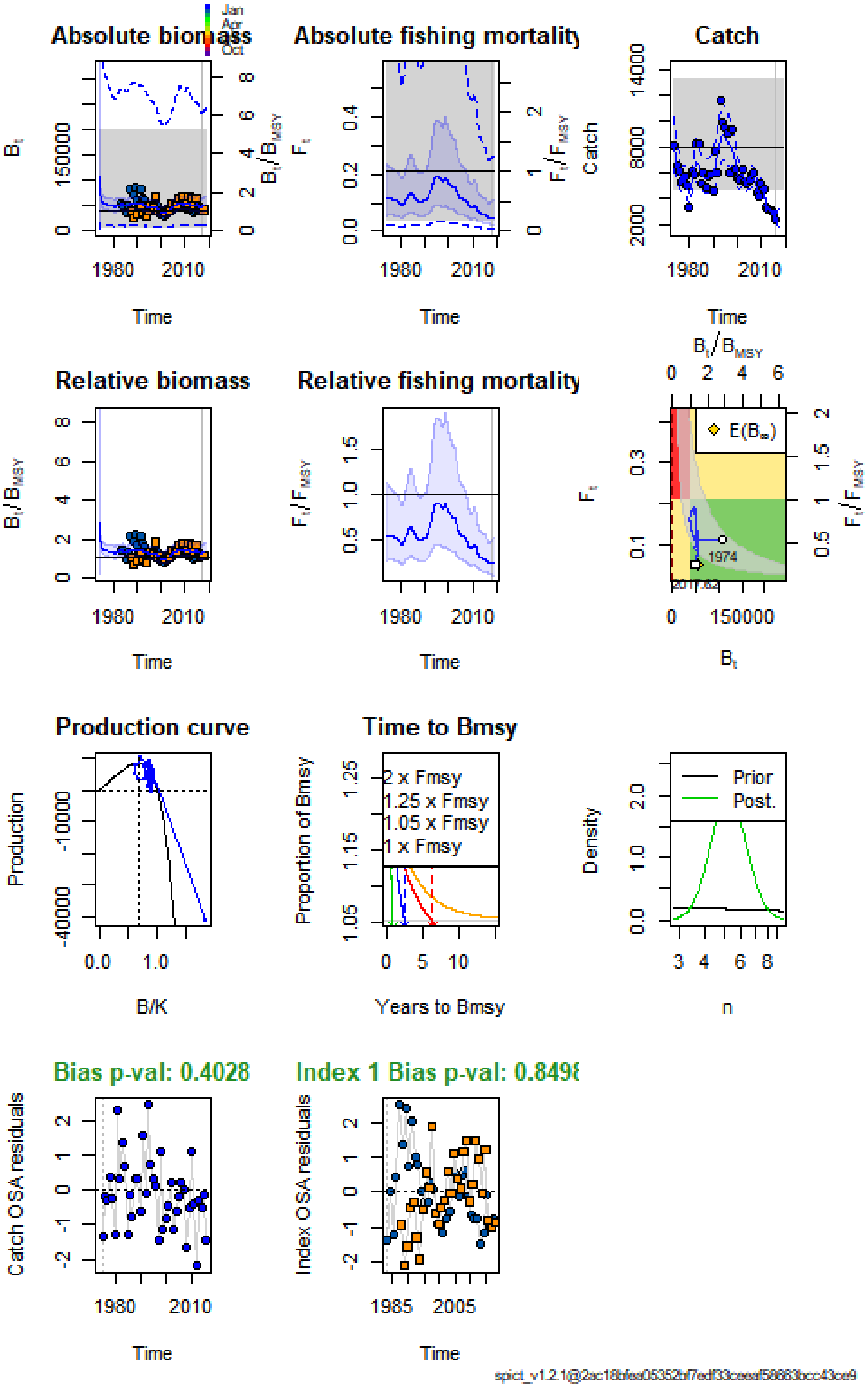
```
starty <- fle_catch[[1]]$time_start>=1974

stdevfacC <- c(rep(3,length(1974:1982)),
               rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index),
                      newidxQ3$Index/mean(newidxQ3$Index)),

            timeC=fle_catch[[1]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),

            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())

inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0


inp <- check.inp(inp)


plotspict.data(inp)
```



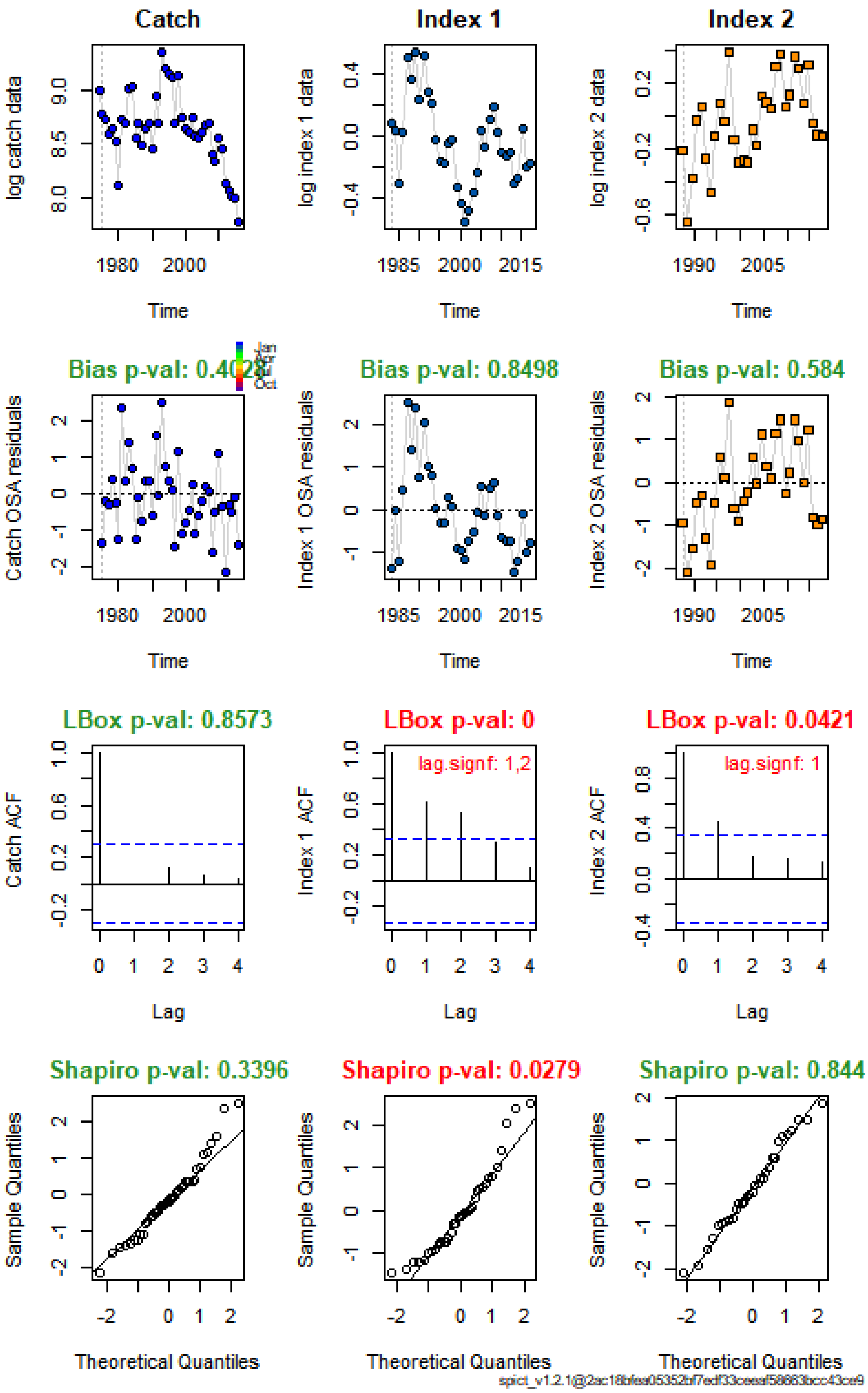

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 12.0782193
## Euler time step (years):  1/16 or 0.0625
```

```
## Nobs C: 43,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.3396 0.4028 0.4546 0.8573       -    -   -    -
##  I1  0.0279 0.8498 0.0003 0.0000       *    - ***  ***
##  I2  0.8440 0.5840 0.0134 0.0421       -    -   *    *
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha1 2.028749e+00 7.635392e-01 5.390456e+00   0.7074196
##  alpha2 1.993891e+00 7.839563e-01 5.071204e+00   0.6900881
##  beta   9.351017e-01 4.560627e-01 1.917313e+00  -0.0671000
##  r      1.147732e+00 3.477927e-01 3.787570e+00   0.1377880
##  rc     4.437168e-01 9.541600e-02 2.063435e+00  -0.8125688
##  rold   2.750202e-01 5.429010e-02 1.393184e+00  -1.2909107
##  m      8.656626e+03 5.087446e+03 1.472982e+04   9.0660803
##  K      5.785029e+04 1.175181e+04 2.847780e+05  10.9656137
##  q1     2.020000e-05 3.800000e-06 1.081000e-04 -10.8097773
##  q2     2.140000e-05 4.000000e-06 1.127000e-04 -10.7539064
##  n      5.173265e+00 3.492134e+00 7.663701e+00   1.6435040
##  sdb    1.116801e-01 4.800120e-02 2.598360e-01  -2.1921171
##  sdf    1.495273e-01 9.072260e-02 2.464481e-01  -1.9002763
##  sdi1   2.265709e-01 1.592174e-01 3.224168e-01  -1.4846975
##  sdi2   2.226779e-01 1.630689e-01 3.040766e-01  -1.5020289
##  sdc    1.398232e-01 9.661120e-02 2.023630e-01  -1.9673763
##
## Deterministic reference points (Drp)
##            estimate       cilow        ciupp   log.est
##  Bmsyd 3.901870e+04 7359.334992 2.068746e+05 10.571796
##  Fmsyd 2.218584e-01    0.047708 1.031717e+00 -1.505716
##  MSYd  8.656626e+03 5087.446173 1.472982e+04  9.066080
## Stochastic reference points (Srp)
##            estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 3.808072e+04 7182.4691698 2.019001e+05 10.547463   -0.02463143
##  Fmsys 2.090483e-01    0.0422247 1.034968e+00 -1.565190   -0.06127809
##  MSYs  7.948692e+03 4787.6650762 1.319677e+04  8.980763   -0.08906290
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp    log.est
##  B_2017.62      4.857424e+04 1.003011e+04 2.352374e+05 10.7908486
##  F_2017.62      4.993070e-02 9.682800e-03 2.574752e-01 -2.9971198
##  B_2017.62/Bmsy 1.275560e+00 9.733011e-01 1.671685e+00  0.2433852
##  F_2017.62/Fmsy 2.388476e-01 1.154153e-01 4.942858e-01 -1.4319297
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
##  B_2017.62      4.857424e+04 1.003011e+04 2.352374e+05 10.7908486
##  F_2017.62      4.993070e-02 9.682800e-03 2.574752e-01 -2.9971198
##  B_2017.62/Bmsy 1.275560e+00 9.733011e-01 1.671685e+00  0.2433852
```

```
## F_2017.62/Fmsy 2.388476e-01 1.154153e-01 4.942858e-01 -1.4319297
## Catch_2017.62  2.510120e+03 1.698340e+03 3.709920e+03  7.8280860
## E(B_inf)       5.292736e+04           NA           NA 10.8766757
plot(fit)
```

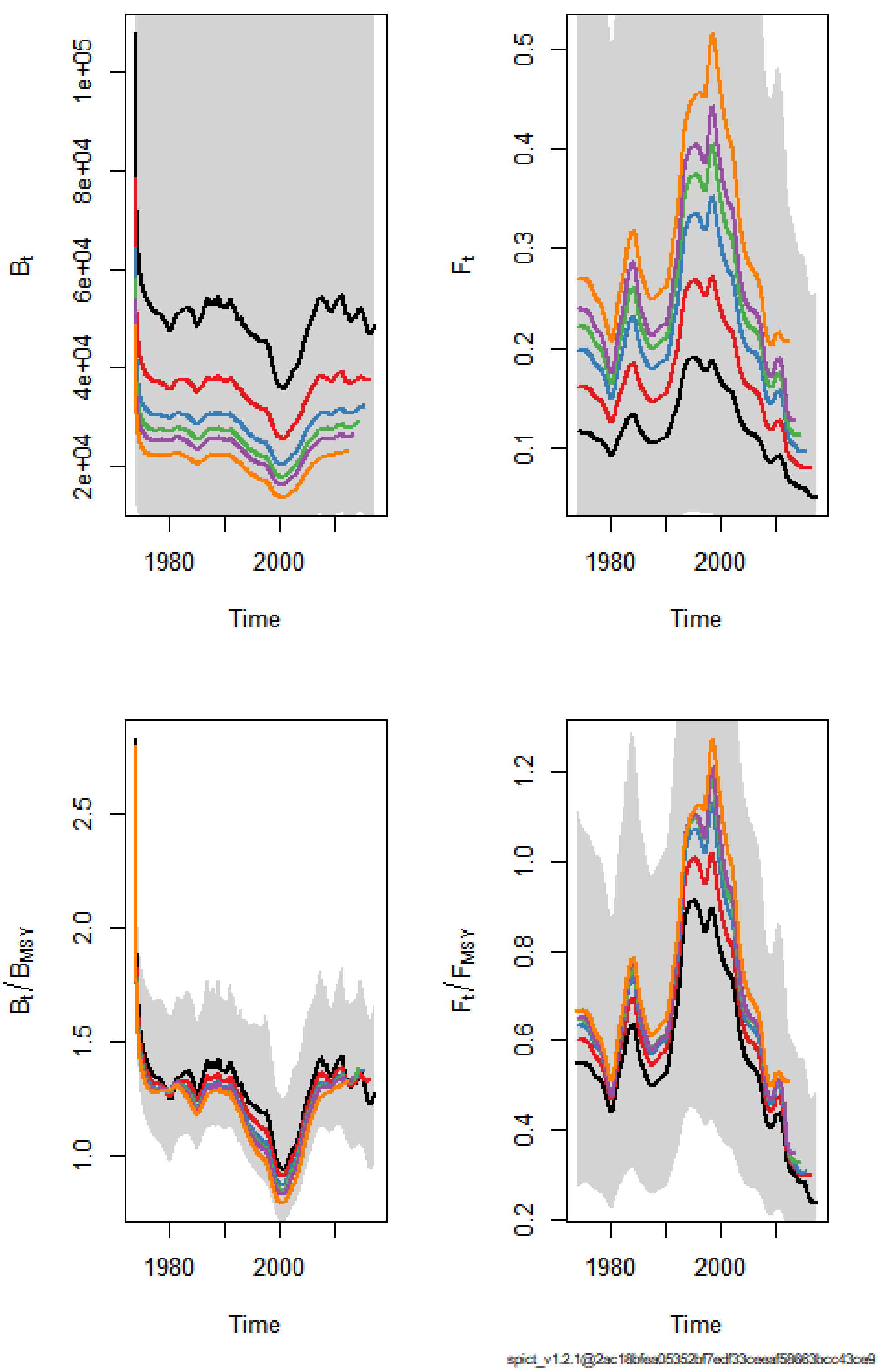


```
plotspict.diagnostic(fit)
```



There are some issues in the fit with the autocorrelation of the residuals of the Q3 biomass index.

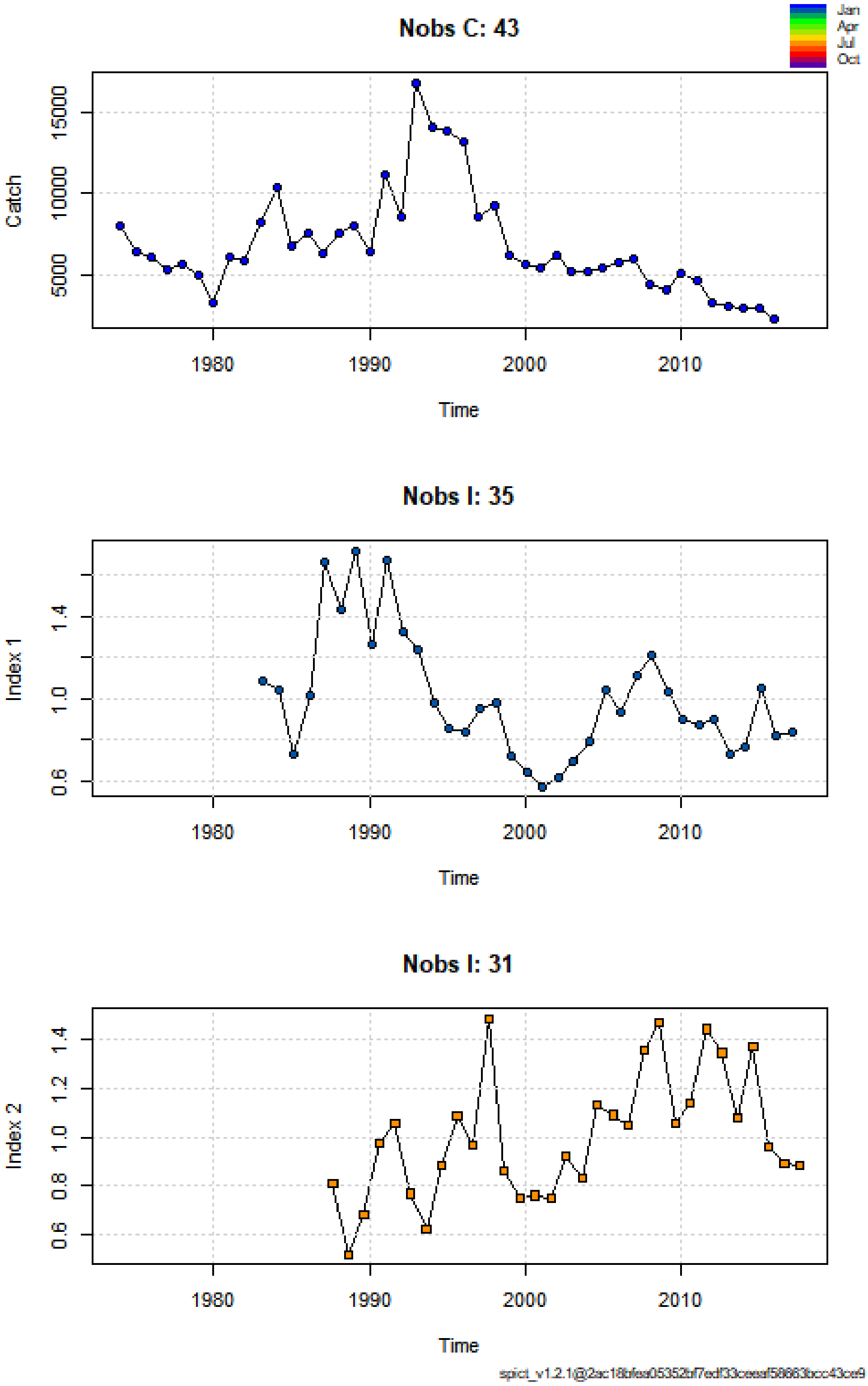
```
retro<-retro(fit)
plotspict.retro(retro)
```



SPiCT Scenario 3:

- InterCatch data 2002-2016
- reconstructed Dutch landings 1984-1997 by applying average Dutch landings proportion (1974 - 1983; 1998 - 2016; 0.76)
- Index Q1 (1983 - 2016); combined Index Q3 (1987 - 2016)
- Different uncertainties were applied for different time periods:
  - (3) 1974 - 1982
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 – 2016
- Prior on sd log(n) set to 0.8

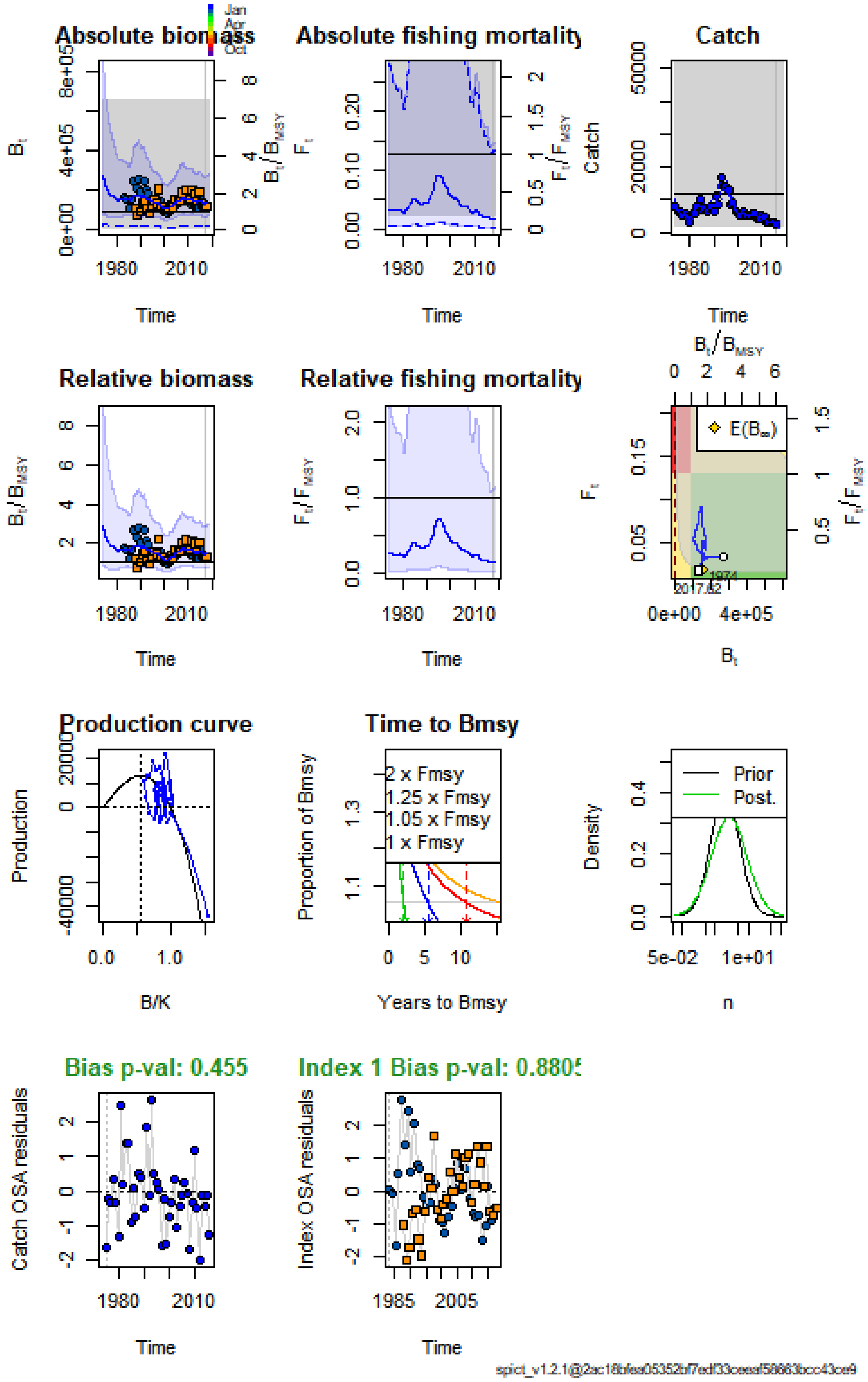
```
starty <- fle_catch[[2]]$time_start>=1974

stdevfacC <-c(rep(3,length(1974:1982)),
             rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[2]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index), newidxQ3$Index/m
ean(newidxQ3$Index)),

            timeC=fle_catch[[2]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),
            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),
            stdevfacC = stdevfacC/mean(stdevfacC),
           priors = list())

inp$priors$logn<-c(log(2),1,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0

inp <- check.inp(inp)

plotspict.data(inp)
```



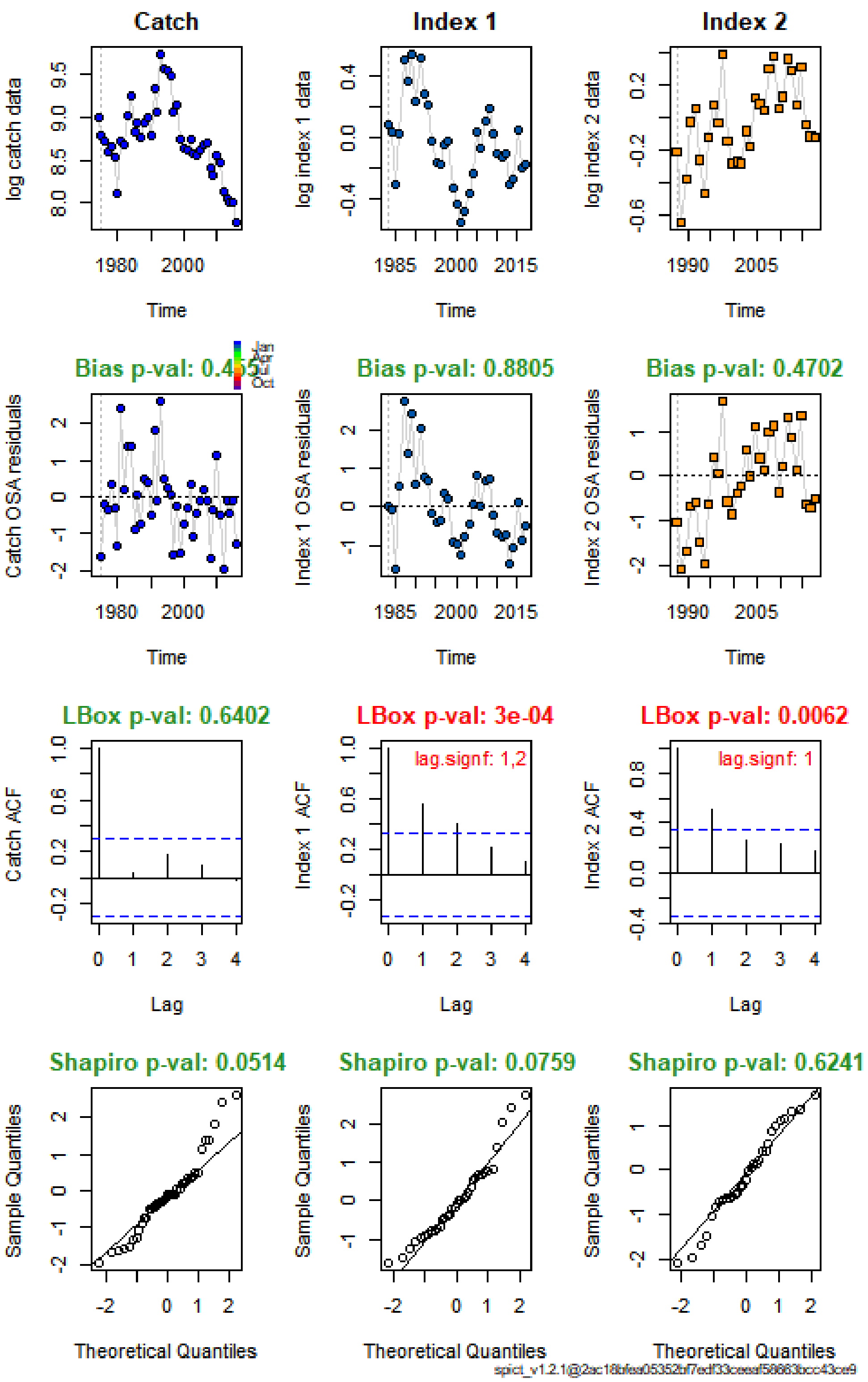

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 13.4281789
## Euler time step (years):  1/16 or 0.0625
```

```
## Nobs C: 43,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.0514 0.4550 0.2646 0.6402       .    -   -    -
##  I1  0.0759 0.8805 0.0009 0.0003       .    - ***  ***
##  I2  0.6241 0.4702 0.0050 0.0062       -    -  **   **
##
## Priors
##      logn  ~  dnorm[log(2), 1^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha1 1.941241e+00 5.924915e-01 6.360287e+00   0.6633274
##  alpha2 2.368608e+00 9.798628e-01 5.725603e+00   0.8623025
##  beta   7.230223e-01 3.538052e-01 1.477540e+00  -0.3243153
##  r      3.553416e-01 3.435560e-02 3.675314e+00  -1.0346758
##  rc     2.667680e-01 5.350040e-02 1.330180e+00  -1.3213758
##  rold   2.135403e-01 1.629570e-02 2.798255e+00  -1.5439297
##  m      1.282276e+04 2.385440e+03 6.892780e+04   9.4589769
##  K      1.732226e+05 3.032954e+04 9.893353e+05  12.0623330
##  q1     6.700000e-06 9.000000e-07 4.860000e-05 -11.9204895
##  q2     7.200000e-06 1.000000e-06 5.350000e-05 -11.8430910
##  n      2.664049e+00 2.302572e-01 3.082274e+01   0.9798472
##  sdb    1.027276e-01 4.752700e-02 2.220412e-01  -2.2756744
##  sdf    1.743733e-01 1.099908e-01 2.764417e-01  -1.7465569
##  sdi1   1.994190e-01 9.735640e-02 4.084780e-01  -1.6123470
##  sdi2   2.433214e-01 1.478566e-01 4.004240e-01  -1.4133719
##  sdc    1.260758e-01 8.399930e-02 1.892289e-01  -2.0708722
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 96134.150179 1.357062e+04 6.810136e+05 11.473500
##  Fmsyd     0.133384 2.675020e-02 6.650902e-01 -2.014523
##  MSYd  12822.758512 2.385440e+03 6.892780e+04  9.458977
## Stochastic reference points (Srp)
##            estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 9.385455e+04 1.344998e+04 6.549210e+05 11.449502  -0.02428861
##  Fmsys 1.290163e-01 2.361120e-02 7.049702e-01 -2.047817  -0.03385394
##  MSYs  1.209881e+04 2.250695e+03 6.503821e+04  9.400862  -0.05983657
##
## States w 95% CI (inp$msytype: s)
##                      estimate        cilow        ciupp    log.est
##  B_2017.62      1.362521e+05 1.903866e+04 9.751021e+05 11.8222623
##  F_2017.62      1.724420e-02 2.268300e-03 1.310925e-01 -4.0602808
##  B_2017.62/Bmsy 1.451737e+00 7.350587e-01 2.867173e+00  0.3727608
##  F_2017.62/Fmsy 1.336589e-01 1.622510e-02 1.101052e+00 -2.0124641
##
## Predictions w 95% CI (inp$msytype: s)
##                    prediction        cilow        ciupp    log.est
##  B_2017.62      1.362521e+05 1.903866e+04 9.751021e+05 11.8222623
##  F_2017.62      1.724420e-02 2.268300e-03 1.310925e-01 -4.0602808
##  B_2017.62/Bmsy 1.451737e+00 7.350587e-01 2.867173e+00  0.3727608
```

```
## F_2017.62/Fmsy 1.336589e-01 1.622510e-02 1.101052e+00 -2.0124641
## Catch_2017.62   2.399371e+03 1.542114e+03 3.733174e+03  7.7829618
## E(B_inf)        1.570458e+05           NA           NA 11.9642928
plot(fit)
```

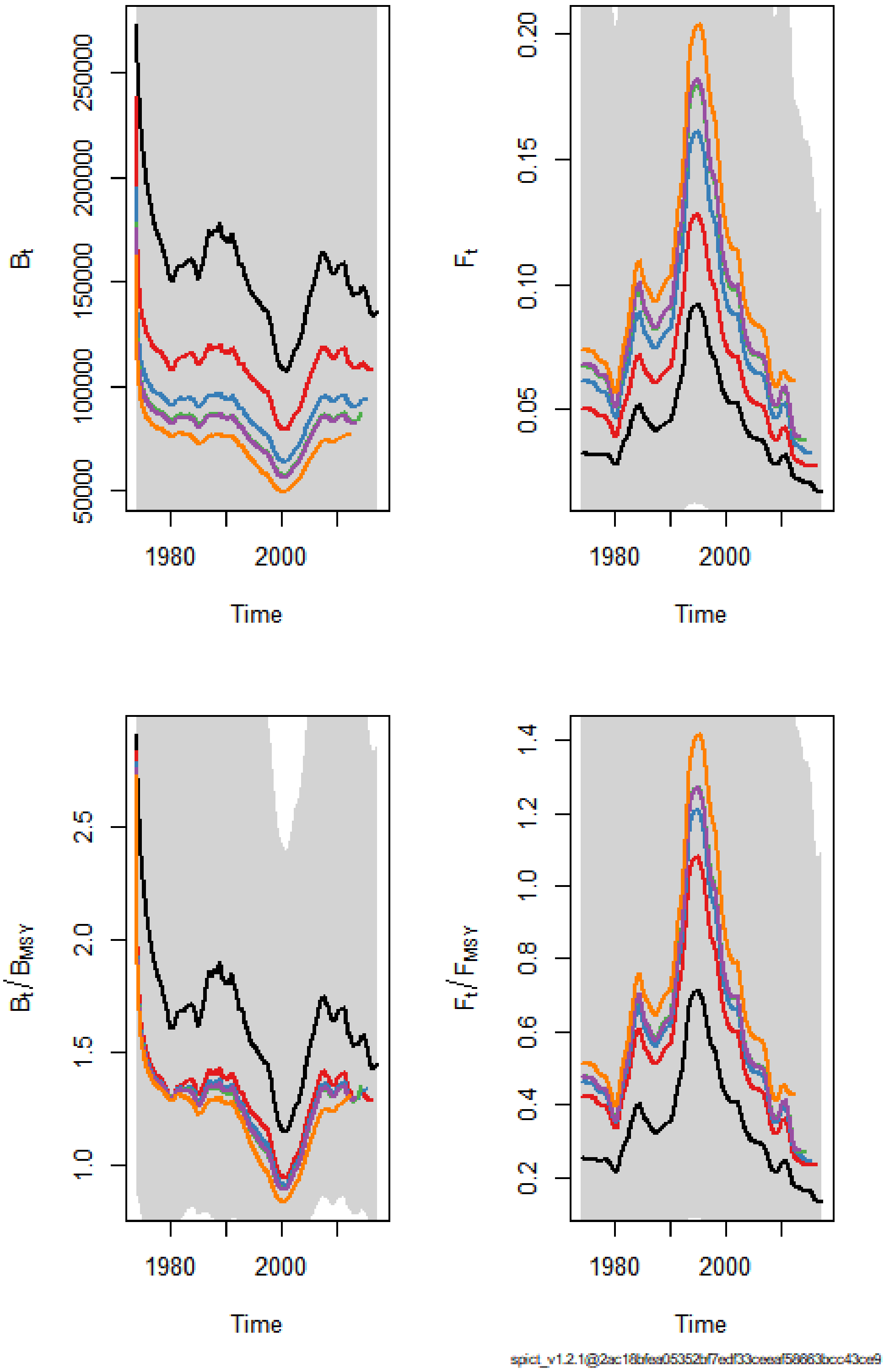



```
plotspict.diagnostic(fit)
```



Some issues in the diagnostics again with the indices.

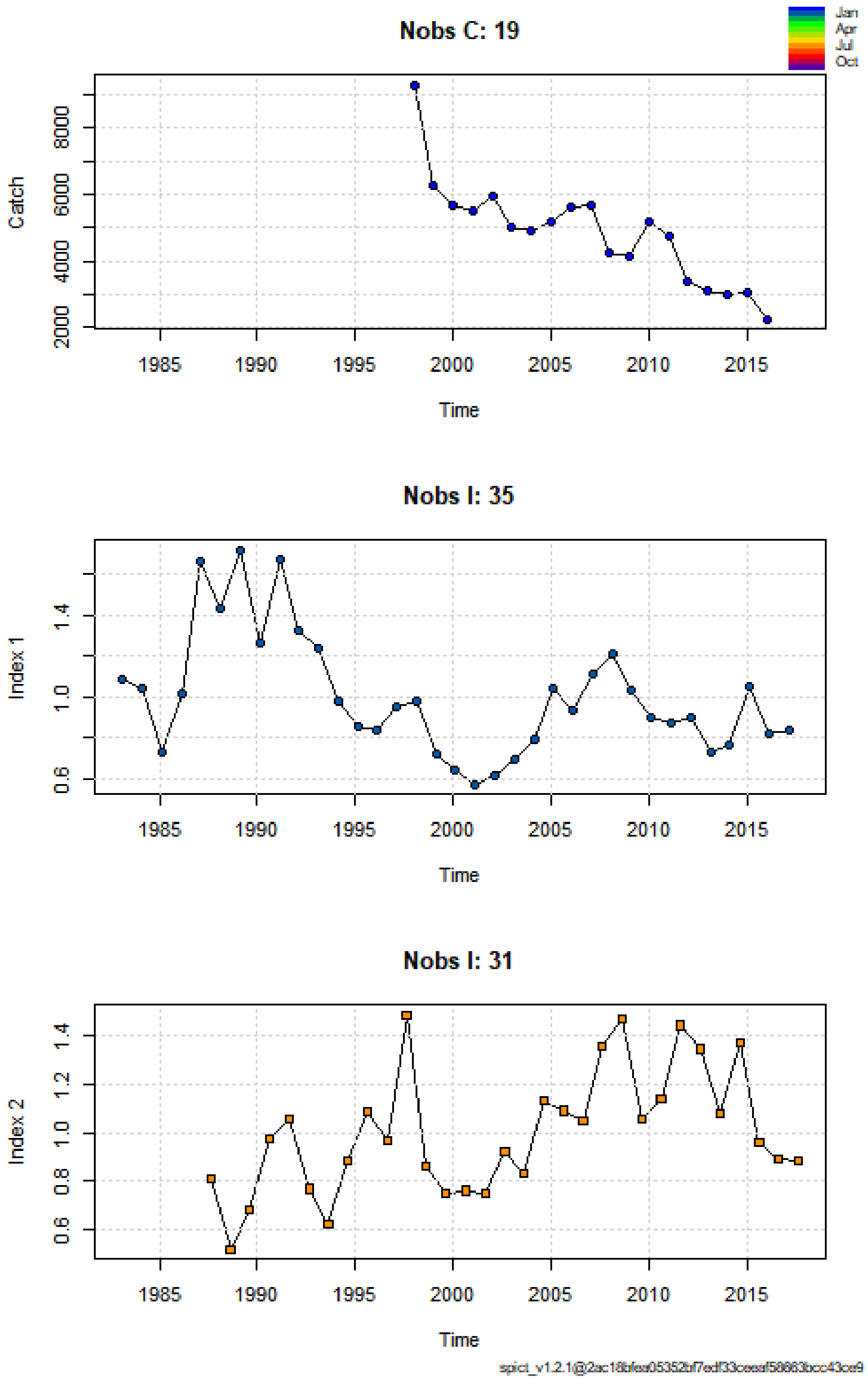
```
retro<-retro(fit)
plotspict.retro(retro)
```



SPiCT Scenario 4:

- using truncated catch time series 1998-2016
- InterCatch data 2002 - 2016
- 1998-2001 applied average discard ratio on official landings (average 2002 - 2016)
- Index Q1 (1983 - 2016); combined Index Q3 (1987 - 2016)
- Different uncertainties were applied for different time periods:
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 – 2016
- Prior on sd log(n) set to 1

```
starty <- fle_catch[[4]]$time_start>=1998

stdevfacC <-c(#rep(3,length(1974:1982)),
              #rep(4,length(1983:1997)),
              rep(3,length(1998:2001)),
              rep(2, length(2002:2010)),
              rep(1,length(2011:2016)))


inp <- list(obsC=fle_catch[[4]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index), newidxQ3$Index/m
ean(newidxQ3$Index)),

            timeC=fle_catch[[4]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),
            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),
            stdevfacC = stdevfacC/mean(stdevfacC),
           priors = list())

inp$priors$logn<-c(log(2),1,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0
inp <- check.inp(inp)
plotspict.data(inp)
```

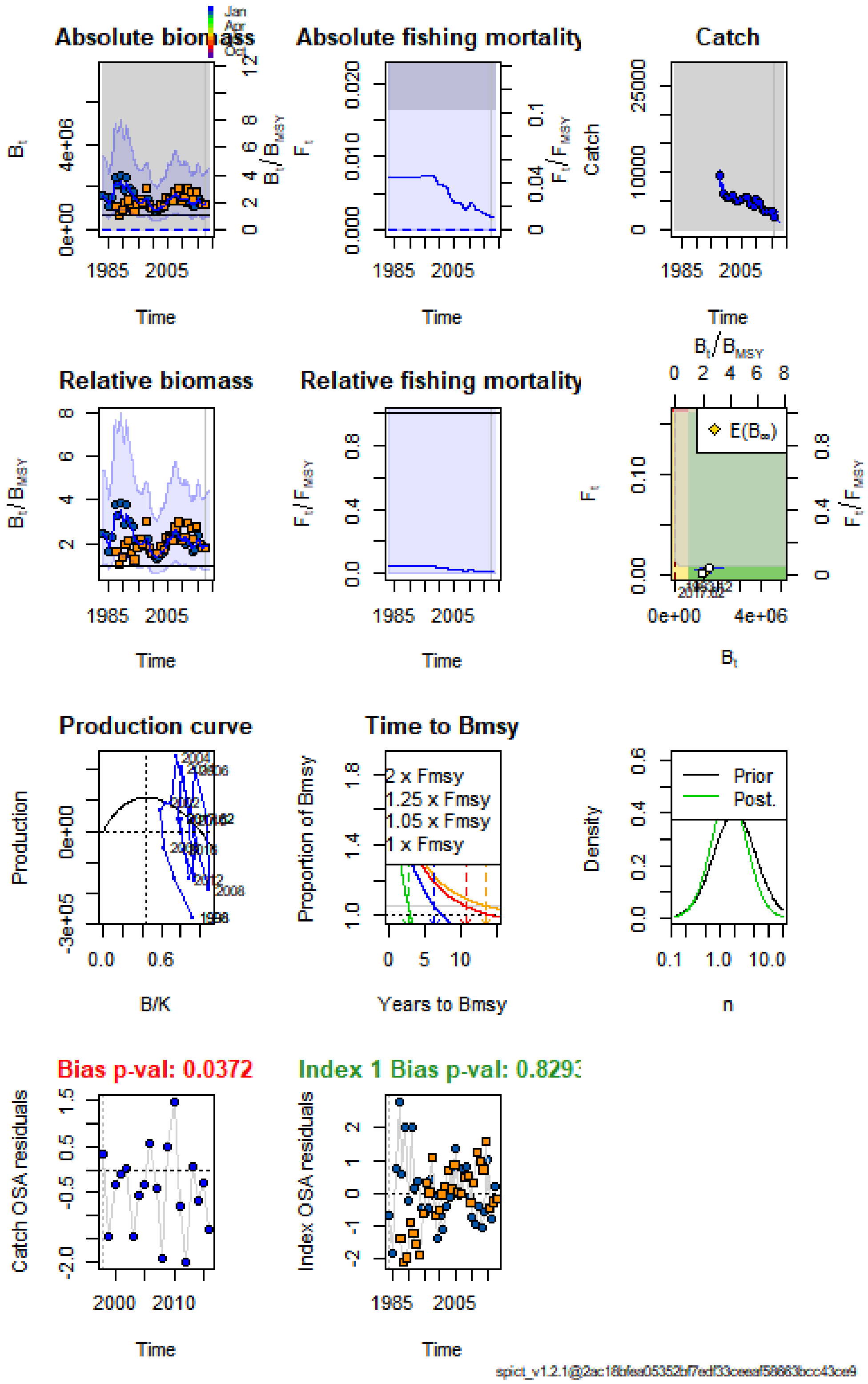



```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)


fit
```

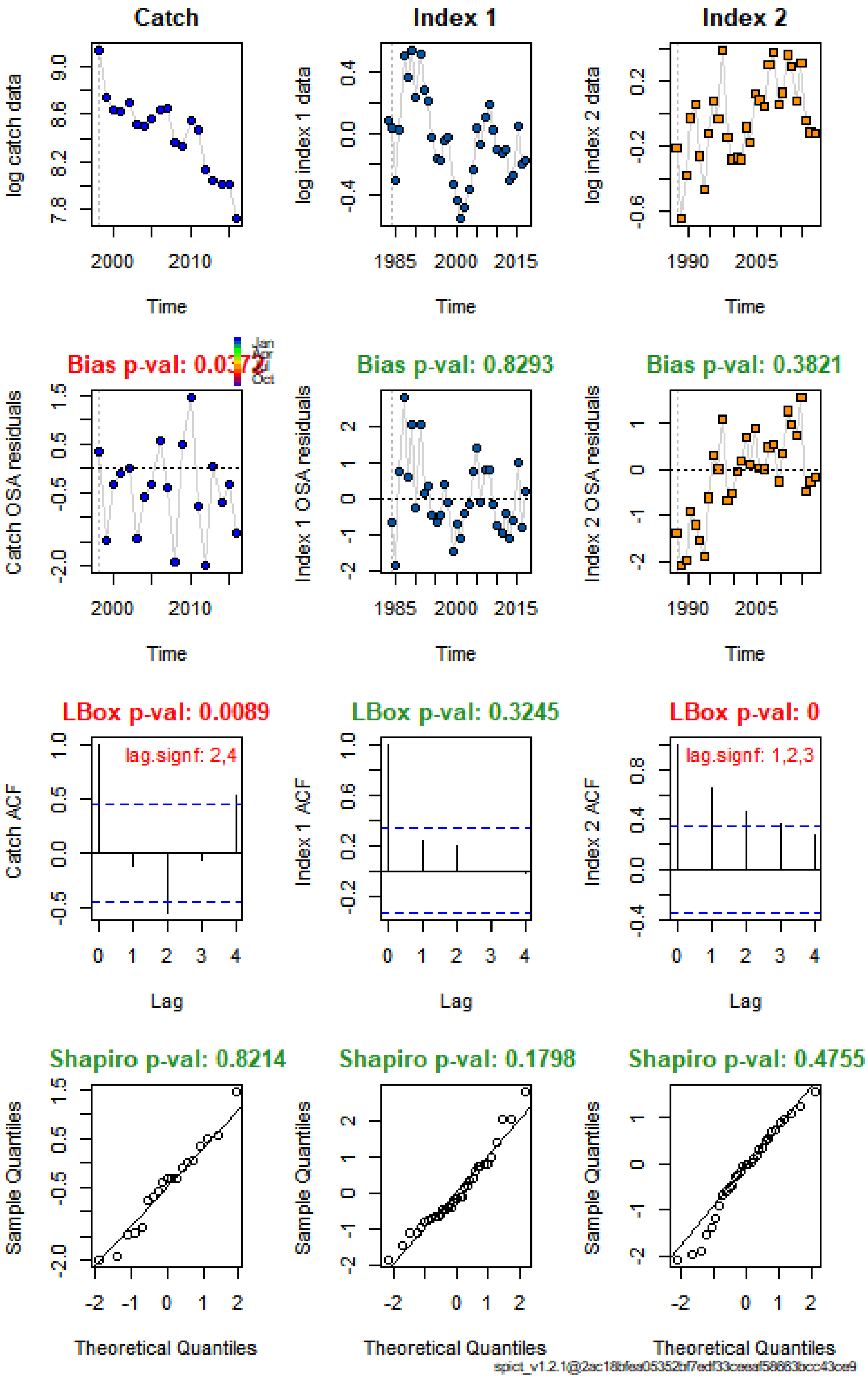
```
## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 9.1827329
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 19,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.8214 0.0372 0.0160 0.0089       -    *   *   **
##  I1  0.1798 0.8293 0.1526 0.3245       -    -   -    -
##  I2  0.4755 0.3821 0.0003 0.0000       -    - ***  ***
##
## Priors
##      logn  ~  dnorm[log(2), 1^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate       cilow        ciupp     log.est
##  alpha1 5.419888e-01   0.1327975 2.212028e+00  -0.6125100
##  alpha2 1.727632e+00   1.0410519 2.867014e+00   0.5467514
##  beta   1.823728e-01   0.0242110 1.373750e+00  -1.7017023
##  r      2.508857e-01   0.0735981 8.552348e-01  -1.3827577
##  rc     3.269808e-01   0.0388078 2.755024e+00  -1.1178537
##  rold   4.693320e-01   0.0031544 6.982984e+01  -0.7564449
##  m      1.108051e+05  27.8628622 4.406497e+08  11.6155277
##  K      1.510035e+06 418.7589633 5.445149e+09  14.2276432
##  q1     7.000000e-07   0.0000000 2.960400e-03 -14.1961411
##  q2     8.000000e-07   0.0000000 3.296100e-03 -14.0890831
##  n      1.534559e+00   0.2917681 8.071041e+00   0.4282432
##  sdb    1.726920e-01   0.1083136 2.753353e-01  -1.7562454
##  sdf    1.665610e-01   0.1047713 2.647918e-01  -1.7923935
##  sdi1   9.359720e-02   0.0324484 2.699806e-01  -2.3687553
##  sdi2   2.983482e-01   0.2217198 4.014601e-01  -1.2094939
##  sdc    3.037620e-02   0.0045180 2.042328e-01  -3.4940957
##
## Deterministic reference points (Drp)
##            estimate       cilow        ciupp   log.est
##  Bmsyd 6.777465e+05 178.3303313 2.575783e+09 13.426529
##  Fmsyd 1.634904e-01   0.0194039 1.377512e+00 -1.811001
##  MSYd  1.108051e+05  27.8628622 4.406497e+08 11.615528
## Stochastic reference points (Srp)
##            estimate       cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 6.424861e+05 170.7383801 2.417666e+09 13.373100  -0.05488114
##  Fmsys 1.595365e-01   0.0164073 1.551258e+00 -1.835482  -0.02478378
##  MSYs  1.023606e+05  24.8147300 4.222367e+08 11.536257  -0.08249728
##
## States w 95% CI (inp$msytype: s)
##                      estimate       cilow        ciupp   log.est
##  B_2017.62      1.215809e+06 283.8639098 5.207398e+09 14.010920
##  F_2017.62      1.820000e-03   0.0000004 7.942485e+00 -6.308892
##  B_2017.62/Bmsy 1.892351e+00   0.8615479 4.156463e+00  0.637820
##  F_2017.62/Fmsy 1.140840e-02   0.0000021 6.318638e+01 -4.473409
##
## Predictions w 95% CI (inp$msytype: s)
##                    prediction        cilow        ciupp   log.est
```

```
## B_2017.62         1.215809e+06  283.8639098 5.207398e+09 14.010920
## F_2017.62         1.820000e-03    0.0000004 7.942485e+00 -6.308892
## B_2017.62/Bmsy    1.892351e+00    0.8615479 4.156463e+00  0.637820
## F_2017.62/Fmsy    1.140840e-02    0.0000021 6.318638e+01 -4.473409
## Catch_2017.62     2.246929e+03 1391.4497787 3.628366e+03  7.717320
## E(B_inf)          1.358178e+06           NA           NA 14.121655
```

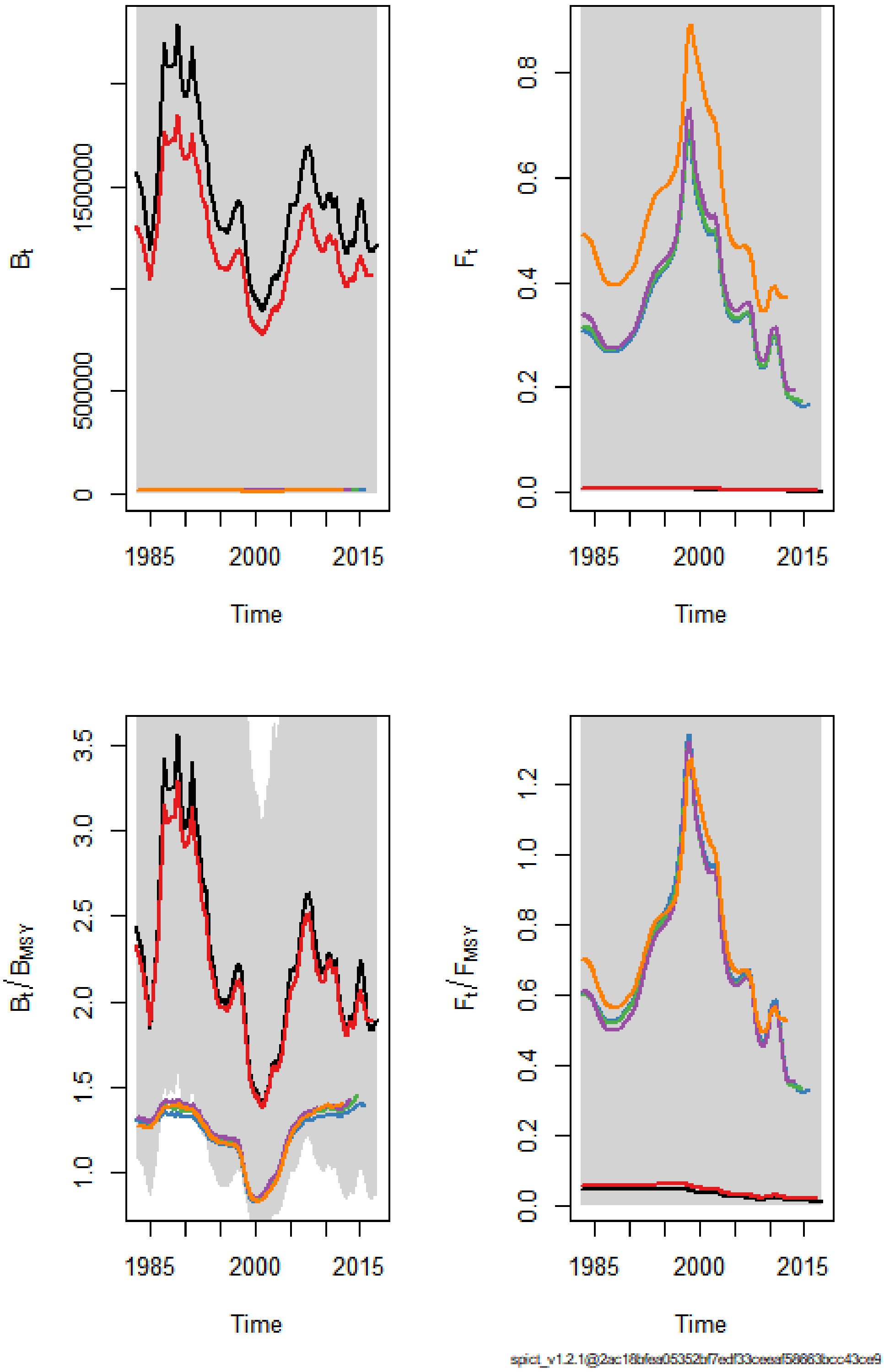
```
plot(fit)
```



```
plotspict.diagnostic(fit)
```



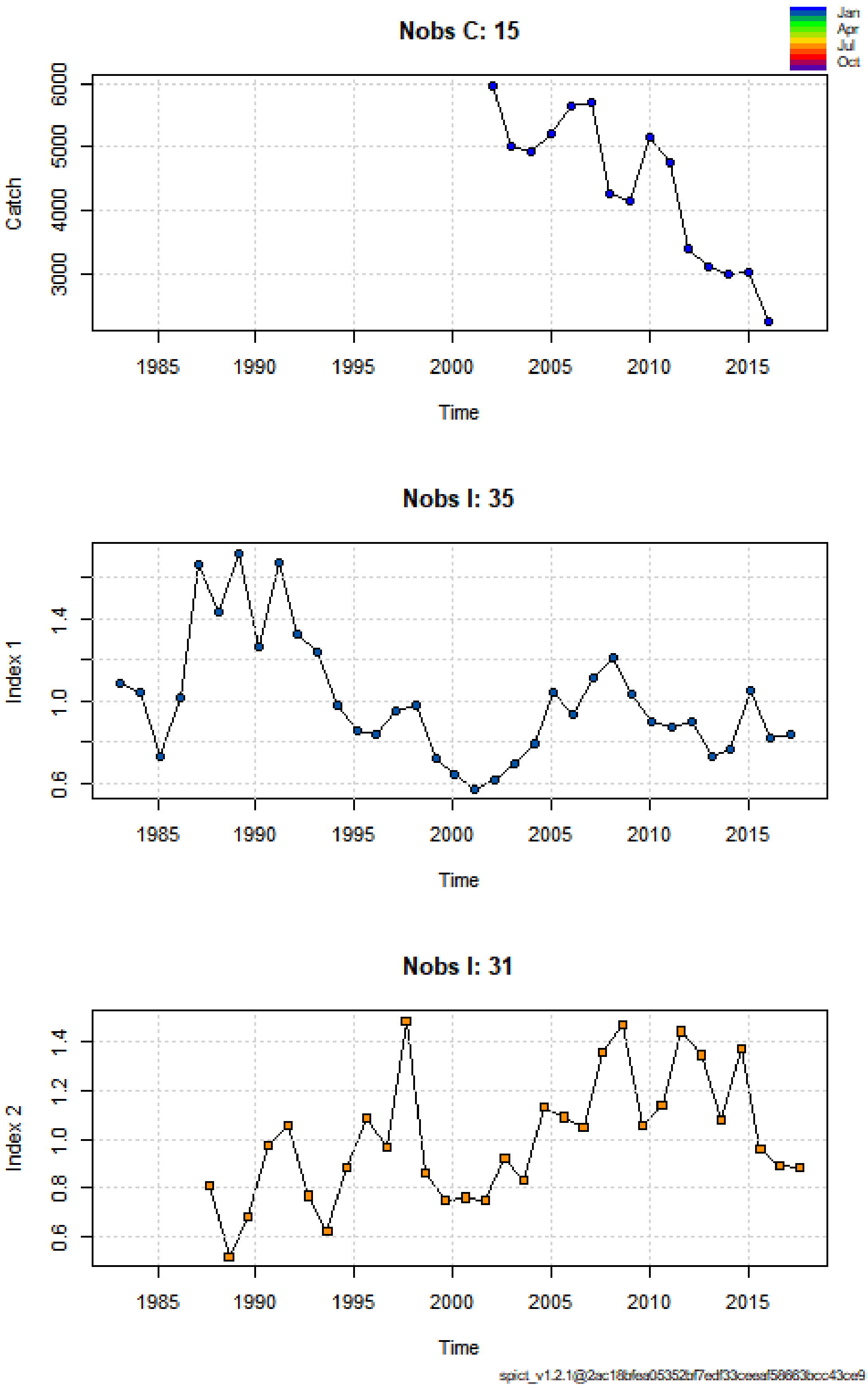
```
retro<-retro(fit)
plotspict.retro(retro)
```



SPiCT Scenario 5:

- short catch time series using only InterCatch data 2002 – 2016
- Index Q1 (1983 - 2016); combined Index Q3 (1987 - 2016)
- Different uncertainties were applied for different time periods:
  - (2) 2002 – 2010
  - (1) 2011 – 2016
- Priors set to default

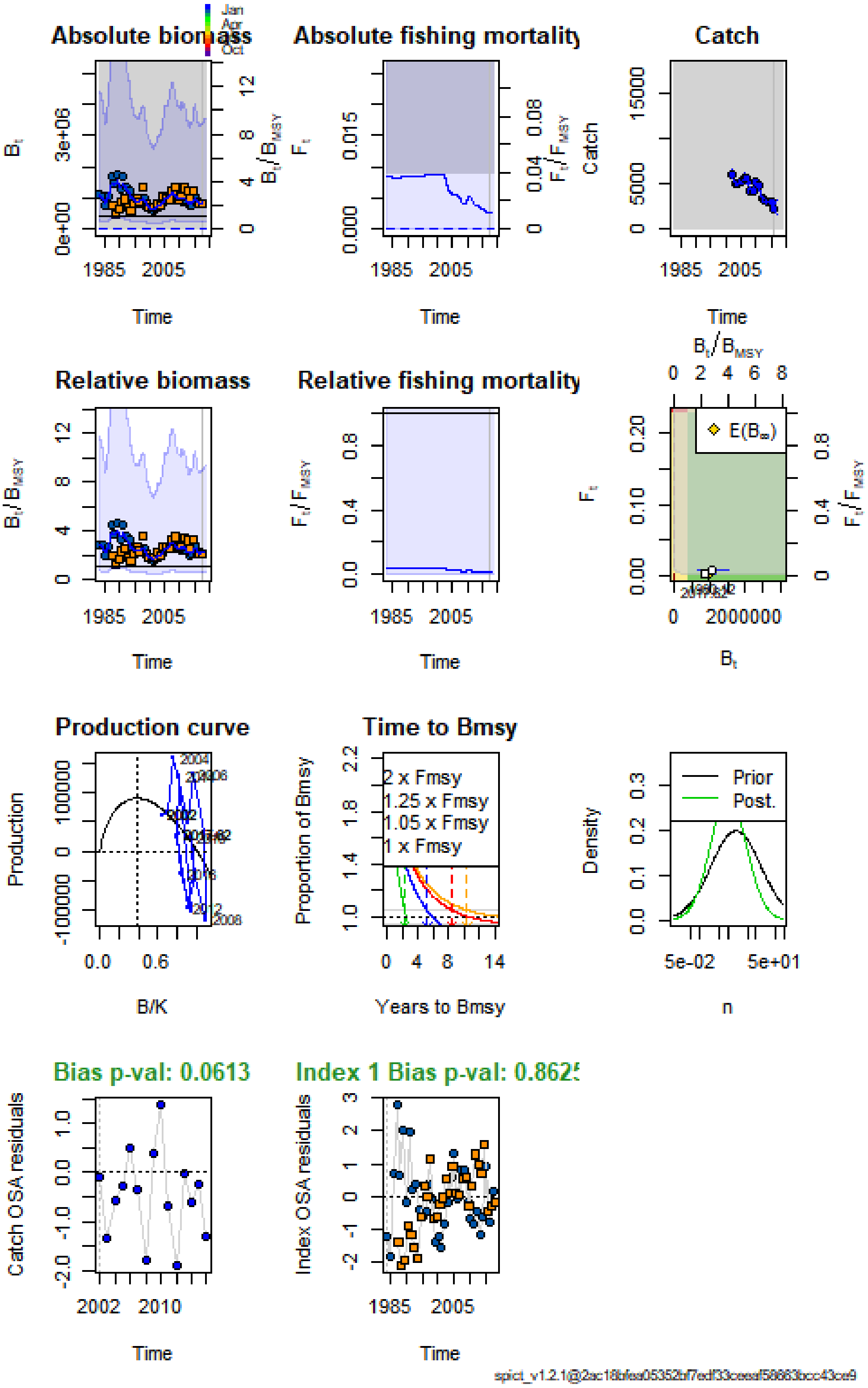
```
starty <- fle_catch[[4]]$time_start>=2002

stdevfacC <-c(#rep(3,length(1974:1982)),
              #rep(4,length(1983:1997)),
              #rep(3,length(1998:2001)),
              rep(1.5, length(2002:2010)),
              rep(1,length(2011:2016)))


inp <- list(obsC=fle_catch[[4]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index), newidxQ3$Index/m
ean(newidxQ3$Index)),

            timeC=fle_catch[[4]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),
            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),
            stdevfacC = stdevfacC/mean(stdevfacC),
           priors = list())

inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0

inp <- check.inp(inp)
plotspict.data(inp)
```



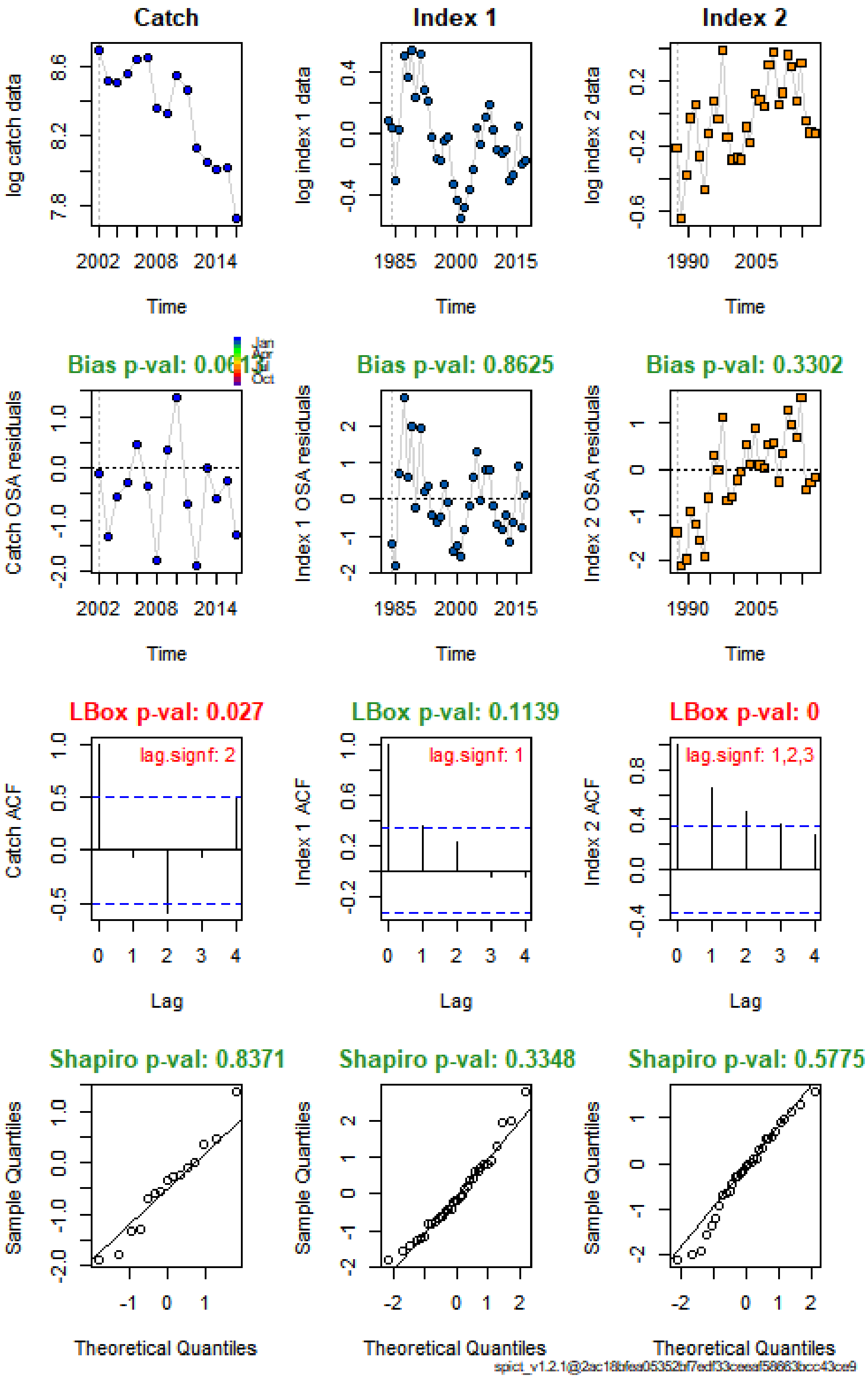

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 12.3377751
## Euler time step (years):  1/16 or 0.0625
```

```
## Nobs C: 15,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.8371 0.0613 0.0217 0.0270       -    .   *    *
##  I1  0.3348 0.8625 0.0414 0.1139       -    -   *    -
##  I2  0.5775 0.3302 0.0003 0.0000       -    - ***  ***
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate       cilow        ciupp     log.est
##  alpha1 6.303074e-01   0.1355001 2.932008e+00  -0.4615476
##  alpha2 1.781027e+00   1.0192402 3.112177e+00   0.5771899
##  beta   2.381711e-01   0.0243397 2.330579e+00  -1.4347659
##  r      2.472238e-01   0.0701459 8.713210e-01  -1.3974613
##  rc     4.541825e-01   0.0198301 1.040244e+01  -0.7892562
##  rold   2.788634e+00   0.0000000 3.270434e+15   1.0255520
##  m      8.985744e+04  16.8907384 4.780348e+08  11.4059797
##  K      1.031488e+06 223.8975091 4.752032e+09  13.8465132
##  q1     1.000000e-06   0.0000000 5.831000e-03 -13.8240546
##  q2     1.100000e-06   0.0000000 6.476600e-03 -13.7189740
##  n      1.088654e+00   0.0648951 1.826283e+01   0.0849421
##  sdb    1.658446e-01   0.0953311 2.885149e-01  -1.7967038
##  sdf    1.762156e-01   0.1003771 3.093530e-01  -1.7360470
##  sdi1   1.045331e-01   0.0350933 3.113751e-01  -2.2582514
##  sdi2   2.953737e-01   0.2165303 4.029258e-01  -1.2195138
##  sdc    4.196950e-02   0.0054134 3.253871e-01  -3.1708129
##
## Deterministic reference points (Drp)
##            estimate      cilow        ciupp   log.est
##  Bmsyd 3.956887e+05 71.0922326 2.202344e+09 12.888383
##  Fmsyd 2.270912e-01  0.0099151 5.201222e+00 -1.482403
##  MSYd  8.985744e+04 16.8907384 4.780348e+08 11.405980
## Stochastic reference points (Srp)
##            estimate      cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 3.820195e+05 70.0032966 2.084743e+09 12.853227 -0.035781473
##  Fmsys 2.264916e-01  0.0090208 5.686688e+00 -1.485047 -0.002647512
##  MSYs  8.651603e+04 15.7849467 4.741874e+08 11.368085 -0.038621892
##
## States w 95% CI (inp$msytype: s)
##                     estimate       cilow        ciupp    log.est
##  B_2017.62      8.399023e+05 145.3868358 4.852130e+09 13.6410408
##  F_2017.62      2.636200e-03   0.0000004 1.561700e+01 -5.9384184
##  B_2017.62/Bmsy 2.198585e+00   0.5418889 8.920232e+00  0.7878139
##  F_2017.62/Fmsy 1.163930e-02   0.0000013 1.082787e+02 -4.4533712
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
##  B_2017.62      8.399023e+05  145.3868358 4.852130e+09 13.6410408
##  F_2017.62      2.636200e-03    0.0000004 1.561700e+01 -5.9384184
##  B_2017.62/Bmsy 2.198585e+00    0.5418889 8.920232e+00  0.7878139
```

```
## F_2017.62/Fmsy 1.163930e-02    0.0000013 1.082787e+02 -4.4533712
## Catch_2017.62   2.247401e+03 1368.3658476 3.691126e+03  7.7175297
## E(B_inf)        9.584903e+05           NA           NA 13.7731148

plot(fit)
```



```r
plotspict.diagnostic(fit)
```



Some issues with the model diagnostics, retro did not converge.

Annex III

Flounder in area 4 and 3a - SPiCT assessment scenarios – different modifications of run 2 and final run

WKNSEA Benchmark Meeting, 04. – 09.02.2018, ICES HQ Copenhagen.

Holger Haslob, Alexandros Kokkalis, Casper Berg

09 February 2018

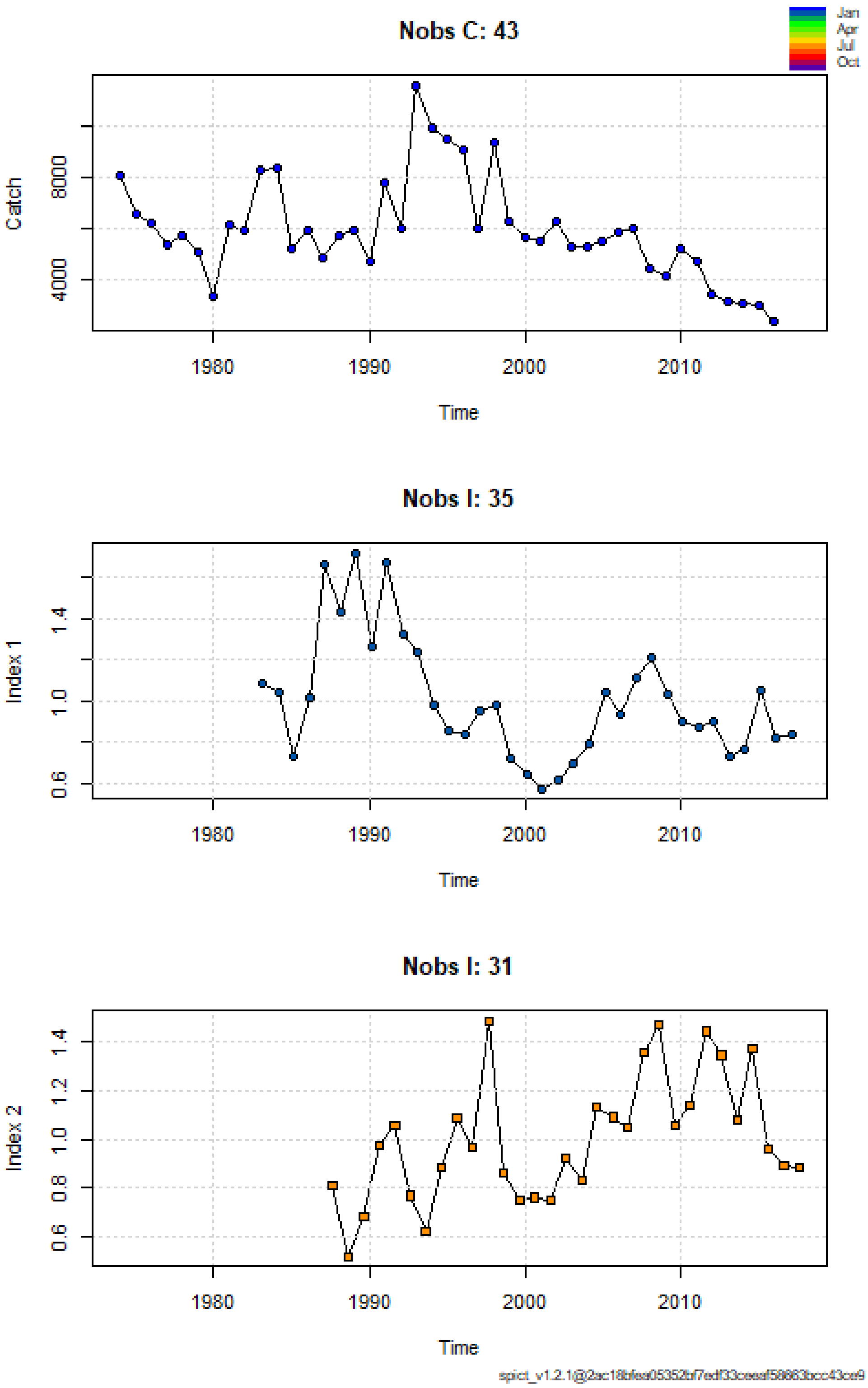
```
library(spict)

## Loading required package: TMB

## Welcome to spict_v1.2.1@2ac18bfea05352bf7edf33ceeaf58663bcc43ce9

load("FLE.Rdata")
load("fle_catch.Rdata")
```

SPiCt scenario 2 = base run:

- InterCatch data 2002-2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- Index Q1 (1983 - 2016), combined index Q3 (1987 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 - 2016.
- priors set to default

```
starty <- fle_catch[[1]]$time_start>=1974

stdevfacC <- c(rep(3,length(1974:1982)),
               rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index),
                      newidxQ3$Index/mean(newidxQ3$Index)),
```

```
            timeC=fle_catch[[1]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),

            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())
inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0inp <- check.inp(inp)
plotspict.data(inp)
```

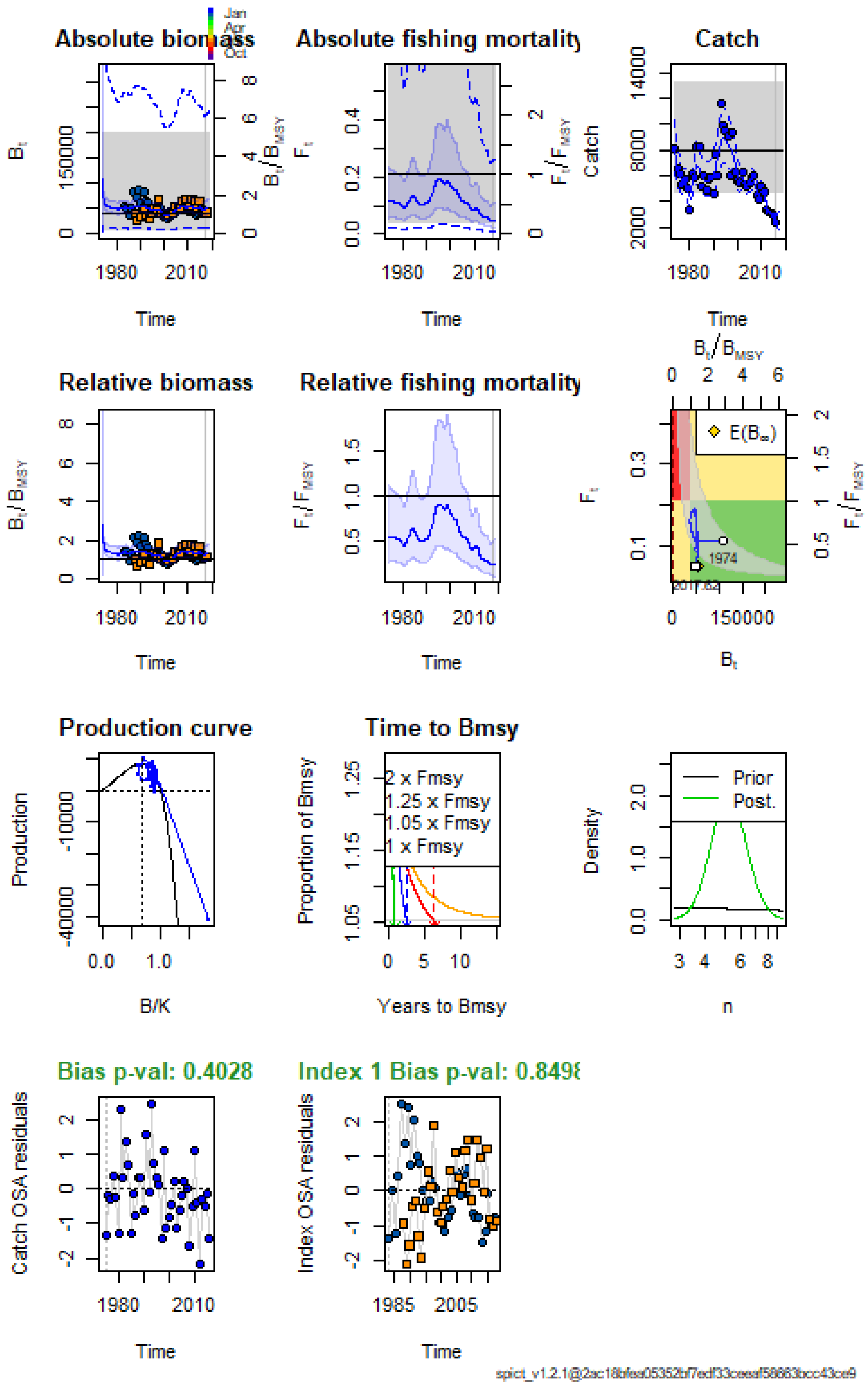



```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 12.0782193
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 43,  Nobs I1: 35,  Nobs I2: 31
##
```

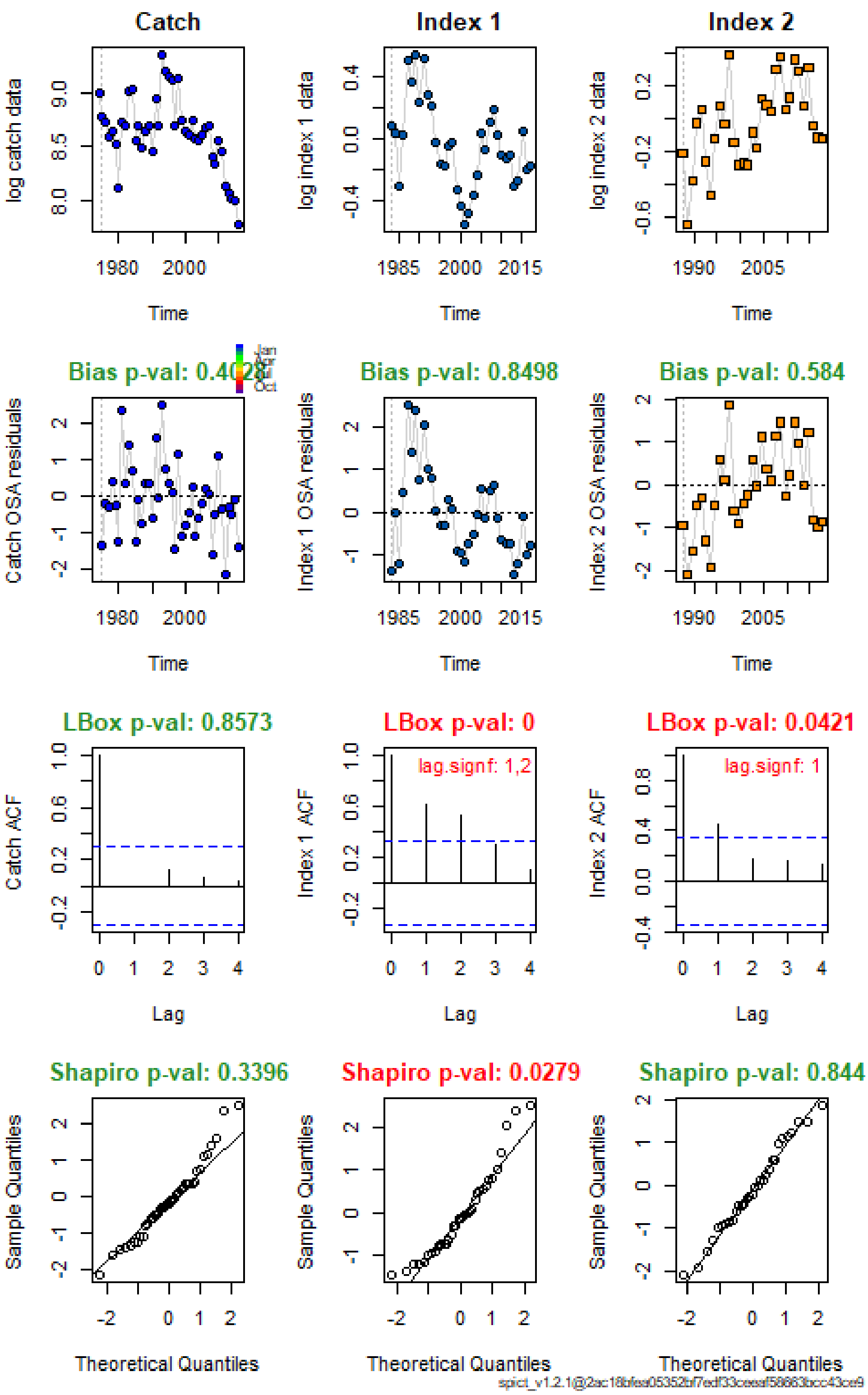
```
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.3396 0.4028 0.4546 0.8573       -    -   -    -
##  I1  0.0279 0.8498 0.0003 0.0000       *    - ***  ***
##  I2  0.8440 0.5840 0.0134 0.0421       -    -   *    *
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha1 2.028749e+00 7.635392e-01 5.390456e+00   0.7074196
##  alpha2 1.993891e+00 7.839563e-01 5.071204e+00   0.6900881
##  beta   9.351017e-01 4.560627e-01 1.917313e+00  -0.0671000
##  r      1.147732e+00 3.477927e-01 3.787570e+00   0.1377880
##  rc     4.437168e-01 9.541600e-02 2.063435e+00  -0.8125688
##  rold   2.750202e-01 5.429010e-02 1.393184e+00  -1.2909107
##  m      8.656626e+03 5.087446e+03 1.472982e+04   9.0660803
##  K      5.785029e+04 1.175181e+04 2.847780e+05  10.9656137
##  q1     2.020000e-05 3.800000e-06 1.081000e-04 -10.8097773
##  q2     2.140000e-05 4.000000e-06 1.127000e-04 -10.7539064
##  n      5.173265e+00 3.492134e+00 7.663701e+00   1.6435040
##  sdb    1.116801e-01 4.800120e-02 2.598360e-01  -2.1921171
##  sdf    1.495273e-01 9.072260e-02 2.464481e-01  -1.9002763
##  sdi1   2.265709e-01 1.592174e-01 3.224168e-01  -1.4846975
##  sdi2   2.226779e-01 1.630689e-01 3.040766e-01  -1.5020289
##  sdc    1.398232e-01 9.661120e-02 2.023630e-01  -1.9673763
##
## Deterministic reference points (Drp)
##            estimate       cilow        ciupp   log.est
##  Bmsyd 3.901870e+04 7359.334992 2.068746e+05 10.571796
##  Fmsyd 2.218584e-01    0.047708 1.031717e+00 -1.505716
##  MSYd  8.656626e+03 5087.446173 1.472982e+04  9.066080
## Stochastic reference points (Srp)
##            estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 3.808072e+04 7182.4691698 2.019001e+05 10.547463  -0.02463143
##  Fmsys 2.090483e-01    0.0422247 1.034968e+00 -1.565190  -0.06127809
##  MSYs  7.948692e+03 4787.6650762 1.319677e+04  8.980763  -0.08906290
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp    log.est
##  B_2017.62      4.857424e+04 1.003011e+04 2.352374e+05 10.7908486
##  F_2017.62      4.993070e-02 9.682800e-03 2.574752e-01 -2.9971198
##  B_2017.62/Bmsy 1.275560e+00 9.733011e-01 1.671685e+00  0.2433852
##  F_2017.62/Fmsy 2.388476e-01 1.154153e-01 4.942858e-01 -1.4319297
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
##  B_2017.62      4.857424e+04 1.003011e+04 2.352374e+05 10.7908486
##  F_2017.62      4.993070e-02 9.682800e-03 2.574752e-01 -2.9971198
##  B_2017.62/Bmsy 1.275560e+00 9.733011e-01 1.671685e+00  0.2433852
##  F_2017.62/Fmsy 2.388476e-01 1.154153e-01 4.942858e-01 -1.4319297
```

```
## Catch_2017.62   2.510120e+03 1.698340e+03 3.709920e+03  7.8280860
## E(B_inf)        5.292736e+04           NA           NA 10.8766757
```

```
plot(fit)
```

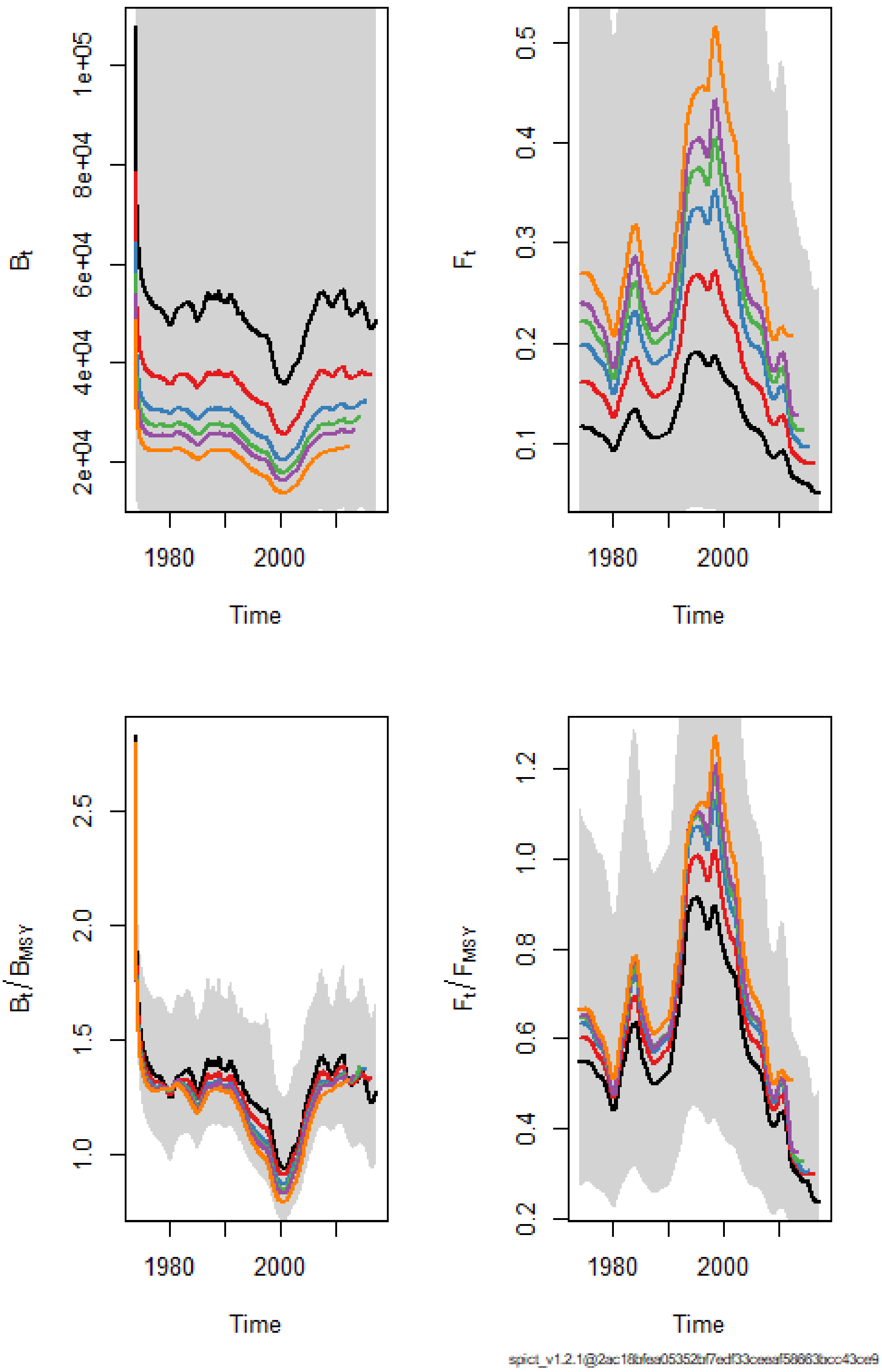



```
plotspict.diagnostic(fit)
```



There are some issues in the fit with the autocorrelation of the residuals of the Q3 biomass index.

```
retro<-retro(fit)
plotspict.retro(retro)
```

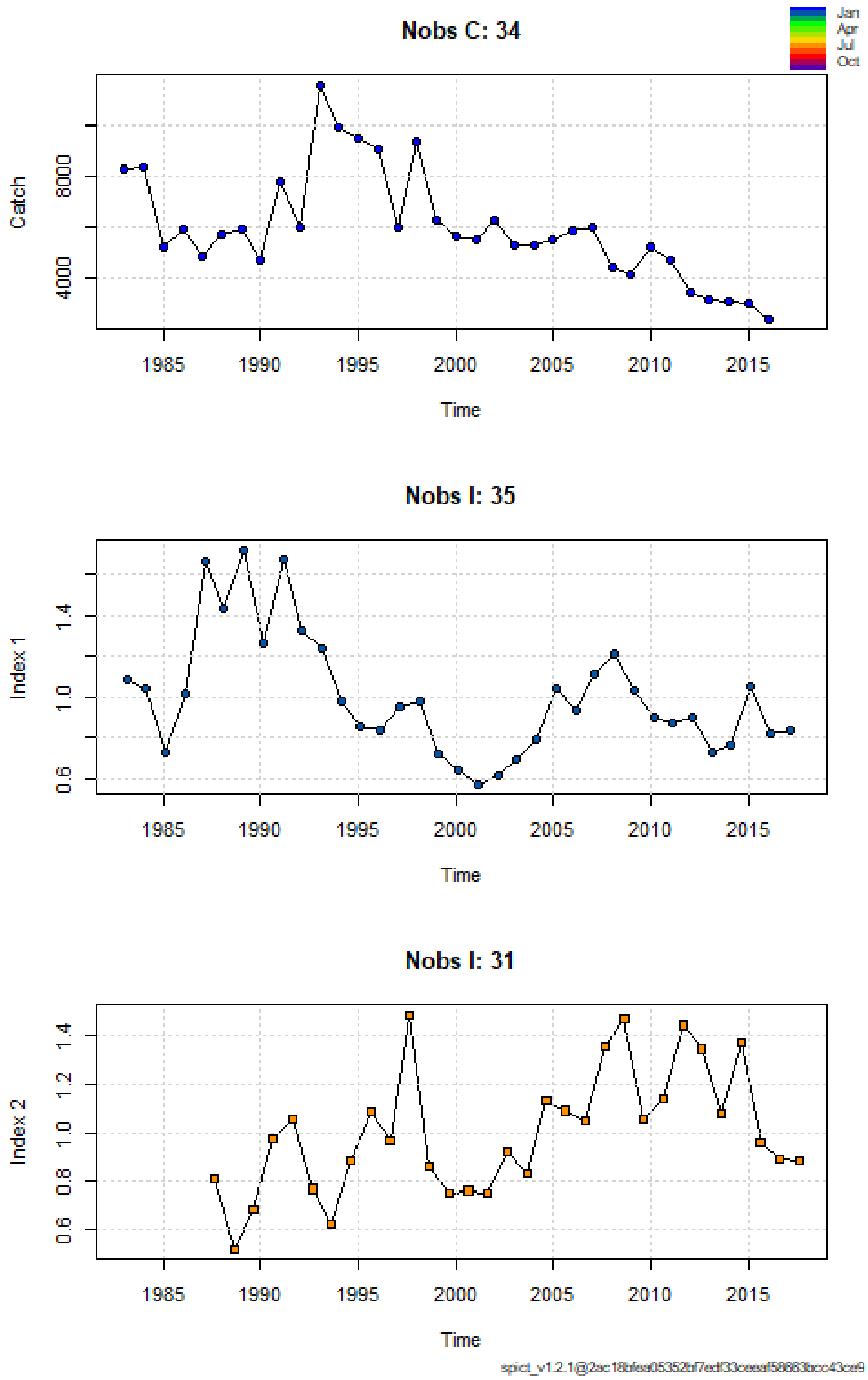


B_t
1e+05
8e+04
6e+04
4e+04
2e+04
1980
2000
Time
F_t
0.5
0.4
0.3
0.2
0.1
1980
2000
Time
B_t/B_MSY
2.5
2.0
1.5
1.0
1980
2000
Time
F_t/F_MSY
1.2
1.0
0.8
0.6
0.4
0.2
1980
2000
Time
spict_v1.2.1@2ac18bfea05352bf7edf33ceeaf58863bcc43ce9

SPiCT scenario 2a:

- InterCatch data 2002-2016
- truncated catch time series 1983 - 2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- Index Q1 (1983 - 2016), combined index Q3 (1987 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 - 2016
- prior on sd log(n) set to 0.8

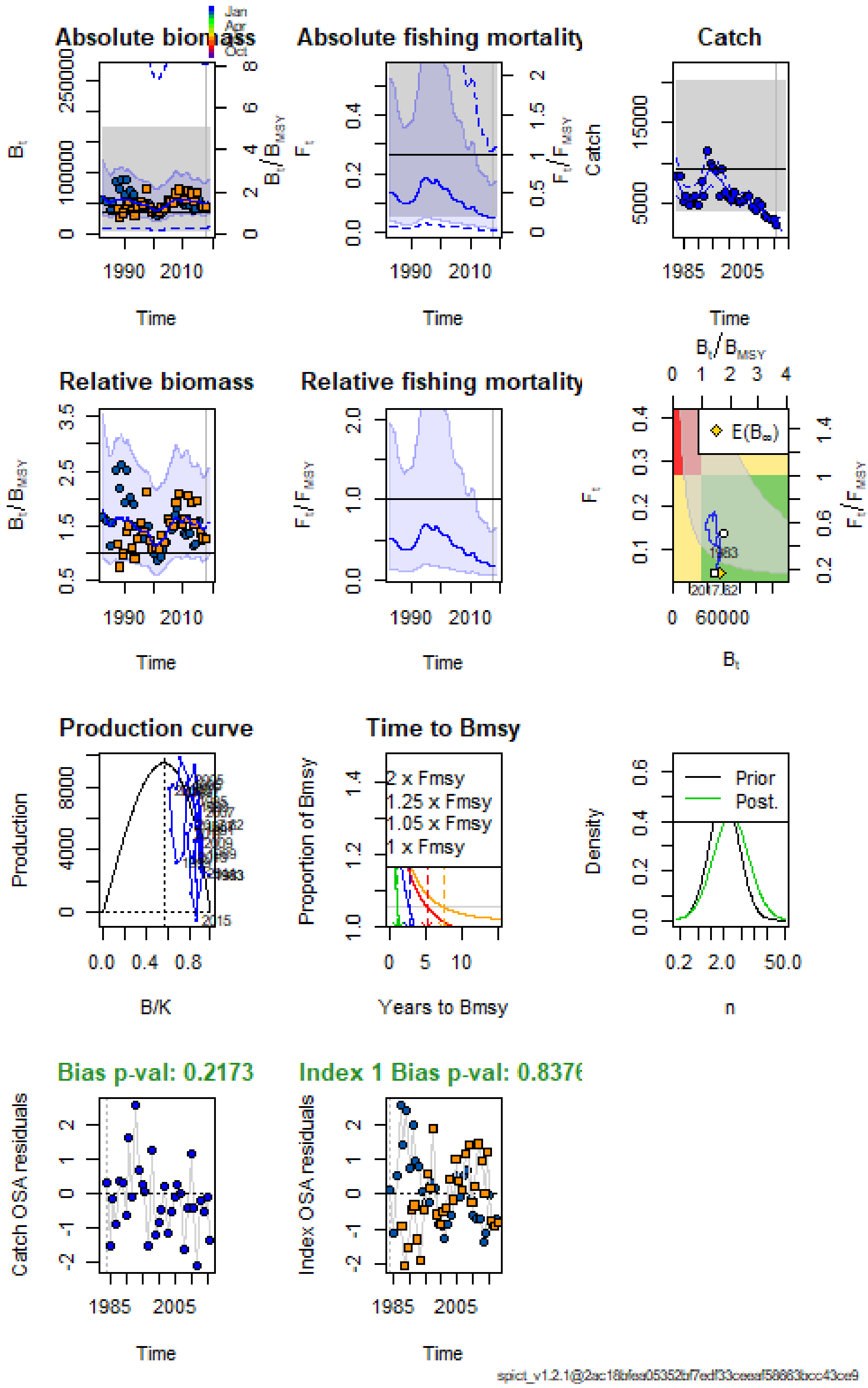
```
starty <- fle_catch[[1]]$time_start>=1983

stdevfacC <- c(#rep(3,length(1974:1982)),
               rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index),
                      newidxQ3$Index/mean(newidxQ3$Index)),

            timeC=fle_catch[[1]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4),

            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3$sd/mean(newidxQ3$sd)),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())
inp <- check.inp(inp)

inp$priors$logn<-c(log(2),0.8,1) ## Change default prior from using sd=2 to
sd=1 for logn
## format: mu, sd, on=1/off=0


plotspict.data(inp)
```



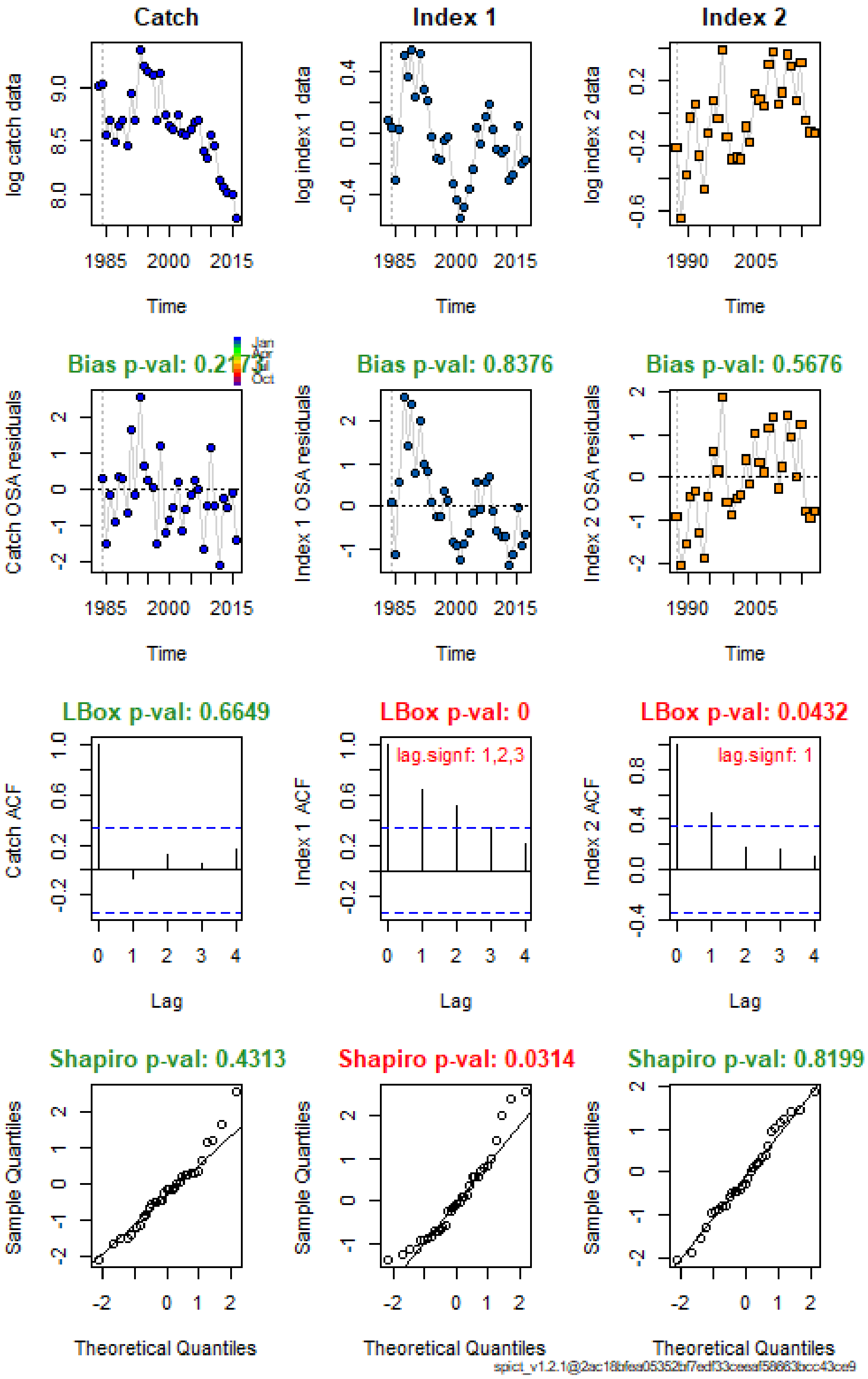

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)

fit
```

```
## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 13.0734327
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 34,  Nobs I1: 35,  Nobs I2: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.4313 0.2173 0.3573 0.6649       -    -   -    -
##  I1  0.0314 0.8376 0.0002 0.0000       *    - ***  ***
##  I2  0.8199 0.5676 0.0130 0.0432       -    -   *    *
##
## Priors
##      logn  ~  dnorm[log(2), 0.8^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha1 2.057173e+00 7.567965e-01 5.591939e+00   0.7213326
##  alpha2 2.020172e+00 7.633675e-01 5.346172e+00   0.7031826
##  beta   8.132554e-01 3.913083e-01 1.690187e+00  -0.2067101
##  r      7.770156e-01 8.921590e-02 6.767328e+00  -0.2522948
##  rc     5.462273e-01 1.246470e-01 2.393673e+00  -0.6047201
##  rold   4.211406e-01 6.138560e-02 2.889266e+00  -0.8647885
##  m      9.526493e+03 4.452225e+03 2.038398e+04   9.1618319
##  K      6.147568e+04 1.075673e+04 3.513391e+05  11.0263969
##  q1     1.920000e-05 3.100000e-06 1.186000e-04 -10.8602998
##  q2     2.040000e-05 3.400000e-06 1.233000e-04 -10.7980254
##  n      2.845026e+00 4.443317e-01 1.821652e+01   1.0455724
##  sdb    1.112567e-01 4.729830e-02 2.617018e-01  -2.1959153
##  sdf    1.564530e-01 9.581110e-02 2.554770e-01  -1.8549999
##  sdi1   2.288742e-01 1.480223e-01 3.538887e-01  -1.4745827
##  sdi2   2.247576e-01 1.582839e-01 3.191480e-01  -1.4927327
##  sdc    1.272362e-01 8.378510e-02 1.932211e-01  -2.0617100
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 3.488105e+04 6884.4746278 1.767292e+05 10.459699
##  Fmsyd 2.731137e-01    0.0623235 1.196837e+00 -1.297867
##  MSYd  9.526493e+03 4452.2251772 2.038398e+04  9.161832
## Stochastic reference points (Srp)
##            estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 34289.766498 6750.1047624 1.741881e+05 10.442602  -0.01724387
##  Fmsys     0.267547    0.0596588 1.199847e+00 -1.318460  -0.02080629
##  MSYs   9170.833072 4156.5473340 2.023414e+04  9.123783  -0.03878159
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp    log.est
##  B_2017.62      5.022535e+04 9132.9271013 2.762078e+05 10.8242752
##  F_2017.62      4.778590e-02    0.0080972 2.820115e-01 -3.0410239
##  B_2017.62/Bmsy 1.464733e+00    0.8793796 2.439723e+00  0.3816729
##  F_2017.62/Fmsy 1.786076e-01    0.0515920 6.183259e-01 -1.7225639
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
```

```
## B_2017.62         5.022535e+04 9132.9271013 2.762078e+05 10.8242752
## F_2017.62         4.778590e-02    0.0080972 2.820115e-01 -3.0410239
## B_2017.62/Bmsy    1.464733e+00    0.8793796 2.439723e+00  0.3816729
## F_2017.62/Fmsy    1.786076e-01    0.0515920 6.183259e-01 -1.7225639
## Catch_2017.62     2.475864e+03 1654.4963961 3.704996e+03  7.8143447
## E(B_inf)          5.600314e+04           NA           NA 10.9331631
plot(fit)
```

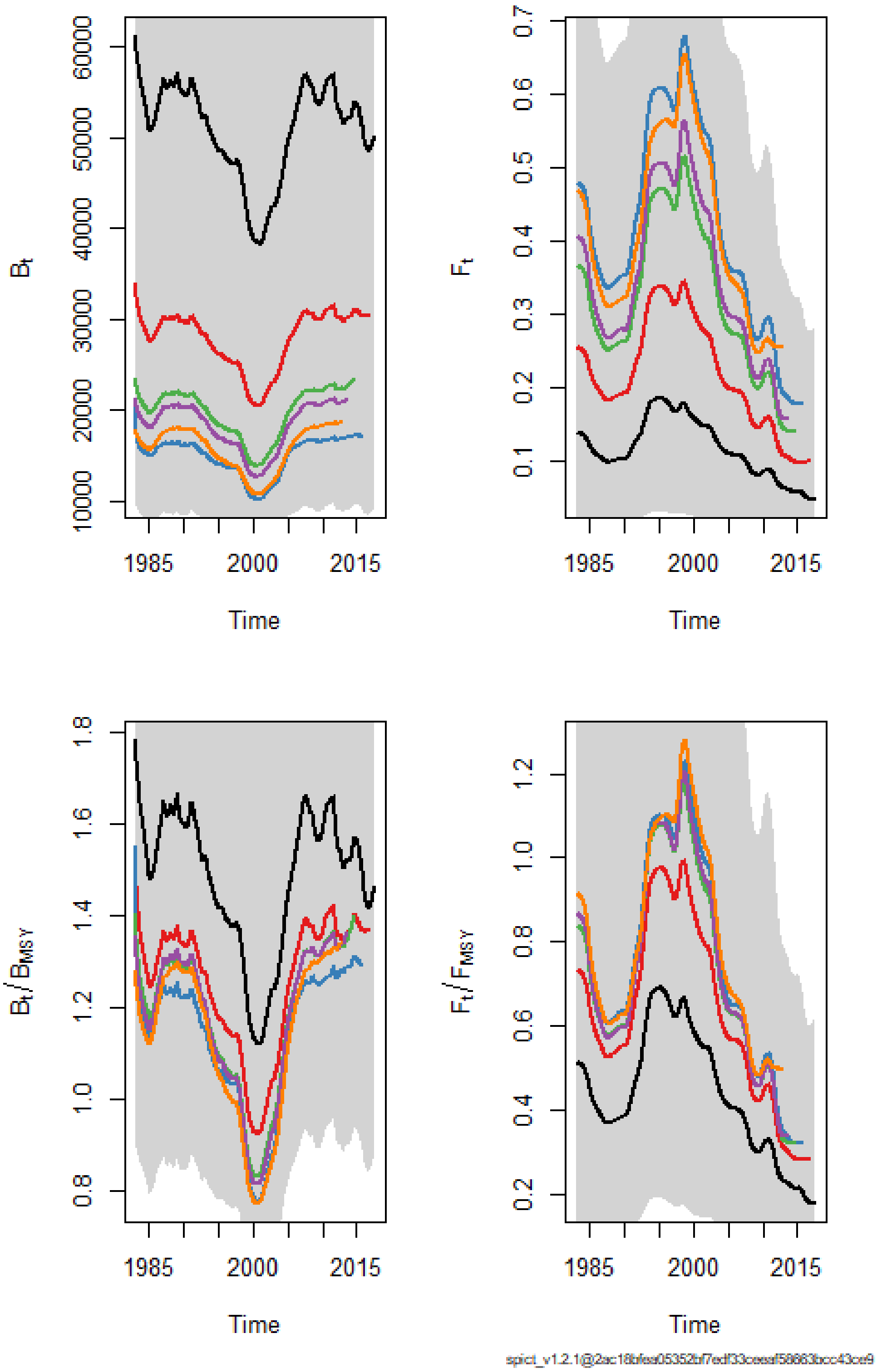



```
plotspict.diagnostic(fit)
```



There are some issues in the fit with the autocorrelation of the residuals of the Q3 biomass index.

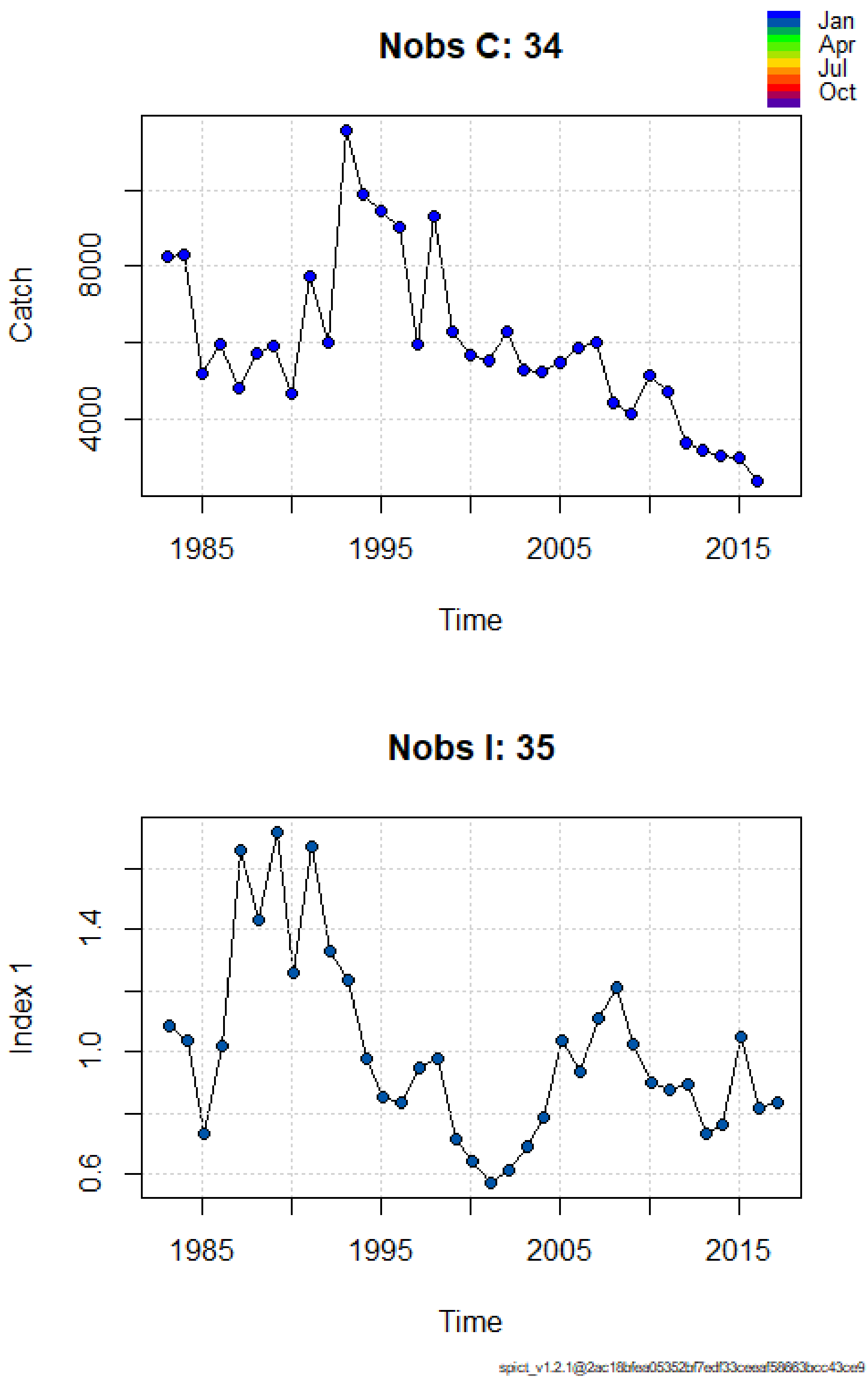
```
retro<-retro(fit)
## Warning in sqrt(diag(cov)): NaNs wurden erzeugt
plotspict.retro(retro)
## Warning in sqrt(rep$diag.cov.random[indran]): NaNs wurden erzeugt
```



SPiCT scenario 2b:

- InterCatch data 2002-2016
- truncated catch time series 1983 - 2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- only Index Q1 (1983 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 - 2016
- priors set to default

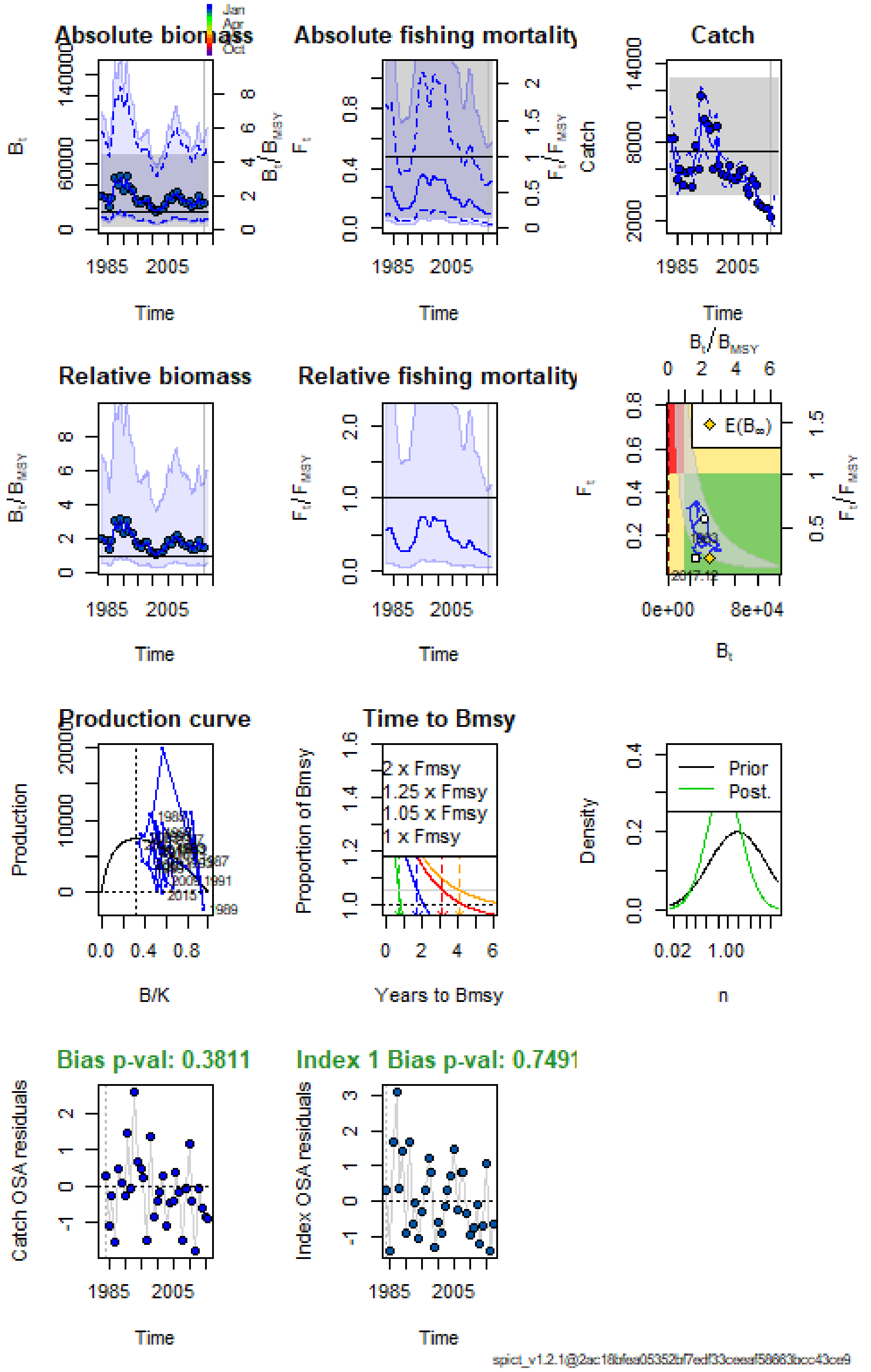
```
starty <- fle_catch[[1]]$time_start>=1983

stdevfacC <- c(#rep(3,length(1974:1982)),
               rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=newidxQ1$Index/mean(newidxQ1$Index),


            timeC=fle_catch[[1]]$time_start[starty],
            timeI=newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,


            stdevfacI = newidxQ1$sd/mean(newidxQ1$sd),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())


inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0



inp <- check.inp(inp)
plotspict.data(inp)
```



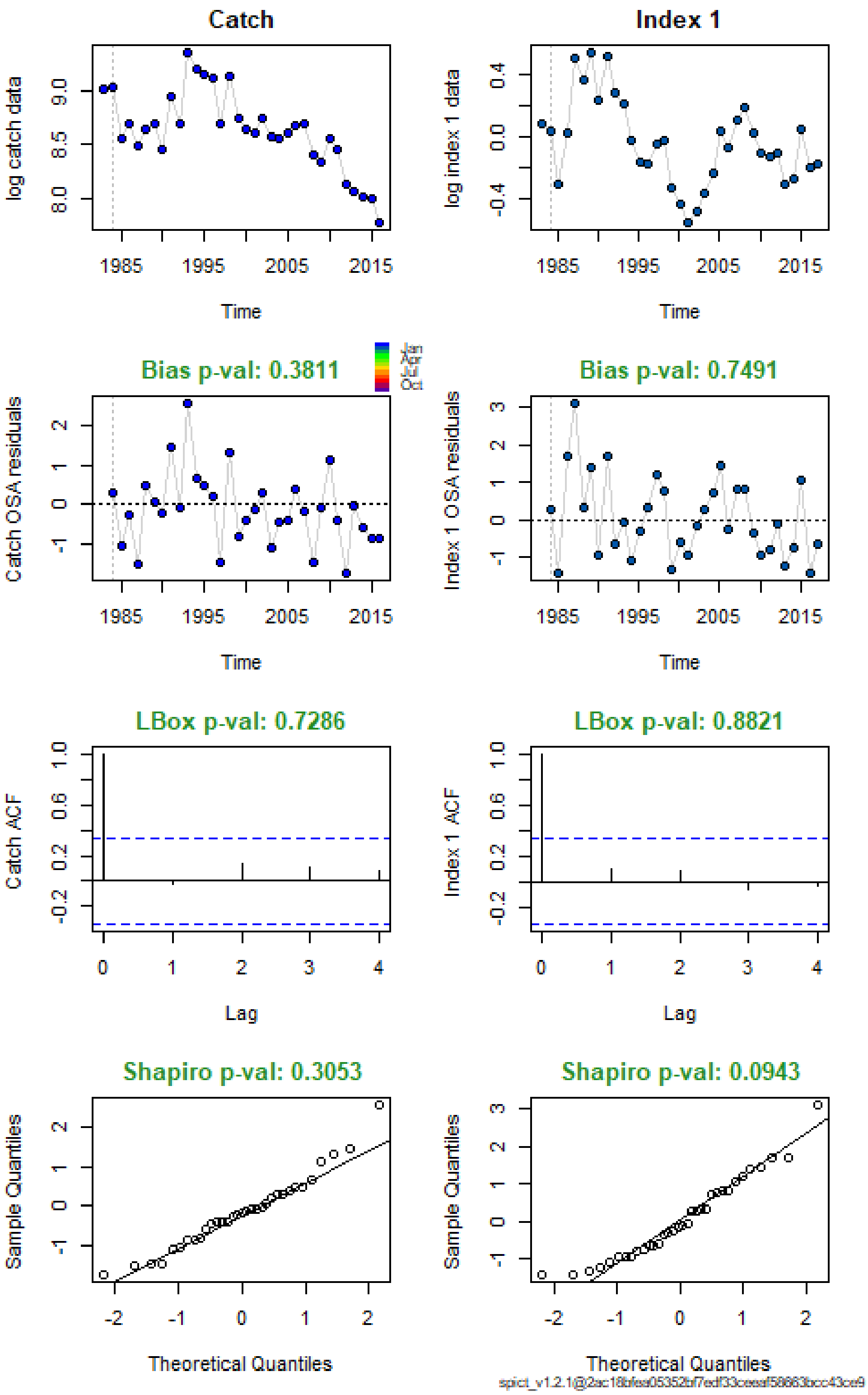

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)
```

```
fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 4.7244917
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 34,  Nobs I1: 35
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.3053 0.3811 0.4149 0.7286       -    -   -    -
##  I1  0.0943 0.7491 0.5759 0.8821       .    -   -    -
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha  3.485694e-01 5.547660e-02 2.190122e+00  -1.0539179
##  beta   5.197994e-01 2.406669e-01 1.122678e+00  -0.6543123
##  r      3.667478e-01 8.958210e-02 1.501461e+00  -1.0030808
##  rc     9.531254e-01 1.635268e-01 5.555348e+00  -0.0480088
##  rold   1.591572e+00 1.376000e-04 1.841148e+04   0.4647225
##  m      7.453186e+03 4.361719e+03 1.273580e+04   8.9163968
##  K      4.873856e+04 1.977432e+04 1.201279e+05  10.7942257
##  q      3.510000e-05 1.260000e-05 9.800000e-05 -10.2563284
##  n      7.695689e-01 6.431060e-02 9.208998e+00  -0.2619248
##  sdb    1.882065e-01 1.185016e-01 2.989130e-01  -1.6702156
##  sdf    2.154466e-01 1.427355e-01 3.251975e-01  -1.5350423
##  sdi    6.560300e-02 1.486630e-02 2.894967e-01  -2.7241335
##  sdc    1.119890e-01 6.599210e-02 1.900460e-01  -2.1893546
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 1.563946e+04 3426.7081474 71378.374535  9.657553
##  Fmsyd 4.765627e-01    0.0817634     2.777674 -0.741156
##  MSYd  7.453186e+03 4361.7185738 12735.799916  8.916397
## Stochastic reference points (Srp)
##            estimate        cilow      ciupp    log.est rel.diff.Drp
##  Bmsys 1.528545e+04 3466.9776358 67391.5176  9.6346565 -0.023160457
##  Fmsys 4.784036e-01    0.0805087     2.8428 -0.7373006  0.003848004
##  MSYs  7.313264e+03 4138.9760777 12921.9963  8.8974450 -0.019132543
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp   log.est
##  B_2017.12      2.413230e+04 8581.0332025 6.786687e+04 10.091306
##  F_2017.12      9.797140e-02    0.0329672 2.911494e-01 -2.323080
##  B_2017.12/Bmsy 1.578776e+00    0.4791480 5.202013e+00  0.456650
##  F_2017.12/Fmsy 2.047881e-01    0.0372303 1.126453e+00 -1.585779
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp   log.est
##  B_2017.12      2.413230e+04 8581.0332025 6.786687e+04 10.091306
##  F_2017.12      9.797140e-02    0.0329672 2.911494e-01 -2.323080
```

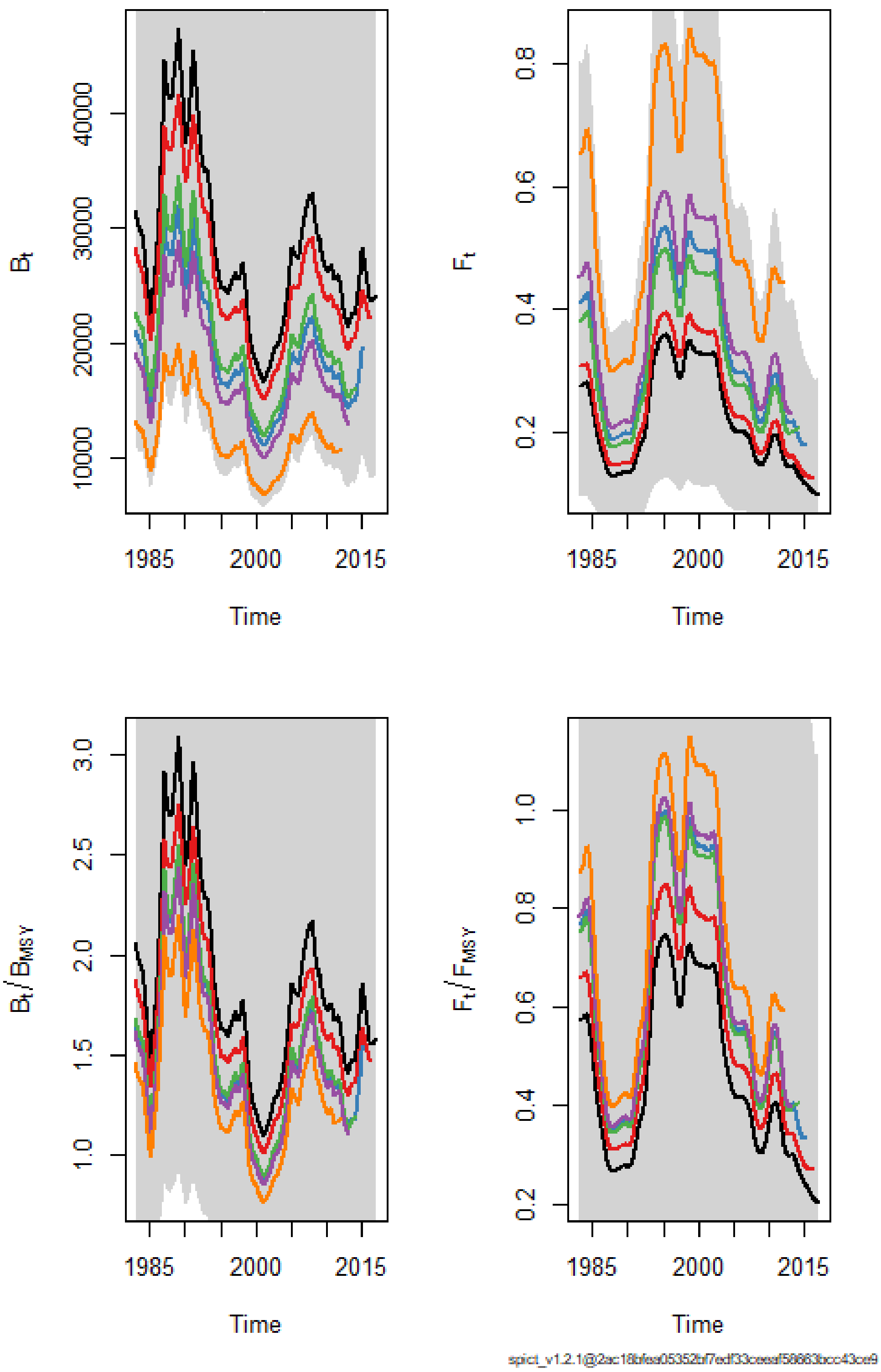
```
## B_2017.12/Bmsy 1.578776e+00    0.4791480 5.202013e+00  0.456650
## F_2017.12/Fmsy 2.047881e-01    0.0372303 1.126453e+00 -1.585779
## Catch_2017.12  2.532936e+03 1635.3018164 3.923290e+03  7.837134
## E(B_inf)       3.633196e+04           NA           NA 10.500453
plot(fit)
```



```
plotspict.diagnostic(fit)
```



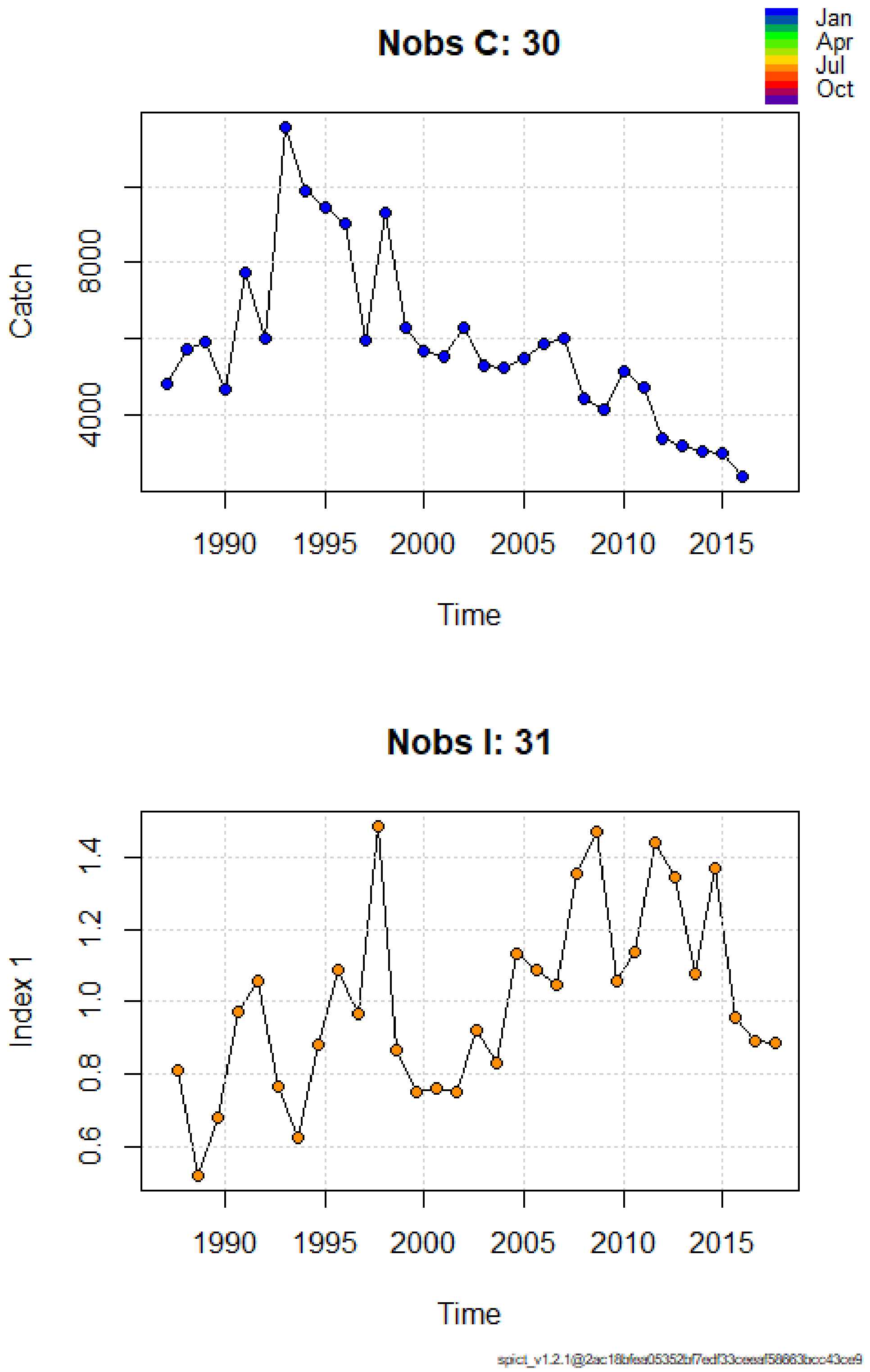
```
retro<-retro(fit)
plotspict.retro(retro)
```



SPiCT scenario 2c:

- InterCatch data 2002-2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- using only combined index Q3 (1987 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (4) 1987 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 - 2016
- priors set to default

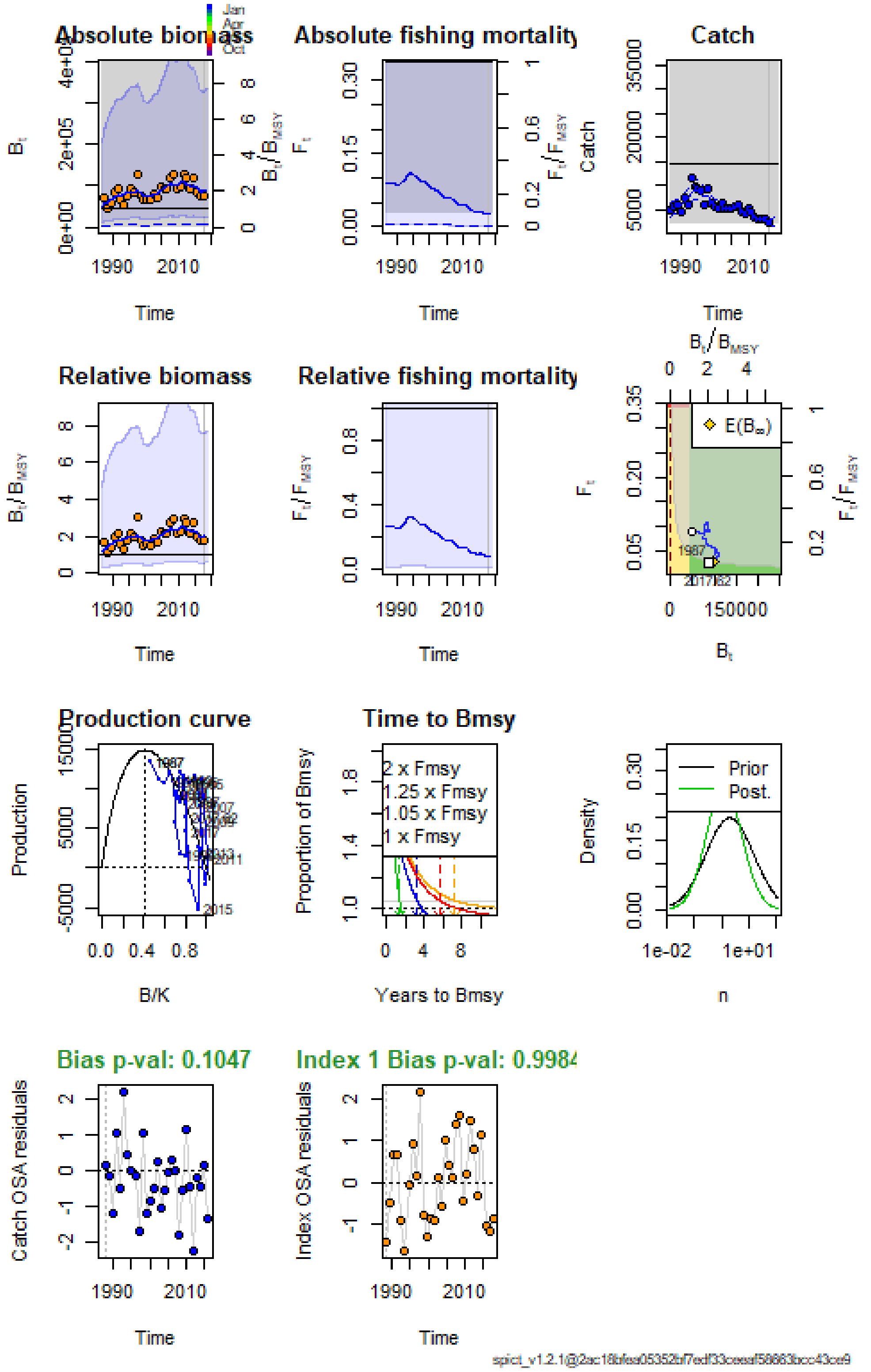
```
starty <- fle_catch[[1]]$time_start>=1987

stdevfacC <- c(#rep(3,length(1974:1982)),
               rep(4,length(1987:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=newidxQ3$Index/mean(newidxQ3$Index),

            timeC=fle_catch[[1]]$time_start[starty],
            timeI=newidxQ3$Year + (newidxQ3$Quarter - 0.5) / 4,

            stdevfacI = newidxQ3$sd/mean(newidxQ3$sd),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())


inp$priors$logn<-c(log(2),2,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0



inp <- check.inp(inp)
plotspict.data(inp)
```



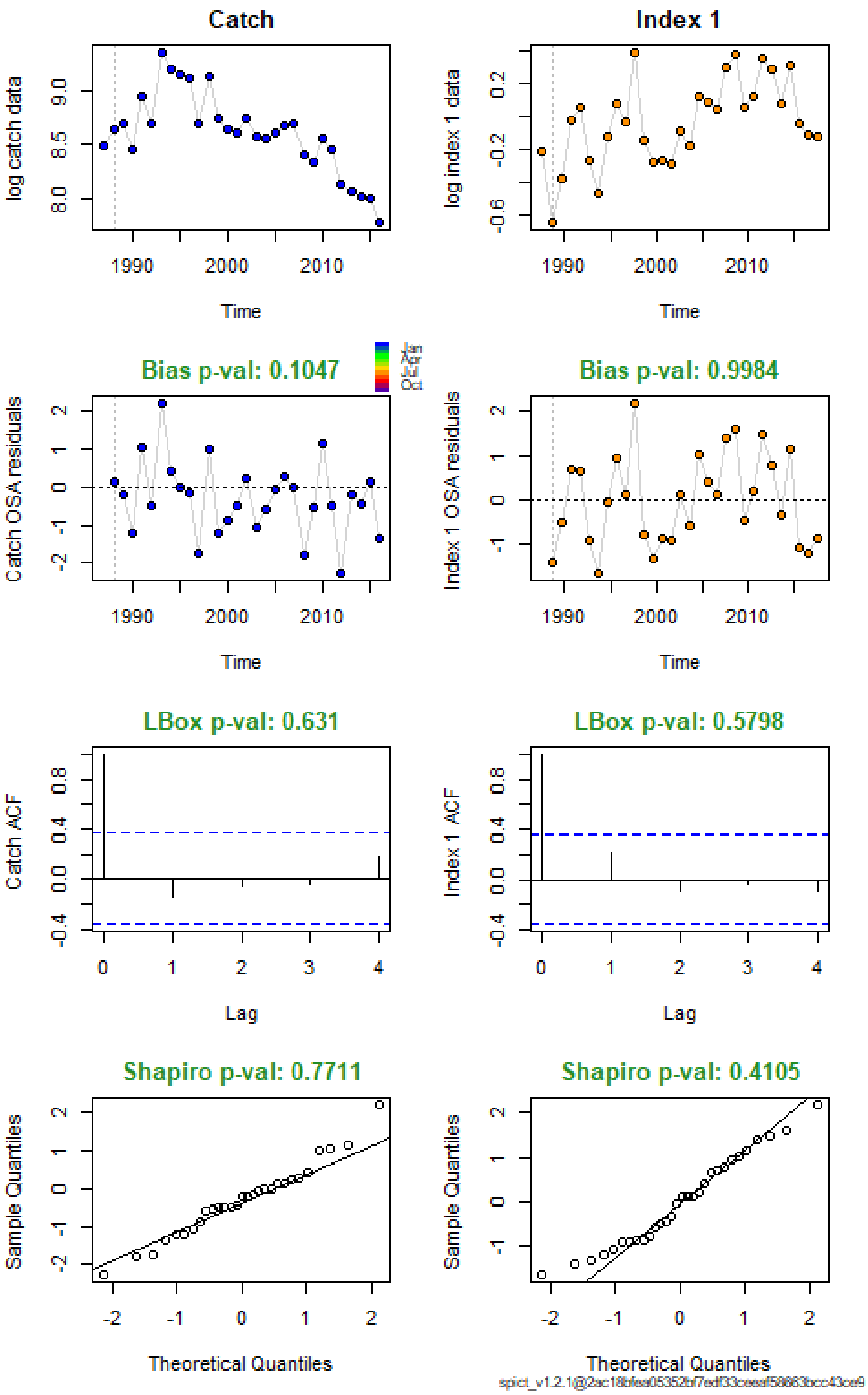

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)
```

```
fit

## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 5.2668046
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 30,  Nobs I1: 31
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.7711 0.1047 0.3299 0.6310       -    -   -    -
##  I1  0.4105 0.9984 0.2320 0.5798       -    -   -    -
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha  1.729619e+00    0.6283365 4.761115e+00   0.5479012
##  beta   9.644422e-01    0.4509656 2.062571e+00  -0.0362053
##  r      4.240409e-01    0.0803258 2.238516e+00  -0.8579254
##  rc     6.783178e-01    0.0630505 7.297562e+00  -0.3881394
##  rold   1.694320e+00    0.0000018 1.565229e+06   0.5272815
##  m      1.488420e+04 2358.3466128 9.393849e+04   9.6080558
##  K      1.071319e+05 7965.2715359 1.440910e+06  11.5818159
##  q      1.150000e-05    0.0000007 1.967000e-04 -11.3739261
##  n      1.250272e+00    0.0666537 2.345227e+01   0.2233611
##  sdb    1.038041e-01    0.0448257 2.403820e-01  -2.2652500
##  sdf    1.344425e-01    0.0791272 2.284272e-01  -2.0066184
##  sdi    1.795415e-01    0.1264795 2.548648e-01  -1.7173487
##  sdc    1.296621e-01    0.0846621 1.985805e-01  -2.0428238
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 4.388564e+04 2776.4687125 6.936686e+05 10.689342
##  Fmsyd 3.391589e-01    0.0315253 3.648781e+00 -1.081287
##  MSYd  1.488420e+04 2358.3466128 9.393849e+04  9.608056
## Stochastic reference points (Srp)
##            estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 4.344443e+04 2773.1998565 6.805924e+05 10.679238  -0.01015554
##  Fmsys 3.385128e-01    0.0306182 3.742578e+00 -1.083193  -0.00190863
##  MSYs  1.470621e+04 2264.1617953 9.551999e+04  9.596025  -0.01210311
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp    log.est
##  B_2017.62      8.691290e+04 5451.9088045 1.385543e+06 11.3726618
##  F_2017.62      2.708680e-02    0.0016039 4.574534e-01 -3.6087090
##  B_2017.62/Bmsy 2.000553e+00    0.5312304 7.533856e+00  0.6934238
##  F_2017.62/Fmsy 8.001700e-02    0.0041247 1.552299e+00 -2.5255157
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
##  B_2017.62      8.691290e+04 5451.9088045 1.385543e+06 11.3726618
##  F_2017.62      2.708680e-02    0.0016039 4.574534e-01 -3.6087090
```

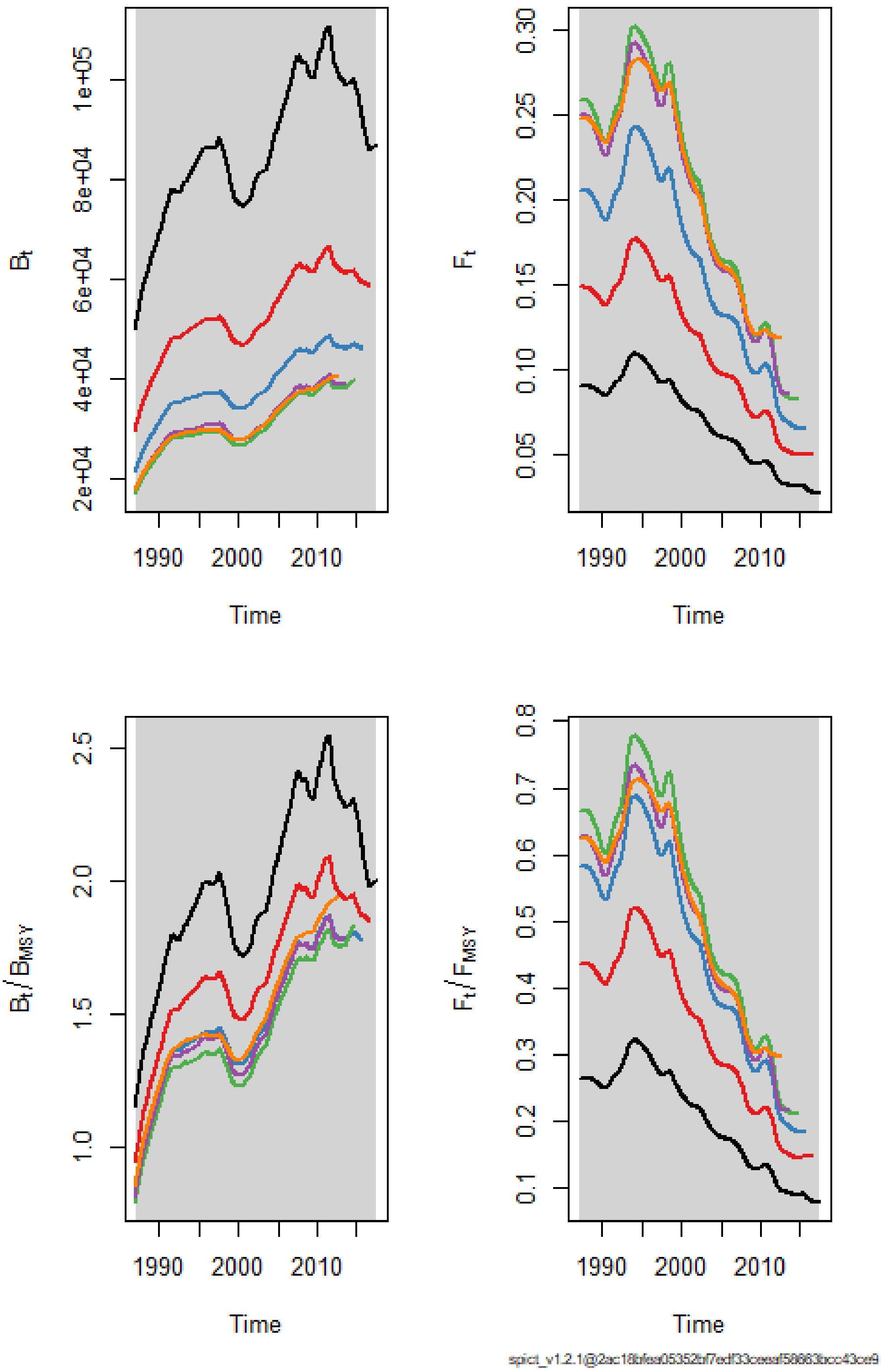
```
## B_2017.62/Bmsy 2.000553e+00    0.5312304 7.533856e+00  0.6934238
## F_2017.62/Fmsy 8.001700e-02    0.0041247 1.552299e+00 -2.5255157
## Catch_2017.62  2.408059e+03 1667.0094856 3.478535e+03  7.7865765
## E(B_inf)       9.881362e+04           NA           NA 11.5009907
plot(fit)
```



```
plotspict.diagnostic(fit)
```




```
retro<-retro(fit)
plotspict.retro(retro)
```

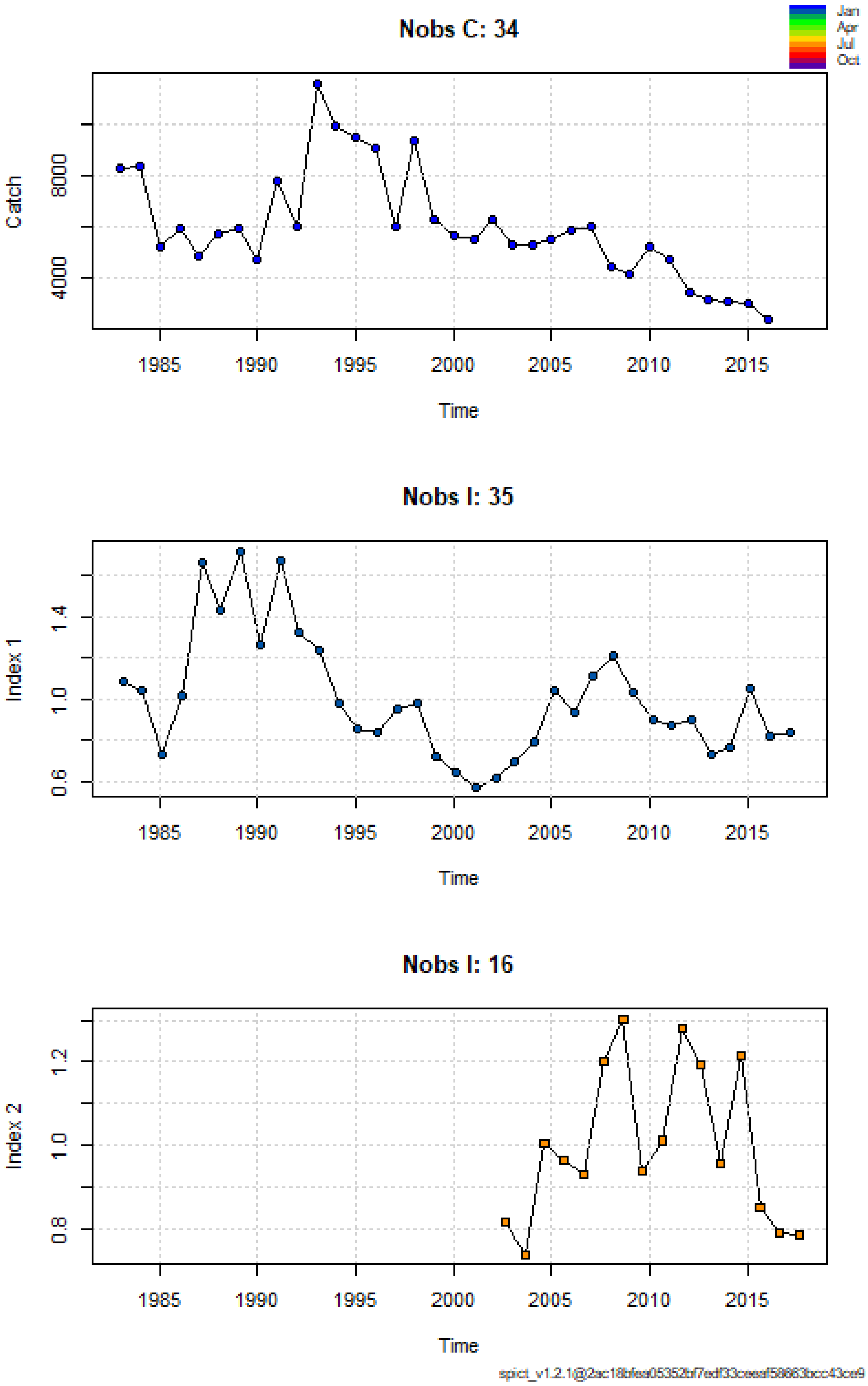

B_t
1e+05
8e+04
6e+04
4e+04
2e+04
1990
2000
2010
Time
F_t
0.30
0.25
0.20
0.15
0.10
0.05
1990
2000
2010
Time
B_t/B_{MSY}
2.5
2.0
1.5
1.0
1990
2000
2010
Time
F_t/F_{MSY}
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1990
2000
2010
Time

SPiCT scenario 2 - final run:

- InterCatch data 2002-2016
- truncated catch time series 1983 - 2016
- reconstructed Dutch landings for time period 1984-1997 by applying average Dutch landings proportion 1974 - 1983 (0.64)
- Index Q1 (1983 - 2016), combined index Q3 (2002 - 2016)
- missing discards information prior to 2002 was estimated by applying the average discard ratio of 0.48 (average 2002 - 2016)
- Different uncertainties were applied for different time periods:
  - (4) 1983 - 1997
  - (3) 1998 - 2001
  - (2) 2002 - 2010
  - (1) 2011 - 2016
- priors on sd log(n) set to 1

```
starty <- fle_catch[[1]]$time_start>=1983

newidxQ3_s <- subset(newidxQ3,newidxQ3$Year>=2002)

stdevfacC <- c(#rep(3,length(1974:1982)),
               rep(4,length(1983:1997)),
               rep(3,length(1998:2001)),
               rep(2, length(2002:2010)),
               rep(1,length(2011:2016)))

inp <- list(obsC=fle_catch[[1]]$obs[starty],
            obsI=list(newidxQ1$Index/mean(newidxQ1$Index),
                      newidxQ3_s$Index/mean(newidxQ3_s$Index)),

            timeC=fle_catch[[1]]$time_start[starty],
            timeI=list(newidxQ1$Year + (newidxQ1$Quarter - 0.5) / 4,
                       newidxQ3_s$Year + (newidxQ3_s$Quarter - 0.5) / 4),

            stdevfacI = list(newidxQ1$sd/mean(newidxQ1$sd),
                             newidxQ3_s$sd/mean(newidxQ3_s$sd)),

            stdevfacC = stdevfacC / mean(stdevfacC),

             priors = list())

inp$priors$logn<-c(log(2),1,1) ## Change default prior from using sd=2 to s
d=1 for logn
## format: mu, sd, on=1/off=0
```

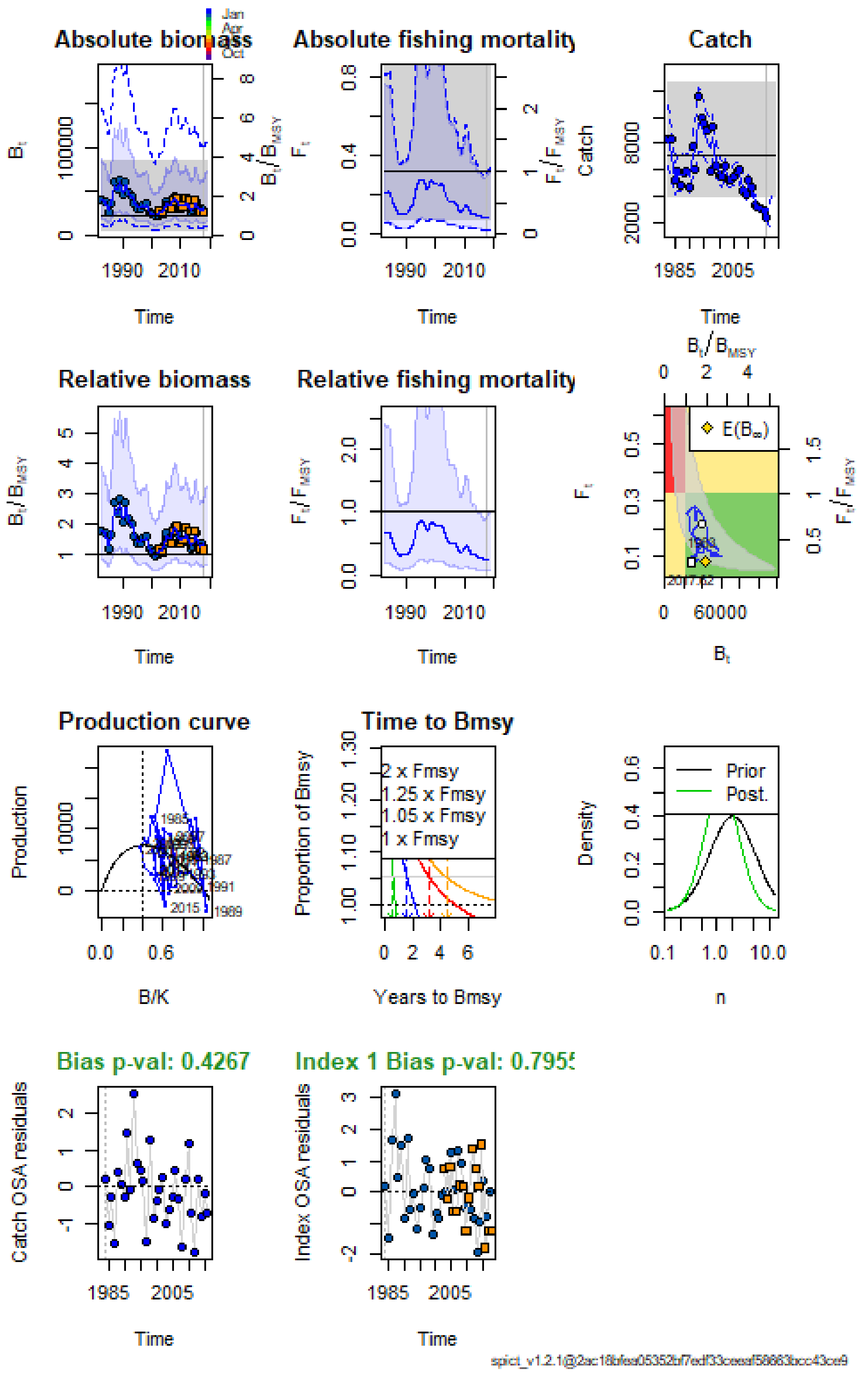
```
inp <- check.inp(inp)
plotspict.data(inp)
```



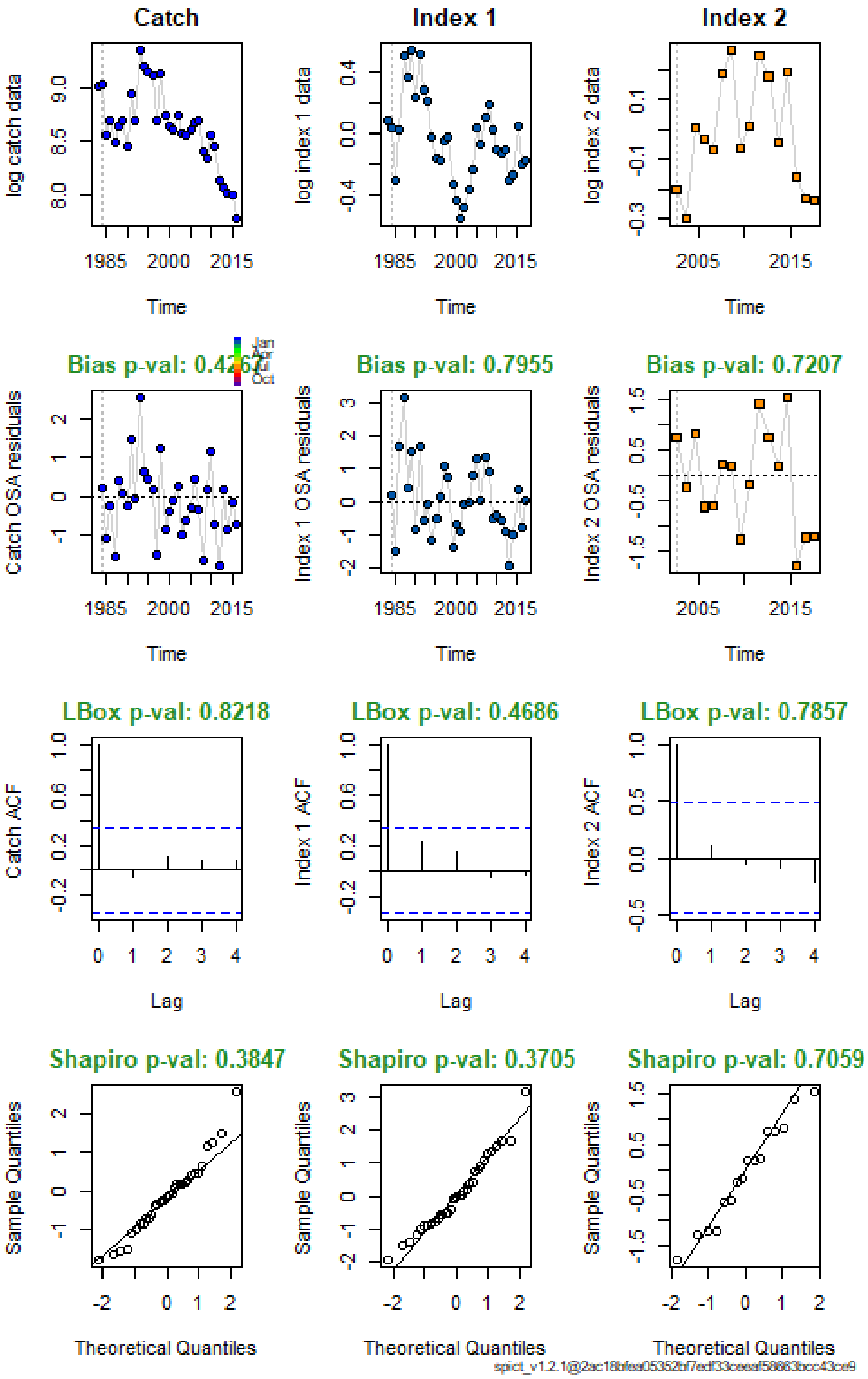

```
fit <- fit.spict(inp)
fit <- calc.osa.resid (fit)


fit
```

```
## Convergence: 0  MSG: both X-convergence and relative convergence (5)
## Objective function at optimum: -0.5255592
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 34,  Nobs I1: 35,  Nobs I2: 16
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.3847 0.4267 0.5131 0.8218       -    -   -    -
##  I1  0.3705 0.7955 0.2017 0.4686       -    -   -    -
##  I2  0.7059 0.7207 0.3970 0.7857       -    -   -    -
##
## Priors
##      logn  ~  dnorm[log(2), 1^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp     log.est
##  alpha1 4.264118e-01 7.578370e-02 2.399288e+00  -0.8523497
##  alpha2 6.705819e-01 2.830956e-01 1.588439e+00  -0.3996094
##  beta   5.499485e-01 2.459506e-01 1.229691e+00  -0.5979307
##  r      3.989689e-01 1.210032e-01 1.315471e+00  -0.9188717
##  rc     6.433963e-01 1.537638e-01 2.692174e+00  -0.4409944
##  rold   1.661010e+00 1.010000e-03 2.731611e+03   0.5074262
##  m      7.403853e+03 4.315360e+03 1.270278e+04   8.9097559
##  K      5.639418e+04 1.914416e+04 1.661240e+05  10.9401213
##  q1     2.740000e-05 7.600000e-06 9.870000e-05 -10.5037800
##  q2     3.050000e-05 8.500000e-06 1.093000e-04 -10.3977210
##  n      1.240196e+00 2.690981e-01 5.715713e+00   0.2152698
##  sdb    1.803293e-01 1.087104e-01 2.991310e-01  -1.7129709
##  sdf    2.099476e-01 1.355672e-01 3.251375e-01  -1.5608973
##  sdi1   7.689450e-02 2.053260e-02 2.879700e-01  -2.5653206
##  sdi2   1.209255e-01 6.359360e-02 2.299443e-01  -2.1125803
##  sdc    1.154604e-01 6.789900e-02 1.963371e-01  -2.1588280
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 2.301491e+04 5954.4628003 88956.129406 10.043897
##  Fmsyd 3.216982e-01    0.0768819     1.346087 -1.134142
##  MSYd  7.403853e+03 4315.3597762 12702.775110  8.909756
## Stochastic reference points (Srp)
##            estimate        cilow       ciupp   log.est rel.diff.Drp
##  Bmsys 2.228990e+04 5894.4867146 84288.88239 10.011889  -0.03252622
##  Fmsys 3.198172e-01    0.0736119     1.38949 -1.140006  -0.00588136
##  MSYs  7.127330e+03 4035.5298008 12587.89638  8.871692  -0.03879763
##
## States w 95% CI (inp$msytype: s)
##                     estimate        cilow        ciupp    log.est
##  B_2017.62      2.876450e+04 8200.5954627 1.008947e+05 10.2668972
##  F_2017.62      8.155040e-02    0.0210403 3.160823e-01 -2.5065337
##  B_2017.62/Bmsy 1.290472e+00    0.6111736 2.724788e+00  0.2550082
##  F_2017.62/Fmsy 2.549908e-01    0.0700037 9.288124e-01 -1.3665279
##
## Predictions w 95% CI (inp$msytype: s)
##                   prediction        cilow        ciupp    log.est
```

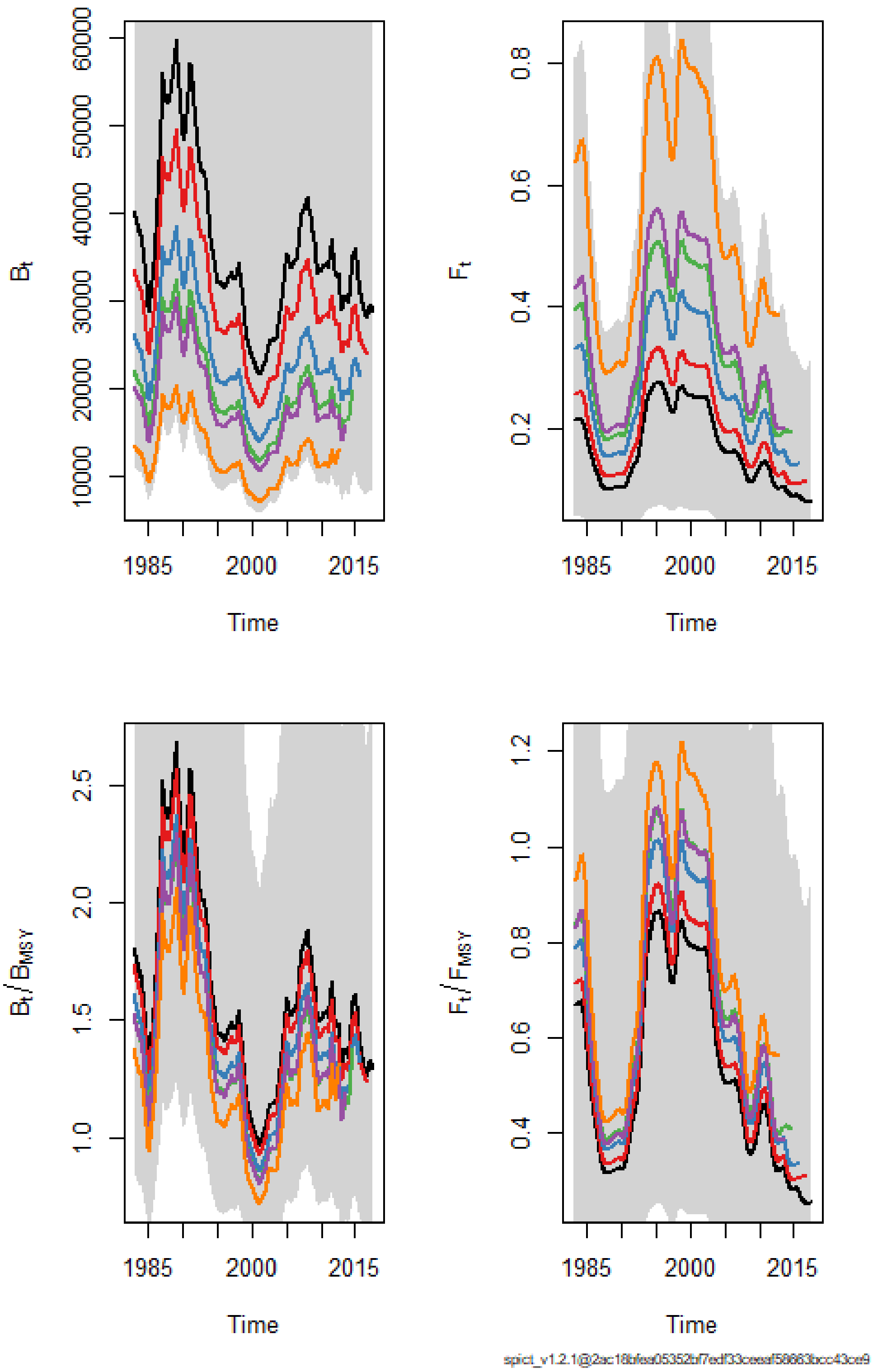
```
## B_2017.62        2.876450e+04 8200.5954627 1.008947e+05 10.2668972
## F_2017.62        8.155040e-02    0.0210403 3.160823e-01 -2.5065337
## B_2017.62/Bmsy 1.290472e+00    0.6111736 2.724788e+00  0.2550082
## F_2017.62/Fmsy 2.549908e-01    0.0700037 9.288124e-01 -1.3665279
## Catch_2017.62    2.502145e+03 1467.4518175 4.266397e+03  7.8249038
## E(B_inf)         4.323049e+04           NA           NA 10.6743013

plot(fit)
```



```
plotspict.diagnostic(fit)
```



```
retro<-retro(fit)
plotspict.retro(retro)
```



Annex 6: Lemon sole working documents

In the following pages, the working documents on lemon sole available at WKNSEA 2018 are inserted.

WP1_North Sea Lemon Sole_WP.docx	05/04/2018 15:48	Microsoft Word D...	1,393 KB
WP2_Survey indices_lemon sole.pdf	05/04/2018 15:48	Adobe Acrobat D...	2,795 KB
WP3_SPiCT Stock Assessments of Lem...	05/04/2018 15:48	Adobe Acrobat D...	2,466 KB

North Sea Lemon Sole

Working Paper for ICES WKNSEA, February 2018

Dr Coby Needle, MSS Marine Laboratory, Aberdeen

1. Introduction

This paper summarises the analysis work done regarding the benchmark of North Sea lemon sole, prepared in advance of the ICES WKNSEA meeting in Copenhagen during 5-9 February 2018. The areas requested for the preparatory work (ICES-WKNSEA 2017), along with a short note for each on where the results are reported in this paper, are as follows:

- 2002-2016 catch data - InterCatch (Coby Needle). See Section 2.
- Biological parameters: stock weights-at-age, maturity, length-weight relationship (Coby Needle). See Section 3.
- Survey indices (Casper Berg, Coby Needle). See Section 3.
- SPiCT assessment (Casper Berg, Alexandros Kokkalis, Rasmus Nielsen). See Section 4.

We also include here a draft SURBAR assessment (see Section 5), along with an exploratory GeoPop assessment by Dr Tanja Buch (see Section 6).

2. 2002-2016 catch data

Catch data for the years 2002-2016 were provided by several participating nations following the WKNSEA data call, and were collated using the InterCatch system. Commercial age samples proved to be sparse (see Tables 1 to 3). They were only provided by two countries (Denmark and Belgium), and although these do provide 27% and 17% respectively of international landings in area 4 (average 2014-2016), and the reported effort of the Danish fleet does cover most of the survey-implied distribution of lemon sole (see Figures 1 and 2), the age data (for discards in particular) were not deemed by WKNSEA to be of sufficient quantity to warrant further consideration of an age-based assessment using commercial data. For this reason, collation in InterCatch used length-based sampling only.

WKNSEA considered whether areas should be considered separately for raising discards and length compositions, but the prevailing view was that there was no evidence of distinct stocks between areas (say, between areas 4 and 3.a), and that therefore all areas should be treated together for raising. Initial exploration demonstrated that final discard raising was significantly influenced by a small number of métiers with discard ratios greater than 1.5 (in other words, those métiers for which discards/landings > 1.5). Subsequently, these métiers were discounted in calculating raising factors as they were thought to be non-representative for a high-value stock such as lemon sole. Otherwise, discards for *all* unsampled fleets were inferred by a discard rate generated using *all* sampled fleets (weighted by the landings CATON), as it was not thought likely that discard rates for an (essentially) bycatch stock such as lemon sole would vary a great deal between different métiers (apart from the extreme and unrepresentative examples discussed above).

Length-distribution allocations were conducted in the same way (weighted by mean numbers at length), with the only distinction being made between landings and discards. Length samples are reasonably well spread across the main countries catching lemon sole, albeit with a large spike in the final year for some countries following the relevant data call, and length-based allocations are likely to be sufficiently representative (see Tables 4 to 6). It is worth noting that the InterCatch raising procedure took a very long time for this stock - on average, each year of data took around half a day to produce, and it is not clear why this should be. The resultant estimates for landings and discards for 2002-2016 are given in Table 7. We note that the official landings for 2012 did not include estimates for the UK, which is why they are considerably lower than the new InterCatch estimates. It can also be seen that the 2013 discard estimate is very high – the estimation has been repeated three times and does not appear to be in error, and it would be helpful to try and determine why discard rates were so high in 2013.

3. Biological parameters

Sex ratios were derived from the *SMALK* (sex-maturity-age-length-key) subset of the DATRAS database. This provides these data for fish for which the relevant measurements were conducted, which generally is around 10% of all lemon sole caught on the survey. Figure 3 illustrates the sex ratio estimates with the proportion female in the IBTS Q1 and Q3 lemon sole caught in 2016, although this can be done for all available years with *SMALK* data (2006-2017). The Figure shows that, as is often the case for marine fish, the larger fish tend to be predominantly female.

SMALK data were also used to determine the proportion mature at age and length for each available year (2006-2017). The results for age from IBTS Q1 are summarised in Table 8. This is a fairly rough-and-ready procedure that converts the range of different maturity indicators used in the *SMALK* dataset to a common mature/not mature indicator, and then summarises the mature proportion across ages and lengths. The analysis further attempts to fit the following model

$$Mat = \frac{\gamma}{1+e^{\alpha+\beta A}} \quad (1)$$

where *A* denotes age or length as required. Figure 4 (upper) shows the results for maturity at age in 2016, using *SMALK* data from IBTS Q1.

A similar calculation was also carried out to determine the mean weight at age or length in the IBTS Q3 survey, which could (in the absence of other information) be used as a proxy for mean weight-at-age in the stock. Figure 4 (lower) shows the results for 2016 from the IBTS Q3 survey, along with a line tracing the mean weight at each age. The mean weight-at-age estimates are also given in Tables 9 (IBTS Q1) and 10 (IBTS Q3).

Finally, a length-weight relationship was derived for each year for which *SMALK* data were available. Figure 5 shows the fitted model $W = L^{\beta}$ for data from the IBTS Q1 and Q3 surveys in 2016.

4. Survey indices

Three survey indices were developed for WKNSEA, based on IBTS Q1 and Q3 and BTS Q3 (either individually or in combination). These are considered further below.

a. Needle estimation

The simplest of the indices, derived for IBTS Q1 and Q3 separately, is based on a postgraduate course in fisheries science given at the University of Aberdeen (Needle 2014). The approach used is intended to demonstrate survey index generation clearly to students who may not have a mathematical background, and is therefore a) quite simplistic, and b) probably not statistically optimal. It is included here as it was presented to the WKNSEA data meeting in November 2017, and it remains a useful fallback should more complicated indices not be available.

The procedure for each year can be summarised as follows:

- Generate an age-length key for the year, using data from the *SMALK* subset of the DATRAS database.
- Collate length data for all lemon sole caught during that year's survey, using the *CPUE per length per haul* subset of DATRAS.
- Apply the age-length key to determine a distribution of inferred ages for each length class, and thereby derive the inferred number of fish caught per age during the survey.
- Rescale as number of fish caught per hour.

The resulting survey index can be used in a survey-based assessment method, but caution must be used – the approach takes no account of statistical issues such as spatial autocorrelation, and as a result may not be particularly reliable.

b. ICES estimation

ICES staff have developed indices for lemon sole following the standard ICES approaches (including area fill-ins as necessary). These are based on the same data as the procedure outlined above, but a different estimation approach is likely to lead to differences.

c. Berg model

At the WKNSEA data meeting, Casper Berg produced IBTS indices for Q1 and combined IBTS-BTS indices for Q3 using the same code that is currently employed to derive indices for North Sea cod (amongst other stocks) and which therefore has been extensively tested and verified (Berg et al 2014). The method used in covered in a separate WP (see Berg 2018).

d. Index comparisons

The three estimation approaches are compared in Figures 6 (Q1) and 7 (Q3). We note that the Berg method for Q3 incorporates both IBTS and BTS survey data, and thus utilises the available data more fully than either the Needle or ICES estimations. From Figure 6, we see some consistency between the methods for ages 2-5 (comparisons are limited to age 5 because the Berg model output was for ages 1-5 only), but there is little similarity between the estimates for age 1 and this must be considered to be a problematic age for IBTS Q1. Consistency is better for Q3 (Figure 7), even allowing for the fact that the Berg method uses both IBTS and BTS data for this quarter (and noting that the youngest age is still poorly estimated).

The Needle method would not be particularly recommended, as it is a teaching tool rather than an optimised data-generation method. For the key ages in both Q1 and Q3, the results of the Berg and ICES methods are relatively similar, and it may be appropriate to consider further testing using survey-based assessment methods to determine which survey index results in the more robust assessment for advice.

5. SPiCT assessment

See Nielsen 2018.

6. SURBAR assessment

To be completed.

7. GeoPop assessment

To be completed.

8. References

Berg, C. W., Nielsen, A. and Kristensen, K. (2014). Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151, 91-99.

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Table 1. North Sea lemon sole. Number of age samples provided to InterCatch (Area 4). Years with no samples are highlighted in red.

Area	27.4

	Belgium Landings	Discards	Denmark Landings	Discards
2002	0	0	772	0
2003	0	0	764	0
2004	0	0	868	0
2005	0	0	1	0
2006	0	0	171	0
2007	0	0	103	0
2008	0	0	225	5
2009	0	0	339	54
2010	0	0	477	1
2011	0	0	265	11
2012	0	0	423	0
2013	237	0	211	0
2014	0	0	799	0
2015	76	0	1418	0
2016	135	0	1637	0

Table 2. North Sea Lemon Sole. Number of age samples provided to InterCatch (Area 3.a). Years with no samples are highlighted in red.

Area	27.3.a

	Belgium Landings	Discards	Denmark Landings	Discards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	3
2009	0	0	0	3
2010	0	0	0	28
2011	0	0	0	15
2012	0	0	0	16
2013	365	0	0	9
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	379	10

Table 3. North Sea Lemon Sole. Number of age samples provided to InterCatch (Area 7.d). Years with no samples are highlighted in red.

Area	27.7.d

	Belgium Landings	Discards	Denmark Landings	Discards
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	175	282	0	0
2015	126	388	0	0
2016	197	184	0	0

Table 4. North Sea lemon sole. Number of length samples provided to InterCatch (area 4), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.4	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	199
		Denmark	61	52	212	80	113	84	69	88	29	87	126	87	66	121	145
		France	0	0	64	0	74	0	0	0	0	0	0	0	0	0	0
		Germany	49	235	20	20	1	32	50	13	6	114	51	153	73	44	2
		Netherlands	0	0	0	0	0	0	0	0	0	47	39	18	46	444	1153
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	200	678	1374	396	287	747	1043	280	177	313	99	302	234	323	559
		UK (Scotland)	0	0	0	0	0	0	0	183	0	0	43	13	0	260	4322
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2616
		Denmark	772	764	868	0	171	103	225	0	0	0	0	99	0	124	1637
		France	0	0	0	0	0	0	0	0	0	0	0	0	59	0	0
		Germany	69	45	30	61	48	32	150	277	182	48	236	98	100	332	392
		Netherlands	0	0	0	0	0	0	0	0	0	31	135	72	169	185	0
		Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	5804	6434	11189	5860	1296	1270	748	294	343	208	0	269	71	394	683
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	72	0	72	0	9135

	3 year average landings
UK	38%
DNK	27%
BEL	17%
NED	14%
GER	2%
FRA	1%
NOR	1%
Other	0%

Table 5. North Sea lemon sole. Number of length samples provided to InterCatch (area 3.a), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.3.a	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Denmark	430	0	0	65	133	116	86	261	293	288	389	222	94	263	357
		France	0	0	71	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	294	0	0	368	445	316	217	204	335	239	251	336	205	62	385
		UK (England)	0	12	245	0	0	0	0	0	0	0	0	0	0	0	0
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379
		France	0	0	106	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	7	0	4	0	0	3	17	0	0	53	3	22
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	59	0
		Sweden	368	0	0	598	1016	222	69	255	347	88	118	65	41	0	0
		UK (England)	0	274	2983	0	0	0	0	0	0	0	0	0	0	0	0
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	3 year average landings
BEL	0%
DNK	90%
GER	2%
NED	3%
SWE	3%
Other	2%

Table 6. North Sea lemon sole. Number of length samples provided to InterCatch (area 7.d), along with the proportion of reported landings from each country. Years with no samples are highlighted in red.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27.7.d	Discards	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3053
		Denmark	0	1	410	0	0	0	0	0	0	0	0	0	0	0	0
		France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	0	0	132	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	1	0	0	110	81	20	80	10	82	99	77	20	45	2	29
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Landings	Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7443
		Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		France	0	0	0	0	0	0	147	0	0	0	0	0	65	0	391
		Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sweden	0	0	184	0	0	0	0	0	0	0	0	0	0	0	0
		UK (England)	45	0	0	1932	90	137	0	272	160	0	167	189	169	156	1148
		UK (Scotland)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	3 year average landings
BEL	47%
DNK	0%
FRA	31%
NED	3%
UK	19%
Other	0%

Table 7. North Sea lemon sole. InterCatch estimates of landings, discards, and total catch along with officially reported landings, for 2002-2016 (all values in tonnes). The high discard estimate in 2013 is highlighted.

Year	Official landings	InterCatch landings	InterCatch discards	InterCatch total catch	Discard rate
2002	4823	4011	511	4522	11.30%
2003	4722	4575	1036	5611	18.46%
2004	4574	4394	635	5028	12.62%
2005	4468	4429	527	4955	10.63%
2006	4290	4294	1515	5809	26.08%
2007	4488	4468	451	4919	9.18%
2008	3976	4153	898	5051	17.77%
2009	3397	3405	996	4401	22.64%
2010	3198	3234	673	3907	17.21%
2011	4019	4030	1024	5055	20.27%
2012	2959	4099	2461	6560	37.52%
2013	3761	3725	**5938**	9663	**61.45%**
2014	3688	3645	1690	5335	31.68%
2015	3393	3480	1636	5116	31.97%
2016	3805	3834	1161	4995	23.25%
				Average	17.22%

Table 8. North Sea lemon sole. Estimated proportion mature-at-age from IBTS Q1. SMALK data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006-2017. The full age-range (0-18) is given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1984	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1985	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1986	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1987	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1988	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1989	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1990	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1991	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1992	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1993	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1994	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1995	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1996	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1997	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1998	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
1999	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2000	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2001	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2002	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2003	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2004	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2005	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2006	NA	0.167	0.747	0.887	0.944	0.905	0.826	0.961	0.919	0.889	1	1	0.957	1	1	1	NA	1	1
2007	NA	NA	0.000	0.667	0.565	0.676	0.690	0.833	0.800	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
2008	NA	NA	0.933	0.898	1.000	0.943	0.846	0.972	0.846	0.875	1	1	0.955	1	1	1	NA	1	NA
2009	NA	1.000	0.933	1.000	0.917	1.000	1.000	1.000	1.000	1.000	1	NA	1.000	1	NA	NA	NA	NA	1
2010	NA	0.000	0.675	0.843	0.957	0.875	0.500	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	0.909	1.000	1.000	0.952	1.000	NA	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	0.900	0.983	0.923	0.933	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	0.000	0.767	0.949	0.950	1.000	1.000	NA	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	0.379	0.587	0.969	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	0.727	0.922	0.976	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	0.818	0.979	1.000	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	0.864	0.913	0.980	1.000	1.000	1.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 9. North Sea lemon sole. Estimated mean weight-at-age from IBTS Q1 survey. SMALK data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006-2017. The full age-range (0-18) is given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1984	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1985	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1986	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1987	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1988	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1989	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1990	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1991	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1992	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1993	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1994	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1995	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1996	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1997	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1998	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
1999	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2000	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2001	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2002	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2003	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2004	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2005	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2006	NA	0.017	0.060	0.115	0.188	0.280	0.330	0.235	0.170	0.118	0.157	0.183	0.143	0.172	0.103	0.160	NA	0.217	0.158
2007	NA	NA	0.056	0.099	0.173	0.326	0.412	0.530	0.220	NA	NA	0.226	NA	NA	NA	NA	NA	NA	NA
2008	NA	NA	0.061	0.111	0.193	0.289	0.230	0.166	0.104	0.112	0.129	0.150	0.137	0.145	0.098	0.153	NA	0.209	NA
2009	NA	0.030	0.085	0.136	0.218	0.242	0.187	0.216	0.164	0.122	0.205	NA	0.142	0.164	NA	NA	NA	NA	0.150
2010	NA	0.013	0.059	0.106	0.159	0.291	0.292	0.315	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	0.060	0.102	0.170	0.231	0.368	NA	0.485	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	0.063	0.152	0.245	0.358	0.372	0.658	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	0.016	0.057	0.139	0.220	0.316	0.510	NA	0.442	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	0.013	0.058	0.110	0.172	0.257	0.218	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	0.046	0.094	0.185	0.174	0.273	0.334	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	0.055	0.099	0.161	0.197	0.139	0.158	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	0.065	0.128	0.197	0.310	0.409	0.494	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 10. North Sea lemon sole. Estimated mean weight-at-age from IBTS Q3 survey. SMALK data are available only from 2006 onwards, so estimates for earlier years are the means of the data from 2006-2017. The full age-range (0-18) is given here.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1991	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1992	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1993	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1994	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1995	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1996	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1997	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1998	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
1999	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2000	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2001	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2002	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2003	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2004	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2005	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839
2006	0.010	0.051	0.083	0.127	0.264	0.251	0.296	0.258	0.250	0.272	0.404	0.290	0.365	NA	NA	NA	NA	NA	NA	NA	NA
2007	0.032	0.055	0.071	0.125	0.259	0.327	0.371	0.340	0.379	0.301	0.408	NA	0.292	0.309	NA	0.325	NA	NA	NA	NA	NA
2008	NA	0.046	0.081	0.135	0.225	0.377	0.307	0.408	0.287	0.410	0.374	0.452	0.316	NA	0.452	0.178	0.178	0.342	NA	NA	NA
2009	0.014	0.054	0.098	0.170	0.259	0.269	0.330	0.276	0.404	NA	NA	0.105	NA	0.138	NA	NA	NA	NA	NA	NA	NA
2010	0.002	0.039	0.062	0.098	0.245	0.235	0.202	0.291	0.283	0.326	0.259	0.393	0.331	0.706	0.162	0.174	NA	0.174	NA	NA	0.817
2011	NA	0.053	0.067	0.104	0.235	0.272	0.293	0.347	0.337	0.286	0.406	0.346	0.325	0.520	0.412	0.403	NA	NA	NA	NA	NA
2012	0.022	0.046	0.088	0.171	0.239	0.318	0.304	0.304	0.391	0.295	0.351	0.333	0.307	0.223	0.200	NA	0.673	0.372	0.575	NA	NA
2013	NA	NA	0.015	0.063	0.101	0.220	0.307	0.284	0.239	0.294	0.395	0.362	0.350	NA	NA	0.970	NA	NA	NA	NA	NA
2014	0.024	0.036	0.072	0.080	0.141	0.225	0.246	0.312	0.256	0.384	0.305	0.280	0.415	0.269	0.340	0.377	0.298	0.363	0.329	NA	NA
2015	NA	0.006	0.048	0.091	0.162	0.207	0.276	0.299	0.374	0.391	0.387	0.370	0.350	0.352	0.223	0.630	NA	0.244	NA	NA	NA
2016	NA	0.022	0.056	0.080	0.141	0.235	0.246	0.304	0.327	0.335	0.346	0.287	0.475	0.254	0.660	0.446	0.435	0.329	NA	NA	NA
2017	0.015	0.047	0.080	0.129	0.214	0.264	0.286	0.309	0.305	0.335	0.368	0.329	0.344	0.313	0.323	0.433	0.422	0.316	0.455	NA	0.839

Figure 1. North Sea lemon sole. Distribution of lemon sole in the North Sea, as indicated by the IBTS Q1 survey. The plots summarise the number (left) or biomass (right) of lemon sole caught per hour at each survey station during the surveys in 2016 and 2015 respectively.

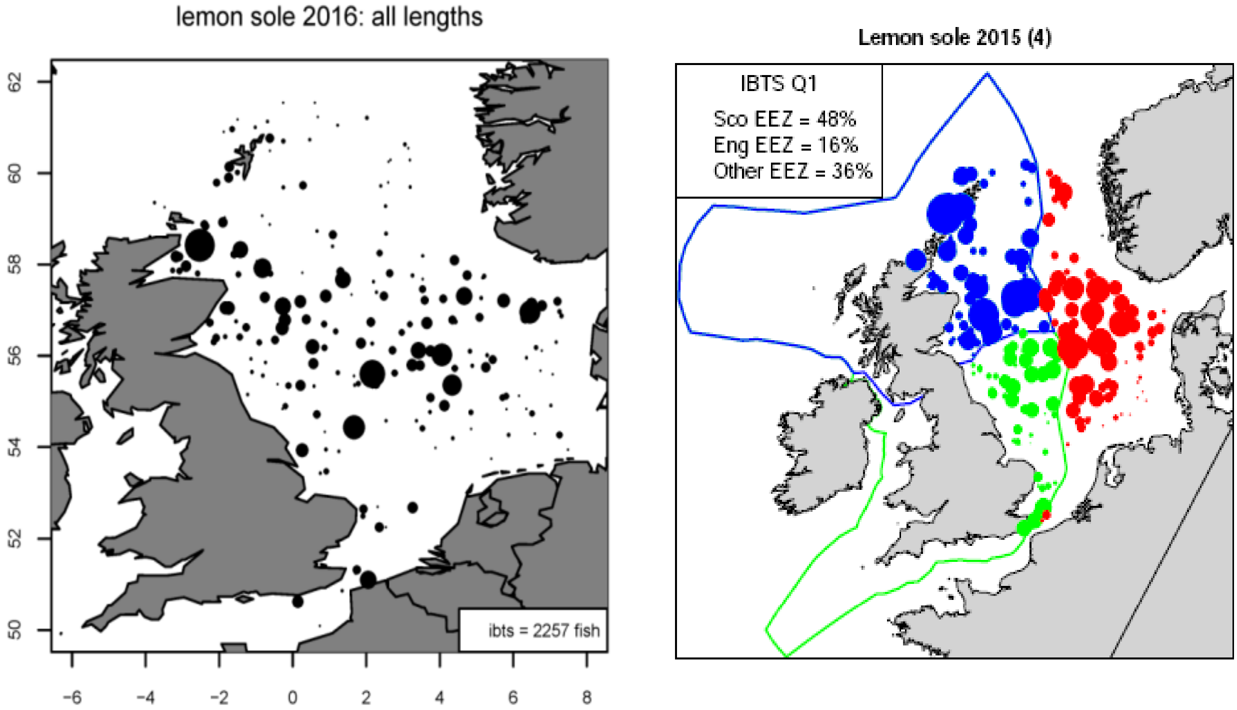


Figure 2. North Sea lemon sole. Reported effort distributions for all gears in the North Sea in 2013, presented separately for the main participating nations. Darker colours indicate more days at sea, as recorded in the STECF database. More details on the scaling used can be found in Needle (2015).

Figure 3. North Sea lemon sole. Proportion female by length for IBTS Q1 (upper) and Q3 (lower) surveys in 2016. The sizes of the points are scaled by the numbe of fish for which maturity was measured per length class (the legend indicates the maximum shown). The solid blue line is a loess curve (span = 1.0) fitted to the points which were weighted by the number of fish measured, while the dotted blue lines are the approximate 95% confidence interval about the curve (±2 se). The red line shows a female proportion of 0.5.

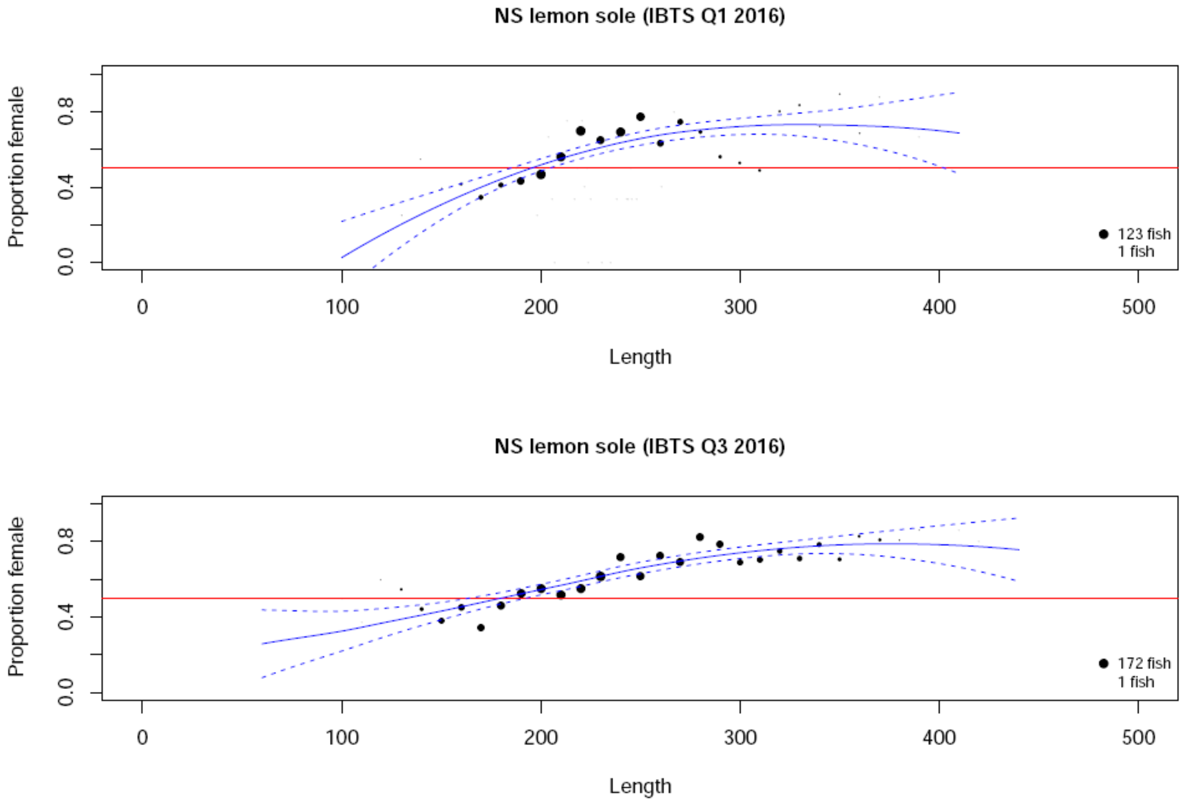
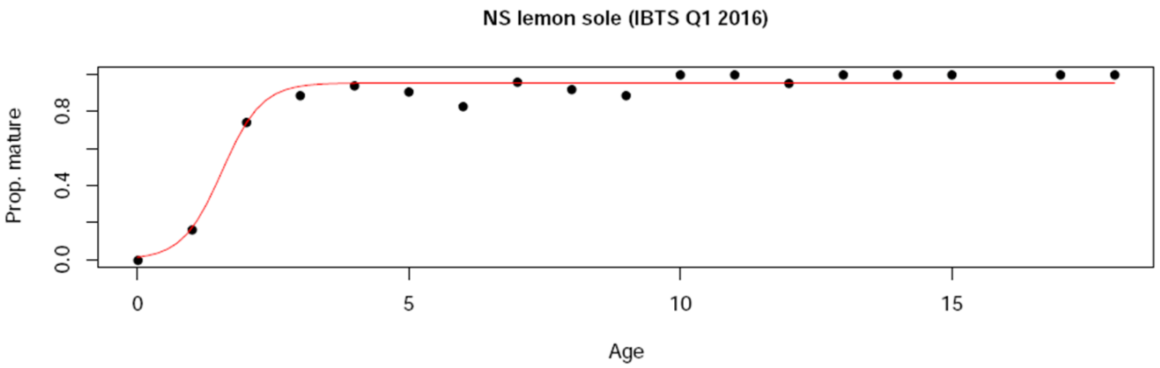


Figure 4. North Sea lemon sole. Upper: estimated proportion mature at age, using SMALK data from IBTS Q1 survey in 2016. The red line shows the fit of Equation 1. Lower: observed weights-at-age from the IBTS Q3 survey in 2016. The red line traces the mean weight for each age.



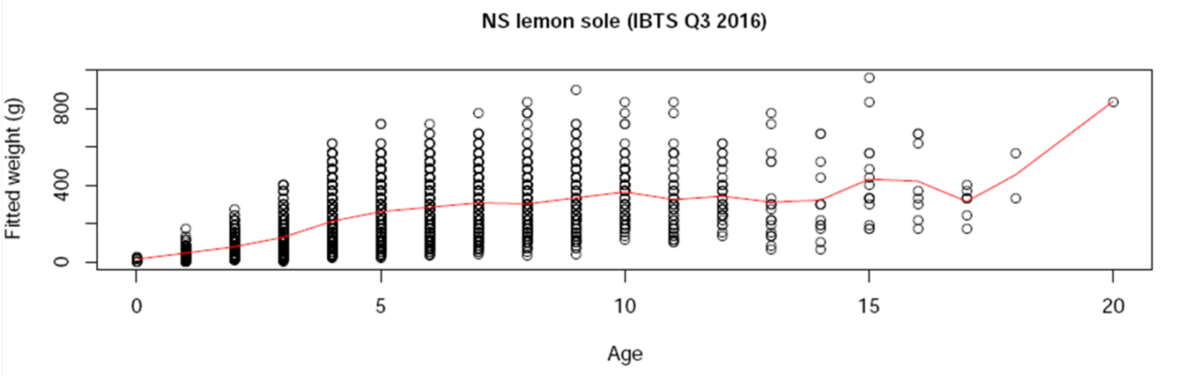
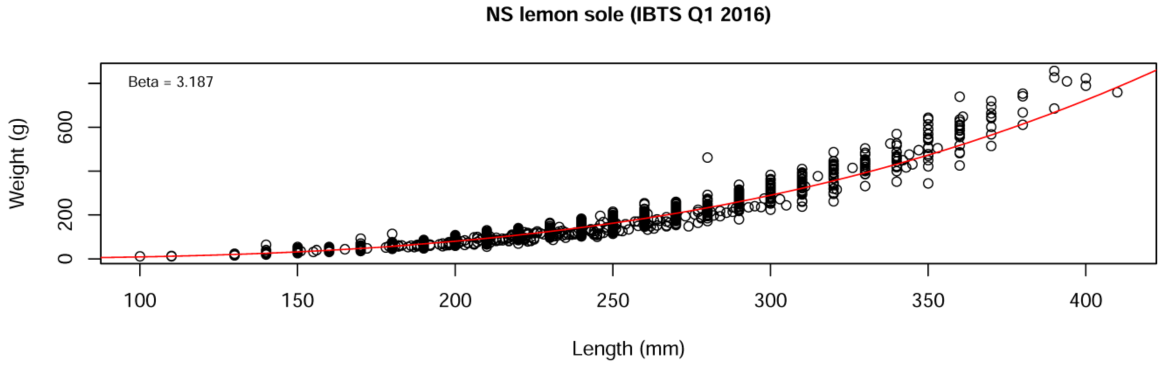


Figure 5. North Sea lemon sole. Length-weight relationships for IBTS Q1 (upper) and Q3 (lower) in 2016, along with the fitted model $W = L^{\beta}$. Parameters were estimated by fitting the linearised model $\ln W = \beta \ln L$, assuming normal errors.



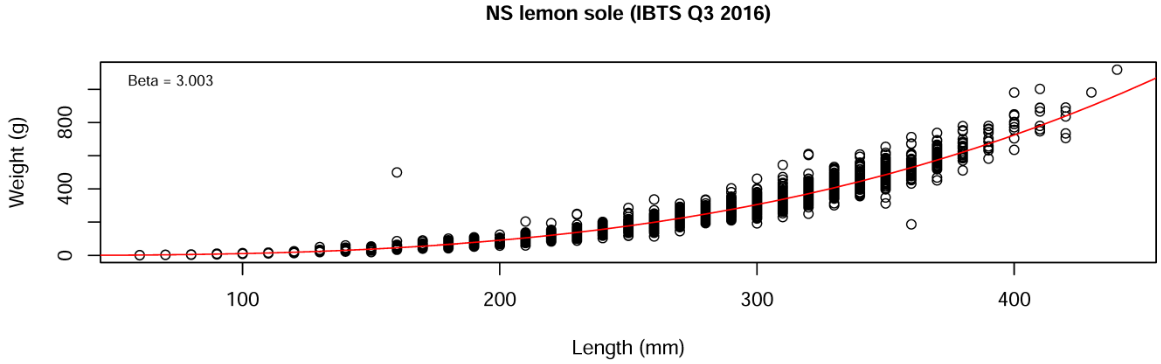


Figure 6. North Sea lemon sole. Comparison plots for Q1 survey indices-at-age for the Needle, Berg and ICES estimation methods (ages 1-5, years 2007-2017). Lines are mean-standardised so that the average of each over years 2007-2017 is 1.0, to allow for direct comparison.

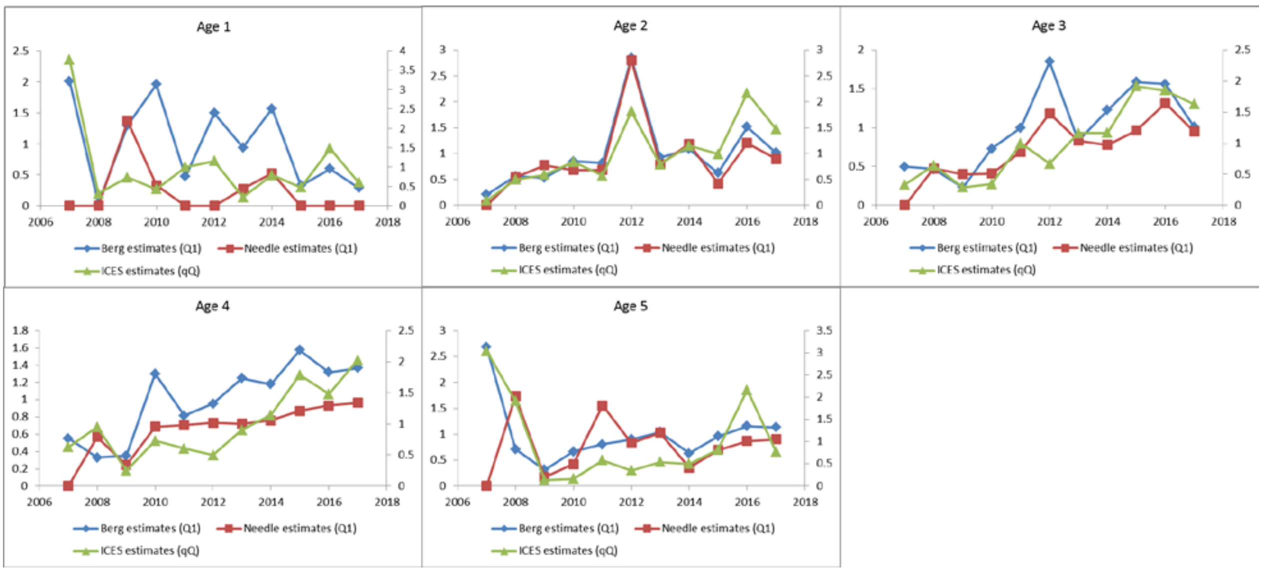
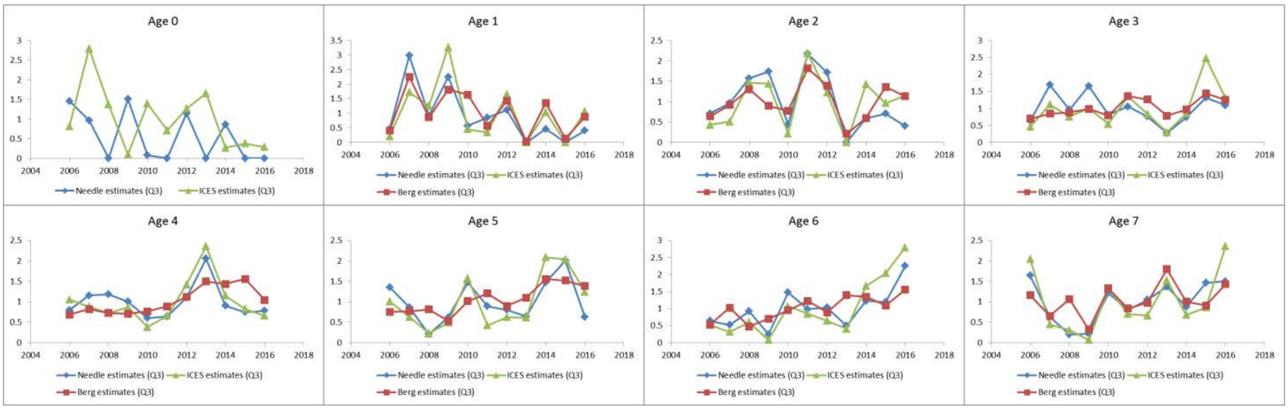


Figure 7. North Sea lemon sole. Comparison plots for Q3 survey indices-at-age for the Needle, Berg and ICES estimation methods (ages 1-5, years 2005-2016). Lines are mean-standardised so that the average of each over years 2005-2016 is 1.0, to allow for direct comparison.



Survey Index Calculations for Lemon Sole from IBTS and BTS data

Casper W. Berg

January 16, 2018

Survey indices of biomass are calculated using the methodology described in [1].

1 Input data

For Q3 data from the NS-IBTS and BTS surveys are used. BT4S is assumed to be the same as BT4A. Only gears with at least 120 hauls are included. For Q1 only the GOV gear is considered.

2 Model

The following equation is used for both the presence-absence and positive part of the model:

$$g(\mu_i) = \text{Year(i)} + \text{Gear(i)} + f_1(\text{lon}_i, \text{lat}_i) + f_2(\text{Depth}_i) + \log(\text{HaulDur}_i)$$

where Gear(i) and Year(i) are categorical effects for the ith haul. The gear effect is not included for the Q1 data because we only consider the GOV gear here. An offset is used for the effect of haul duration ($HaulDur$), i.e. the coefficient is not estimated but taken to be 1. f_1 is a 2-dimensional thin-plate spline for space, f_2 is a 1-dimensional thin plate spline for the effect of bottom depth.

The function g is the link function, which is taken to be the logit function for the binomial model. The log-normal part of the delta-log-normal model is fitted with a log link. Each quarter is estimated separately. The fitted models are then used to sum the expected catches over a fine grid by year to obtain the survey index. Nuisance variables such as Gear and haul duration are corrected for in this process by using the same Gear and haul duration for all predictions.

3 Results

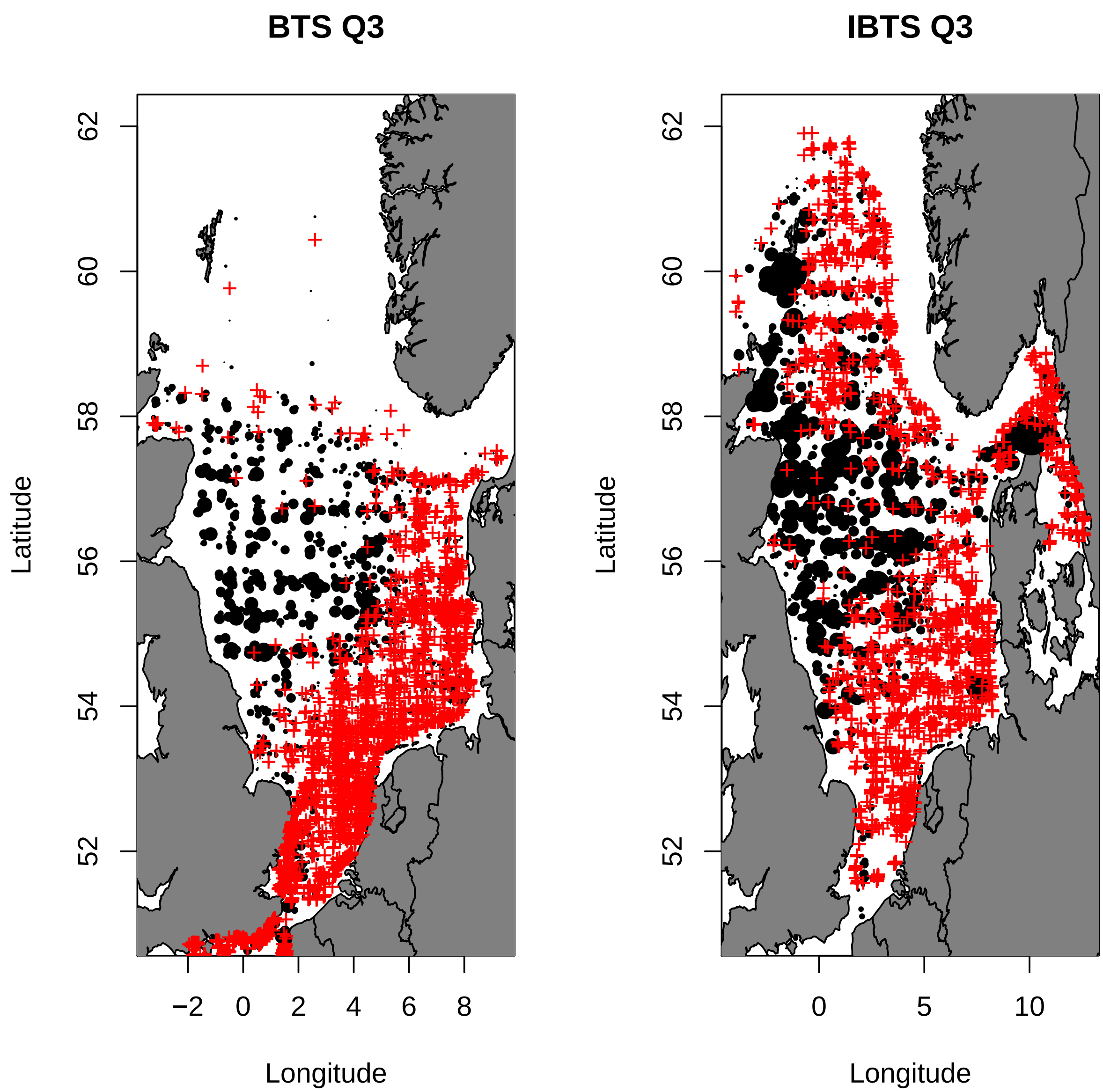


Figure 1: All hauls in the Q3 surveys considered, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls.

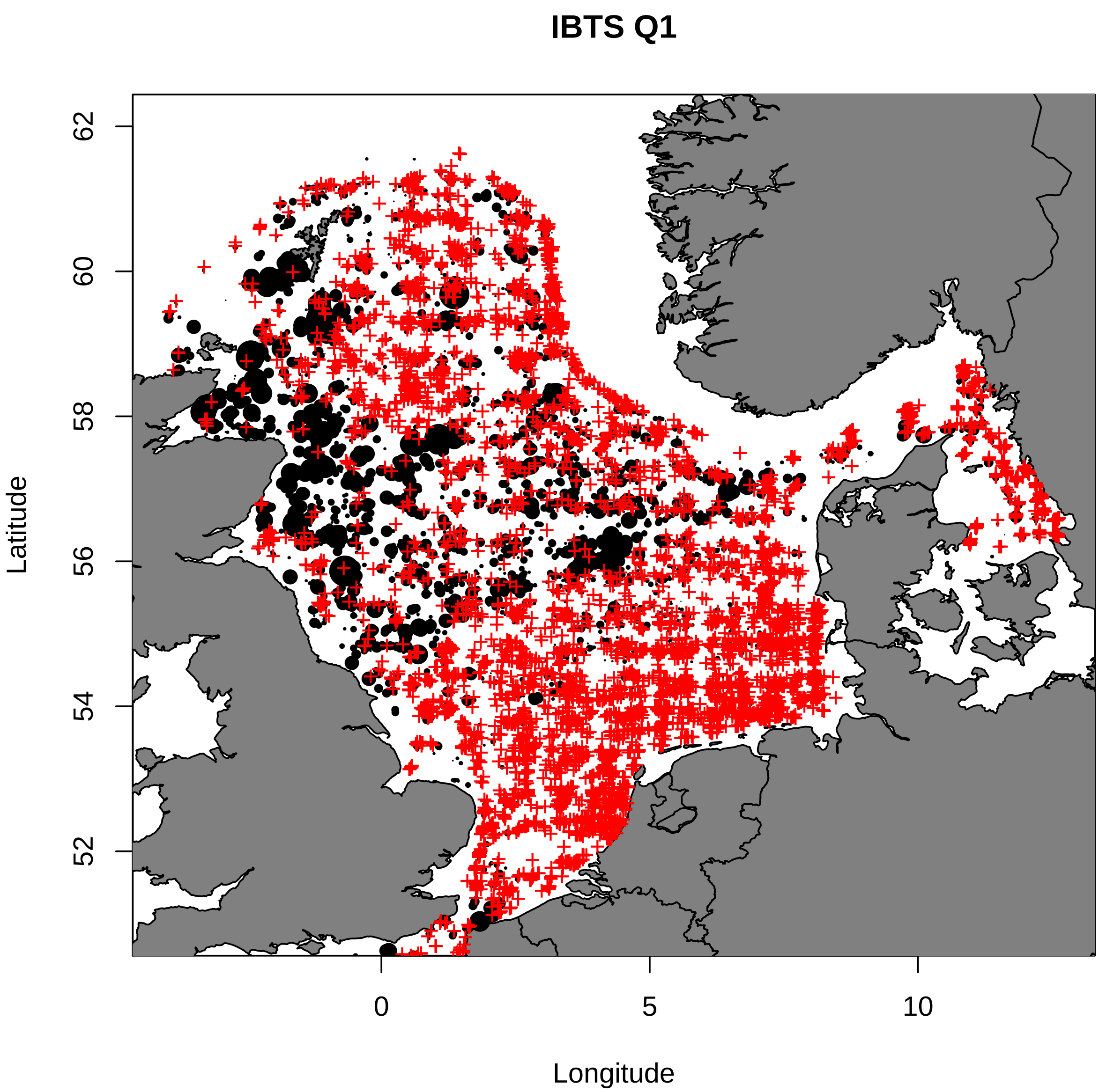


Figure 2: All hauls in Q1, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls.

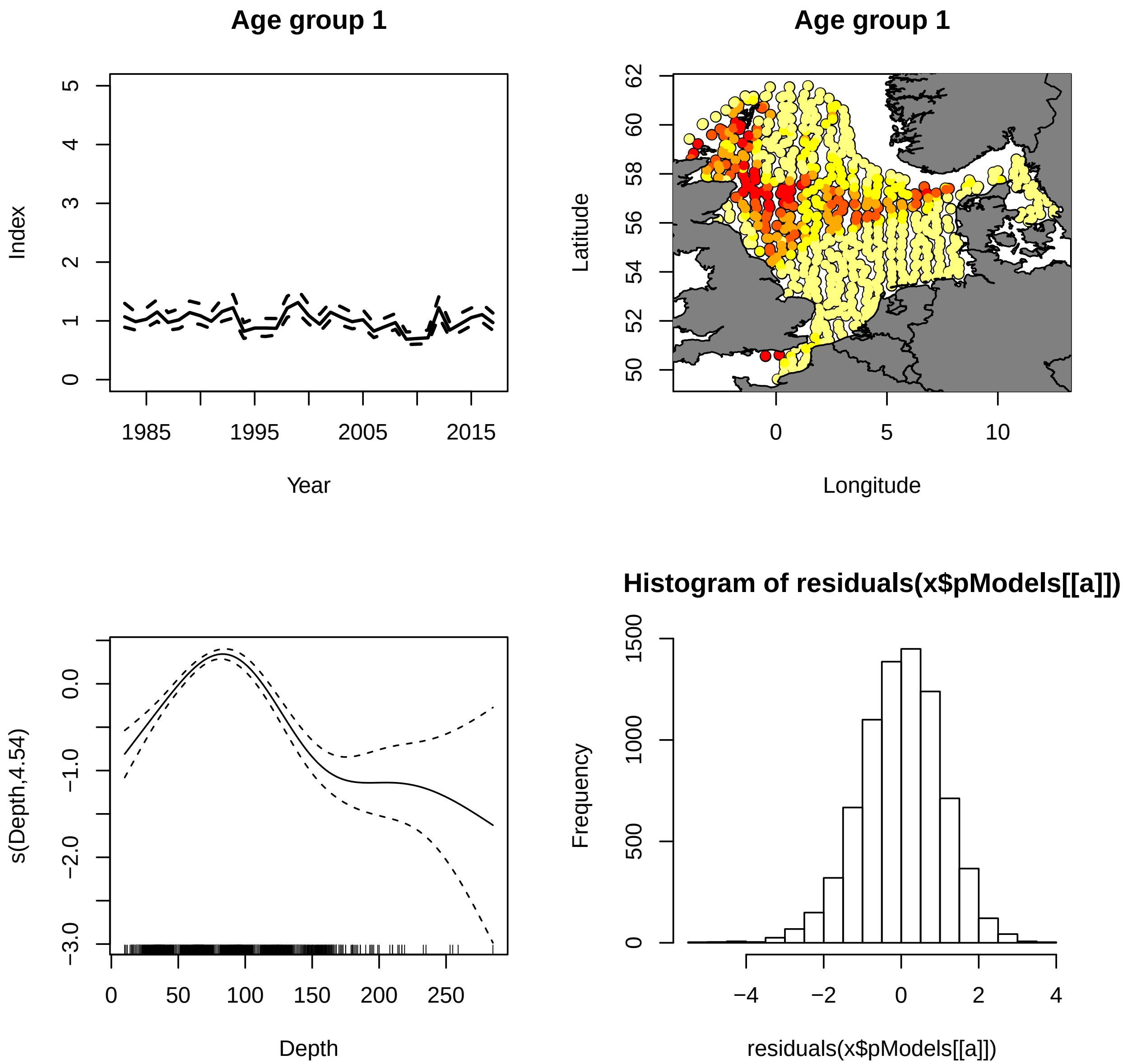


Figure 3: Estimated survey index Q1, stock concentration plot, depth effect, and histogram of residuals (positive part of model only). Note, that labels indicating age groups is wrong – it is total biomass.

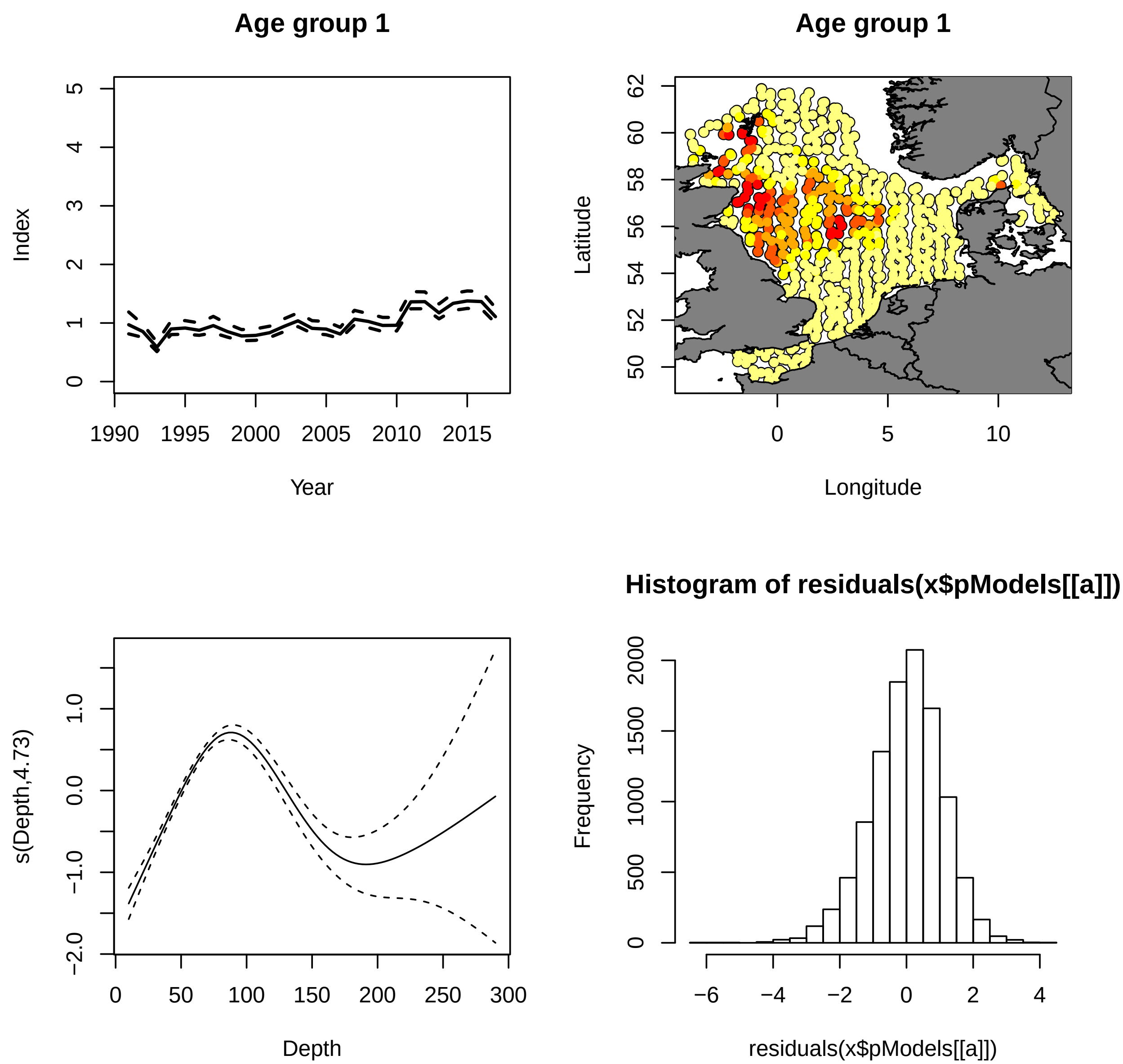


Figure 4: Estimated survey index Q3, stock concentration plot, depth effect, and histogram of residuals (positive part of model only).

References

[1] Casper W Berg, Anders Nielsen, and Kasper Kristensen. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151:91–99, 2014.

Working Document ICES WKNSEA 5-9 February 2018

SPiCT Stock Assessments of Lemon Sole IV, IIIa & VIId

J. Rasmus Nielsen and DTU Aqua Colleagues

Introduction and Assessment Input

Several exploratory SPiCT Assessments and Scenario analyses were conducted.

Scenario	Comm. Fish. Data	Quarter 1 Survey	Quarter 3 Survey	Comment
Scenario1 = Baseline	Catches 1968-2016; Raised catches w. 15,82 % discard rate raising factor 1968-2001; IC catch 2002-2016 excl. catch in 2013	IBTS Q1 1968-2016	IBTS-BTS Q3 1991-2016	Assm converge Retro converge IniCheck OK
Scenario 2	Baseline except now incl. IC catch in 2013	Baseline	Baseline	Could not converge
Scenario 3	Raised catches w. 20,76 % discard rate raising factor; excl. catch in 2013	Baseline	Baseline	Same as Basel., except Retro did not converge
Scenario 4	Baseline	IBTS Q1 1983-2016	Baseline	Converge, but cannot estimate relative B
Scenario 5	IC Catch 2002-2016 excl. catch in 2013	IBTS Q1 1983-2016	Baseline	Could not converge
Scenario 6	IC Catch 2002-2016 incl. catch in 2013	IBTS Q1 1983-2016	Baseline	Assm converge Retro cannot converge IniCheck OK
Scenario 7	Official Landings 1968-2016	Baseline	Baseline	Assm converge Retro cannot converge IniCheck (OK)
Scenario 8	Baseline, but only for the period 1983-2016	IBTS Q1 1983-2016	Baseline	Assm converge Retro converge IniCheck OK
Scenario 9	Baseline, but only for the period 1983-2016	IBTS Q1 1983-2016	Not included	Assm converge Retro converge IniCheck OK
Scenario 10	Baseline, but only for the period 1983-2016	Not included	Baseline	Assm converge Retro cannot converge IniCheck OK

Assessment Scenario 1:
Input data time series:

- Raised Catch 1968-2016 for All Areas: Landings for the period 1968-2002 raised to catch by raising the yearly landings with the average yearly discard rate from 2002-2006 (15,82%), as well as raised InterCatch catches for 2002-2016 from InterCatch, except for 2013 for which the catches have been excluded because of extreme discard; Catches implemented with an uncertainty range of 3 times higher for the period from 1968-2001 compared to the later period from 2002 onwards;
- IBTS Q1 Weight Index 1968-2016 for All Areas including observed uncertainty (CV on each index) as estimated from the survey data evaluation method by Casper Berg. The indices and cv's are standardized to the means, i.e. to the mean of the index or the mean of the cv by dividing by the mean;
- IBTS-BTS-Q3 Weigth Index 1991-2016 for All Areas including observed uncertainty (CV on each index) as estimated from the survey data evaluation method by Casper Berg. The indices and cv's are standardized to the means, i.e. to the mean of the index or the mean of the cv by dividing by the mean;

Assessment Scenario 5:
Input data time series:

- InterCatch Catch All Areas: Catch 2002-2016 excluding 2013 catch because of extreme high discard;
- IBTS Q1 Weight Index 1983-2016 for All Areas including observed uncertainty (CV on each index as estimated from the survey data evaluation method by Casper Berg), and afterwards including an standardization of the CVs to the to the mean CV in the time series;
- IBTS-BTS-Q3 Weigth Index 1991-2016 for All Areas including observed uncertainty (CV on each index as estimated from the survey data evaluation method by Casper Berg), and afterwards including an standardization of the CVs to the to the mean CV in the time series.

Assessment Scenario 7:
Input data time series:

- Official Landings 1968-2016 for All Areas; Landings implemented with an uncertainty range of 3 times higher for the period from 1968-2001 compared to the later period from 2002 onwards;
- IBTS Q1 Weight Index 1968-2016 for All Areas including observed uncertainty (CV on each index) as estimated from the survey data evaluation method by Casper Berg. The indices and cv's are standardized to the means, i.e. to the mean of the index or the mean of the cv by dividing by the mean;
- IBTS-BTS-Q3 Weigth Index 1991-2016 for All Areas including observed uncertainty (CV on each index) as estimated from the survey data evaluation method by Casper Berg. The indices and cv's are standardized to the means, i.e. to the mean of the index or the mean of the cv by dividing by the mean;

Settings for Priors in the SPiCT Assessments:

SPiCT use default priors for (SPiCT Vignette p. 34):
- Estimate, log n
- Noise ratio log alpha

- Noise ratio log beta

Priors used in the main assessment is that default priors on log n, alpha and beta is used
inp1$priors$logn = c(1,1,0)
inp1$priors$logalpha = c(1,1,0)
inp1$priors$logbeta = c(1,1,0)

If production curves not overlapping then it has been tried to remove priors on alpha and beta and first of all it has been tried to remove all default priors):

No priors is used for r(m), F and/or B

Input Data

Table 1. Landings, discard and catch time series (tons) as well as fishery independent weight based survey indices as provided to ICES WKNSEA February 2018.

	Commercial Fishery WKNSEA						Surveys	WKNSEA Survey Indices			
Year	IC Catch	IC Landings	IC Discards	Off Landings	Raised Catch (15 %)	Raised Catch (20 %)	**Year**	IBTS Q1	IBTS-BTS Q3	IBTS Q3	BTS Q3
1966				5775	6689	6974	1966	493701			
1967				6710	7772	8103	1967	139069			
1968				6792	7866	8202	1968	131768			
1969				5000	5791	6038	1969	263995			
1970				3859	4469	4660	1970	147698			
1971				4497	5208	5431	1971	26419			
1972				4315	4998	5211	1972	61089			
1973				5233	6061	6319	1973	298252			
1974				4761	5514	5749	1974	248279			
1975				5379	6230	6496	1975	268733			
1976				5233	6061	6319	1976	185073			
1977				6324	7324	7637	1977	332613			
1978				6952	8052	8395	1978	354471			
1979				7521	8711	9082	1979	297582			
1980				7298	8453	8813	1980	258014			
1981				7016	8126	8473	1981	546292			
1982				8487	9830	10249	1982	618826			
1983				9507	11011	11481	1983	814715			
1984				8111	9394	9795	1984	729508			
1985				7575	8773	9148	1985	766439			
1986				5937	6876	7170	1986	851900			
1987				6495	7523	7843	1987	723265			
1988				6798	7873	8209	1988	761179			
1989				7024	8135	8482	1989	849710			
1990				7485	8669	9039	1990	815650			
1991				7780	9011	9395	1991	738999	1572119	1601672	1209776
1992				7442	8619	8987	1992	864292	1383976	1681769	605825
1993				7413	8586	8952	1993	925032	949758	1089364	698420
1994				6758	7827	8161	1994	608489	1454691	1562601	1266108
1995				6301	7298	7609	1995	647617	1481412	1521628	1425731
1996				6522	7554	7876	1996	655229	1418408	1524994	1065115
1997				6056	7014	7313	1997	652719	1547868	1754212	1080028
1998				7677	8892	9271	1998	911741	1383307	1762753	771792
1999				7297	8451	8812	1999	984171	1261788	1772963	557157
2000				7170	8304	8658	2000	810834	1277006	1664810	686411
2001				6455	7476	7795	2001	711191	1352990	1687999	796873
2002	4522	4011	511	4823	4522	4522	2002	862384	1524639	1903596	931841
2003	5611	4575	1036	4722	5611	5611	2003	797122	1680363	1974614	1071069
2004	5028	4394	635	4574	5028	5028	2004	750800	1472553	1664077	966143
2005	4955	4429	527	4468	4955	4955	2005	768302	1451641	1775099	845690
2006	5809	4294	1515	4290	5809	5809	2006	617401	1314493	1748662	652449
2007	4919	4468	451	4488	4919	4919	2007	690523	1726372	2100342	1057587
2008	5051	4153	898	3976	5051	5051	2008	743804	1661889	1862383	1073760
2009	4401	3405	996	3397	4401	4401	2009	521865	1553081	1802736	966360
2010	3907	3234	673	3198	3907	3907	2010	534482	1556724	1750605	1011732
2011	5055	4030	1024	4019	5055	5055	2011	534031	2205217	2506845	1461577
2012	6560	4099	2461	2959	6560	6560	2012	921545	2210249	2399671	1464566
2013	9663	3725	5938	3761	9663	9663	2013	630621	1899654	1749896	1542743
2014	5335	3645	1690	3688	5335	5335	2014	712109	2164051	2404827	1488964
2015	5116	3480	1636	3393	5116	5116	2015	793234	2229953	2561086	1463463
2016	4995	3834	1161	3805	4995	4995	2016	833914	2213479	2674783	1346924

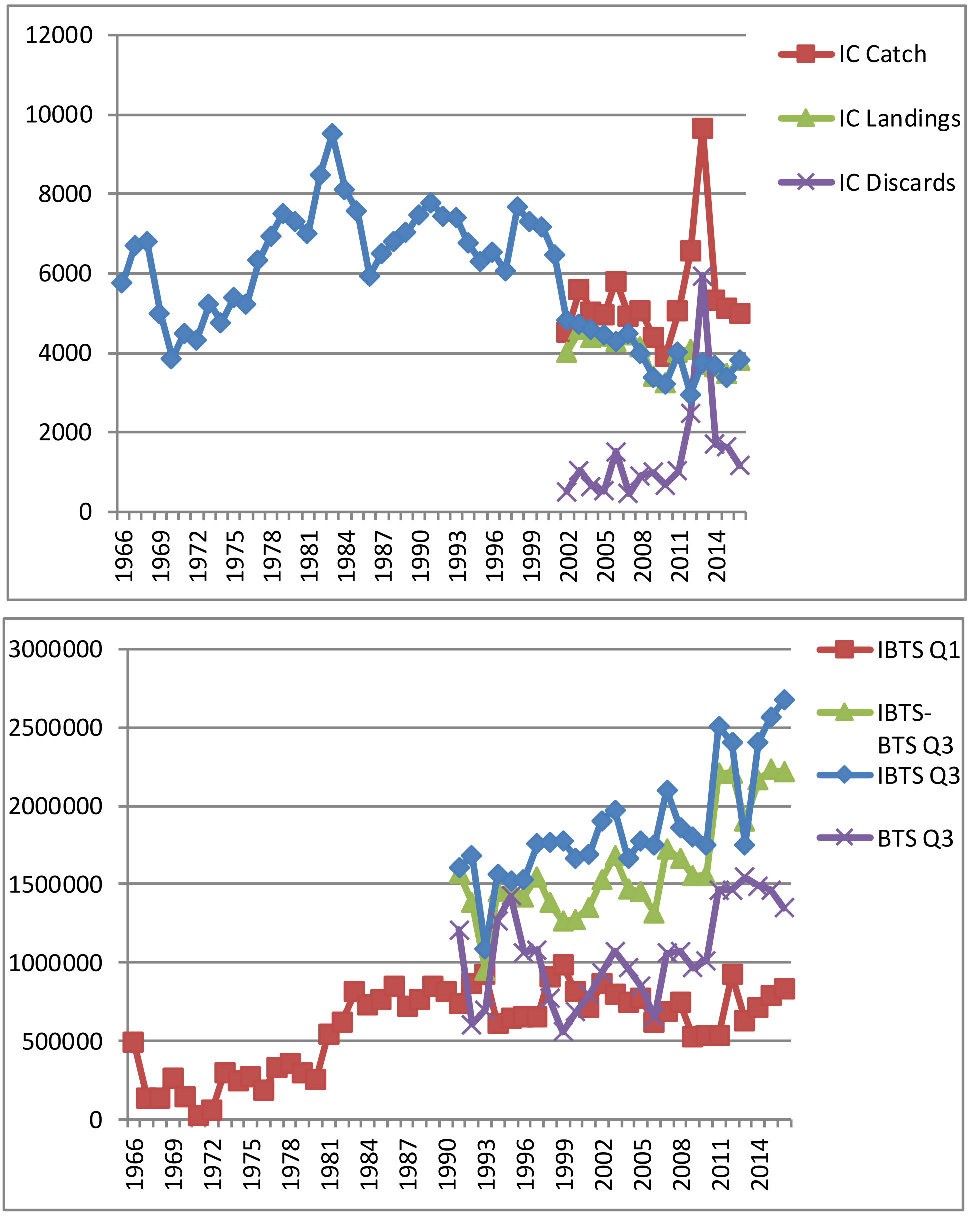


Figure 1. Plots of the catch, landings, discards, and survey index data time series given in Table 1 (WKNSEA 2018).

Table 2. Landings, discard and catch time series (tons) as well as fishery independent weight based survey indices as provided to ICES WGNSSK April- May 2017.

Year	Catch	Landings	Discards	Year	IBTS Q1	IBTS Q3	IBTS Q1 SCO NED
1966	7971	5775	2196	1966	0,327		0,052
1967	9261	6710	2551	1967	0,259		0,108
1968	9375	6792	2583	1968	0,453		1,068
1969	6901	5000	1901	1969	0,664		1,487
1970	5326	3859	1467	1970	0,44		0,935
1971	6207	4497	1710	1971	0,072		0,083
1972	5956	4315	1641	1972	0,181		0,341
1973	7223	5233	1990	1973	0,975		1,367
1974	6571	4761	1810	1974	0,573		1,552
1975	7424	5379	2045	1975	0,402		1,653
1976	7223	5233	1990	1976	0,279		0,971
1977	8729	6324	2405	1977	0,596		0,759
1978	9595	6952	2643	1978	0,565		1,25
1979	10381	7521	2860	1979	0,488		1,166
1980	10073	7298	2775	1980	0,321		0,629
1981	9684	7016	2668	1981	0,963		1,668
1982	11714	8487	3227	1982	0,853		1,666
1983	13122	9507	3615	1983	1,61		1,418
1984	11195	8111	3084	1984	1,629		1,667
1985	10455	7575	2880	1985	1,273		0,581
1986	8194	5937	2257	1986	1,467		1,128
1987	8965	6495	2470	1987	1,313		0,825
1988	9383	6798	2585	1988	1,357		1,15
1989	9695	7024	2671	1989	1,583		1,88
1990	10331	7485	2846	1990	1,548		2,133
1991	10738	7780	2958	1991	1,171	3,373	1,263
1992	10272	7442	2830	1992	1,542	3,987	2,162
1993	10232	7413	2819	1993	1,927	2,369	1,856
1994	9328	6758	2570	1994	1,185	3,048	1,37
1995	8697	6301	2396	1995	1,157	3,557	1,32
1996	9002	6522	2480	1996	1,381	3,317	1,293
1997	8359	6056	2303	1997	1,179	3,438	1,005
1998	10596	7677	2919	1998	1,733	4,246	2,33
1999	10072	7297	2775	1999	1,787	4,382	2,798
2000	9896	7170	2726	2000	1,659	4,557	2,618
2001	8909	6455	2454	2001	1,305	3,602	1,441
2002	6651	4819	1832	2002	1,785	3,748	1,817
2003	6509	4716	1793	2003	1,671	3,969	1,996
2004	6306	4569	1737	2004	1,683	3,125	1,363
2005	6160	4463	1697	2005	1,22	2,958	1,283
2006	5921	4290	1631	2006	1,02	3,452	1,074
2007	6194	4488	1706	2007	1,331	3,9	1,943
2008	5486	3975	1511	2008	1,331	2,927	1,747
2009	4685	3394	1291	2009	0,862	3,293	0,79
2010	4418	3201	1217	2010	0,954	3,854	1,19
2011	5551	4022	1529	2011	1,265	4,106	2,057
2012	5557	4026	1531	2012	1,895	4,474	2,383
2013	4546	3265	1281	2013	1,249	2,575	1,988
2014	5120	3508	1612	2014	0,968	2,766	0,934
2015	4926	3480,985	1445	2015	1,019	2,668	1,179
2016	4802	3784	1018	2016	1,097	2,985	1,068

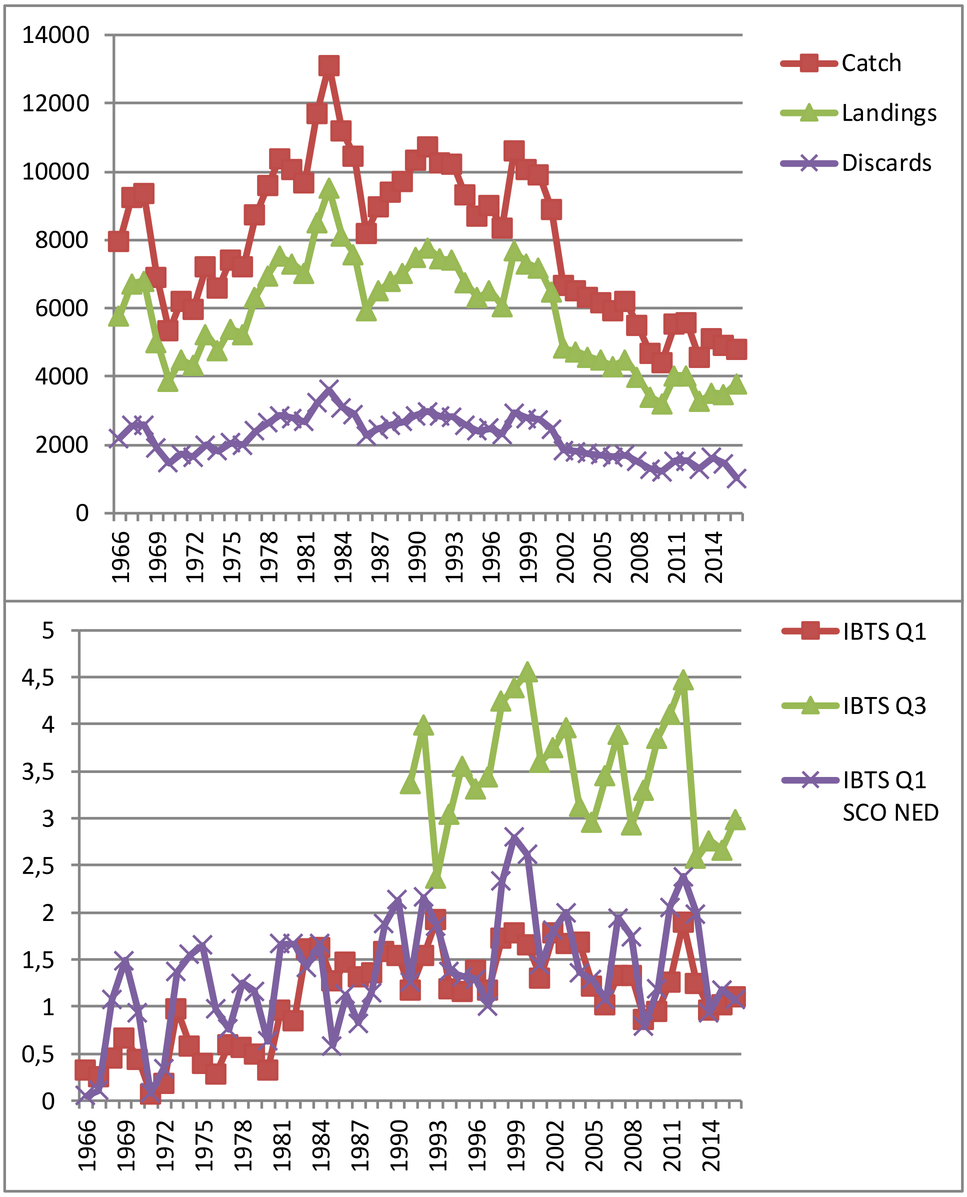
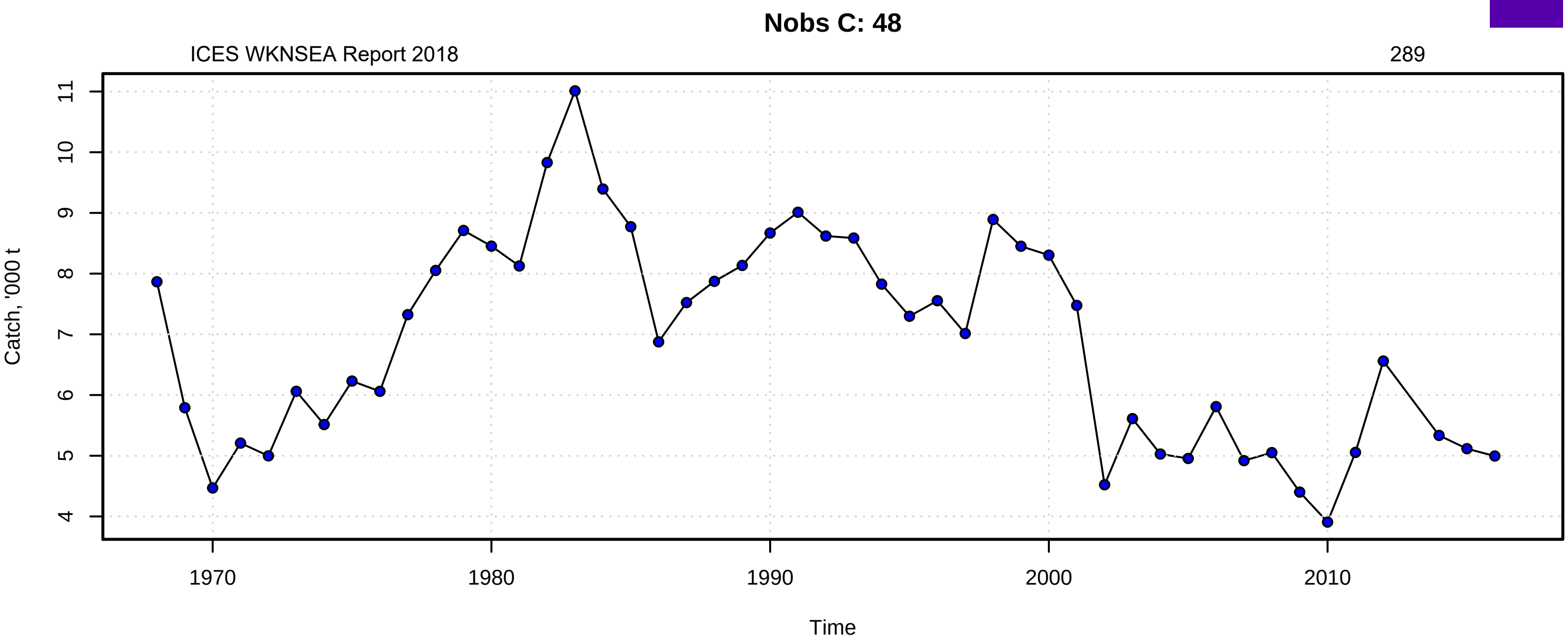
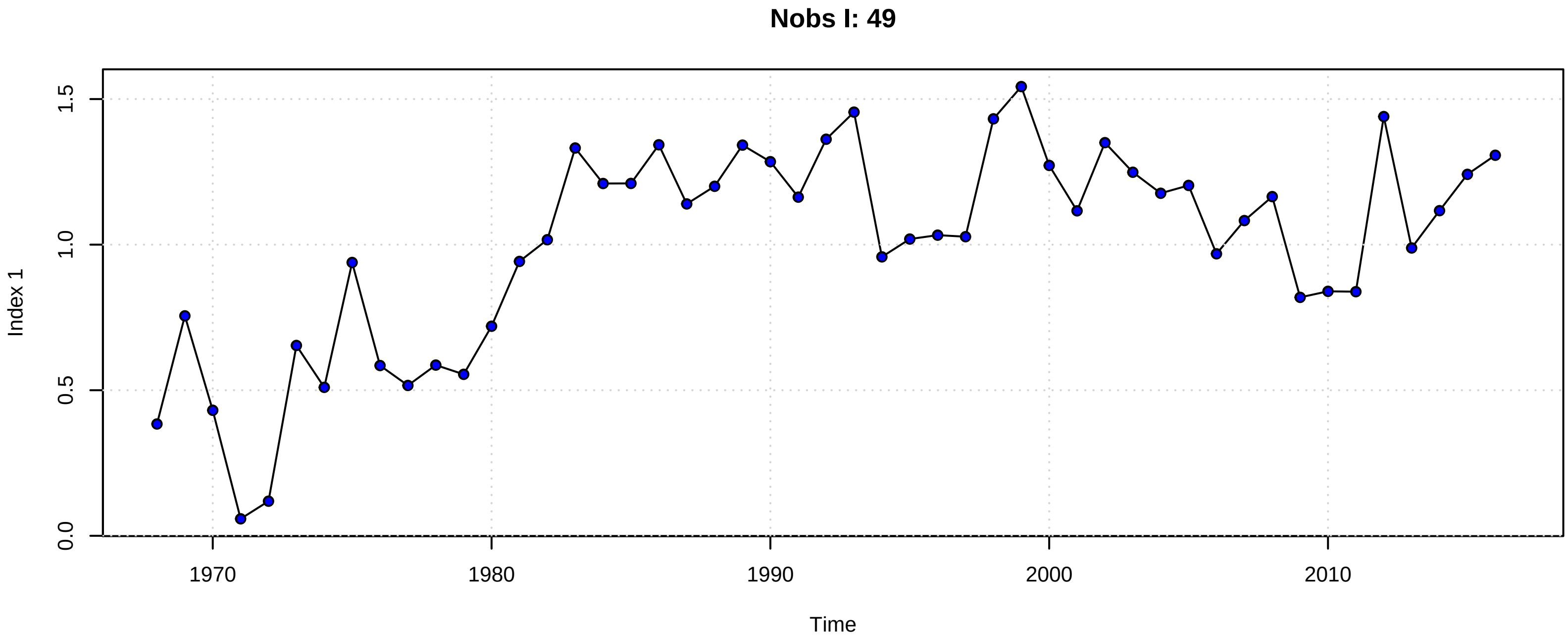
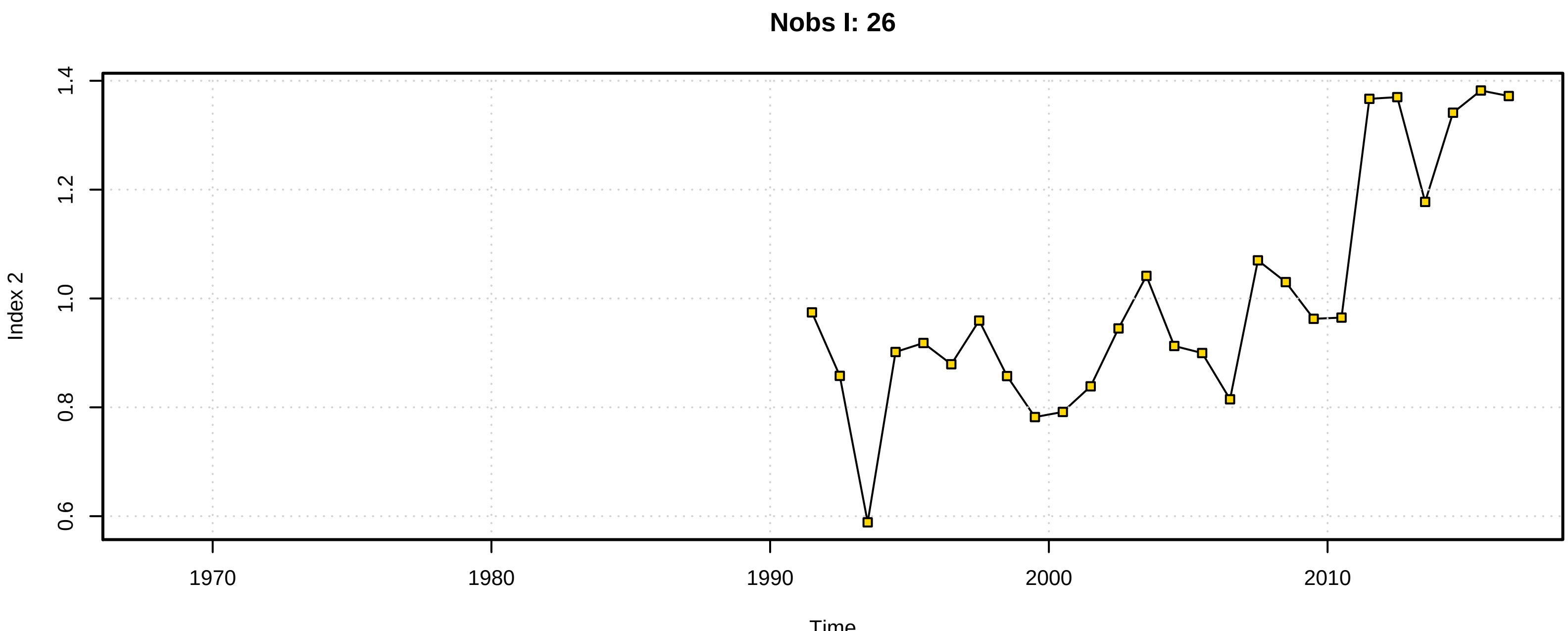


Figure 2. Plots of the catch, landings, discards, and survey index data time series given in Table 2 (WGNSSK 2017).

Results Assessment Scenarios







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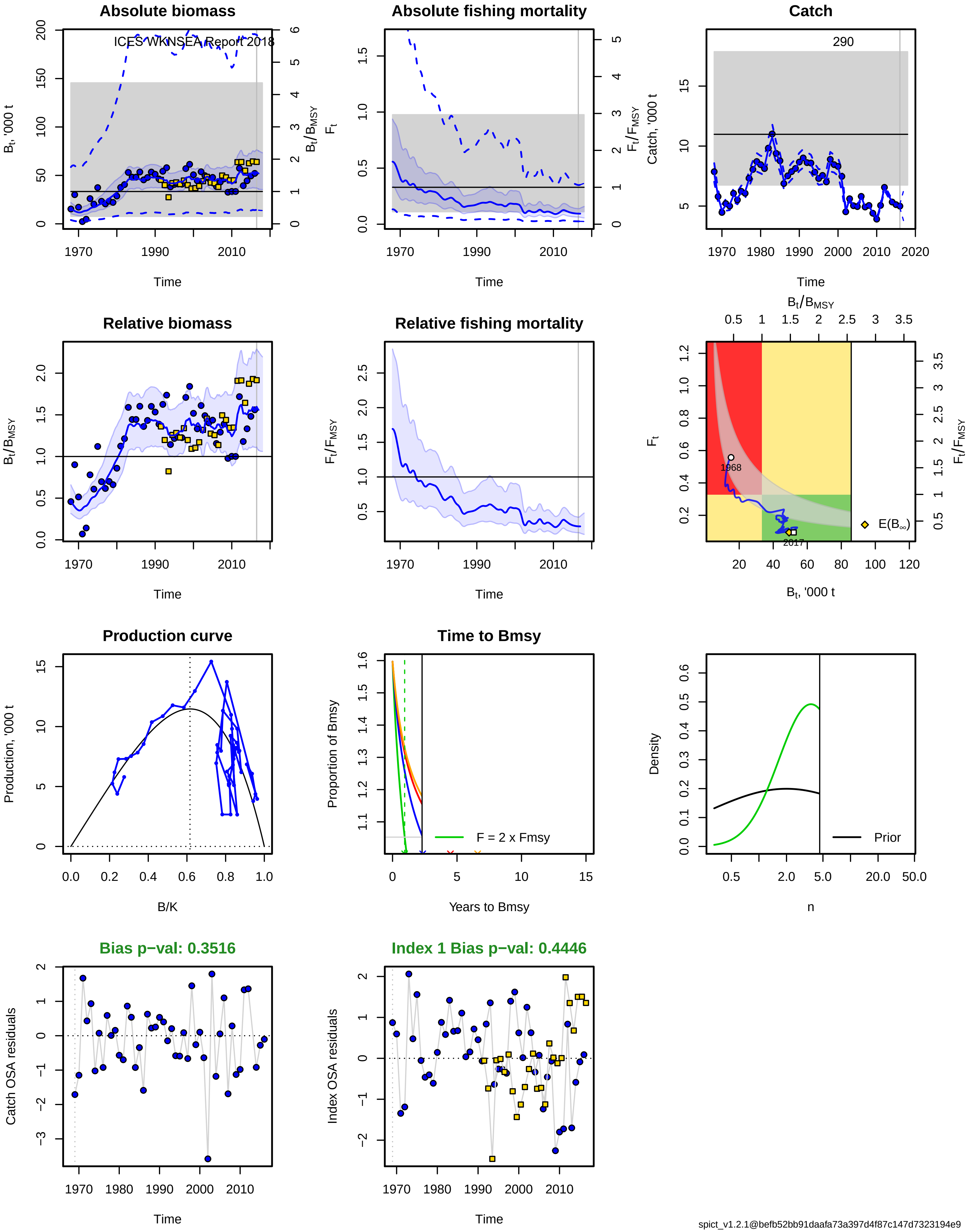
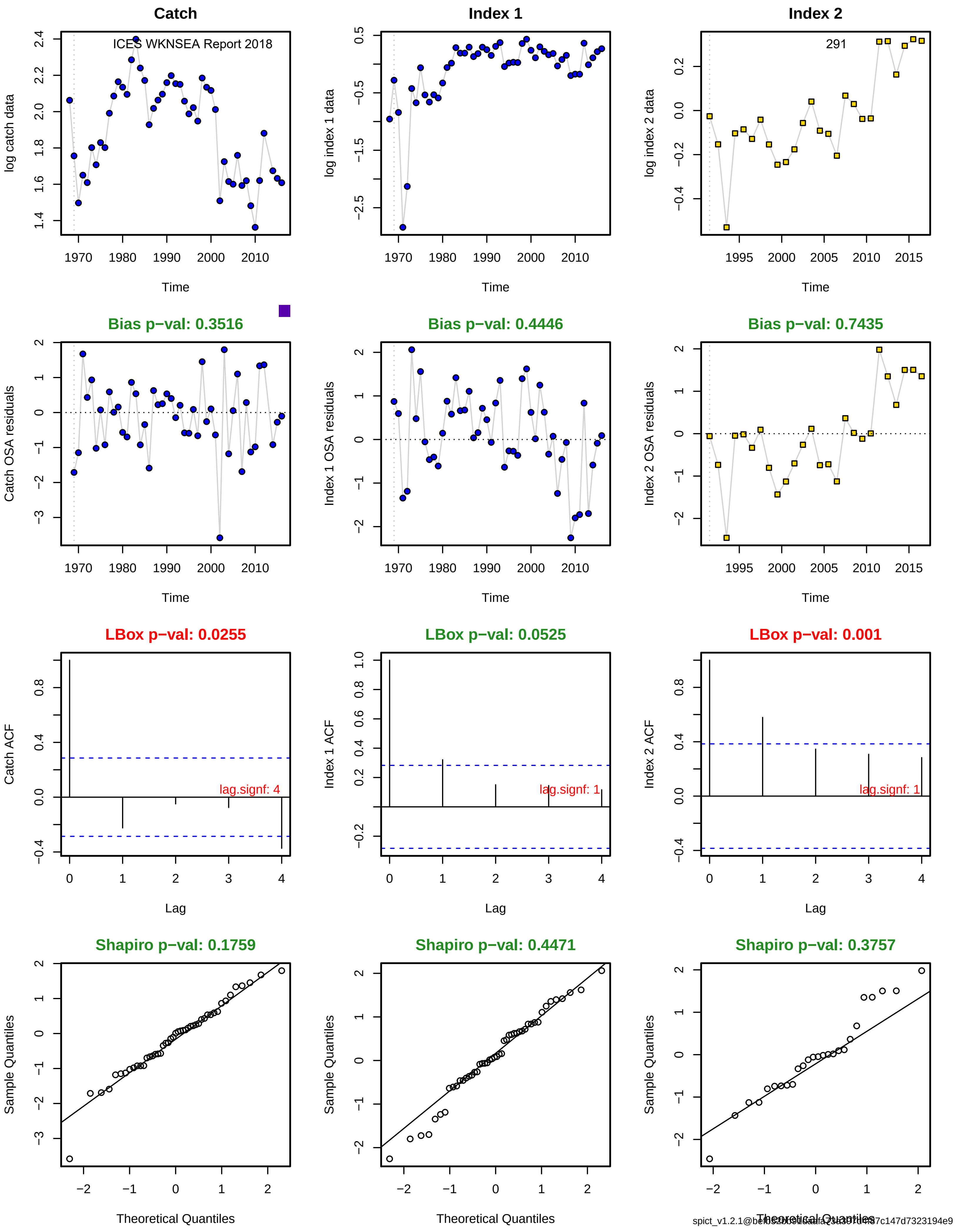
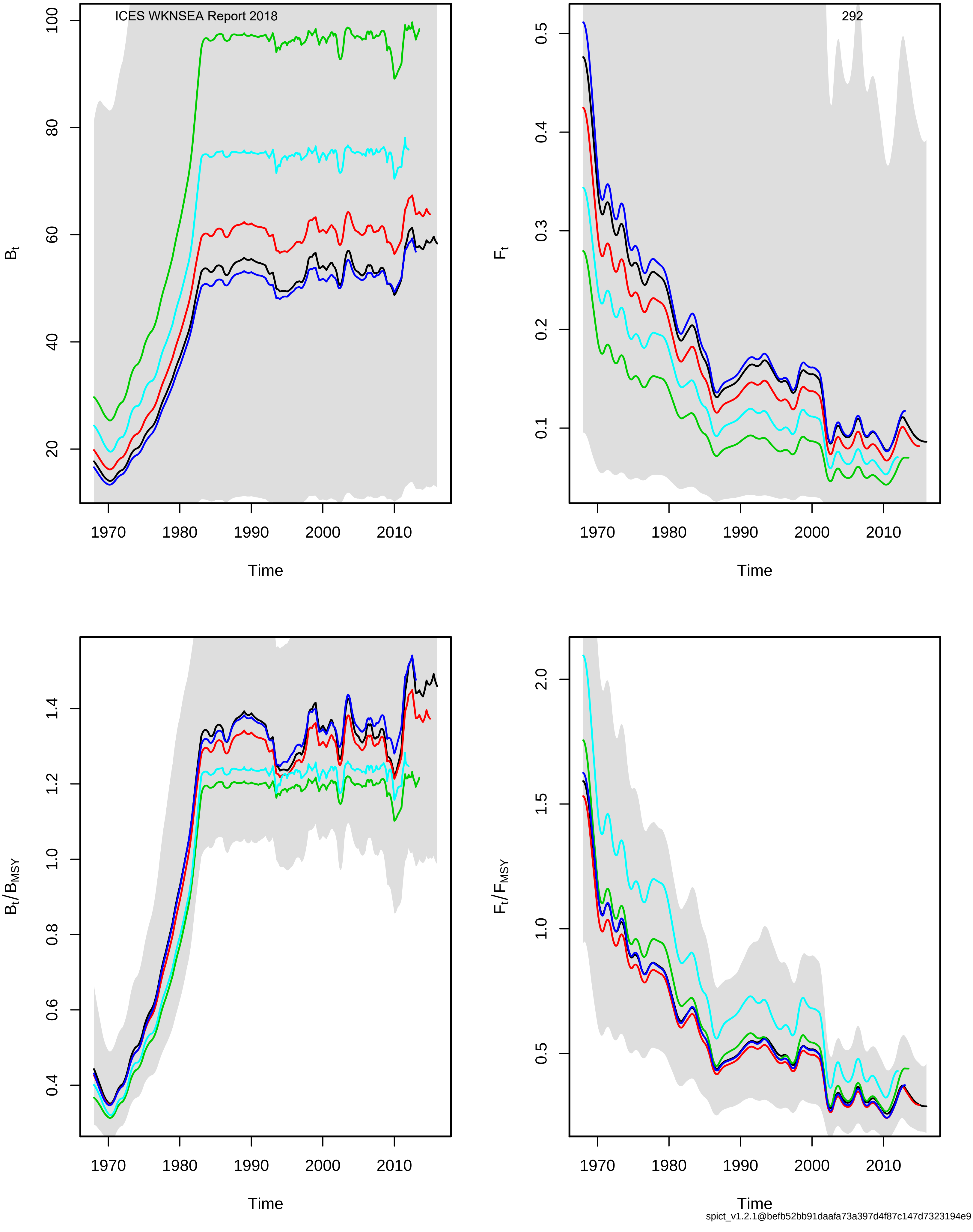

Absolute biomass
Bt, '000 t
Bt/BMSY
Time
Absolute fishing mortality
Ft
Ft/FMSY
Time
Catch
Catch, '000 t
290
Time
Relative biomass
Bt/BMSY
Time
Relative fishing mortality
Ft/FMSY
Time
Bt/BMSY
Ft
Ft/FMSY
1968
2017
E(B∞)
Bt, '000 t
Production curve
Production, '000 t
B/K
Time to Bmsy
Proportion of Bmsy
F = 2 x Fmsy
Years to Bmsy
Density
Prior
n
Bias p−val: 0.3516
Catch OSA residuals
Time
Index 1 Bias p−val: 0.4446
Index OSA residuals
Time
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

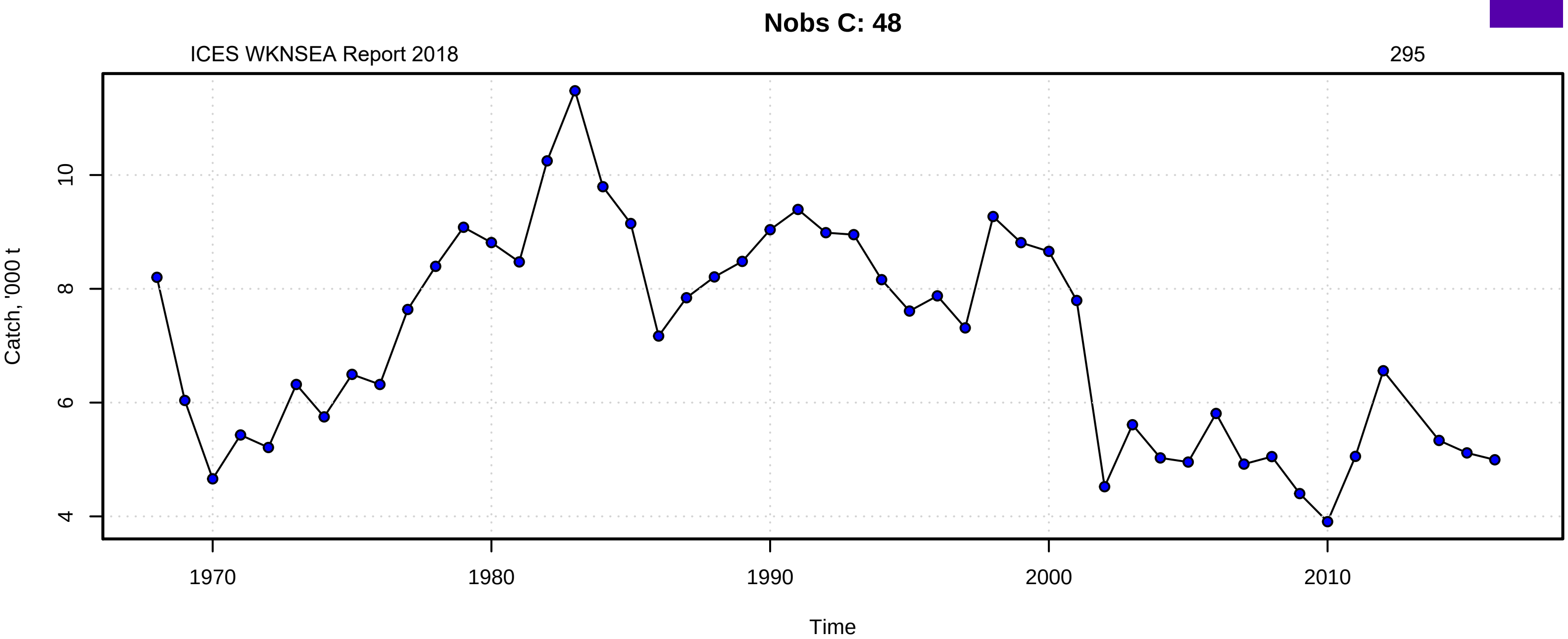

Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.3516
Bias p−val: 0.4446
Bias p−val: 0.7435
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.0255
LBox p−val: 0.0525
LBox p−val: 0.001
Catch ACF
Index 1 ACF
Index 2 ACF
lag.signf: 4
lag.signf: 1
lag.signf: 1
Lag
Shapiro p−val: 0.1759
Shapiro p−val: 0.4471
Shapiro p−val: 0.3757
Sample Quantiles
Theoretical Quantiles

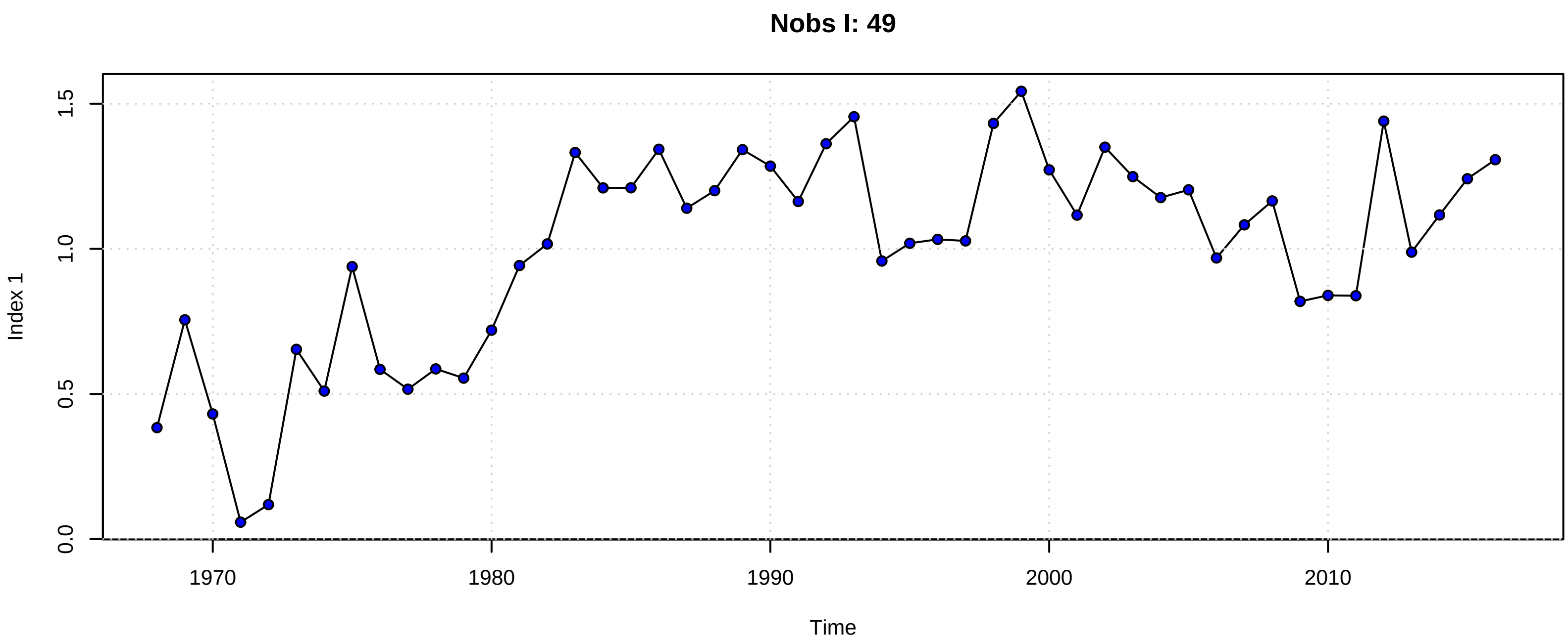


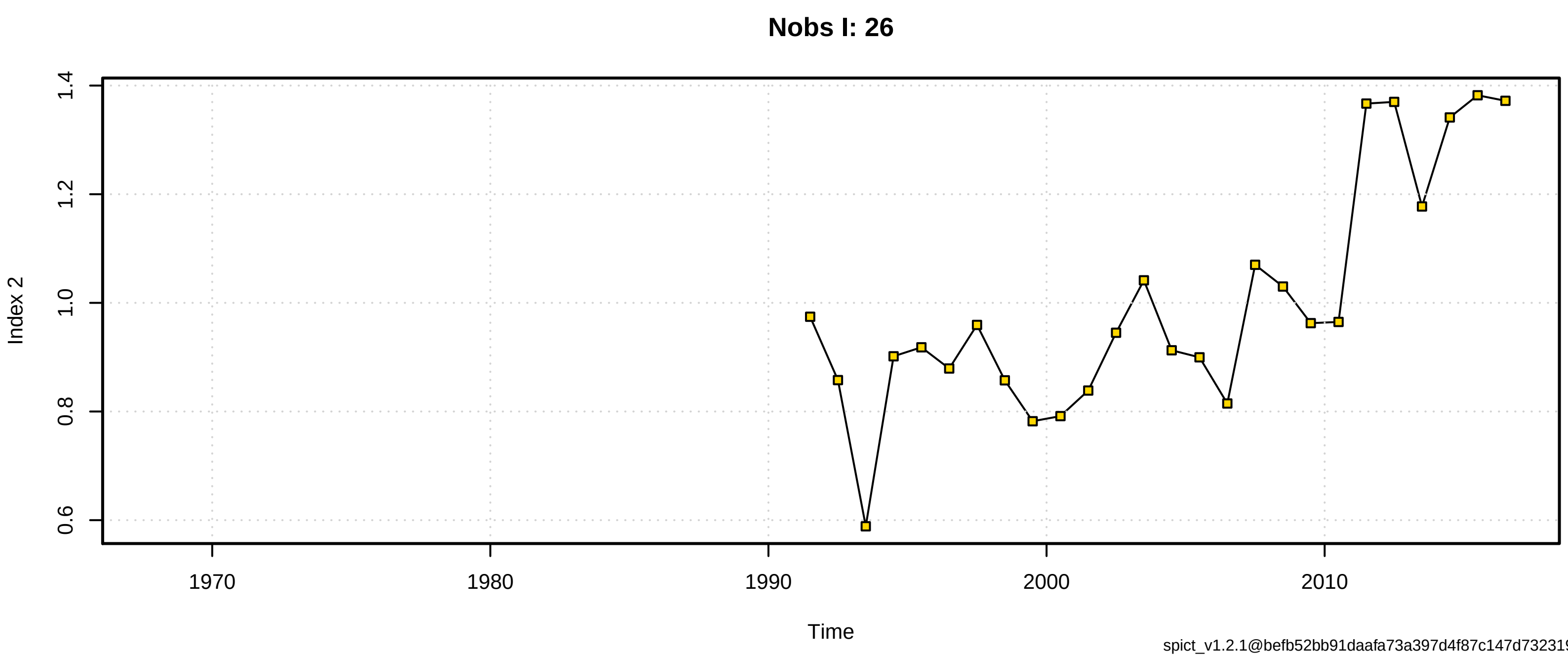
B_t
100
80
60
40
20
1970
1980
1990
2000
2010
Time
F_t
0.5
0.4
0.3
0.2
0.1
B_t/B_MSY
1.4
1.2
1.0
0.8
0.6
0.4
F_t/F_MSY
2.0
1.5
1.0
0.5
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

```
Check of initial parameter settings (baseline)

          logm  logK  logq  logq  logn logsdb logsdf logsdi logsdi logsdc
Trial 1   2.97 -0.48 -0.07  0.24 -0.62  -0.01   0.53   0.65  -0.42   0.11
Trial 2   0.55  0.05  0.16  0.25 -0.65  -0.48  -0.43   1.12   0.59  -0.42
Trial 3   2.11 -0.13  0.62 -0.11 -0.42   0.71  -0.37  -1.05   1.07   0.92
Trial 4  -0.63  0.15  0.34 -0.18 -0.68   1.39  -0.10  -0.62  -0.35   0.19
Trial 5   2.60  0.03 -0.76  0.46 -0.34   0.58   1.21   0.65  -0.46   0.47
Trial 6   2.74 -0.10 -0.14  0.33 -0.30   0.45  -1.33   0.80  -0.13  -0.61
Trial 7   3.13 -0.02 -0.02 -0.39  0.66   0.99   1.01   0.47  -1.42  -0.94
Trial 8  -0.07 -0.06 -0.11 -0.08  0.42   1.22  -0.23  -1.20   0.20   0.41
Trial 9  -2.62 -0.20  0.25  0.68  0.14  -0.88   1.36  -0.86  -0.08  -0.82
Trial 10 -3.22  0.05 -0.28  0.21  0.59   0.77   0.20   0.80  -1.32   0.41

$inimat
         Distance  logn logK logm logq1 logq2 logsdb logsdf logsdi1 logsdi
2 logsdc
Basevec      0.00  0.69 3.79 2.98 -3.35 -3.35  -1.61  -1.61   -1.61   -1.6
1  -1.61
Trial 1      3.87  2.75 1.95 2.76 -4.15 -1.26  -1.59  -2.46   -2.66   -0.9
4  -1.78
Trial 2      3.41  1.07 3.96 3.44 -4.20 -1.16  -0.84  -0.92   -3.41   -2.5
6  -0.93
Trial 3      4.19  2.15 3.28 4.81 -2.97 -1.96  -2.76  -1.02    0.07   -3.3
4  -3.10
Trial 4      3.68  0.26 4.36 3.98 -2.76 -1.07  -3.85  -1.45   -0.61   -1.0
5  -1.91
Trial 5      4.35  2.49 3.91 0.71 -4.88 -2.22  -2.55  -3.56   -2.66   -0.8
6  -2.36
Trial 6      3.73  2.59 3.42 2.55 -4.44 -2.36  -2.34   0.54   -2.90   -1.4
0  -0.63
Trial 7      4.94  2.86 3.72 2.91 -2.06 -5.55  -3.20  -3.24   -2.36    0.6
7  -0.10
Trial 8      3.24  0.65 3.56 2.65 -3.08 -4.77  -3.57  -1.24    0.33   -1.9
4  -2.28
Trial 9      4.49 -1.12 3.04 3.74 -5.62 -3.82  -0.20  -3.79   -0.23   -1.4
9  -0.30
Trial 10     4.28 -1.54 3.97 2.15 -4.06 -5.34  -2.85  -1.93   -2.89    0.5
2  -2.27

$resmat
         Distance     m     K    q    q   n  sdb  sdf  sdi  sdi  sdc
Basevec         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 1         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 2         0    NA    NA   NA   NA  NA   NA   NA   NA   NA   NA
Trial 3         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 4         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 5         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 6         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 7         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 8         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 9         0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
Trial 10        0 11.47 55.19 0.03 0.02 3.7 0.11 0.16 0.24 0.17 0.02
```

```
 [1] "Convergence: 0  MSG: relative convergence (4)"
 [2] "Objective function at optimum: -10.6539256"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 48,  Nobs I1: 49,  Nobs I2: 26"
 [5] "Catch/biomass unit: '000 t "
 [6] ""
 [7] "Residual diagnostics (p-values)"
 [8] "    shapiro   bias    acf   LBox shapiro bias acf LBox  "
 [9] " C   0.1759 0.3516 0.0105 0.0255       -    -   *    *  "
[10] " I1  0.4471 0.4446 0.0261 0.0525       -    -   *    .  "
[11] " I2  0.3757 0.7435 0.0032 0.0010       -    -  **   **  "
[12] ""
[13] "Priors"
[14] "     logn  ~  dnorm[log(2), 2^2]"
[15] " logalpha  ~  dnorm[log(1), 2^2]"
[16] "  logbeta  ~  dnorm[log(1), 2^2]"
[17] ""
[18] "Model parameter estimates w 95% CI "
[19] "          estimate      cilow        ciupp    log.est  "
[20] " alpha1  2.1160389  0.9333478   4.7973763  0.7495459  "
[21] " alpha2  1.5124616  0.7044424   3.2473062  0.4137385  "
[22] " beta    0.1045852  0.0313708   0.3486697 -2.2577537  "
[23] " r       1.2474015  0.3191116   4.8760702  0.2210626  "
[24] " rc      0.6750666  0.2385623   1.9102552 -0.3929439  "
[25] " rold    0.4627479  0.1094538   1.9564022 -0.7705730  "
[26] " m      11.4709072  6.5072828  20.2206845  2.4398140  "
[27] " K      55.1920649 16.5178730 184.4162391  4.0108192  "
[28] " q1      0.0251059  0.0063059   0.0999546 -3.6846515  "
[29] " q2      0.0214552  0.0054582   0.0843370 -3.8417885  "
[30] " n       3.6956397  0.7542042  18.1088278  1.3071537  "
[31] " sdb     0.1138001  0.0591031   0.2191163 -2.1733119  "
[32] " sdf     0.1563254  0.1068470   0.2287162 -1.8558153  "
[33] " sdi1    0.2408054  0.1742956   0.3326949 -1.4237660  "
[34] " sdi2    0.1721183  0.1008957   0.2936171 -1.7595734  "
[35] " sdc     0.0163493  0.0058814   0.0454487 -4.1135690  "
[36] " "
[37] "Deterministic reference points (Drp)"
[38] "         estimate     cilow       ciupp   log.est  "
[39] " Bmsyd 33.9845193 7.7159761 149.6826250  3.525905  "
[40] " Fmsyd  0.3375333 0.1192812   0.9551276 -1.086091  "
[41] " MSYd  11.4709072 6.5072828  20.2206845  2.439814  "
[42] "Stochastic reference points (Srp)"
[43] "         estimate     cilow       ciupp   log.est rel.diff.Drp  "
[44] " Bmsys 33.3777252 7.6517296 145.5974798  3.507889  -0.01817961  "
[45] " Fmsys  0.3291656 0.1109417   0.9766391 -1.111194  -0.02542097  "
[46] " MSYs  10.9817223 6.7489928  17.8690699  2.396232  -0.04454537  "
[47] ""
[48] "States w 95% CI (inp$msytype: s)"
[49] "                  estimate      cilow       ciupp    log.est  "
[50] " B_2016.50      53.3048193 14.5429573 195.3800522  3.976027  "
[51] " F_2016.50       0.0945400  0.0256037   0.3490830 -2.358732  "
[52] " B_2016.50/Bmsy  1.5970177  1.1143189   2.2888113  0.468138  "
[53] " F_2016.50/Fmsy  0.2872111  0.1968215   0.4191117 -1.247538  "
[54] ""
[55] "Predictions w 95% CI (inp$msytype: s)"
[56] "                prediction      cilow       ciupp     log.est  "
[57] " B_2017.00      52.0316240 14.0862135 192.1942961  3.9518517  "
[58] " F_2017.00       0.0943258  0.0253036   0.3516245 -2.3610002  "
[59] " B_2017.00/Bmsy  1.5588727  1.0771332   2.2560664  0.4439629  "
[60] " F_2017.00/Fmsy  0.2865604  0.1901407   0.4318742 -1.2498059  "
[61] " Catch_2017.00   4.8517283  3.7070955   6.3497873  1.5793350  "
[62] " E(B_inf)       49.3357288         NA          NA  3.8986485  "
```







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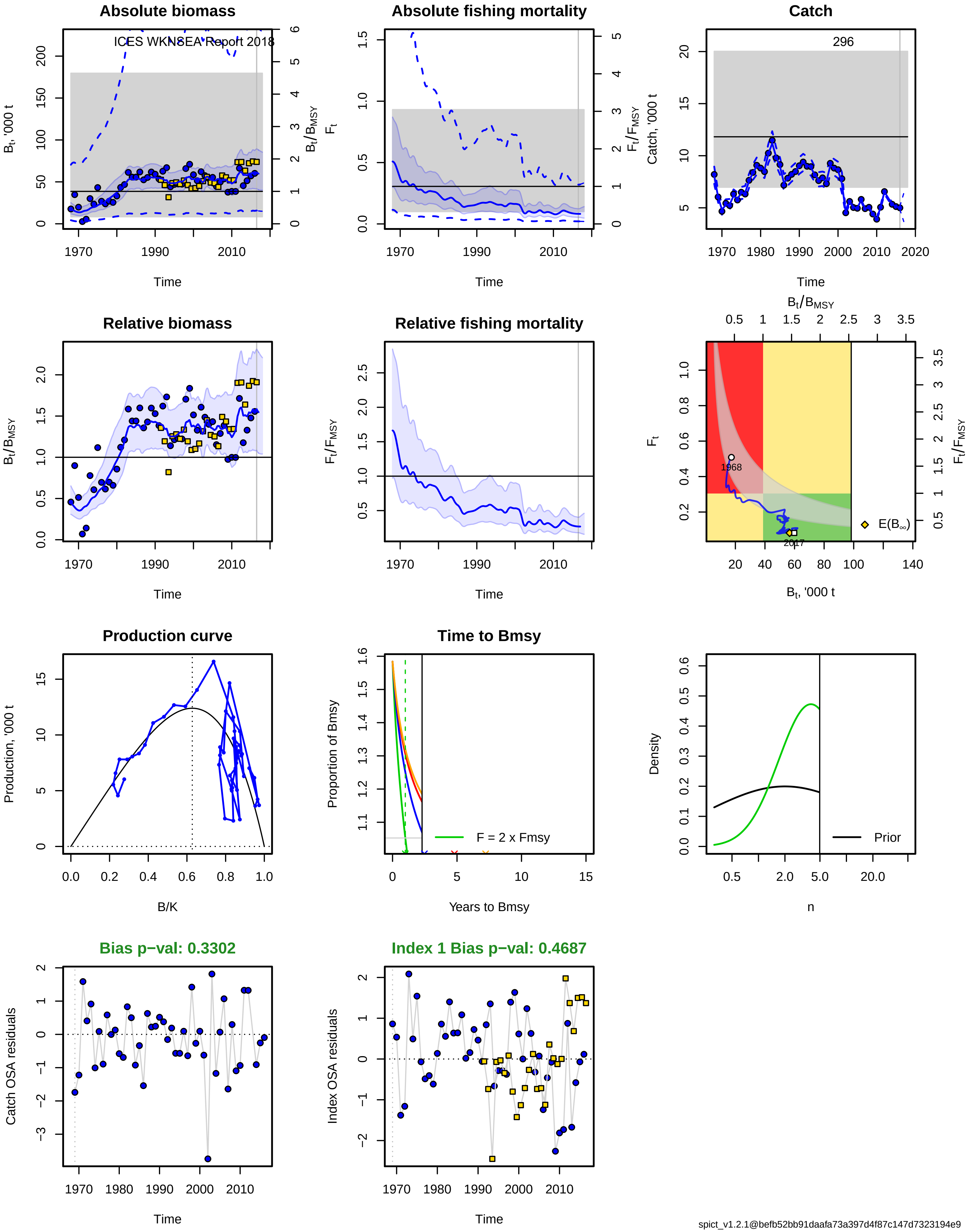
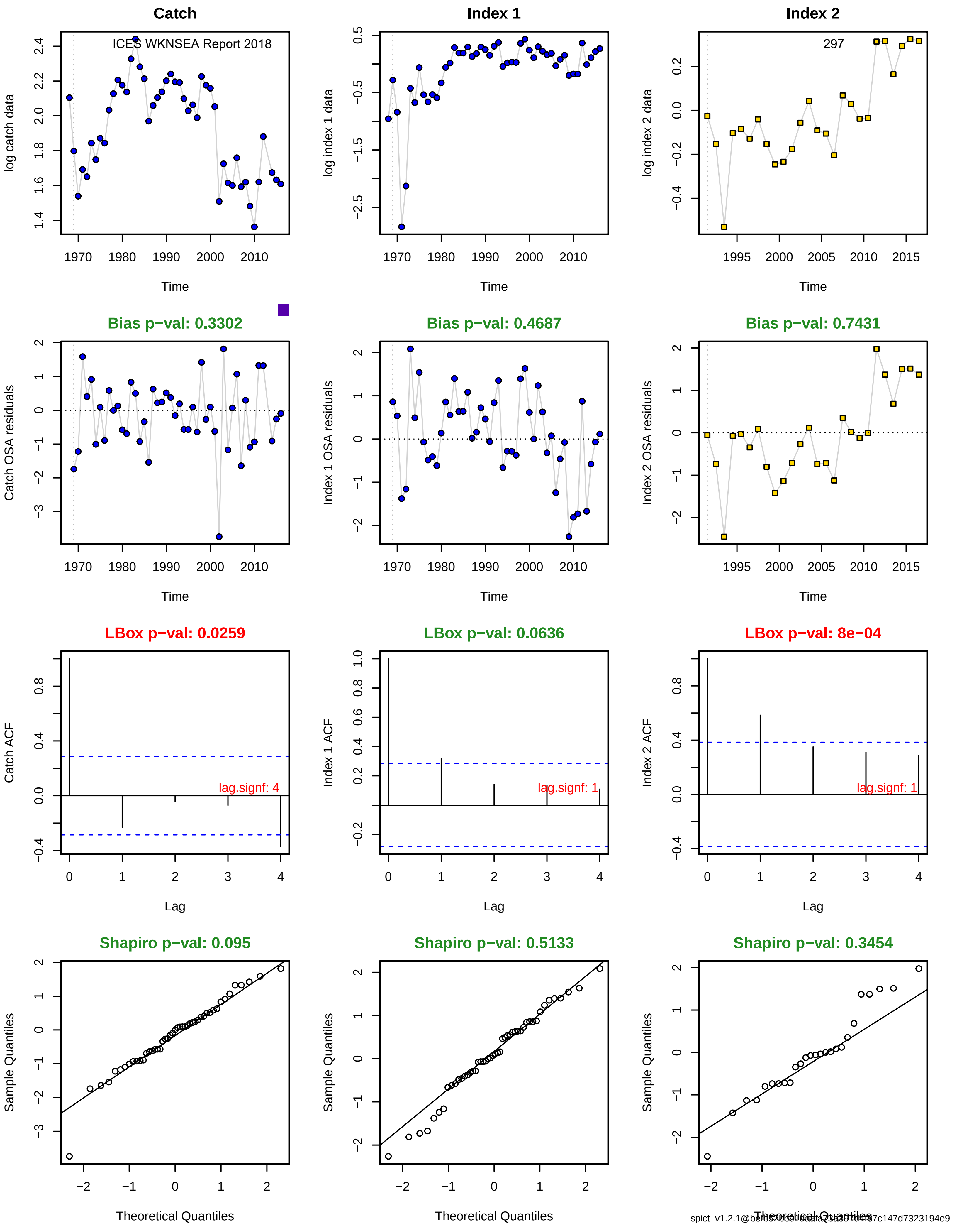
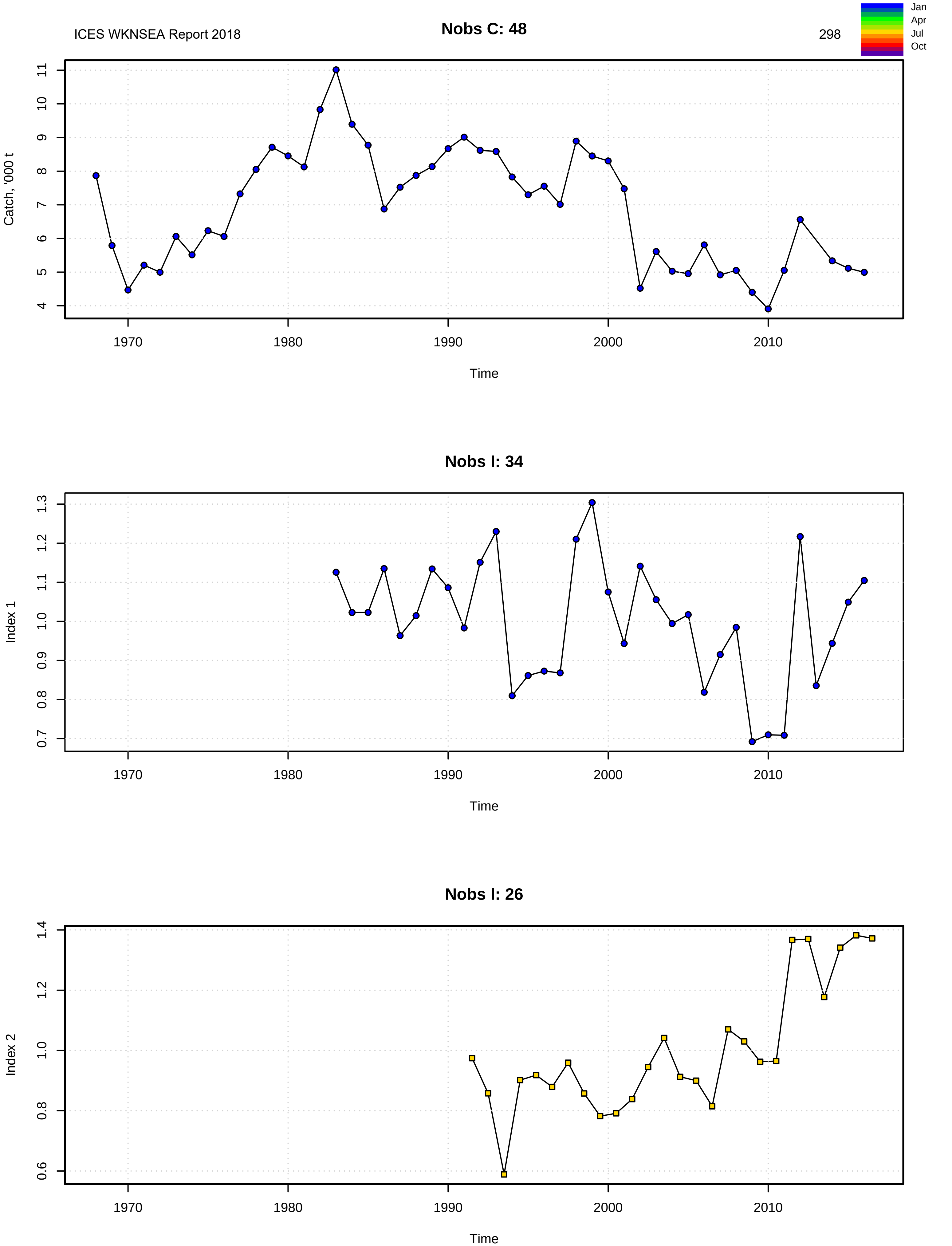
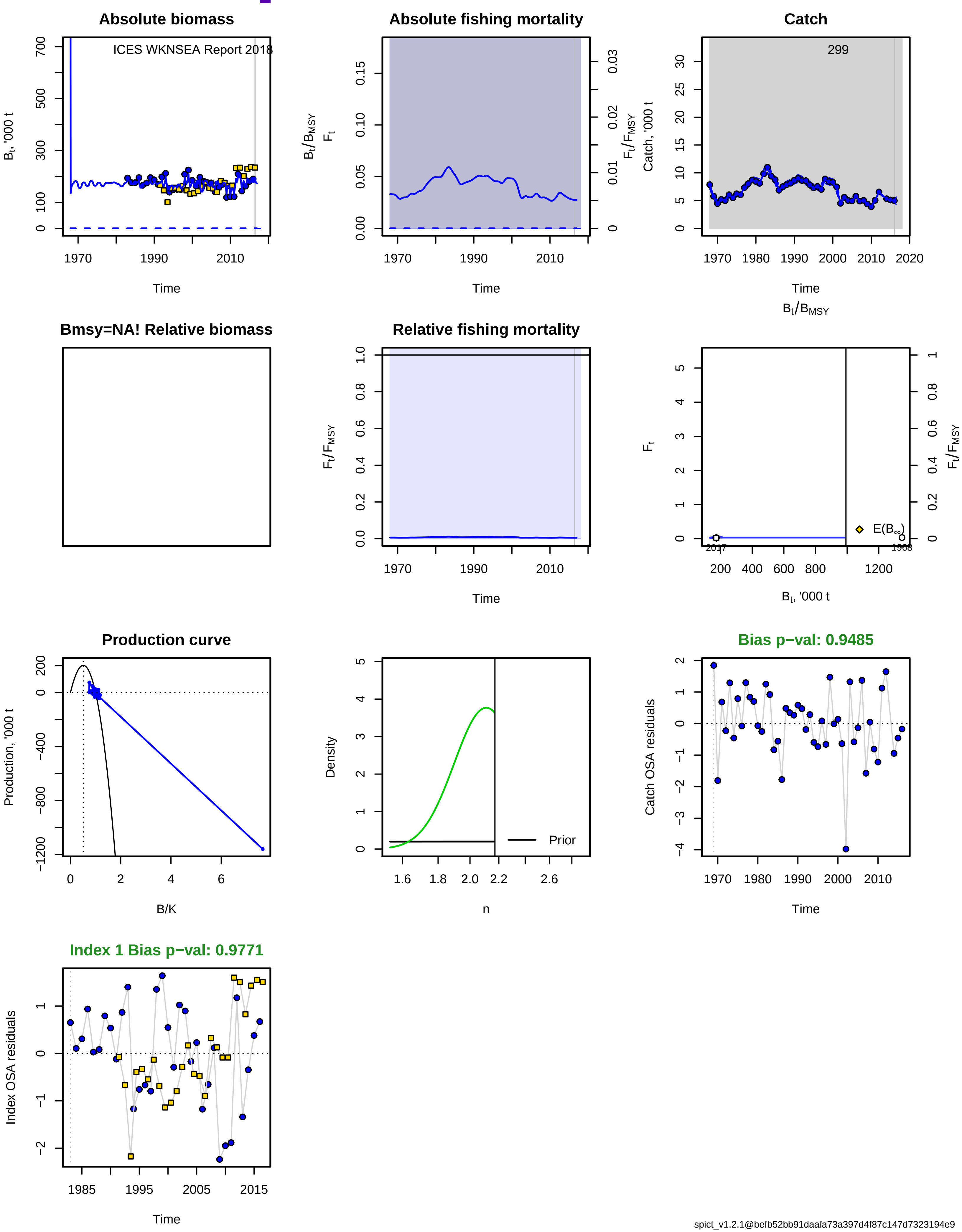
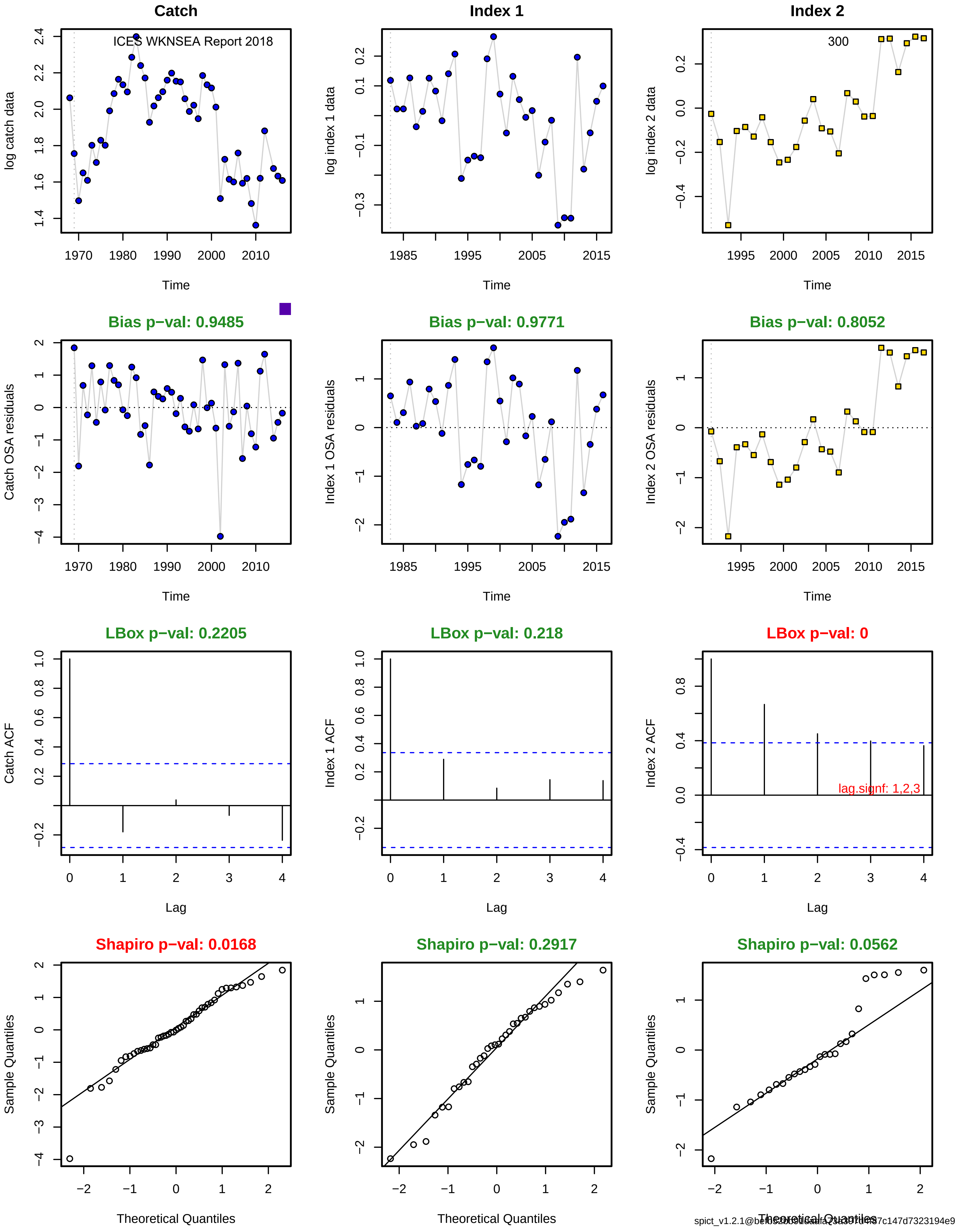

Absolute biomass
Absolute fishing mortality
Catch
Relative biomass
Relative fishing mortality
Production curve
Time to Bmsy
Bias p−val: 0.3302
Index 1 Bias p−val: 0.4687
Time
B/K
Years to Bmsy
n
Density
Prior
F = 2 x Fmsy
Production, '000 t
Proportion of Bmsy
Catch OSA residuals
Index OSA residuals
Catch, '000 t
E(B∞)
1968
2017
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

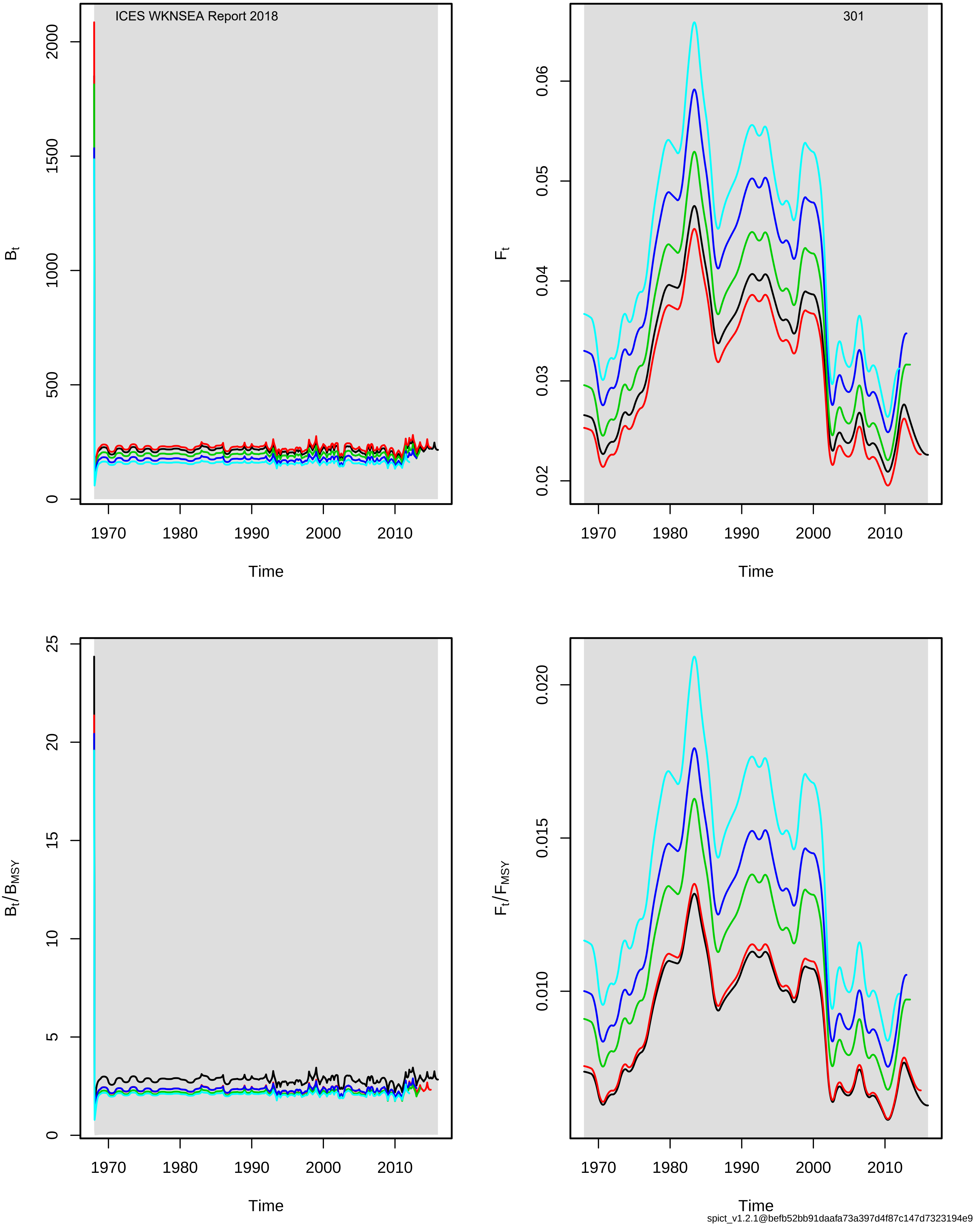

Catch
log catch data
Time
Index 1
log index 1 data
Index 2
log index 2 data
Bias p−val: 0.3302
Catch OSA residuals
Bias p−val: 0.4687
Index 1 OSA residuals
Bias p−val: 0.7431
Index 2 OSA residuals
LBox p−val: 0.0259
Catch ACF
lag.signf: 4
Lag
LBox p−val: 0.0636
Index 1 ACF
lag.signf: 1
LBox p−val: 8e−04
Index 2 ACF
lag.signf: 1
Shapiro p−val: 0.095
Shapiro p−val: 0.5133
Shapiro p−val: 0.3454
Sample Quantiles
Theoretical Quantiles



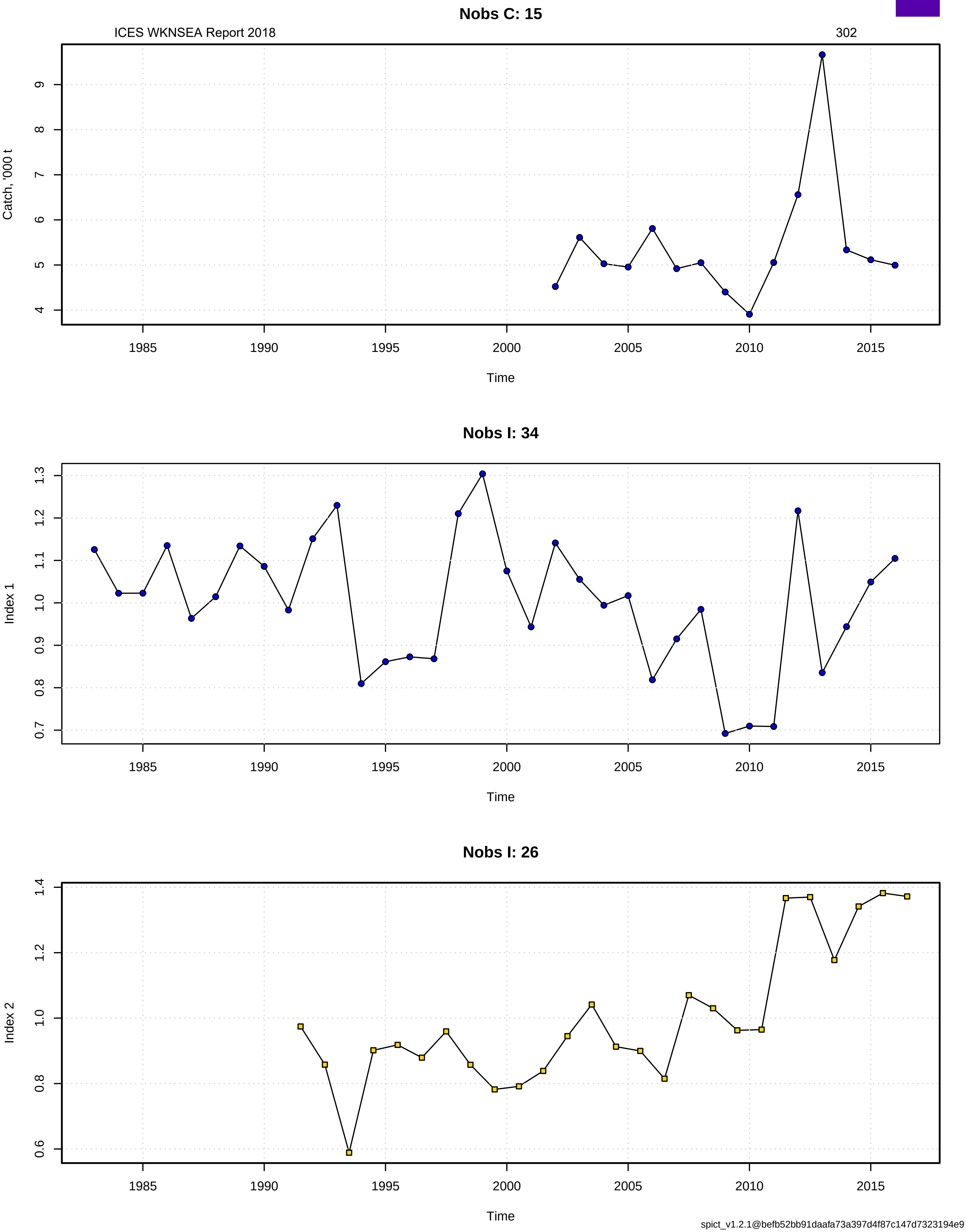
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

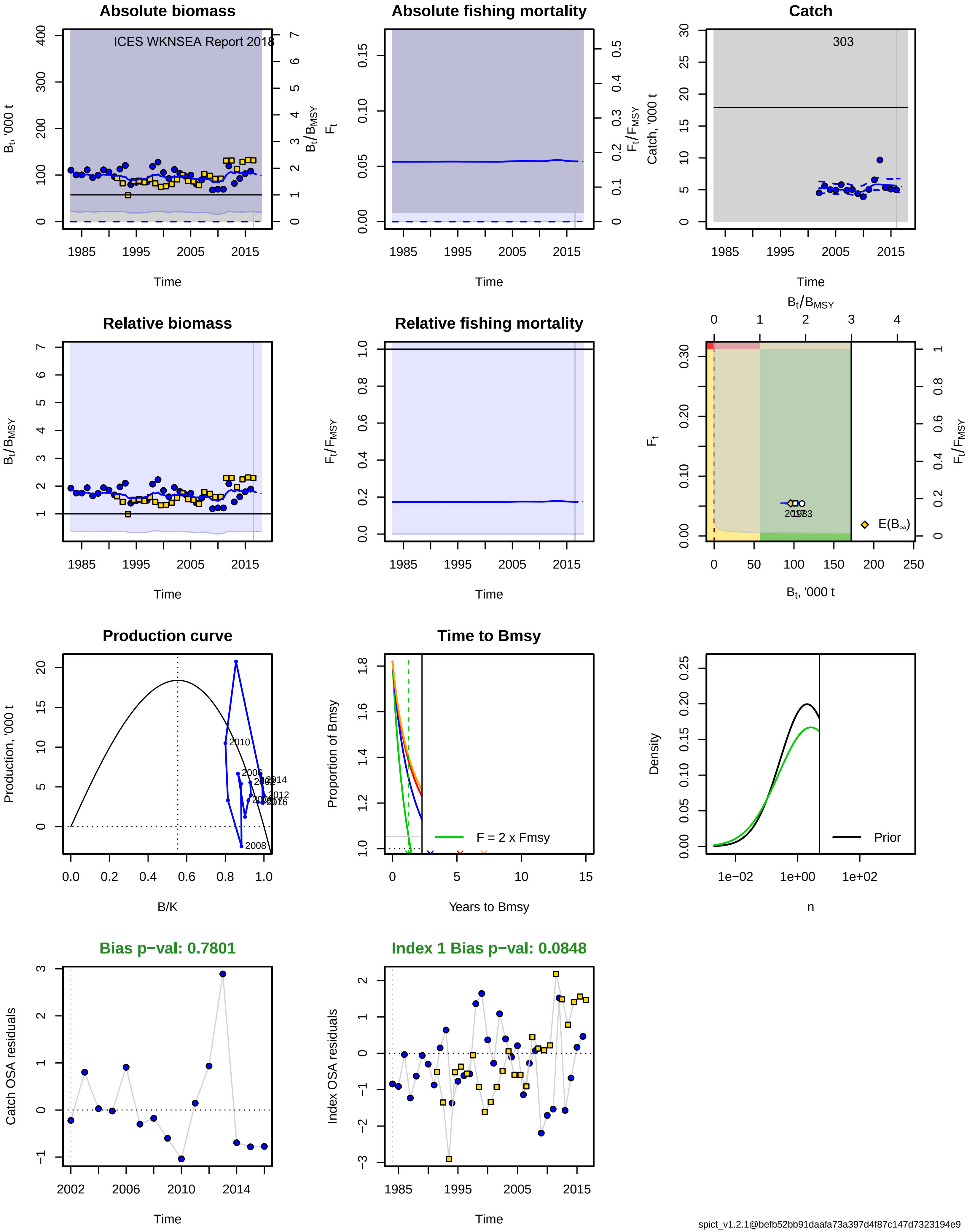

Absolute biomass
ICES WKNSEA Report 2018
Bt, '000 t
Time
Absolute fishing mortality
Bt/BMSY
Ft
Ft/FMSY
Time
Catch
299
Catch, '000 t
Time
Bmsy=NA! Relative biomass
Relative fishing mortality
Ft/FMSY
Time
Bt/BMSY
Ft
Ft/FMSY
E(B∞)
2017
1968
Bt, '000 t
Production curve
Production, '000 t
B/K
Density
Prior
n
Bias p−val: 0.9485
Catch OSA residuals
Time
Index 1 Bias p−val: 0.9771
Index OSA residuals
Time
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

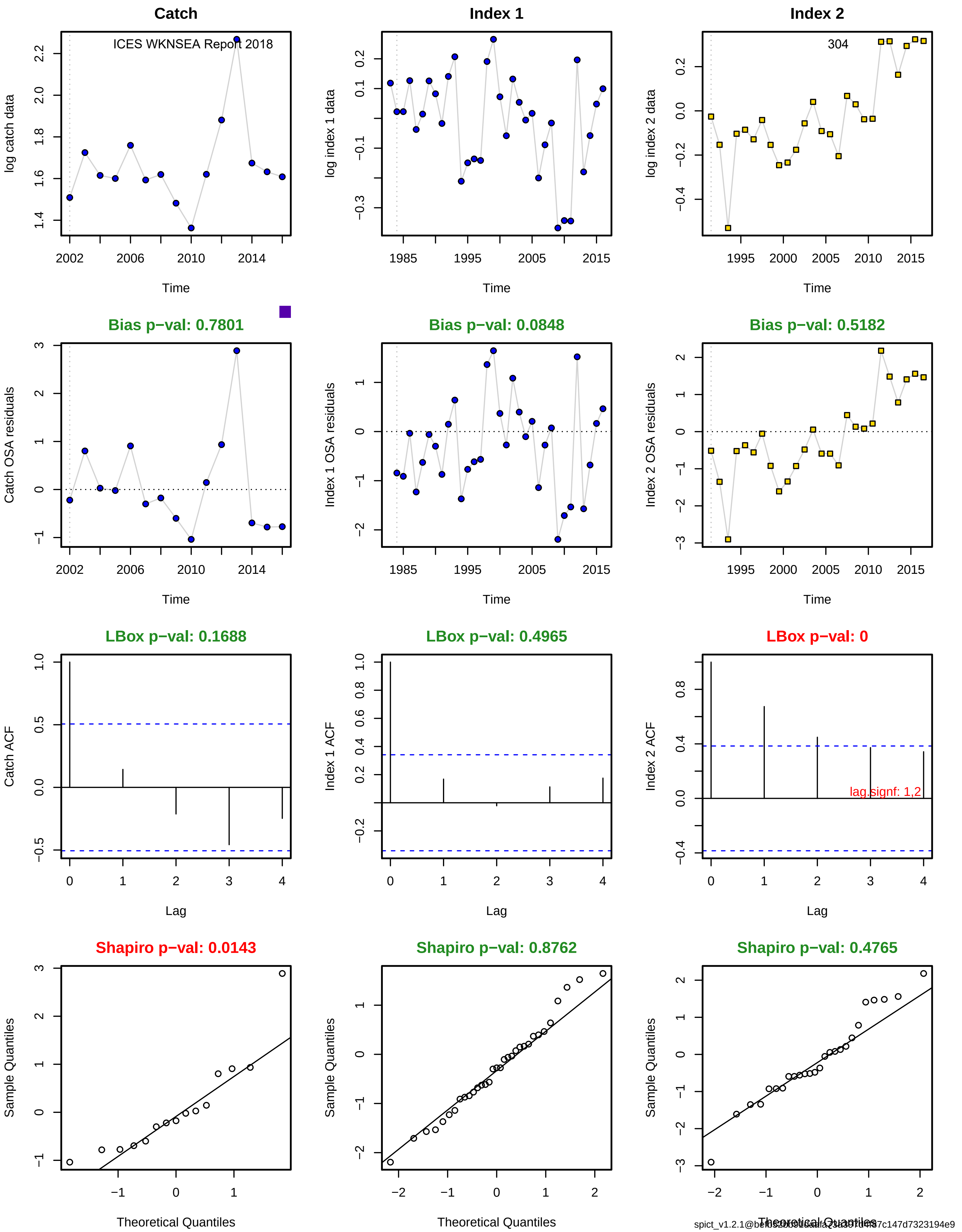

Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.9485
Bias p−val: 0.9771
Bias p−val: 0.8052
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.2205
LBox p−val: 0.218
LBox p−val: 0
Catch ACF
Index 1 ACF
Index 2 ACF
lag.signf: 1,2,3
Lag
Shapiro p−val: 0.0168
Shapiro p−val: 0.2917
Shapiro p−val: 0.0562
Sample Quantiles
Theoretical Quantiles
spict_v1.2.1@be8b32b091adafa23a39fd4f87c147d7323194e9

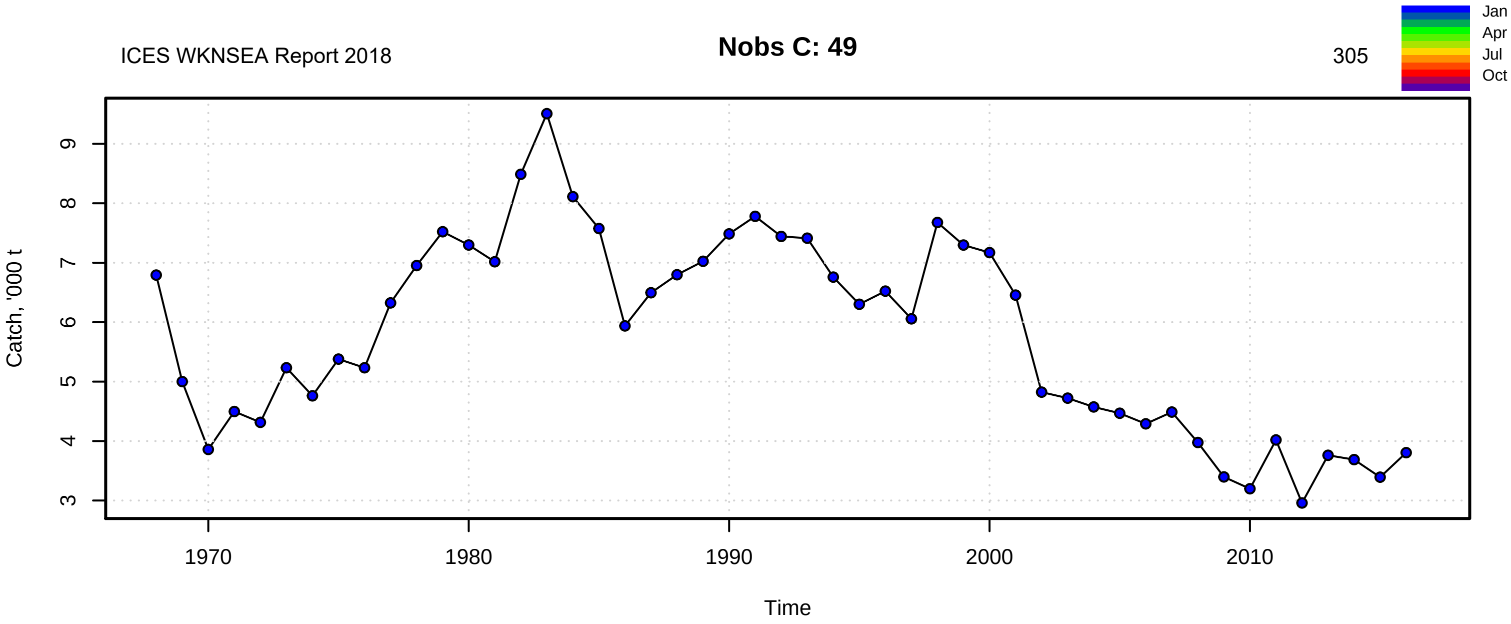


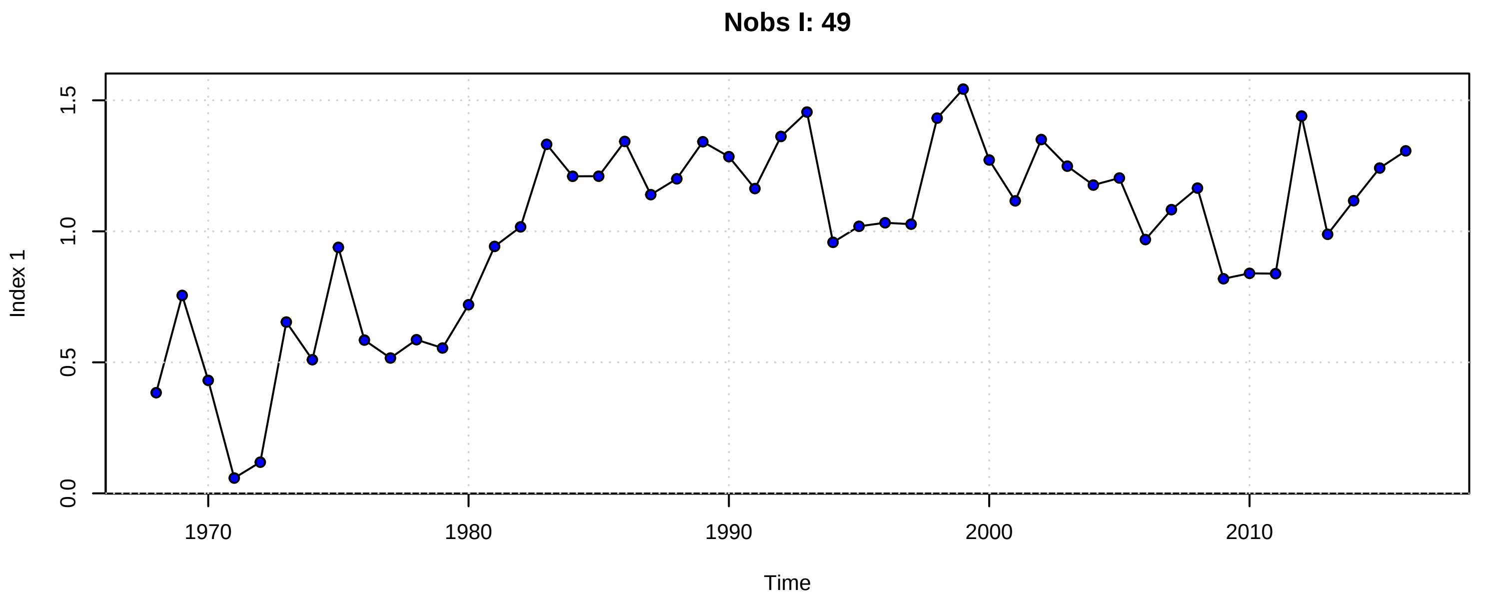
B_t
F_t
B_t/B_{MSY}
F_t/F_{MSY}
Time
Time
Time
Time
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

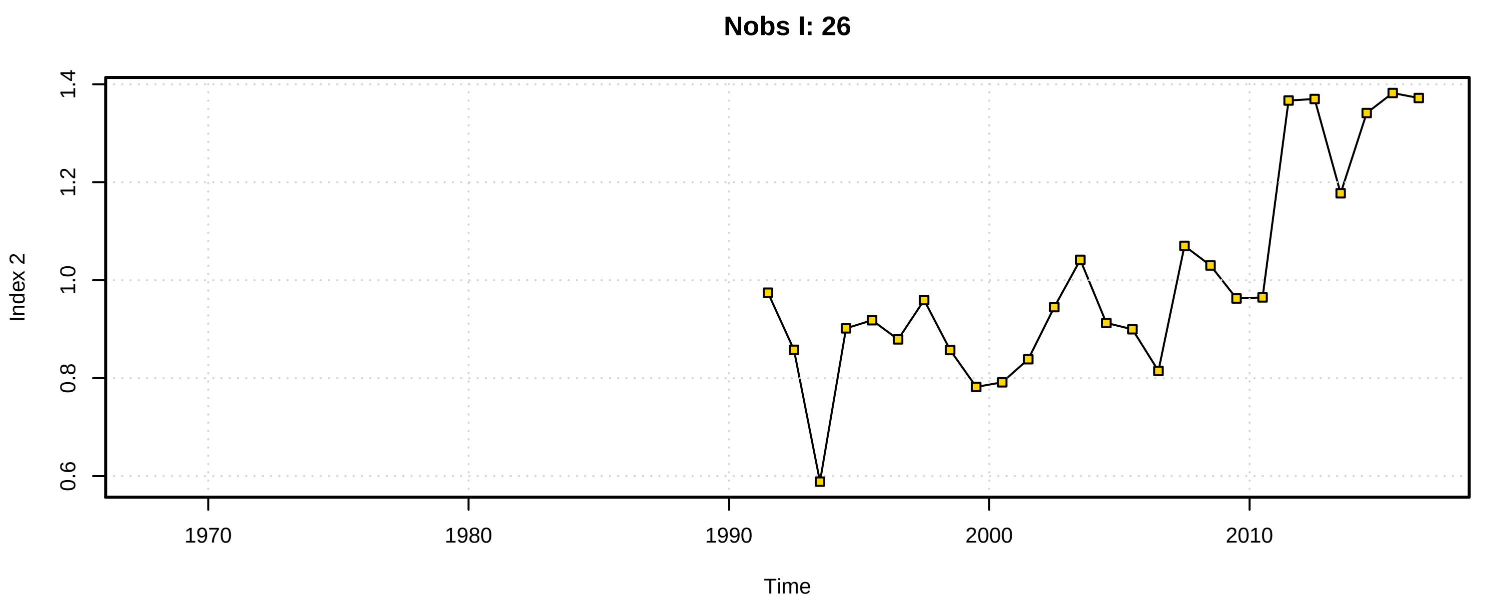

Nobs C: 15
Catch, '000 t
4
5
6
7
8
9
1985
1990
1995
2000
2005
2010
2015
Time
Nobs I: 34
Index 1
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1985
1990
1995
2000
2005
2010
2015
Time
Nobs I: 26
Index 2
0.6
0.8
1.0
1.2
1.4
1985
1990
1995
2000
2005
2010
2015
Time
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9


Absolute biomass
Bt, '000 t
Bt/BMSY
Ft
Time
Absolute fishing mortality
Ft/FMSY
Catch, '000 t
Catch
Relative biomass
Relative fishing mortality
Production curve
Production, '000 t
B/K
Time to Bmsy
Proportion of Bmsy
F = 2 x Fmsy
Years to Bmsy
Density
Prior
n
E(B∞)
Bias p−val: 0.7801
Catch OSA residuals
Index 1 Bias p−val: 0.0848
Index OSA residuals
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

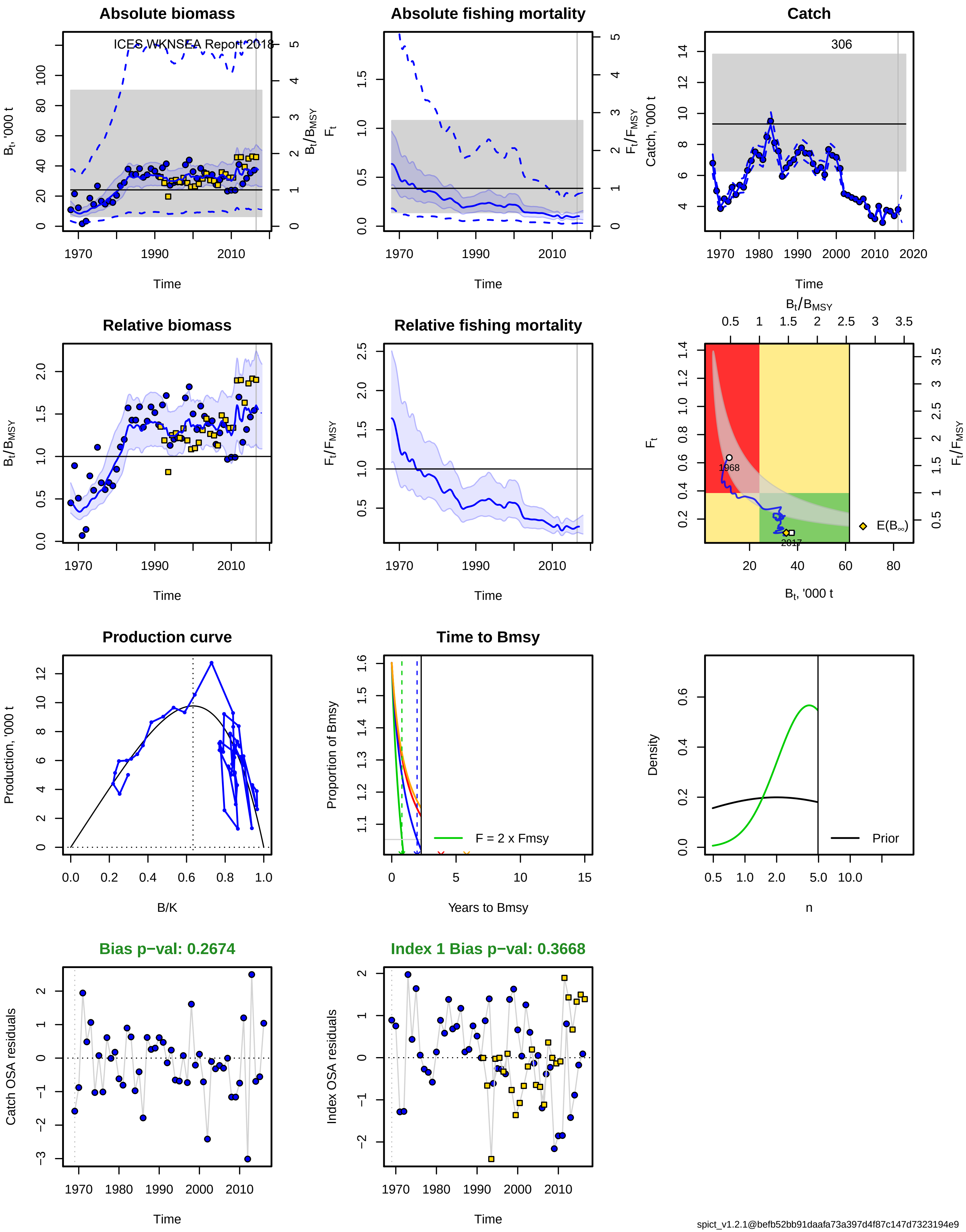

Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.7801
Bias p−val: 0.0848
Bias p−val: 0.5182
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.1688
LBox p−val: 0.4965
LBox p−val: 0
Catch ACF
Index 1 ACF
Index 2 ACF
lag.signf: 1,2
Lag
Shapiro p−val: 0.0143
Shapiro p−val: 0.8762
Shapiro p−val: 0.4765
Sample Quantiles
Theoretical Quantiles



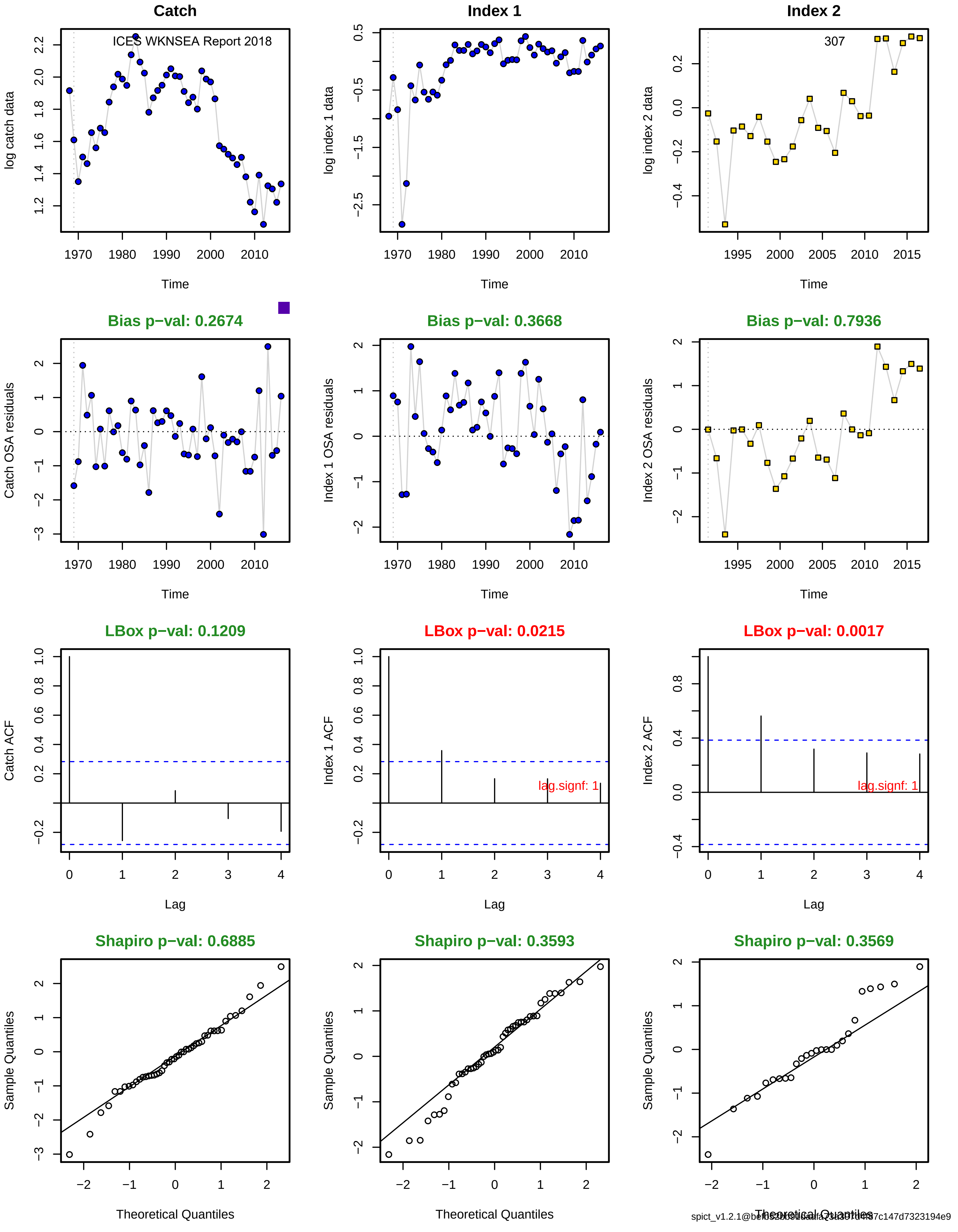




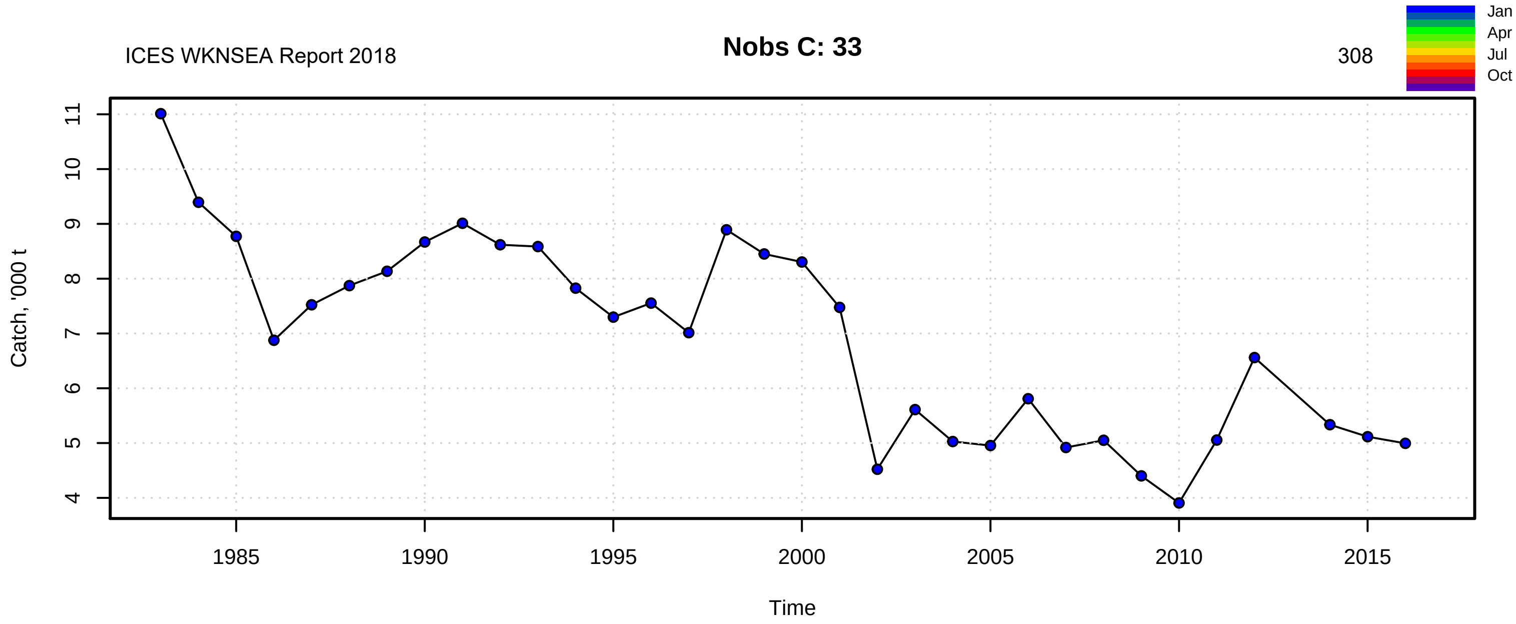
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

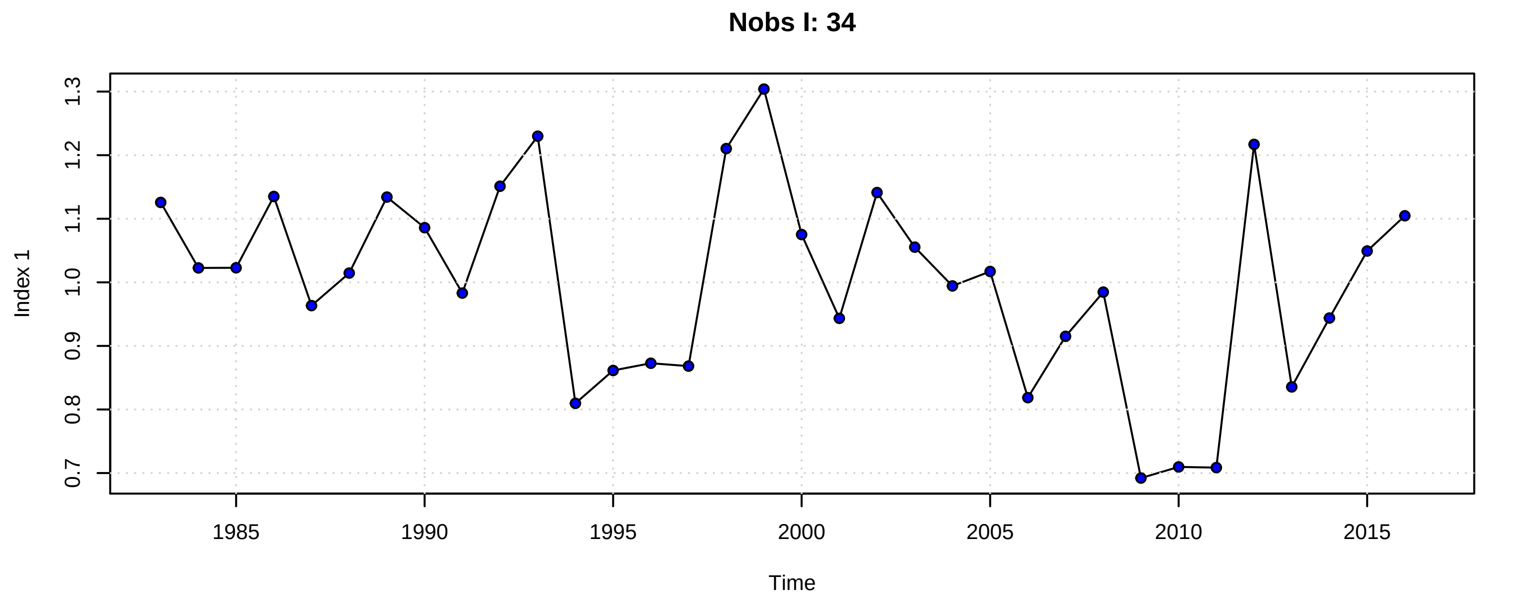


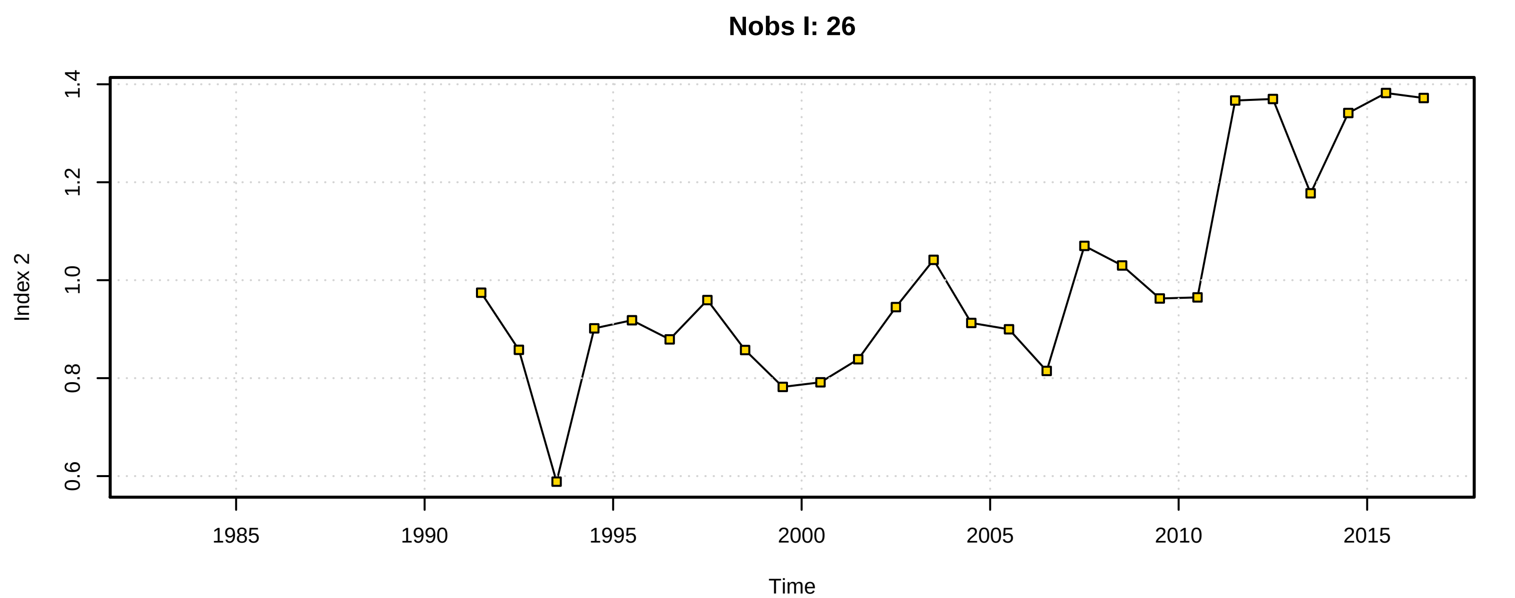
Absolute biomass
Absolute fishing mortality
Catch
306
Relative biomass
Relative fishing mortality
1968
2017
E(B∞)
Production curve
Time to Bmsy
F = 2 x Fmsy
Prior
Bias p−val: 0.2674
Index 1 Bias p−val: 0.3668
Time
B/K
Years to Bmsy
n
Proportion of Bmsy
Production, '000 t
Density
Catch OSA residuals
Index OSA residuals
Catch, '000 t
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

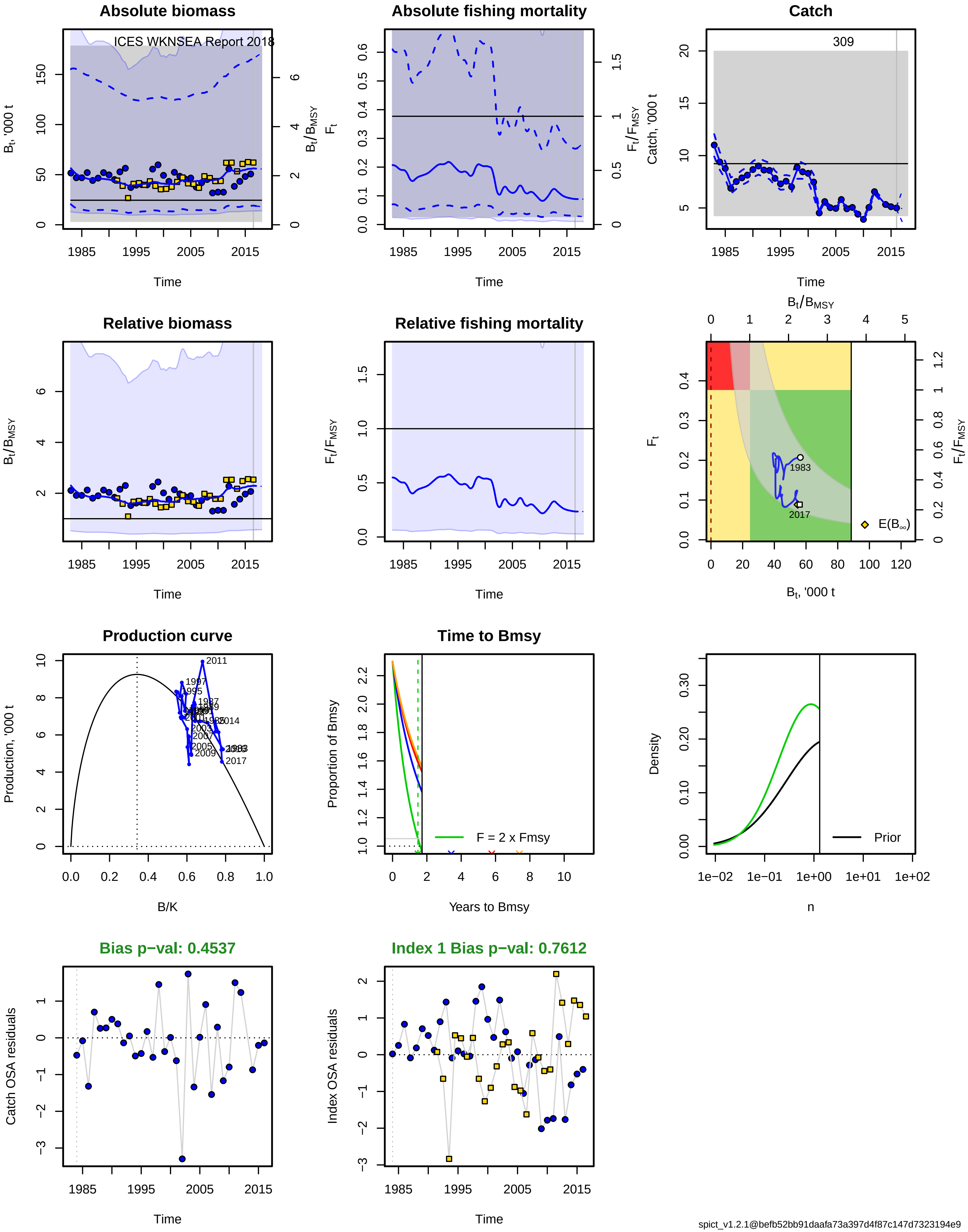


Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.2674
Bias p−val: 0.3668
Bias p−val: 0.7936
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.1209
LBox p−val: 0.0215
LBox p−val: 0.0017
Catch ACF
Index 1 ACF
Index 2 ACF
lag.signf: 1
Lag
Shapiro p−val: 0.6885
Shapiro p−val: 0.3593
Shapiro p−val: 0.3569
Sample Quantiles
Theoretical Quantiles

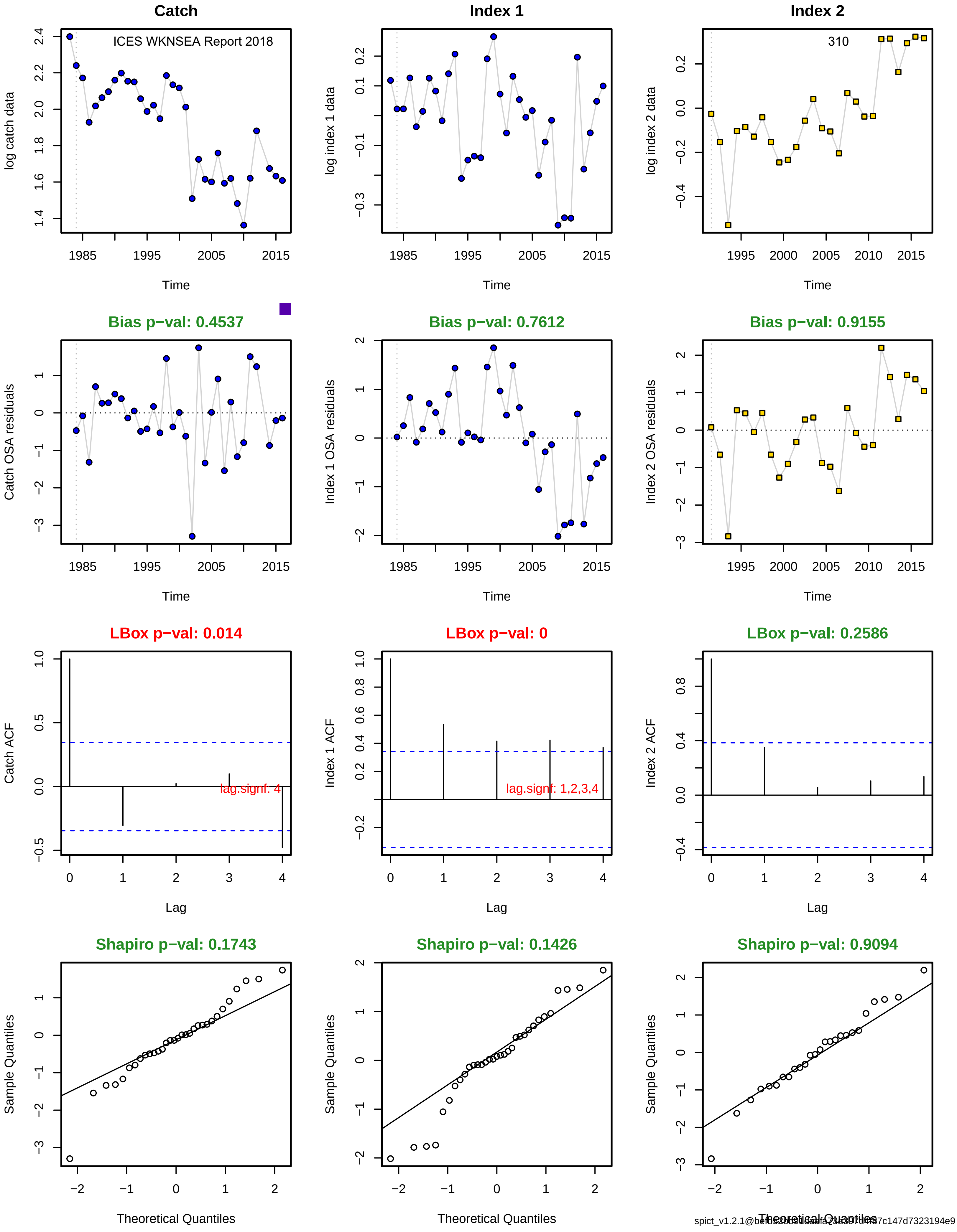

Jan
Apr
Jul
Oct
Nobs C: 33
Catch, '000 t
Time

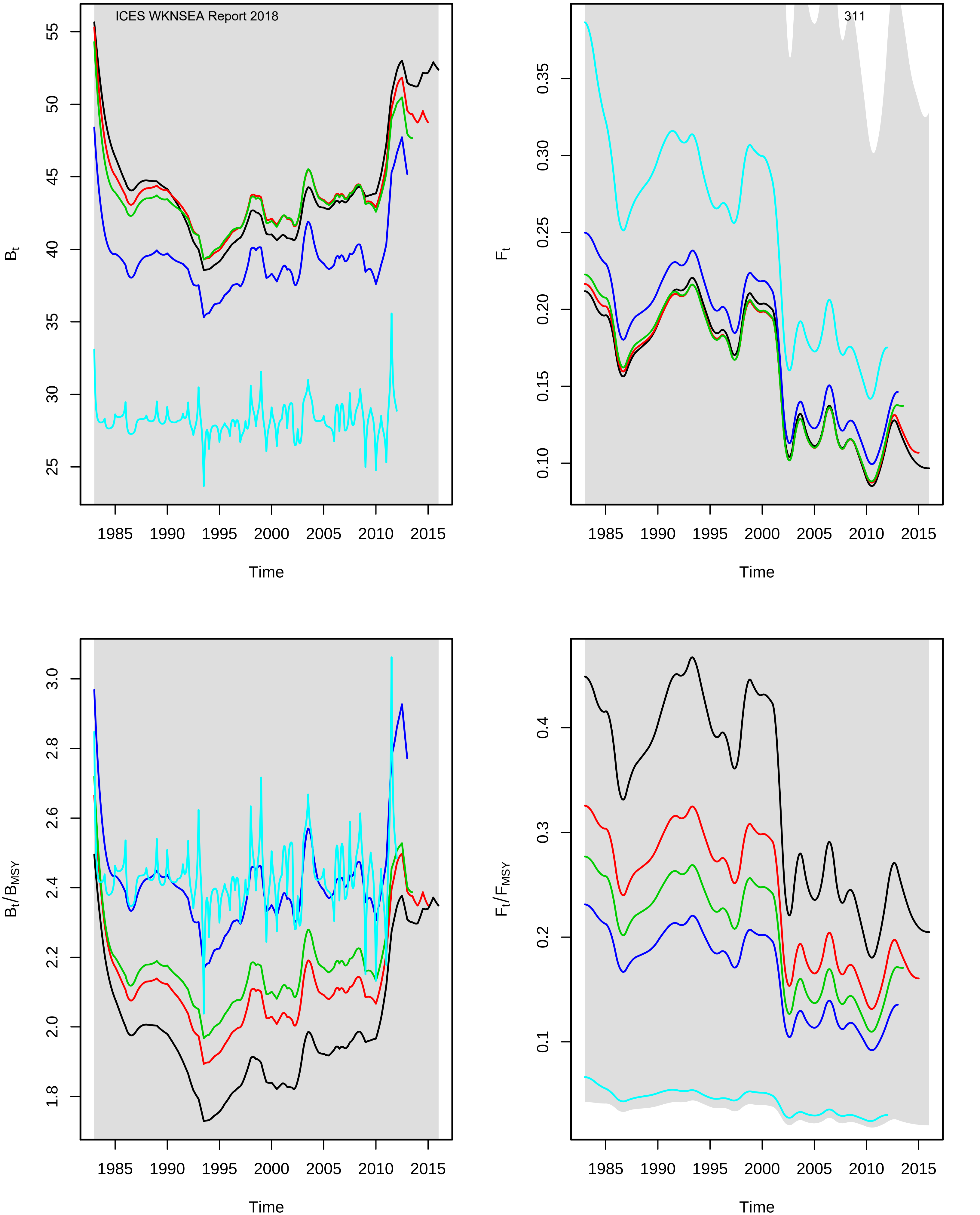

Nobs I: 34
Index 1
Time


Nobs I: 26
Index 2
Time



spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9


Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.4537
Bias p−val: 0.7612
Bias p−val: 0.9155
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.014
LBox p−val: 0
LBox p−val: 0.2586
Catch ACF
Index 1 ACF
Index 2 ACF
lag.signf: 4
lag.signf: 1,2,3,4
Lag
Shapiro p−val: 0.1743
Shapiro p−val: 0.1426
Shapiro p−val: 0.9094
Sample Quantiles
Theoretical Quantiles



B_t
55
50
45
40
35
30
25
1985
1990
1995
2000
2005
2010
2015
Time
F_t
0.35
0.30
0.25
0.20
0.15
0.10
B_t/B_{MSY}
3.0
2.8
2.6
2.4
2.2
2.0
1.8
F_t/F_{MSY}
0.4
0.3
0.2
0.1

$propchng

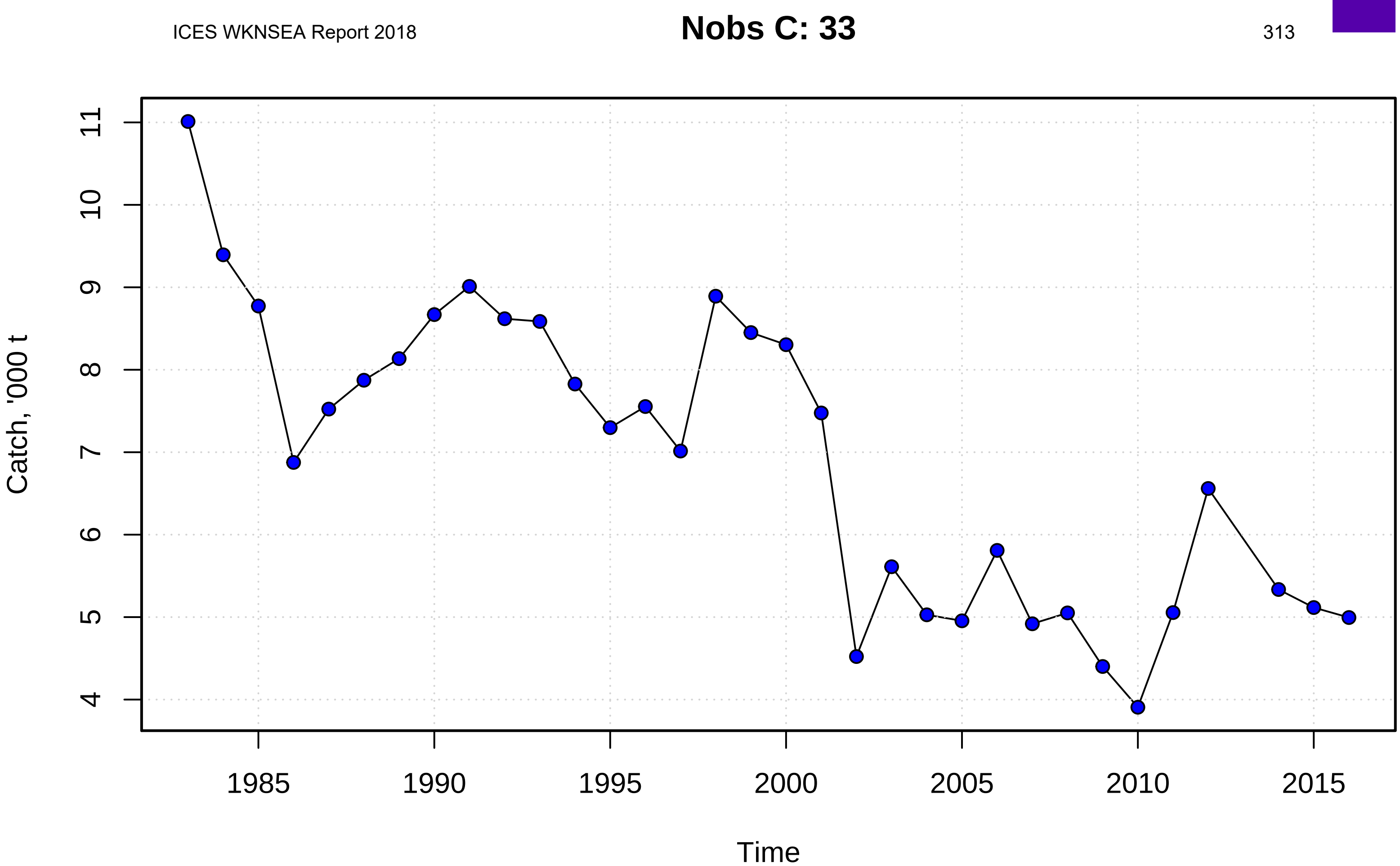
	logm	logK	logq	logq	logn	logsdb	logsdf	logsdi	logsdi	logsdc
Trial 1	-0.56	-0.27	0.49	-0.05	0.20	-0.66	-0.35	-0.72	-1.08	-0.56
Trial 2	2.22	-0.38	-0.19	-0.64	-0.54	0.17	-0.56	0.98	-0.76	0.90
Trial 3	1.94	0.28	-0.54	0.43	0.00	1.35	-1.27	-0.39	-0.72	-1.10
Trial 4	0.43	0.02	0.70	0.48	-0.53	-0.04	0.50	1.09	-0.92	-0.26
Trial 5	-1.62	-0.08	0.27	-0.52	0.55	1.10	0.22	-0.84	-1.17	1.23
Trial 6	0.33	0.60	0.49	0.14	-0.28	-1.09	-1.33	0.91	0.07	-0.10
Trial 7	0.61	-0.35	-1.16	0.00	0.54	-1.42	-0.13	0.31	-0.82	0.43
Trial 8	-2.38	0.59	-0.37	0.31	0.49	-1.12	-0.10	1.29	-1.35	0.05
Trial 9	-0.07	-0.51	0.67	-0.30	0.34	0.73	-0.24	1.02	0.59	0.60
Trial 10	-3.01	-0.43	1.00	-0.32	-0.09	0.68	0.03	-0.38	0.81	-0.18

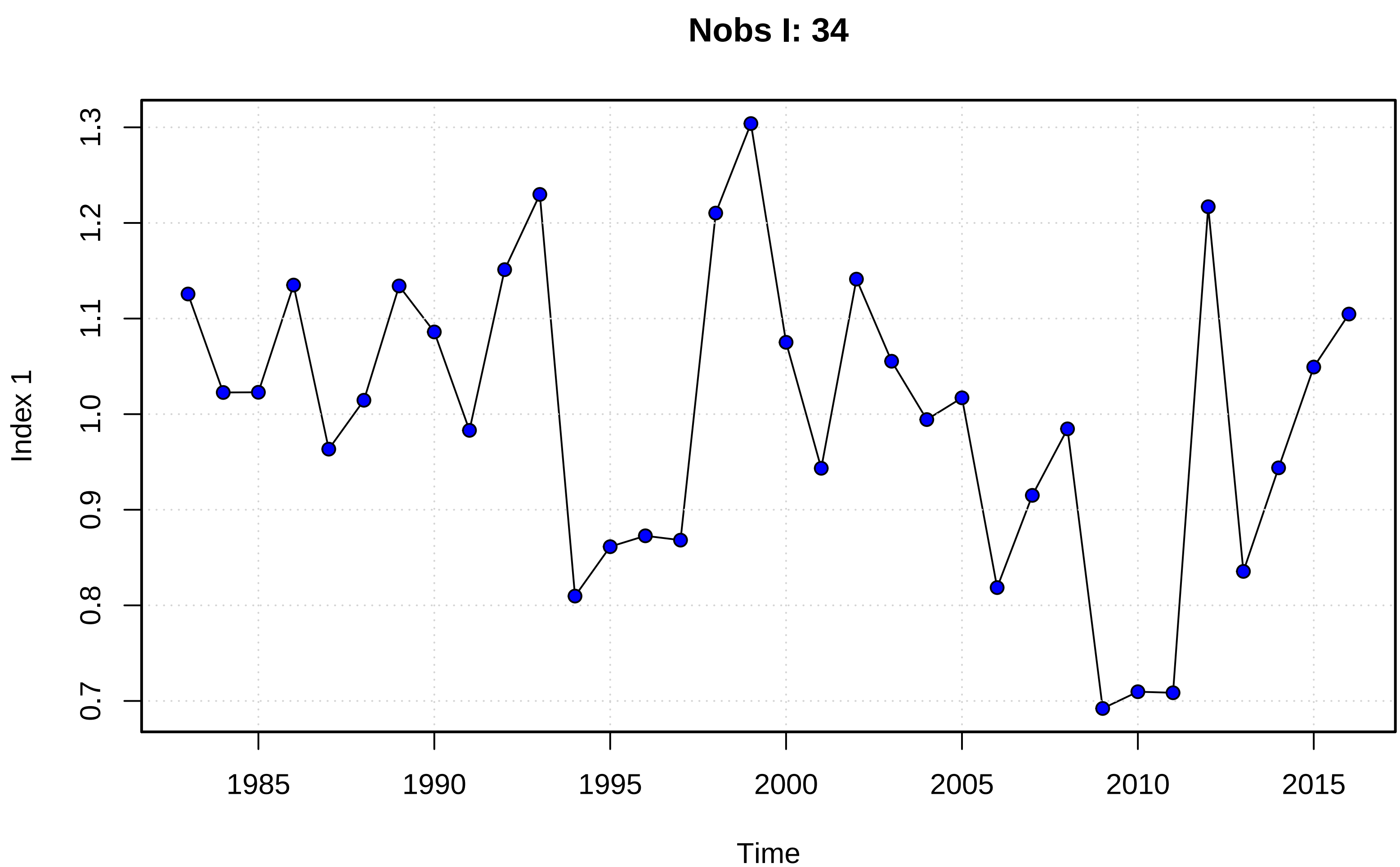
$inimat

	Distance	logn	logK	logm	logq1	logq2	logsdb	logsdf	logsdi1	logsdi2	logsdc
Basevec	0.00	0.69	3.79	1.94	-3.52	-3.52	-1.61	-1.61	-1.61	-1.61	-1.61
Trial 1	3.05	0.30	2.75	2.88	-3.35	-4.24	-0.56	-1.04	-0.44	0.14	-0.71
Trial 2	4.50	2.23	2.34	1.57	-1.27	-1.61	-1.88	-0.72	-3.19	-0.38	-3.06
Trial 3	4.49	2.04	4.83	0.89	-5.05	-3.51	-3.79	0.44	-0.98	-0.46	0.16
Trial 4	3.79	0.99	3.87	3.29	-5.21	-1.64	-1.54	-2.42	-3.36	-0.14	-1.19
Trial 5	4.63	-0.43	3.49	2.46	-1.69	-5.47	-3.39	-1.97	-0.26	0.28	-3.59
Trial 6	4.13	0.92	6.04	2.88	-4.02	-2.54	0.14	0.53	-3.07	-1.72	-1.45
Trial 7	4.29	1.11	2.44	-0.32	-3.52	-5.42	0.67	-1.39	-2.12	-0.29	-2.31
Trial 8	4.96	-0.96	6.02	1.22	-4.61	-5.23	0.19	-1.45	-3.68	0.56	-1.69
Trial 9	3.73	0.65	1.86	3.23	-2.48	-4.71	-2.79	-1.22	-3.25	-2.56	-2.57
Trial 10	3.93	-1.39	2.16	3.87	-2.40	-3.19	-2.70	-1.66	-1.00	-2.91	-1.32

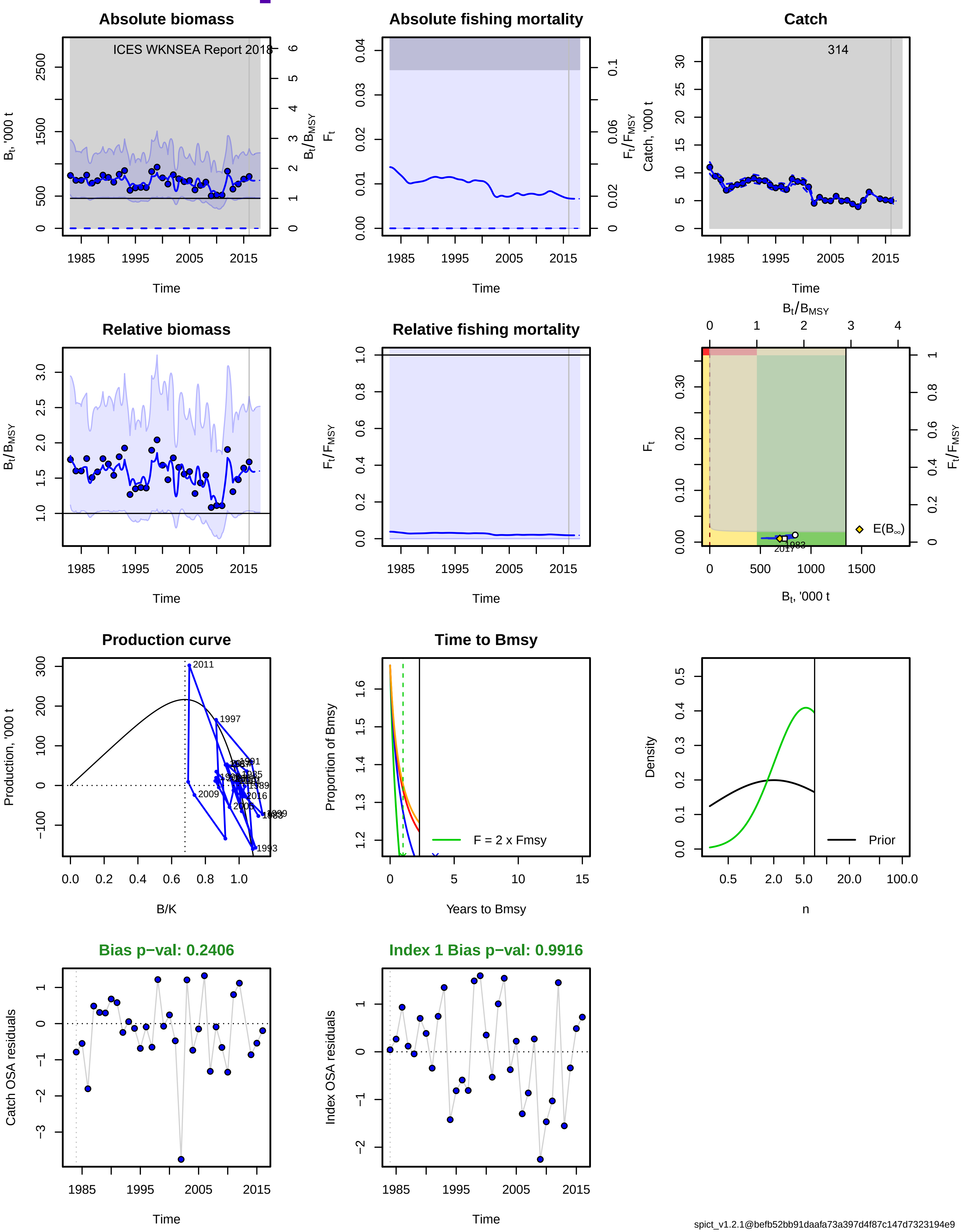
$resmat

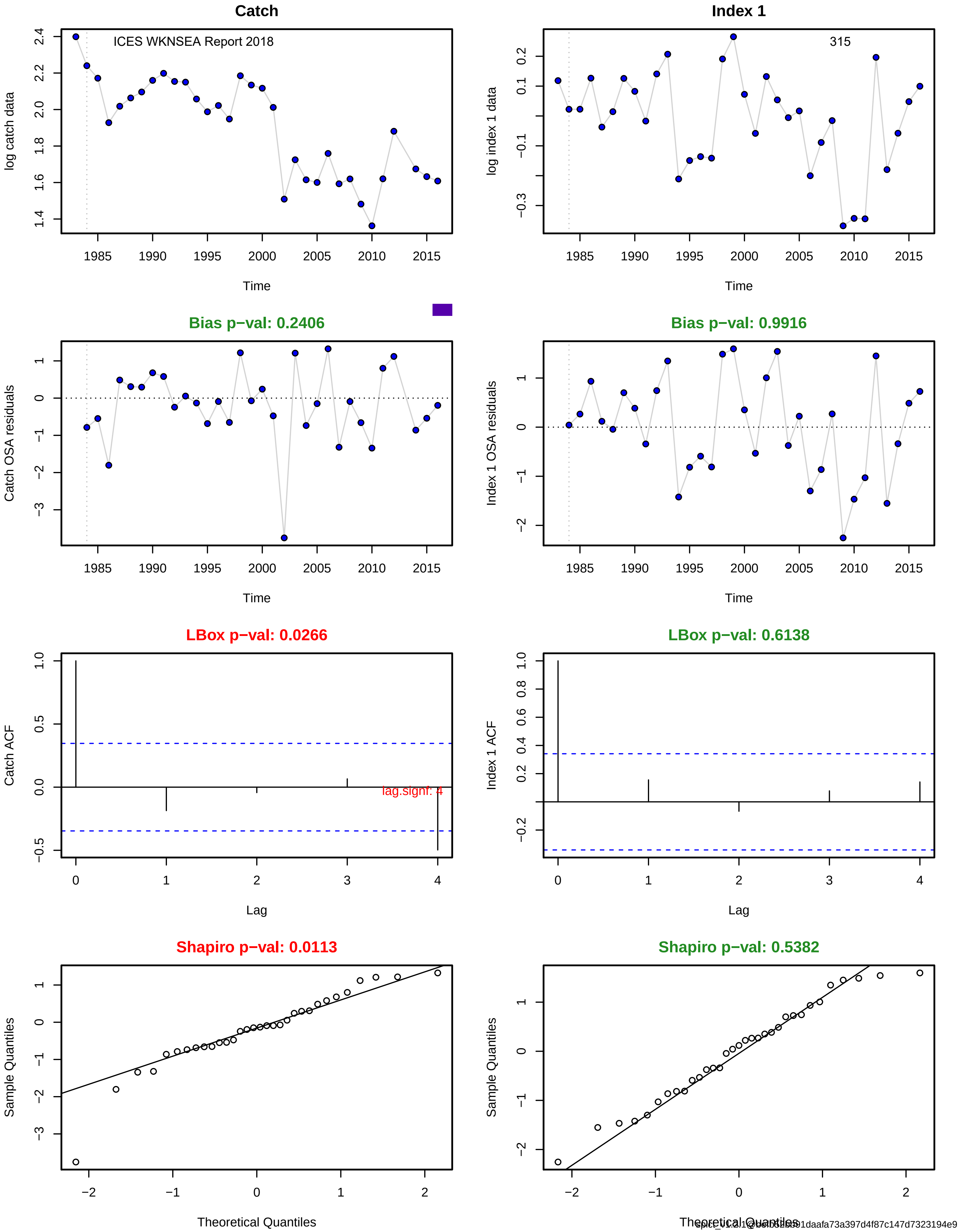
	Distance	m	K	q	q	n	sdb	sdf	sdi	sdi	sdc
Basevec	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 1	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 2	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 3	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 4	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trial 5	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 6	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 7	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 8	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 9	0	9.26	71.75	0.02	0.02	0.87	0.06	0.18	0.19	0.13	0.02
Trial 10	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

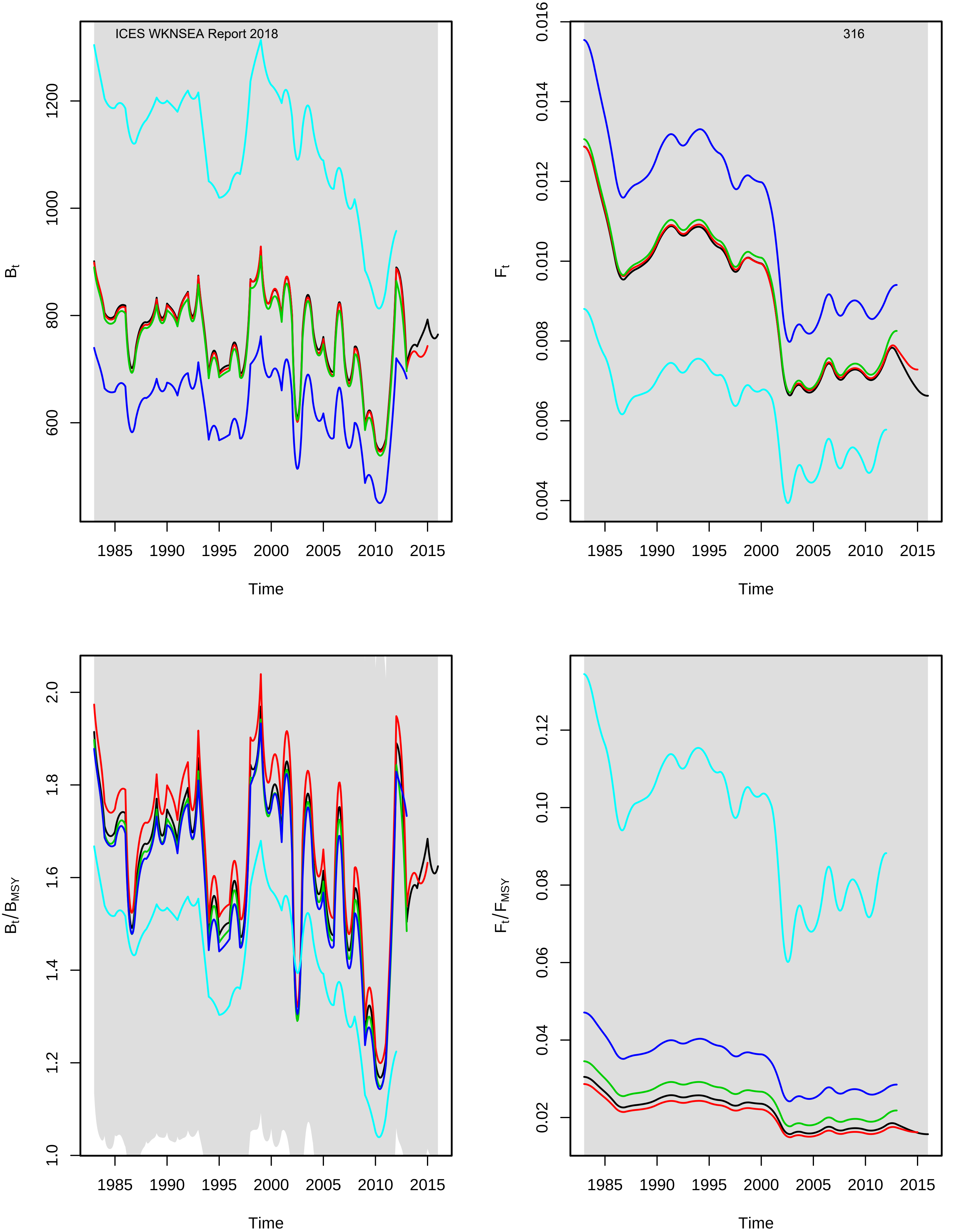




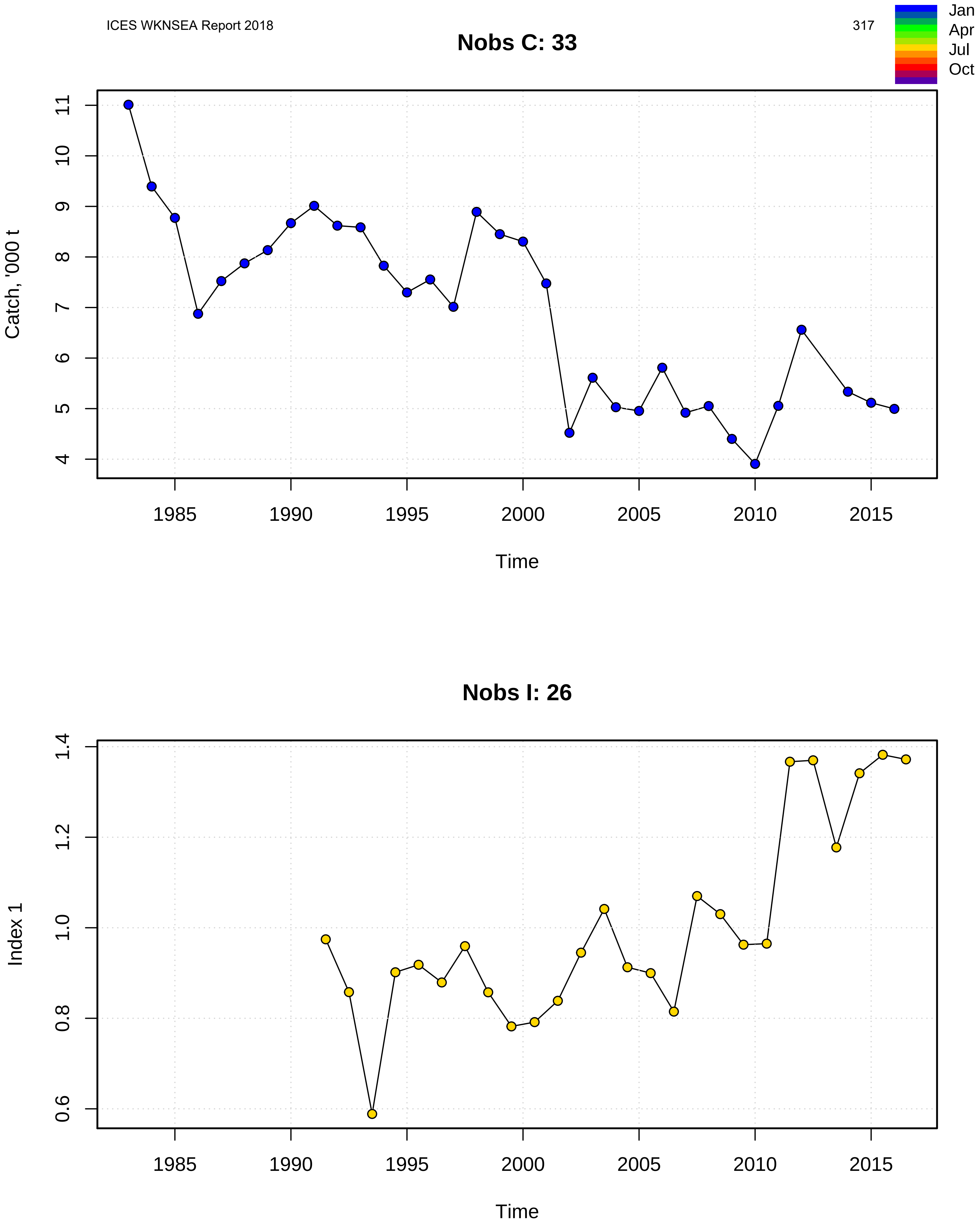
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

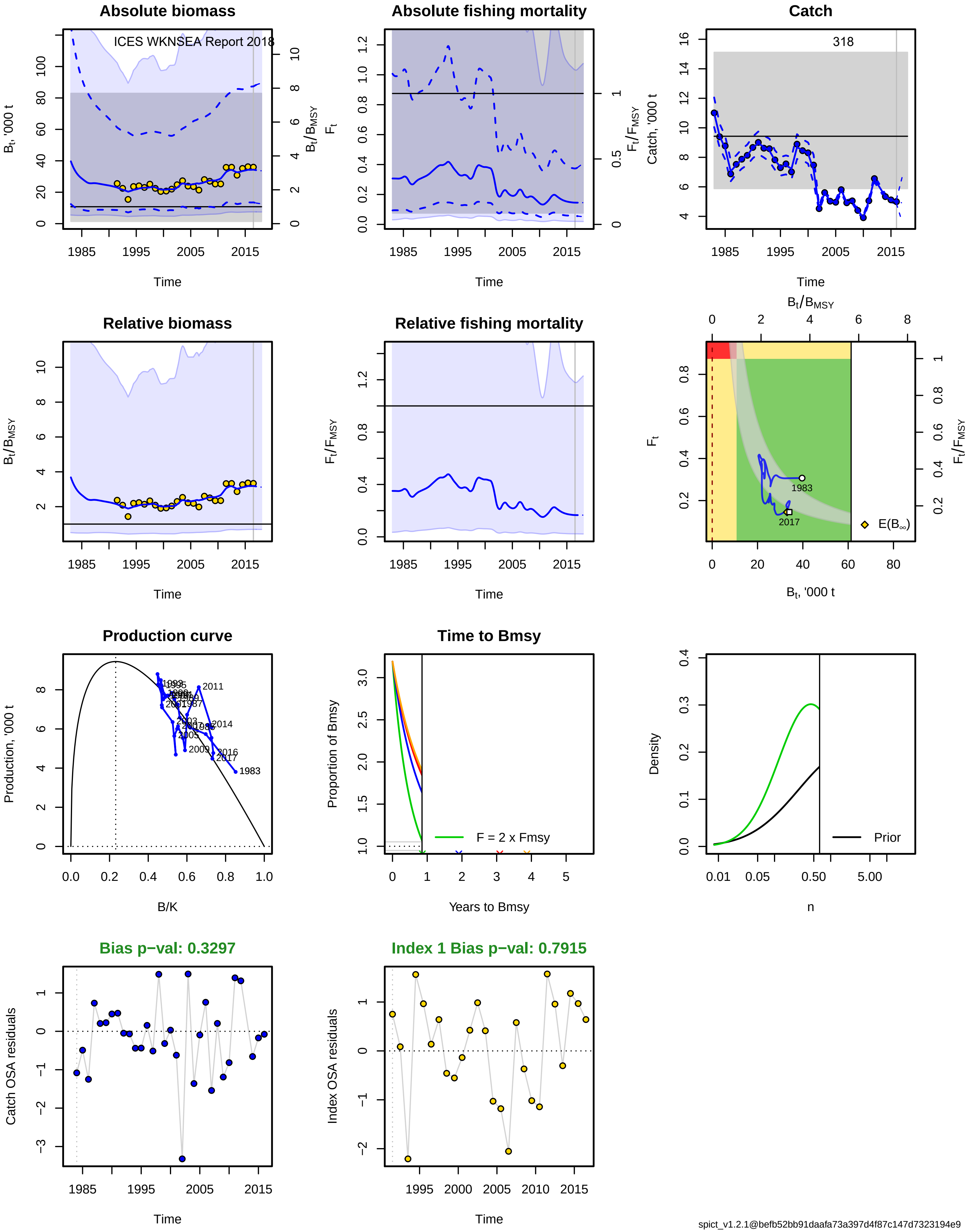

Absolute biomass
ICES WKNSEA Report 2018
Absolute fishing mortality
Catch
314
Relative biomass
Relative fishing mortality
Production curve
Time to Bmsy
F = 2 x Fmsy
E(B∞)
Prior
Bias p−val: 0.2406
Index 1 Bias p−val: 0.9916
Time
Years to Bmsy
B/K
n
Density
Production, '000 t
Proportion of Bmsy
Catch OSA residuals
Index OSA residuals
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9

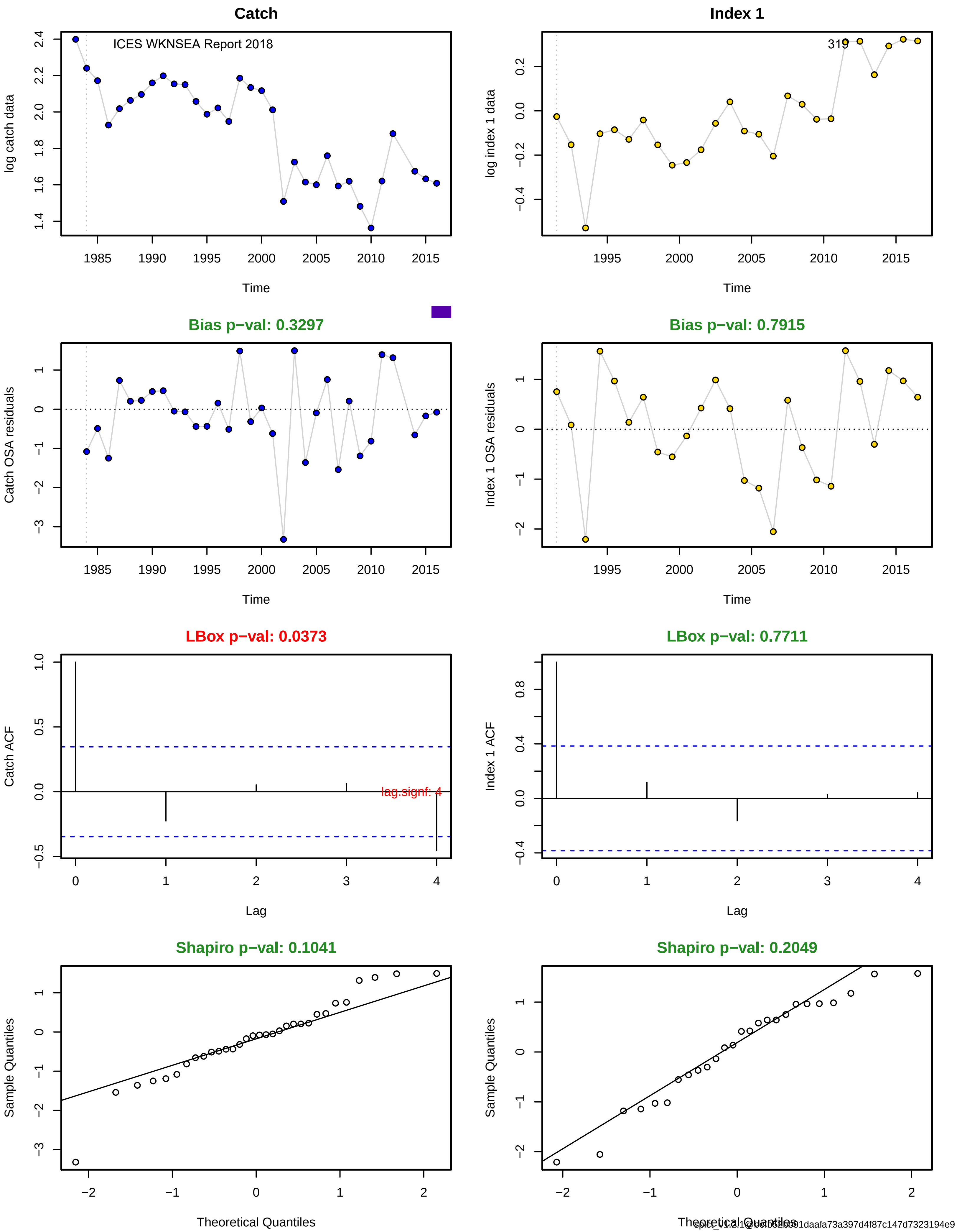

Catch
log catch data
Time
Index 1
log index 1 data
Time
Bias p−val: 0.2406
Catch OSA residuals
Time
Bias p−val: 0.9916
Index 1 OSA residuals
Time
LBox p−val: 0.0266
Catch ACF
lag.signf: 4
Lag
LBox p−val: 0.6138
Index 1 ACF
Lag
Shapiro p−val: 0.0113
Sample Quantiles
Theoretical Quantiles
Shapiro p−val: 0.5382
Sample Quantiles
Theoretical Quantiles



spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9


Jan
Apr
Jul
Oct
Nobs C: 33
Catch, '000 t
Time
Nobs I: 26
Index 1


Absolute biomass
Absolute fishing mortality
Catch
318
Relative biomass
Relative fishing mortality
1983
2017
E(B∞)
Production curve
Time to Bmsy
F = 2 x Fmsy
Prior
Bias p−val: 0.3297
Index 1 Bias p−val: 0.7915
Time
B/K
Years to Bmsy
Proportion of Bmsy
Production, '000 t
Density
n
Catch OSA residuals
Index OSA residuals
spict_v1.2.1@befb52bb91daafa73a397d4f87c147d7323194e9


Catch
log catch data
Time
Index 1
log index 1 data
319
Time
Bias p−val: 0.3297
Catch OSA residuals
Time
Bias p−val: 0.7915
Index 1 OSA residuals
Time
LBox p−val: 0.0373
Catch ACF
lag.signf: 4
Lag
LBox p−val: 0.7711
Index 1 ACF
Lag
Shapiro p−val: 0.1041
Sample Quantiles
Theoretical Quantiles
Shapiro p−val: 0.2049
Sample Quantiles
Theoretical Quantiles
spict_v1.2.1@b6f0525591daafa73a397d4f87c147d7323194e9

Annex 7: Whiting working documents

In the following pages, the working documents on whiting available at WKNSEA 2018 are inserted.

WD 1 Literature review and discussion ...	14/02/2018 13:06	Microsoft Word D...	537 KB
WD 2 Intercatch raising whg.27.47d.do...	23/03/2018 18:32	Microsoft Word D...	3,734 KB
WD 3 Natural mortality whg.27.47d.do...	23/03/2018 18:32	Microsoft Word D...	251 KB
WD 4 Maturity whg.27.47d.docx	27/03/2018 16:39	Microsoft Word D...	1,306 KB
WD 5 Survey indices whg.27.47d.docx	23/03/2018 18:40	Microsoft Word D...	4,715 KB
WD 6 Stock weight at age whg.27.47d....	23/03/2018 18:40	Microsoft Word D...	634 KB
WD 7 SAM whg.27.47d.docx	23/03/2018 18:40	Microsoft Word D...	2,176 KB
WD 8 SURBAR whg.27.47d.docx	23/03/2018 18:41	Microsoft Word D...	275 KB
WD 9 XSA assessment whg.27.47d.docx	23/03/2018 18:41	Microsoft Word D...	298 KB
WD 10 Whiting_Ref points.docx	14/03/2018 14:15	Microsoft Word D...	1,445 KB
WHG 2747d_biological parameters.ppt	25/01/2018 18:54	Microsoft PowerP...	3,577 KB
WHG 2747d_Intercatch raising.ppt	22/01/2018 18:30	Microsoft PowerP...	6,059 KB

WD 1 Literature review of North Sea whiting stock identity

Tanja Miethe, Peter Wright

Marine Scotland Science, 375 Victoria Road, Aberdeen AB11 9DB, UK

1.1. Introduction

Advice for North Sea whiting is given based on an assessment of ICES Subdivision 4 and Division 7d combined. The TAC is then set for Subdivision 4 separately, and for Division 7d in combination with Division 7b-k. The mismatch between assessment and management units can be further complicated by an additional mismatch with the population units (Reiss *et al.*, 2009). For North Sea whiting, literature suggests that neither current assessment nor management units adequately reflect the underlying population structure. Whiting is characterized by an extended spawning period and long pelagic larval phase, which could potentially facilitate dispersal and gene flow (Hislop and Hall, 1974; Charrier *et al.*, 2007; Tobin *et al.*, 2010; Eiríksson and Árnason, 2014). An extended spawning period (>10 weeks) could allow for migrations between spawning units and diverse environmental conditions at egg release. The longer pelagic larval phase, which extends beyond the typical period observed for gadoids, young individuals settle only when reaching 5-10 cm size, could allow for wider passive dispersal away from spawning grounds before settlement (Charrier *et al.*, 2007). The dispersal at the larval, juvenile and adult stage may however be limited by hydrography. The Dogger Bank, along the 50m depth contour, has been repeatedly suggested to act as a natural barrier separating a northern and a southern subpopulation (Hislop and MacKenzie, 1976; Pilcher *et al.*, 1989; De Castro *et al.*, 2013; Holmes *et al.*, 2014). The Dogger Bank is a shallow region in the Central North Sea and represents the boundary of deeper (50-200m) thermally stratified waters influenced from the North Atlantic current in the northern North Sea from the southern North Sea (Reid *et al.*, 1988; Nielsen *et al.*, 1993). The southern North Sea is shallow (<30m) and isothermal throughout the year with water influenced by currents from the English Channel.

A complex population structure for whiting in the North Sea has been proposed repeatedly based on studies about whiting movements using tag-recapture studies, otolith chemistry, and parasite infection levels (Hislop and MacKenzie, 1976; Pilcher *et al.*, 1989; Tobin *et al.*, 2010), spatial differences in life history traits such fecundity and growth (Hislop and Hall, 1974; Barrios *et al.*, 2017), genetic data (Rico *et al.*, 1997; Charrier *et al.*, 2007), identification of spawning aggregation areas (González-Irusta and Wright, 2017; Höffle *et al.*, 2017), and population temporal asynchrony observed in SSB, recruitment and egg abundance between areas (Loots *et al.*, 2010; De Castro *et al.*, 2013; Holmes *et al.*, 2014).

1.2. Restricted movement

The degree of dispersal due to movements and migrations at various life stages, determines the potential for gene flow. Hislop and MacKenzie (1976) conducted tagging studies in the northern North Sea between 1964 and 1972. Whiting was tagged in each year at various times (March-December) and locations (East Coast of Scotland, Orkney and Shetland). Whiting tagged nearshore were mostly also recaptured close to the shore and showed lower rates of parasite infections. Longer migrations (suggested to be spawning migrations) were observed for whiting tagged offshore and near Shetland. Throughout the study period none of the tagged whiting from the northern North Sea were recaptured south of the Dogger Bank. In total only 10% of tagged released whiting were reportedly recaptured. By analysing otolith microchemistry juvenile dispersal in whiting was found to occur around the Scottish coast connecting spawning aggregations west of Scotland with the North Sea (Tobin *et al.*, 2010). Analysing tag-recapture data (1958-1980), adult movement was found to range from 53 to 123 km, and no exchange between North Sea and west of Scotland was observed (Tobin *et al.*, 2010).

Different levels of parasite infestation can give information on the host population ecology and environment and have been used to infer population structure of the host (Shotter, 1973; Mackenzie and Hemmingsen, 2015). Ectoparasite infestation in whiting was investigated using samples from 36 stations in the North Sea on two surveys in August 1985 and February 1986 (Pilcher *et al.*, 1989). A latitudinal cline was identified, with infestation differing in the southern and northern North Sea separated by 56°N latitude (Pilcher *et al.*, 1989). Lang (1990) investigated whiting ectoparasite infestation during 5 research cruises in the North Sea taking place in summer and/or winter 1988-1990 in 14 different sampling locations. Differences in abundance and species of parasites were found in whiting from northern and southern North Sea supporting previous analysis by Pilcher *et al.* (1989). Reasons for different infestation levels in the northern and southern North Sea were suggested, such as hydrographic factors (bottom temperature, salinity level), whiting migration patterns and the availability of intermediate hosts (Pilcher *et al.*, 1989; Lang, 1990).

1.3. Genetic evidence for stock separation

Rico *et al.* (1997) analysed genetic samples of two sampling locations in the North Sea (50-87 individuals each) taken in November 1992. The northern North Sea sampling took place near Shetland, and samples from the southern North Sea originated off the Dutch Coast. Sequencing and analysing two selected DNA microsatellite loci, the samples from southern and northern North Sea showed significant genetic differentiation. Also, Charrier *et al.* (2007) identified significant genetic structure in the North Sea by analysing DNA microsatellite data from four different sampling locations within the North Sea (45-50 individuals each). Samples were taken from mature adults during the spawning period (February 2002) and 7 microsatellite loci selected for analysis. Data suggests that sampled individuals originating from Skarvöyni (south Norway) and the Dogger Bank grouped together, and could be separated from southern samples both at Flamborough Head and the Southern Bight. In contrast, whiting from the west of the British Isles appear not to be differentiated from northern North Sea samples (Charrier *et al.*, 2007). Hydrography affecting larval retention and homing behaviour of adults (natal or learned) were suggested to explain the genetic differences pointing to restricted gene flow between spawning units.

1.4. Differences in life history characteristics

Hislop and Hall (1974) analysed fecundity of whiting from ovary samples (30-126 individuals per year) taken in the northern and southern North Sea in 1964-1969 in March/April. Whiting from the southern North Sea were found to be more fecund at length, but less fecund at age than whiting from samples in the northern North Sea. The exact location where samples originated from was not mentioned in the paper. Analysis of individual growth trajectories based on data of IBTS Q1 survey support the stock split into northern and southern North Sea stocks based on population level growth data of 2005-2012 (Barrios *et al.*, 2017). Individuals in the northern North Sea grow to larger asymptotic sizes than in the southern North Sea.

1.5. Population asynchrony

Subpopulations are expected to differ in SSB and recruitment trends over time, in particular when respective environmental conditions differ and connectivity is low. The abundance of spawning whiting in the North Sea was analysed using IBTS Q1 data by Loots *et al.* (2010), De Castro *et al.* (2013) and Holmes *et al.* (2014). Loots *et al.* (2010) used IBTS data for 1980-2007 and identified two areas of high spawner abundance north and south of the Dogger Bank. Changes over time in spawning stock biomass in the entire North Sea could be related to asynchronous changes in abundance of either southern or northern component. It was pointed out that the IBTS Q1 survey only covered the beginning of the spawning period and may be missing spawners in particular in the northern North Sea, where spawning occurs later than in the South (Loots *et al.*, 2010). Whiting showed high spawning site fidelity which can be linked to geographical and environmental factors (Loots *et al.*, 2011).

De Castro *et al.* (2013) and Holmes *et al.* (2014) found significant differences in SSB as well as recruitment trends in the southern and northern North Sea, based on IBTS Q1 survey data from 1986-2011. The asynchrony in temporal dynamics were evident in SSB and less clear in recruitment (De Castro *et al.*, 2013). The boundary between northern and southern subpopulations may be associated with North Sea hydrography. Spatial analysis of abundance data together with previous results from literature were used to define subpopulation boundaries illustrated in Figure 1 (Holmes *et al.*, 2014). González-Irusta and Wright (2017) used the IBTS quarter 1 survey for 2005-2015 to represent abundance of mature whiting during the spawning period and related the abundance to hydrographic variables (springtide, current velocity, temperature, salinity, depth) rather than spawning site fidelity. Locations of whiting spawning aggregations were characterized by strong tidal currents potentially facilitating offspring dispersal.

IBTS Q1 survey together with additional ichthyoplankton surveys of egg abundance conducted in 2004 and 2009 were used to map whiting egg abundance in the North Sea (Höffle *et al.*, 2017). Previously identified areas of high spawner abundance overlapped with high egg abundance consistent with the previously identified subpopulation structure of northern and southern component (González-Irusta and Wright, 2017; Höffle *et al.*, 2017).

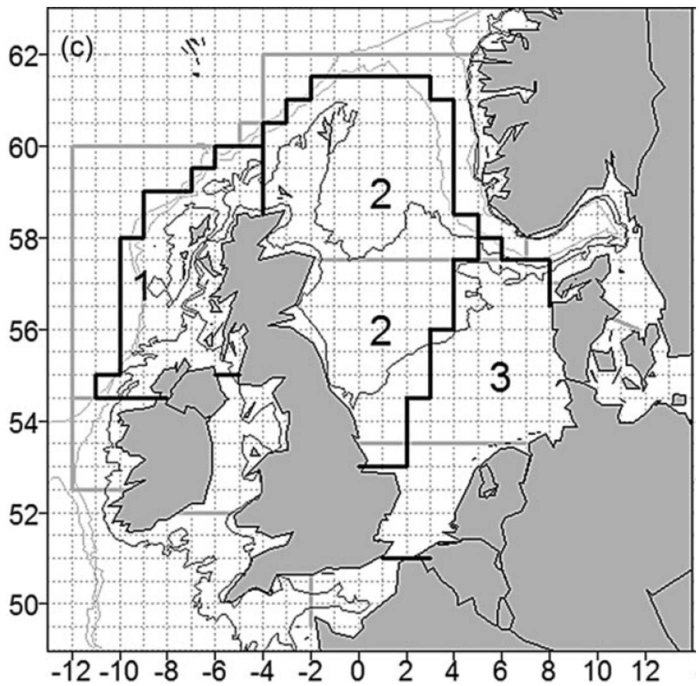


Figure 1. Subpopulation structure as presented by Holmes *et al.* (2014).

1.6. Discussion and Conclusion

The published studies confirm to some degree a split of northern and southern subpopulations. The evidence relate to spatial abundance of individuals during the spawning season. Often the only source of information is the North Sea IBTS quarter 1 survey (Loots *et al.*, 2010; De Castro *et al.*, 2013; Holmes *et al.*, 2014; Barrios *et al.*, 2017). If spatially distinct nursery grounds and spawning areas for the two subpopulations can be defined during the survey period, it remains to be assessed whether the split into spawning units continues throughout the spawning period as well as the rest of the year and is stable over time (Reiss *et al.*, 2009). Tag-recapture studies and analysis of parasite infection give indication that the stock separation may be continuous during the year (Hislop and MacKenzie, 1976; Pilcher *et al.*, 1989; Lang, 1990). There is still a need for more extensive sampling design (spatially and temporally) covering the North Sea, replicated over time (Charrier *et al.*, 2007). A combination evaluation of phenotypical traits (maturity, parasite, otolith chemistry) and genetic analysis can give more insight into population structure and confirming the spatial location of the boundary between subpopulations in the North Sea (and also Channel, Kattegat).

A continuous split into separate populations is expected to manifest itself in genetic differences in whiting caught in the northern and southern North Sea year round. Evidence of genetic differentiation based on micro-satellite DNA is suggesting a multi-generational isolation of northern and southern populations/subpopulations (Rico *et al.*, 1997; Charrier *et al.*, 2007). Nevertheless, in both these studies, the levels of diversity were found to be very low, no clear pattern was observed and the results were confounded by the use of microsatellites that deviated significantly from Hardy Weinberg equilibria. Given the large census population sizes and the potential for some exchange through larval drift and adult movements any genetic divergence among spawning aggregations is expected to be low and probably will require more sensitive genetic markers such as SNPs. Published studies relied on genetic data from a few sampling locations, with samples taken during or early in the spawning period (Rico *et al.*, 1997; Charrier *et al.*, 2007). Even if these studies suggest separate spawning units, they still do not confirm a stable spatial subpopulation separation during the rest of the year. Whiting dispersing between areas during the rest of the year would limit the potential of using spatially structured catch data.

Biophysical models may be used to predict the extent of larval transport in the North Sea knowing the locations of spawning areas. Otolith chemistry and non-genetic tags may be helpful to further investigate movement of older whiting stages.

Failure to take into account population structure can lead to overfishing of some components and reduction of genetic diversity. In the current situation, a split in stock units may not improve stock management if area-specific TAC cannot be not given. Currently, there is a mismatch between assessment area and advice for area 7d. Assessment is done together with area 4, while advice is given together with areas 7b-k. If assessment for the northern and southern component are done separately the TAC is combined, asynchronous dynamics may still lead to overexploitation of one component. In recent years, North Sea whiting received a roll-over TAC ignoring scientific advice for a TAC reduction. However, a separate assessment may highlight dynamics of both areas, which could then be considered when deciding on the TAC.

An area-specific stock assessment would require considerable effort to provide a historical series of national catch data with age samples for the northern and southern North Sea, separately. Previously, such data could not be provided to revise management units to account for stock structures (ICES, 2005). Also for the most recent data call in 2017, new data submissions delivered (from 2002 onwards). A complete data set including sufficient age and discard samples was available for 2009-2016 to update the catch time series. Provision of a historic catch data series at a different aggregation level would require additional workload, and could potentially be provided in the long-term rather than in the timeframe of a data call deadline. A survey index would need to be developed for both quarter 1 and 3 NS IBTS surveys for northern and southern component, separately (DATRAS request to ICES, data provided see additional WD 6). Holmes *et al.* (2014) developed a SSB index using DATRAS NS IBTS data for quarter 1 to compare dynamics in the northern and southern component early in the spawning period. An index including both quarter 1 and quarter 3 survey may improve the information on annual stock dynamics.

Considering the evidence from literature, current management and the workload connected to a split assessment input data, the issue of stock identity is not included in the 2018 benchmark. This conclusion is similar as in 2005 by (ICES, 2005), even though additional literature was published since confirming a stock separation. It is recommended that the stock identity issue should be revisited in the future when further evidence for a continuous split of subpopulations in the North Sea are presented, appropriate historic catch data can be provided and management structures are in place to support a stock specific quota following a stock-specific assessment and advice.

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WD 2 Preparation of catch data (Intercatch) for whiting in area 4 and 7d

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Following the data call in October 2017 to support the ICES Benchmark Workshop for North Sea stocks (WKNSEA), landings, discards, sample information and effort data were provided by data co-ordinators from nations with significant whiting catches. The data was imported into InterCatch (disaggregated by quarter, area, and métier) for 2002–2016.

Although Intercatch was previously used to estimate catch data, calculation were redone following the new data submissions and new stratification design. The landings, discard and industrial bycatch (IBC) and the respective age compositions were estimated using Intercatch. Discard rates and age compositions for unsampled strata were allocated according to stratification detailed in the following.

Official landings of whiting in area 4 and 7d by country are listed in Table 2 and Table 1, respectively. Major landings in area 4 originated from the UK (Scotland, England) and in area 7d from France.

Following the data call, countries submitted data landings (L), discards (D) as summarized below (brackets if submissions differed between years):

- L: NO, SWE, BE (2003), NL (2002-2010), **UK-S (2002-2008)**
- L + D: GER, BE (2014-16), NL (2011-16)
- L + D, age samples (L): **UK-E (2002-2015)**
- L + D, age samples (D): DK
- L + D, age samples (L, D): **FR**, **UK-E (2016), UK-S (2009-2016)**, BE (2004-13)

Landing weights were submitted by all required countries for the entire time period. Discard data and age samples from the French fleet, dominating catches in area 7d, were submitted for the entire period. However, for the Scottish fleet, dominant in area 4, no discard information or age samples could be provided for 2002-2008. Therefore, catch data was re-raised in Intercatch only for the period 2009-2016 where sufficient data on landings, discards as well as age samples from countries with major catches in areas 4 and 7d are available in Intercatch.

Since 2015, some landings below minimum landing size were reported as an extra category (BMS landing). For age allocations and export of data, BMS landing were combined with discards (unwanted catch).

Imported landings and discards into Intercatch are listed by country in Table 3 and Table 4 and plotted in Figure 1 and Figure 2, respectively.

The catch estimation in Intercatch involved a three step process, (i) discard allocation, (ii) age allocation and (iii) export of data by catch category and area. Age samples were allocated for landings, discards/BMS and IBC, separately. There was no stratification by area due to limited number of samples from area 7d.

i. Discard allocation:

Discards were automatically matched to landings by country, area, quarter and métier. Submitted annual discards were then manually matched to the respective available quarterly landings by country, area and fleet. Only matched landings and discards were used to estimate discard-landings ratios, to estimate discards for landings without provided discards. A stratification design was applied by quarter and gear type following data evaluations detailed in section 1.

Area 27.4 and 27.7d combined:
(a) stratification for gear types (TR1, TR2) and quarter (1, 2, 3, 4)
(b) MIS_MIS_0_0_0_IBC: no raising of discards
(c) rest raised all with all by quarter (1, 2, 3, 4) (no stratification by gear)
Weighting: Landings CATON

ii. Age allocation

Landings age allocation:
Age samples of landings were allocated to human consumption landings. The choice of stratification designed is detailed in section 2.

Area 27.4 and 27.7d combined:
(a) stratification for gear types (TR1, TR2) and half year (quarters 1,2 and quarters 3,4 together)

If landing are submitted annually for TR1 and TR2 raise per gear type with all quarters combined.

(b) rest all with all (no stratification by gear or quarter)

Weighting: CATON

IBC age allocation:

There are no age samples submitted for IBC landing. IBC age allocations was done using samples of all catches (complete sampling data).

Area 27.4 and 24.7d combined:

(a) raise with all with all (no stratification by gear or quarter)

Weighting: CATON

Discard and BMS age allocation:

Discard age samples were allocated for discards and BMS landings.

Area 27.4 and 27.7d combined:

(a) stratification for some gear types (TR1 only) and per half year (quarter 1,2 and quarter 3,4)

(b) annual TR1 with all TR1

(c) rest including TR2 with all (no stratification by gear, quarter)

Weighting: CATON

Gear stratification was used for TR1 and TR2, other gear types were grouped together for raising.

TR1 bottom trawls and seines (OTB, OTT, PTB, SDN, SSC, SPR) =>100mm

TR2 bottom trawls and seines (OTB, OTT, PTB, SDN, SSC, SPR) 70-100mm

iii. Export

Data was exported for the whole assessment area combined and for area 4 and 7d, separately. CATON, CANUM and WECA files were used to update the catch time series. Industrial bycatch (IBC) only occurred in area 4 and could be exported separately. Exported landings however included IBC as well as human consumption landings. The export of human consumption landings on its own did not deliver the correct numbers found in the CatchAndSampleDataTables file. Instead, human consumption landings were retrieved by subtracting IBC from total landings (CATON and CANUM values). Individual catch weights at age were used for IBC.

1. Discard raising

1.1. Discard raising by gear type, by quarter

The most important métiers were identified according to landed weight per year (Table 5). In recent years, whiting landings of TR1 gear types have increased, while landings of TR2 decreased. IBC landings of whiting have been increasing in recent years. Discard rates are higher for TR2 gears as compared to TR1 (Table 6). Discard rate is here defined as the proportion of the catch discarded. A stratification for discard raising by gear type (TR1 and TR2) is therefore recommended. Landings of beam trawlers (TBB) are typically low, but can be associated with high discard rates. However, there is a high variability in landing weight and discard rates for beam trawl metiérs, while the mean discard rate is close to 1 (Table 6). When discard rates are allocated for beam trawlers separately, very high discard rates may be allocated to high landings, for example in 2014 (Table 7). In 2015, we find it is possible that beam trawl fleets have zero imported discards, in particular when whiting landings from this fleet were high (TBB_CRU_16-31_0_0_all, Table 8). This may lead to bias of discard from this fleet when incorrectly high discards area allocated to high landings. Therefore, discard rates for beam trawls were allocated using discard rates of all other fleets combined.

Industrial bycatch was imported to Intercatch without discards and no discard raising was applied.

To evaluate whether discards should be raised by quarter, the quarterly discard rates per year and métier were calculated (Table 9). Discard rates in several years are higher in quarter 4 for TR1. For TR2, discard rates can also be high in quarter 1. There is some annual variability, both TR1 and TR2 discard rates vary between quarters. This is can be due to fisheries behaviour depending on quota uptake, changing catchabilities depending on season due to fish behaviours (spawning aggregation, migration, etc.). The difference between quarterly discard rates and annual discard rates per métier are calculated to evaluate the effect of ignoring quarter in the stratification design on estimated discard rates (Table 10). For the main TR1 gears, ignoring quarter has on average little effect on discard rate, but could underestimate or overestimate discards in single years. In contrast, for the main TR2 gears ignoring quarter would mostly overestimate discards. As a conclusion, discards will be raised by both gear type (TR1 and TR2) and by quarter.

The discard raising procedures were tested for the year 2016, using old data and newly submitted data (Table 11). Stratifying by gear type alone leads to higher discards in area 7d, which is dominated by TR2 gears, with both old and new Intercatch data. However, stratification by quarter as well as gear brings discards back to the level without any stratification. The discards change in area 4 and 7 in opposite directions, due to the difference in dominating gear types. With stratification by gear and quarter, the discard estimates for TR2 decrease and slightly increases for TR1, as anticipated. As the proportion of TR1 and TR2 gears in the fishery and area may change over time and quarter, a stratification including both gear and quarter is applied. In 2009, stratification by gear and quarter reduced the discards in both are 4 and 7d (Table 12).

2. Age allocations

Age distributions in samples differ between landings and discards of various gear types. Age samples are allocated for landings and discards separately using the respective sampled age distributions. Discard age distributions are allocated to BMS landings as well. There are no available age samples for IBC, and age allocations are done using all available age distributions (landings and discards). As examples, age distributions for landings and discards are presented for TR1 and TR2 in the years 2009 and 2016 (Figure 3-9). In catches of TR1 gears in 2009 and 2016, more older and less young individuals were observed in the first half of the year (quarter 1 and 2) as compared to the second half (Figure 3, Figure 4). The higher numbers of old individuals coincide with the spawning period when fisheries can target spawning aggregations. For TR2 gears show a similar seasonality in landings (Figure 5, Figure 7). There are generally less age samples for discards available and there is less seasonality in the shape of the age distributions.

Generally only few age distribution samples available for beam trawls landings and discards (Figure 8, Figure 9). Therefore, ages were allocated using all age samples.

Catch numbers at age are similar across discard raising scenarios, as we have raised age samples without any stratification (Table 13). When raising age samples, separately for landings and discards (Scenario 1, final), we observe a slight reduction in old individuals and an increase in individuals aged 0-2. The same pattern can be observed for the year 2009 (scenario final, Table 14). Following the new data submission in 2017, we find higher numbers of age 0 (in 2016) and higher numbers of age 0 and 1 fish (in 2009) in the estimated catch data, which appears to be independent of the stratification design (discard raising or age allocation). In 2009, also the numbers of age 5+ individuals increased significantly, also observed in other years (Table 14, Table 15, Table 16). Old data used in the assessment up to 2017 is listed in Table 15 and the newly raised data set from newly submitted data for 2009 – 2016 in Table 16.

The change in numbers at age 0-2 as well as 5+ is observed in both areas 4 and 7d. The change in young individuals occurred mainly in discards and IBC. Increased numbers of 5+ individuals can be observed in all catch categories. There have been new data submissions to Intercatch which can explain the change in numbers at young and old age.

For example for 2016, discards for age 0 went up substantially. This can be due to new data submissions for Denmark with higher numbers of age 0 individuals for sampled TR2 and BT gears, which contribute largely to discards (Table 19, Table 22).

In 2009, with new data submissions there was an increase in age 0 and 1 individuals as well as 5+. New French submission for landings and discards (Table 20, Table 21) can explain the increase in the number of young individuals in the discards and older individuals in the landings.

TR1, TR2 and other gears show relatively high numbers of age 5+ individuals in the landing samples (Table 23). The higher number of age 0 and 1 individuals relative to age 2 in the discards is due to new data for TR2 and other gears (Table 24).

Weights of catch categories are plotted in Figure 10 for the new data. The proportions discarded at age are plotted for the new data set in Figure 11. Mean individual weights at age in the catch are listed in Table 17 for the old data and Table 18 for the new data are plotted for catch categories in Figure 12.

3. Tables

Table 1. Official landings by country, whiting in area 4 (in tonnes).

Country	2009	2010	2011	2012	2013	2014	2015	2016
BE_4	162	147	74	45	33	46	70	65
DK_4	79	158	135	131	124	160	2375	208
Faroes_4	2	0	0	0	0	0	0	8
FR_4	**2305**	**2644**	**2794**	**1925**	**942**	**1884**	**1131**	**1232**
GER_4	124	156	111	25	44	31	73	0
NL_4	718	614	514	471	495	464	581	644
NO_4	73	118	28	94	560	918	1088	1148
SWE_4	4	8	6	4	1	2	0	6
UK_4	**8853**	**7845**	**8892**	**9893**	**11162**	**10290**	**10015**	**9406**
Total_4	12320	11690	12554	12588	13361	13795	15333	12717

Table 2. Official landings by country, whiting in area 7d (in tonnes).

Country	2009	2010	2011	2012	2013	2014	2015	2016
BE_7d	71	88	78	66	95	90	121	144
FR_7d	**6248**	**5512**	**4833**	**3093**	**3076**	**2126**	**3102**	**2771**
NL_7d	112	275	282	437	650	663	565	557
UK_7d	138	258	271	261	472	345	379	259
Total_7d	6569	6133	5464	3857	4293	3224	4167	3731

Table 3. Whiting in area 4 and 7d. Imported landing (landings and IBC) weights into Intercatch by country (in tonnes).

Country	2009	2010	2011	2012	2013	2014	2015	2016
BE	208	238	153	111	128	135	192	209
DK	1452	1910	1205	1215	1699	1721	2255	4678
FR	8515	8011	8054	5115	3981	3998	4234	3967
GER	124	155	111	25	44	31	73	152
NL	891	973	1151	1728	1156	1132	1116	1165
NO	73	117	28	94	561	914	1088	600
SWE	4	18	6	4	1	2	5	6
UK (EW)	1366	1196	1193	1444	1609	1416	1442	1024
UK(S)	7574	6822	7820	8644	10037	9188	8947	8613
Total	20207	19440	19720	18379	19215	18537	19351	20414

Table 4. Whiting in area 4 and 7d. Imported discard weights into Intercatch by country (in tonnes).

Country	2009	2010	2011	2012	2013	2014	2015	2016
BE	323	250	448	120	199	206	507	196
DK	485	133	72	56	83	31	115	166
FR	2440	4264	2560	1341	1112	1615	2256	1766
GER	262	293	246	28	15	22	319	266
NL	0	0	1559	1474	730	918	2984	1326
UK (EW)	1450	1481	734	1646	932	1261	1091	1403
UK(S)	2874	4924	3721	1789	1528	2797	3490	4529
Total	7833	11345	9339	6454	4599	6851	10761	9651

Table 5. Whiting in area 4 and 7d. Landing weight per gear, type TR 1 and TR 2 (in tonnes).

Fleet	2009	2010	2011	2012	2013	2014	2015	2016
OTB_DEF_>=120_0_0_all	6794	5717	6696	7811	8874	9112	8771	8312
OTB_DEF_>=120_0_0_all_FDF	0	412	106	89	1041	774	1400	0
OTB_CRU_70-99_0_0_all	2004	1643	2062	1843	1603	945	666	479
OTB_DEF_70-99_0_0	7939	7335	7265	4570	3498	2934	3464	3156
OTB_DEF_70-99_0_0_all	543	576	343	328	329	409	401	170
TBB_CRU_16-31_0_0_all	46	38	5	7	2	2	23	30
TBB_DEF_70-99_0_0_all	500	489	473	576	302	248	298	306
MIS_MIS_0_0_0_IBC	1373	1752	1087	1113	1608	1656	2156	4534

Table 6. Whiting in area 4 and 7d. Discard rates (proportion of catch discarded) per métier.

Fleet	2009	2010	2011	2012	2013	2014	2015	2016	Mean
OTB_DEF_>=120_0_0_all	0.18	0.34	0.36	0.25	0.28	0.39	0.22	0.26	0.29
OTB_DEF_>=120_0_0_all_FDF	0	0.33	0.07	0.09	0.25	0.51	0.3	0.12	0.24
OTB_CRU_70-99_0_0_all	0.66	0.72	0.82	0.75	0.62	0.83	0.74	0.73	0.73
OTB_DEF_70-99_0_0	0.24	0.38	0.3	0.28	0.25	0.37	0.45	0.31	0.32
OTB_DEF_70-99_0_0_all	0.26	0.42	0.55	0.55	0.59	0.35	0.48	0.74	0.49
TBB_DEF_70-99_0_0_all	0.78	0.78	0.91	0.84	0.85	0.9	0.92	0.77	0.84
TBB_CRU_16-31_0_0_all	1	1	1	1	1	1	1	0.41	0.93

Table 7. Whiting in area 4 and 7d. Discard rate for beam trawl gears 2014 (weights in kg)

Fleet	Country	Area	Discard Weight Imported	LandWt	DisWt	Discard rate
TBB_DEF_70-99_0_0_all	NL	27.4	TRUE	176699	776492.8	0.815
	BE	27.7.d	TRUE	45621	146722	0.763
	BE	27.4.c	TRUE	11962	38471	0.763
	BE	27.4.b	TRUE	6519	20966	0.763
	UK (E)	27.4	**FALSE**	4502	0	0
	UK (E)	27.7.d	**FALSE**	1617	0	0
	GER	27.4	TRUE	944	8587	0.901
	UK (E)	27.7.d	TRUE	515	3142	0.859
TBB_CRU_16-31_0_0_all	NL	27.4	**FALSE**	1352	0	0
	BE	27.4.c	**FALSE**	481	0	0
	DK	27.4	TRUE	0	15066	1
	UK (E)	27.4	TRUE	0	19050	1

Table 8. Whiting in area 4 and 7d. Discard rate for beam trawl gears 2015 (weights in kg).

Fleet	Country	Area	Discard Weight Imported	LandWt	DisWt	Discard rate
TBB_DEF_70-99_0_0_all	NL	27.4	TRUE	186912	1110251	0.856
	BE	27.7.d	TRUE	68211	345791	0.835
	BE	27.4.c	TRUE	18073	91620	0.835
	BE	27.4.b	TRUE	13570	68791	0.835
	UK (E)	27.4	TRUE	5884	0	0
	GER	27.4	TRUE	4645	29775	0.865
	UK (E)	27.7.d	TRUE	714	0	0
TBB_CRU_16-31_0_0_all	NL	27.4	TRUE	16363	0	0
	BE	27.4.c	TRUE	6498	0	0
	DK	27.4	TRUE	0	71072	1
	UK (E)	27.4	TRUE	0	103158	1

Table 9. Whiting in area 4 and 7d. Quarterly discard rate and average for the time series.

Q	Fleet	2009	2010	2011	2012	2013	2014	2015	2016	Mean
1	OTB_DEF_>=120_0_0_all	0.11	0.38	0.39	0.09	0.36	0.64	0.23	0.24	0.31
2	OTB_DEF_>=120_0_0_all	0.13	0.18	0.22	0.33	0.42	0.57	0.18	0.16	0.27
3	OTB_DEF_>=120_0_0_all	0.13	0.21	0.28	0.23	0.11	0.46	0.25	0.33	0.25
4	OTB_DEF_>=120_0_0_all	0.38	0.52	0.38	0.35	0.00	0.41	0.19	0.32	0.32
1	OTB_DEF_>=120_0_0_all_FDF	NA	0.10	0.00	0.00	0.02	0.33	0.00	0.02	0.07
2	OTB_DEF_>=120_0_0_all_FDF	NA	0.50	0.24	0.14	0.30	0.21	0.92	0.01	0.33
3	OTB_DEF_>=120_0_0_all_FDF	NA	0.57	0.00	0.01	0.11	0.15	0.17	0.11	0.16
4	OTB_DEF_>=120_0_0_all_FDF	NA	0.45	0.00	0.15	0.01	0.12	0.30	0.02	0.15
1	OTB_CRU_70-99_0_0_all	0.57	0.48	0.35	0.85	0.55	0.79	0.72	0.49	0.60
2	OTB_CRU_70-99_0_0_all	0.54	0.32	0.36	0.63	0.38	0.48	0.21	0.87	0.47
3	OTB_CRU_70-99_0_0_all	0.61	0.51	0.48	0.51	0.12	0.66	0.39	0.65	0.49
4	OTB_CRU_70-99_0_0_all	0.84	0.91	0.49	0.57	0.56	0.63	0.57	0.57	0.64
1	OTB_DEF_70-99_0_0	0.24	0.06	0.12	0.29	0.31	0.35	0.26	0.19	0.23
2	OTB_DEF_70-99_0_0	0.38	0.53	0.43	0.28	0.33	0.37	0.68	0.40	0.43
3	OTB_DEF_70-99_0_0	0.09	0.32	0.24	0.47	0.15	0.53	0.50	0.54	0.36
4	OTB_DEF_70-99_0_0	0.03	0.40	0.08	0.15	0.06	0.27	0.32	0.23	0.19
1	OTB_DEF_70-99_0_0_all	0.25	0.56	0.35	0.54	NA	0.66	NA	0.80	0.53
2	OTB_DEF_70-99_0_0_all	0.33	0.46	0.66	0.99	0.36	0.32	0.35	0.49	0.50
3	OTB_DEF_70-99_0_0_all	0.25	0.40	0.16	0.53	0.52	0.22	0.42	0.02	0.32
4	OTB_DEF_70-99_0_0_all	0.14	0.39	0.52	0.11	0.28	0.16	0.00	0.02	0.20
1	TBB_CRU_16-31_0_0_all	NA	NA	0.97	NA	NA	NA	1.00	0.93	0.97
2	TBB_CRU_16-31_0_0_all	NA	NA	1.00	NA	1.00	1.00	NA	0.00	0.75
3	TBB_CRU_16-31_0_0_all	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	0.86
4	TBB_CRU_16-31_0_0_all	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.49	0.94
1	TBB_DEF_70-99_0_0_all	0.96	0.44	0.14	0.72	0.72	0.76	0.84	0.62	0.65
2	TBB_DEF_70-99_0_0_all	NA	0.76	0.94	0.91	0.70	0.77	0.81	0.63	0.79
3	TBB_DEF_70-99_0_0_all	0.83	0.87	0.94	0.94	0.71	0.78	0.84	0.40	0.79
4	TBB_DEF_70-99_0_0_all	0.87	0.99	0.99	0.86	0.73	0.77	0.85	0.40	0.81

Table 10. Whiting in area 4 and 7d. Difference in quarterly values and annual average values, in red ignoring quarter stratification will underestimate discard rate, in blue ignoring quarter stratification overestimate discard rate.

Q	Fleet	2009	2010	2011	2012	2013	2014	2015	2016	Mean
1	OTB_DEF_>=120_0_0_all	-0.07	0.04	0.03	-0.16	0.08	0.25	0.01	-0.02	0.02
2	OTB_DEF_>=120_0_0_all	-0.05	-0.16	-0.14	0.08	0.14	0.18	-0.04	-0.10	-0.01
3	OTB_DEF_>=120_0_0_all	-0.05	-0.13	-0.08	-0.02	-0.17	0.07	0.03	0.07	-0.04
4	OTB_DEF_>=120_0_0_all	0.20	0.18	0.02	0.10	-0.28	0.02	-0.03	0.06	0.03
1	OTB_DEF_>=120_0_0_all_FDF	NA	-0.23	-0.07	-0.09	-0.23	-0.18	-0.30	-0.10	-0.17
2	OTB_DEF_>=120_0_0_all_FDF	NA	0.17	0.17	0.05	0.05	-0.30	0.62	-0.11	0.09
3	OTB_DEF_>=120_0_0_all_FDF	NA	0.24	-0.07	-0.08	-0.14	-0.36	-0.13	-0.01	-0.08
4	OTB_DEF_>=120_0_0_all_FDF	NA	0.12	-0.07	0.06	-0.24	-0.39	0.00	-0.10	-0.09
1	OTB_CRU_70-99_0_0_all	-0.09	-0.24	-0.47	0.10	-0.07	-0.04	-0.02	-0.24	-0.13
2	OTB_CRU_70-99_0_0_all	-0.12	-0.40	-0.46	-0.12	-0.24	-0.35	-0.53	0.14	-0.26
3	OTB_CRU_70-99_0_0_all	-0.05	-0.21	-0.34	-0.24	-0.50	-0.17	-0.35	-0.08	-0.24
4	OTB_CRU_70-99_0_0_all	0.18	0.19	-0.33	-0.18	-0.06	-0.20	-0.17	-0.16	-0.09
1	OTB_DEF_70-99_0_0_all	-0.01	0.14	-0.20	-0.01	NA	0.31	NA	0.06	0.03
2	OTB_DEF_70-99_0_0_all	0.07	0.04	0.11	0.44	-0.23	-0.03	-0.13	-0.25	0.00
3	OTB_DEF_70-99_0_0_all	-0.01	-0.02	-0.39	-0.02	-0.07	-0.13	-0.06	-0.72	-0.18
4	OTB_DEF_70-99_0_0_all	-0.12	-0.03	-0.03	-0.44	-0.31	-0.19	-0.48	-0.72	-0.29

Table 11. Whiting in area 4 and 7d. Discard raising scenario for 2016. Weights given in tonnes.

Scenario	Imported discards	Raised discards	Raised discards area 4	Raised discards area 7	Discard raising	Age raising	Data
1	9676	2041	1310	732	all	L,D	old
2	9676	2474	1329	1145	gear	all	
3	9651	2159	1296	863	all	all	new
4	9651	2537	1254	1283	gear	all	
5	9651	2212	1333	879	gear, 1,23,4	all	
6	9651	2292	1421	871	gear, 1,2,3,4	all	
final	9651	2217	1370	847	gear, 1,2,3,4	New strat	new

Table 12. Whiting in area 4 and 7d. Discard raising scenario for 2009. Weights given in tonnes.

Scenario	Imported discards	Raised discards	Raised discards area 4	Raised discards area 7	Discard raising	Age raising	Data
3	7833	1017	764	253	all	all	new
final	7833	864	653	211	gear, 1,2,3,4	New strat	new

Table 13. Whiting in area 4 and 7d. Catch numbers in 2016 using different discard raising procedures as detailed in Table 11. Numbers given thousands.

Scen.	Age 0	1	2	3	4	5	6	7	8+	Disc	Age	Data
1	8604	25509	38543	35939	9603	7303	6289	2557	1784	all	L,D	old
2	8138	26573	40483	37312	9711	7434	6510	2647	2015	gear	all	
3	16252	25463	33868	35902	9448	7810	6213	2644	1797	all	all	new
4	16418	25723	34212	36267	9544	7889	6276	2671	1815	gear	all	
5	16275	25500	33916	35953	9461	7821	6222	2648	1800	gear, 1,23,4	all	
6	16311	25555	33989	36031	9482	7838	6235	2654	1803	gear, 1,2,3,4	all	
final	17208	27639	36165	36788	9129	7813	6046	2548	1761	gear, 1,2,3,4	New strat	new

Table 14. **Whiting in area 4 and 7d. Catch numbers in 2009 using different discard raising procedures as detailed in Table 11. Numbers given thousands.**

Scen.	Age 0	1	2	3	4	5	6	7	8+	Disc	Age	data
1	2362	19919	56301	14922	11605	5331	1409	613	2837	all	L,D	old
3	10962	52124	30098	15375	13436	7759	3553	2250	6683	all	all	new
final	12139	57412	31004	15181	12782	7432	3380	2153	6390	gear, 1,2,3,4	New strat	new

Table 15. Whiting in area 4 and 7d. Old catch numbers at age (in thousands), old data without stratification for discard raising or age allocations. Numbers given thousands.

Year	Age 0	1	2	3	4	5	6	7	8+
2009	2362	19919	56301	14922	11605	5331	1409	613	2837
2010	1224	26266	60426	24826	8016	5394	2867	518	1510
2011	612	32894	59451	27509	14825	3331	2179	1032	312
2012	1854	28438	29366	22034	17656	6541	2406	1215	546
2013	4979	19972	17442	30164	16063	11179	3598	781	501
2014	4885	39651	18749	19365	20688	9500	3638	1137	336
2015	5939	32225	50035	12293	8802	12871	4507	1536	525
2016	8604	25509	38543	35939	9603	7303	6289	2557	1784

Table 16. Whiting in area 4 and 7d. New catch numbers at age (in thousands), new data with new stratification design. Numbers given thousands.

Year	Age 0	1	2	3	4	5	6	7	8+
2009	12139	57412	31004	15181	12782	7432	3380	2153	6390
2010	3930	33756	33320	25516	9932	7776	6263	2136	6925
2011	3563	31377	42201	28903	12537	3813	3178	2090	2674
2012	3548	53445	32509	18882	14862	6952	2773	1558	2371
2013	4341	20378	15548	25362	15593	10812	3343	1048	1595
2014	6225	29785	14623	17450	19683	11351	4710	2038	2090
2015	7705	48349	53345	15714	10220	14163	5068	2086	2222
2016	17208	27639	36165	36788	9129	7813	6046	2548	1761

Table 17. Whiting in area 4 and 7d. Mean individual catch weights using old Intercatch data (in kg).

Year	Age 0	1	2	3	4	5	6	7	8+
2009	0.042	0.092	0.220	0.289	0.381	0.401	0.465	0.393	0.328
2010	0.022	0.088	0.226	0.305	0.376	0.448	0.422	0.458	0.373
2011	0.046	0.106	0.185	0.315	0.379	0.443	0.499	0.46	0.501
2012	0.021	0.086	0.191	0.275	0.376	0.391	0.403	0.413	0.458
2013	0.045	0.09	0.186	0.244	0.397	0.481	0.497	0.522	0.496
2014	0.027	0.115	0.215	0.286	0.321	0.468	0.5	0.542	0.621
2015	0.033	0.115	0.207	0.322	0.386	0.4	0.492	0.509	0.546
2016	0.054	0.131	0.209	0.296	0.397	0.405	0.411	0.493	0.419

Table 18. Whiting in area 4 and 7d. Mean individual catch weights using new Intercatch data (in kg).

Year	Age 0	1	2	3	4	5	6	7	8+
2009	0.042	0.091	0.213	0.286	0.370	0.374	0.373	0.344	0.340
2010	0.049	0.111	0.234	0.373	0.406	0.456	0.355	0.459	0.346
2011	0.048	0.114	0.214	0.298	0.374	0.415	0.424	0.364	0.339
2012	0.038	0.105	0.195	0.311	0.445	0.411	0.43	0.428	0.395
2013	0.028	0.11	0.222	0.273	0.39	0.468	0.496	0.465	0.386
2014	0.055	0.137	0.227	0.294	0.331	0.442	0.465	0.469	0.394
2015	0.044	0.125	0.218	0.307	0.368	0.386	0.469	0.464	0.379
2016	0.030	0.120	0.210	0.291	0.399	0.389	0.415	0.488	0.459

Table 19 Sampled discards at age (numbers as submitted to Intercatch) aggregated by country for 2016, new Danish data.

Country/Age	0	1	2	3	4	5	6	7	8	9	10	data
France	321	5899	5646	1272	487	232	90	90	21	35	0	old
UK (England)	2662	3300	3634	3123	156	499	368	66	12	3	2	
UK(Scotland)	1930	4510	7291	5615	927	903	348	191	18	0	0	
Denmark	5026	676	288	94	19	3	1	0	0	0	0	new
France	572	6510	3247	1111	93	161	21	38	4	13	7	
UK (England)	2671	3350	3593	2945	123	542	311	59	6	3	1	
UK(Scotland)	1930	4510	7291	5615	927	903	348	191	18	0	0	

Table 20 Sampled landings at age (as submitted to Intercatch) aggregated by country for 2009, new French data.

Country/Age	0	1	2	3	4	5	6	7	8	9	10	11	data
Belgium	0	40	319	165	31	6	2	0	0	0	0	0	old
UK (England)	0	45	1323	1052	699	669	77	140	532	284	83	15	
UK(Scotland)	0	271	2722	4598	7325	3107	1102	352	418	413	68	1	
Belgium	0	40	319	165	31	6	2	0	0	0	0	0	new
France	68	2289	10752	4143	1612	1916	1515	1240	1152	772	1435	0	
UK (England)	0	45	1323	1052	699	669	77	140	532	284	83	15	
UK(Scotland)	0	271	2722	4598	7325	3107	1102	352	418	413	68	1	

Table 21 Sampled discards at age (numbers as submitted to Intercatch) aggregated by country for 2009, new French data.

Country/Age	0	1	2	3	4	5	6	7	8	9	10	data
Belgium	86	810	890	339	43	5	3	0	0	0	0	old
Denmark	2571	11578	382	9	3	3	1	0	0	0	0	
UK(Scotland)	5016	13451	4563	1644	836	384	79	24	39	21	13	
Belgium	86	810	890	339	43	5	3	0	0	0	0	new
Denmark	2571	11578	382	9	3	3	1	0	0	0	0	
France	867	12447	2685	122	2	2	12	10	1	0	1	
UK(Scotland)	5016	13451	4563	1644	836	384	79	24	39	21	13	

Table 22 Sampled discards of Danish fleets in 2016 as submitted to Intercatch in 2017 (numbers at age, weights in kg).

Season	Area	Fleet	Caton	Age0	1	2	3	4	5	6	7	8	9	10
1	27.4	GNS_DEF_120-219_0_0_all	645	0	0	293	1454	1209	0	0				
4	27.4	GNS_DEF_120-219_0_0_all	277	0	0	164	315	0	0	0				
2	27.4	GNS_DEF_120-219_0_0_all	2570	0	0	310	4189	3477	1278	700				
3	27.4	GNS_DEF_120-219_0_0_all	3916	0	140	4967	12698	2485	0	0				
3	27.4	MIS_MIS_0_0_0_HC	94	0	0	0	225	82	0	0				
3	27.4	**OTB_CRU_70-99_0_0_all**	**17573**	**137**	4049	103927	52698	4150	0	0				
2	27.4	OTB_DEF_>=120_0_0_all	2290	0	0	0	2515	2401	1071	552				
3	27.4	OTB_DEF_>=120_0_0_all	480	0	0	0	0	1097	0	0				
4	27.4	OTB_DEF_>=120_0_0_all	5365	0	0	733	10556	0	0	0				
1	27.4	OTB_DEF_>=120_0_0_all_FDF	1014	0	0	0	4289	1149	0	0				
2	27.4	OTB_DEF_>=120_0_0_all_FDF	88	0	0	0	307	169	21	21				
4	27.4	OTB_DEF_>=120_0_0_all_FDF	838	0	191	2962	365	0	0	0				
3	27.4	OTB_DEF_>=120_0_0_all_FDF	2459	0	0	1031	4545	2904	264	0				
1	27.4	TBB_CRU_16-31_0_0_all	8902	0	155067	173316	0	0	0	0				
3	27.4	**TBB_CRU_16-31_0_0_all**	**64160**	**5026327**	516587	0	0	0	0	0				

Table 23 Sampled landings of French fleets in 2009 as submitted to Intercatch in 2017 (numbers at age, weights in kg).

Season	Area	Fleet	Caton	Age 0	1	2	3	4	5	6	7	8	9	10
1	27.7.d	GTR_DEF_90-99_0_0_all	3979	0	129	2310	1814	1542	1160	917	945	751	579	1383
4	27.7.d	GTR_DEF_90-99_0_0_all	3600	60	669	857	938	738	909	482	458	485	560	830
3	27.4	**OTB_DEF_100-119_0_0**	1342	0	0	16	65	97	**137**	**304**	**217**	**114**	**255**	**232**
3	27.7.d	**OTB_DEF_70-99_0_0**	**394790**	0	26938	757068	199901	51829	80369	30635	**44849**	**49349**	**43070**	**47526**
1	27.7.d	**OTB_DEF_70-99_0_0**	**3396072**	0	254564	4260162	2519580	590960	1221252	802778	579320	615618	315334	**941872**
4	27.7.d	OTB_DEF_70-99_0_0	781972	68232	448974	543701	236790	181304	218692	119699	170164	132435	95107	147346
2	27.7.d	**OTB_DEF_70-99_0_0**	**1148348**	0	936145	874340	616509	522869	198179	**300585**	**354014**	**238003**	**195290**	**125580**
2	27.4	OTB_DEF_70-99_0_0	876600	0	35199	2623540	253237	55203	32857	33926	27593	49495	28452	37642
4	27.4	OTB_DEF_70-99_0_0	575753	0	298472	1290057	101962	58501	51746	11074	22535	20432	15879	28962
3	27.4	**OTB_DEF_70-99_0_0**	**406375**	0	260197	299942	166540	129346	93048	**200979**	**23337**	**33217**	**66770**	**90161**
2	27.7.d	OTB_DEF_All_0_0_All	19587	0	13064	14702	12243	8882	2939	4303	7260	3691	4284	2752
1	27.7.d	OTM_DEF_70-99_0_0_all	37771	0	2099	28085	22475	5475	12016	5967	4996	5052	2769	8638
3	27.7.d	OTM_DEF_70-99_0_0_all	19310	0	3969	50317	5669	922	1154	549	1022	918	1614	808
2	27.7.d	OTM_SPF_32-69_0_0_all	10223	0	8180	6621	5113	4631	1665	2827	2853	2106	2045	1445

Table 24 Sampled discards of French fleets in 2009 as submitted to Intercatch in 2017 (numbers at age, weights in kg).

Season	Area	Fleet	Caton	Age 0	1	2	3	4	5	6	7	8	9	10
1	27.7.d	GTR_DEF_90-99_0_0_all	1569	0	6177	2464	559	0	172	0	0	26	0	99
3	27.7.d	**OTB_DEF_All_0_0_All**	**6385**	**120008**	**2706**	0	0	0	0	0	0	0	0	0
2	27.7.d	**OTB_DEF_All_0_0_All**	**38940**	**76751**	**196081**	17788	0	0	0	0	0	0	0	0
2	27.7.d	OTM_SPF_32-69_0_0_all	7493	2444	92348	6098	369	95	0	0	48	119	167	107
3	27.7.d	OTB_DEF_70-99_0_0	33790	25449	210140	40749	189	30	16	10	211	41	25	206
1	27.7.d	**OTB_DEF_70-99_0_0**	**1046102**	**90257**	**4802526**	1782729	85250	50	151	8958	8958	50	0	50
2	27.7.d	**OTB_DEF_70-99_0_0**	**996015**	**208420**	**5800031**	454302	5473	1125	0	458	766	0	105	105
2	27.4	OTB_DEF_>=120_0_0_all	29	2	10	71	10	2	1	1	1	2	1	1
2	27.4	**OTB_DEF_70-99_0_0**	**220351**	**248519**	**1074485**	355116	7557	357	0	322	0	357	0	0
4	27.4	**OTB_DEF_70-99_0_0**	**19868**	**62598**	**60960**	18602	2208	102	51	0	0	51	0	0
3	27.4	**OTB_DEF_70-99_0_0**	**45915**	**32692**	**186174**	6137	20039	72	1943	1985	61	91	0	61
1	27.7.d	**OTM_DEF_70-99_0_0_all**	**2119**	**0**	**14934**	1267	0	0	0	0	0	0	0	0

4. Figures

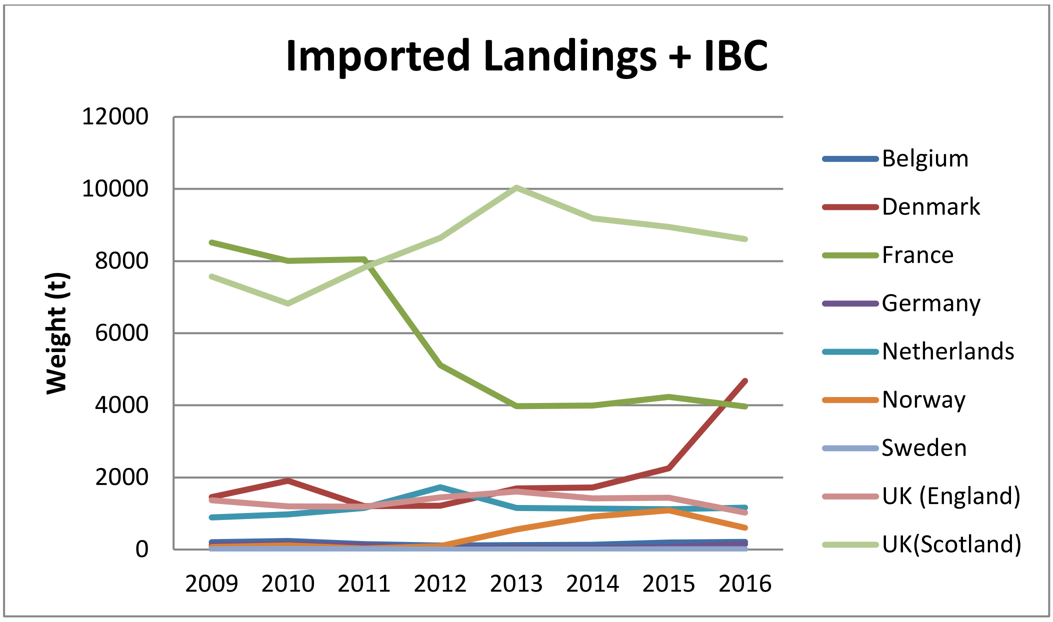

Figure 1. Whiting in area 4 and 7d. Imported landings and industrial bycatch (IBC) (weight in tonnes) into Intercatch by country.

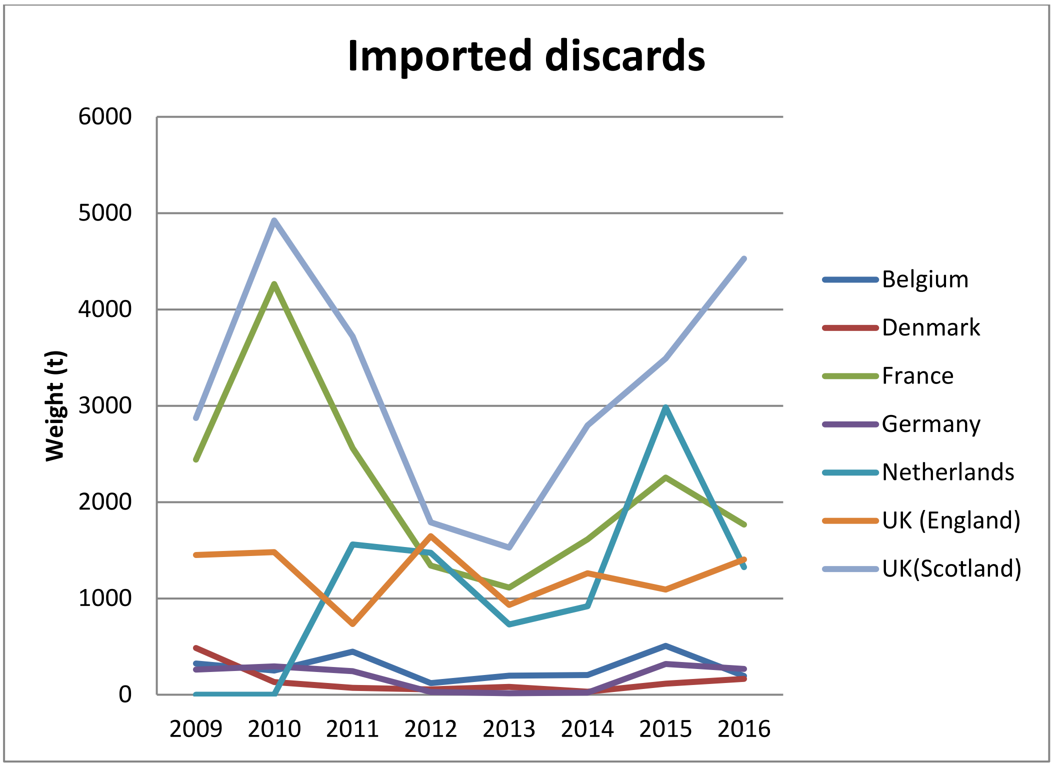

Figure 2. Whiting in area 4 and 7d. Imported discards into Intercatch by country.

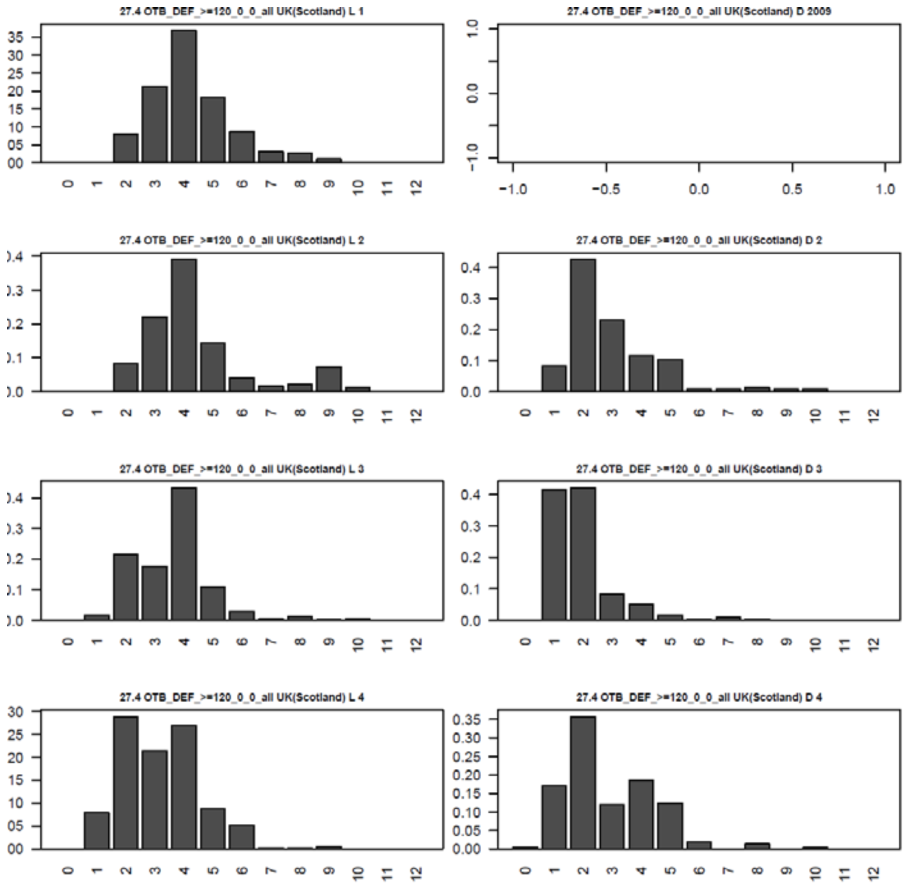

Figure 3. Whiting in area 4. Sampled landings and discard age distribution for OTB_DEF_>=120_0_0_all UK, area 4 (TR1), year 2009.

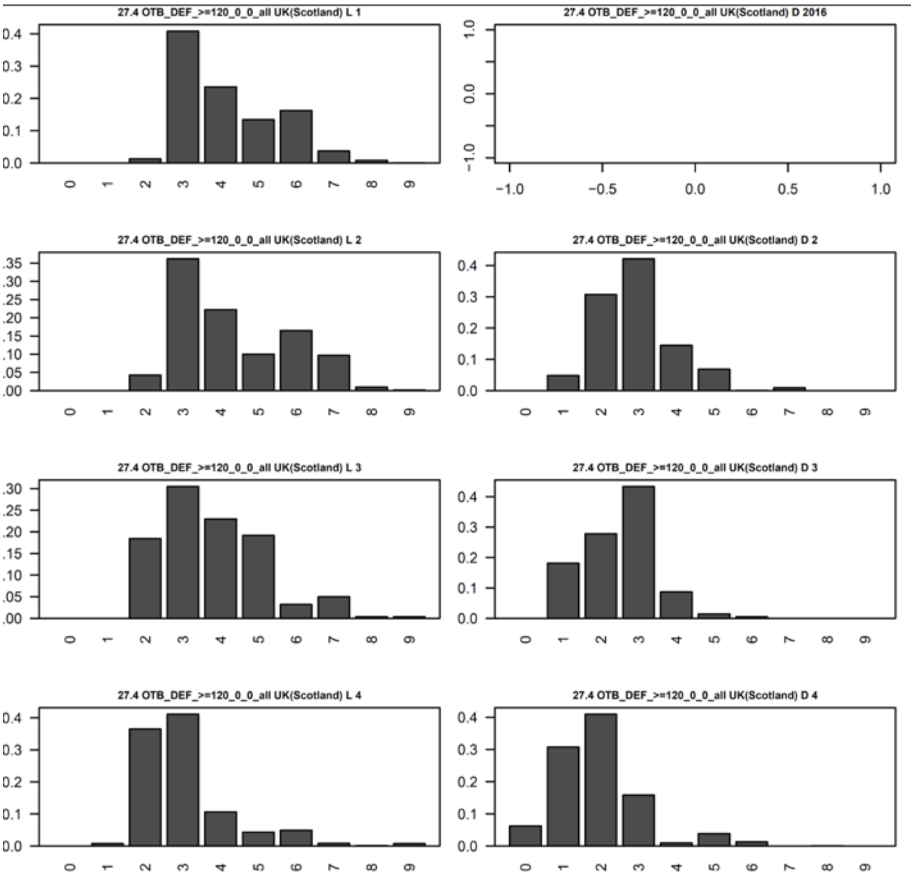

Figure 4. Whiting in area 4. Sampled landings and discard age distribution for OTB_DEF_>=120_0_0_all UK, area 4 (TR1), year 2016.

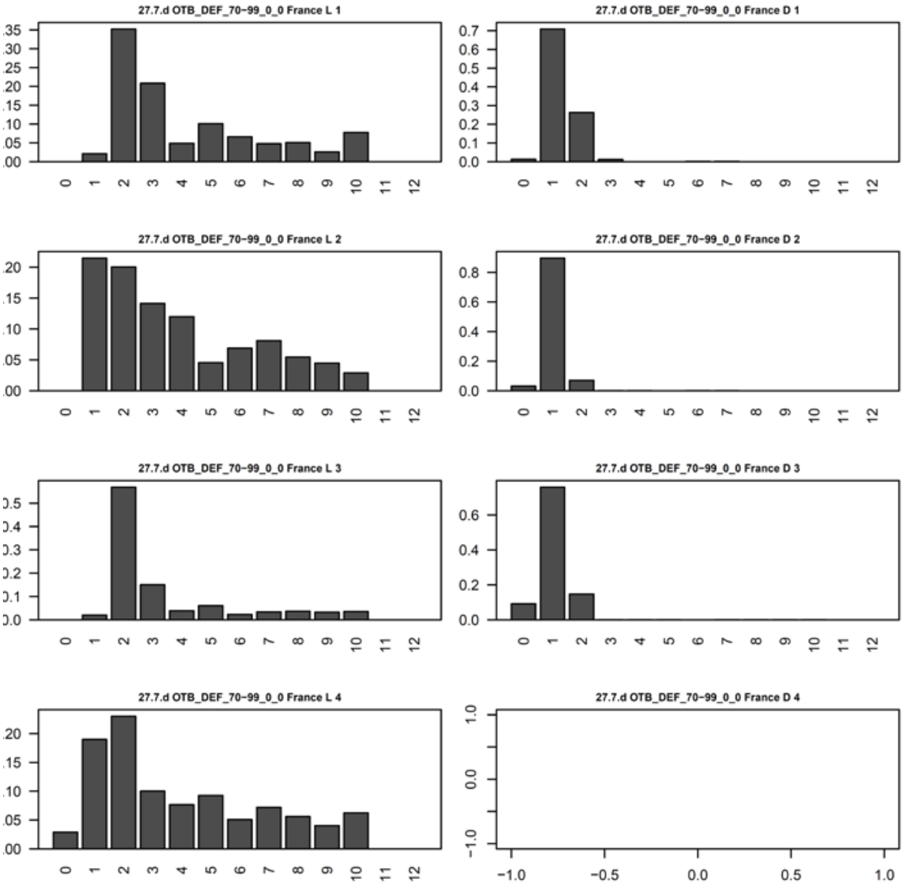

Figure 5. Whiting in area 7d. Sampled landings and discard age distribution for OTB_DEF_70-99_0_0 France, area 7d (TR2), year 2009.

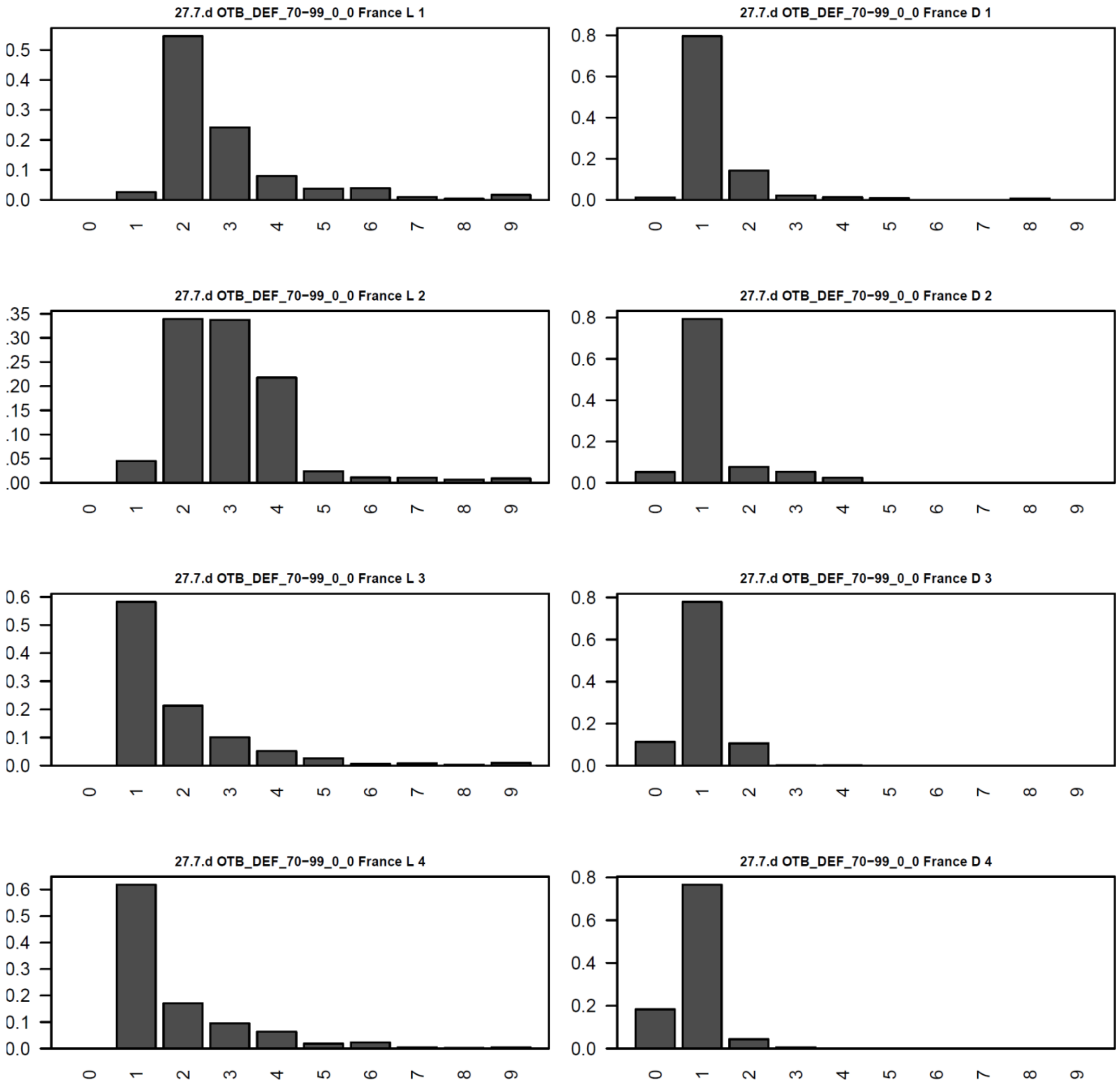

Figure 6 Whiting in area 7d. Sampled landings and discard age distribution for OTB_DEF_70-99_0_0 France, area 7d (TR2), year 2014.

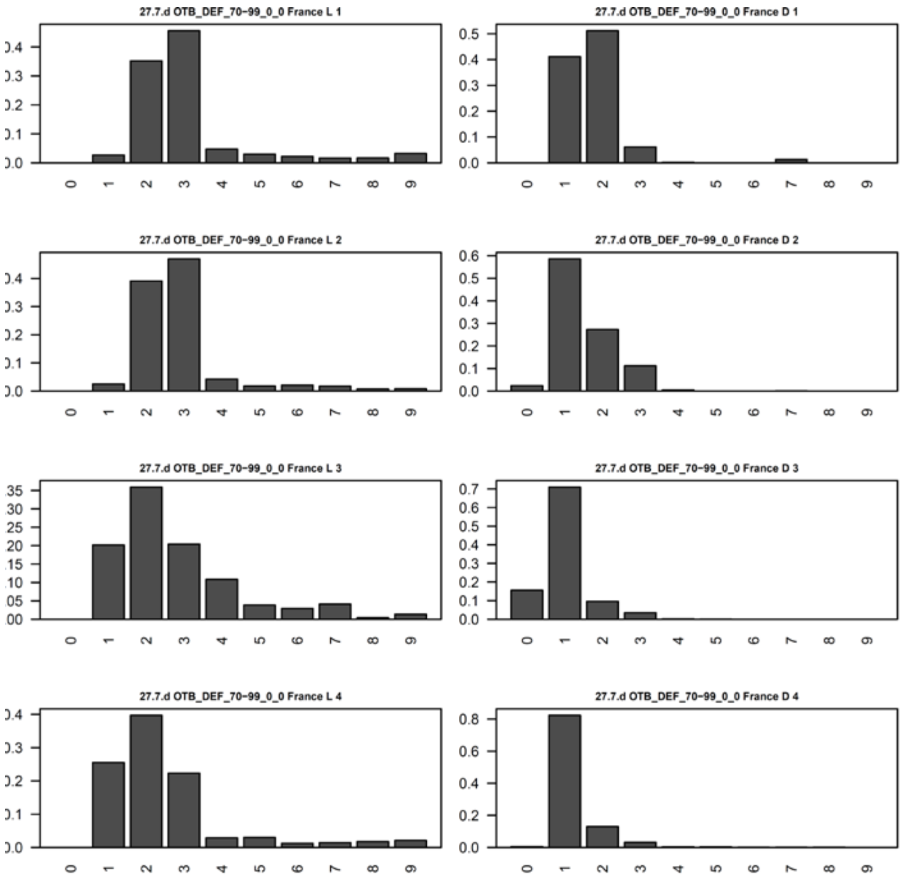

Figure 7. Whiting in area 7d. Sampled landings and discard age distribution for OTB_DEF_70-99_0_0 France, area 7d (TR2), year 2016.

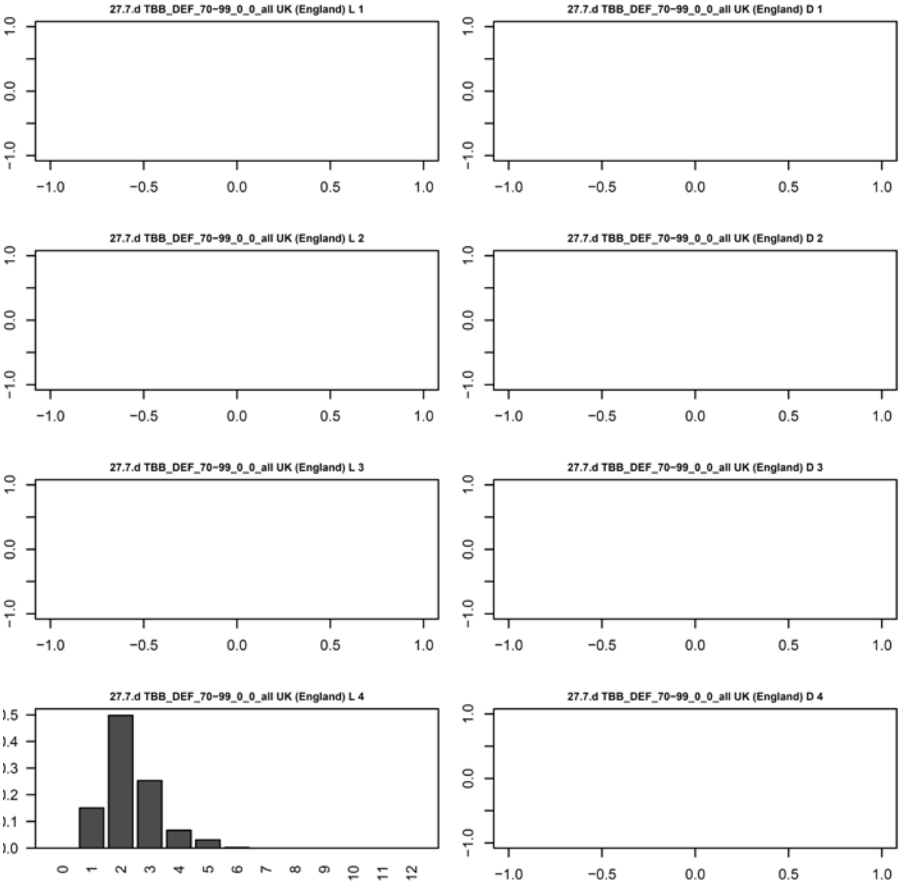

Figure 8. Whiting in area 7d. Sampled landings and discard age distribution for TBB_DEF_70-99_0_0_all UK, area 7d, year 2009.

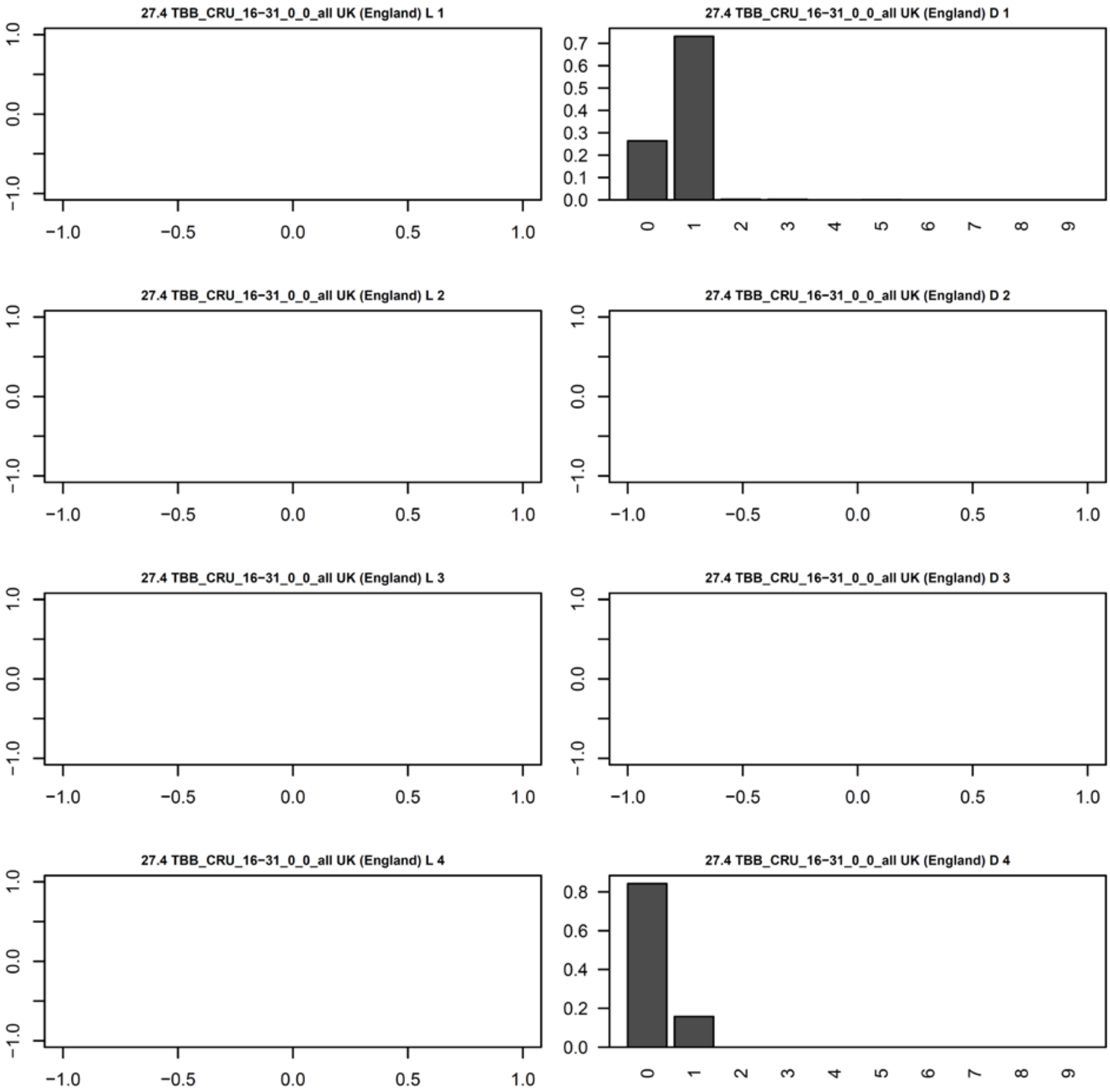

Figure 9. Whiting in area 4. Sampled landings and discard age distribution for TBB_CRU_16-31_0_0_all UK, area 4, year 2016.

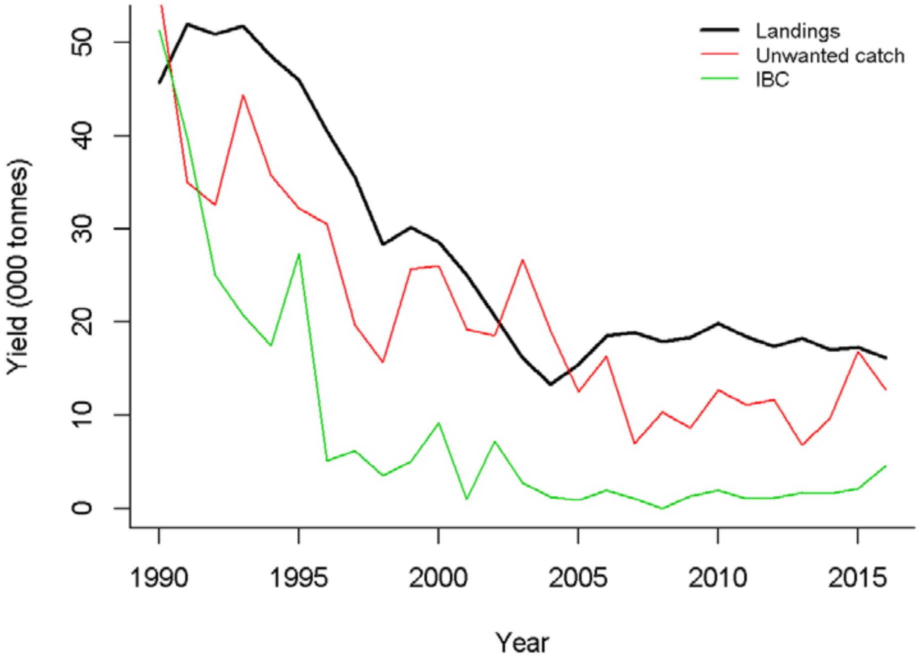

Figure 10. Whiting in area 4 and 7d. Catch categories of landings, unwanted catch (discards, BMS) and IBC as exported from Intercatch.

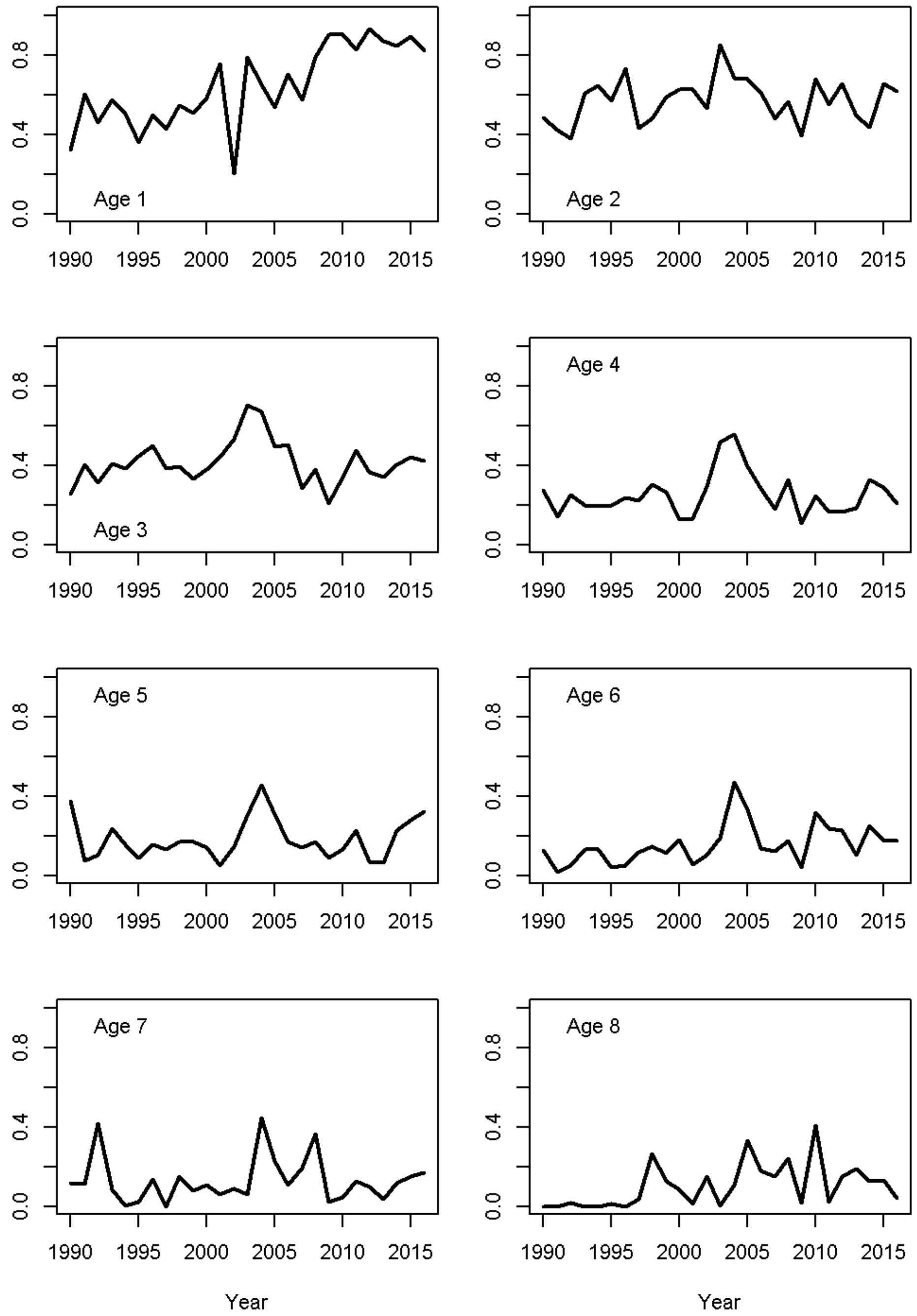

Figure 11. Whiting in area 4 and 7d. Proportion discarded by age.

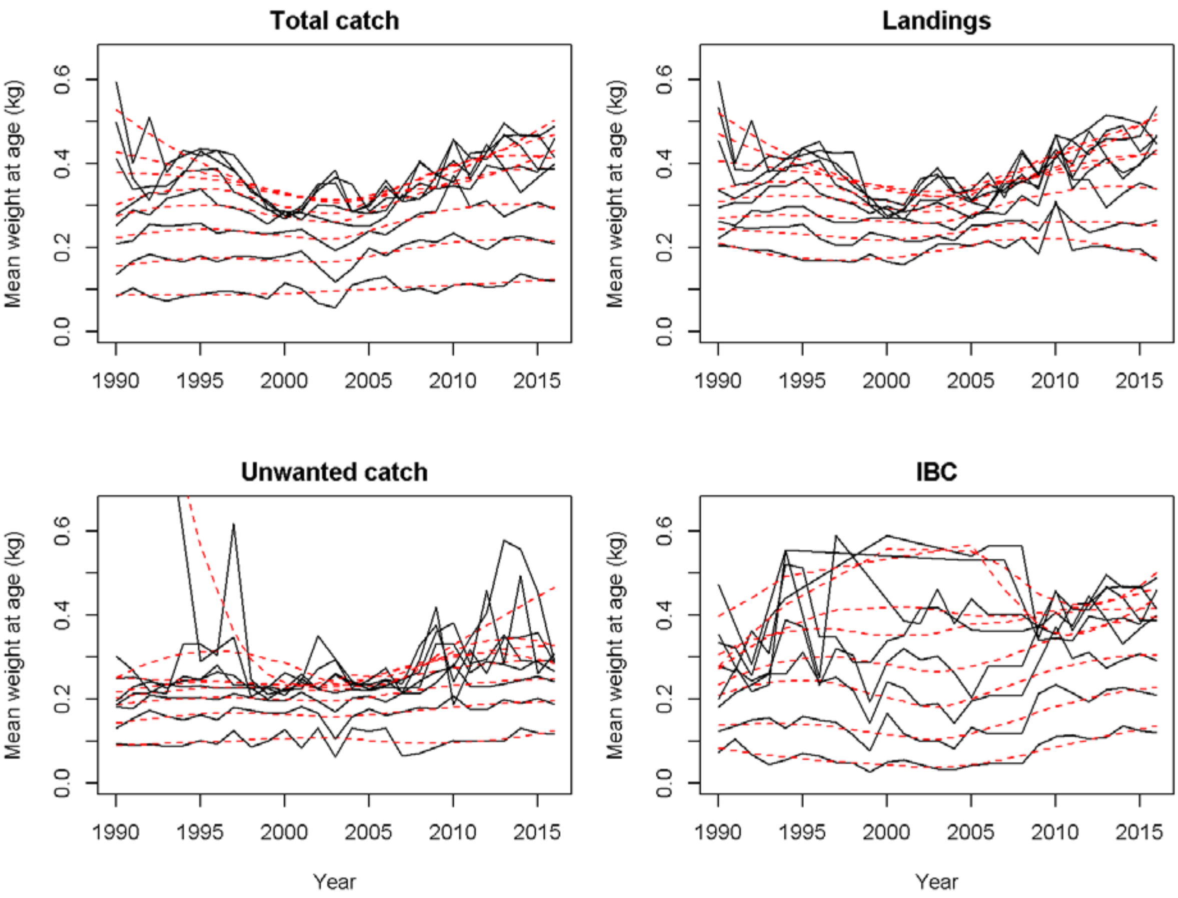

Figure 12. Whiting in area 4 and 7d. Individual weights at age.

WD 3 Natural mortality estimates for whiting in Subarea 4 and division 7d

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In the stock assessment of 2017 for whiting in area 4 and 7d (ICES, 2017), smoothed natural mortality estimates at age were used based on the 2014/15 update of the 2014 SMS key run (ICES, 2014). For the whiting benchmark 2018, new natural mortality estimates were available as produced by WGSAM in the 2017 key run of the North Sea SMS model (ICES, 2018). The new key run included revisions and updates to the input data and a few modifications of the structure of the model.

1. Methods

The input data included analytical stock assessments (by ICES; catch data, survey data, biological data), stock size of external predators (birds, mammals, other fish), diet and ration data for all predators (stomach content).

The abundance of sea birds in the North Sea was estimated from birds counts at sea as collected since 1979 (European Seabirdsat Sea Database) and the number of breeding individuals on land (national databases, ICES Working Group on Seabird Ecology). The derivation of seabird data was updated with more recent years and trends in ICES WGSAM 2011 for two time periods (1979-1991, 1992-2004), and were assumed to be constant since.

Abundance of grey seals and total pup production was estimated from published data on haul-out counts in the North Sea and Orkney for 1984-2009 (Buckland *et al.*, 2004; Duck and Thompson, 2007; Thomas, 2011). Between 4 and 6 aerial surveys were flown each year over the main colonies in Orkney and the Firth of Forth during each breeding season. In addition, data from ground-counts were included after 2001 (Duck and Thompson, 2007; Thompson and Duck, 2016). Before 1984, populations were estimated to follow exponential growth up to 1990 (years 1984–1990 used for parameter estimation). After 2010, the grey seal abundance of 2009 was used as constant abundance for the following years. Recent surveys suggested a levelling off in pup production for the Orkney islands (stationary population 2012-2015), and slight increase in the North Sea grey seal pup production in the same period (SCOS report, 2017).

The abundance of cetaceans in the North Sea was assumed to be constant over the entire time period, with numbers estimated from aggregated aerial and boat-based sightings surveys including corrections for the detectability of the animals. Abundance for starry ray, grey gurnard, horse mackerel and hake was estimated from recent NS IBTS survey data.

Grey seal diets were estimated using sampled scats originating from haulout sites around the UK coast for the years 1985 and 2002. Diet composition for harbour porpoise were estimated from Danish and UK stomach samples with data merged per decade (1984, 1995, 2005). The harbour porpoise data were corrected in 2017, taking into account that residence time of otoliths in the stomach was dependent on the otolith size. Fish stomach data for predator and prey species were obtained from the International stomach sampling program (1981-2013). The samples were collected from all scientific surveys coordinated by ICES in 1981, 1985, 1987, 1991. The majority of samples originated from 1981 and 1991, and the IBTS survey.
Further details were listed in the stock annex for the ICES North Sea SMS configuration (WGSAM, 2017).

In the model, whiting was considered to be both predator and prey. Whiting was preyed upon by a variety of species (Figure 1). Predation patterns differed for whiting aged 0, 1 and 2+. For age 0 whiting, main predator was grey gurnard. Later in life, predation of harbour porpoise, saithe and cod intensified. For older whiting main predator was harbour porpoise. There was cannibalism, in particular on age 0 and age 1 whiting (Figure 1). Predation mortality (M2) on age 0 whiting increased in recent years due to an increase in grey gurnard abundance.

The new raw natural mortality data (Table 1) from the latest key run was smoothed to reduce the effect of interannual variability while tracing the change in natural mortality over time. The function *gam* (R package gam) was used to fit a generalized additive model to smooth natural mortality for each age class separately. Smoothing spline was applied assuming Gaussian error and df=5 (where degrees of freedom df=1 implies a linear fit).

```
> library(gam)
```

```
> gam(M~s(Year,5), M, family=gaussian)
```

2. Results

New raw and smoothed data for the period 1974-2016 estimated for each age class separately were illustrated in Figure 2. The estimate for ages 6, 7 and 8+ were relatively similar, showing lower natural mortality in the beginning at end of the time series. To avoid younger age having smaller predation mortality than older ones, data for ages 6+ were grouped together for smoothing (Figure 3). New smoothed values were listed for 1978-2016 in Table 2 to be used in the stock assessment model. In comparison to the old smoothed values, there was some reduction in natural mortality (Figure 4). The reduction in mortality at older age was due to a reduction in whiting consumption by harbour porpoise, following the correction to relatively longer residence time of whiting otoliths in the stomach applied in the new key run (ICES, 2018).

3. Figures and Tables

Table 1. Whiting in area 4 and 7d. New raw values for natural mortality (quarterly sum of M1 and M2), output from WGSAM (ICES, 2018).

Year/Age	0	1	2	3	4	5	6	7	8
1978	1.418	1.348	0.620	0.539	0.497	0.468	0.468	0.399	0.271
1979	0.931	1.250	0.639	0.537	0.534	0.491	0.465	0.316	0.255
1980	1.295	1.143	0.577	0.504	0.464	0.464	0.422	0.422	0.275
1981	1.865	1.724	0.670	0.548	0.509	0.486	0.468	0.448	0.279
1982	1.404	1.497	0.654	0.583	0.542	0.481	0.418	0.336	0.264
1983	1.113	1.382	0.622	0.523	0.505	0.482	0.474	0.474	0.299
1984	1.650	1.047	0.592	0.501	0.477	0.475	0.457	0.446	0.252
1985	1.107	1.244	0.599	0.497	0.477	0.460	0.452	0.321	0.452
1986	1.298	1.044	0.544	0.502	0.468	0.435	0.383	0.383	0.241
1987	1.627	1.080	0.524	0.456	0.440	0.425	0.421	0.255	0.255
1988	1.086	1.314	0.579	0.527	0.486	0.478	0.439	0.292	0.228
1989	1.604	1.097	0.510	0.492	0.468	0.461	0.446	0.432	0.446
1990	1.510	1.272	0.529	0.486	0.482	0.482	0.452	0.303	0.242
1991	1.342	1.219	0.539	0.509	0.496	0.482	0.482	0.472	0.467
1992	1.562	1.149	0.521	0.487	0.481	0.480	0.473	0.481	0.404
1993	1.429	1.159	0.541	0.480	0.472	0.471	0.462	0.462	0.462
1994	1.402	1.132	0.541	0.499	0.477	0.477	0.477	0.457	0.448
1995	1.631	1.161	0.535	0.472	0.456	0.456	0.449	0.449	0.443
1996	1.426	1.283	0.572	0.518	0.511	0.478	0.478	0.469	0.469
1997	1.837	1.145	0.562	0.499	0.489	0.477	0.464	0.464	0.463
1998	1.878	1.265	0.574	0.507	0.488	0.474	0.469	0.469	0.469
1999	1.924	1.241	0.559	0.534	0.500	0.493	0.483	0.483	0.493
2000	1.910	1.040	0.507	0.469	0.466	0.466	0.466	0.466	0.466
2001	1.948	1.159	0.515	0.460	0.447	0.447	0.442	0.447	0.447
2002	2.422	1.294	0.559	0.520	0.489	0.470	0.465	0.465	0.465
2003	2.438	1.374	0.550	0.524	0.493	0.490	0.465	0.462	0.465
2004	2.263	1.501	0.620	0.587	0.549	0.549	0.549	0.549	0.530
2005	2.273	1.399	0.607	0.564	0.556	0.554	0.552	0.554	0.556
2006	2.372	1.245	0.646	0.584	0.568	0.566	0.528	0.562	0.566
2007	2.253	1.290	0.654	0.563	0.530	0.530	0.535	0.535	0.530
2008	2.249	1.235	0.686	0.595	0.556	0.541	0.541	0.556	0.547
2009	1.757	1.122	0.691	0.571	0.539	0.539	0.465	0.539	0.539
2010	2.074	0.978	0.617	0.513	0.487	0.483	0.487	0.483	0.487
2011	2.635	1.154	0.663	0.514	0.507	0.502	0.297	0.502	0.221

2012	2.414	1.275	0.664	0.562	0.527	0.527	0.527	0.519	0.519
2013	1.993	1.241	0.691	0.571	0.520	0.389	0.319	0.238	0.444
2014	2.086	1.156	0.668	0.571	0.571	0.435	0.306	0.234	0.234
2015	2.417	1.071	0.673	0.551	0.532	0.532	0.368	0.307	0.241
2016	1.751	1.297	0.746	0.620	0.563	0.559	0.559	0.339	0.559

Table 2. Whiting in area 4 and 7d. New smoothed values for natural mortality at age (using the output from WGSAM 2017) for 1978-2016. Estimates of ages 6+ smoothed together.

Year/age	0	1	2	3	4	5	6	7	8+
1978	1.297	1.285	0.660	0.518	0.484	0.416	0.337	0.337	0.337
1979	1.315	1.300	0.648	0.520	0.487	0.433	0.346	0.346	0.346
1980	1.332	1.309	0.637	0.522	0.489	0.446	0.354	0.354	0.354
1981	1.347	1.311	0.626	0.522	0.491	0.457	0.361	0.361	0.361
1982	1.356	1.303	0.615	0.521	0.491	0.464	0.366	0.366	0.366
1983	1.361	1.287	0.604	0.518	0.489	0.468	0.369	0.369	0.369
1984	1.365	1.266	0.592	0.514	0.487	0.469	0.372	0.372	0.372
1985	1.368	1.244	0.580	0.510	0.484	0.470	0.374	0.374	0.374
1986	1.373	1.224	0.569	0.506	0.482	0.470	0.377	0.377	0.377
1987	1.381	1.208	0.559	0.502	0.479	0.469	0.381	0.381	0.381
1988	1.392	1.196	0.551	0.499	0.478	0.469	0.387	0.387	0.387
1989	1.406	1.187	0.544	0.496	0.477	0.470	0.396	0.396	0.396
1990	1.425	1.181	0.539	0.494	0.477	0.470	0.406	0.406	0.406
1991	1.449	1.177	0.536	0.493	0.477	0.471	0.416	0.416	0.416
1992	1.479	1.176	0.535	0.492	0.477	0.471	0.427	0.427	0.427
1993	1.517	1.176	0.535	0.491	0.477	0.471	0.437	0.437	0.437
1994	1.564	1.179	0.536	0.492	0.478	0.472	0.446	0.446	0.446
1995	1.621	1.185	0.538	0.493	0.479	0.472	0.454	0.454	0.454
1996	1.688	1.193	0.541	0.496	0.481	0.474	0.461	0.461	0.461
1997	1.762	1.202	0.543	0.498	0.483	0.476	0.468	0.468	0.468
1998	1.840	1.213	0.546	0.502	0.486	0.479	0.474	0.474	0.474
1999	1.919	1.225	0.550	0.506	0.488	0.482	0.480	0.480	0.480
2000	1.997	1.238	0.556	0.511	0.492	0.487	0.486	0.486	0.486
2001	2.070	1.252	0.563	0.517	0.497	0.492	0.492	0.492	0.492
2002	2.135	1.266	0.572	0.525	0.503	0.499	0.499	0.499	0.499
2003	2.186	1.276	0.583	0.533	0.510	0.506	0.505	0.505	0.505
2004	2.224	1.280	0.596	0.540	0.516	0.512	0.510	0.510	0.510
2005	2.247	1.276	0.609	0.547	0.522	0.517	0.512	0.512	0.512

2006	2.259	1.266	0.621	0.552	0.526	0.520	0.510	0.510	0.510
2007	2.261	1.251	0.633	0.555	0.529	0.520	0.504	0.504	0.504
2008	2.255	1.234	0.644	0.557	0.531	0.518	0.494	0.494	0.494
2009	2.246	1.217	0.653	0.559	0.531	0.515	0.480	0.480	0.480
2010	2.236	1.203	0.661	0.560	0.532	0.510	0.462	0.462	0.462
2011	2.222	1.193	0.668	0.561	0.533	0.505	0.443	0.443	0.443
2012	2.202	1.187	0.676	0.564	0.535	0.501	0.423	0.423	0.423
2013	2.174	1.183	0.684	0.567	0.538	0.498	0.404	0.404	0.404
2014	2.142	1.180	0.692	0.572	0.541	0.497	0.385	0.385	0.385
2015	2.106	1.179	0.701	0.576	0.544	0.498	0.369	0.369	0.369
2016	2.066	1.178	0.710	0.582	0.548	0.500	0.355	0.355	0.355

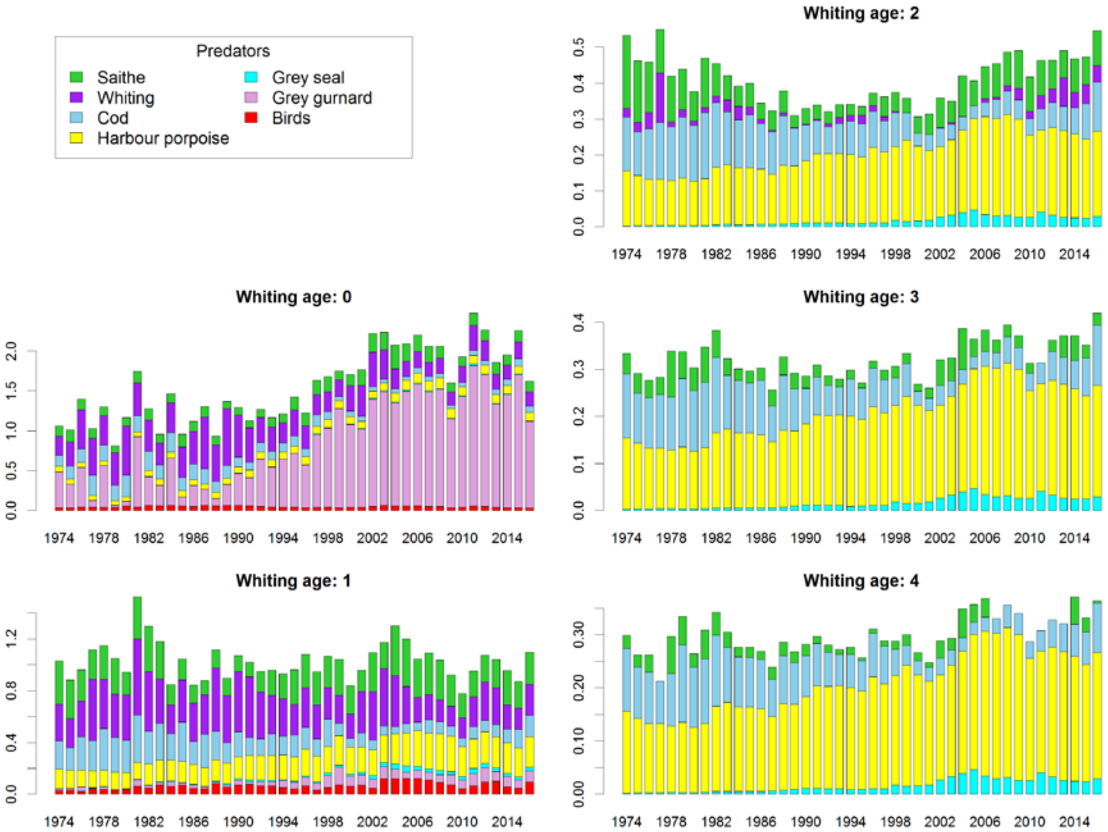

Figure 1 Whiting in area 4 and 7d. Annual predation mortality (M2) by age and predator as given by latest 2017 key run by WGSAM (ICES, 2018). M2 for age 0 includes only the third and fourth quarters.

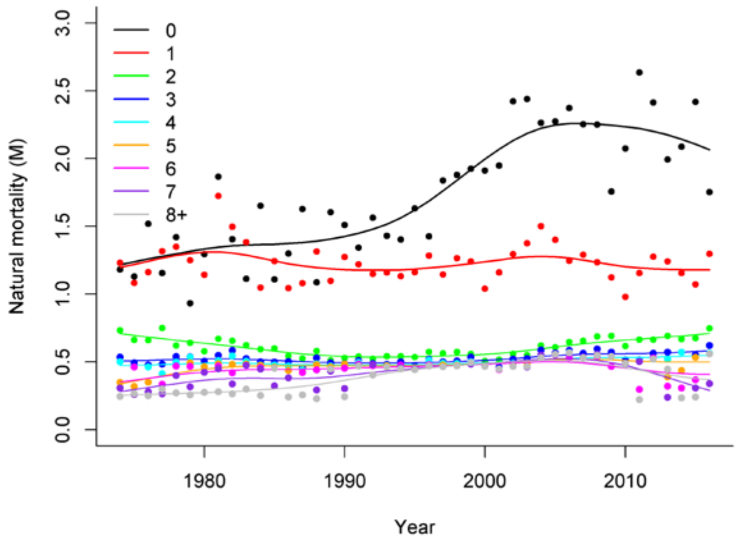

Figure 2. New raw and smoothed natural mortality estimates (using the output from the latest 2017 key run). Ages 0 to 8+ estimated separately.

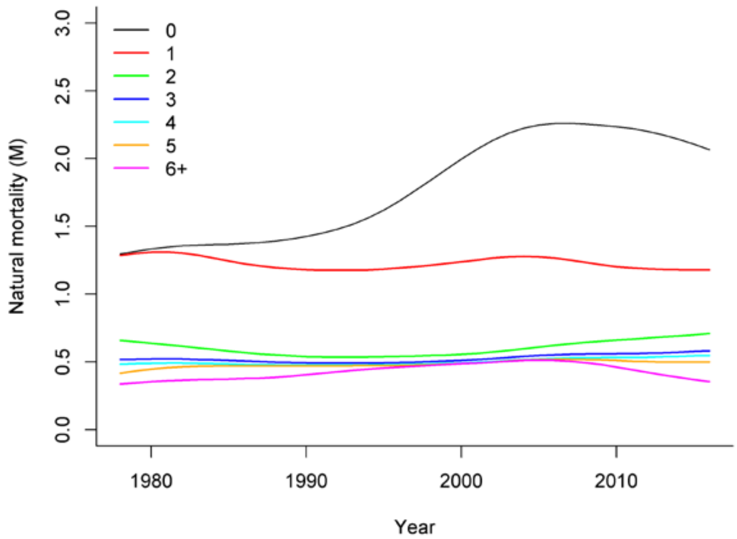

Figure 3. New smoothed natural mortality estimates (using the output from the latest 2017 key run). Ages 0 to 6+ estimated separately.

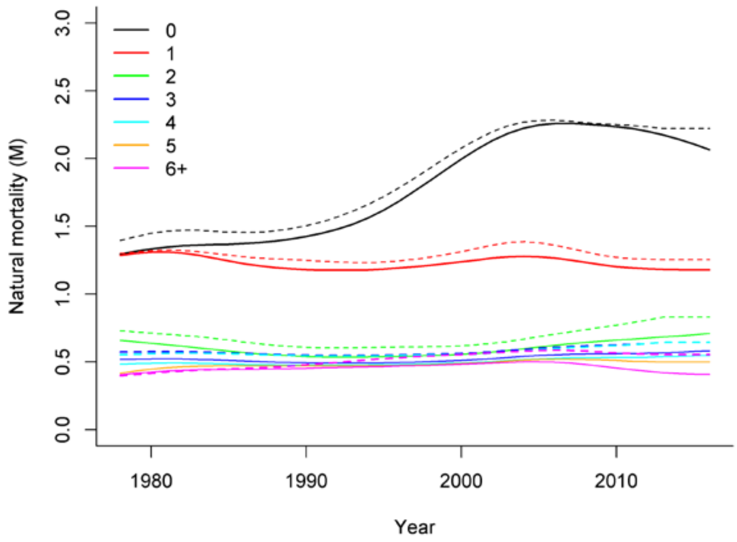

Figure 4. New smoothed (2017 key run, solid) and old smoothed (2014/15 key run, dashed) natural mortality estimates by age and year.

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WD 4: Estimation of a maturity ogive for North Sea Whiting

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Overview

Assessment of North Sea whiting is an age-based analytical assessment but the maturity ogive used has been left unchanged since the 1980s. In addition, there is little information on how this maturity ogive was derived. For the assessment, the maturity ogive was required to be age based, and would not consider spatial or sex differences. However, while the aim of the present working documents is to produce a revised maturity ogive according to a reproducible method recommended by WKMOG (2008), it will also assess potential temporal and spatial effects on maturation and the need for them to be incorporated in the assessment.

1. Available data

Up to 2017, the maturity ogive used for North Sea whiting assessment was assumed to be constant in time:

AGE	1	2	3	4	5	6	7	8+
Maturity Ogive	0.11	0.92	1.00	1.00	1.00	1.00	1.00	1.00

This ogive has been produced in the 1980s using maturity data from North Sea IBTS quarter 1 averaged over the period 1981-1985. However, the calculation method and whether both sexes or a female-only dataset was used is unknown.

In the following sections, maturity ogives were calculated using North Sea IBTS data from Quarter 1 surveys in the period 1991-2017 (truncated time series due to aberrant estimated maturity ogives for years 1989-1990). Quarter 1IBTS survey was chosen to estimate maturity ogives rather than Q3, as the survey in Q1 overlaps with spawning season and provides a better coverage of maturity samples.

2. Methods

Data formatting

North Sea IBTS data for the period 1991-2017 were downloaded from the ICES database in exchange format (DATRAS; http://datras.ices.dk). The data were read in R 3.4.3 using the DATRAS package as a DATRASraw object (Kristensen & Berg 2012) composed of:

-Age data (CA records)

-Hydro data (HH records)

-Length data (HL records)

The raw data were then reduced to whiting (*Merlangius merlangus*) only and maturity stages from the CA record were recoded as immature (0) and mature (1) (**Table 1**).

Table 1: Recoding of maturity stages

Previous code	Description	New code
1	Juvenile/Immature (4-stage scale)	**0**
2	Maturing (4-stage scale)	**1**
3	Spawning (4-stage scale)	**1**
4	Spent (4-stage scale)	**1**
5	Resting/Skip of spawning (4-stage scale, additional option)	**1**
6	Abnormal (4-stage scale, additional option)	**Removed**
61	Juvenile/Immature (6-stage scale)	**0**
62	Maturing (6-stage scale)	**1**
63	Spawning (6-stage scale)	**1**
64	Spent (6-stage scale)	**1**
65	Resting/Skip of spawning (6-stage scale)	**1**
66	Abnormal (6-stage scale)	**Removed**
-9	Missing Value	**Removed**
I	Immature / National BITS scale step	**0**
M	Mature	**1**

For considerations of spatial differences in maturation, hauls were assigned to a “NORTH” or “SOUTH” region according to the sub-structure suggested by Holmes *et al*. (2014, **Figure 1**).

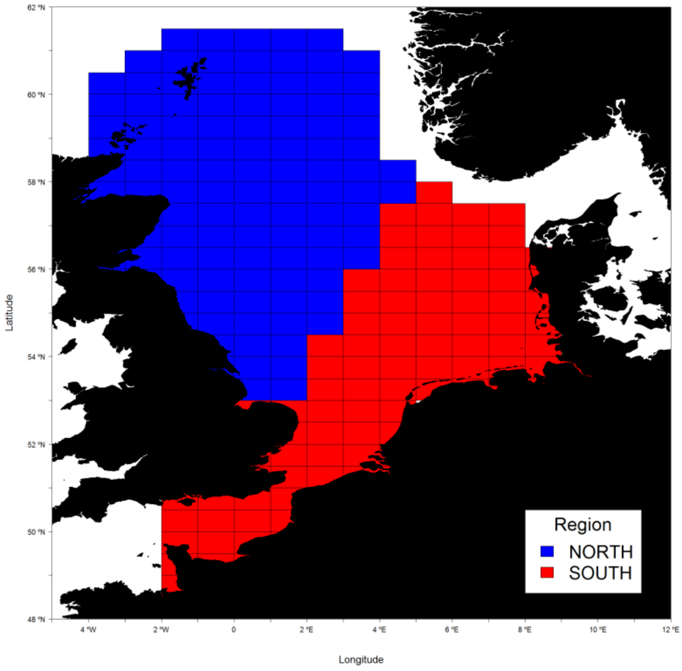

Figure 1: Sub-regions adopted to analyse spatial differences in maturation of North Sea whiting suggested by Holmes *et al*. (2014).

Raising maturity data

Survey data are stratified in two stages. A large random (representative) sample of the catch is measured to produce a length distribution (corresponding to the HL records in the DATRASraw object) and a subsample of these fish (generally a fixed number per length class) is used to obtain biological data (age, weight, sex, maturity stage, corresponding to the CA records in the DATRASraw object). In accordance, a statistical weight accounting for length distribution was used to perform calculations by age as required for the assessment of whiting (age based maturity ogive). Numbers caught (HH data) were standardized for effort (per hour).

While different methods of producing statistical weights are available, the method used thereafter was the one employed in the UK and detailed in the report of the ICES Working Group on Maturity Ogive Estimation for Stock Assessment (ICES WKMOG report 2008) and described as a 3 step process:

1- For each fish with biological data, define a raising factor:

$r_g = n_g / m_g$

Where n_g is the number of fish measured within a length group g, and m_g is the number of fish subsampled in the same length group.

2- Calculate the sum of the raising factors for each age group a

$$R_a = \sum_{a_i=a} r_g$$

where a_i denotes the age of fish *i*.

3- Assign statistical weight, to fish *i* in length group *g* and age *a*

$w_i = m_a \times r_g / R_a$

Where m_a is the number of fish of age *a* with biological data.

Region-specific weights

For whiting, a single ogive is needed for the entire assessment area covered by a survey. In case of differences in maturity ogives between areas, WKMOG 2008 suggested areas should be weighted by area-specific catch rates to produce a combined maturity ogive. As the total weight of the catch was missing for a large number of hauls, total number of fish per haul per hour was used instead. For each year *y* and for each region *R* (South and North), weight, $w_{R,y}$, was calculated as:

$$w_{R,y} = \frac{q_R \overline{NB_{R,y}}}{\overline{NB_y}}$$

With the mean catch rate per area and year:

$$\overline{NB_{R,y}} = \frac{\sum_{i=1}^{n_{R,y}} NB_i}{n_{R,y}}$$

Where, NB_i is the average number of fish per haul in ICES rectangle *i*, and $n_{R,y}$ is the number of sampled ICES rectangles in region *R* and year y. The proportion q_R is the relative area of each region calculated as the ratio of the number of ICES rectangles per region covered by the survey and the total number of rectangles (both regions).

The total catch rate in the combined is the weighted sum of mean catch rate in the Northern and Southern region:

$$\overline{NB_y} = \sum_{r=1}^{R} q_R \overline{NB_{R,y}}$$

In order to calculate the composite maturity ogive for the whole North Sea, the final weighting factor used was the product of the individual statistical weight (w_i) by the region-specific weighting factor ($w_{R,y}$).

Maturity ogive estimation

Maturity ogive were produced by modelling maturity data as a binomial GLM with logit link as described by ICES WKMOG (2008) as current standard practice.

With:

$logit(p) = log(p/1-p)$

Where p is the probability of being mature.

With this transformation, a linear model was applied, of the form:

$logit(p) = \alpha + \beta X$

Where α is the intercept and β the slope and X the variable(s) of interest. In this case, age and also factors such as year and region as well as their interactions were included in the model. The best model was selected on the basis of the Akaike Information Criterion (AIC).

<u>Outputs</u>:

The midpoint of the modelled maturity ogive, or A50 (age at 50% maturity) was produced as:

$A50 = -\alpha/\beta$

And used as an indicator for time related changes in maturation.

The maturity ogives were produced as predictions from the fitted models. 95% Confidence intervals were produced for both A50 and the ogives by bootstrap resampling of the original dataset stratifying by year.

Smoothing of time series

The raw estimated maturity times series from the above described maturity ogive estimation was smoothed for each age class to reduce the effect of interannual variability. The function *gam* (R package gam) was used to fit a generalized additive model for each age class separately. Smoothing spline was applied assuming Gaussian error and respective degrees of freedom (where degrees of freedom df=1 implies a linear fit). Degrees of freedom were selected by minimizing AIC (with df<6). Plus-groups were used when age groups reach a proportion mature of 1 across the whole time series.

```
> library(gam)

> gam(mat~s(year,df), data=M, family=gaussian)
```

The estimated maturity times series was smoothed first for the combined estimates and then also for each area (North and South), separately.

3. Results

Temporal effect on maturation

The best fit was provided by a model including an age effect and a year effect as well as their interaction (**Table 2**).

Table 2: Analysis of deviance for the glm fit of maturity data with a year effect.

	Df	Deviance	Residual Df	Residual Deviance	Likelihood Ratio Test (*p*)
Null model			63851	98632	
Age	1	36371	63850	62262	**<0.0001**
Year	26	1720	63824	60542	**<0.0001**
Age x Year	26	1368	63798	59174	**<0.0001**

The midpoint of the maturity ogive, A50, was stable during the period 1991 to 2000 but showed an obvious decrease on the period 2000-2017. The age at 50% maturity of 1.5 years in late 1990s –early 2000s decreased to 1.2 years by the end of the time series (**Figure 2**). If we now consider the ogives and particularly the proportions mature at age 1 and 2 (**Figure 3**), we find the proportion of age 2 fish mature was stable around 80% between 1991 and 2017. In contrast, the proportion of age 1 fish increased from around 20% between 1991 to 1999 to around 30% by the end of the time series.

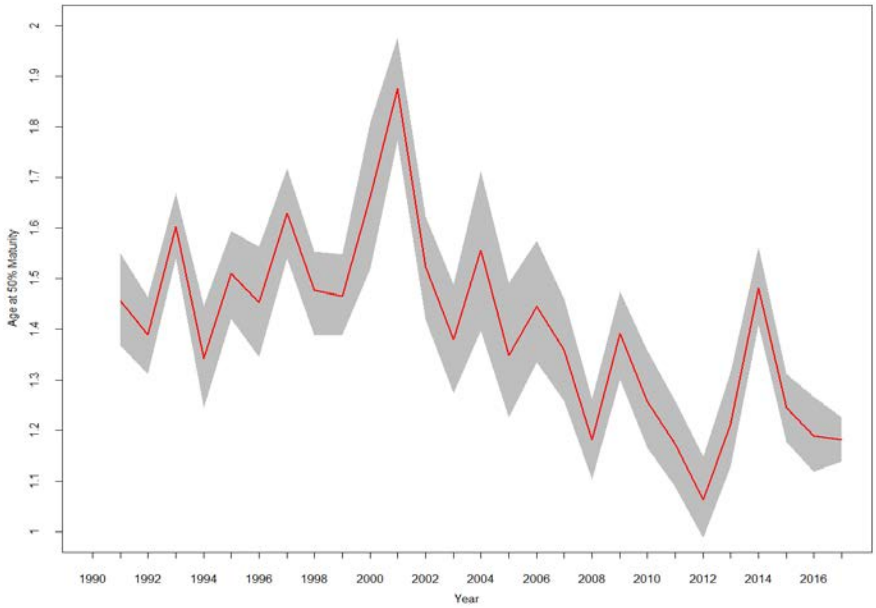

Figure 2: Whiting in Subarea 4 and Division 7d. Time series of Age at 50% maturity, the shaded area represents the bootstrapped 95%CI.

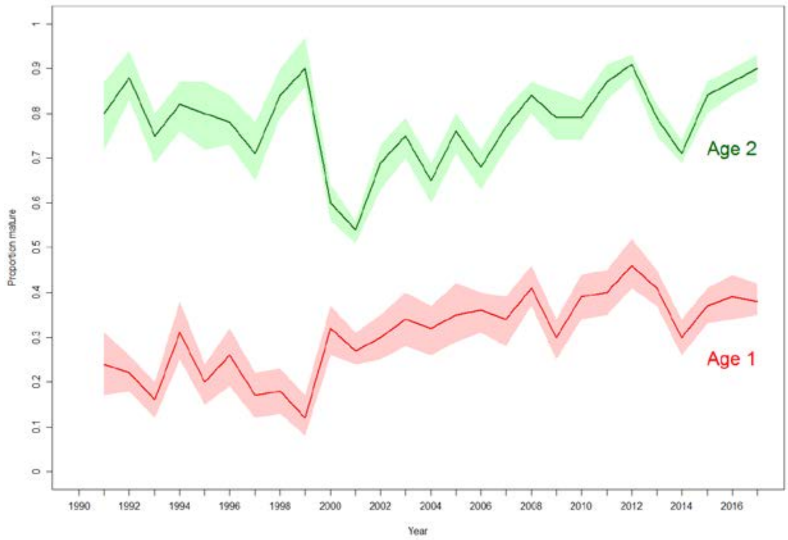

Figure 3: Whiting in Subarea 4 and Division 7d. Proportion mature at age 1 and age 2, the shaded area represent the 95% CI.

Temporal and regional effects on maturation

The best fit was provided by a model including an age effect, a year effect and region effect (North, South; **Figure 1**) as well as their interactions (**Table 3**).

Table 3: Analysis of deviance for the glm fit of maturity data with year and regional effects.

	Df	Deviance	Residual Df	Residual Deviance	Likelihood Ratio Test (*p*)
Null model			63851	98632	
Age	1	36371	63850	62262	**<0.0001**
Year	26	1720	63824	60542	**<0.0001**
Region	1	13	63823	60529	**0.0002**
Age x Year	26	1374	63797	59155	**<0.0001**
Age x Region	1	1255	63796	57900	**<0.0001**
Year x Region	26	402	63770	57498	**<0.0001**
Age x Year x Region	26	217	63744	57282	**<0.0001**

The midpoint of the maturity ogive, A50, showed a slow decrease over the time series in the Northern region, being 1.5 years at the start and 1.3 years at the end (**Figure 4**). In the Southern region, A50 was a lot more variable and shows a clear decrease in the second part of the time series, to an age of 1 year (**Figure 4**). If we now consider the age-specific ogives, the proportions mature at age 1 in the North showed a 5% increase in the second part of the time series, from 20% to 25% mature (**Figure 5**). In the South, there was a 20% increase in the proportion age 1 mature, from 30% to 50% (**Figure 5**). For age 2 fish, the proportion mature was similar at the start and the end of the time-series in both areas but showing a drop in the early 2000s with a subsequent increase.

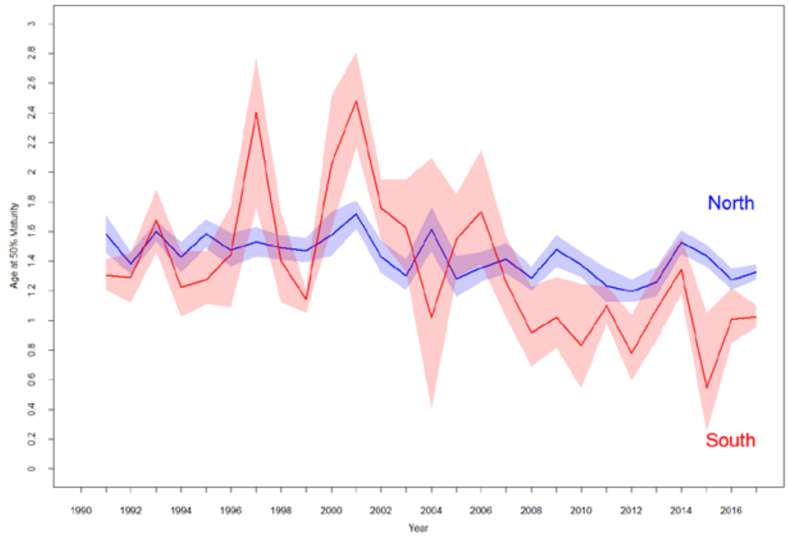

Figure 4: Time series of Age at 50% maturity for the Northern and Southern regions, the shaded areas represent the bootstrapped 95%CI.

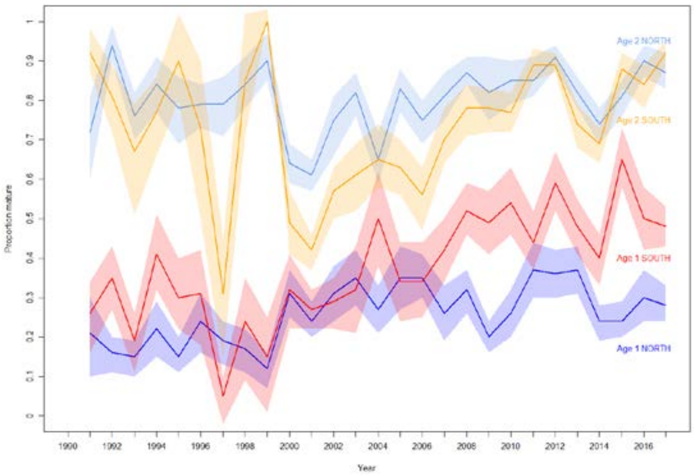

Figure 5: Proportions mature at age 1 and age 2 for the Northern and Southern regions, the shaded areas represent the 95% CI.

Composite maturity ogive

To account for variations in catch rate among regions (**Figure 6**), a composite maturity ogive was calculated for each year using the product of the individual statistical weight (w_i) and the region-specific weighting factor ($w_{R,y}$) as the final individual weighting.

The regional weights incorporate the average regional catch rate and the relative area of each region (**Figure 7**). In recent years the weighting of the southern component increased due to higher catch rates from the area.

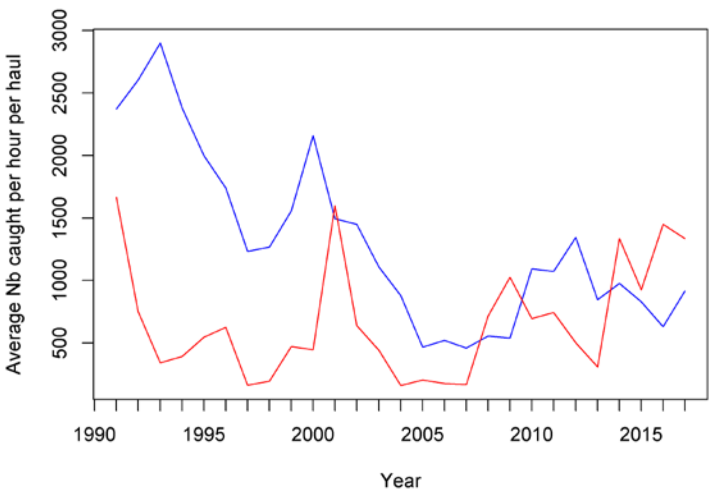

Figure 6: Whiting in Subarea 4 and Division 7d. Average catch rate (in number of fish per hour per haul) in hauls from the Southern (red) and Northern (blue) region.

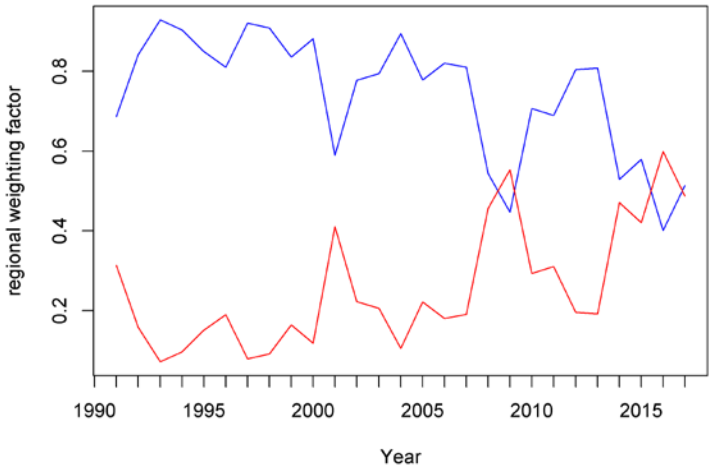

Figure 7: Whiting in Subarea 4 and Division 7d. Regional weighting factor, $w_{R,y}$, for Southern (red) and Northern (blue) region based on regional catch rates.

While slight variations from **Figures 2** and **3** can be observed, age at 50% maturation (**Figure 8**) and the proportions of age 1 and age 2 fish that matured (**Figure 9**) followed a similar pattern. The downward trend in age at maturity remains in the weighted combined ogive with some reduction in interannual variability due to a generally lower weighting of the southern component in the historic time series.

The stronger effect of the southern component in recent years on the proportion mature at age 1 (**Figure 9**) is due to the higher catch rates in the south (**Figure 7**). The proportion mature at age 1 per region are compared to the combined value for the North Sea in **Figure 10a**. We can see that the increase in mature proportion occurred in both North and South, only in recent years the continued increase can be attributed to a stronger effect from the South due to its higher catch rates in these years. Similarly, the age at 50% maturity (A50) shows a dominance of the northern North Sea on the combined ogive for most of the time series (Figure 10b). In recent years, higher catch rates from the South caused the combined ogive to be lower than the northern one.

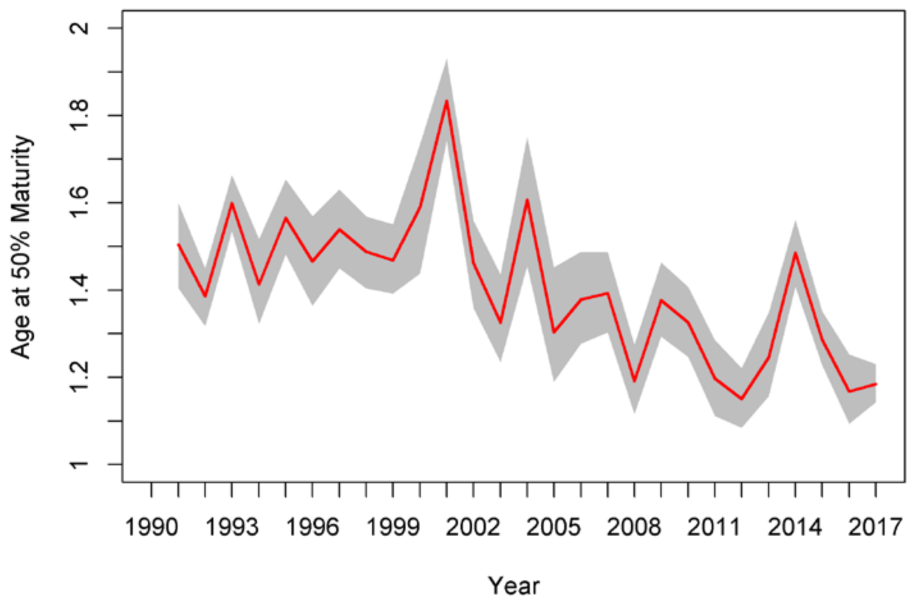

Figure 8: Whiting in Subarea 4 and Division 7d. Time series of Age at 50% maturity calculated using region-specific weight, the shaded area represents the bootstrapped 95%CI.

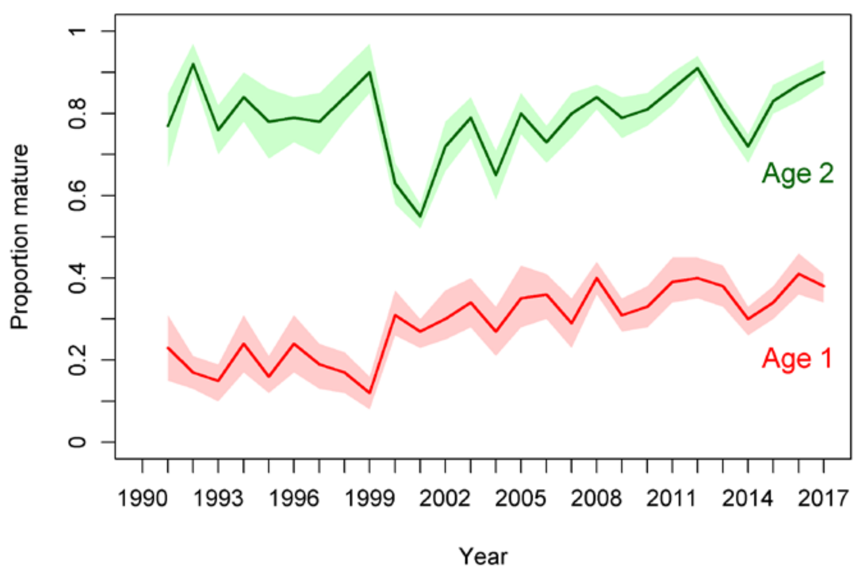

Figure 9: Whiting in Subarea 4 and Division 7d. Proportion mature at age 1 and age 2 calculated using region-specific weight, the shaded area represent the 95% CI.

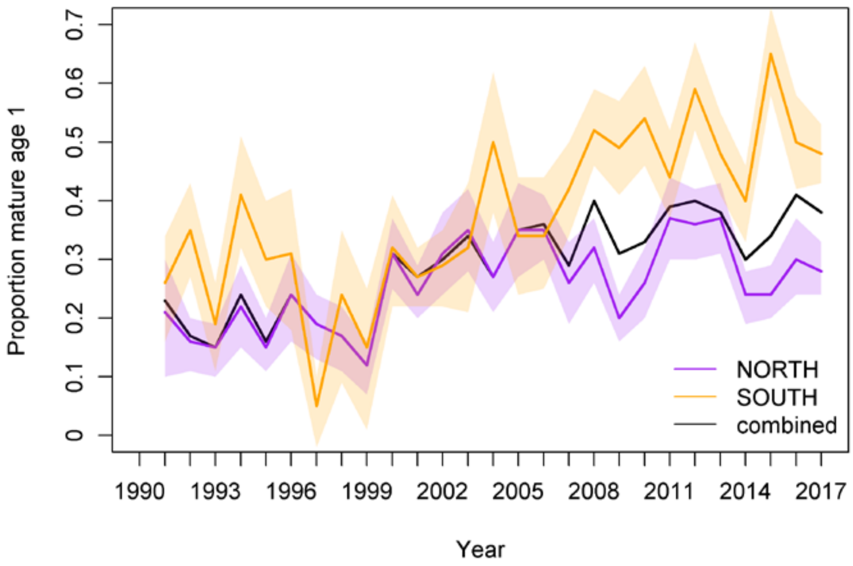

Figure 10a: Whiting in Subarea 4 and Division 7d. Proportion mature at age 1 for NORTH (orange) and SOUTH (purple) and the combined proportion for the North Sea (calculated using region-specific weights), the shaded area represent the 95% CI.

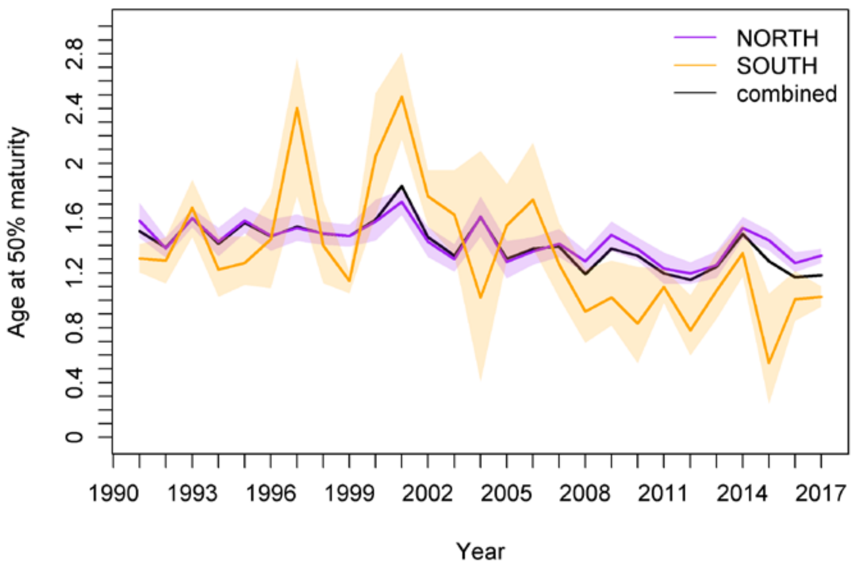

Figure 10b: Whiting in Subarea 4 and Division 7d. Age at 50% maturity for NORTH (orange) and SOUTH (purple) and the combined value for the North Sea (calculated using region-specific weights), the shaded area represent the 95% CI.

Combined raw and smoothed time series

Raw and smoothed data for the period 1991-2017 estimated for each age class separately are illustrated in **Figure 11**. Smoothed values had an upper limit of 1. The estimate of proportion matures for ages 6, 7 and 8 are similar around 1 across the time series and grouped in a plus group (**Figure 12**). Raw values and smoothed values are listed for 1991-2017 in **Table 5** and **Table 6 (Appendix)**, respectively.

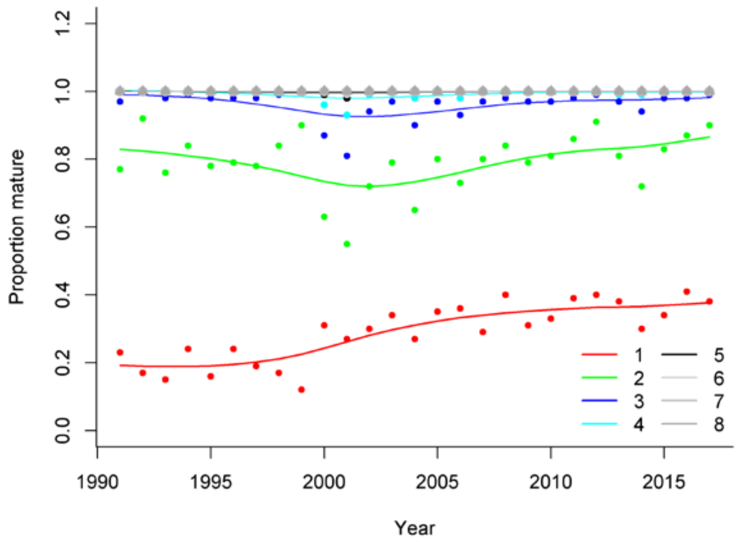

Figure 11: Whiting in Subarea 4 and Division 7d. Proportion mature at age for the combined area, raw estimates (dots) and smoothed values (lines).

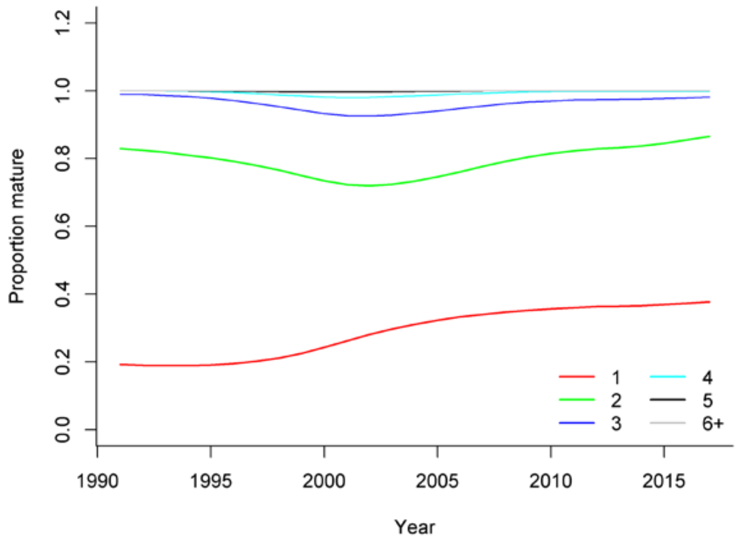

Figure 12: Whiting in Subarea 4 and Division 7d. Proportion mature at age for the combined area, smoothed values (lines) and with plusgroup containing ages 6, 7, 8.

Raw and smoothed estimated maturity time series by area (North, South)

Raw and smoothed data for the period 1991-2017 estimated for each age class and area separately are illustrated in **Figure 13** for North and **Figure 15** for South. Smoothed values had an upper limit of 1. The estimate of proportion matures for ages 6, 7 and 8 are similar around 1 across the time series and grouped in a plus group 6+ for area North (**Figure 13**). Raw estimates and smoothed values are listed for 1991-2017 in **Tables 7-10** in the Appendix.

Comparing the combined and regional maturity ogives, we find that ogives are generally determined by the North due to higher weighting in the historic time series. In particular, the proportion mature of older fish (age 2+) in the combined ogive closely follows trends in the northern component. An increase in the proportion mature age 1 fish is evident in the early 2000s in both regions. Only the further increase in the proportion of mature age 1 fish in the recent 4 years is caused by the southern component due to higher catch rates increase in proportion mature at age 1 (**Figure 6, 7**).

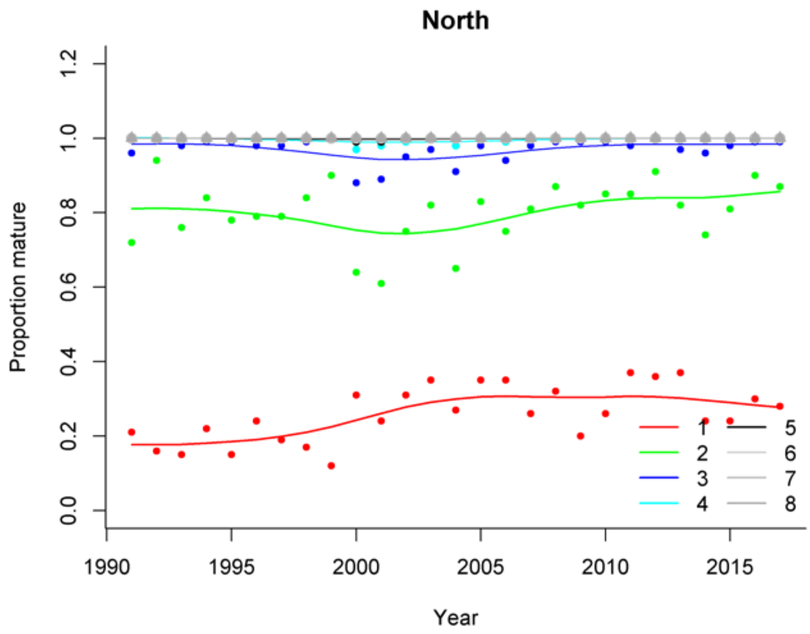

Figure 13: Proportion mature at age for the North area, raw estimated values (dots) and smoothed values (lines).

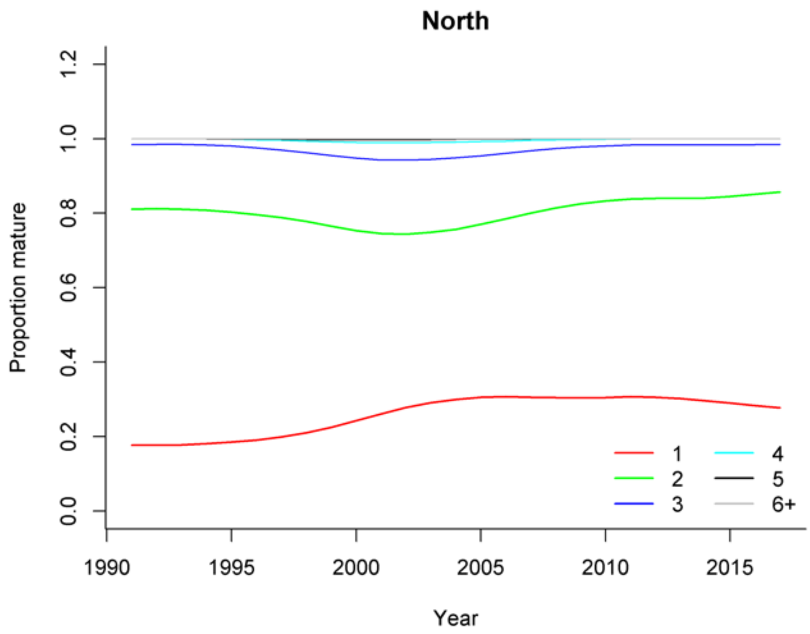

Figure 14: Proportion mature at age for the North area, smoothed values (lines) and with plusgroup 6+ containing ages 6, 7, 8.

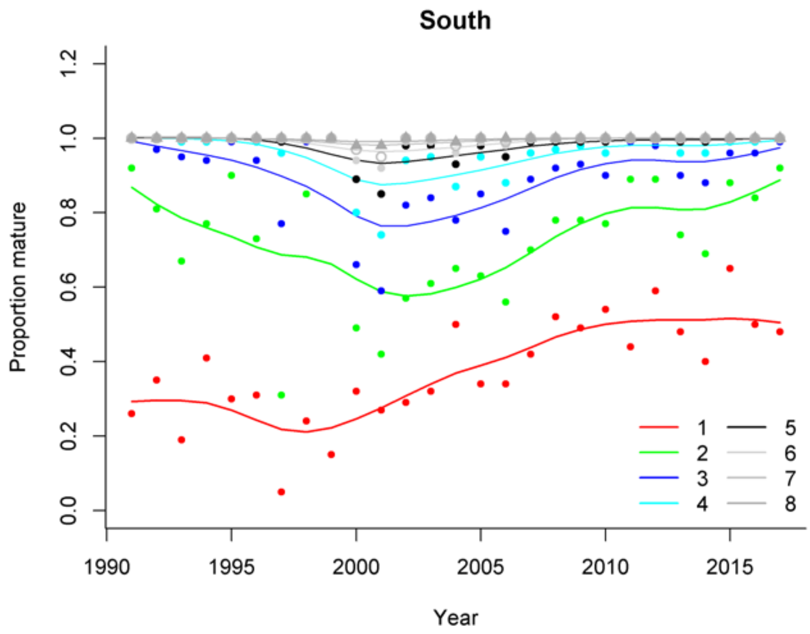

Figure 15: Proportion mature at age for the South area, estimated raw values smoothed values (lines).

4. Conclusions

This document highlights the need to update the maturity ogive currently used for whiting assessment as it has significantly changed since the 1980s when the current maturity ogive was produced. Without considering spatial variations, maturity in whiting occurred at an earlier age, as 35% of age 1 fish were mature in Quarter 1 in recent years while only 11% were assumed to be mature according to the currently used old maturity ogive.

When considering the sub-regions highlighted by Holmes *et al.* (2014), significant differences in the maturation schedule were found. In particular, the high rate of decrease in age at maturity observed in the Southern sub-region highlights the need to consider spatial variation, possibly at an even smaller scale. To account for spatial difference in maturity ogives, we produced a combined ogive for the two regions proposed by Holmes et al. (2014) using a regional-specific weighting by catch rate and area size. Other variables such as sex and body size were not considered here but deserve further work.

The stronger effect of the southern component on the maturity ogive in recent years is due to the higher catch rates in the area. This can be illustrated in particular for age 1 fish in the south, for which higher catch rates of age 1 whiting have been observed in recent years (**Figure 17**, Appendix).

Further work is needed comparing raw and smoothed data series. Using smoothed time series of proportions mature of age 1, 2 and 3 fish (e.g. **Figure 3**) applying a simple GAM as described in the report of the Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK 2017) or using a moving average as described in the report of the ICES Working Group on Maturity Ogive Estimation for Stock Assessment (ICES WKMOG report 2008) is recommended.

Variability in A50 and maturity ogives was higher prior to 1991 (Appendix). In 1989 and 1990 appear to be erroneous. Therefore, maturity ogives prior to 1991 were assumed to be constant using the values of 1991.

5. References

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6. Appendix

Data tables

Table 5: Proportion mature at age raw estimated values for combined area..

Year/Age	1	2	3	4	5	6	7	8
1991	0.23	0.77	0.97	1	1	1	1	1
1992	0.17	0.92	1	1	1	1	1	1
1993	0.15	0.76	0.98	1	1	1	1	1
1994	0.24	0.84	0.99	1	1	1	1	1
1995	0.16	0.78	0.98	1	1	1	1	1
1996	0.24	0.79	0.98	1	1	1	1	1
1997	0.19	0.78	0.98	1	1	1	1	1
1998	0.17	0.84	0.99	1	1	1	1	1
1999	0.12	0.90	1	1	1	1	1	1
2000	0.31	0.63	0.87	0.96	0.99	1	1	1
2001	0.27	0.55	0.81	0.93	0.98	0.99	1	1
2002	0.30	0.72	0.94	0.99	1	1	1	1
2003	0.34	0.79	0.97	1	1	1	1	1
2004	0.27	0.65	0.90	0.98	1	1	1	1
2005	0.35	0.80	0.97	1	1	1	1	1
2006	0.36	0.73	0.93	0.98	1	1	1	1
2007	0.29	0.80	0.97	1	1	1	1	1
2008	0.40	0.84	0.98	1	1	1	1	1
2009	0.31	0.79	0.97	1	1	1	1	1
2010	0.33	0.81	0.97	1	1	1	1	1
2011	0.39	0.86	0.98	1	1	1	1	1
2012	0.40	0.91	0.99	1	1	1	1	1
2013	0.38	0.81	0.97	0.99	1	1	1	1
2014	0.03	0.72	0.94	0.99	1	1	1	1
2015	0.34	0.83	0.98	1	1	1	1	1
2016	0.41	0.87	0.98	1	1	1	1	1
2017	0.38	0.90	0.99	1	1	1	1	1

Table 6: Proportion mature at age smoothed estimated values for combined area.

Year/Age	1	2	3	4	5	6	7	8
1991	0.192	0.83	0.990	1	1	1	1	1
1992	0.190	0.824	0.989	1	1	1	1	1
1993	0.189	0.818	0.986	1	1	1	1	1
1994	0.189	0.810	0.983	0.999	1	1	1	1
1995	0.191	0.802	0.978	0.997	0.999	1	1	1
1996	0.195	0.792	0.971	0.995	0.999	1	1	1
1997	0.202	0.780	0.963	0.992	0.998	1	1	1
1998	0.211	0.766	0.953	0.988	0.997	1	1	1
1999	0.225	0.750	0.943	0.985	0.996	1	1	1
2000	0.243	0.734	0.933	0.982	0.996	1	1	1
2001	0.262	0.723	0.927	0.980	0.996	1	1	1
2002	0.281	0.720	0.926	0.981	0.996	1	1	1
2003	0.297	0.724	0.928	0.983	0.997	1	1	1
2004	0.311	0.733	0.934	0.985	0.998	1	1	1
2005	0.323	0.746	0.940	0.988	0.998	1	1	1
2006	0.333	0.761	0.948	0.991	0.999	1	1	1
2007	0.340	0.777	0.955	0.993	1	1	1	1
2008	0.347	0.792	0.962	0.995	1	1	1	1
2009	0.352	0.805	0.967	0.997	1	1	1	1
2010	0.356	0.815	0.970	0.998	1	1	1	1
2011	0.360	0.823	0.973	0.998	1	1	1	1
2012	0.363	0.829	0.974	0.998	1	1	1	1
2013	0.364	0.832	0.975	0.998	1	1	1	1
2014	0.366	0.837	0.976	0.998	1	1	1	1
2015	0.369	0.845	0.977	0.998	1	1	1	1
2016	0.373	0.855	0.979	0.998	1	1	1	1
2017	0.377	0.866	0.982	0.999	1	1	1	1

Table 7: Proportion mature at age, raw estimated values for area North.

Year/Age	1	2	3	4	5	6	7	8
1991	0.21	0.72	0.96	1	1	1	1	1
1992	0.16	0.94	1	1	1	1	1	1
1993	0.15	0.76	0.98	1	1	1	1	1
1994	0.22	0.84	0.99	1	1	1	1	1
1995	0.15	0.78	0.99	1	1	1	1	1
1996	0.24	0.79	0.98	1	1	1	1	1
1997	0.19	0.79	0.98	1	1	1	1	1
1998	0.17	0.84	0.99	1	1	1	1	1
1999	0.12	0.90	1	1	1	1	1	1
2000	0.31	0.64	0.88	0.97	0.99	1	1	1
2001	0.24	0.61	0.89	0.98	0.99	1	1	1
2002	0.31	0.75	0.95	0.99	1	1	1	1
2003	0.35	0.82	0.97	1	1	1	1	1
2004	0.27	0.65	0.91	0.98	1	1	1	1
2005	0.35	0.83	0.98	1	1	1	1	1
2006	0.35	0.75	0.94	0.99	1	1	1	1
2007	0.26	0.81	0.98	1	1	1	1	1
2008	0.32	0.87	0.99	1	1	1	1	1
2009	0.20	0.82	0.99	1	1	1	1	1
2010	0.26	0.85	0.99	1	1	1	1	1
2011	0.37	0.85	0.98	1	1	1	1	1
2012	0.36	0.91	1	1	1	1	1	1
2013	0.37	0.82	0.97	1	1	1	1	1
2014	0.24	0.74	0.96	1	1	1	1	1
2015	0.24	0.81	0.98	1	1	1	1	1
2016	0.30	0.90	0.99	1	1	1	1	1
2017	0.28	0.87	0.99	1	1	1	1	1

Table 8: Proportion mature at age smoothed values for area North.

Year/Age	1	2	3	4	5	6	7	8
1991	0.177	0.811	0.984	1	1	1	1	1
1992	0.177	0.812	0.985	1	1	1	1	1
1993	0.178	0.811	0.985	1	1	1	1	1
1994	0.181	0.808	0.983	1	1	1	1	1
1995	0.185	0.803	0.981	0.999	0.999	1	1	1
1996	0.191	0.796	0.976	0.997	0.999	1	1	1
1997	0.199	0.788	0.970	0.996	0.999	1	1	1
1998	0.210	0.778	0.963	0.994	0.998	1	1	1
1999	0.225	0.765	0.955	0.992	0.997	1	1	1
2000	0.243	0.753	0.948	0.990	0.997	1	1	1
2001	0.261	0.745	0.943	0.989	0.997	1	1	1
2002	0.278	0.744	0.943	0.989	0.997	1	1	1
2003	0.291	0.749	0.945	0.990	0.998	1	1	1
2004	0.300	0.757	0.949	0.991	0.999	1	1	1
2005	0.306	0.770	0.954	0.993	0.999	1	1	1
2006	0.307	0.785	0.961	0.994	0.999	1	1	1
2007	0.306	0.800	0.968	0.996	1	1	1	1
2008	0.305	0.814	0.974	0.997	1	1	1	1
2009	0.304	0.825	0.978	0.998	1	1	1	1
2010	0.305	0.833	0.981	0.999	1	1	1	1
2011	0.307	0.838	0.983	1	1	1	1	1
2012	0.306	0.840	0.983	1	1	1	1	1
2013	0.302	0.840	0.983	1	1	1	1	1
2014	0.296	0.841	0.983	1	1	1	1	1
2015	0.290	0.845	0.983	1	1	1	1	1
2016	0.283	0.851	0.984	1	1	1	1	1
2017	0.277	0.857	0.985	1	1	1	1	1

Table 9: Proportion mature at age, raw estimated values for area South.

Year/Age	1	2	3	4	5	6	7	8
1991	0.26	0.92	1	1	1	1	1	1
1992	0.35	0.81	0.97	1	1	1	1	1
1993	0.19	0.67	0.95	0.99	1	1	1	1
1994	0.41	0.77	0.94	0.99	1	1	1	1
1995	0.30	0.90	0.99	1	1	1	1	1
1996	0.31	0.73	0.94	0.99	1	1	1	1
1997	0.05	0.31	0.77	0.96	0.99	1	1	1
1998	0.24	0.85	0.99	1	1	1	1	1
1999	0.15	1	1	1	1	1	1	1
2000	0.32	0.49	0.66	0.8	0.89	0.94	0.97	0.98
2001	0.27	0.42	0.59	0.74	0.85	0.92	0.95	0.98
2002	0.29	0.57	0.82	0.94	0.98	0.99	1	1
2003	0.32	0.61	0.84	0.95	0.98	0.99	1	1
2004	0.50	0.65	0.78	0.87	0.93	0.96	0.98	0.99
2005	0.34	0.63	0.85	0.95	0.98	0.99	1	1
2006	0.34	0.56	0.75	0.88	0.95	0.98	0.99	1
2007	0.42	0.70	0.89	0.96	0.99	1	1	1
2008	0.52	0.78	0.92	0.97	0.99	1	1	1
2009	0.49	0.78	0.93	0.98	0.99	1	1	1
2010	0.54	0.77	0.90	0.96	0.99	1	1	1
2011	0.44	0.89	0.99	1	1	1	1	1
2012	0.59	0.89	0.98	1	1	1	1	1
2013	0.48	0.74	0.90	0.96	0.99	1	1	1
2014	0.40	0.69	0.88	0.96	0.99	1	1	1
2015	0.65	0.88	0.96	0.99	1	1	1	1
2016	0.50	0.84	0.96	0.99	1	1	1	1
2017	0.48	0.92	0.99	1	1	1	1	1

Table 10: Proportion mature at age, smoothed values for area South.

Year/Age	1	2	3	4	5	6	7	8
1991	0.293	0.868	0.992	1	1	1	1	1
1992	0.296	0.823	0.979	1	1	1	1	1
1993	0.295	0.786	0.967	0.999	1	1	1	1
1994	0.289	0.760	0.955	0.997	1	1	1	1
1995	0.270	0.736	0.941	0.993	1	1	1	1
1996	0.243	0.708	0.922	0.984	0.996	0.999	0.999	0.999
1997	0.218	0.687	0.898	0.969	0.987	0.994	0.997	0.998
1998	0.211	0.681	0.871	0.948	0.974	0.987	0.993	0.996
1999	0.222	0.662	0.834	0.919	0.957	0.977	0.988	0.994
2000	0.246	0.622	0.791	0.889	0.941	0.968	0.983	0.991
2001	0.276	0.588	0.764	0.875	0.933	0.964	0.982	0.991
2002	0.308	0.576	0.764	0.879	0.937	0.966	0.984	0.992
2003	0.340	0.582	0.776	0.890	0.945	0.971	0.987	0.994
2004	0.369	0.599	0.793	0.902	0.953	0.976	0.990	0.996
2005	0.390	0.622	0.813	0.915	0.962	0.982	0.993	0.997
2006	0.411	0.653	0.837	0.929	0.970	0.988	0.995	0.999
2007	0.438	0.693	0.866	0.945	0.979	0.993	0.997	1
2008	0.466	0.736	0.894	0.959	0.985	0.997	0.999	1
2009	0.487	0.771	0.916	0.970	0.990	0.999	1	1
2010	0.501	0.798	0.932	0.977	0.993	1	1	1
2011	0.508	0.813	0.941	0.981	0.995	1	1	1
2012	0.512	0.814	0.941	0.982	0.996	1	1	1
2013	0.512	0.808	0.937	0.980	0.996	1	1	1
2014	0.513	0.810	0.938	0.981	0.996	1	1	1
2015	0.516	0.829	0.946	0.984	0.997	1	1	1
2016	0.513	0.856	0.959	0.989	0.999	1	1	1
2017	0.505	0.888	0.975	0.995	1	1	1	1

Preliminary comparison of maturity ogives by area North, South, Kattegat/Skagerrak

The assessment of North Sea and Area 3a (Skagerrak, Kattegat) are currently run separately. Preliminary analysis of maturity ogives shows a significant difference between North Sea and Skagerrak/Kattegat. Individuals in area 3a mature later, with lower proportions of mature fish at ages 1 to 3. It is therefore suggested that area 3a should not be joined with North Sea Assessment at this this stage.

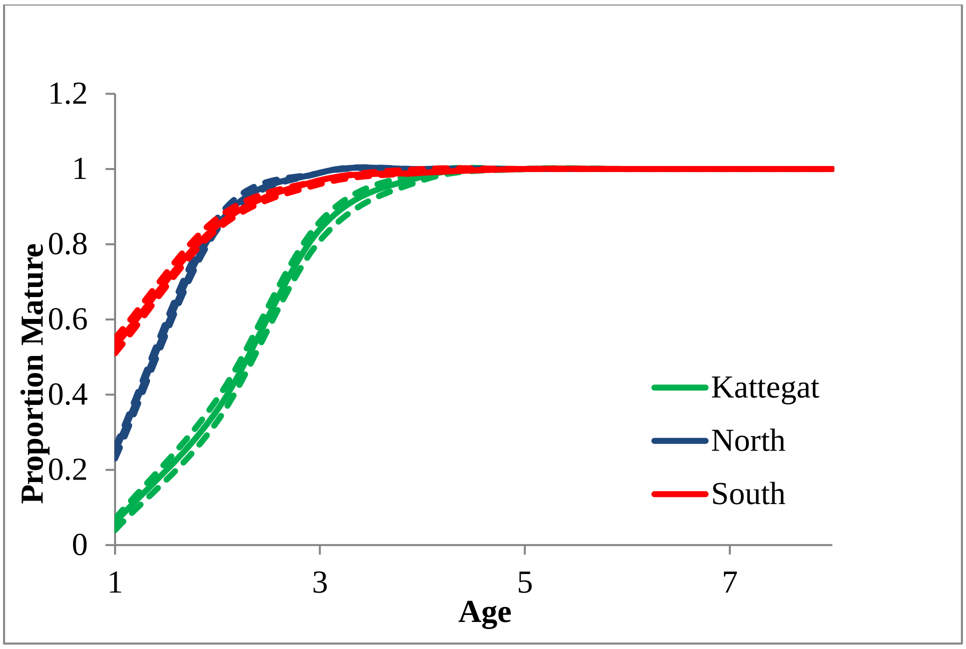

Figure 16: Proportion mature at age for Skagerrak/Kattegat (green), northern (blue) and southern (red) component.

Table 4: Age at 50% maturity (A50) in the most recent 5 years with 95% Confidence Interval.

Region	A50	lower	upper
Kattegat/Skagerrak	2.262	2.207	2.312
North	1.391	1.370	1.412
South	0.931	0.878	0.983

Spatial survey CPUE plots

Figure 17: Whiting in Subarea 4 and Division 7d. Survey distribution maps for ages 1–3+ Q1 2009–2017. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q1 survey in the North Sea.

Maturity ogives prior 1991

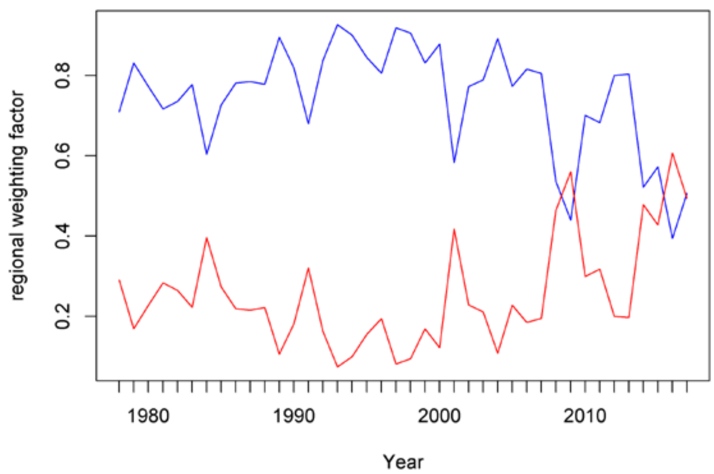

Figure 18: Whiting in Subarea 4 and Division 7d. Regional weighting factor, $w_{R,y}$, for Southern (red) and Northern (blue) region based on regional catch rates.

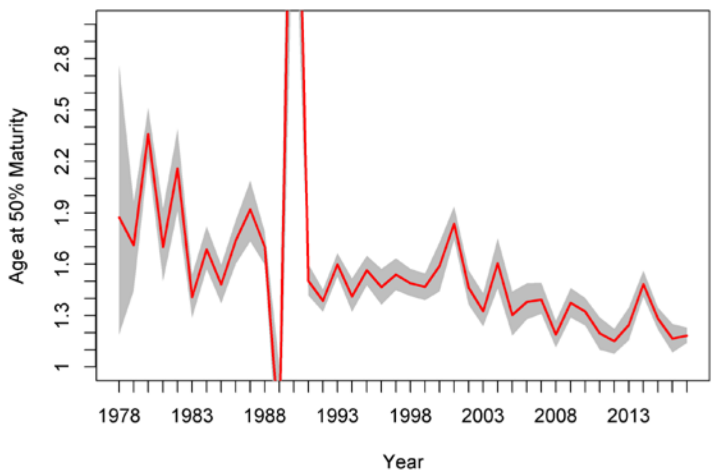

Figure 19: Whiting in Subarea 4 and Division 7d. Time series of Age at 50% maturity from 1978 onwards, the shaded area represents the bootstrapped 95%CI. Results in 1989 and 1990 indicate some error in the data.

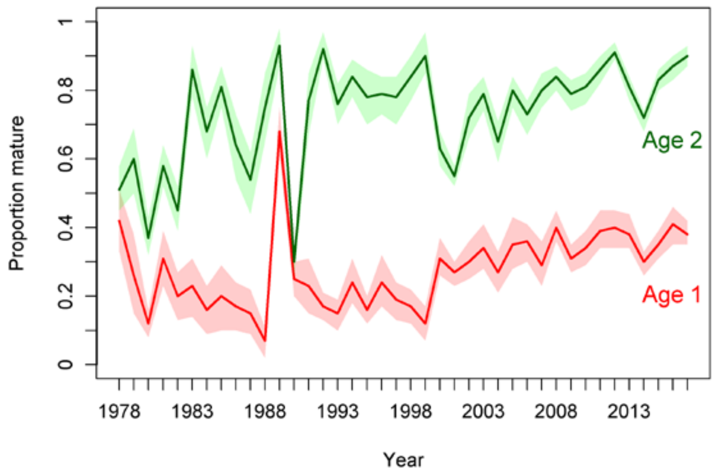

Figure 20: Whiting in Subarea 4 and Division 7d. Proportion mature at age 1 and age 2 calculated using region-specific weight, the shaded area represent the 95% CI.

WD 5 Survey indices for whiting in subarea 4 and division 7d

Tanja Miethe[1] and ICES (DATRAS data, provision of are specific indices by Vaishav Soni)

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1. Introduction

The North Sea International Bottom Trawl Survey (NS IBTS) is conducted annually, in quarter 1 and quarter 3. The surveys aim to provide consistent and standardized data which allow evaluation of spatial and temporal changes in the distribution and relative abundance of fish and of the biological parameters (maturity).

The IBTS initially started in the 1960s as a herring survey and was extended to cover gadoids in 1974. Since 1983 all nations participating in the survey were required to use GOV trawl. In 1991 survey effort was extended to quarter 3.

For whiting in Subarea 4 and Division 7d, North Sea IBTS survey in quarter 1 (1978-2017, age 1-5) and quarter 3 (1991-2017, age 0-5) were available. The abundance indices per age group were routinely calculated for the North Sea (Subarea 4) and the Eastern Channel (Division 7d) combined. For this benchmark also separate indices for a northern and a southern component were provided by ICES following the area definitions for substock structure suggested by Holmes *et al.* (2014).

2. Methods

The IBTS survey combines data from sampling survey stations of multiple vessels from national institutes by haul (Figure 1 for Q3, ICES (2017)). Q1 survey is undertaken in January to March (target month February), Q3 survey takes place in July to September (target month August). Biological data are collected including length, weight, sex and maturity and ageing material.

Each rectangle is sampled by two different countries, such that a minimum of two hauls per rectangle are taken. Some rectangles are surveyed by a single country in case a large proportion of the area is untrawlable (gear damage) or for other efficient, logistical purposes.

Indices are calculated by species-specific index area.

1) For each age the sum of CPUE per length and age and haul, per year, quarter and rectangle divided by the number of hauls per year, quarter and rectangle
2) Mean CPUE per index area at age then calculated as the sum of CPUE of all rectangles across index area divided by the number of rectangles

The combined survey index for NS whiting as provided by DATRAS for Q1 and Q3 are listed in Table 1 and Table 2, respectively. Indices for the Northern (Table 3, Table 4) and Southern substock (Table 5, Table 6) were given by quarter.

3. Results

Combined survey indices for the NS per age were plotted in Figure 2. Q1 and Q3 indices were similar in particular for age 1. For other age groups dynamics were similar, but in Q3 index values were lower. Smooth survey catch curves tracked year classes well. In some curves, age 1 had a lower CPUE than age 2 (Figure 3). There was a drop in index level in the early 2000s. Within survey correlations, comparing different ages of the same year class, showed good internal consistency for Q1 as well as Q3 (Figure 4, Figure 5). The log CPUE plots by survey (Figure 6) support the conclusion of good internal consistency.

Spatial CPUE maps for 2009-2017 per age (Figure 7, Figure 8) indicate an increase in CPUE at age 1 whiting in recent years, in particular in the southern North Sea. Survey indices were evaluated separately for northern and southern component. There was equally good consistency for the northern component in terms of survey index between quarters and correlations between age groups of cohorts (Figure 11, Figure 12, Figure 13). The index for the South component, however, showed less consistency between indices of Q1 and Q3 (Figure 14, Figure 16). Within survey correlations for the southern component in both Q1 and Q3 survey were mostly non-significant (Figure 17, Figure 18).

4. Conclusions

The NS IBTS Q1 and Q3 survey were found to be highly consistent when estimating abundance for the entire North Sea.

The evaluation by stock component (North, South) revealed that the survey was less consistent in tracking abundance in the Southern component. This could be due to the fact that the Southern component does not represent a stock entity. Potential connectivity with the northern component or additional substock structure within the South could affect the survey signals.

Survey indices for the North Sea were used for assessment using SAM, SURBAR and XSA as detailed in the respective working documents (WD 7, 8, 9). Additionally, the area-specific indices were used in SURBAR assessment to compare stock trends in the northern and southern stock components (WD 8).

5. Figures

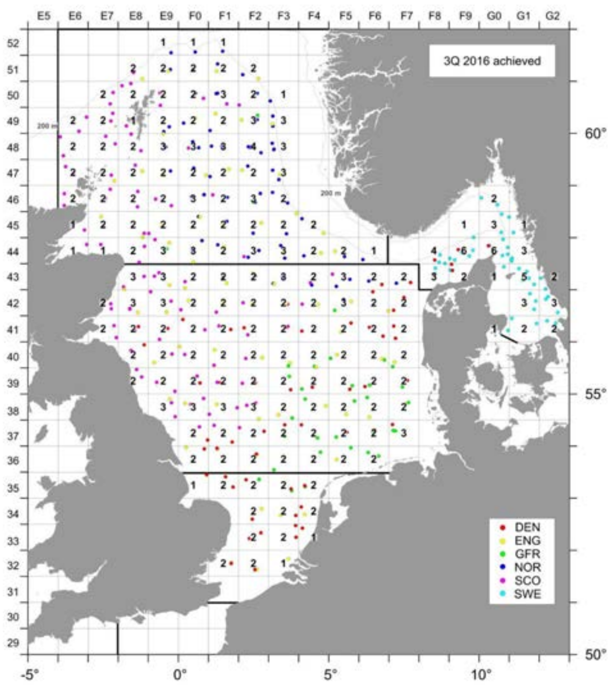

Figure 1 Whiting in Subarea 4 and Division 7d. Number and start position of hauls per ICES rectangle during NS-IBTS Q3 survey in 2016, taken from IBTSWG 2017.

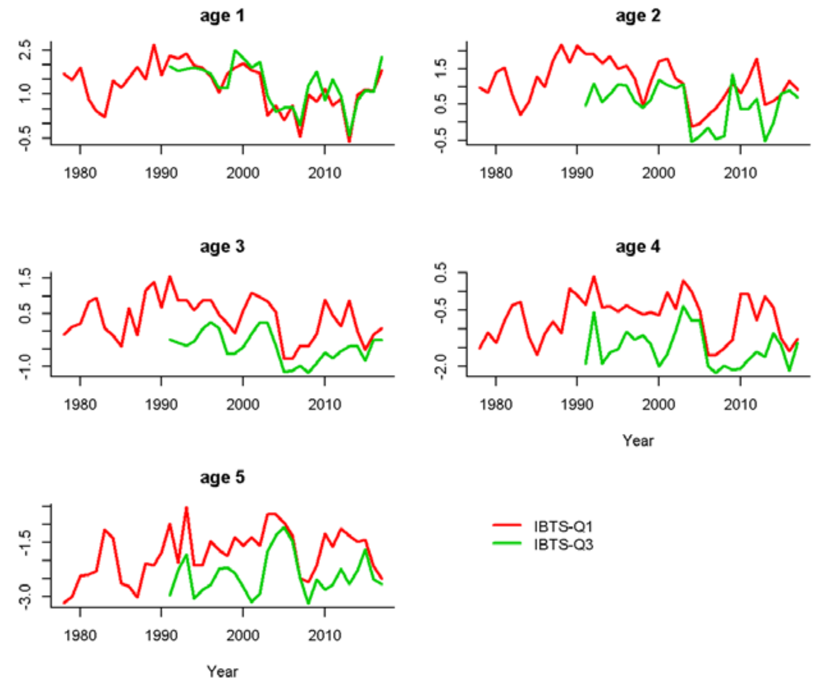

Figure 2 Whiting in Subarea 4 and Division 7d. Log survey index at age.

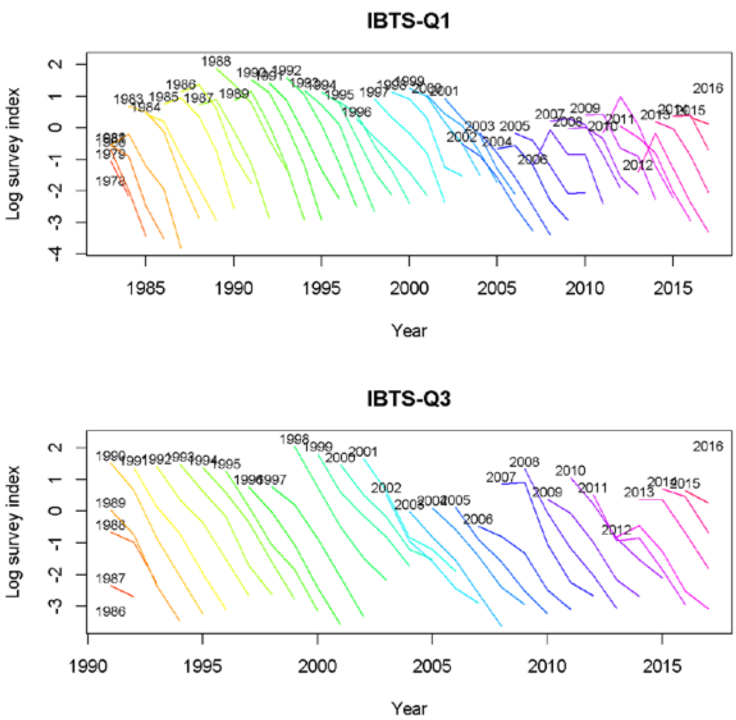

Figure 3 Whiting in Subarea 4 and Division 7d. Log survey index by cohort for each of the two survey indices, the spawning year is indicated at the start of the line.

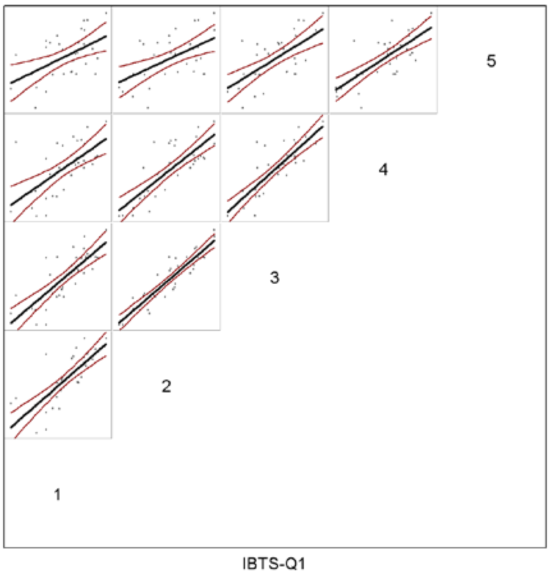

Figure 4 Whiting in Subarea 4 and Division 7d. Within survey correlations for IBTS Q1 survey, comparing indices for different ages of the same year class. In each plot, the straight line is the normal linear model fit: thick line (with black points) represents a significant model fit (p<0.05), while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are shown (red lines).

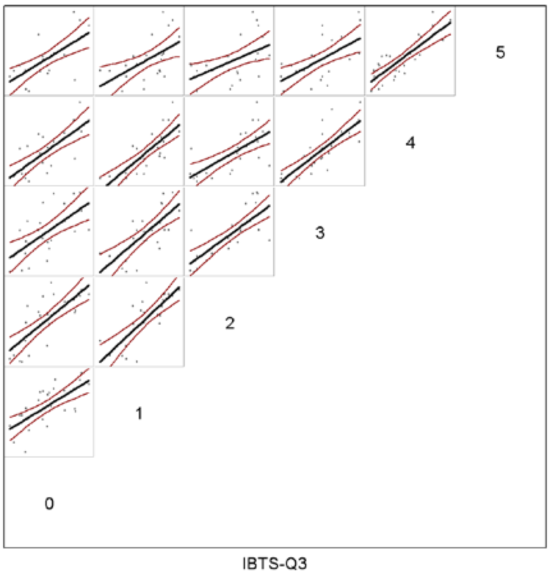

Figure 5 Whiting in Subarea 4 and Division 7d. Within survey correlations for IBTS Q3 survey, comparing indices for different ages of the same year class. In each plot, the straight line is the normal linear model fit: thick line (with black points) represents a significant model fit (p<0.05), while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are shown (red lines).

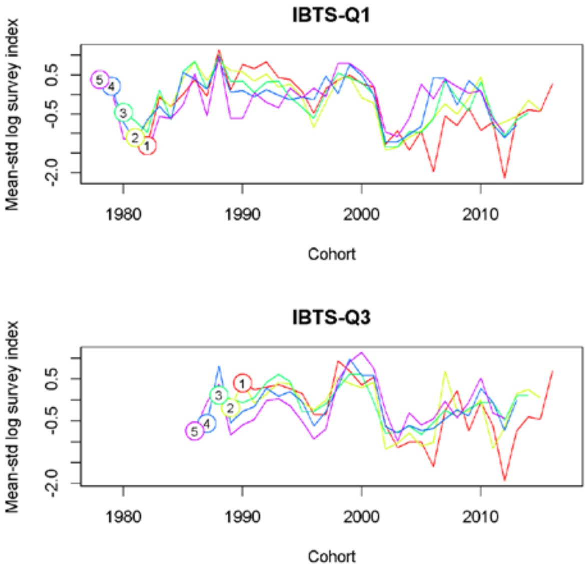

Figure 6 Whiting in Subarea 4 and Division 7d. Survey log CPUE for IBTS Q1 and Q3, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

Figure 7. Whiting in Subarea 4 and Division 7d. Survey distribution maps for ages 1–3+ Q1 2009–2017. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q1 survey in the North Sea.


Q3 2009: whiting age 0
Q3 2010: whiting age 0
Q3 2011: whiting age 0
Q3 2012: whiting age 0
Q3 2013: whiting age 0
Q3 2009: whiting age 1
Q3 2010: whiting age 1
Q3 2011: whiting age 1
Q3 2012: whiting age 1
Q3 2013: whiting age 1
Q3 2009: whiting age 2
Q3 2010: whiting age 2
Q3 2011: whiting age 2
Q3 2012: whiting age 2
Q3 2013: whiting age 2
Q3 2009: whiting age 3+
Q3 2010: whiting age 3+
Q3 2011: whiting age 3+
Q3 2012: whiting age 3+
Q3 2013: whiting age 3+
Survey Positions
Q3 2014: whiting age 0
Q3 2015: whiting age 0
Q3 2016: whiting age 0
Q3 2017: whiting age 0
Q3 2014: whiting age 1
Q3 2015: whiting age 1
Q3 2016: whiting age 1
Q3 2017: whiting age 1
Q3 2014: whiting age 2
Q3 2015: whiting age 2
Q3 2016: whiting age 2
Q3 2017: whiting age 2
Q3 2014: whiting age 3+
Q3 2015: whiting age 3+
Q3 2016: whiting age 3+
Q3 2017: whiting age 3+

Figure 8. Whiting in Subarea 4 and Division 7d. Survey distribution maps for ages 0–3+ Q3 1991–2017. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q3 survey in the North Sea.

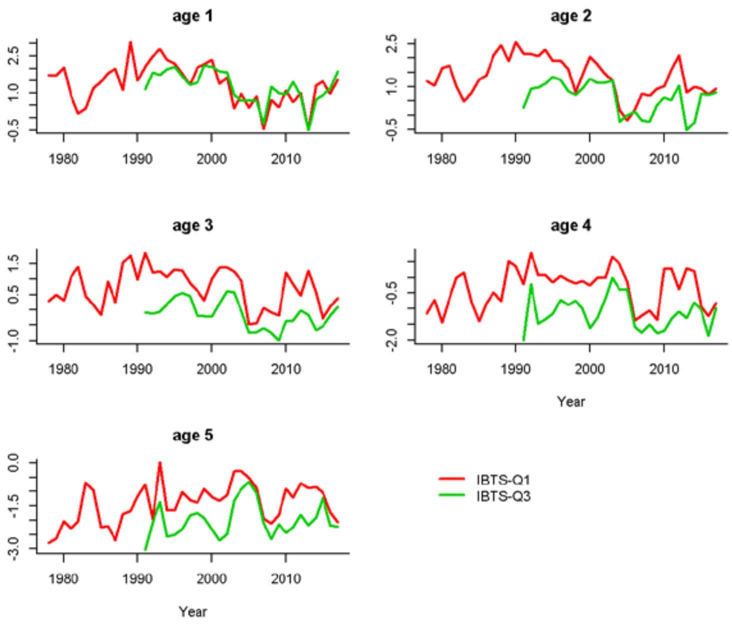

Figure 9 Northern component. Log survey index at age.

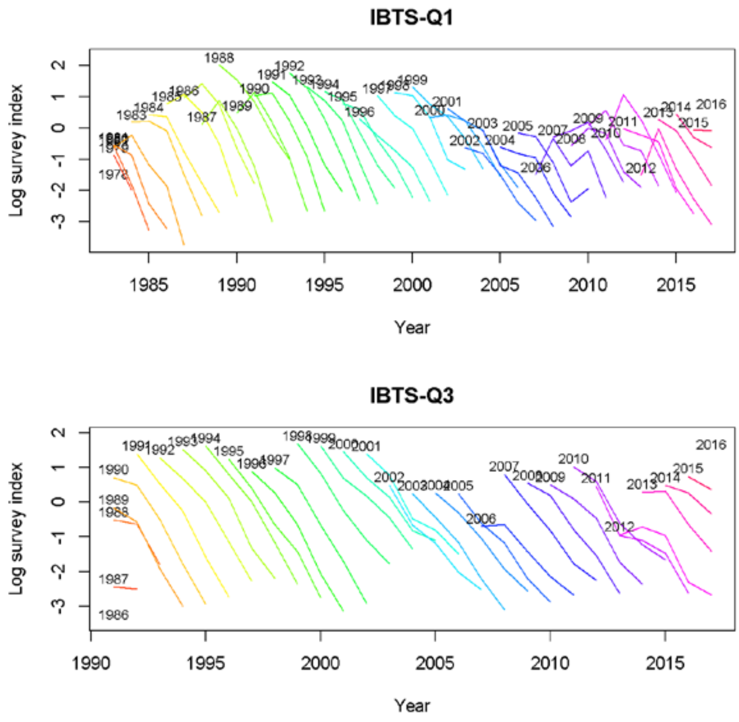

Figure 10 Northern component. Log survey index by cohort for each of the two survey indices, the spawning year is indicated at the start of the line.

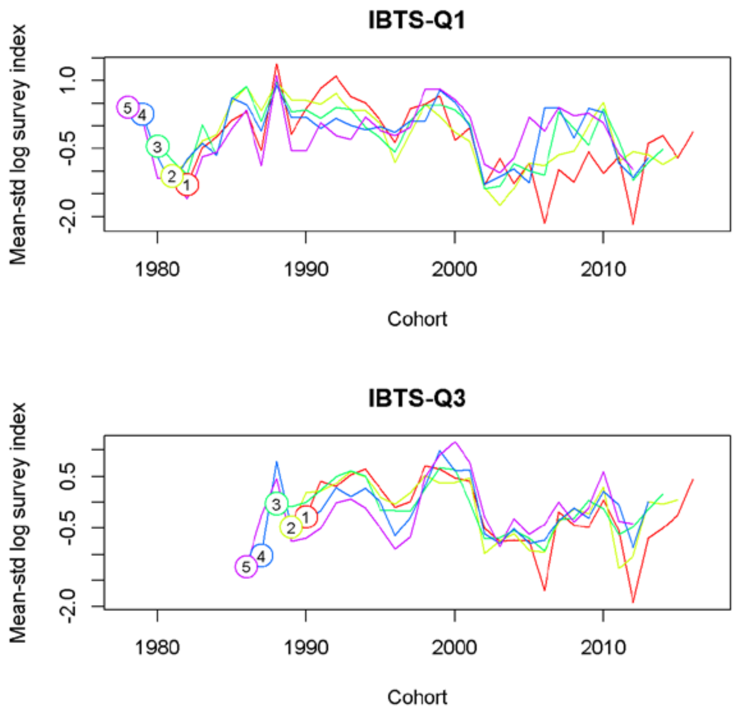

Figure 11 Northern component. Mean standardized log survey CPUE at age by cohort.

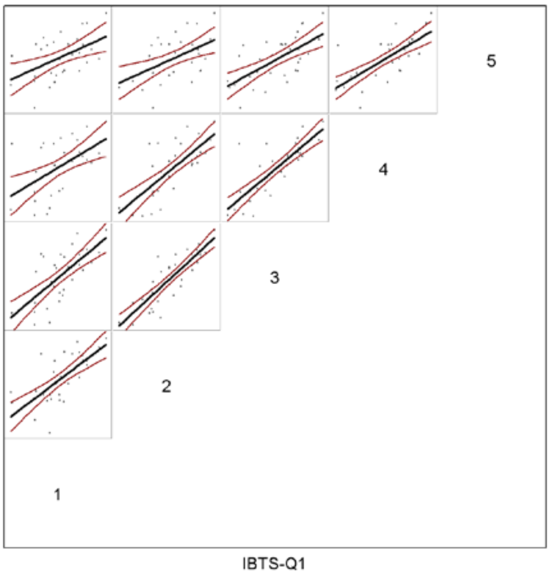

Figure 12 Northern component. Within survey correlations for IBTS Q1 survey, comparing indices for different ages of the same year class.

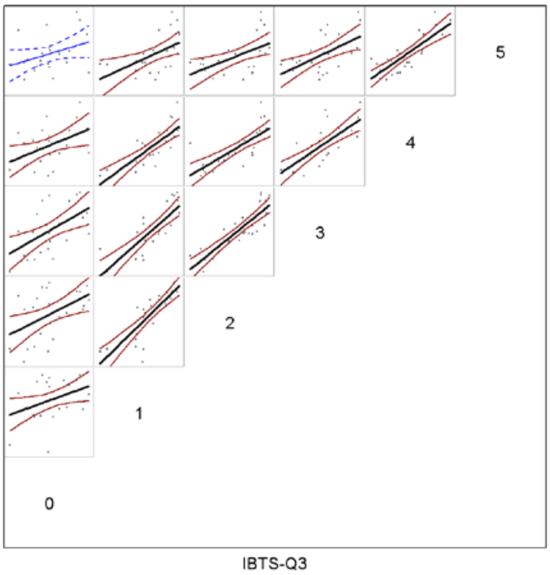

Figure 13 Northern component. Within survey correlations for IBTS Q3 survey, comparing indices for different ages of the same year class.

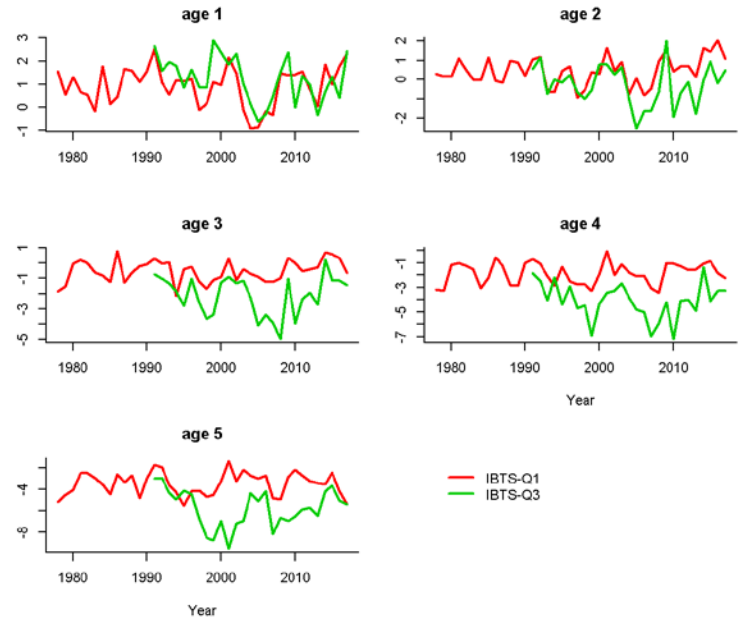

Figure 14. Southern component. Log survey index at age.

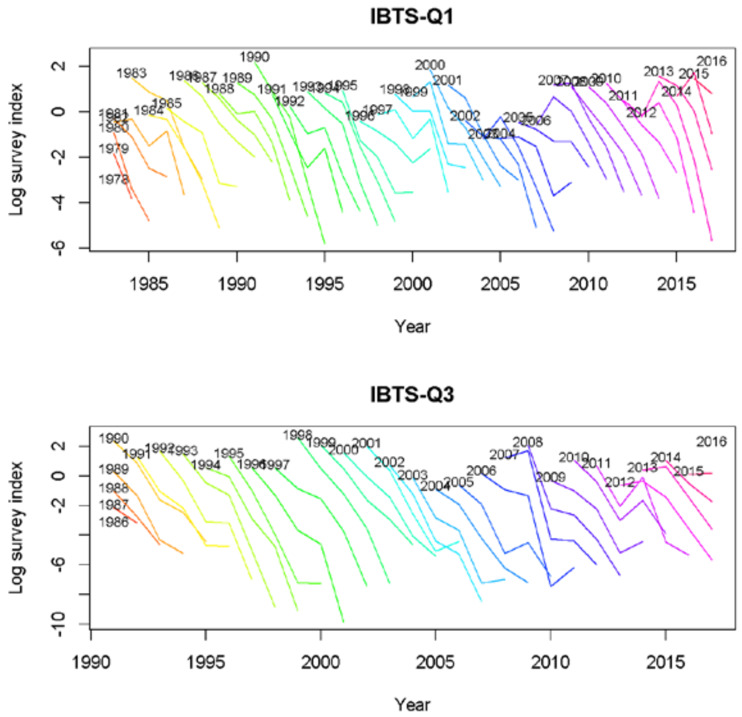

Figure 15 Southern component. Log survey index by cohort for each of the two survey indices, the spawning year is indicated at the start of the line.

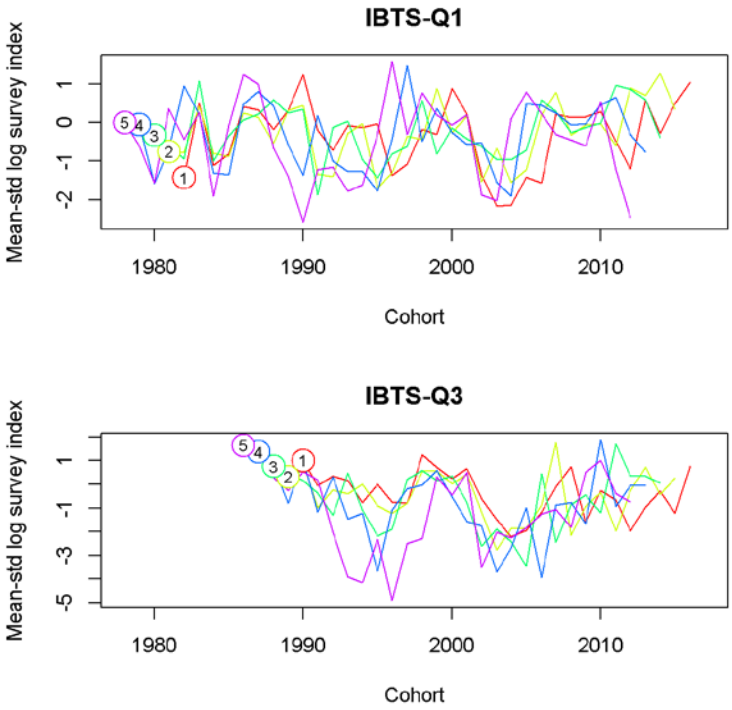

Figure 16 Southern component. Mean standardized log survey CPUE at age by cohort.

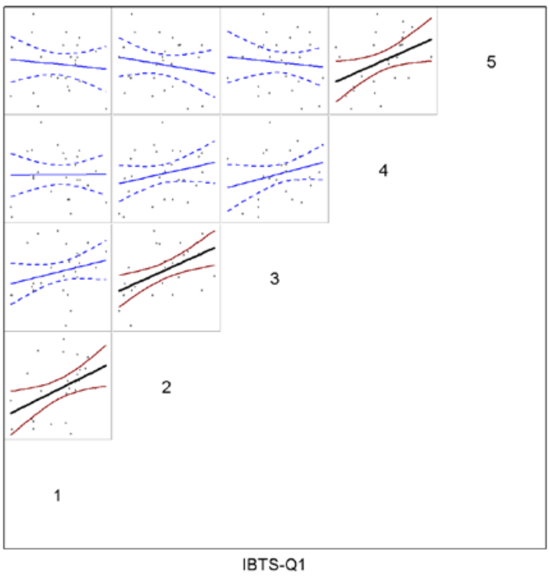

Figure 17 Southern component. Within survey correlations for IBTS Q1 survey, comparing indices for different ages of the same year class.

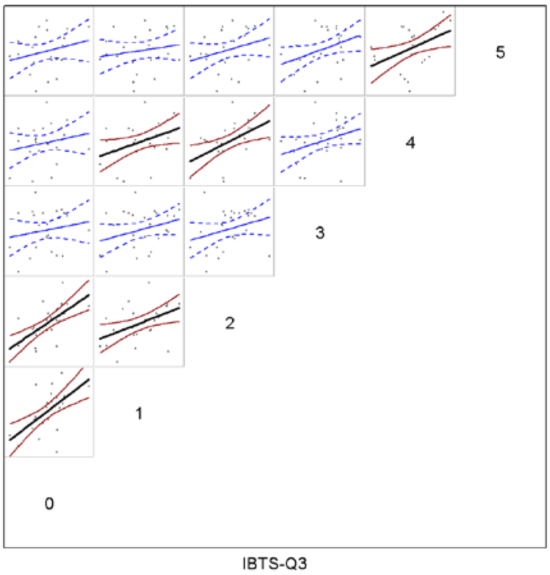

Figure 18 Southern component. Within survey correlations for IBTS Q3 survey, comparing indices for different ages of the same year class.

6. Tables

Table 1 Whiting in Subarea 4 and Division 7d. Tuning series, IBTS Quarter 1.

Year/Age	1	2	3	4	5
1978	5.472	2.629	0.919	0.220	0.042
1979	4.439	2.307	1.143	0.335	0.050
1980	6.750	4.037	1.250	0.254	0.088
1981	2.297	4.635	2.285	0.460	0.091
1982	1.515	2.173	2.581	0.686	0.101
1983	1.266	1.250	1.100	0.764	0.322
1984	4.345	1.780	0.890	0.303	0.254
1985	3.392	3.623	0.659	0.186	0.071
1986	4.687	2.683	1.946	0.321	0.066
1987	6.849	5.611	0.904	0.455	0.049
1988	4.480	8.657	3.143	0.330	0.126
1989	14.476	5.328	4.055	1.073	0.119
1990	5.189	8.624	1.982	0.916	0.169
1991	10.076	6.864	4.796	0.709	0.376
1992	9.073	6.657	2.402	1.508	0.127
1993	10.756	5.228	2.446	0.655	0.590
1994	7.217	6.274	1.810	0.681	0.119
1995	6.786	4.485	2.394	0.581	0.119
1996	5.024	4.860	2.447	0.697	0.231
1997	2.878	3.422	1.624	0.604	0.180
1998	5.431	1.607	1.254	0.540	0.155
1999	6.763	3.054	0.947	0.575	0.258
2000	7.679	5.449	1.836	0.537	0.202
2001	6.142	5.924	2.995	0.983	0.258
2002	5.585	3.428	2.629	0.632	0.208
2003	1.316	2.984	2.367	1.334	0.484
2004	1.844	0.901	1.727	0.999	0.487
2005	1.127	0.978	0.456	0.601	0.390
2006	1.844	1.251	0.455	0.183	0.270
2007	0.645	1.473	0.673	0.186	0.084
2008	2.686	2.058	0.655	0.221	0.075
2009	2.112	2.958	0.936	0.272	0.119
2010	3.262	2.248	2.441	0.948	0.285
2011	1.849	3.371	1.575	0.926	0.197
2012	2.313	5.885	1.148	0.466	0.325
2013	0.545	1.630	2.413	0.883	0.269

2014	2.653	1.846	0.992	0.659	0.228
2015	3.151	2.127	0.598	0.288	0.241
2016	3.022	3.236	0.912	0.204	0.117
2017	6.129	2.486	1.090	0.284	0.081

Table 2 Whiting in Subarea 4 and Division 7d. Tuning series, IBTS Quarter 3.

Year/Age	0	1	2	3	4	5
1991	5.370	7.034	1.586	0.790	0.146	0.052
1992	13.795	6.009	2.961	0.725	0.575	0.103
1993	9.192	6.387	1.774	0.661	0.147	0.159
1994	6.107	6.776	2.195	0.747	0.195	0.047
1995	7.292	6.198	2.912	1.072	0.215	0.060
1996	3.165	5.457	2.782	1.294	0.340	0.069
1997	20.627	3.330	1.807	1.090	0.280	0.107
1998	26.317	3.306	1.502	0.528	0.310	0.112
1999	24.986	12.035	1.906	0.539	0.245	0.095
2000	19.615	9.408	3.265	0.644	0.136	0.065
2001	35.488	6.689	2.831	0.940	0.191	0.043
2002	2.693	8.119	2.572	1.315	0.350	0.055
2003	3.565	2.576	2.928	1.287	0.679	0.173
2004	7.143	1.506	0.590	0.663	0.457	0.271
2005	1.693	1.714	0.683	0.314	0.456	0.340
2006	1.989	1.746	0.863	0.326	0.135	0.233
2007	8.229	0.955	0.636	0.376	0.115	0.084
2008	7.648	3.623	0.689	0.309	0.138	0.041
2009	5.938	5.855	3.848	0.410	0.123	0.080
2010	5.101	2.243	1.457	0.546	0.128	0.060
2011	2.471	4.468	1.444	0.472	0.162	0.069
2012	3.068	2.567	1.935	0.570	0.201	0.106
2013	3.343	0.675	0.601	0.658	0.175	0.071
2014	14.010	2.234	0.980	0.656	0.333	0.103
2015	20.916	3.125	2.226	0.431	0.240	0.184
2016	9.716	2.972	2.437	0.777	0.122	0.081
2017	1.766	9.510	2.008	0.777	0.254	0.070

Table 3 Tuning series for northern component, IBTS Quarter 1.

Year/Age	1	2	3	4	5
1978	5.719	3.287	1.327	0.315	0.062
1979	5.577	2.837	1.625	0.493	0.071
1980	7.776	5.278	1.361	0.234	0.133
1981	2.399	5.652	2.939	0.523	0.100
1982	1.210	2.783	3.993	0.994	0.131
1983	1.472	1.620	1.574	1.175	0.504
1984	3.321	2.202	1.167	0.452	0.386
1985	4.230	3.487	0.848	0.247	0.105
1986	6.035	3.976	2.523	0.433	0.111
1987	7.252	8.139	1.288	0.624	0.067
1988	3.106	11.465	4.530	0.472	0.168
1989	21.020	6.679	5.911	1.686	0.186
1990	4.484	12.770	2.696	1.443	0.313
1991	7.818	8.631	6.473	0.807	0.474
1992	12.227	8.537	3.317	2.240	0.140
1993	16.087	7.872	3.495	1.075	1.016
1994	10.339	9.863	2.888	1.094	0.194
1995	8.933	6.679	3.691	0.854	0.191
1996	5.990	6.746	3.543	1.065	0.359
1997	3.727	5.040	2.402	0.913	0.272
1998	7.769	2.156	1.878	0.833	0.247
1999	8.700	4.139	1.369	0.890	0.407
2000	10.354	7.732	2.732	0.784	0.303
2001	3.931	5.900	3.914	1.004	0.269
2002	5.157	4.213	3.952	0.995	0.322
2003	1.476	3.477	3.503	1.992	0.746
2004	2.602	1.231	2.578	1.526	0.756
2005	1.509	0.837	0.623	0.888	0.597
2006	2.363	1.226	0.655	0.252	0.412
2007	0.630	2.110	1.072	0.297	0.143
2008	2.045	1.999	0.918	0.350	0.120
2009	1.559	2.537	0.831	0.259	0.164
2010	3.013	2.772	3.324	1.327	0.402
2011	1.878	4.855	2.315	1.356	0.298
2012	2.723	8.113	1.616	0.696	0.495
2013	0.611	2.208	3.566	1.337	0.415
2014	3.664	2.710	1.788	1.211	0.437

2015	4.329	2.534	0.744	0.399	0.356
2016	2.640	2.068	1.102	0.289	0.181
2017	4.722	2.515	1.475	0.443	0.127

Table 4 Tuning series for northern component, IBTS Quarter 3.

Year/Age	0	1	2	3	4	5
1991	1.808	3.163	1.315	0.924	0.134	0.048
1992	9.996	6.277	2.540	0.877	0.818	0.126
1993	3.444	5.611	2.636	0.945	0.228	0.257
1994	2.321	7.093	3.033	1.194	0.260	0.077
1995	3.389	7.865	3.821	1.562	0.316	0.082
1996	0.920	5.346	3.450	1.747	0.488	0.100
1997	28.426	3.787	2.329	1.572	0.415	0.160
1998	25.551	4.182	2.045	0.814	0.484	0.174
1999	17.424	8.374	2.548	0.811	0.373	0.147
2000	14.864	7.852	3.558	0.799	0.197	0.099
2001	3.010	6.640	3.090	1.218	0.279	0.067
2002	1.090	6.229	3.123	1.853	0.511	0.083
2003	4.249	2.532	3.384	1.783	0.997	0.264
2004	2.164	1.970	0.798	0.955	0.677	0.401
2005	1.588	2.021	1.011	0.474	0.692	0.516
2006	0.424	1.976	1.148	0.484	0.204	0.350
2007	3.579	0.767	0.845	0.549	0.170	0.124
2008	8.752	3.469	0.809	0.477	0.224	0.070
2009	5.767	2.674	1.459	0.373	0.169	0.118
2010	0.665	2.558	1.874	0.686	0.180	0.088
2011	0.885	4.299	1.704	0.700	0.263	0.106
2012	3.256	2.450	2.811	0.981	0.332	0.163
2013	1.461	0.605	0.594	0.843	0.275	0.112
2014	20.715	2.072	0.760	0.515	0.454	0.146
2015	21.617	2.521	2.133	0.591	0.352	0.296
2016	7.505	3.266	2.038	0.828	0.155	0.113
2017	1.512	6.528	2.225	1.110	0.377	0.107

Table 5 Tuning series for southern component, IBTS Quarter 1.

Year/Age	1	2	3	4	5
1978	4.765	1.374	0.158	0.042	0.006
1979	1.760	1.188	0.218	0.038	0.011

1980	3.748	1.176	0.947	0.315	0.017
1981	1.940	3.104	1.249	0.371	0.085
1982	1.721	1.750	1.005	0.294	0.088
1983	0.855	0.999	0.545	0.213	0.055
1984	5.911	0.969	0.442	0.046	0.030
1985	1.166	3.212	0.296	0.112	0.011
1986	1.579	0.953	2.225	0.582	0.078
1987	5.331	0.870	0.280	0.279	0.035
1988	4.925	2.690	0.542	0.060	0.070
1989	2.974	2.429	0.813	0.058	0.008
1990	4.813	1.237	0.938	0.361	0.050
1991	12.278	2.882	1.366	0.495	0.187
1992	2.914	3.299	0.971	0.345	0.148
1993	1.721	0.550	1.069	0.127	0.028
1994	3.285	0.522	0.116	0.056	0.013
1995	3.102	1.590	0.665	0.269	0.004
1996	3.453	2.035	0.793	0.083	0.016
1997	0.901	0.387	0.292	0.062	0.017
1998	1.197	0.573	0.182	0.062	0.009
1999	2.955	1.481	0.336	0.038	0.011
2000	2.624	1.366	0.412	0.143	0.040
2001	8.597	5.085	1.352	0.974	0.263
2002	4.407	1.617	0.337	0.137	0.040
2003	0.911	2.481	0.662	0.323	0.117
2004	0.404	0.455	0.497	0.171	0.066
2005	0.418	1.089	0.407	0.127	0.051
2006	0.859	0.445	0.290	0.132	0.066
2007	0.736	0.625	0.289	0.047	0.008
2008	4.370	2.586	0.372	0.033	0.007
2009	4.059	4.660	1.382	0.363	0.060
2010	4.101	1.526	1.005	0.346	0.118
2011	4.715	1.975	0.583	0.287	0.068
2012	2.174	2.049	0.669	0.209	0.039
2013	1.062	1.150	0.754	0.216	0.034
2014	6.406	5.192	1.995	0.353	0.030
2015	2.687	4.269	1.802	0.434	0.093
2016	5.833	7.521	1.384	0.164	0.016
2017	10.116	2.988	0.512	0.104	0.005

Table 6 Tuning series for southern component, Quarter 3.

Year/Age	0	1	2	3	4	5
1991	9.946	14.225	1.756	0.485	0.158	0.050
1992	12.133	4.898	3.163	0.360	0.085	0.055
1993	16.541	7.207	0.475	0.265	0.018	0.013
1994	10.277	6.023	1.001	0.154	0.113	0.007
1995	12.658	2.369	0.850	0.061	0.012	0.016
1996	5.447	5.144	1.267	0.365	0.055	0.012
1997	4.927	2.412	0.514	0.076	0.009	0.001
1998	21.382	2.328	0.368	0.025	0.012	0.000
1999	28.962	17.752	0.571	0.034	0.001	0.000
2000	24.140	10.603	2.226	0.283	0.013	0.001
2001	90.875	6.486	2.193	0.404	0.032	0.000
2002	3.992	10.059	1.291	0.268	0.039	0.001
2003	1.365	2.785	1.950	0.318	0.071	0.001
2004	16.341	1.170	0.394	0.104	0.023	0.013
2005	2.135	0.559	0.080	0.017	0.008	0.006
2006	4.578	0.743	0.198	0.034	0.007	0.016
2007	22.639	1.582	0.200	0.020	0.001	0.000
2008	5.516	4.675	0.526	0.007	0.003	0.001
2009	6.449	10.836	7.436	0.358	0.015	0.001
2010	9.481	1.002	0.147	0.019	0.001	0.002
2011	5.318	3.958	0.494	0.096	0.016	0.003
2012	2.134	2.610	0.888	0.145	0.018	0.003
2013	7.888	0.722	0.175	0.067	0.007	0.002
2014	19.067	1.965	0.971	1.239	0.259	0.016
2015	16.880	3.863	2.568	0.322	0.016	0.026
2016	12.865	1.498	0.822	0.321	0.038	0.006
2017	2.087	11.231	1.659	0.241	0.038	0.005

7. References

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WD 6: Stock weights at age for whiting in subarea 4 and division 7d

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1. Introduction

In the current assessment for North Sea whiting in Subarea 4 and Division 7.d, stock weights at age are assumed to be equal to individual weights at age of commercial catches for the entire year. Stock weights at age were necessary to compute SSB in SAM assessment, which is routinely calculated at the beginning of the year (January 1st). Using the weights at age of commercial catches for the entire year leads to an overestimation of SSB as fish, in particular young ones, were expected to grow further during the year. Also, the fact that maturation occurs as early as age 1 (WD 4) and natural mortality was relatively high for this stock (WD 3) emphasizes the need to correct calculation of SSB. This can be done by either calculating SSB in the middle of the year using stock weights at age representative of the middle of the year (WD 7) or calculating SSB in the beginning of the year and estimating stock weights at age also representative of the beginning of the year.

Ideally stock weights at age were calculated from a scientific survey, which has a wide spatial coverages of the assessment area, is standardized in terms of gear, time of year and sample locations. However, individual weights at age data was available from North IBTS survey Q1 only since 2000 and Q3 since 2004. Commercial catch weights at age aggregated for the entire year were available for the time series since 1978. Catch weights at age by quarter were only available from 2009 onwards (new Intercatch raising procedure taking into account quarter, WD 2).

Alternatively, the historic times series of weights at age of commercial catches of the entire year could be scaled to the level of weights in the IBTS survey Q1. It was the aim to evaluate whether correction factors are necessary to scale the historical times series of commercial catch weight at age to represent stock weights at age for quarter 1. Here, weights at age from NS IBTS survey (Q1 and Q3) were explored and compared to commercial catches (entire year and quarter 1 since 2009).

Furtheron, the difference in weights at age from survey data for northern and southern component were compared. Commercial catch weights at age by area cannot be compared as Intercatch data were not provided at the appropriate spatial scale.

2. Methods

3.1. Data formatting of IBTS data

North Sea IBTS data for the period 1990-2017 were downloaded from the ICES database in exchange format (DATRAS; http://datras.ices.dk). The data were read in R 3.4.3 using the DATRAS package as a DATRASraw object (Kristensen & Berg 2012) composed of:

-Age data (CA records)

-Hydro data (HH records)

-Length data (HL records)

For considerations of spatial differences, hauls were assigned to a “NORTH” or “SOUTH” region according to the sub-structure suggested by Holmes *et al*. (2014).

3.2. Raising individual weight data of IBTS data

Survey data for individual weights at age were raised following the raising procedure for maturity at age data (WD 4).

Survey data were stratified in two stages. A large random (representative) sample of the catch was measured to produce a length distribution (corresponding to the HL records in the DATRASraw object) and a subsample of these fish (generally a fixed number per length class) was used to obtain individual biological data (age, weight, sex, corresponding to the CA records in the DATRASraw object). Numbers caught (HH data) were standardized for effort (per hour).

1- For each fish with biological data, define a raising factor:

$r_g = n_g / m_g$

Where n_g was the number of fish measured within a length group g, and m_g was the number of fish subsampled in the same length group.

2- Calculate the sum of the raising factors for each age group a

$$R_a = \sum_{a_i=a} r_g$$

where a_i denotes the age of fish i.

3- Assign statistical weight, to fish i in length group g and age a

$w_i = m_a \times r_g / R_a$

Where m_a was the number of fish of age a with biological data.

3.3. Region-specific weights for IBTS data

As the total weight of the catch was missing for a large number of hauls, total number of fish per haul per hour was used instead. For each year *y* and for each region *R* (South and North), weight, $w_{R,y}$, was calculated as:

$$w_{R,y} = \frac{q_R \overline{NB_{R,y}}}{\overline{NB_y}}$$

with the mean catch rate per area and year:

$$\overline{NB_{R,y}} = \frac{\sum_{i=1}^{n_{R,y}} NB_i}{n_{R,y}}$$

Where, NB_i was the average number of fish per haul in ICES rectangle *i*, and $n_{R,y}$ was the number of sampled ICES rectangles in region *R* and year y. The proportion q_R was the relative area of each region calculated as the ratio of the number of ICES rectangles per region covered by the survey and the total number rectangles (both regions).

The total catch rate in the combined was the weighted sum of mean catch rate in the Northern and Southern region:

$$\overline{NB_y} = \sum_{r=1}^{R} q_R \overline{NB_{R,y}}$$

In order to calculate the individual mean weights for the whole North Sea, the final weighting factor used was the product of the individual statistical weight (w_i) by the region-specific weighting factor ($w_{R,y}$).

3.1. Commercial catch weights at age

The available commercial catch weights at age time series as used in previous assessments were presented together with commercial catch weights at age for quarter 1 as exported from Intercatch (2009 onwards).

3.2. Smoothing

The raw times series were smoothed for each age class to reduce the effect of interannual variability. The function *gam* (R package gam) was used to fit a generalized additive model for each age class separately. Smoothing spline was applied assuming Gaussian error and respective degrees of freedom (where degrees of freedom df=1 implies a linear fit). Degrees of freedom were selected by minimizing

AIC (with df<6). The same degrees f freedom were used for smoothing all age groups of the time series.

```
> library(gam)

> gam(mat~s(year,df), data=M, family=gaussian)
```

The estimated times series was smoothed first for the combined estimates and then also for each area (North and South), separately.

3.3. Correction factors

Correction factors were calculated to adapt the level of commercial catch weight at age time series to the IBTS Q1 survey.

Correction factors were calculated as the value to minimize mean squared error (MSE) between commercial catch weight at age for the entire year and IBTS Q1 survey weights at age. Only values for the years 2000 to 2016 were used for the calculation.

3. Results

3.1. Stock weights at age Quarter 1

Individual weights at age from NS IBTS Q1 survey were available for 2000-2017 ages 1-8+ and in Q3 for 2004-2017 ages 0-8+.

There was a difference in weight at ages at young age and old age between quarter 1 and quarter 3 surveys (Figure 1). Age groups were generally heavier in quarter 3 relating to the greater length at age later in the year (growth during the year, section 3.2). In recent years, older age groups (ages 6+) weights were greater in quarter 1. There was an increase in weight at age in both surveys since 2000.

To represent SSB in the beginning of the year, IBTS Q1 weights at age are more likely to represent stock weights at age than IBTS Q3. Due to the lack of historical data of individual weights at age, the IBTS survey Q1 cannot be used directly.

In Figure 2, commercial catch weights at age for the entire year were plotted. The increase in weights at age since the early 2000s can be observed in both commercial catches and survey catches. Note that for Q1 and Q3 commercial catches the increase was not visible due to the limited available time period 2009-2017 (Figure 3). Weights at age in commercial catches were higher in Q3 due to continued growth during the year. Weights at age in commercial catches were generally higher than in the survey, reflecting the stronger size selectivity of fisheries. This effect was most apparent for younger age groups.

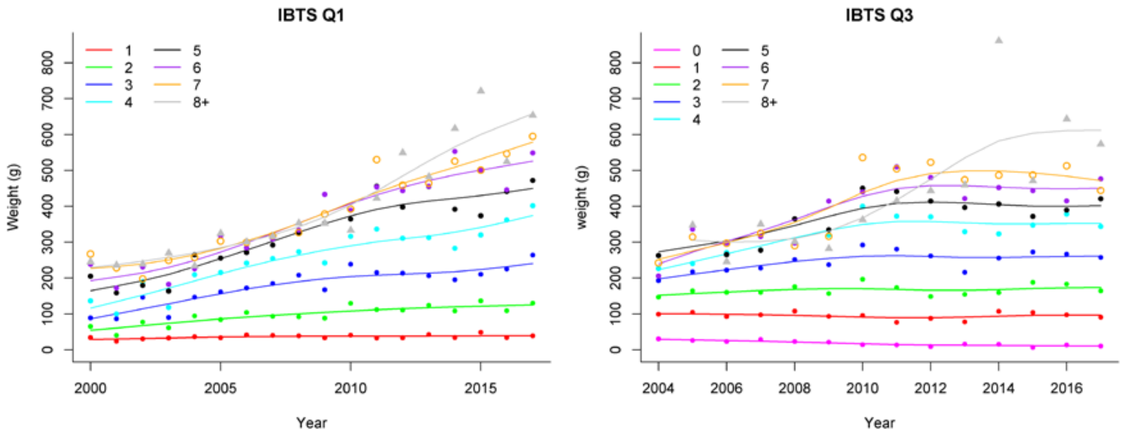

Figure 1 NS IBTS survey quarter 1 and quarter 3 mean weights at age.

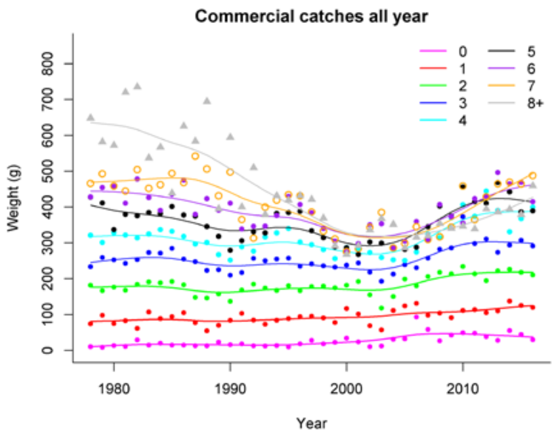

Figure 2 Catch weight at age from commercial catches, using commercial catch sampling data. Ages 0-8+.

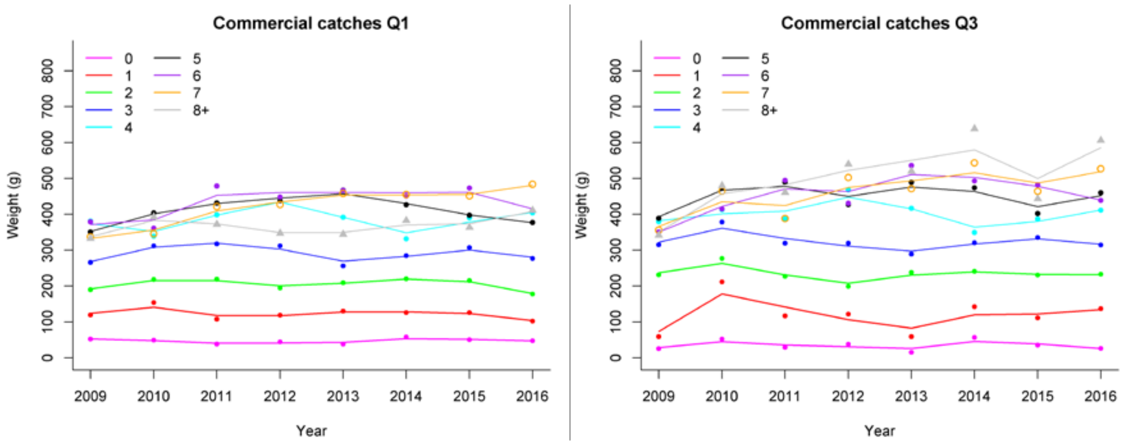

Figure 3. Catch weight at age from commercial catches for Q1 and Q3, using commercial catch sampling data. Ages 0-8+.

3.2. Length at age IBTS Q1 survey

The increase in weight at age at the end of the times series in survey Q1 (Figure 1) can be explained by a difference in length at age (Figure 4). Due to the power scaling of weight with length, the increase was expected to be stronger in weight as compared to length. Prior to the early 2000s fishing mortality was significantly higher and due to fishing selectivity acting on size rather than age, a truncation of the total length distribution and also of the age-specific length distribution can be expected. At lower fishing mortality since the early 2000s, over time more large individuals survived and an increase in lengths and correspondingly weights at age occurred. When comparing length distributions at age from IBTS Q1 surveys, distributions were highly truncated in 2000 and 2005 for ages 2+ (Figure 5). In recent years, length distributions extended for all ages.

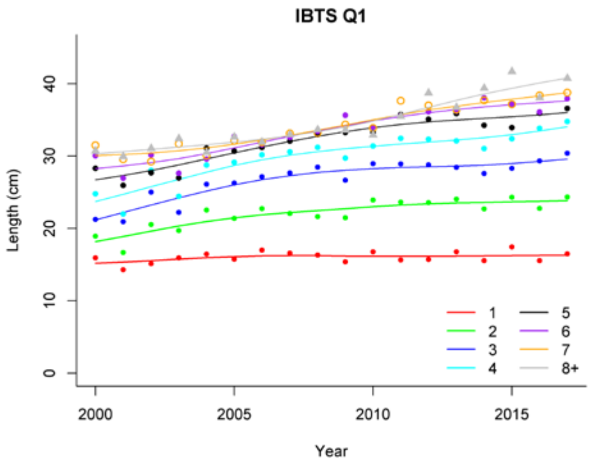

Figure 4 Mean length at age in IBTS Q1 survey.

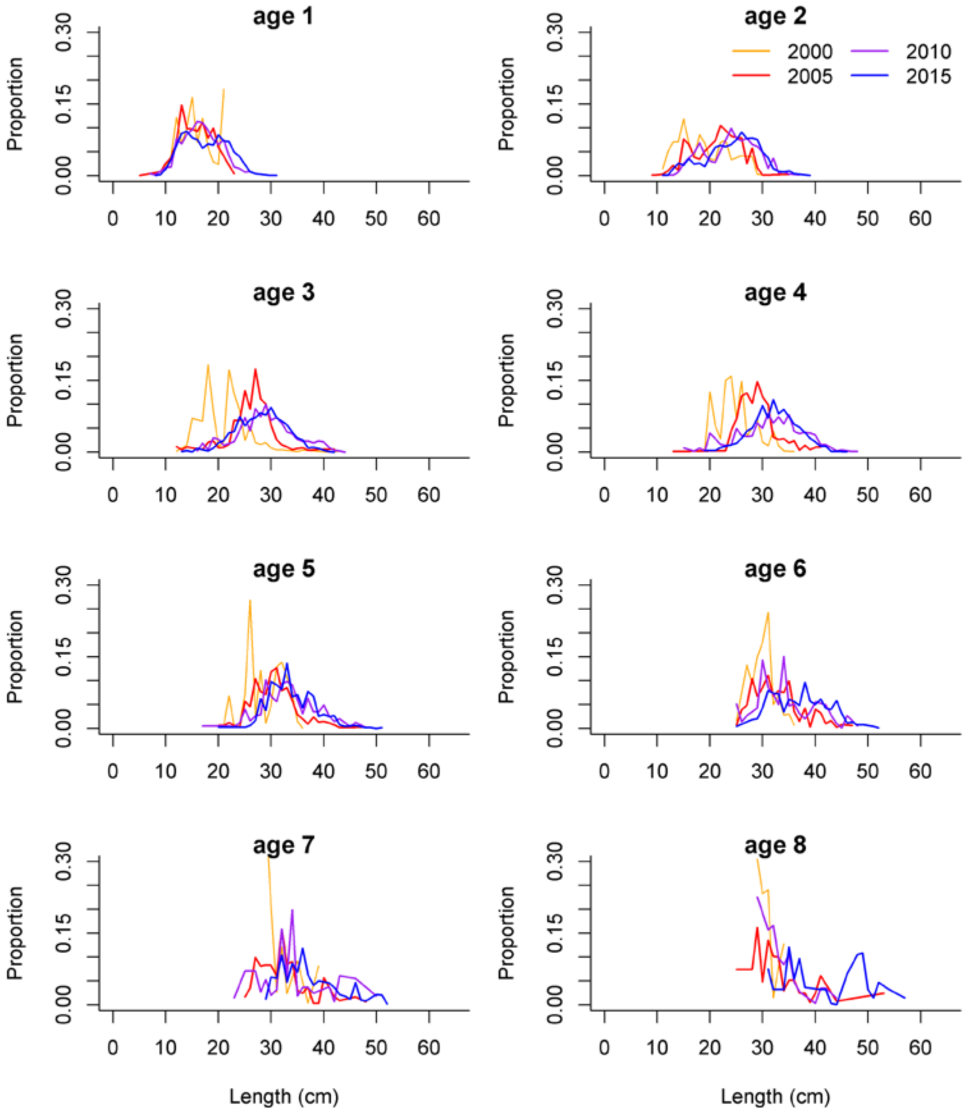

Figure 5 Relative length distributions in IBTS survey Q1 by age for the years 2000, 2005, 2010 and 2015. Age represents a plus group.

3.3. Correction

The catch weight at age time series available since 1978 was corrected using the IBTS Q1 survey. Following correction factors have been calculated. The downward correction was strongest for age1. With increasing age the correction increased to 1, with age 7 staying at the original values. With increasing length growth slows down and the difference between Q1 weight estimates and the average decreases. Only for age 8+ an upward correction was necessary, as oldest individuals in the survey showed higher weights (Table 1).

Table 1 Correction factors for catch weights at age using the IBTS Quarter 1 survey. * For age 0 no IBTS Q1 weight estimates were available, the correction factor of age 1 was used.

Age	Conversion factor

0	0.325 *
1	0.325
2	0.490
3	0.657
4	0.765
5	0.892
6	0.955
7	1.001
8+	1.120

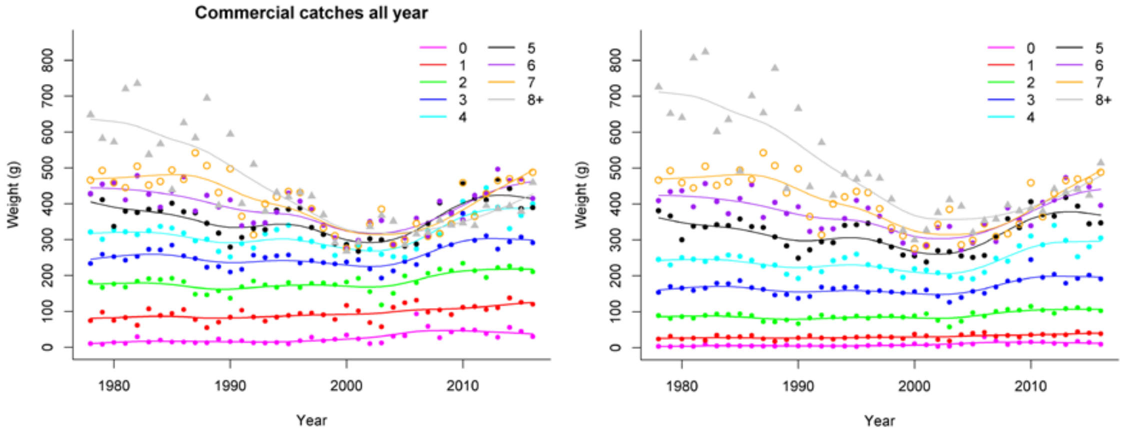

Figure 6 Left panel: Uncorrected commercial catch weights at age (with smoothed values as lines) and Right panel: Estimated stock weights at age using corrected catch weights at age at age (with smoothed values).

3.4. By area comparison

When comparing weights at age in the Northern and Southern component, it is evident that in the South weights at age for age 6+ are poorly estimated due to a lack of data.

Due to the low number of observed old individuals weights at age are variable between years. The recent increase in weights at age can be observed in both areas for ages in Q 1 for ages 2+.

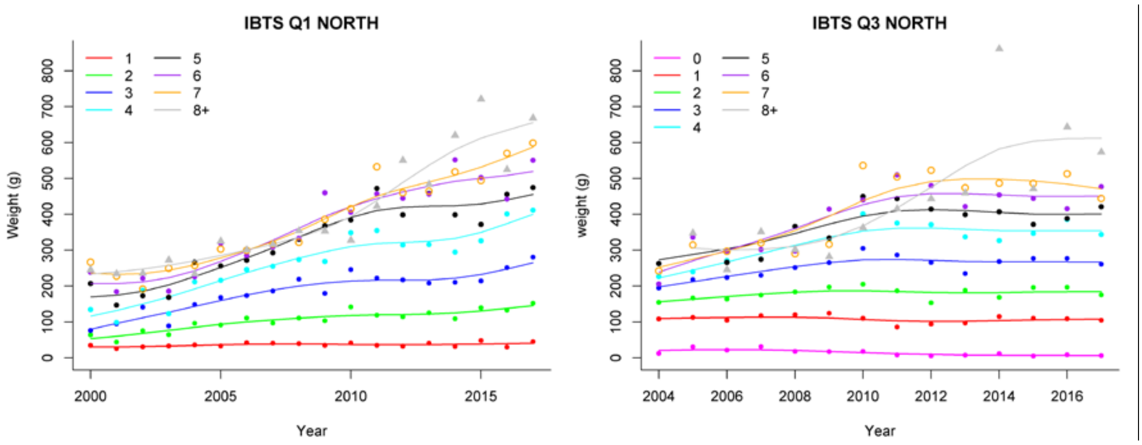

Figure 7 IBTS survey quarter 1 and quarter 3 mean weights at age.

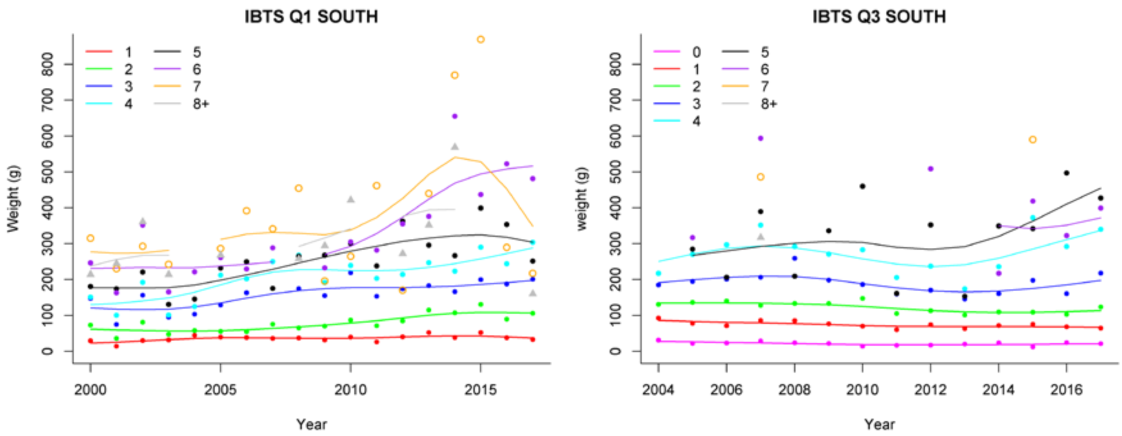

Figure 8 IBTS survey Q1 and Q3 mean weights at age.

4. Discussion

Following the evaluation of weights at age in commercial catches and survey catches, it was concluded that commercial catch weights at age aggregated for the entire year may overestimate stock weights at age and SSB in the beginning of the year. As a complete survey time series was not available for the period 1978-2016, the commercial catch weight at age time series was corrected using the IBTS Q1 survey weight at age for 2000-2016. Commercial catch weights at age representing Q1 raised in Intercatch may not be appropriate for scaling. Here, the effect of gear type, targeted fishing, spatial and temporal variability in fishing activity may not allow for representation of stock weights at age.

For the SAM assessment it is suggested to compare a model run using the raw commercial catch weight at age for the entire year and calculating SSB midyear to model run with raw corrected catch weights at age to represent stock weights at age.

The selection of a correction factor is error prone, as it relies on the assumption that the scaling factor is constant over time for the respective age. To avoid additional error by smoothing, raw corrected weights were suggested to be used as stock weights at age in the model. Runs of smoothed and unsmoothed values were presented in WD7.

For the SURBAR analysis by area only combined stock weights at age will be used to compare stock trends (WD 8). The weight at age estimates for older age groups in the South were not dependable due to the low number of observations.

5. Data tables

Table 2. Commercial catch weights at age for the entire year using new Intercatch data (2009-2016)

Year/Age	0	1	2	3	4	5	6	7	8+
1978	0.010	0.074	0.182	0.234	0.321	0.428	0.428	0.466	0.648
1979	0.009	0.098	0.167	0.259	0.301	0.411	0.455	0.492	0.582
1980	0.013	0.075	0.176	0.252	0.328	0.337	0.457	0.459	0.572
1981	0.011	0.083	0.168	0.242	0.322	0.379	0.411	0.445	0.720
1982	0.029	0.061	0.184	0.253	0.314	0.376	0.478	0.504	0.735
1983	0.015	0.107	0.191	0.273	0.325	0.384	0.426	0.452	0.537
1984	0.020	0.089	0.189	0.271	0.337	0.381	0.390	0.462	0.567
1985	0.014	0.094	0.192	0.284	0.332	0.401	0.435	0.494	0.439
1986	0.015	0.105	0.183	0.255	0.318	0.378	0.475	0.468	0.626
1987	0.013	0.077	0.148	0.247	0.297	0.375	0.380	0.542	0.584
1988	0.013	0.054	0.146	0.223	0.301	0.346	0.424	0.506	0.694
1989	0.023	0.070	0.157	0.225	0.267	0.318	0.391	0.431	0.395
1990	0.016	0.084	0.137	0.210	0.252	0.279	0.411	0.498	0.594
1991	0.018	0.104	0.168	0.217	0.289	0.306	0.339	0.365	0.400
1992	0.013	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.510
1993	0.012	0.073	0.174	0.250	0.316	0.328	0.346	0.400	0.379
1994	0.013	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.431
1995	0.010	0.089	0.180	0.257	0.340	0.384	0.429	0.434	0.419
1996	0.018	0.094	0.167	0.235	0.302	0.388	0.407	0.431	0.432
1997	0.028	0.096	0.178	0.242	0.295	0.334	0.384	0.386	0.421
1998	0.018	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.369
1999	0.023	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.292
2000	0.034	0.117	0.182	0.238	0.287	0.286	0.276	0.275	0.268
2001	0.024	0.101	0.192	0.244	0.282	0.267	0.298	0.284	0.292
2002	0.010	0.069	0.155	0.218	0.273	0.303	0.350	0.343	0.336
2003	0.012	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.368
2004	0.031	0.111	0.150	0.213	0.253	0.286	0.285	0.286	0.351
2005	0.032	0.124	0.199	0.239	0.250	0.282	0.305	0.298	0.286
2006	0.093	0.131	0.180	0.231	0.274	0.288	0.360	0.345	0.316
2007	0.059	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.320
2008	0.027	0.104	0.218	0.282	0.315	0.402	0.407	0.317	0.354
2009	0.042	0.091	0.213	0.286	0.370	0.374	0.373	0.344	0.340
2010	0.049	0.111	0.234	0.373	0.406	0.456	0.355	0.459	0.346
2011	0.048	0.114	0.214	0.298	0.374	0.415	0.424	0.364	0.339
2012	0.038	0.105	0.195	0.311	0.445	0.411	0.430	0.428	0.395
2013	0.028	0.110	0.222	0.273	0.390	0.468	0.496	0.465	0.386
2014	0.055	0.137	0.227	0.294	0.331	0.442	0.465	0.469	0.394
2015	0.044	0.125	0.218	0.307	0.368	0.386	0.469	0.464	0.379

2016	0.030	0.120	0.210	0.291	0.399	0.389	0.415	0.488	0.459

Table 3 Estimated raw stock weights at age, calculated using commercial catch weights at age for the entire year and correction factors from IBTS survey Q1.

Year/Age	0	1	2	3	4	5	6	7	8+
1978	0.003	0.024	0.089	0.154	0.246	0.381	0.409	0.466	0.726
1979	0.003	0.032	0.082	0.170	0.230	0.367	0.434	0.493	0.652
1980	0.004	0.024	0.086	0.166	0.251	0.301	0.437	0.459	0.641
1981	0.004	0.027	0.082	0.159	0.246	0.338	0.392	0.445	0.807
1982	0.009	0.020	0.090	0.166	0.240	0.335	0.457	0.505	0.824
1983	0.005	0.035	0.094	0.179	0.249	0.343	0.407	0.452	0.602
1984	0.007	0.029	0.092	0.178	0.258	0.340	0.373	0.463	0.635
1985	0.005	0.031	0.094	0.187	0.254	0.358	0.416	0.494	0.491
1986	0.005	0.034	0.090	0.167	0.243	0.337	0.454	0.468	0.701
1987	0.004	0.025	0.072	0.162	0.227	0.334	0.363	0.543	0.654
1988	0.004	0.018	0.072	0.147	0.230	0.308	0.405	0.507	0.777
1989	0.007	0.023	0.077	0.148	0.204	0.284	0.373	0.431	0.443
1990	0.005	0.027	0.067	0.138	0.193	0.249	0.392	0.498	0.666
1991	0.006	0.034	0.082	0.143	0.221	0.273	0.323	0.365	0.448
1992	0.004	0.028	0.091	0.169	0.212	0.295	0.331	0.314	0.571
1993	0.004	0.024	0.085	0.164	0.242	0.293	0.331	0.400	0.424
1994	0.004	0.027	0.082	0.168	0.251	0.341	0.360	0.419	0.483
1995	0.003	0.029	0.088	0.169	0.260	0.343	0.410	0.435	0.469
1996	0.006	0.031	0.082	0.154	0.231	0.346	0.389	0.432	0.484
1997	0.009	0.031	0.087	0.159	0.226	0.298	0.366	0.387	0.472
1998	0.006	0.029	0.088	0.155	0.215	0.280	0.325	0.333	0.413
1999	0.007	0.025	0.085	0.152	0.196	0.258	0.291	0.311	0.327
2000	0.011	0.038	0.089	0.156	0.219	0.255	0.263	0.276	0.300
2001	0.008	0.033	0.094	0.160	0.216	0.239	0.285	0.284	0.327
2002	0.003	0.022	0.076	0.143	0.209	0.270	0.334	0.343	0.376
2003	0.004	0.019	0.058	0.127	0.198	0.267	0.338	0.385	0.412
2004	0.010	0.036	0.074	0.140	0.193	0.255	0.273	0.286	0.394
2005	0.010	0.040	0.097	0.157	0.192	0.251	0.291	0.299	0.320
2006	0.030	0.043	0.088	0.152	0.210	0.257	0.343	0.345	0.354
2007	0.019	0.032	0.101	0.169	0.249	0.308	0.295	0.309	0.358
2008	0.009	0.034	0.107	0.185	0.241	0.359	0.389	0.317	0.397
2009	0.014	0.030	0.105	0.188	0.283	0.334	0.356	0.344	0.381
2010	0.016	0.036	0.115	0.245	0.311	0.406	0.339	0.459	0.388
2011	0.016	0.037	0.105	0.196	0.286	0.370	0.404	0.365	0.380
2012	0.012	0.034	0.095	0.204	0.340	0.366	0.411	0.429	0.442
2013	0.009	0.036	0.109	0.180	0.299	0.418	0.474	0.465	0.432
2014	0.018	0.045	0.111	0.193	0.253	0.394	0.444	0.470	0.441
2015	0.014	0.041	0.107	0.202	0.281	0.345	0.448	0.465	0.424
2016	0.010	0.039	0.103	0.191	0.306	0.347	0.396	0.489	0.514

6. References

Holmes, S. J., Millar, C. P., Fryer, R. J., and Wright, P. J. 2014. Gadoid dynamics: differing perceptions when contrasting stock vs. population trends and its implications to management. ICES Journal of Marine Science, 71: 1433-1442.

WD 7: SAM assessment model for whiting in subarea 4 and division 7d

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It was one of the main aims of the WNSEA 2018 benchmark process for whiting to update the current XSA assessment model to an assessment model that allows for uncertainty in the catches. SAM, a state-based assessment model was selected as a candidate for future assessment process. Following a step wise inclusion of new input data and sensitivity analyses, final SAM results were compared to SURBAR and XSA results using the same input data.

1 Methods

1.1 Model

SAM, a state-based assessment model is described in detail by Nielsen and Berg (2014). It connects observed (log-transformed survey, catches) to unobserved states (log-transformed stock size, fishing mortality). The underlying process in the model is considered as the unobserved random variables.

As input data catch data (catches at age), two survey indices at age (NS IBTS Quarter 1, Quarter 3) as well as biological parameters estimated for the stock, i.e. natural mortality at age, proportion mature at age, and stock weights at age. The time series covers catch data from 1978 onwards and survey data from 1983 for Q1 and from 1990 for Q3.

SAM allows for uncertainty in the observed states and produces estimates of the **unobserved** variables without the need to specify variances directly. Instead the distribution of process error can be defined. The prediction noise is assumed to be Gaussian with zero mean and three variance parameters (recruitment, other age groups, fishing mortality). The component of prediction noise relating to stock size at age was assumed to be uncorrelated. A correlation structure for prediction noise in fishing mortalities at age can be specified. The model allowed for time-varying selectivity which determines fishing mortality at age.

A stock-recruitment relationship can be defined. Through the transition functions, recruitment and abundance of age groups were related to each other and connected to both natural and fishing mortalities.

The **observed** states are subject to measurement noise which can be separated from the process noise.

The observation function consists of catch equations for catches and survey. Catchabilities in surveys and catches can be coupled between age groups. The measurement error was assumed to be Gaussian with mean zero. Each data source (catch, survey Q1, Q3) had their own covariance matrix. In the case of autocorrelation, parameters can be coupled for age groups.

The model parameters were estimated from the observations, and the unobserved random variables can be predicted being conditioned on the observations. Laplace approximation was used to calculate the joint likelihood of observed and unobserved states. The software used to solve the high-dimensional non-linear models includes automatic differentiation and Laplace approximation.

1.2 Model settings

In the following the final setting are detailed. Alternatives scenarios (such as minimum age) were detailed in the SAM run scenarios (section 1.3).

The minimum age in the assessment was set to 0, giving recruitment estimates at age 0. The maximum age was 8, representing a plus group.

Observed state process:

Logarithms of total catches were assumed to be independently distributed with error variance being coupled for all ages except age 0 (recruits). The logarithms of survey indices followed an autoregressive process of order 1 (AR(1)). Autocorrelation parameters were coupled for all age pairs except 1-2 in IBTS Q1 and coupling of 0-1 with 1-2 and for all other pairs coupled separately for Q3. A common observation variance was assumed for all ages, for Q1 and Q3 separately. The survey catchabilities were coupled only for the oldest two age groups in each survey separately (age 4 and 5).

Unobserved state process:

It is sometimes assumed that certain fishing mortality parameters are identical. Here, fishing mortality states only for two oldest age groups, age 7 and 8, were coupled. Process variance for fishing mortality was coupled across all age groups. The fishing mortality across ages was modelled with autocorrelation, AR(1). Process variance of stock size was coupled for all ages except for age 0 (recruitment).

The stock recruitment relationship was modelled as a plain random walk.

Table 1 SAM model settings as detailed in the model configuration file www.stockassessment.org

```
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
#
$minAge
# The minimum age class in the assessment
 0
$maxAge
# The maximum age class in the assessment
 8
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1
$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
   0  1  2  3  4  5  6  7  7
  -1 -1 -1 -1 -1 -1 -1 -1 -1
  -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2

$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered by fishing mortality).
  -1 -1 -1 -1 -1 -1 -1 -1 -1
  -1  0  1  2  3  3 -1 -1 -1
   4  5  6  7  8  8 -1 -1 -1
```

$keyQpow

Density dependent catchability power parameters (if any).

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarF

Coupling of process variance parameters for log(F)-process (normally only first row is used)

0 0 0 0 0 0 0 0 0

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN

Coupling of process variance parameters for log(N)-process

0 1 1 1 1 1 1 1 1

$keyVarObs

Coupling of the variance parameters for the observations.

0 1 1 1 1 1 1 1 1

-1 2 2 2 2 2 -1 -1 -1

3 3 3 3 3 3 -1 -1 -1

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "AR" "AR"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

```
#0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
  NA  NA  NA  NA  NA  NA  NA  NA
  -1   0   1   1   1  -1  -1  -1
   2   2   3   3   3  -1  -1  -1


$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0


$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.


$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).


$fbarRange
# lowest and higest age included in Fbar
 2 6


$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1


$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN"
```

$fixVarToWeight

If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).

0

1.3 SAM assessment runs

Different SAM runs were summarized. New data was added sequentially as detailed in Table 1.

Table 1 SAM assessment runs. Scenarios sequentially adding new data.

Section	Name of SAM run on stockassessement.org	Data update	Used in Final
2.2		Final data as in WHG2017_AN_008_surv_catch_mort_mat_cc_1978 with different config setting	
	WHG2017_AN_010_final_test_settings_Fid	F states ID	no
	WHG2017_AN_010_final_test_settings_survid	Both survey fleets ID	no
	WHG2017_AN_010_final_test_settings_cAR	Catch fleet AR(1)	no
2.3	WHG2017_AN_001_short_old_data	None (old data, ages 0-8)	no
	WHG2017_AN_002_survey_	Survey indices (Q1, Q3)	yes
2.4	WHG2017_AN_003_survey_catch	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016	yes
2.5	WHG2017_AN_004_survey_catch_mortality_r	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new raw natural mortality estimates	no
	WHG2017_AN_004_survey_catch_mortality_new	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smoothed natural mortality estimates	yes
2.6	WHG2017_AN_006_surv_catch_mort_mat_r	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smoothnatural mortality estimates, new maturity estimates (raw)	no
	WHG2017_AN_006_surv_catch_mort_mat_new	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates new maturity estimates (smoothed), ages 0:8	yes
2.7	WHG2017_AN_008_surv_catch_mort_mat_ag18	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates, ages 1:8	no
2.8	WHG2017_AN_007_surv_catch_mort_mat_ccJan_us	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates new smooth maturity estimates, s-w-a=corrected unsmooth c-w-a	yes
	WHG2017_AN_007_surv_catch_mort_mat_ccJan	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates, new smooth maturity estimates, s-w-a=smooth corrected c-w-a,Jan1st	no
	WHG2017_AN_008_surv_catch_mort_mat_midyear	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates newsmooth maturity estimates, s-w-a=smooth corrected c-w-a, midyear	no
2.10	WHG2017_AN_008_surv_catch_mort_mat_cc_1983_both	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates, new smooth maturity estimates, s-w-a= corrected c-w-a, Jan1, start 1983	no

	WHG2017_AN_008_surv_catch_mort_mat_cc_1978_both	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates, new smooth maturity estimates, s-w-a= corrected c-w-a, Jan1, start 1978	no
2.1, 2.10	WHG2017_AN_008_surv_catch_mort_mat_cc_1978	Survey indices (Q1, Q3), new raised catch data from Intercatch 2009-2016, new smooth natural mortality estimates, new smooth maturity estimates, s-w-a= corrected c-w-a, Jan1, start catches in 1978 and survey quarter 1 in 1983	Yes (final)

2 SAM results

2.1 Final assessment model

For the final SAM assessment, input catch data from 1978 onwards and survey data from 1983 (NS IBTS Q1) and 1991 (NS IBTS Q3) was used.

In Figure 1 main SAM results were plotted, confidence intervals around estimates are relatively tight.

The correlation in each age group reflects SAM settings of autocorrelations and parameter coupling (Figure 2). Predictions of the model fit well to catch and survey data (Figure 5-Figure 7). The leave-one-out runs show that both surveys used were in agreement (Figure 8). Slight differences in SSB and recruitment estimates were expected when leaving out IBTS Q3 survey, which delivered indices for age 0. The retrospective patterns show that results were robust to removing up to 5 years of recent data (Figure 9).

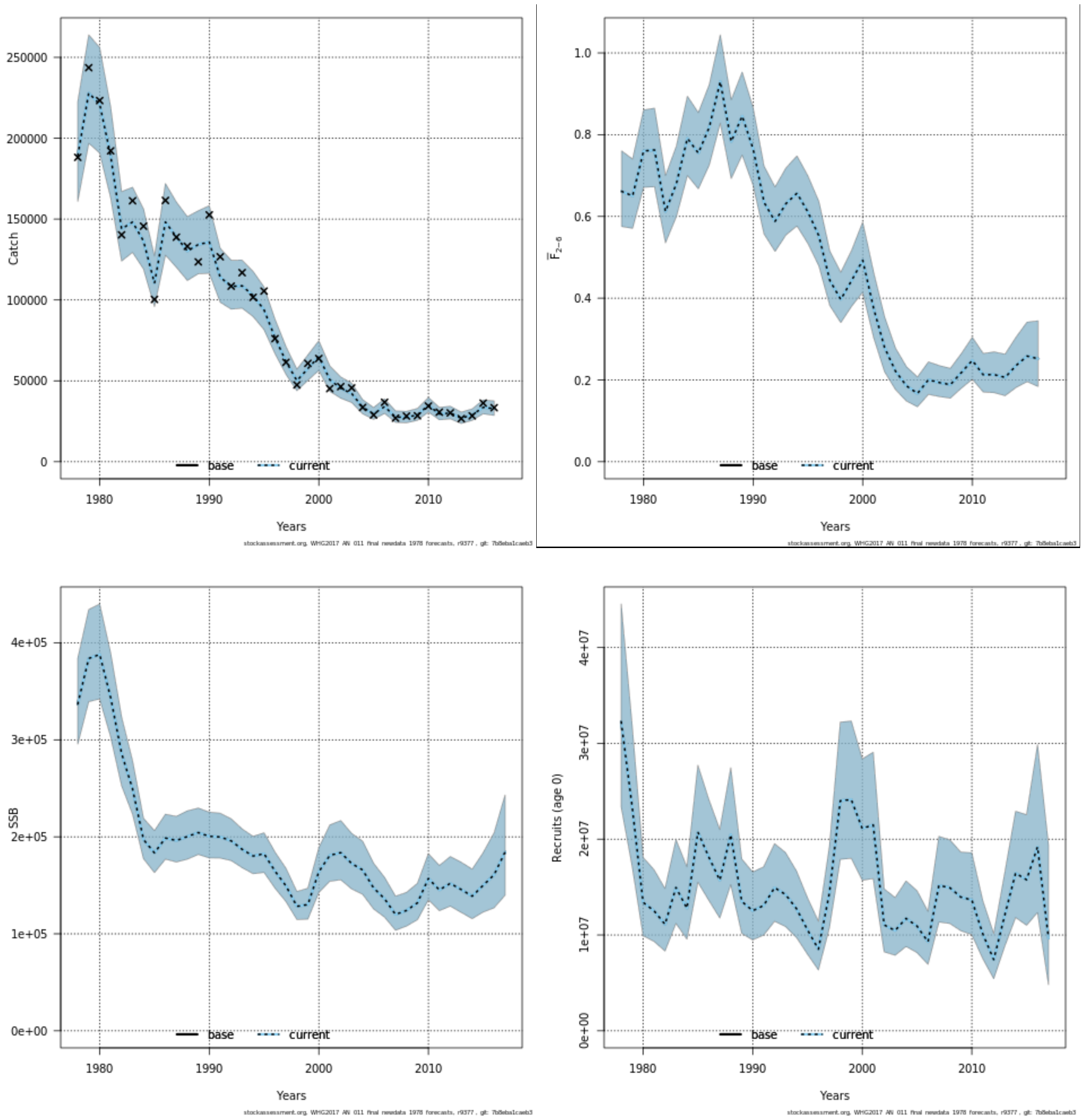


Figure 1 SAM assessment results for new data series (1978-2016) with survey data starting in 1983. Estimates with 95% Confidence intervals for total catch weight, mean fishing mortality, SSB and Recruitment (at age 0).

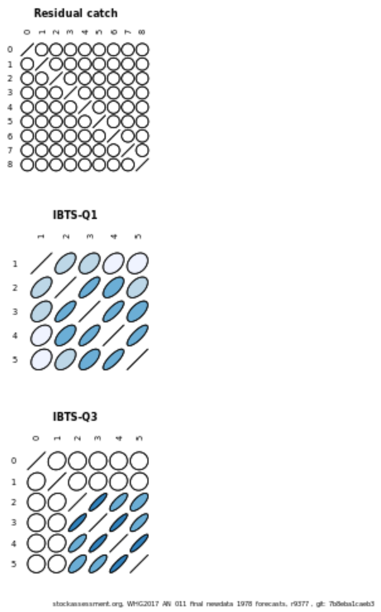


Figure 2 Estimates correlations between age groups for each fleet

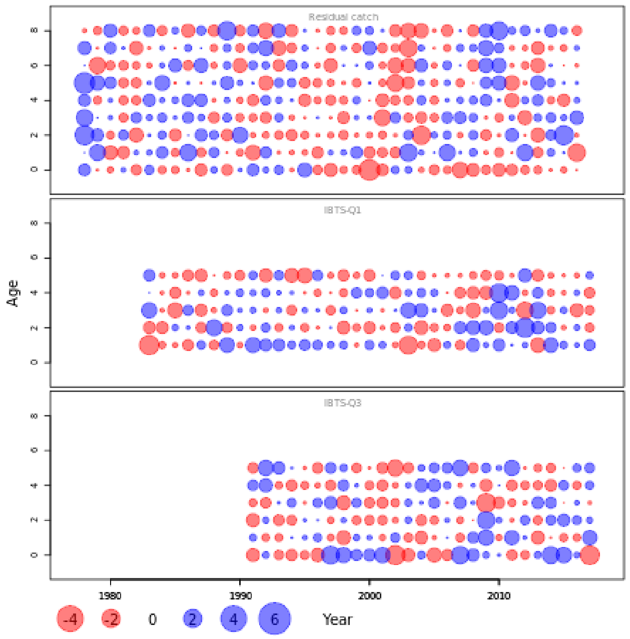


Figure 3 Standardized one-observation-ahead residuals.

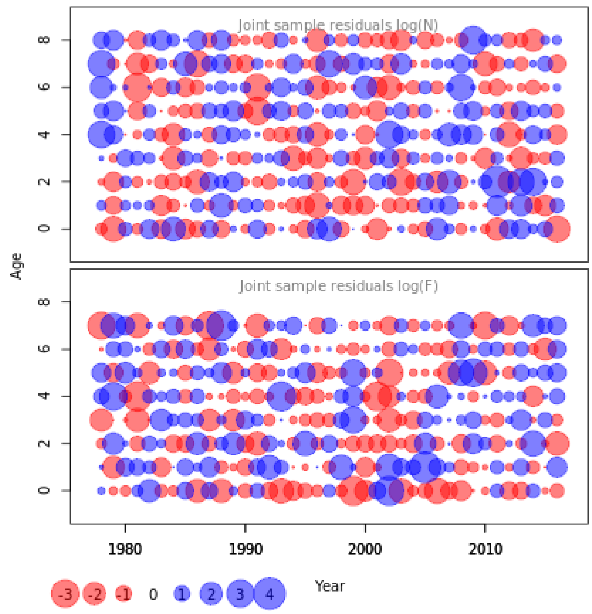


Figure 4 Standardized single-joint-sample residuals of process increments

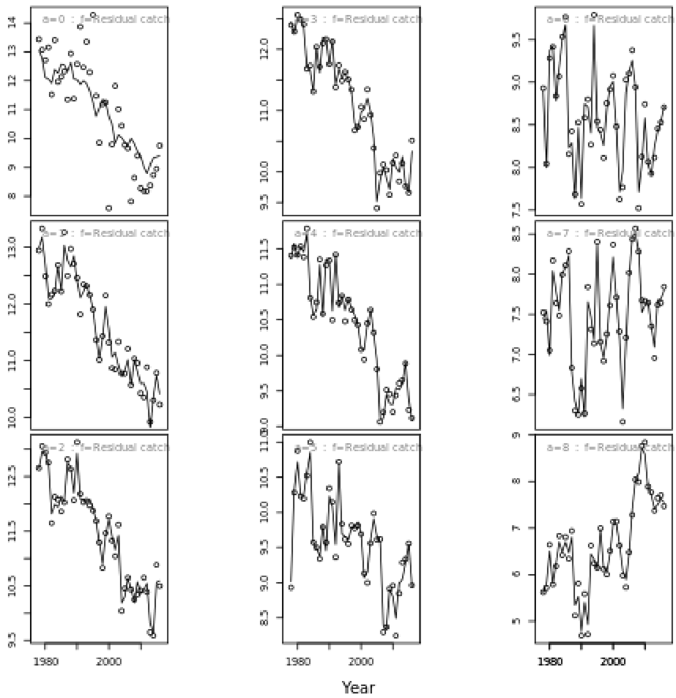


Figure 5 Predicted line and observed points (log scale) for the catch fleet.

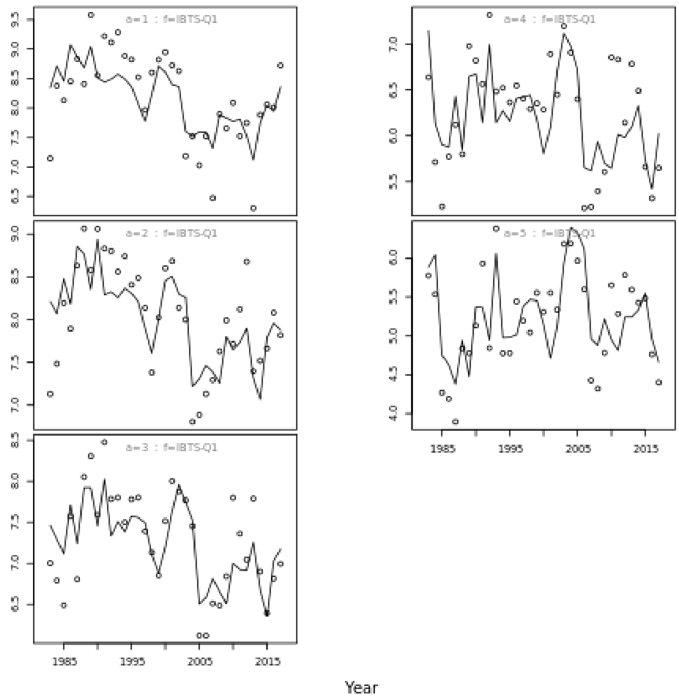


Figure 6 Predicted line and observed points (log scale), for survey fleet IBTS Q1.

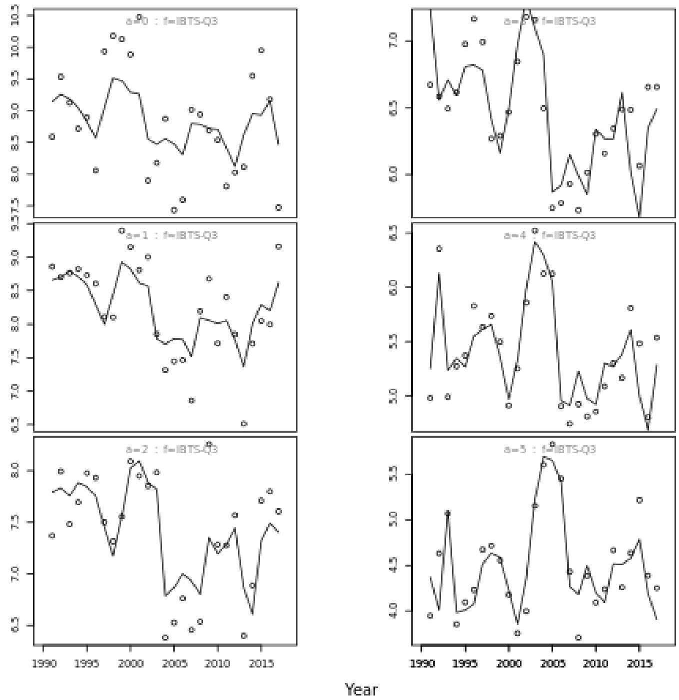


Figure 7. Predicted line and observed points (log scale), for survey fleet IBTS Q3.

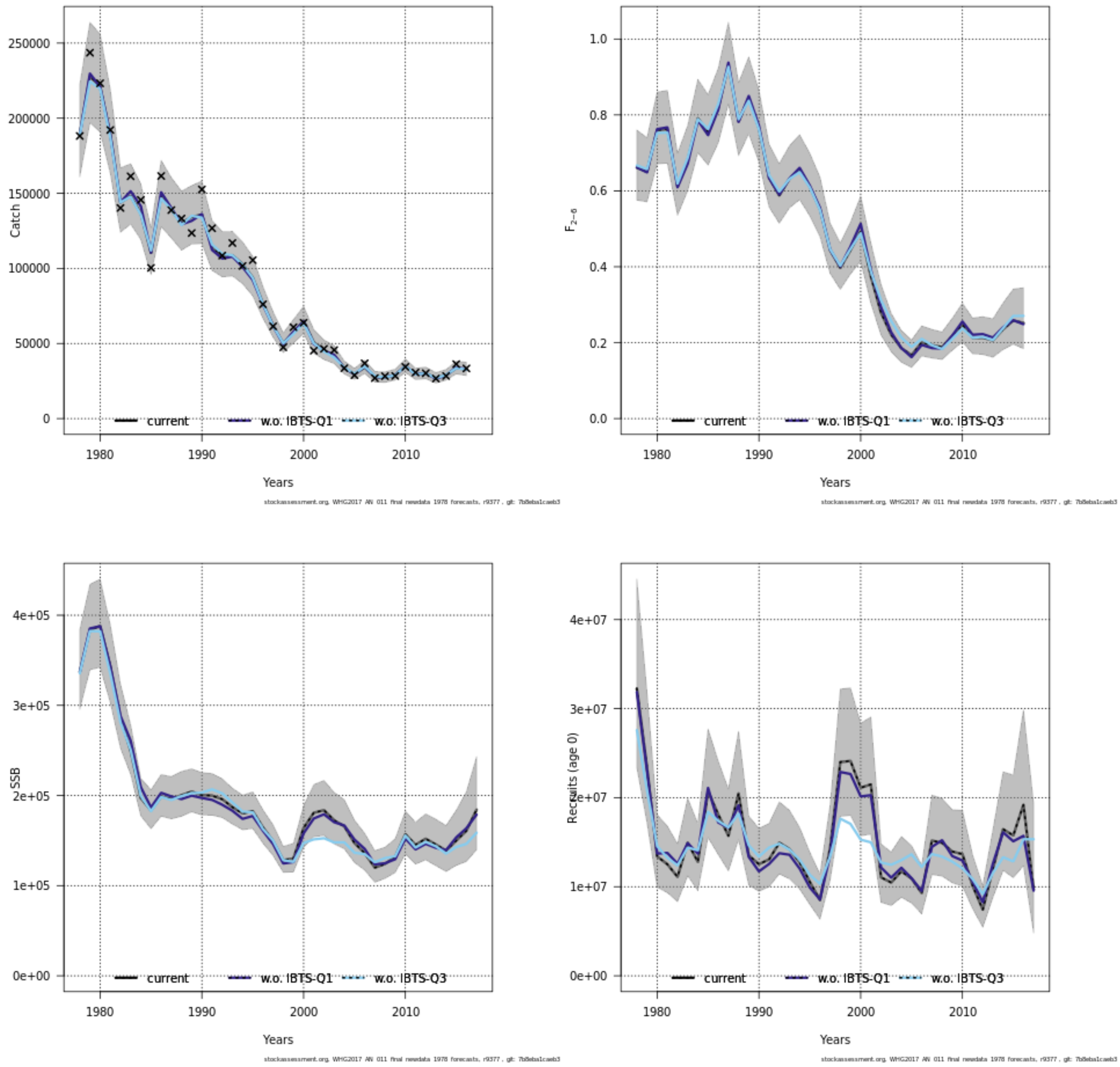


Figure 8 Leave-one-out diagnostics.

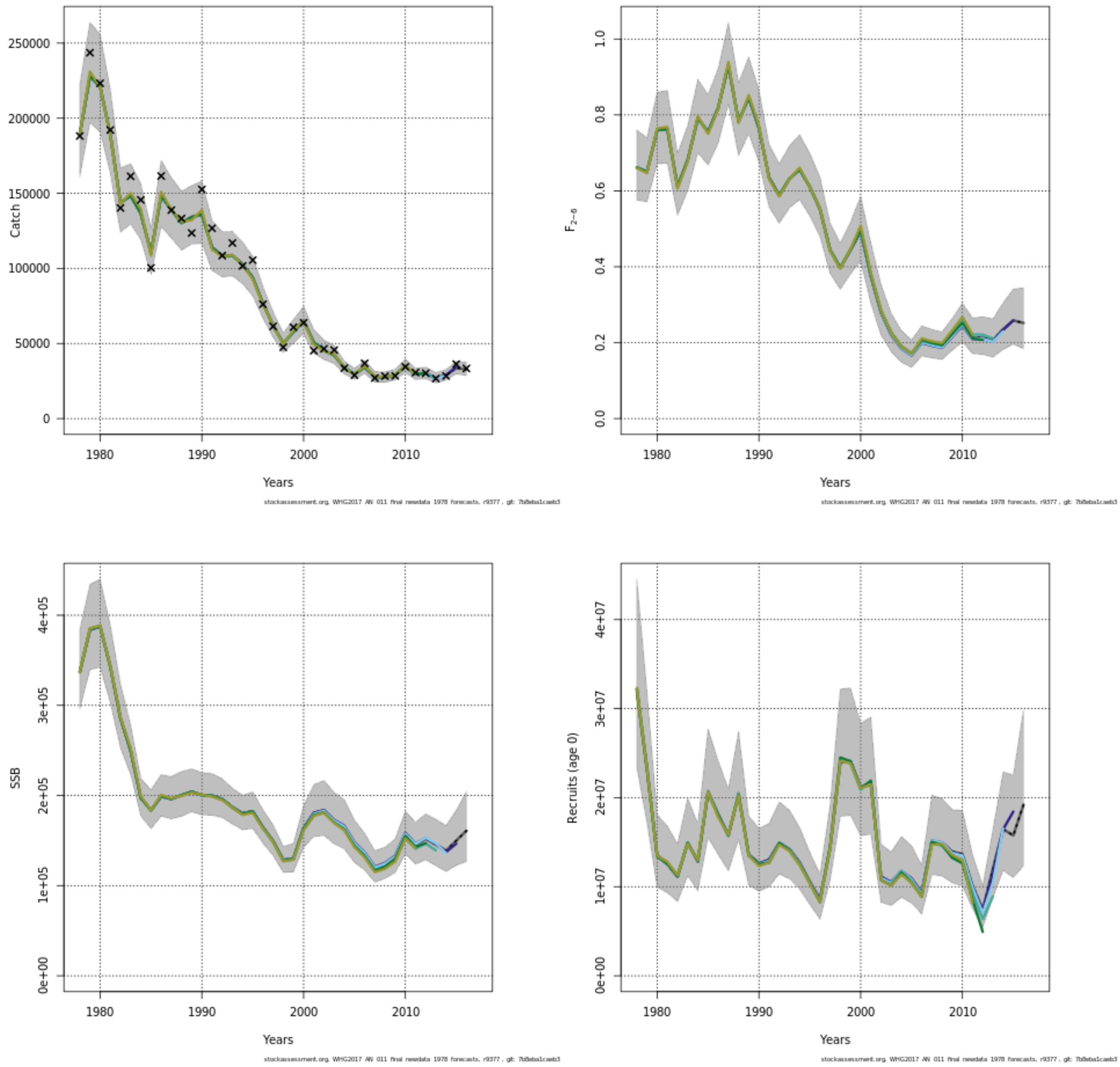


Figure 9 Retrospective pattern.

2.2 Sensitivity to model setting

The final SAM run presented in section 2.1 was tested with alternative setting with regard to the autocorrelation structure. One configuration setting at a time was changed keeping all other settings as in the baseline.

In the **first** alternative run (WHG2017_AN_010_final_test_settings_Fid), the prediction noise in fishing mortality states were assumed to be independently distributed (instead of AR(1) in the baseline):

$corFlag

0

The setting change caused only slight variation in main estimates (Figure 10). The negative log likelihood as well as AIC of the model increased, the setting was therefore rejected (Table 1).

In the **second** alternative run (WHG2017_AN_010_final_test_settings_survid), both survey fleets were assumed to have measurement noise that in independently distributed (instead of AR(1) as in baseline):

$obsCorStruct

"ID" "ID" "ID"

$keyCorObs

NA NA NA NA NA NA NA NA

NA NA NA NA NA NA NA NA

NA NA NA NA NA NA NA NA

Negative log likelihood and AIC increased for the model and was therefore rejected. Ignoring autocorrelation in measurement noise led to higher recruitment estimates, higher SSB and lower fishing mortality estimates in recent years (Figure 10).

In the **third** alternative SAM run, the measurement noise in the catch fleet was assumed to be autocorrelated (ID in the baseline run):

$obsCorStruct

"AR" "AR" "AR"

$keyCorObs

0 0 1 1 1 1 1 1

-1 2 3 3 3 -1 -1 -1

4 4 5 5 5 -1 -1 -1

The negative log likelihood and AIC decreased, and estimates for catches, recruitment, SSB and fishing mortality changed somewhat (Figure 10, Table 2). In this run, estimated fishing mortality in recent years was lower.

The third run was rejected due to larger confidence intervals in comparison to the baseline and lower degree of matching of observed and estimated catches (Figure 11). In some years actual observed catches were outside the 95% confidence intervals. Also, the leave-one out runs for this run (Figure 12) differed more from each other. In contrast note the high level of matching in the baseline case (Figure 8).

Table 2 Alternative SAM runs listing log likelihood and AIC.

RUN	LOG(L)	AIC
WHG2017_AN_008_surv_catch_mort_mat_cc_1978 (final)	-300.38	642.77
WHG2017_AN_010_final_test_settings_Fid	-333.21	706.42
WHG2017_AN_010_final_test_settings_survid	-364.97	763.94
WHG2017_AN_010_final_test_settings_cAR	-275.25	596.5

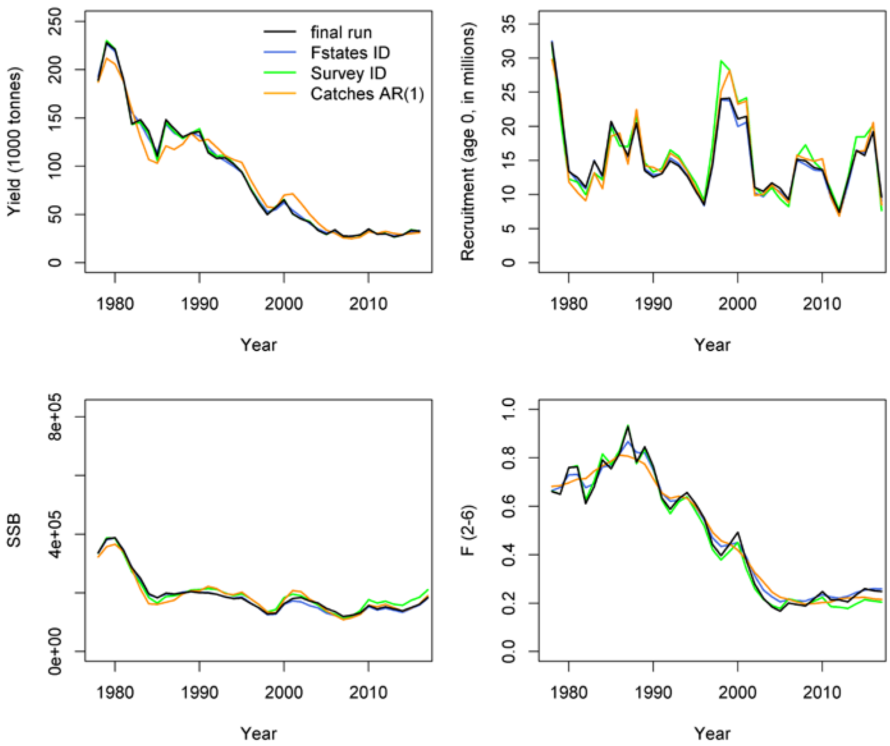


Figure 10 SAM runs using alternative configuration settings.

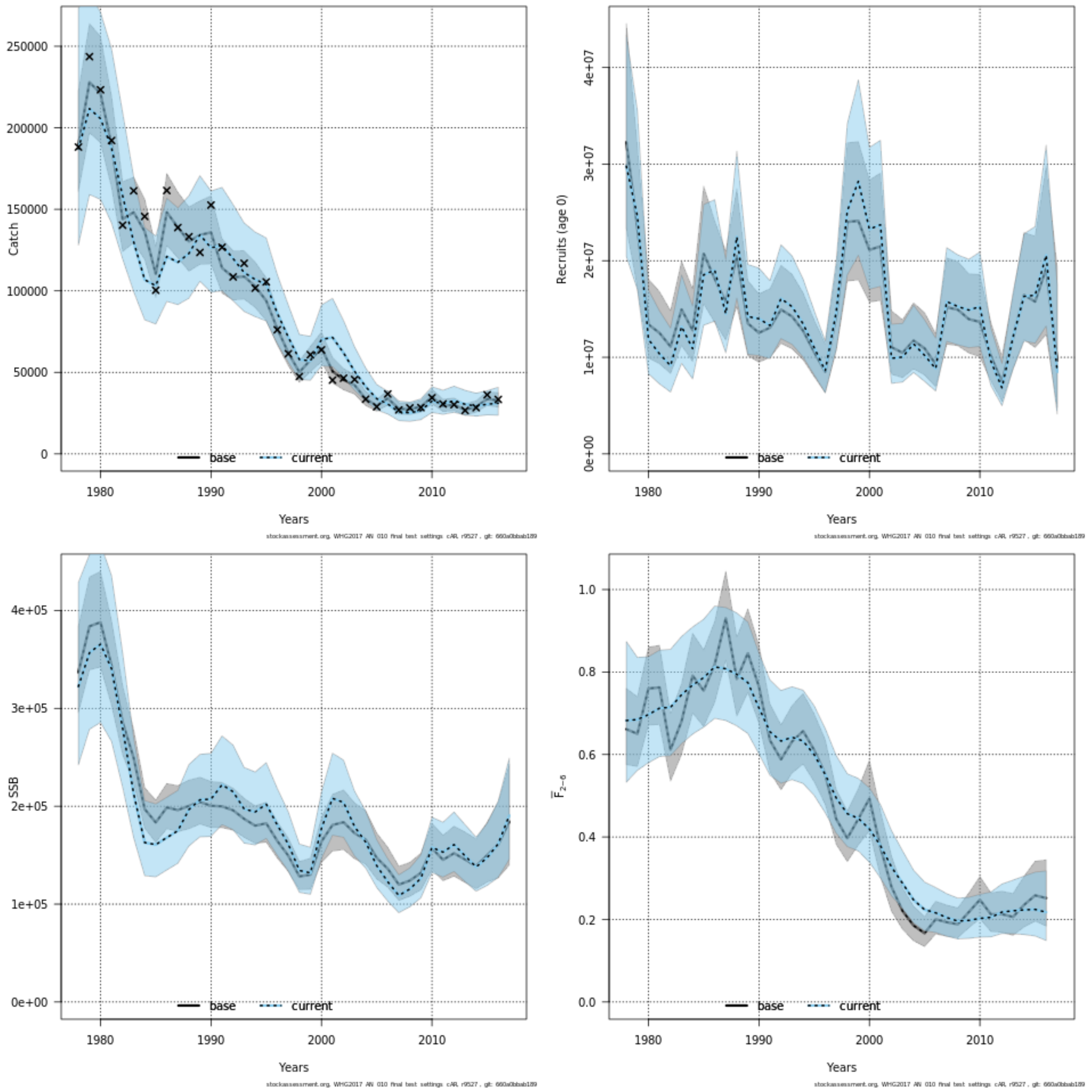


Figure 11 SAM results with autocorrelation in measurement error of the catch fleet (blue, WHG2017_AN_010_final_test_settings_cAR) in comparison to baseline.

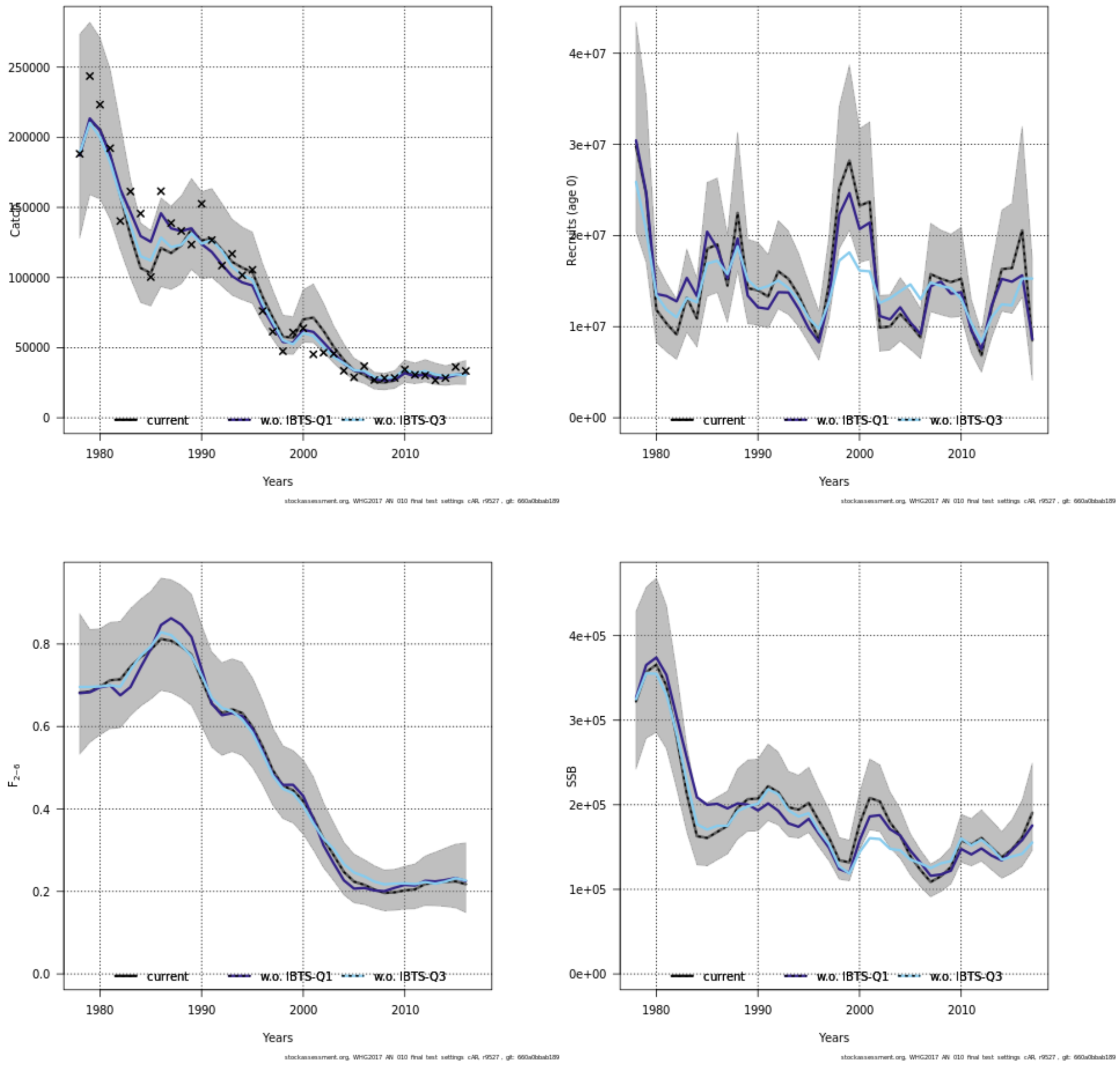


Figure 12 Leave-one-out diagnostics for SAM run with autocorrelation in measurement error of the catch fleet (WHG2017_AN_010_final_test_settings_cAR).

2.3 New survey data

In a stepwise procedure old data as used in the XSA assessment in 2017 for the years (1990-2016) was updated. The old data was implemented in SAM (settings as described in section 1.2) and then updated with new survey data.

New survey data includes updated DATRAS data including additional data for autumn 2017 (NS IBTS Q3). The SAM assessment results are similar with recruitment differing in the final data point due to new survey data (Figure 13).

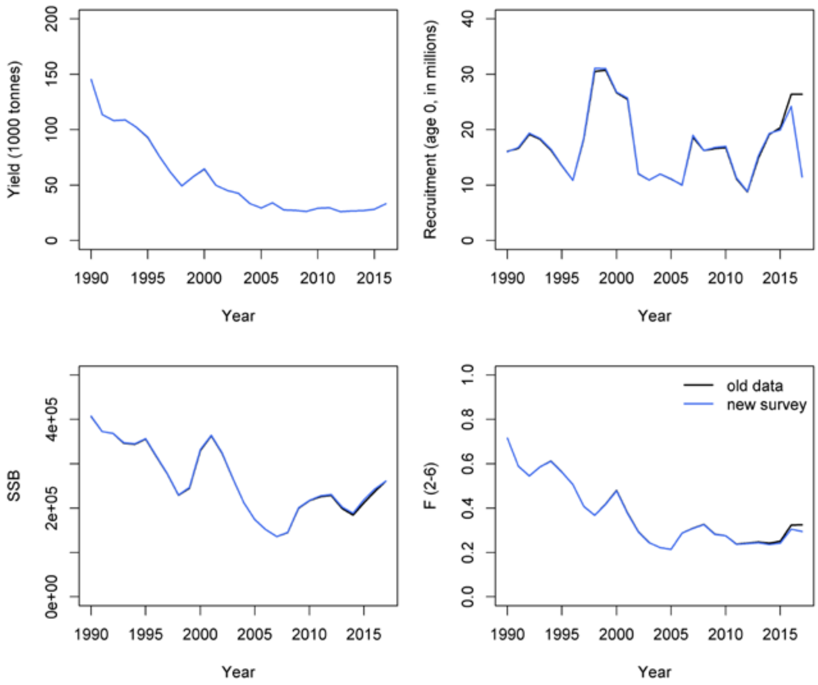


Figure 13 SAM runs: effect of survey data, old data (black) including the new survey data in blue.

2.4 New catch data

New catch data from the WKNSEA 2018 data call were raised according to the raising scheme detailed in WD 2. While overall yield changed only slightly with the new Intercatch data for 2009-2016, increasing catches in some years. Changes in the age distributions of catches affected the recruitment, SSB and F (Figure 14). Relatively higher numbers of age 0 and older individuals were caught according to the newly submitted catch data.

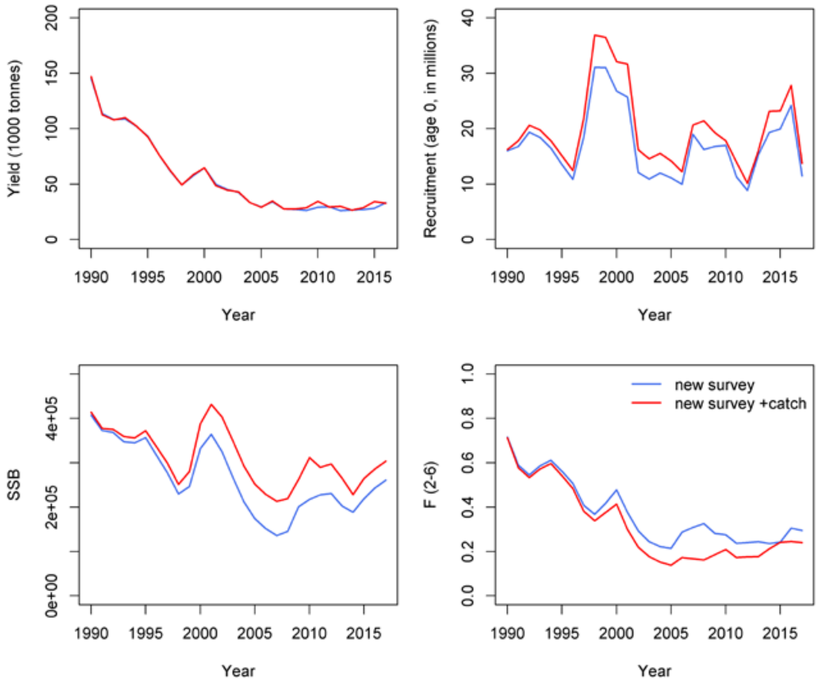


Figure 14 SAM runs: effect of new catch data, data set with new survey (blue) and data series which also includes new catch data (numbers, weights) in red.

2.5 Natural mortality

New natural mortality estimates as provided by WGSAM 2017 were included. Natural mortality at age was estimated to be slightly lower leading to lower recruitment and SSB estimates and higher fishing mortality (Figure 15). It was decided to use smooth estimates of natural mortality in the model, as suggested by WGSAM. Smoothing does not affect Catch, SSB and F estimates. Smoothed estimates lead to smoother less variable recruitment estimates mirroring the dynamics in recruitment using the old smoothed natural mortality estimates.

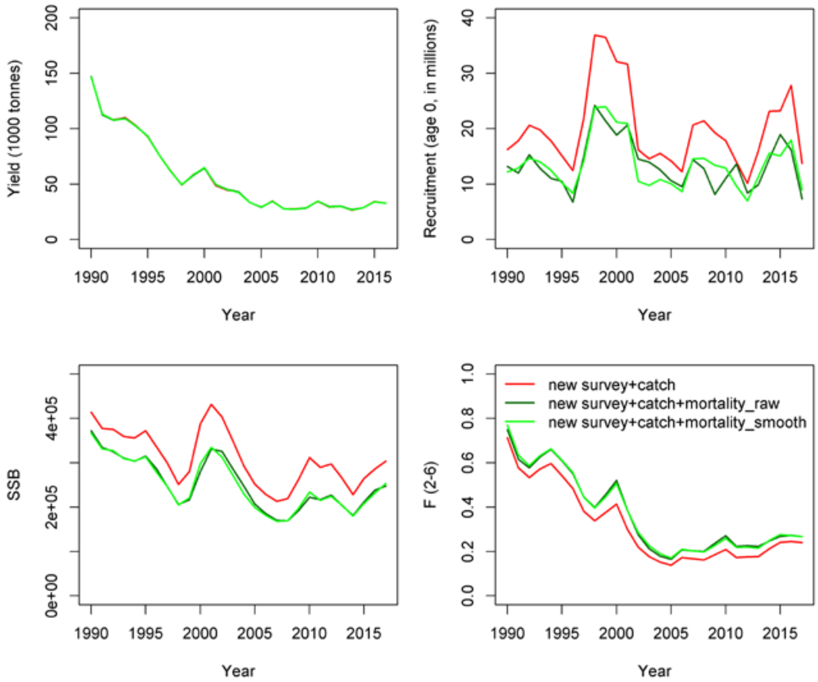


Figure 15. SAM runs: effect of new natural mortality estimates. New data includes survey and catch (red), further runs also include new raw natural mortality estimates (darkgreen) or new smoothed natural mortality estimates (green).

2.6 Maturity data

New maturity ogives were estimated and included in the model. New raw and smoothed values were compared (Figure 16). Only SSB was affected by maturity estimates, which do not enter other calculations in the assessment model. As anticipated, new maturity estimates led to higher SSB in recent years due to the increase in mature individuals at age 1. Smoothing did not affect the SSB much. As discussed with at the benchmark workshop smoothed maturity estimates are used for the final model to reduce interannual variability and track stock dynamics.

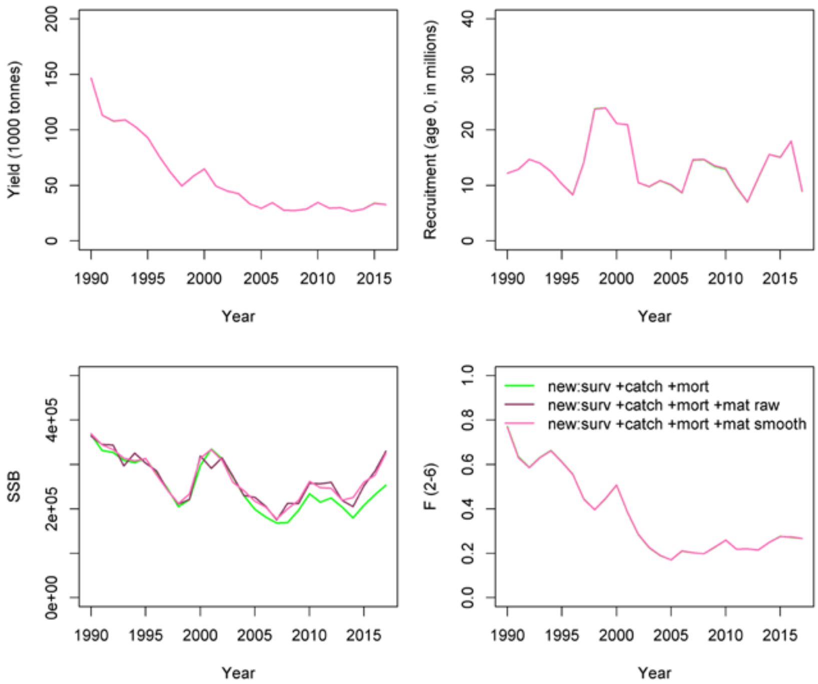


Figure 16 SAM runs: effect of new maturity estimates. New data includes survey, catch and new smoothed natural mortality estimates (green), further runs also include new raw maturity estimates (violet) and new smoothed maturity estimates (pink).

2.7 Age range

The assessment was run using all available ages (0-8+) or a limited set using age 1 to 8+. Main results were very similar (Figure 17). In the most recent years fishing mortality was slightly underestimated using the restricted age range. Recruitment differs substantially as different age classes were presented. The recruitment dynamics were similar but the final year of the assessment overestimated the recruitment when using age 1-8 because new data for age 0 in Q3 survey was ignored. Since indices of neighbouring ages of a cohort were significantly correlated (WD 5), it was recommended to use the full age range to make use of all available data.

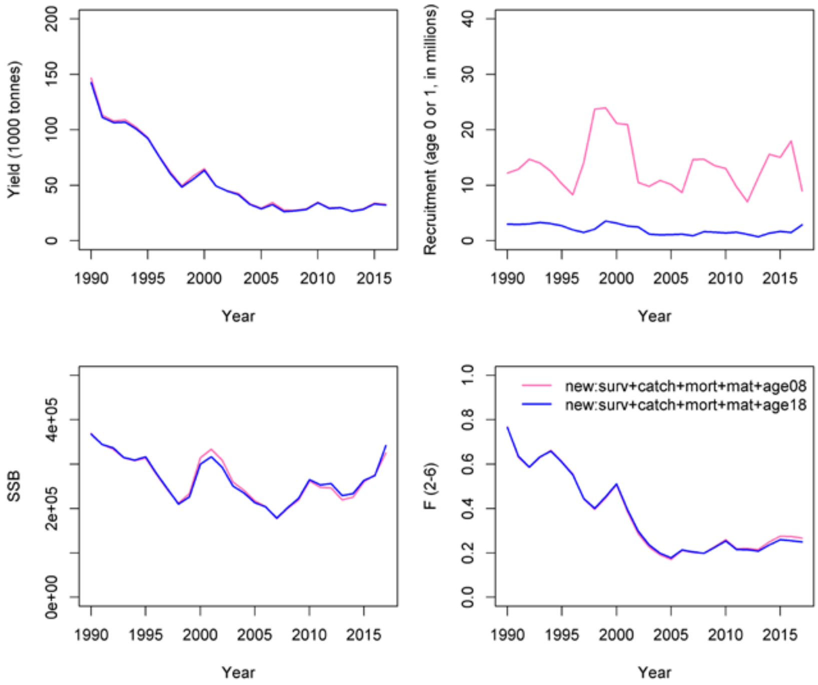


Figure 17 SAM runs: effect of age range included. New data includes survey, catch, new smoothed natural mortality and smoothed maturity estimates, ages 0-8 (green) and excluding age 0 (range 1-8).

2.8 Stock weights at age

In the XSA assessment of year 2017, stock weights at age were assumed to be equal to total catch weights at age and SSB was calculated at the beginning of the year. This can lead to an overestimate of SSB as weights at age were expected to increase during the year. Also catch weight at age may not reflect stock weights at age due to size selectivity of the fishery. To account for the timing mismatch SSB could be calculated midyear (setting the proportion mortality before spawning to 0.5). Alternatively catch weights at age could be corrected using NS IBTS Q1 survey weights at age (WD 6) and SSB calculated at the beginning of the year as usual. The different scenarios accounting for the mismatch between catch weights at age and SSB calculation all led to a reduction in SSB (Figure 18). Since calculation of SSB midyear may not be representative of the spawning season which starts as early as February/March, it was preferred to choose the corrected catch weights at age. Smoothed values led to some change in the SSB results. In some years (for example 1990 and 2003), catch weights at age dropped in multiple age groups (Figure 18). Smoothers corrected the lower mean weights at age in these years in several age groups leading to higher SSB estimates using smoothed values. To maintain interannual variability in weights which occurred consistently across ages unsmoothed corrected stock weights at age were used in the final assessment run. In Figure 19 the reduction in SSB relative to the old set up using catch weight at age as stock weights was calculated. The SSB decreased by around 40%, which was caused by either additional mortality calculating SSB midyear or by rescaling catch weights at age to match stock weights at age calculated from IBTS Q1 survey. Survey weights at age in Q1 were lower for younger age groups, which contribute to SSB.

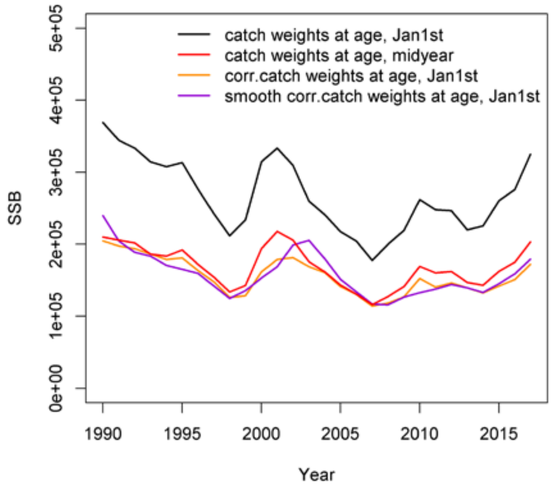


Figure 18 SAM runs: effect of new stock weights at age. New data includes survey, catch, new smoothed natural mortality and maturity estimates, using (scenario black) total catch weights at age as stock weights at age, SSB estimated on the 1st January each year. Alternative runs (scenario red) total catch weights at age as stock weights at age and SSB estimated midyear, (scenario orange) corrected catch weights at age (scaled IBTS Q1) and SSB is estimated January 1st, and (scenario violet) corrected catch weights at age(scaled to IBTS Q1 weights) where SSB is estimated January 1st.

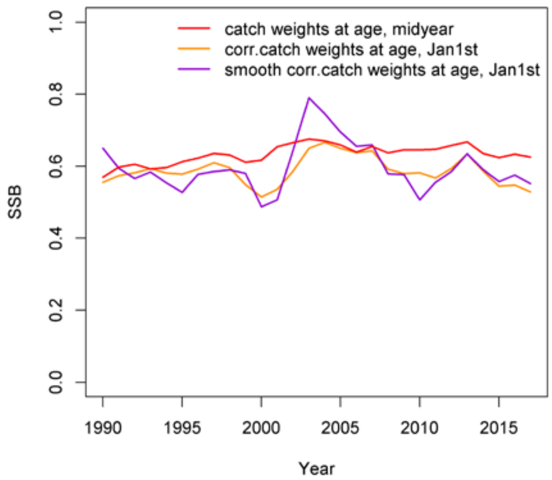


Figure 19 SAM runs: effect of new stock weights at age. Plot relates to Figure 18, with plotted ratio SSB (new stock weights at age scenario)/SSB (using catch weights at age and SSB calculated January 1st).

2.9 Summary of stepwise updates

In comparison, it was shown how the new data input affected the main SAM results (Figure 20). Yield estimates were affected only by the new catch data. Recruitment estimates increased with new catch data but decreased again with new lower natural mortality estimates. Mean fishing mortality decreased with new catch data and increased with new natural mortality estimates. SSB increased with new catch data and decreased with new natural mortality and new stock weights at age. The updates did not change the stock dynamics but scaled its level.

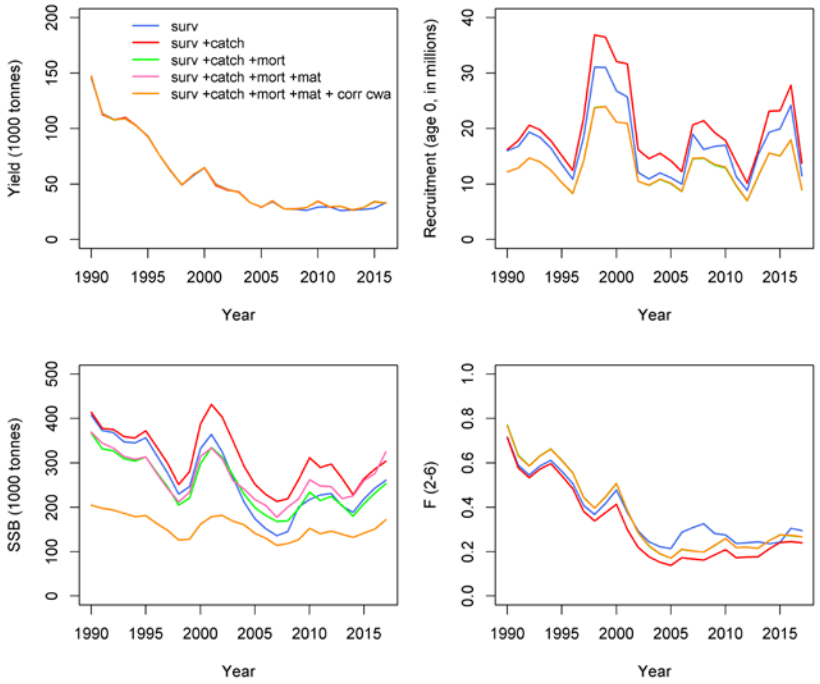


Figure 20 Summary of SAM runs with agreed stepwise updates with new data input. In orange final updated version (1990-2016).

2.10 Long data series

SAM was run with all new data inputs as presented above, but different time periods. Input data was available back to 1978, SAM runs for different time periods were compared. Results were consistent for the different start times (Figure 21). Using longer time series (1978) slightly reduced fishing mortality, but slightly increased recruitment and SSB, in recent years. It was discussed at the Benchmark meeting that the long time series can be used.

The survey time series was assumed to be consistent since 1983 onwards when gear type was standardized across all countries participating in the surveys. Residuals by fleet show some negative values for the survey Q1 fleet in the beginning of the time series, prior to 1983 (Figure 22). The first few years from the survey were excluded, starting NS IBTS Q1 survey in 1983 (Figure 23). The SAM results were not very sensitive to these first years of data. Excluding the first few years only slightly increased fishing mortality and decreased SSB and recruitment in recent years (Figure 23).

Previously in the XSA, catch and survey data prior to 1990 was excluded due to inconsistent signals from catch-based and survey-based assessments. In the following, results from survey based assessments were compared to SAM results and XSA results.

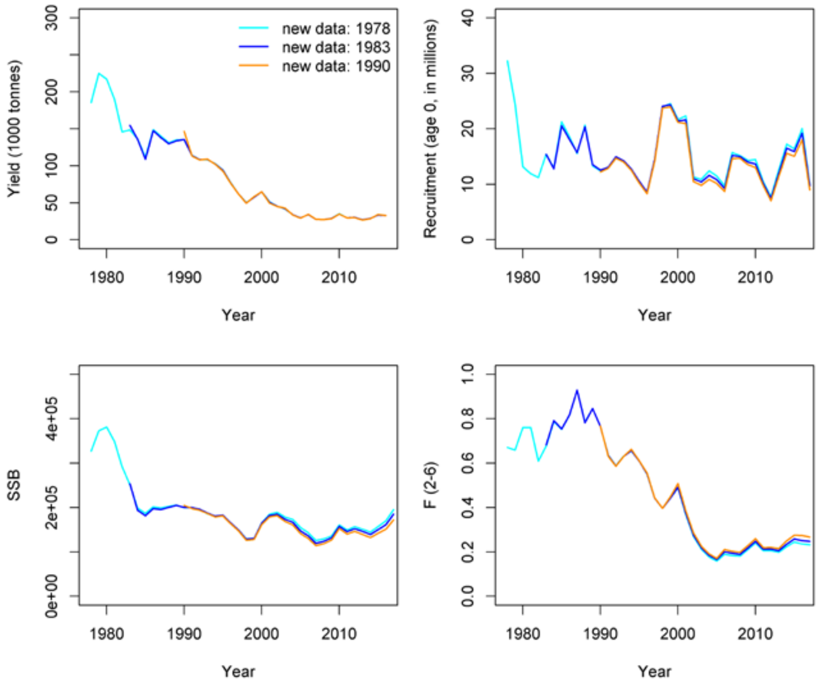
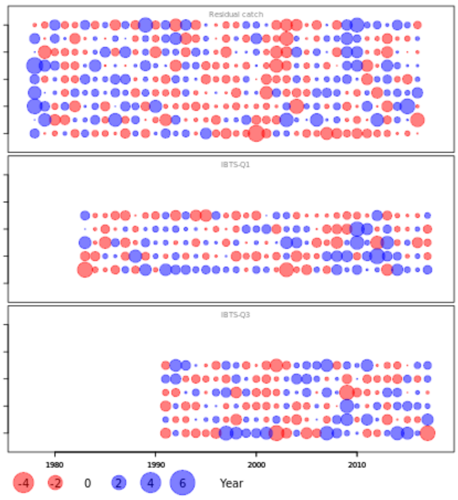


Figure 21. SAM run of new data set for different start times (from 1978, 1983 and 1990).

a)



b)

Figure 22 Residuals by fleet for IBTS Q1 survey starting in (a) 1978 or (b) 1983.

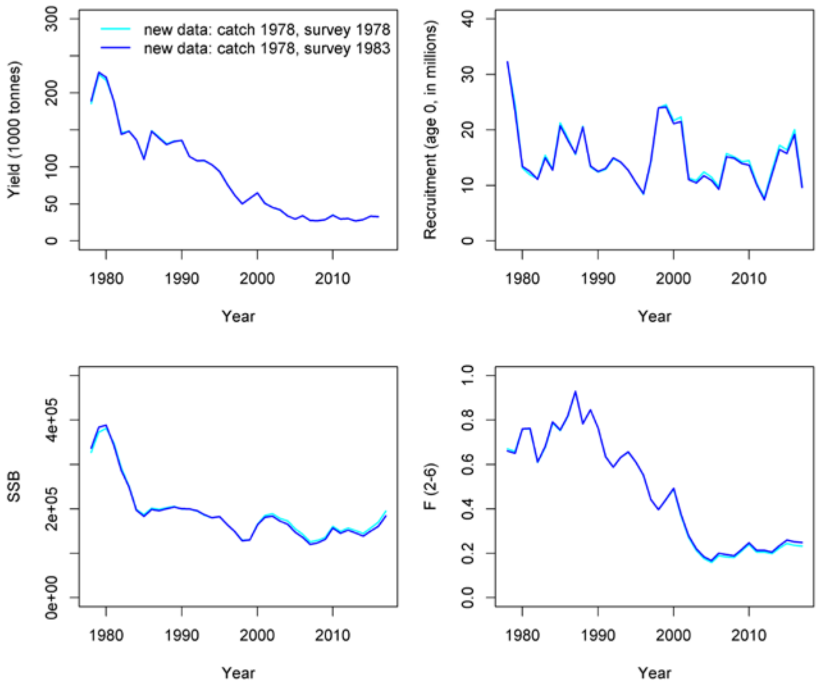


Figure 23 SAM run of new data set for different start times for catch data and biological parameters (from 1978) and survey NS IBTS Q1 (from 1978 or 1983). NS IBTS Q3 started in all cases in 1991.

3 Comparison of SAM results to SURBAR and XSA

To evaluate whether signal from survey and catches were similar, SAM and XSA results were compared to SURBAR results. Mean standardized SSB showed similar dynamics in SAM and XSA, with slightly higher SSB estimates from the XSA in recent years (Figure 24). SURBAR estimates were more variable but showed similar dynamics over time. Differences in the pre-1990 period were not large enough to justify a limitation of the assessment time period. Also when comparing total mortality (Z) from the SURBAR to estimated fishing mortality from XSA and SAM, similar dynamics were observed (Figure 25). Fishing mortality in both XSA and SAM decreased from 0.8 in the early 1980s to around 0.2 and 0.25, respectively. Total mortality decreased from 1.2 to 0.9. Mortality in all three models showed stable high mortality up to around 1990 and a decrease until the early 2000s. Since then mortality stabilized at this lower level. The extended time series using survey data starting in 1983 can be recommended for assessment.

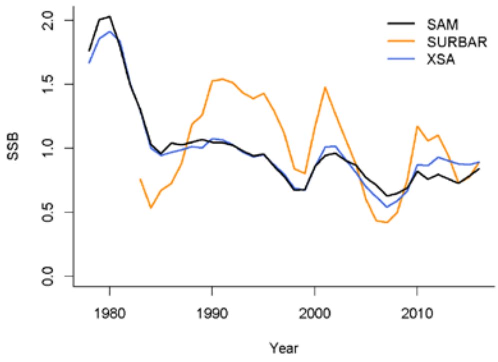


Figure 24 Mean standardized SSB comparing SAM assessment, SURBAR and XSA, using the new input data with NS IBTS Q1 indices starting in 1983.

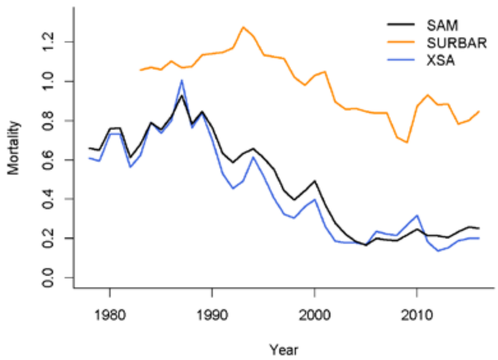


Figure 25 Comparing mean fishing mortality (age 2-6) in the SAM assessment, to mean fishing mortality (age 2-6) from XSA, to total mortality Z (age 2-4) from SURBAR.

4 References

Nielsen, A., and Berg, C. W. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research, 158: 96-101.

WD 8 SURBAR analysis and comparison between stock components for whiting in subarea 4 and division 7d

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1. Introduction

The assessment usually includes fisheries dependent and fisheries-independent data, such as data from scientific surveys. Using a survey-based assessment, differing signals between survey- and fisheries-dependent data can be identified. To explore dynamics in SSB, recruitment and mortality a survey based assessment (SURBAR) was run for the North Sea whiting stock using new input data. While estimated abundances in terms of recruitment and SSB are given as relative values, dynamics and trends can be identified and compared to catch-based assessments such as the SAM output. The new SURBAR results were compared to the old run with data input used in the 2017 assessment. Furthermore, SURBAR allows for a comparison of stock dynamics for the northern and southern component, for which spatially specific commercial catch data is lacking.

2. Methods

SURBAR is a survey-based assessment implemented in R. Total mortality is determined by a year and age effect and used to derive abundances. Thereby, the abundance at each age and year of a cohort is given by the recruiting abundance modified by the cumulative effect of mortality over its lifetime (Mesnil *et al.*, 2009; Needle, 2015). Parameters are estimated by minimising the weighted sum-of-squares of observed and estimated abundance indices. All abundance estimates are relative. SURBAR were run for old and new data and compared. Results for Southern and northern component were compared.

Input data includes natural mortality at age estimates, proportion mature at age, survey indices and stock-weights at age. All these input data were updated for the new assessment run.

New natural mortality estimates were assumed to be the same for combined stock and and regional components (North, South) using the most recent smoothed natural mortalities at age from WGSAM 2017 (ICES, 2018) estimated for the entire North Sea (WD 3).

New maturity ogives were used as calculated in WD 4, with the combined ogive for the North Sea assessment and area-specific ogives for analysis by stock component.

New NS IBTS survey indices Q1 and Q3 were used in the SURBAR run (WD 5). The new indices include additional data from the IBTS Q3 survey in 2017. The combined indices for the North Sea and area specific indices for northern or southern component were used.

The stock mean individual weights at age (using unsmoothed corrected catch weights at age) were assumed to be the same for combined North Sea and by-component analysis (WD 6).

The proportion mortality before spawning is set to 0, assuming SSB is calculated in the beginning of the year.

For the SURBAR analysis, the data period 1983 onwards was used.

Catchability q and SSQ weightings ω both set to be equal to 1.0 across all ages and years.

Smoothing parameter λ set to 5.0 to prevent excessive variation in mean Z estimates.

Mean Z age range set to 2-4.

Reference age set to 3.

3. Results

SURBAR results for the North Sea using new input data showed a reduction in total mortality in the mid 1990s. Lowest biomass occurred in 2007 and recruitment was at medium to low level since 2003 (Figure 1). Confidence intervals were very tight around estimates. In comparison to the old data set, results were rather similar for recruitment and total mortality with some difference in the most recent year estimate due to new survey data for the most recent year (Figure 5, Figure 6). The results using old and new data were relatively similar tracing the SSB dynamics over time (Figure 4). Small differences to the old results were due to updated maturity ogives and stock weights at age.

The SURBAR results for stock components North and South were compared. The summary plots of the results illustrate that there is more uncertainty in estimates for the southern component (Figure 8). SSB dynamics were fairly synchronous in both areas (Figure 9). Some deviations can be observed around 1985 and 2015 when SSB increased in the South where it decreased in the North. Around 1995 the opposite pattern was observed with relatively high SSB in the North and low values in the South. Both components dropped to their lowest SSB levels in 2006/2007. In recent years, the southern component recovered its maximum SSB levels (Figure 9). The combined SURBAR assessment indicates a stronger influence of the Northern component on stock dynamics.

Recruitment dynamics also show similar dynamics in northern and southern components with an increase in recruitment in recent years (Figure 10). In both components, recruitment dropped to the lowest levels of the time series in 2003-2004. In recent years, recruitment level was at medium level. In the southern component, recruitment reached its maximum value in 2017. Total mortality appeared to be higher in the southern component and was at continuously high level for the entire time series without the reduction in mortality observed for the northern component (Figure 11). However, uncertainty around the estimates for the South was also relatively large in the southern component (Figure 8).

4. Conclusion

The SURBAR results using the new data for the longer times series (1983-2017) were in agreement with the analysis using the old data. Differences were caused by an updated maturity ogive, survey data and stock weights at age. A comparison of SURBAR results to the SAM results, which includes fisheries dependent data were detailed in WD 7.

From SURBAR, it can be inferred that stock dynamics in northern and southern component showed roughly similar dynamics in terms of SSB and recruitment. The assessment results for the combined North Sea better reflected the status of the northern component. SSB as well as total mortality were more variable in the South with larger confidence intervals. This can be related to higher variability in maturity estimates (WD 4) and survey indices with lower within survey correlations between age groups of a cohort (WD 5). In recent years, the southern component showed an upwards trend in SSB and recruitment. Therefore currently, management decisions appropriate for the combined stock are not expected to negatively impact the southern component.

5. Figures

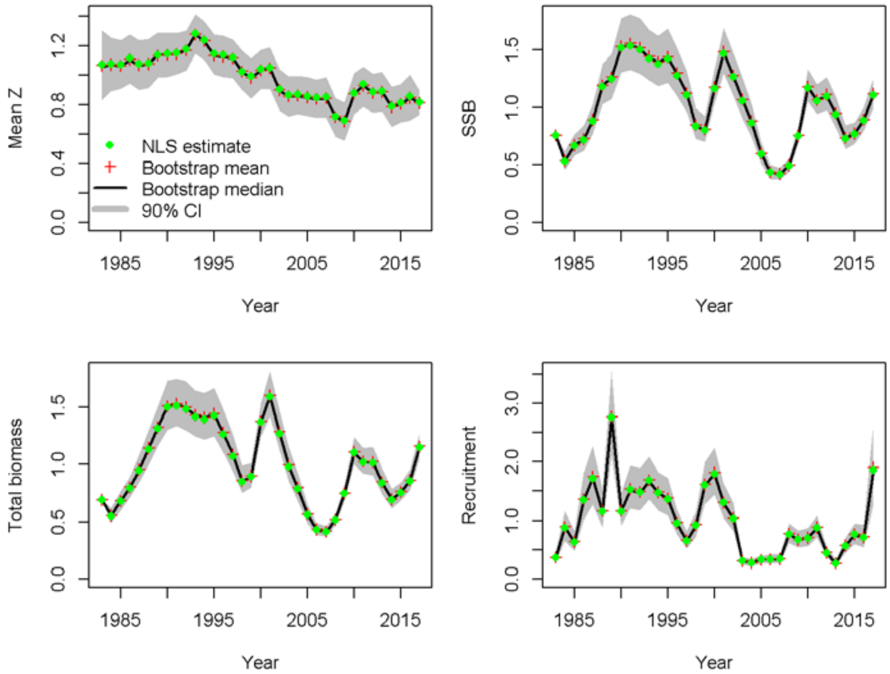

Figure 1. Whiting in area 4 and 7d. Summary plots using new data and both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

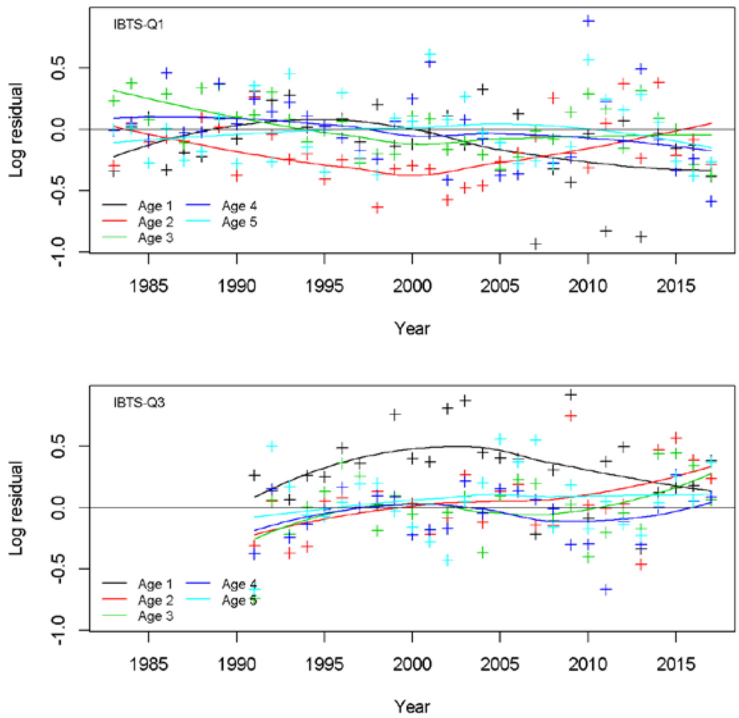

Figure 2 Whiting in area 4 and 7d. Log survey residuals from the SURBAR analysis. Ages are colour-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

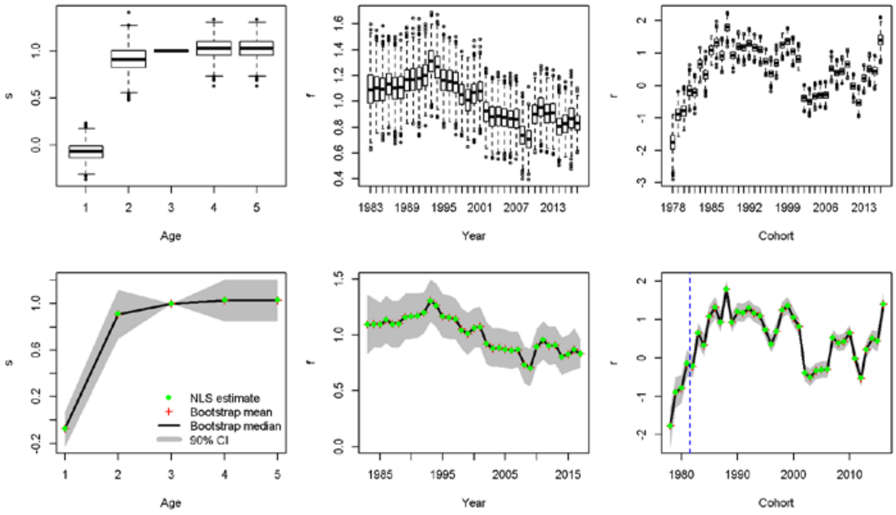

Figure 3 Whiting in area 4 and 7d. Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals

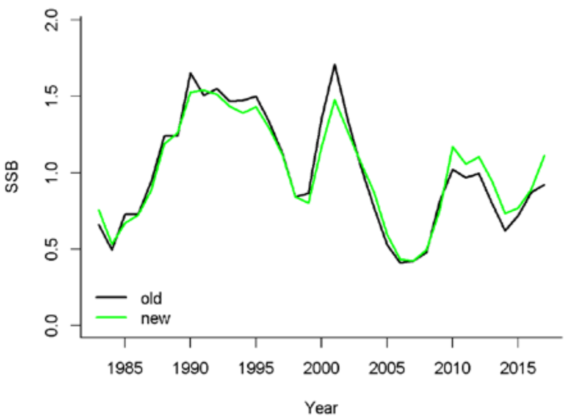

Figure 4. Whiting in area 4 and 7d. Comparison of relative SSB estimates from SURBAR using old (black) and new (green) input data.

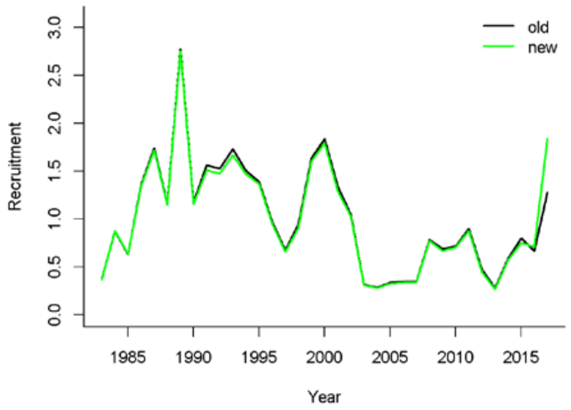

Figure 5. Whiting in area 4 and 7d. Comparison of relative recruitment (age 1) estimates from SURBAR using old (black) and new (green) input data.

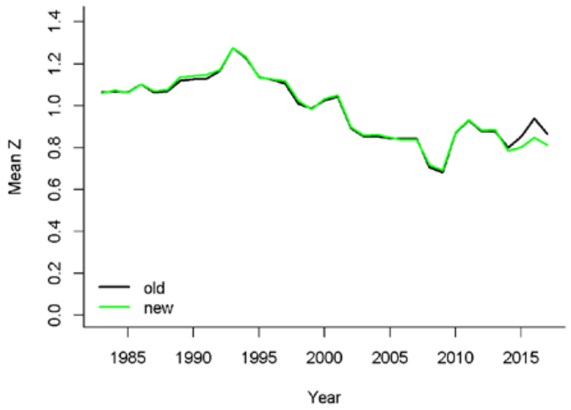

Figure 6. Whiting in area 4 and 7d. Comparison of mean Z estimates (ages 2-4) from SURBAR using old (black) and new (green) input data.

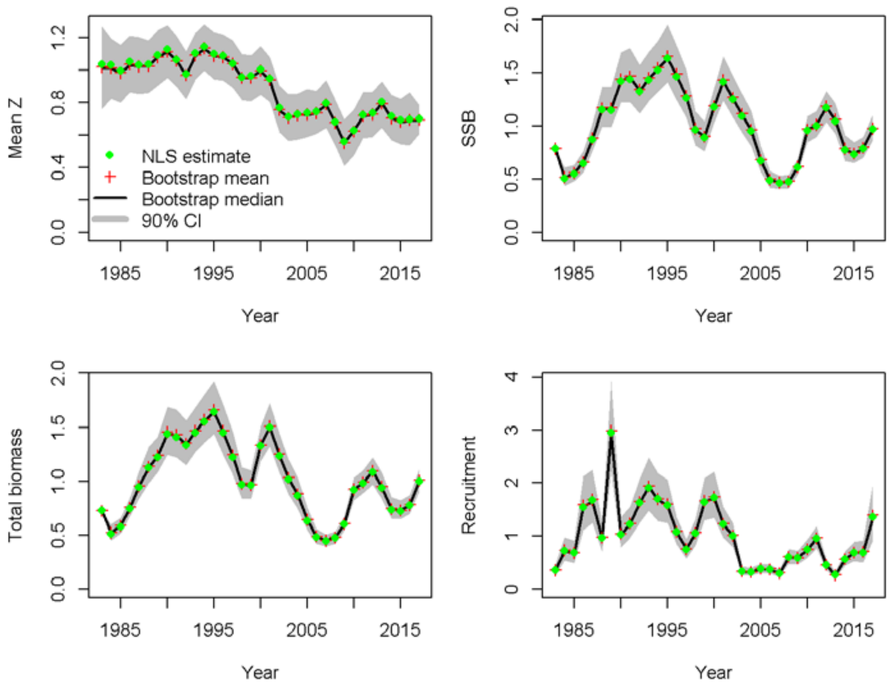

Figure 7 Northern component of the North Sea. Summary plots using new data and both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points are the model estimates, while red crosses and black lines represent mean and median values from the uncertainty estimation bootstrap, respectively.

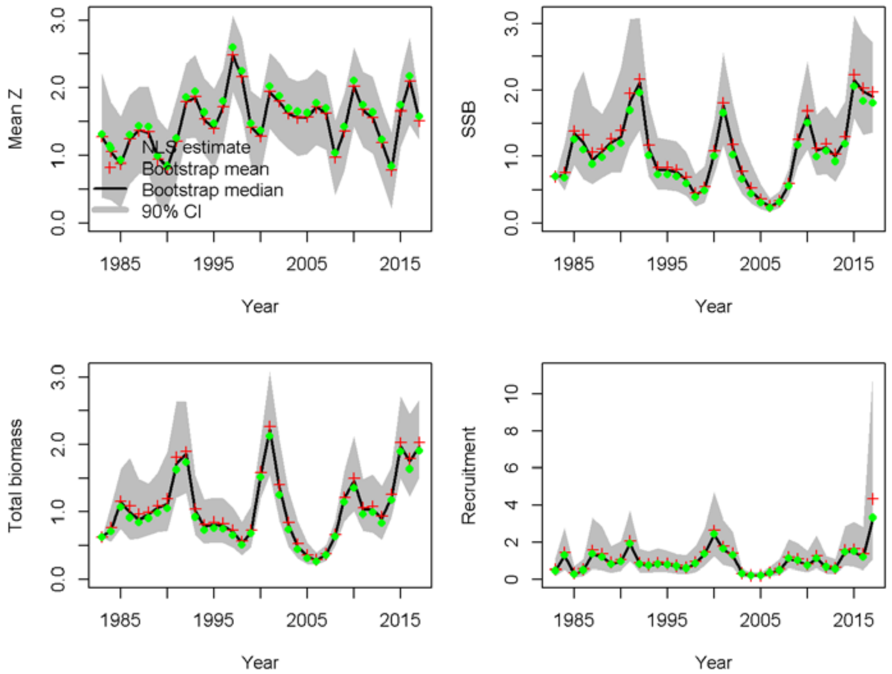

Figure 8 Southern component of the North Sea. Summary plots using new data and both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points are the model estimates, while red crosses and black lines represent mean and median values from the uncertainty estimation bootstrap, respectively.

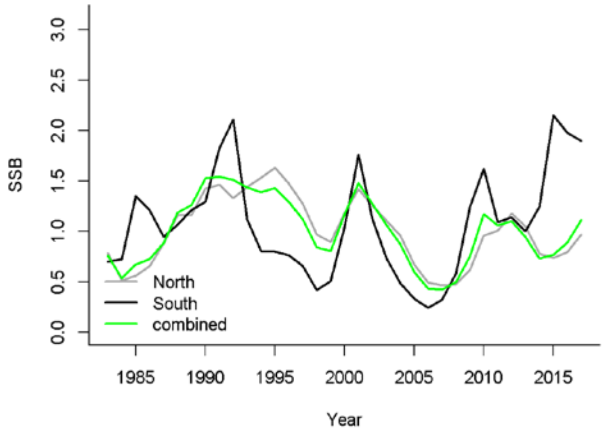

Figure 9 Relative SSB estimated using SURBAR, comparison for area-specific (North in grey, South in black) and combined North Sea (green) values.

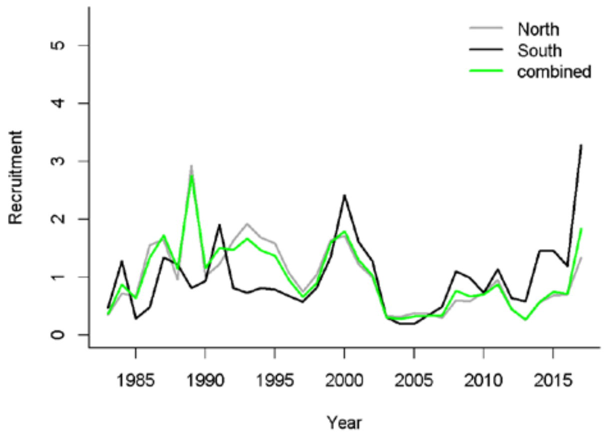

Figure 10 Relative recruitment (age 1) estimated using SURBAR, comparison for area-specific (North in grey, South in black) and combined North Sea (green) values.

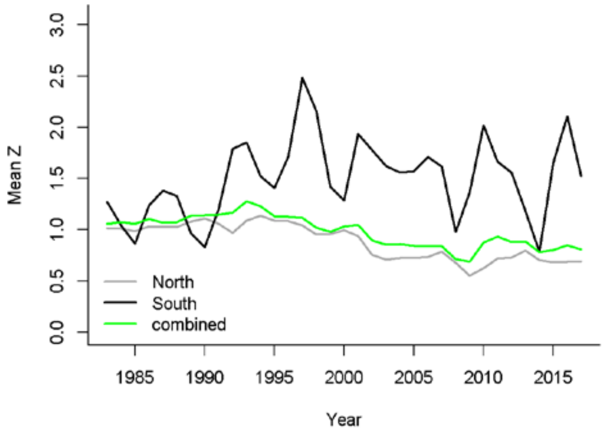

Figure 11 Total mortality Z (ages 2-4), comparison for area-specific and combined SURBAR analysis.

6. References

ICES 2018. Interim Report of the Working Group on Multispecies Assessment Methods (WGSAM), 16-20 October 2017, San Sebastian, Spain. ICES CM 2017/SSGEPI:20: 395pp.

Mesnil, B., Cotter, J., Fryer, R. J., Needle, C. L., and Trenkel, V. M. 2009. A review of fishery-independent assessment models, and initial evaluation based on simulated data. Aquat. Living Resour., 22: 207-216.

Needle, C. L. 2015. Using self-testing to validate the SURBAR survey-based assessment model. Fisheries Research, 171: 78-86.

WD 9 XSA assessment for whiting in subarea 4 and division 7d

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In previous year, the assessment of whiting in the North Sea (Subarea 4) and Eastern Channel (Subdivision 7d) was conducted using an XSA implemented in R (FLXSA library). To compare the new SAM assessment to the previously used model, XSA was run also for this benchmark. The model was updated with new input data and compared to the run with old results. Recruitment was calculated at age 1, SSB was calculated at the beginning of the year.

XSA settings were as follows:

Tolerance (tol):	1e-09
Maximum allowed iterations (maxit):	1000
Minimum standard error for surveys (min.nse):	0.3
Time series weighting in years (tsrange):	100
Time series weighting power (tspower):	0
Years of catch data to use (window):	100
Max age of power relationship in selection (rage):	0
First age of full selection (qage):	4
F shrinkage tolerance (Fse):	2.0
No. at age shrinkage; last # years (shk.yrs):	3
No. at age shrinkage; oldest # ages (shk.ages):	4
Mean F range	2-6

Type	**Name**	**Year range**	**Age range**
Tuning fleet 1	IBTS-Q1	1983-	1-5 (age 6+ not used)
Tuning fleet 2	IBTS-Q3	1991-	1-5 (ages 0 and 6+ not used)

Type	**Name**	**Year range**	**Age range**	**Variable from year to year Yes/No**
Caton	Catch in tonnes	1978-	NA	Yes
Canum	Catch at age (numbers)	1978-	1-8+	Yes
Weca	Weight at age (kg)	1978-	1-8+	Yes
West [corrected	Weight at age of the spawning stock at spawning time.	1978-	1-8+	Yes

Weca]				
Mprop	Proportion of natural mortality before spawning	1978-	1-8+	No (set to 0)
Fprop	Proportion of fishing mortality before spawning	1978-	1-8+	No (set to 0)
Matprop	Proportion mature at age	1978-	1-8+	Yes
Natmor	Natural mortality	1978-	1-8+	Yes

1. Results

The summary of XSA results were plotted in Figure 1. Fishing mortality showed a decrease from a value of 1.0 in 1987 to around 0.2 in recent years (Table 1). Estimated fishing at age and numbers at age were listed in Table 2 and Table 3.

Catch curves for the commercial catch data were plotted in Figure 2 showing numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery at age 1 for a few cohorts. Slopes for the catch curves were less steep for the 2000-2010 cohorts, indicating relatively higher CPUE at higher ages. The negative gradients appear to be fluctuating around a mean level since the 2002 year class that is lower than the mean level before the 1998 year-class, which suggests that recent fishing mortality was lower than in the past (Figure 3, Figure 1). For the 2010 cohort the negative gradient of commercial catch data was lowest in the series (similar to 2000 cohort).

In general, catch numbers correlate well between age groups of cohorts with the relationship breaking down as cohorts are compared across increasing age gaps (Figure 4). Residual patterns show that the 2006 and 2012 year class has a large negative residual at age 1 for both surveys (Figure 5). Negative residuals were observed prior to 1987 for all age groups in Q1, indicating a mismatch between, survey and catch data. Retrospective plots show relatively good agreement for most recent years, with some overestimation of F and underestimation of SSB in the late 2000s (Figure 7).

Results of the XSA using old data (from 2017 assessment) were compared in Figure 8-Figure 11. There was a slight increase in F across the time series, with recent values being equivalent. Recruitment at age 1 and SSB across the entire time series shifted down, while characteristic patterns remained the same.

XSA results were compared to SURBAR and San results in WD 7.

2. Figures and Tables

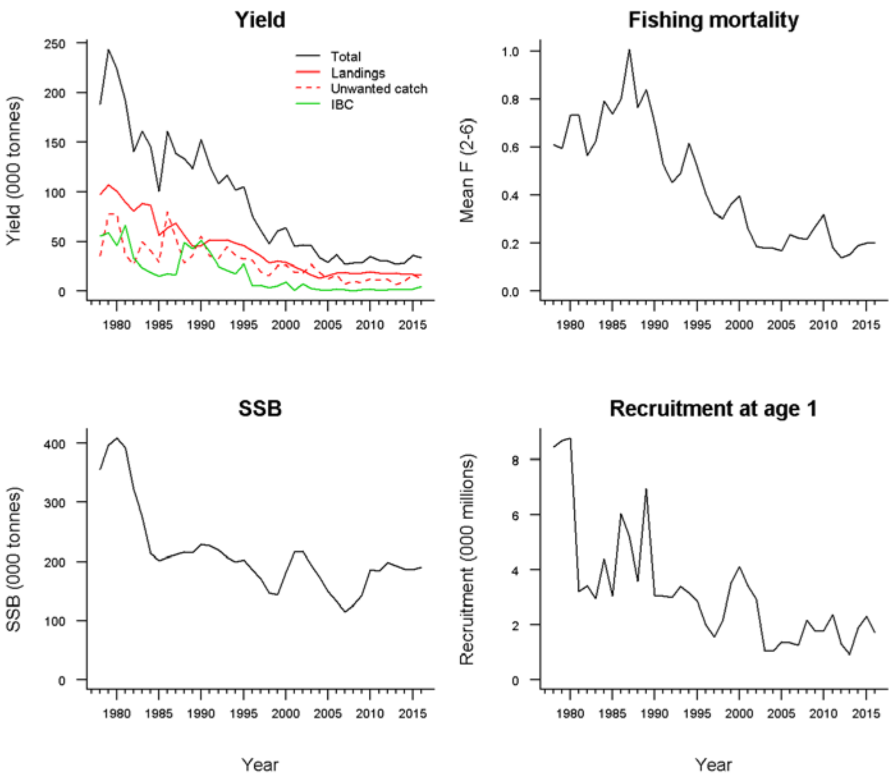

Figure 1 Whiting in Subarea 4 and Division 7d. New data. Summary plots for FLXSA assessment. Recruitment at age 1.

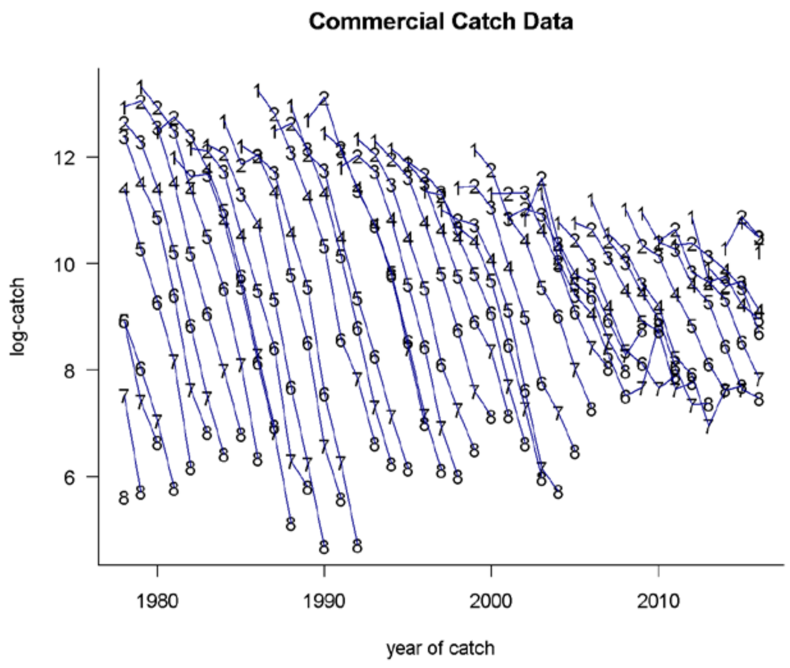

Figure 2 Whiting in Subarea 4 and Division 7.d. Log catch curves by cohort for total catches.

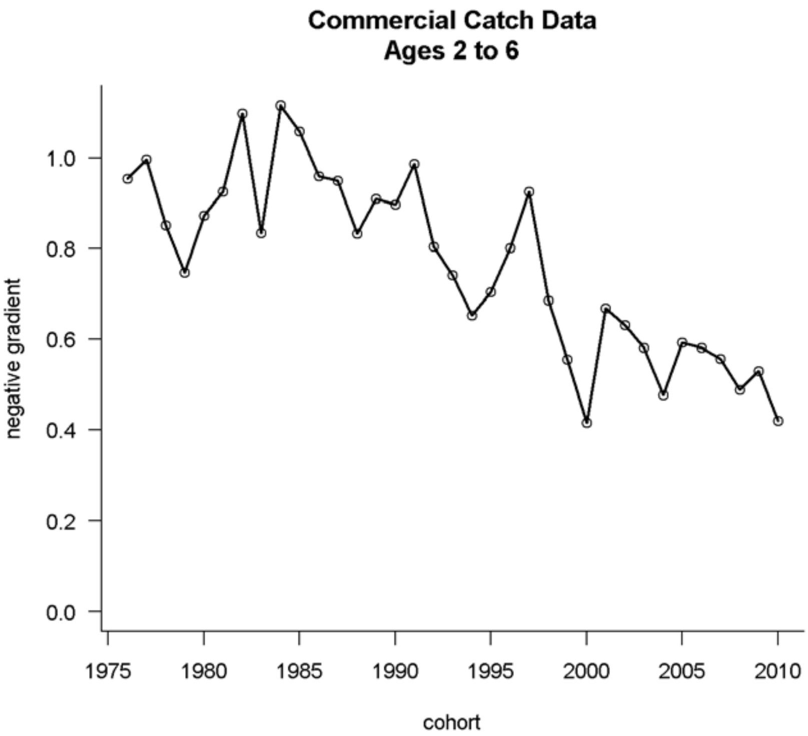

Figure 3 Whiting in Subarea 4 and Division 7.d. Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

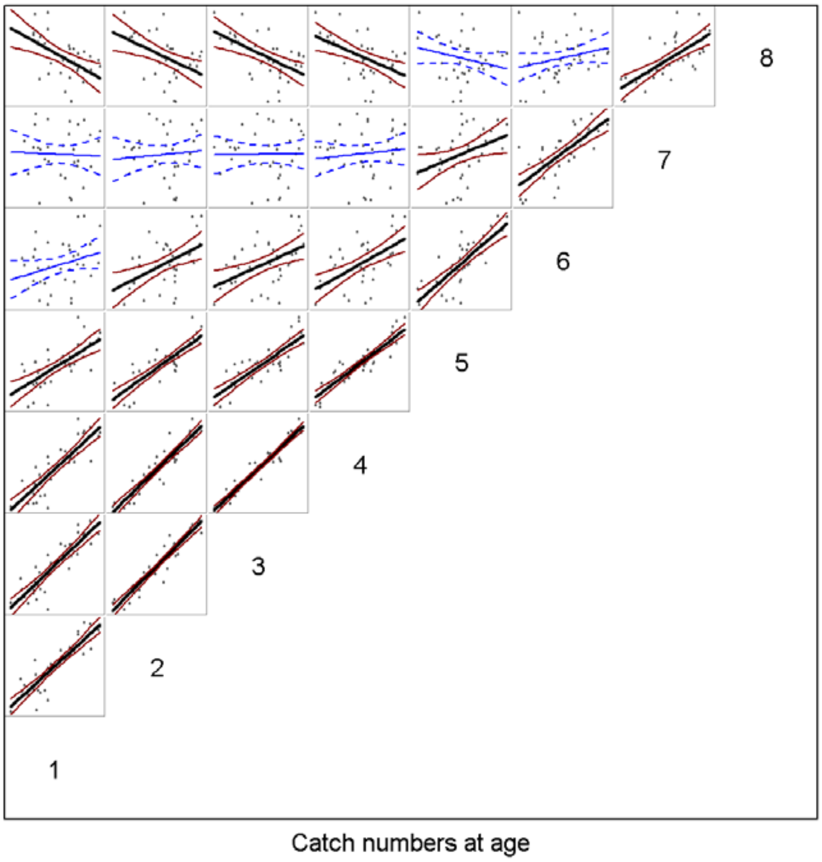

Figure 4 Whiting in Subarea 4 and Division 7.d. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

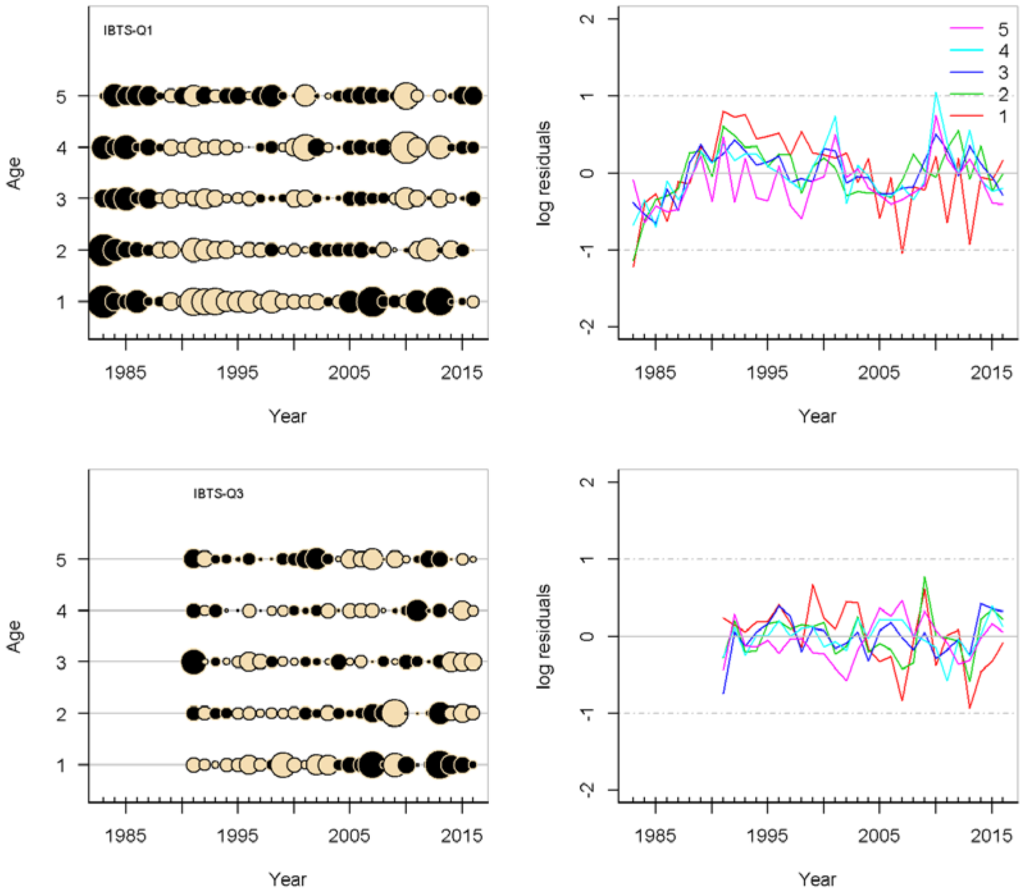

Figure 5 Whiting in Subarea 4 and Division 7.d. Log catchability residuals for final FLXSA assessment (negative values as black bubbles, positive values as yellow bubbles).

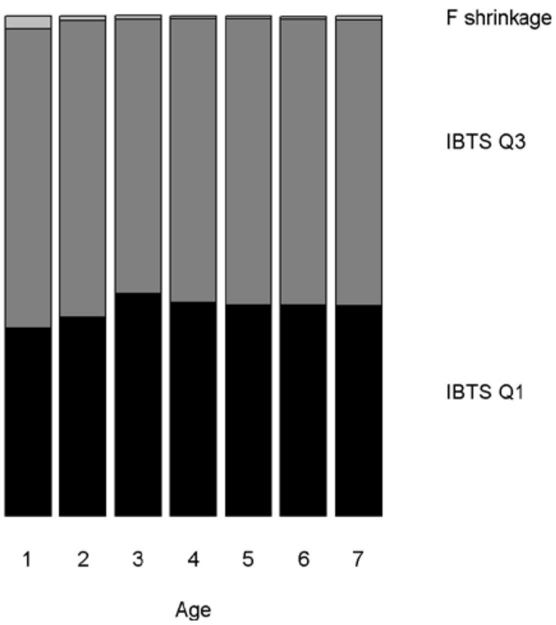

Figure 6 Whiting in Subarea 4 and Division 7.d. Contribution to survivors' estimates in final FLXSA assessment.

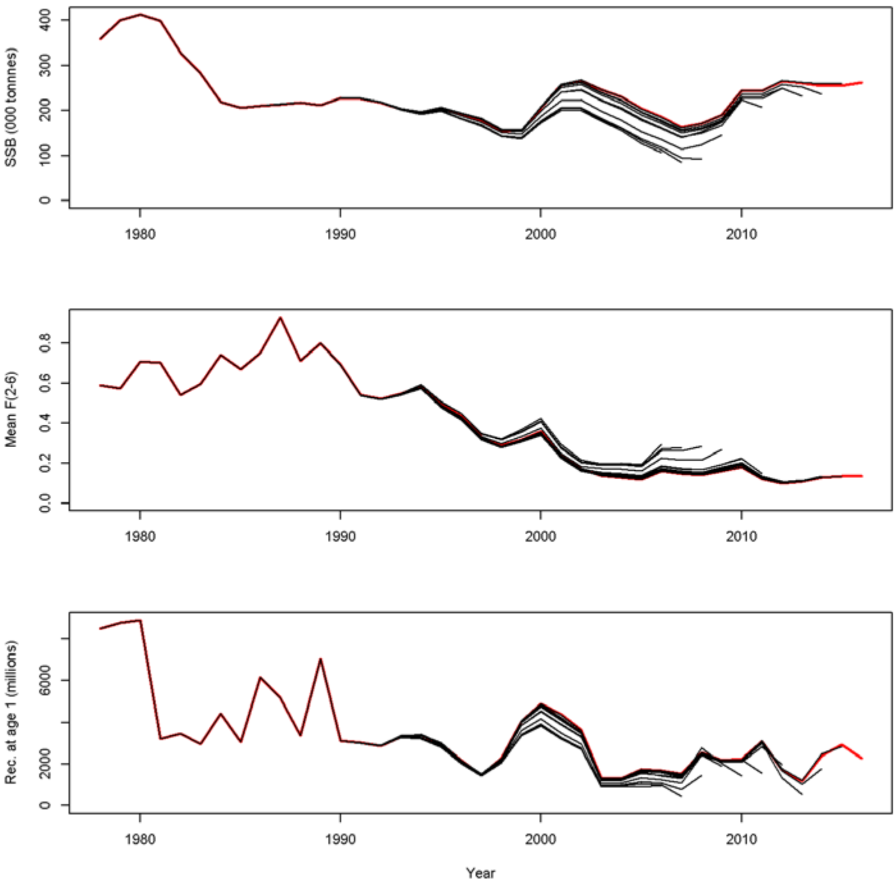

Figure 7 Whiting in Subarea 4 and Division 7.d. Retrospective plots for final FLXSA assessment.

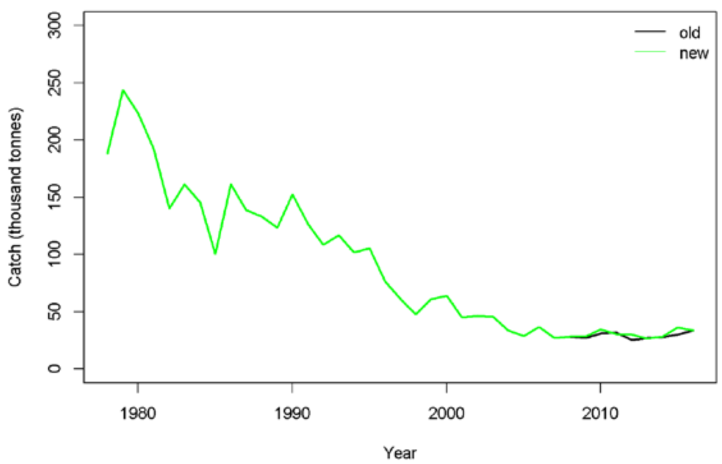

Figure 8 Comparison old data and new data catch as used in XSA

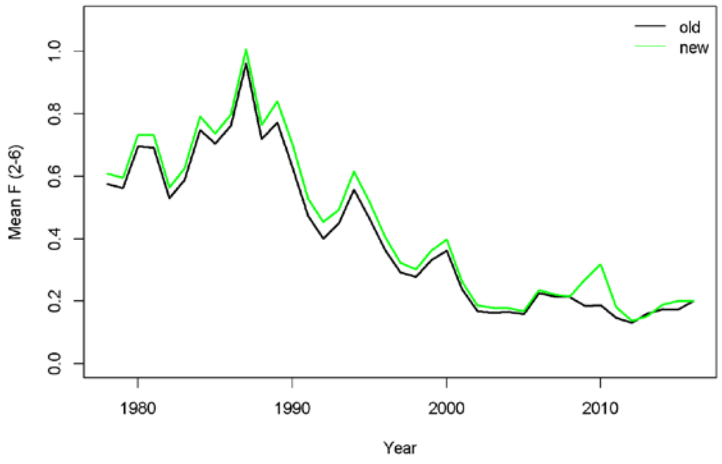

Figure 9 Comparison of Mean F as estimated using FLXSA with old and new input data.

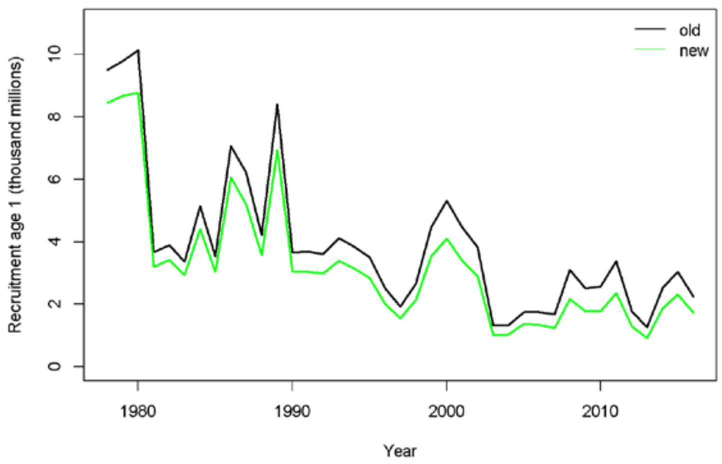

Figure 10 Comparison of recruitment as estimated using FLXSA with old and new input data.

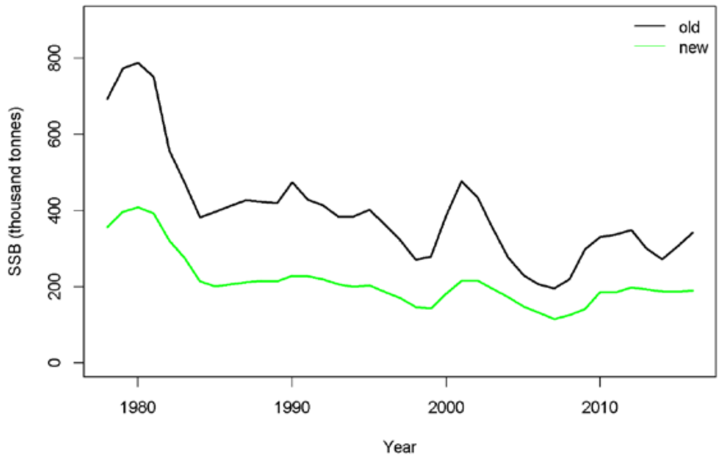

Figure 11 Comparison of recruitment as estimated using FLXSA with old and new input data.

Table 1 Whiting in Subarea 4 and Division 7.d. Final FLXSA summary table. Units are thousands of individuals and tonnes.

Year	Recruit ment	TSB	SSB	Catch	Landings	Unwanted catch	Bycatch	Yield /SSB	Mean F(2-6)
1978	8443837	549121	355856	188197	97528	35382	55287	0.274	0.610
1979	8684295	656490	396936	243627	107287	77391	58948	0.270	0.594
1980	8780871	613060	408708	223298	100711	77003	45584	0.246	0.733
1981	3202605	483609	392235	192190	89655	35894	66641	0.229	0.732
1982	3428212	388070	321808	140265	80589	26620	33055	0.250	0.564
1983	2950177	373692	276363	161345	88030	49562	23753	0.319	0.625
1984	4409895	332845	214045	145634	86273	40483	18878	0.403	0.792
1985	3039964	292674	201795	100358	56087	28961	15310	0.278	0.737
1986	6061809	397262	206922	161535	64059	79523	17953	0.310	0.799
1987	5198294	335330	211167	138818	68398	53901	16519	0.324	1.007
1988	3570371	280478	216184	133215	56100	28146	48969	0.260	0.764
1989	6937967	359900	214475	123556	45125	35787	42643	0.210	0.840
1990	3063964	319167	229350	152603	45662	55603	51337	0.199	0.703
1991	3043422	322325	227261	126742	51929	35057	39755	0.229	0.529
1992	2986394	299996	219065	108556	50947	32564	25045	0.233	0.455
1993	3394145	285277	206721	116911	51818	44370	20723	0.251	0.493
1994	3153542	284479	199275	101651	48486	35692	17473	0.243	0.615
1995	2851095	286727	203380	105493	45938	32176	27379	0.226	0.517
1996	2014352	251459	186400	76123	40503	30504	5116	0.217	0.406
1997	1547765	222761	171045	61435	35563	19659	6213	0.208	0.324
1998	2154123	208601	147336	47475	28288	15693	3494	0.192	0.303
1999	3539815	228004	143550	60845	30130	25677	5038	0.210	0.362
2000	4111923	326077	182542	63806	28583	26063	9160	0.157	0.398

2001	3409133	334356	215763	45242	25061	19237	944	0.116	0.263
2002	2910823	291320	217181	46450	20674	18501	7275	0.095	0.186
2003	1029916	225807	194253	45640	16161	26745	2734	0.083	0.179
2004	1043950	207795	172948	33558	13296	19048	1214	0.077	0.178
2005	1379900	194469	148689	28883	15470	12525	888	0.104	0.169
2006	1342025	179644	132778	36769	18535	16310	1924	0.14	0.236
2007	1248665	150397	115277	26975	18915	6971	1088	0.164	0.222
2008	2168736	182410	125830	28246	17951	10296	0	0.143	0.216
2009	1778105	189685	142206	28417	18393	8680	1344	0.129	0.271
2010	1782112	240299	186210	34443	19859	12677	1907	0.107	0.318
2011	2370147	251830	184769	30663	18468	11159	1035	0.100	0.182
2012	1299141	239421	198420	30212	17407	11688	1117	0.088	0.137
2013	921395	222043	192816	26662	18220	6789	1654	0.094	0.153
2014	1883688	246500	187438	28364	17024	9717	1623	0.091	0.190
2015	2313760	255319	186061	36254	17291	16866	2097	0.093	0.201
2016	1728749	244105	190581	33396	16123	12722	4551	0.085	0.202

Table 2 Whiting in Subarea 4 and Division 7.d. Final abundance estimates from FLXSA (in thousands).

Year	1	2	3	4	5	6	7	8+
1978	8443837	1666271	805312	231653	20075	14650	4360	637
1979	8684295	2115257	636120	292835	72131	7096	4066	728
1980	8780871	2045467	768170	209849	100816	23212	2402	1551
1981	3202605	2233306	779227	235517	57626	22139	7280	652
1982	3428212	778603	940730	256999	64152	14395	5168	1171
1983	2950177	830663	336750	369720	88371	19102	4233	2150
1984	4409895	706243	317635	109171	123674	25895	5982	1197
1985	3039964	1071492	259917	93331	28274	30036	6347	1662
1986	6061809	766848	493877	92489	27797	6273	6194	843
1987	5198294	1469301	308424	166114	20577	6810	1416	1498
1988	3570371	1407024	561634	91189	35776	3861	888	261
1989	6937967	842920	577732	201173	25331	8217	830	511
1990	3063964	1933217	356867	201998	63028	4477	1387	202
1991	3043422	797309	744401	117791	59093	14800	1406	694
1992	2986394	862255	317219	310311	44528	16716	5424	230
1993	3394145	793810	376778	125343	120838	18596	5547	2720
1994	3153542	922908	333181	132258	41385	39642	8879	3572
1995	2851095	863427	418713	127419	41798	11065	11052	1119
1996	2014352	789633	394044	167798	50837	14167	2949	2424
1997	1547765	563390	369146	162280	65737	20536	5250	2319
1998	2154123	431640	265899	158522	67136	26419	10226	2881
1999	3539815	589864	211595	127187	69080	27725	11442	3730
2000	4111923	937294	267740	91910	51467	28297	11300	3194
2001	3409133	1147728	439607	111258	37484	18936	10534	5846

2002	2910823	946359	591051	221836	51452	15676	7799	3939
2003	1029916	793562	487103	284651	107176	24936	7922	6541
2004	1043950	243311	359783	243159	138538	53600	13216	2961
2005	1379900	265016	117004	184774	121604	66182	25729	5427
2006	1342025	359871	118635	58445	95647	60988	32718	10118
2007	1248665	339198	162392	51898	27884	45257	27456	15891
2008	2168736	336509	155316	74342	22970	13488	21382	15624
2009	1778105	597906	156294	71744	33319	10359	6787	19550
2010	1782112	495217	288949	77926	32367	14170	3753	11510
2011	2370147	516538	231845	145840	38159	13410	3955	4829
2012	1299141	701288	234559	110451	75962	20060	6064	9039
2013	921395	366863	333552	119238	53305	40606	10895	16400
2014	1883688	271061	174112	170046	57721	23956	24389	24772
2015	2313760	562330	125339	85197	83975	26246	12408	13052
2016	1728749	685130	241469	58646	41642	39982	13925	9505

Table 3 Whiting in Subarea 4 and Division 7.d. Final fishing mortality estimates from FLXSA.

Year	1	2	3	4	5	6	7	8+
1978	0.099	0.303	0.494	0.683	0.624	0.945	0.698	0.698
1979	0.146	0.365	0.589	0.58	0.701	0.737	0.663	0.663
1980	0.06	0.328	0.661	0.803	1.069	0.805	0.851	0.851
1981	0.103	0.238	0.587	0.81	0.93	1.094	0.873	0.873
1982	0.114	0.223	0.413	0.577	0.748	0.859	0.661	0.661
1983	0.142	0.358	0.608	0.606	0.76	0.792	0.705	0.705
1984	0.149	0.408	0.71	0.864	0.946	1.034	0.908	0.908
1985	0.133	0.195	0.523	0.727	1.036	1.205	1.001	1.001
1986	0.193	0.342	0.584	1.021	0.937	1.112	1.49	1.49
1987	0.099	0.403	0.717	1.056	1.204	1.656	1.574	1.574
1988	0.247	0.339	0.528	0.803	1.002	1.15	1.36	1.36
1989	0.091	0.315	0.555	0.683	1.263	1.383	1.422	1.422
1990	0.165	0.415	0.614	0.752	0.979	0.753	1.007	1.007
1991	0.084	0.385	0.382	0.496	0.792	0.587	0.618	0.618
1992	0.149	0.293	0.437	0.466	0.402	0.676	0.87	0.87
1993	0.126	0.333	0.555	0.631	0.643	0.302	0.411	0.411
1994	0.116	0.254	0.469	0.674	0.847	0.831	0.195	0.195
1995	0.099	0.246	0.421	0.439	0.609	0.868	0.709	0.709
1996	0.081	0.22	0.392	0.456	0.433	0.531	0.793	0.793
1997	0.075	0.208	0.347	0.399	0.436	0.229	0.279	0.279
1998	0.082	0.166	0.236	0.345	0.406	0.363	0.193	0.193
1999	0.104	0.24	0.328	0.416	0.41	0.417	0.254	0.254
2000	0.038	0.202	0.367	0.405	0.513	0.502	0.666	0.666
2001	0.029	0.101	0.167	0.274	0.38	0.395	0.316	0.316
2002	0.034	0.092	0.206	0.224	0.226	0.184	0.275	0.275

2003	0.167	0.208	0.162	0.21	0.187	0.13	0.08	0.08
2004	0.091	0.136	0.126	0.177	0.227	0.224	0.142	0.142
2005	0.068	0.195	0.147	0.136	0.173	0.193	0.166	0.166
2006	0.109	0.174	0.275	0.214	0.229	0.288	0.201	0.201
2007	0.06	0.148	0.226	0.286	0.206	0.246	0.284	0.284
2008	0.055	0.123	0.215	0.272	0.278	0.193	0.27	0.27
2009	0.061	0.075	0.137	0.264	0.34	0.536	0.516	0.516
2010	0.035	0.098	0.124	0.182	0.371	0.814	1.263	1.263
2011	0.024	0.121	0.18	0.119	0.138	0.351	1.077	1.077
2012	0.077	0.067	0.113	0.193	0.125	0.187	0.382	0.382
2013	0.041	0.062	0.106	0.188	0.301	0.106	0.125	0.125
2014	0.029	0.079	0.143	0.165	0.291	0.272	0.107	0.107
2015	0.038	0.145	0.183	0.171	0.244	0.264	0.226	0.226
2016	0.029	0.078	0.228	0.229	0.276	0.199	0.247	0.247

WD 10 Reference points for North Sea Whiting in area 27.4 and 7d

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The EqSim was run on SAM assessment results using new input data (new survey, new catch data, new smoothed natural mortality estimates, new maturity estimates, new stock weights at age). Different EqSim settings were tested to determine reference points. The full time series (since 1978) and also shorter time series were compared. The suggested final setting includes the time series starting in 1983 using the average of the last 10 years of biological data and the last 3 years of fishing selectivity data, default values of sigmaF and sigmaSSB (0.2), and autocorrelation in recruitment. The suggested reference point F_{MSY} was 0.172 for North Sea whiting.

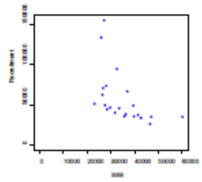
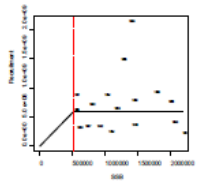
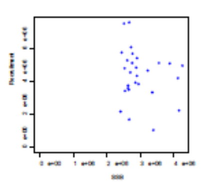
1 Method

New reference points were estimated in a stepwise process, using the EqSim analysis (standardized ICES code) and ICES technical guidelines (ICES, 2014; ICES, 2016b; ICES, 2017).

1.1 Estimating B_{lim} and PA reference points

B_{lim} was an important reference point from which other precautionary reference points were derived. To determine B_{lim}, the full assessment data series should be used to determine stock type in terms of the SSB-recruitment relationship (Table 1).

Table 1 Categorization of stock types as presented in ICES Technical Guidelines (ICES, 2017).

Type 4	Stocks with a wide dynamic range of SSB, and evidence that recruitment increases as SSB decreases.			No B_{lim} from this data, only the PA reference point. (B_{loss} would be a candidate for B_{pa}.)
Type 5	Stocks showing no evidence of impaired recruitment or with no clear relation between stock and recruitment (no apparent S–R signal).		$B_{lim} = B_{loss}$	
Type 6	Stocks with a narrow dynamic range of SSB and showing no evidence of past or present impaired recruitment.			No B_{lim} from this data, only the PA reference point. (B_{loss} could be a candidate for B_{pa}, but this is dependent on considerations involving historical fishing mortality.)

EqSim was run without assessment/advice error and without AR rule (without $B_{trigger}$) to retrieve F_{lim}, as the F (F_{50}) that ensures a 50% probability for SSB to remain above given B_{lim}.

$F_{pa}=F_{lim}*\exp(-1.645*sigmaF)$

$B_{pa}=B_{lim}*\exp(1.645*sigmaSSB)$

For the spawning stock recruitment relationship a segmented regression was used here with B_{lim} as the breakpoint.

1.2 Estimating F_{msy}, MSY $B_{trigger}$

F_{MSY} was initially calculated based on an EqSim with assessment/advice error, which should give maximum yield without advice rule (without MSY $B_{trigger}$). For the spawning stock recruitment relationship a segmented regression was used with a freely estimated breakpoint.

To ensure consistency between the precautionary and the MSY frameworks, F_{MSY} is not allowed to be above F_{pa}; therefore, if the initial F_{MSY} value was above F_{pa}, F_{MSY} is reduced to F_{pa}.

To include assessment and advice error, the values $(F_{cv}, F_{phi}) = (0.212{,}0.423)$, the default values suggested by WKMSYREF4 (ICES, 2016b).

MSY $B_{trigger}$ is a lower bound of the SSB distribution when the stock is fished at F_{MSY} (ICES, 2017). To set MSY $B_{trigger}$ a flowchart in Figure 1 is followed together with recent fishing mortality estimates. Calculations were based on EqSim runs without assessment/advice error and without advice rule, using segmented regression with a freely estimated breakpoint.

When applying the advice rule (AR), F was reduced when SSB falls below this threshold. Using the advice rule, it should be checked that when fishing at F_{MSY} the probability of falling below B_{lim} remains smaller than 5%. Therefore, it should be ensured that the initially calculated F_{MSY} was at or below $F_{.05}$.

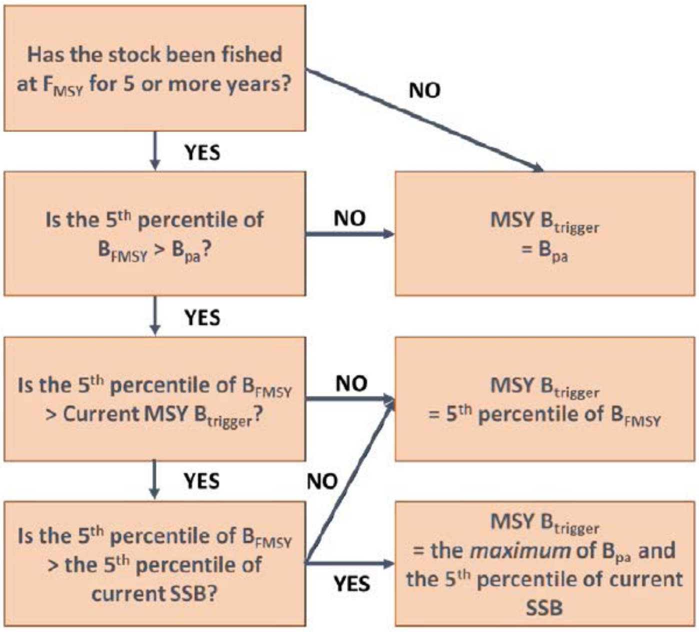


Figure 1 Flow chart to set MSY $B_{trigger}$ as given by ICES Advice Technical guidelines (ICES, 2017).

1.3 EqSim settings

The settings for sigmaF and sigmaSSB were evaluated using either estimated values from SAM results or default values. The use of average of biological parameters of the last 20, 10 or 5 years were compared in the EqSim due to recent changes in biological parameters (WD 3, 4, 6). For fisheries selectivity, an average of the most recent 3 years was found to be representative and was used throughout (Figure 9). Results for different lengths of the time series were evaluated. Three different time series were considered (1) 1978-2016 using the full assessment time series, and shorter series (2) 1983-2016, (3) 1990-2016 and (4) 2003-2016. The effect of including autocorrelation in recruitment on EqSim results was evaluated. The stepwise process to determine EqSim settings were listed in Table 2.

Table 2 Scenarios of EqSim runs, stepwise update of settings

Scenarios	F_{MSY}	settings	accepted
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_sigmaNA	0.132	Estimated sigmaF,sigmaSSB	no
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_20yearav	0.139	default sigmaF,sigmaSSB	yes
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_20yearav_ac (with autocorrelation)	0.087	autocorrelation	no
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_10yearav_ac (with autocorrelation)	0.156	Recent shift in biological parameters (recent years average)	yes
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_5yearav_ac (with autocorrelation)	0.246		no
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_10yearav_ac_short1983 (with autocorrelation)	0.172	time series length	yes (final)
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_10yearav_ac_short1990 (with autocorrelation)	0.169		no
WHG2017_AN_010_surv_catch_mort_mat_cc_1978_10yearav_short2003 (no autocorrelation)	0.188		no

2 Results

2.1 Final setup

The final selected EqSim setup included the data series from 1983 onwards (see Section 2.4 for justification). The EqSim was run with default values 0.2 for both sigmaF and sigmaSSB and autocorrelation in recruitment included. Biological parameters were set to the average of the recent 10 years, and fishing selectivity to the recent 3 years. The EqSim settings were determined in a stepwise procedure as detailed in section 2.2-2.4 and Table 2.

Due to the absence of a spawning stock recruitment relationship and no identifiable SSB level at which recruitment was impaired (Figure 2), following ICES technical guidelines the stock was categorized as type 5. B_{lim} was set to B_{loss} (the lowest observed SSB in the times series, 119970 t in 2007) and a segmented regression was run (Table 1).

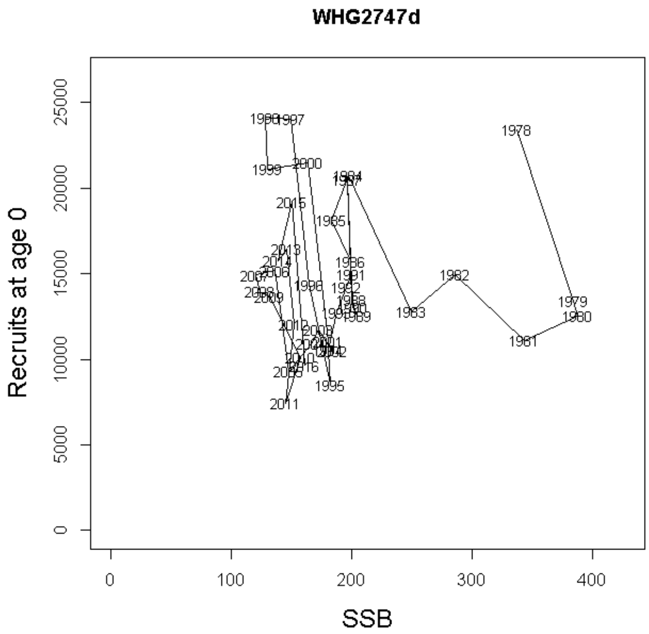


Figure 2 SSB vs Recruitment (age 0) for 1978-2016.

EqSim was run without assessment/advice error, without the advice rule, and with the segmented regression breakpoint fixed at B_{lim} to determine F_{lim} (F_{50}) as 0.458 (Table 3). Precautionary reference points B_{pa} and F_{pa} were calculated from B_{lim} and F_{lim}. F_{pa} was calculated as 0.330 and B_{pa} as 166708.

To estimate the unconstrained F_{MSY}, the EqSim was run without the advice rule and with assessment and advice error using the default values $(F_{cv}, F_{phi}) = (0.212, 0.423)$ as suggested by WKMSYREF4 (ICES, 2016b). Unconstrained F_{MSY} was 0.392, which was larger than F_{pa}=0.330 (Table 5). Therefore, F_{MSY} was reduced to F_{pa}.

For most stocks that lack data on fishing at F_{MSY}, MSY $B_{trigger}$ is set at B_{pa}. However, as a stock starts to be fished consistently with F_{MSY}, a value for MSY $B_{trigger}$ could be set to reflect the 5^{th} percentile definition of MSY $B_{trigger}$. Following the flowchart in Figure 1, F_{MSY} was 0.330 but fishing mortality was lower in recent years (Table 4). The 5^{th} percentile of B_{Fmsy} was calculated running an EqSim without assessment/advice error and without advice rule, using a segmented regression with estimated breakpoint. The 5^{th} percentile of B_{Fmsy} was 162.6 and smaller than B_{pa}=166708. Therefore, B_{pa} was selected as MSY $B_{trigger}$.

$F_{p.05}$ was calculated by running EqSim with assessment/advice error and with advice rule to ensure that the long term risk of SSB<B_{lim} of any F used does not exceed 5% when applying the advice rule. Accordingly, F_{MSY} had to be reduced to $F_{p.05}$=0.172 (Table 6).

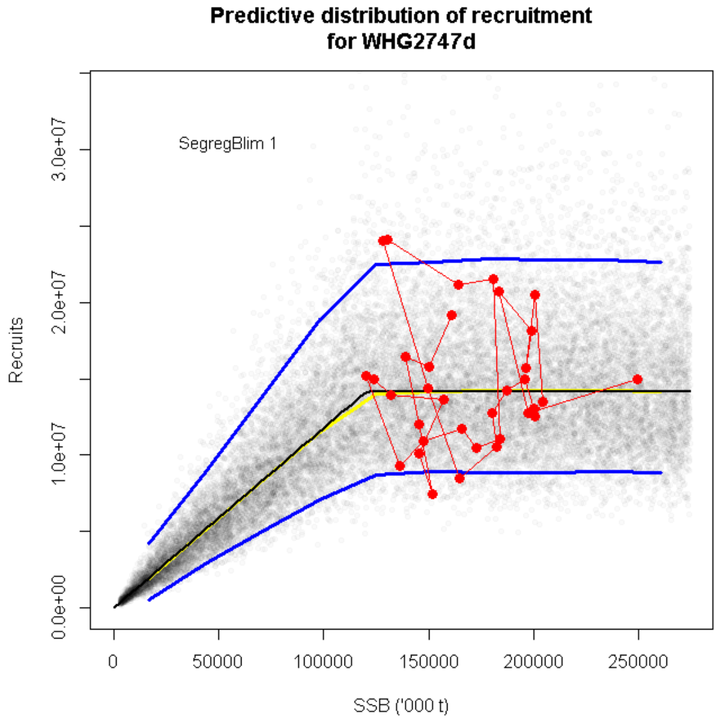


Figure 3 Segmented regression using B_{lim} as breakpoint to fit the spawning stock recruitment relationship.

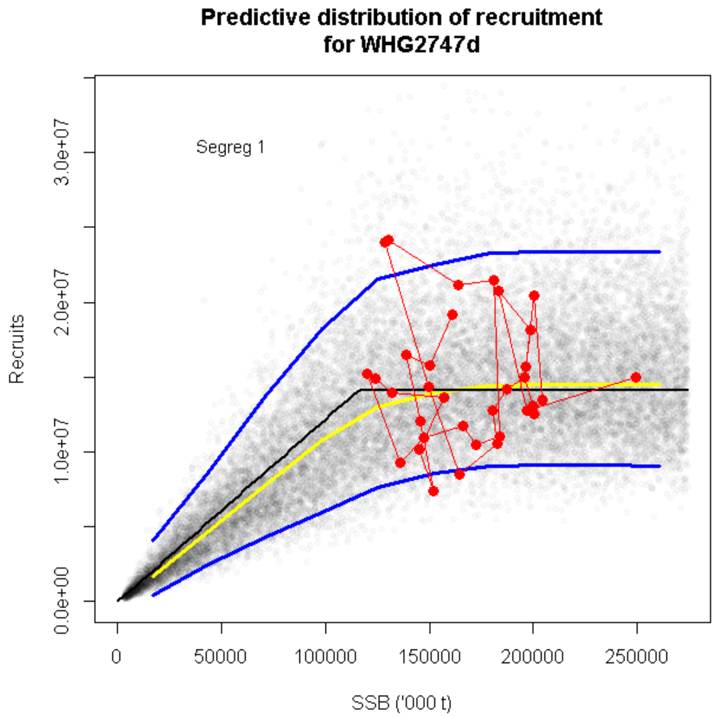


Figure 4 Segmented regression using a freely estimated breakpoint to fit the spawning stock recruitment relationship.

Table 3 EqSim run without advice/assessment error and without advice rule, to determine F_{lim} (segmented regression using B_{lim} as breakpoint).

	catF	lanF	catch	landings	catB	lanB
F05	0.222407	NA	32355.93	NA	166970.4	NA
F10	0.272729	NA	36482.73	NA	157070.8	NA
F50	**0.458103**	NA	43581.17	NA	120003.4	NA
medianMSY	NA	0.435435	NA	43855.96	NA	125948.5
meanMSY	0.41	0.41	43469.29	43469.29	131460	131460
Medlower	NA	0.357357	NA	41643.79	NA	141650
Meanlower	NA	0.334054	NA	40890.86	NA	NA
Medupper	NA	0.495495	NA	41624.93	NA	107242.6
Meanupper	NA	0.477748	NA	40918.66	NA	NA

Table 4 SAM assessment results for the recent 5 years. Current SSB as estimated in the beginning of the year 2017.

Year	Recruitment (age 0)	SSB	F (2-6)
2012	7431796	152003	0.213
2013	12025687	145632	0.206
2014	16459840	138819	0.235
2015	15764353	149974	0.259
2016	19203521	160931	0.252
2017	9657024	184350 (current)	

Table 5 EqSim run with assessment/advice error, without advice rule to find the unconstrained F_{MSY} (segmented regression with estimated breakpoint).

	catF	lanF	catch	landings	catB	lanB
F05	0.131533	NA	22557.22	NA	189044.5	NA
F10	0.165702	NA	26065.88	NA	177347.1	NA
F50	0.366663	NA	34557.75	NA	119960.4	NA
medianMSY	NA	**0.392392**	NA	34677.45	NA	113720.4
meanMSY	0.31	0.31	33693.57	33693.57	134268.2	134268.2
Medlower	NA	0.282282	NA	32938.67	NA	141817.1
Meanlower	NA	0.214144	NA	29512.02	NA	NA
Medupper	NA	0.453453	NA	32972.79	NA	95490.48
Meanupper	NA	0.468829	NA	29491.15	NA	NA

Table 6 EqSim run with assessment/advice error, with advice rule to test whether F_{MSY} was at or below $F_{.05}$ (segmented regression with estimated breakpoint).

	catF	lanF	catch	landings	catB	lanB
F05	**0.171578**	NA	26486.68	NA	178576.2	NA
F10	0.22353	NA	30465.55	NA	165813.3	NA
F50	0.54589	NA	37860.23	NA	119952	NA
medianMSY	NA	0.570571	NA	37890.77	NA	117572.9
meanMSY	0.61	0.61	37827.11	37827.11	113919.1	113919.1
Medlower	NA	0.366366	NA	36020.24	NA	140675.4
Meanlower	NA	0.378649	NA	37125.67	NA	NA
Medupper	NA	0.805806	NA	36013.35	NA	97585.75
Meanupper	NA	0.901892	NA	37123.74	NA	NA

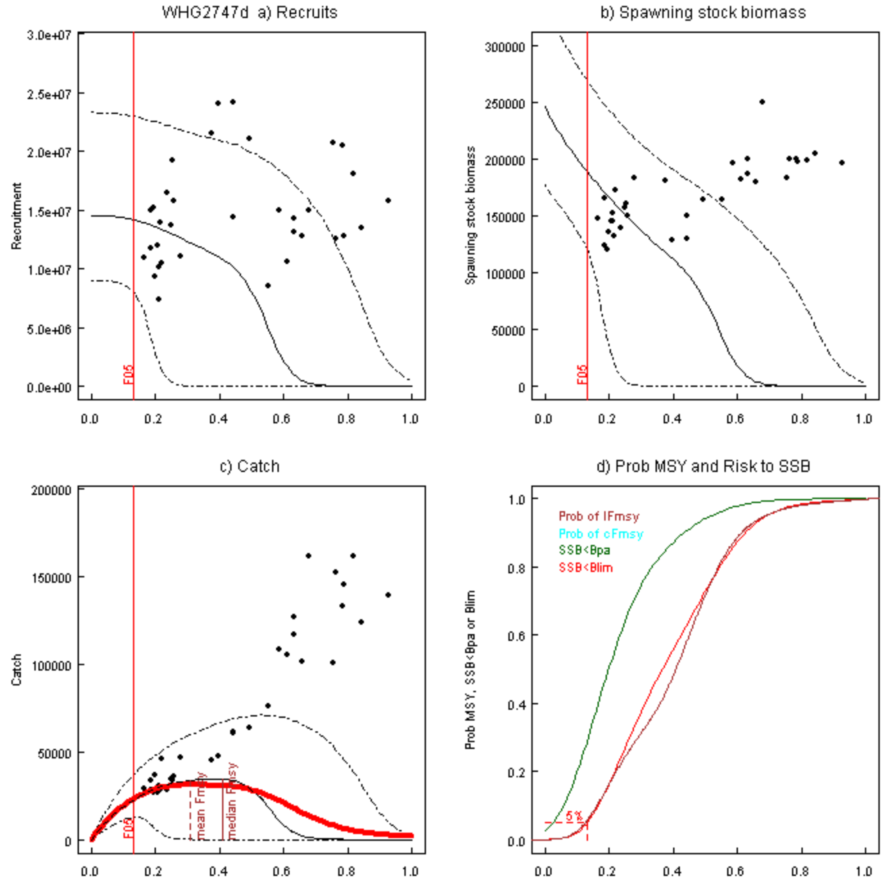


Figure 5 EqSim with assessment/advice error and without $B_{trigger}$.

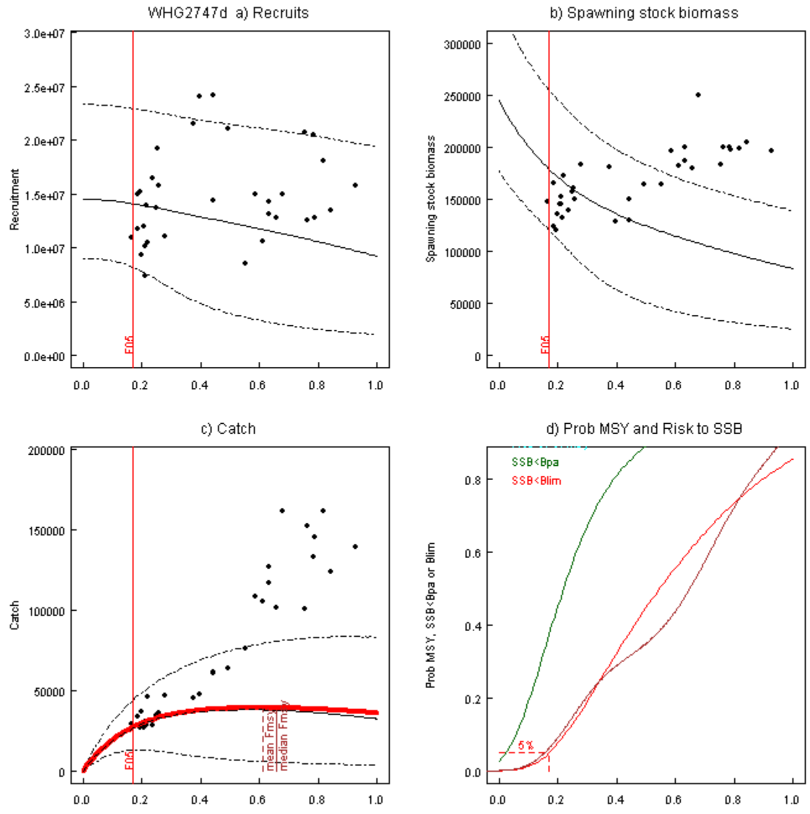


Figure 6 EqSim with assessment/advice error and $B_{trigger}$

Table 7 Reference points from final EqSim settings.

	$B_{trigger}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
value	166707.7	166707.7	119970	0.33	0.458	0.172	0.392	0.172

2.1.1 MSY ranges

The initially estimated F_{msy} and the respective $F_{MSYupper}$ were greater than $F_{p.05}$. Following the guidelines, if the estimated $F_{MSYupper}$ exceeds the estimated $F_{p.05}$, $F_{MSYupper}$ is capped and specified as $F_{p.05}$, which was estimated with error and advice rule (ICES, 2016b). $F_{MSYlower}$ is redefined as the lower fishing mortality providing 95% of the yield at $F_{p.05}$ ($F_{p.05lower}$). F_{msy} ranges are as follows:

Table 8 MSY ranges

Reference point	Value	Technical basis
$F_{MSYlower}$	0.158	$F_{p.05lower}$ (EqSim)
F_{MSY}	0.172	$F_{p.05}$
$F_{MSYupper}$	0.172	$F_{p.05}$

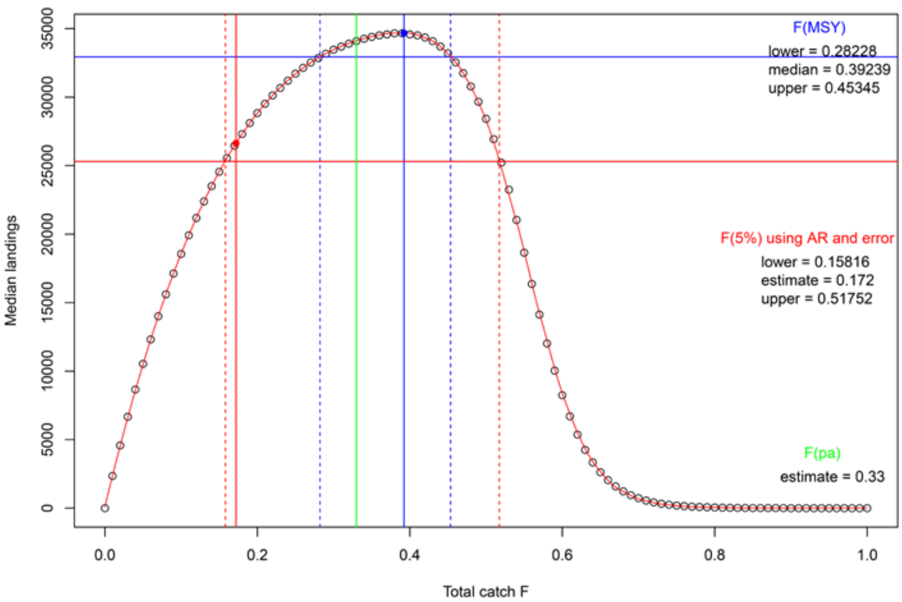


Figure 7 Median yield curve and upper and lower ranges (vertical dashed lines). For F_{msy}=$F_{p.05}$=0.172 (with AR and error) upper and lower bound are given (red) as well as F_{pa} (green).

2.2 Run sigmaF/sigmaSSB scenarios

To determine EqSim settings a stepwise procedure was used to update default value settings, where necessary. As a starting point the full time series, without autocorrelation was used, with average of biological parameters for the recent 20 years.

In the assessment, sigmaSSB and sigmaF were estimated to be 0.138 and 0.157, respectively. This was relatively low in comparison to the defaults values of 0.2. Instead default values were used. Using the defaults increased F_{MSY} from 0.132 to 0.139 (Table 9).

Table 9 Reference points using no autocorrelation, estimated sigmaF=0.1567 and sigmaSSB=0.1383 or default values 0.2.

sigma	$B_{trigger}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
estimated	150612	150612	119970	0.344	0.445	0.132	0.251	0.132
default	166708	166708	119970	0.32	0.445	0.139	0.251	0.139

2.3 Average of biological parameters

Taking the average of the most recent 20 years of biological parameters, as default, may not be appropriate considering recent changes in maturity and stock weights at age for North Sea whiting (Figure 8). Alternative EqSim scenarios were run, using the average of the recent 10 or 5 years. In all scenarios $B_{trigger}$, was set to B_{pa} following the flowchart analysis (Figure 1). If only averages of more recent biological parameters were included, the F_{MSY} estimates increased (Table 10). As biological parameters were variable and future developments were uncertain, the recent 10-year average was used representing sufficiently well the shift in natural mortality, maturity and stock weights at age in recent years (WD 3, 4, 6, Figure 8).

Table 10 Reference points for full times series, using default sigmaF and sigmaSSB, with autocorrelation, 3 year average of fishing selectivity. The scenarios with recent 20, 10 or 5 year average of biological parameters were compared.

average	$B_{trigger}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
20	166708	166708	119970	0.277	0.386	0.087	0.224	0.087
10	166708	166708	119970	0.340	0.473	0.156	0.274	0.156
5	166708	166708	119970	0.426	0.592	0.246	0.334	0.246

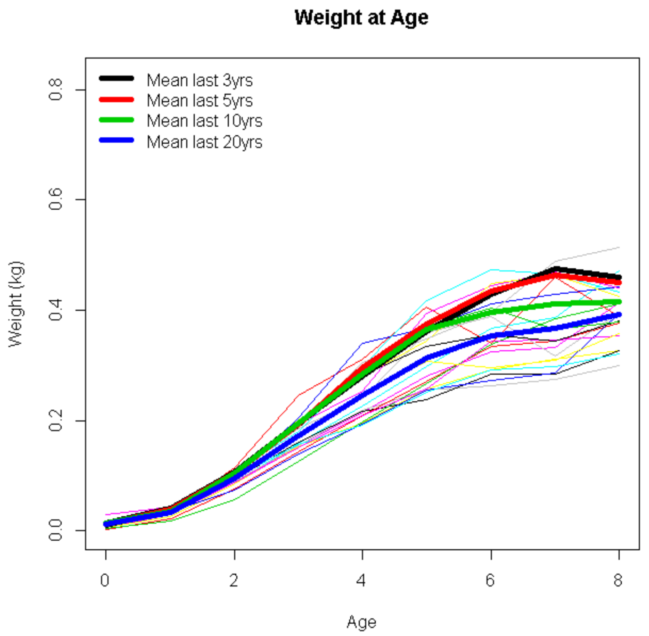


Figure 8 Weight at age by year and averages for recent 3, 5, 10, 20 years.

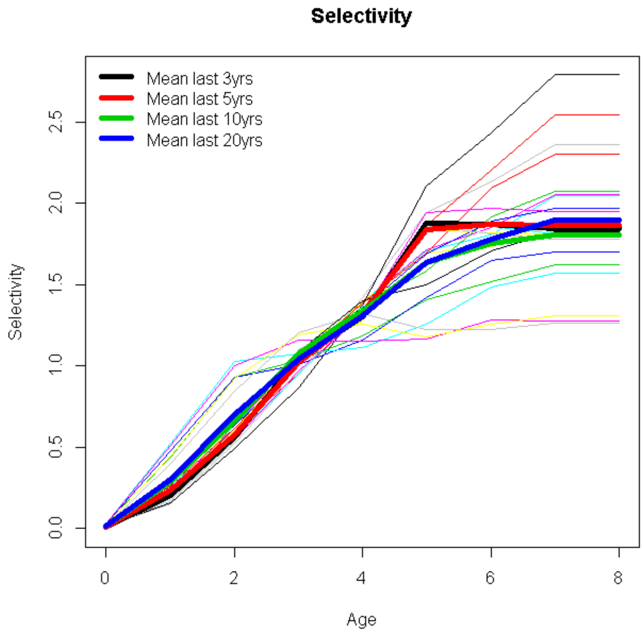


Figure 9 Fishing selectivity at age by year and averages for the recent 3, 5, 10, 20 years.

2.4 Shorter time series and autocorrelation

For the short time series starting in either 1983, 1990 or 2003, there was no apparent spawning stock recruitment relationship. B_{loss} was the same (SSB in 2007), and $B_{trigger}$ was set to B_{pa} in all scenarios. Using a very short time series can affect estimated autocorrelation in recruitment. Autocorrelation was not significant in the shortest time series starting from 2003 (Figure 11) but significant at lag 1 for time series starting in 1990 and 1983 and the full time series, as illustrated in Figure 12 to Figure 14. EqSim was run with autocorrelation as required, using the default settings sigmaF=sigmaSSB=0.2, the average of the last 10 years of biological parameters and the average of the last 3 years of fisheries selectivity.

It was not recommended to use the short time series starting in 2003 (as done during the Interbenchmark ICES (2016a)). Recruitment in 2016 was high, close to levels observed in 1998 to 2001 (Figure 10). The assumptions that recruitment level has shifted to lower levels did not apply anymore.

The next option, to start the time series only in 1990, could be defended. This run represented the year range that had been used in the assessment prior to this benchmark. The F_{MSY} for the time series starting at 1983 and 1990 were relatively similar, with values around 0.17 (Table 11). F_{MSY} for the full time series, starting in 1978 was lower. The SAM assessment was run with survey data entering the assessment only from 1983 onwards when surveys were standardized. In years before 1983, estimated SSB values from SAM were estimated with higher uncertainty and estimates were relatively high and, leading to unusually low values of recruitment/SSB ratios (Figure 10, Figure 15). From the SURBAR analysis, it can be shown that survey data alone would not predict these high values of SSB (Figure 16). Instead very high recorded catches were responsible for the estimate (Figure 18). As the rest of the time series matched well for SURBAR and SAM, it was therefore suggested to use the time series starting in 1983.

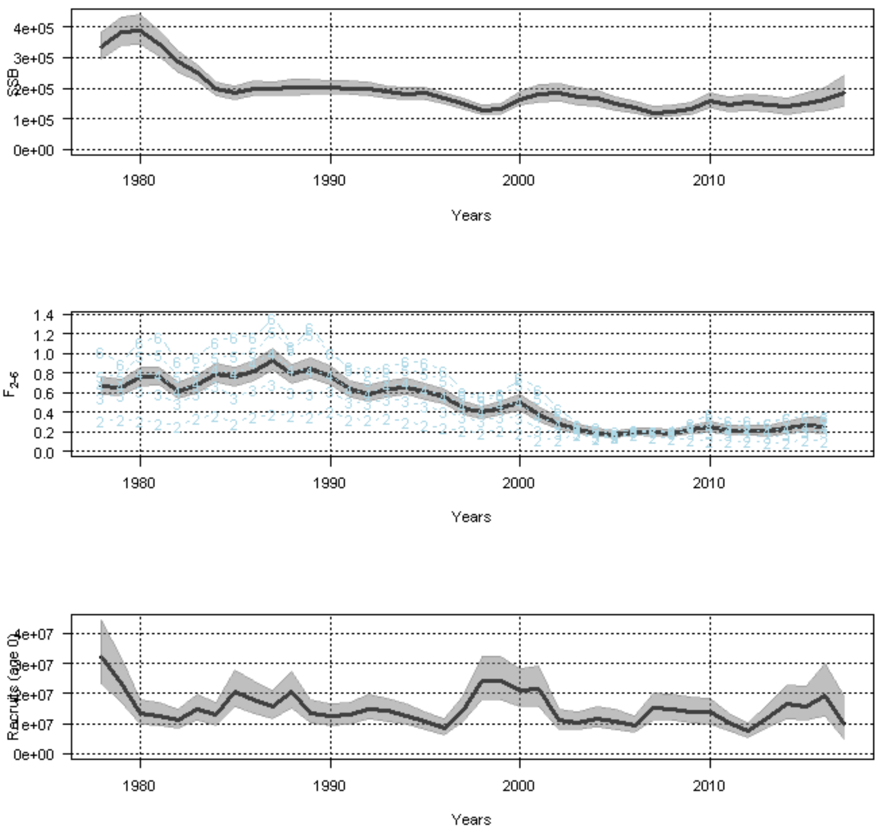


Figure 10 SAM assessment results.

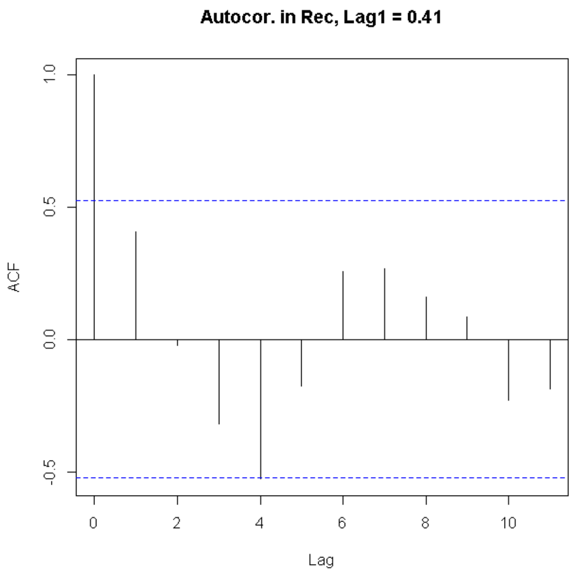


Figure 11 Autocorrelation in recruitment for the time series starting in 2003-2016.

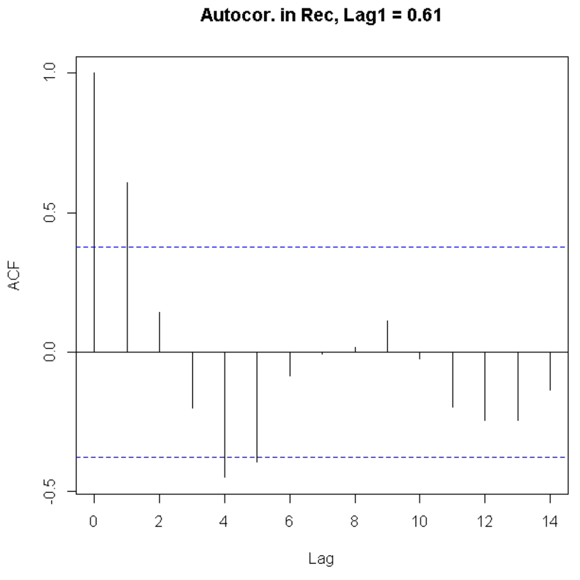


Figure 12 Autocorrelation in recruitment, for the shorter time series 1990-2016.

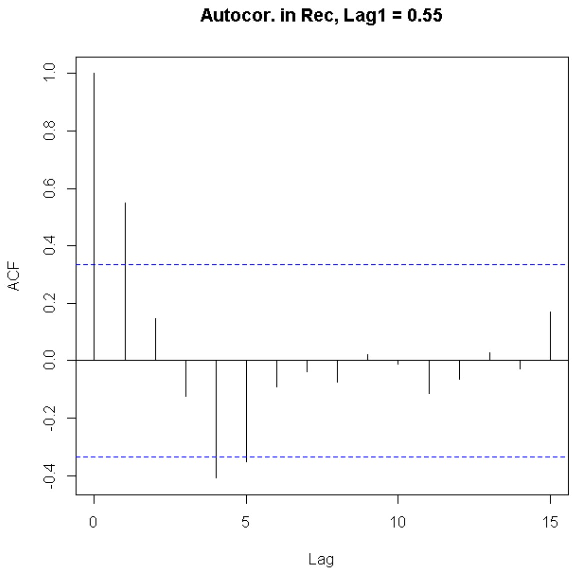


Figure 13 Autocorrelation in recruitment, for the shorter time series 1983-2016.

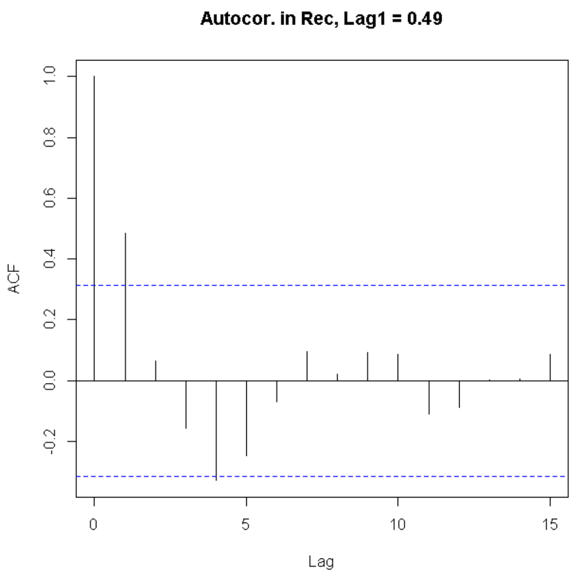


Figure 14 Autocorrelation in recruitment, 1978-2016.

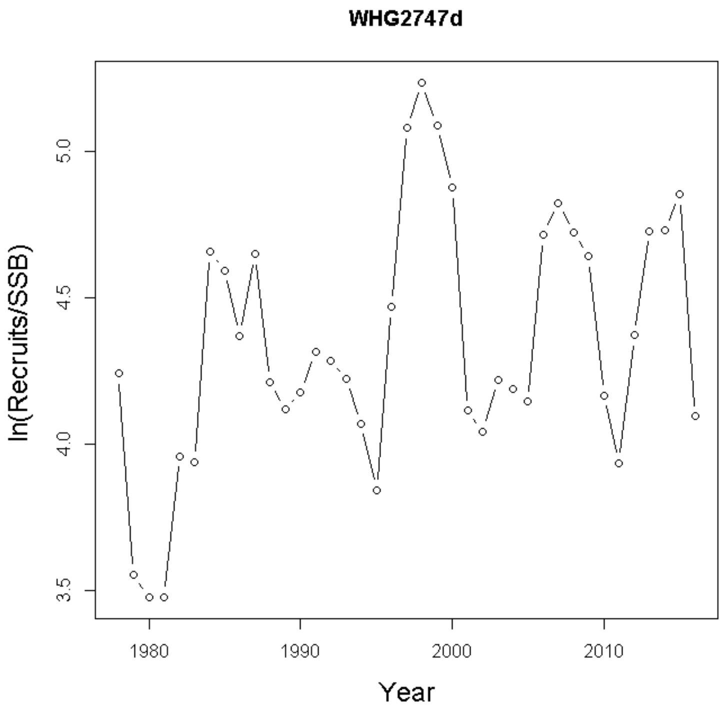


Figure 15 Log Recruits/SSB for the full time series.

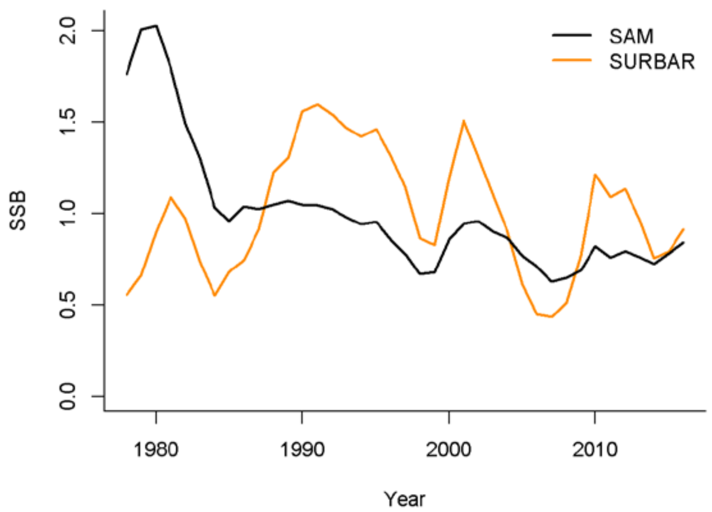


Figure 16 Comparison of SSB from SURBAR (using data starting in 1978) and final SAM assessment.

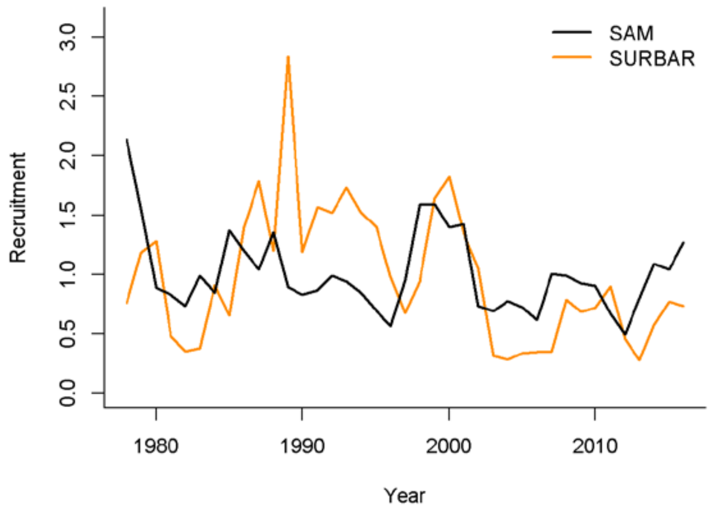


Figure 17 Comparison Recruitment from SURBAR results (using data starting in 1978, recruits age 1) and final SAM assessment (recruits age 0).

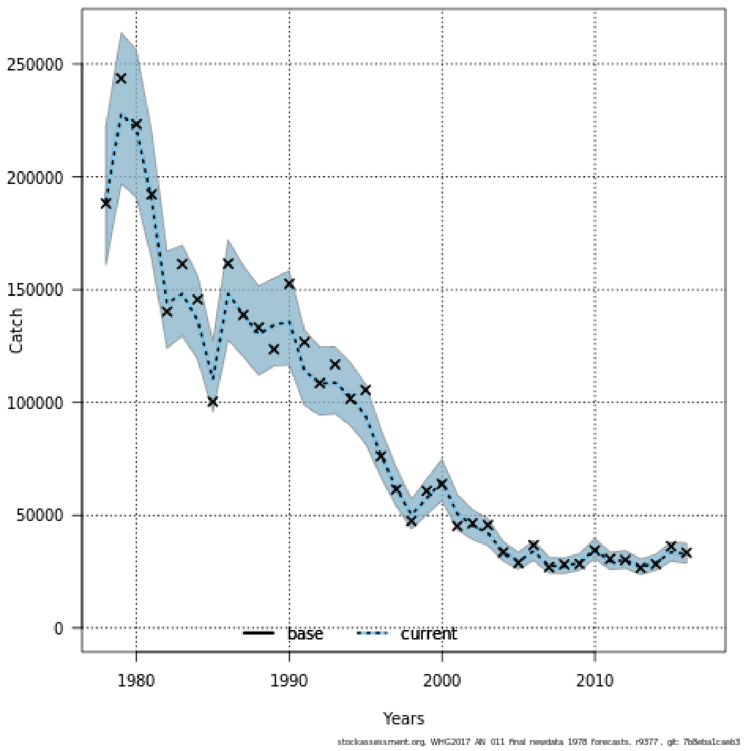


Figure 18 Observed (crosses) and estimated catches (SAM assessment)

Table 11 Reference points for times series of varying starting points, using default sigmaF and sigmaSSB, recent 10 year average of biological parameters, 3 year average of fishing selectivity.

start	Autocorrelation	$B_{trigger}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
1978	yes	166708	166708	119970	0.340	0.473	0.156	0.274	0.156
1983	yes	166708	166708	119970	0.330	0.458	0.172	0.392	0.172
1990	yes	166708	166708	119970	0.288	0.400	0.169	0.375	0.169
2003	no	166708	166708	119970	0.269	0.373	0.188	0.345	0.188

2.5 Different B_{lim}

B_{lim} for this stock is highly uncertain. There was no apparent spawning stock recruitment relationship and no reduction of recruitment with decreasing biomass. To evaluate the effect of a slightly lower B_{lim}, additional scenarios were run using the time series starting in 1983, recent 10 years average of biological data, recent 3 years of fishing selectivity, with autocorrelation in recruitment.

For lower values of B_{lim}, F_{msy} increased. For B_{lim}= 86300 and below EqSim failed to compute F_{lim}.

Table 12 Reference points using alternative B_{lim} values

$B_{trigger}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
166708	166708	119970	0.330	0.458	0.172	0.392	0.172
138958	138958	100000	0.519	0.721	0.204	0.392	0.204
132010	132010	95000	0.583	0.810	0.208	0.392	0.208
125062	125062	90000	0.658	0.915	0.216	0.376	0.216
120060	120060	86400	0.719	0.999	0.219	0.376	0.219

3 References

ICES 2014. Report of the Joint ICES-MYFISH Workshop to consider the basis for Fmsy ranges for all stocks (WKMSYREF3), 17-21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64: 147pp.

ICES 2016a. Report of the Inter-benchmark protocol for Whiting in the North Sea (IBP Whiting), By correspondence, March 2016. ICES IBP Whiting Report 2016. ICES CM 2016/ACOM: 48: 119pp.

ICES 2016b. Report of the Workshop to consider Fmsy ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13-16 October 2015, Brest, France. ICES CM 2015/ACOM:58: 187pp.

ICES 2017. ICES Advice Technical Guidelines. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice 2017, Book 12.

Annex 8: Witch flounder working documents

In the following pages, the witch flounder working documents available at WKNSEA 2018 are inserted.

WD1 Intercatch raising_Wit3a47d.pdf	05/04/2018 15:34	Adobe Acrobat D...	1,575 KB
WD2 Survey Indices_Wit3a47d.pdf	06/04/2018 14:27	Adobe Acrobat D...	1,807 KB
WD3 Biological parameters_Wit3a47d....	06/04/2018 14:18	Adobe Acrobat D...	682 KB
WD4 witch-sam-extended.pdf	23/02/2018 10:52	Adobe Acrobat D...	479 KB
WD5 Witch_spict.pdf	12/02/2018 16:15	Adobe Acrobat D...	1,019 KB

Working Document 1: Preparation of Catch Data for Witch flounder in 3a, IV and VIId (Wit3a47d)

Francesca Vitale and many others

Catch data for 2002-2016

InterCatch was used for estimation of both landings and discards numbers, length composition (2002-2016) and age compositions (2009-2016). Data co-ordinators from each nation input data for 2002-2016 into InterCatch, disaggregated by quarter, area and métier (fleet).
In 2014, witch flounder was included for the first time into the data call for WGNSSK 2014 and since 2015 the data call was extended to obtain landings and discards data for the years 2002–2016.
InterCatch was previously used to estimate 2012-2016 discard ratio; all available years were re-calculated in InterCatch following the 2016 data-call; Catch data for the years 2002-2016 have now been processed through InterCatch for the first time. Allocations of discard ratios (2002-2016), length (2002-2016) and age (2009-2016) compositions for unsampled strata were then performed to obtain the data required for the assessment.

Raising discard data (2002-2016)

If discards were not included for a particular métier-area-quarter-country-year combination, they were assumed to be unknown (non-zero) and raised. The instructions in the data call specified that if discards were 0, this had to be included in the upload to InterCatch (as a 0).

- Discards on a country-area-quarter-métier basis were automatically matched by InterCatch to the corresponding landings
- Annually discards were manually matched to quarterly landings on a country-area-métier basis from 2002 to 2016 (i.e. Scotland and The Netherlands)

In general, fleets using passive gears had no reported discards while fleets using selectivity devices (used only in Area IIIa) had always reported discards. The approach used for unmatched discard was to merge areas (IIIaN, IV and VIId) and treat métiers separately, combined in two categories, i.e. fleets with and without selectivity devices (including passive and active gears). Then, within each of these two categories (ignoring country), where métiers had some samples these were pooled and allocated to unsampled records within that category. Quarters were merged when the samples were not enough otherwise kept separate.
Following the above mentioned raising strategy, discards by country in 2002 resulted really high compared to the following years. This was due to:
OTB_DEF_>=120_0_0_all DK Q4 Area IV (discard ratio 2.17)
OTB_CRU_90-119_0_0_all for DK SD20 Q4 (discard ratio 3.19) and for SE Q4 SD21 (discard ratio 2.61) which had unusually high discard ratio.
Thus national discards data were re-raised still using the two fleets categories (see above), combining quarters and excluding those fleets. This resulted in a lower, compared to the previous raising procedure, but still high, compared to the following years, discard percentage.

When raising discards for 2012, separately for age and length distributed stocks, different values of discards were obtained, despite based on the same procedure. The discards obtained in the length distributed stock were 557,1 vs 554,5 tonnes obtained raising the age distributed stock. When comparing the two set of processed data in InterCatch no differences were detected, except for a value in Dutch data in area 4 (seasons 1,2,3 combined) relative to the fleet OTB_DEF_100-119_0_0_all. This value was present in the age distributed stock but missing in the length distributed stock.
Furthermore, discards data from 2013 reported by The Netherlands are also suspect and needs to be investigated in future

The matched discards-landings were used to estimate a landing-discard ratio, which was then used for further raising (creating discard amounts) of the unmatched discards. The weighting factor for raising the discards was '*Landings CATON*' (landings catch).

Length allocations (2002-2016)

To allocate length compositions, landings and discards were handled separately; samples from landings were used only for landings and samples from discards only for discards.

- Landings

For the years 2002-2004 and 2006-2012 no stratification was made, i.e. allocations were made combining all fleets, all areas and all quarters, due to low sample size. In 2005, 2013 and 2016 fleets and areas were combined but a quarter stratification was applied. However as Q1 had no sampling in the first two years, this was lumped with Q2. In 2014 quarter and area stratifications were applied, while fleets were combined. In 2015 fleets were combined while areas were kept separate. In area 3a Q1 and Q2 were allocated separately while Q3 and Q4 were merged. In area 4, some length classes were poorly represented in some quarters thus quarters were merged in pairs (Q1+Q2 and Q3+Q4).

- Discards

Discards were allocated ignoring fleets and areas, while quarters were stratified when possible. In case of low sample size in certain quarters, those were merged in pairs (Q1+Q2 and Q3+Q4)

Age allocations 2009-2016:

To allocate age compositions, landings and discards were handled separately; samples from landings were used only for landings and samples from discards were used only for discards.

- Landings

In general areas and fleets were combined but Q stratified in all years except for 2011 where no stratification was made as samples from the fleets with grids did not cover all quarters. However in 2009-2010 and 2012-2013 Q3 and Q4 were pooled together as Q3 had low sample sizes.

- Discards

Métiers were threated in two categories, i.e. fleets with no grids (including passive and active gears) and fleets with selectivity devices in all years except 2011 where fleets were combined. Areas were always

combined. Quarters were always combined for fleets with grids while for the rest of the fleets where combined as follows:
2009 –All quarters separated
2010: (Q1+Q2), Q3, Q4
2011-2012 and 2014-2015: Q1, Q2, (Q3+Q4)
2013 and 2016: (Q1+Q2), (Q3+Q4)

The weighting factor used with all scenarios was *Mean Weight weighted by numbers at age*.

Catch data for 1967-2001
No adjustments were made.

Table 1: Overall tonnage estimates of landings and discards. The discards obtained with the first raising of 2002 data (corrected afterwards) was1988 tonnes, with a discard ratio of 0.343. The new values are in red.

Year	Landings	Discards	Discard ratio	Discard ratio WGNSSK 2017
2002	3813	1529	0.286	
2003	3308	349	0.095	
2004	3059	369	0.108	
2005	2960	419	0.124	
2006	2335	296	0.112	
2007	2271	199	0.081	
2008	1999	318	0.137	
2009	1863	455	0.196	
2010	1531	559	0.268	
2011	1567	547	0.259	
2012	1952	557	0.222	0.233
2013	2013	254	0.112	0.111
2014	2685	307	0.103	0.095
2015	2240	449	0.167	0.155
2016	2744	390	0.125	0.141

Table 2. Discard percentage of total catch (landings + discards) by country and year. Data highlighted in red resulted from the first raising on 2002 data while in green are the final ones.

Year	2002	2002 NEW	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	33.7	23.71264	5.9	13.4	10.5	10.1	7.4	18.7	23.7	16.0	20.4	19.2	13.0	10.7	12.2	9.7
Denmark	37.5	31.47876	10.5	11.6	12.1	11.0	6.5	10.7	12.2	30.8	19.2	20.2	6.4	8.3	15.3	5.8
France	20.8	23.71529	5.7	10.7	11.1	11.5	7.5	12.1	23.6	18.0	21.5	23.5	12.1	10.6	12.8	13.6
Germany	36.8	24.00738	9.6	25.2	8.5	13.6	26.8	26.8	17.0	31.2	19.2	9.4	9.7	15.2	11.3	20.2
Ireland	14.2	23.71071	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	14.2	23.71299	8.3	7.2	12.0	11.3	5.9	15.6	23.9	15.8	28.9	22.1	73.2	40.1	45.6	36.3
Norway	37.8	23.71261	10.4	10.2	11.0	10.6	6.5	13.4	23.9	17.8	22.3	20.4	12.9	10.6	15.3	11.9
Sweden	19.2	17.29661	6.6	7.6	14.2	8.7	9.6	19.7	18.8	46.2	65.6	47.2	16.8	11.6	7.9	11.5
UK (England)	30.3	23.70356	9.5	16.7	20.9	43.7	48.0	44.8	33.6	56.9	37.8	24.3	7.9	16.9	24.7	19.8
UK(Northern Ireland)	23.5	23.71322	8.5	9.4	9.8	0	0	0	23.9	0	0	0	0	0	0	13.6
UK(Scotland)	34.8	23.71261	9.2	10.8	11.3	10.9	6.5	13.2	28.6	11.3	16.7	14.4	12.7	12.3	23.2	24.1

Table 3. Number of age measurement and samples per year (total for all fleets combined) for the landings.

	Number age measurements			Number age samples		
Year	Denmark	Sweden	UK(Scotland)	Denmark	Sweden	UK(Scotland)
2009	212	1224	160	1	5	6
2010	395	511	42	7	5	3
2011	270	582	0	3	4	0
2012	415	982	0	3	7	0
2013	222	412	277	4	2	21
2014	1335	821	328	5	11	25
2015	2100	472	150	10	8	10
2016	1537	527	78	7	7	6

Table 4. Number of age measurement and samples per year (total for all fleets combined) for the discards

	Number age measurements		Number age samples	
Year	Denmark	Sweden	Denmark	Sweden
2009	88	766	23	88
2010	233	777	29	72
2011	309	665	21	68
2012	132	950	26	81
2013	182	443	27	50
2014	214	451	30	27
2015	175	405	32	44
2016	244	542	46	61

Table 5. Number of length measurement and samples per year (total for all fleets combined) for the landings.

	Number length measurements					Number length samples				
Year	Denmark	Germany	Sweden	UK (England)	UK(Scotland)	Denmark	Germany	Sweden	UK (England)	UK(Scotland)
2002	0	13	74	0	0	0	6	4	0	0
2003	0	59	91	367	0	0	13	8	13	0
2004	645	73	256	132	0	3	32	5	10	0
2005	619	100	3910	70	0	2	32	33	3	0
2006	660	4	260	0	0	2	3	30	0	0
2007	597	0	54	58	0	2	0	4	1	0
2008	440	46	2327	793	0	1	15	31	3	0
2009	409	22	1271	553	849	2	7	10	6	6
2010	395	1	511	1560	313	7	1	5	9	3
2011	583	46	744	187	0	4	14	14	11	0
2012	415	111	1094	458	0	3	20	10	15	0
2013	608	44	242	284	1825	5	15	6	7	21
2014	1495	107	937	142	2741	9	23	15	11	32
2015	2546	30	722	0	2650	13	10	14	0	28
2016	2104	16	527	0	702	9	5	7	0	6

Table 6. Number of length measurement and samples per year (total for all fleets combined) for the discards.

	Number length measurements						Number length samples					
Year	Denmark	Germany	Netherlands	Sweden	UK (England)	UK(Scotland)	Denmark	Germany	Netherlands	Sweden	UK (England)	UK(Scotland)
2002	1388	3	0	496	1	0	57	2	0	53	3	0
2003	1446	16	0	332	23	0	43	6	0	25	48	0
2004	1385	0	0	411	31	0	49	0	0	26	71	0
2005	795	2	0	1776	74	0	28	2	0	51	57	0
2006	1205	3	0	582	57	0	44	2	0	12	24	0
2007	492	84	0	620	56	0	45	10	0	68	50	0
2008	2140	19	0	752	81	0	44	8	0	33	84	0
2009	1491	6	0	386	54	446	69	4	0	32	62	27
2010	3203	23	0	622	124	275	84	8	0	44	83	25
2011	2800	178	39	504	112	0	83	45	38	37	46	0
2012	2339	1	28	283	56	0	93	1	84	21	51	0
2013	2189	0	118	134	4	317	104	0	44	14	5	51
2014	2975	26	66	765	58	714	115	8	58	28	40	69
2015	3656	1	111	54	67	2661	109	1	256	3	41	79
2016	2655	10	66	566	68	3651	120	5	256	25	35	75

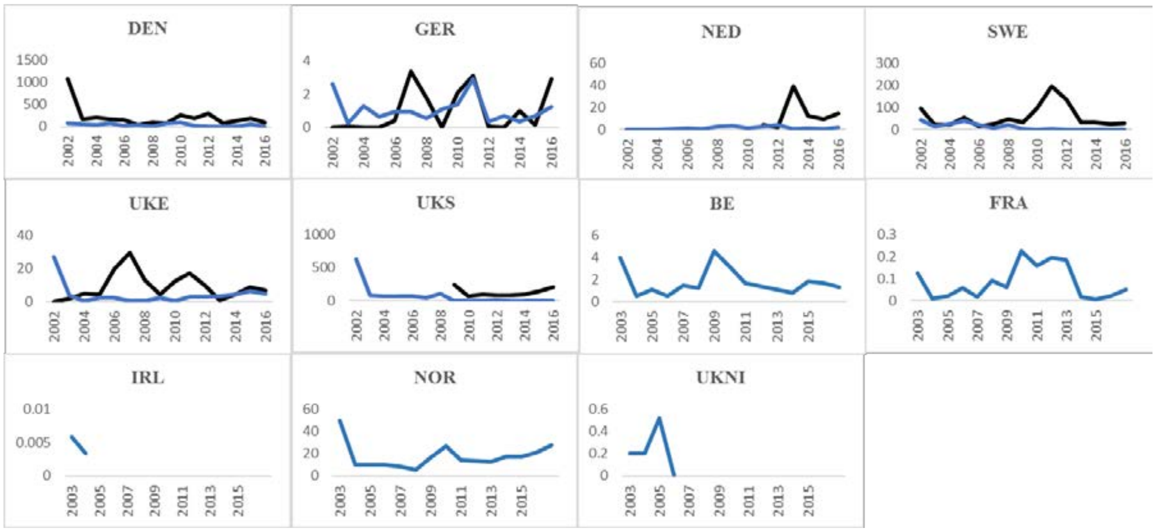


Figure 1. Observed and raised discards by country (Caton) and year. Black line is the observed discards, blue is the raised discards.

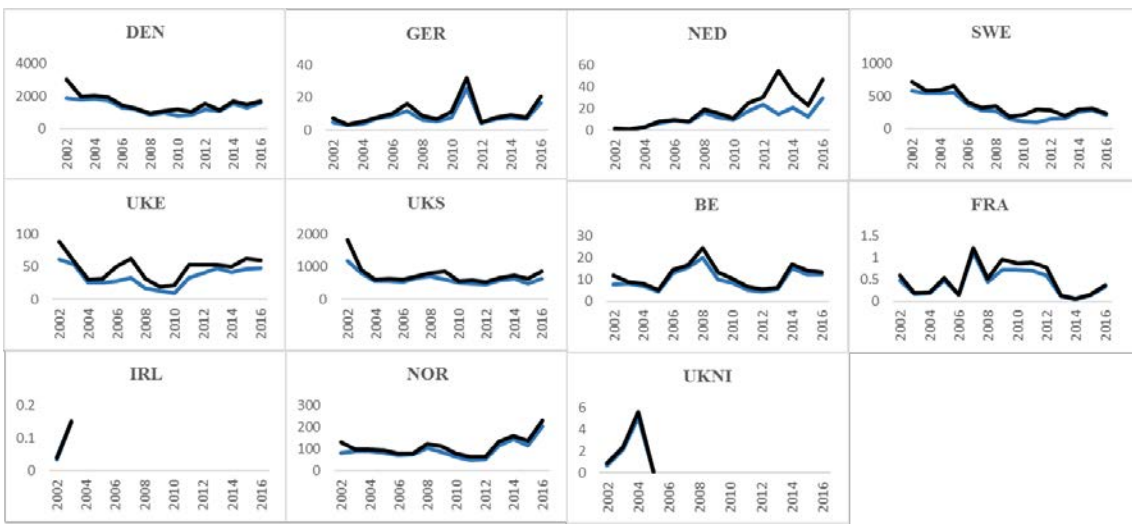


Figure 2. Total catch and landings by country and year.

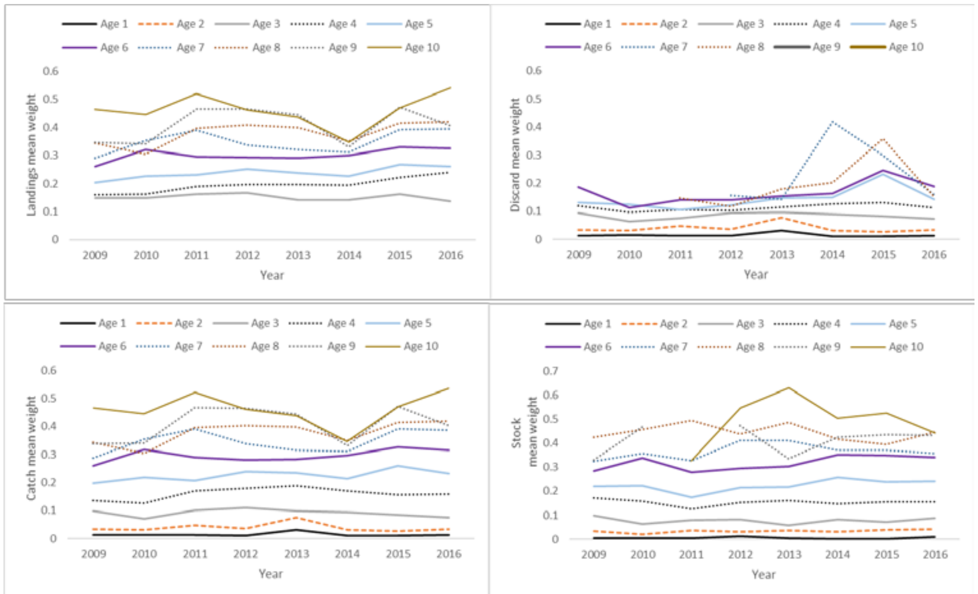


Figure 3. Landings, discard, catch and stock (IBTS) weights at age.

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Appendix 1

Intercatch Details

Guide to the tables in this Appendix:

This Appendix lists 5 sections of tables (A-D) for each Intercatch year (2002-2016). It provides a detailed summary of the Intercatch input data in terms of importance by landed weight and the proportional coverage for age data and discard ratios

Section A: Importance by landed weight

1. Proportion of landings by area and season (note, for later years, season could also be the year itself, since some data are reported by year and not by season).
2. Proportion of landings by métier and country.
3. Proportion of landings by country.
4. Proportion of landings by métier and area.
5. Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum.

Section B: Age coverage of landings and discards

1. Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.
2. Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.
3. Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high.
4. Coverage (proportion) of landings in each métier-country stratum for age composition.
5. Coverage (proportion) of reported discards in each métier-country stratum for age composition. Note: raised discards not included, only reported discards.
6. Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have more than 1% of the total landings.

Section C: Landings age coverage ranked by landed weights

This section shows the proportion of landings covered for age composition, in total and by métier, for all areas combined and for each area in turn. The métiers are ranked by landed weight, so it is easy to check whether the most important métiers have reasonable coverage for age composition.

Section D: Discard ratio coverage ranked by landed weight

As for Section C, but this time for discard ratio coverage.

2009: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2009: Proportion of landings by area and season.

Area	1	2	3	4	2009
IIIa	12.4	12.19	9.33	8.89	0
IV	14.22	17.09	14.11	11.74	0
VIId	0.01	0	0.01	0	0

Table 2. 2009: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0.005	0	-	-	-
GNS_DEF_≥220_0_0_all	-	0.041	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0.006	-	0	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.218	-	0.001	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	0	-	-	0.162	0.005	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.058	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0.001	0	-	-	-
MIS_MIS_0_0_0_HC	-	8.468	0.008	-	-	-	0.001	0	0	-	0.013
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-	-
OTB_CRU_100-119_0_0_all	-	-	0.003	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	1.953	-	-	-	-	1.355	1.559	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.041	-	-	-
OTB_CRU_70-89_2_35_all	-	0.028	-	-	-	-	-	0.017	-	-	-
OTB_CRU_70-99_0_0_all	0.069	2.207	-	0.058	-	0.076	-	-	0.468	0.002	19.861
OTB_CRU_90-119_0_0_all	-	21.582	-	0.005	-	-	-	6.524	-	-	-
OTB_DEF_≥120_0_0_all	0.15	17.95	-	0.181	-	0.218	3.049	0.222	0.177	-	12.424
OTB_DEF_100-119_0_0_all	0.234	-	0.022	-	-	0.092	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	0.003	-	-	0.064	-	-	0.052	-	-
OTB_DWS_100-119_0_0_all	-	-	0.003	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0.076	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0.04	-	-	0.02	-	-	-	-
TBB_DEF_≥120_0_0_all	0.022	0.041	-	-	-	0.067	-	-	0	-	-
TBB_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0.069	-	-	0.002	-	0.018	-	-	0.005	-	-

Table 3. 2009: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
0.5	52.5	0	0.3	0	0.6	4.6	8.4	0.7	0	32.3

Table 4. 2009: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0.005	1	-	-
GNS_DEF_≥220_0_0_all	0	1	0.041	1	-	-
GNS_DEF_100-119_0_0_all	0.006	2	-	-	-	-
GNS_DEF_120-219_0_0_all	0.084	1	0.135	2	-	-
GNS_DEF_all_0_0_all	0.118	3	0.049	1	-	-
GTR_DEF_all_0_0_all	0.058	1	-	-	-	-
LLS_FIF_0_0_0_all	0.001	2	0	1	-	-
MIS_MIS_0_0_0_HC	7.429	4	1.053	3	0.008	2
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	0.003	1
OTB_CRU_32-69_0_0_all	4.597	3	0.271	3	-	-
OTB_CRU_32-69_2_22_all	0.041	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.045	2	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	22.74	7	-	-
OTB_CRU_90-119_0_0_all	28.111	3	-	-	-	-
OTB_DEF_≥120_0_0_all	2.312	4	32.06	8	-	-
OTB_DEF_100-119_0_0_all	-	-	0.344	3	0.004	1
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	-	-	0.117	2	0.003	1
OTB_DWS_100-119_0_0_all	-	-	0.003	1	-	-
OTB_MCD_70-99_0_0_all	-	-	0.076	1	-	-
OTB_SPF_32-69_0_0_all	-	-	0	1	-	-
SSC_DEF_≥120_0_0_all	0.007	2	0.053	2	-	-
TBB_DEF_≥120_0_0_all	0.001	1	0.129	4	-	-
TBB_DEF_100-119_0_0_all	-	-	0	1	-	-
TBB_DEF_70-99_0_0_all	-	-	0.087	4	0.008	1

Table 5. 2009: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_DEF_≥120_0_0_all	8	34.372	34
OTB_CRU_90-119_0_0_all	3	28.111	62
OTB_CRU_70-99_0_0_all	7	22.74	85
MIS_MIS_0_0_0_HC	6	8.49	94
OTB_CRU_32-69_0_0_all	3	4.868	99
OTB_DEF_100-119_0_0_all	3	0.348	99
GNS_DEF_120-219_0_0_all	2	0.219	99
GNS_DEF_all_0_0_all	3	0.167	99
TBB_DEF_≥120_0_0_all	4	0.131	99
OTB_DEF_70-99_0_0_all	3	0.12	100
TBB_DEF_70-99_0_0_all	4	0.094	100
OTB_MCD_70-99_0_0_all	1	0.076	100
SSC_DEF_≥120_0_0_all	2	0.06	100
GTR_DEF_all_0_0_all	1	0.058	100
OTB_CRU_70-89_2_35_all	2	0.045	100
GNS_DEF_≥220_0_0_all	1	0.041	100
OTB_CRU_32-69_2_22_all	1	0.041	100
GNS_DEF_100-119_0_0_all	2	0.006	100
FPO_CRU_0_0_0_all	2	0.005	100
OTB_CRU_100-119_0_0_all	1	0.003	100
OTB_DWS_100-119_0_0_all	1	0.003	100
LLS_FIF_0_0_0_all	2	0.001	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
OTB_SPF_32-69_0_0_all	1	0	100
TBB_DEF_100-119_0_0_all	1	0	100

2009: Appendix B: Age coverage of landings and discards

Table 1. 2009: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	30.61
Discards	17.52

Table 2. 2009: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	73.16	0.53	
Landings	31.91	29.64	0

Table 3. 2009: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2009
Discards	IIIa	90.56	74.45	73.81	66.39	-
Discards	IV	38.88	-	-	-	-
Landings	IIIa	26.56	15.84	-	94.92	-
Landings	IV	26.17	30.55	19.86	44.29	-
Landings	VIId	-	-	-	-	-

Table 4. 2009: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	-	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	0	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	3.13	-	0	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	0	-	-	0	4.48	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	71.71	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-	-
MIS_MIS_0_0_0_HC	-	10.7	0	-	-	-	0	0	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-	-
OTB_CRU_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	9.39	-	-	-	-	0	91.59	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	80.21	-	-	-
OTB_CRU_70-89_2_35_all	-	6.45	-	-	-	-	-	79.12	-	-	-
OTB_CRU_70-99_0_0_all	0	26.79	-	0	-	0	-	-	0	0	26.28
OTB_CRU_90-119_0_0_all	-	22.14	-	0	-	-	-	85.06	-	-	-
OTB_CRU_90-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	16.36	-	0	-	0	0	0	0	-	71.74
OTB_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_100-119_0_0_all	0	-	0	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	0	-	-	0	-	-	0	-	-
OTB_DWS_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	6.77	-	-	-	0	-	-	0	-	-
TBB_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	-	-

Table 5. 2009: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	-	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	0	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-	-
OTB_CRU_70-89_2_35_all	-	0	-	-	-	-	-	48.4	-	-	-
OTB_CRU_70-99_0_0_all	-	-	-	0	-	-	-	-	0	-	0
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	80.24	-	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	12.17	-	0	-	-	-	-	0	-	0
OTB_DEF_≥120_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-	-
OTB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	0	-	-
OTB_DWS_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-	-

Table 6. 2009: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKS
MIS_MIS_0_0_0_HC	10.7	-	-	-
OTB_CRU_32-69_0_0_all	9.4	0	91.6	-
OTB_CRU_70-99_0_0_all	26.8	-	-	26.3
OTB_CRU_90-119_0_0_all	22.1	-	85.1	-
OTB_DEF_≥120_0_0_all	16.4	0	-	71.7

2009: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2009: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	8	34.372	34.47	2
OTB_CRU_90-119_0_0_all	3	28.111	36.74	2
OTB_CRU_70-99_0_0_all	7	22.74	25.56	2
MIS_MIS_0_0_0_HC	6	8.49	10.68	1
OTB_CRU_32-69_0_0_all	3	4.868	33.11	2
OTB_DEF_100-119_0_0_all	3	0.348	-	-
GNS_DEF_120-219_0_0_all	2	0.219	3.11	1
GNS_DEF_all_0_0_all	3	0.167	0.12	1
TBB_DEF_≥120_0_0_all	4	0.131	2.14	1
OTB_DEF_70-99_0_0_all	3	0.12	-	-
TBB_DEF_70-99_0_0_all	4	0.094	-	-
OTB_MCD_70-99_0_0_all	1	0.076	-	-
SSC_DEF_≥120_0_0_all	2	0.06	-	-
GTR_DEF_all_0_0_all	1	0.058	71.71	1
OTB_CRU_70-89_2_35_all	2	0.045	33.83	2
GNS_DEF_≥220_0_0_all	1	0.041	-	-
OTB_CRU_32-69_2_22_all	1	0.041	80.21	1
GNS_DEF_100-119_0_0_all	2	0.006	-	-
FPO_CRU_0_0_0_all	2	0.005	-	-
OTB_CRU_100-119_0_0_all	1	0.003	-	-
OTB_DWS_100-119_0_0_all	1	0.003	-	-
LLS_FIF_0_0_0_all	2	0.001	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
OTB_SPF_32-69_0_0_all	1	0	-	-
TBB_DEF_100-119_0_0_all	1	0	-	-

Table 2. 2009 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	65.662	36.74	2
MIS_MIS_0_0_0_HC	IIIa	4	17.352	9.28	1
OTB_CRU_32-69_0_0_all	IIIa	3	10.738	35.05	2
OTB_DEF_≥120_0_0_all	IIIa	4	5.4	40.65	1
GNS_DEF_all_0_0_all	IIIa	3	0.275	0.17	1
GNS_DEF_120-219_0_0_all	IIIa	1	0.196	3.9	1
GTR_DEF_all_0_0_all	IIIa	1	0.136	71.71	1
OTB_CRU_70-89_2_35_all	IIIa	2	0.106	33.83	2
OTB_CRU_32-69_2_22_all	IIIa	1	0.096	80.21	1
SSC_DEF_≥120_0_0_all	IIIa	2	0.017	-	-
GNS_DEF_100-119_0_0_all	IIIa	2	0.015	-	-
TBB_DEF_≥120_0_0_all	IIIa	1	0.003	-	-
LLS_FIF_0_0_0_all	IIIa	2	0.002	-	-
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all	IIIa	1	0	-	-
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-

Table 3. 2009 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	8	56.086	34.03	2
OTB_CRU_70-99_0_0_all	IV	7	39.781	25.56	2
MIS_MIS_0_0_0_HC	IV	3	1.842	20.64	1
OTB_DEF_100-119_0_0_all	IV	3	0.602	-	-
OTB_CRU_32-69_0_0_all	IV	3	0.474	0.24	1
GNS_DEF_120-219_0_0_all	IV	2	0.236	2.63	1
TBB_DEF_≥120_0_0_all	IV	4	0.226	2.16	1
OTB_DEF_70-99_0_0_all	IV	2	0.204	-	-
TBB_DEF_70-99_0_0_all	IV	4	0.151	-	-
OTB_MCD_70-99_0_0_all	IV	1	0.133	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.092	-	-
GNS_DEF_all_0_0_all	IV	1	0.086	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.072	-	-
FPO_CRU_0_0_0_all	IV	1	0.009	-	-
OTB_DWS_100-119_0_0_all	IV	1	0.005	-	-
TBB_DEF_100-119_0_0_all	IV	1	0.001	-	-
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-
OTB_SPF_32-69_0_0_all	IV	1	0	-	-

Table 4. 2009 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_HC	VIId	2	30.962	-	-
TBB_DEF_70-99_0_0_all	VIId	1	30.544	-	-
OTB_DEF_100-119_0_0_all	VIId	1	14.854	-	-
OTB_DEF_70-99_0_0_all	VIId	1	12.552	-	-
OTB_CRU_100-119_0_0_all	VIId	1	11.088	-	-

2009: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2009: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	3	60.941	-	-
OTB_DEF_≥120_0_0_all	4	15.24	4.57	1
OTB_CRU_90-119_0_0_all	2	8.587	89.71	2
OTB_CRU_32-69_0_0_all	2	8.308	100	2
MIS_MIS_0_0_0_HC	1	4.63	-	-
OTB_CRU_70-89_2_35_all	2	1.292	48.3	1
OTB_DEF_≥120_0_0_all_FDF	1	0.655	-	-
OTB_CRU_32-69_2_22_all	1	0.184	100	1
OTB_CRU_90-119_0_0_all_FDF	1	0.092	-	-
OTB_DEF_70-99_0_0_all	1	0.071	-	-
GNS_DEF_120-219_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-

Table 2. 2009 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	8.587	89.71	2
OTB_CRU_32-69_0_0_all	IIIa	2	8.308	100	2
MIS_MIS_0_0_0_HC	IIIa	1	4.63	-	-
OTB_CRU_70-89_2_35_all	IIIa	2	1.292	48.3	1
OTB_DEF_≥120_0_0_all	IIIa	2	0.295	98.83	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.184	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.092	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2009 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	3	60.941	-	-
OTB_DEF_≥120_0_0_all	IV	4	14.945	2.7	1
OTB_DEF_≥120_0_0_all_FDF	IV	1	0.655	-	-
OTB_DEF_70-99_0_0_all	IV	1	0.071	-	-
MIS_MIS_0_0_0_HC	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-

2010: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2010: Proportion of landings by area and season.

Area	1	2	3	4	2010
IIIa	12.75	11.79	11.09	9.94	0
IV	13.96	15.16	12.38	12.9	0
VIId	0.01	0	0.01	0.02	0

Table 2. 2010: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0.008	0	-	-
GNS_DEF_≥220_0_0_all	-	0.019	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	-	-	0.004	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.089	-	0.002	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.268	0.001	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.066	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	0	-	-
MIS_MIS_0_0_0_HC	-	10.036	0	-	-	-	0.001	0	-	0.015
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_100-119_0_0_all	-	-	0.003	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	0.896	-	-	-	-	1.372	1.828	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.003	-	-
OTB_CRU_70-89_2_35_all	-	0.024	-	-	-	-	-	0.003	-	-
OTB_CRU_70-99_0_0_all	0.034	1.403	-	0.119	-	0.021	-	-	0.231	22.7
OTB_CRU_90-119_0_0_all	-	25.781	-	0.015	-	-	-	5.497	-	-
OTB_DEF_≥120_0_0_all	0.009	11.94	0.012	0.282	-	0.265	2.546	0.013	0.344	9.553
OTB_DEF_≥120_0_0_all_FDF	-	3.378	-	-	-	-	-	-	-	0.196
OTB_DEF_100-119_0_0_all	0.435	-	0.031	-	-	0.118	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0.001	-	-	-	-	0.097	-	-	0.05	-
OTB_DWS_≥120_0_0_all	-	-	0.001	-	-	-	-	-	-	-
OTB_DWS_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0.021	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0.048	-	-	0.025	-	-	-
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	0	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0.031	0.011	-	-	-	0.025	-	-	-	-
TBB_DEF_100-119_0_0_all	0.001	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0.058	-	-	0.031	-	0.038	-	-	0.002	-

Table 3. 2010: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.6	53.6	0	0.5	0	0.6	4.2	7.4	0.6	32.5

Table 4. 2010: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0.008	1	-	-
GNS_DEF_≥220_0_0_all	-	-	0.019	1	-	-
GNS_DEF_100-119_0_0_all	0.004	1	-	-	-	-
GNS_DEF_120-219_0_0_all	0.013	1	0.077	2	-	-
GNS_DEF_120-219_0_0_all_FDF	0	1	0	1	-	-
GNS_DEF_all_0_0_all	0.132	2	0.137	1	-	-
GTR_DEF_all_0_0_all	0.066	1	-	-	-	-
LLS_FIF_0_0_0_all	0	1	0	1	-	-
MIS_MIS_0_0_0_HC	8.691	4	1.36	2	0	2
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	0.003	1
OTB_CRU_32-69_0_0_all	3.865	3	0.231	4	-	-
OTB_CRU_32-69_2_22_all	0.003	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.027	2	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	24.507	6	-	-
OTB_CRU_90-119_0_0_all	31.293	3	-	-	-	-
OTB_DEF_≥120_0_0_all	1.34	3	23.623	9	-	-
OTB_DEF_≥120_0_0_all_FDF	0.114	1	3.461	2	-	-
OTB_DEF_100-119_0_0_all	0.003	1	0.565	3	0.017	1
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	0.003	1	0.145	3	-	-
OTB_DWS_≥120_0_0_all	-	-	0.001	1	-	-
OTB_DWS_100-119_0_0_all	-	-	0	1	-	-
OTB_MCD_70-99_0_0_all	-	-	0.021	1	-	-
OTB_SPF_32-69_0_0_all	-	-	0	1	-	-
SDN_DEF_≥120_0_0_all	-	-	0	1	-	-
SSC_DEF	-	-	0	1	-	-
SSC_DEF_≥120_0_0_all	0.007	2	0.066	2	-	-
SSC_DEF_70-99_0_0_all	-	-	0	1	-	-
TBB_CRU_16-31_0_0_all	-	-	0	1	-	-
TBB_DEF_≥120_0_0_all	0.002	1	0.064	3	-	-
TBB_DEF_100-119_0_0_all	-	-	0.001	1	-	-
TBB_DEF_70-99_0_0_all	-	-	0.123	4	0.007	1

Table 5. 2010: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	31.293	31
OTB_DEF_≥120_0_0_all	9	24.963	56
OTB_CRU_70-99_0_0_all	6	24.507	81
MIS_MIS_0_0_0_HC	5	10.052	91
OTB_CRU_32-69_0_0_all	4	4.096	95
OTB_DEF_≥120_0_0_all_FDF	2	3.574	98
OTB_DEF_100-119_0_0_all	3	0.584	99
GNS_DEF_all_0_0_all	2	0.269	99
OTB_DEF_70-99_0_0_all	3	0.147	99
TBB_DEF_70-99_0_0_all	4	0.13	100
GNS_DEF_120-219_0_0_all	2	0.09	100
SSC_DEF_≥120_0_0_all	2	0.073	100
GTR_DEF_all_0_0_all	1	0.066	100
TBB_DEF_≥120_0_0_all	3	0.066	100
OTB_CRU_70-89_2_35_all	2	0.027	100
OTB_MCD_70-99_0_0_all	1	0.021	100
GNS_DEF_≥220_0_0_all	1	0.019	100
FPO_CRU_0_0_0_all	2	0.008	100
GNS_DEF_100-119_0_0_all	1	0.004	100
OTB_CRU_100-119_0_0_all	1	0.003	100
OTB_CRU_32-69_2_22_all	1	0.003	100
OTB_DWS_≥120_0_0_all	1	0.001	100
TBB_DEF_100-119_0_0_all	1	0.001	100
GNS_DEF_120-219_0_0_all_FDF	1	0	100
LLS_FIF_0_0_0_all	1	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
OTB_DWS_100-119_0_0_all	1	0	100
OTB_SPF_32-69_0_0_all	1	0	100
SDN_DEF_≥120_0_0_all	1	0	100
SSC_DEF	1	0	100
SSC_DEF_70-99_0_0_all	1	0	100
TBB_CRU_16-31_0_0_all	1	0	100

2010: Appendix B: Age coverage of landings and discards

Table 1. 2010: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	50.77
Discards	52.04

Table 2. 2010: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	65.49	3.27	
Landings	87.74	19.85	0

Table 3. 2010: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2010
Discards	IIIa	25.38	88.37	92.85	97.7	-
Discards	IV	-	-	-	24.79	-
Landings	IIIa	76.66	95.76	86.33	94	-
Landings	IV	67.65	-	10.91	-	-
Landings	VIId	-	-	-	-	-

Table 4. 2010: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	-	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	14.44	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	50	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	47.37	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	83.45	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	0	-	-
MIS_MIS_0_0_0_HC	-	83.28	0	-	-	-	0	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	97.01	-	-	-	-	0	54.57	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	55.1	-	-
OTB_CRU_70-89_2_35_all	-	100	-	-	-	-	-	16.67	-	-
OTB_CRU_70-99_0_0_all	0	0	-	0	-	0	-	-	0	28.62
OTB_CRU_90-119_0_0_all	-	100	-	0	-	-	-	49.67	-	-
OTB_CRU_90-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	8.61	0	0	-	0	0	0	0	45.04
OTB_DEF_≥120_0_0_all_FDF	-	3.36	-	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	0	-	0	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0	-	-	-	-	0	-	-	0	-
OTB_DWS_≥120_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_DWS_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
TBB_CRU_16-31_0_0_all	-	-	-	0	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	14.29	-	-	-	0	-	-	-	-
TBB_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	-

Table 5. 2010: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	100	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	0.53	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	63.89	-	-
OTB_CRU_70-99_0_0_all	-	0	-	-	-	-	-	-	0	0
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	80.19	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	35.55	-	0	-	-	-	-	0	0
OTB_DEF_≥120_0_0_all_FDF	-	0	-	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	0	-
OTB_DWS_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_DWS_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	0	-	-	-	-	-	-

Table 6. 2010: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKS
MIS_MIS_0_0_0_HC	83.3	-	-	-
OTB_CRU_32-69_0_0_all	-	0	54.6	-
OTB_CRU_70-99_0_0_all	0	-	-	28.6
OTB_CRU_90-119_0_0_all	100	-	49.7	-
OTB_DEF_≥120_0_0_all	8.6	0	-	45
OTB_DEF_≥120_0_0_all_FDF	3.4	-	-	-

2010: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2010: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	31.293	91.11	2
OTB_DEF_≥120_0_0_all	9	24.963	21.35	2
OTB_CRU_70-99_0_0_all	6	24.507	26.51	1
MIS_MIS_0_0_0_HC	5	10.052	83.15	1
OTB_CRU_32-69_0_0_all	4	4.096	45.57	2
OTB_DEF_≥120_0_0_all_FDF	2	3.574	3.18	1
OTB_DEF_100-119_0_0_all	3	0.584	-	-
GNS_DEF_all_0_0_all	2	0.269	0.22	1
OTB_DEF_70-99_0_0_all	3	0.147	-	-
TBB_DEF_70-99_0_0_all	4	0.13	-	-
GNS_DEF_120-219_0_0_all	2	0.09	14.19	1
SSC_DEF_≥120_0_0_all	2	0.073	-	-
GTR_DEF_all_0_0_all	1	0.066	83.45	1
TBB_DEF_≥120_0_0_all	3	0.066	2.28	1
OTB_CRU_70-89_2_35_all	2	0.027	90.45	2
OTB_MCD_70-99_0_0_all	1	0.021	-	-
GNS_DEF_≥220_0_0_all	1	0.019	-	-
FPO_CRU_0_0_0_all	2	0.008	-	-
GNS_DEF_100-119_0_0_all	1	0.004	-	-
OTB_CRU_100-119_0_0_all	1	0.003	-	-
OTB_CRU_32-69_2_22_all	1	0.003	55.1	1
OTB_DWS_≥120_0_0_all	1	0.001	-	-
TBB_DEF_100-119_0_0_all	1	0.001	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	50	1
LLS_FIF_0_0_0_all	1	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
OTB_DWS_100-119_0_0_all	1	0	-	-
OTB_SPF_32-69_0_0_all	1	0	-	-
SDN_DEF_≥120_0_0_all	1	0	-	-
SSC_DEF	1	0	-	-
SSC_DEF_70-99_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-

Table 2. 2010 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	68.682	91.11	2
MIS_MIS_0_0_0_HC	IIIa	4	19.076	96.16	1
OTB_CRU_32-69_0_0_all	IIIa	3	8.484	48.29	2
OTB_DEF_≥120_0_0_all	IIIa	3	2.941	76.77	1
GNS_DEF_all_0_0_all	IIIa	2	0.289	0.45	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0.249	100	1
GTR_DEF_all_0_0_all	IIIa	1	0.145	83.45	1
OTB_CRU_70-89_2_35_all	IIIa	2	0.06	90.45	2
GNS_DEF_120-219_0_0_all	IIIa	1	0.028	100	1
SSC_DEF_≥120_0_0_all	IIIa	2	0.016	-	-
GNS_DEF_100-119_0_0_all	IIIa	1	0.008	-	-
OTB_CRU_32-69_2_22_all	IIIa	1	0.007	55.1	1
OTB_DEF_100-119_0_0_all	IIIa	1	0.006	-	-
OTB_DEF_70-99_0_0_all	IIIa	1	0.006	-	-
TBB_DEF_≥120_0_0_all	IIIa	1	0.003	100	1
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	100	1
LLS_FIF_0_0_0_all	IIIa	1	0	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-

Table 3. 2010 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	6	45.041	26.51	1
OTB_DEF_≥120_0_0_all	IV	9	43.417	18.21	1
OTB_DEF_≥120_0_0_all_FDF	IV	2	6.361	-	-
MIS_MIS_0_0_0_HC	IV	2	2.5	-	-
OTB_DEF_100-119_0_0_all	IV	3	1.038	-	-
OTB_CRU_32-69_0_0_all	IV	4	0.424	-	-
OTB_DEF_70-99_0_0_all	IV	3	0.266	-	-
GNS_DEF_all_0_0_all	IV	1	0.253	-	-
TBB_DEF_70-99_0_0_all	IV	4	0.226	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.142	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.121	-	-
TBB_DEF_≥120_0_0_all	IV	3	0.118	-	-
OTB_MCD_70-99_0_0_all	IV	1	0.038	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.036	-	-
FPO_CRU_0_0_0_all	IV	1	0.015	-	-
TBB_DEF_100-119_0_0_all	IV	1	0.002	-	-
OTB_DWS_≥120_0_0_all	IV	1	0.001	-	-
SSC_DEF_70-99_0_0_all	IV	1	0.001	-	-
TBB_CRU_16-31_0_0_all	IV	1	0.001	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0	-	-
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-
OTB_DWS_100-119_0_0_all	IV	1	0	-	-
OTB_SPF_32-69_0_0_all	IV	1	0	-	-
SDN_DEF_≥120_0_0_all	IV	1	0	-	-
SSC_DEF	IV	1	0	-	-

Table 4. 2010 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_100-119_0_0_all	VIId	1	62.651	-	-
TBB_DEF_70-99_0_0_all	VIId	1	25.783	-	-
OTB_CRU_100-119_0_0_all	VIId	1	10.12	-	-
MIS_MIS_0_0_0_HC	VIId	2	1.446	-	-

2010: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2010: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	2	32.033	95.87	2
MIS_MIS_0_0_0_HC	1	24.821	0.53	1
OTB_CRU_32-69_0_0_all	2	18.414	100	2
OTB_CRU_70-99_0_0_all	3	12.565	-	-
OTB_DEF_≥120_0_0_all	4	8.081	12.82	1
OTB_CRU_70-89_2_35_all	1	2.735	63.89	1
OTB_DEF_≥120_0_0_all_FDF	2	1.301	-	-
OTB_CRU_32-69_2_22_all	1	0.044	-	-
OTB_DEF_70-99_0_0_all	1	0.004	-	-
GNS_DEF_120-219_0_0_all	1	0.001	100	1
OTB_CRU_90-119_0_0_all_FDF	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-
TBB_DEF_70-99_0_0_all	1	0	-	-

Table 2. 2010 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	32.033	95.87	2
MIS_MIS_0_0_0_HC	IIIa	1	24.821	0.53	1
OTB_CRU_32-69_0_0_all	IIIa	2	18.414	100	2
OTB_CRU_70-89_2_35_all	IIIa	1	2.735	63.89	1
OTB_DEF_≥120_0_0_all	IIIa	1	0.329	100	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.044	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0.001	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2010 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	3	12.565	-	-
OTB_DEF_≥120_0_0_all	IV	4	7.752	9.13	1
OTB_DEF_≥120_0_0_all_FDF	IV	2	1.301	-	-
OTB_DEF_70-99_0_0_all	IV	1	0.004	-	-
GNS_DEF_120-219_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_HC	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-
TBB_DEF_70-99_0_0_all	IV	1	0	-	-

2011: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2011: Proportion of landings by area and season.

Area	1	2	3	4	2011
IIIa	11.98	12.82	10.11	10.74	-
IV	12.63	17.24	13.16	11.29	0
VIId	0.01	0	0.01	0.01	-

Table 2. 2011: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0.005	0	0.001	-
GNS_DEF_≥220_0_0_all	-	0.022	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0.004	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.081	0	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.283	0.007	0.016	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.016	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	0	-	-
MIS_MIS_0_0_0_HC	-	9.026	-	-	-	-	0	0	-	0.043
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_100-119_0_0_all	-	-	0.002	-	-	-	-	-	-	-
OTB_CRU_16-31_0_0_all	-	-	-	0.058	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	1.056	-	-	-	-	1.341	2.188	0.012	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.005	-	-
OTB_CRU_70-89_2_35_all	-	0.007	-	0	-	-	-	0.022	-	-
OTB_CRU_70-99_0_0_all	0.095	0.994	-	0.124	-	0.1	-	-	0.98	18.723
OTB_CRU_70-99_0_0_all_FDF	-	0.012	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	27.617	-	0.005	-	-	-	4.446	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.224	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0.021	4.966	0.01	1.355	-	0.333	1.386	0.02	0.819	12.01
OTB_DEF_≥120_0_0_all_FDF	-	9.771	-	-	-	-	-	-	-	0.436
OTB_DEF_100-119_0_0_all	0.074	-	0.03	-	-	0.395	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0.007	-	-	-	-	0.148	-	-	0.268	-
OTB_DWS_≥120_0_0_all	-	-	0.002	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0.1	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0.069	-	-	0.025	-	-	-
SSC_DEF_100-119_0_0_all	0.001	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	0	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0.041	0.027	-	-	-	-	-	-	0	-
TBB_DEF_100-119_0_0_all	0.001	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0.104	-	-	0.02	-	0.037	-	-	0.006	-

Table 3. 2011: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.3	53.8	0	1.6	0	1.1	3	6.7	2.1	31.2

Table 4. 2011: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0.005	2	-	-
GNS_DEF_≥220_0_0_all	-	-	0.022	1	-	-
GNS_DEF_100-119_0_0_all	0	1	0.004	1	-	-
GNS_DEF_120-219_0_0_all	0.004	1	0.077	2	0	1
GNS_DEF_120-219_0_0_all_FDF	0	1	0	1	-	-
GNS_DEF_all_0_0_all	0.188	2	0.119	2	-	-
GTR_DEF_all_0_0_all	0.016	1	-	-	-	-
LLS_FIF_0_0_0_all	0	1	0	1	-	-
MIS_MIS_0_0_0_HC	8.349	3	0.721	2	-	-
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	0.002	1
OTB_CRU_16-31_0_0_all	-	-	0.058	1	-	-
OTB_CRU_32-69_0_0_all	4.388	3	0.21	4	-	-
OTB_CRU_32-69_2_22_all	0.005	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.029	3	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	21.016	6	-	-
OTB_CRU_70-99_0_0_all_FDF	-	-	0.012	1	-	-
OTB_CRU_90-119_0_0_all	32.068	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.224	1	-	-	-	-
OTB_DEF_≥120_0_0_all	0.193	4	20.727	9	-	-
OTB_DEF_≥120_0_0_all_FDF	0.163	1	10.044	2	-	-
OTB_DEF_100-119_0_0_all	-	-	0.485	3	0.014	1
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	-	-	0.423	3	-	-
OTB_DWS_≥120_0_0_all	-	-	0.002	1	-	-
OTB_MCD_70-99_0_0_all	-	-	0.1	1	-	-
OTB_SPF_32-69_0_0_all	-	-	0	1	-	-
SDN_DEF_≥120_0_0_all	-	-	0	1	-	-
SSC_DEF_≥120_0_0_all	0.029	1	0.065	2	-	-
SSC_DEF_100-119_0_0_all	-	-	0.001	1	-	-
TBB_CRU_16-31_0_0_all	-	-	0	1	-	-
TBB_DEF_≥120_0_0_all	0.001	1	0.068	3	-	-
TBB_DEF_100-119_0_0_all	-	-	0.001	1	-	-
TBB_DEF_70-99_0_0_all	-	-	0.157	4	0.009	1

Table 5. 2011: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	32.068	32
OTB_CRU_70-99_0_0_all	6	21.016	53
OTB_DEF_≥120_0_0_all	9	20.92	74
OTB_DEF_≥120_0_0_all_FDF	2	10.207	84
MIS_MIS_0_0_0_HC	4	9.069	93
OTB_CRU_32-69_0_0_all	4	4.597	98
OTB_DEF_100-119_0_0_all	3	0.499	98
OTB_DEF_70-99_0_0_all	3	0.423	99
GNS_DEF_all_0_0_all	3	0.307	99
OTB_CRU_90-119_0_0_all_FDF	1	0.224	99
TBB_DEF_70-99_0_0_all	4	0.166	99
OTB_MCD_70-99_0_0_all	1	0.1	100
SSC_DEF_≥120_0_0_all	2	0.094	100
GNS_DEF_120-219_0_0_all	3	0.081	100
TBB_DEF_≥120_0_0_all	3	0.068	100
OTB_CRU_16-31_0_0_all	1	0.058	100
OTB_CRU_70-89_2_35_all	3	0.029	100
GNS_DEF_≥220_0_0_all	1	0.022	100
GTR_DEF_all_0_0_all	1	0.016	100
OTB_CRU_70-99_0_0_all_FDF	1	0.012	100
FPO_CRU_0_0_0_all	3	0.005	100
OTB_CRU_32-69_2_22_all	1	0.005	100
GNS_DEF_100-119_0_0_all	1	0.004	100
OTB_CRU_100-119_0_0_all	1	0.002	100
OTB_DWS_≥120_0_0_all	1	0.002	100
SSC_DEF_100-119_0_0_all	1	0.001	100
TBB_DEF_100-119_0_0_all	1	0.001	100
GNS_DEF_120-219_0_0_all_FDF	1	0	100
LLS_FIF_0_0_0_all	1	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
OTB_SPF_32-69_0_0_all	1	0	100
SDN_DEF_≥120_0_0_all	1	0	100
TBB_CRU_16-31_0_0_all	1	0	100

2011: Appendix B: Age coverage of landings and discards

Table 1. 2011: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	25.17
Discards	69.36

Table 2. 2011: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	**IV**	**VIId**
Discards	91.51	8.65	
Landings	49.4	4.83	0

Table 3. 2011: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	**1**	**2**	**3**	**4**	**2011**
Discards	IIIa	96.72	88.32	89.15	92.27	-
Discards	IV	74.83	-	-	-	-
Landings	IIIa	96.27	18.29	-	80.75	-
Landings	IV	-	-	-	23.23	-
Landings	VIId	-	-	-	-	-

Table 4. 2011: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	**DEN**	**FRA**	**GFR**	**IRL**	**NED**	**NOR**	**SWE**	**UKE**	**UKS**
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	0	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	6.16	0	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	33.33	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	29.26	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	23.37	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	0	-	-
MIS_MIS_0_0_0_HC	-	17.62	-	-	-	-	0	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_100-119_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_CRU_16-31_0_0_all	-	-	-	0	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	72.11	-	-	-	-	0	43.63	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	1.16	-	-
OTB_CRU_70-89_2_35_all	-	0	-	0	-	-	-	65.93	-	-
OTB_CRU_70-99_0_0_all	0	26.92	-	0	-	0	-	-	0	0
OTB_CRU_70-99_0_0_all_FDF	-	100	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	56.63	-	0	-	-	-	75.9	-	-
OTB_CRU_90-119_0_0_all_FDF	-	39.12	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	13.34	0	0	-	0	0	0	0	0
OTB_DEF_≥120_0_0_all_FDF	-	18.42	-	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	0	-	0	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0	-	-	-	-	0	-	-	0	-
OTB_DWS_≥120_0_0_all	-	-	0	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-
SSC_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
TBB_CRU_16-31_0_0_all	-	-	-	0	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	2.16	-	-	-	-	-	-	0	-
TBB_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	-

Table 5. 2011: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	1.12	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	43.39	-	-
OTB_CRU_70-99_0_0_all	-	100	-	-	-	0	-	-	0	0
OTB_CRU_70-99_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	94.81	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	3.2	-	0	-	-	-	-	0	0
OTB_DEF_≥120_0_0_all_FDF	-	0	-	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DWS_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-

Table 6. 2011: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	GFR	NOR	SWE	UKS
MIS_MIS_0_0_0_HC	17.6	-	-	-	-
OTB_CRU_32-69_0_0_all	-	-	0	43.6	-
OTB_CRU_70-99_0_0_all	-	-	-	-	0
OTB_CRU_90-119_0_0_all	56.6	-	-	75.9	-
OTB_DEF_≥120_0_0_all	13.3	0	0	-	0
OTB_DEF_≥120_0_0_all_FDF	18.4	-	-	-	-

2011: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2011: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	32.068	59.29	2
OTB_CRU_70-99_0_0_all	6	21.016	1.27	1
OTB_DEF_≥120_0_0_all	9	20.92	3.17	1
OTB_DEF_≥120_0_0_all_FDF	2	10.207	17.63	1
MIS_MIS_0_0_0_HC	4	9.069	17.53	1
OTB_CRU_32-69_0_0_all	4	4.597	37.32	2
OTB_DEF_100-119_0_0_all	3	0.499	-	-
OTB_DEF_70-99_0_0_all	3	0.423	-	-
GNS_DEF_all_0_0_all	3	0.307	0.7	1
OTB_CRU_90-119_0_0_all_FDF	1	0.224	39.12	1
TBB_DEF_70-99_0_0_all	4	0.166	-	-
OTB_MCD_70-99_0_0_all	1	0.1	-	-
SSC_DEF_≥120_0_0_all	2	0.094	-	-
GNS_DEF_120-219_0_0_all	3	0.081	6.14	1
TBB_DEF_≥120_0_0_all	3	0.068	0.84	1
OTB_CRU_16-31_0_0_all	1	0.058	-	-
OTB_CRU_70-89_2_35_all	3	0.029	49.28	1
GNS_DEF_≥220_0_0_all	1	0.022	-	-
GTR_DEF_all_0_0_all	1	0.016	23.37	1
OTB_CRU_70-99_0_0_all_FDF	1	0.012	100	1
FPO_CRU_0_0_0_all	3	0.005	-	-
OTB_CRU_32-69_2_22_all	1	0.005	1.16	1
GNS_DEF_100-119_0_0_all	1	0.004	-	-
OTB_CRU_100-119_0_0_all	1	0.002	-	-
OTB_DWS_≥120_0_0_all	1	0.002	-	-
SSC_DEF_100-119_0_0_all	1	0.001	-	-
TBB_DEF_100-119_0_0_all	1	0.001	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	33.33	1
LLS_FIF_0_0_0_all	1	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
OTB_SPF_32-69_0_0_all	1	0	-	-
SDN_DEF_≥120_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-

Table 2. 2011 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	70.236	59.29	2
MIS_MIS_0_0_0_HC	IIIa	3	18.286	18.6	1
OTB_CRU_32-69_0_0_all	IIIa	3	9.61	38.97	2
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.491	39.12	1
OTB_DEF_≥120_0_0_all	IIIa	4	0.423	39.15	1
GNS_DEF_all_0_0_all	IIIa	2	0.412	1.14	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0.358	54.92	1
OTB_CRU_70-89_2_35_all	IIIa	3	0.063	49.28	1
SSC_DEF_≥120_0_0_all	IIIa	1	0.063	-	-
GTR_DEF_all_0_0_all	IIIa	1	0.035	23.37	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.012	1.16	1
GNS_DEF_120-219_0_0_all	IIIa	1	0.009	81.25	1
TBB_DEF_≥120_0_0_all	IIIa	1	0.002	81.82	1
GNS_DEF_100-119_0_0_all	IIIa	1	0.001	-	-
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	100	1
LLS_FIF_0_0_0_all	IIIa	1	0	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-

Table 3. 2011 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	6	38.691	1.27	1
OTB_DEF_≥120_0_0_all	IV	9	38.159	2.83	1
OTB_DEF_≥120_0_0_all_FDF	IV	2	18.49	17.03	1
MIS_MIS_0_0_0_HC	IV	2	1.327	5.21	1
OTB_DEF_100-119_0_0_all	IV	3	0.892	-	-
OTB_DEF_70-99_0_0_all	IV	3	0.78	-	-
OTB_CRU_32-69_0_0_all	IV	4	0.386	2.8	1
TBB_DEF_70-99_0_0_all	IV	4	0.289	-	-
GNS_DEF_all_0_0_all	IV	2	0.219	-	-
OTB_MCD_70-99_0_0_all	IV	1	0.184	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.142	2.16	1
TBB_DEF_≥120_0_0_all	IV	3	0.125	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.12	-	-
OTB_CRU_16-31_0_0_all	IV	1	0.107	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.041	-	-
OTB_CRU_70-99_0_0_all_FDF	IV	1	0.023	100	1
FPO_CRU_0_0_0_all	IV	2	0.01	-	-
GNS_DEF_100-119_0_0_all	IV	1	0.006	-	-
OTB_DWS_≥120_0_0_all	IV	1	0.004	-	-
TBB_DEF_100-119_0_0_all	IV	1	0.003	-	-
SDN_DEF_≥120_0_0_all	IV	1	0.001	-	-
SSC_DEF_100-119_0_0_all	IV	1	0.001	-	-
TBB_CRU_16-31_0_0_all	IV	1	0.001	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0	-	-
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-
OTB_SPF_32-69_0_0_all	IV	1	0	-	-

Table 4. 2011 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_100-119_0_0_all	VIId	1	54.703	-	-
TBB_DEF_70-99_0_0_all	VIId	1	36.139	-	-
OTB_CRU_100-119_0_0_all	VIId	1	8.911	-	-
GNS_DEF_120-219_0_0_all	VIId	1	0.248	-	-

2011: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2011: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	2	34.55	98.58	2
OTB_CRU_32-69_0_0_all	2	31.857	100	2
OTB_CRU_70-99_0_0_all	4	20.922	11.04	1
OTB_DEF_≥120_0_0_all	4	5.365	0.03	1
MIS_MIS_0_0_0_HC	1	3.889	1.12	1
OTB_CRU_70-89_2_35_all	1	1.986	43.39	1
OTB_CRU_90-119_0_0_all_FDF	1	0.759	-	-
OTB_DEF_≥120_0_0_all_FDF	2	0.28	-	-
OTB_CRU_32-69_2_22_all	1	0.228	100	1
OTB_DEF_70-99_0_0_all	1	0.12	-	-
OTB_DEF_100-119_0_0_all	1	0.045	-	-
GNS_DEF_120-219_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
SSC_DEF_≥120_0_0_all	1	0	-	-
SSC_DEF_100-119_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-
TBB_DEF_100-119_0_0_all	1	0	-	-
TBB_DEF_70-99_0_0_all	1	0	-	-

Table 2. 2011 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	34.55	98.58	2
OTB_CRU_32-69_0_0_all	IIIa	2	31.857	100	2
MIS_MIS_0_0_0_HC	IIIa	1	3.889	1.12	1
OTB_CRU_70-89_2_35_all	IIIa	1	1.986	43.39	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.759	-	-
OTB_CRU_32-69_2_22_all	IIIa	1	0.228	100	1
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-
OTB_DEF_≥120_0_0_all	IIIa	1	0	-	-

Table 3. 2011 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	4	20.922	11.04	1
OTB_DEF_≥120_0_0_all	IV	4	5.365	0.03	1
OTB_DEF_≥120_0_0_all_FDF	IV	2	0.28	-	-
OTB_DEF_70-99_0_0_all	IV	1	0.12	-	-
OTB_DEF_100-119_0_0_all	IV	1	0.045	-	-
GNS_DEF_120-219_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_HC	IV	1	0	-	-
SSC_DEF_≥120_0_0_all	IV	1	0	-	-
SSC_DEF_100-119_0_0_all	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-
TBB_DEF_100-119_0_0_all	IV	1	0	-	-
TBB_DEF_70-99_0_0_all	IV	1	0	-	-

2012: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2012: Proportion of landings by area and season.

Area	1	2	3	4	2012
IIIa	17.77	15.66	11.58	13.47	-
IV	9.65	11.64	9.17	11.01	0
VIId	0.01	0.03	0	0	-

Table 2. 2012: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	0	0	-
GNS_DEF_≥220_0_0_all	-	0.003	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0.006	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.048	-	0.001	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.126	0.004	0.019	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.024	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	9.325	-	-	-	-	0	0	-	0.23
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	0.96	-	-	-	-	1.543	1.837	0.029	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.051	-	-
OTB_CRU_70-89_2_35_all	-	-	-	0	-	-	-	0.011	-	-
OTB_CRU_70-99_0_0_all	0.077	0.741	-	0.121	-	0.127	-	-	0.769	10.701
OTB_CRU_70-99_0_0_all_FDF	-	0.039	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	38.4	-	0	-	-	-	5.991	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.356	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0.039	5.211	0.003	0.064	-	0.176	0.93	0.019	0.991	11.856
OTB_DEF_≥120_0_0_all_FDF	-	7.112	-	0.011	-	-	-	-	-	0.732
OTB_DEF_100-119_0_0_all	0.02	-	0.007	-	-	0.522	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0.003	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	0.021	-	-	0.151	-	-	0.195	-
OTB_DEF_All_0_0_All	-	-	-	-	-	0.075	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0.127	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0.003	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0.001	-	-	0.011	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0.005	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	0.001	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0.042	0.023	-	-	-	0.007	-	-	0	-
TBB_DEF_70-99_0_0_all	0.057	-	-	0.003	-	-	-	-	0.041	-

Table 3. 2012: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.2	62.2	0	0.2	0	1.2	2.6	7.9	2	23.5

Table 4. 2012: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0	1	-	-
GNS_DEF_≥220_0_0_all	0	1	0.002	1	-	-
GNS_DEF_≥220_0_0_all_FDF	-	-	0.006	1	-	-
GNS_DEF_100-119_0_0_all	0	1	0	1	-	-
GNS_DEF_120-219_0_0_all	0.003	2	0.045	2	-	-
GNS_DEF_120-219_0_0_all_FDF	0	1	0	1	-	-
GNS_DEF_all_0_0_all	0.098	2	0.051	2	-	-
GTR_DEF_all_0_0_all	0.024	1	-	-	-	-
LLS_FIF_0_0_0_all	0	2	0	1	-	-
MIS_MIS_0_0_0_HC	8.9	3	0.655	2	-	-
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_32-69_0_0_all	4.166	3	0.202	4	-	-
OTB_CRU_32-69_2_22_all	0.051	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.012	2	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	12.536	6	-	-
OTB_CRU_70-99_0_0_all_FDF	-	-	0.039	1	-	-
OTB_CRU_90-119_0_0_all	44.391	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.356	1	-	-	-	-
OTB_DEF_≥120_0_0_all	0.34	3	18.948	9	-	-
OTB_DEF_≥120_0_0_all_FDF	0.149	2	7.707	3	-	-
OTB_DEF_100-119_0_0_all	-	-	0.542	2	0.007	1
OTB_DEF_100-119_0_0_all_FDF	-	-	0.003	1	-	-
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	-	-	0.347	2	0.021	1
OTB_DEF_All_0_0_All	-	-	0.075	1	-	-
OTB_MCD_70-99_0_0_all	-	-	0.127	1	-	-
OTB_SPF_32-69_0_0_all	-	-	0	1	-	-
SDN_DEF_≥120_0_0_all	-	-	0.003	1	-	-
SSC_DEF	-	-	-	-	0	1
SSC_DEF_≥120_0_0_all	0	1	0.013	2	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	0.005	1	-	-
SSC_DEF_70-99_0_0_all	-	-	0.001	1	-	-
TBB_DEF_≥120_0_0_all	0	1	0.071	4	-	-
TBB_DEF_70-99_0_0_all	-	-	0.091	3	0.011	1

Table 5. 2012: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	44.391	44
OTB_DEF_≥120_0_0_all	9	19.288	64
OTB_CRU_70-99_0_0_all	6	12.536	76
MIS_MIS_0_0_0_HC	4	9.555	86
OTB_DEF_≥120_0_0_all_FDF	3	7.856	94
OTB_CRU_32-69_0_0_all	4	4.369	98
OTB_DEF_100-119_0_0_all	3	0.549	99
OTB_DEF_70-99_0_0_all	3	0.367	99
OTB_CRU_90-119_0_0_all_FDF	1	0.356	99
GNS_DEF_all_0_0_all	3	0.149	99
OTB_MCD_70-99_0_0_all	1	0.127	100
TBB_DEF_70-99_0_0_all	3	0.102	100
OTB_DEF_All_0_0_All	1	0.075	100
TBB_DEF_≥120_0_0_all	4	0.072	100
OTB_CRU_32-69_2_22_all	1	0.051	100
GNS_DEF_120-219_0_0_all	2	0.048	100
OTB_CRU_70-99_0_0_all_FDF	1	0.039	100
GTR_DEF_all_0_0_all	1	0.024	100
SSC_DEF_≥120_0_0_all	2	0.013	100
OTB_CRU_70-89_2_35_all	2	0.012	100
GNS_DEF_≥220_0_0_all_FDF	1	0.006	100
SSC_DEF_≥120_0_0_all_FDF	1	0.005	100
GNS_DEF_≥220_0_0_all	1	0.003	100
OTB_DEF_100-119_0_0_all_FDF	1	0.003	100
SDN_DEF_≥120_0_0_all	1	0.003	100
SSC_DEF_70-99_0_0_all	1	0.001	100
FPO_CRU_0_0_0_all	2	0	100
GNS_DEF_100-119_0_0_all	2	0	100
GNS_DEF_120-219_0_0_all_FDF	1	0	100
LLS_FIF_0_0_0_all	2	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
OTB_SPF_32-69_0_0_all	1	0	100
SSC_DEF	1	0	100

2012: Appendix B: Age coverage of landings and discards

Table 1. 2012: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	46.02
Discards	76.93

Table 2. 2012: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	92.12	16.01	
Landings	78.67	0	0

Table 3. 2012: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2012
Discards	IIIa	92.8	95.5	54.18	92.22	-
Discards	IV	15.94	-	91.6	51.15	-
Landings	IIIa	97.18	97.37	6.17	94.86	-
Landings	IV	-	-	-	-	-
Landings	VIId	-	-	-	-	-

Table 4. 2012: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	0	0	-
GNS_DEF_≥220_0_0_all	-	4	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	5.49	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	50	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	100	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	100	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	54.81	-	-	-	-	0	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	89.69	-	-	-	-	0	95.18	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	0	-	-	-	32.71	-	-
OTB_CRU_70-99_0_0_all	0	0	-	0	-	0	-	-	0	0
OTB_CRU_70-99_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	82.47	-	0	-	-	-	99.54	-	-
OTB_CRU_90-119_0_0_all_FDF	-	56.74	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	4.44	0	0	-	0	0	0	0	0
OTB_DEF_≥120_0_0_all_FDF	-	2.05	-	0	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	0	-	0	-	-	0	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	0	-	-	0	-	-	0	-
OTB_DEF_All_0_0_All	-	-	-	-	-	0	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	1.81	-	-	-	0	-	-	0	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	-	-	-	0	-

Table 5. 2012: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	100	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	12.55	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	34.38	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	64.25	-	-
OTB_CRU_70-99_0_0_all	-	100	-	0	-	0	-	-	0	0
OTB_CRU_70-99_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	89.16	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	100	-	0	-	-	-	-	0	0
OTB_DEF_≥120_0_0_all_FDF	-	99.08	-	0	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_All_0_0_All	-	-	-	-	-	-	-	-	-	-
OTB_MCD_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
OTB_SPF_32-69_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	0	-	0	-	-	-	-

Table 6. 2012: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKS
MIS_MIS_0_0_0_HC	54.8	-	-	-
OTB_CRU_32-69_0_0_all	-	0	95.2	-
OTB_CRU_70-99_0_0_all	-	-	-	0
OTB_CRU_90-119_0_0_all	82.5	-	99.5	-
OTB_DEF_≥120_0_0_all	4.4	-	-	0
OTB_DEF_≥120_0_0_all_FDF	2	-	-	-

2012: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2012: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	44.391	84.77	2
OTB_DEF_≥120_0_0_all	9	19.288	1.2	1
OTB_CRU_70-99_0_0_all	6	12.536	-	-
MIS_MIS_0_0_0_HC	4	9.555	53.49	1
OTB_DEF_≥120_0_0_all_FDF	3	7.856	1.85	1
OTB_CRU_32-69_0_0_all	4	4.369	59.72	2
OTB_DEF_100-119_0_0_all	3	0.549	-	-
OTB_DEF_70-99_0_0_all	3	0.367	-	-
OTB_CRU_90-119_0_0_all_FDF	1	0.356	56.74	1
GNS_DEF_all_0_0_all	3	0.149	2.8	1
OTB_MCD_70-99_0_0_all	1	0.127	-	-
TBB_DEF_70-99_0_0_all	3	0.102	-	-
OTB_DEF_All_0_0_All	1	0.075	-	-
TBB_DEF_≥120_0_0_all	4	0.072	0.57	1
OTB_CRU_32-69_2_22_all	1	0.051	100	1
GNS_DEF_120-219_0_0_all	2	0.048	5.41	1
OTB_CRU_70-99_0_0_all_FDF	1	0.039	-	-
GTR_DEF_all_0_0_all	1	0.024	100	1
SSC_DEF_≥120_0_0_all	2	0.013	-	-
OTB_CRU_70-89_2_35_all	2	0.012	32.56	1
GNS_DEF_≥220_0_0_all_FDF	1	0.006	-	-
SSC_DEF_≥120_0_0_all_FDF	1	0.005	-	-
GNS_DEF_≥220_0_0_all	1	0.003	4	1
OTB_DEF_100-119_0_0_all_FDF	1	0.003	-	-
SDN_DEF_≥120_0_0_all	1	0.003	-	-
SSC_DEF_70-99_0_0_all	1	0.001	-	-
FPO_CRU_0_0_0_all	2	0	-	-
GNS_DEF_100-119_0_0_all	2	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	50	1
LLS_FIF_0_0_0_all	2	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
OTB_SPF_32-69_0_0_all	1	0	-	-
SSC_DEF	1	0	-	-

Table 2. 2012 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	75.895	84.77	2
MIS_MIS_0_0_0_HC	IIIa	3	15.216	57.43	1
OTB_CRU_32-69_0_0_all	IIIa	3	7.123	62.62	2
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.609	56.74	1
OTB_DEF_≥120_0_0_all	IIIa	3	0.581	68.19	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	2	0.254	97.87	1
GNS_DEF_all_0_0_all	IIIa	2	0.168	4.25	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.087	100	1
GTR_DEF_all_0_0_all	IIIa	1	0.04	100	1
OTB_CRU_70-89_2_35_all	IIIa	2	0.02	32.56	1
GNS_DEF_120-219_0_0_all	IIIa	2	0.005	85	1
TBB_DEF_≥120_0_0_all	IIIa	1	0.001	100	1
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all	IIIa	1	0	100	1
GNS_DEF_100-119_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	100	1
LLS_FIF_0_0_0_all	IIIa	2	0	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-
SSC_DEF_≥120_0_0_all	IIIa	1	0	-	-

Table 3. 2012 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	9	45.689	-	-
OTB_CRU_70-99_0_0_all	IV	6	30.227	-	-
OTB_DEF_≥120_0_0_all_FDF	IV	3	18.584	-	-
MIS_MIS_0_0_0_HC	IV	2	1.579	-	-
OTB_DEF_100-119_0_0_all	IV	2	1.308	-	-
OTB_DEF_70-99_0_0_all	IV	2	0.836	-	-
OTB_CRU_32-69_0_0_all	IV	4	0.488	-	-
OTB_MCD_70-99_0_0_all	IV	1	0.306	-	-
TBB_DEF_70-99_0_0_all	IV	3	0.22	-	-
OTB_DEF_All_0_0_All	IV	1	0.181	-	-
TBB_DEF_≥120_0_0_all	IV	4	0.172	-	-
GNS_DEF_all_0_0_all	IV	2	0.123	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.109	-	-
OTB_CRU_70-99_0_0_all_FDF	IV	1	0.095	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.03	-	-
GNS_DEF_≥220_0_0_all_FDF	IV	1	0.015	-	-
SSC_DEF_≥120_0_0_all_FDF	IV	1	0.013	-	-
OTB_DEF_100-119_0_0_all_FDF	IV	1	0.007	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.006	-	-
SDN_DEF_≥120_0_0_all	IV	1	0.006	-	-
SSC_DEF_70-99_0_0_all	IV	1	0.003	-	-
GNS_DEF_100-119_0_0_all	IV	1	0.001	-	-
FPO_CRU_0_0_0_all	IV	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0	-	-
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-
OTB_SPF_32-69_0_0_all	IV	1	0	-	-

Table 4. 2012 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_70-99_0_0_all	VIId	1	54.094	-	-
TBB_DEF_70-99_0_0_all	VIId	1	27.651	-	-
OTB_DEF_100-119_0_0_all	VIId	1	17.852	-	-
SSC_DEF	VIId	1	0.403	-	-

2012: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2012: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	2	51.652	98.72	2
OTB_CRU_32-69_0_0_all	2	20.935	100	2
OTB_CRU_70-99_0_0_all	5	14.49	0.19	1
OTB_DEF_≥120_0_0_all_FDF	3	3.078	89.62	1
MIS_MIS_0_0_0_HC	1	2.529	12.55	1
OTB_CRU_90-119_0_0_all_FDF	1	2.24	-	-
OTB_CRU_70-89_2_35_all	1	2.107	64.25	1
OTB_DEF_≥120_0_0_all	4	1.936	15.37	1
OTB_CRU_32-69_2_22_all	1	0.678	34.38	1
OTB_DEF_70-99_0_0_all	1	0.227	-	-
TBB_DEF_100-119_0_0_all	1	0.048	-	-
OTB_DEF_100-119_0_0_all	1	0.035	-	-
SSC_DEF_100-119_0_0_all	1	0.021	-	-
GNS_DEF_120-219_0_0_all	1	0.012	100	1
TBB_DEF_70-99_0_0_all	2	0.012	-	-
OTB_CRU_70-99_0_0_all_FDF	1	0.001	-	-
GNS_DEF_≥220_0_0_all	1	0	-	-
GNS_DEF_100-119_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
SSC_DEF_≥120_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-

Table 2. 2012 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	51.652	98.72	2
OTB_CRU_32-69_0_0_all	IIIa	2	20.834	100	2
MIS_MIS_0_0_0_HC	IIIa	1	2.529	12.55	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	2.24	-	-
OTB_CRU_70-89_2_35_all	IIIa	1	2.107	64.25	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.678	34.38	1
GNS_DEF_100-119_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-
OTB_DEF_≥120_0_0_all	IIIa	1	0	-	-
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2012 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	**Area**	**Nation.Ct**	**Rank**	**Coverage**	**Nation.Samp**
OTB_CRU_70-99_0_0_all	IV	5	14.49	0.19	1
OTB_DEF_≥120_0_0_all_FDF	IV	3	3.078	89.62	1
OTB_DEF_≥120_0_0_all	IV	4	1.936	15.37	1
OTB_DEF_70-99_0_0_all	IV	1	0.227	-	-
OTB_CRU_32-69_0_0_all	IV	1	0.101	100	1
TBB_DEF_100-119_0_0_all	IV	1	0.048	-	-
OTB_DEF_100-119_0_0_all	IV	1	0.035	-	-
SSC_DEF_100-119_0_0_all	IV	1	0.021	-	-
GNS_DEF_120-219_0_0_all	IV	1	0.012	100	1
TBB_DEF_70-99_0_0_all	IV	2	0.012	-	-
OTB_CRU_70-99_0_0_all_FDF	IV	1	0.001	-	-
GNS_DEF_≥220_0_0_all	IV	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0	-	-
MIS_MIS_0_0_0_HC	IV	1	0	-	-
SSC_DEF_≥120_0_0_all	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-

2013: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2013: Proportion of landings by area and season.

Area	1	2	3	4	2013
IIIa	16.69	10.48	8.69	14.89	0
IV	8.94	13.66	11.99	14.64	0
VIId	0.01	0	0	0	0

Table 2. 2013: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	0	-
GNS_DEF_≥220_0_0_all	-	0.004	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0.001	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.134	-	0.002	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0.003	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.134	0.001	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.017	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	6.283	0	-	-	0.089	0.002	0	-	0.036
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	1.225	-	-	-	-	1.307	1.153	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.007	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	0.016	-	-
OTB_CRU_70-99_0_0_all	0.125	0.45	-	0.208	-	0.171	-	-	0.575	9.717
OTB_CRU_90-119_0_0_all	-	31.141	-	0.004	-	-	-	7.221	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.119	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0.073	7.766	0.003	0.101	-	0.141	4.329	0.02	1.596	18.016
OTB_DEF_≥120_0_0_all_FDF	-	6.605	-	0.01	-	-	-	-	-	0.527
OTB_DEF_100-119_0_0_all	0.002	-	0	-	-	0.235	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0.088	-	-	0.091	-
OTB_DWS_≥120_0_0_all	-	-	0.001	-	-	-	-	-	-	-
SDN_DEF	-	-	-	-	-	-	-	-	0.001	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0.005	-	-
SDN_DEF_70-99_0_0_all	-	-	0.001	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0.112	-
SSC_DEF_≥120_0_0_all	0.01	-	-	0.004	-	-	0.009	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0.005	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	0.003	-	-	-	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	0.001	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0.033	0.028	-	0	-	-	-	-	0.005	-
TBB_DEF_70-99_0_0_all	0.027	-	-	0.003	-	0.001	-	-	0.001	0

Table 3. 2013: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.3	53.8	0	0.3	0	0.7	5.8	8.4	2.4	28.3

Table 4. 2013: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0.001	2	-	-
GNS_DEF_≥220_0_0_all	0	1	0.004	1	-	-
GNS_DEF_≥220_0_0_all_FDF	-	-	0.001	1	-	-
GNS_DEF_100-119_0_0_all	0	1	0	1	-	-
GNS_DEF_120-219_0_0_all	0.009	2	0.127	2	-	-
GNS_DEF_120-219_0_0_all_FDF	0.001	1	0.002	1	-	-
GNS_DEF_all_0_0_all	0.071	2	0.064	2	-	-
GTR_DEF_all_0_0_all	0.017	1	-	-	-	-
LLS_FIF_0_0_0_all	0	2	-	-	-	-
MIS_MIS_0_0_0_HC	6.035	4	0.374	4	0	1
MIS_MIS_0_0_0_IBC	0	1	-	-	-	-
OTB_CRU_32-69_0_0_all	3.579	3	0.106	3	-	-
OTB_CRU_32-69_2_22_all	0.007	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.016	1	-	-	-	-
OTB_CRU_70-99_0_0_all	0	1	11.246	6	0	1
OTB_CRU_90-119_0_0_all	38.366	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.119	1	-	-	-	-
OTB_DEF_≥120_0_0_all	1.893	4	30.146	9	0.008	2
OTB_DEF_≥120_0_0_all_FDF	0.64	2	6.502	3	-	-
OTB_DEF_100-119_0_0_all	-	-	0.237	3	-	-
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	-	-	0.178	2	0.001	1
OTB_DWS_≥120_0_0_all	-	-	0.001	1	-	-
SDN_DEF	-	-	0.001	1	-	-
SDN_DEF_≥120_0_0_all	-	-	0.005	1	-	-
SDN_DEF_70-99_0_0_all	-	-	-	-	0.001	1
SSC_DEF	-	-	0.112	1	-	-
SSC_DEF_≥120_0_0_all	0.001	2	0.022	3	-	-
SSC_DEF_≥120_0_0_all_FDF	0.002	1	0.003	1	-	-
SSC_DEF_100-119_0_0_all	-	-	0.003	1	-	-
SSC_DEF_70-99_0_0_all	-	-	0.001	1	-	-
TBB_DEF_≥120_0_0_all	0.002	1	0.065	4	0	1
TBB_DEF_70-99_0_0_all	-	-	0.028	5	0.004	1

Table 5. 2013: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	38.366	38
OTB_DEF_≥120_0_0_all	9	32.047	70
OTB_CRU_70-99_0_0_all	6	11.246	82
OTB_DEF_≥120_0_0_all_FDF	3	7.141	89
MIS_MIS_0_0_0_HC	6	6.41	95
OTB_CRU_32-69_0_0_all	3	3.685	99
OTB_DEF_100-119_0_0_all	3	0.237	99
OTB_DEF_70-99_0_0_all	2	0.179	99
GNS_DEF_120-219_0_0_all	2	0.136	99
GNS_DEF_all_0_0_all	3	0.135	100
OTB_CRU_90-119_0_0_all_FDF	1	0.119	100
SSC_DEF	1	0.112	100
TBB_DEF_≥120_0_0_all	4	0.067	100
TBB_DEF_70-99_0_0_all	5	0.033	100
SSC_DEF_≥120_0_0_all	3	0.023	100
GTR_DEF_all_0_0_all	1	0.017	100
OTB_CRU_70-89_2_35_all	1	0.016	100
OTB_CRU_32-69_2_22_all	1	0.007	100
SDN_DEF_≥120_0_0_all	1	0.005	100
SSC_DEF_≥120_0_0_all_FDF	1	0.005	100
GNS_DEF_≥220_0_0_all	1	0.004	100
GNS_DEF_120-219_0_0_all_FDF	1	0.003	100
SSC_DEF_100-119_0_0_all	1	0.003	100
FPO_CRU_0_0_0_all	3	0.001	100
GNS_DEF_≥220_0_0_all_FDF	1	0.001	100
OTB_DWS_≥120_0_0_all	1	0.001	100
SDN_DEF	1	0.001	100
SDN_DEF_70-99_0_0_all	1	0.001	100
SSC_DEF_70-99_0_0_all	1	0.001	100
GNS_DEF_100-119_0_0_all	1	0	100
LLS_FIF_0_0_0_all	2	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100

2013: Appendix B: Age coverage of landings and discards

Table 1. 2013: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	62
Discards	35.54

Table 2. 2013: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	**IV**	**VIId**
Discards	78.06	8.02	
Landings	68.53	55.29	0

Table 3. 2013: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	**1**	**2**	**3**	**4**	**2013**
Discards	IIIa	95.64	87.88	54.77	75.89	-
Discards	IV	100	100	-	85.9	-
Landings	IIIa	96.63	82.45	75.62	23.08	-
Landings	IV	29.86	55.73	50.27	74.51	-
Landings	VIId	-	-	-	-	-

Table 4. 2013: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	**DEN**	**FRA**	**GFR**	**IRL**	**NED**	**NOR**	**SWE**	**UKE**	**UKS**
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	0	-
GNS_DEF_≥220_0_0_all	-	6.33	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	75	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	14.43	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	75	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	0	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.59	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	77.83	0	-	-	0	0	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	61.4	-	-	-	-	0	75.84	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	60.67	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	9.23	-	-
OTB_CRU_70-99_0_0_all	0	42.63	-	0	-	0	-	-	0	96.03
OTB_CRU_90-119_0_0_all	-	69.82	-	0	-	-	-	65.19	-	-
OTB_CRU_90-119_0_0_all_FDF	-	66.86	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	28.98	0	0	-	0	0	0	0	82.35
OTB_DEF_≥120_0_0_all_FDF	-	27.03	-	0	-	-	-	-	-	100
OTB_DEF_100-119_0_0_all	0	-	0	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	0	-
OTB_DWS_≥120_0_0_all	-	-	0	-	-	-	-	-	-	-
SDN_DEF	-	-	-	-	-	-	-	-	0	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_70-99_0_0_all	-	-	0	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	0	-	-	0	-	-	0	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	17.75	-	0	-	-	-	-	0	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	0

Table 5. 2013: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	20.35	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	74.04	-	-
OTB_CRU_70-99_0_0_all	-	87.86	-	0	-	0	-	-	0	0
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	75.3	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	100	-	0	-	-	-	-	0	0
OTB_DEF_≥120_0_0_all_FDF	-	73.7	-	0	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DWS_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	0	-	0	-	-	-	-

Table 6. 2013: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKE	UKS
MIS_MIS_0_0_0_HC	77.8	-	-	-	-
OTB_CRU_32-69_0_0_all	61.4	0	75.8	-	-
OTB_CRU_70-99_0_0_all	-	-	-	-	96
OTB_CRU_90-119_0_0_all	69.8	-	65.2	-	-
OTB_DEF_≥120_0_0_all	29	0	-	0	82.3
OTB_DEF_≥120_0_0_all_FDF	27	-	-	-	-

2013: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2013: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	38.366	68.94	2
OTB_DEF_≥120_0_0_all	9	32.047	53.32	2
OTB_CRU_70-99_0_0_all	6	11.246	84.69	2
OTB_DEF_≥120_0_0_all_FDF	3	7.141	32.37	2
MIS_MIS_0_0_0_HC	6	6.41	76.3	1
OTB_CRU_32-69_0_0_all	3	3.685	44.14	2
OTB_DEF_100-119_0_0_all	3	0.237	-	-
OTB_DEF_70-99_0_0_all	2	0.179	-	-
GNS_DEF_120-219_0_0_all	2	0.136	14.25	1
GNS_DEF_all_0_0_all	3	0.135	-	-
OTB_CRU_90-119_0_0_all_FDF	1	0.119	66.86	1
SSC_DEF	1	0.112	-	-
TBB_DEF_≥120_0_0_all	4	0.067	7.54	1
TBB_DEF_70-99_0_0_all	5	0.033	-	-
SSC_DEF_≥120_0_0_all	3	0.023	-	-
GTR_DEF_all_0_0_all	1	0.017	0.59	1
OTB_CRU_70-89_2_35_all	1	0.016	9.23	1
OTB_CRU_32-69_2_22_all	1	0.007	60.67	1
SDN_DEF_≥120_0_0_all	1	0.005	-	-
SSC_DEF_≥120_0_0_all_FDF	1	0.005	-	-
GNS_DEF_≥220_0_0_all	1	0.004	6.33	1
GNS_DEF_120-219_0_0_all_FDF	1	0.003	75	1
SSC_DEF_100-119_0_0_all	1	0.003	-	-
FPO_CRU_0_0_0_all	3	0.001	-	-
GNS_DEF_≥220_0_0_all_FDF	1	0.001	-	-
OTB_DWS_≥120_0_0_all	1	0.001	-	-
SDN_DEF	1	0.001	-	-
SDN_DEF_70-99_0_0_all	1	0.001	-	-
SSC_DEF_70-99_0_0_all	1	0.001	-	-
GNS_DEF_100-119_0_0_all	1	0	75	1
LLS_FIF_0_0_0_all	2	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-

Table 2. 2013 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	75.586	68.94	2
MIS_MIS_0_0_0_HC	IIIa	4	11.89	80.43	1
OTB_CRU_32-69_0_0_all	IIIa	3	7.052	45.44	2
OTB_DEF_≥120_0_0_all	IIIa	4	3.729	71.1	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	2	1.26	64.59	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.234	66.86	1
GNS_DEF_all_0_0_all	IIIa	2	0.14	-	-
GTR_DEF_all_0_0_all	IIIa	1	0.033	0.59	1
OTB_CRU_70-89_2_35_all	IIIa	1	0.032	9.23	1
GNS_DEF_120-219_0_0_all	IIIa	2	0.017	89.08	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.015	60.67	1
SSC_DEF_≥120_0_0_all_FDF	IIIa	1	0.004	-	-
TBB_DEF_≥120_0_0_all	IIIa	1	0.004	77.78	1
SSC_DEF_≥120_0_0_all	IIIa	2	0.002	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0.001	75	1
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all	IIIa	1	0	100	1
GNS_DEF_100-119_0_0_all	IIIa	1	0	100	1

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
LLS_FIF_0_0_0_all	IIIa	2	0	-	-
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-
OTB_CRU_70-99_0_0_all	IIIa	1	0	-	-

Table 3. 2013 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	9	61.237	52.22	2
OTB_CRU_70-99_0_0_all	IV	6	22.845	84.69	2
OTB_DEF_≥120_0_0_all_FDF	IV	3	13.207	29.2	2
MIS_MIS_0_0_0_HC	IV	4	0.761	9.67	1
OTB_DEF_100-119_0_0_all	IV	3	0.481	-	-
OTB_DEF_70-99_0_0_all	IV	2	0.362	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.259	9.17	1
SSC_DEF	IV	1	0.228	-	-
OTB_CRU_32-69_0_0_all	IV	3	0.215	-	-
TBB_DEF_≥120_0_0_all	IV	4	0.131	5.6	1
GNS_DEF_all_0_0_all	IV	2	0.129	-	-
TBB_DEF_70-99_0_0_all	IV	5	0.057	-	-
SSC_DEF_≥120_0_0_all	IV	3	0.046	-	-
SDN_DEF_≥120_0_0_all	IV	1	0.01	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.007	-	-
SSC_DEF_100-119_0_0_all	IV	1	0.006	-	-
SSC_DEF_≥120_0_0_all_FDF	IV	1	0.005	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0.004	75	1
OTB_DWS_≥120_0_0_all	IV	1	0.003	-	-
FPO_CRU_0_0_0_all	IV	2	0.002	-	-
GNS_DEF_≥220_0_0_all_FDF	IV	1	0.002	-	-
SDN_DEF	IV	1	0.002	-	-
SSC_DEF_70-99_0_0_all	IV	1	0.002	-	-
GNS_DEF_100-119_0_0_all	IV	1	0	50	1
OTB_DEF_70-99_0_0	IV	1	0	-	-

Table 4. 2013 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	VIId	2	56.146	-	-
TBB_DEF_70-99_0_0_all	VIId	1	29.236	-	-
SDN_DEF_70-99_0_0_all	VIId	1	9.302	-	-
OTB_DEF_70-99_0_0_all	VIId	1	4.983	-	-
TBB_DEF_≥120_0_0_all	VIId	1	0.332	-	-
MIS_MIS_0_0_0_HC	VIId	1	0	-	-
OTB_CRU_70-99_0_0_all	VIId	1	0	-	-

2013: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2013: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	5	41.878	0.13	1
OTB_CRU_90-119_0_0_all	2	16.828	91.29	2
OTB_CRU_32-69_0_0_all	2	9.758	100	2
OTB_DEF_≥120_0_0_all	4	8.906	18.44	1
MIS_MIS_0_0_0_HC	1	6.77	20.35	1
OTB_DEF_≥120_0_0_all_FDF	3	5.405	60.52	1
OTB_CRU_70-89_2_35_all	1	4.517	74.04	1
SSC_DEF_≥120_0_0_all	1	4.145	-	-
OTB_CRU_32-69_2_22_all	1	0.728	100	1
OTB_CRU_90-119_0_0_all_FDF	1	0.589	-	-
OTB_DEF_70-99_0_0_all	1	0.473	-	-
OTB_DEF_100-119_0_0_all	1	0.005	-	-
GNS_DEF_≥220_0_0_all	1	0	-	-
GNS_DEF_≥220_0_0_all_FDF	1	0	-	-
GNS_DEF_100-119_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
SSC_DEF	1	0	-	-
SSC_DEF_100-119_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-
TBB_DEF_100-119_0_0_all	1	0	-	-
TBB_DEF_70-99_0_0_all	2	0	-	-

Table 2. 2013 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	16.828	91.29	2
OTB_CRU_32-69_0_0_all	IIIa	2	9.758	100	2
MIS_MIS_0_0_0_HC	IIIa	1	6.77	20.35	1
OTB_CRU_70-89_2_35_all	IIIa	1	4.517	74.04	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.728	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.589	-	-
OTB_DEF_≥120_0_0_all	IIIa	1	0.07	100	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0.031	100	1
GNS_DEF_≥220_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all_FDF	IIIa	1	0	-	-
GNS_DEF_100-119_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2013 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	5	41.878	0.13	1
OTB_DEF_≥120_0_0_all	IV	4	8.836	17.8	1
OTB_DEF_≥120_0_0_all_FDF	IV	3	5.374	60.29	1
SSC_DEF_≥120_0_0_all	IV	1	4.145	-	-
OTB_DEF_70-99_0_0_all	IV	1	0.473	-	-
OTB_DEF_100-119_0_0_all	IV	1	0.005	-	-
GNS_DEF_≥220_0_0_all	IV	1	0	-	-
GNS_DEF_120-219_0_0_all	IV	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0	-	-
MIS_MIS_0_0_0_HC	IV	1	0	-	-
SSC_DEF	IV	1	0	-	-
SSC_DEF_100-119_0_0_all	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-
TBB_DEF_100-119_0_0_all	IV	1	0	-	-
TBB_DEF_70-99_0_0_all	IV	2	0	-	-

2014: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2014: Proportion of landings by area and season.

Area	1	2	3	4	2014
IIIa	16.22	17.32	13.75	12.27	0
IV	8.29	12.3	10.17	9.69	0
VIId	0.01	0	0	0	0

Table 2. 2014: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	-	-
GNS_DEF_≥220_0_0_all	-	0.005	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0.003	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.24	-	0.002	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0.002	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.092	0	0.003	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.016	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	11.133	0.002	0	-	-	0.001	0	-	0.013
MIS_MIS_0_0_0_HC_FDF	-	-	-	-	-	0.005	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	1.365	-	-	-	-	0.636	1.732	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.007	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	0.037	-	-
OTB_CRU_70-99_0_0_all	0.11	0.348	-	0.092	-	0.06	-	-	0.227	7.342
OTB_CRU_70-99_0_0_all_FDF	-	0.068	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	33.301	-	0.004	-	-	-	7.889	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.114	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0.003	5.412	-	0.149	-	0.075	4.61	0.028	1.176	15.653
OTB_DEF_≥120_0_0_all_FDF	-	5.989	-	0.027	-	-	-	-	-	0.741
OTB_DEF_100-119_0_0_all	0.355	-	-	-	-	0.354	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0.001	-	-	-	-	0.045	-	-	0.038	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0.006	-	-
SDN_DEF_≥120_0_0_all_FDF	-	-	-	-	-	0.005	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0.093	-
SSC_DEF_≥120_0_0_all	-	-	-	0.004	-	-	0.007	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0.003	-	0.116	-	-	-	-
SSC_DEF_100-119_0_0_all	0.008	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0.049	-	-	-	-
TBB_DEF_≥120_0_0_all	0.053	0.035	-	0.006	-	0.055	-	-	0.001	-
TBB_DEF_70-99_0_0_all	0.043	-	-	0.002	-	-	-	-	0.009	-

Table 3. 2014: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.6	58	0	0.3	0	0.8	5.3	9.7	1.5	23.7

Table 4. 2014: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0	1	-	-
GNS_DEF_≥220_0_0_all	0.001	1	0.004	1	-	-
GNS_DEF_≥220_0_0_all_FDF	-	-	0.003	1	-	-
GNS_DEF_100-119_0_0_all	-	-	0	1	-	-
GNS_DEF_120-219_0_0_all	0.007	1	0.236	2	-	-
GNS_DEF_120-219_0_0_all_FDF	0	1	0.001	1	-	-
GNS_DEF_all_0_0_all	0.04	2	0.055	2	-	-
GTR_DEF_all_0_0_all	0.016	1	-	-	-	-
LLS_FIF_0_0_0_all	0	2	-	-	-	-
MIS_MIS_0_0_0_HC	10.7	4	0.449	4	0	1
MIS_MIS_0_0_0_HC_FDF	-	-	0.005	1	-	-
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_32-69_0_0_all	3.689	3	0.044	3	-	-
OTB_CRU_32-69_2_22_all	0.007	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.037	1	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	8.178	6	0	1
OTB_CRU_70-99_0_0_all_FDF	-	-	0.068	1	-	-
OTB_CRU_90-119_0_0_all	41.193	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.114	1	-	-	-	-
OTB_DEF_≥120_0_0_all	2.728	3	24.377	8	-	-
OTB_DEF_≥120_0_0_all_FDF	0.946	2	5.811	3	-	-
OTB_DEF_100-119_0_0_all	-	-	0.708	2	-	-
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	-	-	0.085	3	-	-
SDN_DEF_≥120_0_0_all	-	-	0.006	1	-	-
SDN_DEF_≥120_0_0_all_FDF	-	-	0.005	1	-	-
SSC_DEF	-	-	0.093	1	-	-
SSC_DEF_≥120_0_0_all	-	-	0.011	2	-	-
SSC_DEF_≥120_0_0_all_FDF	0.067	2	0.052	2	-	-
SSC_DEF_100-119_0_0_all	-	-	0.008	1	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	0.049	1	-	-
TBB_DEF_≥120_0_0_all	0.001	1	0.149	5	-	-
TBB_DEF_70-99_0_0_all	-	-	0.043	3	0.012	1

Table 5. 2014: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	41.193	41
OTB_DEF_≥120_0_0_all	8	27.105	68
MIS_MIS_0_0_0_HC	6	11.149	79
OTB_CRU_70-99_0_0_all	6	8.178	88
OTB_DEF_≥120_0_0_all_FDF	3	6.757	94
OTB_CRU_32-69_0_0_all	3	3.734	98
OTB_DEF_100-119_0_0_all	2	0.708	99
GNS_DEF_120-219_0_0_all	2	0.243	99
TBB_DEF_≥120_0_0_all	5	0.151	99
SSC_DEF_≥120_0_0_all_FDF	2	0.119	99
OTB_CRU_90-119_0_0_all_FDF	1	0.114	99
GNS_DEF_all_0_0_all	3	0.096	100
SSC_DEF	1	0.093	100
OTB_DEF_70-99_0_0_all	3	0.085	100
OTB_CRU_70-99_0_0_all_FDF	1	0.068	100
TBB_DEF_70-99_0_0_all	3	0.054	100
SSC_DEF_100-119_0_0_all_FDF	1	0.049	100
OTB_CRU_70-89_2_35_all	1	0.037	100
GTR_DEF_all_0_0_all	1	0.016	100
SSC_DEF_≥120_0_0_all	2	0.011	100
SSC_DEF_100-119_0_0_all	1	0.008	100
OTB_CRU_32-69_2_22_all	1	0.007	100
SDN_DEF_≥120_0_0_all	1	0.006	100
GNS_DEF_≥220_0_0_all	1	0.005	100
MIS_MIS_0_0_0_HC_FDF	1	0.005	100
SDN_DEF_≥120_0_0_all_FDF	1	0.005	100
GNS_DEF_≥220_0_0_all_FDF	1	0.003	100
GNS_DEF_120-219_0_0_all_FDF	1	0.002	100
FPO_CRU_0_0_0_all	2	0	100
GNS_DEF_100-119_0_0_all	1	0	100
LLS_FIF_0_0_0_all	2	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100

2014: Appendix B: Age coverage of landings and discards

Table 1. 2014: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	55.04
Discards	36.96

Table 2. 2014: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	49.88	26.68	
Landings	52.83	58.32	0

Table 3. 2014: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2014
Discards	IIIa	28.31	84.69	57.27	83.53	-
Discards	IV	28.59	-	100	95.08	-
Landings	IIIa	22.52	14.95	97.34	96.51	-
Landings	IV	81.95	44.23	76.93	36.44	-
Landings	VIId	-	-	-	-	-

Table 4. 2014: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	0	-	-
GNS_DEF_≥220_0_0_all	-	51.39	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	11.26	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	4.65	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	100	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	100	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	44.46	0	0	-	-	0	0	-	0
MIS_MIS_0_0_0_HC_FDF	-	-	-	-	-	0	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	28.69	-	-	-	-	0	99.67	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	46.51	-	-
OTB_CRU_70-99_0_0_all	0	39.48	-	0	-	0	-	-	0	68.35
OTB_CRU_70-99_0_0_all_FDF	-	35.24	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	43.99	-	0	-	-	-	99.62	-	-
OTB_CRU_90-119_0_0_all_FDF	-	97.13	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	0	40.85	-	0	-	0	0	0	0	100
OTB_DEF_≥120_0_0_all_FDF	-	24.86	-	0	-	-	-	-	-	100
OTB_DEF_100-119_0_0_all	0	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0	-	-	-	-	0	-	-	0	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-
SDN_DEF_≥120_0_0_all_FDF	-	-	-	-	-	0	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0	-	0	-	-	-	-
SSC_DEF_100-119_0_0_all	0	-	-	-	-	-	-	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0	38.5	-	0	-	0	-	-	0	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	-	-	-	0	-

Table 5. 2014: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_≥220_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	1.14	-	-	-	-	-	0	-	-
MIS_MIS_0_0_0_HC_FDF	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	36.32	-	-
OTB_CRU_70-99_0_0_all	-	-	-	0	-	0	-	-	0	0
OTB_CRU_70-99_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	82.9	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	95.96	-	0	-	-	-	-	-	0
OTB_DEF_≥120_0_0_all_FDF	-	89.66	-	0	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	100	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-

Table 6. 2014: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKE	UKS
MIS_MIS_0_0_0_HC	44.5	-	-	-	-
OTB_CRU_32-69_0_0_all	28.7	-	99.7	-	-
OTB_CRU_70-99_0_0_all	-	-	-	-	68.3
OTB_CRU_90-119_0_0_all	44	-	99.6	-	-
OTB_DEF_≥120_0_0_all	40.8	0	-	0	100
OTB_DEF_≥120_0_0_all_FDF	24.9	-	-	-	-

2014: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2014: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	41.193	54.64	2
OTB_DEF_≥120_0_0_all	8	27.105	65.9	2
MIS_MIS_0_0_0_HC	6	11.149	44.4	1
OTB_CRU_70-99_0_0_all	6	8.178	63.04	2
OTB_DEF_≥120_0_0_all_FDF	3	6.757	33.01	2
OTB_CRU_32-69_0_0_all	3	3.734	56.72	2
OTB_DEF_100-119_0_0_all	2	0.708	-	-
GNS_DEF_120-219_0_0_all	2	0.243	11.14	1
TBB_DEF_≥120_0_0_all	5	0.151	9.02	1
SSC_DEF_≥120_0_0_all_FDF	2	0.119	-	-
OTB_CRU_90-119_0_0_all_FDF	1	0.114	97.13	1
GNS_DEF_all_0_0_all	3	0.096	0.35	1
SSC_DEF	1	0.093	-	-
OTB_DEF_70-99_0_0_all	3	0.085	-	-
OTB_CRU_70-99_0_0_all_FDF	1	0.068	35.24	1
TBB_DEF_70-99_0_0_all	3	0.054	-	-
SSC_DEF_100-119_0_0_all_FDF	1	0.049	-	-
OTB_CRU_70-89_2_35_all	1	0.037	46.51	1
GTR_DEF_all_0_0_all	1	0.016	100	1
SSC_DEF_≥120_0_0_all	2	0.011	-	-
SSC_DEF_100-119_0_0_all	1	0.008	-	-
OTB_CRU_32-69_2_22_all	1	0.007	100	1
SDN_DEF_≥120_0_0_all	1	0.006	-	-
GNS_DEF_≥220_0_0_all	1	0.005	51.39	1
MIS_MIS_0_0_0_HC_FDF	1	0.005	-	-
SDN_DEF_≥120_0_0_all_FDF	1	0.005	-	-
GNS_DEF_≥220_0_0_all_FDF	1	0.003	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0.002	4.65	1
FPO_CRU_0_0_0_all	2	0	-	-
GNS_DEF_100-119_0_0_all	1	0	-	-
LLS_FIF_0_0_0_all	2	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-

Table 2. 2014 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	69.178	54.64	2
MIS_MIS_0_0_0_HC	IIIa	4	17.968	45.74	1
OTB_CRU_32-69_0_0_all	IIIa	3	6.196	57.23	2
OTB_DEF_≥120_0_0_all	IIIa	3	4.581	62.07	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	2	1.588	10.41	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.192	97.13	1
SSC_DEF_≥120_0_0_all_FDF	IIIa	2	0.113	-	-
GNS_DEF_all_0_0_all	IIIa	2	0.068	0.83	1
OTB_CRU_70-89_2_35_all	IIIa	1	0.062	46.51	1
GTR_DEF_all_0_0_all	IIIa	1	0.027	100	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.012	100	1
GNS_DEF_120-219_0_0_all	IIIa	1	0.011	22.78	1
GNS_DEF_≥220_0_0_all	IIIa	1	0.002	82.76	1
TBB_DEF_≥120_0_0_all	IIIa	1	0.002	30.56	1
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	66.67	1
LLS_FIF_0_0_0_all	IIIa	2	0	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-

Table 3. 2014 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	8	60.277	66.33	2
OTB_CRU_70-99_0_0_all	IV	6	20.223	63.04	2
OTB_DEF_≥120_0_0_all_FDF	IV	3	14.369	36.69	2
OTB_DEF_100-119_0_0_all	IV	2	1.752	-	-
MIS_MIS_0_0_0_HC	IV	4	1.11	12.36	1
GNS_DEF_120-219_0_0_all	IV	2	0.583	10.81	1
TBB_DEF_≥120_0_0_all	IV	5	0.369	8.83	1
SSC_DEF	IV	1	0.229	-	-
OTB_DEF_70-99_0_0_all	IV	3	0.21	-	-
OTB_CRU_70-99_0_0_all_FDF	IV	1	0.167	35.24	1
GNS_DEF_all_0_0_all	IV	2	0.137	-	-
SSC_DEF_≥120_0_0_all_FDF	IV	2	0.128	-	-
SSC_DEF_100-119_0_0_all_FDF	IV	1	0.12	-	-
OTB_CRU_32-69_0_0_all	IV	3	0.11	14.53	1
TBB_DEF_70-99_0_0_all	IV	3	0.105	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.027	-	-
SSC_DEF_100-119_0_0_all	IV	1	0.02	-	-
SDN_DEF_≥120_0_0_all	IV	1	0.015	-	-
MIS_MIS_0_0_0_HC_FDF	IV	1	0.013	-	-
SDN_DEF_≥120_0_0_all_FDF	IV	1	0.013	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.011	43.48	1
GNS_DEF_≥220_0_0_all_FDF	IV	1	0.007	-	-
GNS_DEF_120-219_0_0_all_FDF	IV	1	0.004	-	-
FPO_CRU_0_0_0_all	IV	1	0	-	-
GNS_DEF_100-119_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-

Table 4. 2014 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
TBB_DEF_70-99_0_0_all	VIId	1	100	-	-
MIS_MIS_0_0_0_HC	VIId	1	0	-	-
OTB_CRU_70-99_0_0_all	VIId	1	0	-	-

2014: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2014: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	4	33.561	-	-
MIS_MIS_0_0_0_HC	2	20.905	1.1	1
OTB_DEF_≥120_0_0_all_FDF	3	16.938	86.12	1
OTB_CRU_90-119_0_0_all	2	13.812	94.26	2
OTB_CRU_32-69_0_0_all	2	8.028	100	2
OTB_DEF_≥120_0_0_all	3	2.228	12.02	1
OTB_DEF_70-99_0_0_all	1	1.519	-	-
SSC_DEF_≥120_0_0_all	1	1.338	-	-
OTB_CRU_70-89_2_35_all	1	1.021	36.32	1
OTB_CRU_32-69_2_22_all	1	0.455	100	1
OTB_CRU_90-119_0_0_all_FDF	1	0.1	-	-
TBB_DEF_100-119_0_0_all	1	0.073	-	-
OTB_DEF_100-119_0_0_all	1	0.018	-	-
TBB_CRU_16-31_0_0_all	1	0.004	100	1
GNS_DEF_≥220_0_0_all	1	0	-	-
GNS_DEF_100-119_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
SSC_DEF_100-119_0_0_all	1	0	-	-

Table 2. 2014 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_HC	IIIa	2	20.848	0.83	1
OTB_CRU_90-119_0_0_all	IIIa	2	13.812	94.26	2
OTB_CRU_32-69_0_0_all	IIIa	2	8.028	100	2
OTB_CRU_70-89_2_35_all	IIIa	1	1.021	36.32	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.455	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.1	-	-
OTB_DEF_≥120_0_0_all	IIIa	2	0.065	100	1
GNS_DEF_100-119_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2014 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	4	33.561	-	-
OTB_DEF_≥120_0_0_all_FDF	IV	3	16.938	86.12	1
OTB_DEF_≥120_0_0_all	IV	3	2.163	9.39	1
OTB_DEF_70-99_0_0_all	IV	1	1.519	-	-
SSC_DEF_≥120_0_0_all	IV	1	1.338	-	-
TBB_DEF_100-119_0_0_all	IV	1	0.073	-	-
MIS_MIS_0_0_0_HC	IV	1	0.057	100	1
OTB_DEF_100-119_0_0_all	IV	1	0.018	-	-
TBB_CRU_16-31_0_0_all	IV	1	0.004	100	1
GNS_DEF_≥220_0_0_all	IV	1	0	-	-
GNS_DEF_120-219_0_0_all	IV	1	0	-	-
OTB_CRU_32-69_0_0_all	IV	1	0	-	-
SSC_DEF_100-119_0_0_all	IV	1	0	-	-

2015: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2015: Proportion of landings by area and season.

Area	1	2	3	4	2015
IIIa	20.15	14.68	8.64	13.84	0
IV	6.72	11.34	9.68	9.48	5.47
VIId	0	0	0	0	0

Table 2. 2015: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	0	0	-
GNS_DEF_≥220_0_0_all	-	0.003	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.17	-	0.005	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	0	-	-	0.087	0	0.001	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.013	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	5.48	0.006	-	-	0.013	0.004	0	0.002	0.004
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	1.206	-	-	-	-	0.973	1.783	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.017	-	-
OTB_CRU_70-89_2_35_all	-	0.051	-	-	-	-	-	0.073	-	-
OTB_CRU_70-99_0_0_all	0.332	0.373	-	0.118	-	0.085	-	-	0.278	4.037
OTB_CRU_90-119_0_0_all	-	34.35	-	0	-	-	-	10.881	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.076	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	7.991	-	0.107	-	0.029	4.063	0.034	1.748	16.133
OTB_DEF_≥120_0_0_all_FDF	-	7.118	-	0.037	-	-	-	-	-	1.43
OTB_DEF_100-119_0_0_all	0.116	-	-	-	-	0.129	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0.006	-	-	-	-	0.15	-	-	0.042	-
SDN_DEF	-	-	-	-	-	-	-	-	0.001	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	0.059	0.059	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0.017	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0.002	-	0.098	-	-	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0.004	-	-	-	-
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	0.038	0.042	-	0	-	0.025	0.002	-	0.002	-
TBB_DEF_70-99_0_0_all	0.058	-	-	0.014	-	0.01	-	-	0.013	-

Table 3. 2015: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
0.5	56.9	0	0.3	0	0.5	5.2	12.9	2.1	21.6

Table 4. 2015: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0	1	0	1	-	-
GNS_DEF_≥220_0_0_all	0	1	0.002	1	-	-
GNS_DEF_100-119_0_0_all	-	-	0	1	-	-
GNS_DEF_120-219_0_0_all	0.005	2	0.169	2	-	-
GNS_DEF_120-219_0_0_all_FDF	0	1	-	-	-	-
GNS_DEF_all_0_0_all	0.045	3	0.044	2	0	1
GTR_DEF_all_0_0_all	0.013	1	-	-	-	-
LLS_FIF_0_0_0_all	0	2	0	1	-	-
MIS_MIS_0_0_0_HC	5.232	4	0.277	5	0	1
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_32-69_0_0_all	3.843	3	0.119	4	-	-
OTB_CRU_32-69_2_22_all	0.017	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.124	2	-	-	-	-
OTB_CRU_70-99_0_0_all	-	-	5.222	6	0	1
OTB_CRU_90-119_0_0_all	45.232	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.076	1	-	-	-	-
OTB_DEF_≥120_0_0_all	2.417	4	27.688	7	-	-
OTB_DEF_≥120_0_0_all_FDF	0.21	2	8.375	3	-	-
OTB_DEF_100-119_0_0_all	0.002	1	0.244	2	-	-
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	0.001	1	0.196	3	0	1
SDN_DEF	-	-	0.001	1	-	-
SDN_DEF_≥120_0_0_all	0.033	1	0.086	2	-	-
SSC_DEF	-	-	-	-	0	1
SSC_DEF_≥120_0_0_all	-	-	0.017	1	-	-
SSC_DEF_≥120_0_0_all_FDF	0.055	2	0.045	2	-	-
SSC_DEF_100-119_0_0_all_FDF	0.004	1	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	0	1	-	-
TBB_DEF_≥120_0_0_all	0.003	2	0.107	6	-	-
TBB_DEF_70-99_0_0_all	-	-	0.091	4	0.003	1

Table 5. 2015: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_CRU_90-119_0_0_all	3	45.232	45
OTB_DEF_≥120_0_0_all	7	30.104	75
OTB_DEF_≥120_0_0_all_FDF	3	8.585	84
MIS_MIS_0_0_0_HC	7	5.51	89
OTB_CRU_70-99_0_0_all	6	5.223	95
OTB_CRU_32-69_0_0_all	4	3.962	99
OTB_DEF_100-119_0_0_all	2	0.245	99
OTB_DEF_70-99_0_0_all	3	0.198	99
GNS_DEF_120-219_0_0_all	2	0.174	99
OTB_CRU_70-89_2_35_all	2	0.124	99
SDN_DEF_≥120_0_0_all	2	0.118	99
TBB_DEF_≥120_0_0_all	6	0.11	100
SSC_DEF_≥120_0_0_all_FDF	2	0.1	100
TBB_DEF_70-99_0_0_all	4	0.095	100
GNS_DEF_all_0_0_all	4	0.088	100
OTB_CRU_90-119_0_0_all_FDF	1	0.076	100
OTB_CRU_32-69_2_22_all	1	0.017	100
SSC_DEF_≥120_0_0_all	1	0.017	100
GTR_DEF_all_0_0_all	1	0.013	100
SSC_DEF_100-119_0_0_all_FDF	1	0.004	100
GNS_DEF_≥220_0_0_all	1	0.003	100
SDN_DEF	1	0.001	100
FPO_CRU_0_0_0_all	2	0	100
GNS_DEF_100-119_0_0_all	1	0	100
GNS_DEF_120-219_0_0_all_FDF	1	0	100
LLS_FIF_0_0_0_all	2	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
SSC_DEF	1	0	100
SSC_DEF_70-99_0_0_all	1	0	100

2015: Appendix B: Age coverage of landings and discards

Table 1. 2015: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	76.55
Discards	51.01

Table 2. 2015: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	77.73	44.2	
Landings	96.42	49.88	0

Table 3. 2015: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2015
Discards	IIIa	98.33	98.06	8.31	85.12	-
Discards	IV	-	50.62	81.52	72.04	-
Landings	IIIa	97.38	97.19	93.81	95.83	-
Landings	IV	92.5	79.62	47.71	-	26.14
Landings	VIId	-	-	-	-	-

Table 4. 2015: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	100	0	-
GNS_DEF_≥220_0_0_all	-	100	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	100	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	89.39	-	0	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	100	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	0	-	-	0	100	0	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	93.51	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-
MIS_MIS_0_0_0_HC	-	83.65	0	-	-	0	0	0	0	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-
OTB_CRU_32-69_0_0_all	-	98.54	-	-	-	-	0	98.39	0	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	100	-	-	-	-	-	53.35	-	-
OTB_CRU_70-99_0_0_all	0	92.23	-	0	-	0	-	-	0	0
OTB_CRU_90-119_0_0_all	-	100	-	0	-	-	-	99.38	-	-
OTB_CRU_90-119_0_0_all_FDF	-	100	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	87.65	-	0	-	0	0	0	0	56.58
OTB_DEF_≥120_0_0_all_FDF	-	78.17	-	0	-	-	-	-	-	100
OTB_DEF_100-119_0_0_all	0	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0_all	0	-	-	-	-	0	-	-	0	-
SDN_DEF	-	-	-	-	-	-	-	-	0	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	0	0	-	-
SSC_DEF	-	-	-	-	-	-	-	-	0	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0	-	0	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0	-	-	-	-
SSC_DEF_70-99_0_0_all	0	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
TBB_DEF_≥120_0_0_all	0	89.72	-	0	-	0	0	-	0	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	-

Table 5. 2015: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	0	-	-
GNS_DEF_≥220_0_0_all	-	100	-	-	-	-	-	-	-	-
GNS_DEF_100-119_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	77.26	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	21.87	-	-
OTB_CRU_70-99_0_0_all	-	100	-	-	-	0	-	-	0	0
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	66.85	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	100	-	0	-	-	-	-	0	0
OTB_DEF_≥120_0_0_all_FDF	-	100	-	0	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
SDN_DEF	-	-	-	-	-	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
SSC_DEF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
SSC_DEF_100-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	0	-	0	-	-	-	-

Table 6. 2015: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKE	UKS
MIS_MIS_0_0_0_HC	83.7	-	-	-	-
OTB_CRU_32-69_0_0_all	98.5	-	98.4	-	-
OTB_CRU_70-99_0_0_all	-	-	-	-	0
OTB_CRU_90-119_0_0_all	100	-	99.4	-	-
OTB_DEF_≥120_0_0_all	87.6	0	-	0	56.6
OTB_DEF_≥120_0_0_all_FDF	78.2	-	-	-	100

2015: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2015: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	3	45.232	99.85	2
OTB_DEF_≥120_0_0_all	7	30.104	53.59	2
OTB_DEF_≥120_0_0_all_FDF	3	8.585	81.47	2
MIS_MIS_0_0_0_HC	7	5.51	83.2	1
OTB_CRU_70-99_0_0_all	6	5.223	6.59	1
OTB_CRU_32-69_0_0_all	4	3.962	74.26	2
OTB_DEF_100-119_0_0_all	2	0.245	-	-
OTB_DEF_70-99_0_0_all	3	0.198	-	-
GNS_DEF_120-219_0_0_all	2	0.174	87.01	1
OTB_CRU_70-89_2_35_all	2	0.124	72.53	2
SDN_DEF_≥120_0_0_all	2	0.118	-	-
TBB_DEF_≥120_0_0_all	6	0.11	34.1	1
SSC_DEF_≥120_0_0_all_FDF	2	0.1	-	-
TBB_DEF_70-99_0_0_all	4	0.095	-	-
GNS_DEF_all_0_0_all	4	0.088	0.2	1
OTB_CRU_90-119_0_0_all_FDF	1	0.076	100	1
OTB_CRU_32-69_2_22_all	1	0.017	100	1
SSC_DEF_≥120_0_0_all	1	0.017	-	-
GTR_DEF_all_0_0_all	1	0.013	93.51	1
SSC_DEF_100-119_0_0_all_FDF	1	0.004	-	-
GNS_DEF_≥220_0_0_all	1	0.003	100	1
SDN_DEF	1	0.001	-	-
FPO_CRU_0_0_0_all	2	0	18.18	1
GNS_DEF_100-119_0_0_all	1	0	100	1
GNS_DEF_120-219_0_0_all_FDF	1	0	100	1
LLS_FIF_0_0_0_all	2	0	-	-
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
SSC_DEF	1	0	-	-
SSC_DEF_70-99_0_0_all	1	0	-	-

Table 2. 2015 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	78.922	99.85	2
MIS_MIS_0_0_0_HC	IIIa	4	9.129	84.94	1
OTB_CRU_32-69_0_0_all	IIIa	3	6.705	75.53	2
OTB_DEF_≥120_0_0_all	IIIa	4	4.217	96.72	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	2	0.367	99.58	1
OTB_CRU_70-89_2_35_all	IIIa	2	0.216	72.53	2
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.133	100	1
SSC_DEF_≥120_0_0_all_FDF	IIIa	2	0.096	-	-
GNS_DEF_all_0_0_all	IIIa	3	0.078	0.4	1
SDN_DEF_≥120_0_0_all	IIIa	1	0.057	-	-
OTB_CRU_32-69_2_22_all	IIIa	1	0.03	100	1
GTR_DEF_all_0_0_all	IIIa	1	0.023	93.51	1
GNS_DEF_120-219_0_0_all	IIIa	2	0.009	88.18	1
SSC_DEF_100-119_0_0_all_FDF	IIIa	1	0.007	-	-
TBB_DEF_≥120_0_0_all	IIIa	2	0.005	61.09	1
OTB_DEF_100-119_0_0_all	IIIa	1	0.003	-	-
OTB_DEF_70-99_0_0_all	IIIa	1	0.002	-	-
FPO_CRU_0_0_0_all	IIIa	1	0	100	1
GNS_DEF_≥220_0_0_all	IIIa	1	0	100	1
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	100	1
LLS_FIF_0_0_0_all	IIIa	2	0	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-

Table 3. 2015 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	7	64.866	49.83	2
OTB_DEF_≥120_0_0_all_FDF	IV	3	19.62	81.01	2
OTB_CRU_70-99_0_0_all	IV	6	12.235	6.59	1
MIS_MIS_0_0_0_HC	IV	5	0.65	50.41	1
OTB_DEF_100-119_0_0_all	IV	2	0.571	-	-
OTB_DEF_70-99_0_0_all	IV	3	0.46	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.397	86.98	1
OTB_CRU_32-69_0_0_all	IV	4	0.278	33.18	1
TBB_DEF_≥120_0_0_all	IV	6	0.251	33.4	1
TBB_DEF_70-99_0_0_all	IV	4	0.214	-	-
SDN_DEF_≥120_0_0_all	IV	2	0.2	-	-
SSC_DEF_≥120_0_0_all_FDF	IV	2	0.105	-	-
GNS_DEF_all_0_0_all	IV	2	0.103	-	-
SSC_DEF_≥120_0_0_all	IV	1	0.041	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.006	100	1
SDN_DEF	IV	1	0.002	-	-
FPO_CRU_0_0_0_all	IV	1	0.001	-	-
SSC_DEF_70-99_0_0_all	IV	1	0.001	-	-
GNS_DEF_100-119_0_0_all	IV	1	0	100	1
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-

Table 4. 2015 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
TBB_DEF_70-99_0_0_all	VIId	1	88.235	-	-
SSC_DEF	VIId	1	4.706	-	-
OTB_CRU_70-99_0_0_all	VIId	1	3.529	-	-
OTB_DEF_70-99_0_0_all	VIId	1	3.529	-	-
GNS_DEF_all_0_0_all	VIId	1	0	-	-
MIS_MIS_0_0_0_HC	VIId	1	0	-	-

2015: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2015: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all_FDF	3	34.286	99.76	1
OTB_CRU_70-99_0_0_all	4	29.868	0.03	1
OTB_DEF_≥120_0_0_all	4	14.775	10.68	1
MIS_MIS_0_0_0_HC	1	7.278	77.26	1
OTB_CRU_90-119_0_0_all	2	7.153	90.52	2
OTB_CRU_70-89_2_35_all	1	2.802	21.87	1
OTB_CRU_32-69_0_0_all	2	2.013	100	2
OTB_DEF_70-99_0_0_all	1	0.941	-	-
OTB_CRU_32-69_2_22_all	1	0.486	100	1
TBB_DEF_70-99_0_0_all	2	0.344	-	-
OTB_DEF_100-119_0_0_all	1	0.04	-	-
GNS_DEF_≥220_0_0_all	1	0.012	100	1
OTB_CRU_90-119_0_0_all_FDF	1	0.002	-	-
FPO_CRU_0_0_0_all	1	0	-	-
GNS_DEF_100-119_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
SSC_DEF_≥120_0_0_all	1	0	-	-
SSC_DEF_100-119_0_0_all	1	0	-	-
SSC_DEF_70-99_0_0_all	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-
TBB_DEF_100-119_0_0_all	1	0	-	-

Table 2. 2015 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	2	7.153	90.52	2
MIS_MIS_0_0_0_HC	IIIa	1	6.762	75.52	1
OTB_CRU_70-89_2_35_all	IIIa	1	2.802	21.87	1
OTB_CRU_32-69_0_0_all	IIIa	2	2.013	100	2
OTB_DEF_≥120_0_0_all	IIIa	1	1.087	100	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.486	100	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0.009	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.002	-	-
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all	IIIa	1	0	-	-
GNS_DEF_100-119_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2015 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all_FDF	IV	3	34.277	99.76	1
OTB_CRU_70-99_0_0_all	IV	4	29.868	0.03	1
OTB_DEF_≥120_0_0_all	IV	4	13.688	3.58	1
OTB_DEF_70-99_0_0_all	IV	1	0.941	-	-
MIS_MIS_0_0_0_HC	IV	1	0.516	100	1
TBB_DEF_70-99_0_0_all	IV	2	0.344	-	-
OTB_DEF_100-119_0_0_all	IV	1	0.04	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.012	100	1
GNS_DEF_120-219_0_0_all	IV	1	0	-	-
OTB_CRU_32-69_0_0_all	IV	1	0	-	-
SSC_DEF_≥120_0_0_all	IV	1	0	-	-
SSC_DEF_100-119_0_0_all	IV	1	0	-	-
SSC_DEF_70-99_0_0_all	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-
TBB_DEF_100-119_0_0_all	IV	1	0	-	-

2016: Appendix A: Importance by landed weight

Nation abbreviated names are as follows: BEL = Belgium, DEN = Denmark, FRA = France, GFR = Germany, IRL = Ireland, NED = Netherlands, NOR = Norway, UKE = UK-England, UKNI = UK-Northern Ireland, UKS = UK-Scotland, SWE = Sweden.

Table 1. 2016: Proportion of landings by area and season.

Area	1	2	3	4	2016
IIIa	15.11	13.41	10.01	9.44	0
IV	8.97	12.69	16.04	11.95	2.36
VIId	0.01	0	0.01	0	0

Table 2. 2016: Proportion of landings by métier and nation.

Fleet	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0.004	0	0	-	-
GNS_DEF_≥220_0_0_all	-	0.009	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0.333	-	0	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0.089	0.005	0.004	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	0.009	0	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	0	-	-	-
MIS_MIS_0_0_0_HC	-	9.118	0.012	-	-	0.043	0	-	0.002	-	0.006
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-	-
OTB_CRU_32-69_0_0_all	-	1.257	-	-	-	-	1.414	1.787	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	0.018	-	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	0.046	-	-	-
OTB_CRU_70-99_0_0_all	0.189	0.334	-	0.393	-	0.085	-	-	0.15	0	0.761
OTB_CRU_90-119_0_0_all	-	27.611	-	0.003	-	-	-	5.805	-	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0.001	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	9.81	-	0.131	-	0.047	5.758	0.012	1.534	-	21.03
OTB_DEF_≥120_0_0_all_FDF	-	9.117	-	0.029	-	-	-	-	-	-	1.597
OTB_DEF_100-119_0_0_all	0.154	-	-	-	-	0.266	-	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0.003	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0.091	-	-	0.043	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0.043	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0.024	-	-	0.104	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0.011	-	0.49	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	0	-	-
TBB_DEF_≥120_0_0_all	0.065	0.042	-	-	-	0.041	-	-	0.006	-	-
TBB_DEF_70-99_0_0_all	0.033	-	-	0.01	-	0.006	-	-	0.014	-	-
TBB_DEF_90-99_0_0_all	-	0.001	-	-	-	-	-	-	-	-	-

Table 3. 2016: Proportion of landings by nation.

BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
0.4	57.6	0	0.6	0	1.1	7.4	7.7	1.8	0	23.4

Table 4. 2016: Proportion of landings by métier and area, including the number of nations fishing that métier.

Fleet	IIIa	IIIa.nation	IV	IV.nation	VIId	VIId.nation
FPO_CRU_0_0_0_all	0.004	2	0	1	-	-
GNS_DEF_≥220_0_0_all	0	1	0.009	1	-	-
GNS_DEF_120-219_0_0_all	0.003	1	0.33	2	-	-
GNS_DEF_all_0_0_all	0.034	2	0.064	2	0	1
GTR_DEF_all_0_0_all	0.009	1	-	-	0	1
LLS_FIF_0_0_0_all	0	2	0	1	-	-
MIS_MIS_0_0_0_HC	8.065	2	1.105	6	0.011	2
MIS_MIS_0_0_0_IBC	0	1	0	1	-	-
OTB_CRU_32-69_0_0_all	4.33	3	0.128	3	-	-
OTB_CRU_32-69_2_22_all	0.018	1	-	-	-	-
OTB_CRU_70-89_2_35_all	0.046	1	-	-	-	-
OTB_CRU_70-99_0_0_all	0	1	1.913	7	0	3
OTB_CRU_90-119_0_0_all	33.419	3	-	-	-	-
OTB_CRU_90-119_0_0_all_FDF	0.001	1	-	-	-	-
OTB_DEF_≥120_0_0_all	1.403	4	36.92	7	0	1
OTB_DEF_≥120_0_0_all_FDF	0.354	2	10.389	3	-	-
OTB_DEF_100-119_0_0_all	0.001	1	0.419	2	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	0.003	1	-	-
OTB_DEF_70-99_0_0	-	-	0	1	-	-
OTB_DEF_70-99_0_0_all	0.002	1	0.132	2	-	-
SDN_DEF_≥120_0_0_all	-	-	0.043	1	-	-
SSC_DEF_≥120_0_0_all	0.026	1	0.101	2	-	-
SSC_DEF_≥120_0_0_all_FDF	0.254	2	0.247	2	-	-
TBB_CRU_16-31_0_0_all	-	-	0	1	-	-
TBB_DEF_≥120_0_0_all	0.002	1	0.152	4	-	-
TBB_DEF_70-99_0_0_all	-	-	0.053	4	0.01	1
TBB_DEF_90-99_0_0_all	0.001	1	-	-	-	-

Table 5. 2016: Proportion of landings by métier, ranked from largest to smallest, together with cumulative sum and number of nations fishing that métier.

Fleet	Nation	Rank	Cum
OTB_DEF_≥120_0_0_all	7	38.323	38
OTB_CRU_90-119_0_0_all	3	33.419	72
OTB_DEF_≥120_0_0_all_FDF	3	10.743	82
MIS_MIS_0_0_0_HC	6	9.181	92
OTB_CRU_32-69_0_0_all	3	4.458	96
OTB_CRU_70-99_0_0_all	7	1.913	98
SSC_DEF_≥120_0_0_all_FDF	2	0.501	99
OTB_DEF_100-119_0_0_all	2	0.42	99
GNS_DEF_120-219_0_0_all	2	0.333	99
TBB_DEF_≥120_0_0_all	4	0.153	99
OTB_DEF_70-99_0_0_all	2	0.134	100
SSC_DEF_≥120_0_0_all	2	0.127	100
GNS_DEF_all_0_0_all	3	0.097	100
TBB_DEF_70-99_0_0_all	4	0.063	100
OTB_CRU_70-89_2_35_all	1	0.046	100
SDN_DEF_≥120_0_0_all	1	0.043	100
OTB_CRU_32-69_2_22_all	1	0.018	100
GNS_DEF_≥220_0_0_all	1	0.009	100
GTR_DEF_all_0_0_all	2	0.009	100
FPO_CRU_0_0_0_all	3	0.005	100
OTB_DEF_100-119_0_0_all_FDF	1	0.003	100
OTB_CRU_90-119_0_0_all_FDF	1	0.001	100
TBB_DEF_90-99_0_0_all	1	0.001	100
LLS_FIF_0_0_0_all	2	0	100
MIS_MIS_0_0_0_IBC	1	0	100
OTB_DEF_70-99_0_0	1	0	100
TBB_CRU_16-31_0_0_all	1	0	100

2016: Appendix B: Age coverage of landings and discards

Table 1. 2016: Coverage (total proportion) of the sampled landings and discards for age composition. Note: discards include only reported discards, not raised.

	Percent
Landings	51.98
Discards	28.46

Table 2. 2016: Coverage (proportion) of sampled landings and sampled discards by area for age composition. Note: discards include only reported discards, not raised.

	IIIa	IV	VIId
Discards	71.98	17.52	
Landings	94.76	12.53	0

Table 3. 2016: Coverage (proportion) of sampled landings and sampled discards by area and season for age composition. Note: discards include only reported discards, not raised, therefore, proportions will appear high. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-nation straum..

	Area	1	2	3	4	2016
Discards	IIIa	96.09	95.94	18.85	68.66	-
Discards	IV	6.89	-	55.28	21.86	-
Landings	IIIa	96.97	96.39	93.32	90.45	-
Landings	IV	64.19	-	-	-	32.18
Landings	VIId	-	-	-	-	-

Table 4. 2016: Coverage (proportion) of landings in each métier-nation stratum for age composition. A 0 indicates no sample data where landings were reported, while a - indicates no landings were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	0	100	0	-	-
GNS_DEF_≥220_0_0_all	-	1.16	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	1.03	-	0	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	0	93.16	0	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	95.56	0	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	0	100	-	-	-
MIS_MIS_0_0_0_HC	-	80.62	0	-	-	0	0	-	0	-	0
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	0	-	-	-
OTB_CRU_32-69_0_0_all	-	97.83	-	-	-	-	0	98.98	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	40.38	-	-	-
OTB_CRU_70-99_0_0_all	0	0	-	0	-	0	-	-	0	0	100
OTB_CRU_90-119_0_0_all	-	100	-	0	-	-	-	98.4	-	-	-
OTB_CRU_90-119_0_0_all_FDF	-	100	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	14.04	-	0	-	0	0	0	0	-	27.38
OTB_DEF_≥120_0_0_all_FDF	-	3.88	-	0	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	0	-	-	-	-	0	-	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	0	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	0	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	0	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	0	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	0	-	-	0	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	0	-	0	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	-	-	-	-	-	-	-	0	-	-
TBB_DEF_≥120_0_0_all	0	3.83	-	-	-	0	-	-	0	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_DEF_70-99_0_0_all	0	-	-	0	-	0	-	-	0	-	-

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
TBB_DEF_90-99_0_0_all	-	100	-	-	-	-	-	-	-	-	-

Table 5. 2016: Coverage (proportion) of reported discards in each métier-nation stratum for age composition. Note: raised discards not included, only reported discards. A 0 indicates no sample data where discards were reported, while a - indicates no discards were reported for that métier-country combination.

	BEL	DEN	FRA	GFR	IRL	NED	NOR	SWE	UKE	UKNI	UKS
FPO_CRU_0_0_0_all	-	-	-	-	-	-	-	0	-	-	-
GNS_DEF_≥220_0_0_all	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_120-219_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-	-
GNS_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-	-
GTR_DEF_all_0_0_all	-	-	-	-	-	-	-	-	-	-	-
LLS_FIF_0_0_0_all	-	-	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_HC	-	54.73	-	-	-	-	-	-	-	-	-
MIS_MIS_0_0_0_IBC	-	-	-	-	-	-	-	-	-	-	-
OTB_CRU_32-69_0_0_all	-	100	-	-	-	-	-	100	-	-	-
OTB_CRU_32-69_2_22_all	-	-	-	-	-	-	-	100	-	-	-
OTB_CRU_70-89_2_35_all	-	-	-	-	-	-	-	41.49	-	-	-
OTB_CRU_70-99_0_0_all	-	100	-	0	-	0	-	-	0	-	0
OTB_CRU_90-119_0_0_all	-	100	-	-	-	-	-	7.28	-	-	-
OTB_CRU_90-119_0_0_all_FDF	-	0	-	-	-	-	-	-	-	-	-
OTB_DEF_≥120_0_0_all	-	100	-	0	-	-	-	-	0	-	0
OTB_DEF_≥120_0_0_all_FDF	-	96.77	-	0	-	-	-	-	-	-	0
OTB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-	-
OTB_DEF_100-119_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0	-	-	-	-	-	-	-	-	-	-	-
OTB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-	-
SDN_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-	-
SSC_DEF_≥120_0_0_all	-	-	-	-	-	0	-	-	-	-	-
SSC_DEF_≥120_0_0_all_FDF	-	-	-	-	-	-	-	-	-	-	-
SSC_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-	-
SSC_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-	-
TBB_CRU_16-31_0_0_all	-	0	-	-	-	-	-	-	0	-	-
TBB_DEF_≥120_0_0_all	-	-	-	-	-	-	-	-	-	-	-
TBB_DEF_100-119_0_0_all	-	-	-	-	-	0	-	-	-	-	-
TBB_DEF_70-99_0_0_all	-	-	-	-	-	0	-	-	-	-	-
TBB_DEF_90-99_0_0_all	-	-	-	-	-	-	-	-	-	-	-

Table 6. 2016: Coverage (proportion) of landings in each métier-country stratum for age composition for those métier-country strata that have at least 1% of the total landings. 0 indicates landings were at least 1% of the total landings, but no samples were taken; a - indicates that métier was not included in the 1% of the total landings for that country.

	DEN	NOR	SWE	UKE	UKS
MIS_MIS_0_0_0_HC	80.6	-	-	-	-
OTB_CRU_32-69_0_0_all	97.8	0	99	-	-
OTB_CRU_90-119_0_0_all	100	-	98.4	-	-
OTB_DEF_≥120_0_0_all	14	0	-	0	27.4
OTB_DEF_≥120_0_0_all_FDF	3.9	-	-	-	0

2016: Appendix C: Landings age coverage ranked by landed weights

Table 1. 2016: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	7	38.323	18.62	2
OTB_CRU_90-119_0_0_all	3	33.419	99.71	2
OTB_DEF_≥120_0_0_all_FDF	3	10.743	3.29	1
MIS_MIS_0_0_0_HC	6	9.181	80.07	1
OTB_CRU_32-69_0_0_all	3	4.458	67.26	2
OTB_CRU_70-99_0_0_all	7	1.913	39.75	1
SSC_DEF_≥120_0_0_all_FDF	2	0.501	-	-
OTB_DEF_100-119_0_0_all	2	0.42	-	-
GNS_DEF_120-219_0_0_all	2	0.333	1.03	1
TBB_DEF_≥120_0_0_all	4	0.153	1.05	1
OTB_DEF_70-99_0_0_all	2	0.134	-	-
SSC_DEF_≥120_0_0_all	2	0.127	-	-
GNS_DEF_all_0_0_all	3	0.097	4.59	1
TBB_DEF_70-99_0_0_all	4	0.063	-	-
OTB_CRU_70-89_2_35_all	1	0.046	40.38	1
SDN_DEF_≥120_0_0_all	1	0.043	-	-
OTB_CRU_32-69_2_22_all	1	0.018	100	1
GNS_DEF_≥220_0_0_all	1	0.009	1.16	1
GTR_DEF_all_0_0_all	2	0.009	94.76	1
FPO_CRU_0_0_0_all	3	0.005	0.95	1
OTB_DEF_100-119_0_0_all_FDF	1	0.003	-	-
OTB_CRU_90-119_0_0_all_FDF	1	0.001	100	1
TBB_DEF_90-99_0_0_all	1	0.001	100	1
LLS_FIF_0_0_0_all	2	0	46.88	1
MIS_MIS_0_0_0_IBC	1	0	-	-
OTB_DEF_70-99_0_0	1	0	-	-
TBB_CRU_16-31_0_0_all	1	0	-	-

Table 2. 2016 IIIa: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_90-119_0_0_all	IIIa	3	69.664	99.71	2
MIS_MIS_0_0_0_HC	IIIa	2	16.812	91.15	1
OTB_CRU_32-69_0_0_all	IIIa	3	9.026	69.25	2
OTB_DEF_≥120_0_0_all	IIIa	4	2.925	98.17	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	2	0.738	99.87	1
SSC_DEF_≥120_0_0_all_FDF	IIIa	2	0.53	-	-
OTB_CRU_70-89_2_35_all	IIIa	1	0.096	40.38	1
GNS_DEF_all_0_0_all	IIIa	2	0.07	13.3	1
SSC_DEF_≥120_0_0_all	IIIa	1	0.054	-	-
OTB_CRU_32-69_2_22_all	IIIa	1	0.038	100	1
GTR_DEF_all_0_0_all	IIIa	1	0.018	95.56	1
FPO_CRU_0_0_0_all	IIIa	2	0.009	0.97	1
GNS_DEF_120-219_0_0_all	IIIa	1	0.007	100	1
OTB_DEF_70-99_0_0_all	IIIa	1	0.003	-	-
TBB_DEF_≥120_0_0_all	IIIa	1	0.003	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.002	100	1
OTB_DEF_100-119_0_0_all	IIIa	1	0.002	-	-
TBB_DEF_90-99_0_0_all	IIIa	1	0.001	100	1
GNS_DEF_≥220_0_0_all	IIIa	1	0	100	1
LLS_FIF_0_0_0_all	IIIa	2	0	46.88	1
MIS_MIS_0_0_0_IBC	IIIa	1	0	-	-
OTB_CRU_70-99_0_0_all	IIIa	1	0	-	-

Table 3. 2016 IV: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_≥120_0_0_all	IV	7	70.989	15.59	1
OTB_DEF_≥120_0_0_all_FDF	IV	3	19.975	-	-
OTB_CRU_70-99_0_0_all	IV	7	3.678	39.76	1
MIS_MIS_0_0_0_HC	IV	6	2.124	-	-
OTB_DEF_100-119_0_0_all	IV	2	0.805	-	-
GNS_DEF_120-219_0_0_all	IV	2	0.635	-	-
SSC_DEF_≥120_0_0_all_FDF	IV	2	0.475	-	-
TBB_DEF_≥120_0_0_all	IV	4	0.291	-	-
OTB_DEF_70-99_0_0_all	IV	2	0.255	-	-
OTB_CRU_32-69_0_0_all	IV	3	0.246	-	-
SSC_DEF_≥120_0_0_all	IV	2	0.195	-	-
GNS_DEF_all_0_0_all	IV	2	0.122	-	-
TBB_DEF_70-99_0_0_all	IV	4	0.102	-	-
SDN_DEF_≥120_0_0_all	IV	1	0.082	-	-
GNS_DEF_≥220_0_0_all	IV	1	0.018	-	-
OTB_DEF_100-119_0_0_all_FDF	IV	1	0.007	-	-
FPO_CRU_0_0_0_all	IV	1	0	-	-
LLS_FIF_0_0_0_all	IV	1	0	-	-
MIS_MIS_0_0_0_IBC	IV	1	0	-	-
OTB_DEF_70-99_0_0	IV	1	0	-	-
TBB_CRU_16-31_0_0_all	IV	1	0	-	-

Table 4. 2016 VII: Landings age coverage ranked by landed weights. Nation.Ct is the number of nations fishing that métier, while Nation.Samp is the number of countries sampling that métier.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_HC	VIId	2	51.903	-	-
TBB_DEF_70-99_0_0_all	VIId	1	46.194	-	-
OTB_CRU_70-99_0_0_all	VIId	3	1.557	-	-
GTR_DEF_all_0_0_all	VIId	1	0.346	-	-
GNS_DEF_all_0_0_all	VIId	1	0	-	-
OTB_DEF_≥120_0_0_all	VIId	1	0	-	-

2016: Appendix D: Discard ratio coverage ranked by landed weight

Table 1. 2016: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	5	33.309	2.89	1
OTB_DEF_≥120_0_0_all	4	30.871	5.67	1
OTB_DEF_≥120_0_0_all_FDF	3	12.686	85.59	1
MIS_MIS_0_0_0_HC	1	7.381	54.73	1
OTB_CRU_32-69_0_0_all	2	6.03	100	2
OTB_CRU_90-119_0_0_all	2	5.241	72.31	2
OTB_DEF_70-99_0_0_all	1	2.19	-	-
OTB_CRU_70-89_2_35_all	1	1.432	41.49	1
OTB_CRU_32-69_2_22_all	1	0.44	100	1
TBB_DEF_70-99_0_0_all	1	0.379	-	-
TBB_CRU_16-31_0_0_all	2	0.037	-	-
GNS_DEF_120-219_0_0_all	1	0.004	-	-
OTB_CRU_90-119_0_0_all_FDF	1	0.002	-	-
FPO_CRU_0_0_0_all	1	0	-	-
GNS_DEF_≥220_0_0_all	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	1	0	-	-
OTB_DEF_100-119_0_0_all	1	0	-	-
SSC_DEF_≥120_0_0_all	1	0	-	-
SSC_DEF_100-119_0_0_all	1	0	-	-
SSC_DEF_70-99_0_0_all	1	0	-	-
TBB_DEF_100-119_0_0_all	1	0	-	-

Table 2. 2016 IIIa: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
MIS_MIS_0_0_0_HC	IIIa	1	6.944	51.88	1
OTB_CRU_32-69_0_0_all	IIIa	2	6.03	100	2
OTB_CRU_90-119_0_0_all	IIIa	2	5.241	72.31	2
OTB_CRU_70-89_2_35_all	IIIa	1	1.432	41.49	1
OTB_CRU_32-69_2_22_all	IIIa	1	0.44	100	1
OTB_DEF_≥120_0_0_all	IIIa	1	0.007	100	1
OTB_DEF_≥120_0_0_all_FDF	IIIa	1	0.005	100	1
OTB_CRU_90-119_0_0_all_FDF	IIIa	1	0.002	-	-
FPO_CRU_0_0_0_all	IIIa	1	0	-	-
GNS_DEF_≥220_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all	IIIa	1	0	-	-
GNS_DEF_120-219_0_0_all_FDF	IIIa	1	0	-	-

Table 3. 2016 IV: Reported discards age coverage ranked by reported discards weights. Nation.Ct is the number of nations that report discarding in that métier, while Nation.Samp is the number of countries sampling that métier. Note: this does not include the raised discards information.

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_CRU_70-99_0_0_all	IV	5	33.309	2.89	1
OTB_DEF_≥120_0_0_all	IV	4	30.864	5.64	1
OTB_DEF_≥120_0_0_all_FDF	IV	3	12.681	85.59	1
OTB_DEF_70-99_0_0_all	IV	1	2.19	-	-
MIS_MIS_0_0_0_HC	IV	1	0.437	99.93	1
TBB_DEF_70-99_0_0_all	IV	1	0.379	-	-
TBB_CRU_16-31_0_0_all	IV	2	0.037	-	-
GNS_DEF_120-219_0_0_all	IV	1	0.004	-	-

Fleet	Area	Nation.Ct	Rank	Coverage	Nation.Samp
OTB_DEF_100-119_0_0_all	IV	1	0	-	-
SSC_DEF_≥120_0_0_all	IV	1	0	-	-
SSC_DEF_100-119_0_0_all	IV	1	0	-	-
SSC_DEF_70-99_0_0_all	IV	1	0	-	-
TBB_DEF_100-119_0_0_all	IV	1	0	-	-

Working Document 2: Survey indices for Witch flounder in 3a, IV and VIId (Wit3a47d) from IBTS

Francesca Vitale

2.1. Introduction

The two most important surveys catching witch flounder in the North Sea area and 3a are the International Bottom Trawl Survey (IBTS, 1st and 3rd Quarter) and the Beam Trawl Surveys (BTS, 3rd Quarter). Survey descriptions can be found using the following link http://datras.ices.dk/home/descriptions.aspx.

A valuable database of biological records (length and age measurements) for witch is available for the IBTS since 2009 as this species became then mandatory in the EU Data Collection Framework (DCF). No biological parameters are recorded during the BTS surveys.

Survey indices of biomass at age were calculated using 1) the method described here http://www.ices.dk/marine-data/Documents/DATRAS/DATRAS_dataproducts_units.pdf (Index area is for whole North Sea and there is no borrowing ALK performed), referred as ICES from now on) and 2) the method described in Berg et al (2014) (referred as Berg from now on). The second method was also used for estimating biomass by hauls for IBTSQ1 and IBTSQ3 combined with BTSQ3 (See section 2.3)

2.2 Indices comparison

The two set of estimated indices by age where compared in order to choose the one to be included as tuning indices in assessment models. The following tables and plots show the comparison of the two methods within each age class and relative internal and external consistencies (using log transformation with year lag in the next age).

- **IBTS Indices Q1**

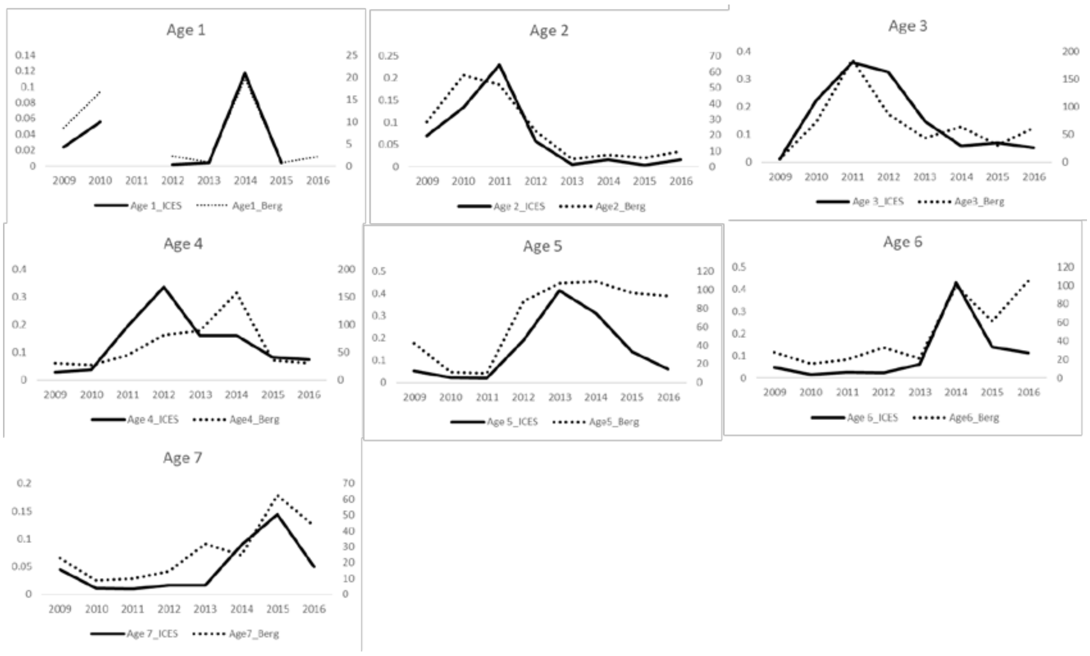
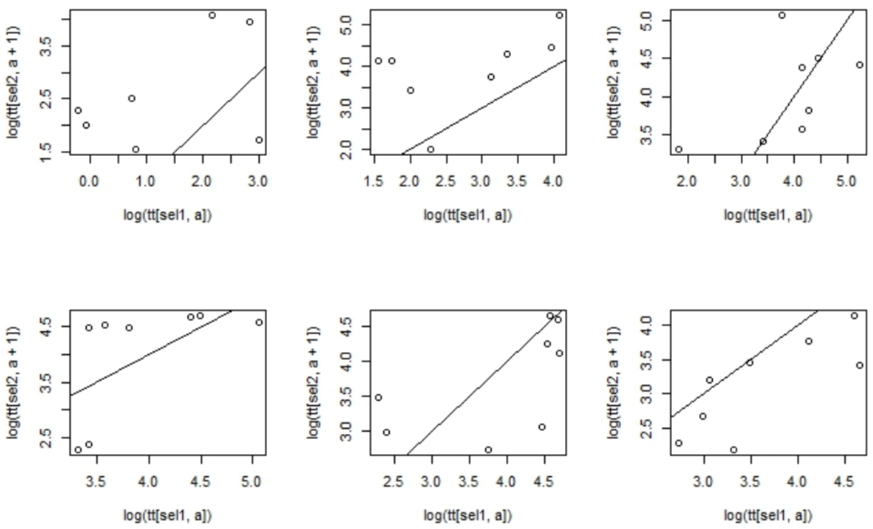


Fig.1 : Comparison of IBTSQ1 indices by age estimated by the ICES and BERG methods

Table 1. Internal consistency relative to IBTS Q1 indices estimated using Berg and ICES methods

Internal consistency	BERG Q1	ICES Q1
Age 1 vs 2	0.4554634	0.3115822
Age 2 vs 3	0.5069675	0.8303257
Age 3 vs 4	0.5335032	0.9426433
Age 4 vs 5	0.5915479	0.9479045
Age 5 vs 6	0.586395	0.8296726
Age 6 vs 7	0.7753766	0.8634571

a)



b)

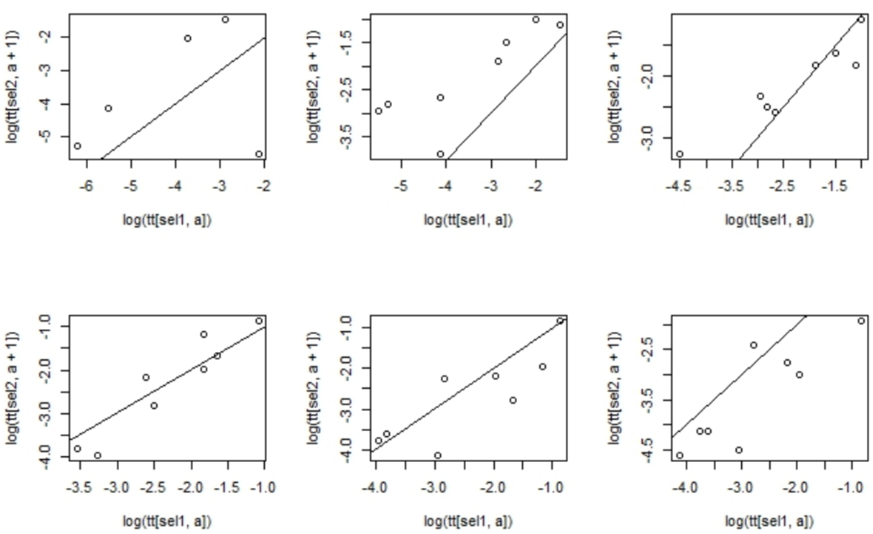


Fig 2. Internal consistency relative to IBTS Q1 indices estimated using Berg a) and ICES b) methods

- **IBTS Indices Q3**

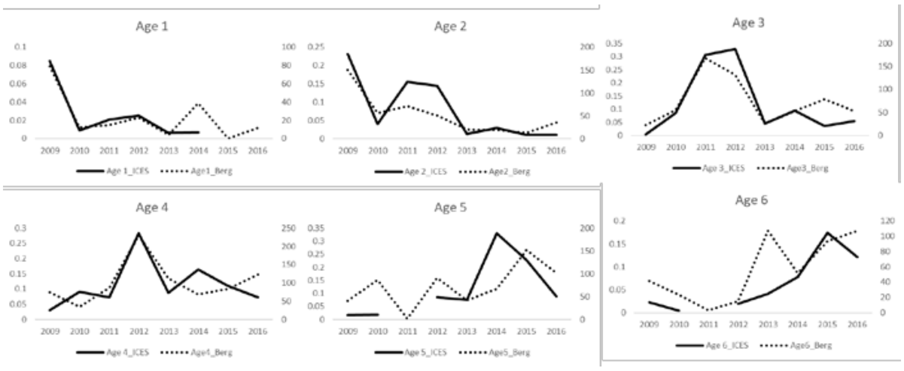
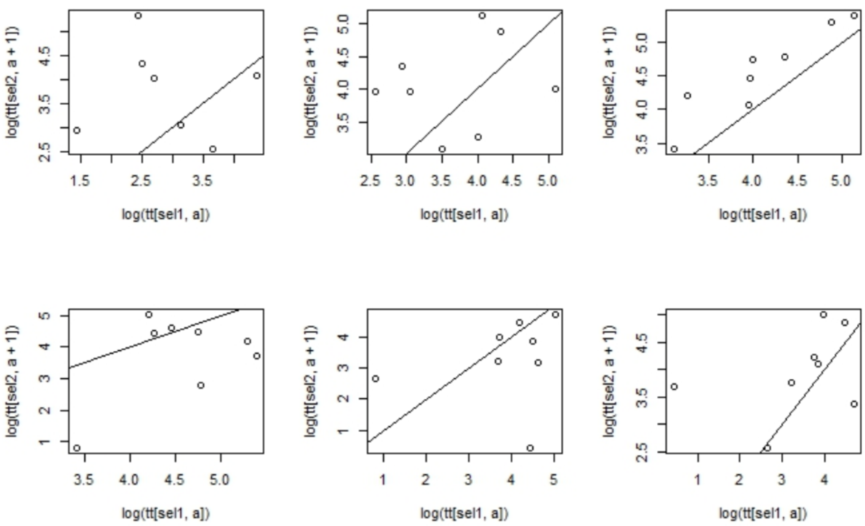


Fig.3. Comparison of IBTQ3 indices by age estimated by the ICES and BERG methods

Table 2. Internal consistency relative to IBTS Q3 indices estimated using Berg and ICES methods

Internal consistency	BERG Q3	ICES Q3
Age 1 vs 2	-0.08869838	0.09291046
Age 2 vs 3	0.149145	0.4543126
Age 3 vs 4	0.886098	0.2299444
Age 4 vs 5	0.4128269	0.5455597
Age 5 vs 6	0.277187	0.9498787
Age 6 vs 7	0.4046679	0.6382936

a)



b)

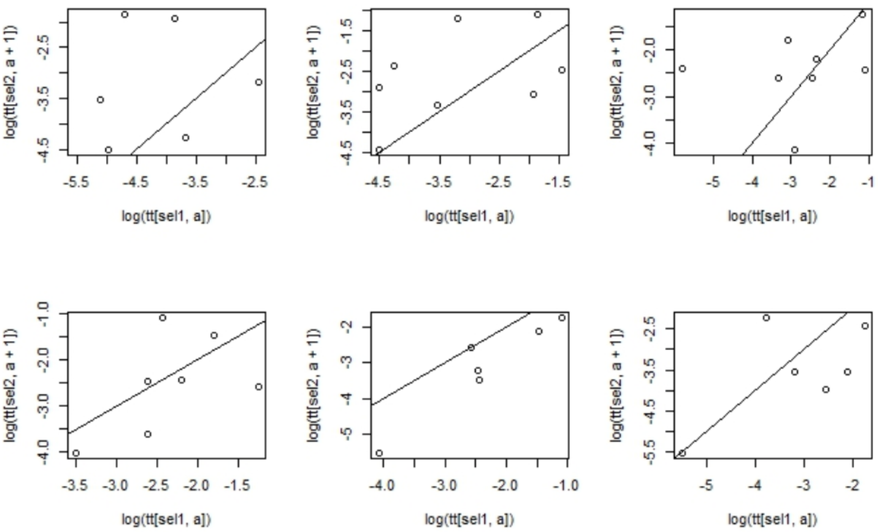
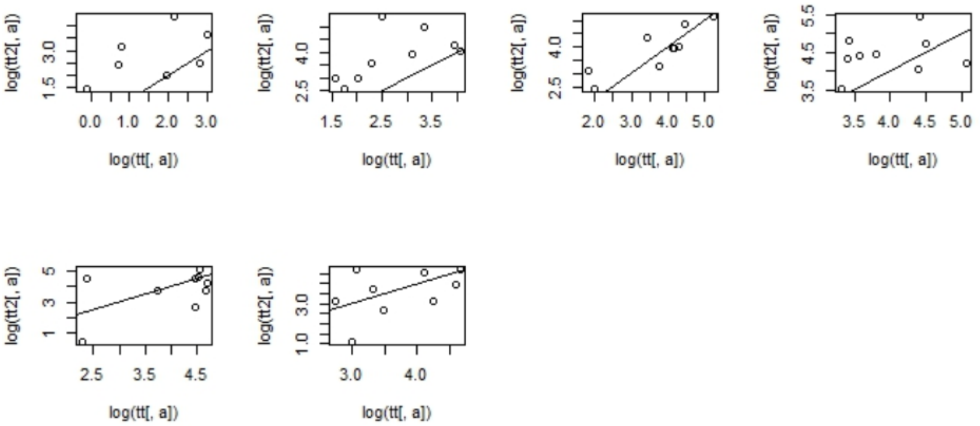


Fig 4. Internal consistency relative to IBTS Q3 indices estimated using Berg a) and ICES b) methods

Table 3. External consistency between IBTSQ1 and IBTSQ3 indices estimated using Berg and ICES methods

External consistency	BERG Q1Q3	ICES Q1Q3
Survey 1 Age 1 vs Survey 2 1	0.540498	-0.1622521
Survey 1 Age 2 vs Survey 2 2	0.5961665	0.8083324
Survey 1 Age 3 vs Survey 2 3	0.8436286	0.9190379
Survey 1 Age 4 vs Survey 2 4	0.2495372	0.5518483
Survey 1 Age 5 vs Survey 2 5	0.5387604	0.6820198
Survey 1 Age 6 vs Survey 2 6	0.4631476	0.8052173
Survey 1 Age 7 vs Survey 2 7	0.3279384	0.09266223

a)



b)

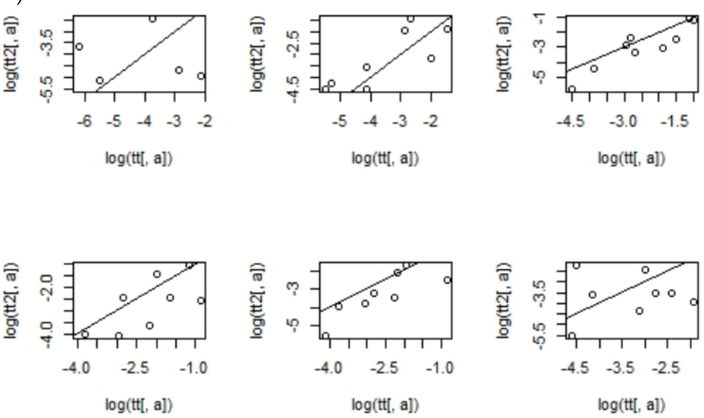


Fig 5. External consistency between IBTSQ1 and IBTSQ3 indices estimated using Berg (a) and ICES (b) methods

2.3 Survey Index Calculations for Witch Flounder from IBTS and BTS data

Casper W. Berg

Survey indices of biomass are calculated using the methodology described in [1], except that biomass by haul is used as response variable rather than numbers-at-age.

2.3.1 Input data

For Q3 data from the NS-IBTS and BTS surveys are used. Only gears with at least 120 hauls are included. For Q1 only the GOV gear is considered.

2.3.2 Exploitable biomass

The length distribution (total number caught by length group over all years divided by total number caught) in the commercial samples was compared with those from the survey (Q1 IBTS) to judge whether the survey catches are representative of the commercial catches (figure 3). The length distributions are similar so there is no need to perform re-weighting of length groups, since the survey may be regarded as representative of exploitable stock biomass.

2.3.3 Model

The following equation is used for both the presence-absence and positive part of the model:

$$g(\mu_i) = \text{Year(i)} + \text{Gear(i)} + f1(\text{lon}_i, \text{lat}_i)$$

$$+ f2(\text{Depth}_i) + \log(\text{HaulDur}_i)$$

where Gear(i) and Year(i) are categorical effects for the *i*th haul. The gear effect is not included for the Q1 data because we only consider the GOV gear here. An offset is used for the effect of haul duration (*HaulDur*), i.e. the coefficient is not estimated but taken to be 1. $f1$ is a 2-dimensional thin-plate spline for space, $f2$ is a 1-dimensional thin plate spline for the effect of bottom depth.

The function g is the link function, which is taken to be the logit function for the binomial model. The log-normal part of the delta-log-normal model is fitted with a log link. Each quarter is estimated separately. The fitted models are then used to sum the expected catches over a fine grid by year to obtain the survey index. Nuisance variables such as Gear and haul duration are corrected for in this process by using the same Gear and haul duration for all predictions.

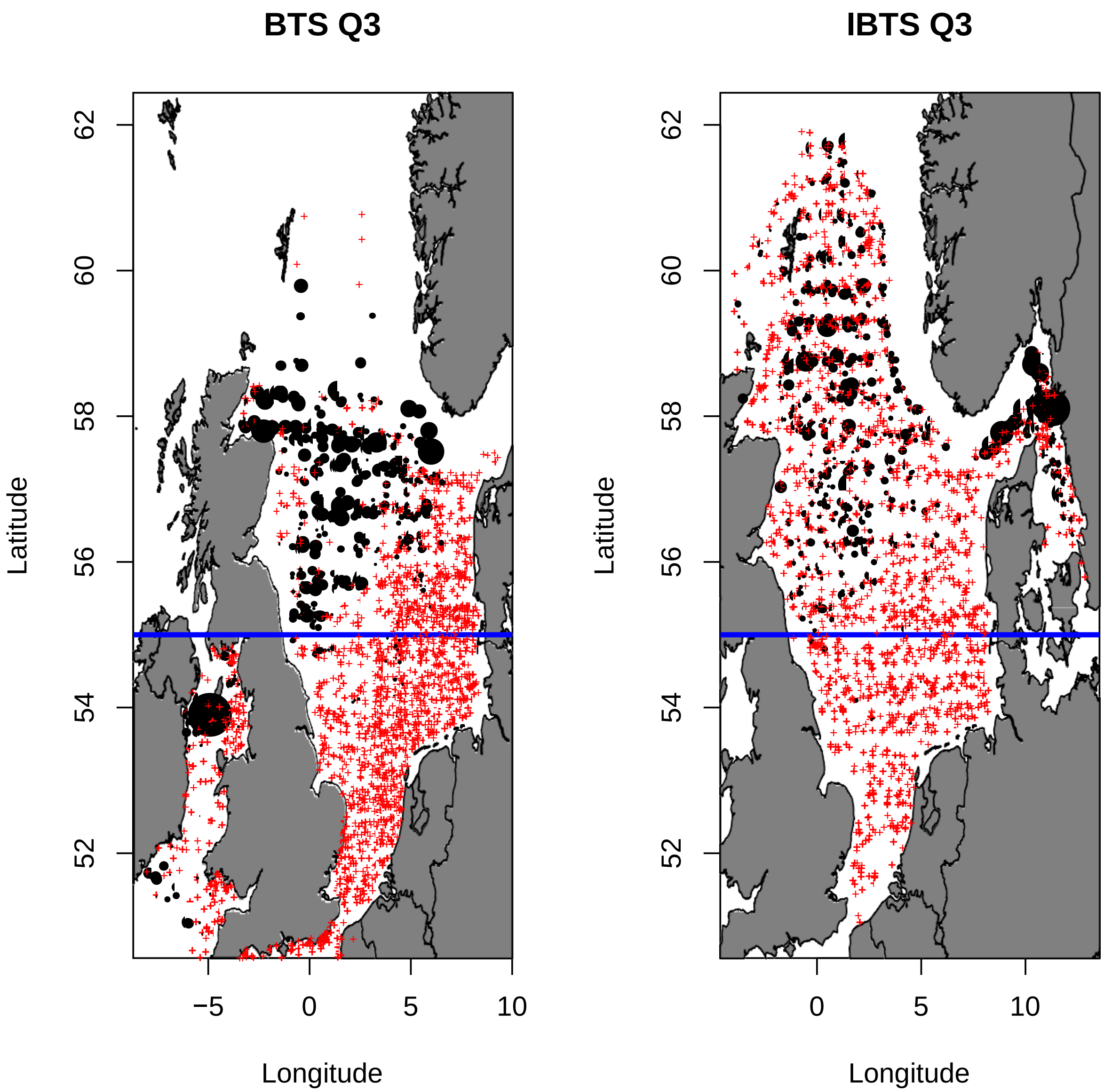


Figure 1: All hauls in the Q3 surveys considered, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls.

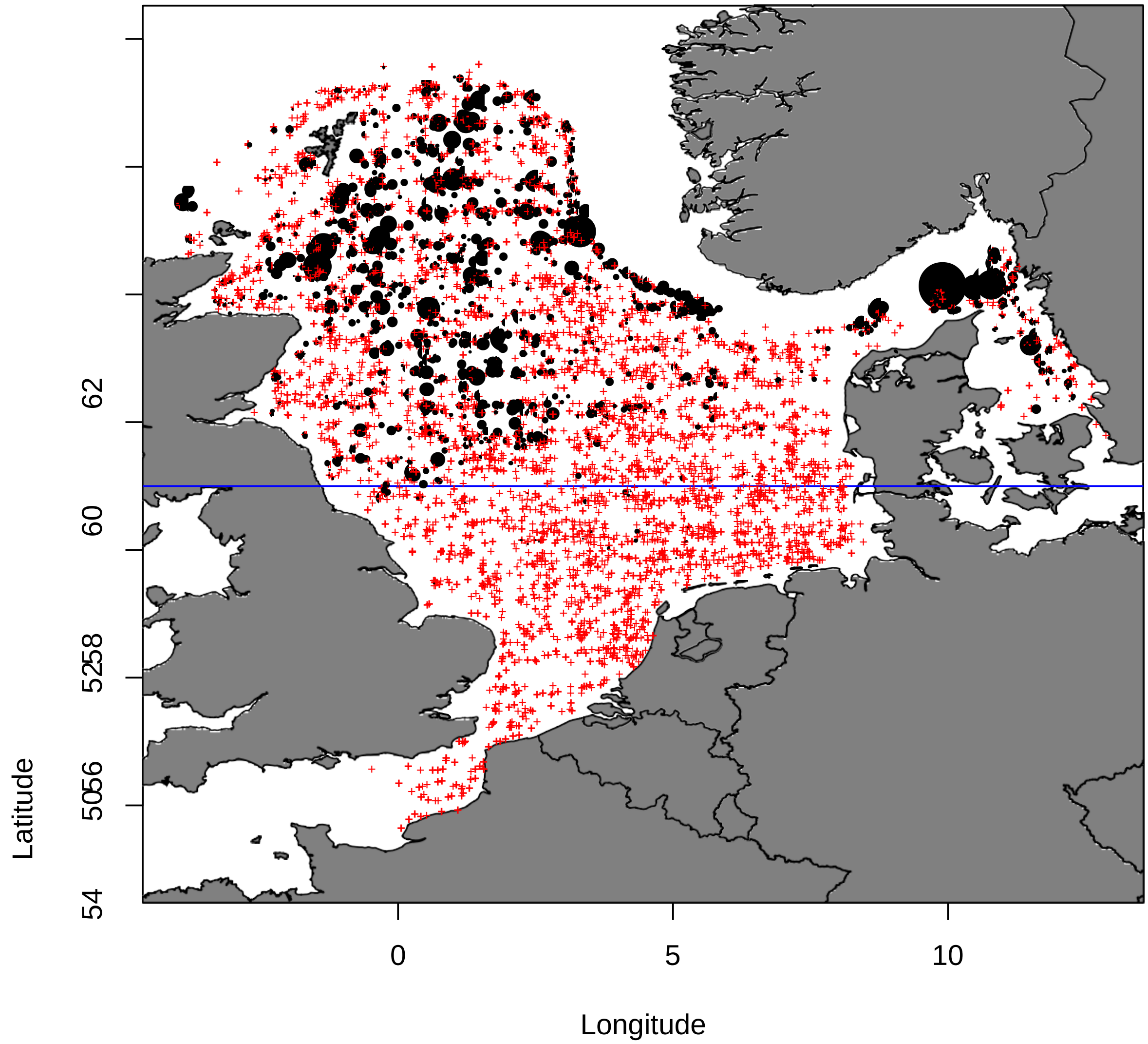


Figure 2: All hauls in Q1, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls.

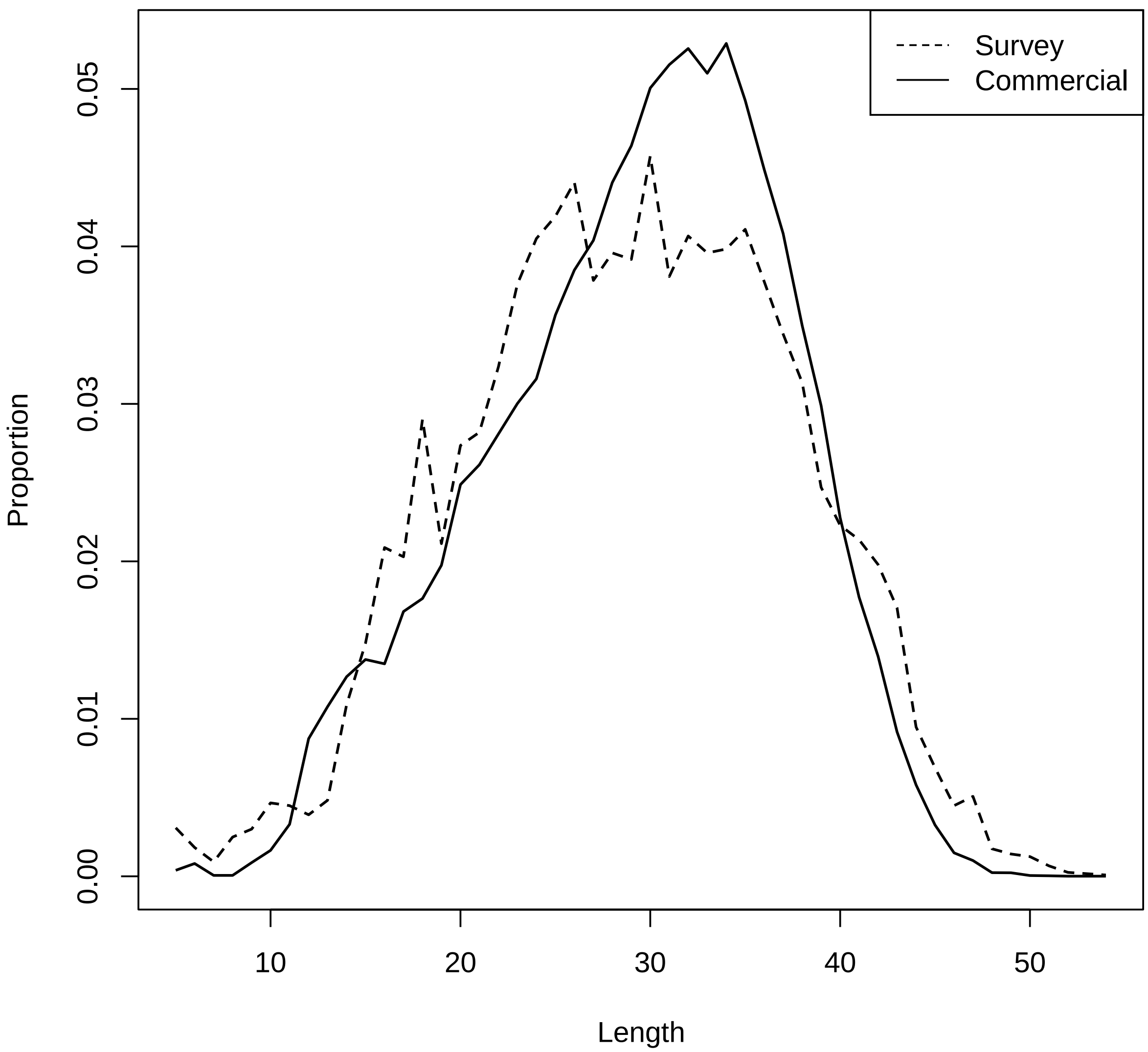


Figure 3: Comparison of length distributions in surveys and commercial catches.

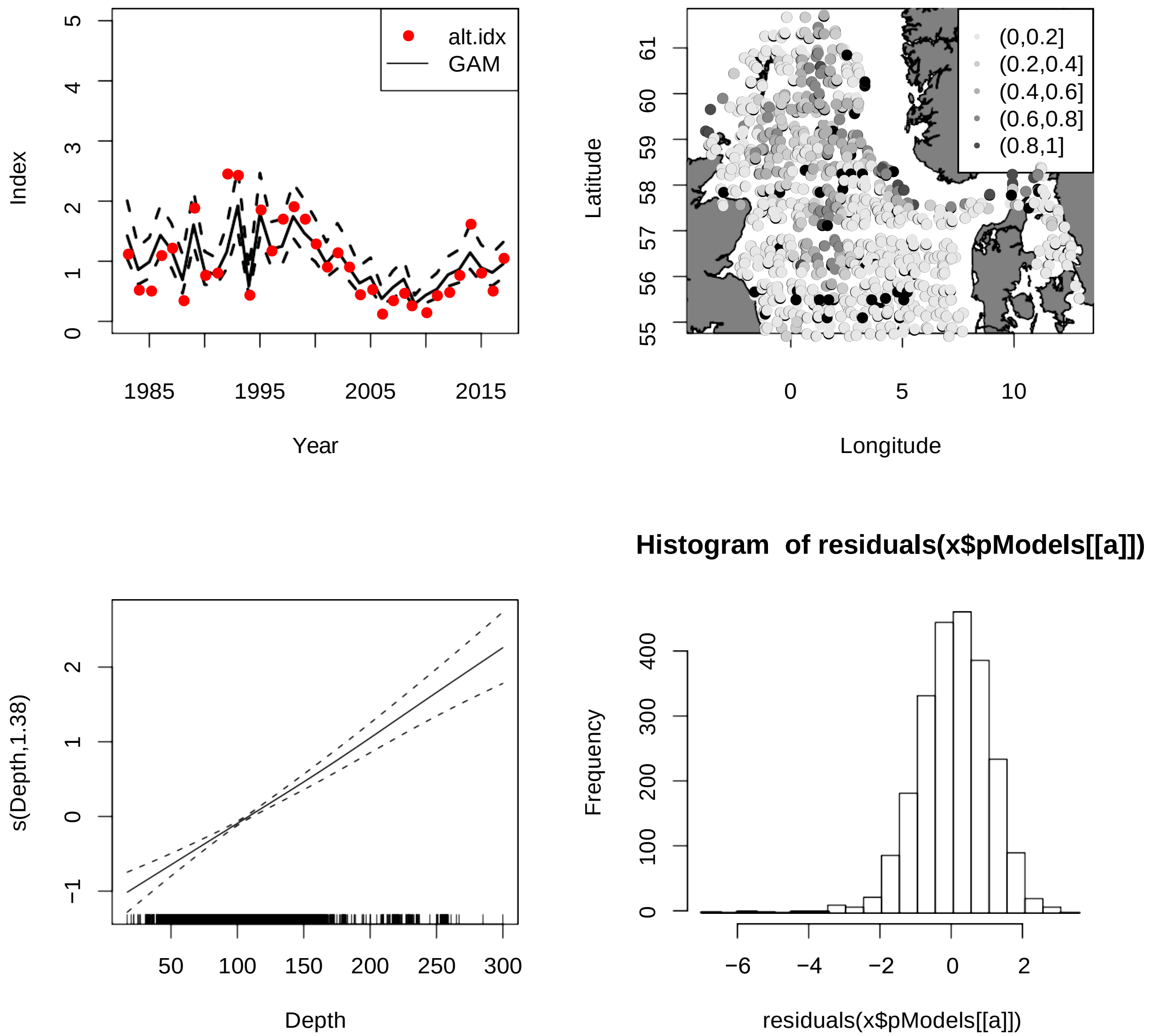


Figure 4: Estimated survey index Q1 ("alt.idx" is calculated using standard ICES stratified mean method), stock concentration plot, depth effect, and histogram of residuals (positive part of model only). Note, that labels indicating age groups is wrong – it is total biomass.

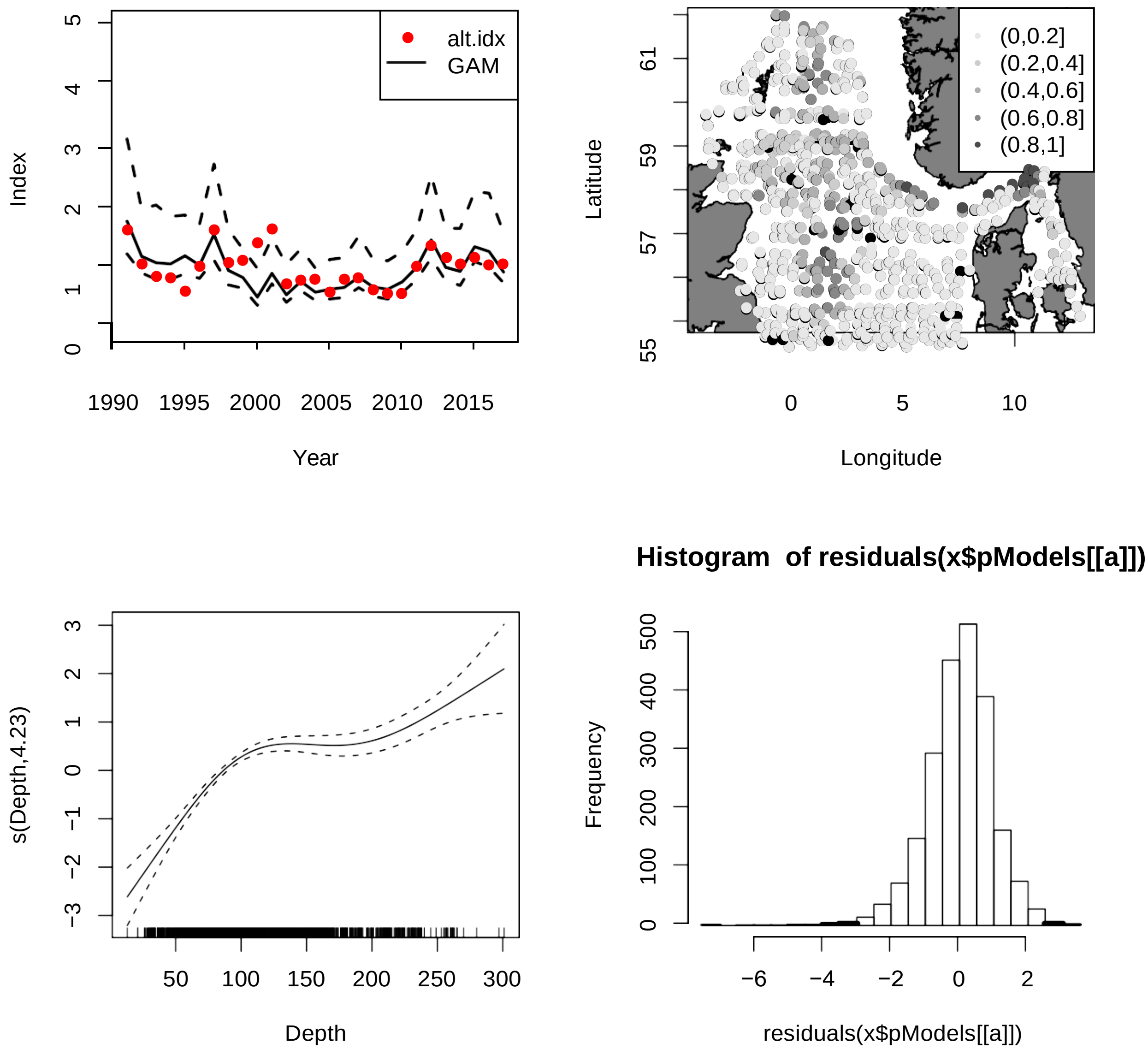


Figure 5: Estimated survey index Q3, stock concentration plot, depth effect, and histogram of residuals (positive part of model only).

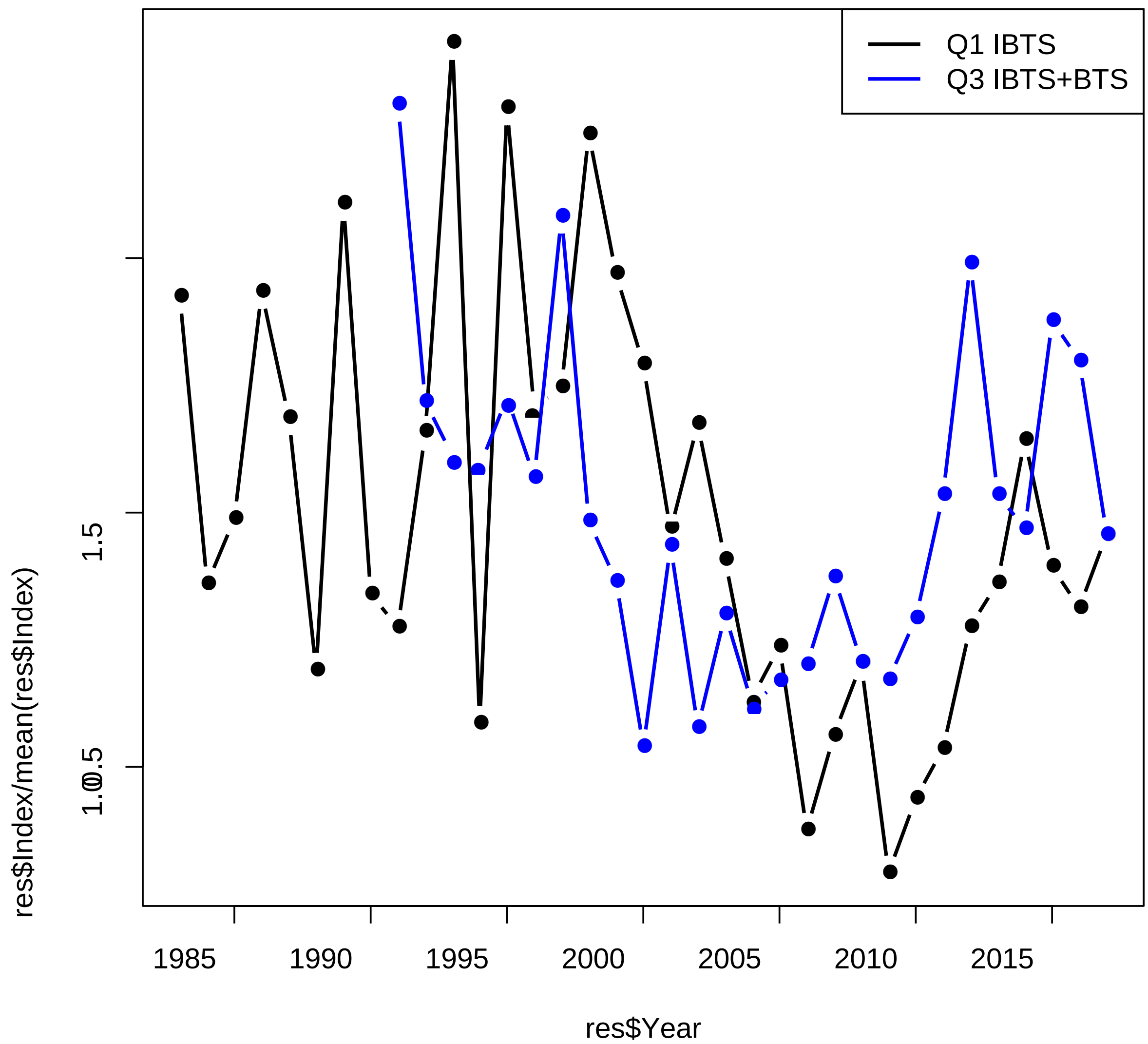


Figure 6: Q1 and Q3 indices (rescaled to mean 1)

References

[1] Casper W Berg, Anders Nielsen, and Kasper Kristensen. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151:91–99, 2014.

Working Document 3: Biological parameters in Witch flounder in 3a, IV and VIId (Wit3a47d)

In 2009 witch flounder has been included as a mandatory species in the EU Data Collection Framework (2009). Since then, Sweden, Denmark and Scotland started to collected otoliths for age estimation. Sweden and Denmark also collect maturity data. It is noteworthy that the maturity evaluation has never been calibrated among stagers nor validated. Moreover, up to 2016 only Sweden was reading the age for this species also for Denmark and Scotland through bilateral agreement. Also for the age reading no validation has ever been performed.

Furthermore, individual length has been recorded for landings and discards by Denmark, Germany and Sweden, since 2002, by England since 2003, by Scotland since 2009 and by The Netherlands since 2011 although only for discards (See also table 3-6 in WD1)

Stock weights-at-age

The stock weights at age were estimated using IBTS quarter combined data from the period 2009-2017 (Figure 1). The catch weights at age, estimated in InterCatch, are also shown for comparison. As the trends become noisy at older ages it was suggested to use age 8 as plus-age.

Fig.1. Catch (left) and Stock (right) weights at age by years.

No real trend is observed over time thus it was deemed preferable to use constant stock weights instead of annual values (Table 1)

Table 1. Stock weights at age use in the SAM model.

Age	1	2	3	4	5	6	7	8+
Stock weights (Kg)	0.0055	0.0328	0.0772	0.151	0.234	0.336	0.377	0.450

Maturity ogives

Data availability

There are two sources of maturity data available for witch. The first source is the International Bottom Trawl Surveys (IBTS) Q1 and Q3, available in DATRAS. Beside very few data in 2005 and 2008, there were 2068 records available from 2009 mostly recorded by Sweden (2022 records). The second source is represented by Swedish commercial samples from 2009 collected mostly on a month basis which include 5800 records. The latter represents a bigger dataset and was therefore further explored.

Data exploration

The national maturity scale used by Sweden is an 8 points maturity key, where stages 1 and 2 are *immature*, stages 3 and 4 are *maturing*, stages 5-7 are *mature/spawning/spent*, stage 8 is *resting* and stage 9 is abnormal. On a binary form, where 0 is immature and 1 is mature, all individuals in the first two stages and stage 9 are considered immature while individuals from stage 3 to stage 8 are considered mature, thus contributing to the Spawning Stock Biomass. It is controversial whether stage 8 has to be included among mature individuals as it depends on when, in relation to the spawning season, the sample has been taken. Thus this decision implies an accurate knowledge of the species spawning season, which is lacking in this case. Moreover, this stage is generally a very confounding one, easily mistaken with stage 2 in several species.

For exploring the monthly trend of recorded maturity stages all available years were pooled together (Figure 2) showing that early maturing (also immature not shown here) individuals can be found all year around. Only 3 specimens in stage 5 and 1 in stage 6 were recorded thus too few for drawing conclusion about the spawning season. The proportion of mature has a peak in September, mostly driven by the highest proportion of resting individuals (stage 8).

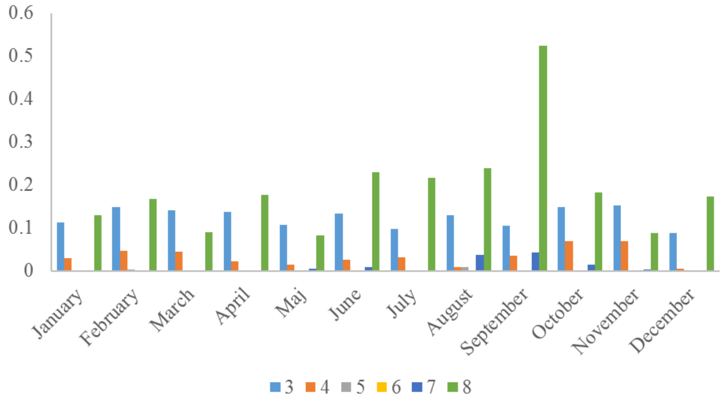


Fig. 2. Monthly trend of recorded maturity stages using Swedish commercial data for the period 2009-2016

The high proportion of individuals in stage 8 in September is not due to differences in the length distribution of samples as the mean length does not differ among months (Figure 3).

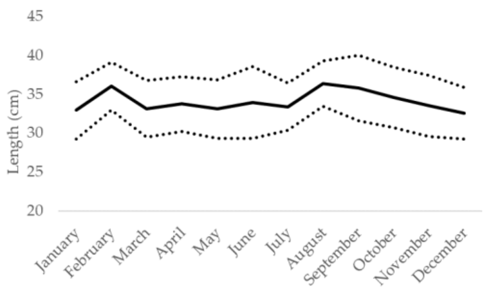


Fig. 3. Monthly trend of mean length using Swedish commercial data for the period 2009-2016

Furthermore, logistic regressions over the four quarters using Swedish commercial data show that in Q1 and Q2 the curve decrease after reaching the L50, which highlights a smaller amount of mature individuals at larger size (Figure 4). Those are most probably individuals in stage 8 (mistakenly assessed as stage 2).

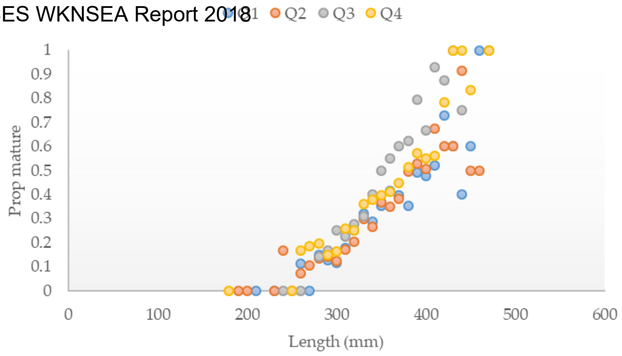


Fig. 4. Quarterly trend of proportion of mature specimens using Swedish commercial data for the period 2009-2016

The same trend is observed in IBTS Q1 and Q3 data (not shown). Furthermore, the really few maturity data collected by the Netherlands during BTS Q3 showed that the only visible stage is during Q3 is spent (not shown).

All this information leads to the assumption that the spawning season may occur during or after summer. However according to old available information (Molander,1935), there are probably two stocks of witch flounder, one in the Kattegat and one in the North Sea and Skagerrak. The Kattegat stock, considered stationary, spawns generally in October-November while the North Sea and Skagerrak stock has the spawning season between May-September. All this highlights the need for investigations not only on the sub-stock structure but also on the spawning strategy and timing of this species.

In order to decide how to calculate the maturity ogives to be included in the assessment model L50 and A50 (i.e. respectively the length and age at which 50% of the population is mature) where estimated through four binomial GLMs using Swedish commercial data from 2009-2016. The first two GLMs used all quarters' data while the last two models included only data from the last two quarters (Table 2). It is evident that maturity ogives in witch are not steep even though the steepness increases when plotted by length (Figure 5). The estimated proportion mature at age were plotted against the ogives previously used in the XSA exploratory run (ICES, 2013), also obtained using Swedish commercial data, all quarters combined (Figure 6).
Taking all this information into account it was thus decided to use all quarters combined constant maturity ogives (Table 3). In the table the proportion of mature individuals is shown up to age 12 as it is the age at which all individuals are mature. However 8+ group was used in the SAM model.

Table 2. Result of the binomial GLMs

Binomial GLM	*Data*	*Intercept*	*Slope*	*Significance*
p ~ age	All quarters	-3.2067334	0.4279864	p<0.001
p ~ age	Q3+Q4	-2.4588485	0.3672006	p<0.001
p ~ length	All quarters	-7.2320029	0.1896699	p<0.001
p ~ length	Q3+Q4	-7.1746148	0.1953607	p<0.001

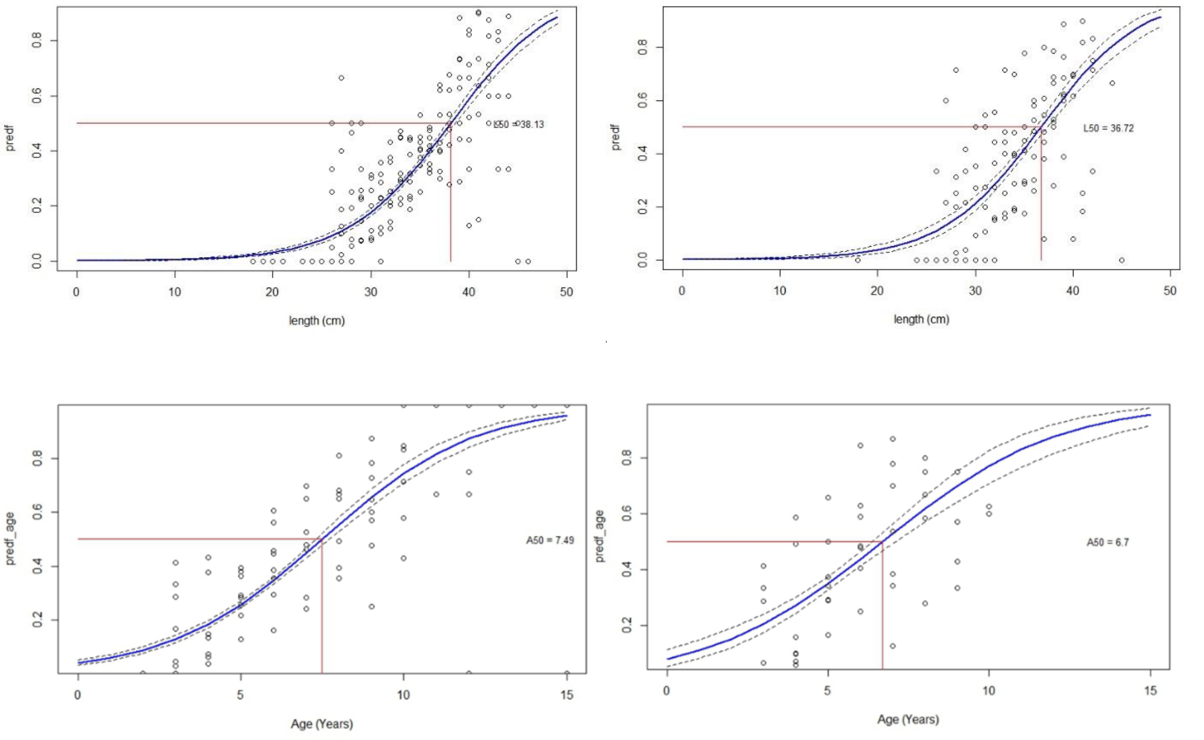


Fig. 5. L50 (upper plots) and A50 (lower plots) were estimated using the coefficients obtained from two binomial GLMs using Swedish commercial data (2009-2016) from all quarters (on the left) and only from the last two quarters (on the right).

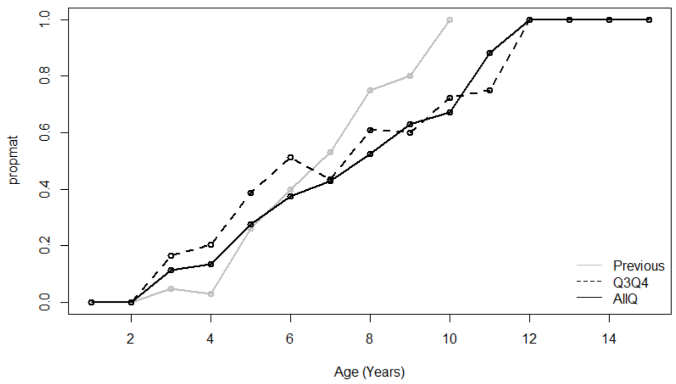


Fig. 6. Comparison between previous, all quarters and only Q3Q4 maturity ogives all estimated using Swedish commercial samples (2009-2016)

Table 3. Constant maturity ogives obtained using Swedish commercial samples 2009-2016 all quarters combined.

Age	1	2	3	4	5	6	7	8	9	10	11	12
Proportion mature	0	0	0.114	0.136	0.275	0.376	0.428	0.524	0.631	0.671	0.882	1

Von Bertalanffy growth function

The Von Bertalanffy growth parameters were estimated using the IBTS data (2009-2017) quarter combined both sex separated (Table 4) and combined. In this case IBTS data were preferred due to a wider age class representativeness compared to commercial data. The estimated curves are shown in Figure 6.

Table 4: Von Bertalanffy growth parameters estimates of male and female witch

	K	L∞	t0
♂	0.156	50.66	0
♀	0.166	51.19	0

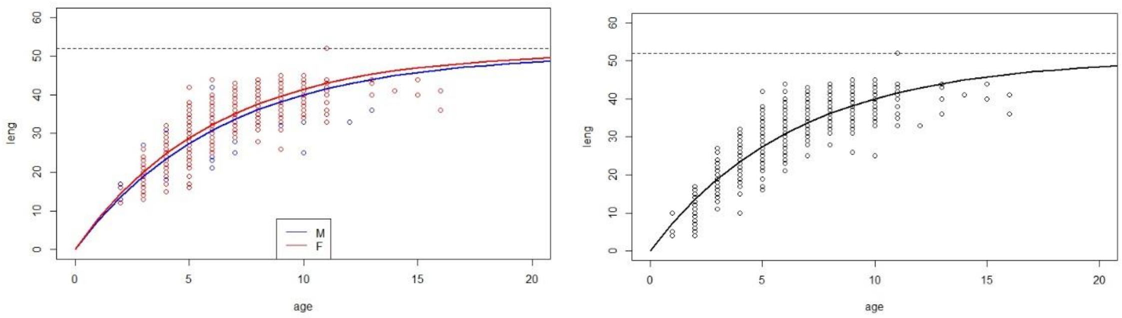


Fig. 6. Von Bertalanffy growth curve, sex separated (on the left) and combined (on the right), estimated using IBTS data, quarter combined, for the period 2009-2017.

Length-weight relationship (IBTS)

The length weight relationship was estimated using data form the IBTS data from 2009-2017. Also here IBTS data were preferred due to a wider length class representativeness compared to commercial data. The estimated curve (a= -6.16, b=3.32, $p<0.001$) is shown in Figure 7.

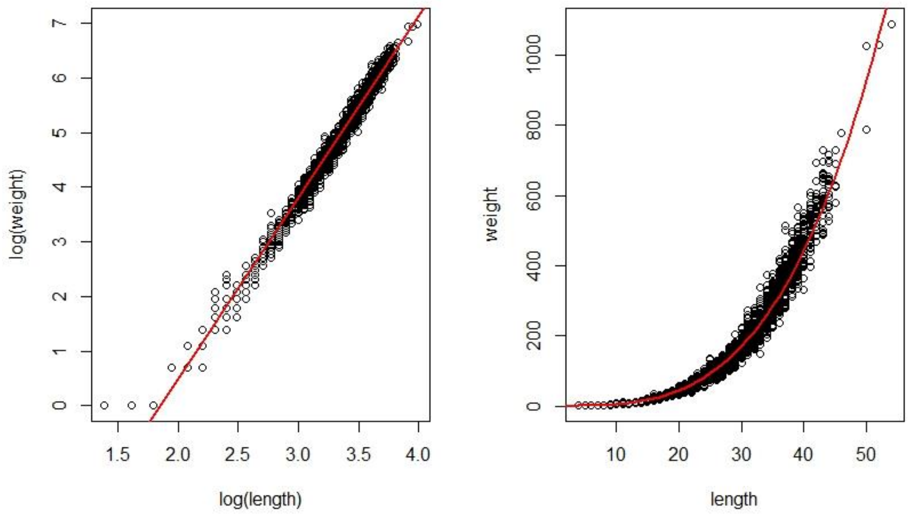


Fig. 7. Length-weight relationship for witch, estimated using IBTS data, quarter combined, for the period 2009-2017.

References

ICES 2013. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM.

Molander, A. (1935). Further data concerning the witch (Pleuronectes cynoglossus L.). Svenska Hydrografiska-Biologiska Kommissionens Skrifter. Ny serie Biologi. Band I. NR 6. 1935. Tryckeriaktiebolaget Tiden, Stockholm.

Note on SAM assessment for Witch Flounder (27.a347d)

The basic state-space assessment model (SAM) is described in Nielsen & Berg (2014). The model has been continuously developed and adapted for different stocks. The current implementation (https://github.com/fishfollower/SAM) is an R-package based on Template Model Builder (TMB) (Kristensen et al. 2016).

The data set used to assess Witch Flounder (27.a347d) uses catches at age $(C_{a,y})_{a=1...10^+,y=2009...2016}$ and age-specific indices from two scientific surveys $(I^{(s=1)}_{a,y})_{a=1...7,y=2009...2016}$, and $(I^{(s=2)}_{a,y})_{a=1...6,y=2009...2016}$. In addition to the observations on catches and surveys a set of biological parameters are available, these include: Mean weight in stock $W^{(s)}_{a,y}$, mean weight in catch $W^{(c)}_{a,y}$, mean weight in landing $W^{(l)}_{a,y}$, proportion mature $P_{a,y}$, and an estimate of natural mortality $M_{a,y}$.

The complete age-specific data set only covers a relative short time period (from 2009 to 2016), so an additional run will be provided, which extends the time series back in time. The only added data used is total landing weights for the period from 1950 to 2008 $(TLW_y)_{y=1950...2008}$.

Standard Model (short time series)

The model for Witch Flounder is a state–space model. The states α are the log-transformed stock sizes $\log N_1, \ldots, \log N_{10^+}$ and fishing mortalities $\log F_1, \ldots, \log F_{6-10^+}$ corresponding to total age specific catches. Notice that it is assumed that $F_6 = \cdots = F_{10^+}$. In any given year y the state is the combined vector $\alpha_y = (\log N_1, \ldots, \log N_{10^+}, \log F_1, \ldots, \log F_{6-10^+})'$. The transition equation describes the distribution of the next years state from a given state in the current year. The following is assumed:

$$\alpha_y = T(\alpha_{y-1}) + \eta_y$$

The transition function T is where the stock equation and assumptions about stock–recruitment enters the model. The equations are:

$$\log N_{1,y} = \log(N_{1,y-1})$$
$$\log N_{a,y} = \log N_{a-1,y-1} - F_{a-1,y-1} - M_{a-1,y-1} \ , \qquad 2 \le a < A$$
$$\log N_{A,y} = \log(N_{A-1,y-1} \exp^{-F_{A-1,y-1}-M_{A-1,y-1}} + N_{A,y-1} \exp^{-F_{A,y-1}-M_{A,y-1}}) \qquad A = 10$$
$$\log F_{a,y} = \log F_{a,y-1} \ , \qquad 1 \le a \le 6$$

Here $M_{a,y}$ is the age and year specific natural mortality parameter, which is assumed known from outside sources. $F_{a,y}$ is the total fishing mortality.

The prediction noise η is assumed to be Gaussian with zero mean, and three separate variance parameters. One for recruitment ($\sigma^2_{N_{a=1}}$), one for survival

($\sigma^2_{N_{a>1}}$), one for fishing mortality at age (σ^2_F). The N-part of η is assumed uncorrelated, and the F-part is assumed correlated according to an ar(1) correlation structure, such that $\text{cor}(\Delta\log(F_{a,y}),\Delta\log(F_{\tilde{a},y})) = \rho^{|a-\tilde{a}|}$.

The observation part of the state–space model describes the distribution of the observations for a given state α_y. Here the vector of all observations from a given year y is denoted x_y. The elements of x_y are age-specific log-catches $\log C_{a,y}$ and age-specific log-indices from scientific surveys $\log I^{(s)}_{a,y}$. The combined observation equation is:

$$x_y = O(\alpha_y) + \varepsilon_y$$

The observation function O consists of the catch equations for total catches and scientific surveys. The measurement noise term ε_y is assumed to be Gaussian. An expanded view of the observation equation becomes:

$$\log C_{a,y} = \log\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right) + \varepsilon^{(c)}_{a,y}$$
$$\log I^{(s)}_{a,y} = \log\left(Q^{(s)}_a e^{-Z_{a,y}\frac{D^{(s)}}{365}} N_{a,y}\right) + \varepsilon^{(s)}_{a,y}$$

Here Z is the total mortality rate $Z_{a,y} = M_{a,y} + F_{a,y}$, $D^{(s)}$ is the number of days into the year where the survey s is conducted, $Q^{(s)}_a$ are model parameters describing catchability coefficients. It is assumed that the catchability is the same for the two oldest ages within each of the two surveys. The variance of ε_y is setup such that each data source catches, and the two scientific surveys have their own covariance matrix.

Observation uncertainty is important e.g. to get the relative weighting of the different information sources correct, so a lot of effort has been invested in getting the optimal options into SAM. In Berg and Nielsen (2016) different covariance structures are compared for four ICES stocks.

The options used for Witch Flounder are the following. The logarithm of the total catches at age are assumed independent Gaussian with the same variance for all ages. The logarithm of the age specific indices from the both surveys are assumed independent Gaussian with a common variance for all ages, but separate for each survey.

Extended Model

For additional run extending the time series back in time the total landing weights are predicted by first predicting the catch-at-age (as above), then multiplying with the average landing weight-at-age and landing-fraction-at-age ($\overline{\psi}_{a,}$) from the period 2009-2016, and then adding the age-specific catch weight predictions.The added observation becomes:

$$\log TLW_y = \log\left(\sum_{a=1}^{10^+}\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right)\overline{\Psi}_{a,}\overline{W}_{a,}^{(l)}\right) + \varepsilon_y^{(tlw)}$$

where $\varepsilon_y^{(tlw)}$ is normally distributed with mean zero and a standard deviation, which is computed (via the delta method) from the standard deviation parameters of the age-specific log-catches. Notice that no additional model parameters are needed.

Extended Model with new exploitable biomass surveys

Two new survey indices of fishable stock biomass (FSB) was presented during the benchmark meeting (see working document Berg 2018). The new index for quarter one is used for the years from 1983 to 2008 and the new index for quarter 3 is used from 1991 to 2008. After 2008 these are replaced by the age-specific indices.

These new observations for each survey are used as:

$$\log FSB_y = \log Q^{(s)} + \log \widehat{FSB}_y + \varepsilon_y^{(s)}$$

where $Q^{(s)}$ is the survey specific catchability and $\varepsilon_y^{(s)}$ is normally distributed with mean zero and a standard deviation specific to the survey.

Likelihood and approximation

The likelihood function for this is set up by first defining the joint likelihood of both random effects (here collected in the α_y states), and the observations (here collected in the x_y vectors). The joint likelihood is:

$$L(\theta,\alpha,x) = \prod_{y=2}^{Y}\{\phi(\alpha_y - T(\alpha_{y-1}),\Sigma_\eta)\}\prod_{y=1}^{Y}\{\phi(x_y - O(\alpha_y),\Sigma_\varepsilon)\}$$

Here θ is a vector of model parameters. Since the random effects α are not observed inference should be obtain from the marginal likelihood:

$$L_M(\theta,x) = \int L(\theta,\alpha,x)d\alpha$$

This integral is difficult to calculate directly, so the Laplace approximation is used. The Laplace approximation is derived by first approximating the joint log likelihood $\ell(\theta,\alpha,x)$ by a second order Taylor approximation around the optimum $\hat{\alpha}$ w.r.t. α. The resulting approximated joint log likelihood can then be integrated by recognizing it as a constant term and a term where the integral is know as the normalizing constant from a multivariate Gaussian. The approximation becomes:

$$\int L(\theta,\alpha,x)d\alpha \approx \sqrt{\frac{(2\pi)^n}{\det(-\ell''_{\alpha\alpha}(\theta,\alpha,x)|_{\alpha=\hat{\alpha}_\theta})}}\exp(\ell(\theta,\hat{\alpha}_\theta,x))$$

Taking the logarithm gives the Laplace approximation of the marginal log likelihood

$$\ell_M(\theta,x) = \ell(\theta,\hat{u}_\theta,x) - \frac{1}{2}\log(\det(-\ell''_{uu}(\theta,u,x)|_{u=\hat{u}_\theta})) + \frac{n}{2}\log(2\pi)$$

Results — standard model

The main results of the standard model (Fig 1). The standard model is fitting to all 3 data sources (Fig 4). The leave-one-out diagnostics shows that all data-sources are in agreement (Fig 3). The retrospective runs show that removing the last two years give no pattern, removing further years does show a pattern (Fig 2). The retrospective runs are however difficult to evaluate, because of the very short time series (8 years). When peeling off years of data the time series becomes too short to obtain reliable convergence, which is a likely explanation for the pattern seen for the runs using only 3 or 4 years of data.

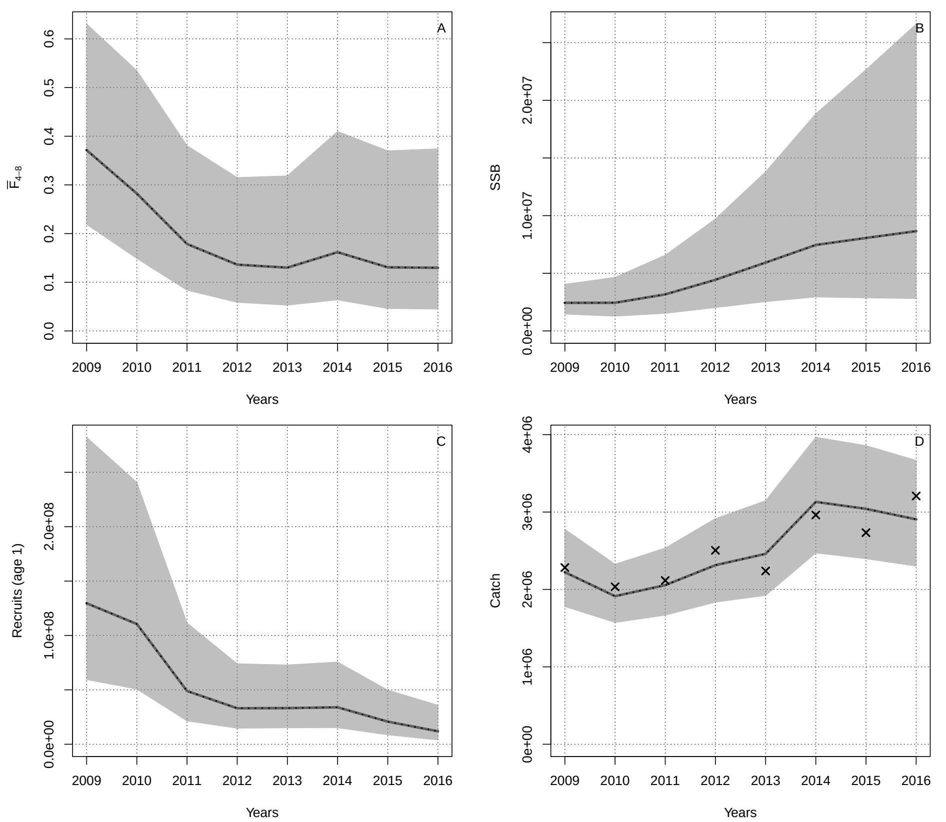


Figure 1: Estimates and point wise 95% confidence intervals of $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D).

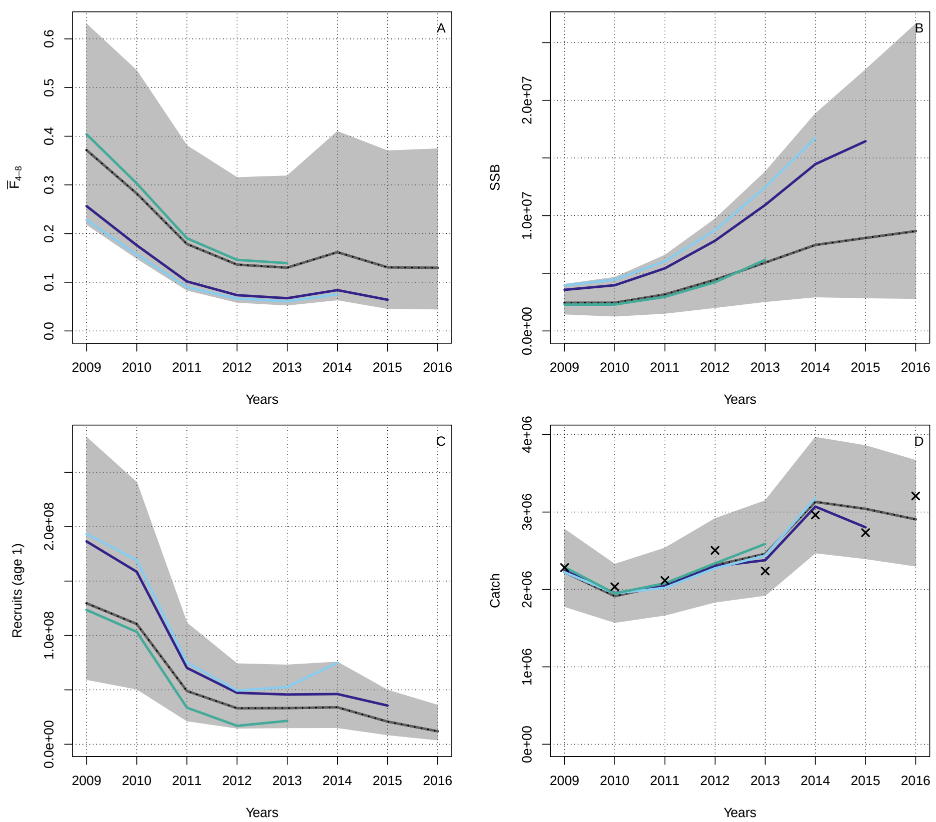


Figure 2: Retrospective pattern for $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D).

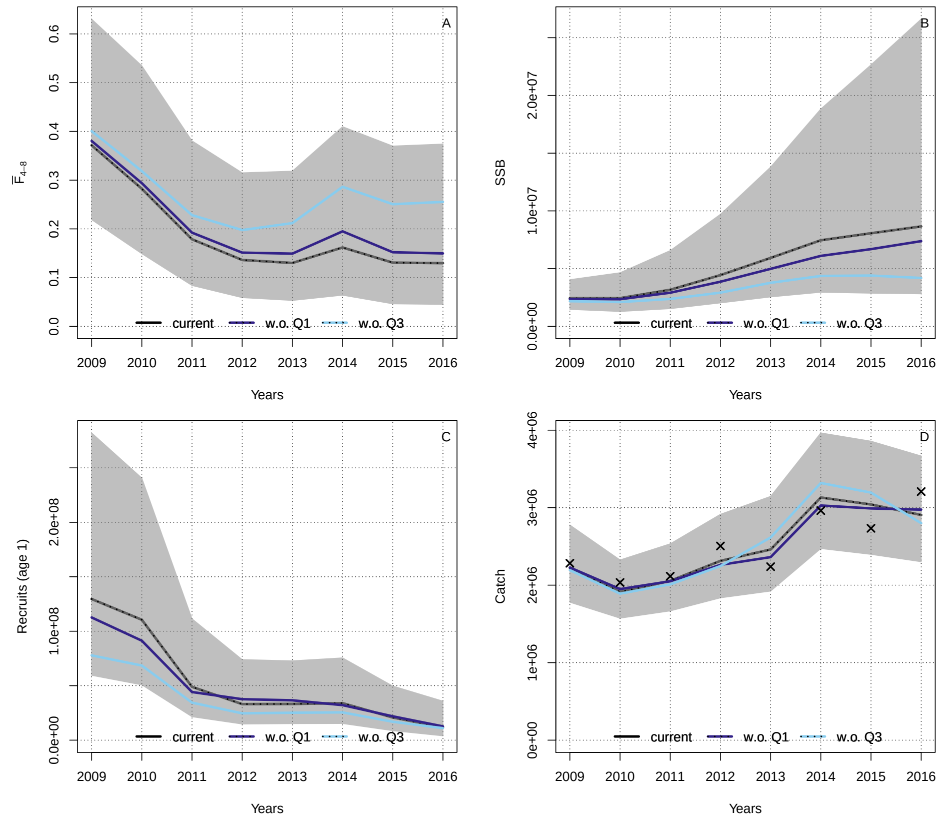


Figure 3: Leave out diagnostics for $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D).

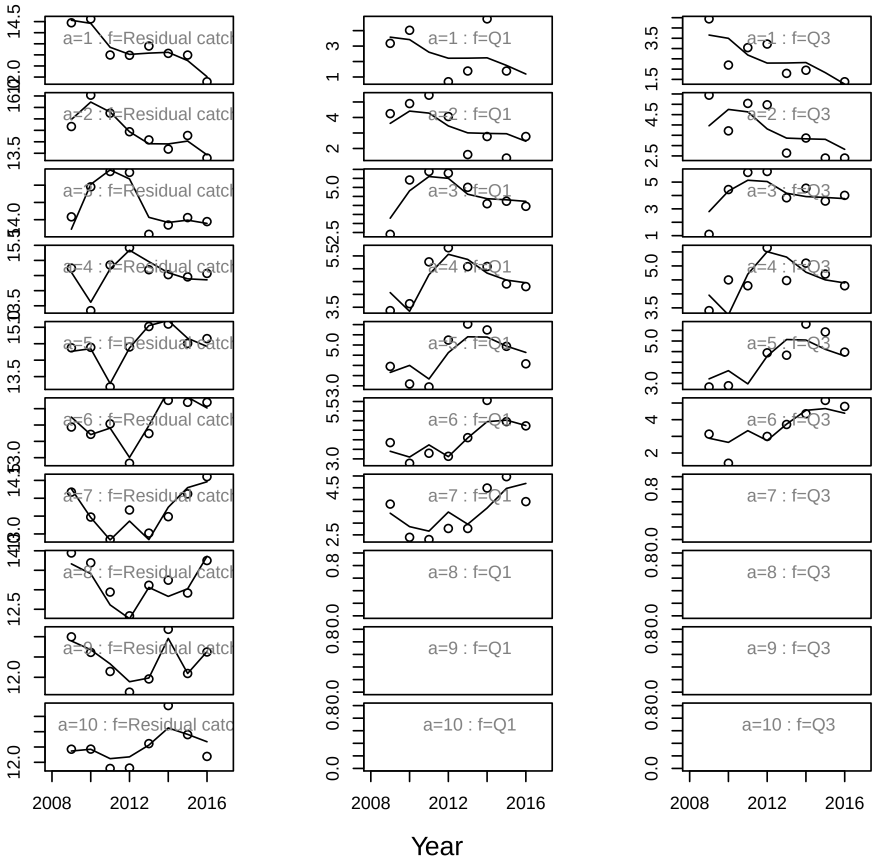


Figure 4: Log-scale observations (circles) and fitted values (lines) for each fleet (columns) and age group (rows).

Results — extended model

The main results of the model model (Fig 5). The standard model is fitting to all 4 data sources (Fig 8). SAM is an age based model and it was difficult to obtain convergence in the first few years when the only data available was the total landings. A technical 'trick' to obtain convergence for the entire data period was to provide artificial catches-at-age 10-6 years prior to the data period (1940-1944), then leaving a period of 5 years with no data before the total landings data started (1950). The artificial catches-at-age were chosen as the average catches-at-age for the observed period (2009-2016). To ensure that the artificial catches did not influence the assessment period two sensitivity runs were performed where all the artificial catches were doubled or halfed. The sensitivity runs showed no important influence of the artificial catches in the assessment period (1950-2016) (Fig 6). The extended model run is consistent with standard model in the period of the standard model (Fig 7).

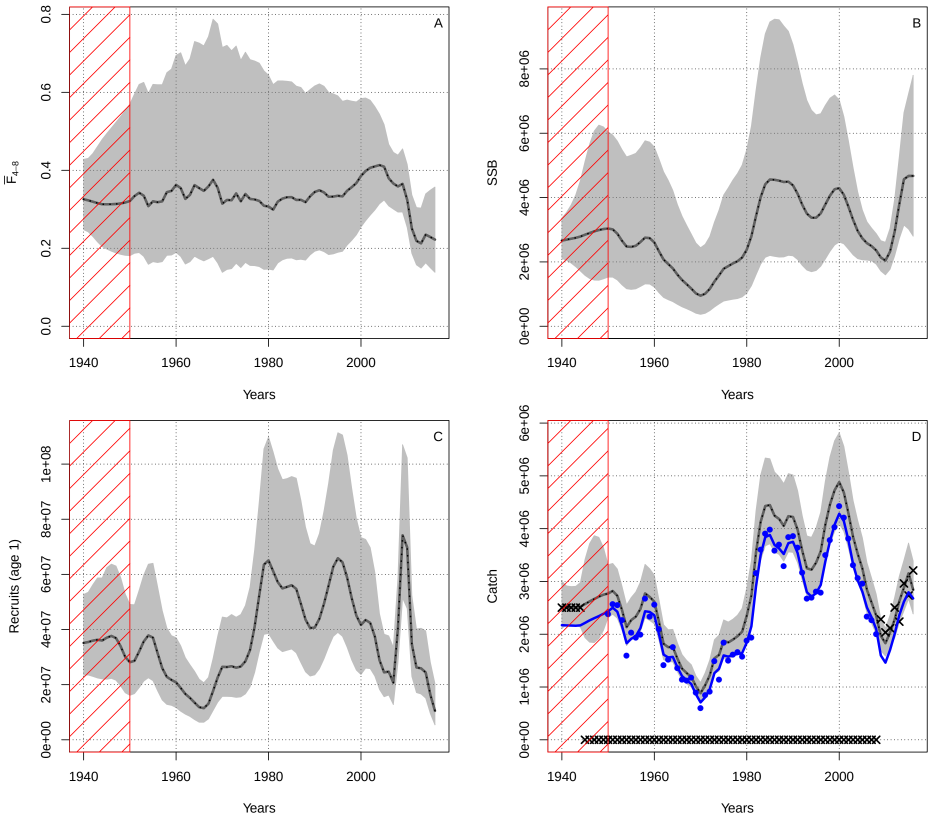


Figure 5: Estimates and point wise 95% confidence intervals of $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D). The area shaded with red lines is the period prior to the observations used for initialization. The blue line and blue points (D) are the predicted and observed total landings.

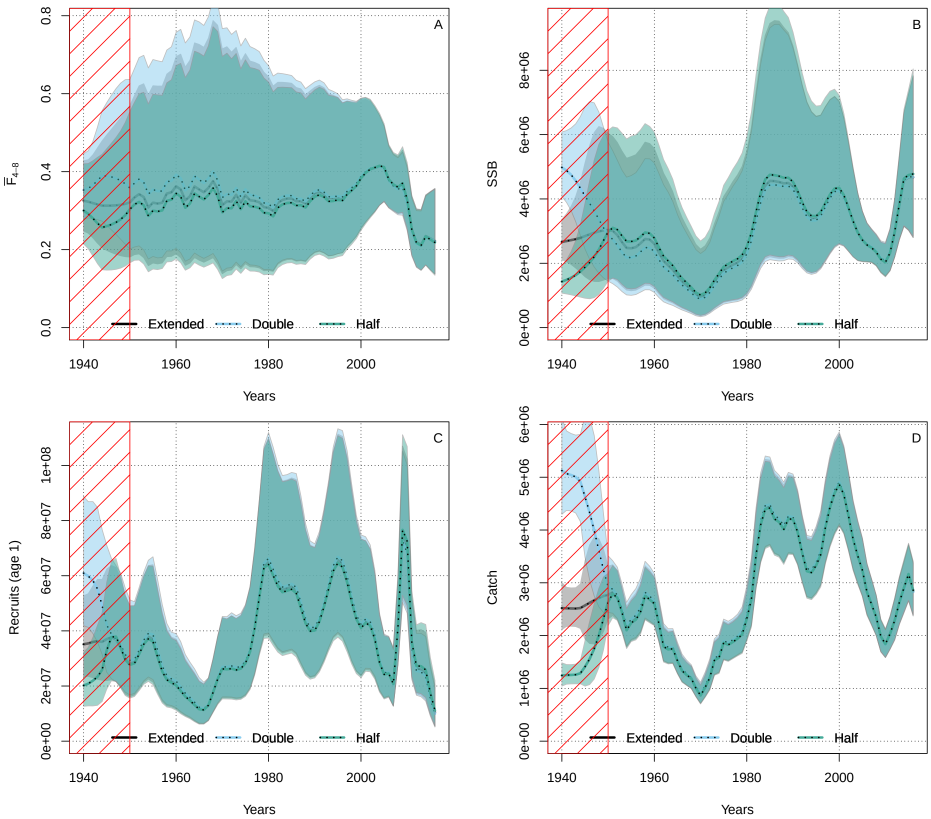


Figure 6: Sensitivity to artificial initial catch in 1940-1944. Estimates and point wise 95% confidence intervals of $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D) compared to runs with half and double initial catch. The area shaded with red lines is the period prior to the observations used for initialization.

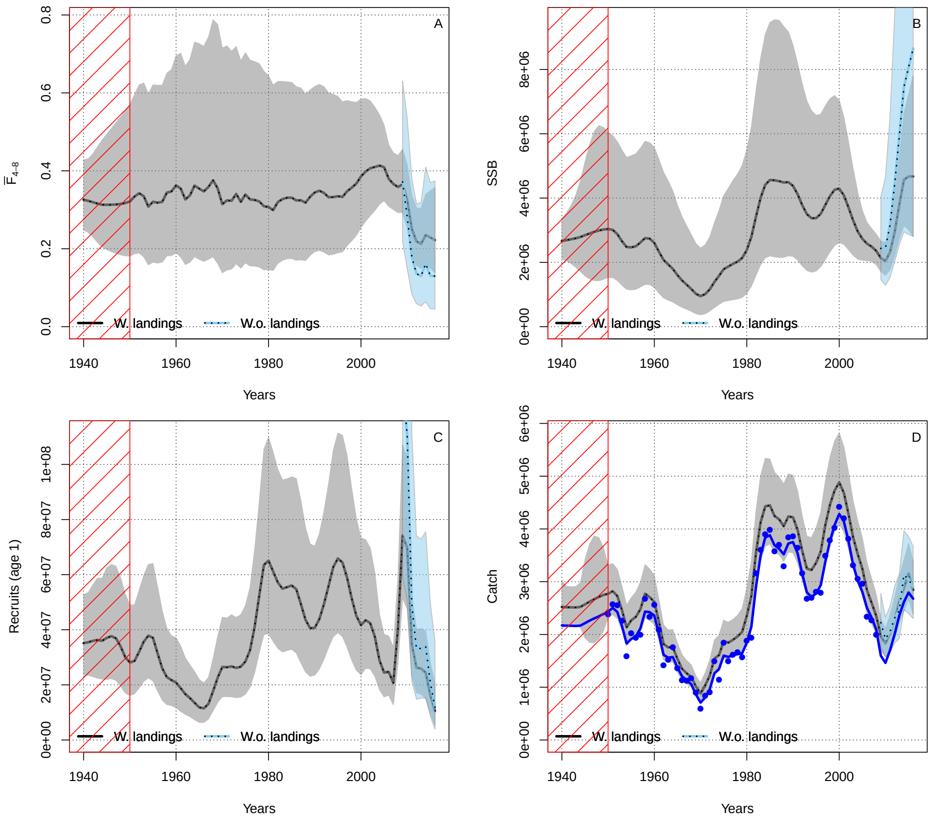


Figure 7: Estimates and point wise 95% confidence intervals of $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D). The area shaded with red lines is the period prior to the observations used for initialization. The blue line and blue points (D) are the predicted and observed total landings. The shaded light blue area and the dotted line is the results from the standard model (not extended back in time).

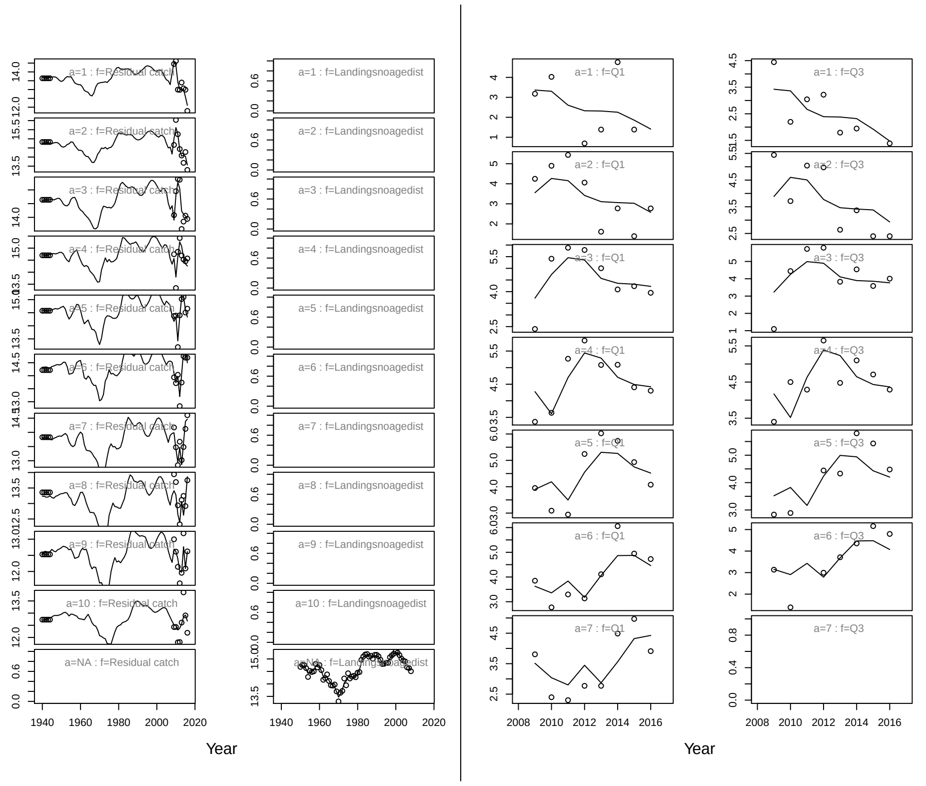


Figure 8: Log-scale observations (circles) and fitted values (lines) for each fleet (columns) and age group (rows).

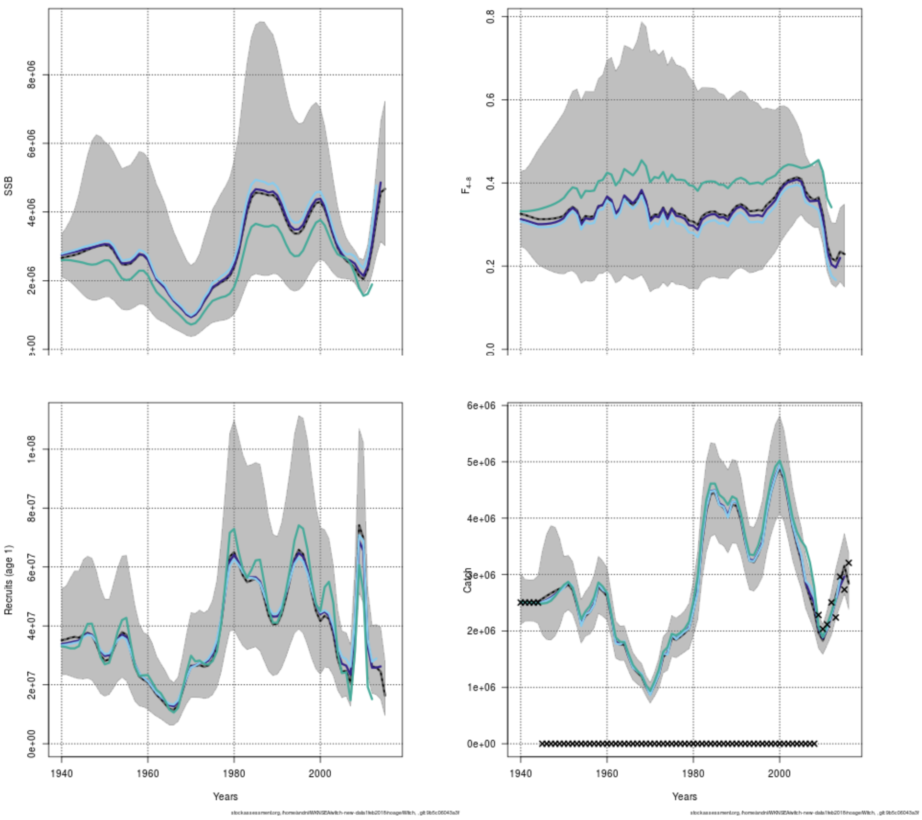


Figure 9: Retrospective for the extended model

Results — Extended Model with new exploitable biomass surveys

The results of the extended model with and without the two new exploitable biomass surveys (Fig 10). The two models show similar trends, and — as expected — the confidence intervals are more narrow in the period covered by the two new exploitable biomass surveys.

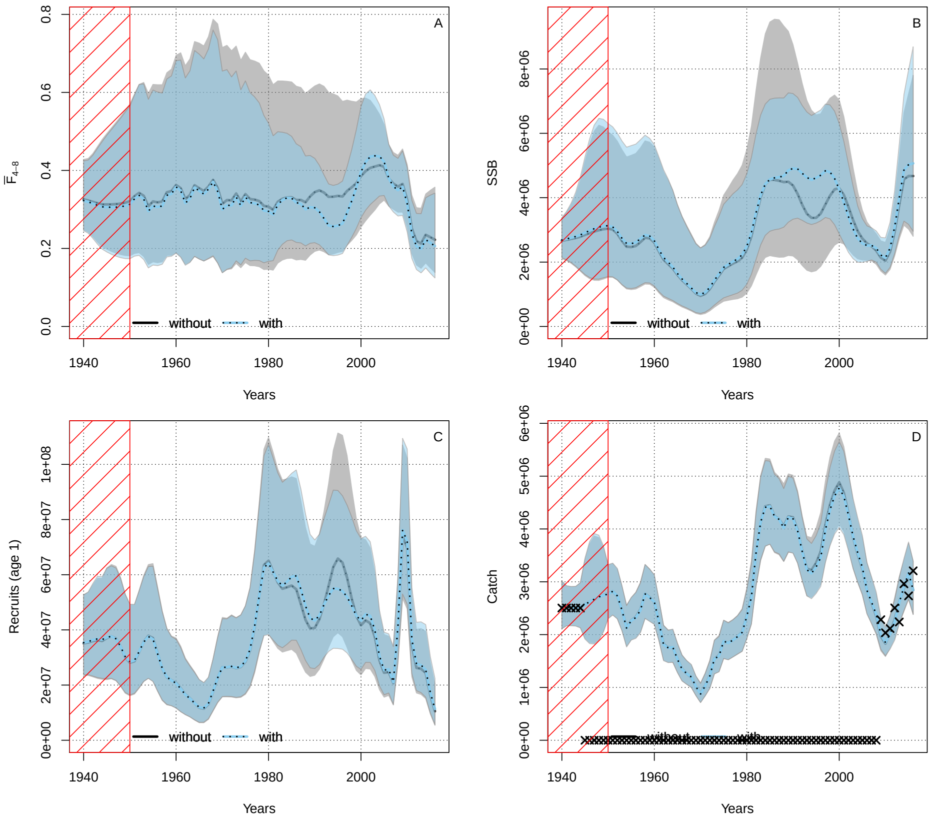


Figure 10: Estimates and point wise 95% confidence intervals of $\bar{F}$ (A), spawning stock biomass (B), recruitment (C), and catch weight (D). The area shaded with red lines is the period prior to the observations used for initialization. The shaded light blue area and the dotted line is the results from the model using the two new indices of exploitable biomass.

References

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Berg C. W., A. Nielsen, K. Kristensen 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research , 151: 91-99.

Berg C. W. 2018. Survey Index Calculations for Witch Flounder from IBTS and BTS data (WD XX presented during benchmark)

Kristensen, K, A. Nielsen, C.W. Berg, H.J. Skaug, B. Bell. 2016. TMB: Automatic differentiation and laplace approximation. Journal of Statistical Software 70 (5), 1-21

Nielsen, A. and C.W. Berg 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research 158, 96-101

Thygesen, U.H., C.M. Albertsen, C.W. Berg, K. Kristensen, and A. Nielsen 2017. Validation of state space models fitted as mixed effects models. (Subm. EES).

Witch flounder in Subarea IV (North Sea) and Division IIIa (Skagerrak, Kattegat) and d (Eastern Channel)

Alexandros Kokkalis

08 February, 2018

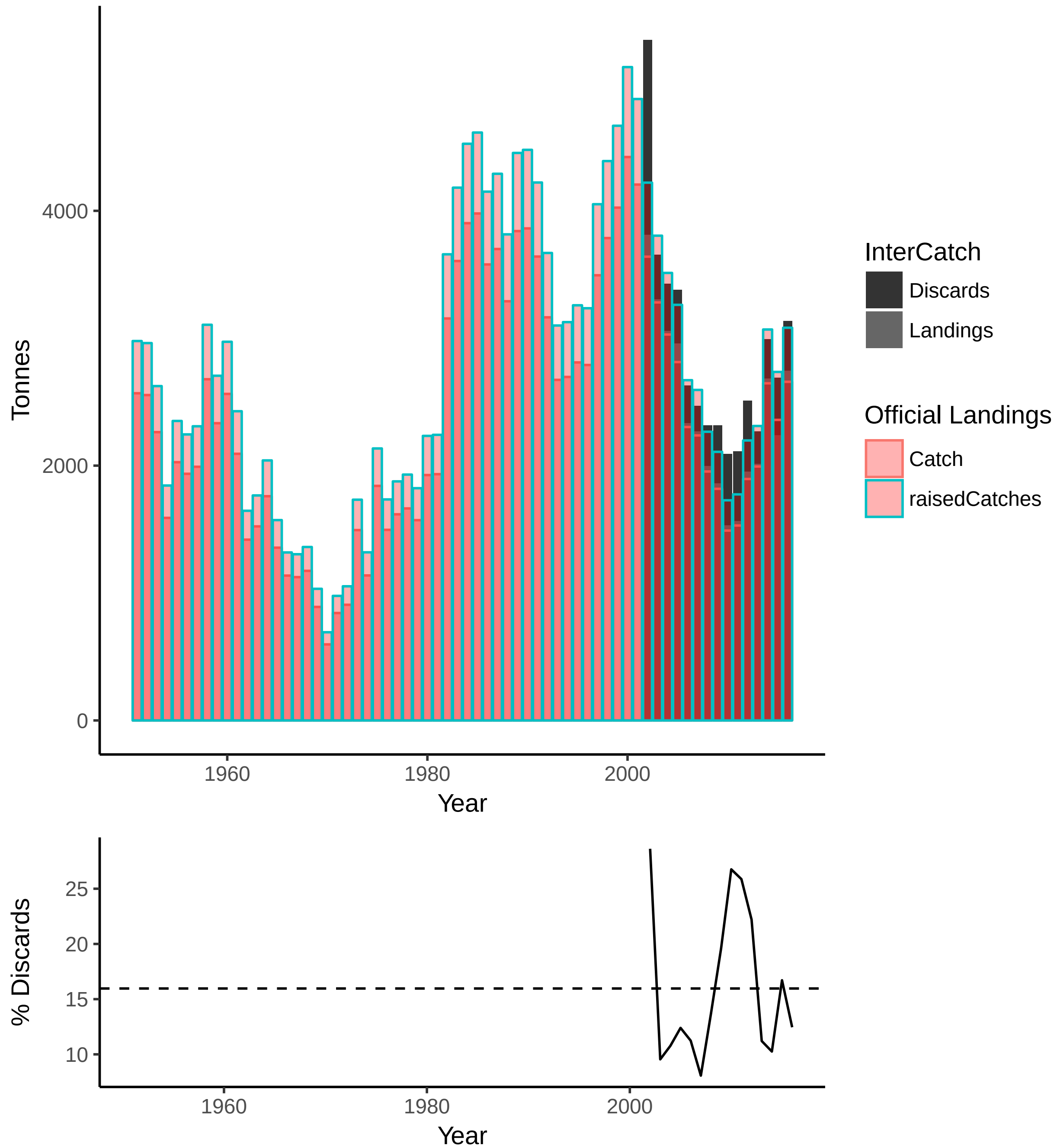
Scenarios overview

Scenario Name	Catch/Landings	Biomass index	Priors	Diagnostics
Scenario 1	IC 2003-2016	Q1 IBTS, Q3 IBTS + BTS	default	Converges, good diagnostics/retro/ini
Scenario 2	IC 2002-2016	Q1 IBTS, Q3 IBTS + BTS	default	**Does not converge**
Scenario 3	Rec. official landings (16%) 1983-2001 + IC 2002-2016	Q1 IBTS, Q3 IBTS + BTS	default	**Does not converge**
Scenario 4	Rec. official landings (16%) 1983-2002 + IC 2003-2016	Q1 IBTS, Q3 IBTS + BTS	default	Converges, good diagnostics/retro/ini
Scenario 5	Same as scenario 1	Same as scenario 1	No n prior	**Does not converge**
Scenario 6	Same as scenario 4	Same as scenario 4	No n prior	Converges, good diagnostics/retro/ini

Compilation of available data

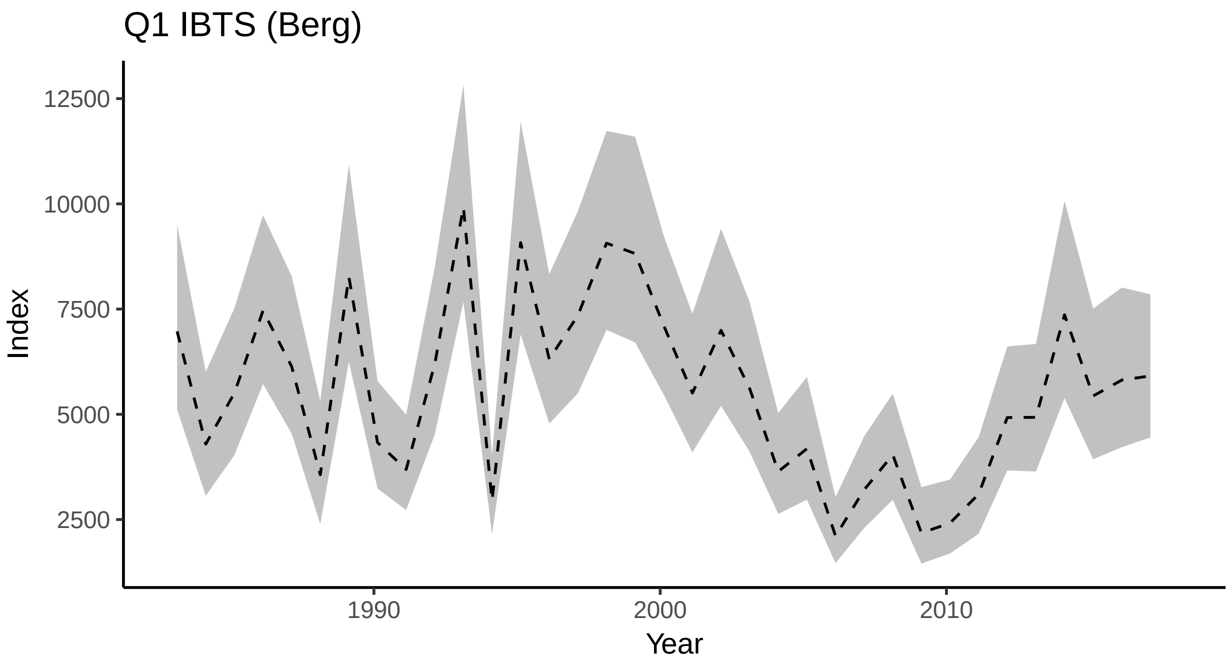
Catch and landings data

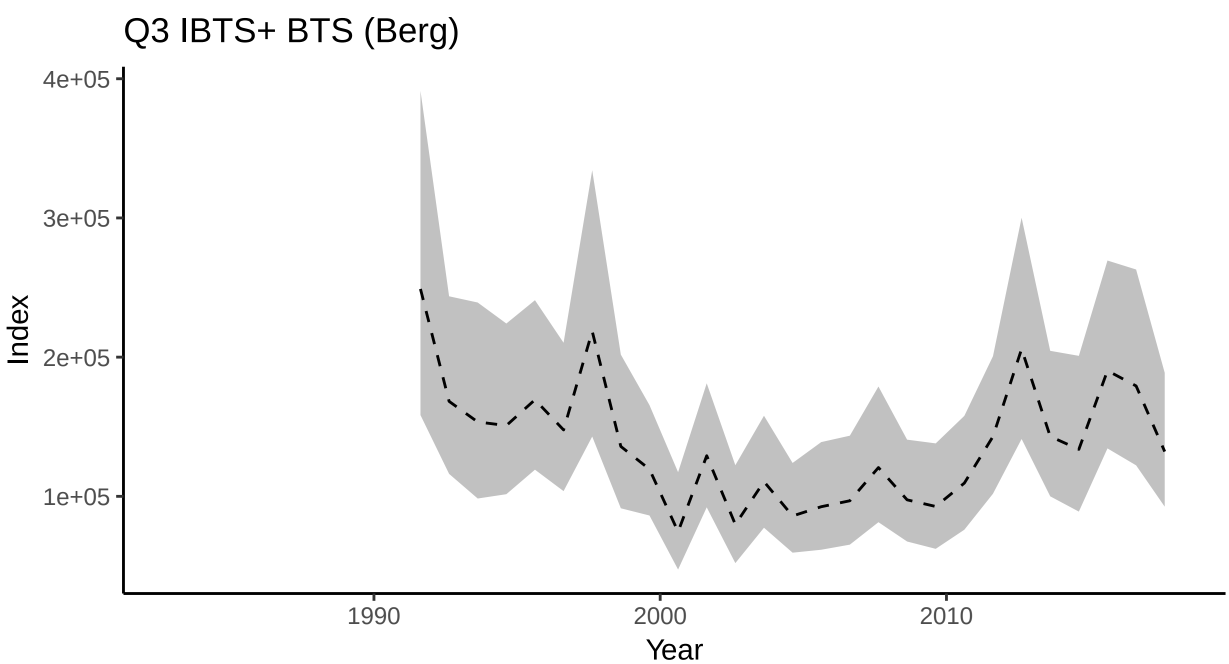
Landings and discards for the years 2002-2016 from InterCatch.



Survey indices

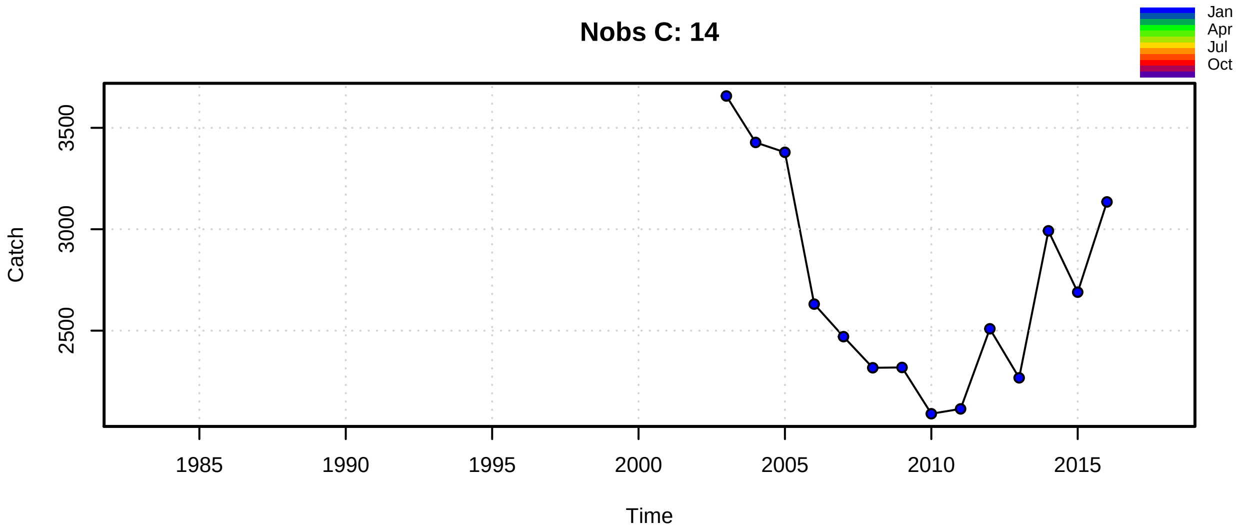
Two new biomass indices were calculated, Q1: using IBTS data and Q3: using IBTS + BTS data.

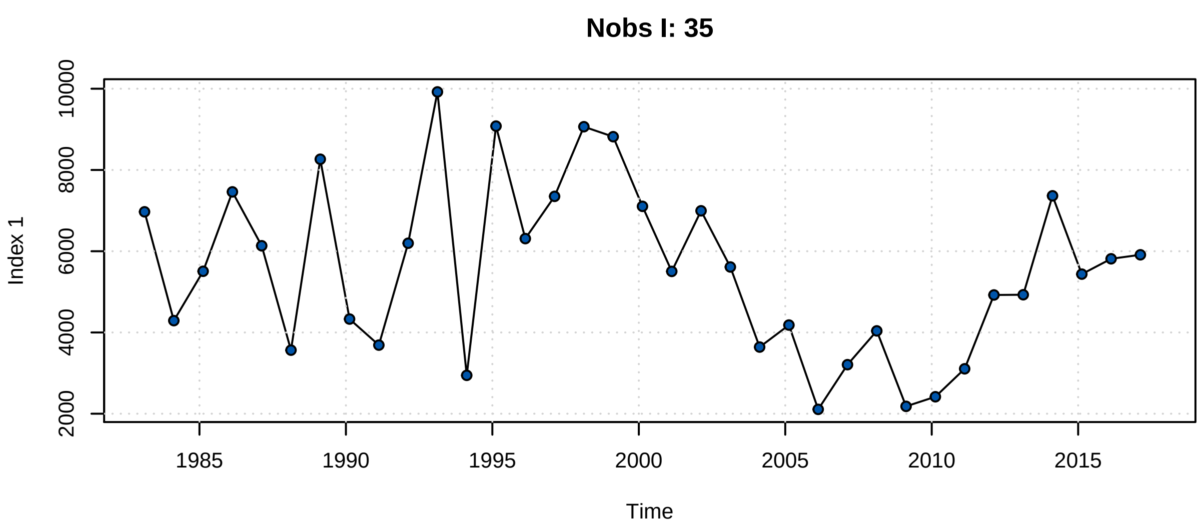

Q1 IBTS (Berg)
12500
10000
7500
5000
2500
Index
1990
2000
2010
Year

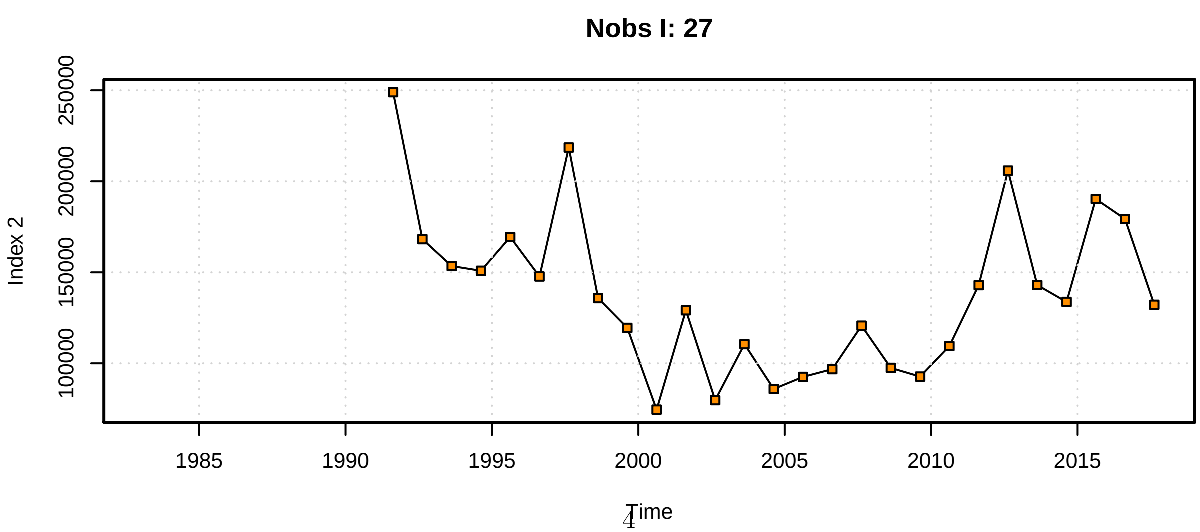

Q3 IBTS+ BTS (Berg)
4e+05
3e+05
2e+05
1e+05
Index
1990
2000
2010
Year

SPiCT assessment

Scenario 1: Intercatch minus 2002



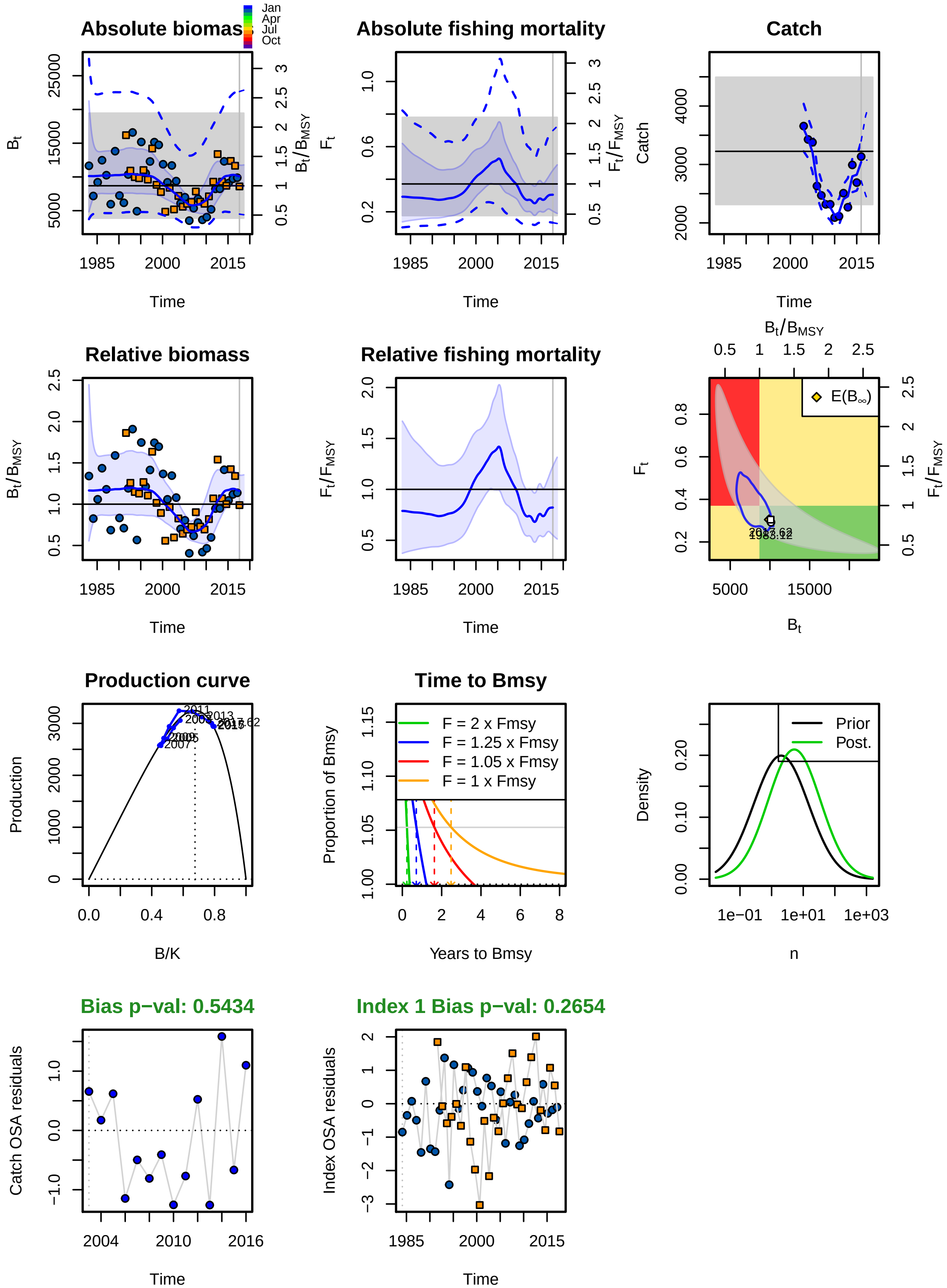




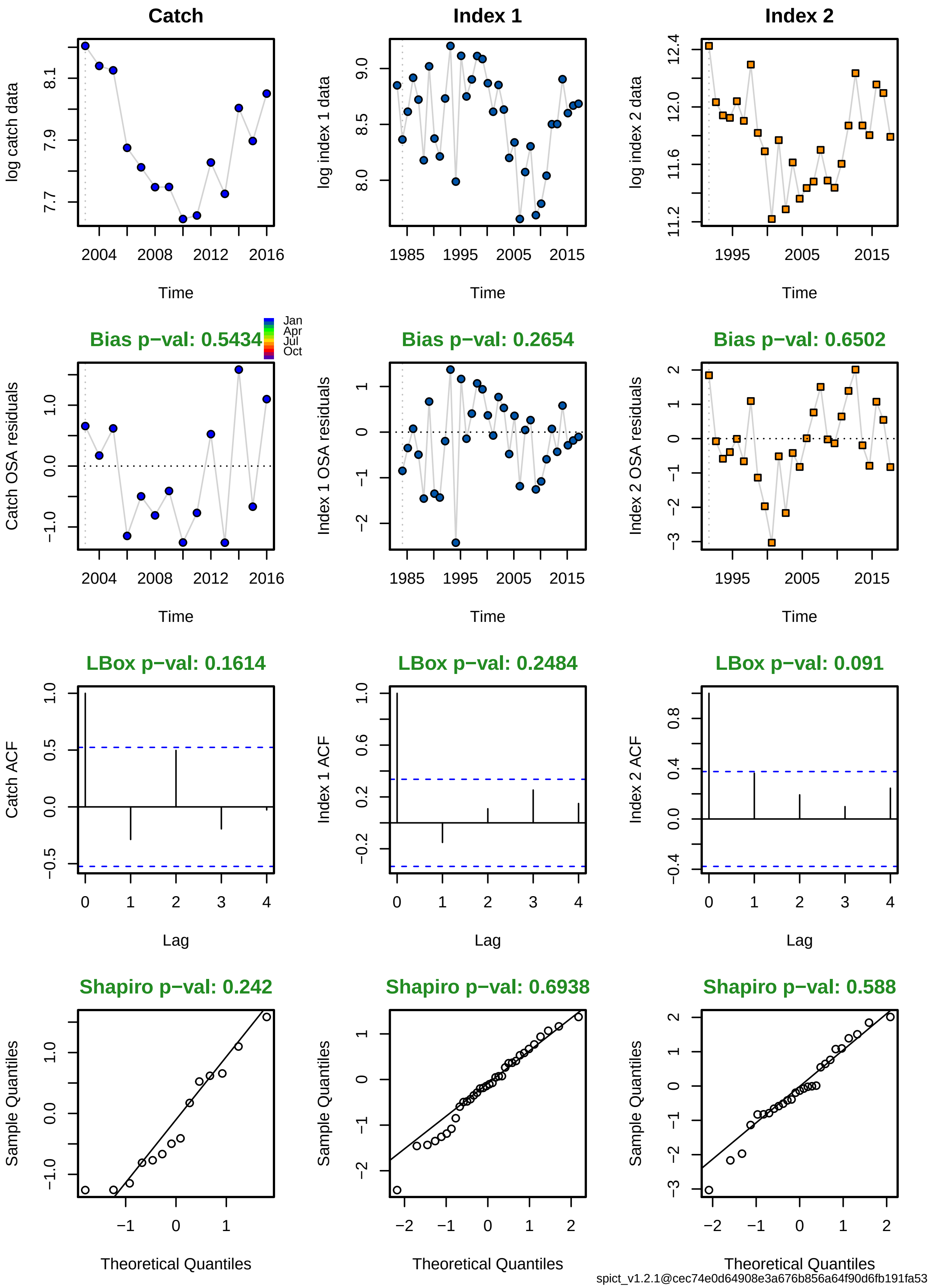
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

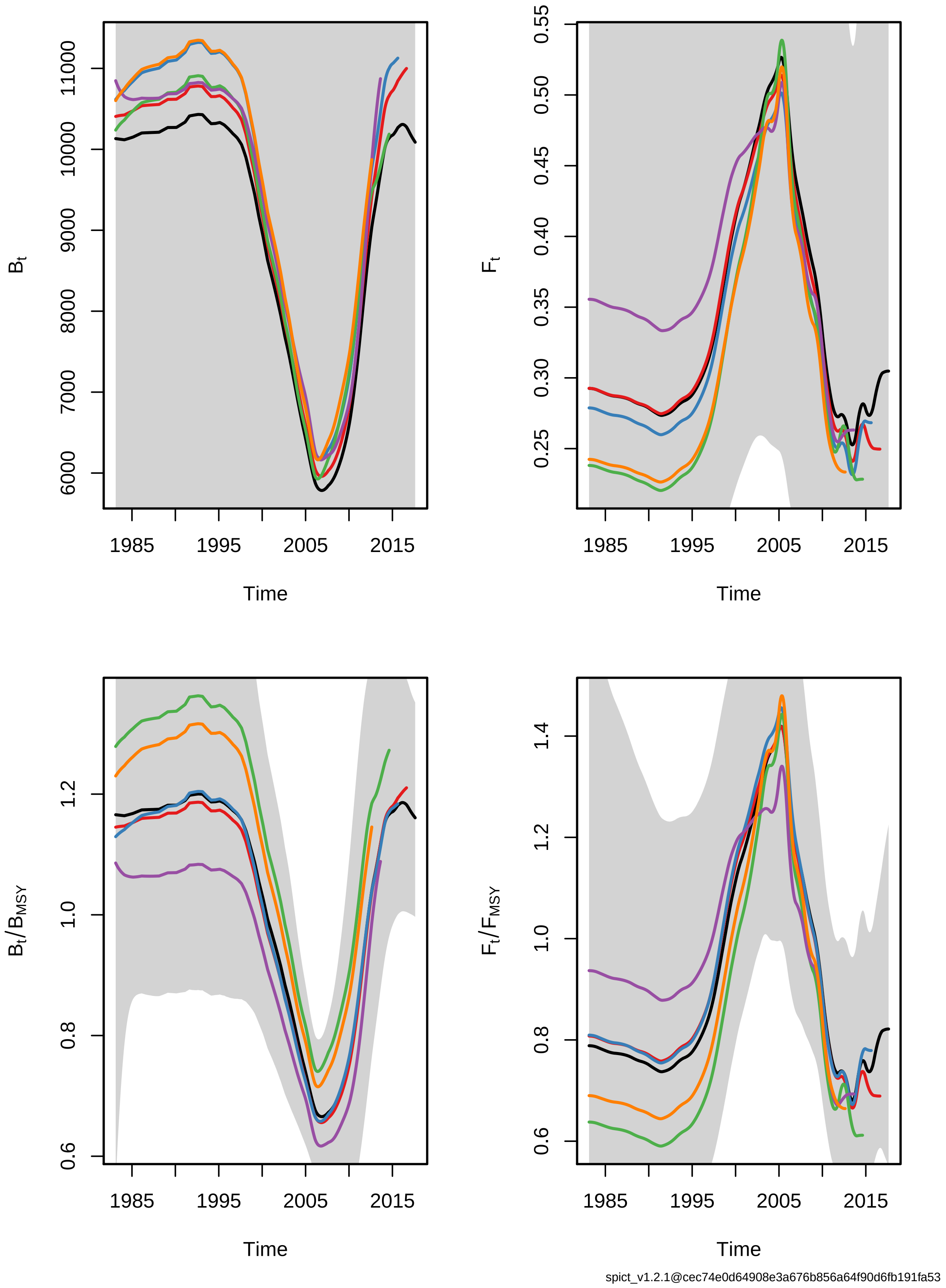
```
## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 19.4557486
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 14,  Nobs I1: 35,  Nobs I2: 27
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.2420 0.5434 0.0629 0.1614       -    -   .    -
##  I1  0.6938 0.2654 0.1395 0.2484       -    -   -    -
##  I2  0.5880 0.6502 0.0583 0.0910       -    -   .    .
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##            estimate        cilow        ciupp    log.est
##  alpha1 8.331594e+00    2.0223433 3.432427e+01  2.1200548
##  alpha2 5.211552e+00    1.2678059 2.142305e+01  1.6508777
##  beta   5.025512e-01    0.1813732 1.392476e+00 -0.6880577
##  r      1.938151e+00    0.0370034 1.015158e+02  0.6617346
##  rc     7.451522e-01    0.3534957 1.570745e+00 -0.2941668
##  rold   4.612418e-01    0.1640045 1.297184e+00 -0.7738328
##  m      3.246316e+03 2272.7838190 4.636854e+03  8.0852760
##  K      1.290063e+04 4334.6007139 3.839481e+04  9.4650312
##  q1     5.981181e-01    0.2817199 1.269862e+00 -0.5139671
##  q2     1.538312e+01    7.2720079 3.254127e+01  2.7332708
##  n      5.202028e+00    0.1241954 2.178914e+02  1.6490486
##  sdb    3.956730e-02    0.0098938 1.582370e-01 -3.2297533
##  sdf    1.269568e-01    0.0687012 2.346105e-01 -2.0639083
##  sdi1   3.296584e-01    0.2543925 4.271928e-01 -1.1096984
##  sdi2   2.062068e-01    0.1496705 2.840991e-01 -1.5788756
##  sdc    6.380230e-02    0.0321441 1.266403e-01 -2.7519660
##
## Deterministic reference points (Drp)
##           estimate        cilow        ciupp   log.est
##  Bmsyd 8713.1622468 3889.6616915 1.951820e+04  9.072590
##  Fmsyd    0.3725761    0.1767478 7.853727e-01 -0.987314
##  MSYd  3246.3158188 2272.7838190 4.636854e+03  8.085276
## Stochastic reference points (Srp)
##           estimate        cilow        ciupp    log.est rel.diff.Drp
##  Bmsys 8691.0923557 3881.7993211 1.945878e+04  9.0700539 -0.002539369
##  Fmsys    0.3710176    0.1764547 7.801103e-01 -0.9915057 -0.004200551
##  MSYs  3224.5141489 2313.9706355 4.493355e+03  8.0785376 -0.006761226
##
## States w 95% CI (inp$msytype: s)
##                  estimate        cilow        ciupp    log.est
##  B_2017.62      1.008795e+04 4492.3745282 2.265324e+04  9.2190974
##  F_2017.62      3.048005e-01    0.1329538 6.987643e-01 -1.1880977
##  B_2017.62/Bmsy 1.160724e+00    0.9966137 1.351857e+00  0.1490435
##  F_2017.62/Fmsy 8.215257e-01    0.5508005 1.225316e+00 -0.1965920
##
## Predictions w 95% CI (inp$msytype: s)
```

```
##                    prediction        cilow        ciupp    log.est
## B_2017.62      1.008795e+04 4492.3745282 2.265324e+04  9.2190974
## F_2017.62      3.048005e-01    0.1329538 6.987643e-01 -1.1880977
## B_2017.62/Bmsy 1.160724e+00    0.9966137 1.351857e+00  0.1490435
## F_2017.62/Fmsy 8.215257e-01    0.5508005 1.225316e+00 -0.1965920
## Catch_2017.62  3.064788e+03 2353.6800712 3.990741e+03  8.0277338
## E(B_inf)       9.891880e+03           NA           NA  9.1994695
```



spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53


Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.5434
Jan
Apr
Jul
Oct
Bias p−val: 0.2654
Bias p−val: 0.6502
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.1614
LBox p−val: 0.2484
LBox p−val: 0.091
Catch ACF
Index 1 ACF
Index 2 ACF
Lag
Shapiro p−val: 0.242
Shapiro p−val: 0.6938
Shapiro p−val: 0.588
Sample Quantiles
Theoretical Quantiles
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53


B_t
Time
F_t
Time
B_t/B_MSY
Time
F_t/F_MSY
Time
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

```
## Checking sensitivity of fit to initial parameter values...
##  Trial 1 ... model fitted!
##  Trial 2 ... convergence not obtained!
##  Trial 3 ... model fitted!
##  Trial 4 ... model fitted!
##  Trial 5 ... model fitted!
##  Trial 6 ... model fitted!
##  Trial 7 ...obj$par:
##       logm       logK       logq       logq       logn     logsdb
##  7.1720218  7.4808875 -2.6275123 -1.5900789  2.3732691 -0.6584951
##     logsdf     logsdi     logsdi     logsdc
## -2.4931942 -1.5700749 -3.6741815 -1.3120828
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
##  fit failed!
##  Trial 8 ... model fitted!
##  Trial 9 ...obj$par:
##       logm       logK       logq       logq       logn     logsdb
##  6.3681119  9.4613522 -0.1843782 -1.7874154  2.6567939  0.2260931
##     logsdf     logsdi     logsdi     logsdc
## -2.1183102 -2.4804102 -3.1750638  0.2150654
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
##  fit failed!
##  Trial 10 ... convergence not obtained!
## $propchng
##           logm  logK  logq  logq  logn logsdb logsdf logsdi logsdi logsdc
## Trial 1  -2.57  0.06  0.06 -1.46 -4.28  -0.40   1.40   0.77  -0.48  -0.04
## Trial 2   1.29  0.02 -0.12 -5.02  2.46  -0.97   0.61   0.67   0.90   0.77
## Trial 3  -1.22 -0.09 -0.20  5.46  3.34  -0.89  -0.07  -1.19  -0.95   1.30
## Trial 4  -0.29 -0.11 -0.11 -0.09  3.78  -0.74   0.85   0.69  -1.41  -0.88
## Trial 5   0.35  0.07 -0.11 -1.44  2.02  -0.01  -0.51   0.04   0.73  -0.76
## Trial 6  -2.83 -0.09  0.12 -0.05  4.12  -0.01   0.02  -0.72   0.93  -1.00
## Trial 7   2.42 -0.22 -0.11  5.77  3.10  -0.59   0.55  -0.02   1.28  -0.18
## Trial 8  -2.51  0.19 -0.28 -3.36  4.86  -0.05   0.33   1.23   0.51  -0.48
## Trial 9   2.83 -0.01 -0.21 -0.53  3.60  -1.14   0.32   0.54   0.97  -1.13
## Trial 10 -2.22  0.19 -0.21  4.37  4.68  -0.03   0.57   1.35   0.54  -0.69
##
## $inimat
##          Distance  logn  logK logm logq1 logq2 logsdb logsdf logsdi1
## Basevec      0.00  0.69  9.59 8.01 -0.39 -0.39  -1.61  -1.61   -1.61
## Trial 1      3.80 -1.09 10.15 8.52  0.18  1.27  -0.96  -3.87   -2.84
## Trial 2      3.83  1.58  9.80 7.01  1.56 -1.34  -0.06  -2.59   -2.68
## Trial 3      4.75 -0.15  8.68 6.44 -2.51 -1.68  -0.18  -1.49    0.30
## Trial 4      3.98  0.49  8.51 7.11 -0.35 -1.86  -0.41  -2.99   -2.72
## Trial 5      2.40  0.94 10.26 7.15  0.17 -1.17  -1.60  -0.79   -1.68
## Trial 6      3.79 -1.27  8.71 9.01 -0.37 -1.99  -1.59  -1.64   -0.45
## Trial 7      4.53  2.37  7.48 7.17 -2.63 -1.59  -0.66  -2.49   -1.57
## Trial 8      4.70 -1.05 11.40 5.78  0.92 -2.28  -1.52  -2.14   -3.59
## Trial 9      4.33  2.66  9.46 6.37 -0.18 -1.79   0.23  -2.12   -2.48
```

```
## Trial 10     4.73 -0.84 11.43 6.33 -2.08 -2.21  -1.56  -2.53   -3.79
##          logsdi2 logsdc
## Basevec    -1.61  -1.61
## Trial 1    -0.84  -1.54
## Trial 2    -3.05  -2.84
## Trial 3    -0.08  -3.70
## Trial 4     0.66  -0.19
## Trial 5    -2.79  -0.39
## Trial 6    -3.11  -0.01
## Trial 7    -3.67  -1.31
## Trial 8    -2.44  -0.83
## Trial 9    -3.18   0.22
## Trial 10   -2.49  -0.49
##
## $resmat
##          Distance       m        K   q     q   n  sdb  sdf  sdi  sdi  sdc
## Basevec      0.00 3246.32 12900.63 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 1      0.02 3246.32 12900.61 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 2      0.00      NA       NA  NA    NA  NA   NA   NA   NA   NA   NA
## Trial 3      0.01 3246.32 12900.61 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 4      0.01 3246.32 12900.61 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 5      0.01 3246.32 12900.64 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 6      0.00 3246.32 12900.62 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 7      0.00      NA       NA  NA    NA  NA   NA   NA   NA   NA   NA
## Trial 8      0.00 3246.32 12900.63 0.6 15.38 5.2 0.04 0.13 0.33 0.21 0.06
## Trial 9      0.00      NA       NA  NA    NA  NA   NA   NA   NA   NA   NA
## Trial 10     0.00      NA       NA  NA    NA  NA   NA   NA   NA   NA   NA

## NULL
```

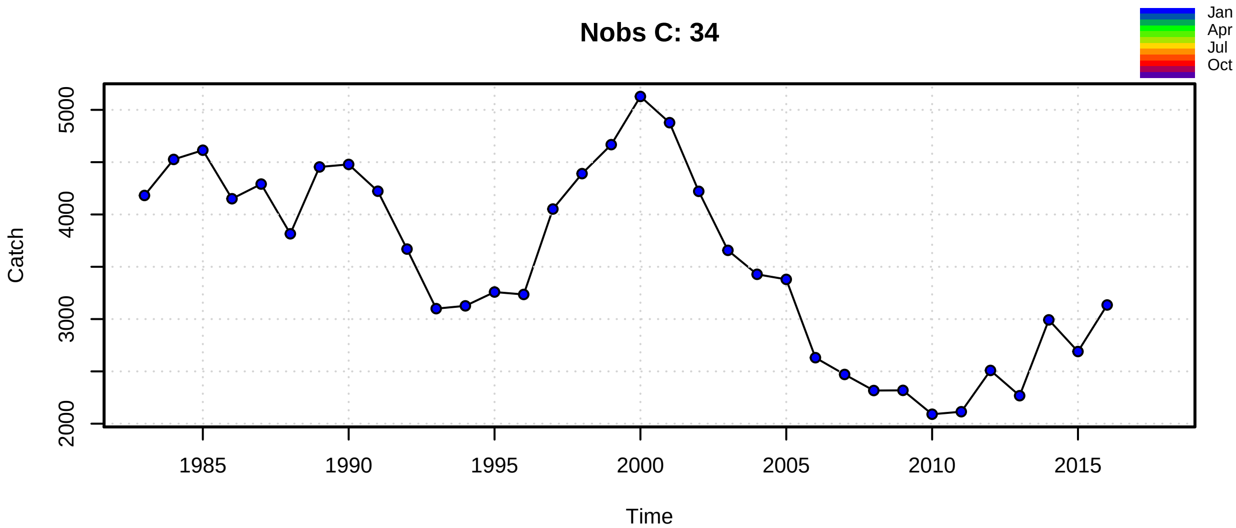
Scenario 2 Intercatch data

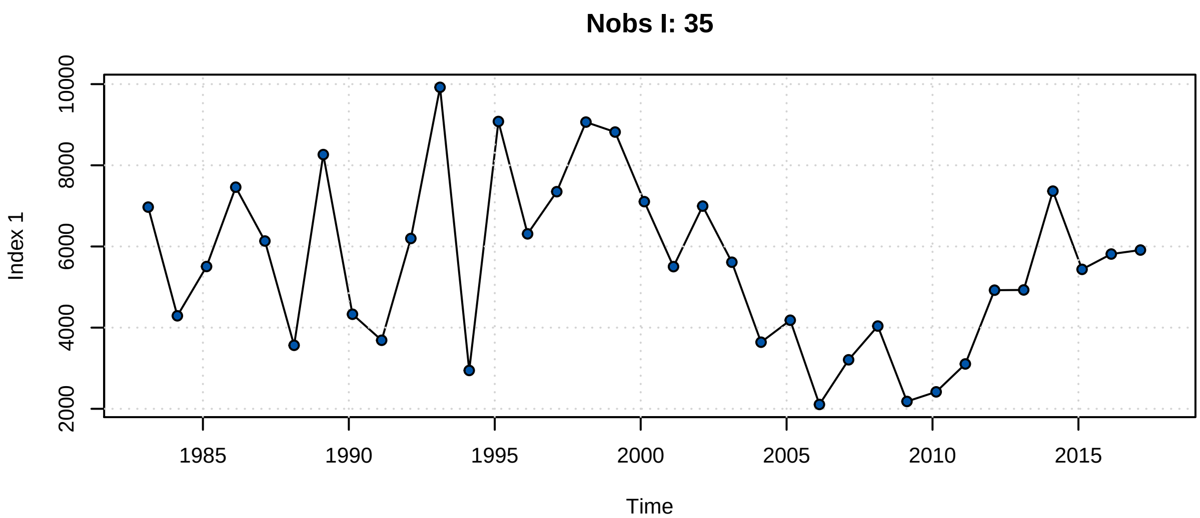
Does not converge

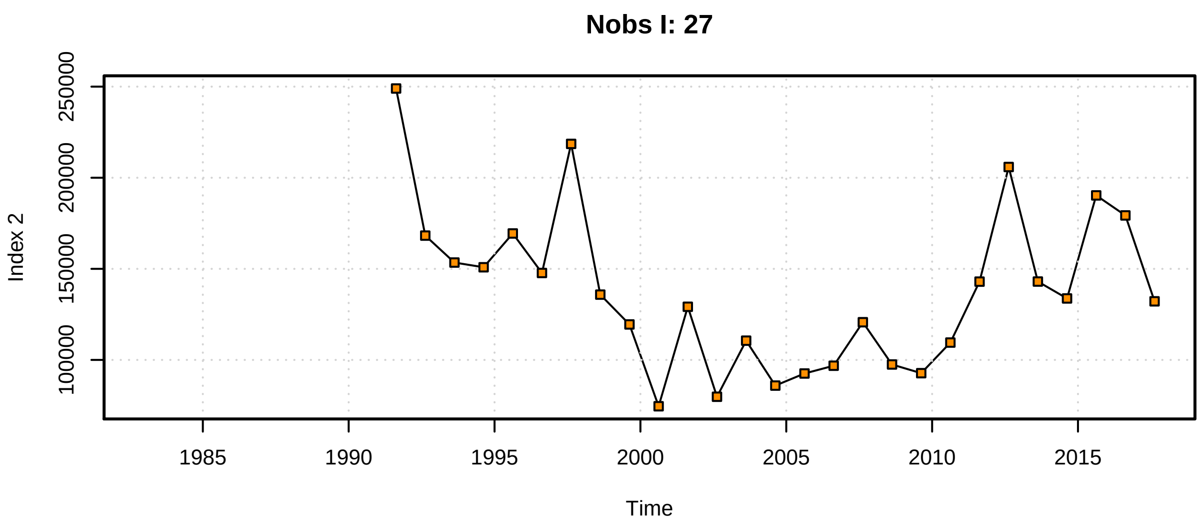
Scenario 3 Intercatch data + Reconstructed off. landings

Does not converge

Scenario 4 Intercatch data (minus 2002) + Reconstructed off. landings



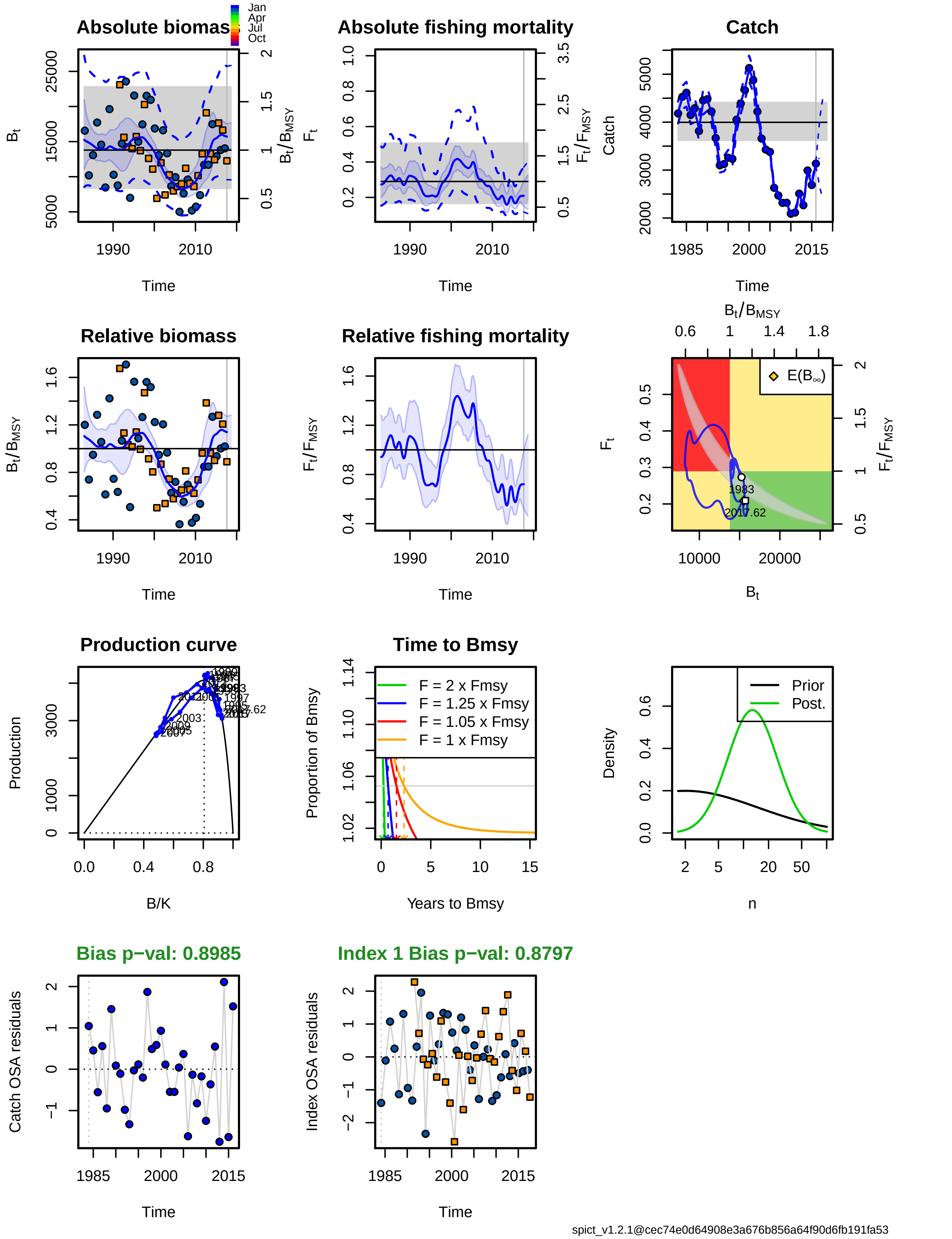




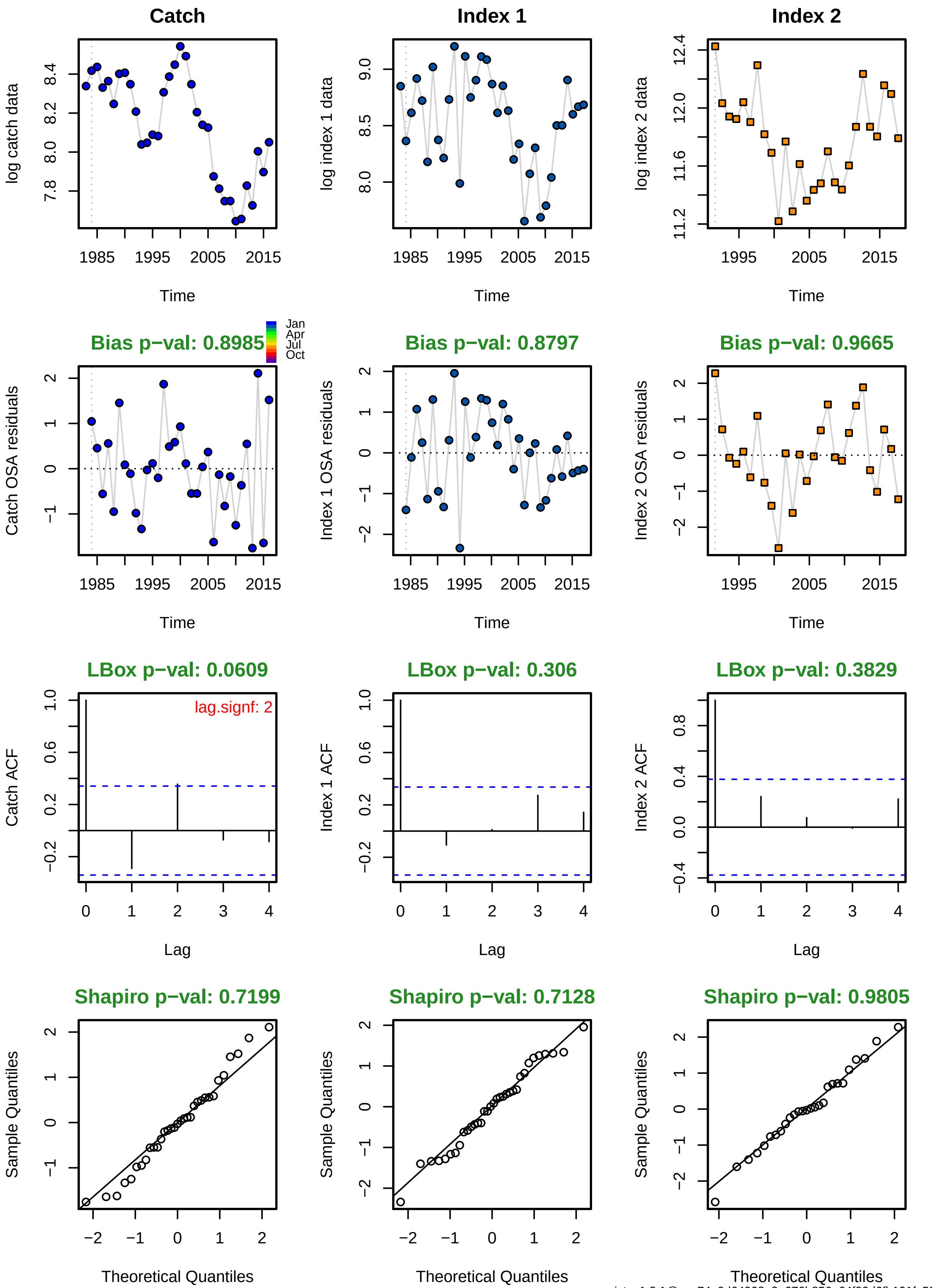
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

```
## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 4.4402231
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 34,  Nobs I1: 35,  Nobs I2: 27
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.7199 0.8985 0.0409 0.0609       -    -   *    .
##  I1  0.7128 0.8797 0.1118 0.3060       -    -   -    -
##  I2  0.9805 0.9665 0.2096 0.3829       -    -   -    -
##
## Priors
##      logn  ~  dnorm[log(2), 2^2]
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##            estimate        cilow        ciupp    log.est
##  alpha1 8.049977e+00 1.555245e+00 4.166684e+01  2.0856692
##  alpha2 5.474798e+00 9.672263e-01 3.098904e+01  1.7001553
##  beta   1.290648e-01 2.317990e-02 7.186268e-01 -2.0474407
##  r      3.773273e+00 8.960818e-01 1.588872e+01  1.3279429
##  rc     5.886158e-01 3.423167e-01 1.012128e+00 -0.5299816
##  rold   3.192053e-01 1.829413e-01 5.569657e-01 -1.1419209
##  m      4.076831e+03 3.671802e+03 4.526537e+03  8.3130751
##  K      1.718884e+04 1.024073e+04 2.885107e+04  9.7520154
##  q1     4.211392e-01 2.527301e-01 7.017694e-01 -0.8647918
##  q2     1.077856e+01 6.499011e+00 1.787616e+01  2.3775590
##  n      1.282084e+01 3.339132e+00 4.922652e+01  2.5510717
##  sdb    3.920470e-02 7.517000e-03 2.044713e-01 -3.2389597
##  sdf    1.555974e-01 1.145331e-01 2.113848e-01 -1.8604834
##  sdi1   3.155966e-01 2.460930e-01 4.047298e-01 -1.1532905
##  sdi2   2.146376e-01 1.553953e-01 2.964651e-01 -1.5388044
##  sdc    2.008210e-02 3.933000e-03 1.025417e-01 -3.9079240
##
## Deterministic reference points (Drp)
##           estimate        cilow        ciupp   log.est
##  Bmsyd 1.385226e+04 8353.3229480 2.297112e+04  9.536204
##  Fmsyd 2.943079e-01    0.1711584 5.060643e-01 -1.223129
##  MSYd  4.076831e+03 3671.8023120 4.526537e+03  8.313075
## Stochastic reference points (Srp)
##           estimate        cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 13787.804755 8337.4738106 2.280110e+04  9.531540 -0.004675067
##  Fmsys     0.289901    0.1659218 5.065191e-01 -1.238216 -0.015201379
##  MSYs   3996.813647 3621.7966454 4.410662e+03  8.293253 -0.020020176
##
## States w 95% CI (inp$msytype: s)
##                    estimate        cilow        ciupp    log.est
##  B_2017.62      1.570987e+04 9590.0827404 2.573493e+04  9.6620447
##  F_2017.62      2.089547e-01    0.1175470 3.714436e-01 -1.5656379
##  B_2017.62/Bmsy 1.139404e+00    1.0212569 1.271218e+00  0.1305049
##  F_2017.62/Fmsy 7.207796e-01    0.5229573 9.934333e-01 -0.3274219
##
## Predictions w 95% CI (inp$msytype: s)
```

```
##                   prediction        cilow        ciupp    log.est
## B_2017.62       1.570987e+04 9590.0827404 2.573493e+04  9.6620447
## F_2017.62       2.089547e-01    0.1175470 3.714436e-01 -1.5656379
## B_2017.62/Bmsy 1.139404e+00    1.0212569 1.271218e+00  0.1305049
## F_2017.62/Fmsy 7.207796e-01    0.5229573 9.934333e-01 -0.3274219
## Catch_2017.62  3.281874e+03 2399.3839890 4.488943e+03  8.0961699
## E(B_inf)       1.554781e+04           NA           NA  9.6516753
```


Absolute biomass
Jan
Apr
Jul
Oct
Absolute fishing mortality
Catch
Relative biomass
Relative fishing mortality
Production curve
Time to Bmsy
F = 2 x Fmsy
F = 1.25 x Fmsy
F = 1.05 x Fmsy
F = 1 x Fmsy
Prior
Post.
Bias p−val: 0.8985
Index 1 Bias p−val: 0.8797
Time
B/K
Years to Bmsy
Production
Proportion of Bmsy
Density
Catch OSA residuals
Index OSA residuals
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

Scenario 4 Intercatch data (minus 2002) + Reconstructed off. landings

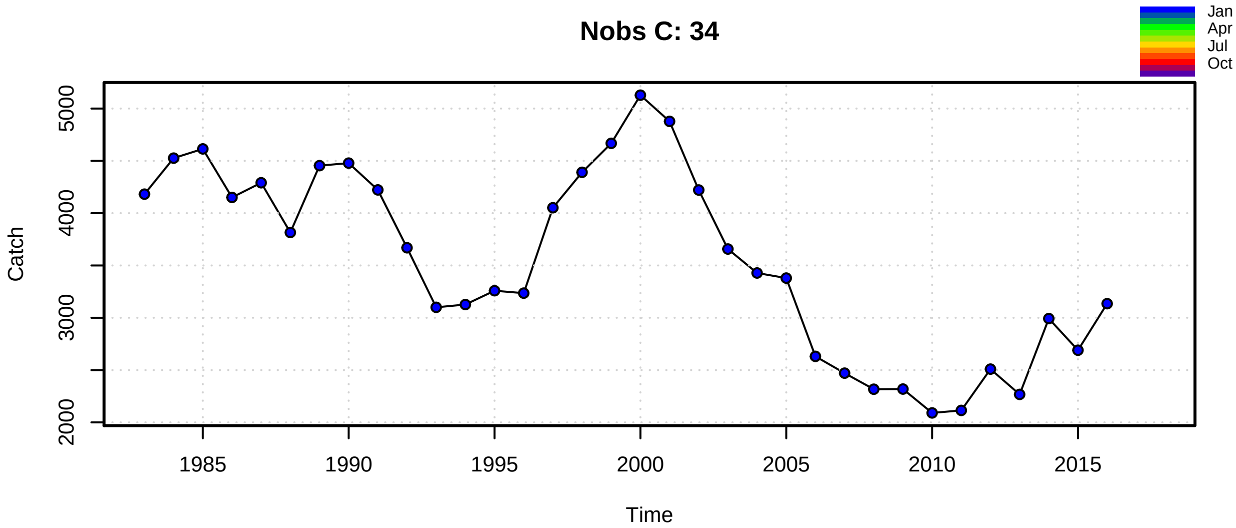


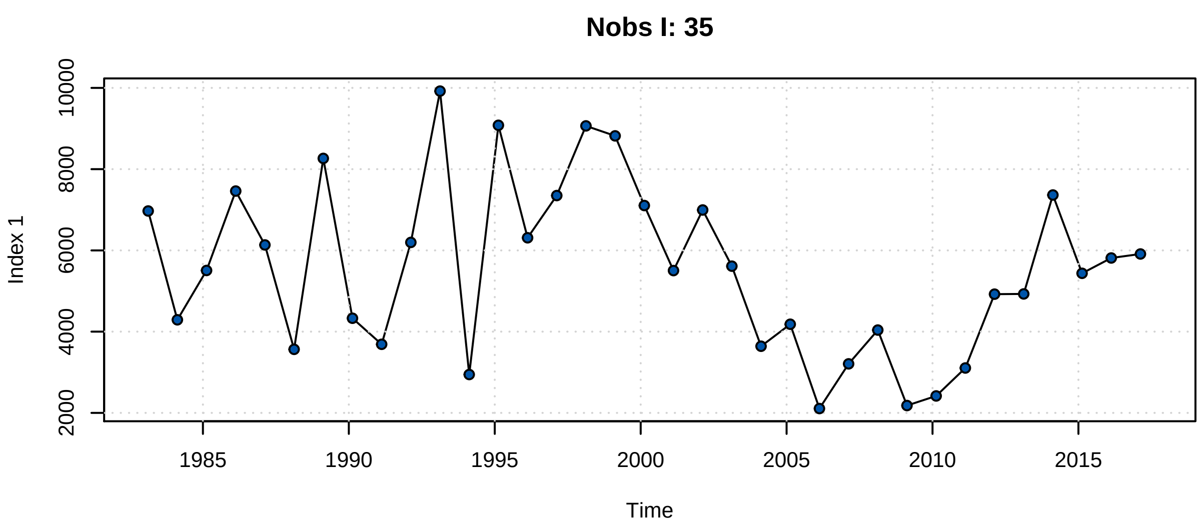
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

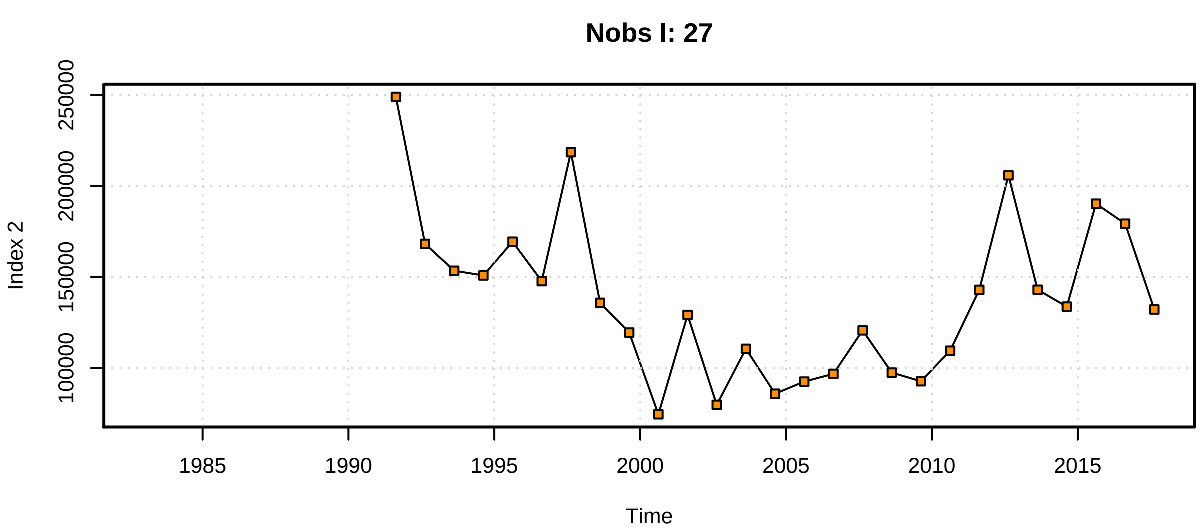
Scenario 5: Intercatch minus 2002 (no n prior)

Does not converge

Scenario 6: Intercatch data (minus 2002) + Reconstructed off. landings (no n prior)





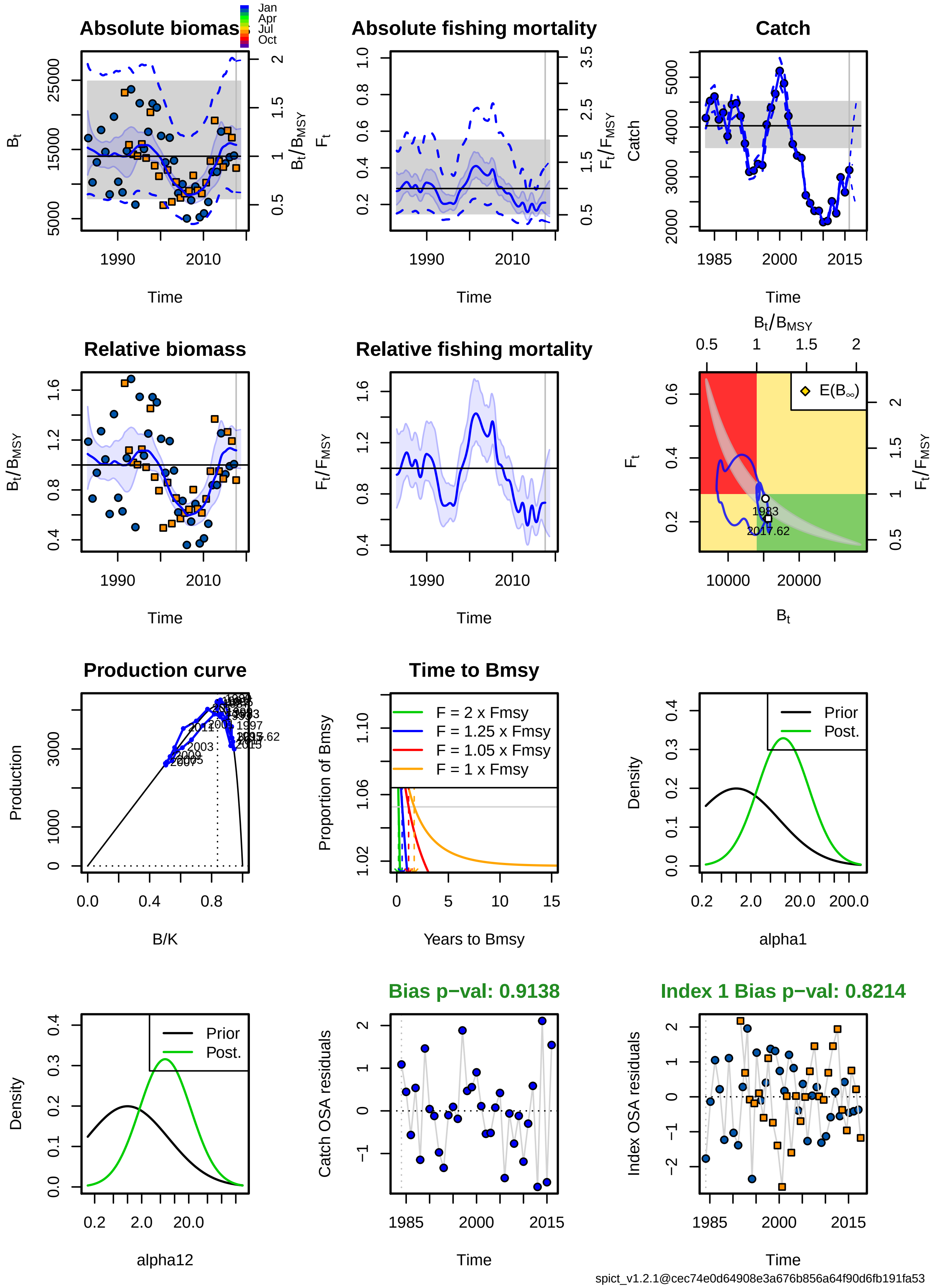


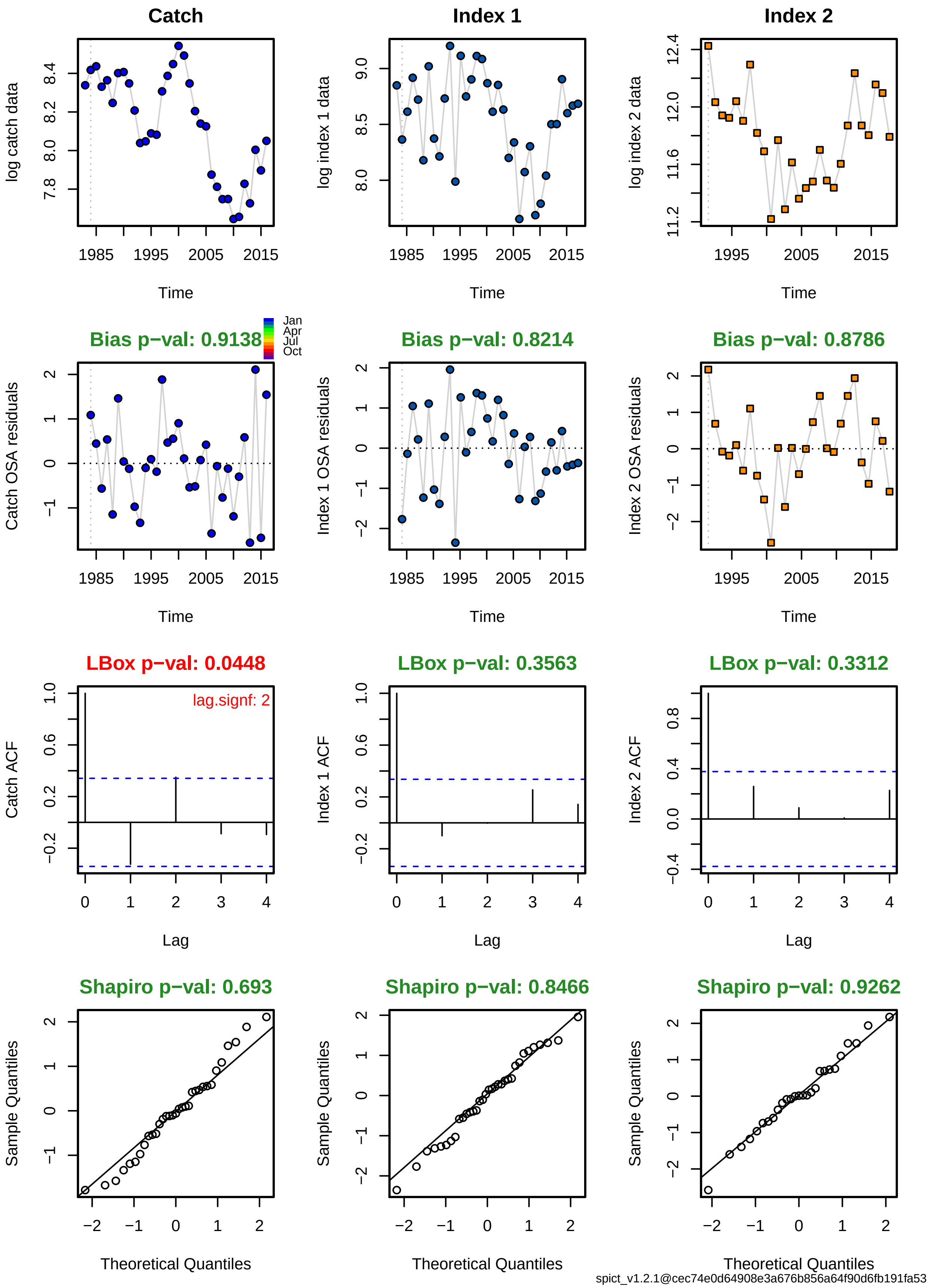
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

```
## Convergence: 0  MSG: relative convergence (4)
## Objective function at optimum: 5.5763448
## Euler time step (years):  1/16 or 0.0625
## Nobs C: 34,  Nobs I1: 35,  Nobs I2: 27
##
## Residual diagnostics (p-values)
##     shapiro   bias    acf   LBox shapiro bias acf LBox
##  C   0.6930 0.9138 0.0446 0.0448       -    -   *    *
##  I1  0.8466 0.8214 0.1375 0.3563       -    -   -    -
##  I2  0.9262 0.8786 0.1788 0.3312       -    -   -    -
##
## Priors
##  logalpha  ~  dnorm[log(1), 2^2]
##   logbeta  ~  dnorm[log(1), 2^2]
##
## Model parameter estimates w 95% CI
##             estimate        cilow        ciupp    log.est
##  alpha1 9.109326e+00    0.8458540 9.810182e+01  2.2092987
##  alpha2 6.299221e+00    0.5297900 7.489796e+01  1.8404261
##  beta   1.290742e-01    0.0225906 7.374816e-01 -2.0473680
##  r      4.979233e+00    0.7719303 3.211787e+01  1.6052759
##  rc     5.834707e-01    0.3190824 1.066928e+00 -0.5387611
##  rold   3.098920e-01    0.1660490 5.783419e-01 -1.1715313
##  m      4.108568e+03 3826.7883066 4.411096e+03  8.3208299
##  K      1.680305e+04 9261.1861914 3.048664e+04  9.7293157
##  q1     4.188036e-01    0.2352287 7.456422e-01 -0.8703532
##  q2     1.072896e+01    6.1009339 1.886770e+01  2.3729467
##  n      1.706764e+01    2.7693633 1.051882e+02  2.8371842
##  sdb    3.438700e-02    0.0030837 3.834608e-01 -3.3700756
##  sdf    1.558765e-01    0.1119937 2.169540e-01 -1.8586914
##  sdi1   3.132427e-01    0.2441424 4.019007e-01 -1.1607769
##  sdi2   2.166116e-01    0.1557583 3.012396e-01 -1.5296496
##  sdc    2.011960e-02    0.0039260 1.031085e-01 -3.9060594
##
## Deterministic reference points (Drp)
##            estimate        cilow        ciupp   log.est
##  Bmsyd 1.408320e+04 7870.2178231 2.520091e+04  9.552738
##  Fmsyd 2.917353e-01    0.1595412 5.334641e-01 -1.231908
##  MSYd  4.108568e+03 3826.7883066 4.411096e+03  8.320830
## Stochastic reference points (Srp)
##            estimate       cilow        ciupp   log.est rel.diff.Drp
##  Bmsys 14020.650117 7911.194870 2.484816e+04  9.548286  -0.00446155
##  Fmsys     0.287124    0.149702 5.506953e-01 -1.247841  -0.01606040
##  MSYs   4025.376541 3591.871927 4.511201e+03  8.300374  -0.02066678
##
## States w 95% CI (inp$msytype: s)
##                    estimate        cilow        ciupp    log.est
##  B_2017.62      1.566012e+04 8834.0702729 2.776063e+04  9.6588726
##  F_2017.62      2.099385e-01    0.1088071 4.050672e-01 -1.5609406
##  B_2017.62/Bmsy 1.116933e+00    0.9773888 1.276399e+00  0.1105861
##  F_2017.62/Fmsy 7.311772e-01    0.5264480 1.015523e+00 -0.3130995
##
## Predictions w 95% CI (inp$msytype: s)
##                  prediction        cilow        ciupp    log.est
```

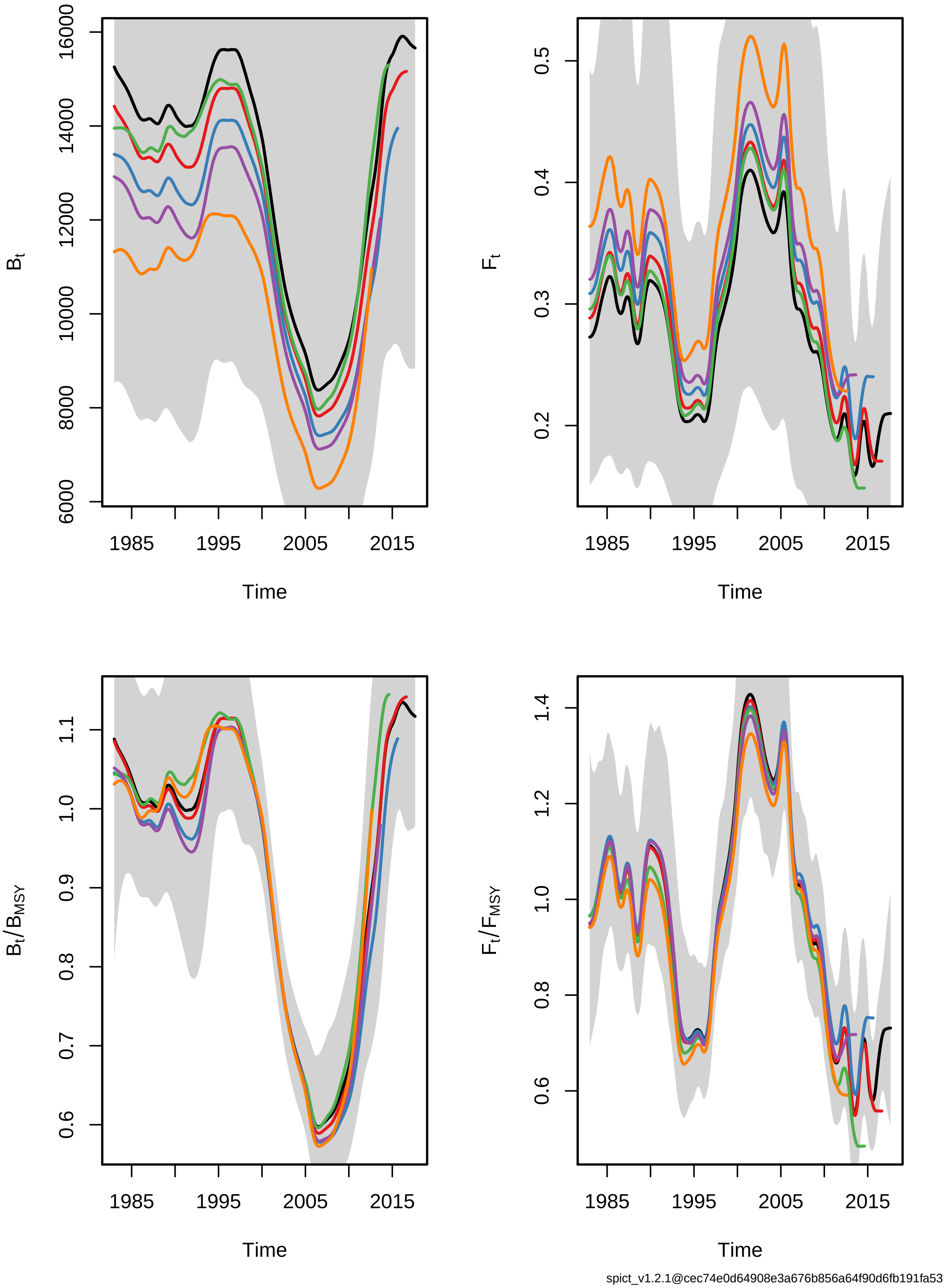
```
## B_2017.62      1.566012e+04 8834.0702729 2.776063e+04  9.6588726
## F_2017.62      2.099385e-01    0.1088071 4.050672e-01 -1.5609406
## B_2017.62/Bmsy 1.116933e+00    0.9773888 1.276399e+00  0.1105861
## F_2017.62/Fmsy 7.311772e-01    0.5264480 1.015523e+00 -0.3130995
## Catch_2017.62  3.287101e+03 2397.4335770 4.506917e+03  8.0977614
## E(B_inf)       1.552379e+04           NA           NA  9.6501288
```

Scenario 6: Intercatch data (minus 2002) + Reconstructed off. landings (no n prior)




Catch
Index 1
Index 2
log catch data
log index 1 data
log index 2 data
Time
Bias p−val: 0.9138
Bias p−val: 0.8214
Bias p−val: 0.8786
Jan
Apr
Jul
Oct
Catch OSA residuals
Index 1 OSA residuals
Index 2 OSA residuals
LBox p−val: 0.0448
LBox p−val: 0.3563
LBox p−val: 0.3312
lag.signf: 2
Catch ACF
Index 1 ACF
Index 2 ACF
Lag
Shapiro p−val: 0.693
Shapiro p−val: 0.8466
Shapiro p−val: 0.9262
Sample Quantiles
Theoretical Quantiles
spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53

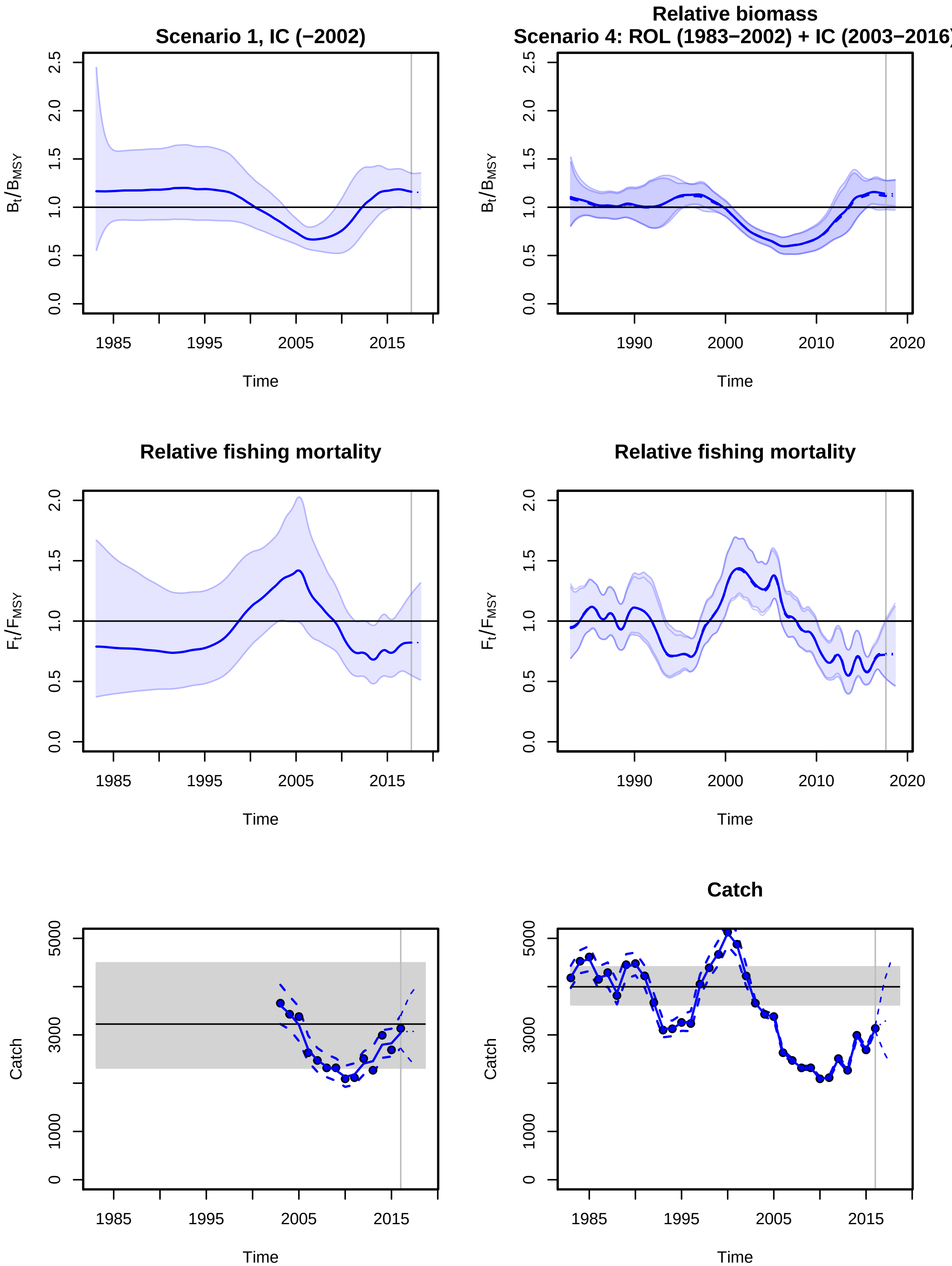
Scenario 6: Intercatch data (minus 2002) + Reconstructed off. landings (no n prior)



```
## Checking sensitivity of fit to initial parameter values...
##  Trial 1 ... model fitted!
##  Trial 2 ...obj$par:
##       logm       logK       logq       logq       logn     logsdb
## 10.3590388  8.0902187 -2.4678740 -2.0173094  1.6754372  0.2929016
##     logsdf     logsdi     logsdi     logsdc
##  0.4437916 -2.6264611 -3.3434176 -0.2409634
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
##  fit failed!
##  Trial 3 ... model fitted!
##  Trial 4 ... convergence not obtained!
##  Trial 5 ... model fitted!
##  Trial 6 ... model fitted!
##  Trial 7 ... model fitted!
##  Trial 8 ...obj$par:
##       logm       logK       logq       logq       logn     logsdb
##  9.2470489 10.3168299 -1.0625695 -1.4466548  1.8780070 -0.4161463
##     logsdf     logsdi     logsdi     logsdc
## -1.9592917 -1.3290417 -3.3771980 -2.5165561
## obj$fn:
## [1] NaN
## attr(,"logarithm")
## [1] TRUE
## obj$gr:
##  [1] NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN
##  fit failed!
##  Trial 9 ... model fitted!
##  Trial 10 ... convergence not obtained!
## $propchng
##           logm  logK  logq  logq  logn logsdb logsdf logsdi logsdi logsdc
## Trial 1  -3.09  0.03 -0.12  1.88  2.32   0.50   0.99   1.06   0.18   1.32
## Trial 2   1.42 -0.19  0.25  2.40  1.78  -1.18  -1.28   0.63   1.08  -0.85
## Trial 3   1.62  0.19  0.27 -2.80  0.09   0.62   0.71  -0.01   0.01   0.52
## Trial 4   3.07  0.06 -0.21  0.49 -2.63   0.09  -1.17  -0.28  -0.38  -1.06
## Trial 5   0.02  0.22 -0.10  0.12  0.91  -0.36  -0.69  -0.19  -1.38  -0.22
## Trial 6  -0.40 -0.13 -0.23 -2.22  1.68  -1.40  -0.29  -1.43   0.36  -0.16
## Trial 7  -0.47  0.04 -0.04  1.74  2.63  -0.39   0.20   1.22  -0.87   0.50
## Trial 8   1.71  0.04  0.12  0.46  0.99  -0.74   0.22  -0.17   1.10   0.56
## Trial 9  -0.14 -0.07  0.06  2.69 -2.89   1.37  -0.98  -0.38   0.54  -0.69
## Trial 10  0.92  0.23 -0.21 -2.43 -1.97  -0.92  -0.96  -0.67  -1.38  -0.40
##
## $inimat
##          Distance  logn  logK  logm logq1 logq2 logsdb logsdf logsdi1
## Basevec      0.00  0.69  9.93  8.29 -0.73 -0.73  -1.61  -1.61   -1.61
## Trial 1      4.59 -1.45 10.23  7.27 -2.09 -2.41  -2.41  -3.20   -3.31
## Trial 2      5.21  1.68  8.09 10.36 -2.47 -2.02   0.29   0.44   -2.63
## Trial 3      4.16  1.82 11.84 10.56  1.31 -0.79  -2.61  -2.75   -1.59
## Trial 4      4.32  2.82 10.55  6.57 -1.08  1.18  -1.76   0.27   -1.16
## Trial 5      3.57  0.71 12.16  7.48 -0.81 -1.38  -1.02  -0.50   -1.31
## Trial 6      4.51  0.41  8.68  6.36  0.89 -1.95   0.64  -1.14    0.69
## Trial 7      3.54  0.37 10.28  7.97 -1.99 -2.64  -0.98  -1.93   -3.58
```

```
## Trial 8      2.95  1.88 10.32  9.25 -1.06 -1.45  -0.42  -1.96   -1.33
## Trial 9      4.32  0.60  9.21  8.75 -2.68  1.37  -3.81  -0.04   -1.00
## Trial 10     4.97  1.33 12.20  6.57  1.04  0.70  -0.13  -0.07   -0.54
##          logsdi2 logsdc
## Basevec    -1.61  -1.61
## Trial 1    -1.91  -3.73
## Trial 2    -3.34  -0.24
## Trial 3    -1.62  -2.45
## Trial 4    -1.00   0.09
## Trial 5     0.60  -1.26
## Trial 6    -2.18  -1.36
## Trial 7    -0.22  -2.41
## Trial 8    -3.38  -2.52
## Trial 9    -2.48  -0.49
## Trial 10    0.62  -0.97
##
## $resmat
##          Distance       m        K    q     q     n  sdb  sdf  sdi  sdi
## Basevec      0.00 4108.57 16803.05 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 1      0.02 4108.57 16803.07 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 2      0.00      NA       NA   NA    NA    NA   NA   NA   NA   NA
## Trial 3      0.00 4108.57 16803.05 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 4      0.00      NA       NA   NA    NA    NA   NA   NA   NA   NA
## Trial 5      0.01 4108.57 16803.06 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 6      0.01 4108.57 16803.06 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 7      0.01 4108.57 16803.06 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 8      0.00      NA       NA   NA    NA    NA   NA   NA   NA   NA
## Trial 9      0.02 4108.57 16803.07 0.42 10.73 17.07 0.03 0.16 0.31 0.22
## Trial 10     0.00      NA       NA   NA    NA    NA   NA   NA   NA   NA
##           sdc
## Basevec  0.02
## Trial 1  0.02
## Trial 2    NA
## Trial 3  0.02
## Trial 4    NA
## Trial 5  0.02
## Trial 6  0.02
## Trial 7  0.02
## Trial 8    NA
## Trial 9  0.02
## Trial 10   NA

## NULL
```




```
## Loading required package: TMB
```

```
## Welcome to spict_v1.2.1@cec74e0d64908e3a676b856a64f90d6fb191fa53
```