WORKING GROUP FOR THE BAY OF BISCAY AND THE IBERIAN WATERS ECOREGION (WGBIE)

VOLUME 3 | ISSUE 48

ICES SCIENTIFIC REPORTS

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

ICES Scientific Reports

Volume 3 | Issue 48

WORKING GROUP FOR THE BAY OF BISCAY AND THE IBERIAN WATERS ECOREGION (WGBIE)

Recommended format for purpose of citation:

ICES. 2021. Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). ICES Scientific Reports. 3:48. 1101 pp. https://doi.org/10.17895/ices.pub.8212

Editors

Cristina Silva • Maria Ching Villanueva

Authors

Esther Abad • Santiago Cerviño López • Mickael Drogou • Spyros Fifas • Dorleta Garcia • Hans Gerritsen Isabel González Herraiz • Maria Grazia Pennino • Ane Iriondo • Francisco Izquierdo Tarín • Eoghan Kelly Jean-Baptiste Lecomte • Catarina Maia • Teresa Moura • Lisa Readdy • Paz Sampedro Pastor • Bárbara Serra-Pereira • Cristina Silva • Agurtzane Urtizberea Ijurco • Youen Vermard • Yolanda Vila Gordillo Maria Ching Villanueva • Mathieu Woillez

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Section contents

9 Hake in subareas 4, 6, and 7; divisions 3.a, 8.a–b, and 8.d (Greater North Sea, Celtic Seas, northern Bay of Biscay)

Merluccius merluccius – hke.27.3a46-8abd

9.1 General

9.1.1 Stock definition and ecosystem aspects

This section is described in the Stock Annex.

9.1.2 Fishery description

The general description of the fishery is now presented in the Stock Annex.

9.1.3 Summary of ICES advice for 2021 and historical management

9.1.3.1 ICES advice for 2021

The stock was considered to be above any potential MSY $B_{trigger}$. Following the ICES MSY framework implied fishing mortality to be maintained at 0.26, resulting in landings of 88 545 t and total catches of 100 278 in 2021.

Like the main stocks of the EU, Northern hake is managed by a TAC and quotas. The TACs for recent years are presented in the table below. In 2021, there has not been an agreement to set an annual TAC.

TAC (t)	2014	2015	2016	2017	2018	2019	2020	2021
3a, 3b,c,d (EC Zone)	2466	2738	2997	3371	3136	4286	3403	
2a (EC Zone), 4	2874	3190	3492	3928	3653	4994	3940	
Vb (EC Zone), 6, 7	45896	50944	61902	67658	62536	79762	63325	
8a,b,d,e	30610	33977	40393	44808	42460	52118	42235	
Total northern Stock	81846	90849	108784	119765	111785	141160	112903	

9.1.3.2 Historical management

The minimum legal sizes for fish caught in subareas 4-6-7 and 8 is set at 27 cm total length (30 cm in Division 3.a) since 1998 (Council Reg. no 850/98).

On 14 June 2001, an Emergency Plan was implemented by the Commission for the recovery of the Northern hake stock (Council Regulations N°1162/2001, 2602/2001 and 494/2002). In addition to a TAC reduction, two technical measures were implemented. First, a 100 mm minimum mesh size was implemented for otter trawlers when hake comprises more than 20% of the total amount of marine organisms retained onboard. This measure did not apply to vessels less than 12 m in length and which return to port within 24 hours of their most recent departure. Furthermore, two areas were defined, one in Subarea 7 and the other in Subarea 8, where a 100 mm minimum mesh size is required for all otter trawlers, whatever the amount of hake caught.

In 2004, explicit management objectives for the recovery of this stock were implemented under the EC Reg. No 811/2004. It was aiming at increasing the quantities of mature fish to values equal to or greater than 140 000 t (the B_{PA} value at that time). This could be achieved by limiting fishing mortality to 0.25 and by allowing a maximum change of 15% in TAC between years. According to ICES advice for 2012, due to the new perspective of historical stock trends resulting from the new assessment, the previously defined precautionary reference points are no longer appropriate. In particular, the absolute levels of spawning biomass, fishing mortality, and recruitment have shifted to different scales. As a consequence, the TAC corresponding to the recovery plan (EC Reg. No. 811/2004) should no longer be considered because the plan uses target values based on precautionary reference points that are no longer appropriate.

The TACs from 2016 to 2019 were slightly below the ICES advised TAC. The difference was due to the way the STECF calculated the TAC adjustments for stocks subject to the landing obligation. In 2019, according to the MSY framework, ICES proposed a decrease in the 2020 TAC advice of 26% from 142 240 t to 104 763 t. The agreed TAC limited the interannual variability to 20% (TAC = 112 903 t). For 2021 there is no TAC for the whole year, only extensions of the previous TAC for several months was agreed.

9.2 Data

9.2.1 Commercial catches and discards

Total landings from the northern stock of hake by area for the period 1961–2020 as used by the WG are given in Table 9.1. They include landings from Division 3.a, subareas 4, 6 and 7, and divisions 8.a, 8.b, and 8.d, as reported to ICES. Unallocated landings are also included in the table; they are high over the first decade (1961–1970) when the uncertainties in the fisheries statistics were high. In the years 2011, 2012 and 2013, they have increased again due to differences between official statistics and scientific estimations. In 2014 and 2015, the differences between scientific and official landings decreased greatly which produced a big decrease in unallocated landings. The 2016 unallocated landings were reported by area and in 2017 there were no unallocated landings, so they disappeared from Table 9.2. Table 9.1 of the Stock Annex provides a historical perspective of the level of aggregation at which landings have been available.

Except for 1995, landings decreased steadily from 66 500 t in 1989 to 35 000 t in 1998. Up to 2003, landings fluctuated around 40 000 t. Since then, except for 2006, landings have been increasing up to 107 500 t in 2016, the highest in the whole time-series. From 2009 to 2015 the landings and in 2016 the catches were above the TAC advice. Since 2016 the catches have decreased every year and they have been below both, the TAC and the catch advice.

The discard data sampling and data availability are presented in the Stock Annex. Table 9.2 presents discard, landings and the number of samples collected for each of the fleets considered in the assessment model since 2013. The discards had an increasing trend until 2011 and decreased steadily afterwards. The increase was general to all the fleets. It is remarkable the case of gillnetters which did not discard before 2012 and since that year they have had a high level of discards. In 2016, the discards increased for all the fleets except for Spanish trawlers in Area 7. In 2017, the total discards decreased for all the fleets, except for the Spanish trawlers, with an overall decrease of 36%. The increase in the Spanish trawlers in divisions 8.a, 8.b, and 8.d was equal to 38%. In 2018, the discards increased in Spanish trawlers in Area 7 and the trawl others fleet but decreased in all the rest of the fleets. The number of samples and number of measured fish is relatively stable every year, except in TRAWLOTH fleet that has high variability. In 2020 a decrease in both, number of samples and the number of measured fish is observed. The decrease is specially marked in LONGLINE fleet and the discards sampling in SPTRAWL7 fleet. Spain contributes the most to the LONGLINE sampling. In 2020, Spain apart from the COVID disruption it has other administrative problems that caused problems in the sampling.

9.2.2 Biological sampling

Which countries contribute to the total catch of each FU and which contribute with length-frequency distribution is given in Table 9.3.

Length compositions of the 2020 landings by Fishery Unit and quarter were provided mainly by Ireland, France, Scotland, Spain, UK(E&W), Denmark. However, some other countries also provide some data.

Length compositions samples are not available for all FUs of each country in which landings are observed (see Stock Annex). Only the main FUs are sampled (Table 9.3).

9.2.3 Abundance indices from surveys

Four surveys provide relative indices of hake abundance over time: (1) the French RESSGASC survey conducted in the Bay of Biscay from 1978 to 2002, (2) the EVHOE-WIBTS-Q4 (G9527) survey covering the Bay of Biscay and the Celtic Sea with a new design since 1997, (3) the SpPGFS-WIBTS-Q3 (G5768) survey conducted in the Porcupine Bank since 2001 and (4) the Irish Groundfish Survey (IGFS-WIBTS-Q4, G7212) carried out in the west of Ireland and the Celtic Sea since 2003. A brief description of each survey is given in the Stock Annex and section 2 of this report. Figure 9.1 presents the abundances indices obtained from these surveys.

From 1985 until the end of the survey in 2002, the index from RESSGASC showed a slightly decreasing trend. The 2002 index is considered not reliable and is not presented in the figure.

Throughout the available time-series, the abundance index provided by EVHOE-WIBTS-Q4 (G9527) showed five peaks in 2002, 2004, 2008, 2012, and 2016. The index obtained in 2012 was the highest value of the series, 193% higher than the previous year. In 2013 and 2014, the index accumulated a decrease of 78%. In 2015 and 2016, it increased and the 2016 index value was three times higher than the 2015 value. In 2017, the index was not available since the survey was not conducted. In 2018, the index value decreased relative to the 2016 value and was around the value in 2015. It increased again in 2019 but in 2020 the value decreased to the historical minimum level.

The abundance index provided by the IGFS-WIBTS-Q4 (G7212) is consistent with EVHOE WIBTS-Q4 (G9527) survey over recent years. The index showed four peaks coincident with those observed in the EVHOE-WIBTS-Q4 (G9527) index but to a lesser extent. In 2012, the index achieved the highest value of the series, 268% higher than the previous year index. The accumulated decrease in 2013 and 2014 was equal to 86%. The index increased moderately from 2015 to 2017. However, the increase in 2016 was not as sharp as that observed with the EVHOE-WIBTS-Q4 (G9527) index. The index decreased in 2018 and in the last two years, the variation has been low. The index is around its historical minimum level.

The abundance index from SpPGFS-WIBTS-Q4 (G5768) survey follows an increasing trend since 2003, reaching its highest value in 2009 and slightly decreasing in 2010 and 2011. After two years of an increasing trend, with an accumulated increase of 218%, the index decreased sharply in 2015 and again but moderately in 2016. The peaks detected by EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) were also detected in this survey but occurring a year later, confirming the sharp increase observed in 2017. This is consistent with the fact that this survey catches bigger individuals. In the last three years, the index has decreased to a value comparable to that observed in 2007.

The spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) biomass indices (kg/hr) is provided in Figure 9.2 since 2005. The SpPGFS-WIBTS-Q4 (G5768) biomass index shows a homogenous spatial distribution in the sampled area throughout the time-series. Among the three surveys, the SpPGFS-WIBTS-Q4 (G5768) shows the higher biomasses values in the maps, confirming that this survey catches bigger individuals. A contraction of the spatial distribution is visible in some years, with the year 2018 showing the greatest contraction (Figure 9.2). In 2017 EVHOE-WIBTS-Q4 (G9527) was only carried out partially). For the IGFS-WIBTS-Q4 (G7212) the spatial distribution of the biomass index was stable throughout the time-series, with a slight decrease in 2018. The southern region of the sampled area showed a higher biomass index in recent years. For the IGFS-WIBTS-Q4 (G7212), high biomass concentration seems to occur in areas closer to the continental French shelf. Overall for all surveys, a contraction of the spatial distribution is visible since 2015.

EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) surveys catch mainly young individuals below 25 cm while SpPGFS-WIBTS-Q4 (G5768) captures larger size individuals (35–75 cm) (Figure 9.3). In the case of EVHOE-WIBTS-Q4 (G9527), the distribution is quite homogeneous year after year, with the mode around 12 cm. In the case of the Irish survey, in 2018 and 2020, most of the individuals were around 25 cm, and there were almost no individuals around 12 cm, which is the mode of the distribution in most of the years. The length distribution from SpPGFS-WIBTS-Q4 (G5768) is quite flat between 40 and 65 cm, with a peak around 20 cm which is associated with previous year recruitment in the previous year. This peak was very high in 2017. The variability of the shape of length-frequency distributions of these two indices could be motivated by the limited area covered compared with the EVHOE-WIBTS-Q4 (G9527) index that covers a bigger area.

9.3 Assessment

This is an update assessment in relation to the assessment carried out during the inter-benchmark working group at the beginning of 2019 (ICES, 2019a). This year in the WKTaDSa (ICES, 2021) the model was updated to the last version of the Stock Synthesis model (3.30) (Methot Jr. and Wetzel, 2013). There were small differences between the estimates of the old and new versions of the software that were considered acceptable by the group.

9.3.1 Input data

See Stock Annex (under "Input data for SS3"). The catch contribution of the fleets used in the configuration of the model has changed over time (Figure 9.4). At the beginning of the time-series more than 75% of the catch was caught by trawlers fleets. However, in the last years, their contribution is around 25% to the total catch. On the contrary, the catch of longliners and gillnetters was residual in the past but currently, the contribution of each of these fleets is similar to the contribution of trawlers. The increase in the biomass of the stock in the last decade has motivated a high increase in the catch of the OTHER fleet. Nowadays the catch outside the Bay of Biscay and Celtic Sea (that covered by the OTHER fleet) is similar to the catch in the Bay of Biscay.

The quarterly length frequency distributions for landings and discards are given in Figure 9.5. For most of the fleets, the length–frequency distribution of landings is quite stable over time. The fleets in Area 8 catch smaller individuals. For trawlers, discards occur in the lower part of the distribution and for gillnetters and OTHER fleet in the whole range indiscriminately. The collection of data from the commercial fishery and research surveys during 2020 were impacted by

COVID-19 restrictions to a varying degree across member states. Spanish discard data and length frequency distributions in SPTRAWL7 fleet were missing in some quarters. The sampling in LONGLINE fleet was lower than in previous years and the corresponding length frequency distributions, which are usually smooth and well defined, had an odd shape.

9.3.1.1 Data Revisions

No data revisions have been provided in 2021.

9.3.2 Model

The Stock Synthesis (SS) assessment model (Methot Jr. and Wetzel, 2013) was selected for use in this assessment. Model description and settings are presented in the Stock Annex (under "Current assessment" for model description and "SS3 settings (input data and control files)" for model settings).

9.3.2.1 Model results

Residuals of the fit to the surveys log(abundance indices) are presented in Figure 9.6. The upward trend, in relative abundance, was observed until 2017 in all three contemporary trawl surveys (EVHOE-WIBTS-Q4 (G9527), SpPGFS-WIBTS-Q4 (G5768) and IGFS-WIBTS-Q4 (G7212), has been captured by the model. In the last three years, the model estimates are higher than the observed values in the IGFS-WIBTS-Q4 (G7212) survey, and SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G7212) surveys in the last two years and last year respectively.

The Pearson residuals of the length-frequency distributions of the EVHOE-WIBTS-Q4 (G7212) survey have a "fairly random" pattern with no general trend or lack of fit (Figure 9.7, where blue and red circles denote positive and negative residuals, respectively). However, in the other two surveys, the model has problems explaining the peak in small individuals observed in SpPGFS-WIBTS-Q4 (G5768) index, and the lack of small individuals in IGFS-WIBTS-Q4 (G7212) index for some years (i.e. 2018 and 2020).

Residuals of the length frequency distributions of the commercial fleets landings and discards (not presented in this report but available on the GitHub repository[1] show some patterns, as mentioned in the benchmark report (ICES, 2014a).

The assessment model includes estimation of size-based selectivity functions (selection pattern at length) for commercial fleets and population abundance indices (surveys). For commercial fleets, total catch is subsequently partitioned into discarded and retained portions. Figure 9.8 presents the selectivity for the total catch and Figure 9.9 the retention functions by fleet estimated by the model. The selection curve is assumed constant over the whole period for all the fleets except for those operating outside areas 7 and 8 (the OTHERS fleet). For the Spanish trawl fleet in Area 7, three retention functions are estimated, one for the period 1978–1997, a second one for the period 1998–2009 and a third one for the period 2010-present. For the Spanish trawl fleet in Area 8, two retention functions are estimated: one for the period 1978–1997 and a second one for 1998-present. The change in retention in 1998 for both trawl fleets was clearly observed when examining the length frequency distributions of the landings and might be due to more rigorous enforcement of the minimum landing size. The most recent change in the retention of the Spanish trawl fleet in Area 7 was motivated by the observed change in the mean size of discards from 23.6 cm before 2010 to 28.8 cm after that year. For the French trawlers targeting *Nephrops* in Area 8, the same retention function is assumed throughout the entire assessment period (1978-present). For the other fleets, both selection and retention curves are considered constant until 2002

[1] https://github.com/ices-taf/2021_hke.27.3a46-8abd_assessment

varying from year-to-year since then. The variation is modelled using a random walk as described in the Stock Annex. The selection pattern has changed significantly over the years. Furthermore, there was a big change in the selection pattern from 2019 to 2020. While in 2019 the retention was similar to those is most recent years (dashed black line), in 2020 the retention curve (solid black line) was the one with the sharper increase near the origin of the whole time-series. However, the retention ogives in 2019 and 2020 were almost identical (Figure 9.9). Residuals of the length frequency distributions of the commercial fleets landings and discards (not presented in this report but available on the GitHub repository[2] show some patterns, as mentioned in the benchmark report (ICES, 2014a).

The retrospective analysis (Figure 9.10) shows that for the three summary indicators (F, SSB and Recruitment) the model results are sensitive to the exclusion of recent data, especially recruitment. The inclusion of new data impacted the recruitment estimates especially in the most recent years, in general, they were revised downwards. The change in the recruitment estimates motivated, in turn, a retrospective pattern in the SSB and fishing mortality. Although the update to 3.30 version had a negligible impact on the stock status estimates for the last year, the retrospective pattern was worst overall. Before, the pattern did not show a clear trend so the cancellation effects reduced the value of Mohn's rho. However, the systematic overestimation of recruitment removed the cancellation effects and the obtained Mohn's rhos were higher (Figure 9.11). Although only some of time-series were within the confidence intervals estimated by the model (Figure 9.10), according to the guidelines of WKFORBIAS (ICES, 2020), the observed retrospective pattern is acceptable to provide advice (see Figure 9.12). The Mohn's rho value for SSB is inside the bounds (< 0.2). For fishing mortality, Mohn's rho is outside the bounds (> 0.2) and 2 recent peels are outside the envelope. However, although an interbenchmark to investigate the pattern is not possible, due to the short time available, as the pattern is close to the limit and the SSB is well below the reference points, it is possible to give advice with the assessment model presented in this report.

Summary results from SS are given in Table 9.4 and Figure 9.13.

Recruitment values (age 0) estimated by the model are provided in Table 9.4. For the recruitment, fluctuations appear to be without substantial trend over the whole series. The recruitment in 2008 was the highest in the whole series with 753 million individuals and the one in 2020 was below the geometric mean (252 million). From high levels at the start of the series (100 000 t in 1980), the SSB decreased steadily to a low level at the end of the 1990s (23 000 t in 1998). Since then, SSB has increased to the highest value of the series in 2016 (291 000 t) and decreased until 2019. In 2020 a slight increase has been predicted by the model.

The fishing mortality is calculated as the average annual F for sizes 15–80 cm. This measure of F is nearly identical with the average F for ages 1–5. Values of F increased from values around 0.5–0.6 in the late 1970s and early 1980s to values around 1.0 during the 1990s. Between 2006 and 2011, F declined sharply. Since 2012, F fluctuates around FMSY (f fmsy). The F estimate for 2020 (0.259) is slightly above F_{msy}.

The 90% confidence intervals are quite narrow (Table 9.4). These intervals correspond to the uncertainty estimated by the SS model and do not include all the existing uncertainty. For example, it does not include uncertainty in the input data. In the next benchmark, the data weighting in SS should be revisited in order to get more realistic confidence intervals.

[2] https://github.com/ices-taf/2021_hke.27.3a46-8abd_assessment

9.4 Catch options and prognosis

9.4.1 Replacement of recruitment in 2019 and 2020 by geometric mean recruitment

In 2019 and 2020 assessments, recruitment estimates for the last two data years (2016–2017 and 2017–2018 respectively), were replaced by the geometric mean (GM). The recruitment in 2017 was the second-highest value in the time-series but this high estimate was not supported by the available data at that time, length frequency distributions and abundance indices (ICES, 2019b). The 2017 year-class had a large contribution to the TAC advice, thus, reliable and precautionary recruitment was required for the short-term projections. With the inclusion of 2020 data, the assessment model has revised the 2017 recruitment downwards and the estimate is closer to the geometric mean (Figure 9.13).

This year, the recruitment estimates for the last two years, (2020 and 2019), were also replaced by the GM. The 2020 recruitment was close to the geometric mean. However, the 2019 estimate was well above that level. The assessment model overestimated the three abundance indices available in the last two years. Furthermore, the model has revised the most recent recruitments downwards. Hence, replacing the recruitment estimates for the last two years was considered more reliable and precautionary for projections.

Figure 9.14 shows the contribution of each age-class to the catch advice in 2020, when $F_{advice} = F_{msy}$ was used, replacing the recruitment in the last two years by the geometric mean and without replacing it. When the recruitment was not replaced, the contribution of 2019 year-class (age 3) to the advice was around 35%. However, when the recruitments were replaced the contribution reduced to half. Thus, the catch advice strongly depends on this year-class and replacing it with the geometric mean is considered more precautionary.

9.4.2 Short-term projections

SS has a forecast module that provides the capability to do a projection for a user-specified number of years that is directly linked to the model ending conditions and associated uncertainty, and a specified level of fishing intensity. The forecast requires information on life history, fishery selectivity, relative harvest rate between fleets, overall fishing intensity, and recruitment. However, due to some inconsistencies with the ICES short-term forecast observed in 2010 on SS short-term projection, the forecast has never been done internally in the model but transferred to and estimated by another module, a specific R script written for this specific task.

For the current projection, unscaled F is used, corresponding to F(15–80 cm) = 0.259. The recruitment used for projections in this WG is the GM calculated from 1990 to the final assessment year minus 2 (2018). Recruitment short-term projection assumption values are given in Table 9.5. Landings in 2022 and SSB in 2023 predicted for various levels of fishing mortality in 2022 are given in Table 9.5 and Figure 9.15.

Maintaining status quo F in 2022 is expected to result in a decrease in the catch and the SSB with respect to 2021, around −24% and −6% respectively.

9.4.3 Yield and biomass per recruit analysis

Options for long-term projection are indicated in the Stock Annex. Results of equilibrium yield and SSB per recruit are presented in Table 9.6 and Figure 9.16. The F-multiplier in Table 9.6 is with respect to *status quo* F (average F in the final 3 assessment years, 2018–2020). Considering the yield and SSB per recruit curves, F_{max}, F0.1, F35% and F30% are respectively estimated to be 99%, 66%, 72%, and 84 of *status quo* F. The maximum equilibrium yield-per-recruit is similar to the equilibrium yield at F_{sq}.

9.5 Biological reference points

Biological reference points for the stock of Northern Hake were calculated in 2019 after the inter-benchmark was carried out in February (Garcia, 2019, WD 06 in ICES, 2019b). This year the value of F_{PA} has been revised according to general ICES guidelines, now it is defined as $F_{P0.5}$ (with $B_{trigger}$). The value was already calculated in 2019. As the new F_{PA} is higher than the F_{LIM} we had before, it has been discarded and new F_{LIM} value has not been defined. The reference points in use for the stock are as follows:

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	56 000	B_{pa} (WD 06, ICES, 2019b)
	F_{MSY}	0.26	F_{MSY} in the segmented regression stock recruitment relationship (WD 06, ICES, 2019b)
Precautionary Approach	B_{lim}	40 000	The median of the breakpoints in the segmented stock recruitment relationship estimated with a Bayesian Model.
	B_{pa}	56 000	1.4Blim (WD 06, ICES, 2019b)
	F_{lim}	Not defined	
	F_{pa}	1.02	$F_{p0.5}$ (WD 06, ICES, 2019b)
MAP	F_{low}	0.18	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)
	F_{upp}	0.4	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)

9.6 Comments on the assessment

The retrospective pattern in 2008 recruitment was partially corrected during the last benchmark (ICES, 2014a). However, the retrospective pattern is still significant. It could be related to the changes in the estimates of the selection patterns for some fleets and surveys. As they are considered constant by the model and new data on length–frequency distributions is introduced every year in the model, if the selection pattern is not really constant, it could result in significant changes in selection curve estimates, which in turn could result in a retrospective pattern in recruitment, F, and SSB. Moreover, the recruitment in the most recent years is difficult to estimate, because there is little information in the data on it. Thus, the uncertainty in the recent estimates of recruitment is high and the estimated value needs several years to stabilize.

In this year assessment, the effective sample size used for 2020 samples has been the default used for all the fleets, as stated in the Stock Annex. However, the number of samples and sampled individuals has been lower than in other years, especially for some countries and fleets. The model results are sensitive to the effective sample size and it should be related to the samples available yearly.

During the working group, it was detected a mistake in the control file of the assessment model, the 'year from which deviations from recruitment are no longer considered parameters, was equal to 2019 instead of 2020. The same mistake was done last year. The results obtained, in trends, were very similar, but the biomass was slightly lower and the fishing mortality higher, which produced significantly lower catch advice.

9.7 Future benchmark

In WKTaDSa (ICES, 2021) a working plan was defined to advance in the improvement of the quality of the stock assessment model configuration for this stock.

- Incorporate the advanced options to model recruitment proposed by Rick Method in WKTaDSA. This has been already included and their impact analysed. The impact is low but significant.
- Biological parameters: Update the biological parameters using the work done in Southern hake. A sensitivity analysis was done changing growth parameters and natural mortality. The obtained indicators had the same trend as the current assessment but the productivity of the stock changed. The differences in the likelihood were not big. The signal in the length frequency distribution and natural mortality was opposite.
- Variability of selection pattern. The fleets more impacted by a retrospective pattern in selection curves have been detected, Gillnetters and Spanish trawlers in areas 7 and 8. There is also a big retrospective pattern in the selectivity of IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) surveys. The introduction of a random walk in the selection pattern of the fleets is straightforward. The problem is in the selectivity of the surveys. The selectivity is constant in the surveys, but changes in the availability of the resources could have the same effect as the model assumes the distribution of fish is homogeneous in the whole area.
- Weighting options. The likelihood of the model is driven by the likelihood in length frequency data. The sensitivity of the estimates to the weighting of likelihood components should be investigated and adequate weights defined. Furthermore, a protocol to update the effective sample size needs to be defined to deal with big changes in sampling.
- Split of OTHER fleet in trawlers and non-trawlers. This could only be done for the years with data in InterCatch. The catch in this fleet started increasing in 2008, with the increase in biomass. Thus, splitting of the fleet since that year could be advisable.

9.8 Management considerations

The significant increase in SSB and the decrease in fishing mortality are the consequences of the strong recruitment in 2008 and 2012. However, the increase rate should be taken with caution as limited information is currently available to explain the variation in abundance of large fish and the model is very sensitive to the data and settings used. It must be noted that the high growth rate combined with the assumed high natural mortality rate (M = 0.4 since the 2010 benchmark, ICES, 2010) generates a rapid turnover of the hake stock dynamic. This means that short-term predictions in SSB and landings are strongly related to variations in recruitment. Now, that the SSB has decreased, caution is needed to avoid a rapid decrease in biomass. Since 2017, the observed catches have been significantly below the TAC and the catch advice, which would be a signal of an overestimation of stock productivity.

The ICES catch advice is for the whole stock but the sum of the TACs for 2019 and 2020 in this report is only for the EU member states.

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9.10 Tables and figures

Table 9.1. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Estimates of landings ('000 t) by area for 1961–2019.

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
1961									95.6	95.6								95.6
1962									86.3	86.3								86.3
1963									86.2	86.2								86.2
1964									76.8	76.8								76.8
1965									64.7	64.7								64.7
1966									60.9	60.9								60.9
1967									62.1	62.1								62.1
1968									62.0	62.0								62.0
1969									54.9	54.9								54.9
1970									64.9	64.9								64.9
1971			8.5				19.4	23.4	0.0	42.8								42.8
1972			9.4				14.9	41.2	0.0	56.1								56.1
1973			9.5				31.2	37.6	0.0	68.8								68.8
1974			9.7				28.9	34.5	0.0	63.4								63.4
1975			11.0				29.2	32.5	0.0	61.7								61.7
1976			12.9				26.7	28.5	0.0	55.2								55.2
1977			8.5				21.0	24.7	0.0	45.7								45.7
1978			8.0				20.3	24.5	-2.2	42.6								42.6
1979			8.7				17.6	27.2	-2.4	42.4								42.4
1980			9.7				22.0	28.4	-2.8	47.6								47.6
1981			8.8				25.6	22.3	-2.8	45.1								45.1
1982			5.9				25.2	26.2	-2.3	49.1								49.1
1983			6.2				26.3	27.1	-2.1	51.3								51.3
1984			9.5				33.0	22.9	-2.1	53.8								53.8
1985			9.2				27.5	21.0	-1.6	46.9								46.9
1986			7.3				27.4	23.9	-1.5	49.8								49.8

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
1987			7.8				32.9	24.7	-2.0	55.6								55.6
1988			8.8				30.9	26.6	-1.5	56.0								56.0
1989			7.4				26.9	32.0	0.2	59.1								59.1
1990			6.7				23.0	34.4	-4.2	53.3								53.3
1991			8.3				21.5	31.6	-3.4	49.8								49.8
1992			8.6				22.5	23.5	2.1	48.1								48.1
1993			8.5				20.5	19.8	3.3	43.7								43.7
1994			5.4				21.1	24.7	0.0	45.8								45.8
1995			5.3				24.1	28.1	0.1	52.3								52.3
1996			4.4				24.7	18.0	0.0	42.8								42.8
1997			3.3				18.9	20.3	-0.1	39.2								39.2
1998			3.2				18.7	13.1	0.0	31.9								31.9
1999			4.3				24.0	11.6	0.0	35.6								35.6
2000			4.0				26.0	12.0	0.0	38.0								38.0
2001			4.4				23.1	9.2	0.0	32.3								32.3
2002			2.9				21.2	15.9	0.0	37.2								37.2
2003			3.3				25.4	14.4	0.0	39.9							1.4	41.3
2004			4.4				27.5	14.5	0.0	42.0							2.6	44.6
2005			5.5				26.6	14.5	0.0	41.1							4.6	45.7
2006			6.1				24.7	10.6	0.0	35.3							1.2	36.6
2007			7.0				27.5	10.6	0.0	38.1							2.2	40.2
2008			10.7				22.8	14.3	0.0	37.2							3.4	40.5
2009			13.1				25.3	20.4	0.0	45.7							11.0	56.8
2010			14.2				33.5	25.1	0.0	58.6							12.1	70.7
2011			18.8				18.6	16.6	32.0	87.5							13.9	101.4
2012			22.4				22.2	16.7	19.3	85.6							14.9	100.5
2013			0.3	10.7		5.2	50.1	19.9	0.0	86.1	0.3	2.9		1.5	6.6	4.1	15.4	101.6
2014			0.4	12.1		11.4	40.5	25.6	0.0	89.9	0.3	3.1		1.0	4.0	1.5	9.8	99.8

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
2015			0.4	14.6	0	7.1	44.4	28.5	0.0	95.0	0.1	3.4		0.1	4.2	3.1	10.9	106.0
2016			0.7	19.6	0	11.4	49.4	26.5	0.0	107.5	0.1	4.2	0	0.3	2.3	4.2	11.1	118.7
2017			0.8	19.7	0	9.6	45.7	28.9	0.0	104.7	0.1	1.8	0	0.3	1.2	3.7	7.1	111.8
2018			0.7	18.9	0	7.3	36.9	25.9	0.0	89.7	0.3	1.3		0.3	2.1	3.1	7.0	96.7
2019	0	0.8	0.7	15.6	0	6.8	36.9	21.5	0.0	82.3	0.2	0.9		0.3	1.4	2.1	4.9	87.2
2020			0.6	13.1	0	4.1	35.1	19.7	0.0	72.6	0.3	0.3		0.3	0.4	2.0	3.3	75.8

[1] Divisions 3a and 4b,c are included in column '3a, 4 and 6' only after 1976. There are some unallocated landings (moreover for the period 1961–1970).

[2]Discard estimates from observer programmes. In 2003–2020, partial discard estimates are available and used in the assessment. For remaining years for which no values are presented, some estimates are available but not considered valid and thus not used in the assessment.

[3]From 1978 total catches used for the Working Group.

Table 9.2. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Discards and landings (in tonnes), number of length samples per catch category (NLgSp_D and NLgSp_L) and number of fish measured per catch category (NLgMs_D and NLgMs_L) since 2013 for the fleets used in the assessment model.

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2013	FRNEP8	1475	1219	0	0	0	0
2014	FRNEP8	391	1566	0	0	0	0
2015	FRNEP8	1134	1197	0	0	0	0
2016	FRNEP8	2310	973	39	51	1414	1627
2017	FRNEP8	1819	1124	31	53	1073	1360
2018	FRNEP8	889	1029	26	92	832	3495
2019	FRNEP8	816	1131	26	75	811	2365
2020	FRNEP8	1193	1076	20	42	551	1031
2013	GILLNET	1257	15671	0	31	0	12133
2014	GILLNET	65	22549	27	412	164	27691
2015	GILLNET	857	16876	29	501	218	28777
2016	GILLNET	1175	25017	475	855	4964	49702
2017	GILLNET	653	25299	228	574	2406	32823
2018	GILLNET	1014	25848	459	526	3339	38290
2019	GILLNET	333	24800	219	536	1803	34874

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2020	GILLNET	444	23003	139	516	3364	20521
2014	LONGLINE	1	26289	0	77	0	37386
2015	LONGLINE	559	36881	0	59	0	26655
2016	LONGLINE	2	31390	0	126	0	42003
2017	LONGLINE	1	29728	0	113	0	28754
2018	LONGLINE	4	20710	0	101	0	33141
2019	LONGLINE	0	19112	0	99	0	30853
2020	LONGLINE	0	18869	0	17	0	1693
2013	LONGLINE		14516		51		24319
2013	OTHER	6287	45004	145	328	7282	20454
2014	OTHER	5007	26165	288	863	9944	20898
2015	OTHER	4154	23515	257	895	11164	13048
2016	OTHER	4687	33099	530	834	11138	34417
2017	OTHER	2326	31371	413	577	9338	17731
2018	OTHER	1943	28396	521	802	17024	27263
2019	OTHER	1817	26437	426	596	16457	22876
2020	OTHER	948	19695	237	516	8860	18712
2013	SPTRAWL7	3495	1948	300	61	2518	13864
2014	SPTRAWL7	1467	1991	310	77	1433	17568
2015	SPTRAWL7	2064	1975	268	52	2125	13773
2016	SPTRAWL7	616	2099	357	48	1208	10898
2017	SPTRAWL7	651	1711	340	56	3014	18703
2018	SPTRAWL7	903	1850	324	57	3063	19211
2019	SPTRAWL7	318	1891	193	51	1340	14001
2020	SPTRAWL7	157	2351	48	5	113	1243
2014	SPTRAWL8	183	2720	287	44	1610	7360
2015	SPTRAWL8	589	4405	0	43	0	9181
2016	SPTRAWL8	656	3647	95	43	3008	9482
2017	SPTRAWL8	906	4622	296	45	9240	9859

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2018	SPTRAWL8	347	3467	280	53	3748	10526
2019	SPTRAWL8	586	2956	299	58	5390	5829
2020	SPTRAWL8	310	2768	213	47	2825	5652
2013	SPTRAWL8		1988		38		5138
2013	TRAWLOTH	2936	5801	0	0	0	0
2014	TRAWLOTH	2718	8659	478	817	24072	7841
2015	TRAWLOTH	1564	10192	381	404	11649	6766
2016	TRAWLOTH	1669	11321	1367	1423	37190	36008
2017	TRAWLOTH	744	10815	169	595	13117	11732
2018	TRAWLOTH	1937	8394	1536	832	71517	21048
2019	TRAWLOTH	1070	5970	408	526	13734	11199
2020	TRAWLOTH	205	4816	204	270	7683	6960

Table 9.3. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Catches (C) and Length Frequency Distribution (LFD) provided in 2020.

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK (Scotland)
FU1 & FU2	1	0	C	0	0	C+LFD	C	0
FU1 & FU2	2	0	C	0	0	C	0	0
FU1 & FU2	3	0	C	0	0	C	C	0
FU1 & FU2	4	0	C	0	0	C	C	0
FU03	1	0	C	C+LFD	0	C+LFD	C+LFD	0
FU03	2	0	C	C+LFD	0	C	C+LFD	0
FU03	3	0	C	C+LFD	0	C	C+LFD	0
FU03	4	0	C	C+LFD	0	C	C+LFD	0
FU4 + FU5 + FU6	1	0	C+LFD	C+LFD	C	C+LFD	C	0
FU4 + FU5 + FU6	2	0	C	C+LFD	C	C	C	0
FU4 + FU5 + FU6	3	0	C	C+LFD	C	C+LFD	C	0
FU4 + FU5 + FU6	4	0	C+LFD	C+LFD	C	C+LFD	C+LFD	0

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK (Scotland)
FU8	1	0	C+LFD	C+LFD	C	0	0	0
FU8	2	0	C	C+LFD	C	0	0	0
FU8	3	0	C	C+LFD	C	0	C	0
FU8	4	0	C	C+LFD	C	0	0	0
FU9	1	0	C	0	0	0	0	0
FU9	2	0	C	0	0	0	0	0
FU9	3	0	C	0	0	0	0	0
FU9	4	0	C	0	0	0	0	0
FU10&FU14	1	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	2	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	3	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	4	0	C+LFD	0	0	C+LFD	C	0
FU12	1	0	C+LFD	0	0	C+LFD	0	0
FU12	2	0	C+LFD	0	0	C+LFD	0	0
FU12	3	0	C+LFD	0	0	C	0	0
FU12	4	0	C	0	0	C	0	0
FU13	1	0	C+LFD	0	0	C+LFD	0	0
FU13	2	0	C+LFD	0	0	C	0	0
FU13	3	0	C+LFD	0	0	C	C	0
FU13	4	0	C+LFD	0	0	C	0	0
FU15	1	0	C	C+LFD	C	0	C	0
FU15	2	0	C	C+LFD	C	0	0	0
FU15	3	0	C	C+LFD	0	0	C+LFD	0
FU15	4	0	C	C+LFD	C	0	C+LFD	0
FU16	1	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	2	C+LFD	C	C+LFD	C+LFD	C+LFD	C	C
FU16	3	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	4	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD

Table 9.4. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b,and 8.d (northern stock). Summary of landings and assessment results.

Year	Recruit Age 0	Total Bio-mass	Total SSB	Landings	Discards	Catch	Yield/SSB	F (15–80 cm)
1978	319509	457282	72229	50551		50551	0.70	0.54
1979	313044	477163	92987	51096		51096	0.55	0.58
1980	307338	448802	95511	57265		57265	0.60	0.68
1981	616913	388237	81942	53918		53918	0.66	0.69
1982	428809	381218	66018	54994		54994	0.83	0.72
1983	140607	415488	64190	57507		57507	0.90	0.66
1984	303080	409535	77358	63286		63286	0.82	0.70
1985	650417	342515	74253	56099		56099	0.76	0.85
1986	383785	295648	55102	57092		57092	1.04	0.95
1987	448690	289942	40364	63369		63369	1.57	1.04
1988	518914	295834	43908	64823	2	64825	1.48	1.05
1989	500919	290262	43036	66473	73	66546	1.55	1.13
1990	500015	279283	40361	59954		59954	1.49	1.07
1991	283680	262868	39644	58129		58129	1.47	1.02
1992	302910	245421	38176	56617		56617	1.48	1.05
1993	541960	213685	37391	52144		52144	1.39	1.10
1994	300812	214402	29333	51259	356	51615	1.76	1.11
1995	156159	239418	28653	57621		57621	2.0	1.17
1996	377299	197402	33659	47210		47210	1.40	1.03
1997	261533	178714	28846	42465		42465	1.47	1.11
1998	434771	176929	23231	35060		35060	1.51	1.03
1999	222697	201770	26594	39814	349	40163	1.51	1.01
2000	193857	208622	29381	42026	83	42109	1.43	0.95
2001	354055	209681	34905	36675		36675	1.05	0.79
2002	283150	231638	35956	40107		40107	1.12	0.84
2003	165395	245150	36566	43162	2110	45272	1.24	0.84
2004	354020	242701	41638	46417	2552	48969	1.18	0.85

Year	Recruit Age 0	Total Biomass	Total SSB	Landings	Discards	Catch	Yield/SSB	F (15–80 cm)
2005	228685	221092	39729	46550	4676	51226	1.29	0.99
2006	306454	227227	32217	41467	1816	43283	1.34	0.88
2007	470423	270604	39067	45028	2191	47219	1.21	0.75
2008	772351	375344	46620	47739	3248	50987	1.09	0.60
2009	249675	618723	70773	58818	10590	69408	0.98	0.49
2010	270027	913343	129738	72799	9978	82777	0.64	0.37
2011	276796	1078613	211698	87540	14156	101696	0.48	0.31
2012	519015	1116520	238004	85677	12680	98357	0.41	0.27
2013	376267	1176338	238566	77753	15886	93639	0.39	0.27
2014	208076	1295903	248043	89940	9913	99853	0.40	0.25
2015	215682	1380741	283027	93670	9820	103490	0.37	0.24
2016	313605	1355913	307092	109106	12741	121847	0.40	0.27
2017	340551	1203555	280165	104671	7386	112057	0.40	0.37
2018	317969	1073415	235279	89671	7034	96705	0.41	0.29
2019	422146	1064739	217121	82298	4940	87238	0.40	0.28
2020	227146	1143594	224675	72579	3257	75836	0.34	0.26
Arithmetic mean	353005	519890	96582	60708	5906	63867	1.01	0.73
Units	Thousands of individuals	Thousands	Tonnes	Tonnes	Tonnes	Tonnes	Percentage	

Table 9.5. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Catch option table.

SSB(2021)	Rec proj	F(15–80 cm)	Catch(2021)	Land(2021)	SSB(2022)		
239 091	309 417	0.28	87 708	82 428	218 924		
Fmult	**Fcatch(15–80 cm)**	**Fland(15–80 cm)**	**Fdisc (15–80 cm)**	**Catch(2022)**	**Land(2022)**	**Disc(2022)**	**SSB(2023)**
0.0	0.0000	0.0000	0.0000	0	0	0	280183
0.1	0.0279	0.0221	0.0059	9255	8617	638	271192
0.2	0.0559	0.0441	0.0117	18199	16937	1262	262508
0.4	0.1117	0.0883	0.0235	35194	32722	2472	246017
0.5	0.1397	0.1104	0.0293	43267	40209	3058	238189
0.7	0.1956	0.1545	0.0411	58609	54416	4193	223320
0.8	0.2235	0.1766	0.0469	65898	61155	4743	216261
0.9	0.2514	0.1986	0.0528	72943	67662	5281	209439
1.0	0.2794	0.2207	0.0587	79754	73945	5808	202847
1.1	0.3073	0.2428	0.0645	86338	80013	6325	196477
1.3	0.3632	0.2869	0.0763	98857	91531	7326	184371
1.4	0.3911	0.3090	0.0821	104806	96995	7811	178621
1.5	0.4190	0.3311	0.0880	110559	102273	8286	173062
1.6	0.4470	0.3531	0.0938	116122	107370	8752	167689
1.7	0.4749	0.3752	0.0997	121501	112293	9208	162495
1.8	0.5029	0.3973	0.1056	126703	117048	9654	157473
1.9	0.5308	0.4193	0.1114	131733	121641	10092	152618
2.0	0.5587	0.4414	0.1173	136598	126077	10521	147924

Table 9.6. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Yield-per-recruit table.

SPR-level	F-mult	F(15–80cm)	YPR-catch	YPR-landings	SSB-PR
1.00	0.00	0.00	0.00	0.00	3.2
0.84	0.100	0.030	0.088	0.085	2.7
0.72	0.20	0.060	0.153	0.146	2.3
0.62	0.30	0.080	0.20	0.191	1.97
0.53	0.40	0.110	0.23	0.22	1.70
0.46	0.50	0.140	0.26	0.24	1.48
0.41	0.60	0.170	0.28	0.26	1.30
0.36	0.70	0.190	0.29	0.27	1.14
0.32	0.80	0.22	0.30	0.28	1.02
0.28	0.90	0.25	0.30	0.28	0.91
0.25	1.00	0.28	0.30	0.28	0.81
0.23	1.10	0.30	0.30	0.28	0.73
0.21	1.20	0.33	0.30	0.28	0.66
0.189	1.30	0.36	0.30	0.27	0.60
0.172	1.40	0.39	0.30	0.27	0.55
0.158	1.50	0.41	0.29	0.26	0.50
0.145	1.60	0.44	0.29	0.26	0.46
0.134	1.70	0.47	0.29	0.26	0.43
0.124	1.80	0.50	0.28	0.25	0.40
0.115	1.90	0.52	0.28	0.24	0.37
0.107	2.0	0.55	0.27	0.24	0.34
SPR.level	F-mult	F(15–80cm)	YPR-catch.	YPR-landings	SSB-PR
0.26	0.99	0.27	0.30	0.28	0.82
0.38	0.66	0.18	0.28	0.27	1.21
0.35	0.72	0.20	0.29	0.27	1.12
0.30	0.84	0.23	0.30	0.28	0.97

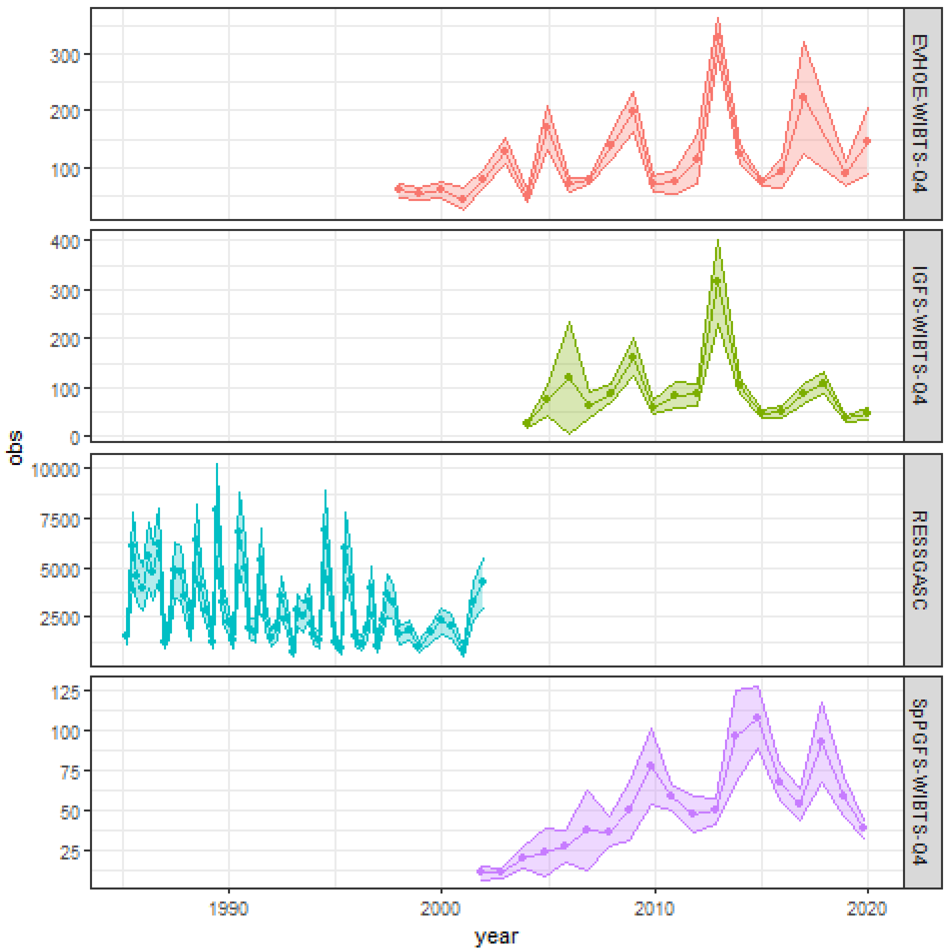

Figure 9.1. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Abundance indices from surveys.

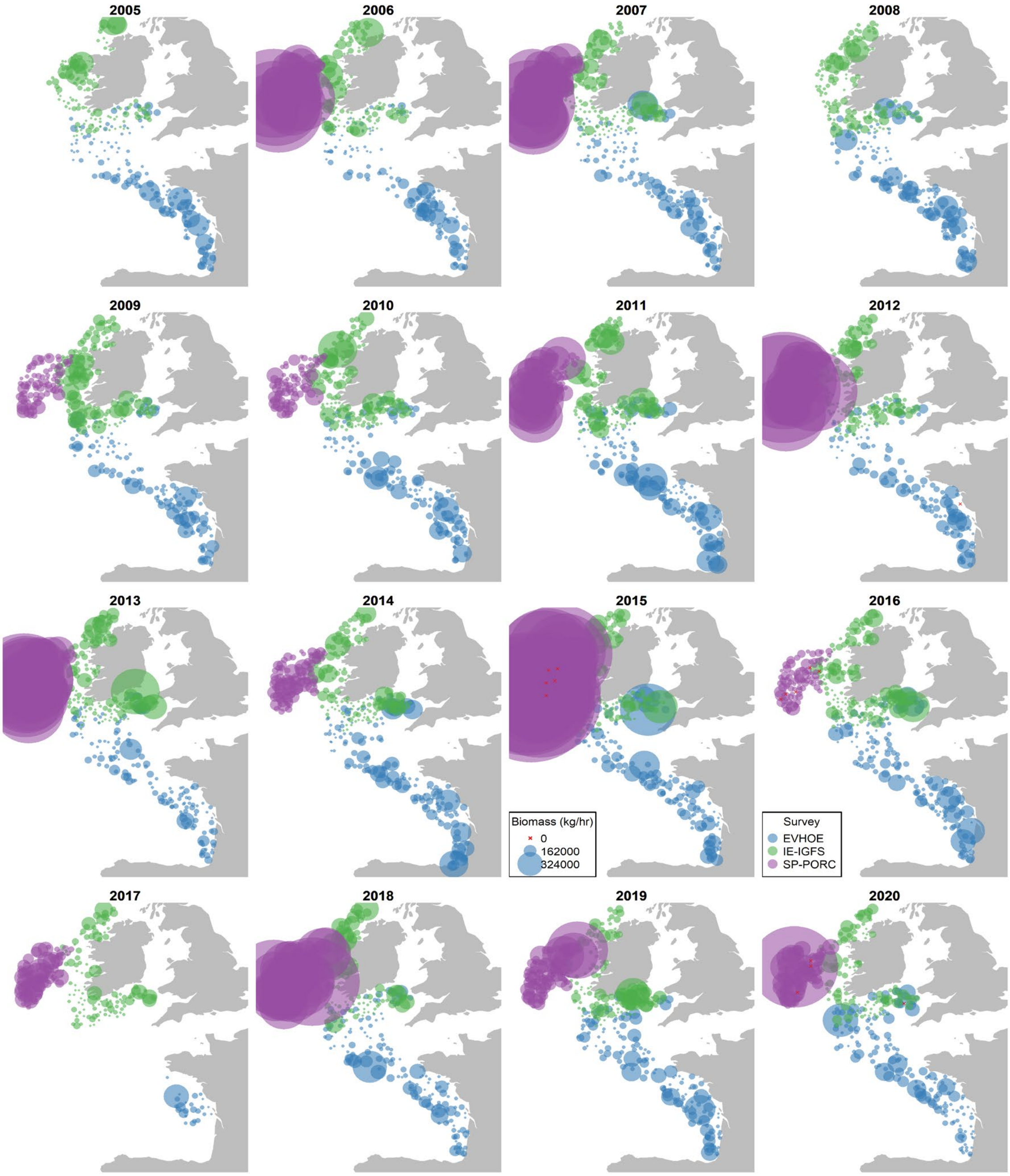

Figure 9.2. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) index of biomass (Kg/hr) from 2003 to 2018.

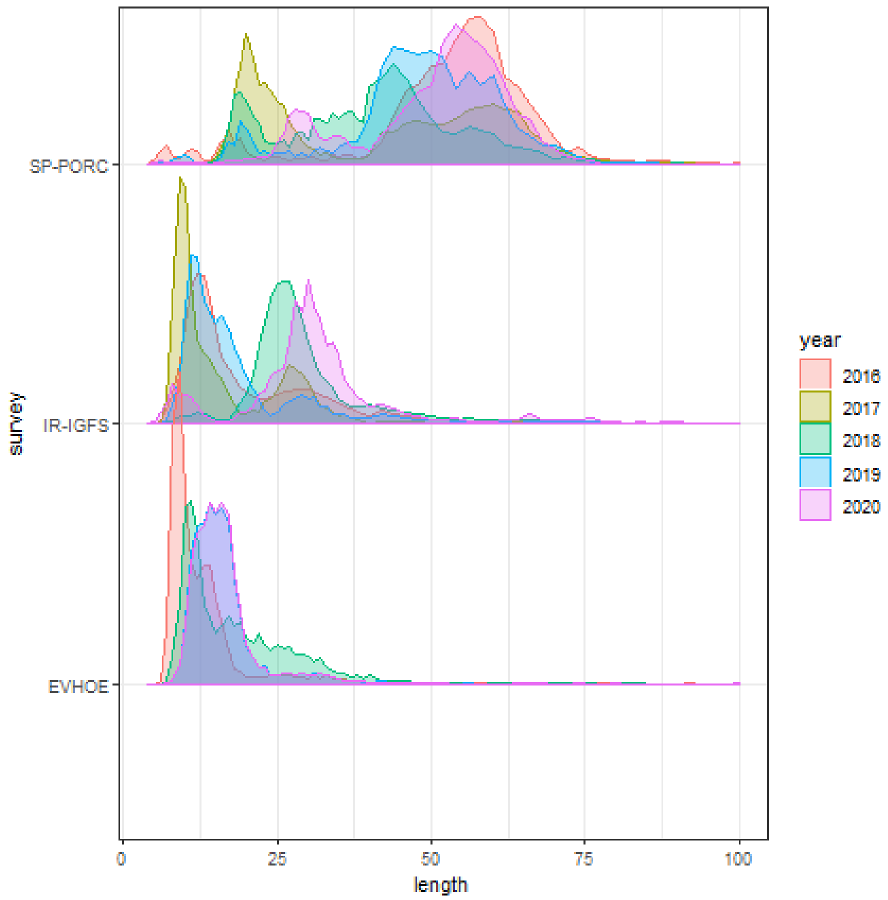

Figure 9.3. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Length frequency distribution of surveys in the most recent years, from 2018 to 2020.

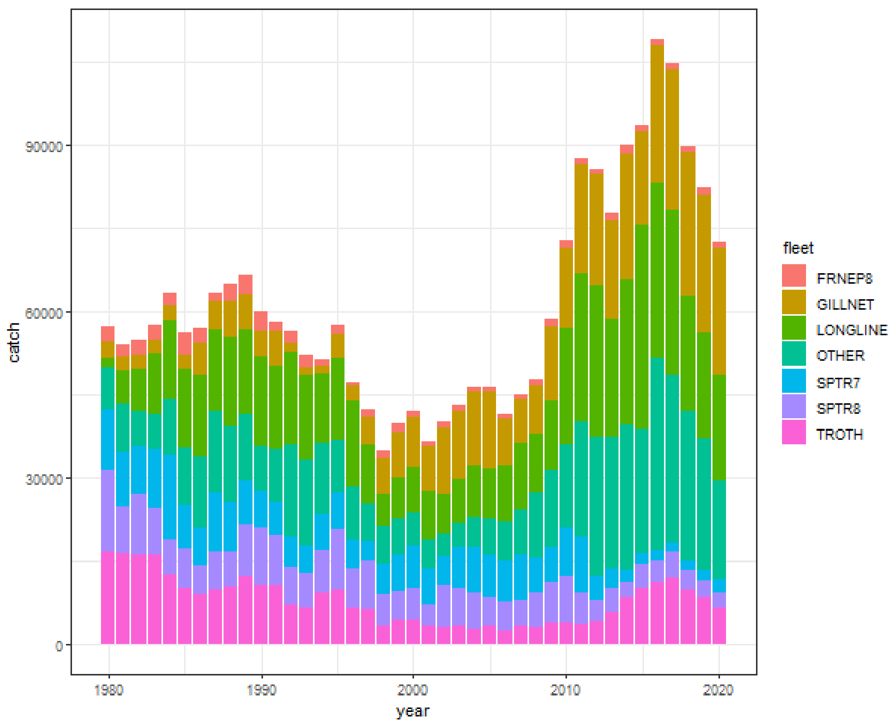

Figure 9.4. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Total catch over time, the colours correspond to the fleets used in the assessment model configuration.

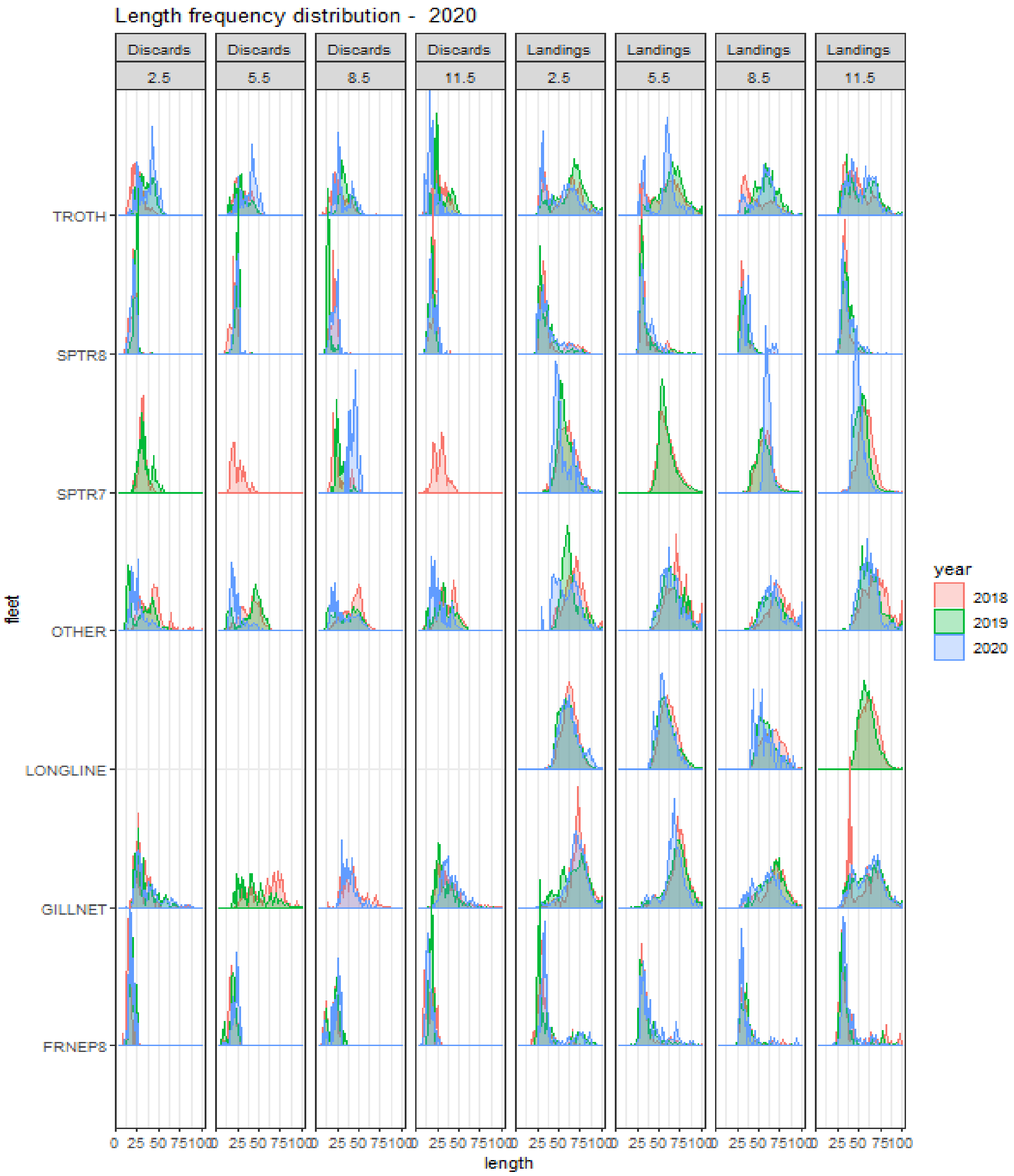

Figure 9.5. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Length frequency distribution for landings and discards by fleet in the most recent years, from 2018 to 2020, by season and the fleet as used in the assessment model configuration.

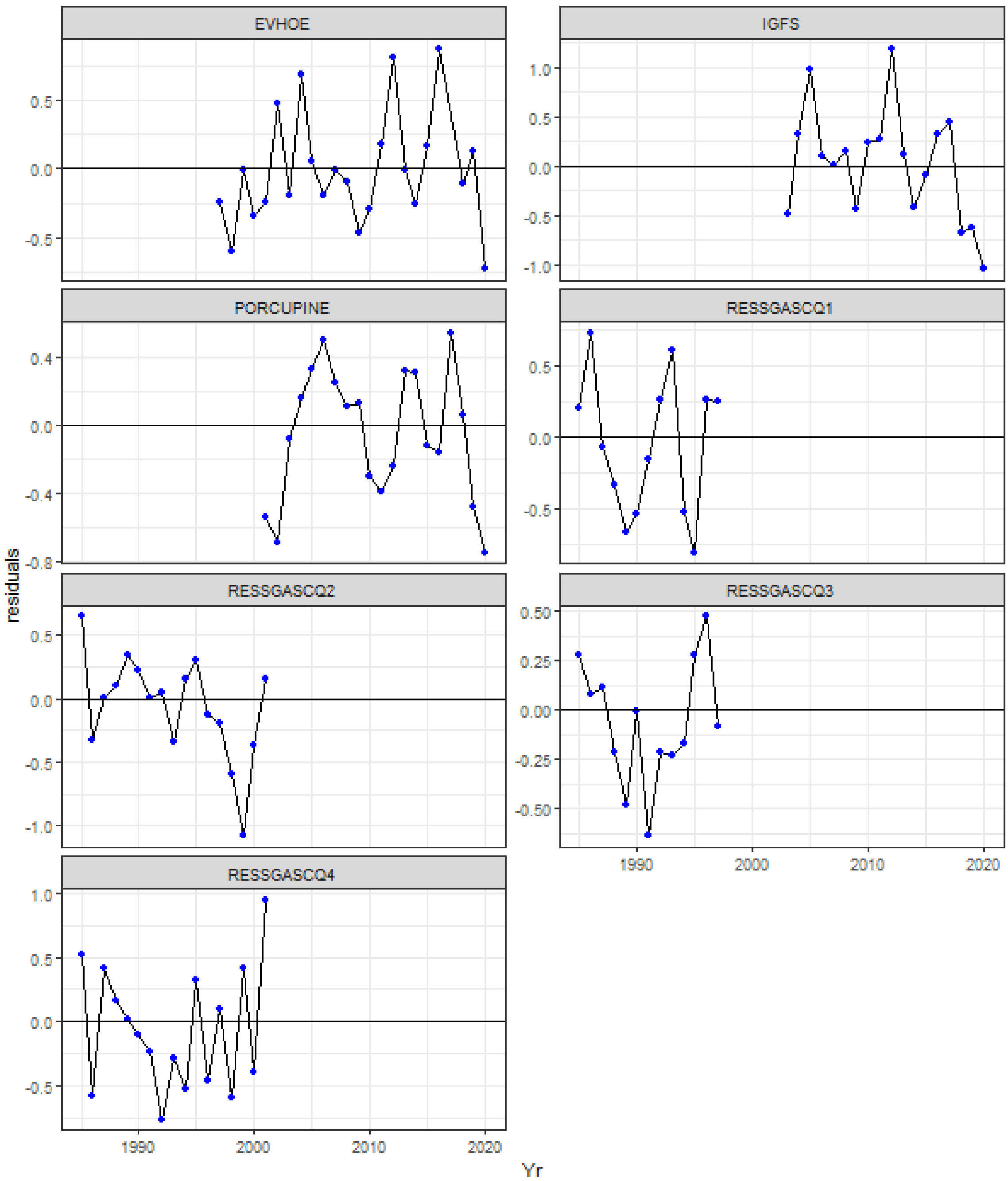

Figure 9.6. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Residuals of the fits to the surveys log(abundance indices). For RESSGASC, EVHOE (EVHOE-WIBTS-Q4), PORCUPINE (SpPGFS-WIBTS-Q3, G5768) and IGFS (IGFS-WIBTS-Q4, G7212), fits are by quarter.

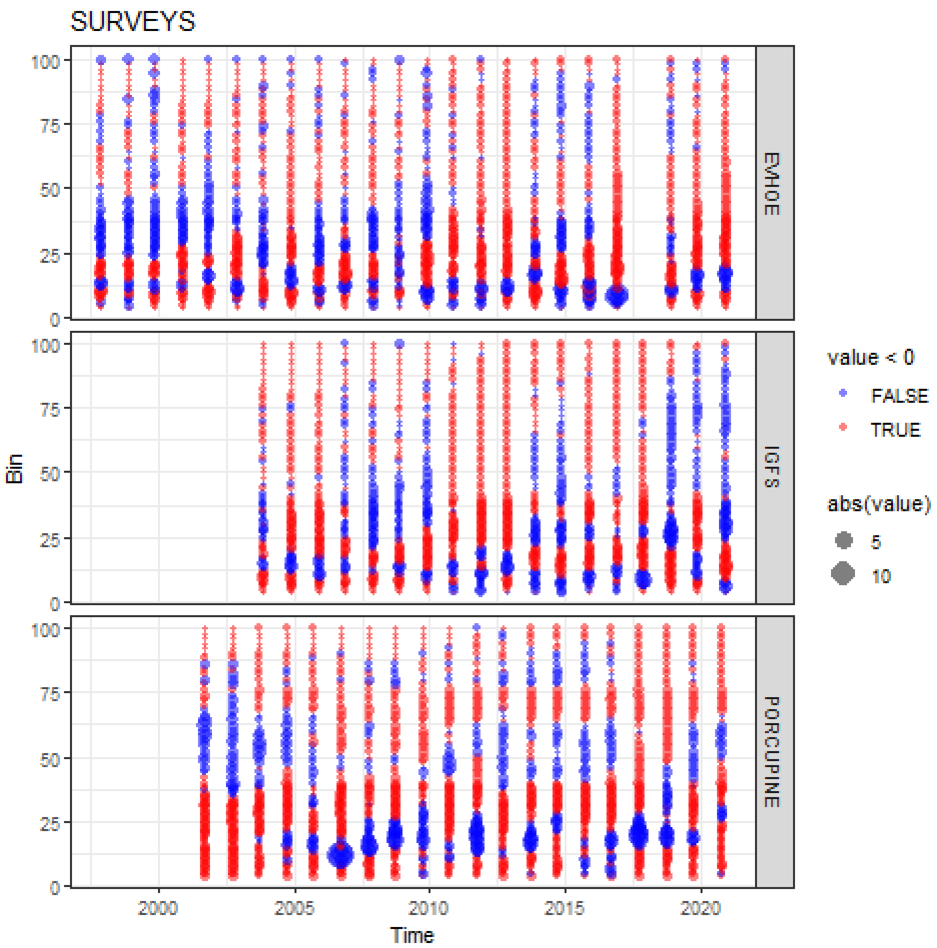

Figure 9.7. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Pearson residuals of the fit to the length distributions of the surveys abundance indices. For EVHOE (EVHOE-WIBTS-Q4), PORCUPINE (SPGFS-WIBTS-Q3) and IGFS (IGFS-WIBTS-Q4, G5768), fits are by quarter.

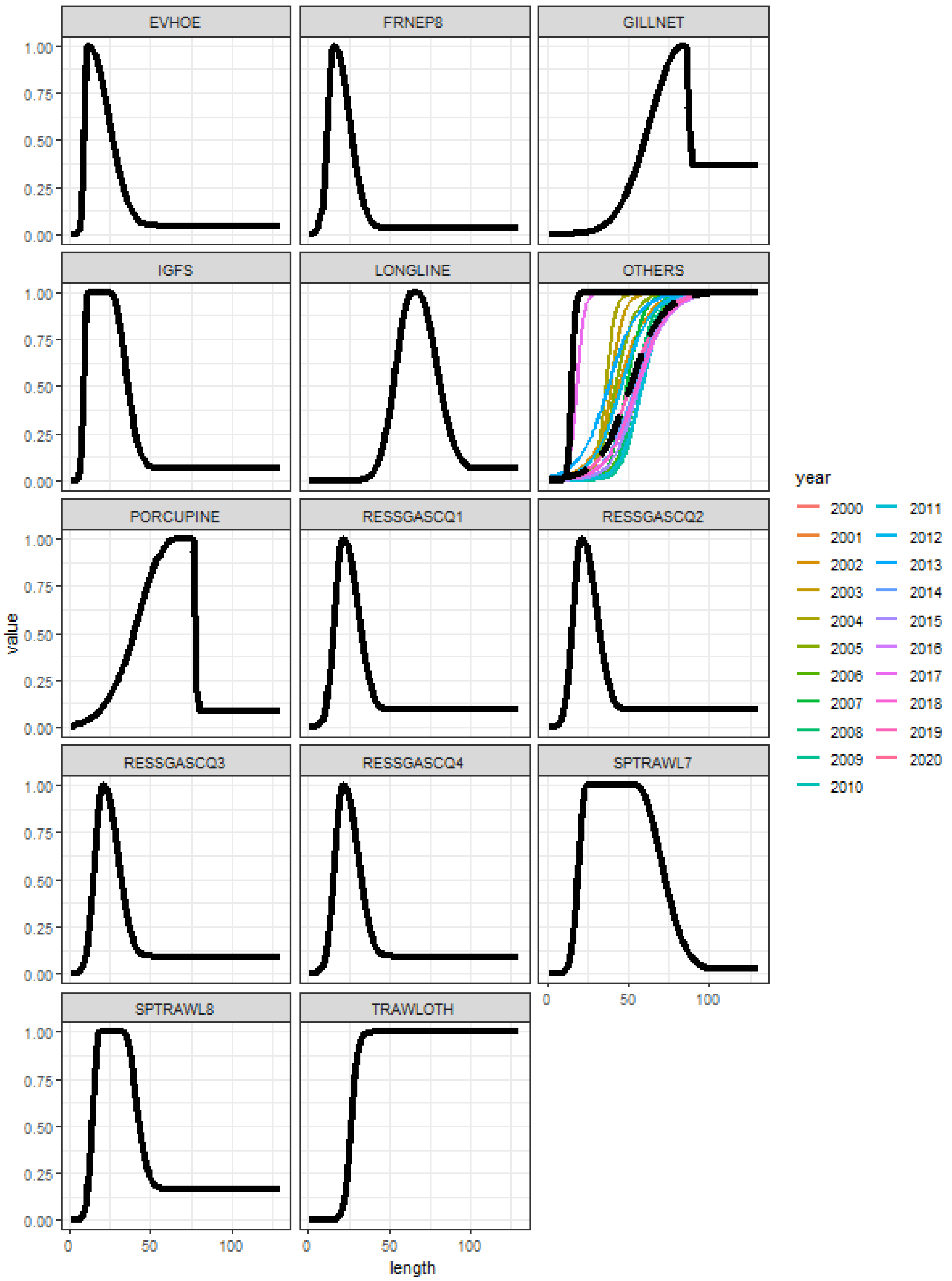

Figure 9.8. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Selection curves by commercial fleet estimated by SS. The solid black line corresponds to the selectivity in 2020 and the black dashed line with the selection in 2019.

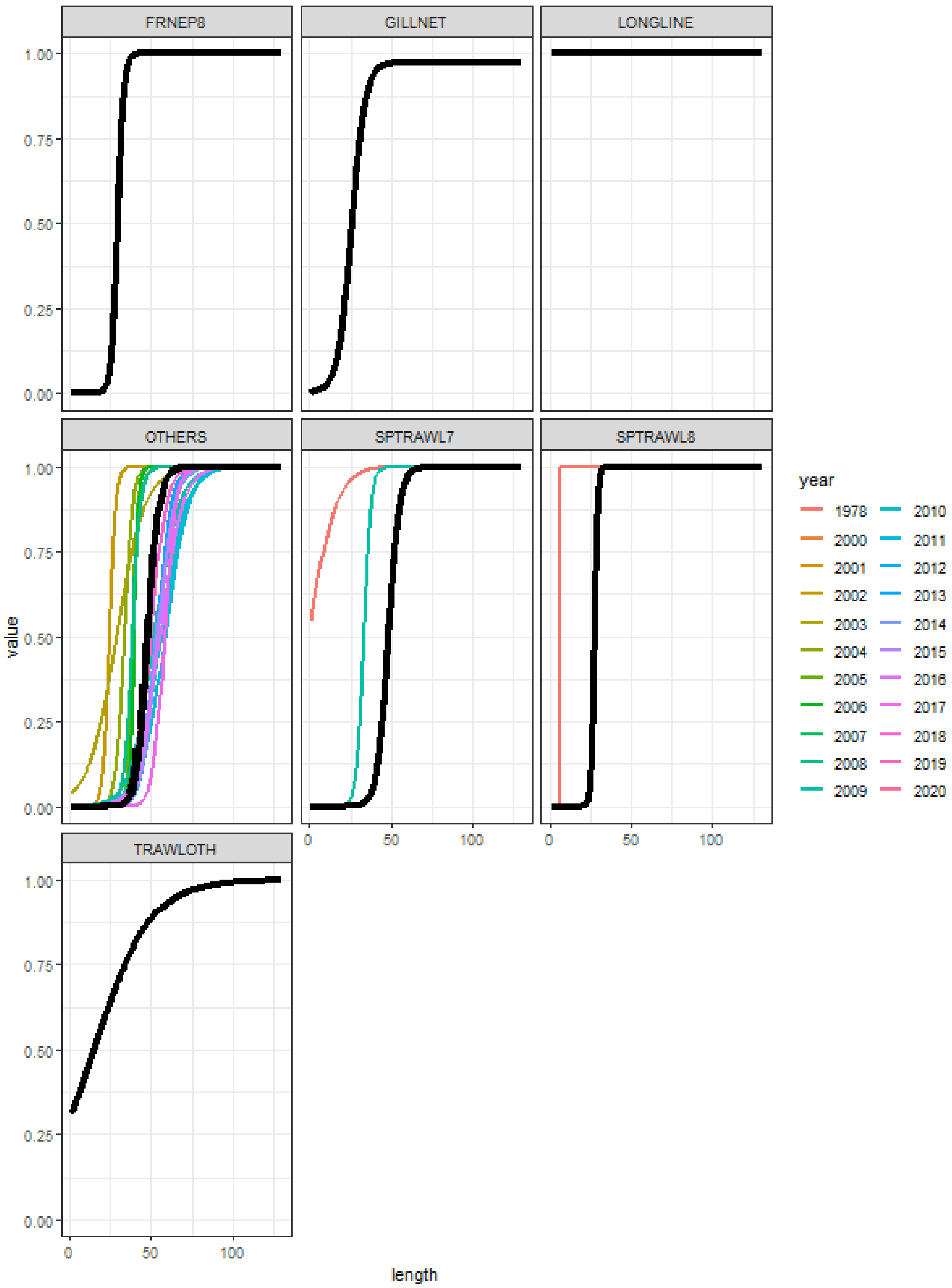

Figure 9.9. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Retention curves by commercial fleet estimated by SS. The solid black line corresponds to the selectivity in 2020 and the black dashed line with the selection in 2019.

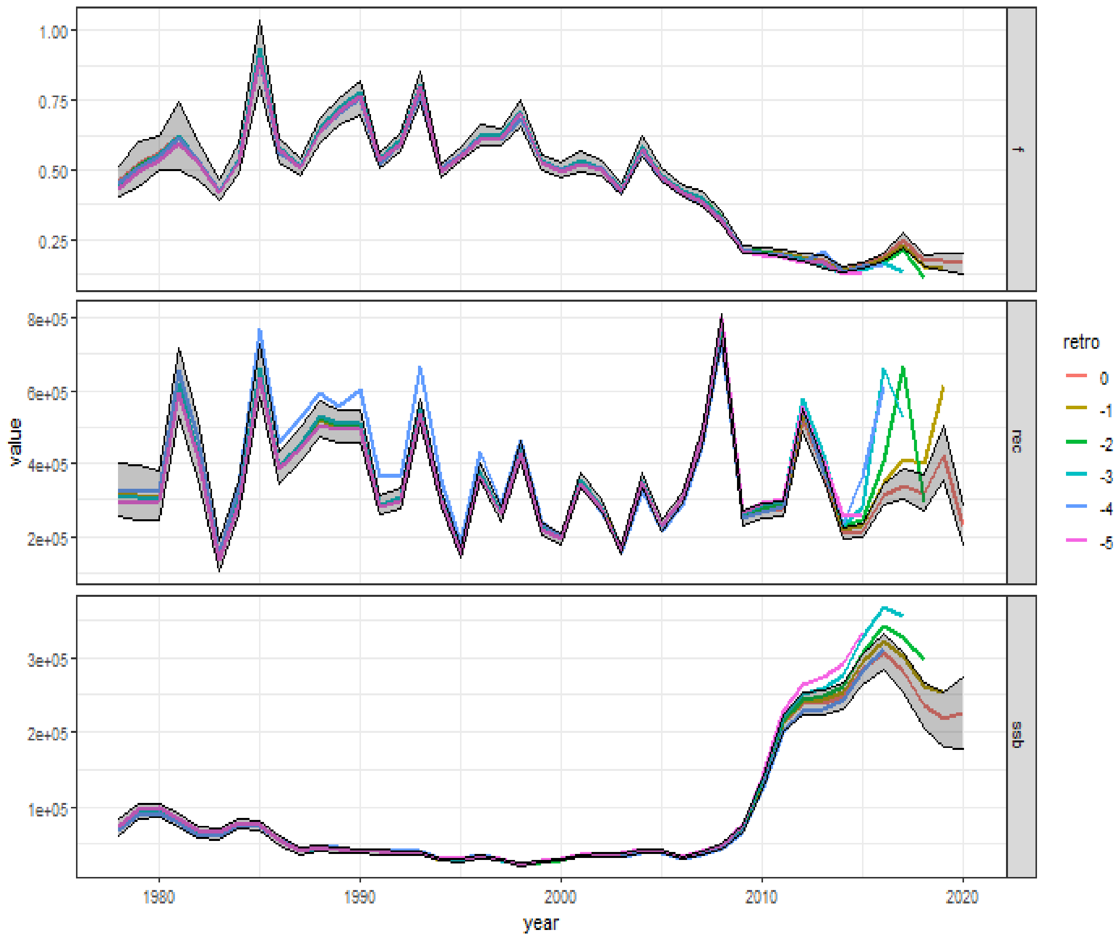

Figure 9.10. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Retrospective plot from SS3 including confidence intervals.

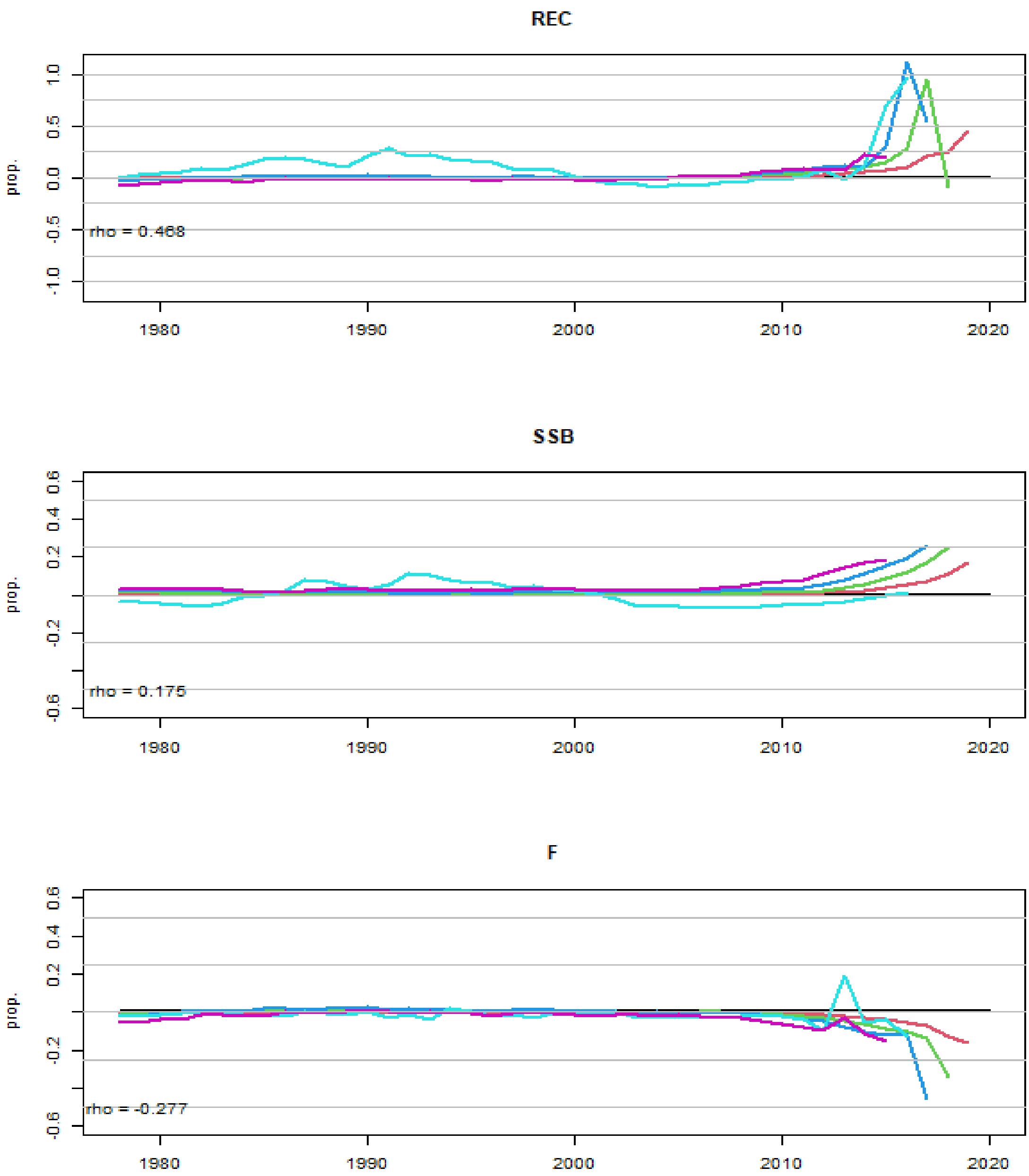

Figure 9.11. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Differences between time-series in the retrospective analysis plot from SS3 for 2015–2020. The number in the bottom-left of the plot corresponds to the Mohn's rho.

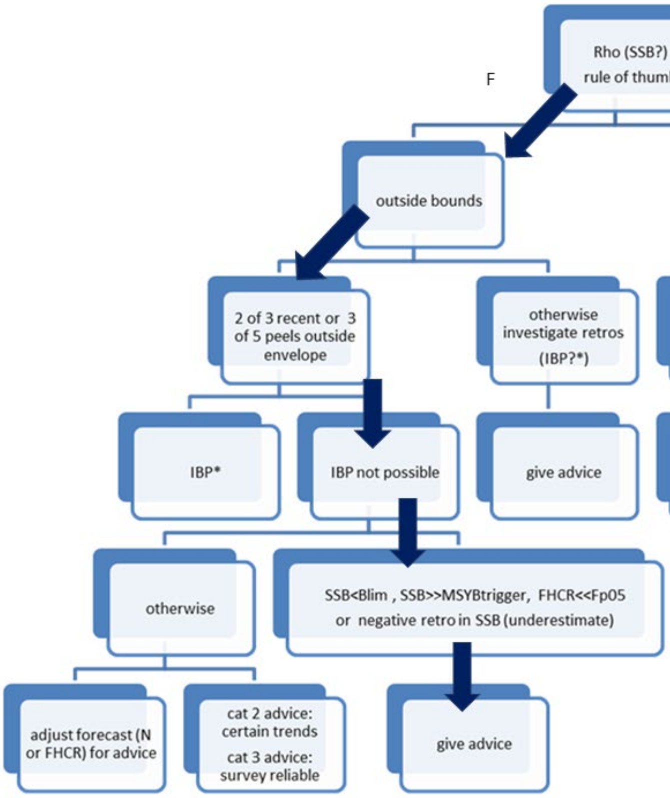

Figure 9.12. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Scheme from WKFORBIAS (ICES, 2020) to assess determine if it is possible to produce advice based on an assessment model with a given retrospective pattern

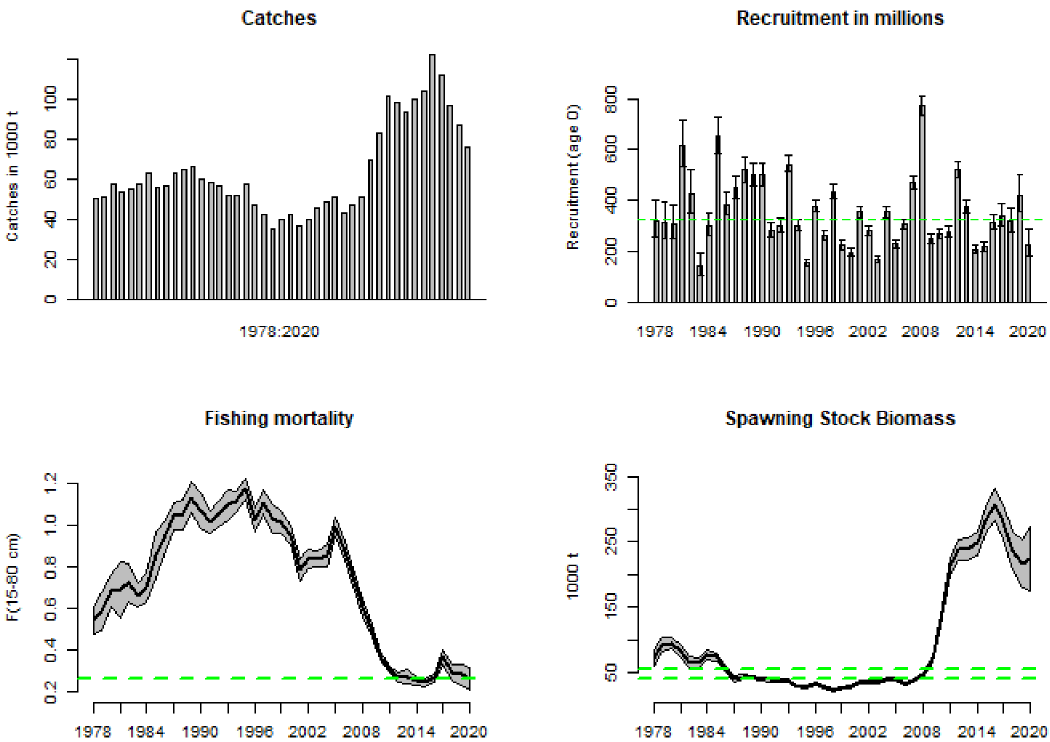

Figure 9.13. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

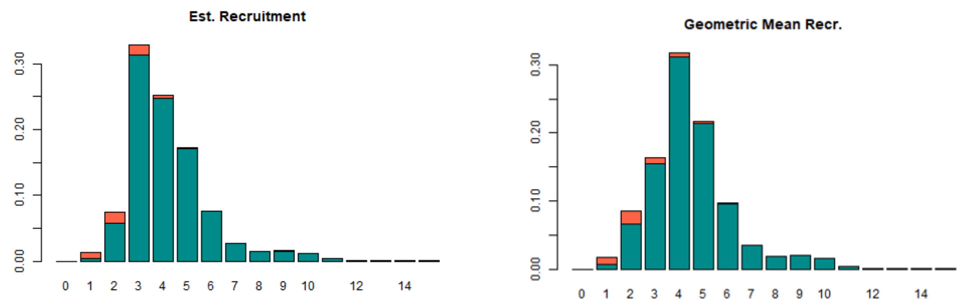

Figure 9.14. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Contribution of age-classes to catch advice in r fy using $F_{advice} = F_{msy}$ in the scenario where the estimated recruitment is used in the whole time-series (top) and in the scenario where the recruitment is replaced by the geometric mean in the last two years (bottom). The blue part of the bar corresponds to landings and red one with discards.

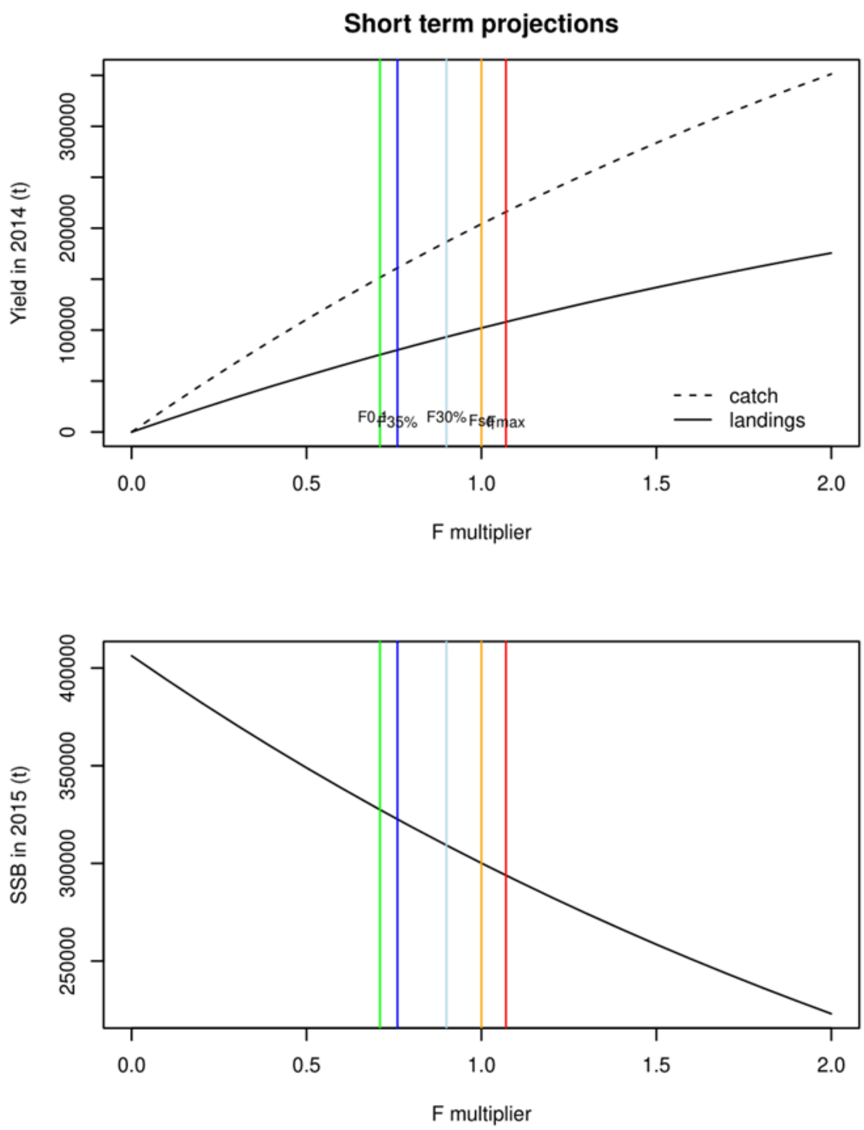

Figure 9.15. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

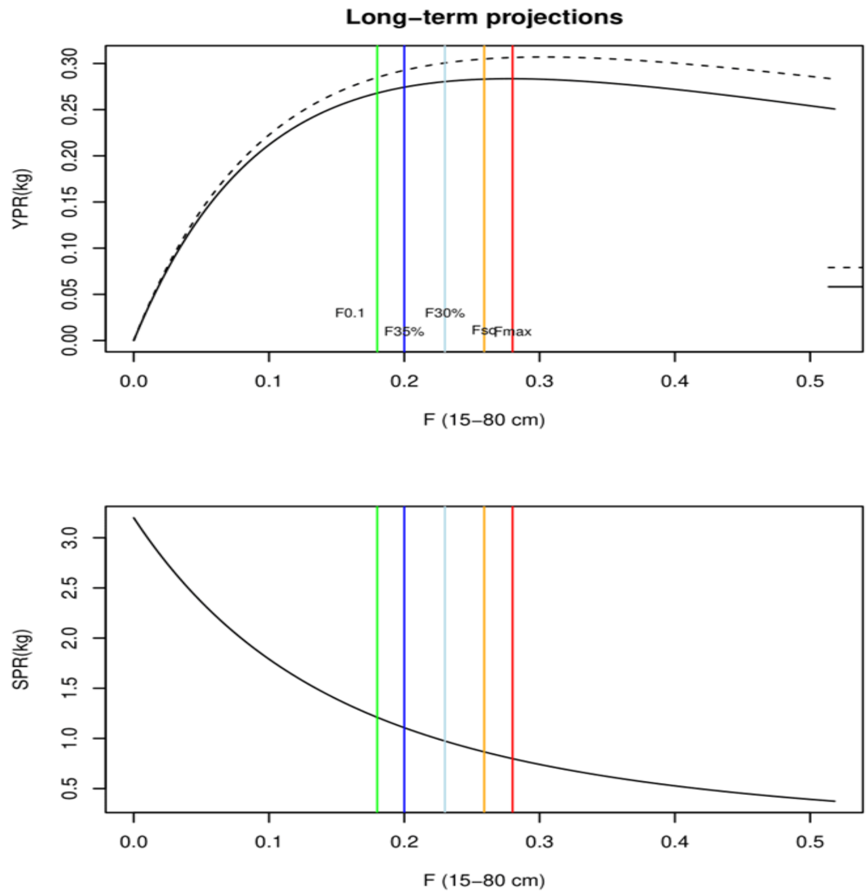

Figure 9.16. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.