9 Hake in Greater North Sea, Celtic Seas, and the northern Bay of Biscay

hke.27.3a46-8abd – *Merluccius merluccius* in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d, Northern stock

9.1 General

9.1.1 Stock definition and ecosystem aspects

This section is described in the Stock Annex which was updated after the WKANGHAKE benchmark[1] (ICES, 2023a).

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 2023 and historical management

9.1.3.1 ICES advice for 2023

The stock was considered to be above any potential MSY $B_{trigger}$. Following the ICES MSY framework implies that fishing mortality (F) should be maintained at 0.24, resulting in landings of 76 360 t and total catches of 83 130 t in 2023.

Like the other EU main fish stocks, northern hake is managed by a TAC and quotas. The TACs for recent years are presented in the table below. The TAC corresponds to northern stock (subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d), plus division 2.a (EU zone only; from 2021 onwards UK only), and divisions 3.b–d (except for 2019 onwards). There is no agreed TAC for Norwegian waters of subarea 4.

TAC(t)	2017	2018	2019	2020	2021	2022	2023
3.a, 3.b,c-d (EC Zone)	3 371	3 136	4 286	3 403	2 974	2 379	2 490
2.a (EC Zone), 4	3 928	3 653	4 994	3 940	3 443	2 754	2 883
5.b (EC Zone), 6, 7	67 658	62 536	79 762	63 325	55 335	44 268	46 335
8.a-b,d-e	44 808	42 460	52 118	42 235	36 906	29 525	31 422
Total northern stock	119 765	111 785	141 160	112 903	98 658	78 926	83 130

[1] ICES. 2022. ICES Stock Annex: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay). Produced by the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) and updated in August 2022 by the Benchmark workshop on anglerfish and hake (WKANGHAKE; ICES 2023a).

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 [EU, 1998]).

The 14th of June 2001, an Emergency Plan was implemented by the Commission for the recovery of the Northern hake stock (Council Regulations N 1162/2001 [EU, 2001a], 2602/2001 [EU, 2001b] and 494/2002 [EU, 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 (EU, 2004). It was aimed 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 F to 0.25 and by allowing a maximum change of 15% in TAC between years. According to the ICES advice for 2012, due to the change of the historical perspective of stock trends following from the migration to a new assessment method, 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 [EU, 2004], repealed by EC Reg. No. 2019/472 [EU, 2019]) 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 catch (Figure 9.1). The difference was due to the way the STECF calculated the TAC adjustments for stocks subject to the landing obligation. In 2021, ICES proposed a decrease in the 2022 catch advice of a 27%, from 102 888 to 75 052 t. The agreed TAC limited the interannual variability to 20% (TAC = 78 926 t). In 2023, the agreed TAC was set to the ICES advised catch (83 130 t), which implied a 5% increase relative to the previous year TAC.

9.2 Data

9.2.1 Commercial catches and discards

Total landings from the Northern hake stock by area for the period 1961-2022, as used by WGBIE, are given in Table 9.1. They include landings from subareas 4, 6, and 7, and from divisions 3.a, 8.a–b, and 8.d, as reported to ICES. Unallocated landings are also included in Table 9.1 and shows that these values were high over the first decade (1961-1970), when the uncertainties in the fisheries statistics were also high. In the years 2011 and 2012, they have increased again due to the differences between official statistics and scientific estimations. In 2014 and 2015, the differences between scientific and official landings decreased significantly which produced a big decrease in unallocated landings. The 2016 unallocated landings were reported by area. In 2017, no unallocated landings were reported such that these disappeared in Table 9.2. Table 1 of the Stock Annex provides a historical perspective of the aggregation level at which landings have been available to WGBIE.

Except for 1995, landings decreased steadily from 59 100 t in 1989 to 31 900 t in 1998. Up to 2003, landings fluctuated at around 40 000 t. Since then, with the exception of 2006, landings have been increasing up to 107 500 t in 2016, the highest in the whole time-series. The landings from 2009

to 2015 and the catches in 2016 were above the TAC advice. Since 2016, the catches have decreased every year and these have been below the TAC and the catch advice.

The discards had an increasing trend until 2011 that decreased steadily afterwards. The increase was general to all the fleets. In the case of gillnetters, discarding did not occur before 2012 and since then they have had a high level of discards. In 2016, the discards increased for all the fleets except for Spanish trawlers. In 2017, the total discards decreased for all the fleets, except for the Spanish trawlers in division 8.a-b and 8.d, with an overall decrease of 36%. The increase in the Spanish trawlers was equal to 28%. In 2018, the discards increased in Spanish trawlers in area 7 and in the gillnetters fleet but decreased in all the rest of the fleets. In the following years the discards follow this decreasing trend.

Discards data sampling and availability are presented in the Stock Annex. Table 9.2 presents discards, landings and the number of samples collected for each of the fleets considered in the assessment model since 2013. The numbers of samples and measured fishes are relatively stable every year, except for the TRAWLOTH fleet which shows high variability over time. In 2020, a decrease in both the number of samples and measured fishes was observed. The decrease is especially marked for the LONGLINE fleet and the discards sampling in SPTRAWL7 fleet. Spain contributes the most to the LONGLINE samplings. In 2020, some issues in the Spanish samplings were encountered due to the COVID-19 disruptions coupled with other national data administrative problems. In 2021, Spain's sampling intensity returned to the previous levels.

9.2.2 Biological sampling

Table 9.3 shows the countries that contribute to the total catch of each Fishery Unit (FU) (see Stock Annex, under "Fishery", for FUs description) and provides the LFDs.

In 2022, landings length compositions by FU and quarter were provided mainly by Ireland, France, Spain, UK(England and Wales), Scotland and Denmark, while some other countries also provided some data.

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

9.2.3 Abundance indices from surveys

Five surveys provide relative indices of hake abundance over time: (1) the French surveys in the Bay of Biscay (FR-RESSGACQ [G2537]) conducted from 1978 to 2002, (2) the French Southern Atlantic Bottom Trawl Survey (EVHOE-WIBTS-Q4 [G9527]) covering the Bay of Biscay and the Celtic Sea with a new design since 1997, (3) the Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3 [G5768]) conducted in the Porcupine Bank since 2001, (4) the Irish Groundfish Survey (IGFS-WIBTS-Q4 [G7212]) carried out in the west of Ireland and the Celtic Sea since 2003, and (5) the Irish Anglerfish and Megrim Survey (IE-IAMS [G3098]) in division 6.a and area 7 since 2016. A brief description of each survey is given in the Stock Annex and in Section 2 of this report. Figure 9.2 presents the abundance indices obtained from these surveys.

The FR-RESSGASC (G2537) survey was a French offshore trawl monitoring programme done by Ifremer from 1984 to 2003 which was completely halted in 2004 (Battaglia, 2002). The annual survey indices from 1985 until 2002 showed a slightly decreasing trend. The 2002 index is considered not reliable and, thus, not presented on Figure 9.2.

Throughout the available time-series, the abundance index provided by EVHOE-WIBTS-Q4 (G9527) survey showed six peaks in 2002, 2004, 2008, 2012, 2016 and 2019. The index obtained in 2012 was the highest value of the series, 192% 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 2.5 times higher than the 2015 value. In 2017, the index was not available since the survey was not conducted due to major vessel technical issues. In 2018, the index value decreased relative to the 2016 value and was around the value observed in 2015. It increased again in 2019 then decreased in 2020 to a historical minimum level for the whole time-series, followed by an increase in 2021 and a new decrease in 2022, being currently in one of the lowest levels of the series.

The abundance index provided by the IGFS-WIBTS-Q4 (G7212) survey is consistent with EVHOE WIBTS-Q4 (G9527) survey over recent years. The IGFS-WIBTS-Q4 (G7212) survey index showed four peaks that coincide with those observed in the EVHOE-WIBTS-Q4 (G9527) survey index but to a lesser extent. In 2012, the index achieved the highest value of the series, 231% higher than the previous year's index. The accumulated decrease in 2013 and 2014 was equal to 84%. The index increased moderately from 2015 to 2017. However, the increase in 2016 was not as significant as that observed with the EVHOE-WIBTS-Q4 (G9527) survey index. The index decreased in 2018 and the observed variation has been low during the last two years. Currently, 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 126%, the index decreased considerably in 2015 followed by a subsequent but moderate decline in 2016. The peaks detected by EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) were also detected in this survey but had occurred 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 2003-2005.

The biomass index from IE-IAMS (G3098) survey also follows the trends of the rest of the other surveys, with a peak in 2017.

The spatial distribution of the EVHOE-WIBTS-Q4 (G9527), SpPGFS-WIBTS-Q4 (G5768), IGFS-WIBTS-Q4 (G7212) and IE-IAMS (G3098) respective survey catch rates (Kg/h) are provided in Figure 9.3 since 2007. It should be noted that EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) surveys use similar gears while the SpPGFS-WIBTS-Q4 (G5768) and IE-IAMS (G3098) employ quite different gears with different catchabilities, which consequently the surveys are not directly comparable in the figure maps. The SpPGFS-WIBTS-Q4 (G5768) survey catch rate shows a homogenous spatial distribution in the sampled area throughout the time-series. Among the four 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 9.3). In 2017, the EVHOE-WIBTS-Q4 (G9527) survey was only carried out partially due to some major vessel technical issues, consequently, the index and length data were not included in the model for that year (ICES, 2018). For the IGFS-WIBTS-Q4 (G7212) survey, the spatial distribution of the catch rates was stable throughout the time-series, with a slight decrease in 2018. The southern region of the sampled area showed a higher catch rate in recent years. For the IGFS-WIBTS-Q4 (G7212) survey, high biomass concentration seems to occur in areas closer to the continental French shelf. The IE-IAMS (G3098) survey showed variable abundance values along the years, with a remarkable increase in 2019. Overall, for all surveys combined, a contraction of the spatial distribution is visible since 2015.

The EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) surveys catch mainly young individuals below 25 cm while the SpPGFS-WIBTS-Q4 (G5768) and IE-IAMS (G3098) capture larger sized individuals (30 – 75 cm) (Figure 9.4). In the case of the EVHOE-WIBTS-Q4 (G9527) survey, the distribution is quite homogeneous year after year, with the mode around 12 cm. In the case of the IGFS-WIBTS-Q4 (G7212) survey, most of the individuals were around 25 cm with almost

no individuals around 12 cm (which is the distribution mode for most of the years in the series) for the years 2018 and 2020. The LFDs from the SpPGFS-WIBTS-Q4 (G5768) survey are quite flat, varying between 40 and 65 cm (with a peak around 20 cm) which is associated with the previous year's recruitment. This peak was very high in 2017. In the case of the IE-IAMS (G3098) survey, the LFDs are also quite flat, varying between 30 and 75 cm. The variability of the shape of LFDs of these three latter indices could be motivated by the limited sampling area covered compared with the index estimated from the EVHOE-WIBTS-Q4 (G9527) that covers a bigger survey area.

9.3 Assessment

This is an update assessment in relation to the assessment carried out during the Benchmark workshop on anglerfish and hake (WKANGHAKE; ICES, 2023a) in 2022. During this benchmark, a new model was developed using the Stock Synthesis (SS) framework (Methot Jr. and Wetzel, 2013). This new model includes an additional fleet (OTHER fleet disaggregated in trawlers and non-trawlers since 2013) and a new survey, the IE-IAMS (G3098), compared to the previous model used by WGBIE in 2021 (ICES, 2021). The population dynamics are now sex-separated with sex-dependent growth and natural mortality (M). Other changes in the assessment this year included the estimation of the steepness by the model, the selectivity is kept random since 1998 for all fleets (previously blocks were defined in some fleets based on observed selectivity changes motivated by changes in legislation and other factors) and the LFDs have been downweighed.

9.3.1 Input data

See Stock Annex (under "Input data for SS"). The catch contribution of the commercial fleets used in the configuration of the model has changed over time (Figure 9.1). At the beginning of the time-series more than 75% of the catch was caught by trawler fleets. However, their contribution declined to around 25% of the total catch in the last years. On the contrary, the combined catches of longliners and gillnetters was relatively small in the past. Currently however, the contribution of each of these fleets has increased and is now similar to the contribution of trawlers at the beginning of the time-series. The increase in the biomass of the stock in the last decade has resulted in a high increase in the catch of the OTHER fleet. Nowadays, the annual catch of the trawlers outside the Bay of Biscay and Celtic Sea (TRAWLOTH) is similar to the catch of trawlers in the Bay of Biscay and the Celtic Sea.

The quarterly LFDs for recent landings and discards are given in Figure 9.5. For most of the fleets, the LFDs 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 while for gillnetters and TROTH fleet this is observed indiscriminately over the whole distribution range. The data collection from the commercial fishery and research surveys during 2020 were affected by COVID-19 restrictions to varying degrees across member states. Spanish discard data and LFDs in SPTRAWL7 fleet were missing for some quarters. The 2020 LONGLINE fleet sampling was also lower compared to previous years with a corresponding odd shaped LFDs. Previous years' LONGLINE fleet sampling LFDs had a smooth and well-defined shape.

9.3.1.1 Data revisions

No data revisions have been provided in 2023.

9.3.2 Model

The SS assessment model (Methot Jr. and Wetzel, 2013) is used for this stock. The model description and settings are presented in the Stock Annex (under "Current assessment" for model description and "SS settings (input data and control files)" for model settings).

9.3.3 Model results

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

The Pearson residuals of the EVHOE-WIBTS-Q4 (G7212) survey LFDs have a "fairly random" pattern with no general trend or lack of fit. This can be observed in Figure 9.7, where blue and red circles denote positive and negative residuals, respectively. However, the current model has difficulties in explaining the peaks in small individuals observed in the SpPGFS-WIBTS-Q4 (G5768) and IE-IAMS (G3098) surveys as well as the lack of small individuals in IGFS-WIBTS-Q4 (G7212) index for some years (i.e. 2018, 2020 and 2021).

Residuals of the LFDs of the commercial fleets' landings and discards (not presented in this report, but available on the GitHub repository[2]) show some patterns, similar as in previous assessments.

The assessment model includes estimation of size-based selectivity functions (selection pattern-at-length) for commercial fleets and for 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 GILLNET, LONGLINE and OTHER fleets. For the North Sea trawlers, two different selectivity functions are estimated. One is for the period 1978-2012 and the other is varying from year to year since 2013. For the other fleets, both selection and retention curves are considered constant until 1997 and varying for the rest of the assessment period (1998-2021). The change in retention in 1998 for Spanish trawl fleets was clearly observed when examining the LFDs of the landings and might be due to a more rigorous enforcement of the minimum landing size. The most recent change in the retention of 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. The variation is modelled using a random walk as described in the Stock Annex. The selection pattern has gradually changed over the years, such as the retention ogives. However, both the selection patterns and retention ogives in 2021 and 2022 are almost identical (Figures 9.8 and 9.9). Residuals of the LFDs of the commercial fleets landings and discards (not presented in this report, but available on the GitHub repository[3]) show some patterns, similar to those seen in previous assessments (ICES, 2022).

The retrospective analysis (Figure 9.10) shows that for the three summary indicators ($F_{1\text{-}7}$, SSB and Recruitment) the model results are sensitive to the exclusion of recent data, especially for SSB and $F_{1\text{-}7}$. The inclusion of new data affected the recruitment estimates especially in the most recent years, the SSB was generally revised downwards, while the $F_{1\text{-}7}$ was revised upwards. The

[2] https://github.com/ices-taf/2023_hke.27.3a46-8abd_assessment

[3] https://github.com/ices-taf/2023_hke.27.3a46-8abd_assessment

inclusion of new data also overestimated the large incoming recruitments in the first years but the impact on the last years' estimates shows the absence of a clear trend. These cancellation effects reduced the value of the Mohn's rho (Mohn, 1999) for the recruitment (at -0.11). However, the systematic overestimation of SSB and underestimation of $F_{1\text{-}7}$ removed the cancellation effects and the obtained Mohn's rho values observed 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 WKFORBIAS guidelines (ICES, 2020), the observed retrospective pattern is acceptable to provide advice (see Figure 9.12). The Mohn's rho values for SSB and $F_{1\text{-}7}$ are outside the bounds (0.30 > 0.20 for SSB and -0.19 < -0.15 for $F_{1\text{-}7}$) with three of the five recent peels outside the envelope. Consequently, these latest patterns observed will be investigated further inter-sessionally before the WGBIE in 2024. However, as the retrospective pattern is close to the retrospective limit (if the last 3 peels are considered) while the SSB is well above MSY $B_{trigger}$ and the $F_{1\text{-}7}$ is well below Fp_{05}, WGBIE is confident that it is possible to give an advice based on the assessment model presented in this report. The inclusion of the 2022 data has led to a reduction to the retrospective patterns compared to those observed during the WKANGHAKE benchmark (ICES, 2023a), as two of the three recent peels for SSB and $F_{1\text{-}7}$ in this year's assessment are still inside the envelope.

Summary results from the SS assessment 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 recruitment, fluctuations appear to be without substantial trend over the whole series. The recruitment in 2007 was the highest in the whole series with 2 177 millions of individuals and the ones in 2020-2022 were below the geometric mean (GM; 722 millions). From high levels at the start of the series (92 412 t in 1980), the SSB decreased steadily to a low level at the end of the 1990s (29 600 t in 1998). Since then, SSB has increased to the highest value of the series in 2015 (293 823 t) and decreased progressively until 2023 (163 204 t).

The F is calculated as the average annual F for ages 1–7. Values of $F_{1\text{–}7}$ increased from values around 0.30-0.38 in the late 1970s and early 1980s to values around 0.60 during the 1990s. Between 2006 and 2013, $F_{1\text{–}7}$ declined sharply. Since 2009, $F_{1\text{–}7}$ remains below F_{MSY} (0.24). The $F_{1\text{–}7}$ estimate for 2021 (0.189) is well below F_{MSY}.

The 90% confidence intervals are wider than before (Figure 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 all of the uncertainty in the input data. However, during the last WKANGHAKE benchmark (ICES, 2023a), the data weighting in SS was revisited in order to get more realistic confidence intervals. Specifically, the weight of the LFDs in the likelihood components has been reduced by multiplying them by 0.1.

9.4 Catch options and prognosis

9.4.1 Assumption on recruitment

In the 2020 and 2021 assessments, recruitment estimates for the last two data years (2018-2019 and 2019-2020, respectively), were replaced by the GM. The 2020 recruitment was close to the GM. 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. In 2022, the recruitment estimates were not replaced. However, the new methodology agreed upon during the WKANGHAKE benchmark (ICES, 2023a) was to replace the recruitment estimates for the last

two data years with the recruitment predicted from SS stock-recruit relationship, but only in cases when WGBIE believes these are not accurately estimated.

This year, the recruitment estimates for the last two years (2022 and 2021) were not replaced. The 2021 and 2022 recruitments were below the GM. The assessment model overestimated two of the four abundance indices available in the last two years. If we focus on the indices that give information on smaller individuals, the assessment overestimates values for the IGFS-WIBTS-Q4 (G7212) survey in both years, whereas these values were underestimated for the EVHOE-WIBTS-Q4 (G9527) survey only in 2021 and quite precisely estimated in 2022. Hence, not replacing the recruitment estimates for the last two years was considered more reliable for projections.

Recruitment in the projection years (2023-2024) was estimated by the model based on fitted Beverton-Holt stock-recruitment relationship.

9.4.2 Short–term projection

SS has a forecast module which provides the capability to do a projection for a user-specified number of years that is directly linked to the model ending conditions, associated uncertainty, and to a specified level of fishing intensity. This was the tool used to carry out the short-term projections, as defined during the WKANGHAKE benchmark (ICES, 2023a) and as described in the Stock Annex.

For the current projection, unscaled F is used, corresponding to $F_{1–7}$ = 0.189. Recruitment short-term projection assumption values are given in Table 9.5. Landings in 2024 and SSB in 2025 predicted for various levels of $F_{1–7}$ in 2024 are also given in Table 9.5 and Figure 9.14.

Maintaining *status quo* $F_{1–7}$ in 2024 is expected to result to a decrease in both the catch and the SSB with respect to 2023, at around -6% and -8%, respectively.

When we compare present year short-term forecast outcomes with previous year ones, we see that the catches, the fishing mortality, and the recruitment assumed last year for 2022 and 2023 have been revised downwards this year, leading to a minor reduction of the SSB (Figure 9.15). Both the selectivity and retention curves are quite stable (Figure 9.15). However, the numbers at age are lower for individuals of below 6-year-old and higher for the older ones. The expected reduction of the SSB is likely for an exploitation at F_{MSY} levels as the stock is currently well above MSY Btrigger.

9.4.3 Yield and biomass per recruit analysis

Long-term projections were carried out using SS. These calculate the equilibrium level of spawner-per-recruit (SPR) and yield-per-recruit (YPR) that would occur if fishing according to a trial level of fishing intensity and based on this SPR and the unfished level (SPR_0) calculate the absolute level of recruitment, spawning biomass, and yield that would occur if fishing intensity were maintained at this rate (Methot Jr. and Wetzel, 2013).

Results of equilibrium yield and SSB-per-recruit are presented in Table 9.6 and Figure 9.18. The F-multiplier in Table 9.6 is with respect to maximum equilibrium yield-per-recruit (F_{max}).

Considering the yield and SSB-per-recruit curves, *status quo* F (F_{sq} = average F_{1-7} in the final 3 assessment years, 2020-2022), $F_{0.1}$, $F_{35\%}$, $F_{30\%}$ and F_{MSY} are respectively estimated to be 150%, 150%, 120%, 140%, and 200% of F_{max}. 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 recalculated in 2022 during the WKANGHAKE benchmark (ICES, 2023a) based on the new model settings. The reference points in use for the stock are as follows:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	78405	B_{pa}; females only, in tonnes.
	F_{MSY}	0.24	Stock Synthesis simulations.
Precautionary approach	B_{lim}	61563	The breakpoint of the segmented regression stock–recruitment relationship; females only, in tonnes.
	B_{pa}	78405	$\exp(1.654 \times \sigma) \times B_{lim,}$ with σ = 0.147; females only, in tonnes.
	F_{lim}	0.73	The F that provides a 50% probability for SSB to be above $B_{lim.}$
	F_{pa}	0.54	F_{P05} with advice rule (AR): the F that provides a 95% probability for SSB to be above $B_{lim.}$
Management plan	F_{mgt}	Not defined	
	SSB_{mgt}	Not defined	
	MAP MSY $B_{trigger}$	78405	MSY $B_{trigger}$; females only, in tonnes.
	MAP B_{lim}	61563	B_{lim}; females only, in tonnes.
	MAP F_{MSY}	0.24	F_{MSY}
	MAP range F_{lower}	0.147	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY.
	MAP range F_{upper}	0.37	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY.

9.6 Comments on the assessment

The current model presents SSB for females only, which is considered as an improvement since egg production is considered a good metric of reproductive potential and female SSB is a better proxy of egg production than total mature biomass. The reference points were calculated relative to the female SSB (ICES, 2023a).

Actual assessment estimates cannot be compared with the assessment estimates prior to 2022 as the assessment model configuration was changed as a result of the WGANGHAKE benchmark (ICES, 2023a) and the perception of the stock changed relative to these new reference points.

The retrospective pattern shows a general trend to correct SSB downwards and F_{1-7} upwards. The causes of this pattern are not yet well understood and should be further explored to identify the causes for this bias.

The sample size provided for the LFDs should be related to the yearly available samples as model results are sensitive to these sample values and can be especially important in years with lower sampling intensity, such as in 2020 when sampling levels declined due to COVID-19 disruptions.

9.6.1 Sensitivity runs

The inclusion of the 2022 data led to a slight reduction of the retrospective patterns in the latest years, relative to those observed in last year's assessment (ICES, 2022). However, this still gave values outside the ICES recommended bounds (ICES, 2020), with Mohn's rho values at 0.30 (>0.20) for SSB and -0.19 (<-0.15) for F_{1-7}. However, given the ICES guidelines, it was possible to give advice.

Given the fact that the estimated recruitments for the interim (Rec2023 = 862 millions) and advice year (Rec2024 = 855 millions) were above the GM recruitment (722), the short-term forecast was carried out replacing these values by the GM recruitment.

The advice for the stock under F_{MSY} (0.24) would imply catches at 72 310 t (when replacing the recruitment by the GM) and for the lower and upper ranges at 46 396 t and 102 105 t, respectively. Very similar to those obtained when using the values from the stock-recruitment relationship fitted by the model.

9.7 Future benchmark

A follow-up IBP was recommended and supported by WGBIE last year (ICES, 2022) to update the biological component of the model based on available data and explore alternative configurations that could further improve the quality of the current northern hake assessment model fit. With the new benchmark process (ICES, 2023b), the update of the biological parameters could be done in the framework of the working group, if it is considered a minor change, or could require external review, if the changes are not considered minor or the impact in the results is relevant. For major changes, a full benchmark process by intersessional work would be required.

The following points should be explored and revised:

- Biological parameters. Revise some biological parameters to obtain stable stock-specific, sex-disaggregated, and time-varying model estimates which can mitigate overestimated stock productivity (ICES, 2022). For example, actual values of M integrated in the model were taken from a study of some fish stocks in the Mediterranean (GCFM, 2019a; 2019b), length-weight parameters have been inherited from the WGBIE southern hake stock while the growth parameters are not sex-specific.
- Weighting options. Further explore and perform sensitivity analyses of the model estimates to better calibrate the weighting of the likelihood components with the adequate weights defined. Furthermore, there is a need for a standardised protocol to determine the effective sample size needed when updating data in the model in order to account for significant data sampling changes.
- Retrospective patterns. Further investigate and identify the contributing factors to the increasing retrospective patterns observed in the current assessment model.

9.8 Management considerations

Although there has been a general decrease in the retrospective patterns for the latest years, there is still a tendency to revise SSB downwards while $F_{1\text{-}7}$ upwards (ICES, 2023a). This may result in an inflated advised catch but still needs to be tested.

Since 2017, the observed catches have been significantly below the TAC and the catch advice, which may indicate an overestimation of stock productivity.

It should be noted that the ICES catch advice provided for this year is for the whole hake stock, including those fished in Norwegian waters (subarea 4). However, the sum of the TACs since 2019 indicated in this report are only for the EU member states and the UK, excluding subarea 4.

9.9 References

Battaglia, A. 2002. Manuel des protocoles de campagne halieutique. Ressources halieutiques du golfe de Gascogne. Campagnes RESSGASC. DRV/RH/DT/2002-006.

EU. 1998. Regulation (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

EU. 2001a. Regulation (EC) No 1162/2001 of 14 June 2001 establishing measures for the recovery of the stock of hake in ICES subareas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e and associated conditions for the control of activities of fishing vessels.

EU. 2001b. Regulation (EC) No 2602/2001 of 27 December 2001 establishing additional technical measures for the recovery of the stock of hake in ICES subareas III, IV, V, VI and VII and ICES divisions VIIIa,b,d,e.

EU. 2002. Regulation (EC) No 494/2002 of 19 March 2002 establishing additional technical measures for the recovery of the stock of hake in ICES subareas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e.

EU. 2004. Regulation (EC) No 811/2004 of 21.4.2004 establishing measures for the recovery of the Northern hake (repealed by Commission Regulation n° 2019/472).

EU. 2019. Regulation (EU) 2019/472 of the European Parliament and of the Council of 19 March 2019 establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008.

GCFM. 2019a. Report of the Working Group on Stock Assessment of Demersal Species (WGSAD). Benchmark session for the assessment of European hake in GSAs 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 22, 23 and 26. FAO headquarters, Rome, Italy, 2–7 December 2019. https://www.fao.org/gfcm/technical-meetings/detail/en/c/1313336/

GCFM. 2019b. Report of the Working Group on Stock Assessment of Demersal Species (WGSAD). Benchmark session for the assessment of European hake in GSAs 17-18. FAO headquarters, Rome, Italy, 15-18 January 2019. https://www.fao.org/gfcm/technical-meetings/detail/en/c/1194087/

ICES. 2010. Report of the Benchmark Workshop on Roundfish (WKROUND), 9–16 February 2010, Copenhagen, Denmark. ICES CM 2010/ACOM: 36, 183 pp

ICES. 2014. Report of the Benchmark Workshop on Southern megrim and hake (WKSOUTH). 3–7 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM: 40. Copenhagen, Denmark.

ICES. 2016. Report of the Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE) 13-19 May 2016 ICES HQ, Copenhagen, Denmark. ICES CM/ACOM: 12, 513 pp.

ICES. 2018. Report of the Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE) 3-10 May 2018 ICES HQ, Copenhagen, Denmark. ICES CM/ACOM: 12, 642 pp.

ICES. 2019a. Inter-benchmark of Hake (*Merluccius merluccius*) in subareas 4, 6, and 7 and divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay) (IBPhake). ICES Scientific Reports. 1:4, 28 pp. http://doi.org/10.17895/ices.pub.4707.

ICES. 2019b. Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). ICES Scientific Reports. 1: 31, 692 pp. http://doi.org/10.17895/ices.pub.5299

ICES. 2020. Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; outputs from 2019 meeting). ICES Scientific Reports. 2:28. 38 pp. http://doi.org/10.17895/ices.pub.5997

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

ICES. 2022. Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). ICES Scientific Reports. 4:52. 847 pp. https://doi.org/10.17895/ices.pub.20068988

ICES. 2023a. Benchmark workshop on anglerfish and hake (WKANGHAKE; outputs from 2022 meeting). ICES Scientific Reports. 5:17. 354 pp. https://doi.org/10.17895/ices.pub.20068997

ICES. 2023b. ICES Guidelines for Benchmarks. Version 1. ICES Guidelines and Policies - Advice Technical Guidelines. 26 pp. https://doi.org/10.17895/ices.pub.22316743

Methot Jr., R.D. and Wetzel C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142: 86-99.

Mohn, R. 1999. The retrospective problem in sequential population analysis: An investigation using cod fishery and simulated data. ICES Journal of Marine Science, 56: 473-488.

9.10 Tables and figures

Table 9.1. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Estimates of catches (in '000 t) by ICES area for 1961-2022 (L: landings and D: discards).

Year	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Unallocated	L_{Total}	D_3	D_4	D_5	D_6	D_7	D_8	D_{Total}	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

Year	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Unal-lo-cated	L_{Total}	D_3	D_4	D_5	D_6	D_7	D_8	D_{To-tal}	Total
1986			7.3				27.4	23.9	-1.5	49.8								49.8
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

Year	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Unallocated	L_{Total}	D_3	D_4	D_5	D_6	D_7	D_8	D_{Total}	Total
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
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	1.1	2.0	4.0	76.5
2021			0.8	9.3	0	3.8	33.4	20.8	0.0	68.1	0.1	0.3		0.6	0.9	1.1	3.1	71.1
2022			1.1	11.1	0	3.8	27.7	23.7	0.0	67.4	0.1	0.2		0.1	0.3	1.2	2.0	69.4

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

[2]Discard estimates from observer programmes. In 2003-2022 partial discard estimates are available and used in the assessment. For the remaining years for which no values are present, 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 (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–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 fishes measured per catch category (NLgMs_D and NLgMs_L) since 2013 for the fleets used in the assessment model.

Year	ss_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
2021	FRNEP8	144	711	5	36	412	1460
2022	FRNEP8	478	773	20	51	941	1506
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
2020	GILLNET	444	23003	139	516	3364	20521
2021	GILLNET	626	24138	329	717	1960	25992
2022	GILLNET	396	25474	359	539	1816	24166
2013	LONGLINE		14516		51		24319
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

Year	ss_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2021	LONGLINE	0	18663	0	65	0	23197
2022	LONGLINE	0	15024	0	62	0	25332
2013	NSTRAWL	4788	9680	130	152	7103	7898
2014	NSTRAWL	4268	11124	211	415	8109	7017
2015	NSTRAWL	3566	13498	197	411	10932	6460
2016	NSTRAWL	4621	17159	484	463	10706	16643
2017	NSTRAWL	2239	15142	392	405	8942	11714
2018	NSTRAWL	1808	13478	485	505	14992	14899
2019	NSTRAWL	1448	13014	394	427	11436	13380
2020	NSTRAWL	906	8575	209	315	5651	10975
2021	NSTRAWL	1067	6956	249	382	7836	15667
2022	NSTRAWL	376	7822	297	503	2226	20177
2013	OTHERS	1499	35324	15	176	179	12556
2014	OTHERS	739	15041	77	448	1835	13881
2015	OTHERS	589	10016	60	484	232	6588
2016	OTHERS	66	15940	46	371	432	17774
2017	OTHERS	87	16229	21	172	396	6017
2018	OTHERS	136	14918	36	297	2032	12364
2019	OTHERS	368	13423	32	169	5021	9496
2020	OTHERS	418	11120	32	201	3257	7737
2021	OTHERS	412	8666	48	163	1464	8999
2022	OTHERS	32	9671	42	190	291	11906
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

Year	ss_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2020	SPTRAWL7	157	2351	48	5	113	1243
2021	SPTRAWL7	87	1729	202	48	151	10641
2022	SPTRAWL7	38	1377	215	47	59	10181
2013	SPTRAWL8		1988		38		5138
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
2018	SPTRAWL8	347	3467	280	53	3748	10526
2019	SPTRAWL8	586	2956	299	58	5390	5829
2020	SPTRAWL8	310	2768	213	47	2825	5652
2021	SPTRAWL8	153	2094	291	79	1746	10914
2022	SPTRAWL8	318	1951	232	168	2968	15778
2013	TRAWLOTH_CRU	745	483	0	0	0	0
2014	TRAWLOTH_CRU	23	644	17	26	8	229
2015	TRAWLOTH_CRU	236	330	28	23	1176	985
2016	TRAWLOTH_CRU	102	334	348	168	10453	6081
2017	TRAWLOTH_CRU	15	337	53	103	423	2688
2018	TRAWLOTH_CRU	103	245	576	103	30872	1668
2019	TRAWLOTH_CRU	109	170	48	14	2488	777
2020	TRAWLOTH_CRU	70	94	80	77	816	920
2021	TRAWLOTH_CRU	77	99	125	7	1243	453
2022	TRAWLOTH_CRU	84	160	56	6	904	361
2013	TRAWLOTH_DEF	2191	5319	0	0	0	0
2014	TRAWLOTH_DEF	2695	8015	461	791	24064	7612
2015	TRAWLOTH_DEF	1328	9862	353	381	10473	5781
2016	TRAWLOTH_DEF	1567	10987	1019	1255	26737	29927
2017	TRAWLOTH_DEF	729	10478	116	492	12694	9044
2018	TRAWLOTH_DEF	1834	8150	960	729	40645	19380

Year	ss_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2019	TRAWLOTH_DEF	961	5800	360	512	11246	10422
2020	TRAWLOTH_DEF	458	4722	108	193	6667	6040
2021	TRAWLOTH_DEF	519	5001	236	226	10432	9694
2022	TRAWLOTH_DEF	230	5179	170	316	5991	11066

Table 9.3: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Catches (C) and length-frequency distribution (LFD) by Fishery Unit (FU) provided in 2022. See Stock Annex for FU definition.

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK(Scotland)
FU1-2	1	0	C	0	0	C+LFD	C	0
FU1-2	2	0	C	0	0	C+LFD	0	0
FU1-2	3	0	C	0	0	C+LFD	C	0
FU1-2	4	0	C	0	0	C+LFD	0	0
FU03	1	0	C	C+LFD	0	C+LFD	C+LFD	0
FU03	2	0	C	C+LFD	0	C+LFD	C+LFD	0
FU03	3	0	C+LFD	C+LFD	C	C+LFD	C+LFD	0
FU03	4	0	C	C+LFD	0	C+LFD	C+LFD	0
FU4-6	1	C	C+LFD	C+LFD	C	C+LFD	C+LFD	0
FU4-6	2	0	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	0
FU4-6	3	0	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	0
FU4-6	4	0	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	0
FU8	1	0	C	C+LFD	C	0	C	0
FU8	2	0	C	C+LFD	C	0	C	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+14	1	C	C+LFD	0	0	C+LFD	0	0
FU10+14	2	0	C+LFD	0	0	C+LFD	0	0
FU10+14	3	0	C+LFD	0	0	C+LFD	0	0
FU10+14	4	0	C+LFD	0	C	C+LFD	0	0
FU12	1	0	C	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+LFD	0	0

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK(Scotland)
FU12	4	0	C	0	0	C+LFD	0	0
FU13	1	0	C+LFD	0	0	C+LFD	0	0
FU13	2	0	C+LFD	0	0	C+LFD	0	0
FU13	3	0	C+LFD	0	0	C+LFD	0	0
FU13	4	0	C+LFD	0	0	C+LFD	0	0
FU15	1	0	C	C+LFD	C	0	C	0
FU15	2	0	C	C+LFD	C	0	C	0
FU15	3	0	C	C+LFD	C	0	C	0
FU15	4	0	C	C+LFD	C	0	C	0
FU16	1	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	2	C+LFD	C+LFD	C+LFD	C	C+LFD	C	C+LFD
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 (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Summary of landings (model fit) and assessment results.

Year	Recruits Age 0 ('000')	Total Biomass ('000')	Female-only SSB (t)	Landings (t)	Discards (t)	Catch (t)	Yield/SSB (%)	F_{1-7}
1978	683384	165738	79678	50551		50551	0.63	0.30
1979	694062	171170	90001	51096		51096	0.57	0.32
1980	838409	166483	92412	57265		57265	0.62	0.38
1981	1178220	152523	84415	53918		53918	0.64	0.38
1982	613194	154552	76401	54994		54994	0.72	0.36
1983	376535	162446	78605	57507		57507	0.73	0.37
1984	625493	155039	82363	63286		63286	0.77	0.44
1985	1110400	128744	70232	56099		56099	0.80	0.48
1986	650651	119970	55495	57092		57092	1.03	0.53
1987	854130	124285	50024	63369		63369	1.27	0.59
1988	775284	127134	51496	64823		64823	1.26	0.60
1989	712232	129229	50794	66473	68	66541	1.31	0.60
1990	683428	123210	51031	59954		59954	1.17	0.54
1991	456869	118656	50914	58129		58129	1.14	0.55
1992	618270	108215	47844	56617		56617	1.18	0.60
1993	910533	93303	41172	52144		52144	1.27	0.64
1994	519549	93170	33741	51259	356	51615	1.53	0.65
1995	308226	97494	35832	57621		57621	1.61	0.71
1996	840607	84850	36444	47210		47210	1.30	0.66
1997	412236	78932	30619	42465		42465	1.39	0.62
1998	732870	80941	29600	35060		35060	1.18	0.50
1999	366861	90687	36011	39814	349	40163	1.12	0.52
2000	443510	95478	39077	42026	77	42103	1.08	0.52
2001	758858	91748	40777	36675		36675	0.90	0.45
2002	592672	97105	40143	40107		40107	1.00	0.48
2003	446780	102157	41882	43162	2110	45272	1.08	0.51
2004	1103400	103335	44512	46417	2548	48965	1.10	0.54
2005	572275	107635	42954	46550	4676	51226	1.19	0.55

Year	Recruits Age 0 ('000')	Total Bio-mass ('000')	Female-only SSB (t)	Landings (t)	Discards (t)	Catch (t)	Yield/SSB (%)	F_{1-7}
2006	1194990	125772	45709	41467	1816	43283	0.95	0.40
2007	2177390	155753	63972	45028	2191	47219	0.74	0.32
2008	1705790	215564	82017	47739	3248	50987	0.62	0.25
2009	544279	331546	125263	58818	10590	69408	0.55	0.21
2010	936255	422679	201808	72799	9978	82777	0.41	0.185
2011	1073530	457676	253369	87540	14156	101696	0.40	0.190
2012	2030650	453682	253728	85677	12680	98357	0.39	0.173
2013	931884	470317	248746	77343	11098	88441	0.36	0.159
2014	654020	510863	267045	89940	12131	102071	0.38	0.171
2015	830926	517217	293823	95043	14446	109489	0.37	0.185
2016	1155580	482595	288515	107547	16041	123588	0.43	0.22
2017	1009600	430998	251115	104670	10488	115158	0.46	0.23
2018	693924	393243	218651	89695	9934	99629	0.46	0.22
2019	728183	374384	205621	82298	6966	89264	0.43	0.21
2020	419888	358379	199765	72579	6946	79525	0.40	0.192
2021	534789	337996	194941	68061	6738	74799	0.38	0.183
2022	439104	310282	183432	67433	3241	70674	0.39	0.191
2023	862134	280323	163204					
Arithmetic mean	800040	216380	109678	61008	6786	64627	0.84	0.40

Table 9.5: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Catch option table.

Rec 2023	F_{1-7} 2023	Catch 2023	Land 2023	SSB 2024	Rec 2024
862,134	0.189	64,096	60,388	147,052	855,364

$F_{multiplier}$	F_{1-7} catch (2024)	F_{1-7} landings (2024)	F_{1-7} discards (2024)	Catch (2024)	Landings (2024)	Discards (2024)	SSB (2025)
0.0	0.00	0.00	0.00	0	0	0	176,869
0.1	0.0123	0.0115	0.00082	4,271	3,988	283	174,037
0.2	0.031	0.029	0.0021	10,548	9,844	703	169,883
0.3	0.049	0.046	0.0033	16,672	15,554	1,119	165,840
0.4	0.068	0.063	0.0046	22,649	21,120	1,529	161,906
0.5	0.086	0.080	0.0059	28,481	26,547	1,934	158,077
0.6	0.105	0.098	0.0072	34,174	31,839	2,335	154,350
0.7	0.129	0.120	0.0089	41,552	38,690	2,862	149,536
0.8	0.148	0.137	0.0102	46,931	43,680	3,252	146,036
0.9	0.168	0.156	0.0117	52,729	49,052	3,677	142,276
1.0	0.187	0.173	0.0131	57,857	53,798	4,059	138,960
1.1	0.20	0.190	0.0145	62,862	58,427	4,436	135,732
1.2	0.22	0.21	0.0159	67,749	62,941	4,808	132,590
1.3	0.24	0.22	0.0173	72,520	67,343	5,177	129,530
1.4	0.26	0.24	0.0187	77,179	71,638	5,541	126,551
1.5	0.28	0.26	0.020	81,728	75,827	5,901	123,651
1.6	0.30	0.28	0.022	86,171	79,913	6,257	120,826
1.7	0.32	0.29	0.023	90,509	83,900	6,610	118,076
1.8	0.33	0.31	0.024	94,747	87,789	6,958	115,398
1.9	0.35	0.33	0.026	98,885	91,583	7,302	112,789
2.0	0.37	0.34	0.027	102,928	95,285	7,643	110,248

Table 9.6: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Yield-per-recruit (YPR) table.

SPR-level	$F_{multiplier}$	F_{1-7}	YPR-catch	SSB-PR
1.00	0.0	0.0000	0.0000	0.780
0.93	0.1	0.0078	0.0098	0.720
0.80	0.2	0.0250	0.0270	0.620
0.74	0.3	0.0330	0.0340	0.580
0.60	0.5	0.0600	0.0510	0.470
0.54	0.6	0.0760	0.0590	0.420
0.50	0.7	0.0870	0.0630	0.390
0.44	0.8	0.1070	0.0690	0.340
0.43	0.9	0.1140	0.0710	0.330
0.40	1.0	0.1240	0.0730	0.310
0.36	1.1	0.1430	0.0760	0.280
0.35	1.2	0.1510	0.0780	0.270
0.31	1.4	0.1730	0.0800	0.240
0.29	1.5	0.1890	0.0820	0.220
0.25	1.7	0.2200	0.0840	0.197
0.24	1.8	0.2300	0.0840	0.189
0.22	2.0	0.2500	0.0850	0.174
SPR-level	$F_{multiplier}$	F_{1-7}	YPR-catch	SSB-PR
0.29	1.5	0.189	0.082	0.220
0.29	1.5	0.189	0.082	0.220
0.35	1.2	0.151	0.078	0.270
0.31	1.4	0.173	0.080	0.240
0.22	2.0	0.250	0.085	0.174

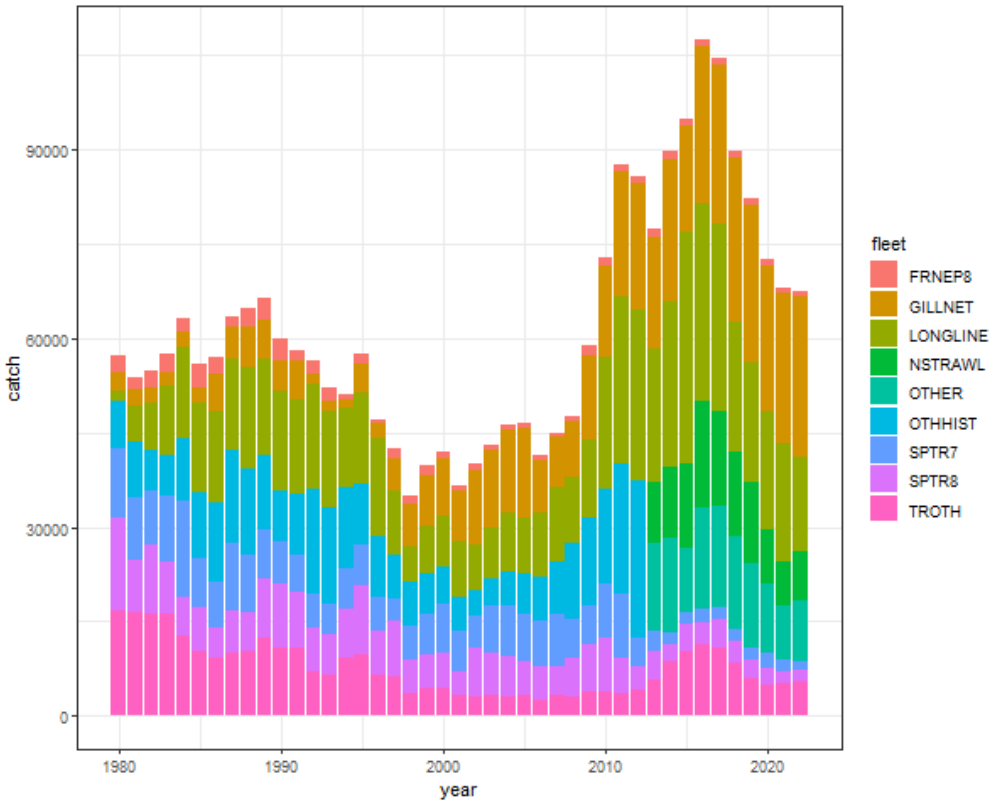

Figure 9.1. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Total catch (in tonnes) over time, the colours correspond to the fleets used in the assessment model configuration.

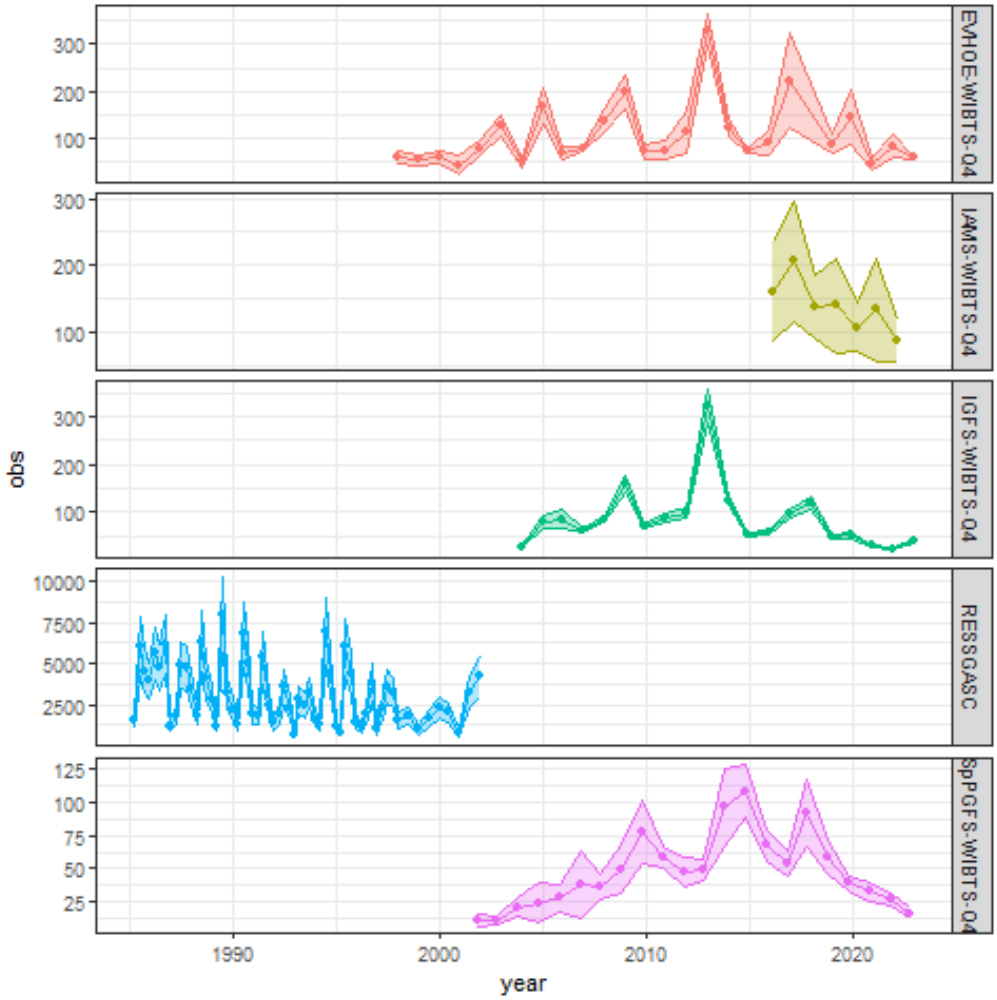

Figure 9.2: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Abundance indices from surveys.

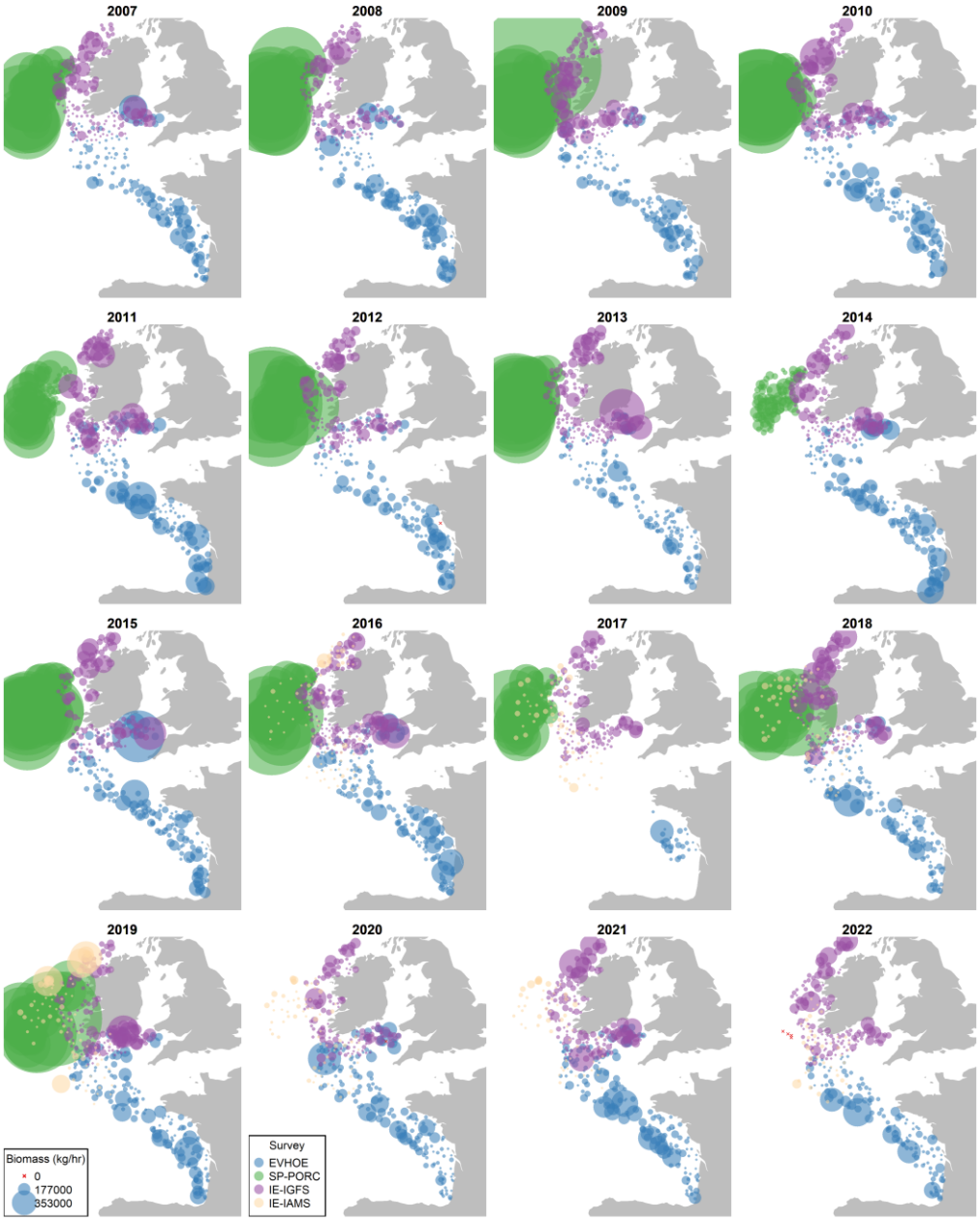

Figure 9.3. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) surveys' biomass (Kg/h) indices from 2006 to 2022. Note that surveys are not directly comparable due to the use of different gears with different catchabilities.

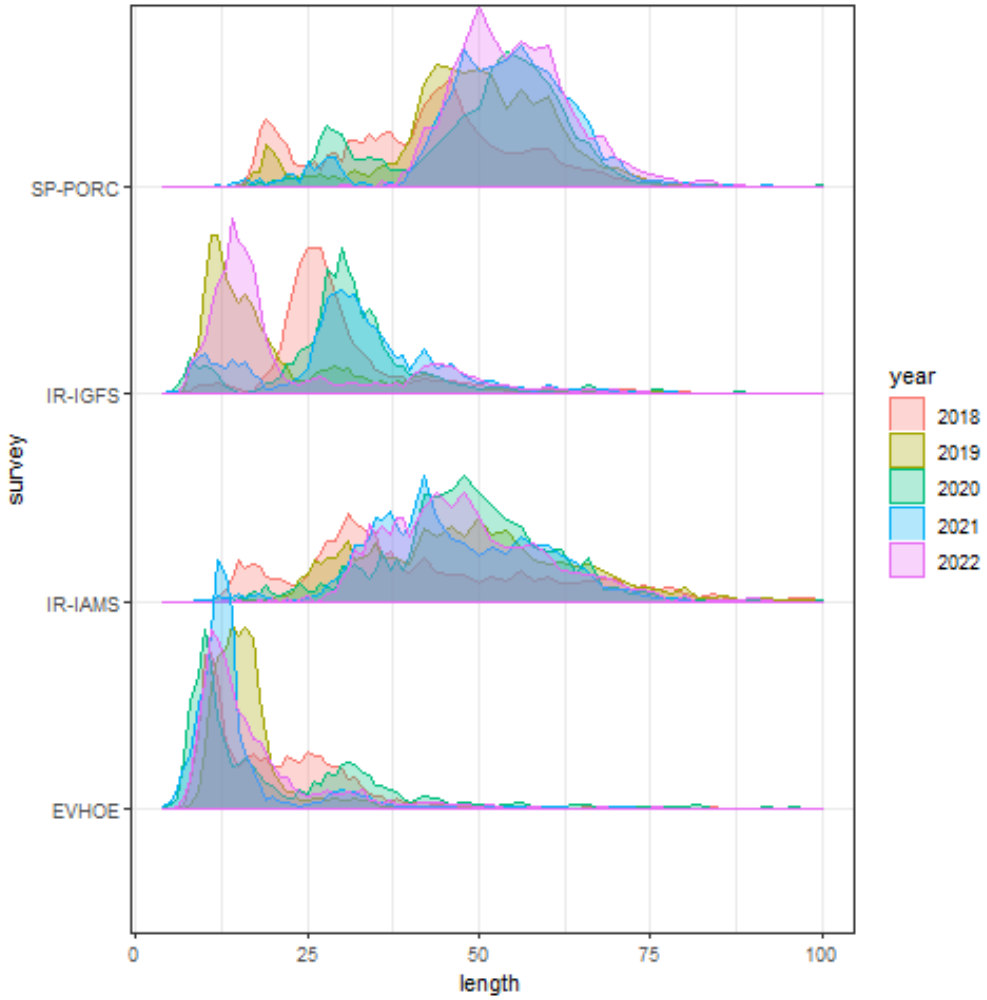

Figure 9.4: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Length-frequency distribution of surveys in the most recent years, from 2017 to 2022.

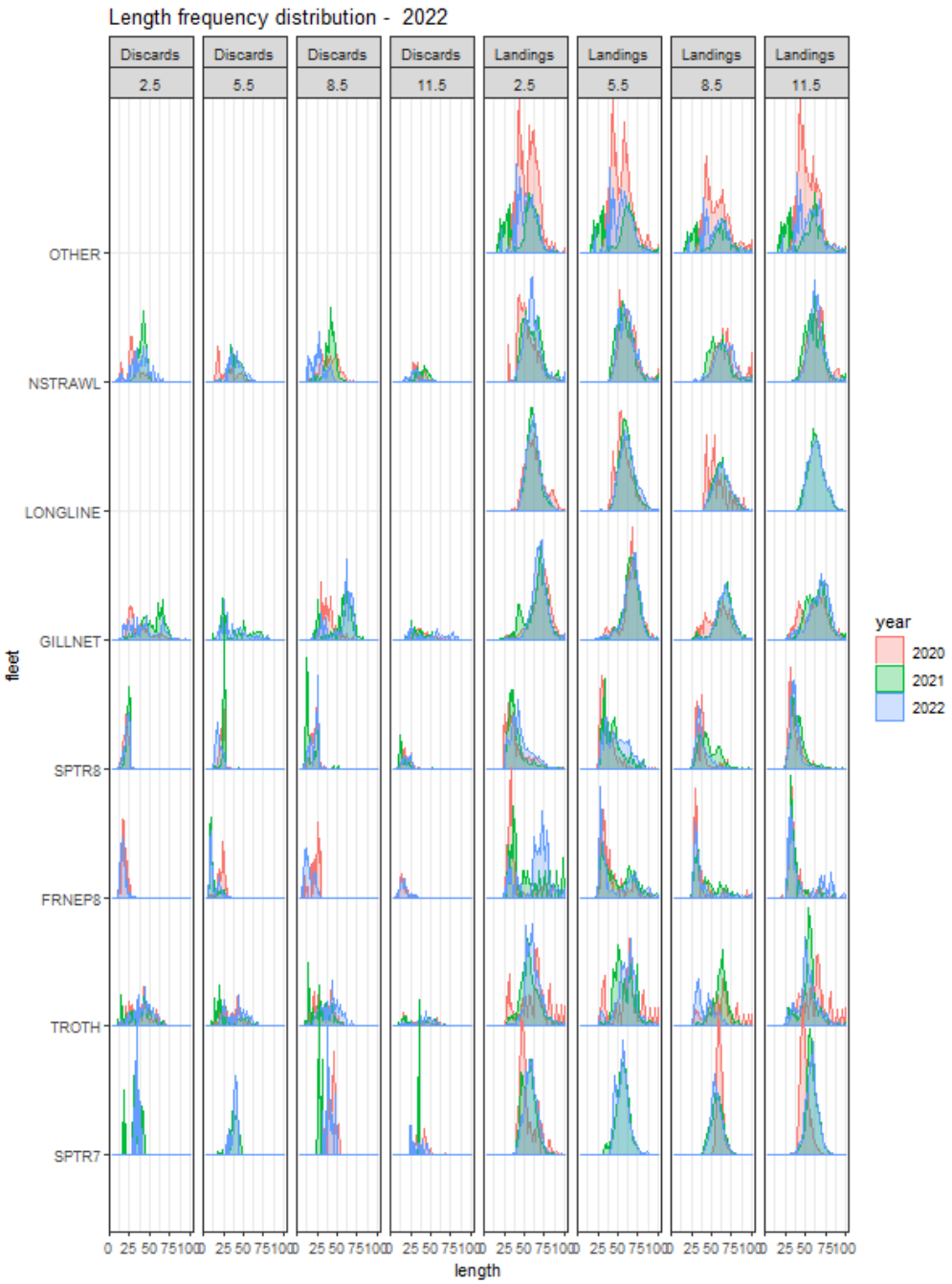

Figure 9.5. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Length-frequency distribution for landings and discards by fleet and by season (columns) in the most recent years, from 2019 to 2022, with the fleet as used in the assessment model configuration.

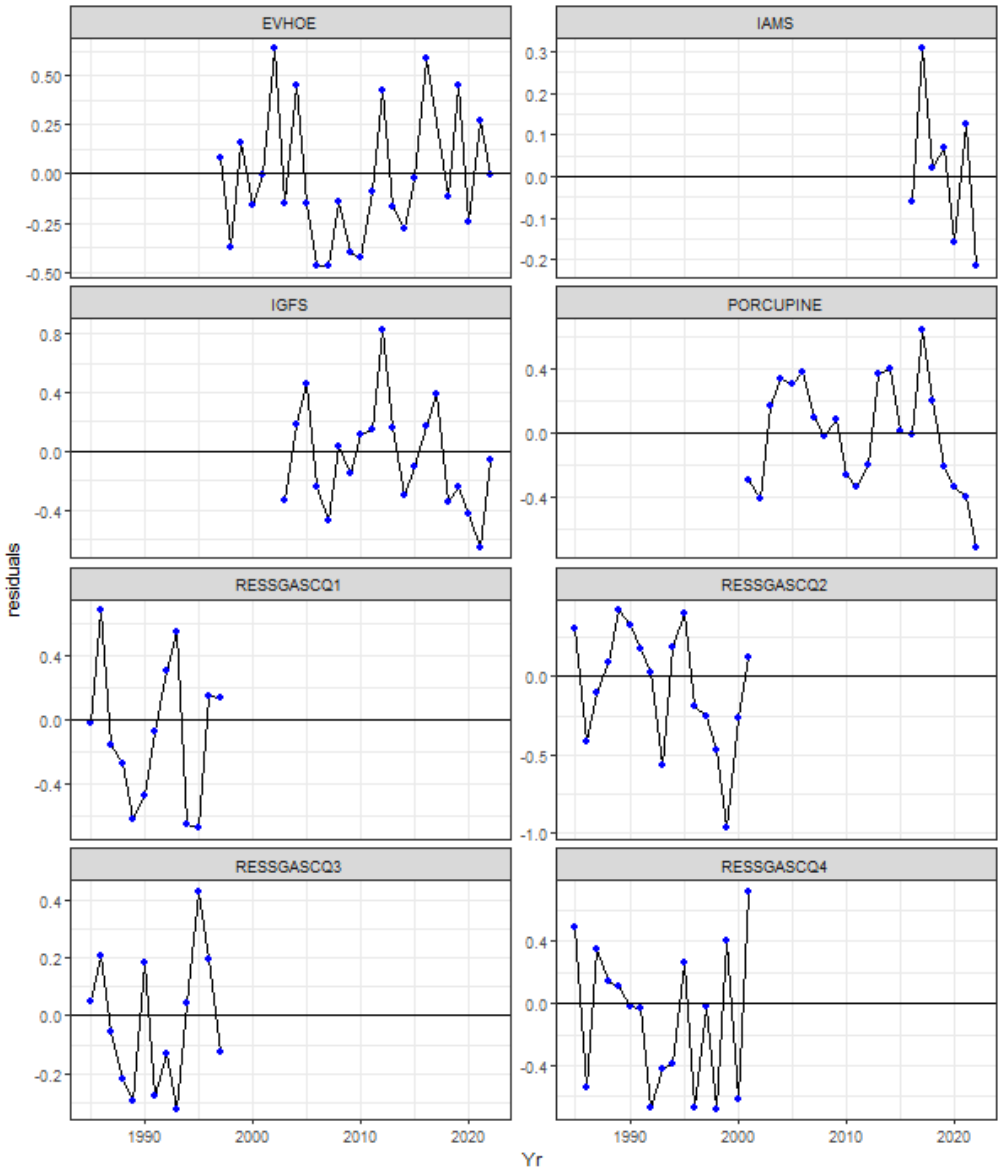

Figure 9.6. **Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Residuals of the fits to the surveys' log(abundance indices) for FR-RESSGASC (G2537), EVHOE-WIBTS-Q4 (G9527), SpPGFS-WIBTS-Q3 (G5768) and IGFS-WIBTS-Q4 (G7212) surveys. Fits are by quarter and sex.**

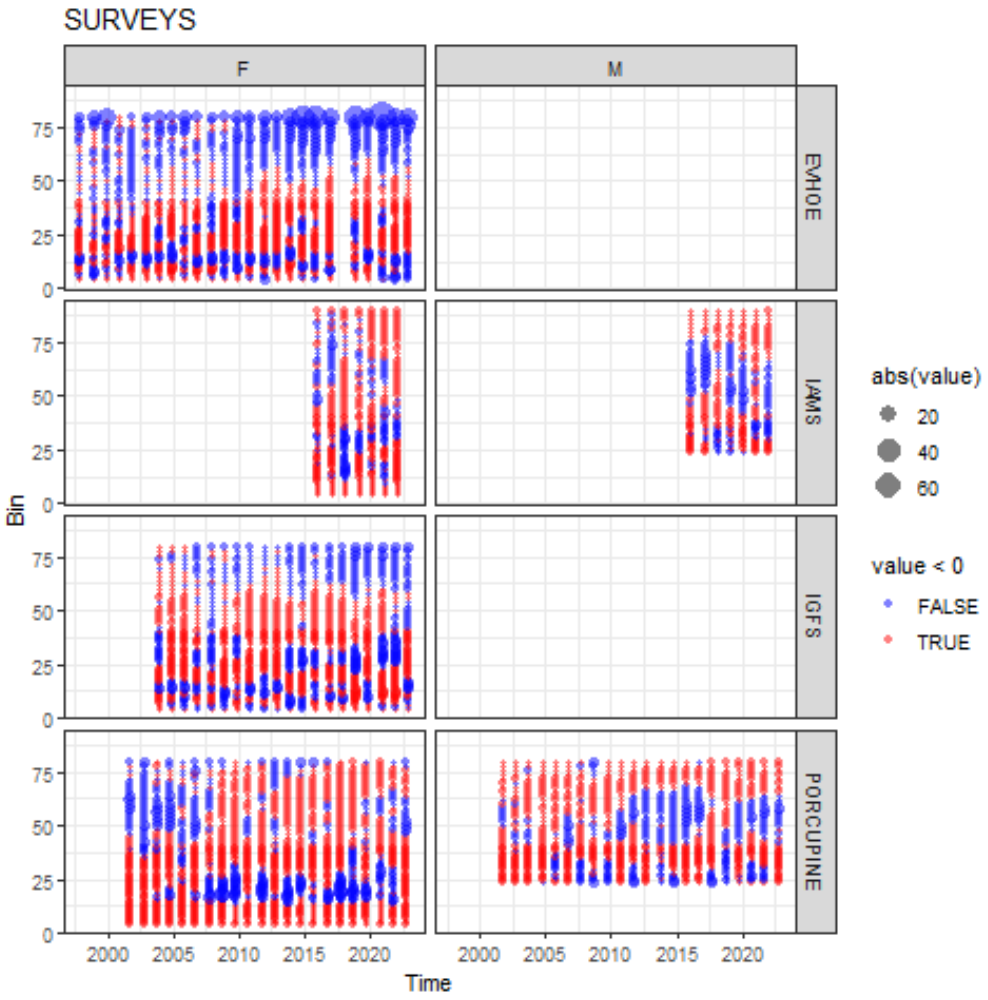

Figure 9.7. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Pearson residuals of the fit to the length distributions of the surveys' abundance indices by sex (F = females, M = males) for EVHOE (EVHOE-WIBTS-Q4), PORCUPINE (SPGFS-WIBTS-Q3, G576) and IGFS (IGFS-WIBTS-Q4, G5768). Fits are by quarter and sex.

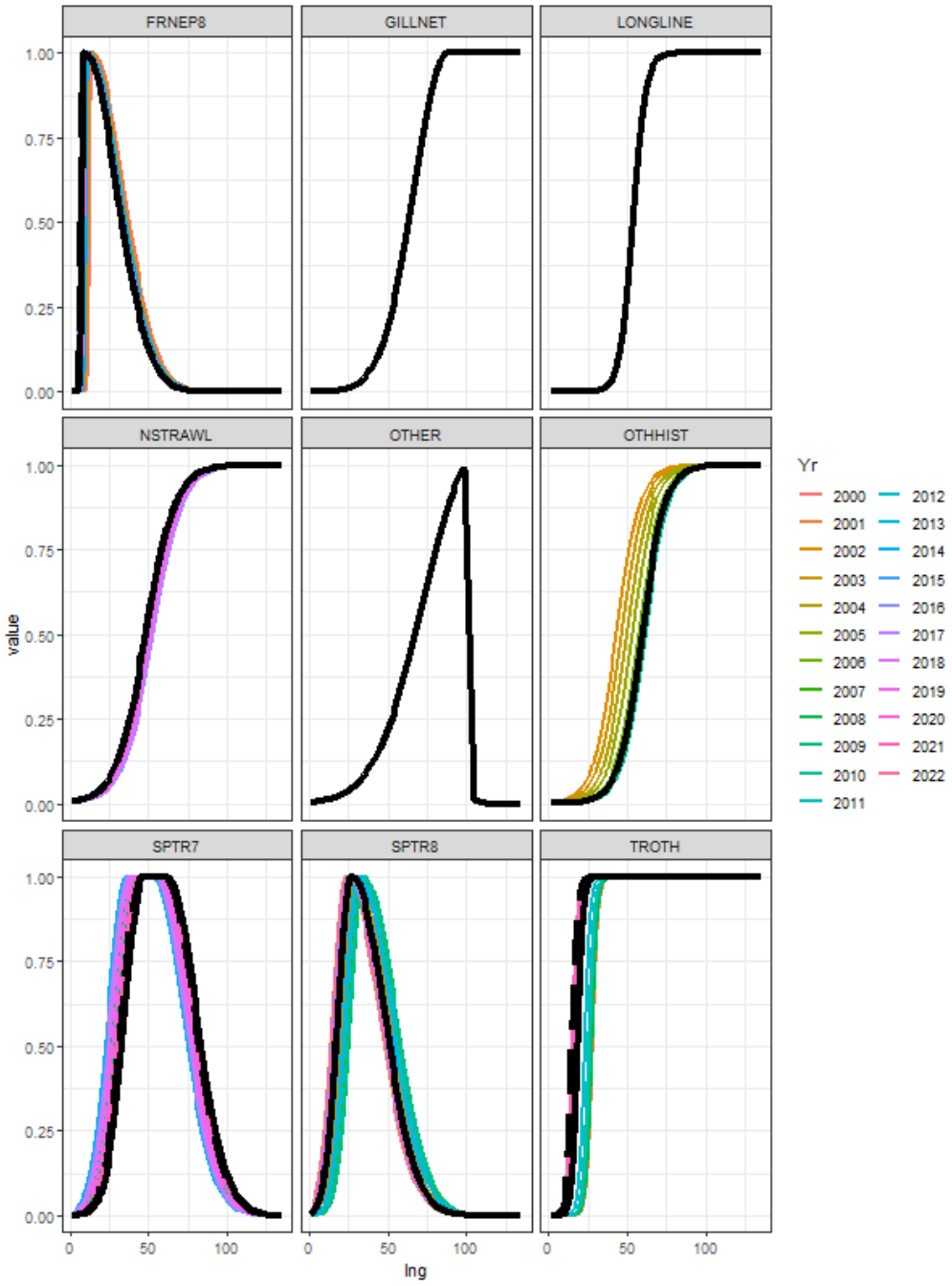

Figure 9.8. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Selection curves, by commercial fleet, estimated by the SS model. Selectivity trends for 2021 (dashed black line) and 2022 (solid black line).

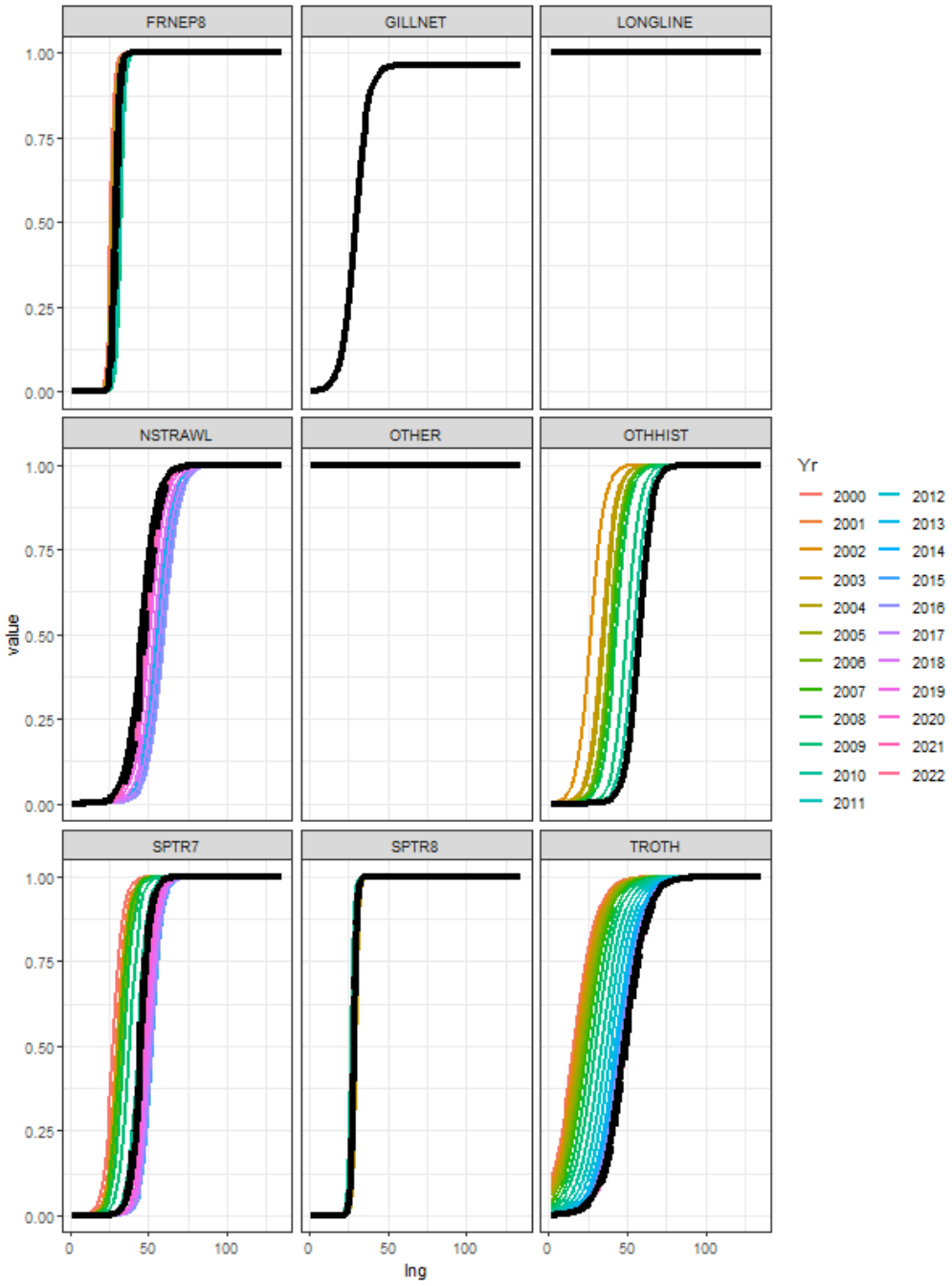

Figure 9.9. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Retention curves, by commercial fleet, estimated by the SS model. Retention trends for 2021 (dashed black line) and 2022 (solid black line).

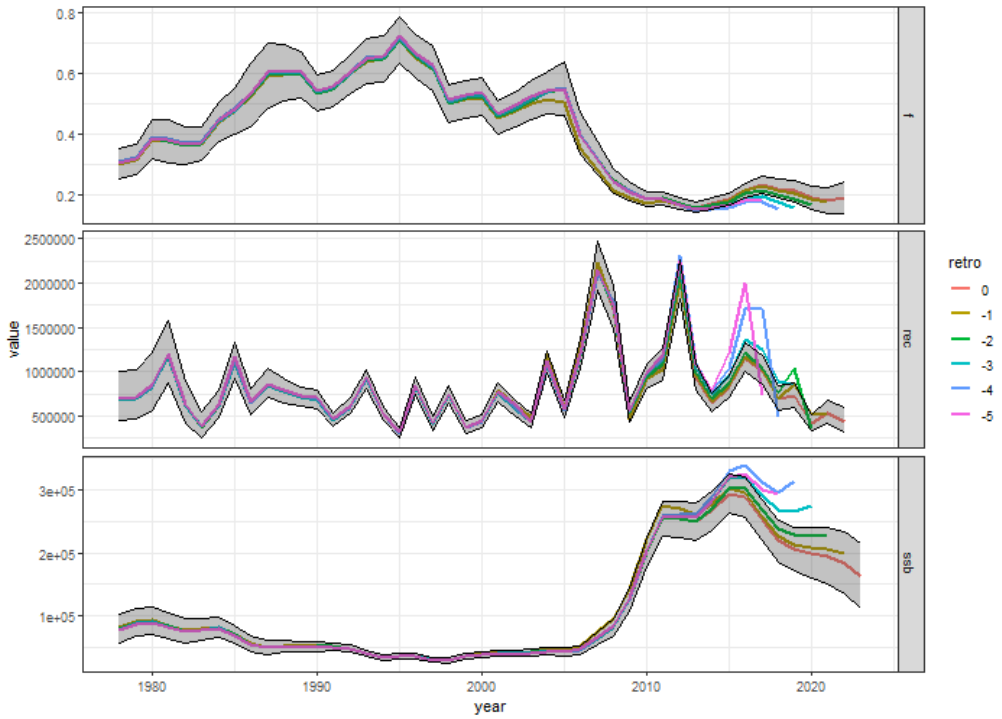

Figure 9.10. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Retrospective plot from the SS assessment model including the confidence intervals (CIs, grey trends).

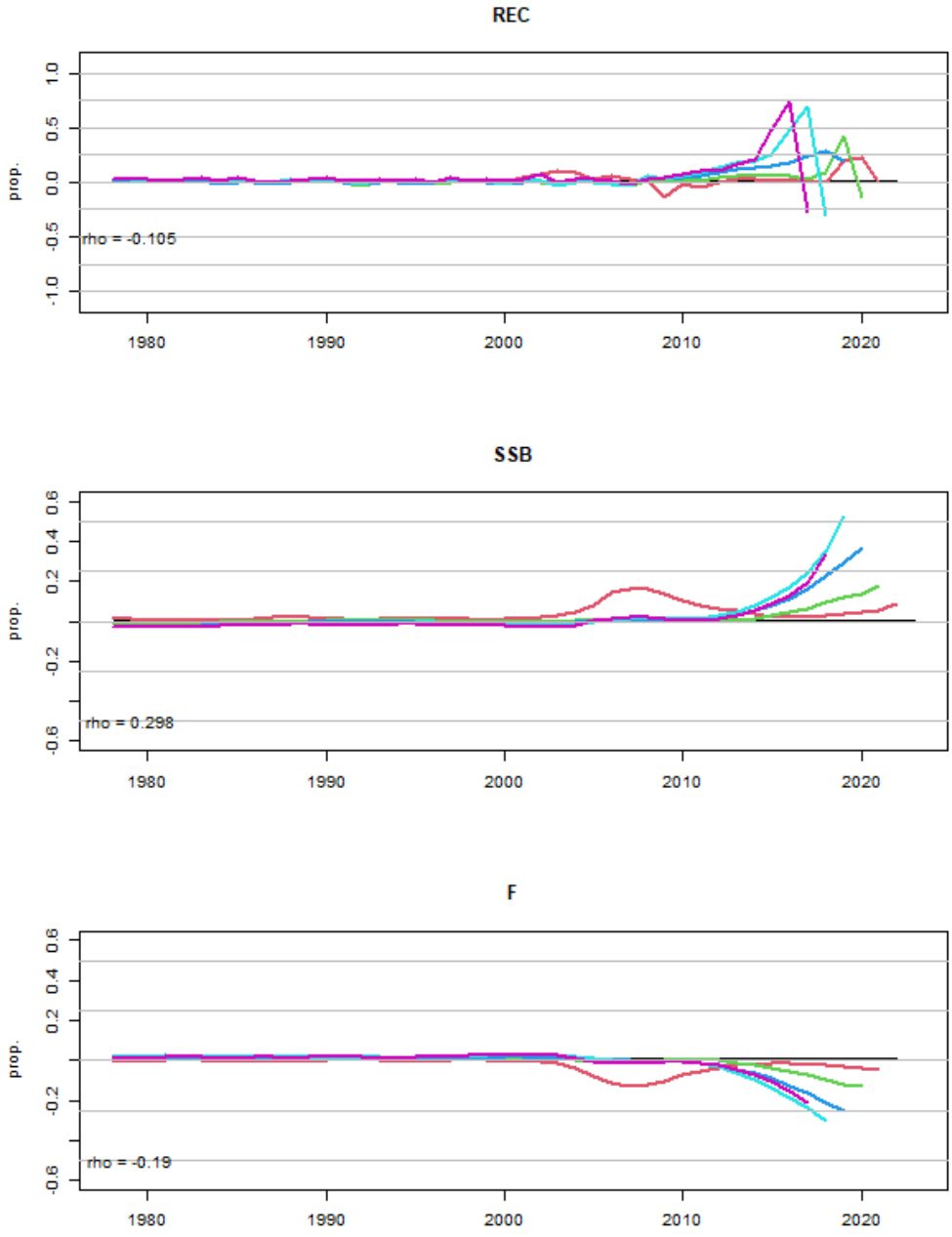

Figure 9.11. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Differences between the time-series in the retrospective analysis plot from the SS model for 2017-2022 using the configuration agreed during the WKANGHAKE benchmark (ICES, 2023a). The value in the bottom-left of each plot corresponds to the Mohn's rho estimates for 2022.

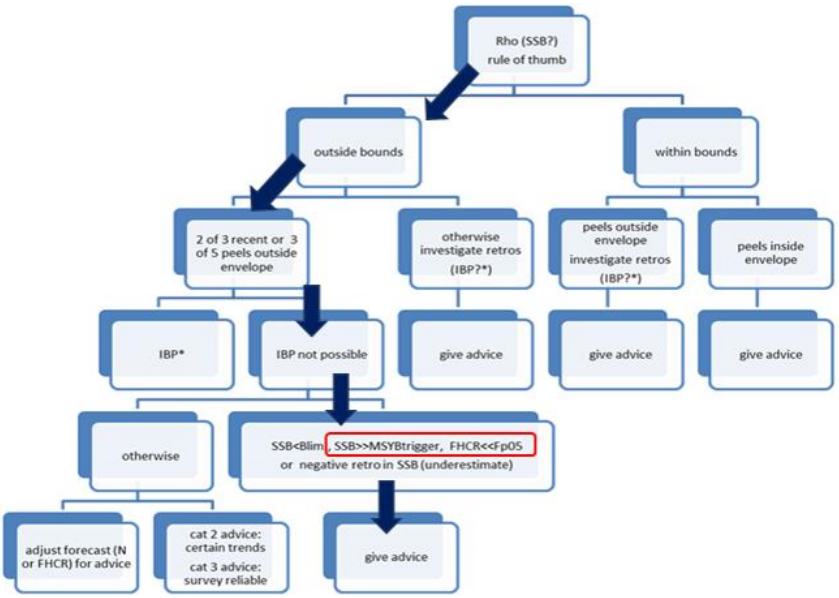

Figure 9.12. Schematic diagram from WKFORBIAS (ICES, 2020). Stepwise procedure pattern (solid blue arrows) implemented to produce the northern hake advice based on the SS assessment model for a given retrospective pattern.

Figure 9.13. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Summary plot of the stock trends. Green dashed lines correspond to the geometric mean (GM) for recruitment (upper right), F_{MSY} (lower left) and, B_{lim} (lower right). Red dashed line (lower right) corresponds to B_{pa}.

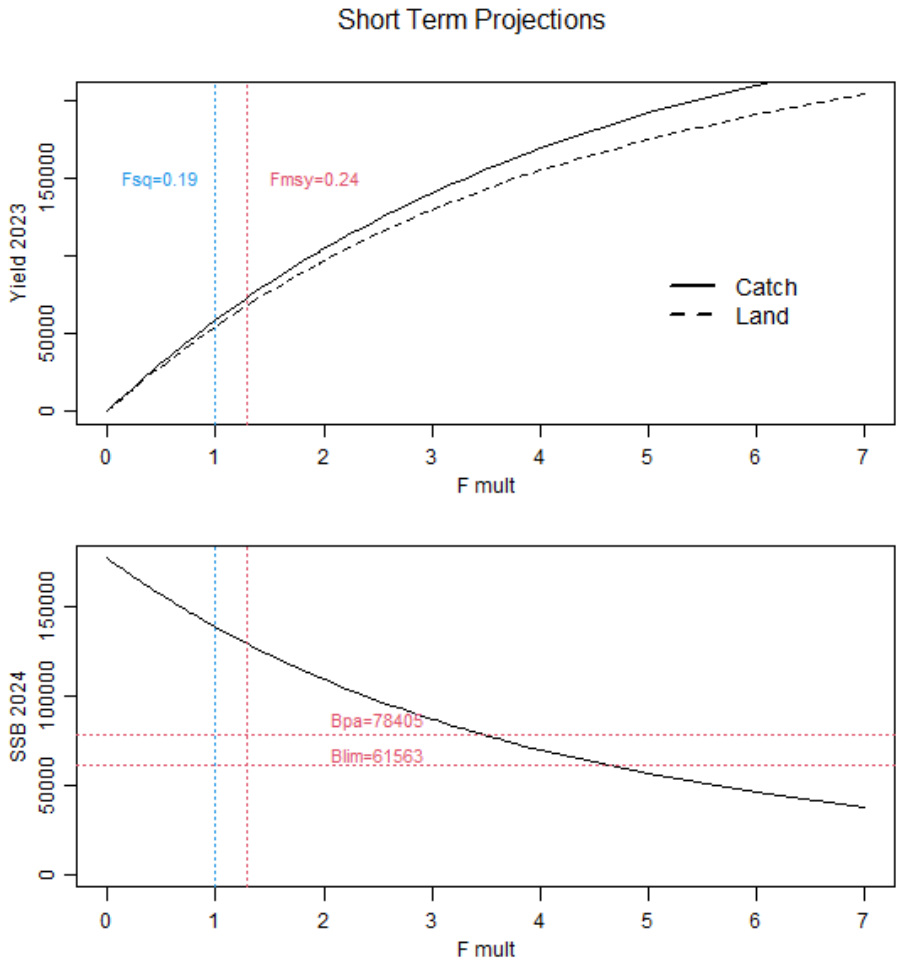

Figure 9.14. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Short term projections for yield and SSB. Vertical lines correspond to F_{MSY} (red) and the assumed $F_{statusquo}$ (blue). Red horizontal lines to B_{lim} and B_{pa}.

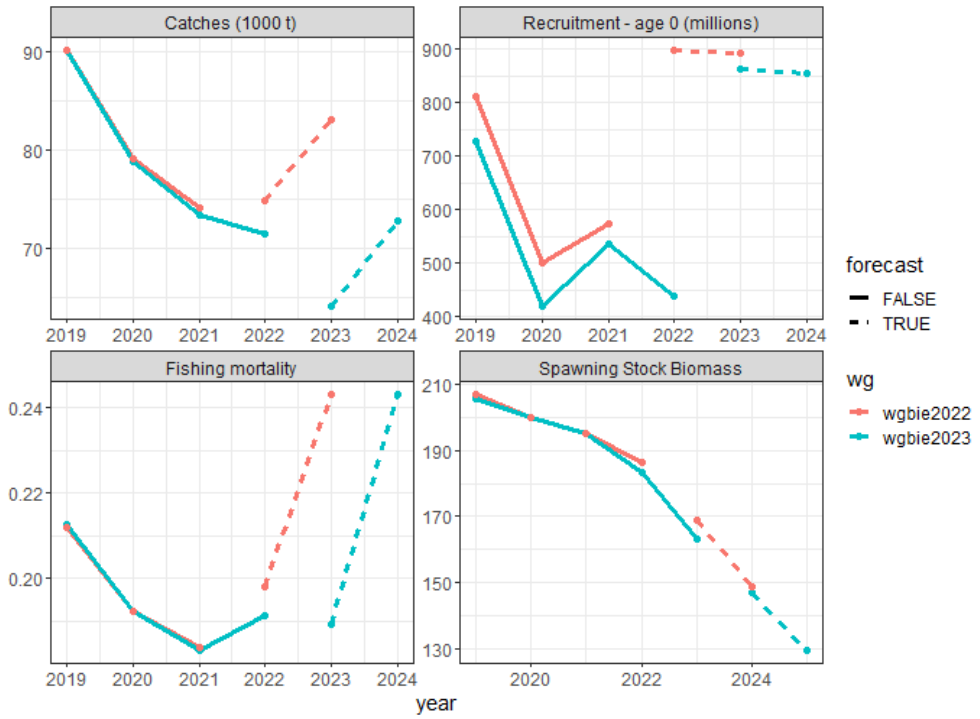

Figure 9.15: Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Summary plot of stock trends in the short-term forecast in the two latest assessments. Green lines correspond to current year assessment (solid line) and short-term forecast (dashed line) and red lines correspond to previous year ones (WGBIE2022; ICES, 2022).

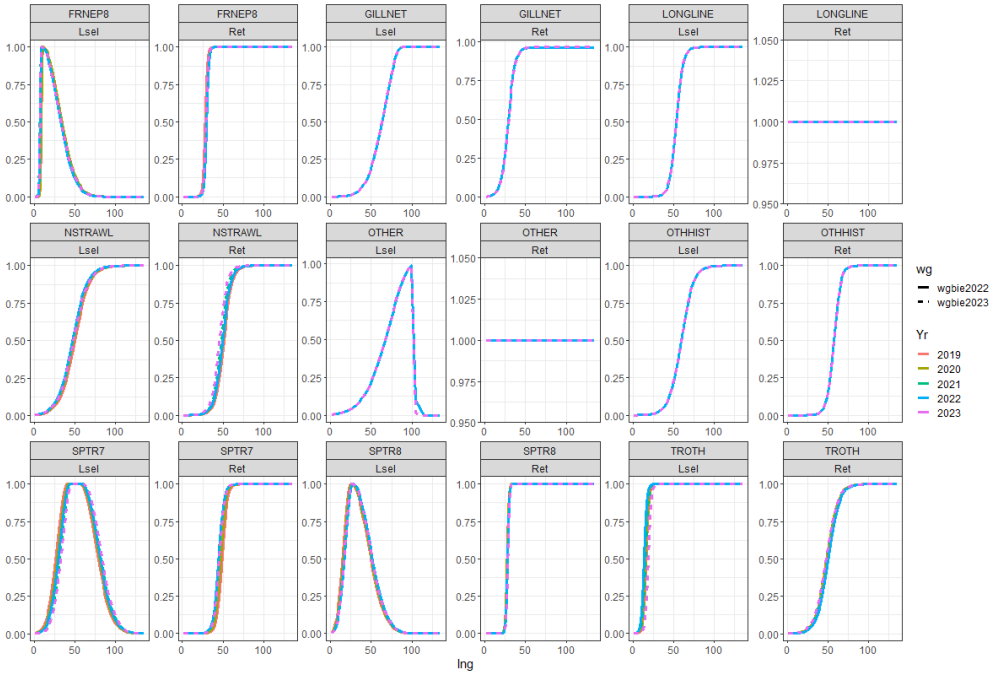

Figure 9.16: Hake (Merluccius merluccius) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Selectivity-at-length (Lsel) and retention (Ret) for the modelled fleets estimated by the current year assessment model (wgbie2023) and last year one (wgbie2022; ICES, 2022).

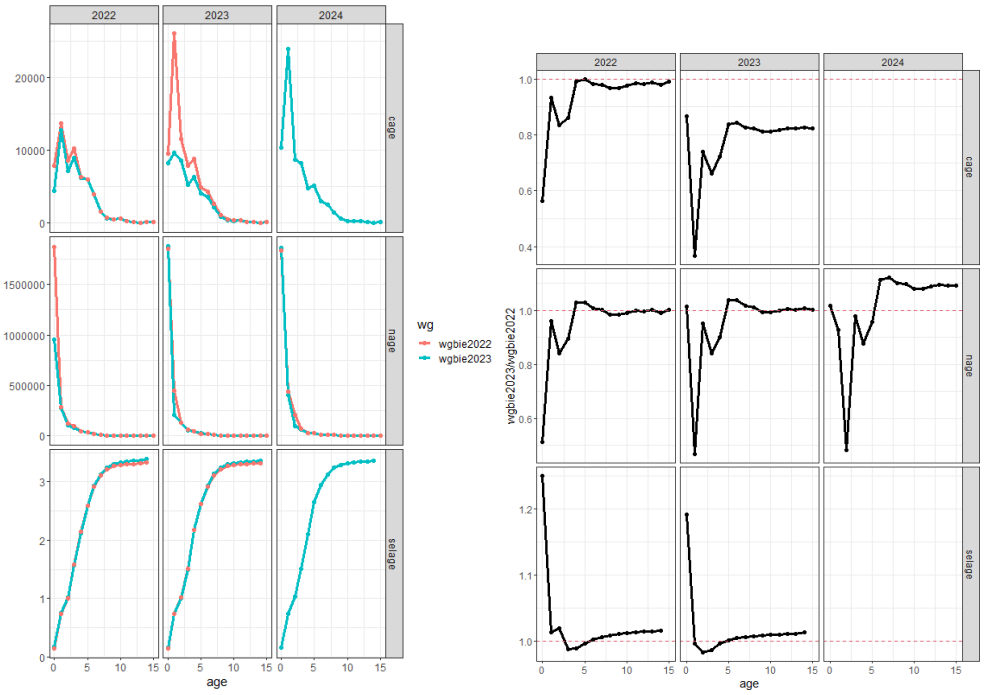

Figure 9.17. Hake *(Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Left plot: numbers-at-age in the catches (cage), in the population (nage) and selectivity-at-age estimated in the current year short-term forecast (wgbie2023, green) and in the year before (wgbie2022, red; ICES, 2022) Right: plot relative values (wgbie2023/wgbie2022).

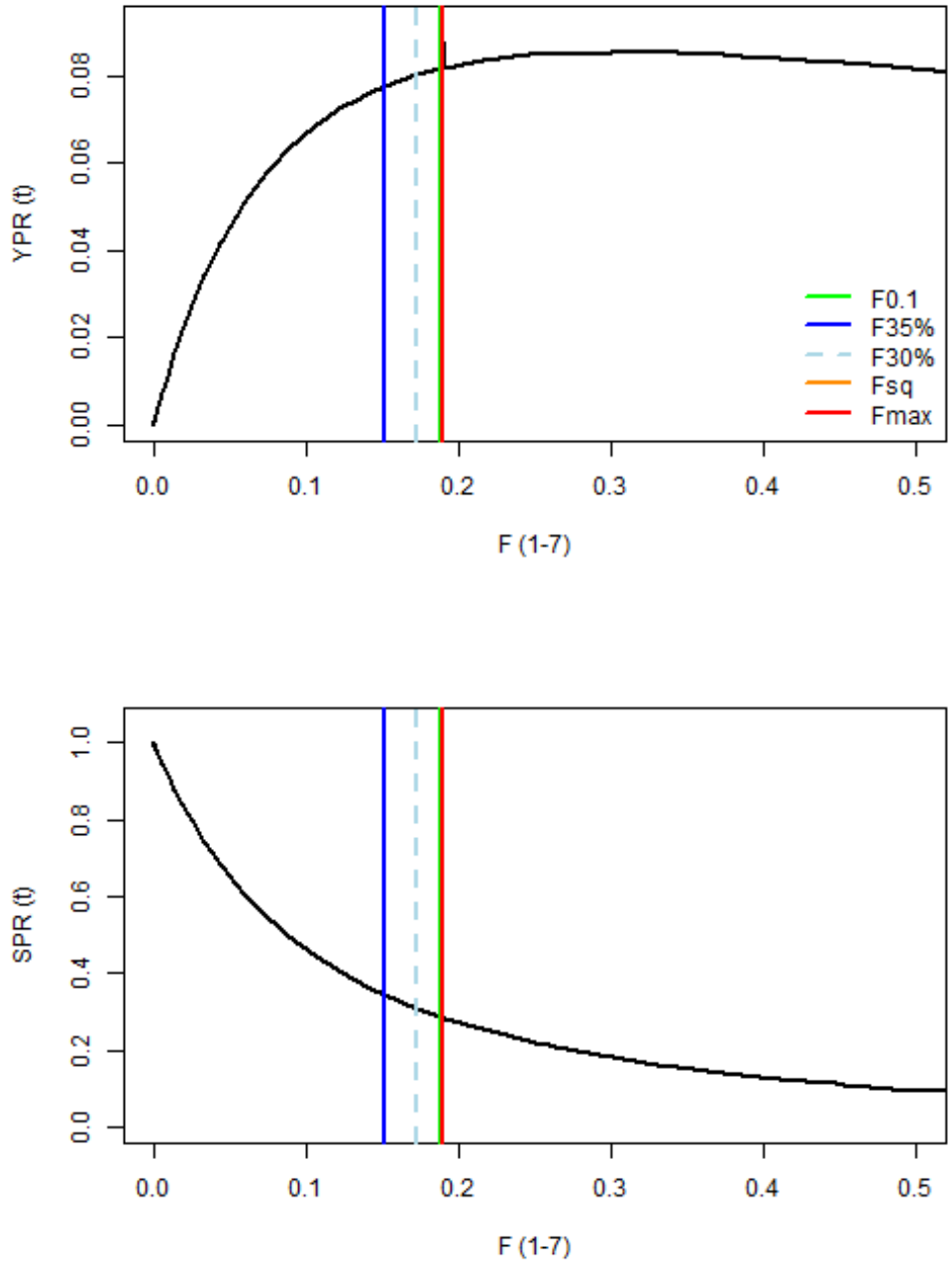

Figure 9.18. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Yield-per-recruit analysis. Vertical lines correspond to $F_{0.1}$, $F_{35\%}$, $F_{30\%}$, F_{sq} and F_{max}.

Contents