18 Eastern English Channel sole

sol.27.7d – *Solea solea* in Division 7.d

This section of the report provides a comprehensive description of the methods and data used for the 2024 assessment of sole in Division 27.7.d. Additional background information can be found in the Stock Annex. This year's assessment shows that the recruitment estimates of the years 2022 and 2023 are highly uncertain due to a lack of data that informs the dynamics of the age 1 individuals. These recruitment estimates may be biased with knock-on effects on the short term forecast and advice. However, the uncertainty is accounted for in the forecasted recruitment by weighting the resampled recruitment with the associated standard deviation.

18.1 General

18.1.1 Stock definition

During the WKNSEA 2017 and WKNSEA 2021 benchmark, the available information on stock identity was investigated, including genetic, tagging and otolith information. Sole in the eastern English Channel (7.d) is still considered to be a stock separated from the larger North Sea stock (27.4) to the east and the smaller geographically-separated stock to the west in 27.7.e (western English Channel). Considering the sub-stock structure, three regions with low connectivity were identified within Division 7.d for larvae, juveniles and adults (Archambault *et al.*, 2016; Lecomte *et al.*, 2020; Randon *et al.*, 2018; 2020). More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES, 2021).

18.1.2 Ecosystem aspects

A general description of the available information on ecological aspects can be found in the Stock Annex.

18.1.3 Fisheries

A general description of the fishery is presented in the Stock Annex.

18.1.3.1 Management regulations

Management of sole in Division 27.7.d is by TAC and technical measures.

The minimum landing size for sole is 24 cm (EU legislation). Sole in the eastern English Channel is fully under the landing obligation since 2018 (partially since 2016) (EU, 2018/2034). There are two exemptions in place which allow for discarding of undersized sole in Division 7.d:

1) a survival exemption for small coastal otter trawlers (<10 m and <221 kW) fishing less than 90 minutes in areas with a depth less than 30 m (outside nursery areas) and with cod-end mesh size of 80–99 mm.

2) a *de minimis* exemption for vessels using trammel and gill nets (max. 3% of annual catches) and using TBB gear with a mesh size of 80–119 mm equipped with the Flemish panel (max. 3% of annual catches).

A historical overview of the TAC for sole 7.d since 2000 is presented in the table below (short version) and in Table 18.1.

Table 18.1. Historical overview of the TACs for sole in Division 27.7.d (2013–2024); Note: TAC represents catch from 2016 onwards (landing obligation)

Year	2013	2014	2015	2016	2017	2018
TAC	5900	4838	3483	3258	2724	3405
Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
TAC	2515	2797	3248	2380	1747	1504

Except for 2009 and 2010, the TAC has not been restrictive since 2003. In 2014, 2022 and 2023, the initial TAC share became restrictive for Belgium, and in 2015 this was the case for Belgium and France (see 18.2.1.1 TAC uptake). Note that initial quota are compared regardless of quota exchanges among countries.

In response to the drop in SSB and the poorer recruitment from 2012 onwards, the main countries participating in the fishery implemented additional conservation measures. For Belgian beam trawlers in 27.7.d (and 27.7.fg, 27.7.a), it is mandatory since 1 April 2015 to incorporate a 3 m long section (tunnel) with a 120 mm mesh size before the cod-end (Flemish panel), in order to reduce the catches of small sole (reduction of undersized sole with 40% and marketable sole with 16%). France engaged in 2016 to i) strengthen the protection of the nursery areas, ii) increase the area closed to fishing within the nursery areas, and iii) increase the minimum conservation reference size to 25 cm for French vessels in accordance with EU legislation, where appropriate. From 11 March until 31 December 2017, the minimum conservation reference size for Belgian vessels also increased to 25 cm. This MCRS is still used up until now (dd. May 2023). Finally, UK beam trawlers usually fish using mesh sizes greater than statutory in order to avoid discarding and to avoid wasting quota.

18.1.3.2 Additional information provided by the fishing industry

In 2019, the French fishing industry provided input on their perceived status of the stock.

The French gillnet fishers state that they have trouble catching sole in the eastern part of the eastern English Channel. The French otter trawl fishers operating mainly in the south-western part of the eastern English Channel have reported a decline in catches in 2016 and 2017, followed by an increase in catches since 2018 to the ten-year average level.

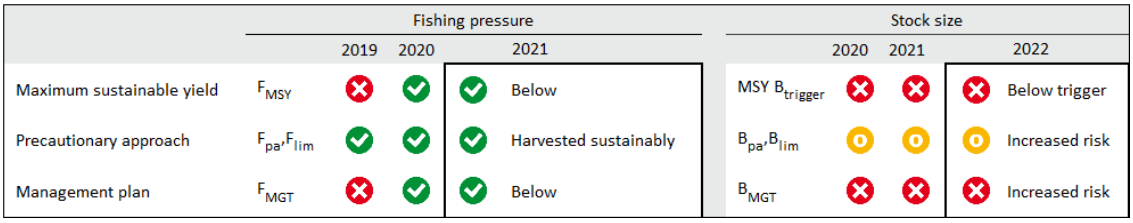
18.1.4 ICES advice

18.1.4.1 ICES advice for 2023

The ICES advice for 2023 was:

ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1747 tonnes.

In 2022, the stock status was presented as follows:



18.1.4.2 ICES advice for 2024

The ICES advice for 2024 was:

ICES advises that when the MSY approach is applied, catches in 2024 should be no more than 1504 tonnes.

In 2023, the stock status was presented as follows:

18.2 Data

As a result of the data call for the 2021 WKNSEA benchmark (ICES, 2021), new landings and discard time-series were uploaded by France and Belgium. Data were processed in InterCatch from 2004 onwards.

18.2.1 Catches

18.2.1.1 TAC uptake

Table 18.1 and Figure 18.1 summarise the official sole landings by country for Division 27.7.d. The landings have steadily increased over the 1970s and 1990s, fluctuated around an average of 4838 t in 2000–2014 (range: 3832 t–6247 t), and dropped to 3411 tonnes in 2015 and even further to 2224 tonnes in 2017. In 2018, a small increase up to 2312 tonnes was observed. In the period 2019-2022, the landings stabilized around 1700 tonnes, but decreased further to 1289 tonnes in 2023. Since 2000, the contribution to the landings of the three main countries involved in this fishery has remained stable over time (~30% Belgium, ~15% UK, and ~55% France) (Figure 18.2). However, since 2019, the proportion of landings caught by the Belgian fleet has increased, while landings by the French fleet have decreased. In 2023, the Belgian fleet caught 42%, the French fleet 44% and the UK fleet 14% of sole landings in Division 7.d.

Since 2010, full uptake of the sole 27.7.d TAC has not been realized. However, in 2014, the Belgian quota was overshot by 15%. In 2015, Belgium overshot its national, initial quota again by 12% and France faced a 1% overshoot. The total uptake in 2015 was 98% (official landings). Since then, the total uptake has decreased to only 51% in 2021. Nevertheless, the strong reduction of the TAC in 2022 and 2023 resulted in an increase of the quota uptake, with an overshoot (3% in 2022 and 18% in 2023) of the initial quota by Belgium. Note that the initial quota is compared with uptake not taking into account quota exchange among countries during the year.

When comparing ICES catch estimates (InterCatch) with the TAC (catch), a total uptake of 70% was realised in 2020, 59% in 2021, 85% in 2022 and 87% in 2023 (Figure 18.3). Figure 18.4 presents

a historic overview of TAC levels compared to official landings and ICES estimates (both landings and discards).

18.2.1.2 ICES catch estimates (InterCatch)

New ICES estimates were uploaded and processed in InterCatch from 2004 onwards as a result of the WKNSEA 2021 benchmark. The new upload involved a thorough revision of the French and Belgian time-series (more information in the WKNSEA 2021 benchmark report: ICES, 2021). In 2024, Belgium updated it's 2021 and 2022 data. Changes were minimal, but total InterCatch landings changed from 1574 to 1567 tonnes (2021) and from 1695 to 1688 tonnes (2022) and InterCatch discards from 350 to 348 tonnes (2021) and from 334 to 333 (2022).

The proportion of landings with associated discards has gradually increased over the years 2004–2012 (Figure 18.5). From 2012 onwards, this increasing trend levelled off, fluctuating between 70 and 80%. A decrease was noted in 2020 to 54%, most likely due to the Covid-19 pandemic. In 2023, the proportion of landings with discards was 67%. The age coverage for landings increased from 2004–2011 and remained stable around 80% (Figure 18.5). The age coverage for 2023 is 91% and shown by country and by fleet in Figure 18.6 and 18.7 respectively. The age coverage for discards fluctuates around 60% over the whole time-series and is at 84% in 2023 (Figure 18.5).

A detailed overview of imported or raised data and sampled or estimated distributions for 2023 is given in Table 18.2.

Discards are included in the assessment from working year 2017 onwards. If discards are unavailable for a particular year-quarter-country-métier combination, they are assumed to be unknown (non-zero) and therefore raised (InterCatch). The weighting factor for raising the discards was '*Landings CATON*' (landings catch). In 2023, no UK strata were available providing information on discard tonnage and distributions.

Discard raising was performed on a **gear level** regardless of season or country. The following groups were distinguished based on gear:

- TBB
- OTB including OTB, OTT, SSC, SDN
- GTR including GTR and GNS

The remaining gears were combined in a REST group (including MIS, FPO, DRB, LHM, LLS).

The GNS/GTR, TBB and OTB/OTT/SSC/SDN contribute respectively 29%, 45% and 24% to the landings of sole in 27.7.d (Table 18.3).

Raising within a gear group was performed when the proportion of landings for which discard weights are available was **equal or larger than 50%** compared to the total landings of that group. For the 2021 and 2022 data, this was the case for the TBB, GTR and OTB gear group. In 2023, this threshold was only reached for the OTB and TBB group. The remaining gears were grouped in the REST group, which was raised using all available information except for strata with a discard rate larger than 50%.

To **allocate age** compositions, landings and discards were handled separately; samples from landings were used only for landings and *vice versa*. When age distributions (both landings and discards) had to be borrowed from other strata, allocations were performed on a **gear level**. The same gear groups (TBB, OTB, GTR and REST) as used for discard raising were applied. When the **threshold of 50%** was reached for the proportion of landings or discards covered by age, allocation of age occurred with all available information within that gear group. For the 2021, 2022 and 2023 landings data, this threshold was reached for all gear groups. For the 2021 discards, this was only the case for the TBB and GTR group and for the 2022 and 2023 discards, this was only the case for the TBB group. When the threshold was not reached, unsampled data were

pooled in the REST group and ages were allocated using all sampled data. The weighting factor was '*Mean Weight weighted by numbers at age*'.

From 2018 onwards, **BMS landings** and **logbook registered discards** were available in InterCatch. However, all were zero up to 2020. In 2020, 247 kg of BMS was reported from the English GNS_DEF_all Q4 and OTB_DEF_70-99 Q4 strata. In 2021, 205 kg of BMS was reported from the English GNS_DEF_all Q1, OTB_DEF_70-99 Q1 and GTR_DEF_all Q3 strata. In 2022 and 2023, no BMS landings and logbook registered discards were reported. Logbook registered discards were not considered for the age allocations. Age allocation of BMS landings was done together with discards.

The official catch statistics have reported BMS landings in 2017 (144 kg), 2019 (2.8 kg), 2020 (249 kg), 2021 (415 kg), 2022 (835 kg) and 2023 (486 kg). No BMS landings were reported in 2018.

18.2.1.3 Reconstruction of discards

Due to the lack of discard information prior to 2004, discards were reconstructed for the period 1982–2003 (ICES, 2021). Similarly, as during the WKNSEA 2017 benchmark, an average discard proportion at age was calculated for the period 2004–2008. This decision was motivated by the fact that discard behaviour at age changed after 2008 and a general increase in discarding was found in the most recent years (Figure 18.8).

First, the InterCatch information from the most recent years (2004–2019) on discards and landings numbers-at-age, weights-at-age and overall tonnage was SOP corrected as follows. Numbers were multiplied with weights and summed per year. Then the ratio between the overall tonnage from InterCatch and this sum was calculated. This gave a SOP factor by year which was then multiplied by the numbers-at-age per year.

Subsequently, only the numbers-at-age were retained for the period 2004–2008 and the mean numbers-at-age were calculated. The ratio of the discards mean numbers-at-age and the landings mean numbers-at-age for 2004–2008 was then multiplied by the old landings numbers-at-age, which were also SOP corrected. This finally resulted in discards numbers-at-age for the period 1982–2003.

Discards weights-at-age were calculated in the same way. A ratio between discards and landings weight-at-age for the period 2004–2008 was calculated and multiplied by the landings weight-at-age for the period 1982–2003. This resulted in discards weight-at-age for the period 1982–2003.

18.2.1.4 Discard rate

The discard rate, calculated as the ratio between ICES discard estimates (tonnes) and ICES catch estimates (tonnes), fluctuates between 3 and 10% over the time-series (1982–2018) (Figure 18.9). However, in 2019, a sudden increase in the discard rate occurred to approximately 20%, levelling off to 16% in 2022 and 15% in 2023. For a target species such as sole, this recent rate is very high.

In 2020, as a result of the Covid-19 pandemic, hampered sampling could have been affecting the discard rate (see §18.2.1.2). Usually most of the imported discards originate from France (62% in 2018) followed by Belgium (34% in 2018) and England (4% in 2018). However, in 2020, 66% of the imported discards originated from Belgium and only 34% from France. This was the result of the reduced sampling by France due to the pandemic. Belgium only submits discard data from the TBB group, while France usually provides a mix of GTR, OTB and TBB strata. Following the discard raising procedures (§18.2.1.2), the threshold of raising the OTB and GTR group using only OTB and GTR strata respectively was not met for the 2020 data (in contrast to the three preceding years). Consequently, these strata were raised in a REST group including BEL TBB_DEF_70-99 (DR = 0.22), FRA GTR_DEF_100-119 Q1 (DR = 0.023), Q3 (DR = 0.018), Q4 (DR = 0.010), FRA GTR_DEF_90-99 Q1 (DR = 0.044), FRA OTB_DEF_70-99 Q3 (DR = 0.326) and ENG OTB_DEF_70-99 Q1 (DR = 0). The French OTB_DEF_70-99 Q1 stratum was not included because

the discard rate exceeded 50% (DR = 0.514). Consequently, the Belgian discard samples had a higher impact for the 2020 data compared to previous years. In 2020, Belgian discard rates were unusually high (22% versus 12% in 2018 and 14% in 2019). However, the Belgian observer programme was not hampered by the Covid-19 pandemic.

Other explanations could be good recruitment entering the fishable population or decreasing size at age. Most likely, a combination of these different factors resulted in the observed increase in discard rate. The fact the stronger 2018 year class is steadily reaching larger sizes, likely results in a gradual decrease of the discard rate in the most recent years.

18.2.1.5 Numbers-at-age

Catch, landings and discards numbers-at-age are shown in Figure 18.10, 18.11, 18.12, 18.13 and Table 18.4.

Catch numbers have decreased over the time-series and lower numbers are caught since 2015 (Figure 18.10). In 2008–2009, a stronger year class entered the stock and was found in the landings from age 2 onwards. The 2018-year class is the first since 2008-2009 that seems large enough to be observed in the landings. However, fewer 2-year olds have been observed in the landings compared to 2008-2009.

Almost half of the 2- and 3-year-old fish were discarded in 2020. In contrast to another period with a strong year class (e.g. 2001-year class), it is apparent that proportionally more 2-year olds end up in the discard fraction (Figure 18.10).

Additionally, Figure 18.13 shows a considerable amount of older discards, especially in 2019 and 2020. Considering the larger impact of the Belgian samples in 2020, Belgian age-length keys (modelled) were investigated (see Figure 18.13a below showing the proportion per age per length class). Discards up to 29 cm were aged and while in 2019 over 40% were younger than age 6, in 2020 this was less than 5%. This confirms the pattern of decreasing length-at-age also found in the UK BTS survey data (ICES, 2021).

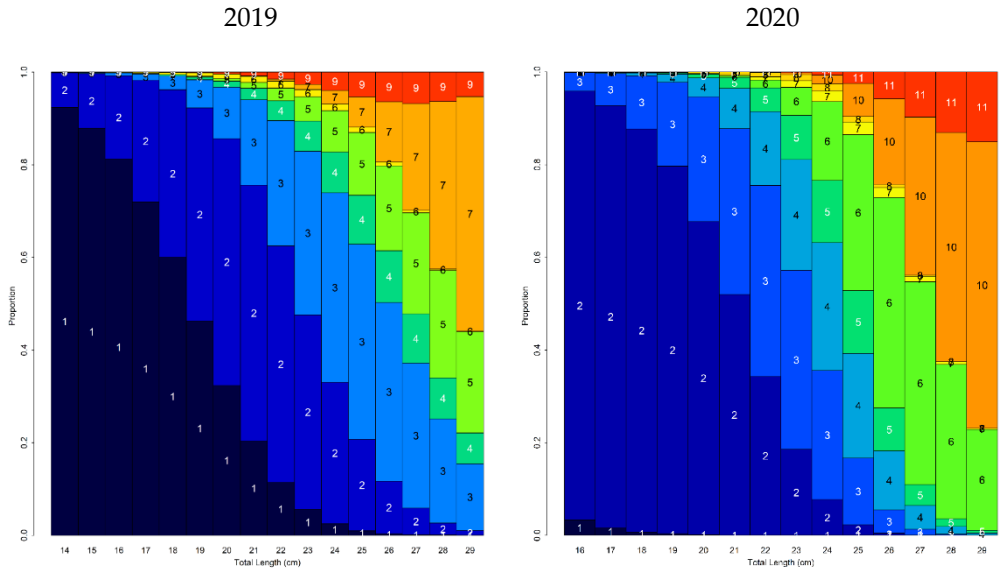


Figure 18.13.a. Sole in Division 7.d. Proportion of ages within each length class for the year 2019 (left panel) and 2020 (right panel).

18.2.1.6 Weight-at-age

Weights-at-age for discards and landings are shown in Figure 18.14 and 18.15 respectively and weights-at-age in the catch are given in Figure 18.16 and Table 18.5. Catch weights-at-age (Figure 18.16) have gradually declined over the past 10 years. Furthermore, although discards of older ages are being caught (up to age 8 and older), their mean weight-at-age varied around 100 grams. This points to a trend of decreasing weight-at-age and thus smaller (§18.2.1.5) and thinner fish.

18.2.2 Stock weight-at-age

Stock weights-at-age were revised during the WKNSEA 2021 benchmark (ICES, 2021). Quarter 1 catch weight-at-age was extracted from InterCatch for the period 2004–2022 and used as stock weight-at-age for this period. Note that Belgian catch information (numbers and mean weight-at-age) was added manually because Belgian data were uploaded per year (not quarter, with the exception of 2018). Subsequently, the mean proportion at age was calculated between the catch weight-at-age in quarter 1 and the overall catch weight-at-age for the period 2004–2019. This ratio was then multiplied by the catch weight-at-age for the period 1982–2003 to get the quarter 1 catch weight-at-age for 1982–2003 (Figure 18.17; Table 18.6).

18.2.3 Maturity and natural mortality

During the WKNSEA 2017 benchmark (ICES, 2017), the knife-edged maturity ogive with full maturation from age 3 onwards was revised. Using data from the French IBTS survey and commercial data from Belgium, France and the UK (15 191 records), a new maturity ogive was constructed (see table below). More information on how this was achieved is provided in the WKNSEA 2017 report and the associated working document (ICES, 2017).

Age	0	1	2	3	4	5	6	7	8	9	10	11(+)
Maturity	0.00	0.00	0.53	0.92	0.96	0.97	1.00	1.00	1.00	1.00	1.00	1.00

Natural mortality is assumed constant over ages and years at 0.1. English and French tagging data were investigated (prior to the WKNSEA 2021 benchmark), but two problems were encountered. First, most of the tagging data dated back to before the beginning of the sole 7.d time-series. Second, in the most recent years, there were too little recaptures which inhibited the calculation of a new estimate for natural mortality (Lecomte *et al.*, 2020).

18.2.4 Tuning series

The assessment of sole in the eastern English Channel is tuned with three survey (UK(E&W)-BTS-Q3, UK-YFS and FRA-YFS) and three commercial tuning series (FRA-COTB, UK(E&W)-CBT and BE-CBT).

During the WKNSEA 2021 benchmark, the Belgian commercial beam trawl index and the French commercial otter trawl index were revised (ICES, 2021). The UK commercial beam trawl index was revised during the 2019 inter-benchmark (ICES, 2019). A minor change was made to the Belgian commercial beam trawl series during the inter-benchmark in June 2022 (ICES, 2022). This change included the removal of the rectangle threshold on the data. All three commercial tuning fleets are included in the assessment as fishable biomass indices (aggregated over all age) (Figure 18.18). The Belgian and French index follow the same trend with the exception of the year 2020 and 2022, where the Belgian index increases or stabilises and the French index decreases. The UK commercial index gives information back up to 1986 and shows an opposite trend around 2005 and in 2008–2014 compared to the Belgian and French index. The opposite trends could be explained by the specific area where the UK beam trawl fleet is fishing (along the southern English coasts). Since 2014, trends are similar up until 2020, where the UK index shows an increase while the other indices point to a decrease. In 2023, all commercial indices show a decrease.

The survey tuning fleets are included as age-disaggregated indices. For the UK beam trawl survey (BTS) information from ages 1–6 is available and the UK and French Young fish surveys provide information on age 1 (Figure 18.19).

18.2.4.1 Belgian commercial beam trawl LPUE index

For the Belgian index (2004–current), both the data and method to derive a tuning series were revised during the WKNSEA 2021 benchmark. In consistence with the correction of the Belgian catch data, the index was calculated using data from fishing trips in which fishing activity, as registered in the electronic logbooks, was restricted to the eastern English Channel (division 27.7d). To reduce the noise generated by the unbalanced sampling design of the logbook data, only observations from fishing vessels that fished at least 5 years in the eastern English Channel were included in the analysis. The threshold present on the ICES statistical rectangles was removed during the 2022 IBP to allow for a more robust index which buffers change to historical data when new data becomes available.

The statistical model used to standardize the landings and effort data was modified during the WKNSEA 2021 benchmark. A logistic regression was applied to model the presence/absence of sole in the landings, whereas a lognormal model was used to standardize the positive catch rate. Both models included an intercept, a seasonal trend, and annual trend. The seasonal trend was introduced by means of a penalized smoothing spline and constrained to be cyclic. To reduce the number of parameters, the same seasonal model was used for both the presence/absence and positive catch rate model. The annual trend in both models was assumed to be a first order autoregressive process such that the year effects in both models were estimated as random effects. The model for the positive catch also included random effects (IID) on the ICES statistical rectangles and vessel reference number to account for respectively, spatial variation, and variation caused by skipper effects or technical characteristics of the vessel. Finally, an index was derived

by multiplying the probability of having a positive catch, and the expected positive catch rate for each year (Table 18.7).

The issues with the Belgian national database, resulting in an unrealistic high number of zero observations in the lpue in 2022 and the exclusion of the 2022 data point from the assessment calculated in 2023 were resolved. Hence the current assessment contains the tuning series including all years from 2004 to 2023.

18.2.4.2 French commercial otter trawl LPUE index

Prior to the WKNSEA 2017 benchmark, no French commercial tuning series were included in the assessment. During the WKNSEA 2017 benchmark, a raw LPUE index was calculated based on the OTB_DEF_70-99 fleet, which targets sole seasonally and mainly along the French coast. During the WKNSEA 2021 benchmark, this index was also recalculated according to the revision of the French catch data and a model was applied (ICES, 2021). To account for dependencies in the landings and effort data, the new French commercial otter trawl index was developed (2005-present) based on a selected number of vessels practicing the OTB_DEF_70_99 métier. Only vessels accounting for the top 95% sole landings of OTB_DEF_70-99 were kept in the analysis and they had to be active in the fishery at least two thirds of the time-series (*i.e.* 10 years as of 2019).

To standardize the LPUE, a hurdle lognormal mixed model (occurrence and lognormal model) is used to correct for vessels, seasonality and spatial effects. The best hurdle model formulation used a first order random walk to fit temporal trends in the main year effect and the spatio-temporal interaction, and the spatial correlation is constrained by a neighbourhood structure using a Besag model. The biomass index is shown in Table 18.8.

18.2.4.3 UK commercial beam trawl LPUE index

Due to database issues, it was no longer possible to provide an LPUE index based on kW. fishing hours for the UK CBT. The new index is a modelled landings per activity days index from 1986–present (ICES, 2019; Table 18.9).

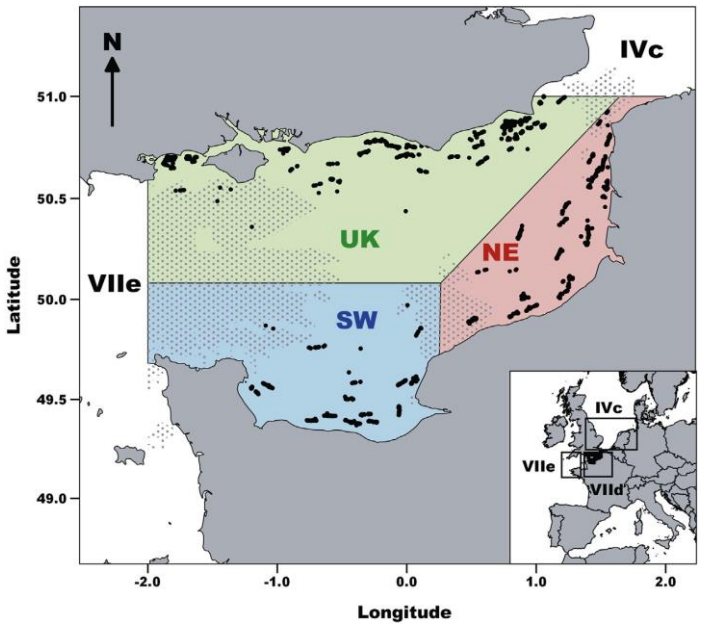
18.2.4.4 Survey tuning indices

During the 2022 IBP, the UK BTS survey was investigated (Table 18.10). It became clear that the survey was able to track the cohorts better in the beginning of the time-series compared to the end of the time-series as shown by Figure 18.20 and 18.21. The internal consistency plots showed that the correlation between ages 1-2, 2-3 and 3-4 changed considerably, while this correlation was more stable for ages 4-5 and 5-6 (Figure 18.21). The age information from ages 1-3 from 2010 onwards was therefore removed. This was most likely related to the changing size at age. However, uncertainty around age readings was also brought up to explain the observed change. This will be investigated further. The UK BTS survey was not conducted in 2022, and therefore, no information was available for 2022.

The French YFS (Table 18.12), which is confined to the Somme estuary (see stock annex), shows a rather constant and low index in the period 2014–2018 (Figure 18.19). In 2019 and 2020, an increase in recruitment is measured. The values for 2021 and 2022 are again back to levels prior to 2019, although the 2023 estimates show a small increase. The UK YFS (Table 18.11) stopped in 2006 and was situated along the southern English coast.

During the WKNSEA 2021 benchmark, evidence for the presence of three subpopulations was investigated (Lecomte *et al.*, 2020; Randon *et al.*, 2018, 2020; indicated on map below). The UK BTS data was further analysed and higher abundances of sole were found in the south-western population (Seine Bay), followed by the northern UK subpopulation (especially age 1–3). Lowest abundances were found in the French NE subpopulation, where the FRA YFS takes place. Nevertheless, trends over all subpopulations were similar with only minor differences in most recent

years. Considering the UK BTS is concentrated in the coastal zones and in quarter 3, further investigation is necessary considering the dynamics of these subpopulations and their impact on the overall stock (ICES, 2021).



18.3 Analyses of stock trends/Assessment

18.3.1 Review of last year's assessment

The indices from the Belgian commercial tuning fleet and the UK-BTS were missing in 2022. Sensitivity analyses were carried out during the WGNSSK 2023 meeting to investigate the potential impact of these missing data, and perceived limited. This year, the 2022 data point from the Belgian commercial tuning fleet could be recovered as national database issues were resolved. Correspondingly, Belgian catch data were updated, which resulted in small differences (§18.2.1.2). Last year's assessment was rerun including this recovered 2022 data point, which confirmed last year's hypothesis that this missing data point had a very limited effect on the assessment (Figure 18.22).

18.3.2 Final assessment

The SAM model input and configuration used in the WGNSSK 2024 assessment are shown in the table below and Figure 18.23 and Table 18.13. The configuration is the same as the revised SAM model approved during the IBP in 2022.

Settings	
Model	SAM
First data year	1982
Last data year	2023

Ages	1–11+
Plus group	Yes
Stock weights-at-age	Q1 catch weight-at-age; reconstructed for 1982-2003
Discards Numbers- and weight-at-age	Reconstructed for 1982-2003
Abundance indices	Commercial: BEL CBT LPUE (2004-present); FRA COTB LPUE (2005-present); UK CBT LPUE (1986-present)
	Survey: UK (E&W) BTS (1989-present; excl. 2022) from 2010-present including only ages 4-6; UK YFS (1987-2006); FRA YFS (1987-present)
Natural mortality	0.1
Maturity ogive	Age1 = 0.00; Age2 = 0.53; Age3 = 0.92; Age4 = 0.96; Age5 = 0.97; Age6-11+ = 1.00
Number of parameters describing F-at-age in catch (keyLogFsta) (columns represent ages)	0 1 2 3 4 5 5 6 6 7 7 (catch)
Correlation of F across ages (corFlag)	0 (independent)
Number of parameters describing F-at-age in surveys (keyLogFpar) (columns represent ages)	0 (BEL CBT LPUE; FSB) 1 (UK CBT LPUE; FSB) 2 (FRA COTB LPUE; FSB) 3 4 5 6 7 7 (UK BTS; age 1 -6) 8 (UK YFS; age 1) 9 (FRA YFS; age 1)
Density dependent catchability power parameters (keyQpow)	None
Coupling of process variance parameters for F (keyVarF)	0 0 0 0 0 0 0 0 0 0 0
Coupling of process variance parameters for log(N) (keyVarLogN)	0 1 1 1 1 1 1 1 1 1 1
Coupling of variance parameters on the observations (keyVarObs) (columns represent ages)	0 1 2 2 2 2 2 2 2 2 2 (catch; age 1 – 11+) 3 (BEL CBT LPUE; FSB) 4 (UK CBT LPUE; FSB) 5 (FRA COTB LPUE; FSB) 6 7 8 8 8 8 (UK BTS; age 1 - 6) 9 (UK YFS; age 1) 10 (FRA YFS; age 1)
Covariance structure per fleet (obsCorStruct) (columns represent fleets: catch, BEL CBT LPUE, UK CBT LPUE, FRA COTB LPUE, UK BTS, UK YFS, FRA YFS) ID = independent AR = autocorrelated	ID ID ID ID AR ID ID
Coupling of correlation parameters (keyCorObs)	0 1 1 1 1 (UK BTS; age 1/2 - age 5/6)

(columns represent ages)	
Stock recruitment code (stockRecruitmentModelCode)	0 (random walk)
Number of years where catch scaling is applied (noScaledYears)	None
Vector of years where catch scaling is applied (keyScaledYears)	None
Matrix specifying coupling of scale parameters (keyParScaledYA)	None
Fbar ranges	3-7
Type of biomass index (keyBiomassTreat)	2 (fishable stock biomass, FSB)
Option for observational likelihood (obsLikelihoodFlag)	LN LN LN LN LN LN LN
Treatment for weight attribute (fixVarToWeight)	/
Fraction of t(3) distribution used in log(F) increment distribution	/
Fraction of t(3) distribution used in log(N) increment distribution	/
Vector describing fraction for fleets (fracMixObs)	/
Vector describing break year between recruitment (constRecBreaks)	/
Coupling of parameters used in prediction-variance link for observations (predVarObsLink)	None

The SAM model fitting diagnostics and survey catchabilities are shown in Table 18.14 and Table 18.15 respectively. The assessment summary is given in Table 18.16 and Figure 18.24.

Catches are approximately 2000 tonnes lower compared to the beginning of the time-series. The model estimates that the *SSB* ranges between 10 000 and 19 000 tonnes in the period 1982–2023. In 2022, the SSB was estimated at the lowest level of the time-series, but shows a slight increase in 2023. SSB at age is highest for age 5 in 2023 (Table 18.19). As a result of the decline in *fishing mortality* and the low recruitment in recent years, the relative biomass proportion of the plus group increased. However, since 2021, the biomass proportion of the plus group seems to have stabilized (Figure 18.25).

The *fishing mortality* (F_{bar}) fluctuated over time with periods of high F in the late 1980s, 1990s and 2000s. Since 2010, F_{bar} has gradually declined, from ~0.40, to ~0.23 in 2019. From 2019 to 2022, F_{bar} fluctuated around 0.23, and is estimated to have declined in 2023 to a level of 0.215. The *fishing mortality-at-age* shows that the age 1 group is hardly caught by the fishery (Figure 18.26; Table 18.18), which is in contrast with all other age groups. The F-at-age shows that the selectivity of the fishery changed remarkably over time. Before 2005, fishing mortality was always highest for age groups 3, 4 and 5, while in the most recent years, fishing mortality for these ages declined strongly. Furthermore, the fishing mortality for age groups 6-11+ also declined with F on ages 10 and 11+ decreasing below F on age 2. In 2023, F-at-age declined for all age groups, except for ages 1 to 3.

The *recruitment* (age 1) is estimated to range between 10 000 and 50 000 thousands individuals, and shows some periods of high recruitment e.g. in the early 1990s and in the period 2000-2010. Since the large recruitment in 2011, recruitment has been stable at lower levels. In 2022, recruitment was estimated at the lowest level of the entire time-series (Table 18.17).

The process residuals do not indicate any major problems with respect to the model configuration (Figure 18.27). However, in 2023, there seems to be a consistent underestimation of ages 2-11 of the log F processes.

The one step ahead residuals for the catch data do not indicate strong patterns across ages and years, except for some of the older ages (age 9 and 11+) in the most recent years (Figure 18.28) and for ages 4 and 6-11+ in 2023. The same is true for the UK BTS: no clear pattern except for an overestimation of the older ages in the last years. The UK CBT index residuals shows some clear patterns over the years, which could be explained by the different trend this index shows compared to the other commercial tuning fleets. The French COTB index shows for 2023 an underestimation.

The retrospective analysis does not indicate large problems with the model with respect to the SSB, Fbar and recruitment estimates (Figure 18.29). All peels fall within the confidence bounds and Mohn's Rho values for SSB and F_{bar} (rho SSB = 0.053; rho F_{bar}(3-7) = 0.038) are within limits as defined at WKFORBIAS (ICES, 2020). The Mohn's Rho for the recruitment (Age 1) is considerably higher (0.238) which is likely related to the lack of informative data sources on age 1.

The leave-one-out runs indicate no strong dependency for one of the tuning fleets (Figure 18.30). However, removing the UK BTS gives a slightly lower SSB and higher F_{bar}, but all within the levels of confidence.

Figure 18.31 gives the model summary compared to the 2023 assessment approved by WGNSSK23. There are no clear differences in terms of estimated catches, SSB, F_{bar} and recruitment.

18.3.3 Historical stock trends

Trends in catch, SSB, F_{bar} and recruitment are presented in Table 18.16 and Figure 18.32.

Catches have been fluctuating around 4000 tonnes up to the year 2000. Catches fluctuating around 5000 tonnes were registered for the period 2000–2014. From 2015 onwards, catches dropped below 4000 tonnes and dropped further below 3000 tonnes in 2016 and below 2000 tonnes in 2020 (1971 tonnes). In 2023, the lowest catches of the time-series have been realised.

The *spawning-stock biomass* (SSB) has been fluctuating without trend since the 1980s between MSY $B_{trigger}$ and B_{lim}. In the period 2000–2015, SSB has been fluctuating around MSY $B_{trigger}$. However, since 2019, SSB has been fluctuating around B_{lim} and is assessed to be below B_{lim} in 2023.

Fishing mortality (F) has been exceeding F_{lim} (0.352) for the major part of the time-series. From 2013 onwards, F decreased to below F_{pa} (0.318), decreasing further to drop below F_{MSY} (0.230) in 2020. Since then, fishing mortality stabilized at levels just below F_{MSY}.

Recruitment has been fluctuating without trend with occasional strong year classes. The last 10 years, recruitment has been lower compared to the earlier part of the time-series.

18.4 Short-term forecast

Since the last benchmark (WKNSEA 2021), the short term forecast of sole in Division 27.7d is performed using the *stockassessment* package. Stock weights-at-age for the next three years are

assumed to be the mean stock weight-at-age of the last five years. Selectivity of the fishery for the next three years is assumed to be the mean selectivity of the last five years.

In contrast to last year, recruitment in the future years is the median of resampling from 2012 until the final assessment year (2012–2023). To account for the higher uncertainty of the final recruitment estimates, a weighted resampling procedure is applied. Hereto, resampling probabilities are defined as the inverse of the standard deviation of the recruitment estimates. This was done to be more consistent with the forecast procedure implemented in the *stockassessment* package that also considers the last recruitment estimate as a starting point for the projection. A stochastic forecast is conducted with 1000 simulations. The process noise F is set to false. The forecast results are split into landings and discards with the proportion of landings calculated as the mean of the last 5 years. An overview of the forecast settings is provided in the stock annex.

For the fishing mortality in the intermediate year, there are two possible scenarios: 1) status quo fishing mortality (Fsq) or 2) TAC constraint. For the status quo fishing mortality, there are again two options: 1a) if the Fbar shows no trend over the last three years, the mean Fbar of the last three years is taken as intermediate year assumption, 1b) if the Fbar shows a decreasing or increasing trend over the last three years, we scale to the last data year, which means that the Fbar in the intermediate years is the same as the last data year. For the TAC constraint option, the Fbar is calculated in the intermediate year as if the TAC would be fully fished in that year.

For this year's assessment, the TAC option constraining catches to be at the TAC (1504 tonnes) in 2024 was considered as the status quo F (no trend, average of the last 3 year) would result in an overshoot of the TAC.

SSB 2025	F_{bar} (age 3–7)	F_{dis}	F_{lan}	recruits (age 1; thousands)
10804 t	0.212	0.046	0.166	15220
landings	**discards**	**catch**	**TAC 2024**	**Catch advice for 2024**
1252 t	252t	1504 t	1504 t	1504 t

Following the ICES advice rules, the target F in the advice year is set at F_{MSY} in case the SSB in the advice year (2025) is above MSY $B_{trigger}$, else, the target F is set as F_{MSY} x ($SSB_{advice\_year}/B_{trigger}$). In case the SSB is insufficient to bring the stock above B_{lim} in the advice year + 1, a zero TAC can be advised.

The SSB in 2025 (10804 tonnes) is below MSY $B_{trigger}$ (15 654 tonnes), which means that F_{MSY} should be rescaled with a factor of 0.690 (MSY approach) to 0.159. This resulted in a catch advice for 2025 of 1209 tonnes, which is a 19.6% decrease compared to the catch advice for 2024 (1504 tonnes). This means a probability of SSB 2026 to fall below B_{lim} of 40%.

This decrease in advice is the result of the lower recruitment and higher fishing mortality estimated for 2023 than assumed last year. This resulted in a strong decline of the 2023 cohort, compared to last years' estimate (Figure 18.34), and a subsequent reduction of the SSB in the advice year as illustrated in Figure 18.35. In addition, the 2025 SSB is below MSY $B_{trigger}$ leading to a reduced F_{MSY}. The evolution of stock weights is shown in Figure 18.33. Comparisons between selectivity, stock weights, stock numbers, and change in biomass at age between this year's estimates and last year's forecast assumptions are given in Figures 18.36 to 18.39.

The output of the forecast, for the TAC constrained option is shown in the table below. MSY $B_{trigger}$ and B_{pa} cannot be reached in 2026, therefore, the scenario cannot be calculated.

basis	catch	landings	discards	$F_{3–7}$	F_lan	F_dis	SSB 2025	SSB 2026	SSB change	Advice change	Probability of SSB (2026) < B_{lim} (%)
F_{target}	1209	990	220	0.159	0.124	0.035	10804	11630	7.6%	-19.6%	40
F_{MSY}	1697	1390	310	0.23	0.180	0.050	10804	11051	2.3%	12.8%	52
F_{lower}	1192	980	220	0.156	0.123	0.033	10804	11649	7.8%	-21%	40
$F_{lower\_rescaled}$	841	690	154	0.108	0.085	0.023	10804	12052	11.6%	-44%	30
F_{upper}	2068	1690	380	0.29	0.22	0.062	10804	10632	-1.59%	38%	71
F = 0	0	0	0	0	0	0	10804	13018	20%	-100%	14.7
F_{pa}	2264	1850	410	0.32	0.25	0.068	10804	10418	-3.6%	51%	66
F_{lim}	2466	2000	450	0.35	0.28	0.076	10804	10183	-5.7%	64%	71
SSB = B_{pa}	-	-	-	-	-	-	-	-	-	-	
SSB = $MSYB_{trigger}$	-	-	-	-	-	-	-	-	-	-	
SSB = B_{lim}	1581	1290	290	0.21	0.167	0.045	10804	11181	3.5%	5.1%	50
F = F_{2024}	1599	1310	290	0.22	0.169	0.046	10804	11161	3.3%	6.3%	50

18.5 Biological reference points

The table below summarizes all known reference points for sole in Division 27.7.d and their technical basis. Reference points have been redefined as a result of the 2022 IBP (ICES, 2022).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	15654	B_{pa}; in tonnes.	ICES (2022)
	F_{MSY}	0.230	Stochastic simulations (EqSim) with segmented regression fixed at B_{lim} based on recruitment period 1982–2020.	ICES (2022)
Precautionary approach	B_{lim}	11181	B_{loss}, lowest observed SSB (2020) with 2021 as the last year of catch data; in tonnes.	ICES (2022)
	B_{pa}	15654	B_{lim} × 1.4; in tonnes.	ICES (2022)

Framework	Reference point	Value	Technical basis	Source
	F_{lim}	0.352	The F that on average leads to B_{lim} from EqSim.	ICES (2022)
	F_{pa}	0.318	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with AR)	ICES (2022)
F_{MSY} ranges	F_{lower}	0.156–0.230	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}	ICES (2016, 2022)
	F_{upper}	0.230–0.287	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}	ICES (2016, 2022)

18.6 Quality of the assessment

The recruitment estimates of the years 2022 and 2023 are highly uncertain due to a lack of data that informs the dynamics of the age 1 individuals. These recruitment estimates may be biased with knock-on effects on the short term forecast and advice. However, the uncertainty is accounted for in the forecasted recruitment by weighting the resampled recruitment with the associated standard deviation.

18.7 Benchmark issue list

18.7.1 Data issues

During the benchmark, it was noted that sole in Division 27.7d exhibited a declining trend in the in the weights and lengths-at-age in recent years and more apparent in the older ages. It is not clear what mechanism is driving such decline. Future work should look into the potential causes for this declining trend.

Maturity estimates were not investigated during the last benchmark (WKNSEA 2021; ICES, 2021). Therefore, maturity estimates as calculated during the WKNSEA 2017 benchmark are used. These are derived from both commercial landings and survey data. Using commercial data could potentially introduce bias. When maturity estimates are revised, only fishery independent data should be considered (if available) to ensure that they align with contemporary stock dynamics. Future work should also revisit growth and natural mortality. However, for the latter data are currently inadequate (Lecomte *et al.,* 2020).

The subpopulation structure in this stock should be investigated further.

To improve estimation of discards in the assessment, discard mortality by gear type could be considered.

The poorer tracking of cohorts and internal consistency in the most recent part of the UK BTS time-series should be investigated further.

18.7.2 Assessment issues

Biological and environmental processes should be explored for potential use in a model. There is also an increase of the biomass proportion in the older age groups and notably the plus group that should be followed up in future assessments. However, this trend seems to have stabilised in this year's assessment.

The retrospective pattern for the recruitment is higher as there is little information to inform the dynamics of the younger ages (1-3).

Alternative methods to calculate the reference points should be investigated, especially for this stock, which is characterised by a narrow range in SSB and no clear stock-recruitment relationship.

18.7.3 Short-term forecast issues

Currently no issues.

18.8 Management considerations

The sole stock in Division 27.7.d is harvested in a mixed fishery with plaice in 27.7.d. Due to the minimum mesh size in the mixed beam and otter trawl fisheries (80 mm), a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

18.9 References

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18.10 Tables and figures

Table 18.1. Sole in Division 7.d. Official landings (tonnes) by country over the period 1974–2023; ICES estimates (as reported in InterCatch) for both landings and discards (tonnes) used by the working group. TAC (tonnes) represents landings until 2015. From 2016 onwards, TAC represents catch. * including BMS

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
1974	159	383	309	3	854	884		
1975	132	464	244	1	841	882		
1976	203	599	404		1206	1305		
1977	225	737	315		1277	1335		
1978	241	782	366		1389	1589		
1979	311	1129	402		1842	2215		
1980	302	1075	159		1536	1923		
1981	464	1513	160		2137	2477		
1982	525	1828	317	4	2674	3190	196	
1983	502	1120	419		2041	3458	101	
1984	592	1309	505		2406	3575	141	
1985	568	2545	520		3633	3837	242	
1986	858	1528	551		2937	3932	145	
1987	1100	2086	655		3841	4791	197	3850
1988	667	2057	578		3302	3853	198	3850
1989	646	1610	689		2945	3805	192	3850
1990	996	1255	785		3036	3647	342	3850
1991	904	2054	826		3784	4351	368	3850
1992	891	2187	706	10	3794	4072	275	3500
1993	917	2322	610	13	3862	4299	273	3200
1994	940	2382	701	15	4038	4383	122	3800
1995	817	2248	669	9	3743	4420	282	3800
1996	899	2322	877		4098	4797	174	3500

Year	Official Landings					ICES estimates		TAC
	Belgium	France	UK (E&W)	Other	Total	Landings	Discards	
1997	1306	1702	933		3941	4764	147	5230
1998	541	1703	803		3047	3363	127	5230
1999	880	2251	769		3900	4135	247	4700
2000	1021	2190	621		3832	3476	201	4100
2001	1313	2482	822		4617	4025	317	4600
2002	1643	2780	976		5399	4733	444	5200
2003	1657	3475	1114	1	6247	6977	584	5400
2004	1485	3070	1112		5667	5819	258	5900
2005	1221	2832	567		4620	4748	344	5700
2006	1547	2627	658	0	4832	4830	315	5720
2007	1530	2981	801	1	5313	5421	332	6220
2008	1368	2880	724	0	4972	4963	183	6590
2009	1475	3047	760	0	5282	4828	287	5274
2010	1294	2476	679	0	4449	4108	273	4219
2011	1222	2281	700	0	4203	4136	342	4852
2012	941	2475	627	0	4043	4058	445	5580
2013	952	2884	605	0	4441	4295	180	5900
2014	1496	2507	648	< 1	4651	4626	216	4838
2015	1048	1895	468	0	3411	3385	263	3483
2016	799	1337	392	< 1	2528	2433	106	3258
2017	697*	1178	349	< 1	2224	2090	156	2724
2018	653	1265	394	< 1	2312	2395	263	3405
2019	603*	925	245*	< 1	1773	1648	404	2515
2020	686*	827	199*	< 1	1712	1562	409*	2797
2021	623*	824	233*	1	1681	1567	348*	3248
2022	644*	884*	262	1	1791	1688	333	2380
2023	539*	567	184	< 1	1289	1288	229	1747
2024								1504

Table 18.2. Sole in Division 7.d. Summary of the InterCatch data in 2023 (imported vs. raised data; sampled vs. estimated data)

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	1172	91
Landings	Imported_Data	Estimated_Distribution	115.2	9
Discards	Imported_Data	Sampled_Distribution	125.8	55
Discards	Imported_Data	Estimated_Distribution	26.04	11
Discards	Raised_Discards	Estimated_Distribution	77.02	34
BMS landing	Imported_Data	Estimated_Distribution	0	NA

Table 18.3. Sole in Division 7.d. Landings percentages by gear type for 2016–2023 (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB/OTT/SSC/SDN = otter trawls and seines; other gears include MIS/FPO/DRB/LHM/LLS)

Landings by gear	2016	2017	2018	2019	2020	2021	2022	2023
GNS/GTR	46%	46%	44%	33%	28%	32%	31%	29%
TBB	34%	31%	28%	33%	36%	35%	34%	45%
OTB/OTT/SSC/SDN	15.9%	17.6%	24%	30%	33%	30%	30%	24%
Other	4.5%	4.7%	4.5%	3.7%	2.8%	2.7%	3.9%	2.6%

Table 18.4. Sole in Division 7.d. Catch numbers at age (in thousands)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	375	0	59	122	122	22	236	405	3092	952	261	211	77	2082
2	3432	1136	2630	4961	1685	4197	2910	4686	3836	9646	5446	6769	934	4006
3	5688	3812	3476	5795	5904	4158	7995	3586	6214	4575	9794	7179	6912	4874
4	1710	3971	2630	1675	3259	3336	1633	4482	1172	4242	1925	5551	6017	4857
5	558	895	1890	1032	911	2068	1167	1443	1505	608	2006	1015	3427	2987
6	636	731	736	1863	771	1046	859	842	302	1000	289	565	586	1986
7	535	624	454	145	1062	1095	390	574	392	258	370	163	570	377
8	233	330	313	158	155	785	255	201	260	247	135	188	109	278
9	118	107	134	156	190	111	256	166	129	258	171	116	147	88
10	81	88	98	69	212	163	83	224	126	92	95	62	93	106
11+	196	191	235	128	372	459	275	282	489	382	231	129	258	241

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	22	60	82	417	343	418	1756	57	121	771	412	168	826	1270
2	2456	2004	1855	4395	4831	8136	9431	15482	4164	6957	6942	7620	2872	4446
3	8650	6761	6259	9470	5412	6905	8367	10669	11013	5185	4285	8307	8562	4494
4	3094	5106	2761	3369	4485	1627	3839	4069	3682	4777	3097	3169	5679	6164
5	3227	2096	1649	1319	1084	2509	1422	2168	4595	1256	3316	1794	1452	2500
6	1830	1676	612	871	507	731	657	656	1670	920	1207	2769	1086	808
7	1289	920	562	352	320	291	299	2068	379	636	1128	1010	758	719
8	271	776	443	672	148	128	129	229	394	392	579	753	410	664
9	319	239	354	351	328	56	97	73	291	211	239	450	157	277
10	112	169	239	192	150	81	57	134	254	104	233	194	168	239
11+	344	267	301	359	248	265	197	285	443	266	383	473	276	425

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	585	353	739	40	372	300	144	565	1643	664	7	1037	451	570
2	5827	6148	3759	1150	1244	2131	1145	1060	3378	2341	2736	1159	2236	1383
3	4255	6938	8544	5951	3502	2101	2185	2467	1846	3086	2683	3311	1619	2065
4	2953	2854	5253	6595	6639	2303	1253	1447	2626	1086	2223	1732	2530	810
5	3034	1562	1433	2539	4259	3496	1308	826	1022	1476	812	1212	1439	1390
6	1621	1469	930	762	1853	2555	1553	876	736	481	915	514	809	449
7	320	562	563	545	687	1194	1059	850	619	312	427	426	434	402
8	277	178	414	535	417	463	598	698	821	227	166	253	309	106
9	288	147	98	205	374	142	188	287	451	392	131	127	204	163
10	102	132	46	59	145	238	211	139	286	282	182	67	75	74
11+	376	179	259	129	255	272	322	194	292	230	331	204	216	116

Table 18.5. Sole in Division 7.d. Catch weights at age (kg)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.078	0.000	0.076	0.068	0.103	0.073	0.078	0.081	0.091	0.087	0.078	0.065	0.076	0.099
2	0.155	0.157	0.162	0.166	0.164	0.159	0.138	0.140	0.162	0.146	0.139	0.134	0.136	0.160
3	0.215	0.220	0.224	0.220	0.203	0.226	0.216	0.184	0.228	0.199	0.194	0.189	0.178	0.171
4	0.309	0.299	0.311	0.279	0.303	0.292	0.276	0.269	0.287	0.264	0.265	0.245	0.233	0.228
5	0.385	0.403	0.379	0.367	0.362	0.352	0.359	0.292	0.348	0.353	0.289	0.334	0.287	0.254
6	0.427	0.435	0.435	0.393	0.386	0.406	0.408	0.357	0.339	0.393	0.402	0.383	0.354	0.332
7	0.439	0.434	0.416	0.515	0.436	0.410	0.458	0.387	0.469	0.421	0.390	0.536	0.380	0.356
8	0.509	0.524	0.538	0.543	0.520	0.482	0.514	0.472	0.465	0.430	0.462	0.553	0.505	0.385
9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459	0.515	0.484	0.490
10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463	0.766	0.496	0.494
11+	0.672	0.628	0.714	0.800	0.602	0.618	0.665	0.701	0.562	0.566	0.566	0.667	0.616	0.654

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.109	0.106	0.101	0.099	0.110	0.082	0.091	0.101	0.097	0.123	0.133	0.095	0.121	0.113
2	0.150	0.139	0.145	0.137	0.129	0.138	0.147	0.148	0.147	0.158	0.150	0.158	0.156	0.155
3	0.170	0.180	0.165	0.181	0.169	0.202	0.195	0.218	0.181	0.191	0.192	0.175	0.207	0.201

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
4	0.227	0.231	0.233	0.213	0.221	0.281	0.251	0.286	0.238	0.262	0.233	0.201	0.243	0.252
5	0.268	0.291	0.285	0.259	0.331	0.287	0.315	0.365	0.269	0.353	0.286	0.267	0.258	0.268
6	0.323	0.342	0.343	0.280	0.376	0.333	0.375	0.407	0.293	0.434	0.338	0.280	0.311	0.322
7	0.360	0.389	0.382	0.290	0.424	0.367	0.376	0.165	0.410	0.455	0.394	0.339	0.370	0.316
8	0.405	0.404	0.417	0.341	0.427	0.374	0.393	0.474	0.449	0.490	0.425	0.387	0.397	0.383
9	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.424	0.390	0.566	0.562	0.452	0.433	0.383
10	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.504	0.487	0.648	0.497	0.424	0.511	0.430
11+	0.585	0.651	0.616	0.535	0.680	0.544	0.531	0.565	0.664	0.550	0.552	0.570	0.509	0.484

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	0.101	0.089	0.058	0.095	0.098	0.077	0.093	0.094	0.081	0.058	0.091	0.083	0.093	0.132
2	0.152	0.148	0.121	0.141	0.134	0.127	0.136	0.143	0.121	0.118	0.114	0.125	0.129	0.127
3	0.192	0.201	0.181	0.189	0.176	0.168	0.199	0.184	0.171	0.175	0.152	0.160	0.155	0.172
4	0.241	0.245	0.233	0.241	0.231	0.223	0.242	0.229	0.214	0.230	0.197	0.197	0.192	0.216
5	0.276	0.301	0.270	0.297	0.267	0.266	0.266	0.252	0.268	0.244	0.224	0.240	0.238	0.220
6	0.322	0.330	0.312	0.301	0.325	0.282	0.285	0.291	0.289	0.274	0.243	0.282	0.269	0.278
7	0.334	0.357	0.375	0.384	0.328	0.330	0.320	0.293	0.289	0.290	0.271	0.286	0.255	0.296
8	0.337	0.424	0.354	0.402	0.389	0.329	0.371	0.362	0.250	0.318	0.312	0.324	0.293	0.354
9	0.367	0.389	0.424	0.415	0.413	0.408	0.361	0.432	0.327	0.272	0.382	0.376	0.333	0.353
10	0.520	0.425	0.544	0.463	0.494	0.372	0.358	0.479	0.362	0.338	0.285	0.394	0.377	0.382
11+	0.502	0.534	0.521	0.572	0.527	0.480	0.436	0.525	0.409	0.394	0.417	0.482	0.420	0.489

Table 18.6. Sole in Division 7.d. Stock weights at age (kg)

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.077	0.078	0.075	0.067	0.102	0.072	0.077	0.080	0.090	0.086	0.077	0.064	0.075	0.098	0.108
2	0.167	0.169	0.175	0.179	0.177	0.172	0.149	0.151	0.175	0.157	0.150	0.145	0.147	0.173	0.162
3	0.243	0.248	0.253	0.248	0.229	0.255	0.244	0.208	0.257	0.225	0.219	0.213	0.201	0.193	0.192
4	0.352	0.340	0.354	0.318	0.345	0.332	0.314	0.306	0.327	0.301	0.302	0.279	0.265	0.260	0.258
5	0.424	0.444	0.417	0.404	0.399	0.388	0.395	0.322	0.383	0.389	0.318	0.368	0.316	0.280	0.295
6	0.472	0.481	0.481	0.435	0.427	0.449	0.451	0.395	0.375	0.435	0.445	0.424	0.392	0.367	0.357

7	0.488	0.482	0.462	0.572	0.485	0.456	0.509	0.430	0.521	0.468	0.434	0.596	0.422	0.396	0.400
8	0.441	0.454	0.466	0.471	0.451	0.418	0.445	0.409	0.403	0.373	0.400	0.479	0.438	0.334	0.351
9	0.486	0.520	0.512	0.575	0.486	0.450	0.536	0.499	0.472	0.420	0.445	0.499	0.469	0.475	0.421
10	0.481	0.606	0.587	0.618	0.543	0.559	0.585	0.568	0.538	0.497	0.481	0.796	0.515	0.513	0.483
11+	0.720	0.676	0.766	0.861	0.646	0.662	0.713	0.754	0.604	0.607	0.606	0.718	0.662	0.701	0.629

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.105	0.100	0.098	0.109	0.081	0.090	0.100	0.097	0.123	0.136	0.087	0.115	0.113	0.101	0.089
2	0.150	0.156	0.148	0.139	0.149	0.159	0.160	0.142	0.154	0.142	0.140	0.141	0.148	0.129	0.119
3	0.203	0.186	0.204	0.191	0.228	0.220	0.246	0.179	0.189	0.182	0.168	0.190	0.196	0.193	0.188
4	0.263	0.265	0.242	0.252	0.320	0.286	0.326	0.225	0.262	0.241	0.220	0.246	0.264	0.260	0.250
5	0.320	0.314	0.285	0.365	0.316	0.347	0.402	0.265	0.361	0.316	0.282	0.249	0.288	0.292	0.313
6	0.378	0.379	0.310	0.416	0.368	0.415	0.450	0.285	0.443	0.352	0.315	0.338	0.344	0.363	0.338
7	0.432	0.425	0.322	0.471	0.408	0.418	0.183	0.409	0.466	0.398	0.346	0.333	0.304	0.363	0.371
8	0.350	0.361	0.295	0.370	0.324	0.341	0.411	0.510	0.514	0.465	0.443	0.435	0.438	0.371	0.481
9	0.487	0.469	0.347	0.372	0.477	0.454	0.411	0.391	0.598	0.574	0.496	0.373	0.352	0.421	0.409
10	0.493	0.452	0.389	0.477	0.531	0.436	0.524	0.514	0.704	0.496	0.397	0.713	0.437	0.542	0.458
11+	0.700	0.661	0.577	0.727	0.585	0.569	0.608	0.692	0.588	0.632	0.613	0.472	0.606	0.537	0.561

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	0.057	0.092	0.097	0.075	0.090	0.094	0.081	0.060	0.093	0.082	0.075	0.099
2	0.104	0.104	0.093	0.102	0.101	0.135	0.111	0.104	0.097	0.125	0.093	0.104
3	0.177	0.163	0.144	0.177	0.211	0.176	0.177	0.177	0.142	0.175	0.131	0.165
4	0.228	0.244	0.235	0.244	0.273	0.229	0.247	0.232	0.203	0.220	0.193	0.224
5	0.275	0.339	0.283	0.296	0.294	0.267	0.296	0.272	0.263	0.276	0.233	0.236
6	0.331	0.340	0.346	0.308	0.331	0.305	0.324	0.305	0.273	0.312	0.274	0.299
7	0.387	0.439	0.396	0.373	0.367	0.323	0.343	0.307	0.317	0.329	0.279	0.327
8	0.384	0.416	0.429	0.336	0.448	0.384	0.332	0.352	0.369	0.376	0.303	0.388
9	0.467	0.431	0.442	0.398	0.537	0.478	0.371	0.286	0.459	0.393	0.348	0.382
10	0.548	0.416	0.592	0.380	0.456	0.508	0.407	0.361	0.346	0.419	0.366	0.374
11+	0.573	0.683	0.541	0.519	0.580	0.575	0.463	0.457	0.495	0.581	0.478	0.552

Table 18.7. Sole in Division 7.d. Tuning series 1: revised Belgian commercial beam trawl LPUE (2004–2023)

	Effort	Biomass index
2004	1	14.81815
2005	1	15.02194
2006	1	16.05270
2007	1	16.75907
2008	1	15.32095
2009	1	19.10150
2010	1	19.44197
2011	1	17.35615
2012	1	18.48797
2013	1	18.56590
2014	1	24.94172
2015	1	18.26557
2016	1	14.49080
2017	1	12.05028
2018	1	12.83800

	Effort	Biomass index
2019	1	11.74349
2020	1	13.42228
2021	1	12.95321
2022	1	12.95774
2023	1	12.17249

Table 18.8. Sole in Division 7.d. Tuning series 2: revised French commercial otter trawl LPUE (2005–2023)

	Effort	Biomass index
2005	1	12.36910885
2006	1	18.8996399
2007	1	15.85538024
2008	1	19.06886736
2009	1	17.17337091
2010	1	21.81635533
2011	1	21.36269262
2012	1	17.71237685
2013	1	20.0483759
2014	1	22.36162591
2015	1	15.45257029
2016	1	15.8986565
2017	1	13.24588624
2018	1	18.7903445
2019	1	15.04714052
2020	1	13.60327479
2021	1	13.20087625
2022	1	12.68286496
2023	1	8.077421514

Table 18.9. Sole in Division 7.d. Tuning series 3: UK (E&W) commercial beam trawl LPUE (1986–2023)

	Effort	Biomass index
1986	1	136.1006293
1987	1	141.4634984
1988	1	132.1128229
1989	1	107.5194241
1990	1	109.3173018
1991	1	70.94909131
1992	1	65.20378412
1993	1	53.75124477
1994	1	55.5567959
1995	1	65.80123782
1996	1	91.32606765
1997	1	88.20729613
1998	1	101.0657169
1999	1	94.18647492
2000	1	93.21166743
2001	1	97.65840194
2002	1	127.6873955
2003	1	117.9562338
2004	1	125.4074662
2005	1	141.0452197
2006	1	125.1363974
2007	1	120.8698007
2008	1	107.941504
2009	1	84.95745678
2010	1	86.28562401
2011	1	82.65974019
2012	1	77.12301426
2013	1	81.40938566
2014	1	86.65966068

	Effort	Biomass index
2015	1	91.8604704
2016	1	96.44934315
2017	1	75.92412872
2018	1	76.77824752
2019	1	73.84602285
2020	1	87.32804064
2021	1	94.76695299
2022	1	107.2693465
2023	1	103.2849031

Table 18.10. Sole in Division 7.d. Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2023); grey values are currently not included in the assessment.

	Effort	Age1	Age2	Age3	Age4	Age5	Age6
1989	1	3.01	22.09	4.62	2.45	0.56	0.35
1990	1	17.96	5.55	5.55	1.24	1.01	0.33
1991	1	12.14	31.17	3.19	2.82	0.48	0.67
1992	1	1.33	15.29	13.47	1.07	1.61	0.34
1993	1	0.82	22.96	11.42	9.97	1.14	1.52
1994	1	8.33	4.26	11.07	4.65	4.3	0.28
1995	1	5.89	16.09	2.22	3.51	1.67	2.12
1996	1	5.3	10.79	5.97	1.07	1.86	1.15
1997	1	24.75	10.85	4.42	1.94	0.26	0.82
1998	1	3.27	24.11	3.67	1.47	0.83	0.19
1999	1	35.99	8.22	11.33	1.59	0.73	1.02
2000	1	14.98	27.45	5.52	4.85	1.48	0.68
2001	1	10.19	27.88	11.55	1.67	2.33	0.75
2002	1	53.56	16.11	8.6	5.11	0.45	1.04
2003	1	11.03	45.65	5.87	3.2	2.05	0.42
2004	1	12.67	11.81	10.97	2.08	2.02	1.34
2005	1	43.27	6.91	3.5	5.18	1.9	1.15

	Effort	Age1	Age2	Age3	Age4	Age5	Age6
2006	1	10.84	42.62	4.51	2.68	2.59	0.55
2007	1	2.57	28.97	15.45	1.47	1.04	1.56
2008	1	3.77	7.35	9.14	5.82	0.4	0.68
2009	1	51.25	19.16	7.1	5.81	5.02	0.44
2010	1	16.59	30.76	5.14	1.66	2.7	2.73
2011	1	13.66	28.6	14.7	1.66	0.54	2.62
2012	1	1.75	9.72	7.51	3.53	0.92	0.39
2013	1	0.72	8.91	15.09	9.72	3.23	1.12
2014	1	25.39	16.35	12.38	11.92	5.09	2.73
2015	1	25.24	21.36	6.04	2.29	4.51	2.08
2016	1	10.17	33.14	11.17	3.16	3.17	3.02
2017	1	27.85	15.18	16.26	2.67	2.13	1.52
2018	1	14.86	36.49	6.66	10.32	1.74	2.13
2019	1	56.54	31.08	19.53	1.18	4.01	2.53
2020	1	1.87	42.73	8.01	4.62	1.15	1.84
2021	1	32.95	16.06	22.82	5.31	4.65	1.10
2022	/	/	/	/	/	/	/
2023	1	19.55	15.49	10.26	2.91	6.26	0.84

Table 18.11. Sole in Division 7.d. Tuning series 5: UK (E&W) young fish survey (1987–2006)

	Effort	Age1
1987	1	1.38
1988	1	1.87
1989	1	0.62
1990	1	1.9
1991	1	3.69
1992	1	1.5
1993	1	1.33
1994	1	2.68

1995	1	2.91
1996	1	0.57
1997	1	1.12
1998	1	1.12
1999	1	1.47
2000	1	2.47
2001	1	0.38
2002	1	4.15
2003	1	1.44
2004	1	2.72
2005	1	4.07
2006	1	2.21

Table 18.12. Sole in Division 7.d. Tuning series 6: French young fish survey (1987–2023) funded by EDF (noursom)

	Effort	Age1
1987	1	0.07
1988	1	0.17
1989	1	0.14
1990	1	0.54
1991	1	0.38
1992	1	0.22
1993	1	0.03
1994	1	0.7
1995	1	0.28
1996	1	0.15
1997	1	0.03
1998	1	0.1
1999	1	0.35
2000	1	0.31
2001	1	1.21

	Effort	Age1
2002	1	0.11
2003	1	0.32
2004	1	0.15
2005	1	0.82
2006	1	0.83
2007	1	0.08
2008	1	0.06
2009	1	2.78
2010	1	0.1
2011	1	0.32
2012	1	0.35
2013	1	0.052
2014	1	0.04
2015	1	0.09
2016	1	0.04
2017	1	0.05
2018	1	0.03
2019	1	0.45
2020	1	0.38
2021	1	0.07
2022	1	0.01
2023	1	0.14

Table 18.13. Sole in Division 7.d. SAM model configuration of the 2023 assessment

```
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive

$minAge
# The minimum age class in the assessment
 1
$maxAge
# The maximum age class in the assessment
 11
$maxAgePlusGroup
```

```
# Is last age group considered a plus group (1 yes, or 0 no).
 1 0 0 0 0 0 0

$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    1    2    3    4    5    5    6    6     7     7
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1))
 0
$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered
by fishing mortality).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]    0   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]    1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]    2   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]    3    4    5    6    7    7   -1   -1   -1    -1    -1
[6,]    8   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]    9   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$keyQpow
# Density dependent catchability power parameters (if any).
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row is used)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    0    0    0    0    0    0    0    0     0     0
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[6,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
    [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]    0    1    2    2    2    2    2    2    2     2     2
[2,]    3   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[3,]    4   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[4,]    5   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[5,]    6    7    8    8    8    8   -1   -1   -1    -1    -1
[6,]    9   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[7,]   10   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
$obsCorStruct
```

```
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). |
Possible values are: "ID" "AR" "US"
 ID ID ID ID AR ID ID
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
    1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11
[1,]  NA  NA  NA  NA  NA  NA  NA  NA   NA    NA
[2,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[3,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[4,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[5,]   0   1   1   1   1  -1  -1  -1   -1    -1
[6,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
[7,]  -1  -1  -1  -1  -1  -1  -1  -1   -1    -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.
 Numeric(0)
$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
<0 x 0 matrix>
$fbarRange
# lowest and highest age included in Fbar
 3 7
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 = SSB index; 1 = catch index; 2 = FSB index; 3 =
total catch; 4 = total landings; 5 = TSB index).
 -1  2  2  2 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 LN LN LN LN LN LN LN
$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight,
1 fix variance to weight).
 0
$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0
$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0 0 0 0 0 0 0 0 0 0
$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of t(3) distribution
used in the distribution of that fleet
0 0 0 0 0 0 0
$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year is included in
the left interval. (This option is only used in combination with stock recruitment code =3)
numeric(0)
$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1    -1
[2,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[3,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[4,]   NA   NA   NA   NA   NA   NA   NA   NA   NA    NA    NA
[5,]   -1   -1   -1   -1   -1   -1   NA   NA   NA    NA    NA
```

```
[6,]   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
[7,]   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
$hockeyStickCurve
20
$stockWeightModel
0
$keyStockWeightMean
NA NA NA NA NA NA NA NA NA NA NA
$keyStockWeightObsVar
NA NA NA NA NA NA NA NA NA NA NA
$catchWeightModel
0
$keyCatchWeightMean
NA NA NA NA NA NA NA NA NA NA NA
$keyCatchWeightObsVar
NA NA NA NA NA NA NA NA NA NA NA
$matureModel
0
$keyMatureMean
NA NA NA NA NA NA NA NA NA NA NA
$mortalityModel
0
$keyMortalityMean
NA NA NA NA NA NA NA NA NA NA NA
$keyMortalityObsVar
NA NA NA NA NA NA NA NA NA NA NA
$keyXtraSd
[,1] [,2] [,3] [,4]
```

Table 18.14. Sole in Division 7.d. SAM model fitting diagnostics of the 2024 assessment

Model fitting		
log(Lik)	#par	AIC
-472.3349	26	996.6698

Table 18.15. Sole in Division 7.d. SAM model survey catchability of the 2024 assessment

estimate	1	2	3	4	5	6	7	8	9	10	11
BE-CBT-LPUE	-4.4108	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-CBT	-2.5890	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-COTB-model	-4.3747	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-BTS-Q3	-7.9934	-7.1646	-7.4966	-7.7502	-7.8898	-7.8898	NA	NA	NA	NA	NA
UK(E&W)-YFS	-9.6613	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-YFS	-11.8239	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

sd	1	2	3	4	5	6	7	8	9	10	11
BE-CBT-LPUE	0.0734	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

sd	1	2	3	4	5	6	7	8	9	10	11
UK(E&W)-CBT	0.0690	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-COTB-model	0.0817	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UK(E&W)-BTS-Q3	0.2004	0.0896	0.0971	0.0797	0.0734	0.0734	NA	NA	NA	NA	NA
UK(E&W)-YFS	0.1355	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FR-YFS	0.1687	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 18.16. Sole in Division 7.d. Assessment summary.

Year	Recruitment (Age 1)			Spawning stock biomass			Landings^	Discards*,^	Fishing pressure (ages 3–7)		
	Low	R	High	Low	SSB	High			Low	F	High
1982	9790	14416	21229	11398	13199	15285	3190	195	0.28	0.34	0.41
1983	15083	21768	31415	11899	13658	15678	3458	101	0.30	0.36	0.42
1984	15670	22447	32154	12201	13891	15816	3574	141	0.32	0.37	0.44
1985	11201	16139	23256	12890	14602	16542	3838	242	0.32	0.37	0.43
1986	17114	24597	35351	12551	14174	16008	3932	145	0.35	0.40	0.46
1987	10859	15508	22149	12254	13808	15560	4790	197	0.39	0.46	0.53
1988	19029	26364	36526	11486	12995	14702	3853	198	0.39	0.45	0.52
1989	12780	17823	24855	10142	11395	12803	3805	192	0.40	0.47	0.54
1990	31873	44157	61175	10736	12088	13612	3647	341	0.38	0.43	0.50
1991	25890	35454	48551	11271	12678	14261	4351	368	0.37	0.43	0.49
1992	21283	29564	41069	12722	14516	16563	4072	276	0.35	0.40	0.47
1993	9851	13881	19559	14141	16077	18278	4299	273	0.33	0.38	0.45
1994	20095	27667	38091	13177	14880	16803	4383	123	0.35	0.40	0.47
1995	16798	23205	32054	12572	14045	15691	4420	283	0.38	0.44	0.50
1996	13707	18910	26088	12218	13641	15230	4797	174	0.43	0.49	0.56
1997	19395	27490	38963	11314	12601	14035	4764	148	0.45	0.52	0.60
1998	14292	19759	27317	10445	11653	13001	3363	128	0.43	0.50	0.57
1999	25128	34537	47469	9885	11164	12608	4135	247	0.42	0.48	0.55
2000	28211	38611	52846	10755	12058	13518	3475	202	0.38	0.43	0.50
2001	23476	32570	45186	12749	14414	16297	4025	317	0.35	0.41	0.47

Year	Recruitment (Age 1)			Spawning stock biomass			Landings^	Discards*,^	Fishing pressure (ages 3–7)		
	Low	R	High	Low	SSB	High			Low	F	High
2002	36050	49914	69111	14064	15840	17841	4733	445	0.34	0.39	0.46
2003	17536	24035	32943	16619	18661	20955	6977	583	0.38	0.43	0.50
2004	16446	23103	32455	13251	14808	16548	5819	258	0.37	0.43	0.49
2005	35416	48762	67138	13791	15366	17122	4748	344	0.35	0.40	0.46
2006	30533	41790	57199	13531	15085	16817	4831	315	0.38	0.43	0.50
2007	14811	20733	29023	13635	15299	17166	5420	332	0.40	0.46	0.53
2008	18609	26047	36458	13495	15183	17083	4963	183	0.38	0.44	0.51
2009	31730	45197	64379	13023	14786	16787	4828	287	0.37	0.44	0.51
2010	30902	43636	61618	12793	14532	16506	4108	273	0.34	0.40	0.47
2011	25270	36048	51423	13599	15357	17341	4136	342	0.31	0.36	0.43
2012	13431	19154	27317	14160	16034	18158	4057	444	0.28	0.33	0.39
2013	9342	13347	19070	15654	17729	20080	4295	180	0.27	0.31	0.37
2014	10476	14933	21288	14543	16746	19282	4626	216	0.27	0.31	0.37
2015	11554	16731	24229	12743	14692	16940	3385	250	0.25	0.30	0.36
2016	8207	11758	16846	12296	14225	16456	2434	106	0.22	0.27	0.32
2017	13884	19762	28129	10502	12264	14321	2090	156	0.21	0.25	0.31
2018	12675	18088	25814	10246	12003	14062	2395	263	0.21	0.25	0.30
2019	15068	21642	31085	9515	11166	13103	1648	403	0.192	0.23	0.28
2020	7506	11090	16387	9330	11073	13142	1563	409	0.191	0.23	0.28
2021	8541	13121	20156	10338	12362	14783	1568	347	0.185	0.23	0.28
2022	5556	9956	17839	8239	9967	12057	1688	330	0.185	0.23	0.29
2023	4941	12333	30783	8438	10435	12904	1288	224	0.168	0.22	0.28
2024		15220**		8259	10467	13452					

*** Discard estimates prior to 2004 assume the average discard proportion by age for 2004–2008 (WKNSEA; ICES, 2021).**

**** Median recruitment resampled (weighted by the inverse of the sd of the recruitment estimates) from the years 2012–2023 (geometric mean shown).**

^ Landings and discards for ages 1–11+ only, as used in the assessment.

Table 18.17. Sole in Division 7.d. Stock numbers for the 2024 SAM assessment (in thousands).

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	14416	21768	22447	16139	24597	15508	26364	17823	44157	35454	29564	13881	27667
2	17873	12470	19969	20815	13844	23390	13173	24814	15108	41560	30369	28581	11631
3	20816	13210	9755	15805	15414	10212	18030	8831	18131	10480	30375	22371	22119
4	5052	13177	7953	5750	9264	8138	5189	9310	4058	10018	5508	17876	13674
5	3203	2988	8256	4707	3546	5428	4212	2868	4726	2077	5519	3198	10701
6	3046	2358	1898	5872	3214	2398	3177	2419	1494	2661	1183	3112	1987
7	1865	2110	1557	1047	3867	2170	1388	1929	1479	980	1575	781	2125
8	920	1198	1408	1008	701	2485	1225	847	1180	945	648	987	549
9	582	619	774	1023	787	501	1589	821	573	803	619	470	677
10	405	413	442	528	793	577	351	1101	557	386	504	399	341
11+	983	994	1021	1020	1253	1496	1386	1222	1645	1440	1147	1056	1082

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	23205	18910	27490	19759	34537	38611	32570	49914	24035	23103	48762	41790	20733
2	25434	19634	17200	26714	17209	31316	34875	29402	46397	20586	19096	43952	38383
3	9727	19742	14713	13748	22970	12328	22765	24112	19716	29625	14005	12351	30216
4	13334	5670	10108	7038	7225	12502	6048	12842	13098	9689	15769	8354	6833
5	7845	7689	3022	4762	3476	3890	7235	3625	7689	8155	5479	9731	4916
6	6359	4628	4229	1533	2476	1891	2353	4219	2229	4614	4374	3453	5837
7	1454	3974	2806	2465	936	1360	1182	1533	3150	1534	2850	2946	2238
8	1409	1060	2339	1671	1573	546	822	774	1088	1802	1117	1905	1775
9	408	1021	804	1402	1080	946	343	594	581	811	1149	791	1241
10	471	305	676	578	850	665	557	248	455	481	518	784	533
11+	1016	1069	917	1059	1083	1216	1257	1235	1092	1107	1013	1070	1250

Age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	26047	45197	43636	36048	19154	13347	14933	16731	11758	19762	18088	21642	11090
2	18008	23277	39175	39758	33000	16396	11838	13390	15335	10038	18418	15836	19813
3	27576	13683	16244	27198	31043	27260	13460	9401	10265	13178	7819	14184	12084

Age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4	17560	17442	8276	9453	16766	21362	21066	9036	6456	6932	10661	5207	10022
5	3522	9651	9817	4640	5463	10216	14152	13193	5957	4468	4819	7265	3723
6	2923	1989	5366	5677	2964	3533	6977	8924	8027	3923	3218	3478	4926
7	3094	1694	1123	2846	3355	2081	2519	4636	5706	5260	2650	2122	2641
8	1291	1835	921	681	1720	2265	1463	1734	3025	3910	3789	1721	1515
9	1009	817	1102	540	439	1085	1579	996	1186	2101	2864	2668	1231
10	746	690	487	685	322	300	741	1093	756	855	1577	2111	1923
11+	1127	1293	1298	1124	1244	1061	1047	1273	1607	1557	1772	2328	3233

Age	2021	2022	2023
1	13121	9956	12333
2	9446	11834	8722
3	15676	7131	8823
4	8231	11542	4801
5	6781	5536	8315
6	2701	4616	3512
7	3371	2009	3233
8	2035	2495	1401
9	1183	1656	1920
10	935	952	1320
11+	3588	3404	3260

Table 18.18. Sole in Division 7.d. Fishing mortality (F) at age for the 2024 SAM assessment.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.01	0.009	0.009	0.009	0.009	0.009	0.01	0.01	0.011	0.011	0.011	0.01	0.01
2	0.176	0.167	0.175	0.191	0.193	0.207	0.223	0.227	0.231	0.219	0.202	0.186	0.163
3	0.382	0.403	0.437	0.469	0.514	0.548	0.566	0.567	0.522	0.508	0.451	0.435	0.449
4	0.415	0.406	0.416	0.42	0.455	0.496	0.497	0.531	0.503	0.497	0.474	0.454	0.486
5	0.261	0.292	0.292	0.305	0.339	0.399	0.429	0.481	0.46	0.446	0.447	0.433	0.439

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
6	0.322	0.345	0.364	0.326	0.351	0.423	0.386	0.377	0.339	0.348	0.318	0.294	0.324
7	0.322	0.345	0.364	0.326	0.351	0.423	0.386	0.377	0.339	0.348	0.318	0.294	0.324
8	0.262	0.254	0.235	0.219	0.248	0.269	0.255	0.267	0.281	0.307	0.29	0.272	0.263
9	0.262	0.254	0.235	0.219	0.248	0.269	0.255	0.267	0.281	0.307	0.29	0.272	0.263
10	0.236	0.236	0.236	0.215	0.267	0.29	0.273	0.273	0.288	0.284	0.254	0.231	0.273
11+	0.236	0.236	0.236	0.215	0.267	0.29	0.273	0.273	0.288	0.284	0.254	0.231	0.273

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.01	0.01	0.01	0.01	0.01	0.011	0.011	0.011	0.011	0.012	0.012	0.013	0.013
2	0.161	0.158	0.157	0.161	0.197	0.217	0.248	0.277	0.288	0.279	0.279	0.25	0.234
3	0.513	0.559	0.589	0.574	0.548	0.549	0.504	0.52	0.556	0.507	0.473	0.452	0.414
4	0.507	0.57	0.602	0.572	0.534	0.471	0.426	0.412	0.417	0.438	0.426	0.459	0.5
5	0.477	0.526	0.583	0.531	0.492	0.442	0.443	0.448	0.438	0.469	0.413	0.427	0.444
6	0.35	0.403	0.419	0.401	0.406	0.355	0.328	0.297	0.374	0.355	0.344	0.411	0.469
7	0.35	0.403	0.419	0.401	0.406	0.355	0.328	0.297	0.374	0.355	0.344	0.411	0.469
8	0.268	0.304	0.337	0.347	0.37	0.327	0.243	0.221	0.23	0.295	0.317	0.35	0.389
9	0.268	0.304	0.337	0.347	0.37	0.327	0.243	0.221	0.23	0.295	0.317	0.35	0.389
10	0.295	0.338	0.337	0.347	0.319	0.278	0.254	0.266	0.32	0.386	0.349	0.364	0.371
11+	0.295	0.338	0.337	0.347	0.319	0.278	0.254	0.266	0.32	0.386	0.349	0.364	0.371

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.014	0.015	0.015	0.016	0.016	0.016	0.017	0.017	0.018	0.019	0.019	0.019	0.019
2	0.217	0.209	0.193	0.167	0.144	0.13	0.131	0.135	0.13	0.14	0.155	0.159	0.162
3	0.392	0.386	0.365	0.332	0.3	0.273	0.277	0.267	0.256	0.243	0.256	0.256	0.259
4	0.475	0.474	0.456	0.422	0.389	0.358	0.349	0.315	0.281	0.271	0.271	0.264	0.26
5	0.458	0.422	0.412	0.391	0.357	0.336	0.339	0.318	0.283	0.257	0.252	0.247	0.245
6	0.44	0.447	0.387	0.335	0.306	0.299	0.301	0.298	0.261	0.243	0.237	0.201	0.198
7	0.44	0.447	0.387	0.335	0.306	0.299	0.301	0.298	0.261	0.243	0.237	0.201	0.198
8	0.347	0.372	0.35	0.334	0.305	0.281	0.266	0.233	0.213	0.195	0.188	0.164	0.139
9	0.347	0.372	0.35	0.334	0.305	0.281	0.266	0.233	0.213	0.195	0.188	0.164	0.139

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
10	0.329	0.325	0.282	0.24	0.224	0.215	0.23	0.236	0.23	0.19	0.17	0.135	0.108
11+	0.329	0.325	0.282	0.24	0.224	0.215	0.23	0.236	0.23	0.19	0.17	0.135	0.108

age	2021	2022	2023
1	0.02	0.021	0.021
2	0.166	0.176	0.177
3	0.257	0.265	0.268
4	0.253	0.245	0.232
5	0.242	0.25	0.228
6	0.193	0.196	0.174
7	0.193	0.196	0.174
8	0.131	0.124	0.108
9	0.131	0.124	0.108
10	0.083	0.073	0.061
11+	0.083	0.073	0.061

Table 18.19. Sole in Division 7.d. Spawning stock biomass (SSB; tonnes) at age for the 2024 SAM assessment.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1582	1117	1852	1975	1299	2132	1040	1986	1401	3458	2414	2196	906
3	4654	3014	2271	3606	3248	2396	4047	1690	4287	2169	6120	4384	4090
4	1707	4301	2703	1755	3068	2594	1564	2735	1274	2895	1597	4788	3479
5	1317	1287	3340	1845	1373	2043	1614	896	1756	784	1702	1142	3280
6	1438	1134	913	2554	1372	1077	1433	956	560	1157	526	1319	779
7	910	1017	719	599	1876	990	706	829	771	459	684	465	897
8	406	544	656	475	316	1039	545	347	475	353	259	473	240
9	283	322	397	588	383	225	852	410	271	337	275	235	317
10	195	250	259	326	431	323	205	626	300	192	242	318	176
11+	708	672	782	879	809	991	988	921	994	874	695	758	716

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2332	1686	1367	2209	1350	2307	2754	2478	3934	1549	1559	3308	2848
3	1727	3487	2748	2353	4311	2166	4775	4880	4462	4879	2435	2068	4670
4	3328	1404	2552	1791	1678	3025	1858	3526	4099	2093	3966	1933	1443
5	2131	2200	938	1450	961	1377	2218	1220	2998	2096	1919	2983	1345
6	2334	1652	1599	581	768	787	866	1751	1003	1315	1938	1216	1839
7	576	1590	1212	1047	301	640	482	641	576	627	1328	1172	774
8	471	372	819	603	464	202	266	264	447	919	574	886	786
9	194	430	392	658	375	352	164	270	239	317	687	454	616
10	242	148	333	261	331	317	296	108	238	247	364	389	211
11+	712	672	642	700	625	884	735	703	664	766	596	676	766

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1346	1826	2678	2508	1819	904	584	724	821	718	1084	873	1019
3	4820	2467	2884	4704	5055	4088	1783	1531	1993	2134	1273	2310	1579
4	4147	4420	2066	2269	3670	5004	4752	2117	1692	1524	2528	1160	1953
5	851	2696	2780	1409	1457	3359	3885	3788	1699	1157	1384	1917	950
6	988	684	1948	1919	981	1201	2414	2749	2657	1196	1043	1061	1345
7	1030	515	408	1056	1298	913	997	1729	2094	1699	909	651	837
8	561	804	342	328	660	942	628	583	1355	1502	1258	606	559
9	376	288	464	221	205	467	698	396	637	1004	1063	763	565
10	532	302	264	314	176	125	439	415	345	435	642	762	665
11+	531	784	697	631	712	725	566	661	932	895	821	1063	1602

age	2021	2022	2023
1	0	0	0
2	626	583	481
3	2524	859	1339
4	1738	2139	1032
5	1815	1251	1903
6	843	1265	1050
7	1109	561	1057
8	765	756	544
9	465	576	733
10	392	349	494
11+	2086	1628	1801

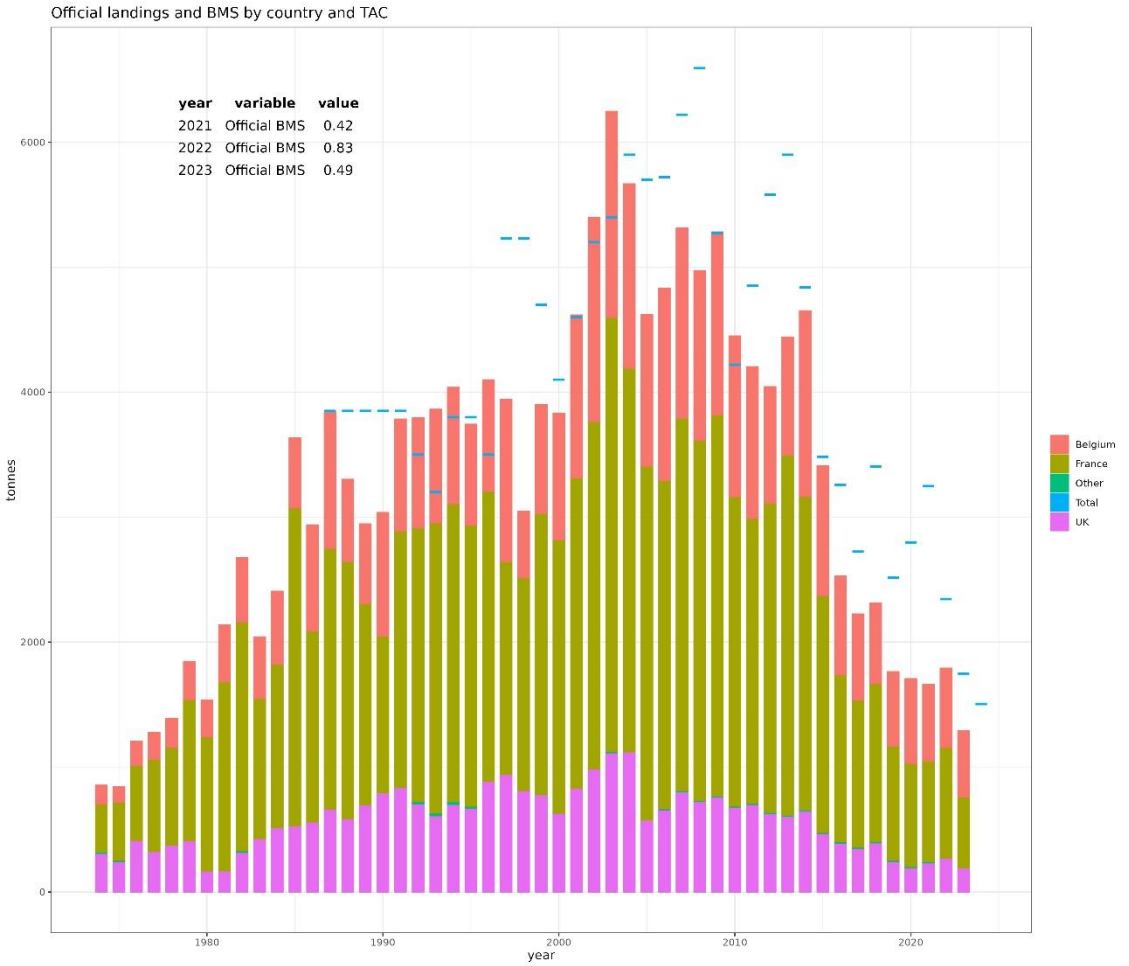


Figure 18.1. Sole in Division 7.d. Official landings (tonnes) by country over the period 1974–2023, as officially reported (Rec 12) (stacked barplot; 'Other' represents landings from e.g. UK Scotland, The Netherlands, Germany or Ireland); blue line represents the initial TAC (landings; note that from 2016 onwards the TAC represents catch); Official BMS are shown for the last three years in tonnes.

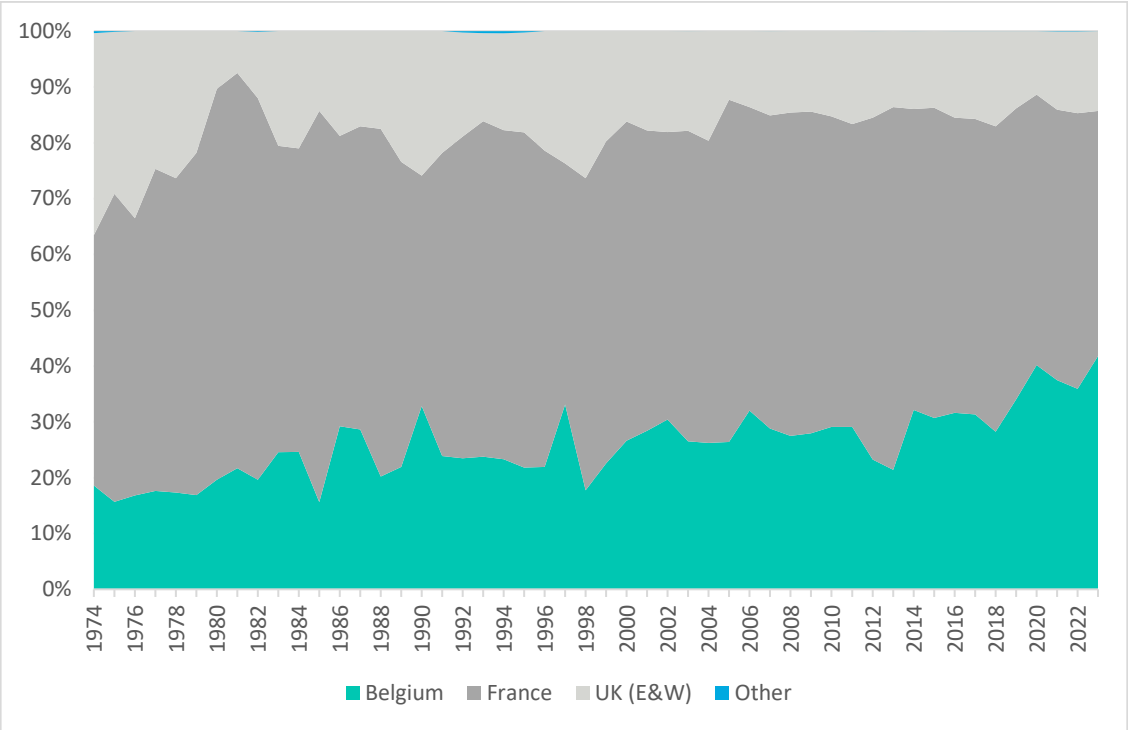


Figure 18.2. Sole in Division 7.d. Relative contribution to the official landings for the main countries involved over the period 1974–2023.

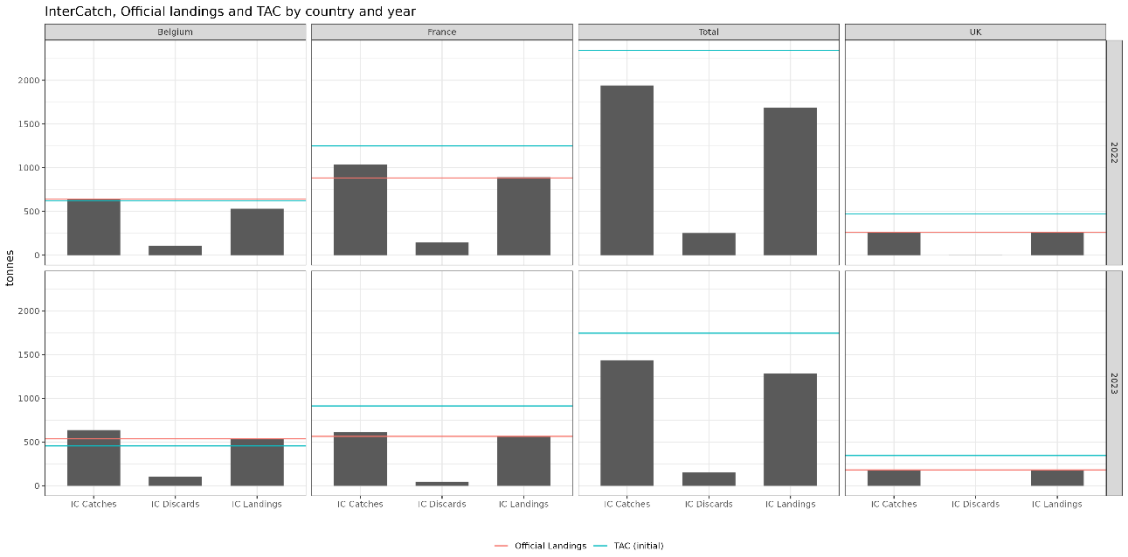


Figure 18.3. Sole in Division 7.d. Uptake of the national quota and total TAC (red line) in 2022 and 2023 in comparison with the InterCatch catches, landings and discards (incl. BMS) (bars) and official landings (blue line).

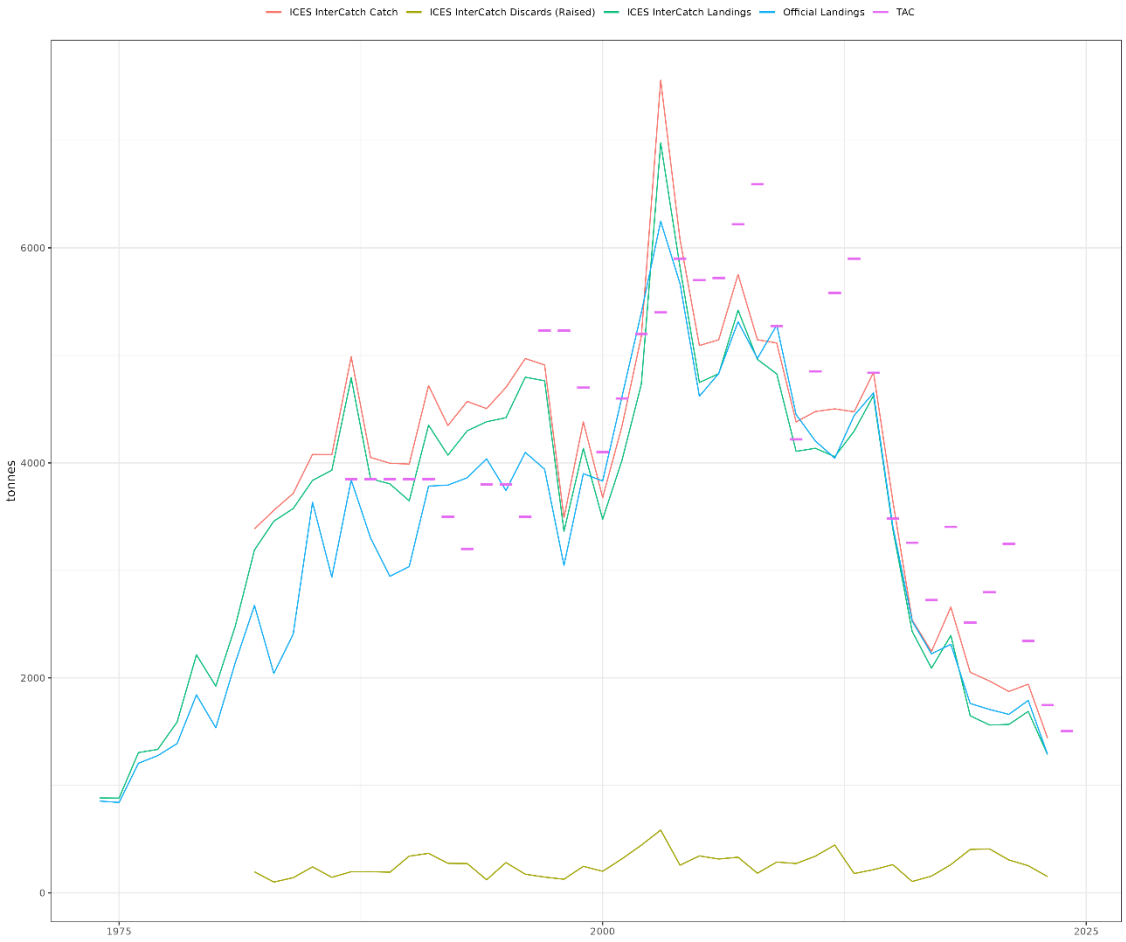


Figure 18.4. Sole in Division 7.d. Historic overview (1974–2023) of the official landings, TAC and ICES estimates (InterCatch; including actual discards from 2004 onwards and extrapolated to years prior to 2004); Note that the TAC value represents catch from 2016 onwards.

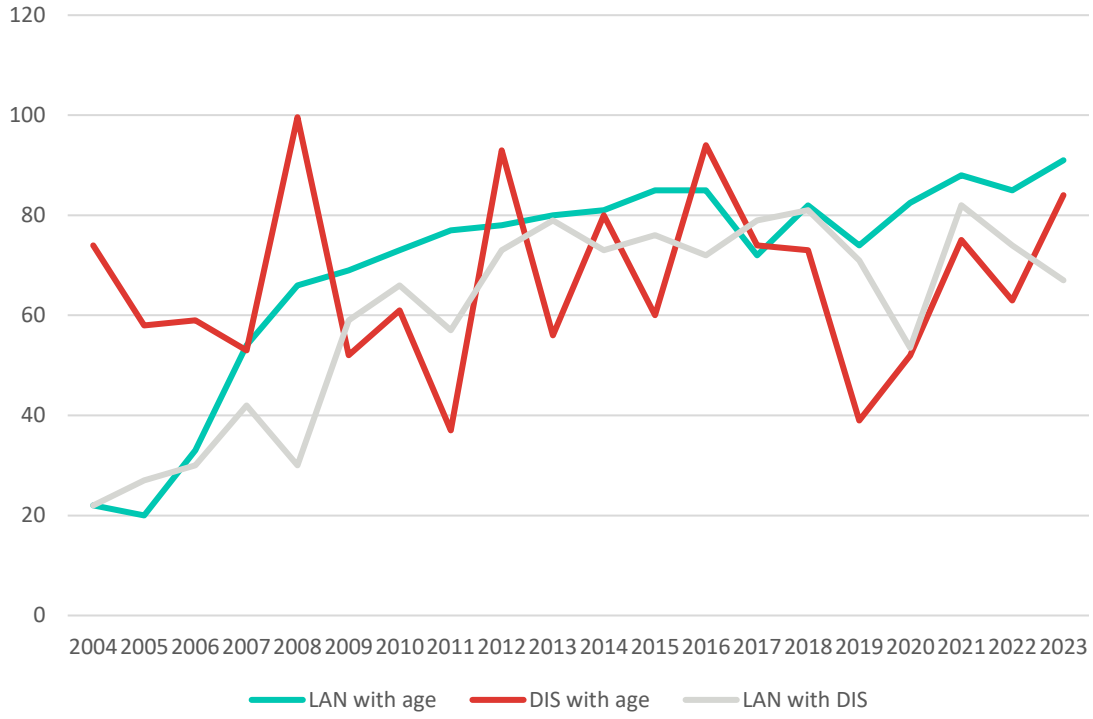


Figure 18.5. Sole in Division 7.d. Overview of data coverage for data uploaded to InterCatch (from 2004 onwards).

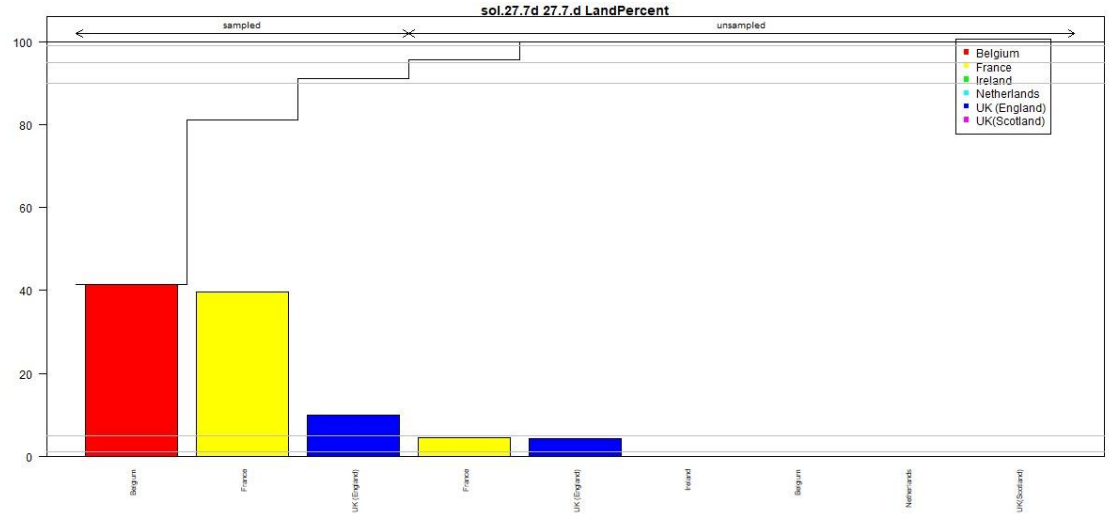


Figure 18.6. Sole in Division 7.d. Overview of the proportion of 2023 landings for which samples (age) have been provided in InterCatch by country.

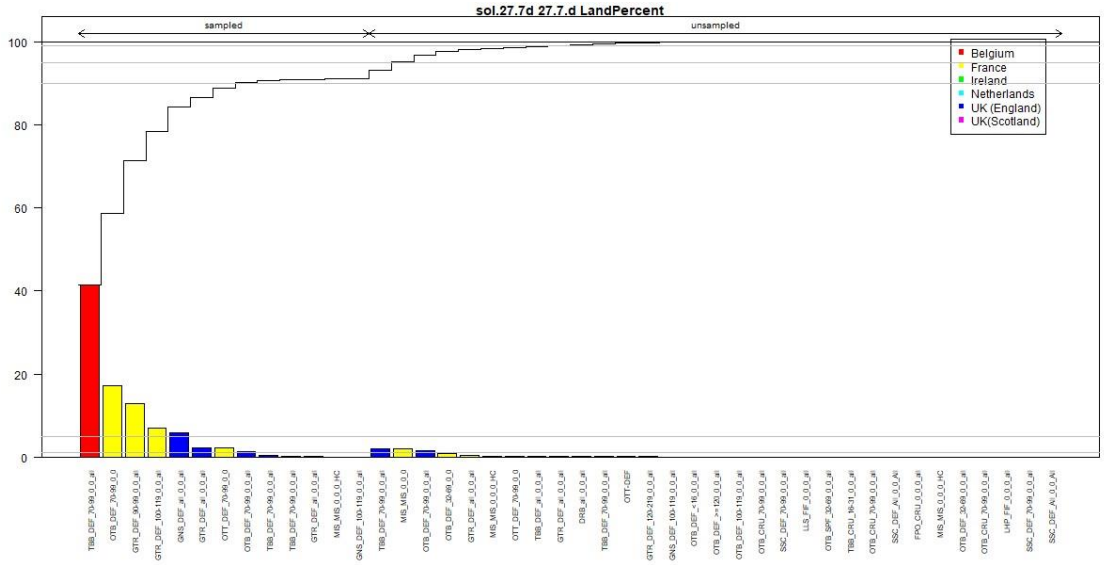


Figure 18.7. Sole in Division 7.d. Overview of the proportion of 2023 landings of sole in Division 27.7.d for which samples have been provided in InterCatch by fleet and country.

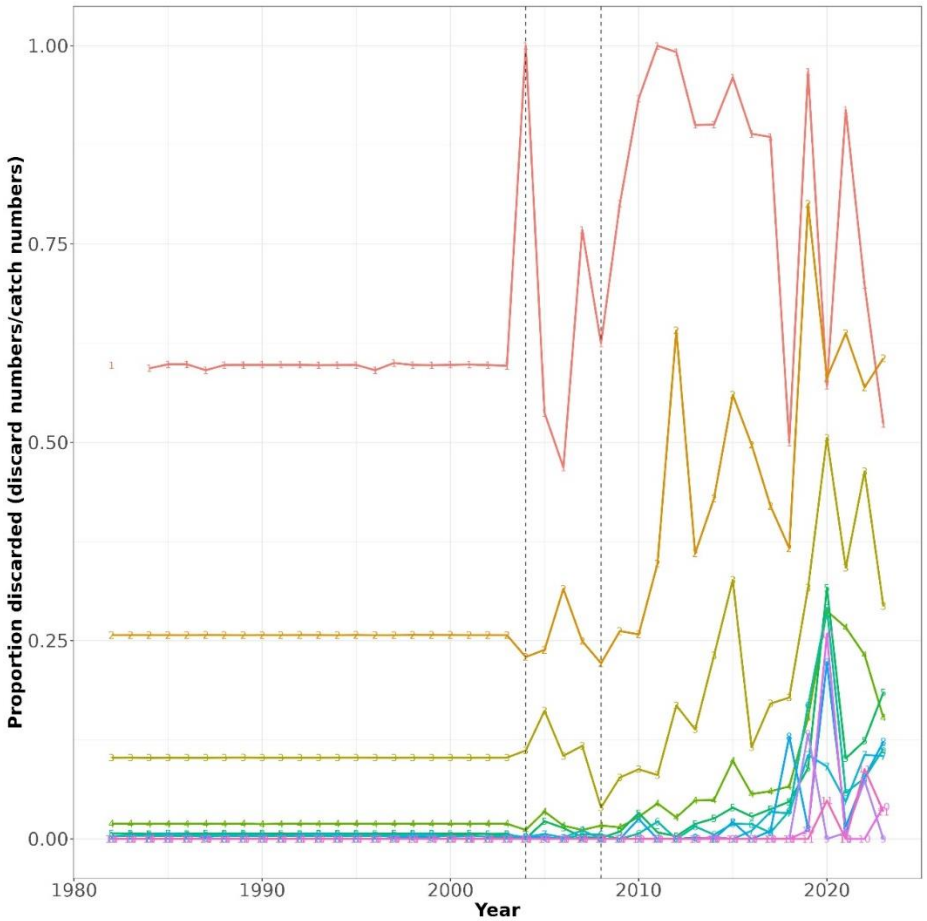


Figure 18.8. Sole in Division 7.d. Proportion discarded (discard numbers at age/catch numbers at age) (data prior to 2004 are estimated using an average discard proportion at age for the period 2004-2008 (indicated by dotted lines)).

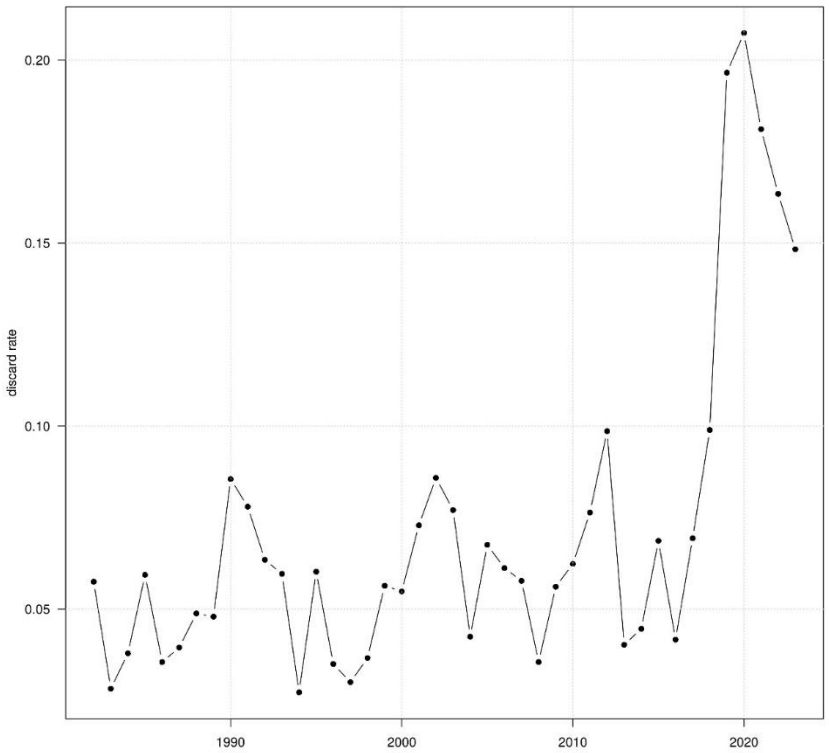


Figure 18.9 Sole in Division 7.d. Discard rate (1982–2023).

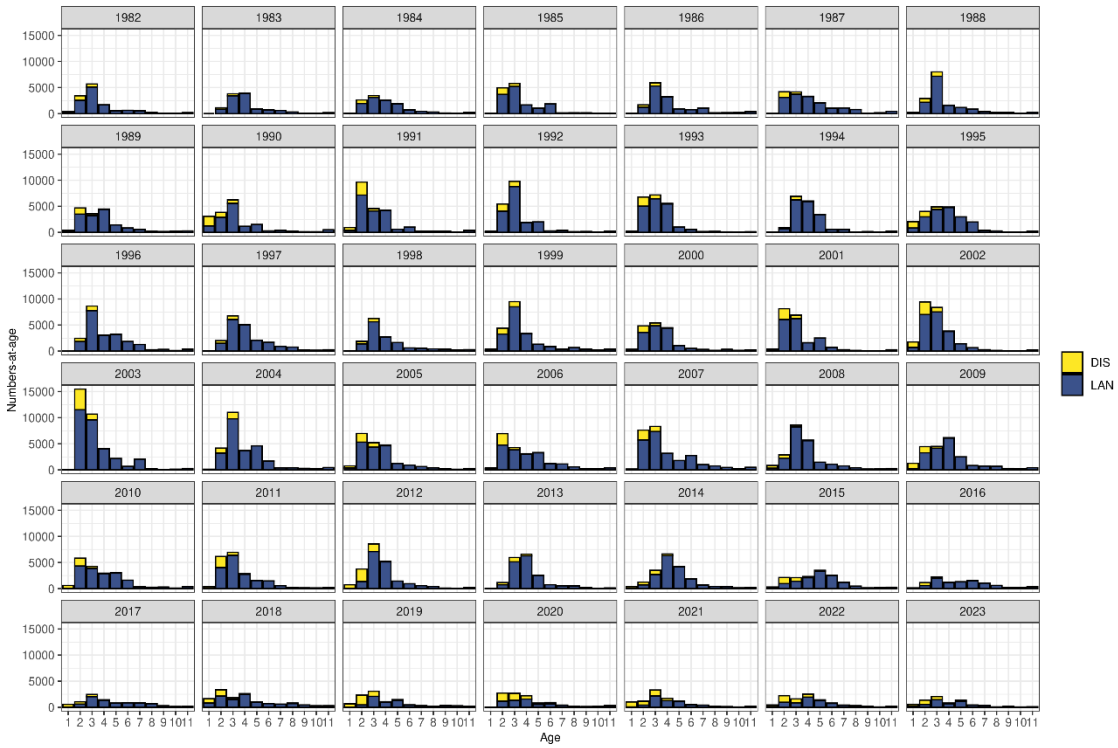


Figure 18.10. Sole in Division 7.d. Landings (blue) and discard (yellow) numbers-at-age over the time-series 1982–2023 for all ages (age 11 is a plusgroup).

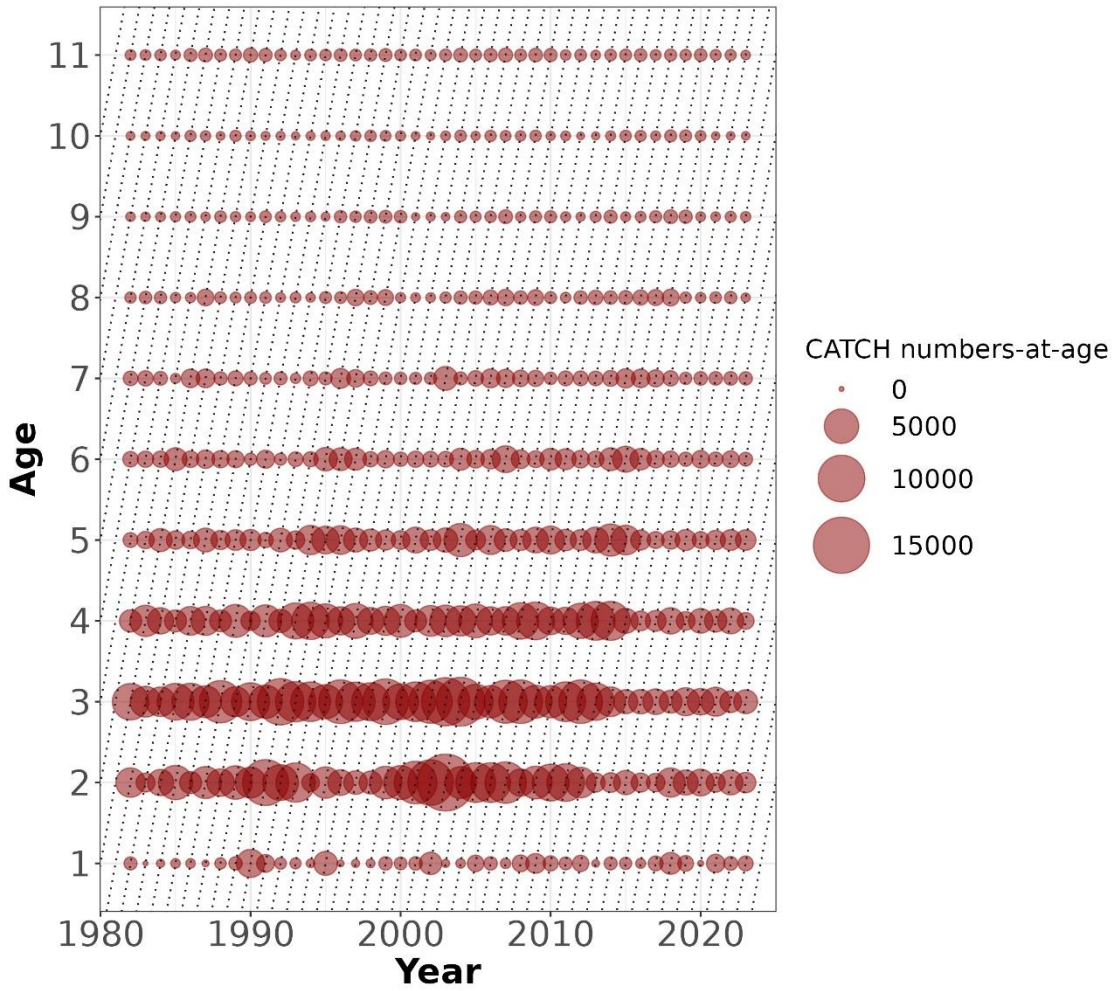


Figure 18.11. Sole in Division 7.d. Catch numbers-at-age over the time-series 1982–2023 for all ages (age 11 is a plusgroup).

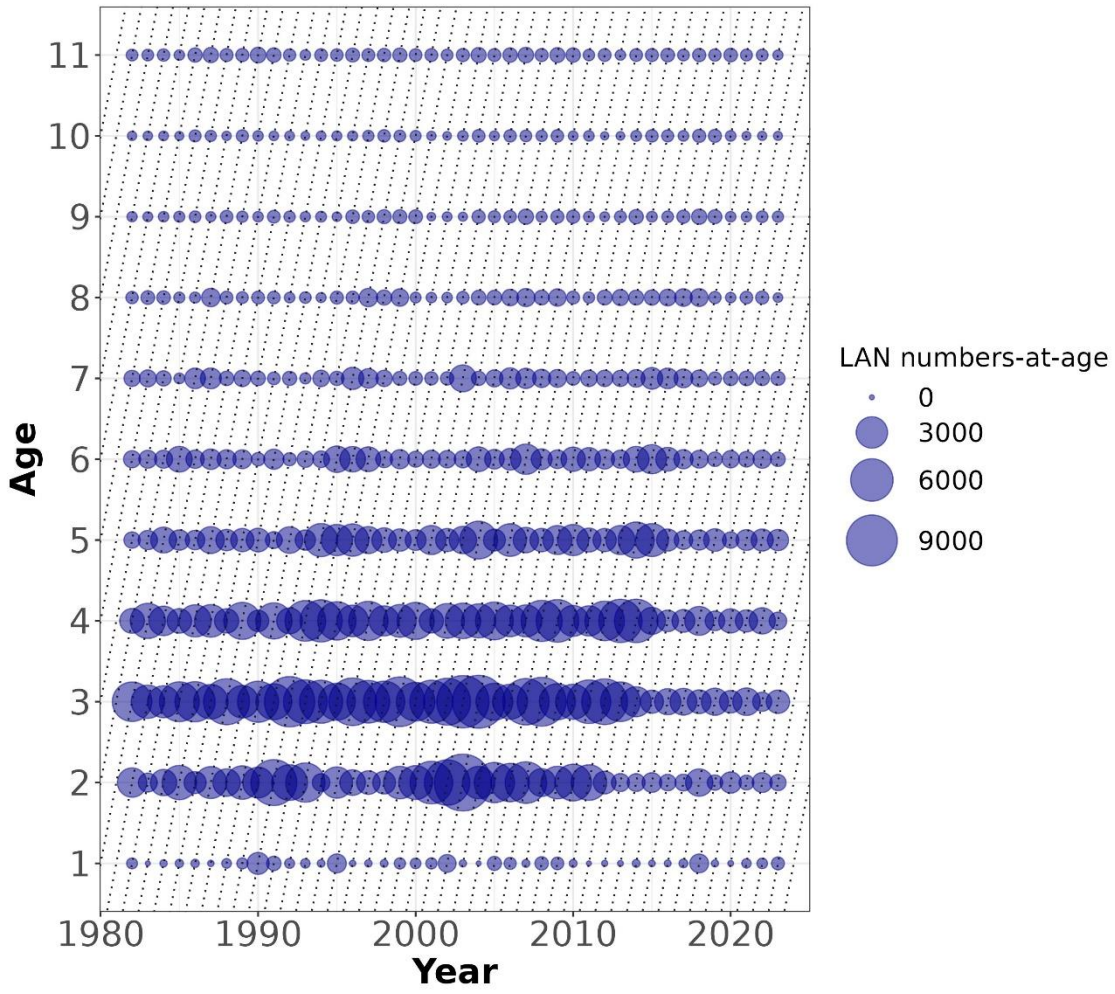


Figure 18.12. Sole in Division 7.d. Landings numbers-at-age over the time-series 1982–2023 for all ages (age 11 is a plusgroup).

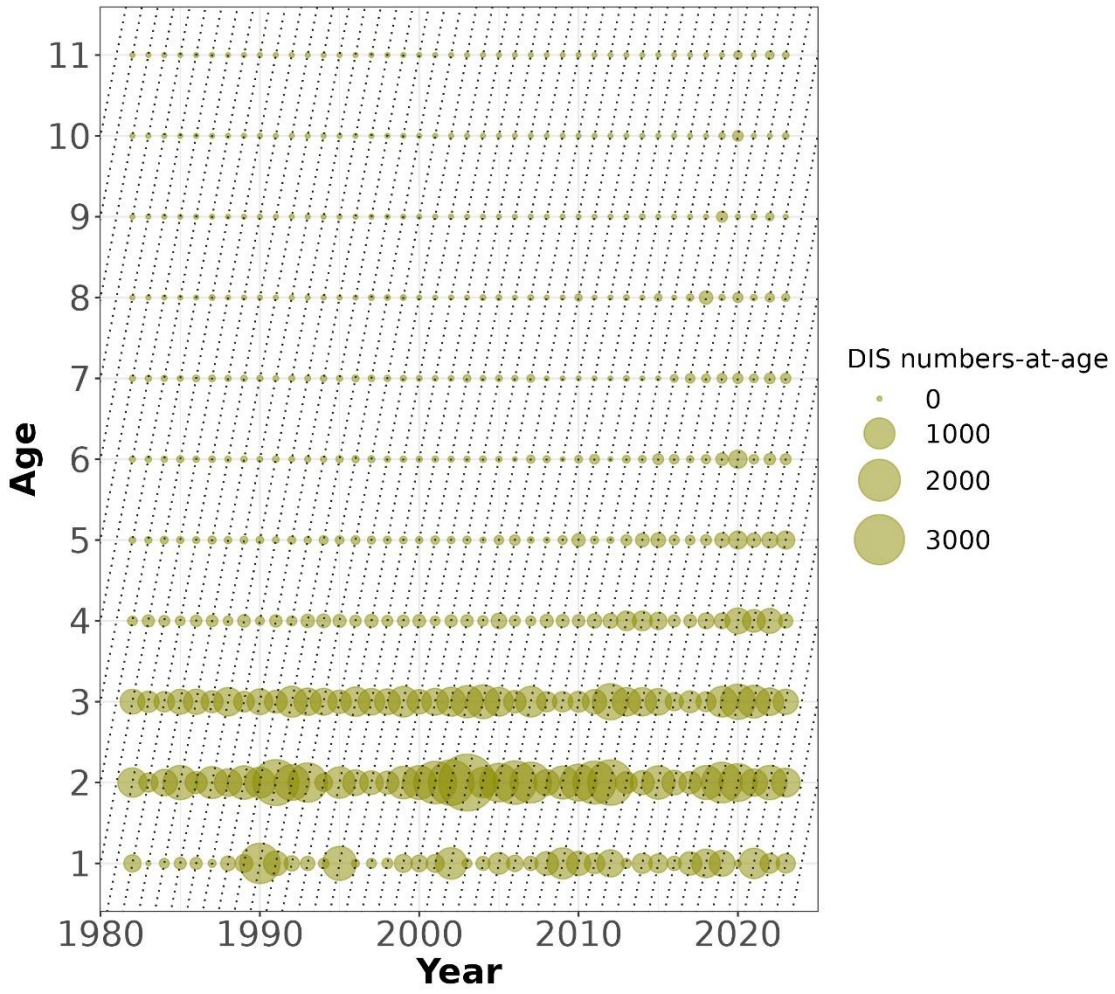


Figure 18.13. Sole in Division 7.d. Discard numbers-at-age over the time-series 1982–2023 for all ages (age 11 is a plusgroup).

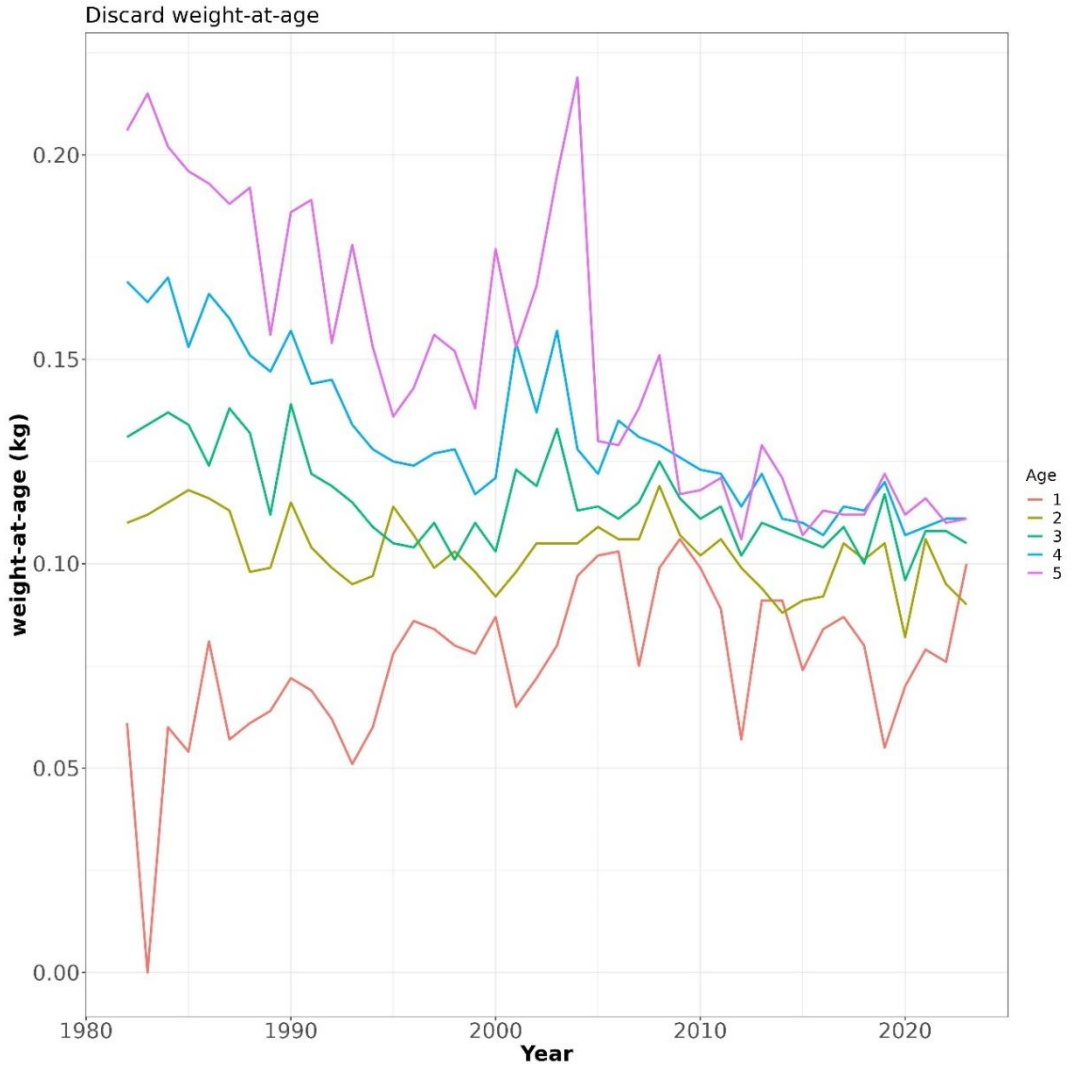


Figure 18.14. Sole in Division 7.d. Discard weights-at-age (ages 1–5 are shown).

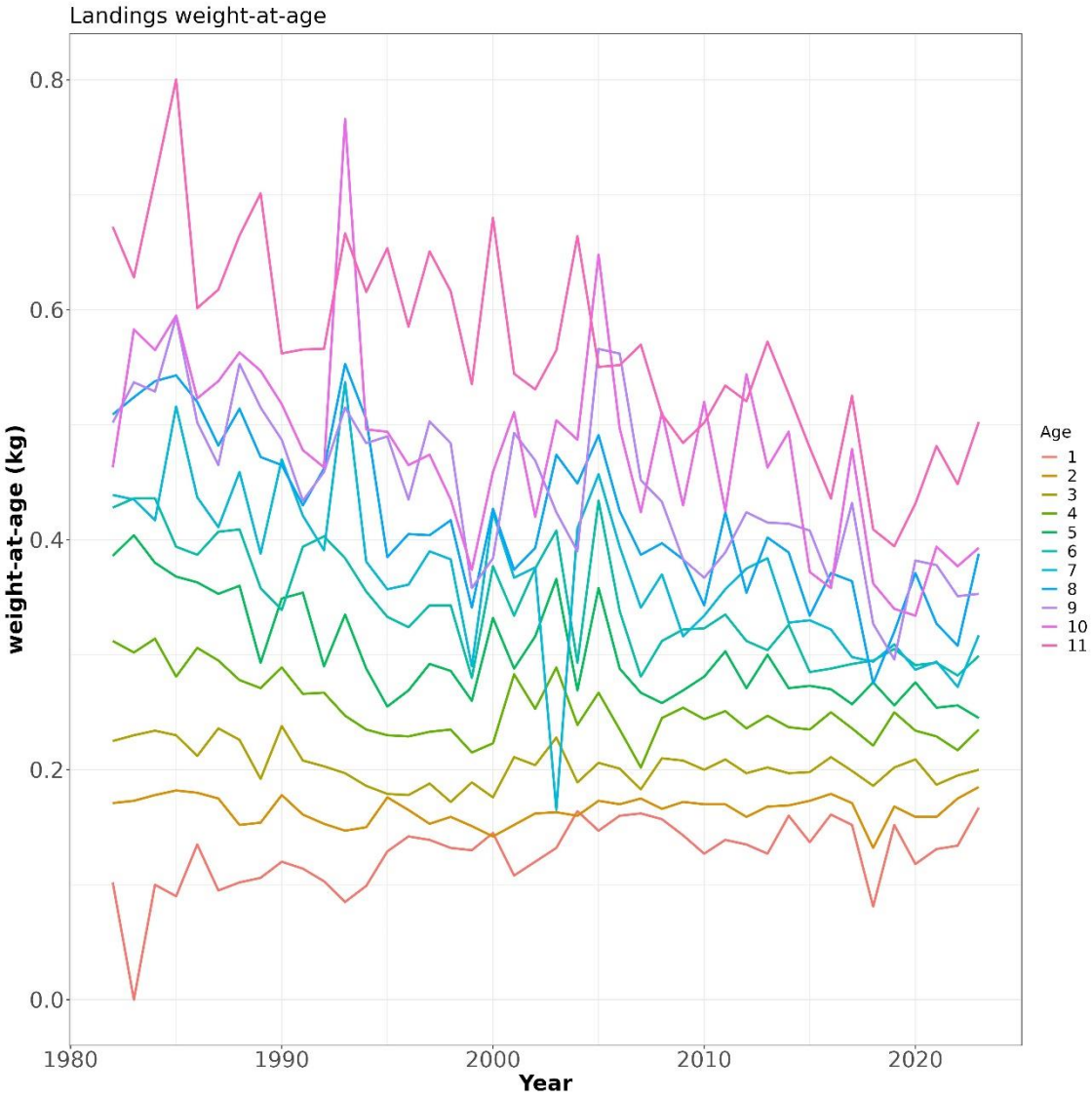


Figure 18.15. Sole in Division 7.d. Landings weights-at-age (age 11 is a plusgroup).

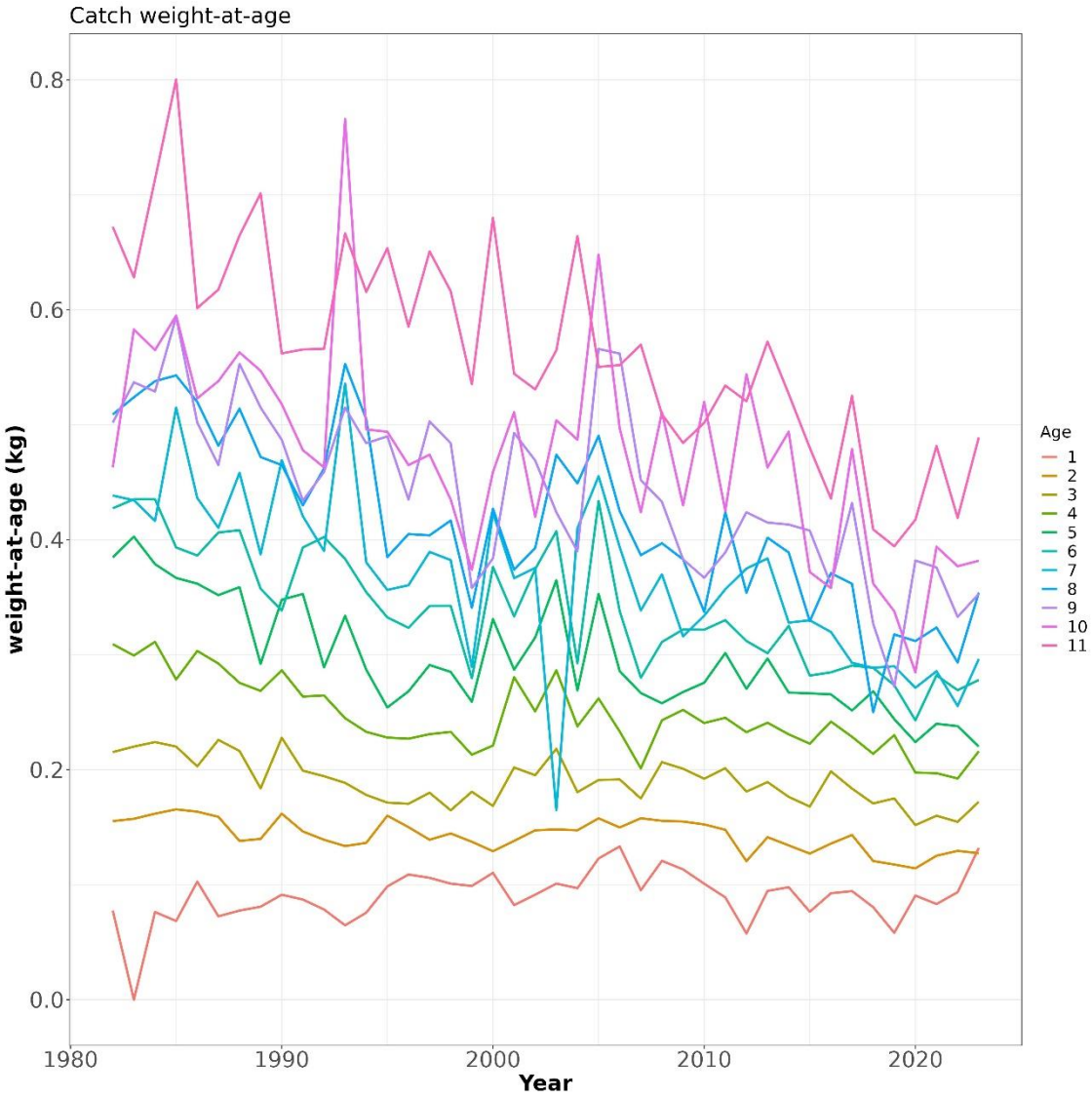


Figure 18.16. Sole in Division 7.d. Catch weights-at-age (age 11 is a plusgroup).

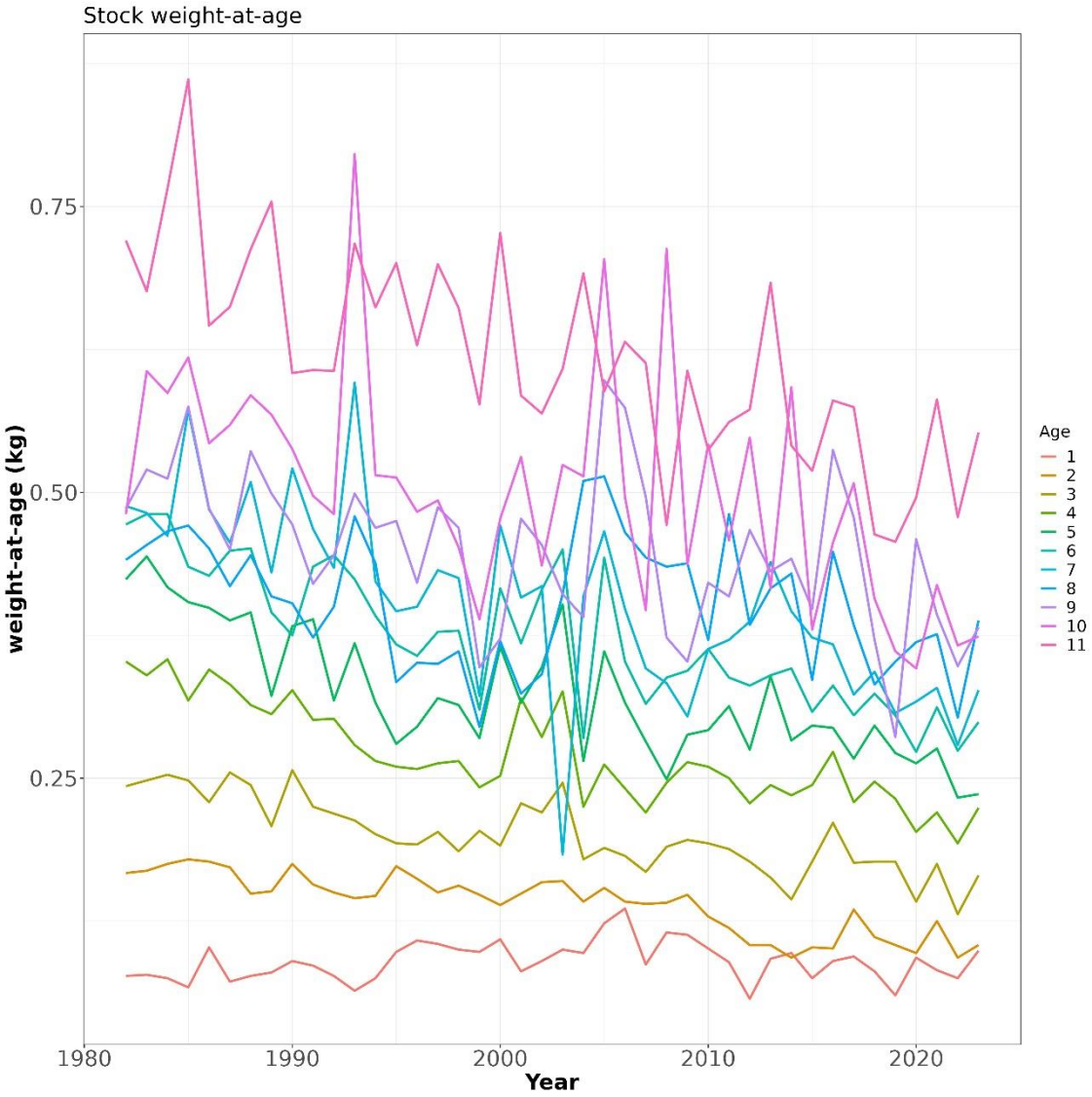


Figure 18.17. Sole in Division 7.d. Quarter 1 stock weights-at-age (kg) (reconstructed for the period 1982–2003 using the ratio of quarter 1 catch weight-at-age and the overall catch weight-at-age for the period 2004–2019 multiplied by the overall catch weight-at-age for 1982–2003).

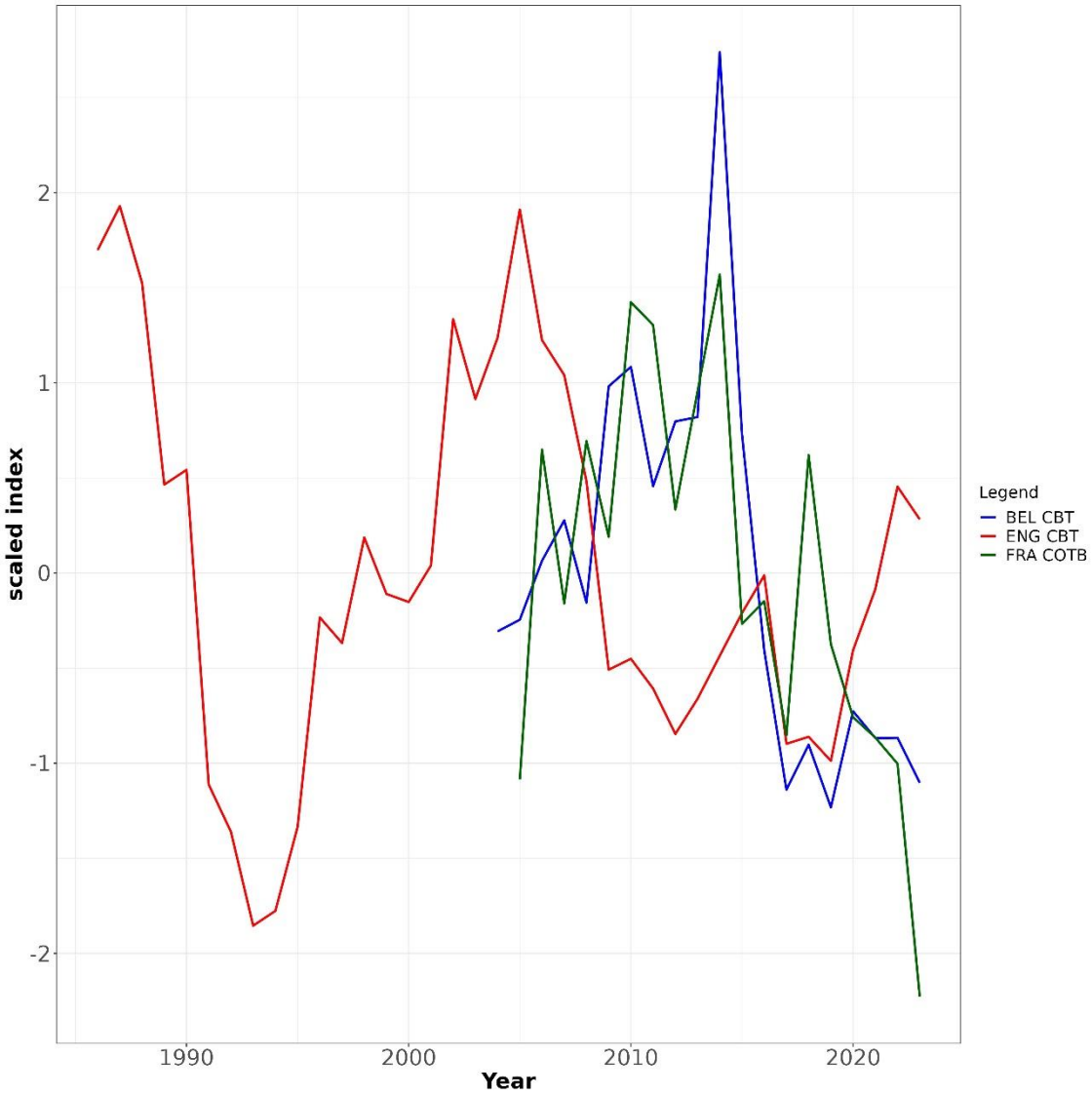


Figure 18.18. Sole in Division 7.d. Scaled commercial tuning indices: Belgian (blue) and UK (red) commercial beam trawl series and French commercial otter trawl series (green).

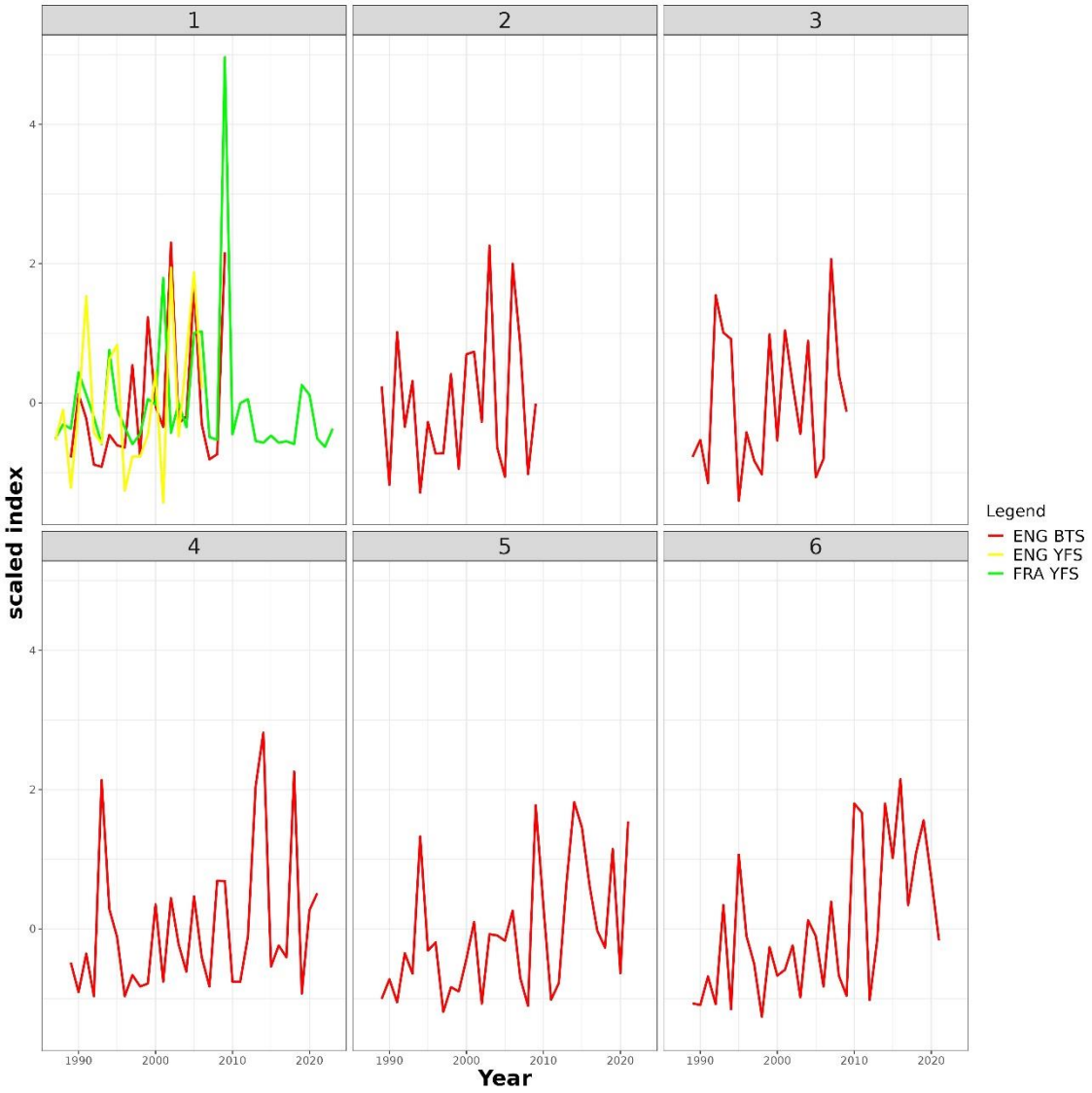


Figure 18.19. Sole in Division 7.d. Scaled survey tuning indices at age: UK (E&W) beam trawl survey (red), UK Young fish survey (yellow) and French Young fish survey (green).

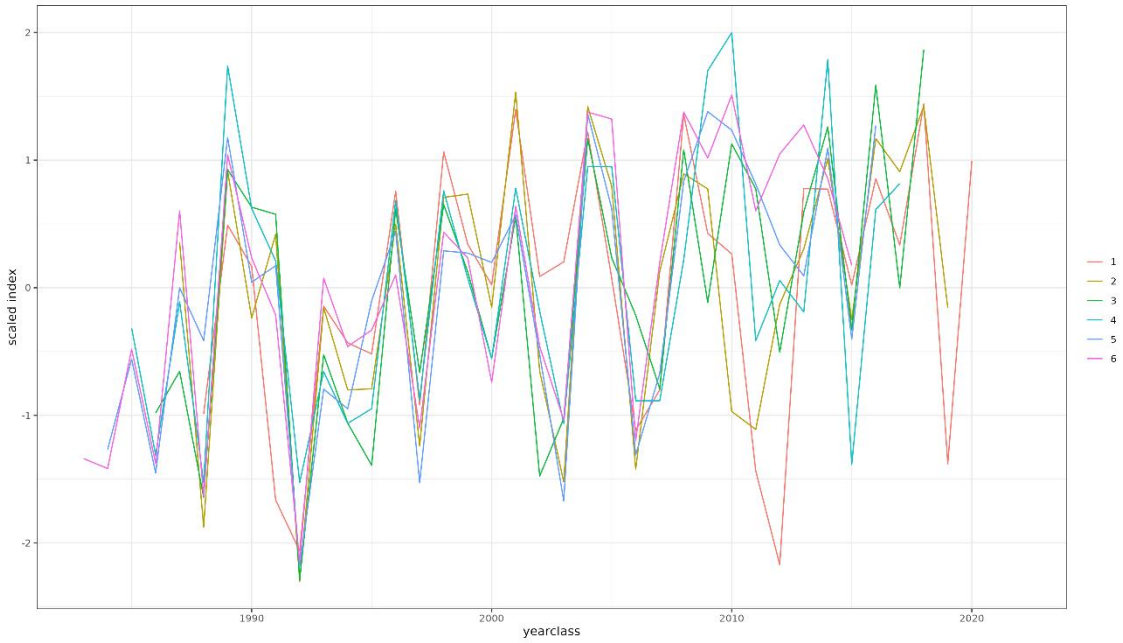


Figure 18.20. Sole in Division 7.d. Log standardised indices of the UK BTS by age and year class.

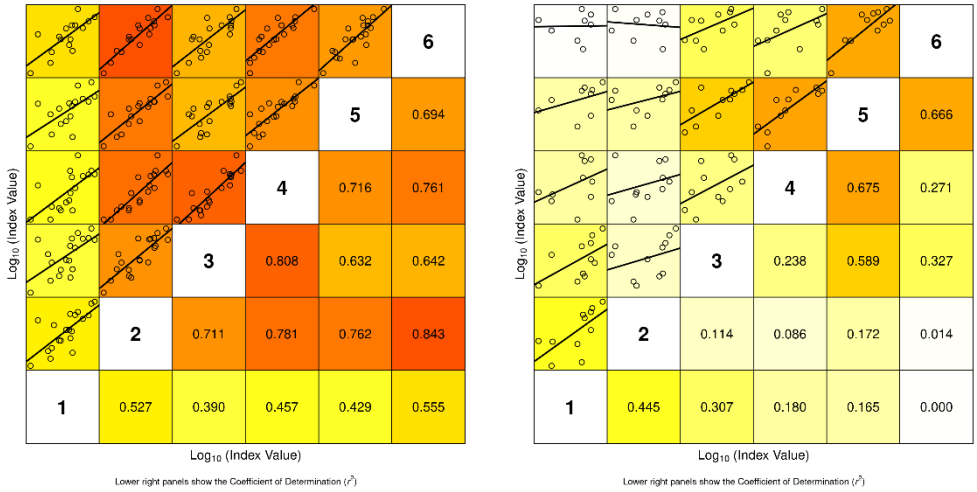


Figure 18.21. Sole in Division 7.d. Internal consistency plot of the UK-BTS tuning series for the early part (1989-2009; left) and last part (2010-2023; right) of the time-series.

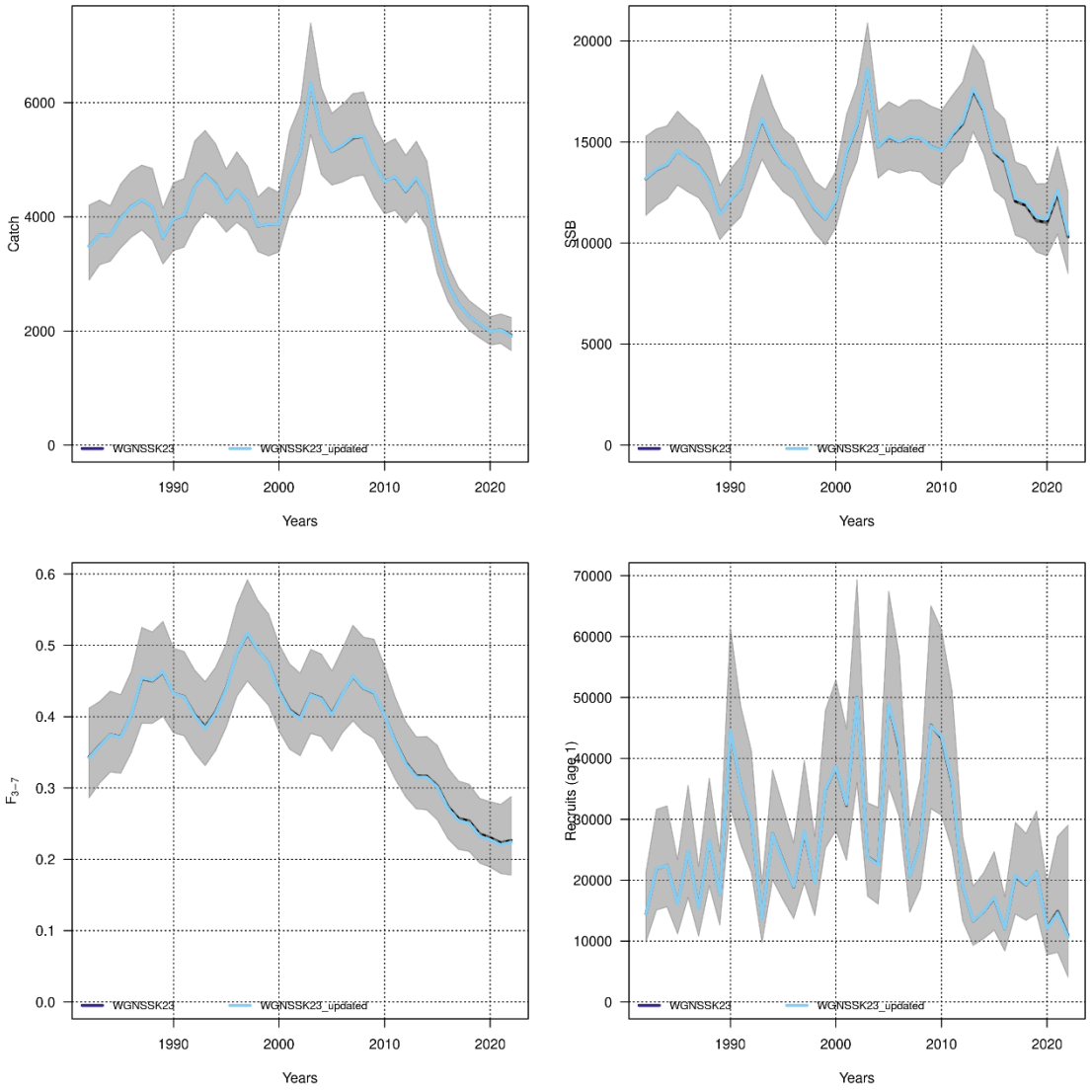


Figure 18.22. Sole in Division 7.d. Summary from last year's assessment (WGNSSK23) and an update of last year's assessment (WGNSSK23_updated) that includes updated catch and tuning information from the Belgian fleet: trends in catch, spawning stock biomass (SSB), F_{bar} and recruitment (in thousands) are shown with relevant confidence intervals.

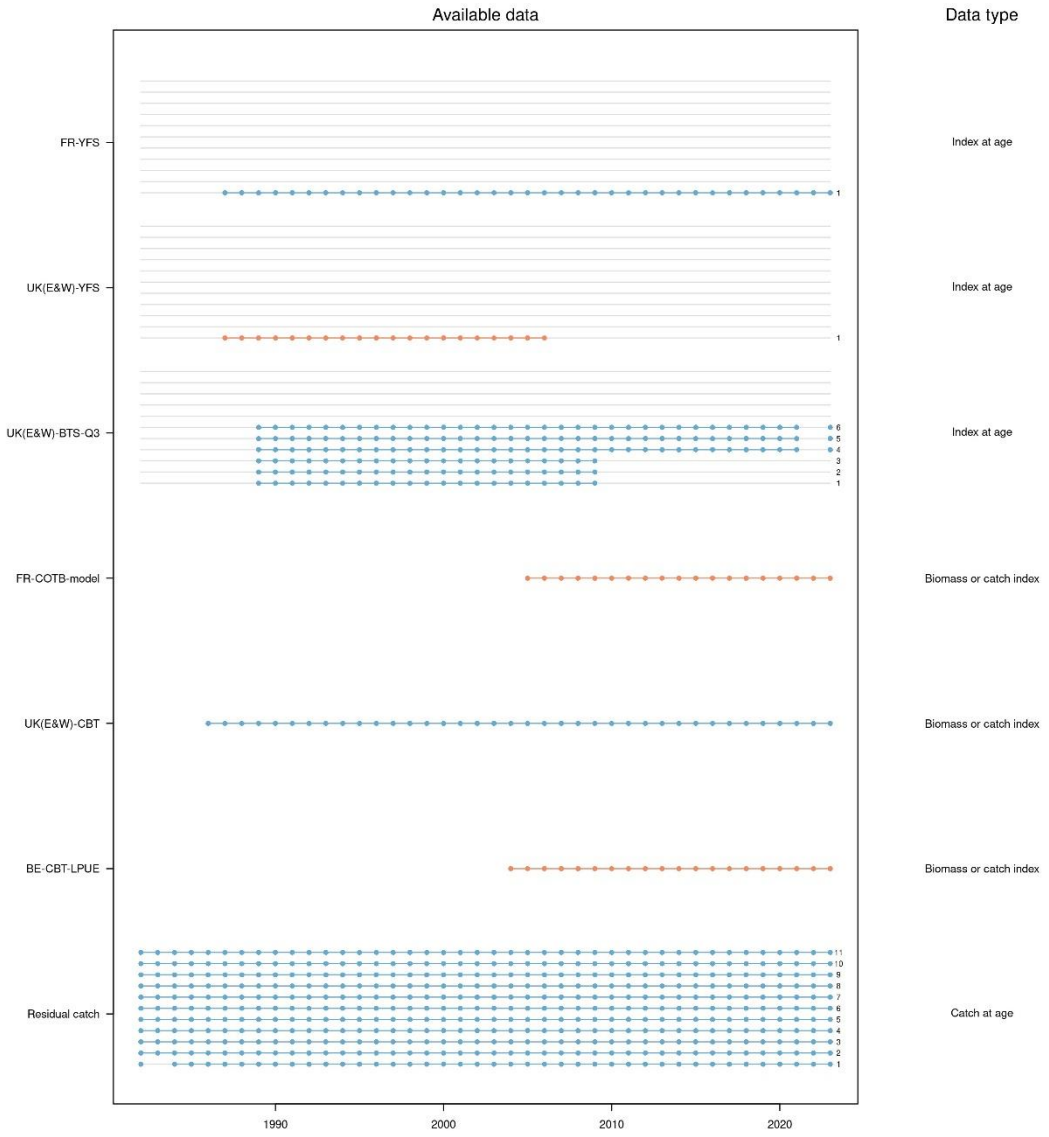


Figure 18.23. Sole in Division 7.d. SAM model input.

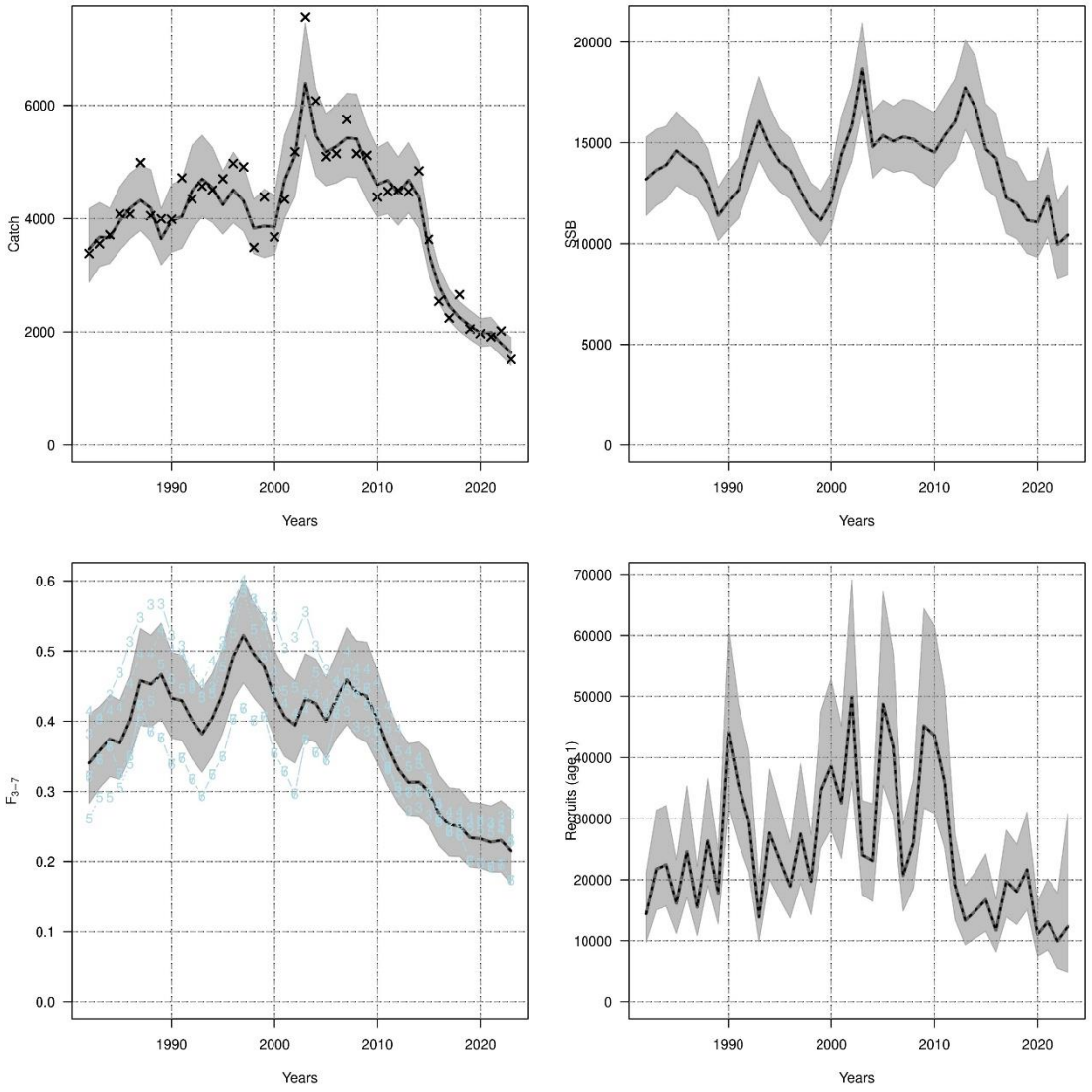


Figure 18.24. Sole in Division 7.d. SAM model summary: trends in catch, spawning stock biomass (SSB), F_{bar} and recruitment (in thousands) are shown with relevant confidence intervals.

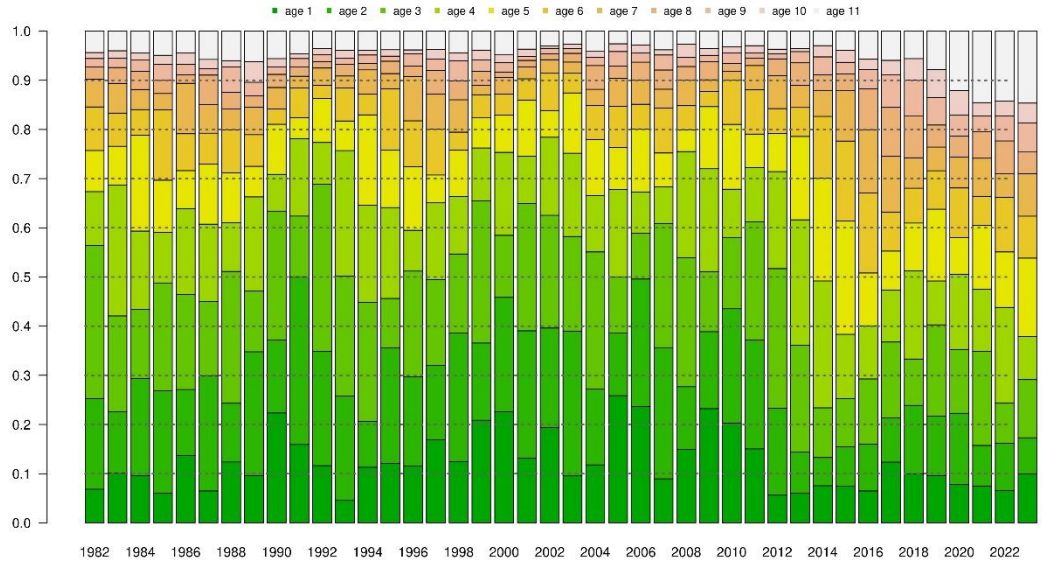


Figure 18.25. Sole in Division 7.d. Proportion of the biomass-at-age.

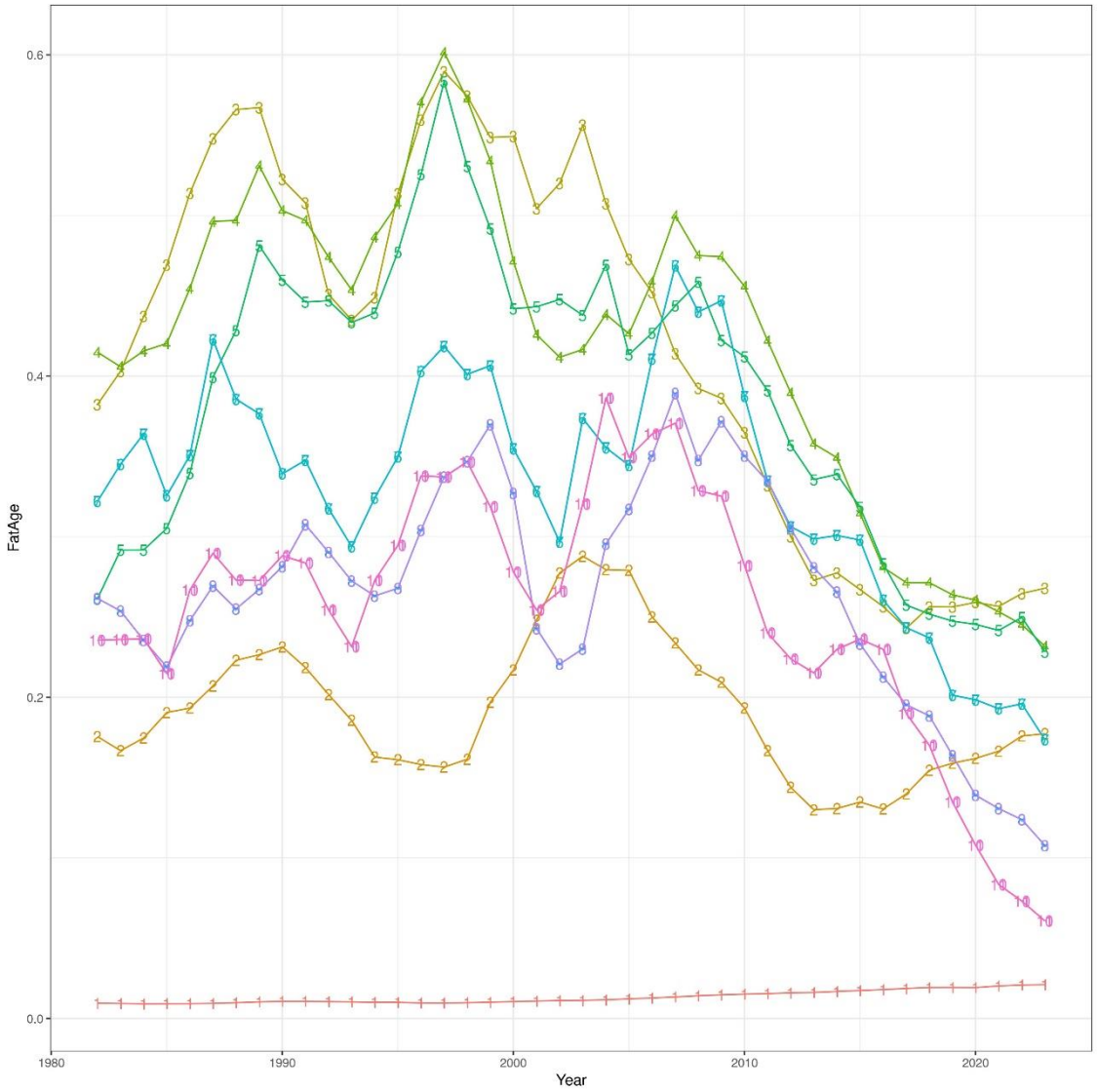


Figure 18.26. Sole in Division 7.d. Fishing mortality at age as estimated by the SAM assessment; Note that age 6 and 7, 8 and 9 and 10 and 11+ overlap.

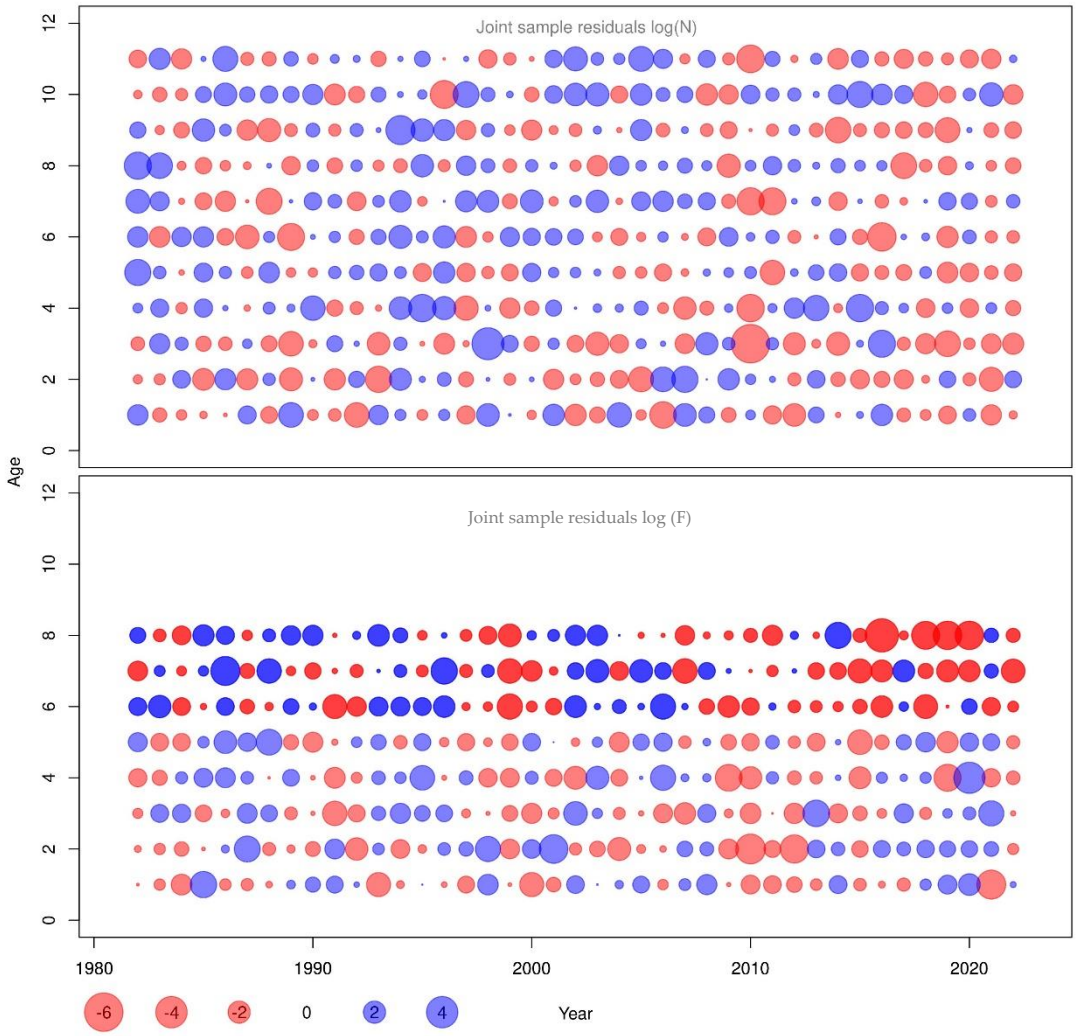


Figure 18.27. Sole in Division 7.d. Process residuals for the survival (logN) and fishing mortality (logF) processes.

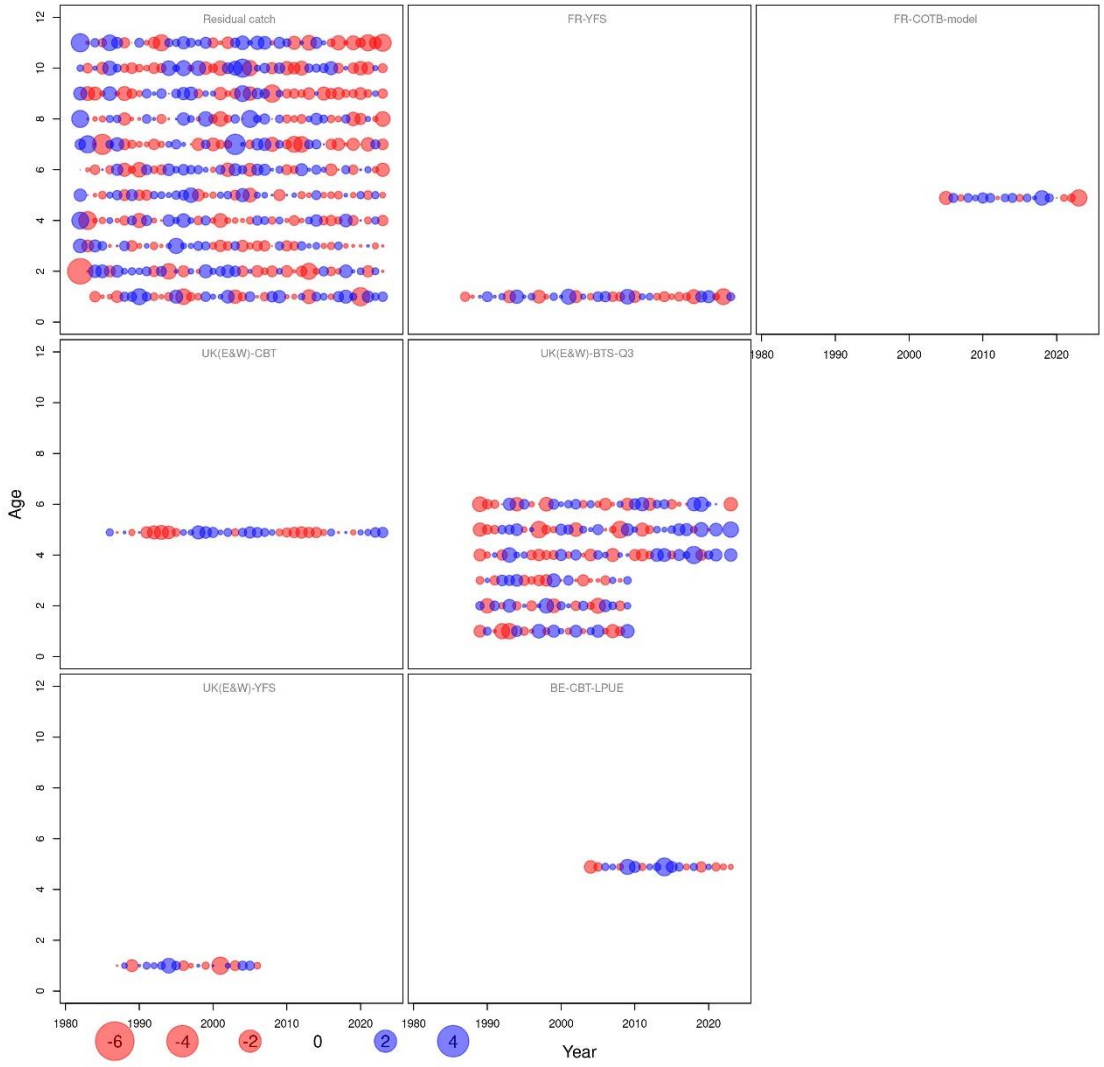
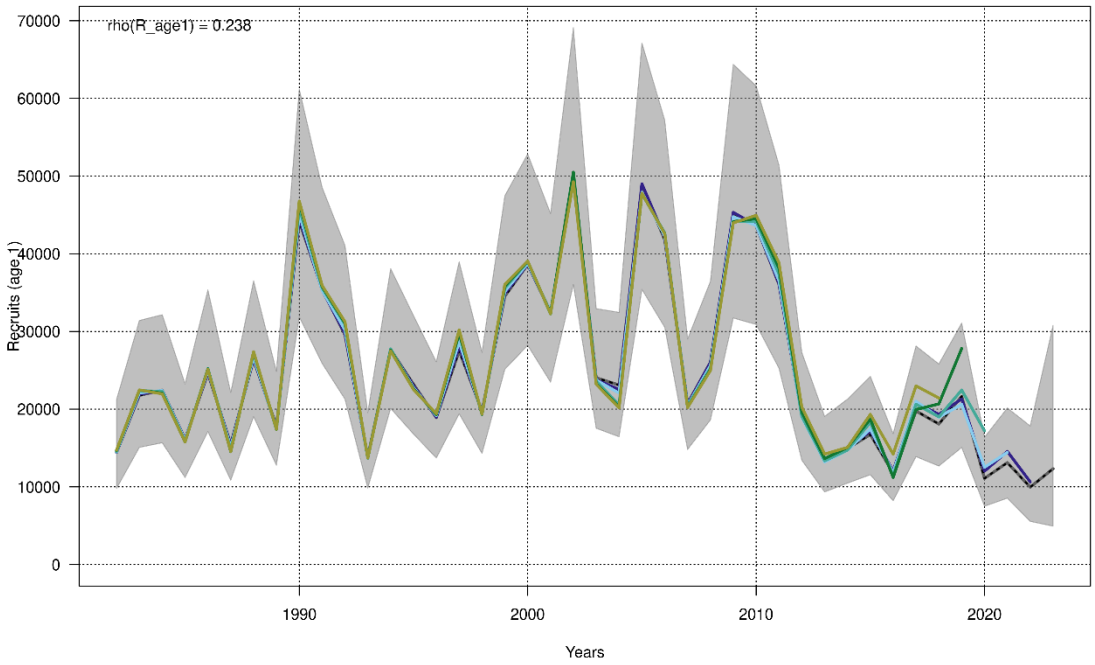
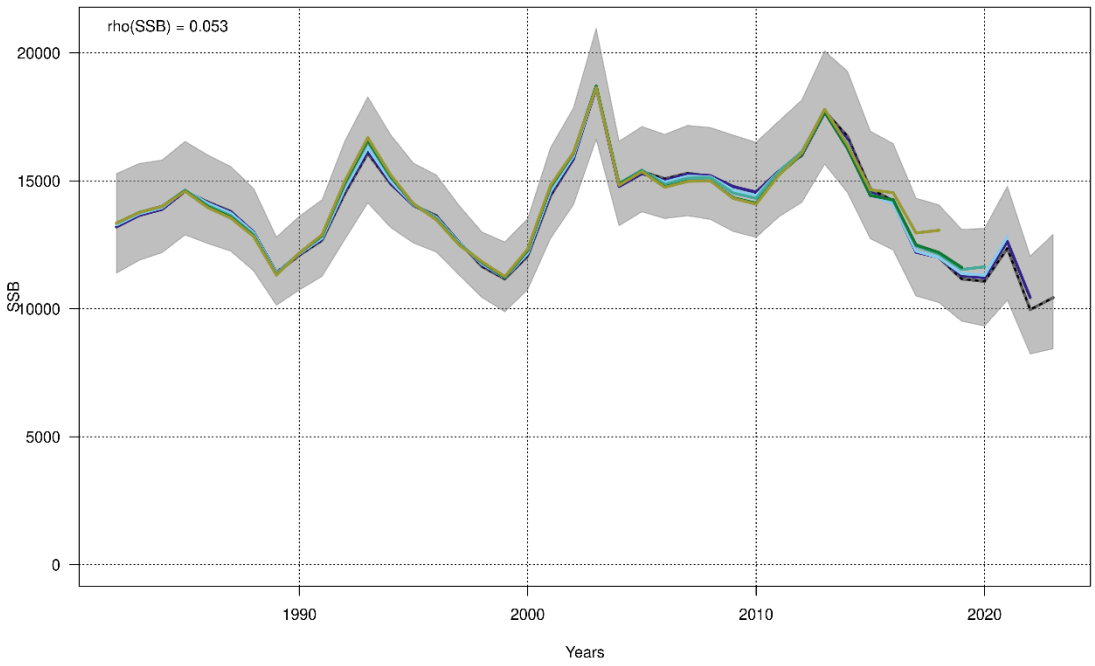


Figure 18.28. Sole in Division 7.d. One step ahead residuals by data stream.


rho(R_age1) = 0.238
Recruits (age 1)
70000
60000
50000
40000
30000
20000
10000
0
1990
2000
2010
2020
Years


rho(SSB) = 0.053
SSB
20000
15000
10000
5000
0
1990
2000
2010
2020
Years

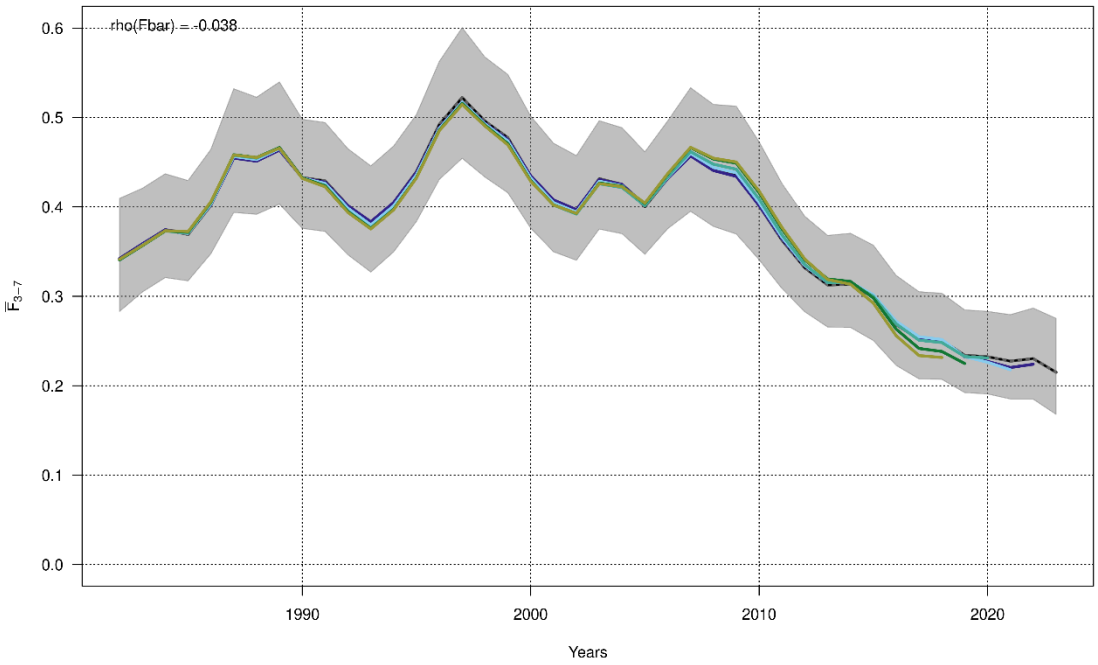


Figure 18.29. Sole in Division 7.d. Retrospective pattern in SSB (Mohn's Rho = 0.053), F_{bar} (Mohn's Rho = 0.038) and recruitment (in thousands; Mohn's Rho = 0.238). The grey shades represent the 95% confidence intervals of the model including all data years.

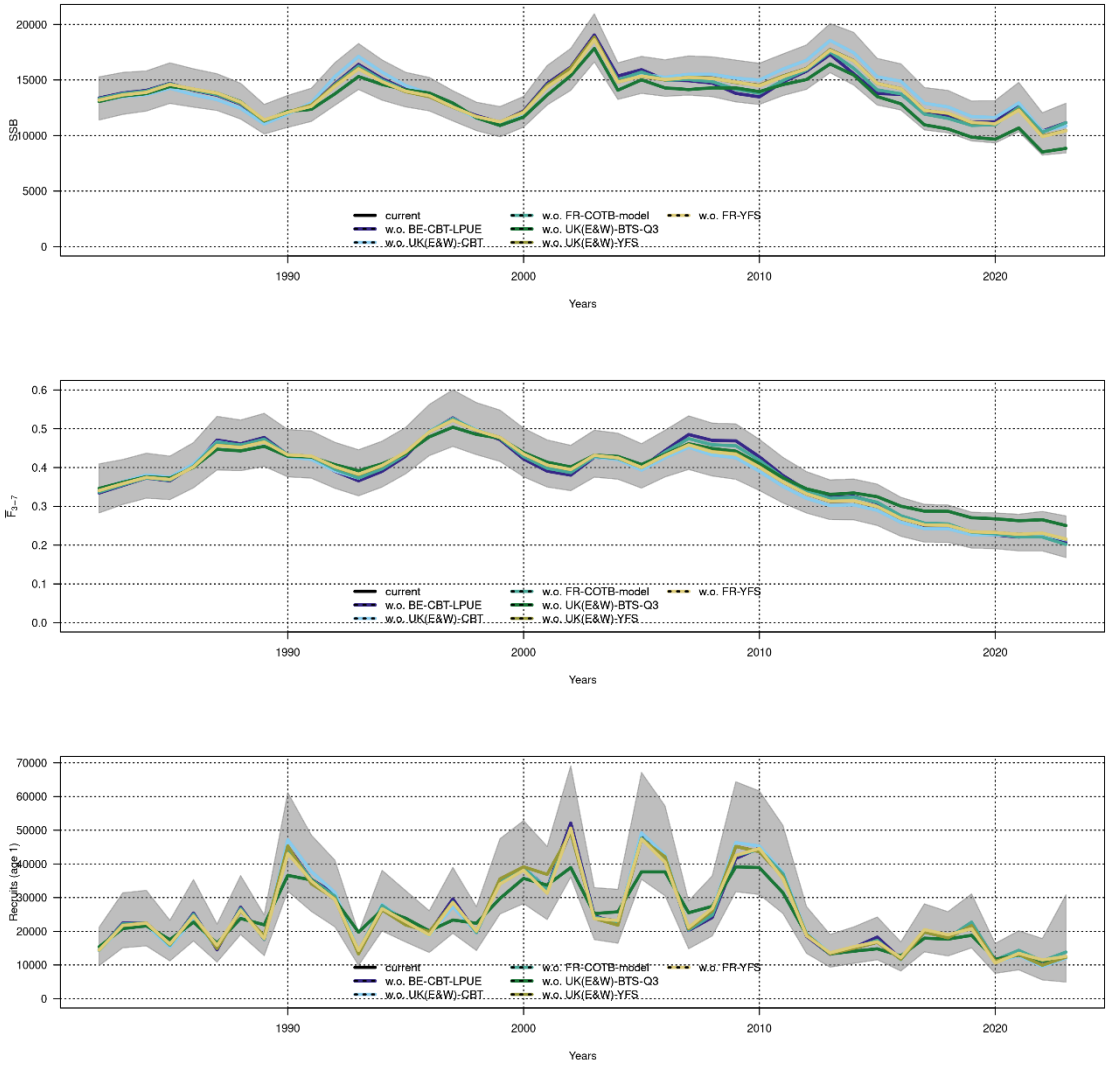


Figure 18.30. Sole in Division 7.d. Leave-one-out analysis. Each coloured line refers to a model fit without the respective tuning fleet. The grey shades represent the 95% confidence intervals of the model including all tuning fleets.

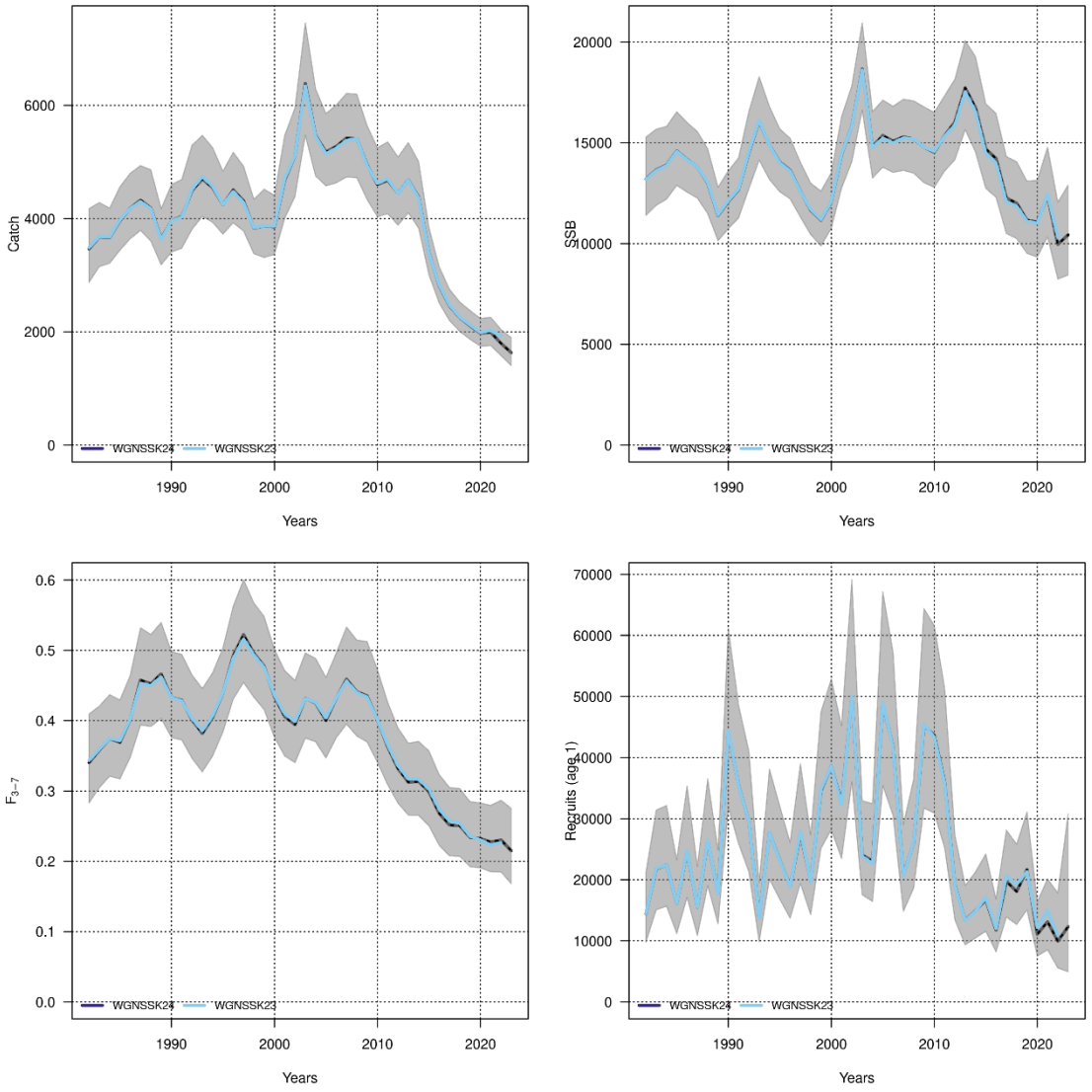


Figure 18.31. Sole in Division 7.d. SAM model summary showing the current model outputs in dark blue (WGNSSK24) and he previous assessment) model in light blue (WGNSSK23). Trends in catch, spawning stock biomass (SSB), F_{bar} and recruitment (in thousands) are shown with relevant confidence intervals.

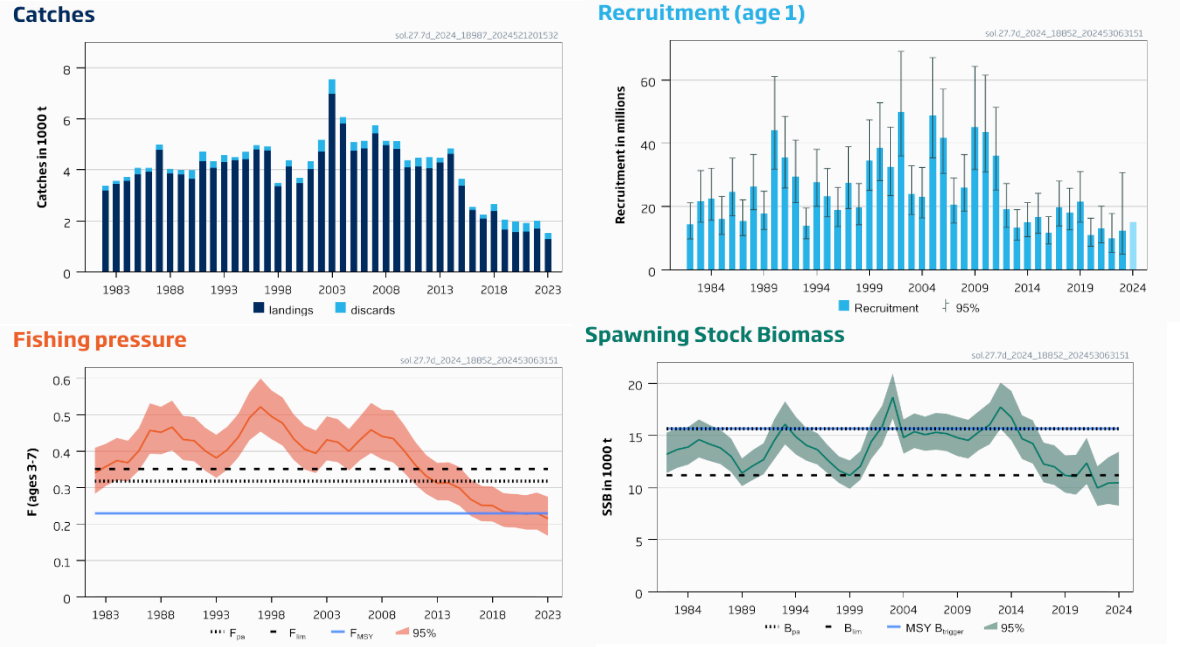


Figure 18.32. Sole in Division 7.d. Summary of the 2024 assessment. The assumed recruitment value for 2024 is shaded in a lighter colour. Discards are reconstructed prior to 2004 and include below minimum size (BMS) landings.

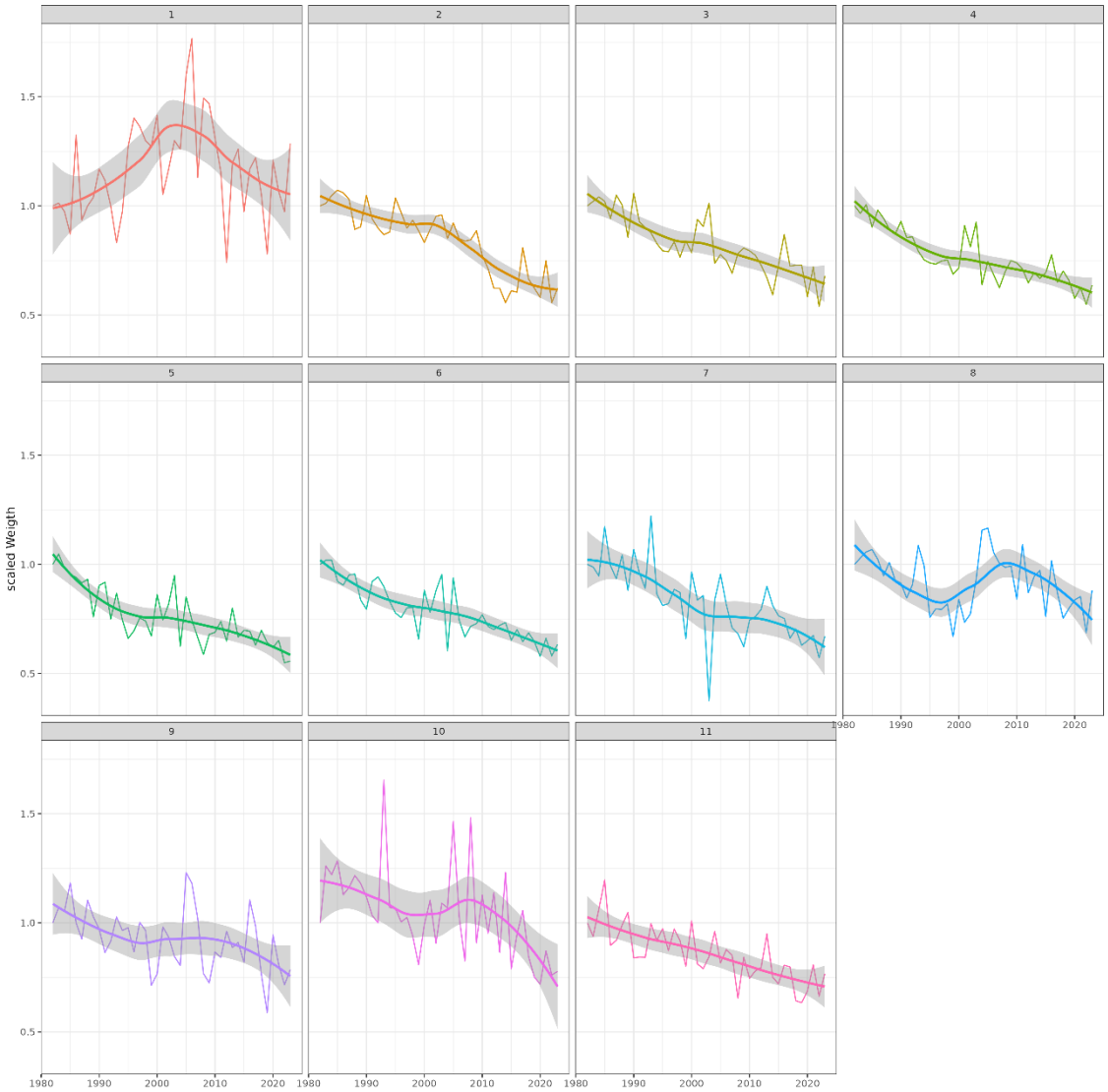


Figure 18.33. Sole in Division 7.d. Development of the stock weights by age group over time scaled to the first value of the time-series. The solid line is a regression spline that aids visualisation of the overall trend.

	1	2	3	4	5	6	7	8	9	10	11
2000	1.000	0.992	1.007	0.994	1.000	1.001	0.996	1.003	0.995	0.993	0.996
2001	1.009	1.001	0.991	1.005	0.997	1.006	1.004	1.002	1.004	0.994	1.000
2002	0.998	1.010	0.999	0.993	1.010	1.000	1.009	1.009	1.008	1.011	1.002
2003	1.009	1.000	1.006	1.001	0.998	1.009	1.008	1.016	1.014	1.014	1.007
2004	1.019	1.008	0.996	1.003	1.005	1.002	1.006	1.004	1.019	1.019	1.009
2005	0.996	1.021	1.010	1.006	1.005	1.006	1.006	1.010	1.005	1.018	1.011
2006	1.004	0.994	1.013	1.007	1.004	1.010	1.009	1.009	1.011	1.008	1.018
2007	1.004	1.005	0.995	1.014	1.005	1.006	1.009	1.008	1.008	1.011	1.015
2008	0.998	1.003	1.001	0.990	1.010	1.004	1.001	1.005	1.003	1.005	1.013
2009	0.995	0.998	1.004	1.001	0.988	1.008	1.004	1.002	1.006	1.006	1.012
2010	1.007	0.993	0.996	1.005	0.995	0.989	1.004	1.002	1.003	1.005	1.011
2011	1.007	1.009	0.999	0.999	1.009	0.996	0.994	1.006	1.004	1.006	1.012
2012	1.006	1.008	1.014	1.006	1.004	1.014	1.003	1.002	1.010	1.007	1.016
2013	1.004	1.005	1.010	1.014	1.010	1.010	1.019	1.010	1.007	1.017	1.018
2014	1.005	1.003	1.008	1.007	1.015	1.014	1.018	1.022	1.014	1.012	1.023
2015	0.981	1.007	1.006	1.011	1.010	1.020	1.021	1.025	1.023	1.017	1.020
2016	0.977	0.980	1.008	1.008	1.016	1.017	1.026	1.028	1.030	1.029	1.020
2017	0.958	0.976	0.983	1.013	1.017	1.028	1.032	1.038	1.036	1.037	1.026
2018	0.939	0.958	0.975	0.983	1.024	1.031	1.046	1.048	1.049	1.046	1.037
2019	1.015	0.933	0.957	0.973	0.996	1.043	1.057	1.067	1.065	1.063	1.052
2020	0.911	1.026	0.916	0.949	0.967	1.009	1.077	1.089	1.090	1.081	1.068
2021	0.882	0.902	1.036	0.883	0.933	0.950	1.025	1.116	1.116	1.110	1.067
2022	0.916	0.875	0.884	1.049	0.824	0.901	0.923	1.036	1.158	1.144	1.041
2023	1.049	0.861	0.866	0.864	0.941	0.731	0.884	0.978	1.064	1.175	1.063
2024	0.916	0.784	0.830	0.764	0.805	1.033	0.725	0.883	0.885	1.040	1.060

Figure 18.34. Sole in Division 7.d. Ratio of the numbers at age of this year's assessment and forecast against last year's assessment and forecast. Blue cells indicate an overestimation of last year's stock numbers, while red cells indicate an underestimation.

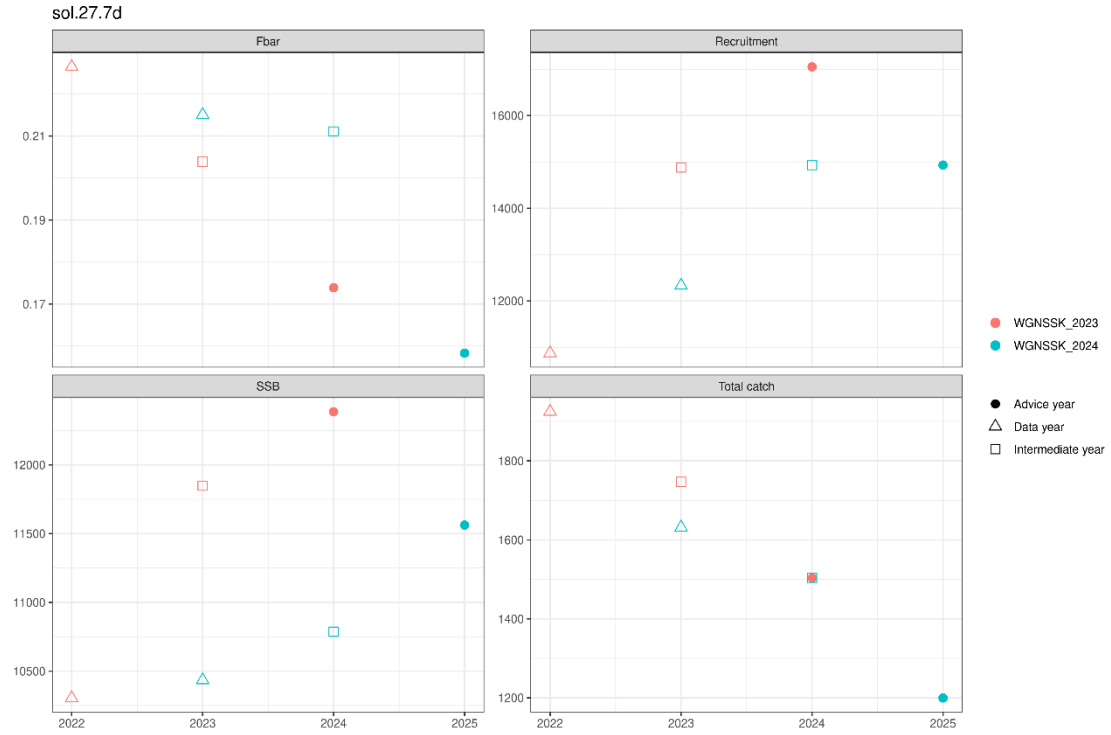


Figure 18.35. Sole in Division 7.d. Comparison of last year's estimates and forecast assumption of SSB, Fbar, recruitment and catch against this year's estimates and forecast assumptions.

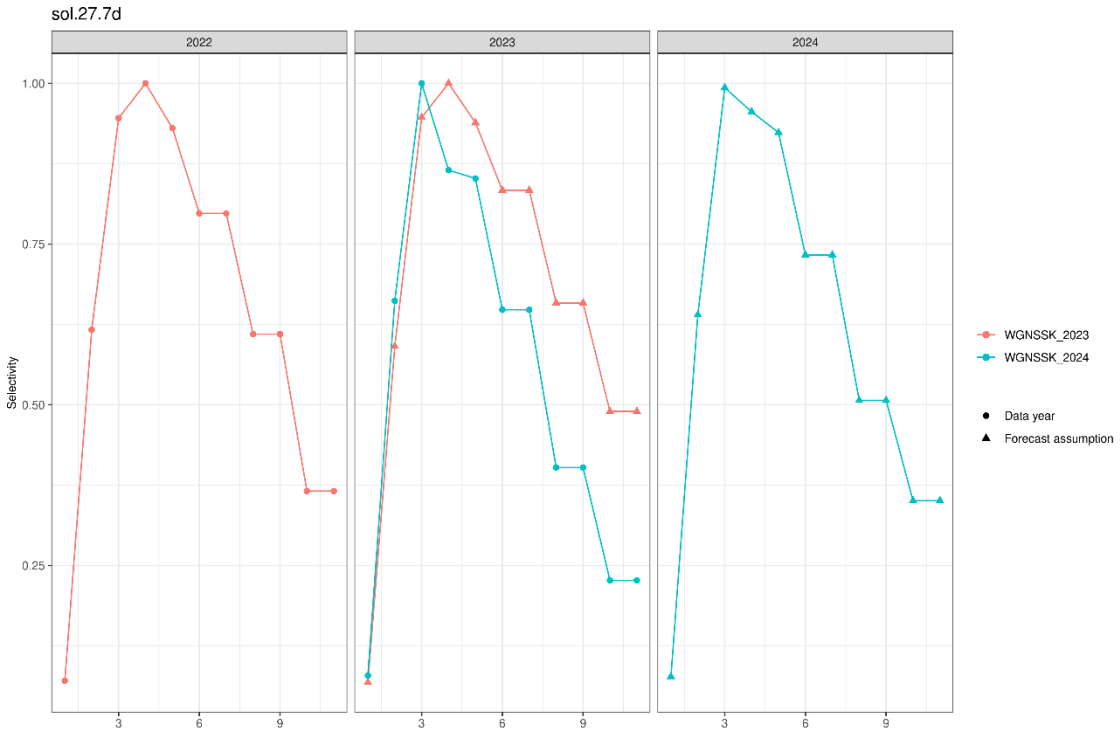


Figure 18.36. Sole in Division 7.d. Comparison of last year's selectivity estimates and assumption against this year's assessment.

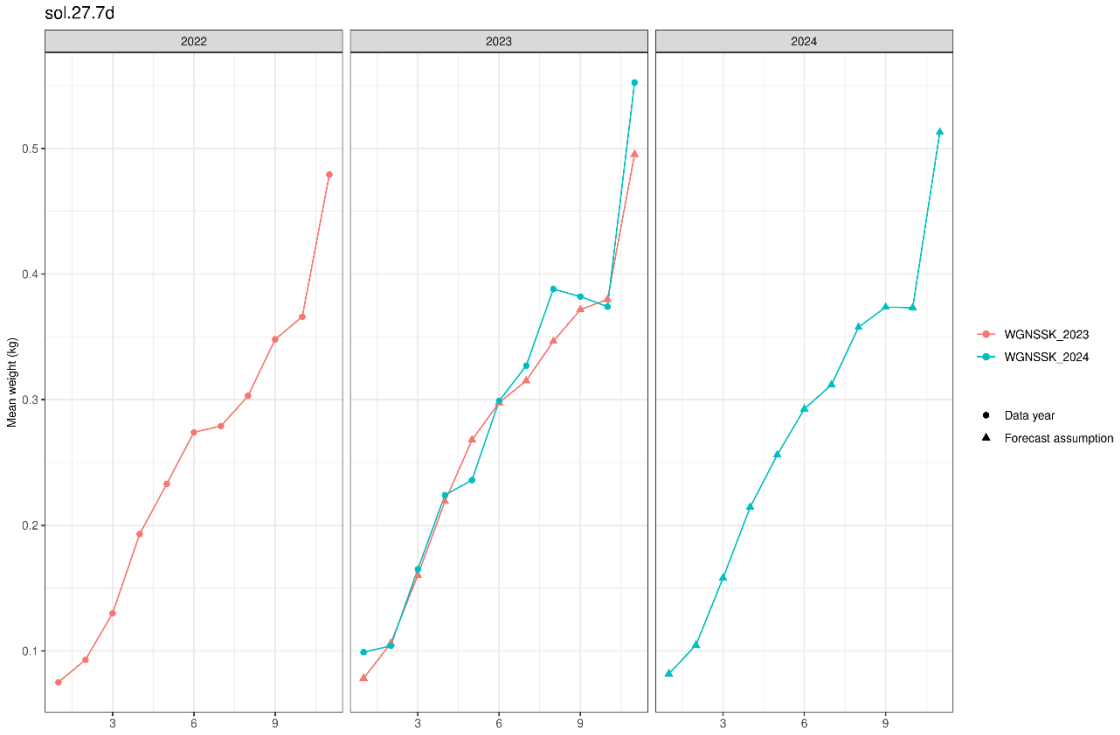


Figure 18.37. Sole in Division 7.d. Comparison of last year's stock weights at age (observed and forecast assumption) against the stock weights at age (observed and forecast assumption) of this year's assessment.

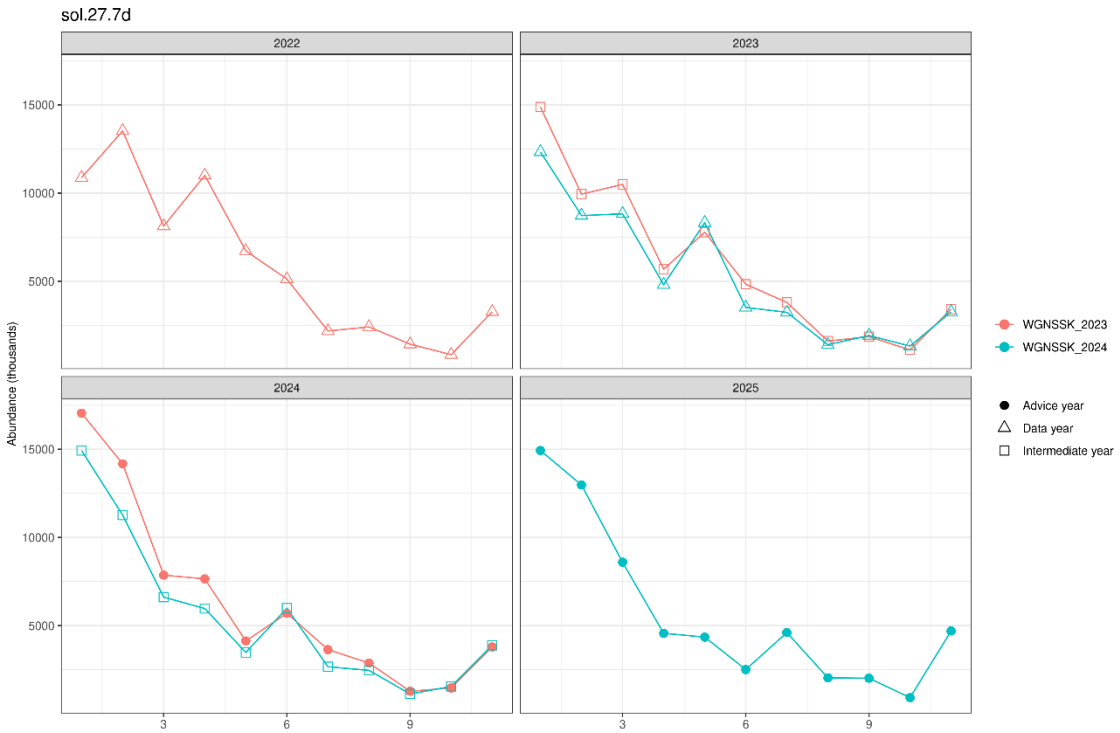


Figure 18.38. Sole in Division 7.d. Comparison of last year's stock numbers at age (estimated, intermediate year and advice year forecast assumption) against the stock numbers at age (estimated, intermediate year and advice year forecast assumption) of this year's assessment.

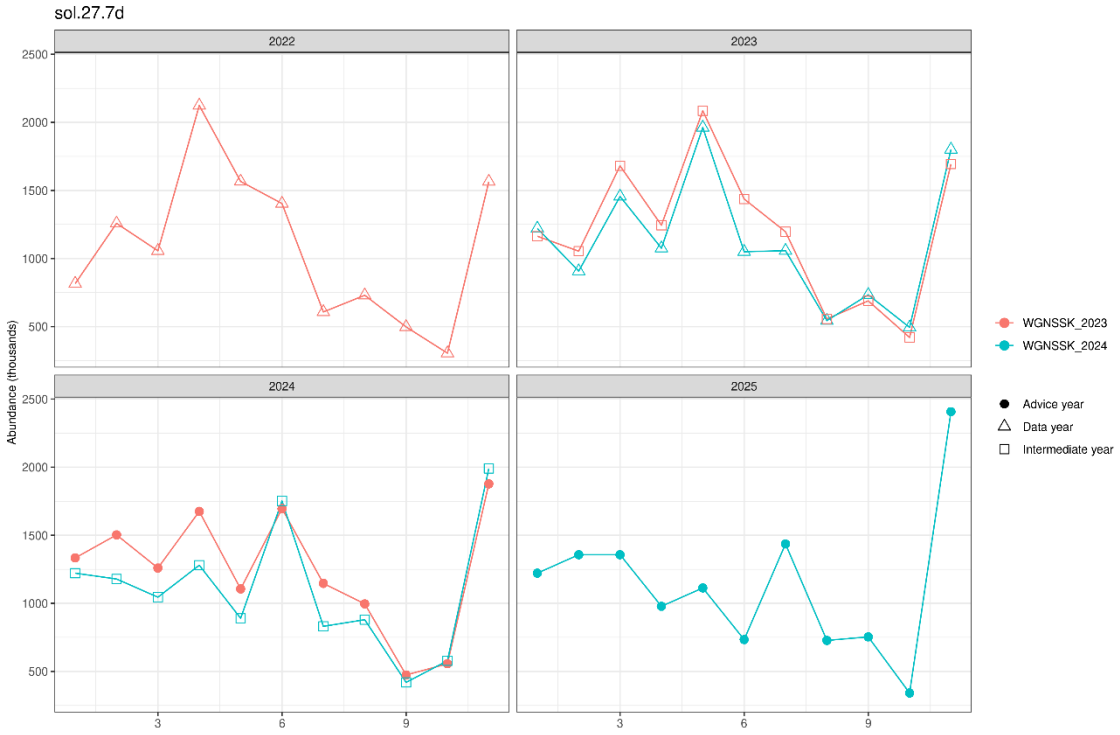


Figure 18.39. Sole in Division 7.d. Comparison of last year's biomass at age (estimated, intermediate year and advice year forecast assumption) against the biomass at age (estimated, intermediate year and advice year forecast assumption) of this year's assessment.

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