3 Black-bellied and white anglerfish in Celtic Seas and Bay of Biscay

ank.27.78abd and mon.27.78abd – *Lophius budegassa* and *Lophius piscatorius* in Subarea 7 and divisions 8.a, 8.b, and 8.d

3.1 General

3.1.1 Stock description and management units

The stock assessment area (27.78.abd) is the same for both species of anglerfish (*L. budegassa* and *L. piscatorius*). The two stocks are managed through TACs for the two species combined. There is a separate TAC for Subarea 27.7 and divisions 27.8.abde. Catches in 27.8.e are negligible.

3.1.2 ICES advice applicable to 2023

For *L. budegassa*, ICES advises that when the precautionary approach is applied, catches in 2023 should be no more than 23 436 t.

For *L. piscatorius*, ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 34 540 t.

ADGBBI 2022: Before 1986 the landings by species *L. piscatorius* and *L. budegassa* are estimated from the official landings of both *Lophius* species, assuming that the proportion of species of the first data years by country were similar to the past. The use of the full time series was discussed and analyzed during the WKANGHAKE benchmark (ICES, 2023b). If landings data before 1986 are removed, the model has to estimate an *F* at the beginning of the times series without knowledge of the earlier development of the fisheries, leading to increased uncertainty about the absolute scale of F and SSB. So, during the benchmark it was decided to use the full time series of landings in the model and to account for higher uncertainty about the historic landings (particularly the species-split), the standard error in the historic part of the landings was set at a higher value (0.2) than in the more recent period (0.1). There is no reason for WGBIE to change this decision.

3.1.3 Management applicable to 2023

The combined TAC for 27.7 and 27.8abde was 57 976 t, which corresponds to the combined advice for the two species. There are no *de minimis* or high-survivability exceptions included in the multiannual plan for the North Western Waters and adjacent waters (EU, 2019) for anglerfish.

Species *Lophiidae*	Subarea 7 (ANF/07)[1] [2] (tonnes)	Divisions 8.a, 8.b, 8.d, and 8.e (ANF/8ABDE)[3] (tonnes)
Belgium	4003	-
Germany	446	-
Spain	1591	1866
France	25687	10386
Ireland	3283	-
The Netherlands	518	-
European Union	35528	12252
UK	10196	-
TAC	45724	12252

3.1.4 The fishery

Both species of anglerfish (*L. piscatorius* and *L. budegassa*) are taken in a mixed fishery mainly with hake, megrim, and *Nephrops*.

The fishery for anglerfish developed in the late 1960s and landings quickly reached around 25 000 t (for both *Lophius* species combined). Since then, landings have fluctuated between 20 and 40 thousand t per year (Figure 3.1.1).

France takes the vast majority of the landings, followed by Spain, the UK, and Ireland. Minor landings have been recorded for Belgium, Germany and Portugal (Figure 3.1.1).

Around 2/3 of the catches are taken by otter trawlers targeting demersal fish; gillnets take between 10–20% and the remainder is taken by beam trawlers and otter trawlers targeting *Nephrops.*

Around 80% of the catch is taken in Subarea 27.7.

3.1.5 Information from stakeholders

WGBIE did not receive information from stakeholders regarding these stocks.

3.1.6 Data

3.1.6.1 Landings and discards

Figure 3.1.1 shows the time-series of the official landings of the combined species.

[1] Stock area code from the Commission of the European communities on the description of the ICES sub-areas and divisions used for the purposes of fishing statistics and regulations in the North East Atlantic

[2] Special condition: of which up to 10% may be fished in 8.a, 8.b, 8.d, and 8.e.

The combined-species landings are split into species-specific landings at the national level using the species composition in the sampling data from the onshore and offshore sampling programmes. Figure 3.1.2 shows the proportions of the two species over time. The overall proportion of *L. piscatorius* in the combined *Lophius* landings varied between 62% and 82% with a mean of 73%. The proportion of *L. piscatorius* in area 8abd is generally lower than in area 7 and more variable. The proportion of *L. piscatorius* in the discards is also lower than in the landings and the last year decreases until 38%.

3.1.7 References

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

3.1.8 Figures and tables

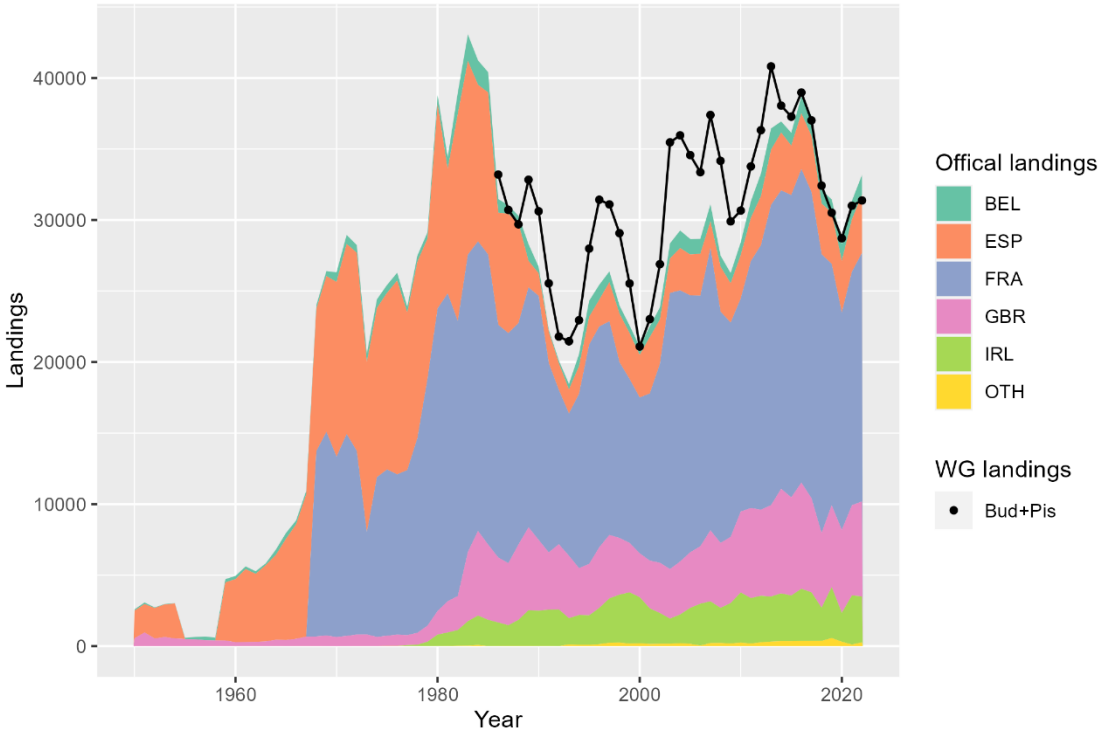

Figure 3.1.1. *Lophius* spp. in 27.78abd. Time-series of the official landings (tonnes) by country: Belgium (BEL), Spain (ESP), France (FRA), Great Britain (GBR), Ireland (IRL), other countries (OTH).

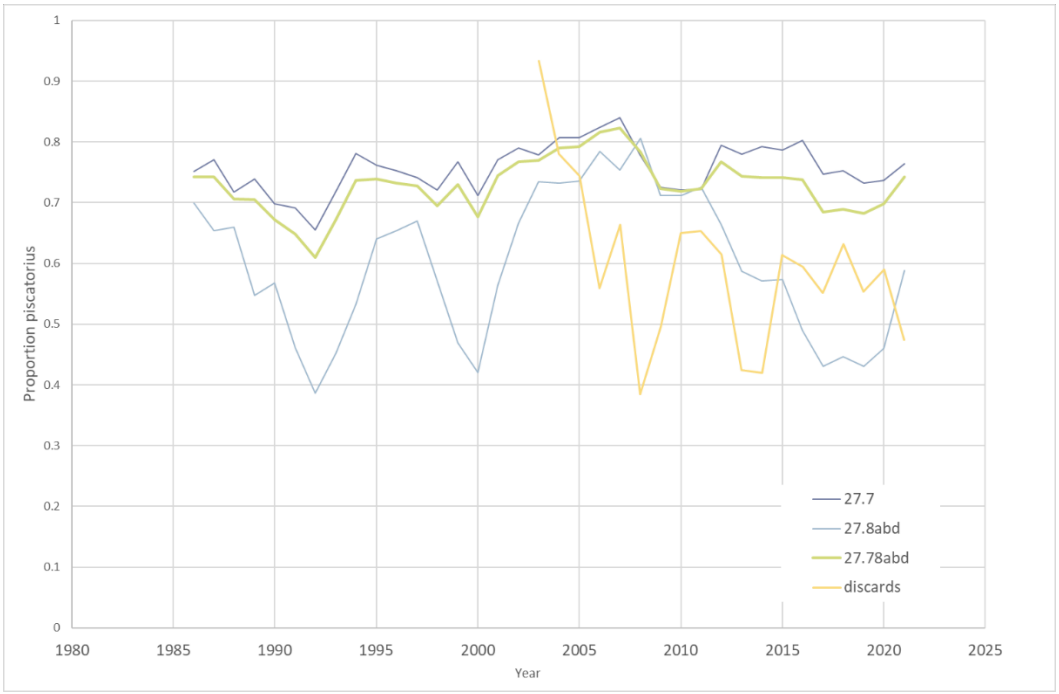

Figure 3.1.2. *Lophius* spp. in 27.78abd. Species composition in the landings (by area) and discards.

3.2 White anglerfish (*Lophius piscatorius*) in Subarea 7 and divisions 8.a, 8.b, and 8.d

3.2.1 Data

3.2.1.1 Landings and discards

Landings and discards data were extracted from InterCatch and processed according to the methods outlined in the Stock Annex. Normally, discard rates (proportion of the catch weight that was discarded) are used to estimate the discard volume for strata with missing discard data. This year, the discard rates of the French OTB_DEF fleets appeared to be unrealistically high (Figure 3.2.1) while the proportion of the Irish discards from OTB_CRU and OTB_DEF was too low compared to previous years. These values were not replaced but they were not considered to fill in unsampled discards. The true discard proportions were assumed to be similar to those observed in previous years. Thus, the average discard rates of those fleets from 2017–2019 were used to fill in unsampled discards.

Overall, discard rates are relatively low and when adding the extrapolated values to fill in missing discards data, has resulted in around 16 % of the estimated discard volume. Discards amount to around 7% of the total catch weight (average of most recent 5 years) (Figure 3.2.2).

Table 3.2.1. provides the ICES landings and discards estimates by country and area. Table 3.2.2. provides the landings and discards by fleet considered in the assessment model and year.

3.2.1.2 Catch numbers at length

The methods for filling in strata with unsampled landings and discards are described in the Stock Annex. Figure 3.2.2. shows that about 50% of the landings had length-associated data. This was an improvement from the year 2020 with less than 50% of landings with length associated data. This may presumably be related to the difficulties in collecting samples during the COVID-19 pandemic starting in 2020.

Figure 3.2.3a. shows the aggregated catch with LFD data both before and after filling in the values for unsampled catches. While discards consist of a relatively small proportion of the catch weight, they contributed to about 36% of the catch numbers over the last 3 years. Increases in mesh size in the trawl fisheries do not appear to have reduced the catches of anglerfish below 30 cm, likely due to their shape, which makes it difficult for even the smallest individuals to escape through the meshes. Figure 3.2.3b. shows the aggregated LFD of the landings and discards data by fleet considered in the assessment. Figures 3.2.3c., 3.2.3d., 3.2.3e., and 3.2.3f. show the LFD of the landings and discards data of gillnets, French trawlers, other trawlers and Spanish trawlers, respectively, which are the fleets considered in the assessment.

3.2.1.3 Surveys

The surveys are described in detail in the Stock Annex. Three surveys indices are used:

- IE-IGFS (G7212) and EVHOE (G9527) surveys; this combined French and Irish survey index is referred to by the ICES acronym FR_IE_IBTS;
- The Irish Anglerfish and Megrim survey IAMS (G3098);
- The SpGFS-WIBTS-Q4 survey (G5768, the previous acronym was SP-PGFS).

The survey indices are provided in Table 3.2.3.

FR_IE_IBTS

Figure 3.2.4a shows the spatial distribution of the catches of recruits on the combined FR_IE_IBTS surveys. Recruitment generally occurs in the western Celtic Sea while only for some years in the

Bay of Biscay. Recruitment in 2022 appears to be higher than in 2021 in the south (EVHOE-WIBTS-Q4) but not in the north (IGFS-WIBTS-Q4).

Figure 3.2.4b shows the comparison between the spatial distribution of the catch weights for the two IBTS surveys. During some years, the catches are highest in the area covered by the IGFS-WIBTS-Q4 (G7212) survey while in other years the EVHOE-WIBTS-Q4 (G9527) survey showed higher catches. It is unclear whether this is due to the movement of the stock or whether it is due to factors affecting the catchability on the surveys (e.g. weather, gear performance, etc.).

Figure 3.2.5 shows the biomass indices of the two IBTS surveys as well as the combined IBTS index. The combined survey biomass index is more stable than the single survey indices. The trends of both surveys in some periods are similar but with some differences in some periods. For example, in 2022 the EVHOE-WIBTS-Q4 (G9527) survey showed a moderate declining trend, while the IGFS-WIBTS-Q4 (G7212) survey index significantly increased (ICES, 2022).

In 2017, the French survey vessel Thalassa suffered major mechanical issues and the majority of the EVHOE-WIBTS-Q4 (G9527) bottom trawl survey could not be completed (ICES, 2018). Therefore, the 2017 data of this index was not included in the model.

IAMS (G3098)

Figure 3.2.6. shows the spatial distribution of the catches on the IAMS (G3098) survey.

Figure 3.2.7. shows the abundance index of the IAMS survey. This survey takes place at the start of the year, but to facilitate the inclusion of an in-year index, the data are provided to the model as if the survey occurred on the last day of the previous year. Such that the 2022 index is used for the assessment performed in WKANGHAKE 2022 (ICES, 2023b), but provided to the model as if it occurred on 31 December 2021.

SpPGFS-WIBTS-Q4 (G5768)

Figure 3.2.8. shows the spatial distribution of the catches on the SpPGFS-WIBTS-Q4 (G5768) survey, the previous acronym SP-PGFS.

Figure 3.2.9. shows the abundance index of the SpPGFS-WIBTS-Q4 (G5768) survey. The index was at the historical maximum in 2014 and 2017 but since 2018 the index is decreasing until 2021 which starts again to increase.

3.2.1.4 Biology and model settings

Maturity, natural mortality, length-weight and female growth parameters are all fixed (not estimated by the model) and described in the Stock Annex, while in the case of males, the maximum length (L_{inf}) is assumed fixed but growth is estimated by the model following a von Bertalanffy growth pattern. For both males and females, the length-at-age 1 is estimated by the model. Figure 3.2.10. shows the growth curves for males and females.

Recruitment bias adjustment settings are updated annually (following the Stock Annex).

3.2.1.5 Deviations from the Stock Annex

There were no deviations from the Stock Annex.

3.2.2 Model diagnostics

The model diagnostics broadly follow the approach described by Carvalho *et al*. (2021).

3.2.2.1 Convergence

- The model was run with the latest SS version available 3.30.21 (Released in February of 2023) while SS version used 3.30.18 was until in 2022 assessment (ICES, 2022b). The outputs with both models gave similar results.
- No parameters are estimated at/or near the bounds nor with unusual large variance.
- Final gradient on the likelihood is 0.00200643, which is larger than the recommended SS value of 0.0001. However, this is not considered a major concern as all the other indicators of convergence are good.
- The Hessian is positive definite.
- The model shows with a jitter analysis that depending on the starting values of the parameters to be estimated within the model, the model can converge to a local minimum. However, the assessment model converged in the global minimum and therefore, WGBIE did not identify any problems with regards to the model convergence (Figure 3.2.11).

3.2.2.2 Goodness-of-fit

Catch

Figure 3.2.12 shows the observed and fitted landings and discards. The fit to the discards does not follow the observations very closely, reflecting the uncertainty in the discard data. For most fleets, the fit is not consistently lower or higher than the observed values. However, the fit for Spanish trawlers is much lower than the observed discards. The fit to the landings is quite close to the observed values during the early 1980s when the model expects higher landings for French trawlers than observed. This occurs just before the sampling data are introduced into the model in 1986. This may reflect the inability of the model to accommodate recruitment variability before 1986. In 2000, the estimated landings of the French trawler are lower than the observed values.

Indices

Figure 3.2.13 shows the fit of the indices. For some years, the indices show some discrepancies for example around 2015 when the FR_IE_IBTS and the other two indices SpPGFS-WIBTS-Q4 (G5768) and IAMS (G3098) surveys show diverging values. During the last year, the three indices show an increase in the population. The combined FR_IE_IBTS and IAMS (G3098) surveys passed the test runs while the SPGFS-WIBTS-Q4 (G5768) survey runs failed. This, however, is not considered a major concern and is to be expected when conflicts between indices occur.

Length compositions

The fit to the length data is quite good, although there are some residual patterns mainly on the SpPGFS-WIBTS-Q4 (G5768) survey (Figure 3.2.13) and male and female LFDs from the combined FR_IE_IBTS and IAMS (G3098) surveys. Figure 3.2.14 shows the fit to the aggregated length distributions and Figure 3.2.15 provides the fit to the mean length size in catches. The residual plots and the runs tests are shown in Figures 3.2.16 and 3.2.17 which indicate that the residuals of the fit for fleet length composition passed the runs test but not for SP_TR, where in this case the residuals are not distributed with a random pattern.

Retention

Retention (the proportion of catches that are landed in each size class) is modelled with a logistic curve and for the French trawler (TR_FR) and other trawlers fleet (TR_OT) is allowed to vary during the period 2003–2022 with a random walk. For Gillnets (GNS) and Spanish trawler (SP_TR), this parameter has no time-varying flexibility. Figure 3.2.18 shows that the length at 50% retention is fitted quite closely to the observed data. The differences observed occurred due to the fitting variations of the landings and discard volumes as well as lengths.

Sex-ratio

Figure 3.2.19 shows the fit to the sex ratio-at-length. This fit is not part of the likelihood optimization but it is a useful diagnostic index for the model fit. The sexual dimorphism that is apparent from the survey data cannot be fully accommodated with the current model settings at the smallest size, but there may also be differences in natural mortality that are currently not accounted for.

Conclusion

WGBIE did not identify significant concerns with the fit of the model.

3.2.2.3 Model consistency

Retrospective analysis

Figure 3.2.20 shows the summary plot of the retrospective analysis. Mohn's rho (Mohn, 1999) values obtained for SSB and F were well inside the WKFORBIAS guidelines (ICES, 2020). All the peels for SSB and F are inside the uncertainty bounds. Therefore, no SSB or F significant retrospective bias is observed. Nevertheless, the estimated F values for the peel-1 is above of the other runs but this is due to local minimum convergency where the estimate of length at age 1 of females (*L_at_Amin_Fem*) is larger, and for males lower (*L_at_Amin_Mal*), and this also affects the growth of males (*VonBert_K_Mal_GP_1*) that is estimated within the model (Figure 3.2.21). The retros were run again fixing this value at 18.98 cm, the estimated value in the assessment run, so that the output of the assessment model is not changed. Thus, this pattern disappears and more similar values are estimated for all peels (Figure 3.2.22). Most peels for recruitment, on the other hand, are outside the uncertainty bounds. WGBIE considers that the model has a poor ability to estimate recruitment in the final year (ICES, 2023c).

Hindcasting

Figure 3.2.23 shows the hindcasting analysis results for the indices. The three surveys show a MASE score of < 1, indicating good prediction skill. The MASE scores for the mean length in the two commercial fleets French trawler (TR_FR) and other trawlers (TR_OT) are < 1 indicating good prediction skill (figure not shown).

Conclusion

WGBIE did not identify significant concerns with the model consistency.

3.2.3 Historical stock development

3.2.3.1 Update assessment

The stock summary is shown in Figure 3.2.24 and Table 3.2.4. Recruitment is highly variable and last year recruitment is replaced following the Stock Annex. F shows a declining trend in the last years . F is estimated to have been below F_{MSY} since 2009. SSB is well above the biomass reference points and has been increasing since 2003.

3.2.3.2 Comparison with previous assessments, alternative runs

No alternative runs were performed.

The current assessment cannot be directly compared to assessments previous to 2022 because the assessment method as well as the reference points have been updated at the WKANGHAKE benchmark (ICES, 2023b). Figure 3.2.25 shows a comparison on a relative scale. The general perception of the stock is unchanged: SSB is above the reference points and shows a generally increasing trend since 2012; F shows an overall decreasing trend and has been below F_{MSY} since

2009 and recruitment is variable, similar to the previous a4a assessment model (Millar and Jardim, 1999) used in WGBIE 2021 (ICES, 2021b). It should be noted that the previous assessment model only indicated that F was below since around 2017 (ICES, 2021b).

Figure 3.2.26 compares the last year assessment results with this year assessment. The estimated outputs are very similar until the forecast year where in WGBIE2022 is assumed as the advice estimated with F_{MSY} and in WGBIE 2023 where the catches and, therefore, F is much lower. The small differences are due to the revised estimate of recruitment as well as in catches at age, SSB at age and F at age (Figure 3.2.27).

3.2.4 Biological reference points

In 2022, the WKANGHAKE benchmark (ICES, 2023b) established new reference points for this stock. However, these values were revised in the WD 01 presented by Urtizberea (2022) during the WGBIE 2022 (ICES, 2022b). Note that although the SS model is sex-disaggregated, the biomass reference points were calculated relative to the combined-sex SSB following the standard ICES approach (ICES, 2023a). All figures and tables refer to the biomass related to the combined-sex biomass for this stock.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	28275	B_{pa}; in tonnes	ICES (2022b)
	F_{MSY}	0.192	Stochastic simulations (EqSim) with Beverton–Holt stock–recruitment relationship estimated by the assessment model.	ICES (2022b)
Precautionary approach	B_{lim}	23868	SSB_{2004}; lowest observed SSB with high recruitment; in tonnes	ICES (2022b)
	B_{pa}	28275	$B_{lim} \times \exp(1.645 \times 0.103)$; in tonnes	ICES (2022b)
	F_{lim}	Undefined	Inconsistent with F_{pa}	ICES (2022b)
	F_{pa}	0.212	$F_{p.05;}$ the F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2022b)
Management plan	MAP MSY $B_{trigger}$	28275	MSY $B_{trigger}$; in tonnes.	ICES (2022b)
	MAP B_{lim}	23868	B_{lim}; in tonnes.	ICES (2022b)
	MAP F_{MSY}	0.192	F_{MSY}	ICES (2022b)
	MAP range F_{lower}	0.131	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}.	ICES (2022b)
	MAP range F_{upper}	0.212	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}.	ICES (2022b)

3.2.5 Short-term projections

The approach used for the short-term projections is outlined in the Stock Annex.

WGBIE decided to replace the recruitment in the most recent year (2022) of data with the predicted recruitment from the stock–recruit relationship estimated in the model following the Stock Annex. The original estimate of 93 341 thousand was replaced with 110 863 thousand, since the retrospective analysis indicates that the model estimate in the final year is unreliable. The recruitment values assumed in 2023 and 2024 in the short term forecast are estimated with the stock recruitment relationship, 111245 and 111482 respectively.

$F_{status\ quo}$ was defined as the average F over the last 3 years 0.125 and was used as the intermediate-year assumption with catches of 24026 t, landings of 21198 t and discards of 2828 t. Landings and discards values of the intermediate year assume the ratio at age as the average of the last 3 years.

Figure 3.2.28 shows the contribution of each cohort to the landings in 2024 and SSB in 2025 under the MSY catch option. The landings are expected to be dominated by the cohorts from 2020 (19%) while the SSB of 2025 is dominated by the cohorts from 2018 to 2020.

3.2.6 Quality of the assessment

The assessment model was developed during the WKANGHAKE benchmark (ICES, 2023b) with the revisions presented in the WD 01 (Urtizberea, 2022) during the WGBIE in 2022 (ICES, 2022).

The comment from the reviewers was:

Overall, the SS assessment model (Methot and Wetzel, 2013) was configured properly and showed good diagnostics. The model exhibited some minor instability (jitters) and an inability to match the observed discards for the TR_SP fleet. These issues should be further evaluated before the next benchmark assessment. In particular, improvements in the sex-specific life history parameters and a better understanding of the stock delimitation may help resolve some of the model instability and data conflicts observed during the WKANGHAKE (ICES, 2023b). An externally derived selectivity pattern for the SPGFS-WIBTS-Q4 (G5768) survey or improved standardization of this survey's composition data can be performed as complementary input data prior to the next SS update assessment model runs and may also improve the model diagnostics.

3.2.6.1 Other indicators

There are no other reliable indicators than the 3 surveys currently considered in the model.

3.2.7 Management considerations

Management of the two anglerfish species under a combined TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. However, since the stock sizes of both species are currently increasing, neither of the *Lophius* species appears to be at risk of overexploitation.

3.2.8 Recommendations for the next benchmark

The SS model (Methot and Wetzel, 2013) was developed during the WKANGHAKE benchmark (ICES, 2023b). The model is very good in terms of the performance in diagnostics compared to the previous a4a assessment model (Millar and Jardim, 2019) used for the stock. However, for the next benchmark, some recommendations are proposed below:

- The SS assessment model shows very good diagnostics in terms of test runs or hindcasting. However, due to the different spatial distribution of the surveys and the different

trends during some periods in the time-series, the inclusion of a spatial model could improve the survey's fit.

- The life history parameters are different for males and females. However, little is known about growth and natural mortality by sex. Future research and additional information on this aspect could improve the model stability (jitter).

3.2.9 References

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3.2.10 Figures and tables

Figure 3.2.1. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. The proportion of discards by gear and country. Discards data are only available from 2003.

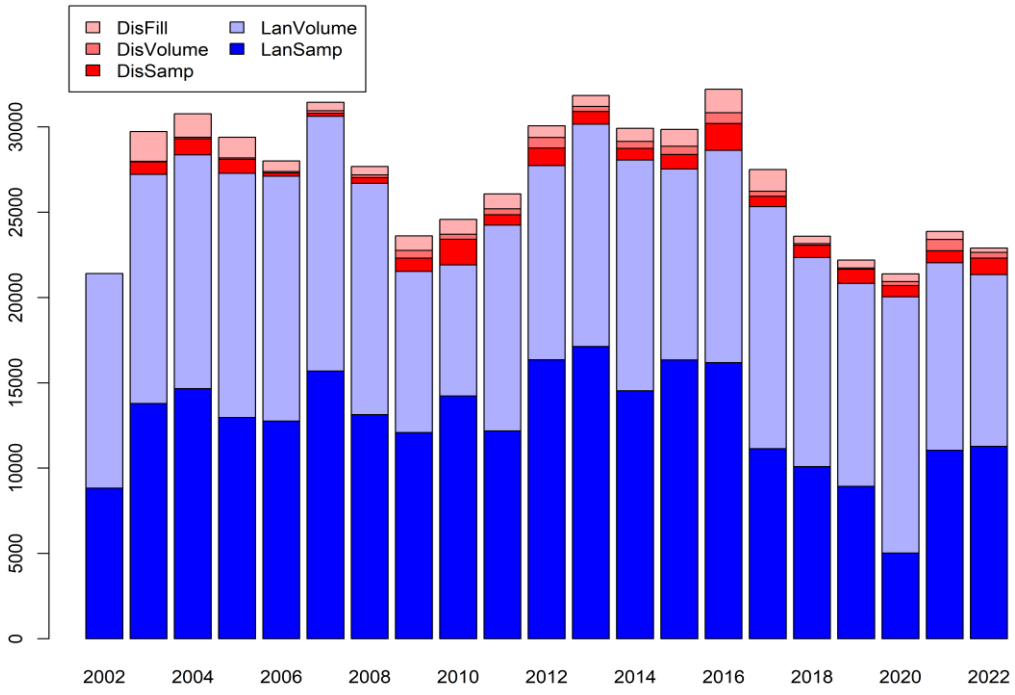

Figure 3.2.2. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Allocations of unsampled landings and discards by year. Dark blue represents the sampled landings while light blue represents landings for which only the total weight (in tonnes) without length data were available and red represents the complete sampled discards (weight and length data). Medium pink represents discards for which an estimate of the weight (in tonnes) was available but no length data (length data 'borrowed' from other strata) while light pink represents the strata for which no discard weight or length data were available and where discard rate and length data were 'borrowed' from other strata.

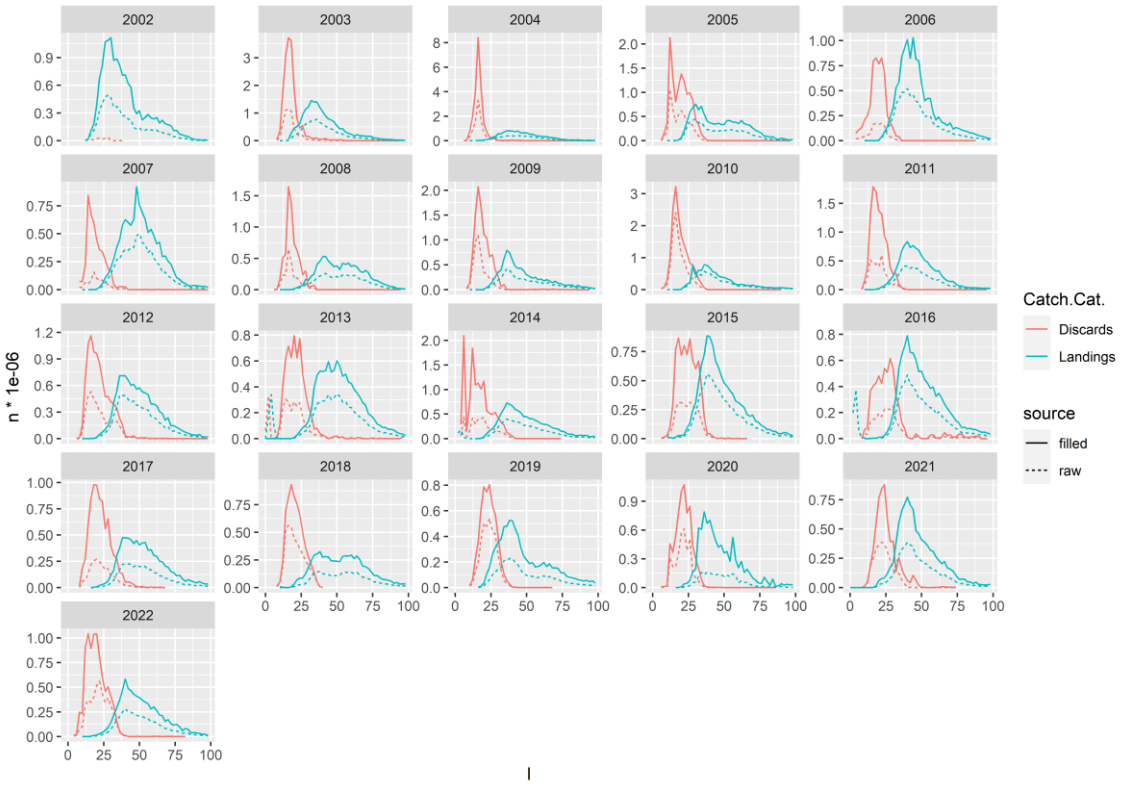

Figure 3.2.3a. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Annual length–frequency distributions of the landings (blue) and discards (red). The dotted lines show the sampled strata submitted to InterCatch; the solid lines are the estimates after allocations of unsampled catches. No discard data were available before 2003.

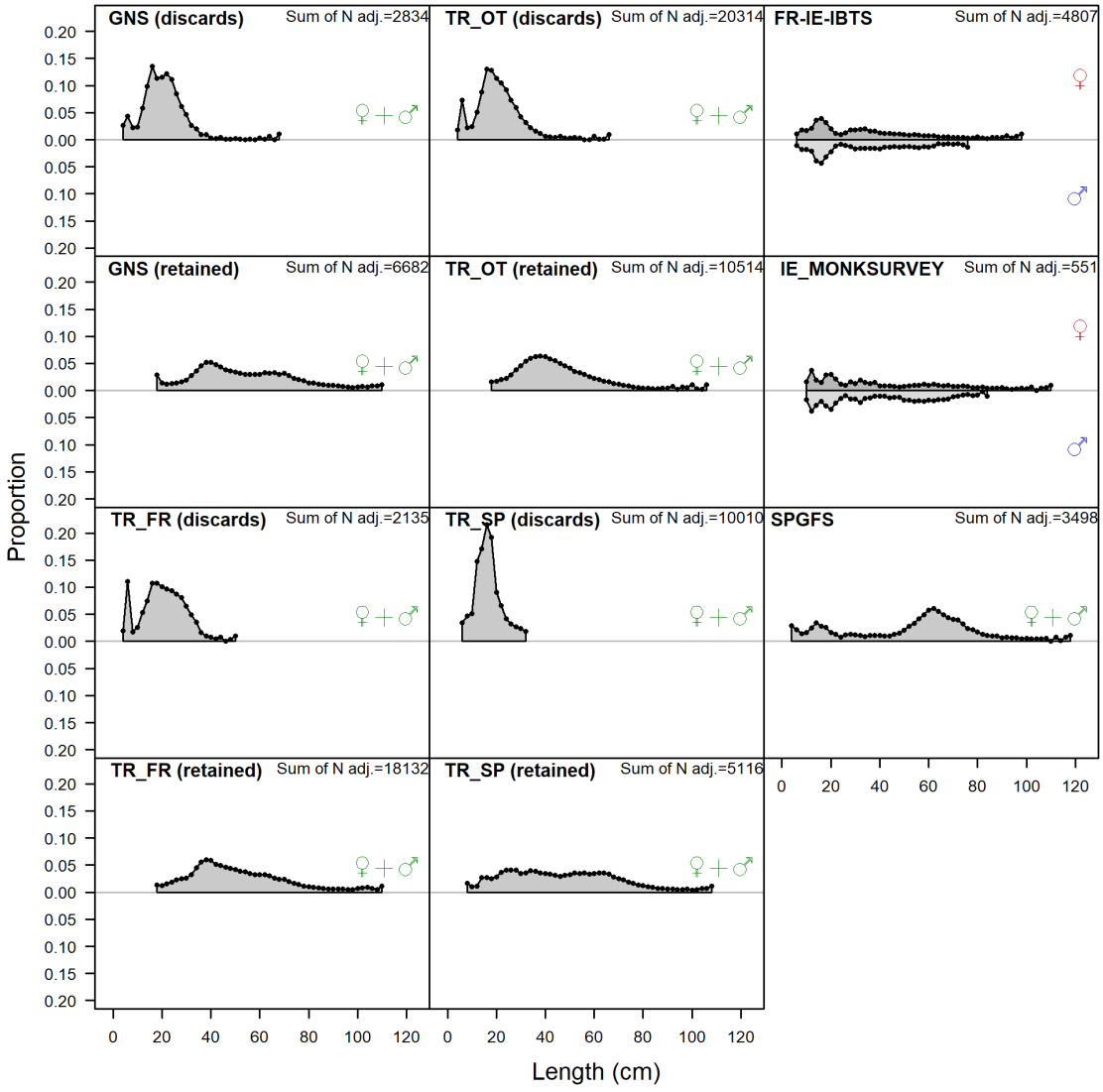

Figure 3.2.3b. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Aggregated length composition by fleet of landings and discards.

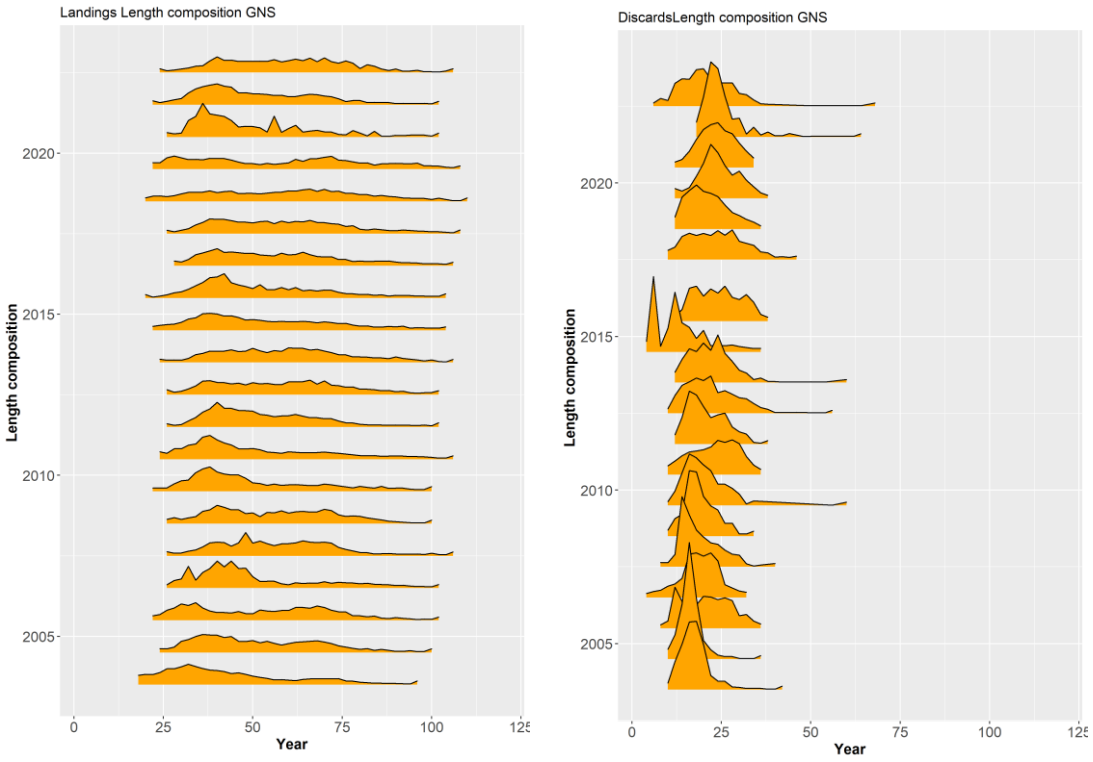

Figure 3.2.3c. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Gillnets (GNS) landings and discards length composition by year (discards length composition available from 2003).

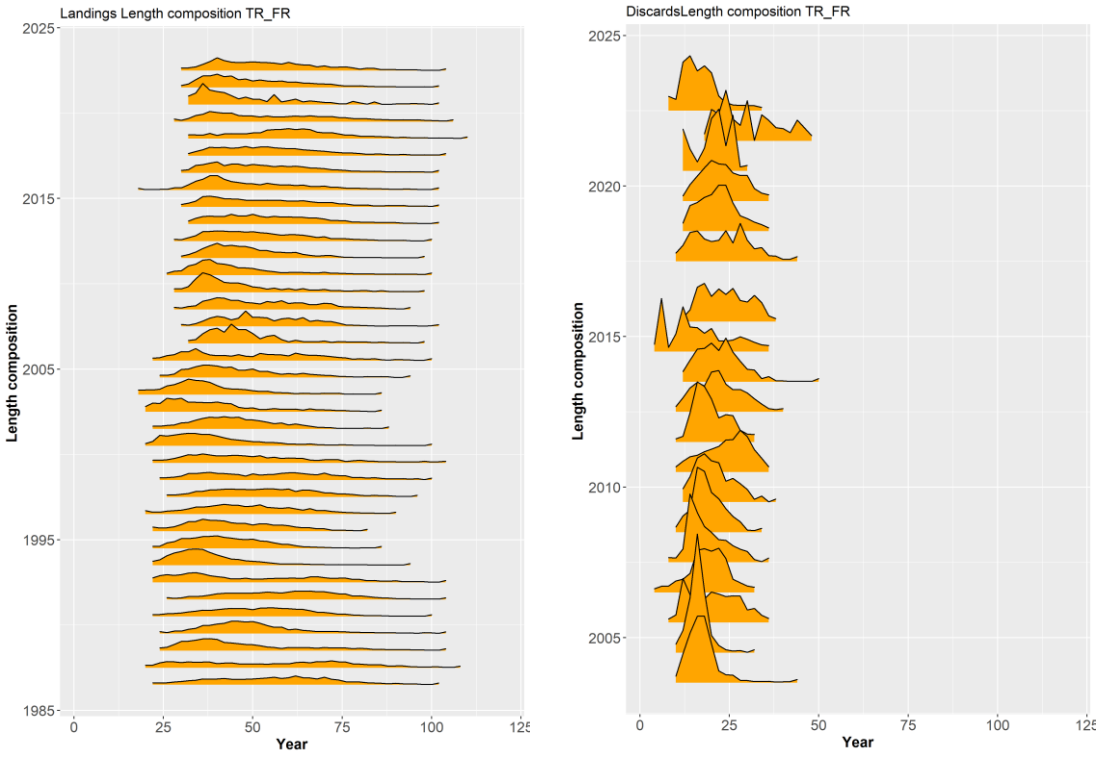

Figure 3.2.3d. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. French trawlers (TR_FR) landings length composition by year (discards length composition available from 2003).

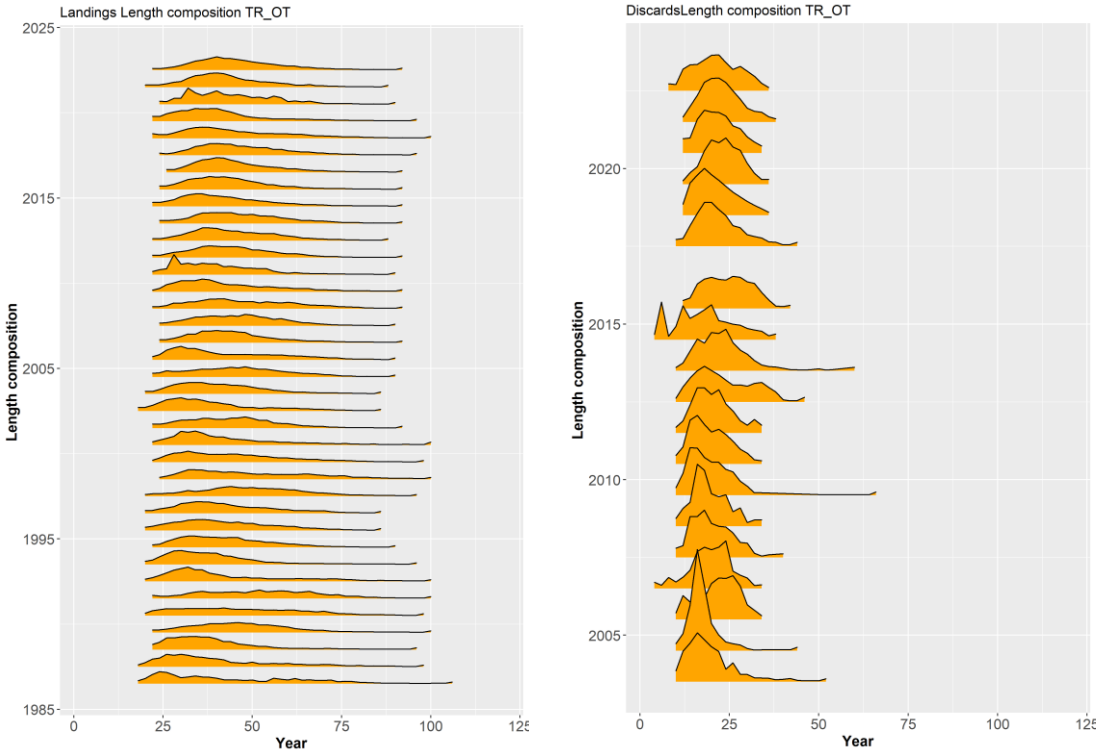

Figure 3.2.3e. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Other trawlers (TR_OT) landings length composition by year (discards length composition available from 2003).

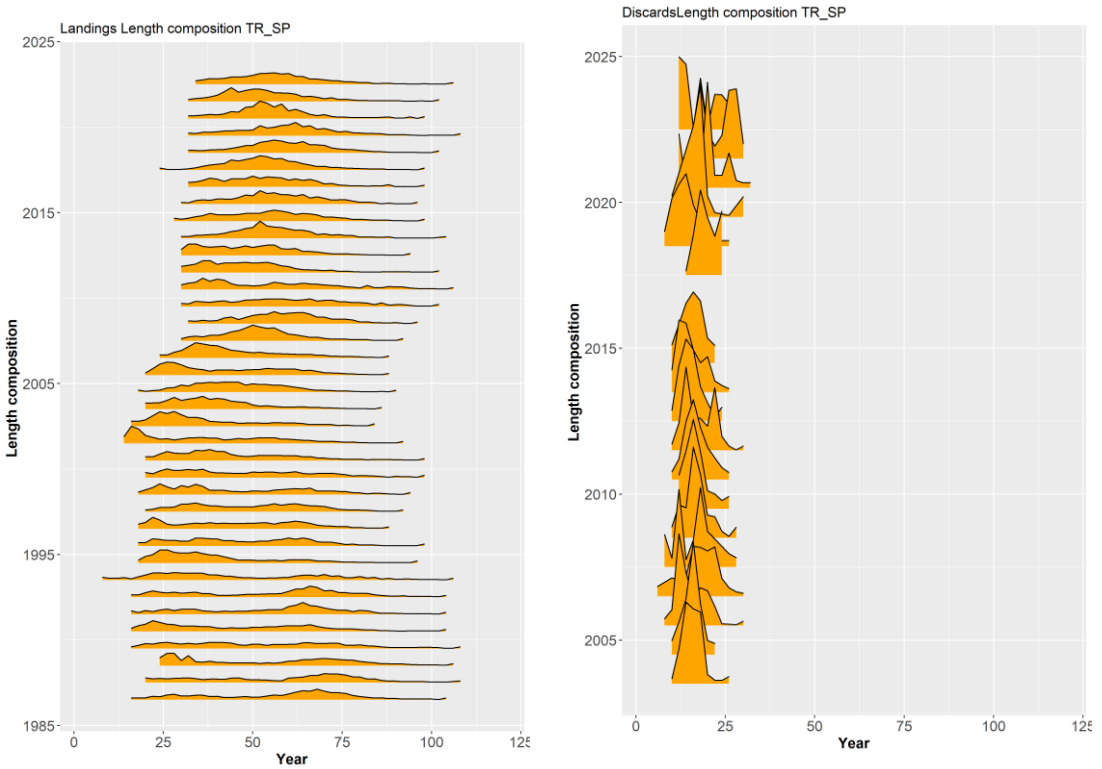

Figure 3.2.3f. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Spanish trawlers (TR_SP) discards length composition by year (discards length composition available from 2003).

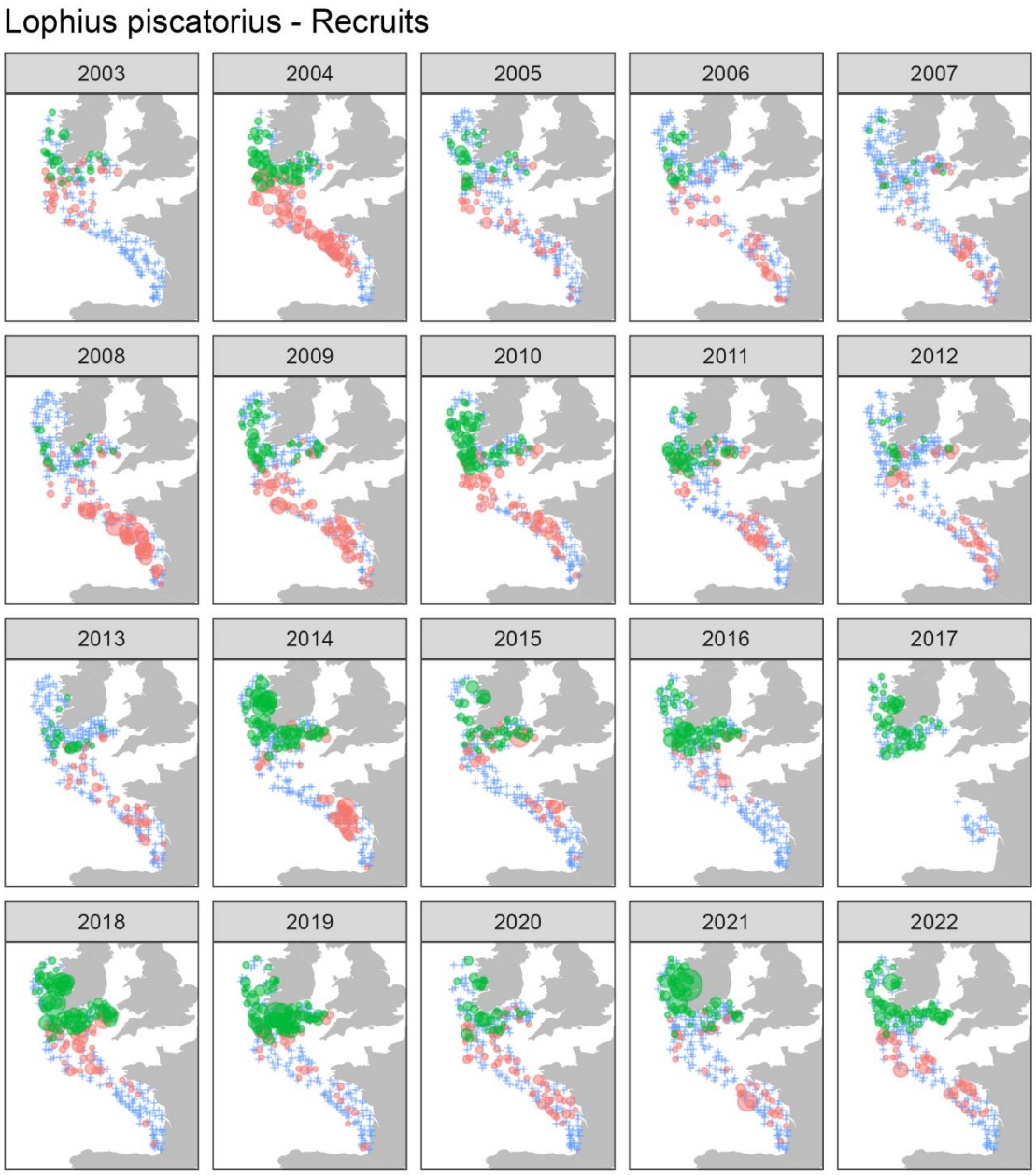

Figure 3.2.4a. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Abundance of recruits (< 24cm) in the IGFS-WIBTS-Q4 (G7212; in green) and EVHOE-WIBTS-Q4 (G9527; in red) surveys.

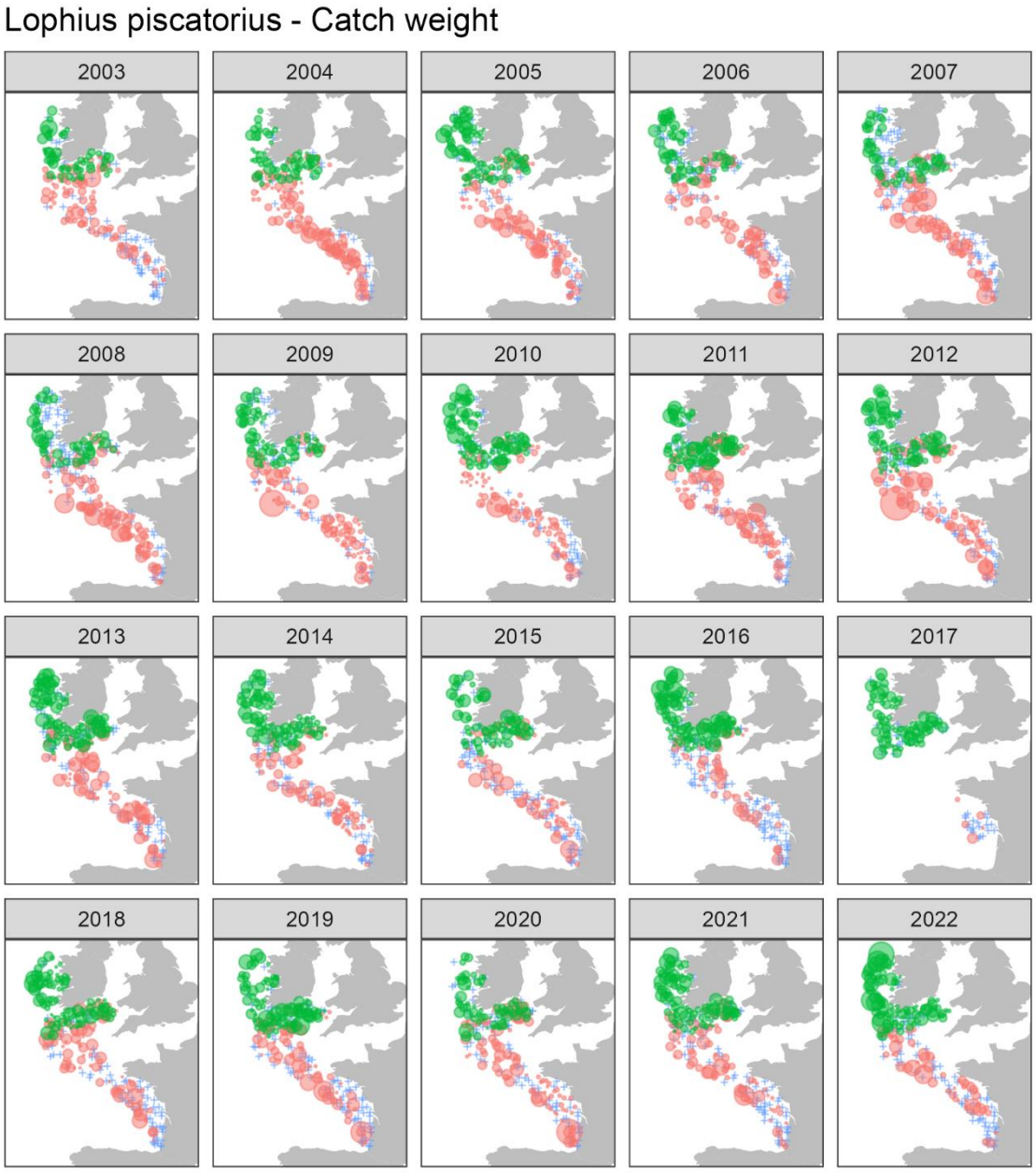

Figure 3.2.4b. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Catch weights in the IGFS-WIBTS-Q4 (G7212; in green) and EVHOE-WIBTS-Q4 (G9527; in red) surveys.

Figure 3.2.5. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Survey index of the EVHOE-WIBTS-Q4 (G9527) index is shown in green, IGFS-WIBTS-Q4 (G7212) in blue and the combined FR_IE_IBTS survey index in red, all with 95% confidence intervals.

Figure 3.2.6. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Catch rates on the IAMS (G3098) survey.

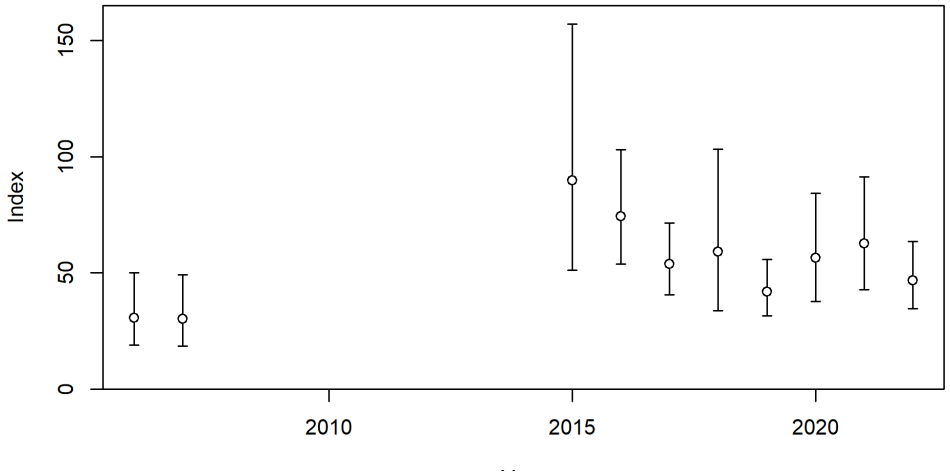

Figure 3.2.7. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Abundance index of the IAMS (G3098) survey.

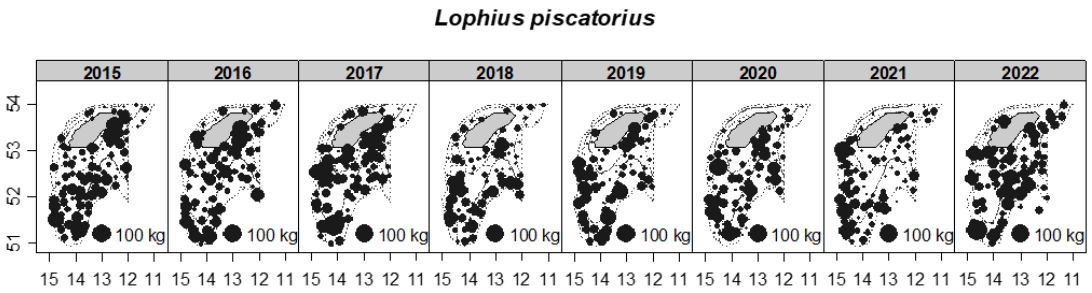

Figure 3.2.8. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Catch rates of the SpPGFS-WIBTS-Q4 (G5768; previous acronym was SP-PGFS) survey.

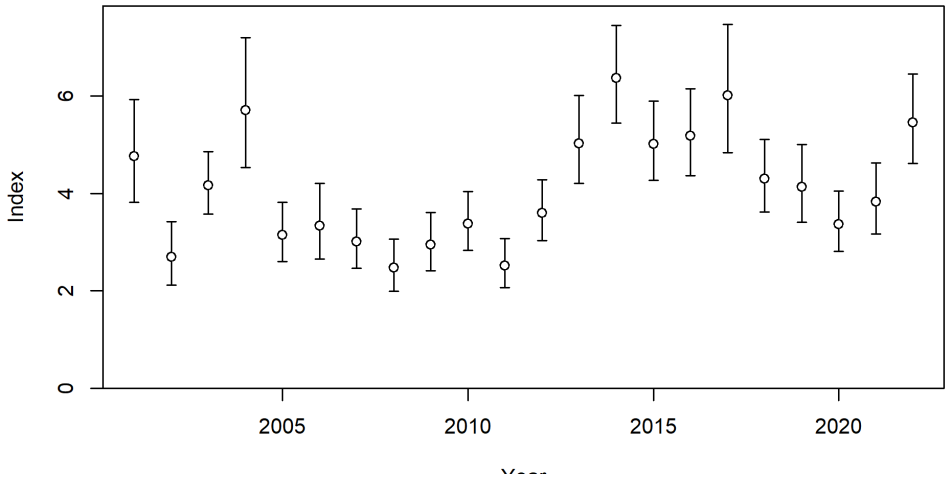

Figure 3.2.9. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Abundance index of the SpPGFS-WIBTS-Q4 (G5768; previous acronym was SP-PGFS) survey.

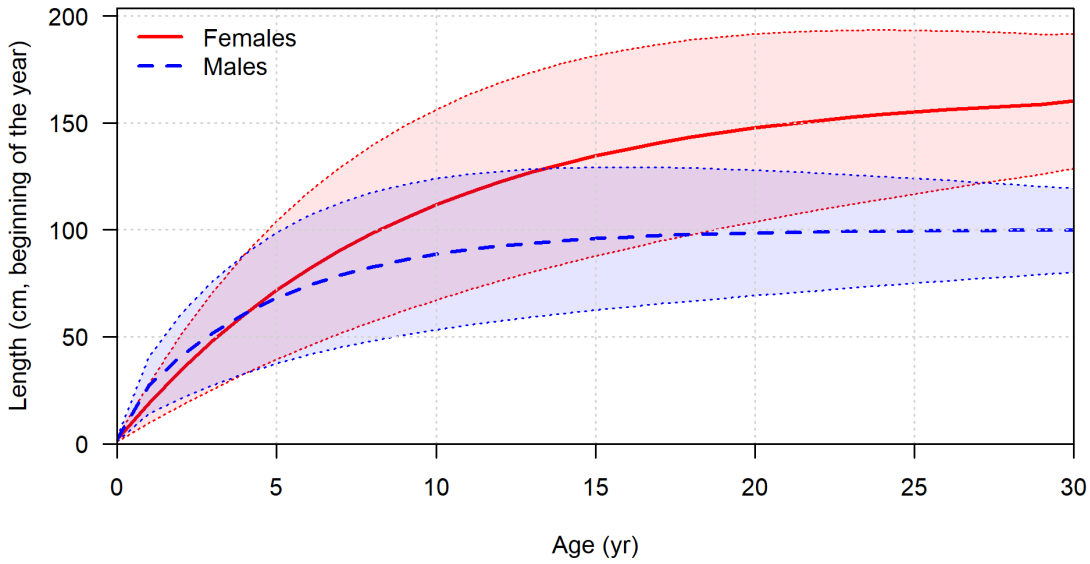

Figure 3.2.10. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Assumed growth curves for females and estimated growth for males assuming a fix maximum length. The length-at-age 1 for both males and females is estimated by the model.

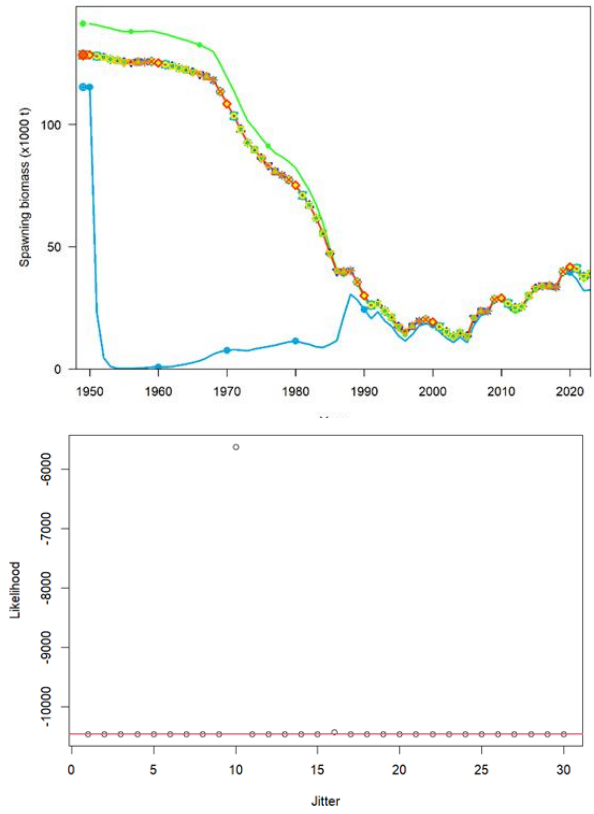

Figure 3.2.11. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Estimated SSB value of 30 runs with a jitter analysis.

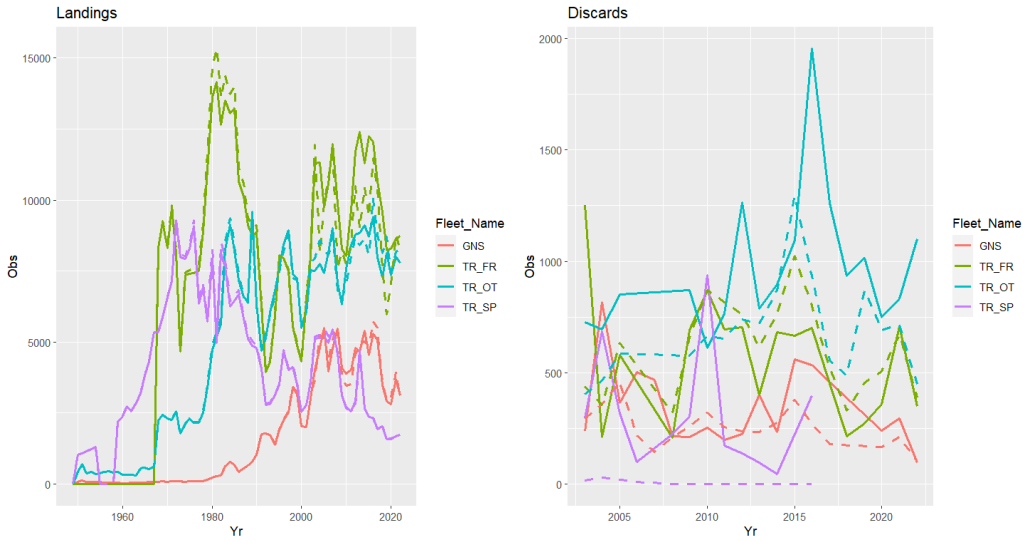

Figure 3.2.12. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Observed (continuous lines) and fitted (discontinuous lines) discards and landings by fleet.

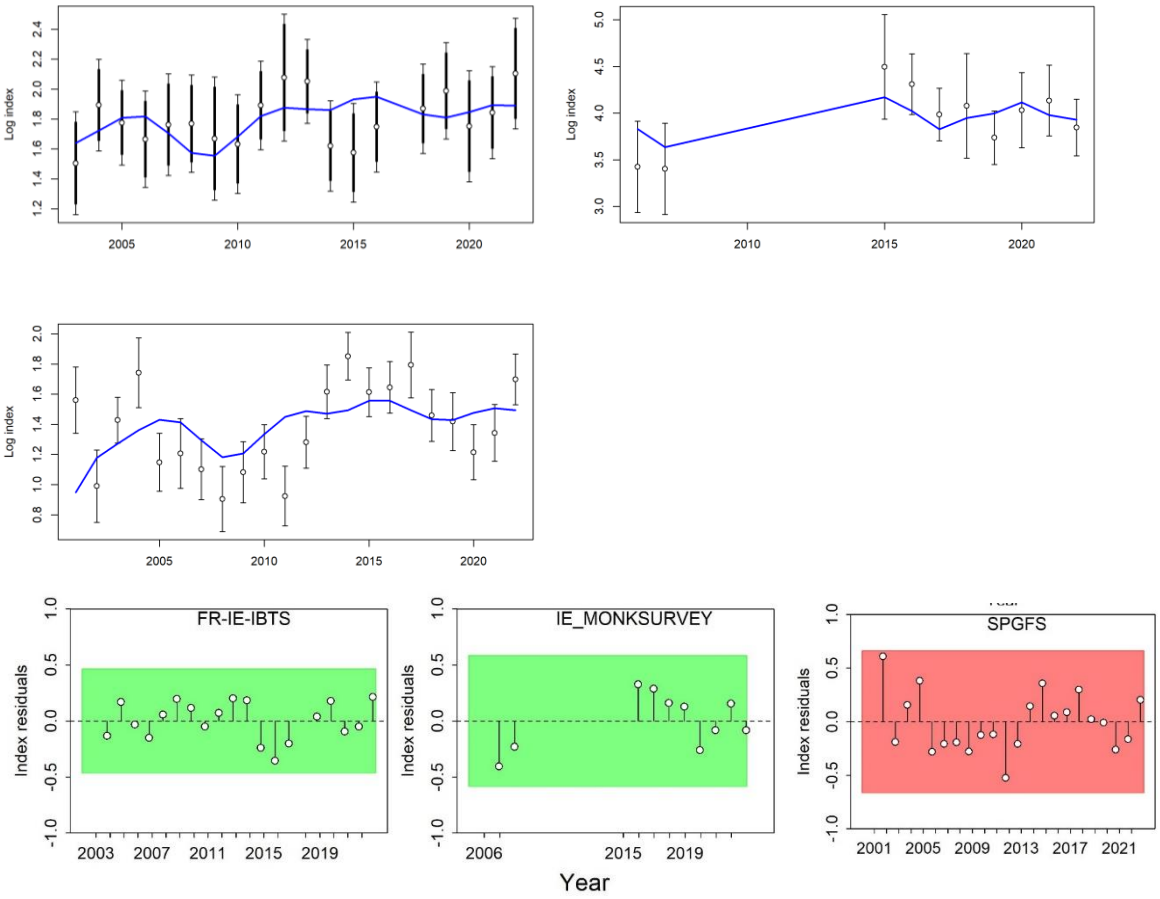

Figure 3.2.13. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Index fit (top) and residuals (bottom). SpPGFS-WIBTS-Q4 (G5768; previous acronym was SP-PGFS) index failed the test runs (red shading) due to the non-randomness in the sign of the residuals. The red and green shadings indicate three standard deviations and observations outside this area and can be considered outliers.

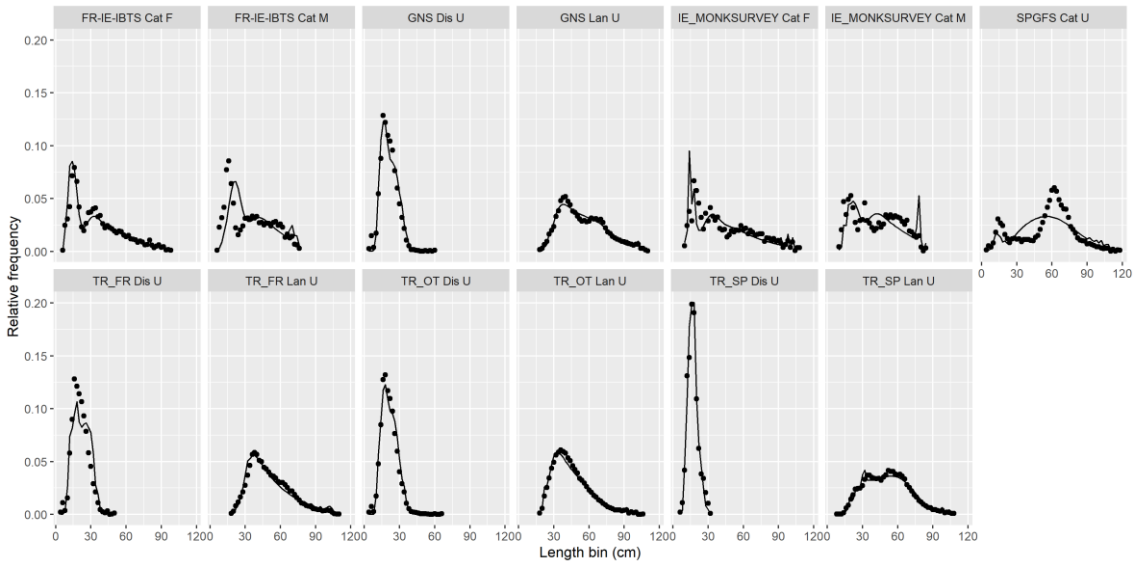

Figure 3.2.14. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Observed (points) and fitted (lines) length compositions of landings, discards and surveys, aggregated overall years. Length compositions for males (Cat M) and females (Cat F) from the EVHOE-WIBTS-Q4 (G9527) and IAMS (G3098) surveys.

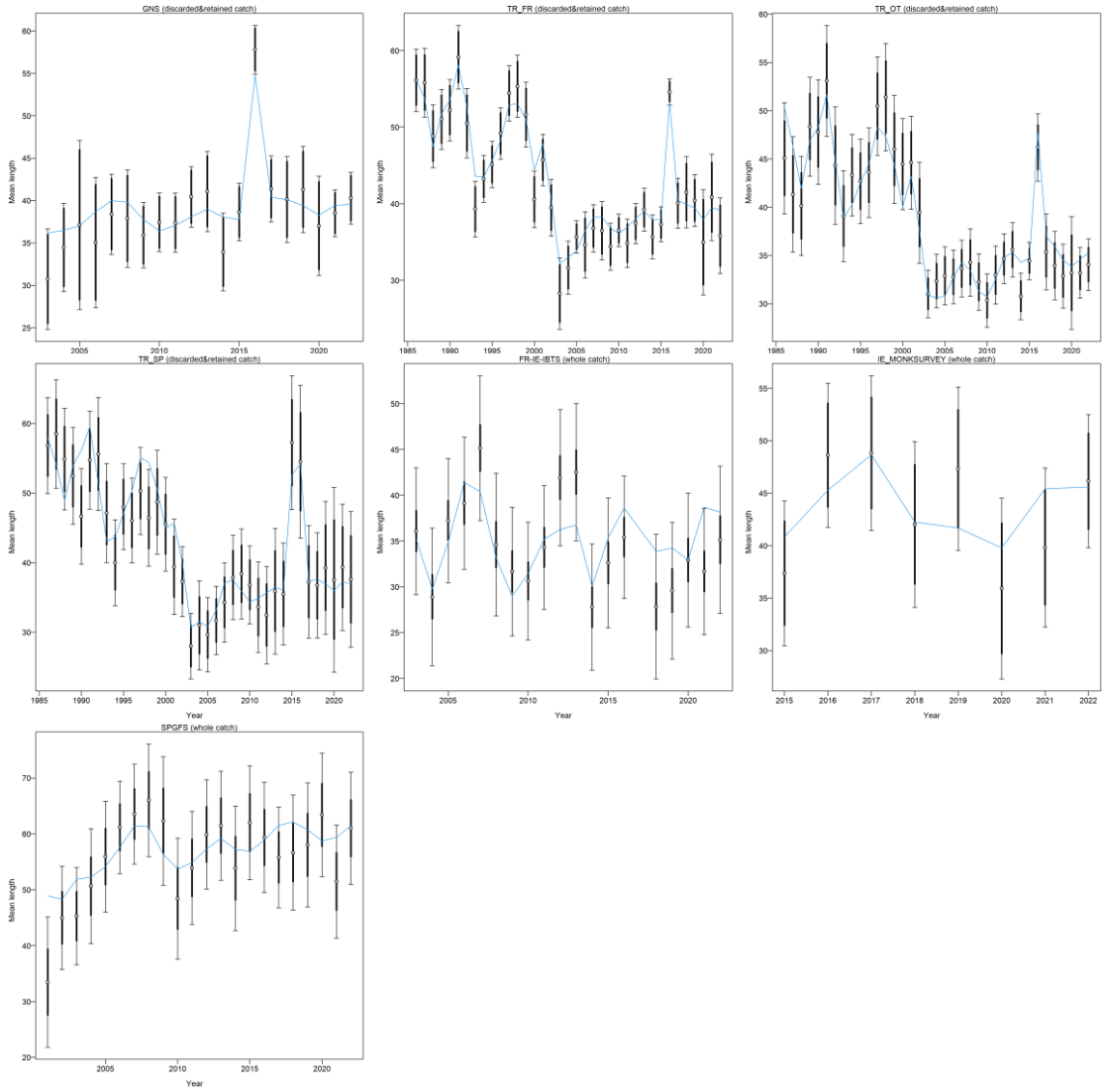

Figure 3.2.15. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Observed (points), the vertical lines the SE and fitted (blue lines) average length compositions by year.

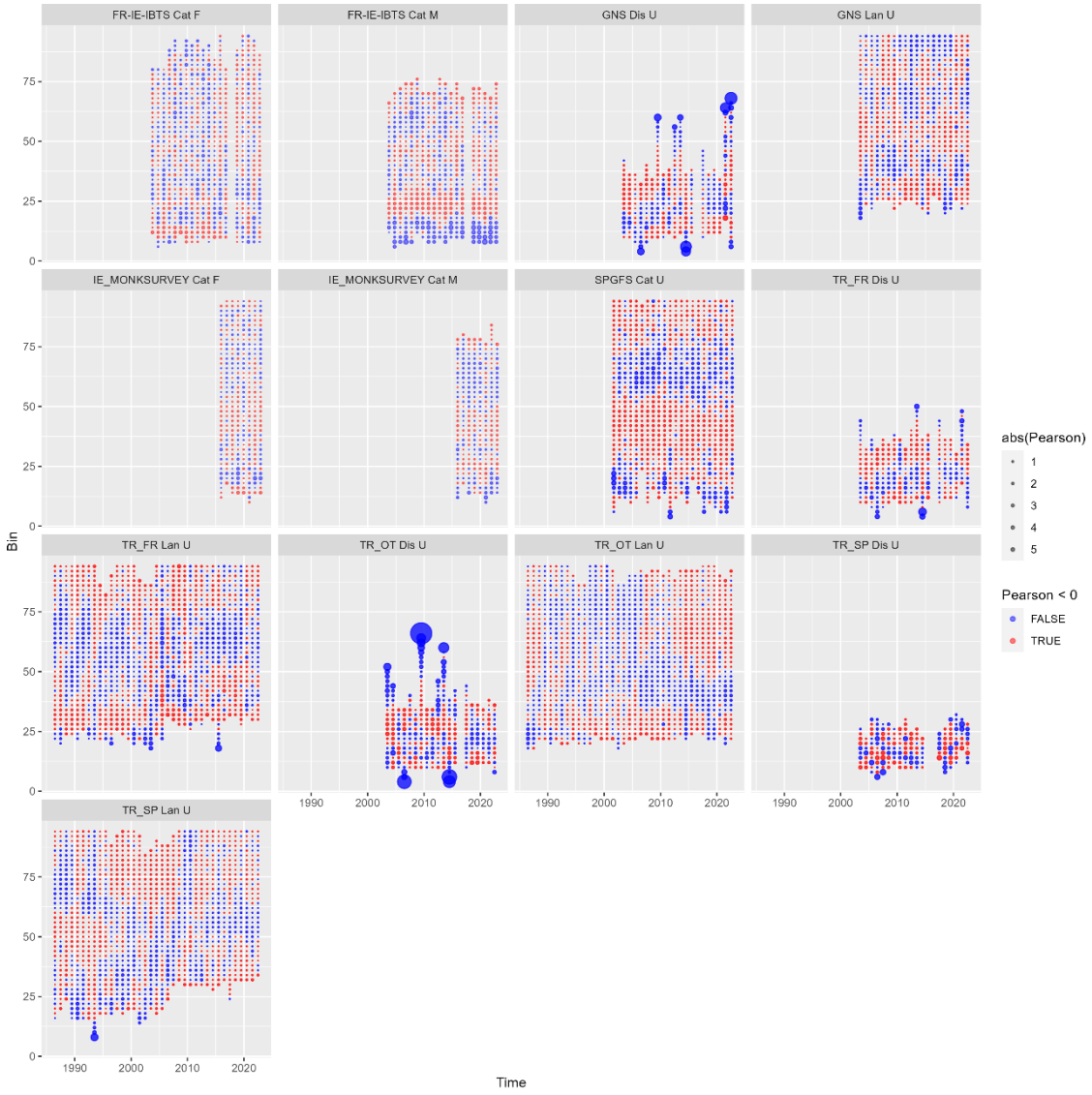

Figure 3.2.16. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Bubble plots of the residuals to the length composition fit.

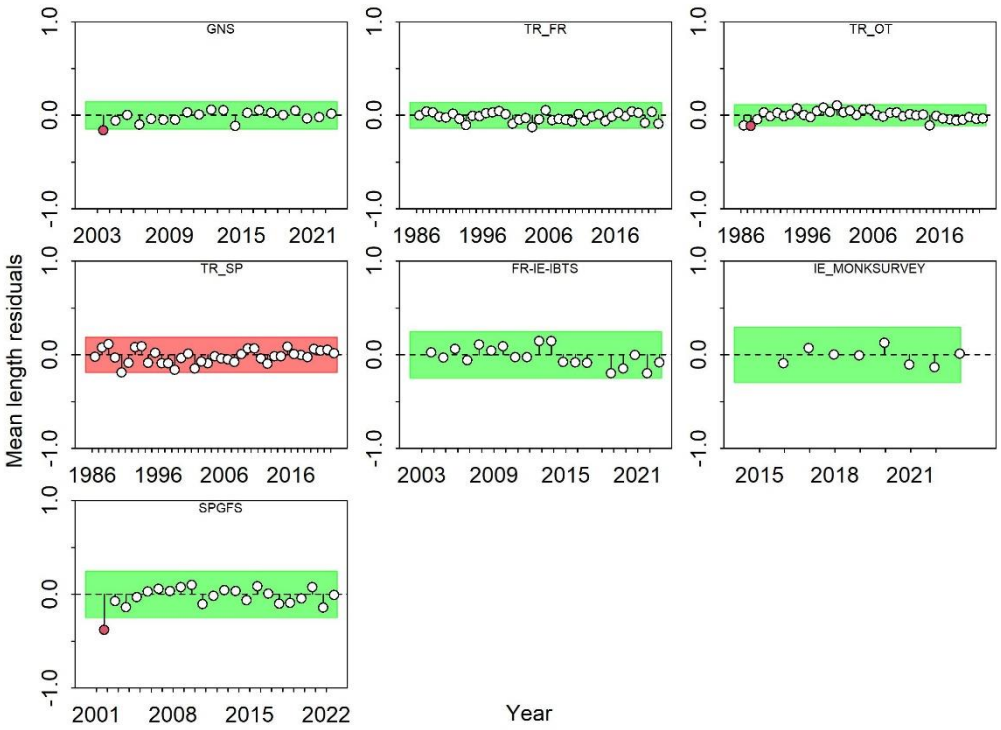

Figure 3.2.17. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Test runs on the mean-length residuals. All the residuals of the commercial fleets and surveys passed the test runs (green shading). This indicates that all the residuals follow a random pattern.

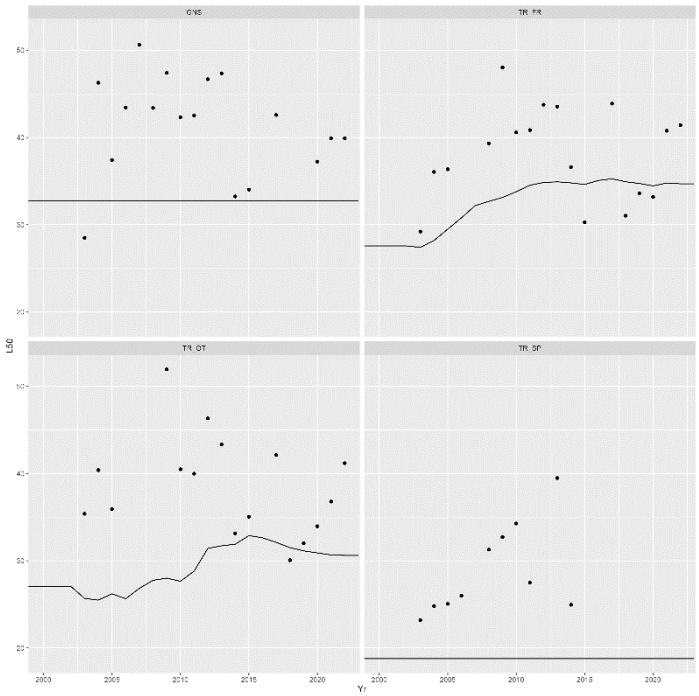

Figure 3.2.18. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Observed (points) and fitted (lines) length at 50% retention. Retention (the proportion of catches that are landed in each size class) is modelled with a logistic curve and the inflection point of the French trawler (TR_FR) and Other trawler (TR_OT) fleets is allowed to vary during the period 2003–2021 with a random walk. For Gillnets (GNS) and Spanish trawler (TR_SP) this parameter has no time-varying flexibility.

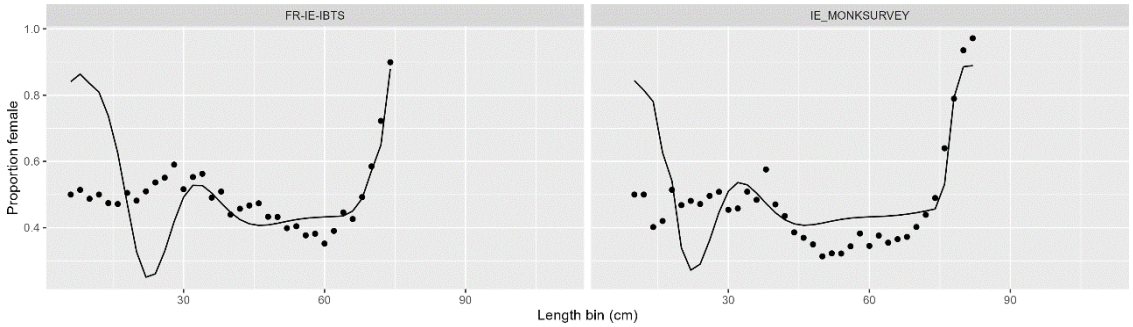

Figure 3.2.19. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Observed (points) and fitted (lines) sex ratio (proportion female) at length. The sexual dimorphism that is apparent from the survey data cannot be fully accommodated with the current settings at the smallest size.

Figure 3.2.20. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Retrospective analysis. The purple line corresponds to the current model run (last data year 2022, for SSB last year 2023). The other colours represent −1 to −5-year peels. The 95% confidence intervals of the final model are indicated by the grey shading.

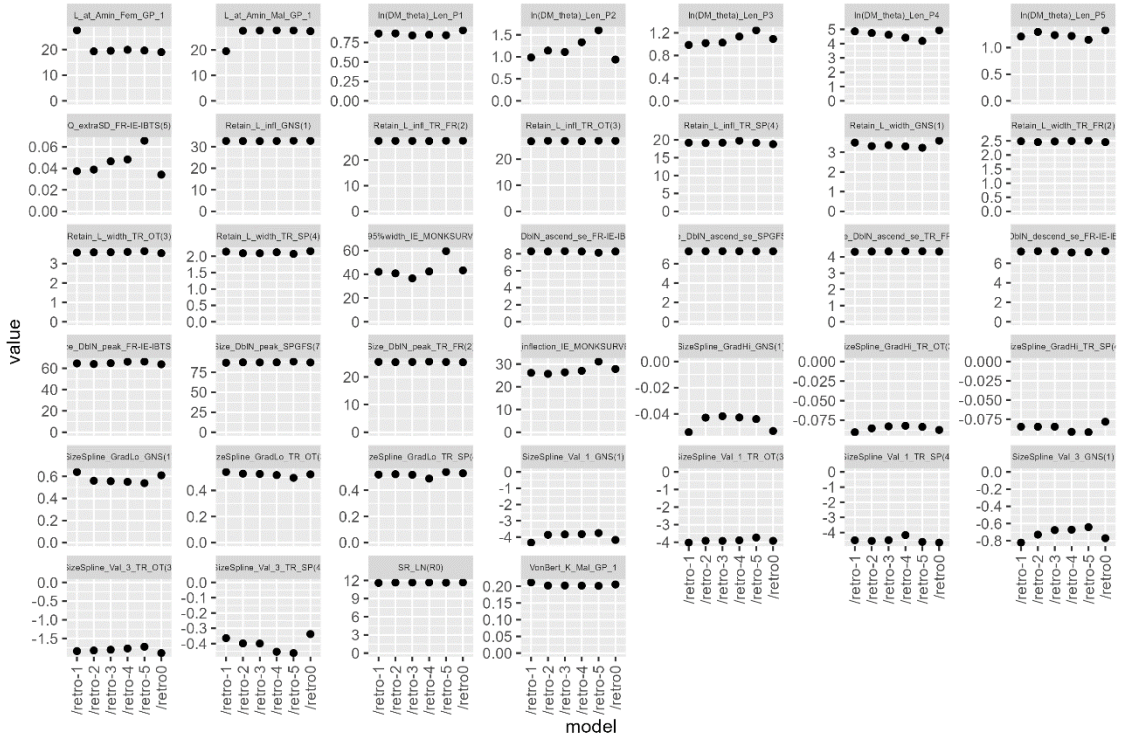

Figure 3.2.21. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. The parameters estimated at each peel from the retrospective analysis.

Figure 3.2.22. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Retrospective analysis assuming a fixed value for length at age 1 for females (*L_at_Amin_Fem* =18.98). The purple line corresponds to the current model run (last data year 2022 and for SSB 2023). The other colours represent −1 to −5-year peels. The 95% confidence intervals of the final model are indicated by the grey shading.

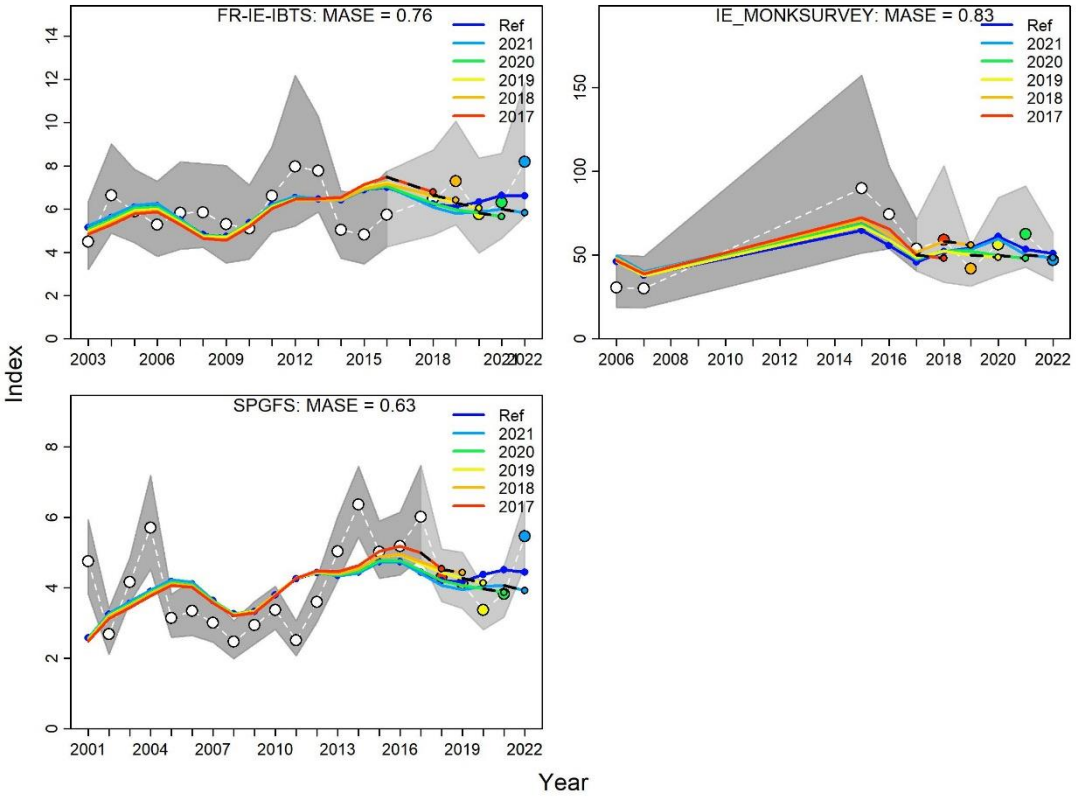

Figure 3.2.23. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Hindcasting results for the survey indices. The three surveys have a very good MASE score of below 1, indicating that the model can predict the indices.

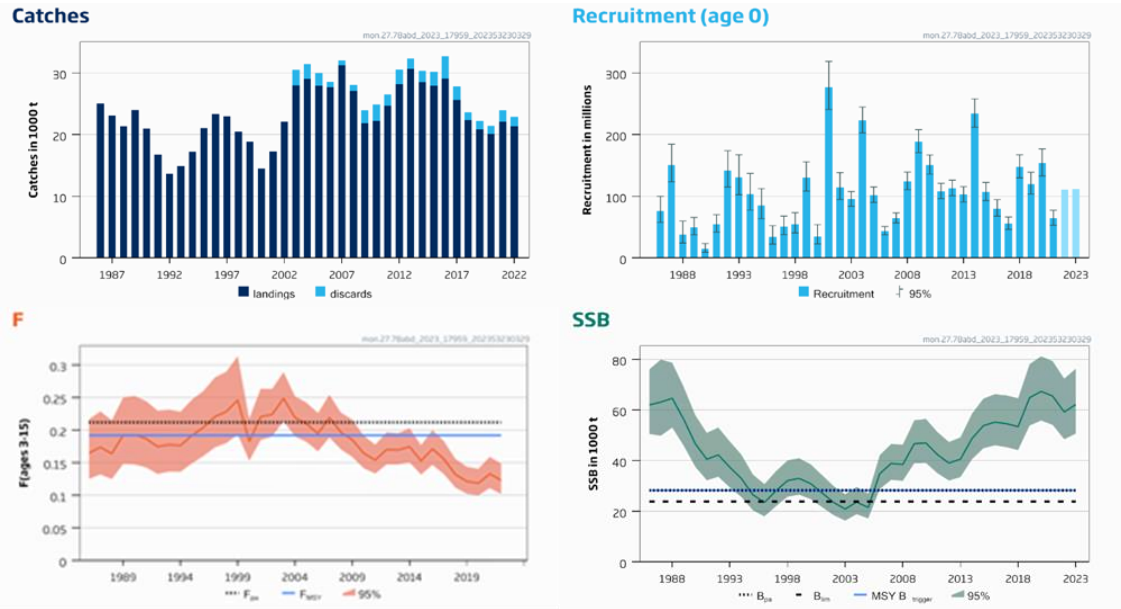

Figure 3.2.24. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Summary plot. Discard observations are available since 2003. Annual landings are available to the model from 1950 but the plots only show the more data-rich period since 1986. SSB displayed here is for both sexes combined. Confidence intervals were scaled up from only the female SSB because the model does not provide CIs for the combined-sex SSB. The assumed recruitment values for 2022 and 2023 are shaded in a lighter colour.

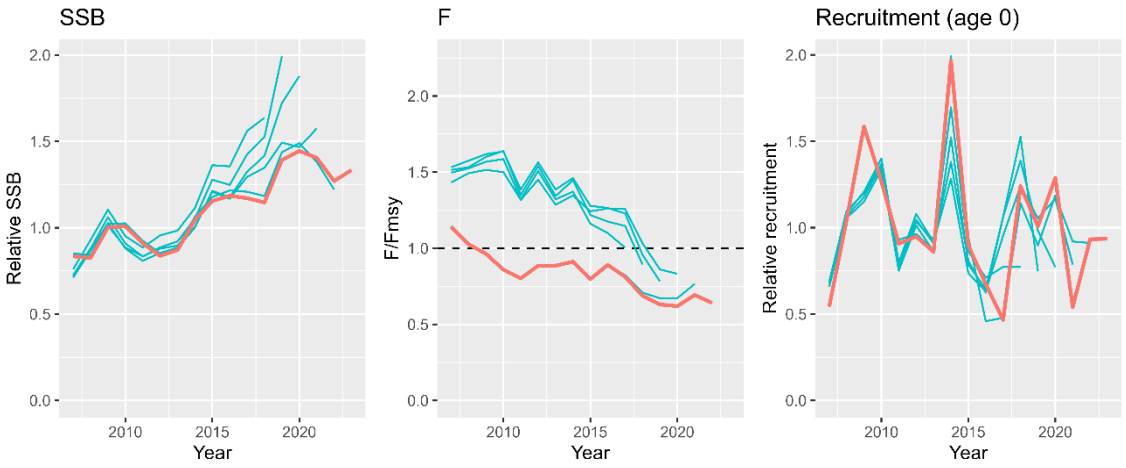

Figure 3.2.25. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Comparison of the current SS assessment (thick, orange line) with the previous assessments (green lines) with SS in 2022 and the previous one with a4a assessment models showing the different reference points. The broad perception of the stock remains unchanged.

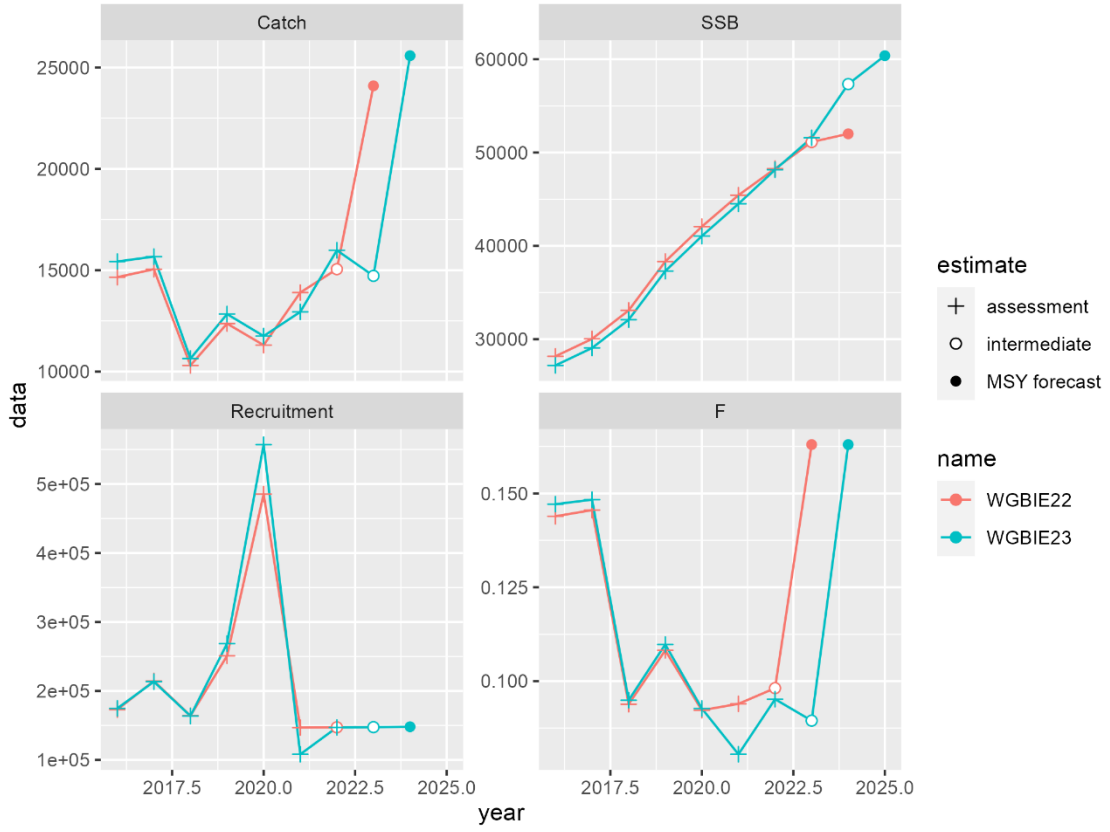

Figure 3.2.26. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Comparison of the current SS assessment (green line) with the previous assessment in 2022 (green line).

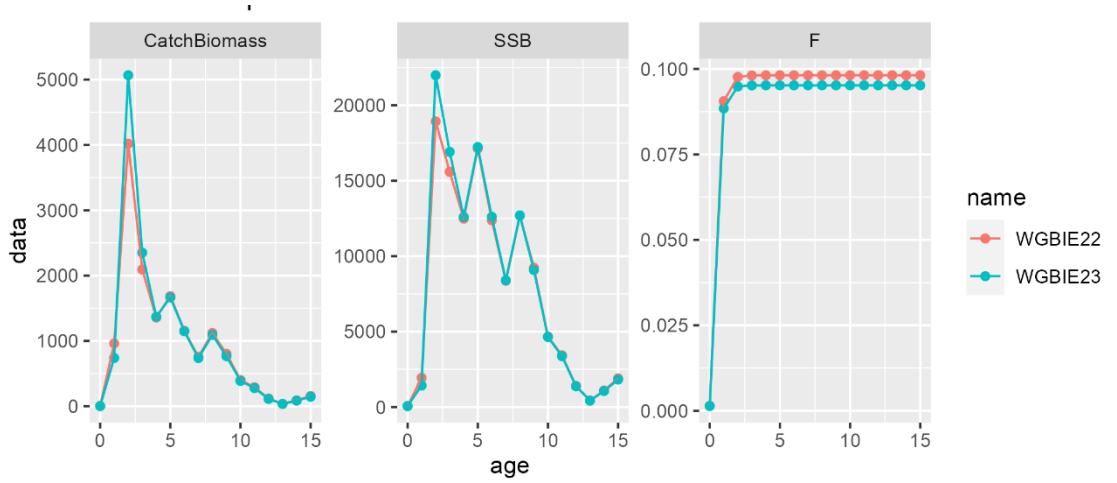

Figure 3.2.27. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Contribution of each age to catches, SSB and the harvest rate at age in 2022.

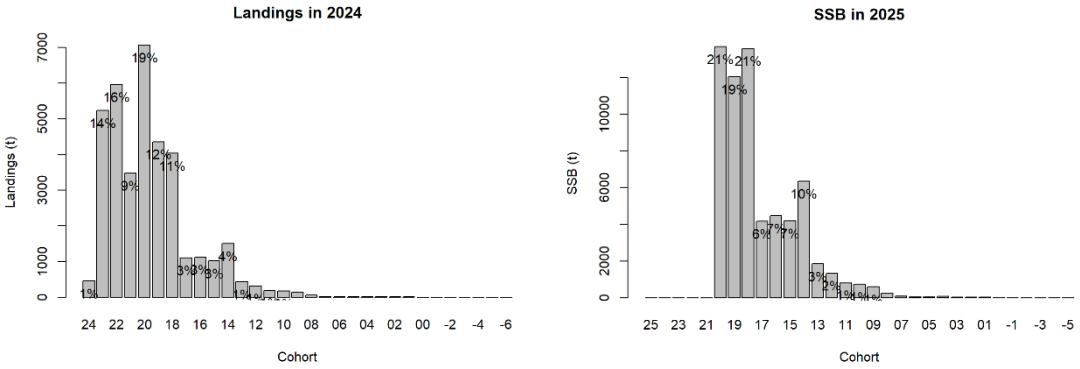

Figure 3.2.28. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Contribution of each cohort to the forecasted landings in 2024 and SSB in 2025.

Table 3.2.1 White-bellied anglerfish (*L. piscatorius*) in 27.78abd. ICES estimates of the catch and landings by area and by country. All weights are in tonnes.

ICES estimated landings from Subarea 7								
Year	FRA	IRL	ESP	GBR	OTH	Unallocated	Total_7	Disc_7
1986	9180	950	5831	3145	1753	0	20859	-
1987	7998	868	5059	3164	1272	0	18361	-
1988	7677	608	4291	3415	1375	0	17366	-
1989	8233	1482	4253	3746	3411	0	21126	-
1990	8161	1371	3985	2647	1440	0	17603	-
1991	6930	1012	3554	2454	655	0	14604	-
1992	5206	1050	2484	2570	946	0	12255	-
1993	5611	1147	2543	2346	1660	0	13308	-

ICES estimated landings from Subarea 7								
Year	FRA	IRL	ESP	GBR	OTH	Unallocated	Total_7	Disc_7
1994	6834	1891	2652	2117	1663	0	15156	-
1995	8867	1541	3004	2374	2134	0	17921	-
1996	9237	1289	3849	2999	1971	0	19345	-
1997	8895	1855	3302	3143	1871	0	19066	-
1998	8052	1896	3403	3049	1287	0	17688	-
1999	7623	3076	2954	2812	853	0	17318	-
2000	6167	1660	2187	2574	831	0	13420	-
2001	7780	1535	2395	2903	1057	0	15669	-
2002	9195	1884	3084	2985	1397	0	18546	-
2003	12081	1456	4662	2850	1569	0	22619	2077
2004	12281	1646	4507	2906	1743	0	23083	1968
2005	11137	2071	4663	3032	1469	0	22371	1779
2006	10607	2656	4589	3137	1375	0	22366	674
2007	12253	2902	5065	4036	1596	0	25852	620
2008	10871	2419	4107	2928	1062	0	21387	743
2009	8691	2048	2754	3013	857	0	17363	1509
2010	8188	2523	2353	3675	993	0	17732	2038
2011	9546	2304	920	4287	1174	1313	19544	1443
2012	12225	2648	1398	4028	1835	1167	23302	1833
2013	12775	2557	3316	4629	1625	1148	26051	1405
2014	11410	2707	1892	6129	1055	337	23529	1443
2015	11721	2582	1693	5644	1284	414	23338	1796
2016	12667	2761	1754	6052	1578	351	25164	3056
2017	11473	2543	1744	5222	1498	0	22479	1912
2018	10360	2148	1810	4156	770	85	19327	1192
2019	9379	2285	1473	4553	858	0	18651	1314
2020	9372	2388	1477	4171	994	0	18185	804
2021	9673	2696	1567	4778	1173	0	19887	1132

ICES estimated landings from Subarea 7								
Year	FRA	IRL	ESP	GBR	OTH	Unallocated	Total_7	Disc_7
2022^	9970	2219	1596	4275	1149	0	19210	985

ICES estimated landings from divisions 8.a–b and 8.d					ICES estimate for Subarea 7 and divisions 8.a–b and 8.d				
Year	FRA	SP	OTH	Unallo-cated	Total_8	Disc_8	Landings	Disc.	Catch
1986	3265	858	0	0	4122	-	24981		0
1987	3955	774	0	0	4729	-	23090		0
1988	3129	819	0	0	3948	-	21314		0
1989	2264	625	0	0	2889	-	24015		0
1990	2580	800	0	0	3379	-	20983		0
1991	1657	502	0	0	2158	-	16763		0
1992	1066	296	0	0	1362	-	13617		0
1993	1314	274	0	0	1587	-	14895		0
1994	1564	481	0	0	2045	-	17201		0
1995	2402	482	0	228	3113	-	21033		0
1996	2216	834	0	938	3988	-	23333		0
1997	2143	707	0	1068	3917	-	22983		0
1998	1534	711	0	542	2787	-	20474		0
1999	924	549	0	0	1473	-	18792		0
2000	690	341	0	0	1032	-	14451		0
2001	1240	384	0	0	1624	-	17293		0
2002	3023	514	0	0	3537	-	22083		0
2003	4806	508	0	0	5315	434	27933	2511	30444
2004	5227	718	0	0	5945	443	29028	2411	31439
2005	4927	571	0	0	5498	332	27869	2110	29980
2006	4819	420	48	0	5287	219	27652	892	28545
2007	4935	401	25	0	5361	197	31213	816	32029
2008	5132	527	7	0	5666	250	27053	993	28046
2009	4065	374	33	0	4472	569	21835	2078	23913

ICES estimated landings from divisions 8.a–b and 8.d					ICES estimate for Subarea 7 and divisions 8.a–b and 8.d				
Year	**FRA**	**SP**	**OTH**	**Unallo-cated**	**Total_8**	**Disc_8**	**Landings**	**Disc.**	**Catch**
2010	4043	367	73	0	4483	634	22215	2672	24886
2011	4569	422	93	30	5114	388	24657	1832	26489
2012	4221	430	194	41	4887	497	28188	2330	30519
2013	4105	318	137	0	4560	279	30611	1684	32295
2014	4279	408	174	84	4945	416	28474	1859	30333
2015	4153	293	65	10	4521	528	27859	2324	30183
2016	3561	283	69	5	3919	529	29083	3585	32668
2017	2886	203	66	0	3154	263	25634	2175	27808
2018	2844	156	15	3	3018	58	22345	1250	23595
2019	1987	130	64	0	2181	50	20832	1364	22196
2020	1666	129	57	0	1852	545	20037	1350	21387
2021	1973	151	29	0	2153	706	22040	1839	23878
2022	1850	219	64	0	2134	567	21343	1552	22895

Table 3.2.2. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Stock assessment model annual landings and discards (in tonnes) input data by fleet: gillnets (GNS), French trawlers (TR_FR), Other trawlers (OT_TR), Spanish trawlers (SP_TR).

Landings

Year	GNS	TR_FR	TR_OT	TR_SP	Year	GNS	TR_FR	TR_OT	TR_SP
1949	0	0	0.00	0	1986	429	10678	7185.00	6689
1950	71.7987	0	416.27	1039.95	1987	560	10132	6565.00	5833
1951	124.25	0.314717	696.75	1070.65	1988	643	9106	6456.00	5109
1952	70.12	0	377.45	1145.29	1989	781	8771	9586.00	4878
1953	82.9043	0	432.85	1229.23	1990	1021	8850	6327.00	4784
1954	70.12	0	362.20	1314.24	1991	1752	6250	4704.00	4056
1955	64.9546	0	383.79	0	1992	1773	3931	5133.00	2780
1956	62.1136	0	425.61	0	1993	1742	4295	6041.00	2817
1957	54.753	0	455.92	0	1994	1377	5901	6790.00	3133
1958	51.8521	0.94415	398.21	0.643461	1995	1915	8026	7605.00	3486
1959	51.5246	0	418.13	2188.45	1996	2244	7960	8446.00	4683

1960	36.0746	0.629434	339.50	2374.41	1997	2538	7494	8941.00	4009
1961	37.0016	0.94415	320.22	2746.76	1998	3398	5559	7404.00	4114
1962	39.7134	0.94415	327.13	2556.95	1999	3162	4885	7242.00	3503
1963	43.3891	0	309.53	2869.1	2000	2034	4322	5567.00	2528
1964	57.6631	0.94415	556.27	3197.5	2001	2002	6463	6048.00	2779
1965	55.786	0	573.59	3811.74	2002	3007	7990	7528.00	3558
1966	66.5734	0.94415	528.56	4309.63	2003	4015	11301	7506.00	5112
1967	86.3309	0.94415	603.29	5358.68	2004	4798	11332	7758.00	5140
1968	88.5032	8297	2223.10	5352.58	2005	5501	9732	7434.00	5203
1969	96.3342	9205.5	2436.38	5865.98	2006	3965	10563	8151.10	4974
1970	83.8082	8313.14	2314.42	6581.38	2007	4775	11980	9012.40	5445
1971	93.235	9708.49	2271.19	7157.23	2008	5467	9900	7067.01	4620
1972	105.291	8127.82	2550.55	9298.86	2009	4101	8287	6337.60	3109
1973	105.936	4669.46	1788.17	7977.11	2010	3902	8023	7583.90	2707
1974	84.1126	7357.35	2117.28	7933.26	2011	4023	9642	8418.76	2573
1975	92.8199	7417.04	2313.70	8289.17	2012	4796	11691	8794.83	2906
1976	102.376	7418.66	2155.80	9092.72	2013	4675	12404	8842.27	4689
1977	90.6984	7508.33	2152.85	6362.12	2014	5393	11294	9114.77	2672
1978	108.883	8877.72	2510.87	6919.76	2015	4544	12250	8710.43	2354
1979	146.074	11058.8	3397.60	5711.61	2016	5287	12052	9408.92	2335
1980	214.829	13638	4709.04	7956.41	2017	5067	10672	7971.52	1922
1981	284.363	14152.6	5184.02	4978.79	2018	3496	9553	7270.00	2025
1982	310.107	12653	5630.97	8132.96	2019	2911	8221	8122.00	1578
1983	630.914	13498.8	8265.45	7619.91	2020	2814	8280	7354.00	1589
1984	772.911	13049.5	9130.690	6260.77	2021	3699	8645	8007	1690
1985	685.339	13225.1	8205.86	6444.24	2022	3106	8724	7780	1733

Discards

Year	GNS	TR_FR	TR_OT	TR_SP	disc.noLikelihood*
2003	237	1250	727.00	297	
2004	817	213	695.00	685	
2005	364	578	853.00	316	
2006	503			100	290.00
2007	468				348.00
2008	215	209		226	343.00
2009	211	691	871.00	304	
2010	254	869	612.00	937	
2011	199	695	764.00	173	
2012	224	705	1265.00	137	
2013	402	399	787.00	96	
2014	235	682	897.00	44	
2015	560	667	1095.00		2.00
2016	535	700	1954.00	396	
2017	457	453	1260.00		6.00
2018	NA	215	936.00		98.00
2019	NA	274	1016.00		74.00
2020	241	358	748.00		3.00
2021	294	707	832		6.00
2022	98	349	1102	4	4

*The discards not considered in the likelihood.

Table 3.2.3. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Survey indices used in the model. IE_Monksurvey (G3098, n/km²) and SpPGFS-WIBTS-Q4 (G5768, previous acronym was SP-PGFS, n/30 mins) survey indices are specified in numbers and the combined FR_IE_IBTS survey in biomass (kg/h). log se is the standard error on the log scale which is similar to the CV of the index.

Year	Month	Fleet	Index	log se	Year	Month	Fleet	Index	log se
2003	10.5	FR_IE_IBTS	1.030	0.18	2001	9.5	SPGFS	4.76	0.11
2004	10.5	FR_IE_IBTS	1.228	0.17	2002	9.5	SPGFS	2.69	0.12
2005	10.5	FR_IE_IBTS	1.128	0.17	2003	9.5	SPGFS	4.17	0.08
2006	10.5	FR_IE_IBTS	1.514	0.14	2004	9.5	SPGFS	5.71	0.12
2007	10.5	FR_IE_IBTS	1.722	0.15	2005	9.5	SPGFS	3.15	0.10

2008	10.5	FR_IE_IBTS	2.921	0.12	2006	9.5	SPGFS	3.34	0.12
2009	10.5	FR_IE_IBTS	2.187	0.13	2007	9.5	SPGFS	3.01	0.10
2010	10.5	FR_IE_IBTS	2.004	0.15	2008	9.5	SPGFS	2.47	0.11
2011	10.5	FR_IE_IBTS	1.926	0.14	2009	9.5	SPGFS	2.95	0.10
2012	10.5	FR_IE_IBTS	2.010	0.16	2010	9.5	SPGFS	3.38	0.09
2013	10.5	FR_IE_IBTS	2.345	0.13	2011	9.5	SPGFS	2.52	0.10
2014	10.5	FR_IE_IBTS	2.001	0.13	2012	9.5	SPGFS	3.60	0.09
2015	10.5	FR_IE_IBTS	1.957	0.22	2013	9.5	SPGFS	5.03	0.09
2016	10.5	FR_IE_IBTS	2.419	0.13	2014	9.5	SPGFS	6.37	0.08
2017	10.5	FR_IE_IBTS	2.877	0.20	2015	9.5	SPGFS	5.02	0.08
2018	10.5	FR_IE_IBTS	4.437	0.12	2016	9.5	SPGFS	5.18	0.09
2019	10.5	FR_IE_IBTS	4.434	0.11	2017	9.5	SPGFS	6.01	0.11
2020	10.5	FR_IE_IBTS	4.416	0.12	2018	9.5	SPGFS	4.30	0.09
2021	10.5	FR_IE_IBTS	4.865	0.11	2019	9.5	SPGFS	4.13	0.10
2022	10.5	FR_IE_IBTS	8.190	0.15	2020	9.5	SPGFS	3.37	0.09
2006	12	IAMS (G3098)	21.890	0.25	2021	9.5	SPGFS	3.83	0.10
2007	12	IAMS (G3098)	29.650	0.25	2022	9.5	SPGFS	5.46	0.09
2015	12	IAMS (G3098)	69.040	0.18					
2016	12	IAMS (G3098)	73.400	0.17					
2017	12	IAMS (G3098)	47.908	0.23					
2018	12	IAMS (G3098)	49.640	0.18					
2019	12	IAMS (G3098)	40.970	0.18					
2020	12	IAMS (G3098)	47.170	0.20					
2021	12	IAMS (G3098)	96.410	0.22					
2022	12	IAMS (G3098)	46.810	0.15					

Table 3.2.4. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Assessment summary results with 95% confidence intervals. Weights are in tonnes and recruitment is in thousands. Discard observations are available since 2003. Annual landings are available to the model from 1950 but the plots only show the more data-rich period since 1986.

Year	Recruitment Age 0			SSB (male + female)			Landings**	Discards**			
	Recruits	2.5%	97.5%	SSB	2.5%	97.5%			F	2.5%	97.5%
1986	57519	75763	99793	50528	61972	76008	24981		0.125	0.165	0.22

Year	Recruitment Age 0			SSB (male + female)			Land-ings**	Dis-cards**			
	Recruits	2.5%	97.5%	SSB	2.5%	97.5%			F	2.5%	97.5%
1987	123260	150769	184417	49806	63082	79896	23090		0.132	0.174	0.23
1988	24145	38013	59847	53031	64603	78701	21314		0.125	0.164	0.22
1989	37525	49634	65651	45832	56278	69104	24015		0.148	0.192	0.25
1990	9107	14629	23501	37545	46659	57984	20983		0.147	0.193	0.25
1991	41931	54312	70348	32240	40536	50965	16763		0.143	0.187	0.24
1992	115044	141371	173722	33628	42248	53079	13617		0.133	0.175	0.23
1993	102491	130972	167367	29372	37378	47566	14895		0.136	0.178	0.23
1994	77813	103308	137157	25603	32938	42374	17201		0.136	0.176	0.23
1995	63614	84591	112486	20354	26515	34541	21033		0.149	0.192	0.25
1996	22327	34133	52181	17977	23510	30745	23333		0.160	0.20	0.26
1997	37939	50797	68013	22007	28085	35843	22983		0.173	0.22	0.28
1998	40661	54569	73233	25713	32115	40112	20474		0.180	0.23	0.29
1999	108278	129937	155928	26558	32988	40975	18792		0.193	0.25	0.31
2000	22699	35071	54186	24818	30945	38585	14451		0.153	0.183	0.22
2001	240639	276937	318711	21624	27237	34307	17293		0.185	0.22	0.26
2002	94592	114360	138260	18459	23518	29963	22083		0.191	0.22	0.26
2003	83850	95044	107732	16301	20883	26754	27933	2511	0.21	0.25	0.29
2004	202603	222581	244529	18855	23639	29637	29028	2411	0.190	0.22	0.25
2005	89974	101811	115206	17143	21484	26925	27869	2110	0.182	0.21	0.24
2006	37444	43708	51020	28770	34833	42173	27652	892	0.167	0.195	0.23
2007	56799	64438	73105	32440	38889	46619	31213	816	0.189	0.22	0.25
2008	110599	124021	139072	31980	38477	46294	27053	993	0.171	0.197	0.23
2009	170622	188403	208037	38969	46693	55949	21835	2078	0.159	0.185	0.22
2010	135881	150672	167074	39092	46986	56473	22215	2672	0.141	0.165	0.191
2011	96149	107917	121126	35024	42392	51311	24657	1832	0.133	0.154	0.178
2012	100727	112756	126222	32134	39019	47379	28188	2330	0.147	0.170	0.197
2013	90614	102286	115462	33482	40577	49175	30611	1684	0.147	0.170	0.195
2014	212047	233878	257957	40541	48713	58532	28474	1859	0.150	0.175	0.20

Year	Recruitment Age 0			SSB (male + female)			Land-ings**	Dis-cards**			
	Recruits	2.5%	97.5%	SSB	2.5%	97.5%			F	2.5%	97.5%
2015	92957	106713	122504	44883	53819	64532	27859	2324	0.132	0.153	0.177
2016	67732	80039	94583	46034	55225	66250	29083	3585	0.147	0.171	0.20
2017	46198	55427	66499	45290	54569	65749	25634	2175	0.132	0.156	0.183
2018	129912	147424	167297	44129	53414	64652	22345	1250	0.112	0.132	0.156
2019	103312	119791	138898	53865	64869	78120	20832	1364	0.102	0.121	0.144
2020	132864	153211	176674	55814	67311	81177	20037	1350	0.100	0.119	0.141
2021	53059	64079	77387	54082	65487	79296	22040	1839	0.111	0.133	0.159
2022	110863*			48419	59187	72349	21343	1552	0.102	0.123	0.149
2023	111245*			50625	62159	76321					

*** Assumed recruitment based on stock–recruit relationship (model estimate was 93 341 t)**

**** Observed landings and discards (tonnes); not all discard observations were provided to the model.**

Table 3.2.5. White-bellied anglerfish (*L. piscatorius*) in 27.78abd. Catch options based on different F values (F mult): Catch, landings and discards in 2023.All weights are in tonnes. F of the catch, landings and discards in 2023. SSB in 2024 (in kilotonnes). dSSB, dadv are the change in SSBand advice with the previous year (%).

F_{mult}	Catch23	Land23	Dis23	FCatch23	FLand23	FDis23	SSB24	dSSB	dadv23
0	0	0	0	0	0	0	79055	23.13	-100%
0.01	2028	1777	251	0.01	0.0099	0.000089	78232	21.84	-94%
0.02	4036	3536	500	0.02	0.0198	0.000177	77417	20.57	-88%
0.03	6022	5276	746	0.03	0.03	0.00027	76611	19.32	-83%
0.04	7989	6999	990	0.04	0.04	0.00035	75814	18.08	-77%
0.05	9934	8703	1231	0.05	0.05	0.00044	75024	16.85	-71%
0.06	11860	10390	1470	0.06	0.059	0.00053	74243	15.63	-66%
0.07	13766	12060	1706	0.07	0.069	0.00062	73470	14.43	-60%
0.08	15653	13712	1941	0.08	0.079	0.00071	72706	13.24	-55%
0.09	17520	15347	2173	0.09	0.089	0.0008	71949	12.06	-49%
0.10	19367	16965	2402	0.10	0.099	0.00089	71200	10.89	-44%
0.11	21196	18567	2629	0.11	0.109	0.00097	70459	9.74	-39%
0.12	23006	20152	2855	0.12	0.119	0.00106	69726	8.60	-33%
0.13	24798	21720	3077	0.13	0.129	0.00115	69001	7.47	-28%
0.14	26571	23273	3298	0.14	0.139	0.00124	68283	6.35	-23%

0.15	28326	24809	3517	0.15	0.149	0.00133	67572	5.24	-18.00%
0.16	30062	26329	3733	0.16	0.159	0.00142	66869	4.15	-13.00%
0.17	31781	27834	3947	0.17	0.168	0.00151	66174	3.06	-8.00%
0.18	33483	29324	4159	0.18	0.178	0.00159	65486	1.99	-3.10%
0.19	35167	30798	4369	0.19	0.188	0.00168	64804	0.93	1.82%
0.20	36834	32256	4577	0.20	0.198	0.00177	64131	-0.12	6.60%
0.21	38484	33700	4783	0.21	0.21	0.00186	63464	-1.16	11.40%
0.22	40117	35129	4987	0.22	0.22	0.00195	62804	-2.19	16.10%
0.23	41733	36543	5189	0.23	0.23	0.002	62151	-3.20	21%
0.24	43333	37943	5390	0.24	0.24	0.0021	61504	-4.21	25%
0.25	44916	39328	5588	0.25	0.25	0.0022	60865	-5.21	30%
0.26	46483	40699	5784	0.26	0.26	0.0023	60232	-6.19	35%
0.27	48035	42056	5978	0.27	0.27	0.0024	59606	-7.17	39%
0.28	49570	43400	6171	0.28	0.28	0.0025	58987	-8.13	44%
0.29	51090	44729	6361	0.29	0.29	0.0026	58373	-9.09	48%
0.30	52595	46045	6550	0.30	0.30	0.0027	57767	-10.03	52%
0.31	54084	47347	6737	0.31	0.31	0.0027	57166	-10.97	57%
0.32	55558	48636	6922	0.32	0.32	0.0028	56572	-11.89	61%
0.33	57017	49912	7105	0.33	0.33	0.0029	55984	-12.81	65%
0.34	58461	51174	7287	0.34	0.34	0.003	55403	-13.71	69%
0.35	59891	52424	7467	0.35	0.35	0.0031	54827	-14.61	73%
0.36	61306	53661	7645	0.36	0.36	0.0032	54258	-15.50	77%
0.37	62707	54885	7821	0.37	0.37	0.0033	53694	-16.37	82%
0.38	64094	56097	7996	0.38	0.38	0.0034	53136	-17.24	86%
0.39	65466	57297	8169	0.39	0.39	0.0035	52584	-18.10	90%
0.40	66825	58484	8341	0.40	0.40	0.0035	52038	-18.95	93%
0.41	68170	59659	8511	0.41	0.41	0.0036	51498	-19.79	97%
0.42	69501	60823	8679	0.42	0.42	0.0037	50963	-20.63	101%
0.43	70819	61974	8845	0.43	0.43	0.0038	50434	-21.45	105%
0.44	72124	63114	9010	0.44	0.44	0.0039	49910	-22.27	109%

0.45	73416	64242	9174	0.45	0.45	0.004	49392	-23.07	113%
0.46	74694	65358	9336	0.46	0.46	0.0041	48879	-23.87	116%
0.47	75960	66464	9496	0.47	0.47	0.0042	48372	-24.66	120%
0.48	77213	67558	9655	0.48	0.48	0.0043	47869	-25.45	124%
0.49	78453	68641	9813	0.49	0.49	0.0043	47372	-26.22	127%
0.50	79681	69713	9969	0.50	0.50	0.0044	46881	-26.98	131%
0.51	80897	70774	10123	0.51	0.51	0.0045	46394	-27.74	134%
0.52	82100	71824	10276	0.52	0.52	0.0046	45913	-28.49	138%
0.53	83292	72864	10428	0.53	0.53	0.0047	45436	-29.24	141%
0.54	84471	73893	10578	0.54	0.54	0.0048	44965	-29.97	145%
0.55	85639	74912	10727	0.55	0.55	0.0049	44498	-30.70	148%
0.56	86795	75920	10875	0.56	0.56	0.005	44037	-31.41	151%
0.57	87939	76918	11021	0.57	0.56	0.005	43580	-32.13	155%
0.58	89072	77907	11166	0.58	0.57	0.0051	43128	-32.83	158%
0.59	90194	78885	11309	0.59	0.58	0.0052	42680	-33.53	161%
0.60	91304	79853	11451	0.60	0.59	0.0053	42238	-34.22	164%
0.61	92404	80812	11592	0.61	0.60	0.0054	41799	-34.90	168%
0.62	93492	81761	11731	0.62	0.61	0.0055	41366	-35.57	171%
0.63	94570	82700	11870	0.63	0.62	0.0056	40937	-36.24	174%
0.64	95637	83630	12007	0.64	0.63	0.0057	40512	-36.90	177%
0.65	96693	84551	12142	0.65	0.64	0.0058	40092	-37.56	180%
0.66	97739	85462	12277	0.66	0.65	0.0058	39677	-38.20	183%
0.67	98774	86364	12410	0.67	0.66	0.0059	39265	-38.85	186%
0.68	99799	87257	12542	0.68	0.67	0.006	38858	-39.48	189%
0.69	100814	88141	12673	0.69	0.68	0.0061	38455	-40.11	192%
0.70	101819	89016	12803	0.70	0.69	0.0062	38057	-40.73	195%
0.71	102814	89883	12931	0.71	0.7	0.0063	37662	-41.34	198%
0.72	103799	90741	13059	0.72	0.71	0.0064	37272	-41.95	200%
0.73	104775	91590	13185	0.73	0.72	0.0065	36886	-42.55	200%
0.74	105741	92431	13310	0.74	0.73	0.0066	36504	-43.15	210%

0.75	106697	93263	13434	0.75	0.74	0.0066	36125	-43.74	210%
0.76	107644	94087	13557	0.76	0.75	0.0067	35751	-44.32	210%
0.77	108581	94903	13679	0.77	0.76	0.0068	35381	-44.9	210%
0.78	109510	95710	13799	0.78	0.77	0.0069	35014	-45.47	220%
0.79	110429	96510	13919	0.79	0.78	0.007	34651	-46.03	220%
0.80	111339	97302	14037	0.80	0.79	0.0071	34292	-46.59	220%
0.81	112240	98085	14155	0.81	0.8	0.0072	33937	-47.14	220%
0.82	113132	98861	14271	0.82	0.81	0.0073	33586	-47.69	230%
0.83	114016	99629	14387	0.83	0.82	0.0073	33238	-48.23	230%
0.84	114891	100390	14501	0.84	0.83	0.0074	32894	-48.77	230%
0.85	115757	101143	14614	0.85	0.84	0.0075	32553	-49.30	240%
0.86	116615	101888	14727	0.86	0.85	0.0076	32216	-49.82	240%
0.87	117465	102626	14838	0.87	0.86	0.0077	31882	-50.34	240%
0.88	118306	103357	14949	0.88	0.87	0.0078	31552	-50.86	240%
0.89	119139	104081	15058	0.89	0.88	0.0079	31226	-51.37	240%
0.90	119964	104797	15167	0.90	0.89	0.0080	30902	-51.87	250%
0.91	120781	105506	15274	0.91	0.90	0.0081	30582	-52.37	250%
0.92	121589	106209	15381	0.92	0.91	0.0081	30266	-52.86	250%
0.93	122390	106904	15487	0.93	0.92	0.0082	29953	-53.35	250%
0.94	123184	107592	15591	0.94	0.93	0.0083	29643	-53.83	260%
0.95	123969	108274	15695	0.95	0.94	0.0084	29336	-54.31	260%
0.96	124747	108949	15798	0.96	0.95	0.0085	29032	-54.78	260%
0.97	125518	109617	15900	0.97	0.96	0.0086	28732	-55.25	260%
0.98	126280	110279	16002	0.98	0.97	0.0087	28435	-55.71	270%
0.99	127036	110934	16102	0.99	0.98	0.0088	28140	-56.17	270%
1.00	127784	111583	16201	1.00	0.99	0.0089	27849	-56.63	270%

3.3 Black-bellied anglerfish (Lophius budegassa) in Subarea 7 and divisions 8.a, 8.b, and 8.d

3.3.1 Data

3.3.1.1 Data revisions

UK submitted revised landings data in October 2022. This resulted in an increase of 1 319 t of landings for 2021.

3.3.1.2 Landings and discards

Landings and discard data were extracted from InterCatch and processed according to methods outlined in the Stock Annex[3]. Normally, discard rates (proportion of the catch weight that was discarded) are used to estimate the discard volume for strata with missing discard data. This year, the discard rates of the French OTB_CRU and OTB_DEF fleets appeared to be unrealistically high (Figure 3.3.1) and were replaced with the average discard rates of other OTB_CRU and OTB_DEF fleets from 2017-2022. (Note that this was to fill in un-sampled discards only).

Overall, discard rates are relatively low (between 5 and 20% of the catch over the full time series; the average of last 3 years was 17%). Typically, between 20 and 55% of the estimated discards result from fill-ins; the average of this figure over the last 3 years was 43% (Figure 3.3.2).

Table 3.3.1 provides the ICES estimates of landings and discards by country and area.

3.3.1.3 Catch numbers-at-length

The Stock Annex describes the methods for filling in un-sampled landings and discards. Figure 3.3.2 shows that >50% of the landings had length data associated with them. This was an improvement from the previous year when this figure was less than 40%. Figure 3.3.3 shows the annual LFDs of the catch data both before and after filling in un-sampled catches.

While discards consist of a relatively small proportion of the catch weight, they contributed 61% of the catch numbers over the last 3 years. Increases in mesh size in the trawl fisheries do not appear to have reduced catches of anglerfish below 30 cm, this is likely due to their shape, which makes it difficult for even the smallest individuals to escape through the meshes.

3.3.1.4 Surveys

The surveys are described in detail in the Stock Annex. Three surveys are used:

- IE-IGFS (G7212) and EVHOE (G9527); this combined French and Irish survey index is referred to by the ICES acronym FR_IE_IBTS.
- The Irish Anglerfish and Megrim survey IAMS (G3098);

The survey indices are provided in Table 3.3.2.

FR_IE_IBTS

Figure 3.3.4a shows the spatial distribution of the catches of recruits on the FR_IE_IBTS surveys. Recruitment generally occurs in the western Celtic Sea and some years in Biscay. In 2020, there

[3] ICES. 2022. ICES Stock Annex: Black-bellied anglerfish (*Lophius budegassa*) in Subarea 7 and divisions 8.a–b and 8.d (Celtic Seas, Bay of Biscay). Produced by the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) and updated in August 2022 by the Benchmark workshop on anglerfish and hake (WKANGHAKE; ICES, 2023b). https://doi.org/10.17895/ices.pub.18622010.

were large numbers of recruits, particularly in the Biscay area. Recruitment in 2022 appears to be quite good in both the Celtic Sea and Biscay but not as high as the year before.

Figure 3.3.4b shows the spatial distribution of the catch weights on the two IBTS surveys. During some years, the catches are highest in the area covered by the IGFS-WIBTS-Q4 (G7212) survey, in other years the EVHOE-WIBTS-Q4 (G9527) survey has higher catches. It is unclear whether this is due to the movement of the stock or whether it is due to factors affecting the catchability on the surveys (e.g. weather, gear performance).

Figure 3.3.5 shows the biomass indices of the two IBTS surveys as well as the combined FR_IE_IBTS index. The combined FR_IE_IBTS survey biomass index is more stable than the single IBTS survey indices. Both the French and Irish IBTS surveys recorded high biomass in the last year. The (Irish) IGFS-WIBTS-Q4 (G7212) survey had shown a moderate declining trend between 2018 and 2020 but had recovered since then. The (French) EVHOE-WIBTS-Q4 (G9527) survey index has been increasing since 2016. The combined FR_IE_IBTS index was stable between 2018 and 2020 and has been increasing moderately in the last 2 years.

In 2017, the French survey vessel Thalassa suffered major mechanical issues and the majority of the EVHOE bottom trawl survey could not be completed. The VAST (Vector Autoregressive Spatio-Temporal; Thorson 2019) model (www.github.com/james-thorson/VAST) was used to estimate the missing 2017 data (Gerritsen and Minto, 2019). VAST is a spatially explicit model that predicts population density for all locations within a spatial domain, and then predicts derived quantities (e.g. biomass, abundance) by aggregating population density across the spatial domain while weighting density estimates by the area associated with each estimate. VAST imputes biomass or abundance in unsampled areas using spatially correlated random effects. Details were provided in Working Document (WD) 01 (Gerritsen and Minto, 2019) to WGBIE in 2019 (ICES, 2019).

IAMS

Figure 3.3.6 shows the spatial distribution of the catches on the IAMS (G3098) survey. The catch rates in 2022 in the south-western Celtic Sea were very high, following exceptional recruitment in 2021.

Figure 3.3.7 shows the index of the IAMS (G3098) survey. The survey takes place at the start of the year, but in order to facilitate the inclusion of an in-year index, the data are provided to the model as if the survey occurred on the last day of the previous year such that, for example, the 2023 index is used for the assessment performed in 2023, but provided to the model as if it occurred on 31 December 2022. An industry-science partnership survey was carried out in 2006 and 2007 on-board a commercial vessel using the same fishing gear and methodology as the IAMS (G3098) survey and these data points were included in order to extend the time series.

3.3.1.5 Biology and model settings

Maturity, natural mortality, growth, and length-weight parameters are all fixed (not estimated by the model) and are described in the Stock Annex. Figure 3.3.8 shows the assumed growth curves for males and females.

Recruitment bias adjustment settings were updated following the Stock Annex.

3.3.1.6 Deviations from the Stock Annex

There were no deviations from the Stock Annex.

3.3.2 Model diagnostics

The model diagnostics broadly follow the approach described by Carvalho *et al*. (2021).

3.3.2.1 Convergence

- No parameters are estimated at or near bounds or with unusually large variance.
- The final gradient is < 1e-7.
- The Hessian is positive definite.
- 50 jitter runs were performed using default settings for magnitude and 37 of these runs converged. Out of the converged runs, 33 converged on the same likelihood as the base run (-15649.5) and 4 runs resulted in a slightly higher negative log-likelihood (-15644.9).
- There was a strong correlation in the parameters controlling the ascending part of the double-normal selectivity curve for the combined FR_IE_IBTS survey (97%). However, because nearly all (33/37) the converged jitter runs found the same solution this correlation was not considered to be problematic.

WGBIE did not identify problems with model convergence.

3.3.2.2 Goodness-of-fit

Catch

Figure 3.3.9 shows the observed and fitted landings and discards. The fit to the discards does not follow the observations very closely, reflecting the uncertainty in the discard data. However, the fit is not consistently lower or higher than the observed discards. The fit to the landings is quite close to the observed values, except in the early 1980s when the model expected higher landings than observed. This occurs just before the sampling data are introduced to the model in 1986 which may reflect the inability of the model to accommodate the variability of recruitment before 1986.

Indices

Figure 3.3.10 shows the fit of the indices. There is some conflict between the two indices, but they agree on an overall increasing trend. The FR_IE_IBTS survey failed the runs test, presumably because the residuals are all positive in the last 5 years while they were mainly negative in the preceding years. This is not a major concern and is to be expected when there is a conflict between indices. The joint residuals are generally negative at the start of the time-series, indicating that there is also some conflict between the surveys and other data sources (probably the catch). However, the Root Mean Square Error RMSE is relatively small (21.9%) indicating a reasonably precise fit to the indices while Carvalho et. al. (2021) suggests a rule-of-thumb value of < 30%.

Length compositions

The fit to the length data is generally quite good, although there are some residual patterns. Figure 3.3.11 shows, by fleet, the fit to the aggregated length distributions and Figure 3.3.12 provides annual length distributions of landings and discards by fleet and for males and females in case of surveys. The residual plots (Figure 3.3.13) indicate that the medium-sized fish (30-60cm) in the landings of fleet 1 (Trawls) tend to be positive, while the large-sized fish (>75cm) have negative residuals. This suggests that the logistic selection curve may be too restrictive. The model has also predominantly positive residuals for females (>25cm) in the combined FR_IE_IBTS survey and negative residuals for large-sized males (>50cm) in the same survey. This indicates that sexual dimorphism cannot be fully accommodated with the current settings. Figure 3.3.14 shows the results from the run test on the mean length. The residuals of the commercial fleets are very small but both failed the runs test, indicating non-randomness in the sign (positive/negative) of the residuals. The two surveys passed the run test, despite some apparent patterns in the residuals. The RMSE of the joint residuals is very small (7.3%) suggesting a precise fit.

Retention

Retention (the proportion of catches that are landed in each size class) is modelled with a logistic curve and the inflection point of the FL1 fleet (Trawls) is allowed to vary during the period 2003–2022 with a random walk. For FL2 (Gillnets), this parameter has no time-varying flexibility. Figure 3.3.15 shows that the length at 50% retention is fitted quite closely to the observed data (the differences occur due to the fitting of the landings and discard volumes as well as lengths).

Sex-ratio

Figure 3.3.16 shows the fit to the sex ratio-at-length. This fit is not part of the likelihood optimization but it is a useful diagnostic for the model fit. The sexual dimorphism that is apparent from the survey data cannot be fully accommodated with the current model settings. The difference in growth rates between males and females might be larger than assumed but there may also be differences in natural mortality that are currently not accounted for.

Conclusion

WGBIE did not identify significant concerns with the fit of the model.

3.3.2.3 Model consistency

Profiling

An R0 profile was performed for the WKANGHAKE benchmark (ICES, 2023b) but no R0 or other profiling was done for the update assessment during WGBIE 2023 (ICES, 2023c).

Retrospective analysis

Figure 3.3.17 shows the summary plot of the retrospective analysis. Mohn's rho (Mohn, 1999) values for SSB and F were well inside the WKFORBIAS guidelines (ICES, 2020). All the peels for SSB are inside the uncertainty bounds and only one of the peels for F is outside the bounds. Therefore, there is no concern of significant retrospective bias in SSB or F. Mohn's rho for recruitment, on the other hand, is large and most peels are outside the uncertainty bounds although the exceptionally strong recruitment that was estimated at the benchmark has not been revised significantly with the addition of an extra year of data. WGBIE considers that the model has a poor ability to estimate recruitment in the final year.

Hindcasting

Figures 3.3.18 and 3.3.19 show the results of the hindcasting analysis for the indices and mean length. The combined FR_IE_IBTS index has a MASE score of >1, indicating poor prediction skill. This may be related to the fact that this index is considerably influenced by recruitment in the survey year, which is unpredictable. The IAMS (G3098) survey index has a MASE score of <1 (0.79) indicating good prediction skill. The MASE scores for the mean length in the two commercial fleets and the combined FR_IE_IBTS survey are <1 indicating good prediction skill, although the reduction in mean length in 2020 due to strong recruitment was not (and could not be) predicted. The MASE score for mean length in the IAMS (G3098) survey has improved since last year and is now just <1 (0.97).

Conclusion

WGBIE did not identify significant concerns with the model consistency.

3.3.3 Historical stock development

3.3.3.1 Update assessment

The stock summary is given in Figure 3.3.20 and Table 3.3.3. Recruitment is highly variable and the 2020 recruitment is the highest in the time-series. F shows a declining trend and is estimated to have been below F_{MSY} since 2015. SSB is well above the biomass reference points and has been increasing since 2003.

3.3.3.2 Comparison with previous assessments, alternative runs

No alternative runs were performed.

The general perception of the stock is unchanged: SSB is increasing, F is decreasing and below F_{MSY} in recent years and recruitment is variable although the current model suggests less variability than the recruitment index from the combined FR_IE_IBTS survey previously suggested (ICES, 2022).

3.3.4 Biological reference points

The WKANGHAKE benchmark (ICES, 2023b) established new reference points for this stock. Note that although the SS model is sex-disaggregated, the biomass reference points were calculated relative to the combined-sex SSB following the standard ICES approach (ICES, 2023a). All figures and tables referring to biomass relate to combined-sex biomass for this stock.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	16776	B_{pa}; in tonnes	ICES (2023b)
	F_{MSY}	0.163	Stochastic simulations (EqSim) with Beverton–Holt stock–recruitment relationship estimated by the assessment model.	ICES (2023b)
Precautionary approach	B_{lim}	12073	SSB_{2004}; lowest observed SSB with high recruitment; in tonnes	ICES (2023b)
	B_{pa}	16776	$B_{lim} \times \exp(1.645 \times 0.2)$; in tonnes	ICES (2023b)
	F_{lim}	Undefined	Inconsistent with F_{pa}	ICES (2023b)
	F_{pa}	0.257	$F_{p.05;}$ the F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2023b)
Management plan	MAP MSY $B_{trigger}$	16776	MSY $B_{trigger}$; in tonnes.	ICES (2023b)
	MAP B_{lim}	12073	B_{lim}; in tonnes.	ICES (2023b)
	MAP F_{MSY}	0.163	F_{MSY}	ICES (2023b)
	MAP range F_{lower}	0.112	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}.	ICES (2023b)

	MAP range F_{upper}	0.245	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with F_{MSY}.	ICES (2023b)

3.3.5 Short-term projections

The approach to short-term projections is outlined in the Stock Annex.

WGBIE decided to replace the recruitment in the most recent data year (2022) with the predicted recruitment from the stock–recruit relationship estimated in the model. The original estimate was very close to the value it was replaced with (147 359 thousand) but the retrospective analysis indicates that the model estimate in the final year is unreliable.

$F_{status\ quo}$ was defined as the average F over the last three years and was used as the intermediate-year assumption.

Figure 3.3.22 shows the contribution of each cohort to the landings in 2023 and SSB in 2024 under the MSY catch option. The landings are expected to be dominated by the (very strong) 2020 cohort (31%) but also include a large number of older age classes. The assumed 2022 and 2023 recruitments are expected to contribute a modest 9% and 7% of the landings, respectively.

3.3.6 Quality of the assessment

The stock was benchmarked at WKANGHAKE in 2022 (ICES, 2023b). The basis for the advice has changed from a trends-based analysis (category 3; ICES, 2021b) to an analytical assessment (category 1). The broad perception of the stock is unchanged ($F < F_{MSY}$ and increasing stock size).

WKANGHAKE (ICES, 2023b) considers the current model to be suitable for providing advice, however, there is room for further development (see section 3.3.8 Recommendations for the next benchmark).

The final year's recruitment is not always estimated accurately (there is a significant retrospective bias), therefore it is replaced by the expected recruitment estimated from the stock–recruit relationship.

3.3.6.1 Other indicators

No other indicators are included in the assessment model.

3.3.7 Management considerations

Management of the two anglerfish species under a combined TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species. However, currently, the stock size of both species is increasing and neither species appears to be at risk of overexploitation.

3.3.8 Recommendations for the next benchmark

- Some of the conflicts in the model may result from regional changes in the stock over time and may be resolved by fitting a model with more than one area.
- The selectivity of the commercial fleets is quite rigid; more flexible options resulted in unrealistic scaling of F and SSB (generally creating large cryptic biomass). Logistic

selection was considered the "least bad" option, however, it does appear to cause some lack of fit.

- The length composition data dominates the likelihood components. Downscaling did not affect the perception of the stock but may be more appropriate.
- Only two commercial fleets were retained in the final model and one of these was responsible for the vast majority of the catch. One of the issues with having more fleets was the poor quality of the discard data. It may be possible to explore an option with a single discard fleet but multiple landings fleets.
- Growth of females for the first 6 years of life or so could be tracked quite well in the length data by following strong cohorts. However, it is not clear whether growth of females continues at the same rate after maturation (around age 6) because so few mature females are caught. Linked to this, natural mortality of spawning females may be considerable but there is currently no information to inform how high this may be. Spent/recovered females have been caught so the species is not entirely semelparous but the investment in reproduction is considerable and this is likely to have consequences for M at older ages.
- Growth of males could only reliably be tracked up to around age 3 (which is also the age at maturation of males). For the first 3 years, the growth of the two sexes is almost identical but the sex ratio-at-length suggests that male growth slows down after this age and/or male natural mortality is higher after this age. More analysis of the sex-ratio information may help improve estimates of male growth and M.

3.3.8.1 Benchmark scoring

1. Assessment has no substantial or only minor issues (score: 2);
2. Minor improvement in data or methods will be available (score: 2);
3. Management importance: all attributes below apply (score: 5);
   a) Catch advice is requested by EC;
   b) The stock is the object of the multi-annual plan for Western Waters (WWMAP; EU, 2019) (although not all parties have agreed);
   c) The stock is object of a dedicated fishery;
   d) Most catches of anglerfish originate in directed fisheries;
4. The stock is not included in the mixed fisheries analysis for the Celtic Sea;
5. The biomass is perceived to be near the highest on record (score: 1);
6. The stock was last benchmarked in 2022 in WKANGHAKE (ICES, 2023b) (score: 1).

Overall score: 2.1, no requirement for a benchmark in the near future.

3.3.9 References

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3.3.10 Figures and tables

Figure 3.3.1. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Un-sampled discards (i.e. métiers with landings without discard data) were filled in using available discard rates following the procedure described in the Stock Annex. However, the French OTB_CRU and OTB_DEF proportions were very different from recently observed values and were average discard rates of other OTB_CRU and OTB_DEF fleets from 2017-2022.

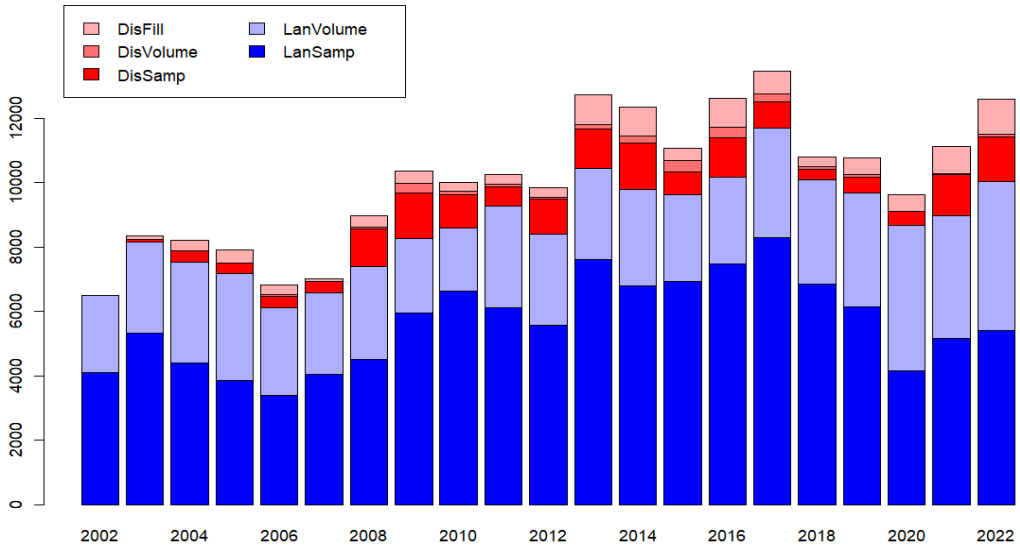

Figure 3.3.2. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Allocations of un-sampled landings and discards by year. Dark blue represents the sampled landings; light blue represents landings for which only the tonnage was available but no length data; Red represents the fully sampled discards (tonnage and length data); medium pink represents discards for which an estimate of the tonnage was available but no length data (length data 'borrowed' from other strata) and light pink represents strata for which no discard tonnage or length data were available (discard rate and length data 'borrowed' from other strata.

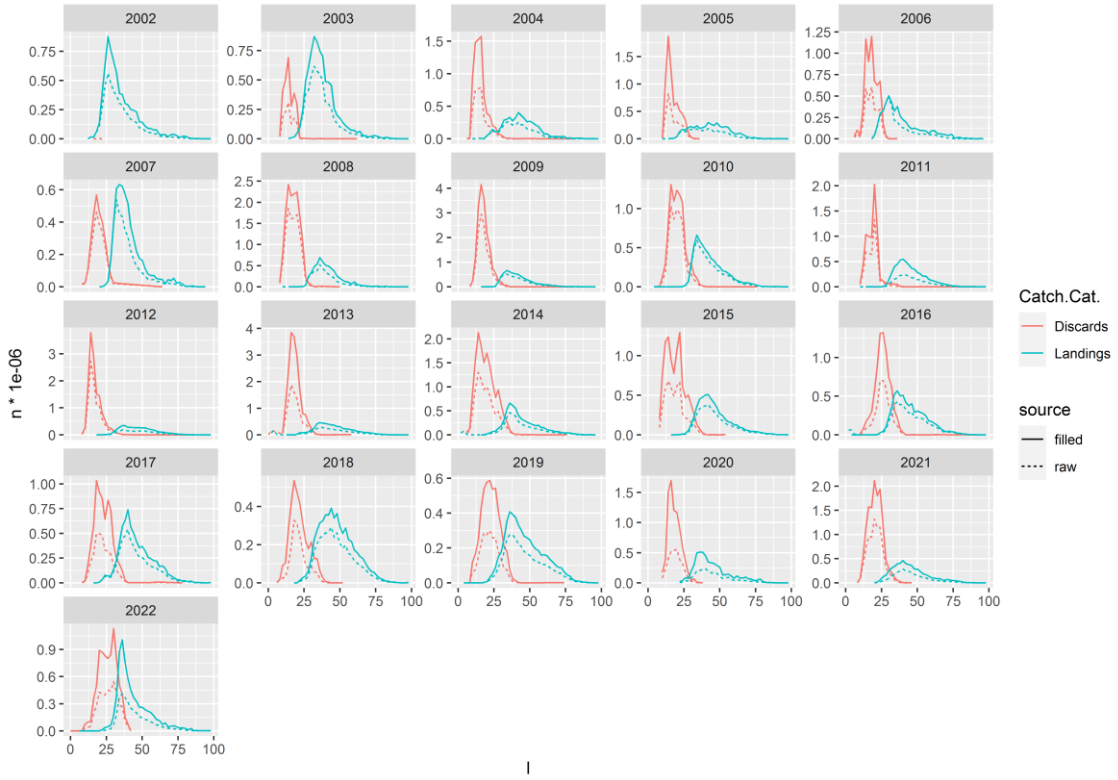

Figure 3.3.3. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Annual length–frequency distributions of the landings (blue) and discards (red). The dotted lines show the sampled strata submitted to InterCatch; the solid lines are the estimates after allocations of unsampled catches. No discard data were available prior to 2003.

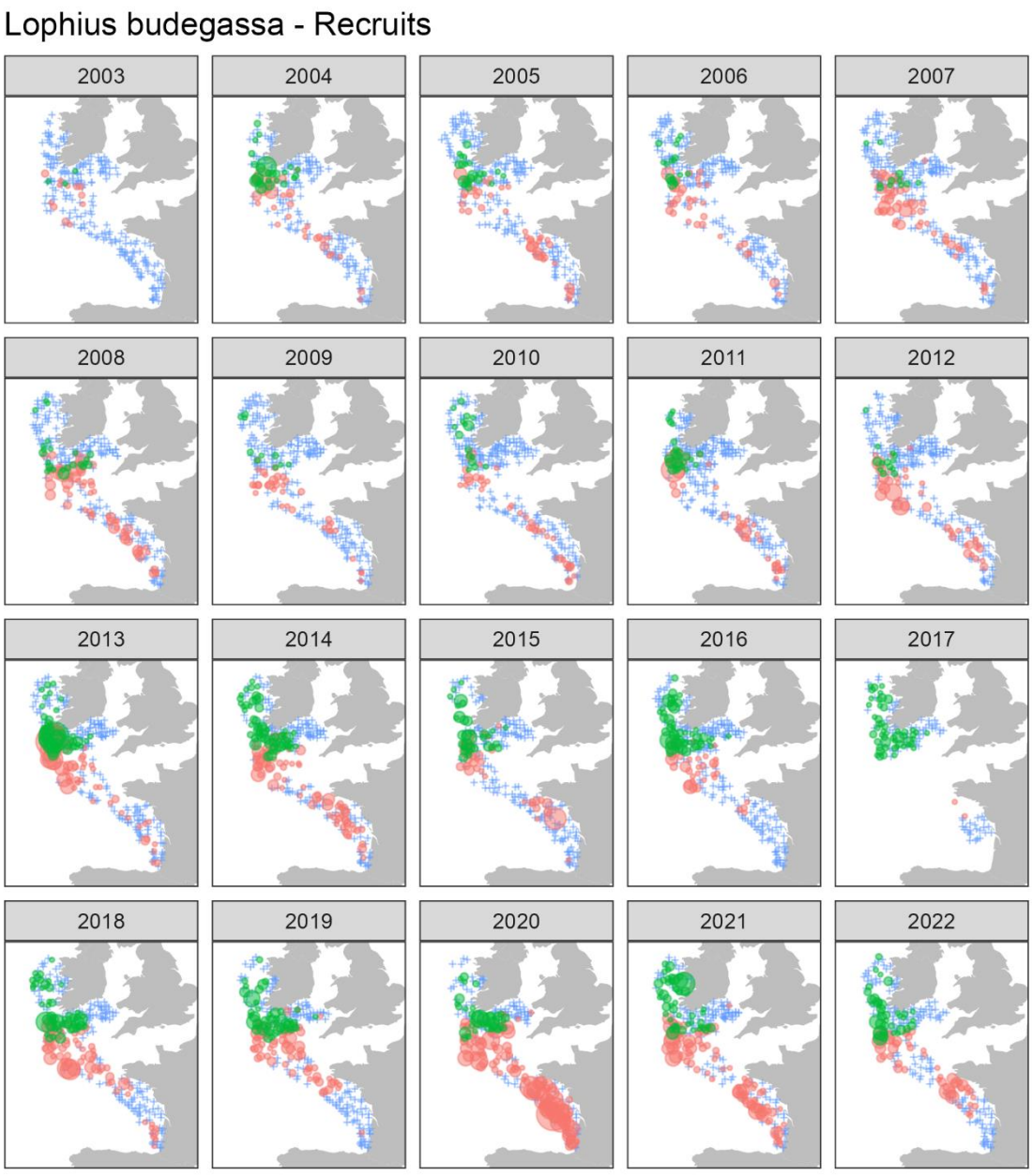

Figure 3.3.4a. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Abundance of recruits (< 24 cm) on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys (blue crosses represent hauls with zero catches).

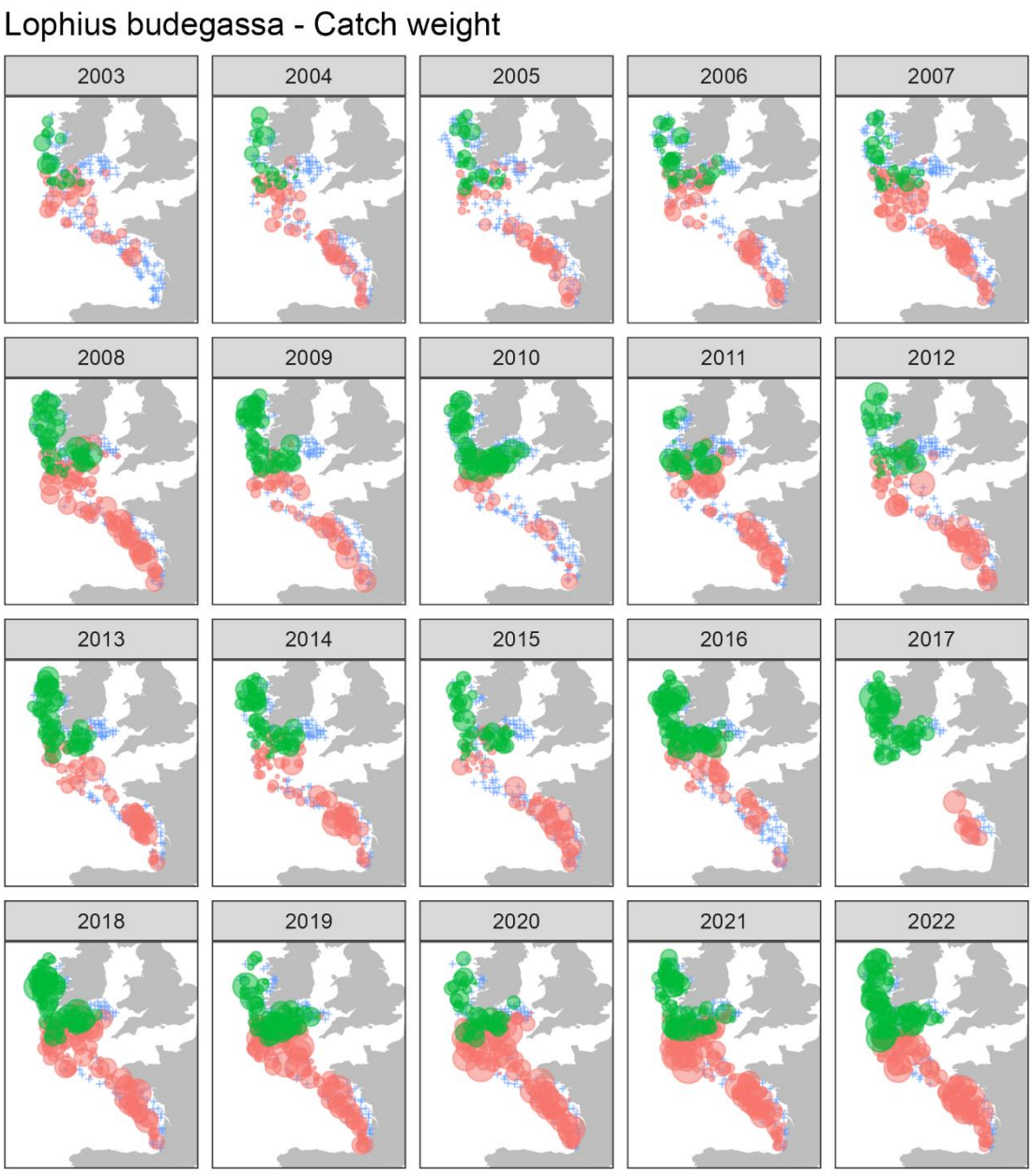

Figure 3.3.4b. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Catch weights on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys (blue crosses represent hauls with zero catches).

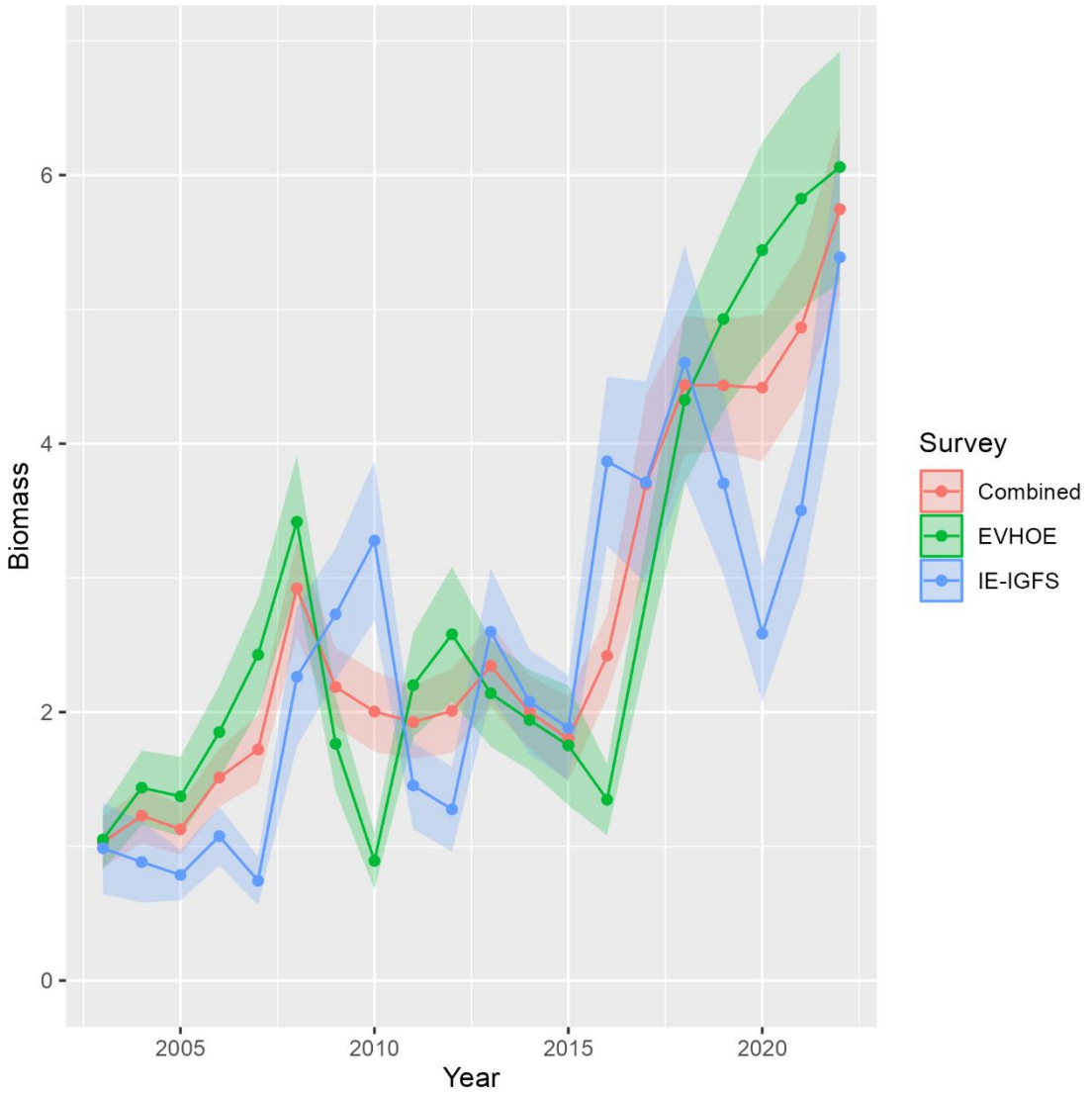

Figure 3.3.5. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Survey index of the EVHOE-WIBTS-Q4 (G9527) index is shown in green, IGFS-WIBTS-Q4 (G7212) in blue and the combined FR_IE_IBTS survey index in red, all with 95% confidence intervals.

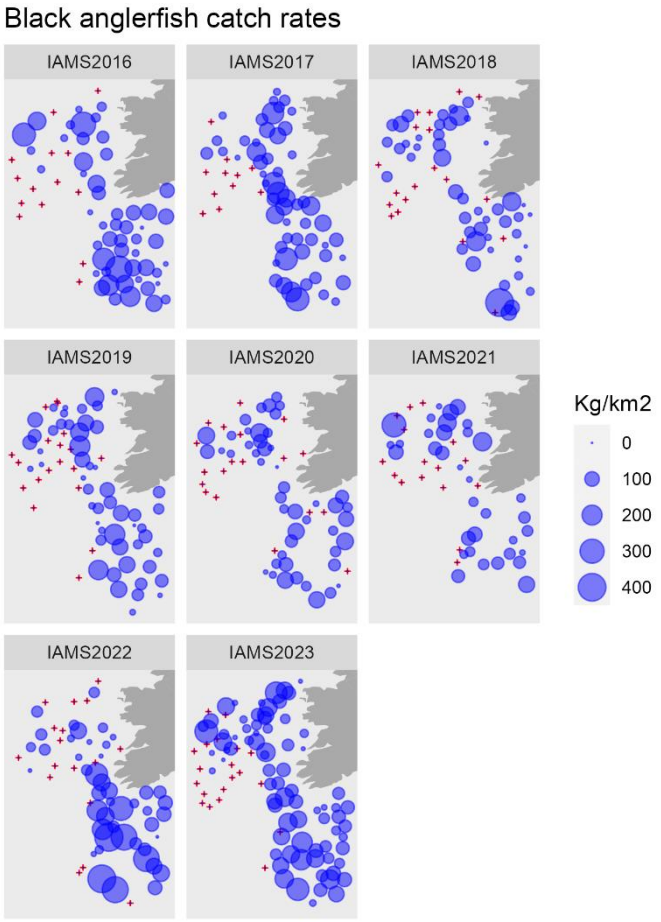

Figure 3.3.6. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Catch rates on the IAMS (G3098) survey (Note: survey indices are included in the assessment as December of the previous year).

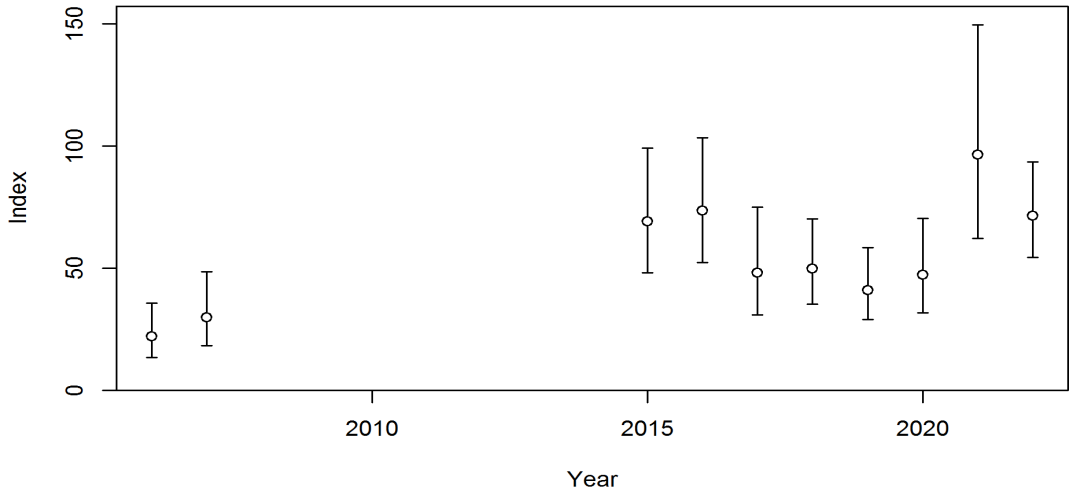

Figure 3.3.7. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Biomass index of the IAMS (G3098) survey (Note: Data points for 2006 and 2007 were from an earlier survey which used the same methodology and procedures as the IAMS (G3098) survey).

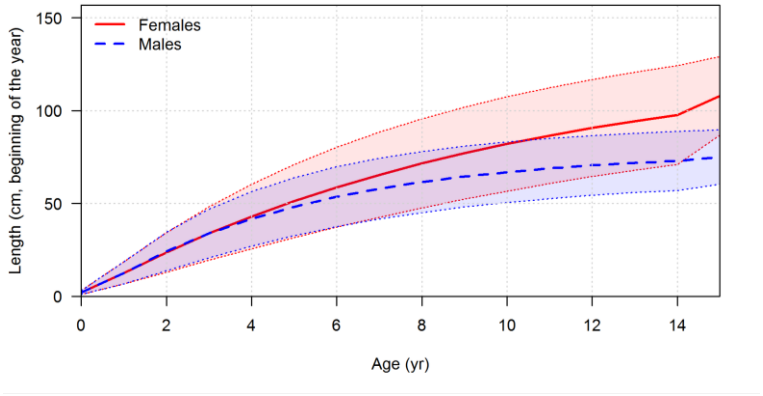

Figure 3.3.8. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Assumed growth curves for males and females.

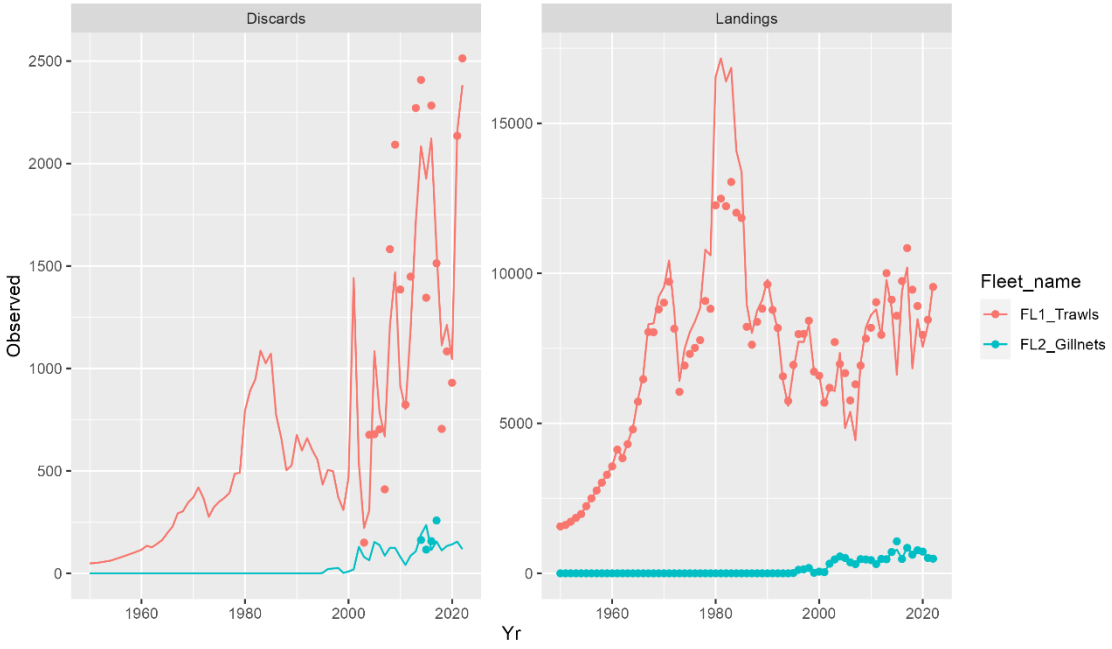

Figure 3.3.9. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Observed (points) and fitted (lines) of discards and landings (in tonnes).

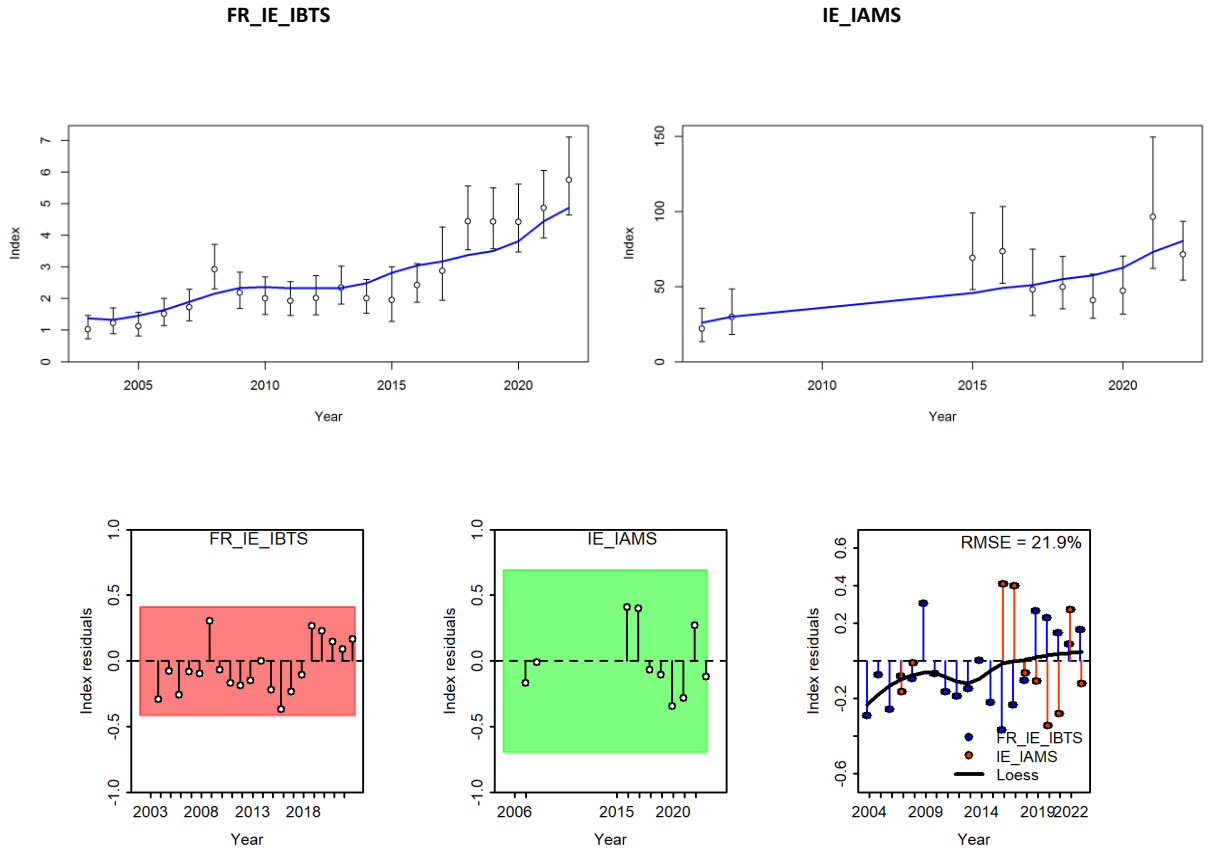

Figure 3.3.10. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Index fit (top) and residuals (bottom). The combined FR_IE_ITBS index failed the runs test (red shading) due to non-randomness in the sign of the residuals. The red and green shading indicates three standard deviations and observations outside this area can be considered outliers. The joint residual RMSE is relatively small (< 30%) indicating a reasonably precise model fit to the indices.

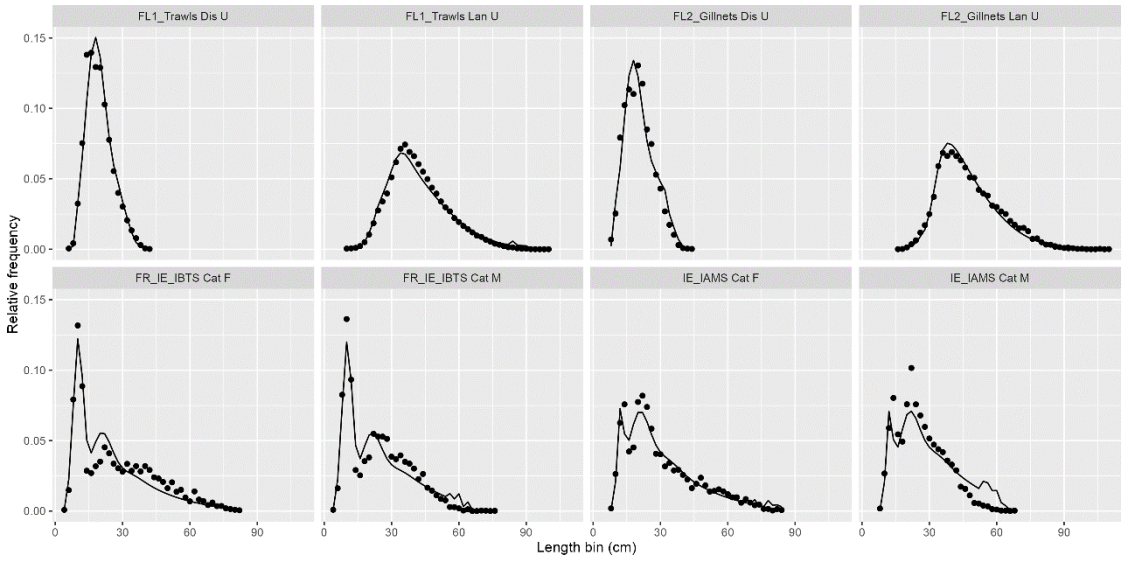

Figure 3.3.11. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Observed (points) and fitted (lines) length compositions, aggregated overall years by fleet.

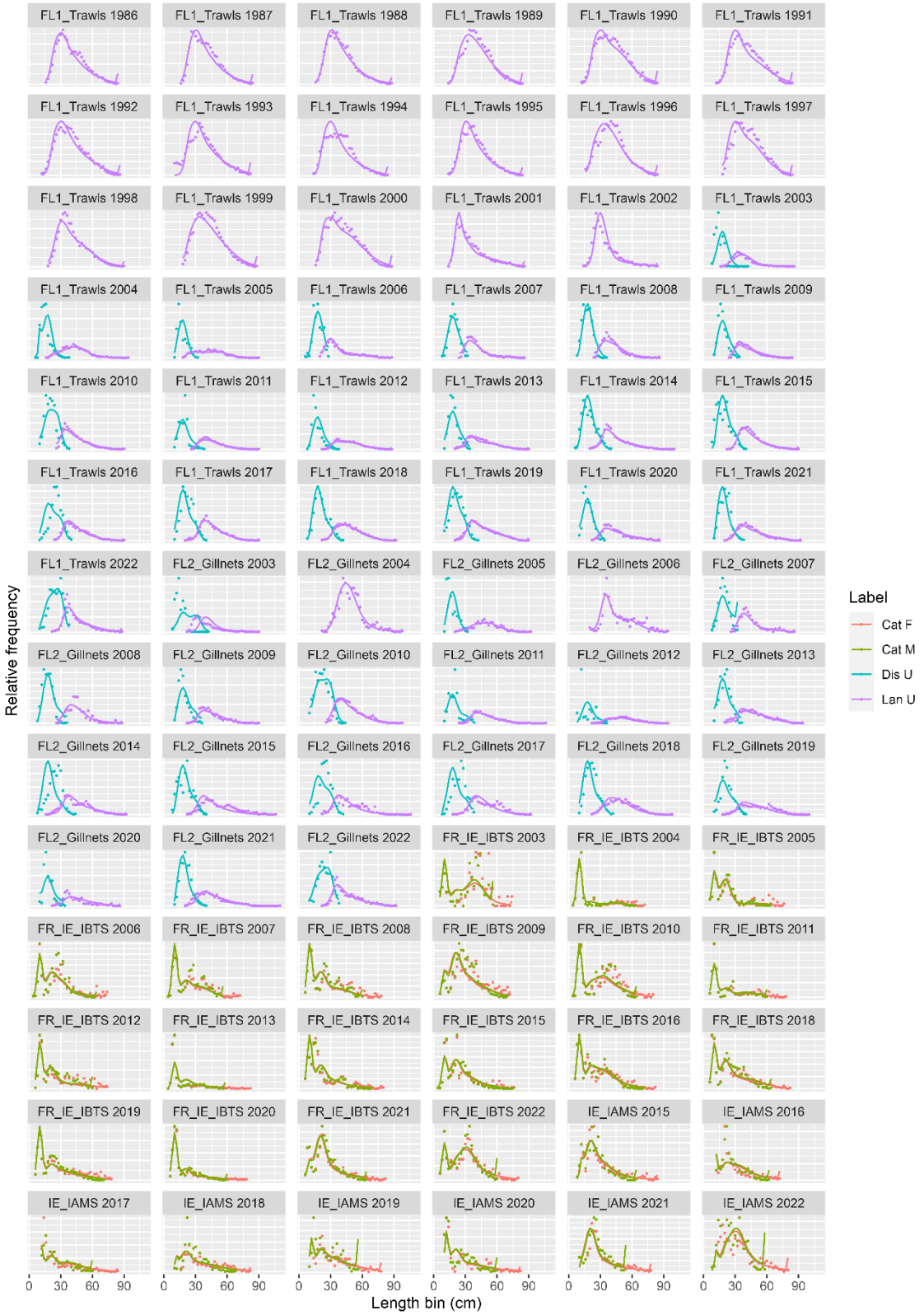

Figure 3.3.12. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Observed (points) and fitted (lines) length

compositions, by year. Note that all length compositions are standardized to a relative scale so landings and discards or males and females cannot be directly compared.

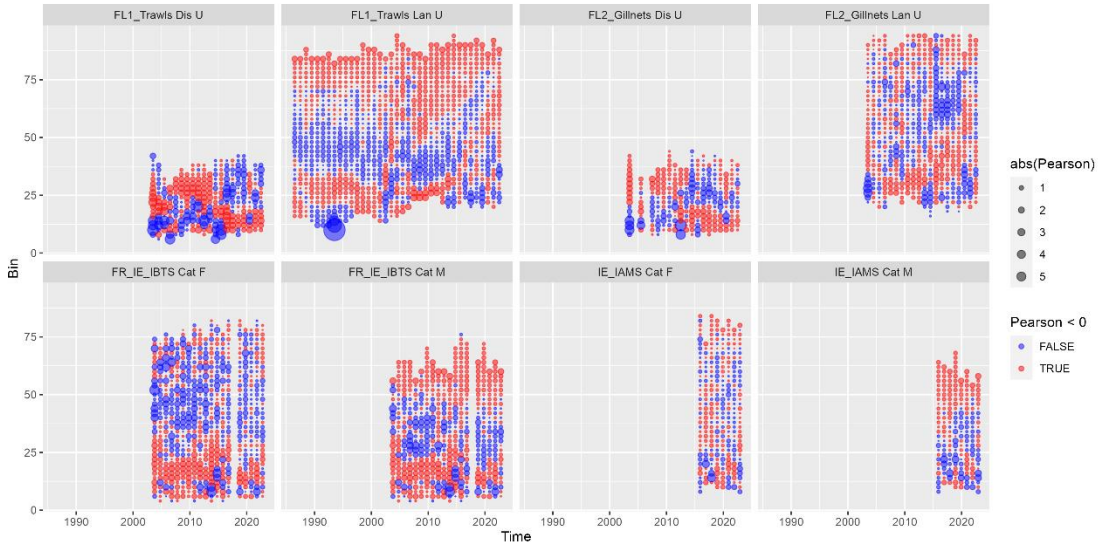

Figure 3.3.13. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Bubble plots of the residuals to the length composition fit.

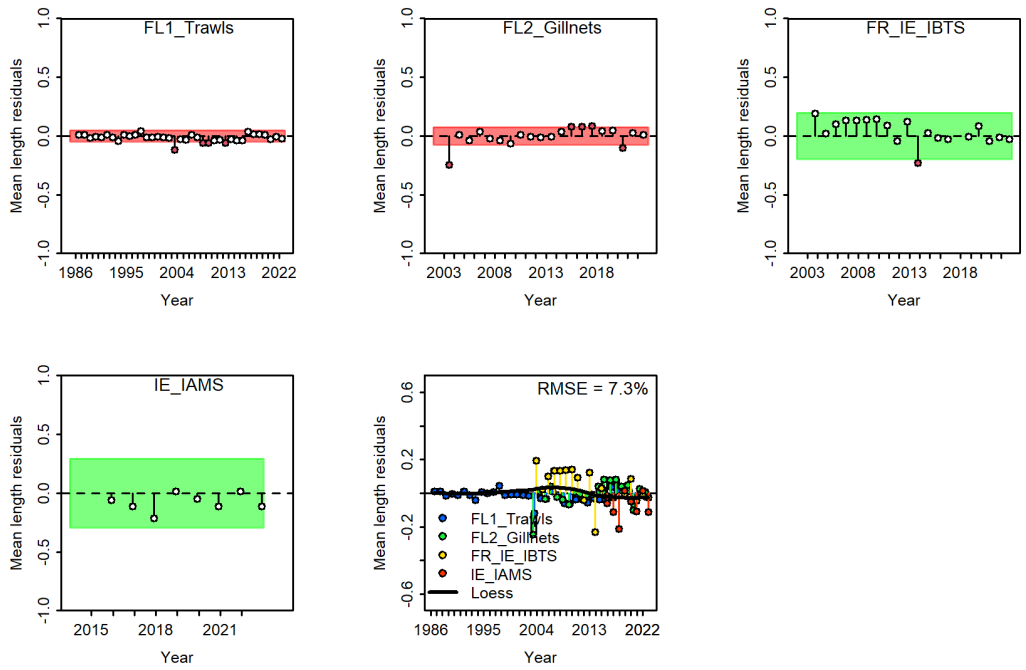

Figure 3.3.14. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Runs tests on the mean-length residuals. The residuals of the two commercial fleets do not vary much from year-to-year but they still fail the runs test (red shading); this indicates some non-randomness in the residuals. The combined FR_IE_IBTS survey passes the runs test (green shading), despite having mainly positive residuals in the first half of the time-series. The IAMS (G3098) survey also passes despite having mostly negative residuals.

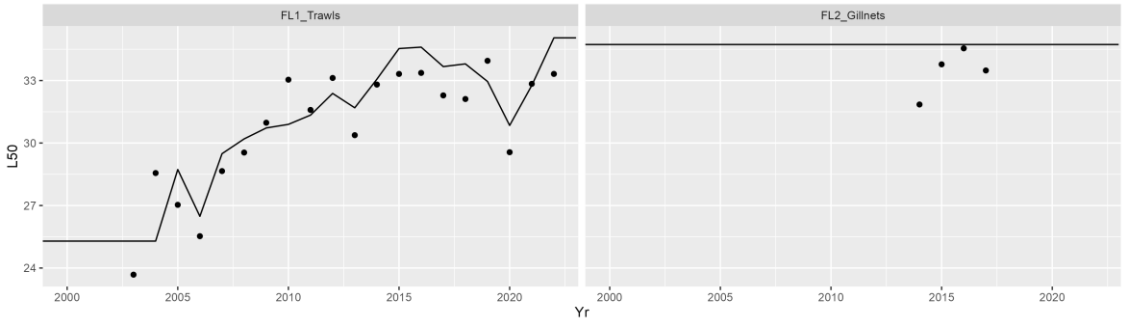

Figure 3.3.15. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Observed (points) and fitted (lines) length at 50% retention. Retention (the proportion of catches that are landed in each size class) is modelled with a logistic curve and the inflection point of the FL1 fleet (Trawls) is allowed to vary during the period 2003–2021 with a random walk. For FL2 (Gillnets), this parameter has no time-varying flexibility.

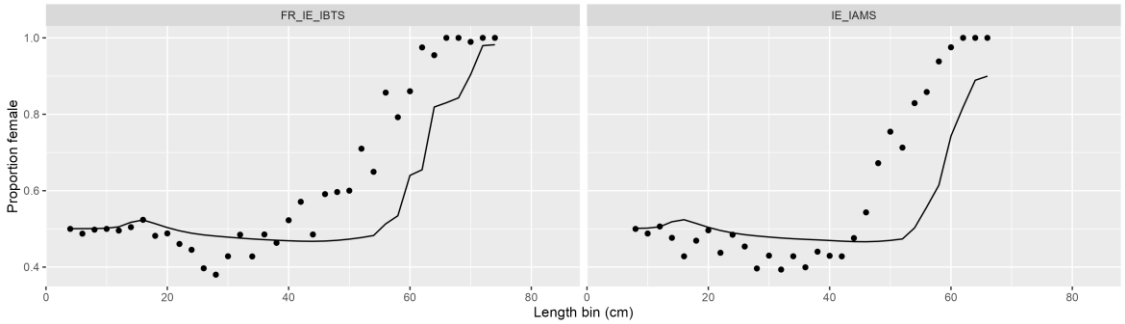

Figure 3.3.16. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Observed (points) and fitted (lines) sex ratio (proportion female) at length. The sexual dimorphism that is apparent from the survey data cannot be fully accommodated with the current settings.

Figure 3.3.17. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Retrospective analysis. The purple line corresponds to the current model run (last data year 2021). The other colours represent −1 to −5-year peels. The 95% confidence intervals of the final model are indicated by grey shading. SSB refers to combined-sex SSB (mature biomass).

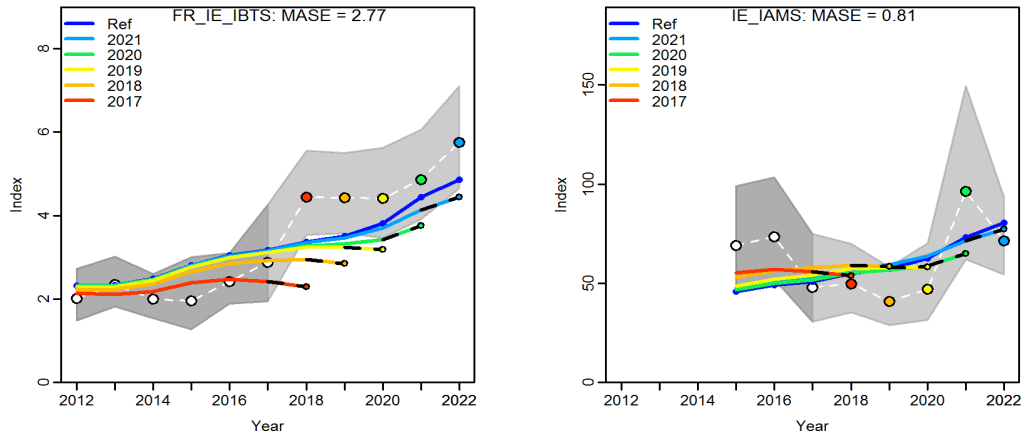

Figure 3.3.18. Black-bellied anglerfish (L. budegassa) in 27.78abd. Hindcasting results for the survey indices. The combined FR_IE_IBTS index has a poor MASE score, indicating that the model has poor capacity to predict this index. This

may not be surprising as the index is influenced considerably by recruitment. The MASE score for the combined FR_IE_IBTS survey is below 1 but the time-series is too short to draw strong conclusions.

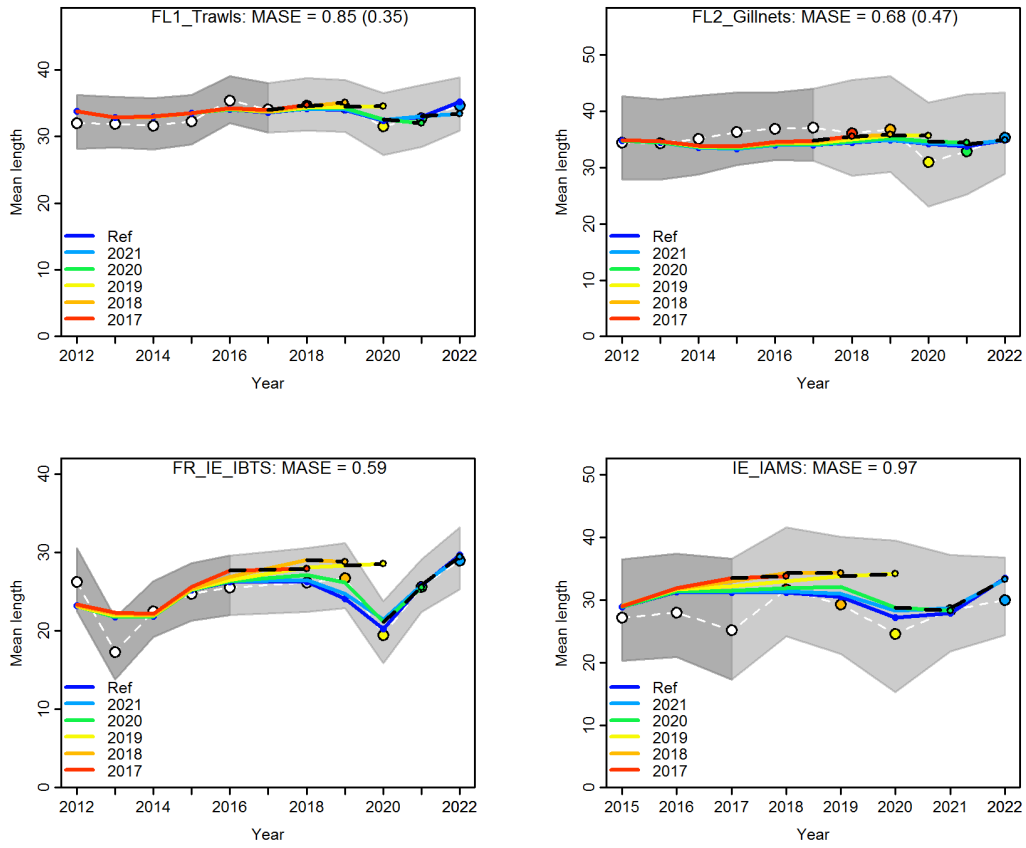

Figure 3.3.19. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Hindcasting results for the mean length in the commercial and survey fleets. The IAMS (G3098) survey has a score >1 but the other fleets have MASE scores <1 indicating good prediction skill.

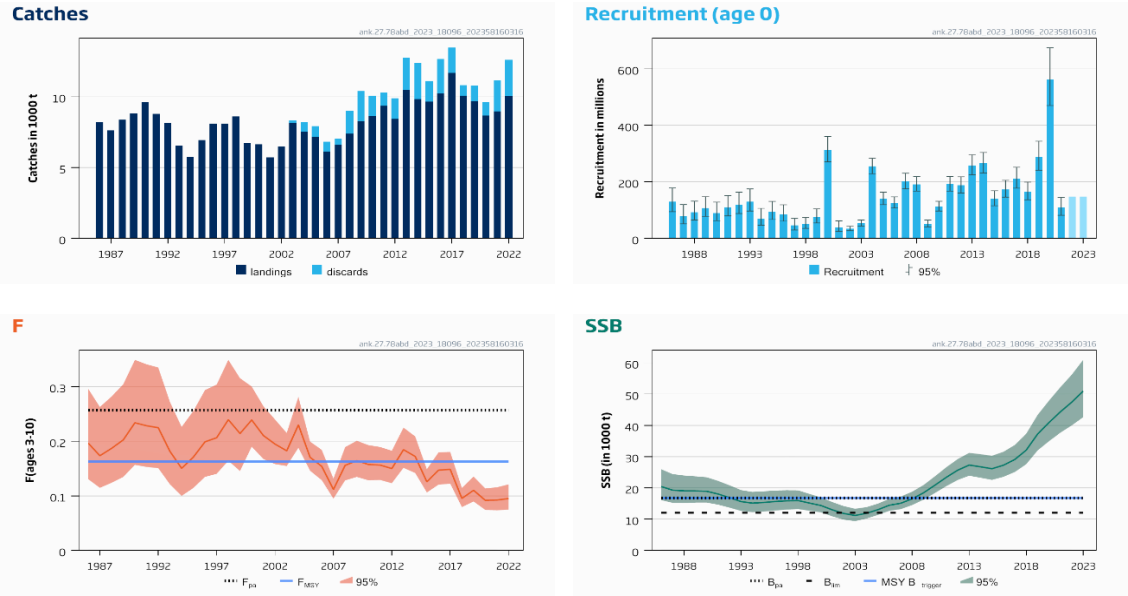

Figure 3.3.20. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Summary plot. Discard observations are available since 2003. Annual landings are available to the model from 1950 but the plots only show the more data-rich period since 1986. The assumed recruitment values for 2022 and 2023 are shaded in a lighter colour.

Figure 3.3.21. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Comparison of the current assessment (thick, orange line) with previous category 3 assessments. The broad perception of the stock is unchanged.

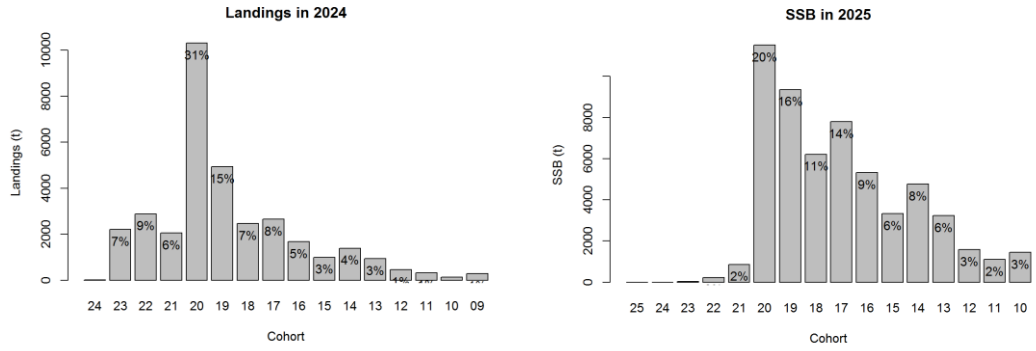

Figure 3.3.22. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Contribution of each cohort to the forecasted landings and SSB.

Table 3.3.1. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. ICES estimates of the catch and landings by area and by country. All weights are in tonnes.

Year	ICES estimated landings from Subarea 7						ICES estimated landings from divisions 8.a, 8.b, 8.d			ICES estimated; Subarea 7 and divisions 8.a, 8.b, 8.d			
	ESP	FRA	GBR	IRL	OTH	Total 7	ESP	FRA	OTH	Total 8.a, 8.b, 8.d	Landings	Discards	Catch
1986	2816	2251	949	262	165	6443	485	1289	0	1775	8217		
1987	2174	1868	805	241	28	5116	953	1551	0	2504	7620		
1988	2316	2572	1160	234	65	6347	695	1341	0	2035	8382		
1989	2445	2932	472	310	275	6434	602	1785	0	2387	8820		
1990	2393	2914	1030	614	109	7061	571	2000	0	2571	9632		
1991	2180	2390	809	858	17	6254	799	1727	0	2526	8780		
1992	1763	2440	1002	774	28	6008	536	1632	0	2168	8176		
1993	1304	1941	727	607	68	4646	589	1331	0	1919	6566		
1994	1374	1820	378	290	86	3948	624	1172	0	1796	5744		
1995	1668	2448	389	630	69	5204	463	1287	0	1750	6954		
1996	1909	2763	576	641	90	5979	525	1589	0	2114	8093		
1997	2143	2804	644	557	38	6185	366	1563	0	1929	8114		
1998	2042	2419	763	1234	53	6510	441	1648	0	2089	8599		
1999	2434	1771	193	529	141	5068	458	1212	0	1670	6739		
2000	2051	1961	167	873	169	5220	445	980	0	1424	6645		

Year	ICES estimated landings from Subarea 7						ICES estimated landings from divisions 8.a, 8.b, 8.d				ICES estimated; Subarea 7 and divisions 8.a, 8.b, 8.d		
	ESP	FRA	GBR	IRL	OTH	Total 7	ESP	FRA	OTH	Total 8.a, 8.b, 8.d	Landings	Discards	Catch
2001	2083	1516	131	580	168	4478	333	918	0	1251	5728		
2002	2451	1710	146	309	119	4734	463	1309	0	1771	6505		
2003	3600	2175	181	180	119	6256	396	1520	0	1916	8171	179	8351
2004	2875	1845	256	224	157	5358	471	1708	0	2178	7537	676	8213
2005	2902	1530	248	365	167	5214	415	1559	0	1974	7187	727	7914
2006	2737	1536	131	200	71	4675	282	1171	2	1456	6131	704	6835
2007	2451	1747	150	348	162	4857	316	1434	1	1751	6608	413	7021
2008	3017	2030	279	508	205	6039	265	1095	1	1360	7399	1585	8985
2009	3498	1635	304	797	244	6478	293	1515	2	1809	8287	2113	10400
2010	2866	2179	469	981	316	6812	317	1490	8	1815	8626	1436	10062
2011	3812	1863	418	941	382	7416	503	1423	8	1933	9348	971	10319
2012	2888	2032	365	621	53	5959	692	1612	167	2471	8429	1459	9888
2013	3896	2211	484	615	68	7274	790	2032	379	3200	10475	2285	12760
2014	1629	2829	862	720	74	6114	945	2526	246	3718	9832	2570	12402
2015	1384	2945	1046	839	69	6284	749	2480	136	3365	9649	1460	11109
2016	1118	2881	1063	970	94	6127	918	2968	206	4093	10220	2441	12660
2017	1287	4255	1183	793	0	7518	941	3000	231	4172	11690	1770	13460
2018	890	3443	898	1110	0	6341	766	2807	161	3734	10076	727	10803
2019	1366	3500	993	940	0	6800	645	2156	79	2880	9680	1084	10764
2020	1538	2575	757	1445	187	6502	611	1547	16	2174	8676	926	9601
2021	1548	3790	1309	721	78	7445	422	1085	13	1520	8965	2141	11107
2022	1758	4345	873	995	213	8185	527	1321	3	1851	10035	2564	12600

Table 3.3.2. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Survey indices used in the model. Both indices are specified in biomass; log se is the standard error on the log scale which is similar to the CV of the index.

Year	Month	Fleet	Index	log se
2003	10.5	FR_IE_IBTS	1.030	0.18

Year	Month	Fleet	Index	log se
2004	10.5	FR_IE_IBTS	1.228	0.17
2005	10.5	FR_IE_IBTS	1.128	0.17
2006	10.5	FR_IE_IBTS	1.514	0.14
2007	10.5	FR_IE_IBTS	1.722	0.15
2008	10.5	FR_IE_IBTS	2.921	0.12
2009	10.5	FR_IE_IBTS	2.187	0.13
2010	10.5	FR_IE_IBTS	2.004	0.15
2011	10.5	FR_IE_IBTS	1.926	0.14
2012	10.5	FR_IE_IBTS	2.010	0.16
2013	10.5	FR_IE_IBTS	2.345	0.13
2014	10.5	FR_IE_IBTS	2.001	0.13
2015	10.5	FR_IE_IBTS	1.801	0.17
2016	10.5	FR_IE_IBTS	2.419	0.13
2017	10.5	FR_IE_IBTS	3.696	0.18
2018	10.5	FR_IE_IBTS	4.437	0.12
2019	10.5	FR_IE_IBTS	4.434	0.11
2020	10.5	FR_IE_IBTS	4.416	0.12
2021	10.5	FR_IE_IBTS	4.865	0.11
2022	10.5	FR_IE_IBTS	5.747	0.11
2015	12	IAMS (G3098)	69.171	0.19
2016	12	IAMS (G3098)	73.559	0.18
2017	12	IAMS (G3098)	48.083	0.23
2018	12	IAMS (G3098)	49.729	0.18
2019	12	IAMS (G3098)	41.051	0.18
2020	12	IAMS (G3098)	47.265	0.21
2021	12	IAMS (G3098)	96.625	0.23
2022	12	IAMS (G3098)	71.295	0.14

Table 3.3.3. Black-bellied anglerfish (*L. budegassa*) in 27.78abd. Assessment summary results with 95% confidence intervals. Weights are in tonnes and recruitment is in thousands. Discard observations are available since 2003. Annual landings are available to the model from 1950 but the plots only show the more data-rich period since 1986.

Year	Recruitment (age 0)			Stock size			Landings (tonnes) **	Discards (tonnes) **	F ages 3–10		
	Low	R	High	Low	SSB	High			Low	F	High
1986	94904	130283	178850	16088	20449	25991	8217		0.131	0.197	0.3
1987	51997	78962	119912	15228	19285	24421	7620		0.115	0.174	0.26
1988	65400	92922	132028	15185	19082	23980	8382		0.124	0.187	0.28
1989	77990	107520	148231	15295	19050	23727	8820		0.135	0.2	0.3
1990	63328	90312	128792	15306	18931	23414	9632		0.157	0.23	0.35
1991	80052	110039	151260	14639	18044	22242	8780		0.153	0.23	0.34
1992	88261	120105	163438	13690	16889	20835	8176		0.151	0.22	0.34
1993	97377	130608	175180	12647	15633	19324	6566		0.121	0.182	0.27
1994	46740	70640	106760	12243	15142	18727	5744		0.1	0.151	0.23
1995	67165	93827	131074	12457	15359	18937	6954		0.114	0.171	0.26
1996	61208	85436	119254	12780	15655	19176	8093		0.135	0.199	0.29
1997	30059	46100	70700	13069	15876	19285	8114		0.14	0.21	0.3
1998	35560	51493	74565	13251	15967	19239	8599		0.164	0.24	0.35
1999	55071	75901	104610	12705	15164	18098	6739		0.145	0.21	0.32
2000	270751	312608	360936	12191	14393	16992	6645		0.19	0.24	0.3
2001	25290	39535	61806	10912	13002	15493	5728		0.168	0.21	0.26
2002	27922	34716	43164	9871	11840	14202	6505		0.158	0.195	0.24
2003	43709	53180	64703	9380	11194	13358	8171	179	0.155	0.183	0.22
2004	228876	254965	284028	10209	11897	13865	7537	676	0.188	0.23	0.28
2005	119640	139906	163605	11370	13057	14993	7187	727	0.146	0.171	0.2
2006	107814	126088	147459	12675	14472	16523	6131	704	0.129	0.154	0.184
2007	175821	201434	230778	13213	15101	17259	6608	413	0.095	0.112	0.132
2008	167679	191704	219171	14518	16519	18795	7399	1585	0.128	0.156	0.189
2009	40753	51389	64801	16244	18444	20941	8287	2113	0.135	0.165	0.2
2010	97144	113129	131744	18380	20885	23731	8626	1436	0.129	0.158	0.193

Year	Recruitment (age 0)			Stock size			Landings (tonnes) **	Discards (tonnes) **	F ages 3–10		
	Low	R	High	Low	SSB	High			Low	F	High
2011	167841	192109	219886	20567	23406	26638	9348	971	0.129	0.157	0.19
2012	161384	187668	218233	22545	25680	29251	8429	1459	0.123	0.15	0.183
2013	225516	258417	296119	23907	27316	31212	10475	2285	0.151	0.185	0.23
2014	231651	265598	304520	23248	26754	30789	9832	2570	0.142	0.172	0.21
2015	115898	139878	168819	22568	26143	30285	9649	1460	0.106	0.126	0.149
2016	146184	173556	206053	23541	27255	31556	10220	2441	0.121	0.147	0.18
2017	178060	211866	252090	25082	29090	33738	11690	1770	0.122	0.149	0.181
2018	136898	165228	199421	27561	32073	37325	10076	730	0.079	0.095	0.115
2019	241241	288185	344264	31960	37220	43347	9680	1099	0.09	0.11	0.136
2020	470211	563375	674998	34921	40906	47917	8676	939	0.074	0.092	0.114
2021	81776	109023	145348	37655	44346	52227	8965	2166	0.074	0.092	0.116
2022		147359*		40004	47436	56249	10035	2564	0.075	0.095	0.121
2023		147781*		42615	50975	60974					

*** Assumed recruitment based on stock–recruit relationship.**

**** Observed landings and discards; not all discard observations were provided to the model.**

Contents